

climate change initiative

→ PERMAFROST

Latest results

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permafrost
cci

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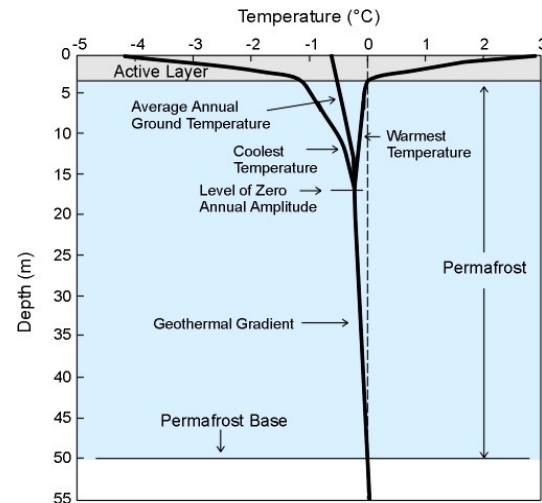
What is required?

Time series of GCOS parameters

- **Active layer thickness**
- **Permafrost temperature**

WMO OSCAR database, user survey etc.

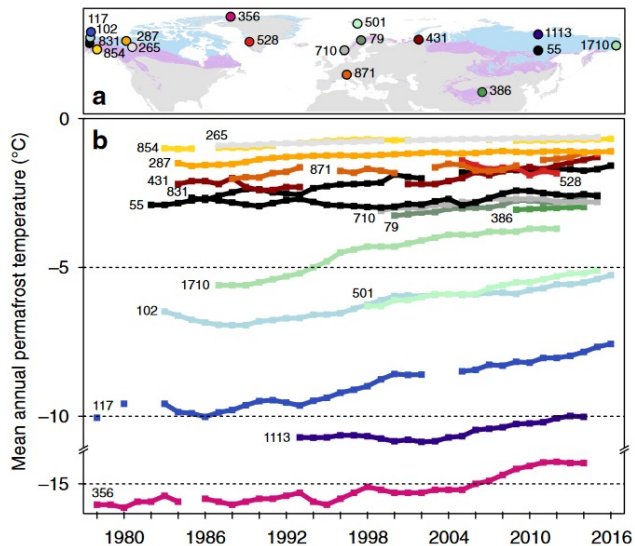
- **Permafrost extent**



http://gsc.nrcan.gc.ca/permafrost/whatis_e.php

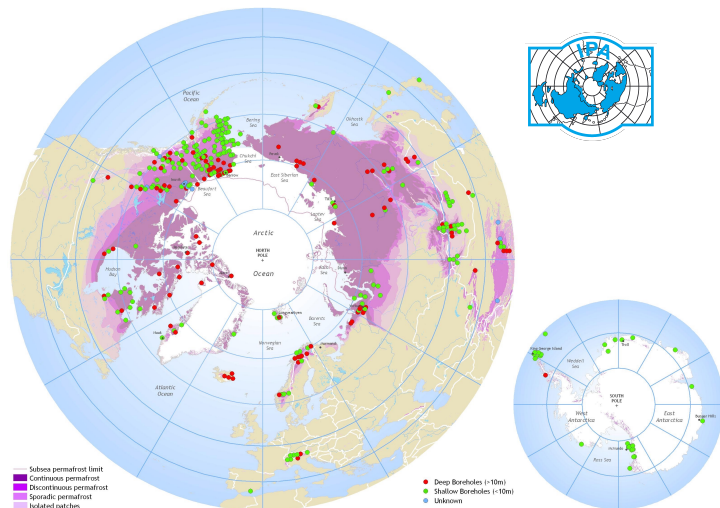


Boreholes



Biskaborn et al. 2019, Nature Communications

Regional mapping



Brown et al. 1997, based on mappings in the 1970s and 1980s

Spatial distribution through modelling using satellite data



CCI+ Permafrost method



MODIS LST + ERA5

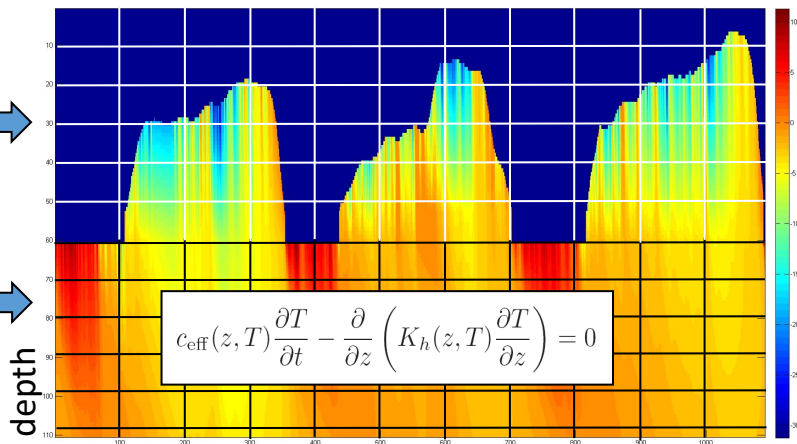
ERA-5



Snow model + Landcover CCI



Landcover r CCI



