climate change initiative

→ PERMAFROST

Validation of Permafrost_cci II products using international and national monitoring networks

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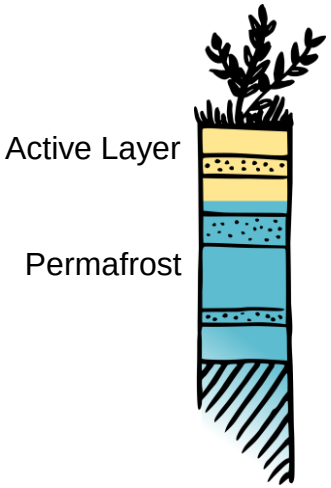
permafrost cci

Permafrost: What is measured in-situ?



Scientific Community ICSU, IUGS, SCAR, IASC

Observing Systems GEOSS, WMO, GCOS, SAON

IPA

National Organisations

GTN-P Global Terrestrial Network for Permafrost

GCOS GTN-P / IPA + PERMOS (CH)

PERMOS

+ national & thematic monitoring networks

ABoVE Science Cloud

Nordicana D

Global Terrestrial Network for Permafrost - Database

Data Repositories

NSF Arctic Data Center

PANGAEA.

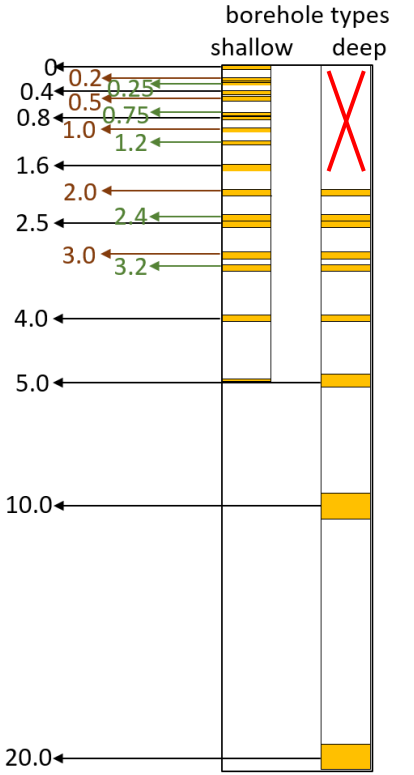
USGS science for a changing world

ABoVE ARCTIC - BOREAL VULNERABILITY EXPERIMENT

NASA

- Ground that is at or below 0° C MAGT for at least 2 consecutive years
- **ECVs: active layer thickness, permafrost temperature**

Ground Temperature Reference Data



Permafrost_cci GTD dephts

0 m

1 m

2 m

5 m

10 m

Permafrost_ cci Ground Temperature per Depth GTD represents Mean Annual GT MAGT

Permafrost_cci GTD time series at 0.0, 1.0, 2.0, 5.0, 10 m depths

Permafrost_cci reference data collection for match-up analyses:

In-situ MAGT time series down to 20 m depth

different depths per measurement programs, filling up missing depths by interpolation (quality criteria: yes, if sensors at high depth resolution)

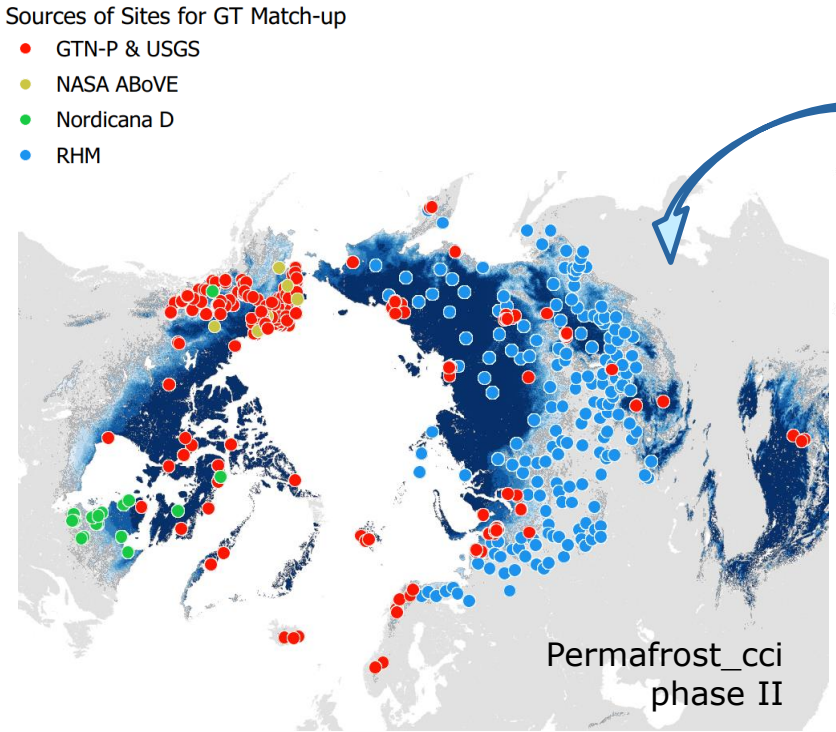
Permafrost_cci product team supplies **GTD time series for all depths for all boreholes** -> validation across all available in-situ depths

