PROGRESS REPORT FY 06/07

An Applied NOAA Research Center:
Regional assessment of interannual climate impacts and support for NOAA ocean observations

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Progress Report: **Base Funding**
June 1, 2006 – April 1, 2007

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COAPS Climate Modeling Activities

An advanced land model (NCAR CLM2) is coupled to the FSU/COAPS regional spectral model to improve seasonal surface climate outlooks at very high spatial and temporal resolution and examine its potential for crop yield estimation. The regional model domain is centered over the southeast United States and run at 20 km resolution. These ensembles are used to make probabilistic forecasts of the crop yield. Twenty ensemble members are calculated from the combinations of 10 different initial conditions and two convective schemes (NCEP/SAS and NRL/RAS) for a period of 18-yrs (1987-2004) during the warm season (March-October). Outputs from the model (max/min surface temperature, precipitation and shortwave radiation at the surface) are used as inputs into the crop model to determine yields. Integration of outputs from the FSU/COAPS regional spectral model with the agricultural models was used to forecast peanut/maize yield in southeast U. S. using the CROPGRO-Peanut & CERES-Maize crop models.

Figure 1 shows peanut yields from 1987 to 2004 simulated at Quincy, FL using observed daily weather and the 20 member ensemble model daily values. Predicted yields are highly variable, indicating that the crop model is sensitive to small weather changes within the ensembles. This is a potential problem of the probabilistic crop forecasts. This project is joint with the University if Florida who shares a special task with the ARC. This special project has one more year to completion.

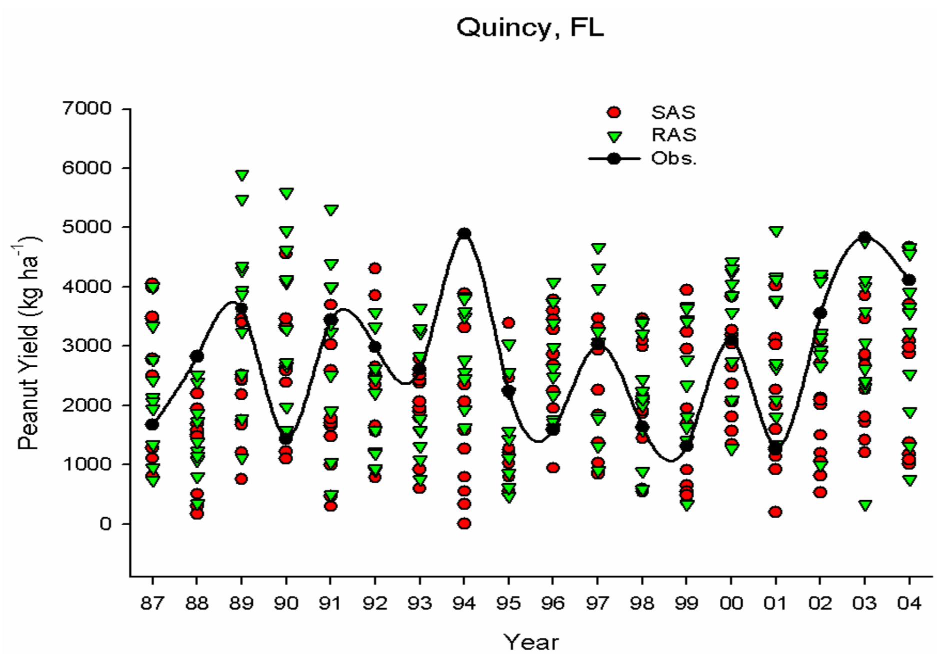

Figure 1. The results show that the crop yields are highly variable indicating that the crop model is very sensitive to small daily weather changes within the model.

Crop yields simulated by dynamic models are highly sensitive to dry-spell occurrences during the cropping season. It was found that increasing the persistence of dry days resulted in an increasing probability of drought stress occurrences, which are accompanied by a decreased mean and increased variance of the grain yields. According to our results, not only increasing the persistence of wet/dry day occurrence is important, but also the timing within the cropping season when these dry-spells occurs is especially important. Figure 2 graphically compares the total by monthly amounts of rainfall during the cropping season of maize yields versus the stress factor affecting the growth during the growing season. As an example, ensemble member 2 receives the maximum amount of rainfall in comparison to the remaining members and the observed data. However, it shows one of the lowest simulated yields. This is because a long dry-spell occurred just before and during tasseling, the most critical period for the production of maize. The opposite occurs in ensemble member 6 where the total rainfall amount is in the below normal tercile, but simulated yields are in the above normal tercile. In this case, most of the water stress occurs after the grain-filling phase when water does not play an important role in determining yields.

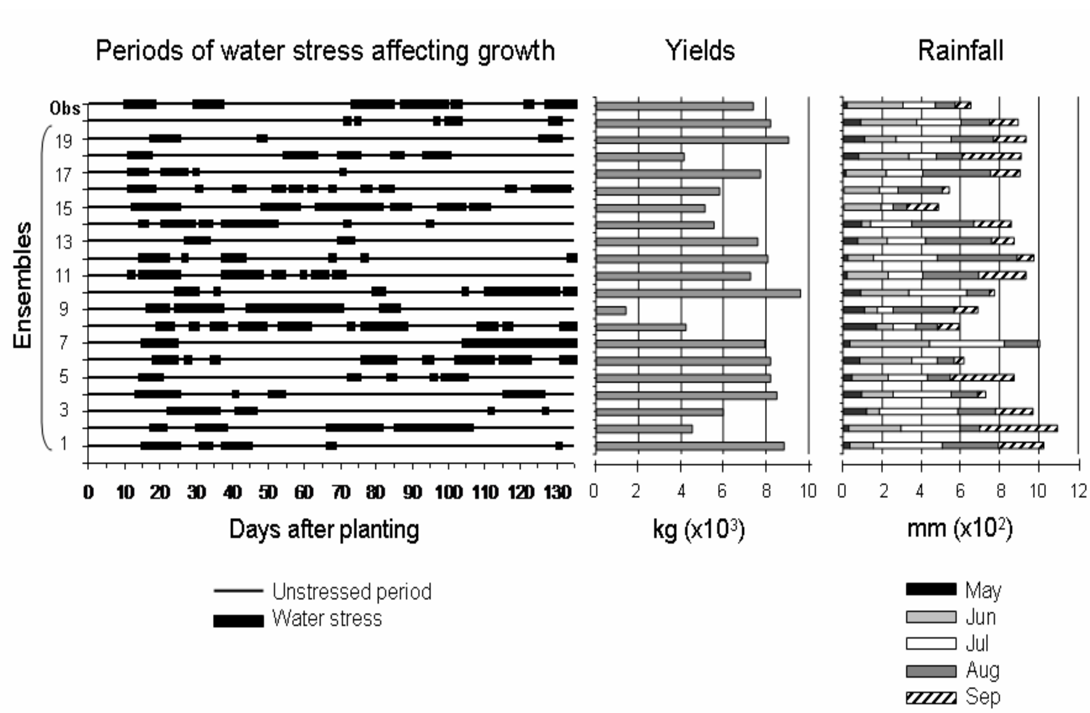

Figure 2. Crop yields are highly sensitive to the timing of the precipitation during the growing season. It was found that increasing the persistence of dry days resulted in an increasing probability of drought stress occurrences, which are accompanied by a decreased mean and increased variance of the grain yields.

Another avenue of research at COAPS is the comparison of statistical versus dynamical downscaling. Coarsely resolved surface temperature and precipitation have been seasonally integrated using the FSU/COAPS (T63)) for the period of 1994 to 2002 (March through September) are downscaled to local spatial scale of ~20 km for the southeast United States by applying both dynamical and statistical methods. Dynamical downscaling is conducted by running the FSU/COAPS RSM, which is nested into the domain of the FSU/COAPS GSM. A statistical downscaling is developed. The rationale for this approach is that clearer separation of prominent local climate signals (e.g., seasonal cycle, dominant intraseasonal or interannual oscillations) in the observations and the GSM over the training period can facilitate the identification of the statistical relationship associated with climate variability between two datasets, which eventually leads to better prediction of local climate scenario from the large-scale simulations. To this end regression based on CSEOF (Cyclostationary EOF) analysis is used.

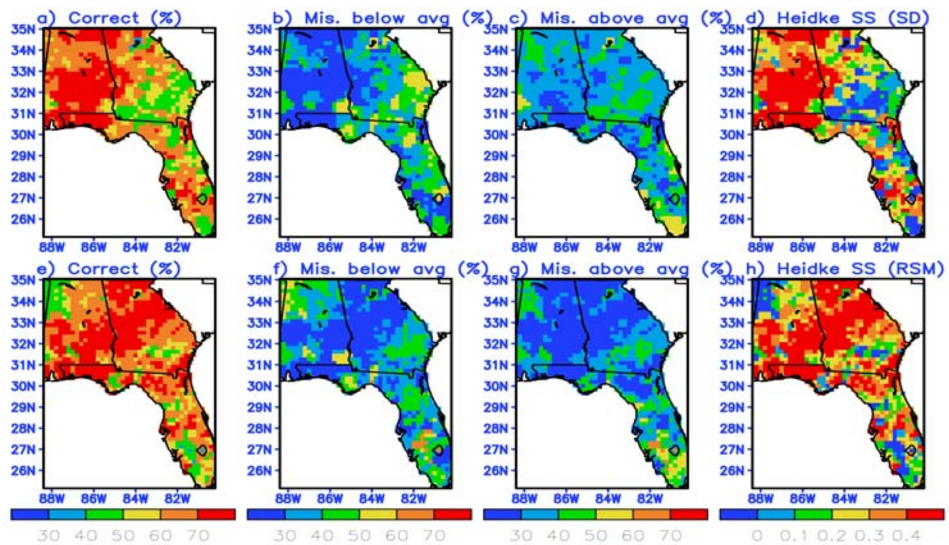

Figure 3. Categorical predictability in percentage (left three columns) and Heidke skill score (HSS) (right columns) for the seasonal Tmax anomaly. Top panel: statistical downscaling, and bottom panel: dynamical downscaling. Percentage correct (left column) prevails from 60 to 80 by both downscaling methods. It is much higher than percentage incorrect (2nd and 3rd columns), which indicates no categorical match between observation and forecast. HSSs are positive up to 0.5 over majority of grid points.

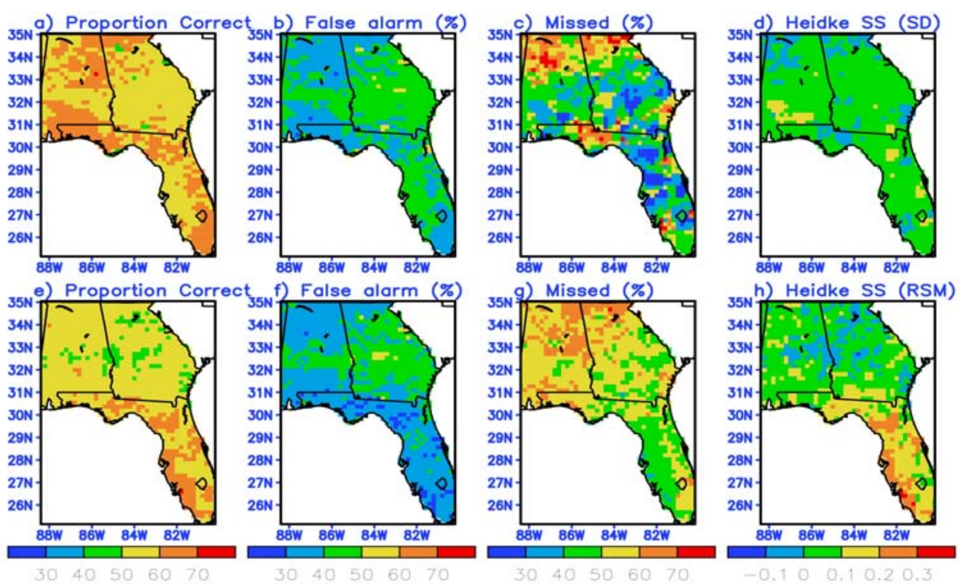

Figure 4. 5-day interval during which rainfall amount is greater than 5mm is classified into wet period otherwise dry period. Percentage correct (1st column) prevails from 50 to 70 by both downscaling methods. It is higher than “false alarm” (2nd column) and “missed” (3rd column), although there remains a room for improvement in predictive skill. HSS are positive up to 0.2 over majority of grid points.

Both downscaled data methods are compared with the FSU/COAPS GSM fields and observations. Both downscaled seasonal anomalies reasonably produce the local surface temperature and precipitation from the coarsely resolved large-scale GCM simulations. Biases from the GSM have also been significantly reduced during both downscaling processes. A series of evaluations including correlations, frequency of extreme events, and categorical predictability demonstrate the reliability of these downscaling models. As shown in Figures 3 and 4 categorical predictability for seasonal maximum temperature anomaly (T_{max}) and wet/dry periods reveals the correctness in percentage prevailing from 60 to 80 (T_{max}) and, from 50 to 70 (precipitation) by both downscaling methods, supporting that both downscaling methods yield predictability greater than random chance. The skill of this local forecast is comparable to or greater than predictability of the large-scale NCEP climate seasonal forecasts [*Saha et al*., 2006]. Much lower incorrectness in percentage shown on the second and third column of the slides, and the Heidke skill scores on the fourth column demonstrate the reliable skill of these downscaling approaches. Although there still remains a room for the improvement in predictive skill, these downscaled model results are reliable and can be directly used in many application models.

Finally, high-resolution western Atlantic Basin seasonal hurricane simulations are conducted using the FSU/COAPS global spectral model at resolution T126L27. An ensemble of four integrations is conducted using time lagged initial atmospheric conditions centered on 1 June for the years 1986 to 2005. The sea surface temperatures (SSTs) are updated using the weekly Reynolds and Smith (1994) SST data set. The storm's morphology and storm tracks are realistic and do not suffer from being too short or moving poleward too quickly (see Figure 5). An objective-tracking algorithm obtained from European Centre for Medium Range Weather Forecasts (ECMWF) and modified for the higher resolution was used to determine the tracks and identification of the storms. Model outputs were saved every six hours for tracking purposes. The interannual variability is also realistic. The overall trend in the increase in hurricane activity from 1995 to 2005 was also captured by the ensemble.

