COOPERATIVE INSTITUTE
FOR
CLIMATE and SATELLITES (CICS)

Scientific Report

For the period:

July 1, 2009 – March 31, 2010

NOAA Grant NA09NES0006

Dr. Phillip Arkin

Director

April 1, 2010

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 who will 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 our leadership of the Cooperative Institute for Climate Studies in collaboration with NOAA beginning in 1983. The Earth Systems Science Interdisciplinary Center (ESSIC) has managed this earlier Cooperative Institute since 2002 and has successfully shepherded it though a period of dramatic growth in both funding and activity levels. CICS-MD focuses on the collaborative research into 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. It 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 DoE Pacific Northwest National Laboratory.

CICS-NC is 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. CICS-NC focuses 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 Dr. Otis Brown and includes numerous partners from academic institutions with specific expertise in the challenges of utilizing satellite observations in climate research and applications.

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 tasks comprise 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 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 to advance transfer of such applications to enhance NOAA operational activities;
- Investigate satellite 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 satellite 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 satellite-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 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. The first meeting of the Executive Board was held at NCSU in Raleigh NC on December 11, 2009, chaired by Dr. Terri Lomax, Vice Chancellor for Research and Graduate Studies at NCSU. In addition to Dr. Lomax, attendees included:

- Dr. Sharon LeDuc, Chief of Staff, NCDC, National Oceanic and Atmospheric Administration
- Dr. Scott Hausman, Deputy Director, NCDC, NOAA
- Dr. Wayne Higgins, Director, CPC, NOAA
- Dr. Al Powell, Director, STAR, NESDIS, NOAA
- Dr. Phil Arkin, Executive Director, CICS and Director CICS-MD, University of Maryland
- Dr. Ray Fornes, Associate Dean for Research, College of Physical and Mathematical Sciences, NCSU
- Dr. Otis Brown, Director, CICS-NC, NCSU
- Dr. Tony Busalacchi, Director, ESSIC, UMD
- Dr. Steve Halperin, Dean, College of Computer Mathematical and Physical Sciences, UMD
- Dr. Mel Bernstein, Vice President for Research, UMD
- Dr. Steve Leath, Vice President for Research, UNC General Administration
- Dr. Chris Brown, Associate Vice Chancellor for Research Development, NCSU
- Bonnie Aldridge, Executive Assistant, Research Development, NCSU

The Executive Board praised the initial efforts of the leadership of CICS, and recommended a continuing effort to implement a unified Cooperative Institute, led by Phil Arkin as Executive Director, with two principal components, CICS-MD and CICS-NC, and a broad consortium of contributing scientists from diverse institutions. The Board recommended a second meeting be held in approximately 6 months at or near College Park, MD, to be chaired by Dr. Bernstein.

The composition of the Council of Fellows is currently being determined, with an initial meeting planned for the June-July 2010 time frame in College Park. for the Executive Board recommended that the proposed CICS Science Meeting be held as a workshop during the summer of 2010. However, the establishment of the NOAA Climate Service and the transition from NPOESS to JPSS has delayed the meeting. Plans will be re-formulated at the upcoming EB meeting.

The 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:

Jin-Ho Yoon joined CICS in 2009. He works off-site collaborating with colleagues at the Climate Prediction Center/NCEP/NWS/NOAA. He received his undergraduate from Seoul National University, Korea in Meteorology and received M.S. (1999) and Ph.D. (2004) from Iowa State University in Meteorology. Since 2004, he had worked at the Department of Atmospheric and Oceanic Science, University of Maryland College Park as a Research Associate. His research focused on studying climate variability and change using various sources including observation and reanalyses. Also, he is an expert in climate modeling using different types of models including Earth System Model at intermediate complexity at UMD and full-blown Climate System Models. He developed a prototype of Ecosystem/Carbon/Fire prediction system based on a Dynamic Vegetation Growth Model and NOAA's climate forecast system (CFS) in intraseasonal to interannual time scales. His major task at CIC is to support hydrological prediction at the Climate Predication Center using NLDAS and to develop a dynamical hydrological prediction system for the Southeast U.S., which was selected as the 2nd pilot study region by the NIDIS.

Eric Hughes joined CICS in October 2009 and currently works off-site at NOAA/NESDIS. Through this collaboration, he is developing an operational volcanic emissions alert/forecasting system to aid in creating timely and accurate warnings of volcanic hazards. Prior to joining CICS, he had been working with the Joint Center for Earth-Systems Technology (JCET) and NASA as part of the Sulfur-Dioxide Remote Sensing group. While with this group, Mr. Hughes developed techniques and statistical methods to derive the injection height of volcanic SO2 from its horizontal transport characteristics. These methods were also used to show the evolution of the SO2 injection height throughout the period of a volcanic eruption. Results from this work were used to write a thesis for a Masters degree in Atmospheric Physics from the University of Maryland, Baltimore County, received in May of 2009. Mr. Hughes also received two undergraduate degrees from this university, a B.S. in Physics and a B.A. in Photography.

Cezar Kongoli is a Visiting Assistant Research scientist specializing in the remote sensing of surface hydrology and precipitation with emphasis on cryospheric environments (snow and ice). Previously, he was physical scientist for Perot Systems at NOAA/NESDIS, developing the NOAA's microwave snow and sea ice algorithms. He has a Masters Degree in Soil and Water from Wageningen University of the Netherlands and a PhD degree in environmental biophysics from UW-Madison, Wisconsin.

Dr. Banghua Yan joined ESSIC in July of 2009. She received her Ph. D. in atmospheric physics from Institute of Atmospheric Physics, Chinese Academy of Sciences, in 1997, and the Ph. D. degree in atmospheric radiation from University of Alaska, Fairbanks, USA, in 2001. From November 1999 on, Dr. Yan has been working in NOAA/NESDIS/Center for Satellite Applications and Research. In past few years, Dr. Yan directly contributed in developments of microwave land, snow and sea ice emissivity models which have significantly improved uses of satellite sounding data in Numerical Weather Prediction (NWP) models and impacted the high latitude weather forecasts. These land, snow and sea ice microwave emissivity models have been implemented into the NOAA NCEP NWP model and the JCSDA community radiative transfer model (CRTM) that has been successfully used in several operational data assimilation systems in the United States. The major fields she is working on include 1) the land and snow microwave emissivity modeling and retrievals, 2) DMPS SSM/I and SSMIS satellite sensor calibration, 3) the assimilation impacts of microwave satellite measurements on global NWP models, and remote sensing of ocean color. Dr. Banghua Yan has published over ten papers in the international peer-reviewed journals in past several years.

Departing CICS in the past year were:

Dr. Matt Sapiano for Colorado State University, Fort Collins, CO

Dr. Joonsuk Lee for the National Institute of Environmental Research in South Korea

Dr. Arnold Gruber, retired (remains Visiting Senior Research Scientist)

2 HIGHLIGHTS OF THIS YEAR'S RESEARCH

Listed below are a few of the research highlights from the first nine months of this new agreement:

- The transition of the AVHRR SST Pathfinder project to NODC is proceeding well with initial code transfer completed. Incorporation of SST algorithm improvements initiated with MODIS SST has improved the long-term and inter-sensor stability leading to an improved multi-sensor CDR.
- New satellite processing system to provide CICS scientists with state-of-the-art satellite data archive for climate studies and applications is under procurement and will have initial capability by the end of 2010
- An examination of the performance of numerical model forecasts of precipitation was conducted over the global Tropics. Results suggest that the NCEP and ECMWF models have improved significantly over the past 10-20 years.
- Research expertise from CICS scientists contributed to the management of competitive research programs at NOAA Climate Program Office.
- A prototype ecosystem prediction system has been developed in which CFS climate forecasts are used to drive a dynamics vegetation model. The results show significant predictability for seasonal-interannual ecosystem prediction, due to both the skill in the climate forecasts and the memory in the ecosystems.
- A new NOAA-16 AMSU-A channel-5 limb correction method was developed that uses channel-6 instead of channel-4 measurements due to the failure of channel-4. This new method is applied to several NOAA-16 products that were interrupted by the channel-4 failure and enables the continuity of these operational products.
- SWAT has been successfully used to simulate the hydrology and nutrient loading from the Rappahannock river basin and has been fully integrated with the CB forecasting model. The SWAT model for Potomac is being developed.
- The preliminary phase of generating VIIRS simulated pixels and evaluating detection capabilities has been extremely successful. Initial analysis of detection capabilities from simulated VIIRS radiances indicates an approximately two-fold decrease in the size of minimum detectable size from unaggregated data for typical fire temperatures at nadir.
- A new correction scheme on SSMI/S high frequency channels shows a lower bias and high correlation between TMI (a high quality sensor onboard TRMM) and SSMI/S when compared with raw SSMI/S retrievals.
- Satellite-derived precipitation data can strengthen the capabilities of agencies in charge of hydrologic planning, design and decision making.
- A significant amount of experience has been gained by the MODIS Science Team in the validation of global land products. The Integrated Program Office is supporting CICS to coordinate and implement a research effort on VIIRS Land Product Validation.

- The CBFS has expanded the old 6-member 14-day forecast to 20 members and began running a new forecast every day instead of every three days. The expanded forecast was made possible with our recent access to the NASA Discover supercomputer. Starting in August 2009, and each month thereafter, CBFS began making seasonal forecasts for the upcoming three month period.

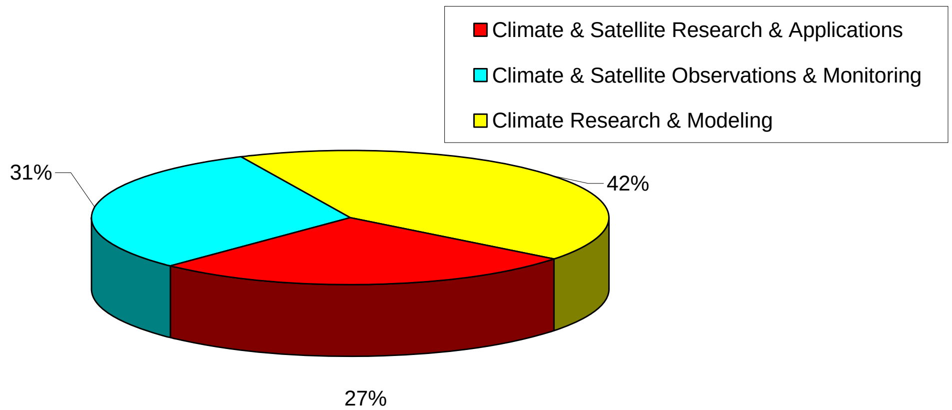
In section 4, CICS personnel describe the research activities and results from the ongoing projects for the period of July 1, 2009 – March 30, 2010. These research tasks, the Principal Investigators, their NOAA collaborators and their applicability to CICS Research Themes and NOAA Strategic Goals are summarized in Table 1. In Figure 1 we summarize graphically the stratification of task funding by CICS Research Theme and by NOAA Strategic Goal. The total task funding during this period was just under $4 Million. In Table 2 we present statistics for peer reviewed and non-peer reviewed papers, as well as the categorization of CICS staff and investigators.

Table 1 CICS Tasks July 1, 2009 to March 31, 2010

Task Leader	NOAA Collaborator	Title	CICS Theme	NOAA Goal
Arkin	Eric Locklear	CIRUN	3	2
Arkin	Eric Locklear	WCRP	3	2
Arkin	Eric Locklear	Advanced Studies Institute for Environmental Protection	3	1
Arkin	Ingrid Guch	Cooperative Research Exchange Program	1	4
Arkin	Gilberto Vicente	Real-Time Automatic Estimation of Volcanic SO2 and Ash Cloud Heights	1	3,4
Arkin	Ivan Csiszar	Development of an enhanced active fire product from VIIRS	1	3,4
Arkin	Ralph Ferraro	CICS Satellite Processing System for Research and Development	1	4
Arkin/Sudradjat	Ralph Ferraro	Improvements to the AMSR-E Rain over Land Algorithm	1	2,3
Arkin/Justice	Jeff Privette	NPP/VIIRS Land Product Validation Research	2	1
Brown, O	John Bates	Support of NCDC Activities in Climate Data Records and Science Data Stewardship	2	2
Sudradjat	Ralph Ferraro	Global Precipitation Climatology Project	1	3
Janowiak	Wayne Higgins	Global Precipitation Analysis Development and Climate Diagnostic Research	3	2
Janowiak/Yoon	Wayne Higgins	Hydrological Support for the Climate Prediction Center	3	2
Lee	Bill Murray	Operational Generation of the HIRS Outgoing Longwave Radiation Climate Data Record	2	2,4
Li	Steve Lord	Development of an integrated system for validating NCEP model cloud, precipitation and radiation outputs against satellite retrievals	3	2,3
Li	Fuzhong Weng	Assessments of Advanced Components for Community Radiative Transfer Model (CRTM) and Satellite Data Assimmilation	1	2,3
Mariotti	Eric Locklear	Management of the Climate Prediction Program for the Americas	3	2
Meng	Ingrid Guch	POES AMSU Monitoring at CICS/SCSB	1	4
Nigam	Chet Ropelewski	South Asian Regional Reanalysis	3	2
Romanov	Igor Appel	Development of Operational Algorithm & Software to Validate Snow Cover Product from NPP VIIRS	1	2
Sapiano	Christopher Brown	CICS Marine Phenology	1	1
Schroeder/Arkin	Ivan Csiszar	Active fire product evaluation and development from MODIS and VIIRS	1	3,4
Vermote	Barbara Macneill	Calibration/Validation of the VIIRS Cloud Mask over Land Surfaces	2	4
Vila	Ingrid Guch	A Prototype STAR Precipitation Product Validation Center	1	2,4
Vila	Ralph Ferraro	Analysis and Improvement of Satellite Derived Global Hydrological Products - Passive Microwave Applications	1	2,4
Vila	Ralph Ferraro	A Special Sensor Microwave Imager/Sounder (SSMI/S) Application for Hydrological Products Retrieval	1	2,4
Vila	Ingrid Guch	Satellite Calibration and Validation (Cal/Val efforts for rainfall estimates and POES-AMSU monitoring	1	2,4
Wang	Ralph Ferraro	Precipitation over Land Utilizing High Frequencies in Support of NOAA's Climate and Prediction Program	1	2,4
Zeng	Jin Huang	Development of a Seasonal Fire Danger Potential Prediction Capability based on CFS and a Dynamic Vegetation Growth Model	3	2,4

	CICS THEME	NOAA STRATEGIC GOAL
1	Climate & Satellite Research & Applications	Ecosystems Approach to Management
2	Climate & Satellite Observations & Monitoring	Climate Variability and Change
3	Climate Research & Modeling	Weather and Water Information
4		Critical NOAA Mission Support

CICS Funding (%) 7/1/09-3/30/10 by Research Theme
Total funding $3,899,540



CICS Funding (%) 7/1/09-3/30/10 by NOAA Strategic Goal
Total funding $3,899,540

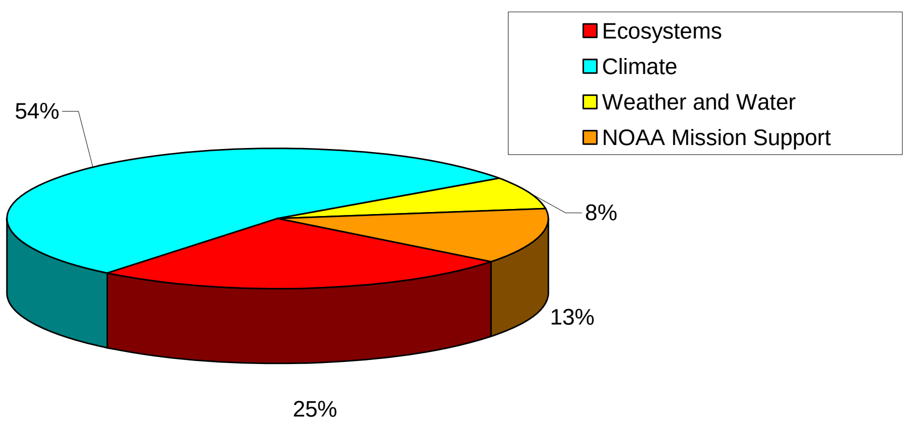


Figure 1 CICS tasks stratified by CICS Theme and NOAA Strategic Goals

Table 2 CICS Publication and Personnel Statistics

Publications	Institute Lead Author	NOAA Lead Author
Peer Reviewed	9	1
Non-Peer Reviewed	15	0

PERSONNEL

Category	Number	BS	MS	PhD
Research Scientist	11			11
Visiting Scientist	2			2
Postdoctoral Fellow	8			8
Research Support Staff	6	1	4	1
Administrative	2	2		
Total (> 50% support)	29	3	4	22
Undergraduate Students				
Graduate Students	8		6	2
Employees that receive < 50% NOAA funding (not including students)	11		1	10
Located at NOAA facility (include name of facility)	10	all at WWB		
Obtained NOAA employment within the last year	0			

3 NOAA/CICS CORE ACTIVITIES

CICS core activities include education, coordination, scientific computing, outreach, and management and administration related to CICS-MD, CICS-NC and Consortium efforts. Much of the first 9 months of CICS has been devoted to ensuring the transfer of ongoing CICS-MD activities initiated under the preceding Cooperative Institute at UMCP and to the essential foundation preparation and collaboration development at CICS-NC and across the Consortium. Despite these urgent efforts, significant progress has been achieved on the full suite of core activities, as described below. In our proposal, we suggested creating Enterprise Teams to coordinate educational, outreach and scientific computing activities. During the initial 9 months, the role and necessity for these constructs has not been defined, and until the requirement is more clearly established we will continue to utilize the CICS-MD and CICS-NC Directors to ensure the necessary collaboration.

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 is currently assessing candidates for a Graduate Research Assistantship (GRA) in the Department of Atmospheric and Oceanic Science at UMCP to be enrolled in the Fall Semester of 2010.

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 2009 CoRP Symposium was held at CREST in New York City, and a number of CICS scientists participated. Oral presentations were made by Dr. Kaushik Gopalan and Prof. Raghu Murtugudde of CICS, and CICS Consortium members from the City College of New York, which hosts CREST, were involved in a large number of oral and poster presentations. Due to the timing of CICS funds during 2009 and the Symposium, participation of CICS-MD scientists was supported by funds carried over from the expiring Cooperative Institute for Climate Studies.

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 Brad Wind under the supervision of the ESSIC IT Manager, Mark Baith, and helping to support a workstation cluster that enables CICS scientists to engage successfully in major data processing and computing projects.

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, has made the most progress in developing this approach, but significant accomplishments have been achieved throughout.

***Seminars*:** CICS-MD conducts a series of informal seminars and participates in the ESSIC seminar series to communicate scientific results to the broader community (see **Education** and Table 3). In addition, CICS-MD scientists make both oral and poster presentations at technical meetings, and frequently visit other institutions to present seminars describing their work. Scientists at CICS-NC and other Consortium members expect to contribute to this method for outreach as their projects mature and begin to produce more results. Table 3 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. The timing of the CICS award and the deadline for this report have the result that Maryland Day 2010 will occur after the report period, and so we can only report presently on our preparations. CICS scientists are participating in preparations for our contribution to the Earth Science tent, where exhibits will be 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!" Maryland Day 2010 will be held in College Park, MD on April 24, 2010.

Web Sites: Several web sites have been/are being developed or refurbished to enhance CICS outreach to all interested sectors. A new URL, climateandsatellites.org, was acquired and a comprehensive site describing the CICS Consortium is under construction. This site will provide the background, mission and vision statements for CICS, as well as links to Consortium participants. In addition, the legacy Cooperative Institute for Climate Studies has been converted into the CICS-MD web site as of September 1, 2009, and plans to upgrade it are underway. CICS-NC developed and implemented its web site, located at http://cicsnc.org/, which went live on February 24, 2010.

Table 3 CICS-related seminars

Speaker	Affliation	Date	Seminar title
Eric Bruning	CICS	8/20/09	Satellite Observations of Lightning
Rachel Albrecht	CICS	8/20/09	Satellite Observations of Lightning
Daniel Vila	CICS	9/10/09	Forecast and Tracking of Active Cloud Clusters
Sinead Farrell	CICS	9/10/09	Satellite Laser Altimetry over Arctic Sea Ice
Steven Fine	NOAA/ARL	9/5/09	NOAA's Air Resources Laboratory
Joonsuk Lee	CICS	10/8/09	AMSU calibration
Lontao Wu	U. Wisconsin	10/9/09	Validation of high latitute ocean precipitation retrievals from AMSR-E
Sid Boukabara	NOAA	10/23/09	MiRS: A Physical Algorithm for Rain, Cloud Sounding
Jon Mittaz	CICS	11/12/09	The Calibration of NOAA broadband IR sensors
Andy Harris	CICS	11/12/09	SST Retrieval Algorithms
John Janowiak	CICS	12/17/09	Evolution of MJO in Numerical Model Precipitation Forecasts
Peter Romanov	CICS	12/17/09	NOAA Snow mapping - applications and analysis
Banghua Yan	CICS	1/15/10	Advances in Satellite Microwave Data Assimilation Developments
Cezar Kongoli	CICS	2/18/10	Assimilation of Snow Climatology Information with Microwave
Aditya Sood	CICS	2/18/10	Progress in Modeling Chesapeake Bay Watershed Using SWAT
Viva Banzon	NOAA	3/26/10	Diurnal SST for the Atlantic
Tangdong Qu	U. Hawaii	9/2/09	Tracking the origin of Equatorial 13C Water using a simulated adjoint tracer
Andre Boustany	Duke U.	9/14/09	Bluefin Tuna Ecology, Movements and Habitat Preference off the US East Coast
Steven Smith	JGCRI/PNNL	9/21/09	The End of the Aerosol Age: 250 Years of Aerosol and Climate
Kristopher Karnauskas	Columbia U.	10/19/09	Anthropogenic climate change in the equatorial Pacific
Paul Houser	GMU	11/19/09	A Water and Energy Community of Practice
Dudley Chelton	Oregon State U.	11/23/09	The Underestimation of SST Influence on Surface Winds in NWP Models
Lisa Goddard	IRI	11/24/09	Climate and Information Across Timescales
Neil Ward	IRI	11/30/09	Climate-Stakeholder-Research Interface: Some Examples
Fernando Miralles-Wilhelm	Florida Int. U.	12/2/09	Modeling Coupled Hydrology - Vegetation Dynamics in Aquatic
Rong-hua Zhang	ESSIC	12/7/09	Representing tropical instability wave-induced surface wind forcing
Bruce Hewitson	U. Cape Town, SA	1/22/10	Developing Actionable Regional Climate Change Information
Anthony Janetos	JGCRI/PNNL	2/1/10	Land-use issues in climate change mitigation and adaptation
Luis de Goncalves	ESSIC	2/22/10	Progress in land surface modeling studies over South America
Hu Yang	Center for Met Sats	2/24/10	An introduction of china meteorological satellite project
Yudong Tian	UMBC/GEST	3/1/10	Measuring Precipitation over U.S.: Where Are We Today?"
Ruba Amarin	U. Central Fla.	3/4/10	HIRAD Hurricane Wind Speed and Rain Rate Simulation
Isaac Moradi	Lulea U. Sweden	3/5/10	Validation of Tropospheric Humidity Retrieved from Microwave Satellite Data
Sujay Kaushal	UMCES	3/8/10	Influence of Land Use, Climate Change, and Watershed Restoration on Nitrogen Dynamics
Yun Qian	PNNL	3/22/10	Air pollution affects Climate and Hydrological-Cycle in China

Management and Administration: The CICS Consortium is led by Dr. Phil Arkin as Executive Director. Dr. Arkin also serves as Director of CICS-MD, which is housed administratively within ESSIC at UMCP, and infrastructure support is provided by ESSIC management and staff, including Andy Negri, Assistant Director, and the ESSIC Business Office, led by Jean LaFonta. Dr. Otis Brown is Director of CICS-NC, located within the NCDC facilities in Asheville, NC. Dr. Brown is supported by administrative staff at NCSU in Raleigh.

