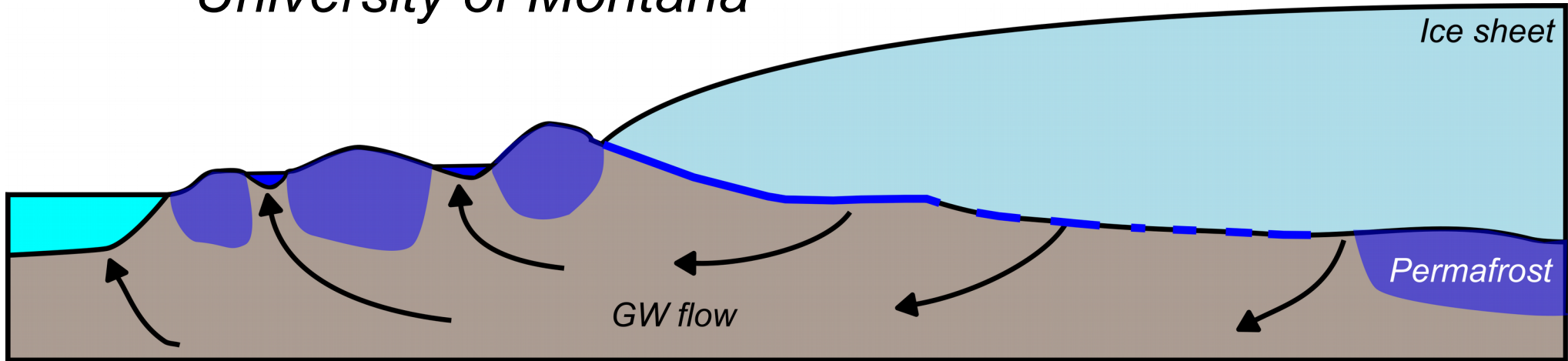


RP1: Ice Sheet Hydrology

Joel Harper,

Toby Meierbachtol

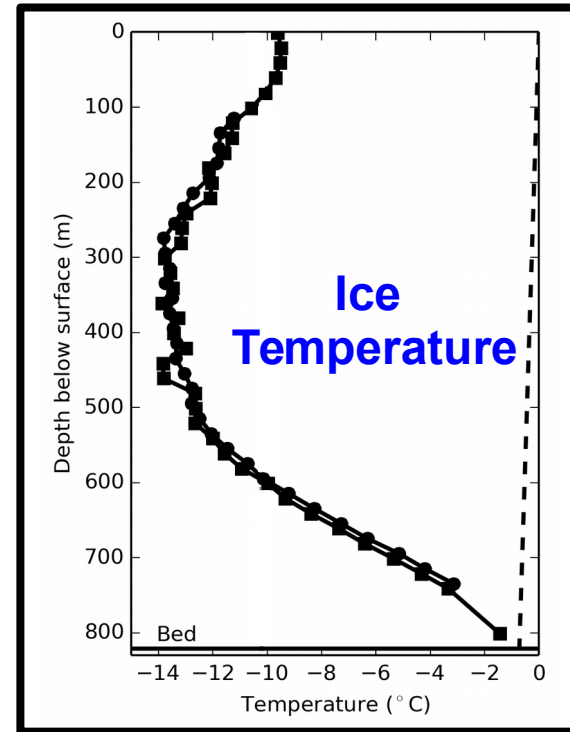
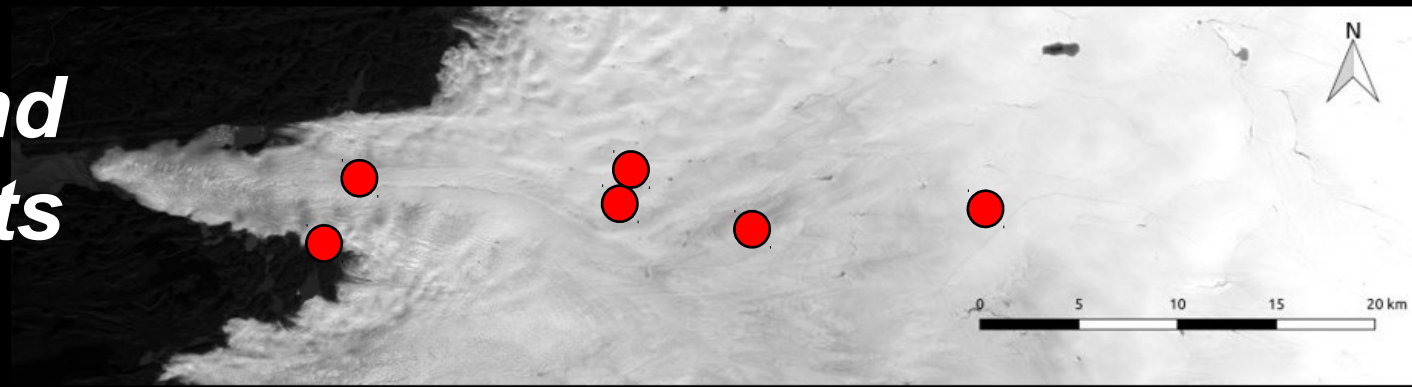
University of Montana



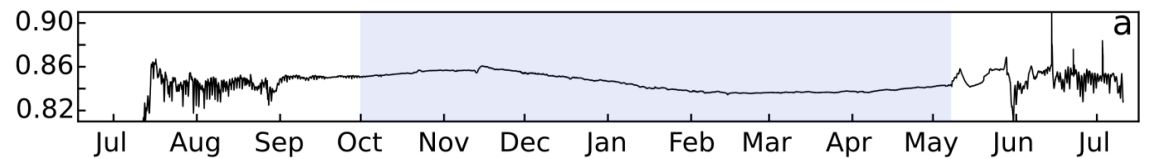
Ice Sheet Boundary to Groundwater and Permafrost

