P1.4

THE LATENCY OF MODEL GENERATED PRECIPITATION IN WINTER TIME CYCLONES

Holly M. Allen[†], John R. Mecikalski[†], and Chris B. Darden[§]

[†]Atmospheric Science Department
University of Alabama in Huntsville

[§]National Weather Service Forecast Office
Huntsville, Alabama

1. INTRODUCTION

Forecasting the initiation and timing of precipitation along the leading edge of mid-latitude cyclones has long been a challenge over the Southeastern United States. Many times the precipitation will initiate over a larger area as early as 12 hours prior to the forecasted time. It is believed this is a result of several problems – poor initial conditions within numerical weather prediction models, low data density over the Gulf of Mexico and the country of Mexico, and model microphysical parameterizations. The implications of these model pitfalls make it more difficult for forecasters to predict the characteristics of the precipitation, to provide quantitative precipitation estimates, and to correctly give the best quantitative precipitation forecast possible. We plan to show that assimilation of satellite data can help alleviate the problems associated with data sparse regions. [1]

The first step to better understanding of the onset of precipitation associated with synoptic scale weather systems across the Southeastern United States is to perform a case study analysis on events that exemplify the problem. All the elements, both synoptic and mesoscale, related to precipitation timing will be identified in order to determine under what conditions latency of model generated precipitation is a problem. Hypotheses on how forecast models can be improved in order to better predict precipitation timing will be made and tested based on the findings of the case study analysis. Training to improve recognition and understanding of the problem for National Weather Service forecasters will be developed.

[1] Corresponding Author: Holly Allen, Atmospheric Science Department, University of Alabama in Huntsville, 320 Sparkman Dr. Huntsville, AL 35805. allen@nsstc.uah.edu

2. BACKGROUND

National Weather Service forecasters have identified the precipitation lag-time problem as being systematic for synoptic scale disturbances that move across the Gulf of Mexico coastline and produce significant areas of precipitation northward across large portions of the Southeast. These events usually occur when a trough develops over the western United States, an upper level low forms over the four-corners region and moves eastward into the western Gulf of Mexico, and the southeastern states are susceptible to southerly flow prior to the event. These conditions tend to develop most often during the winter, or cool season, months.

Many studies have been done to document the implications of poor initialization of numerical models. Generally, if the model is initialized well, it will forecast well and initialized datasets are more important than model setup (Warner et al. 1989). Merrill (1992) showed return flow from the Gulf of Mexico is important to the development of low cloud ceilings and the onset of precipitation within moisture airflows. The amount of moisture within this return flow is dependent on duration over the ocean, air-to-water differences, and wind speeds over the water. It can be hard to determine the moisture variation because of the limited amount of data available over the Gulf waters and Mexico. However, Alexander et al. (1998; 1999) showed that assimilating derived rain rates, precipitable water, and other products from satellite information can improve cyclone forecasting.

From this brief overview and observations made by the forecasters, it has been determined the precipitation lag time problem is related to poor model initializations concerning return flow moisture and thermodynamical fields. Specifically, the lack of data over the Gulf of Mexico and the country of Mexico imply a dry bias in the initialization fields of the model because of poor boundary layer moisture data. Also, poor understanding of boundary layer and surface-coupling dynamics over warm water leads to low-level moisture and temperature advection and moisture fluxes moving into the cyclone to be under-forecasted. Finally, the model microphysical parameterization schemes poorly handle the rainfall in relation to marine aerosols (such as sea-salt) within the moisture inflows in cyclones.

3. CASE STUDY ANALYSIS

Through this case study analysis, we will be able to identify the conditions during which the forecast model has problems correctly predicting the start time of the precipitation. Moisture inflows, moisture fluxes, temperature, boundary layer conditions, low-level jets, and other parameters will be considered.

