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CURRENT AND UPCOMING CHANGES TO THE ETA MODELS

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Introduction

The National Centers for Environmental Prediction (NCEP) operational job suite currently includes a 48km Eta model (the Eta-48), run at 0000 and 1200 UTC and a 29km Eta model (the Eta-29 or Meso Eta) run at 0300 and 1500 UTC. An experimental 10km Eta model (the Eta-10) is currently run at 0900 UTC over a Western Region Domain and evaluated by Western Region forecasters. This Technical Attachment (TA) describes two "bundles of changes" that are being made to the operational Eta models. (A "bundle of changes" is a collection of model changes that are made at the same time in order to reduce the operational workload at NCEP.) The first bundle of changes was implemented February 18, 1997. The most significant change, moving the Eta-29 to the early model slot, is part of the second bundle planned for spring 1997. These bundles of changes reflect a philosophy at the Environmental Modeling Center (EMC) of rapidly implementing new science and technology into the models.

Eta Model Development

The rate of model development at the EMC has increased in recent years. Prior to the 1990s, major changes to NWS operational models occurred less frequently and models were "frozen" once they were considered "mature". In order to keep pace with the rapid advancement of science and technology, the EMC no longer "freezes" models; rather model changes are implemented as soon as they can be tested and operational constraints (e.g., the front-end conversion) allow. Appendix A outlines the major developments of the Eta model. For a history of Eta model changes and their impacts on forecasting, see Staudenmaier (1996a) and Rogers et al., (1996a). Changes to model resolution (Appendix A) demonstrate the rapid development of the Eta model. Since its inception in June 1993, the Eta model has run at 80km resolution, 48km resolution (implemented September, 1993), and 29km (August, 1995). These changes in model resolution led to increased skill in low-level temperature and wind forecasts and in QPF (Staudenmaier 1997). A 15km Eta model was used for the 1996 Summer Olympics in Atlanta and currently an experimental 10km version is under evaluation by Western Region forecasters.

Forecaster evaluations have played an integral part in Eta model development by evaluating the Eta-29 and Eta-10 models and providing feedback to the EMC. The pre-implementation evaluation of the Eta-29 during the summer and fall of 1995 led to fixes in the Eta's post-processing code, in low-level winds, etc., and demonstrated the usefulness of a higher resolution model to the CAFTI committee. (All changes to NCEP models must be approved by CAFTI.) Western Region evaluations have led to several of the changes discussed below, for example, a fix for convection over high terrain and a temporary fix for surface temperatures during the melting of snow. The process of continuously improving NCEP models based on forecaster feedback has proven very successful.

The First Bundle Of Changes

At 1200 UTC 18 February 1997, several changes were implemented in the operational Eta-48 (48km/38lev) model, and at 1500 UTC 18 February 1997, the same changes were implemented in the operational Eta-29 (29km/50lev) model. A brief description of these changes follows.

List of Changes in the First Bundle

- Addition of a form-drag scheme
- Implementation of a more efficient and accurate positive definite advection scheme for moisture and cloud.
- Eccentric (rather than circular) orbit around the Sun
- Corrected atmospheric ozone distribution
- Effect of aerosols on net short-wave radiation added
- Reduced albedo over snow
- Model radiation impacted by cloud in each individual model layer, rather than through 3 deep layers
- Improved computation of cloud fraction
- Improved input fields of vegetation greenness fraction and initial soil moisture
- Enhanced bare soil evaporation
- Corrections to physical processes related to melting snow
- Increased the background level of turbulent mixing

Description of Changes in the First Bundle

The largest impacts on forecasting from the first bundle are:

1. The short-wave radiation package will be modified to reduce the amount of incoming solar radiation (insolation) that reaches the earth's surface. This change is being made in response to a warm/dry bias in the Planetary Boundary Layer (PBL) reported over the plains during the summer. This warm/dry bias was detected by forecasters at NSSL and HPC. EMC examined statistics and determined that the amount of insolation in the model exceeded observed values. Several changes to the Eta radiation scheme will be made to reduce the amount of insolation. The most significant are: (1) reducing the solar constant by three percent to better approximate the absorption by trace gases; (2) including clouds from every level in the radiation scheme (rather than from three deep layers); (3) changing the earth's orbit from circular to eccentric; (4) including the effects of ozone. A concern here is that Western Region forecasters have noted a cold/wet bias this winter when cold air is trapped in valleys. Therefore, Western Region forecasters should monitor and provide feedback on temperature and moisture in the Eta's PBL.

