NCICS Highlights

North Carolina Institute for Climate Studies
Inspire. Advance. Engage.

2017–2018

2017–2018 Institute Highlights

Formally approved as an inter-institutional research institute by the University of North Carolina General Administration in January 2011, the North Carolina Institute for Climate Studies (NCICS) is a unique center of excellence showcasing a partnership between universities, the private sector, non-profit organizations, community groups, and the federal government.

NCICS' primary activity continues to be the operation of the NOAA Cooperative Institute for Climate and Satellites—North Carolina (CICS-NC), which was founded in 2009. CICS-NC's mission is facilitated by its co-location with our primary NOAA sponsor, the National Centers for Environmental Information (NCEI), in the Veach-Baley Federal Complex in Asheville, North Carolina.

Other extramural support continues to expand, however, including federal projects supported by NSF, DoD, DOE, NASA, and NIH as well as several smaller private-industry project awards.

NCICS' main objectives are to:

- promote discovery of new knowledge about global, regional, and local climate variability and its impacts, and

- provide information that is critical for determining trends and validating climate forecasts at all of these spatial scales.

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.

Current Institute Personnel

As of May 2018: Twenty-nine full-time staff, three part-time staff, and four temporary employees. Faculty appointments include two North Carolina State University Research Professors and four adjunct research faculty appointments (1 NCSU, 1 NCSU and NC A&T, 1 Emory, 1 Appalachian State).

Institute Vision

- *Inspire* cutting-edge research and collaboration

- *Advance* understanding of the current and future state of the climate

- *Engage* with business, academia, government, and the public to enhance decision making

Task Streams

NCICS/CICS–NC efforts are organized in eight task/activity streams:

Administration
Administrative and information technology support for Institute activities

Access and Services Development
Supporting improvements to access mechanisms for NCEI's data and product holdings

Assessment Activities
Supporting interagency activities for global, national, and regional assessments of climate change

Reference Environmental Data Records and Science Data Stewardship
Providing quality satellite and in situ climate observing datasets to document the Earth's climate

Climate Literacy, Outreach, Engagement, and Communications
Improving public knowledge and understanding of climate change, its impacts, and options for adaptation and mitigation

Surface Observing Networks
Sustaining and improving the quality of in situ observations and observing networks

Workforce Development
Preparing the next generation of climate scientists, engineers, and technicians

Consortium and Other Projects
Augmenting Institute capabilities through CICS consortium member partnerships and collaborative endeavors supported by various other sponsors

Selected Highlights By Task Stream

Key staff names for each project are shown in brackets.

Administration

- IT staff continue to refine and improve the Institute's high-performance computing (HPC) infrastructure. Our HPC offers 528 processing cores and 3 terabytes of memory, with 224 CPUs and 1.2 terabytes of memory available for use as virtual machines. [Brannock, Wilkins]

- A distributed file system provides 1,210 terabytes of storage and maintains up to two backup copies of datasets.

- A new 100 gigabit-per-second switch greatly increased server bandwidth and provides critical network redundancy in conjunction with the existing 10 gigabit-per-second switch infrastructure. This redundancy is particularly valuable as the Institute expands its data transfer activities in support of NOAA's Big Data Project.

- All hardware servers and core infrastructure virtual machines have been migrated to RedHat 7.
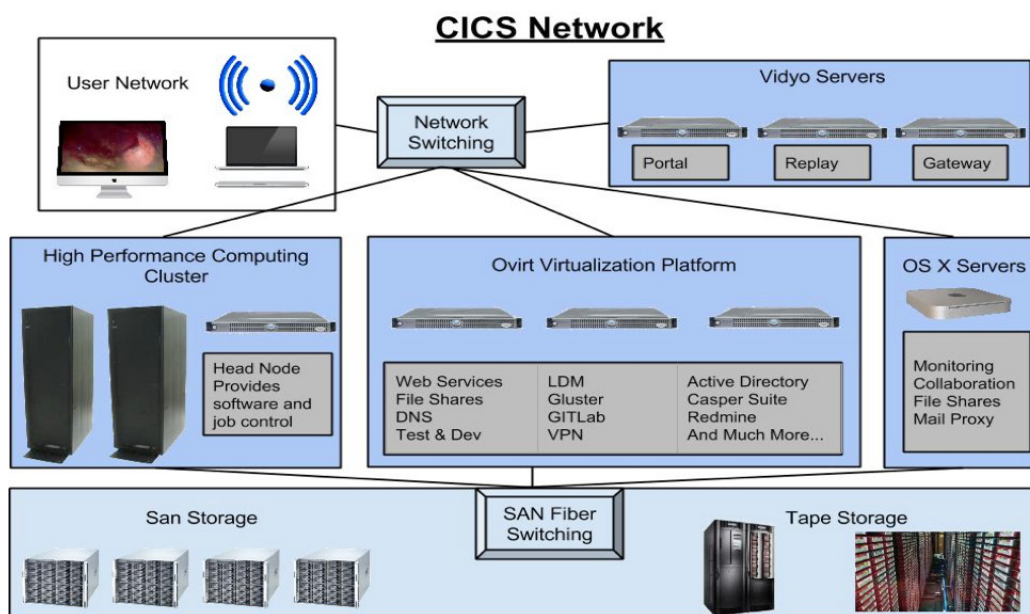
Access and Services Development

- **NOAA's Big Data Project (BDP)** facilitates public use of key NOAA environmental datasets by providing copies of the data in the Cloud, making them more easily accessible to the general public and allowing users to perform analyses directly on the data.

  CICS-NC acts as a broker between NOAA and the public cloud providers, transferring and certifying multiple NOAA datasets to several Cloud platforms, including Amazon Web Services (AWS), Google Cloud Platform (GCP), IBM NOAA Earth Systems Data Portal, and the Open Commons Consortium (OCC).

  Recent accomplishments include:

  › Near-real-time transfer of GOES-16 satellite data to three providers, totaling more than 300 gigabytes of information per day.

  › Transfer of NOAA's National Water Model and High-Resolution Rapid Refresh (HRRR) atmospheric model data to multiple providers.

  › Transfer of NCEI's Global Historical Climatology Network Daily (GHCN-D) temperature dataset.

