

Progress on simulating permafrost change

Site-specific, transient, quality-tested with ground observations



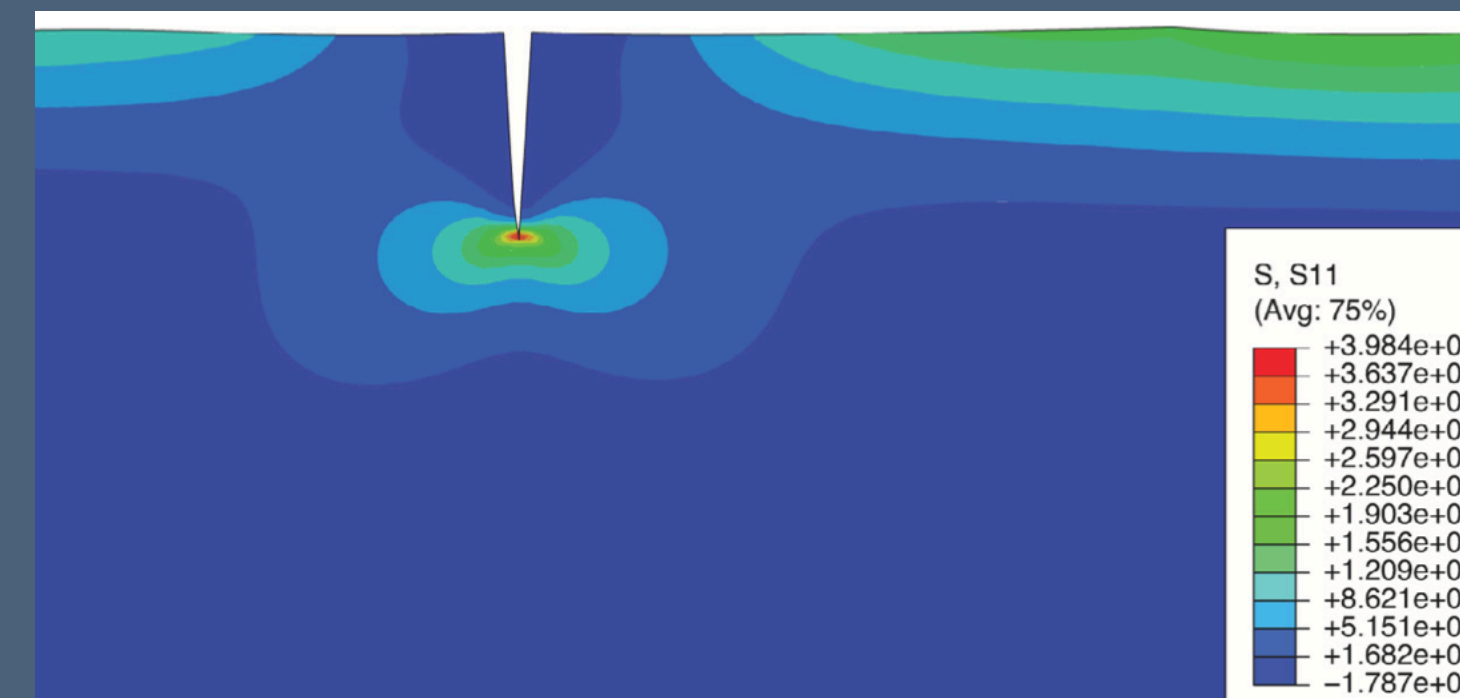
Stephan Gruber, December 2024

Understanding ice wedges better

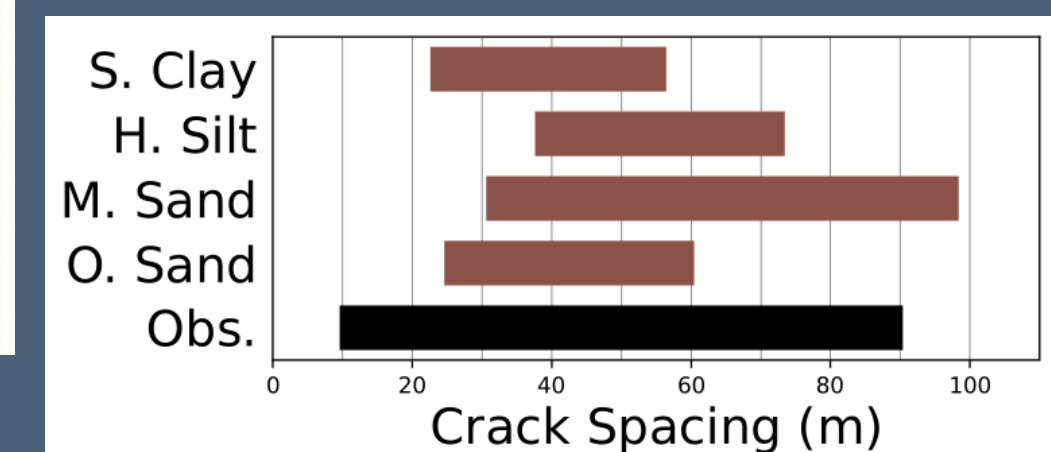
Gabriel Karam and Mehdi Pouragha

Methods and tools: Reproduce cracking with increasingly detailed models

- Soil mechanics, SFCC, ice-water density
- Soil types, layering, new/mature wedges
- Realistic weather (snow) from reanalysis



