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# SENSITIVITY OF MEDIUM-RANGE FORECASTS IN WRF TO SEA SURFACE TEMPERATURES

Kathleen M. Carroll and W. J. Capehart
Institute of Atmospheric Sciences, South Dakota School of Mines and Technology, Rapid City, SD

## 1. INTRODUCTION

Model simulations are sensitive to the input data, with respect to the input data's spatial and temporal resolution, as well as the means by which it is acquired. Sea/lake surface temperature can significantly impact a given forecast based on its original source (e.g., observed, model derived or based on climatologies). Obviously, one would prefer to use the most up-to-date Sea Surface Temperature (SST) data available. However, in some applications, such as event meteorology with simulations conducted on site in the field, so as to limit bandwith to the receiving station, additional layers of land and sea surface data may be considered subordinate to the 3-D atmospheric fields. In such scenarios, surface parameters such as SST may be replaced with climatology values derived from global analyses. The purpose of this study is to determine the sensitivity of precipitation, storm track, and intensity of a coastal cyclogenesis event to the SST sources using Weather Research Forecasting Advanced Research (WRF-ARW, Skamarock et al. 2007).

## 2. MODEL CONFIGURATION, DATA AND METHODS

The explosive cyclogenesis event of 24-26 January 2000 was chosen for this study due to its intensity and impact on the coastal communities along the eastern seaboard. For this scenario, a single 200×200 domain with 15-km grid spacing was used with 27 vertical levels. Our domain is centered over 36.5° N and 76.5° W (Figure 1). The model physics chosen were the Lin et al. scheme (Lin et al. 1983) for the microphysics, the CAM scheme for both longwave and shortwave radiation (Collins et al. 2004), the Kain-Fritsch cumulus scheme (Kain and Fritsch 1990, 1993), the Monin-Obukhov scheme for surface layer physics, the YSU scheme for the planetary boundary layer (Hong et al. 2006), and the NOAH land-surface model (Chen and Dudhia 2001).

* *Corresponding author address:*
Kathleen Carroll, Institute of Atmospheric Science, SD School of Mines, Rapid City, SD 57701-3995; e-mail: Kathleen.Carroll@mines.sdsmt.edu.

The sources of SST data are the North American Regional Reanalysis (NARR, Mesinger et al. 2006), the NOAA Optimum Interpolation SST V2 Product (Reynolds et al. 2002) updated weekly, and 20-yr weekly climatology (1988-2007) derived from the NOAA SST product. NARR data also provided the 3-D and land surface information (e.g, soil temperature and soil moisture). The model was run twice for each SST source, for medium- and short-range forecast scenarios. The medium-range runs were for a period from 00 UTC 17 January 2000 to 00 UTC 28 January 2000 while the short-range forecasts were from 00 UTC 24 January 2000 to 00 UTC 27 January 2000.

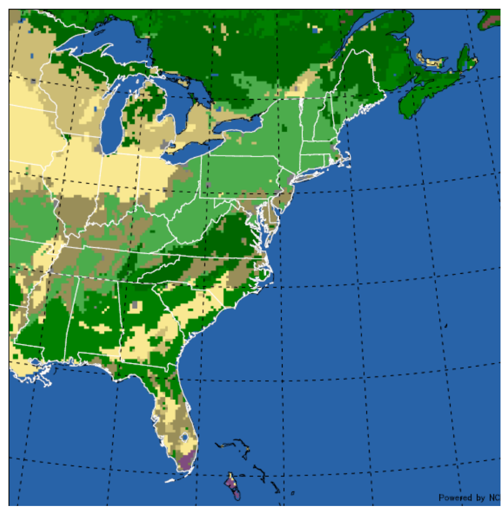

*Figure 1: Land Cover used for the January 2000 explosive cyclogenesis event.*

## 3. RESULTS

Figures 2 and 3 show the comparisons of the NARR vs. NOAA SST and the NARR vs. the NOAA Climate SST, respectively. In the NARR vs. NOAA SST comparison, the SST difference is small but noticeable, with a maximum temperature difference of -1.5 K, located off the U.S. coast from Massachusetts to Virginia. On the other hand, the SST difference in the NARR vs. Climatology comparison is greater, and more widespread. There are maximum differences of ±2 K stretching the entire length of the ocean domain. The most prominent difference when comparing the results of the NARR vs. NOAA SST and NARR vs. Climate comparisons is the warm bias of the Climate SST along the Georgia and Florida coasts, as well as in the Western Atlantic, off the coast of North and South Carolina.