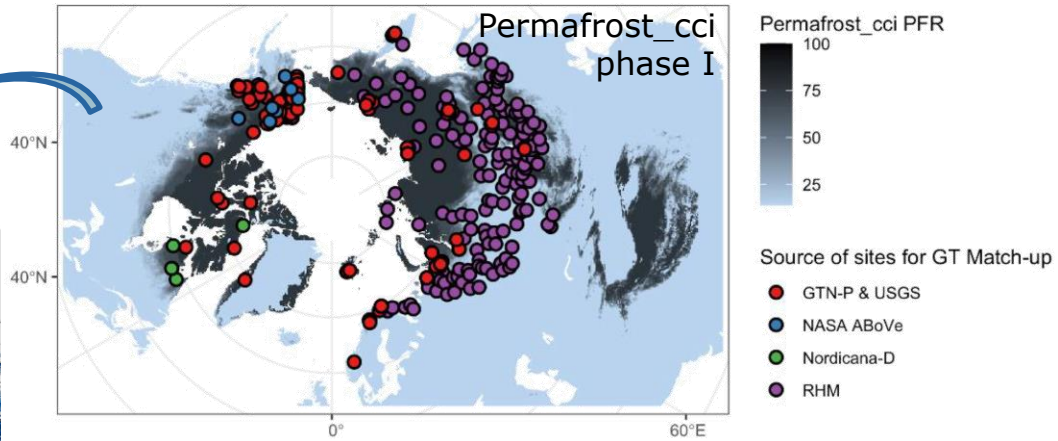
n = 13,614 match-up pairs (in time and depth) for 477 sites

n = 27,389 match-up pairs for 477 sites for the interpolated dataset

Permafrost_cci standardised MAGT reference data FAIR Data Publication in PANGAEA (in submission)
ESSD manuscript (in preparation)

Ground Temperature Reference Data

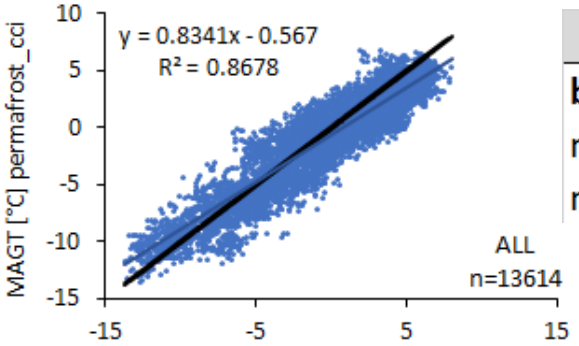




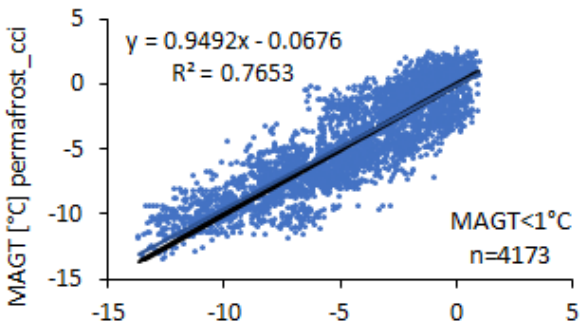
possible due to user feedback from Permafrost_cci workshops:

- additional GT depths for validation: 0.1 m + 1.50 m
- additional in-situ GT and ALT sites
  boreal North America (Alaska, Canada)

Assessment of Permafrost_cci GTDv4



	all	<1°C
bias		
mean±SD	-0.73 ± 1.55	0.15 ± 1.78
median	-0.89	0.38



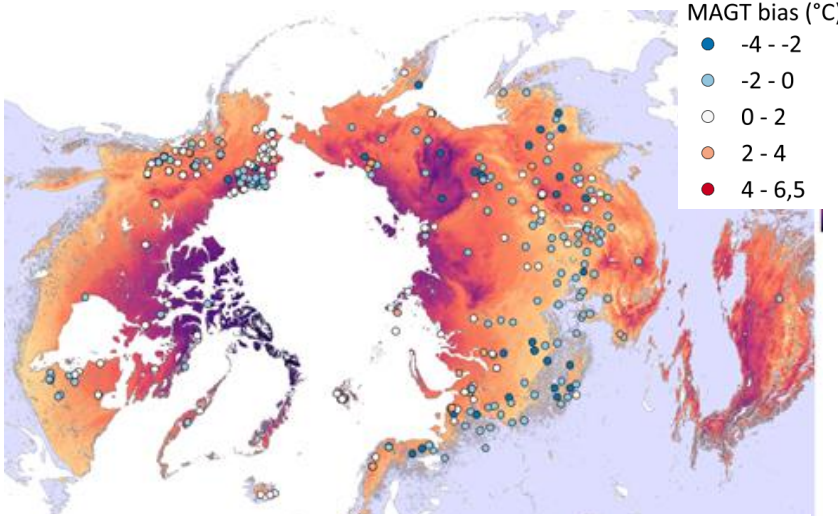
‚permafrost' = MAGT < 1°C

GTD median bias **-0.89 °C**, for ‚cold sites' GTD median bias is lower: **0.38 °C**.

for ‚permafrost sites' without GTD = 0 m the quality is high with a **mean bias of 0.08 °C**.

