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FOR

CLIMATE and SATELLITES (CICS)

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Director

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1 INTRODUCTION

The Cooperative Institute for Climate and Satellites (CICS) was formed through a national consortium of academic, non-profit and community organizations with leadership from the University of Maryland, College Park (UMCP) and the University of North Carolina (UNC) System through North Carolina State University (NCSU). This partnership includes Minority Serving Institutions as well as others with strong faculties that enhance CICS' capability to contribute to NOAA's mission and goals.

CICS consists of two principal locations, one on the M-Square Research Park campus of UMCP adjacent to the NOAA Center for Weather and Climate Prediction, and the other within the National Climatic Data Center. The two locations are referred to as CICS-MD, located in College Park MD, and CICS-NC, located in Asheville NC.

CICS-MD is based upon the model and experience gained by UMCP through the leadership of the Cooperative Institute for Climate Studies in collaboration with NOAA beginning in 1983. The Earth Systems Science Interdisciplinary Center (ESSIC) managed the earlier Cooperative Institute beginning in 2002, successfully shepherding it through a period of dramatic growth in both funding and activity levels. CICS-MD focuses on the collaborative research in satellite observations and Earth System modeling conducted by the Center for Satellite Applications and Research (STAR) of NOAA/NESDIS and the National Centers for Environmental Prediction (NCEP) of NOAA/NWS. CICS-MD is also in the beginning stages of establishing collaborations with other NOAA elements in the Washington, DC area, including the National Oceanographic Data Center (NODC) and the Air Resources Laboratory (ARL). This collaboration is led by ESSIC/UMCP with strong participation from the UMCP Departments of Atmospheric and Oceanic Science (AOSC), Geography (GEOG) and Geology (GEOL), the University of Maryland Institute for Advanced Computer Studies (UMIACS), and the Joint Global Change Research Institute (JGCRI), a collaboration between UMCP and the Department of Energy (DoE) Pacific Northwest National Laboratory.

CICS-NC is an Inter-Institutional Research Center (IRC) of the UNC System, referred to as North Carolina Institute for Climate Studies (NCICS). It is administered by North Carolina State University (NCSU) and affiliated with all of the UNC academic institutions as well as a number of other academic and community partners. CICS-NC focuses primarily on the collaborative research into the use of satellite observations in climate research and applications that is led by the National Climatic Data Center (NCDC) of NOAA/NESDIS. CICS-NC is led by Dr. Otis Brown and includes numerous partners from academic institutions with specific expertise in utilizing satellite observations in climate research, applications and models.

CICS scientific vision centers on the observation, using instruments on Earth-orbiting satellites and in situ 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 and supportive of NOAA's Strategic Goals, and CICS tasks comprise research projects that advance NOAA objectives.

CICS' Vision and Mission derive from the historical expertise of the lead institutions and partners that comprise the CICS Consortium, together with NOAA's requirements. The CICS vision and mission are closely tied to the NOAA Strategic Goals.

VISION: CICS performs collaborative research aimed at enhancing NOAA's ability to use satellite and in situ observations and Earth System models to advance the national climate mission, including monitoring, understanding, predicting and communicating information on climate variability and change.

MISSION: CICS conducts research, education and outreach programs in collaboration with NOAA to:

- Develop innovative applications of national and international satellite observations and advance transfer of such applications to enhance NOAA operational activities;
- Investigate observations and design information products and applications to detect, monitor and understand the impact of climate variability and change on coastal and oceanic ecosystems;
- Identify and satisfy the climate needs of users of NOAA climate information products, including atmospheric and oceanic reanalysis efforts;
- Improve climate forecasts on scales from regional to global through the use of observation-derived information products, particularly through participation in the NOAA/NWS/NCEP Climate Test Bed;
- Develop and advance regional ecosystem models, particularly aimed at the Mid-Atlantic region, to predict the impact of climate variability and change on such ecosystems; and
- Establish and deliver effective and innovative strategies for articulating, communicating and evaluating research results and reliable climate change information to targeted public audiences.

The Research Themes for CICS are:

Theme 1: Climate and Satellite Research and Applications.

Theme 2: Climate and Satellite Observations and Monitoring.

Theme 3: Climate Research and Modeling.

Scientific and executive guidance for CICS is provided by the Council of Fellows, which provides overall advice to the Executive Director and the Directors of CICS-MD and CICS-NC, and the Executive Board, which represents NOAA, UMCP and NCSU senior management and guides and directs Institute operations. During the past year, meetings of the Executive Board were held at UMCP in College Park, MD on June 11, 2010, chaired by Dr. Mel Bernstein, Vice President for Research at UMCP, and at NCSU in Raleigh NC on October 8, 2010, chaired by Dr. Terri Lomax, Vice Chancellor for Research and Graduate Studies at NCSU and Dr. Chris Brown, Associate Vice Chancellor. The next meeting of the Executive Board will be held at UMCP in College Park, MD on August 1, 2011.

An ad-hoc Council of Fellows met in association with the initial CICS Science Meeting at CICS-MD on September 8-9, 2010. The goals of the meeting were to enable CICS scientists to describe ongoing and potential research projects, to learn about potential collaborative research activities from NOAA scientists, and to facilitate interaction among the participants. CICS scientists described ongoing and potential projects in nineteen presentations and NOAA senior managers provided ten programmatic presentations explaining activities and opportunities relevant to CICS. About 50 scientists and managers from CICS and NOAA attended the meeting. The meeting accomplished its specific goals, based on the discussions and informal conversations during and afterwards, and was worthwhile for many of the attendees. The next Science Meeting and Council of Fellows meeting will be held at CICS-NC during summer 2011.

CICS thematic research is organized through Tasks, led by the CICS and NOAA scientists leading the research. Specific reports on research accomplishments by each Task are included in Section 4 of this report.

This year CICS welcomed several new members. They are:

Dr. Scott Rudlosky is a Research Associate at the Cooperative Institute for Climate and Satellites (CICS). Scott joined CICS in January 2011 following completion of his M.S. (2007) and Ph.D. (2010) in Meteorology at Florida State University. He obtained his B.S. (2004) in Geography with a specialization in Atmospheric Science from The Ohio State University. Scott's earliest research examined the characteristics and distribution of positive cloud-to-ground (+CG) lightning in Florida, since +CG flashes often are associated with enhanced structural damage and more frequent wildfire ignitions. This early research, and a recent upgrade to the National Lightning Detection Network (NLDN), motivated Scott to compile cloud-to-ground (CG) lightning climatologies for the contiguous U.S. and the state of

Florida. Both CG climatologies are published in the Monthly Weather Review. More recently, Scott's research has expanded to include analysis of intra-cloud (IC) lightning and severe weather in the Mid-Atlantic Region. His recent work uses the Warning Decision Support System - Integrated Information (WDSSII) software to combine radar, model-derived, CG lightning, and IC lightning data to examine relationships between lightning and radar in severe and non-severe storms. Scott is a member of the GOES-R Risk Reduction Team that develops algorithms and datasets to better understand future operational applications of total lightning datasets that will be provided by the Geostationary Lightning Mapper (GLM) aboard the upcoming GOES-R satellite.

Li Ren joined CICS-MD in January of 2011. Dr. Ren received her Ph.D. degree in Physical Oceanography from University of Washington in Seattle, Washington. Dr. Ren's previous research has focused upon the upper ocean salinity changes and freshwater budget. Her dissertation research is about the observational decadal time scale salinity changes in the North Pacific Ocean. She estimated the mixed layer salinity budget in the Northeast Pacific Ocean from the global Argo profiling float data; evaluated the precipitation and evaporation products including ECMWF, NCEP1, NCEP2, OAFlux, GPCP and CMAP based on the salinity changes. She also investigated the sea ice contribution in the seasonal time scale salinity changes in the Southern Ocean for her postdoctoral research at Florida State University. Dr. Ren is currently working on the development and improvement of global historical oceanic precipitation analyses.

Dan Barrie joined CICS-MD in October of 2010. Dr. Barrie received his B.A. degree in Physics from Colgate University in Hamilton, New York. He received both his M.S. and Ph.D. in Atmospheric and Oceanic Science from The University of Maryland. His thesis research focused on the interaction of wind energy with weather and climate. One aspect of this research project involved modeling the impact of large-scale wind energy on the atmosphere due to the increase in drag in the atmospheric boundary layer caused by wind turbines. Another component of the research project involved assessing the impact of climate change on the United States wind energy resource using CMIP3 and NARCCAP model output.

Chabitha Devaraj joined CICS-MD in November 2010 after completing her Ph.D. in Imaging Science from Rochester Institute of Technology (RIT). As a member of Digital Imaging and Remote Sensing (DIRS) lab, she developed a theoretical framework for validating polarimetric remote sensing systems and investigated the impact of polarization phenomenology on material discriminability for her Doctoral research. She has a M.S. in Electrical Engineering from Syracuse University, with a specialization in digital signal processing. Her research interests include modeling and performance assessment of remote sensing systems, remote sensing instrument calibration and image quality characterization.

Li-Chuan Chen joined CICS-MD in October of 2010. Dr. Chen received her B.S. and M.S.

degrees from National Chung Hsing University in Taiwan, R.O.C. and a Ph.D. degree from the University of Iowa. Her research interests include the role of hydroclimatology in the coupled Earth system. Specifically, it is focused on physical aspects of the global and terrestrial water cycles (including precipitation, evaporation, and runoff), their interactions within the Earth system, and implications for drought forecasts and applications. She is also interested in how the movement of water over and through the land surface links terrestrial processes with those in the atmosphere (including important feedbacks on precipitation), and characterizing changes in precipitation, runoff, and droughts in response to natural climate variability, global change, and human activities. Dr. Chen is a member of the American Geophysical Union (AGU), American Meteorological Society (AMS), and American Society of Civil Engineers (ASCE). She has served on several national and local committees including the AGU Precipitation Committee and ASCE Environmental & Water Resources Institute Probabilistic Approaches Committee. She has published in journals such as Water Resources Research and Journal of Hydrologic Engineering, and serves as a reviewer for Journal of Hydrologic Engineering, Journal of Hydroinformatics, Advances in Water Resources, and Journal of Hydrology. Dr. Chen has received various awards including a prestigious scholarship from the Ministry of Education of Taiwan and travel grants from the American Meteorological Society, and was selected as an Outstanding Reviewer for the Journal of Hydrologic Engineering in Year 2009.

Isaac Moradi joined CICS-MD in January of 2011. Dr. Moradi received his Ph.D. and MSc degrees in Meteorology from University of Tehran, Iran. His PhD dissertation was entitled "Mapping global solar radiation over Iran from Meteosat images". He evaluated the Heliosat-II method to retrieve solar radiation from satellite data and then used the model to develop the solar radiation atlas of Iran. The atlas was a part of a national project to extend the application of renewable energy resources especially solar power plants in Iran. He also did his MS thesis in the same field. In his master thesis, he evaluated different methods to calculate solar radiation on tilted surfaces with arbitrary orientations from data measured on horizontal surfaces at the meteorological stations. After his PhD, Mr. Moradi continued his work with Iranian Ministry of Energy to develop long-term solar radiation atlas of Iran and one year later he moved to the University of Tehran as an assistant professor at the Department of Physical Geography. In total, he published 5 papers in international journals from his PhD and MSc theses. Dr. Moradi moved to Lulea University of Technology in Sweden in October 2008. During his time there, Mr. Moradi used microwave satellite data to develop upper tropospheric humidity (UTH) dataset. He evaluated UTH retrieved from AMSU-B and MHS sensors versus UTH derived from radiosonde data. He also published 2 papers from the works he did in Sweden.

Cecilia Hernandez joined CICS in July 2010. Prior to joining CICS, she worked with the NOAA Cooperative Remote Sensing Science and Technology Center (CREST), at The City University of New York, in the department of civil engineering. Ms. Hernandez is currently working to finish her PhD. Her research topic focuses on the development of an algorithm

to estimate snowfall rates using remotely sensed multispectral microwave information. In May 2007, while working with CREST, Ms. Hernandez finished her master's degree in environmental and water resources, department of civil engineering from the University of Puerto Rico at Mayaguez. She also received her bachelor's degree in Civil Engineering from the University of Puerto Rico at Mayaguez.

Prabhat Koner joined CICS-MD in September of 2010. Dr. Koner received his PhD degree in Energy Engineering from IIT, Delhi. His thesis work involved the design and optimization of solar photovoltaic (SPV) arrays for water pumping in addition to a detailed socio/techno economic analysis and analog and digital electronics controller. He has worked as a postdoctoral fellow at the European Union Joint research Centre, Italy, and Queensland University of Technology, Australia on data analysis, instrument development and quality issues of Electrical grid systems. However, in the last seven years he has been actively involved in the field of satellite remote sensing retrievals. He worked at University of Toronto, Canada, where he developed a new algorithm for remote sensing hyper-spectral retrievals using Fourier transform Infrared (FTIR) measurements. The advantage of the technique he developed is that the retrievals contain low noise with high information contents compared to conventional retrievals algorithms and does not required a-priori information. Subsequently, he has worked at University of Bonn, Germany on rainfall retrievals from space based attenuated radar measurement, and Dalhousie University, Canada, on the retrieval algorithm for the FTIR instrument to the forthcoming NASA/ESA Mars Science Orbiter mission, where he has shown a number of pitfalls of the popular statistical retrieval methods and established the possibility of unique mathematical solutions for satellite based hyper spectral measurements.

This year CICS-NC welcomed several new members. They are:

Jesse Bell joined CICS in October 2010. Dr. Bell completed his Ph.D. on ecosystem ecology and ecohydrology in 2009 from The University of Oklahoma. His research largely focuses on the coupling of the carbon and water cycles, where he employs a variety of techniques to study the consequences and implications of climate change on ecosystem processes. As a graduate student, he participated in the "Terrestrial Ecosystem Response to Atmospheric Climate Change" (TERACC) symposium and was an author on a subsequent report in . He worked and collaborated with researchers at the Chinese Academy of Sciences "Institute of Botany" in Beijing as a NSF supported EAPSI Fellow. The last two years of his graduate education were supported by an NSF GK-12 Fellowship. The primary objective of the program was to develop interactive scientific lessons on current research topics, for use in high school classrooms. As an additional part of his participation in the NSF GK-12 program, he was selected to perform research and science education outreach in Thailand. The research focus of this effort was to model the carbon-water fluxes in tropical forests, while the education component was to administer science lessons to Thai high school teachers and students.

Pui K. Chan joined CICS in January of 2011. Dr. Chan completed her Ph.D. in meteorology from Pennsylvania State University with a focus on the role of energy budgets in Asian monsoon region in 1993. She has an M.Phil. (Physics) from the Chinese University of Hong Kong and a B.Sc. (Physics) from the University of Hong Kong. Prior to joining the CICS she worked as a weather forecaster at the Hong Kong Observatory and as a research scientist for contractor companies at NASA's Goddard Space Flight Center and Langley Research Center. Her research interests include surface radiation budget retrieval, aerosol radiative forcing, climate, remote sensing of water vapor and sea surface temperature.

Jenny Dissen joined CICS-NC in October of 2010. She is the Director of the Summer Institute on Climate Change and supports the Director of CICS on Climate Literacy initiatives. Ms. Dissen is a graduate of North Carolina State University, where she earned her Masters in Civil Engineering – Environmental Systems Analysis, and Bachelors in Environmental Engineering, with a minor in Business Management. Ms. Dissen specializes in management consulting and project management in both public and private sector. Starting with a career at Accenture, Ms. Dissen was a member of their North American Utilities Practice, where she specialized in performance optimization in utility operations and deployment of largescale business transformation initiatives involving process improvement and technology enablement. Her project expertise encompassed electric and gas utilities asset management and capital program planning, helping clients optimize capital and O&M spend and improve value of assets through use of technologies and integrating finance, operations and engineering applications. She also supported the development of a new practice in Climate Change and Sustainability at Accenture. To further her interests in studying climate change impacts and sustainability solutions, Ms. Dissen served as Regional Coordinator in Southeast Asia for the William J. Clinton Foundation in their Clinton Climate Initiative. She was responsible for analyzing, evaluating and developing projects that were technically and financially feasible in the area waste management across Vietnam, Thailand and Indonesia.

Pierre Guillevic joined CICS-NC on July 1, 2010. Dr. Pierre Guillevic received a Ph.D. in radiative transfer and land surface modeling from Paul Sabatier University, Toulouse, France, in 1999. During his postdoctoral work with the Hydrological Sciences Branch, NASA Goddard Space Flight Center, Greenbelt, MD, he participated in the NASA Seasonal to Interannual Prediction Project (NSIPP) and studied the influence of the interannual variability of vegetation parameters derived from satellite observations on seasonal climate prediction. In 2003, he joined the Laboratoire Central des Ponts et Chaussees (LCPC Governmentresearch laboratory on public works), France, as a research scientist and led research onthe water and energy balance of urban surfaces for applications in road safety and urban hydrology, including field experiments and modeling. His main research interests are the retrieval of land biophysical parameters from satellite remotely sensed observations with focus on land surface temperature, and the calibration and validation of satellite products.

Susan Joy Hassol joined CICS in May 2010. Ms. Hassol is a climate change science communicator known for her ability to translate science into English. For two decades, she has been working with scientists to help make their findings more accessible to policymakers and the public. Susan has written and edited numerous reports about climate change and its impacts (see Publications), testified before Congress, written an HBO documentary, appeared on national radio and television shows, and spoken to a variety of audiences. In September 2006, Susan was honored by the Climate Institute with its first ever award for excellence in climate science communication. More about Susan and her work can be found on the website: climatecommunication.org.

Justin Jay Hnilo joined CICS-NC in September of 2010, where he is assisting in the development of requirements and user based access and diagnostics tools for online use, advancing community-wide downscaling access and interoperability. Dr. Hnilo obtained his Ph. D. in 1996 from the University of Alabama-Huntsville. His background is in climate model diagnostics with emphasis on the application of remotely sensed measures. His work includes the quantification of differing methods by which one simulates what a satellite would see if flown over climate models and observations. Specifically for two approaches: the first a comprehensive line-by-line radiation code, and, the second a more simple global weighting function. He quantified how changes in satellite height, surface emissivity and profiles of moisture affect a simulated microwave measure. His research has shown that depending on which method and assumptions one makes these act to influence the end result and in some cases can act to change the sign of the simulated decadal temperature trend. During his 11 years at Lawrence Livermore National Laboratory he worked within the Program for Climate Model Diagnosis and Intercomparison (PCMDI) where he maintained the observational database, established metadata standards, rewrote large volumes of data, worked extensively with the Atmospheric Radiation Measurement (ARM) data and developed new visualization and diagnostic software for both models and remote sensing measures. He returned to the University of Alabama-Huntsville in 2008 and participated in the development of a "geoportal" for climate change science, analysis, assessment and information for decision making. In 2009 he joined Colorado State University and worked to build a continuous high quality observational dataset for the Special Sensor Microwave Imager (SSM/I). This activity is part of NCDC's Fundamental Climate Data Record (FCDR) project.

Anand Inamdar joined CICS-NC in October of 2010. Dr. Inamdar obtained his Ph. D., working on Numerical Analyses of Radiative Transfer in the Atmosphere in the Department of Mechanical Engineering of Indian Institute of Science (Bangalore, India) in 1991. He then joined Scripps Institution of Oceanography at University of California San Diego and served as a co-investigator and participated as a science team member of the NASA/CERES (Clouds and Earth's Radiant Energy System) science team, investigating the role of deep convection, SST, and tropospheric water vapor distribution in the evolution of the atmospheric greenhouse effect. Employing measurements in the CERES broadband longwave and window (8- 2 micron) channels, he further examined the relative roles of

vibration-rotation to pure rotation bands of water vapor and the water vapor continuum region on the longwave heating and cooling rates in the atmosphere. One of his primary contributions to the CERES was the development of the algorithm to estimate the surface LW radiation budget from measurements of TOA window and non-window spectral channels and other ancillary meteorological variables over both ocean and land surfaces, which is currently in operational use. From 2005-2009, he worked at the USDA/Arid Land Agricultural Research Center, Agricultural Research Service (ARS/USDA). There he developed a model for the retrieval of diurnal cycle of land surface temperature on a 1 km scale from MODIS, GOES and other merged geostationery satellite products over the South West US for assimilation into land surface models for application in water resources management in agriculture. His research interests are study of earth radiation budgets, remote sensing of land surface parameters and surface energy balance from satellites.

Kenneth Kunkel joined CICS-NC as a Senior Scientist and Science Lead for Assessments, and, the NCSU Department of Marine, Earth and Atmospheric Sciences as a Research Professor in September of 2010. Dr. Kunkel's recent research has focused on climate variability and change, particularly related to extreme events, such as heavy precipitation, heat waves, cold waves, and winter storms. A particular focus has been the historical variations in the frequency and intensity of such extreme events extending from the late 19th Century to present. An examination of late 19th and early 20th Century variations is important because it establishes the quasi-natural background which provides a context for interpreting recent variations and possible anthropogenic influences. He has also engaged in the diagnostic analysis of both regional and global climate model output. This has focused on the regional fidelity of model simulations of the climate of the U.S., including such features as the North American monsoon and the lack of 20th Century warming in the central U.S. Dr. Kunkel has developed a number of applications of climate data, including a temperature-based model that anticipates the risk of West Nile Virus infections and a soil moisture model for agricultural usage in the Midwest. Due to his interest and involvement in issues related to climate variability and change, he has been a lead author on two recent reports of the U.S. Climate Change Program: Weather and Climate Extremes in a Changing Climate and Climate Models: An Assessment of Strengths and Limitations.

Ronald Leeper joined CICS-NC on November of 2010. Mr. Ronnie Leeper received both his masters and undergraduate degrees from Western Kentucky University (WKU). Using the fifth generation Mesoscale Model (MM5), his master's investigated the affects of vegetation type, thickness, and soil moisture on near-surface atmosphere evolution. As an undergraduate, Mr. Leeper worked on collaborative research projects between WKU and the University of Nebraska-Lincoln, observing the impact of irrigation on temperature and dew point temperature trends in northern Great Plains. More recent research of his is related to soil moisture variability due to both climatic and karst hydrological forcings, and their impact of the simulated atmosphere. Additional interests include development of quality assurance strategies and assessing the affect of data assimilation on regional atmospheric modeling performance.

Jessica Matthews joined CICS-NC as a Postdoctoral Research Associate in August of 2012. Dr. Matthews was awarded a Ph.D. in applied mathematics from North Carolina State University, Raleigh, NC in the fall of 2010. Her dissertation research examined water stress conditioning and sensitivity analysis of photosynthesis and stomatal conductance models. As an undergraduate she participated in a cooperative education experience at NASA Goddard Space Flight Center, Greenbelt, MD, where she supported efforts of the (EOS) including testing of HDF-EOS data manipulation software, evaluating metadata accuracy, conceptualizing architecture for a data pool realizing real time user access, and developing wavelet-based data compression algorithms. Following completion of her master's degree, from 2004 through 2010 she worked as a job mathematician for SRA International, Inc. primarily modeling agents under study by the . Her research interests focus on modeling of physical and biological phenomenon and the underlying mathematical principles.

Janice Mills joined CICS in October of 2010 as Business Manager. Janice Yamamura Mills brings over 25 years of higher education academic and research administration experience to CICS. Ms. Mills received a B.A. in Psychology from the University of Idaho and earned her MBA (with emphases in International Management and Marketing Research) from Texas A&M University where she also held a number of positions in fiscal management, planning and analysis. Her most recent position was as the Assistant Dean for Finance and Administration in the College of Geosciences where she served as both chief financial officer and chief human resources officer for the college. While at TAMU, she served as Chair of the University Council of Senior Business Administrators and also chaired university committees on inventory management and scholarship award administration. In 2002, she was recognized as one of Texas' 100 women leaders through the program. Her strengths are strategic management, process analysis, planning and program implementation and execution.

Olivier Prat joined CICS-NC as a Postdoctoral Research Associate in August of 2010. Dr. Prat obtained a PhD in Physics from the University of Montpellier II (France), a Masters Degree in Fluid Mechanics from the University of Aix-Marseille II (France), and an Engineering Degree from the (currently). His current research interests include the development and implementation of numerical models forthe evolution of rainfall microstructure with explicit representation of microphysical processes. The ultimate goal is to achieve a dynamic simulation of the droplet size distribution that will be used for physical algorithms for radar and satellite rainfall estimation.

Jared Rennie joined CICS-NC in July of 2010. Mr. Rennie received both his M.S. and B.S. degrees in Meteorology from Plymouth State University in Plymouth, New Hampshire. His master's thesis included evaluating and introducing techniques to nowcast microburst events over NASA's Kennedy Space Center in Florida. Using an updated climatology of five minute averaged peak wind data, as well as local products from the WSR-88D, Mr. Rennie

developed advanced statistical techniques in hopes to increase detection of microburst occurrence, while lowering the amount of false alarms. As an undergraduate student, Mr. Rennie received the Ernest F. Hollings Scholarship and participated in a summer internship at the National Weather Service Forecast Office in Norman, Oklahoma. During his time there Mr. Rennie compared conventional radar products to newer technologies, including NSSL's Phased Array Radar.

Richard Reynolds joined CICS-NC in November of 2009. Dr. Richard W. Reynolds has specialized in analyzing sea surface temperatures (SST) since he graduated from the University of Hawaii in 1975 with a PhD. In 1980 Dr. Reynolds began his career at NOAA as the lead scientist responsible for the development, implementation and operational production of sea surface analyses and associated. He has been active in improving the accuracy of the SST analyses by optimizing the advantages of in situ (ship and buoy) and satellite data. Dr. Reynolds joined CICS-NC in November 2009. Dr. Reynolds has received the Department of Commerce Gold Medal in December 1997 for producing SST Analyses for the NCEP atmospheric reanalysis; the Department of Commerce Gold Medal in November 2004 for the development of innovative techniques leading to optimal use of observing systems related to sea surface temperatures; the Department of Commerce Gold Medal; November 2007 for improving the understanding of observed climate change and causes by showing that global average atmospheric warming is similar to surface warming; the Department of Commerce Silver Medal in November 2007 for developing a calibration technique breakthrough enabling detection of reliable long-term atmospheric temperature trends from satellite data; and was elected a Fellow of the American Meteorological Society in January 2007.

Jennifer Roshaven joined CICS in March of 2011 as a University Program Specialist. Ms. Roshaven brings a strong background in higher education resource and personnel management to CICS. Ms. Roshaven has a B.A. with Honors in Psychology from the University of Miami and earned an M.S. in Counseling Psychology from Palm Beach Atlantic University. She directed the Residential Life program at Palm Beach Atlantic University and then was a project manager for Anderson Consulting Team and Kilday & Associates in Palm Beach, FL. Her most recent position was an Executive Assistant to the Dean of the University of Miami's Rosenstiel School of Marine and Atmospheric Science where she provided leadership to the School's administrative and faculty affairs processes, as well as managed the Dean's and Divisional Offices administrative team. Ms. Roshaven is a 2009 graduate of the Greater Miami Chamber of Commerce Leadership Miami Program.

Carl Schreck joined CICS-NC as a Postdoctoral Fellow in August of 2010. Dr. Schreck completed his Ph.D. in 2010 at the University at Albany, State University of New York. His dissertation explored the intraseasonal variability of tropical convection using satellite derived rainfall estimates from NASA's (TRMM). Notable sources of variability included convectively coupled equatorial waves and the Madden-Julian oscillation. Dr. Schreck identified the relative influences of these systems on

tropical cyclone formation around the globe. He is investigating the Madden-Julian oscillation and the El Nino-Southern Oscillation (ENSO) using a climate data record of upper tropospheric water vapor that was recently developed here at NCDC. Dr. Schreck also contributes to a team that develops and maintains the (IBTrACS). This, the world's largest repository of tropical cyclone best track data, is housed at NCDC under the auspices of the World Data Center. Dr. Schreck uses these data to examine the relationships between climate variability and tropical cyclones.

Laura Stevens joined CICS-NC as a Postdoctoral Research Associate in Fall 2010. Ms. Stevens (née Kettles) is currently completing a Ph.D. in atmospheric science from the University of Leeds. Her dissertation research investigates the influence of modifying droplet concentrations on the properties of stratocumulus clouds and climate (using both global and cloud-resolving models), as well as examining the potential for a cloud droplet modification geoengineering technique. As a postgraduate student in 2007 she assisted with field measurements for the (COPS) in Southern Germany. She completed her undergraduate studies in Meteorology at the University of Reading in 2006, which also included an exchange year at the University of Oklahoma. She is a member of the American Meteorological Society and the American Geophysical Union.

Scott Stevens joined CICS-NC on March of 2010. Mr. Stevens received his B.S. degree in Meteorology from the University of Oklahoma and his M.S. degree in Atmospheric Science from Colorado State University. His master's thesis was centered around the transition from warm cloud to rain and its relationship to several meteorological variables, using data from the Atmospheric Radiation Measurement program's station on Nauru Island. Using statistical techniques, Mr. Stevens studied the correlation between these variables and the onset of rain, in the hopes of improving satellite algorithms, which detect rainfall. As an undergraduate, Mr. Stevens also completed an internship with the Oklahoma Climatological Survey, in which he investigated decadal warming trends using the Oklahoma Mesonet, and he presented these findings at the 2006 AMS Annual Meeting in Atlanta, GA.

Peter Thorne joined CICS-NC in May of 2010. Dr. Thorne completed a PhD on climate change detection and attribution in 2001 from the Climatic Research Unit in the University of East Anglia. He then worked at the Met Office Hadley Centre in the UK until 2010 within the Climate Monitoring and Attribution group. Initial work concentrated upon tropospheric temperature records - an issue that still takes up more of his time than it really should. Together with colleagues he created a radiosonde-based temperature dataset, automated the procedure and benchmarked it against realistic test cases. This led to a conclusion that radiosonde temperatures were not adequate to conclusively inform on the debate about an apparent temperature trend discrepancy between the surface and the troposphere. He also contributed significantly to the CCSP report on this subject including lead authorship on two chapters. Most recently he led, together with colleagues from NOAA and Reading

University, a major review of the issue. In the past several years Dr. Thorne's focus has turned to creating climate data records from the land surface network. He supervised a PhD project, which yielded a quality controlled, homogenized surface humidity product at monthly resolution and contributed to subsequent analyses thereof. This analysis utilized the synoptic report resolution Integrated Surface Dataset from NCDC. Subsequent work has been focused on creating a quality controlled version of this database for solely the long running stations utilizing an automated procedure with a view to subsequently undertaking homogenization efforts at the base reporting observation level. Whether this is even possible is an open question being pursued in collaboration with colleagues in the Met Office Hadley Centre and University of New South Wales Climate Change Research Centre. Dr. Thorne also contributed to two chapters of the most recent IPCC Working Group 1 report and published on reanalyzes, which show great potential promise for the future for climate monitoring. He has sat on a joint Global Climate Observing System / World Climate Research Program working group on observations for reanalyzes. For the last 5 years Dr. Thorne has been chair of a Working Group under the Auspices of the Global Climate Observing System whose role is to make the GCOS Reference Upper Air Network a reality. He was recently selected as a lead author for Working Group 1 of the IPCC 5th Assessment Report.

Qiong Yang joined CICS-NC as a Research Associate in January of 2011. **Dr.** Yang received her Ph.D. in Atmospheric Science from the University of Washington, Seattle in December 2010. Her dissertation research was focused on quantifying the radiative energy budget in the tropical upper troposphere and lower stratosphere in order to understand troposphere to stratosphere transports.

Jun Zhang joined CICS-NC as a Postdoctoral Research Scholar in October of 2010. Dr. Zhang received a PhD in Statistics from University of Wisconsin-Madison in 2008 and an MS in Electrical Engineering from Iowa State University in 1999. His dissertation research focused on functional concurrent linear model with varying coefficients for two-dimensional spatial images. The parameter surfaces in this model were transformed into the wavelet domain and a sparse representation was found by using a large scale L1 constrained least squares algorithm. This model has been applied on remote sensing images related to the study of forest nitrogen cycling. Dr. Zhang is on a bridge appointment between CICS-NC and the Statistical and Applied Mathematical Sciences Institute (SAMSI). He has been a postdoctoral fellow at SAMSI since 2009. At SAMSI, he and his collaborators developed a penalized maximum likelihood approach for estimating extreme precipitation levels based on Regional Climate Model output. Prior to his PhD work, he worked for several private companies in the technology and financial sectors.

Departures from CICS-MD include:

Dr. Rachel Albrecht and **Dr. Daniel Villa** for Instituto Nacional De Pesquisas Espaciais (National Institute for Space Research) in Brazil;

Dr. Eric Bruning for Texas Tech University;

Dr. Annarita Mariotti for NOAA's Climate Program Office;

Dr. Peter Romanov for CREST Center of Excellence in Remote Sensing of the Earth;

Dr. Arief Sudrajat for Institute of Technology, Bandung, Indonesia; and

Dr. Jin-ho Yoon for Pacific Northwest National Laboratories.

2 HIGHLIGHTS OF THIS YEAR'S RESEARCH

Listed below are a few of the research highlights from the past twelve months of this agreement:

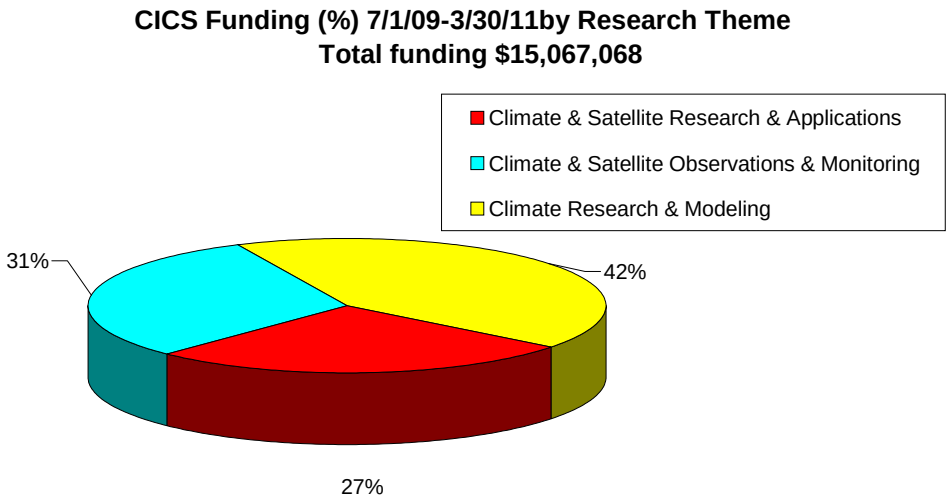
- CICS has continued its support of the GOES-R GLM Risk Reduction activities by improving our global lightning climatology, developing GLM proxy datasets, collaborating with members of the GLM Risk Reduction Team, participating in the CHUVA field campaign and NASA's DC4 experiment, and supporting GOES-R Proving Ground activities. Our collaborative efforts will continue to expand both the number and variety of GOES-R users, and will help to better prepare these users to implement the upcoming GLM data into their operations.
- CICS/CIMMS/TTU continues to support the GOES-R GLM needs for proxy data, validation datasets, and operational demonstrations of total lightning data (in the GOES-R Proving Ground) thorough sustaining support for the Oklahoma and West Texas Lightning Mapping Array. This project has provided funding for operating and maintaining the OKLMA and spinup costs for the WTLMA, and supported a part-time research scientist to complete an analysis of the conditions under which lightning occurs far downstream in thunderstorm anvils and to analyze the range dependence of the Lightning Mapping Array for use in GOES-R proxy data sets and for climatological studies.
- We installed the MIRS system at the University of Maryland, and processed the brightness temperatures from the NOAA-18 AMSU-A & MHS sensors for the year of 2008. The RR estimates from MIRS were compared with TMI and PR estimates using a 0.25° grid. Based on these geographical patterns, it appears that MIRS may overemphasize stratiform rain compared to TMI and PR. However, it is important to note that these differences may be partially caused by the differences in temporal sampling between NOAA-18 and TRMM.
- "The DYNAMO campaign is one of the most important observational expeditions after TOGA-COARE. NCEP/CPC-EMC in collaboration with CICS/ESSIC will optimize the data observation strategies by providing real time monitoring and forecast of weather/climate conditions to the field. Further by utilizing the collected data CICS/ESSIC in collaboration with NCEP will help to improve operational weather and climate prediction at NCEP".
- The HIRS OLR CDR time series Ed.2.2 have been extended to 32 years, from 1979 to 2010. Validations showed very good agreement with the CERES Ed.2.5 SSF product. The error source for the small trended gaps between HIRS and CERES in 2002-2003 is however not yet identifiable. The transition of HIRS OLR CDR algorithm to operation is undergoing smoothly and well within the schedule. The HIRS OLR CDR is expected to become operational at NCDC in September 2011.
- Version 5 of LWRB algorithms for OLR, DLR and ULR have been delivered to AIT and were implemented for Framework run tests. The offline validation results suggest that

these three algorithms can meet the 100% F&PS requirements. More validations with extended data sets covering seasonal representation are in good progress. Development of the Routine and Deep-dive Validation Tools are ongoing and continued.

- A first-of-its kind snow depth analysis product over the Northern Hemisphere is being developed for integration into an enhanced version of the NOAA's Interactive Multi-sensor Snow and Ice Mapping System (IMS). The processing algorithm blends in-situ, satellite and analyst snow depth estimates in an optimal fashion for producing snow depth along with snow cover extent once daily over the Northern Hemisphere and twice daily over US and at a 4-km spatial resolution. The addition of a 4-km snow depth field to IMS will allow the capability of delivering a consistent and optimal suite of IMS snow products to the NCEP community.
- Two CICS-NC scientists are participating and contributing as lead authors for the

- CICS-NC scientists are actively recognized for their leadership roles in several international activities related to the climate observations
- CICS-NC established a 340 node cluster for collaborative development, software validation, and advanced system prototyping

The total task funding for CICS research now stands at approximately $15 million, an increase of more than $11 Million during the past year. In Figure 1 we summarize graphically the stratification of task funding by CICS Research Theme and by NOAA Strategic Goal. In Table 1 we present statistics for peer reviewed and non-peer reviewed papers, as well as the categorization of CICS staff and investigators. In Section 4, CICS-NCSMD and CICS-NC personnel describe the research activities and results from the ongoing projects for the period of April 1, 2010 – March 31, 2011.



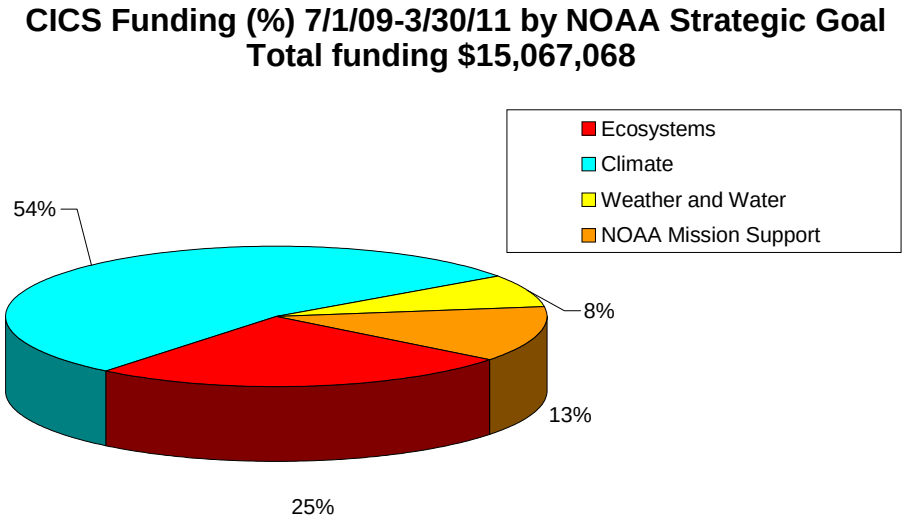


Figure 1: CICS tasks stratified by CICS Theme and NOAA Strategic Goals

Table 1: CICS Publication and Personnel Statistics

Publications	Institute Lead Author	NOAA Lead Author
Peer Reviewed	38	3
Non-Peer Reviewed (includes videos and formal presentations)	122	7

PERSONNEL

Category	Number	BS	MS	PhD
Research Scientist	16	0		16
Visiting Scientist	2	0		1
Postdoctoral Fellow	19	0		17
Research Support Staff	13	1		7
Administrative	5	2		0
Total (> 50% support)	55	3		41
Undergraduate Students	0	0		0
Graduate Students	6	0		6
Employees that receive < 50% NOAA funding (not including students)	11	0		10
Located at NOAA facility (include name of facility)	30	WWB & NCDC		0
Obtained NOAA employment within the last year	2			

3 NOAA/CICS CORE ACTIVITIES

CICS core activities include education, coordination, scientific computing, outreach, management and administration related to CICS-MD, CICS-NC and Consortium efforts. During the past 12 months, CICS leaders have continued to establish the essential administrative and management activities required to support the collaborative science and research. In addition, further progress has been achieved on the full suite of core activities, as described below. The primary mechanisms that will support the Executive Director in ensuring coherent collaboration across the entire Consortium will include the Council Fellows, the Science Meeting, and the personal efforts of the CICS-MD and CICS-NC Directors.

Education: Young scientists, including students and post-doctoral researchers, play an important role in the conduct of research at CICS-MD and are beginning to do so at CICS-NC. Both CICS-MD and CICS-NC are tightly integrated into the graduate programs at the respective host institutions of UMCP and NCSU. CICS scientists participate in courses by serving as guest lecturers and by helping to mentor graduate and undergraduate students. In addition, extensive series of seminars on a variety of topics are organized by CICS. See Table 3 for a list of such seminars conducted at CICS-MD. These include presentations by senior faculty from UMCP and from other institutions as well as informal seminars by junior CICS-MD scientists intended to foster discussion and provide opportunities for interaction among the staff. Finally, CICS-MD has an ongoing program that provides support for 1-2 Graduate Research Assistantships (GRA) in the Department of Atmospheric and Oceanic Science or associated Departments at UMCP. The first student under this program was Ross Fessenden, who enrolled in the Fall Semester of 2010. Unfortunately, Mr. Fessenden decided to transfer for personal reasons to an institution closer to his home at the end of the fall semester. At the present time, CICS-MD is recruiting for 1-2 students to continue this program.

CICS-NC hired five post-doctoral fellows who are working on topics of interest to NCDC scientists (documented under Workforce Development). On the local level CICS-NC is working with The Science House, the NC Arboretum, and the Asheville and Buncombe County School systems to develop curricula which will integrate climate change into the K-8 grades.

Coordination: A major challenge for CICS is to ensure that collaboration and communication across the entire Consortium contributes effectively to advancing NOAA's research mission. Several mechanisms are utilized to this end, ranging from direct discussions among the Directors to participation in the annual CoRP Symposium to facilitating visits among students and scientists associated with CICS and other Cooperative Institutes. The 2010 CoRP Symposium was held at CIRA in Ft. Collins, CO, and the CICS-MD Director attended. CICS Consortium members from the City College of New York, which hosts CREST, were involved in a large number of oral and poster presentations. The 2011

CoRP Symposium will be hosted by CICS-NC and held in Asheville, NC, as will the NESDIS CI Directors meeting.

Scientific Computing: Scientific computing requirements for CICS tasks are supported locally using funds for specific activities and reports for each task describe these efforts. At CICS-MD, Base and cost-sharing funds are used to supplement individual task funds in two ways: by supporting desktop computing related to the project for CICS scientists, which is provided by the ESSIC Information Technology Administration and Planning Unit under the supervision of the its manager, Mark Baith, and by helping to support a workstation cluster that enables CICS scientists to engage successfully in major data processing and computing projects.

CICS-NC has put a 340 node IBM BladeServer cluster into place, which includes the installation of a high-speed internal network and connectivity to NCREN. Both NOAA and NCSU have supported these efforts.

Outreach: Outreach to the scientific community and the general public is a high priority for CICS. The great complexity and diversity of the CICS mission and composition makes this a challenging endeavor, requiring multiple approaches. CICS-MD, as the most mature component of the Consortium, had several ongoing activities.. Significant accomplishments have occurred in the following areas:

> ***Seminars*:** CICS conducts a series of informal seminars and participates in the ESSIC seminar series at College Park and Asheville to communicate scientific results to the broader community (see Education and Table 2). In addition, CICS scientists make both oral and poster presentations at technical meetings, and frequently visit other institutions to present seminars describing their work. Scientists at other Consortium members expect to contribute to this method for outreach as their projects mature and begin to produce more results. Table 2 provides a list of CICS-related seminars.
>
> ***Public Events:*** Maryland Day, an annual event that attracts more than 70,000 visitors to the UMCP campus, provides CICS-MD with an exceptional opportunity to reach out to the public to illustrate our important research results regarding climate and satellites. Maryland Day 2010 was held on April 24, 2010, and CICS scientists are contributed significantly to the Earth Science tent, where exhibits were displayed related to the theme "Exploring Extraordinary Earth: Explore our ever-changing planet with Earth system scientists from UM, NASA, and NOAA! Build your own instruments to measure winds and rain fall amounts. Harvest water and learn about the water cycle. Participate in these and other Earth science-themed activities!" Preparations are now underway for Maryland Day 2011, which will be held in College Park, MD on April 30, 2011.

Web Sites: CICS web sites continue to be developed and refurbished to enhance CICS outreach to all interested sectors. An independent site, climateandsatellites.org, intended to provide a comprehensive description of the CICS Consortium has been established and is in the process of being enhanced. This site provides the background, mission and vision statements for CICS, as well as links to Consortium participants. Both CICS-MD and CICS-NC maintain dedicated sites for their own activities that also include cross-links with others CICS sites using a consistent "look and feel".

Private Enterprise Interactions: Jenny Dissen leads a robust program of informal and more formal outreach activities with the private sector for CICS-NC. A Summer Institute focused on Adaptation to Climate Change is planned for 2012 (planning was done in 2010/2011). A series of interactions with the private energy sector is underway in order to improve understanding of this sector's interests and needs on sub-decadal time scales.

Management and Administration: Dr. Phil Arkin as Executive Director leads the CICS Consortium and also serves as Director of CICS-MD, which is housed administratively within ESSIC at UMCP. Naomi Johnson assists Dr. Arkin ESSIC management and staff, including Andy Negri, Assistant Director, and the ESSIC Business Office, led by Jean LaFonta, provide infrastructure support. Dr. Otis Brown is Director of CICS-NC, located within the NCDC facilities in Asheville, NC. Administrative support at CICS-NC has been enhanced significantly with the addition of Ms. Janice Mills (Business Manager) and Ms. Jennifer Roshaven (University Program Specialist).

	Prof. S. Yoon (Seoul National University)	Long term observation of Asian aerosols at Gosan, Korea: Their optical property and radiative effect
1/11/2011	Dr. Wendy Wang (ESSIC)	The carbon cycle in the earth system: from tropical ocean to arid land
1/13/2011	Dr. Eduardo Agosta (Equipo Interdisciplinario para el Estudio de Procesos Atmosfericos en el Cambi Global Buenos Aires, Argentina)	"The Troposhere/Stratoshere/Ozone Interannual Variability During Austral Spring"
1/15/2011	Dr. Banghua Yan (ESSIC)	"Advances in Satellite Microwave Data Assimilation Developments
1/22/ 2011	Dr. Bruce Hewitson (University of Cape Town, South Africa)	"Bridging the Science-Society Divide: Developing Actionable Regional Climate Change Information"
2/1/2011	Dr. Anthony Janetos (JGCRI)	Land-use issues in climate change mitigation and adaptation
	Prof. Qinyu Liu (The Ocean University of China)	Atmosphere-Ocean-Land Interaction in South China Sea: Formation of spring warm water southwest of the Philippine Islands
2/17/2011	Dr. Wenze Yang (Department of Geography at Hunter College)	Assessing the impacts of surface topography, off-nadir pointing and vegetation structure on vegetation lidar waveforms using an extended geometric optical and radiative transfer model.
2/24/2011	Dr. Hu Yang (Center for Meteorological Satellites of China)	"An introduction of china meteorological satellite project --- status and future plan"
3/1/2011	Dr. Yudong Tian (GEST/UMBC and NASA)	Measuring Precipitation over U.S.: Where Are We Today?
3/4/2011	Dr. Ruba A. Amarin (University of Central Florida)	HIRAD Hurricane Wind Speed and Rain Rate Simulation
3/5/2011	Dr. Isaac Moradi (Lulea University of Technology, Sweden)	Validation of Tropospheric Humidity Retrieved from Microwave Satellite Data
3/8/2011	Dr. Sujay Kaushal (Assistant Professor, Chesapeake Biological Laboratory, University of Maryland Center for Environmental Science)	"Influence of Land Use, Climate Change, and Watershed Restoration on Nitrogen Dynamics"
3/22/2011	Dr. Yun Qian (PNNL)	"Air pollution affects Climate and Hydrological Cycle in China"
	Prof. Thomas W. N. Haine (The Johns Hopkins University)	On the Loss of Energy from the Ocean Mesoscale Flow via Inertia-Gravity Waves
3/25/2011	Dr. Xin-Zhong Liang (Senior Professional Scientist, Illinois State Water Survey, Champaign, Illinois)	Integrated Regional Earth System Modeling: Development and Application
3/26/2011	Dr. Viva Banzon (NOAA)	Diurnal SST for the Atlantic
3/29/2011	Dr. Zhibo Zhang (NASA)	Influence of ice particle microphysical model on ice cloud optical thickness retrieval

4 PROJECT REPORTS: CICS-MD

CICS Support of CPC's Climate Monitoring and Prediction Activities

A. Vintzileos; (NOAA Collaborator: J. Gottschalck) – JJJJ_PREC10

Background: Scientific Problem, Approach, Proposed Work

The Climate Prediction Center (CPC) of NCEP/NWS/NOAA assesses and predicts short-term climate variability and its impact for both the Tropics and the U.S.. The complex nature of the global climate system, and the requirement for continuous improvement in CPC capabilities, makes conducting ongoing collaborative developmental research imperative. This task includes activities of the PI that range from providing improved monitoring products, validation of model forecasts of the Madden-Julian Oscillation (MJO) and subseasonal variability in general and the development of key forecast products to support CPC's operational product suite. Along with the above items, work also includes investigation of the reasons for model forecast successes and failures. The above tasks are directly supporting the operational Global Tropics Hazards and Benefits Assessment (GTH) and the DYNAMO field campaign during 2011-2012.

Accomplishments

During the past year, the PI has continued to collaborate with CPC staff in a number of monitoring and diagnostic roles, particularly involving the Madden-Julian Oscillation (MJO) analysis, and validation. He provided the measure of performance of the new operational NCEP/GFS model regarding its capacity to forecast the MJO and showed that there was substantial improvement from the older version of the GFS. He is member of the Science Steering Committee of DYNAMO and participated in two workshops in which he presented CPC's capacity to provide forecast guidance and collaborated with DYNAMO PIs in order to optimize the DYNAMO related products for aviation, ship and radar operations. He is currently developing the tools and methodologies that will provide considerable operational support via numerical guidance products from the NCEP suite of models to the campaign.

An example of tools under development is shown in Figure 1, which is a forecast of 10 meter winds superimposed on the precipitation forecast valid at 6 hours after initialization. Similar type products are being created for Day 1, Day 2, Day 3, Days 3-4, Days 1-7, Days 8-14 and for several key variables needed for the operational GTH product and DYNAMO campaign.

He is co-PI to the relevant proposal which was funded by CPO. The PI also continued investigating the reasons for the Maritime Continent Prediction Barrier focusing on the atmosphere – ocean coupling. He is the PI of a proposal to CPO that will make use of the DYNAMO oceanographic data to better understand ocean mixed layer processes relevant to the MJO and improve the next version of the CFS.

Planned Work

The PI will continue to work with CPC personnel on the development and application of forecasting tools that will provide forecast support to the GTH operational product and

DYNAMO field campaign. These tools will enrich other CPC operational products as well. In col

CICS Satellite Processing System for Research and Development

P. Arkin and M. Baith (NOAA Collaborator: R. Ferraro) – PAPASLSRD10

Background: Scientific Problem, Approach, Proposed Work

This task is to establish a state-of-the-art computing processing system at CICS that will replace an aging Silicon Graphics system and which will serve as the cornerstone for all future CICS related satellite R&D over the next five years. Anticipated features of this system include high computing capacity, multiple processors and terabytes of RAID storage. Resources for IT support to maintain the RAID, develop common image display tools for CICS, etc. are included. It is anticipated that sustained funding from NESDIS over the next three to five years will exist.

Accomplishments

During the reporting period, a new 30 Tb RAID was purchased and added to the existing workstation (established in the prior year under the previous grant). CICS IT staff and student interns helped to establish an initial operating capability to the new workstation (designated "CICS2") and helped build an archive of NOAA and NASA satellite data of over 20 Tb.

Planned Work

During the upcoming year, CICS2 will be finalized and made to work more efficiently with the large amount of RAID. With the help of student interns and the ESSIC IT staff, the satellite data archive will be maintained, including both retrospective and near-real time data (that will be routinely updated through the development of LINUX based scripts). The archive will include relevant data sets from NOAA, NASA and DMSP satellites. Additionally, some current processing tools will be enhanced to aid in the access and display of the satellite archives.

Global Precipitation Climatology Project

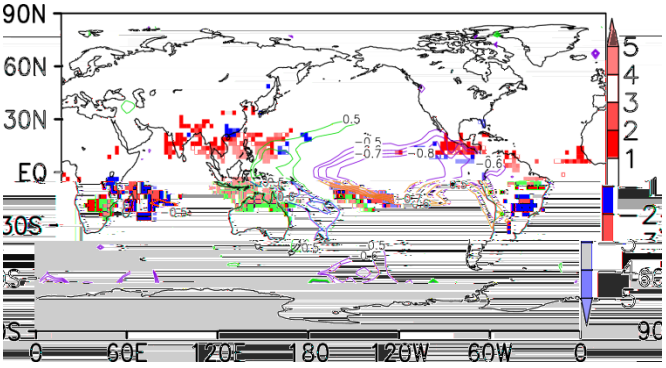
A. Gruber and A. Sudradjat; NOAA Collaborator: R. Ferraro – AGAG_HIRS10

Background: Scientific Problem, Approach, Proposed Work

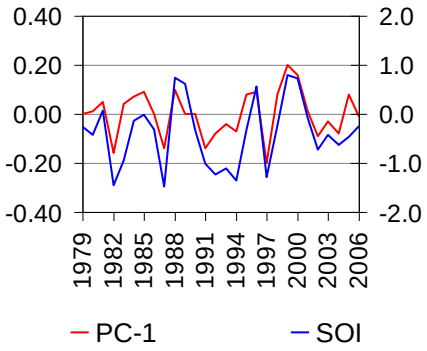
This project emphasizes analysis of the Global Precipitation Climatology Project data which has produced monthly mean data since 1979 and is continuing. We are focusing on issues ranging from global low frequency variations to regional trends.

Accomplishments

During this period we completed our study of rainfall trends in the Indian Monsoon Region and their relationship to changes in surface temperature. In particular, we investigated the co-variability of annual mean precipitation in global monsoon regions in the recently released Global Precipitation Climatology Project (GPCP) Version 2.1 (GPCPV2.1) and annual global surface temperature in the global merged land-air-sea surface temperature during a 28-year period (March 1979 to February 2007). The El Niño Southern Oscillation (ENSO) is shown to dominate monsoon precipitation. A positive trend-like variation in monsoon precipitation is also detected, collocated with land and sea surface temperatures warming. The positive trend-like variation in the SH Micronesian-Polynesian islands is found to coincide with increasing local SST, especially in the last half of the 28-year period. It is detected that the positive trend-like variation is also coincided with increasing surface temperature in the southeast China land region near 30°N latitude and equatorial Indian Ocean and hence surface temperature gradient between the regions. These and increasing zonal and meridional low-level winds over the Webster-Yang monsoon index region and precipitation in the Bengal Bay may indicate intensification of large-scale Asian monsoon circulation. Some of these results are summarized in Figure 1.



(a)



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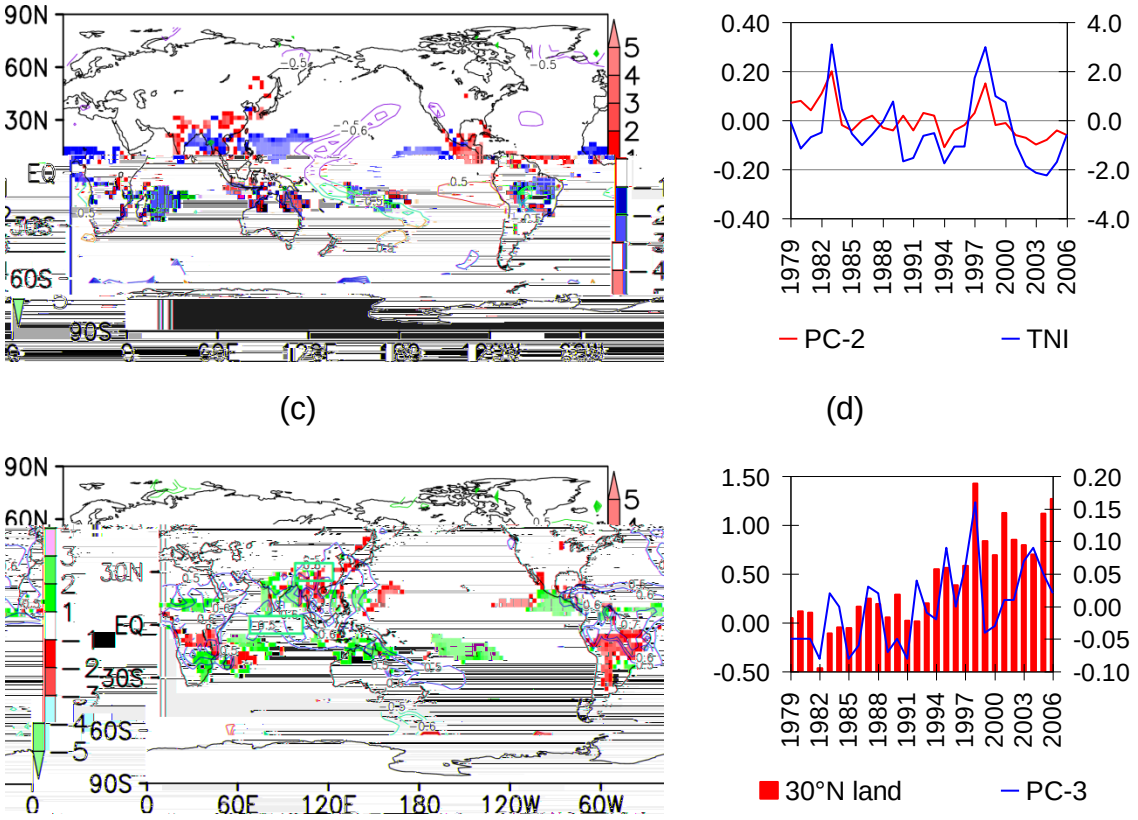

Figure 1. (a) EOF-1 (EV=20.65%) for annual monsoon precipitation GPCP and (b) its time series (PC-1) and the SOI (R=0.83 between them). Also shown are (c) EOF-2 (EV=11.43%) and (d) its time series (PC-2) and the TNI (R=0.68 between them) and (e) EOF-3 (EV=7.57%) and (f) its time series (PC-3). Contours of correlations between each PC and surface temperature (+ green and – purple) are also shown on (a), (c), and (e). The orange rectangles on (e) delineate the equatorial Indian Ocean and 30°N Asian land.

Planned Work

This project has been completed; it is hoped that the work can be published in a refereed journal or NOAA Technical report.

Publications

Sudradjat, A., A. Gruber, J. Janowiak, and R. R. Ferraro, 2011: The variability of annual monsoon precipitation and global surface temperature

Improvements to the AMSR-E Rain Over Land Algorithm

P. Arkin and A. Sudradjat (NOAA Collaborator: R. Ferraro) – PAASAMSRE10

Background: Scientific Problem, Approach, Proposed Work

Measurements from polar orbiting satellites, in particular, microwave sensors, offer perhaps the most viable means to develop global precipitation retrievals. This project focuses on the continued development and improvement of the Advanced Microwave Scanning Radiometer on board the Aqua satellite (AMSR-E) L2 and L3 facility precipitation retrieval algorithm. This project focuses on the land portion of the algorithm, which is incorporated within the Goddard Profiling Algorithm (GPROF). Despite the progress in GPROF over the past several years several improvements are urgently needed for the AMSR-E, and are the basis of this project. One of these is an overhaul of the land surface screening module which is outdated and should incorporate ancillary data sets, as well as other AMSR-E derived products (e.g., snow and sea ice cover, soil moisture, emissivity) and additional channel measurements (e.g., 6.9 and 10.7 GHz).

Accomplishments

This task was completed during the reporting period. We have developed a prototype retrieval system that eliminates the need for radiometric based surface "screening tests" and replaces it with one which relies on ancillary data sets such as high resolution surface classification maps, daily snow and ice cover, and vegetation cover maps (see Figure 1). Additionally, the prototype performs a much more accurate matching of the surface maps to the satellite footprint, whereas, traditionally, fixed gridded maps are used. This vastly improves the delineation of the coastline, which is extremely important in passive microwave retrievals. The results of this work have been presented by the NOAA sponsor, R. Ferraro, at NASA science team meetings and in a forthcoming journal publication (in press). This methodology will be further enhanced through a follow on project that will be receiving funding stating in FY2012.

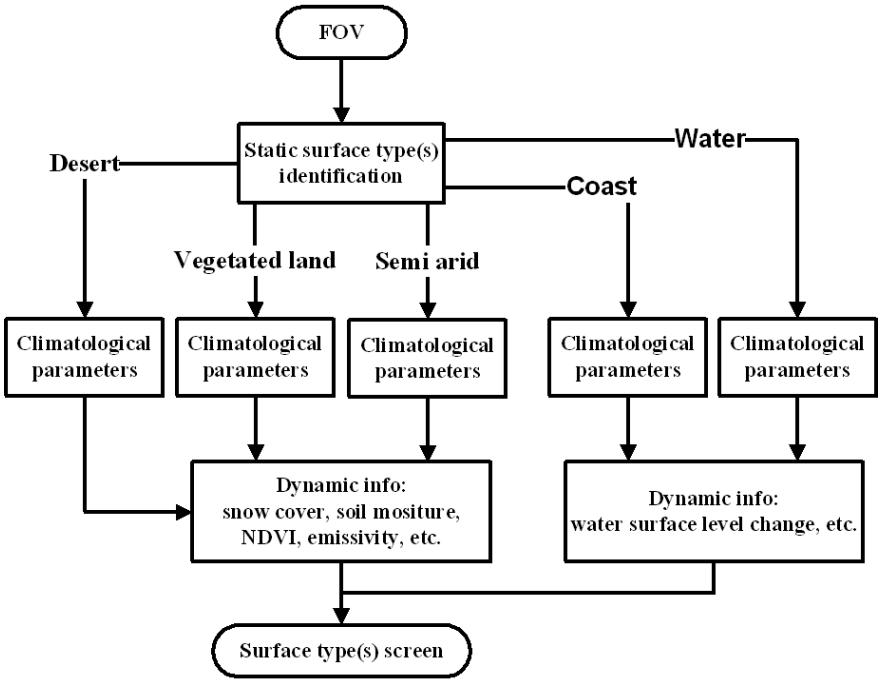

Figure1. Framework for the prototype land surface classification algorithm for passive microwave precipitation retrievals.

Planned Work

Project completed.

Publications

Sudradjat, A., N-Y. Wang, K. Gopalan and R. R. Ferraro, 2011: Prototyping a generic, unified land surface classification and screening methodology for GPM-era microwave land precipitation retrieval algorithms. In Press

Operational Generation of the HIRS Outgoing Longwave Radiation Climate Data Record

Hai-Tien Lee; (NOAA Collaborator: Jeff Privette) – HLHL_HIRS11

Background: Scientific Problem, Approach, and Proposed Work

The primary goals of this project are to prototype an operational production system for the outgoing longwave radiation climate data record while continue the improvements and validation efforts for the existing product and algorithms. An end-to-end system has been proposed to produce OLR CDR product using HIRS level-1b data input. The derivation of climate data record involves several careful procedures with OLR retrieval performed for each HIRS pixel, including intersatllite calibration to maintain continuity; use of diurnal models to minimize orbital drift effects in temporal integral; and consistent radiance calibration. OLR algorithms will be developed for the operational sounders following the HIRS, including the IASI and CrIS, such that the OLR CDR time series can be extended into the foreseeable future (~2040) without data gaps.

Accomplishments

HIRS OLR CDR Quality Assurance

The OLR regression model and intersatellite calibration for NOAA-19/N' have been derived, extending the HIRS OLR time series (Ed2.2) to 32 years from 1979 to 2010.

The HIRS OLR CDR is compared well to the CERES Ed2 and Ed2.5 products. The slight trend (~1-2 Wm^{-2} per decade) in the OLR differences between HIRS and CERES Ed2 after year 2000 (i.e., w.r.t. Terra and Aqua data) is the focus of the validation studies. We are verifying if this trend is caused by the Ed2 CERES OLR biases related to the spectral response function degradation in SW and Total channels. The new calibration method CERES devised is expected to fix this problem and a Ed2.5 product was generated for early phase assessment (the Ed.3 product that would be available at least in another 6 months will include the new calibration method as well as other improvements). Preliminary comparisons of HIRS OLR and CERES Ed2.5 products showed consistent results traceable to the past HIRS/ERBS validation studies. However, it seems that there remains to have trending differences whose existence and causes are yet to be confirmed. We continue to collaborate with NASA colleagues to understand these results.

