



ESSIC'S

Cooperative Institute for Climate and Satellites-Maryland (CICS-MD)

cicsmd.umd.edu

CoRP Symposium College Park, MD Sep 16-17, 2015







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.





CICS-MD Topic areas







Future Satellite Programs GOES-R





Example for March 27, 2014 for the GOES-R proxy (MODISbased) ESI (left) at 2 km and the current GOES ESI capability at 10 km.

Evapotranspiration and Drought Monitoring Using 'GOES-R' Products for NIDIS Chris Hain

The new proxy-based products were shown to provide much higher resolution while providing similar accuracy as current GOES-based products. Findings from this project will help motivate development of operational ALEXI products in the GET-D product system as GOES-R products become available.



Future Satellite Programs

Joint Polar Satellite System (JPSS) Projects



VIIRS Fall Foliage Forecast

Xiaoyang Zhang and Bob Yu

A new method has been developed to monitor and predict short-term (10 days) fall foliage coloration using the VIIRS daily vegetation index.

Developed with the support of the JPSS Proving Ground and Risk Reduction Program, this new data product is the first to measure and predict fall foliage coloration from a satellite data time series. Foliage phase prediction 10 days ahead derived from VIIRS NDVI



Near real-time VIIRS NDVI vegetation index for Fall foliage (verification)





Interdisciplinary approaches



Satellites, biodiversity, and blue carbon*,

Science to support climate change mitigation and adaptation, coastal resilience, and habitat conservation *the carbon sequestered and stored by coastal ecosystems Dr. Ariana Sutton-Grier

Over half the people in the world live in the narrow strip of land within 120 miles of the coast. In 2011, 45% of the U.S. Gross Domestic Product (GDP) was generated in coastal shoreline counties and territories.

Blue Carbon Research Needs

- Extent of seagrasses and health of coastal ecosystems
- Carbon sequestration and storage in coastal ecosystems, as well as emissions
- What happens to the fate of carbon in wetlands that are drowning with sea level rise?
- How quickly can we restore carbon services when we do coastal restoration?

Chronic Diseases and Biodiversity

"Biodiversity" hypothesis: **loss of macrodiversity** leads to loss of microdiversity which leads to changes in human microbiota and **results in variety of disorders**

Biodiversity and Human Health

Limited but growing evidence that not just exposure to nature, but **contact with diverse natural habitats** and many different species, **has important positive impacts for human health**



Building CICS collaborations



Current work



Units: Thousand cubic km for storage, and thousand cubic km/yr for exchanges

NOAA Microwave Hydrological Products

- NOAA polar orbiting satellites contain the AMSU/MHS sensors which are used to retrieve hydrological variables (water vapor, clouds, rain, snow, seaice).
 - When combined with similar measurements from other satellites, useful global data sets of the water cycle can be developed
- CICS-MD has developed a **Climate Data Record** (1998-2010) for AMSU/MHS and will be expanding to 2015.
 - Can be exploited to study "climate" when combined with other parameters



http://cics.umd.edu/AMSU-CDR/home.html

Project Team: NOAA – R. Ferraro, H. Meng, T. Smith CICS-MD – W. Yang, I. Moradi, J. Beauchamp



Chris Hain et al.





Given known radiative energy inputs, how much water loss is required to keep the soil and vegetation at the observed temperatures?

ENERGY BALANCE APPROACH (diagnostic modeling)

ALEXI Annual Evapotranspiration -- 2007





Soil Moisture Operational Product System (SMOPS) Jicheng Liu



The Global Change Observation Mission-Water (GCOM-W1) satellite, part of the Joint Polar Satellite Program (JPSS), has been in orbit since May 2012. Its Advanced Microwave Scanning Radiometer follow-on (AMSR2) instrument will provide a majority of global water cycle Environmental Data Records (EDR). One set of EDRs are the land-surface parameters (*i.e.*, land surface soil moisture, and land surface type).



The GCOM-W1 AMSR2 soil moisture product will play a significant role in the NOAA **Soil Moisture Operational Product System (SMOPS)**, a blended product from different satellite sensors designed for all operational soil moisture needs.



Building CICS collaborations









Develop a *consistent, long-term* dataset that fully represents the water cycle and hence facilitates hydro-climate research and applications

Water Balance

$$\frac{dw(t)}{dt} \approx P - EVT - R$$

w: soil wetness
Evt: evapotranspiration
P: precipitation
R: runoff



Earth System

- Vegetation

- LCLUC
- Ecosystems
- LC Physical

Properties



Climate and Data Assimilation



- Seasonal Drought Prediction based on the Climate Forecast System Version 2
- Precipitation Trends 1900-2005 over the Globe from Reconstruction and Coupled Model Simulations
- A Retrospective Analysis of IPCC Model Projections of Sea Level Rise
- A Simpler Formulation of Forecast Sensitivity to Observations: Application to Ensemble Kalman Filters
- Interaction between Bias Correction and Quality Control in Satellite Data Assimilation
- Exploration of an advanced Ocean Data Assimilation scheme at NCEP
- Using Satellite and In Situ Data to Analyze Climate Fields



Root-mean-square errors of soil moisture anomalies/standard deviation for month-1 forecasts from four forecast methods

Observed sea level rise (mm/yr)





Seasonal Drought Prediction Based on the Climate Forecast System Version 2

- To develop drought prediction capability to support CPC's Drought Outlook activities.
- To conduct an assessment of the precipitation (P), soil moisture (SM), and runoff (RO) forecasts from CFSv2 using its retrospective forecasts from 1982 to 2009 to evaluate their usefulness for drought prediction.
- To understand the contribution of land surface models to the predictive skill of seasonal runoff forecasts.

