The Evolution of METRo in a Roadway DSS

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SIRWEC
15th International Road Weather Conference
February 5, 2010

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Outline

Paving Project, Washington DOT

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The Need for Roadway Decision Support Systems

Accurate weather and pavement condition forecasts are important in helping maintenance managers make effective decisions

Until recently, the road maintenance community has relied on conventional methods for gathering and applying road weather-related intelligence in the treatment and operations decision process

The Federal Highway Administration (FHWA) initiated a program in 2001

The NCAR Maintenance Decision Support System (MDSS) was created to provide objective guidance regarding treatment strategies for adverse winter weather events

The MDSS has evolved over the last 8 years and concepts are now being applied to non-winter decision support systems aimed at helping practitioners make warm season maintenance decisions

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Background / Current Implementations

Since 2004, MDSS has been run operationally by NCAR for the Colorado Department of Transportation and E470.

Two years ago, the system was upgraded to provide runway forecasts for Denver International Airport (DIA)

Recently, MDSS concepts were implemented for use in a new project to assess the use of *Clarus* observation data in improving road weather forecasting

Eventually this system will be used to provide weather and road forecast information to an operational summer maintenance decision support system over Iowa, Indiana and Illinois

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Roadway Decision Support Systems

- Real-time observations
- Advanced weather forecasts
- Road condition forecasts
- Rules of Practice

