18.5 CASE STUDY VERFICATION OF THE MAINTENANCE DECISION SUPPORT SYSTEM (MDSS) FOR THE 2003 OPERATIONAL DEMONSTRATION

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1. INTRODUCTION

The National Center for Atmospheric Research (NCAR) road weather Maintenance Decision Support System (MDSS) was tested at Iowa Department of Transportation (DOT) offices in Ames and Des Moines during the winter of 2003. The Road Weather Forecasting System (RWFS, Myers et al. 2002) is the forecasting component of the MDSS. The RWFS ingests data from a variety of numerical models (e.g. ETA, AVN, MM5, WRF) and observational platforms (METARS, Road Weather Information Systems (RWIS)) to provide optimized forecasts of both standard weather and "extended" highway parameters for DOTs. It is particularly important for winter weather personnel to have accurate forecasts on event start and stop time, precipitation rate and type, as well as road temperature, and wind speed in order to plan their operations accordingly.

Bulk statistical analysis of state (e.g. temperature, wind speed) and road (e.g. road temperature) parameters indicated good overall system performance during the 2003 demonstration, similar to those found for the off-line test following the 2002 operational demonstration in the same region (Wolff et al. 2002). While the bulk statistics are quite valuable, in this paper we will highlight several aspects of the overall system by describing the results of a case study.

On 3-4 February 2003 a light snow event moved across Iowa. Only a few inches of snow fell, but it significantly impacted the road surfaces and DOT operations. The synoptic situation will be briefly described to give an overview of the entire weather system for the event. Observations of air temperature, wind speed, and precipitation type and amount are described and compared to RWFS forecasts. Forecasts created with and without the Forecast Systems Laboratory's (FSL) supplemental models are also compared to see if there is an added benefit in using model ensembles. The supplemental models consisted of the MM5, RAMS and WRF models, initialized with the AVN and ETA, for a six member ensemble. Actual anti-icing and deicing road treatments recorded by the road maintenance personnel are compared to MDSS recommended treatments for two highway segments. Finally, lessons learned from the event are discussed.

2. 3-4 FEBRUARY 2003 SNOW EVENT

2.1 Synoptic Setup

At 6 UTC on 3 February a low pressure system was passing to the southeast of Iowa while another cold front approached the area from the northwest (Fig. 1). As the day progressed the cold front pushed southeastward and brought a swath of light snow and a sharp temperature drop across the state between ~12 UTC on 3 February and ~6 UTC on 4 February (Figs. 2a-c, 3a-c).

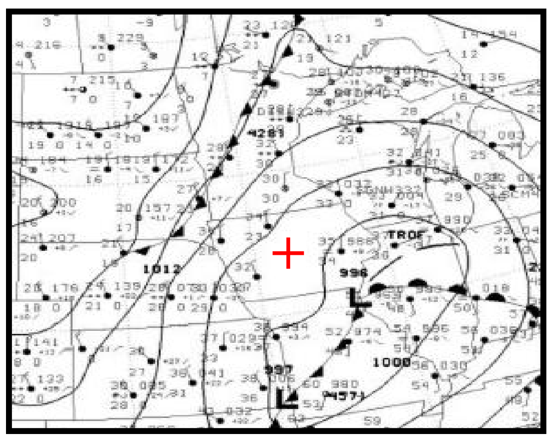

***Figure 1.** Surface chart for 6 UTC, 3 February 2003.*

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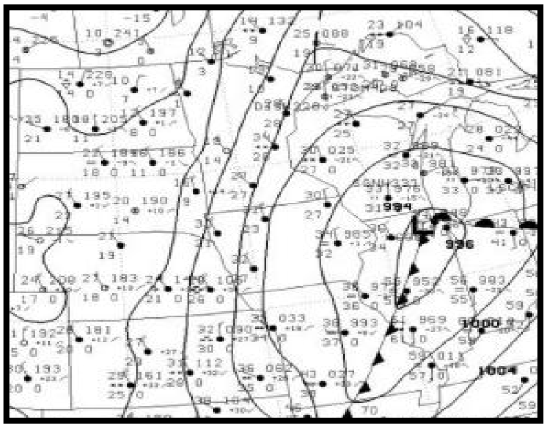

