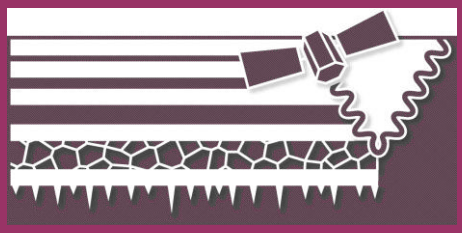
ESA DUE Permafrost



SAR Surface Soil Moisture v2 product guide

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1 Product overview

The SAR Surface Soil Moisture (SSM) product is derived from the ENVISAT ASAR sensor operating in Global Monitoring (GM) mode (Pathe et al. 2009) based on the approach of Wagner et al. (1999). The SAR SSM product is delivered as weekly mean composites at the 1 km spatial resolution. The version 2 release of the data covers the years 2005 through 2011 for the regional sites Ob Estuary, Alaska, Mackenzie and Central Yakutia. For the Laptev Sea Coast site the product is provided for 2005 through 2010. Product availability is limited to availability of ASAR GM data.

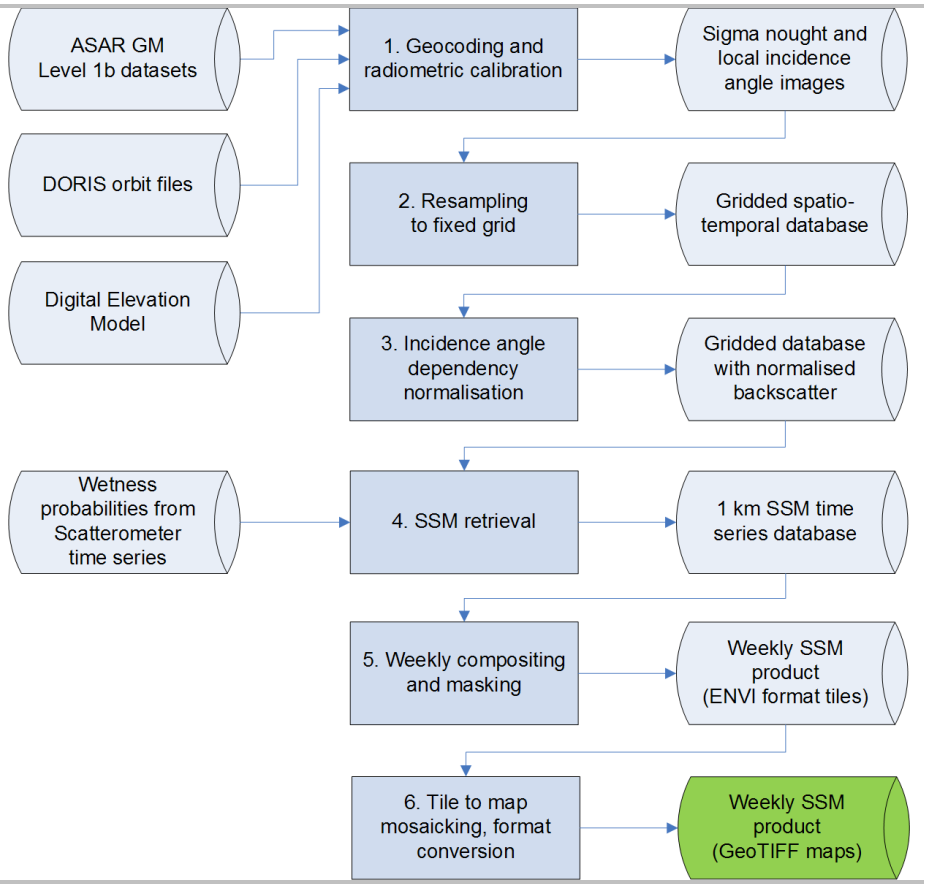

Figure 1
Flowchart for the product retrieval of the 1 km SAR Surface Soil Moisture product

An overview of the product retrieval process is given in Figure 1. The processing steps are explained below:

1. ASAR GM level 1b datasets were radiometrically calibrated and geocoded with a terrain-correction approach (Pathe et al. 2009).

The SRTM30 Digital Elevation Model was used. DORIS orbit files were used in order to improve on the state vectors included in the ASAR GM data.