4 PROJECT REPORTS

Transfer of NOAA/NASA AVHRR Pathfinder SST Processing to NODC

R. Evans; (NOAA Collaborator: Ken Casey) – OBOB_NCDC10

Background: Scientific Problem, Approach, Proposed work

This proposal to NOAA's Scientific Data Stewardship program (SDS) will transfer processing of the highly successful NOAA/NASA AVHRR Pathfinder sea surface temperature fields (PFSST) to the NOAA National Oceanographic Data center (NODC), where their long term availability, survivability, and provenance will be ensured.

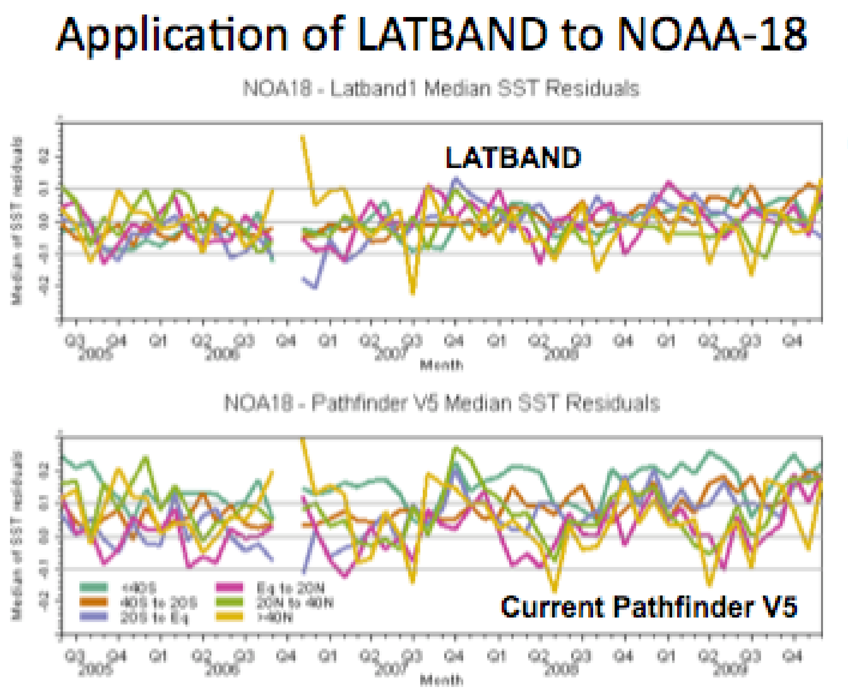
The Pathfinder SST program was originally initiated as a cooperative research project in 1991 between the University of Miami Rosenstiel School of Marine and Atmospheric Science (RSMAS) and the NASA JPL Physical Oceanography Distributed Active Archive Center (PO.DAAC). Beginning in 2002, NODC began partnering with RSMAS to improve the Pathfinder CDR, improve its long-term stewardship, and broaden its usage.

The PFSST products have been reprocessed several times over the years, as the scientific understanding of the AVHRR instruments, algorithms and *in situ* matchup calibration data improved, and now provide a mature archive record of over two decades of global satellite measurements of sea surface temperature from multiple generations of AVHRR sensors.

Building on the success and maturity of the PFSST and the importance of this thematic climate record for research and industry, it is time to transition the production and quality control from the academic setting to a more stable and sustainable operational setting at the NODC. This transition will be accomplished by modernizing the current PFSST processing code into a package that will be compliant with the NODC architecture and easily scalable from large institutional data centers to single users that endeavor to continue to evolve the PFSST CDR in the future.

Accomplishments

Efforts during the current reporting period have been focused on integrating the AVHRR Pathfinder code base into the SeaDAS multi-sensor, multi-platform satellite processing system. The initial ingest of AVHRR L1b and subsequent conversion to swath level SST fields has been completed and transferred to NODC. In addition the AVHRR-*in situ* match-up database has been reformulated to provide a consistent record across all of the 5-channel AVHRR sensors, NOAA-7 through NOAA-18. As part of the improvement of the Pathfinder CDR record, the SST algorithm was reformulated to include improvements that have been introduced for the MODIS infra-red bands. In the new approach, monthly SST equations are developed for a set of 6 zonal bands, LATBAND. A test application of LATBAND to NOAA-18 significantly reduced both zonal and seasonal residuals with respect to *in situ* observations. This in turn has improved the product standard deviation and now both MODIS and AVHRR provide equivalent performance leading to a more consistent inter-sensor long-term SST record



Median of SST residuals (VALIDATION set) by month (2005-2009). Each line corresponds to a latitude band. Upper panel corresponds to latitude-specific SST; lower panel is current Pathfinder SST V5.

Summary statistics for SST residuals, NOAA-18. (11-12μm bands)

Data set	Median (K)	Mean (K)	StdDev
Validation LATBAND	-0.178	-0.198	0.37
Validation Pathfinder V5	-0.093	-0.115	0.39

Summary statistics for SST residuals, MODIS AQUA. (11-12μm bands)

Training	-0.1644	-0.1781	0.3867
Validation	-0.1704	-0.1813	0.3889

The Pathfinder and MODIS SST retrieval equations are developed to produce a "skin SST" leading to the nominal -0.17K offset with respect to buoy measurements and for the first time, a standard deviation less than 0.4.

Planned work

Specific activities for this proposal period include the following:

1) Transition ephemeris based high accuracy navigation into PFSST processing code.

2) Incorporate capability to read attitude corrections to support processing of 1km AVHRR input Level-1b fields.

3) Add 'hypercube' uncertainty fields equivalent to those used in the MODIS SST processing.

4) Transition AVHRR SST algorithm to use MODIS 'LATBAND' 6 zonal band formulation.

5) Compute 'LATBAND' and 'hypercube' tables for 5 channel AVHRR sensors from NOAA-7 through NOAA-18.

6) Finalize and test PFSST scripts in a LINUX cluster environment.

7) Conduct test processing of PFSST codes to verify process.

8) Deliver PFSST processing codes and scripts to NODC.

9) Conduct reciprocal tests to verify compatibility of PFSST AVHRR processing at NODC and RSMAS.

CICS Support of CPC's Climate Monitoring and Prediction Activities

J. Janowiak; (NOAA Collaborator: W. Higgins) 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 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, but are not limited to, an examination of operational numerical weather prediction model performance to forecast the evolution of precipitation variability associated with the Madden-Julian Oscillation phenomena (Fig. 1). The PI also continued to collaborate in the advancement of high time/space resolution global precipitation analyses (CMORPH) and has served as liaison between NCEP 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 participate in planning and coordinating the 2010 Climate Diagnostics and Prediction Workshop which is a marquee event that CPC co-hosts each year, and which will be conducted in Raleigh, NC in October 2010, hosted by CICS-NC. The PI will continue to assist in the migration of CPC processes in anticipation of the move to the NOAA Center for Weather and Climate Prediction (NCWCP) facility on the M-Square campus, will continue to serve as liaison between NCEP and ESSIC/CICS, and will continue with a satellite precipitation validation program.

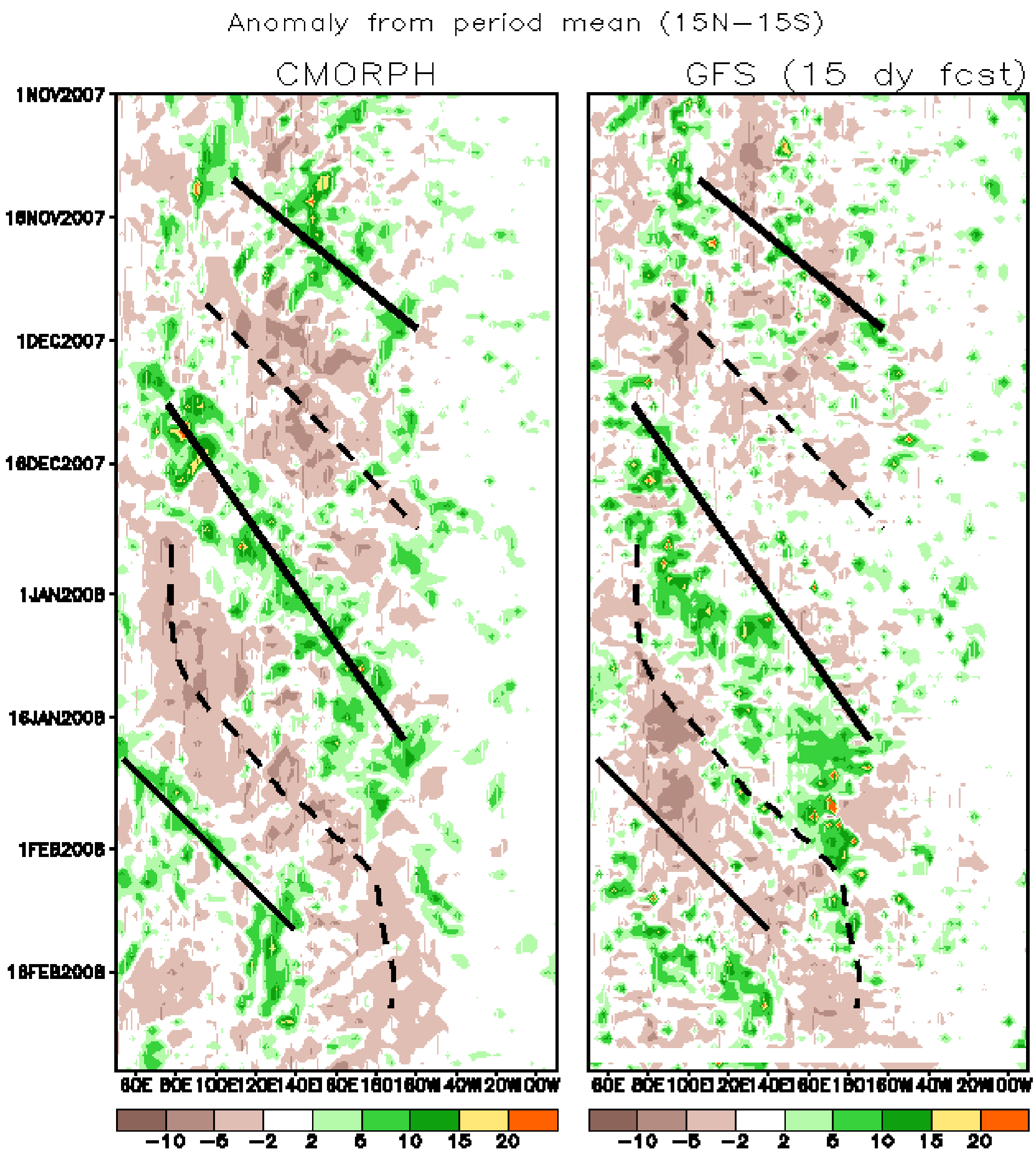


Figure 1. Time-longitude plot (15ºN-15ºS) of (left) observed precipitation anomalies"(differences from the mean over Nov 2007 – Feb 2008) and (right)15-day forecasts of precipitation from the NCEP GFS global model during a period in which the Madden-Julian Oscillation phenomena was active. Lines indicate the west to east progression of enhanced precipitation over the Tropics from the Indian Ocean to Greenwich. Note the time lag in the model forecasts compared to what is observed.

Publications

Joyce, R. J., P. Xie, Y. Yarosh, J. E. Janowiak, and P. A. Arkin, 2009: "CMORPH: A 'Morphing' Approach for High Resolution Precipitation Product Generation". *Satellite Rainfall Applications for Surface Hydrology*, Springer-Verlag, Eds. M. Gebremichael and F. Hossain, IBSN:978-90-481-2914-0, 379 pp.

Augusto J. Pereira Filho, R. E. Carbone, J. E. Janowiak, P. A. Arkin, R. J. Joyce, R. Hallak and C. G. M. Ramos, 2009: Satellite rainfall estimates over South America – possible applicability to the water management of large watersheds. J. Amer. Water Res. Assoc., JAWRA-08-158-P.

CICS Satellite Data Processing System for R&D

P. Arkin and M. Baith; (NOAA Collaborator: R. Ferraro) – PAPASPSRD10

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, two stand-alone DELL workstations (LINUX) were procured to replace outdated machines that are used to support visiting scientists, interns and students that support the CICS scientists. The procurement for a high-end DELL workstation with Terabyte RAID storage has been assembled and will be delivered in April 2010. This procurement was delayed because of uncertainties in the stability of some of the hardware vendors under consideration, thus, the computer system was rescoped several times.

Planned Work

During the upcoming year, the new LINUX box and associated RAID will be installed and configured for use by CICS. With the help of student interns and the ESSIC IT staff, the satellite data archive will be developed, 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 initial processing tools will be developed to aid in the access and display of the satellite archives.

Active Fire Product Evaluation and Development from MODIS and VIIRS

W. Schroeder; (NOAA Collaborators: Ivan Csiszar) – WSWSMOSID11

Background
This work is part of the ongoing NASA EOS/NPP project "Active fires from MODIS and VIIRS and developing the associated Earth Science Data Record" and represents a continuation and enhancement of previous activities. The research and development in this proposal supports the creation of a long-term data record from MODIS with known accuracy, which would form the baseline for the active fire component of the fire Earth System Data Record (ESDR).

This particular task is focused on the completion of the Stage 3 validation of the *Fire and Thermal Anomalies* product and the development of a validation methodology for the Fire Radiative Power (FRP) product derived from the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard the NASA Terra spacecraft. The proposed approach utilizes alternative higher spatial resolution spaceborne and airborne imagery coincident with MODIS observations obtained at different viewing angles. A second component includes the continuing evaluation of the proposed Visible Infrared Imaging Radiometer Suite (VIIRS) Active Fire Application Related Product (ARP) and the adaptation and enhancement of an asynchronous, multi-sensor validation protocol for VIIRS. In this report we present the work accomplished for the first component of the project (i.e., the validation of the MODIS active fire product).

Accomplishments
The Stage 3 validation of the MODIS/Terra active fire product (MOD14) has been implemented. A total of approximately 2,500 ASTER scenes of 60×60km each have been used in the study (Fig. 1). More than 16,000 MODIS/Terra active fire pixels were coincidently mapped by the ASTER scenes above. The data sample used covered 2001-2006 and included both daytime and nighttime data.

Using the data sets above, probability of detection and false alarm rates were derived for the MOD14 product (Fig 2) as a function of vegetation conditions (more specifically in terms of percentage tree cover using Vegetation Continuous Fields (VCF) data). As a result of these analyses, the status of the MOD14 validation stage was upgraded to 3 indicating that "uncertainties are characterized in a statistically robust way over multiple locations and time periods representing global conditions" (see URLs 1 and 2 below).

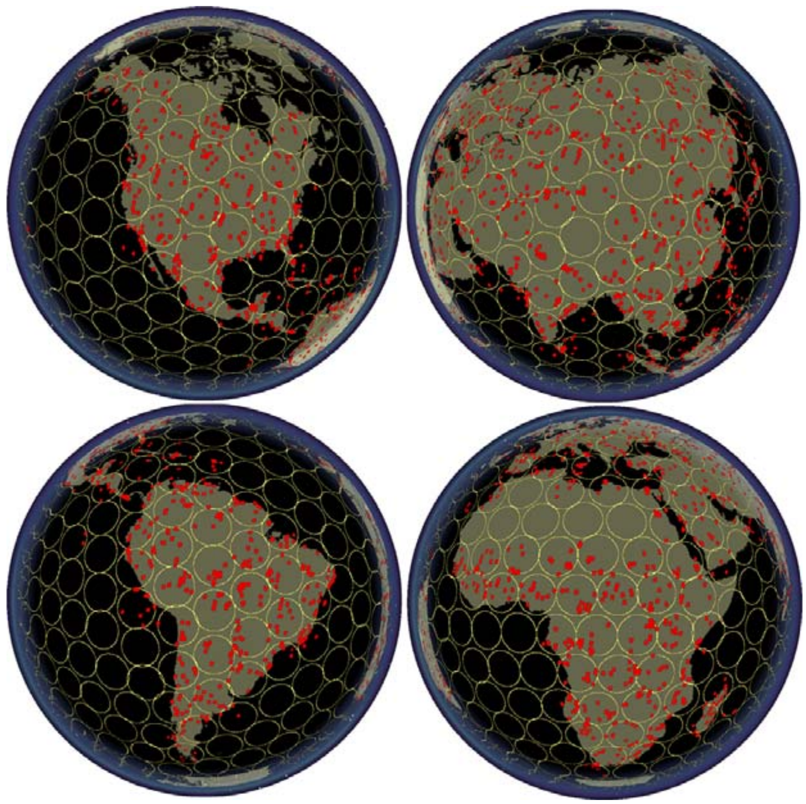


Figure 1: Global distribution of 2,500 ASTER scenes (red shades) used for the validation of the MODIS/Terra active fire product (MOD14). Also shown is the equidistant circular grid used as part of the sampling strategy to guarantee equal representation of different regions of the globe.

Additional MODIS Terra and Aqua fire characterization assessment has been implemented using reference data from ground observations collected during previous campaigns in Amazonia, as well as from ASTER and ETM+ imagery. Fire radiative power (FRP) retrievals from MODIS were also compared to near-simultaneous FRP estimates derived from Geostationary Operational Environmental Satellite (GOES) imager data. Large and variables errors in MODIS FRP estimates were found during the validation of that parameter. Main factors leading to errors in the MODIS FRP data were primarily caused by: (i) the instrument's Point Spread Function (PSF), (ii) the pixel background characterization used in the calculation of FRP, and (iii) omission of small active fire in the vicinity of the target pixel. A publication summarizing the MODIS fire characterization assessment has been submitted to the Journal of Geophysical Research and is currently under review.

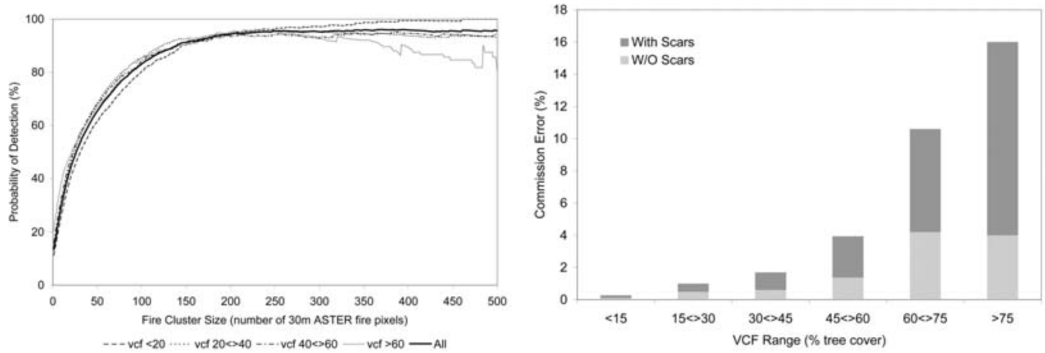


Figure 2: Probability of detection (left panel) and false alarm rates (right panel) derived for the MODIS/Terra active fire product (MOD14) as a function of percentage tree cover (VCF). Probability of detection is given in terms of the number of 30m ASTER active fire pixels counted within the coincident MODIS pixel footprint.

Publication

Schroeder, W., Csiszar, I., Giglio, L., and Schmidt, C. (in review) On the use of fire radiative power, area and temperature estimates to characterize biomass burning via moderate-to-coarse spatial resolution remote sensing data. *Journal of Geophysical Research*.

URL Links from the text:

1. http://landval.gsfc.nasa.gov/index.html

2. http://landval.gsfc.nasa.gov/ProductStatus.php?ProductID=MOD14

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

The last year's effort has been focused on updating previous results by using the recently released Global Precipitation Climatology Project (GPCP) Version 2.1 (GPCPV2.1) (1979-2006). A paper has been written and submitted as a note to the Journal of Climate. The paper is currently under revision after the first review.

EOF analysis on the GPCPV2.1 still shows the low frequency variation of precipitation on annual basis, with a dominant positive change mostly in the Asian-Australian and South Pacific Convergence Zone regions. This result is expected as the GPCPV2.1 is an improvement to the earlier version over land.

Based on the third mode from the EOF analysis, precipitation in the southern Asian monsoon region is shown to concurrently increase with the meridional surface temperature gradient between the equatorial Indian Ocean and land region in India-China near 30°N latitude. The temperature gradient is the primary driver of the monsoon system in the region. Low frequency variability of the gradient is dynamic as both land and ocean surface temperature increases over the period.

Results from the analysis on the zonal and meridional winds at 850 mb and the Webster-Yang (Asian monsoon) index further support the possible intensification of the monsoon system and, hence, precipitation in the southern Asian monsoon region in the 1979-2006 period.

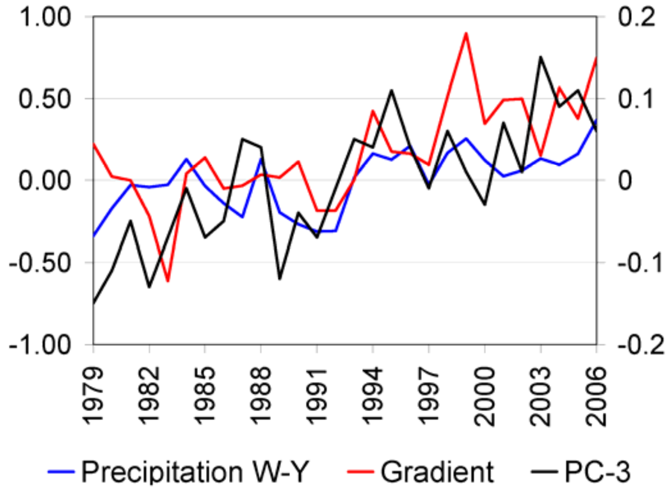


Figure 1. Time series of anomalies of GPCP annual precipitation in the region from which the Webster-Yang index is computed (left y-axis), the surface temperature gradient between the equatorial Indian Ocean and land region in India-China near 30°N latitude (left y-axis), and the time series of the third EOF (right y-axis). All time series increase concurrently and significantly (Spearman-Conley test; α=5%). The significant (t-test; α=5%) correlations between precipitation in the W-Y box and the gradient and PC-3 are 0.6 and 0.63, respectively.

Planned Work

We will try to determine if the detected changes in precipitation in the southern Asian monsoon region due to changes in surface temperature gradient also includes spatial changes in the regional annual cycle of precipitation.

Publications & Presentations

Sudradjat, A., A. Gruber, J. Janowiak, and R. R. Ferraro, 2010: The co-variability of annual monsoon precipitation and global surface temperature. Currently under revision; will be resubmitted to the Journal of Climate.

Sudradjat, A., A. Gruber, J. Janowiak, and R. R. Ferraro, 2009: A global perspective of Southern Asian Monsoon annual precipitation variations in GPCP (1979-2006). Talk presented at the NOAA 34th Climate Diagnostic and Prediction Workshop, Monterey, CA.

