Spring Load Restriction Modeling

Jennifer Hanson

Research Assistant

Surface Transportation Weather Research Center

University of North Dakota

Grand Forks, North Dakota

Outline

- Problem Statement
- Freeze and Thaw Process of Soils
- Spring Load Restrictions (SLRs)
- Case Results
- Research Efforts

Problem Statement

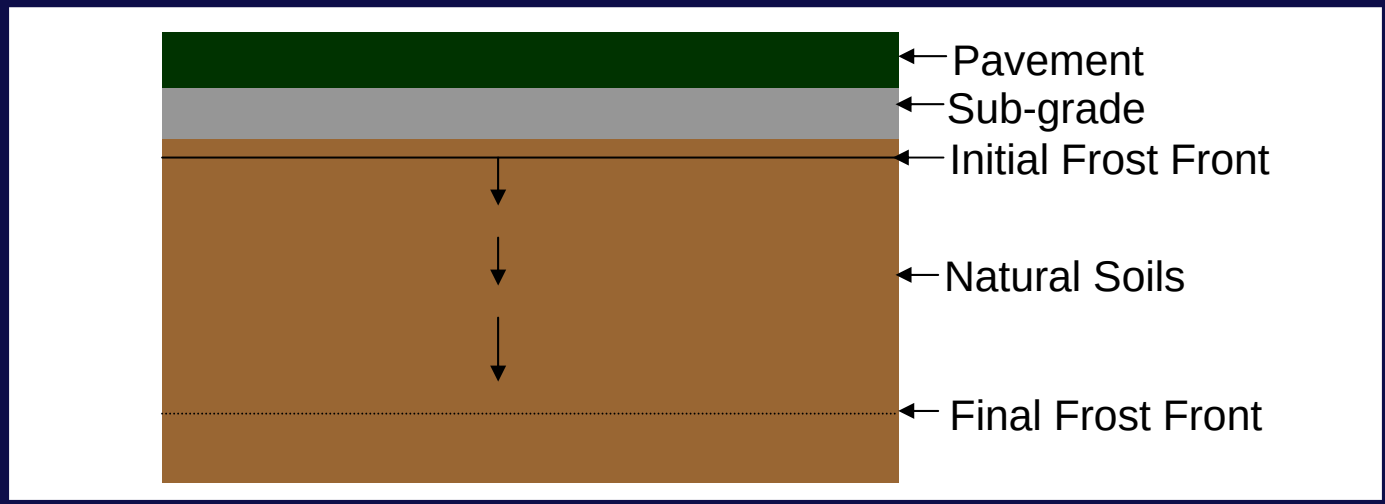
- **Every year hundreds of millions of dollars of damage to roadways occurs in the U.S. due to freezing and thawing of subsurface soils**
  - Transportation Research Board, 2001

Damage: Cause and Effect

- **Cause:**
  - Road Composition
  - Frost Susceptibility of the Soil
  - Subgrade Conditions
  - Groundwater Conditions
  - Temperature
  - Precipitation
  - Traffic
- **Effect:**
  - Surface Cracks
  - Rutting
  - Breakup of Pavement

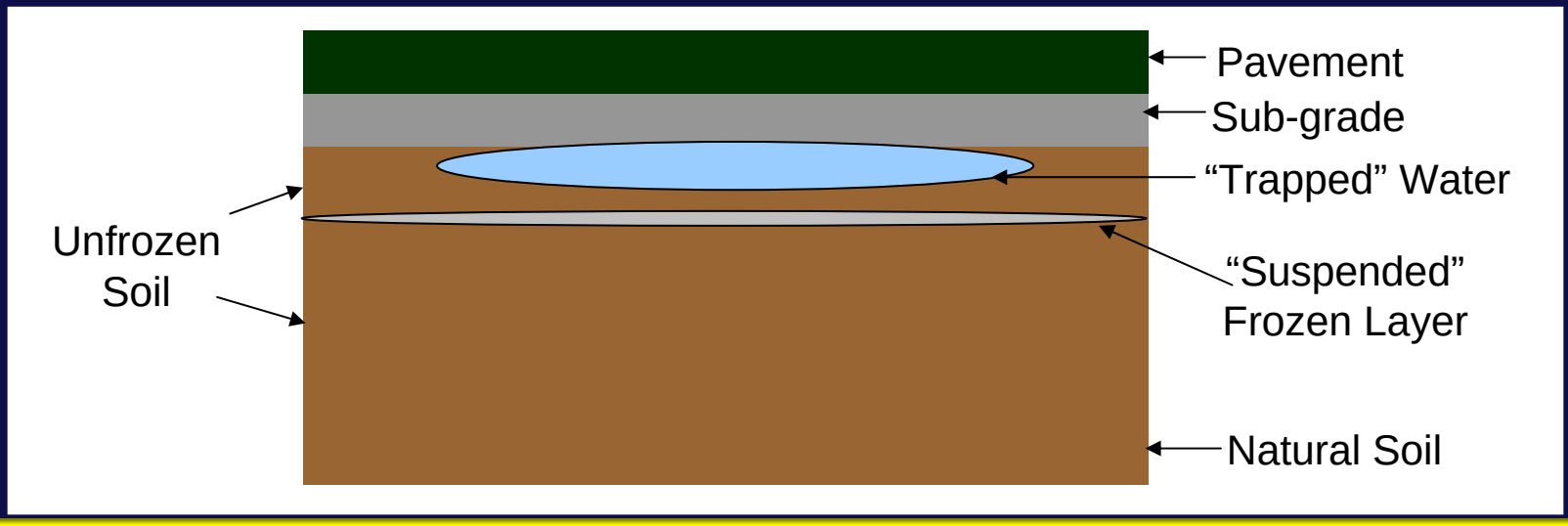
Freezing of Soils
Frost Front Movement

- **Depths at which the soils freeze depend on:**
  - Soil Moisture
  - Ground Cover
  - Sustained Freezing Air Temp