  › Development of a web page highlighting selected BDP resources and datasets: ncics.org/data/noaa-big-data-project
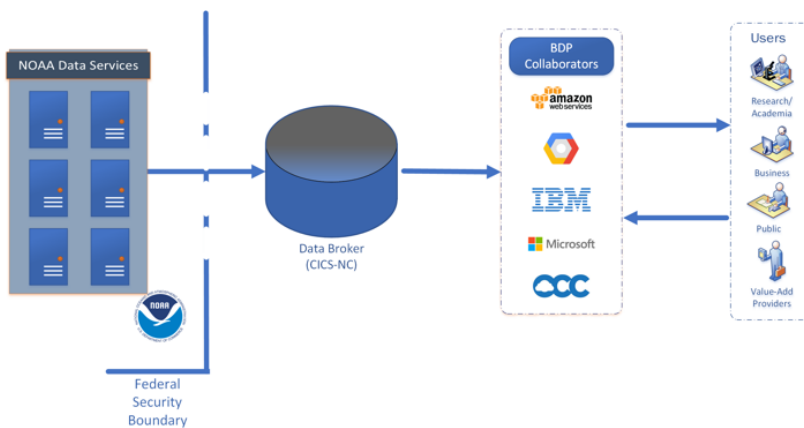

CICS-NC designed the pilot data hub using a stream processing architecture based on Advanced Message Queuing Protocol (AMQP). Python was selected as the programming language of choice due to the library availability for each of the public cloud providers. Docker® was chosen to provide application delivery and scalability. Using a combination of these technologies, the data hub architecture provides high availability, low latency, and a scalable and portable architecture. [Brannock, Wilkins]

- **Programming and Applications Development for Climate Portal:** In support of the overall advancement of NOAA's Climate Services Portal program, UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC) staff contributed to the continued development of the U.S. Climate Resilience Toolkit (toolkit.climate.gov), the new Climate Widget design (part of Climate Explorer 2 through Habitat Seven), the Climate Explorer (1) application redesign, and update of multiple Climate.gov applications.

- **Website Information Architecture Development and User Interface Design for NOAA's National Centers for Environmental Information and NOAA OneStop**: After researching NOAA OneStop's target audience and completing site analytics, Mediacurrent identified key performance indicators for tracking success, prioritized features based on user and stakeholder needs, conducted user testing, and developed an enhanced user interface design for improved user interaction. The outcome of this process was an end-to-end strategy audit, a web accessibility audit, and design mock-ups.

Assessment Activities

- **National Climate Assessment:** The NOAA Assessments Technical Support Unit (TSU), staffed largely by Institute personnel, provides extensive scientific, editorial, graphics, metadata, software, web design, and project management support for U.S. Global Change Research Program (USGCRP) climate change assessment reports and related products. [Kunkel, Biard, Champion, Griffin, Li, Maycock, L. Stevens, Stewart, Sun, Thrasher]

  › Completion and delivery of the *Climate Science Special Report* (Volume I of the Fourth National Climate Assessment, or NCA4) in November 2017. The report is available as downloadable PDFs and via an interactive website at: science2017.globalchange.gov.

  › Delivery of multiple review drafts of NCA4 Volume II, a larger report focusing on climate risks, impacts, and adaptation activities. A draft for public comment and review by the National Academies of Science was released simultaneously with the *Climate Science Special Report*. Another draft for final interagency review and clearance was released in April 2018. Delivery of the final report is expected in December of 2018.

  Global Mean Temperature Change
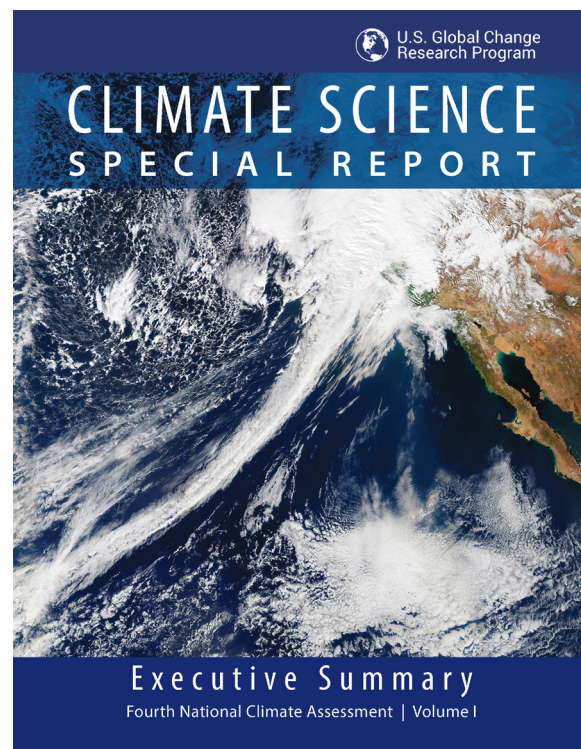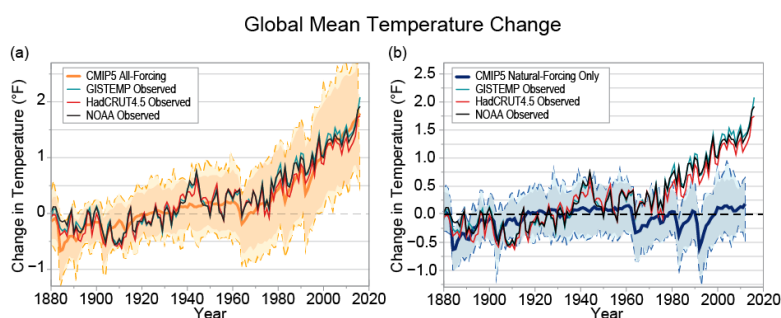
- **State Climate Summaries:** Building on the release of 50 State Climate Summaries in early 2017, Institute staff at the TSU released a state climate summary for Puerto Rico and the U.S. Virgin Islands in June 2018. The summary is at available online at statesummaries.ncics.org/pr.

- **Indicators:** The TSU provides support for USGCRP efforts to produce a comprehensive suite of climate change indicators. Thanks in large part to efforts by CICS-NC scientists, significant progress was made in the development of new indicators and collection of indicator metadata. A new Heavy Precipitation Indicator, developed with TSU input and support, was added to the USGCRP Indicators Platform in 2018. Other new indicators and updates to existing data are planned for the near future. www.globalchange.gov/browse/indicators

  Observed Change in Total Annual Precipitation Falling in the Heaviest 1% of Events (1901 - 2016)
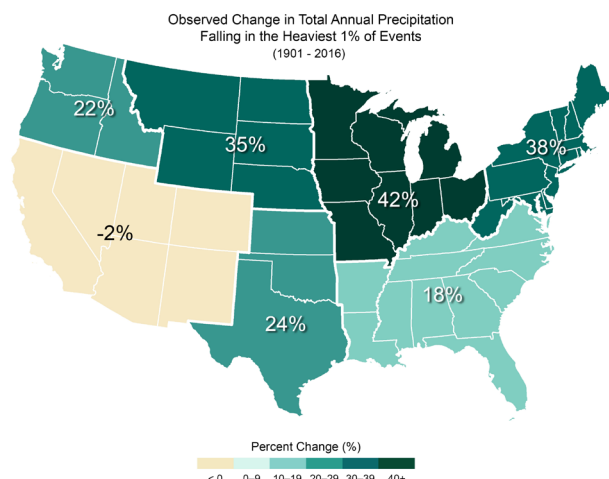
  The new USGCRP Heavy Precipitation Indicator. This map shows the observed change in the amount of precipitation falling in the heaviest 1% of all events. The observed trends for 1901–2016 are calculated as the difference between 1986–2016 and 1901–1960 and are averaged over each National Climate Assessment region. Heavy precipitation is becoming more intense and more frequent across most of the United States, particularly in the Northeast and Midwest.