Roadside Mowing, Idaho DOT

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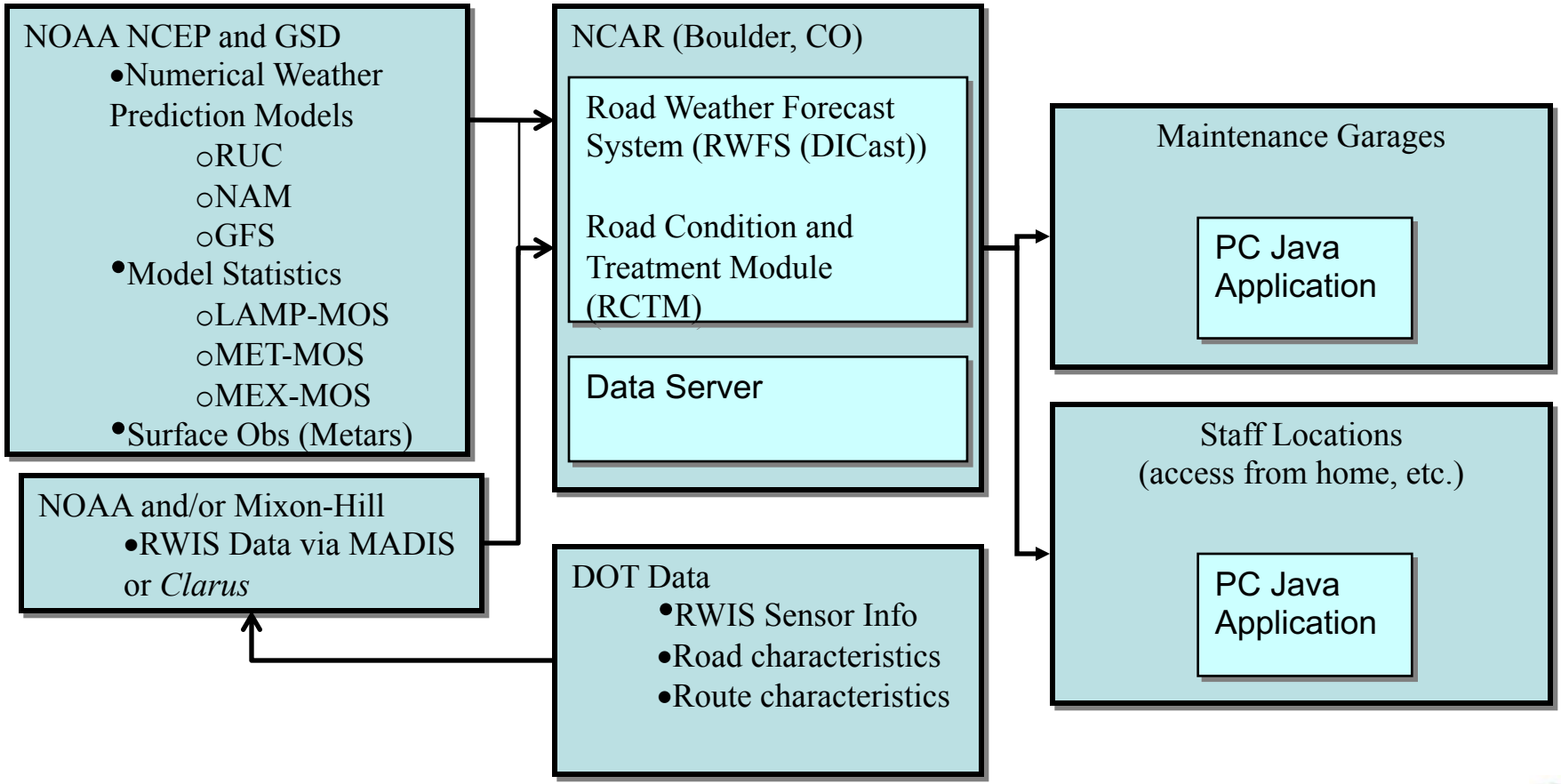
