10.5 VERIFICATION OF THE ROAD WEATHER FOREACST SYSTEM FOR THE MAINTENANCE DECISION SUPPORT SYSTEM

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1. INTRODUCTION

The Road Weather Forecast System (RWFS) was developed by the National Center for Atmospheric Research for the Maintenance Decisions Support System (MDSS) project. The RWFS ingests data from a variety of numerical models (i.e. ETA, AVN, NGM) and observational platforms to provide optimized forecasts of both standard weather and "extended" highway parameters for departments of transportation (Myers et al., 2002).

An important aspect of any real time forecast system is the verification of its output. In this paper, forecast fields such as air temperature, wind speed, precipitation type and road temperature are compared to real-time observations from Aviation Routine Weather Reports (METAR) and Road Weather Information Systems (RWIS) stations. Air temperature and road temperature forecasts are broken into different categories based on coincident observations of cloud cover and precipitation type for the comparison. The road temperature forecast is also compared using output with and without the application of recommended road treatments generated by the RWFS. The effects of forecast length on the RWFS output are also examined. Finally, the quality of the observations used for verification was checked by comparing those from neighboring METAR and RWIS stations.

The verification results are based on a three-week period during which a variety of winter weather events affected the area. The weather ranged from clear to overcast skies with snow flurries to a few cases of more significant snowfall events. This variety of weather proved to be a good test for the RWFS.

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2. SYSTEM SETUP

The MDSS output used for these tests consists of the 0-24 hour RWFS forecasts derived from the standard model input of ETA, AVN, NGM MOS, AVN MOS, MRF MOS, as well as a meso-scale model from the Forecast Systems Laboratory (FSL). Road surface and substrate information was also an input in order to correctly represent the road segments used.

There were three main areas of interest during the winter test period from January to March of 2002 in western Minnesota. The areas included in the study are represented by the boxes in Figure 1. The focus of this paper will be the southern most area (box 3) of Montevideo/Hanley Falls. The forecasts were assessed over a shorter three-week period in late February to early March.

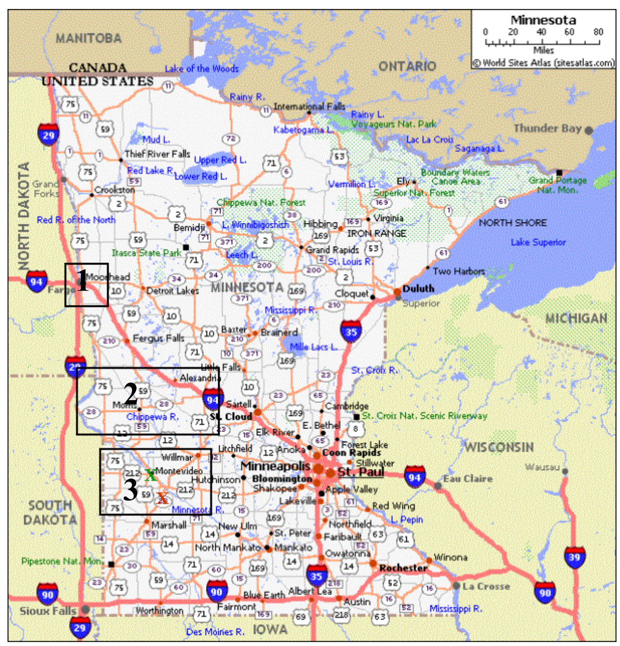

Figure 1: Map of Minnesota showing areas of interest for winter test period.

3. OBSERVATION QUALITY

The quality of observations is important to look at in order to find an acceptable threshold of deviation from the forecast. Figure 2 compares the actual air temperatures recorded from the Montevideo METAR and the Hanley Falls RWIS sites. These two stations are approximately

15 miles apart, and are located near the Minnesota River in very similar terrain. Almost all of the temperature pairs are within +/- 2°C of each other, implying that forecast errors of +/- 2°C are within the expected range of measurement uncertainty for the instruments.