2. The geocoded data were then transferred from image format to a database format in order to allow efficient time series analysis of the data. This was done in the resampling step by means of bilinear interpolation of the sigma nought values in the linear domain. Also the co-located local incidence angle images were resampled to the database.
3. Due to the side-looking geometry of SAR sensors, the recorded backscatter is in general dependent on the incidence angle, with a decrease in backscatter with increased incidence angle. This dependency was normalised before comparing backscatter measurements acquired over the same area but under different incidence angles. The normalisation was carried out by fitting the time series of sigma nought and local incidence angles to a linear model and then reverting the backscatter to a reference local incidence angle of 30 degrees.
4. The SSM estimates were then retrieved from each ASAR image with a change detection method, relating the normalised backscatter values to reference backscatter values corresponding to dry and wet soil conditions (Pathe et al. 2009).
5. The SSM retrievals for each 7-day period were averaged in order to obtain the weekly SSM product, producing 0.5x0.5 degree tiles. Pixels in the tiles expected to contain unreliable SSM estimates were masked. The masking was based on thresholds of local sensitivity to soil moisture changes and amount of open water bodies within the pixel, whereby pixels with sensitivity below 5.5 dB or a water body fraction above 4.4% were masked (i.e. set to the no-data value). The water body fraction was computed for each pixel from the maximum water body extent for the months of July and August for the years 2007, 2008 and 2009 (for Central Yakutia only 2007 and 2008) derived from the Permafrost project's 150 m Water Body product. In case coverage of the Water Body product was not available, only the SSM sensitivity was used for masking.
6. Finally, the masked SSM tiles are mosaicked to full extent maps and converted to the GeoTIFF format, yielding the SSM product.

2 Improvements relative version 1

The improvements of the SSM product version 2 relative version 1 are:

- Extended temporal coverage to include 2010 for all regional sites. In addition, the product was produced for 2011 for the regional sites Alaska, Mackenzie, Ob Estuary and Central Yakutia.
- Applied masking (see Product overview section step 5) to remove estimates expected to be unreliable.
- Improved derivation of backscatter reference for wet soil conditions by excluding wet reference correction which had been optimised for low- and mid-latitude conditions.
- Eliminated artifacts resulting from SAR processing or ASAR level 1b product issues through manual inspection and re-processing.
- Using the same no-data value for masked as for missing data to increase compatibility with image processing software packages.

3 Product specification

The SAR Surface Soil Moisture parameter represents a relative measure of the soil moisture in the top layer of the soil, scaled between references corresponding approximately to wilting level (0%) and field capacity (100%) (Wagner et al. 1999).

The product consists of weekly maps of temporally averaged SSM over five regions of interest (Permafrost project regional sites, see Table 3–3). The product specification is given in Table 3–1. The product is provided in the GeoTIFF file format. In addition to the SSM maps, quality indicator maps provide information on the number of individual SSM retrievals that were averaged in order to achieve the corresponding weekly SSM composites. Furthermore, for each region, the mask applied to the SSM maps is supplied in a GeoTIFF file. The product files are named according to the following pattern:

OOO_SSSSS_PPP_VVV_vvv_yyyymmdd_hhmmss-YYYYMMDD_HHMMSS_RRR_DDD.EEE

The file syntax is specified in Table 3–2.

Subject	Specification
Variable	SSM parameter (*dat.tif). Quality indicator (*num.tif). SSM mask (*msk.tif).
Units	SSM parameter: %, [0-100] Quality indicator: number SSM mask: 1=masked, 0=not masked
Coverage	Five regional sites: Ob Estuary, Mackenzie, Alaska, Laptev Sea Coast and Central Yakutia.
Time period	2005-2011 (-2010 for Laptev Sea Coast)
Temporal frequency	7 days, origin on Jan. 1 at 12:00. (subject to ASAR data availability)
Coordinate system	Plate Carée map projection, WGS84 datum
Spatial resolution	1 km
Spatial sampling	15 arc-seconds
Geometric accuracy	<500 m
Thematic accuracy	10-20% relative soil moisture (Pathe et al. 2009)
Data format	GeoTIFF
Other data codes	-1 for no data

Table 3–1
Product specification.

Product filename field	Field description	F/T v2 value
OOO	Organisation	"TUW"
SSSSS	Sensor and Mode	"ASAGM"
PPP	Product	"SSM"
VVV	Product/software version	"002"
vvv	Processing index	"001"
YYYYMMDD_HHMMSS	Start Date/Time	E.g. "20110702_120000"
yyyymmdd_hhmmss	End Date/Time	E.g. "20110709_115959"
RRR	Region of Interest	E.g. "001" (see Table 3–3)
DDD	Parameter	"dat" (SSM data), "num" (quality indicator) and "msk" (SSM mask)
EEE	Extension	"tif"

Table 3–2
Product filename syntax specification.

