2009/2010 CIRA SHADOW AWARD REPORTS

PROJECT TITLE: Advanced Applications of the Monte Carlo Wind Probability Model

PRINCIPAL INVESTIGATOR: Stan Kidder

NOAA TECHNICAL CONTACT: Ingrid Guch & John Cortinas, NOAA/OAR Cooperative Institute Program

PROJECT OBJECTIVES: Under previous Joint Hurricane Testbed (JHT) support a new program for estimating the probability of occurrence of 34, 50 and 64 kt winds was developed. A Monte Carlo (MC) method was developed by NESDIS/RAMMB and CIRA to combine the uncertainty in the track, intensity and wind structure forecasts. A number of operational products are derived from the MC model, include text and graphical products. In the current two-year project, four new applications of the MC model are under development. These include (1) Landfall timing and intensity distributions; (2) Methods for using the MC model to enhance WFO local products; (3) Probabilities integrated over coastal segments; (4) Automated guidance for issuing coastal watches and warnings.

ACCOMPLISHMENT 1: Landfall timing and intensity distributions. The MC model code was modified to create a new output file that includes the track, intensity and wind radii of all 1000 realizations at every time step. A separate post-processing routine is under development that calculates the landfall timing and intensity distributions for a set of user defined points. Because this application requires a forecaster to select points of interest along the coast, a prototype graphical user interface called Hurricane Landfall Probability Applications (HuLPA) was developed for demonstration of these capabilities. HuLPA is java-based, but a similar application could be developed in the ATCF framework.

ACCOMPLISHMENT 2: WFO local applications. In coordination with the Florida Weather Forecast Offices (WFOs) Miami and Melbourne, an extensive verification of the 12 h incremental probabilities was performed for coastal and inland points to help them refine their WFO applications. 400 forecast cases from 20 land-falling storms from the 2004-2008 hurricane seasons were run with the most current version of the MC model (the 2009 version). Figure 1 shows the tracks of the storms included in this study.

The probabilities of 34, 50 and 64 kt winds were determined from the MC model at a set of about 300 coastal points and a corresponding set of points 50 km inland. Figure 1 shows the coastal and inland points included in the verification. Using the NHC post-season best track, the probabilities were validated using the Threat Score (TS), Peirce Score (PS) and Relative Operating Characteristic (ROC) scores. It was found that the TS was the most useful for determining the optimal thresholds for the WFO applications. The TS score measures the percent overlap of the area within a specified probability threshold and the area that experienced those winds. It is not impacted by the large areas that have zero probabilities and no observed winds. Those large “null” areas are included in the PS and ROC scores, making them less useful.

ACCOMPLISHMENT 3: Integrated probabilities. We are working on adapting the HuLPA application described above to include the ability to calculate probabilities integrated along the coastal points selected by the user.

ACCOMPLISHMENT 4: Automated watch/warning guidance. The HuLPA application is in a process of being adapted to include the ability to provide automated guidance on watches and warnings. Because this calculation does not required a user to select a section of coastline, this application could also be fully automated and run outside of HuLPA. Some experimentation is being performed to determine the impact of NHC's revised definitions of hurricane watches and warnings. However, because the new definitions are actually more consistent with what was done in operations the past few seasons than the previous definitions, the thresholds for raising and lowering warnings are probably reasonable since they were tuned to hurricane warnings from the past few years.