Figure 2a. *Surface chart for 18 UTC, 3 February 2003.*

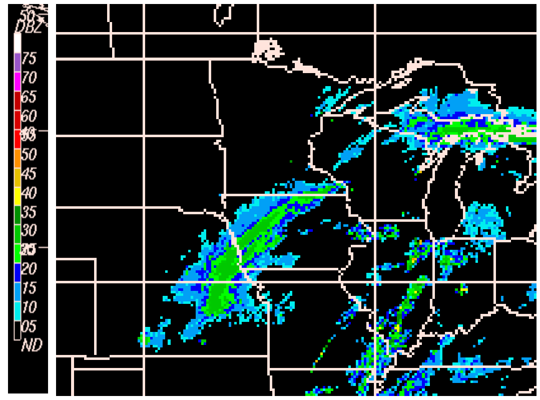

Figure 3a. *Radar Mosaic for 18 UTC, 3 February 2003.*

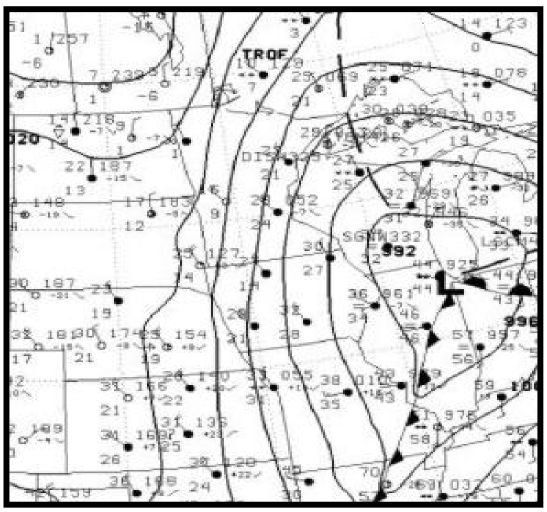

Figure 2b. *Surface chart for 21 UTC, 3 February 2003.*

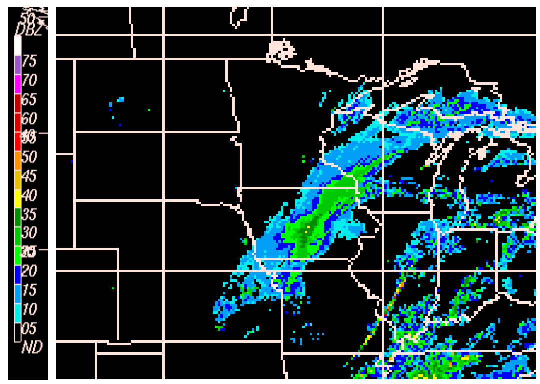

Figure 3b. *Radar Mosaic for 21 UTC, 3 February 2003.*

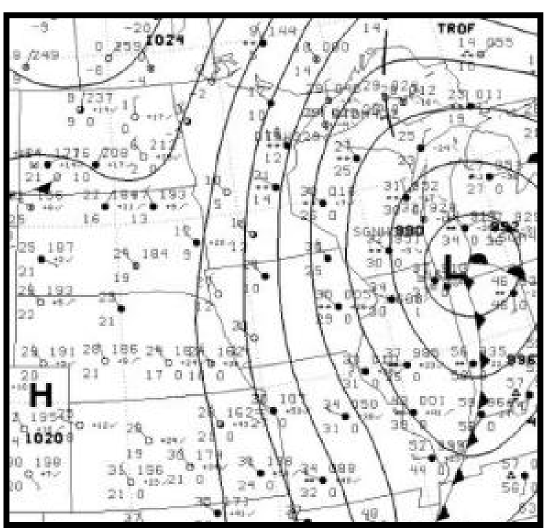

Figure 2c. *Surface chart for 00 UTC, 4 February 2003.*

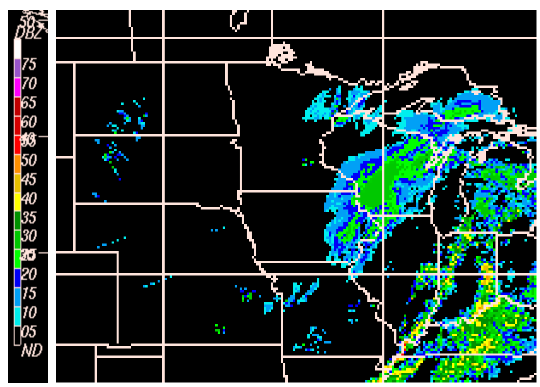

Figure 3c. *Radar Mosaic for 00 UTC, 4 February 2003.*

At both Ames (AMW) and Des Moines (DSM) a sharp temperature drop was associated with the beginning of the snow. Both locations reported -5°C temperatures with blowing snow by 00 UTC on 4 February. This becomes important for the deicing treatments applied late in the event.

2.2 MDSS Verification

2.2.1 Snowfall Amount

Overall, about 1 inch of snow fell around the AMW and DSM area with up to 3 inches elsewhere in the state (Fig. 4a). Snowfall totals forecast by the RWFS (Fig. 4b) compare quite well with the observed snowfall in geographic distribution across the state with the higher values forecast and occurring in the northeast and southwest parts of the state and lower values in the northwest and southeast corners of the state.

The actual amount forecast over the demonstration domain was 0.65 inches, which was very close to the 0.7 inches observed in Des Moines. Liquid equivalent values and patterns (not shown) were also reasonably forecasted.

