CRYOSMOS

WP600
Experimental Datasets generation

D8 Experimental Dataset User Manual (EDUM)

Version 2.0
March 19, 2020

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<table>
<tr><td colspan="4">ESA STUDY CONTRACT REPORT</td></tr>
<tr><td>ESRIN Contract No:

4000112262/14/I-NB</td><td colspan="2">Subject:

CryoSMOS
Support To Science Elements SMOS+Cryosphere</td><td>Contractor:
IFAC</td></tr>
<tr><td>ESA CR ( )No:</td><td>Star Code:</td><td>No of volumes: 1
This is volume no: 1</td><td>Contractor’s Ref:
Deliverable D8</td></tr>
<tr><td colspan="4">ABSTRACT:
This is the Task 6 Report (Deliverable D8) of the study CryoSMOS - Support To Science Elements SMOS+Cryosphere (ESRIN Contract No. 4000112262/14/I-NB).

The Experimental Dataset User Manual (EDUM) - D8 is intended to explain the content of each product. Since the validation of D7 could be quite limited due to the scarcity of ground experimental data, particular care is be put in highlighting the “experimental” character of the dataset produced in this WP.</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">PREPARED BY:
G. Macelloni, F.Montomoli, M. Brogioni, (IFAC), N. Skou, R. Forsberg (DTU), M. Leduc-Leballeur, G. Picard (LGGE), L. Kaleschke, A. Wernecke (UHAM), A. Mialon (CESBIO)</td></tr>
<tr><td colspan="2">ESA STUDY MANAGER:
Ola Grabak</td><td colspan="2">ESA BUDGET HEADING</td></tr>
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DOCUMENT CHANGE LOG

Issue/ Revision	Date	Observations
1/0	16/12/2016	First issue
2/0	19/03/2020	Updaed for ice sheet temperature and melt products

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TABLE OF CONTENTS

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1 Purpose and structure of document

1.1 Purpose

This document is the Experimental Dataset User Manual (EDUM) for the CRYOSMOS project products. Its propose is the description of the products obtained with the methods and algorithms detailed in deliverables D5-2 e D6-6. The products are collected in the deliverable D7 Experimental Dataset (EDS) and available from the project website and CATDS.

1.2 Document Structure

The structure of the document is the following (and summarized in Table 1 -1 against WPs):

- Section 2 – 5 - Detailed description of each case study.
- Section 6 – References

Table 1-1 - Structure of document against subtasks of the work package

WP	Subtask	Section(s) in document	Main contributors
600	1	2	IFAC
600	2	3	DTU
600	3	4	UH
600	4	5	LGGE

1.3 Definitions and Acronyms

Table 1 -2 lists the acronyms and abbreviations used within this document.

Table 1-2 - Acronyms and abbreviations

Acronym	Meaning
AMSR-E	Advanced Microwave Scanning Radiometer for EO
AMSR-2	Advanced Microwave Scanning Radiometer
AMSU	Advanced Microwave Sounding Unit
CEOS-WGCV	Committee on Earth Observation Satellites-Working Group Calibration and Validation
CESBIO	Centre d'Etudes Spatiales de la BIOsphère
CSCR	Case Studies Consolidation Report
DMRT	Dense Media Radiative Transfer model
DTU	Danish Technical University
ECV	Essential Climate Variables
EM	ElectroMagnetic
EO	Earth Observation
EOEP	Earth Observation Envelope Program
EPICA	European Project for Ice Coring in Antarctica
ESA	European Space Agency
GOCE	Gravity field and steady-state Ocean Circulation Explorer
IFAC	Istituto di Fisica Applicata “N.Carrara”
IR	InfraRed
ITT	Invitation To Tender
LGGE	Laboratoire de Glaciologie et Géophysique de l’Environnement
MODIS	Moderate Resolution Imaging Spectroradiometer
MIRAS	Microwave Imaging Radiometer by Aperture Synthesis
ML	Multi-Layer
NIR	Noise Injection Radiometers
NASA	National Aeronautic and Space Administration
QCA-CP	Quasi Crystalline Approximation with Coherent Potential
RB	Requirement Baseline report
SMAP	Soil Moisture Active and Passive mission

