



permafrost
cci

CCI+ PHASE 1 – NEW ECVS

PERMAFROST

CCN3 OPTION 6

**IMPROVED SOIL DESCRIPTION THROUGH A LANDCOVER
MAP DEDICATED FOR THE ARCTIC**

D1.2 PRODUCT SPECIFICATIONS DOCUMENT (PSD)

VERSION 1.0

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PREPARED BY



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EUROPEAN SPACE AGENCY CONTRACT REPORT

The work described in this report was done under ESA contract. Responsibility for the contents resides in the authors or organizations that prepared it.

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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).

This document is the Product Specification Document (PSD) of Option 6 within CCN3 of Phase 1 of the Permafrost_cci project. It describes the product specifications of the permafrost landcover product targeting proxies for soil properties. The product specifications address the main requirements expressed by the users in the User Requirements Document (URDv1.0, RD-3) including those expressed by the Permafrost_cci Climate Research Group (CRG). Since the range of potential user communities of a pan-Arctic landcover product is very wide it is not possible to cover all those requirements. For this reason, the PSD establishes priorities between those requirements, putting in the first place those more sensible to climate researchers, specifically permafrost modelling, while considering current technical constraints.

The PSD includes a glossary of permafrost relevant terms, the product specifications and formats, including details of meta data.

Landcover information will be provided at 20m resolution, polar stereographic projection, covering the Arctic tundra and representing the status 2015-2021. Product level is 4. The data sets are created from the analysis of lower level data, resulting in gridded, gap-free products.

1 INTRODUCTION

1.1 Purpose of the document

This document describes in detail product specifications in order to obtain a pan-arctic permafrost region specific landcover product that is consistent and error-characterised. The purpose of this document is to present the structure, syntax and file naming conventions used to describe the different landcover product. It provides all the necessary data needed by permafrost algorithm developers and users to write and read the products.

1.2 Structure of the document

This document contains a glossary of permafrost specific terms in section 1.7. Section 2 describes the area covered for the service as well as regions of interest for evaluation. The remaining sections detail the product specifications and format.

1.3 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.

1.4 Reference Documents

[RD-1] van Everdingen, Robert, ed. 1998 revised May 2005. Multi-language glossary of permafrost and related ground-ice terms. Boulder, CO: National Snow and Ice Data Center/World Data Center for Glaciology. (<http://nsidc.org/fgdc/glossary/>; accessed 23.09.2009)

[RD-2] Bartsch, A., Westermann, S., Heim, B., Wiczorek, M., Pellet, C., Barboux, C., Kroisleitner, C., Strozzì, T. (2019): ESA CCI+ Permafrost Data Access Requirements Document, v1.0

[RD-3] Bartsch, A., G. Hugelius, Strozzì, T.(2021): ESA CCI+ Permafrost CCN3 Option 6: improved soil description through a landcover map dedicated for the Arctic. User Requirements Document, v1.0

1.5 Bibliography

A complete bibliographic list that support arguments or statements made within the current document is provided in Section 5.1.

1.6 Acronyms

A list of acronyms is provided in section 5.2.

1.7 Glossary

The list below provides a selection of terms relevant for the parameters addressed in Permafrost_cci [RD-7].

active layer

The layer of ground that is subject to annual thawing and freezing in areas underlain by permafrost.

In the zone of continuous permafrost the active layer generally reaches the permafrost table; in the zone of discontinuous permafrost it often does not. The active layer includes the uppermost part of the permafrost wherever either the salinity or clay content of the permafrost allows it to thaw and refreeze annually, even though the material remains cryotic ($T < 0^{\circ}\text{C}$).

The active layer is sometimes referred to as the "active zone"; the term "zone," however, should be reserved for the zones of discontinuous and continuous permafrost.

In Russian and Chinese literature, the term active layer covers two distinct types: (1) the seasonally thawed layer overlying permafrost, and (2) the seasonally frozen layer overlying unfrozen ground inside or outside permafrost areas.

REFERENCES: Muller, 1943; Williams, 1965; Brown, 1971; van Everdingen, 1985.

active-layer thickness

The thickness of the layer of the ground that is subject to annual thawing and freezing in areas underlain by permafrost.

