2.3 IMPACT OF INITIAL CONDITIONS ON LOCAL MODELING

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1. INTRODUCTION

Local modeling efforts have expanded dramatically with explosion of inexpensive, high-speed personal computers. Many National Weather Service (NWS) offices run either the workstation version of the Eta or the NCAR /PSU MM5 models (Grell et al. 1995). Few NWS offices have the computing time necessary to run their own four dimensional data assimilation systems (FDDA). Therefore, in order to run local models, they must rely on initial conditions provided by computing centers, such as the National Centers for Environmental Prediction (NCEP) for both initial and boundary conditions.

Local mesoscale models initialized from centrally produced models for initial conditions may be subject to a multitude of errors. Data problems at NCEP may lead to poor initial states for the local model. Another potential source of errors could arise from initializing a fine scale model that has detailed physics with coarse data. The finer scale physics may act on this coarse data producing an unrealistic solution. Finally, with two years of experience at State College using the Eta as boundary conditions, it appears the local MM5 forecast is significantly influenced by the Eta forecast.

The goal of this paper is to show the impact of low-resolution sea surface temperature (SST) data on a locally run version of the NCAR/PSU MM5. Two model runs were initialized at the same time, the first using the operational NCEP Eta for initial and boundary conditions (***OLDSST***). The second using a parallel run of the Eta with a higher resolution SST analysis for initial and boundary conditions (***NEWSST***). The objective was to examine the impact of SST on each MM5 run.

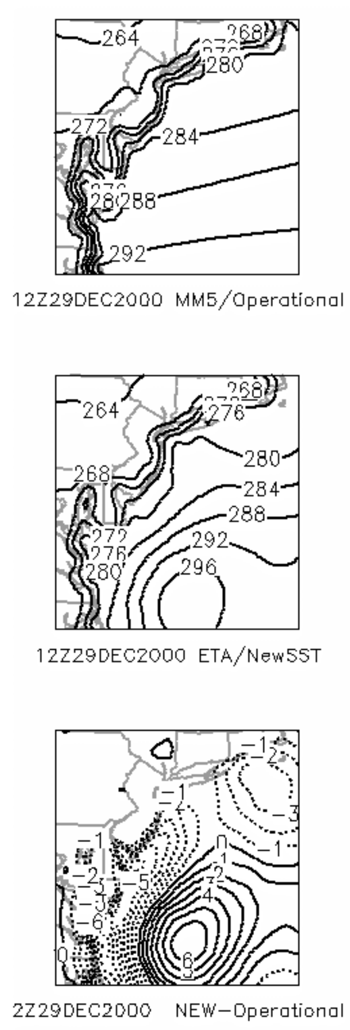

Figure 1. Eta SST (K) data valid at 1200 UTC 29 December 2000 showing a) the operational, and b) the high-resolution analysis and c) the difference field. Isotherms are every 2K and differences every 1K. Dashed contours show negative values.

2. METHOD

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Gridded data, obtained from NCEP, included the operational Eta and a parallel version containing a different SST analysis. Both data sets were initialized at 1200 UTC 29 December 2000 on 40-km grids, and had the same number of vertical levels. The operational Eta data were retrieved in real-time and locally archived. This run included forecasts for the East Coast snowstorm of 30-31 December 2000. The parallel version of the Eta was obtained from NCEP after the event. This model run contained the finer resolution SST field.

The differences in the SST fields can be seen in lower panel of Figure 1. Note the colder SSTs along the New England coast, extending south and westward toward the Delmarva Peninsula. This image shows that the operational Eta did not have the cold shelf water along the immediate coastal areas of New England and the Mid-Atlantic region. It was the suspected impact of these SST differences on the forecasts that prompted this experiment.

The two Eta data sets were used to initialize theMM5,(http://www.mmm.ucar.edu/mm5/mm5-home.html) version 3. The model's inner grid was set at 15-km with an outer nest of 45-km. The same physical parameterizations were used in both runs including the Kain-Fritsch (1993) convective parameterization scheme.

The output of both model runs was displayed using GRADS. (http://grads.iges.org/grads/). Fields displayed and compared included the quantitative precipitation forecasts (QPFs), mean sea-level pressure (MSLP), and other select fields. ***Differences were computed using the NEWSST run forecasts minus the OLDSST run.*** Therefore, a negative value would imply that the quantity was higher in the OLDSST run.

