CCI+ PHASE 1 – NEW ECVS
PERMAFROST

CCN3 OPTION 3
TOWARDS A MULTI-PURPOSE FREEZE/THAW CDR

D3.3 PRODUCT USER GUIDE (PUG)

VERSION 1.0

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PREPARED BY

Document Status Sheet

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1.0	31.05.2023	Completion of v1	A. Bartsch (B.GEOS)

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EXECUTIVE SUMMARY

Within the European Space Agency (ESA), the Climate Change Initiative (CCI) is a global monitoring program which aims to provide long-term satellite-based products to serve the climate modeling and climate user community. Permafrost has been selected as one of the Essential Climate Variables (ECVs) which are elaborated during Phase 1 of CCI+ (2018-2021).

CCN3 option 3 addresses the need for a FT climate data record of relevance for Permafrost monitoring and as well as further applications. The specific aim of this CCI+ Permafrost subproject is to identify algorithms and datasets which are suitable for the production of a consistent time series. It builds on algorithms developed in the framework of ESA DUE Permafrost and GlobPermafrost and ESA SMOS FT.

A potential multi-purpose freeze/thaw CDR is targeted at 25km resolution, polar stereographic projection, covering the northern hemisphere (global as target) and representing 2010-2020 as threshold and back to 1979 as target. Product levels are 4: The data sets are created from the analysis of lower level data, resulting in gridded, gap-free products.

The PUG provides the description of a prototype for a Climate Research Data Package (CRDP). This includes formats, attributes and meta data. The CRDP includes the surface status for the seasonal transition period and short term thaw and refreeze events in midwinter.

The prototype covers the years 2018 to 2020. It covers selected sites of Arctic permafrost environments of the northern hemisphere. Three locations overlap with borehole sites on the Alaskan North Slope, situated on continuous permafrost. An additional site is located in Northern Finland, also in proximity to a borehole, but located in an area with sporadic permafrost. The projection is Arctic Polar Stereographic, with 25 km grid spacing. It is provided in csv format.

1   INTRODUCTION

1.1   Purpose of the document

The PUG provides the description of the Climate Research Data Package (CRDP) prototype. This includes formats, attributes and meta data.

The CRDP v0 subset includes the results of the fusion of four freeze/thaw datasets and from a dedicated mid-winter thaw and refreeze product.

1.2   Structure of the document

The first part of this document details general properties of all products. Attributes and known issues, with reference to the Product Validation and Intercomparison Report (PVIR) are described in a separate chapter. Bibliography is provided at the end of the document.

2   General product properties

2.1   Temporal compositing

The CDRP v0 is released in a single file per region, covering the entire analyses period.

2.2   Spatial resolution

The spatial resolution corresponds to the SMOS freeze/thaw product grid and is 25km.

2.3   Product projection system

The Coordinate Reference System (CRS) used for CRDPv2 is Polar Stereographic projection (Arctic) based on the World Geodetic System 84 (WGS84) reference ellipsoid. The coordinates are specified in meters.

2.4   File formats

The product is delivered in CSV format, with each region an individual file.

2.5   Geographical subsets

CDRP v0 covers selected sites with in situ data. The sites overlap with the following GTN-P boreholes:
- Sagwon, North Slope, Alaska
- Happy Valley, North Slope, Alaska
- Franklin Bluffs, North Slope, Alaska
- (Kaldoaivi), Finland

2.6   Product file naming conventions

The files for each product type are named as follows:

ESACCI-<CCI   Project>-<Processing   Level>-<Data   Type>-<Product   String>[-<Additional Segregator>]-<Start Date>-<End Date>-fv<File version>.nc

<CCI Project>
PERMAFROST for permafrost_cci

<Processing Level>
L4 for Level 4; Data sets are created from the analysis of lower level data, resulting in gridded, gap-free products.

<Data Type>

STM – surface thaw /melt.