The thickness of the active layer depends on such factors as the ambient air temperature, vegetation, drainage, soil or rock type and total water content, snowcover, and degree and orientation of slope. As a rule, the active layer is thin in the High Arctic (it can be less than 15 cm) and becomes thicker farther south (1 m or more).

The thickness of the active layer can vary from year to year, primarily due to variations in the mean annual air temperature, distribution of soil moisture, and snowcover.

The thickness of the active layer includes the uppermost part of the permafrost wherever either the salinity or clay content of the permafrost allows it to thaw and refreeze annually, even though the material remains cryotic ($T < 0^{\circ}\text{C}$).

Use of the term "depth to permafrost" as a synonym for the thickness of the active layer is misleading, especially in areas where the active layer is separated from the permafrost by a residual thaw layer, that is, by a thawed or noncryotic ($T > 0^{\circ}\text{C}$) layer of ground.

REFERENCES: Muller, 1943; Williams, 1965; van Everdingen, 1985.

continuous permafrost

Permafrost occurring everywhere beneath the exposed land surface throughout a geographic region with the exception of widely scattered sites, such as newly deposited unconsolidated sediments, where the climate has just begun to impose its influence on the thermal regime of the ground, causing the development of continuous permafrost.

For practical purposes, the existence of small taliks within continuous permafrost has to be recognized. The term, therefore, generally refers to areas where more than 90 percent of the ground surface is underlain by permafrost.

REFERENCE: Brown, 1970.

continuous permafrost zone

The major subdivision of a permafrost region in which permafrost occurs everywhere beneath the exposed land surface with the exception of widely scattered sites.

Taliks associated with rivers and lakes may occur in the continuous permafrost zone.

REFERENCE: Brown, 1970.

depth of zero annual amplitude

The distance from the ground surface downward to the level beneath which there is practically no annual fluctuation in ground temperature .

A change of no more than 0.1°C throughout the year is arbitrarily considered as "practically no annual fluctuation". The temperature at the depth (or level) of zero annual amplitude ranges from about -0.1°C at the southern limit of the permafrost region to about -15°C in the extreme polar reaches of the zone of continuous permafrost. The depth of zero annual amplitude varies widely but generally lies between 10 and 20 m below the ground surface, depending on climatic and terrain conditions such as amplitude of annual surface temperature variation, vegetation, snowcover and characteristics of the soils and rocks including thermal diffusivity (see thermal properties of frozen ground).

SYNONYMS: (not recommended) zone of minimum annual amplitude, zone of zero annual amplitude.

REFERENCE: Muller, 1943.

discontinuous permafrost

Permafrost occurring in some areas beneath the exposed land surface throughout a geographic region where other areas are free of permafrost.

Discontinuous permafrost occurs between the continuous permafrost zone and the southern latitudinal limit of permafrost in lowlands. Depending on the scale of mapping, several subzones can often be distinguished, based on the percentage (or fraction) of the land surface underlain by permafrost, as shown in the following table.

| <u>Permafrost</u> | <u>English usage</u> | <u>Russian Usage</u> |
|-------------------|----------------------|----------------------|
| Extensive | 65-90% | Massive Island |
| Intermediate | 35-65% | Island |
| Sporadic | 10-35% | Sporadic |
| Isolated Patches | 0-10% | - |

SYNONYMS: (not recommended) insular permafrost; island permafrost; scattered permafrost.

REFERENCES: Brown, 1970; Kudryavtsev, 1978; Heginbottom, 1984; Heginbottom and Radburn, 1992; Brown et al., 1997.

discontinuous permafrost zone

The major subdivision of a permafrost region in which permafrost occurs in some areas beneath the exposed land surface, whereas other areas are free of permafrost.

The zone of discontinuous permafrost lies between the continuous permafrost zone and the southern latitudinal limit of permafrost in lowlands. Near its northern boundary, discontinuous permafrost is extensive, where-as near its southern boundary it occurs as isolated patches of permafrost, and sporadic permafrost. There is no sharp distinction, or boundary, between the continuous and discontinuous permafrost zones.

