

Applied Sciences Highlights Report February 2010



Newly Developed Web Based Tools Enhance VIEWS-TSS Usability

Uma Shankar, University of North Carolina-Institute for the Environment (UNC-IE)

Shawn McClure, Cooperative Institute for Research in the Atmosphere (CIRA)

Highlight: A new set of tools developed for the **VIEWS-TSS*** will enhance its web usability for modelers who use CMAQ to aid routine decision making. The re-gridding tool now projects NASA satellite data to the CMAQ* modeling grid for a *user-specified* domain and grid resolution, enabling one-to-one comparisons between modeled and satellite data at *each* grid cell at the time of overpass. Then, the Atmospheric Model Evaluation Tool v2.0 and the python-based Process Analysis tool respectively provide statistical and diagnostic analyses of these data to help the user understand the biases in the model performance. These tools are critical, as CMAQ is used in routine air quality decision-making by the EPA, the National Park Service (NPS), and regional, state and local air quality planning agencies.

Relevance: VIEWS-TSS is a web-based data system widely used in air quality and visibility assessments. NASA OMI Aerosol Extinction Optical Depth and NO₂ column have been added in VIEWS to evaluate the CMAQ model simulations of one study so far, the Rocky Mountain Atmospheric Nitrogen and Sulfur (RoMANS) field study during the spring/summer of 2006 in Rocky Mountain National Park (RMNP) conducted by the National Park Service (NPS). Locating where the ammonia sources originated was important to the NPS, because there was one monitor on the ground near the vicinity. Including satellite data to the model was critical for understanding sources and impacts.

*VIEWS-TSS: Visibility Information Exchange Web System- Technical Support System

*CMAQ- Community Multi-scale Air Quality

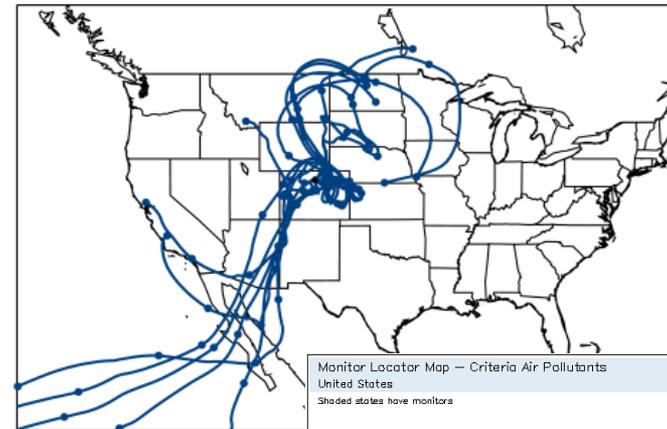


Figure 1

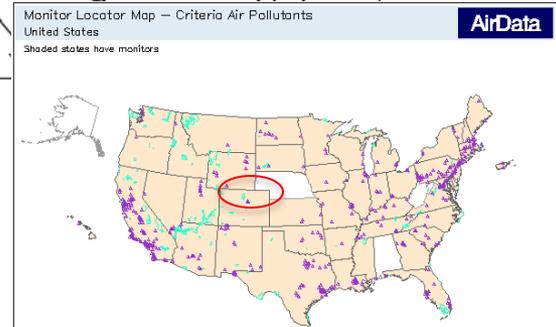
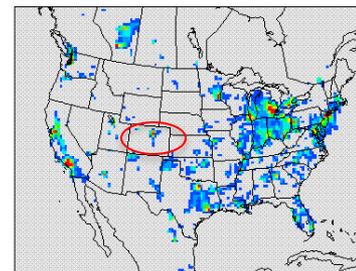


Figure 2

Tropospheric NO₂ Column April 20, 2006



Tropospheric NO₂ Column April 21, 2006

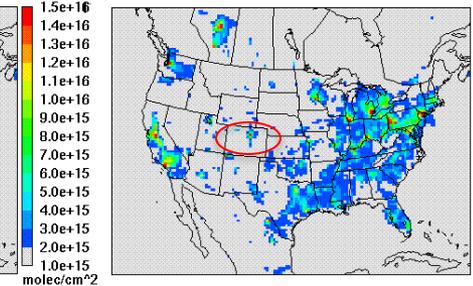


Figure 1 shows air mass originating NO_x source regions in California's Central Valley. **Figure 2** shows the one ground based NO₂ monitor near the national park. **Figure 3** shows post processed 24-hr average tropospheric column NO₂ concentration for the same two days.



