Permafrost_cci status

Annett Bartsch (1), Tazio Strozzi (2), Andreas Wiesmann (2), Sebastian Westermann (3), Kristoffer Aalstad (3), Joel Fiddes (3), Andreas Kääb (3), Jaroslav Obu (3), Guido Grosse (4), Birgit Heim (4), Heidrun Matthes (4), Ingmar Nitze (4), Annette Rinke (4), Gustaf Hugelius (5), Juri Palmtag (5), Chloé Barboux (6), Reynald Delaloye (6), Cecile Pellet (6), Aldo Bertone (6), Christine Kroisleitner (1), Alexandru Onaca (7), Florina Ardelean (7), Valentin Poncos (8), Line Rouyet (9), Hanne Christiansen (10) and Frank Martin Seifert (11)

(1) b.geos Austria, (2) GAMMA Remote Sensing, Switzerland, (3) University of Oslo, Department of Geosciences, Oslo, Norway, (4) Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Germany, (5) University of Stockholm, Sweden, (6) University of Fribourg, Switzerland, (7) University West Timisoara, Romania, (8) Terrasigna, Romania, (9) NORCE, (10) UNIS, (11) European Space Agency

Introduction to permafrost cci

The ultimate objective of Permafrost_cci is to develop and deliver permafrost maps as ECV products primarily derived from satellite measurements.

The required associated parameters by GCOS for the ECV Permafrost are
- **Depth of active layer (m**) and
- **Permafrost temperature (K)**.

Rock glacier kinematics have been proposed as a new parameter and are therefore also addressed in Permafrost_cci.

Algorithms have been identified which can provide these parameters ingesting a set of global satellite data products (Land Surface Temperature LST, Snow Water Equivalent SWE, and landcover) in a permafrost model scheme that computes the ground thermal regime. In Permafrost_cci we will strongly rely on data products from recent, ongoing and future ESA projects (e.g. LST_cci, Snow_cci), which offer consistency over several satellite generations.

Validation and evaluation efforts comprise comparison to in-situ measurements of
- subsurface properties (active layer depth, active layer and permafrost temperatures, organic layer thickness, liquid water content in the active layer and permafrost) and
- surface properties (vegetation cover, snow depth, surface and air temperatures) as well as
- rock glacier inventories, local permafrost maps and geophysical survey measurements.

Status: All tasks of phase 2 have been completed.

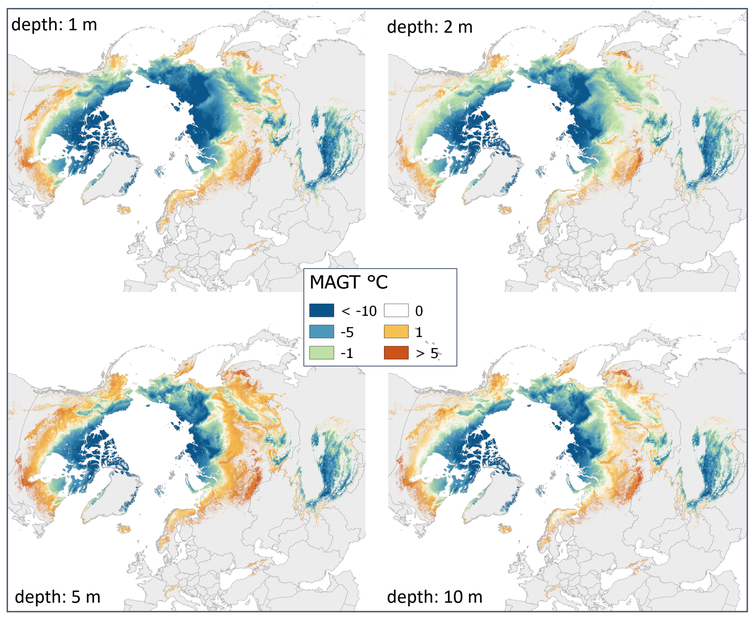
Task 4: Generation & validation

Climate Research Data Package v1

Temporal Coverage: CRDPv1 covers the years from 1997 to 2018, with the data available for each year of the period.

