IMPACT OF HIGH RESOLUTION SST DATA ON REGIONAL WEATHER FORECASTS

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1. INTRODUCTION

Past studies have shown that the use of coarse resolution SST products such as from the real-time global (RTG) SST analysis[1] or other coarse resolution once-a-day products do not properly portray the diurnal variability of fluxes of heat and moisture from the ocean that drive the formation of low level clouds and precipitation over the ocean. For example, the use of high resolution MODIS SST composite [2] to initialize the Advanced Research Weather Research and Forecast (WRF) (ARW) [3] has been shown to improve the prediction of sensible weather parameters in coastal regions [4][5}. In an extend study, [6] compared the MODIS SST composite product to the RTG SST analysis and evaluated forecast differences for a 6 month period from March through August 2007 over the Florida coastal regions. In a comparison to buoy data, they found that that the MODIS SST composites reduced the bias and standard deviation over that of the RTG data. These improvements led to significant changes in the initial and forecasted heat fluxes and the resulting surface temperature fields, wind patterns, and cloud distributions. They also showed that the MODIS composite SST product, produced for the Terra and Aqua satellite overpass times, captured a component of the diurnal cycle in SSTs not represented in the RTG or other one-a-day SST analyses. Failure to properly incorporate these effects in the WRF initialization cycle led to temperature biases in the resulting short term forecasts. The forecast impact was limited in some situations however, due to composite product inaccuracies brought about by data latency during periods of long-term cloud cover. This paper focuses on the forecast impact of an enhanced MODIS / AMSR-E composite SST product designed to reduce inaccuracies due data latency in the MODIS only composite product.

2. ENHANCED COMPOSITING TECHNIQUE

The original polar orbiting SST data compositing technique, which provided spatially continuous, accurate, high-resolution SST fields using data from the Moderate-resolution Imaging Spectrometer (MODIS) on NASA's Terra and Aqua satellites, was developed by [2]. This compositing technique generated four maps of SST data per day using data from the previous days' satellite overpasses to augment and fill in for clouds and missing data in the current day's MODIS coverage. The original approach calculated high-resolution (1km) SST composites based on finding a minimum of three cloud free pixels at each location for a given collection period (up to 30 days). The two warmest pixels were then averaged and the value was used to represent the SST at that pixel. The enhanced SST composite used in current forecast studies is described in [7][8][9]and summarized below. The enhanced approach uses near real time GHRSST L2P SST data from the Physical Oceanography DAAC rather than direct broadcast ground stations. This data stream allows for the inclusion of all MODIS and AMSR-E orbital passes and the use of error characteristics and biases specified in the L2P data set to be properly used to combine the different data types. For MODIS, the L2P near real-time data stream also uses a more conservative cloud mask better eliminating contaminated SST data in the composite data set. For AMSR-E, rain flags identify rain contaminated pixels. The enhanced approach also includes improved compositing methodology by combining both MODIS and AMSR-E data in a resolution - data quality - latency - weighted scheme. Access to the full suite of orbital passes for both data sets allows for the generation of a composite over all coastal regions surrounding the continental U.S. One of the primary issues involved in incorporating the AMSR-E microwave data in the composites is the tradeoff between the decreased spatial resolution of the AMSR-E data (25km) and the increased coverage due to it's near all weather capability. Currently, the AMSR-E is given a weight of around 20% compared to MODIS data. In this way the spatial structure observed in the 1km MODIS data is preserved in the compositing process. An example of the MODIS / AMSR-E SST composite product for June 1, 2007 using the above methodologies is presented in Figure 1. The use of MODIS data preserves much of the detailed structure in the 1km data as can be seen in the various thermal features such as the loop current in the Gulf of Mexico and details of the Gulf Stream off the east coast of the United States. The enhanced approach reduces the bias and RMS in the composites by over 50% compared to the original (MODIS only) data set [8][9].

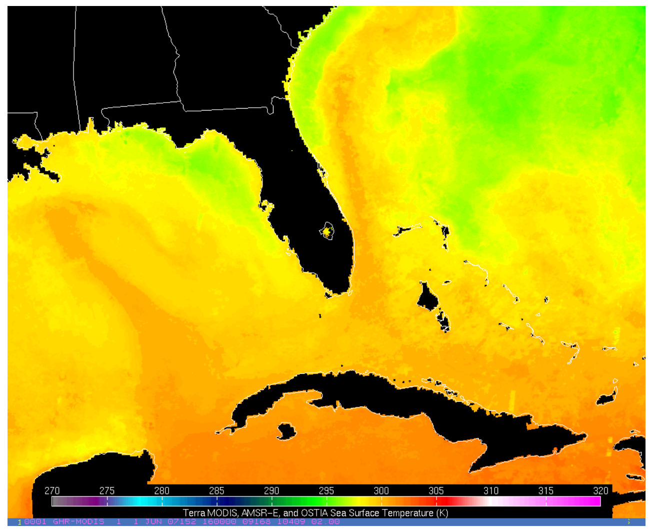

Figure 1. A high resolution enhanced MODIS / AMSR-E SST composite for 1 June 2007 at 1600 UTC.

