# *Land Surface Hydrological Processes and Modelling*

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# Overview

- OBJECTIVE

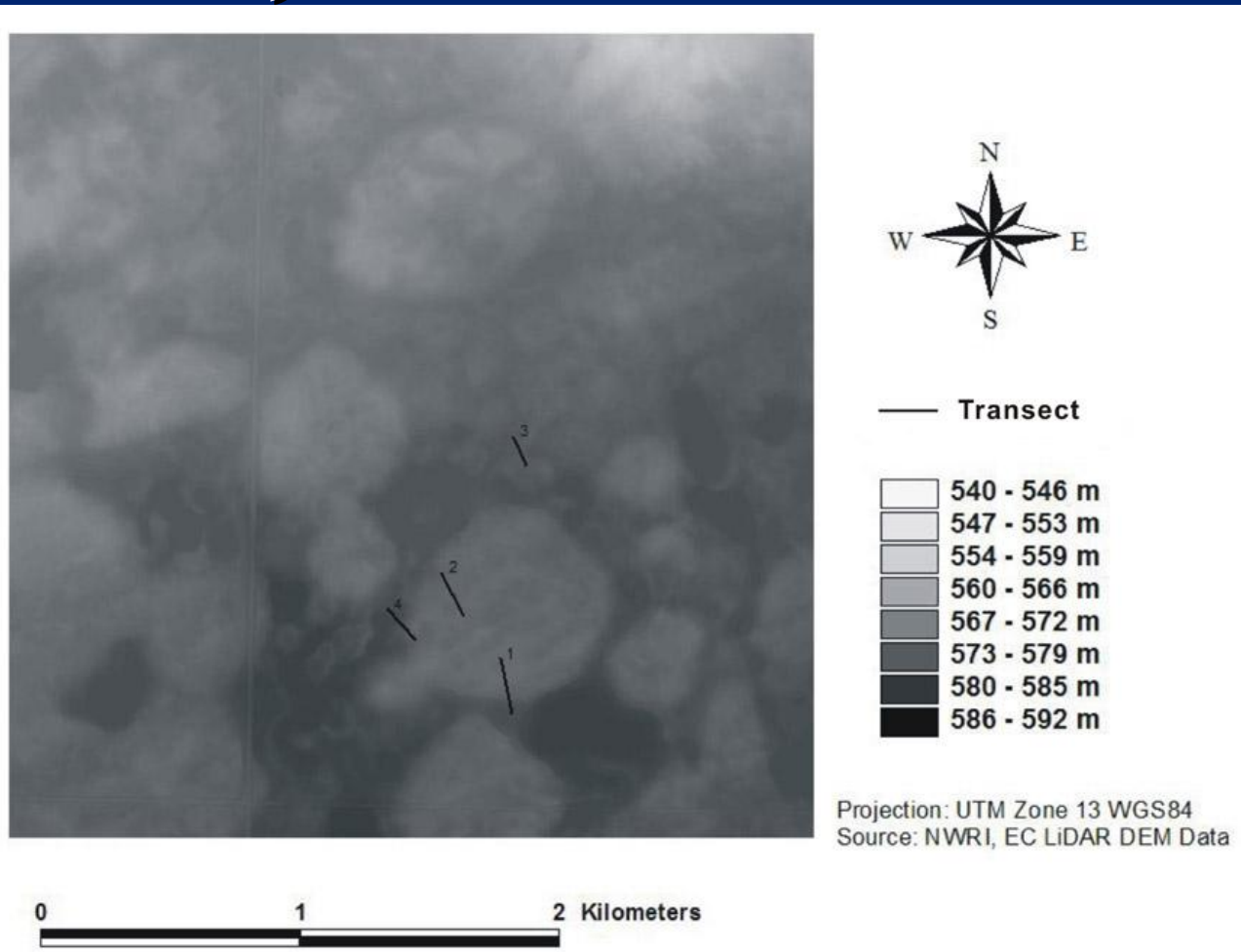
  To better understand, describe and model the development of hydrological drought on the Prairies

- FOCUS – evaluation and drought sensitivity of
  - Snow Accumulation and Wind Redistribution
  - Snowmelt Runoff
  - Areal Evaporation
  - Prairie Basin Hydrological Modelling - CRHM

# Blowing Snow Transport, Sublimation, Redistribution

- SWE calculated using Distributed Blowing Snow Model on finely distributed basis

