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

Sept. 8, 2011
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Meridian Team

- Meridian Environmental Technology, Inc.
- Iteris, Inc.
- University of North Dakota
- 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 Demonstration Use Cases

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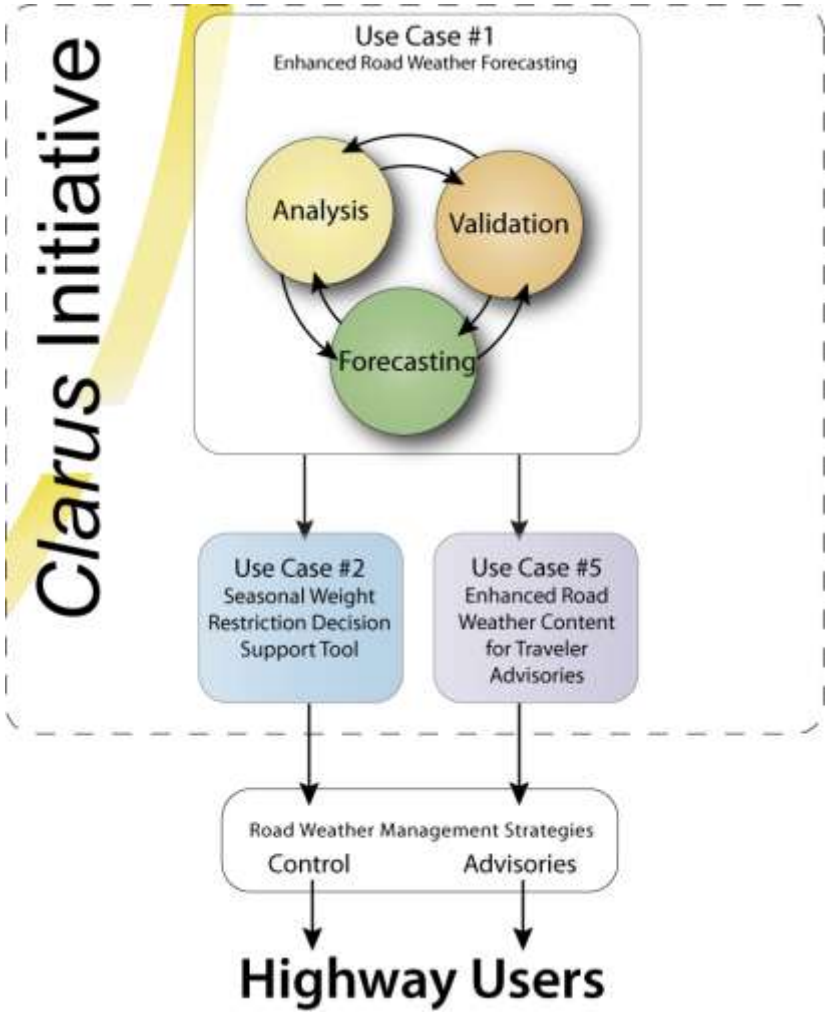
Clarus Road Weather Support

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



Clarus Enhanced Road Weather Forecasting

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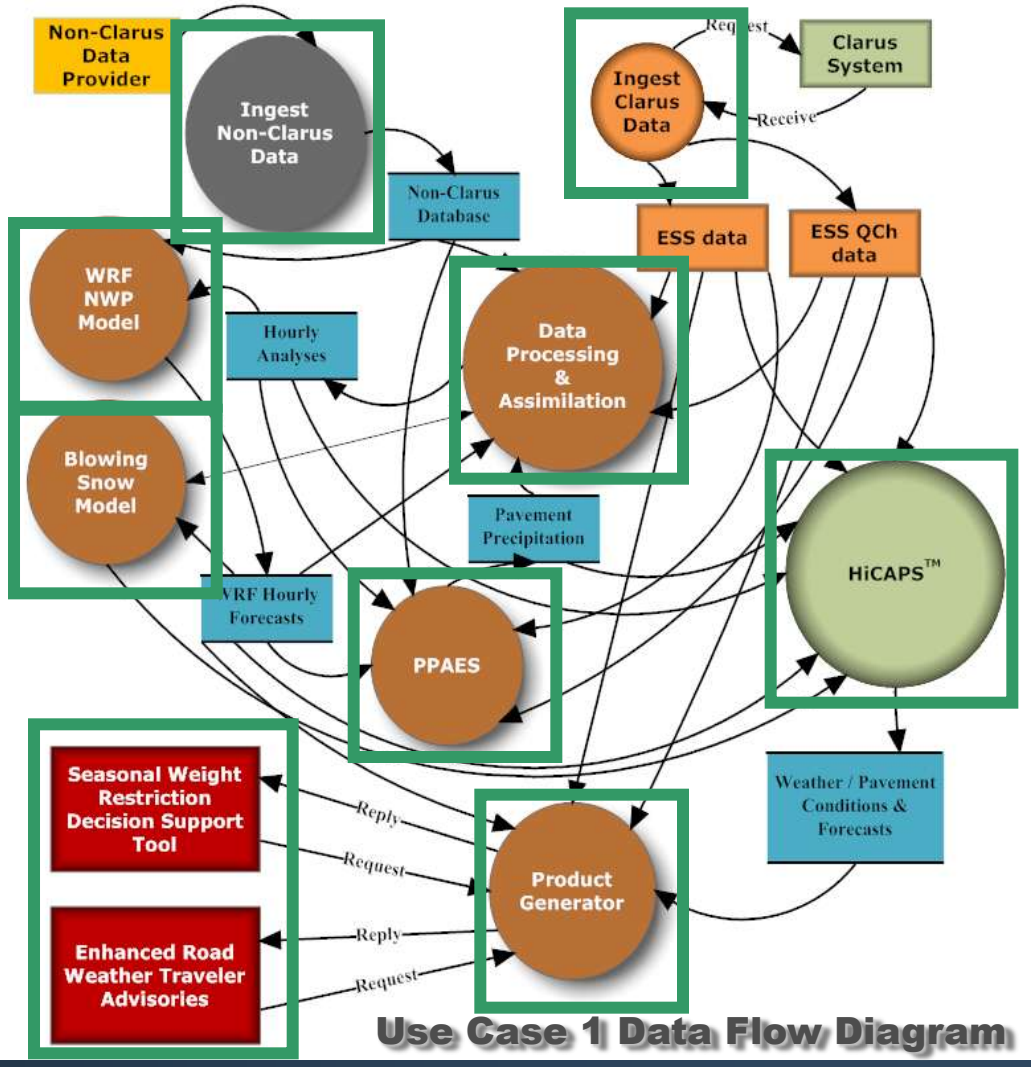
Forecasting framework composed of diverse data, analyses, and modeling systems supporting various end-user decision-making tools

