High-resolution forecasting of circum-Arctic ground thermal regime

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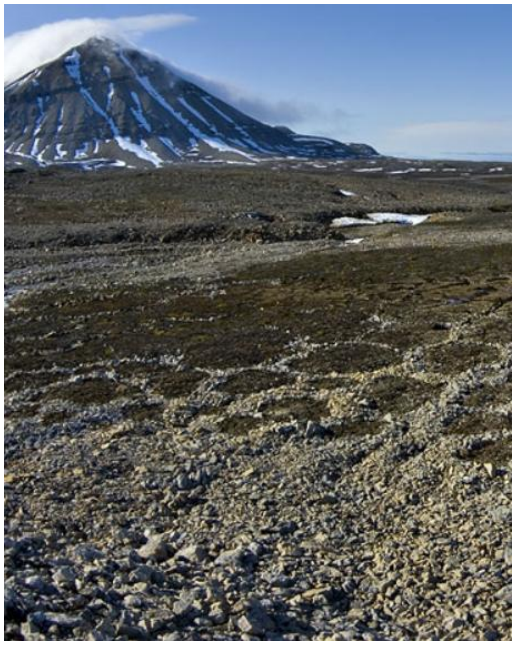
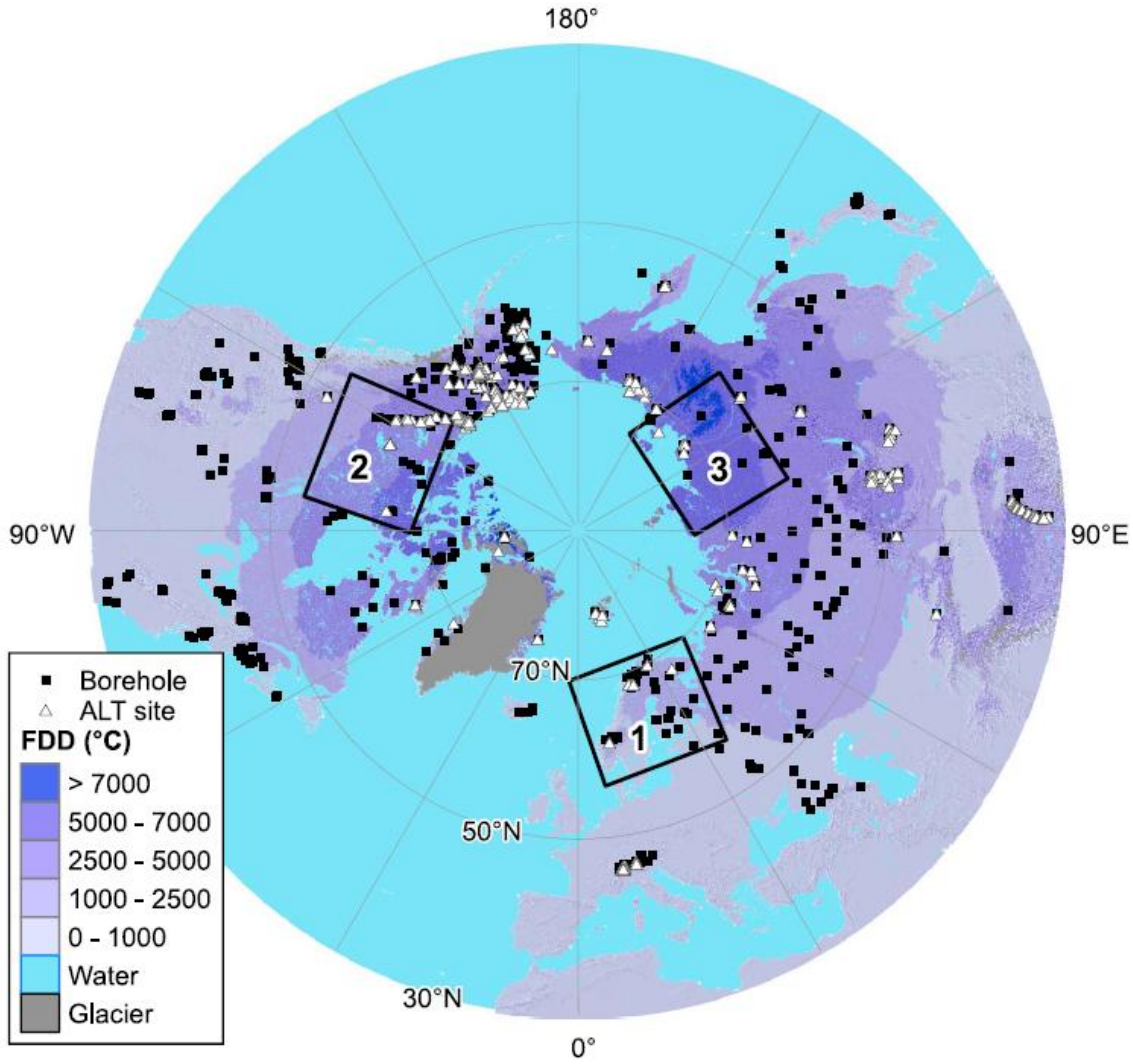
Motivation



