climate change initiative

PERMAFROST

# The CryoGrid community model and Permafrost_CCI results

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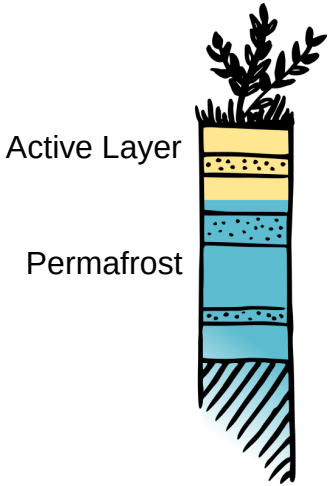
permafrost cci

# Permafrost: What are we talking about?

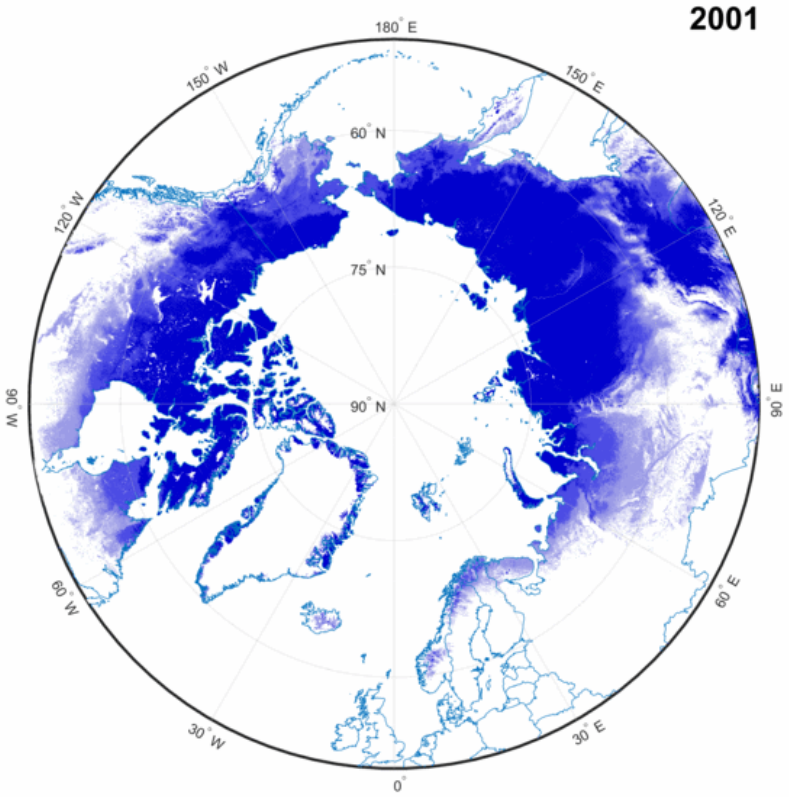



- Ground that is at or below 0° C for at least 2 consecutive years
- ECVs: active layer thickness, permafrost temperature
- Subsurface phenomenon, hard to measure with EO

Modeling needed

# Permafrost: Where is it?

permafrost extent



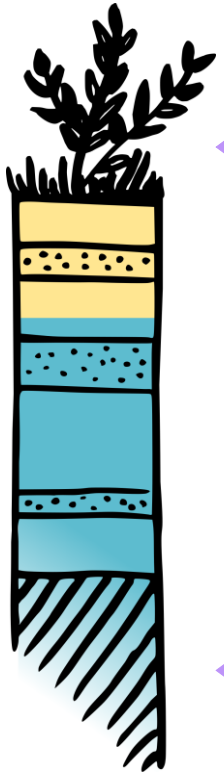
# Permafrost: Where is it?