- **India Partnership for Climate Resilience:** CICS-NC is partnering with NOAA NCEI and other organizations in support of an agreement between the U.S. Department of State and the Government of India to help build climate science capacity and resilience efforts in India. [Dissen]

  › CICS-NC led the development and coordination of two workshops on high-resolution climate modeling and analysis techniques held in India in February 2018. Partners included Texas Tech University and several Indian organizations, including The Energy and Resources Institute (TERI), the Institute for Tropical Meteorology Pune (IITM–Pune), and the Environmental Protection Training Research Institute (EPTRI). These efforts built on the success of an earlier workshop held in March 2017.

Participants and India State Action Planners at the EPTRI workshop held in Hyderabad, India.

  › The World Resources Institute (WRI) and the Partnership for Resilience and Preparedness (PREP) worked with two Indian states, Madhya Pradesh and Uttarakhand, to help implement State Action Plans on Climate Change through collaboration in the development and use of tailored "climate preparedness dashboards" on the PREP platform (www.prepdata.org).

  › CICS-NC partner Texas Tech University led the development of state-of-the-art climate products and analysis tools for resilience planning and sustainable development and the provision of these tools to U.S.–India Partnership for Climate Resilience (PCR) collaborators, including practitioners and researchers at the past year's PCR workshops in India.

  › CICS-NC is working with TERI and its Understanding Climate and Health Associations in India (UCHAI) Initiative on several activities and events to raise awareness of the effects of climate vulnerability and extreme weather patterns on human health and the adoption of measures that can help reduce risks (www.uchai.net).

Reference Environmental Data Records and Science Data Stewardship

- **NCEI Common Ingest Agile Development Team:** CICS-NC software engineers are key members of an Agile team charged with replacing a complex and antiquated legacy data ingest system. [Copley, Vasquez]

  › This year, the team iteratively delivered several versions of the "Common Ingest" solution, including Common Ingest v2.0.0, which delivers all of the functionality required to support the migration of all datasets from the current legacy ingest system to Common Ingest for NCEI-NC.

  › The system stores all steps of processing files through the system, resulting in persistent system status and full file provenance throughout the ingest process. Common Ingest employs a centralized message broker for routing of processing control and status messages throughout the system.

  › Common Ingest is built so that data streams can be user configured by defining the processing steps using multiple processing engines, as in a workflow system. This allows Common Ingest to be configured to handle multiple, complex data streams without the need for additional programming.
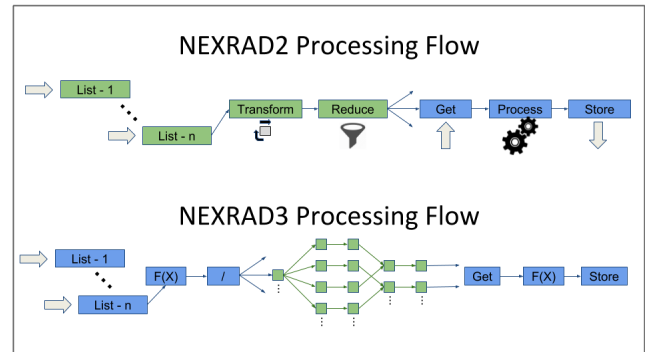
Common Ingest Complex Processing Flows.

- **Scientific Subject Matter Expertise Support and Climate Data Record Product Teams:** CICS-NC scientists serve as subject matter experts on multiple Climate Data Record (CDR) Integrated Product Teams (IPTs) that support the transition of research-grade CDRs into an initial operational capability status as well as acting as Product Leads and Portfolio Area Leads for more than 20 NOAA NCEI products and portfolios. This year, CICS-NC has participated in the IPTs for the following CDRs:
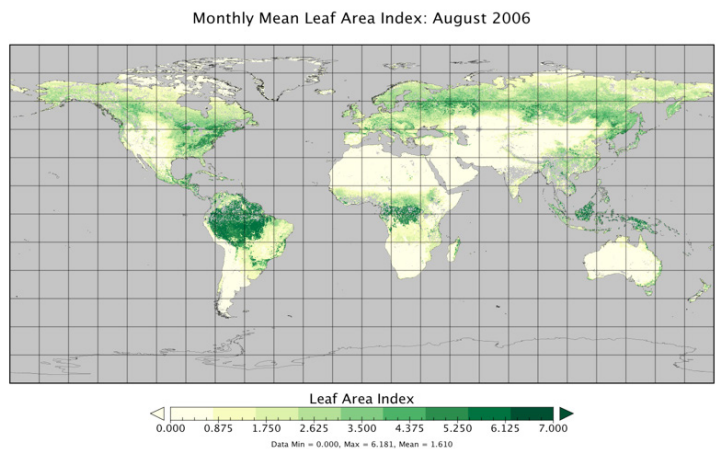
  › Total Solar and Solar Spectral Irradiance [Inamdar]
  › Land Surface Bundle [Matthews]
  › Global Surface Albedo [Matthews]
  › Sea Ice Concentration – Annual [Peng]
  › Ocean Surface Bundle [Peng]
  › Precipitation – PERSIANN-CDR [Prat]
  › Precipitation – CMORPH [Prat]

- **Obs4MIPs Project:** CICS-NC scientists are continuing to make observational products more accessible for comparison with climate models by reformatting datasets into the standard form used by the Coupled Model Intercomparison Project (CMIP) community.

Sample image from obs4MIPs Monthly Leaf Area Index dataset.

  These efforts support the Program for Climate Model Diagnosis and Intercomparison Observations for Model Intercomparison Projects (obs4MIPs). Datasets developed by the Institute are available via our website at: ncics.org/data/obs4mips [Biard, Matthews, Prat, S. Stevens]

- **Spatial–Temporal Reconstruction of Land Surface Temperature from Daily Max/Min Temperatures:** Time series of daily maximum and minimum temperatures combined with estimates of net surface solar radiation (or surface solar absorption) derived from the geostationary visible channel are used in reconstructing the temporal evolution of land surface temperatures under almost all sky conditions. This strategy has potential applications for the new 5 km gridded daily nClimDiv max/min temperature dataset being produced at NCEI. [Inamdar]

- **Transitioning of the International Satellite Cloud Climatology Project Process (ISCCP) to NCEI:** The ISCCP H-series product for the full baseline period (July 1983–2009) was successfully transitioned from NASA GISS to NOAA NCEI in June 2017. Production for the extended period (2010–2012) was completed and archived. A subset of the full ISCCP (ISCCP-Basic, with fewer variables) was produced and made available to users. Ongoing efforts are being made to replace the drifting NOAA-18 with NOAA-19 as the anchor satellite for calibration. www.ncdc.noaa.gov/isccp [Inamdar]