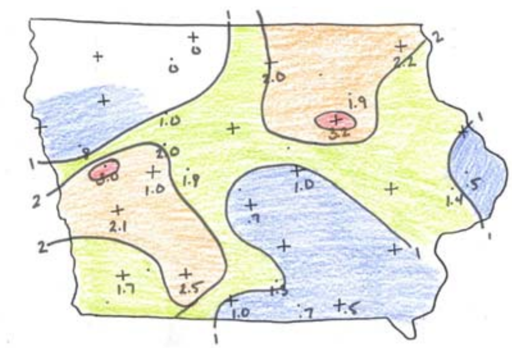

Figure 4a. *Contoured map of observed snowfall (inches) across Iowa from COOP reports.*

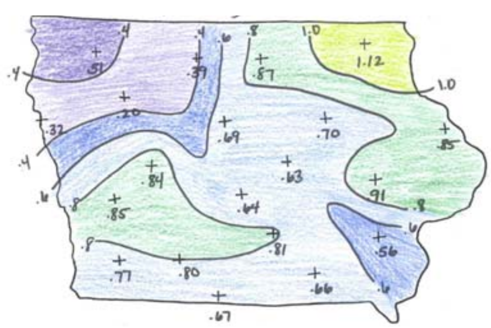

Figure 4b. *Contoured map of forecasted values of snowfall (inches) from the RWFS.*

2.2.2 Air Temperature

The air temperature time series for DSM (Fig. 5a) and AMW (Fig. 5b) illustrate that the air temperature forecast before and during the early part of the snowfall was close to the observed values for both configurations of the system (both with and without the FSL models). After the cold front pushed through the temperature dropped dramatically in a very short time period. While the decrease in temperatures was forecast by both configurations, the initial precipitous drop associated with the snowfall and cold front was not captured well, resulting in a lag in the cooling and a forecast that was consistently 4°C too warm throughout the overnight hours. Also note that the air temperature forecasts with and without FSL models eventually merge and become identical because the supplemental models are three hourly forecasts out to 27 hours and do not affect the forecast beyond that point.

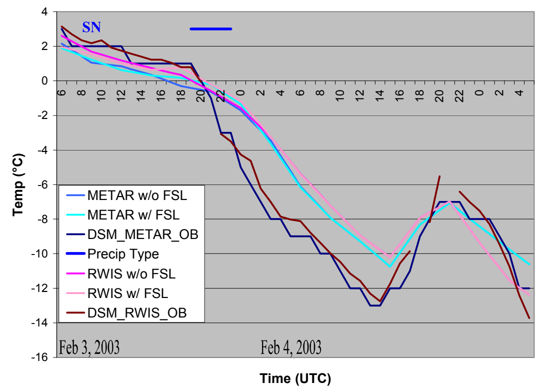

Figure 5a. *Time series of observed air temperature for the DSM METAR and RWIS and the RWFS forecast with and without the FSL supplemental models.*