Using Satellite Data to Reduce Bycatch of Protected Sea Turtles Through Environmental Condition Determinations

Steven Bograd, NOAA NMFS-Southwest Fisheries Science Center

Highlight- After evaluating sea surface temperatures and fishery distributions, the study showed that swordfish were found in slightly warmer temperatures than loggerhead turtles. 18.5 degrees Celsius is chosen as the Northern limit of swordfish fishing in an experimental product made available to fishers, thus helping to minimize bycatch of protected sea turtles.

Relevance – This is one study from a task to develop applications with NOAA fisheries managers to incorporate NASA satellite ocean data products into fisheries and marine resources management and assessment activities that will lead to decision support tools. The goal was to reduce bycatch of protected and endangered sea turtles and reduce the time-area closures of pelagic long-line fisheries. The use of satellite data help determine the environmental conditions under which turtles and fisheries may associate.

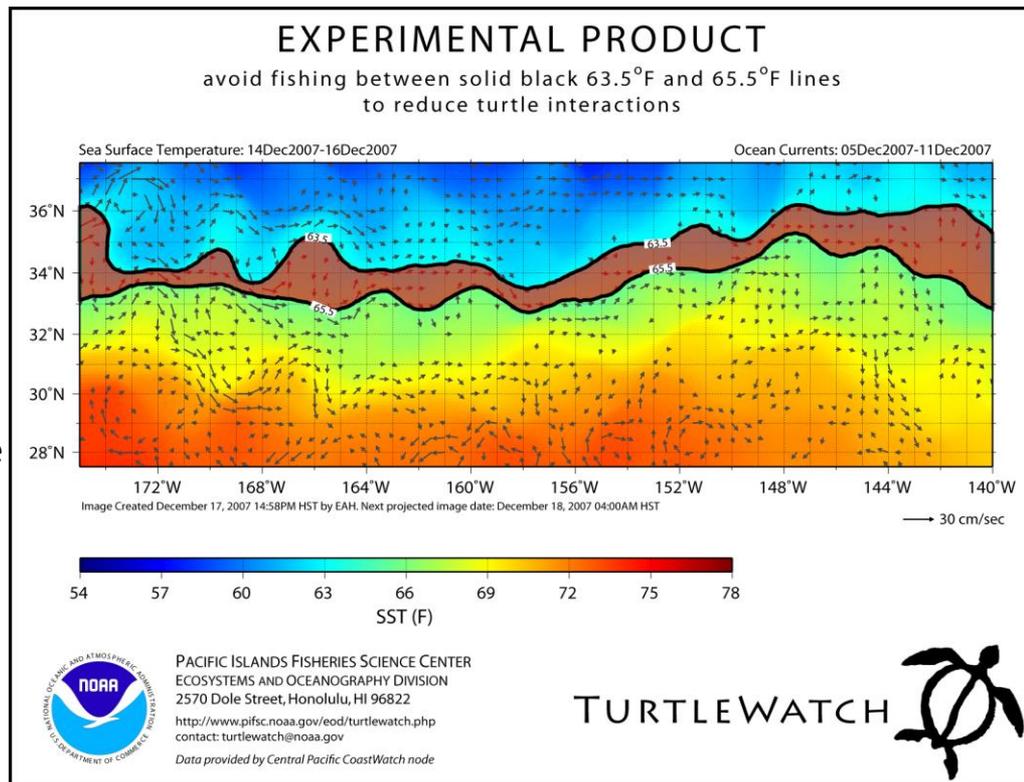


Figure above shows the experimental product given to fisherman on where to avoid fishing to reduce turtle interactions. The solid lines and simply stated temperatures provide clear guidelines.