Linear solution to Jackson-Hunt wind-flow over complex terrain




DBSM - Essery and Pomeroy

LIDAR, LANDSAT and Field Surveys used to charactrize terrain and roughness

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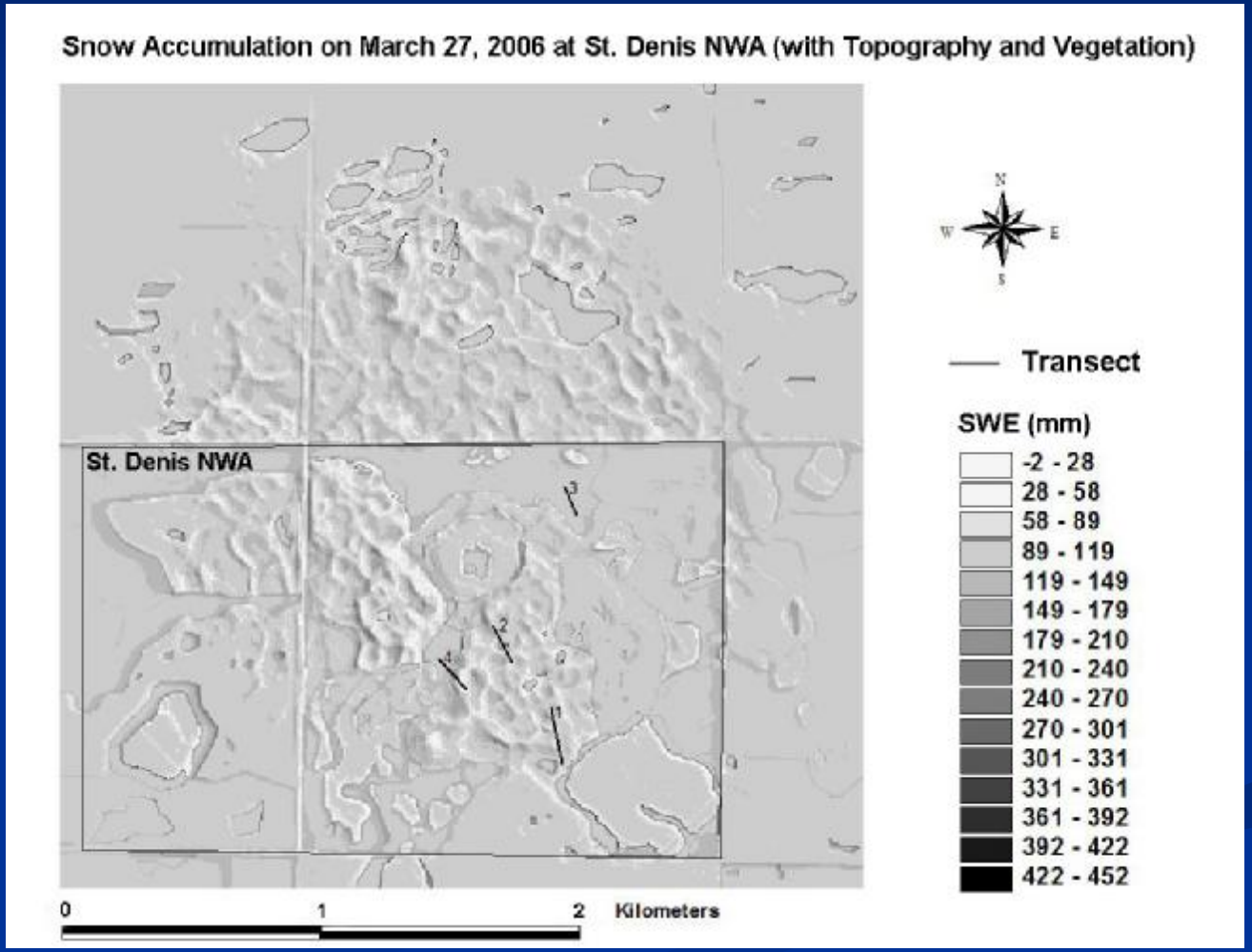
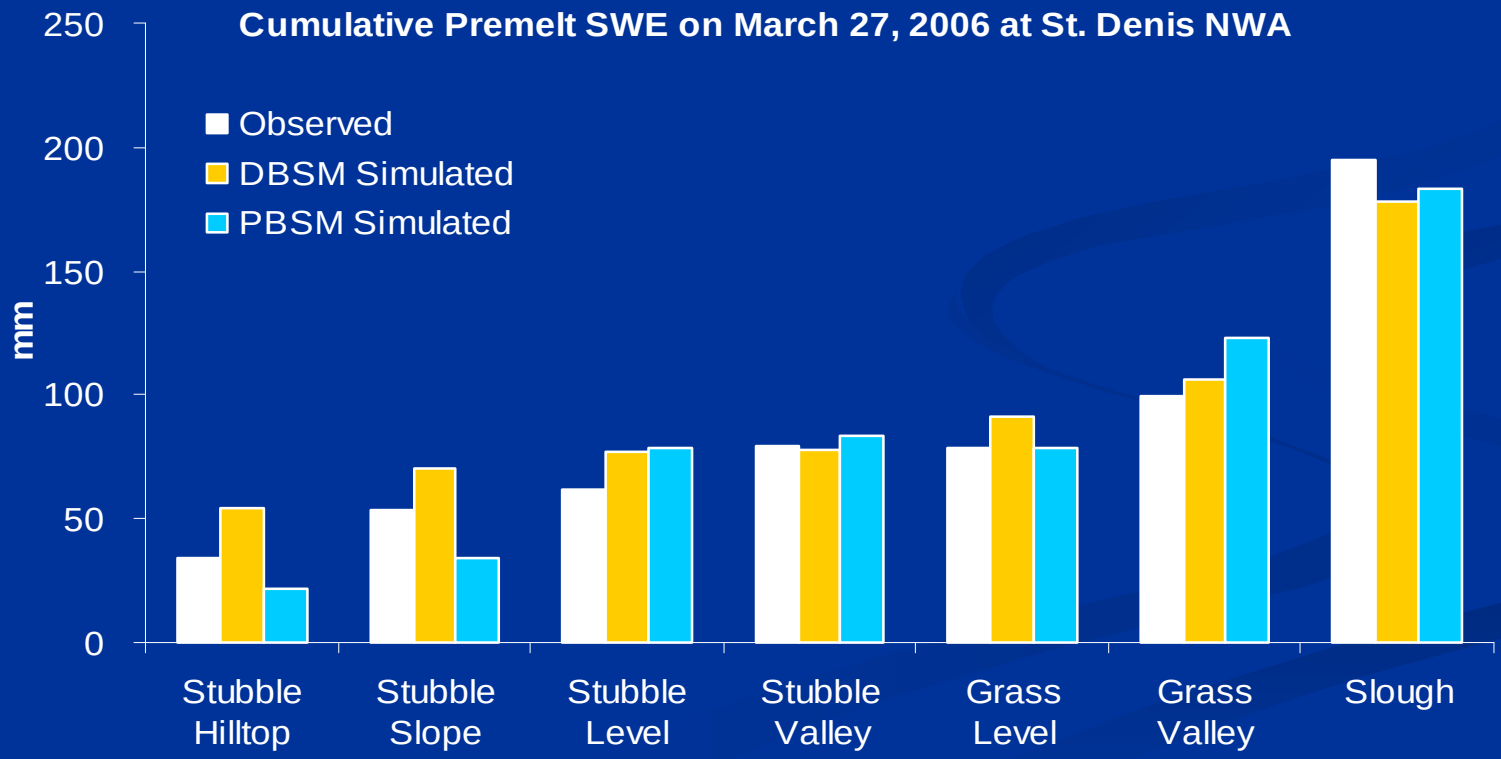


