P9.8 EMC MODELING EFFORTS TO ASSIST AVIATION FORECASTING

Geoffrey S. Manikin, Brad S. Ferrier, Ying Lin, Jeffery T. McQueen, Jun Du, Binbin Zhou, Geoffrey J.DiMego
NOAA/NWS/NCEP/EMC, Mesoscale Modeling Branch Camp Springs, Maryland

1. INTRODUCTION

An overview of activities within the Mesoscale Modeling Branch of the Environmental Modeling Center (EMC) of the National Centers for Environmental Prediction is presented. This includes plans with the Eta, RUC, and Weather Research and Forecasting (WRF) models, and the Short-Range Ensemble Forecasting System (SREF). Emphasis is placed on the analysis and prediction of cloud and moisture fields that are critical to accurate short-term aviation forecasting.

2. NORTH AMERICAN MESO

The North American Mesoscale guidance slot is currently occupied by the 12 km, 60 level Eta Model. An upgrade to the 3DVAR analysis is planned for fall 2004 with improved use of surface observations.

The Eta will be replaced by the WRF in late 2005. The initial version of WRF will have 10 km horizontal resolution and 60 levels. It will use a new gridpoint statistical interpolation (GSI) analysis. By 2008, an 8 km, 70 level version of the WRF is planned with upgrades including the analysis of hydrometeors and the assimilation of 88D reflectivity. The operational version in 2010 will likely have 6.5 km horizontal resolution and 85 levels and include an advanced assimilation.

3. ETA PRECIPITATION ASSIMILATION

NCEP has been assimilating observations of precipitation into the Eta Data Assimilation System (EDAS) since 1998 (Lin et al., 1998). This leads to improved precipitation and moisture forecasts during the start of the forecast as well as superior soil moisture analyses. The latter has a strong long-term influence on many aspects of the forecast, especially low-level temperatures and moisture. Despite the positive impact of this assimilation, the long-noted dry bias of the Eta model for heavier amounts (Fig. 1) has led to too dry soil.

---

* *Corresponding author address:* Geoff Manikin, NCEP/EMC, World Weather Building, 5200 Auth Road, Room 204, Camp Springs, MD 20746. geoffrey.manikin@noaa.gov

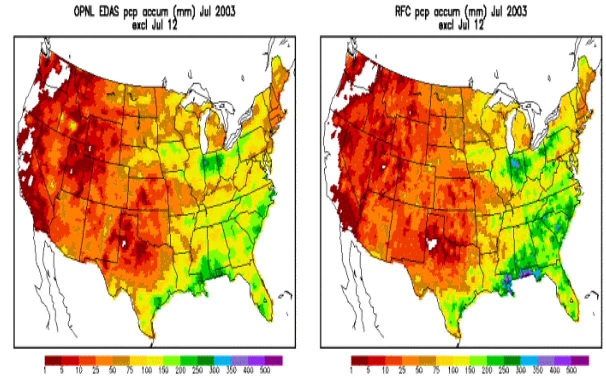

Fig. 1: Total precipitation (mm) forecast during the Eta data assimilation for all of July 2003 compared to the observations (right).

A bias correction was added to the precipitation assimilation in March 2004. The precipitation forecast in the EDAS is compared to the gauge amounts each day (Fig. 2), with the difference tracked in a budget history file. The deficit or surplus is then used to adjust the hourly input with the goal of eliminating the surplus or deficit within one day. The adjustment, however, is limited to 20 per cent of the original total. The new version of the precipitation assimilation was found to improve both precipitation equitable threat and bias scores and soil moisture analyses.

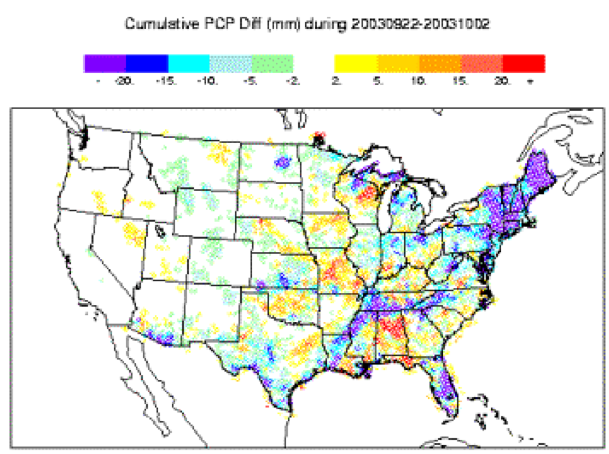

Fig. 2. Example of a daily difference between the forecast precipitation from the operational EDAS and the observed amounts.