Thaw Process and "Suspended" Ice Layer

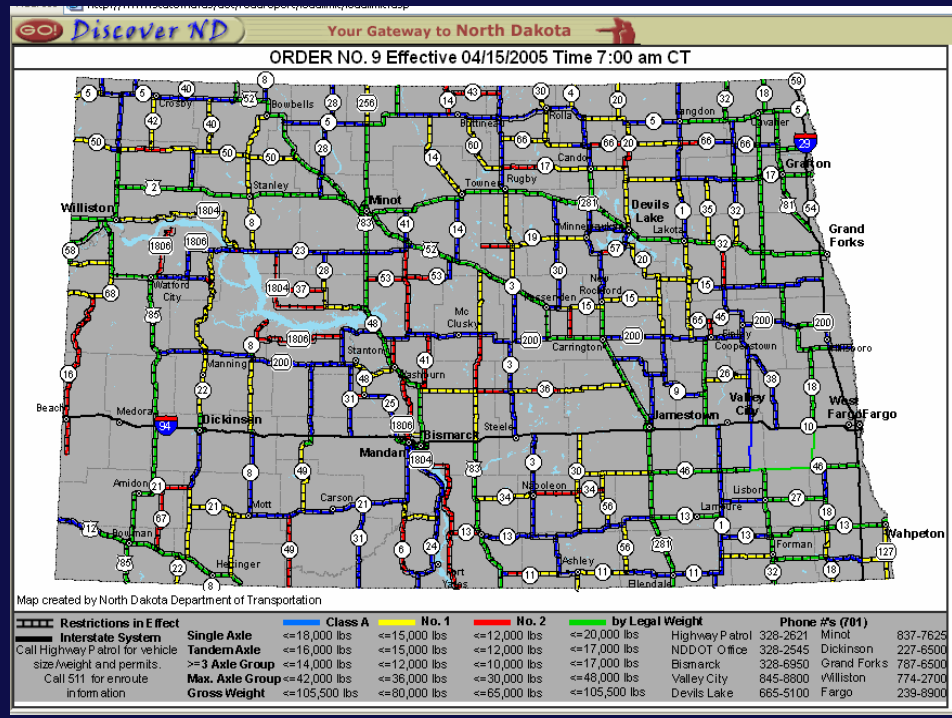
- **Thawing of Soils**
  - Takes place from the surface down and upward from beneath the frozen layer.
  - Warming of the soils above the frozen layer halts the downward movement of the frost front into warmer deeper soils.
  - This results in a "suspended" layer of frozen soil.



Spring Load Restrictions

- State DOTs attempt to mitigate damage to roads by implementing spring load restrictions (SLRs)
- Primary Concern:

  Recognize the best time to place SLRs.



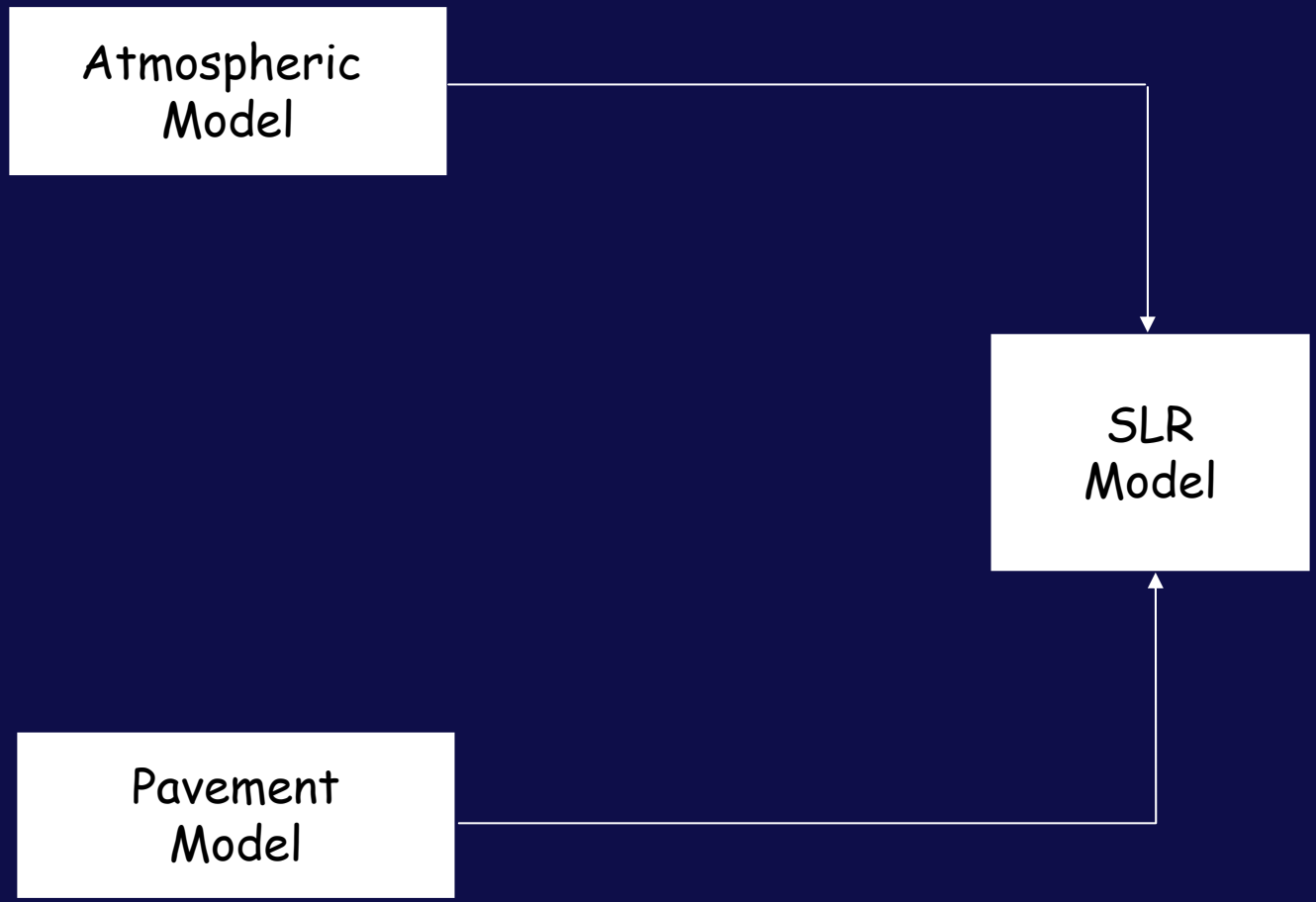
Determining Timing of SLRs

- **No Uniform Method**
  - Frost Tubes
  - Deflection Testing
  - Historical Databases
  - Thaw Index (TI)
  - Expert Judgment
- **Standardize Methods**
  - Proactive rather than reactive