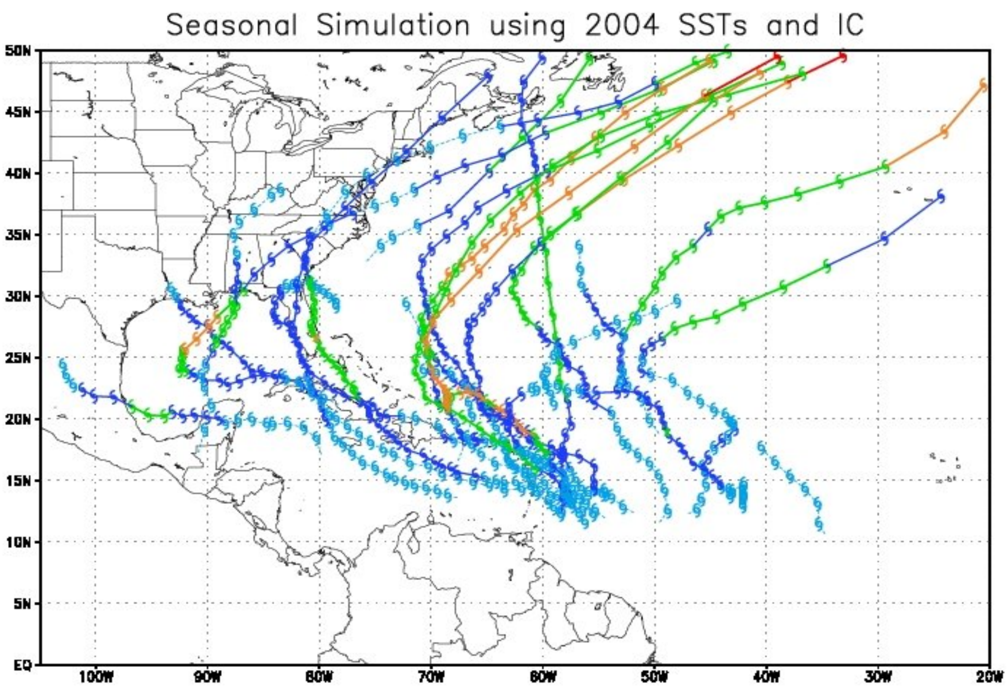

Figure 5. The FSU/COAPS global model shows very realistic storm tracks and numbers for the 2004 hurricane season. Model storm numbers compare very favorably with the observed numbers. The light blue and blue colors represent CAT1 and CAT2 level storms, respectively, using the Saffir-Simpson scale. The green and orange colors are CAT3 and CAT4 level storms.

The number of storms from each ensemble is calculated from the detection algorithm and plotted as a function of time in Figure 6. The observed number of storms is shown in black while the ensemble mean is the shown in red. The spread of the ensembles is shown by the blue and green squares. Overall the ensemble mean does well in simulating the interannual variations in the storm numbers except during the cold ENSO event years of 1998 and 1999 when the ensemble mean was much higher than the observed. The spread of the ensembles was largest during the warm ENSO event of 1997 (a spread of 11 storms) although the ensemble mean was only two storms off the observed. These two facts indicate that the model is sensitive to the ENSO state. The 20 year temporal correlation of the ensemble mean with the observed was 0.78. The observed variance was 25.25 for the 20 years of the study while the ensemble mean variance was slightly lower at 12.55, although ensembles 1 and 4 had variances much closer to the observed with values of 20.2 and 18.01 respectively (not shown).

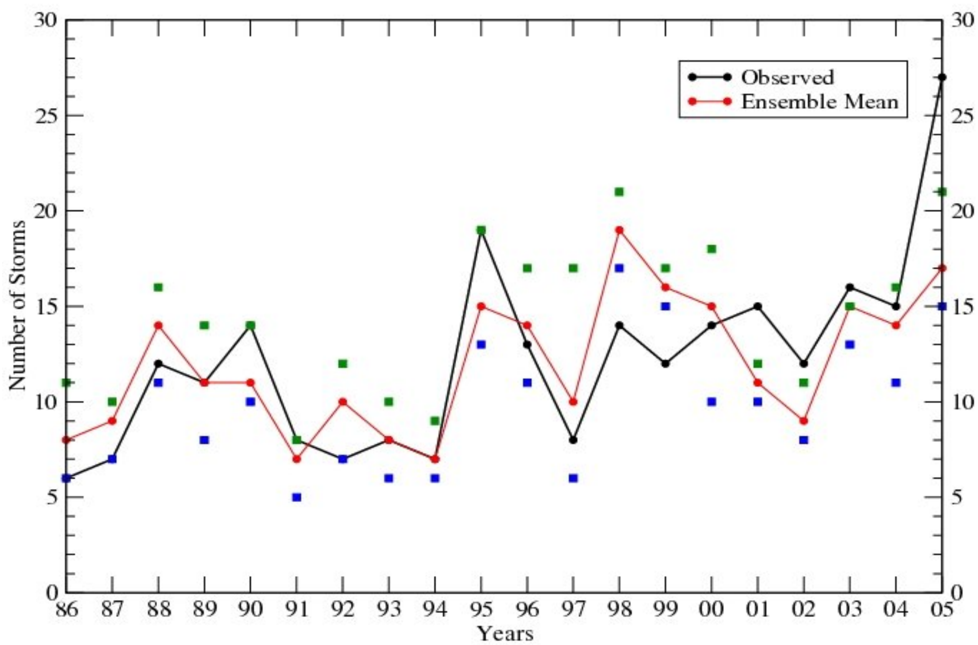

Figure 6. The results show that the ensemble mean is able to capture the variability of the number of storms very well with a correlation of 0.78. The observed variance is 25.25 and the ensemble mean is 12.75. The model was able to capture the increase in storm activity during 1995 and the decrease during 1997 (El Nino). The observed upward trend from 1997 was also simulated well by the ensemble mean. The spread of the ensemble is denoted by the green and blue squares.

For each of the four ensembles, the lowest storm surface pressure was identified and plotted as a histogram. The lowest surface pressure found was 936hPa during 2001, indicating that even at this high horizontal resolution the model was able to generate only one CAT4 storm and no CAT5 storms. The model ensembles produced the largest number of storms (around 600) with surface pressures between 980-1000hPa. There is a sharp decline (to around 70) storms with pressures greater than 1000hPa.

Papers: (Peer Review)

Shin, D. W., J. G. Bellow, T. E. LaRow, S. Cocke and J. J. O'Brien (2006): The role of an advanced land model in seasonal dynamical downscaling for crop model application, Journal of Applied Meteorology and Climatology, 45(5), 686-701.

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Bellow, J.G. ,Shin, D.,W., Schoof, J., Jones, J.W., O'Brien, J.J. (2006): Contribution of Temperature, Precipitation, and Solar Radiation from Dynamically Downscaled Global Climate Model Output to Predicting Peanut Yields and Phenology in the SE USA, Agricultural Systems (in preparation).

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Papers: (Non Peer Review)

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Bellow, J. G., D. W. Shin, J. Schoof, J. W. Jones, J. J. O'Brien (2006): Contribution of temperature, precipitation, and solar radiation from dynamically downscaled global climate model to predicting peanut yields in the SE USA, Research Activities in Atmospheric and Ocean Modeling, CAS/JSC Working Group on Numerical Experimentation.

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Shin, D. W., J. G. Bellow, S. Cocke, T. E. LaRow, and J. J. O'Brien (2006): Seasonal dynamical downscaling for crop yield estimation. Research Activities in Atmospheric and Ocean Modeling, Research Activities in Atmospheric and Ocean Modeling, CAS/JSC Working Group on Numerical Experimentation, 7-25.

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Cocke, S., D.W. Shin and T.E. LaRow (2006): Preliminary Results of High Resolution Dynamical Hurricane Seasonal Simulations. NOAA 31st Annual Climate Diagnostics & Prediction Workshop.

Cocke, S., T. E. LaRow, D. W. Shin, J. Schoof, Y.-K. Lim, J. J. O'Brien, and T. N. Krishnamurti, 2007: FSU climate prediction studies. 3rd WGNE workshop on systematic errors in climate and NWP models, (Feb. 12-16), San Francisco, CA.D007535.

Lim, Y.-K., D. W. Shin, S. Cocke and T. E. LaRow (2006): Comparison of predictive skill between the statistically and the dynamically downscaled temperature and precipitation over the southeast United States. Fall AGU Meeting.

Lim, Y.-K., M. Cai, E. Kalnay, J. J. O'Brien, and L. Zhou (2006): Observational evidences of sensitivity of climate changes to land vegetation types and urbanization. The 86th American Meteorological Society Conference.

Lim, Y.-K., D. W. Shin, S. Cocke, T. E. LaRow, and J. J. O'Brien (2006): Statistical downscaling of the FSUGSM temperature and precipitation over the southeast United States. Spring AGU Conference.

Schoof, J. T., D. W. Shin, T. LaRow, and S. Cocke (2006): Assessment of spatial and temporal skill associated with dynamically and statistically downscaled seasonal temperature forecasts in the southeastern USA. Spring AGU Conference.

Shin, D. W., S. Cocke, and T. E. LaRow (2006): Diurnal cycle of precipitation in the FSU climate model. Spring AGU Conference.

Shin, D. W., J. G. Bellow, S. Cocke, T. E. LaRow, and J. J. O'Brien, (2006): The role of an advanced land model in seasonal dynamical downscaling for crop model application.

Shin, D.W., J. Bellow, S. Cocke, T. E. LaRow and J. J. O'Brien (2006): Probabilistic Crop Yield Forecasts using the Upgraded FSU Regional Spectral Model. NOAA 31st Annual Climate Diagnostics & Prediction Workshop.

NOAA ARC Storm Surge Modeling Activities at COAPS

Over the past year, COAPS researchers have published a first study explaining the unexpectedly high storm surge from hurricane Dennis in 2005, and have developed a prototype storm surge modeling system that couples a very high-resolution unstructured mesh model to a large-scale ocean model.

Following the proposed work plan for the storm surge modeling activities funded under this grant, the following has been accomplished:

- A study that explains a remotely generated contribution to the local storm surge within Apalachee Bay during Hurricane Dennis has been published in Geophysical Research Letters. For this project, a 1/60° barotropic simulation of the Gulf of Mexico was configured (along with a secondary domain encompassing Apalachee Bay) and forced by wind fields constructed using an objective gridding technique applied to HWind data constrained to a NWP-based background field. This study showed that Dennis generated a high sea level anomaly along the Florida Peninsula that traveled as a coastally trapped wave to Apalachee Bay (Figure 1). The storm translation speed was nearly the same as the wave propagation speed, resulting in continual building of the wave as it traveled northward. The wave arrived nearly the same time the local winds turned onshore over the coastline of Apalachee Bay, and added nearly 1m to the locally wind-driven surge.

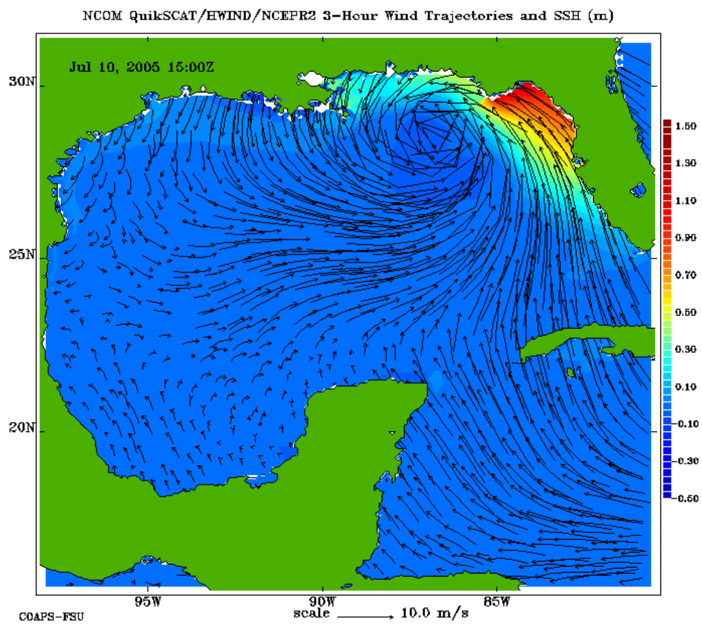

Figure 1. Sea level response to Hurricane Dennis from a Navy Coastal Ocean Model (NCOM) simulation.

The demonstration of this remote forcing mechanism as an explanation to the underpredicted surge let NHC/TPC forecasters to modify surge forecasting techniques for storms in the Gulf of Mexico. Now, in addition to the myriad of local surge domains along the coastline, a larger scale domain encompassing the Gulf of Mexico is run when a storm enters the Gulf to detect whether or not similar remotely generated sea level anomalies may be significant for a local storm surge.

- Analysis of the models used for the above investigation showed that local variability of the storm surge height due to complicated coastline geometry can be important for forecasting, and it is not practical to increase the resolution of the large-scale models to the point where they can resolve such fine scale variability. Instead, a new modeling system is being developed that nests fine-resolution unstructured mesh models with flooding/drying capability inside a larger scale ocean model. This method permits the simulation of large-scale remotely generated sea level anomalies that may be important contributors to storm surge, but can still model the variability of the local surge due to small-scale coastline features and topography. The computational cost of using this method remains tractable for forecasting purposes.

  For demonstration and development purposes, a prototype modeling system has been configured and tested for the previously studied case of Hurricane Dennis. The FVCOM (Finite Volume Coastal Ocean Model) is an unstructured mesh primitive equation three-dimensional model with flooding and drying capability. This model has been configured for a region encompassing Apalachee Bay in the northeastern Gulf of Mexico. The model derives its initial and lateral boundary conditions from an outer larger scale model. The outer model could be any of a number of operational ocean models, but for now, the 1/60° Gulf of Mexico Navy Coastal Ocean Model used for the previous Hurricane Dennis study is used. A model comparison study is performed between the high-resolution (average grid-cell length scale near the coast is 300m) FVCOM simulation and the 1/60° NCOM simulation using identical wind fields. The FVCOM simulation results in a 28% increase in the maximum storm surge height and moves the location of maximum surge from an exposed coastline to a point several kilometers up a river, a previously unresolved feature. Interestingly, this location is near St. Marks, FL, where major flooding occurred and garnered significant media attention during the storm.

