ENSEMBLE SIMULATIONS OF PERMAFROST CHANGE BY TERRAIN TYPE

A conversation starter for permafrost climate services

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BACKGROUND

Warming and thawing permafrost causes local to regional-scale hazards, i.e., ``natural or human-induced physical events that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources'' (IPCC, 2019).

As permafrost is a subsurface feature with its development being dependent on ground conditions, changes in permafrost cannot be directly derived from changes in easily accessible atmospheric variables. Broad-scale hazard identification and assessment is needed across the Arctic to better inform decision-making in the context of adaptation to permafrost thaw.

DEVELOPING PROTOTYPE PRODUCTS FOR A PERMAFROST CLIMATE SERVICE

A permafrost climate service is a framework for the provision of permafrost information that supports decisions for adaptation to future permafrost thaw.

It is the product of co-development between scientists and decision-makers, with the delivered data products directly responding to the information needs for a given decision (Fig. 1).

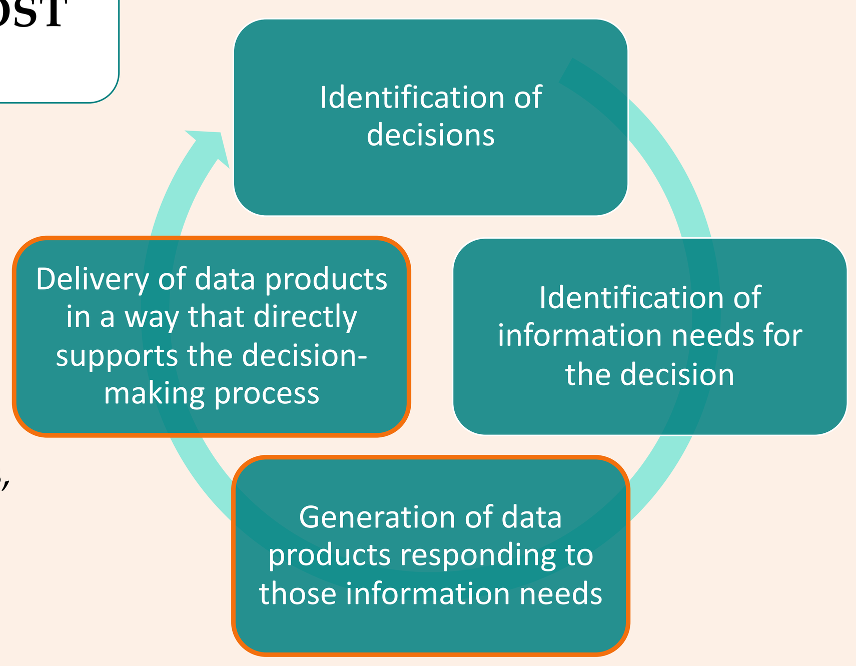


Figure 1. Co-development process of a climate service

The goal of this research effort is to develop prototypes for a simulation-based component of permafrost climate services. This component aims to complement the observation-based component by

- generating data for locations and times at which no observations are available,
- simulating metrics that are hard to measure in the field, and
- capturing and propagating uncertainties related to imperfect representation of ground conditions and uncertainties in driving climate.

The simulation data presented on this poster is a conversation starter, showing possible data products.

ENSEMBLE APPROACH

Due to the variability of permafrost regions in ground conditions and driving climate, ensemble modelling is an important tool to propagate and quantify uncertainties related to climate forcing, modelling approximations, and ground conditions.