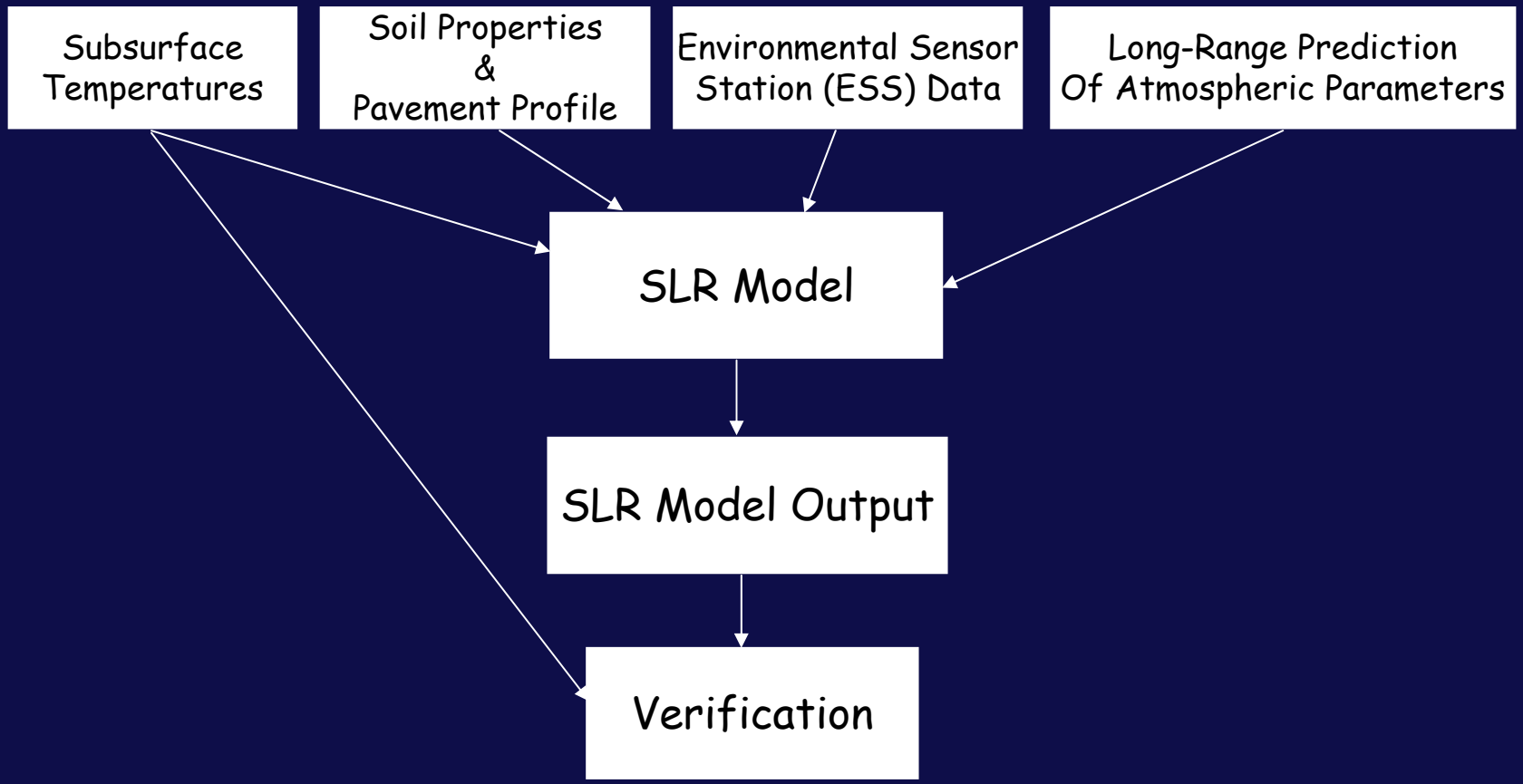
Research Efforts

- **Goal**
  - Develop a more effective method of placing SLRs.
- **Objective**
  - Couple pavement and atmospheric models to predict subsurface conditions to determine if a pavement model could be driven with predicted atmospheric data with the ability to forecast the thaw of subsurface soils.

Spring Load Restriction Model

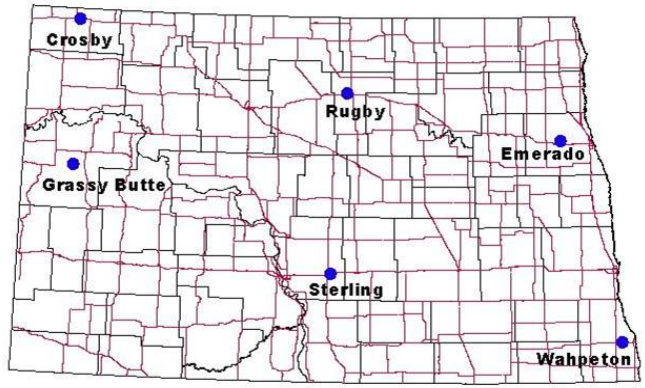


Data Requirements



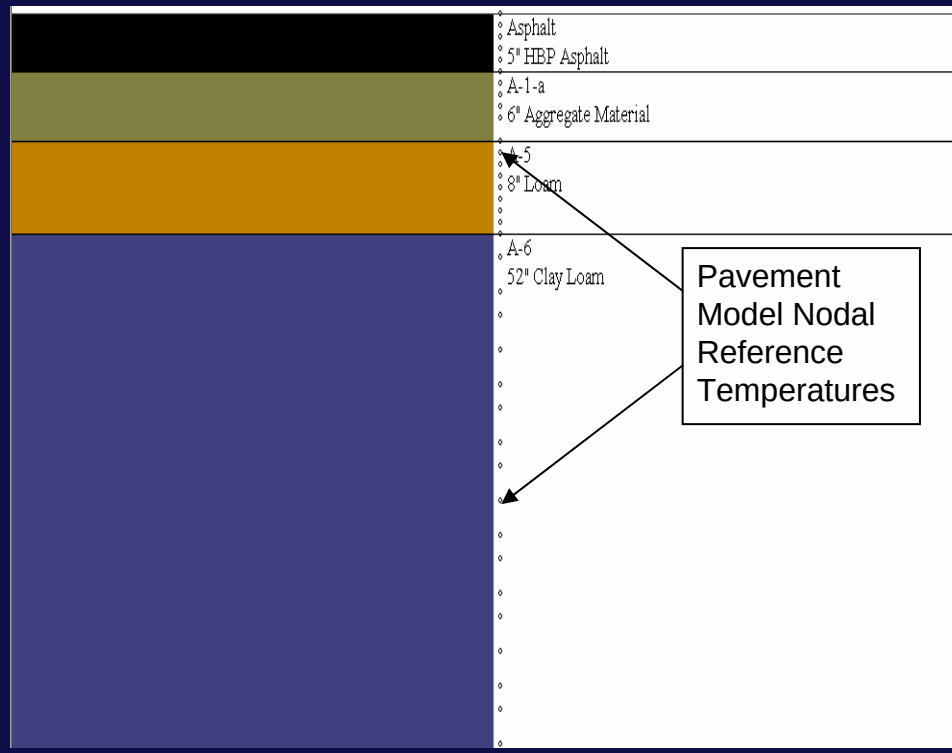
Subsurface Temperatures

- **Subsurface temperature probe project began in April 2003 with the installation of 6 probes around the state of North Dakota.**
  - Probes have 12 integrated circuit temperature sensors.
  - Data recorded from 10cm to 195cm beneath the surface of the pavement.
- **Model Initialization & Verification**