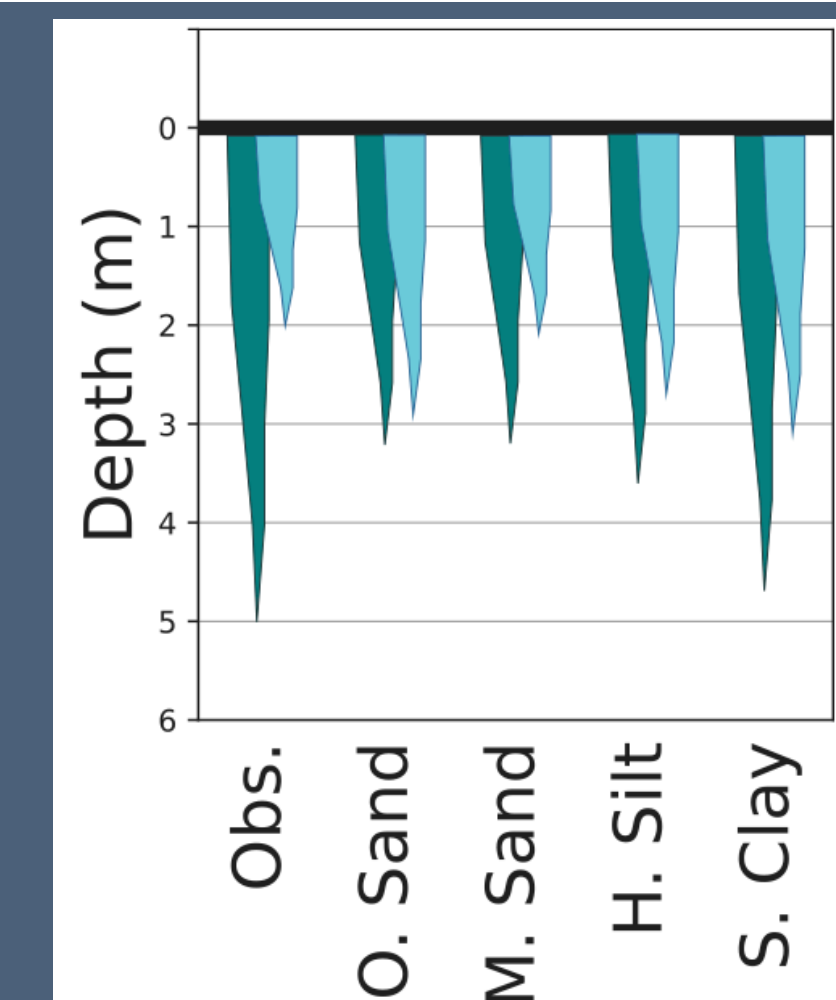
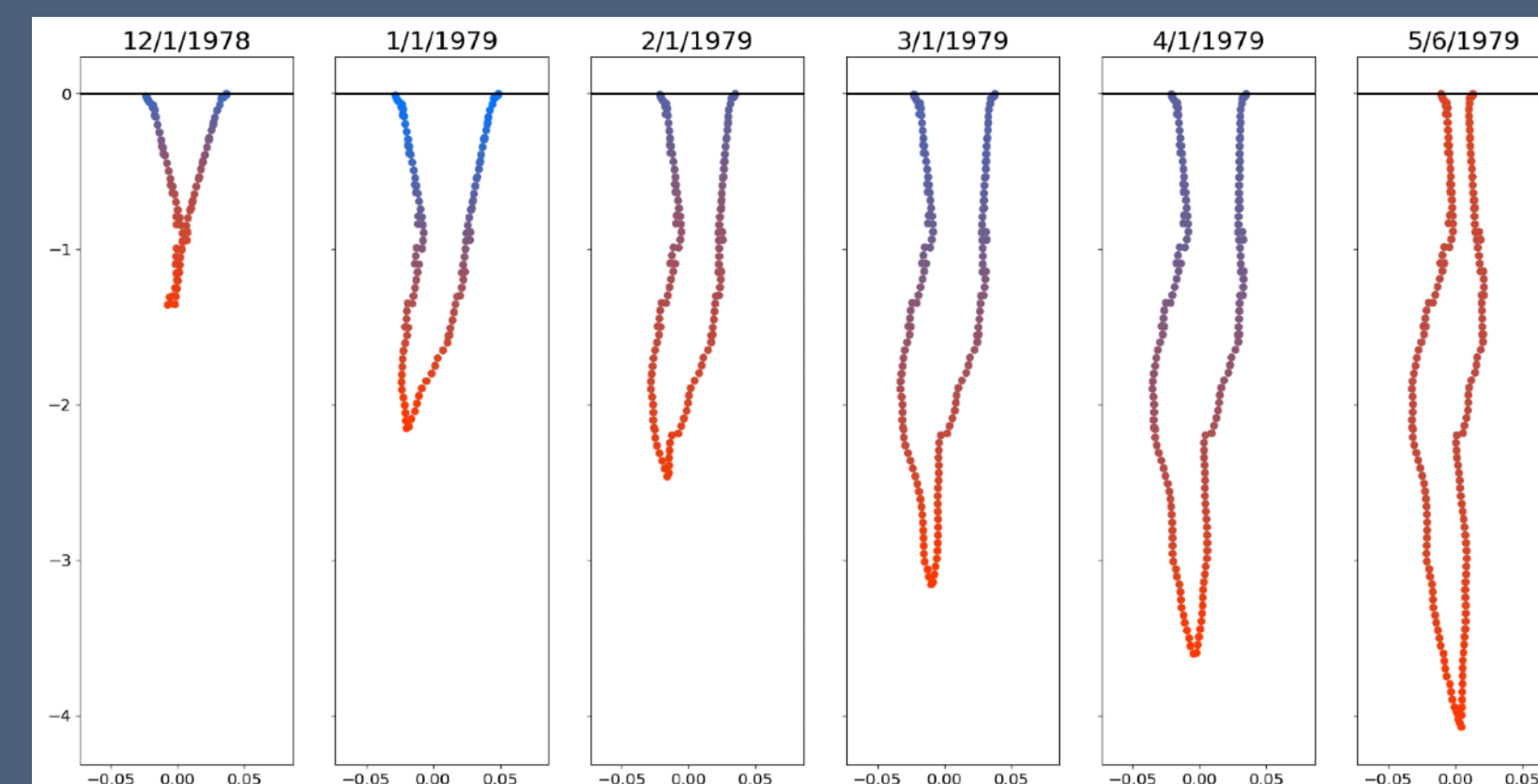
Karam, G., Pouragha, M., & Gruber, S. (2024). Investigating the controls of ice-wedge initiation and growth using XFEM. *Computers and Geotechnics*, 173, 106549.