4. ETA MICROPHYSICS / RADIATION

Several upgrades to improve cloud forecasts were made to the Eta microphysics and radiation in the spring of 2003. A legacy piece of code that essentially eliminated the radiative impact of clouds in the lowest 100 mb was removed. Full cycling of hydrometeor fields was added to bring continuity to the microphysical processes in the Eta system; a major upgrade was made to the model microphysics in 2001, but the input and output from the model were not treated in a way fully consistent with the new scheme until this implementation. With this upgrade, it is now possible to generate many new fields, related to clouds and microphysical parameters, from the model. These include column-integrated rain, snow, cloud water, and cloud ice, various three-dimensional mixing ratios, and pressures of cloud bases and tops broken down into convective and non-convective processes, with the former broken down further by shallow (non-precipitating) and deep processes. The complete list is available at http://www.emc.ncep.noaa.gov/mmb/tpb.spring03/Table1.htm . Finally, other changes were made to the grid-scale and convective clouds to attempt to generate more partial cloudiness. More information can be found at http://www.emc.ncep.noaa.gov/mmb/tpb.spring03/tpb.htm

The cloud processes in the Eta, however, still tend to have a clear or cloudy binary behavior, so more work is underway to revise the optical properties to generate more partial cloud from both the convective and grid-scale clouds. Fig. 4 shows a test Eta forecast of cloud fraction that has generated many values "in the middle", as opposed to the operational run in Fig.3 in which much of the cloud cover is all or nothing. In addition, the shallow branch of the convective scheme is being modified to base the cloud top more on parcel theory. Some entrainment at cloud top level will also be introduced to the scheme.

Finally, the solar radiation package used in the Global Forecast System (GFS) is being tested in the Eta. This multi-spectral approach has a superior treatment of the interaction between radiation and clouds (Hou et al., 2002) and includes improved representations of the optical properties of cloud water, rain, cloud ice, snow, and aerosols.

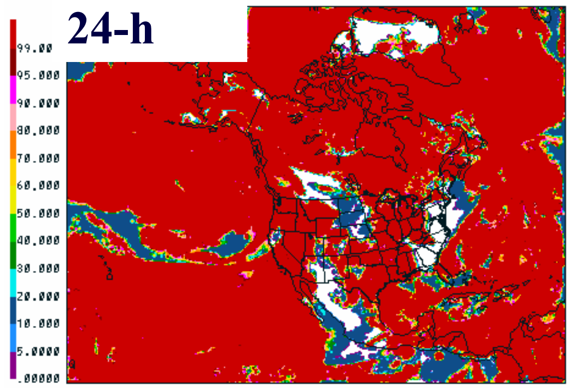

Fig 3. 24-hr fcst. of total cloud fraction from the operational Eta valid 1200 UTC 24 March 2004..

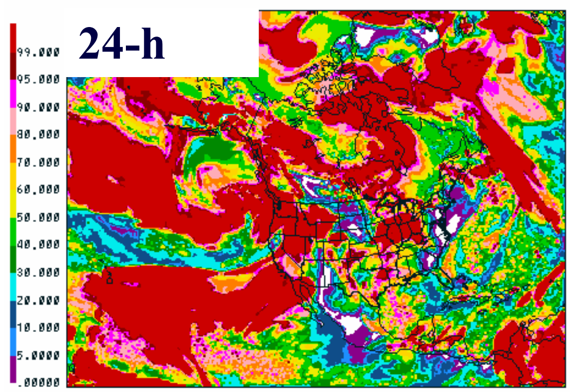

Fig. 4.. Same as in Fig. 3, except for a test version of the Eta with changes designed to increase the amount of partial cloudiness..

5. SREF

The SREF ran in development at NCEP starting in 1996 and became operational in 2001. The system was conceived to deal with the problem of the success of short-range forecasts being limited by the uncertainty that exists due to initial condition and model errors. The original version of the SREF had 5 Eta members and 5 Regional Spectral Model members with 5 Eta members added in 2003 with the Kain-Fritsch (KF) convective parameterization (Kain and Fritsch, 1993). Unfortunately, this system often lead to distinct clusters of 5 members of each model in situations with major synoptic storms and also unrealistic high probabilities of localized heavy rain in warm-season convective events with weak forcing (Fig. 5)

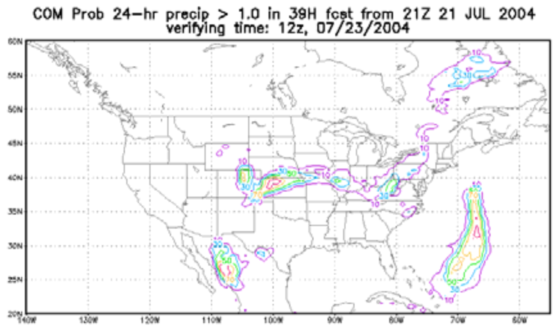

Fig. 5. 39-hr forecast probability of precipitation exceeding 1 inch in the 24-hr period ending 1200 UTC 23 July 2003.