3. RESULTS

The 30-h MSLP forecasts valid at 1800 UTC 31 December 2000 are shown in Figure 2. These data show that the OLDSST version of the MM5 forecast the surface cyclone to track to the west of the NEWSST version. The OLDSST MM5 forecast a 984-hPa cyclone over southeastern New Jersey and the NEWSST version placed a less intense

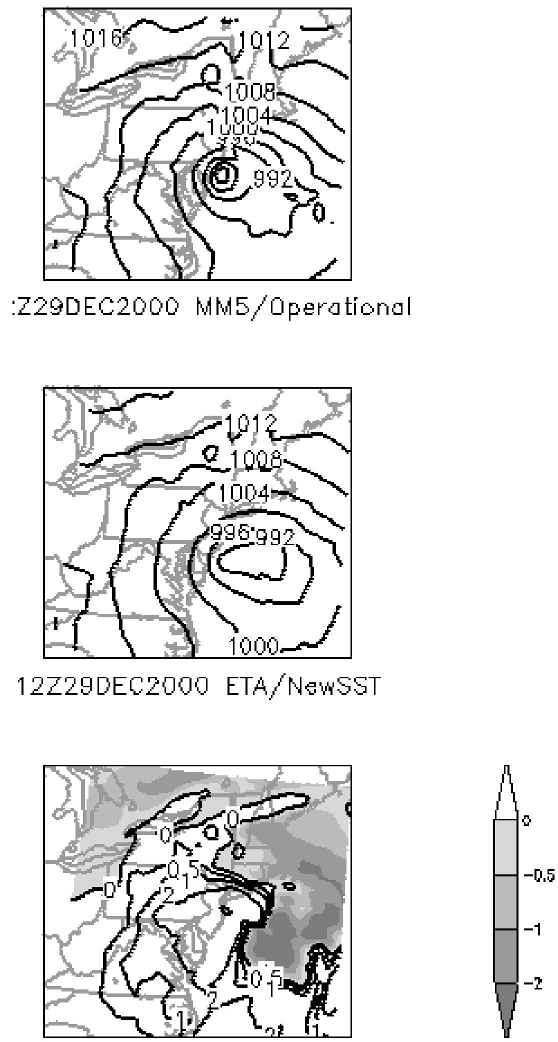

Figure 2. MM5 mean-sea level pressure (hPa) 30-h forecasts valid 1800 UTC 30 December 2000 showing a) the operational MM5, b) the high resolution SST MM5, and c) the difference field. Isobars are every 2hPa. Differences 0.5, 1 and 2 hPa with shading showing negative values.

cyclone south of Long Island.

The 36-h MSLP forecasts (not shown) showed a cyclone of similar intensity with a central pressure around 987hPa in both runs. However, the NEWSST run placed the cyclone center near the south shore of Long Island. The OLDSST MM5 placed the cyclone center to the southwest of New York City.

The differences in the cyclone tracks reflect differences in the mass and thermal fields (not shown). These changes also impacted the models QPFs as shown in Figure 3. As expected, with a more westward cyclone track, the OLDSST MM5 produced more precipitation over inland areas relative to the NEWSST run.

The NEWSST run, with a more northeastward cyclone position, forecast the precipitation shield to move farther into New England. The difference between the OLDSST MM5 QPF and the NEWSST MM5 QPF revealed a general decrease in the amount of QPF over Pennsylvania, Maryland, and Virginia. This decrease in precipitation was significant and may have meant the difference between the issuance of winter storm warnings for heavy snow (note the 1 inch contour through Washington DC in the upper panel) and a winter weather advisory (note in Fig. 3 the 0.25 contour east of Washington DC). Observations (not shown) indicate that most of the Washington DC area received a trace or less of actual precipitation. Similarly, little or no snow was observed over central and south central Pennsylvania.

The SST differences appear to have contributed to the faster arrival of precipitation into southern New England. The direct result of a faster and more northeastward cyclone track.

The 500, 700, and 850 hPa temperature and height forecasts (not shown) suggest the impacts of the SST differences did not just relate to the low-level features. Significant differences were present at these levels as well.

An examination of sensible and latent heat fluxes provides insights into the impacts the different SST fields had on the forecasts. The sensible heat fluxes (SHF) valid at 0000 UTC 31 December 2000 are shown in Figure 4. Although not shown, the patterns of the latent heat fluxes and the convectively produced precipitation fields were similar. Note the dramatic increase in the SHF in the NEWSST run. Due to the presence of the colder shelf water and the warm anomaly (see Figure 1), there were larger SHF fluxes over the ocean near the warm anomaly. This lead to enhanced convection in the