3. FORECAST IMPACT

In order to investigate the sensitivity of WRF model forecasts to surface thermal forcing provided by the enhanced MODIS / AMSR-E SST composite product, a modeling sensitivity experiment is conducted with the WRF in which the ocean / lake surface data RTG SST values are replaced with high-resolution data the MODIS / AMSR-E SST composites. The simulation domain consists of a single grid of 309 x 311 staggered points in the zonal and meridional directions, respectively, at 4-km horizontal grid spacing. The grid contains 39 sigma-pressure vertical levels extending from the surface to a domain top of 50 mb. The vertical spacing is stretched from a minimum of 0.004 sigma near the surface (corresponding to ~40 m) to a maximum of 0.034 sigma at upper levels. For both the RTG and high resolution

SST initialized simulations, the ARW physics options consist of the typical longwave and shortwave radiation schemes and the WRF Single Moment 6-class microphysics scheme [10] is used without any convective parameterization physics; thus, all convection is determined explicitly by the WSM6 microphysics and model dynamics. For the RTG run, all initial conditions for the atmosphere, land, and RTG SSTs come from the native-resolution (12-km, grib 218) NCEP NAM model 3-h forecast initialized at 0000 UTC. Three-hourly boundary conditions for both the RTG and high resolution SST runs are provided by the NAM model 3-h to 30-h forecasts. The SSTs remain fixed throughout the ARW simulations. Interpolation of initial and boundary condition data are done with the WRF Pre-Processing System (WPS) utilities. Figure 2 shows the difference in the in the RTG and enhanced MODIS / AMSR-E SST fields and resulting 6 hour pressure and wind field differences for the coastal region corresponding to the landfall of tropical storm Claudette early on August 17, 2009. Note the large positive and negative SST differences (2-4 degrees C) over the region (left diagram) indicating the enhanced gradient provided by the high resolution SST values. Resulting pressure and wind field changes in the 6h hour WRF forecast resulting for the SSTs indicates significant difference in these parameters (right diagram) that led to an improved location of the position of the tropical storm at landfall (not shown).

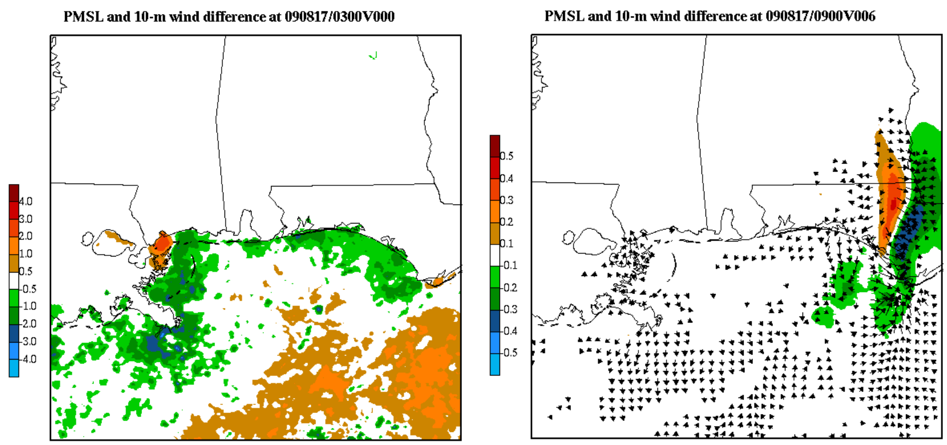

Figure 2. SST (left) and wind and pressure filed differences (right) between initial fields and control and high resolution forecasts for tropical storm Claudette.

A second example illustrating the impact of high resolution sea surface temperatures on weather forecasts looks at intensity forecasts for hurricane Ike (September

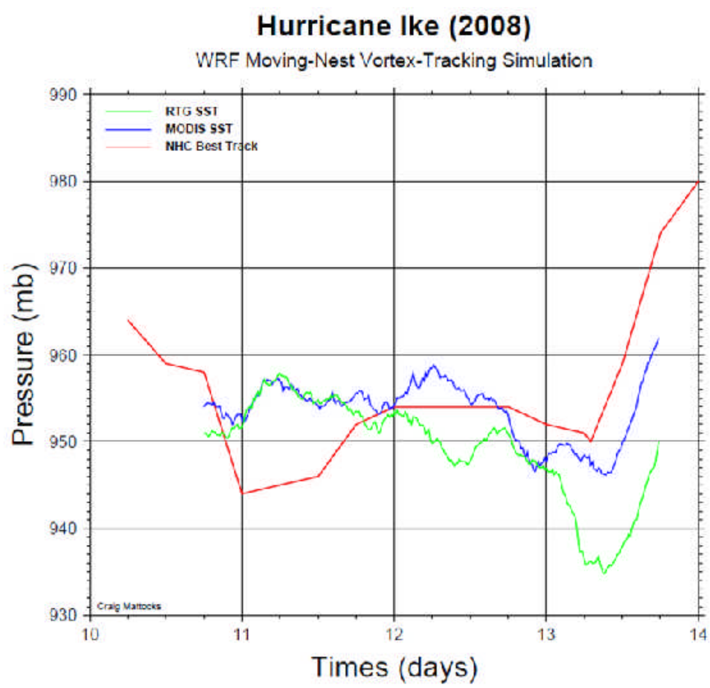

Figure 3. Central pressure (mb) traces from Advanced Hurricane WRF (AHW) simulations of Hurricane Ike (2008) using 50 km horizontal resolution real-time global SST analyses (green) and 1 km horizontal resolution NASA-Marshall SPoRT MODIS SST analyses (blue). The NHC best track central pressure trace is shown in red.

2008) made with the Advanced Hurricane WRF (AHW) [11] . The AHW is a moving-nest, vortex-tracking version of WRF-ARW that includes drag saturation at high wind speeds and a one-dimensional columnar, mixed-layer ocean model to more accurately simulate vertical momentum/heat exchange. The Ike forecast incorporates temporally varying 1-km resolution which significantly improves the simulation of central pressure at landfall when compared with the default 50-km real-time global (RTG) SST analyses (Figure 3). Note how the specification of the high resolution SST composite at the model's lower boundary corrects the predicted over-intensification prior to and after landfall.

4. BIBLIOGRAPHY

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