© Sebastian Westermann

# Permafrost: Where is it?

# Permafrost: Necessary Processes and Properties

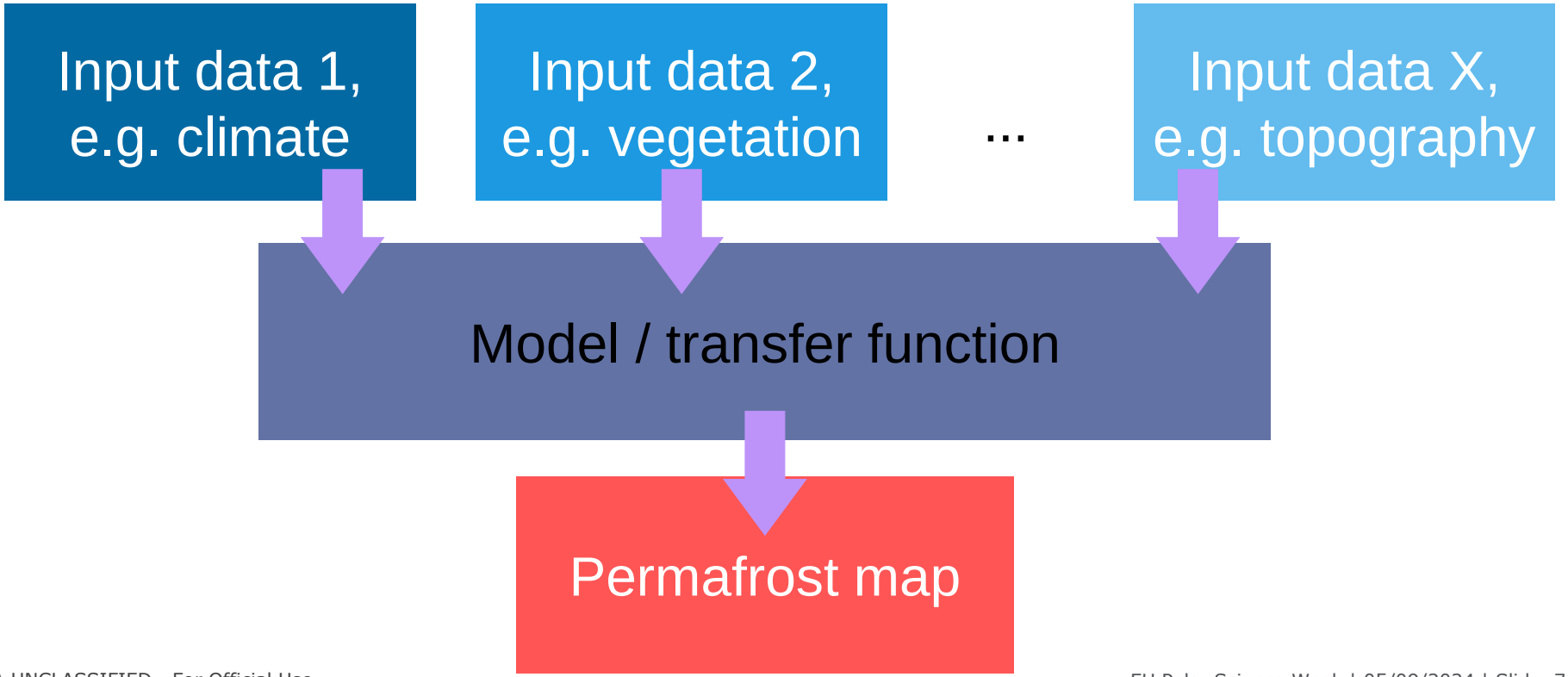


Time series:
- Surface temperatures
- Snowdepth

Site Specifics:
- Ground properties
- Snow properties
- Vegetation
- Topography
- ...