   January 2009 ISCCP percentage of global cloud amount for (a) differences between H- and D-series, (b) H-series HGM product at 1°, and (c) D-series D3 product at 2.5°. As shown in (a), the differences between the products are greatest in the polar and coastal regions where for this case the H-series product has a slightly higher cloud fraction. In general, the H- and D-series distributions of cloud amount have good agreement.
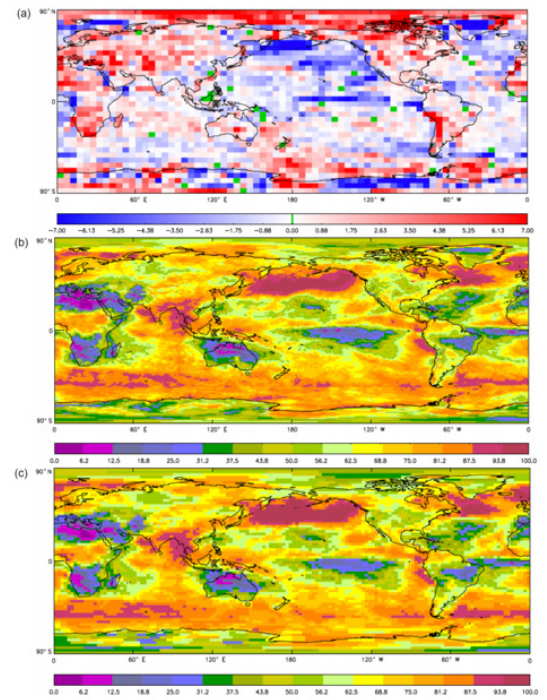
- **Implementation of Geostationary Surface Albedo (GSA) Algorithm with GOES Data:** The GSA algorithm is being implemented as the U.S. contribution to an international collaboration between Europe, Japan, and the United States to produce a joint climate data record of land surface albedo. This project is one of only 10 selected by the SCOPE-CM Executive Panel from an open competition. We 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. We are now in year 5 (2018) of this 5-year plan. [Matthews]

- **HIRS Temperature and Humidity Profiles:** The team is developing a global temperature and humidity profile dataset for the time period of 1978–present. A neural network analysis approach is applied to the NOAA High-resolution Infrared Radiation Sounder (HIRS) observations to produce a global dataset. The "v2016" release is currently under development. Key updates are to remove the HIRS channel 10 dependencies from the neural networks, incorporate emissivity data for all channels, improve the bias correction, and convert output to netCDF format data files. [Matthews]

- **Scientific Data Stewardship for Digital Environmental Data Products:** As of March 2018, the data stewardship maturity matrix (DSMM) developed as part of this effort has been applied to more than 800 individual NCEI datasets. More than 300 of those DSMM assessment ratings have already been captured by ISO standard collection-level metadata and used by the new NOAA OneStop Search and Discovery system for relevancy ranking. An additional 300+ datasets are to be integrated. [Peng]

- **Regional Variability of Sea Ice Coverage:** Temporal and spatial variability of Arctic sea ice coverage and sensitivity of their trends and statistical projections were examined. Long-term, consistent time series of monthly sea ice area and extents were computed for the period of 1979–2015. For the Arctic as a whole, the analysis found significant changes in both annual SIE maximum and minimum. [Peng]

   The first ice-free Arctic summer year (FIASY) projected by six statistical models, grouped by calibration period—first 30 years (1979–2008), climate normal (1980–2010), whole record (1979–2015), and last 30 years (1986–2015). Long-dashed lines denote minimum and maximum projections. Short-dashed lines denote average projections. Values bounded arrows denote the spread. Averages and standard deviations are noted at the top..
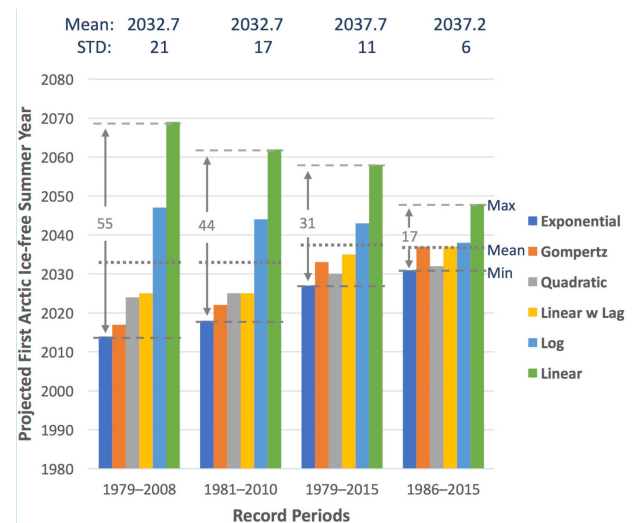
- **Toward the Development of Reference Environmental Data Records (REDRs) for Precipitation:** Global evaluation of satellite based Quantitative Precipitation Estimates (QPEs): The project team conducted a long-term assessment of the different satellite-based precipitation products from the Reference Environmental Data Records (PERSIANN-CDR; GPCP; CMORPH-CDR; AMSU A-B Hydro-bundle) and derived long-term global precipitation characteristics at fine spatial and temporal resolution. This work is part of a broader effort to evaluate long-term multi-sensor QPEs and to develop Reference Environmental Data Records (REDRs) for precipitation. This year, the evaluation of the different satellite precipitation REDRs was extended at the daily scale, with a focus on extreme events (top percentiles). Results indicate that CMORPH performs better in capturing daily extremes. However, it tends to overestimate the light rainfall portion of the spectra. On the other hand, PERSI-ANN-CDR tends to underestimate the top 99th percentile due to the fact that it is monthly bias-corrected with GPCP, which has a lower resolution. [Prat]
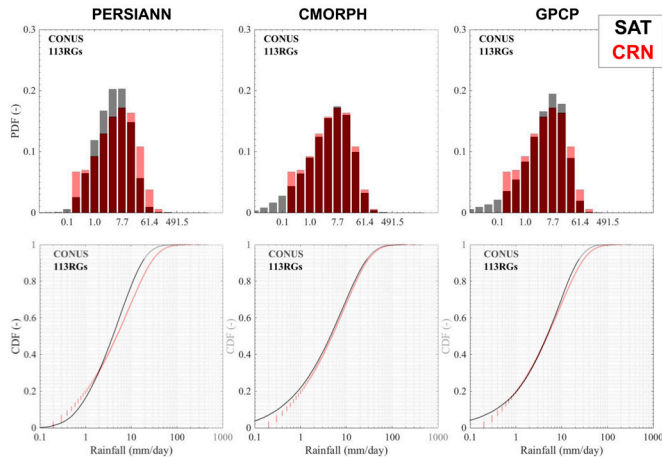
Distribution (top row) and CDF (bottom row) of daily rainfall derived from each satellite REDRs (PERSIANN, CMORPH, GPCP) compared with USCRN daily rainfall computed using the hourly accumulations to match the satellites' daily totals (0Z-0Z). The distributions are for concurrent events for the period 2007–2016. The comparison with USCRN makes it possible to compare the same daily total as the satellite product regardless of the gauge time reporting (GHCN-Daily).

