CICS-NC Annual Report
2014

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CICS-NC Intro Statement

CICS-NC

The Cooperative Institute for Climate and Satellites-North Carolina (CICS–NC) is an Inter–Institutional Research Center (IRC) of the UNC System, referred to as the North Carolina Institute for Climate Studies (NCICS). CICS-NC/NCICS is administered by North Carolina State University and affiliated with the UNC academic institutions as well as a number of other academic and community partners. CICS-NC is collocated within the NOAA/NESDIS National Climatic Data Center (NCDC) in Asheville, NC, and focuses primarily on the collaborative research into the use of satellite and surface observations in climate research and applications that is closely coordinated with NCDC.

CICS-NC is led by the Director of the IRC and includes numerous partners from academic institutions with specific expertise in the challenges of utilizing satellite observations in climate research and applications. NCSU provides CICS-NC with access to a strong graduate program in atmospheric sciences, and many of the CICS partners offer complementary programs. Other team members with exceptional strength in scientific computing include the Renaissance Computing Initiative (RENCI) of the UNC System, and the Oak Ridge National Laboratory (ORNL). A variety of needed skills and/or information sets have been requested by NOAA which were not originally envisaged in the original proposal, thus, a number of additional partners were added to the CICS Consortium. New partners include: University of Michigan, Center for Climate and Energy Solutions (C2ES), and the University of Alabama Huntsville. Additional support for community engagement and outreach is provided by the North Carolina Arboretum, an affiliate member of the UNC System, and by the Centers for Environmental and Climatic Interaction (CECI), an Asheville NC-based organization of academic, non-profit, community, and private organizations with a common interest in advancing the capabilities represented by CICS-NC. CICS-NC anticipates adding Stanford University, University of Pennsylvania, and Harvard University as partners to enhance business and industry climate links over the next five years.

CICS scientific vision centers on the observation, using instruments on Earth-orbiting satellites and surface networks, and prediction using realistic mathematical models of the present and future behavior of the Earth System. In this context, observations include the development of new ways to use existing observations, the invention of new methods of observation, and the creation and application of ways to synthesize observations from many sources into a complete and coherent depiction of the full system. Prediction requires the development and application of coupled models of the complete climate system, including atmosphere, oceans, land surface, cryosphere and ecosystems. Underpinning all of these activities is the fundamental goal of enhancing our collective interdisciplinary understanding of the state and evolution of the full Earth System. This vision is consistent with NOAA's Goals and CICS scientists work on projects that advance NOAA objectives. CICS conducts collaborative research with NOAA scientists in three principal Themes: Satellite Applications, Observations and Modeling, and Modeling and Prediction.

CICS-NC mission focuses on collaborative research into the use of *in situ* and remotely sensed observations in climate research and applications that is led by NCDC; innovation of new products and creation of new methods to understand the state and evolution of the full Earth system through cutting-edge research; preparation of the workforce needed to address climate science and its applications; engagement with corporate leaders to develop climate-literate citizens and a climate-adaptive society; and the facilitation of regional economic development through its Engagement activities.

Highlights

CICS-NC
CICS-NC highlights are arranged by topic with funders noted at the end of the highlight. CICS' primary NOAA funding comes from NESDIS/NCDC, but CICS also receives grants from OAR's Climate Program Office (CPO), the NWS Office of Science and Technology (OST), NESDIS/NODC, OAR/ATDD, NESDIS/JPSSO, the National Ocean Services (NOS), and the OAR's Earth System Research Laboratory (ESRL). Other funding comes from the National Science Foundation (NSF), the Department of Energy (DOE), the National Aeronautics and Space Administration (NASA) and *EarthRisk*.

Administration
Communications Strategy: This task promotes the Cooperative Institute for Climate and Satellites (CICS-NC) to its stakeholders and advanced the National Climatic Data Center's strategic goals among its workforce. A strong communications plan was developed to reach out to CICS-NC audiences and potential partners. The approach was to understand what the key messages were and how they should be delivered by determining which channels should be used for the different audiences **[NCSU and NCDC].**

Information Technology Systems Improvement, Management, and Maintenance: CICS-NC staff requires technological infrastructure and resources at a variety of levels. This task supports those needs by providing modern approaches to keep CICS-NC at the competitive edge of technology, as well as maintaining core technologies as a stable base for CICS-NC staff operations. These systems range from scientific computing, to medium-scale office oriented services. Improvements have been made in all aspects of CICS-NC's IT infrastructure towards a more reliable system that is both flexible and scalable while still supporting cutting- edge technologies that support the communication and computational needs of the administrative and research staff at CICS-NC. **[NCDC/NCSU]**

Climate Literacy, Outreach, and Engagement
Activities in Advancing Climate Engagement, Outreach and Literacy across Public, Private and Academic Institutions: Education, literacy, and outreach are all important elements of the broader CICS mission. CICS-NC engages in the improvement of both formal and informal education approaches to a variety of stakeholders and the public, ultimately to advance climate information and activities in adaptation and resilience. These activities are broadly grouped within K-12 Education, undergraduate and graduate education, business and industry engagement and other interdisciplinary stakeholder groups. Partnering with NCDC's Sectoral Engagement team, CICS-NC Outreach activities focus on user engagement workshops (called Climate Data and Applications Workshops) as well as the Executive Forum on Business and Climate, which targets business leaders from the industry. **[NCDC]**

Highlighting 150 Years of Weather Observations in Asheville: The Science House of NCSU provides K-12 educational outreach for climate and Earth System science in partnership with NOAA's NCDC and CICS-NC. The Science House is collaborating with NCDC on building curriculum and methodologies for using climate data in the classroom. **[NCDC]**

Climate Data and Information Records and Scientific Data Stewardship

Climate Data Record (CDR) Intergrated Product Team (IPT) Support:
Climate Data Record (CDR) IPTs are multi-disciplinary teams comprised of members from offices and organizations supporting the transition of research-grade CDRs into an initial operational capability (IOC) status. The IPTs are formed for the purpose of efficient and effective collaboration, coordination, and execution and reporting of member's office/organization tasks required to transition the CDR to an IOC state. Several CICS-NC scientists serve as Products and Operations Branch representatives on multiple CDR IPTs. **[NCDC]**

Suomi-NPP VIIRS Climate Raw Data Record Production Software Development: The VIIRS Climate Raw Data Record production software development and test were completed and operational production began on October 19, 2013. **[NCDC]**

Optimum Interpolation Sea Surface Temperature (OISST) Transition to Operations: NCDC's Optimum Interpolation Sea Surface Temperature software was refactored in order to meet CDR Program requirements for operational readiness. **[NCDC]**

Suomi-NPP VIIRS Climate Raw Data Record System Infrastructure: The transition of the VIIRS Climate Raw Data Record into the NCDC operational environment was completed and helped define the processes for the NCDC 3-tier software development environment. **[NCDC]**

Transfer NOAA/NASA Advanced Very High Resolution Radiometer (AVHRR) Pathfinder Sea Surface Temperature (SST) Processing to National Oceanographic Data Center (NODC): The Pathfinder Sea Surface Temperature (SST) time series has been extended to include NOAA-19 observations. This is a continuation of the previously submitted time series that covered the Advanced Very High Resolution Radiometer (AVHRR) sensors NOAA-7 through NOAA-18. In addition, the coverage period of NOAA-7 was expanded to include September and October of 1981 through cooperative work with NCDC/RSAD and National Oceanographic Data Center (NODC) to provide the augmented Reynolds OI reference SST fields that are required to process the Pathfinder time series. **[NCDC, NODC]**

Validation of Land Surface Temperature (LST) from Suomi NPP VIIRS: The objective of this task is to provide the LST users community and the algorithm-working group (NOAA STAR) with uncertainty estimates associated with VIIRS LST standard products. **[NCDC/JPSSO]**

Net Surface Radiation Budget at High Spatial and Temporal Resolution from Multi-Sensor Data Fusion: A successful technique to estimate net surface solar radiation from geostationary earth orbit (GEO) satellites has been developed by adapting an algorithm developed for the NASA-operated Clouds and Earth's Radiant Energy System (CERES) instrument on board the EOS/Terra and Aqua. A comparison of the results with ground site measurements revealed excellent agreements comparable to or better than other sophisticated methods or even CERES-parameterized flux products. **[NCDC]**

Independent Evaluations of the Calibration of the Visible Channel in the International Satellite Cloud Climatology Project (ISCCP) B1 Data: Calibration of the Geostationary Earth Orbit (GEO) visible channel in the ISCCP B1 data stream has been completed for all meteorological satellites for the period 1979-2009, by employing AVHRR channel 1 reflectance in the Pathfinder Atmospheres Extended (PATMOS-x) data and validating through other independent results. Separately, the pre-GVAR GOES data (prior to GOES-8) has been reprocessed to conform to a more consistent format with less noise and these reprocessed data files will soon replace the present ISCCP B1 data in the archive. **[NCDC]**

Implementation of Geostationary Surface Albedo (GSA) Algorithm with GOES Data: The GSA algorithm was implemented as the U.S. contribution of an international collaboration between Europe, Japan, and the United States to produce a joint Climate Da-ta Record. **[NCDC]**

Uncertainty Quantification for Climate Data Records: Uncertainty quantification in climate research is a multidisciplinary area of increasing importance. Activity in this task has introduced CICS-NC as an entity in the mathematics/statistics for climate community network. Project topics researched by the group include: detection and attribution when comparing climate model output with observational data, uncertainty quantification for the global carbon cycle, and spatial statistics on distributed data. **[NCDC]**

Comparison of Ground Based Temperature Measurements with Satellite-derived Phenology: This research is a comparison of satellite derived phenology measurements with ground based temperature metrics. The goal of this project is to determine which of air or soil temperatures are better for estimating the growing season and will serve to improve U.S. Climate Reference Network (USCRN) drought monitoring. **[NCDC]**

High-resolution Infrared Radiation Sounder (HIRS) Temperature and Humidity Profiles: CICS is developing a global temperature and humidity profile dataset for the time period of 1978-present. Applying neural networks to High-resolution Infrared Radiation Sounder (HIRS) data produces the new dataset. **[NCDC]**

Maintenance and Production of CDRs for Microwave Sounding Unit (MSU) and Advanced-MSU (AMSU) Atmospheric Temperatures and SSMIS Brightness Temperatures: MSU/AMSU brightness temperatures updated and transferred to CDR Archive at NCDC. SSM/I Version 7 brightness temperatures updated and transferred to CDR Archive at NCDC. **[NCDC]**

Evaluation and Characterization of Satellite Products: Evaluated the NOAA/NSIDC passive microwave sea ice concentration climate data record (CDR) and provided global characterization of decadal trends of sea ice extents in the Arctic and Antarctic Oceans. The NCDC blended sea surface winds product was also evaluated. **[NCDC]**

The Scope and Framework of Long-Term Scientific Stewardship for CDRs: For this task, the scope of long-term stewardship for NOAA digital climate environmental data products was drafted based on U.S. laws and expert bodies' recommendations and associated functional

areas, and, a unified framework for assessing the vigor of stewardship practice applied to individual data product was defined. **[NCDC]**

Toward the Development of Climate Data Records for Precipitation: Characterization of CONUS Rainfall Using a Suite of Satellite, Radar, and Rain Gauge Quantitative Precipitation Estimates (QPE) Products: This task uses a suite of quantitative precipitation estimates (QPEs) derived from satellite, radar, surface observations, and models to derive long-term precipitation characteristics at fine spatial and temporal resolution over CONUS for the period 2002-2012. This work is part of a broader effort to evaluate long-term multi-sensor QPEs in the perspective of developing Climate Data Records (CDRs) for precipitation. **[NCDC]**

Mapping the World's Tropical Cyclone Rainfall Contribution Over Land Using Satellite Data: Precipitation Budget and Extreme Rainfall: This work examined the over-land rain-fall contribution originating from tropical cyclones for basins around the world for the period 1998-2009. Using the global database International Best Track Archive for Climate Stewardship (IBTrACS) and satellite precipitation data from the TRMM Multi-satellite Precipitation Analysis (TMPA) product 3B42, the precipitation budget and extreme rainfall were determined for different tropical cyclone (TC) basins around the world. **[NCDC]**

Dual-Polarization Signature of Microphysical Processes in Warm Rain: This work combines an explicit bin microphysical model with an electromagnetic scattering model. The goal is to assess the signature of microphysical processes (settling, coalescence, drop breakup, evaporation) on radar dual-polarization variables: the reflectivity factor at horizontal polarization (ZH), the differential reflectivity (ZDR), and the specific differential phase (KDP). **[NCDC]**

Role of Kelvin Waves in Tropical Cyclogenesis: Kelvin waves are among the most prominent sources of synoptic scale rainfall variability in the tropics, but their relationship with tropical cyclogenesis remains largely unknown. The relative impacts of convection and dynamical factors in these interactions are being quantified through a novel methodology. This project uses Kelvin-filtered NASA TRMM multisatellite rainfall estimates to identify which Kelvin wave phases produce the most tropical cyclones. **[NASA]**

Reanalyzing Tropical Cyclone Imagery with Citizen Scientists: *CycloneCenter.org* is a web-based interface through which citizen scientists have already produced more than 300,000 classifications of tropical cyclone intensity and structure since launching in September 2012. Preliminary research has shown that these classifications can help address uncertainties in the historical record of these storms. **[NCDC, NCSU]**

Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks Climate Data Record (PERSIANN-CDR): For this project, a new precipitation data set at 0.25^{o} and daily spatio temporal resolutions was developed. This product named PERSIANN-CDR is generated from the PERSIANN (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks) using 3-hourly GridSat-B1 data as input. The PERSIANN estimates are adjusted using the Global Precipitation Climatology Project (GPCP) monthly product to maintain consistency of two data sets at 2.5^{o} monthly scale throughout the

entire reconstruction period. The product covers from 60°S to 60°N and 0° to 360° longitude from 1983 to 2012. **[NCDC]**

Reanalysis of Archived NEXRAD Data Using NMQ/Q2 Algorithms to Create a High-Resolution Precipitation Dataset for the Continental US: The project team has generated four years of a high-resolution gridded precipitation product for the entire continental US at CICS-NC, with an additional seven years being produced at the National Severe Storms Laboratory/CIMMS in Norman, OK. CICS-NC continues to work closely with these partners toward quality assurance and the transfer of this very large dataset. **[NCDC]**

Satellite Product Evaluation and Near Real Time Monitoring: This project applies the Satellite Product Evaluation Center (SPEC) tool to the Surface Fluxes and Analysis (SurFA) project used to generate a Near Real-Time Monitoring (NRTM) website. Ingest operations were supported with modifications to manifest creation in support of multiple archive site common manifest generation. **[NCDC]**

National Climate Assessment

National Climate Assessment Scientific Support Activities: The Technical Support Unit (TSU) Science Team made substantive contributions to the completion of the Third National Climate Assessment Report (NCA3). These included lead author revisions to the draft report in response to public comments, two rounds of NRC panel review, and two rounds of government review. In addition, numerous graphics revisions and scientific analyses were performed to support revisions by a number of the other NCA3 authors. **[CPO]**

Trends in Extra-tropical Cyclone (ETC) Occurrence: Analysis of uncertainties in extra-tropical cyclone (ETC) occurrence have identified periods when the analyzed temporal variations can be considered reliable, including 1891-present for mid-latitude land areas and the North Atlantic, 1921-present for the North Pacific, and 1931-present for high latitude land areas. **[NCDC/CPO]**

National Climate Assessment Technical Support Unit (TSU) Program Support Activities: Implementing new production processes and maintaining a supportive workforce are ongoing priorities. Coordinating TSU/USGCRP activities, especially delivering the Draft National Climate Assessment for public and expert review were primary accomplishments of the TSU in 2013. **[CPO]**

Development of Geospatial Visualizations, Online resources, and Decision Support Tools for the National Climate Assessment: Staff from UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC) created maps and products for the National Climate Assessment; co-developed digital resource environments and interactive and static graphics for users of the Climate Assessment and Indicators team; and researched and presented a decision framework for use by the Climate Assessment. These new products support the overall advancement and progression of the National Climate Assessment program. **[CPO]**

National Climate Assessment Technical Support Unit (TSU): the following efforts contributed to the National Climate Assessment (NCA) efforts:

- *Software Engineering Services*: This task focuses on ensuring the integrity and portability of the programs developed for the NCA and assisting the lead scientist in their creation and development. In addition, to facilitate the overall business of the NCA and its integrity, ancillary software tools must be created and continue to be developed as part of the continuing assessment process.
- *Graphical Services*: CICS staff provided editorial, graphics, and production support for the National Climate Assessment, making significant contributions to the release of the NCA in Spring 2014.
- *Web Development*: Designed and implemented a new web site for CICS-NC. Concluded a performance evaluation of the NCA Comment and Review system. Completed web development support for Dataset Discovery Days and the Executive Forum on Business and Climate websites.
- *Copy Editor*: CICS-NC staff provided editorial, production, and project management support for the NCA, contributing to multiple drafts and the final approved document. Facilitated delivery to layout and website production and contributed to the development of the shorter "*Highlights*" summary of the NCA.
- *Metadata Collection and Management*: TSU built a sustainable process and technical infrastructures to collect, curate, and display the metadata of the National Climate Assessment. The effort satisfies compliance with the Information Quality Act and includes traceability of data, contributors, and scientific analysis methods across graphics, visualizations, references, and photos, at a level of detail to satisfy a requirement to also be reproducible. TSU has completed approximately 10% of the collection.
- *Analysis of Observational and Modeled Climate Data*: Analysis of several observational and model datasets was performed and 23 figures were produced for the Third National Climate Assessment (NCA3) report, along with the compilation of associated metadata.
- *Science Editor/Publication Support*: CICS-NC staff provided editorial, graphics, and production support for NOAA's Technical Support Unit to the National Climate Assessment, making significant contributions to the development of the full report and accompanying *Highlights* document.
- *Scientific Support Activities*: Scientific analysis of Coupled Model Intercomparison Project, Phase 5 (CMIP5) and CMIP3 data was performed to support the development of the Third National Climate Assessment (NCA). **[CPO/NCDC]**

Surface Observing Networks

Validation of US Climate Reference Network (USCRN) Soil Moisture and Temperature: This research is an analysis of USCRN soil observations for developing an under-standing of spatial and temporal variability of soil moisture and temperature. The goal of this project is to determine the changes in soil observations and will serve to improve USCRN for drought monitoring and satellite calibration. **[NCDC/CPO]**

*Research Dealing with the Impacts of Climate on Health***:** This report illustrates the collaboration and interaction with the CDC's Climate and Health Program. The goal of this interaction is to increase the understanding of climate change on human health and assist

with projects that can further this knowledge. In order to develop projects dealing with climate and health, Jesse Bell became a Guest Researcher in the Climate and Health Program (located in CDC's National Center for Environmental Health (NCEH)). His role is to serve as a conduit between NOAA's National Climatic Data Center and CDC's NCEH to assist CDC researchers in accessing climate data and better understanding ways of applying these data. **[NCDC]**

Climate Monitoring and Research Services to the Atmospheric Turbulence and Diffusion Division (ATDD) of NOAA's Air Resources Laboratory: Installed a USCRN site near Paxson, Alaska in August 2013. **[ATDD]**

Investigating the hydrological effects of Tropical Cyclones over the Carolinas from observational and modeling based perspectives: Five Tropical cyclones (Floyd 1999, Isabel 2003, Frances 2004, Alberto 2006, Irene 2011) that impacted the Carolinas were simulated using the Weather Research and Forecasting model (WRF) for an ensemble of microphysical parameterizations. Modeling results were compared against surface and remotely sensed observations to assess the model's ability to capture such extreme events and their impacts on local communities. **[NCDC]**

Development and verification of USCRN Quality Assurance Methods: A field campaign was initiated this year with NOAA's Air Resources Laboratory (ARL) precipitation testbed in Marshall, CO. The field study focused on gauge evaporation over the summer of 2013, which showed USCRN gauges were prone to evaporative losses. Preliminary results indicate that evaporative losses had little impact on total precipitation. A website was developed to both improve the dissemination of USCRN climate quality data and serve as a spatial check for manual quality control (QC). A manuscript describing the new precipitation algorithm for the USCRN network was drafted and is currently being reviewed by the USCRN Project Science Manager. **[NCDC, CPO]**

Collocated US Climate Reference Network (USCRN) and Cooperative Observer Program (COOP) Comparisons: This study compares USCRN and COOP temperature and precipitation measurements and attributes observational discrepancies to station architecture. A manuscript describing network differences between USCRN and COOP networks was completed and submitted for internal review. Pending reviewer responses to revised manuscript, the document will be submitted for publication in a peer-reviewed journal. **[NCDC]**

Maintenance and Streamlining of the Global Historical Climatology Network-Monthly (GHCN-M) Dataset: A new land surface temperature Databank has been publically available through beta releases and work is underway to transition from research to operations. This product will lay the groundwork for the next iteration of GHCN-M, which will include updates to quality assurance and bias correction. **[NCDC]**

Workforce Development

Global Surface Temperature Portfolio: Sea Surface Temperature Analysis-ERSST: This project analyzed the parametric uncertainty quantification for monthly Extended Reconstructed Sea

Surface Temperature (ERSST) version 4 (v4) by adopting a Monte Carlo ensemble approach. **[NCDC]**

Consortium Projects

Maps, Marshes, and Management Application: Ecological Effects of Sea-Level Rise in North Carolina: This project developed and implemented web-based geospatial decision support information for managing coastal marshes. Results from prior funded mapping and modeling efforts have been assimilated on the new NC Coastal Atlas in collaboration with coastal resource management stakeholders. **[NOS]**

Radar-based SPI to Support NIDIS: This project group has transitioned an experimental high-resolution drought-monitoring product into an operational service now used routinely by authors and a contributor to the weekly US Drought Monitor. **[CPO]**

Programming and Applications Development for NOAA's Climate Services Portal: Staff from UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC) assisted with the enhancement of data visualization capabilities with the Global Climate Dashboard, specifically with the development of Multigraph, the Climate Explorer prototype, and Data Snapshots. These new products support the overall advancement and progression of the NOAA's Climate Services Portal (NCSP) program. **[NCDC]**

Spatio-temporal patterns of precipitation and winds in California: Precipitation frequency as a function of altitude in northern California does not correspond to the standard idealized relationship. It is widely variable with respect to both basin and storm type. **[ESRL]**

Other CICS PI Projects

Water Sustainability and Climate Change: A Cross-Regional Perspective: The main objective of this study is to understand and quantify the potential impacts of near-term climate change and population growth on freshwater sustainability-defined here as integrating daily to annual flows required to minimize human vulnerability and maximize ecosystem needs (including native biodiversity) for freshwater-by explicitly incorporating the feedbacks from human-environmental systems on water supply and demand. Model simulations from the CMIP5 hindcast experiment were found to reproduce observed temperature trends for the southeast and southwest U.S. for the period 1981-2004. Precipitation trends for the southeast U.S. were simulated well also. However, the downward trend in precipitation for the southwest U.S. was not simulated well. **[NSF]**

Identifying Tropical Variability with CDRs: Climate Data Records are being leveraged to develop new diagnostics for tracking and predicting the Madden-Julian Oscillation (MJO) and equatorial waves. These diagnostics are tested in near-real time on *monitor.cicsnc.org/mjo* where they are served to hundreds of users in the public and private sectors every month. **[NCDC]**

Administration

Administrative or Task I activities provide a central suite of shared resources for the CICS staff and partners. Primary Task I activities include institute administration, office administration, accounting and finance, proposal development/support, contracts and grants management, human resources, information technology, international linkages, internal and external communications, oversight and management of CICS-NC initiated consortium projects, and coordination with National Climatic Data Center (NCDC) administration and leadership.

BACKGROUND

Under the NOAA Cooperative Agreement, CICS-NC serves as the second of the dual location campuses for CICS and is collocated with NCDC in the Veach-Baley Federal Complex in Asheville, NC. As an Inter-Institutional Research Center (IRC) of the UNC System, referred to as the North Carolina Institute for Climate Studies (NCICS), CICS-NC/NCICS is hosted and administered by North Carolina State University (NCSU) and CICS personnel are hired as NCSU employees and serve under NCSU policies and administrative guidelines. The institute is operated as an administrative unit under NCSU's Office of Research, Innovation, and Economic Development (ORIED) and the CICS-NC Director reports to the NCSU Vice Chancellor for ORIED and the Vice President for Research of the UNC General Administration. CICS-NC administrative staff implement, execute, and coordinate administrative activities with pertinent CICS-MD, UNC, NCSU, ORIED, NOAA, and NCDC administrative offices and personnel.

The CICS-NC Director in coordination with the Business Manager and University Program Specialist is responsible for the operations of CICS-NC. Administrative operations are primarily supported by NCSU with additional support from NOAA via a Task I contract. The NOAA Task I contract provides partial support for the director, a business manager, a university program specialist, and an IT operations and support specialist. There is travel support for administration and research facilitation purposes and a substantial investment in IT infrastructure associated with the dual goal of providing state of the art visualization and connectivity (including telepresence) tools for the Asheville-based staff. Travel support is budgeted to promote face-to-face interactions with the diverse climate science and applications community.

CICS-NC/NCICS administrative activities are currently led by Dr. Otis B. Brown, Director, and are implemented and executed by the following administrative team:

Janice Mills, Business Manager
Theresa Stone, Program Specialist
Jonathan Brannock, Network/Systems Analyst
Scott Wilkins, Operations/Systems Specialist

Communciations Strategy	
Task Leader	Geraldine Guillevic
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 0%; Theme 3: 0%
Main CICS Research Topic	Climate Literacy, Outreach, and Engagement
Contribution to NOAA Goals (%)	Goal 5: 100%

Highlight: This task promoted the Cooperative Institute for Climate and Satellites (CICS-NC) to its stakeholders and advanced the National Climatic Data Center's strategic goals among its workforce.

BACKGROUND

With the fast growth of CICS-NC, a strong communications plan was needed to reach out to its audiences and potential partners. The approach was to understand what the key messages were and how they should be delivered by determining which channels should be used for the different audiences. With more than 300 employees in the center and a growing need for internal, open lines of communications, an impactful approach to understanding and engaging both employees and management was needed to increase motivation for improved performance.

ACCOMPLISHMENTS

CICS-NC Communications

Developed and implemented an effective communications strategic plan:

- Define a proper brand identity aligned with the Institute's core values and assets
- Create a visual cohesion for all CICS-NC communications
- Create a Vision Statement which resonates with the core mission and key-messages to use in all CICS communications
- Build a bridge between CICS-NC and its various partners and stakeholders to promote the Institute's activities by creating powerful messages and using the adapted channels
- Strengthen the Institute's social media voice
- Increase the Institute's presence in the media

Led and organized NOAA's Climate Communications Workshop to enhance Climate Communications in Asheville:

- Emphasize the importance of Climate Communications at NCDC
- Provide effective communications strategies and tips to increase employees' confidence in their relation with the media
- Understand the rules of working with journalists and how to use interviews as an opportunity
- Help scientists develop messages that have impact

NOAA NCDC Internal Communications

Developed an impactful internal communications strategy:

- Conducted center-wide interviews to identify the needs of various segments of the employee audience
- Analyzed and improved existing internal channels and or developed new channels when necessary
- Determined and implemented the most effective methods and channels to achieve internal communications objectives
- Collaborated with the Director's office and management to define appropriate processes to ensure smooth, consistent, and successful workflows and strategic message delivery
- Built strong relationships with management and employees to understand their organizational functions and develop appropriate strategies for their internal communication needs

DELIVERABLES

- CICS-NC brochure
- 30 facts sheets, available on cicsnc.org
- CICS-NC Communications Plan
- Press releases, available on cicsnc.org
- NOAA NCDC Internal Communications plan: an audit with 80 interviews led internally to a short-term actions plan and mid-term actions plan
- Management pagers to help improve performance

PRESENTATIONS

- Bi-weekly internal presentations of internal communications plans to NOAA NCDC Director's Office

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	40
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0

# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Information Technology Systems Improvement, Management and Maintenance

Task Leader	Jonathan Brannock, Scott Wilkins
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 33%; Theme 2: 33%; Theme 3: 33%
Main CICS Research Topic	Data Fusion and Algorithm Development
Contribution to NOAA Goals (%)	Goal 1: 50%; Goal 2: 50%

Highlight: The CICS staff requires technological infrastructure and resources at a variety of levels. This task supports those needs by providing modern approaches to keep CICS-NC at the competitive edge of technology, as well as maintaining core technologies as a stable base for CICS-NC staff operations. These systems range from scientific computing, to medium-scale office oriented services. Improvements have been made in all aspects of CICS-NC's IT infrastructure towards a more reliable system that is both flexible and scalable while still supporting cutting-edge technologies that support the communication and computational needs of the administrative and research staff at CICS-NC.

BACKGROUND

CICS-NC IT staff support a well-rounded set of IT resources and services as well as maintain the necessary infrastructure required to do so. CICS-NC services can be organized into 3 areas. The user network, cluster and computing resources, and Network and SAN infrastructure, see *Figure 1*. The user network is made up of wireless network services, Vidyo telecommunications services, and end user software on Apple desktops and laptops. The cluster and computing resources are centered on a high performance computing cluster and the headnode. The headnode is a powerful server where users can prototype ideas and perform light work tasks including coding and testing. The headnode can then queue heavy workloads onto the cluster where a number of different queues are available to suite different computing requirements. Last, there is the network and storage network (SAN) which supports the former with high-speed access to network resources, high speed storage and tape resources.

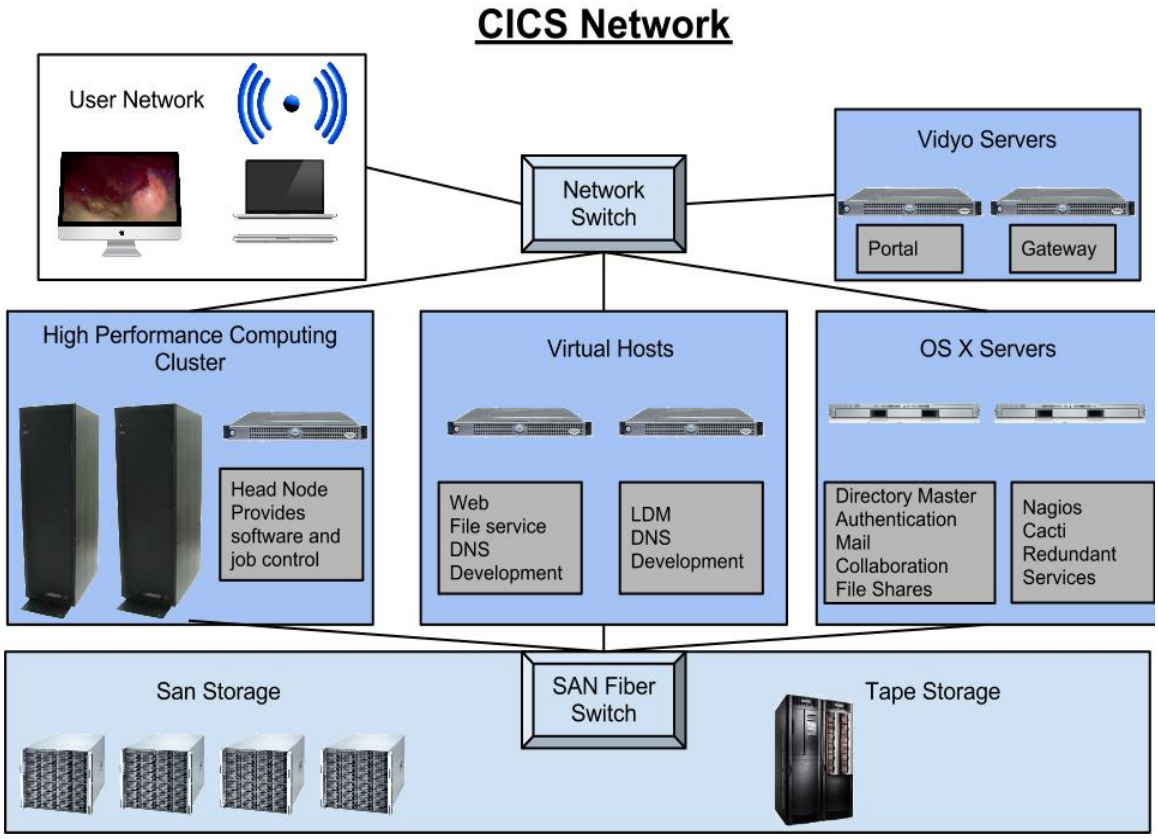


Figure 1: Network, and system diagram.

CICS-NC provides a distributed file system for concurrent system-wide access to high-speed storage. The Quantum Storenext file system is attached to three Promise SANs providing 425 Terabytes of online disk storage. This offers our users high-speed redundant storage for large projects and data sets. Of the total disk storage, 330 Terabytes is managed using Quantum's Storage Manager which makes two copies of the data to separate tapes, providing recovery capability for project data.

The high performance-computing cluster supports research tasks for both CICS-NC and NCDC. CICS-NC currently has 10 blade centers with 600 processing cores and 2.3 terabytes of memory. Each of the processors has access to all of the distributed storage space. The head node provides access to a large variety of software as well as command and control tools to push tasks into the cluster. Users may execute tasks using multiple approaches, including, but not limited to, batch mode processing and OpenMPI.

A building wide wireless network was created to provide both CICS-NC and other partners in the building with strong signal, fast wireless coverage. This allows CICS-NC to quickly integrate and work side-by-side with our NCDC partners.

The CICS-NC network is simple, yet fast, providing 10 Gigabit per second connectivity though the core of the network, to our Internet service provider and to NCDC. This allows users to fully take advantage of the high performance computing cluster as well as the building wireless network. This also gives CICS-NC and our partners an environment where they can quickly perform research tasks as well as testing and development.

A video conferencing solution by *Vidyo* has been made available. This provides users with the ability to quickly and easily set up virtual meetings where they can share video, audio, and desktop content. It provides a method to effectively work with off site employees, teleworkers, and people on travel. It also provides a means to collaborate and attend meetings hosted by other organizations including NCSU and NOAA.

CICS-NC IT utilizes Linux KVM virtualization to enhance security, OS Support, and efficient use of limited resources. Currently CICS-NC has two host servers that can support up to 20 reasonably configured virtual systems with a variety of operating systems, security, and performance requirements ranging from critical network infrastructure to testing and development systems. The KVM environment supports load balancing, live migration, and service redundancy by placing the virtual systems storage on a shared LVM SAN. This allows good scalability, resilience, and reduced maintenance overhead to provide systems with better uptime and service reliability.

CICS-NC IT supports a variety of system services required for data, computing, user and administrative needs. These include: Local Data Manager (LDM) a field standard service for real-time transfer of weather data, Web service for external visibility and collaborator interfacing, FTP for external data sources, and collaboration tools for administrative and internal office oriented interaction.

ACCOMPLISHMENTS

Upgrades were made to distributed-file system controllers. Stornext metadata controllers were upgraded to latest software. This upgrade increased metadata performance by 35%. The tape library drives were upgraded, doubling the capacity of the library to 1.6PB. This allows users to stage more data for processing using the Hierarchical Storage Managment system as it was designed.

Building-wide WIFI access was planned, updated, and deployed. Wi-Fi coverage was improved from 19 access points covering two floors and select areas on 3 other floors to 30 access points covering new areas on the 1st floor, fitness center, and NCDC archive. The most populous areas were upgraded to 802.11AC or gigabit WIFI. Heat maps and simulations were used to place the access points in optimal locations. CICS-NC also extended the wired network with an additional POE switch in the basement.

Virtualization support was improved by setting up a shared storage using logical volume management (LVM) for the VM data. This improvement also gives us the ability to migrate, load balance, and failover VM's between the different host servers. This also improves our ability to scale this platform as needs increase.

The *Vidyo* system was improved by adding two new services. The first is *VidyoReplay*. *VidyoReplay* gives CICS-NC the ability to record meetings for later viewing or dissemination. The *VidyoReplay* also provides the ability to webcast a meeting to as many as 300 additional participants. The second addition is *VidyoVoice*. *VidyoVoice* allows a toll free telephone number to be used to dial into any of the meetings. This allows an additional 10 participants to connect via telephone.

New tools were implemented for daily monitoring and control of IT resources, including *Casper Suite*, *Puppet OSE*, and *Splunk*. The *Casper Suite* by JAMF was implemented to provide an all in one configuration management, auditing, inventory, remote support, and employee self service. This has allowed IT to track and enforce patches and other security threats, track and distribute licensed software, and to provide asset tracking via automated inventory updates. *Casper* also provides a centralized package management and package creation tools. This allows software to be customized and configured then distributed by policy or the self-service portal. CICS-NC has also implemented *Puppet Open Source Edition*. This provides configuration management and enforcement on Linux and Unix platforms. CICS-NC IT staff can write or download configuration modules and then enforce them on any number of servers. This provides unified configuration templates, reduces configuration skew, simplifies new server configuration, and prevents unauthorized or unintended changes to configuration files on the servers. CICS-NC IT has also implemented *Splunk*. *Splunk* provides unified log management, searching, and reporting and gives CICS-NC better visibility into IT operations as a whole with the ability to search for specific events quickly and easily.

CICS-NC IT has worked towards migrating authentication services from *Apple Open Directory* to *Microsoft Active Directory*. This will provide a more stable and sustainable infrastructure for authentication services.

We maintain three data subscriptions from NCDC Comprehensive Large Array-data Stewardship System (CLASS) that provide VIIRS and AVHRR data to our collaborators in Miami. We have completely redesigned the processes moving this data because the previous provider (NOAA/CLASS) will no longer be able to push the files to CICS-NC. This redesign resulted in a 50% reduction in the amount of data we are required to transfer and store.

PLANNED WORK

- Expected upgrades (e.g. server migration, VM improvements, ldm upgrades, OS updates)
- Continuous tasks (maintenance)
- System integration of hardware and software from RSMAS to continue OISST Processing

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	10

# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Climate Literacy, Outreach, and Engagement

Climate Literacy, Education, Outreach, and Engagement,
Climate engagement, outreach, and literacy efforts are focused on improving the public's knowledge and understanding of climate science, variability, change, its impacts, and opportunities for adaptation and mitigation. In response to the demand from NCDC's users, CICS-NC engagement activities provide climate data and information to help build a climate-smart and resilient nation. The broader goal is to engage in activities that supports NCDC's strategic plan for engagement and foster a climate-literate public that understands its vulnerabilities to a changing climate and makes informed decisions.

Background
Understanding changes in our climate has emerged as one of the most important areas of scientific endeavor over the past several decades. There is a rapidly increasing realization that profound changes in the Earth climate system are already occurring and the consequent impacts are already being experienced, either directly or indirectly. It is well recognized globally that there is a need to mitigate the effects of climate change by reducing greenhouse emissions. The magnitude and scale of climate change and its impacts are unpredictable, arguably underestimated, and certain to intensify as past emission levels impact the weather patterns today and into the future. As the discussion on reducing emissions shifts into mainstream awareness, considered as climate mitigation pathways, the question still remains on understanding the inevitable impacts that are already occurring and how we can strategically adapt to adverse conditions.

Anticipated climatic changes, which vary regionally, can include more intense precipitation events, warmer temperatures, shorter snow seasons, and changes in growing seasons, among many others. Collecting and processing the fundamental data on climatic conditions, developing the models and algorithms to simulate natural cycles, assessing the possible projections, and communicating the information are critical activities in building resiliency.

CICS-NC supports NOAA's commitment to the development of a society that is environmentally responsible, climate resilient, and adaptive, and which utilizes effective, science-based problem-solving skills (e.g. STEM based learning) in education. Working collaboratively with other academic and public partners, stakeholders, and the private sector, CICS-NC supports and engages in various educational, engagement, and outreach-related activities that:

- Advance the development of strong and comprehensive education and outreach activities about climate, oceanic, and atmospheric sciences with the intent to:
    - Increase awareness of climate science and changes in the climate system
    - Grow the understanding of how climate data is collected, observed, analyzed, and used in research purposes
    - Increase awareness of NCDC climate datasets and products, and how educational teachers/professors can make use of climate data products for teaching climate science

- Advance climate literacy for private sector partnerships through interdisciplinary activities, including engagement with business solution providers and industry leaders on uses and applications of climate data for climate risk management or innovative opportunities
- Provide operational support to activities in NOAA organizations like NCDC in advancing their outreach with the Sectoral Engagement Team, communication with the Communications Officer, and literacy with the Education Lead
- Support outreach and engagement activities on climate applications to local economic development groups and non-profits

Activities in Advancing Climate Engagment, Outreach, and Literacy across Public, Private, and Academic Institutions

Task Leader	Jenny Dissen
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 100%; Theme 3: 0%
Main CICS Research Topic	Climate Literacy, Education, Outreach, and Engagement
Contribution to NOAA Goals (%)	Goal 1: 40%; Goal 2: 40%; Goal 3: 0%; Goal 4: 0%; Goal 5: 20%

Highlight: Education, literacy, and outreach are all important elements of the broader CICS mission. CICS-NC engages in the improvement of both formal and informal education approaches to a variety of stakeholders and the public, ultimately to advance climate information and activities in adaptation and resilience. These activities are broadly grouped within K-12 Education, undergraduate and graduate education, business and industry engagement and other interdisciplinary stakeholder groups.

BACKGROUND

There is a need to advance climate science information for decision-makers as they explore practical and cost-effective approaches to leverage available resources. However, the provision of climate data for applications and decision support capabilities, which can factor into strategic, planning, and operational decisions, requires partnerships across public, private, and academic organization. CICS-NC engages in several meaningful climate literacy, engagement, and outreach activities for the business and industry as well as members of the general public through education initiatives. These activities are often in conjunction with CICS-NC partners, which include NCDC Customer Services and Monitoring Division (CSMD), NOAA Climate Program Office, and CICS-MD.

Broad areas of key topics or themes for discussion when engaging with the stakeholders are framed under these areas:

- Increase awareness and extend current research information in climate science, variability, and changes in the climate system
- Grow the understanding of how climate data is collected, observed, analyzed, and used in research purposes in academia, legislative staff, and the general public
- Increase awareness of climate datasets and products, as well as discuss areas of uses and applications of these climate data products
- Increase business and industry sector understanding and use of climate data and information for their strategic and operational use
- Demonstrate capacity building on the various impacts of climate change across public, private, and academic arenas

Climate literacy activities require developing frameworks, delivering presentations, engaging in relationship-building and capacity-building activities, enabling catalytic support of innovation in uses of climate data, engaging in individual and executive-level roundtable

discussions, as well as providing ongoing operational support to NOAA organizations like NCDC, NODC, and CPO.

ACCOMPLISHMENTS

To advance climate literacy activities across public, private, and academic partners on climate data, information, and application opportunities, there were several activities accomplished during the reporting period. These include developing an engagement strategy and framework, leading seminars and presentations, engaging in relationship building and capacity- building activities, enabling catalytic support of innovation in uses of climate data, and ongoing operational support to NCDC.

Key highlights of accomplishments in this past year are framed under these areas:

- Advancing literacy and outreach in education with the K-12 audiences and supporting undergraduate and graduate areas
- Engaging in meaningful dialogue on uses, applications, and requirements of climate information with business and industry partners
- Providing operational support to NCDC's activities in advancing their sectoral engagement and outreach as well as communications activities with the NCDC Communications Officer
- Conducting interdisciplinary engagement and outreach and engagement activities to other stakeholder communities (e.g. public policy/legislative groups, local non-profit groups and economic development groups)

Advancing Literacy and Outreach in Education

CICS-NC engages with the K-12 students and teachers to help advance climate science, literacy, and education particularly focusing on the STEM skillsets. During FY13 CICS-NC Outreach Director, Jenny Dissen, and CICS scientists conducted presentations, led lectures, taught courses, developed curricula, lent equipment, and mentored high-school students.

CICS-NC partners with NOAA's NCDC and the NC State University Science House to provide K-12 educational outreach for climate and Earth system science. The Science House serves over 5,000 teachers and over 36,000 students annually from six offices spread across the state of North Carolina. Jenny DIssen collaborates and coordinates proposal activities with The Science House that involve the development of an educational curriculum using NCDC's climate data, where specific climate datasets will be used for teaching exercises for teachers across the U.S. Through this educational engagement, CICS-NC hopes to increase NCDC's understanding of teachers' needs for climate information so they can effectively teach climate science to their students.

In a recent activity, CICS and NCDC partnered with The Science House team to develop a climate guide for 9th grade teachers called "Climate Normals: Accessing NOAA Data for Classroom Use." Teachers use the protocol to access climatic data from NCDC to investigate microclimates using real-world data. Teachers from Buncombe County, North Carolina, then matched this protocol to the existing North Carolina Next Generation Science Standards and brought the course protocol to the students. This pilot effort to bring climate data to the classroom is planned to be available to neighboring Rutherford County schools, as well as

teachers across the U.S. through the NOAA website. Please refer to the task report by Teresa McCowan for more information on this activity.

In addition to partnering with The Science House, CICS-NC also engages in informal support for the local K-12 audiences. CICS-NC scientist Jim Biard organized and lead “Wave Day” an event designed to give 6th Grade students at Asheville Middle School a chance to learn about waves in various ways through direct hands-on experimentation. Seven unique wave examples stations were (with up to four instances of each station) set up and small groups of children navigated through the stations, discovering learning experiments about transverse, latitude, water and other types of waves and physics principles (*Figure 1*). Several CICS-NC staff (Jenny Dissen, Laura Stevens, Linda Copley, Carl Schreck) supported Jim in executing this activity to the students during the Wave Day at the high school.

Figure 1: Students engaging in hands-on physics activity to learn about longitudinal and transverse waves at the Asheville Middle School, as part of the Wave Day, December 2013.

Jim Biard also presented a talk entitled “Flash Floods: Silent but Deadly” to five elementary and middle school FIRST LEGO League teams. FIRST LEGO League is "a robotics program for 9 to 14 year olds, which is designed to get children excited about science and technology and teach them valuable employment and life skills.” FIRST LEGO League has a yearly challenge, in which the teams compete with one another on building an autonomous robot using the LEGO MINDSTORM robot set and programming it to complete tasks on a thematic playing surface. In addition to the robot challenge, each team identifies a problem related to the theme of the competition and creates an innovative solution. The theme for FIRST LEGO League’s 2013 Challenge was “Nature’s Fury”, where the interest was in flash floods.

CICS-NC supports outreach in education to university-level students by providing internship opportunities for graduating college seniors and graduate student researchers who have a strong desire to enhance their research and analysis skills by working with NOAA and CICS. CICS’ competitive internship program is comprehensive and designed to prepare a young meteorologist or climatologist for an entry-level data analysis position or provide desirable research skills in preparation for graduate studies. CICS-NC is closely linked to the North Carolina State University ‘s Marine Earth and Atmospheric Sciences department, as well as UNC Asheville Atmospheric Sciences and Applied Mathematics Department.

During summer of 2013, Jenny DIssen supervised the work of three intern students working on the analysis of precipitation trends for southeastern (SE) states (South Carolina, Georgia, Alabama, Florida, Louisiana, and Mississippi) and precipitation trends across various regions of Brazil using GHCN Daily and monthly datasets. Through this process, the interns learned the challenges of data management, climatology, and best practices uses by scientists to manage missing station data.

Figure 2: CICS-NC interns giving final research presentation to CICS-NC and NCDC seminar series (L – R: Walter Glance, NCDC CDR, Jenny Dissen, CICS-NC, Thomas Winesett, Student Intern, Corey McDonough, Student Intern, Janice Mills, CICS-NC, Kelly Gassert, Student Intern, Otis Brown and Ken Kunkel, CICS-NC)

Engaging with Business and Industry Sectors

CICS' work with Duke Energy continues as we build our engagement capacity. During FY13, Duke Energy's Communications spokesperson contacted CICS-NC to gain a better understanding of precipitation trends and projections in Brazil. Jenny Dissen worked with the student interns to help investigate the reliable data sources for both historical and future projections of precipitation. This request to understand climatology from a business represents one area where industry recognizes climate-related risks, particularly correlated to hydroelectric generation in this case.

In addition to Duke Energy, Jenny Dissen also engaged with Facebook's data center located in Forest City, North Carolina, on the development of a case study related to their experience of using NCDC climate data for the siting and operations of their data farm. Facebook uses an innovative evaporative cooling system instead of a chiller system and is concerned with maintaining certain temperature and humidity conditions in order to maintain an efficient and effective power utilization effectiveness ratio. Their data center in Forest City is deemed as one of the most energy efficient data centers in the world. The

case study intends to elaborate how the engineering and system designers use climate as a key decision driver in the siting and operations of this data center.

Engagement with Facebook has also led to collaborations with NC State Climate Office and Isothermal Community College (ICC) to install and maintain an ECONet climate station in Rutherford County. Jenny Dissen is collaborating with ICC and NC State University to develop innovative ways to incorporate climate data into the community college curriculum and provide teacher training.

Jenny Dissen also provides access to the latest climate information through seminars and webinars with various private sector companies both through formal and informal procesess.

Informally, CICS-NC presents and leads various webinar sessions to advance access to climate data and information to different solutions providers, such as:

- Booz Allen Hamilton Climate Change Community of Practice
- Booz Allen Hamilton Sustainability Community of Practice
- StatWeather Energy Summit (Fall 2012, Spring 2013, Fall 2013)
- Asheville Leadership
- Asheville HUB and Economic Development Coalition
- Air and Waste Management Association (Regulatory Update-George Regional Meeting)
- Air and Waste Management Association-Climate Change Conference
- Tokio Marine Technology Insurance Conference
- Fortune Brainstorm Green (2012 and 2013)
- Facebook Data Center
- CDM Smith (Environmental Engineering Company)-Webinar

Formally, CICS-NC has engaged with business leaders through a program called the Executive Forum on Business and Climate, a groundbreaking approach to bringing together academic researchers, business leaders, and federal science experts to examine how recent weather and climate trends are impacting the industry and how the information is used by business decision-makers in their strategy and operations. In 2013, CICS-NC led two forum discussions. The first focused on a 4-day session centered on the energy industry with keynote messages from U.S. Senator Kay Hagan and Southern Company President, CEO and Chairman, Thomas Fanning. With nearly 35 participants ranging from CEO's to business leaders, scientists and CICS-NC academics, participants learned through case-studies on how climate information is used today to establish competitive advantages and drive market behavior and decisions. More information and the summary report can found at: www.cicsnc.org/events/forum.

Figure 3: Interactions between scientists and business leaders during the Executive Forum on Business and Climate, June 2013

The second Executive Forum on Business and Climate was a 2-day knowledge exchange forum, co-convened by Climate and Energy Solutions (C2ES) and CICS-NC, focused on climate-related risks and opportunities for private sector businesses and investments made today in business resilience by companies. The 2nd Executive Forum on Business and Climate took place on November 4-5, 2013 in Washington, DC. The event explored industry's needs related to climate data, information, and decision-support tools, as well as the avenues for engaging with government agencies. The workshop aimed to strengthen the relationship between business and industry leaders and NOAA's climate science team, identifying ways to access technical expertise. In total, the workshop hosted 44 attendees over the two-day period, including 21 representatives of private-sector organizations. Keynote messages were given by John Firth (CEO and Founder of Acclimatise), Jim Chelius (Engineering Director-Corporate Planning, American Water), Jeff Williams (Director, Climate Consulting, Entergy), Jeff Hopkins (Principal Adviser, International Energy and Climate Policy, Rio Tinto) and Thomas Karl (Director of NOAA's NCDC).
More information and the summary report can found at: www.cicsnc.org/events/forum2.

Figure 4: Interactions between business leaders, government, scientists and members from C2ES at the recent Executive Forum on Business and Climate-Business Resilience, November 2013

Engagement and Outreach in Collaboration with NCDC

In collaboration and partnership with NCDC's Climate Services and Monitoring Division, Jenny Dissen led the development of an ongoing framework and approach for advancing climate data applications through a new activity called Climate Data and Applications Workshops (CDAW) (formerly referred to as Dataset Discovery Day). The objectives of this two-day workshop are to provide an opportunity for NCDC and CICS-NC staff to discuss updates and trends in research of various data products, determine knowledge gaps, assess current and future uses and applications of the climate data with the public and private sector, and build engagement with industry, academia, and solution providers interested in managing their risks, particularly with respect to climate adaptation.

During FY13, Jenny Dissen led two CDAW series in collaboration with Tamara Houston (NCDC) where the outcomes resulted in new information from the user community in the areas of science feedback, requirements, NCDC's operational support capabilities, as well as ease of access to the data. The workshops were titled Frost and Freeze Data (March 20-21st, 2013) and A Focus on Precipitation (December 3-4, 2013). Information and presentations on these workshops can be found on the CICS-NC website: http://cicsnc.org/events.

Integral to outreach activities is the communication of climate information to various stakeholders. In collaboration with NCDC's Communications Coordinator, CICS-NC led and

organized 2 of the 3 Climate Science Communications Training workshops geared towards providing media and communications training to NOAA scientists in effective engagement with media. The training included three workshops at three of the NOAA locations: College Park, Maryland, Boulder, Colorado, and Asheville, North Carolina. These workshops were planned in coordination with NOAA's Communications and Public Affairs and Outreach/Education officess across all three locations. A key output from the workshop discussions was a Best Practices Guide to support scientists at NOAA and NOAA partners on effective ways to engage with the media. The final presentation and best practices guide can be found at this location: http://www.cicsnc.org/events/climate-communications-asheville.

In addition to the above support, CICS-NC also helped develop a perspective on the NCDC Center-wide Engagement strategic plan, an internal document to assess the current engagement-related activities and the development of future activities that support the NCDC Engagement vision and mission. The strategic perspective included elements of stakeholders, how to improve and evolve engagement activities with the current users, and what the next 5 years could look like. This perspective highlighted areas of issues, risks, and opportunities for NCDC to continue its engagement effort. In collaboration with NCDC's CSMD, Communications team and Narayan Strategies, Jenny Dissen also supported the development of the final document *Strategic Plan for NCDC-wide Engagement*.

Supporting Innovation and Economic Development

The overall NOAA strategy for climate information products assumes that the private sector will provide most derived climate products (also termed climate analyses, decision support information, and/or climate information records). Private investment in such activities is in its infancy and needs significant nurturing to flourish at the levels needed for the national climate enterprise.

CICS-NC outreach and engagement activities are under the purview of NC State's Office of Research, Innovation, and Economic Development (ORIED). CICS-NC collaborates with the local Asheville Chamber of Commerce and the Buncombe County Economic Development Coalition to identify and support opportunities in growing the region with STEM skills and capabilities, particularly in climate science. Otis Brown and Jenny Dissen led various discussions to promote the growth of the science and technology sector in the Western North Carolina region, specifically in the weather/climate sciences arena.

CICS-NC supports access to climate information for opportunities through its partnership with the Asheville Buncombe Sustainable Community Initiatives (ABSCI), a NC 501 (c) 3 with a mission to support and catalyze a resilient and enduring prosperity for the community within the context of a rapidly evolving and increasingly complex world. CICS-NC is collaborating with ABSCI and CASE Consultants to launch an initiative called *National Partnership for Resilience* (NPfR). The NPfR aims to fill a major gap in the climate services landscape: the need for sustained engagement among climate-sensitive businesses, climate adaptation providers, public agencies, and academic institutions. The goal of the NPfR is to promote resilience in businesses and communities by adapting to changing climate. Jenny Dissen assisted with the strategic planning and execution of a workshop on March 27, 2014

that brought together members from public, private, and academic arenas. The purpose of the workshop was to bring together leaders from various sectors to define how the Partnership can be most beneficial for all partners, and discuss the following:

- Identify our unmet needs for communication and collaboration
- Prioritize the services the Partnership can offer to meet those needs
- Agree on initial communication & collaboration projects

Outreach with the Legislative/Policy Making Community

Jenny Dissen was selected to participate as a volunteer for Climate Science Day on Capitol Hill, January 28-29 in Washington, DC. The purpose of the visit was to provide Members of Congress with the best possible access to scientific information on climate science when making policy decisions. This non-partisan event was organized by the Climate Science Working Group (CSWG) and included training on effective communication and individual meetings with various Senators and Congressman from North Carolina.

Figure 5: CICS-NC Jenny Dissen, US Senator Kay Hagan, and GST's DeWayne Cecil engaging in conversation regarding climate information with Senator Hagan's staff as part of the 2014 Climate Science Day on Capitol Hill.

PLANNED WORK

- Continue activities in the Executive Forum on Business and Climate
- Continue efforts in the development of the National Partnership for Resilience
- In partnership with the Science House, extend outreach in K-12 in areas counties of Western North Carolina to bring climate data in the classroom
- Hold additional Climate Data and Applications workshops (e.g. regional snowfall index and international surface temperature dataset)
- Support the implementation activities of NCDC's center-wide engagement strategy and assist in the development of prioritizing feedback to NCDC

DELIVERABLES

- Execution of two forums called the Executive Forum on Business and Climate
- Led and developed the Climate Data and Applications Workshop Series; completed the workshop called Precipitation Data and Applications

- Development of a NCDC Center-wide Engagement Strategy
- Support of NCDC and CICS-NC enterprise and administrative activities

PRESENTATIONS

- Dissen, J. (2013). CICS-NC An Overview for Advancing Literacy. Presentation to The Science House, Asheville, NC. July 2013
- Dissen, J. and O. Brown (2013). Precipitation Data and Applications. Presentation to the NCDC Climate Data and Applications Workshop Series, Asheville, NC. December 2013
- Dissen, J. and O. Brown (2013). Climate Data in Context: A CICS-NC Perspective. Presentation to the Leadership Asheville, Asheville, NC. November 2013
- Dissen, J. and O. Brown (2013). CICS-NC: Catalyzing Climate Activities. Presentation to the UNC Asheville Dean of Graduate Studies, Asheville, NC. October 2013
- Dissen, J., O. Brown, T. Houston. (2013). Climate Data to Decisions. Presentation to the AWMA Climate Change Impacts, Policy and Regulation Conference. Herndon, VA. September 2013
- Dissen, J. and O. Brown (2013). Climate Data and Sustainability. Presentation to the Lenoir Rhyne Sustainability Class, Asheville, NC. September 2013
- Dissen, J. and T. Houston (2013). Climate Data to Decisions – a CICS-NC Approach to Outreach. Statweather Energy Summit. Houston, TX. September 2013
- Dissen, J. and O. Brown (2013). CICS-NC Engagement, Outreach and Literacy. NC Science Summit Regional Meeting, Asheville, NC. September 2013
- Dissen, J. and T. Houston (2013). Climate Data to Decisions. Presentation to CDMS Smith Overview. July 2013
- Dissen, J., S. Schollaert-Uz, P. Arkin, O. Brown (2013). Advancing Climate Literacy: A CICS Perspective. NOAA Satellite Conference, College Park, MD. April 2013

OTHER

- Co-chair of American Meteorological Society Committee on Effective Communication of Weather and Climate Information
- Panel Moderator for 2014 American Meteorological Society on "Challenges and Opportunities in Communicating Weather and Climate Information"
- Key participant and voting member of AMS Energy Committee and member of the newly proposed AMS International Committee
- Key lead and contributor in the cultivation of the Asheville Climate Cluster Group, in collaboration with the Asheville-based local nonprofit ABSCI
- Contributor and supporter to the ABSCI efforts on the Collider Space at the Callen Center Building in Asheville, which aims to focus on climate related activites in Asheville
- Completing a certificate course on Climate Change and Society through UNC Asheville

PERFORMANCE METRICS

	FY13

# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	10
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	3

Highlighting 150 Years of Weather Observations in Asheville – Climate Normals: Accessing NOAA Data for Classroom Use

Task Leader	Michelle Benigno and Dr. Teresa H. Cowan
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%.
Main CICS Research Topic	Climate Literacy, Education, Outreach, and Engagement
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: The Science House of NCSU provides K-12 educational outreach for climate and Earth system science in partnership with NOAA's NCDC and CICS-NC. The Science House is collaborating with NCDC on building curriculum and methodologies for using climate data in the classroom.

BACKGROUND

The Science House is an educational outreach arm of NC State University that serves over 5,000 teachers and over 36,000 students annually from six offices spread across the state. The mission of The Science House is to:

- Cultivate and diversify the pool of students pursuing degrees and careers in STEM (Science, Technology, Engineering and Math) fields.
- Improve the quality of teaching and learning in STEM education.
- Communicate innovative scientific and educational research to the public.

The Mountain Satellite Office of The Science House offers programs that are guided by the best research and practices in STEM education. In addition, the Science House leads the K-12 outreach projects for several multi-university STEM research centers that are at the cutting edge of their disciplines.

The Mountain Satellite Office of The Science House served over 1600 teachers and administrators and over 5600 students in 2013 through the equipment loan program or through professional development and support services.

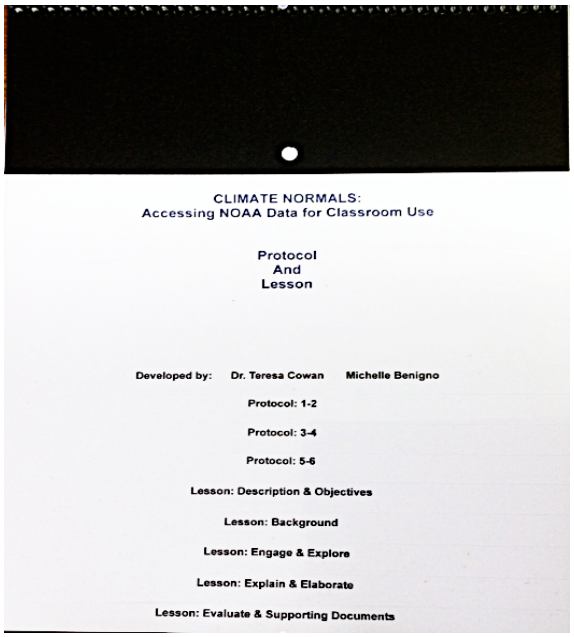
ACCOMPLISHMENTS

Climate science education is a crucial part of the work of The Science House. The Science House leads teacher professional development sessions that focus on understanding the Earth system, the changing nature of the climate and its impacts, resource management, and sustainability. The Science House supports students and teachers by providing climate materials, teaching techniques, and sharing cutting edge research from climate scientists. Laboratory equipment is loaned out to participating teachers at no cost. Students can use this equipment to collect local data, which can then be compared with various data from the National Climatic Data Center (NCDC).

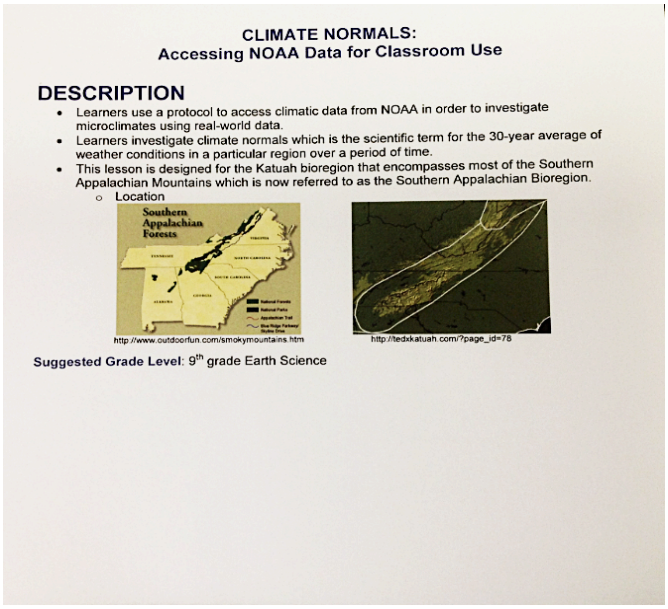
The Science House partners with CICS-NC and collaborates with NOAA's NCDC for outreach to K-12 students and teachers. The Science House is currently collaborating with CICS-NC and NCDC to develop an educational activity for K-12 teachers related to NCDC climate datasets. This activity builds curriculum modules for teachers using climate datasets as a mechanism for teaching students climate science information. This activity will become a methodology and a teaching exercise for teachers across the U.S. on using the NCDC climate dataset as one teaching activity in climate science.

Accomplishments this year included the following:

- Development of a deliverable including a protocol and a lesson for access and use of the NOAA data in classrooms
- Recruitment and coordination of a cohort of Earth Science teachers, representative of a cross section of western North Carolina, to pilot the protocol
- Presentation of protocol to the teaching cohort
- Pilot of protocol by the teaching cohort
- Evaluation and assessment of the implementation of the protocol
- Organization of phase two of the pilot project (teaching cohort to design and pilot a lesson to include in the deliverable)
- Evaluation and assessment of the implementation of the teacher lessons
- Organize session for refinement of the deliverable including protocol and all lessons



Deliverable Design – Protocol and Lesson



Introduction to Lesson

PLANNED WORK/WORK IN PROGRESS

- Continuation of the pilot project entitled: Climate Normals: Accessing NOAA Climatic Data for Classroom Use
- Refinement and completion of the deliverable for using NOAA climatic data
- Design Phase III of project to include the training of teachers across the mountain service area and beyond (train-the-trainer model)
- Continue to develop educational curriculum and methodologies for teachers across the U.S. for using climate data in the classroom
- Continue climate education outreach to K-12 population and continue collaborations on various Earth system educational opportunities.

