

SMOS Freeze and Thaw Processing and Dissemination Service

# Product Description Document

ESRIN Contract Nro: 4000124500/18/I-EF

Issue / Revision: 2 / 0

Date: 7 June 2023

**Prepared by**

Kimmo Rautiainen, Manu Holmberg  
Finnish Meteorological Institute (FMI)



ILMATIETEEN LAITOS  
METEOROLOGISKA INSTITUTET  
FINNISH METEOROLOGICAL INSTITUTE

*This page is intentionally left blank.*

## Document change log

<b>Issue/ Revision</b>	<b>Date</b>	<b>Observations</b>
0.1	20-Jun-2018	Draft issue for Kick-Off meeting
1.0	14-Nov-2018	Changes based on PM meeting (08-Nov-2018) and comments from ESA
1.1	21-Nov-2018	Section 2.5 changed, otherwise only minor corrections
1.2	26-Nov-2018	Table 1 and 2 updated, Appendix A changed
1.3	18-Feb-2019	Updated based on ESA review comments
1.4	25-Feb-2019	Updated table 1, L3FT description and metadata example in Appendix
1.5	28-Feb-2019	Minor updates
1.6	10-Jul-2019	Minor changes to chapter 2.4 "Contents of the daily data file"
2.0	07-Jun-2023	Major updates to all sections, FT processor updated to v300

*This page is intentionally left blank.*

# Contents

<b>1</b>	<b>Introduction</b>	<b>5</b>
<b>2</b>	<b>Description of SMOS L3FT product</b>	<b>6</b>
2.1	Filename convention . . . . .	6
2.2	Data coverage, spatial and temporal resolution . . . . .	6
2.3	Data format . . . . .	6
2.4	Contents of the daily data file . . . . .	7
2.5	Quality flag . . . . .	8
<b>3</b>	<b>Data access</b>	<b>9</b>
<b>4</b>	<b>Contact</b>	<b>9</b>
<b>5</b>	<b>References</b>	<b>10</b>

# 1 Introduction

This document describes the Level 3 SMOS soil Freeze and Thaw (F/T) status product, referred to hereafter as SMOS L3FT. The development work of the product was started within the SMOS+ Innovation Permafrost (ESA ESRIN Contract no: 4000105184/12/I-BG) project and continued within SMOS+ Frost2Study (ESRIN Contract no: 4000110973/14/NL/FF/lf) [1]. The operational service started within the SMOS Freeze and Thaw Processing and Dissemination Service contract (ESRIN Contract no: 4000124500/18/I-EF).

The SMOS L3FT product is generated daily, it contains information on the northern hemisphere soil state retrieved from SMOS daily gridded level 3 brightness temperatures (data provided by Centre Aval de Traitement des Données SMOS - CATDS [2]). Two ancillary datasets: ECMWF 2m air temperature data and NSIDC IMS snow cover data are used. The SMOS L3FT product is provided in the Equal-Area Scalable Earth Grid (EASE2-Grid) at 25 km x 25 km sampling. The product start date is July 1st, 2010.

Detailed information on the algorithm can be found in the Algorithm Theoretical Baseline Document. The latest version is available from the SMOS Freeze and Thaw processing and dissemination service web page:  
<http://nsdc.fmi.fi/services/SMOSService/>

## 2 Description of SMOS L3FT product

### 2.1 Filename convention

The product filename is based on ESA SMOS filename conventions. Each daily file is named as follows:

`W_XX-ESA,SMOS,NH_25KM_EASE2_yyyymmdd_f_vnnn_cc_l3soilft.nc`

The meaning of the different parts of the filename are given in Table 1

Acronym	Description
yyymmdd	Processed date (e.g 20180818 refers to 18-August-2018)
f	Operational   Reprocessed Data Flag. Possible values [o r]
vnnn	SMOS FT processor version, current version is v300
cc	Product counter
l3soilft	Name of the output product, L3 Freeze and Thaw Product
EASE2	Output product grid name, Equal-Area Scalable Earth 2.0 [3], [4]
NH	Output product spatial coverage: NH - Northern Hemisphere
25KM	Output product grid cell size: 25km x 25km

Table 1: SMOS L3FT output filename description

### 2.2 Data coverage, spatial and temporal resolution

Parameter	Description
Temporal coverage	July 2010 - present
Temporal resolution	Daily
Spatial coverage	0°N - 85°N; 180°W - 180°E
Spatial sampling	25km × 25km
Projection	Polar azimuthal equal-area for the Northern Hemisphere
Grid	The Equal-Area Scalable Earth Grid 2.0 (EASE-grid 2.0)
Data dimension	720 × 720 (columns × rows)

Table 2: SMOS L3FT product data coverage, spatial and temporal resolution

### 2.3 Data format

Data format is NetCDF. An example of the SMOS L3FT NetCDF file metadata variables and global attributes are given in appendix 1. Information relevant to users provided in the metadata is shown in Table below.

## 2.4 Contents of the daily data file

The SMOS L3FT product daily data packet contains information on soil state, processing mask, data quality, date of the latest acquisition, latitude and longitude.

Detailed information of the data quality flag is provided in section 2.5.

The product parameters are given in Table 3.