SMOS	Soil Moisture Ocean Salinity mission
SoW	Statement Of Work
SSM/I	Special Sensor Microwave Imager
STSE	Support To Science Elements
TB	Brightness Temperature
UHAM	University of Hamburg
WALOMIS	Wave Approach for LOw-frequency MIcrowave emission in Snow
WP	Work Package

1.4 Reference documents

All the references to scientific works cited in the present report are reported in section 6. Hereinafter are listed some general management documents referred in the present report:

[RD.1] Project Statement of Works
[RD.2] CryoSMOS project proposal
[RD.3] D1 - Requirement Baseline report (RB)
[RD.4] D2 - Case Studies Consolidation report (CSC)
[RD.5] D3 - Dataset
[RD.6] D4 - Dataset User Manual (DUM)
[RD.7] D5-1 - Algorithm Theoretical Basis Documents (ATBD) v1
[RD.8] D6-1 - Product Validation Report (VR) v1
[RD.9] D5-2 - Algorithm Theoretical Basis Documents (ATBD) v2
[RD.10] D6-2 - Product Validation Report (VR) v2

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2 Case study n.1: Quantifying internal ice-sheet temperature

(IFAC-CNR in cooperation with DTU, LGGE, CESBIO)

2.1 Description of the product

The product “internal ice-sheet temperature” is composed by maps of internal temperature for the regions in which the Robin model is valid D5-2 [RD.9] along with the relative uncertainty estimation and a map of the quality of the estimation. It is obtained by using the IFAC-processor whose algorithm is described in D5-2 [RD.9]. It should be noted here that the product is experimental and is intended for scientific reasons.

It is worth to recall here that the uncertainty related to the ice-sheet internal temperature estimate is due to both surface temperature and ice thickness uncertainty. Since the error associated to the surface temperature data cannot be provided all over the continent due to the scarcity of ground measurements (see D2 [RD.4]), the uncertainty is the one related to the ice thickness measurements.

2.1.1 Overview

Table 2-3 : Characteristics of the product

Parameter	Value
Spatial Coverage	N: -63, S: -83, E: 180, W: -180
Spatial Resolution	25 km x 25 km (EASEGrid2 Southern Hemisphere Azimuthal)
Temporal Coverage	n/a, static map
Parameter(s)	Internal ice-sheet temperature
Platform(s)/Sensor(s)	SMOS/ MIRAS
Data Format(s)	NETCDF-3/CDM
Version	Version 2.0
Data Contributor(s)	IFAC-CNR, LGGE

2.1.2 Data Citation

The data are freely disseminated, however the use of this data set must be cited as:
Macelloni G., M. Brogioni, G. Picard and M. Leduc-Leballeur. 2019. SMOS Internal ice-sheet temperature, Version 2. [Indicate subset used]. “Cryosmos. STSE SMOS+Cryosphere”. ESA contract No.4000112262/14/I-NB.

A communication to g.macelloni@ifac.cnr.it would be highly appreciated for any publication/communication, where the product is used.

Reference: Macelloni, G. M. Leduc-Leballeur, F. Montomoli, M. Brogioni, C. Ritz, G. Picard, 2019, On the retrieval of internal temperature of Antarctica Ice Sheet by using SMOS observations, Remote Sensing of Environment, 233, doi:10.1016/j.rse.2019.111405

2.1.3 Description of the data

2.1.3.1 Format

Data files are provided in NETCDF-3/CDM.