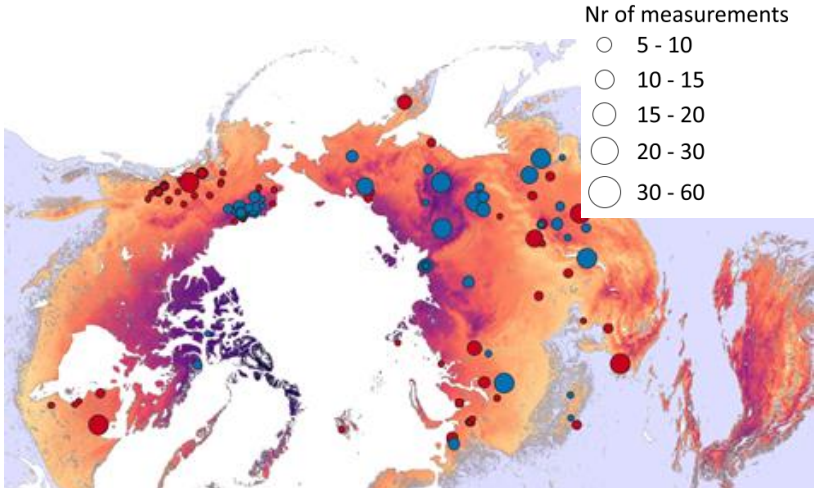
stable GTD bias across depths with a larger negative mean bias in shallow depths (0 to 3m), mainly caused by a negative bias in match-up pairs of the ‚non permafrost sites' (MAGT >= 1°C). The surface temperature GTD = 0 m shows the largest bias of the permafrost site subgroup.

Assessment of Permafrost_cci GTDv4



Permafrost_cci GTD bias is mainly negative at the southern boundary zones in Siberia and Northern America

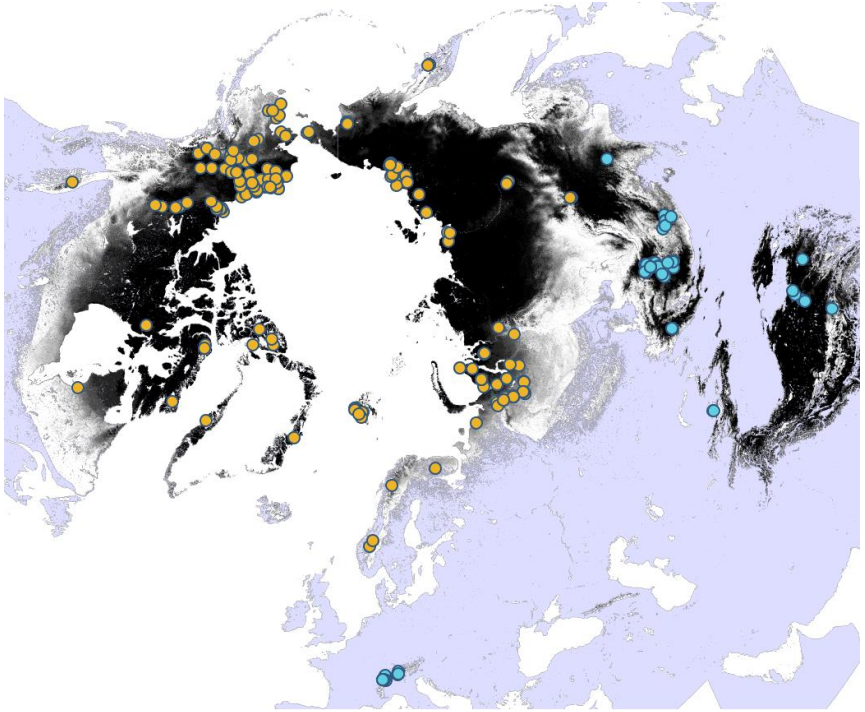
bias



extreme residuals appear with <5% quantile mainly in Northern Alaska and Eastern Siberia and with >95% quantile mainly in the southern discontinous, sporadic and non permafrost zones.

residuals
>95% (red) and <5% quantile (blue)

Active Layer Depth Reference Data



CALM

ALT sites for Match-Up analyses

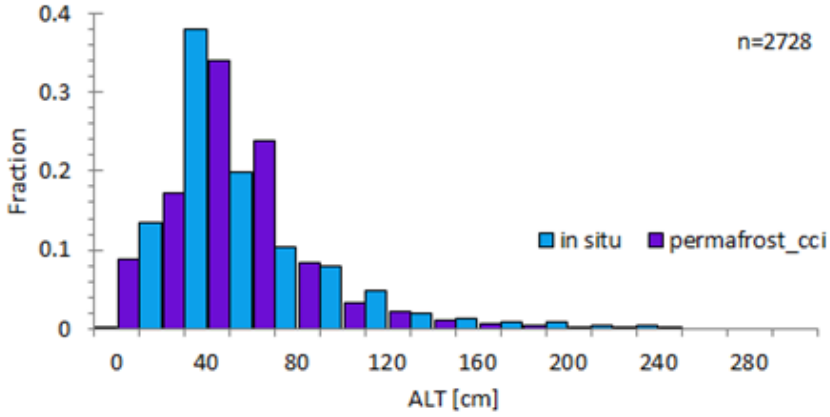
- Region used or validation
- Region excluded from validation

Permafrost_cci PFR (year 2021)