$$c_{\text{eff}}(z, T) \frac{\partial T}{\partial t} - \frac{\partial}{\partial z} \left(K_h(z, T) \frac{\partial T}{\partial z} \right) = 0$$

Transient modelling is required to produce **time slices**

- need of long-term records of
- Land Surface Temperature,
- Snow, and
- suitable soil parameterization

CCI+ version CryoGRID



UiO : University of Oslo



geothermal heat flux

time





Landsurface temperature

- 1997 - 2002
 - Downscaled and bias corrected ERA reanalyses data based on statistics of the overlap period between ERA reanalysis and MODIS LST
- 2002 - 2019
 - MODIS Landsurface temperature, gap-filled with reanalyses data

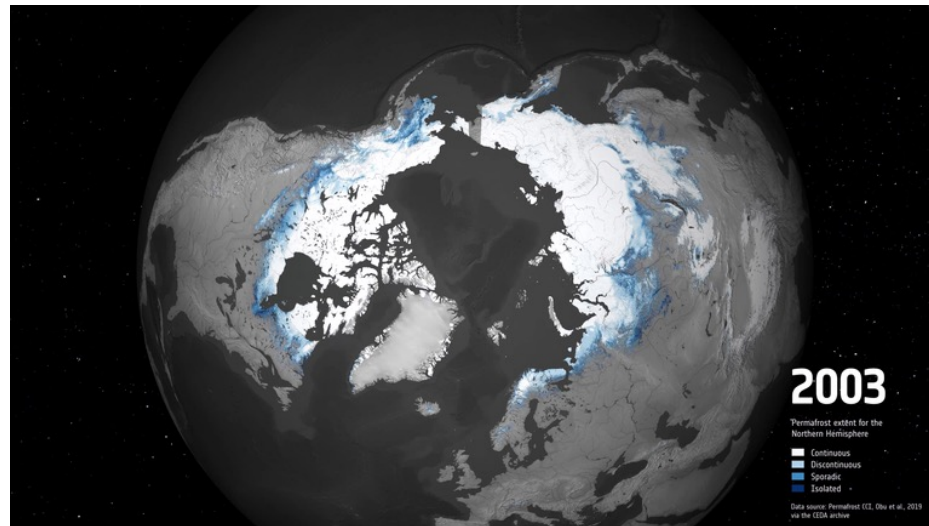


Baseline products for **northern hemisphere (1km)**:

- ❖ Permafrost Temperature
- ❖ Active Layer Thickness
- ❖ Permafrost extent

- ❖ Harmonized borehole records database for calibration and validation
- ❖ Extended and improved DUE Permafrost freeze/thaw product for consistency check