Currently, two events have been chosen that exemplify the problem – January 17-18, 2004 and March 3-8, 2004. These two events brought precipitation to the southeast United States, specifically the county warning area of the National Weather Service Forecast Office in Huntsville, Alabama. Preliminary results show both these events were characterized by a wave pattern having a trough over the western part of the country and a ridge over the east. In the January event, the trough was amplified by a cut-off low, where as in the March event, a series of short waves rotated around the trough (see Figs. 1a and 1b). Preceding the precipitation in both events, the air mass over the southeastern United States was modified by southerly flow from the Gulf of Mexico. This increasing of moisture in the area decreased the dewpoint depressions at 700 millibars across the majority of the region to values below five degrees (see Figs. 2a and 2b). This low-level moisture influx was carried by winds averaging 40 knots over portions of Mississippi and Alabama for the January event and 60 knots over portions of Northern Mississippi and Tennessee for the March event.

At the surface, the January event started as stationary front located along the Gulf Coast moved northward bringing warmer temperatures and more moisture to the region (see Fig. 3a). A broad area of low pressure condensed into a surface cyclone over north central Texas and moved eastward. Overrunning precipitation began to fall at 1800 UTC on the 17th. At this time, the surface low was still located in northeast Texas and the warm frontal boundary stretched southward across Louisiana and coastal Mississippi. During the March event, a surface low formed along an existing cold frontal boundary in Arkansas and moved eastward across the Alabama Tennessee border (see Fig. 3b). Measurable precipitation began at the Huntsville International Airport at 1800 UTC on the 5th. At this time, the surface low was still over central Arkansas. It appears that in both events overrunning of Gulf moisture played a part in the timing of the precipitation.

4. FUTURE PLANS AND GOALS

To complete the case study analysis, additional events will be added and compared. Also, along with the basic analysis of upper air and surface data, more complex, derived variables (such as moisture fluxes, wind fields, etc) will be considered. The results of the case study analysis will be compared to ETA model output from these events to find any discrepancies pertaining to the precipitation start time between the model forecast and the actual observations. GEMPAK will continue to be used as the predominant analysis tool.

Hypotheses will be formed to determine how the forecast models can be improved to compensate for deficiencies, such as lack of moisture. Methods for testing each hypothesis will be developed so that fore mentioned deficiencies can be resolved to improve forecast ability. The findings will be presented to the National Weather Service forecasters and other weather organizations in order to improve their understanding on the precipitation timing problem. This should allow for better quantitative precipitation estimates and forecasts.

One possible method for resolving the lack data over the Gulf of Mexico and the country of Mexico already being considered is to assimilate GOES and AIRS moisture sounding data into the ARPS Data Analysis System (ADAS). Using this forecast analysis tool, it could be determined whether the assimilation of derived moisture data has a positive or negative impact on the short term forecast..

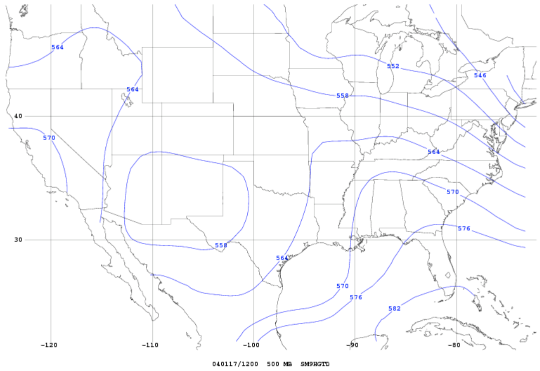

Figure 1A. 500 millibar analysis for 1200 UTC on January 17, 2004. See text for discussion.

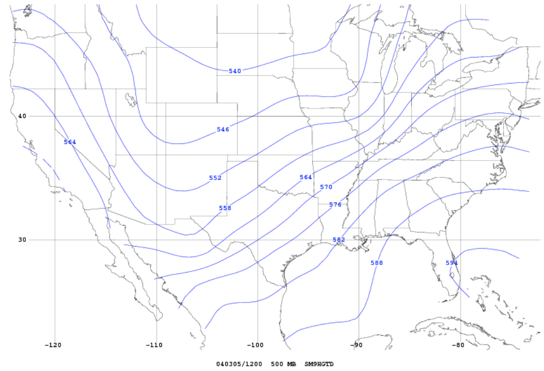

Figure 1B. 500 millibar analysis for 1200 UTC on March 5, 2005.