OTHER

Dr. Teresa H. Cowan is the 2012 Recipient of the Presidential Award for Excellence for Math and Science Teaching.
Michelle Benigno is the Associate Curriculum Director for Madison County Schools.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0

# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

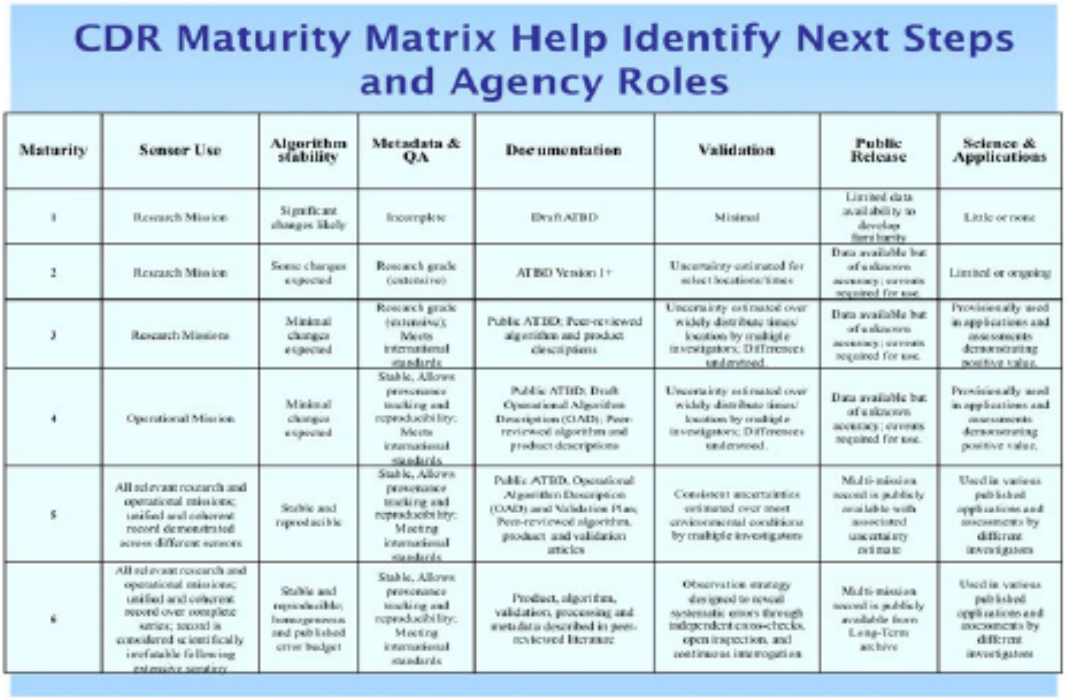
Climate Data and Information Records and Scientific Data Stewardship

Climate Data Records (CDRs) provide climate quality satellite and *in situ* observing datasets that document the Earth's climate.

Background

CICS-NC supports efforts at the National Climatic Data Center (NCDC) for the development and transition from research to operations (R2O) of Climate Data Records. While some of this effort is in-house, a significant part of it is accomplished by CICS partner institutions, which include some of the leading climate science practitioners in the nation working in basic and applied research endeavors.

An appreciation for the functional development from concept to mature observation and agency roles is provided by a slide from Bates, et. al., (2008) excerpted in the figure below.



CDR Maturity Matrix Help Identify Next Steps and Agency Roles

Maturity	Sensor Use	Algorithm stability	Metadata & QA	Documentation	Validation	Public Release	Science & Applications
1	Research Mission	Significant changes likely	Incomplete	Draft ATBD	Minimal	Limited data availability to develop first heritage	Little or none
2	Research Mission	Some changes expected	Research grade (documented)	ATBD Version 1+	Uncertainty estimated for select locations/times	Data available but of unknown accuracy; caveats required for use	Limited or ongoing
3	Research Missions	Minimal changes expected	Research grade (traceable); Meets international standards	Public ATBD; Peer-reviewed algorithm and product descriptions	Uncertainty estimated over widely distributed times/ locations by multiple investigators; Differences understood	Data available but of unknown accuracy; caveats required for use	Provisionally used in applications and assessments demonstrating positive value
4	Operational Mission	Minimal changes expected	Stable, Allows provenance tracking and reproducibility; Meets international standards	Public ATBD; Draft Operational Algorithm Description (OAD); Peer-reviewed algorithm and product descriptions	Uncertainty estimated over widely distributed times/ locations by multiple investigators; Differences understood.	Data available but of unknown accuracy; caveats required for use.	Provisionally used in applications and assessments demonstrating positive value.
5	All relevant research and operational missions; unified and coherent record demonstrated across different sensors	Stable and reproducible	Stable, Allows provenance tracking and reproducibility; Meeting international standards	Public ATBD; Operational Algorithm Description (OAD) and Validation Plan; Peer-reviewed algorithm, product and validation articles	Consistent uncertainties estimated over most environmental conditions by multiple investigators	Multi-mission record is publicly available with associated uncertainty estimate	Used in various published applications and assessments by different investigators
6	All relevant research and operational missions; unified and coherent record over complete series; record is considered scientifically irrefutable following extensive scrutiny	Stable and reproducible; homogeneous and published error budget	Stable, Allows provenance tracking and reproducibility; Meeting international standards	Product, algorithm, validation, processing and metadata described in peer-reviewed literature	Observation strategy designed to reveal systematic errors through independent cross-checks, open inspection, and continuous interrogation	Multi-mission record is publicly available from Long-Term archive	Used in various published applications and assessments by different investigators

Figure 1. Bates, et. al. CDR Maturity Matrix

Work Plan

CDR's primary aim is to develop and sustain as complete and consistent a climate record as possible from remotely sensed and in situ measurements in order to provide users with climate quality data and information products. Support of these activities requires the highly specialized scientific and technical experience that is currently assembled in CICS-NC.

CICS-NC staff of climate and instrument researchers and scientific support staff at the senior, mid-career, and junior levels as well as post-doctoral and graduate students in climate

science and related areas work under the direction of the CICS Director and in coordination with the NCDC project leader and his staff and provide necessary skills in the following areas:

- Expertise needed to coordinate the development of calibration and validation activities and approaches for high quality baseline climate data sets from satellite and *in situ* observations relevant to documentation and detection of climate change in the land, ocean, and atmosphere.
- Expertise needed to develop, refine, and implement algorithms for a daily, global, multi-sensor, optimally interpolated Climate Data Records (CDR), and to characterize the sources and magnitudes of errors and biases in the CDR and to develop methodologies for the reduction of these errors and biases.
- Expertise needed to develop high quality baseline climate data sets from satellite and *in situ* climate data, and develop the relationship(s) between the observed tropospheric and stratospheric trends from the ground-based network with those observed from satellite.
- Software engineering expertise to support coding, code refactoring, code review, database development, and the transition of scientific codes into operationally executable and maintainable processes.
- Development of scientifically-based quality control algorithms for *in situ* climate data of various time scales (hourly, daily, monthly, annually), methods to detect and adjust for inhomogeneities due to issues such as instrumentation changes or observing station relocations, and scientific analyses of structural uncertainty due to these methods.
- Expertise needed to ensure that research to operation transitions occur between data set development activities and the operational use of these data sets in activities such as climate monitoring and climate research, as well as performing research documenting climate variability and change using the observed record and climate model simulations.
- Expertise to provide “transitions management” of various externally developed CDRs to NCDC.
- Expertise to develop and implement interim CDRs for early use of climate relevant observations.
- Expertise needed to support the stewardship of archival and current climate observations

Climate Data Record (CDR) Integrated Product Team (IPT) Support	
Task Leader	Art Burden, Anand Inamdar, Jessica Matthews, Ge Peng, Olivier Prat, Carl Schreck
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: %; Theme 2: %; Theme 3: %.
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: Several CICS-NC scientist have served as Products and Operations Branch representatives on multiple CDR IPTs.

BACKGROUND

Climate Data Record (CDR) IPTs are multi-disciplinary teams comprised of members from offices and organizations supporting the transition of research-grade CDRs into an initial operational capability (IOC) status. The IPTs are formed for the purpose of efficient and effective collaboration, coordination, and execution and reporting of member's office/organization tasks required to transition the CDR to an IOC state.

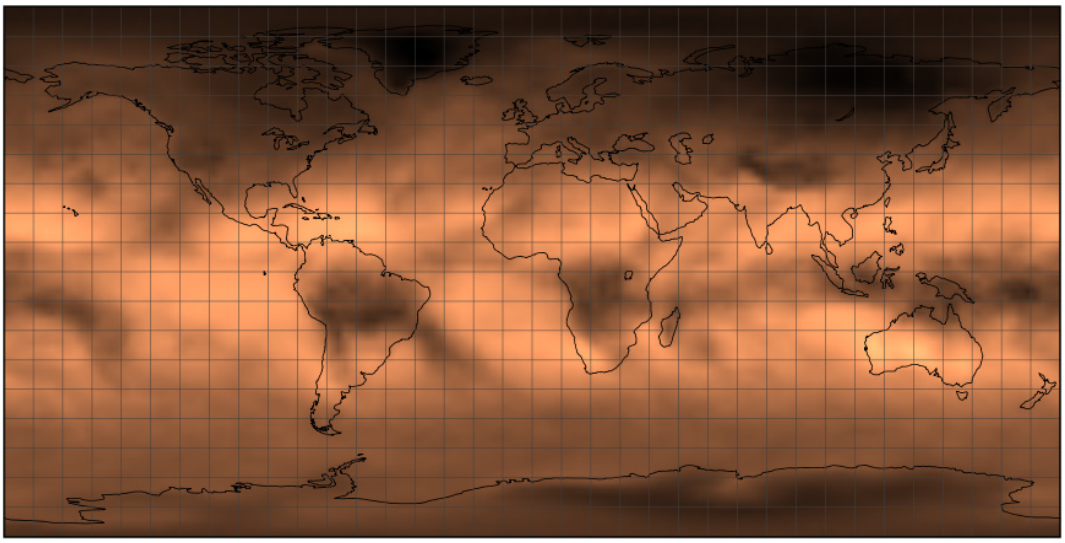


Figure 1. A sample image for the Outgoing Longwave Radiation-Monthly CDR.

ACCOMPLISHMENTS

CICS-NC has participated in the IPTs of the following CDRs during this reporting period:

- Atmospheric Temperature Bundle-MSU and AMSU FCDR (Burden)
- Atmospheric Temperature Bundle-MSU and AMSU TCDR (Burden)
- Cryosphere Bundle-APP and APP-x (Burden)
- Cloud/Moisture Bundle-Cloud Top Pressure, TPW (Burden)
- Cloud Bundle-AVHRR Radiances, Cloud properties (Burden)
- Total Solar Irradiance-Observational (Inamdar)

- Total Solar Irradiance-Composite (Inamdar)
- Calibration of MSRI using the Moon (Inamdar)
- Land Surface Bundle (Matthews)
- Global Surface Albedo (Matthews)
- Sea Ice Concentration-Annual (Peng)
- Ocean Surface Bundle (Peng)
- Cryosphere Bundle-Snow cover fraction (Peng)
- Precipitation-PERSIANN-CDR (Prat)
- Outgoing Longwave Radiation-Monthly (Schreck)
- Outgoing Longwave Radiation-Daily (Schreck)

Products Branch representative IPT responsibilities include:

- Leading and scheduling IPT meetings needed for resolving technical issues on the products with PI
- Conducting initial assessment of CDR readiness for transition from scientific perspective
- Reviewing PI-submitted draft products against IOC requirements
- Providing feedback to PI on draft products
- Verifying PI-submitted final products conform to IOC requirements
- Participating in management and technical meetings as required
- Working with PI, IPT and O&M Project Manager to complete each CR and route for signatures
- Attending Change Control Board meetings, when needed
- Reviewing PI-submitted documents delivered as part of the WA (C-ATBD, Maturity Matrix, Data Flow Diagram, Implementation Plan) and providing feedback
- Reviewing PI-submitted documents delivered as part of the WA (QA procedure, QA results, VDD, annual reports) for information only

Operations Branch representative IPT responsibilities include:

- Leading and scheduling IPT meetings needed for resolving technical issues related to operations
- Assisting with initial assessment of CDR readiness for transition from an operational perspective
- Entering the source code into the NCDC version control system
- Requesting an initial security review
- Verifying source code and Readme packages for compliance with IOC standards
- Informal source code reviewing with feedback for CDRP
- Porting code for implementation on NCDC systems as requested by CDRP, PI, and/or other IPT members
- Assisting with ingest and archival of the CDR source code, documentation, and data packages
- Participating in management and technical meetings as required
- Working with PI, IPT, and O&M Project Manager to complete each CR.

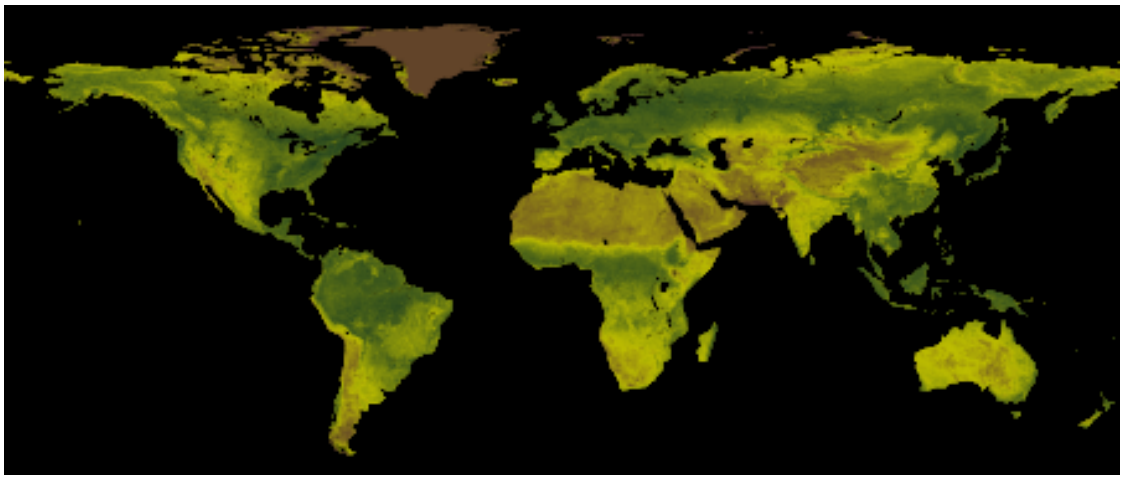


Figure 2: An example image of Normalized Difference Vegetation Index (NDVI) for the Land Surface Bundle CDR.

PLANNED WORK

- Continue participating on CDR IPTs as requested to transition CDRs to initial operational capability status

PUBLICATIONS

- Ashouri, H, K. Hsu, S. Sorooshian, D. Braithwaite, K.R. Knapp, L.D. Cecil, B.R. Nelson, and O.P. Prat, 2014. PERSIANN-CDR: Daily precipitation climate data record from multi-satellite observations for hydrological and climate studies. *Bull. Am. Meteorol. Soc.*, conditionally accepted.

PRESENTATIONS

- Prat, O.P., B.R. Nelson, and L. Vasquez, 2014. Characterization of CONUS rainfall using a multi-sensor approach: Evaluation of radar-based, satellite-based, and ground-based QPE products. Abstract submitted to the *International Weather Radar and Hydrology symposium*, 7-9 April 2014, Washington, DC, USA.
- Prat, O.P., and B.R. Nelson, 2014. Toward the development of an evaluation framework of Climate Data Records for precipitation: A characterization of CONUS rainfall using a suite of satellite, radar, and rain gauge QPE products. *94th annual meeting of the American Meteorological Society,* 2-6 February 2014, Atlanta, GA, USA.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	2
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA	0

guidance	
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	2
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

Olivier Prat participated in the PERSIANN-CDR adjustment to comply with CDR requirements. The Atmospheric Temperature Bundle-MSU and AMSU FCDR and Precipitation-PERSIANN-CDR have been transitioned to IOC status. Prat co-authored one journal article describing the PERSIANN-CDR algorithm and gave presentations using precipitation CDRs.

SNPP VIIRS Climate Raw Data Record Production Software Development	
Task Leader	Jim Biard
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 100%
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 5: 100%

Highlight: The VIIRS Climate Raw Data Record production software development and test were completed and operational production began on October 19, 2013.

BACKGROUND

The Climate Raw Data Record (C-RDR) Project is a part of the Climate Data Record Program. The C-RDR Project is responsible for developing a system to acquire, reformat, and enhance the Suomi National Polar-orbiting Partnership (SNPP) Raw Data Records (RDRs) and support data to facilitate the production of Climate Data Records (CDRs).

CDRs are fully calibrated, long-term time series of climate variables that have the consistency and continuity required for the climate research community. The production of CDRs requires the reprocessing of extensive data sets as algorithms are improved and the sensor performance is better understood. To produce CDRs**,** the raw data are required as input for each iteration of the reprocessing.

The goal of the C-RDR system is to provide the SNPP raw data and supporting data in a format that is enhanced for utilization in research, the production of CDRs, and long-term stewardship. There will be a C-RDR for each science instrument on the SNPP satellite. The C-RDRs contain the raw measurements from the RDRs, decoded, and decompressed so they are easily accessible. Each C-RDR file also contains extensive provenance, discovery, and usage metadata. The C-RDR files use the established, platform-independent, community standard netCDF-4 data format.

The C-RDR system produces C-RDR files from SNPP RDR granules on an operational basis, and will do so for the life of the SNPP mission. The C-RDR files are being archived and are available to the user community.

The C-RDR for the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument was the first one chosen for development.

ACCOMPLISHMENTS

Over the last year, the coding of the applications that makes up the VIIRS C-RDR production system was completed. Internal testing, both within CICS-NC computer systems and in the development system within NCDC's 3-Tier Development Environment, was performed and successfully completed. The VIIRS C-RDR production system applications and associated libraries, scripts, and configuration files were then deployed in the test system within the NCDC 3-Tier Development Environment where they underwent and passed an NCDC

security review. The system acceptance test was then performed with successful results. Once the VIIRS C-RDR production system had passed the acceptance test, an Operational Readiness Review was held and stakeholders agreed that the system was ready for production. The NCDC Information Technology Branch (ITB) deployed the production system within the NCDC 3-Tier Development Environment.

The high-level data flow in the core production system is described in *Figure 1*.

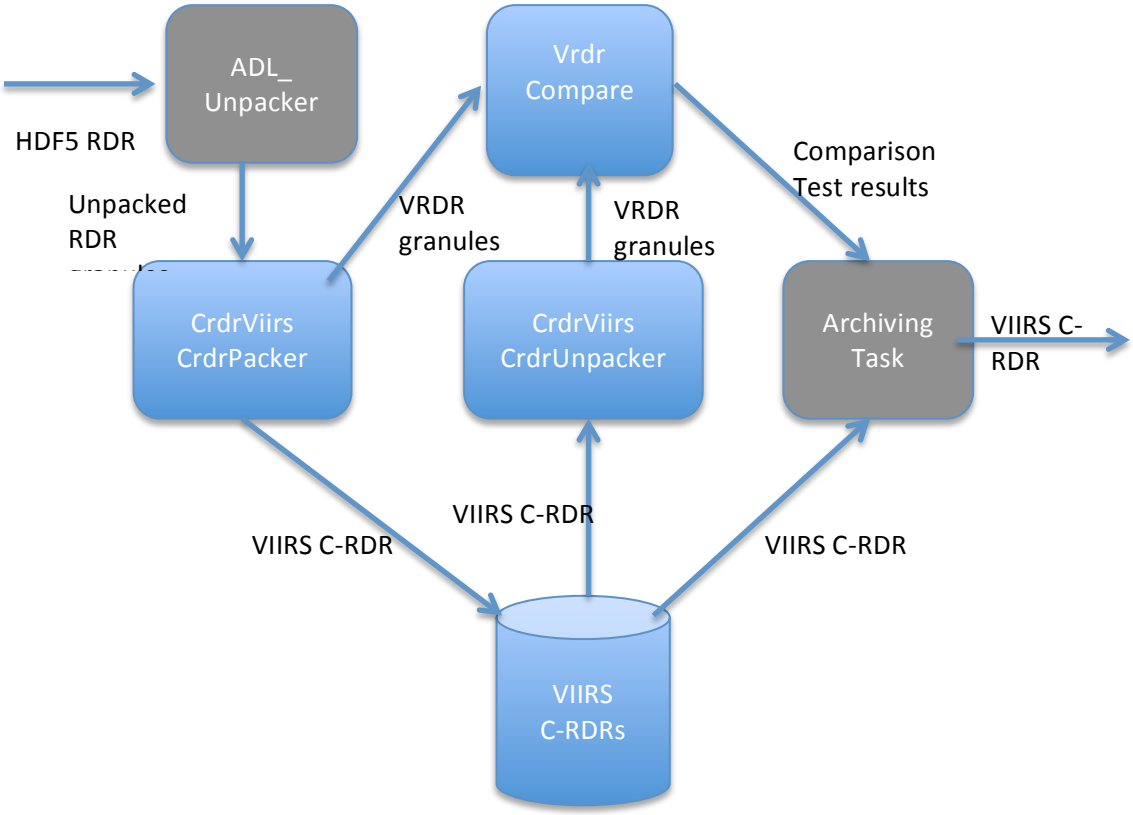


Figure 1: Primary data flow in the VIIRS C-RDR production system

Files containing VIIRS RDR granules, packaged together using the HDF5 format, are retrieved on an ongoing basis from the NOAA Comprehensive Large Array-data Stewardship System (CLASS) and fed into the VIIRS C-RDR production system. The ADL_Unpacker application (provided by the SNPP program) extracts the individual binary RDR granules and their associated metadata, which are passed to the CrdrViirsCrdrPacker application.

The CrdrViirsCrdrPacker application takes the contents of the RDR granules and constructs a C-RDR file. It also constructs Verified RDR (VRDR) granules-one per RDR granule, with metadata, using code provided by the SNPP program. VRDR granules are created as the first step in SNPP operational production of VIIRS Sensor Data Records (SDRs) in the NOAA Interface Data Processing Segment (IDPS). A VRDR is similar to a C-RDR, but it contains a subset of all the data available in an RDR.

Once the CrdrViirsCrdrPacker application has completed its task, the CrdrViirsCrdrUnpacker application is run to create VRDR granules and metadata from the C-RDR file just created. The two sets of VRDR granules and metadata are then passed to the VrdrCompare application, which checks to see if there are any differences in the two sets, and records the success or failure of the test. If there are no differences found, the archiving task (part of the production system executive) feeds the validated VIIRS C-RDR file out to the NCDC archive ingest system. The archive-ingest system delivers the files to the HDSS Access System (HAS) where they are made available for time-based search and download.

Ongoing production of the VIIRS C-RDR began on October 19, 2013. Since that time, analysis of the processing logs has shown that the error rates are well within the success margins specified for the operational system. Further analysis of the logs uncovered a defect in the CrdrViirsCrdrUnpacker application that was causing it to produce faulty VRDR granules under certain rare conditions, which then cause the validation test of the source C-RDR file to fail. This defect was corrected.

As part of the development effort, procedures for the system acceptance test and procedures for configuring a system were written so that it is ready for development and operation of the VIIRS C-RDR production software (including required 3rd party applications and libraries). Documents are being written to describe the VIIRS C-RDR contents and the software design, as well as a User's Guide for the applications and the system executive.

PLANNED WORK

The two main focuses in the project for the coming year will be monitoring and maintenance of the software and completing the documentation. If processing errors are uncovered through monitoring, the responsible code defects will be corrected and the operational software updated.

Another part of the maintenance task is identifying gaps in the VIIRS C-RDR time coverage relative to the available VIIRS RDR granules and filling in those gaps by ordering the missing RDR granules from CLASS and processing them. This will be done on a low-rate basis to extend the VIIRS C-RDR coverage back to the beginning of the available VIIRS RDR coverage, as well as to recover C-RDR files lost on account of data transmission problems or VIIRS C-RDR production system errors.

Turning to the documentation task, the VIIRS C-RDR Data Product Specification document is in final draft form and should be baselined early in FY2014. The Software Design Description and User's Guide should be completed by the end of the first quarter of FY2014.

DELIVERABLES

- VIIRS C-RDR production system software
- VIIRS C-RDR System Acceptance Test
- VIIRS C-RDR production system configuration procedures

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Optimum Interpolation Sea Surface Temperature (OISST) Transition to Operations

Task Leader	Art Burden
Task Code	NC-CDR-03-NCICS-AB
NOAA Sponsor	Drew Saunders
NOAA Office	NCDC
Contribution to CICS Themes (%)	Theme 1: 50%; Theme 2: 50%; Theme 3: 0%
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 0%; Goal 2: 25%; Goal 3: 25%; Goal 4: 25%; Goal 5: 25%

Highlight: NCDC's Optimum Interpolation Sea surface Temperature software is being refactored in order to meet CDR Program requirements for operational readiness.

BACKGROUND

A primary requirement in bringing Climate Data Records (CDRs) to operational readiness within NCDC is that the software is stable, reproducible, portable, and efficient. The CDR Program works with the Principal Investigator to ensure that incoming CDR software meets these goals for long-term stewardship and transparency. To that end, the Optimum Interpolation Sea Surface Temperature (OISST) product has been selected as a pilot case for investigating the feasibility of refactoring scientific software to meet CDR program requirements while keeping costs manageable.

The OISST software was originally written by CICS staff scientist Dr. Richard Reynolds, and currently runs operationally within the Center. OISST is a high quality product with many end users in the scientific community. While the software runs efficiently, its source code contains a large amount of redundancies, difficult to follow 'spaghetti' code, and incomprehensible variables. In addition, it is written in a proprietary language package, has many hardcoded paths, and requires data inputs retrieved via ftp from permission-based sources, all of which affect the portability of the OISST software.

The OISST refactor project has consisted of several scheduled phases conducted by three to four part-time to full-time NCDC staff. These phases include a Technical Assessment Review, source code refactoring, control script refactoring, operational framework integration, Test Readiness Review/system testing, and Operational Readiness Review. In addition, the OISST software lacks an Operation Algorithm Document (OAD), which is necessary for NCDC staff to document for NCDC staff, as well as CDR customers wishing to reproduce OISST results.

ACCOMPLISHMENTS

Toward the beginning of this year, the team finished the first phase of the project, which encompassed the refactoring of approximately 11,000 lines of source code. This resulted in several improvements to the codebase, including:

- 30% reduction in source code volume
- 58% reduction in cyclomatic complexity for the project (measure of independent paths through source code)
- Removal of >2600 coding standard issues found using static analysis

The modified code was tested to compare the resulting OISST with that obtained using the original code. Using a 30-day test dataset, we were able to produce identical output.

The tasks that we spent most of the time on in the second phase of the project relate mostly to control script refactoring and added work related to the OISST data inputs. As an archived, climate-quality product, the OISST CDR should make use of the best possible inputs. Additionally, we strive to incorporate inputs that may be obtained through NCDC, particularly if they are themselves CDRs. To that end, we have been working on updating some of the inputs for both reprocessing and forward processing.

The sea ice inputs were previously obtained from NCEP, but will now be provided by NSIDC for reprocessing. Sea ice from the National Snow and Ice Data Center (NSIDC) provides a more consistent dataset. The *in situ* input data will continue to be provided by NCEP. The satellite data used for reprocessing will be Pathfinder data. The satellite data used for forward processing will continue to be Navy AVHRR, but the inputs used for the 15-day delay product will be obtained from CLASS.

The format of the output netCDF files conforms to the Group for High Resolution Sea Surface Temperature (GHRSST) standard. The metadata were updated to conform to the latest version, which is GHRSST 2.0.

The scripts that perform the interim, final, and reprocessed data products were refactored similarly to the source code, resulting in more streamlined and easier to follow processing. Some of the configuration files were also converted from bash to Python.

Lastly, a draft version of the Operational Algorithm Document was written based on a newly developed template. This document gives detailed information regarding the software execution.

PLANNED WORK

- Perform System Acceptance Testing (SAT)
- Reprocess 30-year dataset
- Transition OISST to NCDC 3-tier operational environment

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0

# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

The OISST source code and scripts have been improved for the transition to operations.

Suomi-NPP VIIRS Climate Raw Data Record System Infrastructure Development

Task Leader	Linda Copley
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%, Goal 5: 0%

Highlight: Completed transition of the VIIRS Climate Raw Data Record into the NCDC operational environment while helping to define the processes for the 3-tier software development environment.

BACKGROUND

The VIIRS Climate Raw Data Record (C-RDR) Project is a sub-system of the Climate Data Record (CDR) Project. The C-RDR Project is responsible for developing a system to acquire, reformat, and enhance the Suomi National Polar-orbiting Partnership (NPP) Raw Data Records (RDRs) and support data required for the production of Climate Data Records (CDRs).

CDRs are fully calibrated, long-term time series having the consistency and continuity required for the climate research community. The production of CDRs requires the reprocessing of extensive data sets as algorithms are improved and the sensor performance is better understood. To produce CDRs, the raw data are required as input for each iteration of the reprocessing.

The goal of the C-RDR system is to provide the NPP and Joint Polar Satellite System (JPSS) raw data and supporting data in a format that is enhanced for utilization in research, the production of CDRs, and long-term stewardship. The C-RDRs contain the raw measurements from the Consultative Committee for Space Data Systems (CCSDS) packets, decoded and decompressed so they are easily accessible in an established data format, netCDF-4. The C-RDRs are quality controlled and assembled into data files, which include information for the computation of earth location and calibration values.

The C-RDR system reformats the NPP and JPSS raw measurements into easily accessible C-RDR files. The C-RDRs contain the information required for the production of CDRs and Climate Information Records (CIRs). The C-RDR system disseminates these C-RDRs to the user community on a routine and operational basis.

This task is focused on developing the system infrastructure to support the production of C-RDRs. The Processing Director system controls the flow of ingested Raw Data Records (RDRs) from the NOAA Comprehensive Large-Array Storage System (CLASS) archive, sets up the processing into C-RDRs, and tracks and controls the status of processing. The system is

being developed with a generic architecture to provide a framework that allows other processing streams to be inserted into the workflow in place of the C-RDR.

ACCOMPLISHMENTS

The production of the VIIRS C-RDR was transitioned into the operational environment at NCDC. Ongoing production of the VIIRS C-RDR began on October 19, 2103. C-RDRs are now being produced routinely as soon as they are downlinked from the NPP satellite and made available in NOAA's CLASS. The C-RDR's are archived at NCDC in the Hierarchical Data Storage System (HDSS) Access System, and are available for download there.

Each C-RDR is validated to ensure that it contains data equivalent to the original bit-based Raw Data Record (RDR). A comparator tool has been created to validate that the raw data contained in the RDR is faithfully replicated in the final C-RDR product. This comparison tool is integrated into the product workflow so that each C-RDR is validated prior to archive.

The transition of the C-RDR into operations at NCDC represented the first transition of a product using virtual machines and the 3-tier development environment.

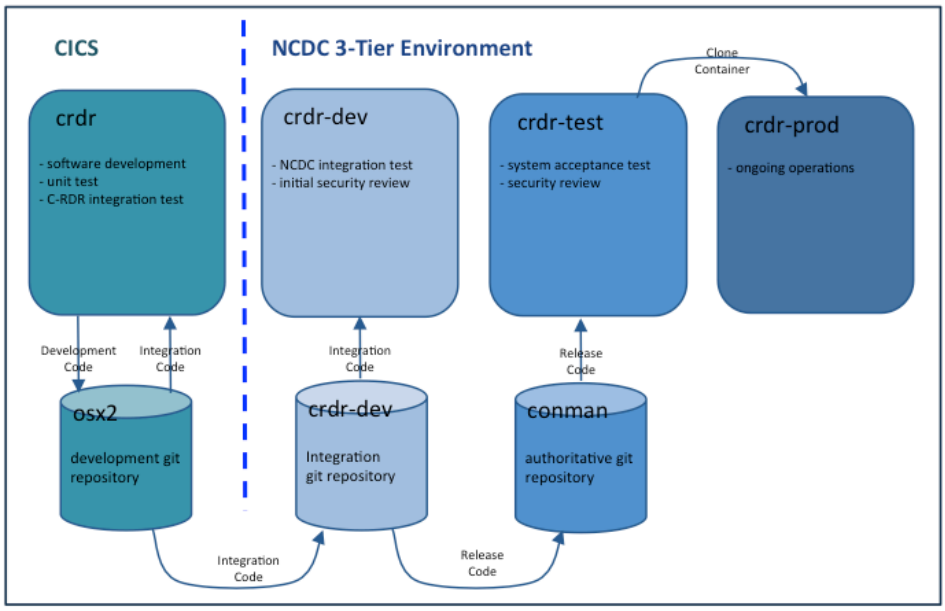


Figure 1: NCDC 3-tier development environment as integrated with the CICS development environment.

As the first product to be developed using this paradigm, the processes and requirements for development and transition in this environment were developed collaboratively with NCDC personnel. The development group determined the requirements for each phase transition as imposed by the Information Technology, Information Security, Operations, Archive, and User Engagement entities at NCDC. Each requirement was satisfied and documented through a series of defined documents and reviews.

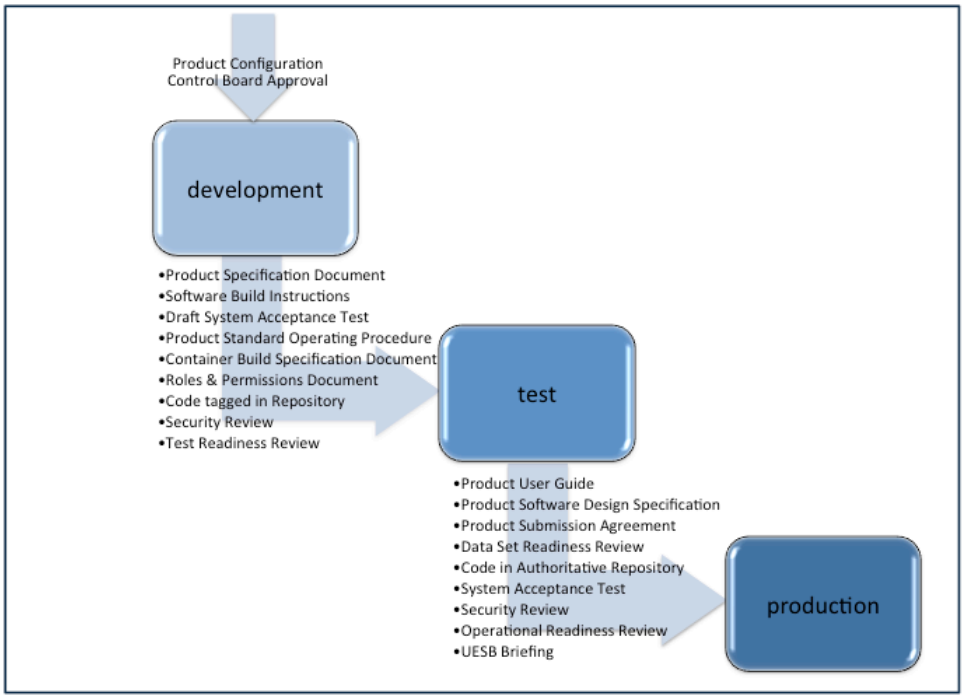


Figure 2: Phase-transition requirements in the NCDC 3-tier development environment.

Some components of the process necessitated the implementation of tools to support the processes. *Git* was installed as our development version management system, and *Gerrit* was implemented for initial and ongoing code review support. Additionally, we developed and implemented a Configuration Management Plan and Configuration Management Process to handle both deployed software and the associated documentation.

PLANNED WORK

- Develop operations status and reporting functions for the Processing Director.
- Integrate additional NCDC products into the Processing Director environment.

DELIVERABLES

- VIIRS C-RDR version 1.0 Processing Director
- VIIRS C-RDR CCB Charter Rev 1.0
- VIIRS C-RDR Configuration Items Rev 1.0
- VIIRS C-RDR Configuration Management Plan Rev 1.0
- VIIRS C-RDR Configuration Management Process Rev 1.0
- VIIRS C-RDR Software Change Request Form Rev 1.0
- VIIRS C-RDR Development to Production Checklist Rev 1.0
- VIIRS C-RDR Standard Operating Procedure Rev 1.0
- VIIRS C-RDR User Guide Rev 1.0

PRESENTATIONS

- Copley, L., 2014: Graph Databases Conceptual Overview. Presentation to NCDC Metadata Working Group, 7 March 2014.

OTHER

- Database architect and database developer for Submission Information Package Generation System (SIPGenSys) configuration subsystem.
- Member of NCDC Metadata Working Group (NMWG).
- Supported 'Hour of Code' at Jones Elementary as part of Computer Science Education Week.
- Supported 'Wave Day' science exploration at Asheville Middle School.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Transfer NOAA/NASA Advanced Very High Resolution Radiometer (AVHRR) Pathfinder Sea Surface Temperature (SST) Processing to National Oceanographic Data Center (NODC)

Task Leader	Robert Evans
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 100%; Theme 3: 0%
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%, Goal 5: 0%

Highlight: The Pathfinder Sea Surface Temperature (SST) time series has been extended to include NOAA-19 observations. This is a continuation of the previously submitted time series that covered the Advanced Very High Resolution Radiometer (AVHRR) sensors NOAA-7 through NOAA-18. In addition, the coverage period of NOAA-7 was expanded to include September and October of 1981 through cooperative work with NCDC/RSAD and National Oceanographic Data Center (NODC) to provide the augmented Reynolds OI reference SST fields that are required to process the Pathfinder time series.

BACKGROUND

The primary goal of this work is to assemble Advanced Very High Resolution Radiometer (AVHRR) Sea Surface Temperature (SST) retrieval algorithms into a robust code package to produce a Climate Quality Data Record (CDR) for the AVHRR SST time series, NOAA-7 (September 1981) through NOAA-19 (2013) and deliver the package to NODC to support on-going production of the AVHRR Pathfinder SST time series. This work was based on the Pathfinder 5.2 approach, originally published in Kilpatrick et. al, 1999 (Pathfinder 5.0). Effort this year was focused on implementing a Pathfinder 5.3 update that added a quality test tree for NOAA-7 and NOAA-19 equivalent to that provided for NOAA-9 through NOAA-18 data set processing. Group for High Resolution Sea Surface Temperature (GHRSST) Version 2.0 file specification and formatted in the GHRSST NetCDF4 files format.

ACCOMPLISHMENTS

Accomplishments during the period April 1, 2013 to March 31, 2014 include:

- Implementation of updated AVHRR SeaDAS 6.4 retrieval codes.
- Include data quality tests for NOAAA-7 and NOAA-19, now Pathfinder 5.3
- Update of C-ATBD to reflect inclusion of NOAA-7 and -19 quality tests
- Process the entire NOAA-7 through NOAA-19 observations using Pathfinder 5.3
- Transfer of Pathfinder 5.3 data sets to NODC for conversion to NetCDF4 format and delivery to NCDC
- Transfer Pathfinder 5.3 code base to NCDC and NODC
- Provide support to NODC to implement Pathfinder processing on the cluster environment
- Update documents provided to CDR reflecting Pathfinder 5.3 version.

PLANNED WORK (Completed)

- Transfer of Pathfinder SeaDAS 6.4 implementation to NODC and NCDC
- Production of Pathfinder 5.3 SST dataset for all NOAA 5 channel sensors.
- Transfer of updated NOAA dataset to NODC for NetCDF file conversion.
- Transfer of Pathfinder on-going production to NODC.
- Update Pathfinder documentation and provide to NCDC.
- Transfer of Pathfinder processing code to NCDC and NODC.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	1
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	1
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Validation of Land Surface Temperature (LST) product from VIIRS onboard Suomi-NPP

Task Leader	Pierre Guillevic
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 10%; Theme 2: 80%; Theme 3: 10%
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: The objective of this task is to provide the LST users community and the algorithm-working group (NOAA STAR) with uncertainty estimates associated with VIIRS LST standard products.

BACKGROUND

Land Surface Temperature (LST) is a key variable for surface water and energy budget calculations and can be obtained from satellite observations. The Visible Infrared Imaging Radiometer Suite (VIIRS) instrument was launched in October 2011 as part of the Suomi National Polar-Orbiting Partnership (S-NPP). VIIRS was designed to improve the capabilities of the Advanced Very High Resolution Radiometer (AVHRR) onboard NOAA's operational polar satellites and provide observation continuity with Moderate Resolution Imaging Spectroradiometer (MODIS) instruments on the NASA Terra and Aqua platforms of the NASA Earth Observing System. High temporal and spatial resolution LST products known as Environmental Data Records (EDR) have been derived from VIIRS data since the cooler doors for the thermal sensor were opened on January 18th, 2012, providing a new and consistent LST source for many applications, including weather forecasting, short-term climate prediction, extreme weather monitoring, and irrigation and water resources management. Users of satellite products put a high priority on providing statements of LST product uncertainty.

ACCOMPLISHMENTS

CICS-NC is developing validation tools to account for spatial variability and directional effects when comparing VIIRS LST products with ground-based measurements or heritage satellite data. Preliminary evaluation of the current VIIRS LST Environmental Data Record (VLSTO) against the Moderate Resolution Imaging Spectroradiometer (MODIS) collection-5 LST products (MYD11_L2) and ground-based measurements show good agreement between the products and *in situ* data over vegetated area and inland water surfaces. Based on comparisons with ground-based LST, the accuracy and precision of the VIIRS product are 0.4K and 2.3K when spatial variability of LST around the station is accounted for in the validation process (Fig. 1). However, inter-comparisons between VIIRS and MODIS LST over deserts and arid regions indicate the algorithm significantly underestimates the LST over these cover types. Algorithm performance is further degraded over regions with high atmospheric water vapor content, where differences up to 15 K have been observed between MODIS and VIIRS LST products (Fig. 2). Over land, results suggest that validation of satellite LST products at moderate resolution (>750 m) should be performed over

homogeneous regions in term of land surface type or using nighttime observations only. Additionally, ground-based measurements over water bodies should be used for monitoring calibration drift or refine retrieval algorithms.

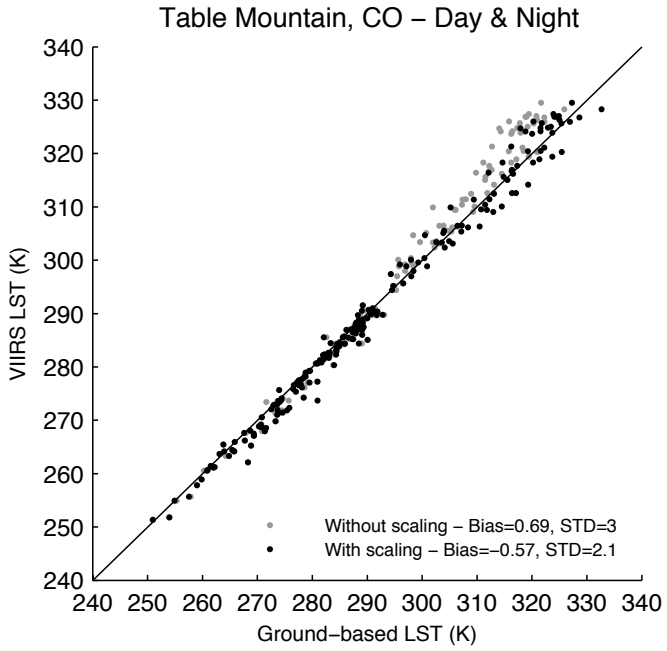


Figure 1: VIIRS LST EDR vs. ground-based LST measurements at Table Mountain, CO.

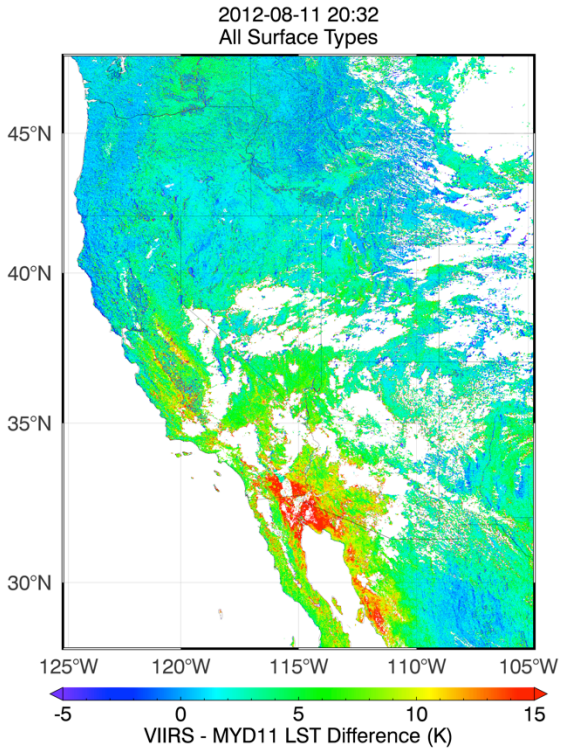


Figure 2: Differences between VIIRS and MODIS (MYD11) LST products observed over western USA on August 11, 2012. The white areas over land represent clouds.

PUBLICATIONS

- Guillevic, P. C., Biard, J., Hulley, G. C., Privette, J. L., Hook, S. J., Göttsche, F.-M., Radocinski, R., Román, M. O., Yu, Y., and Csiszar I. (2014). Validation of Land Surface Temperature products derived from the Visible Infrared Imager Radiometer Suite (VIIRS) using ground-based and heritage satellite measurements. Submitted to Remote Sensing of Environment.
- Merchant, C.J., Matthiessen, S., Rayner, N.A., Remedios, J.J., Jones, P. D., Olesen, F., Trewin, B., Thorne, P.W., Auchmann, R., Corlett, G.K., Guillevic, P.C., and Hulley, G. (2013). The Surface Temperatures of the Earth: Steps towards Integrated Understanding of Variability and Change, Geoscientific Instrumentations, Methods and Data Systems, 2, 305-321.
- Guillevic, P.C., Privette, J.L., Yu, Y., Göttsche, F.M., Hulley, G., Olioso, A., Sobrino, J., Meyers, T., Ghent, D., Bork-Unkelbach, A., Courault, D., Román, M.O., Hook, S., Csiszar, I. (2013). NPP VIIRS land surface temperature product validation using worldwide observation networks. Symposium Proceedings, 2013 IEEE International Geoscience & Remote Sensing Symposium (IGARSS 2013), July 21-26, 2013, Melbourne, Australia. Published by IEEE (USB key). IEEE Catalog Number: CFP13IGA-USB. ISBN: 978-1-4799-1113-4. Paper number: MOP.P23.87. Pages 640-643.
- Olioso, A., Mira, M., Courault, D., Marloie, O., Guillevic, P., 2013. Impact of surface emissivity and atmospheric conditions on surface temperatures estimated from top of canopy brightness temperatures derived from Landsat 7 data. Symposium Proceedings, 2013 IEEE International Geoscience & Remote Sensing Symposium (IGARSS 2013), July 21-26, 2013, Melbourne, Australia. Published by IEEE (USB key). IEEE Catalog Number: CFP13IGA-USB. ISBN: 978-1- 4799-1113-4. Paper number: TH1.T06.4. Pages 3033- 3036.
- Guillevic P.C., A. Bork-Unkelbach, F.M. Goettsche, G. Hulley, J.P. Gastellu-Etchegorry, F. Olesen, and J.L. Privette (2013). Directional viewing effects on Satellite Land Surface Temperature products over sparse vegetation canopies-A multi-sensor analysis. IEEE Geoscience and Remote Sensing Letter, Vol. 10, Issue 6, pp. 1464-1468, doi:10.1109/LGRS.2013.2260319.

PRESENTATIONS

- Guillevic, P., Biard, J., Hulley, G., Goettsche, F., Ghent, D., and Privette J.L. (2013). Validation of satellite Land Surface Temperature products - Protocol, limitations and results. Invited oral presentation at the American Geophysical Union (AGU) fall meeting. San Francisco, CA, USA. 9-13 December 2013.
- Guillevic, P.C., Privette, J.L., Yu, Y., Göttsche, F.M., Hulley, G., Olioso, A., Sobrino, J., Meyers, T., Ghent, D., Bork-Unkelbach, A., Courault, D., Román, M.O., Hook, S., Csiszar, I. (2013). NPP VIIRS land surface temperature product validation using worldwide observation networks. Symposium Proceedings, 2013 IEEE International Geoscience & Remote Sensing Symposium (IGARSS 2013), July 21-26, 2013, Melbourne, Australia. Published by IEEE (USB key). IEEE Catalog Number: CFP13IGA-USB. ISBN: 978-1-4799-1113-4. Paper number: MOP.P23.87. Pages 640-643.
- Olioso, A., Mira, M., Courault, D., Marloie, O., Guillevic, P., 2013. Impact of surface emissivity and atmospheric conditions on surface temperatures estimated from top

of canopy brightness temperatures derived from Landsat 7 data. Symposium Proceedings, 2013 IEEE International Geoscience & Remote Sensing Symposium (IGARSS 2013), July 21-26, 2013, Melbourne, Australia. Published by IEEE (USB key). IEEE Catalog Number: CFP13IGA-USB. ISBN: 978-1- 4799-1113-4. Paper number: TH1.T06.4. Pages 3033- 3036.

- Bork-Unkelbac, A., Guillevic, P., Göttsche, F., and Olesen, F. (2013). Extrapolation of in-situ measurements of Land surface temperature (LST) to satellite spatial resolution. EUMETSAT Satellite Applications Facility on Land Surface Analysis (LSA SAF) workshop, Karlsruhe, Germany, 17-19 June 2013.
- Yu, Y., Csiszar, I., Liang, S., Liu, Y., Wang, D., Yu, P., Tang, Y., Privette, Y., Guillevic, P., Schaaf, C., Wang, Z. (2013). JPSS S-NPP land surface products: status of Land Surface Temperature and Albedo EDRs. EUMETSAT Satellite Applications Facility on Land Surface Analysis (LSA SAF) workshop, Karlsruhe, Germany, 17-19 June 2013.
- Mira, M, Olioso, A., Courault, D., Marloie, O., and Guillevic, P. (2013). Impact of surface emissivity and atmospheric conditions on surface temperatures derived from Landsat 7 brightness temperature. 33rd European Association of remote Sensing Laboratories (EARSeL), 3-6 June 2013, Madera, Italy.

OTHER

- Member of the Cooperative Institute for Climate and Satellites (CICS) Council of Fellows, primary scientific planning and consultative body of CICS.
- Member of the EarthTemp international initiative on Earth surface temperature
- Participant in the European Space Agency (ESA) Glob Temperature initiative on satellite products users for environmental studies

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	4
# of non-peered reviewed papers	6
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of graduate students formally advised	2
# of undergraduate students mentored during the year	1

Net Surface Radiation Budget at High Spatial and Temporal Resolution from Multi-Sensor Data Fusion

Task Leader	Anand Inamdar
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 40%; Theme 2: 40%; Theme 3: 20%
Main CICS Research Topic	Data Fusion and Algorithm Development
Contribution to NOAA Goals (%)	Goal 1: 30%; Goal 2: 70%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: A successful technique to estimate net surface solar radiation from geostationary earth orbit (GEO) satellites has been developed by adapting an algorithm developed for the NASA-operated Clouds and Earth's Radiant Energy System (CERES) instrument on board the EOS/Terra and Aqua. Comparison of results with ground site measurements revealed excellent agreements comparable to or better than other sophisticated methods or even CERES-parameterized flux products.

BACKGROUND

Net surface radiation controls the energy and water exchanges between the biosphere and the atmosphere and has major influences on the Earth's weather and climate. Therefore, the ability to better monitor each of the shortwave and long wave radiative components at the surface at high spatial and temporal resolution is vital to better understand existing feedbacks between the surface energy and hydrological cycles and the past and current Earth's climate, and to better assess future effects of climate change. NASA-operated Clouds and Earth's Radiant Energy System (CERES) instrument on board the EOS platform has been making measurements of net radiation budget (top-of-atmosphere and surface) for over a decade now, but the spatial and temporal resolution lacks what is needed for certain applications like water management in agriculture. However, with a wide array of sensors (like Moderate Resolution Imaging Spectroradiometer (MODIS), the suite of geostationary-orbit meteorological satellites, etc), there is potential to use optimized data fusion techniques to fill in the spatial and temporal gaps.

ACCOMPLISHMENTS

A technique was developed to derive net surface radiation in the shortwave domain from GOES-10 visible imagery. The method does not require characterization of cloud optical properties and relies on adaptation of a standard algorithm developed for the CERES scanner on board the EOS platform. Comparison of results with ground measurements at NOAA's surface radiation network (SURFRAD) sites yields very good agreement comparable to, or many times better than, other sophisticated methods, including the CERES products (see *Fig. 1*). An advantage of this product is a significantly extended spatial and temporal coverage than that offered by the CERES instrument. A journal paper describing this study has been submitted to the IEEE Transactions on Geoscience and Remote Sensing.

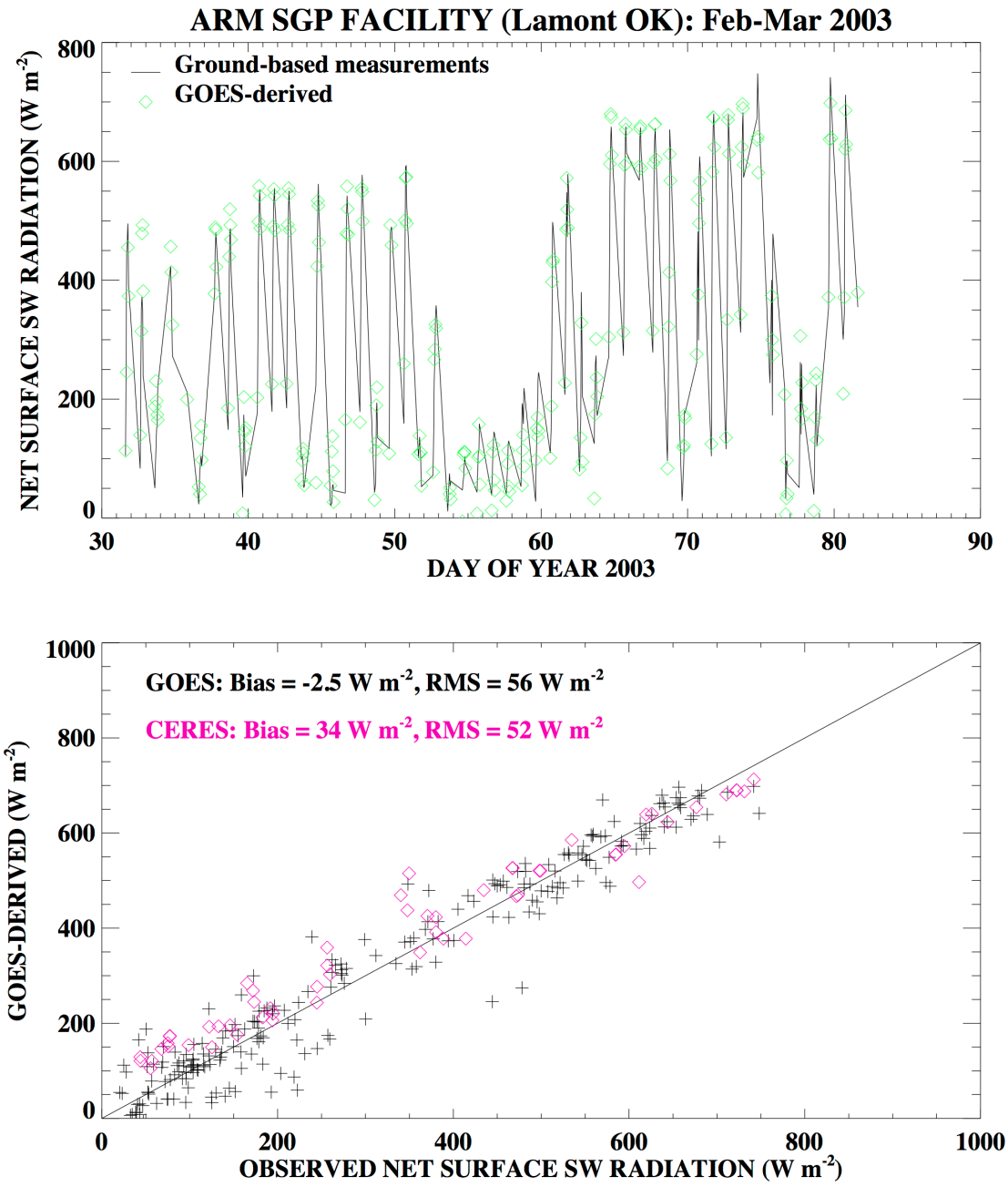


Fig. 1: Top: Time series of net surface SW flux measured at ground (continuous solid line) and those retrieved from GOES-10 (green symbols). Bottom: Scatter plot of matched pairs of observed and modeled values from top panel. Magenta diamond symbols show the comparison with CERES products (Model B in the CERES sub-system).

PLANNED WORK

- Extension of the work to other meteorological satellites around the globe
- Top-of-atmosphere and surface LW radiation from MODIS imager
- Extend the present SW scheme to long wave spectral region for the GEO imagery

- A proposal, "Estimation of top of canopy net radiation using observations from MODIS on-board TERRA and AQUA satellites", has been submitted to NASA with Anand Inamdar as the lead PI and Pierre Guillevic is the Co-I. Decision on award is still pending.

PUBLICATIONS

- Inamdar, A. K., and P. Guillevic, 2014: Estimation of net surface shortwave radiation from GOES imagery. Submitted to *IEEE Trans. Geosci. Remote Sensing*.
- Inamdar, A. K., and P. Guillevic, 2014: "A new approach to monitor net surface solar radiation from geostationary imagery". Proc. of AMS 95th Annual Meeting held at Atlanta Feb 2-6 2014.

PRESENTATIONS

Invited

- "A new approach to monitor net surface solar radiation from geostationary satellites." Earth System Science Inter-disciplinary Center (ESSIC), University of Maryland, College Park MD Sep 9 2013.

Conference

- 28th Hydrology Conference, American Meteorological Society 94th Annual Meeting, Atlanta. Feb 3 2014.

Performance Metrics	**FY13**
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	1
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	1

Independent Evaluations of the Calibration of the Visible Channel in the International Satellite Cloud Climatology Project (ISCCP) B1 Data

Task Leader	Anand Inamdar
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: %; Theme 2: 70%; Theme 3: 30%
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 30%; Goal 2: 70%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: Calibration of the Geostationary Earth Orbit (GEO) visible channel in the ISCCP B1 data stream has been completed for all meteorological satellites for the period 1979-2009, through employing AVHRR channel 1 reflectance in the Pathfinder Atmospheres Extended (PATMOS-x) data and validated through other independent results. Separately, the pre-GVAR GOES data (prior to GOES-8) has been reprocessed to conform to a more consistent format with less noise and these reprocessed data files will soon replace the present ISCCP B1 data in the archive.

BACKGROUND

The ISCCP (International Satellite Cloud Climatology Project) B1 data represents geostationary imagery at 3 hourly and 10 km spatial resolution retrieved from the suite of geostationary meteorological satellites all over the world. It will soon be employed in the reprocessing of the ISCCP Cloud Climatology, surface radiation budget and aerosol retrieval at higher spatial resolution. For accurate retrieval of these geophysical parameters, it is vital to have a good calibration. The visible channel calibration is currently managed by the Meteorological Center in France through normalization with the concurrent Advanced Very High Resolution Radiometer (AVHRR) solar channel on the afternoon NOAA polar-orbiting satellite at the same viewing geometry. However, there are several gaps in the present calibration. For example, data prior to 1983, suffers from too much noise for certain GEO sensors. The main objective of the present project is to fill in these calibration gaps and perform a uniform calibration for all the geostationary satellite visible channels from 1979 until present, through cross-calibration with the MODIS-quality AVHRR visible channel Climate Data Record (CDR) product available at NOAA/NCDC.

ACCOMPLISHMENTS

Cross-calibration of the GEO visible channel counts with the AVHRR PATMOS-x has been performed through direct linear regression, using domain-averaged count values for the GEO, instead of the cumulative histogram matching technique that was used and reported previously. The former scheme has been found to yield better results than the histogram approach as evidenced by comparisons with the ISCCP calibration and also other calibration results. Time variation of the calibration coefficient is derived in terms of a quadratic function of the time lapsed since launch of the satellite. Results for the time series of the calibration coefficients have been validated independently. These include calibration using views of the moon (lunar) which were made available from Thomas Stone of the USGS Lunar Observatory at Flagstaff AZ, and observation of pseudo-invariant stable targets on earth.

Data provided from each Satellite Processing Center (SPC) have been treated separately for calibration purposes. An example of the time variation of the calibration coefficient using different methods is shown in *Figure 1* for the GOES and Meteosat Second Generation 2 (MTS-2) satellite series. A journal paper describing this study has been submitted to the AMS Journal of Atmospheric and Oceanic Technology.

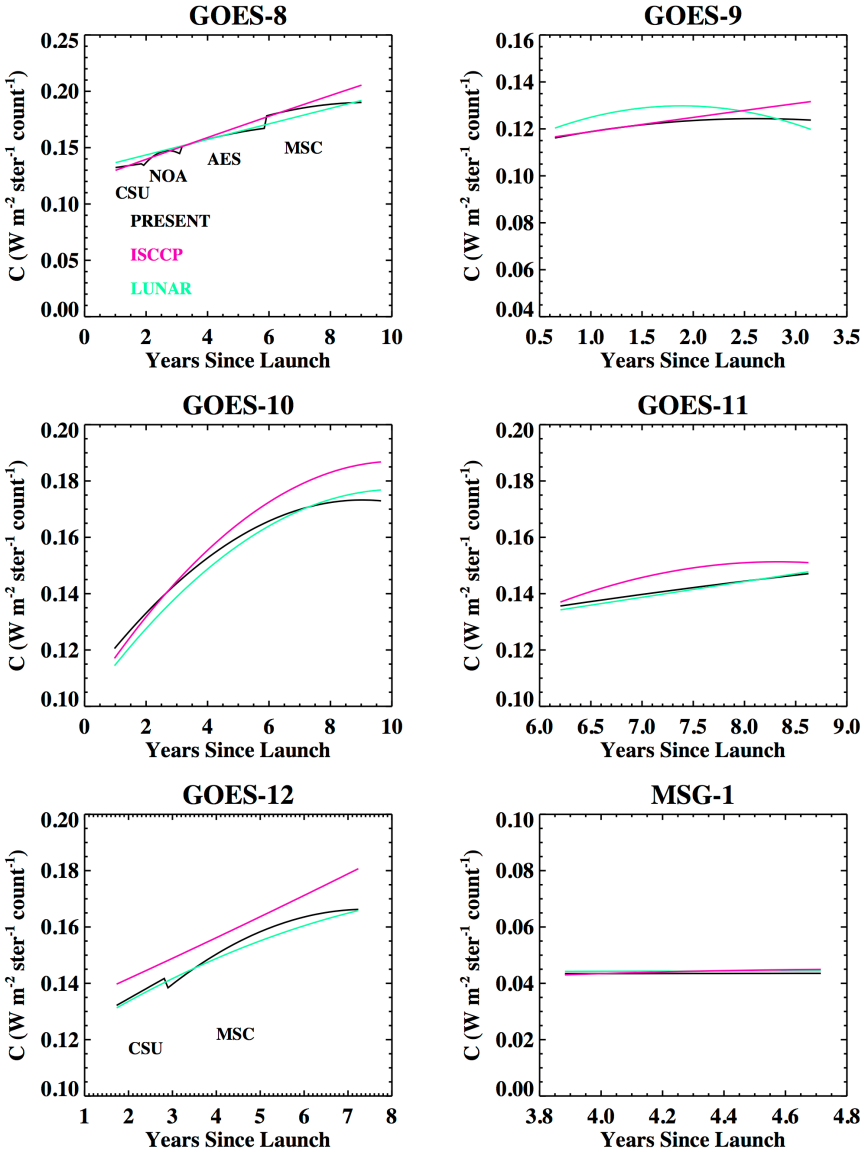


Fig. 1. Comparison of the time variation of the calibration coefficient, derived from ISCCP, present study and lunar calibration for GOES-8 to GOES-12 and also Meteosat Second Generation 2 (MSG-2) satellites. Satellites with multiple SPC data providers (GOES-8 and GOES-12) are identified. The color codes for different curves follow the same pattern shown in the top left corner panel.

PLANNED WORK:

- Quality check of all ISCCP B1 images manually before they are employed in ISCCP cloud processing;

- Comparison with additional calibration results from Lunar and other studies as they become available;
- Re-calibration of the reprocessed pre-GVAR ISCCP B1U data;
- Implementation of the full ISCCP processing at NCDC;
- Processing of ISCCP cloud properties at high spatial resolution using the newly calibrated ISCCP B1U data at NCDC.

PUBLICATIONS

- Inamdar, A. K., and K. Knapp, 2014: Inter-comparison of Independent Calibration Techniques Applied to the Visible Channel of the ISCCP B1 data. Submitted to *J. Atmos. Ocean. Tech*.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	2
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Implementation of Geostationary Surface Albedo (GSA) Algorithm with GOES Data

Task Leader	Jessica Matthews
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: %; Theme 2: %; Theme 3: %.
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: The GSA algorithm is being implemented as the American contribution of an international collaboration between Europe, Japan and the US to produce a joint climate data record.

BACKGROUND

Surface albedo is the fraction of incoming solar radiation reflected by the land surface, and therefore is a sensitive indicator of environmental changes. To this end, surface albedo is identified as an Essential Climate Variable (ECV) by the Global Climate Observing System (GCOS). In support of the Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM), NCDC is implementing the GSA algorithm for GOES data to contribute to an international effort in collaboration with EUMETSAT and JMA. Currently, the GSA algorithm generates products operationally at EUMETSAT using geostationary data from satellites at 0° and 63°E and at JMA using 140°E geostationary data. To create the stitched global Level 3 product as illustrated in Figure 1, NCDC is tasked with implementing the algorithm for GOES-E (75°W) and GOES-W (135°W).

Previously the GSA algorithm was run with GOES data only for viability studies with 10 days of data. To effectively and efficiently generate products with this algorithm over large time periods, much effort must be extended to understand the application to GOES data specifically. The effort may be divided into two general categories: Operations and Science. Examples of Operations tasks include: porting code developed in the EUMETSAT computing environment to be functional in the NCDC computing environment, code development to work with GOES data format imagery, code development for ancillary NWP input data, etc. Examples of Science tasks include: calibration of GOES data, evaluation of the effect of different spatial and temporal resolutions of GOES as compared to the resolutions of EUMETSAT and JMA satellites, validation of the algorithm as applied to GOES data with external data sets, development of uncertainty bounds for the product, etc.

ACCOMPLISHMENTS

This project was one of only 10 selected by the SCOPE-CM Executive Panel from last year's competition. The project proposed to extend the international collaboration into Phase 2 which is planned to last 5 years and includes activities such as: a common cloud mask approach, a common intercalibration method, exploration of different temporal resolutions and formats of output, and validation of Level 2 products. In August 2013, Alessio Lattanzio

and Joerg Schulz of EUMETSAT visited NCDC and the project group made plans for the work to be accomplished by both EUMETSAT and NCDC in 2014.

