Hydrologic research in interior Alaska and beyond

Anna Liljedahl with collaborators

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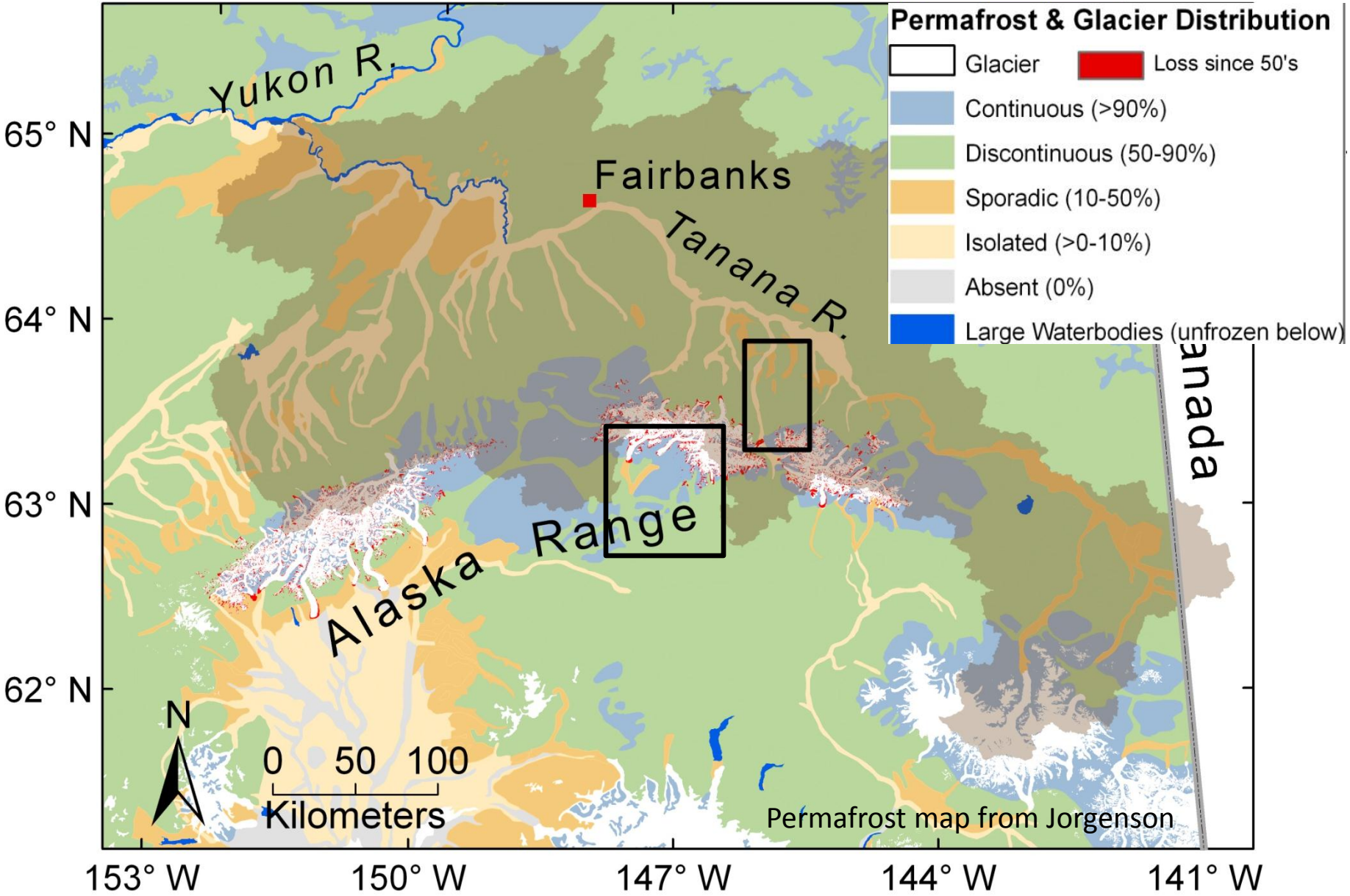
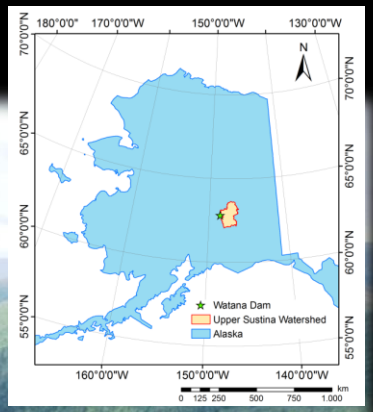
- Glacier-permafrost-hydrology interactions
- Ice wedge polygon & watershed hydrology
- Hydrology model developments

Permafrost & glaciers– what are their role in controlling Interior Alaska watershed hydrology?