Creating new insight

- Reproduce and better learn from past observations, e.g., Illisarvik.
- Estimate patterns of ice-wedge depth and volume based on climate and soil type.

Illisarvik crack development 1978/1979, work in progress.



New insight from thermal monitoring

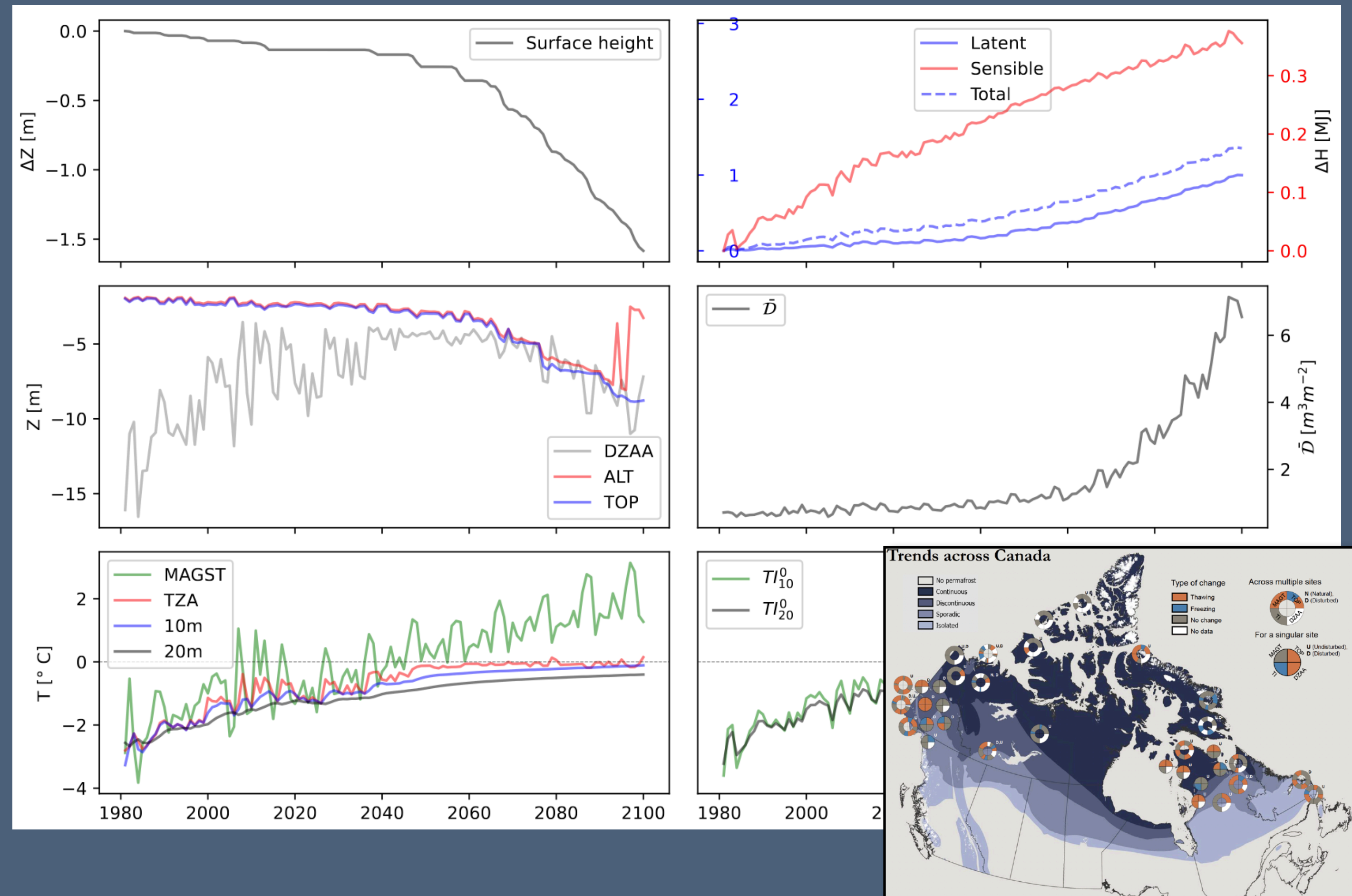
Nick Brown, Niccolo Tubini, Olivia Meier-Legault

Develop and select robust metrics

- Compare temperature-derived metrics to 'true' ice loss.
- Appreciate effects of spatial and temporal variability.

Apply metrics to 100+ observations

- Reveal change that complements, and sometimes contradicts, what MAGT trends reveal.

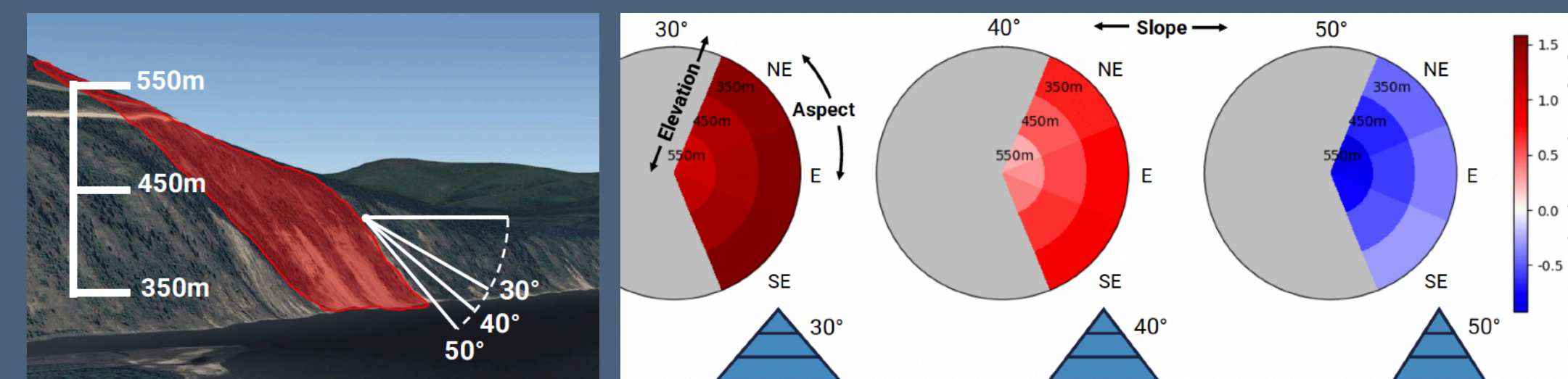


Contextualizing permafrost hazards

Victor Pozsgay, D. Cronmiller, M. Geertsema, E. Stewart-Jones, P. Blake

Estimate permafrost characteristics

- For multiple decades.
- For a realistic range of terrain conditions.