REFERENCE: Brown, 1970.

disequilibrium permafrost

Permafrost that is not in thermal equilibrium with the existing mean annual surface or sea-bottom temperature and the geothermal heat flux.

REFERENCE: Mackay, 1972a.

equilibrium permafrost

Permafrost that is in thermal equilibrium with the existing mean annual surface or sea-bottom temperature and with the geothermal heat flux.

SYNONYM: contemporary permafrost.

REFERENCE: Mackay, 1972a.

extensive discontinuous permafrost

1. (North-American usage) Permafrost underlying 65 to 90 percent of the area of exposed land surface.

2. (Russian usage) Permafrost underlying 70 to 80 percent of the area of exposed land surface.

It is suggested that this term be used as a replacement for "widespread" discontinuous permafrost, because the word "widespread" can mean either "extensively distributed" or "widely spaced".

SYNONYM: widespread discontinuous permafrost.

REFERENCE: Heginbottom and Radburn, 1992.

ground ice

A general term referring to all types of ice contained in freezing and frozen ground .

Ground ice occurs in pores, cavities, voids or other openings in soil or rock and includes massive ice. It generally excludes buried ice, except in Russian usage. Ground ice may be epigenetic or syngenetic, contemporaneous or relict, aggrading or degrading, perennial or seasonal. It may occur as lenses, wedges, veins, sheets, seams, irregular masses, or as individual crystals or coatings on mineral or organic particles. Perennial ground ice can only occur within permafrost bodies.

REFERENCES: Mackay, 1972b; Pollard and French, 1980.

ice content

The amount of ice contained in frozen or partially frozen soil or rock.

Ice content is normally expressed in one of two ways:

1. on a dry-weight basis (gravimetric), as the ratio of the mass of the ice in a sample to the mass of the dry sample, expressed as a percentage, or
2. on a volume basis (volumetric), as the ratio of the volume of ice in a sample to the volume of the whole sample, expressed as a fraction.

The volumetric ice content cannot exceed unity whereas the gravimetric ice content can greatly exceed 100 percent.

REFERENCES: Penner, 1970; Anderson and Morgenstern, 1973; Johnston, 1981.

isolated patches of permafrost

Permafrost underlying less than 10 percent of the exposed land surface.

Individual areas of permafrost are of limited areal extent, widely separated, and are completely surrounded by unfrozen ground.

SYNONYMS: (not recommended) insular permafrost; island permafrost; scattered permafrost.

REFERENCES: Heginbottom and Radburn, 1992.

mean annual ground-surface temperature (MAGST)

Mean annual temperature of the surface of the ground.

Permafrost exists if the mean annual ground-surface temperature is perennially below 0°C. Although the mean annual surface temperature may be below 0°C, the surface temperature will fluctuate during the year, causing a layer of ground immediately beneath the surface to thaw in the summer and freeze in the winter (the active layer). Small changes in the annual range of surface temperature and in the mean annual surface temperature from year to year, or over a period of a few years, may cause a layer of ground between the bottom of the active layer and the permafrost table to remain at a temperature above 0°C, creating a talik or residual thaw layer.

[RD-1]

mean annual ground temperature (MAGT)

Mean annual temperature of the ground at a particular depth.

The mean annual temperature of the ground usually increases with depth below the surface. In some northern areas, however, it is not uncommon to find that the mean annual ground temperature decreases in the upper 50 to 100 metres below the ground surface as a result of past changes in surface and climate conditions. Below that depth, it will increase as a result of the geothermal heat flux from the interior of the earth. The mean annual ground temperature at the depth of zero annual amplitude is often used to assess the thermal regime of the ground at various locations [RD-1]

n-factor

The ratio of the surface freezing or thawing index to the air freezing or thawing index.

At any site, (standard) air temperatures are seldom the same as surface (air/substrate boundary) temperatures. Because air temperatures (measured at weather stations) are usually available and

surface temperatures are not, the n-factor (an empirically determined coefficient) is used to relate air temperatures to surface temperatures in order to establish the thermal boundary condition at the surface, particularly for engineering purposes.