Enhancements derived from ESS atmospheric AND pavement observations



Use Case 1 Data Flow Diagram

Mesoscale Modeling Conceptual Design

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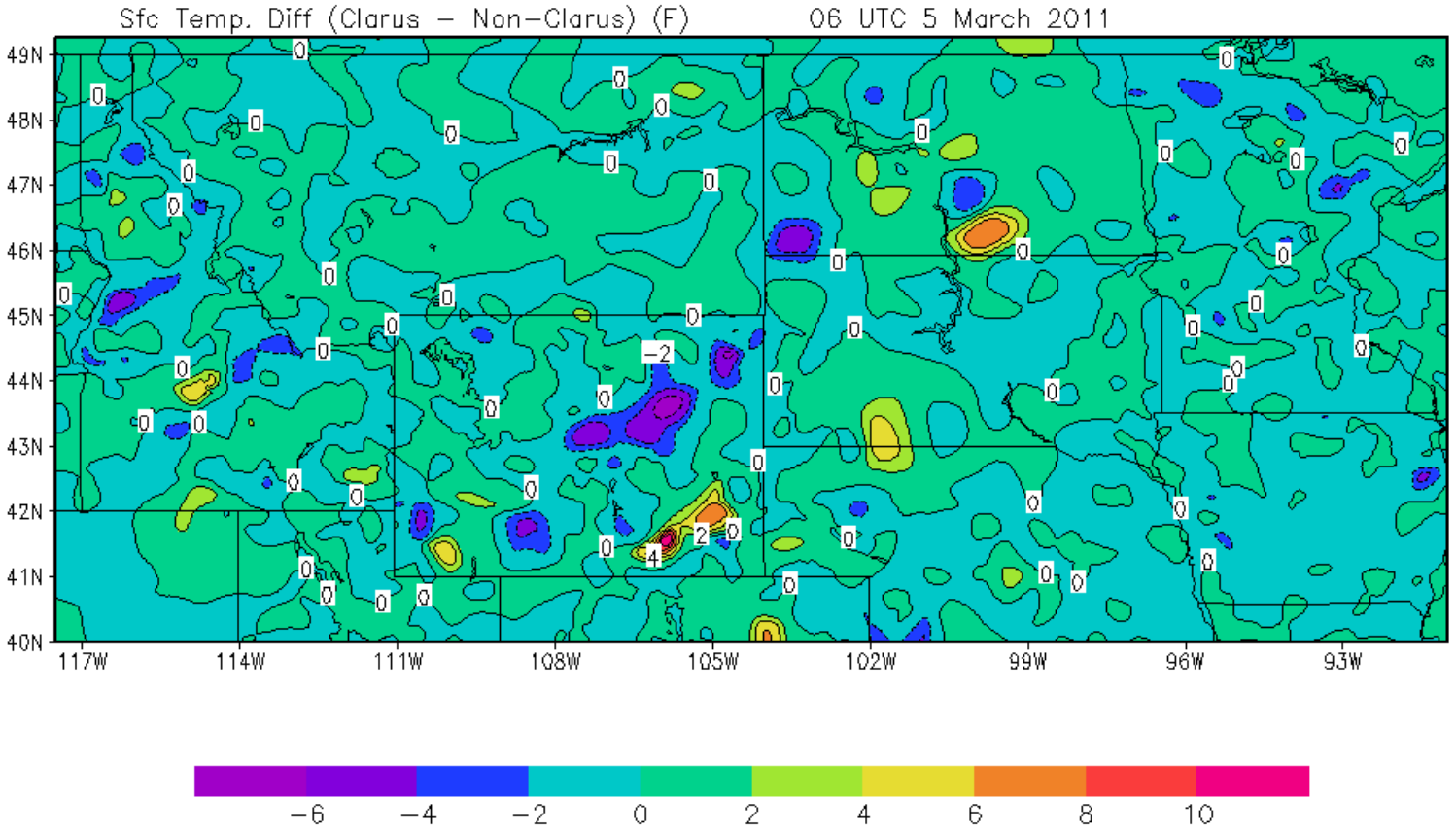
- Challenge
  - How to appropriately incorporate ESS observations utilizing *Clarus* Quality Check flags within mesoscale modeling
- Solution:
  - Incorporate preprocessing methods to apply QCh flags to control data ingest into data assimilation methods used to initialize mesoscale models
- *Clarus* 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)

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- *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)

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- 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

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- 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

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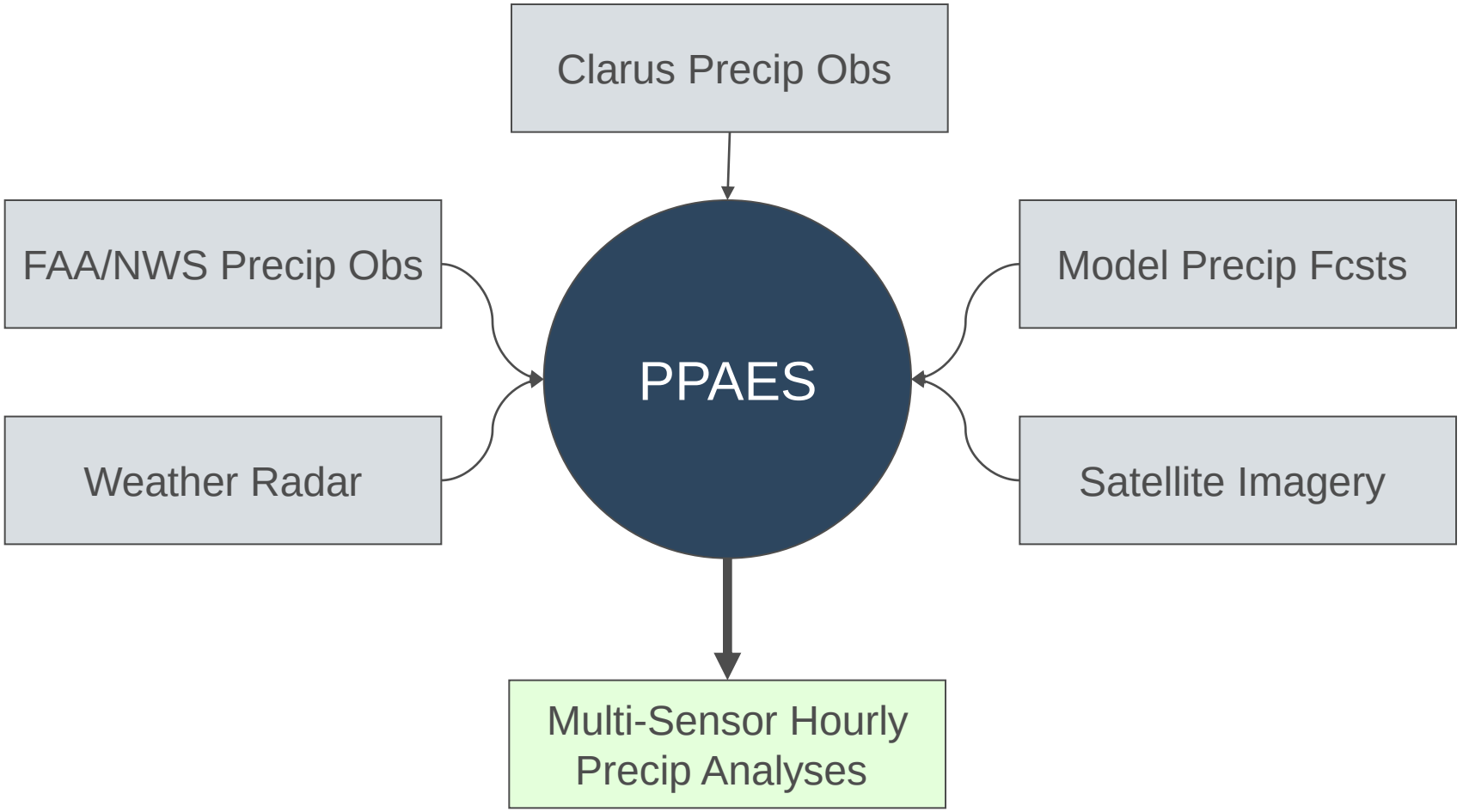
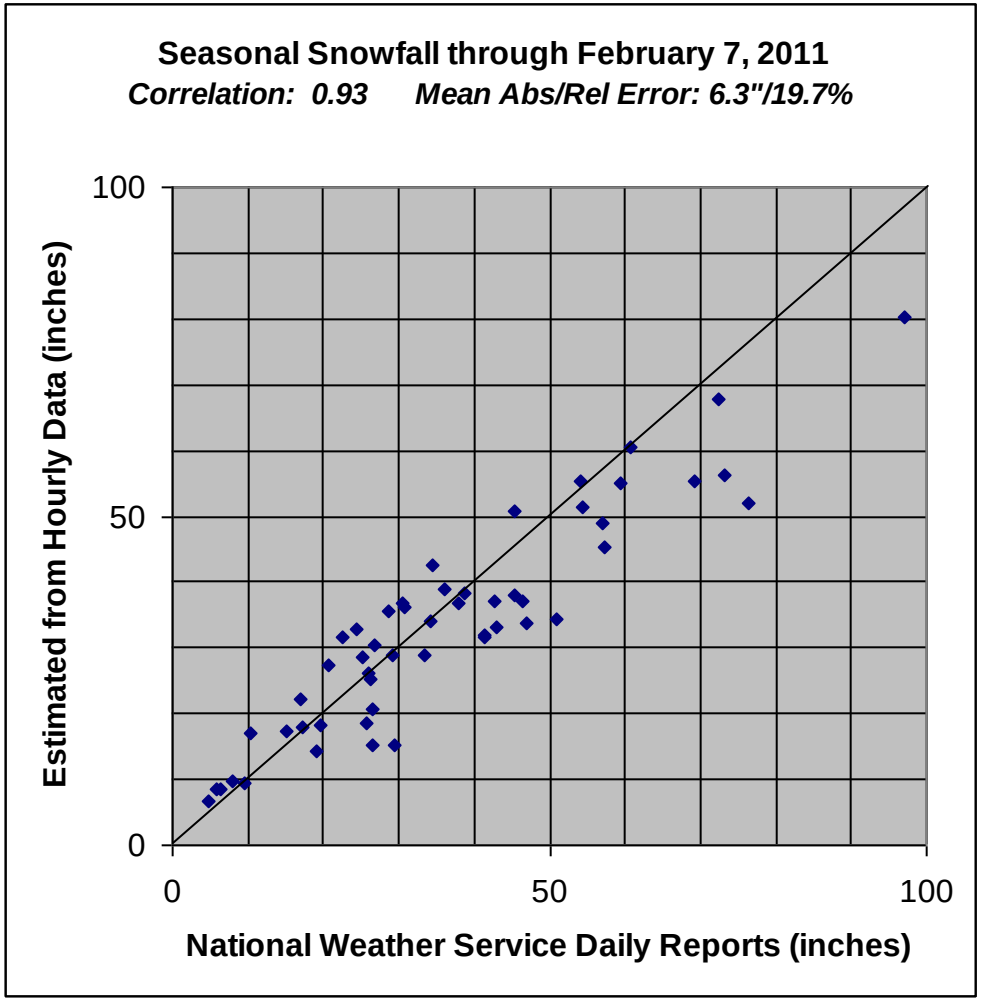