2. A form drag scheme for the Eta terrain will be added to increase friction. Thus, terrain forced phenomena could be impacted, for example the translation of cyclones and fronts could be slowed. According to Mesinger et al. (1996), the form drag scheme could alleviate a systematic error of forecasting lows too deep and too far north in the lee of the Rocky Mountains.

3. The soil package will be changed by improving the "green fraction", allowing bare soil evaporation, and making a small change to the algorithm for the melting of snow. If any snow is melting in the model, the Eta models don't allow the skin temperature to exceed 0 degrees C. The new algorithm will ignore snow levels of less than 2.5 inches. This is an important change since Western Region forecasters noticed that in areas of thin snow cover, the Eta models often held the 2 meter temperature near 3 degrees C in locations where in reality the temperature climbed much higher. A more rigorous change to the melting snow algorithm will be made before the 1997/1998 winter. These changes to the soil package are not expected to create large impacts to QPF. However, changes in the intensity and location of precipitation are possible (Chen et al., 1996).

4. The Eta-10 model will be initiated from the operational 0300 UTC Eta-29 run rather than the experimental 0900 UTC. This change will facilitate the Western Region evaluation of the Eta-10 since the 0300 UTC run of the Eta-10 should be more reliable and timely than the 0900 UTC run.

List of Changes planned for the Second Bundle

- Eta-29 replaces Eta-48 as the "early" model
- 3D-VAR replace OI
- EDAS cycle independent of GDAS
- Precipitation and Cloud Initialization Scheme
- Add explicit 10m level over land
- High Terrain convection refined
- 4 Layer Soil Package

Description of Changes in the Second Bundle

The most significant change will be replacing the Eta-48 1200 and 0000 UTC runs with the Eta-29. The proposal for the new Eta-29 domain (shown in Fig. 1) is larger than the current Eta-29 domain (shown in Fig. 2) but smaller than the current Eta-48 domain (also shown in Fig. 2). The new Eta-29 domain (Fig. 1) completely fills the memory of the NCEP Cray supercomputer. Western Region SSD is discussing with the EMC the possibility of shifting the new Eta-29 domain slightly to the west to provide a better look upstream for west coast forecasters. However, a shift westward would eliminate coverage of Puerto Rico and, therefore, this matter is still under debate.

Cray Corporation programmers recently assisted the EMC in improving the parallelization of the Eta model code. As a result, the new Eta-29 will run out to 48 hours and still complete as fast as the current Eta-48 (approximately 45 minutes of clock time.) This suggests that Western Region forecasters will be able to view the 1200 UTC Eta-29 in their office by 1600 UTC. Another advantage of moving the Eta-29 to the early slot is that the Eta Data Assimilation System (EDAS) will then assimilate data at 29km resolution (rather than the current 48km).

There are several other important changes planned for the second bundle of changes:

1. The current OI data assimilation scheme will be replaced with the 3DVAR scheme (Rogers et al., 1996a). The 3DVAR scheme is currently being tested in the Eta-10. One advantage of the 3DVAR scheme is its ability to directly assimilate satellite radiances. The direct assimilation of satellite radiances in the NCEP global data assimilation system (GDAS) (implemented fall 1995) led to the largest positive

impact in MRF model skill over the last 10 years (Glenn White [EMC], personal communication). The EDAS will also cycle on its own first guess, rather than use a first guess from the GDAS.