2.1.3.2 File Naming Convention

The product name is:

SM_TEST_MIR_ITUDP4_20100101T000000_20150101T000000_100_001_0.nc

SM_TEST_MIR_ITUDP4_[YYYYMMGG]T[hhmmss]_[YYYYMMGG]T[hhmmss]_vvv_ccc_s.nc

Refer to Table 2 -4 for the file name description.

Table 2-4 : Variables in the MODIS File Naming Convention

Variable	Description
SM	SMOS mission
TEST	Test version
MIR	Miras sensor
ITUDP4	Internal ice-sheet Temperature User Data Product L4
[YYYYMMGG]T[hhmmss]_[YYYYMMGG]T[hhmmss]	First and last dates of SMOS L3 data used in the products [year,month,day]T[hour,min,sec]
vvv	Processor version
ccc	File counter (used to make distinction among products having all other filename identifiers identical)
s	Producing site ID (0 = generated outside SMOS operational ground segment)

2.1.3.3 File Size

The file is approximately 17 MB.

2.1.3.4 Spatial Coverage

The coverage is limited to Antarctica. The data contained in the product are georeferenced over the EASEGrid2 Southern Hemisphere Azimuthal. Overall the dimension of the map are 200x224 pixels.

2.1.3.5 Spatial Resolution

The spatial resolution is 25 km x 25 km.

2.1.3.6 Projection and Grid Description

The product is on the EASEGrid2 grid in the Southern Hemisphere Azimuthal projection. Latitude and longitude coordinates are provided inside of the file.

2.1.3.7 Temporal Coverage

As pointed out in the ATBD (D5-2), the internal ice-sheet temperature product is static and is expected to change over centennial time scale. The product is build from the L3 SMOS brightness temperature in average over 2013-2014. Description of the L3 SMOS product is in Al Bitar et al. (2017).

2.1.3.8 Parameters

Internal ice-sheet temperature and related uncertainty estimated from surface up to the bedrock in step of 50 m and quality flag for each pixel are written in a NetCDF-3 file by using Python® software. The parameters of the product are listed in Table 2 -5.

Table 2-5 : Variables description.

Variable	**Description**
Tice	Ice sheet Temperature map (in Kelvin) from the surface down to 4500 m in depth by 50 m step (i.e. 91 levels). • valid range = 0 – 273 K • fill values = -32768
QualityFlag	Quality flag associated to each retrieved temperature profile. • valid range = 0 to 3, 0 is the best quality.good quality • fill values = -32768 / retrieval not performed
Latitude	Pixel latitude in degrees North
Longitude	Pixel longitude in degrees East
Depth	Depth below the ice sheet surface (in meters)

2.1.3.9 Get Data

Data are available via FTP and HTTPS at:

- CATDS : ftp://ftp.ifremer.fr
- Project website: http://www.ifac.cnr.it/cryosmos/Products.html

2.1.3.10 Derivation Techniques and Algorithms

The description of the data processing and the retrieval methods are detailed in D5-2 [RD.9]. The product verification and error estimation are described in D6-2 [RD.10].

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3 Case study n.2: Bedrock topography and/or geothermal heat flux

(DTU in cooperation with IFAC, CESBIO)

3.1 Description of the product

The Ice Thickness product generation is described in [RD.9] and verified in [RD.10]. The product provides an estimate of the Ice Thickness in an area of East Antarctica where the BEDMAP2 data has an uncertainty of 1000 m. The product consists of a NETCDF file containing data in SMOS L3 format. The spatial coverage is provided as an index map in SMOS L3 coordinates. Both ice thickness estimate as well as ice thickness estimate merged onto the surrounding BEDMAP2 ice thickness data, are proved as maps. For user convenience the latitude and longitude coordinate values are also provided. The filename is "SMOS_IceThickness_YYYY_vvv.nc", where YYYY is the year and vvv is the version number. File size is approximately 7 Mbyte. Only year 2015 version 300 is currently provided. The contents of the file are shown in Table 3 -6.