Geothermal heat flux

# How most (current) permafrost maps are produced



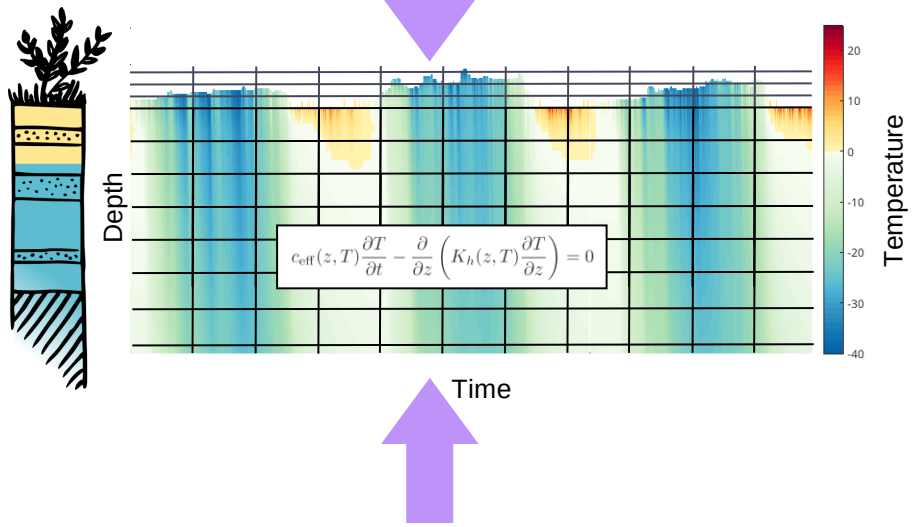
# CryoGrid: Community Model

Time series:

- Surface temperature
- Snowdepth

Site Specifics:

- Ground properties
- Snow properties



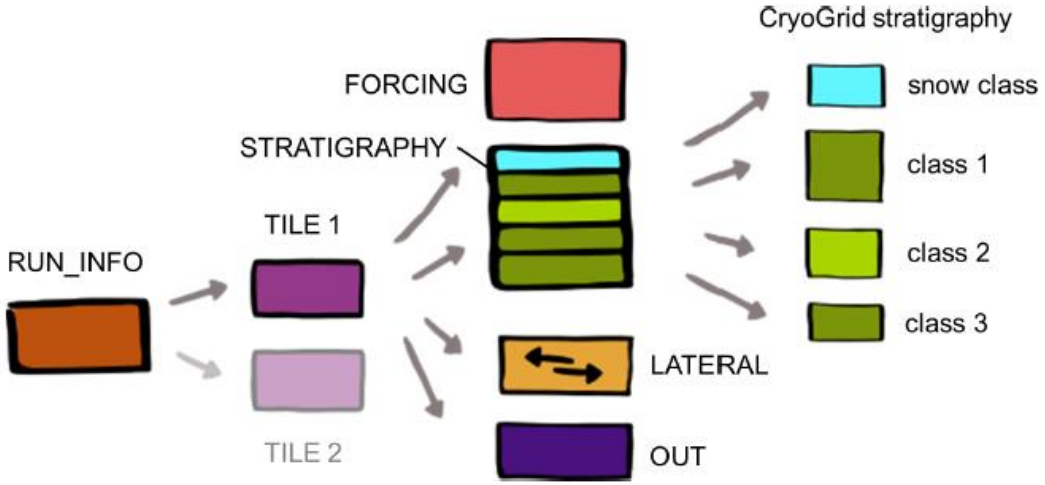

Temperature Field T(z,t)

Geothermal heat flux

Github.com/CryoGrid/CryoGrid
Langer et al. (2013)
Westermann et al. (2017)
Westermann et al. (2023)

# CryoGrid: Community Model

modular structure with inherent compatibility through defined interfaces between «model classes»




- single point/area simulations
- variety of processes
- ensemble simulations
- data assimilation (particle filter, etc.)

# CryoGrid: Community Model

Research article | 05 Oct 2023

Simulating ice segregation and thaw consolidation in perm
comr
Juditha Ag

Research article | 27 Jan 2023

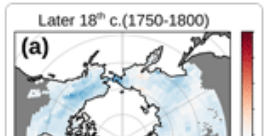
Simulating the effect of subsurface drainag
ground
Cas Renette
Bernd Etzelmü
and Sebastian

Research Article | Open Access

Simulatin
Balance o
Robin B. Zweigel
Clare Webster, S
First published:

Research article | 26 Jan 2024

The evolution of Arctic permafrost over the last 3 centuries from ensemble simi
perr
Moritz L
Simone




Cryogrid modelling of permafrost temperature in the Maritime Antarctic (Barton Peninsula, King George Island)