- Climate change proceeds substantially faster in Arctic than low-latitudes (**Arctic amplification**)
- Arctic ground thermal regimes reflect cold air temperatures (**permafrost, active layer dynamics**)
- Important biotic and abiotic consequences (e.g. carbon cycle, hydrology, infrastucture) → **high-resolution ground-thermal data over large spatial domains are urgently needed!**

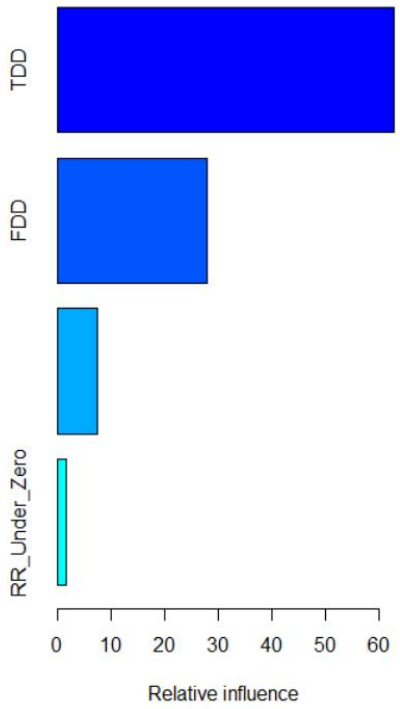
Observation data

- *In-situ* measured mean annual ground temperature (**MAGT**; n=797) and active layer thickness; (**ALT**; n=303) >30°N
- Averages over 2000-2014
- Observations also covering the ”warm-side” of MAGT the gradient



Aalto et al., 2018. *Geophysical Research Letters.*

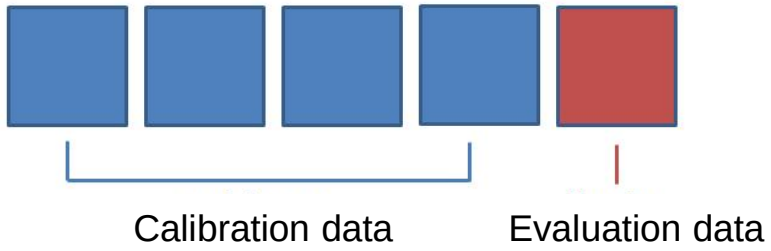
Statistical forecasting



- **A statistical approach** with an ensemble of algorithms (GLM, GAM, BRT, RF)
- Predictors of climate (*Climate only model*), soil and topography (*Full model*) at the spatial resolution of 30 arc seconds
- Current climate (2000-2014) + two future time periods (2041-2060, 2061-2080) + three emission scenarios (RCP2.6, RCP4.5, RCP8.5)
- R-statistical programming, *raster* package functionalities, **multicore-computing using Taito supercluster**