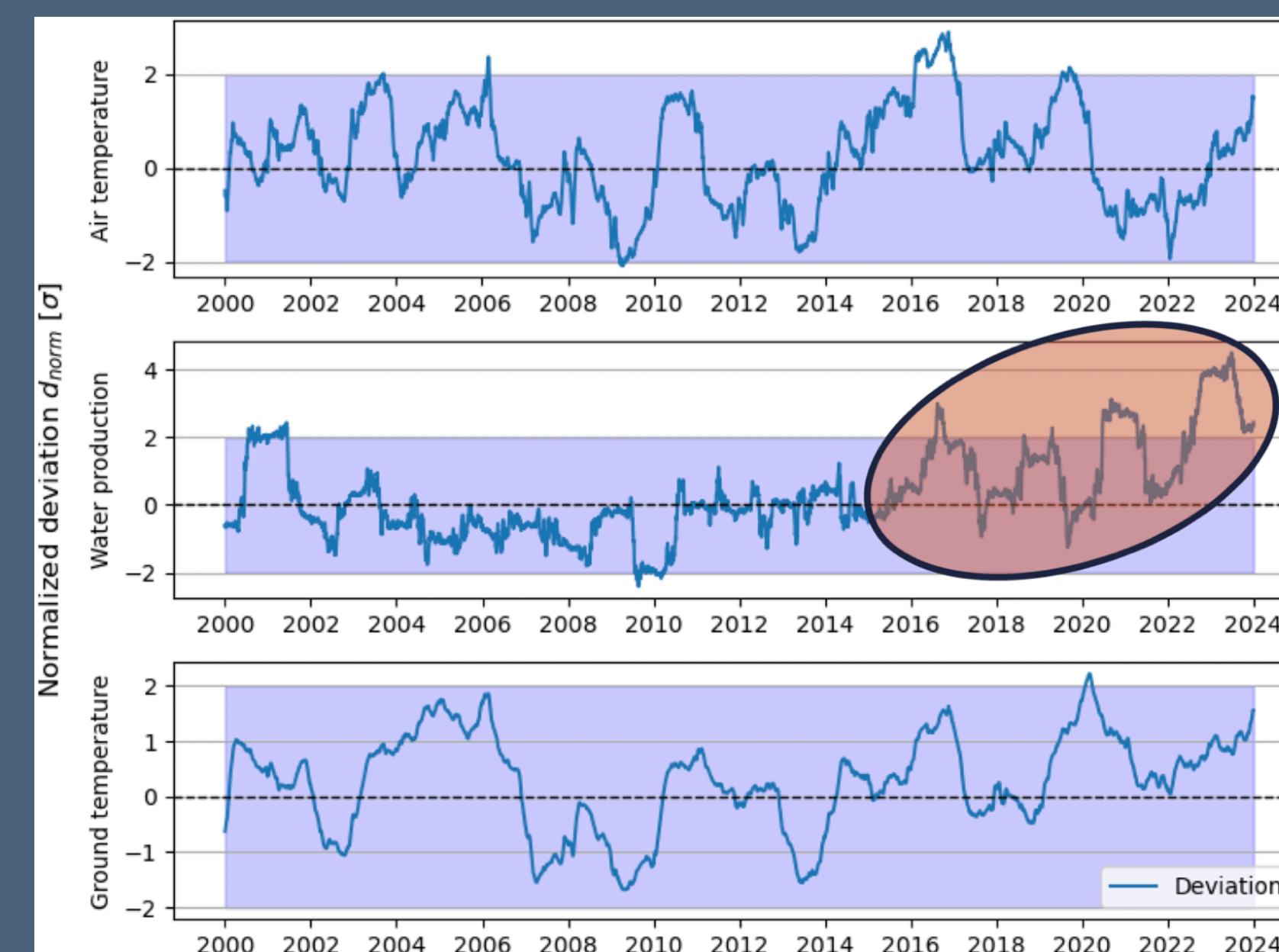


Reproduce effects of past weather

- Enable testing with observations.
- Understand “exceptionality” of events.

Communicate for better interpretation

- Iterative development with partners.