Transition from Research to Operation

The HIRS OLR CDR Processing System Diagram is shown in Figure 1. This diagram shows that the system is consisted of three components: the Online Processing, the Offline Processing, and the Science Maintenance. The Online Processing column depicts the flow chart of the HIRS OLR CDR derivation sequence; while the Offline Processing column contains the corresponding development works that provide the necessary static inputs, e.g., OLR regression coefficients. The Science Maintenance column shows examples of works for future improvements. The system uses Subversion for version control.

NCDC has designated Dr. Lei Shi and Bill Hankins as the Science and Technical point of contact for the HIRS OLR CDR Research to Operation transition.

The complete computation source code package for HIRS OLR CDR Production system has been delivered on April 1st, 2011. The system integrity test for the NOAA-16, 17, 18, 19 and MetOp-2 has been performed and it has passed the verification check. Similar integrity tests will also be conducted for the rest satellites to ensure correct processing at any given month within the time series.

The Operator's manual and code documentations have been delivered along with the source code package.

The "Submission of Agreement" form has been submitted and is under processing.

NCDC has provided the ATBD template on March 28th, 2011 and the ATBD for HIRS OLR CDR is under preparation, expected to deliver in July 2011.

The HIRS OLR CDR Production system is scheduled to be operational in September 2011.

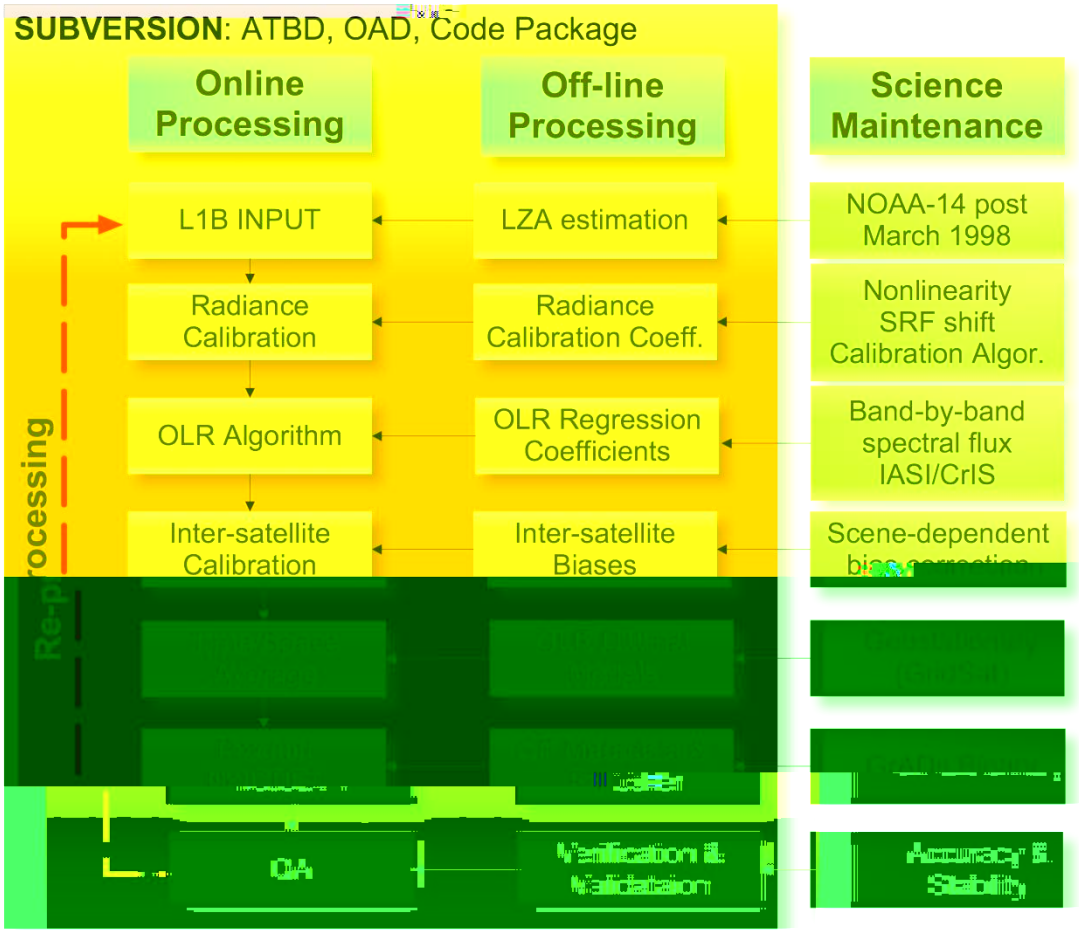

Figure 1 The HIRS OLR CDR Processing System Diagram. This diagram shows that the system is consisted of three components: the Online Processing, the Offline Processing, and the Science Maintenance. The Online Processing column depicts the flow chart of the HIRS OLR CDR derivation sequence; while the Offline Processing column contains the corresponding development works that provide the necessary static inputs, e.g., OLR regression coefficients. The Science Maintenance column shows examples of works for future improvements. The system uses Subversion for version control.

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Hydrological Support for the Climate Prediction Center

J. Janowiak and L.C. Chen; (NOAA Collaborator: Kingtse Mo) JJJJ_HYDRO_10

Background

This work is to support CPC's effort on drought monitoring and prediction. Tasks include monitoring the production of operational data such as NARR and NLDAS to support U.S. Drought Monitor, and developing algorithms and techniques for drought prediction. Seasonal hindcasts of drought indices over the United States are made for the period from 1982 to 2009 based on the NCEP Climate Forecast System Reanalysis and Reforecasts (CFSRR). Three indices: standardized precipitation index (SPI), soil moisture (SM) percentile, andstandardized runoff index (SRI), and their potential use for drought prediction are explored. SPI, which measures precipitation deficits, is used to identify meteorological drought. SM percentile, computed based on probability distributions, is used toclassify agricultural drought. SRI, similar to SPI and measuring runoff deficits, represents hydrological drought. Before predicting drought indices, monthly mean precipitation, soil moisture, and runoff forecasts from the CFS global model are bias corrected and downscaled to regional grids of 50 km resolution based on the probability distribution functions from hindcasts.

Accomplishments

Initial work on SPI and SM percentile forecasts has been conducted and evaluated. Based on preliminary results, prediction skill of drought indices is regionally and seasonally dependent. For the precipitation forecasts, skill drops quickly after one month. Most skill comes from the initial conditions. In the mature phase of El Nino Southern Oscillation (ENSO), the CFS is able to capture the impact of ENSO on drought reasonably well. Forecasts have higher skill in winter and lower skill in summer. The ways to construct ensemble has an impact on the prediction skill, in particularly when the initial conditions are dominant. For the first month, the ensemble with eight youngest members has the best skill. After the first month, the ensemble with 16 members performs superior to other tested ensembles. Overall, both the six-month SPI and SM percentile are skillful out to 3-4 months. For SPI prediction, skill comes from the observations appended to the precipitation forecasts. For predicting SM percentile, it comes from the SM memory and initial conditions. Figure 1 shows an example of SPI forecasts based on CFSv2 with initial condition on 3-4 April 2011.

Planned Work

- Continue work on SRI forecast and evaluate prediction skill of drought indices from CFSv2 forecasts. A routing model will be set up to compute streamflow from CFSv2 runoff. Results will be compared to streamflow prediction from North America Land Data Assimilation System (NLDAS).
- Examine prediction skill of drought indices from coupled CFSv2 with a land surface model.

- Assess the effects of forcing inputs to land surface models on the simulation of drought indices.

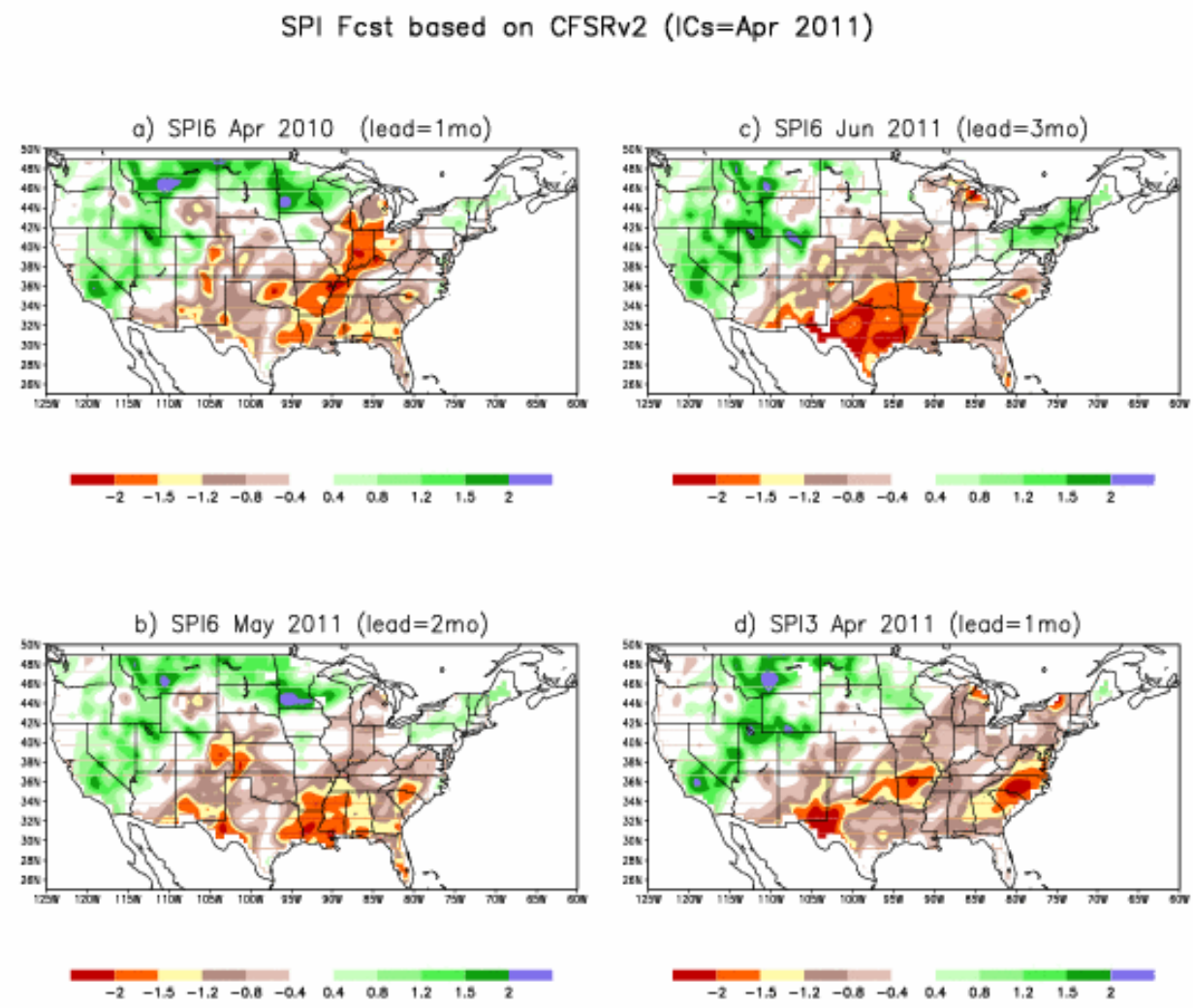


Figure 1: SPI forecasts based on CFSv2 with initial condition on 3 April 2011.

Analysis and Improvement of Satellite Derived Global Hydrological Products - Passive Microwave Applications

Daniel Villa; (NOAA Collaborator: Ralph Ferraro) – DVDV_HYDR11

Background: Scientific Problem, Approach, Proposed Work

Remotely sensed measurements from meteorological satellite instruments play an extremely important role in providing valuable information on many key parameters of the global-scale hydrological cycle (e.g., water vapor, precipitation, snow cover, etc.). These satellite measurements supplement ground-based observations, especially in areas where in situ measurements are limited. The development of rainfall estimates from passive microwave satellite measurements, specifically, those from the Defense Meteorological Satellite Program (DMSP) series, Special Sensor Microwave Imager (SSM/I) have been one of the most important sources of data because: a) the length of the dataset (e.g. SSM/I has been in operation since June 1987 to present); b) the operating frequency range (from 19 GHz to 85 GHz), and c) the conical scan viewing geometry allows to maintain a fixed viewing angle and a constant footprint size along the scan for each frequency. With over 20 years of SSM/I data now available, enhanced QC procedures has been applied to improve the products. Thus, the primary goal of this project was to perform a statistical-based QC procedure on the input data (1/3 degree daily antenna temperature files) to remove spurious values not detected in the original database and reprocess the rainfall product using the current version of the algorithm for the period 1992–2007. The secondary purpose is to assess the discrepancies associated with the SSM/I derived monthly rainfall products through comparisons with various gauge-based and other satellite-derived rainfall estimates.

Accomplishments

We implemented the new QC procedure (Vila et al. 2010) and regenerated the entire time series for the period 1992 – 2010 for the SSM/I F10, F11, F13, F14 and F15 satellites. Updated pentad and monthly global products of rainfall and rain frequency, total precipitable water (TPW), cloud liquid water and cloud frequency, snow cover, sea-ice concentration, and ocean surface wind speed were generated. The products were intercompared with other similar data sets and for the most part, improvements were found (see Figure 1 as an example for the TPW product). A few outstanding anomalies were noted and are being investigated.

The earliest SSM/I data period (1987 – 1991) for the F8 satellite is also being regenerated as we obtained the Remote Sensing Systems V6 data set from NCDC. Additionally, SSMIS data will be folded into the time series.

We have also been working with H. Semunegus (NCDC) on transitioning the data and software for their eventual ownership of the products.

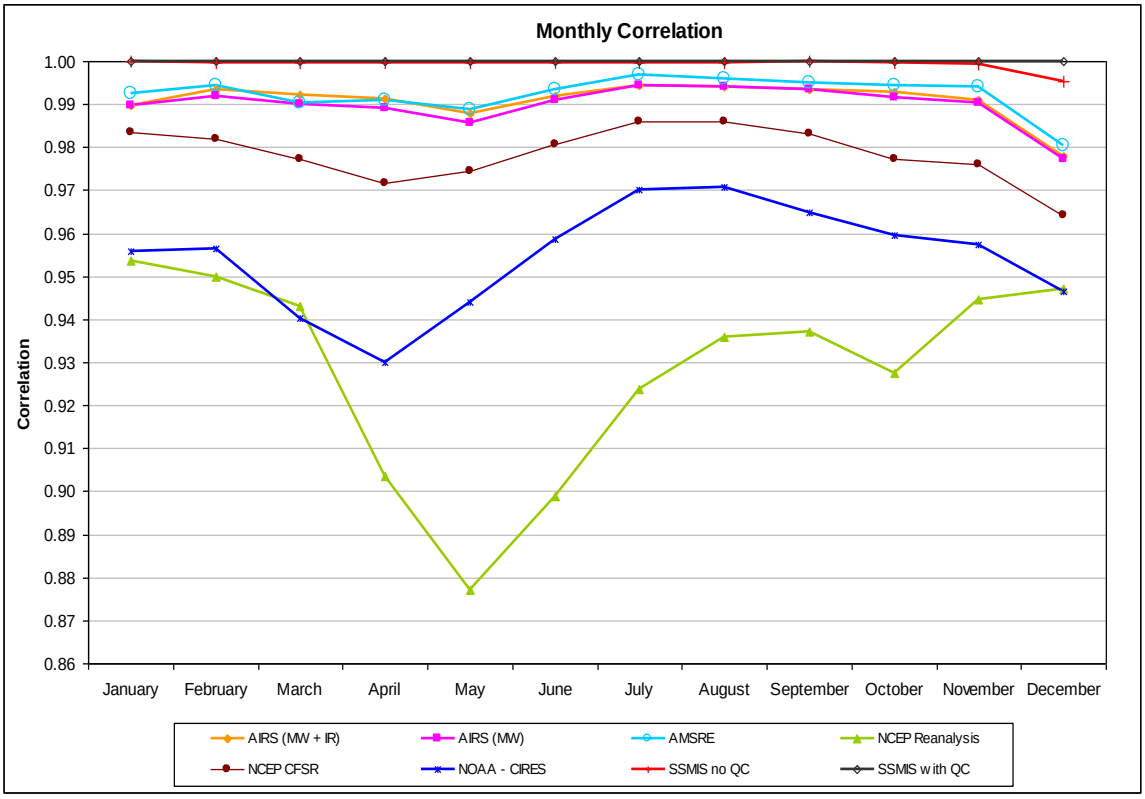


Figure 1: The correlation between the SSM/I-SSMIS data after QC and other data sets as a function of month for the years 1987–2010. The QC and non-QC data are highly correlated, whereas the degree of agreement between the QC data with other independent data sets varies.

Planned Work

This project will be completed in the next reporting period. The major tasks will include:

1. Regenerate the F8 time series with the new QC scheme.
2. Finalize the SSMIS algorithms and software to extend the time series; subject these data to the QC scheme
3. Complete handover to NCDC.

Publications

Vila, D. R. Ferraro and H. Semunegus, 2010: Improved global rainfall retrieval using the Special Sensor Microwave Imager (SSM/I). 49, 1032–1043.

A Special Sensor Microwave Imager/Sounder (SSMI/S) Application for Hydrological Products Retrieval

Daniel Vila, Arief Sudradjat (NOAA Collaborator: Ralph Ferraro) DVDV_SSMI1

Background

Global monthly rainfall estimates and other hydrological products like integrated Cloud Liquid Water (CLW) and Total Precipitable Water (TPW) have been produced from 1987 to present using measurements from the Defense Meteorological Satellite Program (DMSP) series of Special Sensor Microwave Imager (SSM/I). The DMSP F16 satellite was successfully launched on October 18, 2003, carrying onboard the first Special Sensor Microwave Imager/Sounder (SSMI/S) sensor. This first satellite was followed by DMSP F17 launched in 2007 and DMSP F18 launched in 2009. This is the first constellation of operational microwave satellite radiometers for profiling temperature and humidity using conical scanning sensors, so that the viewing area and slant path remain constant as it scans the Earth. SSMI/S imaging channels maintain similar resolution and spectral frequency to the SSM/I except 91.655 GHz on SSMI/S vs. 85.5 GHz on SSM/I. A wider swath, approximately 1700 km for SSMI/S compared with only 1400 km for SSM/I is also a new characteristic of this instrument. This project will be focused on the application of a new correction scheme on SSMI/S high frequency channels in order to mimic SSMI frequencies and run GPROF V7 (originally developed for SSMI channels). An in-depth comparison study between new SSMI/S and SSM/I estimates will be conducted on spatially and temporally collocated data in order to assess the bias of the proposed methodology. Comparisons with other algorithms and some preliminary statistics will also be the aim of this project.

Accomplishments

During the current reporting period, more extensive statistical validation activities have been carried out to evaluate the performance of the proposed scheme. These activities were focused in two tasks: the continuation of the 'Special Sensor Microwave/Imager (SSM/I) and Special Sensor Microwave Imager Sounder (SSMIS) Global Gridded Products' including precipitation, cloud liquid water and total precipitable water, among others; and a near real time application for rainfall retrieval using GPROF algorithm.

The importance of the first task resides on the fact that these products are useful for evaluating the mean climate state, its interannual and seasonal variations, and the detection of anomalies associated with large-scale (e.g. ENSO, Arctic Oscillation) and regional climatic variations. A time series of the entire SSM/I and SSMIS archive includes data from July 1987 to the present. Figure 1 show, in the upper panel, the rainfall retrieval for August 2008 for SSMI/S-f17; while in the bottom panel the same product is presented for SSM/I-f13. The enhanced convection activity over the ITCZ, especially over the ocean, could be to the fact that f17 and f13 ascending nodes are 90 minutes apart and f17 is close to the peak of the convection activity. This fact is under a more extensive research. Both

retrievals appear very close over the southern hemisphere (winter) where the convective activity is not so intense.

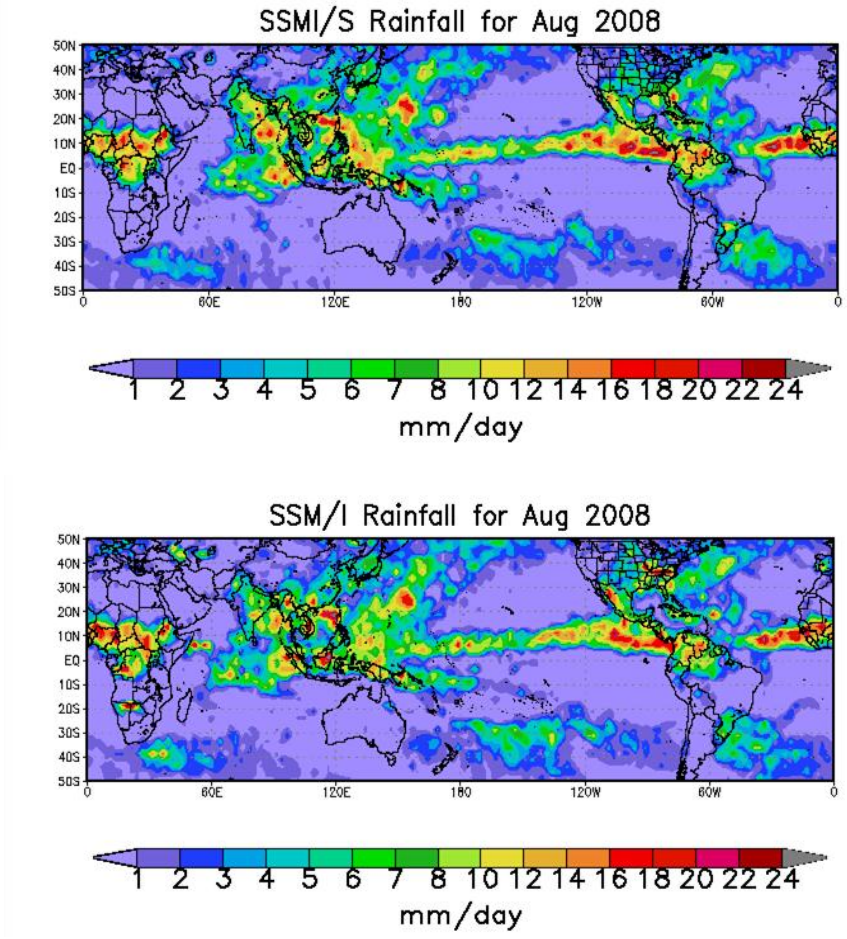


Figure 1: Monthly rainfall retrieval for August 2008. Upper panel: for SSMI/S f17 and bottom panel for SSM/I –f13.

The second task is more related with the links of CICS rainfall retrieval activities with other institutions and researchers. Due to the fact that no SSMI/S based rainfall retrieval algorithm is available for use in near real time, this activity is being developed in collaboration with other developers to make them available for using in different blended techniques (i.e., CMORPH, TMPA). In order to evaluate the quality of the rainfall retrievals, GPROF SSMI/S estimates were compared with collocated high quality TMI retrievals. Figure 2 show two case studies (one over land on the left panel and other over ocean on the right panel) where collocated in space and time SSMI/S retrievals are compared with TMI estimates before and after a bias correction process (called calibrated in the figure) in order to use those retrievals in blended techniques. In this case, the result of SSMI/S adjustments are pretty close over land (even before the bias correction process) while over

ocean SSMI/S retrievals tend to overestimate the amount of rainfall but maintaining the area detection pretty close to TMI estimates.

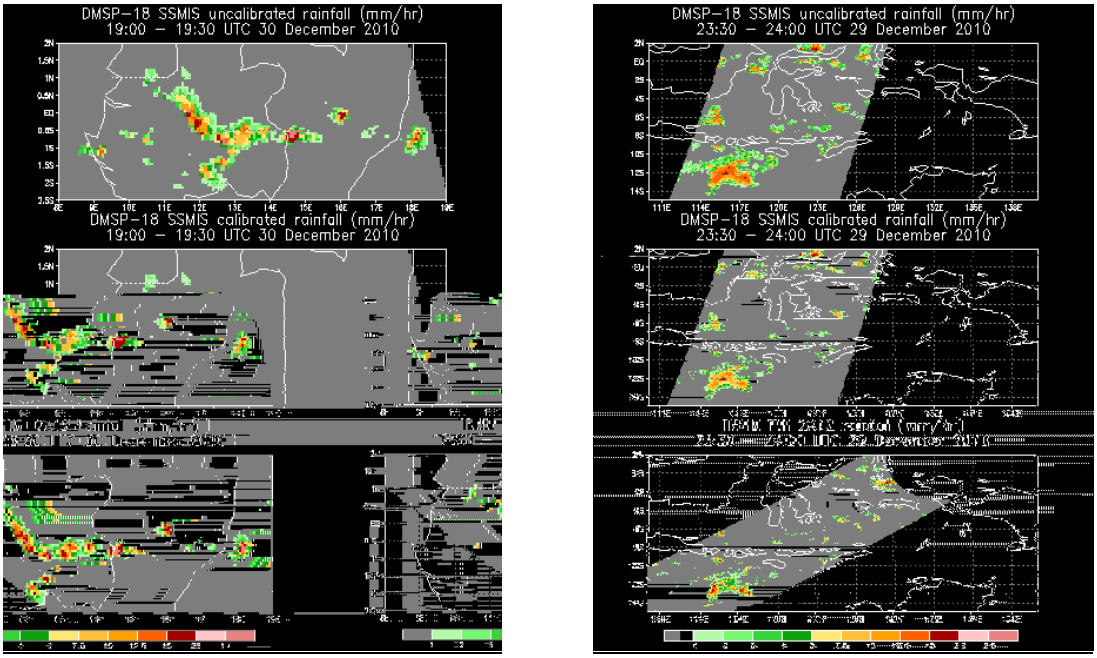


Figure 2: Left panel: DMSP-F18 rainfall retrieval over land before and after bias correction process (upper and middle figures) and corresponding TMI estimate (bottom figures). Right panel: Idem over ocean.

Presentations

Vila D., 2010: SSMI/S Assessment for Rainfall Retrieval: Preliminary Results. Talk presentation at IPWG workshop in Hamburg, Germany on 11-15 October 2010.

Development of an enhanced active fire product from VIIRS

E. Ellicott; (NOAA Collaborators: Ivan Csiszar)EEEEDEAFP11

Background

The work performed in this task is for year 2 of the project "**Development of an enhanced active fire product from VIIRS"** to assist the JPSS in the development, testing, validation and implementation of the VIIRS Fire Code in the pre-launch period. Development of an active fire product from VIIRS which would closely resemble the MODIS product provides continuity of data with intrinsic scientific merit.

As part of the 2nd year our tasks were to continue development of an enhanced "yes/no" fire detection algorithm for VIIRS based on the contextual principles of the MODIS product (Giglio et al., 2003) and the forthcoming collection 6 active fire code (which includes several enhancements, including accounting for background temperature variability). Proper adjustments to account for the different spatial resolution and radiometric characteristics of the VIIRS and MODIS sensor were also tasked for this period and were to be accomplished through improved simulations. To achieve the proper adjustments between VIIRS and MODIS, VIIRS proxy fire and background radiances were planned to continue to provide insight into the behavior and limitations imposed by spatial and radiometric specifications of this sensor.

In addition, per request of the IPO, we were tasked with evaluating the use of bands I4 and I5 as potential replacements or complements to the M13 and M15 bands originally intended for detection. The I4 and I5 bands are spectrally similar to the corresponding M-channels while offering higher spatial resolution retrievals than the (381m x 384m vs. 742m x 777m, respectively).

In the following section we present work accomplished for a few of the above tasks.

Accomplishments

- Evaluation of the VIIRS radiometric and spatial characteristics on active fire detection continue. We have assessed the potential issues of saturation and aggregation for the M15 channel and determined that based on thermal vacuum testing of saturation levels (363K; spec. is 343k) even for large fires pixel saturation (before aggregation) would only occur about 11% of the time (Figure 1). This is relevant to the third bullet in this section.

- Improvement to the simulated VIIRS active fire data continues to develop with the enhancement of our atmospheric correction process. This step is critical to reduce the uncertainty in our proxy MIR VIIRS data being generated from the high resolution ASTER Kinetic Temperature product (AST_08) and ensure a robust analysis between VIIRS and MODIS active fire products. We've recently included

NCEP reanalysis profile data to our processing change to run with the radiative transfer modeling program MODTRAN, thus providing a more realistic atmosphere to characterize attenuation. In addition, we are investigating approaches to properly address emissivity values within ASTER scenes, again with the intention of reducing our proxy data uncertainty and better simulating real fire conditions.

- As part of our task to the JPSS (formerly IPO), we evaluated the potential use of the I4 and I5 bands to be used in lieu of or in tandem with the M13 and M15 bands, respectively. Our assessment revealed that while the higher spatial resolution of the I-bands would help in characterizing the fire location, some limitations render these bands ineffective as the sole channels used for fire detection or as part of the active fire mask creation.
    - Pixel dimensions between I and M channels would complicate blending the two (e.g. M13 and I5; MIR and TIR, respectively) because of the spatial mismatch. This complication would carry over into the contextual algorithm where additional M-channels are incorporated.
    - Dynamic range of the I4 channel is also too low (~356k), especially given the higher resolution of this channel, lacks dual functionality like M13 to overcome this, and given its spectral placement will suffer for greater solar contamination than M13.

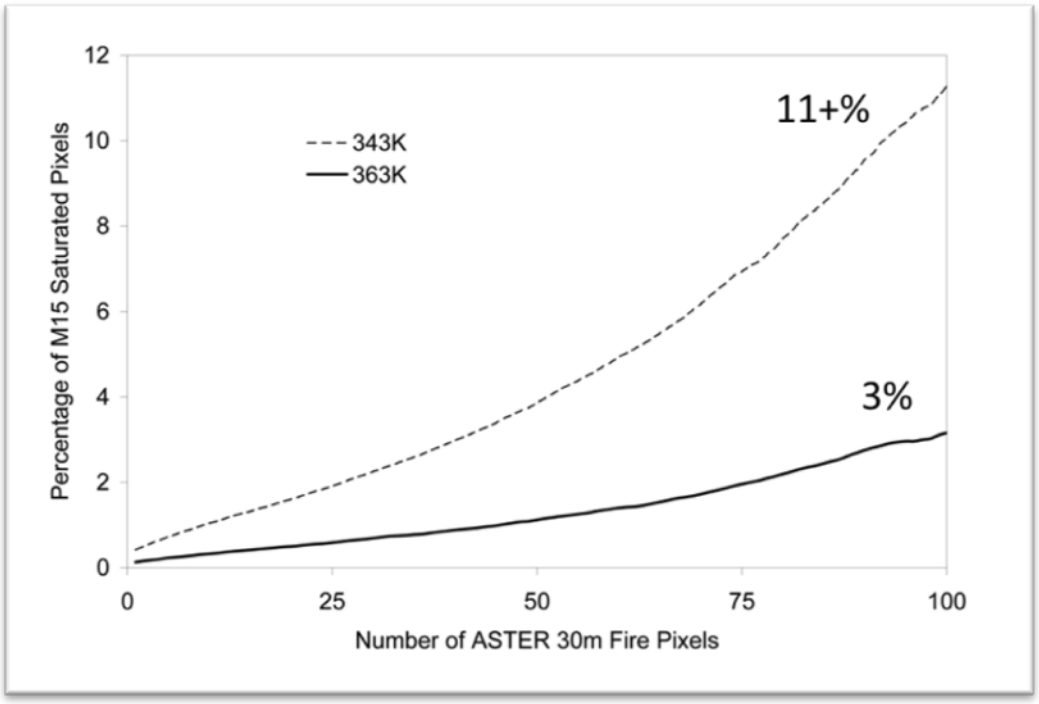


Figure 1: Fraction of simulated, unaggregated VIIRS M15 pixels that exceed a brightness temperature of 343 K (dashed line) and 363 K (solid line) as a function of fire size (expressed as number of ASTER fire pixels).

Planned Work

Continue development and testing of our proxy data, accounting for all sources of potential and real uncertainty in our estimates. Once accomplished, we will expand our simulations globally to include various land cover types, solar geometry, and fire timing (seasonally). In addition, we may include off-nadir examinations through the incorporation of other spaceborne and airborne sensors.

Collection 6 of the MODIS active fire detection algorithm is almost complete and will be modified to VIIRS radiometric, spectral, and spatial specifications. The modified code will

then be used to perform robust statistical analysis of the detection and characterization performance of VIIRS proxy data.

Poster Presentations

Csiszar, I., W. Schroeder, L. Giglio, C. Justice, E. Ellicott. "Quantitative evaluation of active fire detection capabilities from VIIRS", 91st Annual Meeting of the American Meteorological Society in Seattle, WA 23-27 January 2011.

Assessments of Advanced Components for Community Radiative Transfer Model (CRTM) and Satellite Data Assimilation

Zhanqing Li; (NOAA Collaborator: F. Weng)ZLZL_CRTM10

Introduction

The proposal task will provide strong supports to US Joint Center for Satellite Data Assimilation (JCSDA) for accelerated uses of research and operational satellite data in numerical weather prediction models. STAR/Satellite Calibration and Data Assimilation branch works closely with Environmental Modeling Center (EMC) for a hand to hand transition of all data assimilation science and software into NCEP global and regional forecast systems. Several FTE scientists under this contract will develop fast and advanced radiative transfer model schemes, surface emissivity models, and satellite data handling software for NWP data buffering and tests of new data streams through observing system experiments (OSE) and tests for assessing the future instrument through Observation System Simulation Experiments (OSSE).

Accomplishments

Accomplishments include new version of CRTM application on Advanced Microwave Sounding Unit-A (AMSUA) and Microwave Sounding Unit (MSU) data assimilation, Hurricane warm core retrieval assessment and 1DVAR microwave satellite data assimilation development.

Δ CRTM application:

(1)AMSUA has 4 channels that almost are same frequency as MSU. The similarity between these 2 instruments was investigated. Forward simulation of NOAA 18 AMSUA subset and MSU 4 channels by CRTM new version were accomplished. Assessment between AMSUA & MSU brightness temperature under variation of temperature profiles, surface temperature and surface emissivity were done. It is shows these 2 instruments have linear correlation. Weighting function of this 2 instrument are very similar, it is found there are vertical weighting difference causes brightness temperature of AMSUA channel 5 higher than MSU channel 2 and is not effect for AMSUA channel 9 and MSU channel 4.

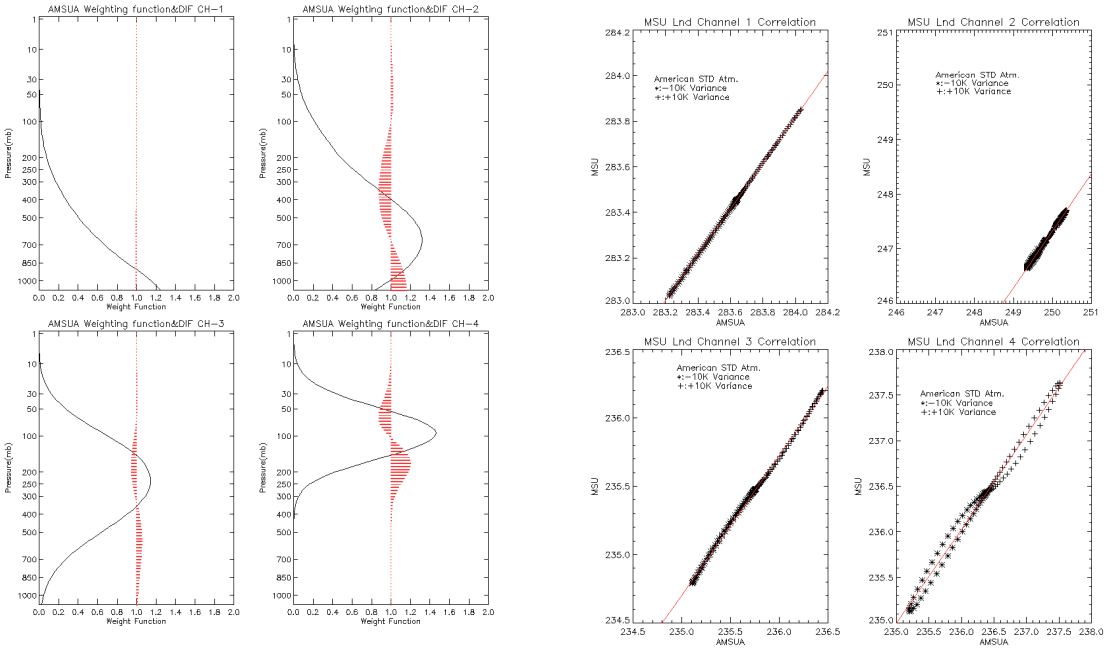


Figure 1. The correlation between AMSUA 15 subset 4 channels and NOAA 14 MSU 4 channels brightness temperature (BT) in different atmosphere temperature. Left figure shows the relationship between AMSU & MSU BT. Right figure shows weighting function of MSU and weighting function difference with AMSUA minus MSU.

Microwave Satellite Data Assimilation developments

(1)Microwave observations areless affected by clouds than infrared ones. AMSUA and MSUprovide temperature retrieval information for operation over 30 years. Assessment of global temperature retrieval capability under clean sky over ocean by AMSUA subset was accomplished. 1DVAR retrieval is applied on CRTM simulated MSU & AMSUA subset and satellite observed data. It is shown that the retrieval accuracy is very similar from AMSUA subset 4 channels and MSU.

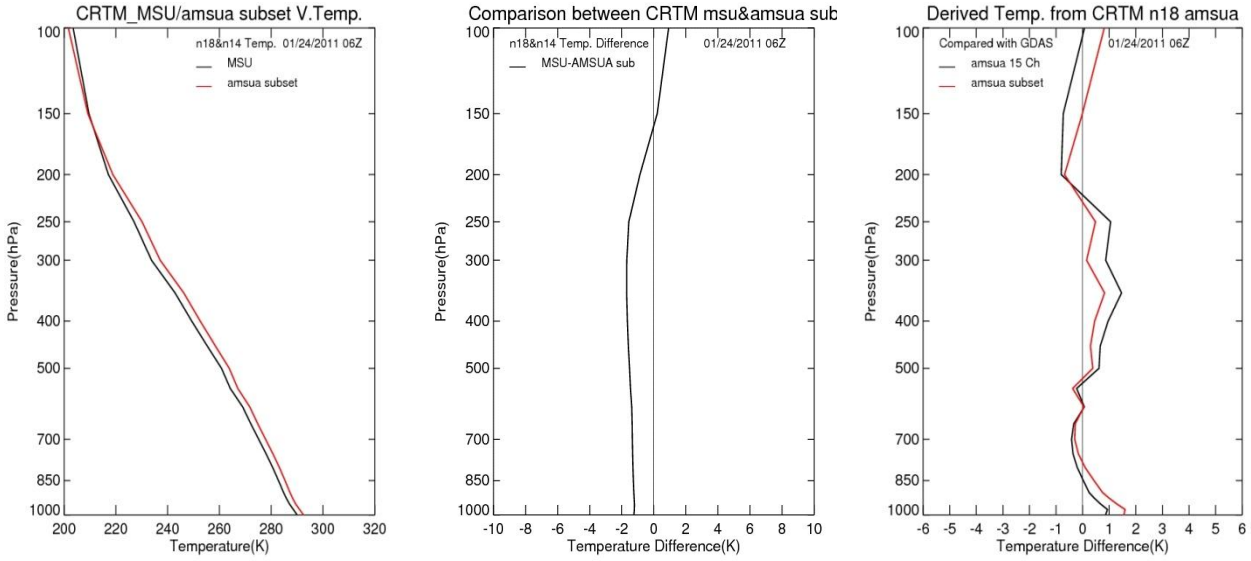


Figure 2. Left: Derived temperature profiles from CRTM simulated MSU & AMSUA subset as input observation. Middle: Derived Temperature bias by CRTM simulated MSU-AMSUA subset. Left: Derived temperature profile compared bias with GDAS input temperature profile in 1/24/2011 06Z.

(2) A study is also performed on hurricane warm core retrieval using 1DVAR. The retrieval without MHS has a higher convergent rate than that with MHS.

Planned Work

(1) Compare the retrieval profiles with GDAS and COSMIC data.

(2)Find out the correlation between real observed MSU and AMSUA level 1B data by Simultaneous Nadir Observation (SNO) matchup data.

(3)Do preliminary study for 30 years global temperature tendency by MSU & AMSUA 1DVAR retrieval.

Management of the Climate Prediction Program for the Americas

A. Mariotti; (NOAA Collaborator: J. Huang) – AMAMMCPPA11

Background: Scientific Problem, Approach and Progress Report

During the reporting period the PI contributed to the Management of NOAA/Climate Program Office's Climate Prediction for the Americas (CPPA) and Climate Test Bed Program working together with the Program Manager Jin Huang. All tasks set for this project period were successfully accomplished. Since the PI has left the project and begun employment as a civil servant, this will constitute the final report on this project.

Major tasks and achievements are relative to Fiscal Years 2009 and 2010 (FY09 and FY10); these include:

- Management of on-going projects
- Selection of Program's new Projects
- Synthesis of Program's achievements
- Dissemination of Program's achievements
- Communication with NOAA and other Agencies/Programs

Management of on-going projects

The PI managed on-going projects, monitoring and assessing progress, and arranged for the continuation of funding in FY09 This task involved

- requesting and analyzing progress reports
- writing a funding recommendation regarding each project

In this activity the PI interacted with the scientific community to refine the information submitted in the progress reports; and with the NOAA Grants Analysts to initiate the "continuation" actions to administer the funds.

She also helped in defining budgets requirements and plans.

Selection of New FY10 Projects

The PI helped in the selection of new projects to be funded by the CPPA and CTB programs in FY10. This activity involved:

- identifying research priorities
- organizing the review process for the selection of new projects (review Letters of Intent, organizing mail and panel reviews)
- contributing to the decision making process

Synthesis of CPPA's achievements

As part of the annual synthesis of Program's achievements, the PI:

- wrote an internal report
- maintained a publication list for the Program

All these efforts contributed to monitor the progress of the CPPA projects in the various research areas and to identify knowledge gaps and future directions.

Dissemination of CPPA achievements

The PI contributed to the preparation of major Program's presentations. In order to make CPPA information available to the public, the PI worked in close collaboration with a web developer to make information regarding the CPPA projects accessible on-line. This web-page continues to be a resource widely used by the research community and other program managers to learn about the CPPA program. In particular, all projects since Fiscal Year 2004 are now listed on the web and linked to files describing their goals and achievements; the CPPA publication list is also on-line and up-to-date; a section dedicated to research "Highlights" is being used as a vehicle to readily publicize information about major CPPA achievements. The PI disseminated CPPA achievements via the quarterly CPO Newsletter and the Climate Change Science Program publication "Our Changing Planet".

Communication with NOAA and other Agencies/Programs

The PI has participated in NOAA/CPO internal meetings and helped the Program Manager respond to upper management requests for information. She also participated in relevant United States Global Change Research Program inter-agency meetings.

CICS Marine Phenology

P. Arkin, M. Sapiano (NOAA Collaborator: C. Brown) – MSMS_PHEN10

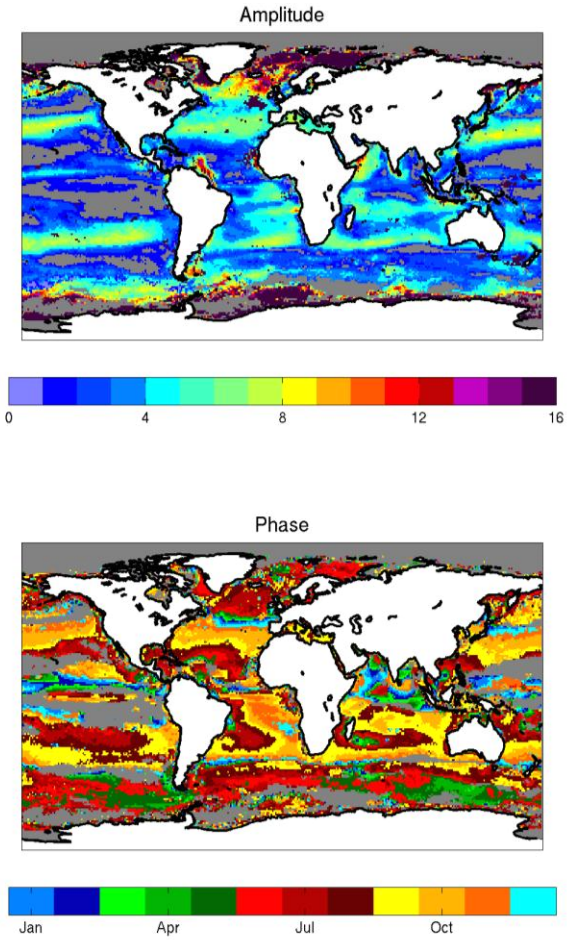
Background: Scientific Problem, Approach, Proposed Work

Climate change affects the timing and magnitude of numerous environmental conditions, such as temperature, wind, ocean circulation, and precipitation. Amongst other repercussions, such changes in the environment will lead to a response in marine ecosystem productivity manifested by changes in the timing and magnitude of phytoplankton biomass and primary production. In addition to establishing a baseline from which to assess any future changes, the proposed research will describe the timing of phytoplankton biomass and relate these changes to physical oceanic variables and assess if any trends over the past decade are present. This will lead to a better understanding of the critical factors that link climate change to the response of marine ecosystems on a regional and global scale and provide insights on the potential impact on the carbon cycle.

These research activities are paid in part by the NASA Ocean Biology & Biogeochemistry Program funding directed to the University of Maryland. Unfortunately, the total amount of funding requested in the proposal was not granted by NASA, and equipment and travel allowances were curtailed severely to the detriment of the project. To augment NASA funding for the project and its CICS members – Dr. Mathew Sapiano and Ms. Stephanie Uz additional funding to enable successful completion of the project was acquired

Accomplishments

In the past year, we extended our preliminary work that that presented a statistical technique for modeling phytoplankton blooms in the North Atlantic using SeaWiFS data (Vargas et al., 2009). We have extended this technique to the global domain and higher temporal and spatial resolution and have replicated the analysis using MODIS Aqua data. The analysis has been updated to use the most recently processed SeaWiFS and MODIS datasets. Daily estimates of chlorophyll concentrations dating from September 1997 to July 2007 with a spatial resolution of 1° were generated from daily, 1/12° SeaWiFS chlorophyll concentrations over the global ocean. Similar estimates where used from MODIS from July 2002 to June 2010. The time series of chlorophyll at each grid box in the study area is modeled using a Gamma Generalized Linear Model (GLM). GLMs are a powerful regression tool that allow for modeling and hypothesis testing for a range of non-Gaussian distributions. Variables were added to the model to represent a linear time trend, the annual cycle and linear time trends in the annual cycle. First and second order sinusoidal shapes were used to represent the annual cycle. In all, eight different models forms were tested which allow for various kinds of shapes in the annual cycle as well as trends in some of the parameters of the statistical model



We are currently preparing a manuscript detailing the analysis and comparing the results for SeaWiFS and MODIS. Figure 1 shows the amplitude and phase of the annual cycle fitted in the model that will be explored in the manuscript.

Planned Work

We have two objectives for the coming year. Our first is to complete and the manuscript describing the GLM model fitted globally and present it at national conferences and to submit it for publication in a peer-reviewed journal.

The second and principal objective is to develop and fit the GAM model to both SeaWiFS and MODIS data in order to accurately depict changes in the shape of the annual cycle and thus changes in the phenological markers is the main task for the coming year. GAMs, which naturally handle non-Gaussian distributed data in a similar way to GLMs, also allow for the use of a range of shapes as the explanatory variables. Careful selection of these

shapes will allow for accurate modeling of the phenology of phytoplankton biomass. Such models can also be used to investigate the effects of other variables (such as ENSO) on the shape of the annual cycle, and thus on the phenological markers.

Publications & Presentations

None

References

Vargas M., Brown C.W. & Sapiano M.R.P. (2009). Phenology of marine phytoplankton from satellite ocean color measurements, Geophys. Res. Lett. 36, L01608, doi:10.1029/2008GL036006.

A Prototype STAR Precipitation Product Validation Center

John Janowiak and Daniel Vila (NOAA Collaborators: R. Kuligowski & L. Zhao)

DVDV_STAR10

Background: Scientific Problem, Approach, Proposed Work

A prototype system has been developed with input from STAR scientists to evaluate operational NESDIS precipitation products – particularly those that are generated from the NOAA-19 and METOP-A platforms, and to analyze the results of these evaluations. This effort is conducted by comparing instantaneous precipitation estimates from individual satellite swaths with hourly radar data (NCEP "Stage IV" mosaic) over the US. We also evaluate NESDIS precipitation products over South America, where daily rain gauge data are used as the reference standard. These evaluations are done within two weeks after the end of each meteorological season (Dec-Feb, Mar-May, etc.) and the results are disseminated via a web page: http://cics.umd.edu/~johnj/STAR/html/MAIN_page.html. In addition, we perform evaluations to assess the performance of new or updated algorithms, as request to do so by the PREPOP.

Accomplishments

Quarterly evaluations of the MiRS, MSPPS, Hydroestimator, and SCaMPR precipitation products were performed for the DJF 2009-2010, MAM 2010, JJA 2010, and SON 2010 seasons. The web pages were updated to include the statistical information that was generated by the evaluation process, and the appropriate STAR scientists were notified when the seasonal evaluations were completed.

In addition to the routine seasonal evaluation, we were requested by the PREPOP to conduct an evaluation of the precipitation algorithm for NOAA-15 that required modification due to a channel failure on the AMSU-B instrument aboard that spacecraft. This evaluation was conducted by comparing the precipitation estimates among the modified NOAA-15 algorithm, the modified algorithm for NOAA-18, and the operational NOAA-18 algorithm. The evaluation was performed as described because all AMSU-B channels aboard the NOAA-18 spacecraft were functioning properly and because the equator crossing times of the two spacecraft were within ~2 hours of each other. Briefings were made to the PREPOP regarding this evaluation in Dec

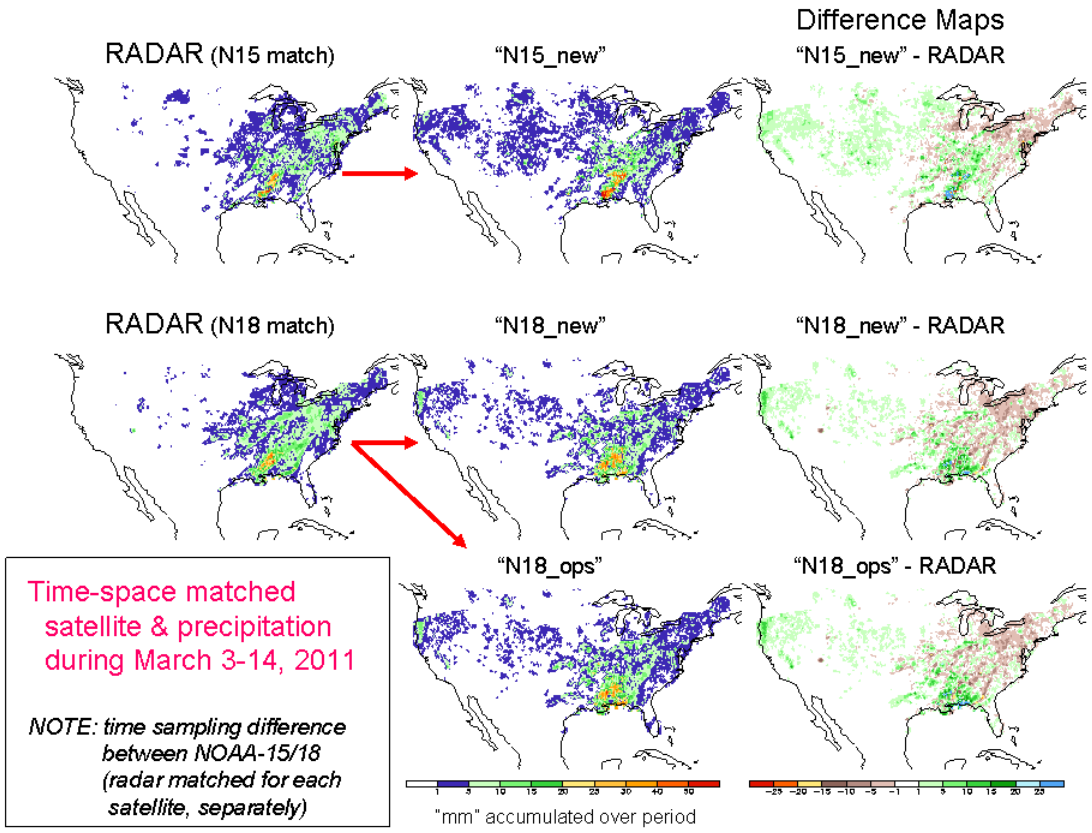


Figure 1. Plots of accumulated precipitation (and differences from hourly ground radar estimates) during the March 3-14, 2011 period for a modified NOAA-15 algorithm ("N15_new"), modified NOAA-18 algorithm ("N18_new") and the operational NOAA-18 algorithm ("N18_ops"). The hourly radar-satellite matchups were made separately for NOAA-15 and NOAA-18 to accommodate the difference in equator crossing times of the two spacecraft.

Figure 1 shows the accumulated precipitation and the differences from hourly ground radar estimates) during the March 3-14, 2011 period for a modified NOAA-15 algorithm, a modified NOAA-18 algorithm and the operational NOAA-18 algorithm. Note that the hourly radar-satellite matchups were made separately for NOAA-15 and NOAA-18 to accommodate the difference in equator crossing times of the two spacecraft. The following conclusions were drawn based on a statistical comparison among these data:

- Spatially, all 3 satellite estimates exhibit very similar patterns and, in general, they underestimate precipitation (relative to radar) in the eastern 1/3 of the nation and overestimate in much of the West.
- Histograms of precipitation rates in the 0.5 to 2 mm h^{-1} range during the

March 2011 case are very similar to the Nov 2010 data, with very good agreement among the satellite estimates and with the radar data in the 1.25 to 2 mm hr-1 range.

- Histograms of precipitation rates in the 2 to 5 mm hr-1 range during the March 2011 period for the modified NOAA15 algorithm are closer to the radar data than the NOAA18 algorithms.
- For precipitation rates of 10 to 20 mm hr-1, the modified NOAA15 results are in very good agreement with the radar data (particularly for rates in the 10-15 mm hr-1 range).
- All of the satellite estimates exhibit considerably more events with precipitation rates of 25 to 30 mm hr-1 compared to radar – although this may be because the radar data are integrated hourly data while the satellite estimates are 'snapshots'

In essence, the differences among the algorithms are essentially indistinguishable from differences due to temporal mismatches in the data and to ambiguities in the radar estimates that were used as the reference standard.

Publications

None

A Prototype STAR Precipitation Product Validation Center over South America

Daniel Vila; NOAA Collaborator: Ralph Ferraro – DVDV_CALVA11

Background

This proposal is focused in the development of a prototype system along with STAR scientists to evaluate operational NESDIS precipitation products – particularly those that are generated from the NOAA-19 and METOP-A platforms – and in an in-depth manner, and to analyze the results of these evaluations and condense the analysis into quarterly reports that will be directed to appropriate NESDIS personnel. This approach is providing valuable input to the algorithm developers because the evaluation is conducted by parties that are not involved with the algorithm development. On the other hand, the users of satellite rainfall estimated are also beneficiated. We use the leverage of our in-depth experience with evaluating precipitation products due to our involvement in the International Precipitation Working Group (IPWG), and propose to conduct the evaluations in much more depth and detail than is presently done within IPWG. This part of the report is focus exclusively on satellite products over South America. These products include MIRS, MSPPS, CMORPH and the HydroEstimator. This proposal aims to regionalize the validation process for regions with similar characteristics expand the array of statistics and provide sub-daily analyses where possible, and to synthesize the validation statistics to provide concise, meaningful and useful interpretations of algorithm performance.

Accomplishments

In the reporting period, maps of statistics over every season (DJF, MAM, JJA and SON) have been constructed so that depictions of the geographical variations of a statistic can be conveyed. For example, in Figure 1 we show the temporal correlation of daily precipitation over the September 2010-December 2010 period for various estimation techniques with a daily rain gauge analysis. Such a representation clearly shows the geographic variation of correlation with the rain gauge analyses and among the various techniques. During the southern hemisphere spring, the onset of the rainy season over southern South America, high correlations are observed over northeastern Argentina, Paraguay, Uruguay and southern Brazil, where the convection activity is enhanced, while over northeastern Brazil the correlation coefficient is very low due to the lack of precipitation during this period of the year. It's noticeable the lack of rain gauges in real time (this analysis is done in near real time) over the Amazonian region.

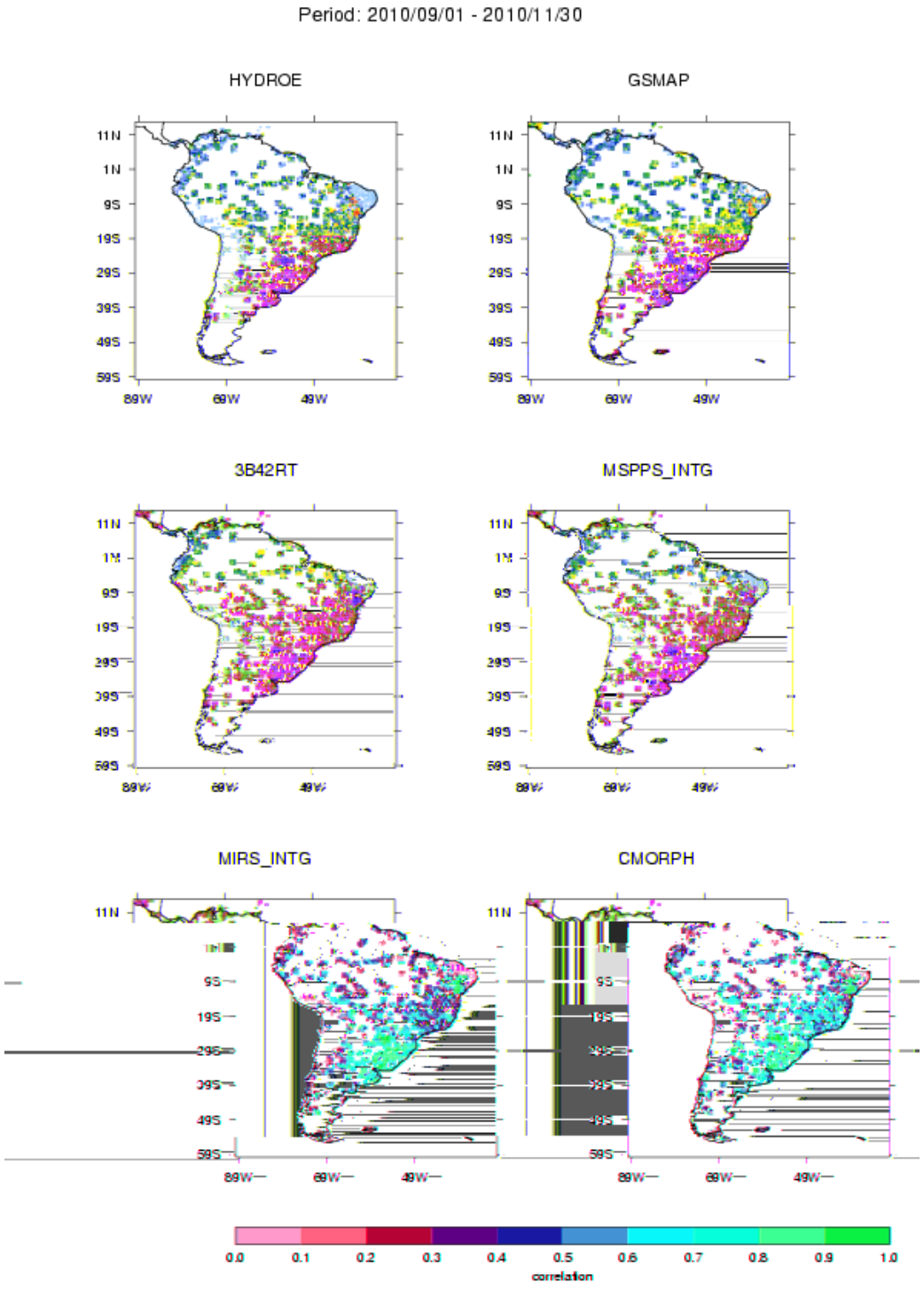


Figure 1. Temporal correlation of daily precipitation during September-December 2010 for various satellite derived and numerical model forecasts with daily rain gauge analyses over south America

The depiction of statistics in time series form is a powerful way to portray the evolution of performance as well as to compare the performance among techniques (Figure 2). Among them the Heidke skill score over South America shows that this parameter is highly dependant on the date (this is a smoothed representation of that parameter) and it seems that blended techniques like 3B42RT and CMORPH make a better work, especially at the end of the spring and the beginning of the summer season.

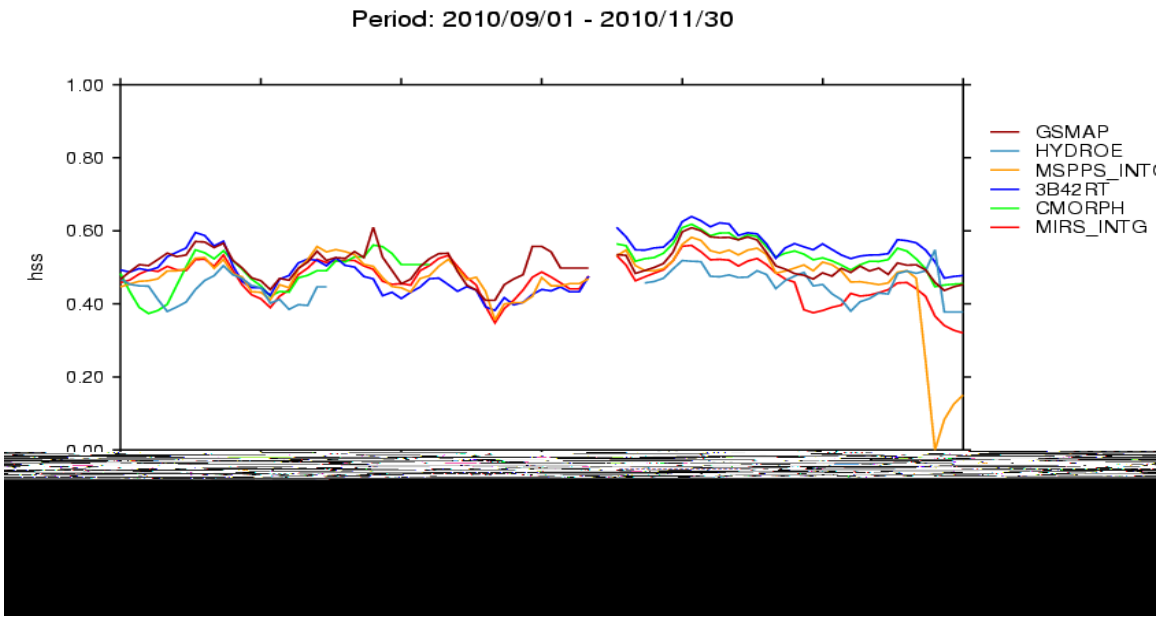


Figure 2: Time series of Heidke skill score over South America during September-December 2010 for various satellite-derived and numerical model forecasts with daily rain gauge analyses.

Presentations

Lima W., E. Vendrasco; D. Vila; C. Angelis; J. Janoviak, 2010: Avaliação de Diferentes Métodos de Estimativa de Precipitação sobre América do Sul. Poster presentation at the Brazilian Meteorology Association Meeting on 13-17 September 2010 in Belem, PA (available in Portuguese)

Vila D. and J. Janowiak, 2010: Rainfall Retrieval Validation over the Americas: The STAR Precipitation Validation Center. Poster presentation at IPWG workshop in Hamburg, Germany on 11-15 October 2010.

South Asian Regional Reanalysis

Sumant Nigam; (NOAA Collaborator: Chet Ropelewski) NSNS_SARR10

Project completed- final report provided to NOAAClimate Program Office.

CIRUN: Climate Information Responding to User Needs

A. Busalacchi (NOAA Collaborator: E. Lockler) – PAPACIRUN10

Background: Scientific Problem, Approach, Proposed Work

Major climate change is upon us, and the next 50 years will see dramatic and rapid changes in our environment. The impact will be international, where population migrations in the many tens of millions are a real possibility, and on almost every sector of our economy. Through CIRUN, the University of Maryland is working with partners to mobilize a national effort to build the capacity to predict these changes in advance on time scales of seasons to decades, and to convert these predictions into information that government and industry can use to plan and adapt. This will open many new opportunities, as the effort will require significant new research in computation, visualization, modeling and earth science.

Accomplishments

Dr. Betty Dabney, UMD School of Public Health is leading the planning of a CIRUN workshop on water borne diseases under climate change. Members of the organizing committee include Juli M. Trtanj, Program Director, NOAA Oceans and Human Health Initiative/NOS, John Balbus/NIH, and Jonathan Patz/U. Wisconsin. The Workshop will focus on physical climate science, human health, and policy implications and information needs of waterborne infectious diseases in a changing climate. Regional case studies: Chesapeake Bay, Great Lakes, and Puget Sound are being considered. The Workshop will be held during the Spring 2011 time frame.