<Product String> : <source>_<algorithm>

    <Source>

           MULT – multiple sensors, incl. SMOS, SMAP, SSMI, AMSR-E, ASCAT

    <algorithm>

           FUSION - fusion of products

<Additional Segregator>

This should be AREA<TILE_NUMBER>

<TILE_NUMBER>being the tile number the subset index: 1- global, 2-North America, 3-Eurasia, 4-Northern Hemisphere, 5-Romania 6-Switzerland, Western Swiss Alps; 7-Norway, Troms; 8-Norway, Finnmark; 9-Svalbard, Nordenskiöld; 10-France, Vanoise; 11-Italy, Sud Val Venosta, Sudtirol; 12-Greenland, Disko Island; 13-Tien Shan; 14-Alaska, Brookes Range; 15-Argentina, Central Andes, 16-New Zealand, Central part of the Southern Alps, 17- Arctic tundra, 18- Northern Finland, 19-North Slope, Alaska, 20-central Lena Delta, Russia, 21 – Central Yamal, Russia, 22 – Lac du Gras, Canada

<Start Date> and <End Date>

The identifying date for this data set:

Format is YYYYMMDD, where YYYY is the four digit year, MM is the two digit month from 01 to 12 and DD is the two digit day of the month from 01 to 31.

fv<File Version>

File version number in the form n{1,}[.n{1,}] (That is 1 or more digits followed by optional . and another 1 or more digits). The most recent version is fv01.0 (released in May 2023).

Examples:

ESACCI-PERMAFROST-L4-STM-MULT_FUSION-AREA19-20180605-20201229-fv01.0.csv

3   Terminology

The surface states frozen, unfrozen and partially frozen refer to the status of the near surface soil layer. The mid-winter thaw and refreeze flag represents changes in snow structure. The later results from short term thawing with potential impact on the temperature of the soil beneath.

4   Abstract for data publication

This dataset contains the prototype for the multipurpose freeze/thaw product. It addresses mid-winter thaw and refreeze (leading to snow structure change) and the seasonal transition periods. The dataset is produced as part of Option 3 of the European Space Agency's (ESA) Climate Change Initiative (CCI) Permafrost project. It is derived from combination of passive and active (scatterometer) microwave satellite records. Mid-winter retrieval is based on a new algorithm. Seasonal transition is addressed by combination of existing products.

Two different locations representing continuous and sporadic permafrost area covered. A status flag is provided. Where available, a frozen fraction of the 25 km grid cell is provided based on Sentinel-1. Records cover different period between the sites, but start earliest with October 2016.

The mid-winter results have been produced for the entire land area north of 65°N and published separately. Only a subset is included in the prototype.

5   Attributes

Table 1: Attributes of the freeze/thaw prototype (Fusion). *an aggregated version covering all area north of 65° is available on Zenodo[1]

| Column	Attribute	Units	Data type
Date	Date	Date (DD.MM.YYYY)	String
Name	Name of borehole site in grid	-	String
X	X coordinate	m	Float
Y	Y coordinate	m	Float
FR	Frozen fraction (for none-water and none- bare areas only), available for appr. 20% of all days	%	Float
ST	Surface state -frozen: 3 -partially frozen: 2 -unfrozen: 1 -mid-winter thaw and refreeze event, November to February: 4*	Discrete classes	Integer
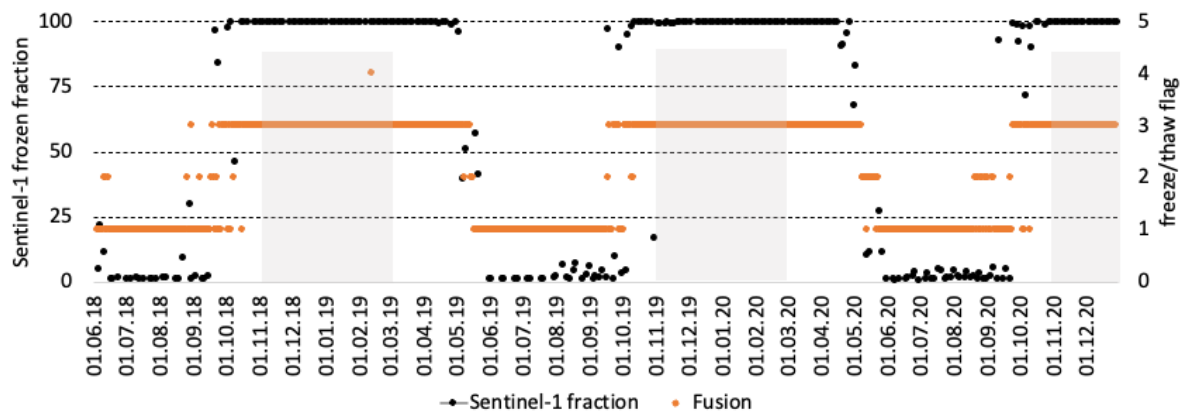
Figure 1: Example of time series at borehole Sagwon. Grey shaded areas indicate retrieval periods (November to February) for mid-winter thaw and refreeze.