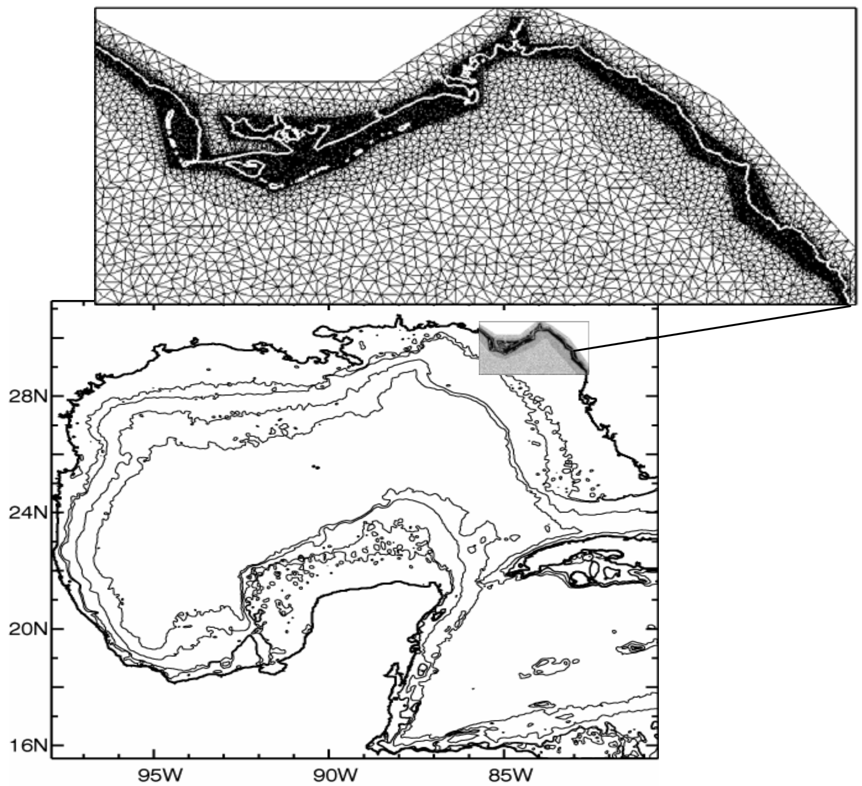

Figure 2. A high-resolution unstructured grid for a Finite Volume Coastal Ocean Model (FVCOM) northeastern Gulf of Mexico domain nested within a 1/60° NCOM Gulf of Mexico model domain.

During the next year, efforts will focus on improving methods of creating computationally efficient grids with accurate topography for the unstructured mesh model that will facilitate creation of storm surge grids for other parts of the coastline. Methods of creating accurate wind fields for both forecasting and post-storm analyses will be investigated. The goal is to test the modeling system in forecast mode to demonstrate its utility.

Publications:

Dukhovskoy, D. S., S. L. Morey, and J. J. O'Brien (2007), Dynamic response of a baroclinic ocean to a tropical cyclone impacting a continental shelf, Continental Shelf Res., In Review.

Kennedy, A.J., M.L. Griffin, S.L. Morey, S.R. Smith, and J.J. O'Brien (2007). Effects of El Nio-Southern Oscillation on sea-level anomalies along the Gulf of Mexico coast, J. Geophys. Res., In Press.

Morey, S.L., S. Baig, M.A. Bourassa, D.S. Dukhovskoy, and J.J. O'Brien (2006), Remote forcing contribution to storm-induced sea level rise during Hurricane Dennis, Geophys. Res. Let. 33, doi: 10.1029/2006GL027021.

Morey, S.L., M.A. Bourassa, D.S. Dukhovksoy, and J.J. O'Brien (2006), Modeling the impacts of remote forcing on hurricane storm surge, in Research Activities in Atmospheric and Ocean Modeling, World Meteorological Organization.

Presentations:

Dukhovskoy, D.S., S.L. Morey (2006), Modeling Topographically Trapped Waves in the Shelf Seas, 13th International Biennial Conference on Physics of Estuaries and Coastal Seas, Astoria, OR.

Dukhovskoy, D.S., S.L. Morey, M.A. Bourassa and J.J. O'Brien (2006), Contribution of Wind-Forced Coastally Trapped Waves to Coastal Sea Level Rise During a Hurricane, annual AMS meeting, Atlanta, GA.

Morey, S.L., D.S. Dukhovskoy, and J.J. O'Brien (2006), Contribution of a remote forcing mechanism to hurricane storm surge, 13th International Biennial Conference on Physics of Estuaries and Coastal Seas, Astoria, OR.

Progress Report: **RISA**
June 1, 2006 – April 1, 2007

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Project Summary

Historically, the Florida State University has been the lead institution in the acquisition and analysis of historical climate data, research on climate variability in the Southeast U.S., dynamic climate modeling, and the production of climate forecast information for incorporation in decision support systems which target the end user. In the interest of brevity, we will focus on activities in which FSU is currently or will be the lead institution rather than a comprehensive accounting of all Southeast Climate Consortium activities by all member institutions.

Objectives

Objectives of the climate strategy fall into five basic categories. While the initial objectives will be directed toward Florida, Georgia, and Alabama, they likely will have applicability to other Southeastern states or North America as a whole.

1. Research and development – Develop a better understanding of climate variability and the overall climate system and produce new and more useful climate information products. Specific areas of research include other modes of variability (NAO, AMO, PDO, etc.), global and regional dynamic modeling and the linkage with crop and hydrologic models, shifts in extremes or tails or the probability distributions rather than near the mean, and variability in extreme events (droughts, freezes, severe weather). Product development will expand the use of spatial presentations through the use of GIS interfaces.
2. Procurement and management of climate data – Historical climate data is the backbone of most of the current climate forecast products and drives much of the basic research of the SECC. Further capabilities are needed in the area of data ingest and quality control, data base management, incorporation of agricultural weather networks in Georgia and Florida and NWS coop modernization stations in Alabama, products updated with near real--time climate data, and development of stochastic weather generators.
3. Partnerships – Continue the strong partnership with extension services, develop and strengthen partnerships with water resource managers and forestry management.
4. Outreach – Work with partners in extension and other agencies to disseminate climate information and provide training and education in the use and interpretation of climate information products. Web delivery of information and decision support systems will remain a priority with continued expansion of products available on *AgClimate* and *Southeast Coastal Climate*.
5. Monitoring and Evaluation – The climate program will continue to work closely with SECC evaluation program to ensure that products, information, and education efforts meet the needs and provide value to the end user. User feedback often provides the impetus for new directions in basic climate research.

Current Progress

Update, expand, and automate climate database operations

Historical weather data is critical to all aspects of this project and provides the basis for all climate information used in the decision support tools, including the wildfire risk forecast. In addition, the historical weather data drives the crop development models whose output is used in peanut, tomato, and potato decision aids. The historical weather data must have a long period (at least 50 years) of relatively homogeneous records and must have a spatial resolution fine enough to reveal detailed climate information at the county level for the states of Florida, Georgia, and Alabama.

The preparation of a historical weather observation database for the Southeast is complete. The weather observations are compiled from the National Weather Service's Cooperative Observer network (NCDC TD 3200) and contain daily values of maximum temperature, minimum temperature, and precipitation for a period of record of at least 50 years extending through December of 2004. The stations are selected based on 1) length of record, 2) data completeness, 3) homogeneity, and 4) representativeness to surrounding agricultural areas. The state climate offices in Florida, Georgia, and Alabama rely on their local expertise and familiarity with the coop network in making the station selections. The final data set contains historical weather records from 92 stations in Florida, 64 stations in Georgia, and 58 stations in Alabama.

Figure1 :NWS Cooperative Observer weather stations used in the historical weather database.

The raw weather data was collected by the state climate offices in Florida, Georgia, and Alabama and sent to Florida State University for quality control and compilation into a common format. The data has been rewritten into portable ASCII files and also into DSSAT format that is used by the crop models. The data was also resample using a technique know as bootstrapping, creating a data set of 1,000 "synthetic" years of monthly data for each weather station and for each ENSO phase. These bootstrapped values are used to generate smooth probability density functions for the climate variables, which drive the probability graphs displayed in the climate tool on

AgClimate (www.AgClimate.org). All of these formats have passed final quality checks and are now used operationally. The data base is available to all SECC members and other interested parties at a common ftp site: ftp://secc.coaps.fsu.edu.

The raw weather observations and the bootstrapped "synthetic" climate date describe the first level of the SECC data base structure, and these data are used both in operations and in research. For operational use in driving the climate decision support tool on *AgClimate*, the data have also been transferred into secondary and tertiary levels using MySQL database server. The secondary level simply mirrors the information found in the primary level, only stored as MySQL data tables and housed on the dedicated SECC server which supports *AgClimate*. The tertiary level of climate data has been condensed into information which is passed directly to the climate tool for display in *AgClimate* in response to user queries.

In order to provide the most current information possible, the historical climate data must be updated periodically. The initial data gathering was done in 2003 by manually downloading the data from servers at the National Climatic Data Center (NCDC). We are currently updating the climate data to include all of 2006 and the manual process has proven cumbersome and time consuming, especially when translating the data to the secondary and tertiary levels. The ability to automate and streamline this update process has become apparent and critical to the future of this project. An automated update process would not only provide the most current information, but allow us to refine some climate and crop-related products to include near-real time climate events and processes.

In conjunction with automating the database updates, we find it beneficial to include weather observations from our partners with the agricultural weather networks in the Southeast, specifically the Florida Automated Weather Network (FAWN) and the Georgia Automated Environmental Monitoring Network (GAEMN). The inclusion of these networks will be instrumental in the development of products that rely on near-real time observations and in filling in gaps that exist in the current NWS Coop network.

Explore other modes of climate variability in the Southeast U.S.

In the past, most climate studies have concentrated on the ENSO cycle, the primary driver of interannual climate variability in the Southeast United States. However, ENSO variability falls short in providing predictive skill to some parts of the Southeast (north Alabama, north Georgia), certain times of the year (warm season), and at other time scales (interdecadal variations, long-term trends). Understanding other modes of variability, such as the Atlantic multidecadal oscillation, PDO, etc. may provide and additional layer of predictability to the climate system. At the very least, this research leads to a better understanding and communication of uncertainties and limitations of forecast products.

In a 2006 study on temperature trends in the U.S. that will be submitted for publication, Daily maximum and minimum temperature data from 758 COOP stations in 19 states are examined. All stations used contain records from 1948 through 2004 and could not be missing more than 5 consecutive years of data. Missing data is replaced using a multiple linear regression technique from surrounding stations. For each station, the maximum and minimum temperatures are first sorted in ascending order for every two years (to remove annual variability) and divided into ten equal parts (or deciles). The first decile represents the coldest temperatures, and the last decile contains the warmest temperatures. A Hanning filter is used to further smooth the high frequency variability. From these decile plots, patterns and trends can be seen over the 56 year period.

To determine if a station has experienced warming or cooling over the period, a linear least-squares interpolation is applied to each decile for the maximum and minimum temperatures. Significant warming or cooling is determined by using the Student's t-test, and bootstrapping the decile data will further examine the validity of significance. Regional maps show the spatial patterns of the warming and cooling trends.

Finally, causes for the trends are examined. Two stations are closely examined. These case studies show that local effects often play a much more important role than large-scale shifts in dictating the significant temperature changes observed at a station. A regional analysis is then performed to determine the reasons for more widespread patterns. Results of this study are presented in a GIS-based web tool at COAPS: http://www.coaps.fsu.edu/gis/decile.php

Focus on variability of extremes and extreme events

Studies have shown that very limited benefit exists in climate forecasts focused on shifts of temperature or precipitation near the mean or climatological average. We feel that the greatest benefit lies in the forecast of extremes, events near the tails of the historical probability distribution. Further research is needed that addresses the likelihood of such extremes, whether it be torrential rainfall, drought, freezes, or severe weather.

The El Nino-Southern Oscillation (ENSO), the North Atlantic Oscillation (NAO), the Pacific Decadal Oscillation (PDO), and the Polar Vortex Oscillation (PVO) produce conditions favorable for monthly extreme temperatures and precipitation. These climate modes produce upper level teleconnection patterns that favor regional droughts, floods, heat waves, and cold spells, and these extremes impact agriculture, energy, forestry, and transportation. The above sectors prefer the knowledge of the worst (and sometimes the best) case scenarios.

Another COAPS 2006 study to be submitted for publication examines the worst and best case scenarios for each phase and the combination of phases that produce the greatest monthly extremes. Data from Canada, Mexico, and the United States are gathered from the Historical Climatology Network (HCN), and data from these stations are bootstrapped in order to expand the time series. Bootstrapping is the stochastic simulation of monthly data by the utilization of daily data with identical ENSO, PDO, and PVO (NAO) characteristics. Because the polar vortex occurs only during the cold season, the PVO is used during January, and the NAO is used during other months. The bootstrapped data are arranged, and the tenth and ninetieth percentiles are analyzed. It has been found that the magnitudes of temperature and precipitation anomalies are the greatest in the western Canada and the southeastern United States during winter, and these anomalies are located near the Pacific North American (PNA) nodes. Summertime anomalies, on the other hand, are weak because temperature variance is low. The magnitudes of the anomalies and the corresponding phase combinations vary regionally and seasonally.

Refinement and development of climate forecast products and their presentation to the end users

AgClimate is a response to the need for information and tools on proactive adaptations to seasonal climate variability forecasts in the southeastern US. Extension agents, agricultural producers, forest managers, crop consultants, and policy makers may use this decision support system to aid in decision making concerning management adjustments in light of climate forecasts. Adaptations include those that might mitigate potential losses as well as maximize yields. *AgClimate* is a web-based climate forecast and information system that was designed and implemented in partnership with the Cooperative State Extension Service. It has two main components: the front end interface and a set of dynamic tools. The main navigation menu includes the *AgClimate* tools, climate forecasts, and management options for crops, forestry, pasture, and livestock. It also includes a climate and El Niño section with background information. The tools section contains two applications that allow a user to examine the climate forecast for his/her county based on the ENSO phase and to evaluate yield potentials for certain crops. *AgClimate* is now operational under the Southeast Climate Consortium and several upgrades are under development and consideration (www.agclimate.org).
FSU will also continue development of new tools and climate variables for inclusion in the agricultural decision support system (AgClimate).

FSU has lead the development of new tools and climate variables for inclusion in the agricultural decision support system (AgClimate). Tools displaying ENSO climate variations in such quantities as chill accumulation, growing-degree days, absolute minimum and maximum temperatures have been added to the basic climate variables available through AgClimate.