Soil Properties & Pavement Profile

- Unique to each location
- Model Initialization (one time per location)
- Type and depth of pavement
- Type and depth of each soil layer



Environmental Sensor Station (ESS) Data

- **Unique to each location**
- **Includes:**
  - Precipitation
  - Wind Speed
  - Temperature
  - % Sunshine
  - Pavement Temperature

Long Range Prediction Of Atmospheric Parameters

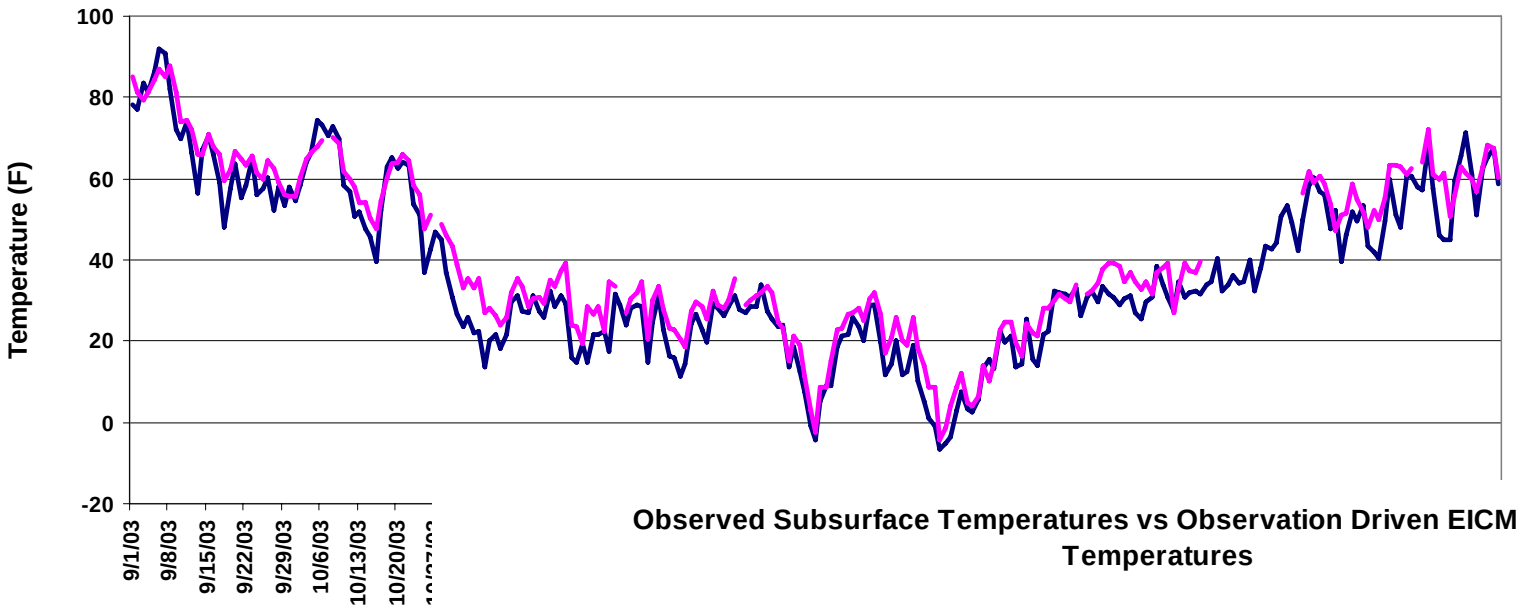
- **NCEP Global Forecast System (GFS) Model**
- **Forecast model from 0 to 384 (and 0 to 240) hours into the future**
- **Data obtained included:**
  - 2-m Temperature
  - 10-m Wind Speed
  - 2-m Precipitation
  - Cloud Cover