- Spatial Coverage: CRDPv1 pertains Arctic and High-Mountain permafrost environments, extending down to 35°N latitude in the North America and down to 25°N in Asia. The projection is Arctic Polar Stereographic, with 0.927 km grid spacing.
- Data availability and release: CRDPv1 will be made available through the CCI Data Portal (http://cci.esa.int/data)

Figure 3: Average ground temperature (2007-2013, CRDPv0) using Cryogrid CCI model for depths of 1,2,5 and 10 meters



Ground temperature versus in situ

Table 2: Permafrost_cci MAGT SIN versus in situ MAGT

	CRDPv1			CRDPv0	
	all sites (n=14254)	Site MAGT<1°C (n=3741)	MAGT<1°C, depth ≥ 40 cm (n=3021)	Site MAGT<1°C (n=2841)	MAGT<1°C, depth ≥ 40 cm (n=2215)
bias	-0.47	1.03	1.01	-0.47	-0.12
RSME	1.65	1.85	1.81	1.98	1.72
Slope	0.76	0.88	0.89	0.94	0.93
Intercept	-0.18	0.55	0.53	-0.73	-0.39
r^2	0.86	0.79	0.80	0.70	0.75
RPE 5% Quantile	-223.50	-347.06	-387.05	-126.95	-126.95
RPE 95% Quantile	105.01	121.13	131.64	283.96	283.96
RPE (%) 5-95% Quantile	32.33	36.17	39.05	15.06	4.64
APE 5% Quantile	3.77	3.51	3.51	2.80	2.80
APE 95% Quantile	399.59	475.93	492.15	428.85	428.85
APE (%) 5-95% Quantile	52.84	68.43	73.40	60.63	56.98

Upcoming

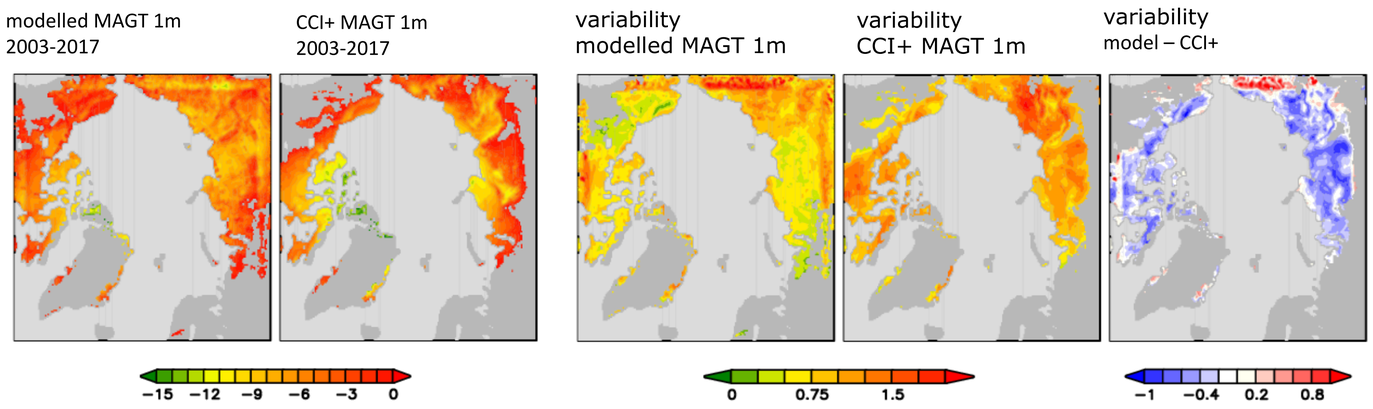
In year 3 further CCI datasets will be utilized for the production of the climate data research package. All planned use cases will be completed.

Task 5: Assessment and case studies

Case studies progress:

❖ Evaluation and assessment of Team Climate ESMValTool for the regional model HIRHAM-CLM.

Figure 1: Comparison between CCI+ Permafrost and HIRHAM-CLM.