A systematic study of chilling for blueberry, peach, and strawberry in Al, FL, and GA was made and the significant impacts of ENSO on chill was characterized for counties and on a regional basis. Ongoing investigation seeks to identify the effects of ENSO signal dynamics on winter chill accumulations. With the support of cooperative extension and producers the research findings were embedded into two perennial fruit management tools that are currently being integrated within the AgClimate.org web site.

The chill accumulation tool allows producers select their crop and location to examine forecasts for chilling for bi-weekly and seasonal periods. The forecasts are presented in a probabilistic format and are modulated on the current JMA ENSO phase. This permits users to examine not only the total amount of chilling that will be accumulated in a year, but also the distribution of chilling through the dormant season. User are also able to examine how the forecast differs from expected conditions in their county and historical data over the preceding five years to help relate seasonal patterns to historical crop performance at their location.

The second application responds to producer requests for forecasts that summarize the available information and present it in a simplified and integrated fashion. Regional maps are provided to users that indicate the probability of chill accumulation for winter fruit crops to exceed the expected values for their location. Users are able to specify the bi-weekly forecast period throughout the winter that they wish to observe and ENSO based forecasts specific to their chosen crop are displayed. The display presents cool conditions in shades of blue and warm conditions in shades of red.

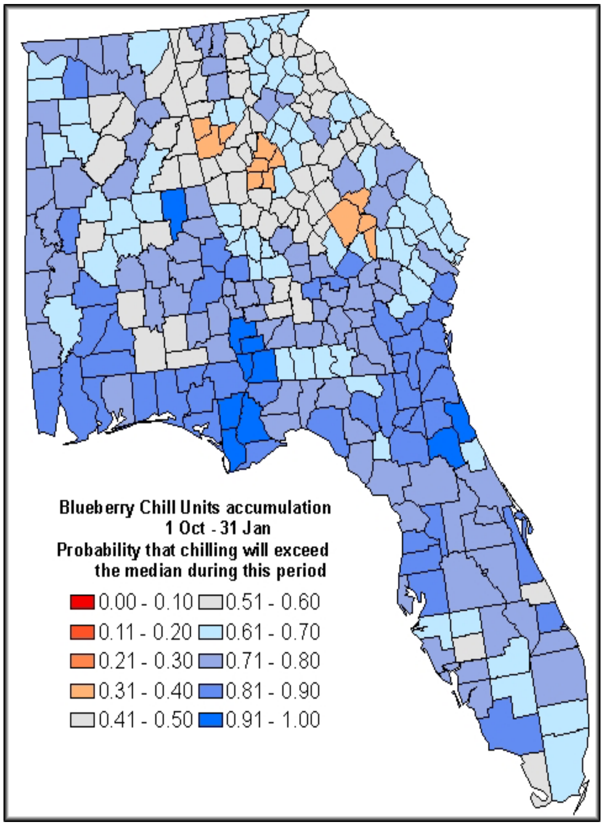


Figure 2: Example of regional chill forecast for Oct 31 through Jan 31 during an El Niño event as it can be seen at *AgClimate (www.agclimate.org).*

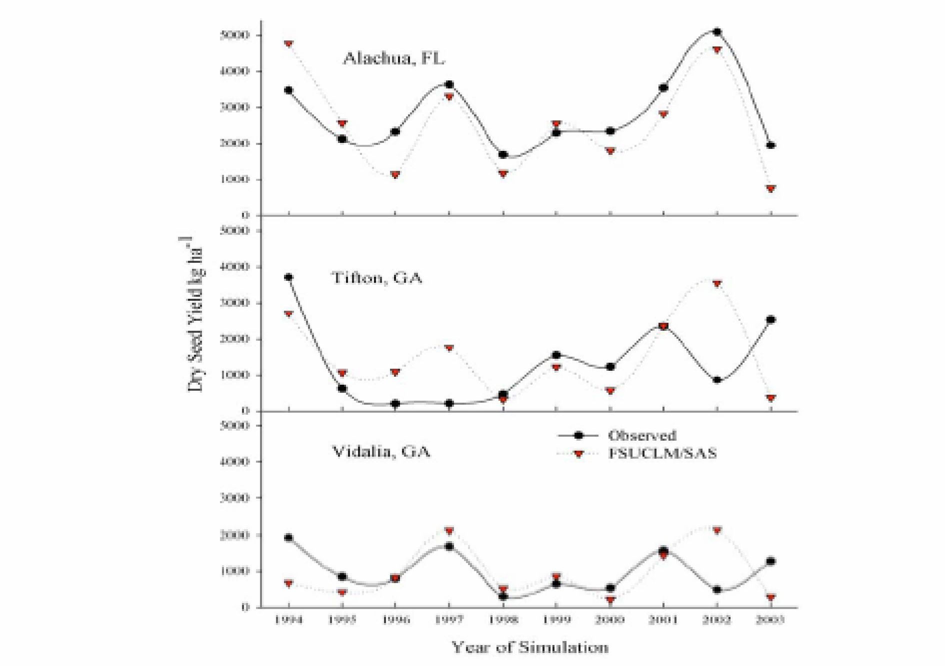
Development, validation and linkage of Global/regional spectral climate model with crop and hydrologic models

In order to build a firm bridge between the numerical climate model and the crop model, the following details must be studied. First, we investigate the performance of an advanced land model, such as the Community Land Model 2, in the seasonal dynamical downscaling of surface fields (maximum and minimum temperatures, precipitation, and solar radiation) through the FSU regional climate model (Shin et al. 2005) and explore the suitability of these surface fields for crop yield estimations using a state-of-the-art process-based crop model (e.g., DSSAT 4.0 family of crop models). These models are able to simulate between 2.5 and 10% of the observed yields when accurate data for crops, soils, and weather are available (Mavromatis et al. 2002).

Second, the dynamical downscaling approach may be compared to statistical/empirical techniques for generating weather variables for the crop models. We also develop hybrid statistical/dynamical methods that will use statistical corrections to dynamically downscaled results to correct biases and to further extract climatic signals to enhance climate prediction for crop model application. It is not only important to forecast monthly means accurately, but daily weather characteristics as well (e.g. frequency of precipitation, diurnal temperature courses, net radiation at the surface, etc.) which are important for crop models. Third, ensemble simulations are used to characterize uncertainty in the forecast. An initial condition ensemble of at least 10 members is used in the climate model. An ensemble based on using different parameterizations in the model can be used in addition to take into account model uncertainty, as was done in the study by LaRow et al. (2005) using convective parameterizations. These ensembles are used to make probabilistic forecasts of crop yields at multiple sites . In addition, a coupled version of atmospheric and land-surface-vegetation models will be developed to capture the nonlinear seasonal weather-yield interactions (Challinor et al. 2003) with the prospect of improving both the yield and climate model forecasts simultaneously.

Satellite information will be used in assessing the performance of the vegetation model to predict the leaf area index (LAI) and soil moisture levels. We intend to offer this technology to the Arizona RISA and the Pacific RISA when we are confident in the performance of this approach. The interannual variability of crop yields is also well simulated by the FSU model, especially in Alachua, FL. Figure 3 Peanut prediction yields using the FSU regional spectral model as daily weather inputs.

Figure 3 Peanut prediction yields using the FSU regional spectral model as daily weather inputs.



Wildfire Risk Forecast System

The wildfire activity potential forecast is based on the Keetch-Byram Drought Index (KBDI). Because of the chaotic nature of weather, all climate forecasts (including this wildfire threat forecast) are presented in terms of probabilities. Weather data that drives the forecast is taken from hundreds of NWS cooperative observer sites in Florida, Georgia, and Alabama. The large number of weather stations makes it possible to provide the forecast at a county level. The wildfire threat forecast is presented in a series of four color-coded maps showing the probability of the KBDI being in the following threat categories:

Abnormally dry (KBDI of 450 or above)
Moderately dry (KBDI of 500 or above)
Severely dry (KBDI of 550 or above)
Extremely dry (KBDI of 650 or above)

Since the KBDI is driven by daily weather and can change drastically based on one or more rainfall events, the maps show the probability of exceeding the threat level *at least 7 days during the month,* rather than for the month as a whole. It has been shown that increased wildfire activity is linked with the deviation of the KBDI from seasonal normals (Goodrick, 1999). The KBDI tends to be at its peak in May in Florida, so values around 400 or 500 are not unusual at this time. Counties are given a plus sign to indicate a greater than normal threat for that month, and given a minus sign to indicate a risk level lower than climatology. The forecast is based on both initial conditions (current KBDI values) and expected climate patterns associated with ocean temperatures in the tropical Pacific. For this reason, the forecast is updated monthly throughout the season as conditions change in the field. The initial forecast is made in January for the months of January through July, and then updated monthly as the season progresses. The wildfire threat forecast is available via the world wide web through *AgClimate (www.agclimate.org)*.

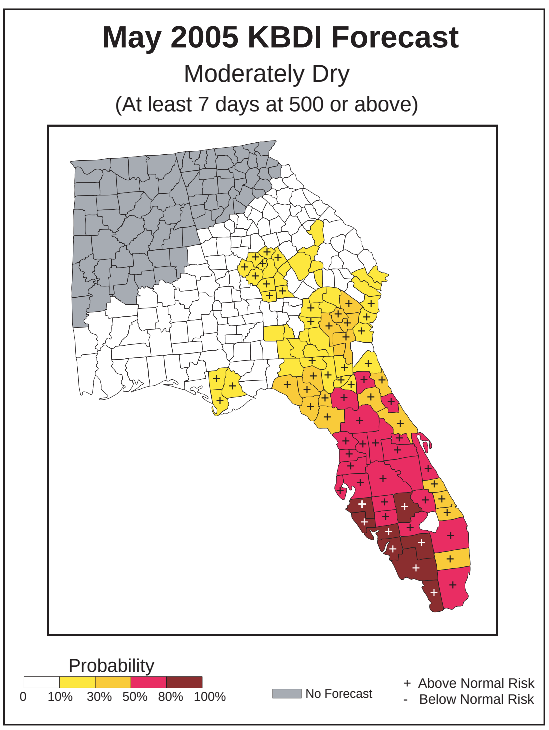


Figure 4. Example KBDI forecast graphic issued in January of 2005 and displayed on *AgClimate* (*www.agclimate.org*).

The KBDI forecast format was developed through many discussions with fire weather experts at the Florida Division of Forestry, the Georgia Forestry Commission, USDA Forest Service, and with extension forestry specialists. The final product resulted after several versions and subsequent refinements from user feedback. The KBDI forecast was presented at the Eastern/Southeastern States Seasonal Assessment Workshop, sponsored by the National Interagency Coordination Center in January of 2006. The forecast was included in the seasonal wildfire outlook for the Southeast that was prepared as a result of this workshop. In addition, the forecast is used by State forestry officials in their allocation of equipment and manpower and in decisions regarding the requests for additional resources. The forecast methods and verification has been submitted for publication (Broley, et al. 2006).

The SECC evaluation team completed an assessment of the wildfire threat forecast system in 2006. State forestry officials, private forest managers, extension specialists, and other forestry interest were introduced or reacquainted with the KBDI forecast products, then interviewed on their presentation and utility. Results from this assessment will be submitted for publication in 2007, and the recommendation will be used to further refine the forecast products and methods.

Outreach

The SECC sees outreach and education as a critical component of our activities. A key to the effective use of the information in *AgClimate* is the proper education and outreach to the users. The agriculture extension services in Florida, Georgia, and Alabama is a key partner in this outreach. FSU has participated in many extension-sponsored workshops in the last year and will continue to provide training and to promote *AgClimate* in the coming year.

Proposed Activities

Update, expand, and automate climate database operations: In order to provide the most current information possible, the historical climate data must be updated periodically. As The ability to automate and streamline this update process has become apparent and critical to the future of this project. An automated update process would not only provide the most current information, but allow us to refine some climate and crop-related products to include near-real time climate events and processes.

In conjunction with automating the database updates, we find it beneficial to include weather observations from our partners with the agricultural weather networks in the Southeast, specifically the Florida Automated Weather Network (FAWN) and the Georgia Automated Environmental Monitoring Network (GAEMN). The inclusion of these networks will be instrumental in the development of products that rely on near-real time observations and in filling in gaps that exist in the current NWS Coop network.

With the NWS cooperative observer network deteriorating and dozens of stations falling out in the last two years, we will explore the use of high-resolution climate data sets such as PRISM and NCEP mesoscale reanalysis for the study of climate variability on local scales and as the data base driving future decision support tools. (D. Zierden, M. Griffin)

Research in pest outbreak appearance and severity: The SECC has begun investigating the role of climate variability in the annual timing and severity of agricultural and forest pests and diseases. We expect to discover that severe outbreaks of some damaging pest populations are closely linked with climate variability on an annual or seasonal scale. The ability to anticipate pest or disease pressures will dramatically increase the effectiveness of integrated pest management (IPM) as well as improve the potential of low-input and sustainable/organic agriculture. (J. Bellow)

Explore other modes of climate variability in the Southeast U.S.: Up until now, all climate information and forecasts produced by the SECC has been based on ENSO alone, the primary driver of interannual climate variability in the Southeast United States. However, ENSO variability falls short in providing predictive skill to some parts of the Southeast (north Alabama, north Georgia), certain times of the year (warm season), and at other time scales (interdecadal variations). Understanding other modes of variability, such as the Atlantic multidecadal oscillation, PDO, etc. may provide and additional layer of predictability to the climate system. At the very least, this research will lead to a better understanding and communication of uncertainties and limitations of forecast products. (J. O'Brien, J. Broley)

Our current technique of forecasting based on annual ENSO climatology has some substantial shortcomings. Two most apparent are A) issues related to skill or accuracy in the 2nd half of each year when the SSTs influencing conditions in the SE may have shifted, but no new ENSO phase can be defined. B) where annual ENSO phases fail to identify ENSO-like conditions such as occurred in the spring 2006 when stereotypical La Niña conditions existed both for SSTs and climate in the SE, yet the period remains defined as a neutral year for climatological purposes. While not straying into the arena of long-term weather forecasting, it is obvious that when clear departures from neutral conditions occur with possibility of impacts on SE climate occur with lead times of 30 to 120 days, farmers can make better decisions.