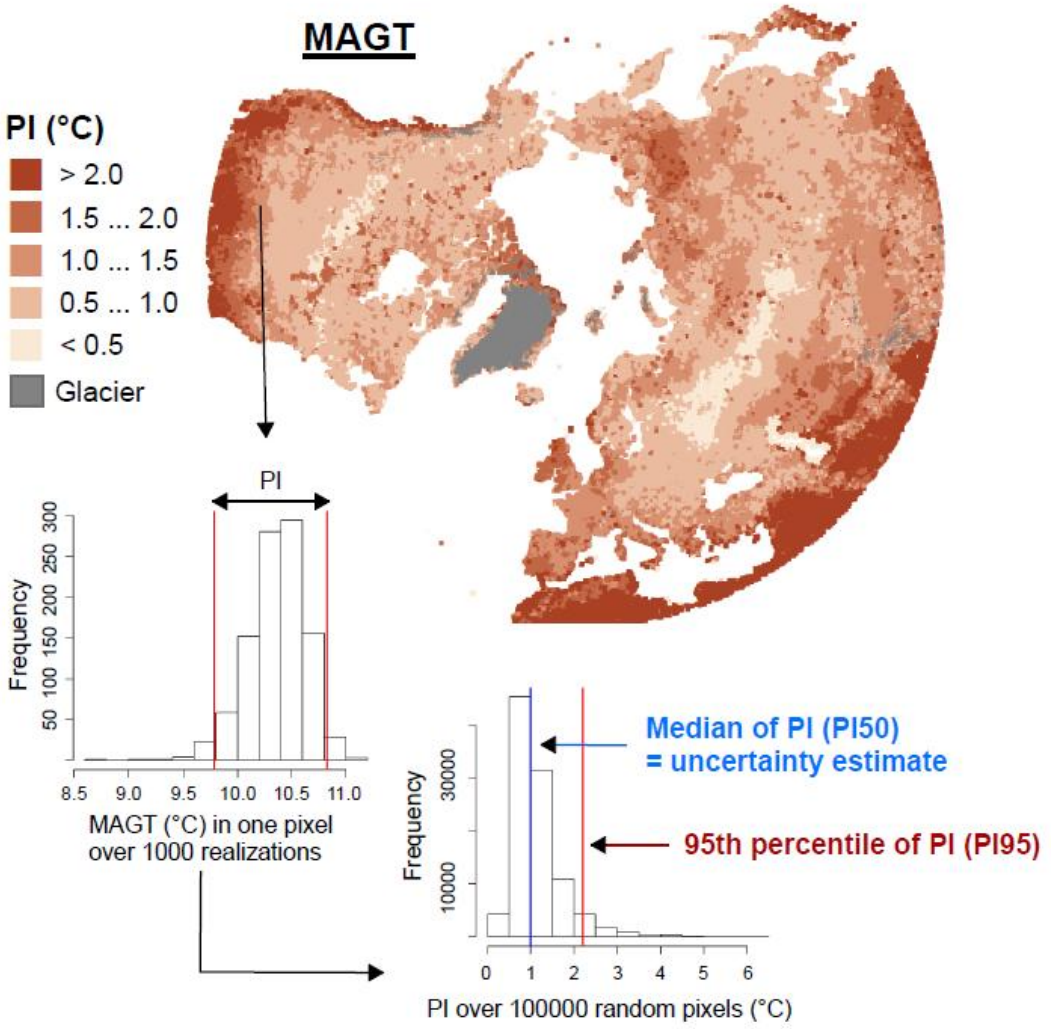
Forecasts' accuracy

- Absolute agreement between observed and forecasted MAGT and ALT
- A repeated random cross-validation (CV) scheme with 1000 repeats, 95% of the data for calibration, 5% for evaluation
- Minimum distance between the cal. and eval. data was set to 500 km (R package *sp*)
- Hincasting to past conditions (1970-1984 and 1985-1999)