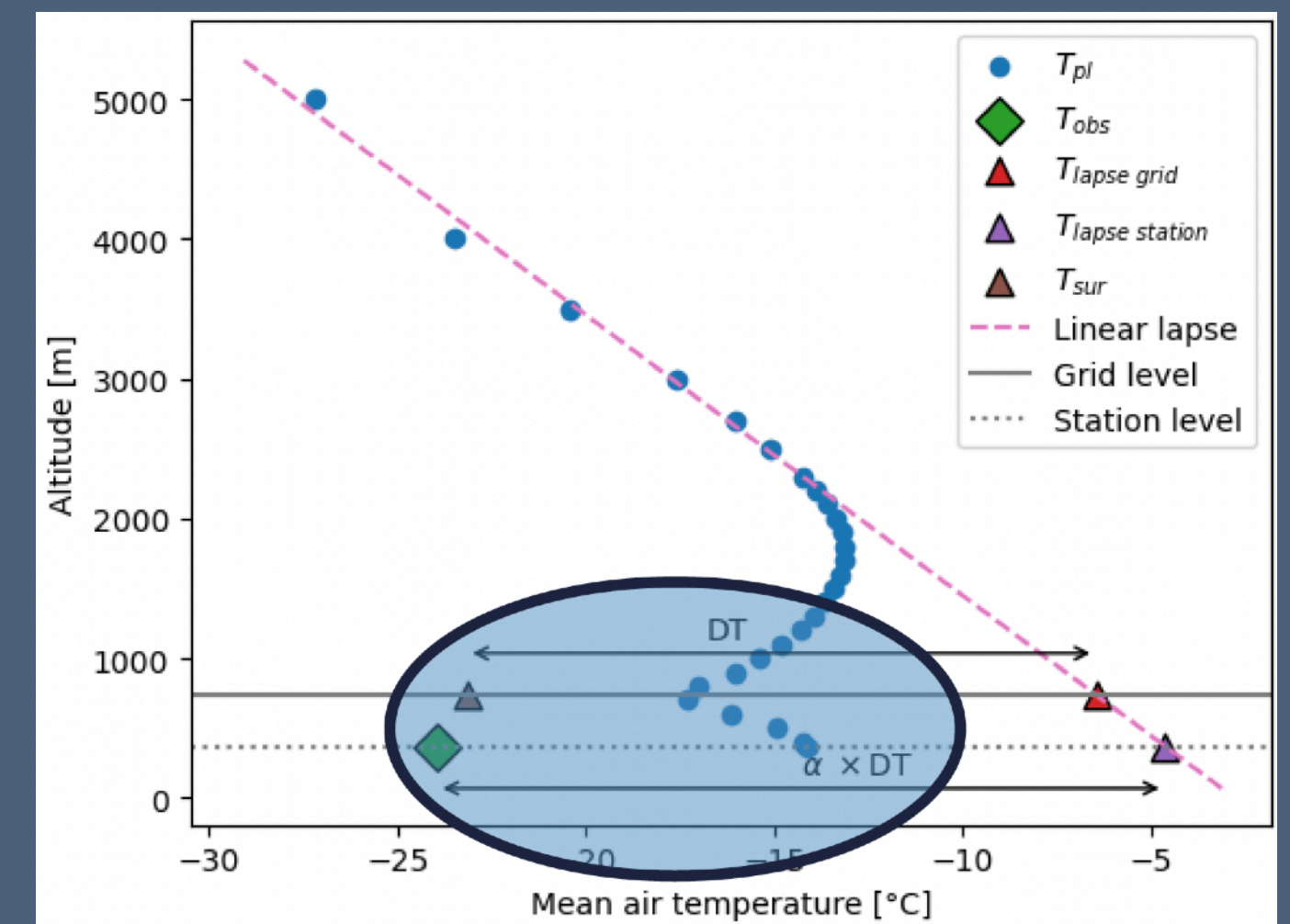
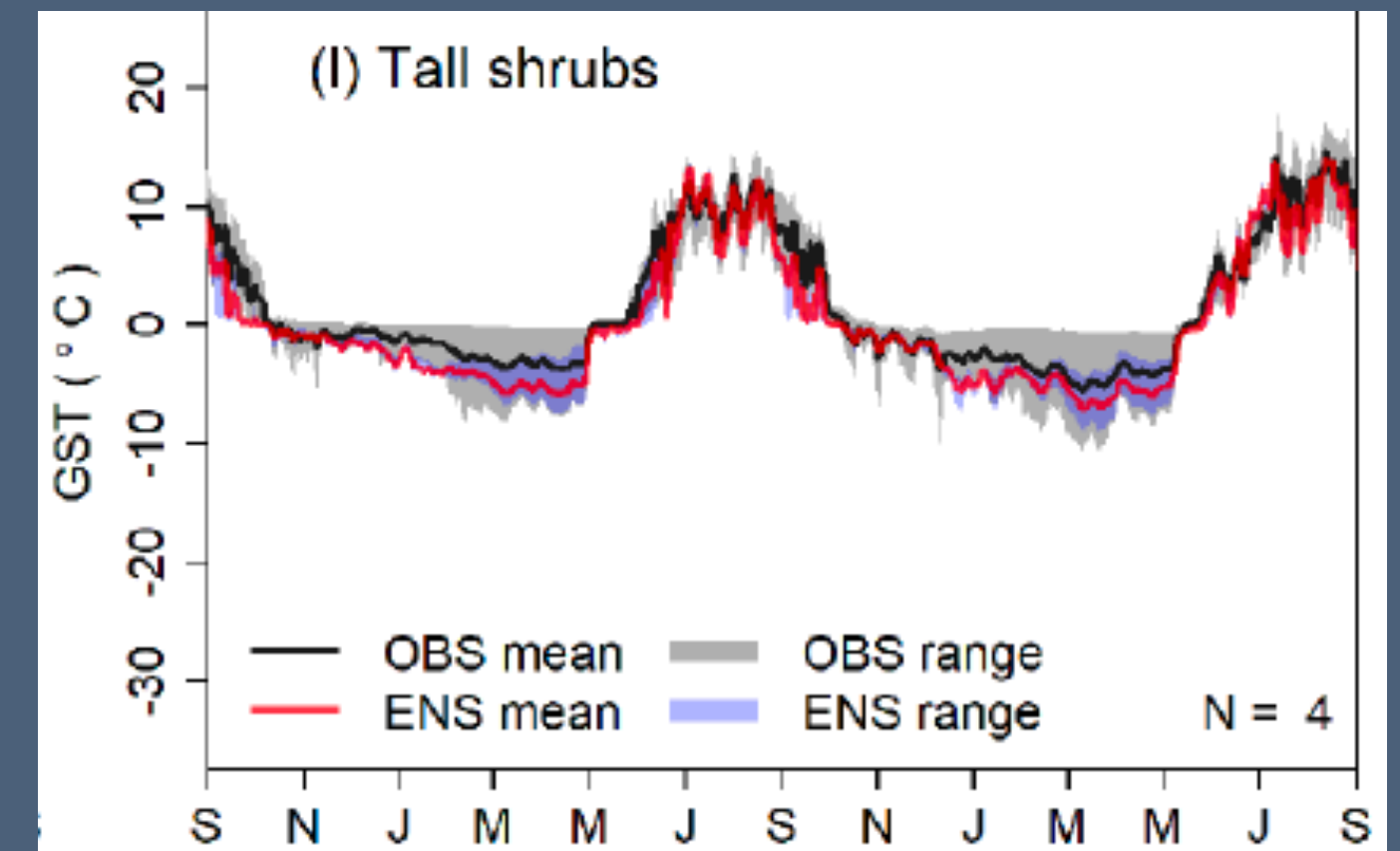