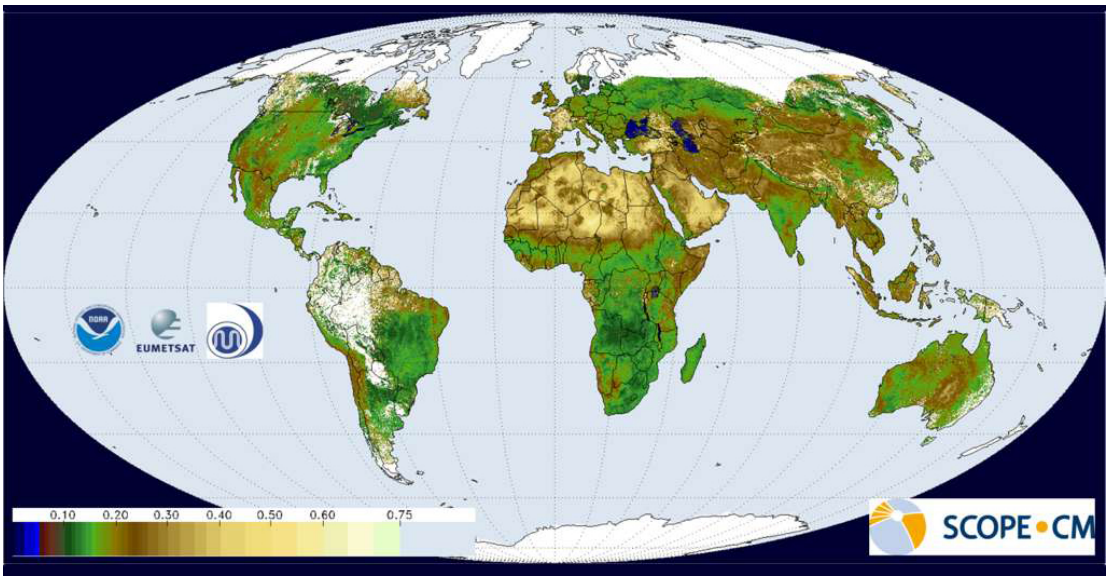


Figure 1: Broadband black sky albedo spatial composite product for the period 1-10 May 2001.

One of the main tasks for 2014 is to have a unified approach to calibration. It was decided that to use the GSICS approach of deep convective cloud (DCC) method. Because the Global Space-based Inter-Calibration System (GSICS) community is already pursuing this, this project will not duplicate their efforts. Contact was made with FangFang Yu, the NOAA representative working with GSICS for GOES calibration, who agreed to share calibration information for GOES.

Another main task for 2014 is to use the same global data set for total column ozone and water vapor inputs into the algorithm. To date, each agency has been using their reanalysis dataset. Moving forward, all agencies have agreed to use the ECMWF reanalysis data.

In January of 2014, Jessica Matthews began collaborating with Brian Reich and Elizabeth Mannshardt of the Statistics Department at North Carolina State University to develop a validation framework for this data set. The group selected a methodology capable of comparing the geostationary-based GSA albedo data to both the polar-orbiting MODIS albedo data and ground-based Ameriflux albedo data. This methodology is flexible to account for issues such as spectral, spatial footprint, and temporal compositing differences between the datasets.

PLANNED WORK

- Update algorithm code to store daily products
- Implement and test code for using ECMWF ozone and water vapor data
- Implement and test cloud mask as developed by the Satellite Application Facility on Climate Monitoring

- Reprocess data with updated calibration coefficients using the DCC method
- Perform validation of GSA products with MODIS and in situ observational data

OTHER
Selected as SCOPE-CM Phase 2 project.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Uncertainty Quantification (UQ) for Climate Data Records

Task Leader	Jessica Matthews
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: %; Theme 2: %; Theme 3: %.
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: Uncertainty quantification in climate research is a multidisciplinary area of increasing importance.

BACKGROUND

Observations are key to uncertainty quantification in climate research because they form the very basis for any evidence of climate change and provide a corroborating source of information about the way in which physical processes are modeled and understood. However, observations themselves possess uncertainties originating from many sources including measurement error and errors imposed by the algorithms generating derived products (see *Figure 1*). Over time global observing systems have undergone transformations on pace with technological advances and these changes require adequate quantification of resultant imposed biases to determine the impact upon long term trends. The uncertainties in climate observations pose a set of methodological and practical challenges for both the analysis of long-term trends and the comparison between data and model simulations.

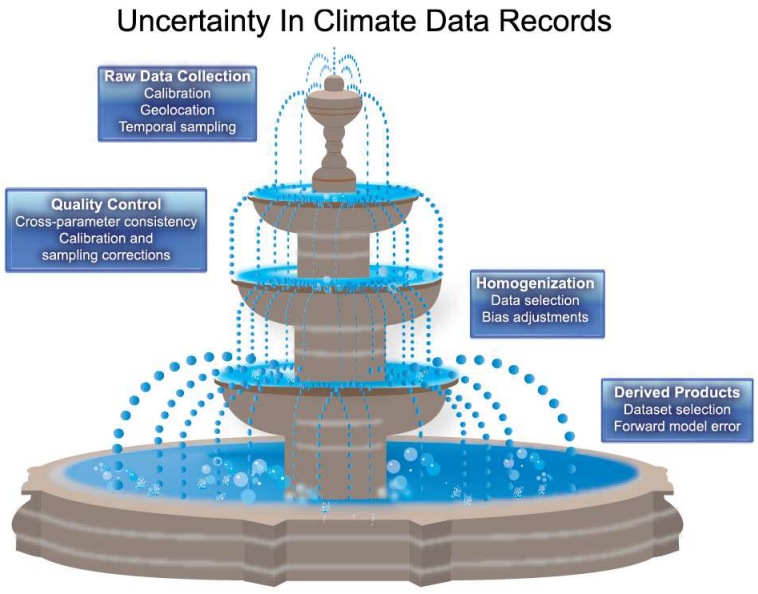


Figure 1. Uncertainties in climate data records; it is necessary to understand all the uncertainties in the observing system and data manipulation processes. Additional uncertainties are introduced at each level leading to an uncertainty cascade.

ACCOMPLISHMENTS

As chairperson of the Climate Working Group for SAMSI's 2012-2013 Program on Statistical and Computational Methodology for Massive Datasets, Jessica Matthews organized virtual weekly meetings throughout the academic year. The participants in the working group included graduate students, postdocs, and scientists from various governmental agencies and academic institutions from across the country and world. This activity has introduced CICS-NC as an entity in the mathematics/statistics for climate community network. Project topics researched by the group included: detection and attribution when comparing climate model output with observational data, uncertainty quantification for the global carbon cycle, and spatial statistics on distributed data.

Collaboration with Sandia National Laboratories began in February 2014 to apply uncertainty quantification technology based on random fields to a NCDC Climate Data Record. In particular, the Pathfinder SST product was selected for this pilot study. This CDR does not yet have a full end-to-end quantification of the product uncertainties. Our goal is to demonstrate uncertainty quantification in the product, thus improving the overall confidence and applicability of the dataset. Pending successful implementation of UQ methodologies to the Pathfinder SST CDR, we hope to encourage the CDR Program to more formally assess uncertainties on other operational and developmental datasets.

Multiple validation exercises to assess the uncertainties in Climate Data Records are ongoing. Working with Brian Reich and Elizabeth Mannshardt of the North Carolina State University Statistics Department, the Geostationary Surface Albedo product is being compared to both MODIS and *in situ* data with careful consideration to spectral, spatial, and temporal compositing differences between the data sets. Comparisons of the nnHIRS temperature and humidity profiles to radiosonde and surface observations are currently underway. Consideration of the uncertainties as provided with select radiosonde observations is included. Additionally, bootstrap methods of the underlying neural network calibration are being investigated which could provide an uncertainty estimate for every nnHIRS profile data point.

PLANNED WORK

- Continue to bridge between NCDC and the largely academic mathematical and statistical communities.
- Evolve the Uncertainty Quantification for Climate Observations workshop, like the one co-organized by CICS-NC and held at NCDC in 2012, into a regular event to facilitate continued cooperation and communication within the science.
- Continue research on methodologies to apply UQ to Climate Data Records.
- Utilize North Carolina State University Mathematics Department Adjunct faculty appointment to engage students in this field.

PRESENTATIONS

- Matthews, J.L., 2013: Research applications at the National Climatic Data Center*, North Carolina State University Statistics Department Environmental seminar*, Raleigh, NC (17 Oct.).
- Matthews, J.L. and Lei Shi, 2014: Validation of satellite-derived temperature and humidity profiles, *SIAM Conference on Uncertainty Quantification*, Savannah, GA (31 Mar).

OTHER

- Scientific committee member for Next Generation Climate Data Products Workshop, Boulder, CO, July 15-19, 2013

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	2
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Comparison of Ground Based Temperature Measurements with Satellite-derived Phenology

Task Leader	Jesse Bell and Jessica Matthews
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: %; Theme 2: %; Theme 3: %.
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 50%; Goal 2: 50%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: This research is a comparison of satellite derived phenology measurements with ground based temperature metrics. The goal of this project is to determine which of air or soil temperatures are better for estimating the growing season and will serve to improve U.S. Climate Reference Network (USCRN) drought monitoring.

BACKGROUND

Climate observations of growing season are essential for understanding plant phenology and physiological development. Air temperature, as it is one of the most commonly recorded climate variables, is traditionally used to define the onset and end of the growing season when phenology measurements are not available. Because belowground activity has been shown to be a predominant indicator of vegetative growth, research was conducted to determine if soil temperature is a better metric for calculating plant phenology than air temperature. Using start of season (SOS) estimates derived from remotely-sensed MODIS normalized difference vegetation index (NDVI) data, comparisons were made with SOS estimates derived from air and soil temperature as measured by the U.S. Climate Reference Network (USCRN).

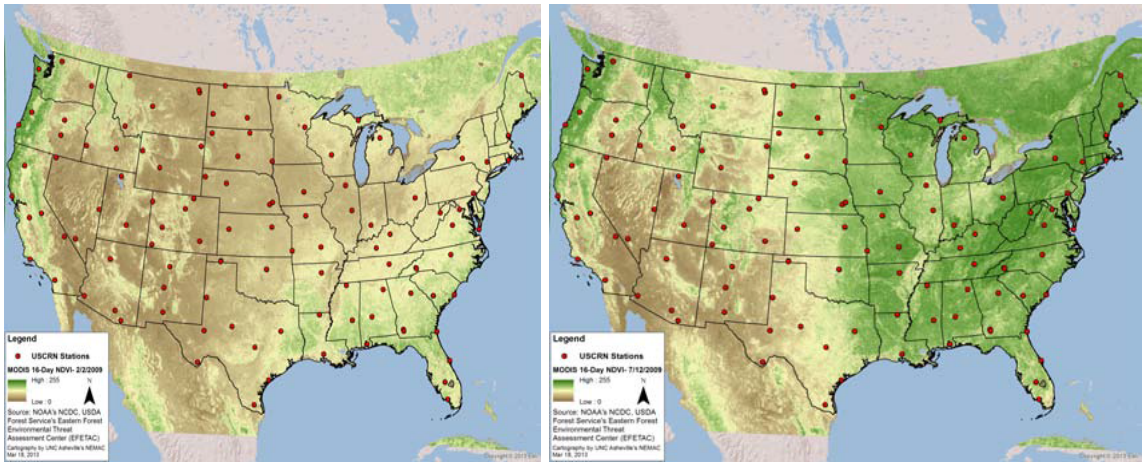


Figure 1. MODIS NDVI data for winter 2009 (left panel) and summer 2009 (right panel) as overlaid with locations of USCRN stations.

ACCOMPLISHMENTS

Different temperature thresholds were investigated to determine which *in situ* temperature variable (of air, surface, or soil) and which threshold (of 0C, 5C, or 10C) provides the most

accurate correlation with the start date of the growing season. Our approach includes an investigation of 39 USCRN stations that have three complete years (2010-2012) of air, surface, and soil (5, 10, 20, and 50 cm) temperature data.

16-day MODIS NDVI data at 250-meter spatial resolution, from both AQUA and TERRA, were used to estimate SOS for each USCRN station in the study. The pixels containing each station were examined for all of 2010-2012. *Figure 1* illustrates the seasonal change of NDVI data along with the USCRN station locations. Two different methods for calculating SOS were applied to the NDVI data: a local threshold-based on yearly minimum and maximum NDVI values (ratio) and slope based estimates from exponential functional fits to NDVI data (exponential).

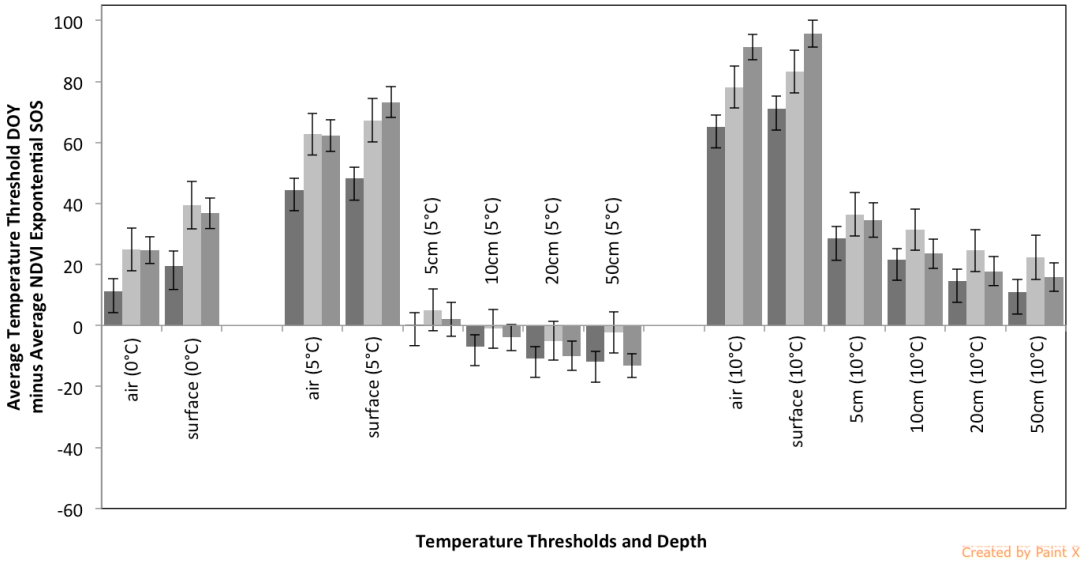


Figure 2: Comparison of the average difference between temperature-derived SOS at various depths and temperature thresholds with NDVI-derived SOS using the exponential method. Dark grey bars indicate 2010, light grey bars indicate 2011, and medium grey bars indicate 2012. Soil temperatures using the 5C threshold are the closest to the NDVI-derived SOS.

The NDVI-based SOS estimates were then compared to the SOS estimates for each of the air and soil temperature thresholds from the ground-based measurements. The best RMSE correlations were with the soil temperature thresholds at 5C and the exponential method (see Figure 2). Assuming that the NDVI-based SOS using the exponential method is a surrogate for truth in the absence of actual phenology data, these results are the first to show large-scale patterns of soil temperature thresholds as an indicator of phenological development. This research provides a new methodology for determining the climatic growing season that will assist in more accurate predictions of plant growth and development for monitoring and modeling purposes.

PLANNED WORK

- Extend research to include analysis of 2013 data with a focus on the impact of different eco-regions

- Pursue funding to extend the USCRN to include web-based camera technology in order to validate this methodology.

PUBLICATIONS

- Bell, J.E. and J.L. Matthews. Evaluation of air and soil temperatures for determining the onset of the growing season. Submitted.

PRESENTATIONS

- Bell J.E., and J.L. Matthews, 2013. Growing Season Analysis during *NCDC Dataset Discovery Day: Frost and Freeze Data and Impacts to the Agriculture, Construction, and Transportation Industry*, 20 March 2013, Asheville, NC.
- Meyer J., 2013. Evaluation of Air and Soil Temperatures for Determining Onset of Growing Season. *NCDC Internal Seminar*, 26 March 2013, Asheville, NC.

OTHER

The analysis for 2012 data was contributed to by UNC-A undergraduate mathematics major Jennifer Meyer.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	2
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	1

PERFORMANCE METRICS EXPLANATION

Jennifer Meyer contributed to this project as a CICS-NC undergraduate intern.

HIRS Temperature and Humidity Profiles

Task Leader	Jessica Matthews
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: %; Theme 2: %; Theme 3: %.
Main CICS Research Topic	Data Fusion and Algorithm Development
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: CICS is developing a global temperature and humidity profile dataset for the time period of 1978-present. Applying neural networks to High-resolution Infrared Radiation Sounder (HIRS) data produces the new dataset.

BACKGROUND

The goal of this task is to derive temperature at 12 different altitudes/pressures (surface, 2m, 1000mb, 850mb, 700mb, 600mb, 500mb, 400mb, 300mb, 200mb, 100mb, and 50mb) and humidity at 8 different altitudes/pressures (2m, 1000mb, 850mb, 700mb, 600mb, 500mb, 400mb, 300mb) using HIRS data.

For the temperature profiles HIRS Channels 2-12 were used, while for the humidity profiles HIRS Channels 4-8 and 10-12 were used as inputs. These selections were based on the known relations of the channel information to the different physical variables. The HIRS data coupled with CO2 data were used as inputs to a neural network. The neural networks were calibrated according to surface pressure bins. There were three different neural nets, one each for: surface pressures less than 700 mb, greater than 850 mb, and those in between 700 and 850 mb. Radiative Transfer for Television Infrared Observation Satellite (TIROS) Operational Vertical Sounder (TOVS) (RTTOV) data was used as inputs of profile data for calibration purposes.

The resultant neural networks were applied to produce global temperature and humidity profiles using a series of 13 satellites during the 1978-2013 time period. When processing the data, United States Geological Survey (USGS) topography information on a 1-degree grid was used to define topography (and thus surface pressure) to select which of the three neural nets to apply. Additionally, monthly CO2 inputs (assumed to be global) were obtained from the Scripps CO2 program.

ACCOMPLISHMENTS

The same RTTOV training data sets as used to calibrate the neural networks for the specific humidity and temperature profiles were used to calibrate neural networks for relative humidity profiles. A Monte Carlo scheme was developed to find the optimum neural network by perturbing such variables as: number of layers, number of nodes per layer, and transfer function relating the layers. The process was implemented in Matlab and parallelized for efficiency.

The existing temperature and specific humidity data sets were processed through 2011. We detected a bug in the 2011 data set. The data set was thusly corrected and also extended to include 1978-2013.

Several independent datasets were compared to the HIRS profile data. Algorithms were developed to co-locate measurements within 0.1 degrees latitude and longitude and within 1 hr of overpass. To date comparisons have been done with Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN) and Constellation Observing System for Meteorology Ionsphere and Climate (COSMIC) observations, which are both largely based on radiosonde measurements.

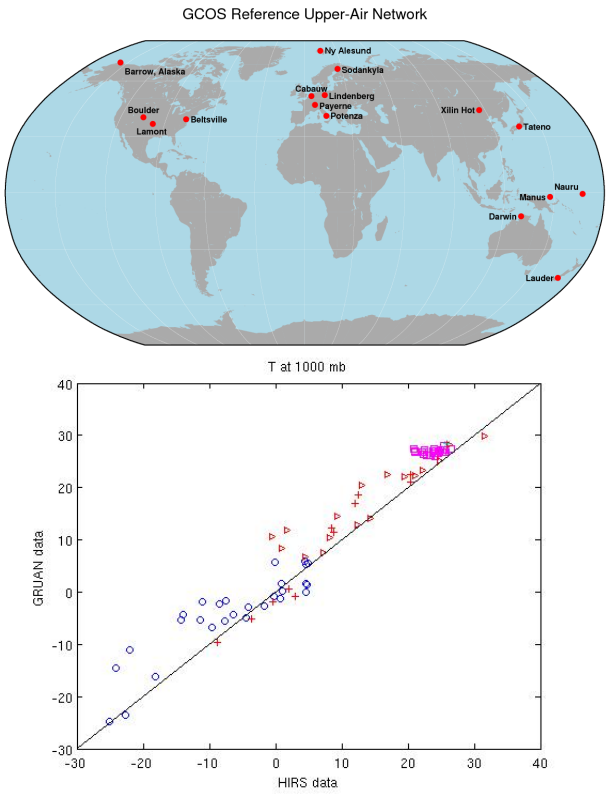


Figure 1: Locations of available GRUAN stations (top). Comparisons of retrieved temperature values based on HIRS data to GRUAN radiosonde observations at a pressure level of 1000 mb (bottom).

PLANNED WORK

- Continue validation work to assess the performance of the algorithms, including comparisons with surface observations from Hadley Integrated Surface Database (HadISD) and U.S. Climate Reference Network (USCRN)
- Explore implementing bootstrap methodology to provide associated uncertainty estimates

DELIVERABLES

- Corrected and extended temperature and specific humidity profile data

PRESENTATIONS

- Matthews, J.L. and Lei Shi, 2014: Validation of satellite-derived temperature and humidity profiles, *SIAM Conference on Uncertainty Quantification*, Savannah, GA (31 Mar).

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	3
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

This year, we developed a new relative humidity product (1). We also corrected and extended the temperature and specific humidity products (2).

Maintenance and Production of CDR's for Microwave Sounding Unit (MSU) and AMSU Atmospheric Temperatures and NCDC Special Sensor Microwave Imager (SSM/I) Brightness Temperatures

Task Leader	Carl Mears
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: %; Theme 2: 100%; Theme 3: %.
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: MSU/AMSU brightness temperatures updated and transferred to CDR Archive at NCDC. SSM/I Version 7 brightness temperatures updated and transferred to CDR Archive at NCDC.

BACKGROUND

NOAA's National Climatic Data Center (NCDC) Climate Data Record Program (CDRP) leads NOAA's development and provision of authoritative satellite climate data records (CDRs) for the atmospheres, oceans, and land. This project addresses CDRP's current need to sustain and maintain two specific CDRs derived from satellite microwave radiometers:

1. Atmospheric temperatures at multiple layers derived from the Microwave Sounding Units (MSUs) and Advanced Microwave Sounding Units (AMSUs)
2. Top of the atmospheric (TOA) brightness temperature (T_B) derived from the SSM/I on the F15 spacecraft and from the SSM/IS on the F17 spacecraft

The air temperature measurements began in late 1978 with the launch of the first Microwave Sounding Unit (MSU), and the SSM/I brightness temperature measurements began in 1987 with the launch of the first SSM/I on the DMSP F08 spacecraft. Both types of measurements will continue to be recorded with the ongoing operation of various Advanced Microwave Sounding Units (AMSUs) on NOAA, NASA, and EUMETSAT platforms and with the four SSM/IS on F16, F17, F18, and F19.

These measurements have been an important part of national (Climate Change Science Program (CCSP)) and international (Institute of Geophysics, Planetary Physics, and Signatures (IGPP)) assessments of climate change, as well as providing a basis for a number of independent studies of climate change. The continuation, validation, and improvement of these datasets are of fundamental importance to our ability to continue to monitor long-term changes in atmospheric temperature. The goal of this proposal is to ensure the continued production of high quality CDRs from both MSU/AMSU and SSMI/SSMIS.

ACCOMPLISHMENTS

The main focus of this project to date has been to transition the MSU/AMSU and SSM/I brightness temperature products from research to operations. The transition is complete and the focus of the project is now routine updates and transfers of data to NCDC as well as ongoing monitoring of the data stream. The two sections below summarize progress for each of the data products.

MSU/AMSU

The group has completed the following tasks for MSU/AMSU.

- Completion and approval of Quality Control and Quality Assurance Description Document.
- On-going data production for AMSU instruments on NOAA-15, NOAA-16, NOAA-18, NOAA-19, and METOP-A satellites.
- On-going routine transfers of the MSU/AMSU data in CF 1.6 compliant netcdf to NCDC on a monthly basis.

An example of the monthly atmospheric temperature anomalies from this dataset is shown below.

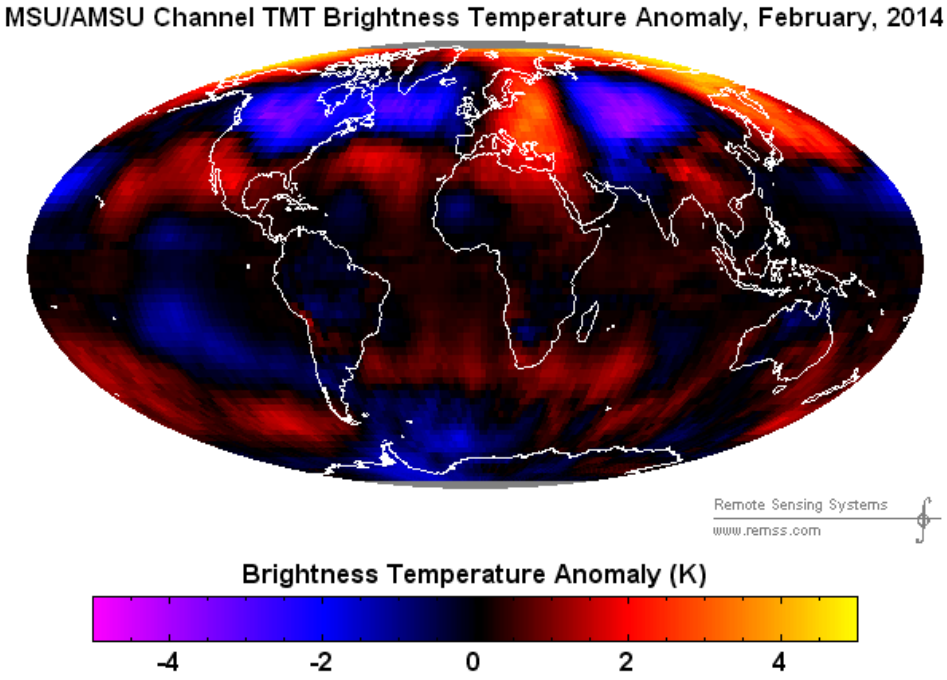


Figure 1: Temperature Anomaly in the lower troposphere for February 2014. The large positive anomaly over Eastern Europe contributed to poor snow conditions at the 2014 Olympics in Sochi, Russia.

SSM/I – SSMIS

We have completed the following tasks for SSM/I – SSMIS.

- Completion and approval of Quality Control and Quality Assurance Description Document.
- Completion of code to write F17 data in netcdf4 format with approved CF-1.6 metadata.
- Conversion of the dataset to netcdf4.
- Transfer of all previous F17 data to NCDC.
- Ongoing production of data from F17
- Routine transfer of SSMIS F17 data to NCDC in netcdf4 format.

A daily map of the 37 GHz H-Pol brightness temperatures is shown below.

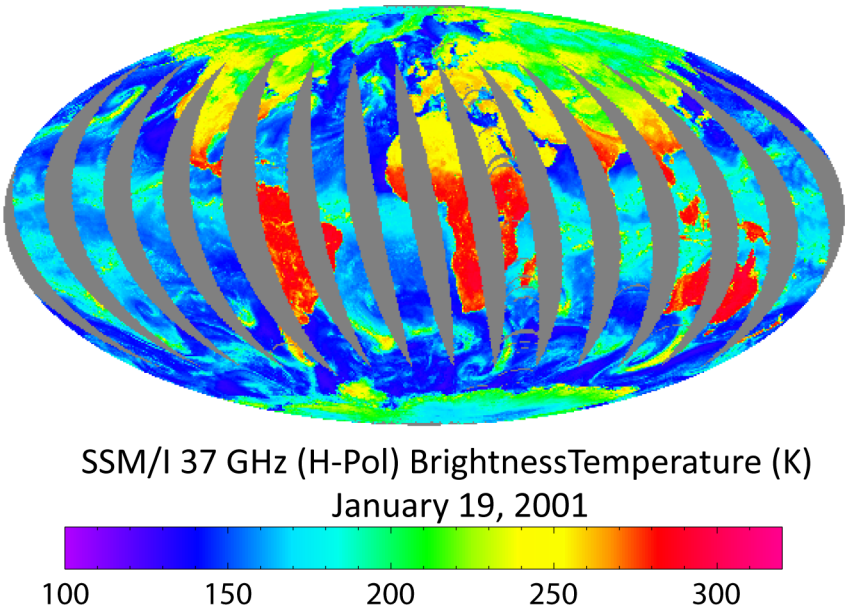


Figure 2: SSM/I 37 GHz H-Pol brightness temperatures for January 19, 2001. These data were obtained from the DSMP F13 satellite. Variations in the brightness temperatures are due to a combination of surface (temperature, emissivity) and atmospheric (water vapor, clouds, and rain) effects.

PLANNED WORK

- Develop simple automated validations tools for both MSU/AMSU and SSM/I brightness temperatures
- Continued production, reformatting and transfer of MSU/AMSU and SSM/I data to NCDC
- Ongoing monitoring and quality assurance of these data streams

DELIVERABLES

- Monthly Updates to the MSU/AMSU datasets, completed by the 10th of the following month
- Monthly Updates to the SSMIS F17 dataset, completed by the 10th of the following month

- Yearly Update to the SSM/I F15 dataset, completed after RSS extends the calibration for this instrument.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	1
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Evaluation and Characterization of Satellite Products

Task Leader	Ge Peng
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 10%; Theme 2: 85%; Theme 3: 5%
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 80%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 20%

Highlight: Evaluated the NOAA/NSIDC passive microwave sea ice concentration climate data record (CDR) and provided global characterization of decadal trends of sea ice extents in the Arctic and Antarctic Oceans. Also evaluated the NCDC blended sea surface winds.

BACKGROUND

The primary objective of this task is to evaluate, validate, and characterize satellite-based products that have been, or are in the process of being, transitioned to operation from research or being developed at NCDC.

The evaluation and characterization of the satellite product will improve data quality, maturity of the product, and provide a baseline and additional quality information for users and identify areas for product improvement.

ACCOMPLISHMENTS

The NOAA/NSIDC passive microwave sea ice concentration climate data record (CDR) has been evaluated comparing to other passive microwave sea ice concentration products. The characterization of the global decadal trends was established in term of sea ice extent (*Figure 1*).

- One paper was published proceeding the 2013 IEEE Geoscience and Remote Sensing Symposium (IGARSS).
- One peer-reviewed paper is published in the Earth System Science Data journal (doi:10.5194/essd-5-311-2013).
- One peer-reviewed paper submitted to the Polar Research journal and is currently under revision.

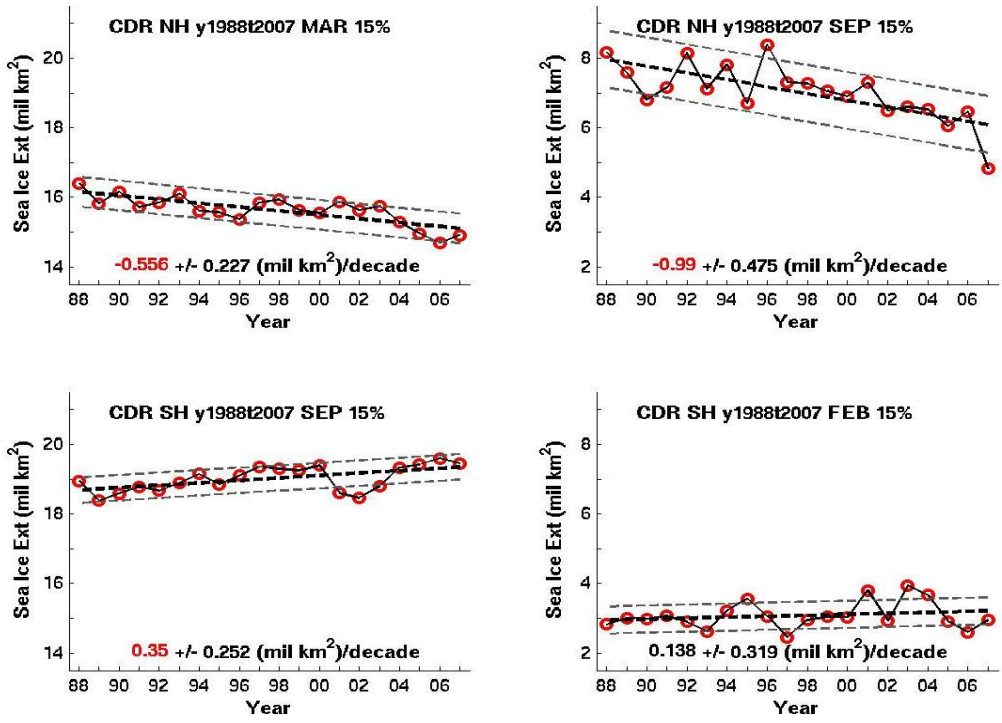


Figure 1: Annual maximum (left panels) and minimum (right panels) CDR sea ice extent from 1988 to 2007 (red circles), with the linear regression ±1 standard deviation of the annual mean sea ice extent (black and grey dashed lines, respectively) for the Northern (top) and Southern (bottom) Hemispheres with the decadal trend and its margin of error-trend in red significant at the 95% confidence level. It shows that significant trends of depletion are observed in the Arctic region-a stronger decadal trend of annual minimum sea ice extent than that of annual maximum. At the same time, sea ice coverage undergoes a slight increase with that of annual maximum being statistically significant at the 95% confidence level.

The NCDC satellite-based blended sea surface wind product has been evaluated along with short-range forecast winds from three international numerical weather prediction (NWP) model centers (the European Center for Medium range Weather Forecasting (ECMWF), the German Weather Service "Deutscher Wetterdienst" (DWD) and the Japan Meteorological Agency (JMA)) and NCEP Climate Forecast System Reanalysis (CFSR) winds using high-quality *in situ* reference time series for year 2009.

- One peer-reviewed paper is published by the AMS Weather and Forecasting journal.
- Recommendation of utilizing single pixel filtering and wind directions from a high-resolution NWP model has been provided to the NCDC scientist and implemented in a development plan for the next version.
- A by-product of this study is the uncovering of a systematic directional bias at one of the TAO buoy array from November 2008 to January 2010 (*Figure 2*). A manuscript was submitted to the peer-review Data Science journal.

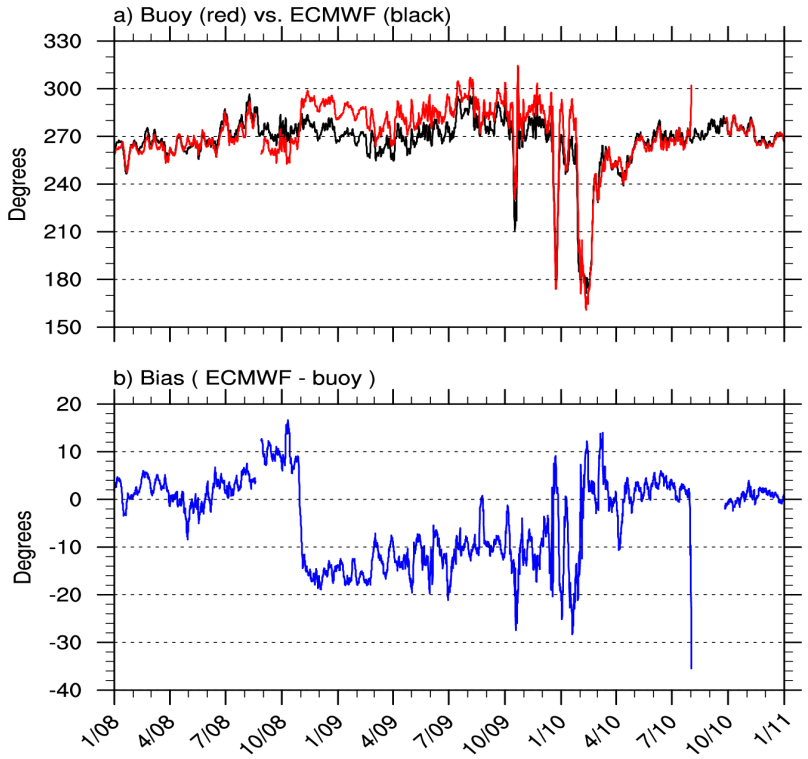


Figure 2: a) wind directions from the 7-day running means of 6-hourly wind components from ECMWF (black) and the WMO 51010 buoy located at 0°N, 170°W in the central equatorial Pacific Ocean (red) from January 2008 to January 2011 and b) the difference between the two. It shows a sudden shift in buoy wind direction in the early November of 2008.

PLANNED WORK

- Examine regional decadal variability of sea ice extent in the Arctic Ocean using the NOAA/NSIDC sea ice concentration CDR
- Evaluate satellite-based surface fluxes products that are under transition or to be transitioned from research to operation in the Polar regions

PUBLICATIONS

- Peng, G., W.N. Meier, D. J. Scott, and M. Savoie, A Long-Term and Reproducible Satellite-Based Passive Microwave Sea Ice Concentration Data Record for Climate Study and Monitoring. *Earth System Science Data Journal*. **5**, 311–318, doi:10.5194/essd-5-311-2013.
- Meier, W. N., G. Peng, D. J. Scott, and M. Savoie, 2013: Evaluation of a passive microwave sea ice concentration climate data record. *Submitted to the Polar Research journal*.
- Peng, G. and W. Meier, 2013: Characterization of a satellite-based passive microwave sea ice concentration climate data record. *Proc. International Geoscience and Remote Sensing Symposium (IGARSS)*, 232 – 235, IEEE International, 21 – 26 Jul, 2013, Melbourne, Australia.

- Peng, G., H.-M. Zhang, H.P. Frank, J.-R. Bidlot, M. Higaki, S. Stevens, and W.R. Hankins, 2013: Evaluation of various surface wind products with OceanSITES buoy measurements. *Weather and Forecasting*, **28**, 1281–1303, doi:10.1175/WAF-D-12-00086.1.
- Peng, G., J.-R. Bidlot, H.P. Freitag, C.J. Schreck, III, 2014: Identifying directional bias of TAO daily wind vectors in the central equatorial Pacific Ocean from November 2008 to January 2010. *Submitted to the Data Science Journal.*

PRESENTATIONS

- Peng, G., L. D. Cecil, and B. Cramer, 2014: An End-to-End Framework for Probabilistic Uncertainty Characterization of Climate Satellite Data and Products. 10th Annual Symposium on New Generation Operational Environmental Satellite Systems, AMS 2014 annual meeting, February 2- 6, 2014, Atlanta, GA, USA.
- Zhang, H.-M., G. Peng, L. Vasquez, W. Hankins, C.W. Fairall, R. Weller, and A. Brown, 2013: The SURFA Project: Towards Near-Real-Time Quality Monitoring of NWP Forecasts and Historical Analysis. 4th WGNE workshop on systematic error in weather and climate models. 15-19 April 2013, Exeter, UK.

OTHER

- Co-PI for the NCDC Ocean Data Management Project.
- Served as a mentor to a NOAA EPP summer intern who participated in the implementation of a near-real-time product quality monitoring web portal.
- Served as NCDC scientific steward for S-NPP Cal/Val data and reviewed 5 S-NPP Cal/Val findings
- Designed and coordinated the implementation of a near-real-time product quality monitoring web portal that was test-released to collaborators in model centers, surface fluxes, and TAO project management.
- Identified an anomalous behavior of sea winds at one of TAO buoy sites utilizing the aforementioned near-real-time product quality monitoring portal and notified our collaborators in the TAO project at NOAA's Pacific Marine Environmental Laboratory, which prompted an analysis of the buoy wind measurements at the site and resulted in a re-categorization of the buoy data quality flag to reflect low data quality for users in a more timely fashion.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	4

# of non-peered reviewed papers	1
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	1

The Scope and Framework of Long-Term Scientific Stewardship for CDRs

Task Leader	Ge Peng
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 100%; Theme 3: %.
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 80%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 20%

Highlight: Drafted the scope of long-term stewardship for NOAA digital climate environmental data products based on U.S. laws and expert bodies' recommendation and associated functional areas. Defined a unified framework for assessing the vigor of stewardship practice applied to individual data product.

BACKGROUND

U.S. Laws (Information Quality Act of 2001 and Federal Information Security Management Act of 2002) require, and expert bodies recommend, that environmental data be:

- Preserved and sustainable
- Secure and accessible
- Transparent and traceable
- Assessed, improved, and scientifically defensible

Currently, there is no systematic framework for assessing the quality of stewardship practices applied to environmental datasets and providing consistent data integrity and usability information to users and stakeholders.

ACCOMPLISHMENTS

- Coordinated more than 15 informal focus group discussions among 30 subject matter experts in the fields of archive, access, user service, system engineering and architecture, software engineering, IT security, data management, configuration management, satellite data product development, and research-to-operation transition at or affiliated with NOAA's NCDC.
- Drafted the scope of long-term stewardship for NOAA digital climate environmental data products (*Figure 1*).
- Defined a unified framework of assessing stewardship practices applied to NOAA climate environmental data products in terms of stewardship maturity matrix with a five-level graduated maturity scale for each component, representing Ad Hoc, Minimal, Intermediate, Advanced, and Optimal stages.

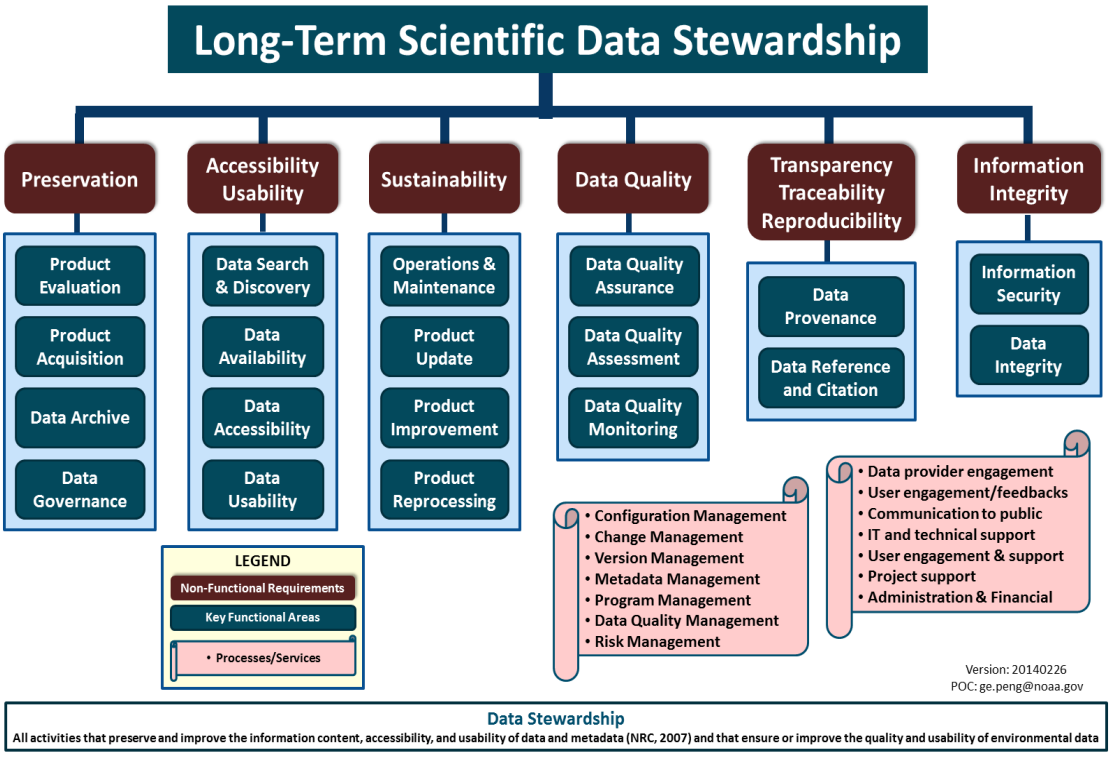


Figure 1: Diagram of the drafted scope of long-term stewardship for NOAA digital climate environmental data products.

PLANNED WORK

- Continue to refine the scope of long-term scientific data stewardship for NOAA climate environmental data products
- Continue to refine the selection of key components of the stewardship matrix
- Continue to refine the definitions of maturity levels for each key component

PRESENTATIONS

- Peng, G. and J. L. Privette, 2014: A stewardship maturity matrix for assessing the state of environmental data quality and usability. 10th Annual Symposium on New Generation Operational Environmental Satellite Systems, AMS 2014 annual meeting, February 2- 6, 2014, Atlanta, GA, USA.
- Peng, G. and J. L. Privette, 2013: Toward a unified scientific data stewardship framework. On August 7, 2013 to NCDC Deputy Director along with CDR program and RSAD division management.
- Peng, G., 2013: A straw man idea on the scope of long-term scientific stewardship CDRs. On March 1, 2013 for the NCDC Metadata Working Group and on March 7, 2013 to NCDC CDR Program management.

OTHER

- A member of the NCDC Metadata Working Group and participated in its monthly meetings

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Toward the Development of Climate Data Records for Precipitation: Characterization of CONUS Rainfall Using a Suite of Satellite, Radar, and Rain Gauge Quantitative Precipitation Estimates (QPE) Products

Task Leader	Olivier Prat
Task Code	NC-CDR-12_NCICS-OP
NOAA Sponsor	Brian Nelson
NOAA Office	NESDIS/NCDC/RSAD
Contribution to CICS Themes (%)	Theme 1: 20%; Theme 2: 75%; Theme 3: 5%
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 80%; Goal 2: 20%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: This task uses a suite of quantitative precipitation estimates (QPEs) derived from satellite, radar, surface observations, and models to derive long-term precipitation characteristics at fine spatial and temporal resolution over CONUS for the period 2002-2012. This work is part of a broader effort to evaluate long-term multi-sensor QPEs in the perspective of developing Climate Data Records (CDRs) for precipitation.

BACKGROUND

The comparison effort includes satellite multi-sensor datasets of TMPA, CMORPH-ADJ, and PERSIANN-CDR along with their respective unadjusted/near-real time version (TMPA-RT, CMORPH, PERSIANN). The satellite based QPEs are compared over the concurrent period with the NCEP Stage IV product, which is a near-real-time product providing precipitation data at the hourly temporal scale gridded at a nominal 4-km spatial resolution. In addition, remotely sensed precipitation datasets are compared with surface observations from the Global Historical Climatology Network (GHCN-Daily) and from the PRISM (Parameter-elevation Regressions on Independent Slopes Model), which provides gridded precipitation estimates that are used as a baseline for multi-sensor QPE products comparison.

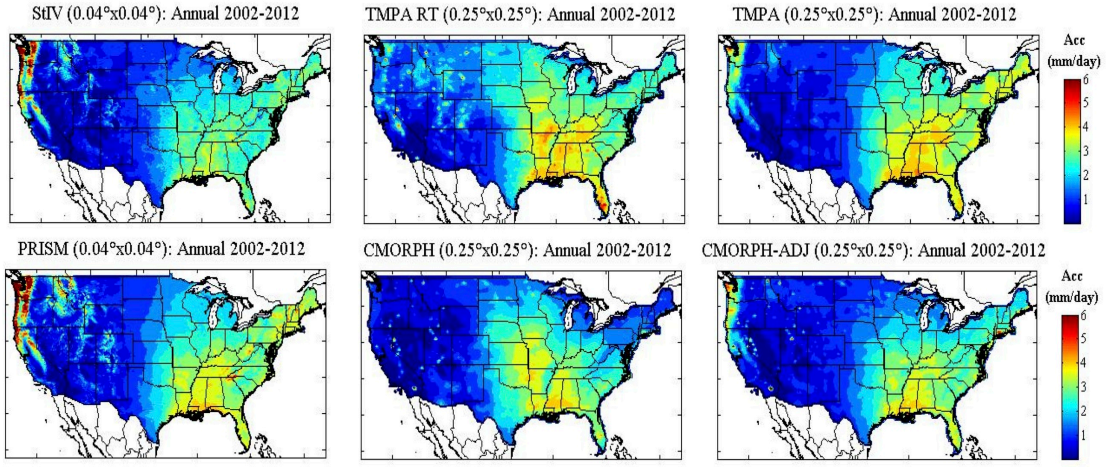


Figure 1. From top left to bottom right. Annual precipitation for the period 2002-2012 derived from Stage IV, TMPA-RT (Real Time), TMPA, PRISM, CMORPH, and CMORPH-ADJ (Adjusted). Figure 1 displays the annual precipitation derived from radar (Stage IV), surface

observation and model (PRISM), unadjusted (TMPA-RT, CMORPH) and adjusted (TMPA, CMORPH-ADJ) satellite QPEs.

ACCOMPLISHMENTS

The comparisons were performed at the annual, seasonal, monthly, and daily scales and at the river forecast center level (major river basins) (Fig. 2).

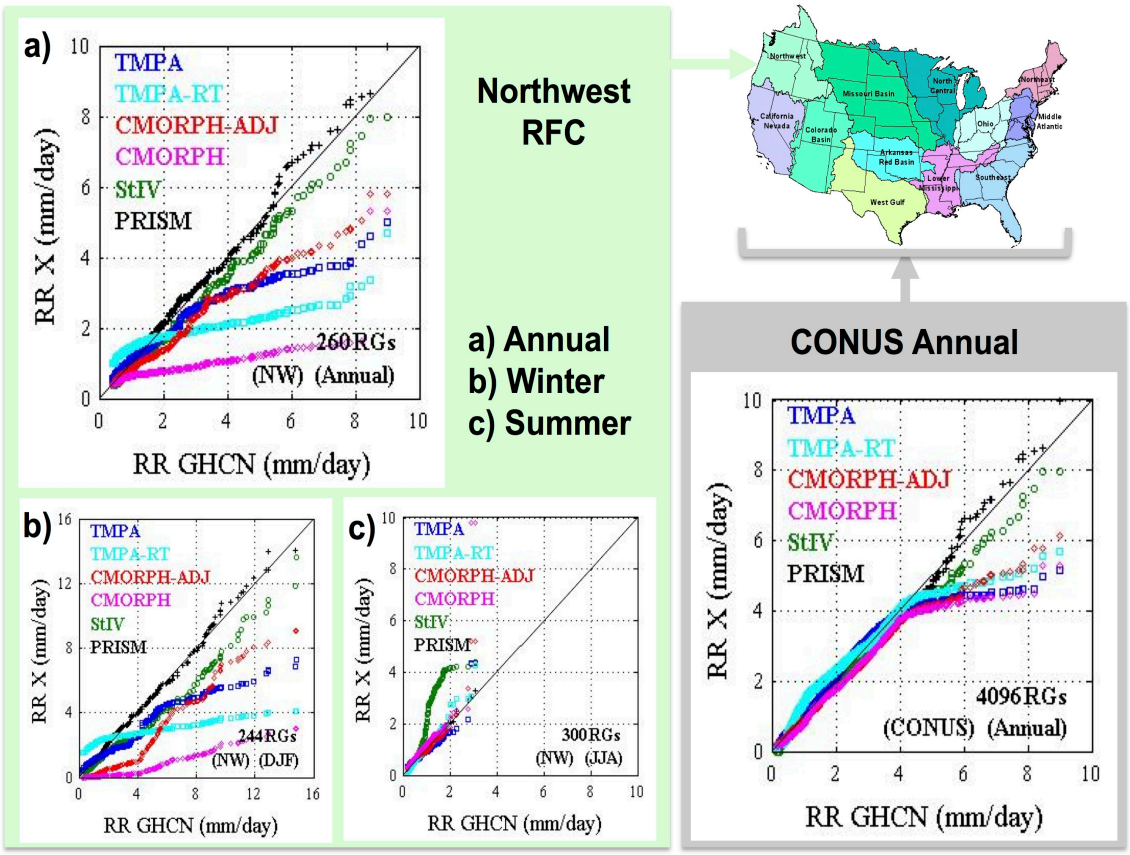


Figure 2: Comparison (Quantile-Quantile plot) of TMPA, TMPA-RT, CMORPH-ADJ, CMORPH, St-IV, and PRISM with surface observations from GHCN-daily for the annual precipitation over CONUS. While a good agreement is found for PRISM (expected because incorporate surface observation including GHCN) and TMPA and CMORPH-ADJ present a severe underestimation at higher rain rates (R>4 mm/day). Differences can be even more important when looking at the river basin scale (or River Forecast Center: RFC) in particular in the West (Fig. a) and at the seasonal scale (Winter: Fig. b; Summer: Fig. c). Please note the different scales for the figures.

The most widely used satellite QPEs have been compared at the annual, seasonal, and daily scales. We are currently extending this effort to other precipitation products. In addition to the evaluation of each of the aforementioned products in the perspective of developing Climate Data Records (CDRs) for precipitation, this work will serve as a benchmark to evaluate the newly available NMQ/Q2 reanalysis over the same period.

PLANNED WORK

- Continue work to include other precipitation datasets (PERSIANN-CDR, GPCP).
- Continue work to investigate the impact of differing spatial and temporal resolutions with respect to the datasets ability to capture extreme rainfall events.
- Use the current work as a benchmark for comparison with the newly available NMQ/Q2 reanalysis.
- Use the Satellite Product Evaluation Center (SPEC) and develop new functionalities to help with QPE products comparison (L. Vasquez).
- Coordinate effort with CICS-MD (R. Ferraro, S. Rudlosky) to extent the ground validation/QPE products comparison to other datasets (Hydro-Estimator, SCaMRP, MIRS, MSPPS, GPI).

PUBLICATIONS

- Prat, O.P., and B.R. Nelson, 2014. Characterization of precipitation features over CONUS using Quantitative Precipitation Estimates derived from satellites, radars, and rain gauges datasets (2002-2012). *Hydrol. Earth Syst. Sc.,* to be submitted.
- Nelson, B.R., O.P Prat, and D.-J. Seo, 2014. Assessment and implications of Stage IV QPE for product inter-comparisons. *Weather Forecast.*, to be submitted.
- Ashouri, H, K. Hsu, S. Sorooshian, D. Braithwaite, K.R. Knapp, L.D. Cecil, B.R. Nelson, and O.P. Prat, 2014. PERSIANN-CDR: Daily precipitation climate data record from multi-satellite observations for hydrological and climate studies. *Bull. Am. Meteorol. Soc.*, conditionally accepted.
- Prat, O.P., and B.R. Nelson, 2014. Characteristics of annual, seasonal, and diurnal precipitation in the Southeastern United States derived from long-term remotely sensed data. *Atmos. Res.*, in press, http://dx.doi.org/10.1016/j.atmosres.2013.07.022

DELIVERABLES

- Complete assessment of the differences between all the QPE products for the period 2002-2012 at the annual, seasonal, and daily scale;
- Metrics quantifying each dataset ability to capture precipitation patterns and extreme precipitation events;
- Software system (SPEC) tailored for comparison of precipitation datasets with differing formats, spatial and temporal resolution; and
- Manuscript summarizing the results of this comparison effort.

PRESENTATIONS

- Prat, O.P., B.R. Nelson, S. Stevens, and D.-J. Seo, 2014. Long-term large-scale bias-adjusted precipitation estimates at high spatial and temporal resolution derived from the National Mosaic and Multi-sensor QPE (NMQ/Q2) precipitation reanalysis over CONUS. Abstract submitted to the *8th European Conference on Radar in Meteorology and Hydrology (ERAD 2014)*, 1-5 September 2014, Garmisch-Partenkirchen, Germany.
- Prat, O.P., B.R. Nelson, and L. Vasquez, 2014. Characterization of CONUS rainfall using a multi-sensor approach: Evaluation of radar-based, satellite-based, and

ground-based QPE products. Abstract submitted to the *International Weather Radar and Hydrology symposium*, 7-9 April 2014, Washington, DC, USA.

- Nelson, B.R, S.E. Stevens, O.P Prat, C. Langston, K. Ortega, J. Zhang, Y. Qi, K. Howard, and T. Smith, 2014. The National Mosaic and Multi-sensor Quantitative Precipitation Estimate (NMQ/Q2) Reanalysis Effort. Abstract submitted to the *International Weather Radar and Hydrology symposium*, 7-9 April 2014, Washington, DC, USA.
- Prat, O.P., and B.R. Nelson, 2014. Toward the development of an evaluation framework of Climate Data Records for precipitation: A characterization of CONUS rainfall using a suite of satellite, radar, and rain gauge QPE products. *94th annual meeting of the American Meteorological Society,* 2-6 February, 2014, Atlanta, GA, USA.
- Prat, O.P., and B.R. Nelson, 2013. Characterization of precipitation features over CONUS derived from satellite, radar, and rain gauge datasets (2002-2012). *2013 AGU fall meeting*, 9-13 December, 2013, San Francisco, CA, USA.
- Nelson, B.R., S.E. Stevens, and O.P. Prat, 2013. NEXRAD: An overview and NCDC/NSSL/CICS Reanalysis effort. *Climate Data and Applications Workshop – A Focus on Precipitation*, 3-4 December, 2013, Asheville, NC, USA.
- Cifelli, R., S. Goodman, R. Ferraro, N.-Y. Wang, P. Xie, R. Joyce, B. Nelson, O.P. Prat, P. Groisman, Y. Xie, S. Albers, D. Birkenhaeuer, K. Mahoney, and S. Rudlosky, 2013. NOAA activities in support of the NASA GPM GV program. *6th international workshop for GPM ground validation,* 5-7 November 2013, Rome, Italy.
- Prat, O.P., and B.R. Nelson, 2013. Characterization of precipitation features over CONUS using quantitative precipitation estimates derived from TRMM satellite and Stage IV data for the period 2002-2012. *11th International Precipitation Conference*. 1-3 July, 2013, Ede-Wageningen, Netherlands.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	1
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	4
# of non-peered reviewed papers	0
# of invited presentations	8
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

This year, we participated in the PERSIANN-CDR adjustment to comply with CDR requirements (1). This development concerned the transition from research to operations (1). One journal article on the precipitation characteristics in the Southeastern United States using long-term remotely sensed data has been published (1). We coauthored one journal article describing the PERSIANN-CDR algorithm (1), and two other journal publications on Stage IV (1) and on multi-sensor QPE (1) are under preparation (2). Five presentations have been made or co-authored on the project (5), and three others have been submitted (3).

Mapping the World's Tropical Cyclone Rainfall Contribution Over Land Using Satellite Data: Precipitation Budget and Extreme Rainfall

Task Leader	Olivier Prat
Task Code	NC-CDR-13_NCICS-OP
NOAA Sponsor	Brian Nelson
NOAA Office	NESDIS/NCDC/RSAD
Contribution to CICS Themes (%)	Theme 1: 50%; Theme 2: 50%; Theme 3: 0%
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 60%; Goal 2: 0%; Goal 3: 0%; Goal 4: 40%; Goal 5: 0%

Highlight: This work examines the over-land rainfall contribution originating from tropical cyclones for basins around the world for the period 1998-2009. Using the global database International Best Track Archive for Climate Stewardship (IBTrACS) and satellite precipitation data from the Tropical Rainfall Measuring Mission (TRMM) Multi-satellite Precipitation Analysis (TMPA) product 3B42, the precipitation budget and extreme rainfall were determined for different Tropical Cyclone (TC) basins around the world.

BACKGROUND

Tropical cyclones constitute one of the major natural disasters around the world as well as an important source of fresh water over areas prone to tropical cyclones. Annually, an average of 119 million people are exposed to tropical cyclone hazards (United Nation Development Program 2004). In this work, we estimated the over-land rainfall contribution of tropical cyclones for basins around the world, using NOAA's NCDC global database IBTrACS and satellite precipitation data from the Tropical Rainfall Measuring Mission (TRMM) Multi-satellite Precipitation Analysis (TMPA 3B42V7).

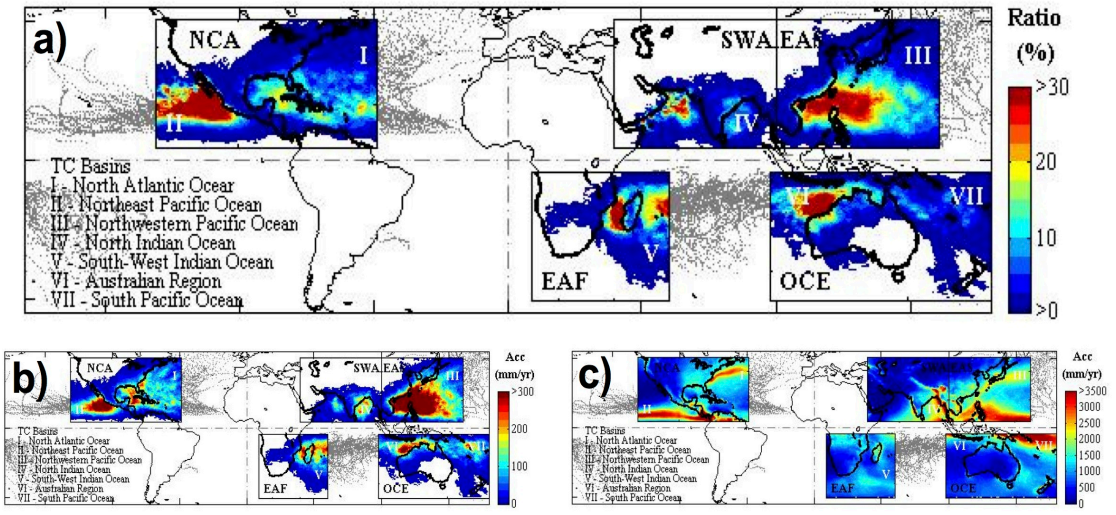


Figure 1. Tropical cyclone (TC) contribution (a), tropical cyclone rainfall (b), and total rainfall (c) for North and Central America (NCA), East Asia (EAS), South and West Asia (SWA), Oceania (OCE) and East Africa (EAF) for 1998-2009. The TC tracks are from the IBTrACS database (Knapp et al. 2010). TC Contribution (a) = 100 x TC Rainfall (b) / Total Rainfall (c).

Results showed that TCs accounted for 6-10% of the annual rainfall over areas prone to cyclonic activity for the different basins (*Fig. 1a*). At the local scale, tropical cyclones contributed to more than 25% and up to 60% (Baja California Sur) of the average annual rainfall over very different climatic areas with arid or tropical characteristics (*Fig. 1a*). East Asia (EAS) presented the higher and most constant tropical cyclone rainfall, while East Africa (EAF) displayed the highest year-to-year variability, and the Americas (NCA) exhibited the lowest average (*Fig. 1b*). Throughout the year, the maximum monthly contribution (8-11%) was found later in the TC season and depended on the peak of cyclonic activity, the cyclone associated rainfall, and the transition between dry and wet regimes, if any. Current work consists of quantifying precipitation extremes in relation with cyclonic activity.

ACCOMPLISHMENTS

A comparison between two versions of the algorithm, TMPA 3B42V7 (version 7: used in Prat and Nelson 2013, *Water. Resour. Res.*), and, TMPA 3B42V6 (version 6: used in Prat and Nelson 2013, *J. Climate*), was performed. The differences between V7 and V6 were mostly significant in terms of total and non-TC rainfall with a negative bias for V6 when compared to V7 (linear regression coefficient: 0.77<a<0.94). The largest differences were observed for the NCA (a=0.77: Fig. 2) and the SWA (a=0.79) domains. The differences in terms of TC rainfall (0.85<a<1.03) and TC contribution (0.93<a<1.08) were less important.

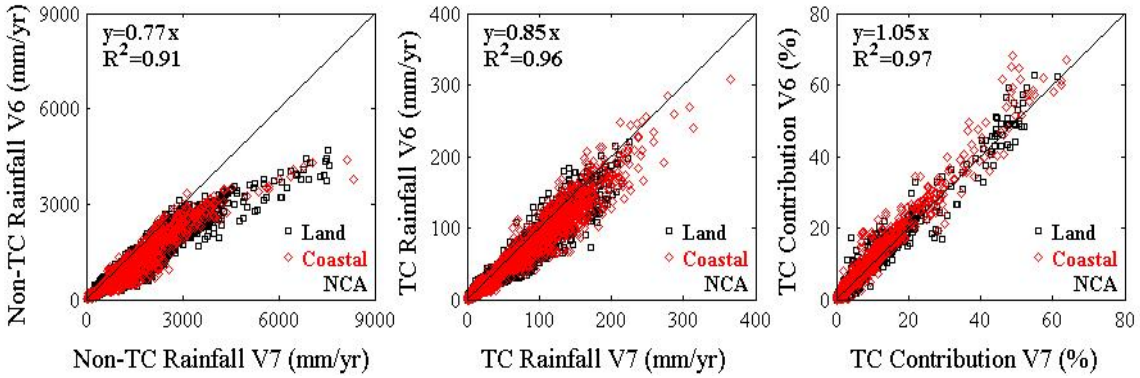


Figure 2: Comparison between TMPA 3B42V7 (version 7) and TMPA 3B42V6 (version 6) for the North and Central America (NCA) domain.

This study was the first that quantifies the tropical cyclone rainfall contribution over land for the different basins around the world. Current work consists of quantifying precipitation extremes in relation with cyclonic activity. Annual and monthly precipitation extremes have been extracted from TMPA 3B42V7 and the period of study was extended to 1998-2012. A manuscript summarizing the findings is currently being finalized for publication.

PLANNED WORK

- Finalize the manuscript on precipitation extremes associated with cyclonic activity.

PUBLICATIONS

- Prat, O.P., and B.R. Nelson, 2014. On the link between tropical cyclones and extreme rainfall. *Environ. Res. Lett.*, to be submitted.

- Prat, O.P., and B.R. Nelson, 2013. Mapping the world's tropical cyclone rainfall contribution overland using the TRMM Multi-satellite precipitation analysis. *Water Resour. Res.*, 49, 7236–7254, http://onlinelibrary.wiley.com/doi/10.1002/wrcr.20527/abstract

DELIVERABLES

- Manuscript summarizing the findings on tropical cyclone rainfall and extreme rainfall.

PRESENTATIONS

- Ferraro, R., R. Cifelli, C. Kondragunta, N.-Y. Wang, P. Xie, R. Joyce, Y. Zhang, D. Kitzmiller, R. Kuligowski, J. Gourley, P. Groisman, B. Nelson, O.P. Prat, K. Mahoney, S. Rudlosky, Y. Xie, S. Albers, and D. Birkenheuer, 2013. NOAA Contributions to and Utilization of GPM-era Data and Products, 2013 GPM Applications Workshop, 12-13 November, 2013, College Park, MD, USA.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

One journal article on the contribution of tropical cyclone rainfall for basins around the world was published (1), and one manuscript on the link between tropical cyclones and extreme rainfall is under preparation (1). Some of the results described above were included in a collaborative poster presentation describing NOAA's applications in connection with the Global Precipitation Mission (GPM).

Dual-Polarization Signature of Microphysical Processes in Warm Rain

Task Leader	Olivier Prat
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 100%; Theme 2: 0%; Theme 3: 0%
Main CICS Research Topic	Surface Observing Networks
Contribution to NOAA Goals (%)	Goal 1: 0%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: This work combines an explicit bin microphysical model with an electromagnetic scattering model. The goal is to assess the signature of microphysical processes (settling, coalescence, drop breakup, evaporation) on radar dual-polarization variables: the reflectivity factor at horizontal polarization (Z_H), the differential reflectivity (Z_{DR}), and the specific differential phase (K_{DP}).