Research Efforts

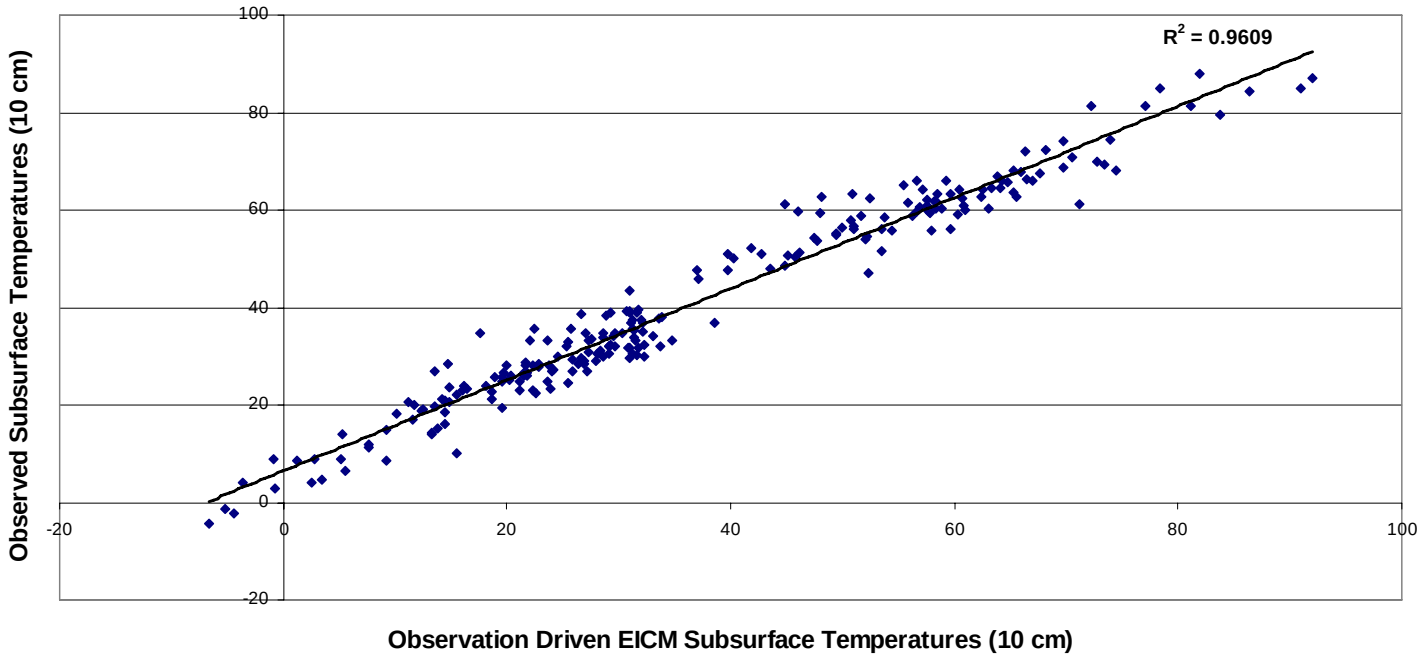
Model Validation

Observation Driven SLR Model at 10cm

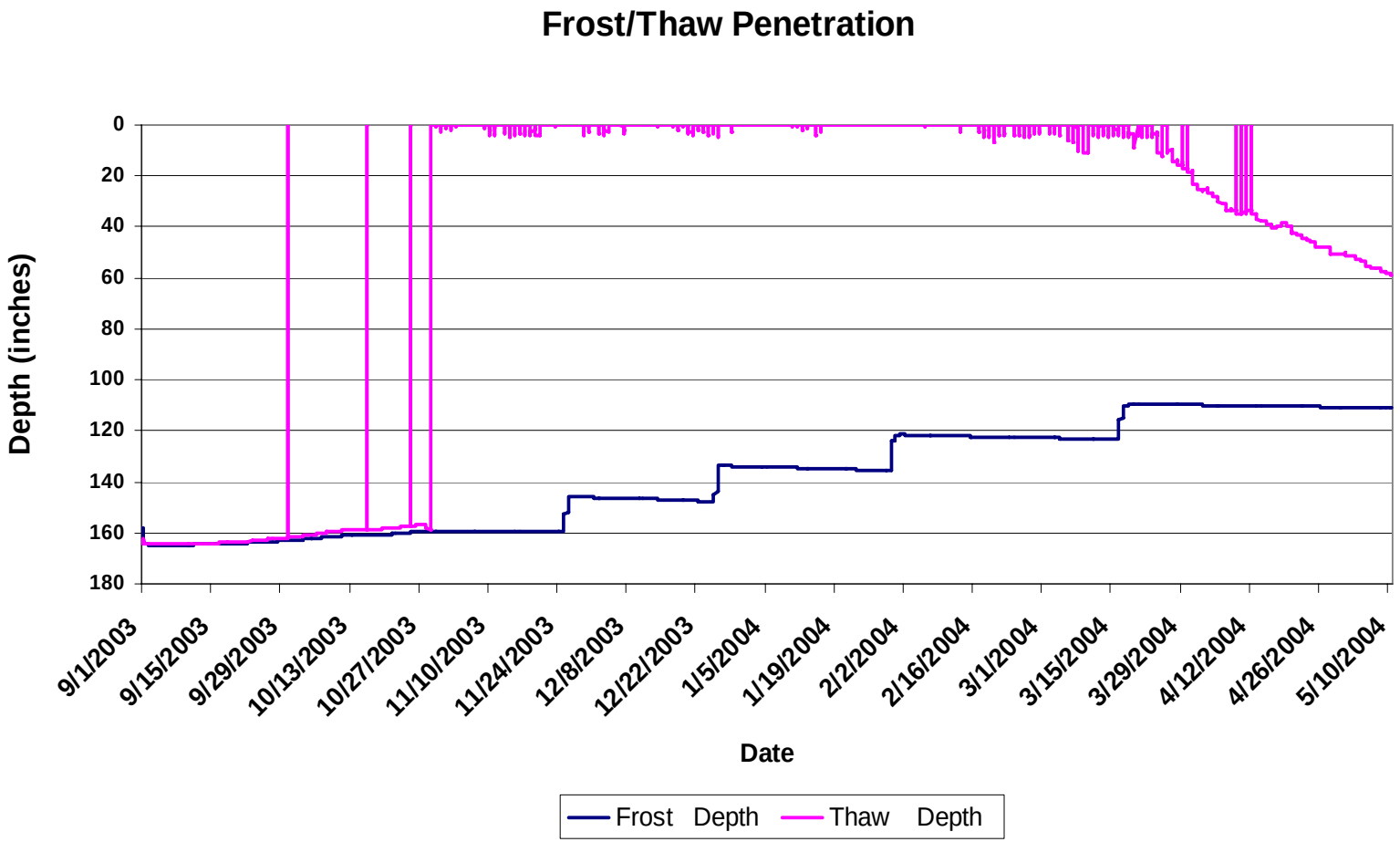
Calculated and Observed Subsurface Temperatures 10 cm Beneath the Pavement



Observed Subsurface Temperatures vs Observation Driven EICM Subsurface Temperatures