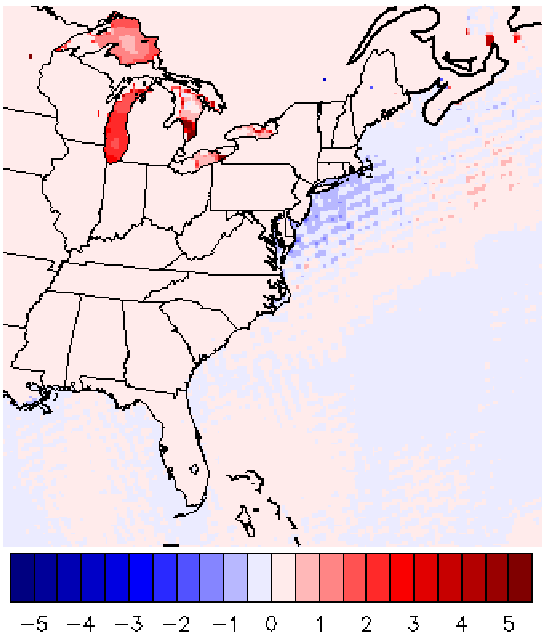


*Figure 2: Comparison of NARR vs. NOAA Analysis SST differences (NARR-NOAA Ambient SSTs, K), valid 24 January 2000.*

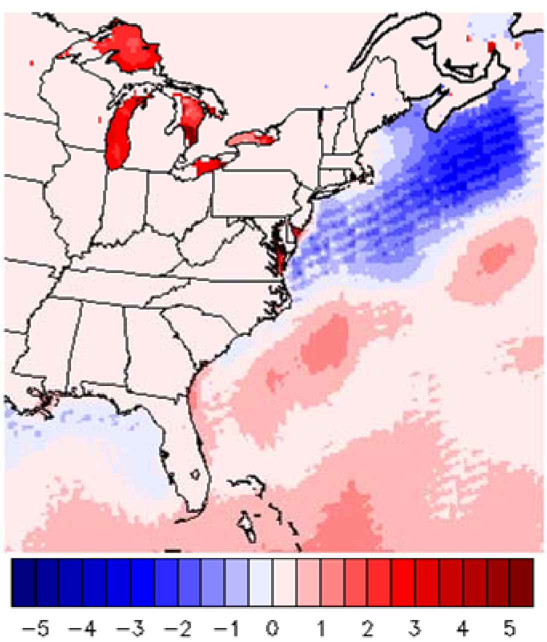


*Figure 3: Comparison of NARR vs, Climatology SST differences (NARR-NOAA Climatology SSTs, K), valid 24 January 2000.*

Figure 4 shows comparisons for mean sea level pressure, $p_{msl}$, valid 18 UTC 25 January 2000. Visible is the relative insensitivity of local $p_{msl}$ to the SST data source. The $p_{msl}$ is, however, very sensitive to the forecasted lead time of the cyclone event, with the medium-range forecast (magenta) placing the central pressure to the east of the short-term forecast central pressure. There is also a significant difference in the strength of the central low pressure. The actual analysis of the storm at this time shows a central pressure of 985 hPa. Figure 4 shows the short-range NOAA climate SST run recording a central pressure of 979 hPa, while the medium-range NARR run records a central pressure of 986 hPa. As such, while the medium-range simulations have a central pressure closer to that of the actual analysis, and the short-range simulations overpredict the intensity, the location of the low in the short-term runs is much closer to that of the actual analysis, which makes for a more accurate forecast.