Sudradjat, A., A. Gruber, J. Janowiak, and R. R. Ferraro, 2010: A global perspective of Southern Asian Monsoon annual mean precipitation variations in the Global Precipitation Climatology Project analyses (1979–2006). Poster presented at the 90th AMS Annual Meeting, Atlanta, GA.

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

We have successfully integrated the UMD 1 km global land cover map to the current GPROF for TRMM 2A12 algorithm. Although we are currently working with TRMM 2A12, the ultimate goal is working for all platforms. The static surface map is dynamically regridded to simulate a 15-km Field of View (FOV) approximating an 85 GHz channel. Unlike the static regridding approach that uses surface cover info that can be as far as the final map's grid resolution (15 km in this study), the dynamic regridding approach allows the use of the closest (within less than 1km) surface cover info to an FOV.

In addition to the static map, we also added the dynamic map of global snow cover. We chose to use the NOAA's Automated Snow Mapping System (source: Peter Romanov) because it uses info from MODIS Terra & Aqua and AMSR-E Aqua allowing a continuous observation even in cloudy or dark conditions. The snow mapping system also has good spatial and temporal resolutions.

We have been in contact with Daniel J. Cecil (University of Alabama-Huntsville) who has been investigating problems in TRMM land precipitation especially over the U.S. Cases showing the problems were investigated to show improvements made possible through this project.

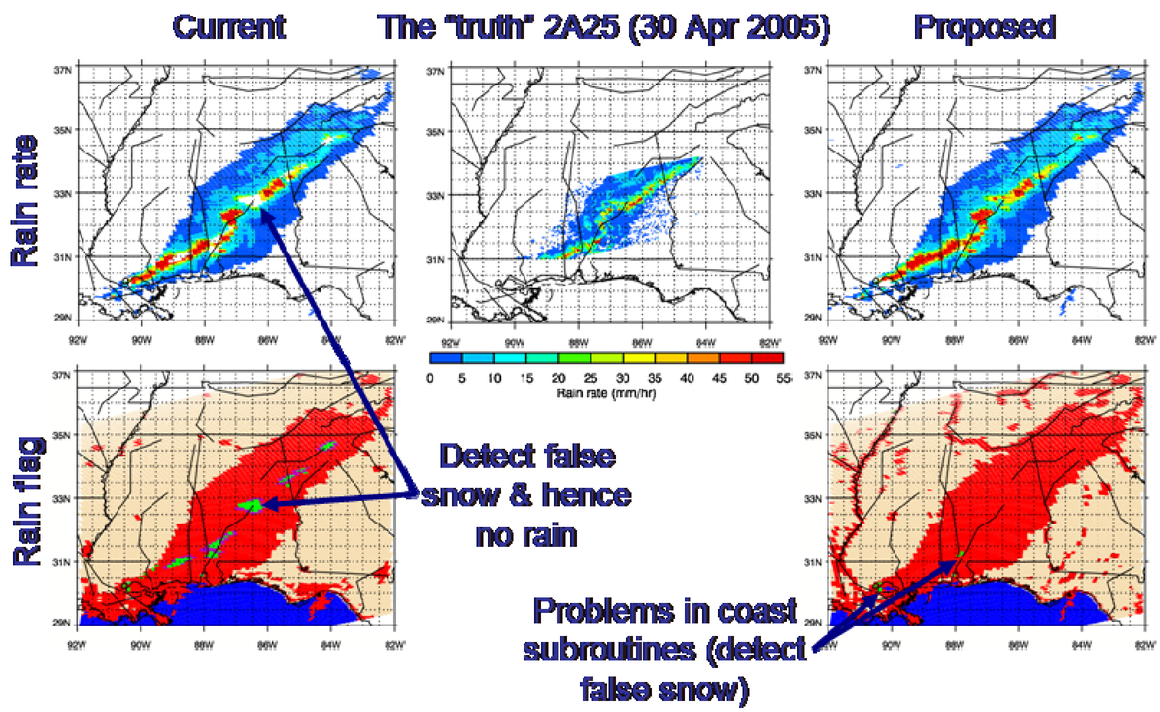


Figure1. TRMM 2A12 (orbit 42496; 30 April 2005) land precipitation from the current (left panels) and proposed (right panels) algorithms and precipitation radar (PR) 2A25 (middle panel). Precipitation from PR 2A25 is considered to be the truth. The bottom left panel shows that the current GPROF approach falsely detects snow in the Mesoscale Convective System (MCS) and hence shows no rain when it was actually raining (top left panel). The bottom right panel shows that the proposed ancillary data approach removes the snow false detections and hence allows rain retrievals (top right panel). The proposed approach also shows better coastal and inland waters delineation (bottom right panel). Because this project does not touch the coast subroutines, false coastal snow detections are still shown in the right panels.

Planned Work

Future works include:

1. Adding more dynamic component, such as desertification, deforestation, greening, by using the NDVI dataset.
2. Adding more rain/snow detection especially for high elevation/ mountainous regions by applying the freezing level or thickness method by using freezing level height and thickness and warm layer info from models, such as the Land Data Assimilation Systems (LDAS), or reanalyses.
3. Performing monthly, seasonal, and annual comparisons.
4. Integrating the proposed land precipitation algorithm with LDAS.

Presentations

Sudradjat, A. and R. R. Ferraro, 2010: Toward an improvement of land surface identification for satellite precipitation retrieval. Talk presented at the 90th AMS Annual Meeting, Atlanta, GA.

Operational Generation of the HIRS Outgoing Longwave Radiation Climate Data Record

Hai-Tien Lee, Arnold Gruber, and Joonsuk Lee; (NOAA Collaborator: W. Murray) – HLHL_HIRS10

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

In the OLR algorithm improvement, we continued to explore the multispectral algorithm by identifying the source of errors in the OLR estimation as well in the inter-satellite calibration. A new OLR model that uses higher order radiance predictors in estimating spectral fluxes seems to present a more uniform residual pattern that could have eliminated most of the scene dependencies. The residual analysis also suggested that it is necessary to treat semi-transparent cirrus condition separately.

The preliminary IASI OLR model has excellent performance that it has a theoretical spectral flux estimation error comparable to that of the CERES spectrum retrievals, ~0.1% (0.3 Wm^{-2} flux equivalent). The ongoing validation of IASI OLR will be in collaboration with NESDIS/STAR. More information about IASI OLR model development will follow. The development of CrIS OLR model is currently pending.

For the HIRS radiance calibration problem, we have shown the significance of nonlinearity in HIRS instrument response and concluded that it is necessary to develop a new calibration algorithm that takes into account of non-linearity effect. We have attempted to use onboard calibration data to reconstruct nonlinearity properties, however, due to the narrow range of calibration temperatures of the internal warm target, the results are not very robust. We need to construct the nonlinear calibration algorithm using the thermal vacuum data and use onboard calibration for consistency check for possible instrument variation and degradation.

The current release is Ver. 2.1 that spans from 1979 to 2008 and it continues to compare well to the CERES ERBE-like product.

IASI OLR Algorithm Development

A band-to-band IASI OLR estimation model is developed that make use of all available IASI radiances to estimate spectral radiances or spectral fluxes. When estimating the spectral radiances, only the un-observed portions of the longwave spectrum is needed, that is, 0-645 cm^{-1} and 2760 to 3000 cm^{-1}. Due to the energy distribution, most uncertainties are in the far IR spectrum. The band-to-band OLR model can be best fitted with log-log transformation, or, equivalently, the nonlinear regression model with power law. Figure 1 shows an example of the IASI OLR models and their performance on estimating the spectral fluxes. The theoretical assessment shows that such band-to-band IASI OLR model can have radiance or flux estimation errors comparable to that of the CERES broadband spectral retrieval errors, about 0.1%, or 0.2 to 0.3 Wm^{-2} for equivalent flux. This result is very encouraging. Validation studies against CERES and HIRS OLR products are currently ongoing.

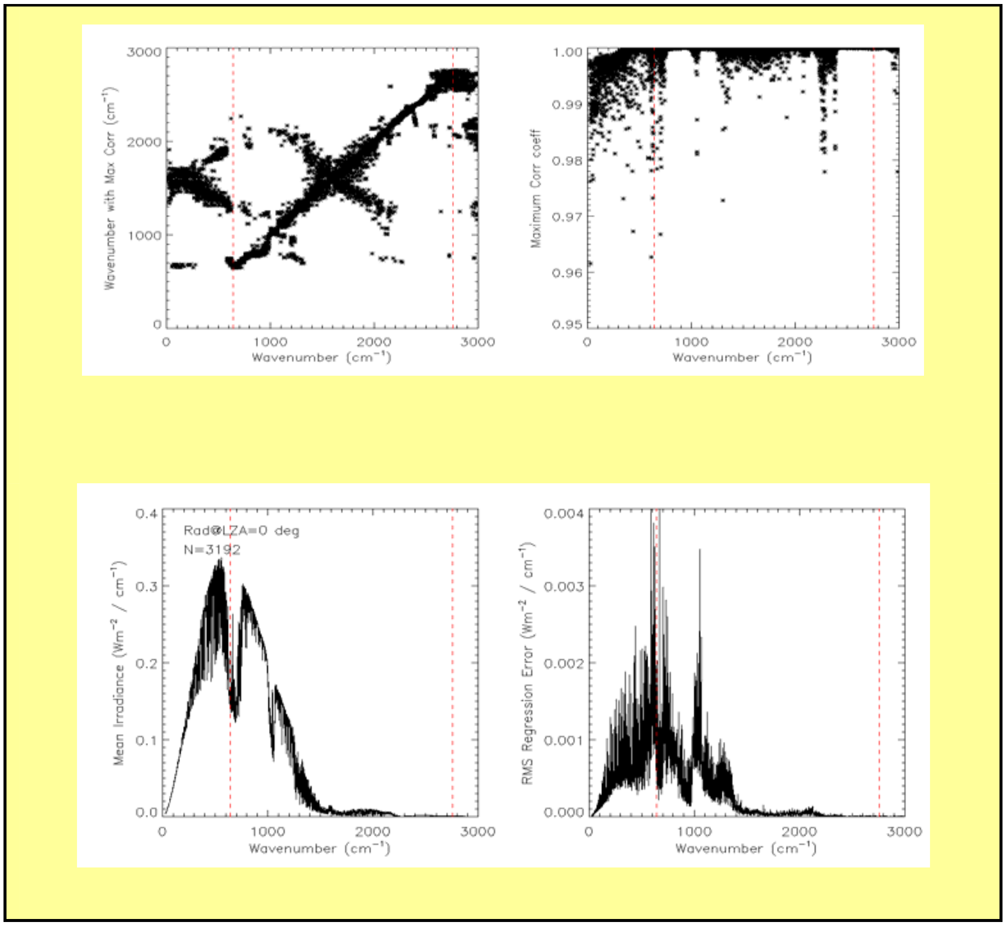


Fig. 1. An example of IASI OLR Modeling and performance. The IASI radiance observations are taken at an effective 0.5 cm-1 resolution (level-1c data) spanning continuously between 645 and 2760 cm^{-1} that indicated by the two dashed red lines in each of the panels. The upper left panel shows the predicting channels for the band-to-band OLR estimation models to be fitted with Power law. Their corresponding linear correlation coefficients between the IASI predicting radiances and spectral fluxes (with log-log transformation) are shown in upper right that for most frequencies the values are greater than 0.99. The estimated OLR spectral fluxes predicted from simulated IASI radiances at local zenith angle 0° are shown in the lower left panel. The associated estimation errors are shown in the lower right approximately proportional to their spectral flux values. The overall flux estimation error is about 0.2 Wm^{-2}, or about 0.1%, which is in similar magnitude for the spectral retrieval errors of the CERES LW flux.

Planned Work

Tasks (Sept 1 2010 – Aug 31 2011):

- Establish HIRS OLR CDR Operational Production System at CICS
- Generate HIRS OLR CDR Product (1979-2010)
  a) In netCDF4 format
  b) Conform to Climate Forecasting (CF) metadata format following ISO 90115-2 procedure
- Prepare Technical Documents
  a) Operational Algorithm Document (OAD)
  b) Algorithm Theoretical Basis Document (ATBD)
- Create HIRS OLR CDR product access and information web site
- Prepare source code package for OLR CDR production
- Proceed with NOAA-NP (N-prime, NOAA-19) OLR CDR production
  — Derive NOAA-NP OLR model
  — Generate off-line temperature-prediction coefficients for radiance calibration
  — Derive bias adjustment through inter-satellite calibration
- Continue HIRS OLR algorithm improvements following the nonlinear multi-band regression experiments reported in Lee et al. (2009).
- Continue IASI OLR algorithm development (see Lee et al., 2010)
- Validation of IASI OLR; Intercomparison of IASI and HIRS OLR from MetOp-2
- Prepare journal articles and conference presentations
- Prepare Submission Agreement

Presentations

Lee, H.-T., I. Laszlo, and A. Gruber, 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, H.-T., R. G. Ellingson, and A. Gruber, 2010: Development of IASI outgoing longwave radiation algorithm. Proceedings of the 2nd IASI International Conference, Annecy, France, January 25-29, 2010.

Hydrological Support for the Climate Prediction Center

J. Janowiak and J.-H. Yoon; (NOAA Collaborator: K. Mo) – JJJJHYDRO10

Background: Scientific problem, Approach, Proposed Work

The overall goal of this task is to support CPC's effort on drought pilot study of the Southeast which was selected by the National Drought Information System (NIDIS). The SE was chosen because of long-lasting drought in 2006-2007 which had various societal and economic impacts. The statistical prediction of drought over this region with longer lead time is difficult because the ENSO impact on precipitation over this region is seasonally depended. In other words, a cold (warm) ENSO winter favors dry (wet) conditions over the SE, there is more (less) precipitation during a cold (warm) ENSO in summer (Mo and Schemm 2008). Therefore, it is much need to have a dynamical drought forecast system. It is our goal that a multi-model ensemble hydrologic forecast system for objective streamflow and soil moisture forecasts and drought prediction is delivered as a final outcome of this project.

A multi-model hydrological drought monitoring system as a part of the North American Land Data Assimilation System (NLDAS) phase 2 activities has been developed and in operation. Princeton University group led by Dr. Eric Wood has developed a seasonal hydrologic forecasting system which successfully perform bias correct and downscale seasonal forecast from CFS dynamical forecasts and CPC official outlook product for the Northeast.

CPC provides leadership and resources in drought assessments by providing drought outlooks and monitoring through the National Drought Monitor. An operational hydrologic prediction system will work toward an objective drought prediction and provide reliable information to water resources manager for their planning with lead time up to 6-9 months. This project is also coordinated with another project with the Colorado River Forecasting Center (CBRFC) and the OHD, which has the very same target for the Colorado River basin.

Accomplishments

One of the key aspect of the Princeton system merges multiple seasonal operational forecasts with observed climatology that optimally weights the seasonal forecasts and climatology by their relative skills to create a posterior distribution that bias corrects and downscales to scales appropriate for hydrologic and drought analysis based on the Bayes theorem. Although it was tested for the eastern U.S., it has not been carefully examined for the SE basin. As a first step, we will examine performance of CFS and bias correction/downscaling methods including not only the Bayesian approach but also others used by the OHD, for example, the Schaake Shuffle method (Clark et al. 2004, Schaake et al. 2007). In doing so, bias corrected and downscaled rainfall can be used to obtain Standardized Precipitation Index (SPI) forecast.

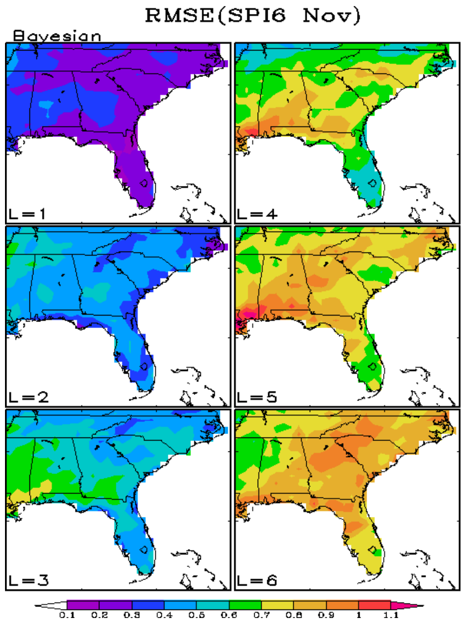


Figure 1. Root mean square error (RMSE) of Standardized Precipitation Index (SPI) forecast up to six month based on CFS's hindcast and the Bayesian method of bias correction and downscaling starting from November to April for the period 1981-2008. CPC Unified rainfall at 0.5x0.5 was used. If 0.8 of SPI is used for assess drought, parts of the Southeast can have valid forecast up to 6 months.

Planned work

- Examine different bias correction and downscaling methods: Statistical methods including the Bayesian, the Schaake shuffle, and probability mapping as well as dynamical methods with Regional Spectral Model (RSM) and high resolution CFS output (t382).

- Develop a drought early warning system for the SE: Based on EMC/Princeton forecast system along with various bias correction/downscaling methods, a drought early warning system for the SE will be developed. Particularly, the NIDIS select the ACF (Apalachicola/Chatterhoochee/Flint) River basin is a target region for the SE.

- Verification of drought indices over the Southeast: There are various drought indices used in the community. It is because of multiple facets of drought and its impact. We will examine sets of these indices and verify which ones are particularly useful in the SE.

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

Daniel Villa; (NOAA Collaborator: Ralph Ferraro) – DVDV_HYDR10

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

A new statistical quality control scheme based on the detection of outliers for each grid box and every channel on the remapped antenna temperature files was performed and around 4% of the surface is flagged as unrealistic input data for each month. After removing all spurious data, the mean bias between the original and the reprocessed dataset is around 3 mm mon-1. This bias is somewhat larger over land (Figure 1) than over ocean. While on global scale this bias is relatively small, that amount could be significant in long trend analysis. The IPCC working group found trends ranging from -7 to +2 mm decade-1 for the 1951-2005 period and slightly larger for last two three decades (IPCC, 2007). On the other hand, on regional scale studies large amount of rainfall (more than 60 mm mon-1 or 2 mm day-1) could be erroneously placed due to the existence of spurious data in the original AT database.

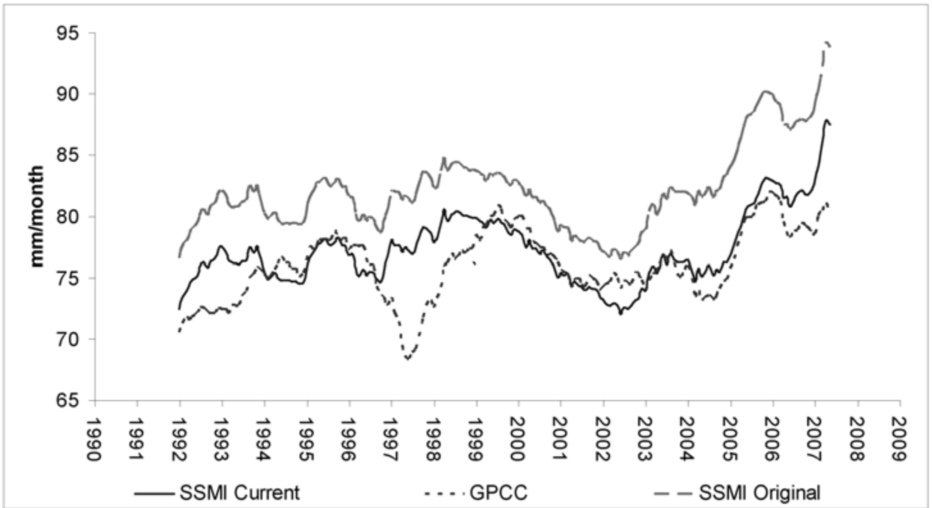


Figure 1: Rainfall annual running mean (in mm mon-1) for the period 1992-2007 over land for three different estimates: SSMI current (reprocessed and QC checked database), GPCC and the original database.

Planned Work

Despite many of the limitations and bias in the SSM/l estimates when compared with other datasets, the SSM/I climatology is clearly useful as a stand alone rainfall product, but more importantly, offers an excellent complement to other rainfall time series. This time series appears to best suited for describing the global scale rainfall patterns and the annual and interannual variations from the mean pattern.. Future research will be focused in similar analysis for other hydrological products like cloud liquid water, total precipitable water and snow and ice extent.

Publications

Vila D., R. Ferraro and H. Semunegus, 2010, Improved Global Rainfall Retrieval using the Special Sensor Microwave Imager (SSM/I), Accepted for publication in the Journal of Applied Meteorology and Climatology - Special Issue on International Precipitation Working Group (IPWG) workshop

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

Daniel Vila, Arief Sudradjat (NOAA Collaborator: Ralph Ferraro) – DVDV_SSMI10

Background: Scientific Problem, Approach, Proposed Work

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 followe 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 remains 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

The result of comparing SSM/I and SSMI/S retrieval shows that 91.655 GHz should be adjusted according to rain-based coefficients for rain rate over the ocean, while over land; the same adjustment should be done for medium and heavy rain rates, while clear-sky-based coefficients should be used to fit the light rain rate values. The statistical analysis performed after applying the proposed schemes, shows a lower bias and high correlation between TMI (a high quality sensor onboard TRMM) and SSMI/S retrievals when compared with raw SSMI/S retrievals (Figure 1).

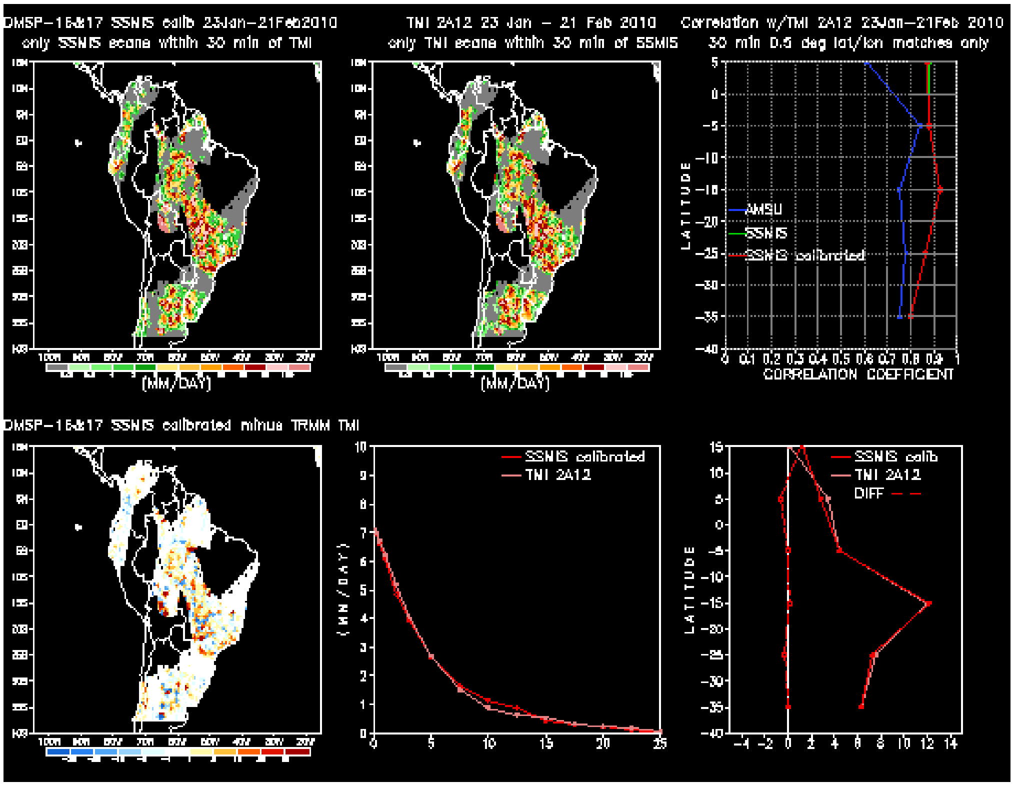


Figure1: Upper left panel: DMSP F16 and F17 GROF V7 retrieval for 23 January to 21 February 2010. Upper middle: idem for TMI. Upper right: Correlation coefficient between TMI (reference) and different rainfall retrievals (AMSU, SSMIS and SSMIS corrected). Bottom left: DMSP F16 & F17 calibrated retrieval minus TMI. Bottom middle: PDF for SSMIS calibrated retrievals and TMI. Bottom right: idem for zonal bias.