An ensemble of permafrost models, driving climate, and terrain descriptions provides the best possible estimate for permafrost variables and can help to identify past and future trends (Fig. 2)

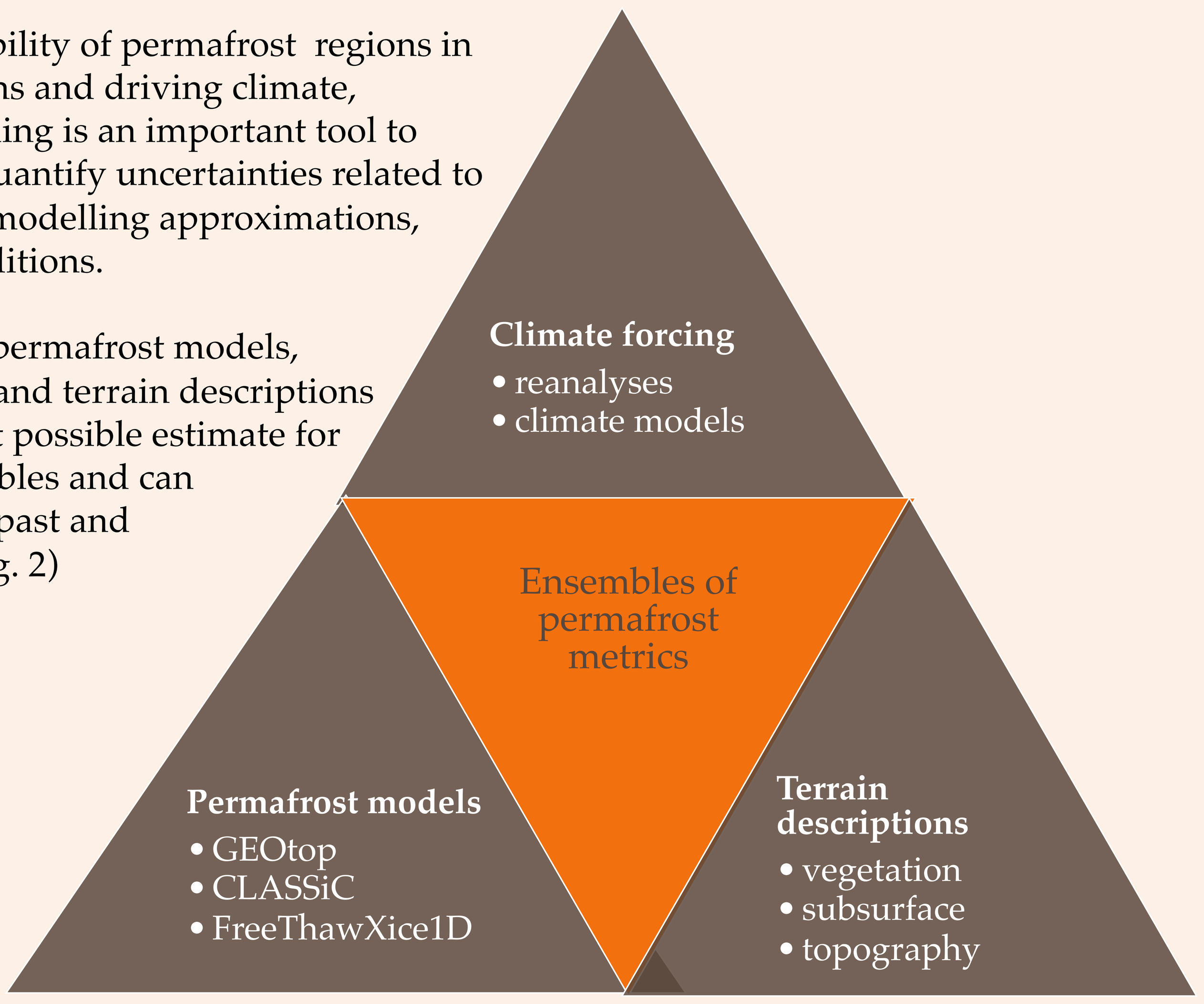


Figure 2. Ensemble simulation setup

PRE-PROCESSING OF CLIMATE FORCING DATA

from grid scale… … to point scale

Driving variables
Air Temperature
Precipitation
Surface thermal and solar radiation
Relative and specific humidity
Wind direction and speed