The difference between air and surface temperatures at any specific time and location is greatly influenced by climatic, surface and subsurface conditions (e.g., latitude, cloud cover, time of day or year, relative humidity, wind speed, type of surface--wet, dry, moss, snow, natural vegetated te-rain, mineral soil, pavements-- and thermal properties of the ground). The average surface temperature and n-factor may vary significantly from year to year, even for a given surface and location, as well as for different sites, surfaces and soil systems.

Values of the freezing and thawing n-factors have been determined for a large number of sites and surfaces and are widely used for predicting sur-face temperatures and the thermal regime of the ground. The data vary widely, however, and indicate that a rigorous value of n for a given site cannot simply be chosen from these data. Direct determination of the n-factor for a specific location is much better and requires concurrent observations of air and surface temperatures throughout at least one and prefer-ably several complete freezing and thawing seasons.

REFERENCES: Carlson and Kersten, 1953; Lunardini, 1978, 1981.

permafrost

Ground (soil or rock and included ice and organic material) that remains at or below 0°C for at least two consecutive years .

Permafrost is synonymous with perennially cryotic ground: it is defined on the basis of temperature. It is not necessarily frozen, because the freezing point of the included water may be depressed several degrees below 0°C; moisture in the form of water or ice may or may not be present. In other words, whereas all perennially frozen ground is permafrost, not all permafrost is perennially frozen. Permafrost should not be regarded as permanent, because natural or man-made changes in the climate or terrain may cause the temperature of the ground to rise above 0°C. Permafrost includes perennial ground ice, but not glacier ice or icings, or bodies of surface water with temperatures perennially below 0°C; it does include man-made perennially frozen ground around or below chilled pipelines, hockey arenas, etc.

Russian usage requires the continuous existence of temperatures below 0°C for at least three years, and also the presence of at least some ice.

SYNONYMS: perennially frozen ground, perennially cryotic ground and (not recommended) biennially frozen ground, climafrost, cryic layer, permanently frozen ground.

REFERENCES: Muller, 1943; van Everdingen, 1976; Kudryavtsev, 1978.

permafrost boundary

1. The geographical boundary between the continuous and discontinuous permafrost zones.
2. The margin of a discrete body of permafrost.

permafrost degradation

A naturally or artificially caused decrease in the thickness and/or areal extent of permafrost.

Permafrost degradation may be caused by climatic warming or by changes in terrain conditions, such as disturbance or removal of an insulating vegetation layer by fire, or by flooding caused by

a landslide-blocked stream, or by human activity. It may be expressed as a thickening of the active layer, a lowering of the permafrost table, a raising of the permafrost base, or a reduction in the areal extent or the complete disappearance of permafrost. [RD-1]

permafrost region

A region in which the temperature of some or all of the ground below the seasonally freezing and thawing layer remains continuously at or below 0°C for at least two consecutive years.

The permafrost region is commonly subdivided into permafrost zones. [RD-1]

permafrost zone

A major subdivision of a permafrost region.

A permafrost region is commonly subdivided into permafrost zones based on the proportion of the ground that is perennially cryotic. The basic subdivision in high latitudes is into zones of continuous permafrost and discontinuous permafrost.

REFERENCES: Muller, 1943; Brown, 1967, 1978; Washburn, 1979; Pewe, 1983.

sporadic discontinuous permafrost

1. (North-American usage) Permafrost underlying 10 to 35 percent of the exposed land surface.
2. (Russian usage) Permafrost underlying 5 to 30 percent of the exposed land surface.

Individual areas of permafrost are completely surrounded by unfrozen ground.

SYNONYMS: (not recommended) insular permafrost; island permafrost; scattered permafrost.

REFERENCES: Muller, 1943; Brown, 1967; Heginbottom and Radburn, 1992.

talik

A layer or body of unfrozen ground occurring in a permafrost area due to a local anomaly in thermal, hydrological, hydrogeological, or hydrochemical conditions .