BACKGROUND

Since spring of 2013, all the WSR-88D Nexrad have been upgraded to a dual-polarization technology. Conventional radars, such as the previous generation of Nexrad, are only able to provide a one-dimensional information on the relative size of objects (i.e. hydrometeors) within the control volume. On the opposite, dual-pol radars provide two-dimensional (horizontal, vertical) information and thus allow accessing the size, the shape, and the variety of object within the control volume. The impact on the polarimetric radar variables: reflectivity factor (Z_H), differential reflectivity (Z_{DR}), and specific differential phase shift (K_{DP}) of selected microphysical processes in warm rain is investigated.

This collaboration is between Dr. Olivier Prat from CICS-NC and Dr. Matthew Kumjian from Pennsylvania State University (PSU). It proposes combining two theoretical models that were developed separately. The project will use the one-dimensional version of a bin-microphysical model (Prat et al. 2012) that resolves explicitly the evolution of the drop size distribution (DSD) under the influence of microphysical processes throughout the rain column. The computed transient and equilibrium DSDs are used as an input for an electromagnetic scattering model (Kumjian and Ryzhkov 2012) that emulates the evolution of the polarimetric radar variables (Z_H, Z_{DR}, K_{DP}). The fingerprint of each individual microphysical processes (drop settling, drop coalescence, aerodynamic breakup, collisional breakup, bounce, evaporation…) as well as the full physic configuration (all processes included with/without updraft/downdrafts) is quantified as a function of the shape of the initial DSD and for different values of the nominal rain rate (RR). *Figure 1* displays the vertical profiles of the polarimetric variables (Z_H; Z_{DR}, K_{DP}) under the influence of selected microphysical processes. In the case of aerodynamic breakup, a slight decrease towards the ground is observed for Z_H, Z_{DR}, and K_{DP} due to the breakup of large drops (d>5 mm). For collisional breakup, the sharp decrease in the vertical profiles (Z_H, Z_{DR}, K_{DP}) is due to drop collisions and subsequent breakup resulting in the creation of a large number of small drops (d<0.5mm). Conversely, for coalescence only vertical profiles (Z_H, Z_{DR}, K_{DP}) increase toward the ground as mass from smaller drops (d<1 mm) is shifted to larger sizes. Finally, the full physics configuration display a decrease in Z_H and Z_{DR} while K_{DP} exhibit a non-monotonous

behavior and first decreases (*breakup of large drops aloft*) then increases toward the ground (*coalescence of drops 0.6<d<1.7 mm with increase in drops 1.7<d<3.1 mm*).

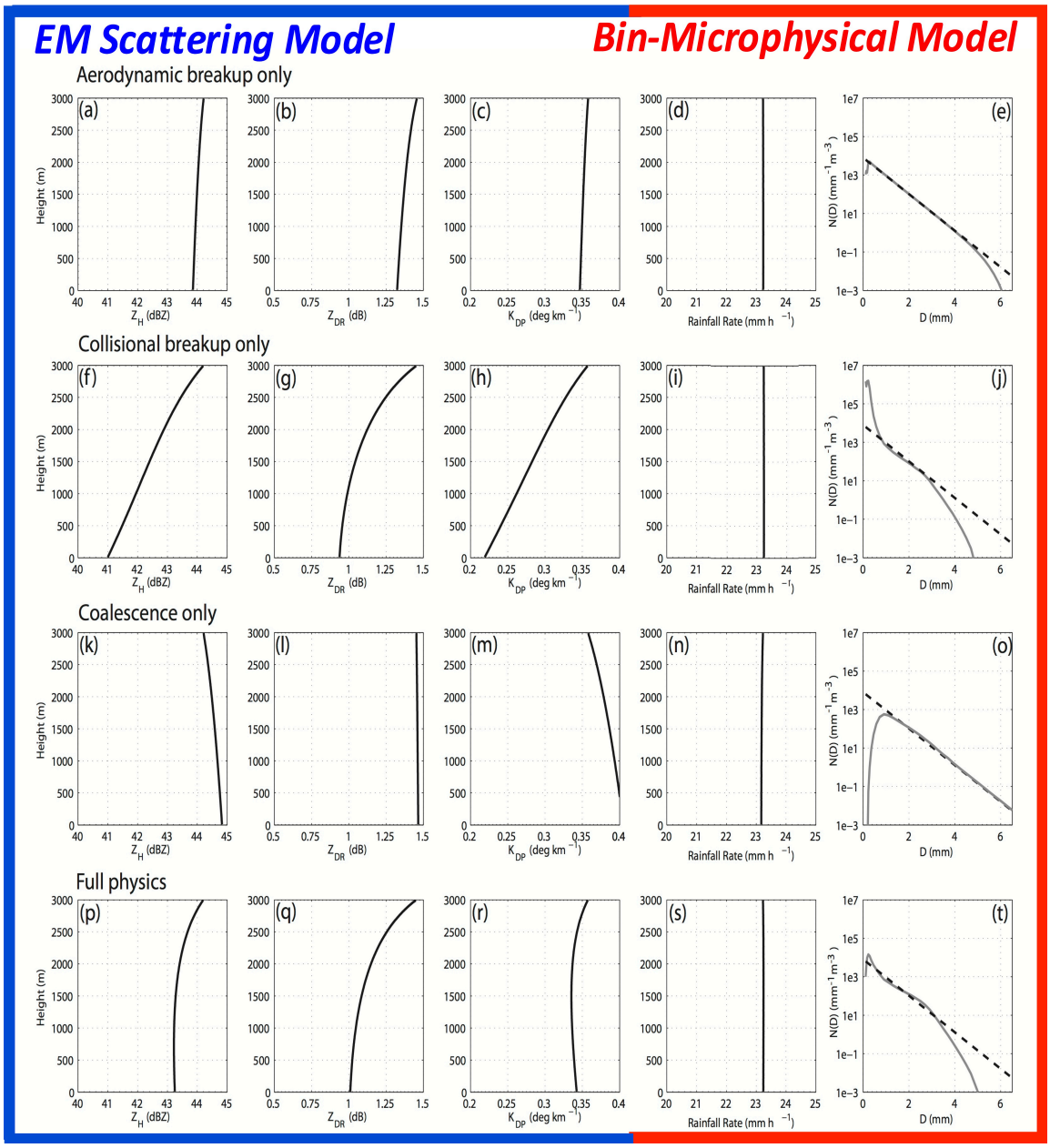


Figure 1: Vertical profiles of the polarimetric variables (Z_H: first column; Z_{DR}: second column: K_{DP}: third column) for selected microphysical processes: aerodynamic breakup (a-c), collisional breakup (f-h), coalescence (k-m), and full physics (p-r). The profiles are established after 60 min. of simulation and for an initial exponential DSD aloft with a nominal rain rate of 20 mm h^{-1}. The forth column shows the rain rate throughout the column as a mass conservation indicator. The last column shows the initial DSD aloft (black dashed line) and the final DSD at the ground (gray solid curves).

ACCOMPLISHMENTS

A few key findings were derived from this work. First, it was found that each individual microphysical processes display a particular signature of Z_H, Z_{DR}, and K_{DP} as indicated in Figure 1 (1). In addition, the polarimetric fingerprints of collisional processes depended on the radar wavelength (S, C, and X bands) as shown in Figure 2 (2). Another interesting finding is that the signal for evaporation (increase in Z_{DR} and decrease in Z_H (K_{DP})) did not overlap with the signal from collisional processes (Fig. 2). This may allow for accurate diagnoses of the physical process dominating the signal in radar observations, particularly in the case of radars operating at multiple frequencies (3). Finally, when compared with radar and disdrometer observations collected for a variety of storm environment (stratiform, convective), theoretical DualPol profiles (Z_H, Z_{DR}, K_{DP}) suggested that the parameterizations of drop breakup were too aggressive for the largest rainfall rates, resulting in very "tropical" DSDs heavily skewed towards smaller drops (4). More importantly, we found an unequivocal dependency between microphysical processes and polarimetric radar variables, suggest that real time radar rainfall field observations could help improving microphysical para-meterization of drop-drop interactions via inverse problem modelling techniques (5).

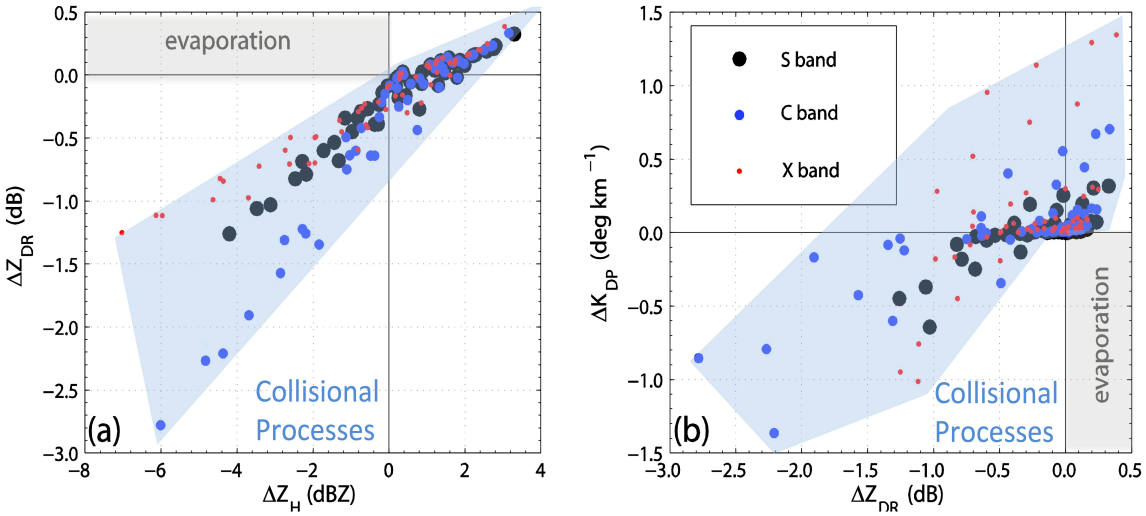


Figure 2: Change in the polarimetric variables in the spaces (Z_H, Z_{DR}) and (Z_{DR}, K_{DP}) over the 3-km rainshaft for a variety of initial DSDs. Calculations are performed for S, C, and X bands. The quadrant marked "evaporation" indicates the region expected for evaporation.

Currently, we are investigating the transient behavior of the polarimetric variables. Synthetic and real rainfall events including stratiform/convective cases covering a wide range of rainfall intensity and duration are used as input to the microphysical model. The transient behavior of the dual-pol variables is quantified as a function of different parameters (shape of the initial DSD, nominal rain rate, type of event, microphysical parameterizations).

PLANNED WORK

- Implement and test additional parameterizations for the microphysical column model.

- Perform a sensitivity analysis using synthetic and real rainfall events covering a wide range of situations.

PUBLICATIONS

- Prat, O.P., and M.R. Kumjian, 2014. Transient behavior of polarimetric signatures of warm rain microphysical processes. *J Appl. Meteorol. Climatol.*, in preparation.
- Kumjian, M.R., and O.P. Prat, 2014. The impact of raindrop collisional processes on the polarimetric radar variables. J. Atmos. Sc., conditionally accepted.

DELIVERABLES

- Manuscript summarizing the findings of the sensitivity analysis and the transient behavior of dual-pol variables.

PRESENTATIONS

- Prat, O.P., and M.R. Kumjian, 2014. Transient behavior of polarimetric signatures of warm rain microphysical processes. Abstract submitted to the *International Weather Radar and Hydrology symposium*, 7-9 April 2014, Washington, DC, USA.
- Kumjian, M.R., and O.P. Prat, 2013. The impact of raindrop collisional processes on the polarimetric radar variables. *36th AMS conference on radar meteorology*, 17-19 September 2013, Breckenridge, CO, USA.
- Prat, O.P., and M.R. Kumjian, 2013. Polarimetric signatures of microphysical processes in warm rain. *11th International Precipitation Conference*, 1-3 July 2013, Ede-Wageningen, Netherlands.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	3
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

One journal article on the signature of raindrop collisional processes on the polarimetric radar variables was submitted for publication and is conditionally accepted (1). Another manuscript on the transient behavior of the polarimetric variables is under preparation (1). Two presentations have been made on the topic (2), and one abstract has been accepted for an upcoming conference (1).

Role of Kelvin Waves in Tropical Cyclogenesis

Task Leader	Carl Schreck
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 50%; Theme 3: 50%
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 0%; Goal 2: 100%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: Kelvin waves are among the most prominent sources of synoptic scale rainfall variability in the tropics, but their relationship with tropical cyclogenesis remains largely unknown. The relative impacts of convection and dynamical factors in these interactions are being quantified through a novel methodology.

BACKGROUND

Kelvin waves are among the most prominent sources of synoptic scale rainfall variability in the tropics, but large uncertainties surround their role in tropical cyclogenesis. It is hypothesized that Kelvin waves may promote tropical cyclogenesis in four primary ways: 1) enhancing deep moist convection; 2) generating low-level cyclonic potential vorticity through diabatic heating; 3) decreasing the vertical wind shear through their vertical circulations; and 4) providing equatorial westerly anomalies that enhance the recirculation of moisture. This project uses Kelvin-filtered NASA TRMM multisatellite rainfall estimates to identify which Kelvin wave phases produce the most tropical cyclones. For each basin and each phase, storm-relative composites are then used to test each of the hypothesized mechanisms.

ACCOMPLISHMENTS

We have binned tropical cyclogenesis points around the globe by the coincident phase of the Kelvin-filtered rainfall. *Figure 1a*. shows the large-scale factors for tropical cyclogenesis that we expected to find in each phase. Based on these anticipated factors, we hypothesized that tropical cyclogenesis would be favored in phases 1-3, which provide enhanced convection and/or cyclonic vorticity.

Figure 1b. shows the results of our binning for the North Atlantic. We expected that Kelvin waves are a secondary factor for cyclogenesis, so it is not surprising that storms form in all phases (red dots). Contrary to our original hypothesis, however, tropical cyclogenesis is actually favored in phases 3–5. Similar results have been found in other basins. Analysis of wave-relative composites is ongoing to better understand why these phases are more conducive to tropical cyclogenesis. We anticipate submitting these results for publication in year 2.

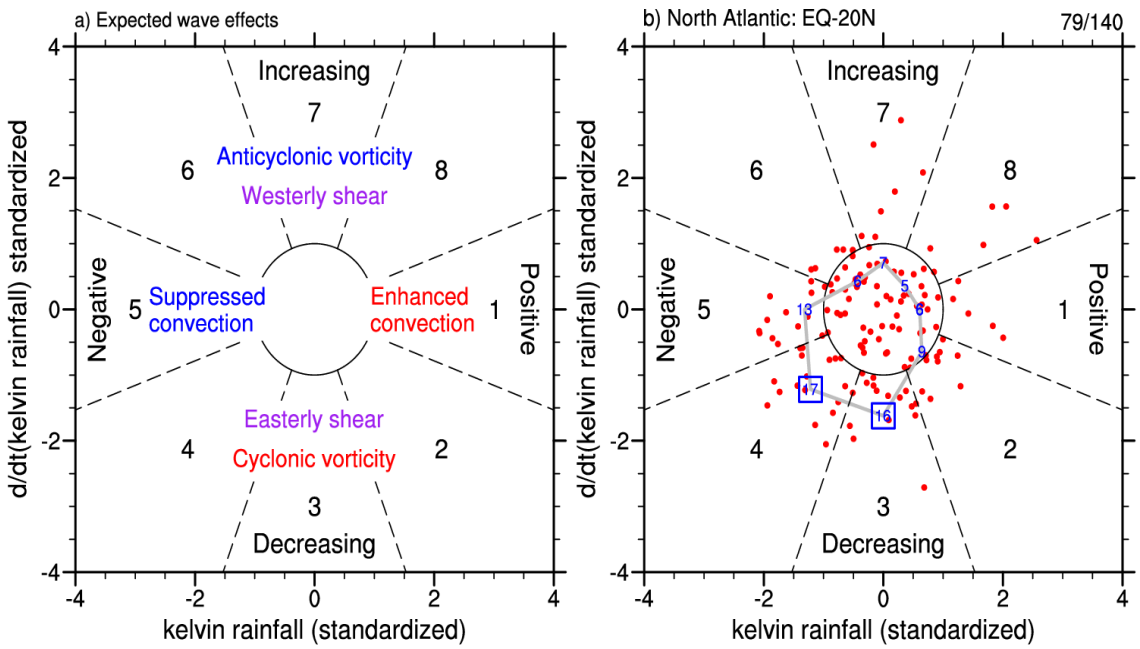


Figure 1.a) Kelvin wave phase space overlaid with anticipated factors for tropical cyclogenesis. Favorable ingredients are in red and unfavorable in blue. Shear anomalies are in purple since their effect depends on the background climatology. b) North Atlantic tropical cyclogenesis events overlaid on their local Kelvin wave phase (red dots). Gray line identifies the relative number of events in each phase, with blue squares identifying phases that account for significantly more than 1/8 of the total.

PLANNED WORK

- Analyze storm-relative composites for storms forming in the most common phases of the Kelvin waves
- Submit the results for publication in *Monthly Weather Review*
- Analyze the developing tropical cyclones in a Lagrangian framework to determine the impacts of Kelvin waves on the developing storms

PRESENTATIONS

Other presentations

- Schreck, C. J. and J. P. Kossin, 2013: Role of Kelvin waves in tropical cyclogenesis. *NASA Precipitation Measurement Mission Science Team Meeting*, 18-21 March 2013, Annapolis, MD.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0

# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Reanalyzing Tropical Cyclones Imagery with Citizen Scientists

Task Leader	Carl Schreck and Scott Stevens
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 100%; Theme 3: 0%
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 0%; Goal 2: 100%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: CycloneCenter.org is a web-based interface through which citizen scientists have already produced more than 300,000 classifications of tropical cyclone intensity and structure. Preliminary research has shown that these classifications can help address uncertainties in the historical record of these storms.

BACKGROUND

The global record of tropical cyclones contains uncertainties caused by differences in analysis procedures around the world and through time. The human eye best recognizes patterns in storm imagery, so we enlisted the public. Interested volunteers are shown one of nearly 300,000 satellite images. They answer questions about that image as part of a simplified technique for estimating the maximum surface wind speed of tropical cyclones.

ACCOMPLISHMENTS

During Year 2 of Cyclone Center, classifications from volunteers continued to be collected and the site has now obtained nearly 300,000 analyses from more than 5,000 scientists. In addition, the site underwent a major overhaul and the way in which storms were selected and questions asked has changed considerably.

Preliminary analysis was performed, comparing output from Cyclone Center with that from both the best track data for cyclone intensity and objective techniques including the Advanced Dvorak Technique (ADT). *Figure 1* shows an example for two storms, Typhoons Ivan (1997) and Yvette (1992). The Cyclone Center estimates reproduce the major features of each storm's lifecycle, including the weakening on day 9 of Yvette (bottom). They also avoid a known issue of ADT, which limits the intensification of a storm until the eye is clearly visible (around days 5–6 for both storms).

The panels on the right in *Fig. 1* show another unique advantage of the Cyclone Center estimates. Since at least 10 citizen scientists analyze each image, we can analyze the uncertainty in those estimates. In this case, we have used a Monte Carlo technique to stitch together randomly selected estimates for each time step.

We presented this initial research at the annual meetings of both the American Geophysical Union and the American Meteorological Society. Addtionally, a manuscript has been submitted to the latter for publication in the *Bulletin of the American Meteorological Society (BAMS)*.

CICS-NC intern, Brady Blackburn, is a recent graduate of Asheville High School with an interest in pursuing a degree in environmental science. During FY13, CICS-NC helped Mr. Blackburn explore that interest by contributing to tropical cyclone research through the Cyclone Center. He examined the classifications provided by Cyclone Center's volunteer users and he compared them with the actual satellite images. In particular, Mr. Blackburn sought to understand why a volunteer might mistakenly classify a storm as having an eye when it does not. His work will help us develop an objective method for evaluating the classifications, which will improve our future analysis.

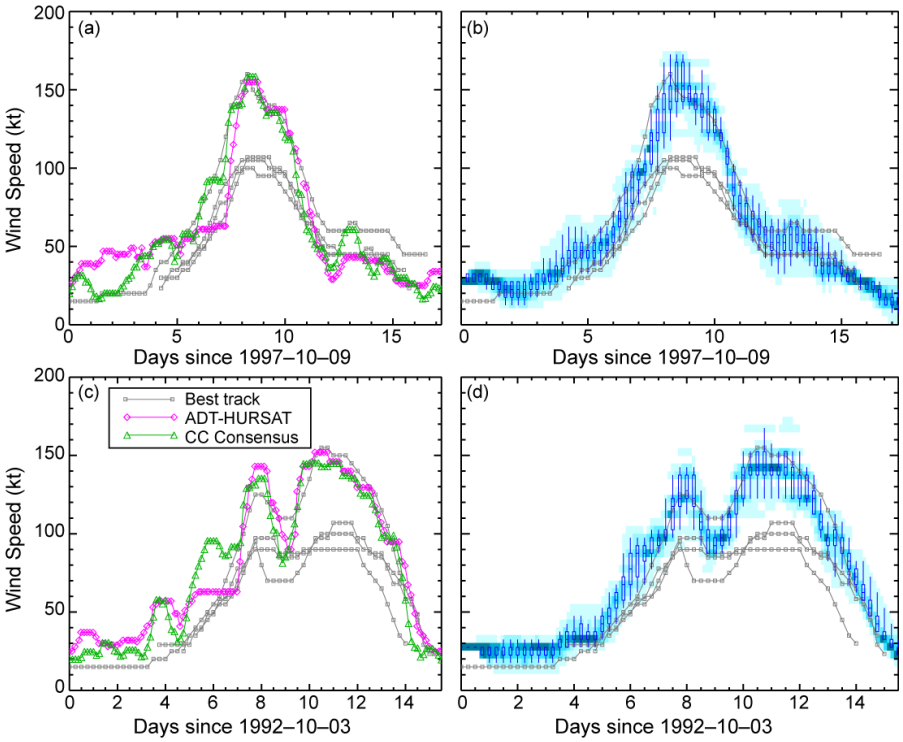


Figure 1: Time series of intensities from (a,b) Typhoon Ivan (1997) and (c,d) Typhoon Yvette (1992). a,c) Comparisons between best tracks, ADT-HURSAT, and Cyclone Center (CC Consensus). b,d) Spread in the Cyclone Center estimates.

PLANNED WORK

- Continue promoting this project through a variety of media outlets, particularly during the 2014 Atlantic Hurricane Season
- Publish the initial results in the *Bulletin of the American Meteorological Society (BAMS)*
- Develop method for applying the full Dvorak analysis to the data collected, including the "Data T-Number"

PRESENTATIONS

Invited

- Hennon, C.C., K.R. Knapp, C.J. Schreck, S.E. Stevens, and J.P. Kossin, 2013: Cyclone Center: Using crowdsourcing to determine tropical cyclone intensity. *AGU Fall Meeting,* 9-13 December 2013, San Francisco, CA.

Other

- Thorne, P.W., C.C. Hennon, K.R. Knapp, C.J. Schreck III, S.E. Stevens, P.A. Hennon, J.P. Kossin, M.C. Kruk, J. Rennie, and L.E. Stevens, 2014: Cyclonecenter: Crowdsourcing insights into historical tropical cyclone intensities. *26th Conference on Climate Variability and Change,* 2-6 February 2014, Atlanta, GA.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	1

Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks Climate Data Record (PERSIANN-CDR)

Task Leader	Soroosh Sorooshian
Task Code	
Date awarded	
Percent contribution to CICS Themes:	
Main CISC Research Topic:	Climate Data and Information Records and Scientific Data Stewardship
Percent contribution to NOAA Goals	Goal 1: 75%; Goal 2: 25%

Highlight: For this project, a new precipitation data set at 0.25^{o} and daily spatio temporal resolutions was developed. This product named PERSIANN-CDR is generated from the PERSIANN (Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks) using 3-hourly GridSat-B1 data as input. The PERSIANN estimates are adjusted using the Global Precipitation Climatology Project (GPCP) monthly product to maintain consistency of two data sets at 2.5^{o} monthly scale throughout the entire reconstruction period. The product covers from 60^{o}S to 60^{o}N and 0° to 360° longitude from 1983 to 2012.

BACKGROUND

This project generated a PERSIANN Precipitation Climate Data Record (PERSIANN-CDR), which is a daily near global precipitation product for the period of 1983 to 2012. The data covers from 60°S to 60°N and 0° to 360° longitude at 0.25 degree spatial resolution. This relatively long record of high resolution near global precipitation estimates is particularly useful for climate studies.

The PERSIANN-CDR product is generated for each time step by estimating precipitation for each GridSat-B1 Infrared Window (IRWIN) file using PERSIANN algorithm. Each month of PERSIANN estimates is then bias corrected with monthly GPCP precipitation data and the final PERSIANN-CDR product results when those bias-corrected precipitation estimates are accumulated to daily. The PERSIANN-CDR data flow chart is listed in *Figure 1*.

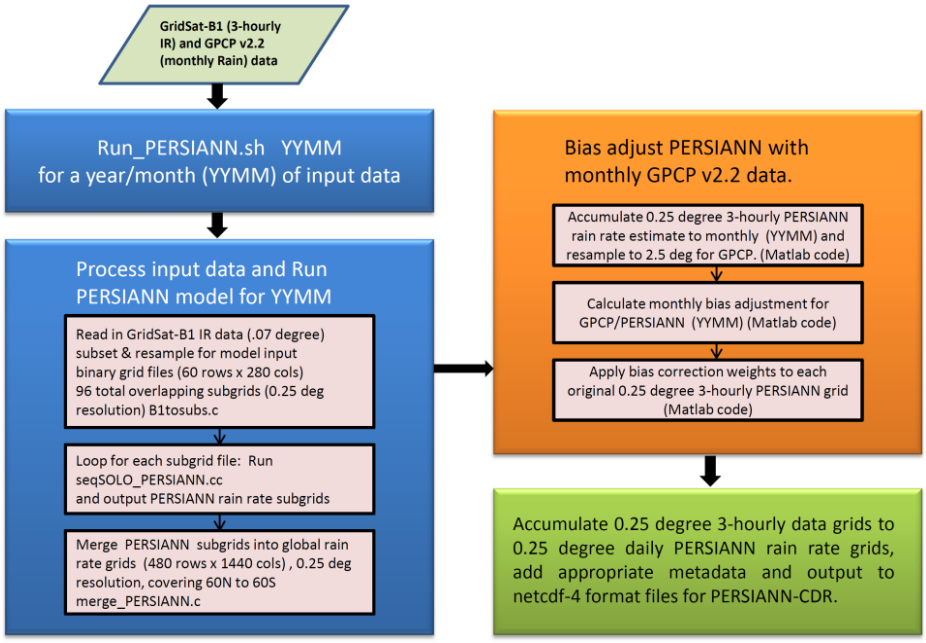


Figure 1. The PERSIANN-CDR flowchart

ACCOMPLISHMENTS

Figure 2 shows comparison of PERSIANN-CDR precipitation data with Stage IV radar data at the 0.25° spatial scale during Hurricane Katrina. As shown, PERSIANN-CDR shows similar precipitation patterns to the radar data. Moreover, in regions where radars are blocked by mountains or a particular radar site is down (e.g., the Lake Charles radar site in Southwest Louisiana during Katrina), the spatial coverage provided by PERSIANN-CDR is very valuable and captures a wide view of the precipitation and hurricane landfall.

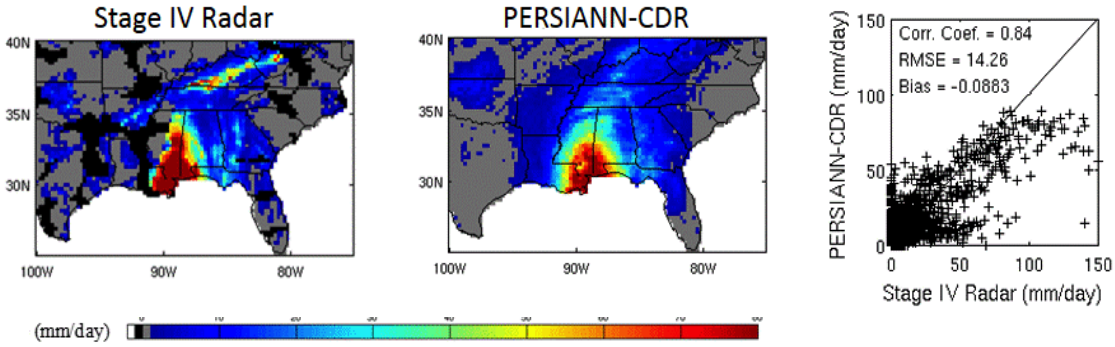


Figure 2. Daily-accumulated rainfall (mm/day) map over land during Hurricane Katrina on 29 August 2005 from PERSIANN-CDR and Stage IV Radar. Black and gray pixels show radar blockages and zero precipitation.

The automated algorithm and the software system have been developed. *Figure 3* presents the top 5% heavy rainfall (mm/day) patterns from PERSIANN-CDR 0.25° for the period of 1997-2012. PERSIANN-CDR shows larger rainfall for extreme precipitation events over the Intertropical Convergence Zone (ITCZ). With the 0.25° rainfall data at daily scale from PERSIANN-CDR, the intensity, duration, and spatial coverage of historical extreme events can be investigated.

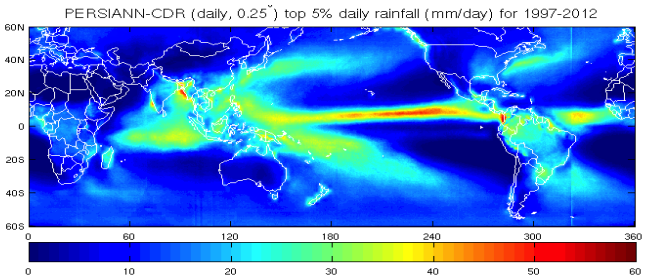


Figure 3. Top 5% heavy rainfall (mm/day) maps from PERSIANN-CDR 0.25° for the period of 1997-2012.

PLANNED WORK

- Continue to access the performance of the product
- Continue to reprocess the data based on new version of data source
- Transition algorithm and data product to NCDC
- Analyze the data product

PUBLICATIONS

- Ashouri H., K. Hsu, S. Sorooshian, D. Braithwaite, K. R. Knapp, L. D. Cecil, B. R. Nelson, O. P. Prat, 2014: "PERSIANN-CDR: Daily Precipitation Climate Data Record from Multi-Satellite Observations for Hydrological and Climate Studies", Bulletin of American Meteorological Society (BAMS), Submitted.
- Ashouri H., K. Hsu, S. Sorooshian, J. Lee, M. G. Bosilovich, and Tsou Chun Jaw, 2013: Trend Analysis of Extreme Daily Precipitation Events over United States using Reanalyses Products. (In progress)
- Hsu, K., H. Ashouri, D. Braithwaite, and S. Sorooshian, 2012. PERSIANN Precipitation Climate Data Record, Climate Algorithm Theoretical Basis Document (C-ATBD), Submitted to Climate Data Record (CDR) Program, National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC), Asheville, North Carolina, USA.
- Nasrollahi, N., K. Hsu, and S. Sorooshian, 2013, Reducing False Alarm in Satellite Precipitation Products, *Journal of Hydrometeorology*, **14**(4). doi:10.1175/JHM-D-12-0172.1.
- Sellers, S., P. Nguyen, W. Chu, X. Gao, K. Hsu, and S. Sorooshian, 2013: Computational Earth Science: Big Data Transformed into Insight. *EOS*, **94**(32), 277-278. *doi: 10.1002/2013EO320001*
- Zahraei, A., K. Hsu, S. Sorooshian, J.J. Gourley, Y. Hong, and A. Behrangi. 2013: Short-term Quantitative Precipitation Forecasting Using An Object-based Approach. *Journal of Hydrology*. **483**, 1-15. *doi: 10.1016/j.jhydrol.2012.09.052.*

DELIVERABLES

- Software and data product for a new daily precipitation analysis at 0.25-degree resolution

- Documentation for software and data product

PRESENTATIONS

- Ashouri H., K. Hsu, S. Sorooshian, D. Braithwaite, K. R. Knapp, and L. D. Cecil, 2012: 33 Years of Near-Global Daily Precipitation from Multisatellite Observations and its Application to Drought Monitoring, American Geophysical Union Fall Meeting, San Francisco, California, December 3-7, 2012, San Francisco, California, USA.
- Ashouri H., K. Hsu, S. Sorooshian, J. Lee, M. G. Bosilovich, and J. Y. Yu, 2014: Evaluation of the Reanalyses Products in Detecting Extreme Precipitation Trends over United States, American Meteorological Society (AMS) 94th Annual Meeting, 28th Conference on Hydrology, February 1-6, 2014, Atlanta, GA.
- Hsu, K. (Invited), 2013: Utilizing PERSIANN Satellite-based Precipitation Dataset for Hydrologic Applications, American Geophysics Union Fall Meeting, 9-13 December, 2013. San Francisco.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	1
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	3
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	2
# of graduate students formally advised	2
# of undergraduate students mentored during the year	0

Reanalysis of Archived NEXRAD Data Using NMQ/Q2 Algorithms to Create a High-Resolution Precipitation Dataset for the Continental US

Task Leader	Scott Stevens
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 70%; Theme 2: 30%; Theme 3: 0%
Main CICS Research Topic	Data Fusion and Algorithm Development
Contribution to NOAA Goals (%)	Goal 1: 10%; Goal 2: 60%; Goal 3: 0%; Goal 4: 30%; Goal 5: 0%

Highlight: The project team has generated four years of a high-resolution gridded precipitation product for the entire continental US at CICS-NC, with an additional seven years being produced at the National Severe Storms Laboratory/CIMMS in Norman, OK. CICS-NC continues to work closely with these partners toward quality assurance and the transfer of this very large dataset.

BACKGROUND

This report summarizes Year 4 of the ongoing NEXRAD reanalysis project. A joint project among partners in Asheville, NC, and Norman, OK, that aims to apply the National Mosaic and Multisensor Quantitative Precipitation Estimate (NMQ/Q2) algorithms to the entire archive of NEXRAD data (1997-2011), producing a suite of gridded precipitation products at a far finer temporal frequency (five-minute) and spatial scale (0.01° / 1km) than is presently available.

The data are pulled from the NCDC archive and processed on the CICS-NC computing cluster using two stages of software provided by NSSL. The end result is a wide variety of severe weather products, three-dimensional radar reflectivity, and quantitative precipitation estimates at high-resolution.

ACCOMPLISHMENTS

The process has been adapted from NSSL's experimental real-time system to run in an archive mode, with processing taking place in parallel across several hundred processors simultaneously, each running a different instance of the software. Since the process takes place in stages-one for single radar processing, one for merging, one for hydrological analysis, etc.-scripts have been developed at CICS-NC to largely automate the process, with each process communicating with the others and initiating new jobs to be submitted.

The result so far is four years of completed processing at CICS-NC, with an additional seven years being completed by the dedicated team in Norman, OK. This represents the majority of the 15-year record being used as input for this dataset. *Figure 1* shows a sample image of daily precipitation over the continental US for a day in 2011. Similar figures can be generated quickly from the dataset for any desired time period for a wide variety of variables including precipitation estimates, hail size, precipitation type, and cloud top height.

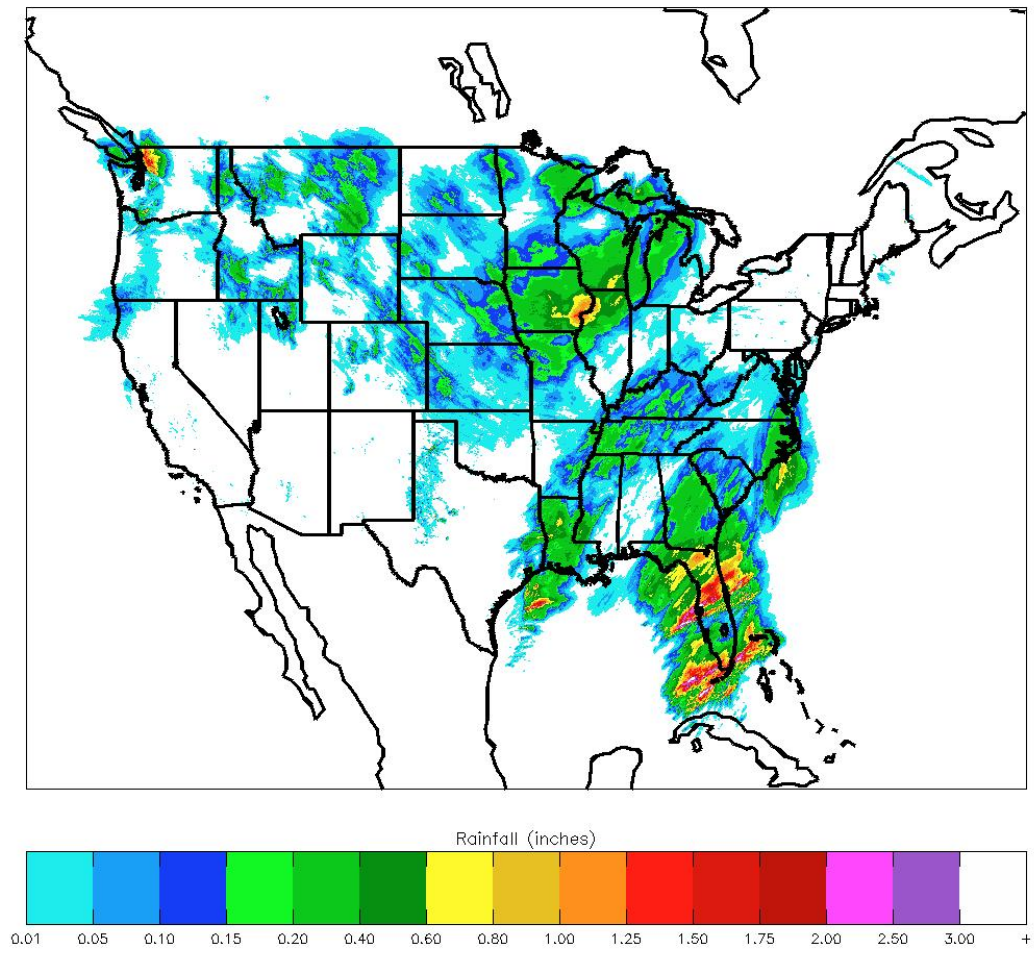


Figure 1: Daily precipitation for 2011 Jan 18 for the continental United States. Custom time periods can be easily aggregated and mapped in a similar fashion.

PLANNED WORK

- Complete first-round processing of the remaining years of data
- Work with NSSL to assess the quality of the product
- Coordinate transfer of this very large dataset between partners in North Carolina and Oklahoma

DELIVERABLES

- Gridded precipitation dataset for continental US for years 2011, 2009, 2007, and 2006 at CICS-NC, with additional years completed at NSSL

PRESENTATIONS

- Stevens, S.E., B.R. Nelson, C.L. Langston, and K.L. Ortega, 2014: Toward a climate-quality high-resolution precipitation dataset: An early look at the National Mosaic and Multisensor Quantitative Precipitation Estimate (NMQ/Q2). *28th Conference on Hydrology*, 2-6 Feburary 2014, Atlanta, GA.

OTHER

- Joined several other CICS scientists in helping with "Wave Day" an activity at a local middle school to help students understand the properties of waves.
- Met with local high school student and aspiring meteorologist to give her information on the career and the education that it requires, as well as a look at our day to day jobs here at CICS-NC.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	2
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	1

PERFORMANCE METRICS EXPLANATION

This year, presentations were given at both the American Meteorological Society's Annual Meeting in Atlanta, GA, and at the NCDC/CICS Dataset Discovery Day focusing on severe weather datasets. In addition, CICS scientist Scott Stevens is providing mentorship to an intern with the National Climate Assessment, who will be focusing on radar-derived precipitation for her senior project.

Satellite Product Evaluation and Near Real Time Monitoring

Task Leader	Lou Vasquez
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 100%; Theme 3: 0%
Main CICS Research Topic	Climate Data and Informaiton Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 0%; Goal 2: 100%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: This project applies the Satellite Product Evaluation Center (SPEC) tool to the Surface Fluxes and Analysis (SurFA) project used to generate a Near Real-Time Monitoring (NRTM) website. Ingest operations were supported with modifications to manifest creation in support of multiple archive site common manifest generation.

BACKGROUND

Satellite Product Evaluation Center (SPEC) software performs subset, analysis, and comparison of multiple datasets to determine aberrant behavior or disparate results between datasets. This project outputs results of analysis in HTML and software parse-able XML for potential further processing.

The Surface Fluxes and Analysis (SurFA) project implements SPEC software to analyze and compare multiple surface winds sources in a near real-time fashion, providing static HTML, email, and downloadable daily output or results noting alerts where operator thresholds are crossed. This output is available for use and further software analysis. The SurFA Near Real-Time Monitoring (NRTM) project converts SurFA SPEC implementation output into a web based, GIS, user-interactive display, for convenient access to near real-time results.

The Remote Sensing and Applications Division (RSAD) Ingest system allow automated provision of data to NCDC from a variety of national sources, processing them prior to, and in preparation, of archive. Manifests of files are created describing its contents to track incoming data along with the data itself for integrity and future access to data after archive.

ACCOMPLISHMENTS

Satellite Product Evaluation Center (SPEC) software was modified for Near Real-Time Monitoring (NRTM) project, extending output formats to allow web services to more easily parse and display analysis output. A prototype webpage was created at request of NCDC project lead for the SPEC project with the intent, upon approval, of releasing, sharing versions, documentation, and relevant information with the public. Code was written and integrated for multiple CF compliant Network Common Data Form (NetCDF) adapters (IOSP). Adapters were integrated into the SPEC subset framework to enable processing of specific QPE datasets in a standardized manner. They included programmatically accessible (API) tools to extract subset and dataset oriented information directly from data files for expedience as well as testing/validation purposes. The project was separated into multiple branches for concurrent development in different environments (NCDC,NCSU) for multiple

purposes (operations,testing/research). The project was also ported to major upgrades of Java, and separately NetCDF toolkit (UITools), with testing and operational output comparison made prior to release.

SURFA (Surface Fluxes and Analysis) daily SPEC runs were coordinated with user feature modifications and bug requests driving changes to the core software project and upgrades to operational code. A repository was created for deployed scripts to track and manage changes to operational and development/testing deployments.

Tests were performed of NMQ/Q2 reanalysis on NOAA NSSL/ESRL and provided a high performance computing system to evaluate additional or alternate resources for processing. The test required rewriting run scripts and working with system administrators to ensure the best use of machines while not impacting other cluster users. Current CICS-NC systems were found to be the best available approach for processing given unique requirements of software and the ability to manipulate equipment to meet these needs.

This project group worked with an NCDC intern converting a mock up SurFA near real-time monitoring (NRTM) web design into initial operational site. The site, seen in *Figure 1*, transforms information from SurFA SPEC project for interactive web display. Development of the site continued until it was prepared for release, adding features to integrate GIS site status with requested date, provide condensed site history display, and other items for page clarity and consistency. Tools were prototyped for data pull to web access using near real-time data. NoSQL database (Mongo) was tested to quickly load daily data and display.

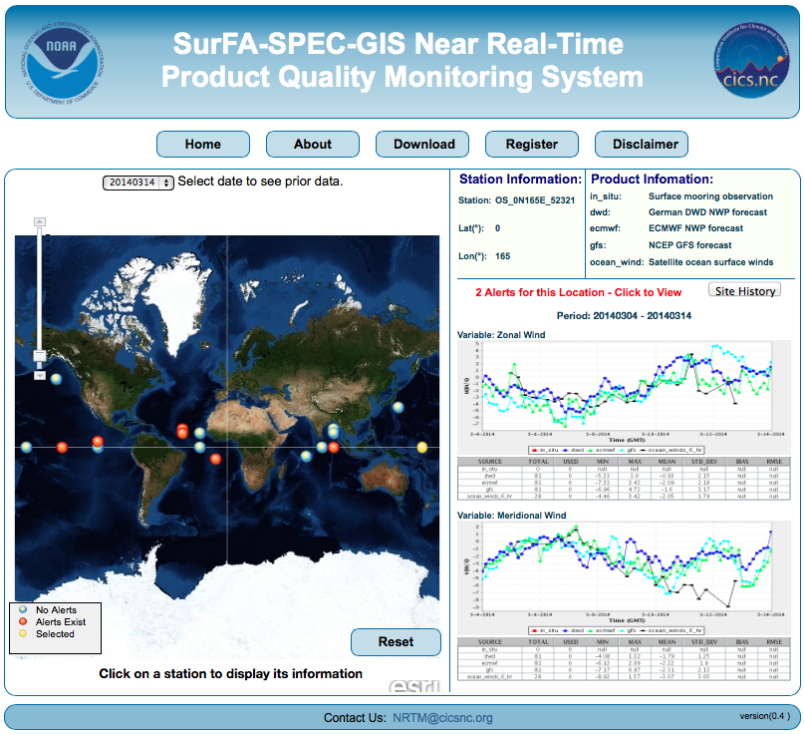


Figure 1: SurFA NRTM operational website showing SPEC results for March 14th of 2014. The left map shows user interactive GIS map of sites color coded to alert state. The right side displays site information, alert details, time series plots, and statistical results.

Training was provided to an NCDC intern in various tools for initial SurFA NRTM website development. The tools included a variety of web-oriented programming languages (DHTML, jQery, JavaScript, PHP), development environments (IDE, editors, git, linux), as well as best practices and related modules required for site.

The Remote Sensing and Applications Division (RSAD) Ingest system manifest creation tool was modified into a common formatting for multiple archival systems. As recommendations for a single manifest were not approved by both parties, the system was modified to fit both requirements by including a complete set of information in original and transforming via XML schema XSL into more stringent requirement set. Various additional modifications to the manifest creation tool were made to meet conditions discovered during ingest operation.

Regular assistance was provided debugging ingest system issues, recreating FTP server failure scenarios, data inconsistencies due to drive array failure, and other items not caused by Ingest system but significantly impacting its operations. Participation also provided in design process as new components are brought into consideration such as load balancing replacement and implementation of iRODS to manage data movement.

The SPEC tool was evaluated for comparison of precipitation measurements across multiple datasets. SPEC NetCDF adapters (IOSP) were created for multiple precipitation datasets (PRISM, TRMM, TMPA-RT, QPE) and IOSPs were validated against 3rd party tools. Initial runs were completed producing total rainfall estimates, average rainfall, and statistics relating requested results to available data with some discrepancies discovered. Additional tools were added to IOSP for low level comparison and direct analysis of data to better understand discrepancies.

PLANNED WORK

- Continue implementing SPEC for precipitation estimation evaluation to better understand discrepancies and compare additional datasets.
- Expand precipitation estimation to include additional statistics.
- Respond to user requests on release of SurFA NRTM site.

DELIVERABLES

- Released SurFA NRTM website.
- New release of Ingest Manifest creator meeting CLASS common ingests requirements.

OTHER

- Participated in NCDC Configuration Management (CM) Initiative producing configuration documents for branch.
- Received “Certificate of Appreciation” for work on CM initiative.
- Assisted QA lead for CDR in creation of recommendations whitepaper.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	2
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	1

PERFORMANCE METRICS EXPLANATION

This year, the SurFA NRTM website project was developed and released (1). During deveopment of site, NCDC undergraduate was mentored (1) in all required web tools for initial operation. The Ingest Manifest tool was improved (1) to meet common ingest requirements for multiple archive sites.

Assessment Activities

Assessment efforts support interagency activities for global, national, and regional assessments of climate change.

Background

NOAA has a number of global, national, regional and sectoral level climate assessment activities underway and an emerging activity to support overall "Assessment Services". NOAA is also participating in the high-level, visible, and legally mandated National Climate Assessment (NCA) process, which will be responsive to greater emphasis on user-driven science needs under the auspices of the US Global Change Research Program (USGCRP). National climate assessments, based on observations made across the country in comparison to predictions from climate system models, are intended to advance the understanding of climate science in the larger social, ecological, and policy systems to provide integrated analyses of impacts and vulnerability.

NOAA's National Climatic Data Center (NCDC) and many parts of NOAA have provided leadership on climate assessment activities for over a decade. A renewed focus on national and regional climate assessments to support improved decision-making across the country continues to emerge. Decisions related to adaptation at all scales, as well as mitigation and other climate-sensitive decisions, will be supported through an assessment design that is collaborative, authoritative, responsive, and transparent. NOAA will be working through an interagency process and will be investing in partnerships across many scales to support this comprehensive assessment activity. The agency also plans to invest in core competencies including modeling, data management, visualization, communication, web management, and other expertise.

Support of NOAA and NCDC led climate assessment activities requires collaboration with the best climate science practitioners in the nation as well as the hiring of outstanding scientific staff with unique skills and backgrounds in Earth System Science and the use of observations for defining climate and its impacts. CICS-NC staff under the CICS-NC Director and in coordination with the NCDC project leader and his staff, will continue to provide necessary expertise in the following areas:

- Scientific expertise and science oversight: A Lead Senior Scientist providing scientific expertise and oversight for the development of NOAA's assessment services, focusing on a contribution to the National Climate Assessment and, in support of the National Climate Assessment and in conjunction with NOAA and other agency expertise, providing scientific oversight and guidance to coordinate and implement distributed and centralized high–resolution modeling capabilities. This will support a more rigorous, appropriate, and organized downscaling activity across the agency and for the National Assessment.
- The Lead Scientist also provides scientific oversight regarding the model-to observational inter-comparisons; works with scientific and technical leadership of the NOAA Climate Model Portal to provide guidance on data access and

management; provides oversight and guidance on appropriateness of data, reports and published literature used in the assessment development; and works with data coordinator to guide framework for ensuring transparency and traceability of data and products incorporated into the assessments.

- Program management expertise providing program management for NOAA's and the NOAA Technical Support Unit's (TSU's) extensive portfolio of national and regional activities associated with the National Climate Assessment including timely delivery of information, graphics, and related content for the national assessment as well as transitioning the assessment activities into a sustaining process and providing assistance to the Chair of TSU for the National Climate Assessment in executing annual plans and budgets and discussing NOAA's National Climate Assessment contribution in interagency settings.
- Climate attribution expertise providing expertise in the integration of surface, model, and satellite fields; contributing to research efforts in domestic and international initiatives; assisting in the development of attribution assessments for important climatic events and anomalous climatic trends of interest; developing attribution analyses; incorporating attribution assessments into periodic broader-scale regional and national assessments to support improved decision-making associated with knowing whether climate trends and events are anthropogenic, natural, or combined in origin; and providing multivariate statistical expertise, model, and observational analysis and experience in working with reanalysis products and data.
- Technical/science expertise to provide support for the lead scientist (on coordination, programming, ad hoc graphics, and data support) with technical and scientific support for the external partners.
- Media coordination and production expertise providing scientific writing/editorial expertise and overall media coordination working with writing and technical implementation teams; leading the overall assessment content development; and production expertise providing scientific graphics and visualizations expertise to develop high quality, dynamic, and user defined visualization tools to support access and utility of assessment data and products and editorial/copy editing expertise for the spectrum of assessment activities and media. Assessment products will be evolving from printed media to more dynamic, web-based products that will allow users flexibility to render images dynamically and access underlying data.
- Software engineering expertise to provide advanced web engineering and scalable device presentation of various scientific assessment data and information; ad hoc data manipulation as well as systematic changes to data processes to enable rapid and high quality/well-documented data access and plots/graph development and to work with the NCDC Climate Monitoring Branch with existing data sets including global temperature, extremes indices, drought, and other types of data.
- Data expertise in information provenance and tracking to support scientific information categorized as "Highly Influential Scientific Assessments (HISAs)".

National Climate Assessment Scientific Support Activities

Task Leader	Kenneth Kunkel
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%.
Main CICS Research Topic	National Climate Assessments
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4:0% Goal 5: 0%

Highlight: The TSU Science Team made substantive contributions to the completion of the Third National Climate Assessment Report (NCA3). These included lead author revisions to the draft report in response to public comments, two rounds of NRC panel review, and two rounds of government review. In addition, numerous graphics revisions and scientific analyses were performed to support revisions by a number of the other NCA3 authors.

BACKGROUND

NOAA is participating in the high-level, visible, and legally mandated National Climate Assessment (NCA) process, which will be responsive to greater emphasis on user-driven science needs under the auspices of the US Global Change Research Program (USGCRP). National climate assessments are intended to advance the understanding of climate science in the larger social, ecological, and policy systems to provide integrated analyses of impacts and vulnerability. NOAA's National Climatic Data Center (NCDC) and many parts of NOAA have provided leadership on climate assessment activities for over a decade. A renewed focus on national and regional climate assessments to support improved decision-making across the country continues to emerge. Decisions related to adaptation at all scales as well as mitigation and other climate-sensitive decisions will be supported through an assessment design that is collaborative, authoritative, responsive, and transparent. NOAA is working through an interagency process and investing in partnerships across many scales to support this comprehensive assessment activity.

To support these activities, CICS has formed a technical support unit (TSU). Within the TSU, a group focused on scientific support has been assembled, consisting of a lead senior scientist (Kenneth Kunkel), a deputy scientist (Liqiang Sun), a support scientist (Laura Stevens), and a software engineer (Andrew Buddenberg). The Lead Senior Scientist provides scientific oversight for the development of NOAA's assessment services, focusing on a contribution to the National Climate Assessment and, in support of the National Climate Assessment and in conjunction with NOAA and other agency expertise, providing scientific oversight and guidance to coordinate and implement distributed and centralized high-resolution modeling capabilities.

ACCOMPLISHMENTS

During FY13, there were several rounds of revisions of the Third National Climate Assessment in response to several rounds of reviews. These include public comments, two reviews by a National Research Council panel, and two rounds of government review. As

one of the lead authors of the climate science sections, Kunkel responded to many of the comments on those sections, with text and graphics revisions and composing responses to these comments. There were also comments on the climate science portions of the other chapters, many of which were addressed by Kunkel. The other members of the science team provided substantial support to this effort by updating analyses and graphics and producing metadata on the graphics.

One major effort was the updating of a number of the graphics in response to the availability of a new statistically downscaled data set (1/8 degree-CONUS Daily Downscaled Climate Projections) produced for the U.S. Geological Survey by Katharine Hayhoe and colleagues. This new data set has statistical properties that better reproduce the climatology of daily observations. Updated maps were produced for several of the regional chapters, and some of the sectoral chapters. Another important update was of a graphic showing the range of model-simulated future projections for high and low scenarios (*Fig. 1*). This update required an analysis of CMIP3 and CMIP5 model simulations and the production of a more-easily understood graphic.

Metadata for a number of the key climate science figures produced by the TSU were compiled and input by the science team to the web system that will make these data available once the report is published. Substantial analysis of the CMIP5 model simulations was conducted. This will be summarized in an upcoming report.

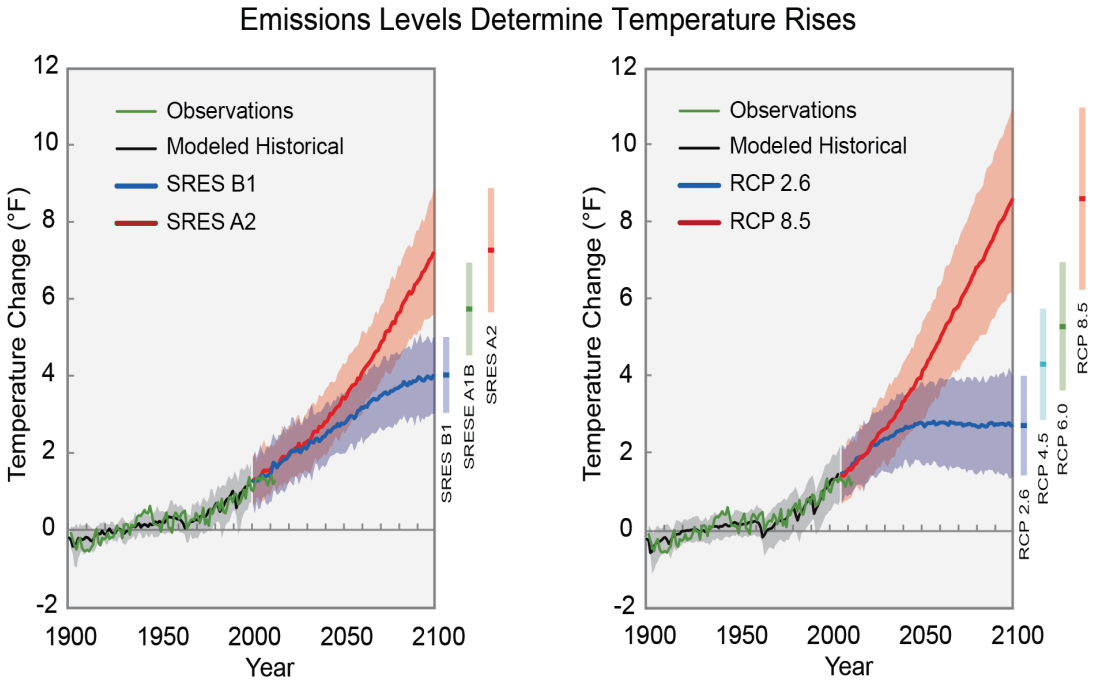


Figure 1: Comparison of climate model simulations of historical and future global temperature changes for high (SRES A2 and RCP 8.5) and low (SRES B1 and RCP 2.6) emissions scenarios. Left graph shows climate model simulations from the Coupled-Model

Intercomparison Project Phase 3 (CMIP3) and right graph shows simulations from CMIP Phase 5. Shading indicates the 5 to 95 percentile range.

All project deliverables (documentation and software) and milestones have been accomplished as planned.

PLANNED WORK

- Publish a report comparing CMIP3 and CMIP5 climate simulations for the NCA regions
- Lead author on climate change and health report
- Complete papers on analysis of historical observations, including the probability distribution of monthly temperature, time of observation effects on extreme precipitation trends, day of the week signals in extreme precipitation, and the effect of the changeover to MMTS on extreme temperature trends

PUBLICATIONS

- Peterson, T.C., T.R. Karl, J.P. Kossin, K.E. Kunkel, J.H. Lawrimore, J.R. McMahon, R.S. Vose and X. Yin, 2014: Changes in weather and climate extremes: State of knowledge relevant to air and water quality in the United States. *Journal of the Air & Waste Management Association*, 64,184-197, DOI:10.1080/10962247.2013.851044.
- Lawrimore, J., T.R. Karl, M. Squires, D.A. Robinson, and K.E. Kunkel, 2013: Trends and variability in severe snowstorms east of the Rocky Mountains. J. Hydromet., submitted.
- Janssen, E., D.J. Wuebbles, K.E. Kunkel, S.C. Olsen, and A. Goodman, 2013: Observed and modeled trends and projections of extreme precipitation over the contiguous United States. *Earth's Future*, accepted.
- Vose, R.S., S. Applequist, M.A. Bourassa, S.C. Pryor, R.J. Barthelmie, B. Blanton, P.D. Bromirski, H.E. Brooks, A.T. DeGaetano, R.M. Dole, D.R. Easterling, R.E. Jensen, T.R. Karl, R.W. Katz, K. Klink, M.C. Kruk, K.E. Kunkel, M.C. MacCracken, T.C. Peterson, K.Shein, B.R. Thomas, J.E. Walsh, X.L. Wang, M.F. Wehner, D.J. Wuebbles, and R.S. Young, 2012: Monitoring and understanding changes in Extremes: Extratropical storms, winds, and waves. *Bull. Amer. Meteor. Soc.*, accepted.
- Wuebbles, D.W., G. Meehl, K. Hayhoe, T. R. Karl, K. Kunkel, B. Santer, M. Wehner, B. Colle, E. M. Fischer, R. Fu, A. Goodman, E. Janssen, H. Lee, W. Li, L. N. Long, S. Olsen, A. Seth, J. Sheffield, and L. Sun, 2013: CMIP5 climate model analyses: Climate extremes in the United States. *Bull. Amer. Meteor. Soc*., accepted
- Peterson, T.C., R.J. Heim, Jr., R. Hirsch, D.P. Kaiser, H. Brooks, N.S. Diffenbaugh, R.M. Dole, J.P. Giovannettone, K. Guiguis, T.R. Karl, R.W. Katz, K.E. Kunkel, D. Lettenmaier, G.J. McCabe, C.J. Paciorek, K. Ryberg, S. Schubert, V.B.S. Silva, B.C. Stewart, A.V. Vecchia, G. Villarini, R.S. Vose, J. Walsh, D. Wolock, K. Wolter, C.A. Woodhouse, M. Wehner, and D. Wuebbles, 2013: Monitoring and understanding changes in heat waves, cold waves, floods and droughts in the United States: State of knowledge. *Bull. Amer. Meteor. Soc*., **94**, 821-834.
- Kunkel, K.E., T.R. Karl, H. Brooks, J. Kossin, J. Lawrimore, D. Arndt, L. Bosart, D. Changnon, S.L. Cutter, N. Doesken, K. Emanuel, P.Ya. Groisman, R.W. Katz, T.

Knutson, J. O'Brien, C. J. Paciorek, T. Peterson, K. Redmond, D. Robinson, J. Trapp, R. Vose, S. Weaver, M. Wehner, K. Wolter, D. Wuebbles, 2013: Monitoring and understanding changes in extreme storms: state of knowledge. *Bull. Amer. Meteor. Soc*., **94**, 499-514, doi: http://dx.doi.org/10.1175/BAMS-D-12-00066.1.

- Wuebbles, D.J., K.E. Kunkel, M. Wehner, and Z. Zobel, 2014: Severe weather in the United States under a changing climate. EOS, accepted.

DELIVERABLES

- Publication of papers summarizing the extremes workshops;
- Updated graphics for NCA report; and
- Compiled metadata for key science chapter graphics.

PRESENTATIONS

- Kunkel, K.E., 2014: Extreme Precipitation Trend Estimation in Conterminous United States (CONUS), poster paper, Donald R. Johnson Symposium, Annual Meeting of the American Meteorological Society, Atlanta, GA (6 February).
- Kunkel, K.E., 2014: Observed Trends in Extreme Precipitation: Illinois and Beyond, invited talk, Stanley A. Changnon Symposium, Annual Meeting of the American Meteorological Society, Atlanta, GA (4 February).
- Kunkel, K.E., 2014: Historical Trends and Future Projections of Extreme Climate Conditions for the U.S. National Climate Assessment, Annual Meeting of the American Meteorological Society, Atlanta, GA (4 February).
- Kunkel, K.E., 2014: What are the Innovations in Science and Scenarios for this and Future Assessments, invited talk, National Council for Science and Engineering 14th National Conference, Washington, DC (28 January).
- Kunkel, K.E., 2013: Observed Trends in Extreme Precipitation in the U.S., invited talk, 2013 Fall Meeting of the American Geophysical Union, San Francisco, CA (13 December).
- Kunkel, K.E., 2013: U.S. Regional Extreme Climate Conditions in CMIP5 Simulations, invited talk, 2013 Fall Meeting of the American Geophysical Union, San Francisco, CA (12 December).
- Kunkel, K.E., 2013: National Climate Assessment Climate Modeling and Downscaling, invited talk, Scoping Workshop for the National Climate Assessment (NCA) Special Report on Climate Change and Health, Washington, DC (21 November).
- Kunkel, K.E., 2013: U.S. Climate Scenarios, invited talk, Second Nature webinar on "Understanding Climate Impacts: Using Tools and Resources to Prepare Your Campus for a Changing Climate" (20 November).
- Kunkel, K.E., 2013: Extreme Precipitation Events: Data Issues and Meteorological Causes, invited talk, U.S. CLIVAR Workshop: Analyses, Dynamics, and Modeling of Large Scale Meteorological Patterns Associated with Extreme Temperature and Precipitation Events, Berkeley, CA (20 August).
- Seyller, E., K.E. Kunkel, and L.E. Stevens, 2013: Regional Climate Trends and Scenarios for the United States, GreenGov Workshop on Climate Science and Adaptation Planning, Washington, D.C. (2 August).

- Kunkel, K.E., 2013: National Climate Assessment: Potential CDR Program Contributions, invited talk, NOAA Climate Data Record Annual Meeting, Asheville, NC (30 July).
- Kunkel, K.E., 2013: Climate Extremes Research: Recent Findings and New Directions, invited talk, Snowmass 2013 Integrated Climate Change Impacts Session, Energy Modeling Forum, Snowmass, CO (24 July).
- Kunkel, K.E., 2013: An Assessment of Extreme Weather and Climate Events, invited talk, Summer Meeting of the Federation of Earth System Information Providers, Raleigh, NC (11 July).
- Kunkel, K.E., 2013: Extreme Weather and Climate Events, invited talk, Tokio Marine's Eighth Summit on Global Warming and Climate Change, Atlanta, GA (28 June).
- Kunkel, K.E., 2013: Observed Trends and Future Projections of Drought, invited talk, Advisory Committee on Water Information, webinar (27 June).
- Kunkel, K.E., 2013: Observed Trends and Future Projections of Extremes, invited talk, 35th MIT Global Change Forum, Cambridge, MA (5 June).
- Kunkel, K.E., 2013: Climate Change and Extreme Weather and Climate Events, invited talk, Executive Forum for Business and Climate, Asheville, NC (4 June).
- Kunkel, K.E., 2013: Observed Trends and Future Projections of Extremes, invited talk, Advisory Committee on Water Information, webinar (30 May).
- Kunkel, K.E., 2013: Analysis of Historical and Future Snow Conditions for the National Climate Assessment, Western Snow Conference, Jackson, Wyoming (16 April).
- Kunkel, K.E., 2014: National Climate Assessment: An Overview, A-B Tech Community College Environmental Biology class, Asheville, NC, (25 March).
- Kunkel, K.E., 2014: Extreme Precipitation Trends and Future Changes in Urban Areas Due to Global Warming, invited talk, International Symposium on Diagnosis and Early Warning of Urban Weather/Climate Extremes, Nanjing, China, (19 March).

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	6
# of non-peered reviewed papers	0
# of invited presentations	16
# of graduate students supported by a CICS task	0

# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

This year, we made major contributions to the revision of the Third National Climate Assessment report. Three journal papers were published and 3 more were accepted. Numerous invited talks were given.