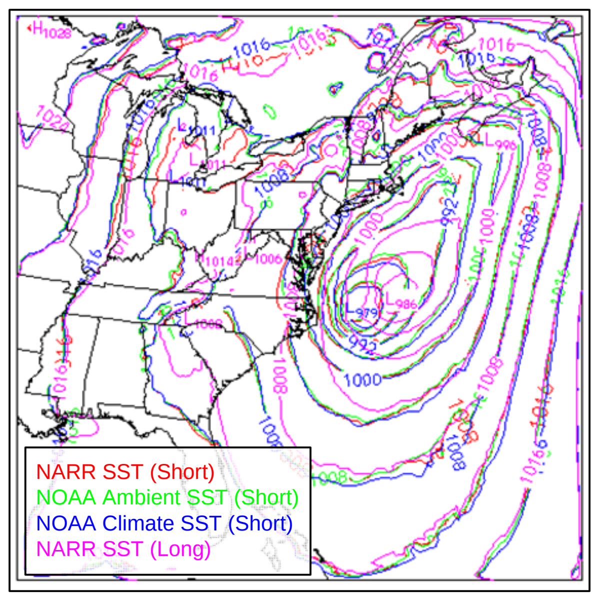


*Figure 4: Comparisons of the mean sea level pressure, $p_{msl}$* (hPa), *of all three short-range runs, and the NARR SST long range run, valid 18 UTC 25 January 2000.*

Comparisons of 500-, 700- and 850-hPa heights were also made. For each pressure level, all of the short runs are compared against one another and all of the medium-range runs are compared against each other. Figure 5 shows the short-term runs vs. the medium-range runs valid at 12 UTC 25 January 2000 at 500 hPa. Here, the short-range forecasts pick up the low pressure off the North Carolina coast but the medium-range forecasts do not. At 700 hPa, both the medium- and short-range runs pick up a low pressure; however, it is much more intense and closer to the coastline in the short-range runs than in the medium-range runs (Figure 6). The results at 850 hPa were similar to those at 700 hPa; however, there was slightly more separation between the NARR and the NOAA SST and the NOAA SST climate plots, with the climate plots being noticeably displaced from the NARR and NOAA plots.

These results show that the longer the model is run, the more important the SST data source becomes. This also demonstrates the role of SSTs in the development of the pre-cyclone atmospheric environment. Although cyclogenesis is mostly controlled by conditions aloft, the SST input and its modification of the lower atmosphere can also have an impact. The differences in SST in the pre-storm environment were very subtle; however, as the storm developed, small differences in strength and location of the storm between the three SST data sources was noticed.

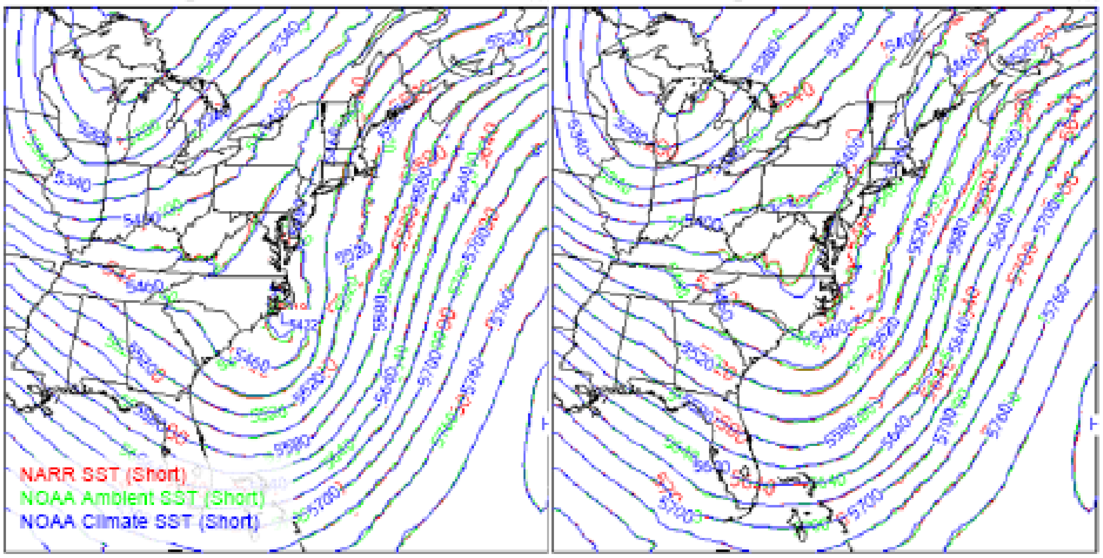


*Figure 5: Comparison of the 500-hPa heights (gpm) for the short-range runs (left) and the medium-range runs (right), valid 12 UTC 25 January 2000.*