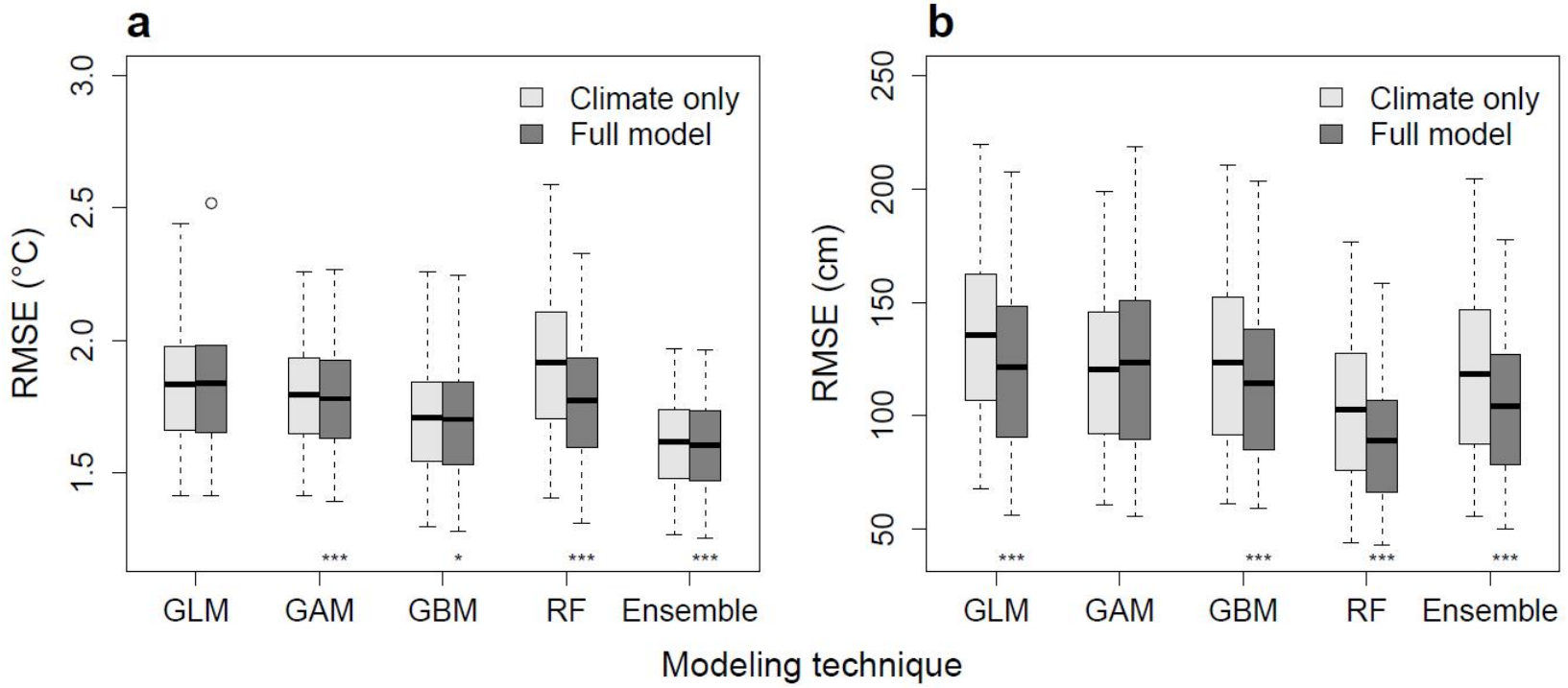
Forecasts' uncertainty

- Quantify MAGT and ALT forecasts' sensitivity to input data
- **1000 forecasts** over **100 000 randomly chosen pixels** using bootstrap sampling of the observation data
- Both present and future conditions, **computationally heavy!**



