Use Case #1: Enhanced Road Weather Content Enabled by Clarus

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Meridian Team

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- Iteris, Inc.
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The Meridian Team’s Partner States
- Idaho Transportation Department
- Minnesota Department of Transportation
- Montana Transportation Department
- North Dakota Department of Transportation
- South Dakota Department of Transportation
**Clarus Road Weather Support**

- Enhancing Road Weather Forecasting Methods Support:
  - Control Strategies (Use Case #2)
  - Advisory Strategies (Use Case #5)
Clarus Enhanced Road Weather Forecasting

Forecasting framework composed of diverse data, analyses, and modeling systems supporting various end-user decision-making tools

Enhancements derived from ESS atmospheric AND pavement observations
Mesoscale Modeling Conceptual Design

- **Challenge**
  - How to appropriately incorporate ESS observations utilizing Clarus Quality Check flags within mesoscale modeling

- **Solution:**
  - Incorporate preprocessing methods to apply QCh flags to control data ingest into data assimilation methods used to initialize mesoscale models

- **Clarus Enhancement:**
  - Extends the availability of observations to low density observations areas
Data Assimilation Results

Large variations indicate both an local enhancement in temperatures and impacts of the distant-dependent objective analysis scheme

- Improvements are isolated but significant for select areas
Findings (Mesoscale Modeling)

- Clarus data offer additional data to initialize the (road) weather environment
  - Greatest benefit to data assimilation for surface conditions in low density observation areas
  - Supports various real-time applications (i.e. blowing snow analyses)
  - Difficulties in applying the QCh flags in a cost effective and efficient manner

- Minor benefits to mesoscale modeling beyond initial hours
  - Non-surface conditions drive the surface state
  - Localized higher-resolution models (~1-km) hold more promise of utilizing greater volume of (surface) observations
Research Needs / Gaps (Mesoscale Modeling)

- Need for improved boundary layer observations
- Improved methods to incorporate QCh flags in an objective (automated) manner
- Better focus (new paradigm) of mesoscale modeling specific to the roadway environment to derive greater benefit from surface observations
- Benefit-Cost study needed to identify the justification for expending higher costs required to operationally support high-resolution mesoscale models
PPAES Conceptual Design

- **Challenge**
  - Substantial benefits to be had from highly-detailed, rapidly-updating wintertime precipitation information, but…
  
  …all the information resources suffer from unique problems

- **Solution:**
  - Extend surface observations with remotely sensed (e.g., weather radar and satellite) and computer model data

- **Clarus Enhancement:**
  - Substantially extends the ‘ground truth’ surface-based observations of precipitation
PPAES Conceptual Design

Clarus Precip Obs

FAA/NWS Precip Obs

Weather Radar

Model Precip Fcsts

Satellite Imagery

Multi-Sensor Hourly Precip Analyses
Seasonal Snowfall through February 7, 2011

Correlation: 0.93  Mean Abs/Rel Error: 6.3”/19.7%

National Weather Service Daily Reports (inches)

Estimated from Hourly Data (inches)
Findings (PPAES)

- Has shown considerable promise and is now being used to support operational road weather products

- Algorithms for integrating data to the maximum benefit are complex

- Quality control of surface observations is a huge issue

- There are significant differences in sensitivity amongst surface observing sites – can dominate the analysis!
Innovation for better mobility
Providing Tomorrow’s Technology Today

Research Needs / Gaps (PPAES)

- Improved quality control techniques for precipitation observations
  - Not just to filter out blatantly bad observations, but also to identify sensor biases

- Improved RWIS maintenance programs, with more emphasis on uniform responsiveness from hardware
Seasonal Weight Restriction (SWR) Decision Support Tool
Use Case 2
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SWR Design

Use Case #1
Enhanced Road Weather Forecasting
- Analysis
- Validation
- Forecasting

Use Case #2
Seasonal Weight Restriction Decision Support Tool
- Commercial Vehicle Operators

Data Integration
- Decision Support Rules for Road-Based Weight Restrictions
- Client-side Decision Support Graphical User Interface
- Notification Services and Alerts

State DOT
Seasonal Weight Restriction Policy and Procedure Guidelines

Clarus
System Data
Enhanced Integrated Climatic Model

A research model comprised of:

- Climatic-Materials-Structures model developed at the University of Illinois
- Infiltration and Drainage model developed at the Texas Transportation Institute
- Frost Heave and Thaw Settlement model developed by the CRREL
EICM Concept - Profile

- PAVEMENT
- BASE
- SUBGRADE
- SOIL

Depth of Constant Temperature
Water Table

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EICM Concept - Thaw

January  --- April

Frozen Soil

Thaw Depth

Freeze Depth

Water Table

Depth of Constant Temperature
EICM Concept – SWR Issues

January → April

- Pumping in Base Layer
- Shear in Subgrade

Depth of Constant Temperature

Water Table
SWR Display - Pictograph

Node Temperature
10 Jan – 9 Feb, 2011
Node % Ice
10 Jan – 9 Feb, 2011
Node Resilient Modulus
10 Jan – 9 Feb, 2011
Implementation of SWR

January

Water Table

Depth of Constant Temperature

Pumping in Base Layer

Shear in Subgrade

Institute Load Restriction

Freeze Depth

Thaw Depth

April
SWR Display - TriState

March 29, 2011
### Node Resilient Modulus

- **Resilient Modulus**
  - Drops rapidly after thawing takes place
  - Typically to values around **0.2 lbs/cu ft**
  - Gradually increases as liquid redistributes in soil
  - **RM ≥ 0.4 lbs/cu ft** limits soil shearing

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*These values are indicative and subject to change based on specific conditions and environmental factors.*
Resilient Modulus Comparison to FrezTrax

- FrezTrax is an index based upon max/min temp
- Heat units used to create a freeze & thaw indices
- Freeze index (FI) increases to max in mid-winter
- Thaw index (TI) erodes effect of freeze index
- When FI – TI reaches near 0 threshold SWR are lifted
- Date when RM passed 0.4 was close to FrezTrax SWR lift date
Findings

- EICM output provides a good representation of sub-pavement profile
- Sub-pavement freeze/thaw processes are quite complex
- EICM requires detailed construction information and responds differently to different construction profiles
- EICM had a cold bias from ~12” – 25”
Findings

- Several thaw & refreeze cycles occur during the winter
- EICM may provide significant value in determining when restrictions should be lifted
DOT Perspectives

- The EICM output provides another resource for SWR decision
- The EICM forecast has reduced SWR decision anxiety
- The SWR guidance provides information about the restoration of subpavement structural stability
  - Not available from other resources
  - May be key to removal of weight restrictions
- The visualization of subsurface conditions helps in the SWR decision process
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