PPAES Performance



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!

Research Needs / Gaps (PPAES)

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- 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

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Seasonal Weight Restriction (SWR) Decision Support Tool Use Case 2

September 8, 2011

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SWR Design

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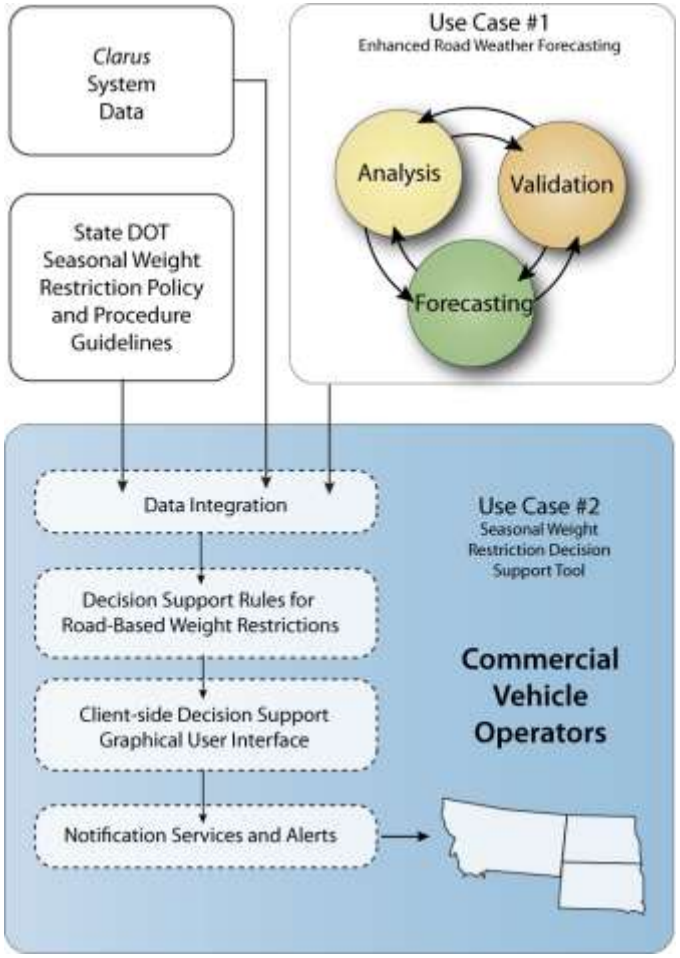

SWR Design/Processing

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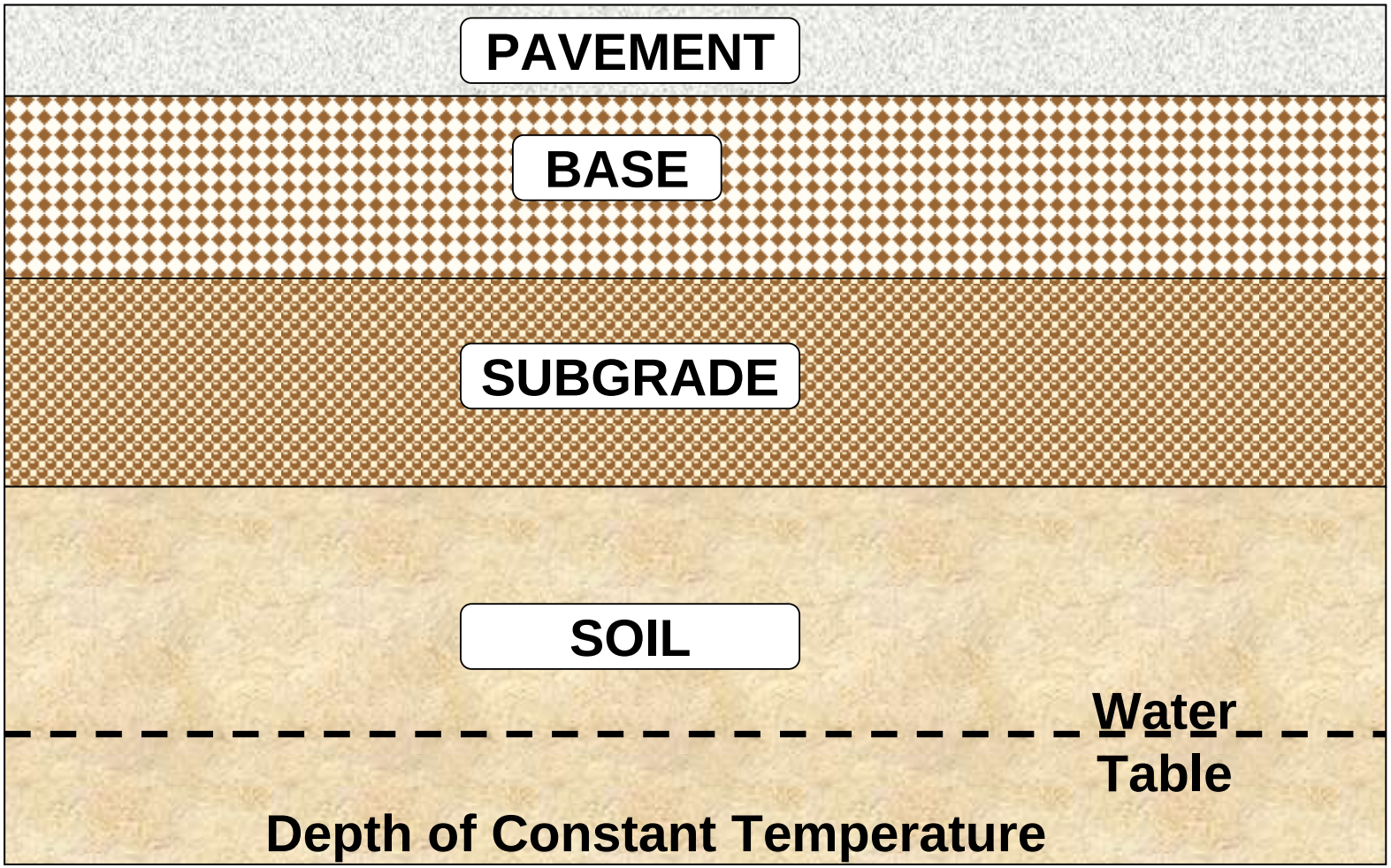
GFS