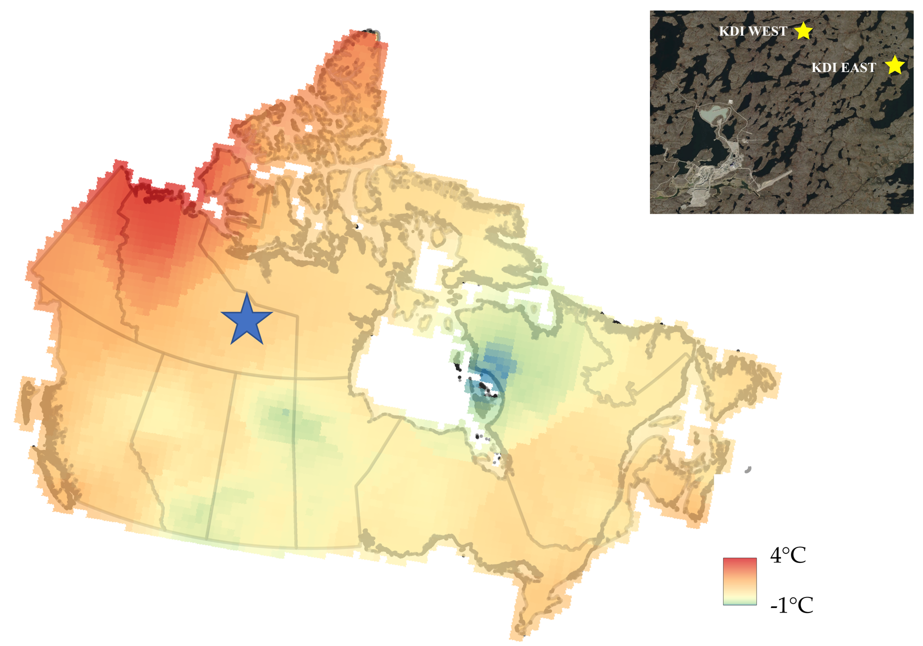


Figure 3. Temperature anomaly for 2018, compared to baseline