Steven Bograd, NOAA NMFS-Southwest Fisheries Science Center
831-648-8314, Steven.Bograd@noaa.gov

Primary Partners:
NOAA PIFSC, NEFSC

Project Summary: This was a joint NASA/NOAA task, where there was a need for basic physical oceans data to combine with fish stock data, to improve understanding-prediction/models of environmental parameters that affect stocks and recruitment, animal distribution and habitat. This project was a part of the 2 year marine habitat classification .

Earth Science Products: The satellite products utilized included altimeter from Topex and Jason-1, chlorophyll-*a* concentration obtained from Sea-viewing Wide Field-of-view Sensor (SeaWiFS) , and AVHRR Pathfinder sea surface temperature data.

Technical Description of the Images: Map shows precise date, ocean current information, sea surface temperature (SST) data in Fahrenheit, longitudinal and latitude information and clearly marked “no-cross” zone for the fisherman. The product is useful to characterize the locations to reduce turtle interactions, which varies by season.

Application to Decision Making: Based on the observed temperature differences between turtle habitats and fisheries, a demonstration decision support tool has been developed to minimize sea turtle bycatch, and reduce the time-area closures of pelagic longline fisheries, both the drift gillnet fishery in southern California during warm ocean events (e.g. El Niño) and in the Atlantic commercial gillnet and bottom trawl. Loggerhead turtles are endangered species protected in US waters. Turtles are often associated with commercial fisheries, but have been found to have a slight preference for colder temperatures. Turtle bycatch can be reduced by fishing in warmer waters.

Scientific Legacy: This study was one of a series of tasks between NASA and NOAA applying NASA data to NOAA fisheries management. Loggerhead turtles are endangered species protected by in US waters. Turtles are often associated with commercial fisheries but have been found to have a slight preference for colder temperatures. Turtle bycatch can be reduced by fishing in warmer waters

References:1) Murray, KT. 2009. Characteristics and magnitude of sea turtle bycatch in U.S. Mid-Atlantic gillnet gear. *Endang Species Res* 8:211-224. **2)** Howell EA, Kobayashi DR, Parker DM, Balazs GH, Polovina JJ. 2008. TurtleWatch: A tool to aid in the bycatch reduction of loggerhead turtles (*Caretta caretta*) in the Hawaii-based longline fishery. *Endang. Species Res.* 5: 267-278.



Uma Shankar, UNC-IE

(919) 966-2102, ushankar@unc.edu

Primary Partners:

WRAP, NPS, EPA OAQPS, NC DENR, UT DEQ

Project Summary: VIEWS-TSS (<http://views.cira.colostate.edu/nasa/>) integrates both ground- and space-based observations with 3-D emissions data and air quality modeling results. Along with advanced analysis tools, the web based tool provides multiple perspectives on the spatial distribution and temporal evolution of atmospheric pollutants, building a more complete body of information to support critical decisions on the control of the responsible pollutant sources.

Earth Science Products: Tropospheric NO₂ column from OMI, and aerosol products from OMI and MODIS, are being used along with intensive field measurements for a diagnostic evaluation of the CMAQ model, to understand the relative impacts of industrial and agricultural emission sources for one NPS field study, RoMANS. The NO₂ column is useful for analyzing both ozone and particulate nitrate chemistry and transport. As both CAMx and CMAQ strongly under predict total ammonium in the field study, TES NH₃ column will also be used to investigate model performance for NH₃.

Technical Description of the Images: 5-day back trajectories (Figure 1) showed these air masses originating in high NO_x source regions in California's Central Valley, as well as the agricultural NH₃ source regions to the east. Figure 2 shows the spatial coverage of the 425 ground-based NO₂ monitors in EPA's AQS database that reported data in 2006. The figure shows one site located near RMNP for comparisons with the RoMANS study data. Post-processed CMAQ 24-hr average tropospheric column NO₂ for the same two days (Figure 4) show some similar spatial patterns to OMI NO₂ but also over prediction on April 21 in RMNP; this, however, it needs to be analyzed further.