Runoff in the Upper Susitna basin: Planning for the Susitna Hydropower Dam



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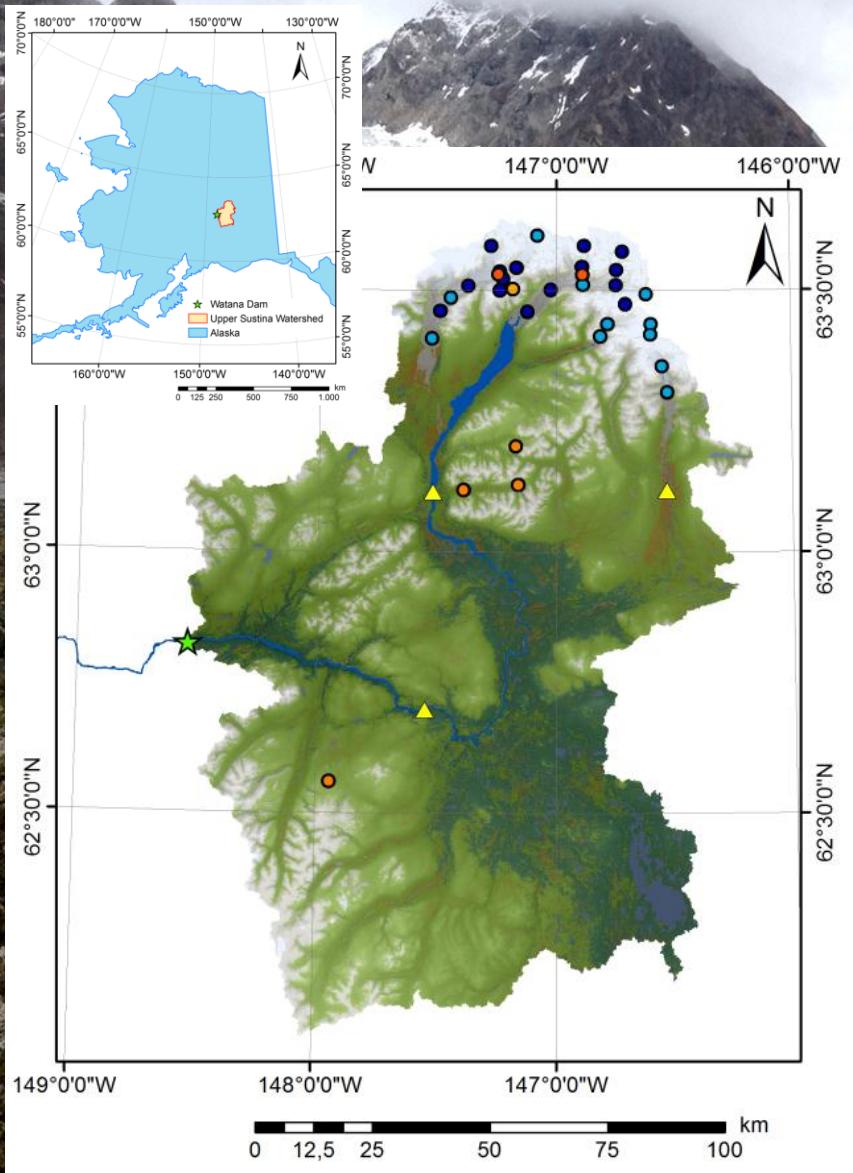
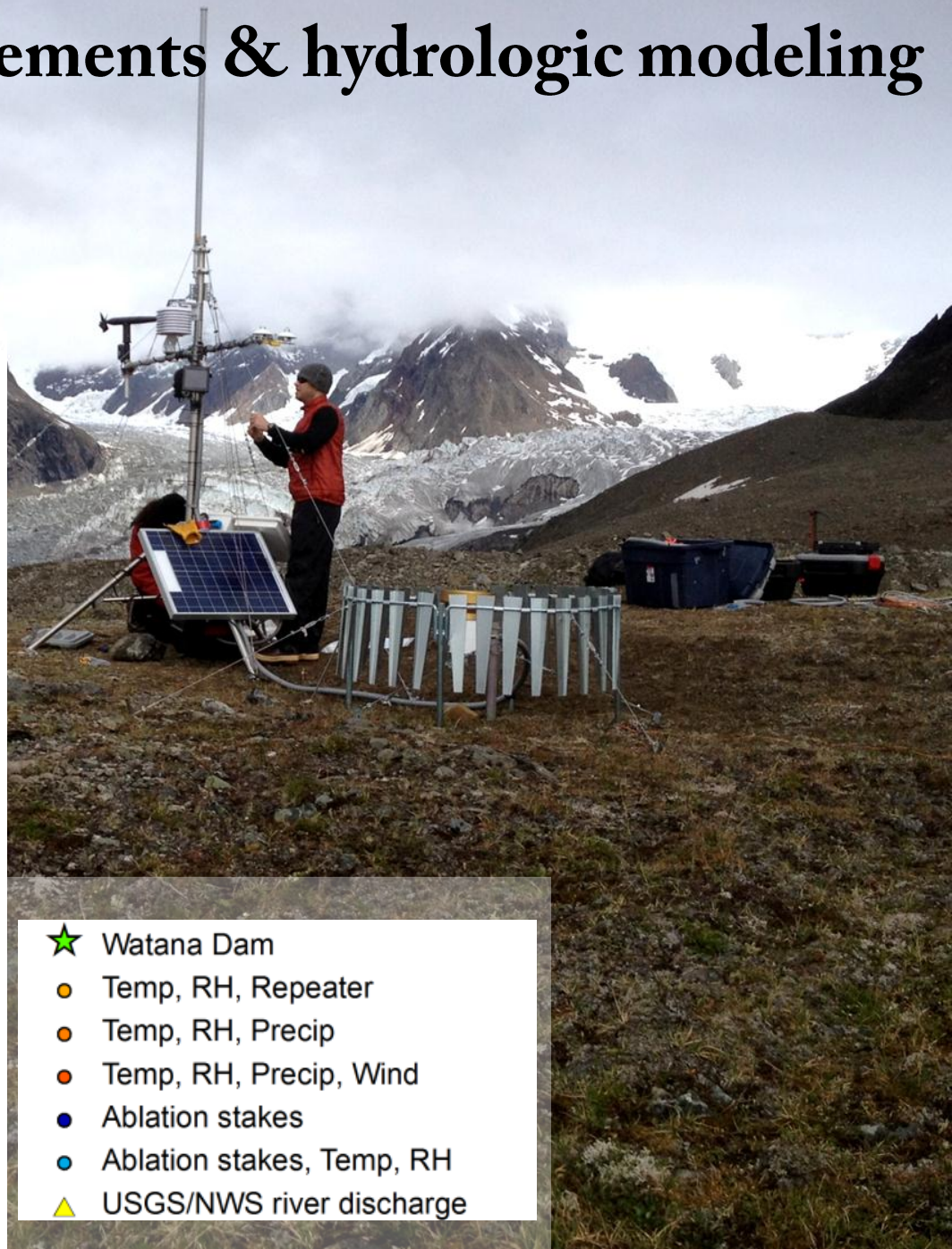
Division of Geophysical & Geological Surveys

Combining field measurements & hydrologic modeling





- Watana Dam
- Temp, RH, Repeater
- Temp, RH, Precip
- Temp, RH, Precip, Wind
- Ablation stakes
- Ablation stakes, Temp, RH
- USGS/NWS river discharge

WaSiM
Water balance Simulation Model

1) *3D groundwater* confined & unconfined, overland flow (kinematic wave approach with stepwise constant parameters).

2) *1D soil heat transfer module* with conduction, advection and phase change (Daanen and Nieber, 2009).

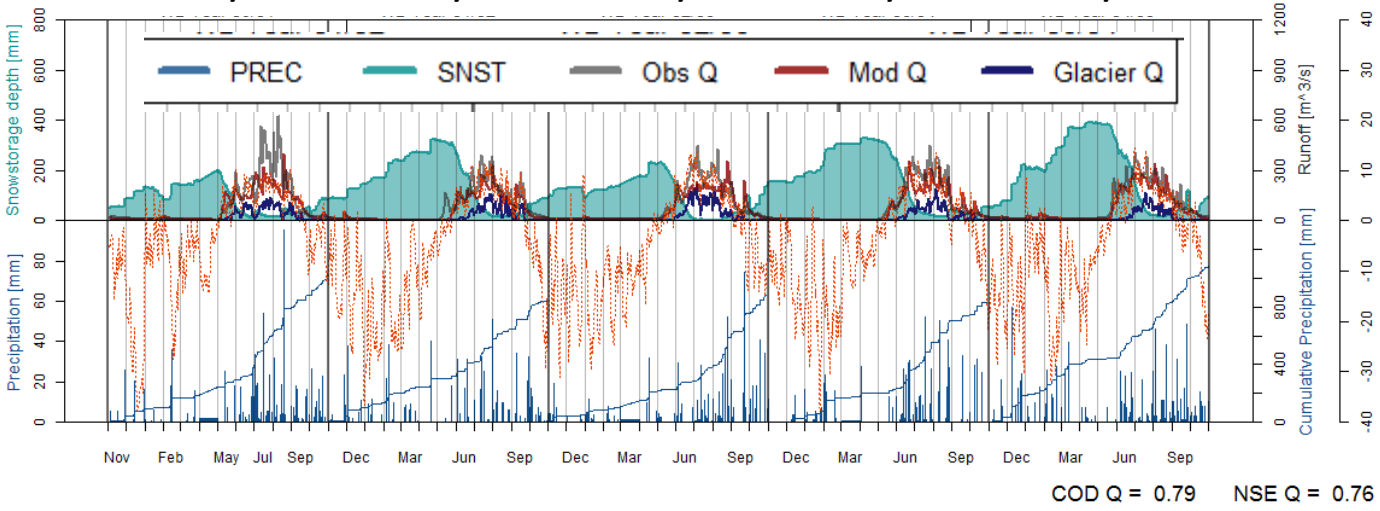
3) *Penman-Monteith multi-layered vegetation parameterization scheme* coupled to *Richard's equation*. Moss evaporation from the top soil layer.

4) *Dynamic glacier module*, glacier can shrink/grow, incl. debris cover.

5) *Parallel programmed* (OpenMP, experimental MPI version).