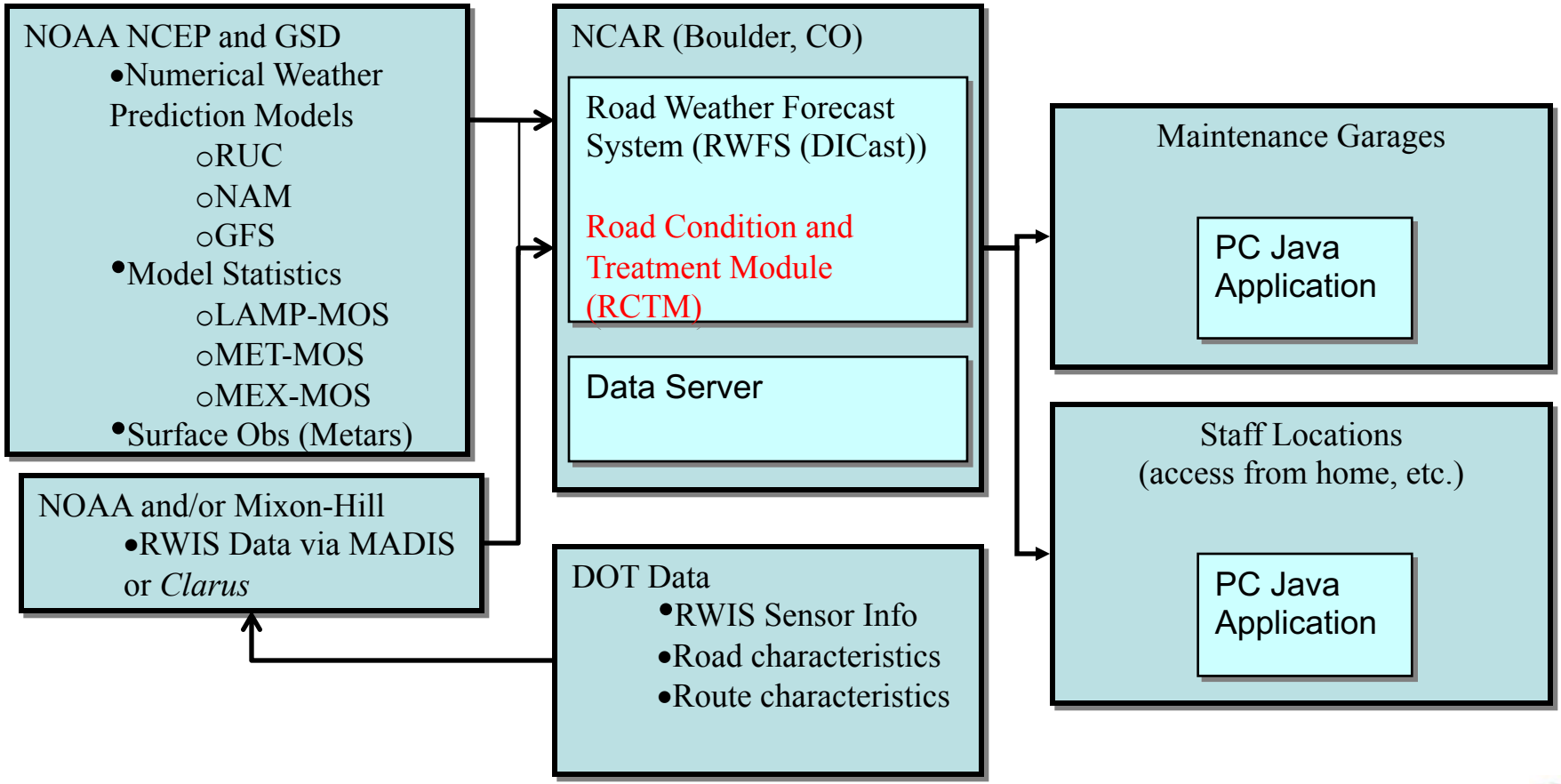
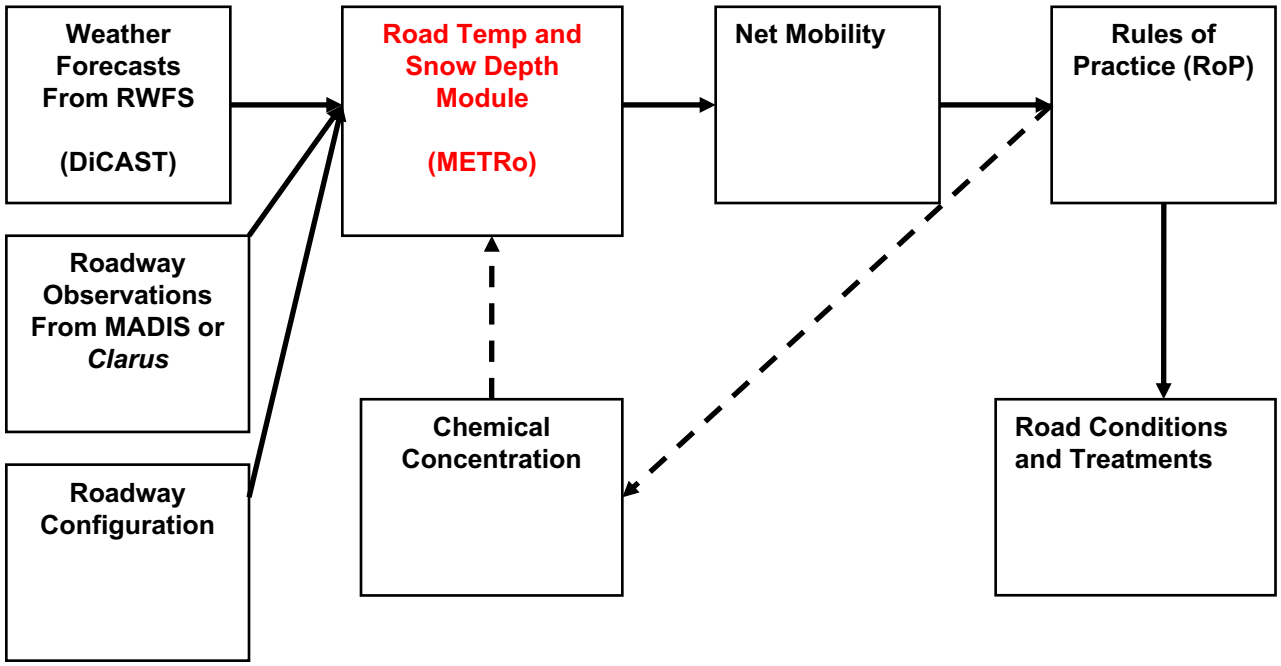
DSS System Overview