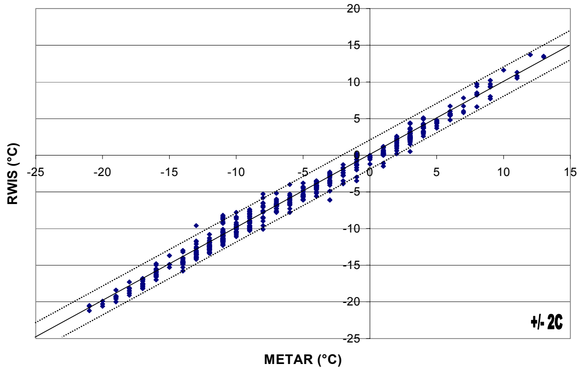

Figure 2: Observed air temperature comparison of the Hanley Falls RWIS versus the Montevideo METAR. Center solid line is 1-to-1 line. Dashed lines on either side are +/- 2°C.

4. MDSS PERFORMANCE

4.1 Air Temperature

Accurate air temperature forecasts are critical to correctly predicting surface precipitation type. Figure 3 shows a time series of the air temperature comparison of the RWFS and the Hanley Falls RWIS for the three-week period. The temperature traces match up quite well even when the RWFS forecast length increases up to 24 hours. Figure 4 illustrates nicely that the RWFS forecasts are generally within +/- 2.5°C of the actual observed temperature at the RWIS station. Thus, they were essentially accurate to within the range of error expected in the measurements themselves.

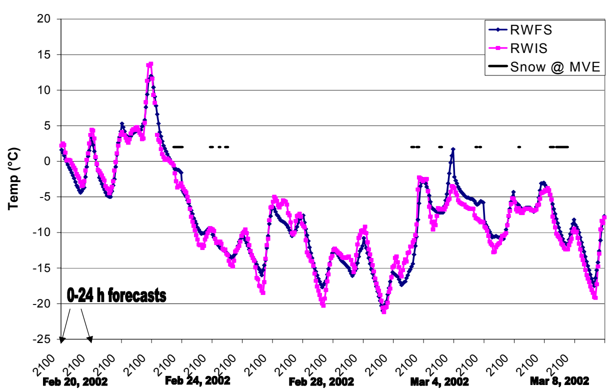

Figure 3: Time series of air temperature comparison from the Hanley Falls RWIS and the RWFS 0-24 hour forecast.

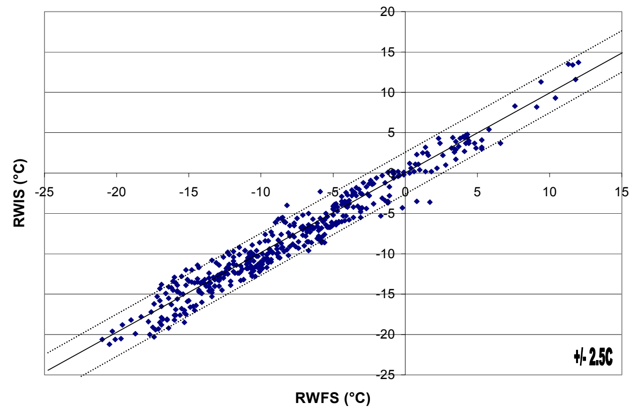

Figure 4: Air temperature comparison of the Hanley Falls RWIS versus the RWFS output.

The effects of forecast length on the air temperature forecasts were also examined. The forecast time lengths were broken down into 0-6 hour, 6-12 hour, 12-18 hour, and 18-24 hour forecasts. Figure 5 shows that there is no discernable trend in the accuracy of the air temperature forecasts with increased forecast length. That is to say, no matter what the forecast length, 0-24 hours, the temperature forecast was almost always within +/- 2.5°C of the measured air temperature.