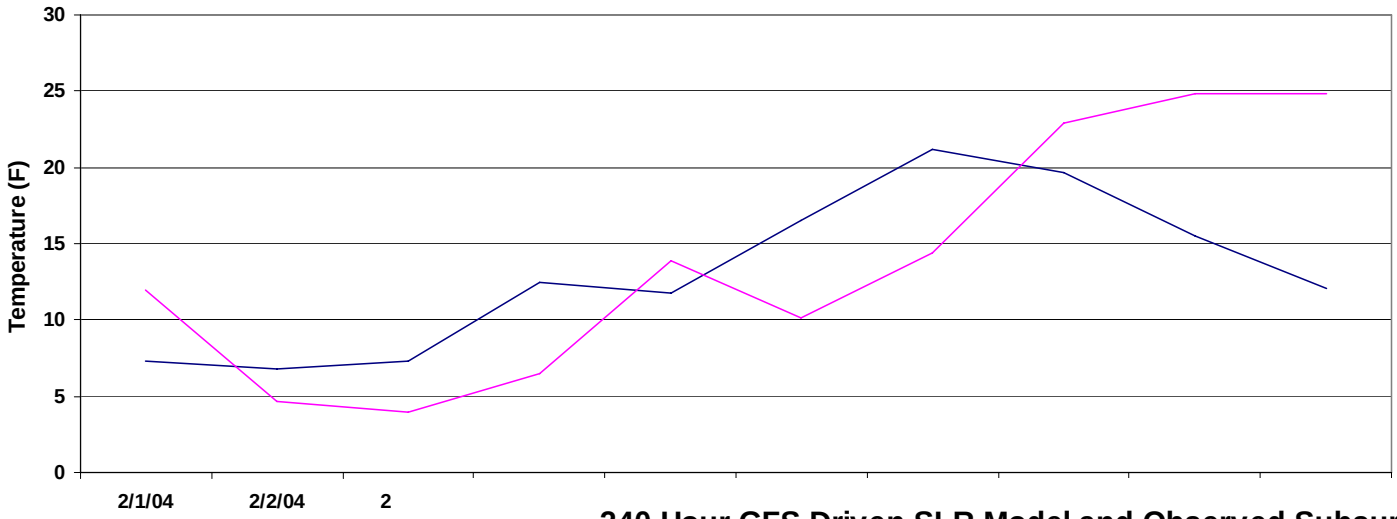


Frost/Thaw Comparison



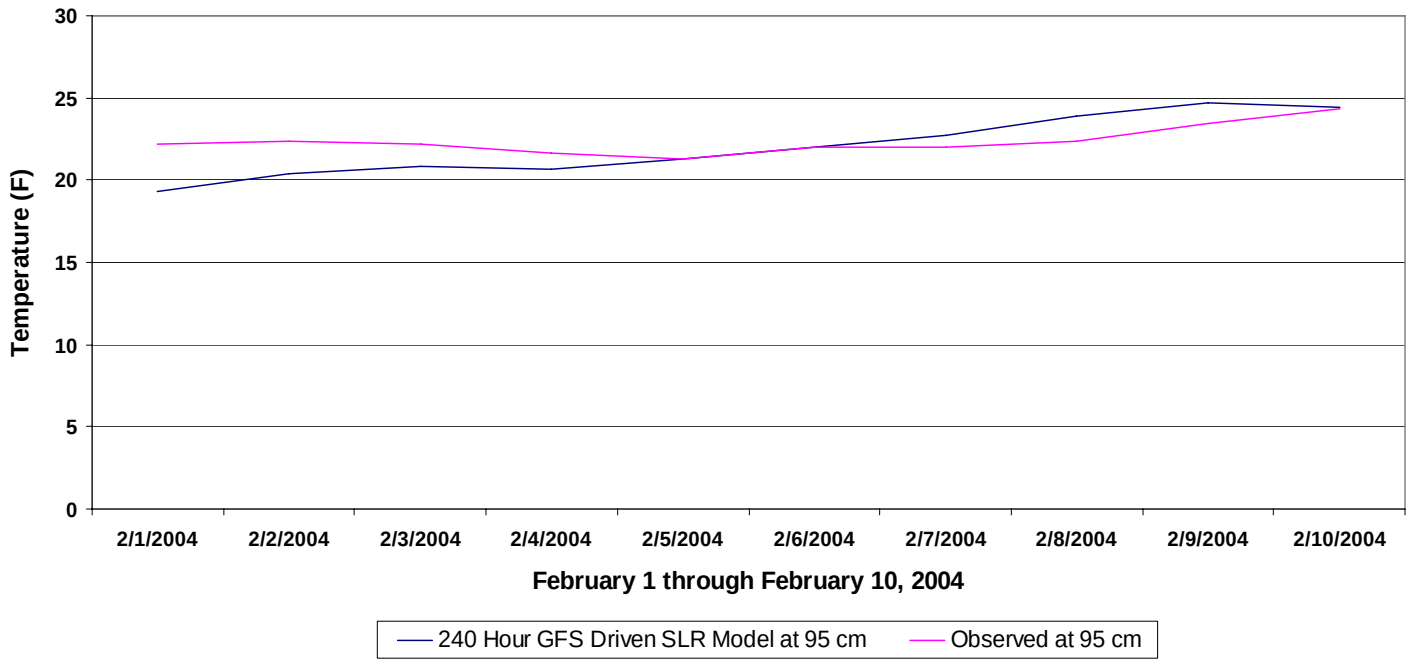
Subsurface Temperature Comparison

240 Hour GFS Driven SLR Model and Observed Subsurface Temperatures 10 cm (20040201 Forecast)

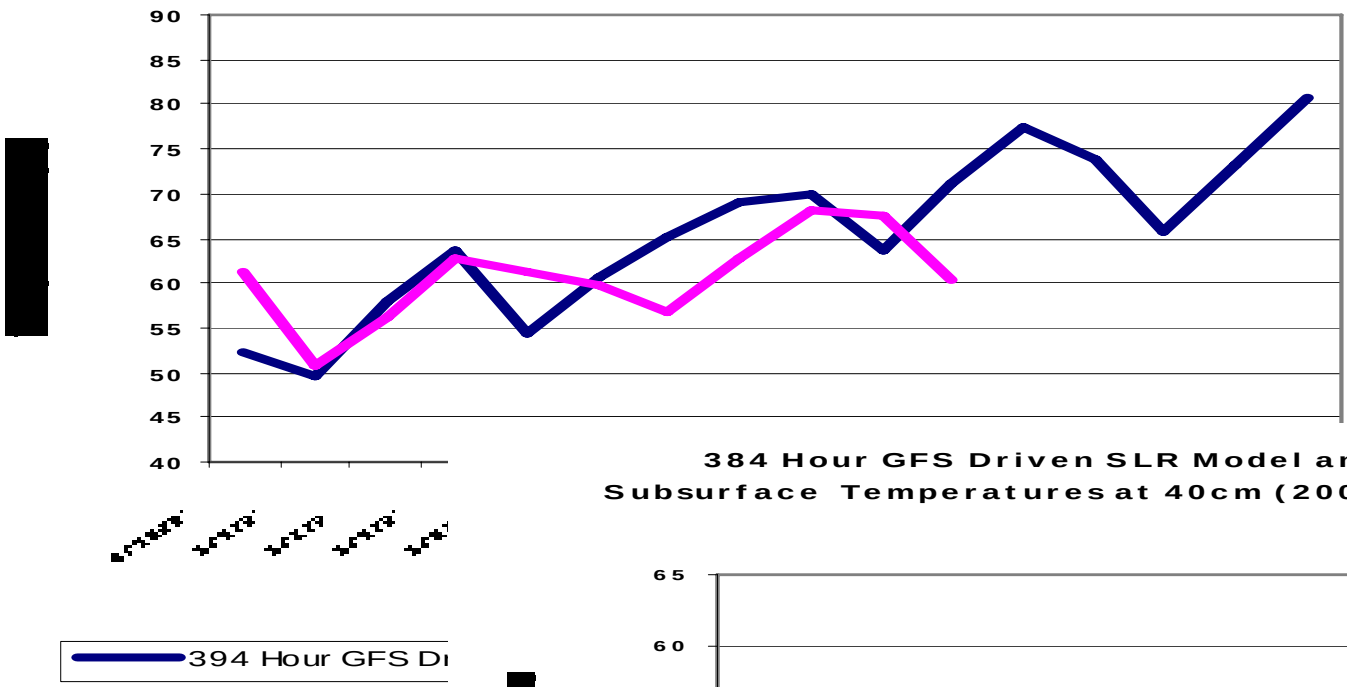


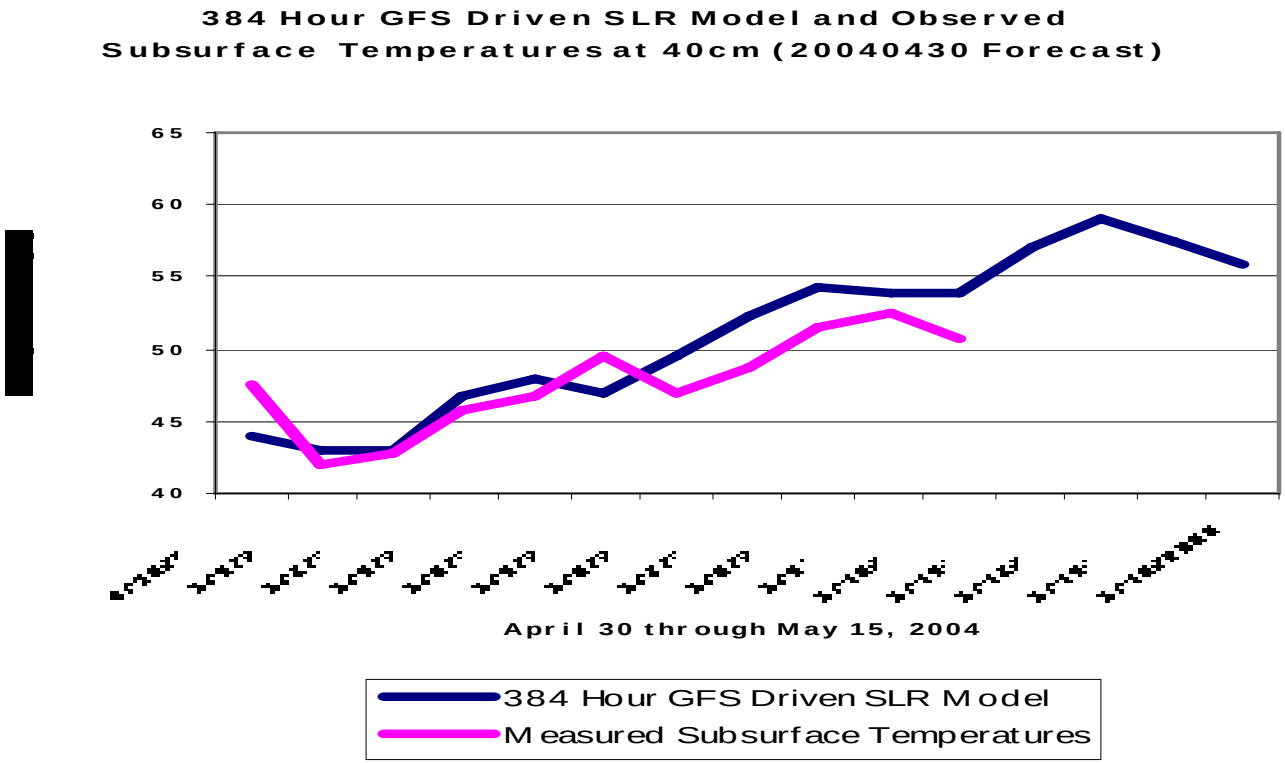
2003-2004 Winter

240 Hour GFS Driven SLR Model and Observed Subsurface Temperatures (20040201 Forecast)



2003-2004 Winter

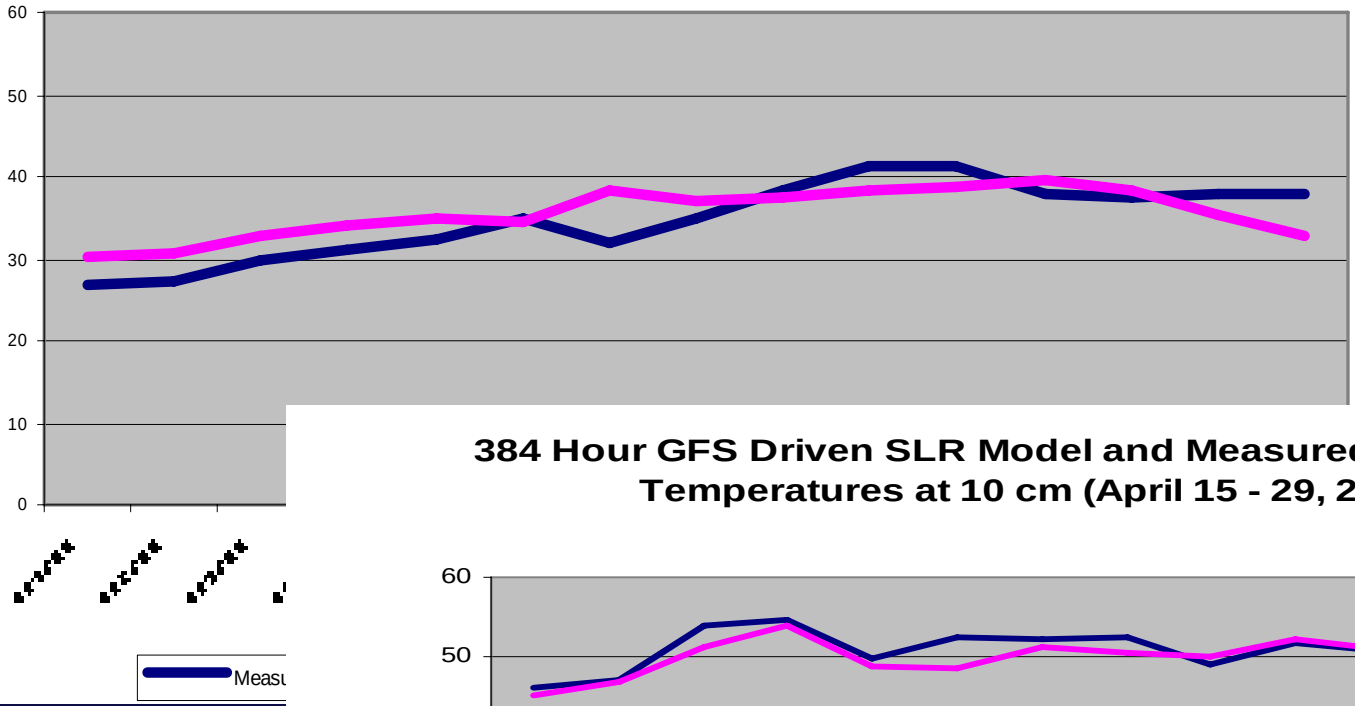




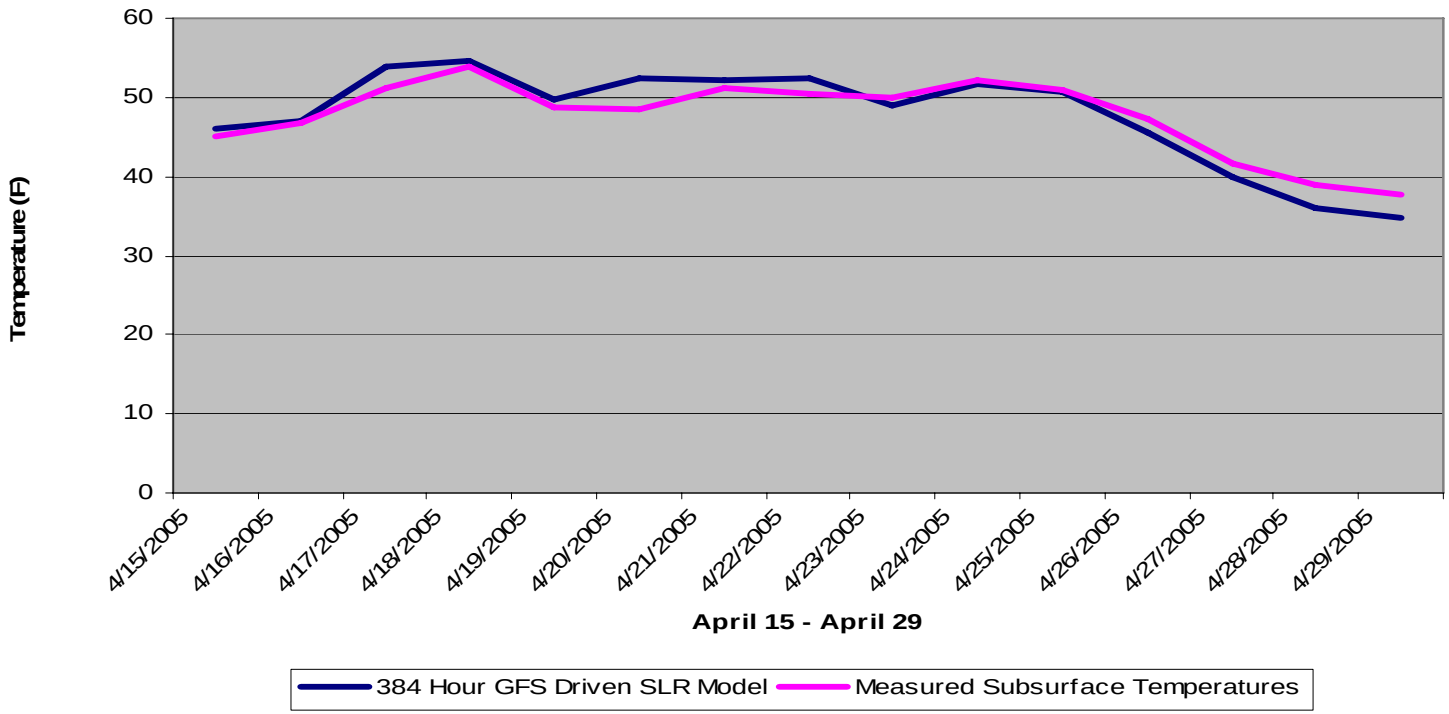
Subsurface Temperature Comparison