DSS System Overview



Road Condition and Treatment Module (RCTM)



METRo Overview

Developed and used by the Meteorological Service of Canada

Uses roads surface observations along with a weather forecast to predict the evolution of pavement temperatures and the accumulation of precipitation on the road

Denver Blizzard, December 2006 (AP Photo/Ed Andrieski)

Composed of three parts:

- **energy balance module for the road surface**
- **heat-conduction module for the road material**
- **module to deal with water, snow and ice accumulation on the road**

METRo documentation is available at http://documentation.wikia.com/wiki/METRo)

METRo Challenges, Limitations and Improvements

Takes a relatively long time to run (~ 2 seconds for a 48 hour point forecast)

- XML input and output files takes up ~90% of the processing time

- Problematic when running over a large number of sites
  - Became apparent in NCAR's new DSS, which is configured to generate road forecasts out to 162 hours for 150 sites

- Using comma separated (csv) input/output files improves run time but is not supported in public releases

Requires and observational history of the road surface temperature

- Generating this history presents challenges in a real-time system and at non-observing sites

- Software was developed to create a history (or pseudo-history) from the combination of a previous METRo forecast and recent observations

- NCAR has made significant improvements to the obs-history software

METRo Challenges, Limitations and Improvements

METRo exhibits poor performance during the summer

- **Originally developed for winter road conditions**
- **METRo over-forecasts road-temperatures during the summer**
  - **15-20°C errors for some sites**
- **METRo developers are currently working on improving the model during the warm season**

METRo developers have continued to improve the model and fix minor bugs

- **Maximum forecast extent is now unlimited**
- **New versions of METRo have been released over the last few years**

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Using METRo as a Tool for Road-temperature QC

As part of the *Clarus* quality control work, NCAR investigated developing climatological bounds for pavement and subsurface temperature observations

Evaluated METRo in conjunction with extreme values from archived pavement and subsurface temperature observations

The METRo data resulted in improved bounds for pavement temperature, but not for subsurface temperature

RWIS, unknown location

Recent Verification / Performance: Colorado MDSS

Verification results based on bulk statistics calculated over the entire 2008-2009 winter season

The plots show median average error (MAE) and bias values per lead time out 48 hours

Observations come from Road Weather Information Stations (RWIS)

The statistics are based on all 12z (5am MST) road-temperature forecasts generated throughout the season, for 10 RWIS sites near Denver