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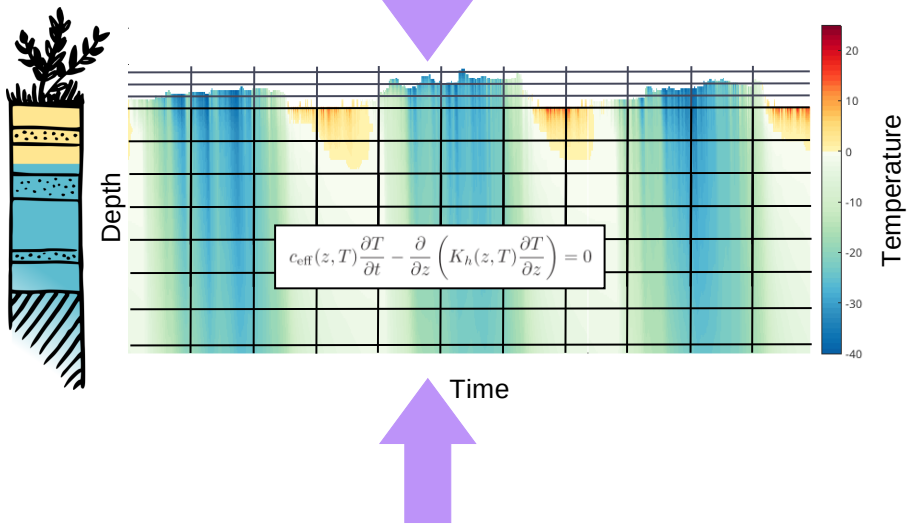
[3]Division of Life Sciences, Korea Polar Research Institute, Incheon, Republic of Korea

# CryoGrid CCI model

Time series:

- MODIS LST + ERA-5
- ERA-5 Snow

- Landcover CCI in-situ Stratigraphies
- Landcover CCI snow model




Temperature Field T(z,t)

- 1km resolution
- (1980) 1997-2021
- Ground temperatures at defined depths
- Active layer thickness
- Permafrost fraction derived from subpixel representation of snow and landcover

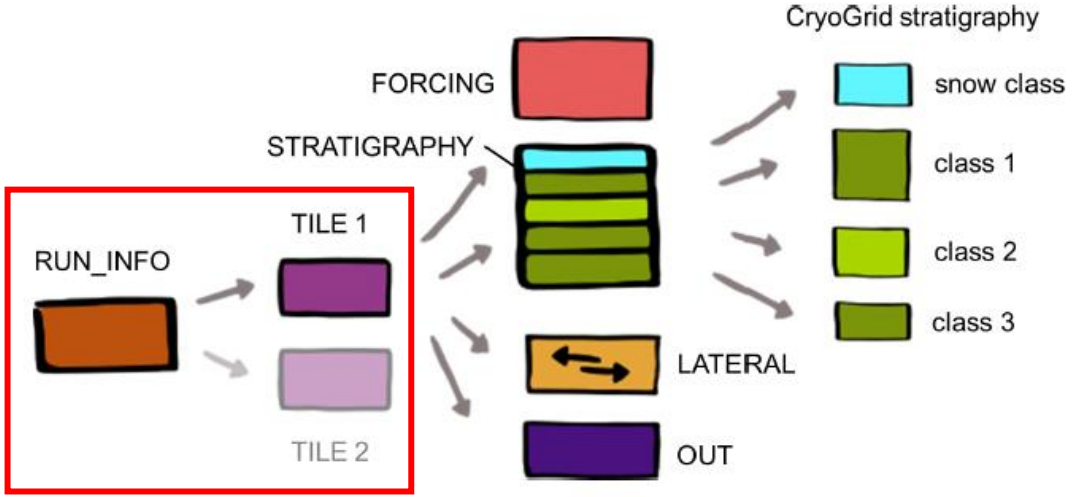
Geothermal heat flux

Github.com/CryoGrid/CryoGrid
Langer et al. (2013)
Westermann et al. (2017)
Westermann et al. (2023)