Application to Decision Making: Reliable emission control strategies for air quality regulatory compliance critically depend on the robust performance of models. The analyses using complementary Earth Science products and ground-based measurements support NPS in its decision-making by providing an understanding of where and when the regulatory models used in these decisions are under- or over-predicting observed nitrogen deposition, whether through an incorrect quantification of emission levels or incorrect specification of deposition rates.

Scientific Heritage: The OMI NO₂ column measurements (Boersma et al., 2007) will be critical in evaluating CMAQ nitrogen predictions aloft. Diagnostic evaluation of CMAQ model performance builds upon the analyses of Barna et al. (2009). A description of the CMAQ model is provided in Byun and Schere (2006) and Binkowski and Roselle (2003).

References: Boersma et al., *Atmos. Chem. Phys.*, 7, 2103, 2007; Byun and Schere, *Appl. Mech. Rev.*, 59, 51, 2006; Binkowski and Roselle, *JGR*, 108(D6), 4183, 2003; Barna et al., *National Park Service Technical Report #ISSN 0737-5352-84*, 2009.



Using Satellite Data to Improve Short-Term Recruitment Predictions for Marine Fish Stocks

Jon Brodziak, NOAA NMFS-Pacific Islands Fisheries Science Center

Highlight : By using NASA sea surface temperature (SST) data, the root mean-squared prediction error was **reduced by 70%** relative to the status quo predictor for Georges Bank cod recruitment prediction. Satellite data improved cod and haddock stock predictive models and have been incorporated into the NOAA Fisheries Toolbox Age Structured Projection (AGEPRO) model projection module for haddock and cod.

Relevance: The study was to examine the recruitment strength of Georges Bank cod and haddock stocks influenced by environmental conditions through the use of satellite data. The recruitment prediction problem was determining what regulates the production of juvenile fish. Researchers sought to understand whether recruitment strength was environmentally driven or is spawner abundance the dominant effect. They found a correlation between recruitment in spring to the plankton bloom in the previous autumn. (i.e. recruitment strength was environmentally driven).