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



EICM Concept - Freeze

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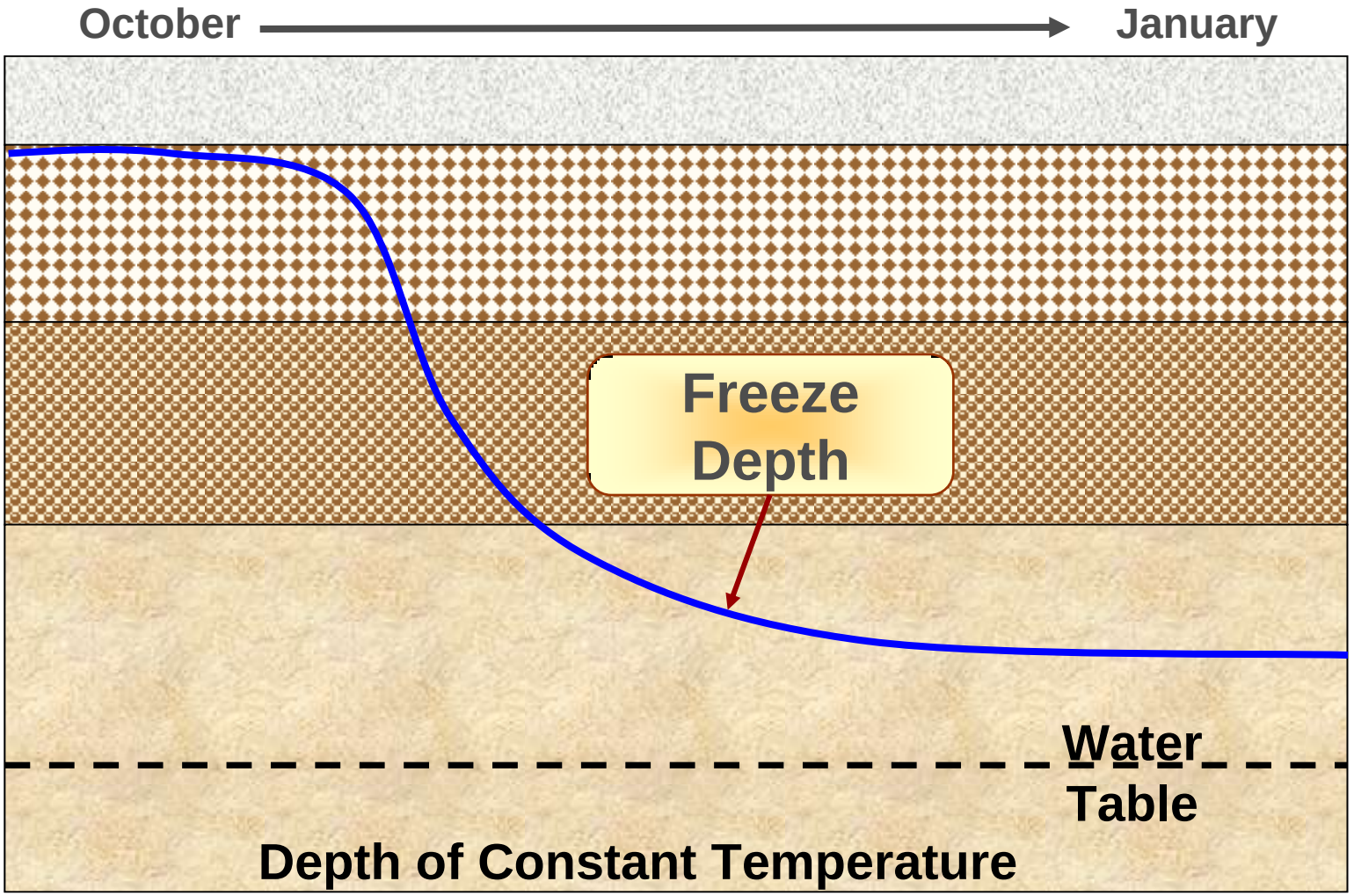

EICM Concept - Thaw

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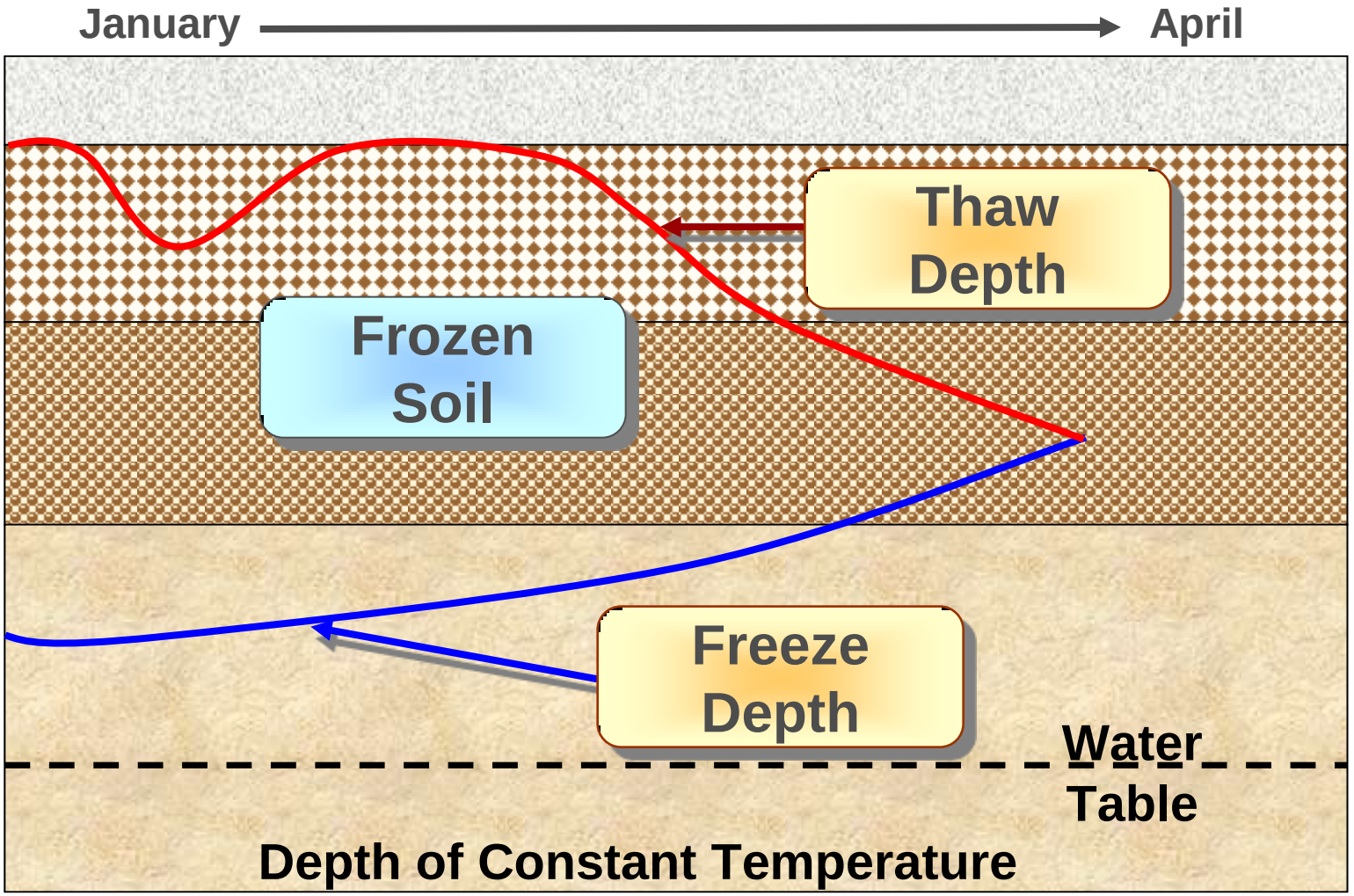