# CryoGrid CCI workflow

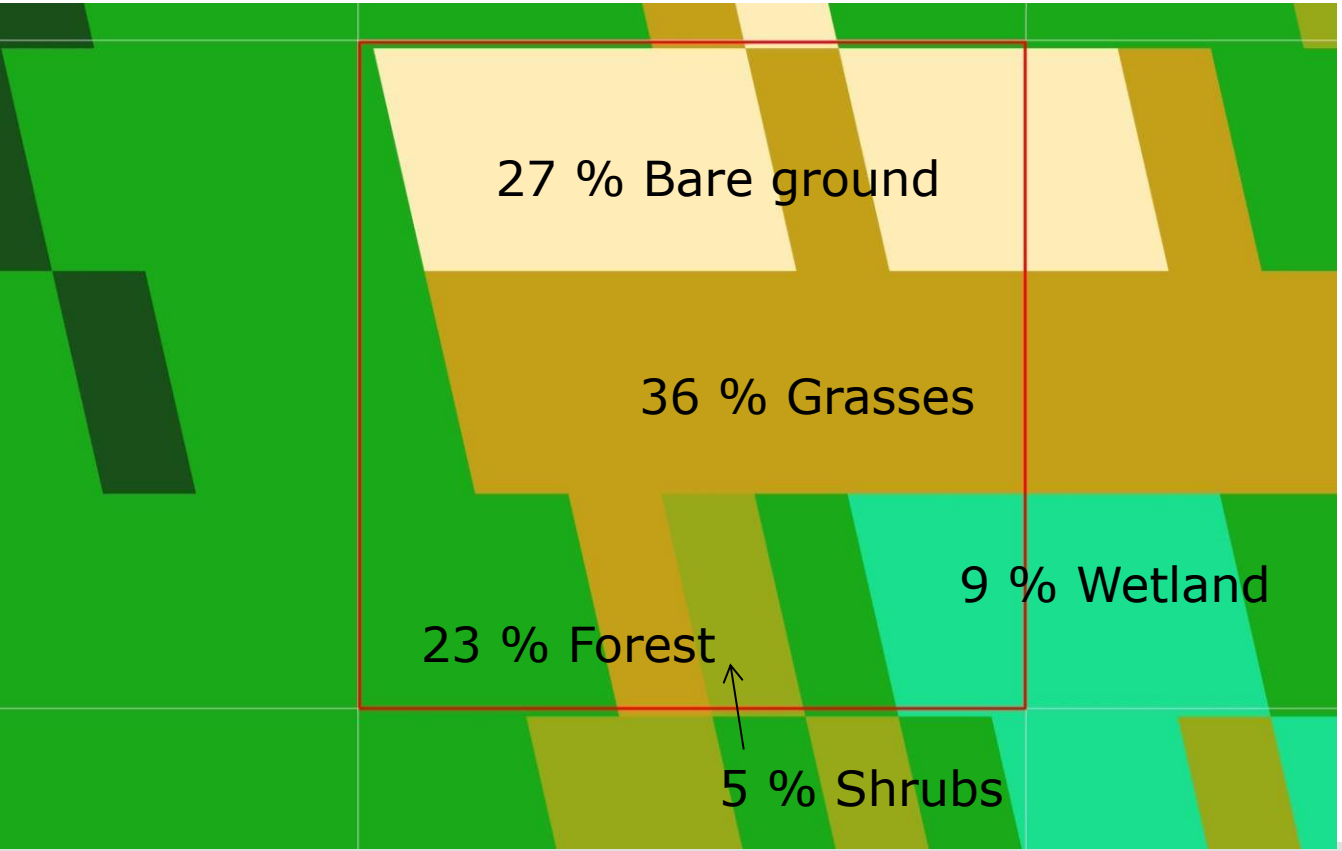
«Data workflow» of ESA CCI processing chain added to CryoGrid community model

already used in several mountain permafrost projects (G. Viera (Portugal), C. Hauck (Switzerland), F. Magnin (France), B. Etzelmüller (Norway))




- single point/area simulations
- spatially distributed simulations
- ensemble simulations
- data assimilation (particle filter, etc.)
- dedicated classes to translate spatial data sets (e.g. DEM, landcover) to model setttings