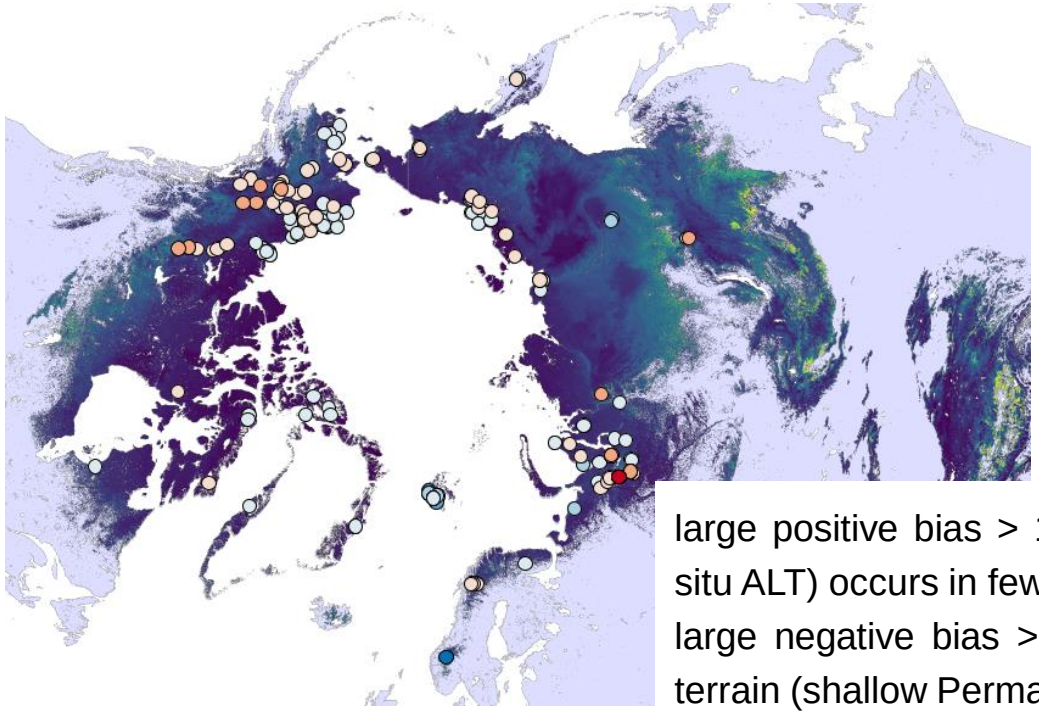
100

0

both Permafrost_cci ALT and in-situ ALT show highest abundance in shallow ALT range



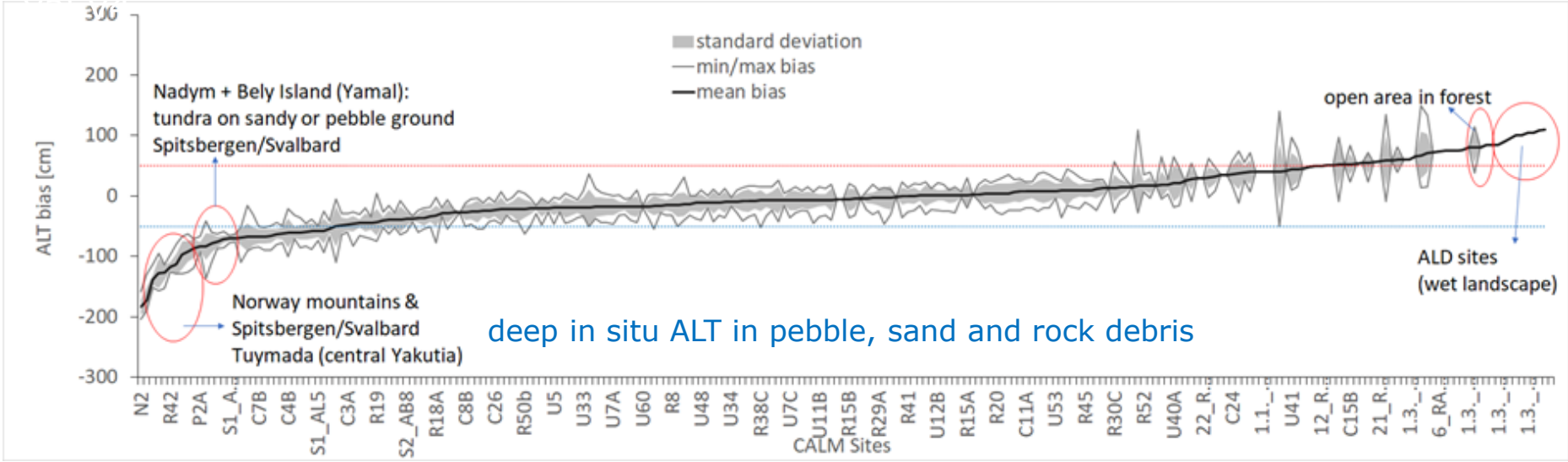
Assessment of Permafrost_cci ALTv4



bias		
mean±SD	-17.33 ±	43.8
median	-13	
abs_bias		
mean±SD	33.31 ±	33.3
median	22	

large positive bias > 1 m (deep Permafrost_cci ALT versus shallow in situ ALT) occurs in few match-up pairs in Alaska, Canada and Russia.
large negative bias > -1.5 m occurs in Svalbard in rocky and pebble terrain (shallow Permafrost_cci ALT versus deep in situ ALT).