Dr. Tony Janetos, Director of the JGCRI is planning a CIRUN workshop on the management of public lands under a changing climate.

A nationwide faculty search for the position of CIRUN Director continues.

Investigations over Arctic Sea Ice using Satellite and Aircraft Altimetry

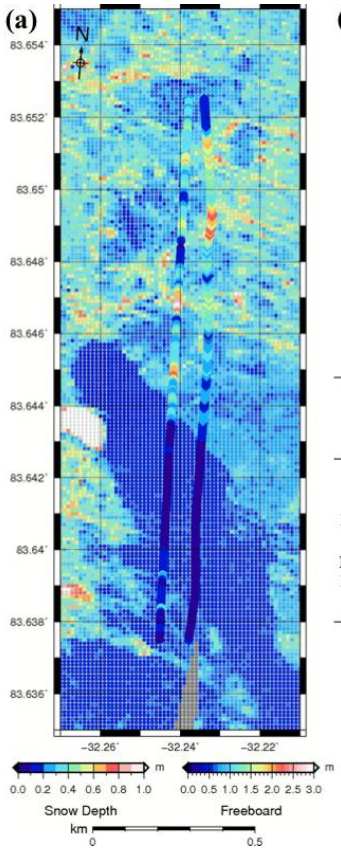
Sinéad L. Farrell (NOAA Collaborator: Laury Miller) – SFSFFIOASI11

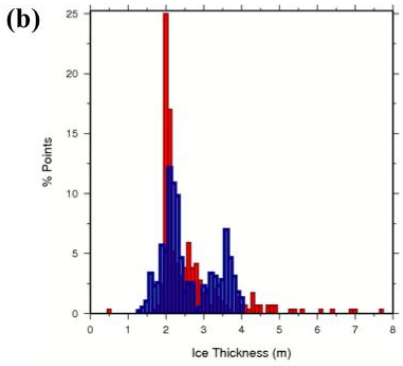
Background

Sea ice mass balance and thickness are leading indicators of the state of the climate system. The ongoing loss of Arctic sea ice has serious implications for the polar environment and climate. Recent satellite passive microwave data show that Arctic sea ice extent is now declining at a rate of -11% per decade and an historical minimum sea ice extent was recorded in September 2007. Satellite altimeter observations of sea ice freeboard also indicate a decrease in the thickness of the pack over the last five years, and highlight in particular the loss of the thickest, multiyear ice. Continuous monitoring of Arctic sea ice using satellite and airborne altimetry is necessary to determine whether these observations are part of a sustained negative trend in Arctic ice thickness, or reflect natural, interannual variability. Furthermore it is essential to validate the measurement capabilities of satellite altimeters via independent aircraft and field data. The goal of this investigation is to assess how well Arctic sea ice elevation and ice thickness can be mapped using satellite altimeters on board the ICESat, Envisat, CryoSat-2 and ICESat-2 satellites.

Accomplishments

The main accomplishment during this reporting period was the analysis of data collected during the Canada Basin Sea Ice Thickness (CBSIT) experiment. The CBSIT experiment was conducted jointly by NOAA and NASA in April 2009, during the Operation Ice Bridge (OIB) mission, and included an overflight of the Danish GreenArc Ice Camp north of Greenland, where in situ field measurements of sea ice and snow thickness were acquired. This experiment was designed to sample the thickest ice of the Arctic Ocean and presented the first opportunity to compare the IceBridge airborne measurements with coincident in situ data. Aircraft laser altimetry measurements of sea ice elevation, and radar measurements of snow thickness, were used to estimate sea ice freeboard and ice thickness. Comparisons with spatially and temporally coincident in-situ ground measurements allowed us to validate the accuracy and precision of the aircraft data. We found that IceBridge data can provide precise measurements of snow and ice thickness, particularly over level ice (Figure 1a). The mean snow and ice thicknesses derived from the airborne dataset agree with in situ measurements to within 0.03 m (Figure 1b). Results of our analyses were submitted to IEEE Trans. on Geoscience and Remote Sensing (, 2011a) and are currently undergoing review. In addition we presented aspects of this analysis at recent IceBridge science team meetings (, 2011c; , 2011; , 2010c) and the American Geophysical Union Fall Meeting (, 2010).





Parameter	# Data Points	Mean (m)	Mode (m)	Standard Deviation (m)
In Situ Sea Ice Thickness	288	2.628	2.000	0.941
IceBridge Sea Ice Thickness	386	2.596	2.100	0.711

Figure 1. (a) Map showing snow depth derived from IceBridge data (circles, left) and measured in situ (diamonds, right) at the GreenArc 2009 sea ice camp. Snow measurements are overlaid on airborne freeboard data. (b) Distributions of in situ ice thickness (red) and IceBridge ice thickness, provided with standard statistics.

The second major accomplishment was the analysis of early CryoSat-2 data, led by the task leader's colleagues at the NOAA Lab. for Satellite Altimetry (L. Connor and D. McAdoo). Twelve days after the launch of CryoSat-2 on April 20, 2010, a 670-km long underflight of a CryoSat-2 ground-track was conducted in the northernmost Arctic Ocean during the OIB Arctic 2010 campaign. Airborne laser altimetry data, digital imagery and radar altimetry were collected with temporally and spatially coincident CryoSat-2 SAR-mode SIRAL data. We performed an initial assessment of the CryoSat-2 and coincident airborne data for the identification of leads and floes in both datasets. Discrimination between lead, floes and ridges, as well as identification of recently refrozen leads in the CryoSat-2 SIRAL data is the first step towards precise estimates of sea ice freeboard. Our preliminary results were presented at both a recent CryoSat-2 workshop (, 2011) organized by the European Space Agency (ESA), as well as at the American Geophysical Union Fall Meeting (, 2010).

Opportunities to demonstrate our research to the wider public via outreach activities included a presentation to the Director of the NASA Science and Exploration Directorate, (Code 600) in August 2010 (, 2010b), and more recently a guest seminar to

undergraduate students in the Department of Atmospheric and Oceanic Science at the University of Maryland (, 2011b). Results of a comparison between spatially coincident ICESat laser altimetry data and measurements collected by the NASA P-3B aircraft during the NOAA Arctic Aircraft Altimeter (AAA) campaign in 2006 were presented at the International Symposium on Sea Ice in June 2010 (, 2010d). We also conducted an analysis into the sampling strategies used by current and planned airborne and satellite laser altimeters, to assess the ability of each system to reproduce the elevation distribution, mean freeboard, lead and ridge height of two sea ice models. We found that the dense along- and across-track sampling of the Airborne Topographic Mapper (ATM) scanning laser altimeter (used by OIB), and the photon counting laser system proposed for the ICESat-2 mission, were best suited for reproducing sea surface height and sea ice elevations consistent with the model data. We concluded that the proposed ICESat-2 instrument would offer some considerable improvements over its predecessor ICESat (, 2010a).

Planned work

The OIB Mission, which commenced in 2009 after the conclusion of ICESat operations, is due to continue monitoring critical regions of the Arctic sea ice pack until the launch of ICESat-2 in 2016. Ongoing work to be completed under this project will be to obtain, process, and analyze data collected during the Operation IceBridge 2010 and 2011 Arctic sea ice campaigns, in conjunction with the acquisition and synthesis of the various complimentary satellite and in situ field data. During the BEaufort Sea Ice Experiment (BESIE) conducted in March 2011 a field experiment in the Beaufort Sea region of the Arctic was conducted. The primary aim was to improve our understanding of the distribution of snow cover on sea ice, determine the accuracy of aircraft and satellite measurements of snow depth and sea ice thickness. Field activities included a detailed ground survey where in situ measurements of sea ice freeboard, thickness, snow depth and density we collected. A comparative analysis of sea ice and snow thickness distributions derived from coincident satellite, airborne, and in situ data will be performed. These studies will further improve our understanding of new sensors such as CryoSat-2's SIRAL radar altimeter.

Journal Publications

Farrell, S. L., N. Kurtz, L. Connor, B. Elder, C. Leuschen, T. Markus, D. C. McAdoo, B. Panzer, J. Richter-Menge, and J. Sonntag (2011a), A First Assessment of IceBridge Snow and Ice Thickness Data over Arctic Sea Ice, , submitted.

Farrell, S. L., T. Markus, R. Kwok, L. Connor (2010a), Laser Altimetry Sampling Strategies over Sea Ice, , 52(57), 69- 76.

Presentations (April 1, 2010 - March 31, 2011)

Farrell, S.L. (2011b), AOSC 401: Global Environment, Aspects of the Cryosphere: Sea Ice and Snow, Guest Lecture for Prof. Zhanqing Li, Dept. of Atmospheric and Oceanic Science, University of Maryland, College Park, MD, 1 April 2011.

Connor, N., Laxon, S., McAdoo, D., Farrell, S., Ridout, A., Cullen, R., Francis, R., Studinger, M., Krabill, W., Sonntag, J., Leuschen, C. (2011), A comparison of CryoSat-2 and ICEBridge Altimetry from April 20, 2010 over Arctic Sea Ice, 2nd CryoSat International Workshop, ESA/ESRIN, Frascati, Italy, 10-13 February 2011.

Farrell, S. L., N. Kurtz, D. McAdoo, T. Markus (2011c), Sea Ice and Snow Thickness Observations via Airborne Altimetry - Bridging the Gap between NASA Satellites, IceBridge Science Team Meeting, NASA Goddard Space Flight Center, 20-21 January 2011

Kurtz, N., S. L. Farrell (2011), Operation IceBridge (OIB) Observations of Sea Ice and Snow Thickness, Sea Ice Thickness Observations Workshop, NASA Goddard Space Flight Center, 19 January 2011

Kurtz, N. T., S. L. Farrell, T. Markus, D. C. McAdoo (2010), Snow and sea ice thickness measurements from Operation IceBridge: bridging the past, present, and future, Abstract C21D-03, presented at the 2010 American Geophysical Union Fall Meeting, San Francisco, Calif., USA, 13-17 December 2010.

Connor, L. N., S. Laxon, D. C. McAdoo, S. L. Farrell, A. Ridout, R. Cullen, R. Francis, M. Studinger, W. B. Krabill, J. G. Sonntag (2010), A first comparison of CryoSat-2 and ICEBridge altimetry from April 20, 2010 over Arctic Sea Ice, Abstract C41D-0506 Poster, presented at the 2010 American Geophysical Union Fall Meeting, San Francisco, Calif., USA, 13-17 Dec. 2010.

Farrell, S. L. (2010b), The Sea Ice Component of Operation Ice Bridge, NASA Science and Exploration Directorate (Code 600) Director's Seminar, NASA Goddard Space Flight Center, Greenbelt, Maryland, 06 August 2010.

Farrell, S. L., N. Kurtz, T. Markus, D. McAdoo, L. Connor, R. Kwok, J. Richter-Menge, B. Elder, M. Hofton, B. Blair, W. Krabill, J. Sonntag, C. Leuschen, B. Panzer (2010c), Preliminary Arctic Sea Ice Results April 2009 Campaign, IceBridge Planning Meeting, University of Washington, Seattle, Washington, June 2010.

Farrell, S. L., Connor, L., D. C. McAdoo, T. Markus and J. Richter-Menge (2010d), Validation of Laser and Radar Altimetry over Arctic Sea Ice, International Symposium on Sea Ice in the Physical and Biogeochemical System, Tromsø, Norway, June 2010

Global Precipitation Analysis Development and Climate Diagnostic

J. Janowiak (NOAA Collaborator: W. Higgins) JJJJ_PREC10

Background: Scientific Problem & Approach

The Climate Prediction Center (CPC) of NCEP/NWS/NOAA assesses and predicts short term climate variability and its impact on the U.S. The complex nature of the global climate system, and the requirement for continuous improvement in CPC capabilities, makes the conduct of ongoing collaborative developmental research imperative. This task includes activities of the PI and his colleagues at CICS that range from providing validation information about satellite-derived and model forecasts of precipitation to streamlining CPC's operational processes, and which contribute to the advancement of the goals of CPC.

Accomplishments

During the past year, the PI has continued to collaborate with CPC staff in a number of monitoring and diagnostic roles, particularly involving precipitation estimation, analysis, and validation. These include validating numerous satellite-derived estimates and NWP forecasts of precipitation over the U.S. To that end, plots such as displayed in Figure 1, which summarize the performance of precipitation estimates from numerous satellite algorithms and from the NOAA/NCEP GFS model have been produced and disseminated to technique developers to help them improve their products. In addition, collaborative work with CPC and international scientists to assess the ability of numerical model weather predictions to characterize variations that are associated with the Madden Julian Oscillation (MJO) phenomenon was completed and published. The PI also continued his collaboration in an effort to advance the accuracy of high time/space resolution global precipitation analyses, and has served as liaison between CPC and ESSIC/CICS.

Planned Work

The PI will continue to work with CPC personnel on the development and application of satellite-based precipitation analyses. He will also maintain and extend his validation activities over the US and maintain the US validation web site.

Publications

Janowiak J. E., P. Bauer, W. Wang, P. A. Arkin, and J. Gottschalck, 2010: An Evaluation of Precipitation Forecasts from Operational Models and Reanalyses Including Precipitation Variations Associated with MJO Activity. 138, 4542-4560, doi:10.1175/2010MWR3436.1

Arkin, P. A., T. M. Smith, M. R. P. Sapiano, and J. Janowiak, 2010: The observed sensitivity of the global hydrological cycle to changes in surface temperature. **5** 035201 doi: 10.1088/1748-9326/5/3/035201

Sapiano, M.R.P., J.E. Janowiak, T.M. Smith, P.A. Arkin, P. Xie, and H. Lee, 2010: Corrections for Temporal Discontinuities in the OPI. ., 27, 457-469.

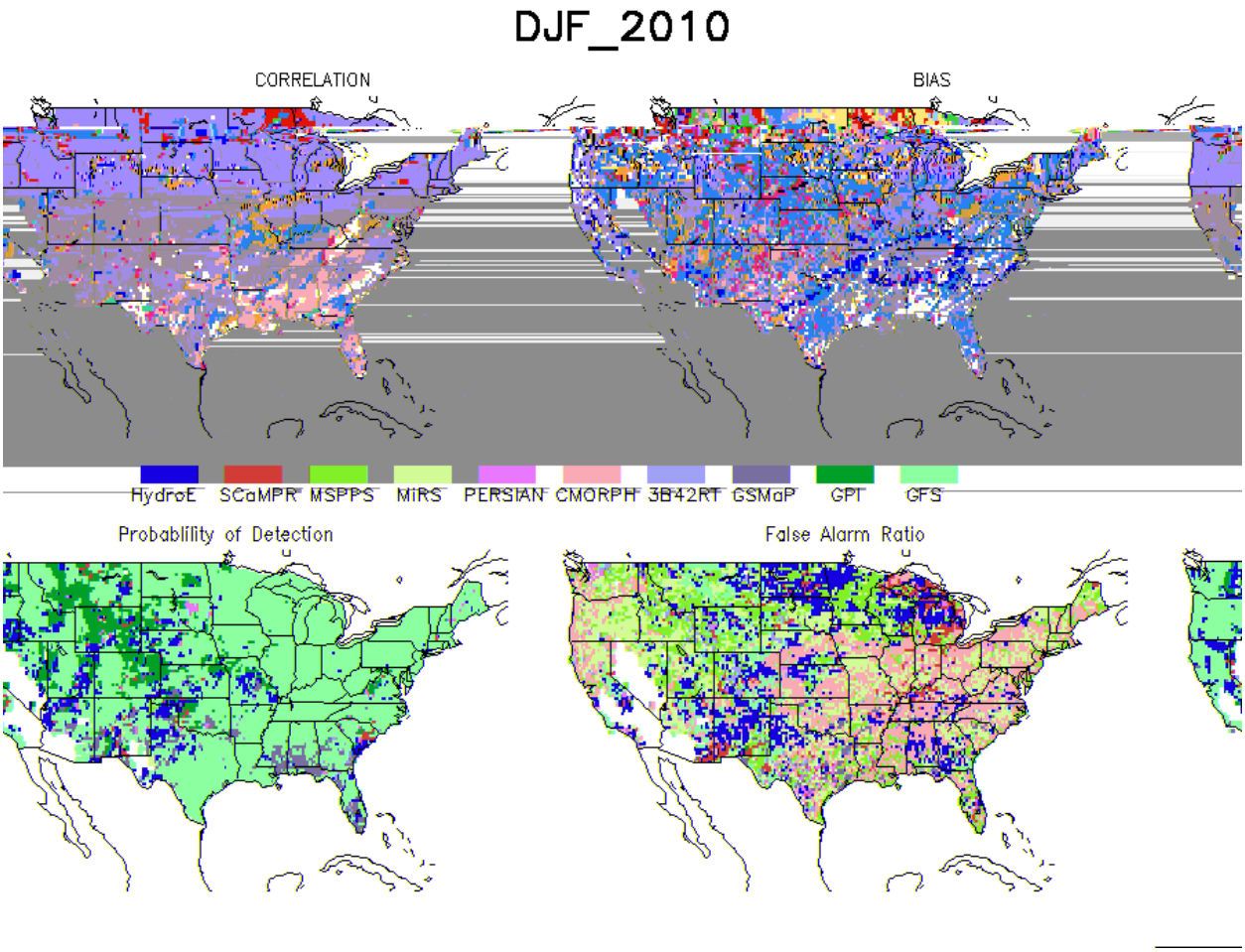


Figure 1. The best performing precipitation estimates for several statistics during the December 2010 to February 2011 period. Each color represents the technique that performed best at a given location for the season.

Prototype development of a microwave radiometer simulator for land surface and precipitation characterization

Eric F. Wood; (NOAA Collaborator: Ralph Ferraro) – EWPRINC11

Background

The poor progress in developing algorithms to characterize land emissivity has limited the assimilation by weather forecast models of space-borne microwave radiometers and sounders over land, especially at lower microwave frequencies. This has also impacted the development of advanced satellite precipitation retrieval algorithms. The project brings together an inter-disciplinary team for an exploratory effort in developing a land-to-space microwave emission forward modeling capability. The goals of the one-year project are (i) to evaluate the Community Radiative Transfer Model (CRTM) ability to characterize surface emissivity, clouds and precipitation when compared to satellite-based observations and retrieved microwave products from selected case studies, and (ii) to assess the feasibility of developing a microwave radiometer forward model based on a coupled modeling package (e.g. WRF-CRM/Noah/CRTM). In the exploratory project, an uncoupled analysis will be done where Noah LSM will be run off-line using NLDAS forcings with the atmospheric variables based on either satellite retrievals (e.g. AIRS) or NWP models (e.g. NARR).

The project will utilize the extensive data base at CREST/CUNY of satellite observations of surface emissivity, surface temperature, cloud and atmospheric water and temperature profiles. This data base will be used to select case studies that span conditions that will include clear sky, non-precipitating clouds, precipitating warm clouds and precipitating cold clouds. Snow covered conditions aren't included at this stage. The surface hydrologic conditions will utilize NCEP's Noah LSM, which solved the surface energy and water budgets and provides surface temperature and soil moisture as prognostic variables These can be used in the CRTM to predict surface emissivity, which will be compared to observed values from CUNY's data base.

Accomplishments

The project has installed the Joint Center for Satellite Data Assimilation, JCSDA microwave emission and radiative transfer model, CRTM at Princeton. As a first step, we are validating CRTM for the atmospheric radiation part for both clear sky and cloudy conditions. This is being done using SSM/I-derived land surface emissivity data as an input to CRTM. Six months (January through June, 2007) of surface emissivity has been provided by CUNY (W Rossow, Ed). There was a delay in obtaining the SMM/I emissivity data from CUNY due to a change in personnel at CUNY. We've also obtained the same atmospheric profiles (temperature, water vapor, ozone and cloud water content) that were used to retrieve the SSM/I surface emissivities.

Planned Work

In the next step of the work, we will compare the TOA brightness temperatures computed with CRTM to SSM/I observations. We also expect to utilize atmospheric data from

reanalysis (ERAInterim, NARR) to characterize the impact of forcing(atmospheric) data. Right now the time period wewill focus on is July 2006July 2007, which will expand on the experimental work designed by t

Developing GOES-R land surface albedo product

S. Liang & D. Wang (NOAA Collaborators: Yunyue Yu) SLSLGOESR11

Background

Surface albedo is defined as the ratio between incoming and outgoing irradiance at the earth surface, which is a key component of surface energy budget. Surface albedo is used to drive climate, mesoscale, atmospheric, hydrological, and land surface models. The accuracy of surface albedo also affects the reliability of weather prediction. The frequent temporal refreshment, fine spectral resolution and large spatial coverage make GOES-R ABI a unique data source for mapping surface albedo.

The goal of this task is to develop algorithms to generate GOES-R LSA product. We will provide science codes to algorithm integration team (AIT) for software implementation and process demonstration. In this task, we will also develop estimation algorithms of surface Bidirectional Reflectance Factor (BRF), as the by-product of LSA. We will also conduct validation activities to evaluation the accuracy and precision of these products and develop validation tools to support routine and deep-dive validation.

Our proposed GOES-R Land Surface Albedo (LSA) algorithm combines atmospheric correction and surface Bidirectional Reflectance Distribution Function (BRDF) modeling in one optimization step. In order to improve computational efficiency, the GOES-R LSA algorithm is separated into offline mode and online mode. The offline mode is carried out at the end of each day, using a time series of clear-sky observations up to the current day to estimate BRDF parameters for the next day's online mode. In the online mode, LSA and BRF products are produced in real-time. This report summarizes our main accomplishments in algorithm development and products validation during the past year.

Accomplishments

The typical three-step albedo estimation algorithm, used by the MODIS and other satellite instrument teams, needs the surface reflectance as the input. However, the surface reflectance is not an independent GOES-R product and will be generated as the by-product of LSA. Moreover, the retrieval of surface reflectance requires aerosol optical depth (AOD), while GOES-R AOD algorithm works only at dark surfaces. To address these issues, we propose an improved optimization method similar to the earlier Meteosat algorithm to directly retrieve surface BRDF parameters, and then use the derived BRDF parameters to calculate LSA and BRF. Our revision over the Meteosat method mainly includes: 1) AOD can vary over time; 2) we use multiple ABI spectral channels enabling accurate production of shortwave broadband albedo; 3) we use a different formulation of the atmospheric radiative transfer and surface BRDF model; 4) we incorporate albedo climatology as the constraint of optimization (Fig. 1).

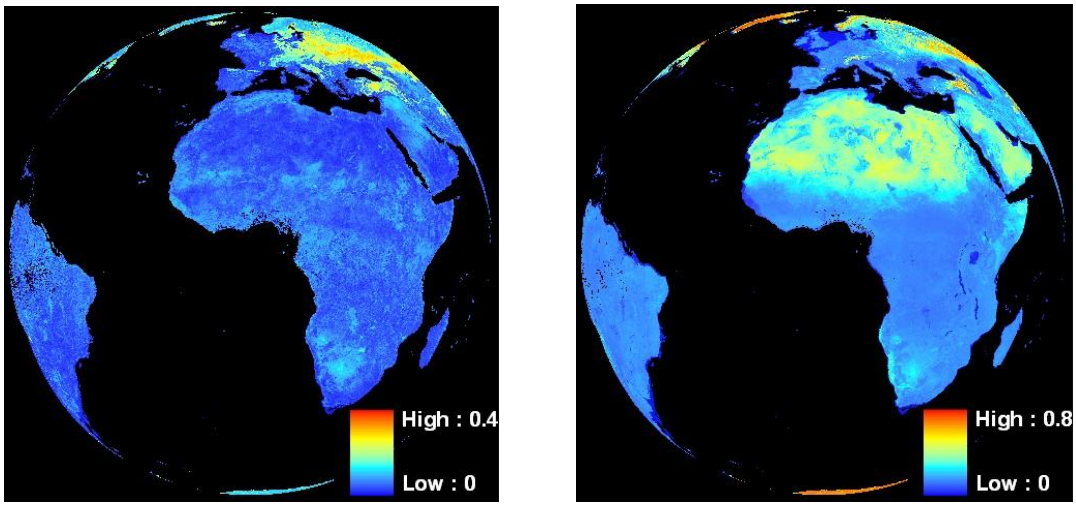


Fig. 1 Albedo climatology calcualted from ten years' MODIS albedo products. a) mean white-sky albedo b) standard deviation of white-sky albedo. Cloud contamination is the major reason for gaps over Central Africa and Amazon where MODIS albedo product usually provides filled values or data of low accuracy from backup algorithm. Both estimation accuracy and computational efficiency are improved through incorporating albedo prior background information.

The retrieval of BRDF parameters needs multiple observations over varied observing geometries. The organization of time series data and optimization of BRDF parameters is a time-consuming process. In order to improve the code efficiency, we divide our algorithm into two parts: the offline mode and the online mode. At the end of each day, an offline mode computation is carried out to perform a full inversion of BRDF parameters using the stacked time series data. The calculated BRDF parameters are saved for the usage of the following day's online mode. In the online mode, the pre-calculated BRDF parameters are used to derive full disk LSA and surface reflectance products every 60 minutes.

To quantify the algorithm accuracy and precision, we validated the albedo algorithm in different ways (See an example shown in Fig. 2). We use both MODIS and MSG/SEVIRI data as proxy data. MODIS has similar spectral configuration (seven bands for the land application) to ABI, whereas SEVIRI imitates ABI better in terms of the orbit specification and refreshing rates. Since none of existing satellite sensors can provide proxy data with both high temporal resolution and multiple-channels as ABI data, we also used extensive simulation from radiative transfer models and POLDER BRDF database to test and verify ABI albedo algorithm.

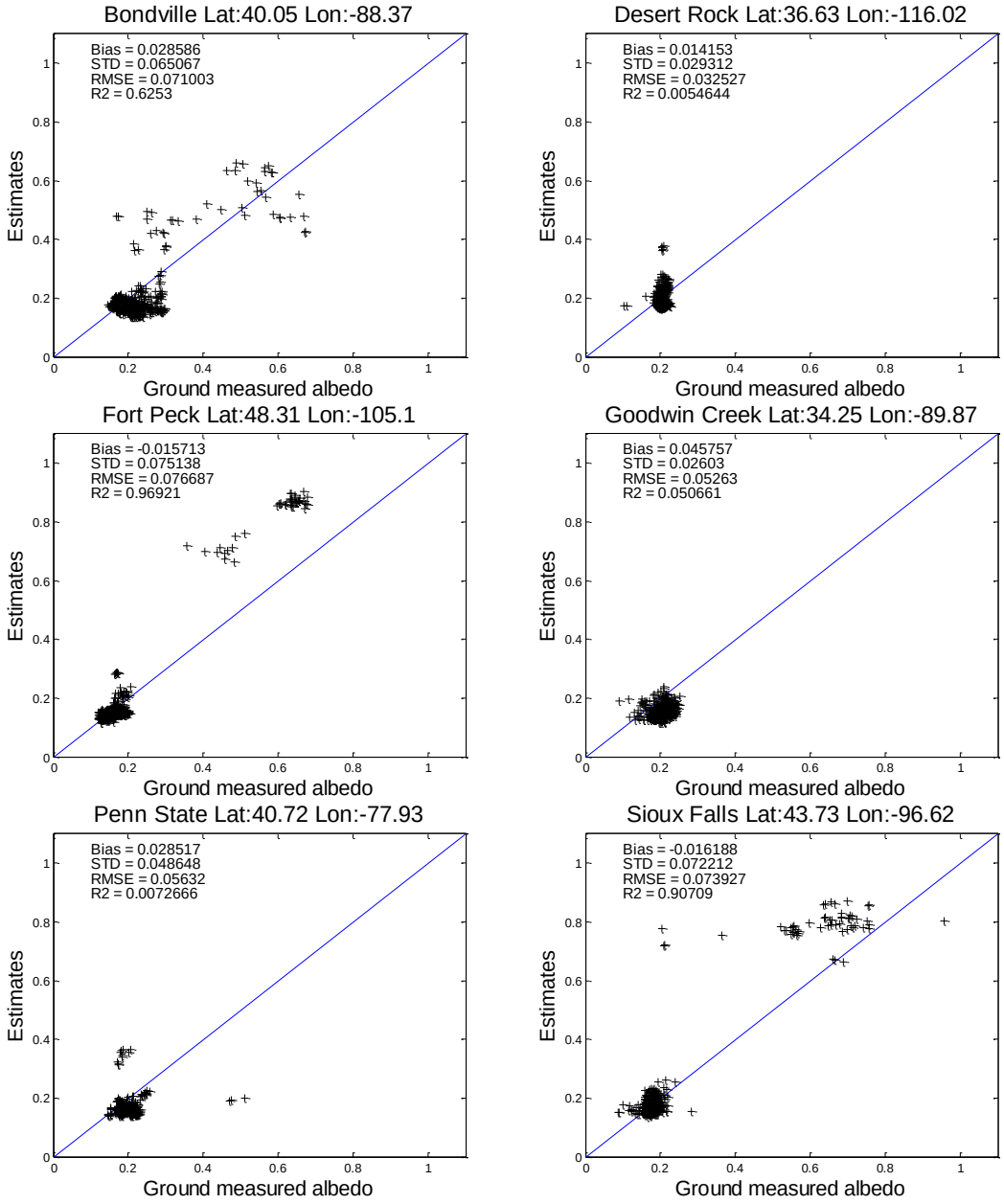


Fig.2 Albedo measurements over six SURFRAD sites were used to validate our albedo retrievals with MODIS as proxy data. Incoming and outgoing shortwave radiation is measured every 3 minutes at SURFRAD sites using the Eppley Precision Spectral Pyranometer (PSP) and the averages of albedo over 30 minutes are used to compare with instantaneous albedo

In terms of algorithm development, we have made milestone achievements. We delivered the Version 3 and 4 codes and passed Test Readiness Review and Unit Test Review during the past year. We also completed writing the Version 1 manuscript of LSA Algorithm

Theoretical Basis Document (ATBD). We then successfully delivered our 80% ATBD and algorithm package to AIT.

Publication

He, T., Liang, S., Wu, H., Wang, D., Yuan, Y., and Wang, J., (2011), Improving Estimation of Instantaneous Albedo and Reflectance from Moderate Resolution Imaging Spectroradiometer Observations. Submitted to .

The Development of AMSU Climate Data Records (CDR's)

Wenze Yang, Chabitha Devaraj, Isaac Moradi, (NOAA Collaborator: Huan Meng) – PAPAAMSU_11

Introduction

Current passive microwave sounder data, used in hydrological applications, are derived from POES satellites for which the primary mission is operational weather prediction. These data are not calibrated with sufficient stability for climate applications. A properly calibrated FCDR needs to be developed to enable the utilization of these data for TCDR and Climate Information Records and to extend their application into the NPOESS era (e.g., POES/AMSU to NPP/ATMS to NPOESS/ATMS). Once developed, TCDR's for water cycle applications (precipitation, water vapor, clouds, etc.) will be developed for use as key components in international programs such as GEWEX, CEOS and GPM.

Passive microwave sounder data have proven their worth in more than just tropospheric temperature and moisture monitoring. NOAA/NESDIS generates operational products from the Advanced Microwave Sounding Unit (AMSU) focused on the hydrological cycle (e.g., rainfall, precipitable water, cloud water, ice water, etc.) through two product systems known as the Microwave Surface and Precipitation Products Systems (MSPPS) and the Microwave Integrated Retrieval System (MIRS) since the launch of NOAA-15 in 1998. These data offer the unique opportunity to develop CDR's that can contribute to other satellite time series with similar capabilities such as the DMSP SSM/I and SSMIS, the TRMM TMI, and Aqua AMSR-E. This project will focus on the development of AMSU FCDR's for the AMSU-A window channels (e.g., 23, 31, 50 and 89 GHz) and the AMSU-B/MHS sensor.

Results and Accomplishments

During the first year of the three-year project period, we finished data collection of AMSU L1B data from 1998 to 2010, AMSU L2 data from 2000 to 2010, ERA-Interim data from 1998 to 2008, and PATMOS-x cloud data from 1998 to 2009. We also collected satellite/sensor metadata from NOAA/NESDIS/STAR MSPPS project log and NOAA/NESDIS/OSDPD operational log. In the research part, we tested geolocation error correction, AMSU-A sensor drift identification, and MHS scan bias characterization, but major effort was on AMSU-A scan bias characterization and investigation of possible reasons and corrections. At the end of the first year of this project, we successfully held a workshop on AMSU/MHS CDR's, together with SSMT2 CDR. Our project website is available at http://cics.umd.edu/AMSU-CDR/home.html.

AMSU-A scan bias characterization is crucial due to that all AMSU-A instruments on-board NOAA POES satellites and MetOP-A suffer across scan asymmetry biases in the window channels observations. These channels are important to the retrieval of a suite of NOAA operational hydrological products such as total precipitable water and cloud liquid water. Uncorrected observations will lead to clear across scan biases in the retrieved products. AMSU-A scan bias is characterized by referencing to simulated brightness temperature

(TB) and taking the difference between observations and simulations over tropical and sub-tropical oceans (30°S-30°N) under clear sky. The difference is adjusted across scan line by its nadir value so there is no systematic difference at nadir. The bias is asymmetric relative to the nadir, and there is little difference between ascending and descending cases. The asymmetry pattern appears to be stable through several years of data examined, but is quite different for each satellite. The asymmetry might be due to both sensor errors and asymmetric environment conditions. An example of the latter is that the angular distribution of precipitable water (PW) showed higher PW at nadir by 10%, generally stable throughout the years and on all satellites examined.

In order to quantify the environmental impact on across scan asymmetry, we stratified the asymmetry results by three most important input variables to the Community Radiative Transfer Model (CRTM): sea surface temperature (SST), precipitable water (PW) and wind speed (V). The stratification comparisons are performed at three levels from wide to narrow variable spaces: category level, class level, and most probable value (MPV) level. At the category level, each variable is divided into high, mid and low value ranges, and the asymmetry results are averaged in the ranges; at the class level, the three variable joined space is divided into 27 classes with high, mid and low value ranges for each of the three variables, e.g., class 1 stands for low SST, low PW and low V; at the MPV level, the center is set at MPV, and the variable range is only plus and minus one tenth of the difference between 95 percentile and 5 percentile. An example of stratification comparison at class level is shown in Figure 1. The variable range does play a role in changing the across scan asymmetry pattern, and wind speed has the most significant impact.

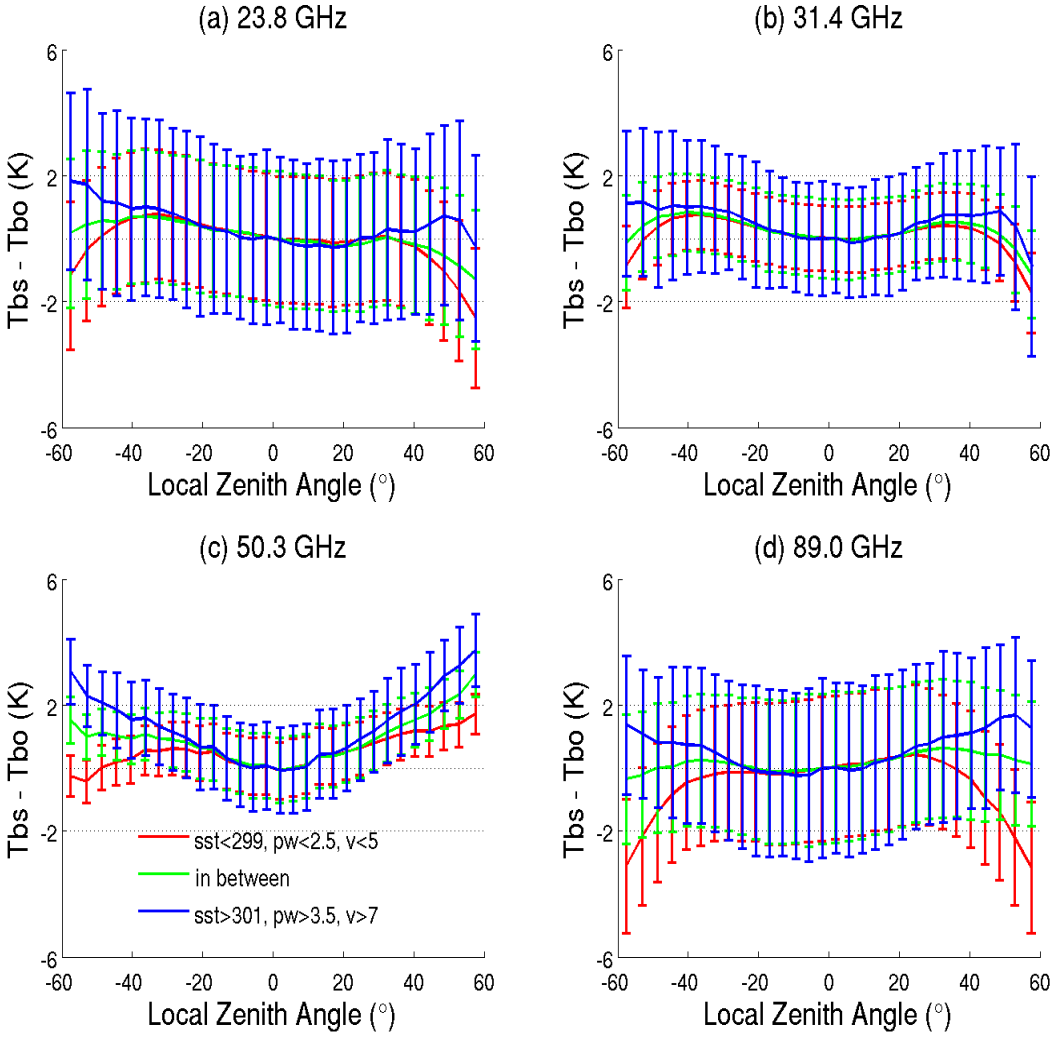


Figure 1. Average differences between the simulated brightness temperatures and the observations from NOAA-18 AMSU-A verses sea surface temperature (sst), precipitable water (pw), and wind speed (v) at (a) 23.8 GHz, (b) 31.4 GHz, (3) 50.3 GHz, and (d) 89 GHz. The observed data are under clear sky and over tropical and subtropical oceans from 30°S-30°N. The stratification comparison is performed at class level, with class 1 in red, class 14 in green, and class 27 in blue.

The distinctive advantages to stratify at MPV level are as follows: firstly, in the narrow MPV range, there is no angular dependence for environmental variables, thus removes the environmental asymmetry; secondly, even at such a narrow range, we can still capture the across scan asymmetry, which strongly resembles the across scan asymmetry without stratification. Combining these two aspects, it is possible to simulate the polarization component of brightness temperature, and adjust the reflector normal angle and polarization alignment angle at MPV level. For example, by adjusting 0.5° of reflector normal angle, and 0.7° of polarization alignment angle, the scan bias of 22.3 GHz could turn rather symmetric.

In regard to geolocation error, there are three different sources including satellite ephemeris data, time offset and satellite and sensor attitude errors (error in pitch, roll, and yaw). The first two sources are deemed minor in AMSU/MHS 1b data compared to the attitude issue. Therefore we are focused on the third source and use difference maps (i.e., the TB difference between ascending and descending orbits) to quantify the geolocation error. This error was found to be up to one pixel shift in along and/or cross scan direction. Currently we are using the Australian coastlines for the evaluation.

Ongoing and Future work

We are now investigating the causes of AMSU-A scan bias, which may be due to satellite and sensor attitude errors, residual bias of antenna pattern correction, polarization twist, reflector misalignment, etc. In addition, we are also investigating the possible bias sources for AMSU-B/MHS measurements, such as sensor RFI, warm target contamination, orbital decay, and sensor/satellite degradations etc.

Once we identify the errors from sensors on individual satellite, we will carry out single satellite calibration, and follow with inter-satellite calibration to correct systematic biases. There are three potential inter-satellite calibration approaches for window and water vapor channels: simultaneous nadir overpass (SNO), vicarious reference, and double differencing technique. We will explore the most suitable approach(es) for our application as the project progresses.

Publication & Presentations

Ferraro, R., H. Meng, Z. J. Luo, W. Yang, C. Devaraj and I. Moradi, 2011: NOAA workshop on climate data records from satellite passive microwave sounders AMSU/MHS/SSMT2. Submitted to .

Ferraro, R. and H. Meng, 2010: The Development of AMSU FCDR's and TCDR's for Hydrological Applications. Talk presented at CDR PI team meeting in Ashville, NC on August 4-5.

Meng, H., W. Yang and R. Ferraro, 2010: Development of AMSU Fundamental CDR's. Talk presented at CALCON meeting in Logan, UT in August 23.

Yang, W., H. Meng, and R. Ferraro, 2010: Development of AMSU Fundamental CDR's. Poster presented at 17th SatMet conference in Annapolis, MD on September 27-30.

Yang, W., H. Meng, and R. Ferraro, 2010: Development of AMSU Fundamental CDR's. Talk presented at Xcal meeting in Ashville, NC on October 21.

Yang, W., H. Meng, and R. Ferraro, 2010: Development of AMSU Fundamental CDR's. Poster presented at AGU meeting in San Francisco, CA on December 13.

Development of Land Surface Characterization for GPM-era Precipitation Measurement

Nai-Yu Wang; (NOAA Collaborator Ralph Ferraro) – NWNWGPMER11

Project Summary and Objectives

If the Global Precipitation Measurement Mission (GPM) is to meet its requirement of global 3-hourly precipitation, the use of sounders such as AMSU will likely be needed. This project utilizes the "traditional" imager channels in conjunction with high frequency observations from AMSU and SSMIS, cloud resolving models and advanced radiative transfer models to:

(1) Study the effects of hydrometeors on the 10-183 GHz radiances and utilize them to improve the current Bayesian precipitation retrieval scheme (e.g. GPROF). Focus will be on cold season precipitation systems (e.g., stratiform rain and snowfall) since the present scheme has focused only on tropical rainfall systems.

(2) Investigate the potential of incorporating microwave sounding channels (50-60 GHz and 183 GHz) to the hydrometeor profile retrieval.

(3) Improve the current GPROF "surface screening" to remove ambiguity between precipitation and other surface signatures that resemble precipitation through the use of innovative methods such as dynamic land surface data sets available from ancillary data sets (i.e., NWP assimilation fields, emerging emissivity products, etc.).

Year 1 Progress

Some of the key scientific questions addressed during the third year of this project include:

- Is there a way to improve upon the warm season bias in the current TRMM 2A12 rainfall over land product?
- Are there ways to better characterize the land surface within the satellite FOV?
- Can we detect light rain and snowfall signals over land from satellite measurements?
- If so, what are the characteristics of these precipitation systems and what will we be able to measure with PMM/GPM from space?

Fundamental to these questions are some other key issues to consider:

- What are the deficiencies in the current 2A12 rain over land algorithm?
- What are the microphysical properties of snow (size, density, shape, and number) to radiative properties (scattering and absorption)?
- What is the best method to obtain information on the highly variable land surface emissivity under precipitating situations?

Three main focus areas were addressed over the past year and are summarized below.

- **Improvement of TMI2A12 Rainfall Over Land**
  Over the last couple of years, we have developed and implemented an improved TRMM TMI2A12 rainfall overland retrieval algorithm. This new algorithmreduces the global overestimation of land rainfall by the TMI land algorithm as compared to TRMM PR. Figure 1 shows the unconditional RR bias maps between TMI and PR for both v6 and the proposed algorithm. The proposed model reduces the RR bias from > 100 mm/month to < 50 mm/month over large sections of South America and Central Africa. However, large RR biases of 150 mm/month and greater remain over the Himalayan mountain ranges and the Gobi desert.

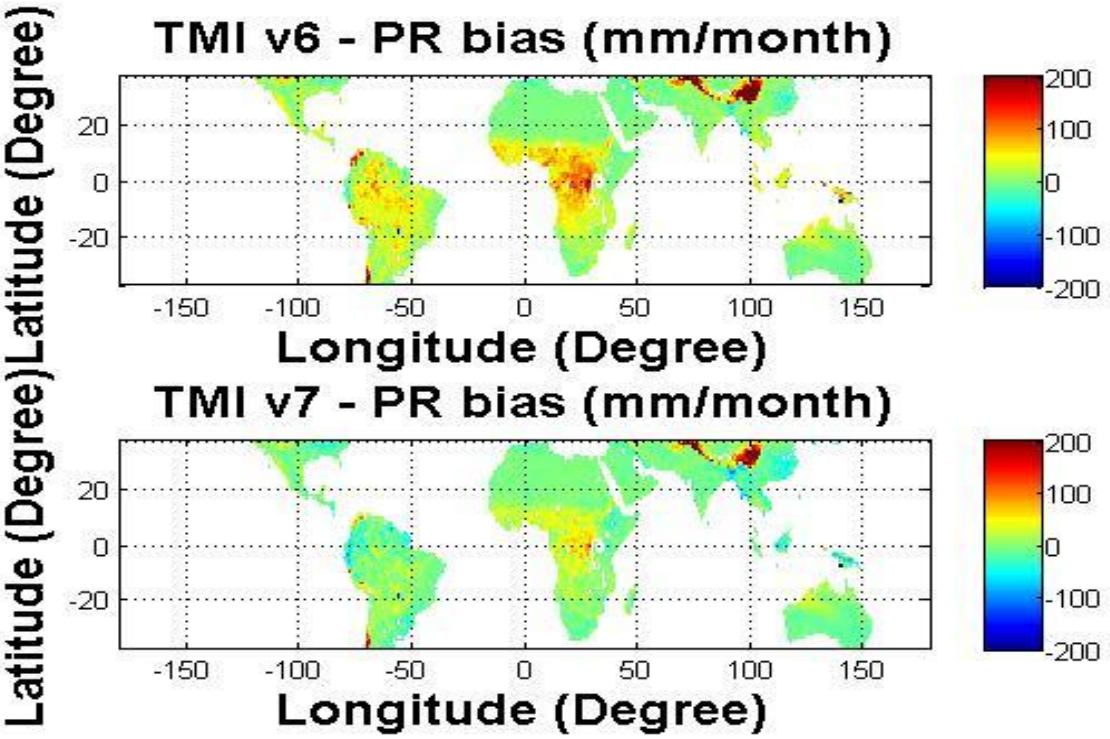


Figure 1 Global comparisons of TMI v6 and v7 with TRMM PR

- **Better Characterize the Land Surface with Satellite FOV**

Over the last couple years we have tested a new gridding method of the information contained in the maps of land surface; preliminary development and testing with promising results has already been accomplished during the past year. For example, figure

2 (top) illustrates the current approach of aggregating land water information in land precipitation retrieval algorithms. Essentially, each grid box in the land water mask (red) contains aggregated information from the smaller grid boxes (blue) of the original land water map. The information in the red grid box is only the percentage of land and remains as a fixed latitude longitude grid, for example one sixth degree in GPROF. This fixed grid cannot realistically represent the scan geometry and the varying FOV with frequency.

In the new method (Figure 2; bottom), all surface cover information (blue) from an original surface cover map and within a sensor resolution (red) is aggregated. The size of the red grid box represents an FOV. The aggregation information is stored in the center grid box (black). By doing so, we avoid averaging the higher resolution original map into a fixed grid lower resolution map. The new aggregation method allows for the use of information from a center grid box (black) that is very close to an FOV and follows the swath of a scan. In the current method, an FOV may have to use information from the red grid box (Figure 2; top) whose center is as far as half of the map's grid diagonal (i.e. the red grid box' diagonal). In the new aggregation method, the distance is less than the original map's resolution. The new method and its impact on TMI rain retrieval is documented in a journal publication (Sudradjat et al., 2011).

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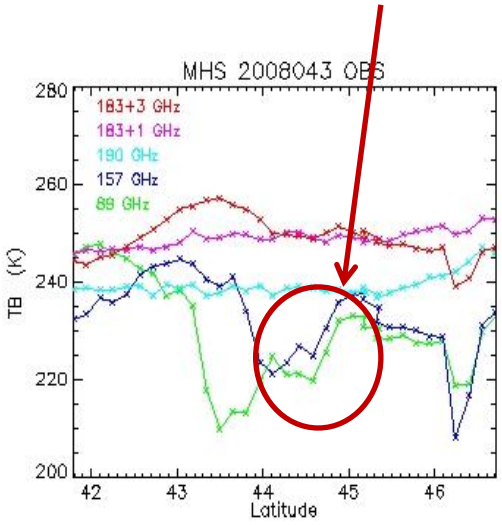
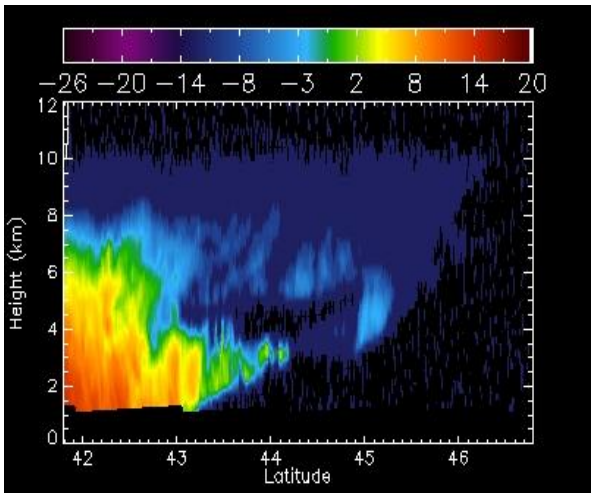
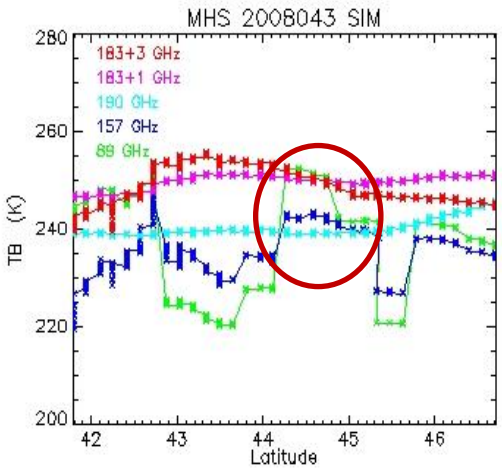

MHS 2008043 OBS
183+3 GHz
183+1 GHz
190 GHz
157 GHz
89 GHz
TB (K)
Latitude


−26 −20 −14 −8 −3 2 8 14 20
Height (km)
Latitude


MHS 2008043 SIM
183+3 GHz
183+1 GHz
190 GHz
157 GHz
89 GHz
TB (K)
Latitude

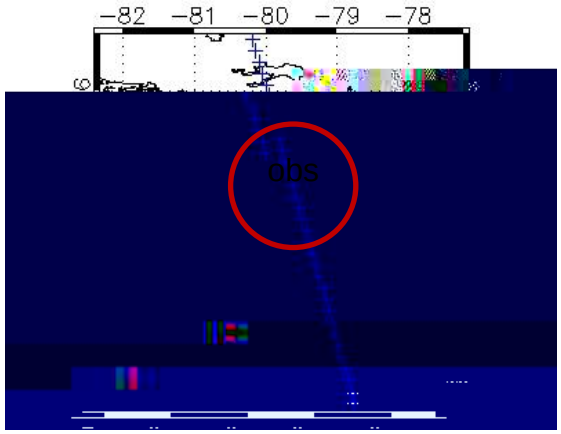

−82 −81 −80 −79 −78
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Figure 3 Snowfall event from February 12, 2008 observed by CloudSat and NOAA 18 MHS. The snowfall forward model simulations of radar reflectivity and passive microwave brightness temperatures are simulated using non-spherical snow particles and radiative transfer model simulations.

Planned Work

The work carried out this year will primarily focus on

- Documented algorithm performance over arid and mountainous terrain and possible improvements using improved surface classification methods
- Improvement on the microwave snowfall retrieval algorithm

Publications

Sudradjat, A., N-Y. Wang, K. Gopalan, R. Ferraro, 2010: Prototyping a Generic, Unified Land Surface Classification and Screening Methodology for GPM Microwave Land Precipitation Retrieval Algorithms,

Gopalan, K., N-Y. Wang, R. Ferraro, and C. Liu, 2010: Status of the TRMM 2A12 Land Precipitation Algorithm. J. Clim. and Appl. Met., ., **27**, 1343 – 1354.

Wang, N-Y, C. Liu, R. Ferraro, D. Wolff, E. Zipser, and C. Kummerow, 2009: The TRMM 2A12 Land Precipitation Product – Status and Future Plans, The Journal of Meteorological Society of Japan (JMSJ) special issue on 'Precipitation Measurements from Space, Vol. 87A, pp 237-253, 2009, DOI:10.2151/JMSJ.87A.237.

Wang, N-Y., R. Ferraro and K. Gopolan, 2009 "Improvement of Cold Season Land Precipitation Retrievals through the use of Field Campaign Data and High Frequency Microwave Radiative Transfer Model".

Combining GOES-R and GPM to improve GOES-R rainrate product

Nai-Yu Wang (NOAA Collaborator: Ingrid Guch, Mark DeMaria)NWNWGOESR11

Project Summary and Objectives

This project focuses on the multi-instrument and multi-platform synergy of combining GOES-R and NASA GPM to improve precipitation products. The proposed project has two objectives: 1) to improve microwave-based precipitation by connecting the ice-phased microphysics commonly observed by GOES-R GLM and GPM microwave instruments 2) to provide GOES-R rain-rate (QPE) algorithm a better microwave rain-rate calibration. Innovative strategy to make use of lighting and microwave data in identifying the convective and stratiform rain types will be developed, which will improve microwave-based rain rate estimates. Because GOES-R ABI rainfall rate (QPE) algorithm requires the microwave-based rain rates as a calibration target (Kuligowski, 2009), the better microwave rain rates will improve the accuracy of GOES-R rainfall rate retrievals.

Boccipio (2005) used a neural network training technique with TMI and LIS data to retrieve PR precipitation type classifications. He found significant improvement by including lighting data, including for convective-stratiform discrimination, where 5-10% improvement was shown in final rain rate estimates. Though these past studies using lightning data in the context of TMI data have shown the potential of the combined datasets, a trial combination of the datasets has not directly targeted the heritage and future operational algorithms. Rectifying this situation is one of the goals of the study.

Year 1 Progress

To this date, we have generated a collocated TRMM TMI/PR/LIS dataset from Jan 2002 Dec 2008 at the TMI 85 GHz resolution (~10 km X10 km). Table 1 enumerates the data extracted from each TMI, PR and LIS instruments and stored in the combined dataset.

The updated CSI for each pixel is estimated as a linear combination of various TMI and LIS inputs from Table 1.

The LIS inputs used are: # of Flashes, # of Groups, Sum of Radiances, # of Flash Extent Density (FED) and # of Group Extent Density (GED). Each LIS input is divided by the LIS View Time (VT) for each 0.1 degree bin and the log of the resultant is incorporated in the linear regression. For the preliminary analysis, we analyzed the results from 8 different combinations of inputs. The PR Conv. Ratio from the year 2002 was used to train a linear regression of theTMI and LIS inputs of the form:

$$CSI = k + \sum_{i=1}^{7} a_i TMIinp_i + bLISinp$$

Where is the i_{th} input from TMI and is the sole input from LIS. The derived coefficients for the 8 different regressions are provided in table 2.

Table 1: Combined TMI-PR-LIS dataset

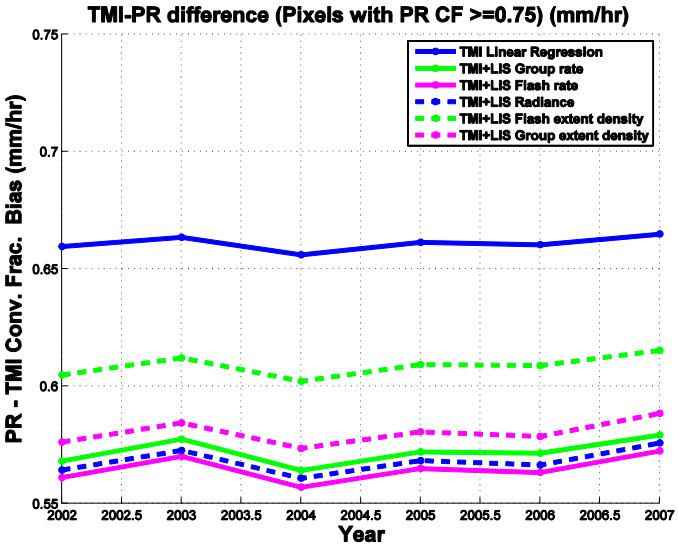
Instrument	PR	TMI	LIS
Data	Mean Near-surface Rain rate (mm/hr) Fraction of Certain Convective pixels Fraction of "Maybe" Convective pixels # of PR pixels matched-up with the TMI pixel	TMI V6 CSI TMI V7 CSI TMI V6 Rain rate (mm/hr) 10V Tb (K) 37V Tb (K) 85 V Tb (K) 85 GHz Polarization (K) 85 GHznormalized polarization 85V Std. Dev (K) 85V Tb Minima Index	LIS view time in 0.1 degree grid point (seconds) # of LIS flashes # of LIS groups # of LIS events Sum of Radiances # of flash extent density # of group extent density

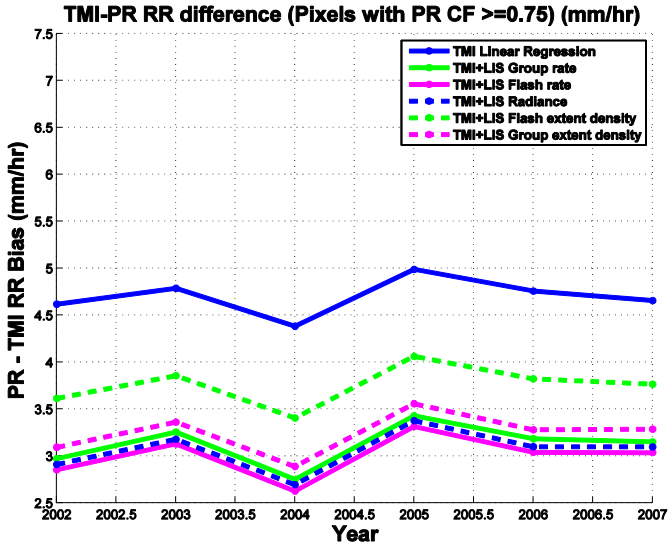
Table 2: Regression coefficients used to calculate CSI

	Regression #1 Coefficients	Regression #2 Coefficients	Regression #3 Coefficients	Regression #4 Coefficients	Regression #5 Coefficients	Regression #6 Coefficients	Regression #7 Coefficients	Regression #8 Coefficients
Constant term: k	0.0281	0.0267	0.029	0.3624	0.1540	-0.0545	0.2396	0.1266
TMI Inputs								

10V	0.0072	0.0061	0.0061	0.0111	0.0120	0.012	0.0127	0.0126
37V	-0.0085	-0.0072	-0.0073	-0.015	-0.0162	-0.0159	-0.017	-0.0168
85V	0.0012	0.001	0.0011	0.0038	0.0041	0.0038	0.0042	0.004
85 GHz Pol.	-0.0066	-0.0058	-0.006	-0.0024	-0.0045	-0.0053	-0.0035	-0.0052
85 GHz Normalized Pol.	0.0007	0.0006	0.0006	0.0022	0.0020	0.0018	0.0022	0.002
85V Std. Dev	0.0034	0.0026	0.0024	0.0014	0.0017	0.0015	0.0016	0.0017
85V Tb Minima Index	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0003	0.0003
LIS Inputs								
Flash incidence		0.1442						
Group incidence			0.1217					
log2(#Flashes/VT)				0.0417				
log2(#Groups/VT)					0.0177			
log2(∑Radiance/VT)						0.0123		
log2(#FED/VT)							0.0228	
log2(#GED/VT)								0.0119

Figure 1 shows the CSI bias between PR and various TMI/LIS combinations for the convective rain and figure 2 shows the rainrate bias between PR and various TMI/LIS combinations for the convective rain. Clearly, including lighting information improves TMI's performance on both the convective-stratiform classification and rain estimations. The improvement on convective rainrate is around 10%. For stratiform rain, there is virtually no improvement on either the convectivestratiform classification or rain estimation by combing LIS and TMI data (figures on shown here).





Planned Work

Work is underway to implement the lighting information into the passive microwave rain retrievals and document their improvements.

Risk Reduction Research for the GOES-R Geostationary Lightning Mapper

P. Arkin, R. Albrecht, E. Bruning, and S. Rudlosky; (NOAA Collaborator: S. Goodman)
EBRAGOESR11

Background: Scientific Problem, Approach, Proposed Work

The instrument complement on the planned Geostationary Operational Environmental Satellite-R (GOES-R) will include the Geostationary Lightning Mapper (GLM). This instrument will provide regular and frequent depictions of lightning occurrence from geostationary orbit for the first time, offering a significant advance in the ability of scientists to observe and understand the role of lightning in severe weather, tropical storms, and climate.

Dr. R. Albrecht of the Cooperative Institute for Climate Studies (CICS) will participate in risk reduction and algorithm development activities in support of the GOES-R GLM. Dr. Albrecht will serve as a NESDIS/STAR subject matter expert supporting GLM science and applications development, and will serve as a member of the GLM Risk Reduction Team. She will initially develop methods to ensure user readiness for GLM data by working with proxy data from other observing programs, including the Tropical Rainfall Measuring Mission (TRMM) Lightning Imaging Sensor (LIS), Lightning Mapping Arrays (LMA), and models, including numerical weather prediction forecast models and models that combine observations from Meteosat Second Generation and ground-based lightning observations. The algorithms will utilize data from the GLM in a variety of nowcasting, severe storm identification, aviation weather, forest fire, and precipitation applications.

Accomplishments

Dr. Albrecht upgraded the TRMM/LIS climatology to include 13 years of data (1998-2010) at an improved resolution (0.10 degree, Figure 1). In this improved total lightning climatology, Lake Maracaibo, Venezuela remains as the Earth's lightning hotspot. A manuscript was written to document this research, and currently is under review by the co-authors prior to journal submission.

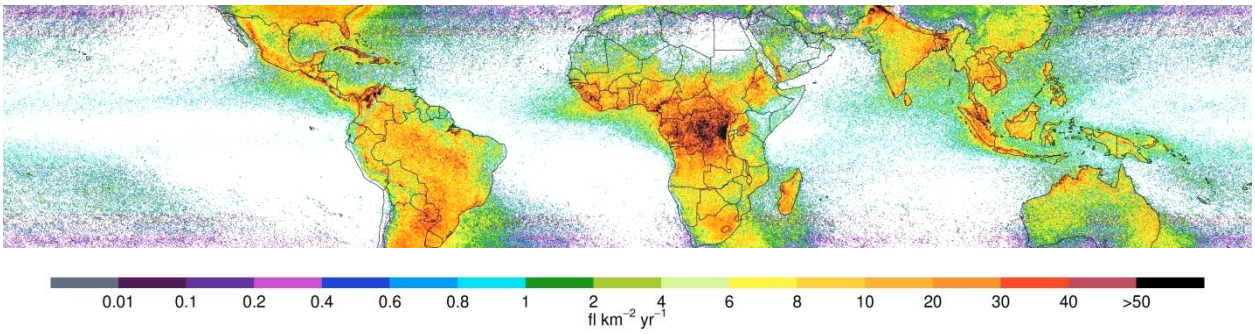


Figure 1 – TRMM/LIS total lightning flash rate density (FRD) climatology from 1998 to 2010.

Dr. Albrecht also collaborated with Dr. Kenneth Pickering (AOSC/UMD) to investigate lightning characteristics in thunderstorms during NASA's Tropical Composition, Cloud and Climate Coupling (TC4) project, and a paper was published in the Journal of Geophysical Research (doi:10.1029/2009JD013118). Dr. Albrecht's doctoral research also was published in the Journal of Geophysical Research (doi:10.1029/2010JD014756).

The re-processing of the TRMM/LIS dataset also revealed a decrease in the greatest total lightning flash rate densities (FRD) over most of the tropics. A quantile linear regression method for regional boxes was applied to the cumulative daily total FRD. Figure 2 summarizes the results and shows a decrease in the greatest FRD (0.95 quantile) over land and ocean in nearly all regions. This work was done in collaboration with Dr. Walt Petersen (MSFC/NASA) and Dennis Buechler (UAH) and was presented in an oral session during the 2009 AGU Fall Meeting. These results motivated a post-launch calibration study for GLM using stable bright targets, based on TRMM/VIRS and LIS observations. Dr. Dennis Buechler (UAH) performed a Deep Convective Clouds (DCC) method on LIS background images and found that the sensor is stable up to this date. This result improves confidence on the decreasing trends found for the greatest FRD.

