CCI+ PHASE 1 – NEW ECVS
PERMAFROST

CCN1 & CCN2
ROCK GLACIER KINEMATICS AS NEW ASSOCIATED PARAMETER OF ECV PERMAFROST

D2.4 Algorithm Development Plan (ADP)

VERSION 1.0

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PREPARED BY

b·geos
GAMMA REMOTE SENSING
West University of Timisoara
TERRASIGNA
NORCE
UNI FR
UNIVERSITÉ DE FRIBOURG
UNIVERSITÄT FREIBURG
UiO : University of Oslo
UNIS
The University Centre in Svalbard
AWI
Stockholm University

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Author team

Line Rouyet and Tom Rune Lauknes, NORCE

Chloé Barboux, Aldo Bertone and Reynald Delaloye, UNIFR

Andreas Kääb, GUIO

Hanne H. Christiansen, UNIS

Alexandru Onaca and Flavius Sirbu, WUT

Valentin Poncos, TERRASIGNA

Tazio Strozzi, GAMMA

Annett Bartsch, B.GEOS

ESA Technical Officer:

Frank Martin Seifert

EUROPEAN SPACE AGENCY CONTRACT REPORT

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The European Space Agency (ESA) Climate Change Initiative (CCI) is a global monitoring program that aims to provide long-term satellite-based products to serve the climate modelling and climate data user community. Permafrost has been selected as one of the Essential Climate Variables (ECVs) that are elaborated during Phase 1 of CCI+ (2018-2021). As part of the Permafrost_cci baseline project, ground temperature and active layer thickness were considered to be the primary variables that require climate-standard continuity as defined by the Global Climate Observing System (GCOS). Permafrost extent and zonation are secondary parameters, but of high interest to users. The ultimate objective of Permafrost_cci is to develop and deliver permafrost maps as ECV products primarily derived from satellite measurements. Algorithms have been identified, which can provide these parameters by 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. Annual averages of ground temperature and annual maxima of thaw depth (active layer thickness) were provided at 1 km spatial resolution during Year 1 of Permafrost_cci. The data sets were created from the analysis of lower level data, resulting in gridded, gap-free products.

In periglacial mountain environments, the permafrost occurrence is patchy, and the preservation of permafrost is controlled by site-specific conditions. Three options initiated within CCN1 and CCN2 address the need for additional regional cases in cooperation with dedicated users in characterizing mountain permafrost as local indicator for climate change and direct impact on the society in mountainous areas. Started in October 2018, CCN1 is led by a Romanian team focusing on case studies in the Carpathians. The specific objective of CCN1 is to develop and deliver maps and products for mountain permafrost, such as (i) rock glacier inventories, (ii) kinematical time series of selected rock glaciers and (iii) a permafrost distribution model, primarily derived from satellite measurements. Started in September 2019, CCN2 consists of two options led by Swiss and Norwegian teams focusing on the investigation and definition of a new associated ECV Permafrost product related to rock glacier kinematics. Early 2020, Rock Glacier Kinematics (RGK) has been proposed as a new product to the ECV Permafrost for the next GCOS implementation plan (IP). It would consist of a global dataset of surface velocity time series measured/computed on single rock glacier units. A proper rock glacier kinematics monitoring network, adapted to climate research needs, builds up a unique validation dataset of climate models for mountain regions, where direct permafrost (thermal state) measurements are very scarce or even lacking totally. The international Action Group *Rock glacier inventories and kinematics*, under the IPA (International Permafrost Association), gathering about one hundred members, supports this integration and CCN2 is working closely with this Action Group [RD-10 to RD-13]. Following the recommendations of this IPA Action Group, the overall goal of CCN2 is achieved through the development of two products: (i) regional rock glacier inventories and (ii) kinematical time series of selected rock glacier. User Requirements, Product Specifications and Data Access Requirements are described in D1.1-1.3 of CCN1-2 [RD-6 to RD-8].