Planned Work

More extensive statistical validation activities have been carried out in order to evaluate the performance of GPROF V7 with SSMI/S input channels. The transition into operation of the correction scheme developed for SSMI/S channels is also under consideration.

Development of an Enhanced Active Fire Product from VIIRS

E. Ellicott; (NOAA Collaborators: Ivan Csiszar) - PAPA_VIIRS10

Background

The Visible Infrared Imaging Radiometer Suite (VIIRS) instrument on board the NPOESS Preparatory Project (NPP) and NPOESS satellites will provide radiometric measurements that offer useful information for the detection and characterization of active fires. The current baseline algorithm for the fire Application Related Product (ARP) primarily uses the moderate resolution 4 µm band (M13) and the 11 µm band (M15) measurements, aggregated from the native resolution observations into pixels according to a scheme aimed at maintaining a near-constant spatial resolution along the scanline.

The overall goal of this task is to develop an enhanced active fire product, taking advantage of the native spatial resolution and radiometric information provided by the VIIRS sensor. This task will produce science support and justification for addressing two fundamental issues related to VIIRS instrument characteristics relevant to fire detection. First, we will provide a quantitative evaluation of the added value of an active fire product suite (i.e. detection and FRP) from unaggregated data. Second, we will address the issue of suboptimal saturation temperature of M15. Our analysis will provide information to understand the impact and support the case for higher saturation level after launch and on successive flight units.

In order to simulate real fires we use coincident ASTER fire observations to generate accurate VIIRS-like scenes in the presence of active fires and thus no assumptions of sub-pixel fire characteristics are required. Proxy radiances are generated using VIIRS spectral information and geometry and therefore more accurate than approaches (e.g. remapping MODIS radiances). VIIRS non-fire pixels are generated directly from ASTER radiances while pixels containing fire are created through an ASTER-MODIS fusion process. Using this approach we can evaluate the impact of aggregation schemes and saturation levels on fire detection and characterization. For algorithm development and testing, this procedure is performed for representative samples of different fire regimes. A VIIRS-specific contextual detection algorithm is run over the simulated VIIRS scenes and algorithm performance is evaluated.

Accomplishments

The preliminary phase of generating VIIRS simulated pixels and evaluating detection capabilities has been extremely successful. We have demonstrated the effectiveness of producing simulated VIIRS and MODIS pixels from higher resolution ASTER radiances (Figure 1). This process of generating simulated VIIRS pixels allows us to investigate the influence of the planned aggregation scheme of native resolution observations and explored how this scheme compares with unaggregated, native resolution fire detections (specifically from nadir to ~30˚). The simulation of real fire observations by ASTER offers the unique opportunity to examine fire detections from unaggregated and aggregated VIIRS pixels, while using coincident MODIS data for perspective.

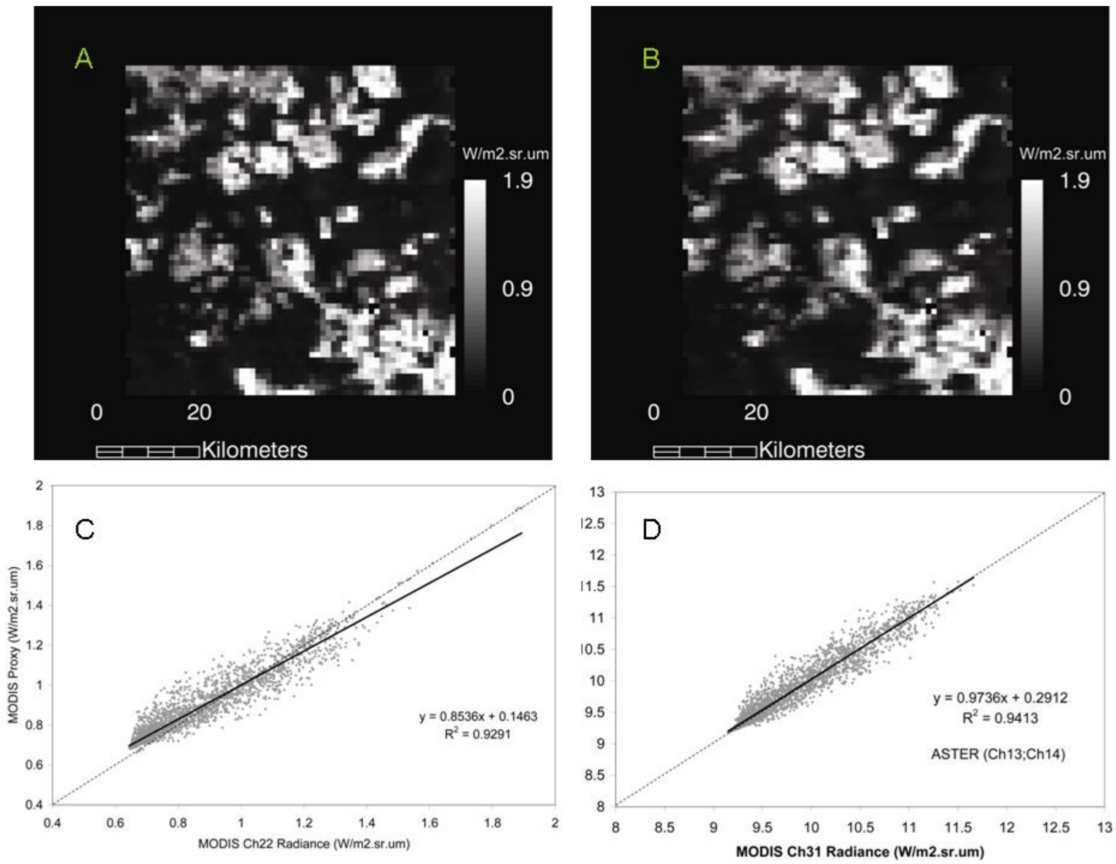


Figure 1: Performance results from ASTER-based simulation of MODIS pixels. Upper figures show radiance values for (a) MODIS and (b) ASTER-based simulated "MODIS" pixels. Lower figures show the strong agreement between radiances for the (c) middle infrared (4 μm) and (d) thermal infrared (11 μm) between MODIS and simulated "MODIS" pixels.

Initial analysis of detection capabilities from simulated VIIRS radiances indicates an approximately two-fold decrease in the size of minimum detectable size from unaggregated data for typical fire temperatures at nadir. Not surprisingly, greater spatial resolution yields greater detection capability (Figure 1).

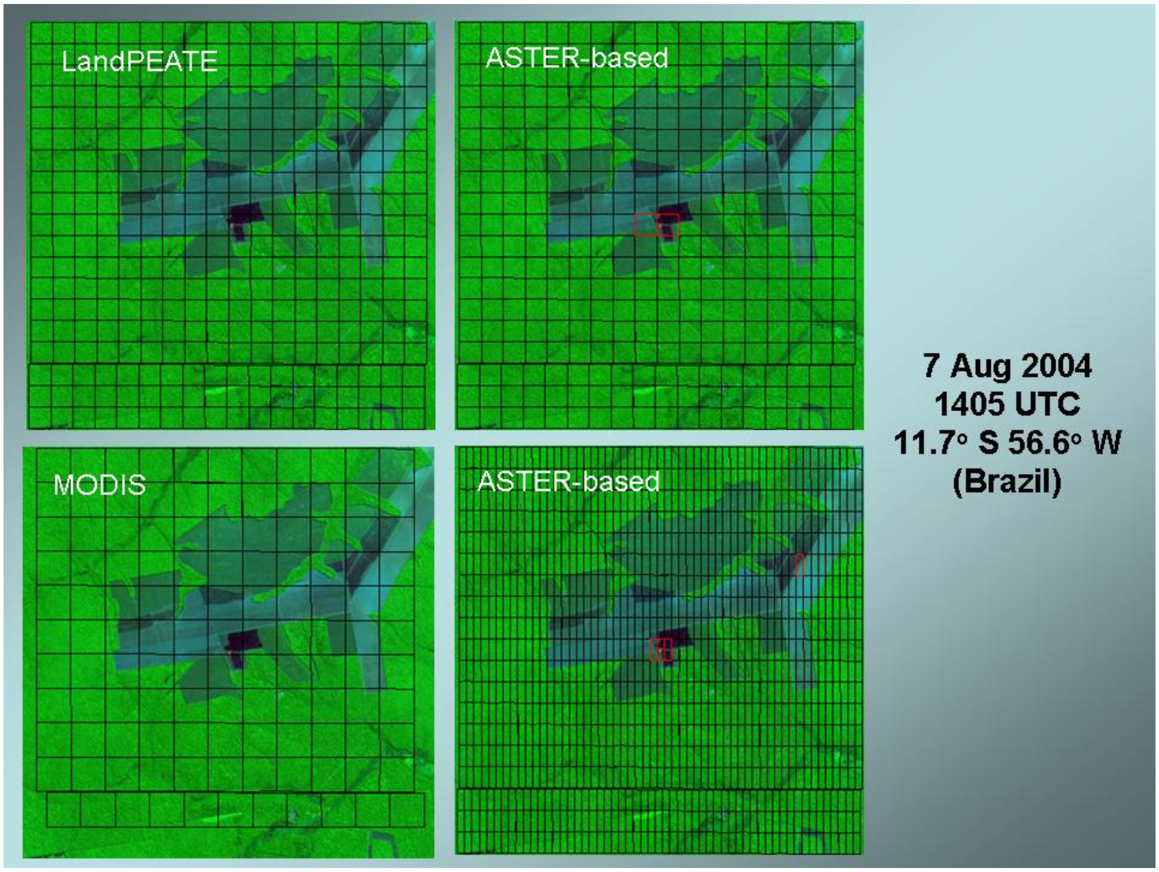


Figure 2: Comparison of fire detections from MODIS, VIIRS simulated in NASA's LandPEATE (Product Evaluation and Test Element), and our ASTER-based VIIRS simulation at aggregated (upper right) and unaggregated (lower right) resolution. Initial results indicate a two-fold increase in detection capability with unaggregated VIIRS pixels at nadir as compared with aggregated ones.

Planned Work

Currently, one test case from Brazil, constituting several ASTER fire scenes and a single coincident MODIS granule, has been explored to develop realistic proxy VIIRS fire observations. Although this offered multiple fire events to examine, the next step will include processing and evaluating a statistically robust sample of simulated VIIRS fire detections using nearly ~2500 ASTER scenes.

Additional work will include investigation of M15 saturation levels and the impact this may have on fire characterization, especially in light of the planned aggregation scheme in which a saturated pixel, when average among three pixels, may go unaccounted for.

Presentation

I. Csiszar, W. Schroeder, E. Ellicott, L. Giglio, C.O. Justice, *Towards an enhanced active fire product from VIIRS*, 6th Annual Symposium on Future National Operational Environmental Satellite Systems-NPOESS and GOES-R 2.1; January 21, 2010, Atlanta, Georgia, U.S.A.

Precipitation Climatology Using Q2

R. Boyles; (NOAA Collaborator: S. DelGreco) – OBOB_NCDC10

Background: Scientific problem, approach, proposed work

NOAA does not have an accurate long-term precipitation archive that has a high temporal and spatial resolution and addresses issues in the StageIV MPE product. NSSL has developed and is testing a 2nd generation QPE (called Q2) that provides 1km spatial resolution with 5min temporal resolution.

NOAA needs a central archive to for accurate, high-quality, precipitation information temporal and spatial resolutions to support local-scale climate analysis and climate monitoring. NSSL has recently agreed to develop a 3-year Q2 re-analysis in support of CI-FLOW and SECART. NCSU is working NSSL and NCDC to expand the Q2 reanalysis for provide a 10-year period of record. Year 1 of this project will focus on project initiation, transfer of technology from NSSL to NCDC, and preliminary development of the Q2 products from WSR-88D level 2 data over a pilot domain that includes the Carolinas.

Accomplishments

The leadership team has created a plan for project implementation along with K. Howard at National Severe Storms Lab. A research scientist, Mr. Scott Stevens, has been hired and began work on March 8, 2009.

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 developments in CRTM, emissivity model, and satellite data assimilation.

∆ CRTM developments:

(1) Developed and Implemented Visible/UV components in CRTM and a transmittance training package for assimilations of data from Visible/UV sensors.

(2) Implemented SSMIS Zeeman and SSU transmittance algorithms into CRTM version 2 under the MTAF.

(3) Extended CRTM for CrIS/ATMS-NPP, SSMIS on DMSP 17-20, AVHRR3, HIRS4, AMSUA, and MHS on NOAA-19, ABI on GOES-R, IMAGER and SOUNDER on GOES-14 for both ODPS and ODAS (Compact-OPTRAN), FY-3 IRAS, MWTS, MWHS, MWRI transmittance algorithms.

∆ Emissivity model/algorithm developments:

(1) Developed a multi-layer microwave canopy vegetation emissivity model, which includes a radiative transfer scheme for deriving microwave emissivity and reflectivity for a vertically stratified soil and vegetation boundary, and prepared JCSDA readiness for the new missions of SMOS and SMAP.

(2) Demonstrated the impact of the microwave desert emissivity empirical algorithm for AMSU-A data, which is revised based on the previously developed AMSU empirical emissivity algorithm.

∆ Microwave Satellite Data Assimilation developments:

(1) A new bias correction algorithm has been derived, which can result in a positive impact. This is because the current bias correction algorithm can remove scan beam position-dependent and air-mass dependent biases, but it cannot remove the region-dependent biases in F16 SSMIS UPP data (see Figure 1).

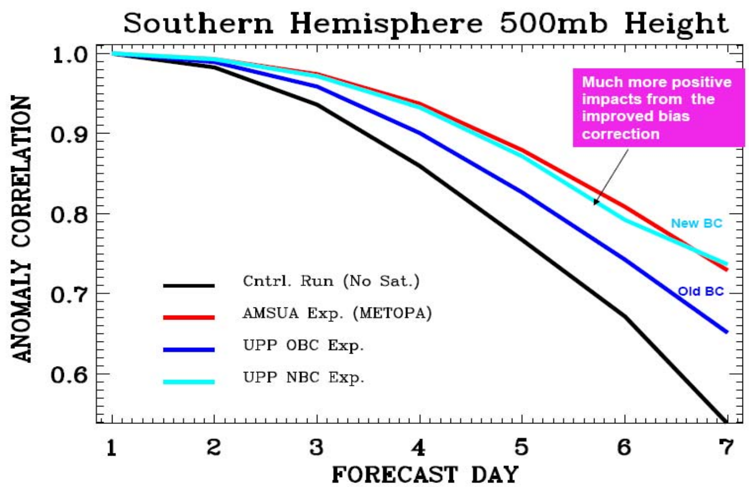


Figure 1. Anomaly correlations at 500 mb for several runs. 'AMSUA Exp.', 'UPP OBC Exp.'(using old bias correction algorithm) and 'UPP NBC Exp.' (using new bias correction).

(2) Improved assimilation impacts of AMSU-A/B and MHS water vapor sounding channels in GFS

Planned Work

(1) Improve CRTM computational efficiency for cloudy radiance assimilations by optimizing the number of radiative transfer streams and scattering interactions between layers.

(2) In collaboration with EMC, provide timely service for software maintenance including bug fixes and code upgrades, RTM module upgrades to incorporate model component upgrades, RTM database files (transmittance coefficients) upgrades to catch up the base model upgrades (i.e. the LBLRTM upgrades).

(3) Develop a microwave integrated land emissivity system for GPM precipitation retrievals and data assimilations

(4) Develop a parameterized scheme for computing surface snow optical parameters according to snow grain size and density based on Quasi-Crystalline Approximation (QCA)

(5) Continue to improve the two-layer microwave snow emissivity fast model with the parameterized snow optical calculation scheme from QCA calculations

(6) Assess the bias feature DMSP F17/F18 SSMIS measurements and develop the appropriate bias correction and quality control schemes for the SSMIS LAS channels. (B. Yan)

(7) Develop the bias correction and quality control schemes for the SSMIS data at water vapor channels. (B. Yan)

Presentations

Yan, B., F. Weng and J. Derber (2009a), Improvements in F16 SSMIS data assimilation into National Centers for Environmental Prediction global forecast system, *the 7th JCSDA annual workshop,* Baltimore, MD.

Yan, B., F. Weng and J. Derber (2009b), Impact of microwave land emissivity on satellite microwave data assimilation impact in NCEP Global Forecast System, *the 2nd Workshop on Remote Sensing and Modeling of Surface Properties,* Météo France,Toulouse.

Yan, B. and F. Weng (2010), Uses of Microwave Emissivity Data over Desert to Improve Assimilation of AMSU-A in NCEP Global Forecast System (GFS), submitted to *IEEE Trans Geos Remote Sens Special Issue.*

Management of the Climate Prediction Program for the Americas

A. Mariotti; (NOAA Collaborator: J. Huang) – AMAMMCPPA10

Background: Scientific Problem, Approach, 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.

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 is becoming 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 new 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 has participated to the Climate Change Science Program (now United States Global Change Research Program) inter-agencies meetings.

POES AMSU Monitoring at CICS/SCSB

P. Arkin; (NOAA Collaborator: H. Meng) – HMHM_AMSU10

Background: Scientific Problem, Approach, Proposed Work

Proper characterization of NOAA satellite sensors is crucial for the creation of Climate Data Records (CDR's). Currently, the set of sensors on board NOAA satellite were designed for "weather" applications, thus, much of the sensor calibration work is performed shortly after satellite launch and then the general health of the sensor is monitored during its operation, however, no attempt is made to retrospectively adjust the radiances as the sensor performance changes over time. Although NOAA does develop time series of products from its satellites, the proper treatment of the sensor changes has only recently been emerging as a priority area at NESDIS, and this task is one of the initial efforts to develop and sustain the characterization of the Advanced Microwave Sounding Unit (AMSU) and its impact on the production of hydrological products. In addition to the changes in characteristics over time, the AMSU sensors also suffer from failed channels caused by various reasons. Such events will interrupt the production of certain hydrological products that rely on the measurements from these channels. Algorithm adjustments are necessary in such cases to enable product continuity and maintain uninterrupted data record.

The NOAA-16 AMSU-A1 channel-4 (52.8 GHz) was declared unusable on March 26, 2008. Several AMSU algorithms use this channel including Rain Rate, Ice Water Path, Snowfall Detection, and Snow Cover. The failure of this channel has resulted in either compromised quality or complete loss of these AMSU operational products from NOAA-16. Channel-4 brightness temperature (Tb) is used in these algorithm to correct the limb effect in channel-5 (53.6 GHz) measurement. In lieu of channel-4, channel-6 (54.4 GHz) Tb is used to eliminate the limb effect in channel-5 Tb due to the affinity between the latter two highly-correlated channels: similar limb effect, being influenced by atmosphere and surface, etc.

The basic correction approach is to take the limb-corrected channel-5 Tb at nadir as the target value and use multivariate regression to establish the relationship between the limb-corrected channel-5 Tb and the Tbs of channel-5 and channel-6 at each scan angle. The target value is derived by applying the current limb-correction method to one-month of NOAA-16 data over land before channel-4 failed. The empirical equation takes the following form

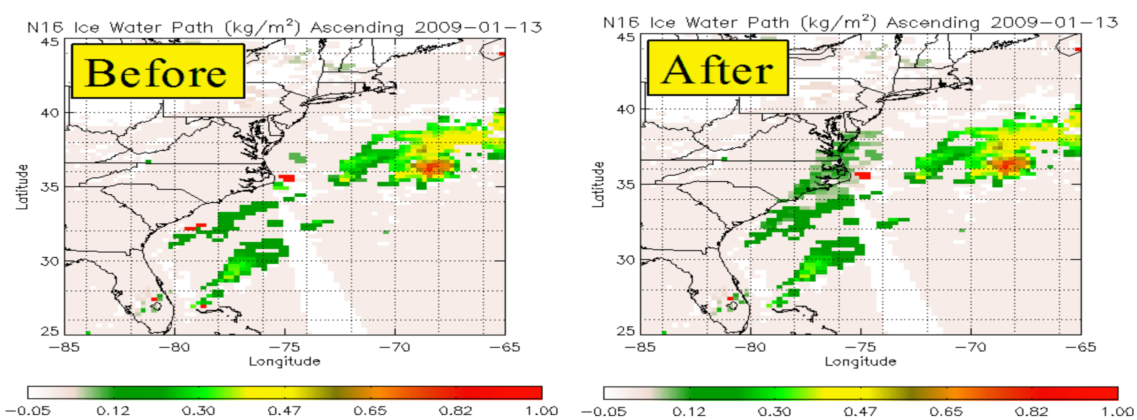
$$Tb_{5\_corrected\_i} = a_{0\_i} + a_{1\_i} Tb_5 + a_{2\_i} Tb_6$$

where i (i=1, 30) indicates the beam position; a_0, a_1, and a_2 are regression coefficients; Tb_5 and Tb_6 are respectively the brightness temperatures at channel-5 and channel-6.

Accomplishments

The new channel-5 limb correction approach compares favorably with the previous channel-4 based method. The latter still showed some residual limb effect in channel-5 Tb while the monthly averaged Tb corrected with the new scheme has minimal across scan variation with view angle. The AMSU products using the new correction approach also show good retrievals. Figure 1 compares the Ice Water Path (IWP) product before and after the new channel-5 limb correction is applied. The correction scheme allows the successful IWP retrievals along the coast.

Figure 1. NOAA-16 AMSU Ice Water Path (IWP) product images before and after the new channel-5 limb correction method is applied. No coastal IWP was retrieved before the correction due to the failed channel-4 which was used previously for channel-5 limb correction. The new channel-5 correction method uses channel-6 instead of channel-4. The new approach ensures that several NOAA-16 products are kept intact and the data record uninterrupted.



Planned Work

All AMSU-A instruments onboard of NOAA POES satellites and MetOp-A have cross scan asymmetry biases. Such bias has to be corrected to ensure the quality of the retrieved products. We plan to develop methods to correct the biases in AMSU-A window channels (21.8, 31.4, 50.3, and 89.0 GHz) from NOAA-15 and NOAA-16 for every year from 2000-2009. There are evidences that asymmetry patterns vary in time. This project will ensure the consistency of product quality and provide a good set of data for satellite climate study. NESDIS' Community Radiative Transfer Model (CRTM) will be employed to retrieve the brightness temperatures at the four frequencies. The differences between the CRTM retrievals and the observations at these frequencies will be used to characterize the asymmetric characteristics and develop correction equations.

