A Blowing and Drifting Snow Algorithm Supporting Winter Road Maintenance Decision Making

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Outline

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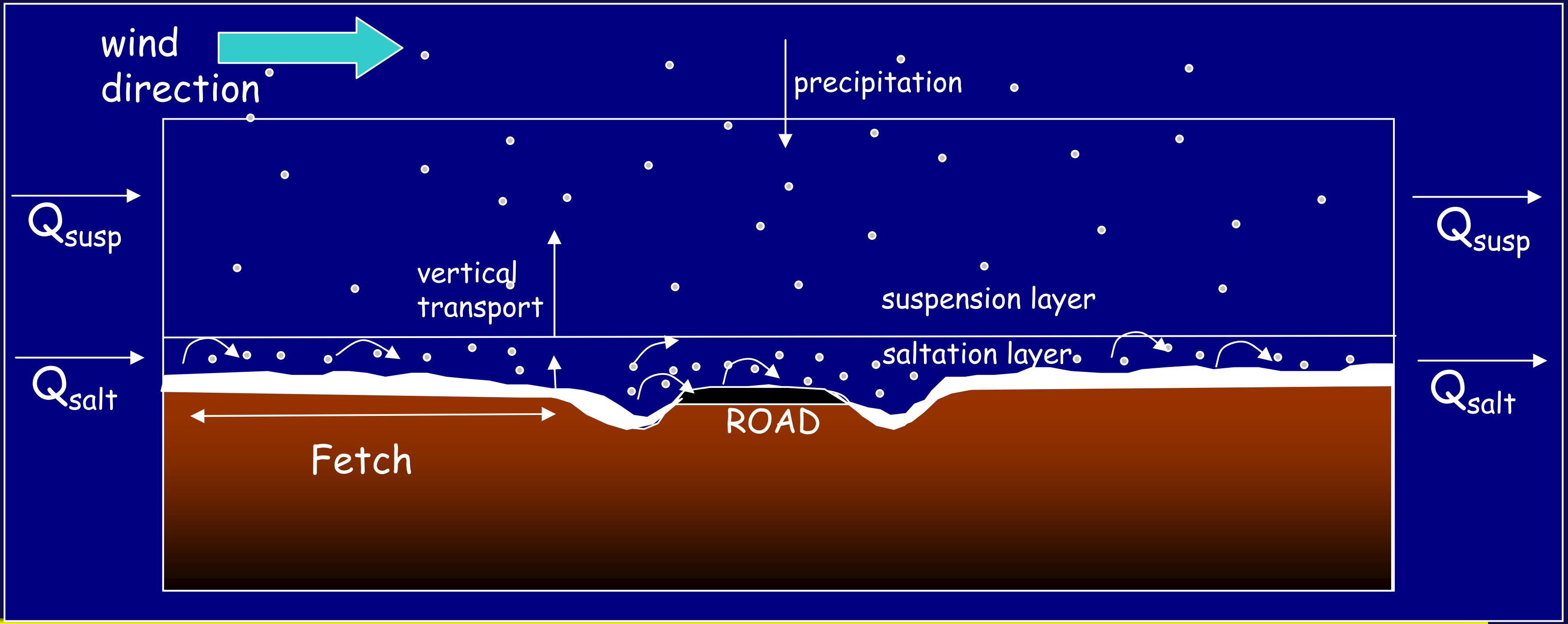
Problem Statement & Objectives

- ➢ **Blowing snow in the roadway presents a serious challenge to winter maintenance activities and driver safety**
- ✓ **Current project is to develop a road environment blowing snow modeling system**
  - ❖ Incorporation of mesoscale weather models
  - ❖ Integration with blowing snow model tailored to the roadway environment
  - ❖ Validation across broad terrain settings
- ✓ **Operational testing & deployment**

Snow Mass Flux Prediction

- **Two critical layers monitored**
  - ❖ Saltation Layer (where snow creeps/rolls in short trajectories)
  - ❖ Suspension Layer (where lofted snow attains a height that impairs driver visibility)



Blowing Snow Characteristics

- **Critical variables include:**
  - Extent and age of snow cover adjacent to road
    - Influenced by roadway geometry and vegetative cover
  - Land cover and terrain adjacent to road
  - Wind strength and its orientation relative to the road surface direction
  - Past, present and future air temperature and relative humidity
  - Amount of incident solar radiation