EICM Concept – SWR Issues

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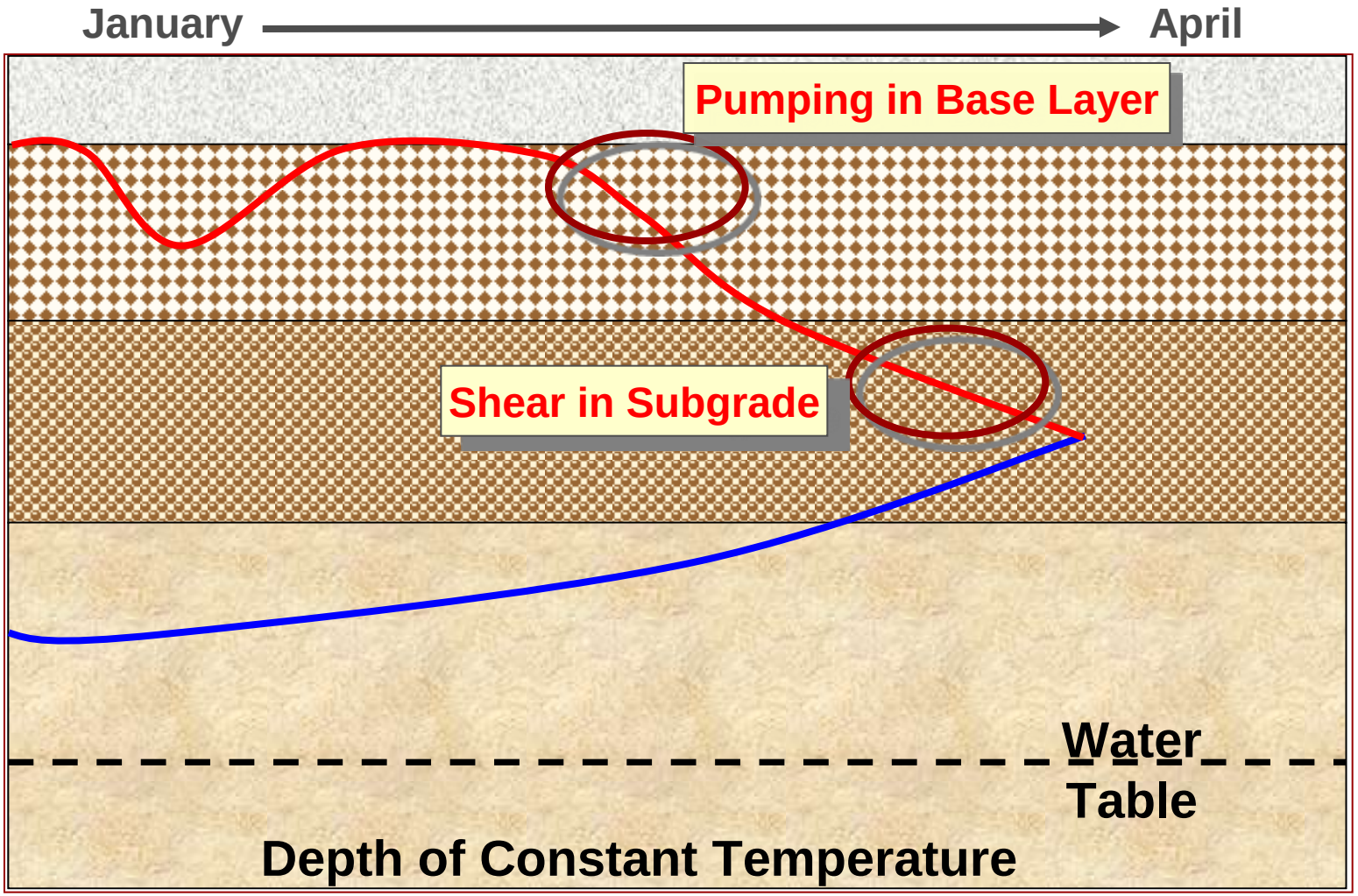

SWR Display - Pictograph

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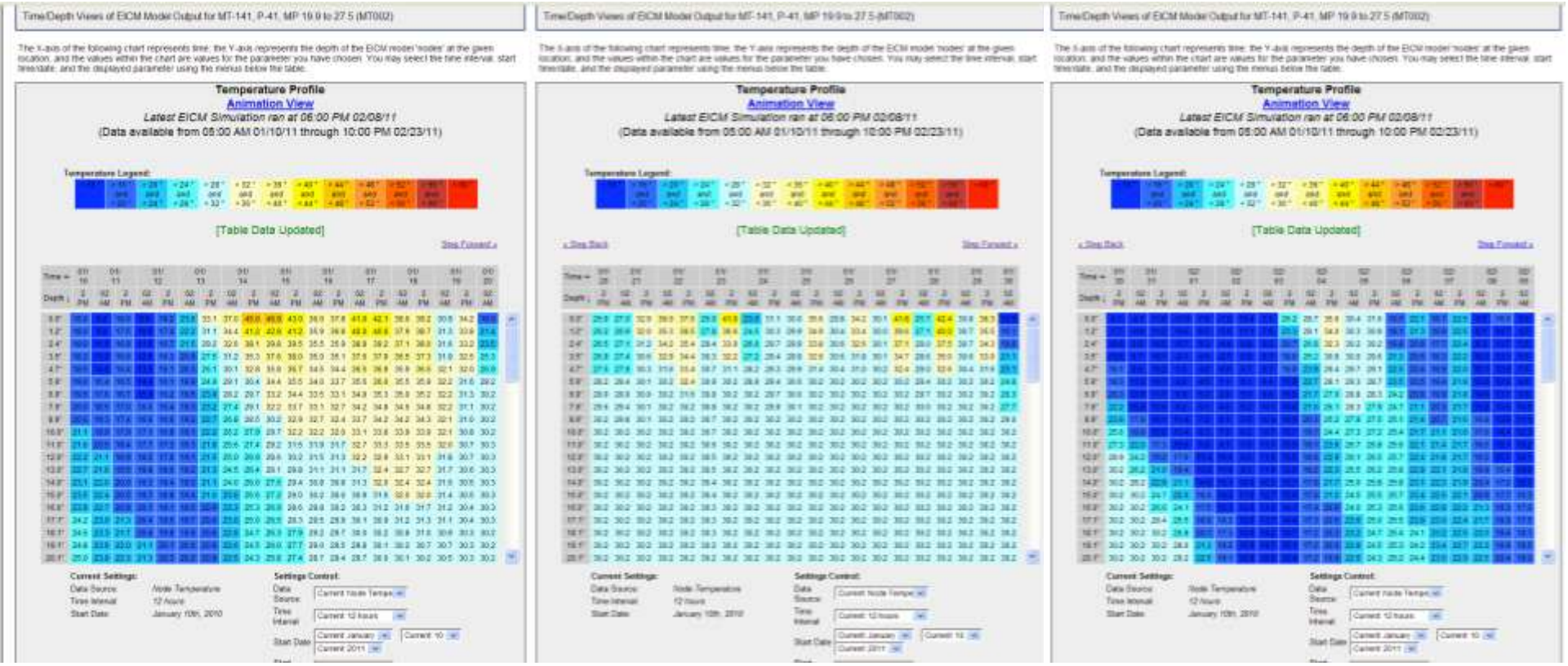
Node Temperature
10 Jan – 9 Feb, 2011