Driving transient simulations anywhere

Nick Brown, Bin Cao, Victor Pozsgay, Hannah Macdonell

A maturing set of methods and software (GlobSim)

- Facilitate site-specific usage of atmospheric reanalyses
- Download and pre-processing
- Harmonize multiple reanalyses
- Produce sub-daily weather data from ~1950 onwards
- Represent topography effects (work on inversions in progress)



Testing simulations with ground observations

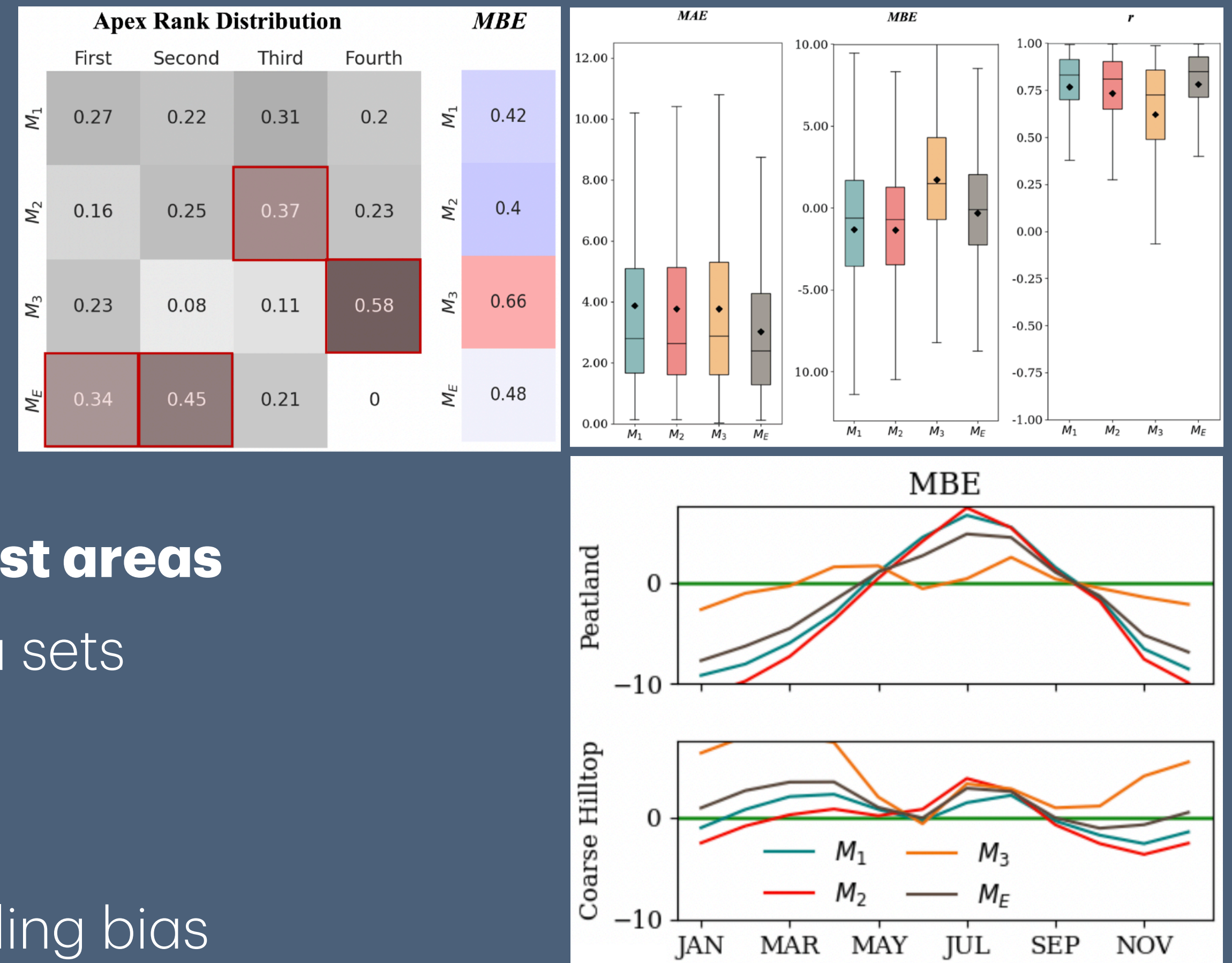
Hannah Macdonell, Luis Padilla-Ramirez

An opportunity and challenge

- More ground thermal data
- Ability to simulate anywhere
- No consensus method for model evaluation

Accomatic – a model testing tool for permafrost areas

- Suitable for ground temperature and large data sets
- Summary for easy interpretation
- Relevant details for experts
- Exposes spatial & seasonal variation and sampling bias