Current version (May 2021): 1997-2019, CRDPv2



Animation: 2003-2017, CRDPv0



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Overview CCI+ Permafrost products

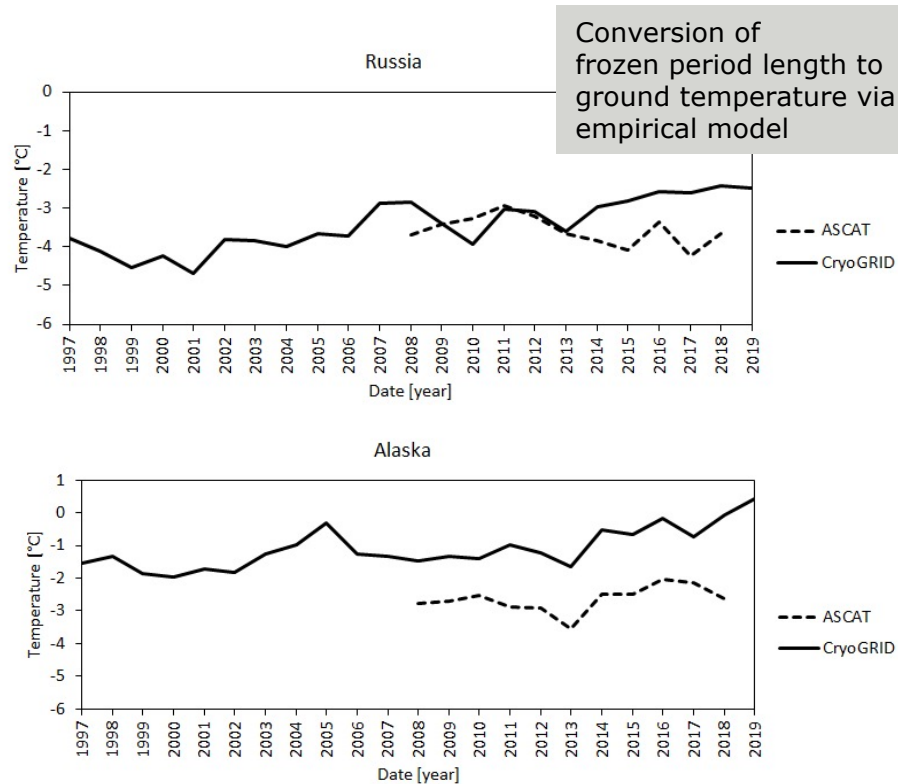


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Options “Rock glacier kinematics as a new parameter of the ECV permafrost”

- Three subprojects with regional focus (Romania, Norway and Switzerland)
- Supporting IPA action group
- Guidelines were applied by different institutes on 11 regions worldwide to produce RGIs including kinematics
- Kinematic time series were produced from DInSAR, SAR offset-tracking and matching of optical images on selected rock glaciers

Rock glacier inventory using InSAR (kinematic approach)

Practical Guidelines v3.0.2

11.06.2020

<https://www3.unifr.ch/geo/geomatics/ibm/research/geo-action-group-research-eligibility/#/page/Group-subgroup>

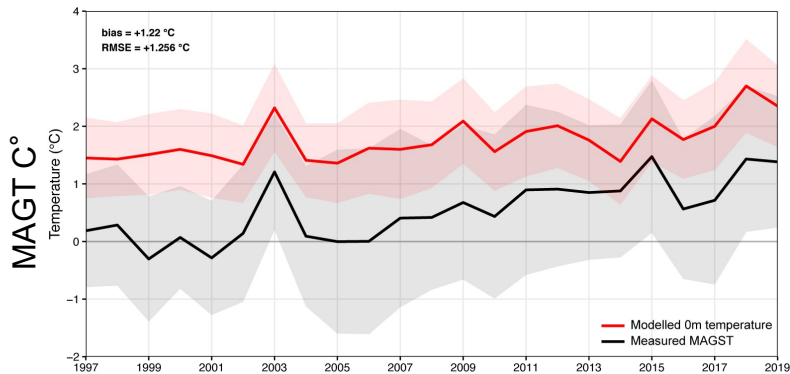
Standard guidelines to produce homogeneous remote sensing based inventories of moving areas and kinematics-based rock glacier inventories

kinematical time series have been developed thanks to the **close collaboration with the international initiative IPA (International Permafrost Association) Action Group «Rock glacier inventories and kinematics»**