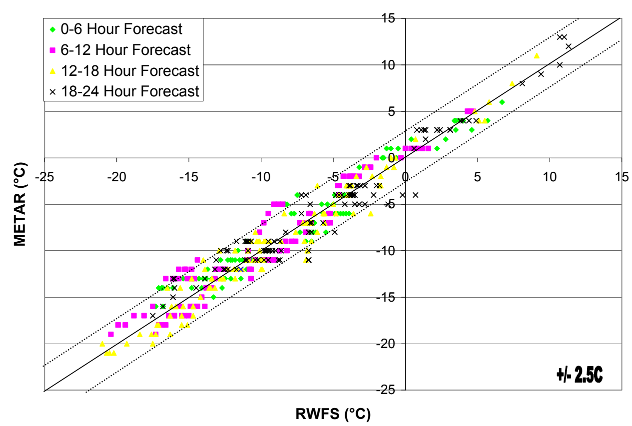

Figure 5: Air temperature comparison of the Montevideo METAR versus the RWFS output broken down by forecast length.

4.2 Wind Speed

Wind speed is an especially important parameter during and following snowstorms because significant winds may cause blowing and drifting snow that results in reduced visibility. As seen in Figure 6 the RWFS wind speed performs quite well with the majority of forecasts being within +/- 2.5 m/s when compared with the Montevideo METAR. This is true even during times of moderate (5-10 m/s) to relatively strong (>10 m/s) sustained winds, which can be critical after a cold front moves through and brings strong northwesterly flow behind it.

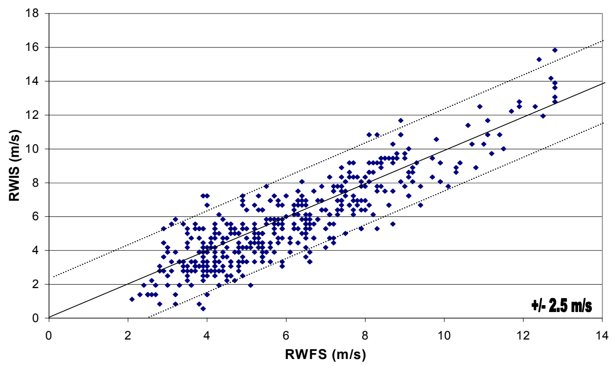

Figure 6: Wind Speed comparison of the Hanley Falls RWIS versus the RWFS output.

4.3 Road Temperature

Road temperature forecasts are rather complex because they are not only dependent on the forecast weather, but also the substrate, pavement type, and whether treatments are applied to the roadway or not. These same parameters have an effect on the verification data as well. If there is a snowfall that is not cleared off the surface, the road temperature may hold steady around the freezing mark because the snow will insulate the road surface. However, if the snow is cleared off the road temperature will decrease or increase depending on the air temperature and subsurface temperature. It is impossible to take all of this into account without high precision, frequent observations, which were not available. It is possible, however, to get a hint at the performance of the road temperature forecasts and when the predictions are good/poor by binning the forecasts into categories based on cloud cover and precipitation occurrence. Furthermore, the predicted road temperatures from "treated" and "untreated" roads (based on the system recommendation, not actual treatment) can be checked.

Figures 7 and 8 show the difference in road temperature forecast without treatment and with the recommended treatment, respectively. There is a slight bias for RWFS to forecast on the warm side, especially for untreated roads, but overall most points are within +/- 2.5°C of the actual recorded road temperature. Predictions made with the suggested treatments taken into account appear to be somewhat more accurate. Most forecast values outside the +/- 2.5°C range occurred when skies were overcast, but non-precipitating. Some relatively poor predictions also occurred with clear skies.

It can be seen in Figure 7 that without treatment during snow events the RWFS forecasted road temperature is steady at about –5°C, due to insulation from the snow, while the RWIS temperatures are much colder. However in Figure 8 these temperatures fall much closer to the one-to-one line, which implies that the RWFS recommended treatment matched well with the actual treatment during these cases and the forecast of road temperatures with recommended treatment is quite good.