Georges Bank cod

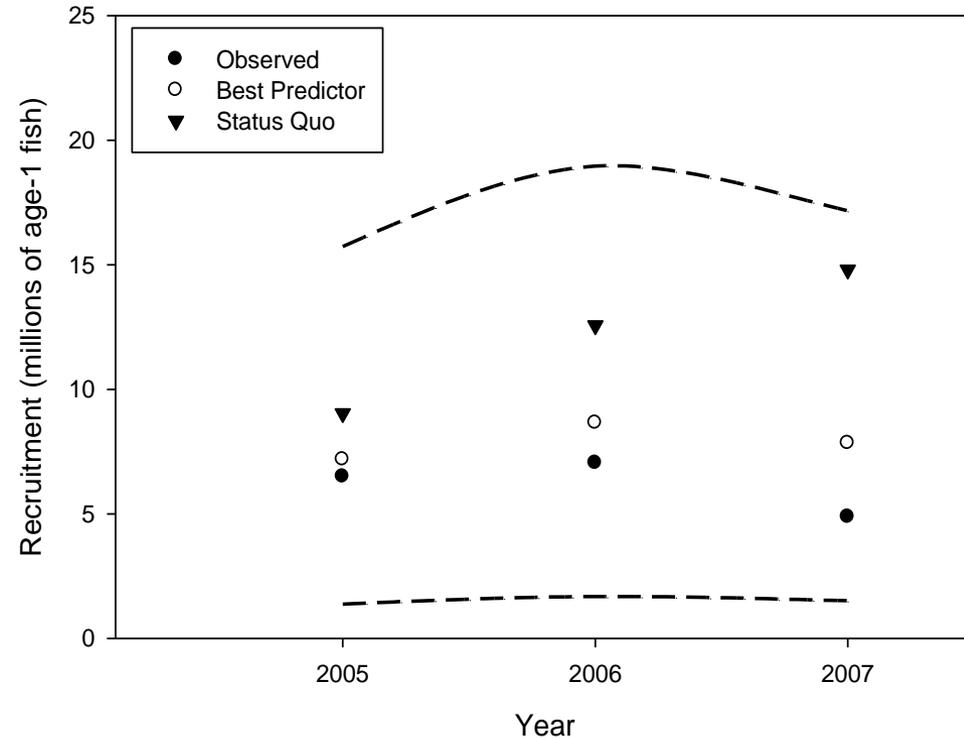


Figure 1. Using sea surface temperature (SST) during February-May improved predictions of Georges Bank cod recruitment (R) during 2004-2007 and reduced root mean-squared prediction error by 70% relative to the status quo predictor.



Jon Brodziak, NOAA NMFS-Pacific Islands Fisheries Science Center
808/983-2964 Jon.Brodziak@NOAA.GOV

Project Summary: This was a joint NASA/NOAA task, where there was a need for basic physical ocean data and using it with fish stock data, to improve understanding-prediction/models of environmental parameters that affect stocks and recruitment, animal distribution and habitat. This project was to examine the recruitment strength of Georges Bank cod and haddock stocks influenced by environmental conditions through the use of satellite data.

Earth Science Products: This study utilized data from AVHRR Pathfinder sea surface temperature and SeaWiFS Chlorophyll-A and primary productivity monthly composite index, a derived satellite data product.

Technical Description of the Images: By using sea surface temperature (SST) during February-May improved predictions of Georges Bank cod recruitment (R) during 2004-2007 and reduced root mean-squared prediction error by 70% relative to the status quo predictor.

Application to Decision Making: The results of this study will improve the prediction of recruitment for both cod and haddock in the Georges Bank region.

Scientific Legacy: Previous research indicated that cod and haddock recruitment were influenced by the North American oscillation index, wind stress patterns. The focus of this project was to investigate the importance of other environmental covariates on cod and haddock recruitment, such as water temperature and food availability, that are known to affect larval growth and early life history stage survival of cod and haddock.

References: Friedland, K., Hare, J., Wood, G., Col, L., Buckley, L., Mountain, D., Kane, D., Brodziak, J., Lough, G., and Pilskaln, C. 2008. Does the fall phytoplankton bloom control recruitment of Georges Bank haddock, *Melanogrammus aeglefinus*, through parental condition? *Can. J. Fish. Aquat. Sci.* 65:1076-1086.



Predicting Zoonotic Hemorrhagic Fever Events in Africa using NASA Earth science Data

PI: Jorge E. Pinzon, Science Systems and Applications Inc. (SSAI)

Highlight- The project has developed an operational predictive monitoring system based on NASA Earth science data to identify, detect and use reliable environmental-related disease (EID) emergence signals of increased risk of hemorrhagic fever events (Rift Valley fever, Ebola and Marburg) in Africa.

Relevance- In 1996, the Department of Defense Global Emerging Infectious Surveillance and Response System (DoD-GEIS) was created in response to Presidential Decision Directive NSTC-7 to adequately protect Americans from EID. The derived monthly risk maps support the predictive surveillance program of the Department of Defense (DoD)-Armed Forces Health Surveillance Center/Division of Global Emergence Infections Surveillance Operations (AFHSC/GEIS). The maps bring to DoD public health decision makers, science based, advanced awareness on developing infectious disease threats, and provide the opportunity to plan and execute disease outbreak prevention, preparedness, and control-and-response actions. These predictions are used by host-country ministries of health and agriculture, as well as World Health Organization (WHO) and Food and Agriculture Organization (FAO), to prepare for and mitigate the impact of outbreaks.

