The Evolution of METRo in a Roadway DSS

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Outline

• The Need for Roadway Decision Support Systems

• Background / Current Implementations

• METRo Overview

• Using METRo in a DSS: Challenges, Limitations, and Improvements

• Using METRo as a tool for QC

• Recent Performance

• Future Recommendations

Paving Project, Washington DOT
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.
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.
Roadway Decision Support Systems

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

NOAA NCEP and GSD
- Numerical Weather Prediction Models
  - RUC
  - NAM
  - GFS
- Model Statistics
  - LAMP-MOS
  - MET-MOS
  - MEX-MOS
- Surface Obs (Metars)

NOAA and/or Mixon-Hill
- RWIS Data via MADIS or Clarus

NCAR (Boulder, CO)
- Road Weather Forecast System (RWFS (DICast))
- Road Condition and Treatment Module (RCTM)

Data Server

Maintenance Garages
- PC Java Application

Staff Locations (access from home, etc.)
- PC Java Application

DOT Data
- RWIS Sensor Info
- Road characteristics
- Route characteristics
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PC Java Application

DOT Data

PC Java Application
Road Condition and Treatment Module (RCTM)

Weather Forecasts From RWFS (DiCAST)

Road Temp and Snow Depth Module (METRo)

Net Mobility

Rules of Practice (RoP)

Chemical Concentration

Roadway Configuration

Roadway Observations From MADIS or Clarus

Road Conditions and Treatments
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

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](http://documentation.wikia.com/wiki/METRo)
METRö 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 METRö 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
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
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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
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
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)
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
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 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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Questions ?

Herbicide Application, Idaho DOT