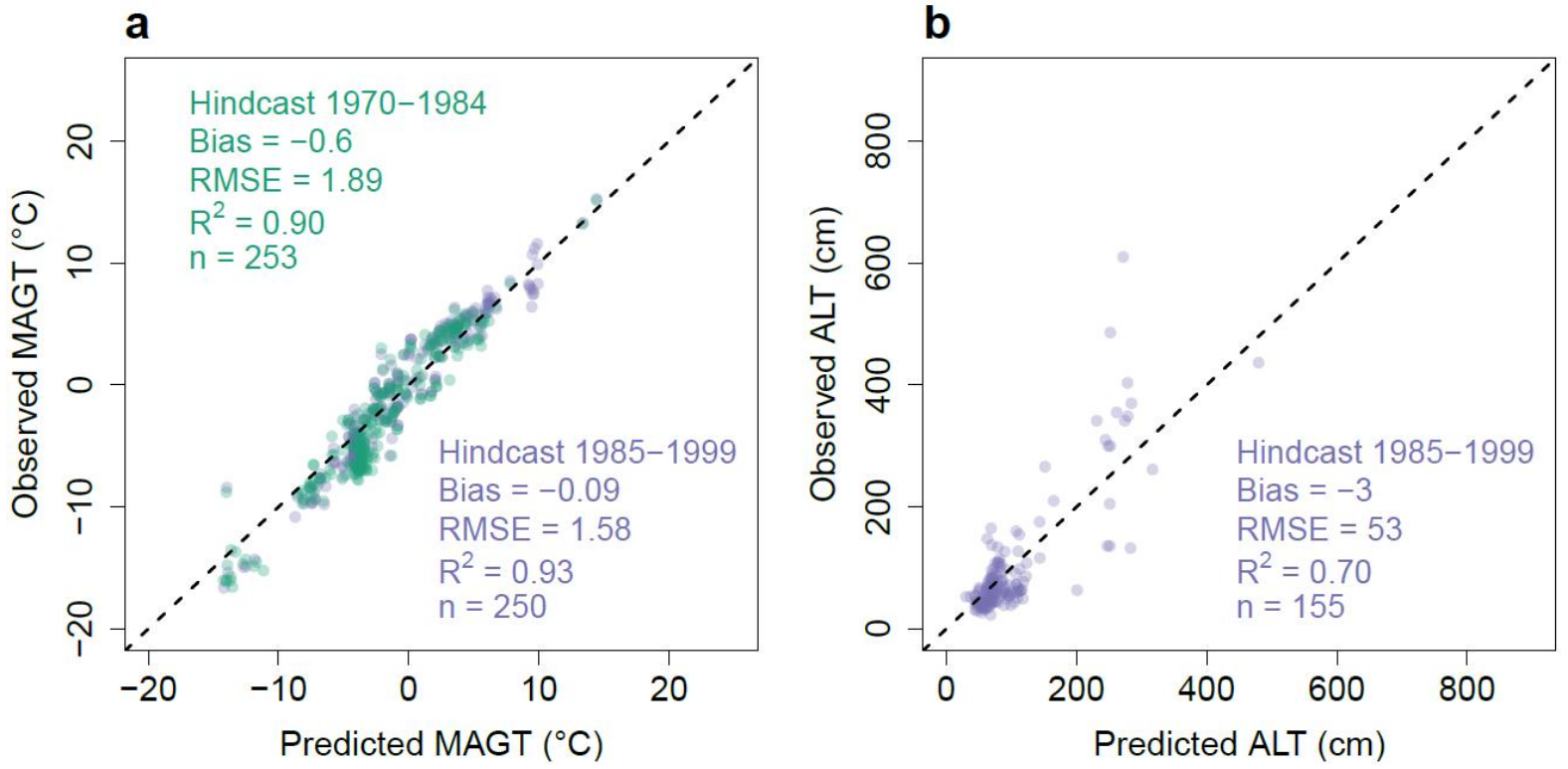
Aalto et al., 2018. *Geophysical Research Letters.*