The new SREF attempts to better sample the uncertainty associated with both the initial conditions and the model physics. Different versions of the Betts-Miller-Janjic (BMJ) scheme (used the operational Eta) (Betts 1986, Janjic 1994) and KF parameterization in the Eta and the Arakawa-Schubert scheme in the RSM are combined with a new breeding of initial condition perturbations to generate more spread in the system. Bias scores for the ensemble mean are displayed in Fig. 6, and the initial impression is that the new system displays a pronounced dry bias at higher amounts. Bias scores for individual members, however, show that many of the members have a wet bias or no bias at all (Fig. 7). This indicates that the increased spread of the new system is causing the maxima from different members to be predicted in different locations, such that the mean of the system is lower at most individual locations. Bias correction is being developed for the SREF to address this issue; in the meantime, it is recommended that users examine spread and not just the ensemble mean. It is also noted that these scores are for a warm-season period, and initial cold-season results suggest that the mean will be a more useful tool at that time of year.

The longer-range plans for the SREF system involve using members with various WRF configurations. The tentative plans are to have 20 WRF members with 22 km resolution by October 2006 with the resolution increased to 15 km in 2008. Updates to SREF plans can be found at http://www.emc.ncep.noaa.gov/mmb/SREF-Docs Specific work done by the SREF group to assist in aviation forecasting is detailed in the paper by Zhou et al. (this volume). Aviation-based SREF graphics are available at http://www.emc.ncep.noaa.gov/mmb/SREF/FCST/AVN/web_site .

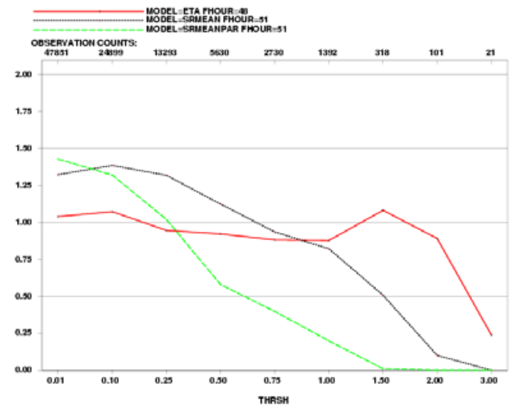

Fig.6. 48-hour precipitation bias for the operational Eta (red), old SREF configuration (gray), and the new version of the SREF (green)

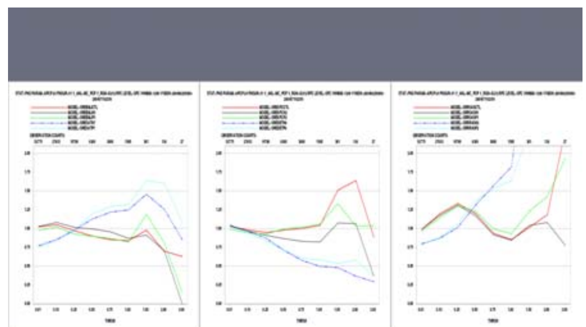

Fig.7. Scores for all members of the new SREF. The first set is for all of the BMJ and modified BMJ members, the second set is for the KF members, and the third set is for the RSM members. Precipitation amount thresholds are listed along the x-axis.

6. RUC

The Rapid Update Cycle will continue to provide high-frequency, detailed analyses and short-range forecasts. An upgrade to the analysis code is planned for the fall of 2004 (Benjamin et al, 2004), with the use of the model forecast of boundary layer depth to determine an appropriate depth over which to apply the influence of surface data. Code will be also added to prevent the addition of moist increments to locations at which the model has already moistened the atmosphere through deep convective processes.

These changes can have dramatic impacts on low-level temperature and moisture forecasts, particularly in locations far removed from raob data. The field of convective available potential energy (CAPE) is especially affected. Fig. 8 compares CAPE analyses from the operational RUC and the version with the new analysis code. The largest discrepancies are found in the area where Oregon, Nevada, and Idaho meet. The operational RUC analysis of CAPE values exceeding 5000 J/kg in that region is certainly incorrect. Observed vertical profiles in that region do not exist, but the corresponding Eta analysis (not shown) indicates that CAPE values were in the 500-1500 range. Further reason to not believe the operational RUC values is shown in Fig. 9 which compares analyzed vertical profiles from a location in that region. The operational moisture structure looks completely unrealistic, while the test run gives a more reasonable mixing of low-level moisture.