We will aim to reindex the past 55 years of TD3200 data (COOP) using 5-month mean JMA SST anomalies. I will continue to use -0.5 and +0.5 as the classification threshold and examine the impacts of this alternate classification scheme with 30, 60, & 90 day lags on 15 day thermal time accumulations. A publication that compares the forecast of GDDs using annual ENSO climatology and the lagged monthly index to the observed accumulations will be readily publishable. The results will also indicate the potential skill that we will have if we were to attempt to provide forecasts with 1 month, 2 month, or 3 month leads based on current 3-month mean JMA SST anomalies. (J. Bellow, D. Zierden)

Focus on variability of extremes and extreme events: Studies have shown that very limited benefit exists in climate forecasts focused on shifts of temperature or precipitation near the mean or climatological average. We feel that the greatest benefit lies in the forecast of extremes, events near the tails of the historical probability distribution. Further research is needed that addresses the likelihood of such extremes, whether it be torrential rainfall, drought, freezes, or severe weather. (J. O'Brien)

Development, validation and linkage of Global/regional spectral climate model with crop and hydrologic models: We envision a time when dynamic climate models will outperform ENSO-based forecast systems, especially in the weak areas described above. Basic research in refining the model system and linking output to other physical models will lay the groundwork for taking this step in the future. (T. Larow, D. Shin)

Previous work has suggested that the temperature field forecasts from the FSU regional climate model contributed only small amounts of the total error in crop yield simulations for peanut in the summer months. It may be that these forecasts can be readily applied to crop development models where crops are assumed to be well watered, ie. horticultural crops. It is possible that the skill of these numerical model forecasts exceeds that of climatological based. We will bias correct the 20 ensembles of the FSU RCM for the period 1983-2004 and apply the forecast to GDD accumulations. The forecast skill of the FSU-RCM temperature fields will be assessed for it ability to predict the dates of accumulation thresholds associated with maturity for several common crop types when compared to observations or ENSO climatology. (J. Bellow, D. Shin)

Refinement and development of climate forecast products and their presentation to the end users: The SECC climate program will continue to rely on extension and stakeholders to identify and address climate information that will be of most use. Stakeholder requests have in the past been a major source for the applied climate research conducted by the SECC. The climate program will respond to findings of the evaluation team to test and refine products that optimize understanding and utility for the stakeholder. We anticipate a major effort in the spatial presentation of forecast information using GIS technology.

FSU will also continue development of new tools and climate variables for inclusion in the agricultural decision support system (AgClimate). Tools displaying ENSO climate variations in such quantities as chill accumulation, growing-degree days, absolute minimum and maximum temperatures are needed additions to the basic climate variables available through AgClimate. (D. Zierden, G. Watry)

Enhance the wildfire potential forecast system and extend to other forestry applications:
In response to the wildfire threat forecast assessment, the KBDI forecast tool will be expanded and enhanced for greater utility. A tool will be developed that can display historical, current, or forecasted KBDI values for the Southeast in the same web interface. A KBDI real-time monitoring system will be established that utilizes high-resolution rainfall data such as the NWS stage III radar estimates. The forecast will also be expanded to all 12 months of the year, rather than just the wildfire season. (D. Zierden, G. Watry).

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Progress Report: **Climate Variability in Ocean Surface Turbulent Fluxes**
October 1, 2005 – September 30, 2006

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Project Summary

FSU produces fields of surface turbulent air-sea fluxes and the flux related variables (winds, SST, near surface air temperature, near surface humidity, and surface pressure) for use in global climate studies. Surface fluxes are by definition rates of exchange, per unit surface area, between the ocean and the atmosphere. Stress is the flux of horizontal momentum (imparted by the wind on the ocean). The evaporative moisture flux would be the rate, per unit area, at which moisture is transferred from the ocean to the air. The latent heat flux (LHF) is related to the moisture flux: it is the rate (per unit area) at which energy associated with the phase change of water is transferred from the ocean to the atmosphere. Similarly, the sensible heat flux (SHF) is the rate at which thermal energy (associated with heating, but without a phase change) is transferred from the ocean to the atmosphere. In the tropics, the latent heat flux is typically an order of magnitude greater than the sensible heat flux; however, in polar regions the SHF can dominate.

The FSU activity is motivated by a need to better understand interactions between the ocean and atmosphere on weekly to interdecadal time scales. Air-sea exchanges (fluxes) are sensitive indicators of changes in the climate, with links to floods and droughts (Enfield et al. 2001), East Coast storm intensity (Hurrell and Dickson 2004), and storm tracks (Hurrell and Dickson 2004). On smaller spatial and temporal scales they can be related to the storm surge, and tropical storm intensity. On longer temporal scales, several well known climate variations (e.g., El Nino/Southern Oscillation (ENSO); North Atlantic Oscillation (NAO), Pacific Decadal Oscillation (PDO)) have been identified as having direct impact on the U.S. economy and its citizens. Improved predictions of ENSO phase and its associated impact on regional weather patterns could be extremely useful to the agricultural community. Agricultural decisions in the southeast U.S. sector based on ENSO predictions could benefit the U.S. economy by over $100 million annually (Adams et al., 1995). A similar, more recent estimate for the entire U.S. agricultural production suggests economic value of non-perfect ENSO predictions to be over $240 million annually (Solow et al., 1998). These impacts could easily be extended to other economic sectors, adding further economic value. Moreover, similar economic value could be foreseen in other world economies, making the present study valuable to the global meteorological community.

ENSO, PDO, and NAO (AO) each have atmospheric and oceanic components that are linked through the surface of the ocean. Changes in the upper ocean circulation result in modifications to the SST and near surface wind patterns. Variations in SSTs can be related to ENSO and other climate patterns; however, it is the fluxes of heat and radiation near the ocean surface that transfer energy across the air-sea interface. It is an improved understanding of these turbulent fluxes and their variability that motivates our research (radiative fluxes are difficult to accurately estimate from in situ data; however, satellite-based estimates are available). By constructing high quality fields of surface fluxes we provide the research community the improved capabilities to investigate the energy exchange at the ocean surface.

FSU produces both monthly in-situ based and hybrid satellite/numerical weather prediction (NWP) fields of fluxes and the flux-related variables. Our long-term monthly fields are well suited for seasonal to decadal studies, and our hybrid satellite/NWP fields are ideal for daily to annual variability and quality assessment of the monthly products. The flux-related variables are useful for ocean forcing in models, testing coupled ocean/atmospheric models, and for understanding climate related variability (e,g., the monthly Atlantic surface pressure is a good indicator of extreme monthly air temperatures over Florida).

The flux project at FSU targets the data assimilation milestones within the Program Plan. Our assimilation efforts combine ocean surface data from multiple Ocean Observing System networks (e.g., VOS, moored and drifting buoys, and satellites). One set of performance measures targeted in the Program Plan is the air-sea exchange of heat, momentum, and fresh water. When the FSU products are combined with ocean models (either at FSU or other institutes), performance measures relating to surface circulation and ocean transports can be addressed. The FSU flux project also focuses on the task of evaluating operational assimilation systems (e.g., NCEP and ECMWF reanalyses) and continues to provide timely data products that are used for a wide range of ENSO forecast systems. All products are distributed in a free and open manner at: http://www.coaps.fsu.edu/RVSMDC/FSUFluxes/.

Accomplishments

Our focus over the past year was the expansion of our research-quality, in-situ monthly Atlantic and Indian Ocean products to include the turbulent fluxes. Through this process several data problems were identified and corrected. These products have been compared to a select set of flux and satellite products. In summer 2006, we began developing a the FSU3 flux product for the Pacific Ocean. We also continued our operational production of monthly quick-look wind fields for the tropical Pacific and Indian Oceans. All products are available on a new web site which also includes methods for tracking data users.

Global and Regional satellite stress products have continued to improve through more effective use of rain-flagged (suspect) observations. Preliminary validation of our in situ wind products in comparison to satellite wind products indicate excellent similarity. Formal analysis of uncertainty was delayed when we discovered biases in the NCDC TD-1129 data set lead to biases in our flux products. These biases were corrected through use of the ICOADS data set. We have been working on bias correction of NWP temperature and moisture data, which will be used in our satellite/NWP flux products. We have also improved blending of satellite and a NOAA tropical cyclone analysis product (H*WIND), which was used in a study identifying the cause of a storm surge far greater than the NOAA prediction (Morey et al. 2006). That study lead to a change in NOAA prediction of storm surges, which should prevent this type of error in future forecasts.

Deliverables for FY 2006 included:

1. Complete 1978-present research-quality 1˚ in situ wind and flux analyses for Atlantic, Indian, and Pacific Oceans (north of 30˚S)
    - Subtask 1: Reduce regional and temporal biases in the in situ FSU winds and Fluxes, and improve estimates of random error.
    - Subtask 2: Reprocess 1998-2004 fields based on expected release of new ICOADS data set
    - Subtask 3: Reduce regional biases in the tropics
2. Continue operational production of quick-look winds for tropical Pacific and Indian oceans
3. Complete variability analysis of 1978-present 1˚ analyses for tropical Pacific, Indian, and Atlantic Oceans

4. Evaluate methods for extending tropical Pacific and Indian Ocean fields prior to 1978
5. Extend development of uncertainty fields to cover fluxes
6. Calculate wind uncertainty fields for completed ocean basins
7. Continue comparisons of FSU winds and fluxes to available products
8. Produce global (over water) satellite fields scalar winds and fluxes
9. Develop an objective technique for assessing periods for temporal averaging of satellite data.
10. Produce and distribute products containing surface turbulent and radiative fluxes

Production of research quality 1˚ in-situ fluxes [Deliverable 1]

Over the past year we completed the 1978-2004 1˚ wind and flux products for the Atlantic Ocean (north of 34˚S) and the Indian Ocean (north of 30˚S). Examples of these monthly products, known as the FSU3 (version 3.0 of the Bourassa objective method; Hughes et al. 2006), are provided in Figures 1 and 2. During this process, we discovered that using the NCDC TD-1129 marine observations for 1998-2004 resulted in a discontinuity in the wind and flux products, as well as an error that increased with time. The reasons for this are beyond the scope of our investigations. In Fall 2005, the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) project released version 2.2 of their product. The product included a full update of the 1998-2004 period, so we decided to replace the NCDC data with the ICOADS and reprocessed the FSU winds and fluxes. This required additional man hours to be allocated to the Indian and Atlantic products. The resulting ICOADS based products did not exhibit the same discontinuity that appeared in the version using the NCDC data, and the winds were and excellent match to satellite observations (which are an excellent comparison data set). The ICOADS-based products are now being distributed to the community (see below).

The downside of reprocessing the 1998-2004 period for the Atlantic and Indian oceans it that it delayed our work on a 1˚ product for the Pacific Ocean and our formal error analysis. Analysis of the tropical and North Pacific began in summer 2006 and is 40% complete for the period 1978-2004.

Production of in-situ quick-look products [Deliverable 2]

An older version (the FSU2) of the Bourassa et al. (2005) objective method continues to be applied to create two-degree tropical Pacific Ocean wind (pseudo-stress) fields based on in-situ data. Quick-look two-degree gridded pseudo-stress fields are produced at the beginning of each month using the previous month's GTS-transmitted data. In addition to the Pacific, COAPS continues to produce one-degree pseudo-stress fields for the tropical Indian Ocean using the method of Legler et al. (1989). Related research quality products exist through 2004 for the Pacific and 2003 for the Indian Ocean. We have not updated the FSU2 and Legler research products as we had anticipated switching to the Bourassa 3.0 method. This switch was delayed by the problems discovered with the NCDC data. We anticipate the switch to occur once the 1˚ FSU3 product is completed for the Pacific. Both two-degree fields for the Pacific Ocean and one-degree fields for the Indian Ocean FSU winds are available at http://www.coaps.fsu.edu/RVSMDC/SAC/index.shtml.

Complete variability analysis of 1978-present 1˚ analyses for tropical Pacific, Indian, and Atlantic Oceans [Deliverable 3]

Atlantic Ocean fluxes have been completed; Indian Ocean fluxes have been completed for 1978 through October 2006; and Pacific Ocean fluxes are still being processed (40% complete for the 'modern period'). We have completed a preliminary analysis of variability in the Atlantic (Hughes 2006) and Indian (Banks 2005) Oceans for the available periods.

Evaluate methods for extending tropical Pacific and Indian Ocean fields prior to 1978 [Deliverable 4]

This deliverable was dependent on developments from NASA supported activities, for which funding has been delayed for more than a year.

Extend development of uncertainty fields to cover fluxes [Deliverable 5]

The conceptual framework on uncertainties has been extended to fluxes. The mathematical formulas have been determined, and some of the coding has been completed.

Calculate wind uncertainty fields for completed ocean basins [Deliverable 6]

This task appears to be nearly completed. It was delayed due to the man-hours lost in resolving the issues associated with the subtle flaws in the NCDC TD-1129 data set. We have compared satellite and in situ winds for the QSCAT observational period. The satellite observations are an excellent standard of comparison; therefore, this study resulted in good estimates of uncertainty and biases for that period. These results will be ideal for evaluating the technique we are developing to estimate uncertainty directly from in situ observations.

Continue comparisons of FSU winds and fluxes to available products [Deliverable 7]

We found large difference in winds and particularly surface turbulent fluxes among the products that we compared: FSU3, NOC, WHOI, and NCEPR2. Due to the problems with the NCDC TD-1129 data set, we focused much of our attention to comparisons between the above products and satellite winds (which have less observational uncertainty and much better sampling). The FSU3 and NOC products were very good matches to satellite winds (winds are not included in the WHOI product). Nevertheless, there were large differences in NOC and FSU3 energy fluxes. These differences could be due to either flux algorithms or biases in temperatures and humidities.

Produce global (over water) satellite fields scalar winds and fluxes [Deliverable 8]

This product is dependent on completion of bias corrections in NWP temperatures and humidities. That evaluation was delayed due to the man-hours lost in resolving the issues associated with the subtle flaws in the NCDC TD-1129 data set. We have acquired the data sets to be used in this comparison.

Develop an objective technique for assessing periods for temporal averaging of satellite data [Deliverable 9]

This objective is dependent on the completion of the objective determination of uncertainties (deliverable 6), which was delayed due to the man-hours lost in resolving the issues associated with the subtle flaws in the NCDC TD-1129 data set.

Completion of FSU Flux web page [Deliverable 10]

A new distribution web site for the FSU Fluxes is now available (http://www.coaps.fsu.edu/RVSMDC/FSUFluxes/). The web site provides an overview of the FSU Flux project and User Notes allow the community to make an informed choice about which FSU products (in-situ or satellite/NWP) would best serve their research needs. Access is provided for all scatterometer products, the FSU3, and all older versions of the FSU fluxes and winds. Links to publications resulting from the FSU winds and flux project and technical documentation are provided. New to flux pages is an extensive catalog of "Related Products". This page includes links to available in-situ, satellite, and blended flux products, NWP products, high latitude fields, ocean analyses and wave products, and in-situ flux validation data. The products catalog was produced in response to a need put forward by the World Climate Research Program Working Group on Surface Fluxes.