Results - CV



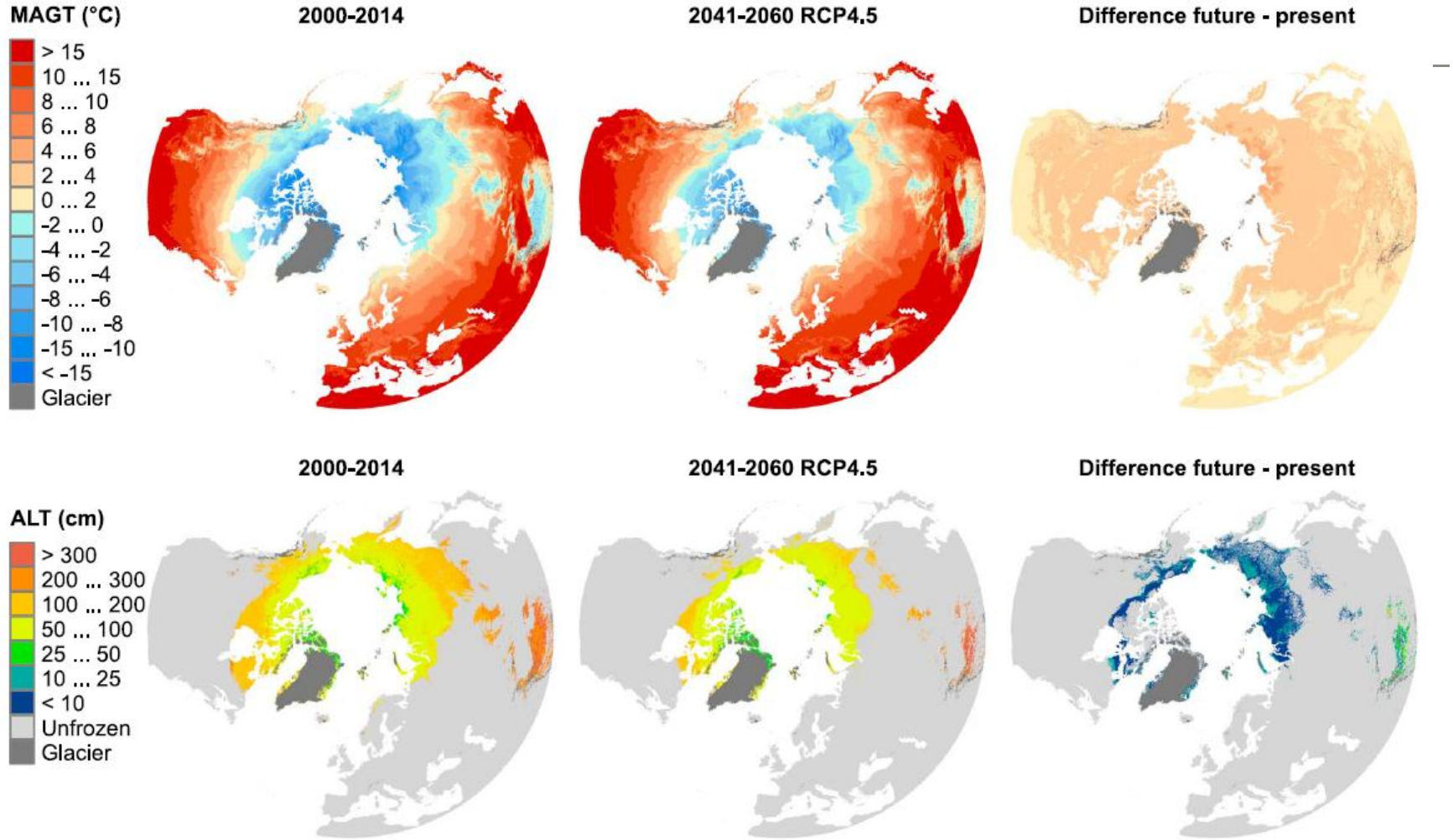
Consideration of non-climatic predictors significantly improved the forecasts' accuracy for both MAGT (a) and ALT (b)

