Product documentation:
Mountain Permafrost

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Consortium:

ZAMG Zentralanstalt für Meteorologie und Geodynamik

UiO : University of Oslo

AWI ALFRED WEGENER INSTITUT

GAMMA REMOTE SENSING

H2 geomatics

Signatures

	Name	**Organisation**	**Signature**
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Distribution

Version	People and/or Organisation	Publicly available on website
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Change Log

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1. Product overview

1.1. General

The GlobPermafrost project develops, validates and implements Earth Observation (EO) products to support research communities and international organisations in their work on better understanding permafrost.

The best visual expression of mountain permafrost that can be mapped and monitored directly using remotely sensed data is represented by rockglaciers (Kääb, 2008; Kääb, 2013). Besides being environmental indicators, rockglaciers and their changes impact on geohazards and the water cycle. Long-term monitoring of rockglacier motion will be performed for a worldwide network of sites with matching of repeat optical data and satellite radar interferometry. Changes in rock glacier motion are indeed believed to be the most indicative short- to medium-term response of rockglaciers to environmental changes and thus an indicator of mountain permafrost conditions in general (Kääb et al., 2007).

Our analysis is divided in two major steps. SAR interferometry data are first considered as a base for an inventory of periglacial slope instabilities, including rock glaciers. In a second step, matching of repeat optical data (Kääb and Vollmer, 2000) and SAR interferometry (Strozzi et al., 2004; Lauknes et al., 2010) are considered to quantify the rate of surface movement and the relative changes over time of a few significant active rockglaciers.

This version represents data availability by the end of September 2017. An update will be released at the end of 2018.

1.2. Rock glacier and slope instability inventory

Past investigations conducted in the Swiss Alps and Brooks Range of Alaska demonstrated that the visual analysis of satellite differential Synthetic Aperture Radar interferograms (InSAR) can be employed for the estimation of the surface deformation rates of rockglaciers and other periglacial slope instabilities (Delaloye et al., 2007; Barboux et al., 2014; Rick et al., 2015). Deformation rates are expressed using different classes (i.e. 0-2 cm/a, 2-10 cm/a, 10-50 cm/a, 50-100 cm/a, > 100 cm/a). Classification of the process types and validation of the spatial extent is done using optical imagery. The rock glacier and slope instability will be a static product performed using all available archived satellite SAR sensors.

1.3. Rock glacier motion maps

The mountain permafrost product based on matching of repeat optical data is generated using the image correlation software CIASavailable at GUIO (http://www.mn.uio.no/geo/english/research/projects/icemass/cias). The user-friendly processing chain is based on the normalized cross-correlation (NCC) and orientation correlation (NCC-O) and is summarized in the Design Justification File. The mountain permafrost product based on matching of repeat optical data consists of ASCII lists of horizontal offsets in cartesian and polar coordinates and correlation coefficients. The temporal frequency and spatial resolution (grid spacing) will vary depending on the optical sensor data availability for the identified mountain region.

The mountain permafrost product based on satellite radar interferometry is generated using the GAMMA software. The processing chain is summarized in the Design Justification File. The mountain permafrost product based on satellite radar interferometry consists of geotiff's with displacements in the satellite line-of-sight direction between the acquisitions of the two satellite SAR images. The temporal frequency and spatial resolution (grid spacing) will vary depending on SAR sensor data availability for identified mountain regions.

2. Product Specification

Table 1: Specifications of the file naming nomenclature for the mountain permafrost products.

Subject	*Code*	*Specification*
Organization	GUO	Department of Geosciences University of Oslo
	GRS	Gamma Remote Sensing
Product	MNP	Mountain permafrost
Algorithm	MROPT	Matching of repeat optical data
	INSAR	Satellite SAR Interferometry
Satellite sensor and mode used to create product	POLYG	Rock glacier inventory (various)
	LAND8	Landsat 8
	SENT2	Sentinel-2
	AIRPH	Airphotos
	CORON	Corona
	HRSAT	High resolution optical satellites
	ERS12	ERS-1/2
	ENVIS	ENVISAT
	ALOS1	ALOS-1 PALSAR-1
	TERRA	TerraSAR-X
	COSMO	Cosmo-SkyMed
	ALOS2	ALOS-1 PALSAR-1
	SENT1	Sentinel-1
Product version	VVV	E.g. V01
Start date and time	YYYYMMDD	E.g. 20150815
End date and time	YYYYMMDD	E.g. 20160815
Region of interest*	MS1	Oberwallis
	MS2	Tien Shan
	MS3	Brooks Range
	MS4	Leh/Ladakh
	MS5	Tapado
File Extension	SHP	Shape files
	ASC	Ascii table
	TIF	Geotiff