SWR Display - Pictograph

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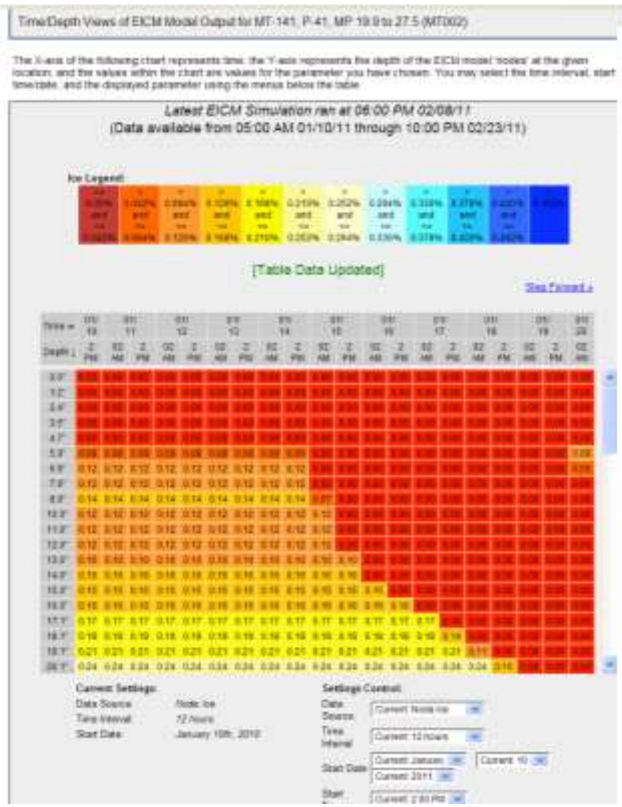
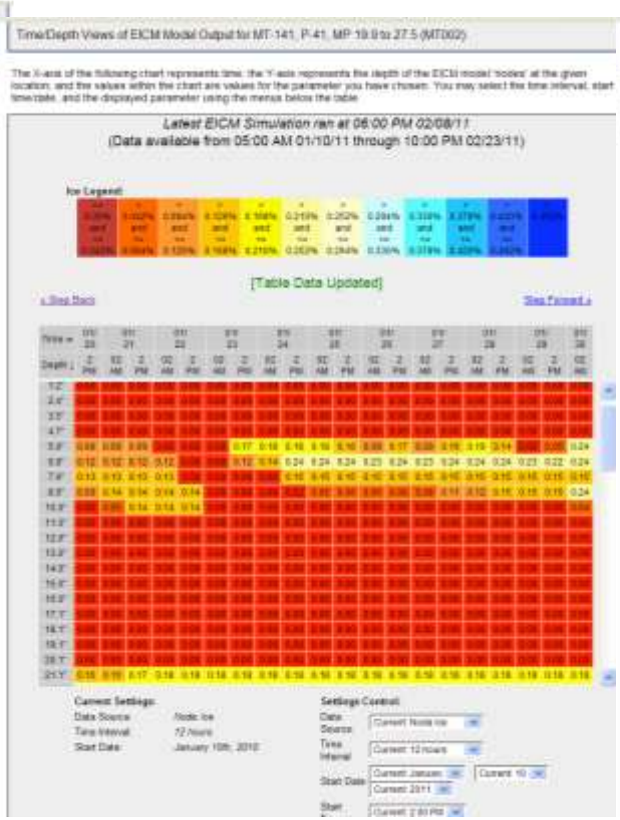
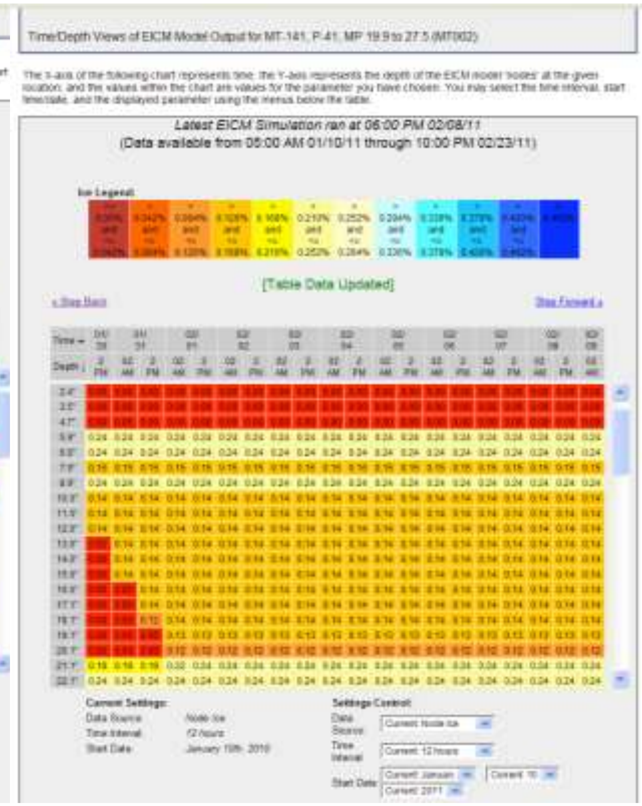
Node % Ice
10 Jan – 9 Feb, 2011