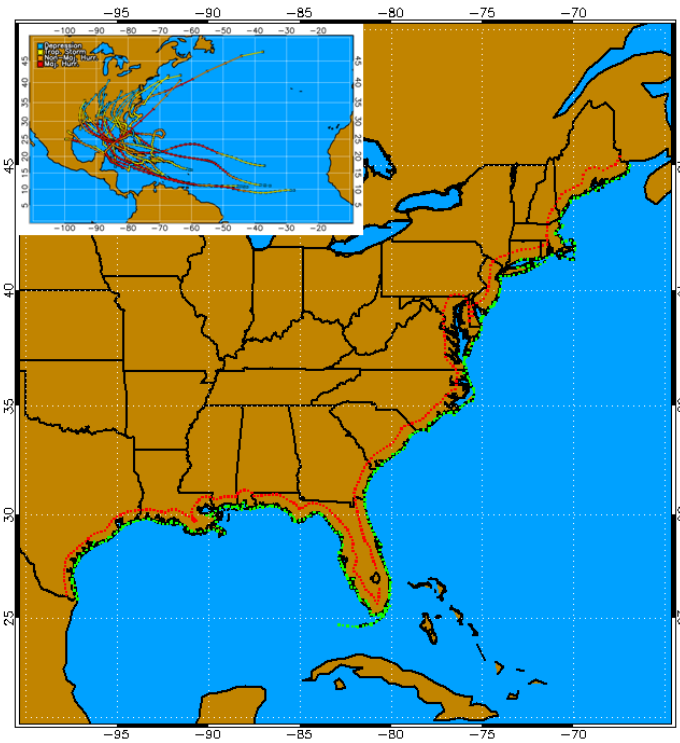

Figure 1: Tracks of storm cases used in this WFO verification study (insert) as well as coastal and inland points for which verification was conducted. Inland points (286) are in red and coastal points (343) in green. Inland points are about 50 km from the coast.

PROJECT TITLE: A Fundamental Climate Data Record of SSM/I, SSMIS and Future Microwave Imagers

PRINCIPAL INVESTIGATORS: Christian D. Kummerow (CSU), Wesley Berg (CSU), Fuzhong Weng (NOAA/NESDIS) and Song Yang (NOAA/NESDIS

NOAA TECHNICAL CONTACT: Jeff Privette, NOAA/National Climate Data Center

PROJECT OBJECTIVE: To construct a Fundamental Climate Data record of SSMI and SSMIS sensors starting from the TDR data collected by NOAA and research community.

ACCOMPLISHMENTS: The task began in October 2009 and thus is only 4 month old at this time. The task was split into two components. The first is the logical organization of data files. For this task we developed a logical NetCDF format that contains all of the original information contained in the TDR files plus satellite ephemeris data that has been calculated from publicly available orbital Two Line Elements for each of the SSMI/SSIS satellites. These files have been orbitized with each orbit beginning on the ascending equator crossing node. These are referred to as the “baseline” files that will serve as the starting point for any procedures applied to the data. Initial quality control has been applied to these fields and a NETCDF output file has been written. These activities will be reviewed by the community in an open workshop in Washington DC on March 22-24, 2010.

In addition to the file specification work, we have begun looking at calibration uncertainties using wind speed. Specifically, we are examining biases between retrieved wind speed and buoys from the available network of observations. Multiple algorithms are being used in order to not bias results toward single algorithm configurations or channel selections. It is too early to make definitive statements about calibration accuracy or stability at this time but all algorithms seem to show some coherent drift in the relative biases against in situ observations over time. Figure 1 shows the wind speed bias from several different wind algorithms applied to TMI, SSMI F11, F13, F14 and F15. Note that the TMI (red line) is dominated by effects related to the boost in August 2001, except in algorithms that explicitly include incidence angle. Bias is calculated by comparison with matching buoys at 89 climatologically consistent stations and the results shown are for matchups where the SST was in the rage 299-301K so as to avoid effects of co-trending temperature. Different types of algorithms tend to show slightly different trends in the bias. The data in Fig. 1 was centered to enhance the trend, but a similar analysis will be used to obtain calibration offsets, which will be used to inter-calibrate the whole SSM/I and SSMIS series from 1987.