❖ Mean annual ground temperature

Layer	Attribute	Units	Data type	notes
GST	Ground surface temperature (depth 0)	Kelvin	Integer	Scaled by 100
T1m	Ground temperature at 1m depth	Kelvin	Integer	Scaled by 100
T2m	Ground temperature at 2m depth	Kelvin	Integer	Scaled by 100
T5m	Ground temperature at 5m depth	Kelvin	Integer	Scaled by 100
T10m	Ground temperature at 10m depth	Kelvin	Integer	Scaled by 100

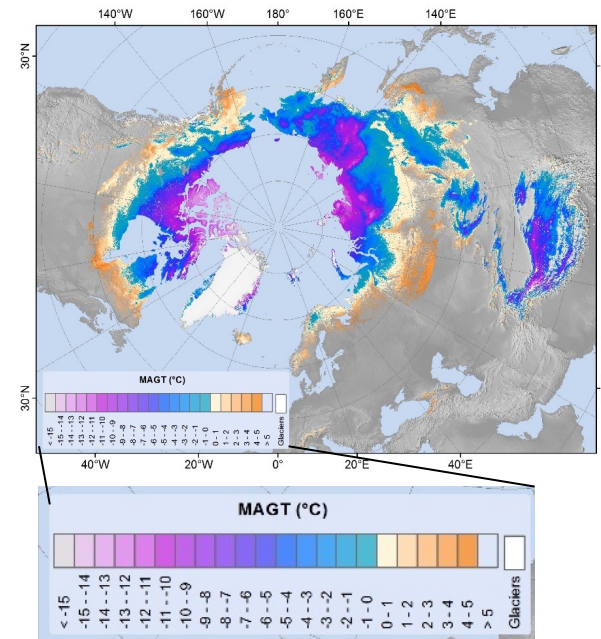


Performance in mountains?



Permafrost_cci MAGST (0m) vs. PERMOS in situ MAGST averaged entire Swiss Alps between 2500-3000 m

1km, polar stereographic



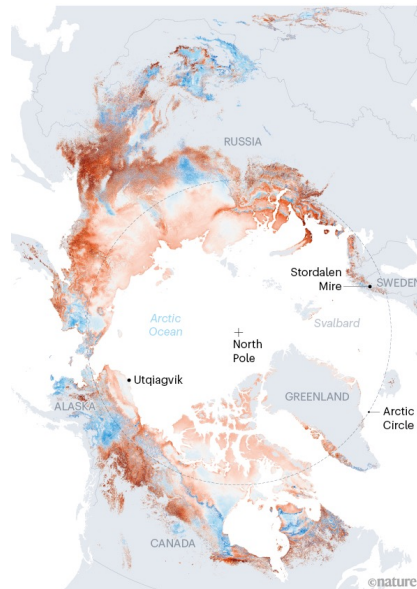
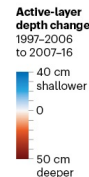


❖ Active layer thickness (ALT):
news feature in Nature 2021

Monique Brouillette (2021): How microbes in permafrost could trigger a massive carbon bomb
Genomics studies are helping to reveal how bacteria and archaea influence one of Earth's largest carbon stores as it begins to thaw. News Feature. Nature 591, 360-362 (2021), doi: <https://doi.org/10.1038/d41586-021-00659-y>

THE BIG THAW

Scientists can track the loss of permafrost using satellite data. The active layer, the soil that thaws and refreezes seasonally, deepened by an average of 2.5 cm across the Northern Hemisphere during 2007-16 compared with the previous decade. For about 5% of the area, the active layer has deepened by more than 30 cm. The deepening active layer destabilizes the landscape and makes more carbon available to microbes in the soil.