AMSU-A window channels are strongly influenced by signals from the ground. Therefore, the plan is to do bias correction only over ocean due to the fact that CRTM (or other RTMs) is not capable of reliably estimating emissivity over land and hence brightness temperature. An outline of the required work follows: 1) collect

GDAS data from year 2000 to 2009 which will provide the temperature and vapor profiles for CRTM simulations; 2) configure CRTM for the four window channels depending on their different characteristics; 3) define the criteria for screening the four frequencies and apply the criteria to obtain a set of “clean” AMSU-A data; 4) simulate Tbs at the four frequencies using CRTM; 5) compare the CRTM retrievals with the “clean” observations, analyze the bias patterns at each channel and derive asymmetry correction equations; 6) derive the asymmetry correction equations for both NOAA-15 and NOAA-16 AMSU-A for every year from year 2000 to 2009.

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 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 – an amount of $15,000 is requested to enable successful completion of the project.

Accomplishments

This task funded Mathew Sapiano and Stephanie Uz to attend the 2010 AGU Ocean Sciences meeting in Portland Oregon from 22 to 26 February 2010. They presented a poster presentation entitled "Marine Phytoplankton Phenology Derived From Satellite Ocean Color Observations". Additionally, Stephanie Uz presented a poster presentation entitled "Detecting Emiliania huxleyi in 25 years of AVHRR remote-sensing reflectances".

A Prototype STAR Precipitation Product Validation Center

Daniel Vila, John Janowiak (NOAA Collaborators: Bob Kuliwoski, Limin Zhao) – DVDV_STAR10

Background: Scientific Problem, Approach, Proposed Work

The need for cal/val activities for satellite-based precipitation product has had only a modicum of support at NESDIS. At present, several precipitation products that are generated operationally by NESDIS (and originally by STAR algorithm developers) are routinely validated by one or more IPWG validation sites. Additionally, experimental algorithms are also validated. These products include SCaMPR, MIRS, MSPPS, GMSRA, GPROF and the HydroEstimator. We propose to regionalize the validation so as to provide evaluations 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. We will provide these enhancements for the U.S. and South America.

Accomplishments

Even though the IPWG validation effort produces statistics on continental-scale areas, they ingest and save the precipitation estimates and daily gauge analysis at 0.25o lat/lon for the U.S. (also radar estimates are saved over U.S.) and 0.5o lat/lon over the entire globe (Cheng et al, 2008) in near real time. Therefore, regionalization is not only possible, but maps of statistics 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 June-September 2008 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. Similarly, statistics other than those that are in the routine IPWG suite of validation products can be plotted and analyzed.

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. Among them the Heidke skill score over the U.S shows that the satellite techniques are superior to the model forecasts during the warm season (even the simple IR-based GPI), but the model clearly does better than most satellite techniques during the cold season.

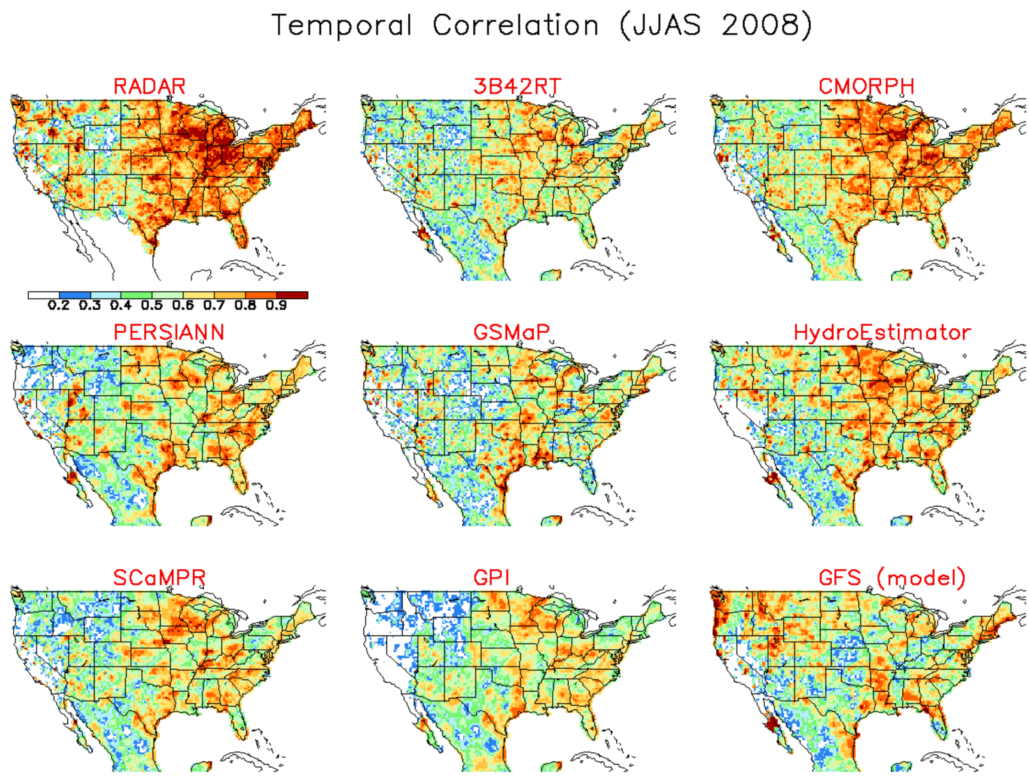


Figure 1. Temporal correlation of daily precipitation during June-September 2008 for various satellite-derived and numerical model forecasts with daily rain gauge analyses over the U.S.

Planned Work

We propose to provide a quarterly digest to STAR that evaluates precipitation algorithm performance over the U.S. and South America over a 1-year period. We envision this digest to be a concise summary and evaluation of algorithm performance that will have continuity with analyses of previous quarters. Each digest will begin with a one-page overarching synopsis to satisfy the needs of those that need only an overview, and will be followed by more detailed analyses and graphics as warranted. We will provide a set of standard products (to be determined with the input of STAR) but we will also provide new and different graphics, as needed, to illustrate the concepts that we have gleaned for the particular evaluation period that we are working on. After this initial 1-year effort, the NESDIS/PREPOP will assess the effectiveness of the analysis and information provided to determine whether the effort should be sustained, terminated, or handed over to a NESDIS operational unit.

Satellite Calibration and Validation (Cal/Val Efforts for Rainfall Estimates and POES-AMSU monitoring)

Daniel Vila; (NOAA Collaborator: Ingrid Guch) – DVDV_CALVAL11

Background

NOAA/NESDIS/Center for Satellite Applications and Research (STAR) is the lead NESDIS office for Satellite Calibration and Validation (Cal/Val). As part of this endeavor, a variety of projects are being addressed to insure both the quality of satellite radiance data sets and satellite derived products. Also included in STAR's Cal/Val effort is the WMO based Global Space-based Inter-Calibration System (GSICS), for which STAR is the international leader. During the past year, CICS has embarked on two projects that are contributing to STAR's Cal/Val effort. This proposal is for the continued support of two efforts - one to accurately characterize the asymmetric behavior of the AMSU-A sensor and one to validate the suite of STAR satellite-based precipitation products.

Task 1: A Prototype STAR Precipitation Product Validation Center

Among the ongoing research, the validation of instantaneous rainfall is being carried out over the U. S. using hourly mosaic radar data. Because data reference data are composed of near-continuous observations and therefore are truly representative of daily totals whereas “daily” satellite estimates are derived from ‘snapshots’ at just a handful of times during each day. For these situations it makes more sense to do “swath” validations so that the satellite estimates and the validating reference data match in time and space.

Furthermore, because precipitation is very discontinuous and evolves with time on the order of minutes, combined with the fact that it is impossible to always have exact time-space matchups between the satellite estimates and the validating ground reference data sets, it makes sense to ‘reward’ (or at least not penalize) the satellite estimates for ‘near misses’, i.e. cases when the satellite estimates clearly depict the pattern of precipitation but are displaced in space-time by a few pixels – which are likely due to unavoidable mis-matches between the satellite and in situ data. Such “blob” validation is an accepted practice in the numerical weather prediction modeling validation efforts and should be considered for this effort as well.

Task 2: POES AMSU Monitoring at CICS/SCSB

All AMSU-A instruments onboard of 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 hydrologic products such as total precipitable water and cloud liquid water. Uncorrected observations will lead to clear across scan biases in the retrieved products. Such bias was characterized and corrected soon after each POES satellite (and MetOp-A) was launched and was never analyzed again. However, our preliminary study has shown the time dependence in asymmetry pattern in the NOAA-15 AMSU-A channel-1 antenna temperature. It is therefore crucial that an asymmetry-free AMSU window channels data record is developed for generating consistent, high quality hydrologic products.

Precipitation Over Land in Support of NOAA's Climate and Prediction Program

Nai-Yu Wang; (NOAA Collaborator, R. Ferraro) – NWNW_NCPP10

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 3 Progress

A few key scientific questions addressed during the second 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?

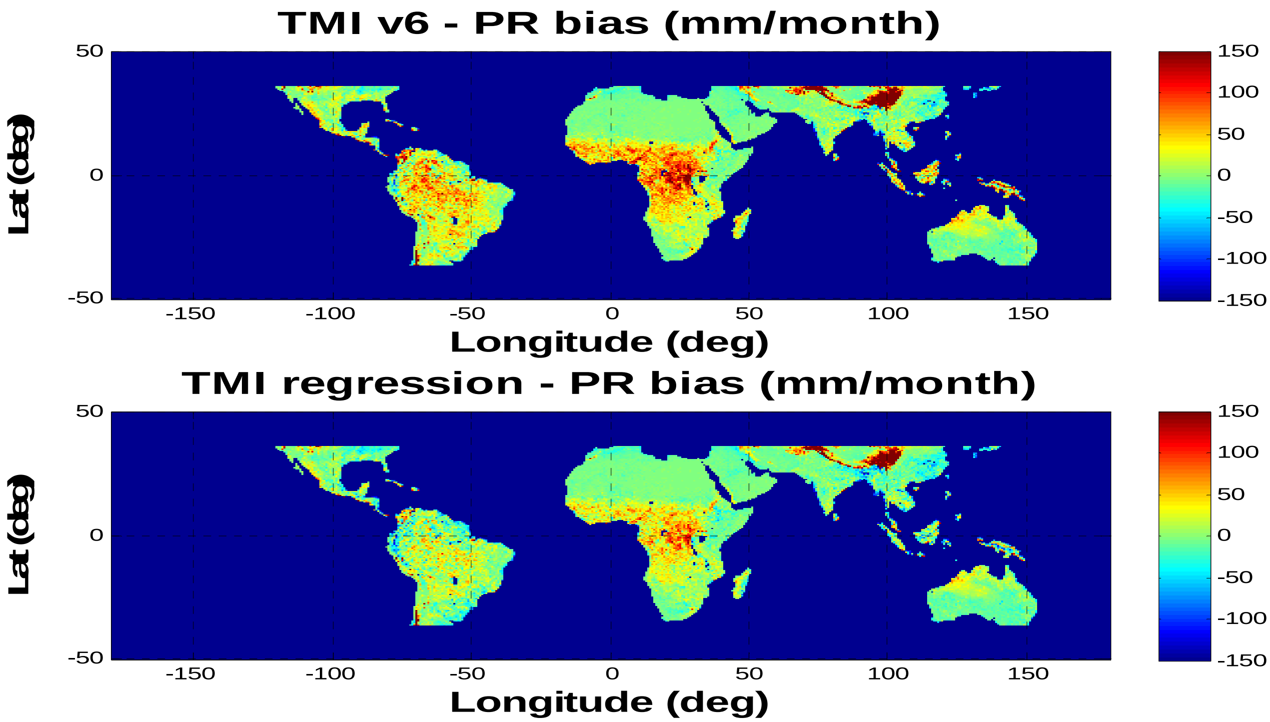
- What are the microphysical properties of snow (size, density, shape, and number) to radiative properties (scattering and absorption)?
- What is the best method to obtain information on the highly variable land surface emissivity under precipitating situations?

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

Improved TRMM 2A12 Rain Over Land

After the 2008 PMM Science Team meeting, the PI's were charged with finding a short-term solution to the current 2A12 rainfall over land warm season bias, which has been well documented and needed to be addressed in time for the next TRMM version (V7). As such, we agreed to solving this problem (without a total overhaul to the algorithm) delivering the algorithm/code by March 2009.

It was discovered that one of the main culprits in this bias is in the convective-stratiform (CSI) separation. Additionally, the TB to rain rate relationships were not robust. The new algorithm, created from nearly 10-years of TMI and PR matchups, abandons the cloud resolving model data base and simply uses an improved CSI and TB to RR relationship. It has been delivered to NASA where it is undergoing testing. The figure below summarizes the TMI – PR biases (current – top; new- bottom) based on the entire TRMM record. As can be seen, the warm season bias has been substantially reduced. Remaining biases are partially attributed to inadequate land surface screening which we are starting to address (next section). The results have been summarized in a paper by Gopolan et al. (2010).



Surface Characterization

At the July 2008 PMM Science Team meeting, a new working group was established – The Land Surface Characterization Working Group (LSWG). The LSWG has met (in person and over phone) three times since then and have devised a simple emissivity intercomparison effort. Radiances from TMI, AMSU, SSMI, SSMIS and AMSR-E were extracted for 10 target areas across the globe (of varying surface characteristics, e.g., snow, desert, rain forest, etc.). Additionally, cloud mask data, NWP model fields, and land surface model parameters have also be extracted for these targets.

The exercise is for each participant to retrieve emissivity for these targets and sensors and frequency ranges so that we can compare and see their similarities and differences.

Radiative Transfer in Snowing Atmospheres

Extensive work continues on using the C3VP field campaign data to extract precipitation related parameters in snowing atmospheres that are critical to radiative transfer modeling, in particular, to frequencies at and above 85 GHz. The figures below illustrate some of these parameters and summarize how this data is being used.

Development of a Seasonal Fire Danger Potential Prediction Capability Based on CFS and a Dynamic Vegetation Growth Model

Ning Zeng; (**NOAA collaborator:** Arun Kumar) – NZNZ_FIRE10

Introduction

In recent years, many advances have been made in the science and practice of seasonal climate predictions. For example, seasonal climate predictions have attained operational status and have come to rely increasingly more on dynamical prediction models. Such advances notwithstanding, application of seasonal climate outlooks to applications of societal importance has been slow to materialize.

The aim of this project is to develop one such application, i.e., a capability to forecast fire danger potential on seasonal time-scale. The development of an outlook capability for the fire danger potential will rely on several components that have evolved following independent pathways and have reached a state of maturity in their respective domains of interest. The key effort of this proposal will be bringing together these modeling and prediction component systems.

The modeling components of the proposed fire danger potential predictive capability include:

1. A dynamic Vegetation-Global-Atmosphere-Soil (VEGAS) model
2. Operational climate forecasts at the Climate Prediction Center and dynamical seasonal forecasts based on the Climate Forecast System (CFS) (both at NCEP)

Results and Accomplishments

We have conducted a 25-year hindcast experiment to explore the possibility of seasonal-interannual prediction of terrestrial ecosystem and the global carbon cycle. This has been achieved using a prototype forecasting system in which the dynamic vegetation and terrestrial carbon cycle model VEGAS was forced with the 15-member ensemble climate prediction and lead time up to 9 month from the NCEP/CFS climate forecast system. The results show that the predictability is dominated by the ENSO signal for its major infuence on the tropical and subtropical regions, including the Amazon, Indonesia, western US and central Asia. The hindcasted ecosystem variables and carbon flux show significantly slower decrease in skill compared to the climate forcing, partly due to the memories in land and vegetation processes that filter out the higher frequency noise and sustain the signal.

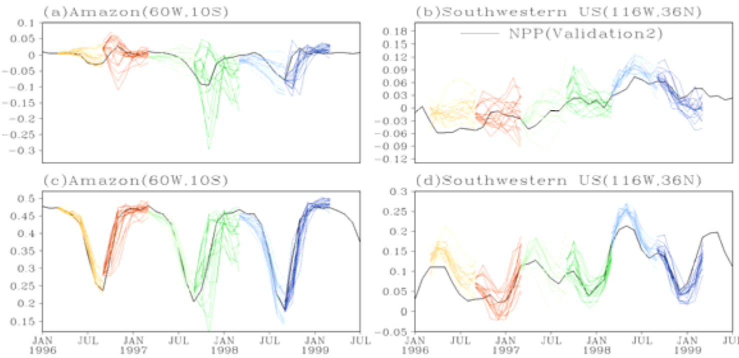


Figure 1. Example of of the CFS/VEGAS handcast: a time section of the predicted NPP anomalies kgC m^{-2} y^{-1} for two grid points, one over the Amazon, the other one southwestern US, compared to the validation (black line). Each line represents one individual member of a 15-member ensemble forecast. For clarity, the forecasts were 'thinned' to show only every 6 months and for a 6-month long forecast while the actual forecasts were monthly and 9 month long. The top two panels are for anomalies while the lower panels include seasonal cycle.From Zeng et al., (2008, GBC, the last in the pub list).

Publications

Qian, H.-F., R. Joseph, N. Zeng, 2009: Enhanced terrestrial carbon uptake in the northern high latitudes in the 21st century from the C4MIP model projections. *Global Change Biology*, in press.

Yoon, J.-H. and N. Zeng, 2009: An Atlantic influence on Amazon rainfall. Climate Dynamics accepted on 28 Feb 2009, doi:10.1007/s00382-009-0551-6.

Development of an Integrated System for Validating NCEP Model Cloud, Precipitation and Radiation Outputs Against Satellite Retrievals

Zhanqing Li; (NOAA Collaborator: Steve Lord) – ZLZLCLOUD10

Background: Scientific Problem, Approach

The main objective of this study is to evaluate a variety of variables forecasted by the NCEP Global Forecast System (GFS) against various satellite products derived from such sensors as MODIS, AIRS, CloudSat, and CALIPSO. Although clouds have a huge influence on the Earth's energy budget, weather, and climate, the clouds simulated by the model have not been systematically and rigorously evaluated. The global distributions of cloud variables and their seasonal variations have been compared with passive satellite retrievals, but they are concerned with the horizontal coverage of clouds. The A-Train satellite constellation now has active remote sensing instruments onboard the CloudSat and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) platforms, making it possible to determine cloud vertical structure with known atmospheric parameters. We have diagnosed cloud distributions of GFS model on global scales by focusing on the cloud vertical structure in the atmosphere to understand any fundamental drawbacks that may be attributed to cloud parameterization schemes. Also, we are attempting to gain further insights into the causes of the differences by examining meteorological variables such as temperature and relative humidity profiles.

Accomplishments

In light of the 3D nature of clouds, a new concept called Cloud Vertical Fraction (CVF) is introduced to examine a more detailed cloud vertical structure. The CVF is based on the effective cloud thickness within various cloud categories (*e.g.,* high, middle, and low clouds). In general, the CVF of the GFS model follows the pattern of cloud horizontal distribution, but with larger disagreements against satellite measurements. GFS model results are most compatible with observation for middle clouds, but high clouds and low clouds are underestimated. In particular, we focused more on the lowest a single cloud layer (LSC) regardless of the presence of overlapped high clouds. The main feature of the zonal-mean LSC distribution is that CloudSat-CALIPSO (C-C) data show much lower cloud height of the LSC against GFS model results. Mean top height of the LSC in the C-C data varies between 1 km and 2 km whereas the GFS result displays from 3 km to 5 km in the Southern Hemisphere.

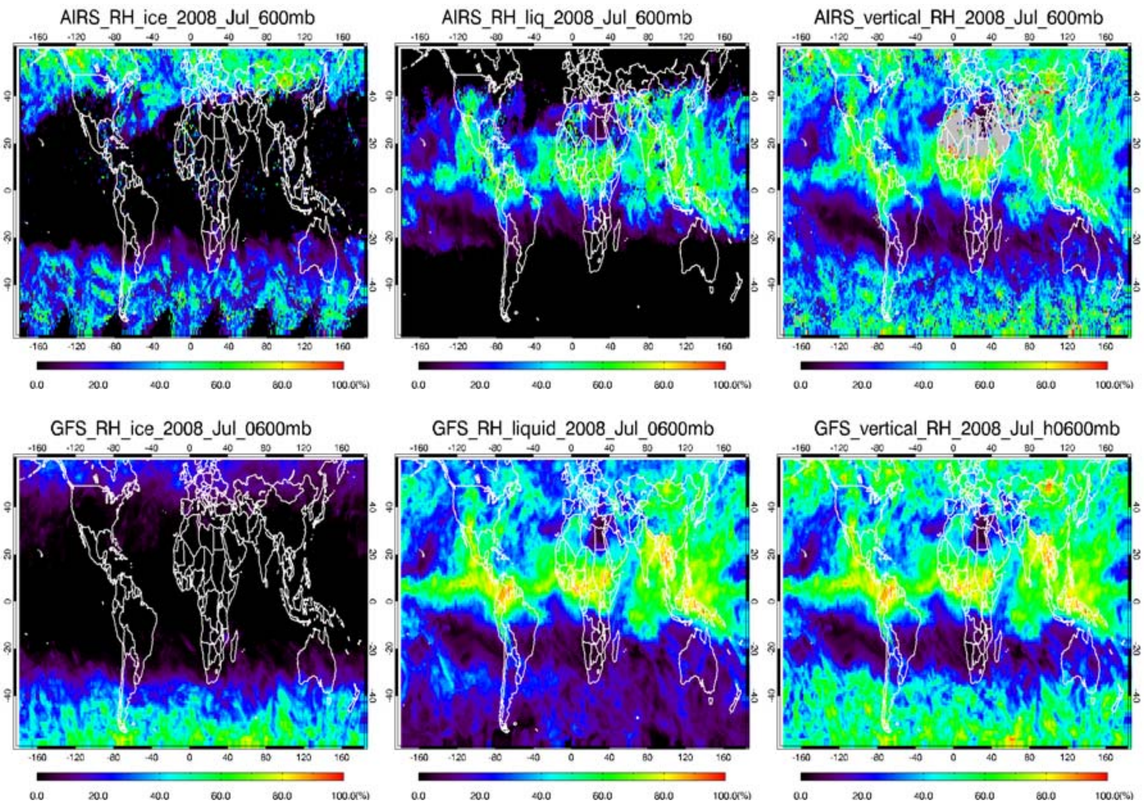


Figure 1. Comparisons of the monthly mean relative humidity field at 600 mb in July of 2008: (Top left) AIRS RH with respect to ice, (Top middle) AIRS RH with respect to liquid water, (Top right) AIRS total RH, (Bottom left) GFS RH with respect to ice, (Bottom middle) GFS RH with respect to liquid water, and (Bottom right) GFS total RH.

Ongoing and Future work

We are now investigating into the causes of errors in modeled clouds by comparing both cloud variables and associated meteorological parameters. The GFS temperature tends to be overestimated compared with satellite retrievals with smaller values of root mean square error (RMSE), implying less variability. The near-global RMSE of the mean temperature at 150 mb, 500 mb, and 1000 mb in July of 2008 are 1.22, 1.35, and 4.77, respectively. Relative Humidity (RH) is also analyzed with respect to ice and water phase (Figure 1). As shown in the Figure 1, the discrepancies between satellite observation and modeling in RH are likely due to the following two reasons; 1) contamination from undetected low clouds resulting in dryer conditions in the AIRS observation, and 2) insufficient transport of vertical moisture by the model.

