WESTERN REGION TECHNICAL ATTACHMENT
NO. 98-03
JANUARY 27, 1998

THE ETA-32 MODEL

Jon Mittelstadt - WRH-SSD, Salt Lake City, UT

Introduction

NCEP plans to implement the Eta-32 model in the "early slot" on February 2, 1998, replacing the Eta-48. The Eta-29 (Meso Eta) will continue to run at 03Z and 15Z for several months. The Eta-32 will at first use the same model physics as the Eta-29 and Eta-48 versions, but will employ a new data assimilation system called the 3DVAR (3-Dimensional Variational) Data Assimilation Scheme. The Eta-32 will produce 48-hour forecasts.

A "bundle of changes", planned for spring 1998, will upgrade the convective parameterization and change the NCEP jobstream so the Eta-32 produces 48-hour forecasts 4 times/day at 00,06,12, and 18Z (at which time the 03 and 15Z runs of the Eta-29 will stop).

Western Region (WR) forecasters have evaluated the Eta models since the summer of 1995. Their experience has shown that, at times, the Eta-48 is the better model due to 00/12Z initial conditions, and, at other times, the Eta-29 is the better model due to increased resolution. Therefore, the Eta-32 holds promise for producing better guidance with finer resolution than the Eta-48 and better initial conditions than the Eta-29.

New Characteristics Of The Eta-32

Figure 1 is a table showing the basic differences between the initial implementation of the Eta-32 and other Eta versions. Some characteristics of the Eta-32 are:

- The Eta-32 output will at first be available for NTRANS on the same 80-km grids as the Eta-48. Within a few months, the Eta-32 output will be available on a 40 km grid.

- The lack of vertical resolution over high terrain has been blamed for many problems WR forecasters have seen in the Planetary Boundary Layer (PBL), for example light winds (Staudenmaier and Mittelstadt, 1997). The Eta-32

has 45 vertical levels, more than the Eta-48 (38 levels) but less than the Eta-29 (50 levels). The actual distribution of vertical layers over high terrain is better than the Eta-48 but worse than the Eta-29. Near 700mb, the vertical depth of the layer is 32 mb, 28 mb, and 22 mb in the Eta-48, Eta-32 and Eta-29 models respectively. Hence, the Eta-32 is not expected to substantially correct the PBL problems.

- The horizontal domain of the Eta-32 is smaller than that of the Eta-48 but quite a bit larger than that of the Eta-29 (Fig. 2). The larger domain reduces errors over WR caused by lateral boundary problems (Mesinger, 1998).

- Eta-32 boundary conditions will be updated every 3 hours from the latest (6-hour old) run of the AVN. This is an improvement over the Eta-48, which uses 6 hour updates from the AVN run that is 12-hours old. This improvement will also reduce errors from the lateral boundaries.

- The first-guess initial fields for soil temperature and moisture, cloud water/ice, and turbulent kinetic energy will come from the Eta model. Spin up problems should be reduced since these fields will now cycle on themselves. Other first-guess fields will continue to be derived from AVN model forecasts, but NCEP plans eventually to cycle all first-guess initialization fields from the Eta.

- An improvement in the way mass and wind variables are updated, each timestep has eliminated some high frequency noise (Fig. 3). However, spurious low-frequency gravity waves can still exist (Barnes 1996).

- The most significant change is the new data assimilation system described in the next section.

The 3DVAR Data Assimilation System

The Eta OI Data Assimilation will be replaced with the 3-Dimensional Variational scheme (3DVAR) (Rogers et al.,1996). The 3DVAR will continue to assimilate data over a 12-hour period prior to each model run, assimilating new data every 3 hours. The Eta 3DVAR is a modified version of the scheme used by the MRF/AVN models. The old OI scheme calculates values for each model grid point independently, whereas the new 3DVAR does the calculations for the entire model domain simultaneously. The 3DVAR uses a "variational" mathematical technique to minimize the "distance" between observations and the model first -guess. The 3DVAR is an important step in the evolution of the Eta model, because it can assimilate non-standard data sources like satellite radiances, and has the potential for making better use of surface data.