- **Toward Earlier Drought Detection Using Remotely Sensed Precipitation Data from the Reference Environmental Data Record (REDR) CMORPH:** The feasibility of using satellite precipitation data from the REDR program (CMORPH) to detect and monitor drought on a global scale is being investigated, with a focus on the implementation of the drought indices and their evaluation over CONUS. The Drought Group ingested and developed algorithms for the implementation of the drought indices (SPI) using the CMORPH precipitation datasets. Preliminary runs provided for short and long-term SPI (1-month, 3-month, 6-month, 9-month, 12-month, 24-month) derived from raw CMORPH and bias-adjusted CMORPH. The different SPI are computed on a monthly basis. Results show that SPI indices obtained using raw/bias-adjusted satellite QPEs present similar patterns with some noticeable quantitative differences.

- **Identifying Tropical Variability with CDRs:** As part of ongoing efforts to improve understanding and forecasting of modes of tropical variability, CICS-NC and UNC Asheville co-hosted the Workshop on Global Tropical Cyclone Reanalysis at The Collider in May 2017. The topic of the workshop was how to address the challenges posed by discrepancies in the historical tropical cyclone record. The consensus outcome was a desire to seek funding from scientific agencies and the private sector, particularly the reinsurance industry, to fund a global reanalysis of best track data. This research also provides input to the annual *State of the Climate* report produced by NCEI, particularly the "Tropics" chapter. [Schreck]

- **ENSO Normals:** A new methodology for identifying moderate and strong El Niño and La Niña events was developed and has been preliminarily applied to nClimGrid to identify typical conditions during each phase of ENSO. NOAA's Climate Prediction Center (CPC) uses the Oceanic Niño Index (ONI) to identify ENSO events, but the challenge for our project is that ENSO has a marked annual cycle in which it is more active in boreal fall and winter and less active in spring and summer. Because CPC uses a fixed ONI threshold, the number of ENSO events varies by season. We overcame this challenge by identifying thresholds for each of the 12 overlapping 3-month seasons using the percentiles of the seasonal ONI. Weak events were identified using terciles; stronger events were identified using the top and bottom one-sixth of the ONI record for a given season. Events identified with our methodology compare favorably with those from CPC, although our definition naturally extends the events farther into the spring and summer. Preliminary composites for these events present reasonable but still scientifically interesting patterns. [Schreck, Inamdar]

Climate Literacy, Outreach, Engagement, and Communications

Engagement Activities

CICS-NC conducted numerous engagement activities to reach various types of stakeholders in the areas of environmental data and information, climate change and variability, adaptation and mitigation, and interdisciplinary uses and applications of information to inform decision-making and to inspire innovation. [Dissen]

Key areas of success this year included:

- Providing operational support to NCEI's Climate and Weather Center Information Services Division to advance their strategy, operations, sectoral engagement, and outreach as well as processes for sustainably managing customer information.

- Engaging in meaningful dialogue on the uses, applications, and requirements of environmental information across various user groups.

- With support from CICS-NC staff, conducting interdisciplinary outreach activities to academia and the public.

In addition to significant efforts in support of the U.S.–India Partnership for Climate Resilience (see "Assessments" section above), five engagement activities were held at The Collider in Asheville in collaboration with CASE Consultants International. All of these events shared a goal of reaching business and industry sectors along with other public and NGO organizations:

- Climate Wise Brownfields, June 13, 2017

- The Climate Resilience Grid, June 13–14, 2017 (NCEI sponsored, CICS-NC lead; speakers included Jessica Matthews, Otis Brown, Jenny Dissen)

- Game Changing Resilient Infrastructure, June 22, 2017

- Climate and Respiratory Health—A Focus on Asthma, November 9, 2017 (CICS-NC speakers included Ken Kunkel and Jesse Bell)

- ClimateCon, Panel on the Foundational Role of Government in Climate Products and Services, Mar 20, 2018, (included panelist Carl Schreck)

Stephanie Herring of NOAA NCEI speaks at the "Climate Resilient Grid" event held at The Collider in Asheville in June 2017.

Carl Schreck was one of the speakers at ClimateCon in March 2018.

Educational and Public Outreach [Multiple Staff Members]

CICS-NC conducts outreach activities across K–12, higher education, and the general public to advance awareness of environmental information and increase climate literacy.

This year, the Institute participated in more than 30 outreach events that included presentations to a small class of graduate students, educational events involving hundreds of K–12 students, and several large public events, including the outdoor Solar Eclipse Festival held in downtown Asheville, NC.

Institute staff served as speakers at a variety of other events, including the Summit for Emerging Climate Leaders and the Climate Solutions Showcase, both part of the Climate-Con event held at The Collider in March 2018.

Outreach to Higher Education Institutions: Engagement with academic institutions was an area of particular focus this year, highlighted by the instruction of a graduate-level distance education course as well as invited speaking engagements with university students and faculty audiences and mentoring of undergraduate and graduate students.

Jared Rennie speaks to students at North Buncombe Elementary School in Weaverville, NC, in November 2017.

Dr. Jessica Matthews taught the first offering of "Mathematics of Climate Science," a graduate-level distance education course available to NCSU students in the Fall 2017 semester. This new course was developed to satisfy the need for training graduate-level researchers in how mathematics contributes to the study of the Earth's climate. The course was taught remotely from NCICS' offices in Asheville, NC.

This course, developed by Dr. Matthews in collaboration with NCSU Distance Education and Learning Technology Application (DELTA) staff under a competitive grant award, was the first NCSU graduate-level mathematics course offered in an online environment. Course topics included climate and satellite data fundamentals, atmospheric carbon dioxide, global temperatures, sea ice concentration, El Niño characterization, precipitation, and the impact of climate change on growing season trends and vector-borne diseases.