Assessment of Permafrost_cci ALTv4

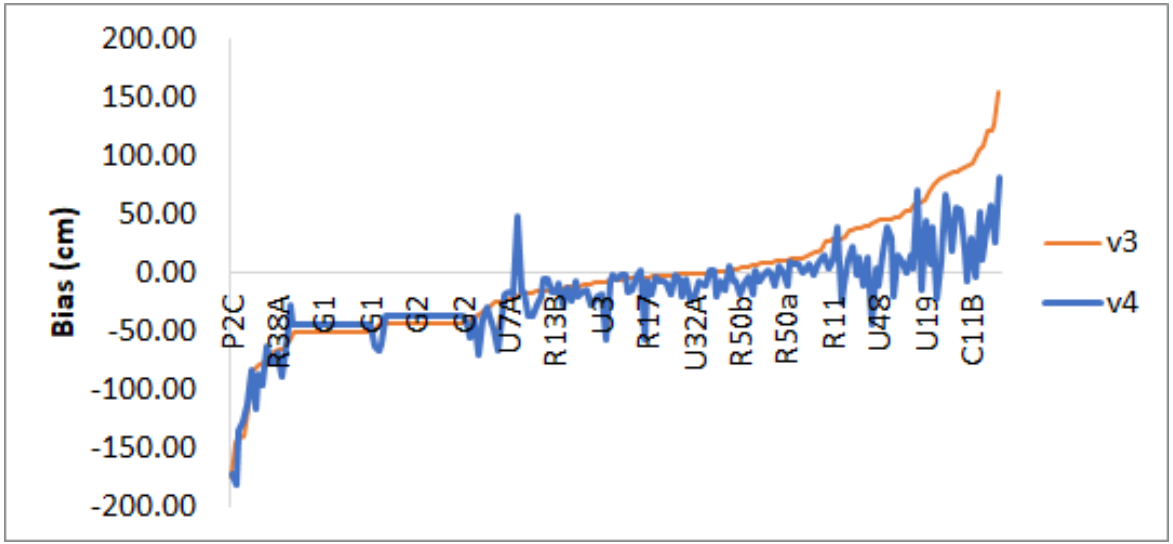


mean bias (Mongolia, China, Swiss Mountains excl.). x-Axis sorted by mean bias.

blue line = bias - 50 cm (Permafrost cci ALT too shallow)

red line = bias + 50 cm (Permafrost_cci ALT too deep).

Active Layer Thickness ALT Improvements phase II vs I



	bias		abs_bias	
Permafrost_cci	I	II	I	II
Canada	19.12	-18.68	55.17	45.33
Greenland	-44.70	-39.37	44.70	39.37
Svalbard	-119.05	-111.23	119.05	111.23
Russia	-7.29	-21.88	28.09	30.30
US	10.53	-2.75	23.33	19.82

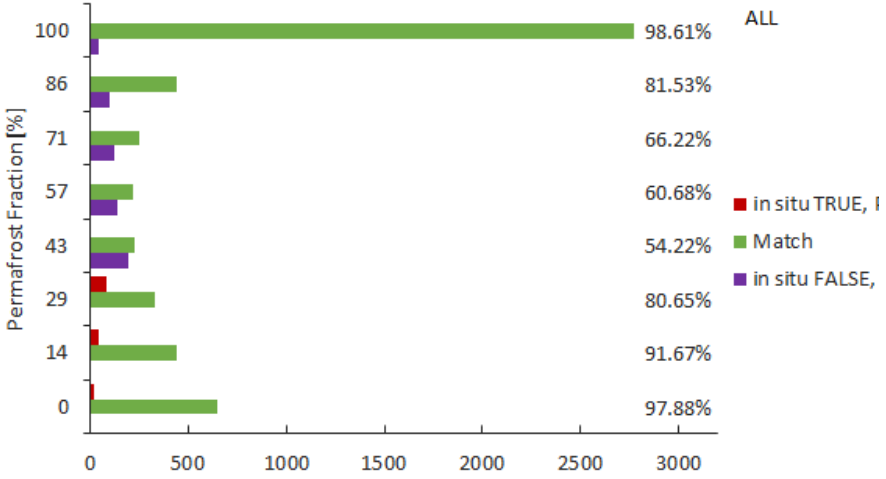
only sites available in both validation rounds are used for the comparison

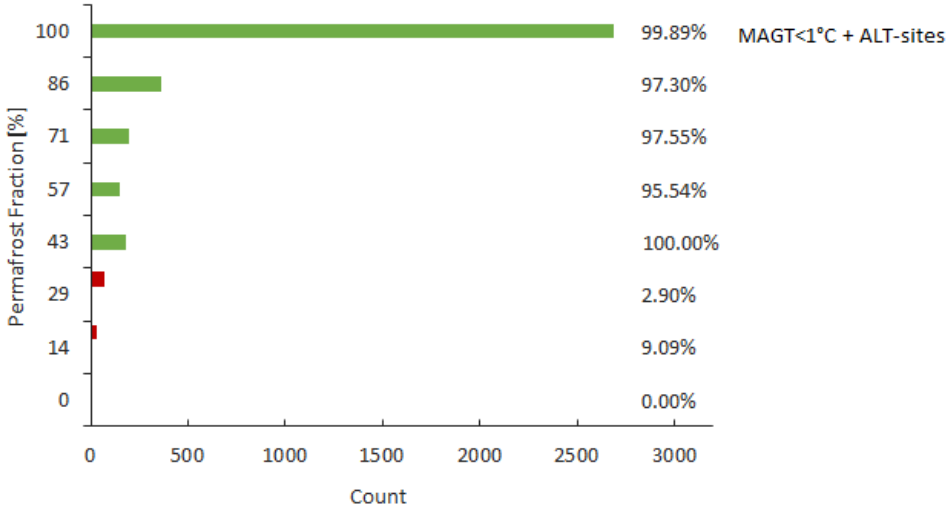
mean bias (Mongolia, China, Swiss Mountains excl.). x-Axis sorted by phase I mean bias.