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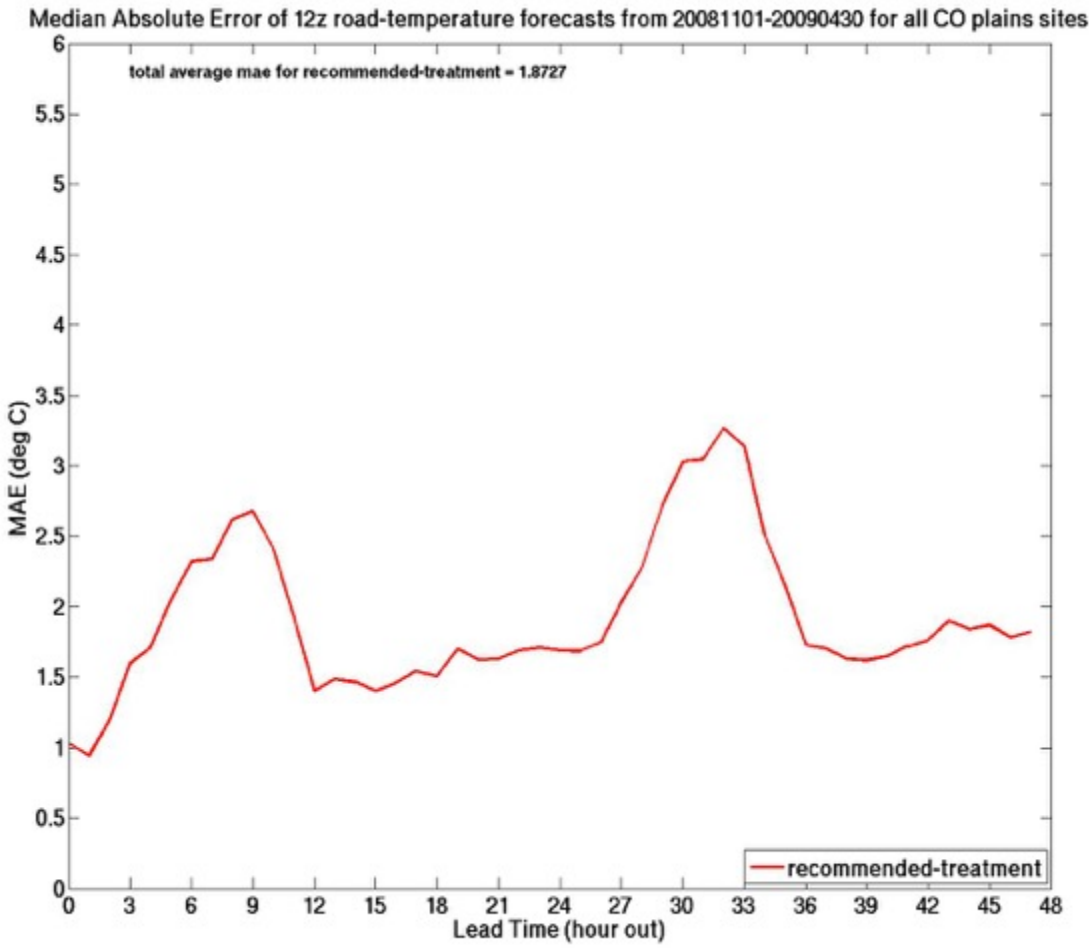
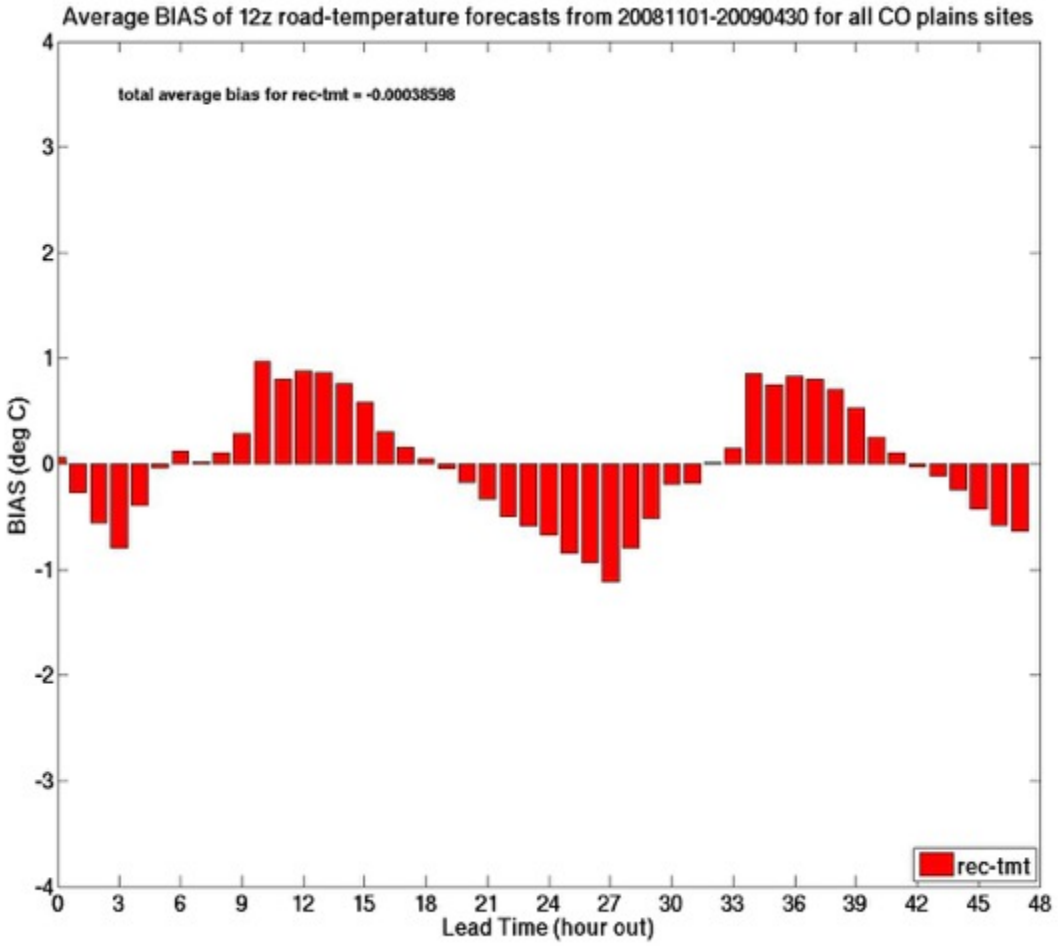
MAE of 12z METRo forecasts from Colorado MDSS