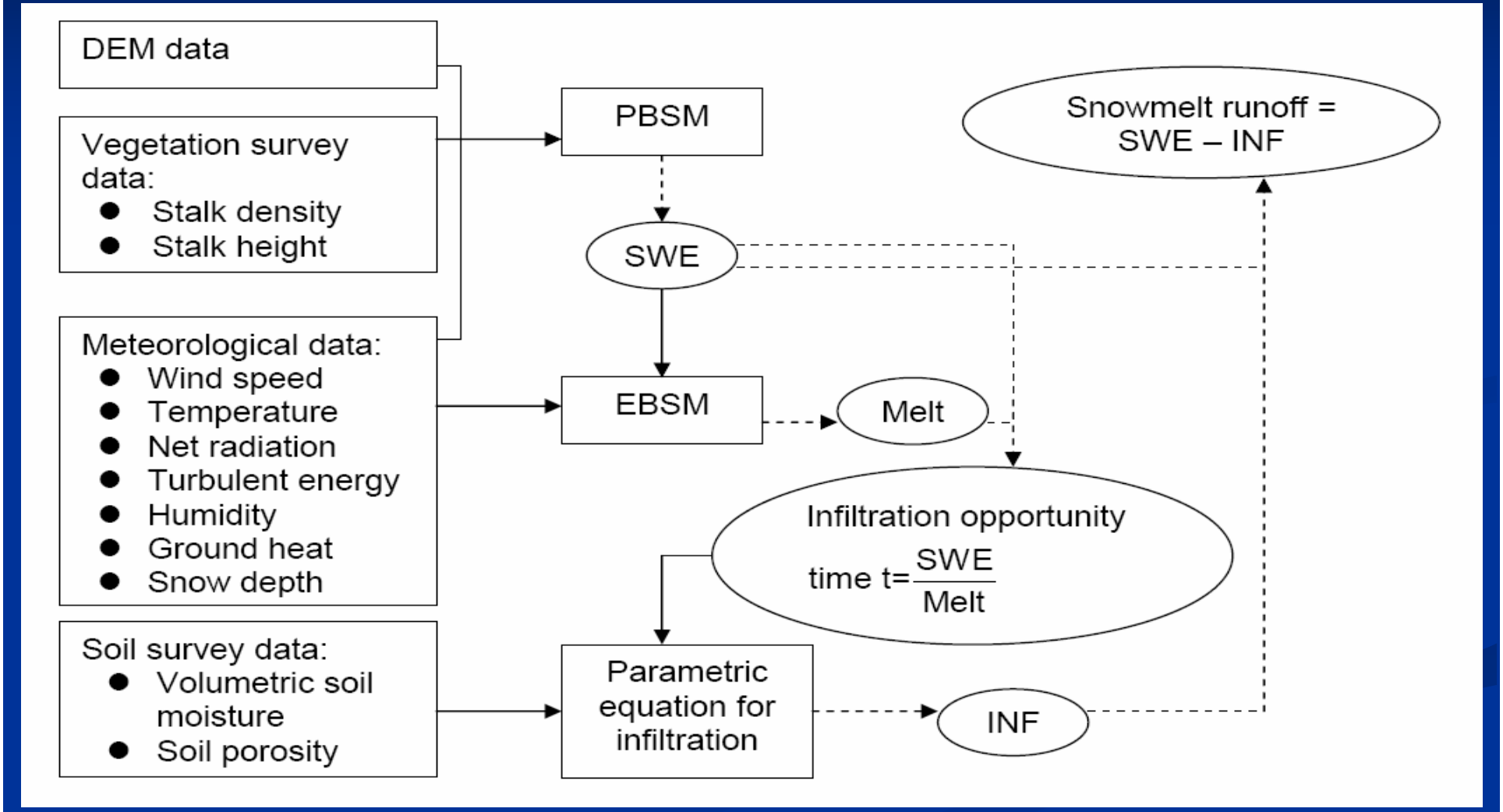

LIDAR, LANDSAT and Field Surveys used to charactrize terrain and roughness

# Aggregation of Blowing Snow Calculations over Complex Prairie Terrain

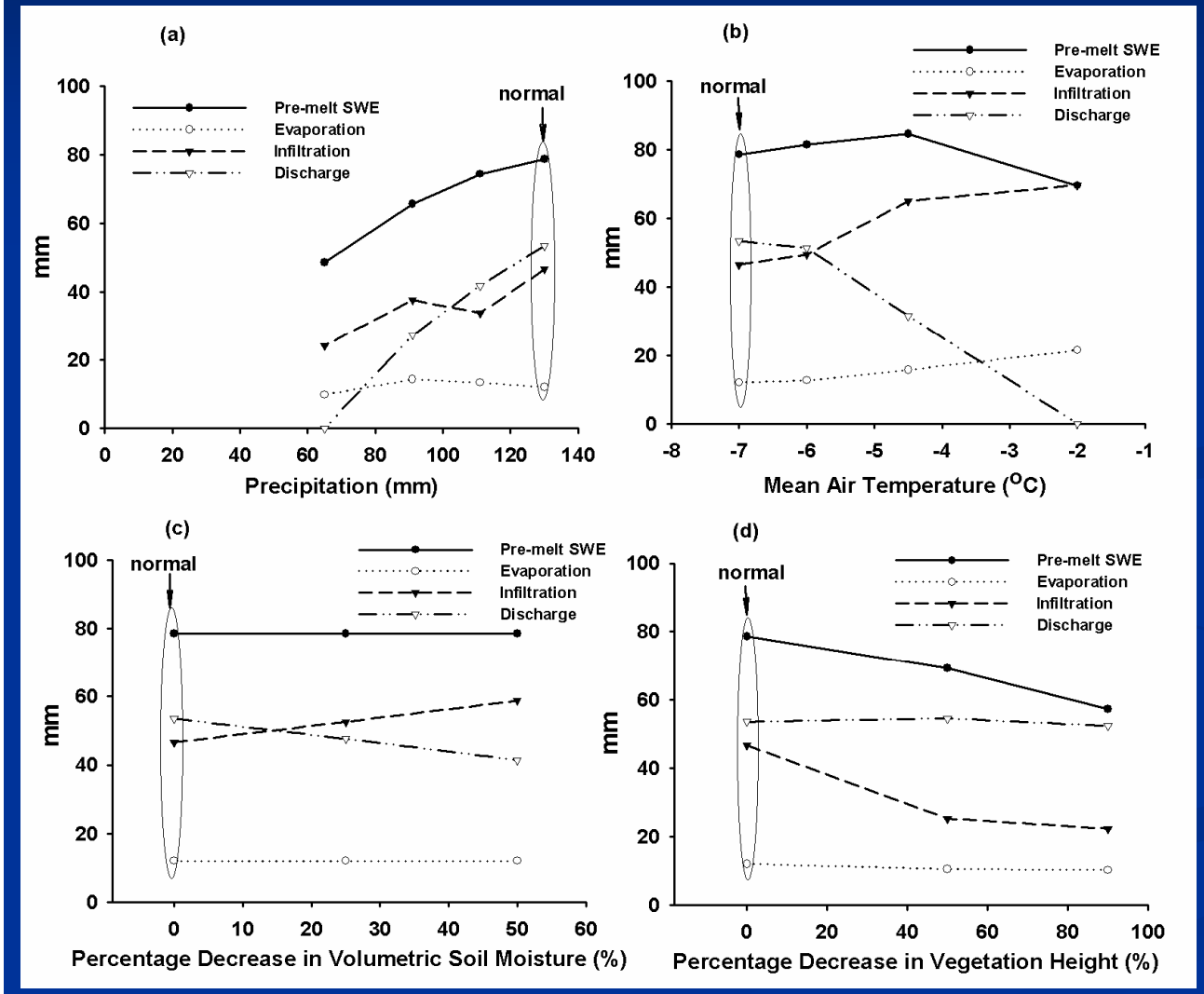
- DBSM run at 5 m resolution grid
  - Special datasets needed to run model at this scale, >10,000 grid cells
- Prairie Blowing Snow Model (in CRHM) run at Hydrological Response Unit (HRU) resolution 18 HRU.