The Eta-29 will continue to use the old OI. This means the period between Eta-32 implementation and the next bundle of changes will be an opportunity to evaluate the impacts of the 3DVAR, i.e., by comparing Eta-29 and Eta-32 analyses and forecasts. 3DVAR has the following advantages over the OI system:

- A much smoother (less noisy) vertical profile of temperature and dewpoint temperature is produced. Many of the unrealistic lapse rates often seen in Eta model SKEW-T's will be eliminated.

- A new surface pressure treatment means that more surface observations will have a chance of impacting initial analyses. The OI system rejects surface observations that are greater than 25mb away from the model surface. Staudenmaier (1996) showed that about 14 percent of WR surface observations make it into the Eta-29. The new treatment accepts all observations but weights them according to their distance from the model's surface.

- New data sets will be included in the assimilation: aircraft temperatures, VAD wind profiles, GOES precipitable water (8&9), surface winds over land, and SSMI sea-surface wind speeds. Note: the impacts of these new data sources have not been studied.

- The 3DVAR can directly assimilate satellite radiances, a feature that is now being tested for the Eta model. Satellite radiances can provide information about the atmosphere over data void areas, such as the Eastern Pacific. The direct assimilation of satellite radiances had a significant positive impact on the skill of the MRF model.

- Rogers et al., (1998) tested the Eta-32 3DVAR system over the period August-November 1996 and reported slightly better skill in QPF. More recent tests over November 1997 showed the Eta-32 had more skill than the Eta-48 in forecasting heavy rain events, but tended to overforecast light rain.

Three weaknesses of the current 3DVAR scheme for the Eta are:

- Preliminary tests have indicated a wet-bias east of the Rocky Mountains for low-level relative humidity that leads to an increase of light precipitation. The Eta models have always had a bias towards excessive light precipitation, especially in warm air advection regimes.

- The 3DVAR may produce less accurate initial height fields. Eta height fields have, in the past, often shown very fine-scale wiggles, and this is likely to continue. The 3DVAR scheme uses temperature as the primary basis for its

assimilation and NCEP modelers expect that the initial temperature field, when compared to observations, will be more accurate than the old OI system. However, they expect the initial height field to be less accurate.

- The Eta-32 has shown a tendency to produce very light precipitation off the West Coast under shallow stratus. Since most coastal WSR-88Ds can't observe the marine layer, it is not clear whether this light precipitation actually occurs.

Summary

The Eta-32 model will initially have the same model physics as the Eta-48 and Eta-29 versions. Due to improved resolution and the new 3DVAR assimilation system, the Eta-32 has the potential to produce better forecasts. However, as described by this Technical Attachment, the new 3DVAR assimilation system has the potential to introduce new errors that need to be identified. As always, WR will continue to evaluate model performance and provide feedback to NCEP modelers.

References

Barnes, S.L., F. Carecena, A. Marroquin, 1996: Extracting Synoptic-Scale Diagnostic Information from Mesoscale Models: The Eta Model, Gravity Waves, and Quasigeostrophic Diagnostics. *Bull. Amer. Meteor. Soc.*, March .

Mesinger, F., 1998: Comparison of Quantitative Precipitation Forecasts by the 48- and by the 29-km Eta Model: An Update and Possible Implications. Joint Preprints, 12th AMS Conference on Numerical Weather Prediction or 16th Conference on Weather Analysis and 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., D. Parrish, and G.J. DiMego, 1998: Data Assimilation Experiments with the Regional 3-D Variational Analysis at the National Centers for Environmental Prediction. Preprints, 12th AMS Conference on Numerical Weather Prediction.