We plan to continue the studies with more quantitative and detailed analyses that may yield an useful insight into modeling problem. First, we will move from overall studies on the global and monthly mean scales to case oriented and regional analyses using instantaneous satellite products. Since certain cloud types are normally associated with some specific geographic regions, it is essential to select such cloud regimes as storm tracks, marine stratus, and tropical convective cloud regimes for close-up investigations. In addition, it is necessary to separate them over land and ocean areas to examine any special features in detail. This work entails the use of more extensive and higher quality satellite data. Second, a more detailed examination of meteorological variables will be carried out to yield clues and lay foundation for model improvement. Clouds from GFS model generally capture reasonably well the patterns in some areas (or at some levels) while poorly in other places. To evaluate the capabilities of model forecasting, we will explore some case studies that model produces reasonable atmospheric conditions however predicted clouds largely off the track. Then the further analysis may give us refined information and insightful ideas to guide tuning cloud formulation, leading to more reasonable cloud optical properties.

Real-time Automatic Estimation of Volcanic SO2 and Ash Cloud Heights Derived from OMI/AIRS Observations and Atmospheric Modeling and Near Real-Time NASA Volcanic Cloud Data for NOAA, FAA and USGS Decision Support Systems

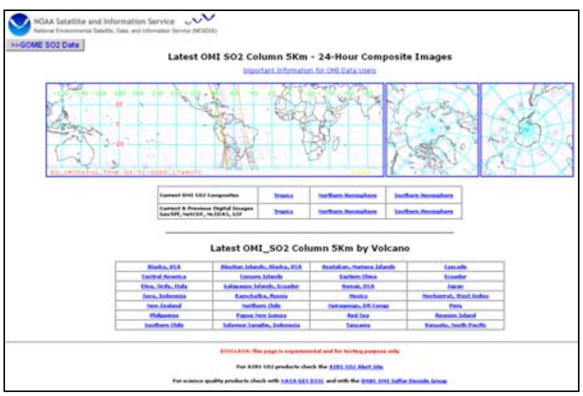
E. Hughes and W. Schroeder; (NOAA Collaborators: G. Vicente, G. Serafino, A. Irving) – PAPA_VOLC10

Background

This project is composed of two inter-related tasks aimed to: (i) implement an operational near-real time volcanic cloud detection and monitoring system and (ii) derive volcanic cloud heights using an iterative scheme based on atmospheric transport model data and SO2/ash data derived from spaceborne instruments.

Accomplishments

A web-site has been implemented for displaying near-real time volcanic SO2 and ash data (Fig. 1; URLs 1-3). Currently, volcanic SO2 and ash data derived from the Ozone Monitoring Instrument (OMI), the Global Ozone Monitoring Experiment (GOME-2), and the Atmospheric Infrared Sounder (AIRS) L1B data are being displayed. An alert system was developed for the OMI instrument data, generating automated messages for high SO2 concentration areas detected around the globe (Fig. 1).



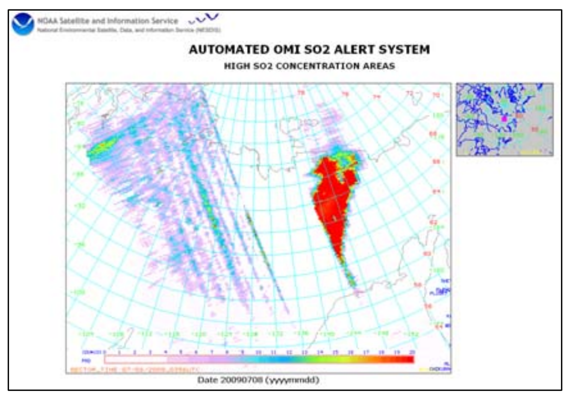


Fig 1: NOAA/NESDIS OMI volcanic SO2 and ash monitoring portal (left panel) and OMI automated SO2 alert system output (right panel).

A volcanic ash dispersion model (PUFF) was implemented at NOAA/NESDIS using 1×1º Global Forecast System (GFS) input data. The model is being used to generate multiple simulations of volcanic emissions transport, where the injection height of the volcanic cloud is varied for each simulation. Height estimates of the observed cloud are found by means of an iterative scheme that searches for the best possible simulation output; comparing the model output to the observed horizontal plume distribution data derived from OMI and GOME-2 following an eruption. The system implementation provides quick and efficient turnaround of volcanic cloud height information with minimum user input.

Product Testing

The assessment of PUFF volcanic plume transport modeling is being performed using data derived from previous eruptions captured by the OMI instrument. Figure 2 shows the simulation of the 2008 eruption of the Kasatochi volcano which started on 07 August 2008 at 2300UTC. Approximately 26 hours later (09 August 01:00UTC), the OMI instrument imaged the area generating the Sulfur Dioxide (SO2) product displayed on Figure 2a. Using the actual eruption time to initialize PUFF, multiple ~24h model runs were generated using different plume entrainment height scenarios (wind fields will vary with altitude resulting in different plume trajectories). Using statistical analysis to compare the volcanic cloud morphology generated by the different 24h model runs to the near coincident OMI/SO2 data, we could estimate the plume injection height at 10,000m. Comparisons with other studies of this eruption [Kai et. al, *under review*] have shown agreement with this result. Routines have been developed to use the plume injection height estimate from the PUFF simulations to forecast the location of the SO2 cloud, but this has not yet been preformed for this case.

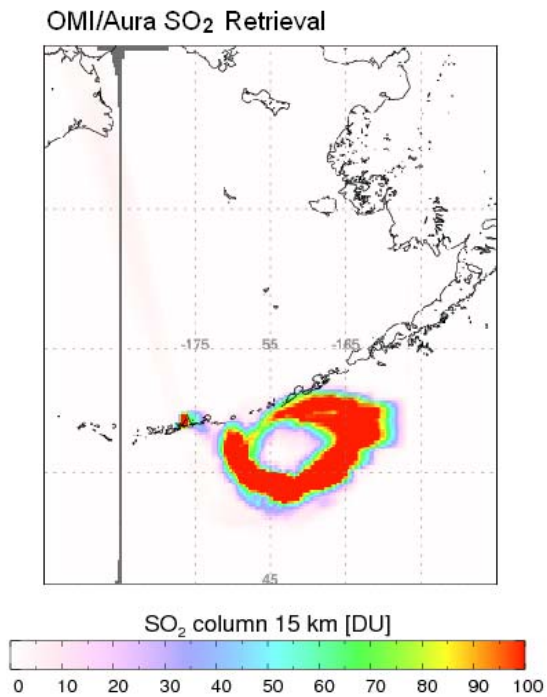


Fig 2: Mount Kasatachi volcanic eruption data derived from OMI Sulfur dioxide (SO2) and PUFF model simulations; (a) OMI/SO2 data acquired on 08/08/09 01:00UTC; (b) PUFF 24h simulation (08/08/09 01:00UTC) using 10,000m plume injection height estimate.

Planned Work

Much of the experimental code to perform these tasks has been successfully developed, yet work is needed to prepare the code to meet operational implementation standards. The automatic height estimation technique will also need to undergo several other case studies to show it's applicability to various types of volcanic eruptions and confirm its accuracy. This project will eventually begin to shift its focus from of volcanic SO2 height estimation toward height estimates of ash.

A web interface is being developed which will allow users to specify volcano parameters and visualize model outputs shortly after a major eruption is identified by the alert system depicted in Figure 1. This system is expected to provide important information for the Volcano Ash Advisory Centers (VAACs) in support of general aviation operations.

Publications

Krueger, A., N. Krotkov, K. Yang, S. Carn, G. Vicente, W. Schroeder ."Applications of Satellite-based Sulfur Dioxide Monitoring." (2009). *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 2(4), 293-298.

Yang, Kai, Xiong Liu, Pawan K. Bhartia, Nickolay A. Krotkov, Simon A. Carn, Arlin J. Krueger, Eric Huges, Robert J.D. Spurr, and S. G. Trahan. 2010: "Direct Retrieval of Sulfur Dioxide Amount and Altitude from Spaceborne Hyper-spectral UV Measurements: Theory and Application." (Under Review). *J. Geophysical Research*.

URL Links from the text

1. http://satepsanone.nesdis.noaa.gov/pub/OMI/OMISO2/index.html
2. http://satepsanone.nesdis.noaa.gov/pub/GOME/GOMESO2/index.html
3. http://satepsanone.nesdis.noaa.gov/pub/OMI/OMISO2/Alert/alert.html

Calibration/Validation for the VIIRS Cloud Mask Over Land Surfaces

E. Vermote; (NOAA Collaborator: Jeff Privette) – EVEVVIIRS10

Background: Scientific Problem, Approach

The overall objective of this proposal is to develop the methodology for the validation of the VIIRS cloud mask over land surfaces, a critical step for the successful production of downstream land product (e.g. surface reflectance, vegetation indices and albedo). The approach is to use the MODIS and AVHRR data record in the pre-launch phase to test and validate the techniques that will be used post-launch for VIIRS. We will use three complementary approaches for the cloud mask validation:

Using time series of surface reflectance corrected for BRDF effect (Vermote et al., 2009), and analyzing noise will enable to detect case of leakage (or omission of clouds).

Analysis of the percentage of detected clouds over specific area and comparison to MODIS climatology of those percentages will point to commission error (or labeling clear area as cloud).

One to one comparison of near coincident (in time) MODIS Aqua and VIIRS cloud masks (this has been used to evaluate AVHRR CLAVR cloud mask on NOAA16)

Planned Work

In the first phase of the project we will:

- Prototype the time series analysis using MODIS CMG data, in particular establish the performances of the technique for both omission and commission error
- Prototype the near-coincident technique using AVHRR and MODIS Aqua data
- Application of the technique to the VIIRS proxy data produced by the Land PEATE System, including documentation of problems and communication with the VCM team

Publication

Vermote, E., C. O. Justice, et al. (2009). "Towards a Generalized Approach for Correction of the BRDF Effect in MODIS Directional Reflectances." IEEE Transactions on Geoscience and Remote Sensing 47(3): 898-908.

South Asian Regional Reanalysis

Sumant Nigam; (NOAA Collaborator: Chet Ropelewski) – NSNS_SARR10

Project completed - final report provided to NOAA Climate Program Office.

Development of Operational Algorithm & Software to Validate Snow Cover Product from NPP VIIRS

P. Romanov; NOAA Collaborator: Igor Appel – PRPR_VIIR10

Background: Scientific Problem, Approach

The Binary Snow Cover and the Snow Cover Fraction are among the suite of land surface products which will be derived from observations of the 22-band Visible/Infrared Imager/Radiometer Suite (VIIRS) onboard the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) (launch expected in 2011) and afternoon overpass NPOESS platforms (launches expected in 2014 and 2021).

The objective of this consists in the development of algorithms and software to routinely validate the snow cover products derived from VIIRS instrument data onboard NPOESS. This report describes our activities during the first year of the project implementation. The work during this period was concentrated on the following three tasks: (1) Development of tools, algorithms and codes to acquire simulated VIIRS data from NPP-Land PEATE, (2) Development of tools to acquire observations of snow depth at ground-based meteorological stations, and (3) Development of approaches and tools compare and validate snow retrievals from VIIRS with surface observation data.

Accomplishments

As the first step towards comprehensive assessment and validation of VIIRS snow cover products, we have accessed, downloaded and examined VIIRS Binary Snow Cover maps for the Global Test period of 07/12/2003 – 07/27/2003. The product is posted on PEATE website in the form of tiles. It was found that quality of current snow maps is unacceptable. There is a lot of false snow cover identifications in the equatorial and tropical area where snow cover is never observed. Most false snow identifications apparently occur due to inaccurate cloud masking.

In situ observations of snow cover at ground-based meteorological stations will be the primary source of information for future validation of VIIRS snow cover maps. To access the accuracy of VIIRS snow retrievals we will rely primarily on operational daily reports of the depth of snow on the ground from first-order (WMO) meteorological stations and from US Cooperative Network Stations. The number of daily reports of snow depth varies with season and depends on the areal extent of the snow cover. In the peak of the Northern Hemisphere winter season, NOAA/NESDIS typically receives about 2000 valid daily snow depth reports.

A special tool has been developed to match snow cover data in gridded satellite-derived snow maps to surface observation data and calculate the statistics of correspondence of the two datasets. However at this time this tool is not yet needed due to very poor quality of the VIIRS product. Fig.1 presents the location of ground based stations which will be used in routine validation of the future VIIRS NPOESS snow maps.

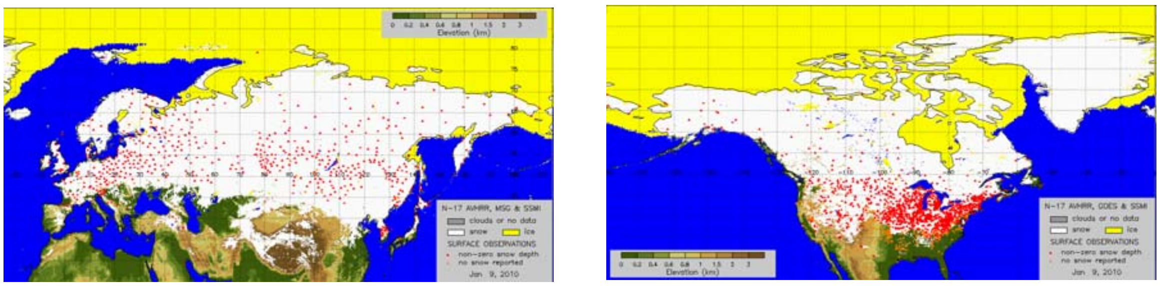


Figure 1. Spatial distribution of stations operationally reporting snow depth in North America and in Eurasia. Pictures include both WMO and US Cooperative network stations.

Future Work

The work to develop tools for routine validation of the future VIIRS snow cover product has been carried out in accordance with the approved schedule. We have started evaluating the snow cover product derived from VIIRS proxy data. Algorithms and tools to acquire in situ snow depth data for the snow product validation are available and are routinely used to get snow depth reports from first-order and US Cooperative network stations. Preliminary qualitative evaluation of VIIRS binary snow cover maps has revealed their poor quality. Therefore direct comparison of VIIRS snow product with surface observations of snow cover has been postponed till at least some problems in VIIRS snow map generation (e.g., accurate cloud identification, application of proper land/water mask) are fixed.

The future work will include the development of the technique, algorithms and software to validate VIIRS snow cover maps with NOAA interactive snow/ice charts generated within Interactive Multisensor Snow and Ice Mapping System (IMS).

Satellite Data Support for Hydrologic and Water Resource Planning and Management

S. Sorooshian, K. Hsu, X. Gao, B. Imam, A. AghaKouchak; (NOAA Collaborator: John Bates)

Background: Scientific Problem, Approach

Precipitation estimation with high spatial and temporal resolution is crucial for climate studies, engineering design, verification of regional numerical weather models and environmental applications especially hydrologic processes. Currently, applicability of satellite precipitation products to climate studies and hydrologic applications is limited due to factors such as limitation on record length, and lack of quantitative information about uncertainties in satellite precipitation at the required spatial and temporal scales. This study 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 four different thematic areas:

I. Characterization of sub-daily variability of precipitation under climate change;

II. Continue and expand research towards quantitative error and uncertainty analysis of satellite based precipitation estimation in comparisons with gauges and NEXRAD data;

III. Assessment of nonstationarity in extreme precipitation data and spatiotemporal framework to improve regional characterization of return periods with various duration and area extent.

Accomplishments

A significant progress is made toward preparing a White Paper that provides a framework for future research in application of satellite-based precipitation products in hydrometeorological applications. Furthermore, a meeting at the NCDC is scheduled for April 6-7, 2010 to discuss the progress of the work and research scope. As mentioned above, one of the objectives of this study is to use satellite data to support extreme precipitation analysis. In order to validate satellite-based precipitation products with respect to extremes, different satellite-derived precipitation patterns are compared to the Stage II radar-based gauge-adjusted precipitation pattern. Figures 1(a) to 1(c) show three satellite images, occurred on 9/24/05 at 9:00 UTC, with a spatial resolution of 0.25^{o} (1(a): TRMM 3B42; 1(b): CMORPH; 1(c): PERSIANN). Notice that in Figures 1(a) to 1(c), only values above 50 percentile threshold are considered in order to avoid unreliable small rainfall rates. Figure 1(d) displays the corresponding Stage II image. The Stage II data, provide estimates of precipitation using a combination of radar and rain gauge measurements. The data is available on the Hydrologic Rainfall Analysis Project

(HRAP) grid, with a spatial resolution of approximately 4km. The Stage II data are aggregated in space to match the spatial resolution of the TRMM, CMORPH and PERSIANN data (0.25°). Figures 1(e) to 1(h) and 1(i) to 1(l) present similar figures for precipitation values exceeding 75 percentile and 90 percentile, respectively. One can see that satellite products may identify patterns of extreme events significantly differently. Currently, various statistical and geometrical measures are being developed to evaluate extreme precipitation patterns in order to integrate this concept into practical applications.

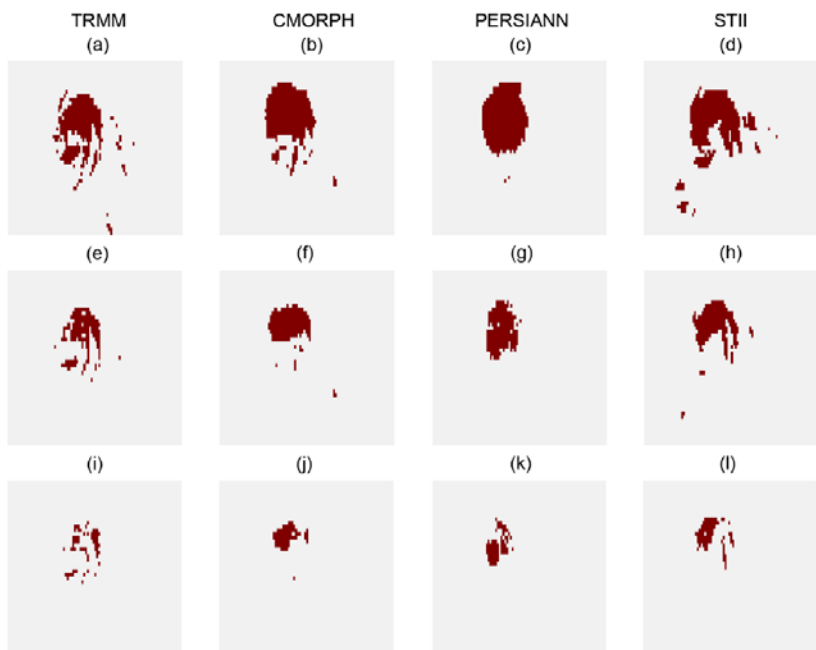


Figure 1: TRMM, CMORPH, PERSIANN and Stage II precipitation patterns for rainfall rates above: 50 percentile ((a)-(d)); 75 percentile ((e-h)); 90 percentile ((i)-(l)).

Planned Work

In addition to data collection and quality control, the planned work involves the following tasks:

(a) Using local gauge/radar measurement to adjust multi-satellite precipitation estimation and extend the precipitation measurements to un-gauged regions using bias corrected satellite data.

(b) Extreme precipitation analysis by examining the trend of extreme storm events at each climate region based on precipitation intensity and frequency (e.g. the annual extreme event, N-largest, peaks over thresholds, % of historical data).

(c) Identify presence of nonstationary in extreme precipitation data.

(d) Validation of satellite precipitation estimates for 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, which may result in significant advancements in data assimilation techniques and ensemble generation.

(e) Analysis of multivariate probability distribution of precipitation extremes using advanced statistical techniques (e.g., copulas) at locations where reliable ground reference measurements exist.

(f) 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.

(g) Utilization of extreme events 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.

Publications & Presentations

A. AghaKouchak, B. Imam, K. Hsu, A. Behrangi, X. Gao, S. Sorooshian, Verification of Extreme Precipitation Events Using Satellite-Based Remotely Sensed Data. Abstract submitted to the Hydrology Conference, San Diego, October 11-13, 2010.

Amir AghaKouchak, Nasrin Nasrollahi, Bisher Imam, Soroosh Sorooshian, 2010: Geometrical Characterization of Precipitation Patterns, Journal of Hydrometeorology, under review.

NPP/VIIRS Land Product Validation Research

P. Arkin, C. Justice, A. Lyapustin, A. Huete, C. Schaaf, M. Friedl (NOAA Collaborator: Jeff Privette) PACJ_LAND10

Background: Scientific Problem, Approach
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 on-going 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 Surface Albedo, Vegetation Index and Surface Reflectance, Active Fires and Surface Type.

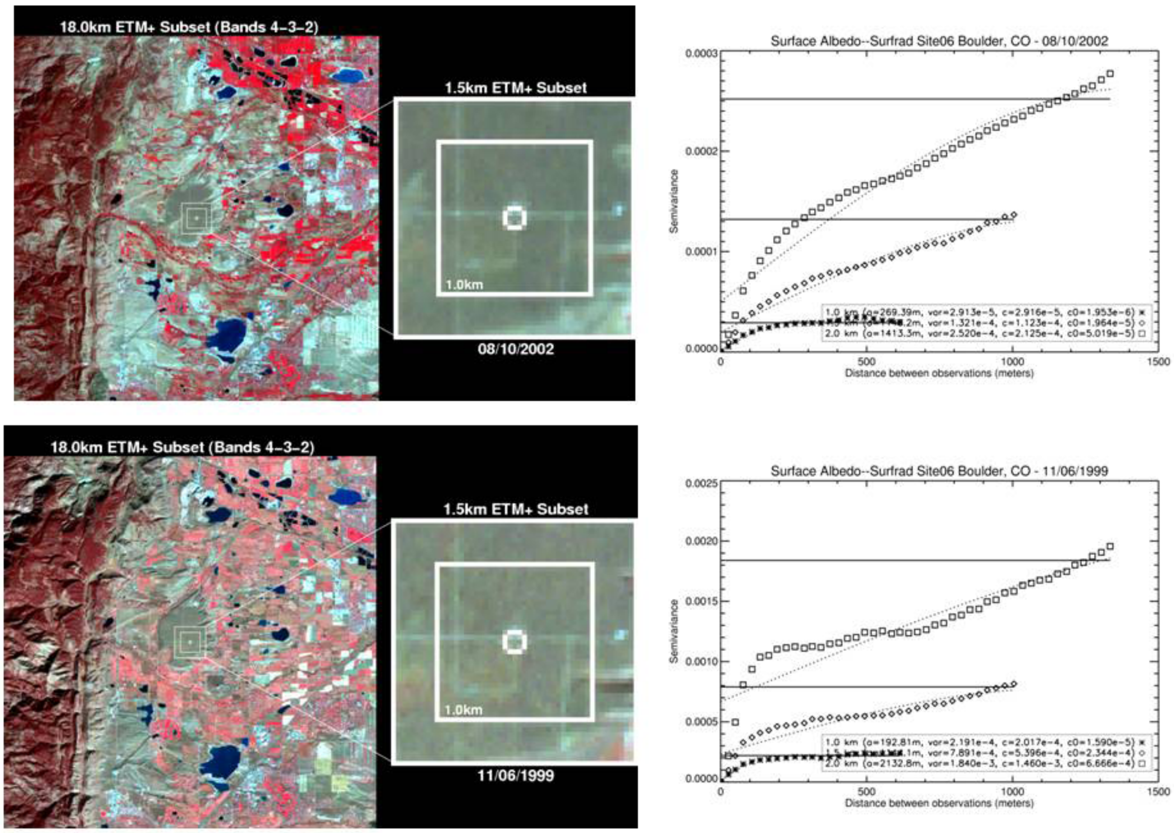
Accomplishments
- The AERONET-based Surface Reflectance Validation Network (ASRVN) is an operational data collection and processing system designed for global validation of Surface Reflectance from multiple sensors. In this period of performance: 1) the ASRVN product suite was expanded with surface reflectance and NDVI generated in the swath format which enables direct comparison with operational VIIRS products. 2) The ASRVN spectral surface reflectance was compared with results of operational MODIS atmospheric correction (MOD09) and showed that uncompensated atmospheric scattering caused by Lambertian model systematically biases the results. The magnitude of biases grows with the amount of scattering in the atmosphere, i.e. at higher aerosol concentration, at shorter wavelengths and at larger sun and view zenith angles. The slope of regression of Lambertian surface reflectance vs ASRVN bidirectional reflectance factor was found to be ~0.85 in the red and ~0.6 in the green bands.