# Calculating Prairie Snowmelt Runoff



# Spring Runoff Generating Processes in Drought



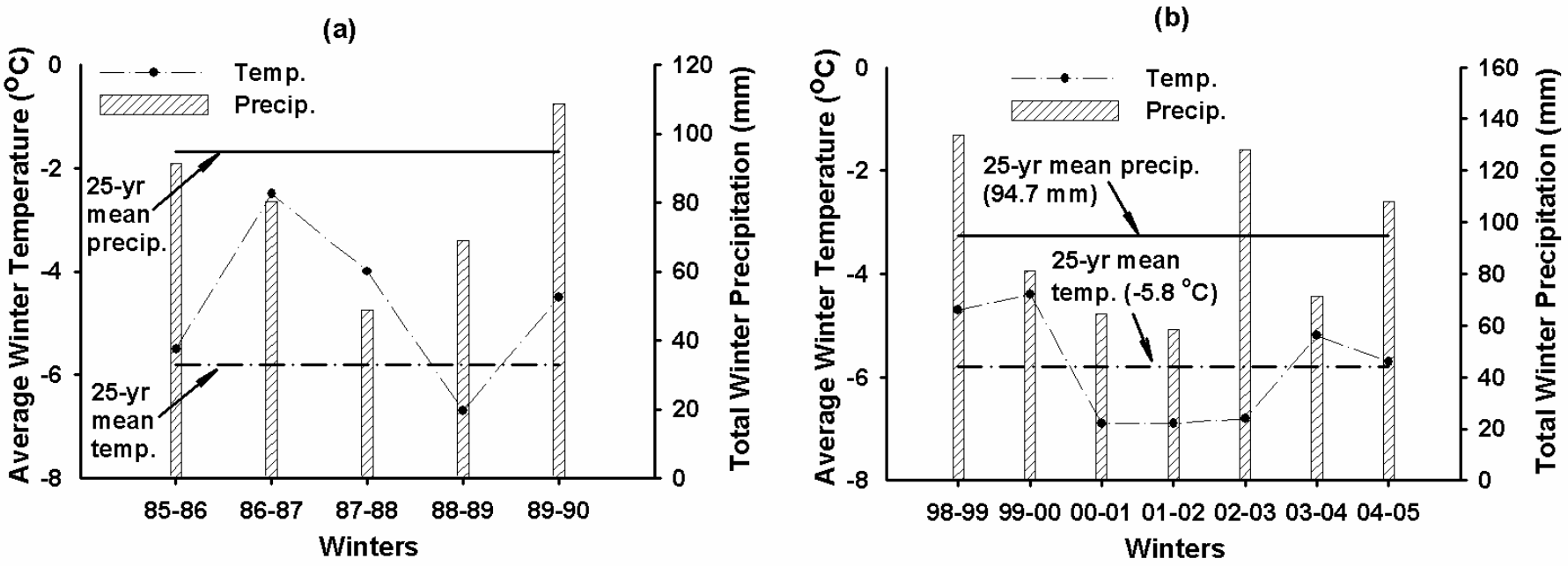

Drought Factors
Winter Precipitation
Winter Air Temperature
Fall Soil Moisture
Summer Vegetation Growth

Drought Response
Winter Evaporation
Maximum Snowpack
Spring Infiltration
Spring Stream Discharge