- 1) Thermal conditions
- 2) GW flow field

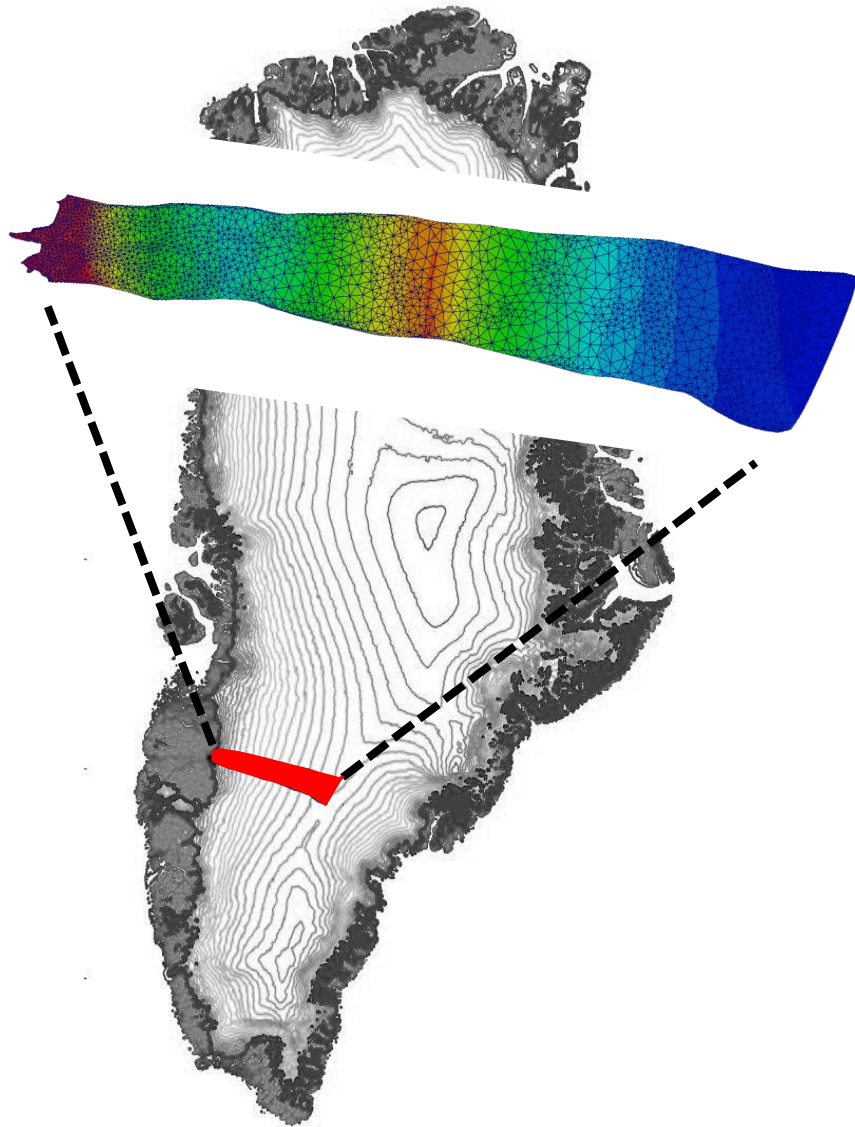
36 boreholes and field experiments



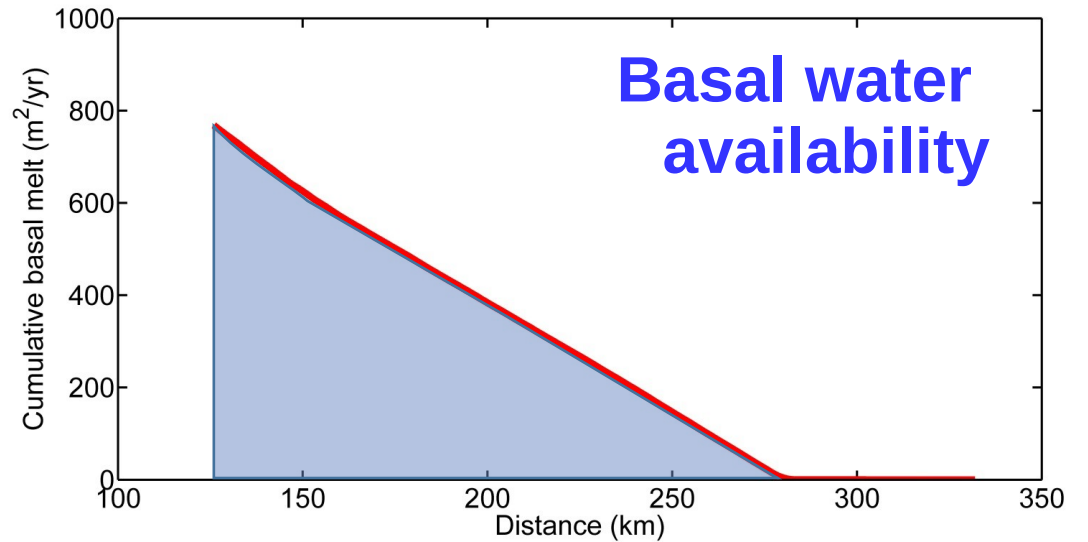
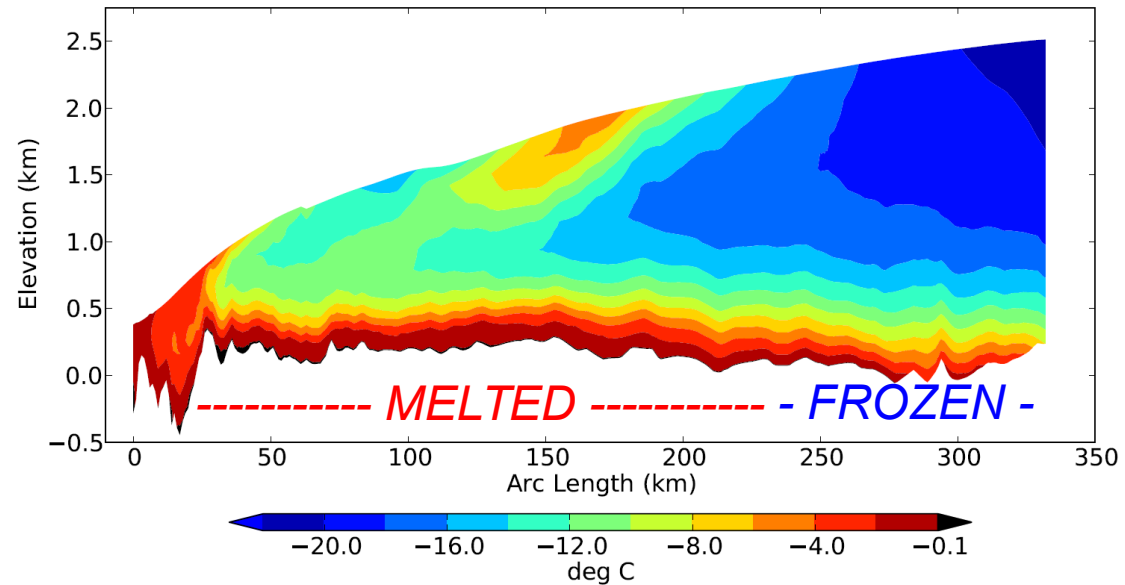
Basal Water Pressure