Further down the line, a resolution upgrade to 13 km is in development (Benjamin et al., 2004). NCEP testing will begin this fall with the goal of an implementation in the spring of 2005. The latest RUC news can always be found in the user forum at http://maps.fsl.noaa.gov .

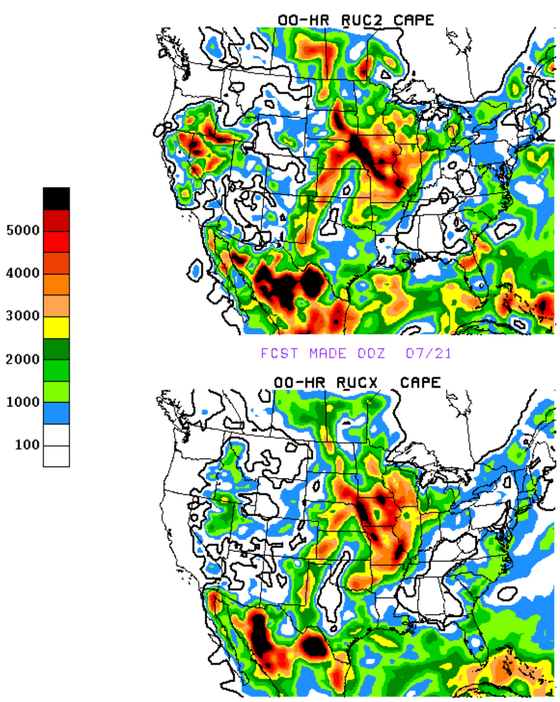

Fig. 8. Comparison of convective available potential energy (J/kg) analyses from the operational RUC (top) and test version with new analysis code (bottom) valid 0000 UTC 21 July 2004.

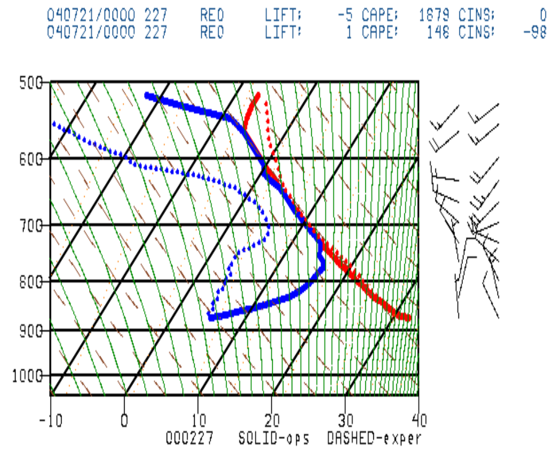

Fig. 9 Analysis soundings for Rome, Oregon valid 0000 UTC 21 July 2004. Solid lines and top line of parameters represent the operational RUC, while dashed lines and the second line of parameters denote the test version.

7. REFERENCES

Arakawa, A, and W. H. Schubert, 1974: Interaction of cumulus cloud ensemble with the large scale environment, Part I. *J. Atmos.* Sci., **31**, 674-701

Benjamin, S, and co-authors. A 13-km RUC and beyond. Recent developments and future plans. Paper J1.6. This volume.

Benjamin. S., and co-authors. Improved moisture and PBL initialization in the RUC using METAR data. Paper 17.3, *20th Conf on Severe Local Storms*.

Betts, A. K., 1986: A new convective adjustment scheme. Part I: Observational and theoretical basis. *Quart. J. Roy. Meteor. Soc.* **112**, 677-692.

Hou, Y-T., S. Moorthi, and K. Campana, 2002 Parameterization of solar radiation transfer in the NCEP models. NCEP Office Note 441.

Janjic, Z. I., 1994: The step-mountain eta coordinate model: Further developments of the convection, viscous sublayer, and turbulence closure schemes. *Mon. Wea. Rev*., **122**, 927-945.

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. *Meteor. Monogr*., No. 24, Amer. Meteor. Soc., 165-170

Lin, Y., K. E. Mitchell, E. Rogers, and M. E. Baldwin, 1998: Assimilation of real-time, multi-sensor hourly precipitation observations into the NCEP Eta model. Preprints, *12th Conf. on Numerical Weather Prediction, Phoenix* Arizona, Amer. Meteor. Soc., 174-175.

Zhou, B., and co-authors. An introduction to NCEP SREF aviation project. Paper 9.15. This volume.