SWR Display - Pictograph

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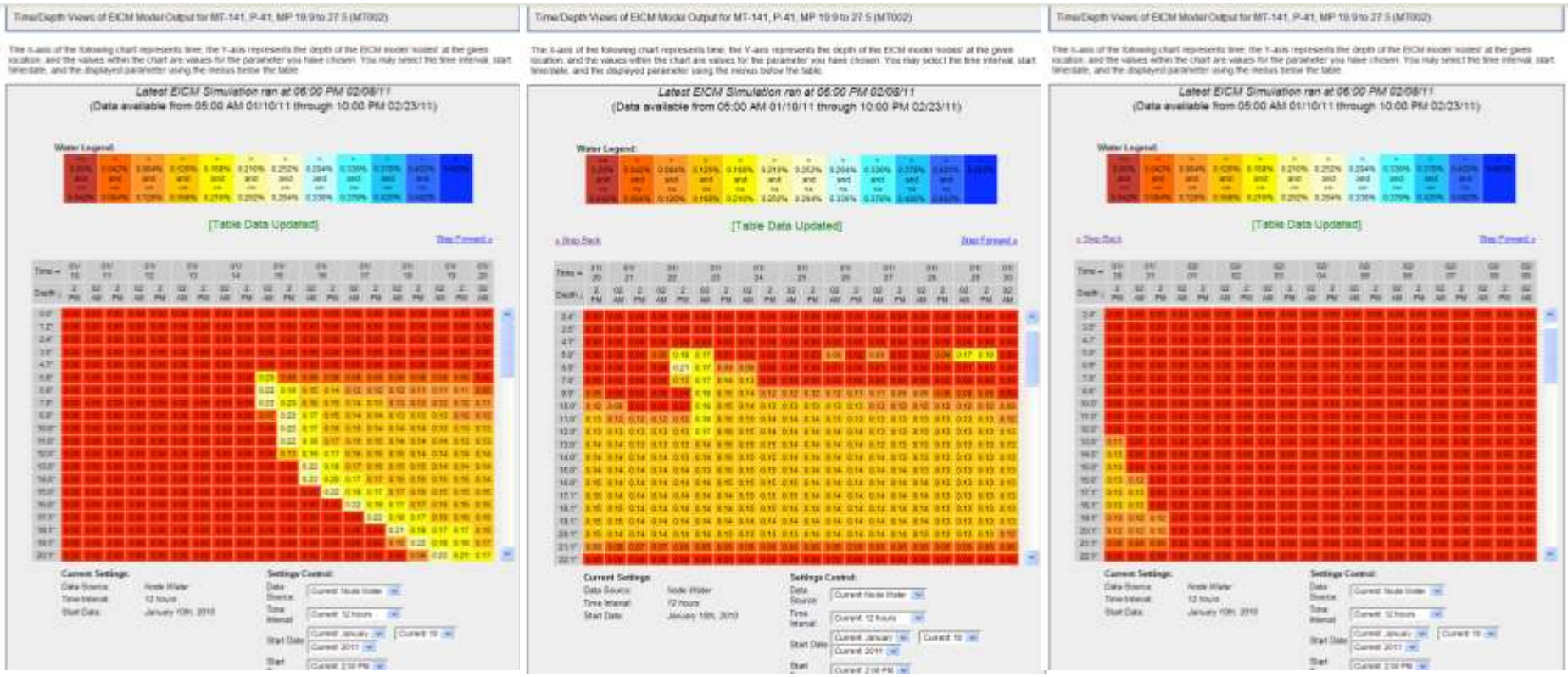
Node % Water
10 Jan – 9 Feb, 2011



SWR Display - Pictograph

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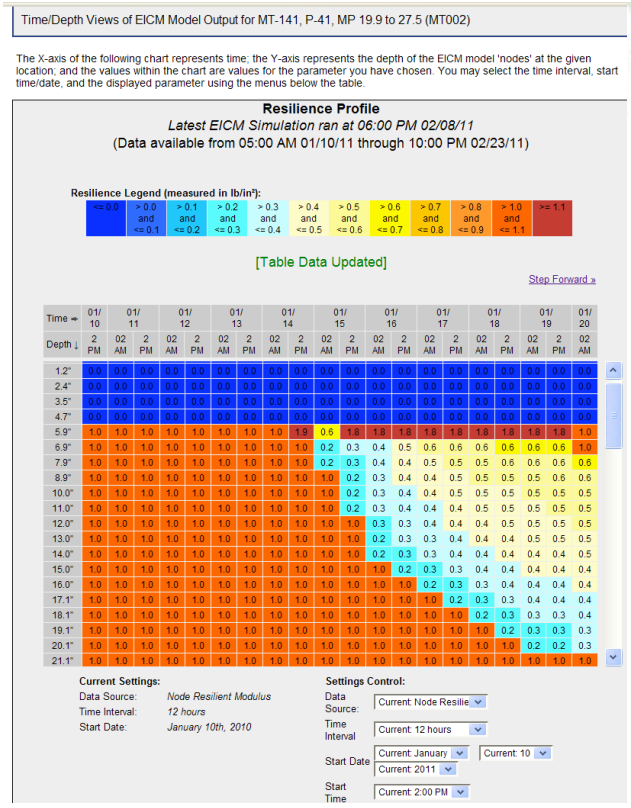
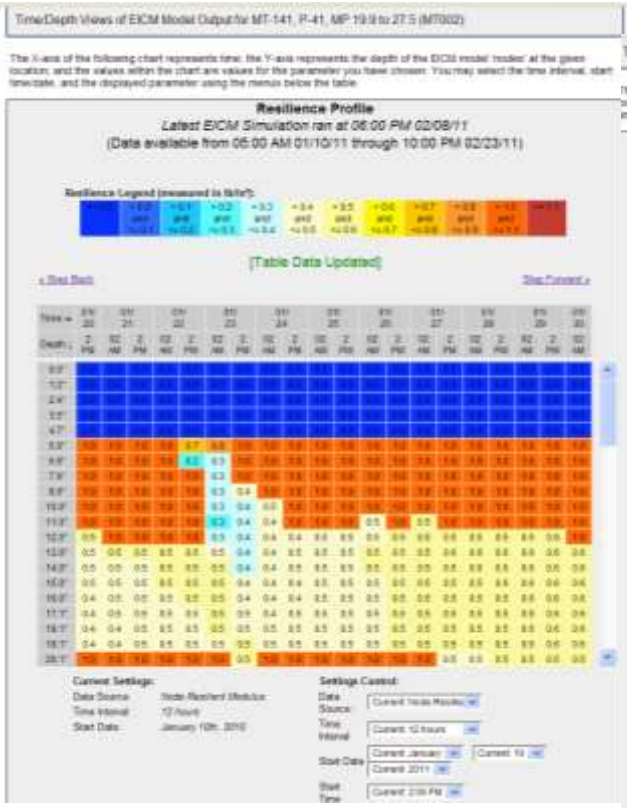
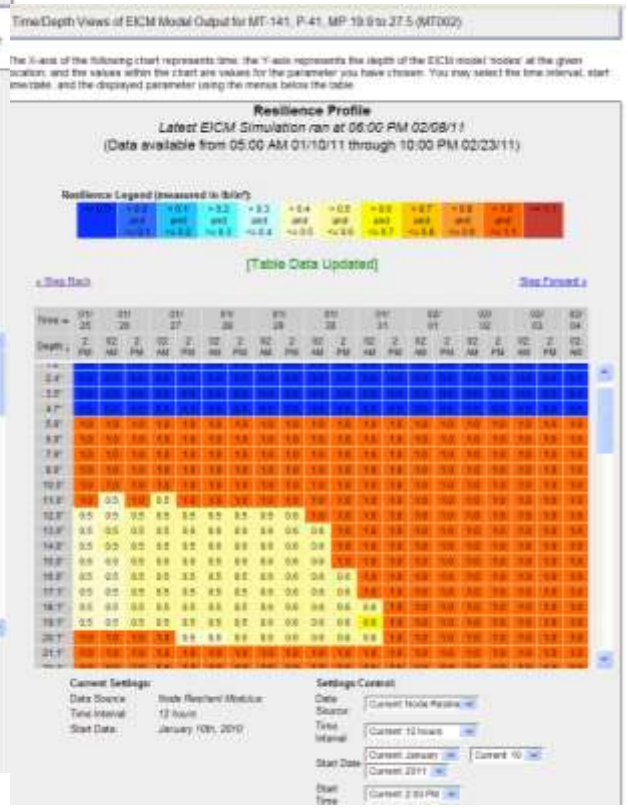
Node Resilient Modulus
10 Jan – 9 Feb, 2011