Methodology: Initialization Activities

- **Data Assimilation**
  - Supports model initialization and follow-up validation efforts
  - Utilizes the NOAA ESRL Local Analysis and Prediction System (LAPS)
    - 10-kilometer grid extending across 70% of the United States
    - Hourly assimilation cycle
- **Mesoscale Model**
  - Provides background fields of atmospheric dependent data
  - Models incorporated include
    - 6-member WRF ensemble
    - Workstation ETA
    - Models discretized to a 10-kilometer domain (same as the LAPS domain)
- **Downscaled Model Data to 1-kilometer**
  - Constructs fine resolution fields of winds and temperature
  - Accounts for local variations in land-cover and terrain

Methodology: Initialization Activities

- **Land Surface / Land-Use Characterization**
  - Provides a detailed reference of significant vegetative and terrain features along roadway
  - Used to generate a database for each road reference point that initializes static physical features used within the blowing snow model
  - Utilizes air photo and land resource satellite imagery to delineate critical features:
    - Fetch distances along the roadway at 1-kilometer resolution
    - Evaluation of sharp changes in terrain and vegetation features adjacent to roadway
  - Will be used to construct and utilize a blowing snow susceptibility index along roadways

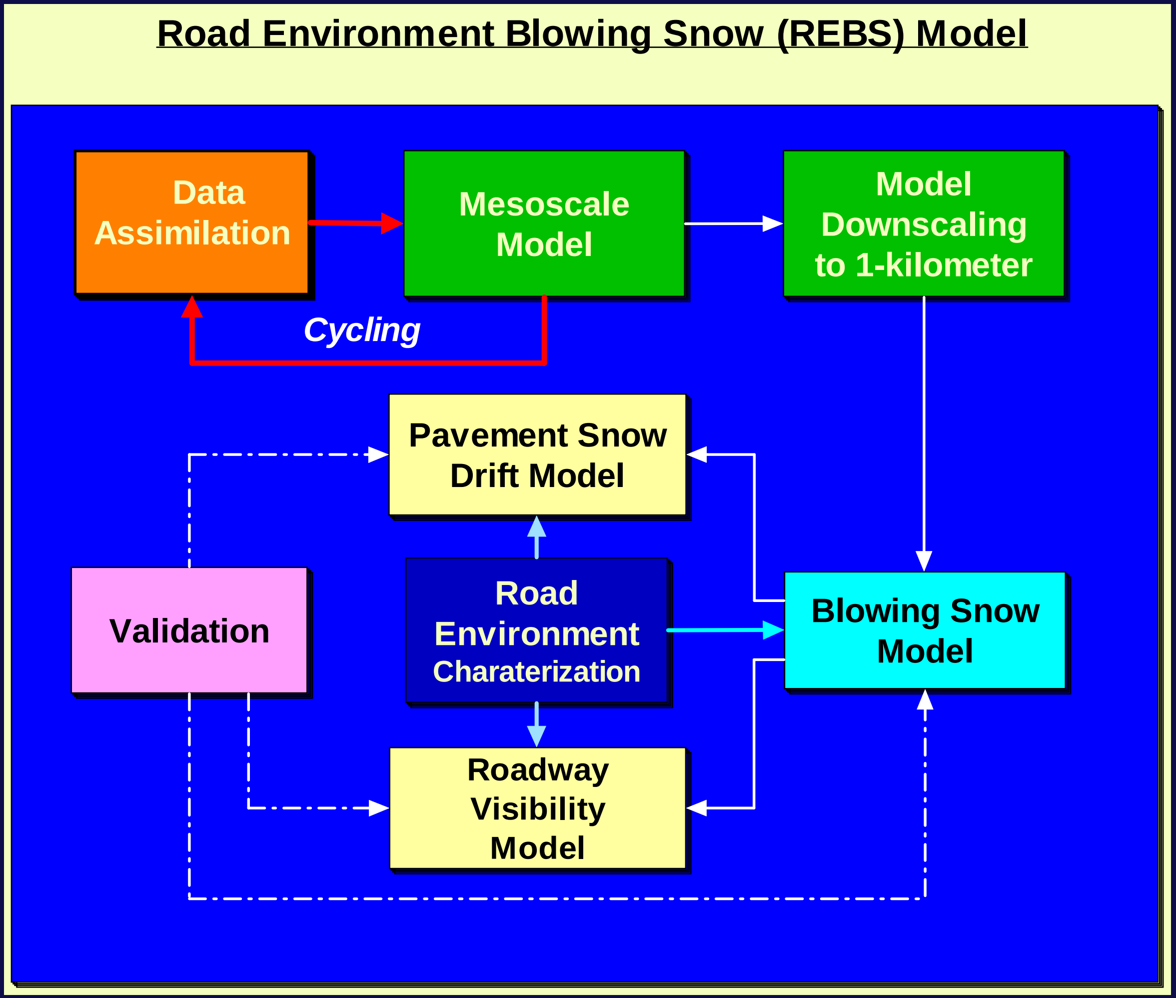
Methodology: Blowing Snow Model

- **Blowing Snow Model**
  - Generates snow mass flux estimates within saltation, $Q_{salt,}$ and suspension layers, Q_{susp}
  - Algorithm based upon modified Prairie Blowing Snow Model*
- **Roadway Visibility Model**
  - Utilizes mass flux within suspension layer, Q_{susp}
  - Visibility determined by $\log(Vis) = -0.773\log(Q_{subl}) + 2.845$ **
- **Pavement Drift Model**
  - Identifies presence of rolling/creeping snow that impacts ice formation on road surface
  - Utilizes mass flux within saltation layer, $Q_{salt,}$, to determine drift density
- **Model output provide for future 30-hour period**

*Pomeroy, J.W and L. Li, 2000: "Prairie and arctic areal snow cover mass balance using a blowing snow model. J. Geo. Res., 105, pp26,619-26,634.

**Matsuzawa, M. and M. Takeuchi, 2002: "Study on Methods to Calculate Visibility on Blowing Snow". 11th International Road Weather Conference, Jan. 26-28, Sapporo, Japan