- A comparitive analysis of the ASRVN surface reflectance with ground measurements was initiated with Dr. Czapla-Myers (University of Arizona) and Dr. Thome (GSFC). An initial comparison of data for the Railroad Valley site shows a good agreement.

- Optimization of the ASVRN dataset for Vegetation Index (VI) validation and uncertainty characterization was completed. 40 sites were deemed useful for daily VI analysis over a range of aerosol and sun-sensor view geometries.

- Multi-sensor spectral bandpass dependencies of the enhanced vegetation index (EVI), a 2-band EVI (EVI2), and the normalized difference vegetation index (NDVI) were investigated using spectrally convolved Earth Observing-1 (EO-1) Hyperion satellite images acquired over a range of vegetation conditions. Two types of analysis were carried out, including (1) empirical relationships among sensor reflectances and VIs and (2) decomposition of bandpass contributions to observed cross-sensor VI differences. VI differences were a function of cross-sensor bandpass disparities and the integrative manner in which bandpass differences in red, near-infrared (NIR), and blue reflectances combined to influence a VI. Disparities in blue bandpasses were the primary cause of EVI differences between the Moderate Resolution Imaging Spectroradiometer (MODIS) and other course resolution sensors, including the upcoming Visible Infrared Imager / Radiometer Suite (VIIRS). The highest compatibility was between VIIRS and MODIS EVI2 while AVHRR NDVI and EVI2 were the least compatible to MODIS.

- Validation of the VIIRS Albedo Product will rely on comparison of satellite-derived albedo products and in situ albedometer measurements collected at various tower networks sites. Questions arise regarding the representativeness of each site with respect to moderate resolution satellite pixels. A geostatistical framework that relies on high resolution satellite imagery (primarily Landsat ETM+) is being used to assess the representativeness of each site for the NPP/VIIRS Albedo product. To date, fifty six sites have been assessed under both leaf-on and leaf-off conditions. An assessment of ideal tower height to achieve representativeness has also been performed (to identify those sites where a modest increase in tower height would be sufficient to change a site from being spatially unrepresentative to one that would be of use for validation of satellite albedo products. ASTER imagery was utilized for a limited number of these sites to assess the representativeness of the site with regards to satellite brightness temperature. Work continues on capturing the seasonal variation and extending the analysis to additional tower sites.



SURFRAD Boulder site indicating the spatial uniformity at 1km (Yang et al 2010)

- In support of the NPP Surface Type EDR validation, a global land cover validation data set using a formal probability sample design is being developed, that includes 500 25 km2 sites, stratified by climate, geography, and population density. At each site high-resolution imagery (< 4m) are being acquired. A draft document describing the sampling design has been written and is currently undergoing review and revision. Current activities are focused on (1) acquisition of high resolution imagery for a subset of the 500 validation sites; (2) developing protocols for classifying land cover at each site; and (3) developing methods for aggregating the high spatial resolution classifications at each validation site to the spatial resolution of the surface type EDR. This database will be maintained on an operational basis and will provide the basis for validating the surface type EDR, including reliable estimates for standard errors for overall and class specific accuracies.

- In support of the VIIRS Active Fire ARP, an automated method was developed and tested for co-registering and validating coarse resolution with high resolution active fire data (MODIS and ASTER). Procedures were also developed for reporting accuracy results. Planning is underway with NASA AMES to acquire UAV data to prototype VIIRS active fire validation.

Planned Work

Albedo

i) Conduct site characterization and scaling studies on SurfRad and 20 CRN, ii) Conduct hypothetical site characterizations assuming CRN or SurfRad tower extensions, iii) Conduct site characterization and scaling studies on additional CRN sites and address characaterization across four seasons, iv) Perform comparisons between site data and MODIS heritage results.

Vegetation Index

i) Adapt ASRVN codes to work with VIIRS, ii) Develop ASRVN-VIIRS EVI and BRF

iii) Evaluate ASRVN-VIIRS performance with Proxy VIIRS Data, iv) Develop operational ingest and processing codes for BSRN, v) Develop BSRN-based spectral reflectance product and feasibility of BSRN-based VI Product. vi) Evaluate BSRN reflectance performance with Proxy VIIRS Data

Land Surface Type

i) Development and implementation of a global stratification to support sampling and selection of validation sites. ii) Identification of site locations, development of a protocol for site definition, and acquisition of imagery.

Fire

i) Case studies using previously collected airborne imagery, ii) Secondary active fire validation: testing and development using CEOS/EOS burned area validation database iii) FRP validation: evaluating Landsat-class and airborne.

Publications & Presentations

Kim, Y., Huete, A.R., Miura, T., Jiang, Z., Spectral compatibility of vegetation indices across sensors: A band decomposition analysis with Hyperion data, *Journal of Applied Remote Sensing, 2010* (in press).

Yang, X., Schaaf, C. & Román, M.O. (2010). Geostatistical Analysis of Validation Sites for Assessment of Moderate Resolution Satellite-Derived Albedo and Thermal Products. Geostatistics. (in press)

Zhangyan Jiang, Alfredo Huete, Yujie Wang, Alexei Lyapustin. 2010. Evaluation of uncertainties of MODIS VI products using the AERONET-based Surface Reflectance Validation Network dataset. Presented at PIERS 2010 Conference in Xi-an, China, March 22-26 2010.

Visible/Infrared Imager Radiometer Suite (VIIRS) and the Associated Environmental Data Records for Land Science. Chapter 4. EDR Land Validation and additional needs for Science Product Validation 28-35. GSFC.

The Chesapeake Bay Forecast System

R. Murtugudde; (NOAA Collaborator: E. Locklear) ASEIP-CBFS

Background:

The goal of the CBFS is to develop an end-to-end, expert forecast system for the Chesapeake Bay to provide scientific and socio-economic foundation for management and policy decision applications on the state and health of the Chesapeake Bay and its watershed including the regional climate variability and associated oceanic and terrestrial environments at seasonal to decadal time-scales.

The Chesapeake Bay is experiencing and will continue to undergo climate and environmental change over the next 50 years. A paramount question facing decision makers in the region is how to prepare and adapt to the certainty of change in the coming decades. In response to this information need, the Earth System Science Interdisciplinary Center (ESSIC) is leading the Chesapeake Bay Forecast System project based on a regional Earth System model. This expert decision-support tool will provide integrated Earth System analyses and prediction capabilities for the Chesapeake Bay and its watershed with products designed to address user needs at time scales from days to decades. Such a system will allow users to access existing observations and predictions to obtain outcomes and scenarios based on user-defined "if-then" queries that take into account future changes in climate (temperature, sea level, rainfall), demographics, water resources, run off, point and distributed nutrient/contaminant loading from agriculture/farms/urban centers, sea level rise, severe storms, land use change, harmful algal blooms and human pathogens, low-impact developments, reforestation, etc. The Chesapeake Bay Forecast System would provide decision support to enable policy makers, urban development planners, natural resource managers and planners, as well as a variety of private users, to base their decisions on a convenient information system that provides a synthesis of the state of their concerned environment as well as predicted future changes. Catchment level vegetation and crop-models capable of predicting runoff and nutrient loading will be coupled to the Bay ecosystem from algae to sea grasses to mid-trophic and top predators to continuously monitor the health of the Bay and its watershed including human interactions and aerial depositions due to human activities.

This prototype regional demonstration project addresses the global issue of providing meaningful and practical observational and forecasting capabilities while working closely with the "user" community. It will provide a proof of concept and demonstration of the coupling of atmospheric, hydrologic, oceanic, and ecosystem models and observations and their interactions with society, for quantifying the prediction of the relevant components of the Earth System. Almost important impacts of global change will be local and this system will deliver a dynamic downscaling system that will be modular and can be adapted to any part of the U.S. or World.

The Chesapeake Bay, including its watershed, is an ideal test bed for such a project. Seven states are in its watershed and this, the largest estuary of the US, is one of the most studied and yet not fully understood in terms of its ecosystem services, expected sea level change, response to human activities, and actions needed for its sustainable use. Therefore, tremendous interest exists in the health and well being of the bay and its environments as well as its influence on the surrounding land and urban areas. As a result, numerous ongoing operational and scientific programs exist that closely monitor different aspects of the Bay, providing data and experience as well as a number of predictive models.

Under the leadership of UMCP through ESSIC, the Bay will be used as a test-bed to demonstrate ongoing capabilities for observing and predicting interactions between both climate variability and environmental phenomena of ocean, bay and land based processes.

Objectives: Specific objectives of this program include but are not limited to (Note that these are not in order of priority.):

- Identify current and potential user communities and the products and applications required to meet the needs of these groups

- Complete the development of models of the Bay and its watershed that provides the user community important and accurate nowcasts and forecasts of the conditions in the Bay and its surrounding environments

- Apply the capabilities demonstrated using the Bay as a “test bed” to selected national and international locations

- Provide new “user friendly” and standardized expert interfaces for various forms of data and information

- Develop processes for outreach to, education of, and interface with the users and local populations including capacity-building for other national and international system-level users

There are several components of the CBFS that are discussed in detail in the following sections:

The use of the Weather Research Model (WRF), Research Associate: John Strack

The use of the Regional Ocean Model (ROMS), Research Associate: Mohan Karyampudi

Watershed Modeling using SWAT, Research Associate: Aditya Sood, (with Huan Meng/NOAA and Michael Maddox)

Biogeochemistry and the prediction of oxygen, striped bass habitat suitability index, Research Associate: Bala Prasad Mathukumalli

Forecast website, Developer: Dmitry Zotkin/UMIACS

Seasonal forecasts, Research Associate: Bin Zhang

A) The Use of the Weather Research and Forecasting (WRF)

Background

The goal of the CBFS is to provide real-time high-resolution forecasts of weather, climate, and runoff in the Chesapeake Bay watershed, as well as for water quality and water levels in the bay itself. Forecasts are provided on time scales ranging from days to seasons. The system also has the additional capability of downscaling decadal projections of potential climate change produced by course resolution GCMS. The system consists of three basic components: 1.) The Weather Research and Forecasting Model (WRF), 2.) The Soil Water Assessment Tool (SWAT) and 3.) The Regional Ocean Modeling System (ROMS). WRF is used to produce high spatial resolution forecasts of various atmospheric parameters which are then used to drive SWAT and ROMS. SWAT produces river discharges from the WRF forcing which are then provided to ROMS. We hope to show that this integrated modeling system is a useful tool for coastal environmental prediction which can be easily set up for any region of the world.

Accomplishments

Starting in August 2009, and each month thereafter, we began making forecasts for the upcoming three month period. These forecasts are forced with ECHAM4.5 GCM seasonal forecasts provided by the International Research Institute for Climate and Society (IRI) at Columbia University. IRI uses three different SST scenarios for the upcoming 7 months to produce 7-month forecasts with the ECHAM4.5. Five ensemble members are run for each SST scenario making a total of 15 forecasts. The data becomes available to us in the first half of each month and we then downscale the first 4 months of all 15 members to produce a high resolution (~8 km) forecast for the Chesapeake Bay Watershed. At the present time we initialize soil moisture and temperature from the NCEP operational NAM model analysis. We will verify the seasonal forecasts as soon as sufficient observations become available.

We have expanded the old 6-member 14-day forecast to 20 members and began running a new forecast every day instead of every three days. The expanded forecast was made possible with our recent access to the NASA Discover supercomputer. The attached figure shows an example of the forecast of daily rainfall for the Rappahannock Basin. Each colored line represents a different ensemble member and the heavy black line represents the ensemble mean. The forecasts are provided daily to the ROMS and SWAT teams. The WRF post processing software (WPP) has been setup to provide a number of derived values such as surface wind gust and visibility. These variables along with a selection of others is made available to our graphics specialist and displayed daily on the web.

Planned Work

During the next few weeks all of the 14-day WRF forecasts which have been run so far will be verified against observations of precipitation and temperature. For the first week of each forecast we are looking at equitable threat scores and bias for precipitation and root mean square errors for temperature on each day. For the second week of each forecast we compute Heidke skill scores showing how well the model can predict below and above normal temperatures and precipitation.

During the next few months we also plan to downscale a 30-year period (2000-2030) from the "SRESA2" climate change scenario. We will also run a 10-year simulation spanning only 2020-2030 and compare the results with the 2020-2030 period from the above mentioned 2000-2030 run. This will enable us to determine if the time-slice size chosen for decadal-scale downscaling has significance.

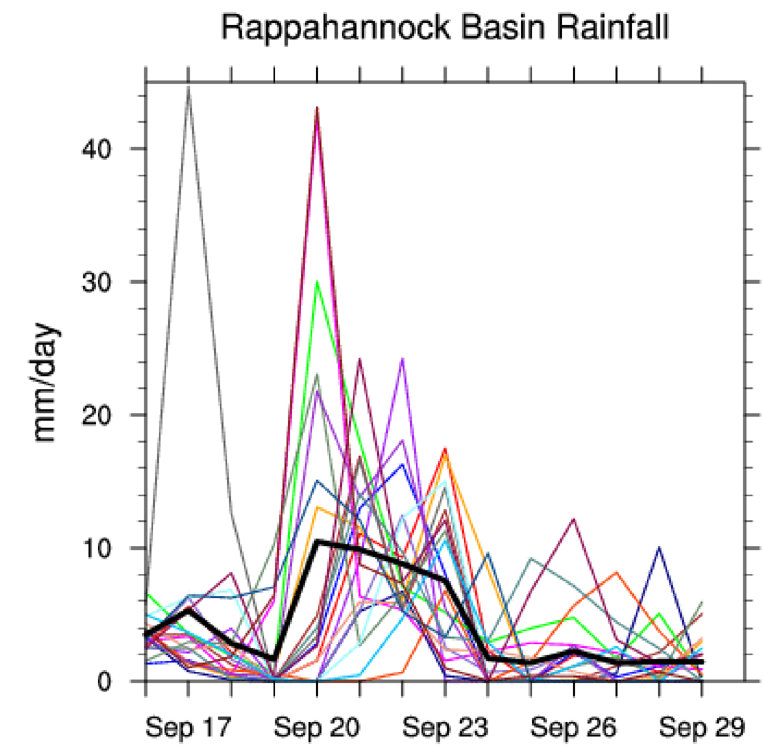


Figure 1. Daily total precipitation forecast by the WRF ensemble in the Rappahannock Basin for the period 17-29 September 2009. Each colored line represents a different ensemble member and the heavy black line represents the ensemble mean.

B) The use of the Regional Ocean Model (ROMS)

Background: Scientific problem, approach, proposed work

The Rutgers Ocean Modeling System (ROMS) model has been applied very successfully to applications ranging from regional to basin scale simulations. One application of the model currently carried out by NOAA is mapping the sea nettles in the Chesapeake Bay in real time from the simulations of sea surface temperature and salinity using the near-time observational data and short-range meteorological forecasts. The purpose of this project, however, is to test, validate and operationally run the ChesROMS (Chesapeake bay ROMS) for the Chesapeake Bay to produce 16-day forecasts. This can be achieved by forecasting of sea surface temperature and salinity including biological and geochemical cycles of nutrients by incorporating the river run off from SWAT (Soil and Water Application Tool) and atmospheric forcing from the WRF (Weather Research and Forecasting) models. Until the river runoff from SWAT is available, the river forcing for the ROMS forecast is obtained by applying regression relationships based on the correlation between the North American Regional analysis rainfall (NARR) and the USGS river gauge data from 1991 to 2005.

Accomplishments

Regression between river runoff and rainfall averaged over 15 year (1991-2005 year) period is obtained from maximum correlation with optimal time lag for each of the 9 rivers (i.e., Chester, Choptank, James, Nanticoke, Patuxent, Potomac, Rappahanock, Susquehanna and York). Linear fit is found to give the best relationship. In general, the predicted runoff is less than the observed runoff for all the nine rivers. For example, the relationship is skewed toward an underestimation of the predicted runoff for James River as shown in Fig. 1. The underestimation of the predicted runoff for all the rivers appears to be related to the neglect of ground water flow because the regression relationship only accounts for river runoff from rainfall and snow melt but not ground water flow.

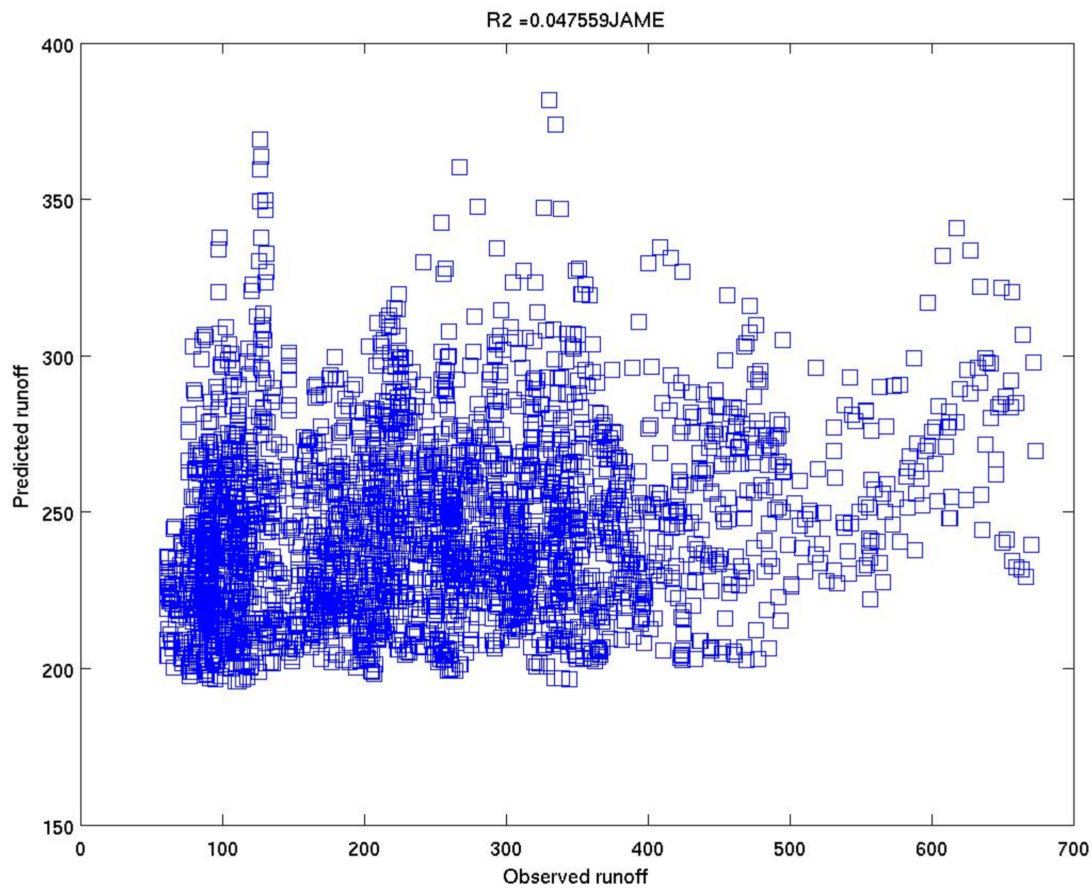


Fig. 1: Predicted runoff obtained from the linear regression equation is plotted against the observed runoff.

Model skill scores were calculated for Feb-June 2009 period. Although skill score plots were made for 11 stations, only two stations (Tolchester Beach and Yorktown Uscg Training Center) showed good data. The data is either bad or missing for the rest of the stations. These two stations showed high skill scores ranging from 0.986 to 0.94 during the 16-day forecast. Correlation coefficients were also calculated for these two stations, which also showed high correlations coefficients (from 0.983 to 0.909 for Tolchester Beach and from 0.984 to 0.942 for Yorktown Uscg Training Center). These high correlation coefficients suggest that the forecasts were reliable.

Planned Work

Although 16-day ROMS forecasts are being carried out on an operational basis, seasonal forecasting is yet to be performed. Using the WRF forecast for atmospheric forcing, seasonal forecast (4 month) will be made.

C) Watershed Modeling of Chesapeake Bay using Soil and Water Assessment Tool (SWAT)

Background: Scientific problem, approach, proposed work

Soil and Water Assessment Tool (SWAT) is one of the major components of the Chesapeake Bay Forecasting System (CBFS) project that links the Atmospheric Model to the Ocean Model. Developed by US Department of Agriculture, SWAT is a physically based, continuous-time watershed model used to predict the impact of land management practices on the quality and quantity of water in the watershed over a long period of time. In CBFS, it is proposed to use SWAT to simulate the hydrology and water quality of the prominent tributaries in the CB watershed. This will help in providing accurate inputs to the ocean model and also help in future land use/climate change related scenario studies.

Accomplishments

The implementation of SWAT model in the Rappahannock river basin has been completed. Streamflow, sediment load and Nutrient (Nitrate and Phosphate) loads calibration and validation were performed. Based on publication by Moriasi et al., 2007, three performance indicators were used - Nash-Sutcliffe efficiency (NSE); ratio of the root mean square error to the standard deviation of measured data (RSR); and absolute percent bias (|PBIAS|). Two additional statistics from SWAT-CUP (the calibration tool) were applied in this study: P-factor and R-factor. The former is the percentage of measured data bracketed by the 95% prediction uncertainty (95PPU) while the latter is the average thickness of the 95PPU band divided by the standard deviation of the observed data. A P-factor of one and R-factor of zero is a simulation that exactly corresponds to the observed data. All the variables meet the Moriasi et al., 2007 criteria except Phosphate load. Also, P- and R-factor show low uncertainty for streamflow but high for Phosphate simulation.