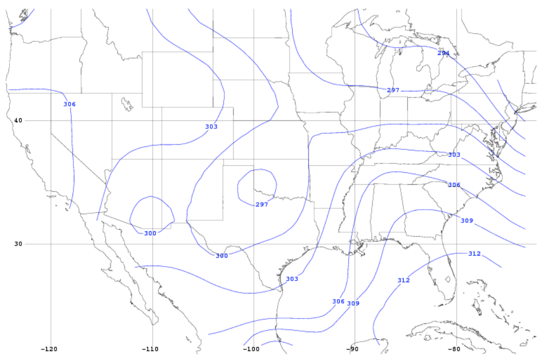

Figure 2A. 700 millibar analysis for 1200 UTC on January 17, 2004.

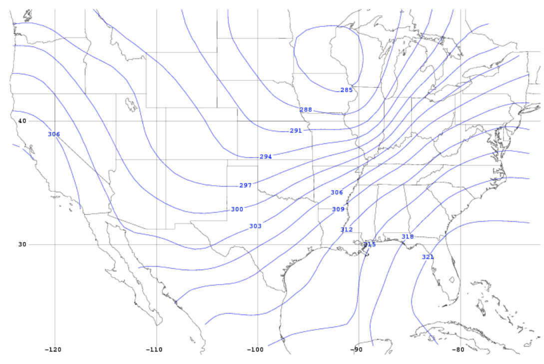

Figure 2B. 700 Millibar analysis for 1200 UTC March 5, 2004.

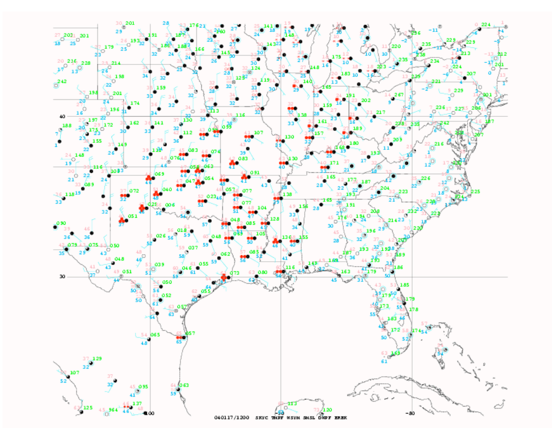

Figure 3A. Surface analysis for 1200 UTC on January 17, 2004. At this time, precipitation had begun to fall across portions of the Southeast.

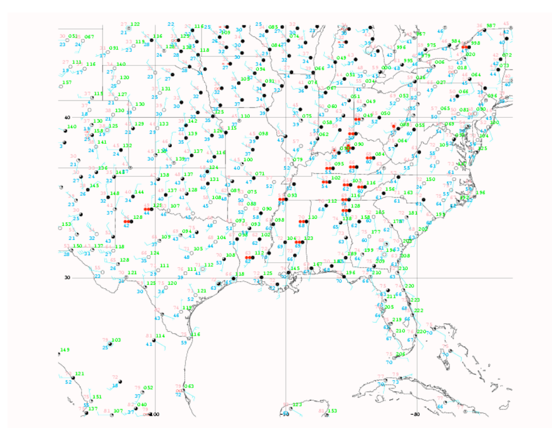

Figure 3B. Surface analysis for 0000 UTC on March 6, 2004. Note that precipitation is being reported by stations located in the Tennessee, Ohio, and Mississippi River Valleys at this time.

5. Acknowledgements

This work is supported by a grant through the NASA Short-term Prediction Research and Transition (SPoRT) Center at the Marshall Space Flight Center, and by the National Weather Service, Student Career Experience Program (SCEP).

6. References

Alexander, G. D., J. A. Weinman, V.M. Karayampudi, W. S. Olson, and A. C. L. Lee, 1999: The effect of assimilating rain rates derived from satellites and lightning on forecasts of the 1993 Superstorm. *Mon. Wea. Rev.,* **127** 1433-1457.

Merrill, R.T. 1992: Synoptic analysis of the GUFMEX return-flow event of 10-12 March 1988. *J. Appl. Meteor.*, **31**, 849-867.

Warner, T. T., L. E. Key, and A. M. Lario, 1989: Sensitivity of mesoscale-model forecast skill to some initial-data characteristics, data density, data Position, analysis procedure and measurement error. *Mon. Wea. Rev.,* **117**, 1281-1310.