Fang and Pomeroy, in press

# Hydrological Drought Winters can be *Colder* or *Warmer* than Average

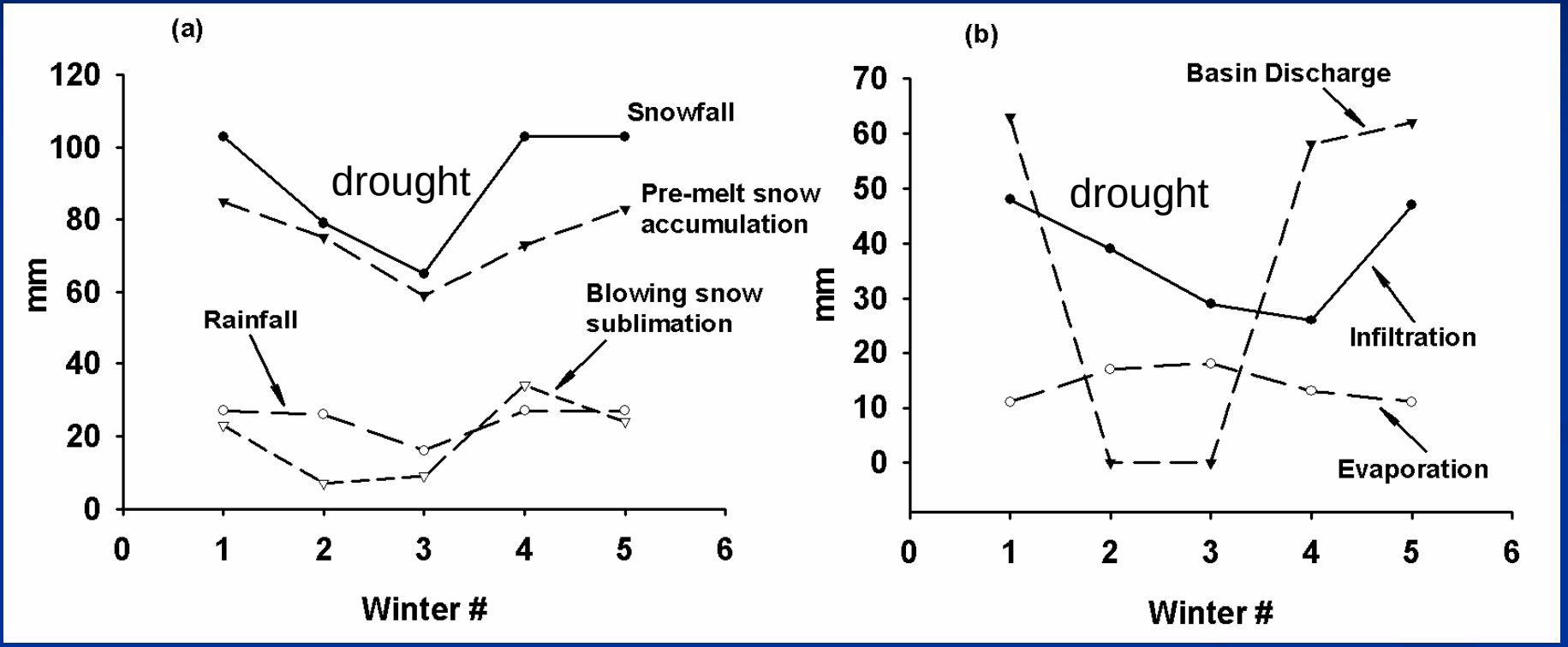
Rosetown, Saskatchewan




Hydrological Winter 1 October to 30 April

Fang and Pomeroy, in press

# Hydrological Drought Sequence

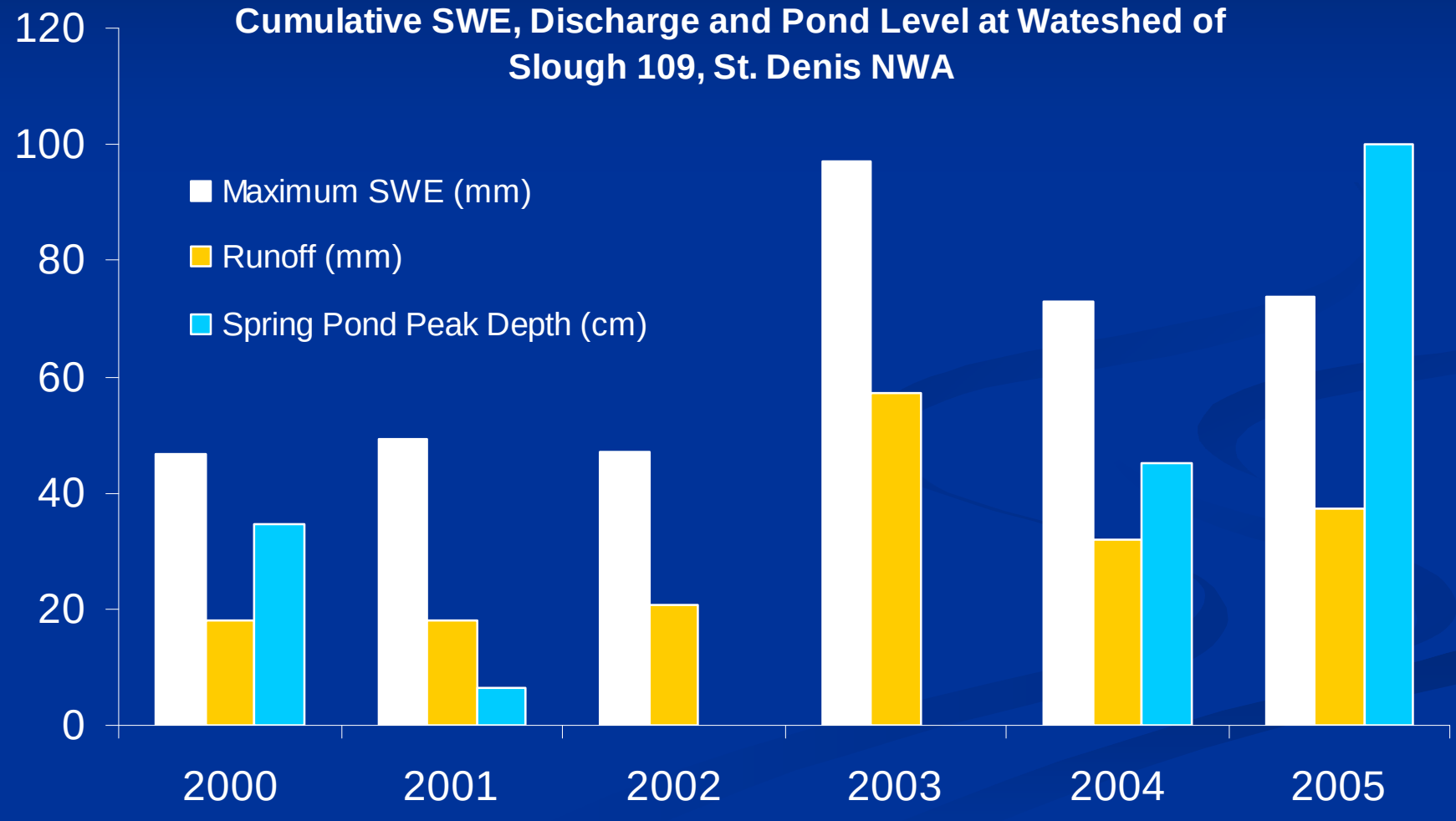



Hydrological Recovery delayed one season after meteorological recovery in simple well drained prairie basin

Predictions continue with process based hydrological model driven by atmospheric model

Fang and Pomeroy, in press

# St Denis Drought Sequence -with basin storage



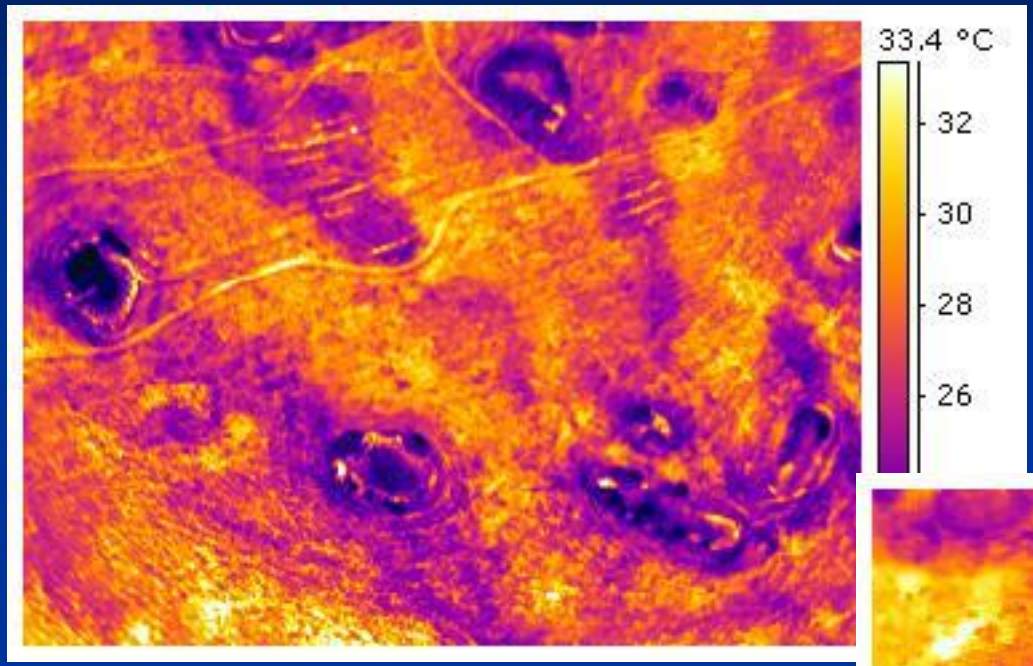
# Prairie Evaporation

- Actual Evaporation critical component of drought
- Uncertainty in estimating Evaporation
  - Various theoretical relationships with differing sets of parameters ( $\alpha$ , $z_o$, d, vegetation, water), variables (K $\downarrow$ , L $\downarrow$ , u, T, q) and state variables ( $\theta$ , $T_s$)
  - Highly spatial variability) –
    - subgrid variability
    - Advection to ponds
    - Open water driven by convective transfer, $T_s$ not well related to radiation (Granger)
- Aggregation in LSS.
  - Tiles
  - Problem of changing tile area during drought
- Continuity
  - All models limit water for evaporation by tracking supply
  - Prairie plants don't care and send roots to available water (+3 m)