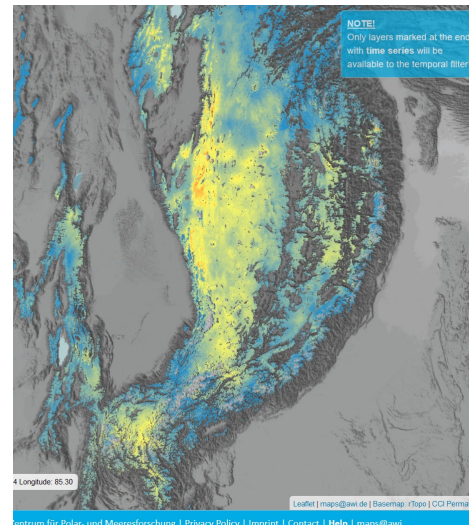
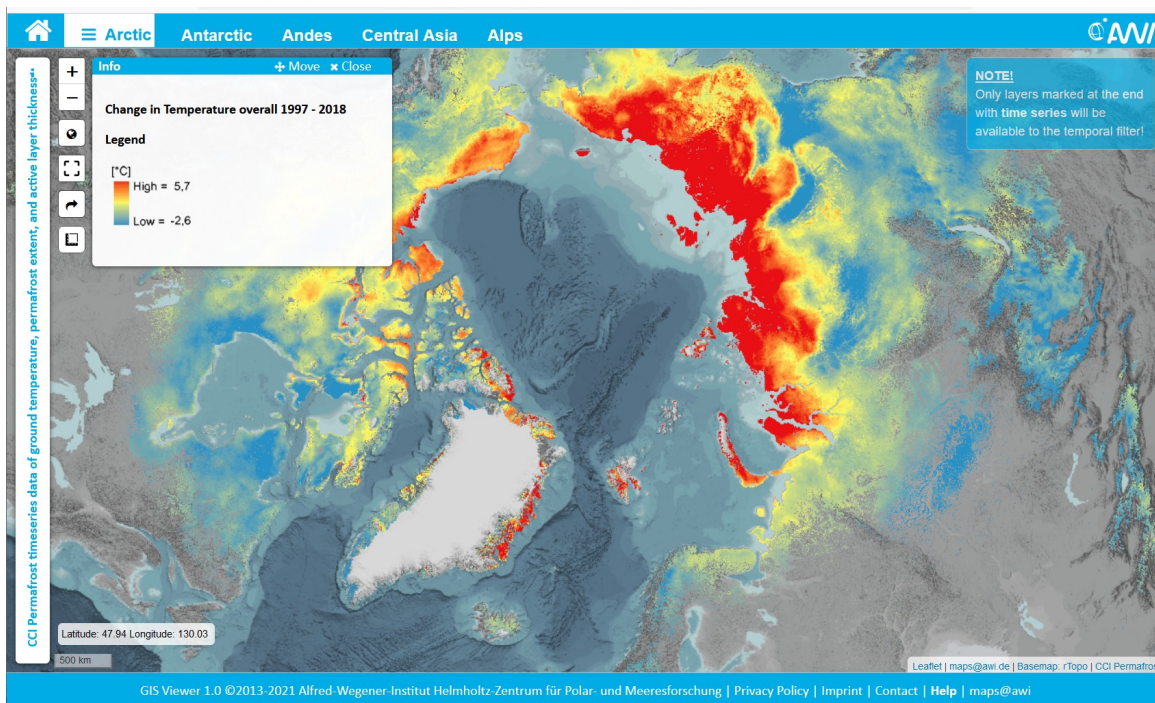
Difference between two decadal averages