Implementation of SWR

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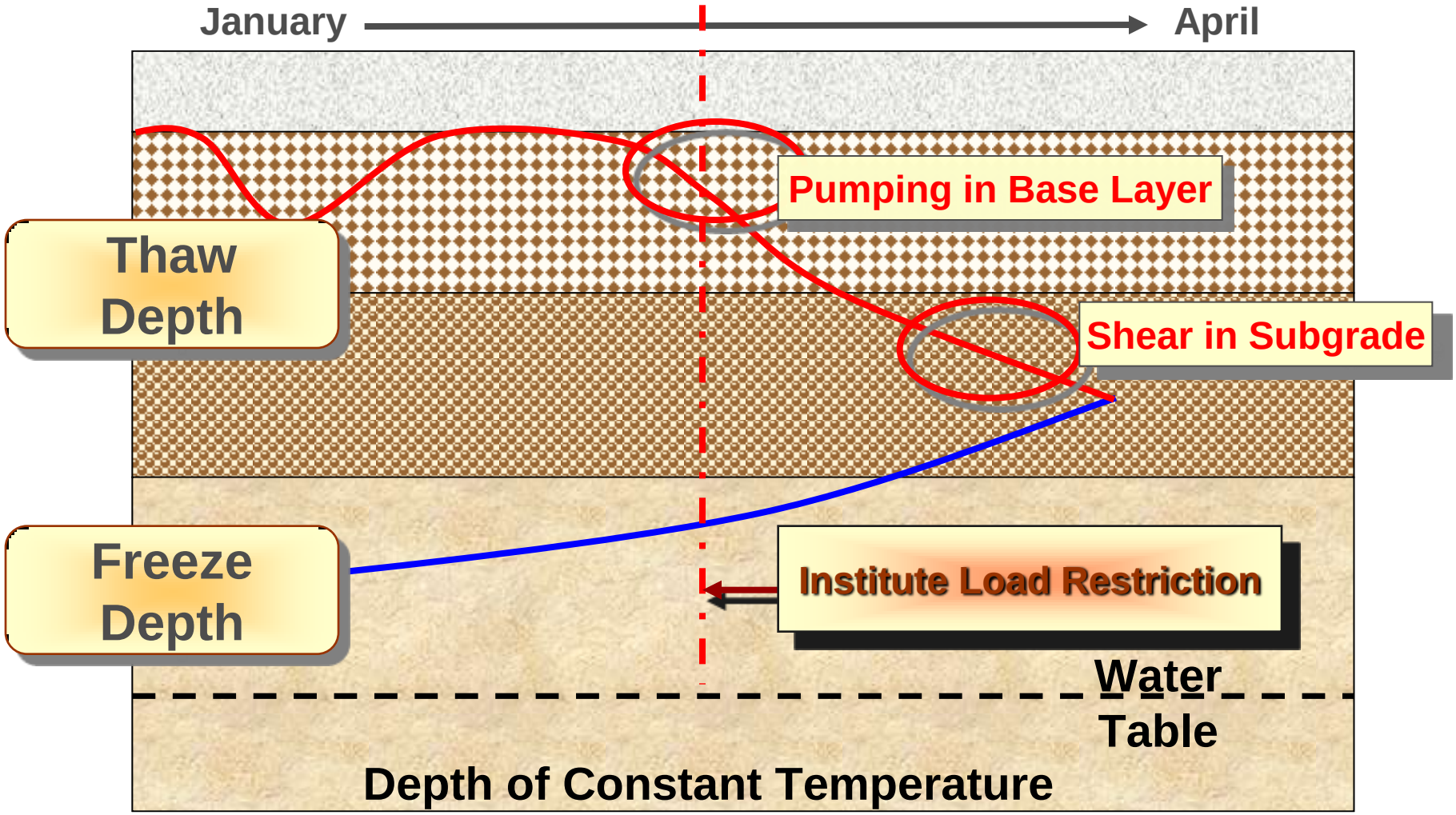

SWR Display - TriState

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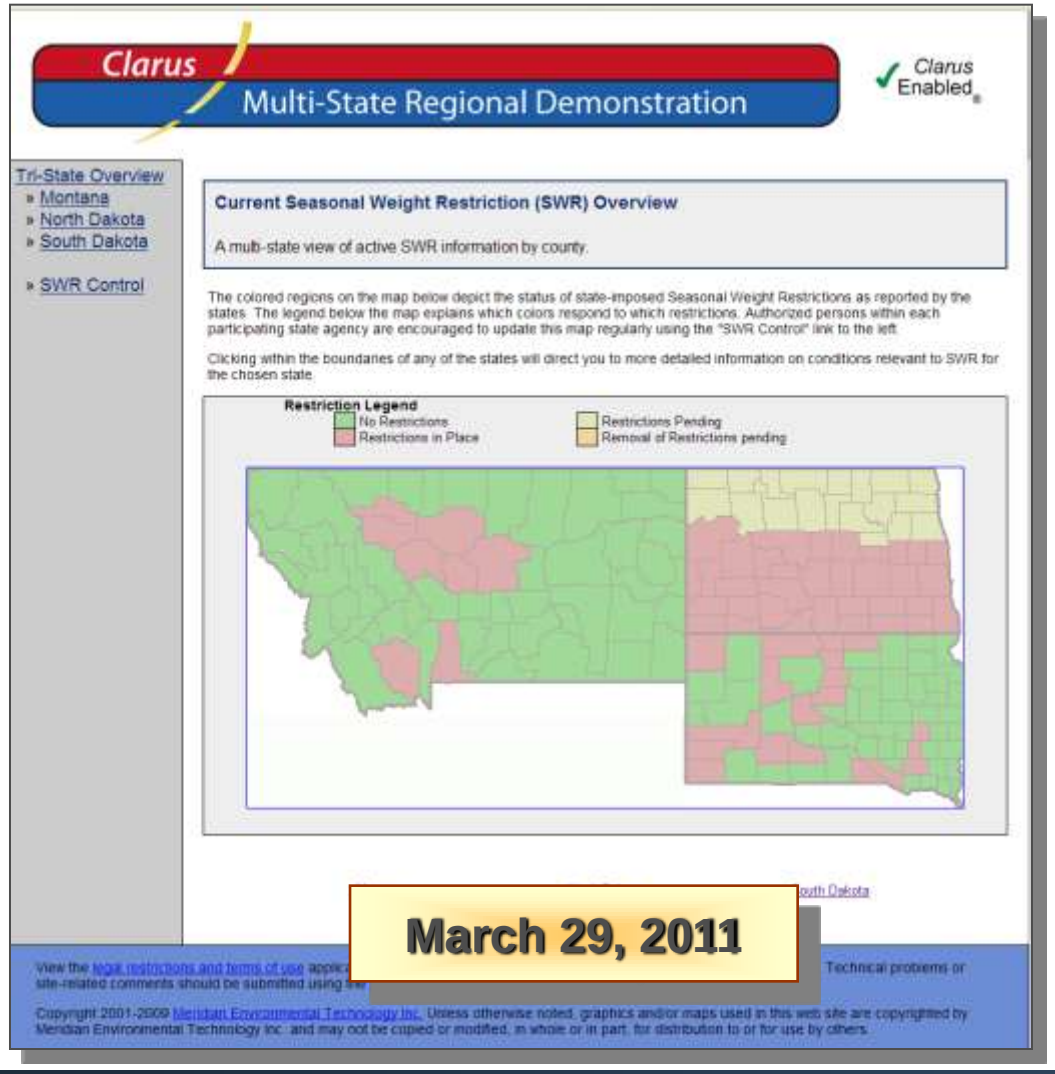

Node Resilient Modulus

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Time ⇒	01/	01/	01/	01/	01/	01/	01/	01/	01/	01/	01/
12.0"	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5
13.0"	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.2	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5
14.0"	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5
15.0"	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.2	0.3	0.3	0.4	0.4	0.4	0.4	0.4
16.0"	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.2	0.3	0.3	0.4	0.4	0.4	0.4
17.1"	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.2	0.3	0.3	0.4	0.4	0.4
18.1"	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.2	0.3	0.3	0.3	0.4
19.1"	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.2	0.3	0.3	0.3
20.1"	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.2	0.2	0.3
21.1"	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

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

Lifting Load Restrictions

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Time ⇒	01/	01/	01/	01/	01/	01/	01/	01/	01/	01/	01/

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
- <u>Date when RM passed 0.4 was close to FrezTrax SWR lift date</u>

20.1"	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.2	0.2	0.3
21.1"	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Findings

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- 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

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- 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

Contact Information

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