2. Observed clouds and precipitation will be utilized by the new scheme to alleviate spin-up problems and potentially improve QPF (Ying Lin et al., 1996).

3. An additional model level will be added just above the model terrain. This may alleviate the problem described by Staudenmaier (1996c) in capturing the thermodynamic profile in the lowest 50mb over mountainous regions.

4. Two changes will be made to the Eta's convective scheme to increase the potential for convection over high terrain: (1) reducing the deep convection threshold of a minimum cloud depth of 290 mb; (2) changing the reference moisture profile. These changes will only impact gridpoints in locations of high terrain. For a description of the Eta model convective scheme, see Staudenmaier (1996b).

Conclusion

The EMC will continue to improve the Eta models based on new science and technology and based on forecaster feedback. Beyond the time frame of the changes described here, the EMC is developing a non-hydrostatic Eta model, testing the assimilation of WSR-88D VAD winds (currently being tested in the Eta-10), investigating the use of Eta short-range ensemble forecasts as well as several other projects. Western Region is very grateful for the speed with which EMC model developers have responded to forecaster feedback with model developments. The Western Region evaluation of the Eta-10 model has been underway for one month, and initial results indicate the Eta-10 can have a large positive impact on our operations.

Acknowledgments

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References

Baldwin, M., T. Black, Precipitation Forecasting Experiments in the Western U.S. with NCEP's Mesoscale Eta Model. Preprints, 11th AMS Conference on Numerical Weather Prediction.

Chen F., K. Mitchell, Z. Janjic, M. Baldwin, 1996: Land-Surface Modeling Progress in the NCEP Mesoscale Eta Model. Preprints, 11th AMS Conference on Numerical Weather Prediction.

Mesinger F., R. Wobus, M. Baldwin, 1996: Parameterization Of Form Drag in the Eta Model at the National Centers For Environmental Prediction. Preprints, 11th AMS Conference on Numerical Weather Prediction.

Rogers, E., D. Parrish, Y. Lin and G.J. DiMego, 1996: The NCEP Eta Data Assimilation System: Tests with a Regional 3-D Variational Analysis and Continuous Cycling. Preprints, 11th AMS Conference on Numerical Weather Prediction.

Rogers, E., T.L. Black, D. Deaven, G.J. DiMego, Q. Zhao, M. Baldwin, N. Junker, Y. Lin, 1997: Changes to the Operational "Early" Eta Analysis/Forecast System at the National Centers For Environmental Prediction. *Wea. Forecasting*, **11**, 391-413.

Staudenmaier, M.J., 1996: A Description of the Meso Eta Model. WR-Technical Attachment 96-06.

Staudenmaier, M.J., 1996: The Convective Parameterization Scheme in the Meso Eta Model. WR-Technical Attachment 96-23

Staudenmaier, M.J., 1996: The Initialization Procedure in the Meso Eta Model. WR-Technical Attachment 96-30.

Staudenmaier, M.J., 1997: The Benefits of Higher Resolution in Representing Topography. WR-Technical Attachment 97-01.

Ying, L., K. Mitchell, E. Rogers, M. Baldwin, 1996: Impact of Hourly Precipitation Input on the NCEP Eta Model. Preprints, 11th AMS Conference on Numerical Weather Prediction.

APPENDIX A - PAST IMPLEMENTATIONS FOR THE ETA MODELS

June 1993 - 80km/38 level Eta runs in 00z and 12z early slot

Sept 1994 - analysis bundle and 'slim' mountains for Early Eta

Aug 1995 - 29km/50 level Meso Eta runs at 03z and 15z, predictive clouds, land-surface-soil package and pbl/TKE

Oct 1995 - Early Eta Upgrade: 48km, predictive clouds and EDAS

Jan 1996 - Land-surface-soil package and pbl/TKE in Early Eta

Apr 1996 - Fast Eta code in Meso Eta

June-August 1996 - Olympic 10km/60 level nested Eta runs at 03z and 15z

January 1997 - "Nest-in-the-west" 10km Eta at 09z

Fig. 1. The proposed domain (solid line) for the Eta-29 when it is moved to the "early" 0000 and 1200 UTC slot.