# Field Observation NECESSARY

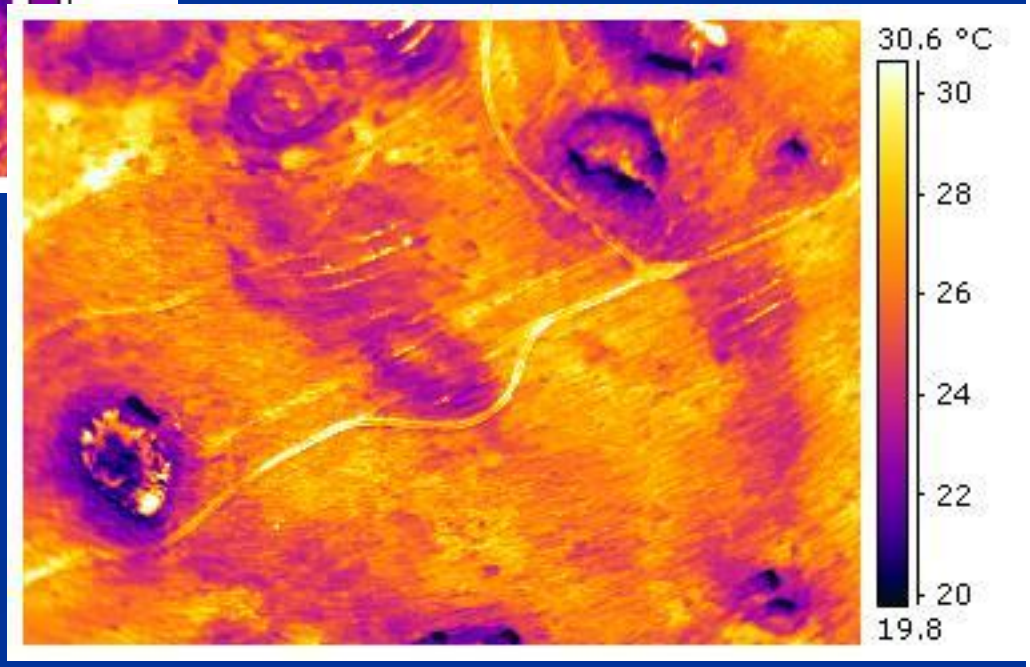
St Denis National Wildlife Area, Saskatchewan