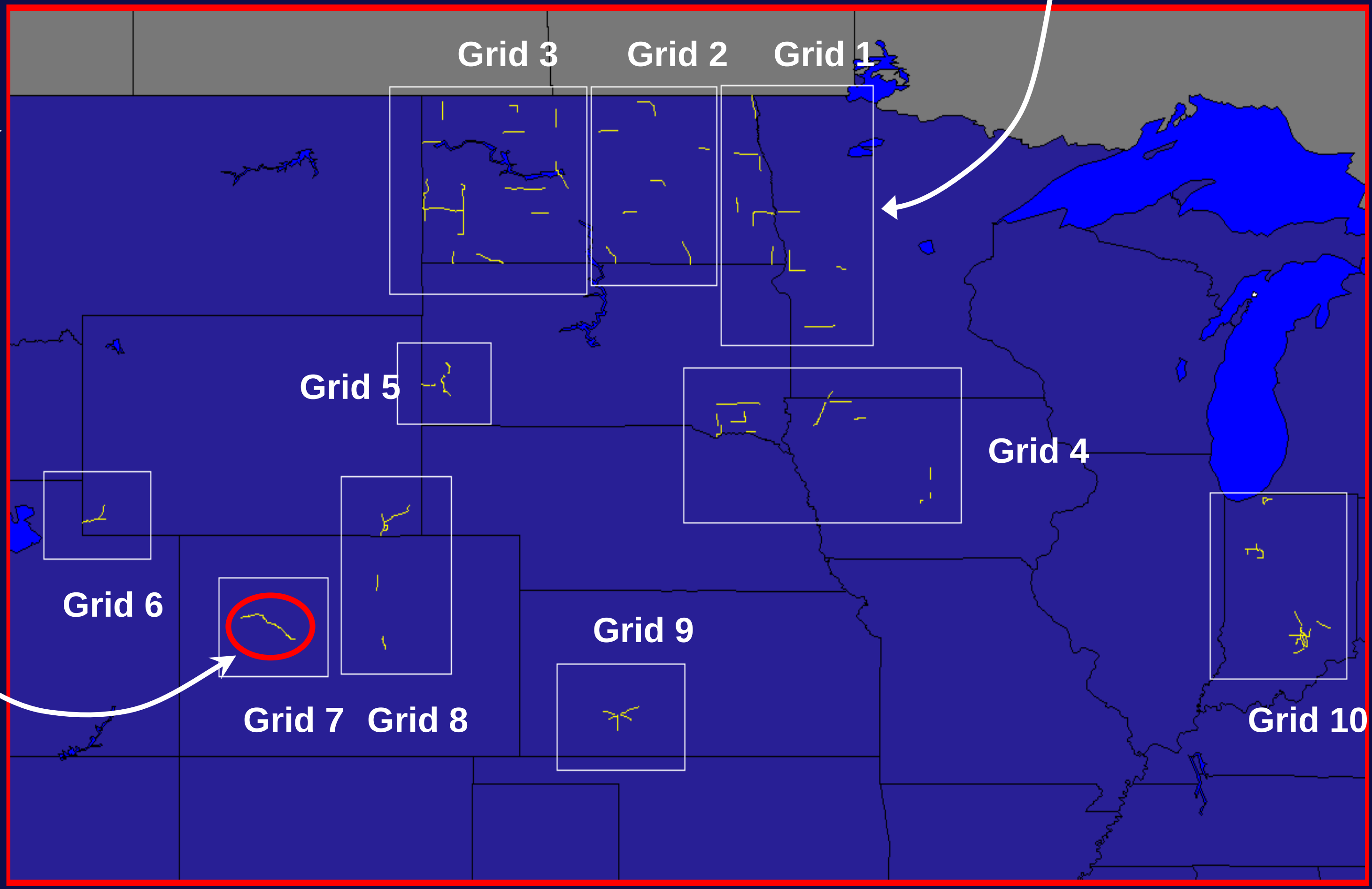
Computational Framework



Focus Research Areas

Ten 1-kilometer Blowing Snow Domains

One 10-kilometer Primary MDSS Domain

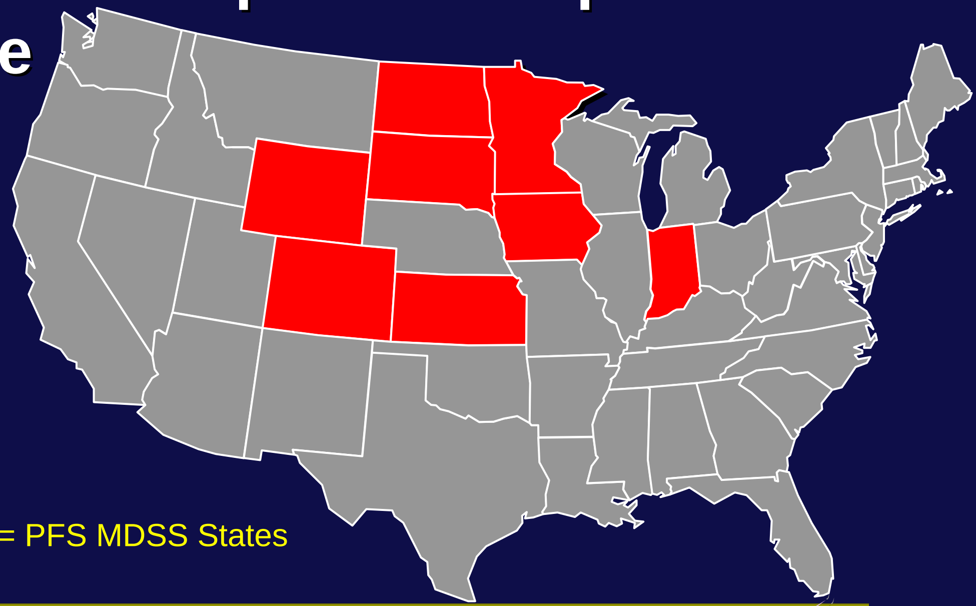


Each 1-kilometer Domain Focuses on Specific Winter Maintenance Routes

UND Winter 2005-06 Operational Testing

- Validation of blowing snow research is part of the Pooled Fund Study Maintenance Decision Support System (PFS MDSS) Field Tests
  - 1 November 2005 to 15 March 2006
- Resulting technology to be incorporated as part of the PFS MDSS package
- To monitor progress