Table 3-6 : Characteristics of the product

Variable Name	Data type	Unit	Fill value	Description
lat	Single	Degrees North	NA	SMOS L3 grid latitude
lon	Single	Degrees East	NA	SMOS L3 grid longitude
est	Single	Meter	0	Ice thickness estimate
mrg	Single	Meter	0	Ice thickness estimate merged onto BEDMAP2 ice thickness data
Idx	Int8	NA	0	Index equal to 1 where ice thickness is estimated from SMOS data

3.2 Data availability

Data can be retrieved from:

- CATDS : ftp://ftp.ifremer.fr
- Project website: http://www.ifac.cnr.it/cryosmos/Products.html

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4 Case study n.3: Characterization of ice shelves

(UHAM)

4.1 File name convention

The ice shelf product consists of two types of NETCDF-4 files, one containing yearly mean quantities and one containing differential quantities as well as static surface type masks.
Names of the first file type are "SMOS_TB_for_Origin_*yyyy_vvv*.nc", where "*yyyy*" is the respective year and "*vvv*" the dataset version.
Names of the second file type are "SMOS_Origin_*yyyy_yyyy_vvv*.nc" where the first "*yyyy*" indicates the first year, the second "*yyyy*" the second year and "*vvv*" the dataset version. All differential quantities are based on the yearly mean of the second year minus the yearly mean of first year.

4.2 File structure

4.2.1 SMOS_TB_for_Origin_yyyy_vvv.nc

#	Variable Name	Data Type	Fillvalue	Unit	Description
1	"lat"	32b float	---	deg North	Central latitude
2	"lon"	32b float	---	deg East	Central longitude
3	"TB_nn"	32b float	-999	Kelvin	Yearly mean near nadir Brightness Temperature[1,2]
4	"TB_v40"	32b float	-999	Kelvin	Yearly mean Brightness Temperature at 40 deg vertical polarization[1,3]
5	"TB_h40"	32b float	-999	Kelvin	Yearly mean Brightness Temperature at 40 deg horizontal polarization[1,3]
6	"STD_TB_nn"	32b float	-999	Kelvin	Standard deviation for deriving #3[4]
7	"STD_TB_v40"	32b float	-999	Kelvin	Standard deviation for deriving #4[4]
8	"STD_TB_h40"	32b float	-999	Kelvin	Standard deviation for deriving #5[4]
9	"Region_ID"	16b integer	-999	unitless	Region identifier[5]

[1]The periods used for yearly means are restricted to times of the year when no surface melt is expected and vary from region to region (see #9 and corresponding comment).

[2]Near nadir is defined here as the mean of all v and h polarization measurements with incidence angle <40 deg.

[3]Brightness Temperature values at a specific incidence angle are based on a semi empirical fit to the full range of incidence angles. See ATBD for more information.

[4]based on a daily product.

[5]Names and periods used for means and standard deviations:

Region_ID	Name of Region	Start Date	End Date
1	Antarctic Peninsula	Apr. 1	Aug. 1
2	Ronne Filchner IS	Feb. 1	Dec. 1
3	Ross IS	Mar. 1	Dec. 1
4	Amery IS	Mar. 1	Nov. 1
5	Shackelton IS	Mar 1	Dec. 1
6	DomeC / Lake Vostoc	Jan. 1	Dec. 31
7	Queen Mauld Land	Jan. 1	Dec. 31

4.2.2 SMOS_Origin_yyyy_yyyy_vvv.nc

#	Variable Name	Data Type	Fillvalue	Unit	Describtion
1	“lat”	32b float	---	deg North	Central latitude
2	“lon”	32b float	---	deg East	Central longitude
3	“Origin”	32b float	-999	unitless	Origin of change in SMOS signal ranging from 0 (bottom/interior of ice shelf) to 1 (near surface)[1]
4	“Amp_change”	32b float	-999	unitless	Scaled amplitude of SMOS signal change[2]
5	“dTB_nn”	32b float	-999	Kelvin	Absolute difference in near nadir Brightness Temperature
6	“dPOL_40”	32b float	-999	unitless	Absolute difference in normalized polarization difference at 40 deg incidence angle
7	“ice_shelf”	8b integer	---	unitless	Binary mask, 1 for ice shelves 0 else[3]
8	“land”	8b integer	---	unitless	Binary mask, 1 for land, 0 else[3]