* The value of the “Region of Interest” field is defined according to the Observation Strategy document.

Table 2: Specifications of the rock glacier and slope instability inventory.

Subject	*Specification*
Variable	Mountain permafrost
Coverage	Mountain permafrost cold spot
Time period	1991 to present
Temporal frequency	static
Coordinate system	UTM, WGS84
Spatial resolution (grid spacing)	30 m or better
Geometric accuracy	Subpixel
Thematic accuracy	tbd
Data (file) format	Shape file
Attributes	State of activity: - 0-2 cm/year - 2-10 cm/year - 10-50 cm/year - 50-100 cm/year - > 100 cm/year Process types: - rockglacier - solifluction - superficial debris movement - debris-covered glacier - dead ice - ice-cored moraine - landslide - subsidence - undefined

Table 3: Specifications of the mountain permafrost product based on matching of repeat optical data.

Subject	*Specification*
Variable	Horizontal displacement
Units	m
Coverage	Rockglaciers
Time period	Starting in ~'70, HRSAT since 2000
Temporal frequency	5-10 years
Coordinate system	UTM, WGS84
Spatial resolution (grid spacing)	30 m or better
Geometric accuracy	Subpixel
Thematic accuracy	<1 m
Data (file) format	ASCII list of offsets in cartesian and polar coordinates and correlation coefficients
Other data codes	-

Table 4: Specifications of the mountain permafrost product based on satellite radar interferometry.

Subject	*Specification*
Variable	Line-of-sight displacement
Units	m
Coverage	Rockglaciers
Time period	Starting in 1991
Temporal frequency	5-10 years
Coordinate system	UTM, WGS84
Spatial resolution (grid spacing)	30 m or better
Geometric accuracy	Subpixel
Thematic accuracy	±5 mm
Data (file) format	Geotiff
Data codes	-