New to the FSU Flux page is a user tracking tool. When a user first accesses the "In-Situ Fluxes" link on the page, they are asked to enter some basic user contact information (the system is modeled on one used by the National Center for Atmospheric Research Data Support Section). The user's email address is collected and is used as their password for future access to the data site. There are no restrictions on who can access the data, the information collected simply allows us to track our user community. The information is stored in a database and allows the data center to contact users with updates and information related to the FSU Flux products. As of 1 November 2006, we have 24 registered users from 7 countries (Brazil, China, France, Germany, India, U.S., and the UK).

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Figures

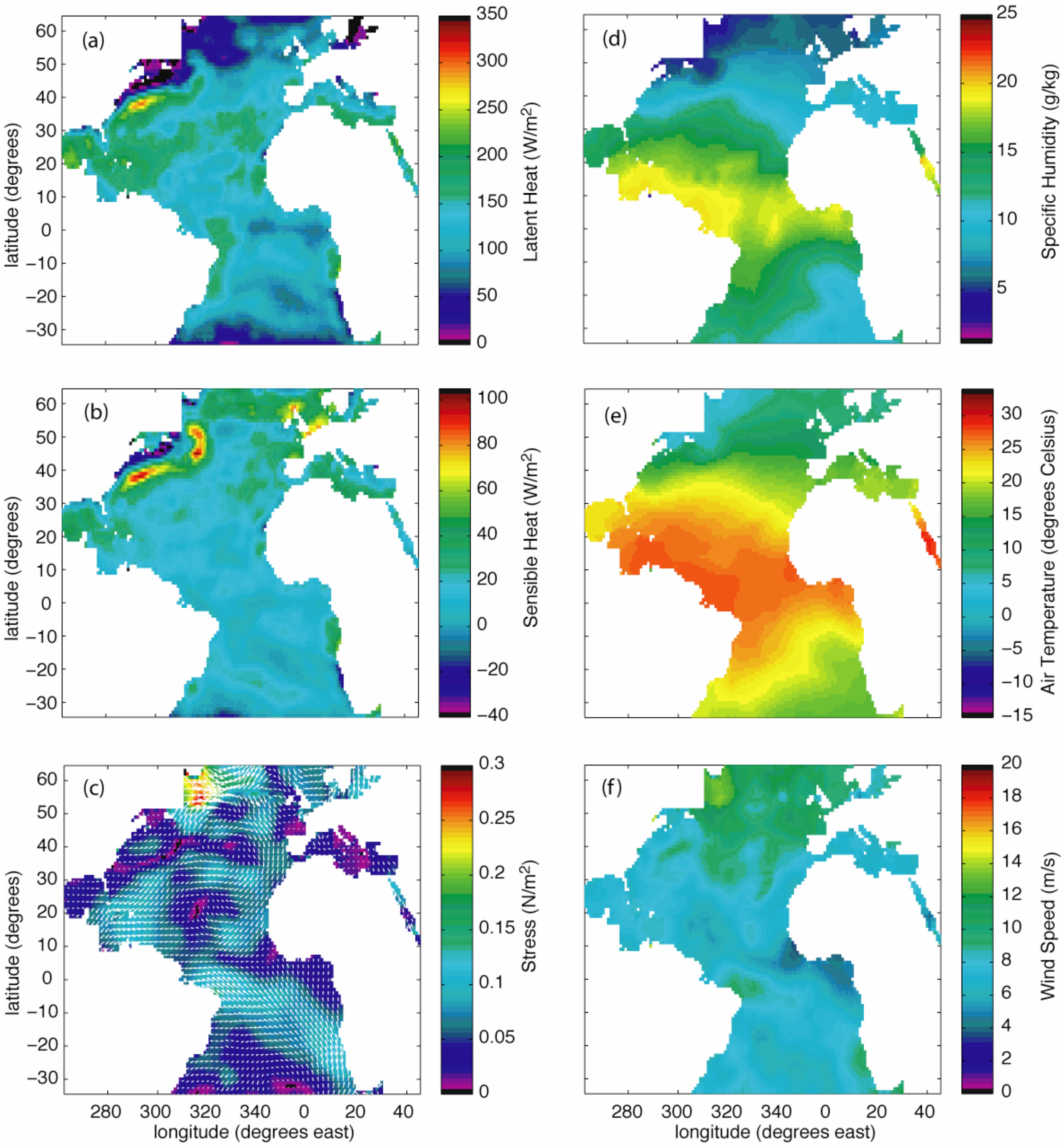

Figure 1. Atlantic Ocean FSU3 flux products for November 2005: (a) latent and (b) sensible heat flux, (c) momentum flux (wind stress), (d) 10 m specific humidity, (e) 10 m air temperature, and (f) 10 m wind speed. Scales and units are noted in the color bars.

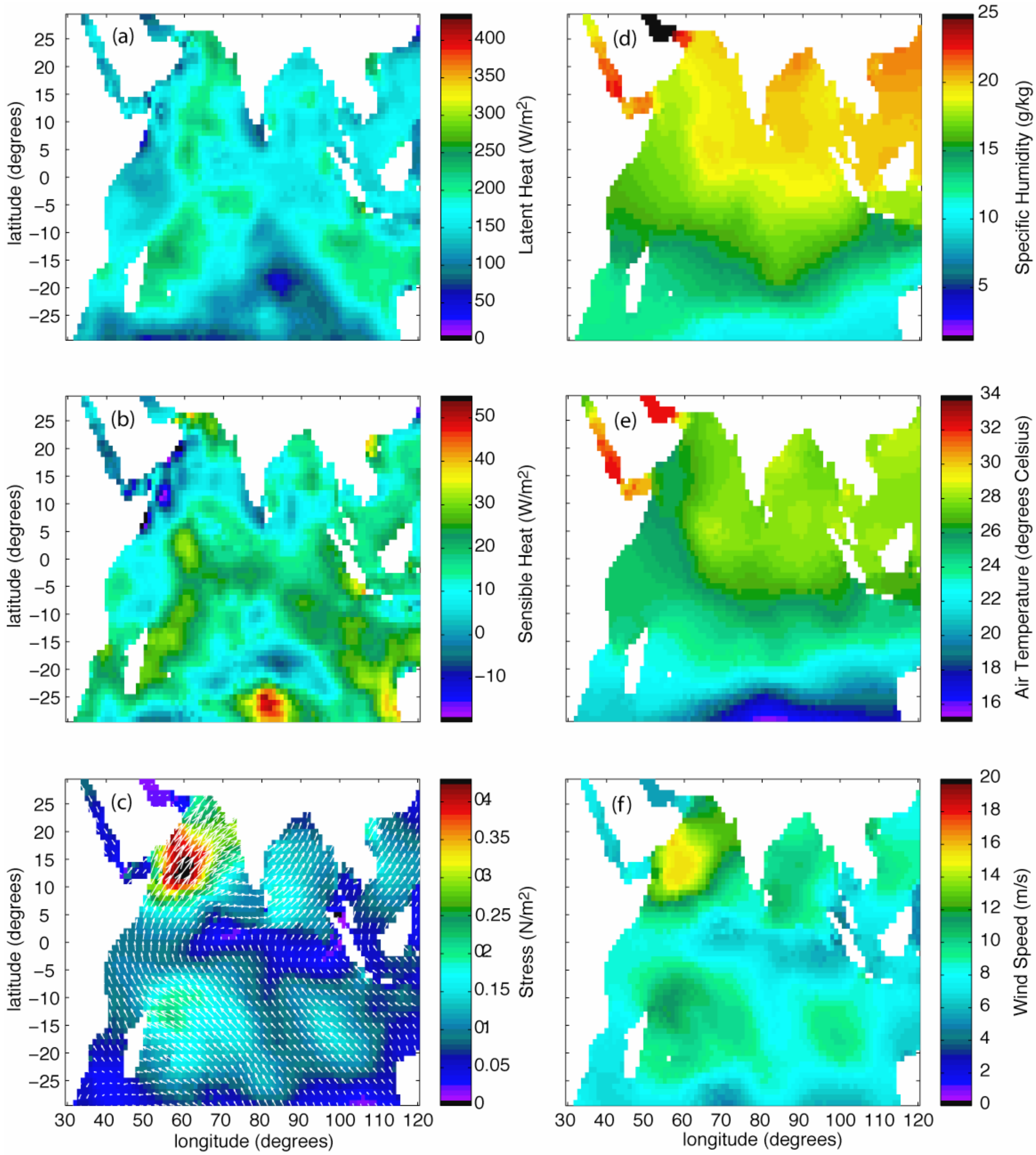

Figure 2. Indian Ocean FSU3 flux products for July 2006: (a) latent and (b) sensible heat flux, (c) momentum flux (wind stress), (d) 10 m specific humidity, (e) 10 m air temperature, and (f) 10 m wind speed. Scales and units are noted in the color bars.

Progress Report: **U.S. Research Vessel Surface Meteorology Data Assembly Center**
October 1, 2005 – September, 30, 2006

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Project Summary

The central activity of the U.S. Research Vessel Surface Meteorology Data Assembly Center (DAC) is the continued development of the Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative (http://samos.coaps.fsu.edu/). The SAMOS initiative focuses on improving the quality of and access to surface marine meteorological and oceanographic data collected *in-situ* by automated instrumentation on research vessels and ships of opportunity. The DAC activities focus primarily on NOAA Strategic Plan Goals 2 and 3 by providing high quality weather and near surface ocean data for use in validating satellite products, global air-sea flux analyses, and model fields. Research vessels are mobile observing platforms that are an essential component of the global ocean observing system. These vessels travel to remote and hard to observe ocean locations that are far from normal shipping lanes.

The rationale for this activity centers on the desire to understand the physical and thermodynamic interaction between the ocean and atmosphere. This interaction is key to our understanding of how marine weather systems evolve, how they impact the ocean, and how the oceans impact the weather. On longer time scales, understanding the interaction between the ocean and atmosphere is necessary to assess our changing global climate system. The role of the DAC is providing the high quality marine meteorological and surface ocean measurements to the research and operational community so that they can address these ocean-atmospheric interactions. High quality observations are essential to our scientific understanding of the ocean-atmosphere interactions.

The DAC was established at the Florida State University specifically to coordinate the collection, quality evaluation, distribution, and future archival of SAMOS data. SAMOS are typically a computerized data logging system that continuously records navigation (ship's position, course, speed, and heading), meteorological (winds, air temperature, pressure, moisture, rainfall, and radiation), and near ocean surface (sea temperature and salinity) parameters while a vessel is at sea. Measurements are recorded at high-temporal sampling rates (typically 1 minute or less). The DAC collaborated with the Woods Hole Oceanographic Institution (WHOI) to design a ship-to-shore-to-user data pathway for U.S. research vessel SAMOS data. In the past, the data flowed from ship to shore only in a delayed-mode with a 3 month to 2 year lag between collection and availability to the user community. The new data pathway supports automated data transmission from each ship to the DAC on a daily basis. A "preliminary" version of the SAMOS data are available on-line within 5 minutes of receipt by the DAC. The preliminary data undergo common formatting, metadata enhancement, and automated quality control. Visual inspection and further scientific quality control result in a "research" quality SAMOS product which are distributed with a delay of several weeks. All quality-evaluated research vessel data at the DAC are freely available to the user community (http://www.coaps.fsu.edu/RVSMDC/html/data.shtml), and we continue to work with several world data center archives (e.g., National Oceanographic Data Center, National Center for Atmospheric Research) to ensure long term stewardship of these data.

Accomplishments

Over the past year our efforts have focused on the continued development of the SAMOS Initiative. We wrapped up a successful data exchange pilot project with WHOI and now are receiving routine data transmissions from the *Knorr* and *Atlantis* while they are at sea. We continued to expand our SAMOS data quality evaluation system and have improved access to both preliminary data files and metadata on our web pages. Throughout the year DAC personnel have been actively promoting the SAMOS Initiative through meetings and working groups, and in May 2006 the DAC coordinated the 1st Joint SAMOS/GOSUD Workshop in Boulder, Colorado (with supplemental funding from a one-off add task from NOAA/OCO). Finally, we continued our delayed mode data processing for NOAA vessels and have actively recruited additional vessels to participate in SAMOS.

Deliverables for FY 2006 included:

1. Recruiting additional vessels to provide daily data transfers to the SAMOS DAC through collaboration with UNOLS, USCG, NOAA, etc.
2. Establishing, where possible, data transfers from international vessels through collaboration with GOSUD and international research vessel operators.
3. Continuing daily and delayed mode quality processing and distribution of meteorological data from select NOAA vessels and vessels recruited to SAMOS
4. Evaluating and improving data ingest and quality control system based on FY 2005 experience.
5. Expanding data and metadata distribution, including collaboration with national archive centers.
6. Compare R/V observations to global reanalysis products and to independent marine platforms (e.g., tropical moorings).
7. Produce a one or more written reports from the 1st Joint GOSUD/SAMOS Workshop (from one-off FY 2006 add task).

The following accomplishments address the deliverables. Also noted are impediments to achieving the deliverables.

Vessel recruitment [Deliverable 1]

Recruitment of additional vessels to participate in the SAMOS Initiative has been an ongoing, albeit slow, process. The project manager (Smith) attended the annual UNOLS RVTEC meeting in Oregon in November 2005 and had good conversations with several vessel operators. Most expressed interest in participating, but initiating new data transfers is still difficult in these times of tight operational budgets for research vessels. In spring 2006 a plan was established with NOAA OMAO to use a new fisheries vessel, the *Bigelow*, as a pilot vessel to establish SAMOS data transfers from NOAA vessels. Most NOAA vessels are equipped with the scientific computing system (SCS) software and the latest version of SCS will be installed on the *Bigelow*. The new SCS will facilitate SAMOS data transfers and once tested can then be spread to other vessels in the NOAA fleet. Due to problems with the *Bigelow* at the shipyard, early tests of data transmissions from NOAA vessels were conducted in August 2006 with data from the *Miller Freeman*. In addition to the NOAA vessels, a dialog is underway with several other UNOLS operators to bring additional vessels into the SAMOS Initiative.