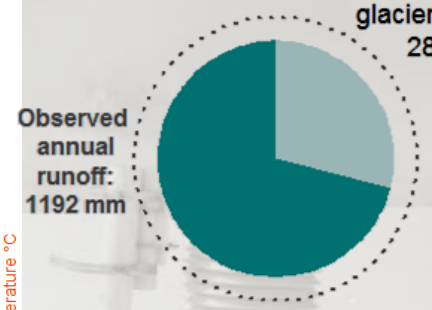
Preliminary results (calibration phase): Glacier melt 10-30% of runoff

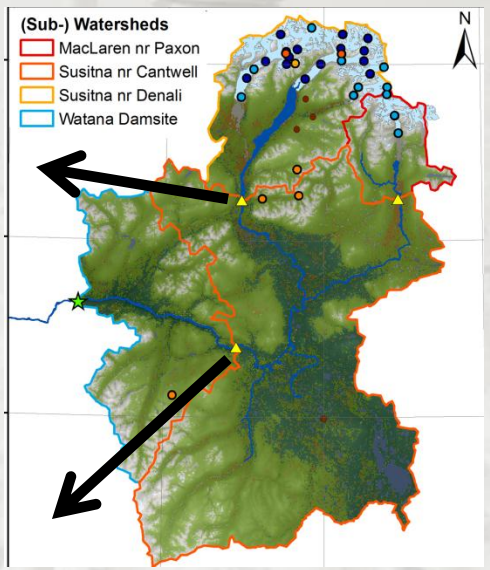
Susitna River near Denali



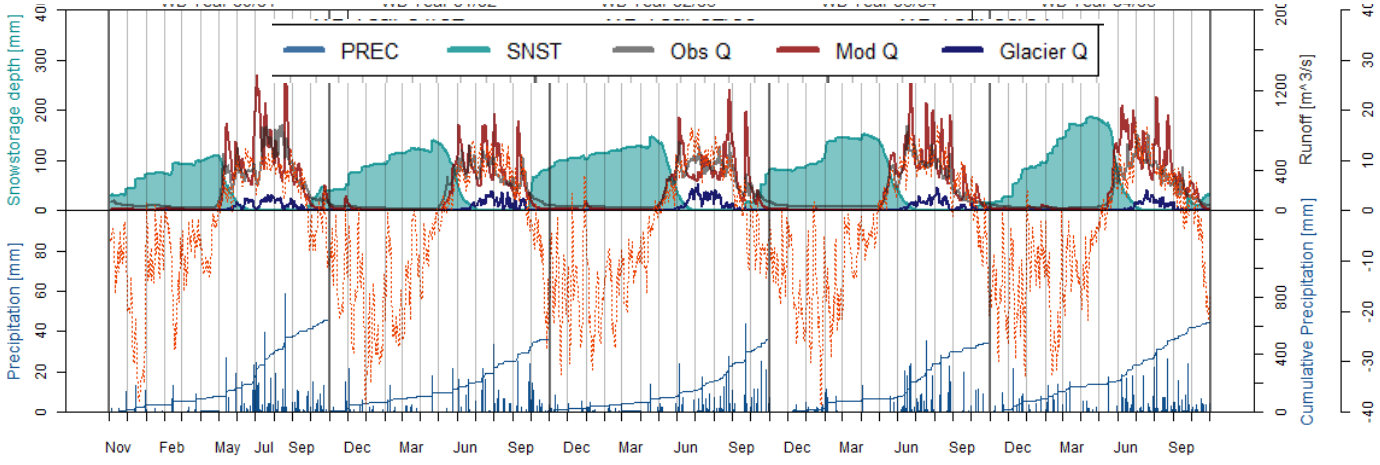
COD Q = 0.79 NSE Q = 0.76

Modeled mean annual runoff = 993 mm
Modeled mean annual glacier runoff = 287 mm





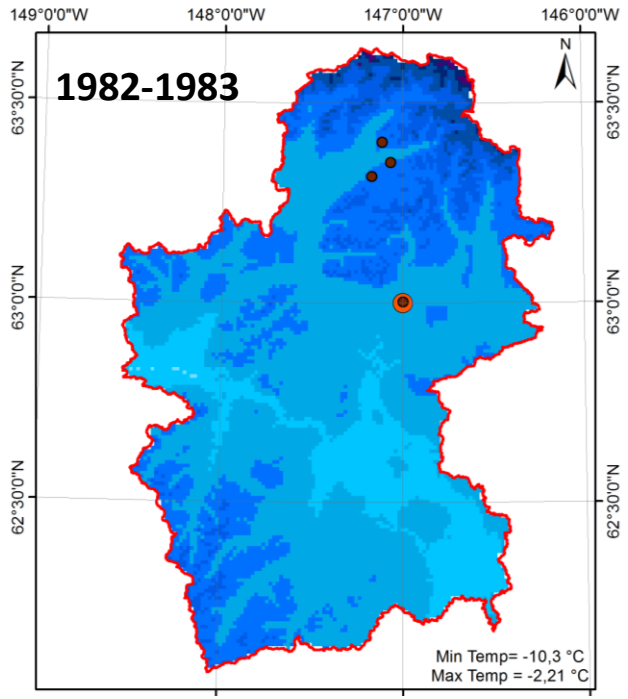
Susitna River near Cantwell

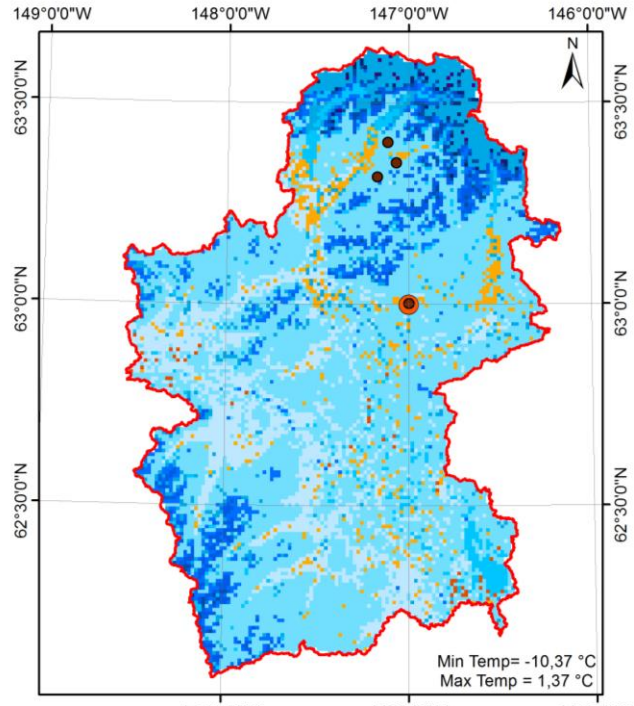


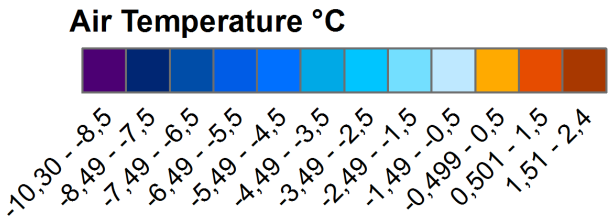
COD Q = 0.72 NSE Q = 0.43

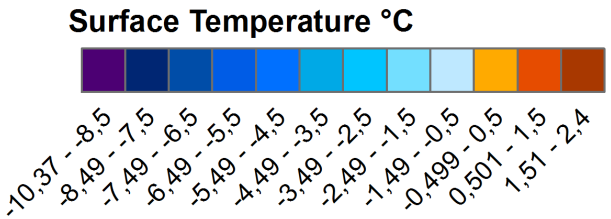
Modeled mean annual runoff = 609 mm
Modeled mean annual glacier runoff = 70 mm