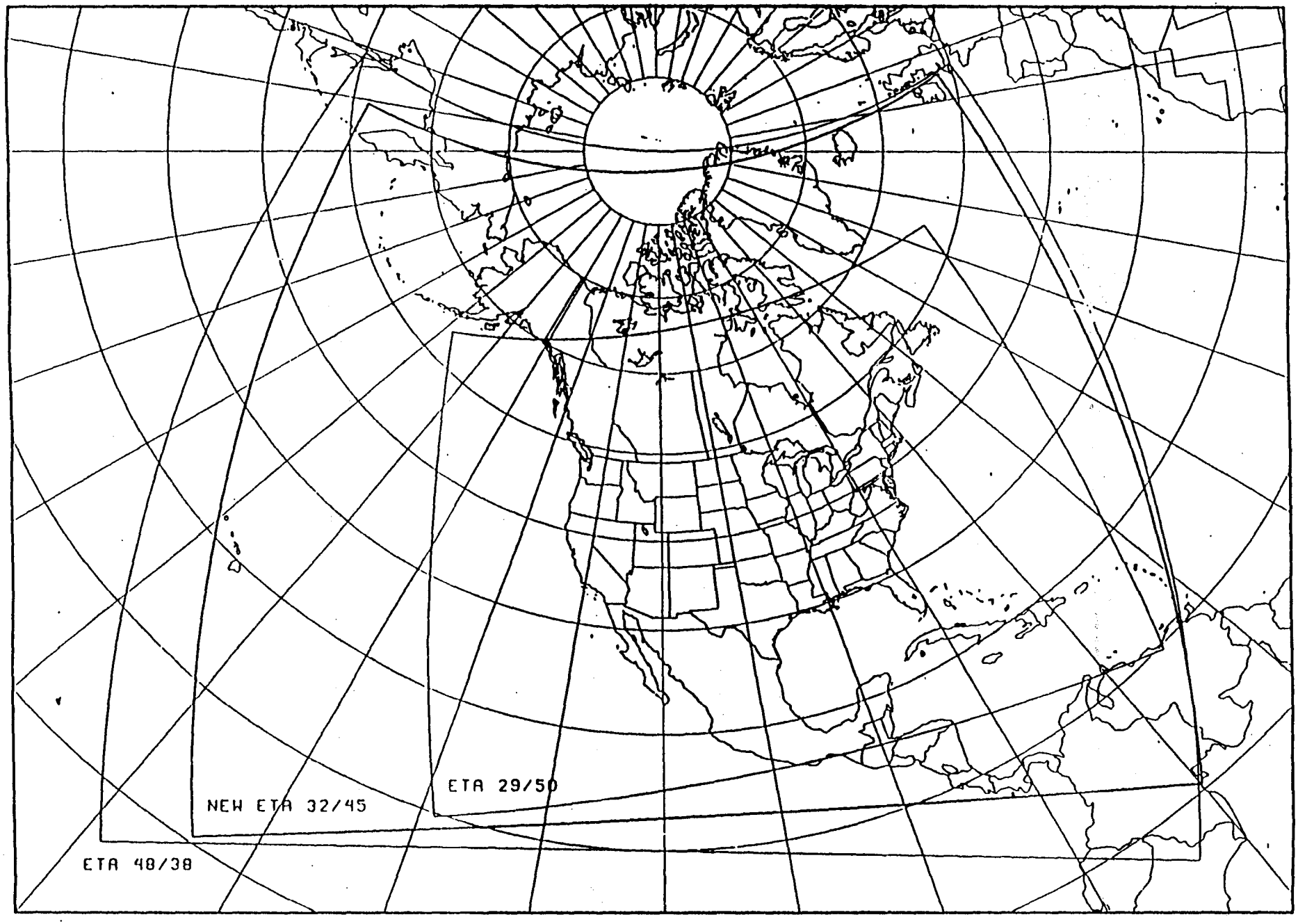
Staudenmaier, M., 1996: The Initialization Procedure in the Meso Eta Model. WR-Technical Attachment 96-30.

Staudenmaier, M., and J. Mittelstadt, 1997: Results of the Western Region Evaluation of the Eta-10 Model. WR-Technical Attachment 97-18.

NEW FEATURE	STRENGTH	RISK
32km Horizontal Resolution	representation of terrain	small
3DVAR data assimilation	can handle non-standard observations	it is a new system and could introduce new errors
domain size smaller than Eta-48 but much larger than Eta-29.	reduces errors from lateral boundaries	western boundary is closer to WR than in Eta-48
Vertical Resolution	better than in Eta-48	won't eliminate PBL problems
clouds and soil moisture cycled from Eta not AVN.	Reduces spin-up problems in QPF, etc.	Eta was developed using AVN first-guesses, so new errors are possible
3-hr Boundary Condition Updates	reduces errors from lateral boundaries	small
new surface pressure treatment	assimilate more surface observations	small
new driver to update mass and wind each time step	removes spurious high-frequency waves	small

Figure 1. A table describing the new features of the Eta-32.