Variable name	Description	Unit
L3FT_asc	Soil state estimate from ascending (AM) orbit data, soil state provided in three levels as follows: 1 - thawed 2 - partially frozen 3 - frozen 255 - no data value	flag
L3FT_dsc	Soil state estimate from descending (PM) orbit data, soil state provided in three levels as follows: 1 - thawed 2 - partially frozen 3 - frozen 255 - no data value	flag
PM	Processing mask derived from 2m air temperature and snow cover extent data. PM is used to detect and correct possible erroneous estimates during summer and/or winter seasons. PM is provided in 8 levels as follows: 1,2 – summer season 3,4 – freezing season 5,6 – winter season 7,8 – melting season 255 – no data value	flag
QF_asc	Quality flag for ascending orbit data. An 8-bit value, detailed information provided in section 2.5	flag
QF_dsc	Quality flag for descending orbit data. An 8-bit value, detailed information provided in section 2.5	flag
delta_dnum_asc	Number of days since last observation from the ascending orbit	days
delta_dnum_dsc	Number of days since last observation from the descending orbit	days
lon	Longitude coordinate for each pixel centre	degrees
lat	Latitude coordinate for each pixel centre	degrees

Table 3: SMOS L3FT product parameters



## 2.5 Quality flag

The quality flag information is accompanied with both ascending and descending L3FT products. This information help users to detect possible problematic and/or unreliable data. The quality information is coded into an 8-bit unsigned integer. The 8-bit integer is coded in the following manner

Rwwxxyyz

The least significant bit **z** indicates if the L3FT product is available for that grid point. The SMOS satellite performs global coverage in 3 days, and has more frequent over pass at higher latitudes. The bits **yy** indicate the number of days since the last observation for that grid point. The L3FT algorithm uses Kalman filter to remove noise from the SMOS signal. As a result, the filtered value of the signal is affected by the past measurements. The fraction of the filtered signal value believed to be affected by the RFI is evaluated and expressed with the bits **xx**. As the L3FT is an empirical algorithm, it is challenging to provide comprehensive uncertainty estimate. The uncertainty caused by the measurement noise is indicated in the bits **ww**. These bits indicate the estimated probability of the given freeze-thaw state being the true state, when considering the possible effect of the measurement noise to the L3FT algorithm. However, it is natural that the product uncertainty is low during transition periods, and should not necessarily be interpreted as low product quality. Table 4 summarizes the quality flags.

Recommended use for the quality flags depends on the application. In general, the use of results with **yy** = 11 and **xx** = 11 is not recommended. For more cautious application, omitting results with **yy** = 10 or **xx** = 10 should be considered. The use of bits **ww** is not necessary, but it can provide information, in particular if the flags are on for longer periods of time.

Bit	Name	Coded information
<b>z</b>	Data available	0 - no data available 1 - data available
<b>yy</b>	Days since last observation	00 - maximum of <b>one</b> day since last observations was acquired 01 - <b>two</b> to <b>three</b> days since last observation was acquired 10 - <b>four</b> to <b>seven</b> days since last observation was acquired 11 - more than <b>seven</b> days since last observation was acquired
<b>xx</b>	Presence of suspected RFI in the acquisitions	00 - less than <b>5%</b> suspected to be affected by RFI 01 - from <b>5%</b> to <b>15%</b> suspected to be affected by RFI 10 - from <b>15%</b> to <b>30%</b> suspected to be affected by RFI 11 - more than <b>30%</b> suspected to be affected by RFI
<b>ww</b>	Probability of the estimated freeze-thaw state	00 - more than <b>90%</b> 01 - between <b>70%</b> and <b>90%</b> 10 - between <b>50%</b> and <b>70%</b> 11 - less than <b>50%</b>
<b>R</b>	Not used	Reserved for further use

Table 4: Quality flag information included in the SMOS L3FT product.

### 3 Data access

Unrestricted data access through FMI and ESA ftp/http dissemination services.

FMI download dissemination service: <ftp://litdb.fmi.fi/outgoing/SMOS-FTService/>

ESA download dissemination service: <https://smos-diss.eo.esa.int/oads/access/>

Links to above dissemination services also via project web page:

<http://nsdc.fmi.fi/services/SMOSService/>

### 4 Contact

#### Science

Dr. Kimmo Rautiainen

Finnish Meteorological Institute, Earth Observation Research

email: [kimmo.rautiainen@fmi.fi](mailto:kimmo.rautiainen@fmi.fi)

#### FMI Data

[smos.dissemination.support@nsdc.fmi.fi](mailto:smos.dissemination.support@nsdc.fmi.fi)

#### ESA Data

[smos.dissemination.support@esa.int](mailto:smos.dissemination.support@esa.int)

## 5 References

### References

- [1] Rautiainen, K., Parkkinen, T., Lemmetyinen, J., Schwank, M., Wiesmann, A., Ikonen, J., Derksen, C., Davydov, S., Davydova, A., Boike, J., Langer, M., Drusch, M., Pulliainen, J., (2016) SMOS prototype algorithm for detecting autumn soil freezing. *Remote Sensing of Environment*, SMOS special issue 180:346-360
- [2] Al Bitar A., Mialon A., Kerr Y.H., Cabot F., Richaume P., Jacquette E., Quesney A., Mahmoodi A., Tarot S., Parrens M., Al-Yaari A., Pellarin T., Rodriguez-Fernandez N., & Wigneron J.P. (2017). The global SMOS Level 3 daily soil moisture and brightness temperature maps. *Earth System Science Data*, 9(1), 293-315. doi:10.5194/essd-9-293-2017, Open Access version: <http://archimer.ifremer.fr/doc/00388/49941/>
- [3] Brodzik, M. J. and Knowles, K. W., (2002) Chapter 5: EASE-Grid: A Versatile Set of Equal-Area Projections and Grids. in Michael F.Goodchild (Ed.) *Discrete Global Grids: A Web Book*. Santa Barbara, California USA: National Center for Geographic Information & Analysis. <https://escholarship.org/uc/item/9492q6sm>.
- [4] Brodzik, M. J., Billingsley, B., Haran, T., Raup, B., Savoie, M. H., (2012) EASE-Grid 2.0: Incremental but Significant Improvements for Earth-Gridded Data Sets. *ISPRS International Journal of Geo-Information*, 1(1):32-45, doi:10.3390/ijgi1010032.