Trends in Extra-tropical Cyclone Occurrence

Task Leader	Kenneth Kunkel
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%.
Main CICS Research Topic	National Climate Assessments
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: Analysis of uncertainties in extra-tropical cyclone (ETC) occurrence have identified periods when the analyzed temporal variations can be considered reliable, including 1891-present for mid-latitude land areas and the North Atlantic, 1921-present for the North Pacific, and 1931-present for high latitude land areas.

BACKGROUND

ETCs are large-scale, non-tropical, low-pressure storm systems that typically develop along a frontal boundary between air masses of contrasting temperature. The ETC is the principal atmospheric phenomenon through which sensible and latent heat fluxes are exchanged between the subtropical and polar regions. These large-scale cyclonic storms are the major feature of mid-latitude weather during the colder times of the year and often have severe weather associated with them. These storms can produce large snowfall amounts that, together with high winds, result in blizzard conditions, large waves leading to coastal erosion, and severe convective events with lightning and tornadoes. In fact, these storms (or their absence in the case of drought) are responsible for many of the extreme weather types experienced at mid- and high-latitudes. ETCs are ubiquitous throughout the year, but tend to be stronger and located more equatorward in the cold season. Future changes in extreme weather in mid- to high-latitudes will likely involve changes in the frequency, intensity, and tracks of ETCs.

A number of recent studies focused on the Northern Hemisphere have documented a significant poleward shift of the storm track in both the Pacific and Atlantic Ocean basins, a decrease in ETC frequency in mid-latitudes, and a corresponding increase in ETC activity at higher latitudes for the latter half of the 20th century. Future climate warming may lead to a decrease in polar low activity. A new analysis of surface pressure data has extended the availability of pressure field data from the mid-20th century as used in previous studies, back to the late 19th Century. We have used this new 20th Century Reanalysis (20CR) data set to extend the analysis of ETC occurrence in the Northern Hemisphere to the period 1871-2007.

ACCOMPLISHMENTS

Previous work found some notable trends in ETC activity. From 1871 to 2010, statistically significant trends in high latitude ETC activity were found in the Pacific sector (downward) and in the Europe and Asia sectors (upward). Upward, statistically significant trends were found for all mid-latitude sectors (bottom panels). These results imply a substantial equator-ward shift over the North American and Pacific sectors. The main focus of effort this year was to address issues of uncertainty. Specifically, how robust are these observed trends in

the context of changes over time in the availability of pressure observations to drive the reanalysis model.

The availability of a 56-ensemble set of reanalysis output provides an opportunity to quantify the uncertainties. This project analyzed the variability of cyclone tracks and computed the average variability over consecutive 5-year periods. Two of the periods are illustrated in *Figs. 1* and *2*. In the early part of the reanalysis period, variability is quite high over the North Pacific and much of the high latitude area, indicating greater uncertainty. These coincide with areas of low data availability. By contrast, variability is quite low, indicating lower uncertainty, over most land areas and the North Atlantic. By the middle of the 20th Century (e.g. *Fig. 2*), data availability has increased in most areas. In the North Pacific and high latitudes, variability of ETC tracks has decreased by about a factor of three, indicating substantially lower uncertainties.

The analysis results were interpreted to mean that the ETC counts over the North Pacific are probably reliable back to the 1920s or so and back to the 1930s for high latitude locations except for the Arctic Ocean, but before those points in time the uncertainties are large enough to call into question the reality of the analyzed temporal variations. For mid-latitude land areas and the North Atlantic, estimates of ETC activity can probably be considered reliable back to the 1890s.

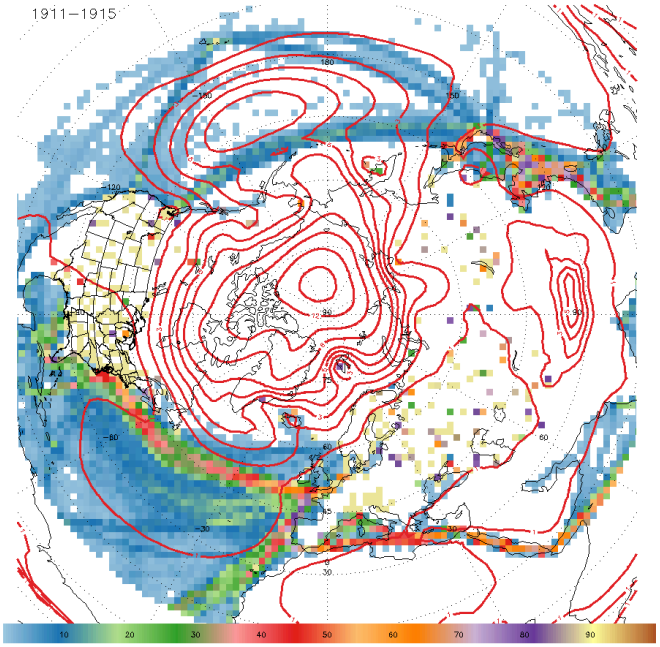


Figure 1: Variability in cyclone track location (contours) for the period 1911-1915. Color shading shows the percentage of days with at least one pressure observation in the grid box.

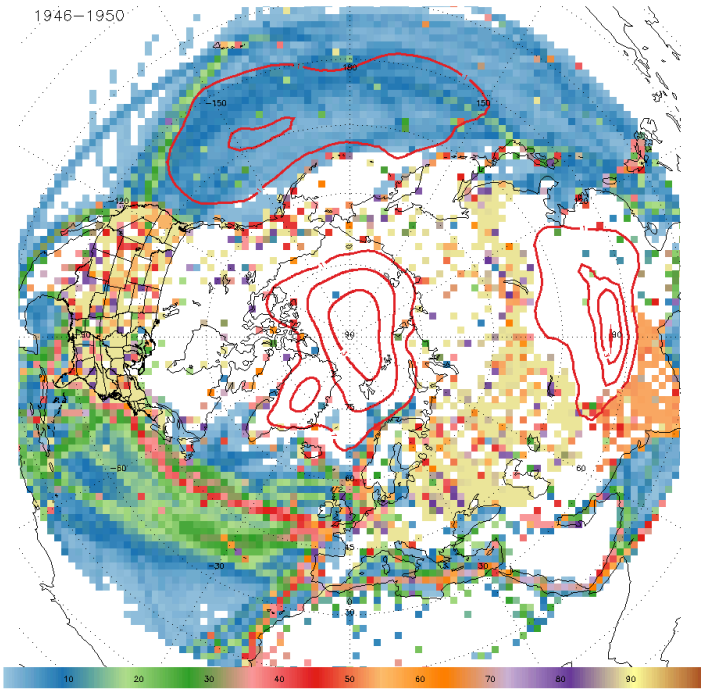


Figure 2: Variability in cyclone track location (contours) for the period 1946-1950. Color shading shows the percentage of days with at least one pressure observation in the grid box. Compared to 1911-1915 (Fig. 1), variability is much reduced in the North Pacific and high latitudes

A web site is being developed that will show the results of this project. Specifically, it will provide maps of individual ETC tracks and climatologies for various periods.

PLANNED WORK

- Complete and submit a paper on reliable periods of ETC activity
- Complete web site providing maps of ETC tracks

PUBLICATIONS

- Vose, R.S., S. Applequist, M.A. Bourassa, S.C. Pryor, R.J. Barthelmie, B. Blanton, P.D. Bromirski, H.E. Brooks, A.T. DeGaetano, R.M. Dole, D.R. Easterling, R.E. Jensen, T.R. Karl, R.W. Katz, K. Klink, M.C. Kruk, K.E. Kunkel, M.C. MacCracken, T.C. Peterson, K.Shein, B.R. Thomas, J.E. Walsh, X.L. Wang, M.F. Wehner, D.J. Wuebbles, and R.S. Young, 2012: Monitoring and understanding changes in Extremes: Extratropical storms, winds, and waves. *Bull. Amer. Meteor. Soc.*, accepted.
- Wuebbles, D.W., G. Meehl, K. Hayhoe, T. R. Karl, K. Kunkel, B. Santer, M. Wehner, B. Colle, E. M. Fischer, R. Fu, A. Goodman, E. Janssen, H. Lee, W. Li, L. N. Long, S. Olsen, A. Seth, J. Sheffield, and L. Sun, 2013: CMIP5 climate model analyses: Climate extremes in the United States. *Bull. Amer. Meteor. Soc*., accepted.

DELIVERABLES

- Completion of uncertainty analysis

PRESENTATIONS

- Kunkel, K.E., 2013: Extreme Precipitation Events: Data Issues and Meteorological Causes, invited talk, U.S. CLIVAR Workshop: Analyses, Dynamics, and Modeling of Large Scale Meteorological Patterns Associated with Extreme Temperature and Precipitation Events, Berkeley, CA (20 August).

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	2
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

Two papers on extremes included work on historical trends and future projections of ETCs. A talk on the role of ETCs in extreme precipitation was given.

National Cliamte Assessment Technical Support Unit Program Support Activities

Task Leader	Paula Ann Hennon
Task Code	NC-NCA-03-NCICS-PH
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%
Main CICS Research Topic	National Climate Assessments
Contribution to NOAA Goals (%)	Goal 1: 100%

Highlight: Implementing new production processes and maintaining a supportive workforce are ongoing priorities. Coordinating TSU/USGCRP activities, especially delivering the Draft National Climate Assessment for public and expert review were primary accomplishments of the TSU in 2013.

BACKGROUND

In its fourth year at NCDC, NOAA's Assessment Technical Support Unit (TSU) continued to provide critical input and support to the National Climate Assessment (NCA), a premier activity of the U.S. Global Change Research Program. The NCA is being conducted under the auspices of the Global Change Research Act of 1990, which calls for a report to the President and Congress that evaluates, integrates, and interprets the findings of the federal research program on global change (USGCRP) every four years. As the agencies comprising USGCRP seek to establish an ongoing, sustainable assessment process, as well as deliver a timely report in 2014, NCDC's TSU and the staff at USGCRP work in concert to provide coordination and technical support to a wide network of interagency and external groups and individuals.

ACCOMPLISHMENTS

The editorial team, responsible for translating the scientific text and assessment information contributed by the authors into a non-scientific, public facing document, readable by the Congress and the general public, achieved a significant milestone with the release of the draft 2014 report to the public for comment and review, expert review, and multiple NRC reviews. (http://ncadac.globalchange.gov/) The draft of "Climate Change Impacts in the United States: The Third National Climate Assessment," and its associated Highlights document and Overview Brochure underwent intense scrutiny including screening for scientific accuracy and cross-chapter coordination. The editorial and science teams documented and addressed each and every review comment in conjunction with the Authors, the NCA Development Advisory Committee members, and Ex Officio members from Federal Agencies.

The web development team designed and implemented web access to the NCA while ensuring robust traceability of sources and enhancing connection to other climate and environmental information across the Government and elsewhere through participation in

the development of the Global Change Information System. This web-focused activity of the NCA will serve as a key component of the ongoing, sustainable process.

Production planning of the final report, including incorporating written draft materials from more than 240 authors and managing the input from public and agency reviews and comments was completed. The Graphical Design Team began producing printed materials and digital assets for the website so the final report and its accompanying enhanced visualizations can be distributed in multiple formats.

The TSU coordinated and facilitated several meetings of the National Climate Assessment and Development Advisory Committee, the federal advisory committee for the NCA, as well as a series of author team meetings to facilitate writing the report and engagement and outreach meeting to coordinate the rollout.

PLANNED WORK

- Publish the Third National Climate Assessment in Spring 2014.
- Strategic planning for the NCA TSU's sustained process
- Continue to manage the overall team, their activities and milestones, and provide general management oversight of the report completion process

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	3
# of products or techniques transitioned from research to ops following NOAA guidance	1
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

National Climate Assessment Technical Support Unit Software Engineer

Task Leader	Andrew Buddenberg
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%.
Main CICS Research Topic	National Climate Assessments
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 25%; Goal 3: 25%; Goal 4: 25%; Goal 5: 0%

Highlight: CICS technical support staff have applied the best practices of software engineering to the scientific research workflow.

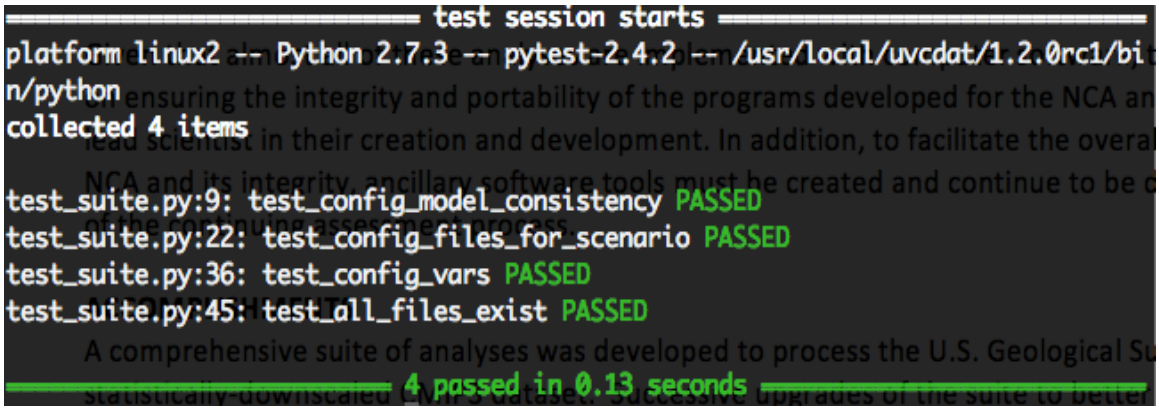
BACKGROUND

The National Climate Assessment integrates, evaluates, and interprets the findings of the U.S. Global Change Research Program (USGCRP) into a single cohesive report for policymakers and private entities to inform their decision-making and planning for the future. The far-reaching effects of this report demand the highest levels of traceability and reproducibility of the datasets and scientific analyses that operate upon them.

Given that almost all of these analyses are implemented with computer software, this task focuses on ensuring the integrity and portability of the programs developed for the NCA and assisting the lead scientist in their creation and development. In addition, to facilitate the overall business of the NCA and its integrity, ancillary software tools must be created and continue to be developed as part of the continuing assessment process.

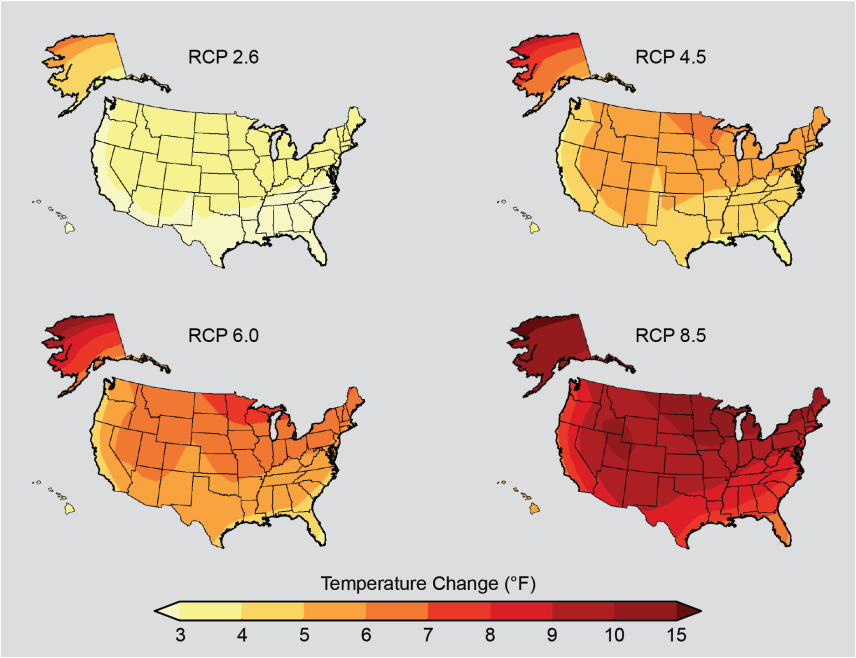
ACCOMPLISHMENTS

A comprehensive suite of analyses was developed to process the U.S. Geological Survey's new statistically downscaled CMIP3 dataset. Successive upgrades of the suite to better take advantage of cluster computing resources reduced the complete runtime of all analyses from several hours to approximately five minutes. The inclusion of an automated unit-testing framework greatly increased the detection rate and control of configuration errors (see below). Beyond their use in the NCA, these results were made available to the Centers for Disease Control for use in their research.



These cluster computing techniques were further employed in a separate but similar set of analyses of a 1/8 degree gridded observational dataset by Ed Maurer out of Santa Clara University. Incorporating lessons learned from the statistically downscaled CMIP3 analyses, this package was written in a more modular fashion; enabling the use of the unit-testing framework to detect data processing errors. Computations were similarly performant: ~100,000 grid points * 60 years processed in a matter of minutes.

Using these and other datasets in collaboration with Kenneth Kunkel (lead senior scientist), Laura Stevens (support scientist), and Jessicca Griffin (graphic designer), several figures and tables for the National Climate Assessment were produced with examples below:



Projected Temperature Change by 2071-2099 (CMIP5 models):

The largest uncertainty in projecting climate change beyond the next few decades is the level of heat-trapping gas emissions. The most recent model projections (CMIP5) take into account a wider range of options with regard to human behavior, including a lower scenario than has been considered before (RCP 2.6). This scenario assumes rapid reductions in emissions-more than 70% cuts from current levels by 2050 and further large decreases by 2100 -and the corresponding smaller amount of warming. On the higher end, the scenarios include one that assumes continued increases in emissions (RCP 8.5) and the corresponding greater amount of warming. Also shown are temperature changes for the intermediate scenarios RCP 4.5 (which is most similar to B1) and RCP 6.0 (which is most similar to A1B; see the Climate Science Appendix). Projections show change in average temperature in the later part of this century (2071-2099) relative to the late part of last century (1970-1999). (Figure source: NOAA NCDC / CICS-NC).

	Consequences: Challenges and Opportunities	
Region	**Cooling**	**Heating**
Physical Impacts - High Likelihood	**Hotter and longer summers** Number of Additional Extreme Hot Days (> 95°F) and % Increase in Cooling Degree Days per Year in 2041-2070 above 1971-2000 Level	**Warmer winters** Number of Fewer Extreme Cold Days (< 10°F) and % Decrease in Heating Degree Days per Year in 2041-2070 below 1971-2000 Level
Northeast	+10 days, +77%	-12 days, -17%
Southeast	+23 days, +43%	-2 days, -19%
Midwest	+14 days, +64%	-14 days, -15%
Great Plains	+22 days, +37%	-4 days, -18%
Southwest	+20 days, +44%	-3 days, -20%
Northwest	+5 days, +89%	-7 days, -15%
Alaska	Not studied	Not studied
Pacific Islands	Not studied	Not studied

Changing Energy Use for Heating and Cooling Will Vary by Region:
Hotter and longer summers will increase the amount of electricity necessary to run air conditioning, especially in the Southeast and Southwest. Warmer winters will decrease the amount of natural gas required to heat buildings, especially in the Northeast, Midwest, and Northwest. This information table is adapted from multi-model means from 8 NARCCAP regional climate simulations for the higher emissions scenario (A2) considered in this report and is weighted by population. (Source: adapted from Regional Climate Trends and Scenarios reports)

In collaboration with and in support of US Global Change Research Program's (USGCRP) greater emphasis on user-driven science needs, the Global Change Information System (GCIS) has been developed and a beta version has been released to serve the immediate needs of the National Climate Assessment.
From USGCRP:
The Global Change Information System (GCIS) is intended to eventually become the United States Government's unified web based source of authoritative, accessible, usable, and timely information about climate and global change for use by scientists, decision makers, and the public.

To support these efforts, a Structured Data Server (SDS) was developed to provide a common repository to collect, discover, and disseminate metadata about the data used in analyses. The TSU Software Engineer created the initial relational database schema for this system as well as proof-of-concept RESTful web services; USGCRP staff iterated upon that design to its current version (0.65 as of this writing) in consultation with the TSU.

To facilitate the automated transfer of NCA metadata to the SDS, several software products have been developed:

- A Drupal module (formsrv.module) to provide HTTP GET access to NCA TSU metadata survey results.
- Client software to access the SDS RESTful API, pull survey results, and perform the actual translation and transfer (gcis_client.py, webform_client.py, and sync.py, respectively) as well as an automated test suite (test_suite.py) to ensure the integrity of the software.
- A semi-automated problem discovery and resolution tool (problems.py) to ensure the integrity of the data transferred between the two systems' data models.
- Scripts to reverse-engineer Thomson-Reuters' Endnote file format to facilitate automatic assignment of identifiers to citations within the NCA and their transmission to the SDS.

To further the TSU's objectives to adhere to best practices of data management and software engineering, version control of both scientific datasets and analysis software continues to be employed. A document management system with native versioning capability was also evaluated for incorporation in future assessments. These tools proved their worth both internally and when disseminating work products with external collaborators.

The software engineer continues to demonstrate these best practices to groups of undergraduate interns as well as basic techniques of scientific computing.

PLANNED WORK

- Continue development of GCIS SDS and supporting technologies.
- Continue transitioning legacy research code to operations.
- Continue assisting lead scientist and associates with scientific programming tasks.
- Continue to mentor undergraduate interns.

DELIVERABLES

- GCIS SDS populated with all available metadata supporting the NCA publication.
- GCIS SDS client software for packaged for public release, including documentation and test suite.
- Various figures and analyses used in the National Climate Assessment with comprehensive supporting metadata.

PRESENTATIONS

- Stevens, L.E. and A. Buddenberg, 2013: Climate Modeling for the National Climate Assessment, UNC Asheville, Asheville, NC (11 September).

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	7
# of products or techniques transitioned from research to ops following NOAA guidance	2
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	5

PERFORMANCE METRICS EXPLANATION

This year, we created two data analysis packages, approximately twenty figures for the National Climate Assessment, one Drupal module, one client software package for GCIS SDS, one metadata problem discovery and resolution tool, and one hack for Endnote (7). TSU transitioned one database schema and one version control tool from research to operations. An invited presentation was given to students at UNC-A (1) and five undergraduate interns (5) were mentored.

Information Quality Act Compliance and Metadata Collection for the Third National Climate Assessment

Task Leader	Sarah Champion
Task Code	
NOAA Sponsor	David Easterling
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%.
Main CICS Research Topic	National Climate Assessments
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: TSU built a sustainable process and technical infrastructures to collect, curate, and display the metadata of the National Climate Assessment. The effort satisfies compliance with the Information Quality Act and includes traceability of data, contributors, and scientific analysis methods across graphics, visualizations, references, and photos, at a level of detail to satisfy a requirement to also be reproducible. TSU has completed approximately 10% of the collection.

BACKGROUND

This report summarizes the work of the ongoing NOAA data sources project entitled "Information Quality Act Compliance and Metadata Collection for the Third National Climate Assessment". The Technical Support Unit (TSU) Data Team has built a sustainable process to collect, curate, and display all associated metadata for the National Climate Assessment, and future Assessments. This effort is in direct response to a Federal requirement for the Assessment to meet guidelines in the Information Quality Act and a Highly Influential Scientific Assessment, requiring traceability (transparency), and reproducibility of all data. The sustainable process includes a collection point and repository of metadata inputs, ongoing documentation of the collected information and status within the overall process, connection to a structured data server with integration to the U.S. Global Change Research Program (USGCRP) future Global Change Information System (GCIS) (development is ongoing), and a metadata viewer, integrated with the web design/display of the full Report.

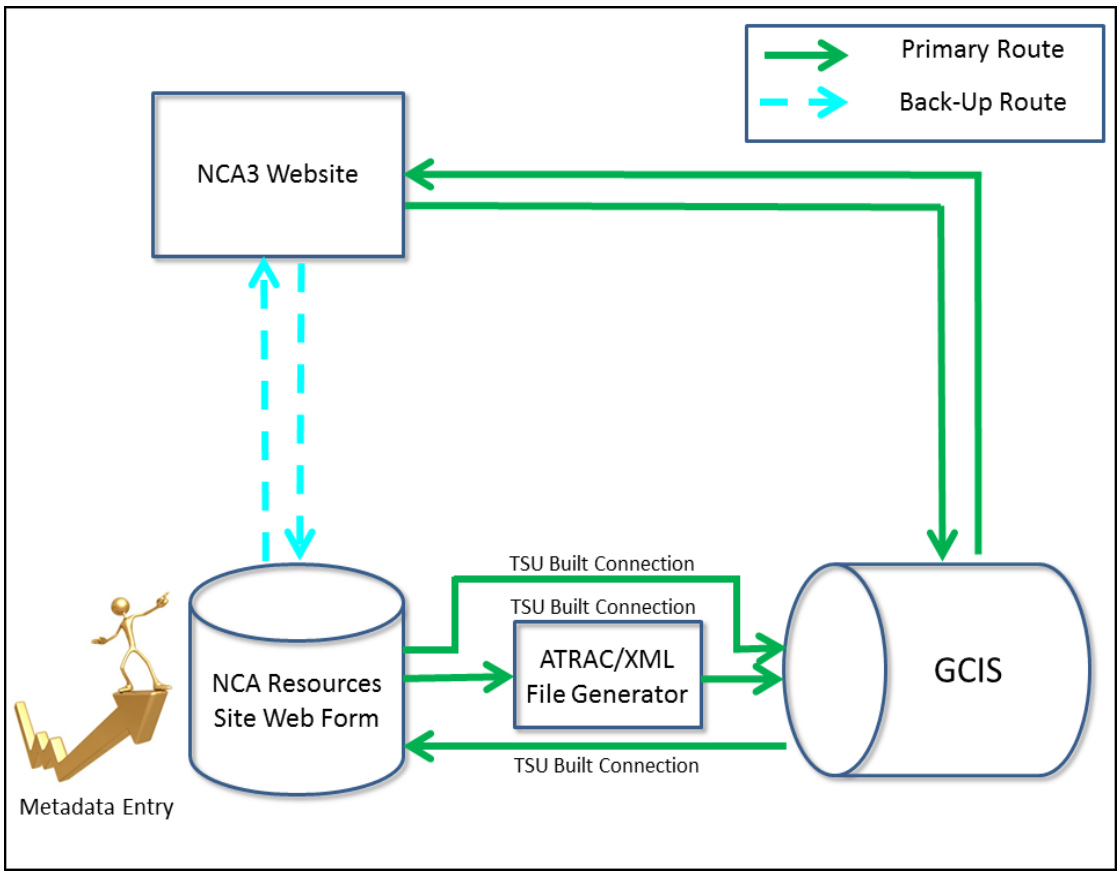


Figure 1: The TSU Data Team workflow and sustainable metadata collection process. The process is initiated, as indicated in the lower left of the figure, with the "metadata entry" into the "web form". The content contained in this web form is pulled into the GCIS/Structured Data Server, either directly, or after requiring filtering through an XML Metadata File generator. The workflow also depicts a back-up solution to collect, store, and display collected information, should the connection to the GCIS ever be terminated. This technical infrastructure has been successfully built and implemented, using a series of software development collaborations, internally with the TSU and through collaboration with USGCRP GCIS Developers.

ACCOMPLISHMENTS

The process and level of detail are a first-time success in the history of the National Climate Assessment project. The web form, connections between the web form, GCIS, and the Metadata Viewer on the National Climate Assessment website (to include the website itself), have been completely built and designed internally. All components have been designed, built, and executed. The infrastructure was recently tested during development to satisfy a high-level request for metadata pertaining to a potential "show-stopper" comment during the Report Draft review period. Demonstration and delivery of this particular metadata satisfied the interested parties and the concern was eliminated. Additionally, the level of detail of metadata input and collection has successfully traced challenging contributions such as analysis and methods with modified model output data. To date, we have collected approximately 10% of the Report metadata, with another 10% anticipated by the time the Report is officially published in its final form.

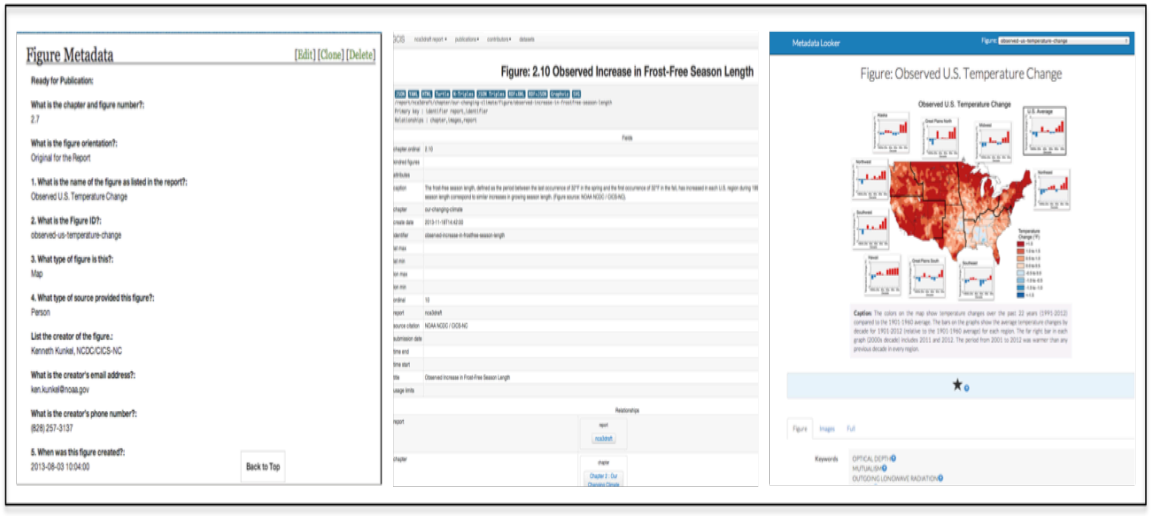


Figure 2: Examples of the three main components of the metadata collection process. The first panel depicts a portion of collected input for a graphic within the Report. The middle panel shows the same input from the left panel as it is stored and organized within the GCIS/Structured Data Server. The far right panel depicts the metadata viewer on the Report website, with selected input displayed for a typical user. This is not all-inclusive of the complete functionality of all three components, but is meant to demonstrate how the information is processed throughout the collection process.

All project deliverables (documentation and software) and milestones have been accomplished as planned. Currently, the software system is being tested and preparations are under way for the Test Readiness Review (TRR).

PLANNED WORK

- Continue to finalize the connection points between the input survey, the structured data server, and the website metadata viewer
- Continue collaborative efforts with GCRP in populating the GCIS with Report metadata, data, and contributors
- Continue metadata collection efforts for all 300 Report graphics, references, and data (approximate)

DELIVERABLES

- Automated algorithm for a new 4-km global snow depth analysis;
- Software system for a new 4-km global snow depth analysis; and
- Documentation for automated algorithm and software system.

PRESENTATIONS

- Timles, C., Champion, S., and Aulenbach, S. 2014: *The Federation of Earth Science Information Partners Winter Meeting, Washington, D.C., ESIP*

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	2
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

This year, TSU developed a process to collect metadata in accordance with Federal Requirements (1), and two additional supporting components to support a sustainable and seamless process (2). The progress of these components and process were invited as part of a presentation at the Winter ESIP meeting in Washington D.C.

Development of Geospatial Visualizations, Online resources, and Decision Support Tools for the National Climate Assessment

Task Leader	Jim Fox
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 100%; Theme 2: 0%; Theme 3: 0%
Main CICS Research Topic	National Climate Assessments
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: Staff from UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC) created maps and products for the National Climate Assessment; co-developed digital resource environments and interactive and static graphics for users of the Climate Assessment and Indicators team; and researched and presented a decision framework for use by the Climate Assessment. These new products support the overall advancement and progression of the National Climate Assessment program.

BACKGROUND

The University of North Carolina Asheville's (UNCA) National Environmental Modeling and Analysis Center (NEMAC) has assisted CICS-NC and the NOAA Assessments Technical Support Unit (TSU) thorough the provision of expertise, staff time, and technical resources.

The University of North Carolina Asheville's (UNCA's) National Environmental Modeling and Analysis Center (NEMAC) specializes in using science communication and delivery to develop decision-making tools for local and regional planners, decision makers, and the public. UNCA's NEMAC's staff members have expertise in visualization, geographic information systems (GIS), programming, multimedia, marketing, community engagement, outreach, meeting facilitation, and environmental science. Located in Asheville, site of NOAA's National Climatic Data Center and NOAA's Cooperative Institute for Climate and Satellites, UNCA's NEMAC is uniquely situated to address the needs of NOAA Assessments Technical Support Unit (TSU) through the provision of expertise, staff time and technical resources.

NEMAC provides its expertise and resources to initially address three task areas:

- Geographic Information Systems/Climate Projections Resource Development
- Development of Regional and State-based Web Services
- Co-Development of Online Environment for National Climate Assessment/Global Change Information System
- Decision Support

ACCOMPLISHMENTS

Geographic Information Systems/Climate Projections Resource Development

UNCA's NEMAC will continue to provide assistance in developing and maintaining a 'library' of GIS maps and shapefiles from model output associated with CMIP5 and other resources. Multiple parameters over multiple time periods and regions will be required, building a

superior, accessible, well-documented library of maps and metadata for non-technical users of model output. The development of the GIS viewer, in coordination with CICS-NC/TSU, will serve non-technical and scientific audiences of the National Climate Assessment and Global Change community. These visualization tools will help achieve accessibility and interpretation of complex scientific data in a way that facilitates decision-making, conveys scientific uncertainty where appropriate, and allows full transparency and traceability of the underlying data.

In the period covered by this report:

- CMIP5 and updated CMIP3 data are being processed for a new set of climate maps. The goal with this set of maps will be to better compare CMIP5 (*Figure 1*) and CMIP3. Three sets of maps are being produced:
    1. CMIP3 (A2, A1B, B1) and CMIP5 (RCP 8.5, RCP 6.0, RCP 4.5, RCP 2.6) scenario comparison maps for each time period (2021-2050, 2041-2070, 2071-2099)-precipitation and temperature
    2. CMIP3 (A2) and CMIP5 (RCP 8.5) seasonal (winter, spring, summer, fall) comparison maps for the 2041-2070 time period-precipitation and temperature
    3. CMIP5 CLIMDEX variable maps for 8 temperature variables and 5 precipitation variables. Each map will include:
        a. Difference
        b. Climatology
        c. Total values
- Research and development tasks on the GIS Viewer have included work towards a unified code base to serve National Climate Assessment products using PostGIS and other web services.

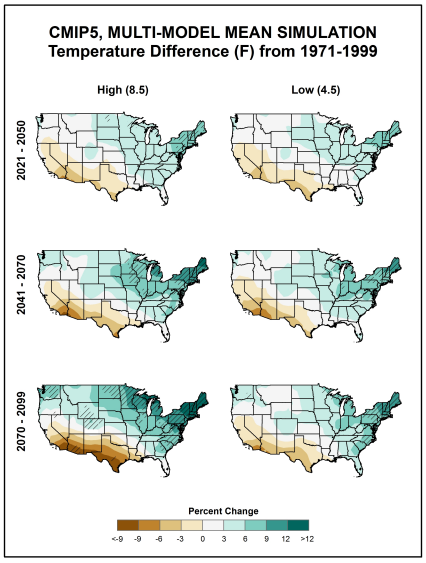


Figure 2. Preliminary CMIP5 annual precipitation data comparison between the RCP 8.5 (high) and RCP 4.5 (low) scenarios.

Development of Regional and State-based Web Services

The NOAA TSU aims to provide NCA-based materials for stakeholders such as State Climatologists, RCCs, and RISAs to disseminate to their stakeholders. UNCA's NEMAC will

assist with the reference implementation of a web application showcasing relevant material from the NCA (or other NOAA climate assessments like the scenarios, etc.).
In the period covered by this report:

- Jim Fox has interacted and met with a variety of partners towards this effort, including the South Atlantic, Gulf Coast and Appalachian Landscape Conservation Cooperatives, the Southern Appalachian Man and Biosphere program, and RISAs in the Carolinas, Colorado, and Arizona.
- NEMAC continues to work with Broward County (Ft. Lauderdale), Florida's Natural Resources Planning and Management Division on applications of the National Climate Assessment at local levels. These efforts have focused on sea-level rise, storm surge and other flooding, and salt-water intrusion issues. In the fall of 2013, NEMAC jointly submitted a NOAA SARP proposal with Broward County to develop 3D visualization and decision support tools to help address these and other closely related issues. Dr. Jennifer Jurado, Director of the Natural Resources Planning and Management Division, was an invited speaker by NEMAC at the 94th AMS Annual Meeting in February. NEMAC has additionally submitted a proposed statement of work to Dr. Jurado and Broward County to develop a prototype of the 3D visualization tools that would be developed in full capacity should the SARP grant be received. This prototype effort would take place during the spring-fall timeframe of 2014.

Co-Development of Online Environment for National Climate Assessment/Global Change Information System

UNCA's NEMAC will assist with the following tasks: 1) Co-development of Drupal interface to implement an ensemble of websites, to access a wide array of information and to design and implement key features, initially focusing on the website for the Third National Climate Assessment; 2) Co-developmentment of web sites and services for climate indicators; 3) Maintenance of collaborative environments for authors, the science community, and federal staff, as needed; and 4) Assist with identifying personnel who can lead and scope the needs for the user experience design process. The goal is to bring the design a curated "museum-like" feel and for it to be accessible and provide easy access to the NCA source material.
In the period covered by this report:

- NEMAC worked with the *HabitatSeven* team to create several interactive graphics applications for the NCA report web site.
- NEMAC worked with Melissa Kenney and Ainsley Lloyd from GCRP on the Indicators graphics effort. This work has included gathering original source data from Indicator authors and re-designing the original graphic to have a consistent look and feel. Thus far, six indicators have been redesigned (i.e. Annual Greenhouse Gas Index, Global Mean Temperature Anomalies, etc.), with the plan to complete approximately 30 graphics for the pilot project.
- In response to a request from Tom Peterson, NEMAC developed an author collaboration web site using Drupal for the Climate Extremes report authors (*Figure 2*). The site is similar to the "NCA Resources" and "State of the Climate" author sites

that NEMAC has previously developed; it allows report authors to share documents and images with each other during the writing of the report.

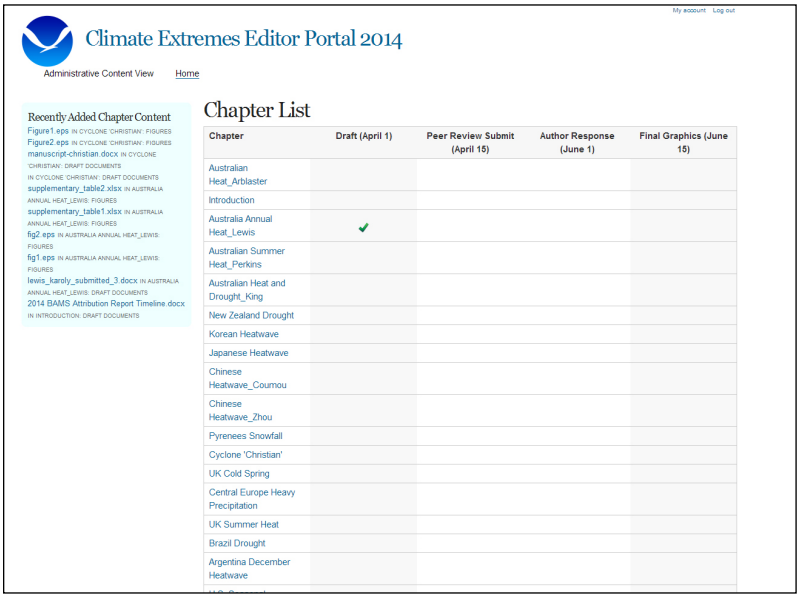


Figure 3 Screen shot of Climate Extremes Editor Portal 2014

Decision Support

UNCA's NEMAC will provide decision support assistance to NCA communities in order to help in the application and communication of data. This will be part of an effort to achieve a vision of "data-to-decisions" supporting NOAA and NCA goals. UNCA's NEMAC will work with NOAA, CICS-NC, the NCA Network of partners (NCANET), as well as internal NCA employees and technical teams, NCA ambassadors, and other key stakeholders of NOAA and NCA information. Methods of engagement and interaction will include leading and participating in workshops on data and user needs as NOAA and the NCA provides data to multiple users, and facilitating the development of indicators for scenario planning as needed. It is expected that this component of the award will evolve significantly over time, will make use of existing opportunities and will be collaboratively designed.

In the period covered by this report:

- Data Discovery Days
  - Jim Fox presented at and attended the Frost and Freeze workshop in March 2013, which led to two follow-up meetings with attendees in April 2013.
  - Jim Fox's presentation at the Precipitation workshop in December 2013 led to six meetings with other users and participants.
- Jim Fox participated in an Outreach workshop in Washington D.C, February 17th-19th. Jim has been very active in Decisions group and is now working with sub-group on the national rollout planned for May.
- NEMAC has been having discussions with the NC Sea Grant's Dr. Jessica Whitehead, whom is the Coastal Communities Hazards Adaptation Specialist, about applying NEMAC's decision support tools and facilitation efforts to various projects and programs led by their organization. As the NC Sea Grant works closely with communities all along both the North and South Carolina coastline, they are

challenged with the lack of effective decision support tools and capacity to help address local decision makers and stakeholders whom are dealing with a variety of climate hazards and threats from varying climate and climate change. Thus, they are very interested in assistance that NEMAC could provide.

PLANNED WORK

Planned work for the remainder of this fiscal year (through June 30, 2014) includes the following tasks:

- Presentation to be given in collaboration with NCDC's Mike Squires at the 71st Eastern Snow Conference in Boone, NC, June 3-5th, titled "Local Applications of the NOAA Regional Snowfall Indices and GIS Snowstorm Database".
- Presentation to be given at the Carolinas Climate Resilience Conference in Charlotte, April 28th and 29th, titled "Moving from Analysis to Action-The Next Step for Climate Adaptation".
- Jim Fox will be attending the White House Reception on the Climate Data Initiative on March 19th, 2014.
- Finish interactive graphics for NCA report site.
- Complete pilot project for graphics re-design for approximately thirty Indicators.
- Complete the sets of comparison maps for CMIP3 and CMIP5.
- Continue to collaborate with Frank Niepold and David Herring on the coordination between work on Climate.gov, the Climate Resilience Toolkit, and the NCA.

PUBLICATIONS

- Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, J. Rennells, A. DeGaetano, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 1. Climate of the Northeast U.S., *NOAA Technical Report NESDIS* 142-1, 79 pp.
- Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, C.E. Konrad II, C.M. Fuhrman, B.D. Keim, M.C. Kruk, A. Billet, H. Needham, M. Schafer, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 2. Climate of the Southeast U.S., *NOAA Technical Report NESDIS* 142-2, 94 pp.
- Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, S.D. Hilberg, M.S. Timlin, L. Stoecker, N.E. Westcott, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 3. Climate of the Midwest U.S., *NOAA Technical Report NESDIS* 142-3, 95 pp.
- Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, M.C. Kruk, D.P. Thomas, M. Shulski, N. Umphlett, K. Hubbard, K. Robbins, L. Romolo, A. Akyuz, T. Pathak, T. Bergantino, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 4. Climate of the U.S. Great Plains, *NOAA Technical Report NESDIS* 142-4, 82 pp.
- Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K.T. Redmond, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 5. Climate of the Southwest U.S., *NOAA Technical Report NESDIS* 142-5, 79 pp.

- Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K.T. Redmond, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 6. Climate of the Northwest U.S., *NOAA Technical Report NESDIS* 142-6, 75 pp.
- Kunkel, K.E, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 9. Climate of the Contiguous United States, *NOAA Technical Report NESDIS 142-9*, 77 pp.

PRESENTATIONS

- NEMAC's Greg Dobson and Jim Fox co-organized and co-chaired a session at the 94th AMS Annual Meeting February 2-6, 2014, in Atlanta, Georgia. The session was titled "Identifying the Needs and Opportunities of Small and Medium-Sized Communities for Data, Information, and Integrated Tools for Enhanced Decision Support-Part I: Users." This was a two-part session that NEMAC organized along with Riverside Technology's George Smith and Larry Brazil. The second part, co-organized and co-chaired by Riverside Technology, focused on Providers.
- Dobson, J.G. and J.F. Fox. *"Providing Meaningful and Actionable Decision Tools to Local and Regional Stakeholders across the Southeastern U.S."* The 94th American Meteorological Society's Annual Meeting, 9th Symposium on Policy and Socioeconomic Research. February 2nd- 6th, 2014, Atlanta, Georgia.
- Fox, J.F. and J.G. Dobson. *"Framing the Climate Issue for Small and Medium-Sized Communities across the Southeastern U.S."* The 94th American Meteorological Society's Annual Meeting, 9th Symposium on Policy and Socioeconomic Research. February 2nd- 6th, 2014, Atlanta, Georgia.
- Kunkel, K.E, L.E. Stevens, and J.G. Dobson. *"Uncertainties in Model Simulations of the Regional U.S. Climate."* (Poster). The International Conference on Regional Climate – CORDEX 2103. November 4th- 7th, 2013, Brussels, Belgium.
- Fox, J.F. and J.G. Dobson. *"Framing the Climate Issue for Small and Medium-Sized Communities across the Southeastern U.S."* The 94th American Meteorological Society's Annual Meeting, 9th Symposium on Policy and Socioeconomic Research. February 2nd- 6th, 2014, Atlanta, Georgia.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	7
# of products or techniques transitioned from research to ops following NOAA guidance	1
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0

# of peer reviewed papers	7
# of non-peered reviewed papers	0
# of invited presentations	5
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	3

PERFORMANCE METRICS EXPLANATION

The following products and projects have been improved or developed during this year: a) CMIP5 mapped products; b) CMIP3 mapped products; c) CMIP5 CLIMDEX products; d) research of PostGIS options for GIS Viewer; e) interactive graphics for the NCA report website; f) re-designed graphics for Indicators pilot project; and g) the Climate Extremes portal. The Climate Extremes portal has transitions from research and development phase to operational phase.

National Climate Assessment Technical Support Unit Graphical Services	
Task Leader	Jessicca Griffin
Task Code	
NOAA Sponsor	
NOAA Office	NESDIS/OSD/SGSP/SEID
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%
Main CICS Research Topic	National Climate Assessment
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: %; Goal 3: %; Goal 4: %; Goal 5: %

Highlight: CICS staff provided editorial, graphics, and production support for the National Climate Assessment, making significant contributions to the release of the NCA in Spring 2014.

BACKGROUND

The National Climate Assessment (NCA) is intended to provide the President, Congress, other stakeholders, and the general public with a report on the current state of climate change science, the impacts of climate change, and the effectiveness of mitigation and adaptation efforts. Given the intended audience, it is essential that the report is written and graphically represented in clear language that is easily understood by a broad audience while maintaining the highest possible standards of accuracy and transparency.

ACCOMPLISHMENTS

Graphic design support services were provided for the development of the National Climate Assessment report. Tasks included basic image editing as well as more extensive editing and new creations to improve readability and ensure accuracy. Production services included preparing graphics for various pre-release drafts, as well as the final PDFs released to the public and Legislative Referral Memorandum (LRM) for review in March 2014. With tight deadlines and short turnaround times, delivery of that draft also required successful integration of the functions of multiple staff members within the TSU and effective coordination between the TSU staff and the USGCRP office in Washington, D.C.

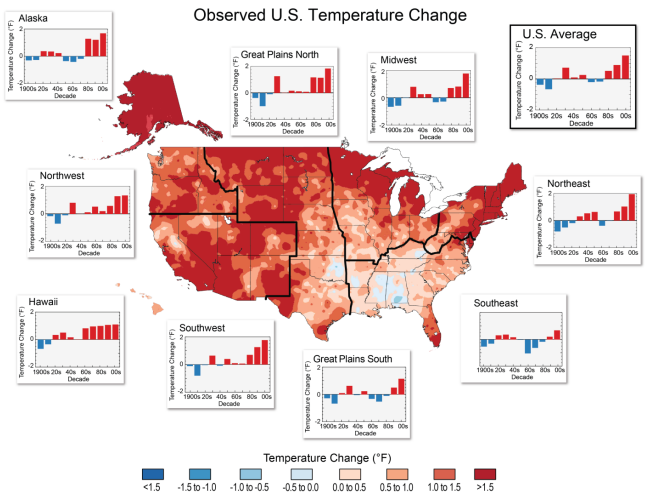


Figure 1. Observed U.S. Temperature Change.

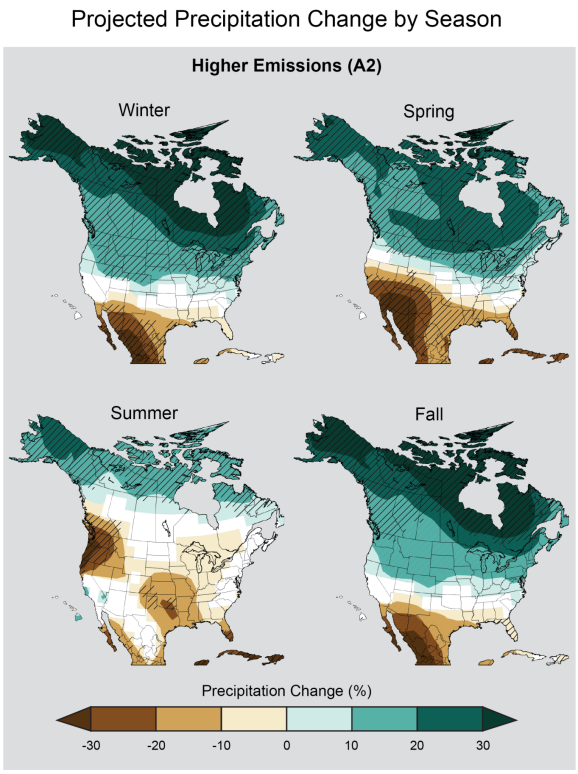


Figure 2 Projected Precipitation Change by Season.

PLANNED WORK

- Complete development of the "Highlights" version of the Third NCA, which will be the only printed version.
- Develop and design the Third NCA Full report in the form of a PDF.
- Continue with interactive graphical editing tasks for subsequent drafts of the NCA.
- Contribute to the development of various supplemental products, online content, and interactive products

DELIVERABLES

- Third NCA Full report.
- Third NCA Highlights document.
- Third NCA supplemental products
    - Brochure
    - Regional factsheets
    - Media package

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	0

# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

This past year, we have developed and designed the Highlights portion of the Third NCA.

Web Development for National Climate Assessment	
Task Leader	Angel Li
Task Code	
NOAA Sponsor	
NOAA Office	NESDIS/OSD/SGSP/SEID
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%
Main CICS Research Topic	National Climate Assessment
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: %; Goal 3: %; Goal 4: %; Goal 5: %

Highlight: Designed and implemented a new web site for CICS-NC. Concluded a performance evaluation of the NCA Comment and Review system. Completed web development support for Dataset Discovery Days and the Executive Forum on Business and Climate websites.

BACKGROUND

The National Climate Assessment integrates, evaluates, and interprets the findings of the U.S. Global Change Research Program (USGCRP) into a single cohesive report for policymakers and private entities to inform their decision-making and planning for the future. As print media is being phased out, the web is now a much more vital resource for reports such as the National Climate Assessment report. As tablet sales continue to outpace personal computer sales, the e-Book version of the report proves to be an important addition to the NCA products.

ACCOMPLISHMENTS

- NCDC newsletter modeled after the CICS-NC newsletter
- Load testing of Review and Comment System for NCA
- Optimization of Review and Comment System
- Working on the 3rd National Climate Asssessment: Setting up development servers, styling and design of the NCA3 website, inputing content, re-formatting images, hosting server configuration and management
- Support for the National Climate Assessment meeting web site
- Maintained and edited CICS-NC website
- Produced HTML newsletter for CICS-NC

PLANNED WORK

- Updated look of CICS-NC web site
- Continued support of the NCA website(s)
- Contributed to CICS-NC outreach efforts

PRESENTATIONS

- Responsible for design and deployment of CICSNC website: http://cicsnc.org

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

National Climate Assessment Editorial Services	
Task Leader	Tom Maycock
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%
Main CICS Research Topic	National Climate Assessment
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5:0%

Highlight: Provided editorial, production, and project management support for the NCA, contributing to multiple drafts and the final approved document. Facilitated delivery to layout and website production and contributed to the development of the shorter *"Highlights"* summary of the NCA.

BACKGROUND

In its fourth year at NCDC, NOAA's Assessment Technical Support Unit (TSU) continued to provide critical input and support to the National Climate Assessment (NCA), a premier activity of the U.S. Global Change Research Program. The NCA is being conducted under the auspices of the Global Change Research Act of 1990, which calls for a report to the President and Congress that evaluates, integrates, and interprets the findings of the federal research program on global change (USGCRP) every four years. As the agencies comprising USGCRP seek to establish an ongoing, sustainable assessment process, as well as deliver a timely report in 2014, NCDC's TSU and the staff at USGCRP work in concert to provide coordination and technical support to a wide network of interagency and external groups and individuals.

ACCOMPLISHMENTS

NCA Full Report: Editorial Services provided editorial, production, and project management support for the development of several drafts of the full version of the NCA, as well as the final version of the report, which was approved in March 2014. Tom Maycock worked closely with authors, the TSU editorial and graphics teams, and United States Global Change Research Program (USGCRP) coordinating staff to develop and refine changes made in response to the initial public/National Research Council (NRC) review, a subsequent agency/NRC review, and a final government review. The editorial focus was on ensuring that the document would be readable for a general audience while maintaining the strictest standards for scientific accuracy. In addition to editorial work, Tom Maycock helped coordinate and conduct webinars/teleconferences with lead authors and provided technical production and project management support to the the TSU group. As of March 2014, editorial services continue working on final copyediting, layout, and web production of the report.

NCA Highlights: Tom Maycock worked closely with fellow members of editorial team and the graphics team to select content from the 1,200+ page full report for inclusion in the 150-page *"Highlights"* version. Editors worked with authors to refine content selections and language and provided "traceability" information, allowing reviews to ensure that Highlights content was entirely derivative from the full report. TSU also worked to update *"Highlights"* drafts as needed as final edits were made to full report.

NCA References Database: A significant portion of time was devoted to curating the EndNote database of more than 3,600 references used in the NCA. Tom Maycock worked to identify and correct errors and improve consistency throughout the year. A major task was re-linking all references for all chapters in the NCA. NCA editorial staff also developed a solution for linking and maintaining references for the derivative *Highlights* document. Tom Maycock also assisted TSU/CICS-NC software engineer with the task of connecting the EndNote database to the Global Change Information System (GCIS) data server.

Tom Maycock contributed to revisions to two figures in the National Climate Assessment and Development Advisory Committee (NCADAC) special report "Preparing the Nation for Change: Building a Sustained National Climate Assessment" and provided editorial support for the development of two-page summaries of the nine-part "Regional Climate Trends and Scenarios" report (NOAA Technical Report NESDIS 142). The summaries are available at: http://scenarios.globalchange.gov/.

PLANNED WORK

- Facilitate delivery of final NCA drafts into production, providing customized versions of documents to graphics team for layout and web team for website production
- Review PDF and website content to ensure accuracy
- Contribute to development of additional supplementary NCA materials, including 2-page regional summary documents.
- Update "*Highlights*" document in response to final government review, assist in final production of printed document.
- Continue to refine EndNote database, coordinating with GCIS staff to identify and resolve conflicts between the two databases.

DELIVERABLES

Due in April-May 2014:

- Full NCA report in PDF and web form
- NCA Highlights document, in print, interactive PDF, and web form

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0

# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

National Climate Assessment Science Support: Analysis of Observational and Modeled Climate Data	
Task Leader	Laura Stevens
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%.
Main CICS Research Topic	National Climate Assessments
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: Analysis of several observational and model datasets was performed and 23 figures were produced for the Third National Climate Assessment (NCA3) report, along with the compilation of associated metadata.

BACKGROUND

Primary science and technical support is being provided to NOAA and the NOAA Technical Support Unit (TSU) of the National Climate Assessment (NCA). This includes the processing and analysis of observational and modeled climate data, production of graphics for the latest NCA report, and research on Assessment-relevant topics.

ACCOMPLISHMENTS

Analyses of several observational and model data sets were carried out in order to produce figures for the Third National Climate Assessment (NCA3). A total of 23 figures were produced for the NCA3 report in collaboration with Dr. Kenneth Kunkel (lead senior scientist), Andrew Buddenberg (software engineer), and Jessicca Griffin (graphic designer).

Three datasets were used for analysis of the historical climate: Global Historical Climate Network-Monthly (GHCN-M), Global Historical Climate Network-Daily (GHCN-D), and Climate Division Database version 2 (CDDv2). These data were used to create time series and bar graphs in order to analyze regional trends in temperature and precipitation, including metrics of extremes (e.g. days with very heavy precipitation). All figures were recently updated to include the years 2012 and 2013. An example is given in *Figure 1*.

The primary model data used were the 1/8 degree-CONUS Daily Downscaled Climate Projections. Several figures were updated to use this new statistically downscaled data set, derived from CMIP3 projections (see “National Climate Assessment Scientific Support Activities”). These figures show future climate simulations, based on two emissions scenarios, for multiple temperature and precipitation-based metrics, such as the length of the frost-free season, and the number of consecutive dry days. Such climate projections are of interest to a wide-range of communities and decision makers and are included in several sectoral chapters of the NCA3 report (e.g. Agriculture, Energy Supply and Use, Rural Communities), as well as several regional chapters. An example is given in *Figure 2*.

Alongside the creation of figures for the NCA3 report, associated metadata for these and additional graphics produced by the TSU were compiled and input to the NCA web system.

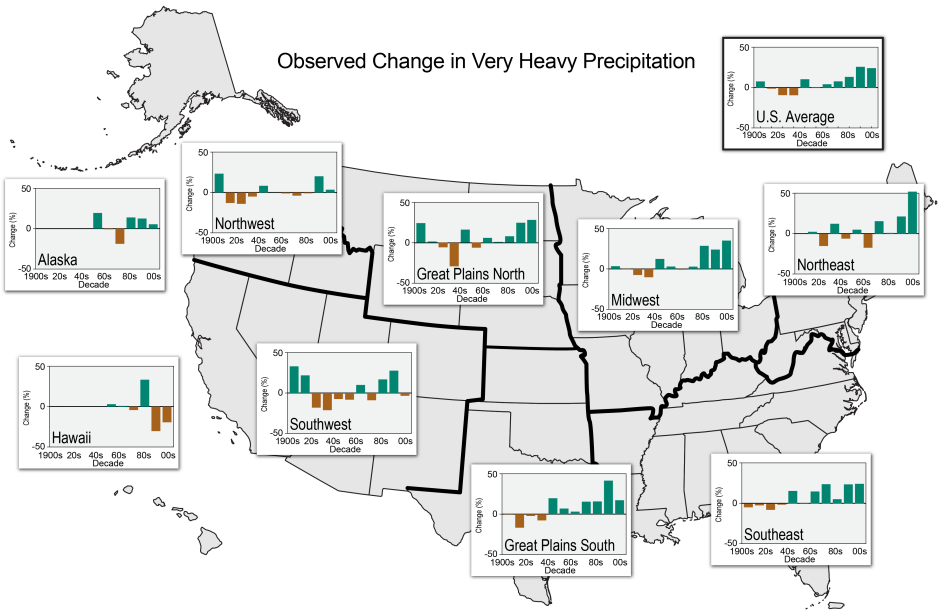


Figure 1: Percent changes in the annual amount of precipitation falling in very heavy events, defined as the heaviest 1% of all daily events from 1901 to 2012 for each region. The far right bar is for 2001-2012. In recent decades there have been increases nationally, with the largest increases in the Northeast, Great Plains, Midwest, and Southeast. Changes are compared to the 1901-1960 average for all regions except Alaska and Hawai'i, which are relative to the 1951-1980 average.

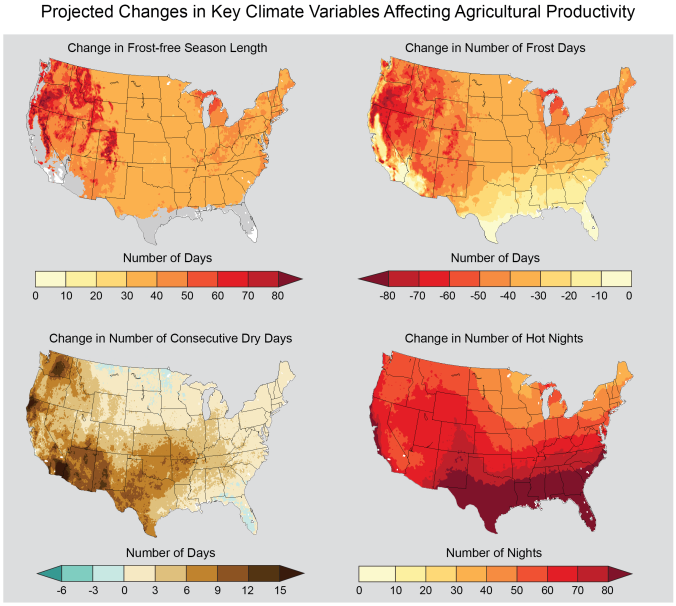


Figure 2: Many climate variables affect agriculture. The maps above show projected changes in key climate variables affecting agricultural productivity for the end of the century (2070-2099) compared to 1971-2000. On the frost-free map, white areas experienced no freezes during the reference period (1971-2000), and gray areas experienced more than 10 frost-free years during the same period. In the lower left graph, consecutive dry days are defined

as days with less than 0.01 inches of precipitation. In the lower right graph, hot nights are defined as nights with a minimum temperature higher than 98% of minimum temperatures between 1971 and 2000.

In addition to the production of figures, scientific assistance was given to the TSU graphics team in selecting appropriate photographs to aid in illustrating key components of the NCA3 report.

Another task was to produce summaries for the nine-part "Regional Climate Trends and Scenarios" report (NOAA Technical Report NESDIS 142). Information from the full report was synthesized into two-page documents with the assistance of the TSU lead scientist, editorial team, and graphic designer. The summaries are hosted on http://scenarios.globalchange.gov/.

PLANNED WORK

- Continuation of metadata compilation for figures in the NCA3 report;
- Data analysis and creation of figures for a supplemental report to the NOAA Technical Report NESDIS 142 series, comparing CMIP3 and CMIP5 temperature and precipitation simulations for the NCA regions;
- Additional data analysis on Assessment-relevant topics, e.g. co-author of a paper assessing temporal changes in the probability distribution of U.S. monthly temperatures.

PUBLICATIONS

- Stevens, L.E. (2013), *Regional Climate Trends and Scenarios: The Northeast U.S.*, NOAA Technical Report NESDIS 142-1 Summary, 2 pp.
- Stevens, L.E. (2013), *Regional Climate Trends and Scenarios: The Southeast U.S.*, NOAA Technical Report NESDIS 142-2 Summary, 2 pp.
- Stevens, L.E. (2013), *Regional Climate Trends and Scenarios: The Midwest U.S.*, NOAA Technical Report NESDIS 142-3 Summary, 2 pp.
- Stevens, L.E. (2013), *Regional Climate Trends and Scenarios: The U.S. Great Plains*, NOAA Technical Report NESDIS 142-4 Summary, 2 pp.
- Stevens, L.E. (2013), *Regional Climate Trends and Scenarios: The Southwest U.S.*, NOAA Technical Report NESDIS 142-5 Summary, 2 pp.
- Stevens, L.E. (2013), *Regional Climate Trends and Scenarios: The Northwest U.S.*, NOAA Technical Report NESDIS 142-6 Summary, 2 pp.
- Stevens, L.E. and B. Stewart (2013), *Regional Climate Trends and Scenarios: Alaska*, NOAA Technical Report NESDIS 142-7 Summary, 2 pp.
- Stevens, L.E. (2013), *Regional Climate Trends and Scenarios: Hawai'i and Pacific Islands*, NOAA Technical Report NESDIS 142-8 Summary, 2 pp.
- Stevens, L.E. (2013), *Regional Climate Trends and Scenarios: Contiguous United States*, NOAA Technical Report NESDIS 142-9 Summary, 2 pp.

DELIVERABLES

- New and updated graphics for the NCA3 report;

- Compilation and logging of metadata for many NCA3 graphics;
- Selection of photographs for the NCA3 report;
- Two-page summaries produced for the NOAA Technical Report NESDIS 142 series.

PRESENTATIONS

- Stevens, L.E., 2014: National Climate Assessment Panel Discussion, 94th Annual Meeting of the American Meteorological Society, Atlanta, GA (2 February).
- Stevens, L.E. and A. Buddenberg, 2013: Climate Modeling for the National Climate Assessment, UNC Asheville, Asheville, NC (11 September).
- Seyller, E., K.E. Kunkel, and L.E. Stevens, 2013: Regional Climate Trends and Scenarios for the United States, GreenGov Workshop on Climate Science and Adaptation Planning, Washington, D.C. (2 August).

OTHER

- North Carolina State University "Pride of the Wolfpack Award". This award was received as a nominee for the 2013 Awards of Excellence, in recognition of outstanding overall job performance for the North Carolina State University Office of Research and Innovation;
- Participated in "Wave Day", an outreach event at Asheville Middle School.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	9
# of invited presentations	3
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

The majority of work was carried out on the Third National Climate Assessment report, as well as finalizing the NOAA Technical Report NESDIS 142 series. Additional research is being conducted on Assessment-relevant topics, including one paper currently in preparation (see "Planned Work" section). Two NCA-related invited talks were given.

Science Editor/Publication Support for the National Climate Assessment Technical Support Unit	
Task Leader	Brooke Stewart
Task Code	NC-NCA-11-NCICS-BS
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: %; Theme 2: %; Theme 3: 100%
Main CICS Research Topic	National Climate Assessments
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: %; Goal 3: %; Goal 4: %; Goal 5: %

Highlight: CICS-NC staff provided editorial, graphics, and production support for NOAA's Technical Support Unit to the National Climate Assessment, making significant contributions to the development of the full report and accompanying Highlights document.

BACKGROUND

In its fourth year at NCDC, NOAA's Assessment Technical Support Unit (TSU) continued to provide critical input and support to the National Climate Assessment (NCA), a premier activity of the U.S. Global Change Research Program. The NCA is being conducted under the auspices of the Global Change Research Act of 1990, which calls for a report to the President and Congress that evaluates, integrates, and interprets the findings of the federal research program on global change (USGCRP) every four years. As the agencies comprising USGCRP seek to establish an ongoing, sustainable assessment process, as well as deliver a timely report in 2014, NCDC's TSU and the staff at USGCRP work in concert to provide coordination and technical support to a wide network of interagency and external groups and individuals.