Communications

CICS-NC communication activities serve to raise awareness of the Institute and the accomplishments of its staff through web stories, press releases, social media, and outreach events. The Institute also supports the external and internal communications efforts of NOAA's National Centers for Environmental Information. [Maycock]

2017 Solar Eclipse Activities. The most visible activity this year revolved around the August 21, 2017, total solar eclipse. Coordination between CICS-NC scientists and both NCEI and CICS-NC communication staff resulted in the production of an online GIS map of "eclipse viewability" that used station-based historical cloudiness data to project the likelihood of having clear skies for locations across the country at the time of the eclipse. Web stories and social media posts from NCEI and CICS-NC generated tremendous national interest and coverage in at least two dozen newspapers and other media outlets. The NCEI version of the web story received nearly 248,000 page views, more than any other NCEI web page in 2017.
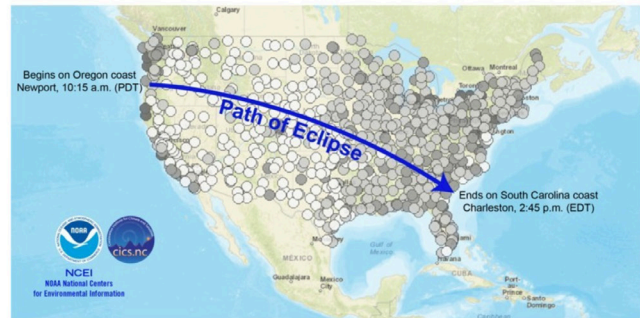
Social Media Efforts. Another focus this year was building the audiences for the Institute's Facebook and Twitter social media platforms and leveraging those platforms to increase visibility of research and engagement activities. Results included a 19% growth in Facebook audience (to 634 followers) and a 33% growth in Twitter followers (to 343). Tweets highlighting a new research paper projecting possible dates of an ice-free Arctic generated 10,000 impressions, with more than 80 users clicking through to read the web story.

Institute Newsletter and Video Display. We produced two editions of the *Trends* newsletter as well as a video loop of slides featuring high-impact images and brief text descriptions of key Institute tasks and focus areas. The video provides an attractive overview of major activities and recent accomplishments.

Above: Web version of a July 26, 2017, story in the Atlanta Journal-Constitution featuring the CICS-NC/ NOAA NCEI eclipse viewability map and online tool (link).

Left: One of eighteen images from a video loop highlighting major Institute projects and accomplishments.

Surface Observing Networks

- **Improving U.S. Climate Reference Network (USCRN) Soil Observations:** Improvements in the quality and usability of United States soil moisture measurements are being made through application of quality-controlled methods to create improved soil observation datasets. The team developed software to plot soil measurements on the fly, plot sensors individually, visualize quality control statistics, and produce 3-panel graphs showing statistics on soil sensor values. Consolidated plots and data analyses are used to evaluate sensor performance, providing for a more thorough and efficient quality control process for soil moisture and temperature measurements. [Bell]

- **U.S. Climate Reference Network (USCRN) Applications:** Several projects utilizing USCRN data were initiated, including two satellite-based projects providing USCRN data and support for remote sensing validation and algorithm development, the update of an hourly precipitation dataset, an update of network-wide precipitation extremes through 2017, and a sensor sensitivity study related to urbanization. [Leeper]

- **The Utility of In Situ Observations for the 2017 Great American Solar Eclipse:** The Great American Solar Eclipse of 2017 was the first time in over a century that the path of a total eclipse of the Sun traversed the country from coast to coast. This track provided spectators a rare opportunity to view a total solar eclipse along the path, as long as weather (i.e., clouds) didn't obscure one's view. In addition, the eclipse presented an opportunity to monitor the impact of the solar eclipse on surface measurements of air temperature and humidity. To this end, CICS-NC researchers created an interactive web product utilizing hourly cloud cover normals from automated weather stations to determine the likelihood of cloudiness for the solar eclipse hour at stations across the country. The web-based tool was viewed over 380,000 times with more than 2 million interactions. An analysis of the post-eclipse in situ data revealed the impact of reduced solar insolation on near-surface temperatures and relative humidity. [Leeper, Rennie, Schreck, Maycock]
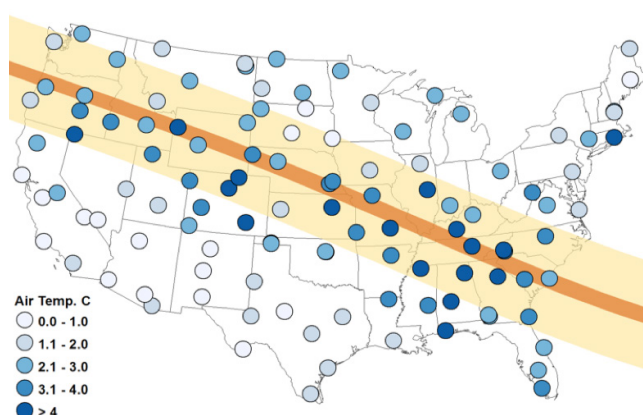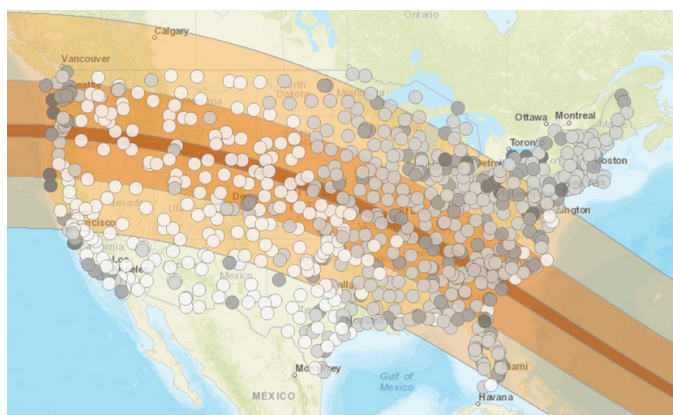
Above left: Map of station viewability during the Great American Solar Eclipse of 2017. Above right: USCRN observed temperature change during the Great American Solar Eclipse of 2017.

- **Standardization of U.S. Climate Reference Network Soil Moisture Observations:** A methodology to standardize hourly volumetric soil moisture observations from a short term (7–8 year) data record was developed. This approach was evaluated using station observations from the longer-term (15-year) Soil Climate Analysis Network (SCAN). Results showed the methodology could produce a soil moisture climatology similar to the 15-year inter-annual mean with 7 or more years of data. [Leeper]

USCRN sampled 5 cm soil moisture climatology (gray) and standard deviation (red) for two USCRN stations (Bowling Green, KY; Elgin, AZ).
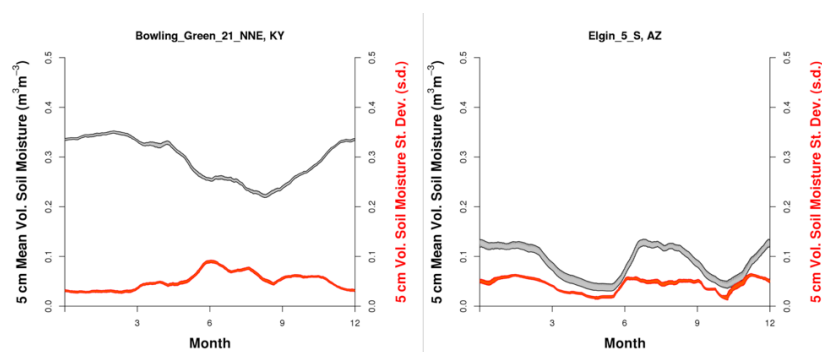
- **Maintenance and Streamlining of the Global Historical Climatology Network-Monthly (GHCN-M):** The next iteration of NOAA's global temperature product has been developed and released as a second public beta. This new version of GHCN-M is based on the International Surface Temperature Initiative (ISTI)—an open and transparent databank of land surface stations. A manuscript has been submitted and the dataset will become operational once the manuscript is accepted. [Rennie]

  Recent accomplishments include:

  › updates to the ISTI databank based on user feedback, including numerous changes to underlying station data and metadata and a bug fix to the ISTI code resulting in Version 1.1.1, which was released in November 2017 along with appropriate documentation updates.