Algorithm Development Plan (ADP) is not required for CCN1 and CCN2.

1 INTRODUCTION

1.1 Purpose of the document

The products required within CCN1 and CCN2 of the ESA Permafrost_cci project for mountain permafrost regions include (i) regional rock glaciers inventories, including a kinematical attribute (RGI), (ii) kinematical time series on selected rock glaciers (KTS), and (iii) a mountain permafrost distribution model in the Carpathians (MPDM). The Algorithm Development Plan (ADP) is stating that no algorithm development is currently foreseen in CCN1 and CCN2.

1.2 Structure of the document

- Section 1 provides information about the purpose and background of this document.
- Section 2 describes the algorithm development plan.

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. 2019-11-01. GTOS-62.

[AD-4] GCOS-200. 2016. The Global Observing System for Climate: Implementation Needs. GCOS Implementation Plan, WMO.

1.4 Reference Documents

[RD-1] Bartsch, A., Westermann, S., Strozzi, T. 2019. ESA CCI+ Permafrost. D2.1 Product Validation and Algorithm Selection Report (PVASR), v2.0.

[RD-2] Westermann, S., Bartsch, A., Strozzi, T. 2019. ESA CCI+ Permafrost. D2.2 Algorithm Theoretical Basis Document (ATBD), v2.0.

[RD-3] Westermann, S., Bartsch, A., Heim, B., A., Strozzi, T. 2019. ESA CCI+ Permafrost. D2.3 End-to-End ECV Uncertainty Budget (E3UB), v2.0.

[RD-4] Westermann, S., Bartsch, A., Heim, B., A., Strozzi, T. 2019. ESA CCI+ Permafrost. D2.4 Algorithm Development Plan (ADP), v2.0.

[RD-5] Heim, B., Wieczorek, M., Pellet, C., Delaloye, R., Barboux, C., Westermann, S., Bartsch, A., Strozzi, T. 2019. ESA CCI+ Permafrost. D2.5 Product Validation Plan (PVP), v2.0.

[RD-6] Barboux, C., Bertone, A., Delaloye, R., Onaca, A., Ardelean, F., Poncos, V., Kääb, A., Rouyet, L., Christiansen, H.H., Strozzi, T., Bartsch, A. 2019. ESA CCI+ Permafrost. CCN1 & CCN2

Rock Glacier Kinematics as New Associated Parameter of ECV Permafrost. D1.1 User Requirement Document (URD), v1.0.

[RD-7] Barboux, C., Bertone, A., Delaloye, R., Onaca, A., Ardelean, F., Poncos, V., Kääb, A., Rouyet, L., Christiansen, H.H., Strozzi, T., Bartsch, A. 2019. ESA CCI+ Permafrost. CCN1 & CCN2 Rock Glacier Kinematics as New Associated Parameter of ECV Permafrost. D1.2 Product Specification Document (PSD), v1.0.

[RD-8] Barboux, C., Bertone, A., Delaloye, R., Onaca, A., Ardelean, F., Poncos, V., Kääb, A., Rouyet, L., Christiansen, H.H., Strozzi, T., Bartsch, A. 2019. ESA CCI+ Permafrost. CCN1 & CCN2 Rock Glacier Kinematics as New Associated Parameter of ECV Permafrost. D1.3 Data Access Requirement Document (DARD), v1.0.

[RD-9] Strozzi, T., Sîrbu, F., Onaca, A, Ardelean, F., Poncos, V., Bartsch, A. 2019. . ESA CCI+ Permafrost. CCN1 Rock Glacier Kinematics in the Carpathians (Romania). D2. Algorithm Development Document, v1.0.