ACCOMPLISHMENTS

Overall leadership and coordination of the Technical Support Unit's (TSU) editorial, graphics, and production efforts for the draft National Climate Assessment (NCA) report resulted in the successful and timely incorporation of input from a variety of sources (staff and management at USGCRP and TSU, authors, scientists, and federal advisory committee members) to finalize production and revisions of more than 300 figures for the assessment report. Source and copyright information was collected for report figures, as well as preliminary information to aid in the continued collection of metadata.

Extensive editing was performed to help ensure scientific accuracy and consistency throughout the draft report. Work with a large team of editors, authors, and staff to respond to comments received from the public, an expert review panel, and government agencies, led to the finalization of full-report chapters. This work required extensive organization, collaboration, and multiple iterations on every change made in each of more than 30 chapters.

Worked with editors, authors, and federal advisory committee members to revise and produce the NCA *Highlights* report, a brief document that provides highlights from across the full NCA report. The *Highlights* report is out for agency review until mid-March.

Helped develop graphics for "Preparing the Nation for Change: Building a Sustained National Climate Assessment Process", a federal advisory committee report, published in September 2013.

Assisted with the production of summaries for the nine-part "Regional Climate Trends and Scenarios" report (NOAA Technical Report NESDIS 142). The summaries are hosted on http://scenarios.globalchange.gov/.

PLANNED WORK

- Work with graphics and editorial team to complete layout of NCA full report
- Work with USGCRP staff and TSU production team to respond to comments received from agency review regarding Highlights report
- Coordinate final production and distribution of full NCA report and Highlights report (along with editors, graphic designers, and USGCRP staff) to ensure timely delivery of both products by late-April to mid-May (exact date is TBD)
- Provide support to metadata team in their continued effort to gather information for report figures
- Work with web team to develop interactive graphics for NCA
- Begin research on climatological changes of atmospheric blocking events

PUBLICATIONS

- Stevens, L.E. and B. Stewart (2013), Regional Climate Trends and Scenarios: Alaska, NOAA Technical Report NESDIS 142-7 Summary, 2 pp.

PERFORMANCE METRICS

Performance Metrics	**FY13**
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	1
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

National Climate Assessment Scientific Support Activities

Task Leader	Liqiang Sun
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%.
Main CICS Research Topic	National Climate Assessments
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: Scientific analysis of Coupled Model Intercomparison Project, Phase 5 (CMIP5) and CMIP3 data was performed to support the development of the Third National Climate Assessment (NCA).

BACKGROUND

The Technical Support Unit (TSU) at CICS is to develop state-of-art scientific products that support the development of the NCA Reports. The primary effort is the preparation of robust and reliable climate information at regional scales for the United States, using observations, CMIP3 and CMIP5 model simulations, and dynamically and statistically downscaled data. Research on understanding of climate change and uncertainty is also conducted to improve the continuing assessment process.

ACCOMPLISHMENTS

Scientific analyses of CMIP5 model data are performed on annual, seasonal, monthly, and daily temporal scales, for scenarios of RCP8.5, RCP6.0, RCP4.5, RCP2.6, historical runs and historical runs with natural forcing only. These analyses are based on 1) all the models and ensembles available, and 2) a common set of models and ensembles. The analyses are used to produce robust and reliable climate information at regional scales for the United States, including, annual, seasonal, and monthly temperature and precipitation for historical and possible future conditions with uncertainty estimate.

The analyses of climate extremes using CLIMDEX data are also carried out to support the NCA activities. The extremes include warm (cold) spell duration, consecutive dry (wet) days, maximum 1 (5) day precipitation, precipitation above 99^{th} percentile, minimum T_{max} and T_{min}, and maximum T_{max}, growing season length, number of nights above $20^{o}C$, and number of nights below $0^{o}C$.

Comparison between CMIP3 and CMIP5 simulations is in process. We assess the ability of two sets of models to simulate the historical climate conditions over the United States and document their projections for NCA regions.

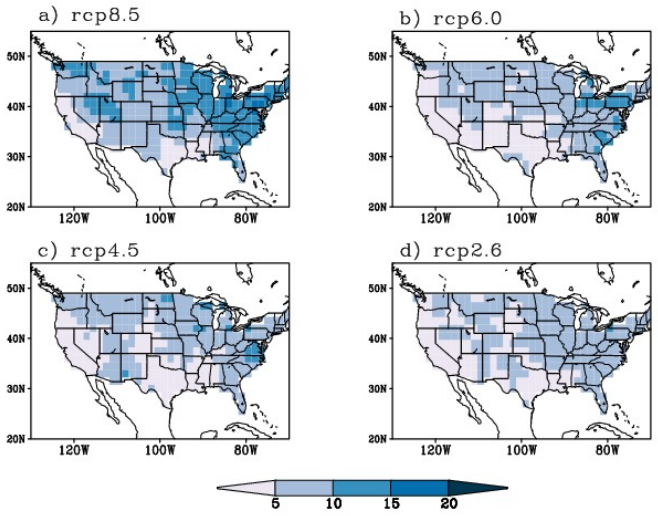


Figure 1: Simulated difference of maximum consecutive 5-day precipitation (%) for future time period of 2046-2075, with respect to the reference period of 1971-2000.
These are CMIP5 multi-model multi-ensemble means for emissions scenarios of rcp8.5, rcp6.0, rcp4.5 and rcp2.6.

PLANNED WORK

- Continue ongoing comparison between CMIP5 and CMIP3 model simulations
- Continue research on mesoscale convection systems in changing climate
- Data analysis to meet the specific needs of the assessment.

PUBLICATIONS

- Li, H., M. Kanamitsu, S-Y Hong, K. Yoshimura, D. Cayan, V. Misra, and L. Sun, 2014: Projected climate change scenario over California by a regional ocean-atmosphere Coupled Model system. *Climatic Change*, doi:10.1007/s10584-013-1025-8.
- Wuebbles, D., G. Meehl, K. Hayhoe, T. R. Karl, K. Kunkle, B. Santer, M. Wehner, B. Colle, E. Fischer, R. Fu, A. Goodman, E. Janssen, H. Lee, W. Li, L. Long, S. Olsen, S. Rauscher, A. Seth, J. Sheffield, L. Sun, 2014: CMIP5 climate model analyses: Climate extremes in the United States. *Bull. Amer. Meteor. Soc*., doi: 10.1175/BAMS-D-12-00172.1
- Dehaan, L., M. Kanamitsu, F. D. Sales, and L. Sun, 2014: Seasonal prediction downscaling over North America using regional models: Added values. *Climate Dynamics*, in review.

DELIVERABLES

- Comparison of CMIP5 and CMIP3 simulations for NOAA technical report
- Graphics for NCA report
- Submit a regional model paper for publication

PRESENTATIONS

- Sun, L., 2014: Multi-model ensemble seasonal climate forecasts for Northeast Brazil, invited talk via Skype, 16th Semi-Arid Northeast Brazil Climate Outlook Forum, Fortaleza, Brazil (17 January)
- Sun, L., 2013: climate-crop modeling: a climatological perspective, 4th Annual AgMIP Global Workshop, New York (29 October)
- Sun, L., 2013: lead panel discussions on "identify, evaluate and develop improved climate-prediction metrics for applications-based use, U.S. CLIVAR 2013 Summit, Annapolis, MD (10 July)

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	3
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

The primary effort is the preparation of robust and reliable climate information for NCA regions, using observations, CMIP3 and CMIP5 model simulations, and downscaled data.

Surface Observing Networks

Surface observing network efforts address sustaining and improving the quality of *in situ* climate observations and observing networks.

Background

The National Climatic Data Center (NCDC) along with NOAA partner institutions leads two new climate-observing programs, the U.S. Climate Reference Network (USCRN) and U.S. Historical Climatology Network-Modernized (USHCN-M). NOAA's U.S. Climate Reference Network (USCRN) consists of over 110 stations across the continental United States collecting sustainable observational climate data to provide a 50–year picture of climate change. Deployment of additional stations in Hawaii and Alaska to provide for the detection of regional climate change signals under the management of NCDC in partnership with NOAA's Atmospheric Turbulence and Diffusion Division.

NCDC also manages a number of other climate network initiatives, including the Global Historical Climatology Network (GHCN) and the Hourly Precipitation Data (HPD) Network, and archives and maintains observational data for such systems as the Hydrometeorological Automated Data System (HADS) and the Automated Surface Observing Systems (ASOS). Primary activities associated with these programs and systems include (1) collection and analysis of observations of soil moisture and soil temperature, (2) climate related studies and analyses involving climate change and variation, climate monitoring, and visualization, and (3) development of quality control processes to ensure the fidelity of the climate record.

To support these activities, CICS has built a task group of research scientists supporting various climate observing network initiatives and providing relevant scientific expertise.

Support of NOAA and NCDC led climate observing network activities requires collaboration with the best climate science practitioners in the nation as well as the hiring of outstanding scientific staff with unique skills and backgrounds in Earth System Science and the use of observations for defining climate and its impacts. CICS-NC staff under the CICS-NC Director in coordination with the NCDC project leaders and their respective staff, will continue to provide necessary expertise in the following areas:

- Expertise in the integration of surface, model, and satellite fields focusing on surface temperature dataset construction to pull through methodological lessons from a decade of research into radiosonde temperatures and supporting legacy projects on quality control of synoptic land data.
- Expertise in Quality assurance in the USCRN program through comparison of USCRN observations with those from other surface observing networks (e.g., COOP, ASOS, etc.), for the purpose of developing transfer functions and integrating networks for climate change studies; application of statistical techniques to examine uncertainties in operational USCRN measurements, QC techniques, and missing data treatments; development of methods for the automated production of USCRN

derived data products, map graphics, and time series for climate monitoring; and preparation of research data sets in various formats for internal and external use.

- Expertise in drought data monitoring and establishing drought-monitoring products for the USCRN network through comparison of drought monitoring products developed using the combined USHCN-M/USCRN instrument suite to objective SCAN soil moisture data and subjective U.S. Drought Monitor assessments; contribution to the scientific analysis of USCRN soil moisture/temperature data for the purposes of improving data quality and advancing the understanding of soil climate behavior as a function of the ensemble of USCRN observations; and providing access to the USCRN/USHCN-M observations and drought tools through the U.S. Drought Portal.
- Software engineering expertise in support of the maintenance and streamlining of the GHCN-M and HPD datasets through the following activities: review and analysis of the entire datasets processing including ingest, quality control, and homogeneity adjustments; daily processing oversight and troubleshooting, and initial development of a suite of quality control procedures through advanced statistics.
- Technical/scientific expertise (post-doctoral researchers) to provide support for the Global Temperature Portfolio targeting specific activities in ocean (sea surface temperature) and land temperature fields and products.

Validation of U.S. Climate Reference Network (USCRN) Soil Moisture and Temperature Observations

Task Leader:	Jesse E. Bell
Task Code:	
NOAA Sponsor:	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 100%; Theme 3: 0%
Main CICS Research Topic	Surface Observing Networks
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlights: This research is an analysis of USCRN soil observations for developing an understanding of spatial and temporal variability of soil moisture and temperature. The goal of this project is to determine the changes in soil observations and will serve to improve USCRN for drought monitoring and satellite calibration.

Background

The US Climate Reference Network is a series of climate monitoring stations maintained and operated by NOAA. To increase the network's capability of monitoring soil processes and accurately estimating drought, it was decided to add soil observations to the list of USCRN instrumentation. In the summer of 2011, the USCRN team completed the installation of all soil observational probes in the contiguous US. Each station, along with traditional measurements of surface air temperature, precipitation, infrared ground surface temperature, wind speed, and solar radiation, now also transmits relative humidity, soil temperature, and soil moisture measurements every hour. The data is maintained and stored at NOAA's National Climatic Data Center, while installation and maintenance is performed by NOAA's Atmospheric Turbulence and Diffusion Division (ATDD). In order to improve the ability of the network, multiple projects were started to analyze soil moisture variability and change. 1). An analysis of the 2012 drought using soil moisture observations from 2011-2013. 2). Spatial representativeness of USCRN soil observations using a dense temporary network.

ACCOMPLISHMENTS

USCRN soil observations were fully installed in 2011, which does not allow for much time to perform long-term analysis. However, dramatic changes in soil moisture conditions occurred over the first three years after installation. In 2011, many of the stations in the midwestern region of the United States experience flooding and saturated soil conditions. The following year there was a severe drought that covered much of the United States. These yearly changes allow for a national analysis of soil moisture. Soil moisture was analyzed on a monthly basis for each station in the CONUS for 2011-2013. Analysis was then performed to determine seasonal and regional changes in soil moisture for the period of record. USCRN soil observations showed a decreasing national soil moisture signal. The results of individual climate regions varied based on local conditions.

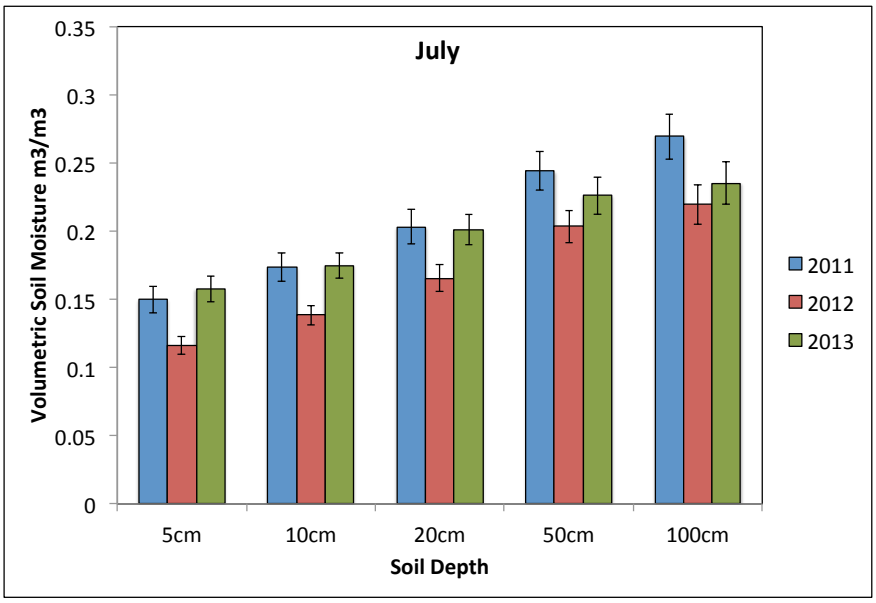


Figure 1. National soil moisture signal for each soil depth of the USCRN soil observations during July of 2011 -2013. The top three levels experienced recovery from the 2012 drought, but the bottom two levels never fully rebounded.

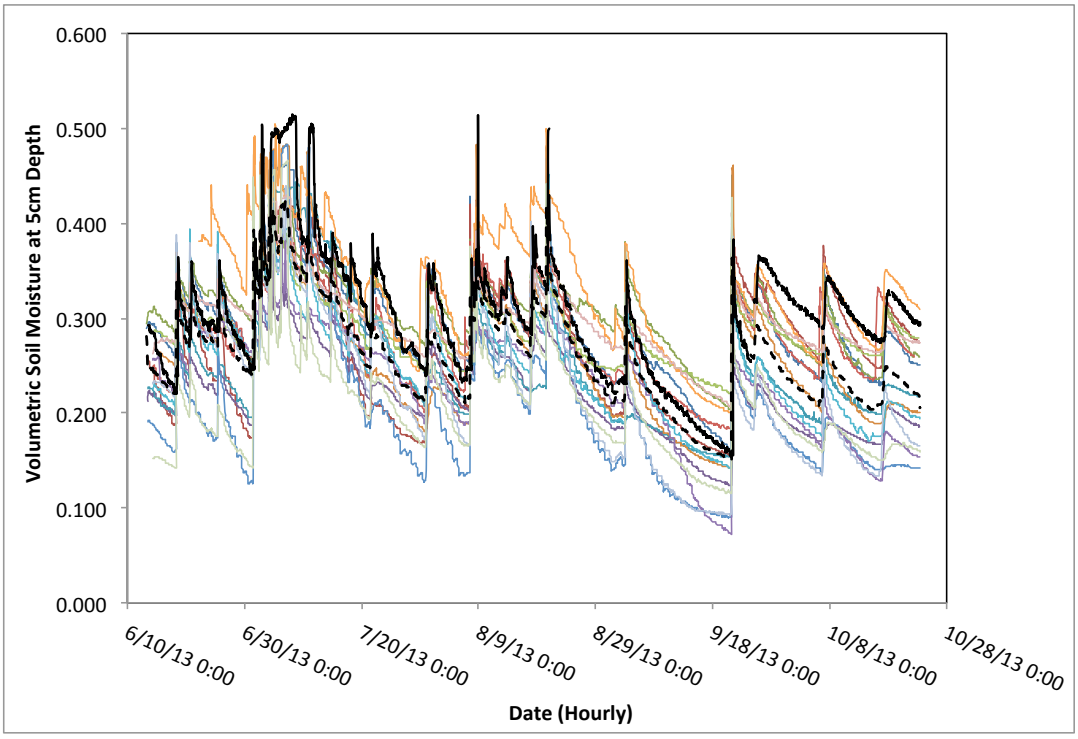


Figure 2. Results of the spatial representativeness study at Crossville, TN. The solid black line represents the USCRN soil moisture observations and the colored lines represent each station in the temporary network. The dashed black line represents the average of the temporary network.

To assist with drought analysis and improve satellite calibration activities, two temporary networks were installed around the USCRN stations at Crossville, TN and Millbrook, NY. Each temporary network was installed around the USCRN station in 3km grids to represent the minimum spatial extent of the NASA SMAP satellite. The Millbrook site was also expanded to a 9km grid to represent the larger satellite product of SMAP. Each network consists of 15 to 25 stations that were randomly installed in various habitats to represent the nature soil variability around the stations. Both networks were installed for the growing season of 2013 and remained in the ground for the fall of 2013. This amount of time allowed for the sensors to catch the entire wetting and drying cycle of the soil for that season. Analysis was then performed to determine the spatial variability and change between the temporary network and the permanent USCRN station. Soil samples were also collected at each USCRN station to determine the gravimetric soil moisture and bulk density of the soil near the temporary station. This research provides a tool for determining the spatial representativeness of a permanent station to the surrounding area for improved calibration and research activities.

Planned Work

- Finish work on 2012 drought and submit for review.
- Analyze Millbrook and Crossville sites.
- Determine if Crossville site can be continued for the 2014-growing season.
- Work on publications for the spatial representativeness study.
- Determine feasibility of constructing historical soil moisture record with USCRN precipitation data.

PUBLICATIONS

- Palecki, M.A., & J.E. Bell. 2013. U. S. Climate Reference Network: soil moisture variability and uncertainty. Vadose Zone Journal. doi:10.2136/v2j2012.0158
- Bell, J.E. M.A. Palecki, C.B. Baker, W. Collins, J.H.Lawrimore, R.D. Leeper, M.E. Hall, J. Kochendorfer, T.P. Meyers, T. Wilson, & H.J. Diamond. 2013. US Climate Reference Network soil moisture and temperature observations. Journal of Hydrometeorology, 14, 977-988
- Diamond, H.J., T.R. Karl, M.A. Palecki, C.B. Baker, J.E. Bell, R.D. Leeper, D.R. Easterling, J.H. Lawrimore, T.P. Meyer, M.R. Helfert, G. Goodge, & P.W. Thorne. 2013. U.S. Climate Reference Network after One Decade of Operations: Status and Assessment. Bull. Amer. Meteor. Soc., 94, 485-498

DELIVERABLES

- Instrumentation development for scaling and calibration.

PRESENTATIONS

- Bell, J.E. Evaluation of the 2012 drought with a newly established national soil monitoring network (USCRN). AMS Annual Meeting, Atlanta, GA. February 2014.
- Bell, J.E., M. Cosh, and M. Hall. (Invited Poster Presentation) Validating USCRN Soil Observations with a Dense Temporary Network. AGU Annual Meeting, San Francisco, CA. December 2013.

- Bell, J.E. Preparation of NOAA's USCRN for NASA's SMAP Mission. Pasadena, CA. November 2013.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	3
# of non-peered reviewed papers	0
# of invited presentations	3
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Research Dealing with the Impacts of Climate on Health

Task Leader:	Jesse E. Bell
Task Code:	
NOAA Sponsor:	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 100%; Theme 3: 0%
Main CICS Research Topic	Surface Observing Networks
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlights: This report illustrates the collaboration and interaction with the CDC's Climate and Health Program. The goal of this interaction is to increase the understanding of climate change on human health and assist with projects that can further this knowledge.

BACKGROUND

Changes in the world's climate are having adverse impacts on human health and will likely have increase in the future. Understanding the potential health risks associated with climate change is important for preparing for the future. The Centers for Disease Control and Prevention (CDC) has dedicated time and resources to addressing the issues that will arise from global climate change. The CDC has formed the Climate and Health Program to focus solely on preparing for climate change and the impacts on the health of US residents. Besides leading climate and health research, the Climate and Health Program is responsible for providing funding to state and city health departments to prepare for the adverse effects of climate change.

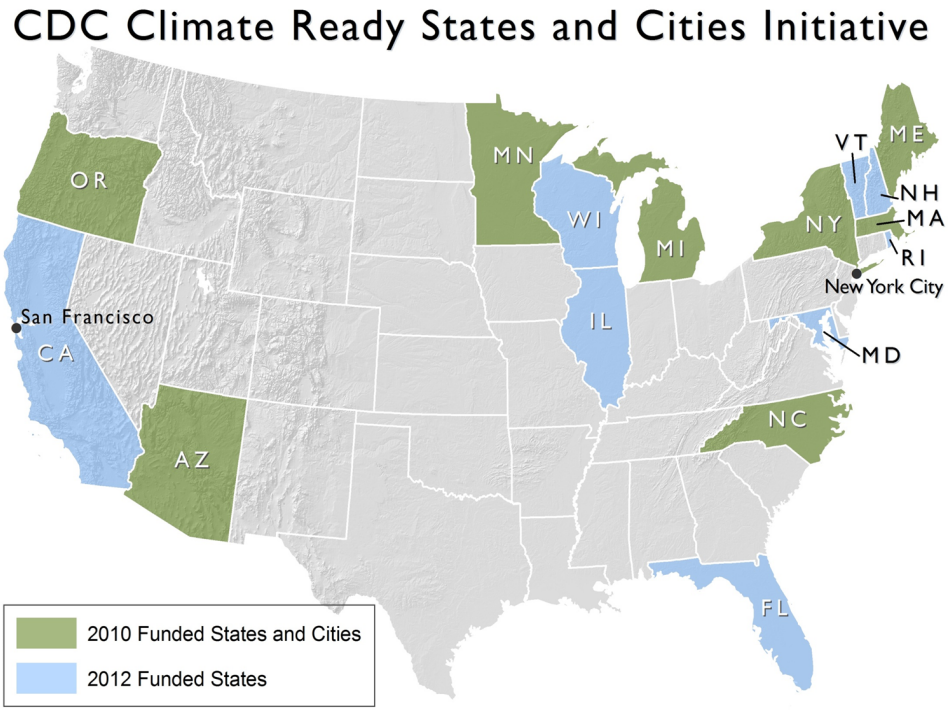


Figure 1. List of states and cities being funded by CDC's Climate-Ready States and Cities Initiative.

ACCOMPLISHMENTS

In order to develop projects dealing with climate and health, Jesse E. Bell became a Guest Researcher in the Climate and Health Program (located in CDC's National Center for Environmental Health (NCEH)). His role is to serve as a conduit between NOAA's National Climatic Data Center and CDC's NCEH to assist CDC researchers in accessing climate data and better understanding ways of applying these data. Through this interaction, he has helped develop projects dealing with precipitation extremes and traffic accidents, soil moisture conditions and Valley Fever, and assisting CDC grantees with climate expertise. He has also helped CDC gain access to NCA climate change projections and National Integrated Drought Information System (NIDIS) drought data for the National Environmental Health Tracking Network. Dr. Bell was also able to obtain an Adjunct Professor Position in the Rollins School of Public Health at Emory University and has started mentoring Masters of Public Health students that are interested in working on topics dealing with climate and health.

PLANNED WORK

- Develop projects that deal with drought and human health.
- Extend project dealing with traffic accidents and precipitation intensity (precipitation is measured with the Q2 radar product) to places outside Atlanta.
- Work on NCA – Interim Report on Climate and Health chapter on Extremes and Human Health.
- Continue to mentor MPH students at Emory University.
- Continue to develop CICS connections to health community.

PRESENTATIONS

- Bell, J.E. Collaboration on climate and health. Emory University, August 2013.

OTHER

- Started mentoring three MPH students' thesis project from Rollins School of Public Health at Emory University.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0

# of invited presentations	2
# of graduate students supported by a CICS task	0
# of graduate students formally advised	4
# of undergraduate students mentored during the year	0

Climate Monitoring and Research Support NOAA's Air Resources Laboratory (ARL) Atmospheric Turbulence and Diffusion Division (ATDD)

Task Leader	Mark E. Hall
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 100%; Theme 3: 0%.
Main CICS Research Topic	Surface Observing Networks
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: Installed a USCRN site near Paxson, Alaska in August 2013.

BACKGROUND

Atmospheric Turbulence and Diffusion Division (ATDD) is one of three field divisions of the NOAA's Air Resources Laboratory (ARL). Federal and Oak Ridge Associated Universities (ORAU) contractor personnel work closely with NOAA to perform lower atmosphere research in the areas of air quality, contaminant dispersion, and climate. ATDD is also responsible for the installation and maintenance of the infrastructure and instruments used to gather data for research.

ATDD's objectives are to:

- Develop better methods for predicting transport and dispersion of air pollutants.
- Improve modeling of air-surface exchange of water, energy, and carbon so that their effect on the earth's climate may be better understood.
- Make high-quality measurements in support of these efforts toward increased understanding.
- Install and maintain a long-term, reliable system of uniform instruments providing trustworthy data used in monitoring climate across the United States.

ATDD's staff has historically consisted of NOAA Federal civil service and contractor personnel from ORAU. The ORAU contractors are dedicated 100% to supporting ATDD's mission, working toward goals set by the ATDD Director and are co-located with the Federal personnel.

One of the primary foci for the ATDD/ORAU partnership has been sustaining NOAA's climate observing systems and developing research efforts that will enhance our understanding of a changing environment in the different ecosystems within the United States.

ACCOMPLISHMENTS

A new site was installed in Alaska about 70 miles north of Glennallen. The site is near the intersection of the Denali and Richardson Highways (Paxson) at a small landing strip. This station is solar powered, supplemented by a methanol fuel cell during the winter months. This brings the total of Alaska USCRN sites to 13. Four of these stations are remotely powered. Improvements to the design of the methanol fuel cell enclosure were made at

three of these sites to improve performance during the extreme cold conditions of the Alaska winter. Annual maintenance was performed at all existing Alaska stations.

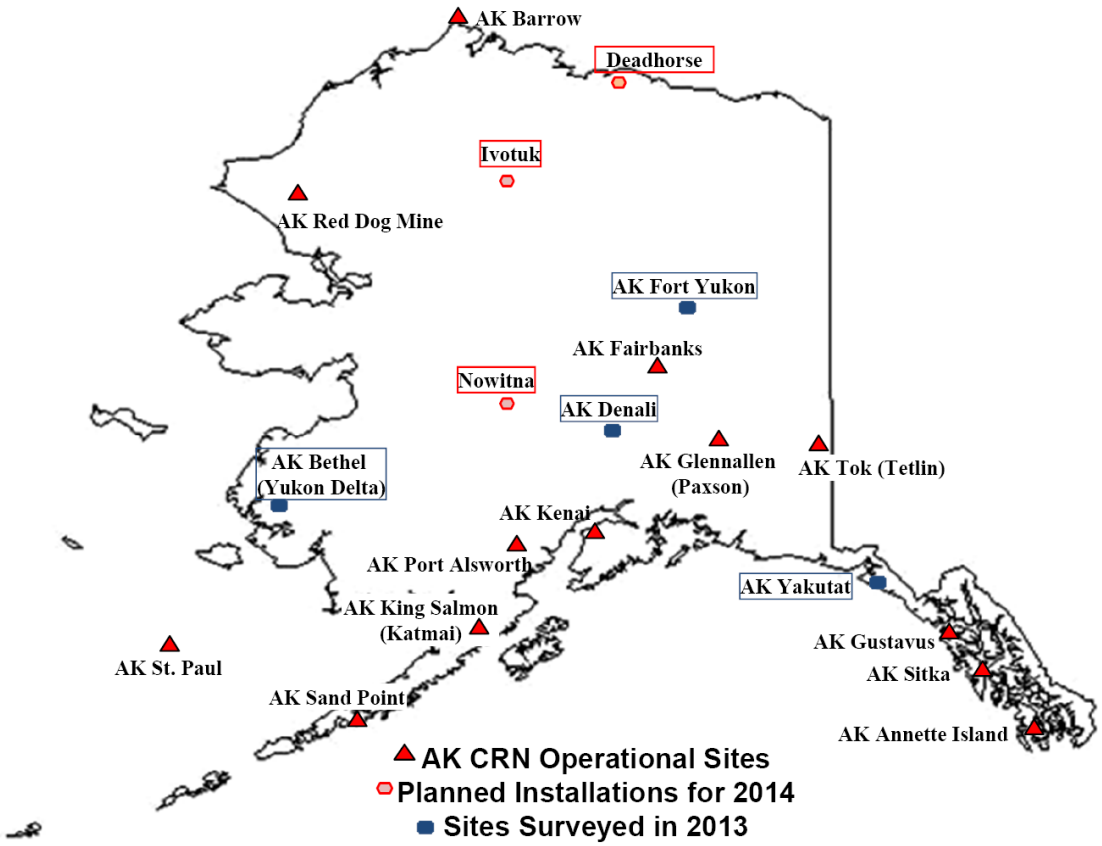
A design change was made to the precipitation gauge inlet heater at the site at Barrow, AK. This site experiences long periods of extreme cold that caused frost buildup in the gauge inlet. The design change has allowed the inlet to stay frost free in these conditions.

A site survey trip was completed to identify potential sites for future installs. Four locations were selected and work has begun to get site licenses in place. These sites will most likely be installed in FY2015 and beyond. The locations selected are near Fort Yukon, Denali National Park, Yakutat, and Bethel.

Figure 1: Maintenance at King Salmon (Katmai National Park) Alaska CRN Site.

PLANNED WORK

Three installations are planned for Alaska this summer. They are near Deadhorse, Ivotuk, and Nowitna. All three of these sites will be powered remotely. Deadhorse and Nowitna will have solar and methanol fuel systems, like the existing remote powered sites. The site at Ivotuk will be powered by a solar, wind, and diesel generator system already installed at this National Science Foundation research location.



PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	2
# of products or techniques transitioned from research to ops following NOAA guidance	1
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0

# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Investigating the hydrological impacts of Tropical Cyclones over the Carolinas from Observational and Modeling Based Perspectives.

Task Leader	Ronald Leeper and Olivier Prat
Task Code	
NOAA Sponsor	
NOAA Office	NESDIS/NOAA/NCDC
Contribution to CICS Themes (%)	Theme 1: 5%; Theme 2: 40%; Theme 3: 55%
Main CICS Research Topic	Surface Observing Network and Earth System Monitoring from Satellites
Contribution to NOAA Goals (%)	Goal 1: 60%; Goal 2: 40%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: Four Tropical cyclones (Floyd 1999, Isabel 2003, Frances 2004, and Irene 2011) that impacted the Carolinas were simulated using the Weather Research and Forecasting model (WRF) for an ensemble of microphysical parameterizations. Modeling results were compared against surface and remotely sensed observations to assess the model's ability to capture such extreme events and their impacts on local communities.

BACKGROUND

The Carolinas are often frequented by Tropical Cyclones (TCs) that bring intense precipitation and damaging winds. The societal risks TCs pose are not limited to coastal areas (direct hit storms), impacting interior communities following landfall (e.g. Frances 1999 and Isabel 2003). Assessing societal risks of TCs is challenging given the limited nature of observing systems. This is particularly true over the complex terrain that exists in the Western Carolinas (Appalachian). Sharp contrasts in precipitation intensity over short spatial and temporal scales are difficult to resolve with near-ground (radar; beam-blockage and Z-R relationships) and space-based (satellite; timing and resolution constraints) observing systems. Advancements in numerical methods (e.g. higher resolution and domain following) for TCs provide an opportunity to explore these challenges and improve societal risk assessments by bridging observational gaps.

ACCOMPLISHMENTS

Seven member ensembles for the selected TCs (Floyd 1999, Isabel 2003, Frances 2004, and Irene 2011) were initialized with commonly used microphysical schemes (ETA, Lin, Morrison, Thompson, WSM3, WSM5, and WSM6) for a total of 28 distinct simulations. Model performance was evaluated against IBTrACS TC center (*figure 1*), wind speed and minimum pressure. Overall, model performance was sensitive to the selection of microphysics and storm track. For instance, variance among ensemble member tracks was much lower for Irene 2011 (less curvature over flat coastal plain) than the more complex track (greater curvature over mountainous terrain) of TC Frances 2004.

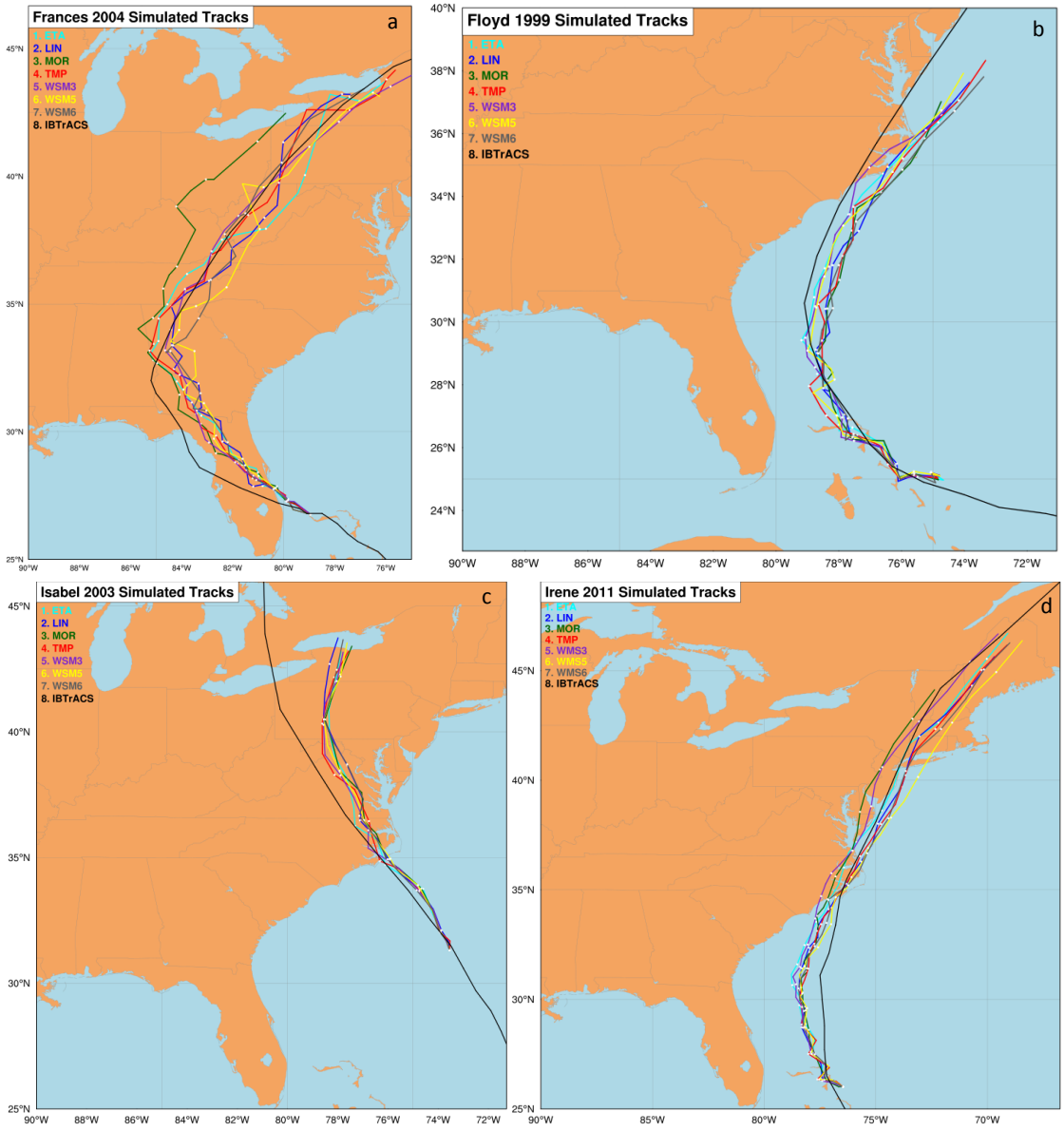


Figure 1: Observed (black) IBTrACS and ensemble member (light blue) ETA, (blue) LIN, (green) Morrison, (red) Thompson, (purple) WSM3, (yellow) WSM5, and (gray) WSM6 TC tracks for (a) Frances 2004, (b) Floyd 1999, (c) Isabel 2003, and (d) Irene 2011.

To explore the use of simulated precipitation fields, modeled and satellite precipitation intensity and location of maxima were compared against available surface observations. The WRF model was in good agreement with station observations and in some locations (particularly over complex terrain) outperformed satellite-based measurements (*figure 2*).

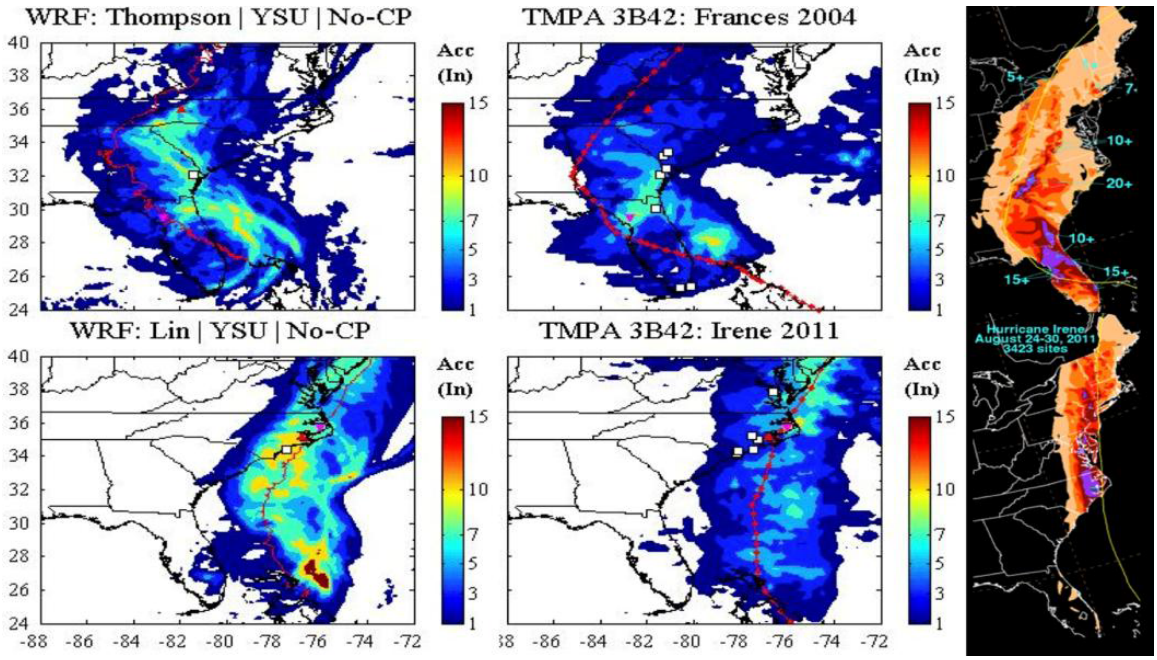


Figure 2: Modeled (WRF; left), remotely sensed (TMPA 3B42; middle), and station observed (right) rainfall accumulation for hurricane Frances (2004; top) and hurricane Irene (2011; bottom). Locations of the ground based (red triangle), remotely sensed (pink triangle), and modeled (white squares) precipitation maxima.

PLANNED WORK

- Complete model and satellite precipitation comparisons with surface measurements (GHCN-D, CRN). Extend the model/satellite comparison to other datasets (TMPA 3B42RT, CMORPH, CMORPH-Corrected, PERSIANN, PERSIANN-CDR)
- Include radar based estimates of precipitation (Stage IV) for the four TCs

DELIVERABLES

- A manuscript describing the challenges and usefulness of numerical methods to investigate TC based hydrological events.

PRESENTATIONS

- Leeper, R.D., O.P. Prat, and B.O. Blanton. Evaluating the Sensitivity of the Weather Research and Forecasting (WRF) Model for Tropical Cyclones Impacting the Carolinas. Abstract submitted to the *Carolinas Climate Resilience Conference*. 28-29 April 2014, Charlotte, NC.
- Prat, O.P., R.D. Leeper, and B.O. Blanton. Comparison of Weather Research and Forecasting (WRF) Model-Simulated Tropical Cyclones and Multi-Sensor Precipitation Estimates Over the Carolinas. Abstract submitted to the *Carolinas Climate Resilience Conference*. 28-29 April 2014.

OTHER

- This project is conducted in collaboration with Brian O. Blanton (Renaissance Computing Institute) for high performance computing and storm surge modeling.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	2
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

The evaluation of the WRF model performance with respect to TC track evolution and precipitation fields will be presented at a conference in Charlotte (April 2014).

Development and verification of US Climate Reference Network (USCRN) Quality Assurance Methods

Task Leader	Ronald Leeper
Task Code	NC-SON-NCICS-RL
NOAA Sponsor	
NOAA Office	NESDIS/NOAA/NCDC
Contribution to CICS Themes (%)	Theme 1: 5%; Theme 2: 40%; Theme 3: 55%
Main CICS Research Topic	Surface Observing Network
Contribution to NOAA Goals (%)	Goal 1: 20%; Goal 2: 80%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: A field campaign was initiated this year with NOAA's Air Resources Laboratory (ARL) precipitation testbed in Marshall, CO. The field study focused on gauge evaporation over the summer of 2013, which showed USCRN gauges were prone to evaporative losses. However, preliminary results indicate that evaporative losses had little impact on total precipitation. In addition, a website was developed to both improve the dissemination of USCRN climate quality data and serve as a spatial check for manual quality control (QC). A manuscript describing the new precipitation algorithm for the USCRN network was drafted and is currently being reviewed by the USCRN Project Science Manager.

BACKGROUND

The US Climate Reference Network (USCRN) monitors the US climate from over 124 well representative (obstacle free) locations across the US, including Alaska and Hawaii. Climate variables of interest (e.g. temperature and precipitation) are observed redundantly with sensors in triplicate to ensure data quality and continuity. Network quality assurance (QA) methods are responsible for both identifying suspicious sensor activity and combining redundant measurements into a single observation. The QA methods provide the foundation for the network to achieve its mission of monitoring the Nation's climate and serve as a valuable resource of current weather and climate information.

ACCOMPLISHMENTS

The previously developed QA algorithm for precipitation was fined tuned as it was recoded into Java (USCRN production language) and deployed within a testing environment prior to production. From the testing environment, the new precipitation algorithm was evaluated in more detail (precipitation event scales) for a selection of 42 stations. Overall, the new precipitation algorithm reported more precipitation inline with earlier network-wide comparisons across all seasons and months. However, algorithms were more dissimilar over the winter season (*figure 1*). Additional analysis revealed that the auxiliary disdrometer, used as an indicator of wetness, had slower response times to hydrological activity, during windy, snowy conditions. The complete analysis (network-wide and station subset studies) and a description of the algorithm have been described in a manuscript that is currently being revised by the USCRN science project manager.

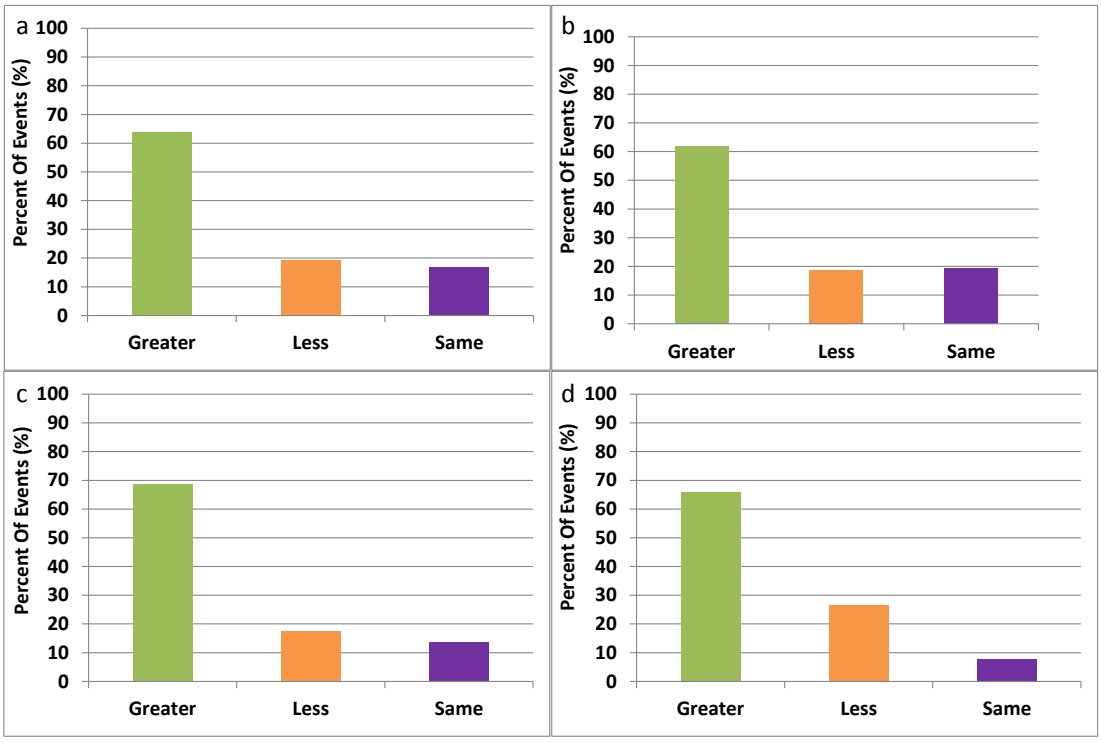


Figure 1: Percentage of precipitation events wAvgQA had (green) greater, (orange) less, and (purple) the same accumulations as currentQA for (a) all cases, and (b) warm (Avg. temperature > 5 C), (c) near-freezing (Avg. temperature < 5 & > -5 C), and (d) frozen (Avg. temperature <= -5 C) temperature conditions.

A gauge evaporation field campaign was initiated at NOAA's ARL testbed over the summer of 2013. The purpose of this campaign was to quantify potential evaporative losses from USCRN gauges and determine what impact these losses may have on precipitation measurements. Over the study period (May to October), there were numerous precipitation events that culminated into one of Colorado's wettest years on record, including the record-breaking precipitation event in early September. Results indicate that USCRN precipitation gauges were prone to evaporative losses, likely due to the lack of a gauge funnel, but had little impact on total precipitation (*figure 2*). The minimum impact of gauge evaporation on QA results may have resulted from the above normal precipitation pattern that existed across much of the Eastern half of the US.

In an effort to enhance access to USCRN data, an interactive website was deployed to disseminate USCRN climate quality data and promote the network's research activities (*figure 3a*). Using geographic information system technology, USCRN data is visually provided in an easy to comprehend content. Beyond disseminating climate data, the website has a dual purpose as a tool for manual QA inspection (spatial consistency check). In addition, a web mapping Application Programming Interface (API) was developed to depict the location of USCRN stations and provide users tools to identify and select stations of interest interactively with embedded links to station data (*figure 3b*).

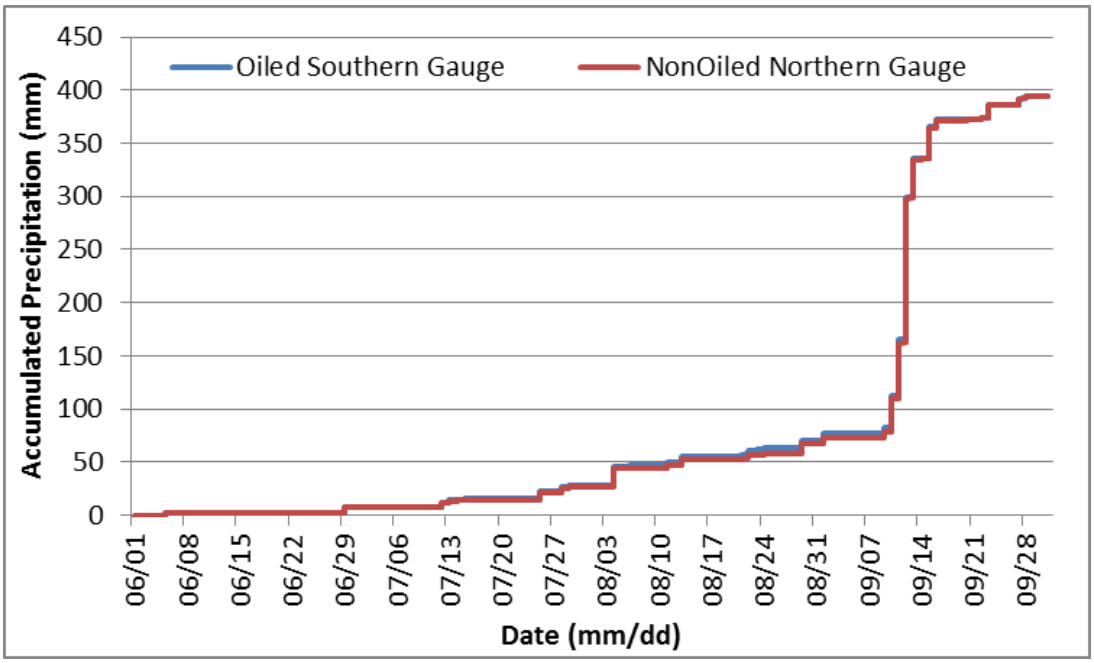


Figure 2: Accumulated precipitation from the (blue) oiled-southern gauge and (red) non-oiled northern gauge at Marshall, CO ARL Precipitation Testbed from June to October of 2013.

PLANNED WORK

- Revise and submit manuscript describing the precipitation algorithm
- Complete analysis of gauge evaporation field campaign
- Transition data visualization and mapping API to USCRN website

DELIVERABLES

- A new QA algorithm to process redundant measures of precipitation.
- A dataset that can be used to evaluate the sensitivity of future precipitation QA methods to gauge evaporation.
- A manuscript documenting the potential evaporative losses from gauges and its impacts on USCRN measures of precipitation
- Enhance methods of communication and user interaction of USCRN climate quality datasets

PRESENTATIONS

- Leeper, R. D. U.S. Climate Reference Network Gauge Evaporation and Impacts on Precipitation Observations. National Climatic Data Center. Asheville, NC. March 2013

OTHER

- NOAA's ARL precipitation testbed experiments were conducted in collaboration with John Kochendorfer of the Atmospheric Turbulent Diffusion Division (ATDD)

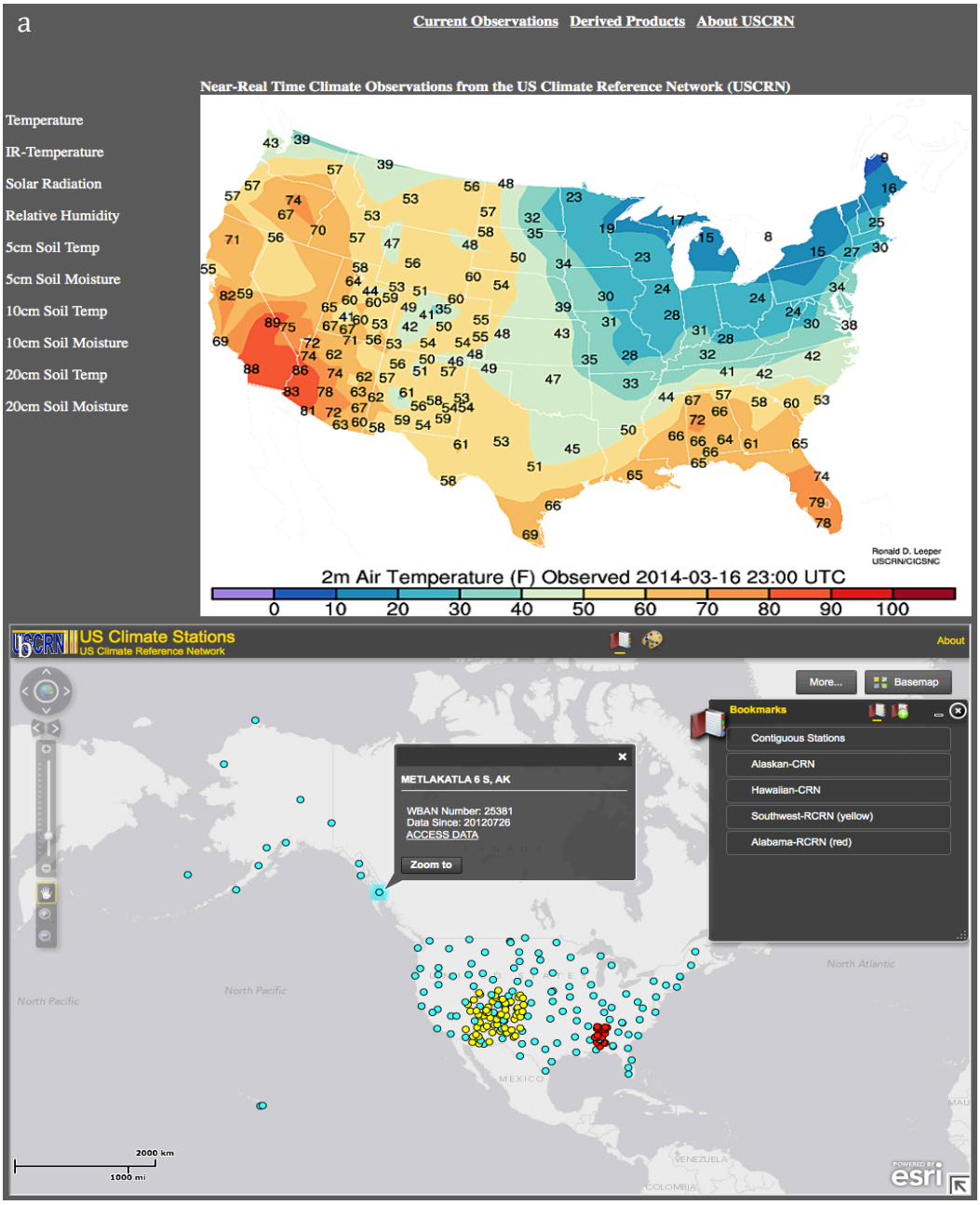


Figure 3: Snapshots of CRNSpatial (a) main page showing two-meter air temperature from USCRN and US Regional Climate Reference Network (USRCRN) stations, and (b) web mapping API depicting station popup information.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	0

# of new or improved products developed without NOAA guidance	2
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

Previously designed QA algorithm for precipitation was slightly modified during recoding. In addition, development of spatial graphics for USCRN climate quality data and web mapping API were developed within the cooperative institute environment. The sole presentation was given via NCDC's internal seminar series on the role of gauge evaporation on USCRN measures of precipitation.

Collocated US Climate Reference Network (USCRN) and Cooperative Observer Network (COOP) Comparisons

Task Leader	Ronald Leeper and Jared Rennie
Task Code	NC-SON-NCICS-RL
NOAA Sponsor	
NOAA Office	NESDIS/NOAA/NCDC
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 80%; Theme 3: 20%
Main CICS Research Topic	Surface Observing Network
Contribution to NOAA Goals (%)	Goal 1: 30%; Goal 2: 70%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: A manuscript describing network differences between USCRN and COOP networks was completed and submitted for internal review. Pending reviewer responses to revised manuscript, the document will be submitted for publication in a peer-reviewed journal.

BACKGROUND

The United States Climate Reference Network (USCRN) was specifically engineered to detect and attribute climate signals over the next 50 years. From station placement, sensor selection and shielding, calibration standards, and redundancy, this network was designed to limit the effect of observational biases on data records. As USCRN data becomes increasingly utilized in climate-focused tasks, differences between traditional cooperative observer (COOP) and modern USCRN networks will become increasingly relevant. The purpose of this study is to compare USCRN and COOP temperature and precipitation measurements and attribute observational discrepancies to station architecture.

ACCOMPLISHMENTS

USCRN and COOP comparisons were reanalyzed to better account for shifts in local observation time as a result of daylight saving adjustments, which had little impact on comparison results. Additional analysis was carried out investigating the synchronization of USCRN and COOP maintenance logs to shifts in network biases, which revealed human observers partially explained some of the inter-station variability in network differences. Regardless of the temperature biases noted in study, anomalous national temperature trends for COOP and USCRN were within 0.1 °C (*figure 1*), indicating the importance of homogenization routines applied to COOP station data. The manuscript describing the network comparison has been internally reviewed with revisions and comments resubmitted.

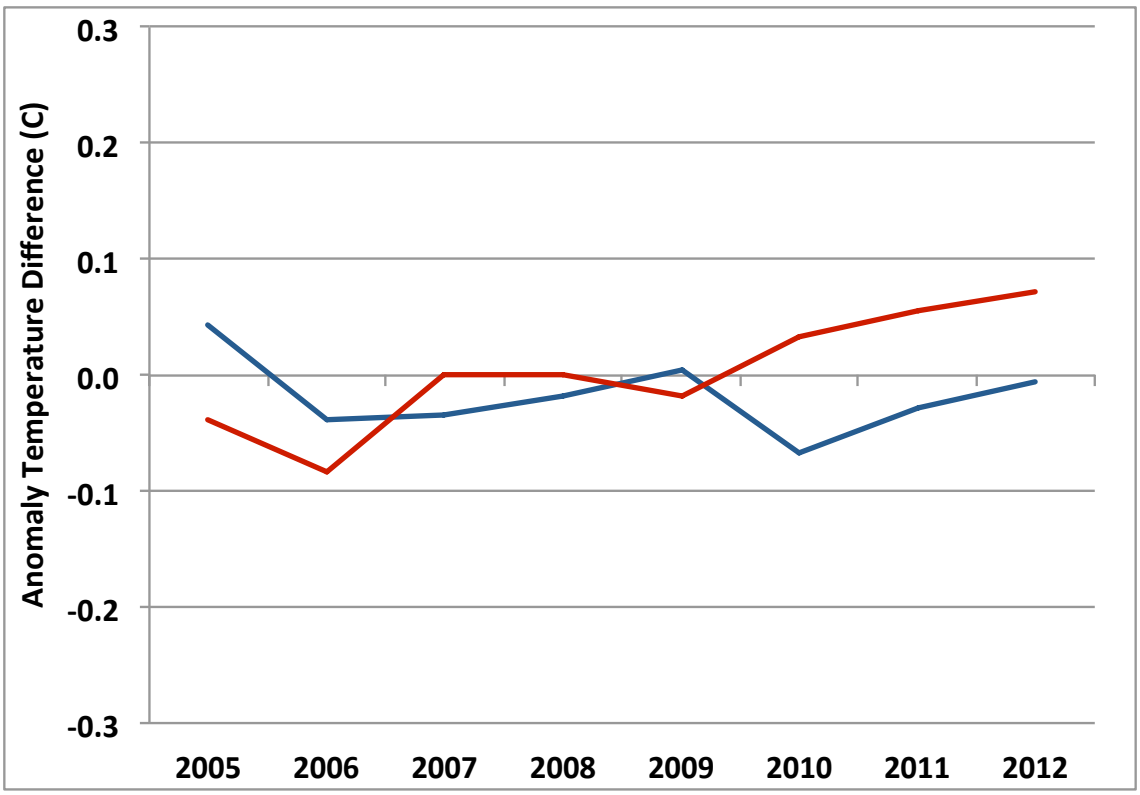


Figure 1: Annual USCRN and USHCNv2.5 maximum (red) and minimum (blue) anomalous National temperature differences

PLANNED WORK

- Submit manuscript externally for publication

DELIVERABLES

- A manuscript describing differences between two networks that will be used in future climate studies.

PRESENTATIONS

- Leeper, R. D. First and last day of frost: A USCRN perspective. Cooperative Institute for Climate and Satellites North Carolina (CICS-NC) Workshop. March 2013.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0

# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

The identification and correction of suspicious COOP observations, mainly precipitation, has resulted in an improvement in the COOP daily record. A presentation was given at the Frost and Freeze workshop hosted by CICS-NC to illustrate how data collection routines can alter the timing of the first and last day of frost.

Maintenance and Streamlining of the Global Historical Climatology Network-Monthly (GHCN-M) Dataset

Task Leader	Jared Rennie
Task Code	NC-SON-07-NCICS-JR
NOAA Sponsor	Jay Lawrimore
NOAA Office	NESDIS/NCDC/GCAD/IAB
Contribution to CICS Themes (%)	Theme 1: 50%; Theme 2: 50%; Theme 3: 0%
Main CICS Research Topic	Surface Observing Networks
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: A new land surface temperature Databank has been publically available through beta releases and work is underway to transition from research to operations. This product will lay the groundwork for the next iteration of GHCN-M, which will include updates to quality assurance and bias correction.

BACKGROUND

Since the early 1990s, the Global Historical Climatology Network-Monthly (GHCN-M) dataset has been an internationally recognized source of data for the study of observed variability and change in land surface temperature. The third version of this product has undergone many updates since its initial release in 2011. Updates include incorporating monthly maximum and minimum temperature, improving processing run time, and providing user driven products.

While there have been tremendous advances in the understanding of climate change since its release, there remain substantial spatial and temporal gaps in GHCN-M due to deficiencies in global collections of data. In addition, there has been limited success at completely documenting the provenance and implementing version control from the point measurement through dissemination and data sharing pathways, quality control, bias correction, and archive and access. More can be done to improve practices to ensure full openness, transparency, and availability of data and the details associated with each processing step.

To address these concerns, scientists from both CICS-NC and NCDC established the International Surface Temperature Initiative (ISTI) in 2010. Since its inception, the initiative has worked to create a single, comprehensive global Databank of surface temperature observations in a consistent and traceable manner. The Databank is version controlled and has data provenance flags appended to every single value, in order to remain open and transparent. There are multiple stages of the Databank, including the original paper record (Stage Zero), keyed data in its native format (Stage One and Two), and a merged dataset with duplicate source data reconciled (Stage Three). All data, along with its underlying code, is available to the public free of charge.

ACCOMPLISHMENTS

Multiple sources of data on numerous timescales have been submitted to NCDC and are currently hosted on the Databank FTP site. Currently the Databank comprises of 33 daily

and 25 monthly sources, collected and converted to a common format (known as Stage Two). In order to have a more robust record of monthly data, daily sources are converted to monthly averages, following standards set by the World Meteorological Organization (WMO). Out of the 58 total sources, 23 of them have regular updates (i.e. daily, monthly, quarterly, etc.). These sources have been updated to include data up to December 2013.

An algorithm has been in development to merge these Stage Two sources together to create a consolidate dataset of monthly global temperature (known as Stage Three). The algorithm attempts to identify and remove duplicate stations, merge identical stations to produce a longer station record (see *Figure 1*), add stations considered unique, and withhold records where it is unclear whether to merge the record or create a new unique record. Using a probabilistic approach, the algorithm attempts to mimic the decisions a hand analyst would make, consisting of metadata matching and data equivalence criteria. Using user-defined thresholds, a candidate station works through these tests and its fate is to merge with an existing station, become unique in its own right, or be withheld for future research.

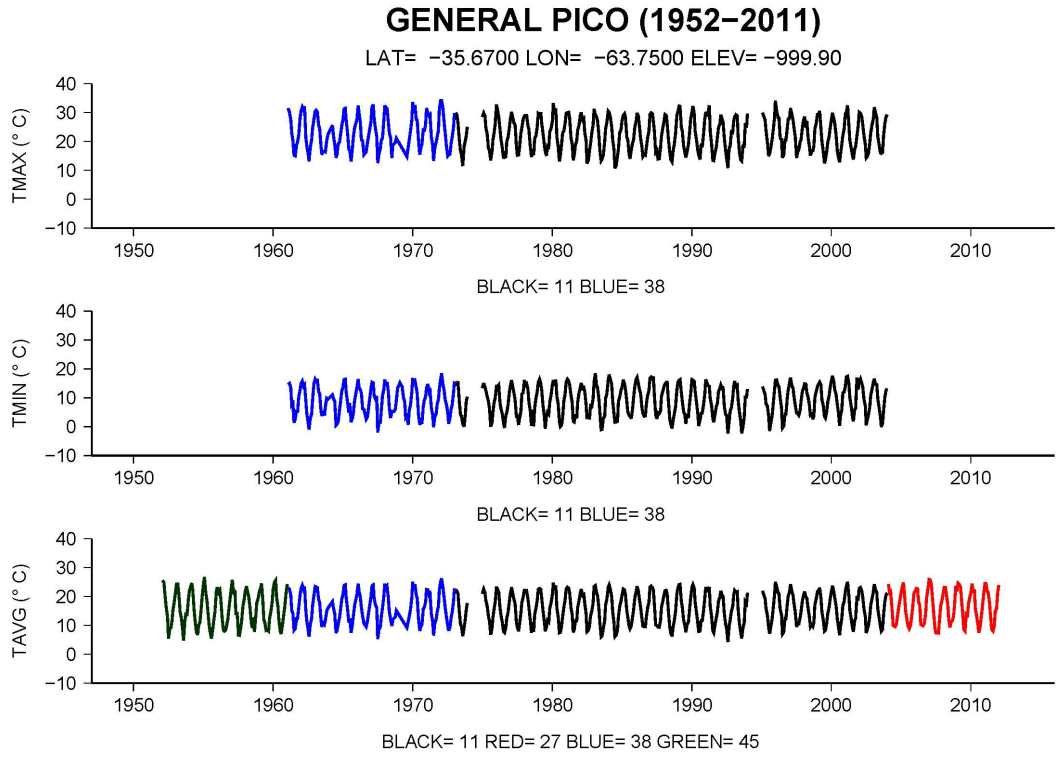


Figure 1: Station series of TMAX, TMIN, and TAVG for General Pico, Argentina. Four data sources consist of the final merged product (Stage Three) including data from Argentina's National Institute of Agriculture (source 11, black), Monthly Climatic Data for the World (source 27, red), NOAA's National Climatic Data Center (source 38, blue), and UK Met Office's CRUTEM4 (source 45, green).