blue line = phase II bias, orange line = phase I sorted bias

Permafrost Fraction PFRv4

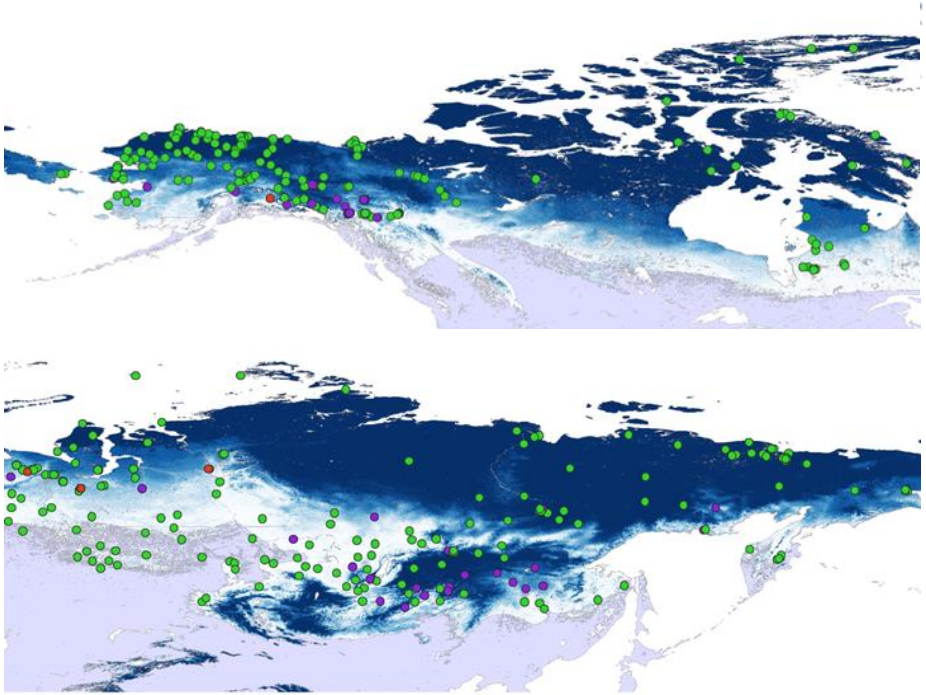
agreement of non permafrost for PFR<= 29 % and permafrost for PFR >=71%





TRUE: PFR > 40 % AND (IN SITU MAGT< 0.5°C OR ALT)

Permafrost Fraction PFRv4



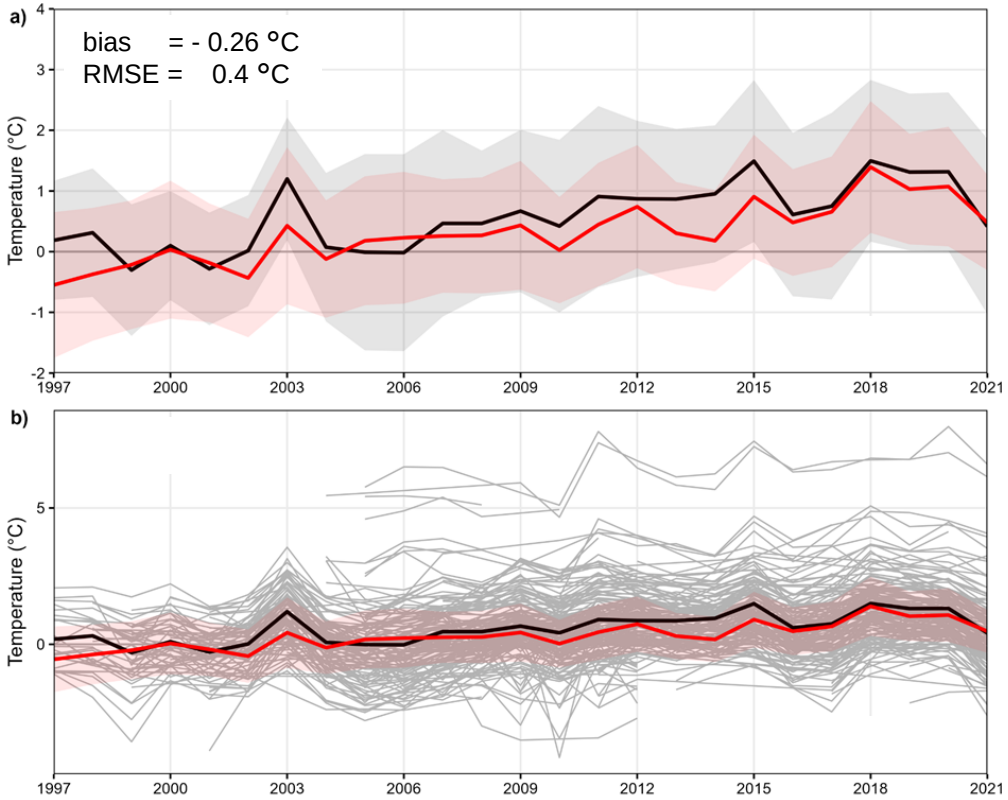
majority of PFR match-up pairs

(83.89 % PFR <=14 % and 87.99 % for PFR <= 29 %)

in agreement between in-situ vs. Permafrost_cci abundance yes / no.

notably, the **100 % and the 0 % Permafrost_cci PFR show high percentage of agreement, with 98.61 % and 97.88 % match**.