Daily processing of Knorr and Atlantis data [Deliverable 3]

The DAC completed development of the preliminary processing of SAMOS observations received via daily email messages from participating research vessels. Currently two vessels, the *Knorr* and *Atlantis*, have automated their transmission of daily data messages (which include all one minute average observations for the day) to the DAC. The data messages are generated on each vessel by scripts developed by WHOI. Once the data file arrives at the DAC (as an attachment to an email), the data are unpacked, verified that they conform to the format and parameters expected for the individual vessel, and finally are converted to a common netCDF format. The data for each day are then passed through an automated quality evaluation program and data quality statistics are calculated prior to the file being posted for users on the web and ftp (see below). The entire process from arrival at the DAC to distribution of the preliminary data files is fully automated. Preliminary files appear on the data distribution site within 5 minutes of their arrival at the DAC (typically shortly after 0000 UTC). Strict version control is used to track individual data files received from their original email attachment to the preliminary netCDF files posted for users.

The expanded spatial coverage of data received, processed, and on-line from the *Knorr* and *Atlantis* is shown in Figure 1 for FY 2005 and 2006. In FY 2005, the Knorr and Atlantis provided approximately 300,000 individual one minute marine reports. Their contributions doubled to ~600,000 reports in FY 2006, in part due to the inception of SAMOS data transfers in the middle of FY 2005. The quality of the preliminary data for both vessels was good with on average less than 5% of the individual data values being flagged as suspect. The majority of the suspect observations were shortwave radiation values below zero. These unrealistic values often occur because the shortwave sensor is not sensitive to low values and can report negative values at night. Several minor problems with the underway sensors (e.g., an RH sensor that had drifted and was recording anomalously high values) were noted by the DAC analyst and were reported to WHOI. These near-real time reports resulted in rapid repair of problems and a continuous stream of high quality observations.

Continue delayed-mode evaluation of NOAA ship data [Deliverable 3]

The DAC continues to evaluate the quality of the meteorological observations collected by the NOAA vessels *Ronald Brown* and *Ka'Imimoana*. Over the past year the DAC has received and processed *Ronald Brown* observations for the periods May 2004 – March 2005 (Rolph and Smith 2005) and July 2005 – November 2005 (Rolph and Smith 2006). We continue to see improvements in the quality of the meteorological observations from the *Ronald Brown* and these data make up an extensive (1999-2005) data set for a wide array of satellite and model validation studies. In September 2006 we received the underway data from the Ronald Brown covering the period 17 February – 11 September 2006. The data for the *Ka'Imimoana* tend to arrive in multiple data formats which complicates their conversion for quality processing. We recently converted observations for September 2004 - December 2005 and have completed the visual quality evaluation. The quality report and data files for this period of Ka'Imimoana data will be posted on-line shortly. We continue to receive and process additional data for the *Ka'Imimoana* on a regular basis.

Delayed-mode SAMOS processing [Deliverable 4]

The initial processing of SAMOS observations is completed in near-real time (see 1 above). Due to data logging problems on the ship or communication drop-outs, some data arrive several days after they were collected. Often the data are noted to be missing by the analyst at the DAC and arrive after the analyst notifies the vessel technician at sea. In addition, data for a single day can be fragmented and may arrive as multiple files attached to an email. As a result, the DAC developed a method to merge multiple files for a single observing day into a combined, delayed-mode data file. This merged file undergoes additional automated and visual data quality evaluation and is then released as a "research-quality" SAMOS data file for the particular observation day.

Over the past six months, the code to merge multiple files has been developed, tested, and is now operational. The merge program is designed to eliminate duplicate records from the files being merged. Duplicates are eliminated based on a series of rules that take into account the automated quality control applied to the preliminary data files. The merge process is fully automated and the merged files are tracked within the file tracking data base. Currently the merge occurs 10 calendar days after the observation day (when the preliminary data should arrive at the DAC). Using the file tracking database, the analyst can easily reference the original file pieces that were merged to create a single data file for each observation day. Once merged, a summary of the data quality flags on the new file is produced and stored in the database. Developing the delayed-mode processing has been slowed by the heavy demands on our computer programmers (from multiple projects) but we anticipate completion of the codes for visual data quality inspection of the merged files late in 2006.

Public access to observations and metadata [Deliverables 1, 3, 5 and 7]

A web presence for SAMOS has been completed and is accessible at: http://samos.coaps.fsu.edu/. The pages provide information on the SAMOS Initiative as a whole, provides links to relevant literature, and access to past SAMOS workshops (including the 1st Joint GOSUD/SAMOS Workshop). Through these pages, the DAC provides access to the preliminary quality controlled data for the *Knorr* and *Atlantis*. A metadata portal allows users to access ship- and parameter-specific metadata along with digital photos and schematics of participating vessels. Both the metadata portal and data access are user searchable. Criteria include searches by vessel and the observation dates. The web site also provides access to desired SAMOS parameters, accuracy requirements, and training materials. In September 2006 an extensive ship recruiting section was added to the SAMOS web page that includes necessary metadata forms and data specifications for vessels interested in contributing to the SAMOS Initiative.

Liaison activities [Deliverables 2 and 7]

The SAMOS DAC serves as the international coordination office for the SAMOS Initiative. In this capacity, DAC personnel facilitate U.S. and international collaborations on topics ranging from data accuracy, data acquisition and exchange, training activities, and data archival. As a result, Smith and Bourassa have presented at numerous conferences and workshops (see below).

Foremost among the liaison activities was the coordination of the 1st Joint 1st Joint Global Ocean Surface Underway Data (GOSUD)/Shipboard Automated Meteorological and Oceanographic System (SAMOS) Workshop held in Boulder, CO on 2-4 May 2006. In response to an FY 2006 Add Task, NOAA supported the travel, logistics, and venue for the workshop through the UCAR Joint Office for Science Support (JOSS). The SAMOS DAC supported all planning of the scientific program, pre- and post-meeting documentation, and the workshop web page (http://www.coaps.fsu.edu/RVSMDC/marine_workshop3/). The workshop focused on establishing collaboration between GOSUD and SAMOS and addressing the need of the research and operational community for high-quality underway oceanographic and meteorological observations from ships. The SAMOS initiative is working to improve access to calibrated, quality-controlled, surface marine meteorological data collected in-situ by automated instrumentation on research vessels (primarily) and merchant ships. GOSUD focuses on the collection, quality evaluation, and distribution of near surface ocean parameters (salinity and sea temperature) from vessels.

The workshop organizing committee (Shawn Smith, Robert Keeley, Thierry Delcroix, Mark Bourassa, and Christopher Fairall) brought together representatives from the scientific and operational marine observational communities. Participants from the U.S. government represented NOAA (ESRL, AOML, NDBC, NODC, OMAO), the Army Cold Regions Laboratory, and the U.S. Coast Guard. The U. S. university community was represented by the Woods Hole Oceanographic Institution, the Scripps Institution of Oceanography, the University of Miami, University of Alaska, Oregon State University, the National Center for Atmospheric Research, and the Florida State University. A significant international presence included representatives from the CSIRO (Australia); CNRS, IRD, IFREMER, and Mercator Ocean (France and New Caledonia); Environment Canada and MEDS (Canada); Tokai University and JAMSTEC (Japan); and the NOC (UK). Finally, the private sector was represented by Raytheon Polar Services, ADA Technologies, Earth and Space Research, and the International Sea Keepers Society.

The workshop was organized in three sessions: (1) parallel SAMOS and GOSUD technical working group meetings, (2) invited talks and posters focusing on applications of SAMOS and GOSUD observations and potential collaborations between marine observing programs, and (3) a plenary discussion encompassing sessions (1) and (2). A primary discussion topic was the scientific user needs for high-quality, automated, near-surface ocean and atmosphere measurements to achieve objectives ranging from satellite calibration and validation, ocean data assimilation, polar studies, air-sea flux estimation, and improving analyses of waves, precipitation, and radiation. The quantification and reduction of measurement bias and uncertainty was also addressed. The SAMOS and GOSUD working groups addressed both issues internal to each program as well as future interaction between SAMOS, GOSUD, and other international marine observing programs. The result of the workshop was a series of action items, recommendations, and reports (Smith 2006, Smith et al. 2006).

Additional collaborative activities are promoted by the SAMOS DAC. Colleagues at NOAA/ESRL/PSD and WHOI are working to develop a portable seagoing air-sea flux standard instrument suite. This system will be deployed on UNOLS and other research vessels to assess the accuracy of the SAMOS installations on those vessels. Once deployed recommendations for improving SAMOS on individual vessels can be made. The SAMOS DAC continues to promote the development of training materials for marine technicians and scientists planning to make meteorological measurements at sea. The first achievement of the training effort will be the Fall 2006 publication of a "Guide to making climate quality meteorological and flux measurements at sea". Lead authors of the guide are Frank Bradley (CSIRO, Australia) and Chris Fairall (NOAA/ESRL/PSD) and the guide has been a collaborative effort of the SAMOS initiative and the WCRP Working Group on Surface Fluxes. A new collaboration with the National Oceanography Centre (UK) and NOAA/ESRL will allow the SAMOS Initiative to undertake a program of computational fluid dynamics (CFD) modeling of research vessels. The primary focus of the CFD modeling is to identify the accelerations/decelerations of the wind flow over the vessel structure, allowing sensors to be moved to the "best" possible exposure on the vessel.

The program will evaluate existing techniques and new methods to model the maximum number of vessels for the lowest cost. Finally, Smith has joined the Baseline Surface Radiation Network (BSRN) Ocean Working Group to expand the role of the SAMOS Initiative in resolving questions related to radiation measurements at sea.

SAMOS vs. bridge data comparisons [Deliverable 6]

A preliminary comparison was completed between marine meteorological observations that currently are available in the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) and those collected by automated science instrument systems on a dozen research vessels (R/Vs). Research vessels are typically equipped with both an automated science instrument system and a set of independent sensors used by the bridge crew for routine weather reports. The routine bridge reports are the typical source of observations in ICOADS and tend to be reported at one, three, or six hourly intervals. Hourly observations, derived from one-minute interval science system data, are used to evaluate the ICOADS reports from each R/V.

For this experiment, comparison data come from a dozen R/Vs that participated in the World Ocean Circulation Experiment. The comparison reveals large differences in temporal coverage provided by the bridge and science reporting systems on R/Vs. For the vessels examined, a large fraction of the bridge observations do not routinely appear in ICOADS (Figure 2). Using standard statistical techniques, differences in atmospheric pressure, sea and air temperature, humidity, and true wind direction and speed are examined. In some cases, large differences exist between bridge and science observations on individual vessels (Figure 3). Using available metadata (e.g., instrument heights, varying data sources in ICOADS, etc.) we will next consider possible causes for observed differences between the bridge and science observations and their impact on turbulent air-sea fluxes.

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Figures

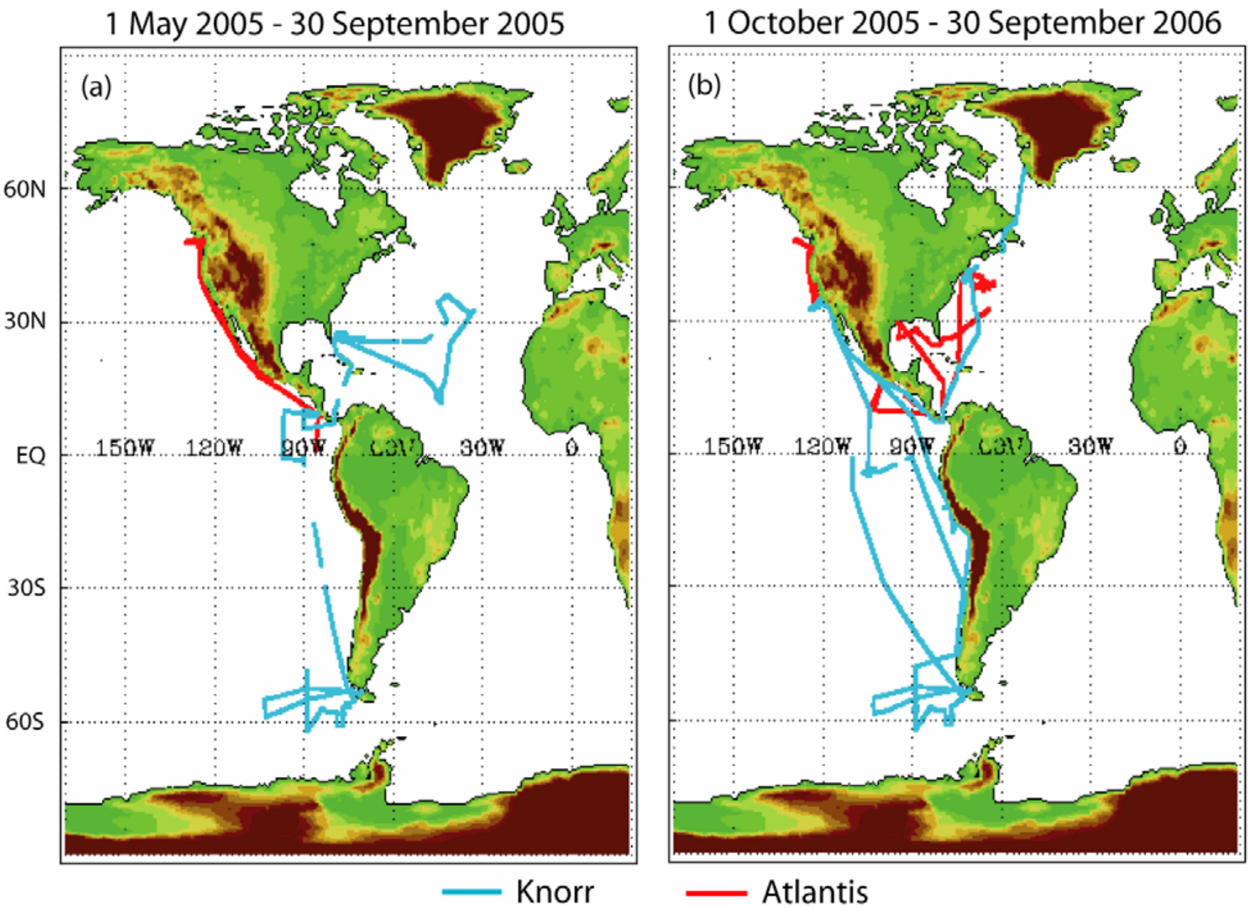

Figure 1. Cruise tracks for the *Knorr* and *Atlantis* for which SAMOS data were received, processed, and distributed by the DAC. The period of record is (a) 1 May 2005 through 30 September 2005 and (b) 1 October 2005 through 30 September 2006.