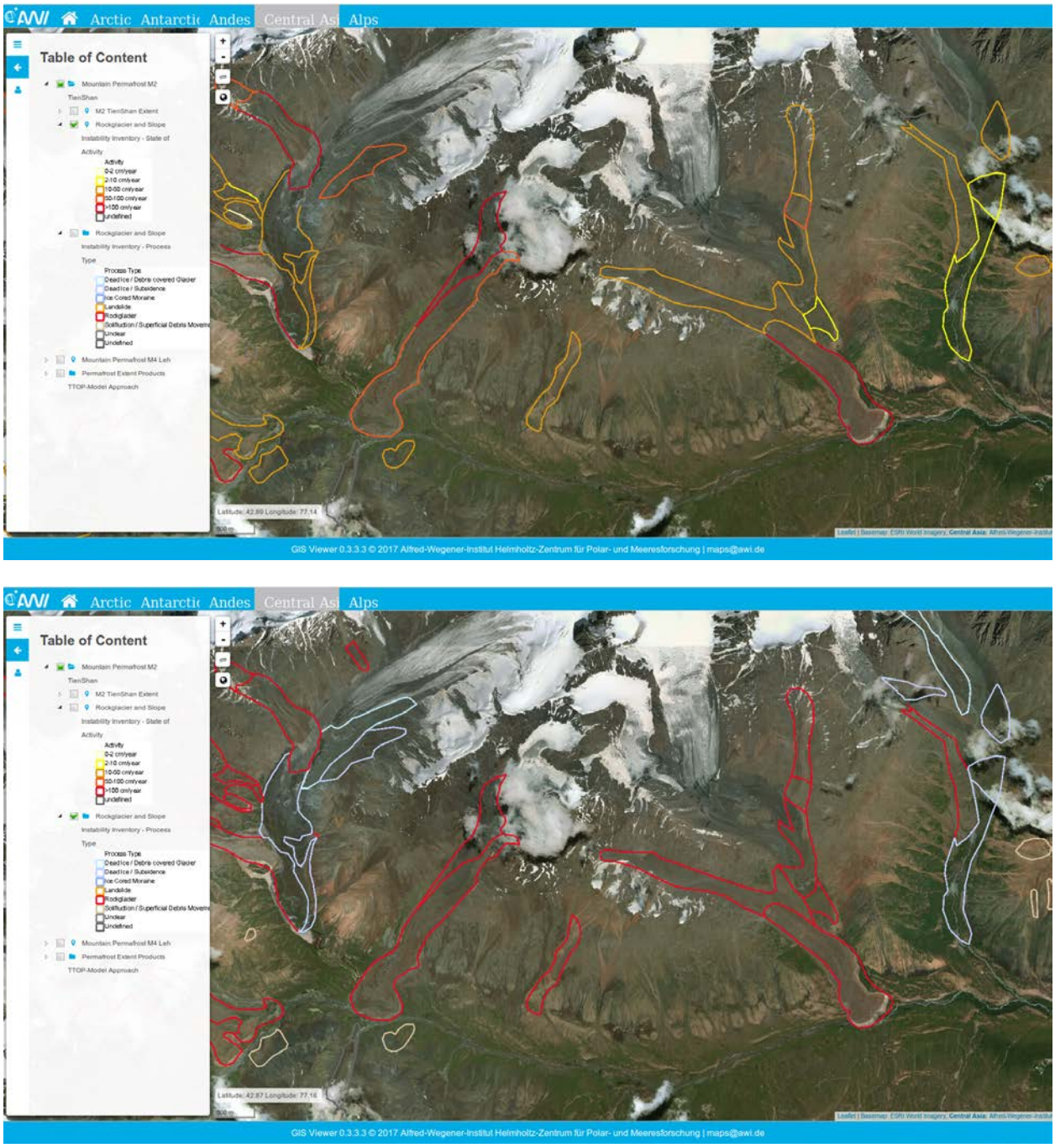

Figure 1: Rock glacier and slope instability inventory for part of the Tien Shan Region (MS2) as visualized in the AWI WebGIS. Above is the state of activity and below the process type.

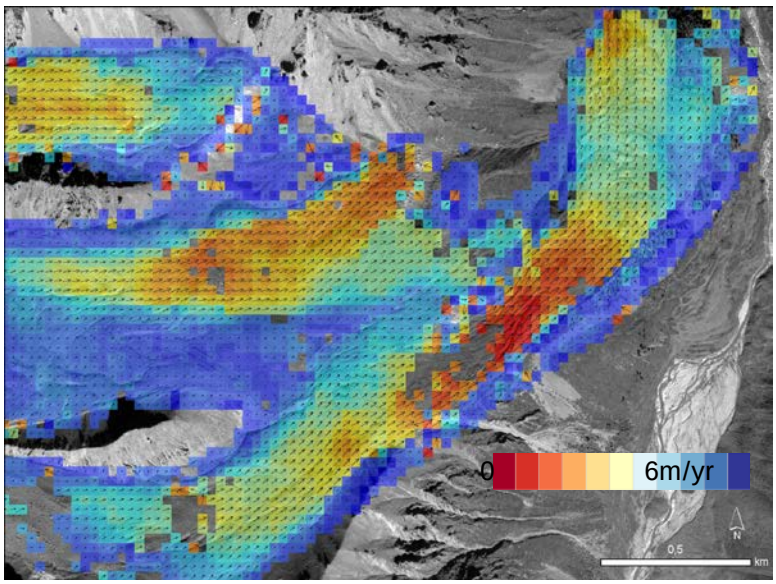

Figure 2: Rock glacier motion map of Ordzhonikidze rock glacier (Tien Shan) from matching of repeat satellite optical data between 2009 and 2013.