PERMOS Assessment of Permafrost_cci GTDv4



Permafrost_cci GTD 1997 - 2021
PERMOS permafrost monitoring

a) CH mean MAGST (black)
b) MAGST at each logger

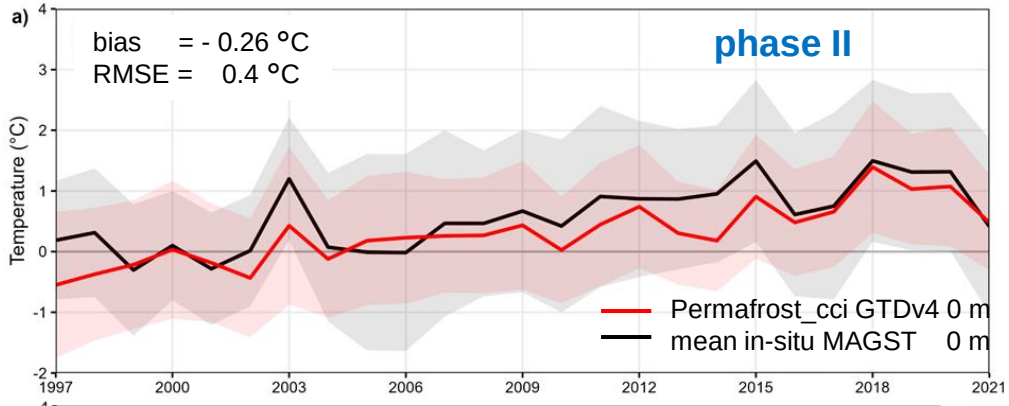
compared to **mean Permafrost_cci GTD at 0 m** (red) over the entire Swiss Alps between 2500 and 3000 m a.s.l. (shaded ± sdv.)

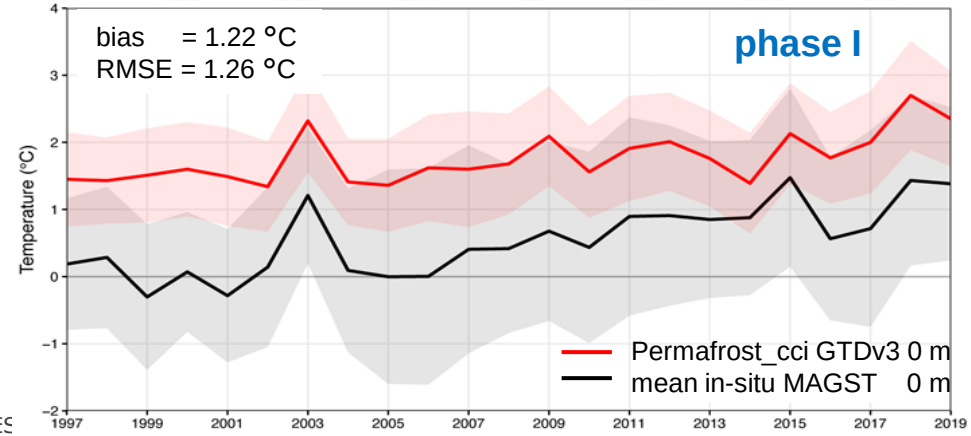
Permafrost_cci GTD 0 m cold bias -0.27 °C

Warming tendency observed in-situ well reproduced by Permafrost_cci GTDv4, as well as the inter-annual variability.

- Permafrost_cci GTD 0 m
- in-situ MAGST/ site 0 m
- mean in-situ MAGST 0 m

PERMOS Assessment of Permafrost_cci GTDv4





Permafrost_cci GTD 1997 - 2021
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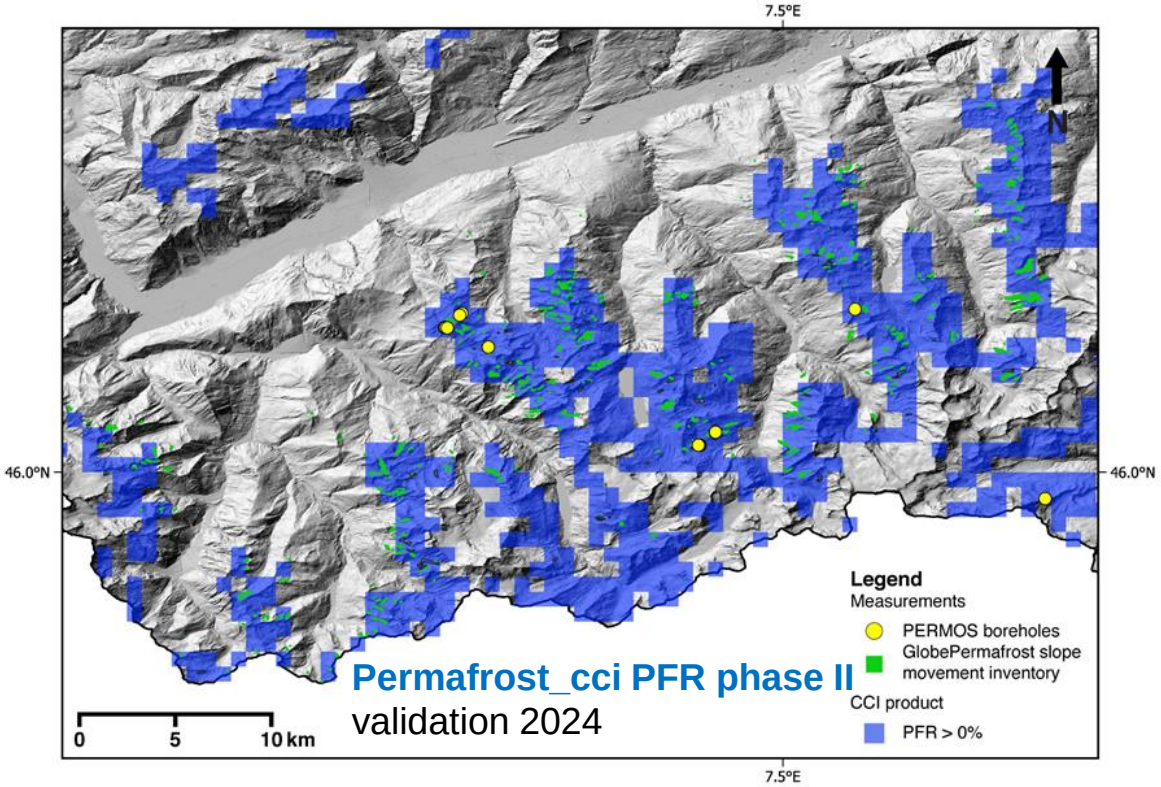
compared to **mean Permafrost_cci GTD at 0 m** (red) over the entire Swiss Alps between 2500 and 3000 m a.s.l. shaded ± sdv.