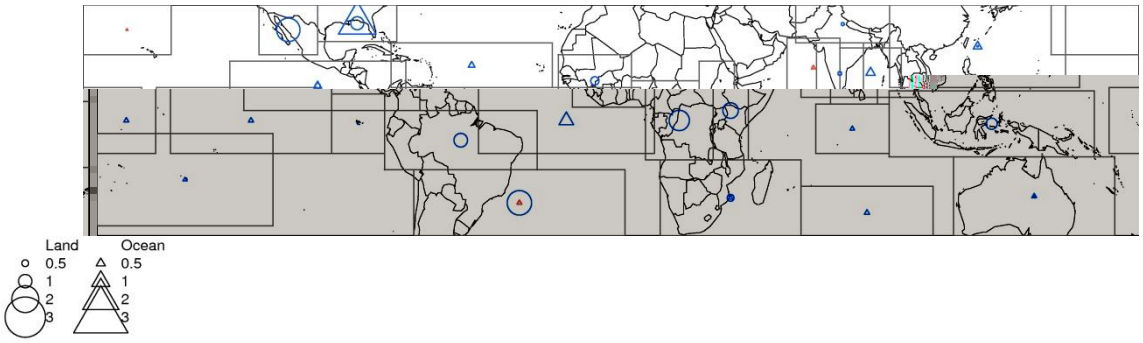


Figure 2 – 0.95 quantile tendency (in FRD fl km^{-2} yr^{-1} per year) over land (circles) and ocean (triangles) for each regional box considered in the quantile linear regression analysis of daily FRD. Blue symbols represent negative trends and red symbols indicate positive trends.

Dr. Albrecht also is working on statistical analysis of individual TRMM/LIS events, groups, and flashes combined with measurements of TRMM/TMI and TRMM/PR. This research aims to better understand lightning behavior under convective and stratiform areas to develop and improve QPE algorithms (in collaboration with Dr. Bringi, Dr. Nai-Yu Wang and Dr. Kaushik Gopalan of CICS/UMD).

The GLM Science Team will deploy a Lightning Mapping Array (LMA) to the metropolitan area of Sao Paulo, SP, Brazil, as part of the proxy data acquisition under MeteoSat SEVIRI coverage. The LMA deployment is in coordination with the Brazilian field experiment CHUVA (lead by Dr. Luiz Machado, CPTEC/INPE). Dr. Albrecht is coordinating this effort with the Brazilian institutions (e.g., INPE, USP, FEI, SIMEPAR). A preliminary site survey was conducted with Jeff Bailey (UAH) during July 2010, using a portable LMA station to test

seven possible locations. Dr. Albrecht visited UAH during February 2010 for training on LMA site surveys. Dr. Albrecht will conduct more site surveys in Brazil during April and May 2011. Additional institutions have agreed to participate in this field experiment, including DLR/EUMETSAT, WSI, Vaisala, WWLLN, and WeatherBug. INPE also will provide high speed cameras. This field experiment is planned for November through December 2011, and will be the first time that these lightning detection networks will be intercompared. This intercomparison will improve our knowledge on lightning and help evaluate our ability to detect lightning discharges.

Professional service was provided by serving as reviewer for Atmosfera, Meteorology and Atmospheric Physics, Journal of Geophysical Research and Atmospheric Environment. Dr. Albrecht also attended three meetings: GOES-R GLM Science Team meeting (December 2010), AGU Fall Meeting (December 2010), and AMS Annual Meeting (January 2011).

Planned Work

During the upcoming year, Dr. Albrecht will continue her work on the TRMM/LIS dataset, which provides a foundation for GLM Risk Reduction activities. Additional work on total lightning characteristics seen by LIS will be continued. Statistical analysis on events, groups, and flashes will help improve our understanding of lightning NOx production and flash rate behavior for science and QPE purposes. Dr. Albrecht also will continue to coordinate the Brazilian side of the LMA deployment and testing to Sao Paulo in collaboration with Brazilian institutions, UAH, and NASA MSFC.

Planned travel for Dr. Albrecht includes two visits to CICS/ESSIC/UMD, GOES-R GLM Science Team meeting (Huntsville, AL), and AGU Fall meeting (San Francisco, CA).

Dr. S. Rudlosky recently was hired by CICS to work on GLM Risk Reduction activities. Dr. Rudlosky also will serve as a NESDIS/STAR subject matter expert supporting GLM science and applications development, and as a member of the GLM Risk Reduction Team. His initial research will compare data from the World Wide Lightning Location Network (WWLLN), Vaisala's Global Lightning Dataset (GLD360), and WeatherBug's Total Lightning Network (WTLN) with data from the TRMM/LIS to determine the fraction of TRMM/LIS flashes that are observed by the various ground-based networks. This project also will investigate spatial variability in the documented relationships, and provide performance statistics to several Proving Ground partners that currently use these data.

Dr. Rudlosky next will apply the findings from part one of his study to develop a GLM proxy dataset at an improved temporal resolution and larger spatial scale than is currently available to the GLM Science Team. The new GLM proxy dataset will be provided to members of the Algorithm Working Group (AWG) as well as GOES-R Proving Ground partners. This research will greatly expand both the number and variety of users and will help to better prepare the various users to implement the upcoming GLM data into their operations.

Dr. Rudlosky also will participate in the LMA deployment during the Brazilian field experiment (CHUVA). He will focus on compiling and analyzing datasets that incorporate as much information as possible from the multitude of sensors involved in the CHUVA campaign. This research will expand the collaborative effort between the GLM and ABI risk reduction teams, and investigate the potential for applications that combine information from these two GOES-R sensors.

Planned travel for Dr. Rudlosky includes visits to the GOES-R Satellite and User Readiness Workshop (Boulder, CO), GOES-R Proving Ground at the Hazardous Weather Testbed (Norman, OK), Algorithm Working Group Year-End Review (Fort Collins, CO), Southern Thunder Total Lightning Workshop (Norman, OK), International Conference on Atmospheric Electricity (Rio de Janeiro, Brazil), GOES-R GLM Science Team Meeting (Huntsville, AL), NWA Annual Meeting / Seventh GOES User's Conference (Birmingham, AL), and AMS Annual Meeting (New Orleans, LA).

Publications

Albrecht, R. I., C. A. Morales, and M. A. F. Silva Dias, 2011: Electrification of precipitating systems over the Amazon: Physical processes of thunderstorm development, J. Geophys. Res., doi:10.1029/2010JD014756, in press. (Accepted 21 January 2011)

Bucsela, E. J., and co-authors, 2010: Lightning-generated NOx seen by the Ozone Monitoring Instrument during NASA's Tropical Composition, Cloud and Climate Coupling Experiment (TC4), J. Geophys. Res., 115, D00J10, doi:10.1029/2009JD013118.

Presentations

Goodman, S. J., R. J. Blakeslee, W. Koshak, W. A. Petersen, L. D. Carey, D. Mach, D. Buechler, M. Bateman, E. McCaul, E. Bruning, R. Albrecht, and D. MacGorman, 2010: The Geostationary Lightning Mapper (GLM) for the GOES-R Series Next Generation Operational Environmental Satellite Constellation. , Vaisala, Orlando, FL, April 19-20.

Albrecht, R., K. Gopalan, N.-Y. Wang, E. Bruning, S. Goodman, and R. Ferraro, 2010: Improving microwave precipitation retrieval using total lightning data: A look into GOES-R and GPM multi-sensor and multi-platform era. , Meet. Am. Suppl., Foz do Iguacu, PR, Brazil, abstract #H33D-05.

Albrecht, R. I., R. Blakeslee, J. C. Bailey, L. Carey, S. J. Goodman, E. Bruning, W. J. Koshak, C. A. Morales, L. A. T. Machado, C. F. Angelis, O. Pinto Jr., K. P. Naccarato, and M. Sabba, 2010: . The São Paulo lightning mapping array (SPLMA): Prospects for GOES-R GLM and CHUVA. , Belém, PA.

Albrecht, R. I.; K. Gopalan, N.-Y. Wang, E. C. Bruning, S. J. Goodman, and R. R. Ferraro, 2010: Total lightning flash characteristics observed from TRMM Lightning Imaging Sensor

(LIS) and their relationship with regional convection and precipitation type. , Fall Meeting, San Francisco, CA, abstract #AE21A-0263.

Albrecht, R. I., K. P. Naccarato, O. Pinto Jr., and I. R. C. A. Pinto, 2011: Total lightning and precipitation over Brazil: An overview from 12 years of TRMM satellite. , Amer. Meteor. Soc., Seattle, WA, January 24-26, Paper 4.4.

Bruning, E., N.-Y. Wang, R. I. Albrecht, and K. Gopalan, 2011: A Lightning Mapping Array for West Texas: Deployment and Research Plans. , Amer. Meteor. Soc., Seattle, WA, January 24-26, Paper 6.2

Rudlosky, S. R., and H. E. Fuelberg, 2011: Determining relationships between lightning and radar in severe and non-severe storms. , Amer. Meteor. Soc., Seattle, WA, January 24-26, Paper 323.

CIMMS and Texas Tech University Support to GOES-R Risk Reduction

E. Bruning, D. MacGorman; (NOAA Collaborator: Steve Goodman, GOES-R)

Background

This task supports GOES-R GLM needs for proxy data, validation datasets, and operational demonstrations of total lightning data (in the GOES-R Proving Ground) thorough sustaining support for the Oklahoma and West Texas Lightning Mapping Array (OKLMA and WTLMA, respectively). Detection of total lightning in the new WTLMA will complement the OKLMA, creating a unique regional-scale domain where total flash rates can be retrieved for larger mesoscale storm complexes and other severe weather outbreaks that are frequent producers of damaging wind and tornadoes. The continued operation of this network will allow for the determination of instantaneous local flash rates and a regional total lightning climatology that will serve as validation datasets for the GOES-R GLM.

Accomplishments

Funding was received by the Cooperative Institute for Mesoscale Meterological Studies around 1 January 2011, with a portion subcontracted thereafter to TTU. Since then, it has provided funding for operating and maintaining the OKLMA and spinup costs for the WTLMA. It also has supported a part-time research scientist to complete an analysis of the conditions under which lightning occurs far downstream in thunderstorm anvils and to analyze the range dependence of the Lightning Mapping Array for use in GOES-R proxy data sets and for climatological studies.

WTLMA deployment is ongoing as of this writing. Initial site survey work was carried out in Fall 2011, with results of that survey work reported in an invited talk at the AMS Annual Meeting in January 2011. Travel funds from this task supported this presentation. The likely network configuration, and its overlap with the central and southwest Oklahoma networks is shown in Fig. 1 and discussed in further detail in Bruning et al (2011). Work is now transitioning to final deployment, drawing on expertise from a funded senior engineer. Final deployment of the LMA is now scheduled for early fall 2011.

Scientific studies at TTU have focused on explaining the flash rate and flash extent observed by total lightning mapping systems. A promising line of inquiry relating the flash size spectrum to the thunderstorm turbulent kinetic energy spectrum has been developed, based on the similar appearance of these two spectra, including similar peaks and slopes in the spectra shape. These early results are also summarized in Bruning et al. (2011).

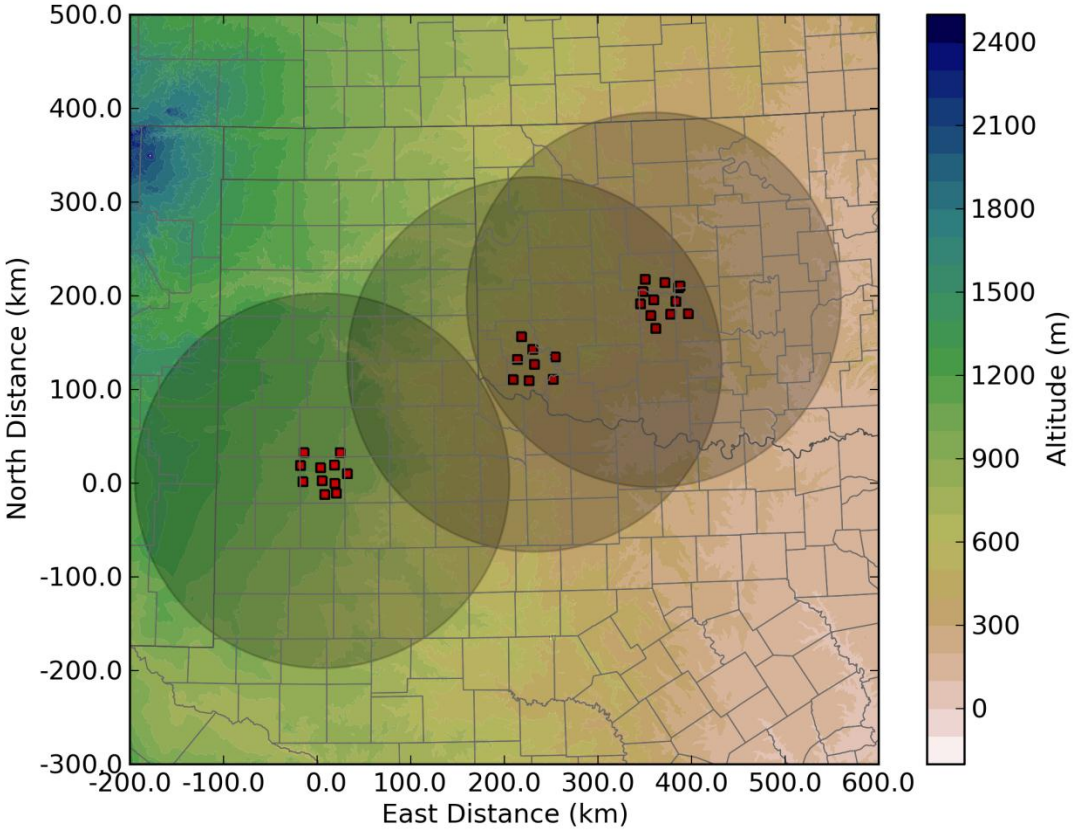


Figure 1: West Texas and Oklahoma Lightning Mapping Array site locations and 2D coverage domain.

Formal Publication

Emersic, C., P. L. Heinselman, D. R. MacGorman, and E. C. Bruning, 2011: Lightning activity in a hail-producing storm observed with phased-array radar. , in press, 10.1175/2010MWR3574.1.

Conference Presentations

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Bruning, E. C., 2011a: A Python wrapper for NASA's Radar Software Library. Special-Symposium on Advances in Modeling and Analysis Using Python, Seattle, WA, USA, American Meteorological Society. P. 4.4.

Allen, B., E. R. Mansell, and E. C. Bruning, 2011: Fractal characteristics of simulated and LMA-detected lightning flashes. Fifth Conference on Meteorological Applications of Lightning Data, Seattle, WA, USA, American Meteorological Society. P. 308

Ziegler, C. L., E. R. Mansell, and E. C. Bruning, 2010: Impact of varying CCN concentration on the precipitation processes of a simulated convective storm. Proc. 13th Conf. Cloud Physics, Portland, OR, Amer. Meteor. Soc., JP3.17

Kuhlman, K., D. Kingfield, G. Stano, E. Bruning, B. Barnowski, and C. Siewert, 2010: Use and evaluation of lightning data within the 2010 Experimental Warning Program and GOES-R Proving Ground. 25th Conference on Severe Local Storms, Denver, CO, American Meteorological Society, P4.2

Albrecht, R., K. Gopalan, N.-Y. Wang, E. Bruning, S. Goodman, and R. Ferraro, 2010: Improving microwave precipitation retrieval using total lightning data: A look into GOES-R and GPM multi-sensor and multi-platform era. Eos Trans. AGU, Meet. Am. Suppl., Vol. 91 (26), Abstract H33D-05

Advanced Study Institute for Environmental Prediction

A. Busalacchi and J. Stra(NOAA Collaborators: Eric Lockler) – PAPA_ENVI10 and JSJSASIEP11

Background

It is expected that the Earth System will experience real climate change over the next 50 years, substantially exceeding the scope of natural variability. A vital question facing society is how to adapt to these changes. The need of the hour is unprecedented collaborations and powerful partnerships between climate scientists and the consumers of climate information - businesses, government agencies from federal to local, policy organizations and planning offices that need specific kinds of information to ensure the best decisions in adapting to climate change.

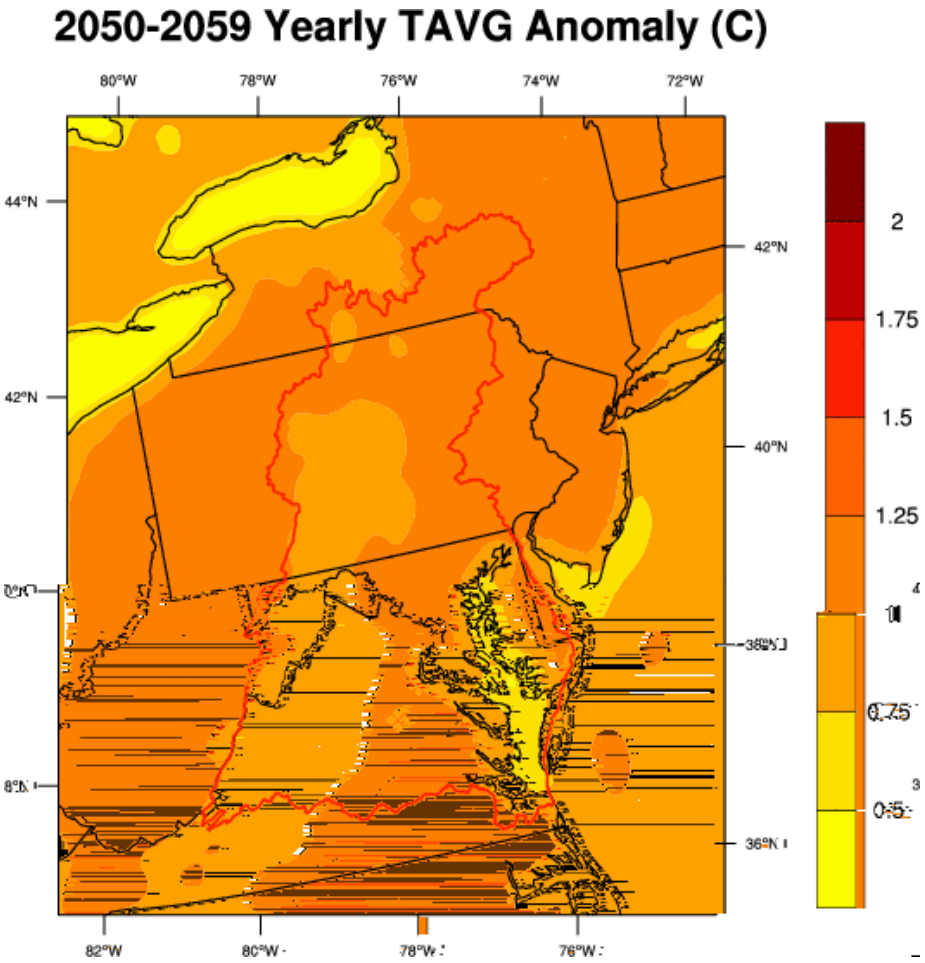
The modeling component of the US Climate Change Science Program (CCSP) is based upon a two-center modeling axis between National Center for Atmospheric Research (NCAR) and Geophysical Fluid Dynamics Laboratory (GFDL) for global change projections. The National Research Council (NRC) review of the CCSP has criticized this approach as incomplete. The NRC has indicated that a national strategy is lacking and needs to be developed for comprehensive climate prediction on times scales that range from seasons to decades. Such a strategy must include the nation's leading center for climate prediction (as distinct from global warming projections) NOAA NCEP and the modeling/assimilation expertise of NASA Goddard.

The key issues, therefore is, how must one make climate change forecast products on time scales that real people can use to make intelligent decisions? The requirement now is to fill the gaping void between five-day local weather forecasts and century-long global climate models. Businesses and organizations have to make decisions in time frames of and on geographic scales from and its trading partners. But at present, there are no suitable products to help them.

The United States government, in particular NOAA and NASA, has demonstrated international leadership with the concept of a Global Earth Observation System of Systems (GEOSS). A key to the success of GEOSS in the long-term will be the sustained use and demand for such observations of the Earth System in support of operational prediction across the atmosphere, ocean, land and ecosystem sectors. The development of a predictive capability for the Earth System has unique policy implications at both the national and international levels, especially in the areas of agriculture, energy, transportation, commerce, health and homeland security, as well as regional "downscaling" of such application sectors in areas such as the Chesapeake Bay.

Accomplishments

Dynamic downscaling of the 1990-1999 period from the GFDL2.1 "Climate of the 20th Century" run and the 2050-2059 period from the "SRESA2" climate change scenario, also from GFDL, has been completed. For the downscaling we configured WRF with three concentric grids. The horizontal increments for the outer, middle, and inner grids are 96, 32, and 8 km respectively. The lateral boundaries of the outer grid were updated every 6 hours with the GFDL2.1 data during the course of the simulations. Soil moisture was initialized using the NASA Land Information System (LIS). The LIS was used to force the NOAH LSM offline with the GFDL2.1 data for the 10 year period before each WRF atmospheric simulation. The resulting soil moisture and temperature fields were then used to initialize the WRF model soil. The attached figure shows the predicted temperature anomaly for the Chesapeake Bay watershed in the 2050s based on these downscaled runs.



Projected anomalies for average 2-m air temperatures for the 2050s based on WRF downscaling of GFDL2.1 data.

Proposed work:
In the future we plan to re-run the simulations of the 1990s and 2050s with different combinations of microphysics, convective and radiative schemes. In addition, we would like to use some of The North American Regional Climate Change Assessment Program (NARCCAP) data for forcing. The NARCCAP consists of IPCC climate scenarios which have been downscaled to around 50 km resolution for North America. We would like to downscale them to less than 10 km over the watershed using WRF.

Publications:
A report detailing the ASIEP is available at:
http://cbfs.umd.edu/report-pdfs/ASIEP_Final_Report_Feb-2011.pdf

Land Surface Temperature Diurnal Analysis (Diurnal) to Validate the Performance of GOES-R Advance Baseline

Konstantin Vinnikov; (NOAA Collaborator: Yunyue Yu) KVKVGOESR11

Background

The goals of this Task are to evaluate diurnal/seasonal LST retrieval error distribution and to assess consistency of satellite retrieved LST resulted from using four different coefficients sets for day and night, wet and dry atmospheric conditions. It is assumed that currently accepted GOES-R split windows Land Surface Temperature retrieval algorithm (Yu et al., 2009) will have different systematic and random errors for different time of a day and seasons of a year. Natural component of diurnal and seasonal dependence of these errors is a result of diurnal and seasonal variations in air temperature and water vapor profiles near the land surface. Another component in diurnal/seasonal distribution of LST retrieval errors is caused by using different sets of retrieval coefficients for wet or dry atmospheric conditions for daytime or nighttime observations. Archived data of GOES-8 and GOES-10 observations are going to be used as a surrogate to GOES-R ES East and West retrieved LST. Observed Upward and Downward broad band IR fluxes at the Surface Radiation (SURFRAD) stations network used to obtain quite reasonable LST Ground Truth data.

Accomplishments

Hourly LST data are from three (2001, 2004, and 2005) years of observations of six SURFRAD stations, and GOES-8 and 10 satellites retrieved LST at the locations of these stations. The statistical algorithm [Chen et al, 2011, in preparation] is applied to eliminate cloud contaminated data uses both satellite and SURFRAD observations. This algorithm is more objective than the earlier one, used by Vinnikov et al. [2008], and detects nighttime cirrus cloudiness more accurately than the algorithms that do not use satellite observations. Time dependent validation differences (LSTg-LSTs) between GOES observed LSTg and SURFRAD observed LSTs contain systematic and random components which were approximated by simple mathematical model, that was earlier tested for LST and other meteorological variables by Vinnikov and Grody [2003] and Vinnikov et al. [2004, 2006, 2008]. The same approximation was applied to squared validation differences to evaluate diurnal-seasonal variations in variance and standard deviation. Two top rows of panels in Figure 1 display empirical estimates of diurnal-seasonal patterns of expected value E(LSTg-LSTs) and of standard deviation, STD(LSTg-LSTs), of the validation difference for four SURFRAD stations. Two important conclusions follow from these estimates:

- Systematic and diurnally-seasonally depended bias is the main error in satellite retrieved LST.
- Standard errors of satellite observations are mostly smaller than 1.5°C and do not have significant diurnal-seasonal dependence. Such precision corresponds to the requirements to LST data.

Bias problem has three different sources:

- Size of observational plot at SURFRAD station is much smaller compared to size of satellite pixel.
- Angular anisotropy of LST field.
- Satellite LSTg retrieval algorithm uses four different sets of coefficients: for day wet, day dry, night wet, & night dry conditions.

All these three sources of error can produce diurnal & seasonal pattern in the bias of satellite observed LST. None of them really have an effect on random component in validation difference (LSTg-LSTs). This subject is discussed in more details by Vinnikov et al. [2011].

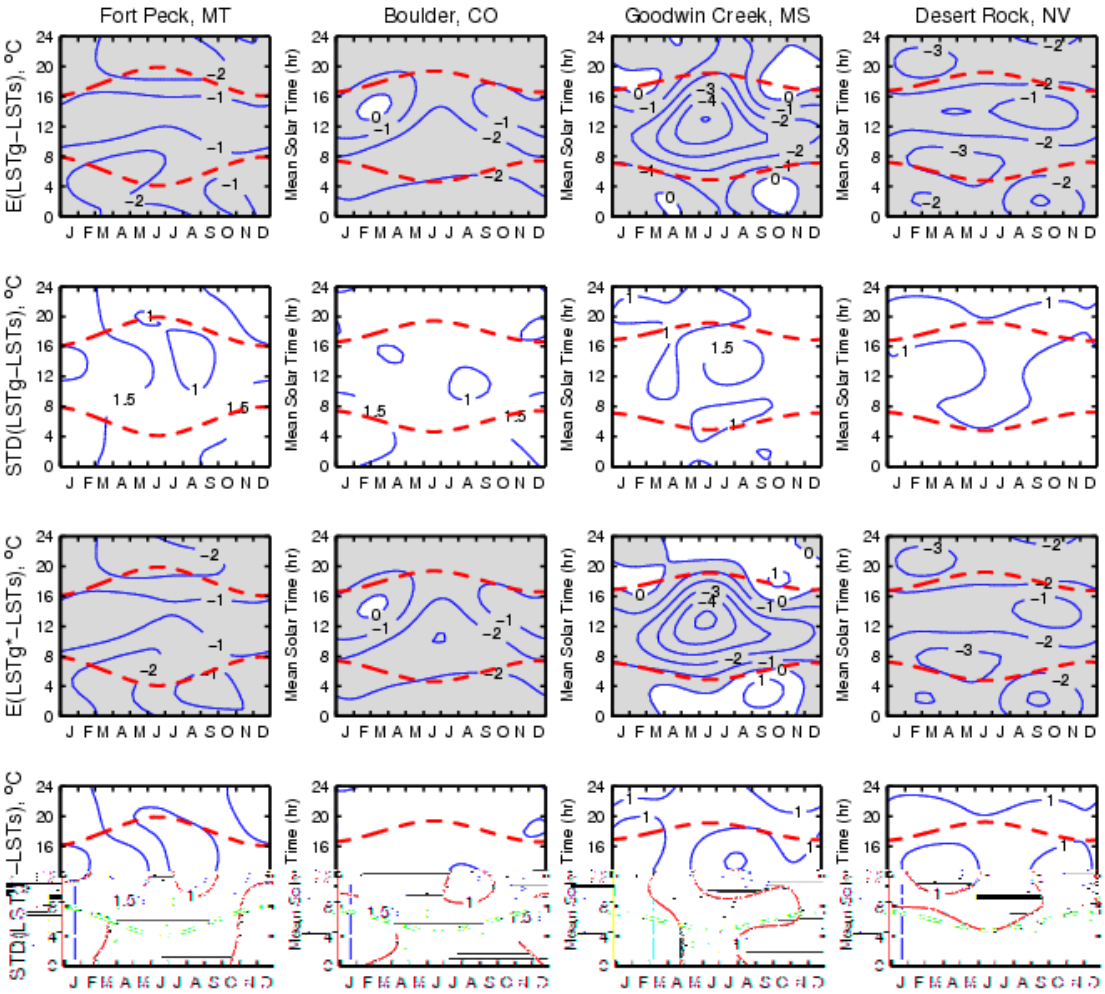


Figure 1. Diurnal-seasonal patterns of systematic and random components in time dependent validation differences. E(LSTg–LSTs) is expected value and STS(LSTg–LSTs) is standard deviation of these validation differences. .

We then evaluated LSTg retrieval errors caused by using different sets of retrieval coefficients for wet or dry atmospheric conditions for daytime or nighttime satellite observations. As an example, rows 3 and 4 in Figure 1 display diurnal-seasonal patterns of bias and standard error of LSTg retrieval from the same observations, but using for all cases only one single set of coefficients (for NIGHTIME DRY conditions) in the algorithm #6 [Yu et al., 2009]. Such temperatures we denote as LSTg*. The difference between estimates presented in the first two and in the last two rows of panels in Figure 1 is almost negligible. We also obtained statistics of validation differences for each of six SURFRAD stations and for all stations together. The results of such testing, presented in Table 1, show that using one single set of coefficients recommended for NIGHTTIME DRY

CONDITIONS instead of four different sets increases precision of LST retrieval at six SURFRAD stations. This result shows perspectives for empirical adjustment of the LST retrieval algorithm. Such adjustment willbe really possible after observation of GOES-R satellite will be accumulated for at least one full year. Observation of more than six SURFRAD stations is needed to empirically improve algorithm performance for all conditions.

Table 1. Testing of four sets of the coefficients in the GOES-R LST algorithm #6 (Yu et al., 2009) using GOES-8 & GOES-10 satellite observation at locations of six SURFRAD stations. N is number of observations. BIAS and RMSE of validation difference (LST$_G$-LST$_S$) are given in °C. ND means that Dry Night, NW – Wet Night, DW – Day Wet coefficients are used to compute LST$_G$.

LST_{GOES}-$LST_{SURFRAD}$	GOES-8			GOES-10		
	N	BIAS	RMSE	N	BIAS	RMSE
ALL data/Algorithm #6 as is	10,333	-0.43	1.71	35,540	-1.63	1.58
ALL data/Algorithm #6 with ND coeff.	10,333	-0.46	1.66	35,540	-1.53	1.55
DAYTIME data/Algorithm #6 as is	6,059	-0.34	1.69	20,763	-1.63	1.65
DAYTIME data/Algorithm #6 with ND	6,059	-0.47	1.61	20,763	-1.58	1.60
NIGHTTIME data/Algorithm #6 as is	4,274	-0.56	1.72	14,777	-1.63	1.48
NIGHTTIME data/Algorithm #6 with ND	4,274	-0.44	1.71	14,777	-1.47	1,47
WET-DAYTIME data/ #6 with DW	939	-0.43	1.71	1,676	-1.78	1.75
WET-DAYTIME data/ #6 with ND	939	-0.61	1.45	1,676	-1.21	1.62
WET-NIGHTTIME data/ #6 with NW	784	-0.14	1.79	1,900	-2.07	1.57
WET-NIGHTTIME data/ #6 with ND	784	+0.50	1.45	1,900	-0.77	1.38

Planned work

The work on assessment of LST consistency issue using four different sets of LST retrieval coefficients will be continued. Further work will be concentrated on analysis of bias component in satellite LST observations. It will include statistical evaluation of angular anisotropy of LST using available simultaneous land based and satellites GOES-E and GOES-W observations at locations of SURFRAD stations; developing the algorithm for correcting GOES-R retrieved clear sky LST for angular anisotropy of LST field; taking into account angular anisotropy of LST in validation of GOES-R observed LST.

Publication

Vinnikov, K. Y., Y. Yu, M. D. Goldberg, M. Chen, and D. Tarpley (2011), Scales of temporal and spatial variability of midlatitude land surface temperature, ., 116, D02105, doi:10.1029/2010JD014868.

Presentation

Vinnikov, K.Y., Y. Yu, M. Chen, D. Tarpley, M. Goldberg (2010), Scales of temporal and spatial variability of land surface temperature. American Meteorological Society. . Annapolis, MD.

NPOESS data exploitation (nde)-MIRS precipitation RETRIEVAL

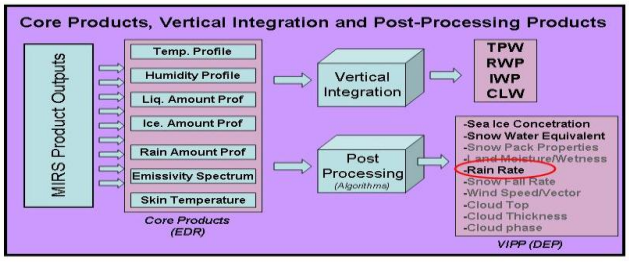
N.-Y. Wang (NOAA Collaborator: R. Ferraro) NWAHAPSDI11

Background

This task is a continuation of the previous year and is in direct support of the NOAA plan to continue its operational generation of precipitation products from the AMSU/MHS series and expand this into the SSMIS and NPOESS Preparatory Project's (NPP) Advanced Technology Microwave Sounder (ATMS), which will also fly on NPOESS itself. The current production software system, known as the Microwave Surface and Precipitation Products System (MSPPS, Ferraro et al, 2002), is being upgraded to a more general, but more physically sophisticated system know as the Microwave Integrated Retrieval System (MIRS, Boukabara, et al., 2006). MIRS uses 1DVAR retrieval methodology that incorporates all channels on-board sensors such as AMSU, SSMIS and ATMS. Thus, the output suite of products, which includes temperature, moisture and hydrometeor profiles, as well as surface precipitation rate, snow water equivalent, land surface temperature and emissivity, will all be physically consistent. The MIRS "physics package" will be portable from sensor to sensor, with only the development of sensor specific testbeds and sensor calibration being required. This will allow for physical consistency between sensors as well. MIRS is being developed under the auspices of the NESDIS Office of Systems Development and NESDIS/STAR through the POES and JPSS programs.

Statement of Work

The MIRS rain-rate is generated from the MIRS physically-based retrieval algorithm (1-DVAR) core products through a post processing process. The MIRS core products used for rain rate include the vertically integrated ice water (ice water path, IWP), rain water (rain water path, RWP), and cloud liquid water (cloud liquid water path, CLW). The schematic (courtesy of MIRS project) on the right outlines the MIRS core product suites and the post-processing product suites (including rain rate). Through a multiple regression between the vertically integrated hydrometeor products and rainfall rate from a given well-known reference (currently this reference is MM5), the rainfall rate (RR, mm/hr) is obtained



$$RR = A0 + A1*IWP + A2*RWP + A3*CLW$$

The regression coefficients A0, A1, and A2 are constant.

Several validation and inter-comparison of daily precipitation from MIRS and other satellite estimates are being pursued by the International Precipitation Working Group (IPWG). Figure 1 shows the time series (February 2009 to February 2010) of temporal

correlation of 10-day averaged satellite precipitation estimates with US rain gauges from the IPWG's CPC precipitation verification page (http://cics.umd.edu/~johnj/us_web.html). In general, the pattern of the spatial correlation among MIRS (black line), CMORPH (Joyce, et al., 2004) microwave only (red line), TMPA (Huffman et al., 2007) microwave only (blue line), and radar (black line) are very similar. However, MIRS has the lowest spatial correlation with rain gauges compare to the other satellite and ground radar estimates, especially during the spring and summer months (April through October).

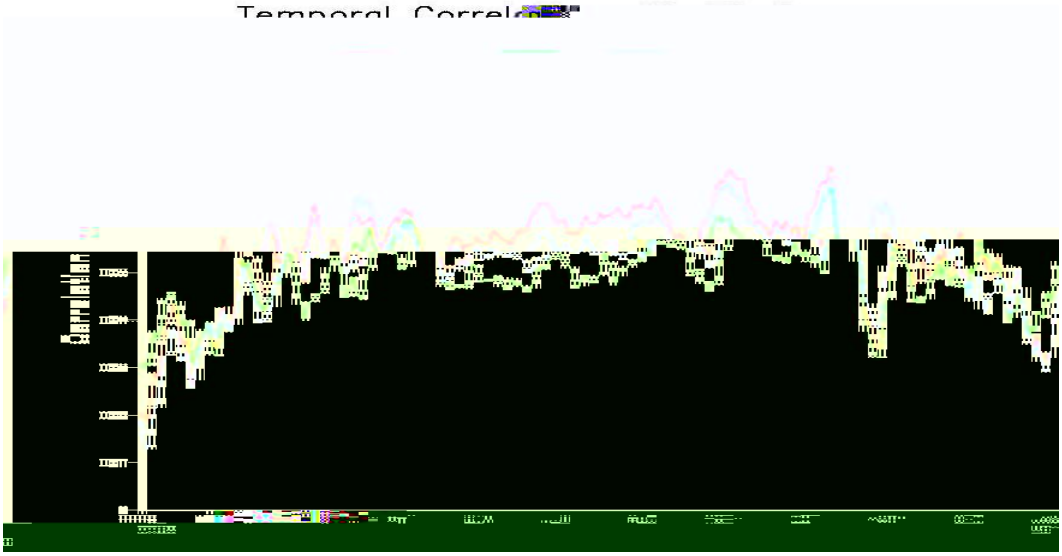


Figure 1. Time series of temporal correlation with US rain gauges from MIRS (green line), MWCOMB (CMORPH microwave only, red line), 3B40RT (TMPA microwave only, blue line), and radars (black line)

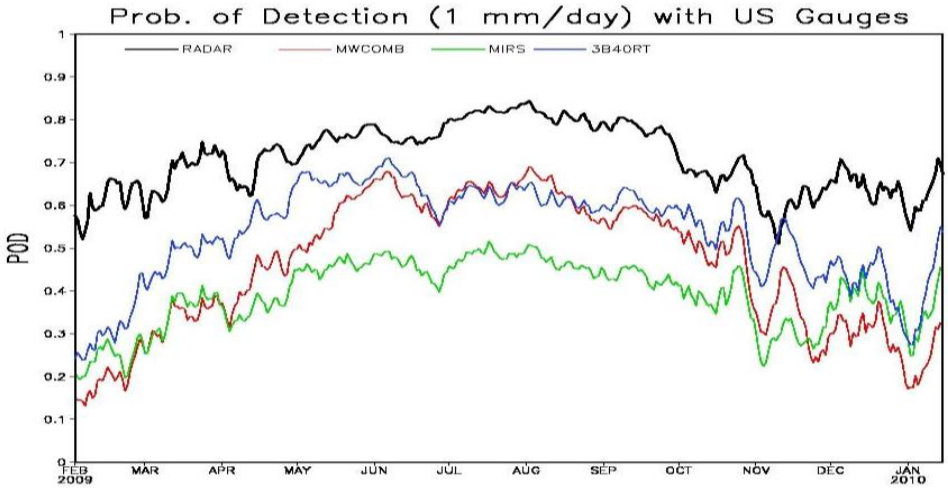


Figure 2. The probability of detection (POD) compared with U.S. rain gauges for MIRS (green), CMORPH microwave only (red), TMPA microwave only (blue), and radar (black).

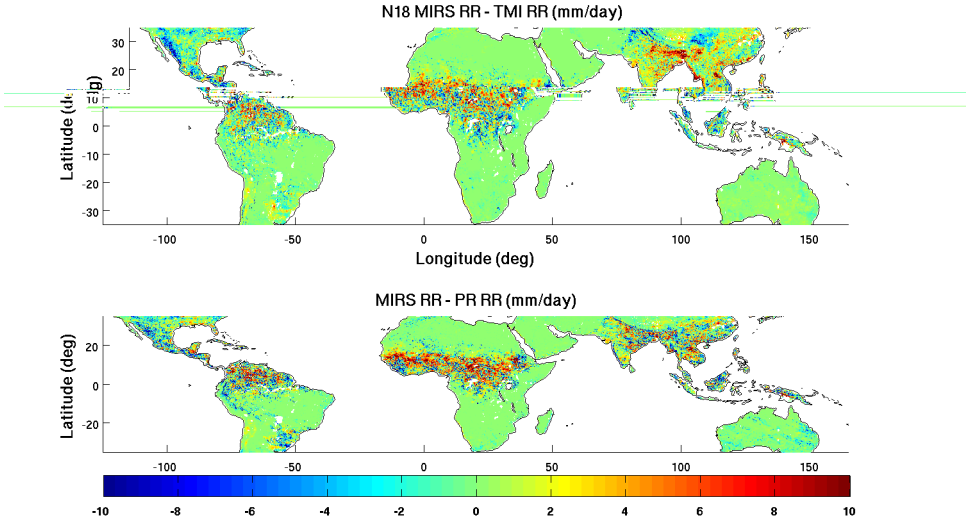
Figure 2 shows the probability of detection (POD) among the three satellite precipitation estimates relative to the rain gauges in the U.S. MIRS's rain detection is comparable with CMORPH and TMPA in the winter and early spring (December through April). However, in the spring, summer and early winter months (late April through November), the probability of detection from MIRS is consistently lower (~30%) than CMORPH and TMPA.

There are two probable reasons that may explain the discrepancy between MIRS and CMORPH and TMPA. First is the sampling issue. MIRS daily rainfall is produced by NOAA and DMSP operational microwave sensors (AMSU/MHS and F-16 SSMIS), while CMORPH and TMPA utilize NOAA and DMSP operational microwave radiometers (AMSU/MHS and SSMIS), plus additional research microwave radiometers such as NASA AMSR-E and TRMM TMI. CMORPH and TMPA have the larger number of rainfall samples from more satellites than MIRS, which might attribute to better correlation with rain gauges. The 2nd issue might be the MIRS rainfall rate algorithm. In the spring and summer months, the frequency of convective storms is higher than the winter and early spring. The fact that MIRS detects less rain occurrences in the spring and summer seem to indicate that MIRS rainfall regression might be trained with model simulations from mostly stratiform rain type. At this point, this is only an educated guess. To verify if this is true or not, we need to take a close look of the dataset that is used to train the regression. We also plan to investigate the MIRS rainrate regression relation with other independent data source such as TRMM TMI/PR to gain some insight of the regression relation in the future.

Planned Work

We're currently in the process of installing MIRS software package on a Linux desktop. Once MIRS is installed and up and running, we plan to run MIRS for a few months of satellite data (e.g., summer and winter). We will examine the rain rate estimates from MIRS relative to an independent satellite source such as TRMM to understand the reason as to why MIRS seems to do a better job of detecting and estimating rain better in the winter than in the summer. We recently completed a new TRMM TMI 2A12 land precipitation algorithm (2A12 v7). The rain rates from the new TMI 2A12 v7 algorithm and new PR (precipitation radar) algorithm are good candidates for this purpose because MIRS does not use TRMM brightness temperatures. We'll also examine the MM5 dataset (or whatever data MIRS uses to train the rain rate regression) and investigate how well these data represent the nature of rain typ9 Tm [20087urough this Tm (r)4(oces(,)-4( )10 w)4(eie)-3(nt)-3eand

Brahmaputra basin, but detects lower RR over the United States. During DJF, MIRS detects significantly higher RRs compared to TMI & PR over South America and Southern Africa. TMI overestimates RR compared to both MIRS and PR over the Himalayas and the Chinese highlands; this is caused by surface scattering from snow and ice on the ground. The TMI land algorithm is particularly sensitive to ice scattering since it primarily relies on the depression of 85 GHz Tbs to detect rainfall, whereas the MIRS algorithm seems to be unaffected by the surface conditions in this region.



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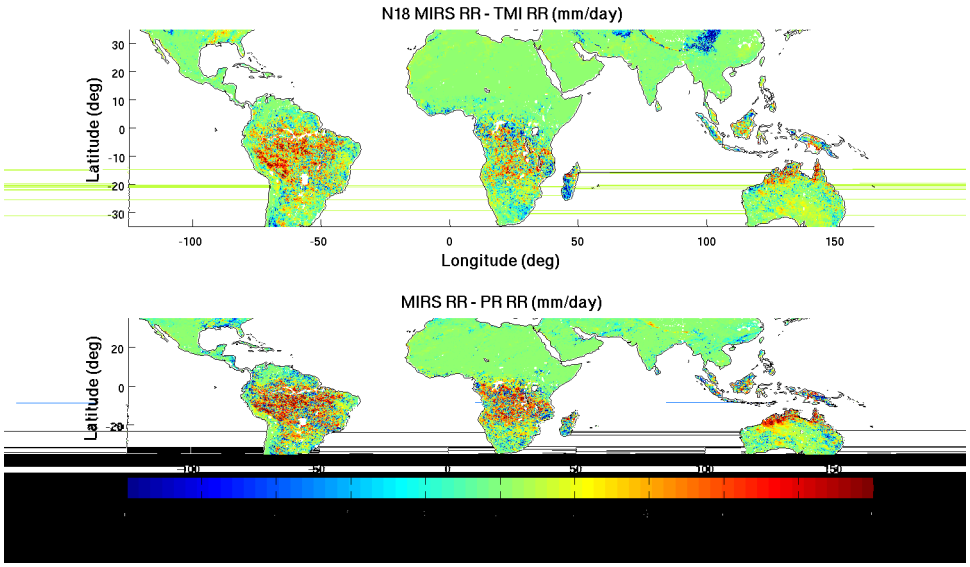

DJF

Figure 4: RR comparison of MIRS N18 with TMI (top panel in each figure) and PR (bottom panel) for a) JJA and b) DJF.

Figure 5 shows the percentage of pixels having non-zero rain rates for MIRS and PR for DJF. It is observed that MIRS detects a significantly higher fraction of raining pixels, primarily over South America and Southern Africa. We calculated the PR rain accumulation separately for convective and stratiform pixels for this season (see Figure 6). The

Based on these geographical patterns, it appears that MIRS may overemphasize stratiform rain compared to TMI and PR. However, it is important to note that these differences may be partially caused by the differences in temporal sampling between NOAA-18 and TRMM. For example, Negri et al. (2002) studied the diurnal sampling of precipitation using TMI and PR, and observed that the highest RRs over the Amazon occurred between ~1 pm to ~ 5pm. Since the NOAA-18 sampling during ascending passes occurs close to this time (~1:30 pm local time at nadir, varying by < ±1 hour over each scan), it is perhaps not too surprising that MIRS generally retrieves higher RRs over this region.

In summary, we observe that MIRS/N18 generally retrieves higher RR relative to TMI and PR, particularly over regions with heavy stratiform rainfall. It is difficult to determine the extent to which these differences are caused by issues with the MIRS algorithm, since the different diurnal sampling between NOAA 18 and TRMM could explain some of these anomalies.

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Validation and Refinement of GOES-R Fire Detection Capabilities

W. Schroeder (NOAA Collaborator: Ivan Csiszar) WSWSGOESR11

Background

This task relates to the pre-launch validation of the GOES-R ABI active fire detection and characterization algorithm using higher spatial resolution reference data. This methodology has been previously applied to moderate- to-coarse spatial resolution data, including the global validation of the Terra MODIS product (MOD14)[http://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD14], and the regional validation of the GOES Imager Wildfire Automated Biomass Burning Algorithm (WF_ABBA) [Schroeder . 2008a] and NOAA/NESDIS's Hazard Mapping System (HMS)[Schroeder ., 2008b]. The fire detection probabilities and false alarm rates are derived from the summary fire statistics derived from binary fire masks (fire – no fire) produced by near-coincident higher spatial resolution Landsat-class data [Giglio ., 2008; Schroeder ., 2008a].

Accomplishments

The initial validation assessment of the binary (fire – no fire) GOES-R ABI active fire detection product included the analyses of approximately 300 ASTER scenes distributed across North and South America. ABI fire proxy data were derived from input 1km MODIS L1B radiances, spatially and spectrally transformed to mimic ABI sensor characteristics. Data co-location and validation science algorithms were developed using paired ABI-ASTER input files. Fire detection probability and false alarm rates were derived, along with data visualization tools to facilitate interpretation of validation results (Figure 1).

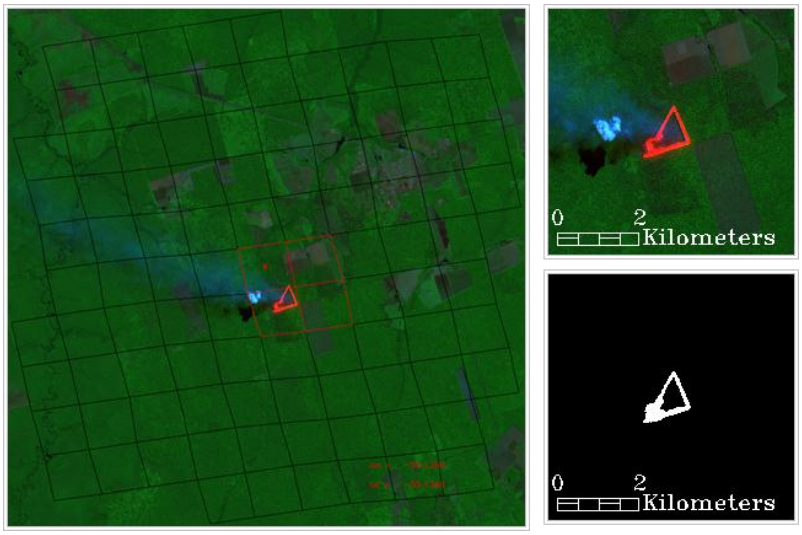

Figure 1: Visual output of the validation of ABI's active fire detection product. Left panel shows ABI's nominal pixel footprint grid overlaid on top of coincident ASTER RGB (3-3-1); ABI fire pixels are marked red. Right panels show zoom over active fire in the reference ASTER scene (top), and the corresponding binary (fire – no fire) mask (bottom).

Due to the lack of firededicated middle infrared bands and the frequent saturation of thermal infrared channels, the ASTER scenes used for the validation of the binary ABI fire detection product are of little utility for the validation of ABI's fire characterization parameters (fire size, temperature, and radiative power). To fill in this gap, sample airborne fire science data from two separate sensors were tested. Figure 2 shows a fire imaged by the NASA Ames Research Center Autonomous Modular Sensor-Wildfire (AMS) over Southern California in 2007. Fire characterization retrievals were experimented, including fire size, temperature and radiative power. A second airborne sensor, U.S. Forest Service's FireMapper, was also tested showing similarly good potential for use in support of ABI fire characterization validation. Methods will be developed to colocate paired ABI-airborne data, mirroring the ABI-ASTER validation scheme.

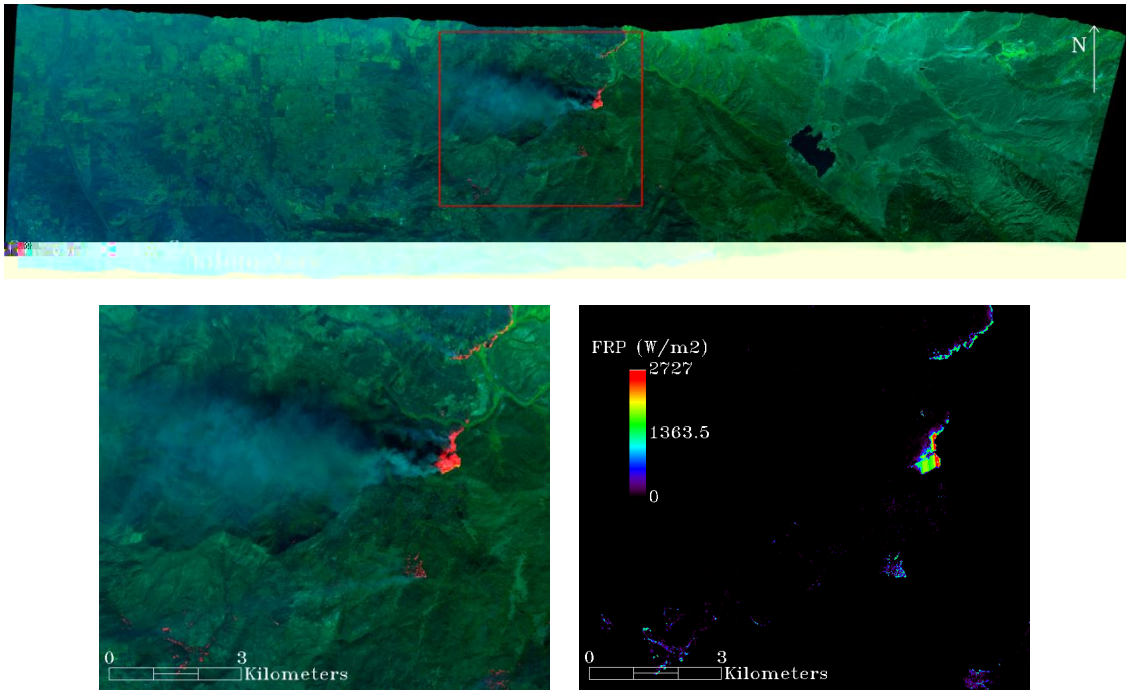

Figure 2: Airborne fire reference data derived from NASA/Ames AMS-Wildfire sensor over Southern California fire in 2007. Top panel shows image swath of fire and background region; bottom panels show zoom over active fire (left) and fire radiative power retrieval (right).

Outreach

The GOES-R ABI active fire validation results described above were presented at two venues, namely the GOES-R Algorithm Working Group Science Meeting at the University of Wisconsin, Madison (June 7-11, 2010), and the IGARSS annual meeting in Honolulu, Hawaii (July 25-30, 2010).

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Development of Operational Algorithms & Software to Derive and Validate NDVI and Green Vegetation Fraction (GVF) Product from GOES-R.

P. Romanov (NOAA Collaborator: Bob Yu., IMSG Collaborators: Yuhong Tian, Hui Xu) CUNY – PRPRGOESR11

Background

The final objective of this project consists in the development of algorithms and software to routinely produce and validate two land surface products, the Normalized Differential Vegetation Index (NDVI) and the Green Vegetation Fraction (GVF) from GOES-R Advanced Baseline Imager (ABI) instrument data. The primary NDVI product is an image-based map of the top of the atmosphere NDVI generated on an hourly basis. The external cloud mask will be used to limit NDVI estimates to cloud-clear pixels only. The GVF product presents the fraction of green vegetation with every land pixel of GOES-R ABI. It is derived from the observed NDVI using a linear mixture approach.

The goal of this work is to perform the tasks as defined in the Algorithm Working Group (AWG) Land Team NDVI and GVF schedule and validation plan. During the current year we have prepared and delivered to AIT new versions of the software and conducted a number of reviews for both products.

Accomplishments

During the previous year we have finalized the development and testing of the GOES-R NDVI algorithm at 100% readiness. The new NDVI algorithm has been delivered to the Algorithm Implementation Team (AIT) along with all required documentation. The work on NDVI algorithm and its testing was conducted using Meteosat Second Generation (MSG) SEVIRI data as proxy to GOES-R ABI. The archive of SEVIRI data is routinely collected and maintained. At this time we have more than three years time series of half-hourly images from SEVIRI, which is enough for the algorithm development and testing purposes. The work on the NDVI product towards 100% readiness included the testing and review process of the corresponding algorithm and processing as well as update of the ATBD to meet 100% readiness requirements.

Comprehensive routine and divein validation tools for the NVDI product have been designed. The routine validation system estimates day-to-day temporal variations of the derived NDVI. These estimates are used to assess the accuracy of retrievals. Cases with NDVI daily change exceeding 0.05 are identified and labeled as "questionable NDVI estimate". The validation system estimates the overall fraction of "questionable" NDVI retrievals on a daily basis and for each particular half-hourly image.

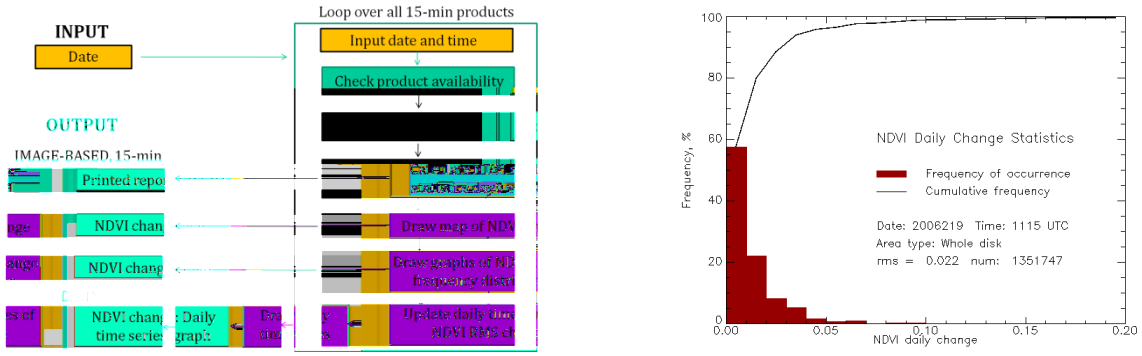


Figure 1. Left: Flow chart of the routine validation tool for the GOES-R NDVI product. Right: Example of frequency distribution and cumulative frequency distribution of NDVI daily change.

The development and testing of Version 3 of the GVF product has continued. We have prepared and conducted the Critical Design Review (CDR) and the Test Readiness Review (TRR) for this product. The GVF algorithm and supporting documentation at 80% readiness have been delivered to AIT. We have conducted an additional testing of the NDVI anisotropical correction incorporated in the GVF algorithm. At this time correction is performed with a kernel-driven NDVI angular anisotropy model. The kernel loadings have been estimated empirically using available daily time series of cloud-clear observations from MSG SEVIRI. In this part of the work we have collected additional cloud clear observations over the whole range of possible land surface cover types and tested the developed algorithm over the new dataset.

In August 2010 both product were presented at the ADEB review and received a generally positive evaluation.

Future Work

The future work on the NDVI product will mostly focus on the development of the routine and dive-in validation tools. The dive-in validation tool will in clude codes and scripts to compare NDVI derived from GOES-R with NDVI derived from polar orbiting satellites. The tool will be tested with MSG SEVIRI data as proxy for GOES-R ABI.

The next year the development of the GVF fraction algorithm and codes will be completed. The algorithm will be brought to 100% readiness and the ATBD will be modified accordingly.

Presentations

Romanov P. , H. Xu NDVI product for GOES-R ABI: Current Status. 2010 NOAA STAR AWG/GOES-R TRR Review Madison, WI, 7-11 June 2010.

Romanov P. , Y. Tian GVF product for GOES-R ABI: Current Status. 2010 NOAA STAR AWG/GOES-R TRR Review Madison, WI, 7-11 June 2010.

Development of an Advanced Technique for Mapping Sea Ice with ABI

Marouane Temimi; (NOAA Collaborators: Jeffery Key) –

Background

The ultimate objective of this research is to explore the potential of the future GOES-R ABI in mapping sea ice and to develop an automated ice mapping algorithm, which would make maximum use of ABI's improved observing capabilities. Availability of observations in the visible, middle-infrared and infrared spectral bands from geostationary satellites makes them a relevant source of information on ice cover and concentration.

Large area coverage and frequent repeat cycle make satellite observations an effective tool for ice cover observation and monitoring. When selecting a particular type of satellite data for ice monitoring, most often the choice is made in favor of observations in the passive microwave. Another technique that is actively used for remote mapping and monitoring of ice distribution is based on satellite observations in the visible and infrared. Unlike microwave data, application of satellite observations in the visible and infrared is limited to daytime clear-sky conditions. Their finer spatial resolution, on the order of 1 km or less, gives them an advantage over microwave data in mapping and monitoring ice cover over small inland water bodies, lakes and even some rivers. Visible and infrared data are also more effective in detecting ice along coastal lines. Availability of observations in the visible, middle-infrared and infrared spectral bands from geostationary satellites makes them another potential source of information on ice cover and concentration. The primary advantage of geostationary satellites over polar orbiting satellites consists in a much higher temporal frequency of observations. Frequent, 15 to 30 minutes, observations from geostationary satellites give better chances to observe cloud clear scenes during the day than with 1-2 observations per day available from polar-orbiting platforms. Frequent temporal coverage and high spatial resolution enable better tracking of ice motion.

Accomplishments

The daily and seasonal variations and other properties of each channel has been individually studied. The optical channels have been investigated for the angular variations of the solar, satellite and zenith angle. It has been established that the High Resolution Visible (HRV 0.6-0.9) and R01 visible (VIS 0.6) have the highest sensitivity and near infrared channel (NIR 1.6) has the least sensitivity to the variations of solar angle. The results of that finding led to the formation of the BRDF model and the establishment of the daily minimum and maximum values for each spectral band. In the following correlations of the channels, derived parameters and indices will be investigated for the formation of the classification model. In addition to the parameters and values there is a need for a set of criteria and boundaries for each class. When two of these parameters are plotted against each other, clusters or pattern will be recognized. After the recognition, these patterns could reveal the location of these pixels. If a group of the pixels have high reflectance values in VIS 0.6 and NIR 1.6 bands, as it can be seen in the Figure 1, then they can be classified as cloud. Figure 2 indicates that the pixels that have low reflectance in both VIS 0.6 and NIR

1.6 belong to the lower part of Caspian Sea (lower right graph) where, there is no ice or cloud and is water. The green arrow in the figure points to the location of these pixels on the Caspian Sea image. The scatter plot in the Figure 2 further illustrates that ice and cloud can be separated by their unique act in the combination of these two bands. As it could be seen ice has high reflectance in VIS 0.6 and low reflectance in NIR 1.6 which separates it from cloud. The red arrow in the Figure points to the location of ice on the image.

When other key parameters like NDSI and NIR 1.6 are plotted some other pattern are being revealed. Figure 1shows that ice has high values of NDSI and low values of NIR 1.6 and cloud has very high value of NIR 1.6 and low value of NDSI.

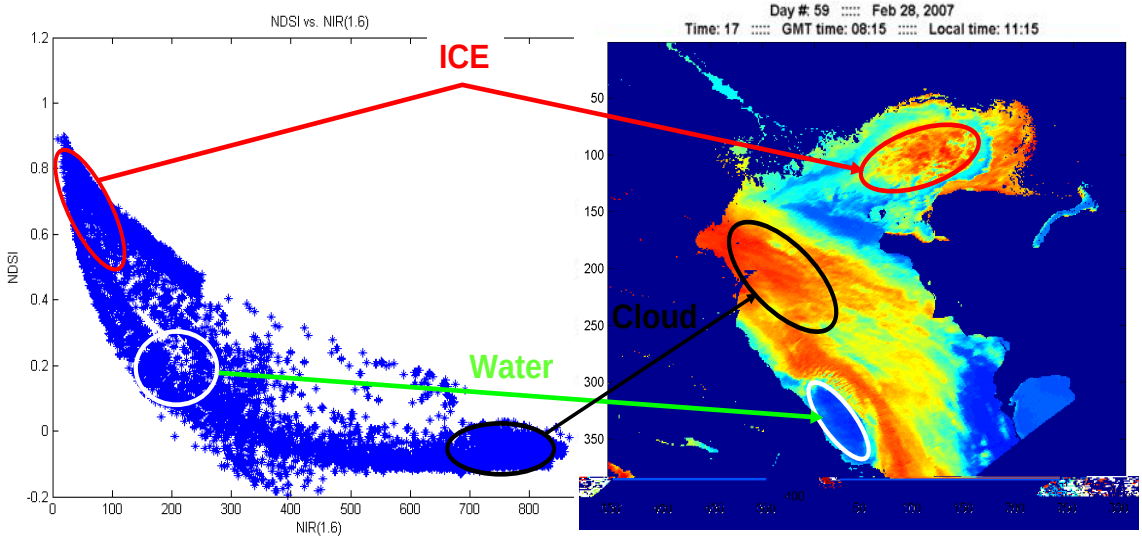


Figure 1: Scatter Plot (left) of NDSI vs. near infrared (band 1.6) HRV image (right) shows clouds (black oval), Ice (red oval) and Water (white oval)

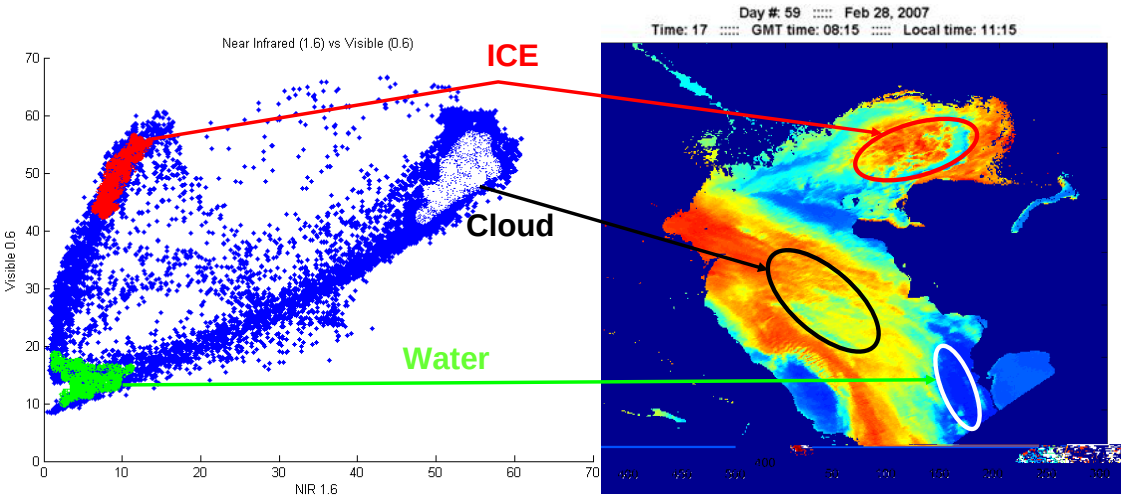


Figure 2: Scatter Plot (left) of near infrared (band 1.6) vs. visible (0.8), HRV image (right) shows clouds (black oval), Ice (red oval) and Water (white oval)

Publication

Marouane Temimi, Peter Romanov, Hosni Ghedira, Reza Khanbilvardi and Kim Smith. (2011). An automated approach for determining sea-ice concentration for the future GOES-R ABI sensor. International Journal of Remote Sensing. Vol. 32, No. 6. Page: 1575–1593. DOI: 10.1080/01431160903578820.