Taliks may have temperatures above 0°C (noncryotic) or below 0°C (cryotic, forming part of the permafrost). Some taliks may be affected by seasonal freezing. Several types of taliks can be distinguished on the basis of their relationship to the permafrost (closed, open, lateral, isolated and transient taliks), and on the basis of the mechanism responsible for their unfrozen condition (hydrochemical, hydrothermal and thermal taliks):

1. closed talik - a noncryotic talik occupying a depression in the permafrost table below a lake or river (also called "lake talik" and "river talik"); its temperature remains above 0°C because of the heat storage effect of the surface water;
2. hydrochemical talik - a cryotic talik in which freezing is prevented by mineralized groundwater flowing through the talik.
3. hydrothermal talik - a noncryotic talik, the temperature of which is maintained above 0°C by the heat supplied by groundwater flowing through the talik;
4. isolated talik - a talik entirely surrounded by perennially frozen ground; usually cryotic (see isolated cryopeg), but may be noncryotic (see transient talik);
5. lateral talik - a talik overlain and underlain by perennially frozen ground; can be noncryotic or cryotic;
6. open talik - a talik that penetrates the permafrost completely, connecting suprapermafrost and subpermafrost water, (e.g., below large rivers and lakes).

It may be noncryotic (see hydrothermal talik) or cryotic (see hydro-chemical talik).

SYNONYMS: (not recommended) through talik, penetrating talik, perforating talik, piercing talik;

7. thermal talik - a noncryotic talik, the temperature of which is above 0°C due to the local thermal regime of the ground;

8. transient talik - a talik that is gradually being eliminated by freezing, e.g., the initially noncryotic closed talik below a small lake which, upon draining of the lake, is turned into a transient isolated talik by permafrost aggradation (see also closed-system pingo).

REFERENCES: Williams, 1965; Washburn, 1973; van Everdingen, 1976.

2 KEY REGIONS FOR STUDY

2.1 Circumpolar landcover

Permafrost is a phenomenon of the subsurface thermal state across vast areas. Permafrost underlies approx. 24% of the terrestrial Northern Hemisphere (Figure 1). Specifically, tundra regions are very heterogeneous regarding landcover and soil properties what is so far unaccounted for in global landcover dataset. The landcover product will therefore cover all tundra area in the Arctic which is underlain by permafrost.