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[1] Bartsch, Annett, Bergstedt, Helena, Pointner, Georg, Muri, Xaver, & Rautiainen, Kimmo. (2023). Circumpolar mid-winter thaw and refreeze based on fusion of Metop ASCAT and SMOS, 2011/2012 - 2021/2022 (v1.0) [Data set]. Zenodo. https://doi.org/10.5281/zenodo.7575927

6   KNOWN LIMITATIONS

The retrieval is in all cases only applicable outside of forested areas. The midwinter thaw and refreeze detection is in general limited to north of 65°N due to data availability issues of SMOS and ASCAT (Bartsch et al. 2023).

Currently only November to February is considered for circumpolar retrieval of mid-winter thaw and refreeze.

7 REFERENCES AND ACRONYMS

7.1 Applicable documents

[AD-1] ESA 2017: Climate Change Initiative Extension (CCI+) Phase 1 – New Essential Climate Variables - Statement of Work. ESA-CCI-PRGM-EOPS-SW-17-0032

[AD-2] Requirements for monitoring of permafrost in polar regions - A community white paper in response to the WMO Polar Space Task Group (PSTG), Version 4, 2014-10-09. Austrian Polar Research Institute, Vienna, Austria, 20 pp

[AD-3] ECV 9 Permafrost: assessment report on available methodological standards and guides, 1 Nov 2009, GTOS-62

[AD-4] GCOS-200, the Global Observing System for Climate: Implementation Needs (2016 GCOS Implementation Plan, 2015.

[AD-5] ESA Climate Office 2020: CCI Data Standards v2.2. Reference CCI-PRGM-EOPS-TN-13-0009

7.2 Reference Documents

[RD-1] Bartsch, A., Westermann, Strozzi, T., Wiesmann, A., Kroisleitner, C. (2019): ESA CCI+ Permafrost Product Specifications Document, v1.0

[RD-2] Heim, B., Wieczorek, M., Pellet, C., Barboux, C., Delaloye, R., Bartsch, A., Strozzi, T. (2020): ESA CCI+ Permafrost Product Validation and Intercomparison Report, v2.0

[RD-3] Heim, B., Wieczorek, M., Pellet, C., Delaloye, R., Bartsch, A., Strozzi, T. (2020): ESA CCI+ PVIR, v2.0

[RD-4] Bartsch, A., Muri, X., Bergstedt, H., Wuite, Hetzenegger, M., J., Rautiainen, K., Nagler, T., Strozzi, T. (2023): ESA CCI+ Permafrost CCN3 Option 3 – Design Engineering document, v1.1

7.3 Bibliography

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Muller S.W, 1943: Permafrost or permanently frozen ground and related engineering problems. U.S. Engineers Office, Strategic Engineering Study, Special Report No. 62. 136p. (Reprinted in 1947, J. W. Edwards, Ann Arbor, Michigan, 231p.)

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