Ice flow modeling

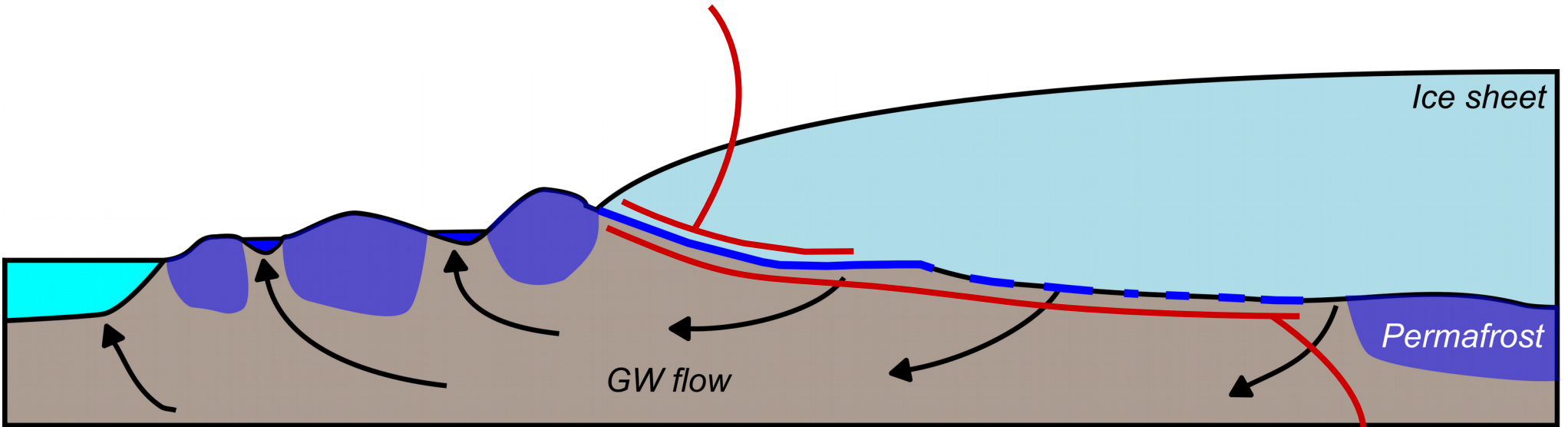


Steady state representation of basal thermal conditions



Improved understanding:

Basal drainage state and processes

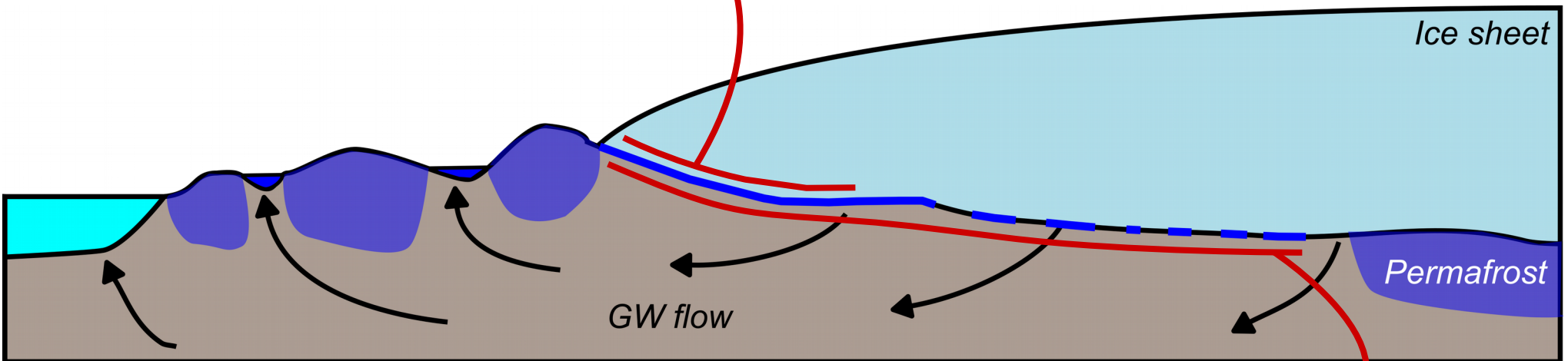


Basal thermal regime and water production

Outstanding challenges

Basal drainage state and processes

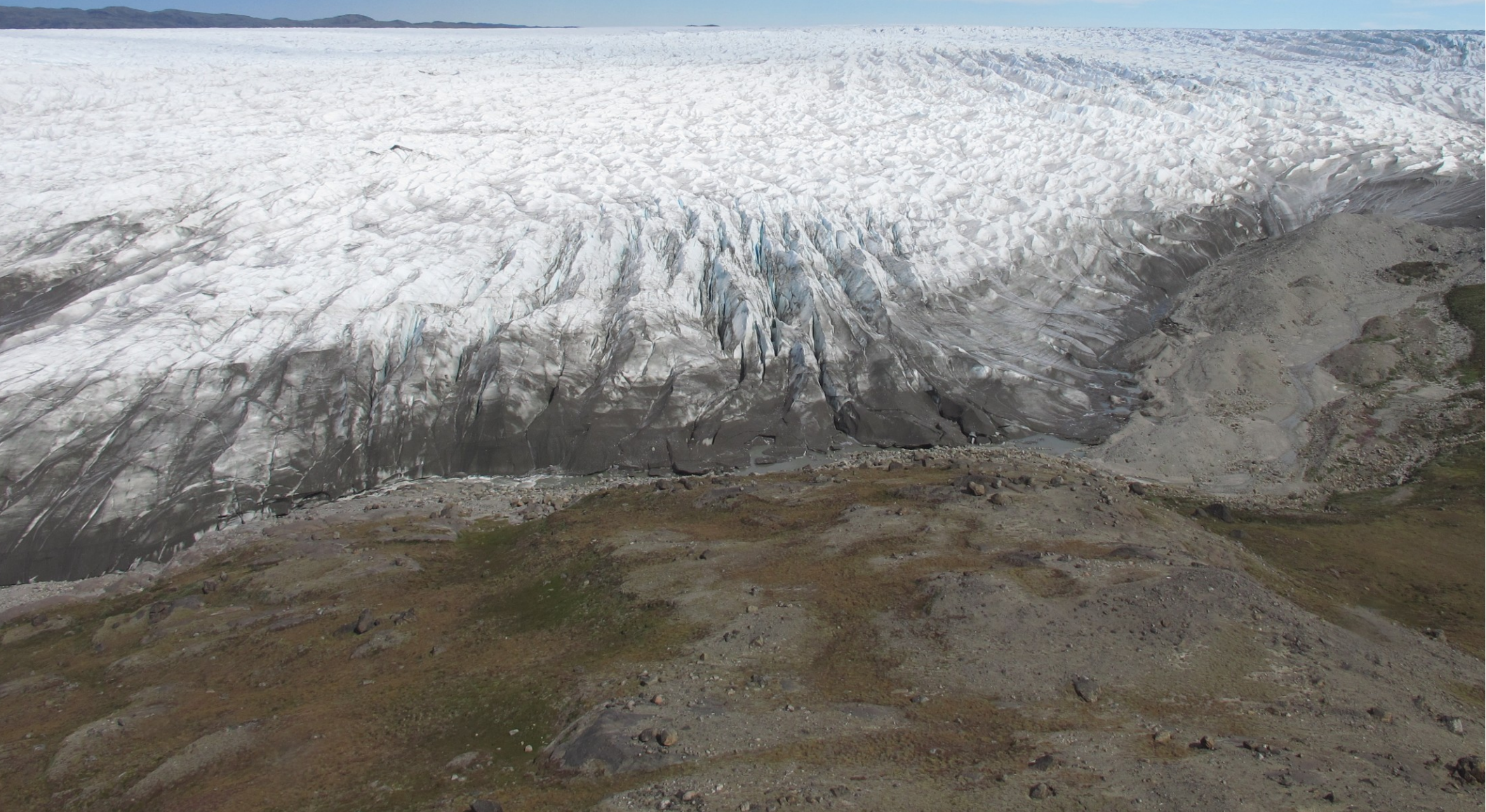
1. Boundary prescription:
know what's there but
not what to use