ESD Applied Sciences Program

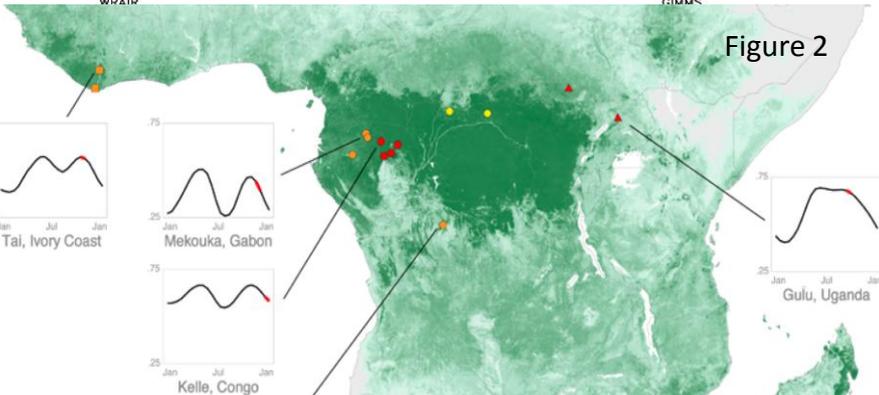
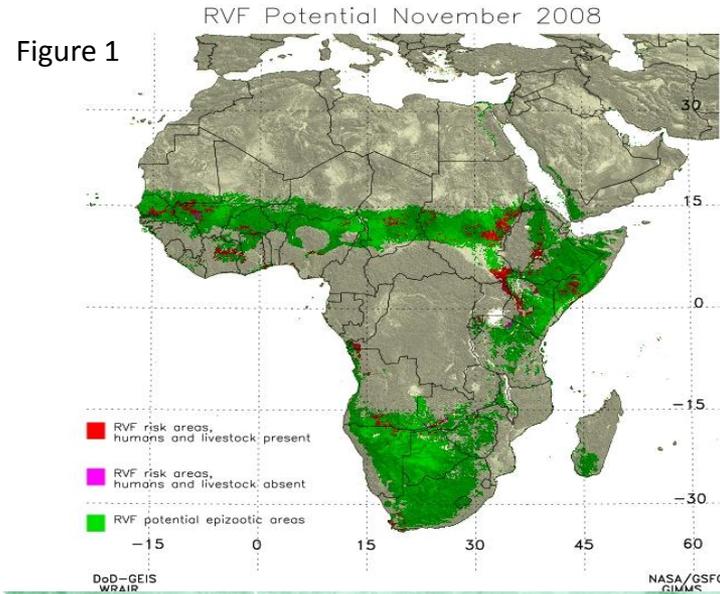


Fig 1: Rift Valley Fever map based on Normalized Difference Vegetation Index (NDVI). **Fig 2** shows pattern that despite a wide range of locations, Ebola outbreaks (noted as circles on each graph) tend to occur toward the edge of a forest and toward the end of the rainy season, or after a seasonal peak in NDVI.

Public Health Applications



Jorge E. Pinzon, SSAI

301-614-6685, jorge.e.pinzon@nasa.gov

Primary Partners:

DOD-AFHSC/GEIS, USDA-CMAVE

Project Summary: The project supports DoD-AFHSC/GEIS program with a pro-active public health practice, by providing advisories and alerts on zoonotic disease emergence directed to preparedness, prevention and control, and response decision-making.

Earth Science Products: Monthly and on-demand ranking risk maps of endemic regions that are timely delivered at appropriate temporal and spatial resolution, by integrating information from a consistent AVHRR-NDVI record, MODIS on Terra and MODIS and AMSR-E on Aqua, TRMM and SRTM data, and as well as simulated products from NPP and GPM upcoming missions to ensure data continuity.

Technical Description of the Images: Figure 1. Enhanced RVF risk map based on NDVI dynamics incorporating livestock, human population data and SRTM digital data resulting in a two-level risk category at continental scale. Selected set of RVF sentinel monitoring sites (~ 40 sites) has been set up for East Africa, Arabian Peninsular, Madagascar and Southern Africa. Source NASA/GSFC/GIMMS. Figure 2. Map of tropical forest in Africa with temporal plots of NDVI data for five selected locations, which shows MODIS percentage tree cover, and highlights Ebola outbreaks from several decades. A pattern that becomes clear, despite a wide range of locations, is that Ebola outbreaks (noted as circles on each graph) tend to occur toward the edge of a forest and toward the end of the rainy season, or after a seasonal peak in NDVI. Source NASA/GSFC-GIMMS.