Average Error = 1.9°C

Largest errors occur during the afternoon

Bias of 12z METRo forecasts from Colorado MDSS



Average Bias = 0.0°C

Cold bias in the morning and a warm bias in the afternoon

METRo is slightly out of phase with the observed road temperature

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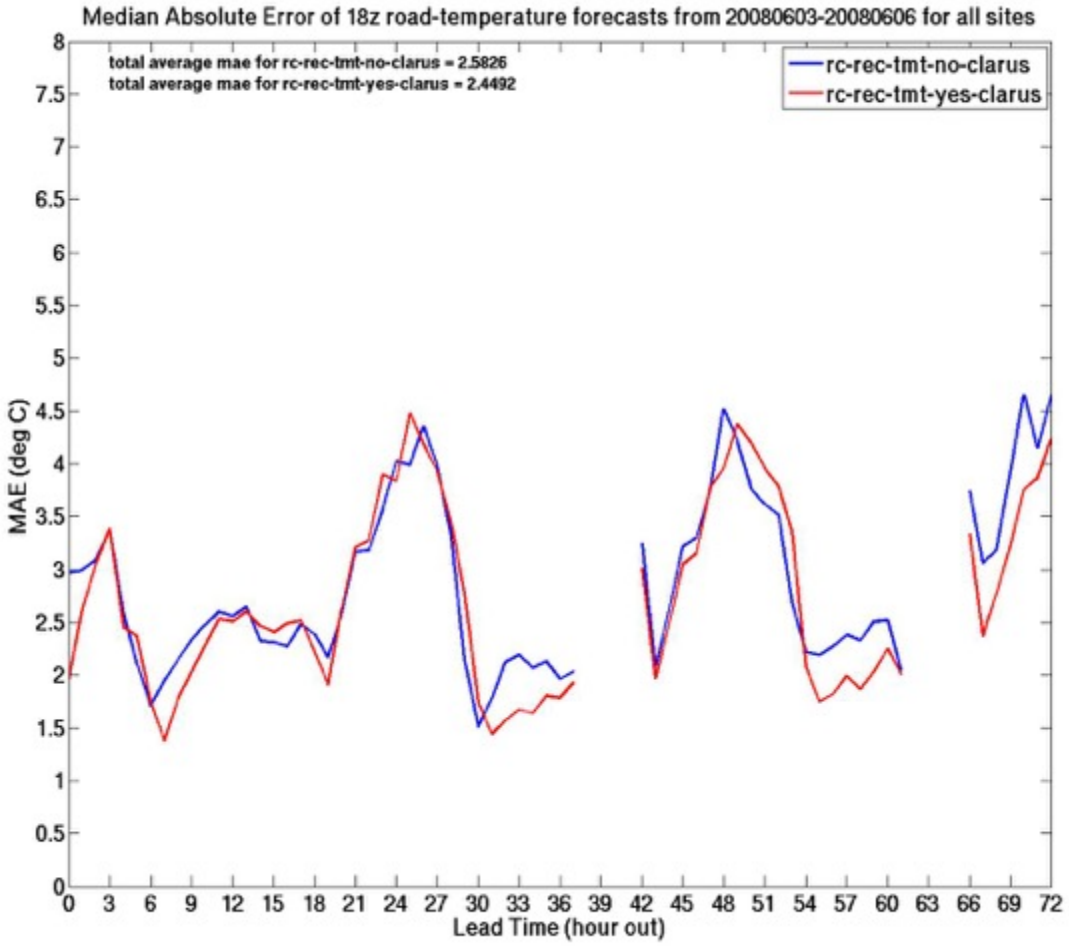
Recent Verification / Performance: *Clarus* DSS

A study was done to see if observations improve the METRo forecast

Plot compares MAE values from road forecasts generated with and without actual observations

- **MAE values are based on all 18z (12pm CST) forecasts generated over three days in June 2008 for 150 Clarus sites in IA, IL and IN (this was from a heavy rain case)**

MAE of 18z METRo forecasts from *Clarus* DSS



Average Error
with *Clarus* Obs = 2.4°C

Average Error
w/o *Clarus* Obs = 2.6°C

Reduction in error most evident in first 3 hours

Improvement at later lead times can only be attributed to a better weather forecast (that has been tuned with obs)

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Recent Verification / Performance: *Clarus* DSS