  › an update of GHCN-M to its second beta (v4.b.2), incorporating the changes noted above and updates in the GHCN processing software.

  › updates to the Pairwise Homogeneity Algorithm (PHA), which detects non-climate shifts in station data, resulting in a third test version of GHCN-M Version 4.

- **Development of a Homogenized Sub-Monthly Temperature Monitoring Tool:** A system developed by CICS-NC scientists to calculate homogenized temperature data at sub-monthly frequencies (available at ncics.org/portfolio/monitor/sub-monthly-temperatures) is being used to analyze extreme heat events. Using three-day events exceeding the 98th percentile as a definition of an extreme heat event, statistics are calculated, including departure from normal, extreme daily maximum and minimum temperatures, and ranks against the period of record. Probability density functions are used to determine how severe an event is compared to its period of record. Trends are calculated using the Mann-Kendall method, which assesses the significance of a monotonic upward or downward trend over time.

  Overall results show an increase in the number, length, and severity of extreme heat events. Overnight minimum temperature extreme events are occurring more often than daytime maximum extreme events, which is consistent with the literature. The spatial extent varies by state, but most states show increases since 1950.
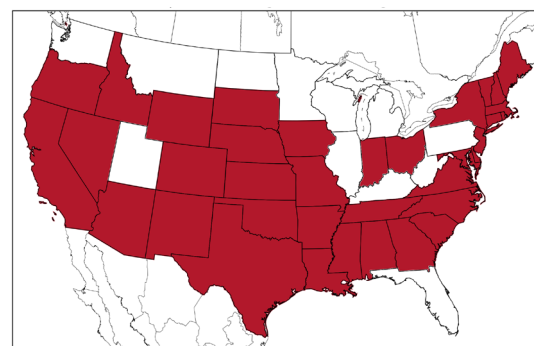
States experiencing an increase in heat event length in overnight minimum temperatures. Trends are from 1950–2016 and red indicates an increasing trend while white is no trend.

Night Marine Air Temperature Near Real-Time Dataset Development: Night marine air temperature (NMAT) data provides the ocean's complement to land surface temperatures and allows for a global representation of surface temperature. NCEI's NMAT data, which are measured at different heights above the ocean surface (largely due to different ship types), were adjusted to a common (homogenized) height of 10 meters, and a preliminary global ocean monthly NMAT dataset was generated on a 5°X 5° grid for January 2002 to August 2017.
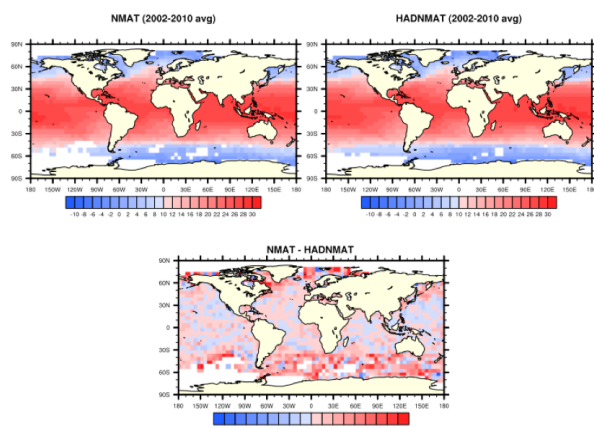
Comparisons of this dataset with the HadNMAT2 data indicates good agreement between 30°S and 60°N, but with a larger warm bias in the NCEI NMAT in the Arctic (above 60°N) and in the Southern Ocean (between 30°S and 60°S). These two regions are also where observational data are sparse. Globally, the differences are about 0.5°C, but the warm bias is due to the larger disagreements in Arctic and Southern Oceans. [Stegall]

The 2002–2010 gridded mean NCEI NMAT and the HadNMAT2 in °C (top two plots). The bottom plot is the NCEI minus the HadNMAT2.

Workforce Development

CICS-NC actively works to identify and train the next generation of scientifically and technically skilled climate scientists. Junior and/or aspiring scientists, including post-doctoral researchers and students, play an important role in the conduct of research at CICS-NC. High school, undergraduate, and graduate students as well as recent post-docs support projects across the CICS-NC task streams.

- Andrew Ballinger, Post-Doctoral Research Scholar, is in his second year working with Kenneth Kunkel on the multi-institutional, NSF-sponsored Urban Resilience to Extremes—Sustainability Research Network (UREx SRN) project. The highly interdisciplinary and geographically dispersed UREx SRN team is developing a diverse suite of methods and tools to assess how infrastructure can be resilient, provide ecosystem services, improve social well-being, and exploit new technologies in ways that benefit all segments of urban populations.

  Current efforts include characterization of recent historical trends of climate extremes and the development of future climate extreme scenarios for nine pilot cities in the United States (including Puerto Rico), Mexico, and Chile. The team continued its analysis of 32 LOCA-downscaled climate models for seven pilot cities and analyzed 23 ARRM-downscaled climate models for three other locations. They coordinated and hosted a two-day Climate and Hydrologic Extremes Working Group workshop in Asheville and participated in several other workshops.
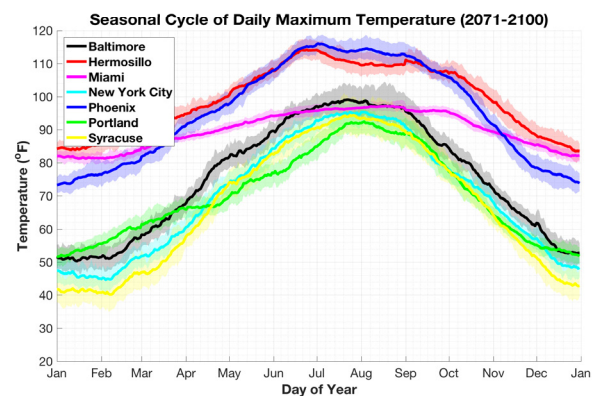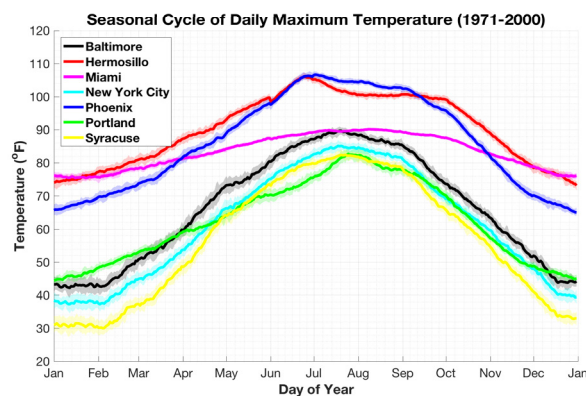
The multimodel ensemble-mean seasonal cycle of daily maximum temperature for several cities in the UREx network, analyzed from LOCA-downscaled CMIP5 simulations over the historic period (left panel), and projected 100 years into the future under the RCP8.5 scenario (right panel).