period 1960-1980

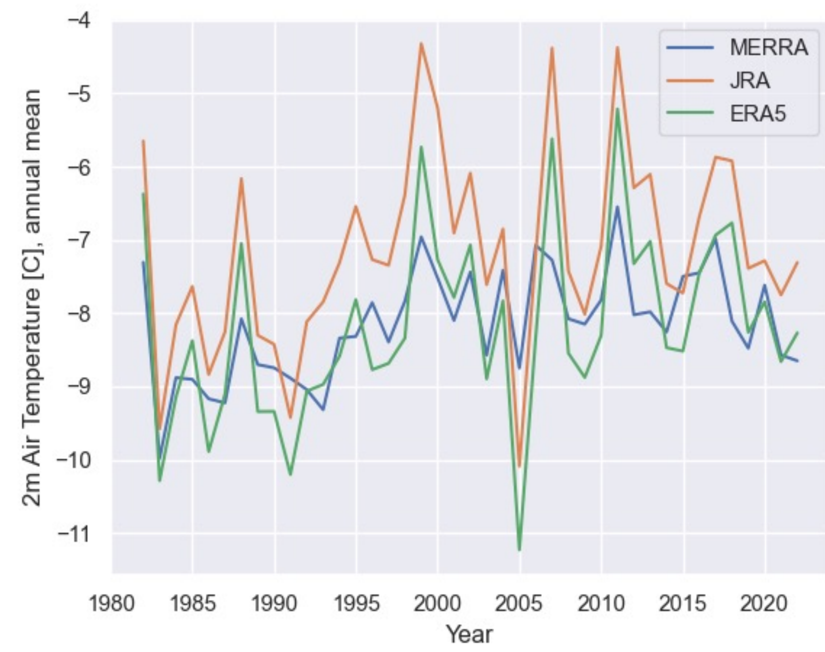
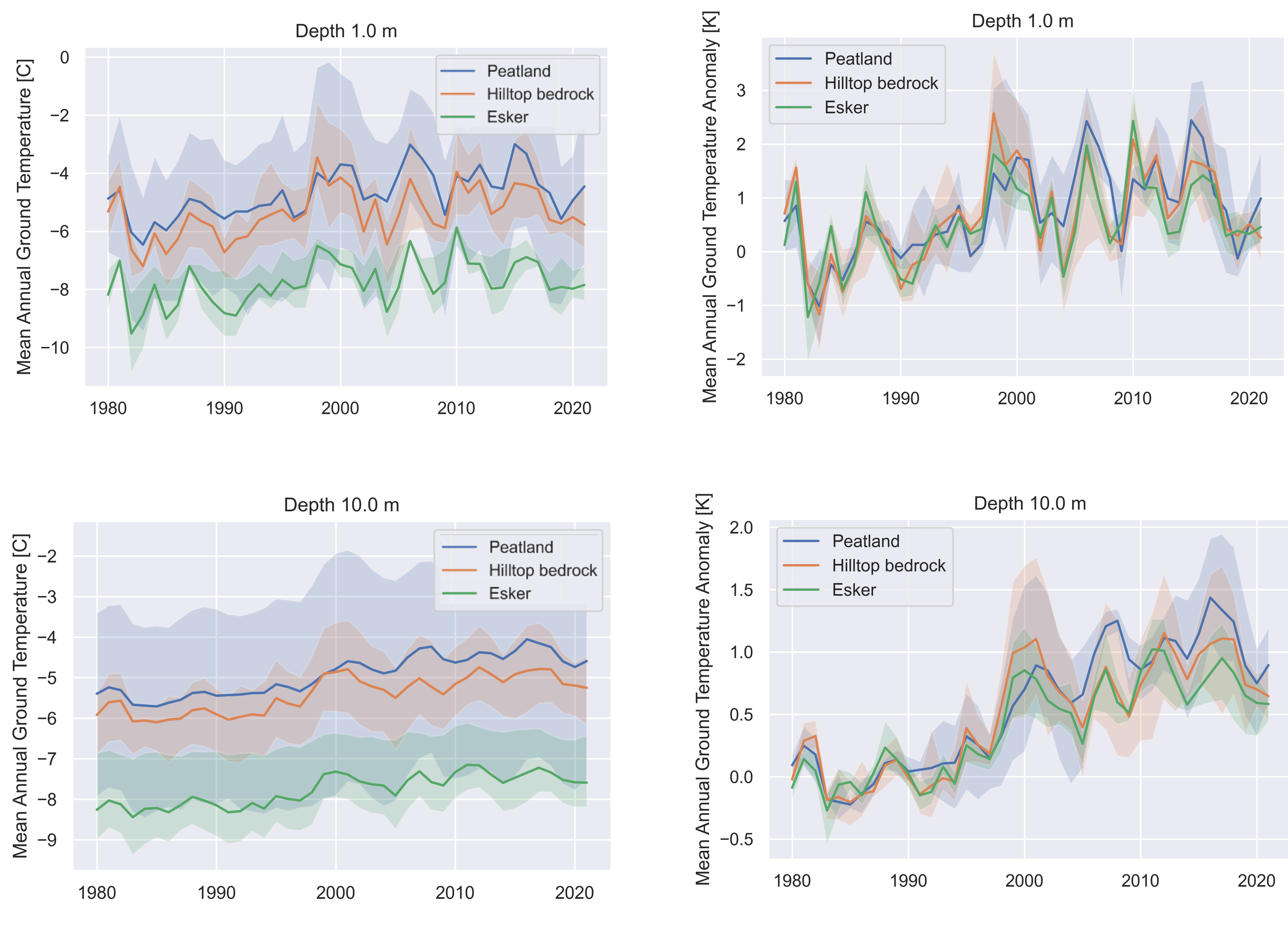