Mesoscale Convective System Climatology using Geostationary Infrared Imagery

Brian Vant-Hull; (NOAA Collaborators: Robert Kuligowski) – DVDVGOESR11

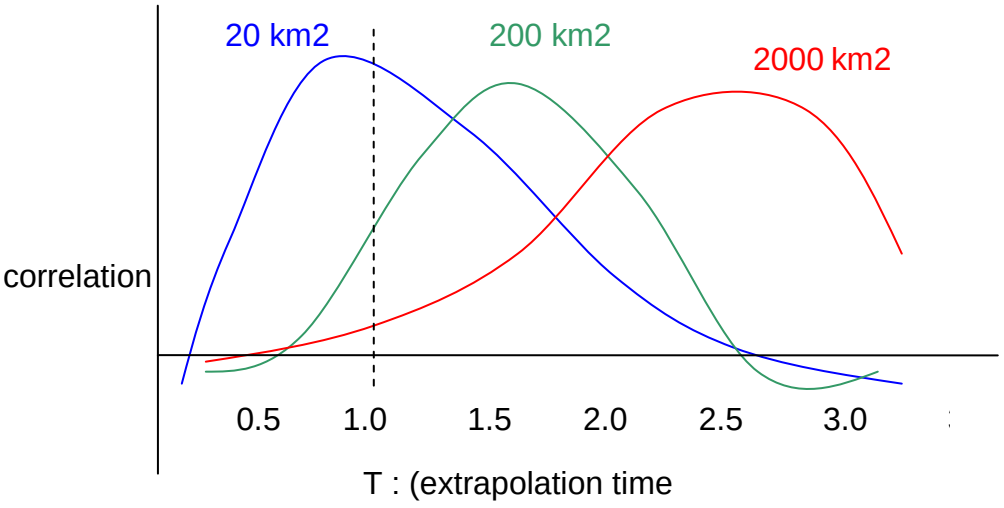
Background

The precipitation retrieval algorithm selected by the GOESR AWG is the Self-Calibrating Multi-spectral Precipitation Retrieval (SCaMPR) package originally developed by Robert Kuligowski of NESDIS/STAR. Nowcasting of the precipitation estimates will be done by the WDSS-II segmotion algorithm. Segmotion segments the current image by applying the K-Means watershed technique to group pixels around local extrema. The size of each segment is set by one of 3 area thresholds, and maps are created and extrapolated for each of these 3 scales. It is expected that larger advection times should use larger spatial scales. The current default scales are (20,200,2000) km^2, with the first scale used for advection up to 30 minutes, the middle scale used for advection between 30 minutes and 2 hours, and the last scale used for advection beyond 2 hours.

The purpose of this project is to find the best match between spatial scales and advection times. Correlations will be formed between advected precipitation estimations from the past and current estimations. It is expected that different spatial scales will exhibit peaks in the correlation for different advection times. The final step is to find a weighting scheme for a linear superposition of advection scales that will maximize the extrapolation skill.

Accomplishments

A month of SCaMPR estimated precipitation data from west africa and the tropical atlantic (25x25 degrees) was advected out to 3.5 hours using the WDSS-II advector algorithm at 3 sets of spatial scales: (10,100,1000) km^2, (20,200,2000) km^2, (50,500,5000) km^2. Code has been written to calculate correlations as a function of extrapolation time for each of the spatial scales, with the intention of producing output similar to the following:



A first guess for a linear weighting of scales for a given time might be given by the goodness of fit for each scale at that time. The dotted line above shows that a first guess to find the best match for 1 hour extrapolation would consist mainly of the 20 km^2 scale, with progressively smaller contributions from the 200 and 2000 km^2 scales.

At this moment there are noise issue that must be dealt with before representative correlations can be calculated. It is believed that the application of a simple filter before processing will address the issue.

Publication
None

URL Links from the text:
None

Incorporating Cooling Rates into GOESR Precipitation Retrieval

Brian Vant-Hull, Shayesteh Mahani (NOAA Collaborators: Robert Kuligowski)

Background

The precipitation retrieval algorithm selected by the GOES-R AWG is Self Calibrating Multispectral Precipitation Retrieval (SCaMPR) package originally developed by Robert Kuligowski of NESDIS/STAR. The current version performs multivariable regression of channel radiances against recent microwave retrievals in the region, thereby using information from a single image for each retrieval. It has been hypothesized that a regression that included cooling rates in all channels would improve the retrieval skill, since precipitation is often associated with the growing phase of cumulus clouds.

The WDSS-II segmotion tracking algorithm was selected by the AWG for extrapolation of the SCaMPR estimated precipitation rates into the near future. It was sensible to use this same algorithm to calculate cooling rates by subtracting extrapolated IR fields from the previous image (with no growth rates) from the current IR fields. The cooling rate field can then be incorporated into the SCaMPR algorithm and the results compared to ground truth to see if the new variable indeed improves precipitation estimation.

Accomplishments

A suite of C-code functions run by a bash script was created to calculate cooling rates. When it was discovered that the intended full-disk data was too large for the WDSS-II algorithm to ingest, the code was modified to slice the data into smaller regions with buffer zones around each to address edge effects, run the analysis on each region separately, and splice the results back into a full-disk image.

Unfortunately the WDSS-II code runs too slow by about a factor of 4 to process multiple channels full-disk in real time. One plan to increase speed is to calculate advection vectors for the 11 µm window channel alone, and apply the advection to all other channels. This entails a significant amount of programming overhead, so it is expedient to first test for indications that cooling rates result in significant improvement before reprogramming. At the time of writing the code is being run on a few days of data to see if significant improvements result.

Publication

None

URL Links from the text:

None

Inter-Calibration and Scaling-Up Algorithm for SEVIRI and NOAA-18 data (development, validation and application) (II)

Leonid Roytman;(NOAA Collaborators: Felix Kogan)

Background

This work is part of the CICS/NESDISPO project (Award number 760341001 "Inter-Calibration and Scaling-Up Algorithm for SEVIRI and NOAA-18 data (development, validation and application) (II)". The NDVI could be used to predict the ecological system of the particular earth surface It could also be used to observe any ecological improvement or disaster of a region. So it is a strong tool to protect an environmental downfall by taking necessary action beforehand. It could be used as a monitoring tool to observe periodic improvement of any region. The mainobjective was to tie (inter-calibrate) the SEVIRI climatology data to the NOAA-18 climatology data in order to produce SEVIRI synthetic longer-term time series. In the future it's envisioned to begin with testing all of the experimental GOES-R climatology products based upon the latest results. It will be of particularly great utility to integrate the inter-calibrated SEVIRI data sets in Malaria early detection and monitoring products currently under development at CREST (with the use of NOAA POES data) for several African countries. In summary it's proposed to continue the development of GOES-R products in order to minimize the time needed to fully utilize GOES-R as soon as possible after launch.The proposed approach utilizes the following components

a) Geographic location Selection: Five study sites (within MSG SEVIRI footprint) were chosen from a variety of vegetation types in Africa and Europe (Figure1).

b) Transform Data to allow comparisons: At each stage in this process, the best estimate of the channel radiance should be produced, together with an estimate of its uncertainty. In this process Spectral Matching, Spatial Matching and Temporal Matching criteria will be followed.

c) Filtering: Uniformity Test will be performed to reduce uncertainty in the comparison due to spatial/temporal mismatches. Outlier Rejection will be tested to prevent anomalous observations having undue influence on the results, "outliers' may be identified and rejected on a statistical basis.

d) Statistical Analysis:

The NOAA-18 climatology data overlaid onto SEVIRI data according to the tie point selection by visual interpretation and the resampling procedure of AVHRR data by bilinear interpolation

This allowed us to investigate how biases depend on various geophysical variables and provide statistics of any significant dependence, which can be used to investigate their possible causes. Regression coefficients will be

applied to estimate expected bias and uncertainty for reference scenes in NDVI, accounting for correlation between regression coefficients. The results may be expressed in absolute or percentage bias in NDVI. Any non-linearity in the relative differences between satellites will be characterized, or, at least, limits should be placed on its maximum magnitude.

EDF approach is based on the physical reality, that each Ecosystem may be characterized by very specific statistical distribution, independent of the time of observation. It is the best available technique to normalize satellite data. EDF technique will be used to statistically remove the negative bias.

Accomplishments

Study area consists of five different sites from Africa and European continents. These sites have four different land surface/ecosystem types (Figure1). Data collected by SEVIRI instrument onboard of Meteosat Second Generation (MSG) satellite are used as prototype.

The approach used in the algorithm development includes daily cloud-clearing image compositing as well as pixel-by-pixel image classification using spectral criteria. All available spectral channels (reflectance and temperature) have been tested and used in a statistical-based approach to accurately discriminate between cloudy pixels and VH.

In this study, SEVIRI data recorded at half hour interval was collected and used, and five study stations were chosen from a variety of vegetation types and geo-locations from the Africa and Europe based on data from January, 2005 to December end of 2009.

Normalized Difference Vegetation Index (NDVI) is related to the proportion of photo synthetically absorbed radiation. Many natural surfaces are about equally as bright in the visible red and near-infrared part of the spectrum with the notable exception of green vegetation. The magnitude of NDVI is related to the level of photosynthetic activity in the observed vegetation. In general higher values of NDVI indicate greater vigour and amounts of vegetation. NDVI ranges from -1 to +1 is nonlinear function that varies between -1 to +1 (undefined when NIR and VIS are zero). Values of NDVI for vegetated land generally range from about 0.1 to 0.7, with values greater than 0.5 indicating healthy vegetation. with values 0.5 Different criteria of estimating VHI were set to find the best method for obtaining the best quality and highest values of NDVI and BT on daily base.

Daily and weekly NDVI and BT products are generated using the maximum NDVI (figure 2) compositing algorithms. Daily maximum NDVI values are derived for 3 sites it is seen that most frequently maximum NDVI value is observed from 10 AM to 13 PM local time. The position of the geostationary MSG SEVIRI is fixed; hence pixel reflectance is only influenced by changes in the sun position compared to polar orbiting satellites with both variations in solar and sensor geometry.

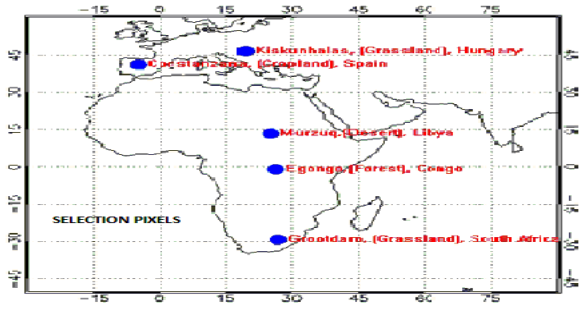


Figure1. Study area in Europe and Africa

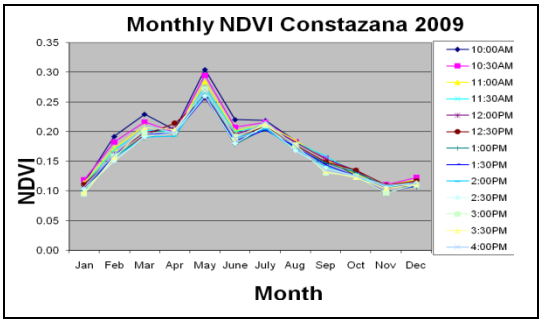


Figure 2. Monthly NDVI for 2009 at Constanzana, Spain, Europe cropland ecology from 10AM to 4PM

Publications

Mohammad Nizamuddin, Leonid Roytman, Mitch Goldberg, and Felix Kogan," "Potential of using satellite remote sensing data for estimation of Aus rice yield in Bangladesh", SPIE Defense, Security, and Sensing which will be held 25-29 April 2011 in Orlando, Florida United States. Paper Number 8027-33 (Accepted)

Mohammad Nizamuddin, Leonid Roytman, Mitch Goldberg, and Felix Kogan,2011 "Modeling and forecasting of malaria vector distribution in Orissa based on AVHRR based remote sensing data" (Still Working on it)

Mohammad Nizamuddin, Leonid Roytman, Mitch Goldberg, and Felix Kogan,2010 "Potential of using remote sensing for forecasting malaria in Tripura, India" (working on it for publication)

Integration soil moisture satellite observations and model simulations into the global crop assessment decision support system of USDA Foreign Agricultural Service

Zhanqing Li & Xin Wang (NOAA Collaborators: Xiwu Zhan & Jicheng Liu) LZLSMSO11

Background

The proposed project aims at enhancing the U. S. Department of Agriculture (USDA) Foreign Agricultural Service (FAS) global crop assessment decision support system via the integration of NASA soil moisture data products and adoption of NASA land surface modeling and data assimilation tools. USDA FAS crop yield forecasts affect decisions made by farmers, businesses, and governments by predicting fundamental conditions in global commodity markets. Regional and national crop yield forecasts are made by crop analysts based on the Crop Condition Data Retrieval and Evaluation (CADRE) Data Base Management System (DBMS). Soil moisture availability is a major factor impacting these forecasts and the CADRE DBMS system currently estimates soil moisture from a simple water balance model (the Palmer model) based on precipitation and temperature datasets operationally obtained from the World Meteorological Organization and U.S. Air Force Weather Agency.

An on-going NASA Applied Sciences project has successfully assimilated NASA Advanced Microwave Scanning Radiometer (AMSRE) soil moisture retrievals into the existing USDA FAS Palmer model to create a global soil moisture analysis product. However, this existing product could be further enhanced in several aspects. First, its reliability is currently limited by the simplicity of the Palmer model. Recent software advances at NASA have led to the development of the Land Information System (LIS) data assimilation system. The modular nature of LIS enables the use of multiple (more physically complex) land surface models and contains an imbedded Ensemble Kalman filter data assimilation capability. As such, LIS provides an optimal framework for the integration of soil moisture products into the USDA CADRE system. Second, concerns over the future availability of AMSRE observations are hindering complete adoption of the approach. To address this need, new satellite sources of soil moisture retrieval products can be exploited to ensure the future continuity of soil moisture to USDA FAS.

The specific objectives of the proposed project will be 1) maintaining the continuity of AMSRE soil moisture to the USDA FAS CADRE system, 2) developing contingency plans for a possible disruption in the availability of AMSRE data during the proposed project period, 3 designing a prototype of the CADRE DBMS system centered around NASA LIS, and 4) developing a LIS-compliant data assimilation system to integrate future soil moisture products from the upcoming NASA Soil Moisture Active/Passive mission into the CADRE DBMS system.

In this task, as a part of the project team, we will be responsible for the number 2) of the above objectives: Develop a contingency capacity for the generation and (near real-time)

delivery of surface soil moisture retrieval products from alternative satellites data sources. We will also assist PI from USDA-ARS and other Co-Investigators form USDA-FAS, NASA-GSFC) on assimilating the alternative soil moisture data into NASA LIS to routinely provide USDA-FAS with global soil moisture analysis data products.

Accomplishments

Mr. Xin Wang has just arrived at ICCS from China to start to work on the project on April 3, 2011. Collaborating with Drs. Xiwu Zhan and Jicheng Liu, he is carrying out the following tasks in the first half year of his one year visit to UMD:

1) Improve the NASA AMSR-E soil moisture data product with alternative retrieval algorithms;
2) Make available alternative global soil moisture data products from the Microwave Radiometric Imager (MWRI) on board of FengYun-3 satellite of China Meteorological Administration that is planned to be one of the contingency sensor for the satellite soil moisture data product for the USDA-FAS applications.

For the second half of his one year visit, Mr. Wang will
1) Test data assimilation algorithms implemented in LIS for generating root-zone soil moisture data;
2) Validate the various soil moisture data products with available in situ measurements.

Publications:

Two journal papers are planned from the results of the above stated tasks. Based on these results, Mr. Wang will complete his Ph.D. degree dissertation.

General Support and Preparation for the Transition of CERES/ERB Processing System to NOAA/NCDC Operation

Zhanqing Li (NOAA Collaborator: Tom Zhao) ZLZLCERES11

Background:

Earth radiation budget products include both solar-reflected/absorbed and Earth-emitted radiation from the top of the atmosphere (TOA) down to Earth's surface. Determination of Earth's radiation budget (ERB) components from satellite measurements requires intensive data processing as well as radiative transfer modeling efforts, especially for the determination of ERB in the atmosphere and on the surface. The NOAA's mission of Scientific Data Stewardship (SDS) Program was created for generalization, application and validation of mature algorithms over multiple satellites and sensors to produce long-time series of climate-relevant data and information. These climate data records (CDRs) will have sufficient accuracy through refined instrument calibration and improved retrieval algorithms so that they can be used for climate change studies and applications. The focus of our study is to provide a general scientific support for developing and implementing a robust, sustainable and scientifically defensible Earth radiation budget datasets from CERES, ERBE etc.

Accomplishments:

1) Attended the Workshop on Continuity of Earth Radiation Budget (CERB) Observations: Post-CERES Requirements science team meeting, and interact with the members of the team in an effort to write the .
2) Wrote part of a report to instrumentation and algorithms concerning the Earth Radiation Budget (ERB) and the transition of CERES/ERB processing system to NCDC operation
3) Provided consulting service to the NCDC/CDR program to a) identify the purposes and current uses of Earth radiation budget observations, b) document the current status of research and applications of Earth radiation budget; c) identify observing system requirements for the continuity of the Earth radiation budget climate data records (CDR).

Accuracy of the ERB and its components depends not only on the accuracy to which observing instruments have been calibrated, but to a large degree on the accuracies of input data and the inversion models used. It is therefore essential that we have the best possible models and input data in order to minimize the errors in the radiation budget data products (see Table 4.1). Surface radiation budget (SRB) has been estimated from limited ground based observations and global satellite measurements, but important discrepancies still exit even among the recent satellite-based estimates. These discrepancies are, however, much smaller than the systematic differences that used to exist between models and observation based estimates. We have extended the survey study of Li et al. 1997 to document all the

estimates of ERB and its disposition between the atmosphere and surface in both shortwave and longwave bands as shown in the following table.

Comparison of historical estimates of the solar energy deposition estimated from ground and/or satellite observations (After Li et al. 1997 with updates).

Comparison of historical estimates of the solar energy deposition estimated from ground and/or satellite observations (After Li et al. 1997 with updates).

Sources	Coverage	TOA	Surface	Atmosphere
Abbot & Fowle (1908)	NH	0.37	0.42	0.21
Houghton (1954)	NH	0.34	0.47	0.19
London (1957)	NH	0.35	0.48	0.17
Sasamori et al. (1972)	SH	0.35	0.45	0.20
Budyko (1982)	Global	0.30	0.46	0.24
Pinker & Laszlo (1992)	Global	0.29	0.50	0.21
Ohmura & Gilgen (1993)	Global	0.30	0.42	0.28
Li & Lighton (1993)	Global	0.30	0.46	0.24
Rossow & Zhang (1995)	Global	0.32	0.48	0.19
Kiehl and and Trenberth (1997)	Global	0.31	0.49	0.20
Zhang et al. (2004)	Global	0.31	0.48	0.21
Loeb et al. (2009a), Kato et al. (2008)	Global	0.29	0.49	0.22
Trenberth et al. (2009)	Global	0.30	0.47	0.23
Stackhouse et al. (2010)	Global	0.30	0.49	0.22

Publications:

Reports of the Workshop on Continuity of Earth Radiation Budget (ERB) Observations: Post-CERES Requirements, Asheville, North Carolina, July 14-18, 2010, (eds. J. Bates and T. Zhao), pp41.

Development of Algorithms for Shortwave Radiation Budget from GOES-R

R. T. Pinker (NOAA Collaborator: M. Goldberg) – RPRPGOESR21

Background

Under the GOES-R activity, developed are new algorithms for deriving surface and Top of the Atmosphere (TOA) radiative fluxes from the ABI sensor. This project supports the development and testing of this STAR effort. Specifically, scene dependent narrow-to-broadband transformation and angular distribution models (ADM) are developed, to facilitate the use of observations from ABI. The n/b transformations are based on theoretical simulations with MODTRAN 3.7 using the International Geosphere-Biosphere Programme (IGBP) land use classifications. The newly developed ADMs are a combination of MODTRAN 3.7 simulations and the Clouds and the Earth's Radiant Energy System (CERES) observed ADMs. The current focus is on validation and improvement.

Accomplishments

Following is a brief summary of issues encountered and solutions:

- A large bias in fluxes occurred for optically thick ice clouds. We completed additional simulations of ice clouds, including altostratus clouds. We determined that the best way to implement the n/b coefficients for MODIS is to use water cloud coefficients when the COD reported for MODIS ice clouds is > 5.
- Unrealistically high n/b coefficients were calculated for certain channels of MODIS data (mainly 1.6 and 2.1 μm). Since there are only 20 cases used per regression we have combined all viewing and azimuth angles and stratify the coefficients by solar zenith angle (SZA); this improved the results. Figure 1 shows a comparison of CERES TOA SW upward fluxes against those derived from MODIS using three channels (0.4, 0.6, and 0.8 μm). We chose these channels for the official algorithm, but we developed and began testing 12 different channel combinations to provide more flexibility when certain ABI channels may be missing or become noisy. Evaluation is still in progress.

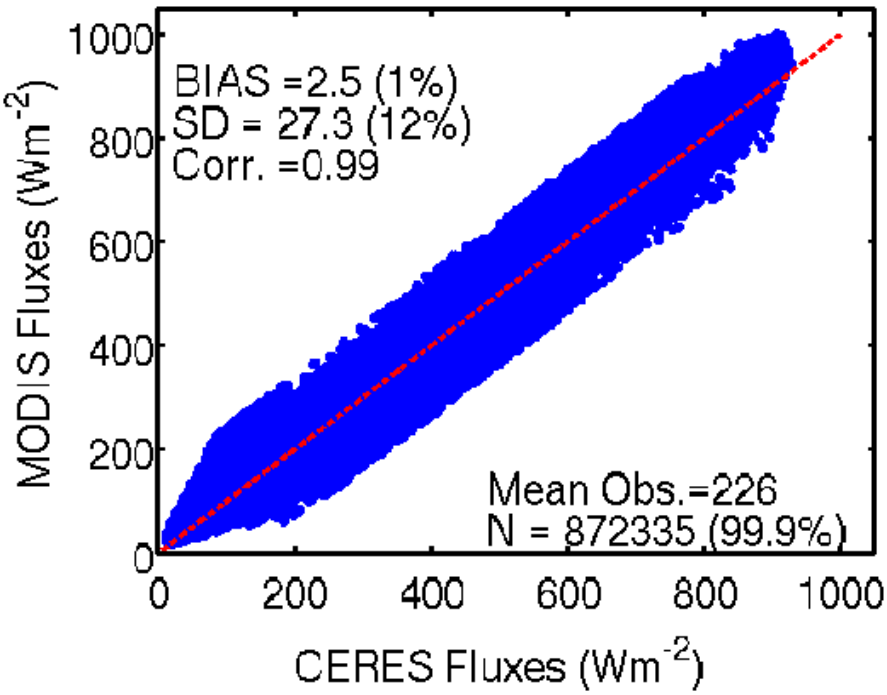


Figure 1.Evaluation of MODIS and CERES top-of-the-atmosphere shortwave upward fluxes from all data available during the hours of 0- 23 UTC on July 8, 2006. A small fraction of data (0.1%) is eliminated from the comparison, where the differences between estimated MODIS fluxes and observed CERES fluxes were larger than five times the standard deviation of the differences.

Deliveries

Updated input data, code, and documentation for developing NTB coefficients with MODIS proxy data on 6/25/2010. This set of coefficients was stratified by SZA only and used 3 channels. Updated ATBD on 6/30/2010.

Publications from project

Niu, X., R. T. Pinker, 2010. Improved Narrow-to-Broadband Transformations and Anisotropic Corrections for Satellite Estimates of Radiative Fluxes. IJRM, in press.

General References:

Loeb, N. G., N. M. Smith, S. Kato, W. F. Miller, S. K. Gupta, P. Minnis, and B. A. Wielicki, 2003. Angular Distribution Models for Top-of Atmosphere Radiative Flux Estimation from the Clouds and the Earth's Radiant Energy System Instrument on the Tropical Rainfall Measuring Mission Satellite. Part I: Methodology. Journal of Applied Meteorology, 42 (February 2003), 240-265.

Minnis, P., P. W. Heck, D. F. Young, C. W. Fairall, and J. B. Snider, 1992: Stratocumulus cloud properties derived from simultaneous satellite and island-based instrumentation during FIRE. J. Appl. Meteor., 31, 317-339.

Rutan, D., F. Rose, M. Roman, N. Manalo-Smith, C. Schaaf, and T. Charlock, 2009: Development and assessment of broadband surface albedo from Clouds and the Earth's Radiant Energy System Clouds and Radiation Swath data product. J. Geophys. Res., 114, D08125, doi:10.1029/2008JD0

Support for NOAA's GOES-R Algorithm Working Group Ocean Dynamics

A. Harris; (NOAA Collaborator: Eileen Maturi) – AHAHGOESR11

Background

The GOES-R ABI Ocean Dynamics Products Algorithm (ODPA) employs a sequence of a single spectral band images to derive the Ocean Dynamics product. These images will be used to track ocean motion in cloud free areas over time, either directly using ABI window bands or employing retrieved sea surface temperature data.

The algorithm will utilize the ABI data to derive an ocean motion. The ODPA will generate products over the various ABI Full Disk (FD), Continental United States (CONUS), and mesoscale scans. Currently, the ODPA employs a sequence of ABI images to estimate ocean motion for a set of targeted tracers in cloud-free areas.

The goal of this task is to develop and evaluate algorithm toward requirement for ABI Ocean Surface Currents (OSC) product generation. This task will provide science codes to the GOES-R algorithm integration team (AIT) for software implementation and process demonstration.

Accomplishments

The ODPA developed for the GOES-R ABI instrument has its heritage with the Atmosphere Motion Vectors algorithm being used operationally today at NOAA/NESDIS for the present series of GOES satellites (Breaker et al, 2005; Castelao et al, 2005, 2006). The Ocean Dynamics algorithm is based upon the Sum of Squared Distances (SSD) Method that the Derived Wind Product Algorithm (DWPA) has also used at NOAA/NESDIS for deriving Atmospheric Motion Vectors (GOES-R ABI Derived Motion Winds ATBD; Merrill et al, 1989, 1991; Nieman et al, 1997, Velden et al, 2005).

The following steps are carried out in the process of generating the Ocean Dynamics product:

1. Collect three consecutive calibrated, navigated, and co-registered images for the same area of observations in predetermined spectral channels;
2. Locate and select a suitable cloud free targets in the second image (middle image; time=t0) of image triplet;
3. Use a pattern matching algorithm to locate the cloud free targets in an earlier and later image;
4. Compute corresponding displacement vectors for the targets from their original locations for each image pair of the triplets;
5. Compute mean vector displacement (average from speeds derived for each pair) valid at time = t0;

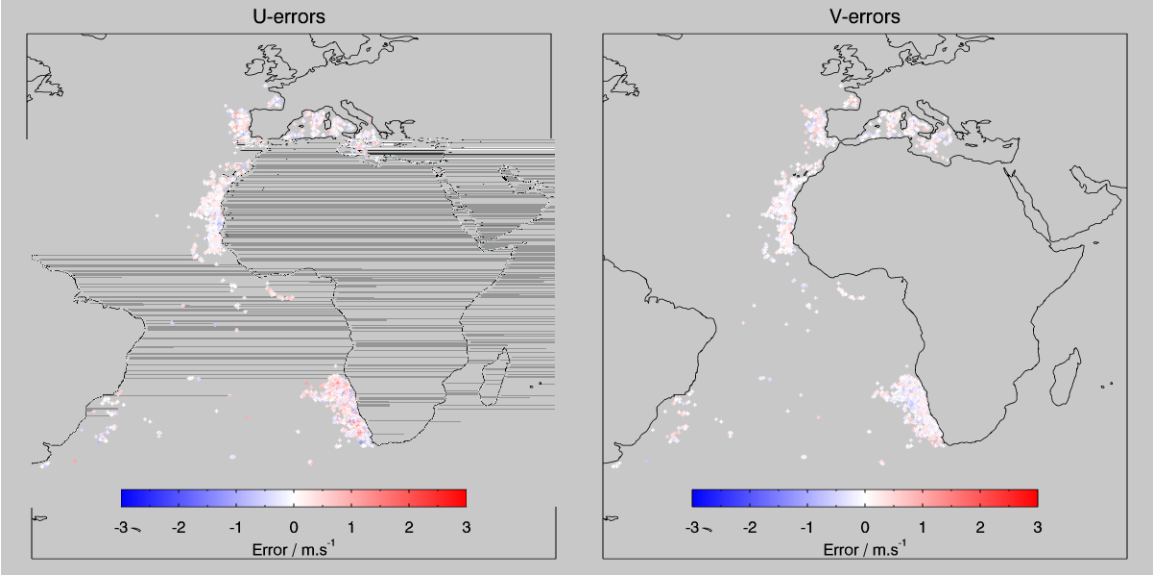


Figure 1. Locations and magnitudes of current U&V component biases w.r.t. Navy Global NCOM. As can be seen, while the V-component shows relatively little bias, the U-component displays a significant geographical preference.

6. Perform quality assurance on ocean motion vectors. Flag suspect vectors. Compute and append quality indicators to each vector. If the quality of the vectors is poor, then the vectors are removed from the output and are not included in the results.

First year work has showed that, while the 80% target for accuracy were largely being met after the application of quality control measures based on a feature gradient strength metric, there is potential scope for improvement (see Figure 1).

Proposed work

We will conduct an objective validation study of the ABI OD algorithm. This may involve comparison of: 1) Ocean Surface Currents using heritage GOES SST as input, with 2) co-located data and/or coastal ocean radar and 3) ocean circulation models. Additional validation work involves utilizing heritage GOES IR and ABI Proxy (Meteosat SEVIRI) data. A study of the effect of clouds and the GOES AWG Cloud Mask on the accuracy on the OD algorithm will be performed. Validation work will be extended to estimate the relative contribution of geolocation/colocation errors in the proxy data, and assess the independent uncertainty associated with intrinsic algorithm performance. The objective validation study, as well as an Algorithm Implementation and Test Plan, will transition into the development of Validation Tools for the Ocean Dynamics algorithm. Statistical analysis will be performed on a near-realtime basis. Specific program tasks also include development of the 100% requirement algorithm and preparation of its associated algorithm theoretical basis document.

Publications

GOES-R Advanced Baseline Imager (ABI) Algorithm Theoretical Basis Document For Ocean Dynamics, NOAA NESDIS Center for Satellite Applications and Research, September 3, 2010

Studies In Support Of NOAA's POES-GOES SST Analysis

A. Harris; (NOAA Collaborator: Eileen Maturi) – AHAHPOES11

Background: Scientific Problem, Approach, Proposed Work

NESDIS have been in the process of developing a new high-resolution (0.1°×0.1°) global SST analysis to replace the previous 10-km, 50-km and 14-km (regional) products. The new scheme, which uses a recursive estimator to emulate the Kalman filter, also provides continuously updated uncertainty estimates for each analysis grid point. Since the analysis is entirely satellite-based, there is no explicit attempt to correct regional biases to an in situ standard. However, biases between individual datasets are corrected in a statistical manner, with certain assumptions of persistence and correlation length scale. This past year, work has primarily focused on the testing and implementation of a 0.05°×0.05° resolution of the analysis.

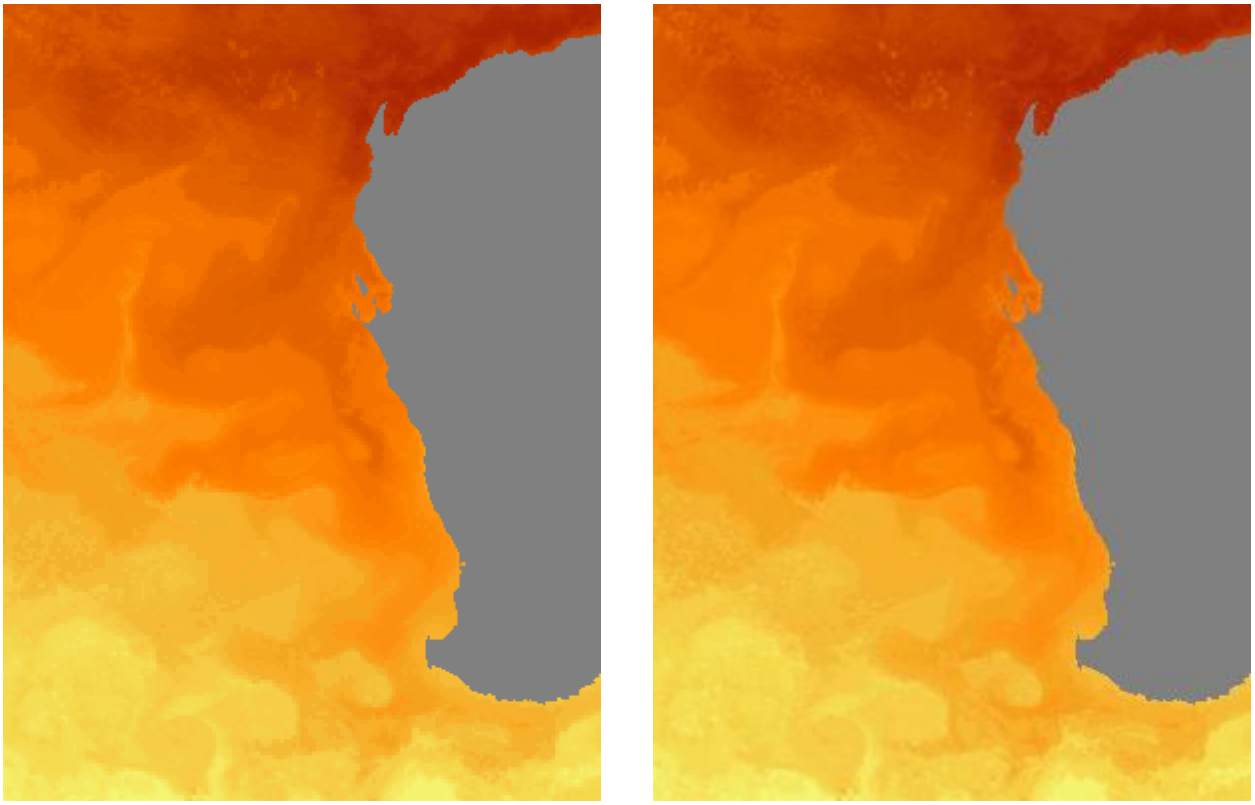


Figure 1. 0.1 degree resolution SST analysis (left) compared with 0.05 degree resolution SST analysis (rig Features are better defined in the higher resolution analysis, although the vast majority are still resolved in the 0.1 degree analysis.

Accomplishments

The analysis code has been adapted to operate at double the resolution of the previous analysis (see Figure 1). The opportunity was taken to clean up the software, including removal of several hard-coded elements, especially those relating to changes in resolution. This required development and testing of generalized scaling routines. While operational implementation has been delayed due to IT security related issues at OSPO, the various key elements for the 0.05°×0.05° resolution of the analysis, including a new land mask and redefined ocean basins, are now available. Additional analysis variants have been developed include a polar-only version of the analysis to replace the old NOAA twice-weekly polar-only 50 km analysis, as well as 1-day nighttime polar-only and 3-day nighttime polar-only versions for NOAA's Coral Reef Watch program. Finally, the analysis is being made available in GHRSST L4 format for the international user community.

Proposed work

Next year's effort will primarily be directed at the inclusion of AMSR-E passive microwave SST data and the development of a bias correction system which includes the use of the Along-Track Scanning Radiometer. The former task is important in order to address issues with regions of persistent cloud cover, whilst dealing with an observation system which has a coarser footprint than the analysis resolution. The latter task is necessary in order to obtain a measure of independence from the NCEP operational SST analysis (RTG_SST) which has occasionally been a source of bias in our POES-GOES Analysis.

University of Maryland Center of Excellence in Data Assimilation

J.A. Carton (NOAA Collaborators: Steve Lord) JCJCUMCED11

Background

This is a proposal to continue development of a world class center of excellence in data assimilation education/research at the University of Maryland by expanding our academic capabilities through the hire of a faculty member in this critical area. The demand for students with scientific training in atmospheric and oceanic science is high due to the increasing recognition of the impacts that weather, climate, and the environment have on our lives. Within atmospheric and oceanic science data assimilation is a key area of technology which combines information obtained from environmental sensors with that obtained from numerical simulation to provide a 'best estimate' of the evolving earth system – North American weather, or Gulf of Mexico currents, for example. Data assimilation thus links together expertise in the fields of applied mathematics and numerical analysis with such earth science disciplines as meteorology, physical oceanography, and hydrology.

Accomplishments

A search committee was formed consisting of three University of Maryland faculty and two NOAA scientists (Sid Ahmed Boukabara and Stephen Lord). We received about 20 excellent candidates. The search committee met on February 10 and chose a tentative short list of 4 candidates. Additional independent letters were solicited. After review by the Search Committee and the Department of Atmospheric and Oceanic Science faculty a recommendation was forwarded to the Dean who has accepted it. We are now in the final stages of negotiations with the candidate and expect to have someone in place by July 1.

Exploration of an advanced ocean data assimilation scheme at NCEP

J.A. Carton and E. Kalnay (NOAA Collaborators: Steve Lord and David Behringer)
PAJCEAODA11

Background

This is a proposal to explore improvements to the 3DVar filter used in the Global Ocean Data Assimilation System by development of a hybrid filter through a UMD/NCEP collaboration. The hybrid approach we propose is that of (2007a,b; 2008a,b) in which the error covariance matrix is determined as a weighted average of the original 3DVar and the flow-dependent error covariance determined by a set of ensembles.

In designing the hybrid filter we are guided by several principles. The first is that the new filter should build on the current 3DVar with minor software extensions. The second is that the results of the new filter must be at least as good as the 3DVar, even before any tuning. The third is that while the new filter will require additional computer time, the time required should be significantly less than for a full ensemble Kalman Filter or 4DVar.

Accomplishments

The first step in exploring hybrid schemes is to develop the individual schemes. As part of his dissertation research a student from the Math Department, Steve Penny, has implemented the Local Ensemble Transform Kalman Filter (LETKF) in a course (1^o) resolution global ocean model using MOMV2 numerics, along with a widely used 1-D based data assimilation scheme (SODA). Steve has carried out a series of intercomparison studies indicating significant improvement of LETKF over SODA (which in turn is algorithmically similar to NCEP's GODAS). For example, **Fig. 1** shows that the LETKF using a time initialization scheme called running in place has RMS observation minus analysis temperature errors of 0.5°C while they are 0.8°C for SODA. Curiously, the widely used Incremental Analysis Updates gives poorer results.

In order to apply LETKF to the ocean Steve has carried out a number of algorithmic developments, detailed in his dissertation, for example relating to the need to 'inflate' the variance of the ensemble so that its statistics provide a realistic measure of the forecast error. The introduction of an ensemble filter comes at significant cost, also detailed in his dissertation, may be an issue when this approach is applied to the high, eddy permitting resolution, NCEP model.

Steve successfully completed his dissertation on April 25 and is now, a week later, transitioning to a postdoctoral position where he will work directly with David Behringer on the introducing an ensemble filter into GODAS in preparation for his work on hybrid schemes. He is also beginning the task of writing up his dissertation work for publication.

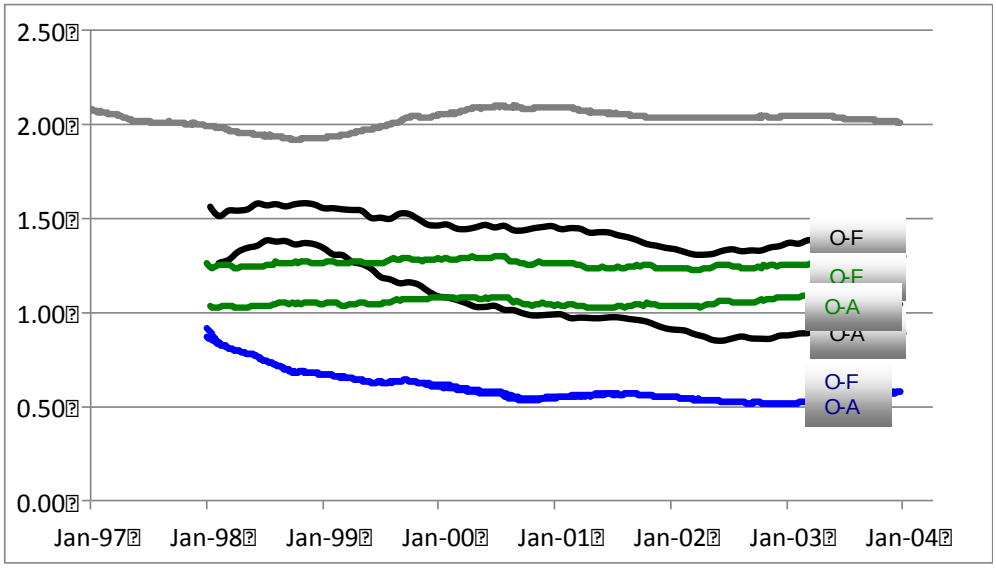


Figure 1 Comparison of RMS observation-minus-forecast and observation-minus-analysis differences for global data assimilation experiments using Optimal Interpolation (similar to 3DVar, green) and the Local Ensemble Transform Kalman Filter (black, IAblue, running in place) for the seven year period 1997-2003. Grey line shows results from simulation. Vertical axis is temperature (°C). Here differences are summed over all depths.

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Wang, X., T. M. Hamill, J. S. Whitaker and C. H. Bishop, 2007b: A comparison of hybrid ensemble transform Kalman filter-OI and ensemble square-root filter analysis schemes. Mon. Wea. Rev., 135, 1055-1076.

Wang, X., D. Barker, C. Snyder, T. M. Hamill, 2008a: A hybrid ETKF-3DVar data assimilation scheme for the WRF model. Part I: observing system simulation experiment. Mon. Wea. Rev., 136, 5116-5131.

Wang, X., D. Barker, C. Snyder, T. M. Hamill, 2008b: A hybrid ETKF-3DVar data assimilation scheme for the WRF model. Part II: real observation experiments. Mon. Wea. Rev., 136, 5132-5147.

A Retrospective Analysis of IPCC TAR & FAR Model Projections of Sea Level Rise

J.A. Carton; (NOAA Collaborator Laury Miller)JCJCSIPCC11 Supplement

Background

Observations of global sea level, available since 1991, have shown a rise of over 3mm/yr, significantly in excess of the 100yr average rise of under 2mm/yr IPCC projections are quite uncertain, but suggest that these numbers may grow alarmingly in the next century. Part of the concern has to do with the possibility of local regions such as the eastern United States, where sea level rise may substantially exceed the global average due to a combination of post glacial rebound, changing currents, and warming of the mid-depth ocean associated with changes in the meridional overturning circulation ( ). Within NOAA GFDL has extensive commitment to producing coupled climate model projections and are adding physical processes such as those controlling continental ice melt and the ocean freshwater budget for the purpose of providing more accurate sea level projections. Observational data related to sea level is maintained at NOAA's Laboratory for Satellite Altimetry (satellite altimetry), National Ocean Survey (tide gauges), and National Ocean Data Center (subsurface temperature). The purpose of this work is to bring together the model projections and the observations to learn about the processes regulating sea level rise and thus the accuracy of future projections.

Accomplishments

An initial study of sea level rise in the Southern Ocean, as it appears in the IPCC AR4 projections and in observations has been carried out and is being prepared for publication. The Southern Ocean is of particular interest because sea level has risen by as much as 6mm/yr in the past fifteen years, well above the global average (**Fig. 1**). We are in the process of recruting a postdoctoral fellow who will carry this work forward (the hire has been delayed as our first candidate turned us down and we decided to repeat the search).

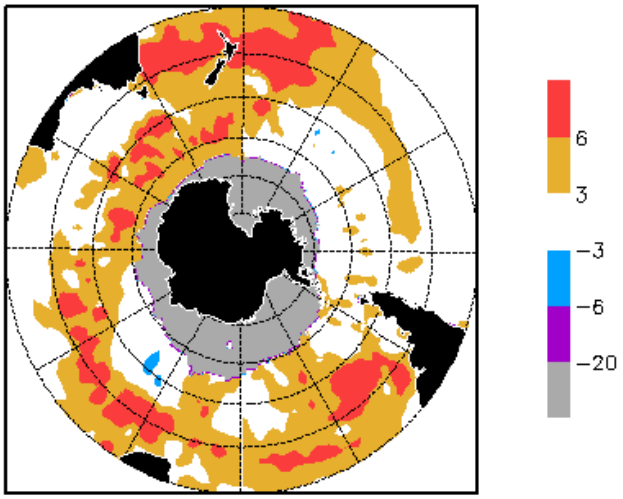

Fig. 1 Observed sea level rise (mm/yr) based on combined monthly altimetry 1993–2007. Seasonal maximum ice distribution is shown in grey. The effects of post-glacial rebound have not been included.

References

Yin, Jianjun, Stephen M. Griffies, Ronald J. Stouffer, 2010: Spatial Variability of Sea Level Rise in Twenty-First Century Projections , **23**, 4585–4607. doi: 10.1175/2010JCLI3533.1

Diel Cycles in Aerosol Optical Properties: Aircraft Profiles in Support of the GOES-R Mission

R.R. Dickerson (NOAA Collaborator: Shobha Kondragunta, NESDIS/STAR/GOESR11)

Background

The composition of the atmosphere (trace gases and aerosols) has a profound effect on human health, visibility, and the Earth's radiative properties. Aerosol optical depth (AOD) observed from satellites can provide a view broad in space and time, but the accuracy of retrievals for varying surface properties, and varying aerosol optical properties, as well as the relationship between remotely sensed AOD and surface concentration of PM2.5 (in mass per unit volume, called suspended matter in GOES-R ATBD&PS requirements document) remain as major unanswered questions in atmospheric science (EPA, 2009).

Accomplishments

In the first half of this one-year seed grant from the GOES-R Program, we flew several missions with the UMD research aircraft, coordinated with surface-based remote-sensing, in support of GOES-R observations. New aircraft measurements and tests over the Mid-Atlantic region included:

- Aerosol absorption at 7 wavelengths (borrowed Aethalometer)
- Demonstrated pressure-independence of CRDS measurements of NO_2
- Successful testing of the aerosol inlet and filter system.
- Supported the surface based NO_2/SO_2/AOD campaign in Frostburg, MD.
- Planned aircraft support of the DISCOVER-AQ mission to be conducted in and around Baltimore and Washington, D.C. in July 2011.
- Conducted preliminary comparisons of proxy GOES-R ABI retrievals with UMD aircraft profile data.

The new isokinetic inlet (Figure 1) allows the detection of aerosols up to 5 μm in diameter, and the new 7-λ Aethalometer provides information on the vertical distribution of light absorption due to aerosols over a broad spectral range. With separate funds we are purchasing a new Aethalometer for use during NASA's DISCOVER–AQ this summer.

The bulk of this research will be performed this July in conjunction with NASA-B and Kingaire aircraft as they fly over the Mid Atlantic region to evaluate satellite measurements of trace gases and aerosols. These combined with the historical data set of aircraft profiles provide for estimates of aerosols for retrievals from satellite measurements. The altitude integral of aerosol extinction provides the aerosol optical

depth (AOD). A proposal for additional flight hours and research has been submitted to NOAA.

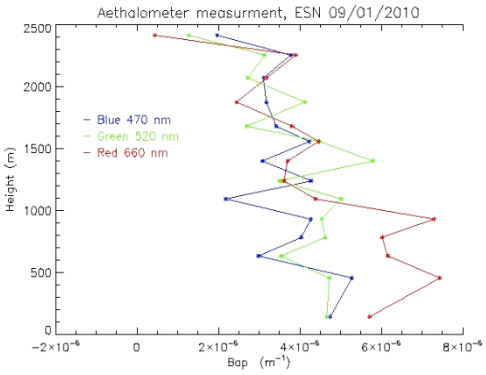

Figure 1. Left, Cessna 402B with aerosol inlet that has a 50% passing efficiency for 5 µm particles [, 2004; , 2007]. **Right,** results of a test flight showing absorption coefficient as a function of altitude over Easton, MD; for clarity only three wavelengths are shown.

With our NOAA colleagues, we have taken initial steps toward validation and improvement of GOES-R ABI AOD/Suspended Matter retrievals. The aircraft data extant and to be collected during the proposed field campaigns will be used to validate the GOES-R ABI aerosol products using the approach shown in Figure 2. Aircraft profiles of aerosol extinction should ideally be matched with GOES-R ABI AOD within a window of five to fifteen minutes to obtain a clear view (a composite can be created using multiple snapshots of ABI) co-located with aircraft profile and integrated to compare AODs. Because MODIS is being used as a proxy for ABI, we have limited matchups. For example, for the seven aircraft flight profiles available on June 10, 2010 only two matchups were obtained for ABI retrievals whereas for GOES we obtained 6 matchups. The example profile shown in Figure 2 uses GOES-12 AODs (a composite over 3-hr temporal window to obtain clear views) with an aircraft aerosol extinction profile overlaid. The aircraft extinction profile is integrated to obtain AOD and compared to GOES AODs and ABI AOD/suspended matter generated using MODIS radiances as proxy for ABI.

Initial results will be presented at the Fall AGU meeting in a session convened by the PI entitled: REMOTE SENSING OF TRACE GASES AND AEROSOLS: AIR QUALITY APPLICATIONS

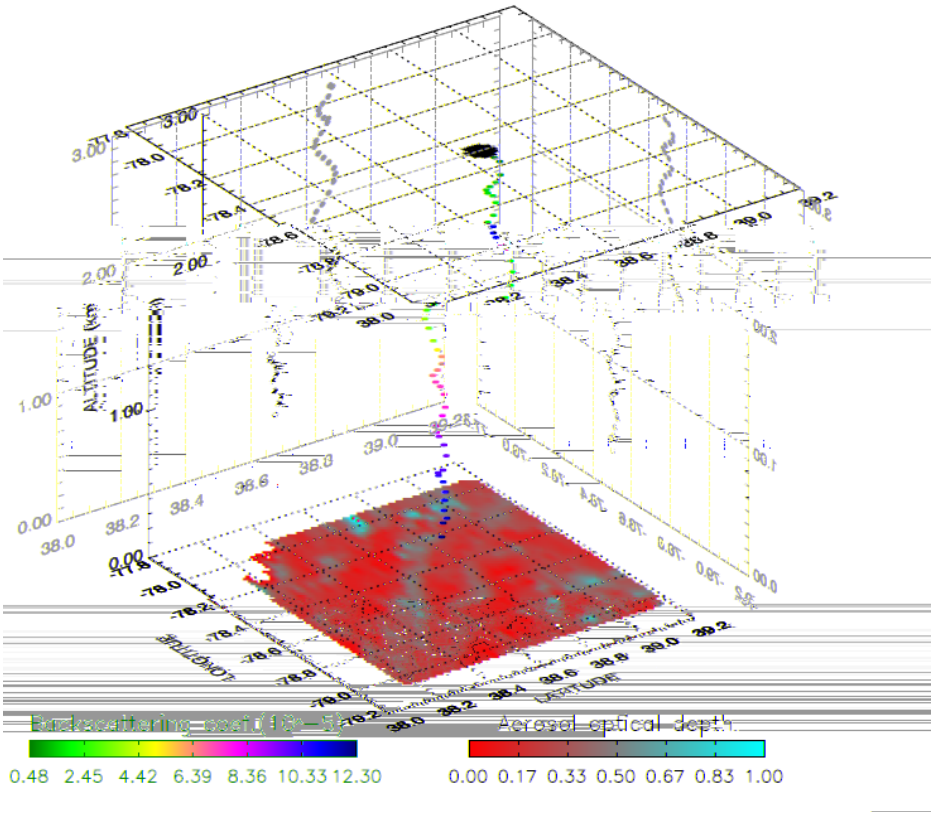

Figure 2. Sample aircraft profile of aerosol extinction obtained by UMD aircraft measurements on June 9, 2011 superimposed on the 2D Field of GOES AOD. The GOES AOD composite was created from a 3 hour window around the aircraft profile measurement time.

Development of a 4-km snow depth product for the version 3 Interactive Multi-Sensor Snow and Ice System (IMS)

Cezar Kongoli (PI); (NOAA Collaborators: Sean Helfrich) CKPRAPSDI11

Background

The project goal is development of a new operational 4-km spatial resolution snow depth product over the Northern hemisphere and its integration into an enhanced IMS platform. This is a first-of-its kind snow depth product for two main reasons: First, it blends in-situ, satellite and analyst inputs of SD in an optimal fashion and second, it would be the first high resolution SD monitoring product with a global coverage. The justification for product

confidence over specific pixels as determined by the analyst's available information. This analyst input will be re-evaluated by the automated algorithm and optimally blended with other data streams (if available) for producing the final SD product.

- **Preliminary software architecture.** A software directory system called _____ has been set up temporarily on STAR's orbit095l @ _____ local subdirectory. Source code is being developed for the SD processing in Fortran 90/95, for input/output mapping in IDL and for software implementation in Unix Shells. Figure 1 below depicts algorithm data flow of the generation of the SD product.
- **Processing** of daily 4-km IMS output files. The daily IMS ASCII files are currently being ftp-ed to and processed at orbit095l from the OSDPD server. The processing of IMS snow cover is needed to determine snow-covered pixels for SD processing algorithm.
- **Processing** of ancillary 4-km elevation data. These elevation files were put together from the processing of USGS GTOPOG30 data. The processing of elevation information is needed for the SD processing algorithm.
- **Processing** of daily SYNOP snow depth reports. Currently, these data are being obtained from McIDAS and US Cooperative Stations reports.
- **Mapping** of 4 km IMS output, Elevation and SYNOP and COOP snow depth reports.
- **Partial processing** of historical SD/SWE reports for the period 2005 – current for (off-line) climatological analysis. Such an analysis is being conducted to determine spatial structure and statistical parameters (correlation and summary statistics functions) needed for near-real time SD processing of surface reports.
- **Partial coding** for the OI scheme. Figure 2 depicts a snapshot of the spatial interpolation of SD in-situ stations and associated error fields generated from the processing of in-situ SD stations only. Work continues to fine-tune and further test the optimal interpolation method over other areas. Note that the microwave-SD processing is another data stream (not started yet).

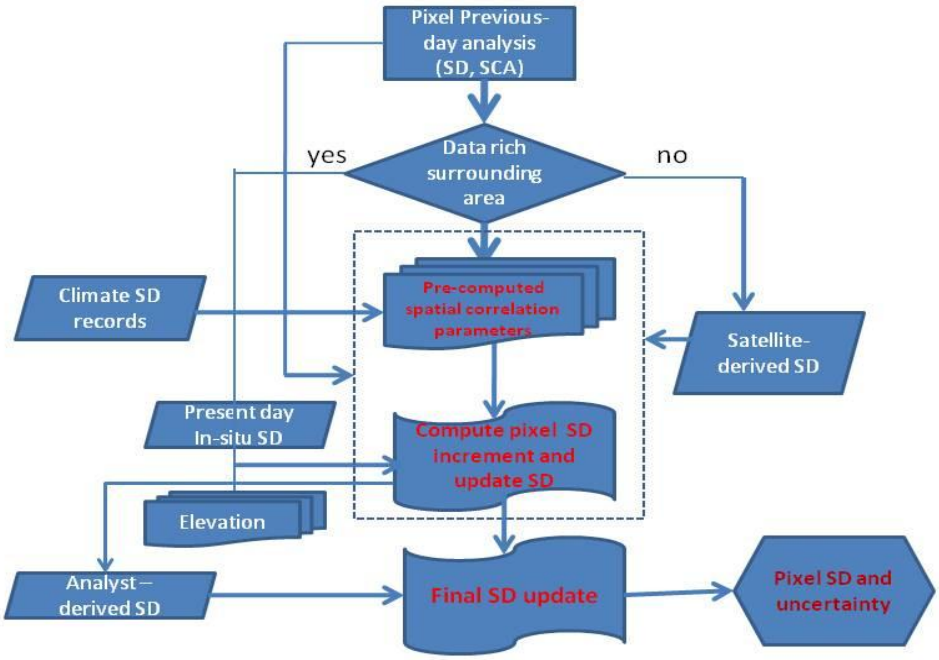

Figure 1. Data flow for the generation of the IMS Snow Depth.

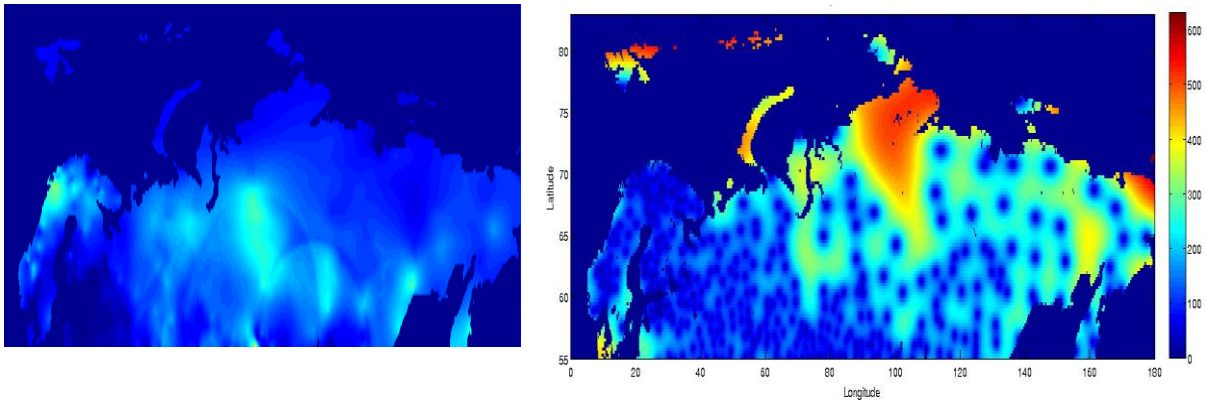

Figure 2. A snapshot of spatial interpolation of in-situ SD stations (top) and corresponding errors (bottom) generated by the optimal interpolation method.

Development of Longwave Radiation Budget Products for GOES-R ABI Instrument

H.-T. Lee, A. Gruber (; NOAA Collaborator: I. Laszlo -) HLHLGOES R11

Background: Scientific Problem, Approach, Proposed Work

This work supports the GOES-R Algorithm Working Group tasks for the development and validation of three longwave radiation budget (LWRB) products for the Advanced Baseline Imager (ABI) instrument.

The GOES-R LWRB products include the outgoing longwave radiation flux density (OLR) at the top of the atmosphere and the downward and upward longwave radiation flux density (DLR and ULR) at the Earth's surface. FY10 activities include algorithm development, validation, and documentation activity leading up to delivery of an Algorithm Package (AP) to the GOES-R Ground Segment Project (GSP) on September 30, 2010; and Development of product validation "tools" that include those targeted for use in operations (routine tools) and in STAR (deep dive tools.

Accomplishments

Summary

The LW ERB products are the Option 2 products whose schedules are initially one year behind the Baseline products. Since the early start of the OLR algorithm development, we have moved forward and aligned the LW ERB schedule to the Baseline shortwave ERB products.

The LWERB algorithms have been developed, validated, coded in Fortran, and implemented into the framework for system integration testing. All three algorithms have met the 100% F&PS requirements. The 100% code package and ATBD documents are completed and delivered. The software bug found through the second two-week framework run has been corrected and tested. The validations of four-month framework test run for all DLR and ULR have been performed, showing expected results. The version 1 validation tools have been delivered and the version 2 tools are current under development. The Technical Readiness Review (TRR) and Code Unit Test Review (CUTR) have been completed. The Algorithm Development Executive Board (ADEB) review and Algorithm Readiness Review (ARR) were completed. The Responses to ADEB comments on LWRB products will soon be submitted. We continue to provide the LWRB Algorithm Verification and Validation (V&V) support.

DLR Ver.4 Algorithm Development

The v4 DLR algorithm is validated with the operational GOES 11/12 Sounder retrievals from Jan 1 to Sept 30, 2008. The ground-truth reference is the up-looking PIR observations obtained from seven sites in the SURFRAD network. The lapse rate constraint is added to prevent overestimation over super hot surfaces.

Table 1 summarized the current assessment of performance and Figure 1 shows scatter plot of the DLR generated with v4 algorithm compared to the SURFRAD ground observations.

Table 3 Validation results for the DLR retrievals over homogeneous clear sky scenes.

	Mean (Wm^2)	STD (Wm^2)	RMS (Wm^2)	N
Satellite minus Ground	-6.8±0.2	12.5	14.2	2813

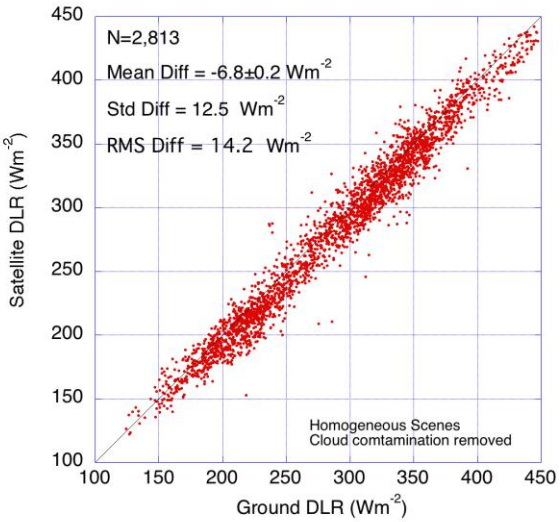

Fig. 1 Comparison of GOES Sounder-based DLR estimates against SURFRAD observations for homogeneous clear sky scenes (Nine-month offline validation)

Validation of LW ERB Products for Four-Month Framework Run

ULW and DLW

The Sfc LW ERB Product (ULW and DLW) has been produced by the 4-month framework runs. The validation using routine validation tools and deep dive tools were performed.

The ULW is shown to meet F&PS requirements (see Figure 2 and Table 2). The DLW, however, is not. We suspect the poorer performance of the DLW can be attributed to quality of the near surface retrievals in the MODIS profile product.

The complementary validation for DLW using offline retrievals with operational GOES sounding products is undergoing.

OLR

The framework run for OLR is not available yet.

Table 2. Summary of ULW validation results for the four-month framework runs over seven SURFRAD stations (product horizontal resolution is 25 km)

Four-Month Framework Run			**F&PS Requirements**	
Number of cases	Bias (Wm^{-2})	Std Deviation (Wm^{-2})	Accuracy (Wm^{-2})	Precision (Wm^{-2})
1790	-5.1	19.3	30	20

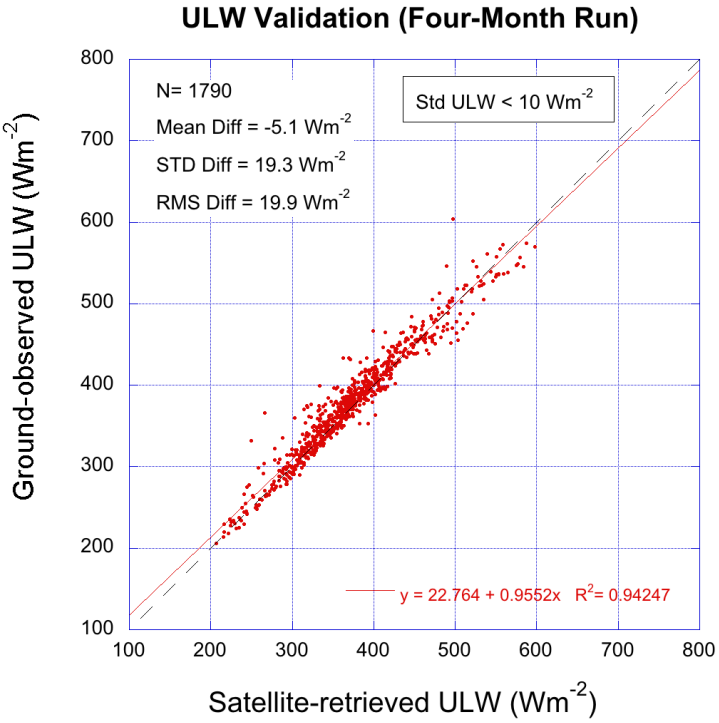

Figure 2 Scatter plot of satellite retrieved ULW versus SURFRAD ground observations from all stations in homogenous condition.

Planned Work

The planned works for the next year include:

- Completion of ADEB 80% to 100% Reviews.
- Continuation of the development of Routine and Deep Dive validation tools.
- Performing algorithm validations with extended data sets (for seasonal representation)
- Preparation of validation documentations

- Continue algorithm refinement and error identification (for OLR and DLR algorithms)
- Continue support of AIT framework test
- Continue support of Verification and Validation (V&V)
- Continue support of Vendor product and validation (TIM)

Publications & Presentations

Lee, H.-T., A. Gruber, and J. Lee, 2009: Recent improvements in the HIRS outgoing longwave radiation climate data record. 16th Conference on Satellite Meteorology and Oceanography / 89th AMS Annual Meeting, January 11-15, 2009. Phoenix, Arizona.

Lee, Hai-Tien, R. G. Ellingson, A. Gruber, 2010: Development of IASI outgoing longwave radiation algorithm. Proceedings of the 2nd IASI International Conference. Annecy, France, Jan 25-29, 2010.