Figure 2. Domain sizes of the Eta-48, Eta-32 and Eta-29 models.



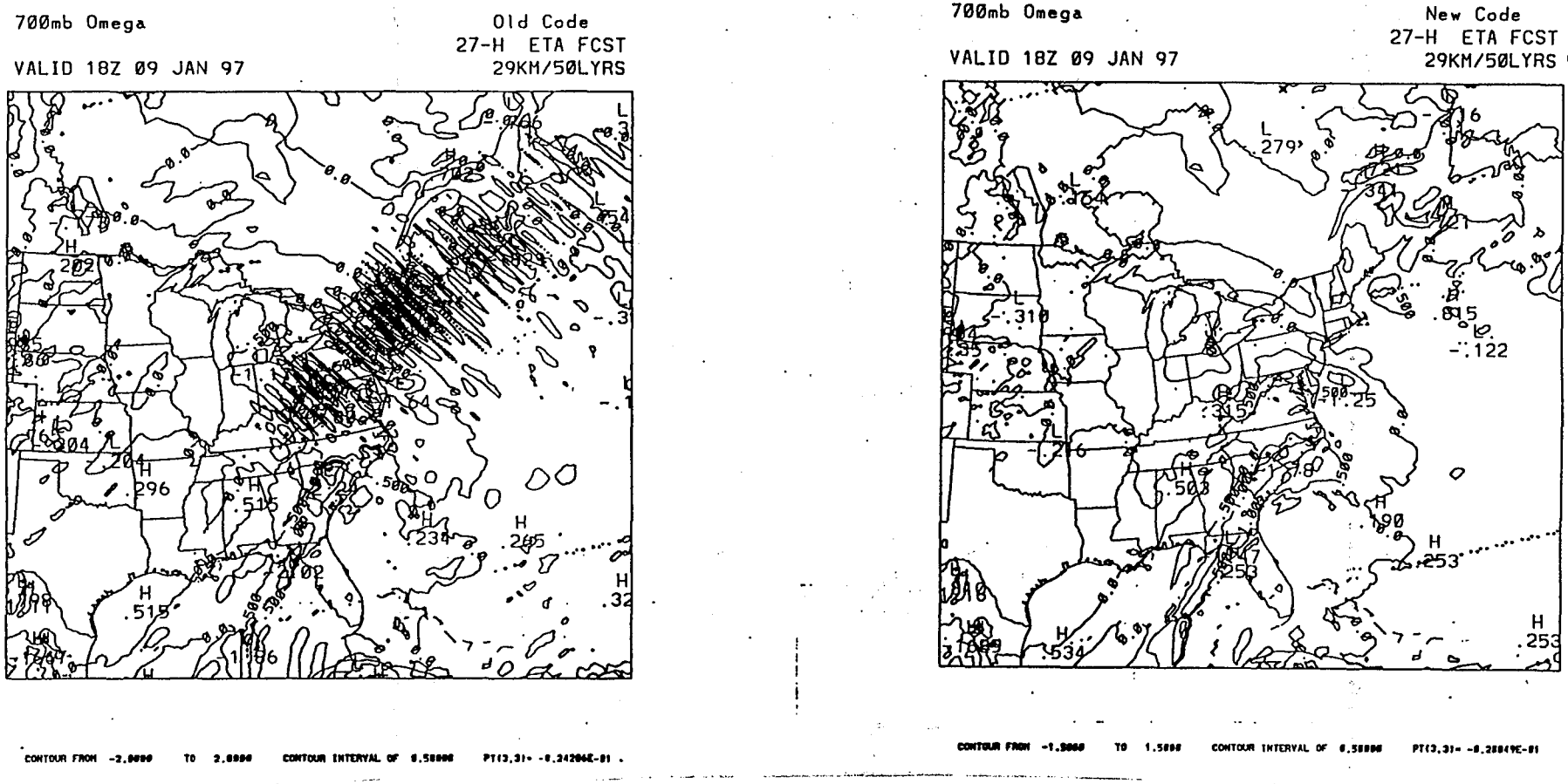


Figure 3. Before and after the new code which eliminates very high frequency gravity wave noise.