# Subpixel spatial variability




for each grid cell run ensemble to generate subpixel statistics

Landcover + snow
→ different subsurface stratigraphies and snow properties

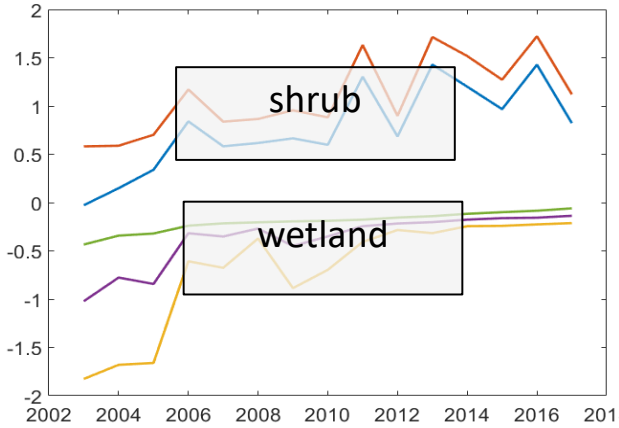
LST has no subpixel varibility

# Model ensembles for each pixel

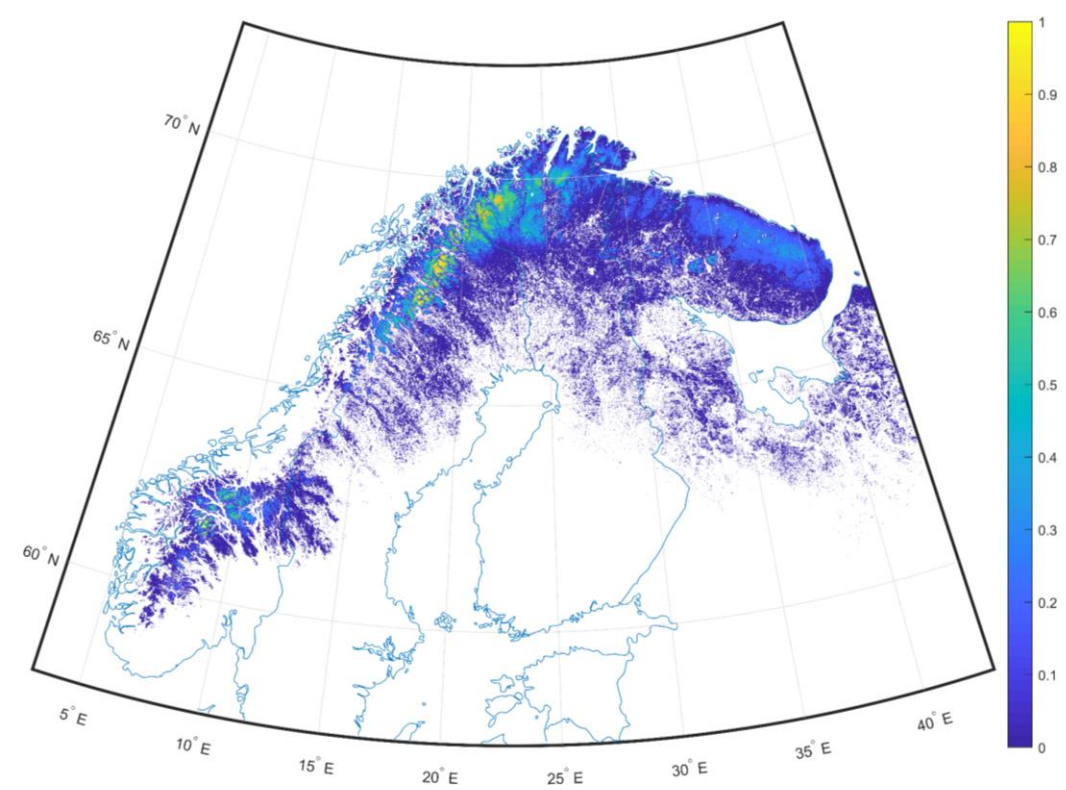
Peat Plateau, Scandinavia

Ground surface temperature

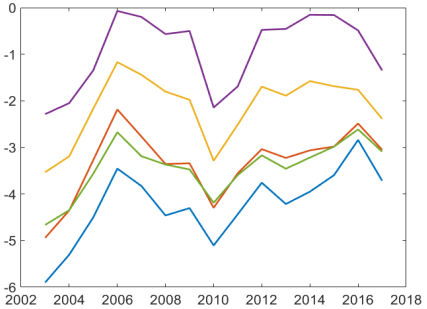

Ground temperature in 1m depth



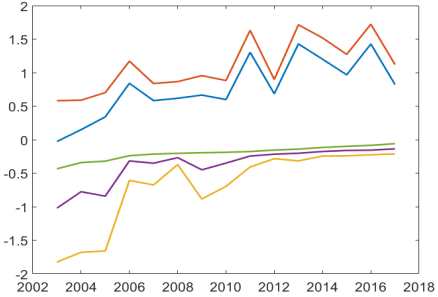
# Permafrost fraction from ensemble runs