Basal thermal regime and water production

2. Sensitivity to change over
relevant time scales?

1. Boundary Prescription



Groundwater pressure time series

- 7 years
- Seasonal oscillations (multi-meter)
- Long term decline (>1 m/yr)



Timing similar to seasonality of multiple ice sheet processes

● Bedrock borehole

● Two Boat Lake

● Watson River Discharge

Image Landsat / Copernicus

Google Earth

Imagery Date: 12/31/2013 | lat: 67.124295° | lon: -50.363686° | elev: 370 m | elev alt: 49.16 km

-- Water flux/availability --

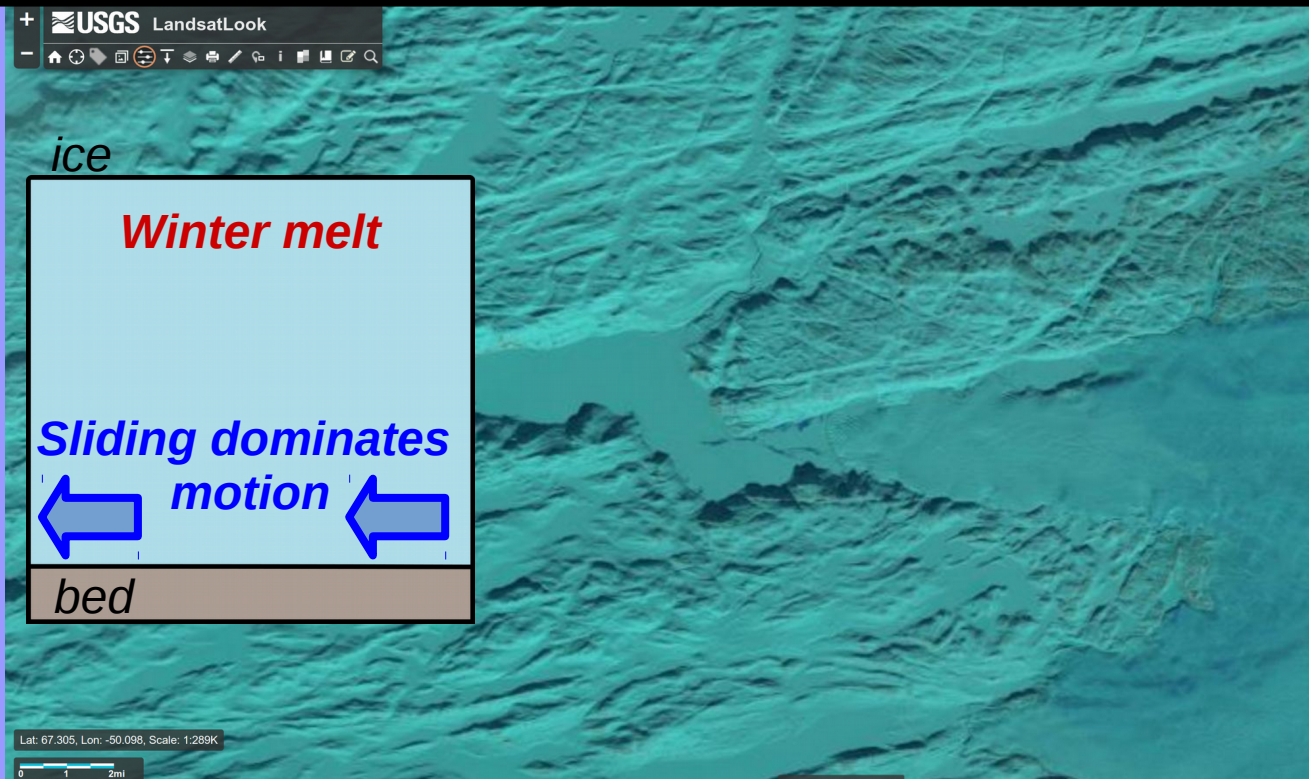
Summer

- Surface melt
- Enormous runoff



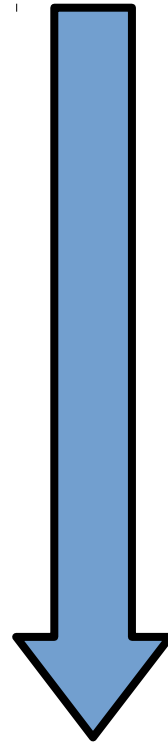
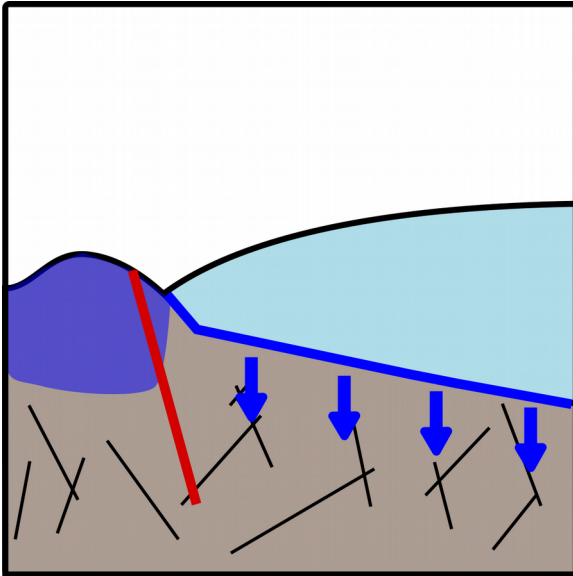
Winter