Throughout the algorithm development, multiple beta versions of the Stage Three Databank have been released to the public. For every beta, there exists a recommended product, endorsed by ISTI, along with multiple variants in order to characterize the uncertainty of the algorithm. In June of 2013, a fourth beta release was made publicly available. This update included code improvements, a format change to the Stage Three data, and the inclusion of an additional format in netCDF. Having the Databank in netCDF format was a request made from earlier betas, and developed to be compliant with the Climate and Forecast (CF) Metadata Conventions, version 1.6. The current recommended version of the merged product contains over 32,000 stations, more than four times as many stations as GHCN-M version 3. A histogram of station count by record length compared to GHCN-M version 3 is shown in *Figure 2*. There are not only many more stations in the recommended merge, but also more stations with long series (100+ years).

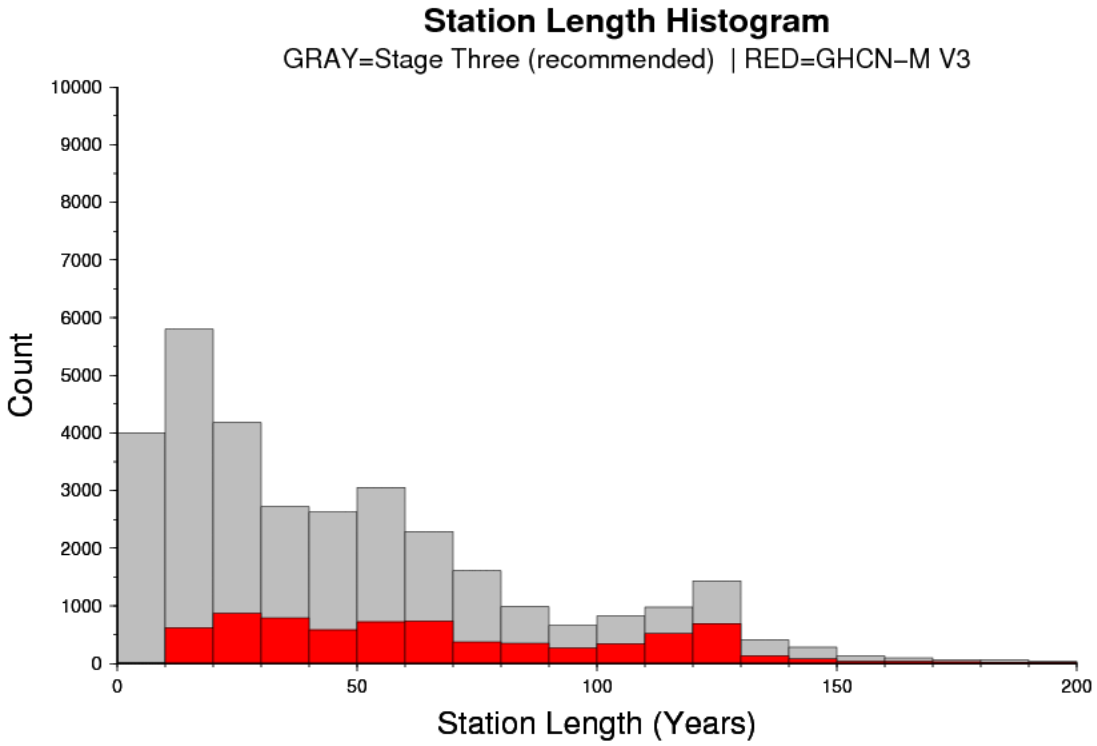


Figure 2: Histogram of station count by record length for the recommended version of the merge product (gray), compared to the operational version of GHCN-M (red).

Currently, the final product is in its final revisions for a version 1 release. A landmark paper describing the methods was written and submitted to Geoscience Data Journal. As of October 2013, this paper has been accepted and is currently on hold to be timed with an official release. NCDC has asked the Databank to go under an Operational Readiness Review (ORR) prior to release. This includes providing documentation of the overall process, including Level Flow Diagrams (see *Figure 3*). These are currently being drafted and will be completed by the end of March 2014.

Once released, the recommended product will serve as the basis for GHCN-M version 4. A development environment has been set up and tests have already been applied to the Databank, including a statistical test for variance. Work is also underway to provide monthly updates, quality control, and bias corrections using NCDC's pairwise homogeneity algorithm. The final output, known currently as alpha 1 (GHCN-M v4.a.1) has been running and will be tested against current operational versions (GHCN-M v3.2.2).

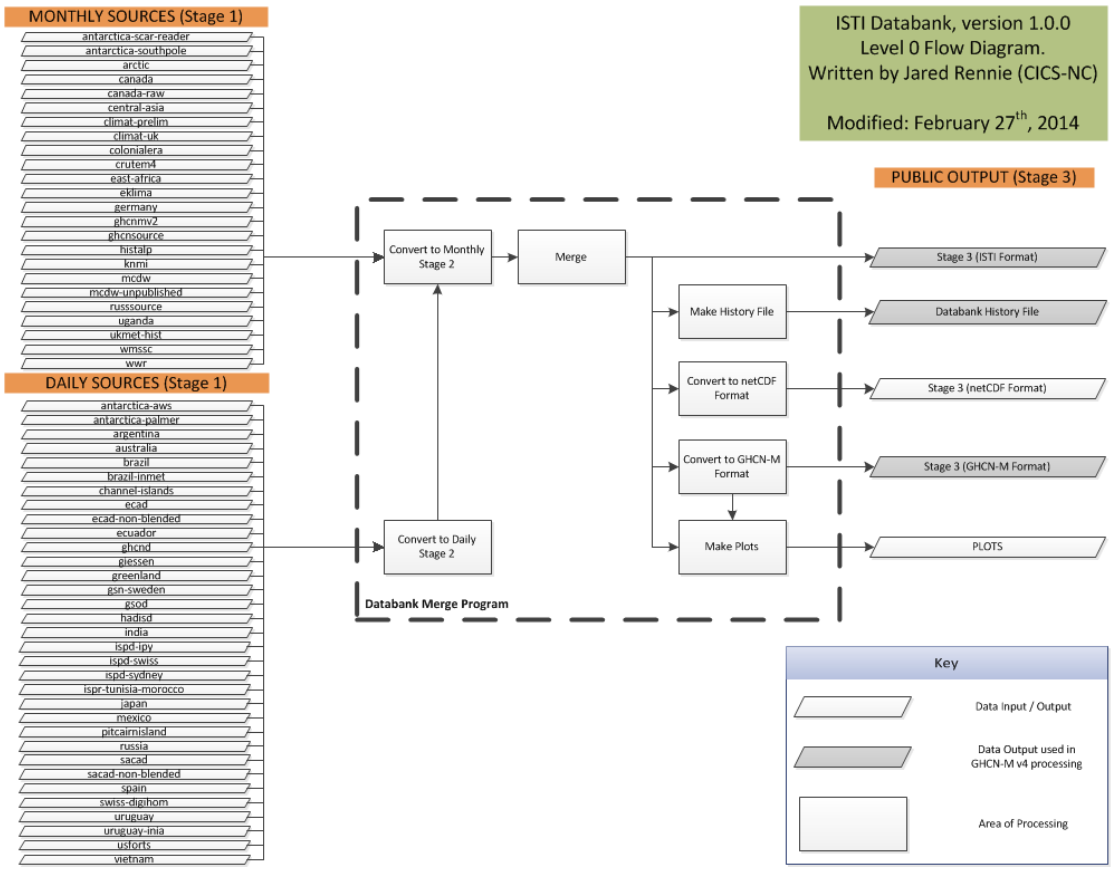


Figure 3: Level 0 Flow Diagram of the entire Databank process to be instituted for version 1.

PLANNED WORK

- Finalize documentation required for Operational Readiness Review
- Release Version 1 of the Databank, and engage with public on feedback.
- Provide updates as needed, including addition of monthly data, as well as action items from user suggestions.
- Continue development of GHCN-M Version 4, Alpha 1, including updating quality control and bias correction algorithms used in GHCN-M version 3 to account for an increase in the number of stations.
- Establish end-to-end process for GHCN-M version 4.0.0, including adhering to standards provided by the Capability Maturity Model Integration (CMMI) model.

PUBLICATIONS

- Rennie, J.J. and coauthors (2013), The International Surface Temperature Initiative's Global Land Surface Databank: Monthly Temperature Data Version 1 Release Description and Methods. Accepted, Geoscience Data Journal.

DELIVERABLES

- Fourth beta release of Stage Three Databank
- Automated algorithm to merge sources together to one consolidated dataset
- Documentation for merging algorithm and software system.
- Alpha versions of GHCN-M version 4.

PRESENTATIONS

- Rennie, J.J. (2013) An Open and Transparent Databank of Global Land Surface Temperature, AGU Fall Meeting, San Francisco, CA, 12 Dec 2013

OTHER RELEVANT INFORMATION

- Location of latest GHCN-M version 3 dataset: http://www.ncdc.noaa.gov/ghcnm/v3.php
- The International Surface Temperature Initiative: www.surfacetemperatures.org
- FTP site of the Global Databank: http://www.gosic.org/GLOBAL_SURFACE_DATABANK/GBD.html

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	2
# of products or techniques transitioned from research to ops following NOAA guidance	1
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	1

PERFORMANCE METRICS EXPLANATION

This year, we have worked on improving our Stage Three Databank Product, and are working to transition from research to operations (a version 1 release). In addition, we have developed an alpha version of GHCN-M version 4 for internal use. One journal paper was written, submitted, and accepted by Geoscience Data Journal. A poster, summarizing the Databank, was presented at the AGU fall meeting in December 2013. CICS-NC Intern Andrew Rodgers assisted with Databank activities from March to September 2013.

Workforce Development

Workforce development is long-term investment in NOAA's future workforce. NCDC has a continuing number of research and workforce requirements that necessitate collaboration with the best climate science practitioners in the nation. This requires the hiring of outstanding scientific staff with unique skills and backgrounds in Earth System Science and the use of observations for defining climate and its impacts. To meet this demand, CICS-NC has hired a cadre of dedicated research staff and is actively working to identify and train the next generation of scientifically and technically skilled climate scientists. Junior and/or aspiring scientists, including students and post-doctoral researchers, play an important role in the conduct of research at CICS-NC. While consistent funding remains a challenge, CICS-NC is nevertheless working to identify prospective future scientists, to nurture interest in climate applications and to provide opportunities for training and mentorship on various levels.

Senior CICS-NC scientists hold research faculty positions in the Marine, Earth, and Atmospheric Sciences Department (MEAS) in the College of Science (COS) at NCSU and provide mentorship to junior scientists and students both in CICS-NC and MEAS. Several junior scientists have also secured adjunct appointments in pertinent departments to gain experience and exposure with their academic peers. CICS-NC scientists are also engaged in various outreach activities to promote awareness and pique interest in science and climate studies at the K-12 level.

CICS-NC initiated its program in workforce development through the hiring of an initial cadre of post-doctoral fellows working on applied research topics in Climate Data Records and Surface Observing Networks. Senior scientists from NOAA and CICS-NC provide mentoring for these fellows. The expectation is a 2-3 year commitment, dependent on circumstances and individual interests.

Meanwhile, CICS-NC has been successful in recruiting and involving local UNC Asheville undergraduates in temporary student internships, providing an opportunity for the students to explore their interest in science and/or apply their ongoing education to current projects within the institute under the oversight of CICS-NC and NCDC mentors.

- William Clark is an Atmospheric Sciences w/ Concentration in Weather Forecasting major at the University of North Carolina-Asheville. As an undergraduate intern, William is working closely with the Technical Support Unit and the National Climate Assessment to learn about climate modeling and gain knowledge in Python. William hopes to explore his interests in carbon dioxide, emissions scenarios, and ocean acidification
- Kelly Gassert is persuing a second bachelor's degree in Atmospheric Sciences at the University of North Carolina-Asheville. She interned with CICS-NC in the summer of 2013, working with Jenny Dissen and Dr. Kenneth Kunkel on the examination of precipitation trends throughout the Southeastern United States and throughout Brazil. She is currently involved in another internship through CICS-NC, where she

will be developing a project in support of the next National Climate Assessment. Under the guidance of Dr. Paula Hennon, Scott Stevens, Andrew Buddenberg, and others, she will analyze radar data, gain knowledge in Python, and continue a more detailed study of climate science.

- Tiffany Maupin is currently a Junior at the University of North Carolina-Asheville. She will be graduating in May 2015 with a major in Weather Forecasting and a minor in Mathematics. As an undergraduate CICS-NC intern, Tiffany is working closely with the Technical Support Unit and the National Climate Assessment and is learning the process of climate modeling with computer applications.
- Jennifer Meyer graduated in May 2013 as an Applied Mathematics major from the University of North Carolina-Asheville. As an undergraduate CICS-NC intern, she gained a greater understanding of the applications of mathematics to the field of climatology. In particular, Ms. Meyer worked with CICS-NC scientists, Drs. Jessica Matthews and Jesse Bell, on the "Comparison of ground based temperature measurements with satellite-derived phenology" task. She applied the methodology developed for 2010-2011 to the 2012 datasets. This experience furthered math skills learned in the classroom and provided an outlet to use these skills to solve real world problems. In addition to advancing her mathematical skills, Ms. Meyer also improved her programming skills, particularly in utilizing Matlab. Her contribution to the CICS-NC project is providing an additional year of analysis, where only two years were previously accomplished.
- Dr. Elsa Nickl Dr. Elsa Nickl completed her Ph.D. in 2012 at the University of Delaware. In her dissertation, she analyzed the spatial and temporal patterns of annual land-surface precipitation over 100-plus years using three sets of available estimates (CRU, GPCC and University of Delaware datasets). Substantial differences among precipitation variability estimates were found, especially within mountainous regions. This encouraged her to develop a new spatial interpolation method for precipitation, which takes into account topographic influences. Her interests are climate variability and change with emphasis in mountainous regions. Dr. Nickl joined CICS-NC as a post-doctoral research scholar in March 2014. She is collaborating in the analysis of the impact of Polar Regions missing information on the global temperature average as part of the Global Surface temperature Portfolio team. She is also collaborating in the application of spatial interpolation methods for precipitation estimation.
- Andrew Rogers joined CICS-NC as an intern in March 2013 and worked with CICS-NC and NCDC staff to further the development of the International Surface Temperature Initiative's (ISTI's) Global Land Surface Databank through the summer of 2013. Work included in depth analysis of a recently developed algorithm to merge temperature stations using advanced statistical measures. Particular attention will be paid to classifying problematic stations and working on optimized solutions using both qualitative analysis and software development. Mr. Rogers has a Bachelor Degree in Meteorology from the University of North Carolina-Charlotte.
- Bobby Taylor is an Atmospheric Sciences major from the University of North Carolina-Asheville, with a concentration in Climatology and minor in mathematics. As an undergraduate CICS-NC intern, he is gaining a greater understanding of the

intersection between climate science and policy, as well as developing strategies for public outreach and engagement surrounding the forthcoming National Climate Assessment. In particular, Mr. Taylor worked with NCA lead science writer Susan Hassol and copy editor Tom Maycock on the NCA3 *Highlights* Document. Mr. Taylor also assisted the Technical Support Unit at the February 2014 NCADAC meeting. Moving forward, Mr. Taylor will contribute to the TSU's support of the USGCRP's National Climate Indicators System through his understanding of climate science and geographic information systems. In addition to his work with the National Climate Indicators, Mr. Taylor will participate in an ongoing outreach and engagement effort after the release of the National Climate Assessment.

- Dr. Wei Liu completed his Ph.D. in 2012 at the University of Wisconsin-Madison. In his dissertation, he studied the stability of the Atlantic Meridional Overturning Circulation (AMOC) using the NCAR CCSM3 model. Dr. Wei Liu proposed and developed an indicator that correctly monitors the AMOC stability in CCSM3. More generally, he has broad interests in physical oceanography and climate dynamics and has studied internal wave breaking and associated diapycnal mixing in the interior ocean by using direct numerical simulation. Dr. Liu joined CICS-NC as a post-doctoral research scholar in March 2013. He supported the development of a next generation integrated global surface temperature analysis and provided an inter-comparison analysis and development of scenarios for specific datasets as part of the Global Surface Temperature Portfolio team.

Global Surface Temperature Portfolio: Sea Surface Temperature Analysis-ERSST

Task Leader	Wei Liu
Task Code	
NOAA Sponsor	
NOAA Office	NCDC
Contribution to CICS Themes (%)	Theme 1: 70%; Theme 2: 30%; Theme 3: 0%
Main CICS Research Topic	Data Fusion and Algorithm Development
Contribution to NOAA Goals (%)	Goal 1: 0%; Goal 2: 25%; Goal 3: 25%; Goal 4: 25%; Goal 5: 25%

Highlight: This project analyzed the parametric uncertainty quantification for monthly Extended Reconstructed Sea Surface Temperature (ERSST) version 4 (v4) by adopting a Monte Carlo ensemble approach.

BACKGROUND

This report summarizes Dr. Wei Liu's work of the ongoing NOAA project entitled "Global Surface Temperature Portfolio: Sea Surface Temperature Analysis-ERSST." An updated version of ERSST (ERSST.v4) has been developed, featured with an analysis of parameter uncertainty.

Table of ERSST.v4 operational and ensemble settings

	Parameter	ERSST.v4 "Operational"	Option 1	Option 2	Option 3
1	SST STD for QC	**From OISST 1982-2011 (70%)**	From COADS 1950-1979 (30%)		
2	SSTA Calculation in QC	**On an *in situ* basis (70%)**	On a grid box basis (30%)		
3	NMAT for Bias Correction*	**HadNMAT2 (70%)**	UKMO NMAT (30%)		
4	Bias Correction Smoothing	**f=0.10 (40%)**	f=0.05 (20%)	f=0.20 (20%)	Linear as v3b (20%)
5	Ship-Buoy Adjustment	**0.12 (50%)**	0.10 (25%)	0.14 (25%)	
6	LF Anomaly Filling	**Nearby anomaly filling (70%)**	Zero-anomaly filling (30%)		
7	EOT Training Period	**1982-2011 (50%)**	1982-2005 (25%)	1988-2011 (25%)	
8	EOT Weighting	**$W=N/(N+\xi^2)\cos(\varphi)$ (70%)**	$W=\cos(\varphi)$ (30%)		
9	EOT Critical Value	**0.10 (50%)**	0.08 (25%)	0.12 (25%)	
*Adjustment is linear before 1886 using 1886 adjustment					

Table 1. Parameter settings in ERSST.v4 operational and ensemble runs.

A total of 9 of the changed parameters included in ERSST.v4 have been varied and for each parameter, 2-4 options are possible (operational product settings and 1 to 3 alternates). The

operational run in ERSST.v4 is conducted by using the first selection of each of the parameters shown in the table. Meanwhile, 100 ensemble runs are carried out with a Monte Carlo ensemble approach in which a random sampling is repeated for achieving 100 unique sets of parameter combinations, based on a probability weighting on each parameter option. Note here, bias adjustments prior to 1886 are set as the annual cycle in 1886, since the night marine air temperature (NMAT) data in HadMAT2 and UKMO NMAT are not reliable before 1886.

ACCOMPLISHMENTS

Globally, this ensemble exhibits a wider uncertainty range before 1900 as well as an uncertainty maxima around WWII. Changes at smaller spatial scales in many regions, or for important features such as Niño-3.4 variability, are dominated by distinct parameter choices.

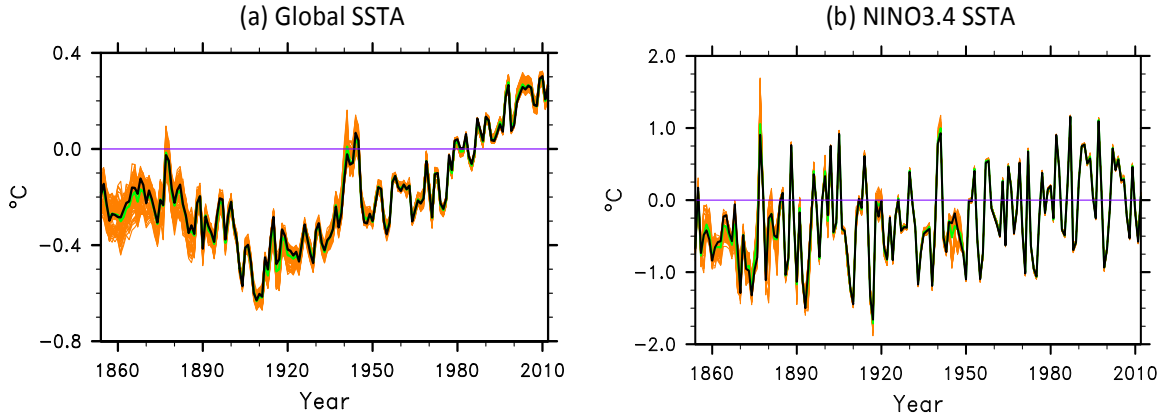


Figure 1: SST anomalies (SSTAs) relative to a climatological SST (1971-2000) for (a) globe, (b) NINO3.4 region in ERSST.v4 ensemble runs (orange), the operational run (black), and the ensemble mean (light green).

PLANNED WORK

- Continue work on developing ERSST.v5

PUBLICATIONS

- Huang, B., V. F. Banzon, E. Freeman, J. Lawrimore, W. Liu, T. C. Peterson, T. M. Smith, P. W. Thorne, S. D. Woodruff, and H-M Zhang, 2014: Extended Reconstructed Sea Surface Temperature version 4 (ERSST.v4), part I: Upgrades and Intercomparsions. *J. Climate*, in review.
- Liu, W., B. Huang, P. W. Thorne, V. F. Banzon, H-M Zhang, E. Freeman, J. Lawrimore, T. C. Peterson, T. M. Smith, and S. D. Woodruff, 2014: Extended Reconstructed Sea Surface Temperature version 4 (ERSST.v4), part II: Uncertainty Estimation. *J. Climate*, in review.
- Liu, W., Z. Liu, J. Cheng, and H. Hu, 2014: On the stability of the Atlantic meridional overturning circulation during the past deglaciation. Clim. Dyn., in revision.

PRESENTATIONS

- Liu W., Z. Liu, E. Brady, and J. Cheng, 2013: The forcing mechanism on the Southern Ocean upwelling during the last deglaciation, Woods Hole Oceanographic Institution, MA (30 May).
- Liu, W., B. Huang, P. W. Thorne, V. F. Banzon, H-M Zhang, E. Freeman, J. Lawrimore, T. C. Peterson, T. M. Smith, and S. D. Woodruff, 2014: Extended Reconstructed Sea Surface Temperature version 4 (ERSST.v4). *2014 Ocean Science Meeting*, Honolulu, HI, (23-28 Feb.).

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	3
# of non-peered reviewed papers	0
# of invited presentations	2
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

This year, the project group developed a new version of ERSST (1). Two journal papers on ERSST related to the project have been under review (2). One presentation was made related to this project (1).

Consortium Projects

The CICS Consortium includes a wide range of research universities, non-profit organizations, and community groups. Its role is to augment the capabilities of CICS and to extend its ability to conduct innovative and original collaborative research with NOAA. The CICS Consortium provides NOAA with extraordinary opportunity to engage the extra-federal scientific and user communities on research, development, and outreach issues. It is a remarkably broad and flexible mechanism that enables NOAA to benefit from the collective wisdom and capability of its members.

Consortium projects have involved such projects as quantifying the ecological effects of sea level rise in North Carolina, the development and distribution of high resolution gridded Standardized Precipitation Index (SPI); enhancing the data visualization capabilities of NOAA's Climate Services Portal; and studying the spatio-temporal patterns of precipitation and winds in flood prediction.

Maps, Marshes and Management Application: Ecological Effects of Sea-Level Rise in North Carolina

Task Leader	Tom Allen
Task Code	
NOAA Sponsor	
NOAA Office	NOAA CSCOR
Contribution to CICS Themes (%)	Theme 1: 10%; Theme 2: 40%; Theme 3: 50%
Main CICS Research Topic	Extreme Climate research, Data Assimilation and Modeling
Contribution to NOAA Goals (%)	Goal 1: 60%; Goal 2:0%; Goal 3: 0%; Goal 4: 30%; Goal 5: 10%

Highlight: This project developed and implemented web-based geospatial decision support information for managing coastal marshes. Results from prior funded mapping and modeling efforts have been assimilated on the new NC Coastal Atlas in collaboration with coastal resource management stakeholders.

BACKGROUND

Coastal managers in North Carolina and beyond depend upon scientists to provide information on sea-level rise. The prior NOAA-supported North Carolina Ecological Effects of Sea-Level Rise (NCEESLR) project focused on process investigations of relative sea-level rise, acquisition of baseline data, and model simulations for estimating wetland responses to sea-level rise. Maps, shoreline and erosion rates, and wetland vulnerability, and observations of estuarine system evolution were developed.

This task aimed to synthesize these research results and geospatial data and compile maps for coastal management decision-making and communications for sea-level rise (SLR) in North Carolina. Towards this, we conducted needs assessments and workshops with management partners to discover, prioritize, and capture design and distribution methods for EESLR information. These tasks led to a groundswell of requests for support to develop a portal for dissemination and interaction, spawning the prototype architecture for the North Carolina Coastal Atlas and ultimately a partnership to connect resource agencies, researchers, and the management community. Sea-level rise was the primary impetus for ongoing resource management in agencies including NC Sea Grant, The Nature Conservancy, Albemarle-Pamlico National Estuary Progrm (APNEP), NC-DENR Division of Coastal Management (NC Estuarine Research Reserves and other programs), NC Coastal Federation, and several others are who joined together in this effort.

Results of scoping efforts drafted the prototype online portal using sea-level rise and associated geospatial data. However, policy challenges in NC promulgated impediments to the State agencies' willingness to focus on SLR, and the SLR focus was temporarily shifted to the background of the atlas themes (although data were still warehoused and the architecture for maps and tools developed). Recently, the Atlas partnership has rejuvenated this SLR theme in partnership and support of NC-DCM (February 2014 Steering Committee meeting of the Atlas.) Several partners on the steering committee expressed their strong desire and commitment to publishing SLR-related data. The project also partnered with

university and other agencies (including the NOAA NC Sentinel Sites Cooperative on SLR) to publish a master list of projects and publications on SLR and related data and publications.

New coastal marsh products are being integrated in the atlas along with targeted data and tools to support DCM coastal management mandates. These maps include the historical shorelines (estuarine and oceanfront) and marshes used in the NCEESLR project as well as new layers directly targeted at the outset of our project-marsh migration and response rates, the marsh vulnerability metrics from the Marsh Equilibrium and hypsometric vulnerability metrics, and new maps and information on marsh loss and migration (e.g., orthophotography since the Nor'Ida storm and hurricanes Irene and Sandy) as well as numerous base maps (land cover, transportation, and NOAA bathymetry).

The NC Coastal Atlas portal:
http://www.nccoastalatlas.org/

ACCOMPLISHMENTS

Key accomplishments are:

- Hosted a workshop on the atlas for agencies and interested partners in May 2013 (35 attendees) at Manteo, NC.
- Joined in partnership with parallel SLR and coastal web atlas publishers to share information and ensure compatibility across State and other jurisdictions
- Maintain ongoing communications with peer projects in the adjoining states and regions (Governor's South Atlantic Alliance data portal, MARACOOS, Virginia Coastal GEMS web atlas).
- Secured agreements from SLR map producers in NOAA Coastal Services Center and Climate Centrol to stream their SLR map layers into the NC Coastal Atlas via webmap services.
- Obtained NC Floodplain Mapping Program permission and data for sharing LiDAR elevation data, updated floodplain maps and building footprints, and new marsh response maps for SLR (produced for future floodplain mapping in the unreleased NC Sea Level Rise Risk Mgt Study). The latter data were obtained with NCFMP permission from Dewberry contractor and are now being added to the atlas wetland thematic map theme.
- Partnered with NOAA NC Sentinel Site Cooperative to inventory projects and build a thematic map for project activity.
- Developed a data catalog and bibliography for coastal NC geospatial data and research publications. The bibliography now exceeds 900 publications that can be visualized by geotagged entries and searched by a master keyword list.
- User case experiences and case studies are undergoing a targeted evaluation by ECU technical communications faculty (the "UserEx" study) with results to feedback for atlas improvements in the coming fiscal year.
- Secured ongoing funding from NCDENR-DCM for five years (annually renewing at $35k) in support of NC CZMA.

- Acquired student support to develop SLR maps for three NC communities (Manteo, Plymouth, and New Bern) and host these on the atlas portal from Carolinas Integrated Science and Assessments (CISA).
- Presented the atlas to diverse and numerous audiences, including NOAA Social Coast Forum, APNEP Symposium on the Sounds, ECU FaculTea and Geography Department Colloquia, NC ArcGIS User Group, NC Triangle Environmental Health Collaborative, and Coastal and Estuarine Research Federation.

Thematic Map

Our stakeholder engagement efforts in needs assessment and workshops and presentations resulted on focusing on both interactive mapping and custom ready to use thematic maps. The guidance and tutorials for interactive mapping is in progress, but our thematic map for wetlands has been published. This map is also the location where SLR-related marsh response and vulnerability layers are being added.

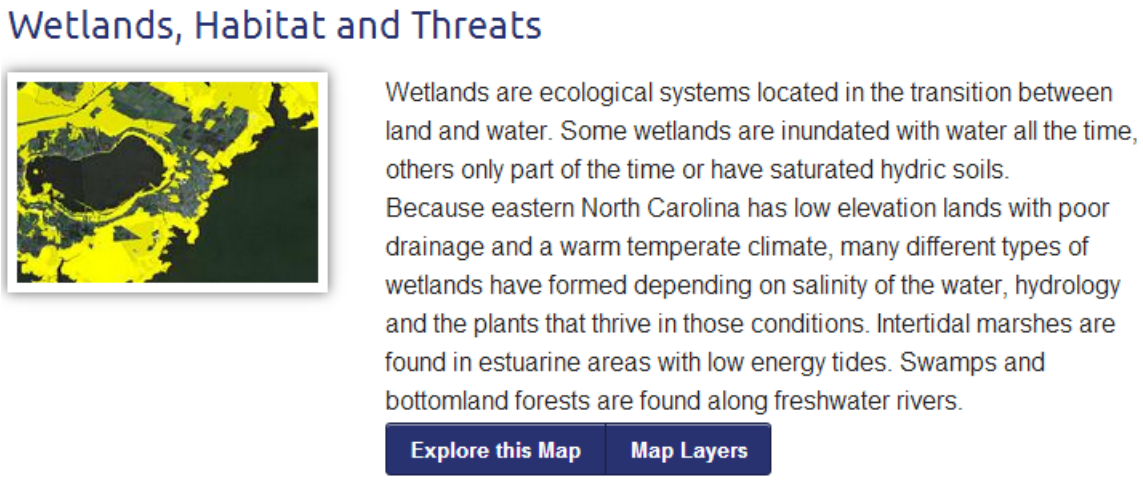


Figure 4. Screenshot from the wetlands thematic map's "landing page" (http://www.nccoastalatlas.org/maps)

User guidance on this map is detailed further in the documentation.
http://www.nccoastalatlas.org/maps/by-title/wetlands-habitat-and-threats#layers

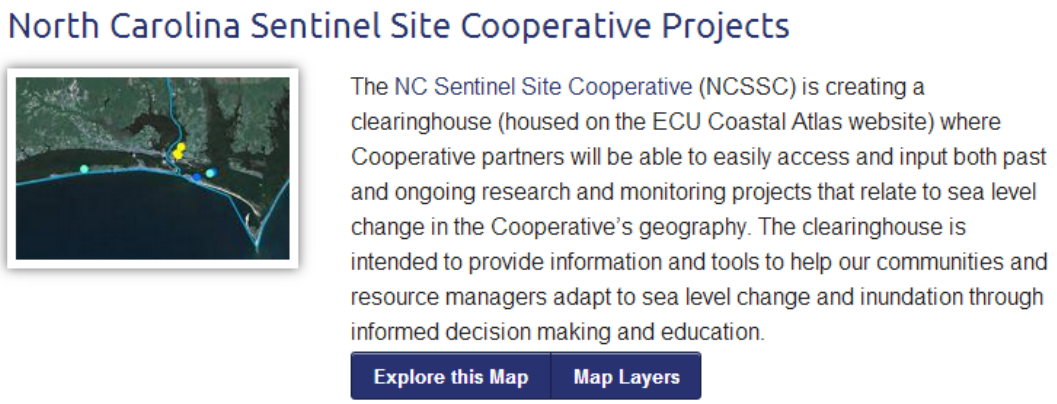


Figure 5. NC Sentinel Sites Cooperative thumbnail introduction leads to a landing page (Map Layers) and custom map (Explore this Map.)

CISA Support for Community Water Infrastructure

The NOAA-supported Carolinas Integrated Science Assessments (CISA) provided grant funds for a graduate student to utilize the atlas for developing community-level vulnerability in three coastal towns (Manteo, Plymouth, and New Bern). For each community, the water infrastructure is mapped and overlaid on current floodplains and future SLR scenarios (*including SLR marsh migration layers*.)

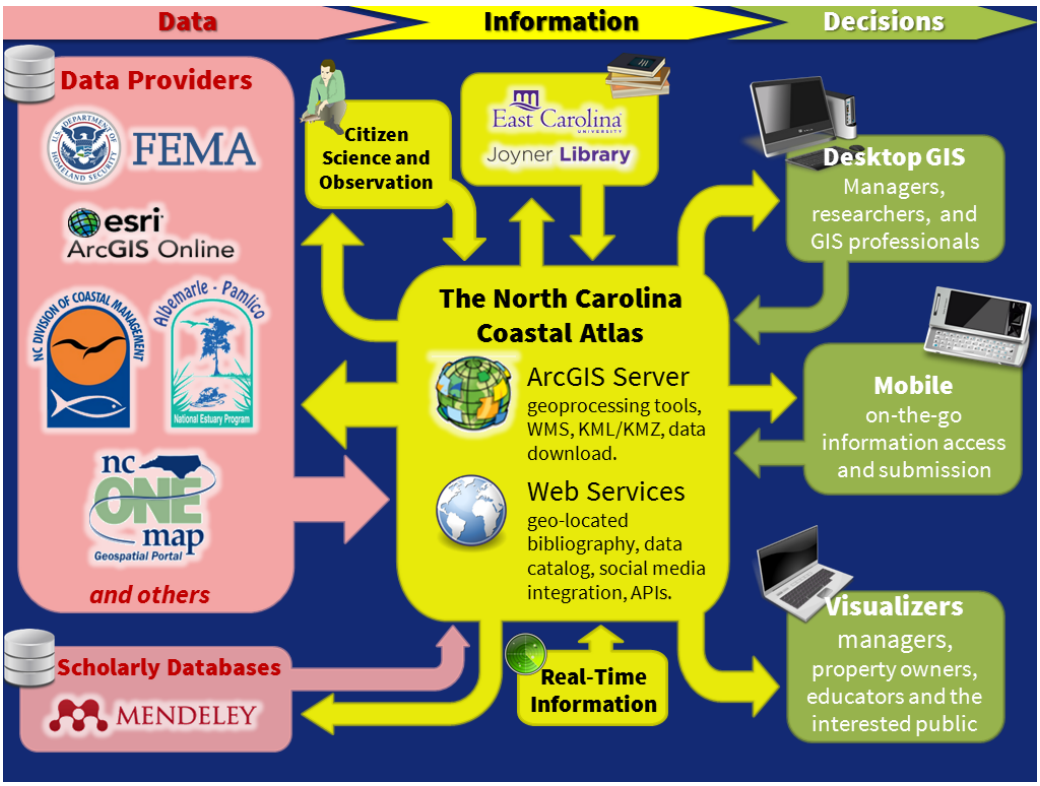


Figure 6. Schematic overview of NC Coastal Atlas organization. Planning is ongoing for modifications for mobile applications and interactive citizen science/participatory uses. Real-time observations are foreseeable but not in operational plans.

PLANNED WORK

Future work will expand upon the developed maps and atlas infrastructure in the following specific tasks pending available funding:

- Incorporate new satellite-based maps and trends for coastal marshes and related ecosystems (e.g., Landsat 8 data marsh indices, land use/cover change trends, submerged aquatic vegetation and invasive species)
- Add high and low marsh extent maps from an ongoing project of the South Atlantic Landscape Conservation Cooperative (SALCC)
- Finalize the symbology of map layers of marsh loss and migration and historical shorelines in collaboration with the steering committee and partners.
- Include forthcoming maps of marsh vulnerability (data forthcoming from Baruch Marine Institute on SALCC project)
- Seek and establish partnerships and funding to support ongoing management and outreach activities of NC Sea Grant, Albemarle-Pamlico National Estuary Program, and other divisions of NC-DENR (Shellfish/sanitation, marine fisheries) and other NC universities.
- Further implement atlas layers and maps in operational permit review applications in the coming fiscal year for NC DCM.
- Forthcoming Post-Sandy Lidar under a mission of USGS-FEMA will be acquired and integrated in the atlas upon availability (expected December 2014) and utilized in a not yet funded project to update the marsh vulnerability mapping and equilibrium model.
- Development ongoing partnership with the NC Land of Water non-profit foundation to enhance resilient economic community development, expanding the inventory of coastal natural resources and adding cultural heritage assets.

PUBLICATIONS

- One book chapter featuring the SLR and wetland related maps and graphics was published and another one is in review. The published map on surge visualization incorporates elevation data used in the project for marsh elevation uncertainty.
- Allen, T. R., Sanchagrin, S., & McLeod, G. (2013). Visualization for Hurricane Storm Surge Risk Awareness and Emergency Communication. In John Tiefenbacher (Ed.), *Approaches to Disaster Management- Examining the Implications of Hazards, Emergencies, and Disasters* (pp. 105-129). Rijeka, Croatia: InTech.
- Allen, T. R. (2014). Advances in Remote Sensing of Coastal Wetlands: Case Studies from North Carolina. Under Review, In Charles Finkl and Antonio Klein (Eds.), *Advances in Coastal and Marine Resources: Remote Sensing and Modeling*. (in review)

DELIVERABLES

The project delivered multiple web-based map layers, metadata, and associated spatial analysis tools for coastal marsh management. All geospatial data are hosted and served by the atlas website.

The maps include standard federal wetland inventories, state critical wetland habitats, elevation, and vulnerability to sea level rise. Each layer is also supported by metadata documentation and lineage. A dedicated wetland thematic map has been published with custom cartography and a "landing page" for users to review for guidance in use and application. Further, we have begun to populate a supporting bibliography with online linkages to published peer-reviewed research and grey literature. Finally, ancillary GIS layers are included for mapping, such as historical land use/land cover, orthophotography (for visualizing erosion and marsh dieback/migration), and shoreline erosion and structures. At the conclusion of the project, the last maps to be added are future scenarios of marsh extents derived from the NC Sea Level Rise Risk Management Study with projections for future relative SLR of 40, 70, 100, and 140 cm.

PRESENTATIONS

The project was presented at the following meetings in the last year:

- NC Coastal Atlas Workshop, May 14-15, Manteo, NC
- NC Hurricane Workshop, May 23, Greenville, NC
- ECU Geography, Planning and Environment Colloquium, Oct. 15, Greenville, NC
- NC ArcUser Group, Oct. 29-30, Carolina Beach, NC
- APNEP Symposium on the Sounds, Nov. 18, New Bern, NC
- Coastal and Estuarine Research Federation, Nov. 3-5, San Diego, CA
- NOAA Social Coast Forum, Feb. 18-20, Charleston, SC
- ECU FaculTea, March 5, Greenville, NC

OTHER

A map produced for the project by four students advised by the PI was awarded Best Map in the *Florida GIS Conference Map Gallery* (2013). "Potential Sea-Level Rise Impacts in North Carolina." A related map was presented at the *ESRI International User Conference 2012* and awarded runner-up for Best Digital Map Compilation from among 3,000 map presentations. This map was also invited and published in ESRI's annual map book.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	1
# of products or techniques transitioned from research to ops following NOAA guidance	1
# of new or improved products developed without NOAA guidance	2
# of products or techniques transitioned from research to ops without NOAA guidance	2
# of peer reviewed papers	1
# of non-peered reviewed papers	1
# of invited presentations	8

# of graduate students supported by a CICS task	2
# of graduate students formally advised	5
# of undergraduate students mentored during the year	1

PERFORMANCE METRICS EXPLANATION

The enumeration of products counts the aggregated coastal atlas portal. Additional tools and data produced without NOAA guidance include ancillary geospatial data and the volunteered effort of the coastal bibliography. Peer reviewed papers include one published book chapter (but not one in review). Presentations only count public events and not small group invited presentations (e.g., APNEP Policy Board or Science and Technical Advisory Committee). Graduate students supported and advised included three doctoral students in Coastal Resources Management, two Master's students in geography, and one biology undergraduate.

Note:

CICS-NC support of this project at East Carolina University ended 12/31/2013 following an approved no-cost extension June 2013.

Radar-based SPI to Support NIDIS

Task Leader	Ryan Boyles
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 50%; Theme 2: 50%
Main CICS Research Topic	Data Fusion and Algorithm
Contribution to NOAA Goals (%)	Goal 1: 75%; Goal 2:25%

Highlight: This project group has transitioned an experimental high-resolution drought-monitoring product into an operational service now used routinely by authors and contributor to the weekly US Drought Monitor.

Background

This summarized the effort implement web service middleware technology to enable NIDIS and Drought.gov to directly access and visualize high resolution Standardized Precipitation Index (SPI) created using Multi-sensor Precipitation Estimates (MPE). The methodology for this product was introduced in "McRoberts, D. Brent, John W. Nielsen-Gammon, 2012: The Use of a High-Resolution Standardized Precipitation Index for Drought Monitoring and Assessment. *J. Appl. Meteor. Climatol.*, **51**, 68–83". Modification of this, and expansion was supported by USDA award 2011-67019-20042 to Nielsen-Gammon, Boyles, and Niyogi. The USDA award allowed the team to create SPI products that provide spatial resolution of ~5km over the full extent of CONUS. National authors for the US Drought Monitor had requested that this product be make operational and routinely accessible into their weekly mapping framework. This CICS-NC award enabled the transition of an experimental product into an operational framework that now supports routine drought monitoring for the US Drought Monitor (USDM) authors and contributors.

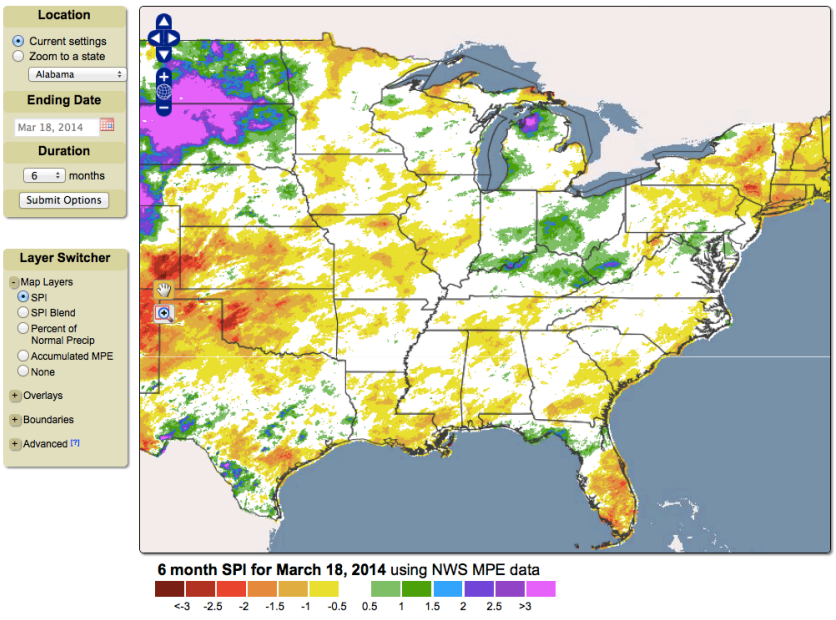


Figure 1. Screen shot of the operational website driven on THREDDS middleware data service.

ACCOMPLISHMENTS

An implementation of the THREDDS gridded data server was tested to provide routine web service access for the gridded SPI products. THREDDS supports Open Geospatial Consortium (OGC) standards for web services, including Web Mapping Service (WMS), Web Coverage Service (WCS), and Web Feature Service (WFS) for geospatial data. These standards are widely used to allow web- and desktop-based tools to download and display distributed data sets efficiently, and are supported in standard mapping software including the ESRI ArcMap tools used by US Drought Monitor authors.

OGC services were confirmed and implemented for front-end web page (http://www.nc-climate.sncsu.edu/drought/), then replicated for other locations (e.g. http://atmo.tamu.edu/osc/drought/). Scientists worked with USDM authors to enable routine production of data grids in GeoTIFF format and WMS-compliant maps colorized for the USDM standards.

THREDDS is installed and implemented on a robust Linux server that allows for future expansion of storage and enable long-term operational production of these data. The full set of data is available for public access via the THREDDS catalog at: http://convection.meas.ncsu.edu:8080/thredds/catalog/sco/spi/catalog.html

Documentation of the methods and guidance on implementation is available at: http://www.nc-climate.ncsu.edu/spi/SPI_HowToDocument.pdf

PLANNED WORK

This project was completed in December 2013. However, we are looking for opportunities to develop other drought monitoring products using MPE as the input. The THREDDS service will serve as the home for future products.

DELIVERABLES

- Operational web service delivery of high-resolution drought grids.

PRESENTATIONS

- American Association of State Climatologists, July 2013, St. Louis, MO

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	1
# of peer reviewed papers	0

# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	1
# of undergraduate students mentored during the year	0

Programming and Applications Development for NOAA's Climate Services Portal (NCSP)

Task Leader	Jim Fox
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 100%; Theme 2: 0%; Theme 3: 0%
Main CICS Research Topic	Climate Research, Data Assimilation, and Modeling
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: Staff from UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC) assisted with the enhancement of data visualization capabilities with the Global Climate Dashboard, specifically with the development of Multigraph, the Climate Explorer prototype, and Data Snapshots. These new products support the overall advancement and progression of the NOAA's Climate Services Portal (NCSP) program.

BACKGROUND

There is an increasing need within NOAA's online climate services for greater collaboration to incorporate climate services across NOAA and enhance NOAA's web presence in response to customer requirements. NOAA's Climate Services Portal (NCSP) is envisioned to be the "go-to" website for NOAA's climate data, products and services for all users. Towards this end, the NCSP has had a need for expertise and resources to support programming work for applications development and data visualization in support of the Global Climate Dashboard, the new Climate Conditions section, the Data section, and other sections of the Portal.

This work addressed NCSP's immediate needs in the following three task areas: a) enhancement of current data visualization capabilities (Multi-Graph, etc); b) enhancement of current online mapping (GIS-based) applications; and c) Past Weather Widget replacement and related activities.

ACCOMPLISHMENTS

Enhancement of current data visualization capabilities:

Multigraph is a software library, developed at NEMAC, which supports the creation of interactive data graphs in web pages and web-based applications. It has been in use for several years on NCDC's web site and on climate.gov.

In the period covered by this report:

- Several maintenance updates were made to the core Multigraph codebase to support features needed for the Global Climate Dashboard and the Climate Explorer; these adjustments allow applications to have more control over the display of graph axes, and labels along the axes.

The “Global Climate Dashboard” is a web application that provides the user an interactive view of several global climate data sets such as temperature, carbon dioxide, arctic sea ice extent, etc, which are key to understanding climate change trends. The current Dashboard application was written by NEMAC in 2011 and has been deployed on the home page of climate.gov since October of that year.
In the period covered by this report:

- A new version of the Dashboard was deployed to climate.gov in October (*Figure 1*) to work around a bug in Internet Explorer; this version allows the Dashboard to work correctly in IE in spite of the bug.
- Another new version of the Dashboard, and the Drupal module that contains it, was deployed in February, to allow the data sets displayed in the Dashboard to be moderated and edited by site editors as Drupal content types.

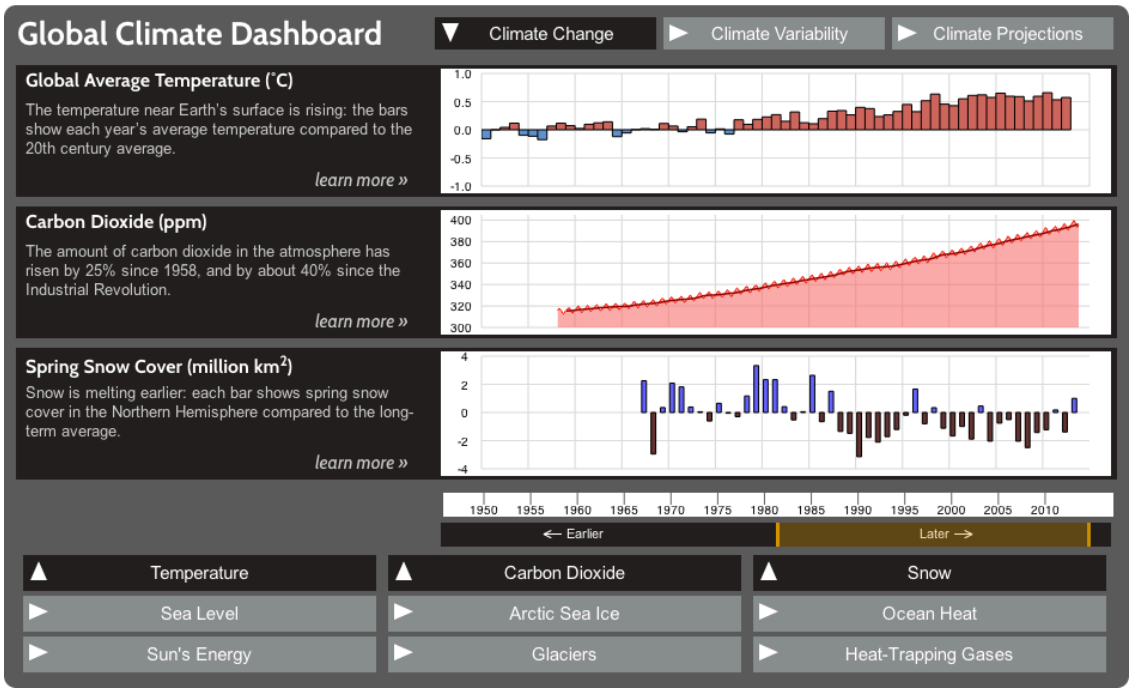


Figure 7 Screenshot of Global Climate Dashboard

Enhancement of current on-line mapping (GIS-based) applications:
The “Climate Explorer” is a web application in the early stages of development, whose purpose is to facilitate the viewing of historical weather data in the context of long-term climate. It is intended in some sense to be a replacement for the current “Past Weather Widget” of climate.gov, which allows users to call up a text display of past weather conditions at any location in the United States (see below). The Climate Explorer, however, will provide a more in-depth and graphical display of historical weather, in the context of the long-term climate conditions of the location.
During the period of this report:

- A prototype of the Climate Explorer application was developed and deployed to NEMAC’s development server. This prototype allows the user to browse and view daily temperature, precipitation, and snowfall data from roughly 10,000 stations in

the GHCND data set. The application also includes 2010 normals data for temperature and precipitation.

Climate Widget

The "Past Weather Widget" is a web application that will allow users to call up a short graphical summary of the climate of a given location. It is somewhat similar in concept to the Climate Explorer application, but is intended as a small "widget" that takes up a much smaller region of the screen and for displaying information from only one location at a time. The Climate Widget will be built in late spring/early summer 2013 by leveraging components of the JavaScript/HTML5 version of Multigraph and the Climate Explorer application described above.

During the period of this report:

- In order to allow work on the Data Snapshots project (see below), work on the Climate Widget was suspended for the period of this report.

Data Snapshots

This is a new project started in September 2013, creating an application that will provide a common interface for viewing map-based "snapshots" of several key data sets from the period 2000 to present (*Figure 2*). NEMAC developed a *Drupal* module that allows users to move between different data sets and time points by adjusting sliders on the page. The module will be ready for deployment by June 2014.

OTHER

Currently in production, ClimateCast is a series of climate videos published as completed in the online News & Features section of NOAA's Climate.gov web portal. Each video is three to five minutes long and features NOAA scientists and staff offering insight and interpretation to climate-driven weather events and other features of the climate system. The videos complement on-screen shots of scientists with dynamic visualizations produced expressly for video by NOAA staff and scientists, contractors to NOAA working on the NOAA Climate.gov web portal, and other collaborators. Videos are filmed at the NEMAC Engagement Site in Asheville, NC, utilizing projectors, computers, and a visualization wall located at the site.

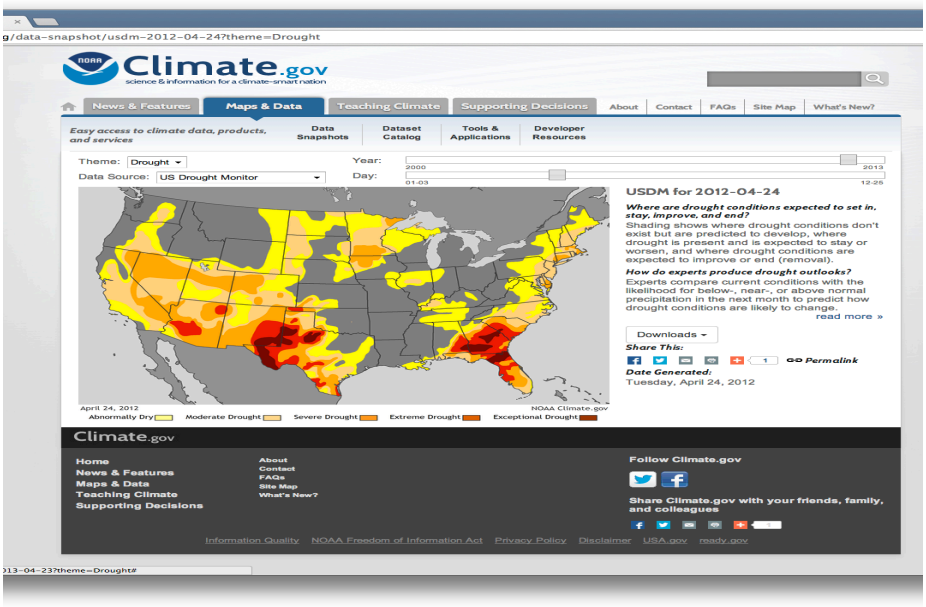


Figure 8 Screenshot of Data Snapshots

To date this period, the following episodes have been filmed at the RENCI Engagement Site and were completed and uploaded to the NOAA Climate.gov web portal:

- March: Out Like a Lion | Posted April 18, 2013
- Local Is Not Global: Pockets of Cold in a Warming Planet | Posted April 19, 2013
- Local Is Everything: Climate Divisions Tell Your Story | Posted May 20, 2013
- To Escape Drought, Slow and Steady Wins the Race | Posted May 20, 2013

The NEMAC Engagement Site was used during the production, both as a set and for preproduction and postproduction sessions. During this reporting period, production and filming sessions have occurred at the Engagement Site during the following periods:

- April 10-12, 2013
- May 8-10, 2013
- July 18-19, 2013
- January 28-30, 2014

PLANNED WORK

Anticipated work for the remainder of this fiscal year (through June 30, 2014) includes the following tasks:

- Complete and deploy the Data Snapshots module
- Complete and deploy a preliminary version of the Climate Explorer
- The Climate Widget will be built in late spring /early summer 2014 by leveraging components of the JavaScript/HTML5 version of Multigraph and the Climate Explorer application described above.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	3
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	1
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	5

PERFORMANCE METRICS EXPLANATION

This year, we developed a new application that provides a common interface for viewing map-based “snapshots” of several key data sets from the period 2000 to present, improved the Multigraph software and upgraded the Climate Explorer GIS application (3). A new version of the Climate Dashboard was deployed to climate.gov in October (1).

Spatio-Temporal Patterns of Precipitation and Winds in California

Task Leader	Dr. Sandra Yuter
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1:100%; Theme 2: 0%;Theme 3: 0%
Main CICS Research Topic	Land and Hydrology
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 100%

Highlight: Precipitation frequency as a function of altitude in northern California does not correspond to the standard idealized relationship. It is widely variable with respect to both basin and storm type.

BACKGROUND

Atmospheric rivers (ARs) are narrow corridors of enhanced water vapor transport within extratropical cyclones. When they arrive in California, ARs contribute significantly to the water supply and flood generation in the State. Although focused research during the last few years has yielded quantitative linkages between ARs and both regional water supply and extreme precipitation events, questions remain regarding the modification and redistribution of water vapor and precipitation in ARs by California's coastal mountains and Sierra Nevada. Previous work indicates that all recent flooding events on the US west coast were associated with an AR but not all ARs yielded flooding. Several factors can potentially turn an AR event into a flooding event. There is limited understanding of the relative roles of atmospheric stability, barrier jets, and small-scale ridges along the windward slope on watershed precipitation totals.

A key piece missing on the role of ARs in flooding events is knowledge of the detailed spatial distribution of precipitation over the windward slopes of the Sierra Nevada for each AR event and for groupings of AR events with similar environmental variables. The proposed work will utilize operational radar data from six National Weather Service WSR-88D radars (KBHX, KBBX, KRGX, KDAX, KMUX and KHNK) to construct a radar echo precipitation climatology of AR events for a 10 year period. Long-term radar echo climatology is needed since existing rain gauges provide only incomplete information on precipitation in this region, particularly over rugged mountainous terrain.

ACCOMPLISHMENTS

The project group completed National Weather Service WSR-88D radar data processing for all 64 atmospheric river storms during the period from 2005-2010 for which archived radar data are available for at least KBBX and KDAX. A methodology was developed to "stitch" together precipitation frequency maps from the multiple radars to obtain regional maps.

Upper air soundings were analyzed from two California sites to characterize the range of environments of AR events; 439 soundings from KDAK (Oakland, CA; soundings every 12 hours during AR events from Oct 1997 – Apr. 2011) and 68 soundings from KLHM (Lincoln, CA; soundings ~4-6 hours during events from Dec. 2010 – Mar 2011). Typical AR storms, (between the 25th and 75th percentiles) are stable, have cross-barrier wind speeds of 0 to 7

m/s, and freezing level heights between 2.5 and 4 km. Higher freezing levels > 4 km are associated with higher stability and higher cross-barrier wind speeds.

Previous studies have developed an idealized precipitation model for the Sierra Nevada hydrologic region that produces a doubling of precipitation from 0 to 1 km MSL and constant precipitation above 1 km MSL. The accuracy of this model was tested by comparing the normalized hours of precipitation (P) from the storm type composites (below) relative to a 1 km reference level in the Sierra Nevada region. The idealized model was then compared to the change of relative precipitation with elevation in the other hydrologic regions to test the model's transportability (*Fig. 1*). It was determined that the idealized model consistently under predicts relative precipitation frequency in the lowest 1 km, while precipitation frequency above 1 km altitude is widely variable with respect to both basin and storm type.

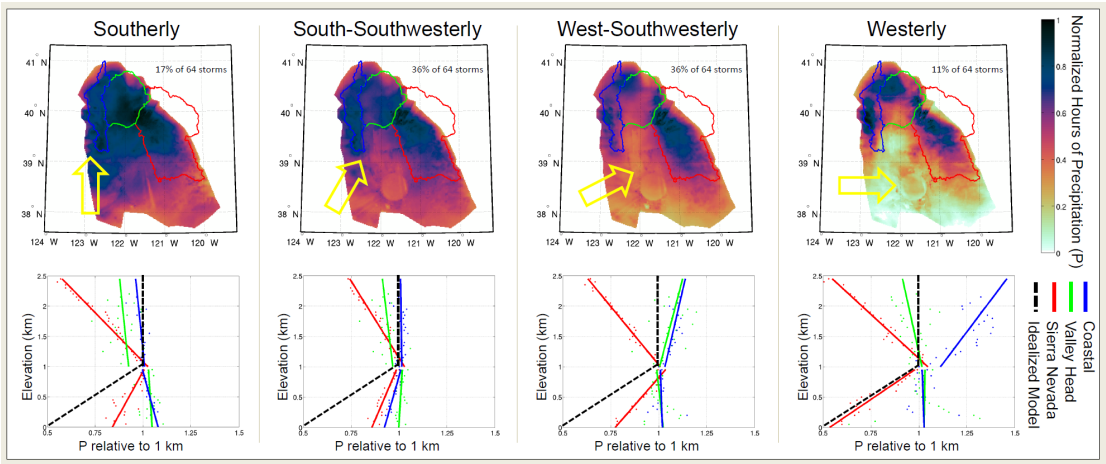


Fig. 1. Top row: Multi-radar composites of precipitation frequency for periods with different wind directions at Bodega Bay (yellow arrow). Bottom row: Precipitation frequency normalized to value at 1 km altitude above sea level. Different colors correspond to different basins (blue=coastal, green=valley, red=Sierra Nevada, black=standard idealized model).

PLANNED WORK

- Finish writing up results for publication

PUBLICATIONS

- Kingsmill, D. E., P. J. Neiman, B. J. Moore. M. Hughes, S. E. Yuter and F. M. Ralph, 2013: Kinematic and thermodynamic structures of Sierra barrier jets and overrunning atmospheric rivers during a land-falling winter storm in northern California. *Mon. Wea. Rev., 141, 2015-2036*.

PRESENTATIONS

- Corbin, N., and S. Yuter, 2013: A six-year climatology of precipitation within major storms in northern California. Poster presentation at NC State Summer Undergraduate Research Symposium, 31 July 2013.

- Corbin, N., S. Yuter, and A. Hall, 2014: A six-year climatology of precipitation within major storms in northern California. Poster presentation at NC State College of Sciences Access Day, 6 Feb 2014

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	1
# of non-peered reviewed papers	0
# of invited presentations	0
# of graduate students supported by a CICS task	1
# of graduate students formally advised	0
# of undergraduate students mentored during the year	2

Other CICS PI Projects

Water Sustainability and Climate Change: A Cross-Regional Perspective

Task Leader	Kenneth Kunkel
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 0%; Theme 3: 100%.
Main CICS Research Topic	National Climate Assessments
Contribution to NOAA Goals (%)	Goal 1: 100%; Goal 2: 0%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: Model simulations from the CMIP5 hindcast experiment were found to reproduce observed temperature trends for the southeast and southwest U.S. for the period 1981-2004. Precipitation trends for the southeast U.S. were simulated well also. However, the downward trend in precipitation for the southwest U.S. was not simulated well.

BACKGROUND

Water resource availability varies across the Sunbelt of the United States with a sharp East-West transition at 105° W. Arid regions west of the 105th Meridian produce less runoff. On the other hand, humid regions in the east produce greater than 40 cm of mean annual runoff. Consequently, reservoirs in the west are over-year systems holding multiple years of inflows, whereas reservoirs in the east are within-year storage systems with the need to refill the system in the beginning of spring. Accordingly, water policies also differ substantially with western states pursuing “prior appropriation” and the eastern states following “riparian rights” for allocation. These contrasting strategies also impact freshwater biodiversity with the ratio of non-native to native fish species being nearly 6 times higher in the West compared to the East. In spite of these cross-regional differences, both regions face two common stressors: (a) uncertainty in available water arising from global climate change and (b) increased human demand due to population growth and consumption. Consequently, there is an ever-increasing need for an integrated assessment of fresh water sustainability under these two stressors over the planning horizon (10-30 years). The main objective of this study is to understand and quantify the potential impacts of near-term climate change and population growth on freshwater sustainability-defined here as integrating daily to annual flows required to minimize human vulnerability and maximize ecosystem needs (including native biodiversity) for freshwater-by explicitly incorporating the feedbacks from human-environmental systems on water supply and demand. Using retro-analyses involving CMIP5 multimodel climate change hindcasts, we will revisit how freshwater sustainability could have been better achieved over the past five decades across the Sunbelt. To couple the hydroclimatic and hydro-ecological system dynamics with the management of water infrastructure systems, a two-level agent-based modeling framework will explicitly simulate adaptive behaviors and feedbacks between policy and consumers.

This interdisciplinary project involves collaboration between three universities, North Carolina State University (NCSU), Arizona State University (ASU), and Florida International University (FIU). Findings from the CMIP5 retro-analyses will evaluate and recommend societal options (i.e., supply augmentation vs. demand reduction) for promoting future (2015-2034) freshwater sustainability across the Sunbelt. Cross-regional synthesis of policies and media sources for the targeted basins will identify de/centralized adaptive strategies that have been employed independently and collectively to maintain flows, increase supplies, or reduce demands. Utilizing the near-term hydroclimatic projections, we will quantify how current policies on reservoir operations and groundwater extraction could impact the reliability of future water supplies for cities and also alter the key attributes of hydrographs that are critical for maintaining freshwater biodiversity. In doing so, the project will also investigate the degree to which regions have pursued 'hard path' (i.e., supply augmentation) vs. 'soft path' (i.e., demand reduction) strategies by explicitly modeling potential societal interventions for water sustainability.

ACCOMPLISHMENTS

The major objective this year was to complete an initial analysis of the CMIP5 hindcast simulations.

Monthly temperature and precipitation data were obtained for thirteen models from the CMIP5 30-yr hindcast experiment for 1980-2009. The total number of ensemble members for these thirteen models was 75. Several types of analyses were performed on these model simulations:

1. Temperature and precipitation trends were calculated for the period 1980-2004 for the contiguous U.S. as a whole and for two of the regions of study in this project: the southeast and the southwest. The trends were calculated for the year as a whole and the seasons of summer and winter. The trends and the mean values of temperature and precipitation were compared with observations.
2. The correlation coefficients between monthly temperature and precipitation were calculated for the year as a whole and for the sub-periods of winter and summer.
3. Decadal-average anomalies of precipitation were calculated for each ensemble member and compared with precipitation for the southwest region.

All models simulate upward trends in temperature for 1981-2004. For the southeast U.S., the magnitude of the multi-model mean trends is almost exactly equal to observations. For the southwest U.S. (*Fig. 1*), the magnitude of the observed trend (0.42°C/decade) is about double the multi-model mean trend, but the range of individual model trends straddles the observed value. Precipitation trends in the southeast are small and not statistically significant both for observations and for all model simulations. For the southwest, observed precipitation trends are more negative than any model (*Fig. 1*), although trends for 3 of the 13 models are nearly as negative.