# Spatial Variability

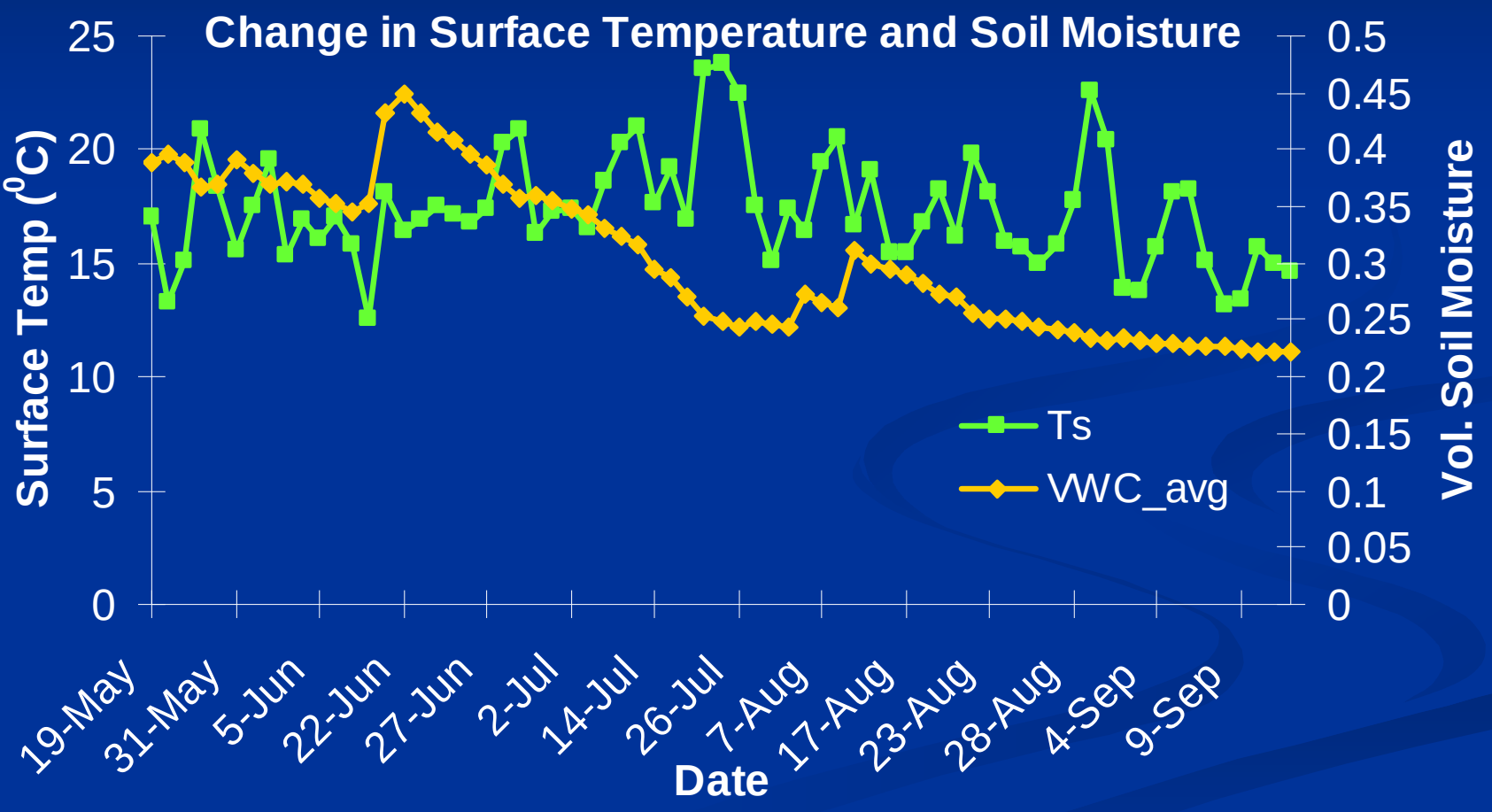



Topography
Soil structure
Vegetation
Water / ponds

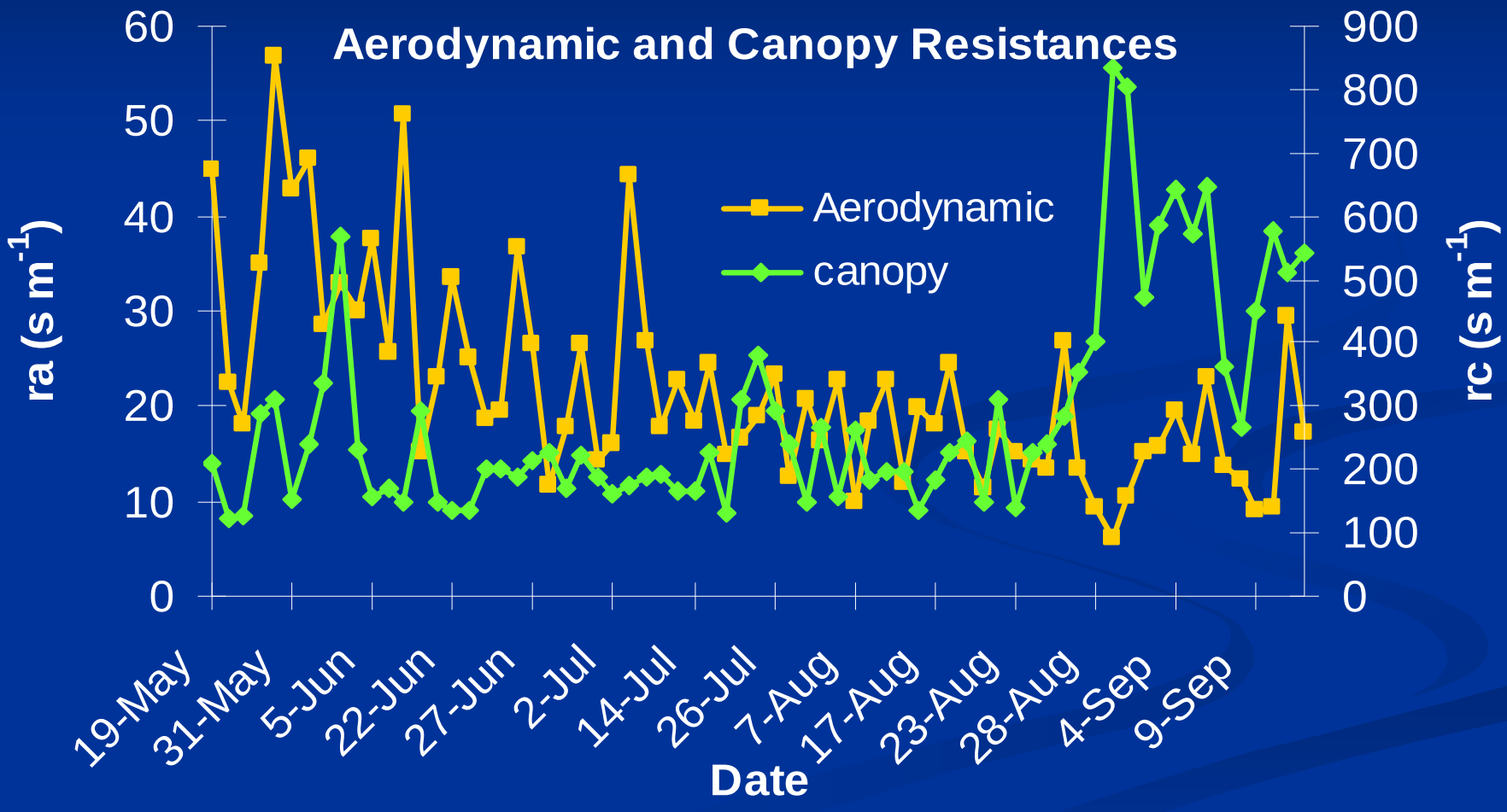
Surface Temperature
Soil Moisture



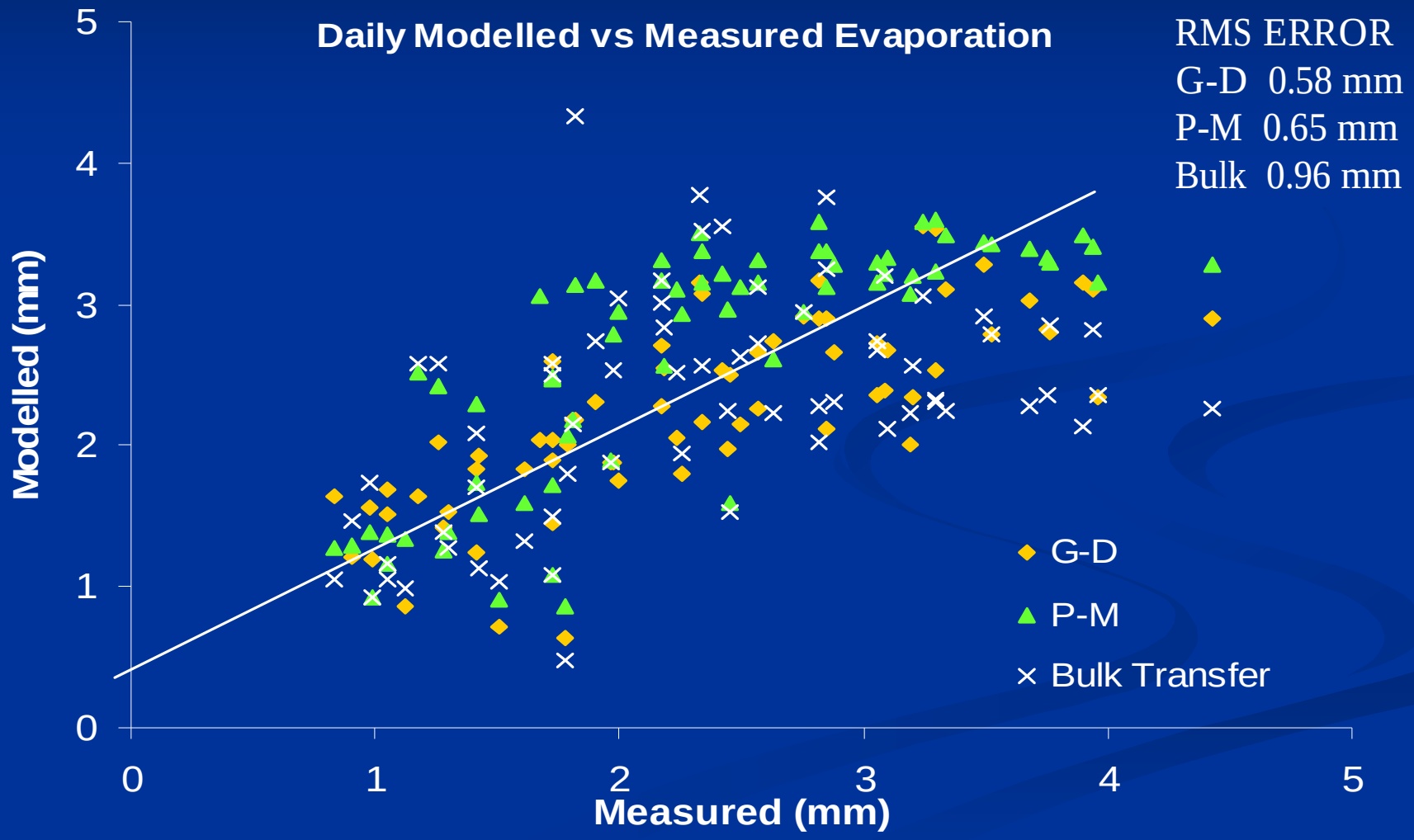
# Change in State Variables for Evaporation during Prairie Desiccation