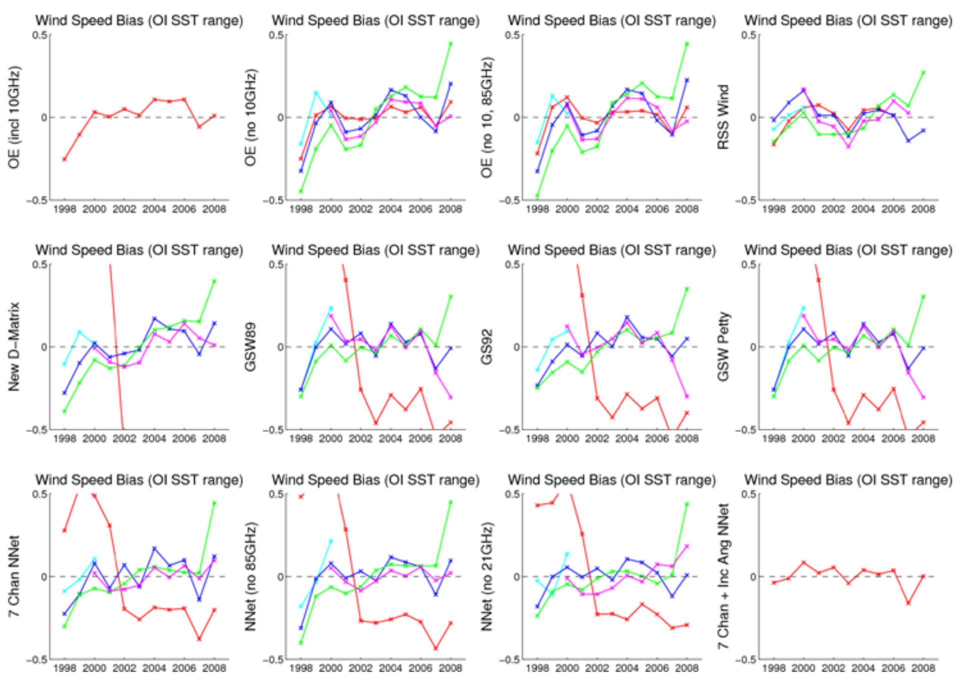

Figure 1: Wind speed bias (satellite minus buoy; ms^{-1}) for each year (1998-2008) for SSM/I F11 (cyan line), F13 (blue line), F14 (green line), F15 (magenta line) and TMI (red line). Each panel shows a different wind algorithm. Values are centered by subtracting the arithmetic mean for each satellite/algorithm.

PROJECT TITLE: Development of an Improved Climate Rainfall Dataset from SSM/I

PRINCIPAL INVESTIGATORS: Christian Kummerow and Wesley Berg

NOAA TECHNICAL CONTACT: Chris Miller, Program Manager, Climate Change Data and Detection Program, NOAA Climate Program Office

PROJECT OBJECTIVE 1: Implement GPROF-2008 for SSM/I. This involves the development of specific rainfall databases and procedures, which are consistent with funded efforts to produce rainfall products from TMI and AMSR-E.

ACCOMPLISHMENT 1: GPROF 2008 has been implemented for SSM/I. Rainfall estimates for the period from December 1997 through 2009 have been computed. Current efforts are focused on identifying and correcting issues with the current retrieval before the final rainfall product is produced.

PROJECT OBJECTIVE 2: Investigate the sensitivity of the SSM/I rainfall products to Tb variability:

1) Across DMSP platforms using F13 as the calibration standard

2) Across radiometer platforms using TMI as the calibration standard

ACCOMPLISHMENT 2: Calibration of the SSM/I sensors is ongoing at this time. While efforts to calibrate the SSM/I TBs using TMI as a reference standard have been done, we are currently working to investigate calibration offsets in SSM/I TBs prior to the launch of TMI in December of 1997 using in-situ ocean buoy wind data. While significant progress has been made, differences between wind speed based calibration efforts and the TMI reference calibration are currently being investigated.

PROJECT OBJECTIVE 3: Investigate the impact of changes in rainfall associated with the diurnal cycle over the tropics using TMI. Since TMI processes throughout the diurnal cycle, the 8+ years of available data can be used to determine the impact of diurnal variations on the different overpass times of the multiple sun-synchronous DMSP satellites within the tropics. Changes in the local observing times of the DMSP satellites due to orbit drift will also be addressed.

ACCOMPLISHMENT 3: The investigation of diurnal cycle impacts is ongoing.