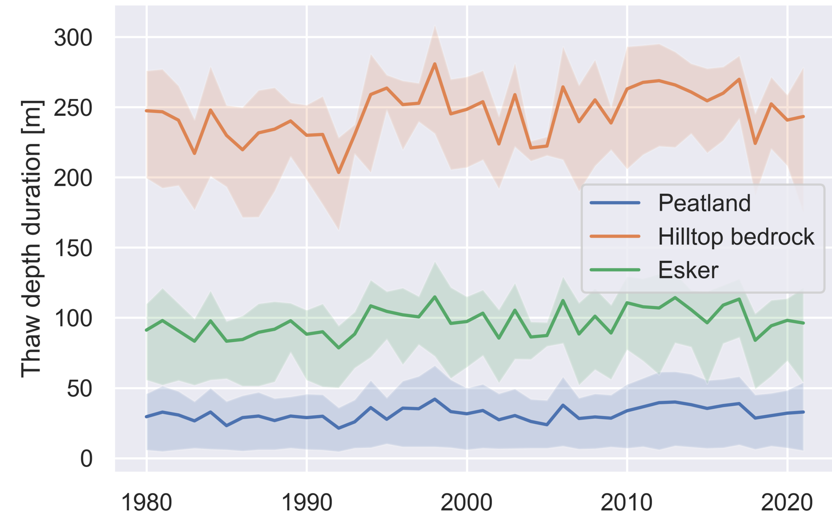
Figure 4. Mean annual air temperatures for three reanalyses, 1980-2020

RESULTS AND METRICS

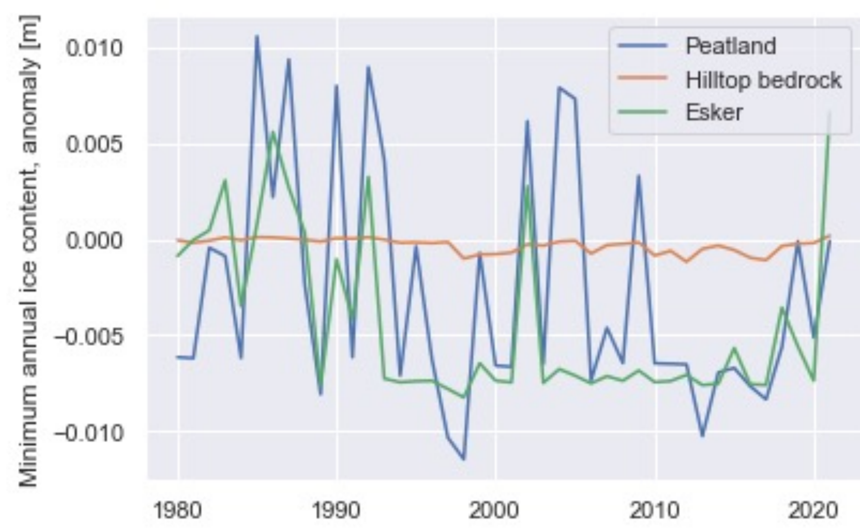
… to site scale



Ground Temperature, annual mean – standard metric for monitoring the annual and long-term thermal state of the soil column; Essential Climate Variables



Thaw depth duration, annual – soil in the column warmer than 0°C, integrated over both depth and time; indicator for susceptibility to landslides and degradation of organic material



Ice content, annual minimum – characterizes permafrost thaw; indicator for stability of the ground and the hydrological impact of permafrost warming

ADDED VALUE OF ENSEMBLE PERMAFROST SIMULATIONS

Representation of **change** and multiple permafrost variables

Propagation of **uncertainties** related to driving climate

Portability, spatial and temporal

Regional to local **scale**, by integration of terrain types

NEXT STEPS

Identification and parameterisation of terrain types describing region of interest

Extension of timescales to include future climate scenarios (via de-biased climate models)

Calibration / selection of ensemble output through comparison with field observations

References

Cao, Bin et al. 2019. "GlobSim (v1.0): Deriving Meteorological Time Series for Point Locations from Multiple Global Reanalyses." Geoscientific Model Development 12(11): 4661–79.

Harp, D. R. et al.: Effect of soil property uncertainties on permafrost thaw projections: A calibration-constrained analysis, Cryosphere, 10, 341–358, doi:10.5194/ tc-10-341-2016, 2016.

GTPEM,Grid Toolkit for Permafrost Ensemble Modelling, https://gitlab.com/permafrostnet/gtpem

Acknowledgements

Nick Brown (PermafrostNet), GTPEM, GlobSim, and overall technical support

Permafrost lab group at CarletonU, general support and cheerleading

Digital Research Alliance of Canada, access to supercomputer

westgrid, access to cloud virtual machine

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