2004-2005 Winter

384 Hour GFS Driven SLR Model Predicted Temperatures and Measured Subsurface Temperatures at 50cm (April 1 - 15, 2005)



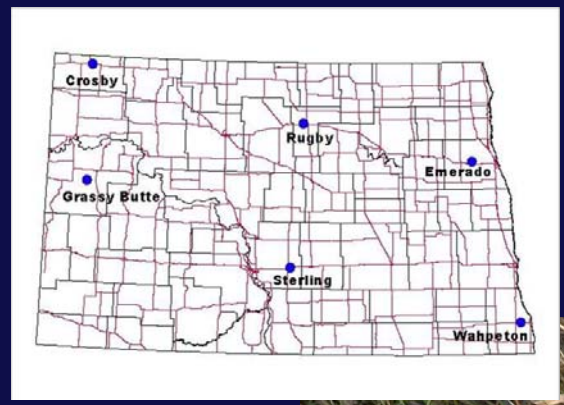
384 Hour GFS Driven SLR Model and Measured Subsurface Temperatures at 10 cm (April 15 - 29, 2005)



Subsurface Temperatur Comparison

Ongoing Efforts

- **Ongoing Research**
  - Data used by the NDDOT in an experimental capacity
  - Model winter 2005-2006
  - Winter 2006-2007 Operational Demonstration
  - UND Road Weather Field Research Facility providing long term test facility



Acknowledgments

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- Leon Osborne, Jr.

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SURFACE TRANSPORTATION WEATHER RESEARCH CENTER

UNIVERSITY OF NORTH DAKOTA, GRAND FORKS, NORTH DAKOTA

3980 Campus Road
University of North Dakota
Grand Forks, North Dakota 58202
http://stwrc.rwic.und.edu
701-777-2479

Thank You!

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SURFACE TRANSPORTATION WEATHER RESEARCH CENTER
UNIVERSITY OF NORTH DAKOTA, GRAND FORKS, NORTH DAKOTA