Continuous: 100%



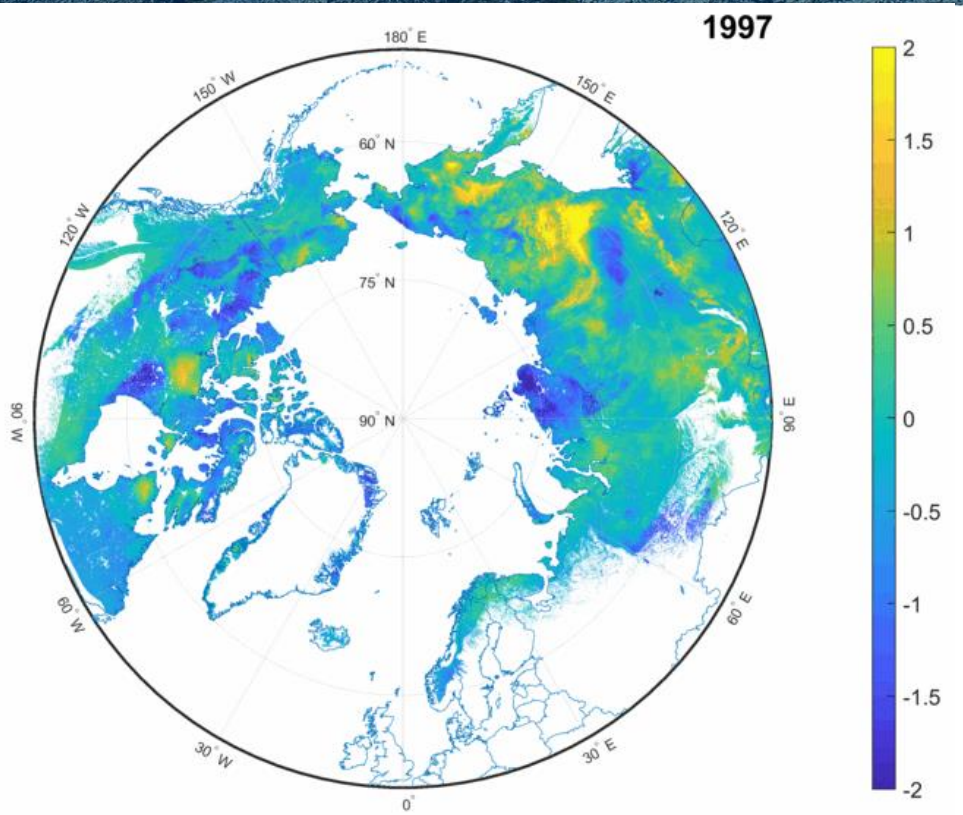

Dis-continuous: 66%



# Results: Ground temperature

2m ground temperature

difference from 2000-2009 average



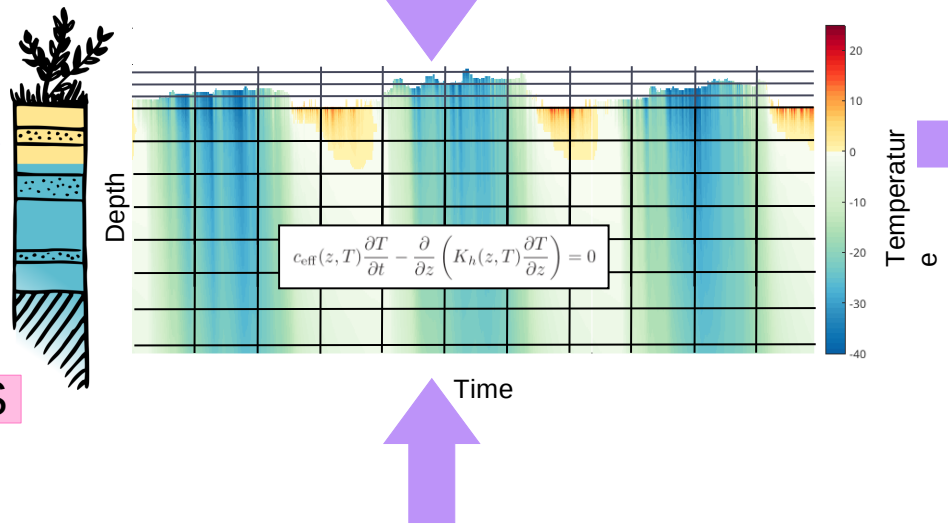
# CryoGrid CCI model improvements

Time series:

- LST_CCI
- SNOW_CCI

- Landcover CCI in-situ stratigraphies
- Londcover CCI snow model

based on CROCUS




Temperature Field T(z,t)

- 0.1° resolution
- (1980) 1997-2021
- Ground temperatures at defined depths
- Active layer thickness
- Permafrost fraction derived from subpixel representation of snow and landcover