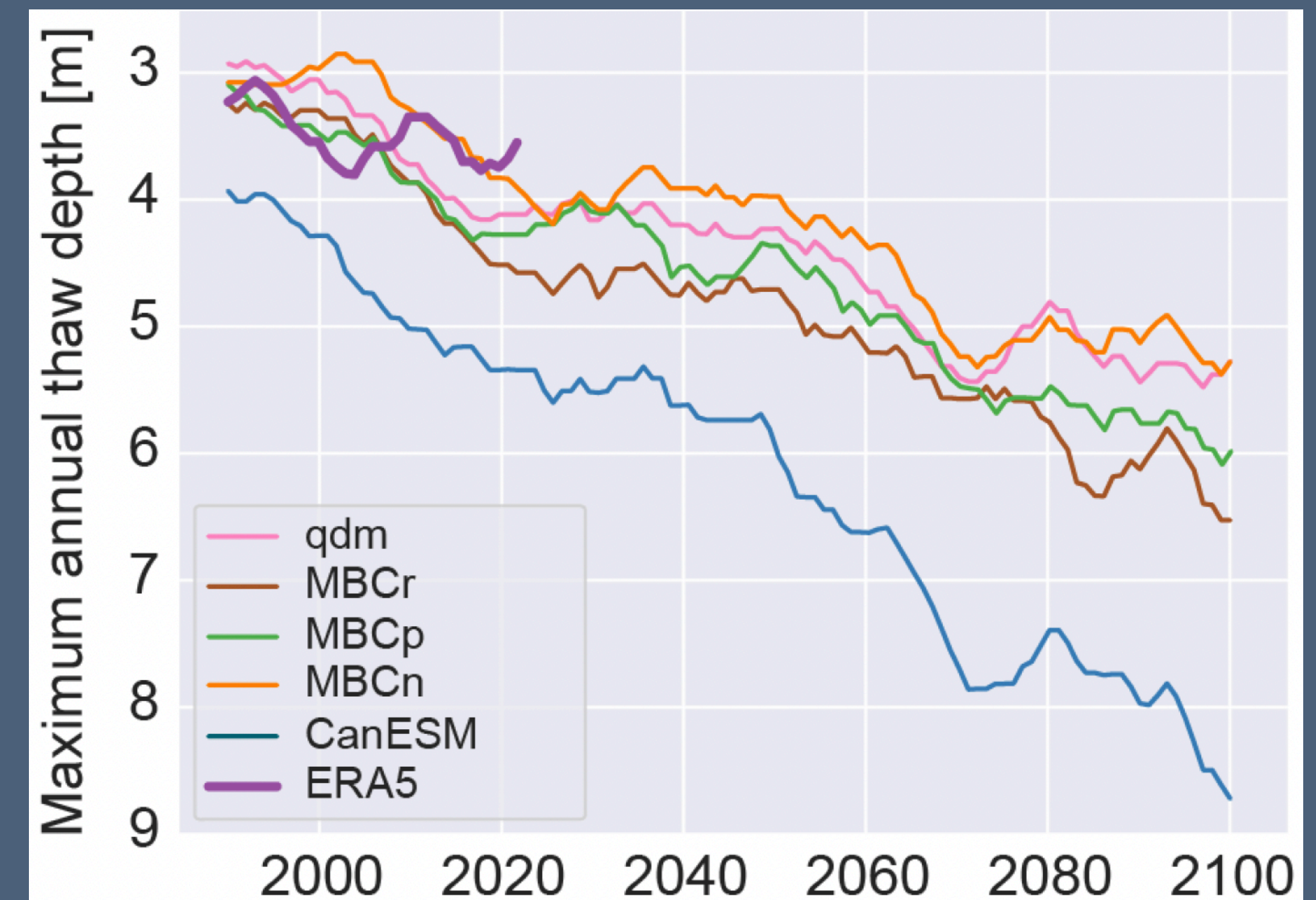


Connecting ground, weather, and climate

Galina Jonat, Alex Cannon

Building tools and experience

- Multi-decade permafrost reference simulations (GST observations, Globsim, Accomatic)
- Debias climate model data (multiple methods, reanalysis as reference)
- Simulate permafrost metrics with debiased data
- Compare statistical distributions of debiased data with reanalysis (climate and permafrost variables)
- Make ensemble simulations with selected data
- Contextualize results with simulation quality assessment – now traceable to ground observations