- Surface melt = 0
- Runoff = 0
- Basal melt > 0



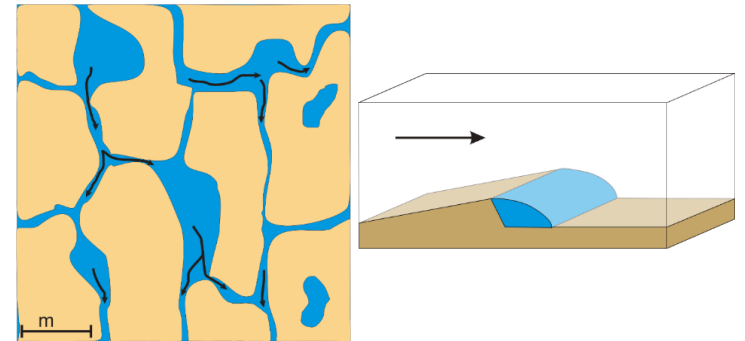
-- Drainage System Pressure --

Winter
High P_w

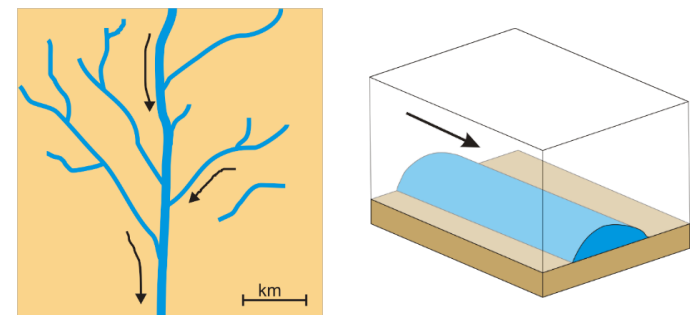


Summer
Low P_w

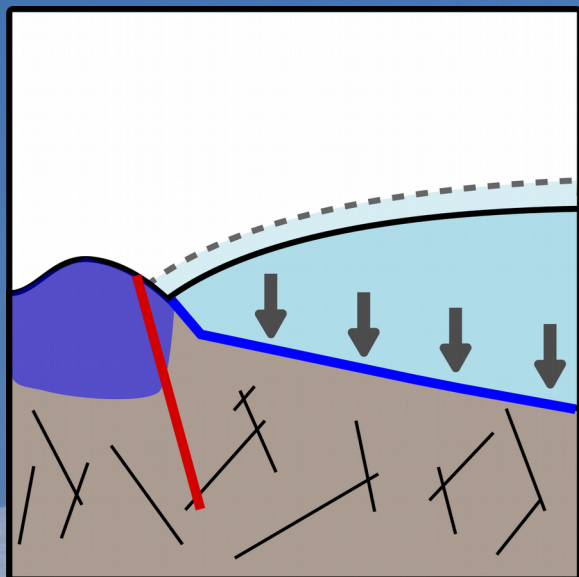
Distributed/Isolated
low transmissivity



Channelized
high transmissivity

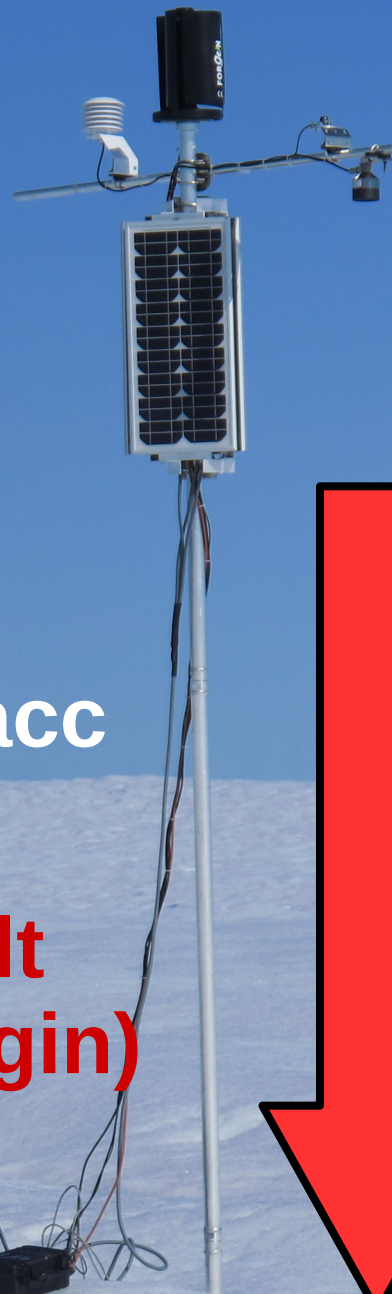
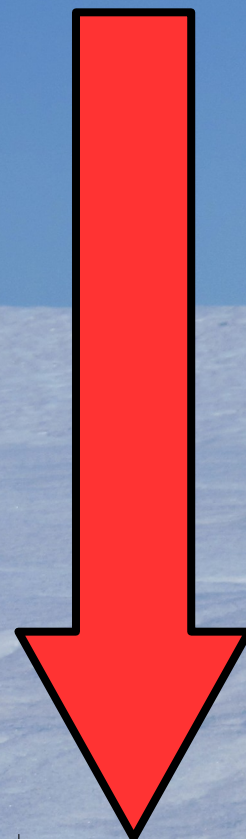


-- Ice Load --



Winter
uplift/acc

Summer melt
(5+m at margin)



Objective: Establish data framework of ice sheet processes to assist in interpretation of ice sheet forcing on GW pressure record

Runoff/Flux:

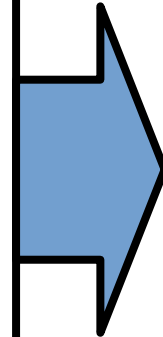
- Runoff quantification, integrated with Watson River discharge – van As et al. (2017)
- Winter water production

Drainage System Pressure:

- Timescales for drainage system development
- Explicit drainage system modeling

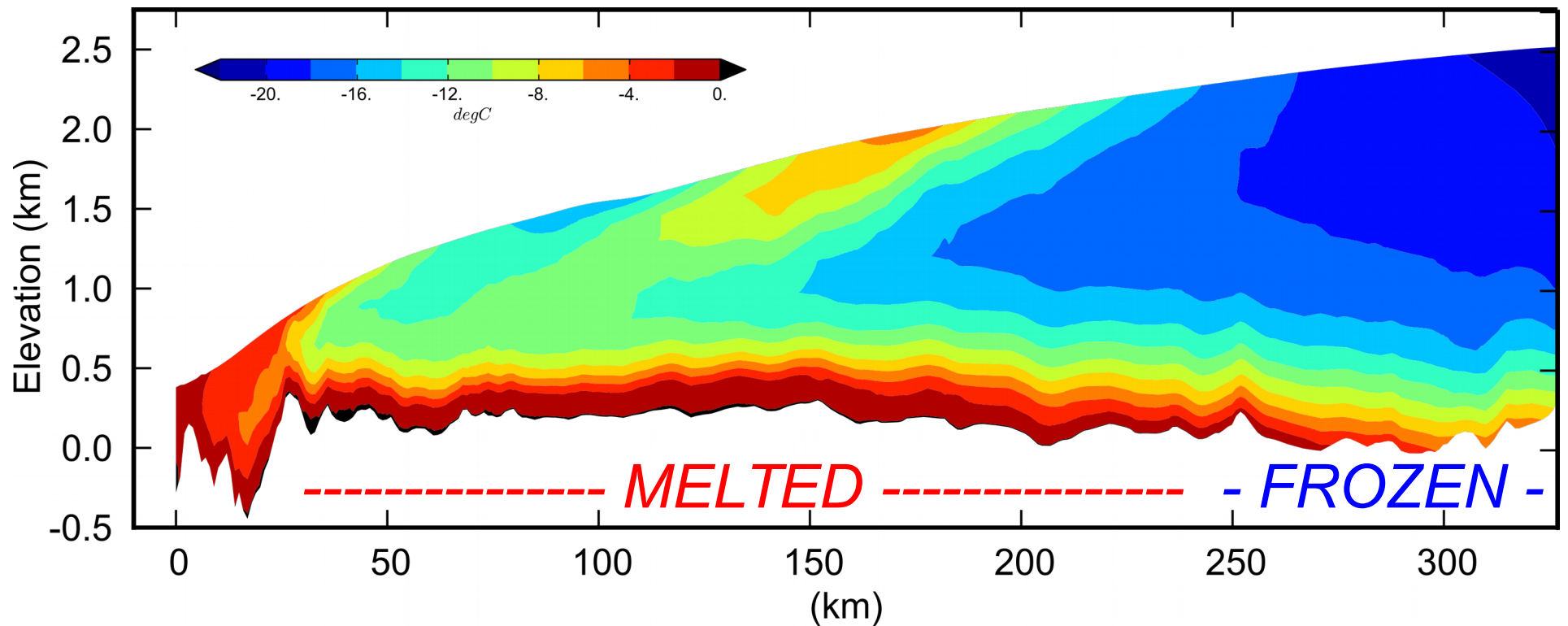
Ice Load:

- DEM analysis
- Time lapse camera processing
- Off-ice GPS analysis

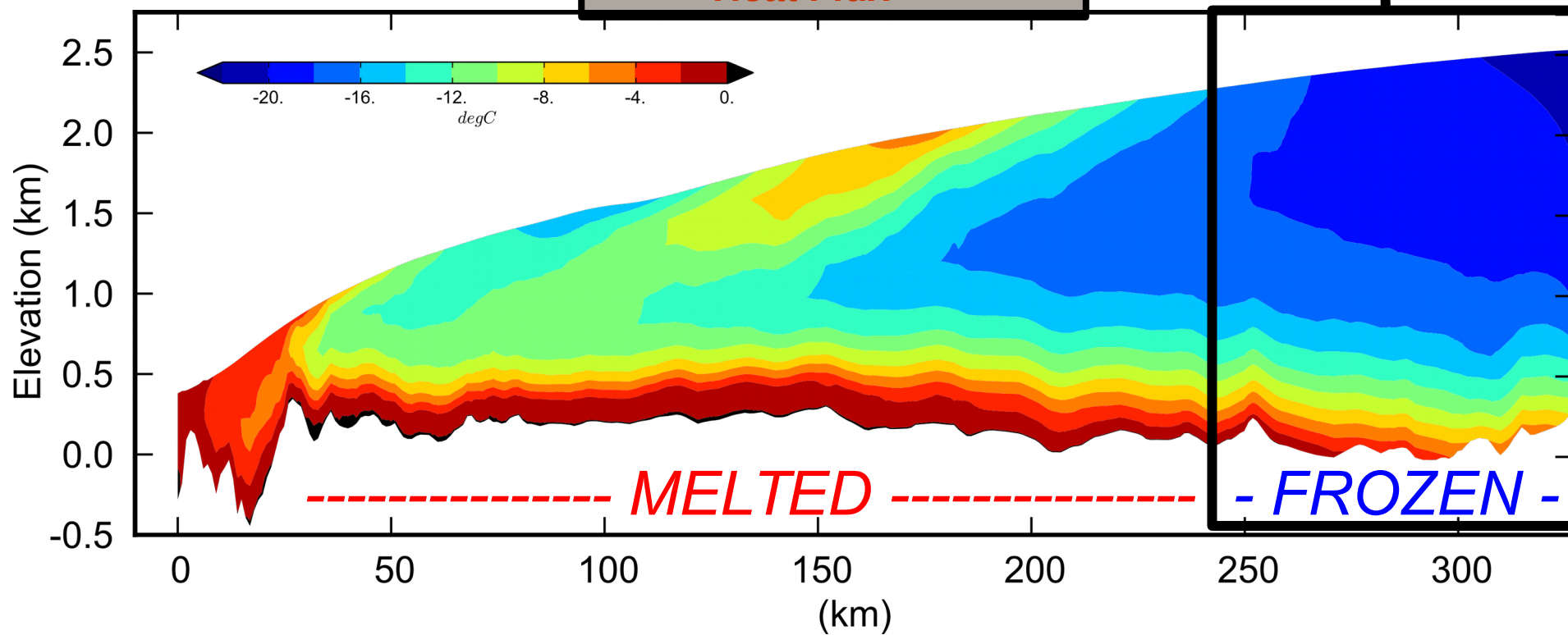
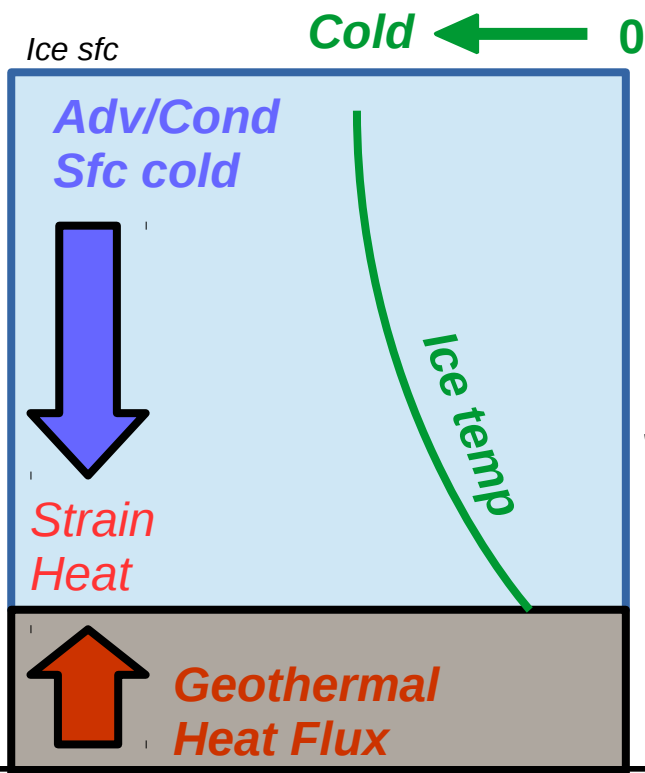