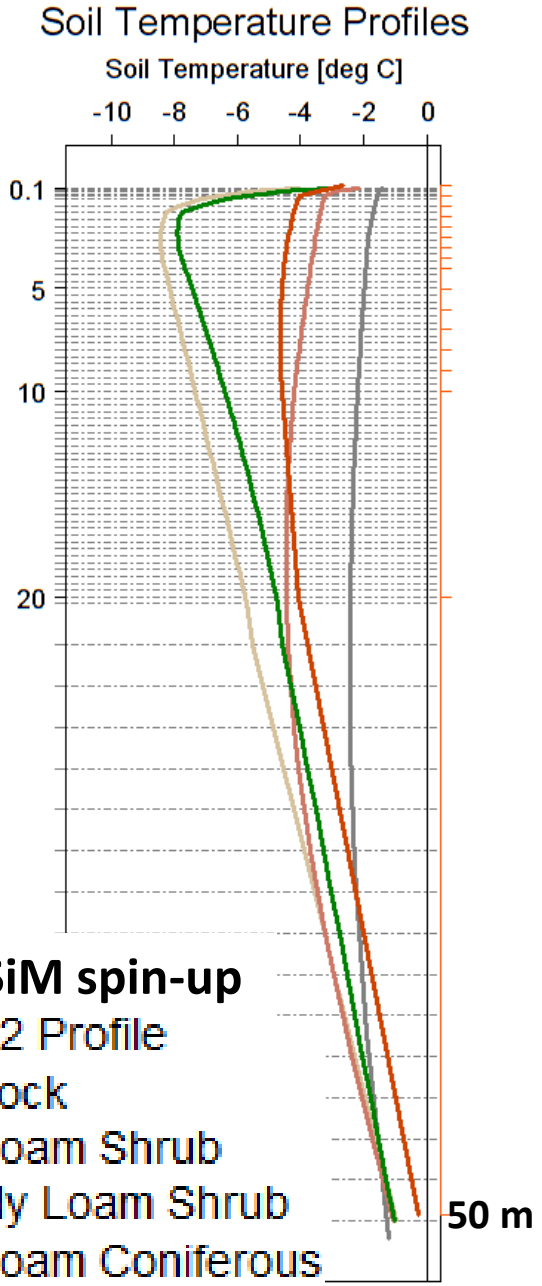
Soil heat transfer modeling: Preliminary results











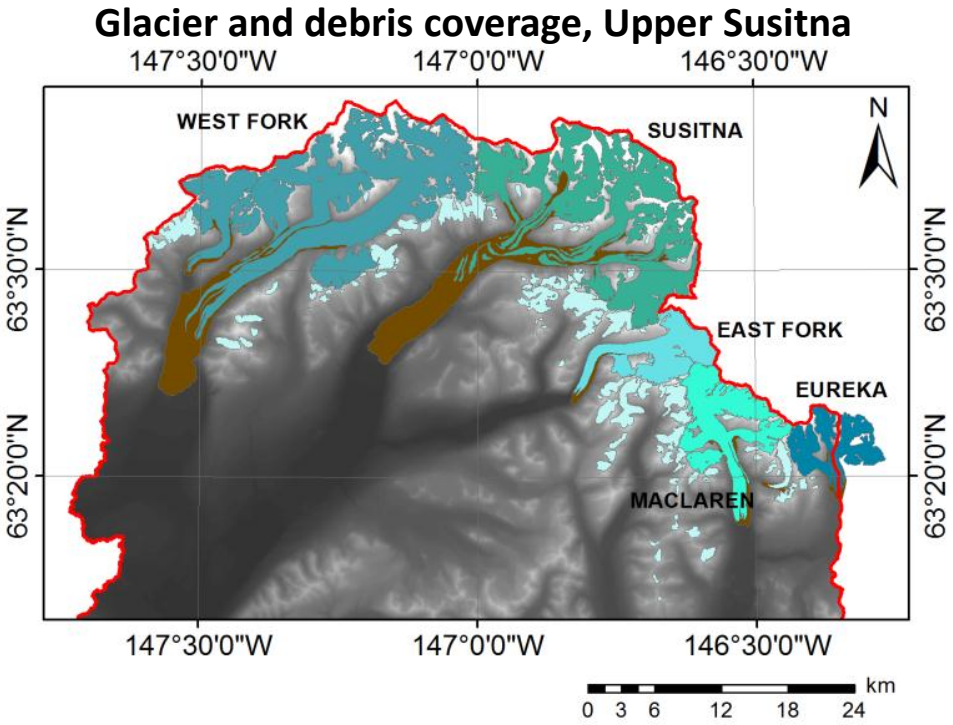
Future work in Susitna

-Finish calibration of glacier melt and 50 m soil temperature profile

- Continue and expand monitoring network

- Validate simulations on 2012 and future data

- Future projections



Modeling the effects of climate change on US Army training lands: CPCRW as the test basin

Charles Downer and Nawa Pradhan, ***Engineering Research and Development Center***

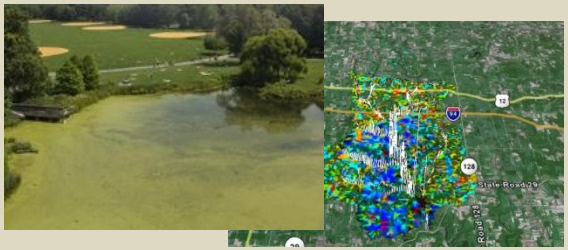
Sergei Marchenko, ***UAF***

*** Thomas Douglas (PI),** ***CRREL***

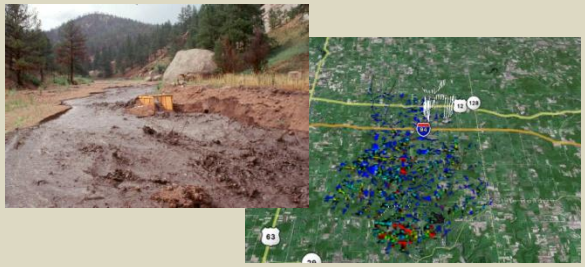
Gridded Surface Subsurface Hydrologic Analysis (GSSHA)

Surface water hydrology

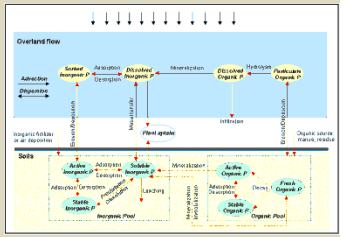
Surface Water/Groundwater Interaction

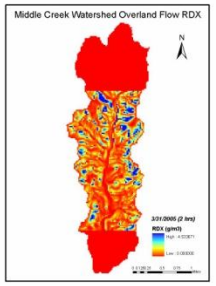


Surface water quality and TMDL's



Sediment Management





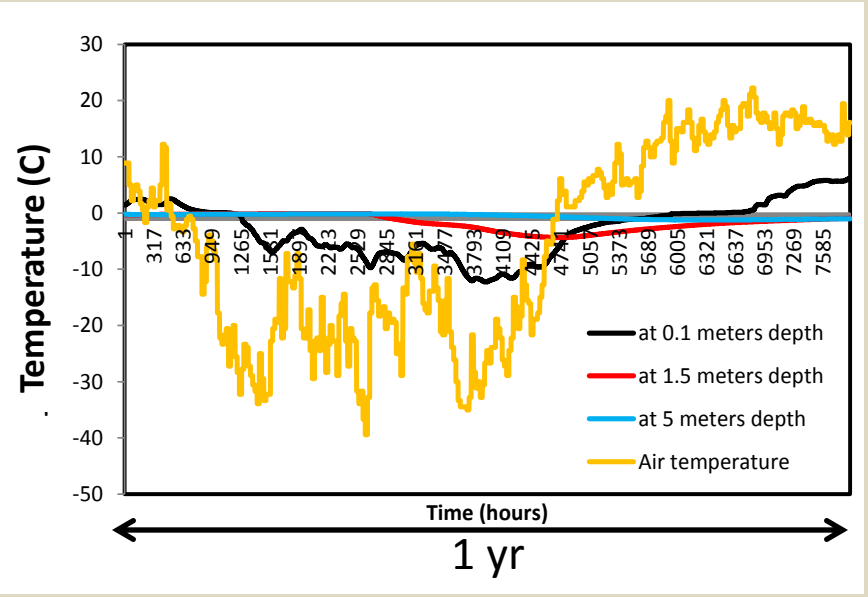
Contaminant fate/transport in surface water and groundwater and related health risk assessment