[1]SMOS changes within the range of modelled changes result in a value of the origin parameter of 0 (bottom) or 1 (near surface) respectively. Changes in SMOS outside of these ranges are asigned values between 0 and 1 linearly with their distance to the classes.

[2]Scale factors are 0.16 K and 0.0008 for the near nadir TB and normalized polarization difference, respectively. Amp_change corresponds to “R” in the ATBD.

[3]Based on the Bedmap2 data set.

4.3 General remarks

The Origin parameter is not valid for very small changes in SMOS. Those cases have to be identified and excluded from further analysis. Possible ways to do so include thresholds on the Amp_change parameter like e.g. 4 or 6 but can also be based on the absolute changes (dTB_nn and dPOL_40). Note that using only one of the two mentioned parameters can privilege the exclusion of surface or bottom driven changes.

The dataset includes grounded areas adjacent to ice shelves but also the regions “DomeC / Lake Vostok” and “Queen Maud Land” which are completely grounded. Note that the EM model used to identity the influence of bottom and surface parameters was developed for ice shelves (including a base layer of sea water).

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5 Case study n.4: Characterization of surface processes

(LGGE in cooperation with IFAC, CESBIO)

5.1 Description of the product

The product “Occurrence of Surface Melting” includes the melted/not melted status of every pixel each day, as well as the mask which excludes the ocean as well as areas never experiencing melting. Surface melting is retrieved from passive microwave radiometer SMOS using the algorithm described in D5-2.

5.1.1 Overview

Table 5-7 : Characteristics of the product

Parameter	**Value**
Spatial Coverage	N: -60, S: -83, E: 180, W: -180
Spatial Resolution	Depends on latitude (EASEGrid2 Global Cylindrical)
Temporal Coverage	daily
Parameter(s):	Occurrence of surface melting
Platform(s)/Sensor(s)	SMOS/ MIRAS
Data Format(s):	NETCDF-4
Version:	Version 2.0
Data Contributor(s):	LGGE, IFAC-CNR

5.1.2 Data Citation

The data are freely disseminated, however the use of this data set must be cited as:
M. Leduc–Leballeur, G. Picard, G. Macelloni and M. Brogioni. 2016. SMOS Surface Melting, Version 1. [Indicate subset used]. “Cryosmos. STSE SMOS+Cryosphere”. ESA contract No.4000112262/14/I-NB.

A communication to ghislain.picard@univ-grenoble-alpes.fr or m.leduc@ifac.cnr.it would be highly appreciated for any publication/communication, where the product is used.

Reference: Leduc-Leballeur M., Picard G., Macelloni G., Arnaud L., Mialon A., Kerr Y., 2020, Melt in Antarctica derived from Soil Moisture and Ocean Salinity (SMOS) observations at L band, The Cryosphere, 14, 539–548, doi:10.5194/tc-14-539-2020.

5.1.3 Description of the data

5.1.3.1 Format

Data files are provided in NETCDF-4.

5.1.3.2 File Naming Convention

The product name is:
SM_TEST_MIR_OSMDP4_20100101T000000_20150101T000000_100_001_0.nc

SM_TEST_MIR_OSMDP4_[YYYYMMGG]T[hhmmss]_[YYYYMMGG]T[hhmmss]_vvv_ccc_s.nc

Refer to Table 5 -8 for the file name description.