Application to Decision Making: A prompt response to disease emergence can greatly reduce morbidity and mortality from a disease. Thus, informed pre-emptive decisions about disease management and prevention would be more sustainable and cost-beneficial than a usual “ fire-fighting” approach.

Scientific Legacy: Earth observation by satellite remote sensing over nearly thirty years has enabled systematic analysis and mapping of the close coupling between vectors of disease and the driver indicators of climate variability, e.g. El Niño/Southern Oscillation (ENSO), rainfall, temperature and vegetation, on a global scale at high-temporal and moderate spatial resolutions. The integration of satellite measurements provides a better understanding and prediction of the spatio-temporal ecologic factors associated to hemorrhagic fever events that cannot be treated using only epidemiological models.

References: Anyamba A, Chretien J, Small J, Tucker CJ, Formenty P, Richardson JH, Britch SC, Schnabel DC, Erickson RL, Linthicum K (2009). Prediction of a Rift Valley fever Outbreak. *Proceedings of the National Academy of Sciences* 106(3): 955-959.
Pinzon JE, Wilson JM, Tucker CJ, Arthur R, Jahrling P, and Formenty P, 2004. Trigger Events: Enviro-Climatic Coupling of Ebola Hemorrhagic Fever Outbreaks, *The American Journal of Tropical Medicine & Hygiene*, Vol. 71 (5): 664-674.



Developing Seasonal Predictive Capability for Drought Mitigation Decision Support

Ximing Cai, University of Illinois at Urbana-Champaign

Highlight- Due to the Climate Research and Forecasting Model (CWRf) downscaling (reduction in geographic scale), a decision model based on the short-term forecast (up to 2 weeks) was developed to access the value of the improved forecast. CWRf downscaling was improved for the short-term based on National Centers for Environmental Prediction (NCEP) Reanalysis 2 (RII) and for seasonal prediction (up to 3 months) based on Global Modeling and Assimilation Office (GMAO).). A user survey indicated a significant value for the improved forecasts.

Relevance- The improved short- and mid-term forecasts are being incorporated into Drought Monitor, a Decision Support System (DSS), with National Drought Mitigation Center at U of Nebraska. The decision model shows the improved forecasts can increase farmers' net profit by **25-40%**. The survey indicates that forecasts will affect farmers' decision making if the statistical confidence is increased to at least 75-80%. Currently, improved forecast skills are at 67% for maximum daily temp, 66% for minimum daily temp, and 33% for total daily precipitation.

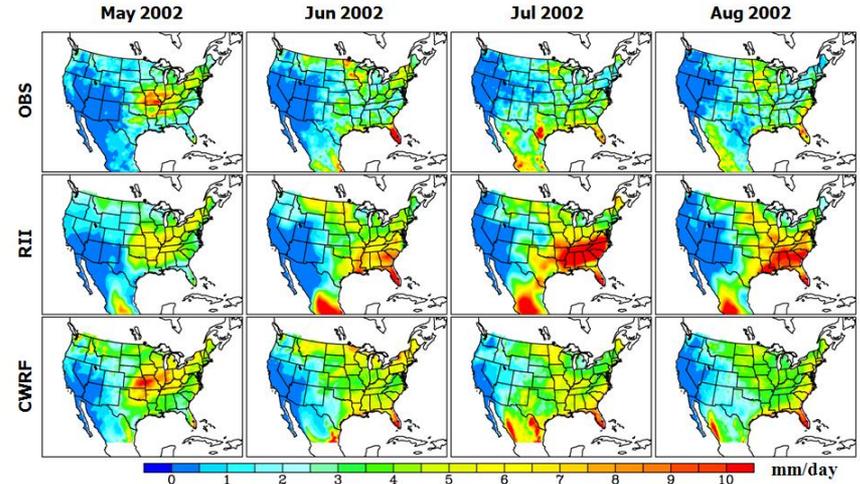


Fig 1. Observed, RII simulated, and CWRf downscaled ensemble monthly mean precipitation, May- Aug, 2002. CWRf is much closer to the observed than RII.