Highlights CCI+ Permafrost



Data available via a WebGIS which was setup as part of ESA DUE GlobPermafrost

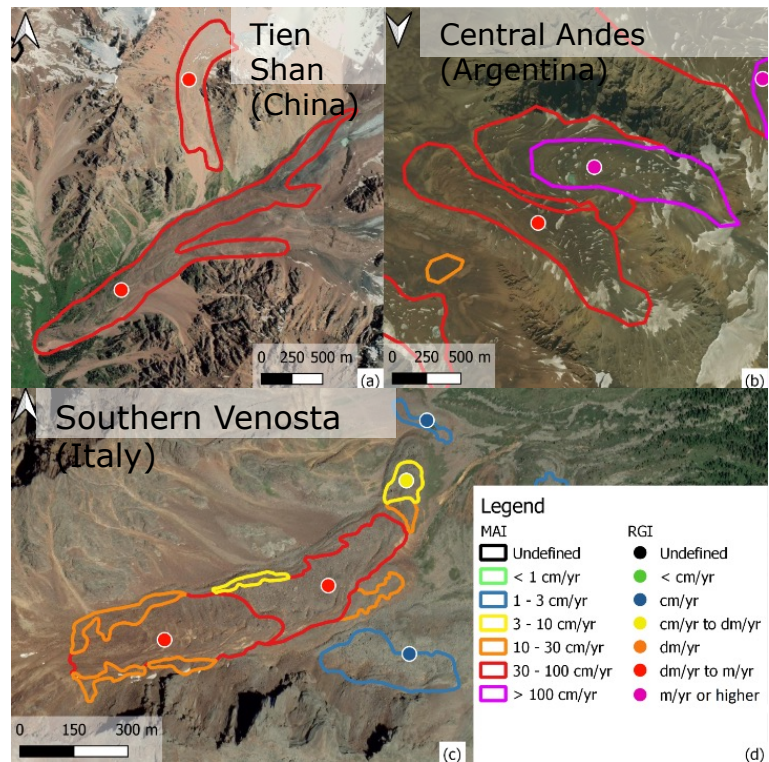
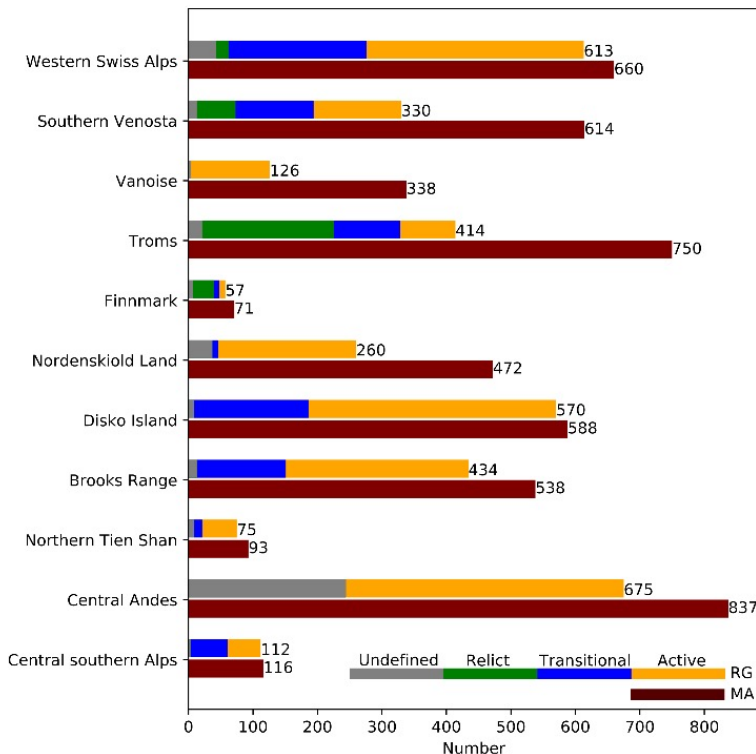




