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THE MDSS ENSEMBLE OF MESOSCALE MODELS: LESSONS LEARNED FROM THE 2003 DEMO AND CHANGES FOR THE 2004 DEMO

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1. INTRODUCTION

During the late winter of 2003, FSL produced a set of six mesoscale model runs four times daily to support a project sponsored by the Federal Highways Administration. This project, called the Maintenance Decision Support System (Mahoney 2001), is intended to provide a tool to snow removal equipment garage supervisors to assist in determining when and where snowplows should be deployed, and what chemical treatments should be applied. The FSL model runs were transmitted in real time to NCAR/RAP, where they were ingested into the Road Weather Forecast System. RWFS produces point forecasts of pavement temperature and chemical concentration along roadways, and applies encoded rules of practice to suggest plow and treatment plans. The system was demonstrated in cooperation with the Iowa Department of Transportation, specifically three garages near Ames and Des Moines.

The ensemble (Schultz 2002) consisted of three different mesoscale models (MM5, RAMS, and WRF) using two different larger-scale models (Eta and AVN) for lateral boundary conditions, for a total of six members. The models were configured with identical grid size, resolution, and geometry, centered on Iowa. The four-per-day execution schedule follows the update frequency of the lateral bounds models as provided by NCEP.

This plan reflects the requirements as put forth by the MDSS stakeholder group, to focus on the 12-24 hr forecast, for which it was expected that lateral bounds would be an important controller of forecast quality. However, experience gained during the 2003 Demo indicated that greater value from the forecasting system could be gained by concentrating on the earlier hours of the forecast, the 2-12 h range. Furthermore, model forecast verification statistics suggest that some of the models used during the 2003 Demo were not as good as others (Schultz 2004). Thus, a different modeling strategy will be used for the 2004 Demo.

2. THE ENSEMBLE MODELS

For the 2003 MDSS demonstration, the six mesoscale model runs were initialized at 03, 09, 15, and 21 UTC, which is shortly after the arrival at FSL of the Eta and AVN (now called Global Forecast System, or GFS) gridded datasets from the NWS National Center for Environmental Prediction. The grid domain (Fig. 1) was centered on Iowa, the grid increment was 12 km, and the grid size was

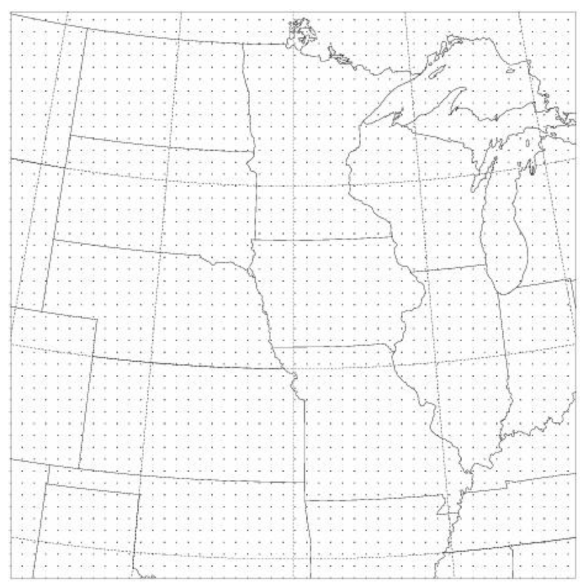

Figure 1. MDSS modeling domain. Every third grid point is shown.

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144×144×30. The time step was 30 s, and the models were run out to 27 h to provide a 24-h forecast service. All these model runs used only explicit precipitation physics, i.e., convective parameterizations were not used. This is appropriate for use in wintertime weather scenarios such as this demonstration, which ran through February and March of 2003. (Summertime weather requires a finer grid than 12 km or the use of a convective parameterization.) All six model runs used the same initial conditions, which were provided by the LAPS "hot start" method for diabatic initialization (Shaw et al. 2001; Schultz and Albers 2001).

The basic premise behind ensemble forecasting is that multiple predictions can be combined into a single prediction which is usually better than any of the ensemble members (Leith 1974). The ensemble needs two important attributes. First, all ensemble members should have approximately equal chance of being the best predictor for any given case; and second, the error characteristics of the various models should be uncorrelated from each other. Such an ensemble is said to have good *dispersion* characteristics. If all six models consistently make the same kinds of mistakes, then those mistakes will be manifest in the ensemble prediction.

There are three basic ways to construct an ensemble of mesoscale models that lead to the desired dispersion (Stensrud et al. 1999 and 2000). They are listed here with discussion of their application in the 2003 MDSS demonstration.

1) Include various *physics parameterizations*. The three mesoscale models each used different methods for advection, cloud physics, surface fluxes, and radiation.

2) Use a variety of *initializations*. There was only one kind of initialization used here because there were no alternatives to the LAPS hot-start initialization that could be made to run efficiently enough to run in real time. Using alternative methods for initialization (e.g., simple interpolation from large-scale grids) would lead to ensemble members that had no chance of similar forecast skill, at least in the first six hours of integration, where the diabatic initialization gives a performance benefit over models initialized with other methods (Shaw et al. 2001).

3) Use a variety of *lateral boundary conditions* (large-scale models). We used both Eta and AVN, which are reliably provided by the NWS via the NOAAport Satellite Broadcast Network.

3. LESSONS LEARNED FROM THE 2003 MDSS DEMONSTRATION

Verification statistics to be presented to the NWS conference of this AMS Meeting (Schultz 2004) give several important indications. First, the RAMS configuration was inferior at forecasting precipitation and temperatures, compared to MM5 and WRF, and will not be included. Second, forecasts that were different only in their lateral boundary models were statistically (and visually) very similar, so there is little value added by varying the lateral boundary conditions (an unexpected result). Consequently, we will use only the MM5 and WRF models, and only one model for lateral boundary conditions, the Eta.

Additional information was provided by the users of this forecast information during the demonstration. Going into this project it was assumed that the forecast information in the 12-24 h time range would be most useful, but users wanted more emphasis on the 2-12 h window to get more precision in the start and end times of precipitation events. Consequently, model outputs for the 2004 Demo will come at 1-h time resolution, instead of 3-h, and the forecasts will run out to 15 h, instead of 27.

Users were disappointed at the tendency of forecasts to "jump around" from one forecast cycle to the next. Because of this, and the attractiveness of using as much of the available radar and satellite data for initialization as possible, we will start new model runs each hour. This approach is intended to add to the ensemble dispersion by adding greater variety of initialization.

Thus, the reconfigured ensemble for the 2004 MDSS Demonstration will consist of two models, MM5 and WRF, each initialized with the LAPS hot-start diabatic initialization, each bounded with the NWS Eta model, and each run out to 15 h. Time-lagged ensemble methods (Brundage et al. 2001) will be employed, such that for, say, a 5-h forecast, the 5-h forecasts from the current model runs will be combined with 6-h and 7-hr forecasts from previous runs, all valid at the same time. This strategy is based on the belief that forecast skill deteriorates only slightly in one or two hours. Verification efforts following the 2004 Demo will attempt to examine this assumption.

The ensemble model runs are posted in real time at `http://laps.fsl.noaa.gov/mdss`

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