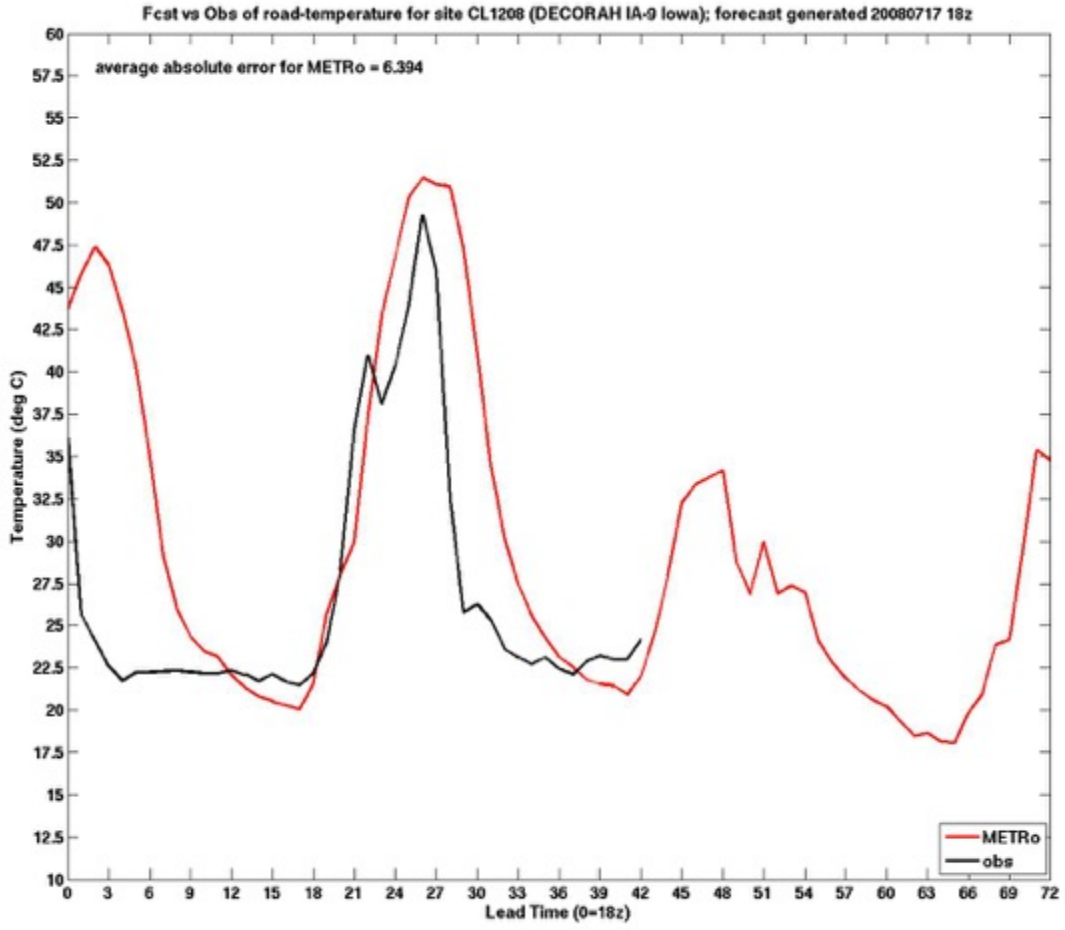
The second part of the verification from the *Clarus* DSS highlights the issue that METRo has a problem forecasting road temperature during the summer

- **The plot shows a forecast versus observations time series for a 72 hour forecast generated at 18z on July 17th, 2008 for a site on IA-9 near Decorah, Iowa (this was from a record high temperature case)**

- **The observations come from the RWIS located at this site**

Fcst vs. Obs of 18z METRo forecast from Clarus DSS

Example of a bad forecast during the summer for one site



Average Error = 6.4°C

Forecast quickly diverges from the obs

Errors in excess of 20°C during the afternoon

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Conclusion / Future Recommendations

METRo has proven to be a good pavement model to use in winter decision support systems

The dependency on a non-missing obs-history can present a real challenge for non-observing sites or new sites

- **Suggestion: METRo software could internally could come up with a default obs-history if any of the critical observations were missing**

Runtime is problematic in real-time systems (due to XML files)

- **Suggestion: use a different input and output file format that is much more efficient (such as csv)**

Biggest concern going into the future is METRo's poor performance during the summer

- **Suggestion: Model performance needs to be improved during the warm season if it's going to be used in a non-winter DSS**

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Acknowledgements

This work would not be possible without the ongoing support from:

Paul Pisano and the FHWA Office of Transportation Operations Road Weather Management Program

City and County of Denver, E-470 and Denver International Airport (DIA)

Miguel Tremblay and the developers of METRo from the Meteorological Service of Canada

Questions ?

Herbicide Application, Idaho DOT

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