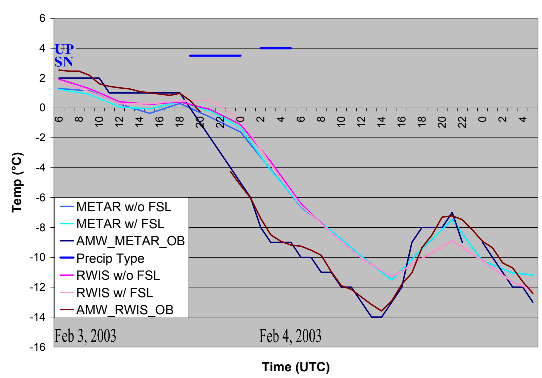

Figure 5b. *Same as Figure 11 except for AMW.*

2.2.3 Snowfall onset and cessation

For precipitation to be declared by the RWFS the probability of precipitation (POP) must equal or exceed 0.25 and the quantitative precipitation forecast (QPF) must be greater then 0.1mm/3hr. QPF and POP thresholds indicated that precipitation should have begun and ended at ~16 and ~03 UTC without the FSL models and ~17 and ~03 UTC with the FSL models at DSM (Figs. 6a). In reality the snow began at 1830 UTC and ended at 0430 UTC. In both cases, the forecasts started and ended the precipitation too early, but the "with FSL" version was slightly better on the start time. At AMW (Fig. 6b) the beginning of the event was predicted to start too early, but the end of the event was captured well. Both locations received most of their snowfall in the first five hours of the event. There was a break at DSM and then another brief, light period of snowfall. Neither configuration of the system (with or without FSL) indicated a break in the precipitation during the middle of the event, but both did indicate peak POP and QPF values during the time of the highest accumulation.

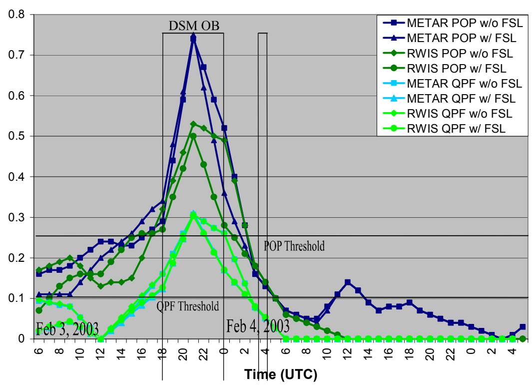

Figure 6a. *RWFS forecast POP and QPF values for DSM METAR and RWIS both with and without the FSL supplemental models. The observed start and stop times from the METAR observations are indicated by the long vertical lines.*

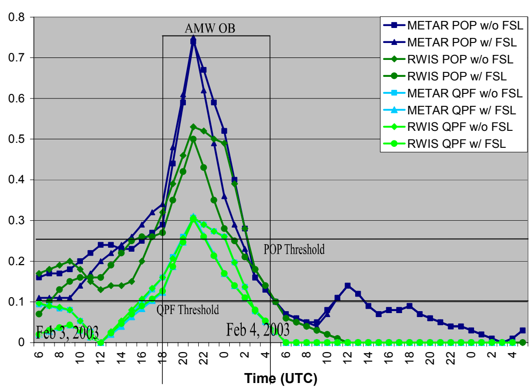

Figure 6b. *Same as Figure 13 but for AMW.*

2.2.4 Road Treatment Recommendations

Figure 7 shows a comparison of the suggested treatments from the MDSS and the actual treatments performed by the Des Moines and Ames DOT garages with predicted and observed weather as context. The predicted light snow event prompted the MDSS to recommend a pretreatment of 110 lb per lane mile of brine at about 17 UTC (not shown), followed by a single plowing and salt treatment of 150 lb per lane mile between 20 and 22 UTC on February 3 at both locations. This nicely matched the timing of the snow buildup on the road and should have allowed enough chemical to melt the snow that fell after the plowing was complete.