Permafrost_cci GTD phase II considerably better performance compared to phase I

warm bias +1.22°C became a slight cold bias -0.26°C.

PERMOS Assessment of Permafrost_cci PFRv4

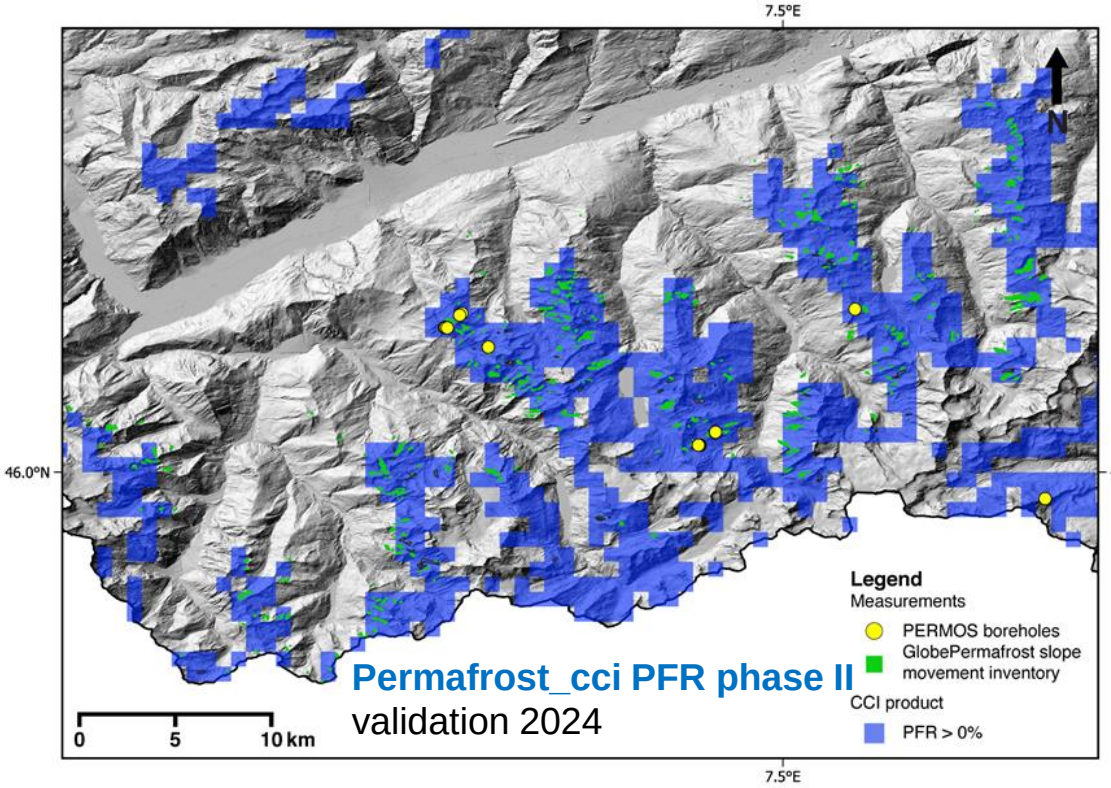


Permafrost_cci PFR 2021
Bas-Valais (CH)

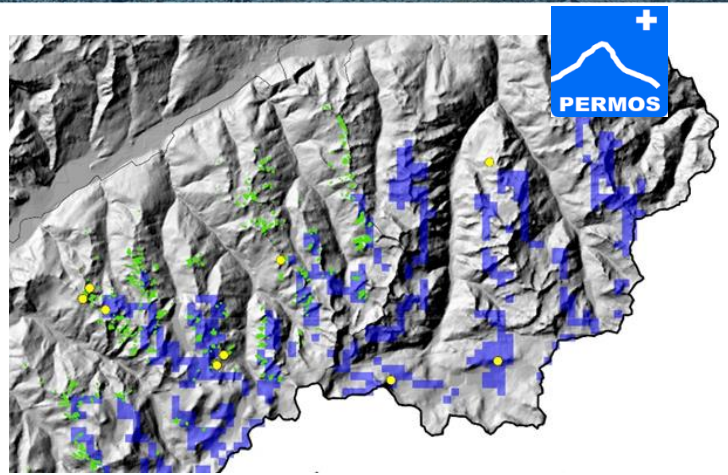
ESA GlobPermafrost slope movement inventory
(rock glaciers, push moraines)

PERMOS permafrost monitoring boreholes
11 PERMOS boreholes in Permafrost one not in PFR > 0%

PERMOS Assessment of Permafrost_cci PFR



Permafrost_cci PFR phase II
validation 2024



Permafrost_cci PFR phase I
validation 2021
majority of slope movement and PERMOS boreholes outside permafrost.

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Thanks to IPA/GTN-P, to all measurement programs and all data providers and data repositories

FAIR Permafrost

permafrost cci