For temperatures from 0°C to 15°C on overcast days it can be seen that the RWFS tends to be too warm on the forecast road temperature. This may be due to the models under forecasting cloudiness. The opposite of this is seen in the colder temperatures of –15°C to -20°C during clear skies. This could be due to the models having a few clouds instead of clear skies and more radiational cooling occurs than was expected.

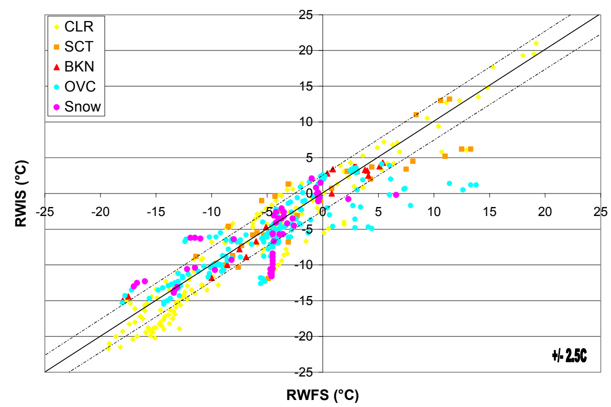

Figure 7: Road temperature comparison of the Hanley Falls RWIS versus the RWFS output. **NO TREATMENT**. (CLR=Clear, SCT=Scattered, BKN=Broken, OVC=Overcast)

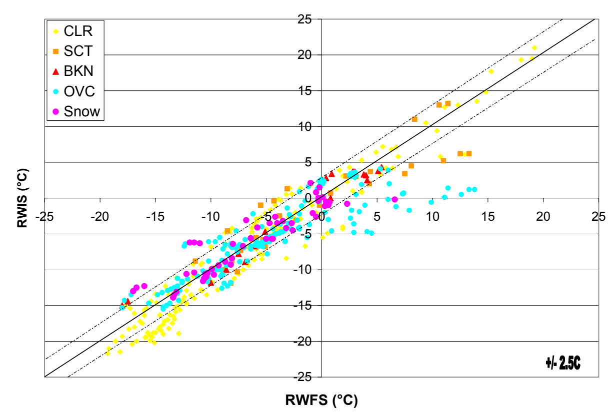

Figure 8: Road temperature comparison of the Hanley Falls RWIS versus the RWFS output. **WITH TREATMENT**. (CLR=Clear, SCT=Scattered, BKN=Broken, OVC=Overcast)

5. CONCLUSIONS

Overall, these preliminary results show that the RWFS has good skill. The system constructs reasonable forecasts within +/- 2.5°C for both air and road temperature and within +/- 2.5 m/s for wind speed. Of course, three weeks of data is insufficient to determine if the recommended treatments were reasonable or not, but this exercise does provide some initial insight about the quality of the system output.

It should be noted that the RWFS was not optimized or tuned during this period. It is anticipated that the results will improve once the system is fully configured and tuned for a particular region. It is also important to note that the system was tested in relatively flat terrain and that results may differ in steep terrain. There is a plan to do a more in depth assessment during the winter of 2003 to further study the reliability of the RWFS forecasts.

6. REFERENCES

Myers, B., M. Petty and J. Cowie, 2002: An automated road weather prediction system for road maintenance decision support. *Preprints*, 18th Int'l Conf. On Interactive Information and Processing Systems for Meteorology, Oceanography and Hydrology. Amer. Met. Soc., 40-41.

7. ACKNOWLEDGEMENTS

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The development of the MDSS functional prototype is a team effort involving several U.S. national laboratories including CRREL, MIT/LL, NOAA/FSL, and NOAA/NSSL. Each national laboratory has contributed by providing technologies that support MDSS objectives.