Geothermal heat flux

Github.com/CryoGrid/CryoGrid
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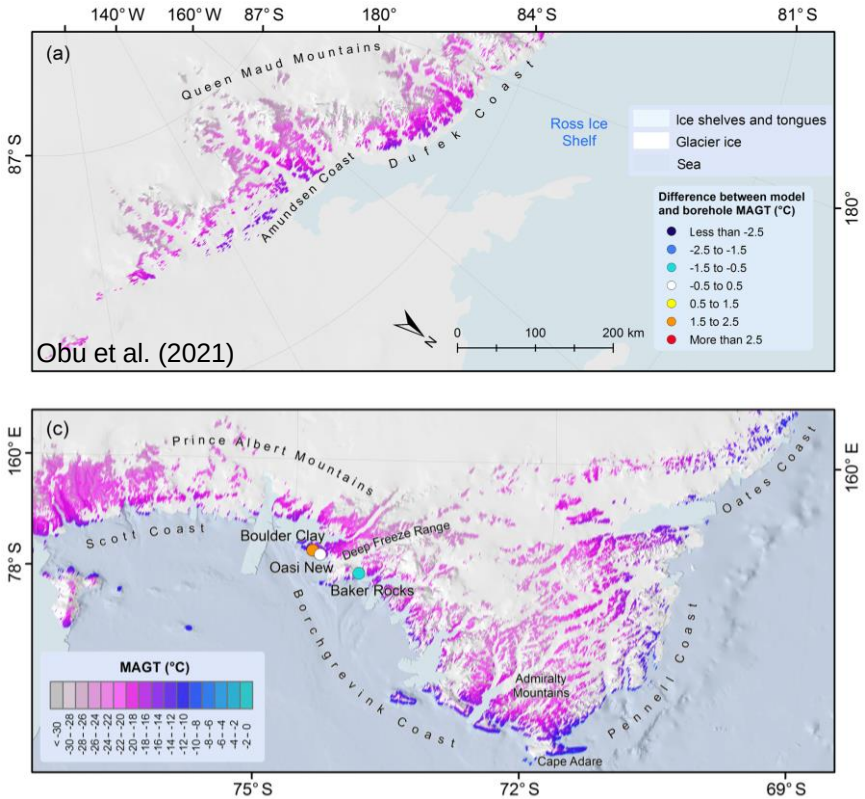
Westermann et al. (2023)

# Ongoing activities: Antarctica

- Current state of the art: static TTOP map from GlobPermafrost (Obu et al., 2021)
- Challenge 1: “normal” permafrost on Antarctic peninsula vs. “Dry valley permafrost” →use snow extent products
- Challenge 2: Antarctica is not covered by snow extent products



# Permafrost: Where will it be?

permafrost extent