Results - hindcasting



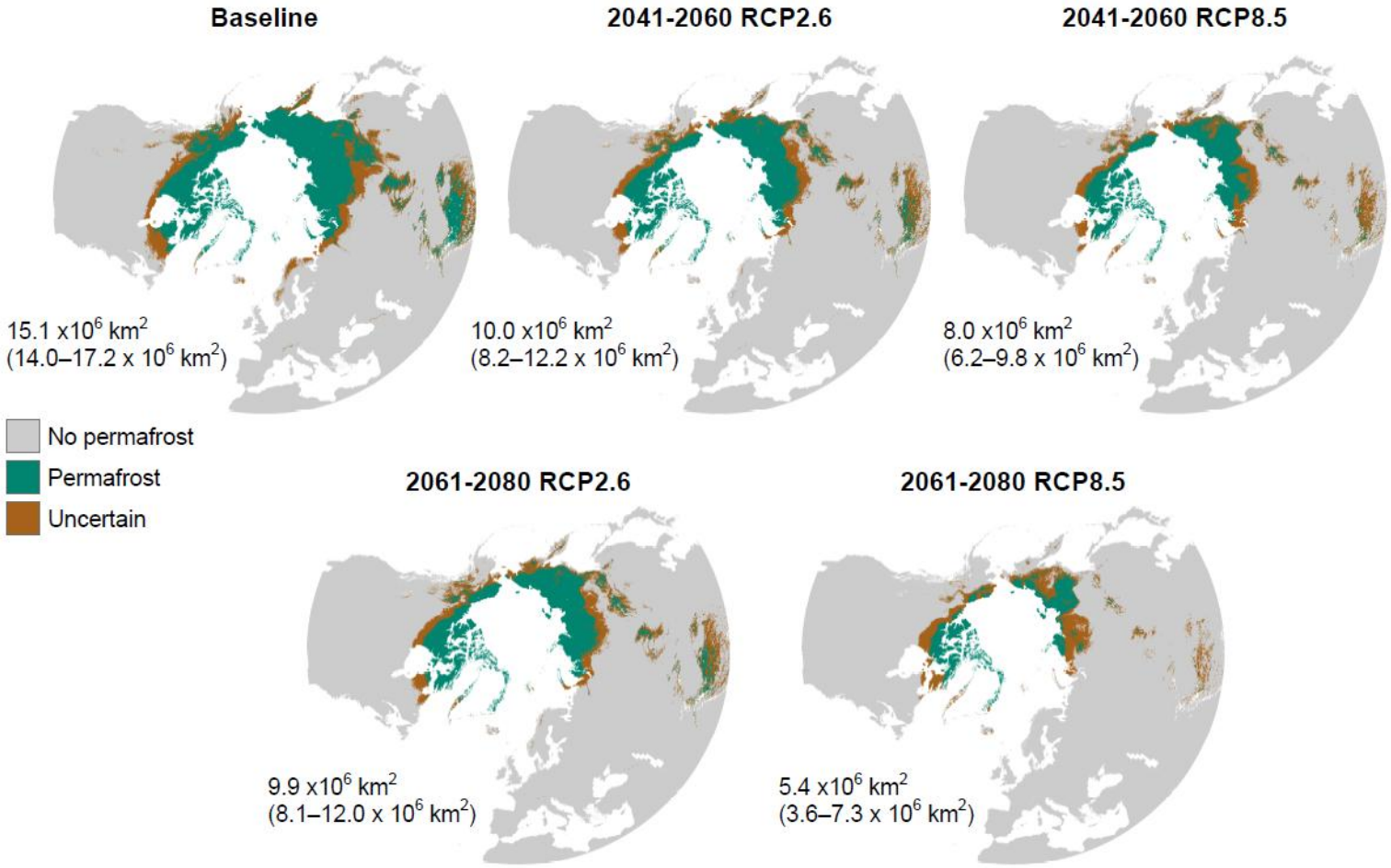
Good model transferability in time → realistic future forecasts!

Results - circum-Arctic forecasts



Aalto et al., 2018. *Geophysical Research Letters.*

Results – permafrost extent



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Summary

- High-performance CSC computing environment enabled forecasting circum-Arctic ground thermal conditions at high-spatial resolution
- Forecasts indicate severe near-term changes in ground thermal regime due to climate change
- The produced data layers are valuable for assessing future ground thermal state, biogeochemical feedbacks and infrastructure-related risks

Publication

- **Publication:**

Aalto, J., Karjalainen, O., Hjort, J., Luoto, M. 2018. Statistical forecasting of current and future circum-Arctic ground temperatures and active layer thickness. *Geophysical Research Letters* 45: 4889-4898. https://doi.org/10.1029/2018GL078007

- **Data:**

Aalto, J., Karjalainen, O., Hjort, J., Luoto, M. 2018. Data from: Statistical forecasting of current and future circum-Arctic ground temperatures and active layer thickness. *Dryad Digital Repository*. https://doi.org/10.5061/dryad.886pr72