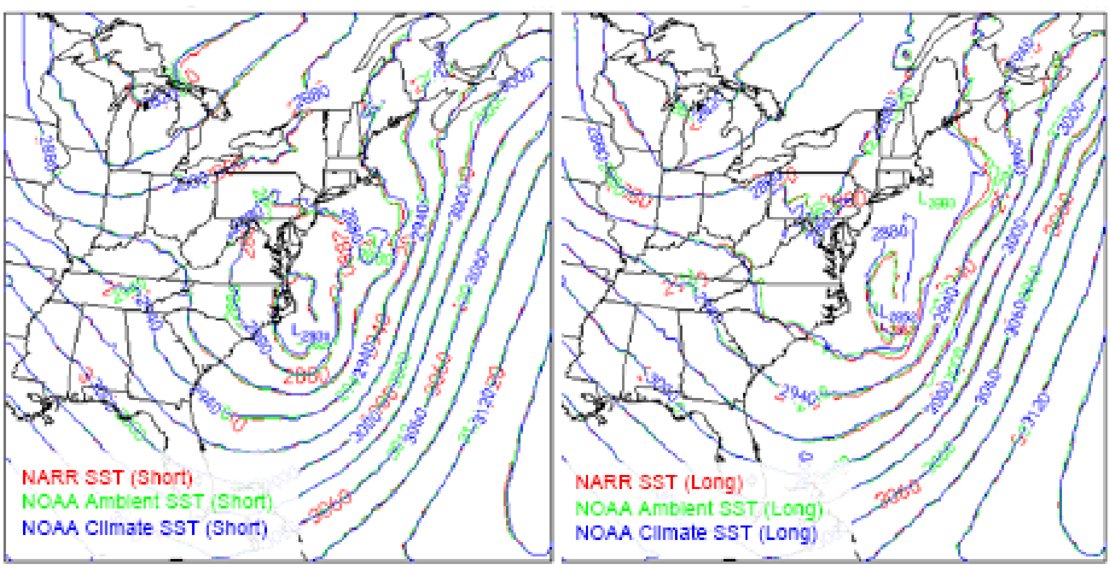


*Figure 6: Comparison of the 700-hPa heights (gpm) for the short-range runs (left) and the medium-range runs (right), valid 12 UTC 25 January 2000.*

Examined next is the total daily precipitation valid 12 UTC 25 January 2000 to 12 UTC 26 January 2000. All six runs were plotted separately, and as with the rest of the parameters discussed previously, there was little difference in daily precipitation with respect to SST data source. There was, however, a large difference in the totals for the short-range runs compared to the medium-range runs. Figure 7 shows the total daily precipitation comparison of the short- and medium-range NARR runs. The difference in both location and the amount of precipitation is substantial. This difference is attributed to the difference in storm track and intensity of this storm, as will now be discussed.

Figure 8 shows the analyzed and simulated storm tracks from 12 UTC 24 January 2000 to 06 UTC 26 January 2000. The black track shows the storm's actual track, illustrating how both the short- and medium-range simulations track the storm further from the coast than the analysis. The medium-range track is much further out from the coast than the short-range tracks, and is the main reason why the simulated daily precipitation totals along the eastern seaboard are much less than the short-range runs. Again, the similarities between all three short-range runs with one another are shown. There is very little difference in the storm track for the three different but reasonable SST data sources, which again proves that the SST data source had little impact on the intensity and location of this storm.