[RD-10] IPA Action Group Rock glacier inventories and kinematics. 2020. Towards standard guidelines for inventorying rock glaciers. Baseline concepts. Last version available on: https://bigweb.unifr.ch/Science/Geosciences/Geomorphology/Pub/Website/IPA/CurrentVersion/Current_Baseline_Concepts_Inventorying_Rock_Glaciers.pdf

[RD-11] IPA Action Group Rock glacier inventories and kinematics. 2020. Kinematics as an optional attribute of standardized rock glacier inventories. Last version available on: https://bigweb.unifr.ch/Science/Geosciences/Geomorphology/Pub/Website/IPA/CurrentVersion/Current_KinematicalAttribute.pdf

[RD-12] IPA Action Group Rock glacier inventories and kinematics. 2020. Rock glaciers kinematics as an associated parameter of ECV Permafrost. Last version available on: https://bigweb.unifr.ch/Science/Geosciences/Geomorphology/Pub/Website/IPA/CurrentVersion/Current_RockGlacierKinematics.pdf

[RD-13] IPA Action Group Rock glacier inventories and kinematics. 2020. Response to GCOS ECV review – ECV Permafrost. ECV Product: Rock Glacier Kinematics. Available on: https://gcos.wmo.int/en/ecv-review-2020.

[RD-14] 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).

1.5 Bibliography

A complete bibliographic list that supports arguments or statements made within the current document is provided in Section 3.1.

1.6 Acronyms

A list of acronyms is provided in Section 3.2.

1.7 Glossary

A comprehensive glossary of terms relevant for the parameters addressed in Permafrost_cci is available as part of the Reference Documents of the baseline project [RD-1 to RD-5] and of CCN 1&2 [RD-6 to RD-9], as well as in [RD-14].

2 ALGORITHM DEVELOPMENT PLAN

CCN1/CCN2 comprise only one algorithm iteration over 18 months. No phases in algorithm development are therefore for the moment foreseen.

3 REFERENCES

3.1 Bibliography

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3.2 Acronyms

AD	Applicable Document
ADP	Algorithm Development Plan
ATBD	Algorithm Theoretical Basis Document
AUC	Area Under the Receiver Operating Curve
B.GEOS	b.geos GmbH
BTS	Bottom Temperature of Snow Cover
CCI	Climate Change Initiative
CCN	Contract Change Notice
CRS	Coordinate Reference System
DARD	Data Access Requirement Document
DEM	Digital Elevation Model
ECV	Essential Climate Variable
EO	Earth Observation
ERT	Electrical Resistivity Tomography
ESA	European Space Agency
ESA DUE	ESA Data User Element
E3UB	End-to-End ECV Uncertainty Budget
GAMMA	Gamma Remote Sensing AG
GCOS	Global Climate Observing System
GFI	Ground Freezing Index
GPR	Ground Penetrating Radar
GST	Ground Surface Temperature
GT	Ground Temperature
GTOS	Global Terrestrial Observing System
GUIO	Department of Geosciences University of Oslo
INSAR	Synthetic Aperture Radar Interferometry
IPA	International Permafrost Association
KTS	Kinematical Time Series
LST	Land Surface Temperature
MAGT	Mean Annual Ground Temperature
MAGST	Mean Annual Ground Surface Temperature
MPDM	Mountain Permafrost Distribution Model
MRI	Mountains Research Initiative
MTD	Miniature Temperature Data Loggers
NMA	National Meteorological Administration
NORCE	Norwegian Research Centre AS
NSIDC	National Snow and Ice Data Center

PSD	Product Specifications Document
PVASR	Product Validation and Algorithm Selection Report
PVP	Product Validation Plan
RF	Random Forest
RD	Reference Document
RGI	Rock Glacier Inventories
RMSE	Root Mean Square Error
SAR	Synthetic Aperture Radar
S4C	Science for the Carpathians
SWE	Snow Water Equivalent
T	Temperature
UNIFR	Department of Geosciences University of Fribourg
UNIS	University Centre in Svalbard
URD	Users Requirement Document
UTM	Universal Transverse Mercator
WGS	World Geodetic System
WUT	West University of Timisoara