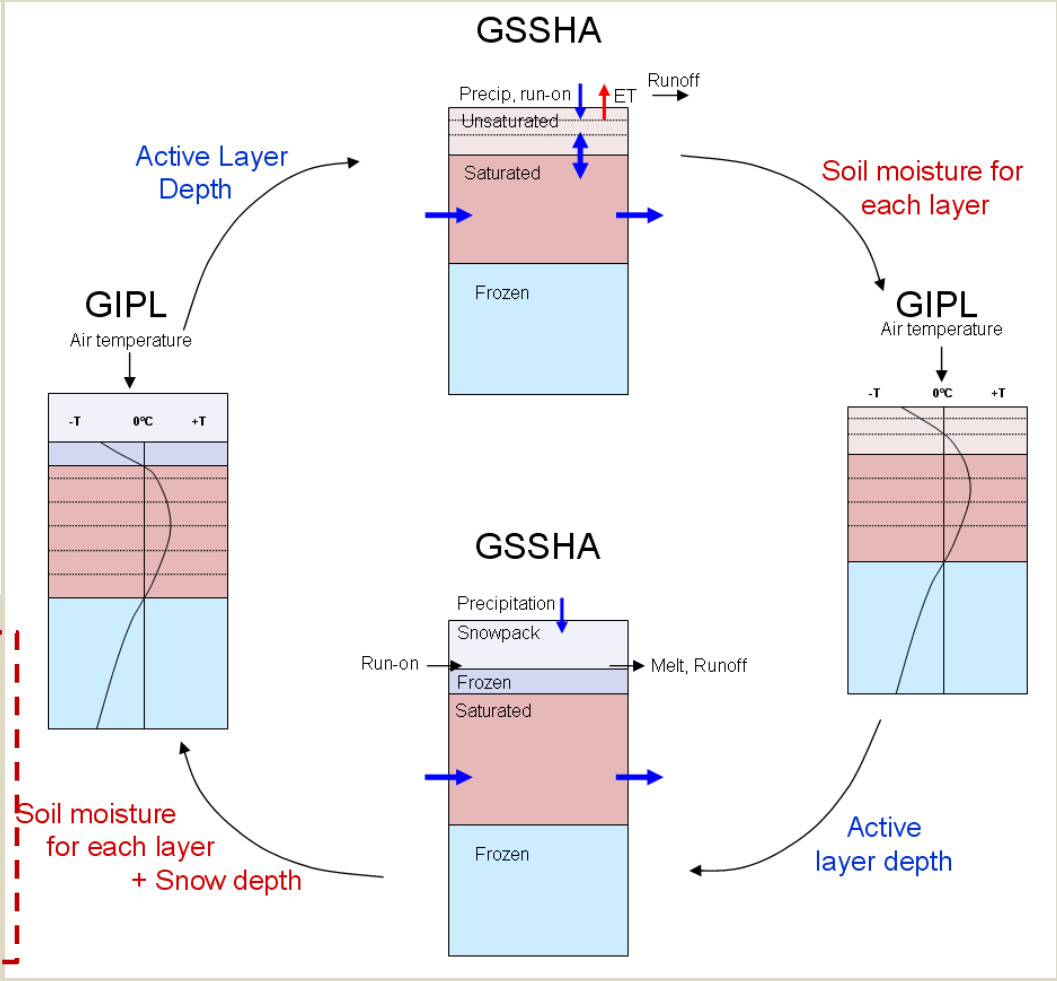
Watershed Modeling and Management

Downer, C. W. *Identification and Modeling of Important Stream Flow Producing Processes in Watersheds,* PhD Dissertation, University of Connecticut, 2002.

Linking GSSHA with GIPL

Charles Downer
Nawa Pradhan
Sergei Marchenko



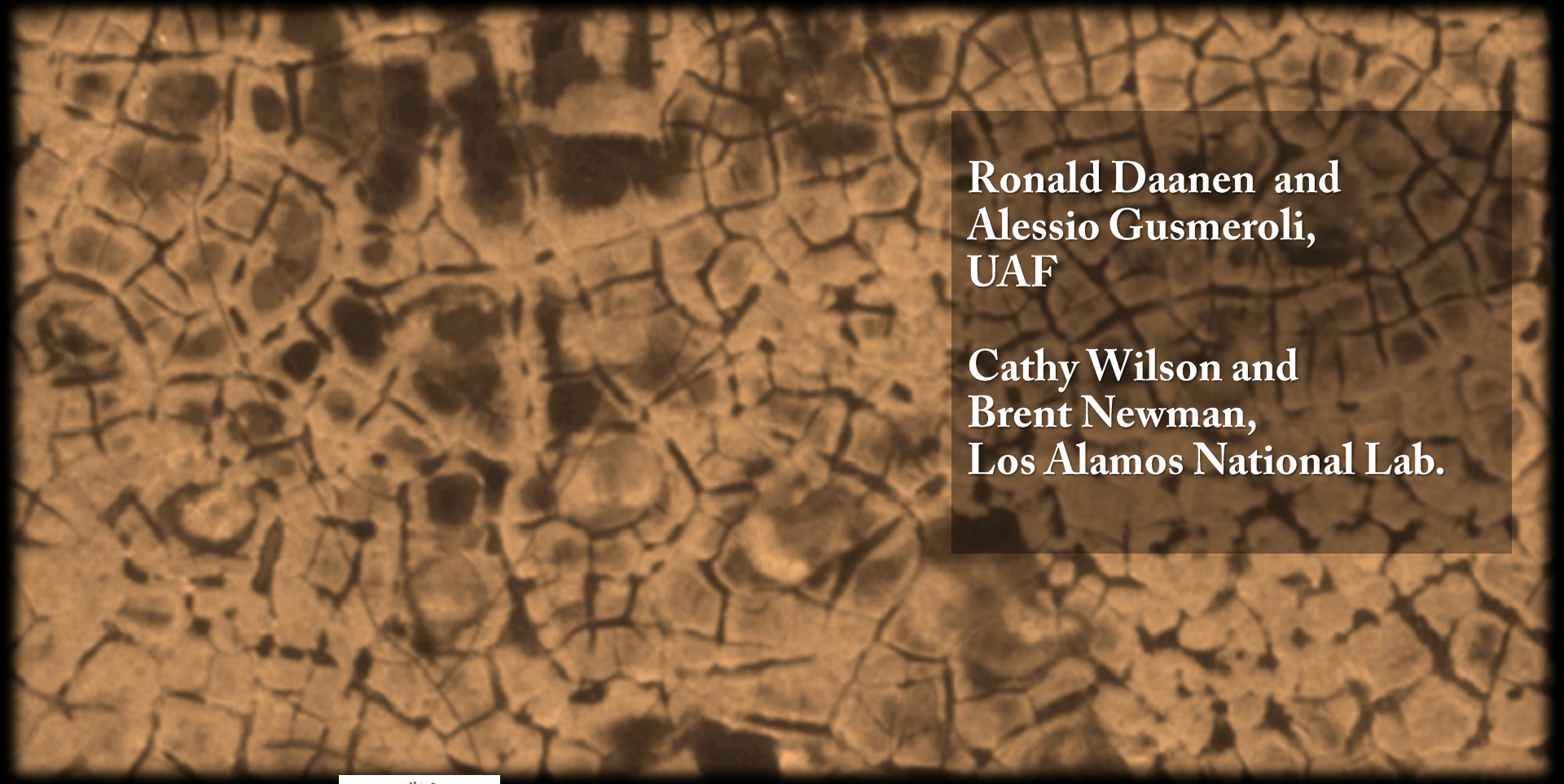


Future work:

-Testing GSSHA-GIPL on CPCRW

- Applying it on US Army land

Water balance of Arctic wetlands with differing ice wedge polygon type



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University of Alaska Fairbanks

Los Alamos
NATIONAL LABORATORY
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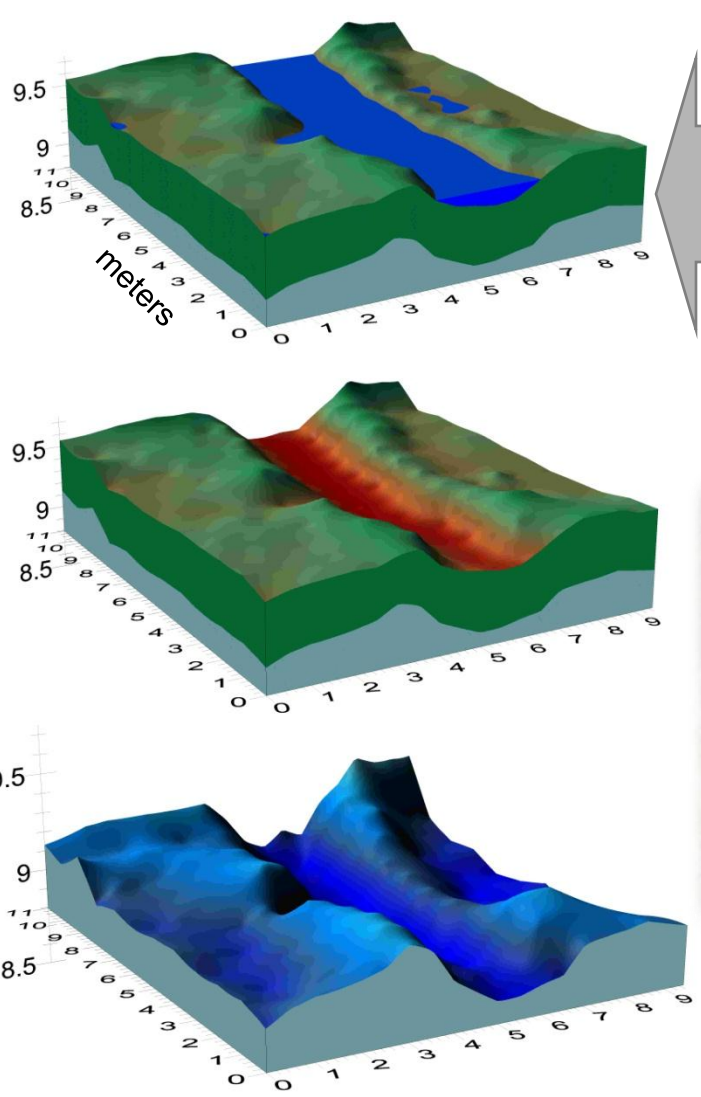
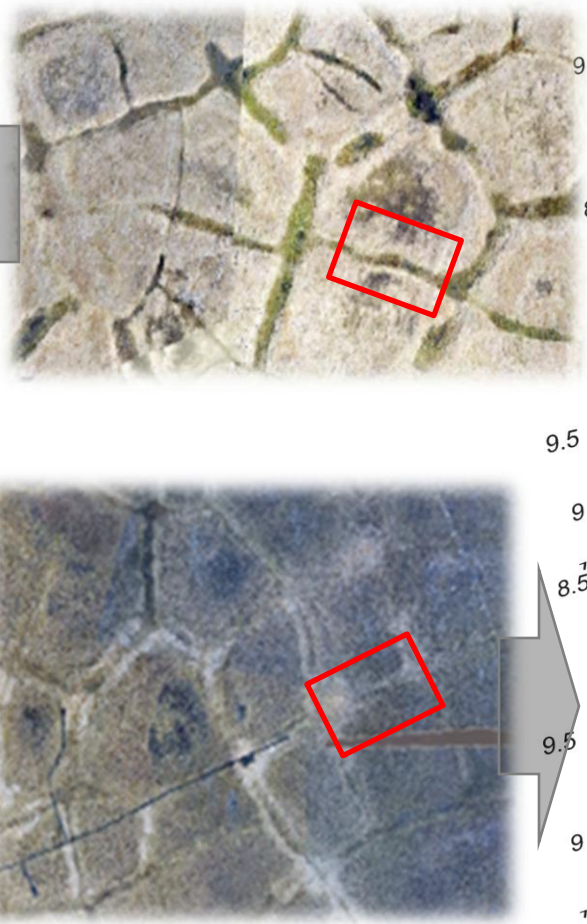
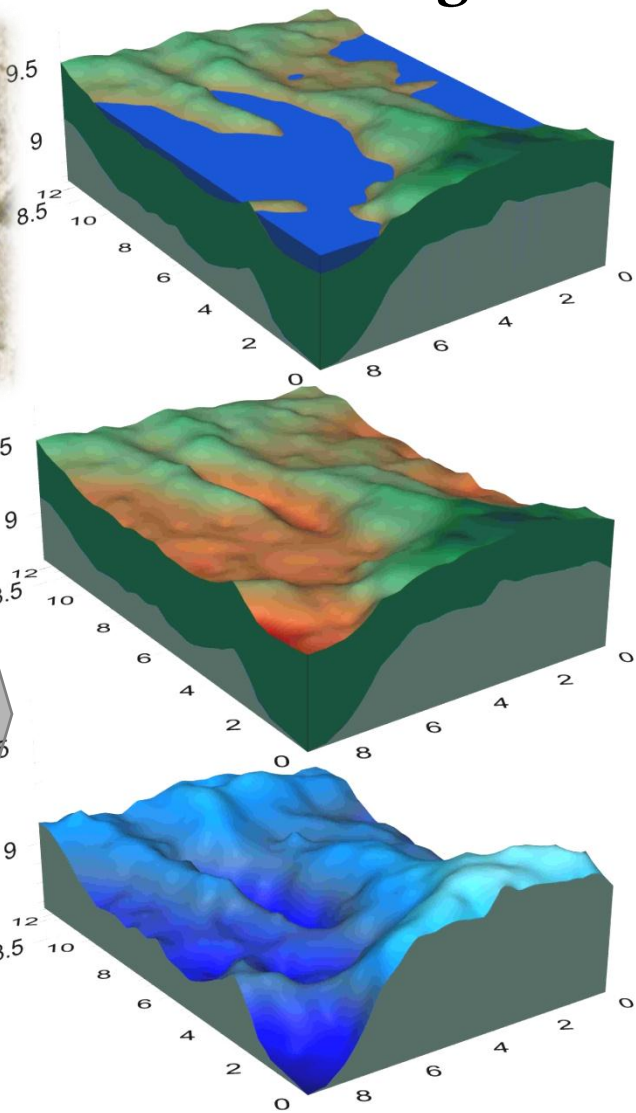
Variations in surface and frost tables