The correlations between monthly precipitation and temperature are similar among the models for summer. In most areas, the correlations are negative. In the southwest, all models simulate near-zero correlations. For winter, many models simulate positive

correlations in the northwestern and northeastern regions and negative correlations in the Great Plains.

The decade of 2000-2009 was a dry period, relative to the 1980s and 1990s, for the southwest region. The observed dryness had substantial impacts in the region. Most model simulations do not produce this feature. However, there are several individual ensemble members that do produce this feature. This suggests that variability internal to the coupled atmosphere-ocean-land system can produce this and the cause is not due to external forcing, either anthropogenic or natural.

None of the CMIP5 models simulates this feature robustly. However, there are a few ensemble members that do resemble the observed decadal anomalies. This suggests this feature may be the result of internal variability, not external forcing from increased greenhouse gas concentrations.

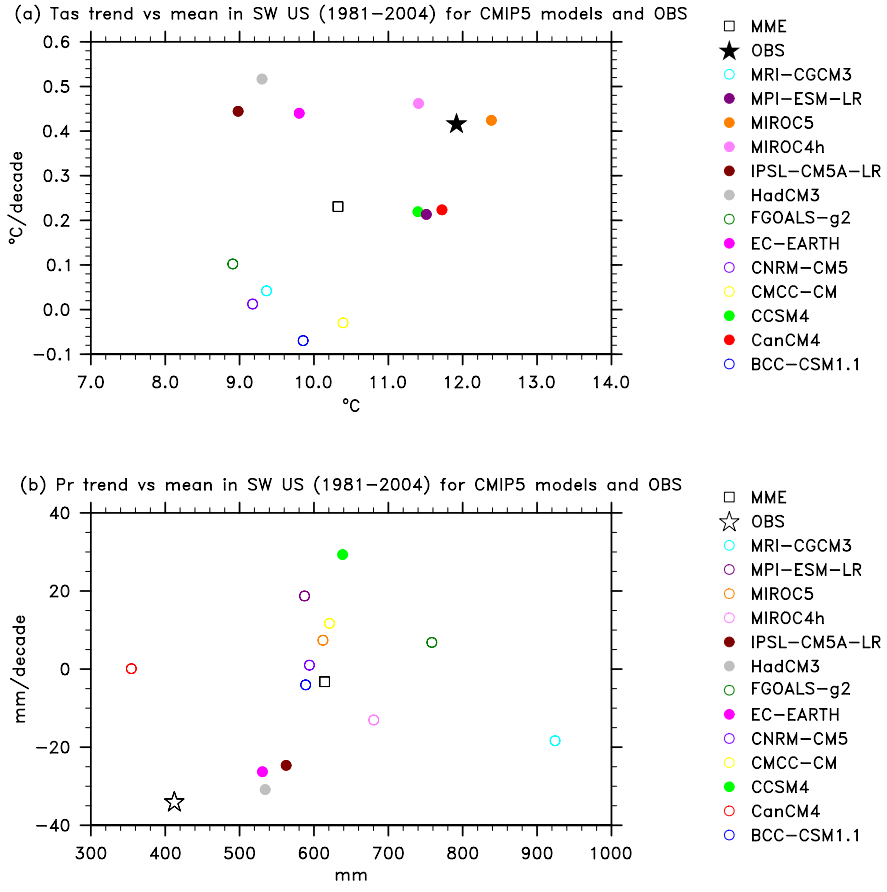


Figure 1: Comparison of CMIP5 simulations of temperature and precipitation mean annual values and trends for 1981-2004 with observations for the Southwest U.S. For temperature, the range of CMIP5 simulated trends straddles the observed trend. For precipitation, the

observed trend is more negative than any model, although trends for 3 of the 13 models are close to observed.

PLANNED WORK

- Complete and submit a paper on CMIP5 hindcast simulations
- Analyze CMIP5 hindcast simulations for extremes

PRESENTATIONS

- Arumugam, S., K.E. Kunkel, and T. Sinha, 2014: Water Sustainability under Near-term Climate Change: A Cross-Regional Analysis Incorporating Socio-Ecological Feedbacks and Adaptations, annual investigator meeting for NSF Watershed Science and Climate Program, Washington, DC (30 January).

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	0
# of non-peered reviewed papers	0
# of invited presentations	1
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

PERFORMANCE METRICS EXPLANATION

A paper reviewing progress was given at an NSF program meeting.

Identifying Tropical Variability with CDRs

Task Leader	Carl Schreck
Task Code	
NOAA Sponsor	
NOAA Office	
Contribution to CICS Themes (%)	Theme 1: 0%; Theme 2: 50%; Theme 3: 50%
Main CICS Research Topic	Climate Data and Information Records and Scientific Data Stewardship
Contribution to NOAA Goals (%)	Goal 1: 0%; Goal 2: 100%; Goal 3: 0%; Goal 4: 0%; Goal 5: 0%

Highlight: Climate Data Records are being leveraged to develop new diagnostics for tracking and predicting the Madden-Julian Oscillation (MJO) and equatorial waves. These diagnostics are tested in near-real time on monitor.cicsnc.org/mjo where they are served to hundreds of users in the public and private sectors every month.

BACKGROUND

The Madden-Julian Oscillation (MJO), equatorial Rossby waves, and Kelvin waves are the dominant sources of synoptic-to-subseasonal variability in the tropics. The divergent circulations from their convection can influence tropical cyclones and other weather patterns around the globe. Forecasters in the Energy Industry pay particular attention to these modes, harnessing their long time scales and global impacts to anticipate energy demand in the United States. Climate Data Records (CDRs) play a key role in the identification and forecasting of these modes. This project endeavors develop new diagnostics for tracking tropical modes using CDRs.

ACCOMPLISHMENTS

This project produced several peer-reviewed papers in FY13 that demonstrated the value of CDRs of monitoring and predicting tropical variability:

- Schreck et al. (2013) demonstrated the use of a new index, the Multivariate Pacific–North American (MVP) index, that uses Outgoing Longwave Radiation (OLR) in conjunction with dynamical fields to identify which MJO events affect temperatures over North America and which do not.
- Gottschalk et al. (2013) used OLR to summarize the large-scale conditions during the international DYNAMO (Dynamics of the MJO) field campaign during 2011/12.
- Kruk et al. (2013) used OLR and NOAA's Optimum Interpolation Sea Surface Temperature (OI SST) analysis to identify the conditions for hurricanes in the eastern Pacific during 2012.
- Shi et al. (2013) evaluated the interactions between the CDR of HIRS above-cloud water vapor and various climate modes.
- Ventrice et al. (2013) compared two indices for tracking the MJO to identifying the strengths and weaknesses of including OLR.

Figure 1. shows an example from Schreck et al. (2013) of how the MVP can be used to anticipate weather patterns over the United States. Tropical convection is identified by the shaded OLR anomalies, while the extratropical response is shown by the contours of 200-

hPa streamfunction. Both composites are for the same phase of the MJO, as indicated by the large area of convection near the Maritime Continent. However, they are subdivided by the phase of the MVP.

When the MVP is negative (bottom), a secondary maximum in convection appears near Hawaii. This convection is associated with an extratropical wave train (contours) that leads to warm temperatures over the eastern United States. Such a pattern is expected for this phase of the MJO. However, this pattern is strikingly absent when the MVP is positive (top). Even though the forcing from the MJO is similar in both patterns, the MVP identifies which set of dates produces the expected extratropical response and which does not.

Combinations of the MJO and the MVP can influence North American temperature patterns for as long as 20 days. For this reason, the MVP has been added to a suite of other CDR-based diagnostics on monitor.cicsnc.org/mjo, which serves hundreds of unique users and the public and private sectors every month.

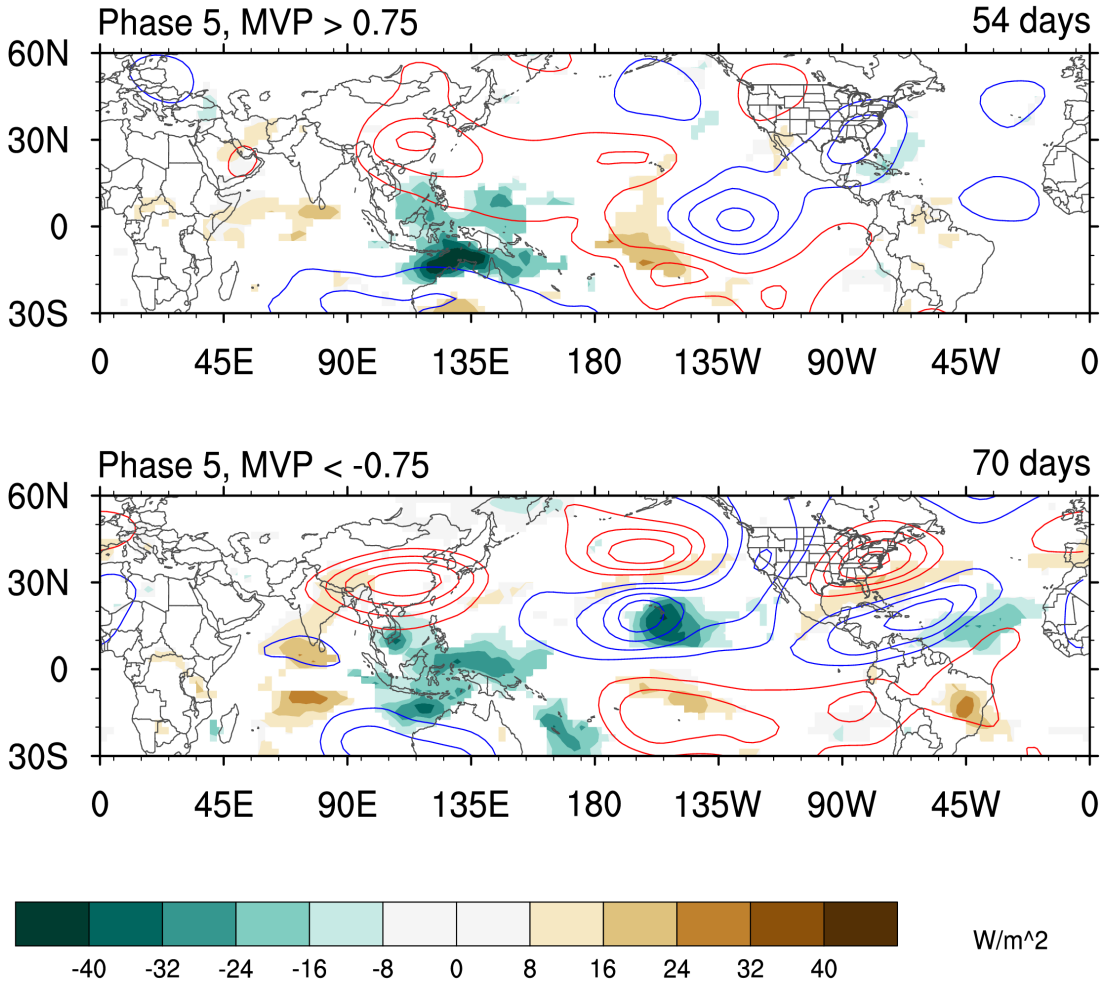


Figure 1: Composites of OLR (shading) and 200-hPa streamfunction anomalies. Both composites show the same phase of the MJO but different phases of the MVP.

PLANNED WORK

- Evaluate new CDR of daily OLR
- Revise monitor.cicsnc.org/mjo to leverage the new interim CDR of daily OLR

PUBLICATIONS

- Schreck, C. J., J. M. Cordeira, and D. Margolin, 2013: Which MJO events affect North American temperatures? *Mon. Wea. Rev.*, **141**, 3840–3850, doi:10.1175/MWR-D-13-00118.1.
- Gottschalck, J., P. E. Roundy, C. J. Schreck III, A. Vintzileos, and C. Zhang, 2013: Large-scale atmospheric and oceanic conditions during the 2011–12 DYNAMO field campaign. *Mon. Wea. Rev.*, **141**, 4173–4196, doi:10.1175/MWR-D-13-00022.1.
- Kruk, M. C., C. J. Schreck, and R. Tanabe, 2013: [The Tropics] Eastern North Pacific basin [in "State of the Climate in 2012"]. *Bull. Amer. Meteor. Soc.*, **94**, S89–S92, doi:10.1175/2013BAMSStateoftheClimate.1.
- Shi, L., C. J. Schreck, and V. O. John, 2013: An improved HIRS upper tropospheric water vapor dataset and its correlations with major climate indices. *Atmos. Chem. Phys*, **12**, 33411–33442, doi:10.5194/acpd-12-33411-2012.
- Ventrice, M. J., M. C. Wheeler, H. H. Hendon, C. J. Schreck, C. D. Thorncroft, and G. N. Kiladis, 2013: A modified multivariate Madden–Julian Oscillation index using velocity potential. *Mon. Wea. Rev.*, **141**, 4197–4210, doi:10.1175/MWR-D-12-00327.1.

DELIVERABLES

- monitor.cicsnc.org/mjo served CDR-based diagnostics to an average of 270 unique visitors every month
- Developed a business case study for the CICS-NC Executive Forum on Business and Climate on CDR use by the energy industry

PRESENTATIONS

Invited

- Schreck, C. J., 2013: The latest on the MJO. MDA Weather Services' 12th Annual Energy Conference for Traders and Analysts, Las Vegas, NV, 17 October 2013.
- Schreck, C. J., 2013: Overview of hurricanes and seasonal hurricane prediction. Statistical and Applied Mathematical Sciences Institute Undergraduate Modeling Workshop. Raleigh, NC, 13 May 2013.
- Schreck, C. J., 2013: Scale interactions: Bridging the gap between the tropics and extratropics. Third Workshop on Medium/Long Range Weather Forecasting and Subseasonal Atmospheric Drivers, Albany, NY, 15 May 2013.
- Schreck, C. J., 2013: Use of NOAA satellite products by the energy sector. NOAA Satellite Conference for Direct Readout, GOES/POES, and GOES-R/JPSS Users, College Park, MD, 11 April 2013.

Other presentations

- Schreck, C. J., 2013: Comparing MJO diagnostics during DYNAMO. *MJO Field Data and Science Workshop*, 4-8 March 2013, Kohala Coast, HI.

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	0
# of products or techniques transitioned from research to ops following NOAA guidance	0
# of new or improved products developed without NOAA guidance	0
# of products or techniques transitioned from research to ops without NOAA guidance	0
# of peer reviewed papers	5
# of non-peered reviewed papers	0
# of invited presentations	4
# of graduate students supported by a CICS task	0
# of graduate students formally advised	0
# of undergraduate students mentored during the year	0

Appendix 1: Personnel Statistics for CICS-NC

CICS-NC Personnel Statistics 2014

Category	Total	AA or less	BS	MS	PhD
Research Scientist	7		2	2	3
Visiting Scientist	0				
Postdoctoral Fellow	1				
Research Support Staff	18	3	3	7	5
Administrative	3			2	1
Total (> 50% support)	**29**				
Undergraduate Students	**5**	4	1		
Graduate Students	0				
Employees that receive < 50% NOAA funding (not including students)	**2**			2	
TOTAL CICS-NC EMPLOYEES	**36**				
Located at NOAA facility (National Climatic Data Center)	33				
Obtained NOAA employment within the last year	4				

Appendix 2: Performance Metrics for CICS-NC

PERFORMANCE METRICS

	FY13
# of new or improved products developed following NOAA guidance	97
# of products or techniques transitioned from research to ops following NOAA guidance	13
# of new or improved products developed without NOAA guidance	7
# of products or techniques transitioned from research to ops without NOAA guidance	4
# of peer reviewed papers	53
# of non-peered reviewed papers	19
# of invited presentations	88
# of graduate students supported by a CICS task	5
# of graduate students formally advised	14
# of undergraduate students mentored during the year	27

Appendix 3: CICS-NC PUBLICATIONS

- **Allen, T. R.**, Sanchagrin, S., & McLeod, G. (2013). Visualization for Hurricane Storm Surge Risk Awareness and Emergency Communication. In John Tiefenbacher (Ed.), Approaches to Disaster Management- Examining the Implications of Hazards, Emergencies, and Disasters (pp. 105-129). Rijeka, Croatia: InTech.
- **Allen, T. R.** (2014). Advances in Remote Sensing of Coastal Wetlands: Case Studies from North Carolina. Under Review, In Charles Finkl and Antonio Klein (Eds.), Advances in Coastal and Marine Resources: Remote Sensing and Modeling. (in review)
- **Bell, J.E.** and J.L. Matthews. Evaluation of air and soil temperatures for determining the onset of the growing season. Submitted.
- Palecki, M.A., & **J.E. Bell**. 2013. U. S. Climate Reference Network: soil moisture variability and uncertainty. Vadose Zone Journal. doi:10.2136/v2j2012.0158
- **Bell, J.E.** M.A. Palecki, C.B. Baker, W. Collins, J.H.Lawrimore, R.D. Leeper, M.E. Hall, J. Kochendorfer, T.P. Meyers, T. Wilson, & H.J. Diamond. 2013. US Climate Reference Network soil moisture and temperature observations. Journal of Hydrometeorology, 14, 977-988
- Diamond, H.J., T.R. Karl, M.A. Palecki, C.B. Baker, **J.E. Bell**, R.D. Leeper, D.R. Easterling, J.H. Lawrimore, T.P. Meyer, M.R. Helfert, G. Goodge, & P.W. Thorne. 2013. U.S. Climate Reference Network after One Decade of Operations: Status and Assessment. Bull. Amer. Meteor. Soc., 94, 485-498
- **Guillevic, P. C**., Biard, J., Hulley, G. C., Privette, J. L., Hook, S. J., Göttsche, F.-M., Radocinski, R., Román, M. O., Yu, Y., and Csiszar I. (2014). Validation of Land Surface Temperature products derived from the Visible Infrared Imager Radiometer Suite (VIIRS) using ground-based and heritage satellite measurements. Submitted to Remote Sensing of Environment.
- Merchant, C.J., Matthiessen, S., Rayner, N.A., Remedios, J.J., Jones, P. D., Olesen, F., Trewin, B., Thorne, P.W., Auchmann, R., Corlett, G.K., **Guillevic, P.C.**, and Hulley, G. (2013). The Surface Temperatures of the Earth: Steps towards Integrated Understanding of Variability and Change, Geoscientific Instrumentations, Methods and Data Systems, 2, 305-321.
- **Guillevic, P.C.**, Privette, J.L., Yu, Y., Göttsche, F.M., Hulley, G., Olioso, A., Sobrino, J., Meyers, T., Ghent, D., Bork-Unkelbach, A., Courault, D., Román, M.O., Hook, S., Csiszar, I. (2013). NPP VIIRS land surface temperature product validation using worldwide observation networks. Symposium Proceedings, 2013 IEEE International Geoscience & Remote Sensing Symposium (IGARSS 2013), July 21-26, 2013, Melbourne, Australia. Published by IEEE (USB key). IEEE Catalog Number: CFP13IGA-USB. ISBN: 978-1-4799-1113-4. Paper number: MOP.P23.87. Pages 640-643.
- Olioso, A., Mira, M., Courault, D., Marloie, O., **Guillevic, P.**, 2013. Impact of surface emissivity and atmospheric conditions on surface temperatures estimated from top of canopy brightness temperatures derived from Landsat 7 data. Symposium Proceedings, 2013 IEEE International Geoscience & Remote Sensing Symposium (IGARSS 2013), July 21-26, 2013, Melbourne, Australia. Published by IEEE (USB key).

IEEE Catalog Number: CFP13IGA-USB. ISBN: 978-1- 4799-1113-4. Paper number: TH1.T06.4. Pages 3033- 3036.

- **Guillevic P.C.**, A. Bork-Unkelbach, F.M. Goettsche, G. Hulley, J.P. Gastellu-Etchegorry, F. Olesen, and J.L. Privette (2013). Directional viewing effects on Satellite Land Surface Temperature products over sparse vegetation canopies-A multi-sensor analysis. IEEE Geoscience and Remote Sensing Letter, Vol. 10, Issue 6, pp. 1464-1468, doi:10.1109/LGRS.2013.2260319.
- **Inamdar, A. K.**, and Guillevic P., 2014: Estimation of net surface shortwave radiation from GOES imagery. Submitted to IEEE Trans. Geosci. Remote Sensing.
- **Inamdar, A. K.**, and P. Guillevic, 2014: "A new approach to monitor net surface solar radiation from geostationary imagery". Proc. of AMS 95th Annual Meeting held at Atlanta Feb 2-6 2014.
- **Inamdar, A. K.**, and K. Knapp, 2014: Inter-comparison of Independent Calibration Techniques Applied to the Visible Channel of the ISCCP B1 data. Submitted to J. Atmos. Ocean. Tech.
- Peterson, T.C., T.R. Karl, J.P. Kossin, **K.E. Kunkel**, J.H. Lawrimore, J.R. McMahon, R.S. Vose and X. Yin, 2014: Changes in weather and climate extremes: State of knowledge relevant to air and water quality in the United States. Journal of the Air & Waste Management Association, 64,184-197, DOI:10.1080/10962247.2013.851044.
- Lawrimore, J., T.R. Karl, M. Squires, D.A. Robinson, and **K.E. Kunkel**, 2013: Trends and variability in severe snowstorms east of the Rocky Mountains. J. Hydromet., submitted.
- Janssen, E., D.J. Wuebbles, **K.E. Kunkel**, S.C. Olsen, and A. Goodman, 2013: Observed and modeled trends and projections of extreme precipitation over the contiguous United States. Earth's Future, accepted.
- Vose, R.S., S. Applequist, M.A. Bourassa, S.C. Pryor, R.J. Barthelmie, B. Blanton, P.D. Bromirski, H.E. Brooks, A.T. DeGaetano, R.M. Dole, D.R. Easterling, R.E. Jensen, T.R. Karl, R.W. Katz, K. Klink, M.C. Kruk, **K.E. Kunkel**, M.C. MacCracken, T.C. Peterson, K.Shein, B.R. Thomas, J.E. Walsh, X.L. Wang, M.F. Wehner, D.J. Wuebbles, and R.S. Young, 2012: Monitoring and understanding changes in Extremes: Extratropical storms, winds, and waves. Bull. Amer. Meteor. Soc., accepted.
- Wuebbles, D.W., G. Meehl, K. Hayhoe, T. R. Karl, **K. Kunkel**, B. Santer, M. Wehner, B. Colle, E. M. Fischer, R. Fu, A. Goodman, E. Janssen, H. Lee, W. Li, L. N. Long, S. Olsen, A. Seth, J. Sheffield, and L. Sun, 2013: CMIP5 climate model analyses: Climate extremes in the United States. Bull. Amer. Meteor. Soc., accepted
- Peterson, T.C., R.J. Heim, Jr., R. Hirsch, D.P. Kaiser, H. Brooks, N.S. Diffenbaugh, R.M. Dole, J.P. Giovannettone, K. Guiguis, T.R. Karl, R.W. Katz, **K.E. Kunkel**, D. Lettenmaier, G.J. McCabe, C.J. Paciorek, K. Ryberg, S. Schubert, V.B.S. Silva, B.C. Stewart, A.V. Vecchia, G. Villarini, R.S. Vose, J. Walsh, D. Wolock, K. Wolter, C.A. Woodhouse, M. Wehner, and D. Wuebbles, 2013: Monitoring and understanding changes in heat waves, cold waves, floods and droughts in the United States: State of knowledge. Bull. Amer. Meteor. Soc., 94, 821-834.
- **Kunkel, K.E.**, T.R. Karl, H. Brooks, J. Kossin, J. Lawrimore, D. Arndt, L. Bosart, D. Changnon, S.L. Cutter, N. Doesken, K. Emanuel, P.Ya. Groisman, R.W. Katz, T. Knutson, J. O'Brien, C. J. Paciorek, T. Peterson, K. Redmond, D. Robinson, J. Trapp, R.

Vose, S. Weaver, M. Wehner, K. Wolter, D. Wuebbles, 2013: Monitoring and understanding changes in extreme storms: state of knowledge. Bull. Amer. Meteor. Soc., 94, 499-514, doi: http://dx.doi.org/10.1175/BAMS-D-12-00066.1.

- Vose, R.S., S. Applequist, M.A. Bourassa, S.C. Pryor, R.J. Barthelmie, B. Blanton, P.D. Bromirski, H.E. Brooks, A.T. DeGaetano, R.M. Dole, D.R. Easterling, R.E. Jensen, T.R. Karl, R.W. Katz, K. Klink, M.C. Kruk, **K.E. Kunkel**, M.C. MacCracken, T.C. Peterson, K.Shein, B.R. Thomas, J.E. Walsh, X.L. Wang, M.F. Wehner, D.J. Wuebbles, and R.S. Young, 2012: Monitoring and understanding changes in Extremes: Extratropical storms, winds, and waves. Bull. Amer. Meteor. Soc., accepted.
- Wuebbles, D.W., G. Meehl, K. Hayhoe, T. R. Karl, **K. Kunkel**, B. Santer, M. Wehner, B. Colle, E. M. Fischer, R. Fu, A. Goodman, E. Janssen, H. Lee, W. Li, L. N. Long, S. Olsen, A. Seth, J. Sheffield, and L. Sun, 2013: CMIP5 climate model analyses: Climate extremes in the United States. Bull. Amer. Meteor. Soc., accepted.
- Wuebbles, D.J., **K.E. Kunkel**, M. Wehner, and Z. Zobel, 2014: Severe weather in the United States under a changing climate. EOS, accepted.
- **Kunkel, K.E**, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, J. Rennells, A. DeGaetano, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 1. Climate of the Northeast U.S., NOAA Technical Report NESDIS 142-1, 79 pp.
- **Kunkel, K.E**, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, C.E. Konrad II, C.M. Fuhrman, B.D. Keim, M.C. Kruk, A. Billet, H. Needham, M. Schafer, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 2. Climate of the Southeast U.S., NOAA Technical Report NESDIS 142-2, 94 pp.
- **Kunkel, K.E**, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, S.D. Hilberg, M.S. Timlin, L. Stoecker, N.E. Westcott, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 3. Climate of the Midwest U.S., NOAA Technical Report NESDIS 142-3, 95 pp.
- **Kunkel, K.E**, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, M.C. Kruk, D.P. Thomas, M. Shulski, N. Umphlett, K. Hubbard, K. Robbins, L. Romolo, A. Akyuz, T. Pathak, T. Bergantino, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 4. Climate of the U.S. Great Plains, NOAA Technical Report NESDIS 142-4, 82 pp.
- **Kunkel, K.E**, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K.T. Redmond, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 5. Climate of the Southwest U.S., NOAA Technical Report NESDIS 142-5, 79 pp.
- **Kunkel, K.E**, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K.T. Redmond, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 6. Climate of the Northwest U.S., NOAA Technical Report NESDIS 142-6, 75 pp.
- **Kunkel, K.E**, L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, and J.G. Dobson. 2013. "Regional Climate Trends and Scenarios for the U.S. National Climate Assessment." Part 9. Climate of the Contiguous United States, NOAA Technical Report NESDIS 142-9, 77 pp.

- Wuebbles, D., G. Meehl, K. Hayhoe, T. R. Karl, **K. Kunkle**, B. Santer, M. Wehner, B. Colle, E. Fischer, R. Fu, A. Goodman, E. Janssen, H. Lee, W. Li, L. Long, S. Olsen, S. Rauscher, A. Seth, J. Sheffield, L. Sun, 2014: CMIP5 climate model analyses: Climate extremes in the United States. Bull. Amer. Meteor. Soc., doi: 10.1175/BAMS-D-12-00172.1
- Huang, B., V. F. Banzon, E. Freeman, J. Lawrimore, **W. Liu**, T. C. Peterson, T. M. Smith, P. W. Thorne, S. D. Woodruff, and H-M Zhang, 2014: Extended Reconstructed Sea Surface Temperature version 4 (ERSST.v4), part I: Upgrades and Intercomparsions. J. Climate, in review.
- **Liu, W.**, B. Huang, P. W. Thorne, V. F. Banzon, H-M Zhang, E. Freeman, J. Lawrimore, T. C. Peterson, T. M. Smith, and S. D. Woodruff, 2014: Extended Reconstructed Sea Surface Temperature version 4 (ERSST.v4), part II: Uncertainty Estimation. J. Climate, in review.
- **Liu, W.**, Z. Liu, J. Cheng, and H. Hu, 2014: On the stability of the Atlantic meridional overturning circulation during the past deglaciation. Clim. Dyn., in revision.
- **Peng, G.**, W.N. Meier, D. J. Scott, and M. Savoie, A Long-Term and Reproducible Satellite-Based Passive Microwave Sea Ice Concentration Data Record for Climate Study and Monitoring. Earth System Science Data Journal. 5, 311–318, doi:10.5194/essd-5-311-2013.
- Meier, W. N., **G. Peng**, D. J. Scott, and M. Savoie, 2013: Evaluation of a passive microwave sea ice concentration climate data record. Submitted to the Polar Research journal.
- **Peng, G.** and W. Meier, 2013: Characterization of a satellite-based passive microwave sea ice concentration climate data record. Proc. International Geoscience and Remote Sensing Symposium (IGARSS), 232 – 235, IEEE International, 21 – 26 Jul, 2013, Melbourne, Australia.
- **Peng, G.**, H.-M. Zhang, H.P. Frank, J.-R. Bidlot, M. Higaki, S. Stevens, and W.R. Hankins, 2013: Evaluation of various surface wind products with OceanSITES buoy measurements. *Weather and Forecasting*, **28**, 1281–1303, doi:10.1175/WAF-D-12-00086.1.
- **Peng, G.**, J.-R. Bidlot, H.P. Freitag, C.J. Schreck, III, 2014: Identifying directional bias of TAO daily wind vectors in the central equatorial Pacific Ocean from November 2008 to January 2010. Submitted to the Data Science Journal.
- **Prat, O.P.**, and B.R. Nelson, 2014. Characterization of precipitation features over CONUS using Quantitative Precipitation Estimates derived from satellites, radars, and rain gauges datasets (2002-2012). Hydrol. Earth Syst. Sc., to be submitted.
- Nelson, B.R., **O.P Prat**, and D.-J. Seo, 2014. Assessment and implications of Stage IV QPE for product inter-comparisons. Weather Forecast., to be submitted.
- **Prat, O.P.**, and B.R. Nelson, 2014. Characteristics of annual, seasonal, and diurnal precipitation in the Southeastern United States derived from long-term remotely sensed data. Atmos. Res., in press, http://dx.doi.org/10.1016/j.atmosres.2013.07.022
- **Prat, O.P.**, and B.R. Nelson, 2014. On the link between tropical cyclones and extreme rainfall. Environ. Res. Lett., to be submitted.

- **Prat, O.P.**, and B.R. Nelson, 2013. Mapping the world's tropical cyclone rainfall contribution overland using the TRMM Multi-satellite precipitation analysis. Water Resour. Res., 49, 7236–7254, http://onlinelibrary.wiley.com/doi/10.1002/wrcr.20527/abstract
- **Prat, O.P.**, and M.R. Kumjian, 2014. Transient behavior of polarimetric signatures of warm rain microphysical processes. J Appl. Meteorol. Climatol., in preparation.
- Kumjian, M.R., and **O.P. Prat**, 2014. The impact of raindrop collisional processes on the polarimetric radar variables. J. Atmos. Sc., conditionally accepted.
- **Rennie, J.J.** and coauthors (2013), The International Surface Temperature Initiative's Global Land Surface Databank: Monthly Temperature Data Version 1 Release Description and Methods. Accepted, Geoscience Data Journal.
- **Schreck, C. J.**, J. M. Cordeira, and D. Margolin, 2013: Which MJO events affect North American temperatures? Mon. Wea. Rev., 141, 3840–3850, doi:10.1175/MWR-D-13-00118.1.
- Gottschalck, J., P. E. Roundy, **C. J. Schreck III**, A. Vintzileos, and C. Zhang, 2013: Large-scale atmospheric and oceanic conditions during the 2011–12 DYNAMO field campaign. Mon. Wea. Rev., 141, 4173–4196, doi:10.1175/MWR-D-13-00022.1.
- Kruk, M. C., **C. J. Schreck**, and R. Tanabe, 2013: [The Tropics] Eastern North Pacific basin [in "State of the Climate in 2012"]. Bull. Amer. Meteor. Soc., 94, S89–S92, doi:10.1175/2013BAMSStateoftheClimate.1.
- Shi, L., **C. J. Schreck**, and V. O. John, 2013: An improved HIRS upper tropospheric water vapor dataset and its correlations with major climate indices. Atmos. Chem. Phys, 12, 33411–33442, doi:10.5194/acpd-12-33411-2012.
- Ventrice, M. J., M. C. Wheeler, H. H. Hendon, **C. J. Schreck**, C. D. Thorncroft, and G. N. Kiladis, 2013: A modified multivariate Madden–Julian Oscillation index using velocity potential. Mon. Wea. Rev., 141, 4197–4210, doi:10.1175/MWR-D-12-00327.1.
- Ashouri, H, K. Hsu, **S. Sorooshian**, D. Braithwaite, K.R. Knapp, L.D. Cecil, B.R. Nelson, and O.P. Prat, 2014. PERSIANN-CDR: Daily precipitation climate data record from multi-satellite observations for hydrological and climate studies. Bull. Am. Meteorol. Soc., conditionally accepted.
- Ashouri H., K. Hsu, **S. Sorooshian**, D. Braithwaite, K. R. Knapp, L. D. Cecil, B. R. Nelson, O. P. Prat, 2014: "PERSIANN-CDR: Daily Precipitation Climate Data Record from Multi-Satellite Observations for Hydrological and Climate Studies", Bulletin of American Meteorological Society (BAMS), Submitted.
- Ashouri H., K. Hsu, **S. Sorooshian**, J. Lee, M. G. Bosilovich, and Tsou Chun Jaw, 2013: Trend Analysis of Extreme Daily Precipitation Events over United States using Reanalyses Products. (In progress)
- Hsu, K., H. Ashouri, D. Braithwaite, and **S. Sorooshian**, 2012. PERSIANN Precipitation Climate Data Record, Climate Algorithm Theoretical Basis Document (C-ATBD), Submitted to Climate Data Record (CDR) Program, National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (NCDC), Asheville, North Carolina, USA.

- Nasrollahi, N., K. Hsu, and **S. Sorooshian**, 2013, Reducing False Alarm in Satellite Precipitation Products, Journal of Hydrometeorology, 14(4). doi:10.1175/JHM-D-12-0172.1.
- Sellers, S., P. Nguyen, W. Chu, X. Gao, K. Hsu, and **S. Sorooshian**, 2013: Computational Earth Science: Big Data Transformed into Insight. EOS, 94(32), 277-278. doi: 10.1002/2013EO320001
- Zahraei, A., K. Hsu, **S. Sorooshian**, J.J. Gourley, Y. Hong, and A. Behrangi. 2013: Short-term Quantitative Precipitation Forecasting Using An Object-based Approach. Journal of Hydrology. 483, 1-15. doi: 10.1016/j.jhydrol.2012.09.052.
- **Stevens, L.E.** (2013), Regional Climate Trends and Scenarios: The Northeast U.S., NOAA Technical Report NESDIS 142-1 Summary, 2 pp.
- **Stevens, L.E.** (2013), Regional Climate Trends and Scenarios: The Southeast U.S., NOAA Technical Report NESDIS 142-2 Summary, 2 pp.
- **Stevens, L.E.** (2013), Regional Climate Trends and Scenarios: The Midwest U.S., NOAA Technical Report NESDIS 142-3 Summary, 2 pp.
- **Stevens, L.E.** (2013), Regional Climate Trends and Scenarios: The U.S. Great Plains, NOAA Technical Report NESDIS 142-4 Summary, 2 pp.
- **Stevens, L.E.** (2013), Regional Climate Trends and Scenarios: The Southwest U.S., NOAA Technical Report NESDIS 142-5 Summary, 2 pp.
- **Stevens, L.E.** (2013), Regional Climate Trends and Scenarios: The Northwest U.S., NOAA Technical Report NESDIS 142-6 Summary, 2 pp.
- **Stevens, L.E.** and B. Stewart (2013), Regional Climate Trends and Scenarios: Alaska, NOAA Technical Report NESDIS 142-7 Summary, 2 pp.
- **Stevens, L.E**. (2013), Regional Climate Trends and Scenarios: Hawai'i and Pacific Islands, NOAA Technical Report NESDIS 142-8 Summary, 2 pp.
- **Stevens, L.E.** (2013), Regional Climate Trends and Scenarios: Contiguous United States, NOAA Technical Report NESDIS 142-9 Summary, 2 pp.
- Li, H., M. Kanamitsu, S-Y Hong, K. Yoshimura, D. Cayan, V. Misra, and **L. Sun**, 2014: Projected climate change scenario over California by a regional ocean-atmosphere Coupled Model system. Climatic Change, doi:10.1007/s10584-013-1025-8.
- Dehaan, L., M. Kanamitsu, F. D. Sales, and **L. Sun**, 2014: Seasonal prediction downscaling over North America using regional models: Added values. Climate Dynamics, in review.
- Kingsmill, D. E., P. J. Neiman, B. J. Moore. M. Hughes, **S. E. Yuter** and F. M. Ralph, 2013: Kinematic and thermodynamic structures of Sierra barrier jets and overrunning atmospheric rivers during a land-falling winter storm in northern California. Mon. Wea. Rev., 141, 2015-2036.

Appendix 4: CICS-NC PRESENTATIONS

- **Bell J.E.**, and **J.L. Matthews**, 2013. Growing Season Analysis during *NCDC Dataset Discovery Day: Frost and Freeze Data and Impacts to the Agriculture, Construction, and Transportation Industry*, 20 March 2013, Asheville, NC.
- **Bell, J.E.** Collaboration on climate and health. Emory University, August 2013.
- **Bell, J.E.** Preparation of NOAA's USCRN for NASA's SMAP Mission. Pasadena, CA. November 2013.
- **Bell, J.E.**, M. Cosh, and M. Hall. (Invited Poster Presentation) Validating USCRN Soil Observations with a Dense Temporary Network. AGU Annual Meeting, San Francisco, CA. December 2013.
- **Bell, J.E.** Evaluation of the 2012 drought with a newly established national soil monitoring network (USCRN). AMS Annual Meeting, Atlanta, GA. February 2014.
- Timles, C., **Champion, S.**, and Aulenbach, S. 2014: *The Federation of Earth Science Information Partners Winter Meeting, Washington, D.C., ESIP*
- **Copley, L.**, 2014: Graph Databases Conceptual Overview. Presentation to NCDC Metadata Working Group, 7 March 2014.
- **Dissen, J.**, S. Schollaert-Uz, P. Arkin, **O. Brown** (2013). Advancing Climate Literacy: A CICS Perspective. NOAA Satellite Conference, College Park, MD. April 2013
- **Dissen, J.** (2013). CICS-NC An Overview for Advancing Literacy. Presentation to The Science House, Asheville, NC. July 2013
- **Dissen, J.** and T. Houston (2013). Climate Data to Decisions. Presentation to CDMS Smith Overview. July 2013
- **Dissen, J.**, **O. Brown**, T. Houston. (2013). Climate Data to Decisions. Presentation to the AWMA Climate Change Impacts, Policy and Regulation Conference. Herndon, VA. September 2013
- **Dissen, J.** and **O. Brown** (2013). Climate Data and Sustainability. Presentation to the Lenoir Rhyne Sustainability Class, Asheville, NC. September 2013
- **Dissen, J.** and T. Houston (2013). Climate Data to Decisions: A CICS-NC Approach to Outreach. Statweather Energy Summit. Houston, TX. September 2013
- **Dissen, J.** and **O. Brown** (2013). CICS-NC Engagement, Outreach and Literacy. NC Science Summit Regional Meeting, Asheville, NC. September 2013
- **Dissen, J.** and **O. Brown** (2013). CICS-NC: Catalyzing Climate Activities. Presentation to the UNC Asheville Dean of Graduate Studies, Asheville, NC. October 2013
- **Dissen, J.** and **O. Brown** (2013). Climate Data in Context: A CICS-NC Perspective. Presentation to the Leadership Asheville, Asheville, NC. November 2013
- **Dissen, J.** and **O. Brown** (2013). Precipitation Data and Applications. Presentation to the NCDC Climate Data and Applications Workshop Series, Asheville, NC. December 2013
- NEMAC's Greg Dobson and **Jim Fox** co-organized and co-chaired a session at the 94th AMS Annual Meeting February 2-6, 2014, in Atlanta, Georgia. The session was titled *"Identifying the Needs and Opportunities of Small and Medium-Sized Communities for Data, Information, and Integrated Tools for Enhanced Decision Support-Part I: Users."* This was a two-part session that NEMAC organized along with Riverside

Technology's George Smith and Larry Brazil. The second part, co-organized and co-chaired by Riverside Technology, focused on Providers.

- Dobson, J.G. and **J.F. Fox**. *"Providing Meaningful and Actionable Decision Tools to Local and Regional Stakeholders across the Southeastern U.S."* The 94th American Meteorological Society's Annual Meeting, 9th Symposium on Policy and Socioeconomic Research. February 2nd- 6th, 2014, Atlanta, Georgia.
- **Fox, J.F.** and J.G. Dobson. *"Framing the Climate Issue for Small and Medium-Sized Communities across the Southeastern U.S."* The 94th American Meteorological Society's Annual Meeting, 9th Symposium on Policy and Socioeconomic Research. February 2nd- 6th, 2014, Atlanta, Georgia.
- **Fox, J.F.** and J.G. Dobson. *"Framing the Climate Issue for Small and Medium-Sized Communities across the Southeastern U.S."* The 94th American Meteorological Society's Annual Meeting, 9th Symposium on Policy and Socioeconomic Research. February 2nd- 6th, 2014, Atlanta, Georgia.
- Bork-Unkelbac, A., **Guillevic, P.**, Göttsche, F., and Olesen, F. (2013). Extrapolation of in-situ measurements of Land surface temperature (LST) to satellite spatial resolution. EUMETSAT Satellite Applications Facility on Land Surface Analysis (LSA SAF) workshop, Karlsruhe, Germany, 17-19 June 2013.
- Yu, Y., Csiszar, I., Liang, S., Liu, Y., Wang, D., Yu, P., Tang, Y., Privette, Y., **Guillevic, P.**, Schaaf, C., Wang, Z. (2013). JPSS S-NPP land surface products: status of Land Surface Temperature and Albedo EDRs. EUMETSAT Satellite Applications Facility on Land Surface Analysis (LSA SAF) workshop, Karlsruhe, Germany, 17-19 June 2013.
- Mira, M, Olioso, A., Courault, D., Marloie, O., and **Guillevic, P.** (2013). Impact of surface emissivity and atmospheric conditions on surface temperatures derived from Landsat 7 brightness temperature. 33rd European Association of remote Sensing Laboratories (EARSeL), 3-6 June 2013, Madera, Italy.
- **Guillevic, P.C.**, Privette, J.L., Yu, Y., Göttsche, F.M., Hulley, G., Olioso, A., Sobrino, J., Meyers, T., Ghent, D., Bork-Unkelbach, A., Courault, D., Román, M.O., Hook, S., Csiszar, I. (2013). NPP VIIRS land surface temperature product validation using worldwide observation networks. Symposium Proceedings, 2013 IEEE International Geoscience & Remote Sensing Symposium (IGARSS 2013), July 21-26, 2013, Melbourne, Australia. Published by IEEE (USB key). IEEE Catalog Number: CFP13IGA-USB. ISBN: 978-1-4799-1113-4. Paper number: MOP.P23.87. Pages 640-643.
- Olioso, A., Mira, M., Courault, D., Marloie, O., **Guillevic, P.**, 2013. Impact of surface emissivity and atmospheric conditions on surface temperatures estimated from top of canopy brightness temperatures derived from Landsat 7 data. Symposium Proceedings, 2013 IEEE International Geoscience & Remote Sensing Symposium (IGARSS 2013), July 21-26, 2013, Melbourne, Australia. Published by IEEE (USB key). IEEE Catalog Number: CFP13IGA-USB. ISBN: 978-1- 4799-1113-4. Paper number: TH1.T06.4. Pages 3033- 3036.
- **Guillevic, P.**, **Biard, J.**, Hulley, G., Goettsche, F., Ghent, D., and Privette J.L. (2013). Validation of satellite Land Surface Temperature products - Protocol, limitations and results. Invited oral presentation at the American Geophysical Union (AGU) fall meeting. San Francisco, CA, USA. 9-13 December 2013.

- **Hsu, K.** (Invited), 2013: Utilizing PERSIANN Satellite-based Precipitation Dataset for Hydrologic Applications, American Geophysics Union Fall Meeting, 9-13 December, 2013. San Francisco.
- **Inamdar, Anand**: "A new approach to monitor net surface solar radiation from geostationary satellites." Earth System Science Inter-disciplinary Center (ESSIC), University of Maryland, College Park MD Sep 9 2013.
- **Inamdar, Anand**: 28th Hydrology Conference, American Meteorological Society 94th Annual Meeting, Atlanta. Feb 3 2014.
- **Kunkel, K.E.**, 2013: Analysis of Historical and Future Snow Conditions for the National Climate Assessment, Western Snow Conference, Jackson, Wyoming (16 April).
- **Kunkel, K.E.**, 2013: Observed Trends and Future Projections of Extremes, invited talk, Advisory Committee on Water Information, webinar (30 May).
- **Kunkel, K.E.**, 2013: Climate Change and Extreme Weather and Climate Events, invited talk, Executive Forum for Business and Climate, Asheville, NC (4 June).
- **Kunkel, K.E.**, 2013: Observed Trends and Future Projections of Extremes, invited talk, 35th MIT Global Change Forum, Cambridge, MA (5 June).
- **Kunkel, K.E.**, 2013: Observed Trends and Future Projections of Drought, invited talk, Advisory Committee on Water Information, webinar (27 June).
- **Kunkel, K.E**., 2013: Extreme Weather and Climate Events, invited talk, Tokio Marine's Eighth Summit on Global Warming and Climate Change, Atlanta, GA (28 June).
- **Kunkel, K.E.**, 2013: An Assessment of Extreme Weather and Climate Events, invited talk, Summer Meeting of the Federation of Earth System Information Providers, Raleigh, NC (11 July).
- **Kunkel, K.E.**, 2013: Climate Extremes Research: Recent Findings and New Directions, invited talk, Snowmass 2013 Integrated Climate Change Impacts Session, Energy Modeling Forum, Snowmass, CO (24 July).
- **Kunkel, K.E.**, 2013: National Climate Assessment: Potential CDR Program Contributions, invited talk, NOAA Climate Data Record Annual Meeting, Asheville, NC (30 July).
- Seyller, E., **K.E. Kunkel**, and **L.E. Stevens**, 2013: Regional Climate Trends and Scenarios for the United States, GreenGov Workshop on Climate Science and Adaptation Planning, Washington, D.C. (2 August).
- **Kunkel, K.E.**, 2013: Extreme Precipitation Events: Data Issues and Meteorological Causes, invited talk, U.S. CLIVAR Workshop: Analyses, Dynamics, and Modeling of Large Scale Meteorological Patterns Associated with Extreme Temperature and Precipitation Events, Berkeley, CA (20 August).
- **Kunkel, K.E**, **L.E. Stevens**, and J.G. Dobson. *"Uncertainties in Model Simulations of the Regional U.S. Climate."* (Poster). The International Conference on Regional Climate – CORDEX 2103. November 4th- 7th, 2013, Brussels, Belgium.
- **Kunkel, K.E.**, 2013: U.S. Climate Scenarios, invited talk, Second Nature webinar on "Understanding Climate Impacts: Using Tools and Resources to Prepare Your Campus for a Changing Climate" (20 November).

- **Kunkel, K.E.**, 2013: National Climate Assessment Climate Modeling and Downscaling, invited talk, Scoping Workshop for the National Climate Assessment (NCA) Special Report on Climate Change and Health, Washington, DC (21 November).
- **Kunkel, K.E.**, 2013: U.S. Regional Extreme Climate Conditions in CMIP5 Simulations, invited talk, 2013 Fall Meeting of the American Geophysical Union, San Francisco, CA (12 December).
- **Kunkel, K.E.**, 2013: Observed Trends in Extreme Precipitation in the U.S., invited talk, 2013 Fall Meeting of the American Geophysical Union, San Francisco, CA (13 December).
- **Kunkel, K.E.**, 2014: What are the Innovations in Science and Scenarios for this and Future Assessments, invited talk, National Council for Science and Engineering 14th National Conference, Washington, DC (28 January).
- Arumugam, S., **K.E. Kunkel**, and T. Sinha, 2014: Water Sustainability under Near-term Climate Change: A Cross-Regional Analysis Incorporating Socio-Ecological Feedbacks and Adaptations, annual investigator meeting for NSF Watershed Science and Climate Program, Washington, DC (30 January).
- **Kunkel, K.E.**, 2014: Observed Trends in Extreme Precipitation: Illinois and Beyond, invited talk, Stanley A. Changnon Symposium, Annual Meeting of the American Meteorological Society, Atlanta, GA (4 February).
- **Kunkel, K.E.**, 2014: Historical Trends and Future Projections of Extreme Climate Conditions for the U.S. National Climate Assessment, Annual Meeting of the American Meteorological Society, Atlanta, GA (4 February).
- **Kunkel, K.E.**, 2014: Extreme Precipitation Trend Estimation in Conterminous United States (CONUS), poster paper, Donald R. Johnson Symposium, Annual Meeting of the American Meteorological Society, Atlanta, GA (6 February).
- **Kunkel, K.E.**, 2014: Extreme Precipitation Trends and Future Changes in Urban Areas Due to Global Warming, invited talk, International Symposium on Diagnosis and Early Warning of Urban Weather/Climate Extremes, Nanjing, China, (19 March).
- **Kunkel, K.E.**, 2014: National Climate Assessment: An Overview, A-B Tech Community College Environmental Biology class, Asheville, NC, (25 March).
- **Leeper, R. D.** U.S. Climate Reference Network Gauge Evaporation and Impacts on Precipitation Observations. National Climatic Data Center. Asheville, NC. March 2013
- **Leeper, R. D.** First and last day of frost: A USCRN perspective. Cooperative Institute for Climate and Satellites North Carolina (CICS-NC) Workshop. March 2013.
- **Leeper, R.D.**, **O.P. Prat**, and B.O. Blanton. Evaluating the Sensitivity of the Weather Research and Forecasting (WRF) Model for Tropical Cyclones Impacting the Carolinas. Abstract submitted to the *Carolinas Climate Resilience Conference*. 28-29 April 2014, Charlotte, NC.
- **Liu W.**, Z. Liu, E. Brady, and J. Cheng, 2013: The forcing mechanism on the Southern Ocean upwelling during the last deglaciation, Woods Hole Oceanographic Institution, MA (30 May).
- **Liu, W.**, B. Huang, P. W. Thorne, V. F. Banzon, H-M Zhang, E. Freeman, J. Lawrimore, T. C. Peterson, T. M. Smith, and S. D. Woodruff, 2014: Extended Reconstructed Sea

Surface Temperature version 4 (ERSST.v4). *2014 Ocean Science Meeting*, Honolulu, HI, (23-28 Feb.).

- **Matthews, J.L.**, 2013: Research applications at the National Climatic Data Center*, North Carolina State University Statistics Department Environmental seminar*, Raleigh, NC (17 Oct.).
- **Matthews, J.L.** and Lei Shi, 2014: Validation of satellite-derived temperature and humidity profiles, *SIAM Conference on Uncertainty Quantification*, Savannah, GA (31 Mar).
- **Matthews, J.L.** and Lei Shi, 2014: Validation of satellite-derived temperature and humidity profiles, *SIAM Conference on Uncertainty Quantification*, Savannah, GA (31 Mar).
- **Meyer J.**, 2013. Evaluation of Air and Soil Temperatures for Determining Onset of Growing Season. *NCDC Internal Seminar*, 26 March 2013, Asheville, NC.
- **Peng, G.**, 2013: A straw man idea on the scope of long-term scientific stewardship CDRs. On March 1, 2013 for the NCDC Metadata Working Group and on March 7, 2013 to NCDC CDR Program management.
- Zhang, H.-M., **G. Peng**, **L. Vasquez**, W. Hankins, C.W. Fairall, R. Weller, and A. Brown, 2013: The SURFA Project: Towards Near-Real-Time Quality Monitoring of NWP Forecasts and Historical Analysis. 4th WGNE workshop on systematic error in weather and climate models. 15-19 April 2013, Exeter, UK.
- **Peng, G.** and J. L. Privette, 2013: Toward a unified scientific data stewardship framework. On August 7, 2013 to NCDC Deputy Director along with CDR program and RSAD division management.
- **Peng, G.**, L. D. Cecil, and B. Cramer, 2014: An End-to-End Framework for Probabilistic Uncertainty Characterization of Climate Satellite Data and Products. 10th Annual Symposium on New Generation Operational Environmental Satellite Systems, AMS 2014 annual meeting, February 2- 6, 2014, Atlanta, GA, USA.
- **Peng, G.** and J. L. Privette, 2014: A stewardship maturity matrix for assessing the state of environmental data quality and usability. 10th Annual Symposium on New Generation Operational Environmental Satellite Systems, AMS 2014 annual meeting, February 2- 6, 2014, Atlanta, GA, USA.
- **Prat, O.P.**, and B.R. Nelson, 2013. Characterization of precipitation features over CONUS using quantitative precipitation estimates derived from TRMM satellite and Stage IV data for the period 2002-2012. *11th International Precipitation Conference*. 1-3 July, 2013, Ede-Wageningen, Netherlands.
- **Prat, O.P**., and M.R. Kumjian, 2013. Polarimetric signatures of microphysical processes in warm rain. *11th International Precipitation Conference*, 1-3 July 2013, Ede-Wageningen, Netherlands.
- Kumjian, M.R., and **O.P. Prat**, 2013. The impact of raindrop collisional processes on the polarimetric radar variables. *36th AMS conference on radar meteorology*, 17-19 September 2013, Breckenridge, CO, USA.
- Cifelli, R., S. Goodman, R. Ferraro, N.-Y. Wang, P. Xie, R. Joyce, B. Nelson, **O.P. Prat**, P. Groisman, Y. Xie, S. Albers, D. Birkenhaeuer, K. Mahoney, and S. Rudlosky, 2013. NOAA activities in support of the NASA GPM GV program. *6th international workshop for GPM ground validation,* 5-7 November 2013, Rome, Italy.

- Ferraro, R., R. Cifelli, C. Kondragunta, N.-Y. Wang, P. Xie, R. Joyce, Y. Zhang, D. Kitzmiller, R. Kuligowski, J. Gourley, P. Groisman, B. Nelson, **O.P. Prat**, K. Mahoney, S. Rudlosky, Y. Xie, S. Albers, and D. Birkenheuer, 2013. NOAA Contributions to and Utilization of GPM-era Data and Products, 2013 GPM Applications Workshop, 12-13 November, 2013, College Park, MD, USA.
- **Prat, O.P.**, and B.R. Nelson, 2013. Characterization of precipitation features over CONUS derived from satellite, radar, and rain gauge datasets (2002-2012). *2013 AGU fall meeting*, 9-13 December, 2013, San Francisco, CA, USA.
- **Prat, O.P.**, and B.R. Nelson, 2014. Toward the development of an evaluation framework of Climate Data Records for precipitation: A characterization of CONUS rainfall using a suite of satellite, radar, and rain gauge QPE products. *94th annual meeting of the American Meteorological Society,* 2-6 February 2014, Atlanta, GA, USA.
- **Prat, O.P.**, B.R. Nelson, and **L. Vasquez**, 2014. Characterization of CONUS rainfall using a multi-sensor approach: Evaluation of radar-based, satellite-based, and ground-based QPE products. Abstract submitted to the *International Weather Radar and Hydrology symposium*, 7-9 April 2014, Washington, DC, USA.
- **Prat, O.P.**, and M.R. Kumjian, 2014. Transient behavior of polarimetric signatures of warm rain microphysical processes. Abstract submitted to the *International Weather Radar and Hydrology symposium*, 7-9 April 2014, Washington, DC, USA.
- **Prat, O.P.**, **R.D. Leeper**, and B.O. Blanton. Comparison of Weather Research and Forecasting (WRF) Model-Simulated Tropical Cyclones and Multi-Sensor Precipitation Estimates Over the Carolinas. Abstract submitted to the *Carolinas Climate Resilience Conference*. 28-29 April 2014.
- **Rennie, J.J.** (2013) An Open and Transparent Databank of Global Land Surface Temperature, AGU Fall Meeting, San Francisco, CA, 12 Dec 2013
- **Schreck, C. J.**, 2013: Comparing MJO diagnostics during DYNAMO. *MJO Field Data and Science Workshop*, 4-8 March 2013, Kohala Coast, HI.
- **Schreck, C. J.** and J. P. Kossin, 2013: Role of Kelvin waves in tropical cyclogenesis. *NASA Precipitation Measurement Mission Science Team Meeting*, 18-21 March 2013, Annapolis, MD.
- **Schreck, C. J.**, 2013: Use of NOAA satellite products by the energy sector. NOAA Satellite Conference for Direct Readout, GOES/POES, and GOES-R/JPSS Users, College Park, MD, 11 April 2013.
- **Schreck, C. J.**, 2013: Overview of hurricanes and seasonal hurricane prediction. Statistical and Applied Mathematical Sciences Institute Undergraduate Modeling Workshop. Raleigh, NC, 13 May 2013.
- **Schreck, C. J.**, 2013: Scale interactions: Bridging the gap between the tropics and extratropics. Third Workshop on Medium/Long Range Weather Forecasting and Subseasonal Atmospheric Drivers, Albany, NY, 15 May 2013.
- **Schreck, C. J.**, 2013: The latest on the MJO. MDA Weather Services' 12th Annual Energy Conference for Traders and Analysts, Las Vegas, NV, 17 October 2013.
- Hennon, C.C., K.R. Knapp, **C.J. Schreck**, **S.E. Stevens**, and J.P. Kossin, 2013: Cyclone Center: Using crowdsourcing to determine tropical cyclone intensity. *AGU Fall Meeting,* 9-13 December 2013, San Francisco, CA.

- Thorne, P.W., C.C. Hennon, K.R. Knapp, **C.J. Schreck III**, **S.E. Stevens**, **P.A. Hennon**, J.P. Kossin, M.C. Kruk, **J. Rennie**, and **L.E. Stevens**, 2014: Cyclonecenter: Crowdsourcing insights into historical tropical cyclone intensities. *26th Conference on Climate Variability and Change,* 2-6 February 2014, Atlanta, GA.
- Ashouri H., K. Hsu, **S. Sorooshian**, J. Lee, M. G. Bosilovich, and J. Y. Yu, 2014: Evaluation of the Reanalyses Products in Detecting Extreme Precipitation Trends over United States, American Meteorological Society (AMS) 94th Annual Meeting, 28th Conference on Hydrology, February 1-6, 2014, Atlanta, GA.
- **Stevens, L.E.** and **A. Buddenberg**, 2013: Climate Modeling for the National Climate Assessment, UNC Asheville, Asheville, NC (11 September).
- **Stevens, L.E.**, 2014: National Climate Assessment Panel Discussion, 94th Annual Meeting of the American Meteorological Society, Atlanta, GA (2 February).
- Nelson, B.R., **S.E. Stevens**, and **O.P. Prat**, 2013. NEXRAD: An overview and NCDC/NSSL/CICS Reanalysis effort. *Climate Data and Applications Workshop-A Focus on Precipitation*, 3-4 December, 2013, Asheville, NC, USA.
- **Stevens, S.E.**, B.R. Nelson, C.L. Langston, and K.L. Ortega, 2014: Toward a climate-quality high-resolution precipitation dataset: An early look at the National Mosaic and Multisensor Quantitative Precipitation Estimate (NMQ/Q2). *28th Conference on Hydrology*, 2-6 Feburary 2014, Atlanta, GA.
- Nelson, B.R, **S.E. Stevens**, **O.P Prat**, C. Langston, K. Ortega, J. Zhang, Y. Qi, K. Howard, and T. Smith, 2014. The National Mosaic and Multi-sensor Quantitative Precipitation Estimate (NMQ/Q2) Reanalysis Effort. Abstract submitted to the *International Weather Radar and Hydrology symposium*, 7-9 April 2014, Washington, DC, USA.
- **Sun, L.**, 2013: lead panel discussions on "identify, evaluate and develop improved climate-prediction metrics for applications-based use, U.S. CLIVAR 2013 Summit, Annapolis, MD (10 July)
- **Sun, L.**, 2013: climate-crop modeling: a climatological perspective, 4th Annual AgMIP Global Workshop, New York (29 October)
- **Sun, L.**, 2014: Multi-model ensemble seasonal climate forecasts for Northeast Brazil, invited talk via Skype, 16th Semi-Arid Northeast Brazil Climate Outlook Forum, Fortaleza, Brazil (17 January)
- Corbin, N., and **S. Yuter**, 2013: A six-year climatology of precipitation within major storms in northern California. Poster presentation at NC State Summer Undergraduate Research Symposium, 31 July 2013.
- Corbin, N., **S. Yuter**, and **A. Hall**, 2014: A six-year climatology of precipitation within major storms in northern California. Poster presentation at NC State College of Sciences Access Day, 6 Feb 2014
- The Maps, Mashes, and Management Application Project was presented at the following meetings:
    - » NC Coastal Atlas Workshop, May 14-15, Manteo, NC
    - » NC Hurricane Workshop, May 23, Greenville, NC
    - » ECU Geography, Planning and Environment Colloquium, Oct. 15, Greenville, NC
    - » NC ArcUser Group, Oct. 29-30, Carolina Beach, NC
    - » APNEP Symposium on the Sounds, Nov. 18, New Bern, NC

    - » Coastal and Estuarine Research Federation, Nov. 3-5, San Diego, CA
    - » NOAA Social Coast Forum, Feb. 18-20, Charleston, SC
    - » ECU FaculTea, March 5, Greenville, NC
- The Radar-based SPI project was presented to the American Association of State Climatologists, July 2013, St. Louis, MO.

Appendix 5: Related Seminars, Workshops, and Presentations

- **James Biard**: Flash Floods: Silent but deadly, requested presentation, FIRST LEGO league team visit to NCDC. Claxton Elementary, 8/23/2013, Vance Elementary 9/11/2013, Asheville Middle School 9/19/2013, Asheville 4-H 10/9/2013, Asheville, NC.
- **James Biard:** Hands-on Educational Experience, Asheville Middle School Wave Day, 12/17/2013, Asheville, NC.
- **James Biard:** Inter-comparison of Land Surface Temperature products from NPP/VIIRS and Aqua/MODIS-Protocol, Limitations and Validation Results, Poster Presentation, 10th Symposium on New Generation Operational Environmental Satellite Systems/94th AMS Annual Meeting, 2/5/2014, Atlanta, GA.
- **Otis Brown**: WCRP Data Advisory Council-Second Meeting, Convened meeting as the Chair, 3/4-3/5/2013, European Space Agency, Darmstadt, Germany.
- **Otis Brown**: NASA/JPL Climate Center Advisory Board, Provide advice to their climate science program, 3/4/2014, NASA/JPL, Pasadena, CA.
- **Otis Brown**: Science Partnering with the Private Sector Workshop, Leopold Leadership Program, sponsored by Stanford Wood Institute for the Environment, 3/17/2014, Stanford University, Stanford, CA.
- **Otis Brown** and **Jenny Dissen**: National Partnership for Resilience Workshop, 3/27/2014, Biltmore Company Corporate Headquarters, Asheville, NC.
- **Sarah Champion**: Progress with GCIS and NCA Metadata Collection Presentation, Earth Systems Information Partners (ESIP) Winter Meeting, 1/10/2014, Washington, D.C.
- **Jenny Dissen** and **Otis Brown**: "Frost and Freeze Data and Impacts to the Agriculture, Construction and Transportation Industry", part of the Climate Data and Applications Workshop series, 03/20-03/21, 2013, NOAA/NCDC, Asheville, NC.
- **Jenny Dissen** and DeWayne Cecil: NASA DEVELOP Student Visit Meeting, 3/28/2013, NOAA/NCDC, Asheville, NC.
- **Jenny Dissen**: Climate Communications Training Workshop, 4/25/2013, Boulder, CO.
- **Jenny Dissen**: Climate Communications Support Workshop, 5/6/2013, Washington, DC.
- **Jenny Dissen** and **Otis Brown**: Executive Forum on Business and Climate, 06/03-06/06, 2013, Asheville, NC.
- **Jenny Dissen** and **Otis Brown**: Executive Forum on Business and Climate-Business Resilience, 11/4/2013, Washington, DC.
- **Jenny Dissen** and **Otis Brown**: Precipitation Data and Applications Workshop, part of the Climate Data and Applications Workshop series. 12/3-12/4, 2013, NOAA/NCDC, Asheville, NC.
- **Geraldine Guillevic** and **Jenny Dissen**: Climate Communications Support Workshop, 5/29/2013, NOAA/NCDC, Asheville, NC.

- **Ronald D. Leeper**: Frost and Freeze Data and Impacts to the Agriculture, Construction and Transportation Industry, First and Last Day of Frost: A USCRN Perspective Presentation, 3/21/2013, Asheville, NC.
- **Ronald D. Leeper**: Monitoring Agricultural and Health Related Metrics At Sub-hourly Scales with the US Climate Reference Network Presentation, Stanley A. Changnon Symposium/94th AMS Annual Meeting, 2/4/2014, Atlanta, GA.
- **Jessica Matthews**: Next Generation Climate Data Products Workshop, 7/15-7/19/2013, NCAR, Boulder, CO.
- **Jared Rennie**/Peter Thorne, ISTI Benchmarking Workshop, 7/1- 7/3/2013, NOAA/NCDC, Asheville, NC.
- **Jared Rennie**: Increasing our International Land Surface In-Situ Data. Talk, CICS-NC, 10/22/2013, NOAA/NCDC, Asheville, NC.
- **Carl Schreck**: How the Energy Industry uses CDRs: A Forecast Discussion, CICS-NC, 1/7/2014, NOAA/NCDC, Asheville, NC.
- **Laura Stevens**: National Climate Assessment: An Overview. Presentation for the Montreat Presbyterian Earth Care Team, CICS-NC, 3/21/2014, NCDC, Asheville, NC.
- **Scott Stevens**: Severe Weather Safety, Radar, and Storm Chasing. Presentation for WNC Science Olympiad Team, CICS-NC, 3/26/2014, NOAA/NCDC, Asheville, NC.