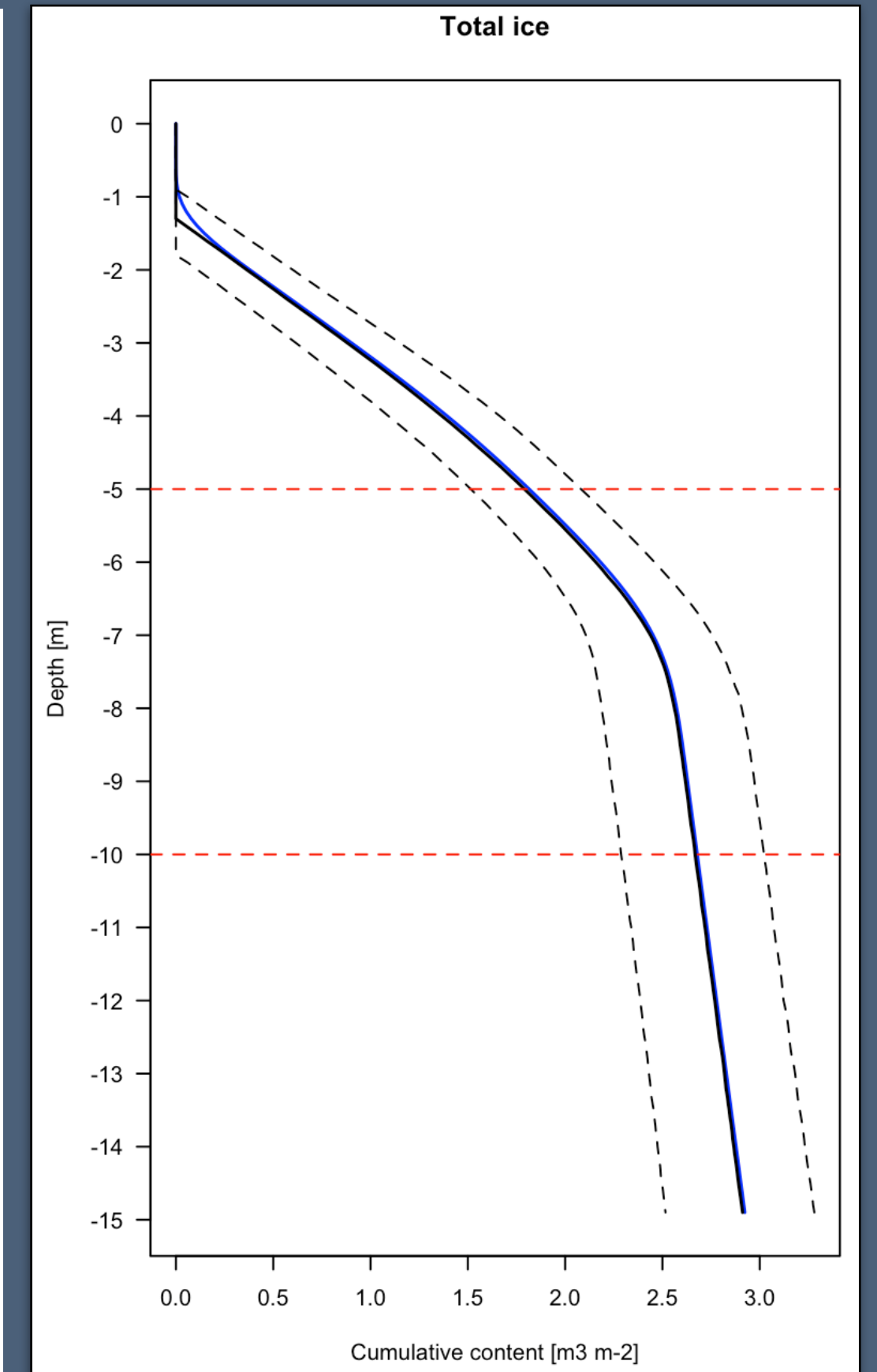
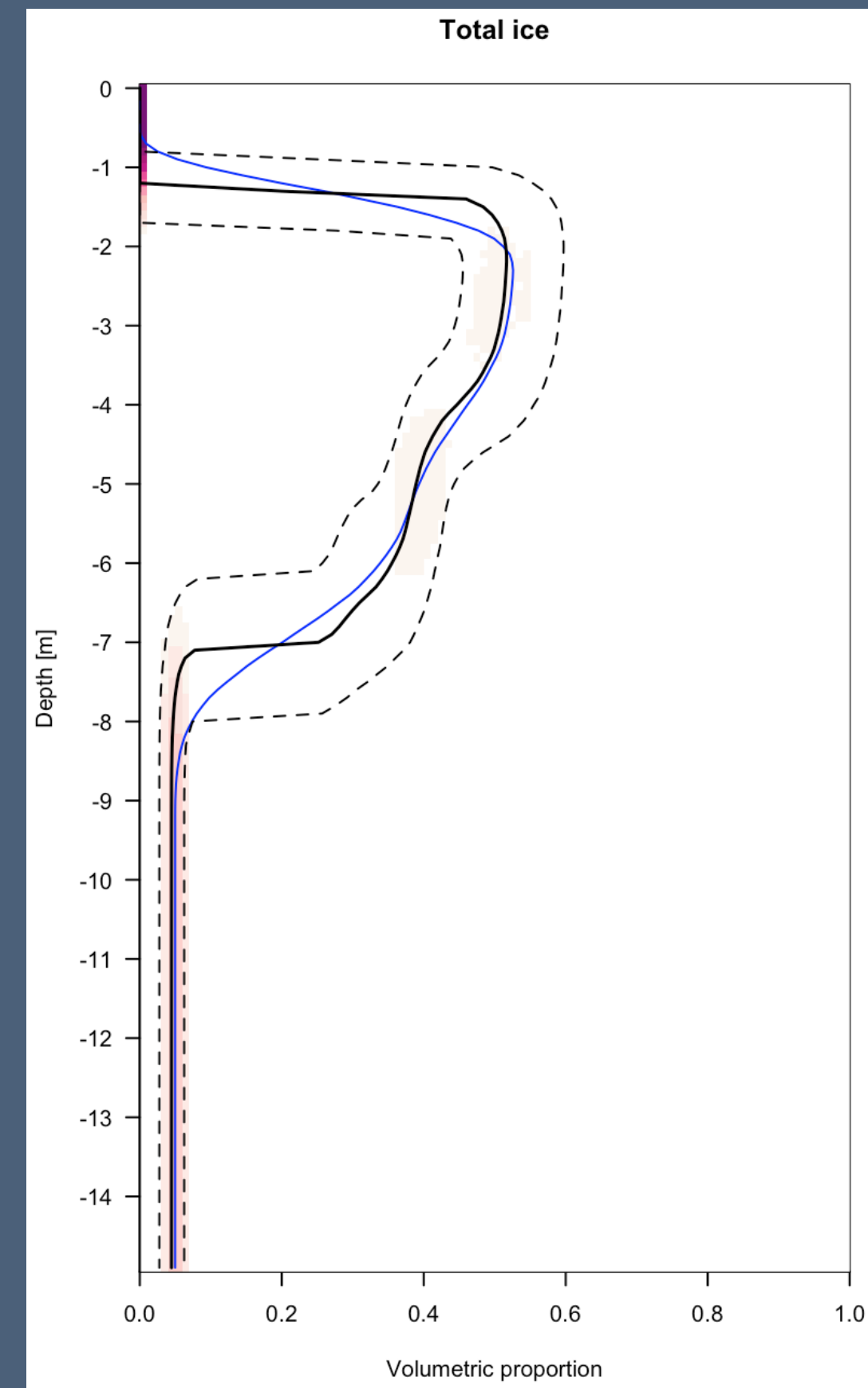
Stochastic permafrost ground profiles

Parameterize subsurface characteristics

- Differing ice types, carbon, geotech., solutes
- Spatial and stratigraphic variation
- Use measurements or expert knowledge

Generate data products

- Profile realizations as input for thermal models
- Cumulative values per depth interval
- Stochastic propagation of uncertainty



Enabling factors

How has the network made this possible?

- **Expertise:** Consistent support of students by partners.
- **Momentum:** Multiple students working on related topics.
- **Capacity:** A network data scientist with domain expertise.
- **Infrastructure:** Compute infrastructure, supported software, emerging data conventions, databases.
- **Friendliness:** Working together across domains, taking students who work on simulations into the field and exposing field scientists to modelling approaches, investing time into conversations.