Lee, H.-T., I. Laszlo, and A. Gruber, 2010: ABI Earth Radiation Budget Outgoing Longwave Radiation. NOAA NESDIS Center for Satellite Applications and Research (STAR) Algorithm Theoretical Basis Document (ATBD 100% delivery)

Lee, H.-T., I. Laszlo, and A. Gruber, 2010: ABI Earth Radiation Budget Surface Downward Longwave Radiation. NOAA NESDIS Center for Satellite Applications and Research (STAR) Algorithm Theoretical Basis Document (ATBD 100% delivery)

Lee, H.-T., I. Laszlo, and A. Gruber, 2010: ABI Earth Radiation Budget Surface Upward Longwave Radiation. NOAA NESDIS Center for Satellite Applications and Research (STAR) Algorithm Theoretical Basis Document (ATBD 100% delivery)

Lee, H.-T., 2010, GOES-R AWG Radiation Budget Team: Upward Longwave Radiation-Surface (ULR), GOES-R 2010 AWG Annual Meeting, Madison, WI June 7-10, 2010

Lee, H.-T., 2010, GOES-R AWG Radiation Budget Team: Downward Longwave Radiation-Surface (DLR), GOES-R 2010 AWG Annual Meeting, Madison, WI June 7-10, 2010

Lee, H.-T., 2010, GOES-R AWG Radiation Budget Team: Upward Longwave Radiation-TOA (OLR), GOES-R 2010 AWG Annual Meeting, Madison, WI June 7-10, 2010

Active Fire

Chris Justice, Evan Ellicott (NOAA Collaborators: Ivan Csiszar and Wilfrid Schroeder) – EEEEDEAFP11

Overview

The NPP VIIRS Instrument provides a precursor to the JPSS VIIRS instrument. Whether the resulting data products are used for operational applications or science, there is a need for their accuracy to be quantified. This will require a comprehensive program of validation. In this pre-launch phase, the emphasis is on developing the infrastructure to enable routine and as far as possible, automated validation. These activities build on experience gained using the MODIS instrument and will lay a foundation for ongoing validation of the NPOESS VIIRS land products.

The focus of this activity is to assess the accuracy of the products using independent validation data sources, with emphasis on i) determining whether the Environmental Data Records (EDRs) generated by the NPOESS Contractor (NGAS) meet the product specification, ii) inter-comparison with the equivalent MODIS products, iii) providing feedback to the algorithm developers, iv) providing validation data sets which can be used to determine the accuracy of Climate Data Records (CDRs) developed from the NPP VIIRS by the science community. The products being addressed in this funding phase include Active Fires, Cloud Mask, Surface Albedo, Vegetation Index, Surface Reflectance and Surface Type. This collaborative effort on VIIRS validation has been coordinated in close collaboration with Dr. Miguel Roman who is the GSFC point person on VIIRS Land Validation.

Refinement of VIIRS Proxy data aimed at sub-pixel fire analyses. Development of VIIRS active fire proxy data continued during the current reporting period. Routines were developed to download and extract atmospheric profiles from NCEP's Re-analyses data. The data are being used as input to a radiative transfer code (MODTRAN) in order to generate site-specific atmospheric attenuation parameters to more realistically simulate VIIRS fire data from input ASTER imagery.

Off-Nadir Active Fire Validation

Assessment of off-nadir viewing conditions on fire detection performance was completed using 3,600+ Landsat-5 TM scenes and Terra/MODIS near-coincident global data. Over 270,000 MODIS fire pixels were sampled covering the scan angle interval of 17-55^{o} (Figure 1). Commission error rates and probability of detection were derived as a function of pixel area (Figure 2).

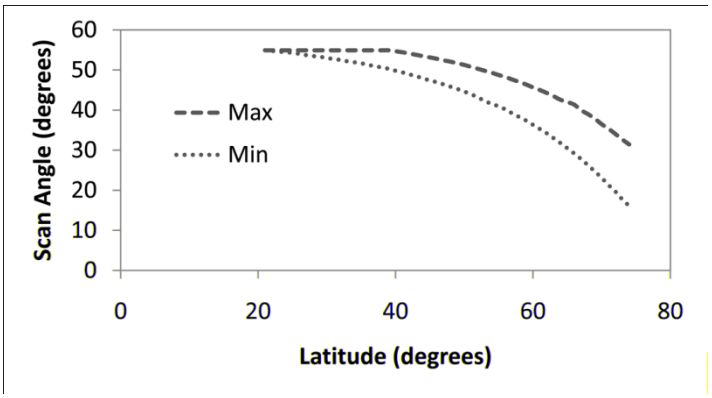

Figure 1: Range of Terra/MODIS scan angles sampled by 3,600+ Landsat ETM scenes. Note that Terra/MODIS and Landsat-5 orbits begin to overlap at approximately ±20° latitude where MODIS scan angle is maximum (55°), then gradually converge towards higher latitudes.

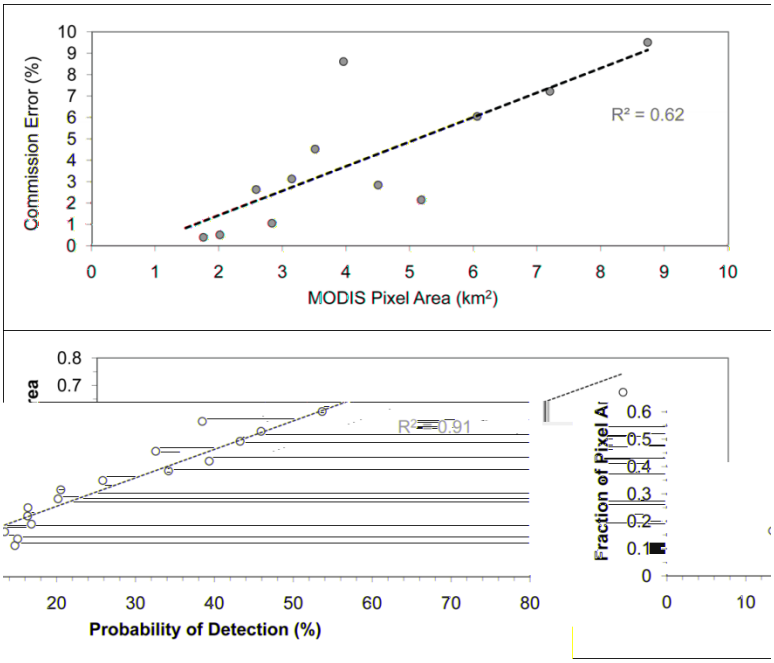

Figure 2: Validation results for Terra/MODIS fire product (commission error rate and probability of detection) indicating a linear response of fire algorithm performance to pixel area.

- **Fire characterization validation using airborne data**. Development of version 1 of fire algorithms using input airborne data has been completed. The software package is based on IDL programming language routines and provides automated identification of active fires in the scene, retrieval of fire characterization parameters (area, temperature, fire radiative power), and data mapping using customizable projection parameters for use in validation analyses.

Airborne fire data product was generated for several fire scenes acquired by the NASA/Ames Autonomous Modular Sensor (AMS) during 2007-2008, providing a fire mask product, as well as fire characterization parameters (separating smoldering/flaming phases, fire radiative power, and area) (Figure 3).

U.S. Forest Service FireMapper airborne sensor data management software was tested locally using Southern CA fire data acquired in 2008. The instrument PI, Dr. Phil Riggan, provided remote training on the use of the software.

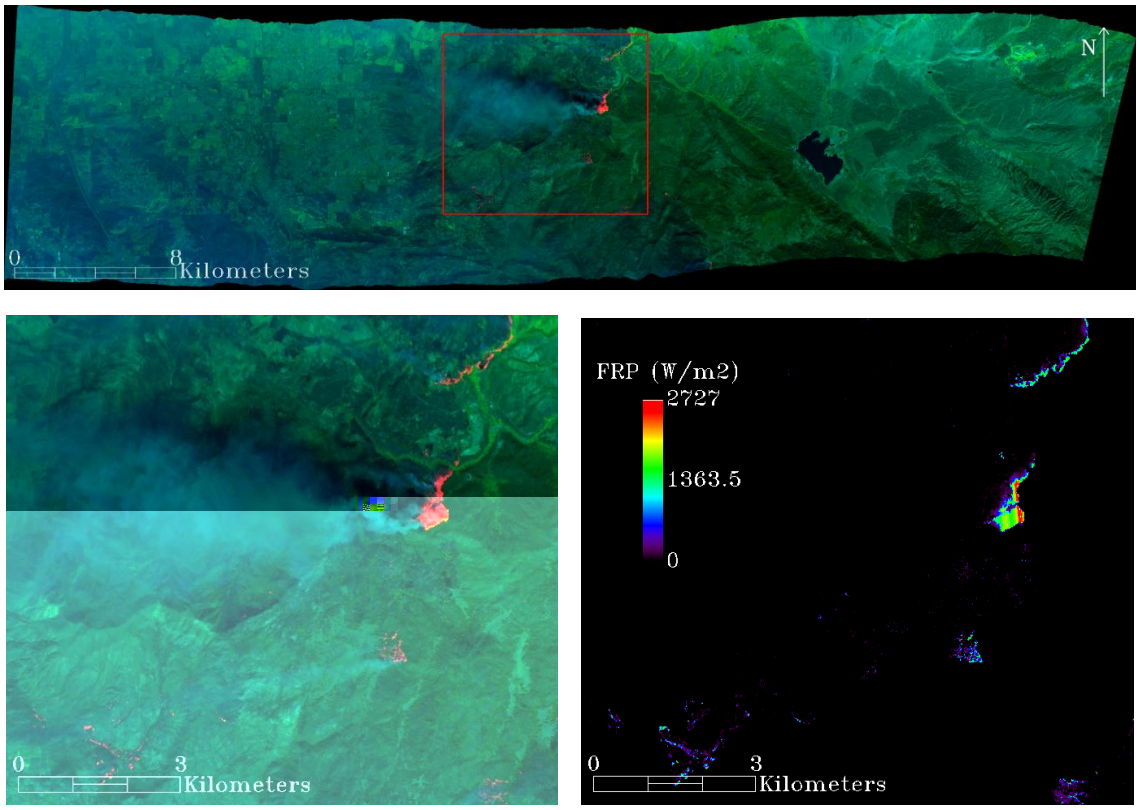

Figure 3: Single AMS overpass of Southern CA fire acquired on 24 October 2007 (33.25°N 116.9°W) (upper panel; RGB composite designed to highlight active fires). Lower panels show zoom over main fire line (left panel) and the corresponding fire radiative power retrieval (right panel) which is indicative of fire intensity and biomass consumed.

VIIRS Cloud Mask Over Land (Co. I- Eric Vermote: UMCP)

- Continued the prototyping of the cloud mask performance evaluation over Land on MODIS CMG BRDF corrected time series for Aqua and Terra (analysis over the AERONET sites).
- Performed the same analysis on AVHRR (using the NOAA Reflectance Climate Data Record Version 3 1981 to 2004).
- Developed the CMG code for VIIRS and delivered to Land PEATE.

Surface Reflectance (SR) Intermediate Product (Co. I- Alexei Lyapustin– GEST UMBC)

- Added hemispherical-directional reflectance (HDRF) as a standard ASRVN product for validation analysis. HDRF is an atsurface reflected radiance normalized to the reflectance units. HDRF is the surface reflectance that is also measured at the ground. It is required for the verification of ASRVN processing by the independent ground measurements of BSRN, FluxNet, NEON, and other current and future networks of calibrated ground radiometers.

- Initiated verification of ASRVN processing against ground measurements of University of Arizona team (site at Railroad Playa). Initial comparison shows a good agreement at wavelengths >0.55 µm. Some discrepancy is observed at the blue wavelength, which is expected to be explained or resolved shortly.

- Continued prototyping the VIIRS SR validation using MODIS SR data as proxy. The analysis is based on the Accuracy-Precision-Uncertainty (APU) values and includes spectral, spatial and temporal domains. The capability for stratified analysis over a range of conditions (low/high zenith angles, low/high aerosol loading, dark vs bright surfaces etc.) was added. These data help reveal systematic biases in the MODIS/VIIRS processing algorithm.

- Adapted ASRVN software to ingest VIIRS synthetic datastream.

- **Conducted verification of ASRVN processing** against ground measurements of University of Arizona team (site at Railroad Playa).

  ASRVN HDRF has been compared with field measurements over a calibration site Railroad Playa for MODIS on Terra and Aqua. The results show that the ASRVN results agree with ground data for all 7 MODIS solar reflective bands well within the uncertainty of measurements due to the surface heterogeneity (Figure 6). The manuscript is in the final stage of preparation.

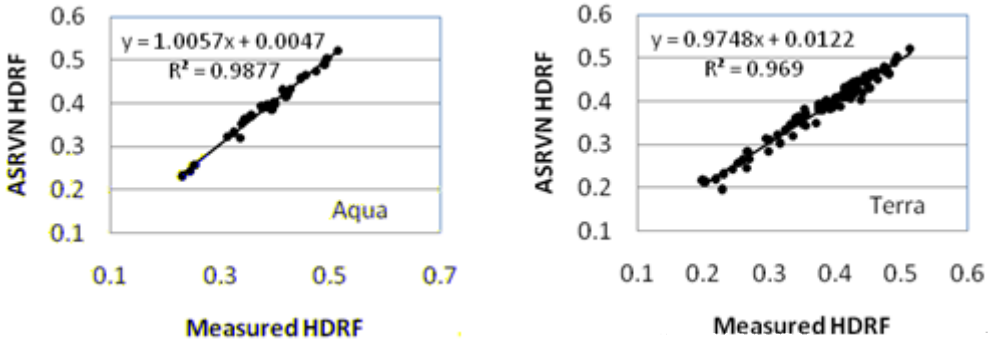

Figure 6: A summary regression plot between the measured and ASRVN HDRF for 7 MODIS solar reflective bands at Railroad site.

- **Initiated verification of ASRVN processing against NOAA BSRN data.**

  The Atmospheric Radiation Measurement (ARM) data over CART Site, has been downloaded and analyzed. A thorough comparison with ASRVN surface albedo is underway.

- **Continued prototyping the VIIRS SR validation using MODIS SR data as proxy.**

  The analysis is based on the Accuracy-Precision-Uncertainty (APU) values and includes angular, spectral, spatial and temporal domains.

  Software has been developed to perform stratified analysis at both regional/global and a single site scale over a range of conditions (different surface brightness, aerosol loading, sun-view geometry etc.)

Vegetation Index EDR (Co. I. Alfredo Huete – University of Arizona)

- 40 Aerosol Robotic Network (AERONET) sites were selected globally to evaluate the uncertainty of VIIRS VI product, using MODIS MOD13A2 as proxy data (Fig. 4). These sites include a complete range of land cover types and represent various climatic and geographic conditions. In addition, these sites were selected to overlap with some FLUXNET and BSRN sites.
- The AERONET-based Surface Reflectance Validation Network (ASRVN), developed by Dr. Alexei Lyapustin is used for retrieval of in-situ, atmosphere corrected reflectances for input to derivation of the normalized difference vegetation index (NDVI) and Enhanced Vegetation Index (EVI).
- Worked on evaluation of nadir and BRDF-angular uncertainties and their propagation from surface reflectances to the Vegetation Indices, NDVI and EVI.
- Continued work on decomposition of errors in Vegetation Indices into their individual band components (see Fig. 5.)
- Submitted an abstract to the ISRSE conference in April 2011.

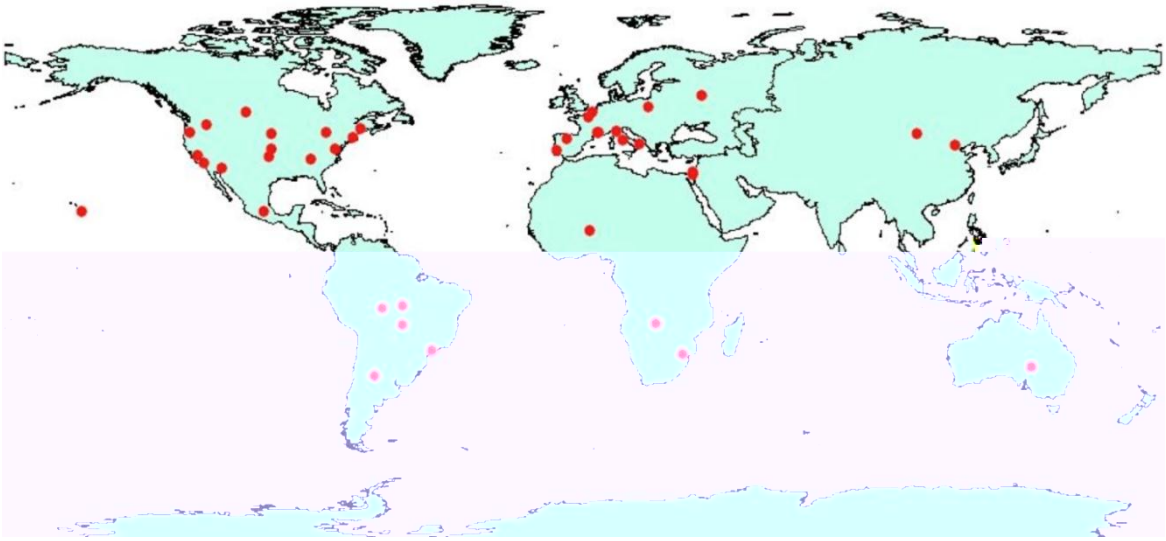

Figure 4: Location of 40 AERONET sites where ASRVN data are generated.

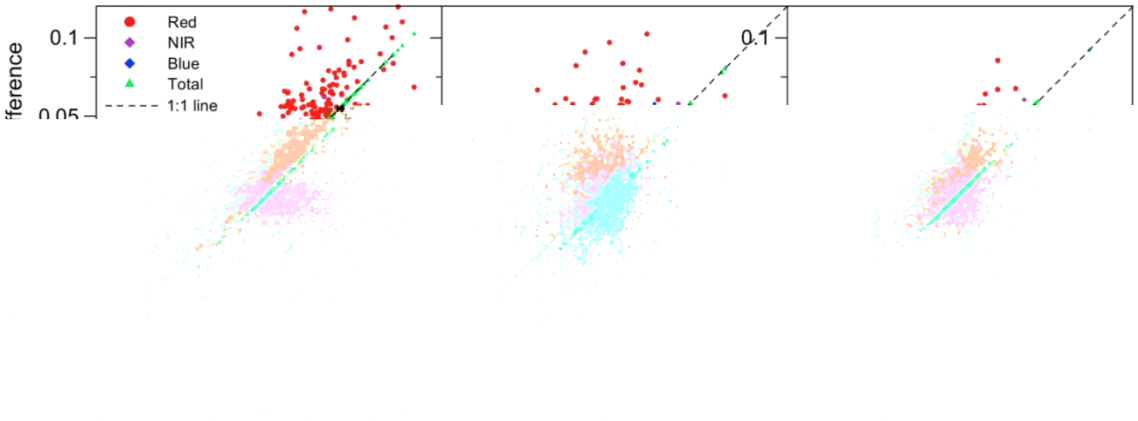

Figure 5: Scatter of the band component differences that account for the MODIS-ASRVN VI differences associated with their 1-day comparisons.

- ***Continued work and refinement***

  The ASRVN was for retrieval of in-situ, atmosphere corrected reflectances for input to derivation of the normalized difference vegetation index (NDVI) and Enhanced Vegetation Index (EVI). We are using the ASRVN data as a reference to evaluate the quality of VIIRS simulated (MODIS NDVI, EVI, and EVI2. Figure 4 shows an example of daily ASRVN Vegetation Index results plotted as a function of satellite view zenith angle.

- **Preliminary results in comparing the ASRVN derived VIs** with the daily equivalent data from Terra-MODIS show a negative bias of the MODIS red reflectance compared with the in-situ derived ASRVN reflectance, which is responsible for the positive bias in the MODIS NDVI and two-band EVI (EVI2) (Fig. 5).
- **Negative biases of the MODIS blue reflectance** nullifies the effects of the red bias on the MODIS EVI, resulting in significant bias in EVI (Fig.5). The Atmospherically resistant vegetation index (ARVI) (Kaufman & Tanré, 1992) and EVI, were designed to minimize atmospheric effects on the red reflectance by utilizing the difference between the red and blue reflectance
- The overall mean absolute differences MODIS VIs and ASRVN VIs are fairly low, < 0.015 and overall our analyses show the MODIS VI and hence, VIIRS product to have good quality (see Fig. 5).

Figure 4: Relationships between ASRVN VIs and view zenith angles over the GSFC Aeronet site (Lat 38.993˚, Lon -76.840˚) during DOY 241-256, 2002.

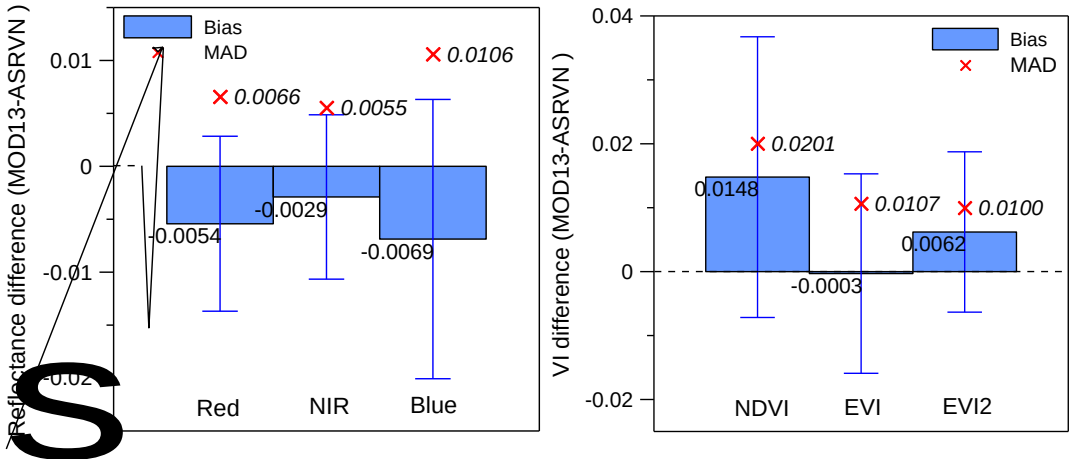

Figure 5: Errors in MOD13A2 input reflectances from daily comparisons: (a) mean, standard deviation and mean absolution difference (MAD) of the reflectances, (b) subsequent influences and bias in the vegetation indices.

Surface Albedo EDR (Co. I. Crystal Schaaf – Boston University)

- Fifty six tower sites have already been evaluated for spatial representativeness during both the leaf-on and leaf-off seasons, including:
  - 20 Atmospheric Radiation Measurements (ARM) sites (Román. et. al, 2010)
  - 16 AmeriFlux sites (Román et. al, 2009)
  - 13 NOAA Climate Reference Network (CRN) sites
  - 7 Surface Radiation Budget Observing Network (SurfRad) sites
- The latter sites, along with some of the ARM sites, contribute to the international Baseline Surface Radiation Network (BSRN). The results of this analysis have been summarized in a white paper prepared for the project in February, 2010 (available at: ***ftp://crsftp.bu.edu/modis/mroman/VIIRS-Land/VIIRS_GEOSTATS-report-Feb2010.pdf***). In general, the dormant seasons are frequently less spatially representative because of the impact of deciduous trees or understory and the exposure of underlying soil or residual snow cover. (cf., Fig. 3).
- An International FluxNet initiative identified 253 sites from various national flux networks and worked collaboratively to prepare sensor data (including albedo measures) for the research community. Known as the FluxNet Synthesis Data Set (or more commonly the "La Thuile Data Set"), more information about the data is available at

http://www.fluxdata.org/default.aspx . In response, recent efforts for this evaluation exercise have focused on these adding additional sites to bring the total to just over 100 sites under analysis.

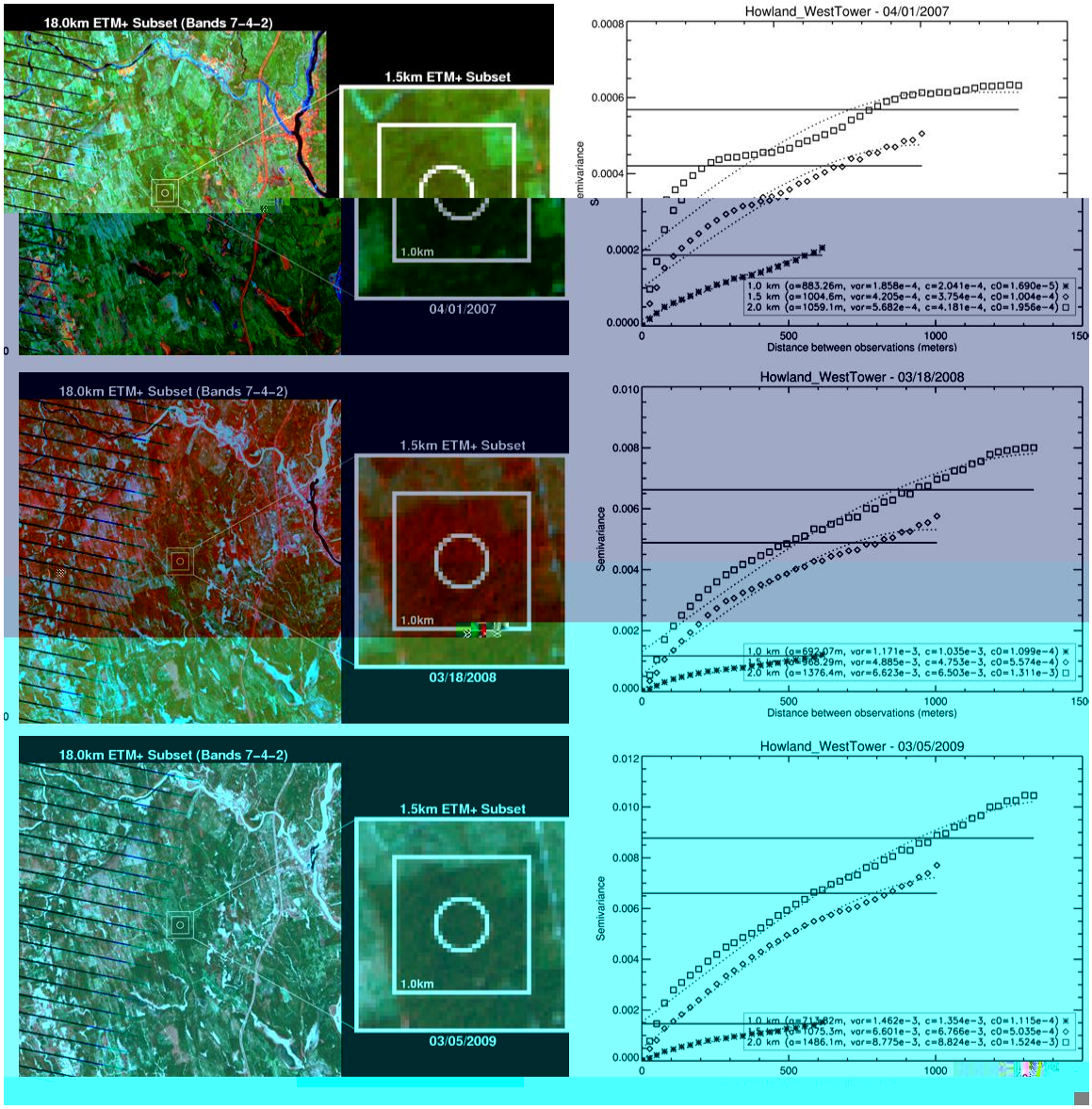

Figure 3: Top-of-Atmosphere (TOA) shortwave reflectance composite (ETM+ Bands 7-4-2) and corresponding semi-variogram functions, variogram estimator (points), spherical model (dotted curves), and sample variance (solid straight lines) using regions of 1.0 km (asterisks), 1.5 km (diamonds), and 2.0 km (squares), centered over Howland west on 04/01/2007 (top), 03/18/2008 (middle), and on 03/05/2009 (bottom). The circle stands for the tower footprint (30m) and the black stripes are caused by the Landsat ETM+ Scan Line Corrector (SLC) off background.

- **An additional 45 tower sites** from the Fluxnet Synthesis Data Set have been evaluated for spatial representativeness for leaf-on and leaf-off conditions. More information about the Fluxnet data (more commonly known as the "La Thuile Data Set"), is available at http://www.fluxdata.org/default.aspx . This brings the total number of sites investigated to just over 100 locations. The PI has also submitted a formal proposal to the Fluxnet Scientific Moderation Committee to use the Fluxnet site albedometer data in intercomparisons and validations with the VIIRS instrument (prior to this, the use of the data had only been authorized for MODIS comparisons).
- A presentation on the sites was provided at the VIIRS Land Team Validation Workshop

Example of a Representative Site

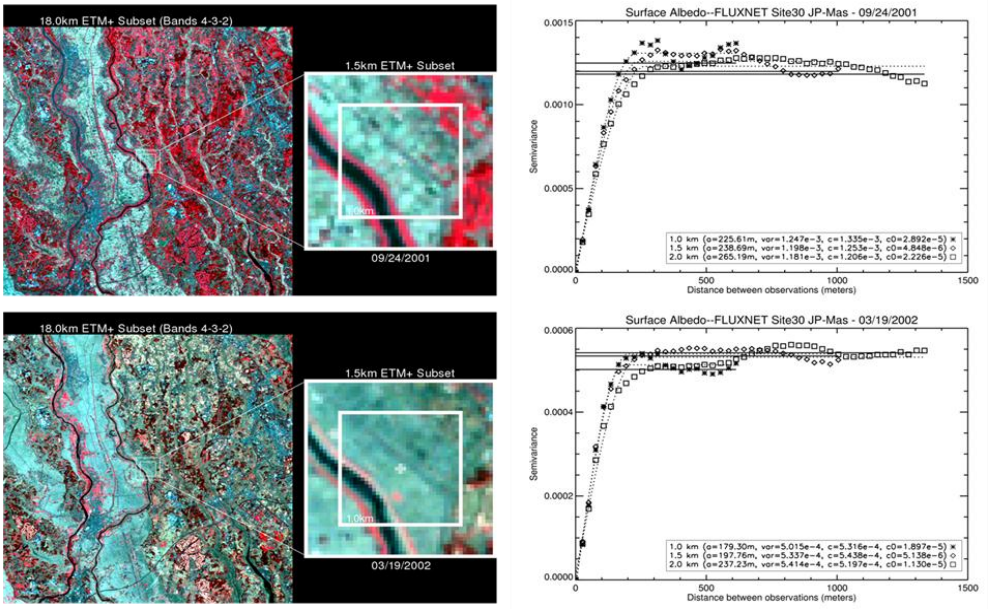

Figure 3: Top-of-Atmosphere (TOA) shortwave reflectance composite (ETM+ Bands 3-4-2) and corresponding semivariogram functions, variogram estimator (points), spherical model (dotted curves), and sample variance (solid straight lines) using regions of 1.0 km (asterisks), 1.5 km (diamonds), and 2.0 km (squares), centered over Mase paddy flux site, Japan (JP-Mas) on 09/24/2001 (leaf-on) and 03/19/2002 (leaf-off).

Example of Less Representative Site

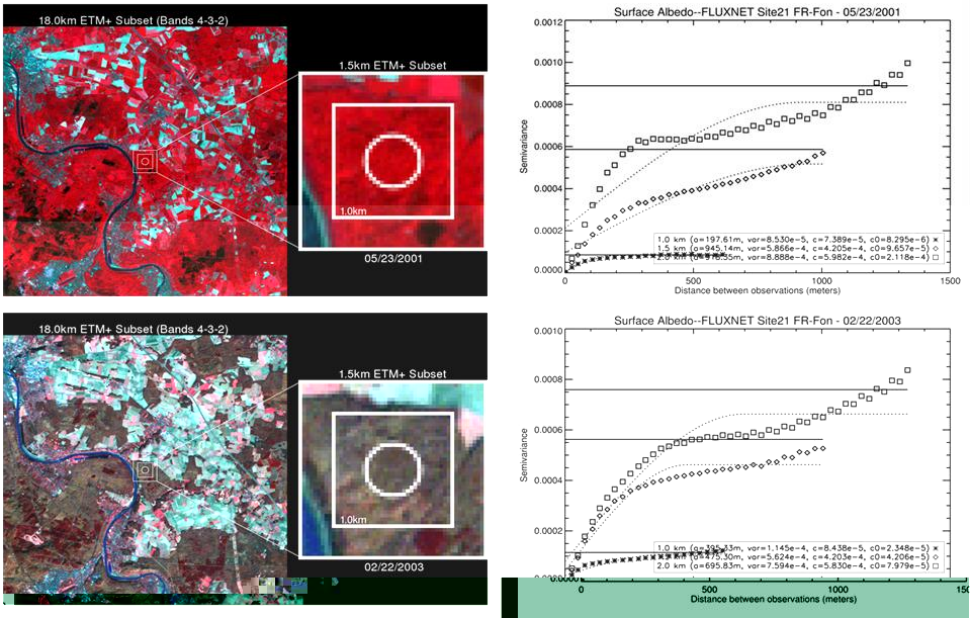

Figure 4: Top-of-Atmosphere (TOA) shortwave reflectance composite (ETM+ Bands 4-3-2) and corresponding semivariogram functions, variogram estimator (points), spherical model (dotted curves), and sample variance (solid straight lines) using regions of 1.0 km (asterisks), 1.5 km (diamonds), and 2.0 km (squares), centered over Fontainebleau, France (FR-Fon) on 05/23/2001 (leaf-on) and 02/22/2003 (leaf-off). The circle stands for the tower footprint. While representative at higher spatial resolutions, this site is less representative at lower resolutions due to the influence of the nearby river and surrounding agricultural fields.

Surface Type EDR (PI: Mark Friedl – Boston University)

- **Global sample design finalized.**

  A probability sample of 500 validation sites was finalized based on a stratified random sample of climate regions and population density (Fig. 2).

  The validity of the methodology was assessed using the MODIS Land Cover and GlobCover products. Results from analyses conducted at continental scale support the statistical robustness of the sample design.

  Results presented at Spatial Accuracy 2010 (Stehman et al., 2010) and an abstract has been submitted to AGU describing the design methodology (Sulla-Menashe et al., 2010)

- **Prototype methodology for site classification developed**

  High-resolution multispectral QuickBird imagery was acquired for five sites in North America spanning a range of land cover types.

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

- ***Analysis Design Implementation***

  In parallel with efforts focusing on response design implementation, we also focused efforts on developing methods to scale and compare high-resolution maps with maps compiled at lower (i.e., at the spatial resolution of the VIIRS Surface Type EDR).

  This work is ongoing, but is focused on development of a hierarchical classification system and associated scaling methodology that will allow different classification schemes to be cross-walked across spatial resolutions, thereby allowing features identifiable at high spatial resolution to be aggregated and compared to maps generated at lower spatial resolutions.

  Results from efforts focusing on response design implementation are currently being written-up as a two-paper series being prepared for submission to the

New Activities in Development of Climate Data and Information Records and Scientific Data

Otis Brown; (NOAA Collaborator: John Bates) – OBOB/NADCD11

Background

The NCDC has a number of research and workforce needs that necessitate 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. This task from CICS-NC bundles several research elements within CICS-NC to address these workforce and research needs.

Accomplishments

Over the past year, CICS-NC has recruited and on-boarded a team of talented and dedicated climate science and instrument researchers, as well as scientific support personnel at the senior, mid-career and junior levels. The CICS-NC team is well underway to being established and charged with accelerating activities such planning for a Summer Institute to be held annually starting in 2012, and, supporting post doctoral fellows and graduate students in climate science and related areas[1] This group is currently:

- Developing calibration and validation approaches for high quality baseline climate data sets from satellite and in situ observations
    - For the detection and documentation of climate change
    - To develop the relationships between the observed tropospheric and stratospheric trends from the ground-based network with those observed from satellite
- Developing, refining, and implementing algorithms for a daily, global, multi-sensor, optimally interpolated Climate Data Records (CDRs), and to characterize the sources and magnitudes of errors and biases in the CDR and develop methodologies for the reduction of these errors and biases.
- Developing 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 events like instrument changes, or observing station moves including analyses of structural uncertainty due to these methods
- Supporting the transition of research to operation activities to ensure that that transitions occur between development of the data sets and the operational use of these data sets, particularly in activities such as:

[1] Graduate students and faculty advisor support was postponed due to budgetary constraints

    - Climate monitoring and climate research
    - Documenting climate variability and change using the observed record and climate model simulations
- Supporting ongoing analyses of climate information toward documentation of biases, levels of accuracy and confidence intervals
- Supporting the stewardship of climate observations
- Providing advanced planning support for a Climate Summer School to be hosted annually in Asheville starting in 2012
- Developing the next generation workforce by engaging students and post-doctoral fellows in the studies associated with climate science, assessment, mitigation, impacts and policy

The research professionals hired include: Drs. Pui Chan, Anand Inamdar and Qiong Yang. The four post-doctoral fellows hired as part of the Workforce Development initiative include Drs. Jessica Matthews, Olivier Prat, Carl Schreck and Laura Stevens. Jenny Dissen was hired to develop the Summer Institute and Climate Literacy programs.

Individual project summaries for each staff members are provided below.

AVHRR Aerosol Retrieval

Pui K. Chan; (NOAA Collaborator: Dr. Tom Zhao)

Background

The NCDC aerosol climatic data record (CDR) is based on an "independent" two-channel algorithm and produced from the AVHRR PATMOS-X Data Processing System using PATMOS-X level-2b data (Zhao, X., 2011: "Aerosol Climate Algorithm Theoretical Basis Document"). Aerosol optical thickness (AOT) is retrieved from radiances measured by the NOAA operational AVHRR sensor. Retrieval is made at pixels during daytime, clear sky condition, over ocean surface with glint angle >40° to avoid sun glint, on anti-solar side of satellite orbit, with solar zenith angle < 70° and view zenith angle < 60°. The look up table used in the retrieval is based on top of atmosphere reflectance computed using the 6S radiative transfer model (Vermote et al., 1997) with a weekly absorbing aerosol model and bimodal log-normal size distribution.

The final products are mapped to a 0.5°x0.5° grid and include both daily and monthly average products. The primary retrieval product is AOT at 0.63 mm. AOT at 0.83um (or 1.61 mm) is also retrieved for consistency check.

Accomplishments

Accomplishments to date on this research include:

- Development of an IDL program to convert aerosol CDR data products from HDF to NETCDF format, including writing of IDL programs to display contents of HDF and NETCDF aerosol files
- Gathering and synthesizing information on aerosol CDR program and aerosol retrieval code, modifying and streamlining aerosol retrieval code, and establishing literature references on aerosols
- Examining and identifying causes of anomalous features in AVHRR global distribution of aerosol optical thickness (AOT) derived from PATMOS-X level-2b data prior to year 2000
- Collecting information for COSMIC-2 mission for Dr. John Bates "end-to-end stewardship" planning, specifically on current COSMIC data volume and made estimates for future COSMIC-2 data volume.

Planned Work

The ongoing research efforts are to:

- Continue to resolve issues associated with anomalous features in the global AOT distribution and re-process aerosol optical thickness retrieval
- Investigate the effect of cloud mask on long-term trend of aerosol optical thickness.

Assessment of Calibration of the Visible Channel of Geostationary Satellites in the ISCCP B1 Data

Anand K. Inamdar; (Collaborators: Pierre Guillevic (CICS), William Sprigg (University of Arizona, Tuscan)

Background

International Satellite Cloud Climatology Project (ISCCP), established in 1982 as part of the World Climate Research Program (WCRP), has been collecting and processing data from the polar orbiting and geostationary satellites (GEOs) from all over the world since 1983. The goal was to collect and analyze satellite radiance measurements to infer the global distribution of clouds, their properties, and their diurnal, seasonal, and interannual variations. Although the native resolution of the GEOs data archives is less than 10 km, data were sub-sampled to 30 km for processing due to computing limitations at the time. Recently, Dr. Ken Knapp (NOAA's National Climatic Data Center) led the rescue of the archived data to produce ISCCP B1 data, which represents geostationary imagery from satellites worldwide that are sub-sampled to 10 km and at 3 hour-resolution. One of the primary tasks in enhancing the scientific value of these salvaged data is assessing the calibration of the 3 primary channels available for GEOs, namely the Visible (0.67 micron), infra-red water vapor (6.7 mi) and infra-red window (11 mi). The research effort focused here addresses the calibration of the Visible channel

The goal of this research activity is to provide a stable and consistent set of GEOs radiances globally which is normalized to a single standard. Calibration of the GOES visible channel is performed prior to launch and undergoes significant degradation after the launch, due to lack of any on-board calibration source. On the other hand, the Advanced Very High Resolution (AVHRR) instrument on board the NOAA polar orbiting satellites and the Moderate Resolution Imaging Instrument (MODIS) aboard the NASA EOS have on-board calibration and can thus provide a stable reference standard. Presently, all the GEOs radiances are normalized with respect to the current afternoon polar satellite (Desormauux et. al., 1993) at Centre de Meteorlogie Institute in France. However there are variations in the calibration of the different polar orbiters themselves requiring corrections in calibration drift with time. Independent assessment of the calibration of the ISCCP visible channel identified certain deficiencies in the present approach.

The work being performed at present follows a similar approach of calibration using match-ups with the current AVHRR, however employing a set of calibration coefficients for all AVHRR sensors derived from a consistent approach (Heidinger et. al., 2010). This set of better solar reflectance calibration data is available in the AVHRR Pathfinder Atmospheres Extended (PATMOS-X) dataset.

The calibration method employs both the morning and afternoon overpasses, a prescribed set of matching criteria between GEOs and AVHRR target areas, and a histogram-matching technique for each individual month.

Accomplishments

Thus far, the research activities have completed the processing of calibration for GOES series of satellites from 1990 – 2009. Comparison of our results with the original ISCCP calibration coefficients and separately with the coherent reflected radiance Fundamental Climate Data Record (FCDR) product produced by the NASA Langley Research Group yields good agreements as shown in the accompanying Figure 1 below. The unscaled radiance ($W\ m^{-2}\ \mu m^{-1}\ ster^{-1}$) can be expressed in terms of raw counts, X, as a quadratic gain per day since the launch of satellite, as:

$$L = (a0 + a_1 d + a_2 d^2)(X - X0)$$

Where d is the number of days since launch and X_0 is the offset count equal to 29.

Some of the outliers can be attributed to some inherent problems in the GOES data such as problems associated with data transmission, striping, and higher reflectance values due to the extended spectral domain of GOES getting its signal from off-nadir views of vegetation body.

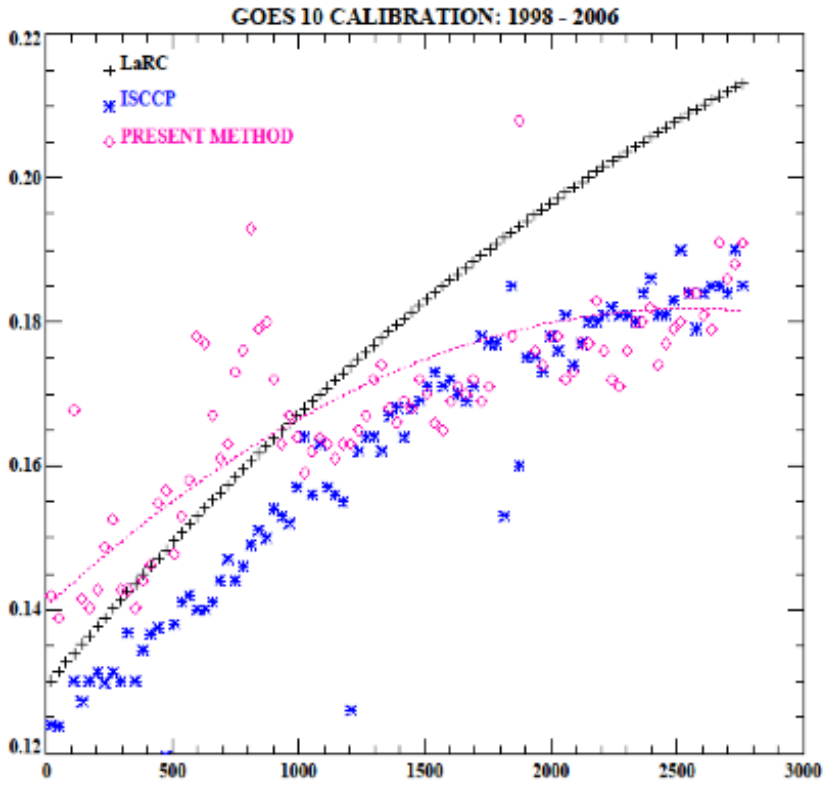

Figure 2 Comparison of original ISCCP calibration coefficients and coherent reflected radiance CDR (NASA Langley Research Group)

Planned Work

The research effort will continue to examine the following:

1. Extension of calibration to other GEOs such as METEOSAT, GMS, etc.
2. Reprocessing of all GOES data to address some problems identified by Dr. Bill Rossow, which includes among other things homogenization of all GOES data records with respect to bit depth;
3. Employ GEOs visible reflectance in retrieving the Aerosol optical depth;
4. Collaborate with former USDA contacts/colleagues in the estimation of Evapotranspiration (ET), which has identified as an Essentail Climate Variable (ECV) recently, from GOES retrieved surface solar insolation. Another CICS colleaugue, Dr. Pierre Guillevic has also expressed keen interest.
5. Engage in collaboration with Dr. William Sprigg (University of Arizona, Tucson) in using GOES in the study of dust episodes and diurnal cycle of dust aerosol optical depth

Publications

French, A. and A. K. Inamdar. Land cover characterization for hydrological modeling using thermal infrared emissivities. , 31:14, 3867-3883, DOI: 10.1080/01431161.2010,483491.

Sea Surface Air Temperature and Humidity Derived from the Advanced Microwave Sounding Unit

Qiong Yang; (NOAA Collaborator: Lei Shi)

Background

This project was initiated in January 2011, so this summary is for the first several months of activity.

The goal of this activity is to develop CDR-quality sea surface temperature and humidity estimates using NOAA polar orbiting passive microwave sensor systems. Currently data streams are being analyzed from the Advanced Microwave Sounding Unit (AMSU), which is composed of two instruments: AMSU-A with 15 microwave channels and AMSU-B with 5 microwave channels. A neural network technique has been used to retrieve sea surface air temperature and humidity based on the AMSU measured brightness temperatures.

Accomplishments

Thus far, the newly developed neural network functions have been tested. Sea surface air temperature and humidity have been derived from AMSU measurements from the NOAA-16 satellite.

Planned Work

The research effort is to continue deriving sea surface air temperature and humidity for other NOAA satellites, as well as continue performing inter-satellite calibrations.

Inter-satellite Calibrations for the High Resolution Infrared Radiation Sounders

Qiong Yang; (NOAA Collaborator: Lei Shi)

Background

The High Resolution Infrared Radiation Sounder (HIRS) has been on board the NOAA polar orbiting satellites for more than 30 years. It provides the global measurements from the surface to the stratosphere, and has been used for a number of climate change studies. For example, HIRS data were used to study trends in upper tropospheric water vapor, outgoing longwave radiation and global cloud covers. However, there are significant challenges in making the HIRS observations from different satellites consistent for climate studies. The HIRS observations from each satellite were calibrated independently. Because of the independent calibration that is based on each individual HIRS channel spectral response function along with other factors, biases exist from satellite to satellite. These inter-satellite biases have become a common source of uncertainty faced by long-term climate studies. Thus, the goal of this project is to perform inter-satellite calibrations to HIRS measurements.

Accomplishments

HIRS inter-satellite calibrations have been performed based on the step functions derived from the simultaneous nadir overpass (SNO) observations. The Metop-A was used as the base satellite. HIRS measurements from NOAA-6 to NOAA-17 have been calibrated to Metop-A to achieve a homogeneous dataset.

Channel 4 was found to have a relatively large inter-satellite biases. Additionally, a new inter-satellite calibration method for channel 4 has been developed.

Planned Work

The planned effort is to continue development and testing the new inter-satellite calibration method and applying it to other channels. Additionally, a test will be conducted to assess if there is any latitudinal dependence in the inter-satellite biases.

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

Jessica Matthews; (Collaborators: Anand Inamdar (CICS-NC), Ken Knapp (NOAA), Bill Hankins (NOAA/STG), Alessio Lattanzio (EUMETSAT), Yves Govaerts (EUMETSAT))

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 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

To date, much of the effort for this project has been directed towards issues surrounding implementation of an operational algorithm at NCDC. This include, etc.

- Porting the 32-bit algorithm to the 64-bit computing environment at NCDC.
- Beginning the code review, including bug detection and correction.
- Beginning the development for GOES-specific application of GSA (defining GOES calibration coefficients, arrangement for GOES data format, NCEP ancillary input data, netCDF conversion, etc.)

Planned Work

The ongoing research efforts are to achieve the following:

- Complete code review and bug correction
- Complete development for GOES-Specific application
- Generate products with GSA for GOES-E and GOES-W for the SCOPE-ICM requested period of 2000-2003
- Pending validation, implement algorithm for entire historical record of GOES data (1979-present)
- Algorithm validation for GOES data using MODIS and in situ data
- Development of uncertainty analysis technique for GSA products

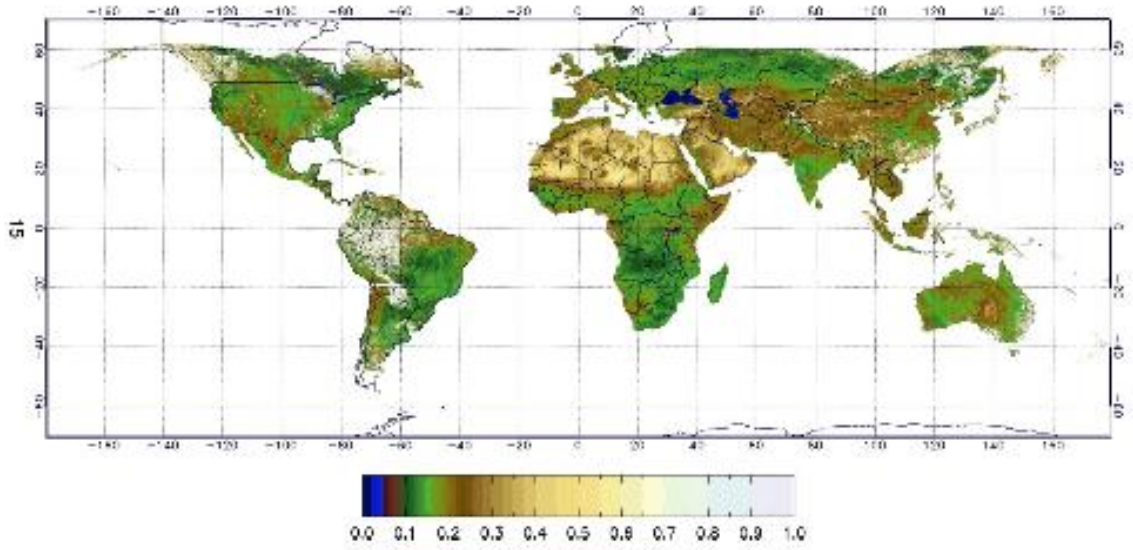

Figure 3 An example of globally gridded surface Directional-Hemispherical Reflectance (black sky albedo) map derived in Govaerts et al., 2008.

Presentations

Govaerts Y, Lattanzio A, Knapp K, Matthews J, Okuyama A, Schuller L. 2011. Generation of a surface albedo data set from a constellation of archived geostationary satellite observations. European Geosciences Union General Assembly, April 3-8, 2011, Vienna, Austria.

Characterization of Precipitation Features in the Southeastern United States Using a Multi-sensor Approach

Olivier P. Prat; (NOAA Collaborator: Brian Nelson)

Background

The precipitation climatology of the Southeastern United States and the Carolinas region in particular spans a very broad spectrum of precipitation regimes. a warm season that is characterized by isolated thunderstorms, squall line mesoscale convective systems (MCS), and tropical cyclones (TC), and a winter season characterized by widespread frontal rain, ice, and snowfall. Each of these types of precipitation systems impacts regional hydrology in very different ways, and are associated with a large variety of natural hazards. In this work, we propose to develop a comprehensive climatology of precipitation using a multi-sensor approach (ground based: Q2, rain gauges; and remotely sensed products) with the goal to derive hydrological characteristics of precipitation.

The goal of this study is two-fold. In the first aspect of this work we will derive diurnal, seasonal, and yearly trends as it concern the temporal frequency and spatial distribution of precipitation patterns with a particular focus on extreme events (e.g. localized thunderstorms, tropical storms, droughts, etc.) that account for an important part of the hydrological budget. The second aspect of this work will focus on the microphysical aspects of the aforementioned precipitation systems. Vertical profiles of rain rate and reflectivity from the NMQ (Multi-sensor Quantitative Precipitation Estimation) Mosaic 3D and TRMM 2A25 PR will be used to access spatial, temporal, and event based microphysical characteristics of precipitation. Finally, this study will propose to extend the current period of study for all the duration of available datasets and set the foundation of a longer term approach that proposes to derive trends in the evolution of precipitation patterns and assessment of climate change effects on precipitation.

Accomplishments

During the first eight months the following tasks were accomplished:

- Processed all available data (1998-2010) of TRMM TMPA (Multi-satellite Precipitation Analysis) 3B42V6 and TRMM PR 2A25 for the Southeastern US ([104W -72W] [24N 40N]). TRMM 3B42 is a combination of different remotely sensed microwave (TMI, SSM/I, AMSR, AMSU) and calibrated IR estimates with rain gauge corrected monthly accumulation, provides 3h/0.25deg precipitation estimates. TRMM 2A25 provides instantaneous rain intensity at the time the satellite overpass (1/day). We derived seasonal, daily, and sub-daily precipitation trends from both datasets.

- Extracted from TRMM TMPA 3B42, the tropical cyclone contribution (global, local, yearly, monthly) to the precipitation budget for the period 1998-2009. TC information was provided by the IBTrACS database.

The major findings are summarized below:

1. **Seasonal precipitation patterns 1998-2010:** Strong contrast between cold and warm season precipitation with higher accumulation in winter and spring west of the Appalachian, and higher accumulation along the coasts in summer and fall. The Tropical Cyclone activity can clearly dominate the seasonal means for the Atlantic and Gulf Coasts while we note an important precipitation activity throughout the year along the Gulf Stream. The seasonal contribution to the yearly precipitation total (Fig. 1) indicates that winter is characterized by a higher accumulation centered around the Mississippi River Basin and West of the Appalachian contrasting with a comparatively drier East/South/Texas/Midwest. We found comparable patterns for winter and spring with precipitation moving upward toward mid-western states, while there is an opposite pattern for winter and summer. We also note a positive contribution in fall along the coasts due to predominant TC activity.

2. **Diurnal characteristics of precipitation 1998-2010:** No significant land/ocean contrast in winter. Higher number of precipitation events occurs at nighttime (Fig.1) with however an almost equal repartition of rain events throughout the day in winter. On the opposite, we found a strong land/ocean signature in summer with a higher number of precipitation events occuring in the afternoon over land vs. in the morning over ocean. Along the coasts, there is a predominance of afternoon rain events in summer (>20%). More than 30% of the rain events occur in the afternoon (15:00-18:00 LCT) in Southern FL (Figure 3).

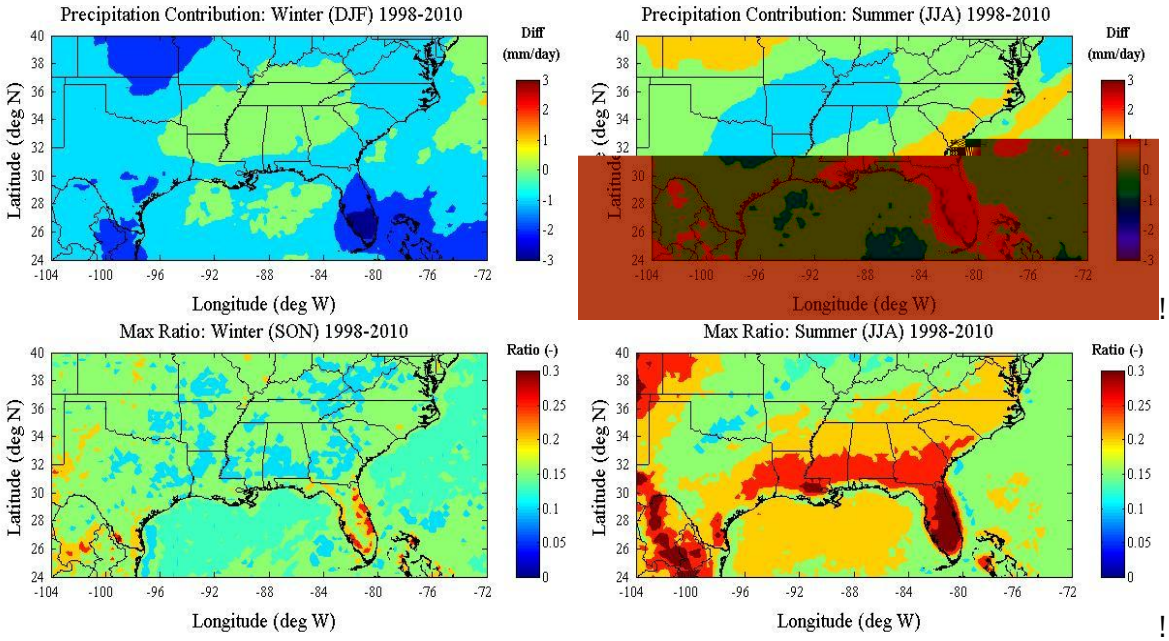

Figure 4 seasonal precipitation contributions for the yearly precipitation total for winter (top left) and summer (top right) for 1998-2010. Diurnal cyclecharacteristics: daily maximum ratio of rain events (3h period) for winter (bottom left) and summer (bottom right) for 1998-2010.

3. **Extreme events – TC contribution 1998-2009:** The TC global contribution for the domain over land is 7%. The TC maximum contribution (15-20%) is along the coasts for the 12-year period (Fig. 2). The year-to-year contribution is between 1% and up to 14% for the Southeastern US (Fig. 4) and can be locally above 50% for record events (Floyd 1999, Katrina 2005). The TCs contribute up to 20% of the monthly precipitation total in September (Figure 4).

Planned Work

Future work proposes to extend the current study and integrate other sensors as well as focus on other types of precipitation. The work will evolve around two major areas:

1. Using the data available from the NMQ/Q2 reanalysis currently in progress (5min/0.01deg), we will assess precipitation estimates uncertainties between ground based and remotely sensed data with a focus on geographical areas where these precipitation estimates are less reliable (mountainous area). Dataset intercomparison will be provided for the years 2008-2009 and later extended for the available period of records (1998 to present). This work includes significant code development (Fortran) for dataset comparison and statistical analysis.

2. Complete the characterization of precipitation features in the southern United States. While the first parcJ ct-3(h3(it)ud(teyJ cfes.)ocuJ s-3(ed)3(itropes i)cal cy)5

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Prat, O. P., and B. R. Nelson, 2011: Characterization of Precipitation Features in the Southeastern United States Using a Multi-Sensor Approach – Milestones for a Longer Term Assessment of Climate Change Impacts. 19th AMS Conference on Applied Climatology, 18-20 July 2011, Asheville, NC, USA.

Prat, O. P., and B. R. Nelson, 2011: Precipitation contribution of tropical cyclones in the Southeastern United States from 1998 to 2009 using TRMM precipitation data.

The Madden–Julian Oscillation and Tropical Cyclones in the Western Hemisphere

Carl Schreck; (NOAA Collaborators: James Kossin and Lei Shi)

Background

The Madden–Julian oscillation (MJO) has frequently been identified with proxies for convection such as outgoing longwave radiation (OLR). These data are suitable for the Eastern Hemisphere where deep tropical convection is commonplace. However, the convective signal becomes weaker in the Western Hemisphere, even as the signal persists in the upper troposphere. Inter-satellite calibration techniques have recently produced a homogeneous 31-year dataset of upper tropospheric water vapor (UTWV) from the high-resolution infrared radiation sounder (HIRS). These data are being used to develop a global view of the MJO.

The MJO significantly affects tropical cyclone activity around the globe. This project will use the UTWV data to identify how the MJO influences tropical cyclogenesis over the eastern North Pacific and the North Atlantic. Possible mechanisms include the local enhancement of convection and low-level vorticity, amplification of easterly waves, and remote impacts on the vertical wind shear. These issues will be explored through a case study of the record-breaking Atlantic hurricane season in 2005.

Tropical cyclone activity will be diagnosed using the International Best Track Archive for Climate Stewardship (IBTrACS) from NOAA's National Climatic Data Center. IBTrACS combines tropical cyclone data from numerous international agencies. Operational procedures have evolved through time, and they vary greatly between agencies. Research is ongoing to document and mitigate these heterogeneities in the record.

Accomplishments

Processing has been completed on 31 years (1979–2009) of HIRS UTWV data. These data have been calibrated for variations between satellites and binned into once-daily 2.5° latitude–longitude grids. Spectral analysis of these grids has demonstrated their utility for identifying the MJO.

Figure 5 shows maps of MJO-filtered variance using OLR (top panel) and UTWV (bottom panel). Previous studies have relied on OLR data, but the signal is confined to Indian Ocean and the western Pacific warm pool. With UTWV, significant MJO variance occurs at all longitudes. The UTWV signals also lie farther poleward, suggesting that they might diagnose tropical–extratropical interactions within the MJO.

Additionally work is pursued in working with the IBTrACS team as they continue refining their dataset. In April 2011, the 2nd IBTrACS Workshop was held, which brought together data providers and data users from 13 countries around the globe.

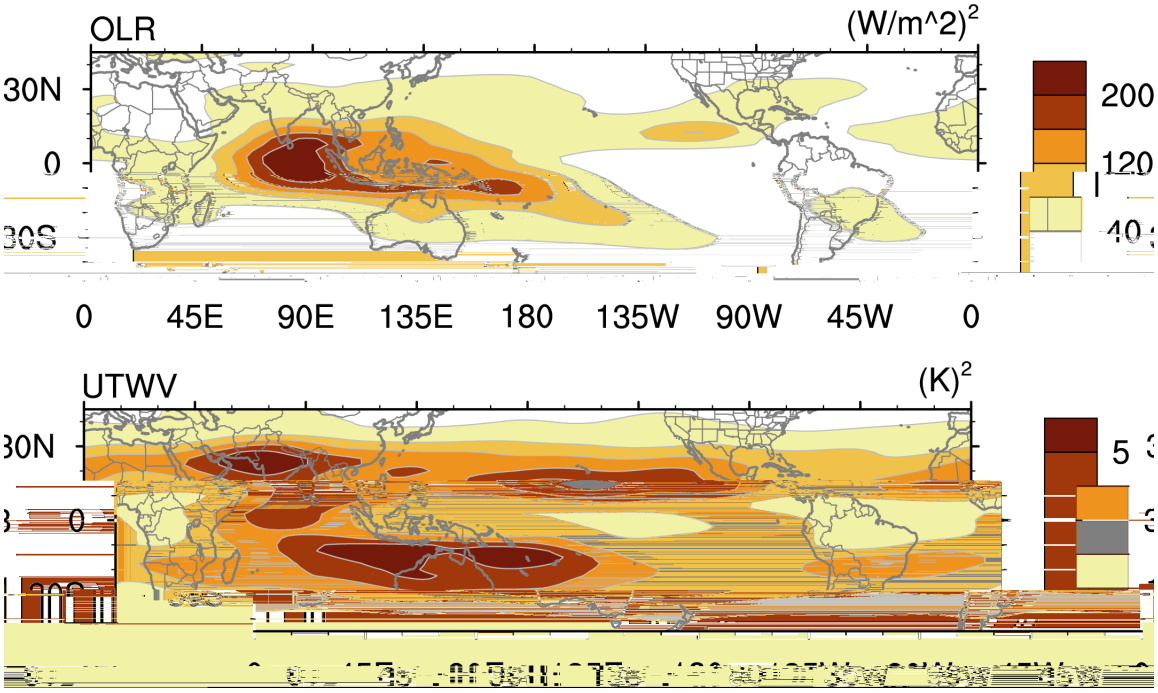

Figure 6 MJO-filtered variance for the period 1979-2009 in OLR (upper panel) and UTWV (lower panel).

Planned Work

Principal component analysis of UTWV data will be used to create an index of the MJO in the Western Hemisphere. A climatology will be constructed from this index, and the results will be submitted for publication. The index will also be tested as a tool for monitoring of the MJO.

IBTrACS is the world's most comprehensive repository of tropical cyclone data. This dataset offers a unique opportunity to revisit the global climatology of tropical cyclones. The annual number of tropical cyclones, their seasonality, and their genesis locations will be explored and reported.

Publications

Schreck, C. J., and J. Molinari, 2011: Tropical cyclogenesis associated with Kelvin waves and the Madden–Julian oscillation. , In Press.

Schreck, C. J., J. Molinari, and K. I. Mohr, 2011: Attributing tropical cyclogenesis to equatorial waves in the western North Pacific.

Presentations

Schreck, C. J., 2011a: Best track continuit , 11-13 April 2011, Honolulu, HI.