Ice sheet forcing on GW pressure

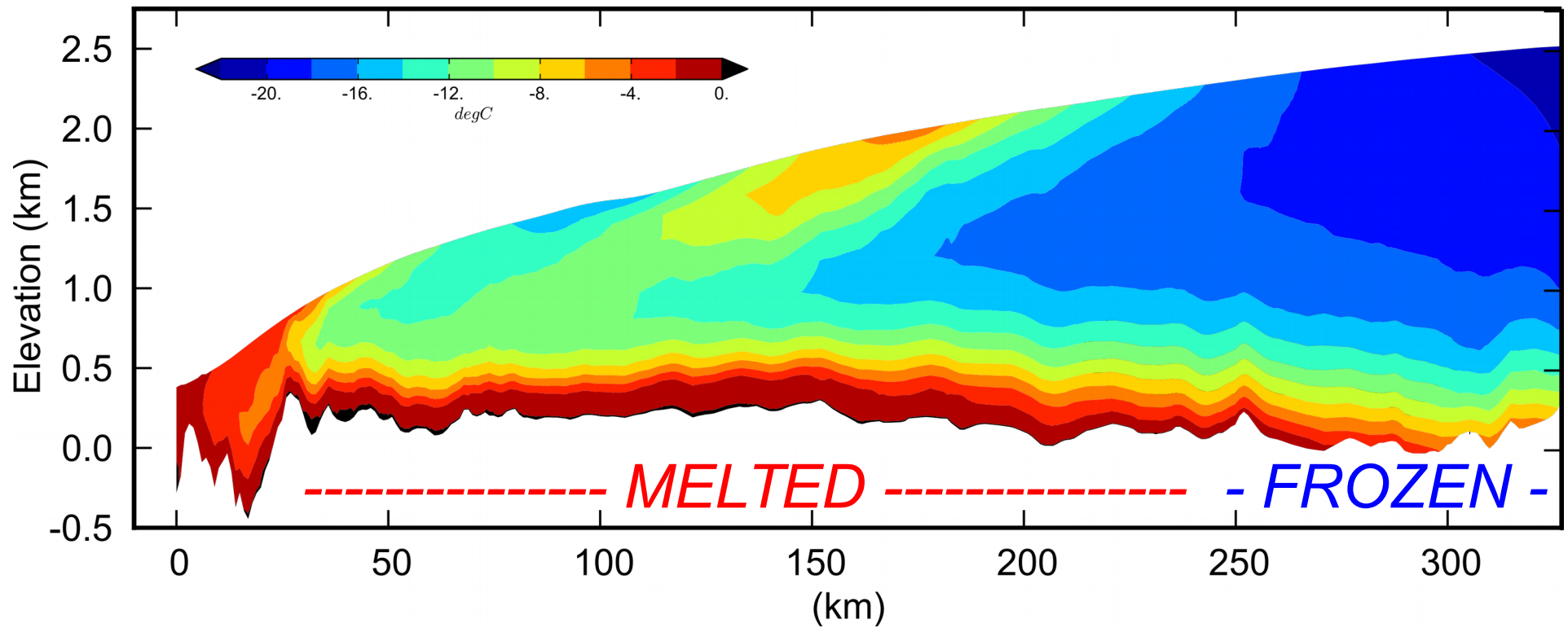
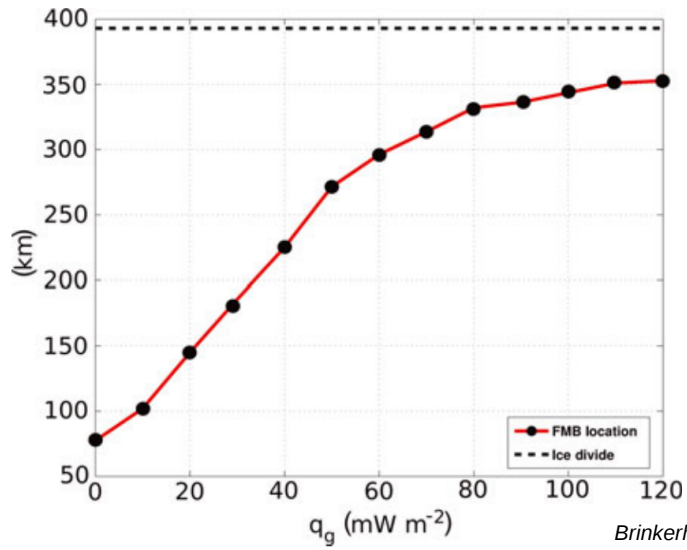
2. Time changes in frozen – melted transition



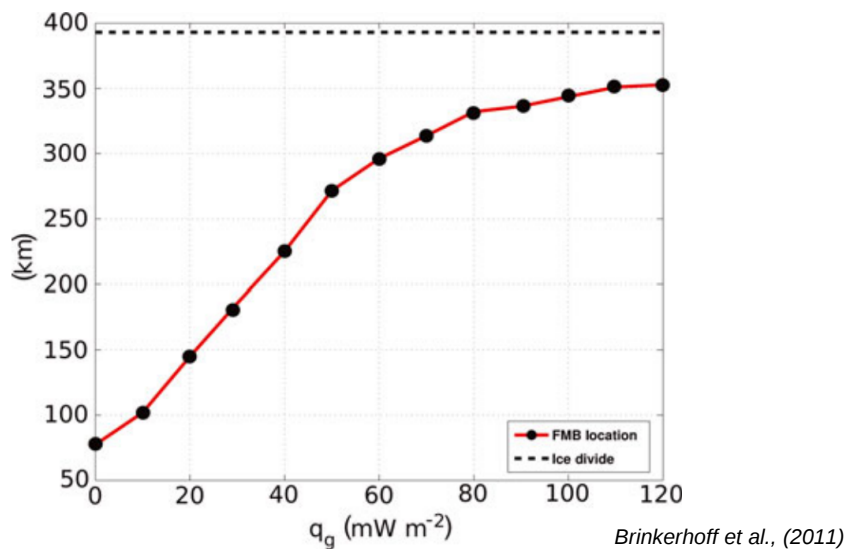
$$T_{\text{bed}} = f(T_{\text{sfc}}, b)$$



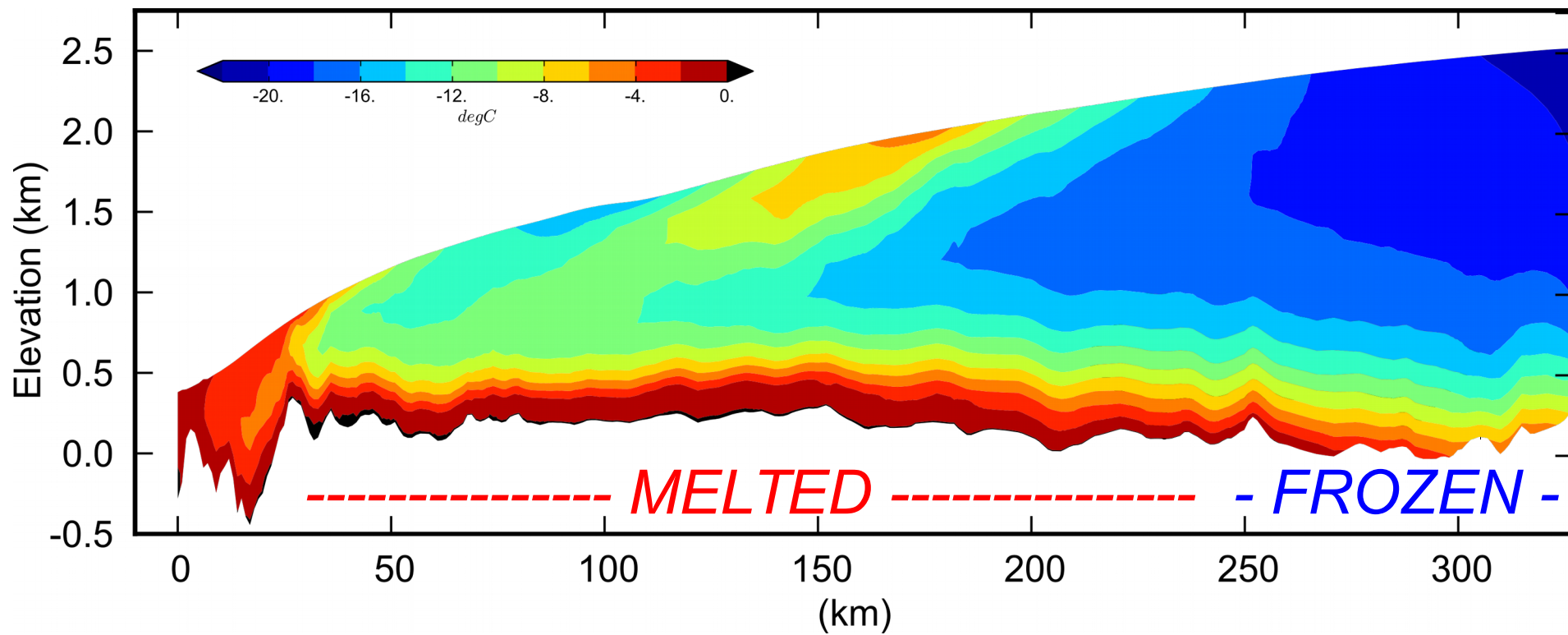
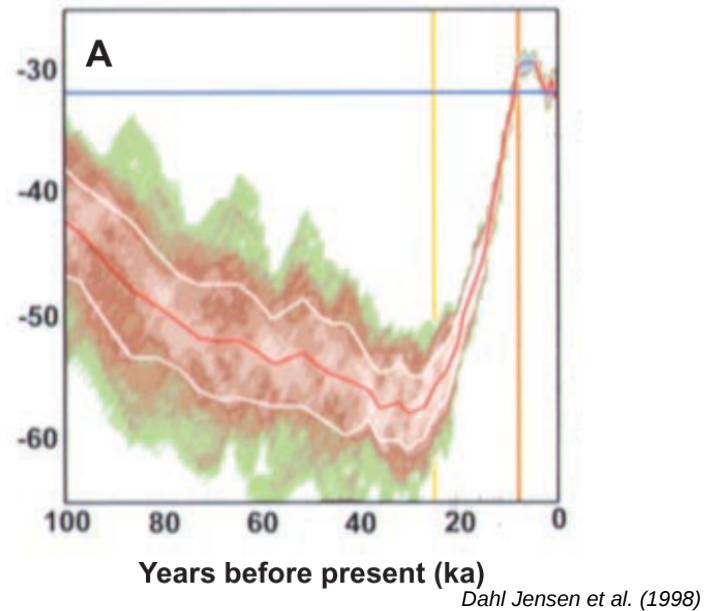
Transition sensitive to perturbations in basal heat balance