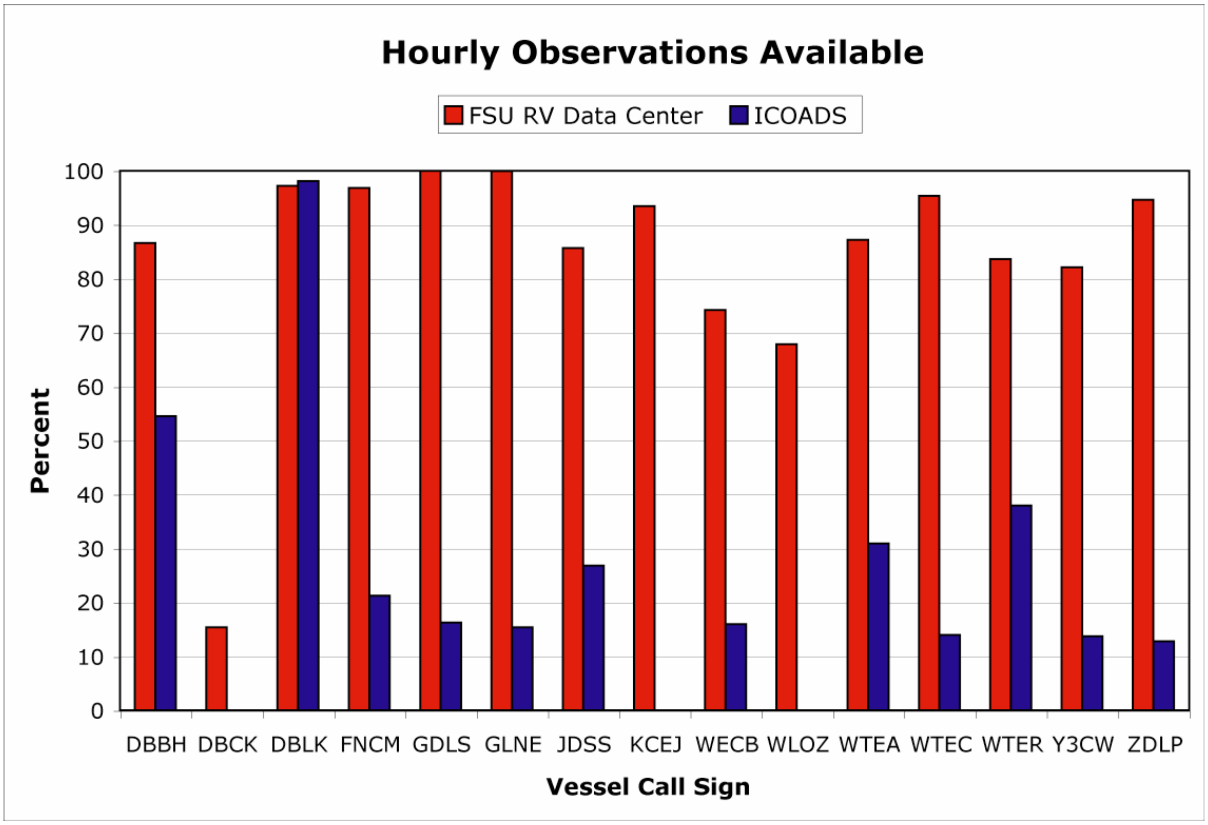

Figure 2: Percentage of hourly marine reports available during 90 WOCE cruises from the ICOADS (bridge) and FSU R/V data center. Vessels evaluated include the *Meteor* (DBBH), *Heincke* (DBCK), *Polarstern* (DBLK), *L'Atalante* (FNCM), *Charles Darwin* (GDLS), *Discovery* (GLNE), *Hakuho Maru* (JDSS), *Knorr* (KCEJ), *Melville* (WECB), *Maurice Ewing* (WLOZ), *Discoverer* (WTEA), *Ronald Brown* (WTEC), *Malcolm Baldrige* (WTER), *A. von Humboldt* (Y3CW); and the *James C. Ross* (ZDLP).

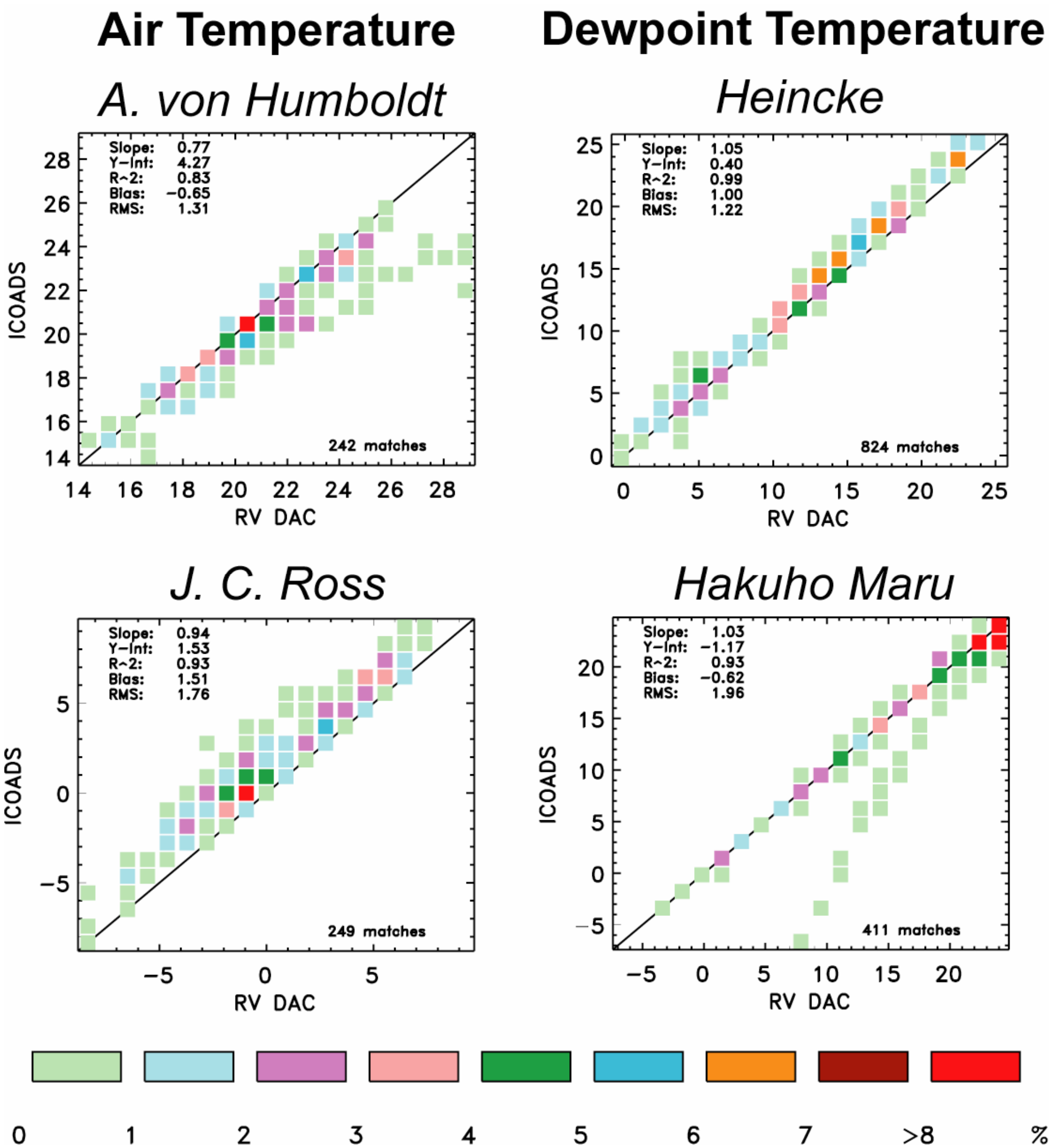

Figure 3: Comparison histograms for unadjusted air (left) and dewpoint (right) temperature (˚C). Histograms represent the percentage of one-to-one matches that fall within each bin on the graph (similar to a scatter plot). Each graph is divided into 20 equal bins on the x and y axis. Percentages are calculated relative to the number of matches for each variable (lower right on each plot). Plots are labeled with the vessel that provided the observations.

Interim Progress Report: Support for NOAA Ocean Observations

The ocean observation component of the NOAA Applied Research Center at COAPS focuses on three areas: (1) the FSU flux products, (2) high-quality meteorological observations from research vessels (R/Vs), and (3) training the next generation of scientists. The members of the ocean observations team also collaborate with a number of national and international panels and working groups to further the objectives of this component of the NOAA ARC.

FSU wind and flux products

We continue the production and distribution of a variety of wind and air-sea flux products. Recently completed objective in-situ wind and flux products include (1) 1978-2004 1˚ fluxes for Indian and Atlantic oceans (north of 30˚S), (2) 1978-present 2˚ winds for tropical Pacific (30˚S-30˚N), and (3) 1990-2004 1˚ fluxes for the Pacific (north of 30˚S). Routine satellite products include (1) daily averaged 1˚ global (over water) winds, (2) monthly averaged ½˚ global (over water) winds, and (3) ½˚ 12 hourly Gulf of Mexico winds. Recent satellite products are hybrid NWP/scatterometer/H*WIND wind fields for studies related to tropical cyclones.

The FSU winds and fluxes are being used to address a number of research questions. We are undertaking a comprehensive comparison of nine recent air-sea flux products in an effort to not only show the differences in the products, but to evaluate how differences in methodology and the input fields used to derive the products can impact the resulting flux fields. Products under consideration include 3 atmospheric reanalyses (NCEPR2, ERA40, JRA25), two in-situ only products (FSU3, NOC-Southampton), three satellite products (HOAPS2, GSSTF2, IFREMER), and one blended product (WHOI-OA). Initial results show the satellite heat fluxes to provide good spatial structure, but these products have suspect magnitudes. The in-situ products have more representative magnitudes and, like the reanalysis products, are relatively smooth.

Recent thesis work by Paul Hughes and Robert Banks explored the interannual variability in the FSU3 wind products. These studies have shown the range of magnitudes of turbulent fluxes (of momentum and energy) associated with natural variability such as the Asian and Indian monsoons, the Indian Ocean Dipole, the North Atlantic Oscillation, and some suggestion of an Atlantic Multi-decadal Oscillation. We also investigated (and continue to investigate) links between the patterns of monthly averaged fluxes and the location of Atlantic Ocean tropical cyclogenesis. Gloria Arrocha used an earlier version of the FSU winds to explore the impact of ENSO on the precipitation regimes in her native Panama. She found the wind pattern associated with ENSO warm (cold) phases to reduce (enhance) precipitation on the Pacific coast of Panama.

The ocean observation group at COAPS is an active participant in the Office of Climate Observation's team of ocean experts. Our role includes the above mentioned work on Atlantic tropical cyclogenesis, analysis of global (over ocean) winds, and studies of variability in ocean fluxes. We are also comparing a wide range of ocean forcing products and plan to evaluate surface fluxes derived by new ocean data assimilation systems (e.g., GODAS, ECCO).

SAMOS initiative

The Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative is becoming well recognized in the U. S. and international R/V community. Although we are currently only receiving data from two U. S. vessels (*Knorr* and *Atlantis*), an ongoing dialog with several additional vessel operators will add a number of vessels to the initiative in 2007. The NOAA Office of Marine and Aviation Operations (OMAO) has completed development of version 4.0 of their Scientific Computing System (SCS) software. Version 4.0 has an application to support SAMOS data delivery to FSU and it is now being deployed on the NOAA fleet. To date we have received test messages from 6 NOAA vessels (*Miller Freeman, Nancy Foster, Henry Bigelow, Ka'Imimoana, Oscar Dyson*, and *Hi'Ialakai*) and we anticipate daily data flow to begin in the coming months. In addition, SCS 4.0 has been licensed to 9 university operators and the USCG enabling these operators' vessels to be integrated into the SAMOS initiative. We thank our colleagues at OMAO for their support of the SAMOS initiative. Finally, we are collaborating with the NSF contractor, Raytheon Polar Services, to establish SAMOS data transfers from the NSF polar vessels. We recently received test SAMOS messages from the *Lawrence M. Gould*. Inclusion of the NSF polar vessels will expand the reach of SAMOS to the under-sampled Southern Ocean.

The final parts of the routine SAMOS data quality evaluation procedures are nearing completion by the data center. This includes establishing a protocol for long term archival of SAMOS data at national data centers. On 6 February 2007, Mr. Smith participated in a conference call with NOAA NODC, OMAO, and NCAR to develop a plan for SAMOS data archival. A draft protocol is in place and the first set of SAMOS data will be sent to NODC in mid-2007.

The data center continues to produce specialized R/V data sets to meet community needs. A select set of high wind speed ≥20 m/s) data has been extracted from our holdings to provide a unique validation set for satellite and flux products. An additional subset of the R/V data was extracted in a format compatible with the International Comprehensive Ocean Atmosphere Data Set. These products extend the impact of our R/V data evaluation efforts to the satellite, air-sea flux, and global climate communities.

Student development

The ocean observation component of the ARC trains future scientist through graduate assistantships, undergraduate employment, and high-school summer programs. Current graduate students include P. Hughes (meteorology), T. Suen (computer science), B. Olafson (meteorology), and D. Moroni (meteorology). Two meteorology undergraduates (K. McKee, J. Griffin) support the FSU flux production and shipboard data center. Recent graduates include: S. Tesoriere (MS., computer science), R. Gange (BS, computer engineering), A. Kennedy (BS, meteorology), Shane Prorok (BS, meteorology), R. Banks (MS, meteorology), and P. Hughes (MS, meteorology). During the summer, we participate in the FSU Young Scholars program offering research experiences for 2-3 high school students.

Outside collaborations

Dr. Bourassa and Mr. Smith continue to promote the research and data activities of the ARC's ocean observation component through participation on a number of panels and working groups. Mr. Smith serves as the data specialist on the WCRP Working Group on Surface Fluxes (WGSF) and was recently appointed to the Baseline Surface Radiation Network (BSRN) ocean working group. Dr. Bourassa is a member of the SEAFLUX working group and several relevant NASA science teams. Mr. Smith and Dr. Bourassa contributed to the production of a "Guide to making climate quality meteorological and flux measurements at sea" (http://samos.coaps.fsu.edu/html/docs/NOAA-TM_OAR_PSD-311.pdf). Lead authorship of this guide was E. F. Bradley and C. Fairall and was undertaken by the WGSF.