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Data assimilation and OSSEs

Kayo Ide, Sean Casey ...



The Joint Center for Satellite Data Assimilation (JCSDA)

improves and accelerates the use of research and operational satellite data in numerical weather and climate prediction models.

Observing System Simulation Experiments (OSSEs) provide a rigorous, cost-effective approach to evaluate the impact of the new (envisioned) observing systems and alternate deployment strategy for the existing systems, by the assimilation of synthetic observations drawn from a realistic model simulation, called a nature run (NR), into a data assimilation system (DAS).

OSSEs can be also used to evaluate DAS. A clear advantage of OSSEs over any real observing system experiments (OSEs) is the availability of the NR as the truth.



Data assimilation

The CICS-MD OSSE Project led by Kayo Ide is currently using the operational 3D-hybrid data assimilation system in two different ways:

i) Observing System Experiments (OSEs) using real observations, to investigate the impact of hyperspectral IR sensors (IAS, CR, CrIS, and AIRS); and

- ii) Observing System Simulation Experiments (OSSEs) using simulated observations, to investigate the impact of the geostationary microwave observations.
- iii) The geo microwave sensor with high refresh rate may contribute to the improvement further by providing better time-evolving information that can be useful in the 4D hybrid DAS.

Undergraduate Educational Activities (2013-2015)

The CICS-MD Summer Initiative (CSI) series provides training and outreach opportunities for both graduate and undergraduate students.

It <u>pairs students with mentors</u> to conduct original scientific research and help train future NOAA scientists.

Students not only learn new tools but are already <u>contributing to generate</u> <u>products with value to NOAA</u>

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Proving Ground and Training Center (PGTC)

NOAA's **proving grounds** facilitate pre-deployment testing and operational readiness/suitability evaluation in operational proving grounds.

The CICS-MD PGTC has begun its transition from proposal to place.

The Warning Decision Support System (WDSS) software has been installed, and plans are in place to install AWIPS-II and McIDAS.

These machines were funded by a University of Maryland grant.

CICS-MD Proving Ground and Training Center (PGTC)

Thanks...

Climate Monitoring from Satellites

- GOES Operational SST Retrievals
- Monitoring Arctic Sea Ice Thickness Using Airborne and Satellite Altimetry
- A 4-km Snow Depth Product
- Comparison Analysis between NODC In Situ Analyzed Sea Surface Salinity and Aquarius Sea Surface Salinity
- Operational Generation of the HIRS Outgoing Longwave Radiation Climate Data Record
- Assessment of Oceanic Freshwater Flux Using Salinity Observations

 A Recalibration of the AVHRR data record to provide an accurate and well parameterized FCDR

OLR CDR

CoRTAD version 4 sea surface temperature climatology

Future Satellite Programs GOES-R

- Surface Water and Energy Budgets
 - Longwave radiation budget
 - Shortwave radiation budget
 - Land surface albedo
 - Land surface temperature
 - Snowmelt mapping
 - SST algorithm
 - Cloud and precipitation products
 - Dual assimilation soil moisture into NLDAS
- Fire Detection Capabilities

Drought early warning index contribution to NIDIS

Vertical cross sections of radar reflectivity detected by the CloudSat CPR

Data Fusion and Algorithm Development

- Support for the GOES-R Algorithm Working Group tasks for the development and validation of three longwave radiation budget (LWRB) products for the Advanced Baseline Imager (ABI) instrument.
- Combining GOES-R and GPM to Improve GOES-R Rainrate Product
- Combining GLM and ABI Data for Enhanced GOES-R Rainfall Estimates
- Snow Cover Algorithms for the Global Change Observation Mission (GCOM) 1 AMSR2 Instrument
- The Global Precipitation Climatology Project (GPCP): Current Status and Transfer to Operations at NCDC

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Calibration and Validation

- Research for Advanced Calibration of Joint Polar Satellite System (JPSS) Instrument
- Diagnosing Variabilities/Changes in Global Precipitation Patterns during the Past Three Decades Using Satellite-Based Measurements
- Continuity of VIIRS/MODIS Radiometric Measurements: Simultaneous Nadir Overpass Comparisons for Reflective Solar Bands
 - Cross-Scan Asymmetry of AMSU-A Window Channels: Characterization,Correction and Verification

Developing Climate Data Records from Microwave Satellite Data
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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.