Low centered polygon with trough

Low centered polygon limited trough

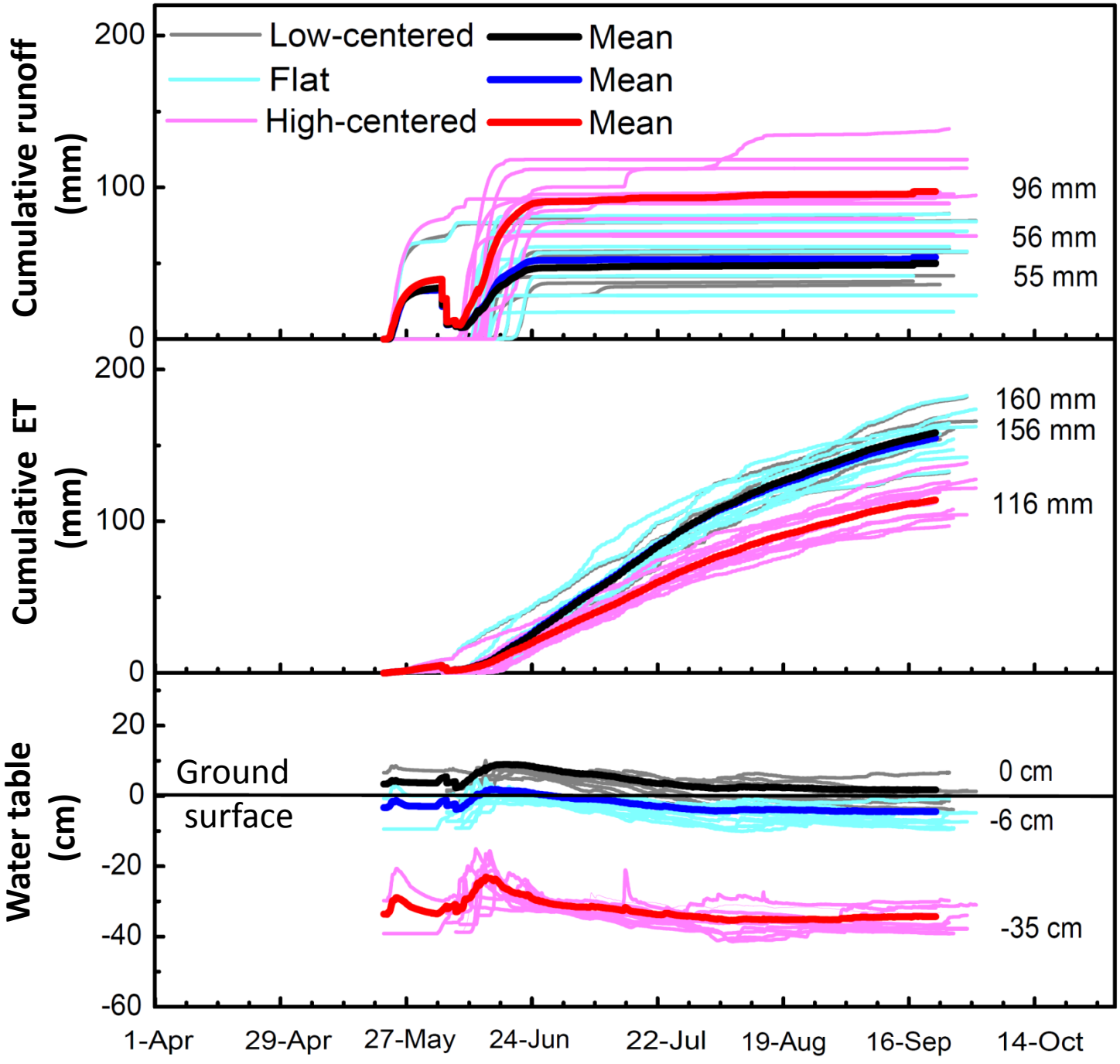






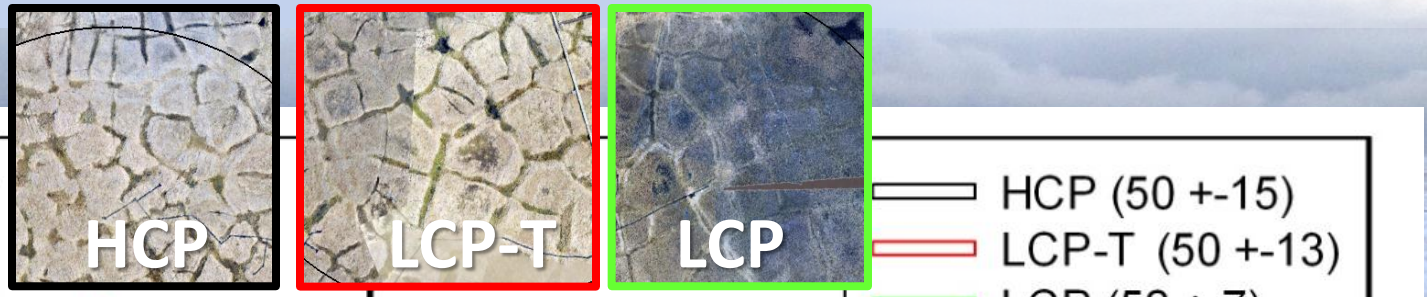
WaSiM model experiment

Polygon type control watershed hydrology

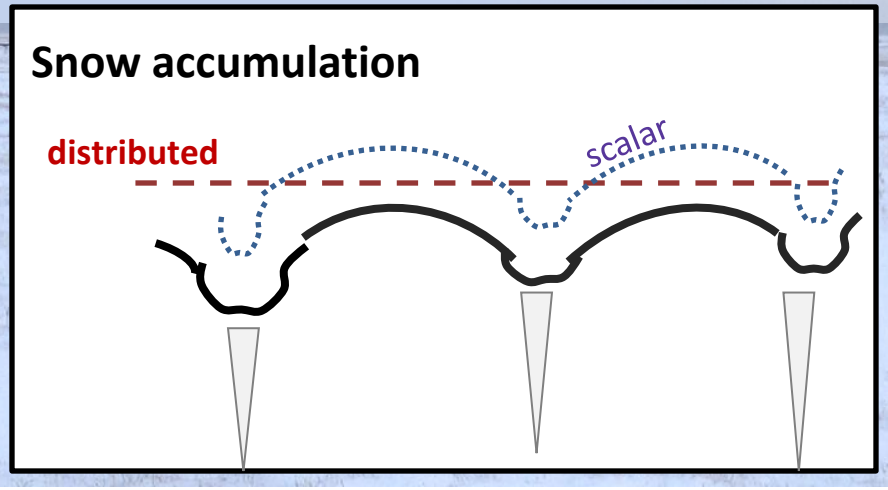


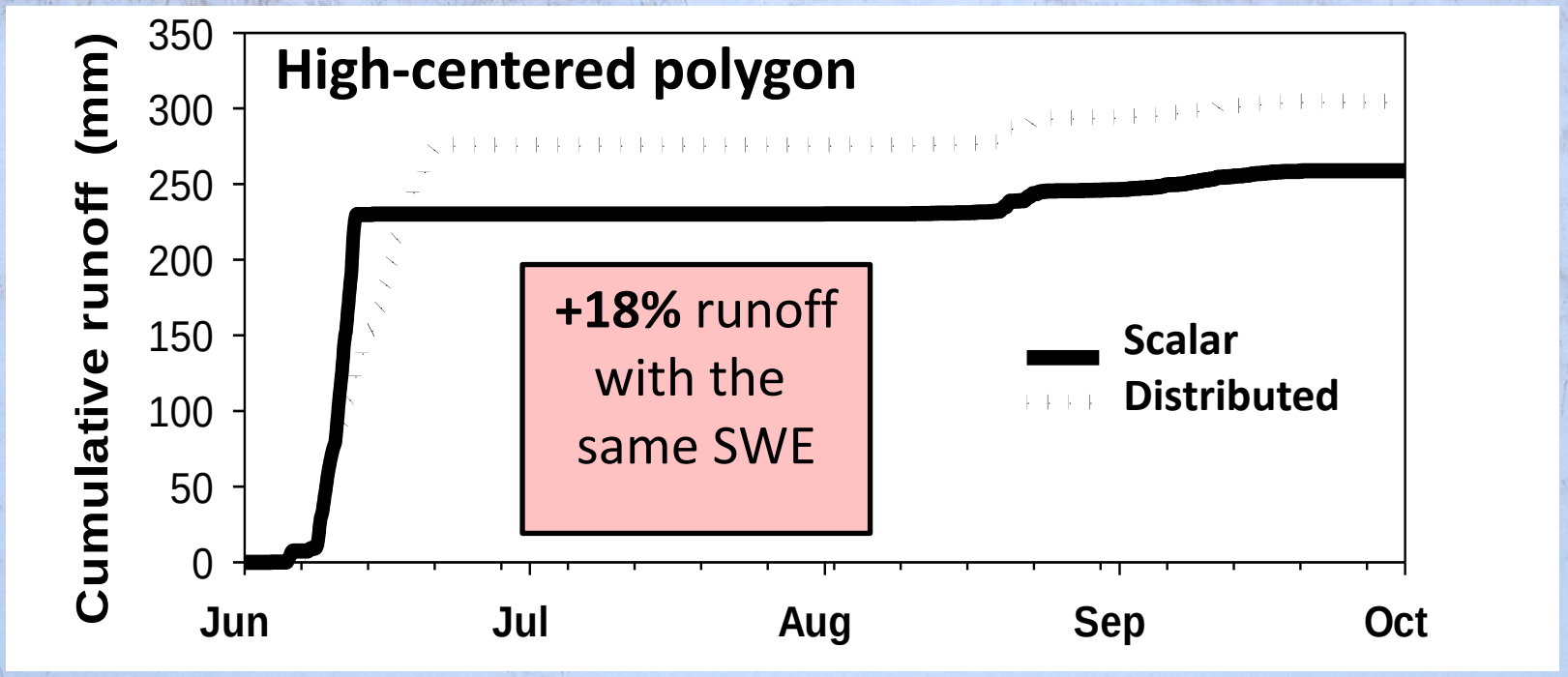
Liljedahl et al. 2012

Similar total SWE but differing spatial variability



Model experiment: The large snow accumulation in troughs favors runoff





Future efforts in Barrow

Continue water level, frost table and snow surveys
