

# Product Description Document

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## Deliverable

**ESRIN Contract Nro:** 4000124500/18/I-EF

**Issue / Revision:** 1 / 6

**Date:** 10 July 2019

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## Document change log

Issue/ Revision	Date	Observations
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"

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## 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). The product is finalised within the SMOS Freeze and Thaw Processing and Dissemination Service (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). 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 1<sup>st</sup>, 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

where

yyymmdd is the sensing date (eg. 20180818 refers to 18-August-2018)

f is Operational | Reprocessed Data Flag. Possible values [o|r]

vnnn is Product version reflecting S/W version used and possible changes the SMOS and Auxiliary input products

cc Product counter in case of regeneration

l3soilft Product Type, fixed string indicating the L3 Freeze and Thaw Product

## 2.2 Data coverage, spatial and temporal resolution

<b>Parameter</b>	<b>Description</b>
Temporal coverage	July 2010 - present
Temporal resolution:	Daily
Spatial coverage:	0° - 85° N; 180°W - 180°E
Spatial sampling	25 km x 25 km
Projection	Polar-stereographic
Grid	EASE-2
Data dimension	720 x 720 (columns x rows)

## 2.3 Data format

Data format is NetCDF

## 2.4 Contents of the daily data file

The SMOS L3FTproduct daily data packet contains information on soil state, processing mask, data quality, latitude and longitude. The data quality includes information on the number of observation days within each moving average window and the effect of the processing mask, more detailed information is provided in section 2.5. The uncertainty field in version 2.01 product has not been computed; instead it is filled with default no data value. This field will be computed in further versions of SMOS L3FT product.

The product parameters are given in Table 1.

**Table 1. F/T product parameters on daily data packet**

<b>Name in NetCDF file</b>	<b>Description</b>	<b>Unit</b>
L3FT	Estimated soil state within a pixel in three levels as follows: 1– thaw 2 – partially frozen 3 – frozen 255 – no data value	Flag
PM	Processing mask derived from ECMWF 2m air temperature and IMS snow cover used to detect and correct possible erroneous estimates during summer and/or winter seasons. 1,2 – summer season 3,4 – freezing season 5,6 – winter season 7,8 – melting season 255 – no data value	Flag
quality flag	Quality flag. An 8-bit value, detailed information provided below in section 2.5	Flag
latitude	Latitude coordinate for each pixel centre	degrees
longitude	Longitude coordinate for each pixel centre	degrees
uncertainty	Uncertainty percentage of the soil state estimation 255 - no data value	%

## 2.5 Quality flag

As part of the soil freeze/thaw algorithm, obvious errors during summer periods (false detection of frozen soil) and winter periods (failure to detect frozen soil) are corrected through an independently determined processing mask (PM). Information on the amount of false alarms that has been corrected with the processing mask is used to estimate the quality of the SMOS L3FT product. This affects the reliability on correctly detecting the onset of the soil freezing.

A 20-day moving average has been applied to the SMOS observations to reduce the noise. Since a daily gridded input data is used, ideally, the averaged information includes observations from 20 different days. Due to the SMOS orbit configuration, the amount of observation days is naturally dependent on the latitude of the observed area. The amount of observation days may be also reduced due to other reasons, main reason being man-made radio frequency interferences (RFI). The quality flag includes also information on the amount of observation days within the 20-day moving average.

The quality information is provided as unsigned 8-bit integer. The 8-bit integer is grouped as follow:

WWWZZYYX (where, X is the least significant bit)

**The user is advised not to use data if YY equals to '00' or ZZ equals to '11'.**

The flag provide information as follows:

X	Data available	0 – no data (if no data the flag is 0 – in binary form: 0000 0000) 1 – data available
YY	Number of observation days	00 – observations from 1 to 5 days (at least one, maximum of 5) 01 – observations from 6 to 10 days 10 – observations from 11 to 15 days 11 – observations from 16 to 20 days
ZZ	Effect of the processing mask (PM)	00 – maximum of 5 false alarms during last 20 acquisitions 01 – from 6 to 10 false alarms during last 20 acquisitions 10 – from 11 to 15 false alarms during last 20 acquisitions 11 – over 15 false alarms during last 20 acquisitions
WWW	Not used	Reserved for further use

For example, a flag value of 13 (decimal) converts to 00001101 (8-bit binary). This value is grouped from WWW = 000, ZZ = 01, YY = 10 and X = 1.

## 2.6 Metadata and global variables in NetCDF file

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 2 below.

Table 2. L3SOILF metadata

Name	Description
Moving average	The F/T algorithm uses moving average to suppress noise. A 20-day moving average is used in product version 2.0.
Incidence angle range	The SMOS input data (CATDS) is angle-binned brightness temperature (TB) product. The F/T algorithm uses the incidence angle range of 50°-55° (Bitar et al. 2017)
Orbits included	The ascending orbits are less affected by the RFI in Eurasian content and the descending orbits in North-America. However, due to sun contamination flag the ascending orbits include less data in general in the high latitudes. Each daily file provides one single estimation on the soil state for each pixel. Current version uses only descending orbits for estimating the soil F/T state
Version of the Input data	Version of CATDS processor is provided here as well as information on ECMWF air temperature data and IMS snow cover data source.