Schreck, C. J., 2011b: Best track data in synoptic studies: What is a tropical cyclone? , 11-13 April 2011, Honolulu, HI.

Comparison of Observational Satellite Data with Climate Model Output

Laura Stevens; (NOAA Collaborator: John Bates)

Background

Marine stratocumulus clouds are of particular interest with regard to global warming, due to their widespread cover (about one third of the oceanic surface) and relatively high albedos. It has been suggested that it is possible to ameliorate the effects of global warming by deliberately modifying the microphysical properties of these marine stratocumulus clouds. This could be done by the injection of sea-salt aerosol into the atmosphere at cloud base which act as cloud condensation nuclei, thereby increasing the cloud droplet number concentrations and leading to an increased albedo. A negative radiative forcing would be generated via the aerosol indirect effects, resulting in a significant cooling of the Earth's climate.

This cloud albedo modification geoengineering idea forms the basis of a Ph.D. project with the University of Leeds, UK, which is currently nearing completion. This consists of a computational study in which droplet concentrations in marine stratocumulus clouds are enhanced, in order to assess if such global cooling could be achieved. The project involves the use of both a general circulation model (GCM) to investigate changes in the global radiation balance and a cloud-resolving model (CRM) to examine the sensitivity of the stratocumulus cloud microphysics.

Accomplishments

Although the main modeling study was carried out at the University of Leeds, the continuation of this work through CICS-NC has greatly improved the quality of the research, due to the availability of additional data and analysis tools at NCDC.

The overall results of the Ph.D. work indicate that increasing cloud droplet number concentrations in regions of marine stratocumulus clouds would cause a decrease in cloud droplet effective radius and an increase in cloud liquid water, i.e., demonstrations of the cloud albedo effect and cloud lifetime effect, respectively. If such a cloud albedo enhancement geoengineering scheme were to be implemented, it could potentially yield a negative radiative forcing of –7.97 W m^2, i.e., more than twice that required to offset the warming produced by a doubling of carbon dioxide, with the greatest response occurring in the Southern Hemisphere during spring and summer. This resultant cooling of the global climate is demonstrated in Figure 6

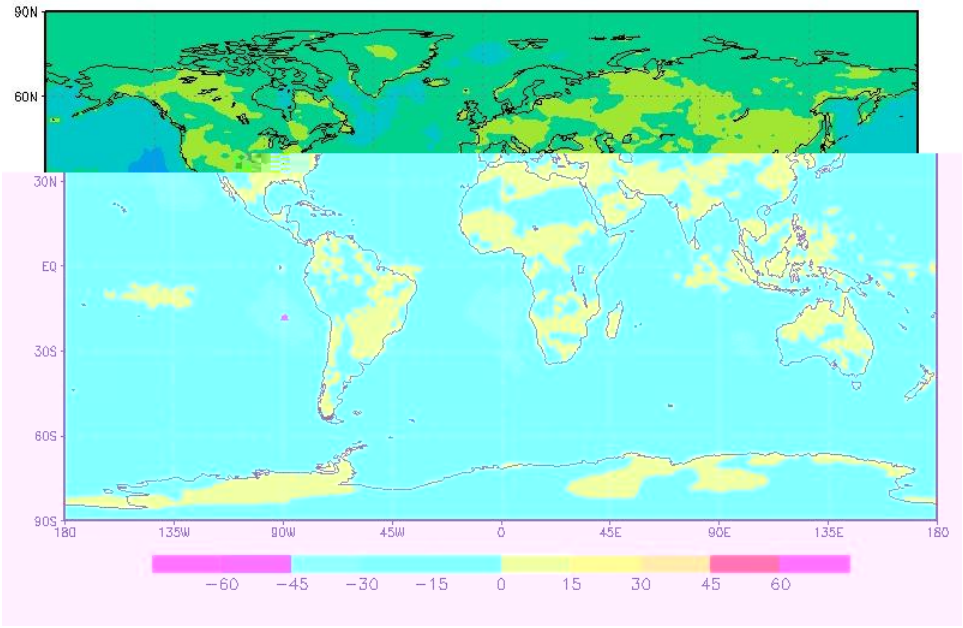

Figure 7 Annual mean difference in radiative forcing (W m^{-2}) between the GCM control simulation and that in which cloud droplet number concentrations were set to 375 cm^{-3} in regions of low-level maritime cloud.

Planned Work

According to the IPCC Fourth Assessment Report, the current generation of GCMs covers a range of climate sensitivity estimates, from 2.1 to 4.4°C. Although climate models have undergone substantial developments in recent years, their predictions are still greatly affected by the parameterization of clouds and other boundary layer processes. The influence of a given change on climate sensitivity is largely model dependent, due to the interaction of these differing parameterizations, which are often nonlinear. It is therefore necessary to evaluate the simulation of key climate feedback processes by comparing model output to observational data, in order to help eliminate any model biases.

Upon Ph.D. completion, postdoctoral research will commence with CICS-NC, collaborating with John Bates and others at NCDC. The project will involve a comparison of observational data with climate model output as described above, aiming to improve model simulations and ultimately develop climate-quality observational data sets. This will be achieved through the processing and analysis of satellite, radar and/or surface based observations, in comparison with model data. Particular areas of interest include simulation of the water vapor feedback, which has a significant effect on climate, as well as cloud feedbacks, which are the largest source of uncertainty in GCMs (as indicated in Fig. 7).

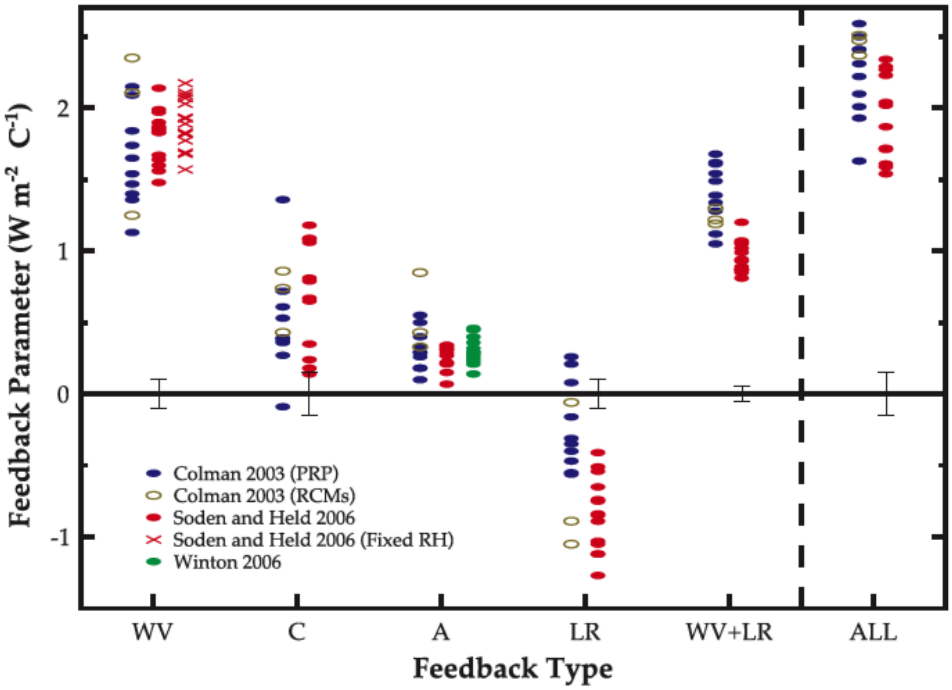

Figure 8 Comparison of GCM Feedback parameters for water vapor (WV), cloud (C), surface albedo (A) and lapse rate (LR). Courtesy of the IPCC Fourth Assessment Report (2007).

Model data used for the project will include output from one or more of the following databases of coordinated GCM experiments, carried out under standardized conditions:

- AMIP (the Atmospheric Model Intercomparison Project)
  http://www-pcmdi.llnl.gov/projects/amip/
- CMIP (the Coupled Model Intercomparison Project)
  http://cmip-pcmdi.llnl.gov/cmip5/
- CFMIP (the Cloud Feedback Model Intercomparison Project)
  http://cfmip.metoffice.com/

Also desirable is the use of COSP (the CFMIP Observation Simulator Package), which is capable of simulating ISCCP, CloudSat and CALIPSO satellite observations. COSP uses model outputs to diagnose quantities that can be directly observed from satellites, enabling GCM output and observations to be quantitatively compared.

The initial observations used for comparison will be satellite data sets, several of which are accessible at NCDC. Potential options include, but are not limited to:

- AMSU: a microwave radiometer measuring temperature and humidity
- HIRS: a visible/infrared sounder measuring temperature profiles, moisture content, cloud height and surface albedo
- ISCCP: measurements of cloud cover and various cloud properties

As CMIP has been successful in providing widespread access to climate model data sets, it is desirable to coordinate a similar effort for observational climate data sets. As discussed at the "Workshop on Ensuring Trustworthiness of Climate Observations and Models for Society" in March, 2010, the main tasks include:

- Working with modeling and observation communities to identify data sets
- Working with observational teams to produce a document describing strengths/weaknesses, uncertainties, dos and don'ts, etc., regarding model interpretations and comparisons
- Transform the data into climate-forecast (CF) compliant netCDF format
- Organize data sets and their access in a similar way to the model data archive
- Advertise the availability of observations for use in CMIP analysis

It is therefore desirable to identify observational data sets that meet the above criteria for comparison to CMIP fields, as well as converting them to standard grids and CF format (with accompanying documentation). Formulation of satellite data is particularly desirable, as the complexity of the data can often hinder its usage by researchers.

Climate Literacy and Adaptation Strategies

Jenny Dissen; (NOAA Collaborator: Eileen Shea, Katy Vincent)

Background

Over the last decade or so, understanding changes in our climate has emerged as one of the most important areas of scientific endeavors. There is a rapidly increasing realization that profound changes in the earth climate system are already occurring and will impact nearly everyone either directly or indirectly. It is well recognized globally the need to mitigate the effects of climate change by reducing greenhouse emissions. The International Scientific Congress on Climate Change (March 2009, Copenhagen[2]) indicated that we are already following the path of the worst-case IPCC emissions scenarios trajectories. We as a society will need to adapt to the historic greenhouse gas emissions locked into the climate system. The magnitude and scale of climate change and its impact are unpredictable, arguably under-estimated, 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 pathway, 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 by regions, can include more intense precipitation events, warmer temperatures, and shorter snow seasons, changes in growing seasons, among many others[3]. Collecting and processing the fundamental data in climatic conditions, developing the models and algorithms to simulate the natural cycles, assessing the possible projections, and communicating the information are critical activities in building resiliency.

Adaptation to climate variability can be considered in the following context: 1) reducing the exposure to the risk of damage, 2) to build resiliency capacity to cope with the unavoidable damage, and 3) to take advantage of opportunities to avoid or reduce the damage. With respect to inevitable challenge of climate change, adaptation is an on-going fluid and flexible effort; there is no end-point nor is there a one-size fits all solution. Although there has been tremendous progress and advancement in our understanding and modeling of the earth system, there are a lot of unknown factors still being investigated. The uncertainty creates further complications relative to investment planning and deliberate policy decision making today.

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[2] *Key Messages from the Congress.* International Scientific Congress on Climate Change: Global Risks, Challenges and Decisions. 10-12 March 2009, Copenhagen. http://climatecongress.ku.dk/newsroom/congress_key_messages/. Accessed 19 April 2009.

[3] *Global Climate Change Impacts in the United States*. Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.

Understanding and communicating the science of what drives changes in these conditions is critical, as these conditions have implications for all modes of the industries in terms of structural integrity, safety, success of operations, ability to deliver and serve the society, etc. One of the current outreach efforts is designed to explore and build relationships with various economic sector (private / businesses / industries) members to understand their climate information and adaptation needs and how they might be addressed. It is suggested that most private sector adaptation will occur on time scales of less than a decade and maybe even 5 years. The state of understanding impacts and projections on these timescales is in its infancy and developing.

Accomplishments

The following activities have taken place in the past six months to develop collaborations to establish outreach pathways to the private enterprise.

In February 2011, under the sponsorship and support of the FCO UK, CICS-NC met with various governmental, academic and a few private institutions across UK to understand their progress and advancement to date with respect to engaging with private enterprise on climate adaptation[4]. Through building these relationships and collaborative communication pathways with international members, CICS has been able to better understand what others have tried, their success in increasing awareness with private sector and how these tactics can be replicated on the national front.

Also in February 2011, CICS-NC supported the launch of a global strategy game, "Fate of the World," that was based on scientific and economic data from NOAA at an international press release. CICS-NC was a contributing and recognized institution at this exhibition, which was a nexus of cutting edge games, science, technology, arts and innovation. The launch of an innovative strategy game is one example to advance innovation in scientific research and raise awareness about impacts of climate change.

CICS-NC has initiated communication with a North Carolina based private electric energy utility company to engage in a collaborative project effort to discuss impacts and opportunities of climate variability to their company.

Planned Work

CICS has started the planning efforts for the Summer Institute on Climate Adaptation, to take place during the summer of 2012 in Asheville, North Carolina. The multi-

industries/sectors on understanding the impacts and opportunities of climate adaptation, developing a risk management profile of impacts and mitigation alternatives, and developing decision support tools to enable investments.

CICS-NC plans to continue to engage with private enterprise across other selected industries to demonstrate the opportunities of advanced planning to address impacts of climate variability.

Development of Climate Data and Information Records and Scientific Data Stewardship

Otis Brown; (NOAA Collaborator: John Bates) – OBOBCSDCD11

Background

The NCDC has a number of research and workforce needs that necessitate 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. This proposal from CICSNC bundles several research elements at various institutions and within CICSNC to address these workforce and research needs.

The plans are to manage research interactions with NC State University faculty member (1), continue subcontracts with the University of Miami – Rosenstiel School and University of California, Irvine for two of these components (2, 3), and continue to support a group of dedicated climate researchers (4). The components of this proposal include:

1. Continuing support of Climate Science Researchers at the NCDC [Otis Brown, North Carolina State University]: $481,512
    - Richard Reynolds – SST products, operational products and Climate Data Records (CDRs)
    - Peter Thorne - Integration of surface, model and satellite fields
    - Pierre Guillevic - Land surface temperature modeling, calibration and validation and CDRs

2. Precipitation Reanalysis using Q2 Processing [Ray Boyles, NC State University]: $150,000
    - Combine L2 radar reflectivity and rain gauge data to estimate multi-year time series of rainfall intensity using Q2 methodology in support of CIFLOW
    - Characterize the different sources of bias and error in the gauge and radar data
    - Produce enhanced estimates of the coastal discharge from the 3 major river systems in NC and SC to evaluate its impacts from the Piedmont to the coastal ecosystems in the NOAA SECART region

3. Miami Pathfinder SST Processing Technology Transfer to NODC [Robert Evans, University of Miami]: $ 143,000
    - Transition ephemeris based high accuracy navigation into PFSST processing code
    - Incorporate capability to read attitude corrections to support

processing of 1 km AVHRR input Level 1b fields
- Add 'hypercube' uncertainty fields equivalent to those used in the MODIS SST processing
- Transition AVHRR SST algorithm to use MODIS 'LATBAND' 6 zonal band formulation
- Compute 'LATBAND' and 'hypercube' tables for 5 channel AVHRR sensors from NOAA-7 through NOAA-18
- Finalize and test PFSST scripts in a LINUX cluster environment
- Conduct test processing of PFSST codes to verify process
- Deliver PFSST processing codes and scripts to NODC
- Conduct reciprocal tests to verify compatibility of PFSST AVHRR processing at NODC and RSMAS

4. Satellite Data Support for Hydrologic and Water Resource Planning and Management [Soroosh Sorooshian, University of California, Irvine]: $309,600
    - Characterize spatial and temporal variability of sub-daily precipitation under climate change
    - Continue and expand research towards quantitative error and uncertainty analysis of satellite based precipitation estimation in comparisons with gauges and NEXRAD data
    - Investigate spatio-temporal framework for frequency analysis of heavy storm, using high-resolution satellite-derived precipitation estimates

Summary project activities and details for CICS-NC staff (Reynolds, Thorne and Guillevic) and subcontractors (Boyles, Evans and Sorooshian) are provided below.

Statement of Work CICS-NC

Otis Brown: (NOAA Collaborator: John Bates)

Background

The Cooperative Institute for Climate and Satellites (CICS) is formed through a consortium of academic, non-profit and community organizations with leadership from the University of Maryland, College Park (UMCP) and the University of North Carolina (UNC) System through North Carolina State University (NCSU). CICS will provide foci for collaborative research and associated activities in support of NOAA mission goals related to meteorological satellite and climate data and information research and development. CICS consists of two principal locations, one on the Research Park campus of UMCP adjacent to the NOAA Center for Weather and Climate Prediction, and the other within or in close proximity to the National Climatic Data Center in Asheville, NC. The two locations will be referred to as CICS-MD, located in College Park MD, and CICS-NC in Asheville. This proposal is to support the activities associated with CICS-NC, which will be a subcontract from the UMCP.

CICS-NC will be an Inter-Institutional Research Center (IRC) of the UNC System, administered by North Carolina State University and affiliated with several of the UNC academic institutions as well as a number of other academic and community partners – the UNC System has given it "authority to plan" and we expect the IRC to be formed this year. The partner institutions, in addition to NCSU, the lead UNC System partner, include Duke University, the University of Miami, Oregon State University, Colorado State University and Remote Sensing Systems.

CICS-NC will focus primarily on the collaborative research into the use of satellite observations in climate research and applications that will be led by the National Climatic Data Center (NCDC) of NOAA/NESDIS. 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 other 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). Additional support for community engagement and outreach is provided by the North Carolina Arboretum, an affiliate member of the UNC System, and by CECI, the Centers for Climate Interaction, an Asheville NC-based organization of academic, non-profit, community and private organizations with a common interest in advancing the capabilities represented by CICSNC.

CICS scientific vision centers on the observation, using instruments on Earth orbiting satellites, 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 will conduct collaborative research with NOAA scientists in three principal Themes: Satellite Applications, Satellite Observations and Modeling, and Modeling and Prediction. Research projects will be carried out in College Park, MD and Asheville, NC, as well as at the sites of teaming institutions when appropriate. Council of Fellows will provide overall advice to the Directors of CICS and the main centers: CICS-MD and CICS-NC. An Executive Board will represent NOAA, UMCP and NCSU senior management and will guide and direct Institute Operations.

Accomplishments

Accomplishments to date include general onboarding of the CICS-NC team, recruiting of the business and administrative staff, spearheading the research activities under the aforementioned themes, and developing the interinstitutional partnerships within the UNC System.

Publications

None

URL Links from the text:

http://cicsnc.org

High Resolution SST Analysis

Richard W. Reynolds; (NOAA Collaborator: D. Chelton)

Background

A two-stage analysis procedure has been developed with a high-resolution analysis built on top of a low-resolution analysis. Reynolds, et al. (2007, Journal of Climate) developed two lower-resolution SST analysis products using optimum interpolation (OI). The analyses have a spatial grid resolution of 0.25° and temporal resolution of 1 day. One product uses Advanced Very High Resolution Radiometer (AVHRR) satellite SST data: henceforth AVHRR-only. The other uses Advanced Microwave Scanning Radiometer (AMSR) and AVHRR satellite SST data: henceforth AMSR+AVHRR. Both products also use in situ data from ships and buoys and include a large-scale adjustment of satellite biases with respect to the in situ data. For this effort the AMSR+AVHRR product is used as the low-resolution analysis because that analysis has the superior coverage compared to AVHRR-only due to the use of microwave data. The high-resolution analysis also used an OI procedure with a grid resolution of 4.4 km using only AVHRR data. A schematic of the two-stage analysis is shown in Figure8.

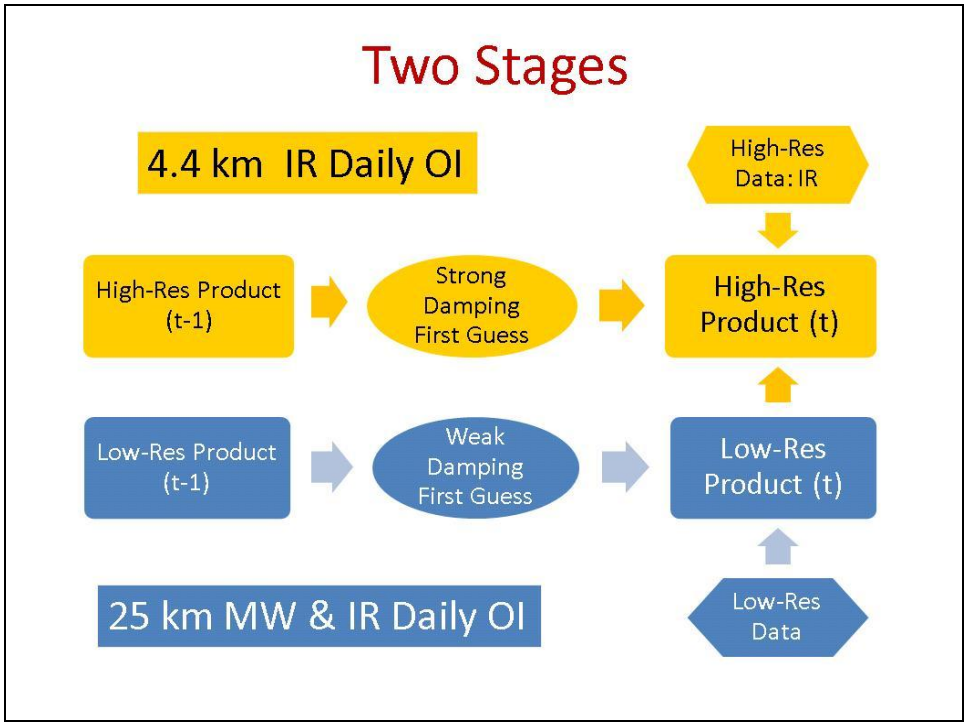

Figure 9 Schematic of the high (yellow) and the low (blue) resolution OI Processing

Accomplishments

Examination of the analyses in 2003 showed problems in the high-resolution analysis near the edge of the high-resolution data. These problems were corrected by adjusting the bias of the high-resolution data with respect to the low resolution and by increasing the noise to signal ratio near the edge of the high-resolution data. Increasing the signal to noise ratio decreases the importance of the high-resolution data. This decrease is sensible near the edge of the data because cloud contamination is more likely there. The high-resolution analysis has now been reprocessed with these changes from June 2002 (the beginning of the AMSR retrievals) through the end of 2003.

Planned Work

The high-resolution analysis will be produced from 2004 to 2009. The codes and scripts will be documented and the analysis will be made operational at NCDC.

A cross-validation project is being completed to demonstrate that the analysis grid resolution is actually the lower limit and not the same as the analysis resolution. The SSTs from the ocean model (http://ecco2.jpl.nasa.gov/) will be assumed to be the "true" SST and then sub-sampled to simulate actual infrared AVHRR and microwave AMSR satellite data distributions. The SST model data will be averaged onto the AVHRR Pathfinder v5 (4.4 km) to simulate "high-resolution" SST data. The model data will be smoothed to 50 km and averaged onto a 1/4° degree grid to simulate "low-resolution" SST data. The analysis procedure will be carried out using the two-stage low- and high-resolution OI analysis procedures. Zonal wavenumber spectra will be computed for several regions. Comparisons of the spectral results should show how the actual resolution is reduced by the OI analysis procedures and by the actual distributions of data.

Presentations

1) GHRSST Science Team meeting, Lima, Peru, 21-25 June 2010.

2) CICS, Science Meeting, College Park MD, September 8, 2010.

3) NASA, SST Science Team Meeting, Seattle, WA, November 2010.

Extended Abstract

Reynolds, R. W., D. B. Chelton (2) and T. M. Smith, 2010 "High resolution daily sea surface temperature analyses." Available at: https://www.ghrsst.org/documents/q/category/ghrsst-science-team-meetings/ghrsst-xi-science-team-meeting/ in the pdf file "Proceedings from the GHRSST XI Science Team Meeting", pages 103-106.

Publications

Saha, Suranjana, and Coauthors, 2010: The NCEP Climate Forecast System Reanalysis. , 91, 1015–1057. doi: 10.1175/2010BAMS3001.1

Integration of Surface, Model and Satellite Fields

Peter Thorne; (NOAA Collaborator: Jay Lawrimore, Matt Menne, Claude Williams, Russ Vose, Tom Peterson, Dian Seidel, John Lanzante, Dale Hurst, Deke Arndt, Howard Diamond, Chris Miller, Bill Murray)

Background

Two major international initiatives are underway as part of this research activity: the GCOS Reference Upper Air Network (www.gruan.org); and the International Surface Temperatures Initiative (www.surfacetemperatures.org). My personal research focus is on surface temperature dataset construction efforts trying to pull through methodological lessons from a decade of research into radiosonde temperatures. Additionally, I serve as the lead author on the atmospheric observations chapter of IPCC AR5, as well as supporting legacy projects on radiosonde temperatures (completed) and quality control of synoptic land data (ongoing).

The GCOS Reference Upper Air Network is the result of more than a decade of efforts by a multi-national group of experts to assure the future observing network capabilities. Referenced through numerous white papers in the 1990s, it was formally adopted as part of the GCOS Implementation Plan in 2003 and a Working Group set up for its advancement in 2004. DWD host a lead centre facility through their Lindenberg observatory. The network presently consists of 15 stations and is in an initiation phase facilitated by annual stakeholder meetings termed ICMs. The network is envisaged to provide reference quality measures including fully traceable uncertainties and measurement redundancy in support of trend determination, calibration and validation of other measures, including satellites, and process studies.

The International Surface Temperatures Initiative results from a UK submission to the 15th Session of the Commission for Climatology. An initiation workshop, which I chaired, was held at the UK Met Office in September 2010. The Initiative envisages work on a fundamental databank with provenance and version tracking, creation of redundant analysis methodologies, a consistent benchmarking of those methodologies, and provision of data and advice. Despite being in its infancy, a significant databank effort already exists attesting to the perceived importance.

The IPCC continues to represent the authoritative global report on climate change. Released approximately every five years, it synthesizes an ever-growing body of literature and evidence. The Zero Order Draft has now been produced and various review and revision cycles will follow culminating in Spring 2013 publication in Stockholm.

Accomplishments

Accomplishments achieved thus far through this research effort are as follows:

- Surface Temperatures Initiative
  - Lead of workshop on surface temperature initiative, Exeter, UK, Sept 2010
  - Steering committee set up and several meetings held
  - Data rescue task team set up and meetings held
  - Surfacetemperatures.org domain maintained and updated, blogs set up and maintained
  - First new data published on databank website held through gosic.org

- GRUAN
  - Co-lead of GRUAN ICM-3 workshop in New Zealand, March 2011
  - Task teams set up to answer specific issues
  - First data flow through the NCDC ftp portal

- IPCC
  - Attended first Lead Authors meeting of WG1 AR5
  - Zero Order Draft of temperatures section of observations chapter delivered on time
  - Chapter FAQ and two chapter boxes also delivered for ZOD

- Media and Other
  - 9 papers published / in press on surface data, radiosonde data, satellite data and reanalyzes
  - 2 talks in addition to workshops alluded to above (NCSU, Thirsty Thursday series)
  - Editor on global chapter of State of the Climate 2010
  - Hosting of visits by two UK Met Office staff and Zooniverse, funded through UK Foreign and Commonwealth Office SIN money.
  - Ad hoc advice to UK Science museum, Met Office Chief Scientist, UK Dept of Energy and Climate Change, c20c modeling project, President of Royal Met Society
  - Science, AP, Reuters, AFP on evidence the world is warming
  - Economist, Guardian, Telegraph, Times – Surface Temperatures Initiative
  - Guardian, LA Times – Berkeley Earth Surface Temperature effort

Planned Work

Work commitments will be continued around GRUAN implementation, International Surface Temperatures Initiative and Intergovernmental Panel on Climate Change. This largely accounts for approximately 75% of the effort. Approximately 20% of

the effort will be on personal research, publications and developing links with NCSU including PhD studentship involvement and possible grant proposal writing and project oversight. All remaining effort will be to foster collaborations between UK Met Office partners and NOAA's NCDC and CICS-NC.

Publications

Stott, P. A., Thorne P. W., 2010, How best to log local temperatures? Nature, 465, 158-159 (Opinion)

Willett, K. M. and coauthors, 2010, A comparison of large scale changes in surface humidity over land in observations and CMIP3 general circulation models, ERL, doi: 10.1088/1748-9326/5/2/025210

Willett, K. M., Alexander, L. V., Thorne, P.W. eds, Global Chapter in Arndt, D. S, Baringer, M. O. and Johnson, M. eds., 2010, State of the climate 2009, BAMS, 91,

Immler, F.J., Dykema, J., Gardiner, T., Whiteman, D. N., Thorne, P.W., and Vömel, H., 2010, Reference Quality Upper Air Measurements: guidance for developing GRUAN data products, Atmos. Meas. Tech., 3, 1217-1231, doi:10.5194/amt-3-1217-2010

Thorne, P. W., Vose, R. S, 2011, Reply to Comments on "Reanalyses Suitable for Characterizing Long-Term Trends", BAMS, 92, 70-72

Thorne, P. W., Lanzante, J. R., Peterson, T. C., Seidel, D. J., and Shine, K. P., 2011, Tropospheric temperature trends: history of an ongoing controversy, WIRES: Climate Change, 2, 66-88

Dai, A., J. Wang, P.W. Thorne, D.E. Parker, L. Haimberger, and X.L. Wang, 2011, A new approach to homogenize daily radiosonde humidity data. J. Climate, 24, 965-991

Mears, C. A., F. J. Wentz, P. Thorne, and D. Bernie, 2011, Assessing uncertainty in estimates of atmospheric temperature changes from MSU and AMSU using a Monte-Carlo estimation technique, JGR, 116, D08112 doi:10.1029/2010JD014954

Thorne, P. W., P. Brohan, H. A. Titchner, M. P. McCarthy, S. C. Sherwood, T. C. Peterson, L. Haimberger, D. E. Parker, S. F. B. Tett, B. D. Santer, D. R. Fereday, and J. J. Kennedy, 2011, A quantification of uncertainties in historical tropical

tropospheric temperature trends from radiosondes JGR., doi:10.1029/2010JD015487, in press.

Land Surface Temperature product validation over mixed pixels – Scaling methodology for NOAA satellite programs at moderate resolution (VIIRS, GOES-R)

Pierre Guillevic; (NOAA Collaborator: Jeffrey Privette)

Background

The Land Surface Temperature (LST) product from NOAA satellite observations the Visible Infrared Imager Radiometer Suite (VIIRS) and the Geostationary Operational Environmental Satellite R Series (GOES-R), for instance- has the potential to provide key information for monitoring Earth surface energy and water fluxes, improving weather forecasting at high spatial and temporal resolutions and monitoring climate change. However, unlike Sea Surface Temperature (SST), LST products are not widely used by operational weather and climate centers through direct analysis or data assimilation in atmospheric models. The main limitations in using satellite data over land surface are the need to correct for surface emissivity and atmospheric water vapor attenuation, and the difficulty in quantifying LST product accuracy due to the lack of comparable in situ measurements.

The objective of this project is to develop a new methodology for VIIRS data that monitors the quality of satellite LST products, estimates the quantitative uncertainty in the product, and contributes to improving the retrieval algorithm. This methodology was initiated under NPOESS/JPSS program, was tested and proven with NASA/MODIS, and is readily adaptable to other satellite programs at moderate resolution, such as GOES-R. Ultimately, this should result in the tailoring of LST products with the high level of required data characteristics essential to support weather forecast, hydrological applications, and climate studies. The proposed validation approach has the capability to explore scaling issues over terrestrial surfaces spanning a large range of climate regimes and land cover types, including forests and mixed vegetated areas. The scaling methodology consists of the merging of information collected at different spatial resolutions and a land surface model to fully characterize the satellite products, measurements from ground sites, instrumented aircrafts, and satellites platforms at high and moderate resolutions.

The final goal of thisstudy is to establish, in near real time, the accuracy of the LST products derived from satellite observations over a selection of field validation sites for the algorithm working groups and the science user community.

Accomplishments

Accomplishments through this research effort are highlighted as follows:

- Development of data processing tools to ingest ground measurements of atmospheric forcing and LST from operational field networks (CRN,

AmeriFlux, SURFRAD networks): re-sampling, reformatting, filling missing points, data combination.

- Development of tools to process MODIS products: subsets extraction, basic treatment. The products currently used by the methodology are MOD11A1 (Terra LST) and MYD11A1 (Aqua LST), MCD43A3 (Albedo), MCD15A2 (LAI 1km), MOD13A2 (Vegetation index 1km) and MOD13Q1 (Vegetation index 250m). The tools will be adapted for VIIRS data.
- Development of the SEtHyS land surface model (Coudert , 2006[5]). The implementation of the model has been completed for the NPP/VIIRS program and will be adapted for GOES-R. First results obtained over Bondville, IL using MODIS LST products at 1 km resolution as proxy are very encouraging (Figure 9).

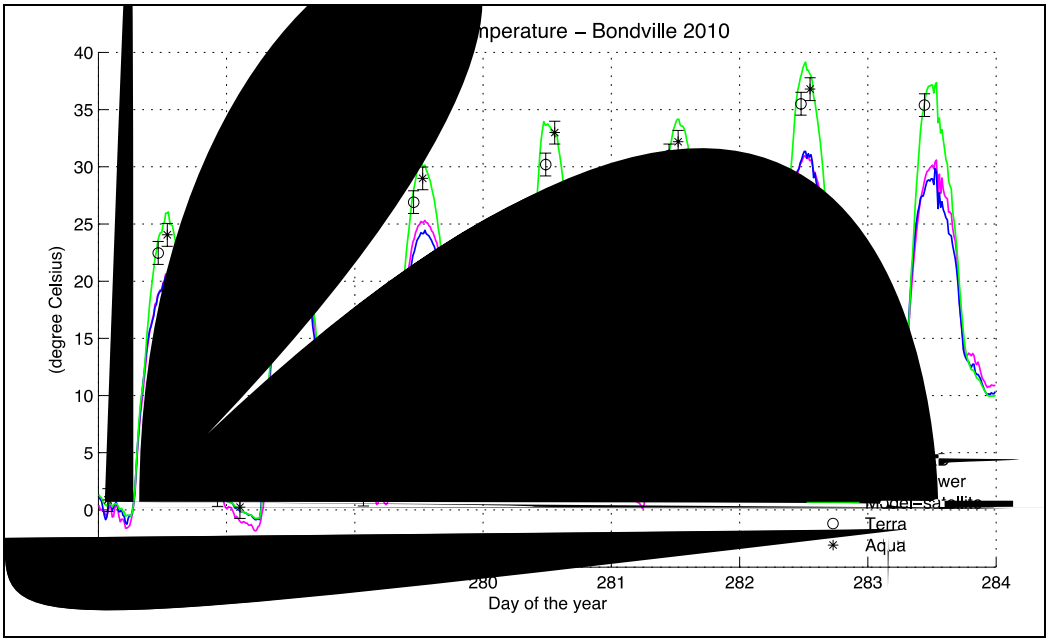

Figure 10 Land Surface Temperature measured by a SURFRAD station, and by MODIS satellites over Bondville, IL, and simulated by the SEtHyS model at both tower and satellite resolution. Error bars represent the possible errors associated with MODIS data from MODIS quality flags. The efficacy of the SEtHyS model for scaling point field data to satellite pixel area is clear in the close correspondence of the green "Model-satellite" line to the actual Terra and Aqua MODIS samples.

[5] Coudert, B., C. Ottle, B. Boudevillain, J. Demarty, and P. Guillevic (2006), Contribution of thermal infrared remote sensing data in multiobjective calibration of a dual-source SVAT model, Journal of Hydrometeorology, 404-420.

Planned Work

The additional work through this research effort includes:

- Development and implementation of an automatic model calibration procedure using ground measurements. For geostationary satellites, the approach will be optimized using diurnal cycle information.
- Development of an interactive visualizing tool to perform routine validation (periodically) and more specific validation (for interested sites, detailed LST evaluation).
- Test the approach over various sites and climate regimes, including leaf-on and leaf-off periods. The final objective is to combine results over 12-25 different validation sites (table 1) to fully characterized VIIRS products before the launch scheduled for October 2011.
- Assess the approach uncertainties by propagating errors associated to ground measurements, model outputs, satellite uncertainties.
- Compare the proposed validation approach with different approaches based on a statistical representation of scaling issues. Use the physically based approach to refine the statistical approach.

Table 1: List of selected sites for validation of the GOES-R ABI LST product.

	Name	Location	Lat.	Lon.	Network	Land type
1	Bondville 1	IL, USA	40.05° N	88.37°W	CRN, SURFRAD	Grass
2	Bondville 2	IL, USA	40.01° N	88.29°W	Ameriflux	Corn/Soybean
3	Crossville	TN, USA	36.01° N	85.13°W	CRN	Grass
4	Desert Rock	NV, USA	36.62° N	116.02° W	CRN, SURFRAD	Desert
5	Fort Peck	MT, USA	48.31° N	105.1°W	CRN, SURFRAD	Grass
6	Chesnut Ridge	TN, USA	35.93° N	84.33°W	Ameriflux	Forest
7	Gobabeb	Namibia, Africa	23.55°S	15.05°E	LSA-SAF	Desert
8	RMZ	Namibia, Africa	23.01°S	18.35°E	LSA-SAF	Savannah
9	Dahra	Senegal, Africa	15.40° N	15.43°W	LSA-SAF	Savannah
10	Crau 1	France	43.6°N	4.7°E	HYMEX	Wheat
11	Crau 2	France	43.61° N	4.71°E	HYMEX	Irrig. Grassland
12	Camargue	France	43.62° N	4.58°E	HYMEX	Rice

Pending proposal

Title: "GOES-R Land Surface Temperature Product Validation Over Mixed Pixels" in response to the GOES-R Calibration/Validation Field Campaign call (April 2011).
Role: Principal Investigator
Co-Investigators: Jeffrey Privette (NOAA/NESDIS/NCDC), Yunyue Yu (NOAA/NESDIS/STAR) and Tilden Meyers (NOAA/ARL/ATDD).
Source of Support: NOAA/NESDIS
Total Award Amount: $233,796 for the period from 10/01/2011 to 9/30/2013 (2 years)
Location of the project: CICS-NC

Publications

Guillevic P., Krishnan P., Muratore J. F., Kochendorfer J., Martos B., Dumas E. J., Coudert B., Privette J. L., Meyers T. P., Corda S., and Baker C. B. (2011). Abstract submitted to the 19th Conference on Applied Climatology, AMS, Asheville, NC. July 2011.

Oral Presentation in Workshops and Meetings

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Guillevic P. and Privette J. (2010). Conceptual elements of an integrated global land validation effort. VIIRS Land validation Team meeting. College Park, Md. October 5-6, 2010.

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Guillevic P. (2011). Land Surface Temperature EDR validation. Quarterly report for the VIIRS calibration and validation scientific panel. February 2011.

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Privette J. and the VIIRS Land and Cryosphere Validation Team: Csiszar I., Fried M., Guillevic P., Huete A., Justice C., Key J., Lyaspustin A., Maslanik J., Roman M., Romanov P., Schaaf C., Vermote E. and Yu Y (2011). NPOESS Preparatory Project Validation Program for Land Data Products from the Visible Infrared Imager

Radiometer Suite (VIIRS). The AMS meeting, Poster session. Seattle, WA. January 23 - 27, 2011.

Privette J. and the VIIRS Land and Cryosphere Validation Team: Csiszar I., Fried M., Guillevic P., Huete A., Justice C., Key J., Lyaspustin A., Maslanik J., Roman M., Romanov P., Schaaf C., Vermote E. and Yu Y (2011). NPOESS Preparatory Project Validation Program for Land Data Products from the Visible Infrared Imager Radiometer Suite (VIIRS). International Symposium on the A-Train Satellite Constellation in New Orleans, LA, on October 25-28, 2010.

Main collaborations

- NOAA/NESDIS/STAR (Yunyue Yu) to compare and evaluate different LST product validation approaches developed for VIIRS and GOES-R.
- NOAA/ARL/ATDD (Tilden Meyers) and the University of Tennessee Space Institute's Aviation Systems and Flight Research Department to utilize an instrumented aircraft to perform measurements of Earth's skin temperature over selected climate stations operated by NOAA.
- NASA/JPL (Simon Hook and Glynn Hulley) to develop a methodology for producing coincident LST products using the same retrieval algorithm from TERRA MODIS data at 1 km resolution, and from ASTER data at 90 m resolution, for each of the field validation sites.
- Karlsruhe Institute of Technology (KIT), Germany (Frank Goettsche) to test the approach over four permanent validation stations within the framework of LSA-SAF and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), and compare with LST products derived from MSG/SEVIRI.
- INRA Avignon, France (Dominique Courault and Frederic Baret) to test the approach over multiple field experiments in France that support aircraft campaign and satellite products validation, such as the high resolution satellite FROMOS-2T (8m resolution) and the FLIR thermal infrared sensor onboard a fully instrumented airplane.

Precipitation Re-analysis using Q2

Ryan Boyles, Scott Stevens, (NOAA Collaborators: Brian Nelson, Stephen Del Greco)

Background

At present, NOAA does not have a precipitation product with high spatial and temporal resolution. The Q2 product, developed at NSSL in Norman, OK, provides quantitative precipitation information at 1-km resolution at a five-minute interval. This product is generated in real-time at NSSL, but only archived for a limited period of time. Using the archive of NEXRAD data kept on location, NCDC, in partnership with NSSL and CICS, is in the process of creating a 10 to 15 year reanalysis using the Q2 algorithms, beginning with a pilot domain centered over Virginia and the Carolinas.

Accomplishments

Focus over the past year has been on the transfer of knowledge and technology from NSSL to NCDC, as well as the implementation of the software to generate precipitation products. Working relationships have been established and maintained with NSSL as well as the Renaissance Computing Institute (RENCI) in Chapel Hill, NC, due to the very high computing resource requirement for this project. CICS-NC scientist based in Asheville, Scott Stevens, has become familiar with the NSSL NMQ/Q2 software and adapted it for use in the NCDC archive setting. Scripts have also been developed to fully utilize the supercomputing resources at RENCI to expedite processing of the full Level-II radar archive at NCDC.

Extensive collaboration has taken place between these entities. Both raw data and the analysis output have been shared between NSSL and NCDC in an effort to create an inclusive set over the period of record. The collaborative effort has enabled a mutually beneficial feedback mechanism between NCDC and RENCI in an effort to streamline the process and make it more efficient.

This effort has enabled the successful creation of a quantitative precipitation product over the pilot domain for the years 1999-2002; this is currently in the process of being compared to products generated at NSSL. Figure 1 below shows the QPE estimates using NMQ/Q2 for the period during landfall of Hurricane Floyd in September 1999.

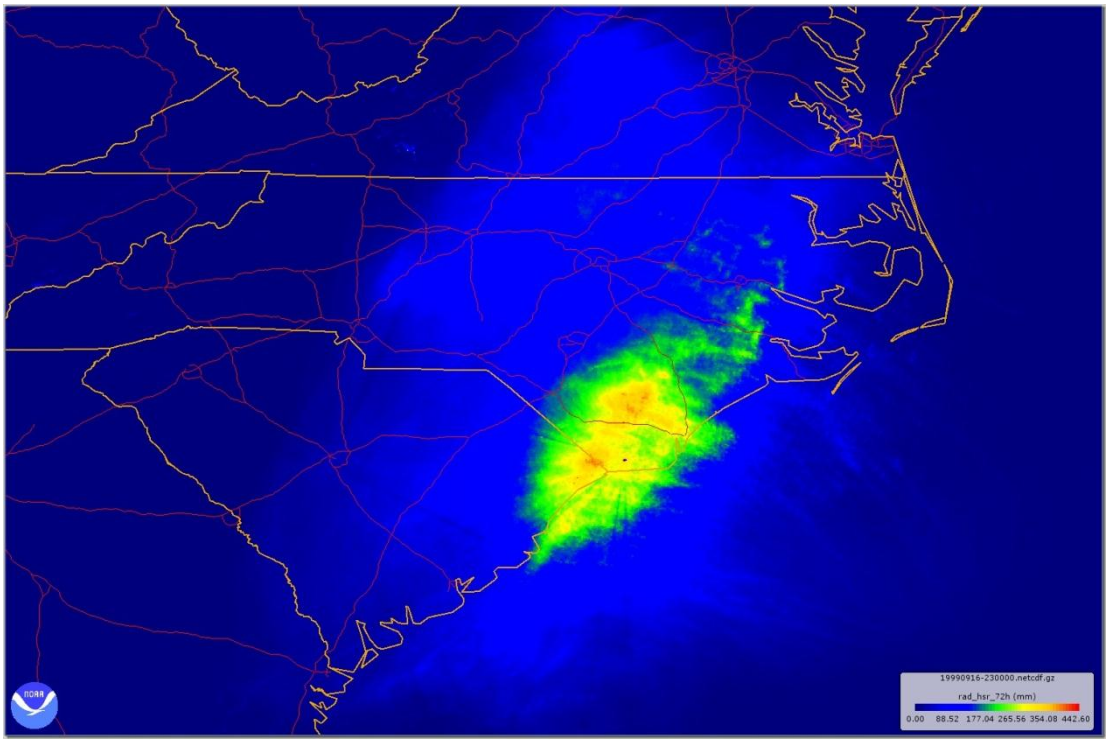

Figure 11 NMQ/Q2 generated precipitation estimate during landfall of Hurricane Floyd along the Carolina coastline in September 1999.

Planned Work

Over the next year, the Q2 analysis will be expanded to cover the period 1998-2010 for the pilot domain. Upon completion of the product generation, detailed analysis will be performed on the output in ordo o id-11(g)4(e3(eratm [y)-5(strengths(ild)5(em [y)5(Huk)-6(

Transfer NOAA/NASA AVHRR Pathfinder SST Processing to NODC

Robert Evans; (NOAA Collaborator: Kenneth Casey)

Background

The primary goal of this work is to assemble AVHRR SST retrieval algorithms into a robust code package to produce a Climate Quality data Record (CDR) for the AVHRR time series, NOAA-7 (1981) through NOAA-18 (2010) and deliver the package to NODC to support on-going production of the AVHRR Pathfinder SST time series. This activity includes updating the SST retrieval codes to Pathfinder Version 6 (monthly zonal latitude band coefficients), generating the per retrieval uncertainty estimates (uncertainty Hypercubes), selecting the SST reference field and generating the daily, global SST fields for validation and distribution of Pathfinder fields at NODC.

Accomplishments

Accomplishments during the period April 1, 2010 to March 31, 2011 include:

- Delivery of the AVHRR SeaDAS code to NODC,
- Extensive runs comparing the Pathfinder SST to various reference SST fields (e.g. Reynolds V2 daily, ¼ degree OI, AMSR, AATSR),
- Extensive interaction with Ken Casey's group at NODC to define and generate extensions to the OI reference fields to include the user community requested rivers and lakes,
- Generation of an improved land mask,
- NODC development of a conversion program to convert the SeaDAS HDF product files into GHRSST compliant NetCDF files with associated metadata,
- Transfer of Pathfinder HDF files to NODC,
- NODC subsequent file conversion and
- Transfer of a prototype NetCDF file to NCDC to initiate transfer into the CDR program and a prototype processing of all NOAA AVHRR global GAC observations from 1981 to 2010 to test completeness of the CLASS supplied L1b files.

This calculation provides the basis for constructing the Pathfinder time series by assisting in determination of the valid time periods for each sensor's operation. NCDC requested delivery of an interim Pathfinder data set, Figure 1, to provide a consistent product to the user community while the final Pathfinder 6 dataset and algorithms are being tested. Together with NODC and in consultation with NCDC, the decision was made to produce a Pathfinder 5.2 time series that is based on Pathfinder 6 processing and quality tests, the use of Reynolds V2 ¼ degree, daily SST reference fields and the Pathfinder 5 SST retrieval algorithm and retrieval

equation coefficients. Both the Pathfinder 5.2 and 6.0 algorithms have been validated through comparison to a suite of SST reference fields as well as a large database of co-located, contemporaneous satellite-in situ observations of radiometric and drifting buoy SST.

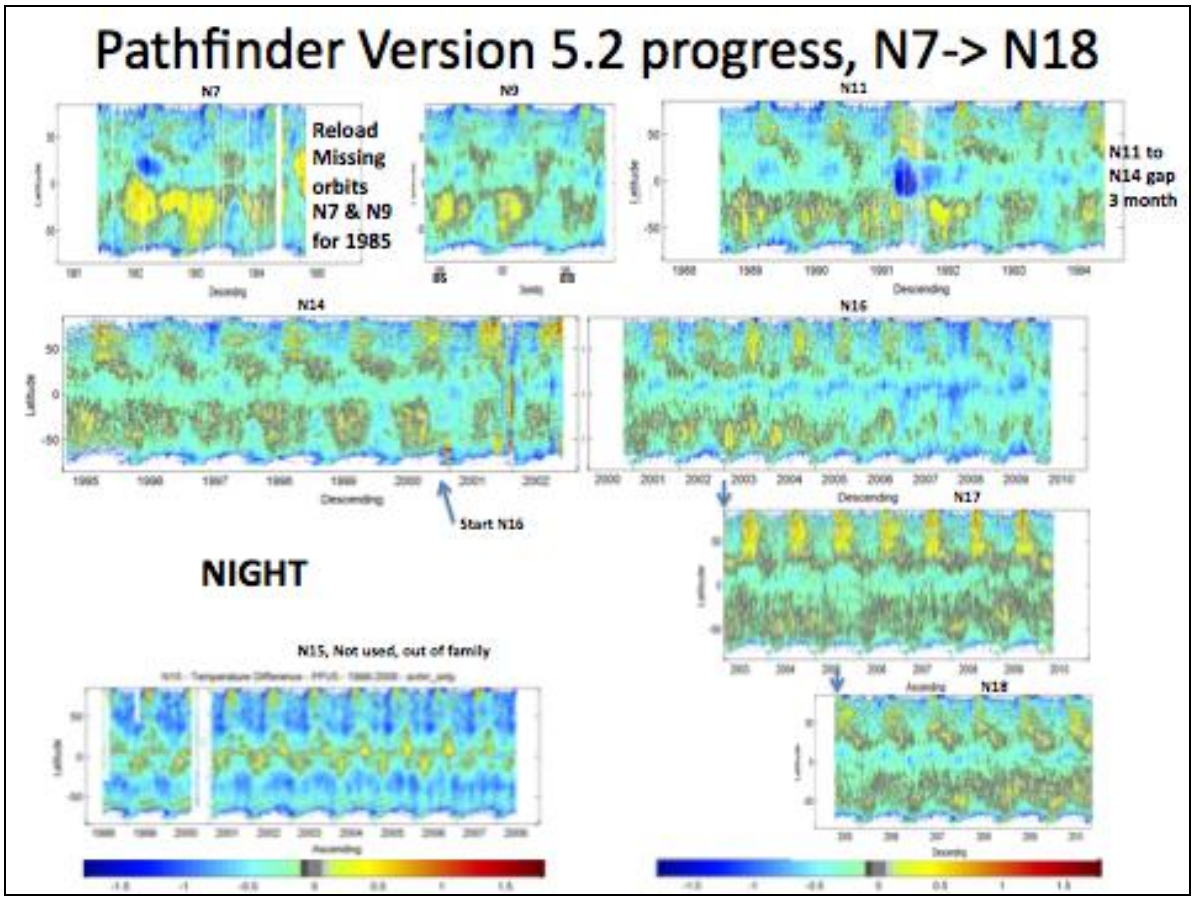

Figure 12 Pathfinder 5.2 latitude, time plots showing the residuals of Pathfinder 5.2 SST-Reynolds 1/4 degree, daily OI reference field.

Difference fields are shown for NOAA-7, 9, 11, 14, 16, 17 and 18. The difference map for NOAA-15 shows a pattern that is incompatible with those of the other AVHRR sensors indicating a sensor anomaly. The NOAA-15 data thus will not be included in the Pathfinder time series. The blue regions seen north of the equator in the NOAA-7 and NOAA-11 maps are a consequence of the presence of volcanic aerosols from the eruption of El Chichon and Mt. Pinatubo. It is expected that the Pathfinder 6 processing will be able to more completely correct for these cold retrievals. The transition times between satellites are marked and fortunately occur prior to the degradation of the previous sensor. Unfortunately, due to the loss of NOAA-13 shortly after launch, there is a time gap of 3 months between NOAA-11 and NOAA-14. The high latitude seasonal oscillations seen in the time series are a consequence

of using a single reference field that does not reflect diurnal variations that are present in the AVHRR fields. These oscillations are nearly non-existent when a reference field that is temporally consistent with the AVHRR observation time is used to construct the difference field (e.g. AMSR).

Planned Work

A series of validation exercises is currently underway to validate the Pathfinder 5.2 process, generation of the complete time series, transfer of the HDF files from RSMAS to NODC, conversion of HDF files to GHRSST compliant NetCDF format at NODC, and transfer of the NetCDF files from NODC to NCDC for inclusion in the CDR project. During the April/May period RSMAS and NODC will process several years of N18 global data and post these files for comment by the user community. This initial data set will serve to expose the file format to the community as well as providing feedback on the dataset. Following a comment period, production and delivery of the entire Pathfinder 5.2 data set will commence.

Publications

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Evans, R., G. Podesta, Characterizing and comparison of uncertainty in the AVHRR Pathfinder SST field, Versions 5 & 6, GHRSST Calibration and Validation Meeting, Boulder CO., March 1, 2011.

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Banzon,V., R Evans, R Reynolds, T Smith, A preliminary investigation of the cold bias in the extended reconstruction of sea surface temperature analysis introduced by the inclusion of Pathfinder data. GHRSST XI, Lima Peru, June 10, 2010.

Precipitation Re-analysis using Q2

Soroosh Sorooshian; (NOAA Collaborator: John Bates)

Background

Satellite-derived precipitation products are gaining recognition as viable source of information on precipitation for research and application. Among these applications is regional hydrologic modeling, data assimilation into weather models, and validation and verification of regional numerical weather models as well as global climate models. However, the applicability of satellite precipitation to hydrologic applications that focus on design and planning is limited due to factors such as their spatial resolution, limitation on record length, and lack of quantitative information about uncertainties in satellite precipitation at the required spatial and temporal scales. This task will focus on addressing these challenges and initiating the development of approaches that can lead to improve utilization of satellite precipitation in hydrologic application and water resources planning and management. This research effort intends to focus on three different thematic areas: (1) climatic analysis of spatial and temporal variability of sub-daily extreme precipitation over United States for past decades, (2) quantification of uncertainty in satellite precipitation estimation, and (3) expanded frequency analysis of extreme rainfall using satellite precipitation data.

The Center for Hydrometeorology and Remote Sensing (CHRS) at the University of California, Irvine, plans to use the expertise of its current interdisciplinary staff of scientists. Our work will focus on the following sub-tasks.

The IPCC AR4 report suggests that extreme precipitation events will become more intense as a result of global warming (IPCC, 2007). It also implies that the variability of extreme precipitation, in terms of their intensity, frequency, duration, and spatial/temporal distribution, may be enhanced due to climate change. These changes will impactthe applicability of the assumption of stationary process, which is a key assumption in most frequency analysis based engineering applications. In the proposed activity, we will investigate the daily and sub-daily precipitation data from gauge and satellite measurement for a period representing recent climatology (30 years). The goal of the investigation is to provide a statistical summary of recent stationary and non-stationary trends in extreme precipitation events. This involves the following tasks:

a. Collect and analyze data: Collect multiple years of precipitation data from gauge and radar over the continental United States; classify heavy storm

events according to their rainfall intensity, accumulation, and duration.

b. Extend data over un-gauged regions using satellite estimates: Use local gauge/radar measurement to adjust multi-satellite precipitation estimation and extend the precipitation measurements to un-gauged regions using bias corrected satellite-based precipitation estimates.
c. Develop extreme precipitation analysis: Examine the trend of extreme storm events at each climate region based on precipitation intensity and frequency. Analyze the variation of frequency of extreme storm events with respect to the local and regional surface temperature changing over time.
d. Identify stationary or non-stationary features of extreme storms: Evaluate the limitation of the current engineering stationary frequency analysis; investigate the use of variation of statistical moments in the non-stationary process analysis and risk assessment.

Compared with rain gauge measurements, satellite precipitation data provide higher spatial and temporal resolution. However, they data are subject to different types of error such as sampling uncertainty, inherent measurement and retrieval errors, among others (Tian et al., 2009). Despite extensive research, the uncertainties associated with satellitebased precipitation data have not yet been well quantified (Sorooshian et al., 2000). Characterization and quantification of such uncertainties are extremely important, as it is believed that inaccurate input rainfall is one of the main sources of error in hydrologic predictions and climate studies (Yilmaz et al., 2005). In order to understand the characteristics of precipitation error the following analyses are planed:

a. Validation of satellite precipitation estimatesfor different thresholds of precipitation (e.g., 95, 90, 75, 50, 25 and 10 percentiles) using NEXRAD radar data and rain gauge measurements. The results will lead to characterization of error, particularly its variance, with respect to the magnitude of rain rate. This information may result in significant advancements in data assimilation techniques and ensemble generation. The analysis will focus on sub-daily (hourly, 3 hours, and 6 hours) intervals.
b. Analysis of multivariate probability distribution of precipitation extremes using statistical copulas method at locations where reliable ground reference measurements exist. Copulas will allow us to build a multivariate relationship with probability occurrence of precipitation at different locations. Having developed such relationship, one can quantify the probability of detecting extremes using satellite data, where no ground

reference measurements are available.

c. Investigation of the dependence structure of satellite precipitation error in space using spatial empirical copulas. These techniques can provide valuable information regarding error and its spatial characteristics.
d. Investigating whether the tail dependencies of satellite precipitation estimates correspond to those of radar estimates. While there are some studies on distribution tail dependencies of rain gauge data, satellite and radar estimates are not well researched with regard to their tail dependence.

a. Develop a 4-dimensional data base of heavy events (location, incremental depth/intensity, time) from satellite -based and radar observations: Using a spatio-temporal connectivity algorithm developed at CHRS, we will develop a data base of extreme heavy precipitation events that accounts for the spatio-temporal evolution of each event and identifies storm track (origin, pathway, and termination) along with the three dimensional description of the storm at each interval along its track.
b. Utilize the above-described database to conduct seasonal and regional analysis of heavy precipitation events. Initially, the analysis will focus on characterizing heavy events within given regions in terms of their spatial extent, duration, depth, and storm origin.
c. c. For the period of satellite/radar observation, connect (gauge) point observations of annual maximum/partial duration series of precipitation to spatial storm structure by extracting from satellite and/or radar observations the spatial patterns of storms associated with the said extreme (point-based) event. Repeating the analysis for multiple neighboring gauges within a given region will result in identifying storms that cause maximum depth for a given duration in multiple neighboring gauges as well as in evaluating spatial dependency of extreme events.

Accomplishments

Through the above activities, the research effort established characterization of spatial and temporal variability of sub-daily precipitation under climate change. We will continue and expand research towards quantitative error and uncertainty analysis of satellite based precipitation estimation in comparisons with gauges and NEXRAD data. Additionally, the research will investigate spatio-temporal framework for frequency analysis of heavy storm: using high-resolution satellite-derived precipitation estimates.

Climate Assessment Activities

Otis Brown; (NOAA Collaborator: Scott Hausman) OBOBCAANC11

Background

NOAA has a number of national, regional and sectoral level climate assessment activities underway and emerging, responding, in part to the injection of new funding to support 'Assessments Services' in this fiscal cycle. NOAA will also be participating in a high-level, visible, and legally mandated National Climate Assessment process, which will be responsive to greater emphasis on user-driven science needs. NOAA has a number of research and workforce needs that necessitate 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. This proposal from CICS-NC bundles several research elements within CICS-NC to address these workforce and research needs.

NOAA's National Climatic Data Cener (NCDC) and many parts of NOAA have provided leadership on climate assessment activities for over a decade through such efforts as the first National Assessment in 2000, the WMO ozone assessments, IPCC, annual reports on the , and through the interagency U.S. Global Change Research Program assessments process. A renewed focus on national and regional climate assessments to support improved decision-making across the country is now emerging. 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 will also be looking to invest in core competencies including modeling, data management, visualization, communication, web management and other expertise, much of which is reflected below in the position highlights.

Accomplishments

Accomplishments to date on this activity include searching for 3 new positions, including:

- Assessments Science Oversight: (Senior) Scientist
- Assessment Program Coordinator
- Research Associate (Attribution)

A senior scientist, Dr. Kenneth Kunkel, has been hired. The other two searches are underway.

An individual project summary with specific accomplishments is provided below.

National Climate Assessment Scientific Support Activities

Kenneth E. Kunkel; (NOAA Collaborator: Thomas Karl)

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 instituted a task group of a senior scientist, a deputy focused on coordination, an attribution support member and a DC-based staff support member. 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

The lead senior scientist has participated in numerous conference calls and in the following meetings: Workshop on Planning Regional and Sectoral Assessments for the National Climate Assessment (Nov. 15-17, 2010), Climate Change Modeling and Downscaling Workshop (Dec. 8-10, 2010), Workshop on Tracking climate change impacts and vulnerabilities: Physical climate indicators for the National Climate Assessment (March 29-30, 2011), inaugural meeting of the National Climate Assessment Development and Advisory Committee (April 4-6, 2011).

In support of these workshops and related NCA activity, the following written documents were prepared:

- "White Paper on Downscaling for National Climate Assessment Regional Information"
- Physical climate outlook plan

- "Regional climate vulnerabilities and trends – Midwest". Figure 12 shows an example of the type of information included in this report.
- "Climate Model Expert Subgroup Recommendations to NCADAC"
- "White Paper on Physical indicators of climate change" (co-author with Fred Lipshulz

Four presentations were prepared and given (see list below). An informal group of climate model experts was organized to provide recommendations to the federal advisory committee. Two conference calls were held and a draft set of recommendations was prepared.

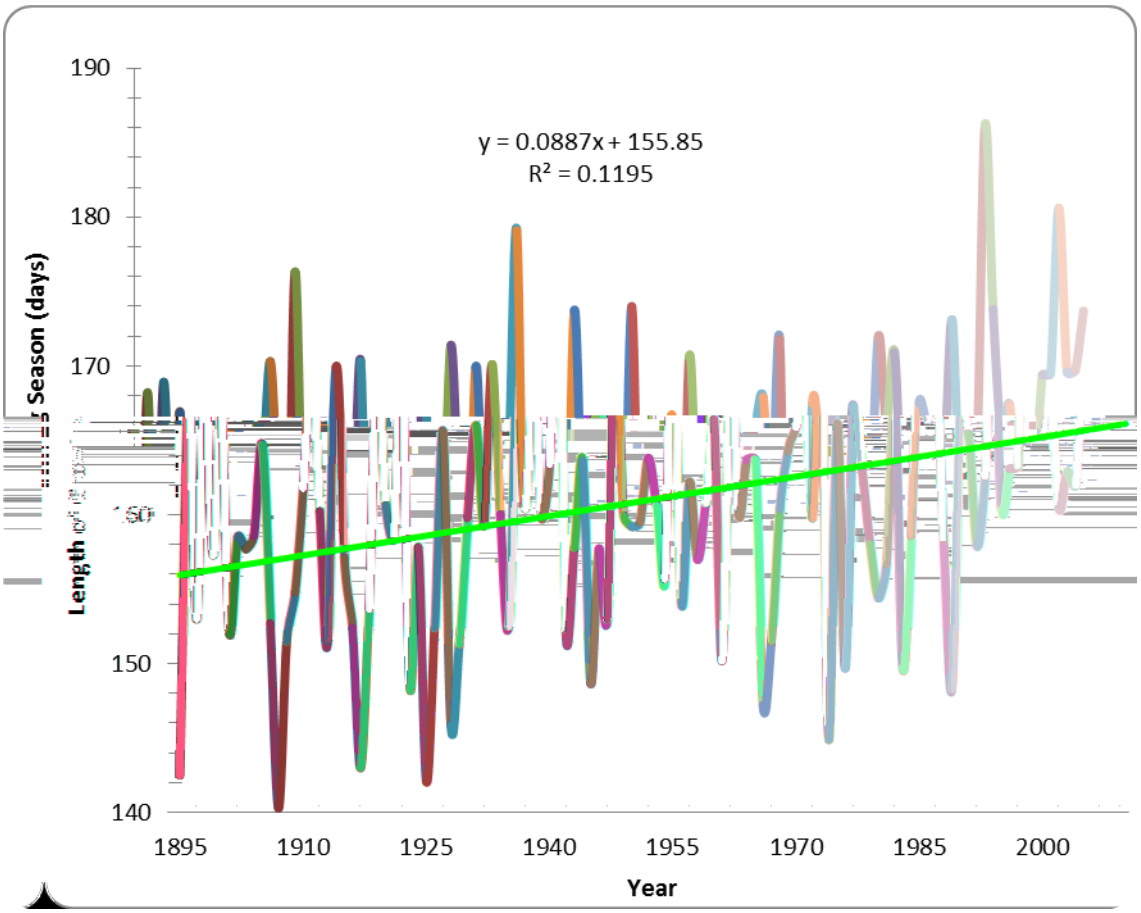

Figure 13 Length of the growing season is defined as the period between the last occurrence of 32°F in the spring and first occurrence of 32°F in the fall. Red line is a linear fit. Based on data from the National Climatic Data Center for the cooperative observer network and updated from Kunkel et al. (2004).