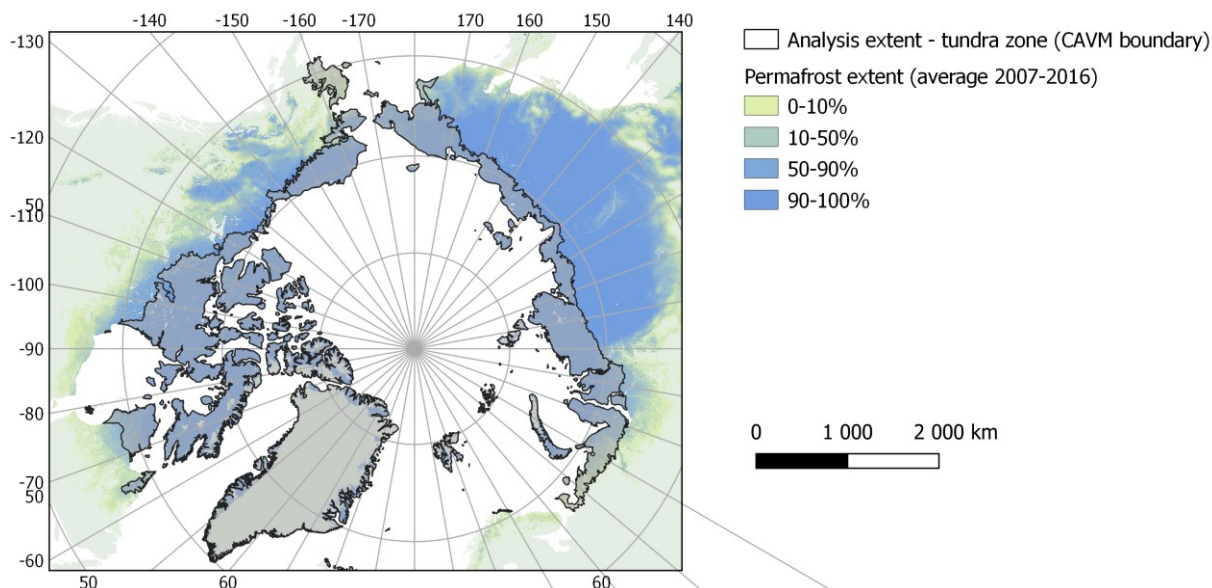


Figure 1: Analyses extent for the landcover product. Permafrost extent: CRDPv1 - Obu et al., 2020, Tundra extent: Circumarctic vegetation map (CAVM) – Raynolds et al. (2019)

2.2 Regions for evaluation

In situ data and high resolution landcover maps developed for the Arctic are utilized as benchmark for validation. Existing landcover dataset for the Lena Delta, Usa basin and the Alaskan North Slope are documented in Bartsch et al. (2016b). Further on, vegetation surveys will be considered for the assessment (see Table 1 in Bartsch et al. 2020). This includes specifically data from Western Siberia. Soil descriptions as documented in Bartsch et al. (2016b) will complement the in situ records.

3 PRODUCTS SPECIFICATIONS

3.1. Product description

This product addresses tundra specific landcover classes, vegetation communities which reflect climatic and soil conditions.

3.2. Temporal compositing

The product is static and is a mosaic of acquisitions from 2015 to 2021, depending on availability of cloud free Sentinel-1 data during the vegetation peak season.

3.3. Spatial resolution

The Spatial resolution of the landcover product is linked to the available resolution of the input sensors. This includes Sentinel-1 and Sentinel-2, both with 10m nominal resolution. Considering noise and resampling affects 20m are foreseen.

3.4 Pixel attributes

| Product variable | unit | property | values provided | Product string |
|------------------|------------------|---|-----------------|----------------|
| Landcover | discrete classes | vegetation communities which reflect climatic and soil conditions | class (tbd) | CLS |

3.4 Product accuracy

With respect to the threshold user requirements documented in [RD-3] the following accuracy is targeted:

- Threshold: better accuracy than available to date
- Target: 10-15% classification error

3.5 Data dissemination for all products

All datasets are distributed via the CCI portal, published on PANGAEA and delivered to the Permafrost Information System hosted by AWI.

3.6 Data documentation

The data documentation will be available on the ESA CCI webpage (<https://climate.esa.int/en/projects/permafrost/key-documents/>).

4 PRODUCT FORMATS

4.1 Product projection system

The Coordinate Reference System (CRS) used for the Arctic landcover product will be Polar Stereographic (Arctic) based on the World Geodetic System 84 (WGS84) reference ellipsoid. The coordinates are specified in meters.

4.2 Subsets

Subsets are not no foreseen.

4.3 File formats

All datasets are provided in NetCDF format.

4.4 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>

CLS – landcover class.

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

SENTINEL1-2_ XGB or SENTINEL1-2_ MLH

<Source>

- SENTINEL1-2 - - Fusion of Sentinel-1 and Sentinel-2 data.

<algorithm>

- XGB – Gradient boosting machines approach (XGBoost)
- MLH – Maximum Likelihood approach (prototype method, Bartsch et al. 2019)

<Additional Segregator>

This should be AREA<TILE_NUMBER>_<Layer type>

<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

<Layer type>

- LC: layer type 1, corresponding to value of the landcover parameter.

<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 fv02.0 (released in May 2020).