PROJECT OBJECTIVE 4: Produce and distribute daily and monthly gridded SSM/I rainfall products for the period of record. We will distribute the data via both ftp and from our current website (http://rain.atmos.colostate.edu/RAINMAP) In addition, we will work with the community (i.e. GPCP, CPC, and other potential users) to develop a mechanism for long-term distribution of the data though NCDC and/or other data archive centers.

ACCOMPLISHMENT 4: As mentioned above, we have produced daily and monthly rainfall products from the SSM/I sensors for the period from December 1997 through 2009. While the current products are a beta test version which has yet to be finalized, they are publically available online (http://rain.atmos.colostate.edu/RAINMAP08). There are currently both daily and monthly gridded data files containing surface precipitation, total precipitable water, surface wind speed, SST from Reynolds, and cloud, rain, and ice water path estimates. The digital gridded data files are available for download from F11, F13, F14, and F15 along with prerendered images and the capability for users to create custom plots of any of the variables listed above.

PROJECT OBJECTIVE 5: Create a composite monthly climate rainfall product from the available SSM/I data. We will apply the results from our investigation of diurnal cycle impacts on the sun-synchronous sampling of the DMSP sensors to account for sampling-related climate biases.

ACCOMPLISHMENT 5: The creation of a composite monthly climate rainfall product will be done once the algorithm and calibration are finalized and the final products are computed.

PROJECT TITLE: Future Changes of the Southern Ocean CO_2 Fluxes

PRINCIPAL INVESTIGATOR: Taka Ito

NOAA TECHNICAL CONTACT: Ken Mooney, CPO

PROJECT OBJECTIVE: The objective of this project is to better understand the variability of the Southern Ocean carbon sink and to improve our ability to detect physical and biogeochemical responses to current and future environmental changes. Specifically, we aim to (1) quantify the sensitivity of the Southern Ocean circulation to the surface climate over inter-annual to centennial timescales and, to (2) evaluate how circulation changes impact the natural and anthropogenic carbon fluxes, and to (3) determine the "fingerprint" pattern of physical and biogeochemical properties for the detection of predicted climate change impacts.

ACCOMPLISHMENTS: This is a new project.

PROJECT TITLE: Remote Versus Local Forcing of Intraseasonal Variability in the IAS Region: Consequences for Prediction

PRINCIPAL INVESTIGATORS: Eric Maloney (CSU), Shang-Ping Xie (U of Hawaii)

NOAA TECHNICAL CONTACT: Jin Huang, NOAA/CPO

PROJECT OBJECTIVE 1: Determine whether intraseasonal variability in the IAS region primarily locally or remotely initiated.

PROJECT OBJECTIVE 2: Determine how remote forcing by intraseasonal Kelvin wave fronts initiates intraseasonal variability in the IAS region.

PROJECT OBJECTIVE 3: Determine the local feedbacks regulating intraseasonal variability in the IAS region.

PROJECT OBJECTIVE 4: Determine the consequences of local or remote forcing for prediction of tropical cyclones.

ACCOMPLISHMENTS – OBJECTIVES 2 AND 3: Intraseasonal variability in the eastern Pacific warm pool in summer was studied, using a regional ocean-atmosphere model, a linear baroclinic model, and satellite observations. The atmospheric component of the model is forced by lateral boundary conditions from reanalysis data. The aim is to quantify the importance to atmospheric deep convection of local air-sea coupling. In particular, the effect of sea surface temperature (SST) anomalies on surface heat fluxes is examined.

Intraseasonal (20-90 day) east Pacific warm-pool zonal wind and OLR variability in the regional coupled model are correlated at 0.8 and 0.6 with observations, respectively, significant at the 99% confidence level. The strength of the intraseasonal variability in the coupled model, as measured by the variance of outgoing longwave radiation, is close in magnitude to that observed. East Pacific warm pool intraseasonal convection and winds agrees in phase with those from observations, suggesting that remote forcing at the boundaries associated with the Madden-Julian Oscillation (MJO) determines the phase of intraseasonal convection in the east Pacific warm pool.

Sensitivity experiments with the regional atmosphere-only model in which intraseasonal SST variability is removed indicate that convective variability has only a weak dependence on the SST variability, but a stronger dependence on the climatological mean SST distribution.