The actual DOT treatments at Des Moines and Ames did not include any pretreatment. Plowing and salt application started an hour earlier at Des Moines and an hour later at Ames than the suggested plowing and treatment. The actual amount applied initially was 300 lb per lane mile. The problem with both the suggested and actual treatments was that the sharp temperature drop after the snowfall was not expected. The salt applied in the treatments caused the snow to melt and then when the temperature fell sharply, the melted snow froze and created icy roads.

Another issue was that 5-10 ms^{-1} winds occurred during and for several hours following the snowfall, causing blowing snow, something the current version of the MDSS does not handle. Because of the ice and blowing snow the garages had to continue to treat the roads throughout the night and into the morning until the sun helped melt the snow and ice off the roadways.

3. SUMMARY AND LESSONS LEARNED

Overall, the February 3-4, 2003 light snow event was predicted well and the road treatments suggested by the MDSS were reasonable, given the forecast. Snowfall amounts and timing were well forecast for Des Moines and Ames, as well as for the entire state. The areas where the highest and lowest accumulation would occur were forecast very well. The air temperature forecast was good prior to and during the beginning of the snowfall. However, the system forecast the sharp temperature drop to occur about 3 hours late, causing it to be 4°C too warm overnight. The missed air temperature forecast hurt the treatment recommendations portion of the system later in the event. The suggested road treatments were reasonable given the RWFS forecast for the event and matched reality at the beginning of the event. The differences came when the melted snow refroze on the roadway, so treatments continued for a much longer period of time then was expected.

From this case study a few lessons have been learned that will help the MDSS system capture this type of even better in the future. The

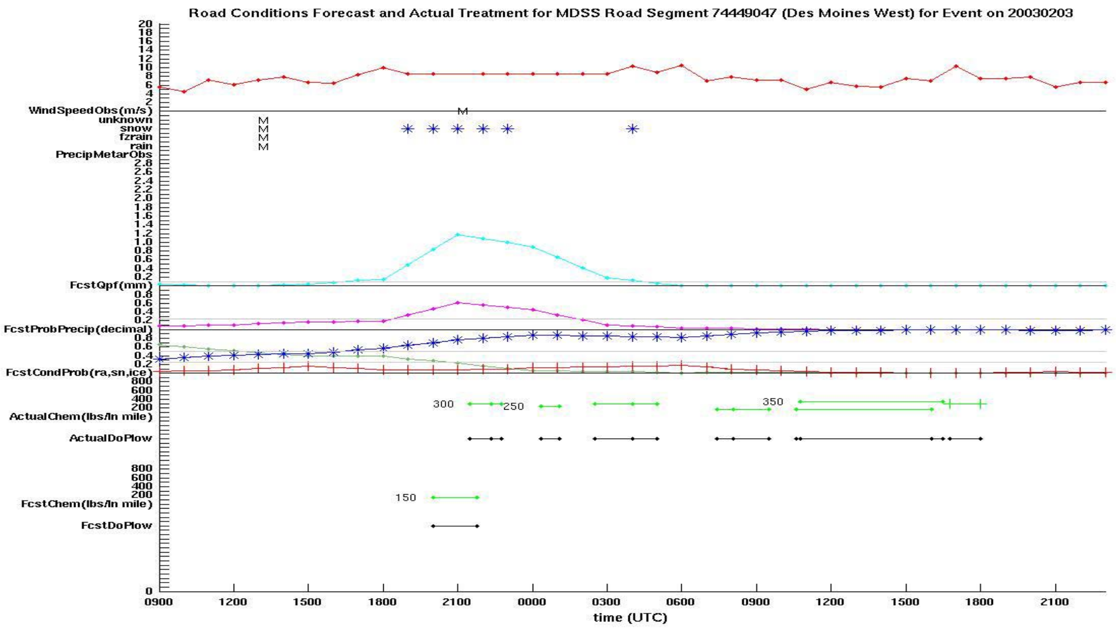

Figure 7a. *Time series of forecast wind speed (top red line), observed precipitation type (stars=snow, dots=rain, open circles=unknown precipitation type, M=missing), forecast QPF, POP, conditional probabilities of snow (blue line), rain (green line), and ice (red line), actual salt applications (upper, discontinuous, green dotted line with amount in pounds per lane mile), actual plowing periods (upper, discontinuous, black dotted line) and suggested salt applications (lower, green dotted line with amount in pounds per lane mile) and suggested plowing periods (lower, discontinuous, black dotted line) for highway segment along I-35, just southwest of Des Moines.*