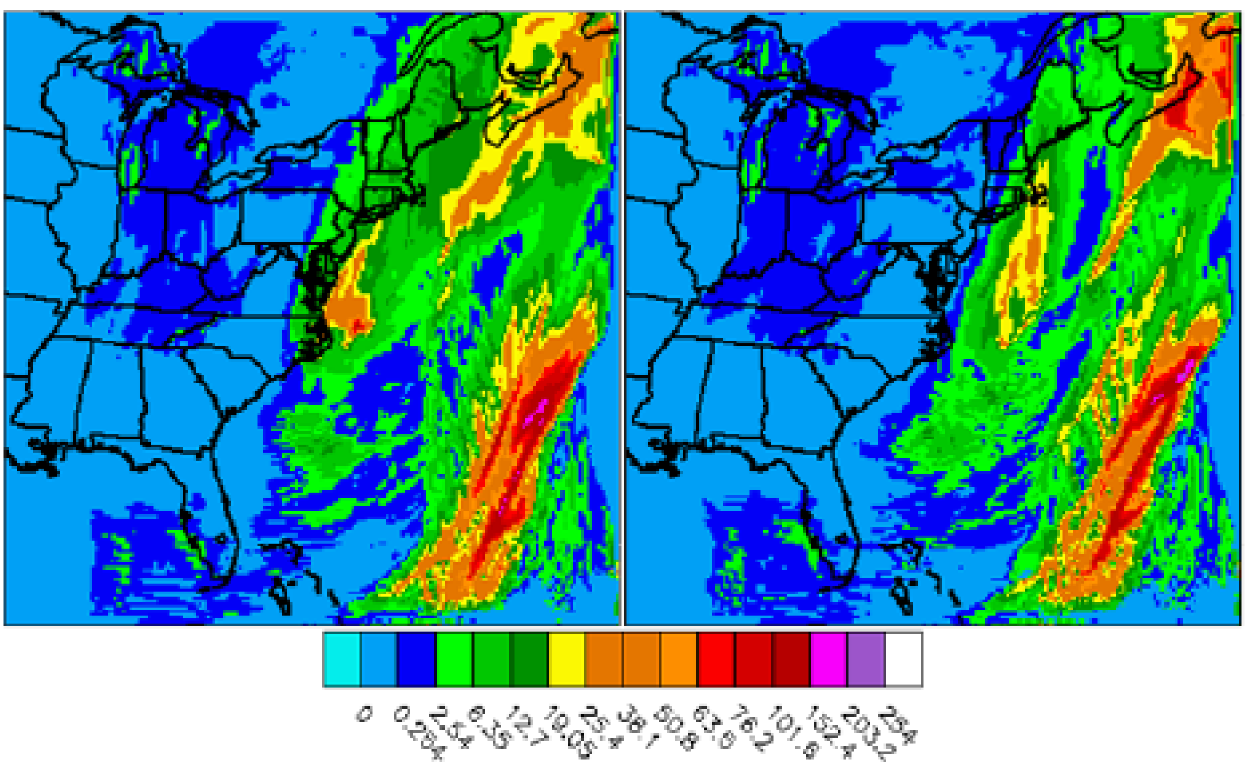


*Figure 7: Total daily precipitation (mm) for the NARR SST short-range (left) and medium-range (right) runs, valid from 12 UTC 25 January 2000 to 12 UTC 26 January 2000.*

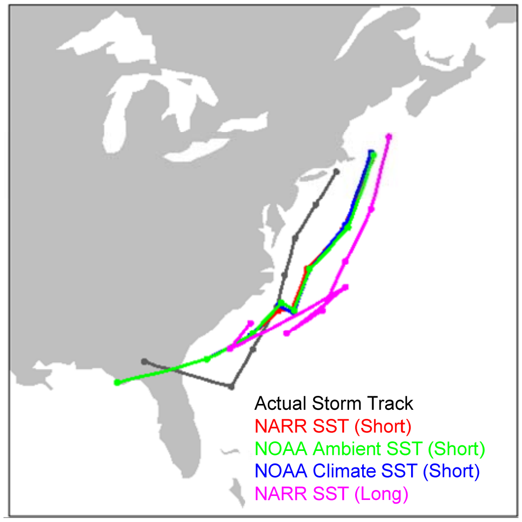


*Figure 8: Storm tracks, valid from 12 UTC 24 January 2000 to 06 UTC 26 January 2000.*

## 4. CONCLUSIONS AND FUTURE WORK

This study shows that the time of forecast initialization has a greater impact on the location and intensity of a coastal US middle latitude storm than does the choice of ambient vs. climatological SST data source. These results, however, are important for forecasts conducted in the field where data and resources are limited. Given these results, a climatology SST data set performed satisfactorily against a more ambient or detailed dataset for a synoptic scale system, such as the one analyzed in this study. With that being said, if one were to look at coastal events on the meso- or microscale, the SST data source may become increasingly more important and, as such, these results do not transfer to those smaller scale features. A follow-on study to this one could follow a similar comparison scheme, but have a smaller domain and assess the effect of the SST data source on small scale features, such as land-sea breezes. A conclusion could then be made to determine under what circumstances it would be acceptable to use SST climatologies, and when more representative SST input data are needed.

## 5. ACKNOWLEDGEMENTS

This work was supported through US Army Contract W15QKN-06-D-0006 0007.

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