A linear baroclinic model is used to show that local feedbacks would serve to amplify intraseasonal convection and the large-scale circulation. Further, Hovmöller diagrams reveal that whereas a significant dynamic intraseasonal signal enters the model domain from the west, the strong deep convection mostly arises within the domain. Taken together, the regional and linear model results suggest that in this region remote forcing and local convection-circulation feedbacks are both important to the intraseasonal variability, but ocean-atmosphere coupling has only a small effect.

In another study, satellite-derived QuikSCAT winds and NOAA Outgoing Long-wave Radiation (OLR) for the period of 2000-06, together with reanalysis winds with longer records, are analyzed to understand the sources of the 40-60-day winds and the global propagation of MJO surface signatures. The results demonstrate that the MJO propagates eastward from the Indo-Pacific Ocean to the Atlantic during winter and spring, and the Isthmus of Panama appears to be a dominant pathway for these surface wind anomalies to propagate into the Atlantic.

ACCOMPLISHMENTS – OBJECTIVE 4: Secular changes to Atlantic basin tropical cyclogenesis rates, hurricane power, and resultant hurricane impacts are subjects of considerable ongoing debate. Accurate projection of the north Atlantic environment in the future requires, at a minimum, accurate representation of its present variability in the current climate. Here we examine one metric of Atlantic basin tropical cyclone variability—its well-documented association with the El Niño-Southern Oscillation (ENSO)—in both reanalyses and IPCC AR4 20th century simulations. We find that only 2 of the 22 AR4 models examined realistically represent ENSO-related changes in upper tropospheric winds, vertical wind shear, and genesis potential. This poor showing, coupled with the often sub-optimal representations of ENSO within the same models, calls into question their current utility for projecting future changes to Atlantic basin tropical cyclone activity.

PROJECT TITLE: The Madden-Julian Oscillation: Model Development and Diagnosis of Mechanisms

PRINCIPAL INVESTIGATORS: Eric Maloney (CSU), Adam Sobel (Columbia), Dargan Frierson (U of Washington)

NOAA TECHNICAL CONTACT: Jin Huang, NOAA/CPO

PROJECT OBJECTIVE 1: Contribute to improving the simulation of the Madden-Julian Oscillation (MJO) in the Atmosphere Model 3 (AM3) of the Geophysical Fluid Dynamics Laboratory (GFDL);

PROJECT OBJECTIVE 2: Provide understanding of MJO physics by diagnosing the mechanisms operating in the AM3.

ACCOMPLISHMENTS – OBJECTIVE 2: An aquaplanet atmospheric general circulation model simulation with a robust intraseasonal oscillation was analyzed. The SST boundary condition resembles the observed December-April average with continents omitted, although with the meridional SST gradient reduced to be one-quarter of that observed poleward of 10^{o} latitude. Slow, regular eastward propagation at 5 m s^{-1} in winds and precipitation with amplitude greater than that in the observed MJO is clearly identified in unfiltered fields. Local precipitation rate is a strongly non-linear and increasing function of column precipitable water, as in observations. The model intraseasonal oscillation resembles a moisture mode that is destabilized by wind-evaporation feedback, and that propagates eastward through advection of anomalous humidity by the sum of perturbation winds and mean westerly flow.

A series of sensitivity experiments are conducted to test hypothesized mechanisms. A mechanism denial experiment in which intraseasonal latent heat flux variability is removed largely eliminates intraseasonal wind and precipitation variability. Reducing the lower-troposphere westerly flow in the warm pool by reducing the zonal SST gradient slows eastward propagation, supporting the importance of horizontal advection by the low-level wind to eastward propagation. A zonally symmetric SST basic state produces weak and unrealistic intraseasonal variability between 30 and 90 day timescales, indicating the importance of mean low-level westerly winds and hence a realistic phase relationship between precipitation and surface flux anomalies for producing realistic tropical intraseasonal variability.

2009/2010 CIRA SHADOW AWARD PUBLICATIONS

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