Work Plan

The CICS-NC assessment team will have a central role in the preparation of material on the physical climate aspects of the 2013 report. They will coordinate and provide leadership for the development of regional climatologies and regional climate outlooks. They will provide expertise in developing requirements to manage and access climate datasets (of different sizes, formats and types) for a user community ranging from novice to advanced. A special focus on providing traceability for users to understand the data 'chain of custody' will be necessary.

Presentations

"National Climate Assessment and NARCCAP", invited talk, NARCCAP Users Workshop, Boulder, CO, April 7, 2011.

"Development of Regional Climate Information for the National Climate Assessment", invited talk, inaugural meeting of the National Climate Assessment Development and Advisory Committee, Washington, DC, April 5, 2011.

"Physical Indicators: Considerations and Previous Work", invited talk, Workshop on Physical Indicators for the National Climate Assessment, Washington, DC, March 29, 2011.

"Downscaling Activities for the National Climate Assessment, National Climate Assessment Workshop on Climate Modeling, Washington, DC, December 8, 2010.

Research on Climate Modeling, Variability, Extremes, and Applications

Kenneth E. Kunkel; (NOAA Collaborator: Thomas Karl)

Background

The overall objective of this research program is to achieve a better understanding of past variations and trends in extreme weather and climate conditions and of potential future changes due to natural and anthropogenic forcing. Some of the ongoing research thrusts include (1) providing the theoretical and empirical foundations for incorporation of climate change into estimates of probable maximum precipitation (PMP); (2) investigating the meteorological causes of historical changes in extreme precipitation; (3) examining century+ trends in extratropical cyclone (ETC) frequency and intensity using a new reanalysis product that extends back to the late 19th Century; and (4) analyzing regional climate simulations with regard to potential future changes in extremes.

Accomplishments

Upward trends in extreme precipitation events are concentrated in the eastern half of the U.S. and are associated with fronts and tropical cyclones, but no trends for other meteorological causes. The recent (last 25 years) elevated level of frequency of extreme event occurrence is accompanied by increases in the precipitable water associated with events in the warm season (Fig. 1). These points are suggestive that increases in water vapor may play a principal role.

One global and several regional climate model simulations were analyzed to evaluate potential future changes in maximum precipitable water (P_{wmax}), one of the principal factors used as input to PMP estimation. Initial analysis of one global climate model (GFDL 2.1) simulation suggests that changes in P_{wmax} over land are similar to the nearby oceans with increases of P_{wmax} of 10% to >50% for the latter third of the 21st Century over the U.S. for the A2 scenario. Examination of 3 simulations from the NARCCAP regional climate model suite (for the A2 scenario) for the middle of the 21st Century shows increases generally around 10-20% for much of the U.S. Examination of simulations from another regional climate model for the middle of the 21st Century shows a high sensitivity to emissions scenario, with increases generally less than 10% for a low emissions scenario but 15-30% for a very high emissions scenario.

Preliminary analysis of ETC trends suggests that the ratio of the number of high latitude to mid latitude ETCs was much higher in the late 19th early 20th Centuries; this implies a shift in the mean track of ETCs to the south during the latter two-thirds of the 20th Century. The lowest mid-latitude values occur in the 1910s through 1930s, a signal that is most prominent in the Pacific. The mid-latitudes

became more active after the 1930s. At the same time, at high latitudes there is a shift with higher (lesser) activity in the eastern (western) Hemisphere.

Planned Activities

The Army Corps of Engineers and the Bureau of Reclamation are also keenly interested in incorporating climate change information in estimates of PMP. Two major tasks in the near future: (1) analysis of CMIP5 simulations regarding potential future changes in the factors used to estimate PMP values; and (2) modeling studies of the influence of environmental changes on the dynamics of historical extreme storms. Research on the meteorological causes of historical extreme precipitation trends will explore whether there have been changes in the number or characteristics of fronts, which account for most of the observed trend. ETC trends will be analyzed to determine the association with climate modes of variability and SST trends.

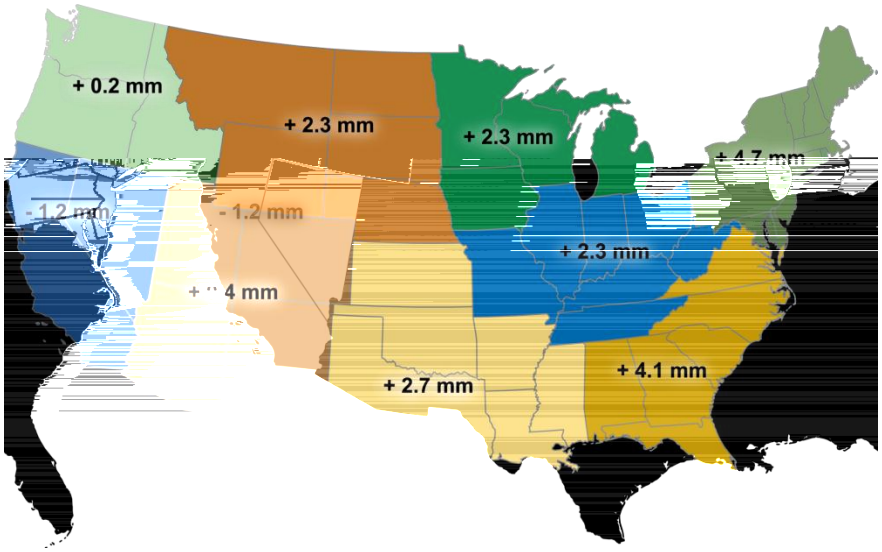

Figure 14 Differences in precipitable water anomalies associated with extreme events between 1982-2006 and 1961-1981.

Publications

Liang, X.-Z., M. Xu, X. Yuan, T. Ling, H. I. Choi, F. Zhang, L. Chen, S. Liu, S. Su, F. Qiao, J.X.L. Wang, K.E. Kunkel, W. Gao, E. Joseph, V. Morris, T.-W. Yu, J. Dudhia, and J. Michalakes, 2011: Development of CWRF for regional weather and climate prediction: General model description and basic skill evaluation. , submitted.

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Kunkel, K.E., D. Easterling, D.A.R. Kristovich, B. Gleason, L. Stoecker, and R. Smith, 2010: Recent increases in U.S. heavy precipitation associated with tropical cyclones. , **37**, L24706, 4 pp., doi:10.1029/2010GL045164.

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Prototypes of Weather Information Impacts on Emergency Management Decision Processes

Otis Brown; (NOAA Collaborator: Deidre Jones)OBOBPWIIE11

Background

Prototypes of Weather Information Impacts on Emergency Management Decision Processes

K. Galluppi and B. Montz Covey; (NOAA Collaborators: Steve Cruz, Paula Davidson, Woody Roberts, Darin Figurskey)

Background

This work was initiated as a cooperative project between the NWS/OST, NOAA ESRL/GSD, RENCI at UNC-Chapel Hill, and East Carolina University. The goal of the research is to understand how to improve NWS weather decision support to the emergency management (EM) community to save lives and protect property. This project has four objectives:

1. To understand the EM decision processes for risk and crisis management,
2. To understand what is effective translation of scientific information into knowledge for decision making,
3. To understand how collaborative technologies can facilitate knowledge exchange and situational understanding, and
4. To demonstrate prototyping methods fusing together social sciences, physical sciences, and technological advances to advance decision support. To accomplish our work, we employed an incremental and iterative research and development process with EM decision-makers guiding the process.

The main theme of the project is to understand what critical decisions, and by whom, are being made; what are their consequences and risk; what climate or weather knowledge is needed to make these decisions; and what factors influence decision-maker confidence. We accomplish this task by researching how information is transformed into knowledge, communicated, and results used in decisions and confidence building.

Accomplishments

Rapid iterative research and developments were segmented into quarterly scopes of work, which commenced on July 1, 2010. Each quarter ended with full group meetings to review progress and chart the next quarterly increment.

The goal of the first increment (July-September 2010), through an emergency management (EM) social network analysis, was to identify key decisions, processes, and data flows that emerge during a winter storm case study. Three focus groups were held with representatives from 11 emergency support functions such as public health, fire, and public works. Class, Responsibility, and Collaboration (CRC) card methodology, a common technique used in software design, was applied as a method to collect information from participants about the social network. Three critical decision-maker sub-groups were established as the result of this process: transportation/public works, power companies, and schools. School closures, as a major social impact was chosen for further exploration in the use of weather information. The information flow shown in figure 1 shows a typical ad

hoc social network analysis that resulted from this process and revealed important findings for exploration in subsequent iterations.

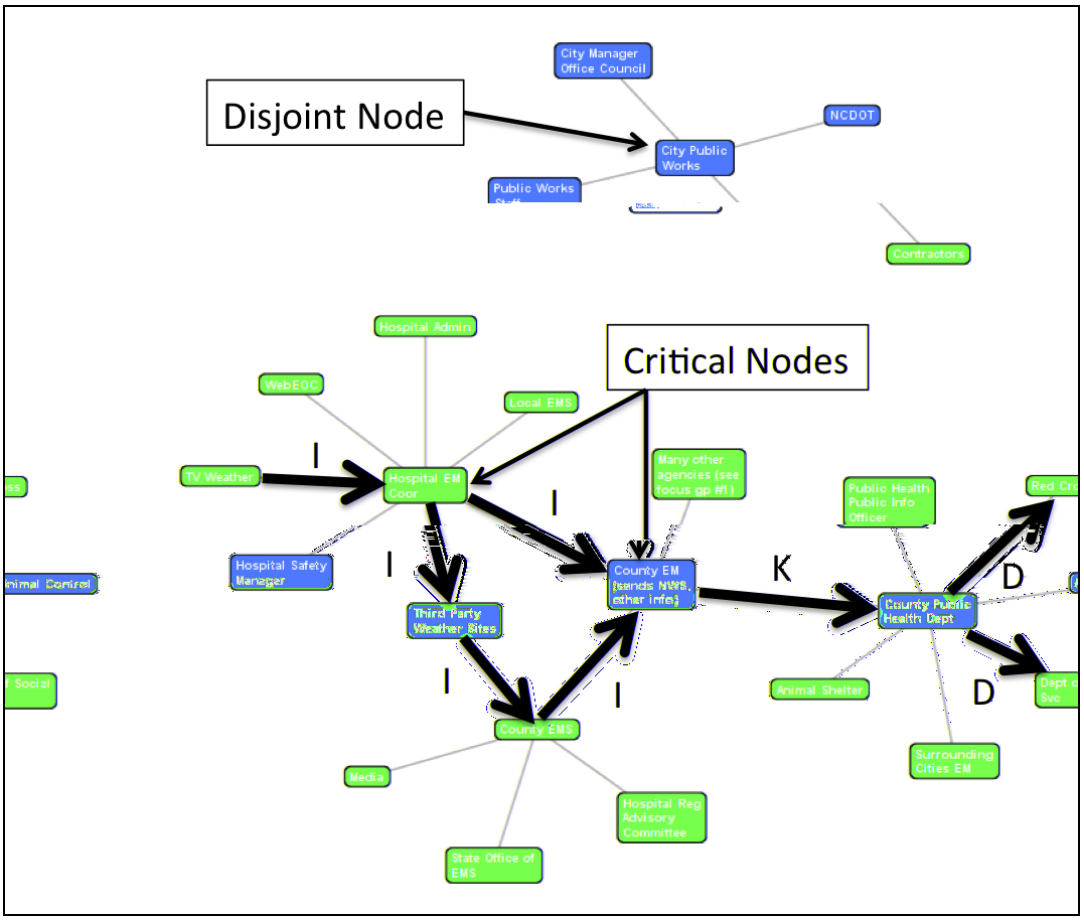

Figure 15 T_A differences for 11 overlap periods after applying all the corrections. Each overlap period is shown in a different color with the color-coding given by Table 2. The 7 frames show the 7 channels going from 19V at the top to 85H at the bottom in the order 19V, 19H, 22V, 37V, 37H, 85V and 85H."These results are for the evening portion of the orbit. (This is Figure 8 in the Technical Report: , October 2010– see link below.)

For the second increment (October–December 2010), we focused on the school subgroup as it emerged as the most underserved by weather information during winter events. We established a test group of nine schools. Throughout this increment, we interviewed school transportation representatives and superintendents in detail to establish a baseline understanding of their decision processes and critical roles, of weather information needs and gaps, and of node bottlenecks and path lengths. In order to keep the school decision making in context with the larger EM community, we conducted surveys about winter

weather and data needs at the statewide EM conference and with a statewide survey of school representatives.

The third increment (January-March 2011) of the project was comprised of four iterations. The first iteration completed the base case assessment of school current decision processes for comparison in future tests and evaluations. The second iteration was a measure of school's information gatherers and decision-makers use of NWS products and services knowledge and application prowess. We introduced as necessary existing NWS products and services to critical school staff to determine if they would aid in their decision processes. The third iteration was a series of 14 rapid prototypes to assess different presentation and modes of knowledge conveyance to understand changes to decisions or the decision process. The fourth iteration was an exercise to test and evaluate product and service findings from earlier iterations. This task was done with four new test schools that were new to the project, and three of the original test schools. This iteration verified many findings from previous increments and provided new insights to schools needs.

Thirty-six key findings resulting from increment three were presented at the quarterly meeting at the end of March and included items such as:

- School inclement weather decisions are based upon road hazard impacts and not the weather itself. Teenage and other driver safety is the main concern, not costs.
- NWS should consider creating road impact products and services and not leave the interpretation of weather up to untrained school officials.
- Several existing NWS products, such as the Hourly Weather Graph, are important but need further exploration, as there is a range in awareness of its existence, and interpreting its information.
- A single web location for decision makers to find weather information is recommended; key parameters at key times must be easy to find and understand.
- Proactive injection of NWS consequence weather information into school decisions, i.e., briefing packages, would have a high impact.

Presentations

Losego, J.L., K. Galluppi, An Update on the Weather and Emergency Management Decision Support Project, 2011 North Carolina Emergency Management Association-All Hazards Conference, Sunset Beach, NC, March 2011.

Losego, J.L., K. Galluppi, B. Montz, C. Smith, and S. Schotz, A cooperative pilot project on emergency management and decision support for winter weather, 2011 National Severe Weather Workshop, Norman, OK, March 2011.

Losego, J.L., B.E. Montz, S.S. Schotz, E. Mandel, K. Galluppi, B.J. Etherton, W.F. Roberts, and G. Austin, A cooperative pilot project on weather and emergency management decision

support, 27th Conference on Interactive Information Processing Systems, 91st American Meteorological Society Annual Meeting, Seattle, WA, January 2011.

Montz, B.E., J.L. Losego, and C.F. Smith, CRC Cards: A method to learn about emergency management decision processes, Sixth Symposium on Policy and Socioeconomic Research, 91st American Meteorological Society Annual Meeting, Seattle, WA, January 2011.

K.J. Galluppi, B. Montz, L.J. Losego, D. Logan, and J. Orrock, Panel Discussion: A Collaborative Weather and Emergency Management Decision Support Project, North Carolina Emergency Management Association Fall Conference, Hickory, NC, October 2010.

URL Link to Project Page

https://wxem.renci.org (protected site, please contact the PI's for access)

Providing SSM/I Fundamental Climate Data Records to NOAA

Otis Brown, Frank Wentz; (NOAA Collaborators: Jeffrey Privette) - OBOBWPAAMI11

Background

The Special Sensor Microwave Imagers (SSM/I) are a series of 6 satellite radiometers that have been in operation since 1987. These satellite sensors measure the natural microwave emission coming from the Earth's surface. These emission measurements contain valuable information on many important climate variables including winds over the ocean, the moisture and rain in the atmosphere, sea ice, and snow cover. However, the extraction of this information from the raw satellite measurements is a complicated process requiring considerable care and diligence. The first step in the process is the generation of Fundamental Climate Data Records (FCDR) of the sensor measurements in term of antenna temperatures and brightness temperatures. Since the first SSM/I was launched in 1987, Remote Sensing Systems (RSS) has been providing SSM/I data to the research and climate communities. The most current RSS dataset is called Version 6 and is generally recognized as the most complete and accurate SSM/I FCDR available.

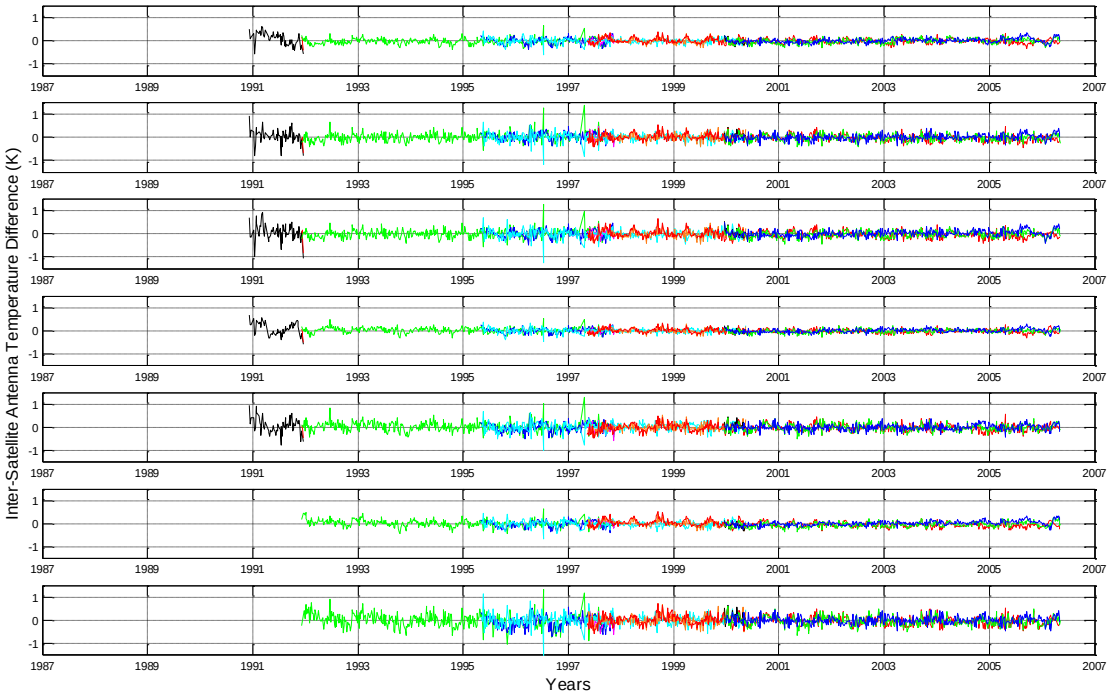

Figure 15 T_A differences for 11 overlap periods after1 151.7 0 3.-5(S)-3(M)-4(/I)4Rying Ss olrPrrall S tio1sforE4(e)8

black	red	green	blue	magenta	cyan	orange	black	red	green	blue
F08	F08	F10	F10	F10	F11	F11	F11	F13	F13	F14
F10	F11	F11	F13	F14	F13	F14	F15	F14	F15	F15

Accomplishments

This year RSS delivered to NCDC/NOAA the complete SSM/I Version-6 FCDR consisting of observations over 24 years from 6 satellites, thereby providing free access to this very important dataset. In addition, RSS provided 5 Technical Reports describing the SSM/I characteristics, geolocation procedures, quality control, data formats, and software for managing the SSM/I FCDR. One of these reports entitled,

provides the inter-satellite calibration method that was applied to the 6 SSM/Is. The figure on the next page shows the residual inter-satellite antenna temperature differences that remain after the on-orbit calibration has been applied. All 5 Technical Reports can be downloaded from ftp://eclipse.ncdc.noaa.gov/pub/ssmi/rss_v6_ssmi/doc/. Additional documentation can be found at www.ssmi.com. RSS has also been providing some support to NOAA for integrating the SSM/I FCDR into the NCDC computer environment and providing some help related to turning the SSM/I FCDR into an operational CDR.

Planned Work

The bulk of this investigation was the Year-1 work described above. In Years 2 and 3, we will provide User support for the SSM/I FCDR. This support includes (1) the continue processing of the F15 SSM/I, (2) a complete reprocessing of all SSM/I data when Version 7 is finalized, (3) converting the RSS binary format into the netCDF4 format, and (4) supporting Users inquiries and feedback and attending meetings and conferences.

Publications

None

Technical Reports

To download the 5 Technical Reports, please visit the following website:
ftp://eclipse.ncdc.noaa.gov/pub/ssmi/rss_v6_ssmi/doc/

Year 2 Climate Data and Information Records, Scientific Data Stewardship and Climate Services

Otis Brown; (NOAA Collaborator: Scott Hausman)OBOBCDIR_11

Background

The National Climatic Data Center (NCDC) has a number of research and workforce needs that necessitate 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. This proposal from CICSNC bundles several research hires within CICSNC to address workforce and research needs. The new staff will work in three areas: the National Climate Model Portal (NCMP), improvement of in situ climate observations, and support of high-volume environmental computing. The National Climate Model Portal (NCMP) will be developed and an extension of the technologies and capabilities currently operational in the NOAA Operational Model Archive and Distribution System (NOMADS). NCMP FY10 activities will include 1) a requirements specification process, functional requirements, and preliminary design document; 2) a proof of concept model-to-observational capability using existing but enhanced tools and applications; 3) a downscaling proof-of-concept capability; and 4) a user interface portal and community workspace into NOAA's suite of Climate and Weather Models. NCMP, in close coordination with the NOAA Climate Service Portal (NCSP) will serve as an on-line resource to both improve models for modelers, and to convey key aspects of complex scientific data in a manner accessible to both climate and weather modelers and to non-specialists or particular user communities. 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). The USCRN consists of stations developed, deployed, managed, and maintained by NOAA in the continental United States for the express purpose of detecting the national signal of climate change. The USHCN-M has been initiated with a pilot project in the Southwest, and expansion into other regions of the U.S. will follow. USHCN-M stations are being deployed at finer spatial resolution to provide for the detection of regional climate change signals. FY10-11 activities associated with these programs will 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.

NCDC is also engaged in the production of Climate Data Records (CDRs) from NOAA's earth-observing satellite systems. Many decades of global satellite data sets require reprocessing to accurately determine any climate change signals. The Petabytes of data to be processed require specialized computing methods and techniques that are being incorporated into the NCDC operational computing environment. NCDC and the CDR program would greatly benefit from advice and guidance from a software engineer

with experience in the configuration and management such a specialized computing system.

Accomplishments

- NCMP Science Oversight (Senior) Scientist Assigned to Scientific Services Division: coordination by NCMP Project Manager.
- NCMP Development and Implementation Research Scientist Assigned to Climate Services Division.
- NCMP Research Associate (Computer Scientist) Assigned to Climate Services Division.
- NIDIS/Soil (Drought) Research Scientist* Assigned to Scientific Services Division.
- Climate Research Network Research Scientist* Assigned to Scientific Services Division.
- Post doctoral fellow* Assigned to Scientific Services Division.
- Software Engineer Consultant Assigned to Remote Sensing and Applications Division.

Accomplishments

Five full time scientists and engineers were hired specifically for these activities; a consultant was employed to support specialized aspects of the projects' computing requirements, and a post-doc was hired with an 18-month appointment term. Brown works with Scott Hausman, David Easterling, John Bates, Eileen Shea, Jay Lawrimore, Ed Kearns and Glenn Rutledge (or their designees) to identify and hire these scientists to coordinate various aspects of this research program. Hires include a Senior Scientist (CSD), three Research Scientists (CSD and ScSD), a Research Associate (ScSD), a Post doc (ScD) and a Consultant (RSAD).

CICS-NC staff in this task include Dr. Jay Hnilo, Dr. Jesse Bell, Mr. Ronald Leeper, Dr. Jun Zhang and John Baringer.

Individual project summaries follow.

NOAA's National Climate Model Portal (NCMP)

Justin Jay Hnilo, (NOAA Collaborator: Glenn Rutledge)

Background

The National Operational Model Archive and Distribution System (NOMADS) is a Web-services based project providing both real-time and retrospective format independent access to climate and weather model data. NOMADS was established to specifically address the growing need for this remote access to high volume numerical weather prediction and global climate models and data and to facilitate climate model and observational data inter-comparison issues. The National Climate Model Portal (NCMP) continues to be developed to extend the technologies and capabilities currently operational in NOMADS. NCMP, in close coordination with the NOAA Climate Service Portal (NCSP) will serve as an on-line resource to both improve models for modelers, and to convey key aspects of complex scientific data in a manner accessible to both climate and weather modelers and to non-specialists or other particular user communities. NCMP activities in the coming contract year will include: 1) continuing development of a requirements specification process, functional requirements, and preliminary design document; 2) additional proof of concept model-to observational capability using existing but enhanced tools and applications; 3) a downscaling proof-of-concept capability; 4) a user interface portal and community workspace into NOAA's suite of Climate and Weather Models; and (5) the development of on-line climate model diagnostic tools and resources.

Initial work emphasizes the development of diagnostic tools. In this initial phase we have developed tools that regrid, extract average annual, seasonal, diurnal cycles from data as well various statistical measures and the extraction of station data equivalents from gridded data. Other capabilities we are developing are the examination of anomalies, measures of extreme events, climate sensitivity, decadal trends and ratios of variances.

Accomplishments

We have implemented a set of first look diagnostics that allow one for example to simply run a python script and extract station data equivalents from large gridded data (e.g., CFSR). As our website continues to evolve we will be serving such scripts and showing small plots of the output. These tools can be readily applied to both observational estimates (e.g., reanalyses) as well as model data. From models we have started to calculate derived values and diagnostics from the large IPCC (e.g., AR4) data holdings and will eventually serve these calculated values on the website. We have used these tools to support both the US National Assessment and continuing sectoral engagements at NCDC.

Our work extends beyond diagnostic tool development to acquiring valuable new data. In support of the new National Climatic Projection and Prediction (NCPP) Initiative we are acquiring and will serve the statistically downscaled CMIP3 data holdings. These data offer one the unique ability to see the evolution of both temperature and precipitation at 1/8 degree for the US and 1/2 degree globally for all models and scenarios from the AR4.

We are also in the process of negotiating the acquisition of participant models runs to the US CLIVAR hurricane working group. These high resolution gridded and storm track data will offer a unique supplement to the existing CMIP3 and CMIP5 archive.

Annually averaged global surface temperature for all participant AR4 models

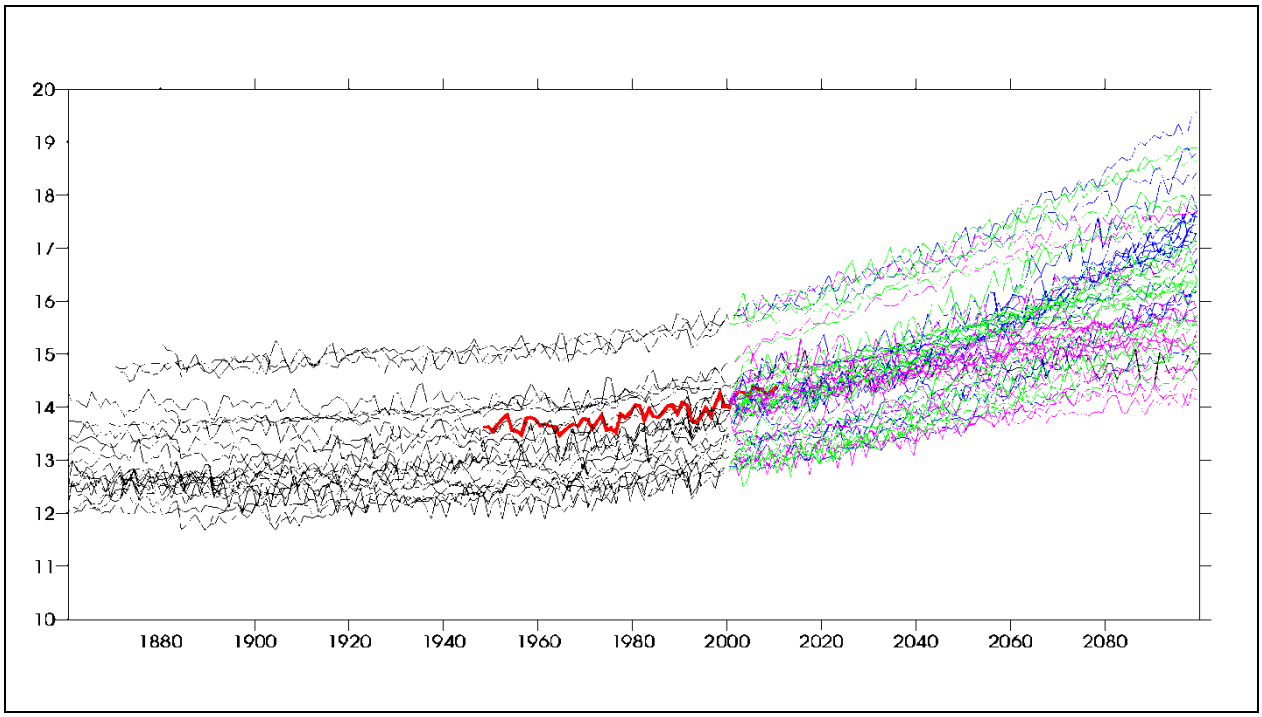

Figure 16 Globally averaged surface temperature (C) for all participant models and scenarios for the IPCC AR4. The climate of the 20th century run is in black, the SRESA2 scenario in blue, The SRESA1B scenario in green and the SRESB1 in purple. An observational estimate the NCEP/NCAR reanalysis is in thicker red.

An average of all models plot will appear on the climate services page

Planned Work

1. Post diagnostics on NCMP webpage with sample outputs.
2. Implement new ability to extract shapefile regions from gridded data
3. Continue to expand data holdings and build suitable diagnostics for community review and use.

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

J Jared Rennie (NOAA Collaborators: Jay Lawrimore, Byron Gleason, Claude Williams, David Wuertz, Matt Menne, Russ Vose)

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. It provides monthly mean temperature data for 7280 stations from 226 countries and territories, ongoing monthly updates of more than 2000 stations to support monitoring of current and evolving climate conditions, and homogeneity adjustments to remove non-climatic influences that can bias the observed temperature record. Version 3, which marks the first major revision to this dataset in over ten years, will become operational on May 1st, 2011. This version introduces a number of improvements and changes that include consolidating "duplicate" series, updating records from recent decades, and the use of new approaches to homogenization and quality assurance.

Accomplishments

Accomplishments noted thus far include the following:

- Became familiar with entire GHCN-M processing, including ingest, quality control, and homogeneity adjustments
- Introduced new data sources to increase the amount of data for 7280 stations. This includes World Weather Record data, Antarctic stations from the British Antarctic Survey, and European data from the Royal Netherlands Meteorological Institute.
- Created a troubleshooting tool to ensure daily processing is running correctly and to archive data for future use.

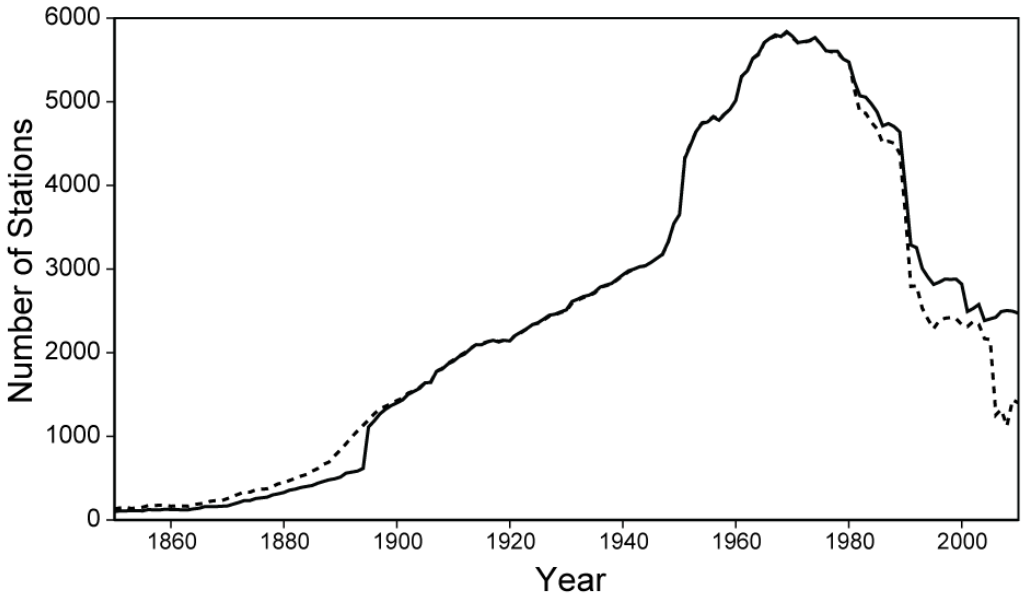

Figure 17 Number of Stations in GHCN-M version 2 (dashed line) and version 3 (solid line)

Planned Work

Future planned activities for this research effort are to:

- Incorporate maximum temperature, minimum temperature, and precipitation into GHCN-M processing
- Increase the amount of stations through new datasets, as well as incorporating data from the Global Historical Climatology Network – Daily (GHCN-D) dataset.

Publications

Lawrimore, J.H., M.J. Menne, B.E. Gleason, C.N. Williams, D.B. Wuertz, R.S. Vose, and J.J. Rennie, 2011: An Overview of the Global Historical Climatology Network Monthly Mean Temperature Dataset, Version 3.

Maintenance and Streamlining of the Hourly Precipitation Data (HPD) Network Dataset

J Jared Rennie (NOAA Collaborators: Jay Lawrimore, Stuart Hinson, Ron Ray, Matt Menne)

Background

For decades NOAA's National Climatic Data Center (NCDC) has collected, quality controlled, and archived data from the COOP Fischer & Porter (F&P) network of more than 2000 stations. This dataset is produced through ongoing quality control processing that includes extensive manual review and intervention by a trained meteorological technician. Not only does this require extensive resources in time and personnel, it results in delays of up to six months before a month of observations are fully quality controlled and available to the public. Using new methods of automated quality control, an experimental HPD dataset has been developed. Still in testing phase, this dataset contains the more than 2000 F&P stations along with thousands of additional stations (e.g. ASOS, USCRN, NWS Hydrometeorological Automated Data System) that report hourly precipitation. These data have been quality controlled using a set of checks including checks for spikes, global extremes, gaps, and climatological outliers. Efforts mo-2(E)-47al ouoro thment(d)5(3(rmplg)4(.4(t

Accomplishments

Accomplishments noted for this research activity include:

- Became familiar with the entire HPD processing, including ingest, and quality control
- Ensured processing runs daily, and debugged if issues arise
- Began process to build a suite of QC procedures through advanced statistics

Planned Work

The planned effort for this research work is to:

- Continue building upon theQC procedures to make the data more robust
- Dataset to become operational in 2012

Publications

Rennie, J.J., A. Wilson, J.H. Lawrimore, M.J. Menne, and R. Ray, 2011: Implementing New Quality Control and Processing Systems for Hourly Precipitation Data.

Assistance with Data Rescue for the Global Databank

J Jared Rennie (NOAA/CICS; collaborators: Jay Lawrimore)

Background

Currently there is an international effort to develop a single comprehensive surface temperature databank. This databank will contain actual meteorological observations taken globally at monthly, daily, and sub-daily resolutions. This databank will be version controlled and seek to ascertain data provenance, preferably enabling researchers to drill down all the way to the original data record. It will also have associated metadata, including changes in instrumentation and station moves.

Accomplishments (Began Work on January 3rd, 2011)

Accomplishments noted for this activity include:

- Gathered data in its native format (stage 1), and converted them into a common format (stage 2)
- Worked with Jay Lawrimore on determining a valid data format, as well as assigning the proper data provenance tracking flags

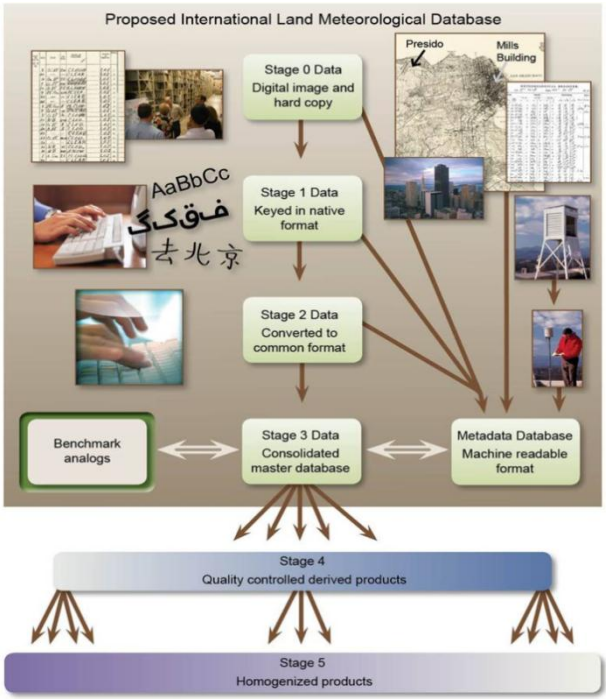

Figure 19 Proposed databank stages (source: www.surfacetemperatures.org)

Planned Work

The planned research activities are to:

- Continuing conversion of data from stage 1 to stage 2 as data becomes available
- Begin merging process to convert stage 2 data into a master database (stage 3)

Release code to FTP to ensure transparency

Detecting and Correcting Artificial Discontinuities for Land Surface Temperature Series

Jun Zhang (NOAA Collaborator: Matthew Menne)

Background

Artificial discontinuities in land sur 69-3(f1nt)-3i4ott38.3S3:iti8ls3i4ott38.i3i4ots ampev [(Cry(itu Tm

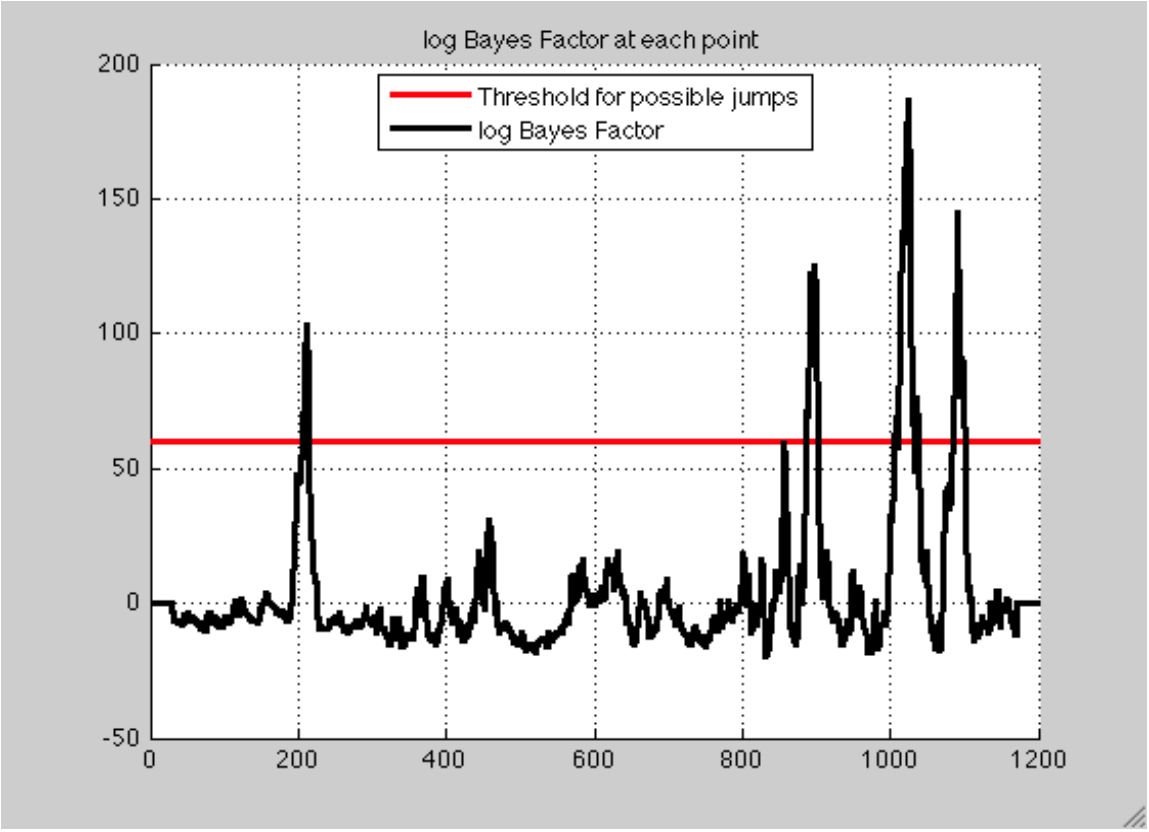

Figure 20 Log Bayes Factor at each point

Planned Work

This project should be completed before next reporting period. The major tasks are to:

1) Complete the implementation.
2) Run the algorithm on simulated test data sets and check the results against the truth.
3) Run the algorithm on real data sets and check its results against the results from the current operational algorithm.

Multisensory Precipitation Estimate by an Adaptive Wavelets Thresholding Method

Jun Zhang (NOAA Collaborator: Dongsoo Kim)

Background

Precipitation measurements are obtained mainly either with radar or with rain gauges. When we have radar and rain gauge measurements for a certain area, we often would like to efficiently merge the information from these two measurements. We propose a method of merging hourly gauge precipitation data and radar based quantitative precipitation estimate (QPE) by thresholding wavelet coefficients. In our approach, we find the optimal thresholding parameter by minimizing the objective function, which simultaneously measure the fitness to gauge observations and high-resolution radar QPE observations. The wavelet thresholding algorithm is computationally efficient and reproducible each time.

Accomplishments

We have evaluated the algorithm over simulated data sets and real data sets. Based on pooled residual plots, it seems that the algorithm works well.

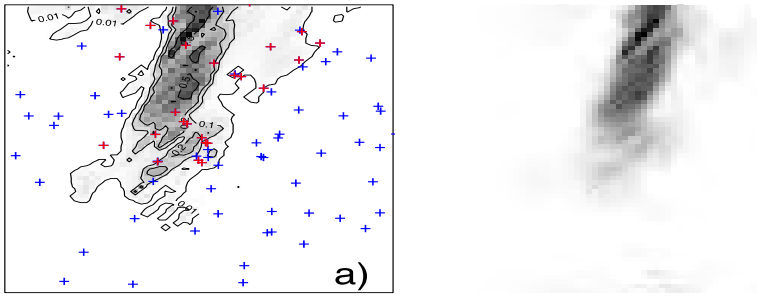

Figure 21: Log Bayes Factor(LBF) at each point. The threshold is obtained by permuting the difference series and applying the same algorithm. The area of interest is in the regions above the threshold.

Planned Work

We will continue our evaluation of the algorithm. The project should be completed in the next two months. We may try to improve current algorithm by incorporating temporal information.

Improving USCRN Solar Radiation and Precipitation Quality Assurance Methods

Ronald D. Leeper (NOAA Collaborators: Michael Palecki and Jesse Davis)

Background

As the U.S. Climate Reference Network (USCRN) continues to add new stations (surpassing 124 stations nationwide), focus has begun to shift toward improving/reevaluating current quality assurance (QA) strategies. With the deployment of newer observational technologies (wetness sensors) since USCRN's commission in 2004 and a sizable data record, robust daily, seasonal, and yearly evaluations of QA procedures across the network are not only becoming possible, but necessary for fulfillment of stated goals as the network to detect climate change in the U.S.

While USCRN observes a host of variables such as soil moisture and temperature at various depths and air and ground temperatures, initial efforts will be devoted to the precipitation and solar radiation QA algorithms. USCRN precipitation QA is much more developed than solar radiation; however, for very light precipitation events its performance has been suboptimal. Moreover, the intended purpose is to provide QA recommendations to USCRN with the objective of improving these methods for the detection of faulty sensors and reported precipitation and solar radiation observations.

Accomplishments

The initial phase of this work included many multi-network station comparisons for both precipitation and solar radiation. For stations that had abnormally high maximum solar radiation compared to a clear-sky model, this trend was oddly well correlated with annual maintenance visits (AMVs). During AMVs, much of a station's instruments are replaced with newly calibrated equipment, and these results indicate that improperly calibrated pyranometers may have made found their way to some stations. To this end, I proposed to use a clear-sky model that can be executed with minimal input and provide hourly maximum solar radiation values for a QA approach that can detect malfunctioning sensors within hours of a station's AMV.

USCRN weighting bucket (Geonor vibrating wire) under-catch other rain gauges (tipping buckets) under very light precipitation events mainly due to improper specification of gauge reference depth. For any weighting bucket configuration, the QA method must have knowledge of the bucket's depth (amount) of water before and after a rain event to resolve accumulated precipitation. In this instance, when rainfall starts out slowly USCRN gauge depth will slowly increase; however, if the precipitation signal undetectable from the noise (signal to noise ratio) no precipitation will be reported. This presents a challenge because the reference depth (depth prior to rainfall) will then rise despite no reported precipitation and result in under-catch for the next period of

rainfall. The reference depth has also been found to reduce in time under dry, hot conditions as moisture is evaporated from the gauge, which makes proper specification of the reference depth prior to rainfall even more challenging.

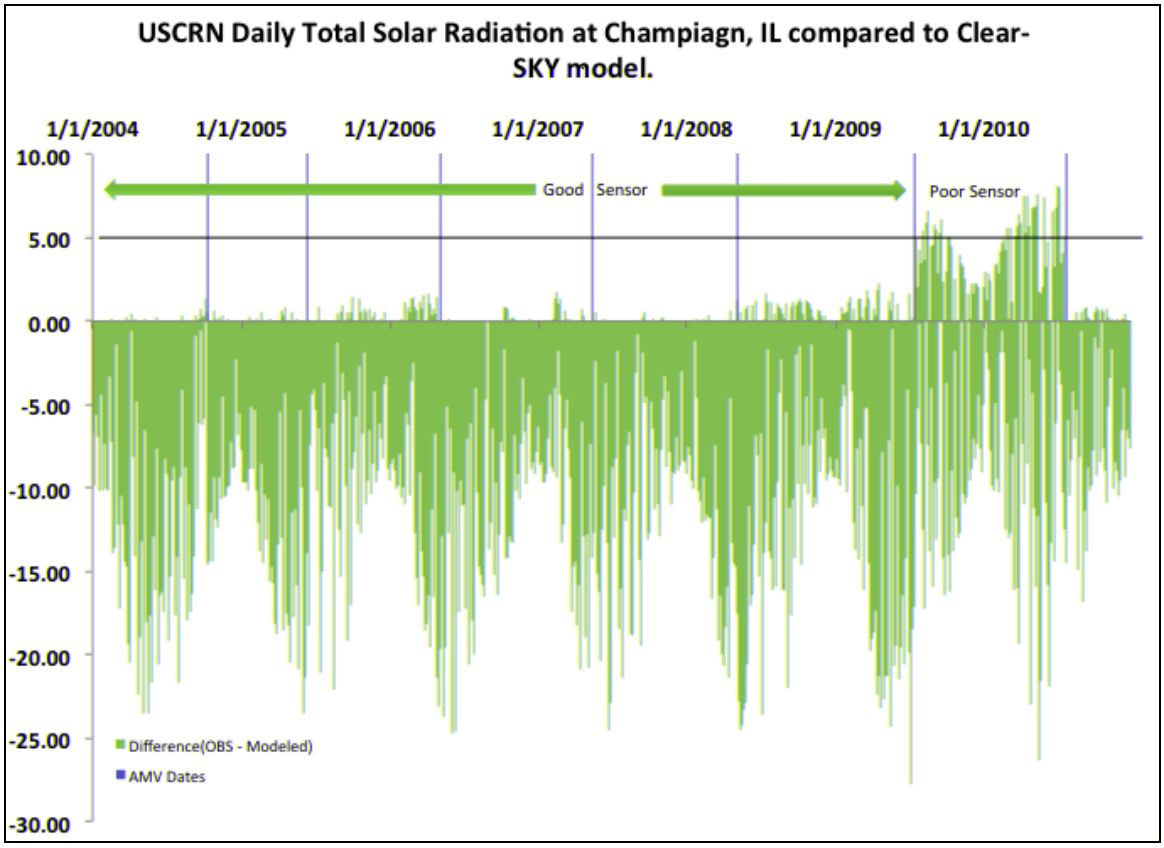

Figure 21 USCRN Daily Total Solar Radiation at Champaign, IL compared to Clear-SKY model.

While it is not possible to completely remove gauge noise, I have developed a proposal to improve the calculation of Geonor gauge reference depth based on wetness (from the wetness sensor) that should help resolve some of the known under-catch issues under light and sporadic precipitation events. In this approach, the reference depth is based on the last known dry period prior to rainfall. In this way, if the precipitation signal is too small initially it can still accumulate with additional rainfall later and be included in reported precipitation. Additional work is currently progressing toward the detecting and mitigating gauge evaporation.

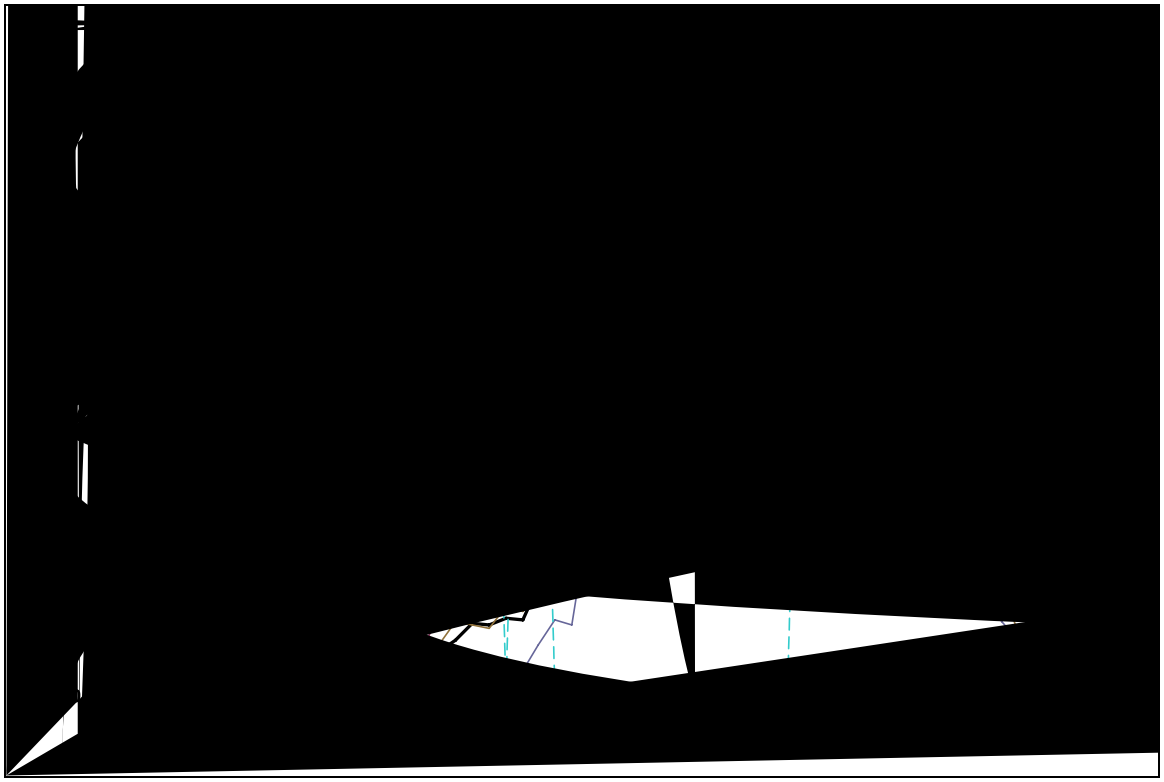

Figure 22 A tipping bucket within 25 meters of this location recorded 0.3 mm to USRCRN 0.0mm

Planned Work

The next phase would be to complete the coding of proposed improvements to calculated reference depth and solar radiation in the current USCRN QA and test them system wide. Testing will include initially historical events as well as some artificial engineered cases where actual precipitation for an event is known. These tests and previously mentioned multi-station comparisons will eventually lead to publications that include a technical document outlining the precipitation algorithm, an overview paper of inter-station comparisons for the full suite of USCRN observables, and a follow up paper describing the significance of triplicate redundancy on data quality and integrity.

Validation of US Climate Reference Network (USCRN) Soil Moisture and Temperature and Development of Growing Season Products

Jesse E. Bell (NOAA Collaborator: Mike Palecki)

Background

USCRN is a series of climate monitoring stations across the continental United States. In 2009, NOAA began to deploy soil moisture and temperature probes across the stations in the 48 contiguous states. These in situ measurements will assist in detecting regional soil climate signals and monitoring drought conditions.

In order to understand the variability of soil moisture across different spatial scales, I have been comparing USCRN soil moisture and temperature measurements with collocated USCRN stations and other soil monitoring networks (e.g. Oklahoma Mesonet and SCAN).

In addition, I have been responsible for establishing drought-monitoring products for the USCRN network. My initial work has been establishing ways to monitor growing season and growing degree-days. Because of the strong correlation with soil temperature and plant phenological development, I constructed a method of using soil temperature to determine growing season and growing degree-days.

Accomplishment

Accomplishments on this research activity are as follows:

- The research effort primarily focused on studying the spatial variability of soil moisture and temperature. Because each USCRN station has three replicate measurements of soil moisture and temperature, I was able to initiate a comparison of the soil moisture and temperature variability at each location. After an analysis of the individual sites, I focused on determining the spatial variability of collocated sites in the network. With the USCRN network having a few select sites that have two stations in a close proximity to each other, I was able to analyze and evaluate the spatial variability of each of these collocated stations. Lastly, I determined USCRN locations that had other soil moisture networks in a similar region and analyzed those regions for spatial variability.

- As part of a secondary project, I am to develop products for monitoring and recording drought at USCRN stations. Before I can determine when drought occurs, I need to accurately define the periods of vegetation phenological development. Because of the strong link between soil temperature and plant development, we are able to use USCRN soil temperature to accurately define growing season and growing degree-days. This work is in the preliminary stage, however, I have already devised an index and computer code for monitoring growing season with soil temperature. After this work is validated with field data, it will be used to calculate wilting point and field capacity for drought-monitoring products.

- We have also been evaluating different QC methods for soil moisture and temperature.

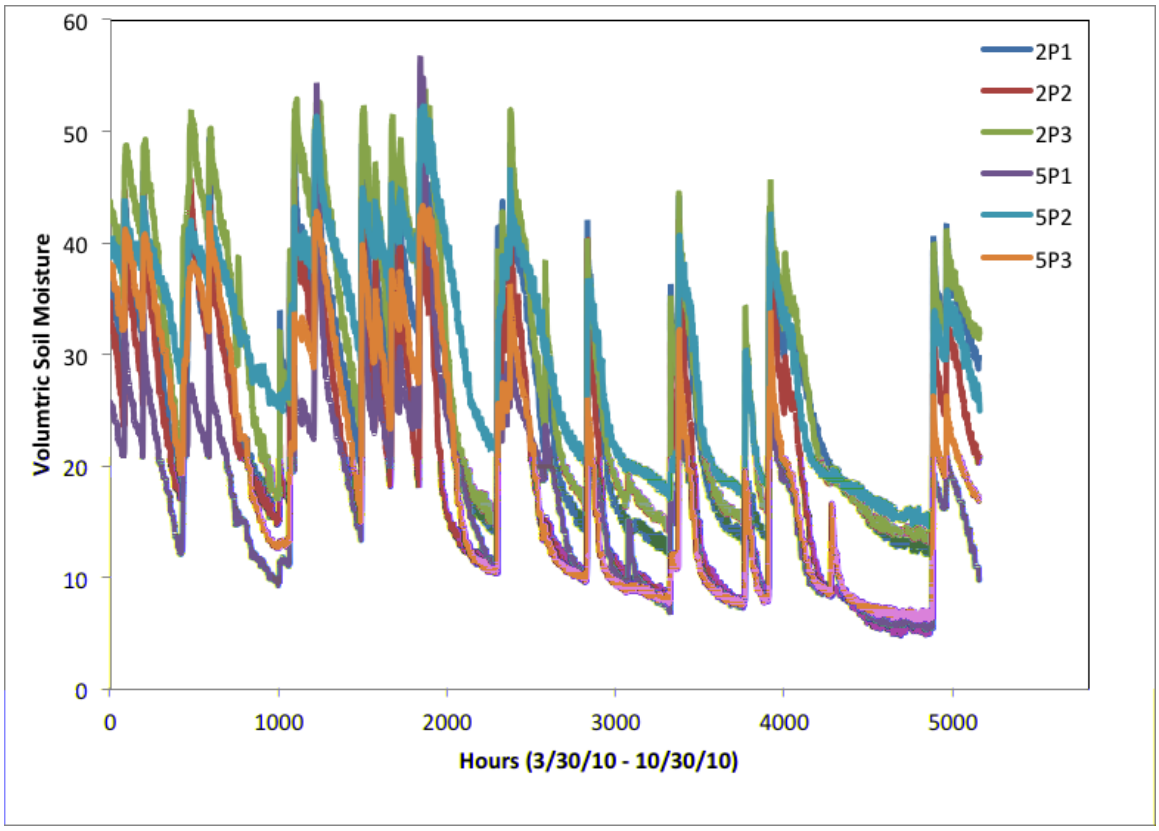

Figure 23 Shows the soil moisture moisture spatial and temporal variability for two collocated USCRN sites in Stillwater, OK. 2P1, 2P2, 2P3 are the probes located at the Stillwater 2 location. 5P1, 5P2, 5P3 are the probes located at the Stillwater 5 location.

Planned Work

The soil moisture and temperature comparisons will be finished in the next six months. Other major tasks will include:

- Finish my growing season work and prepare a manuscript.
- Use growing season work to estimate field capacity and wilting point.
- Help write a manuscript on USCRN soil moisture variability.
- Connect a terrestrial ecosystem model to USCRN.

Support of the Development of Climate Data and Information Records and Scientific Data Stewardship

Otis Brown, Heidi Cullen; (NOAA Collaborator: Eileen Shea) - OBOB SDCDI 11

Background

The US Department of Commerce estimates that, of America's $11 trillion economy, $3 trillion is directly affected by weather and climate. Depending on how we choose to manage and communicate the risks associated with climate variability (i.e., ENSO, NAO, PDO) and change (anthropogenic global warming), our overall weather-related risk can either grow or shrink.

With this in mind, Climate Central – an independent, non-profit journalism and research organization - in collaboration with NCDC scientists, is highlighting the data, tools, and expertise available to proactively communicate information regarding climate science and risks (on seasonal to decadal and longer timescales) through a series of short video segments called .

Drawing upon the format of ESPN's Climate Central is producing two-minute climate segments that utilize the highest quality climate and weather data to create compelling graphics, animations and short video reports that make climate variability and change an issue of vital interest to climate professionals and American citizens—not remote and abstract, but local, concrete and relevant. Drawing upon research efforts within CICS and NCDC, as well as studies like the 2009 USGCRP Global Climate Change Impacts in the United States report, this video content is being distributed to a variety of media partners at both the local and national level, as well as on the Climate Central and NOAA-related websites.

routinely utilizes the data, maps and forecast products produced by NCDC scientists to better connect climate science to news and weather events in an engaging, familiar format. Climate topics are selected by a team consisting of Climate Central and NCDC scientists and video releases are timed in accordance with NCDC product releases (i.e., monthly State of the Climate reports, etc.). Scripts are vetted by NCDC scientists.

The ultimate goal of is to establish the routine relevancy of climate science information and provide the climate context to extreme weather and news events. Climate also seeks to raise climate literacy by showcasing the findings of the upcoming National Assessment report.

Accomplishments

During the period April 1, 2010 to March 31, 2011 a graphics package for Climate was built and a pilot version was beta-tested with NCDC scientists. We began taping segments at the Princeton Broadcast Center in July 2010. The segments cover the following topics:

- State of the Climate: 2009 July 28th, 2010
- Severe Weather of Summer 2010 August 16th, 2010
- Global Temperatures and the Hurricane Season September 15th, 2010
- What La Nina means for winter weather October 15th, 2010
- La Niña Update November 18th, 2010
- The Top Five December 17th, 2010
- The New Normals January 19th, 2011
- Wind 101 February 25th, 2011
- Spring Outlook March 11th, 2011

Figure 24 An example of a ClimateCenter video. The left hand bar provides definitions and explanation. The scroll along the bottom provides further localized detail. Each video is roughly 2 minutes and explains key aspects of climate change, climate variability, extreme weather and renewable energy.

Additional Products

In addition to Climate , we have also produced a series of educational videos titled . " is an engaging, fun, and fast-paced educational series that explains how scientists know the answers to fundamental climate science questions. Each segment features one prominent scientist (including Otis Brown, CICS-NC and Sta Wilson, NOAA) and highlights the technology that

helps provide answers to these big climate questions. The series, which is featured on the Climate Central website, has been distributed to more than 120 local TV meteorologists via the NEEF (National Environmental Education Foundation) Earth Gauge Network. It will also be a featured series by Georgia Public Broadcasting as part of its "Race to the Top" educational programming in coming months. This twelve part series covers sea level rise, extreme weather, food & climate, and ocean acidification. Each segment is roughly 2 minutes long.

Sea Level Rise

1. How do we know…the Greenland ice sheet is melting?

2. How do we know…sea level is rising?

3. How do we know…Arctic sea ice is shrinking?

4. How do we know…sea ice is thinning?

Extreme Weather

5. How do we know…tornadoes are forming?

6. How do we know…the track of a hurricane?

Food & Climate

7. How do we know…when a region is in a drought?

8. How do we know…the tropical rainforest is disappearing?

9. How do we know…groundwater is being depleted?

Ocean Acidification

10. How do we know…how salty the oceans are?

11. How do we know…where the carbon dioxide is coming from?

12. How do we know…the ocean's are sucking up CO2 and becoming more acidic?

Planned Work

Climate Central continues to produce Climate videos in collaboration with scientists at NCDC. In addition, we continue to focus on increasing the distribution of Climate videos. Currently the following outlets have/plan to air Climate :

- Grist: http://www.grist.org
- Mother Nature Network: http://www.mnn.com/
- NEEF EarthGauge (with outreach to 120 local TV mets): http://www.neefusa.org/programs/earthgauge.htm
- The Daily Climate: http://www.dailyclimate.org/
- Washington Post Capitol Weather Gang: http://www.washingtonpost.com/blogs/capital-weather-gang
- The Weather Channel: weather.com
- Weather Underground: http://www.wunderground.com/
- WGBH ClimateTide http://climatide.wgbh.org/

Publications

None

URL Links from the text:

	CLIMATE*CENTER*
Climate : State of the Climate: 2009	http://www.climatecentral.org/videos/web_features/state_of_the_climate_2009
Climate : Severe Weather of Summer 2010	http://www.climatecentral.org/videos/web_features/severe_weather_of_summer_2010
Climate : Global Temperatures and the Hurricane Season	http://www.climatecentral.org/videos/web_features/global_temps_and_the_hurricane_season
Climate : What La Nina Means for Winter Weather	http://www.climatecentral.org/videos/web_features/climatecenter_what_la_nina_means_for_winter_weather
Climate : La Nina	http://www.climatecentral.org/videos/web_features

Update	/climate_center_la_nina_update
Climate : The Top 5	http://www.climatecentral.org/videos/web_features_/five -big-ones
Climate : The New Normals	http:// www.climatecentral.org/videos/web_features /the -new-normals
Climate : Wind 101	http://www.climatecentral.org/videos/web_features_/climatecenter-wind-101
Climate : Spring Outlook	http://www.climatecentral.org/videos/web_features_/climatecenter-spring-outlook
	HOW DO WE KNOW?
How do we know...the Greenland Ice Sheet is Melting?	http://www.climatecentral.org/videos/web_features_/how_do_we_know_greenlands_melting_ice_sheet/
How do we know...sea level is rising?	http://www.climatecentral.org/videos/web_features_/how_do_we_know_sea_level_rise/
How do we know..Arctic sea ice is shrinking?	http://www.climatecentral.org/videos/web_features_/how -do-we-know-shrinking-arctic-sea-ice/
How do we know...sea ice is thinning?	http://www.climatecentral.org/videos/web_features_/how -do-we-know-thinning-sea-ice/
How do we know...tornadoes are forming?	http://www.climatecentral.org/videos/web_features_/how -do-we-know-tracking-tornados/
How do we know...the track of hurricane?	http://www.climatecent_ral.org/videos/web_features /how -do-we-know-hurricane-hunting/
How do we know..when a region is in a drought?	http://www.climatecentral.org/videos/web_features_/how_do_we_know_drought/
How do we know...the tropical rainforest is disappearing?	http://www.climatecentral.org/videos/web_features_/proof_in_the_pixels/
How do we know...groundwater is being depleted?	http://www.climatecentral.org/videos/web_features_/how_do_we_know_groundwater/

How do we know...how salty the oceans are?	http://www.climatecentral.org/videos/web_features_/how_do_we_know_salty_seas/
How do we know...where the carbon dioxide is coming from?	http://www.climatecentral.org/videos/web_features_/how -do-we-know-tracking-c02-emissions/
How do we know...the oceans are sucking up CO2 and becoming more acidic?	http://www.climatecentral.org/videos/web_features_/how_do_we_know_ocean_acidification/