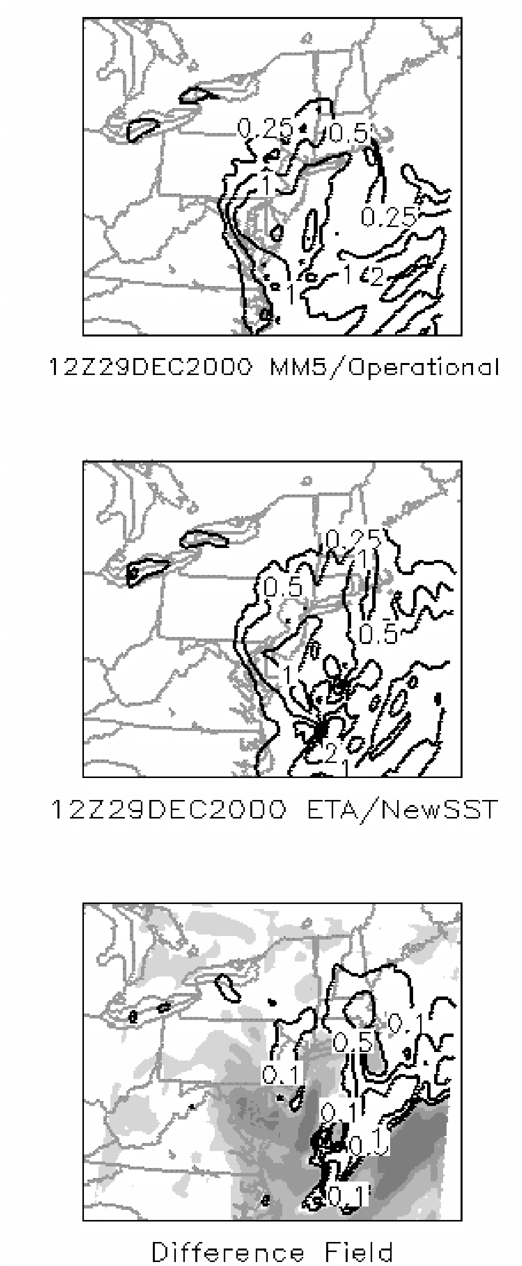

Figure 3. As in Figure 2 except accumulated QPF (in) valid at 0000 UTC 31 December 2000. QPF contours are 0.25, 0.50, 1, 2, and 3 inches. Difference contours area 0.1, 0.5, 1, and 2 inches with shading showing negative values.

NEWSST MM5 run in this same location.

4. DISCUSSION

The data shown here demonstrate the impact of initial conditions, in this case, SST differences, on a model run. With local modeling efforts increasing dramatically, it essential that those making these efforts are

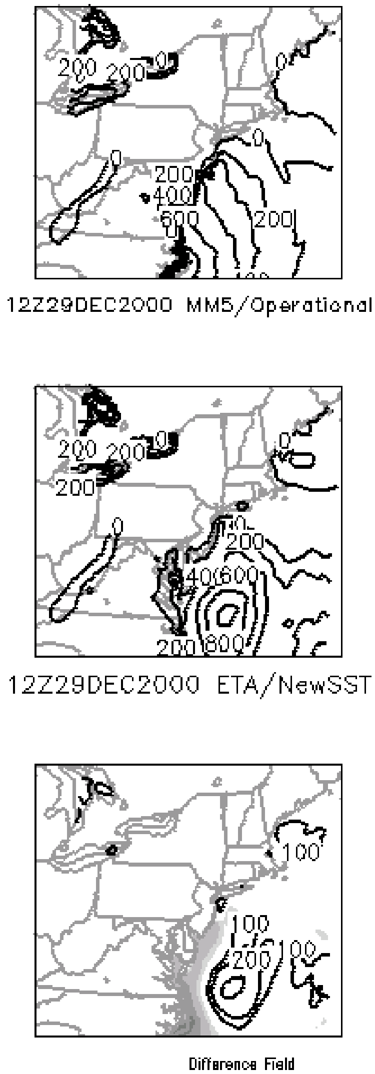

Figure 4. As in Figure 3 except sensible heat flux (wm^{-2}). Contour interval is every 200 wm^{-2} except difference field were contours a 400,200 and 100 wm^{-2} .

aware of the significant impact of initial conditions on their local model run. In this paper, we showed the critical impact of SST data on a local MM5 model run.

The preliminary results show that higher resolution SST data correctly produced a more eastward cyclone track. Though not shown, the actual cyclone tracked to the east of this forecast. This suggests there were other impacts on the forecast in addition to the SST problem.

The SHF data suggests that convection and the location of convection played a significant role in the cyclone evolution. The higher resolution SST data produced larger sensible heat fluxes near and east of the enhanced baroclinic zone over the warm Gulf waters. This resulted in convection, which led to enhanced cyclogenesis farther east. In the real atmosphere (not shown), convection broke out near this region, which lead to rapid cyclogenesis, well east of the OLDSST MM5's forecast position. It would be interesting to see what impacts changing the convective parameterization scheme to the Betts-Miller would produce.

The sensitivity of the MM5 to the SST analysis suggests the need for optimal initial conditions for the resolution of the model to be run. The coarse SST data, at about 80-km resolution, caused large errors in the 15-km MM5 runs. This implies the data resolution should match the model resolution as closely as possible. The impacts of initial conditions shown here also reinforce the necessity to use an ensemble of models when making a weather forecast.

Although not shown, the more westerly track forecast by the OLDSST MM5 would likely have caused forecasters to consider the rain/snow line to be farther west. The impact of changing the SST field to a more accurate and higher resolution field caused the 850 hPa zero degree isotherm to shift 100 km to the east. This is further evidence of why forecasters need to consider both the impact of initial conditions and the use of an ensemble of model forecasts.

5. References:

Grell, G. A., J. Dudhia, and D. R. Stauffer, 1995: A description of the fifth-generation Penn State/NCAR Mesoscale Model (MM5). NCAR Technical Note TN-398+STR, 122 pp.

Kain, J. S., and J. M. Fritsch, 1993: Convective parameterization for mesoscale models: The Kain-Fritsch scheme. *The representation of cumulus convection in numerical models*, K. A. Emanuel and D. J. Raymond, Eds., Amer. Meteor. Soc. , 246 pp.