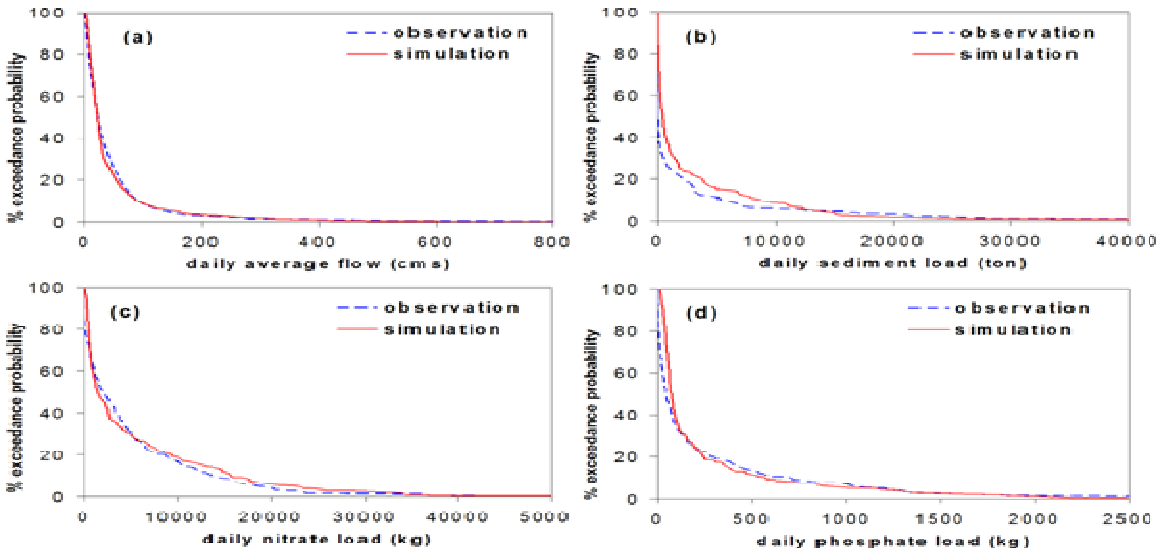


Figure 1. Percent exceedance probability curves of observed and simulated (a) daily average flows, (b) daily sediment loads, (c) daily nitrate loads, and (d) daily phosphate loads at the outlet of Rappahonnock River Sub-basin 7 from year 1995 to year 2002.

The percent exceedance probability curves of observed and simulated flow and constituents are displayed in figure 1. The distribution of the simulated flow shows good agreement with observation. Sediment load is overestimated in the low to medium range and compensates by underestimating high load. The simulated nitrate and phosphate also display certain degree of deviations from the observations in different value ranges.

Equitable Threat Score (ETS or Gilbert skill score) were calculated for Rappahannock streamflow forecast with three streamflow thresholds. ETS ranges from -1/3 to 1 with 1 being the perfect score and 0 without any skill in the forecast. For the period of Sept 2, 2008 to June 30, 2009 at roughly 3-day interval, the result shows that the lower the streamflow, the longer the skill is maintained. For threshold at and lower than the daily mean, ETS is about 0.6 for the 1st day forecast and about 0.4 up to the 7th and 5th days, respectively. For threshold at 1.5 times of the daily mean, ETS is about 0.5 for the 1st day forecast and lowers to between 0.2 and 0.4 up to the 5th day.

The routine forecast on the Linux box was further automated by automating the processing of the input weather data for SWAT. The input weather data for the SWAT is acquired from three NOAA sources respectively for gauge and radar combined precipitation data, satellite solar radiation product, and weather station observations of temperature, relative humidity, and wind speed. The retrieved data is preprocessed to conform to the SWAT requirement before the forecasting is run.

Planned Work
The future work plan is to model Potomac watershed using SWAT. This involves:

- Defining sub-basins
- Calculating land use change between 1992, 2001 and 2006
- Collecting and input point sources, reservoir, ponds, and consumption information
- Collecting weather data for input in the model
- Developing management files with crop rotation, tillage, fertilizer application, harvesting, grazing, and dry/wet atmospheric deposition
- Calibrating and validating the SWAT model and calculating skills for the forecasts.

Reference
Moriasi, D.N., J.G. Arnold, M.W. Van Liew, R.L. Bingner, R.D. Harmel, T.L. Veith. 2007. Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. Transactions of the ASABE 50: 885-900.

D) Chesapeake Bay Forecast System - Biogeochemistry, Prediction of Oxygen and Striped Bass Habitat Suitability Index in the Chesapeake Bay

Background: Scientific problem, approach, proposed work
The aim of this research is to develop the ecosystem models to understand intricate interactions among various biogeochemical processes and to predict dissolved oxygen (DO) and habitat conditions of ecologically and recreationally important fish, striped bass (Morone saxatilis), in the Chesapeake Bay. Our responsibilities include (1) to develop an integrated biogeochemical–NPZD (Nitrogen-Phytoplankton-Zooplankton-Detritus) model, and (2) to develop a statistical model that predicts dissolved oxygen (DO) and habitat suitability conditions for striped bass in the Chesapeake Bay.

Accomplishments
For the period from July 1, 2009 to present, we accomplished the following:

We have analyzed the long-term variability of dissolved nutrients in the Chesapeake Bay and also analyzed nutrients variability in relation with the external nutrient loadings. We also characterized the inter-annual variability in the nutrient structure and biological productivity in the Chesapeake Bay in terms of the N:P ratio and chlorophyll distribution. Further, we investigated linkages among river discharge, chlorophyll and climate indices (NAO and ENSO).

We are doing model-sensitivity experiments to standardize the biogeochemical–NPZD model by adjusting various input parameters. The main goal of this exercise is to simulate the biogeochemical variables to understand the ecosystem dynamics in relation to various natural and anthropogenic stresses.

We have completed the multi-regression statistical model for prediction of spatially-explicit DO levels in the Chesapeake Bay as a function of water temperature, salinity, total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP). The model validation yielded an R2 ≥ 0.80 (Fig. 1). The forecasts of DO are further coupled with temperature forecasts from the ChesROMS hydrodynamic model to predict the striped bass habitat suitability conditions.

Planned work

In the coming year, we plan to:

Standardize the biogeochemical-NPZD model to predict the important biogeochemical parameters, i.e. NO3, NH4, phytoplankton, oxygen, etc., in the Chesapeake Bay.

Evaluate the skill of physical and biogeochemical predictions, both abiotic and biotic, by comparing with in-situ observations.

Evaluate the predictability of the habitat suitability conditions for striped bass in the Chesapeake Bay with the in-situ observations.

Write and submit manuscripts on the prediction of DO and habitat suitability conditions of striped bass in the Chesapeake Bay.

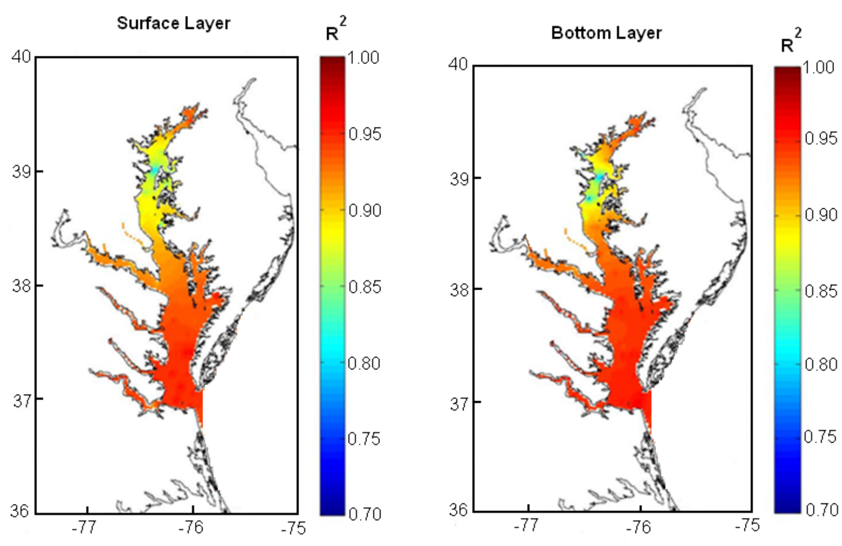


Figure 1: Correlation (R2) between observed and predicted DO concentrations for both surface and bottom layers.

E) Forecast website

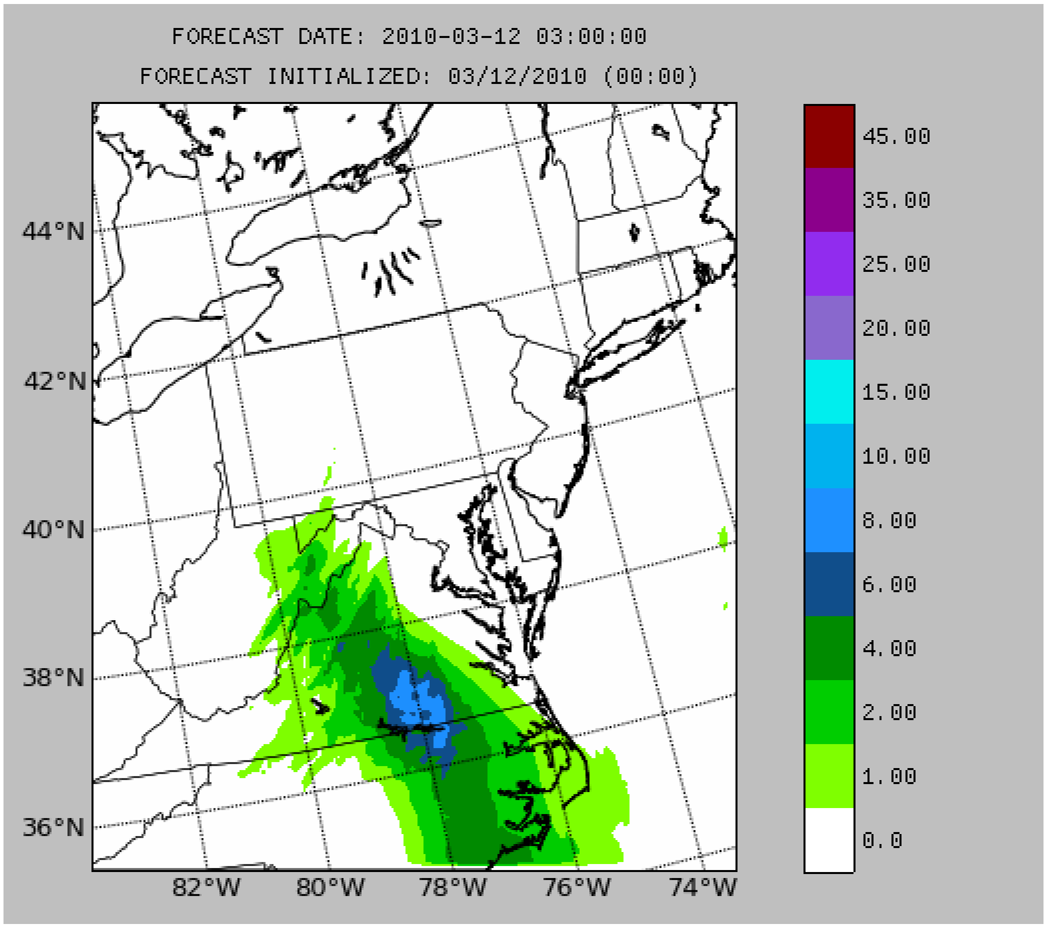
Chesapeake Bay Forecasting System Project

Select Variable	Select Parameters
Mean Sea-level Pressure (mb) Skin Temperature (C) 2-m Air Temperature (C) 2-m Specific Humidity (g/kg) Precipitable Water (mm) CAPE (J/kg) Latent Heat Flux (W/m^2) Sensible Heat Flux (W/m^2) Downward Shortwave Radiation (W/m^2) Downward Longwave Radiation (W/m^2) Surface Wind Gust (m/s) 3hr Accumulated Total Precipitation (mm) 3hr Accumulated Convective Precipitation (mm) 3hr Accumulated Large Scale Precipitation (mm) Maximum Radar Reflectivity (dbZ) Visibility (m) 10-m Wind Speed (m/s) Geopotential Heights (m) Temperature (C) Relative Humidity (%) Wind Speed (m/s) Bay Temperature (C) Bay Salinity (psu) Sea Nettle Likelihood (%) Vibrio Cholera Likelihood (%) Karlodinium Veneficum (HAB) Likelihood (%) Surface water velocity (m/s)	Date: 2010-03-12 00:00:00

Forecasts are updated daily.

A project of Earth System Science Interdisciplinary Center (ESSIC). Please read the disclaimer.

A screen shot of the CBFS output product menu at
http://xing.pc.umiacs.umd.edu:32880/middleware/op



Sample output from the CBFS website at http://xing.pc.umiacs.umd.edu:32880/middleware/op

F) Seasonal forecasts

Accomplishments

At this time, methods for the seasonal forecast using ROMS in the Chesapeake Bay are similar to those for the 16 day forecasting. We use the seasonal forecast from WRF as the surface forcing for ROMS. The river runoff is calculated as the same as the 16 day forecasting but with 4 months forecast period. The initial condition of ROMS is extracted from the continuous 16 day operational ROMS forecast results. The first seasonal forecast cycle starts from February 1st,2010 and ends May 31st, 2010. The forecast will be carried out operationally each month with updated seasonal forecast from WRF. The results are published on the same format as the 16 day forecast results, including the physics and biology forecast. A screen shot from the seasonal forecast is shown in Fig. 1 comparing with the 16 day forecast at the same time.

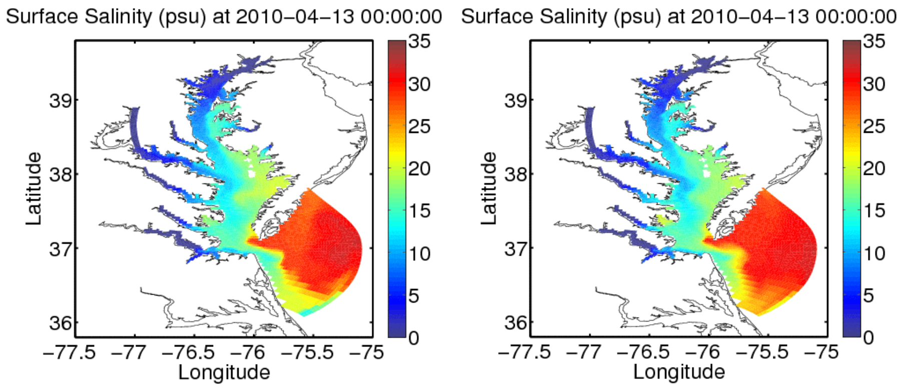


Fig. 1 Surface salinity snapshots from seasonal forecast(left) and 16 day forecast(right) respectively.

Planned Work

The success of seasonal ROMS forecast depends on the reliable seasonal forecast of WRF and river discharge. While WRF model will be further validated with observations so that the surface forcing can be improved, the correlation between river runoff and WRF precipitation needs further tuned with newly available observations and SWAT results. In the coming few weeks, We will collaborate with SWAT team to get a time series of snow-melting river runoff and road salt amount into each river and adjust these into ROMS to look at their impacts on the physics and biology in the Bay.

Publications

Meng, H, A. Sexton, M. Maddox, A. Sood, C. Brown, R. Ferraro, R. Murtugudde, 2009: Modeling the Chesapeake Bay watershed using SWAT: Rappahanock, the pilot river basin. sub judice, Appl. Engg. Agricult.

Murtugudde, R., 2010: Earth System Science and the 2nd Copernican Revolution: An educational imperative. Invited article to Current Science. Journal of the Indian Academy of Science.

Prasad, M.B.K., Sapiano, M.R.P., Anderson, C.R., Long, W., Murtugudde, R. 2010: Long-term variability of nutrients and chlorophyll in the Chesapeake Bay: A retrospective analysis 1985-2008. Estuaries and Coasts, in review.

Prasad, M.B.K., Long, W., Zhang, X., Wood, R.J., Murtugudde, R. 2010: Prediction of dissolved oxygen in the Chesapeake Bay. To be submitted to Estuaries and Coasts.

Anderson, C.A., Sapiano, M.R.P., Prasad, M.B.K., Long, W., Tango, P.J., Brown, C.W., Murtugudde, R. 2010: Predicting potentially toxic Pseudo-nitzschia blooms in the Chesapeake Bay. Journal of Marine Systems, in review.

Presentations

Prasad, M.B.K., Long, W., Zhang, X., Wood, R.J., Murtugudde, R. Prediction of dissolved oxygen in the Chesapeake Bay. Poster presented at the 2010 Ocean Science Meeting, 22-26 February 2010, Portland, Oregon.

Zhang, X., Wood, R.J., Bahner, L., Ludsin, S.A., Martino, S.A., Prasad, M.B.K., Long, W., Murtugudde, R. Chesapeake Bay striped bass habitat suitability forecasting: moving ecosystem modeling from research to operation. Poster presented at the 2010 Ocean Science Meeting, 22-26 February 2010, Portland, Oregon.

CIRUN: Climate Information Responding to User Needs

A. Busalacchi; NOAA Collaborator: E. Locklear

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

On October 13, 2009, the UMD Climate Adaptation Project meeting was held. Minutes of the meeting are reproduced here:

Participants: Steve Halperin, Kaye Brubaker, Tony Busalacchi, Maureen Cropper, Michael Evans, Gerry Galloway, Robert Hill, Eric Kasischke, Ken Gertz, Nathan Hultman, Tony Janetos, Jeff Lapides, Don Milton, Richard Moss, Raghu Murtugudde, Brian Needelman, Matthias Ruth, Mark Sagoff, Amir Sapkota, John Steinbruner, Carolyn Voorhees, Karl Valentine, Cheng-I Wei, Ning Zhang, Da-Lin Zhang

Context: Coming decades will see major climate change with a wide range of impacts. There is intense interest in the federal government on how to adapt to these changes, possibly through a national climate service.

Opening remarks were made by Dean Steve Halperin, CMPS, who stated that the Climate Project group was a University of Maryland initiative created with the intention of uniting climate research faculty from across campus and disciplines to collaboratively respond to an anticipated National Climate Service RFP. Building a university-wide collaborative effort prototype would add real value in responding to a major funding opportunity with the possibility of influencing the debate on the structure of a National Climate Service.

Participants introduced themselves, and spoke of their individual research interests which included:

- Asthma onset and exacerbation resulting from environmental exposures and environmental changes

Built environments and their impact on physical activities

Carbon sequestration

Climate adaptation

Climate change impacts on high northern latitudes and on natural disturbance (fire): ecosystem response

Climate change models: environmental change/impact and adaptation

Climate change on migration

Climate choices: helping people make good decisions

Climate impact of deforestation/reforestation

Climate modeling and the Chesapeake Bay

Climate variability and predictability

Earth's water cycle (e.g. do we build more reservoirs and dams for water shortages)

Environmental ethics: who will pay, sacrificing for the future

Epidemiology

health outcomes on group's perception of their environment

Hydrology and heat islands (e.g. Washington DC effect on Baltimore MD)

International climate policy

Nutrient filters for drainage ditches, precipitation and drought, sea level research and marsh vegetation

Policy - security, transmission of diseases

Risk assessment of natural hazards, policies on hurricanes and floods

Soils, coasts and wetlands

Discussion: During the conversation, several suggestions were offered on the structure, administration and research focus of the group. It was reiterated that participants should think locally and regionally.

Several people suggested identifying specific topics for strategic advantage

Scenario science, coordinating across disciplines

Offer a program to systematically educate on climate adaptation

Look at Neural Cognitive Sciences as a structural template

Monthly seminar series with proactive speakers from off-campus (Dr. Hultman has volunteered to organize).

Subgroup to focus on investment in perception. Define adaptation, measure adaptation to specific circumstances and places and conceptualization of adaptation.

A website will be created consisting of public and private (password protected) pages. Funding sources, research topics, conference/events information, suggestions, topic or speaker, for the monthly seminars and looking for help (partners on research proposals) will be easily accessible to group members.

Reference was made to the USGS publication (1331) Climate Change and Water Resources Management: A Federal Perspective - "how do you make things happen at the local level."

Action Items:

Build public/private website to include:

- Mission Statement
- Invitation to Participate
- Participants, with one - paragraph biography/research interests (to be submitted)
- Relevant lectures/conferences/events/workshops
- List of possible funding opportunities
- Research topics, which will be posted on the password-protected pages, with opportunity for participates to indicate their interest
- Recommendations for additional participants to be submitted
- Suggestions for possible speakers at the above-mentioned seminar series.

Director of CIRUN, hiring status

An announcement was posted in May 2009 on the AMS Website and EOS Transactions for a full tenured professor/Director of CIRUN. The announcement is reproduced at the end of this report. In response, we had 12 applicants. A short list of 6 was selected for telephone interviews, which took place the week of Oct 19, 2009. From that, 4 were invited to present seminars and meet our faculty and staff. This took place between Nov. 19 and Dec. 3, 2009. On Dec 23, a candidate was selected, and an Appointment/Promotion/Tenure (APT) process was initiated in the Dept. of Atmospheric and Oceanic Sciences.

Future Workshops
A workshop on Climate and Human Health is planned for the Fall 2011.

Faculty Position
Earth System Science Interdisciplinary Center (ESSIC)
University of Maryland, College Park

The Earth System Science Interdisciplinary Center (ESSIC) at the University of Maryland invites applications for a tenured Full Professor pertaining to climate applications and decision support.

ESSIC is a joint center between the University of Maryland Departments of Atmospheric and Oceanic Science, Geology, and Geography together with the Sciences and Exploration Directorate at the NASA/Goddard Space Flight Center. It is located at M-Square, a new research park three miles from the main campus and future home to NOAA's new National Center for Weather and Climate Prediction. ESSIC also administers the Cooperative Institute for Climate Studies (CICS), which is a joint center with NOAA's National Centers for Environmental Prediction (NCEP) and the National Environmental Satellite, Data and Information Service (NESDIS). The goal of ESSIC is to enhance our understanding of the interactions of the coupled atmosphere-ocean-land-biosphere components of the Earth system as well as the influence of human activities on the system. The ESSIC staff is currently composed of approximately 60 academic and research faculty spanning meteorology, oceanography, geology, and geography. The Director of ESSIC is Prof. Antonio Busalacchi.

Applications are solicited for the Director of CIRUN (Climate Information: Responding to User Needs).

Through CIRUN the University of Maryland is working with partners to mobilize a national effort to build the capacity to predict major climate changes on time scales of seasons to decades, and to convert these predictions into information that government and industry can use to plan and adapt. Information on CIRUN may be found at http://www.climateneeds.umd.edu/

The appointee shall have a high level of competence in teaching and advisement in relevant climate disciplines, and shall have demonstrated significant research and scholarship across basic research, applied research, and engagement with stakeholders needing climate information. The appointee shall have established a national and international reputation for outstanding research, scholarship and a distinguished record of teaching. There also must be a record of continuing evidence of relevant and effective professional service. The responsibilities of the position include the need to:

- Research effective means of the provision of climate information
- Develop decision support tools for climate services
- Coordinate cross campus efforts pertaining to the application of climate information
- In collaboration with NOAA and NASA partners, lead the university's efforts to support a National Climate Service
- Engage a wide range of stakeholders in researching, assessing, and supporting their needs for climate information
- Focus on the provision of environmental information, with an emphasis on the atmospheric, climate, hydrological and oceanographic areas
- Support early and informed response by government, industry and the general public to significant events and/or changes in the climate system that will be occurring on a regional, national or global scale over the coming decades
- Communicate with regional and national policy makers
- Lead fund raising efforts to public and private organizations in support of CIRUN.

The position will be filled at the tenured Full Professor level. The appointment is state-funded for the academic year. A Ph.D. degree in an appropriate discipline of Earth System Science is required. The successful applicant is expected to demonstrate a commitment to excellence in research and teaching and a desire to work in a multi-disciplinary environment.