- Sarah Champion and Brooke Stewart-Garrod are engaged in NCSU doctoral studies in Atmospheric Sciences, with Champion focusing on extreme precipitation and Stewart-Garrod investigating atmospheric blocking highs. [Champion, Stewart-Garrod]

- During the past year, NCICS scientists mentored three NASA DEVELOP teams (three students per team), two NOAA Hollings Scholars, six graduate students, two undergraduate students, and two high school students. Projects included analyzing tropical cyclone vulnerability, visualizing changes in extreme precipitation, understanding temperature trends in the northeastern United States, using wearable sensor technology to assess exposure to cold among outdoor workers, and developing a curriculum for teachers and students using the NOAA NCEI Storm Events Database. For example, one of the NASA DEVELOP teams working under project advisors Olivier Prat and Brian Nelson (NCEI) used precipitation estimates from NASA earth observations and NOAA climate data records to enhance understanding of extreme precipitation events in the Carolinas. Their results are available at: develop.larc.nasa.gov/2018/spring/CarolinasDisasters.html.

Other NCICS Projects

Funding organizations indicated in brackets.

- **Collaboration with the Centers for Disease Control on Issues Related to Climate and Health:** CICS-NC staff have established and strengthened a collaborative relationship between NOAA and CDC by integrating NOAA environmental data into targeted CDC health studies to increase the understanding of climate effects on human health. Projects over the past year have dealt with topics such as extreme heat surveillance, soil moisture conditions and Valley fever, and evaluation of mental health outcomes from drought. [NCEI / CDC]

- **Changes of Freezing Precipitation Frequency:** Several international efforts are underway to conduct environmental change research focused on the regions of the northern extratropics to better inform vulnerable societies and better prepare them for potential future developments. [MULTIPLE]

- **The Urban Resilience to Extremes Sustainability Research Network (UREx SRN):** CICS-NC scientists are leading the Climate and Hydrologic Extremes Working Group (CHExWG) efforts for a large multi-institutional project led by Arizona State University. (See "Workforce Development" section above.) [NSF]

- **Climate Model Data Support to the Assistant Secretary of Air Force Climate Projection Engineering Weather Data (EWD) Project:** Future engineering design values were estimated for Air Force bases at Langley, VA, and Thule, Greenland, based on two scenarios for future climate change. Substantial future increases were calculated for temperature and humidity variables. [DOD / USAF]

- **Water Sustainability and Climate Change—A Cross-Regional Perspective:** Analysis of CMIP5 decadal experiment simulations indicate that future projections of extreme precipitation for 2006–2035 reflect increases in all regions with respect to 1981–2010. This suggests that there is merit in incorporating future extreme precipitation increases in planning in this near-term future time horizon. [NSF]

- **Climate Indicators to Track the Seasonal Evolution of the Arctic Sea Ice Cover to Support Stakeholders:** The NOAA National Snow and Ice Data Center's Sea Ice Concentration Climate Data Record was used to develop a consistent, high-quality suite of sea ice climate indicators that track the seasonal evolution (sea ice melt onset, opening, retreat, freeze-up, and advance) of the Arctic sea ice cover and to examine long-term average and temporal variability of the new sea ice climate indicators. [NASA]

- **Synthesis of Observed and Simulated Rain Microphysics to Inform a New Bayesian Statistical Framework for Microphysical Parameterization in Climate Models:** This multi-institutional research project aims at comprehensively investigating the representation and associated uncertainties of rain microphysical processes in weather and climate models. In order to quantify those uncertainties in microphysical formulations, the team developed an innovative Bayesian statistical framework that combines the extensive radar and ground-based data from ARM field campaigns, bin microphysical modeling, and a new bulk parameterization. [DOE]

- **Incorporation of Climate Change into Intensity–Duration–Frequency Design Values:** Increases in heavy precipitation events are one of the more robust climate change signals, and increases in heavy precipitation are expected to continue in the future as global warming results in continuing increases in atmospheric water vapor concentrations. We collaborated with Lawrence Berkeley National Laboratory to apply Deep Learning methods to this issue. A 2-dimensional convolutional neural network algorithm was developed and validated against a dataset of manually drawn fronts. This algorithm can reproduce the observed spatial pattern of the frequency of fronts. The number of detected fronts is about 20% lower than observed, but the automated algorithm detects nearly 100% of fronts associated with extreme precipitation events. [DoD / SERDP]

- **Continuous Monitoring of Individual Exposure to Cold Work Environment—A Participatory Sensing Study:** This pilot study utilizes new wearable sensor technology to test and implement more sensitive means of evaluating cold temperatures as an occupational hazard and develop effective report-back strategies as a means to communicate with participants about harmful occupational exposures and their associated health risks. [NIH / NIOSH]

- **Multiscale Convection and the Maritime Continent:** This multi-institutional team is examining the strong diurnal cycle of convection over the Maritime Continent and determining how it impacts subseasonal-to-seasonal forecasts. [NASA]

- **Investigations between Kelvin Waves and Easterly Waves Using CYGNSS Data:** This team is using NASA's new Cyclone Global Navigation Satellite System (CYGNSS) retrievals to investigate surface interactions between Kelvin waves and easterly waves. [NASA]

- **Developing New Forecast Tools for the USAF 14th Weather Squadron's Tropical Pacific Convective Outlook:** Key tropical subseasonal metrics from CICS-NC's Madden–Julian Oscillation (MJO) monitoring page (ncics.org/mjo) are being transitioned into operations in the USAF 14th Weather Squadron. [DOD / USAF]

- **Investigation of Trends in Airport Weather Conditions:** Several decades of surface observations were assessed to quantify a trend in the frequency of low-visibility conditions at the nation's busiest airports.

- **Collaborative Support for the Development of the Quantitative Urban-Scale Microclimatic Modeling Tool (QUEST):** In collaboration with the Urban Redevelopment Authority of Singapore, CICS-NC is providing climate modeling and customized global/regional datasets to support the development of a climate information system for urban heat island effect for Singapore urban planning. [URA]