# Change in Resistances to Evaporation during Prairie Desiccation

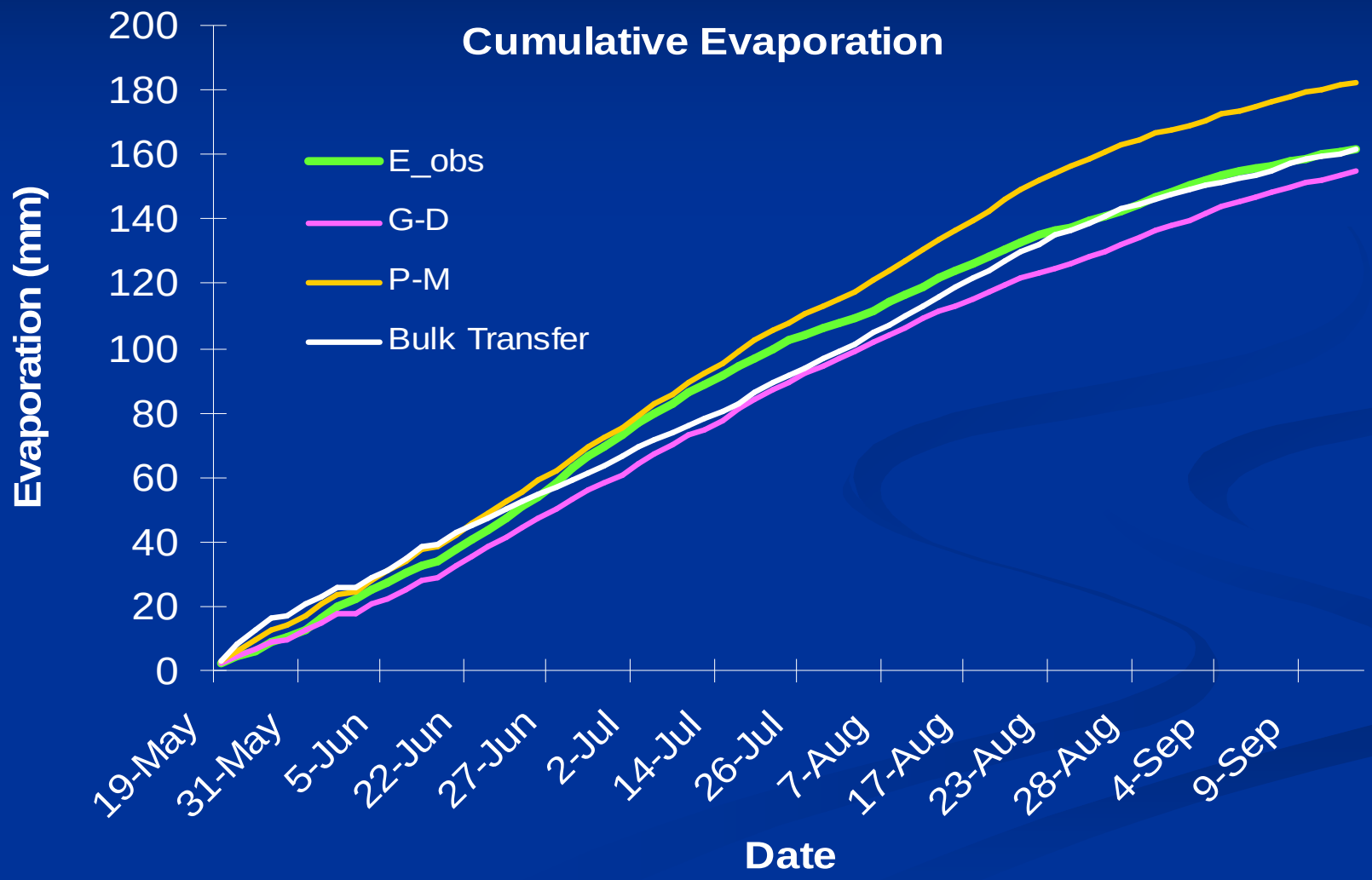


# Uncertainty in Daily Evaporation Estimation is Considerable




RMS ERROR
G-D 0.58 mm
P-M 0.65 mm
Bulk 0.96 mm

# Cumulative Evaporation Robust



# Cold Regions Hydrological Model Process Modules

- Developed from research at University of Saskatchewan and NHRC over several decades
- Radiation (slopes, estimation procedures)
- Blowing snow (snow transport & sublimation)
- Interception (rain and snow)
- Snowmelt (open & forest, advection, energy balance & degree day options)
- Infiltration (frozen and unfrozen soils)
- Evaporation (unsaturated surfaces)
- Soil moisture balance (with groundwater interaction)
- Routing (hillslopes, sub-surface and streamflow)

# CRHM Use for DRI

- Hydrological evolution and feedbacks in drought
- Hydrological Drought Indices based on small basin soil moisture, streamflow and slough levels
- Scaling methodology and process test bed
- Evaluate prairie land surface parameterisations and aggregation for MESH
- Test prairie hydrology routing for MESH

# Conclusions

- First successful physically-based prairie hydrological modelling for small basin - CRHM
- Sensitivity of snowmelt runoff processes to drought – spring runoff VERY sensitive to winter temperature and precipitation
- Hydrological drought sequence - delayed runoff response to changes in meteorology
- Evaporation model evaluation
- Problem of spatial variability in evaporation and modelling framework selected
- NEXT STEPS –
  - MESH
  - Upscale
  - Run CRHM ‘virtual basin’ over prairies during drought