  http://stwrc.rwic.und.edu



For information on the PFS MDSS
http://mdss.meridian-enviro.com

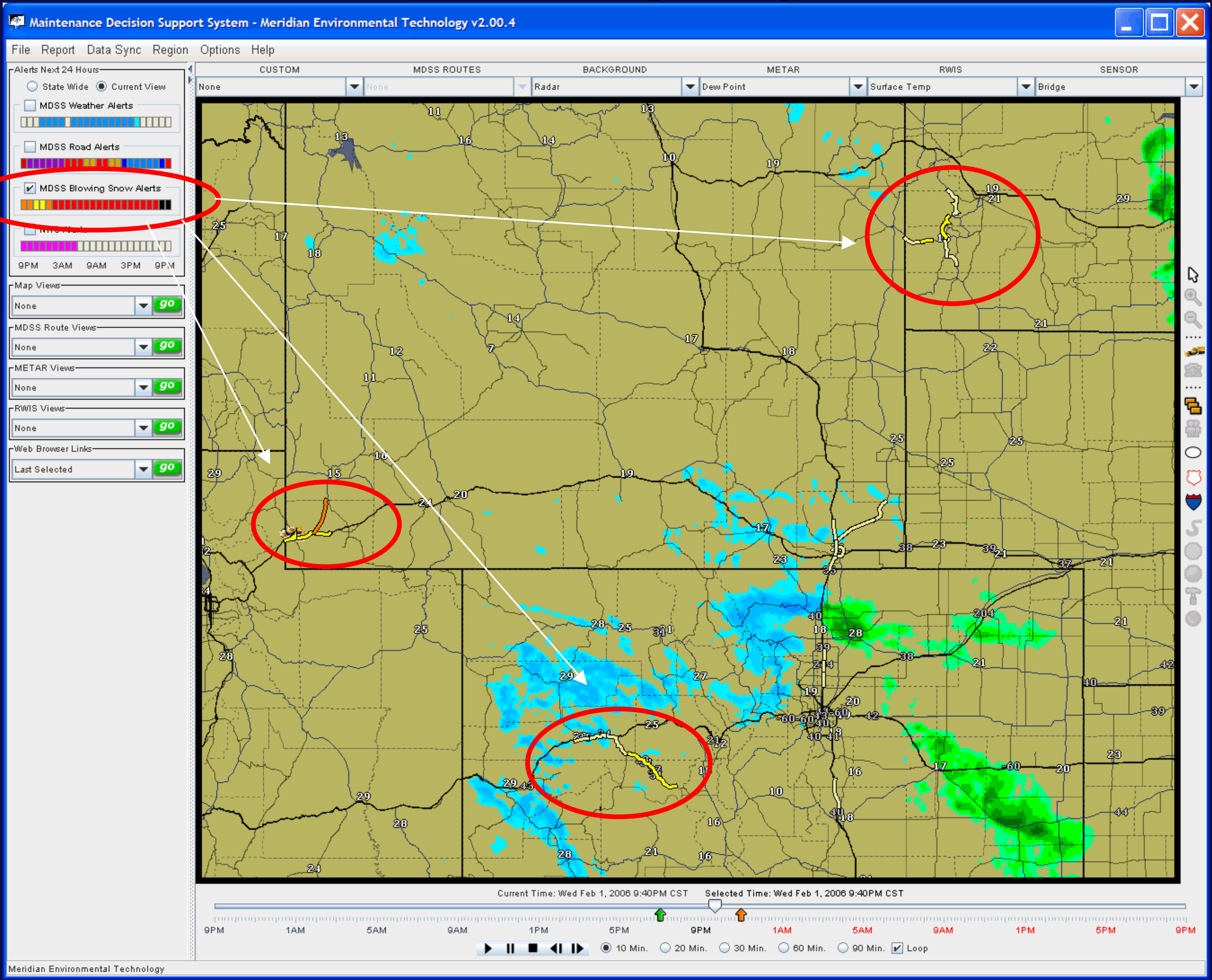
Operational Testing & Deployment

- **Presently supports blowing snow alerts within the PFS MDSS graphical user interface**

- **Provides route-specific alerts**
  - 183 winter maintenance routes across eight states
  - Hourly forecasts through 24-hours
  - Alerts provided for four levels
    1. No Risk – No Blowing Snow Expected
    2. Slight Problem : $0 > Q_{susp} < 50\ g\ m^{-2}\ s^{-1}$
    3. Problematic : $50\ g\ m^{-2}\ s^{-1} > Q_{susp} < 100\ g\ m^{-2}\ s^{-1}$
    4. Severe : $Q_{susp} > 100\ g\ m^{-2}\ s^{-1}$

Operational MDSS Display

Blowing Snow Alert



Preliminary Findings

- **Results this winter indicate the advantages of 1-kilometer data resolution primarily beneficial for coarse terrains**
  - Will permit future larger (tailored) grid spacing for non-obstructed terrain . . . Reduce computational requirements!
  - Higher resolution grids are as important for temperature fields as for wind fields . . . Strong blowing snow model dependency on temperature for initiation of saltation.
- **Land-use / land-cover / snow pack accounting are crucial for fine-resolution depiction of drifting snow**
  - Incorporation of a blowing snow susceptibility index along routes will provide improvement in spatial definition of drifting snow

Preliminary Findings

- **Importance of the blowing snow varies greatly between users of the road and maintainers of the road**
  - Winter pavement condition models must account for drifting snow in addition to falling snow

Ongoing Work

- **Validation activities are underway across all PFS MDSS states**
  - Focused validation activities ongoing at the UND Road Weather Research Facility (www.stwrc.rwic.und.edu)
  - Field observations include use of video disdrometers for detailed measurements of snow mass flux
- **Addition of broader precipitation inputs for snow pack accounting**
- **Evaluation of historical hourly weather observations to establish blowing snow climatology**

Future Work

- **Incorporation of visibility predictions within the PFS MDSS interface and as part of 511 messages**
- **Addition of drifting snow into mass and energy balance computations within pavement conditions models**
- **Optimization and parallelization of codes to improve run-time efficiencies**
  - Present codes require too great of computational resources to be sustained in an operational setting such as MDSS

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