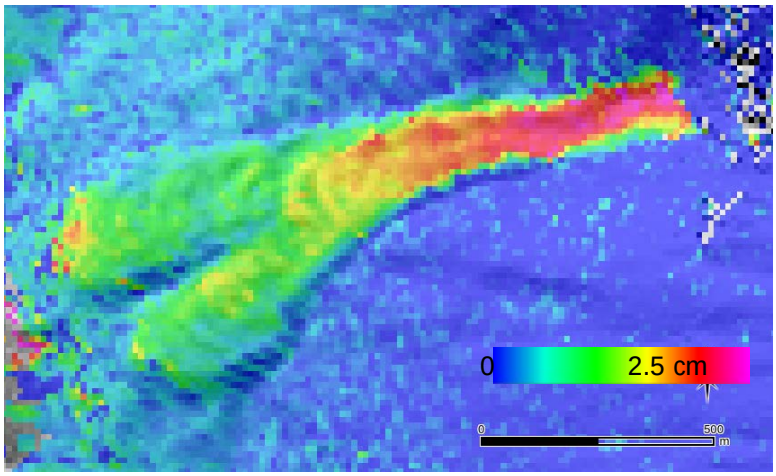

Figure 3: Rock glacier motion map of Dos

Lenguas rock glacier (Tapado Region) in the satellite line-of-sight direction from Sentinel-1 interferometry data between 21 and 26 April 2017.

3. Data access and contact information

Data are available for download via the Permafrost Information System “PerSys”. They follow the structure described in section 3.

PerSys:

https://apgc.awi.de/group/persys-mnp

All layers are also available on the PerSys-WebGIS for visualization and browsing.

WebGIS-Link: https://maps.awi.de/map/map.html?cu=globpermafrost_overview#mapcontent

For data access and more information about the datasets please contact strozzi@gamma-rs.ch.

4. References

Barboux C., R. Delaloye and C. Lambiel, 2014: Inventorying slope movements in an Alpine environment using DInSAR. *Processes Land Earth*, **39**(15), 2087–2099.

Delaloye, R., C. Lambiel, R. Lugon, H. Raetzo, and T. Strozzi T., 2007: ERS InSAR for detecting slope movement in a periglacial mountain environment (Western Valais Alps, Switzerland). In: P*roc. HMRSC-IX, Grazer Schriften Geographie und Raumforschung*, **43**, 113–120.

Kääb A. and Vollmer M., 2000: Surface geometry, thickness changes and flow fields on creeping mountain permafrost: automatic extraction by digital image analysis. *Permafrost Periglacial Processes,* **11**, 315-326.

Kääb, A., R. Frauenfelder and I. Roer, 2007: On the response of rockglacier creep to surface temperature increases. *Global Planetary Change*. **56**(1-2), 172-187.

Kääb, A., 2008: Remote sensing of permafrost-related problems and hazards. *Permafrost Periglacial Processes*. **19**(2), 107-136.

Kääb, A., 2013: Rock Glaciers and Protalus Forms. In: Elias S.A. (ed.) *Encyclopedia Quat Science*, **3**, 535-541.

Lauknes, T. R., LY. Larsen, E. Malnes, and H.H. Christiansen, 2010: Permafrost monitoring using SAR and ground based techniques in Svalbard, *3rd Europ Conf Permafrost (EUCOP III)*, Longyearbyen, Svalbard, Norway, 13–17 June 2010.

Rick B., R. Delaloye, C. Barboux, and T. Strozzi, 2015: Detection and inventorying of slope movements in the Brooks Range, Alaska using DInSAR: a test study. Proceedings of GEOQuébec 2015: 68 th Canadian Geotechnical Conference and 7 th Canadian Permafrost Conference, Quebec City Convention Centre, Canada, September 20-23.

Strozzi, T., A. Kääb, and R. Frauenfelder, 2004: Detecting and quantifying mountain permafrost creep from in situ inventory, space-borne radar interferometry and airborne digital photogrammetry. International Journal of Remote Sensing, 25(15), 2919–2931.