### 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

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#### FMI Data

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#### ESA Data

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

## 5 References

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

Rautiainen et al., 2017. SMOS+ Frost2Study, Final Report, ESA ESRIN Contract No: 4000110973/14/NL/FF/If

Rautiainen et al., 2018. SMOS Freeze and Thaw Processing and Dissemination Service, Algorithm theoretical baseline document v2.0, ESA ESRIN Contract No: 4000124500/18/I-EF

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/>

## 6 Appendices

### Appendix A

#### Example metadata in SMOS L3FT daily NetCDF file

```
netcdf file:/D:/FTdata/Oper/05ProductOutput/03NetCdfData/W_XX-
ESA,SMOS,NH_25KM_EASE2_20190219_o_v200_01_l3soilft.nc {
  dimensions:
    x = 720;
    y = 720;
    time = UNLIMITED; // (0 currently)
  variables:
    char crs;
      :grid_mapping_name = "lambert_azimuthal_equal_area";
      :false_easting = 0L; // long
      :false_northing = 0L; // long
      :latitude_of_projection_origin = 90L; // long
      :longitude_of_projection_origin = 0L; // long
      :longitude_of_prime_meridian = 0L; // long
      :semi_major_axis = 6380000.0; // double
      :inverse_flattening = 298L; // long
      :spatial_ref = "PROJCS[\"unnamed\",GEOGCS[\"WGS
84\",DATUM[\"unknown\",SPHEROID[\"WGS84\",6378137,298.257223563]],PRIMEM[\"Green
wich\",0],UNIT[\"degree\",0.0174532925199433]],PROJECTION[\"Lambert_Azimuthal_Eq
ual_Area\"],PARAMETER[\"latitude_of_center\",90],PARAMETER[\"longitude_of_center
\",0],PARAMETER[\"false_easting\",0],PARAMETER[\"false_northing\",0],UNIT[\"metr
e\",1,AUTHORITY[\"EPSG\",\"9001\"]]]";
      :GeoTransform = "-9000000 25000 0 9000000 0 -25000 ";

    ushort L3FT(y=720, x=720);
      :long_name = "SMOS Level 3 Freeze Thaw Estimates";
      :valid_range = 1UB, 3UB; // ubyte
      :grid_mapping = "crs";
      :flag_meanings = "Thaw Partial Frozen";
      :FillValue = 255UB; // ubyte
      :flag_values = 1UB, 2UB, 3UB; // ubyte

    ushort PM(y=720, x=720);
      :long_name = "Processing Mask";
      :valid_range = 0UB, 8UB; // ubyte
      :grid_mapping = "crs";
      :FillValue = 255UB; // ubyte

    ushort quality_flag(y=720, x=720);
      :FillValue = 255UB; // ubyte
      :long_name = "Quality Flag";
      :valid_range = 0UB, 255UB; // ubyte
      :grid_mapping = "crs";

    ushort uncertainty(y=720, x=720);
      :FillValue = 255UB; // ubyte
      :long_name = "Uncertainty";
      :valid_range = 0UB, 100UB; // ubyte
      :grid_mapping = "crs";

    double x(x=720);
```

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```
        :_CoordinateAxisType = "GeoX";

double y(y=720);
    :_CoordinateAxisType = "GeoY";

float time(time=0);
    :_ChunkSizes = 1048576U; // uint

double lon(y=720, x=720);
    :valid_range = -180.0, 180.0; // double
    :axis = "X";
    :long_name = "Longitude";
    :units = "degree_east";
    :grid_mapping = "crs";
    :_CoordinateAxisType = "Lon";

double lat(y=720, x=720);
    :long_name = "Latitude";
    :grid_mapping = "crs";
    :valid_range = -90.0, 90.0; // double
    :axis = "Y";
    :units = "degree_north";
    :_CoordinateAxisType = "Lat";

// global attributes:
:title = "SMOS Freeze and Thaw Processing and Dissemination Service";
:sensor = "SMOS";
:data_date = "20190219";
:processing_date = "2019-02-22";
:coordinate_system = "Equal-Area Scalable Earth Grid 2.0 (EASE-Grid 2.0) -
Northern Hemisphere";
:latitude_range = "0N - 85N";
:longitude_range = "180W - 180E";
:spatial_resolution = "25 X 25 sq.km";
:processing_software_name = "FMI SMOS F/T processing software (Rautiainen,
Cohen, Hiltunen, Ikonen, Parkkinen, Moisander, Takala 2016-2019)";
:processing_software_version = "v_2.00";
:processing_organisation = "Finnish Meteorological Institute";
:project_id = "SMOS Freeze and Thaw Processing and Dissemination Service";
:moving_average = "20 days";
:incidence_angle_range = "50-55 degrees";
:orbits_included = "Currently only descending orbits used";
:smosinputdataversion = "SMOS input data: CATDS v620";
:ancillarydata_2mair = "Ancillary data for 2m airtemperature: ECMWF ERA
Interim reanalysis (1-Jul-2010 - 31-Jul-2018) and ECMWF NRT data (1-Aug-2018
onwards)";
:ancillarydata_snowcover = "Ancillary data for snow cover: IMS DAILY NORTHERN
HEMISPHERE SNOW AND ICE ANALYSIS AT 4 KM";
:contact = "Kimmo Rautiainen <kimmo.rautiainen@fmi.fi>";
:_CoordSysBuilder = "ucar.nc2.dataset.conv.DefaultConvention";
}
```