❖ Assessment of linkages between carbon pools, land surface changes, and permafrost using GlobPermafrost products

& Evaluation of Arctic climate change in coastal permafrost regions (HORIZON2020 Nunataryuk)

Table 1: Erosion rate retrieval summary from Bartsch et al. (2020). Most sites show increased recent rates as well as increasing ground temperatures (Fig.2)

	Rate from GlobPermafrost trend product 1999-2014	Rate from L-band SAR 2007-2018	Previously published rates
Varandai (c)	n.a.	-5.41 ± 2.64	-1.8 (1951-2013) [1]
Herschel (B)	-4.19 ± 2.8	-7.02 ± 2.65	-6.8 (2012-2013) [2]
Kay Point (B)	-3.94 ± 1.4	-5.90 ± 0.41	-1.7 (1990-2011) [3]
Bykosvky (D)	-5.83 ± 2.8	-4.81 ± 1.37	-1 - -2 (1951-2006) [4]

(1) Sinistyn et al. 2019, (2) Obu et al. 2016, (3) Irrgang et al. 2017, (4) Lantuit et al. 2011

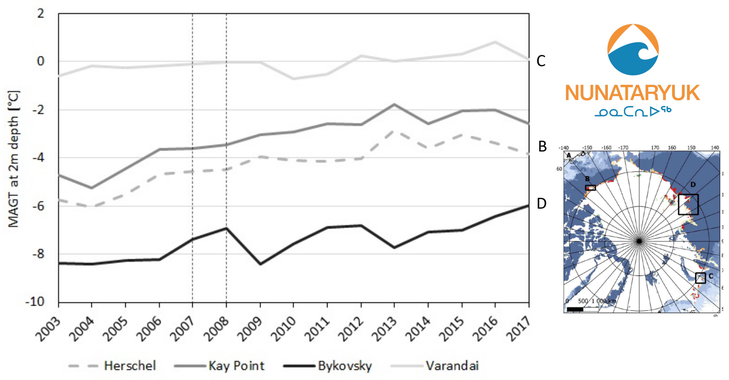


Figure 2: CRDPv0 ground temperature at sites with recent increase in coastal erosion rates (Bartsch A, Ley S, Nitze I, Pointner G and Vieira G (2020) Feasibility Study for the Application of Synthetic Aperture Radar for Coastal Erosion Rate Quantification Across the Arctic. Front. Environ. Sci. 8:143. doi: 10.3389/fenvs.2020.00143)

Rock glacier kinematics

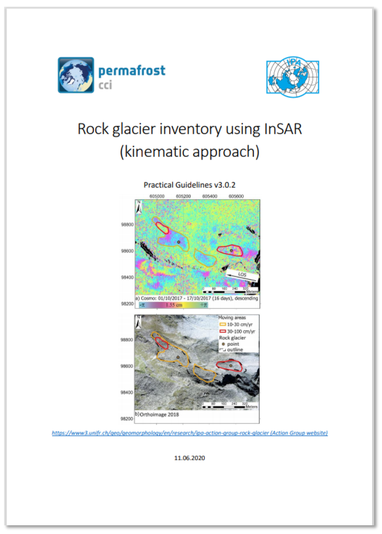
For mountain permafrost the following remote sensing-based products are required:

i. regional rock glacier inventories and

ii. kinematical time series of selected rock glaciers.

Specific user requirements for both products have been determined.

Standard guidelines to produce homogeneous remote sensing based regional rock glacier inventories and kinematical time series of selected rock glaciers at global scale have been developed thanks to the close collaboration with the international initiative IPA (International Permafrost Association) Action Group *rock glacier inventories and kinematics*.



IPA Action Group events:
- Workshop I (23-27.09.2019, Switzerland) was mainly devoted to the definition of standard guidelines for inventorying rock glaciers.
- Workshop II (11-13.02.2020, Switzerland) was devoted to the preparation of "products" which could serve for monitoring rock glacier kinematics as a new associated parameter of the ECV (Essential Climate Variable) Permafrost.

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ESA-ECSAT
Fermi Avenue
Harwell Campus, Didcot, OX11 0FD
United Kingdom
cci.esa.int | @esaclimate

European Space Agency