Examples:

ESACCI-PERMAFROST-L4-CLS-SENTINEL1-2-AREA17_LC-2015-2021-fv01.0.nc

4.5 File meta data - NetCDF

The following attributes are included in the NetCDF file:

| Global Attribute | Content |
|----------------------------|--|
| title | ESA CCI permafrost <parameter name> |
| institution | b.geos |
| source | <text> |
| history | YYYY-MM-DD HH:MM:SS |
| references | http://cci.esa.int/Permafrost [and publications] |
| tracking_id | <xxxxxxxx-yyyy-zzzz-nnnn-mmmmmmmmmmm> a UUID (Universal Unique Identifier) value |
| Conventions | CF-1.9 |
| product_version | <number> |
| summary | <text> |
| keywords | <text> |
| id | <filename> |
| naming authority | b.geos |
| keywords_vocabulary | NASA Global Change Master Directory (GCMD) Science Keywords |
| cdm_data_type | Grid |

| Global Attribute | Content |
|----------------------------------|--|
| comment | These data were produced at ESACCI as part of the ESA Permafrost CCI+ project Contract No 4000123681/18/I-NB |
| date_created | <file creation date> |
| creator_name | b.geos |
| creator_url | https://www.bgeos.at/ |
| project | Climate Change Initiative - European Space Agency |
| geospatial_lat_min | 55 |
| geospatial_lat_max | 90 |
| geospatial_lon_min | -180 |
| geospatial_lon_max | 180 |
| geospatial_vertical_min | 0.0 |
| geospatial_vertical_max | 0.0 |
| time_coverage_start | YYYYMMDDTHHMMSSZ |
| time_coverage_end | YYYYMMDDTHHMMSSZ |
| time_coverage_duration | P<number of years>Y |
| time_coverage_resolution | P<number><unit> |
| standard_name_vocabulary | CF Standard Name Table v73 |
| license | ESA CCI Data Policy: free and open access |
| platform | <name> |
| spatial_resolution | <number>< |
| geospatial_lat_units | none |
| geospatial_lon_units | none |
| geospatial_lon_resolution | <number>< |
| geospatial_lat_resolution | <number>< |
| key_variables | <name> |
| Format_version | CCI Data Standards v2.2 |

5 REFERENCES

5.1 Bibliography

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Bartsch, Annett; Widhalm, Barbara; Pointner, Georg; Ermokhina, Ksenia; Leibman, Marina; Heim, Birgit (2019): Landcover derived from Sentinel-1 and Sentinel-2 satellite data (2015-2018) for subarctic and arctic environments. Zentralanstalt für Meteorologie und Geodynamik, Wien, PANGAEA, <https://doi.org/10.1594/PANGAEA.897916>

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5.2 Acronyms

| | |
|---------|---|
| AD | Applicable Document |
| ALT | Active Layer Thickness |
| AWI | Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research |
| B.GEOS | b.geos GmbH |
| CCI | Climate Change Initiative |
| CRG | Climate Research Group |
| CRDP | Climate Research Data Package |
| CRS | Coordinate Reference System |
| DARD | Data Access Requirements Document |
| ECV | Essential Climate Variable |
| EO | Earth Observation |
| ESA | European Space Agency |
| ESA DUE | ESA Data User Element |
| GAMMA | Gamma Remote Sensing AG |
| GCOS | Global Climate Observing System |
| GCMD | Global Change Master Directory |
| GIPL | Geophysical Institute Permafrost Laboratory |
| GTD | Ground Temperature at certain depth |
| GTN-P | Global Terrestrial Network for Permafrost |
| GUIO | Department of Geosciences University of Oslo |
| IPA | International Permafrost Association |

| | |
|--------|---|
| IPCC | Intergovernmental Panel on Climate Change |
| LST | Land Surface Temperature |
| MAGT | Mean Annual Ground Temperature |
| MAGST | Mean Annual Ground Surface Temperature |
| NetCDF | Network Common Data Format |
| NSIDC | National Snow and Ice Data Center |
| PFR | Permafrost extent (Fraction) |
| PFF | Permafrost-Free Fraction |
| PFT | Permafrost underlain by Talik |
| PSD | Product Specifications Document |
| PSTG | Polar Space Task Group |
| PZO | Permafrost Zone |
| RD | Reference Document |
| RMSE | Root Mean Square Error |
| RS | Remote Sensing |
| SU | Department of Physical Geography Stockholm University |
| TSP | Thermal State of Permafrost |
| UAF | University of Alaska, Fairbanks |
| URD | Users Requirement Document |
| WGS 84 | World Geodetic System 1984 |