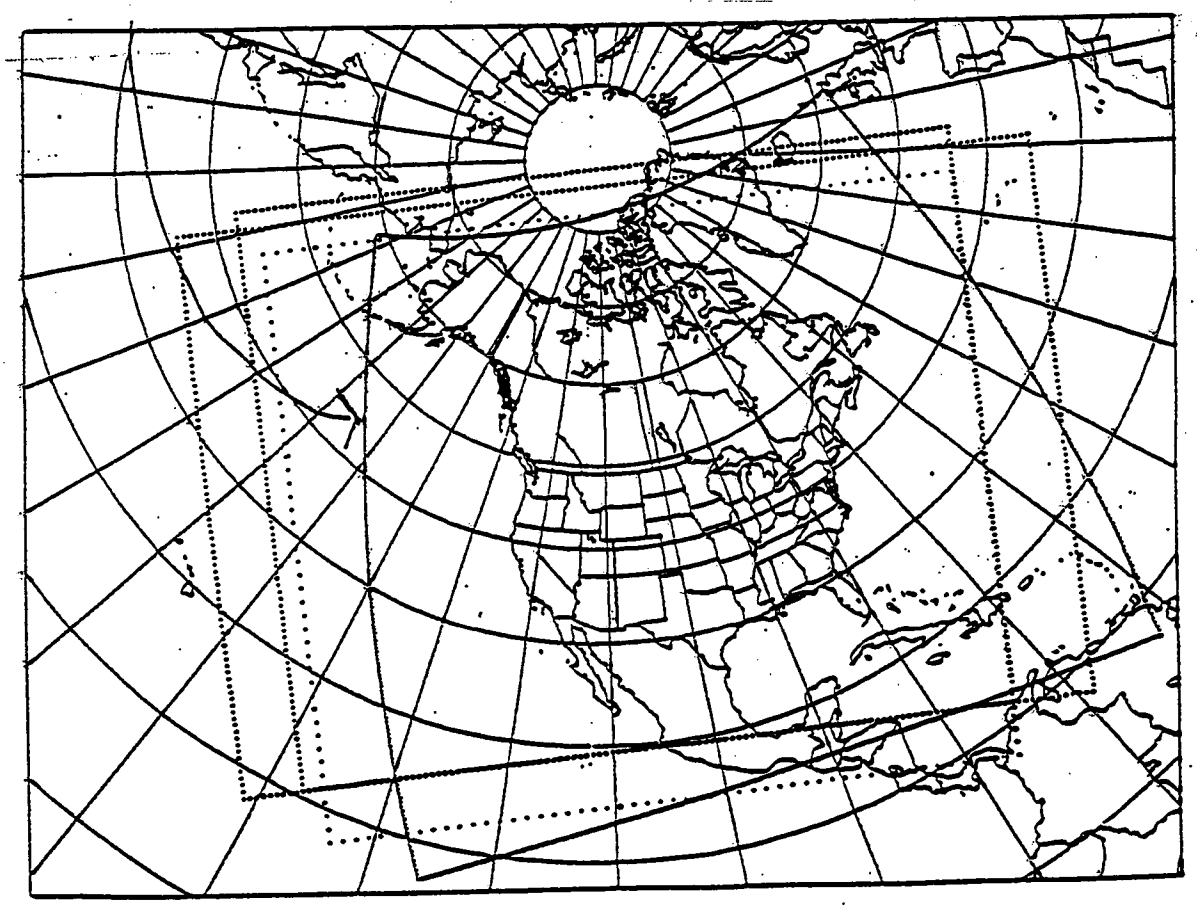

Fig. 2. Current domains. Solid lines indicate the current domains of the Eta-48, Eta-29, and Eta-10 models. Dashed lines indicate the domains of various AWIPS grids.