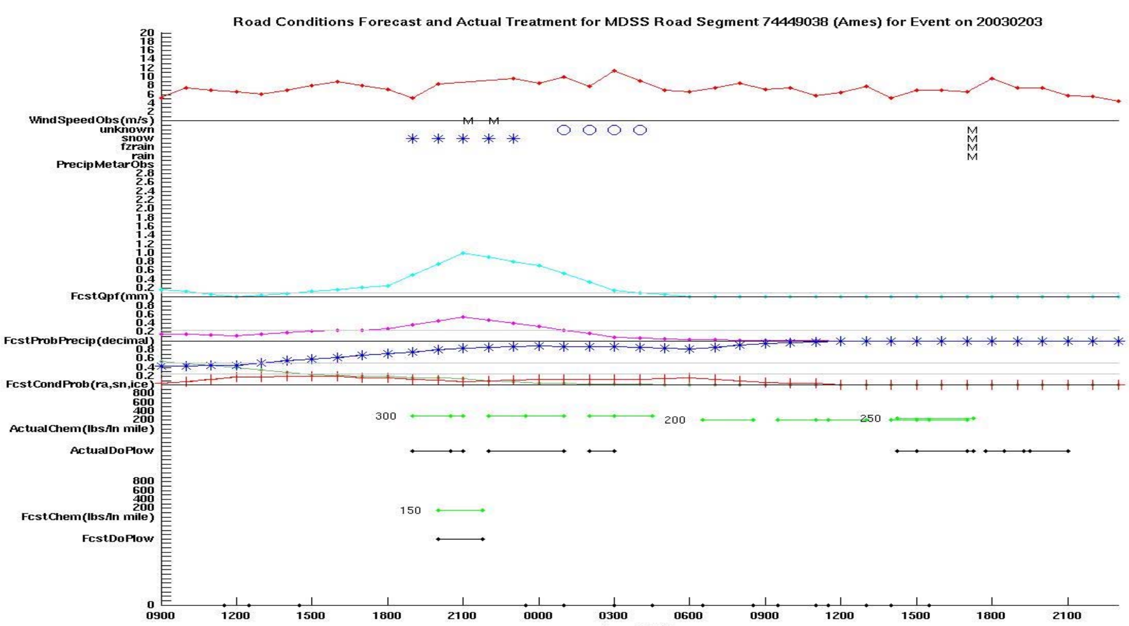

Figure 7b. *Same as Figure 7a but for highway segment I-35 just south of Ames.*

first, and perhaps most complex, is the recognition of the need for a blowing snow module in the system. Some method for alerting on conditions with the potential to cause blowing snow would be very useful to DOT personnel. This module will have to take into account, among other things, wind speed and direction (relative to the road) and the freshness of the snow. One key issue for the maintenance personnel will be local knowledge of the surrounding area, such as the locations of open fields, valleys, or forested areas. These different types of areas can greatly affect blowing snow. The second lesson learned is that when making road treatment recommendations the system needs to take the entire event as a whole instead of looking just a few hours ahead depending on the length of the plow route. This will help avoid a situation like this case where the snow was melted by chemicals but did not have enough time to dry before it got too cold and refroze.

The 2003 winter season was the first year that the MDSS was running real-time in an operational setting. It was a relatively early version of the system and many upgrade are planned that should enhance both its accuracy and utility for decision makers. The lessons learned from this case study will also be used to improve the system for the 2004 operational demonstration.

4. REFERENCES

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Wolff, J. K., B. C. Bernstein and B. Myers, 2003: Verification of the road weather forecast system for the maintenance decision support system. *Preprints*, 19th Int'l Conf. On Interactive Information and Processing systems for Meteorology, Oceanography, and Hydrology. Amer. Met. Soc.

5. ACKNOWLEDGEMENTS

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