Highlights CCI+ Permafrost



- Rock Glaciers Inventories including kinematics were produced on 11 regions worldwide (paper in preparation)



<https://www.unifr.ch/geo/geomorphology/en/research/cci-permafrost.html>

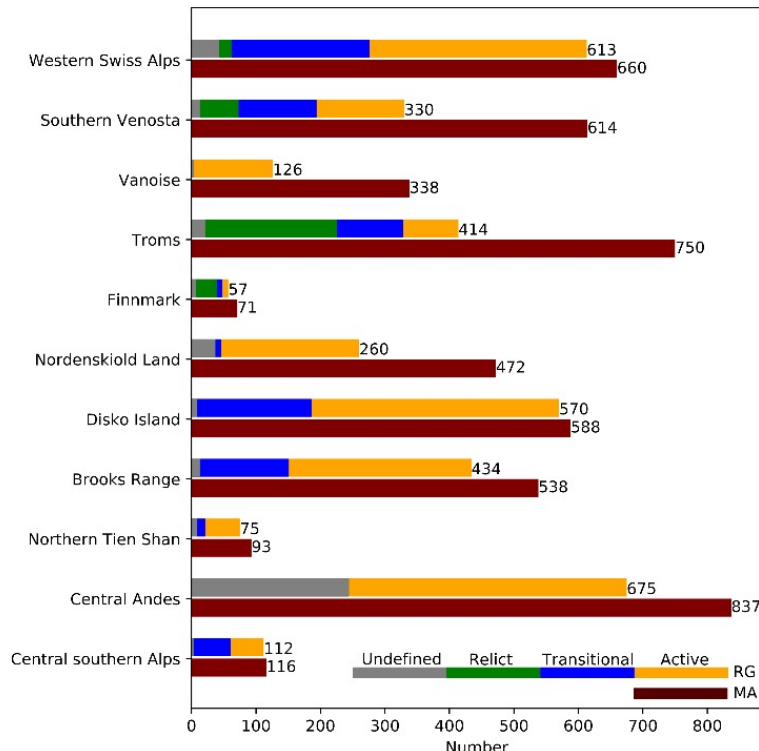




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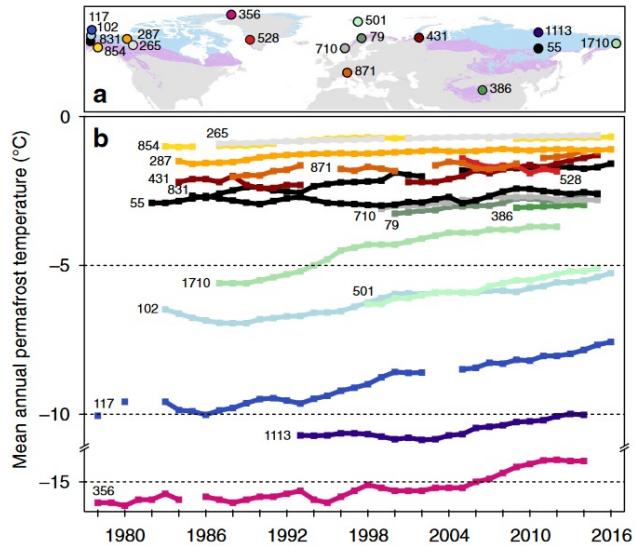
In 2021, Rock Glacier Kinematics was accepted as a new associated parameter to the variable ECV Permafrost for the new GCOS implementation plan.

<https://www.unifr.ch/geo/geomorphology/en/research/cci-permafrost.html>





Boreholes



Biskaborn et al. 2019, Nature Communications

Permafrost_cci CRDPv2

Ground temperature at 2 m depth - CRDPv2 regional average
(spatial subset < 0°C at least 1 year)