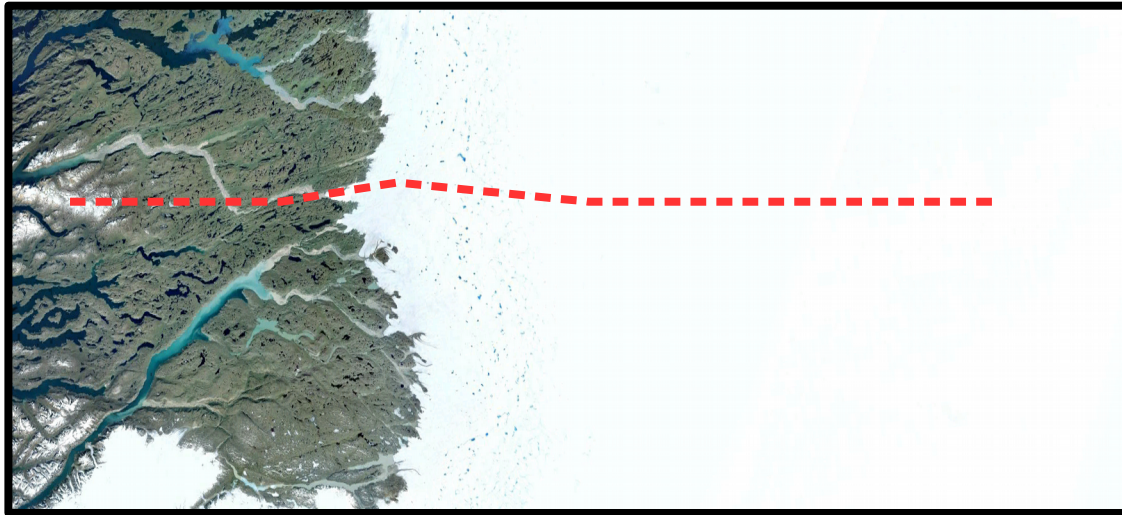
Transition sensitive to perturbations in basal heat balance



Transient T_{sfc}



Objective: Quantify migration of frozen/melted transition under climate forcing representing ice age cycle. Sensitivity to physical conditions (e.g. geothermal heat flux, perturbation magnitude, duration).

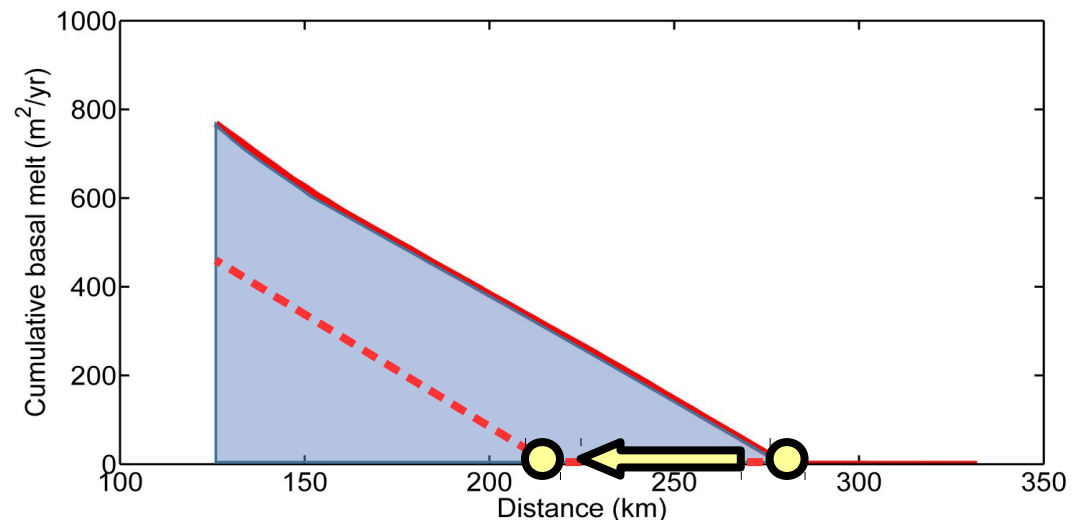


Modeling:

- Flowline, thermomechanically coupled ice sheet modeling
- Setup informed by western GrIS conditions

Variables of interest:

- FMB migration
- Effect on basal water production



1. Boundary Prescription

Research Tasks

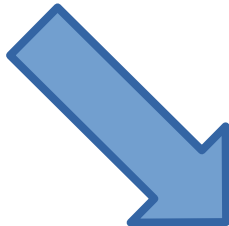
2. Frozen/melted Migration



Ice sheet BC for periglacial modeling

Connection to RP 1

Inform thermal conditions that constrain regional GW flow under different climate scenarios



Conceptual Model development:
Coupled Ice sheet,
Groundwater,
Permafrost system