Measure surface runoff and subsurface flows

WaSiM developments

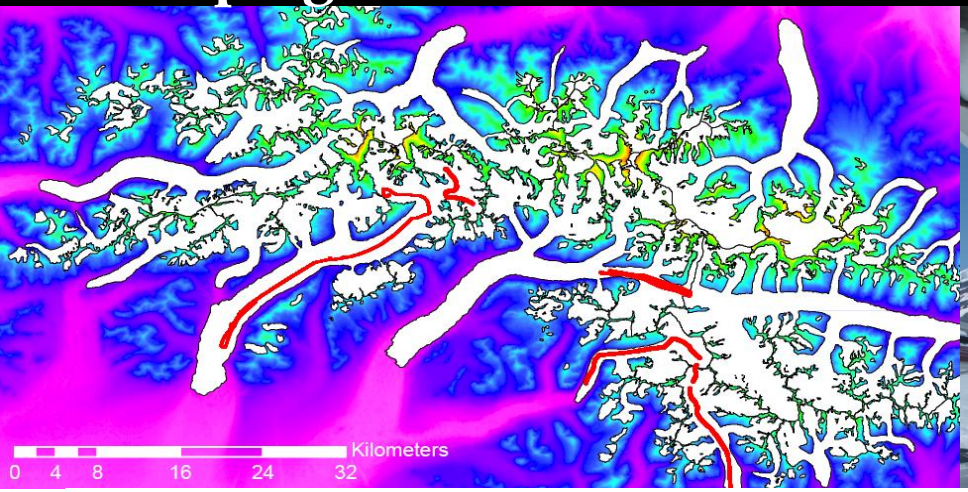
1D soil heat transfer ✓

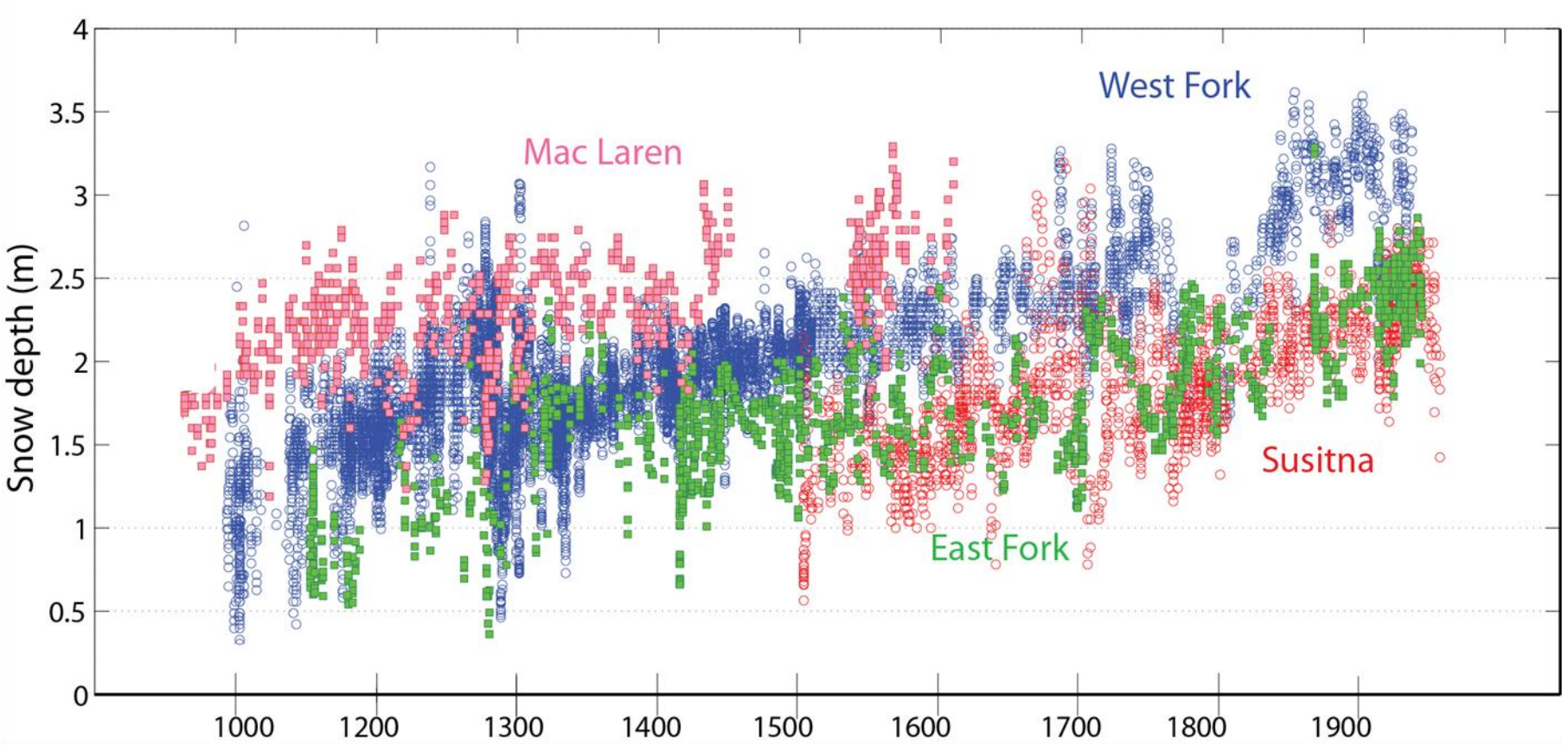
Dynamic glacier and debris cover ✓

2D soil heat transfer…

Thank You

Developing solutions – Snow accumulation measurements





Land cover	n-factors	
	Oct - May	June - Sep
Water	1	1
Glacier/Snow	0.5	0
Barren Land	1.2	2
Deciduous Forest	1	0.5
Coniferous Forest	0.5	0.5
Mixed Forest	0.5	0.5
Shrub	0.5	0.7
Tundra	0.9	0.9
Wetlands	0.6	1.5