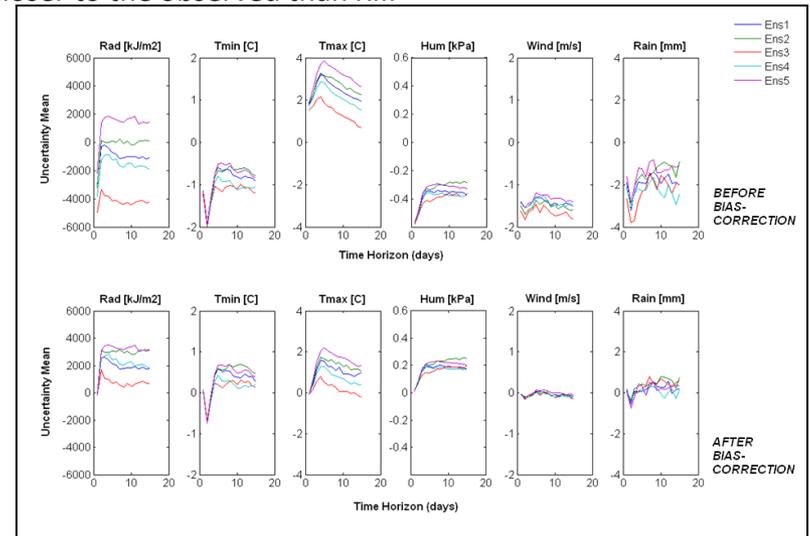


Fig 2. Correcting the model bias brings it closer to zero.



Ximing Cai, Univ. of Illinois, Urbana-Champaign

(217) 333 4935

Primary Partners:

Univ. of Nebraska-Lincoln

Project Summary: The project plans to develop short-term (2-week) and seasonal predictive capacity for real-time decision support to improve irrigation scheduling and reservoir operation.

Earth Science Products: NOAA NCEP Reanalysis 2 (R2) and NASA Global Modeling and Assimilation Office (GMAO) coupled General Circulation Model (GCM) and MODIS.

Technical Description of the Figures: Fig. 1 shows observed, R2 simulated, and CWRP downscaled ensemble monthly mean distributions of precipitation (mm/day) from May to August, 2002. The CWRP results are significantly better than the driving R2 product, indicating the skill enhancement from the CWRP downscaling. Fig. 2 shows that after bias-correction, the model bias is closer to zero.

Application to Decision Making: A real-time decision model based on the two-week CWRP forecast has been developed to support irrigation scheduling, and a model based on seasonal forecast for improving reservoir operation during a drought period is under testing; a user survey on the use of weather forecast has been conducted, with collaboration from National Corn Growers' Association (NCGA).

Scientific Legacy: The CWRP downscaling approach with an optimal ensemble of alternative physics representations largely reduces biases of the driving global models, and provides significant skill enhancement for predicting precipitation at regional-local scales. Both model and forecast uncertainties are incorporated into the irrigation scheduling decision support system, allowing a realistic, quantitative assessment of the value of the forecasts. By the survey, there is a significant demand for more accurate forecasts that allow the end user (e.g. agriculture producers) to utilize the forecasts in their decision making, especially if the statistical confidence is above 75-80%.

References: **1.** Ryu et al., An evaluation framework for hydrologic forecasts in system operations during droughts, *Wat. Resou. Res.*, in review. **2.** Ryu et al., Finding Potential Extents for ENSO-Driven Hydrologic Drought Forecasts in the United States, *Climatic Change*, in press. **3.** Cai et al., *The value of probabilistic weather forecasts—An assessment by real-time optimization of irrigation scheduling*, *J. of Wat. Resou Plan. and Managt.*, in review.

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