Table 5-8 : Variables in the MODIS File Naming Convention

Variable	**Description**
SM	SMOS mission
TEST	Test version
MIR	Miras sensor
OSMUDP4	Occurrence of Surface Melting User Data Product L4
[YYYYMMGG]T[hhmmss]_[YYYYMMGG]T[hhmmss]	dates of first and last SMOS L3 data used in the products [year,month,day]T[hour,min,sec]
vvv	Processor version
ccc	File counter (used to make distinction among products having all other filename identifiers identical)
s	Producing site ID (0 = generated outside SMOS operational ground segment)

5.1.3.3 File Size

The file is approximately 345 MB.

5.1.3.4 Spatial Coverage

The coverage is limited to Antarctica. The product is geo-referenced over the EASEGrid2 in Global Cylindrical projection. Overall the dimensions of the map are 38 X 1388 pixels (latitude X longitude).

5.1.3.5 Spatial Resolution

The spatial resolution is determined by the EASEGrid2 in Global Cylindrical projection.

5.1.3.6 Projection and Grid Description

EASEGrid2 in Global Cylindrical projection. Latitude and longitude coordinates are provided inside of the file.

5.1.3.7 Temporal Coverage

The occurrence of surface melting product provides daily April 2010 until March 2019.

5.1.3.8 Parameters

The occurrence of surface melting and the mask for each pixel are written to NetCDF-4 file by using Python® software. The parameters of the product are listed in Table 5 -9.

Table 5-9 : Variables Description

Variable	**Description**
melt	Daily maps of the occurrences of surface melt. • valid range = 0: no melt; 1: melt • fill value = -10
Latitude	Vector of latitude in degreee North
Longitude	Vector of longitude in degrees East
TIme	Days since 2009-01-01

5.1.3.9 Get Data

Data are available via FTP and HTTPS at:

- CATDS : ftp://ftp.ifremer.fr
- Project website: http://www.ifac.cnr.it/cryosmos/Products.html

5.1.3.10 Derivation Techniques and Algorithms

The description of the data processing and the retrieval methods are detailed in D5-2 [RD.9]. The product verification and error estimation are described in D6-2 [RD.10].

6 References

Al Bitar A., A. Mialon, Y. H. Kerr, F. Cabot, A. Mahmoudi, P. Richaume, A. Al-Yaari, E. Jacquette, A. Quesney, M. Parrens, S. K. Tomer, B. Molero, T. Pellarin, J.P. Wigneron, 2017, The SMOS Level 3 daily soil moisture and brightness temperature maps.

Brogioni, M., Macelloni, G., Montomoli, F. and Jezek, K.C., 2015, Simulating Multifrequency Ground-Based Radiometric Measurements at Dome C Antarctica., IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 99, 1-13, 10.1109/JSTARS.2015.2427512

Jezek K. C., J.T. Johnson, M.R. Drinkwater, G. Macelloni, and L. Tsang, 2015, Radiometric approach for estimating relative changes in intraglacier average temperature, IEEE Trans. Geosci. Remote Sens., 53(1), 134–143.

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Leduc-Leballeur M., Picard G., Macelloni G., Arnaud L., Mialon A., Kerr Y., 2020, Melt in Antarctica derived from Soil Moisture and Ocean Salinity (SMOS) observations at L band, The Cryosphere, 14, 539–548, doi:10.5194/tc-14-539-2020

Macelloni, G. M. Leduc-Leballeur, F. Montomoli, M. Brogioni, C. Ritz, G. Picard, 2019, On the retrieval of internal temperature of Antarctica Ice Sheet by using SMOS observations, Remote Sensing of Environment, 233, doi:10.1016/j.rse.2019.111405

Macelloni G., Leduc-Leballeur M., Brogioni M. , Ritz C., Picard G., 2016, Analyzing and modeling the SMOS spatial variations in the East Antarctic Plateau, Remote Sensing of the Environment, 180, 193 - 204, doi: 10.1016/j.rse.2016.02.037