The value of the "Region of Interest" field, specified in Table 3–3, is defined according to the Permafrost Observation Strategy document ("Service Case Areas").

Permafrost Regional site	"Region of Interest" field
Alaska	001
Mackenzie	002
Laptev Sea Coast	003
Central Yakutia	004
Ob Estuary	005

Table 3-3
Definitions for the "Region of Interest" field in the product file name.

An example of the mask (see Product overview section step 5) applied to the SSM maps is shown in Figure 2. It should be noted that large water bodies such as the Kara Sea were masked out during the SAR pre-processing stage. Therefore it was not necessary to force the SSM product mask to handle these areas, as can be seen in Figure 2. This fact can be observed in the weekly SSM map for Ob Estuary in Figure 3[1] demonstrating that both oceans and inland water bodies were masked out. It must also be noted that the masking of pixels due to occurrence of open water bodies was subject to availability of the Permafrost project Water Body product, which did not always cover the entire regions. This can be seen in the east part of the Ob Estuary mask. In case coverage of the Water Body product was not available, only the SSM sensitivity is used for masking. The quality indicator map representing the number of SSM estimates that were averaged to achieve the weekly composite is shown in Figure 4.

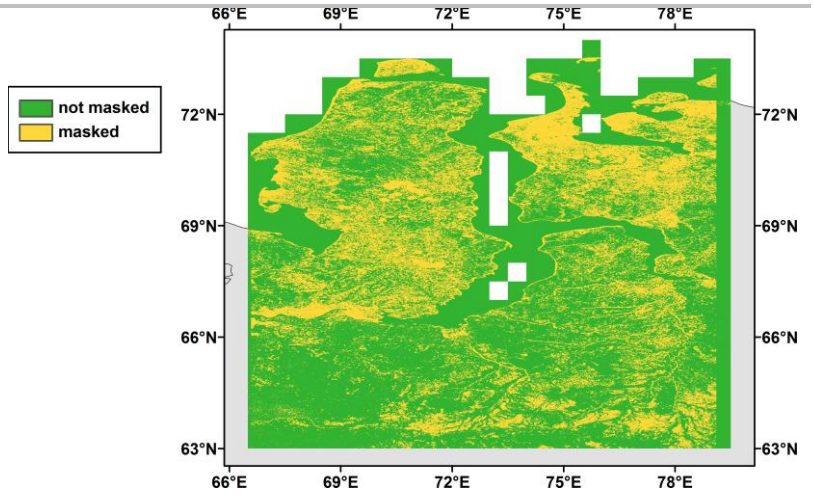

Figure 2
Mask applied to the SSM product for the Ob Estuary site.

[1] Please note that color schemes and map/legend layouts are not included in the product.

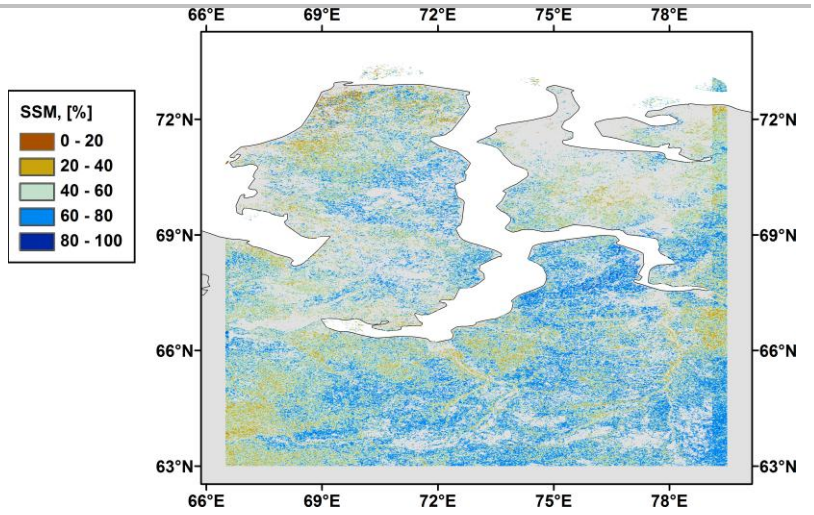

Figure 3
Surface Soil Moisture product for the Ob Estuary regional site for the 7-day period between 16th and 23rd of July 2011.

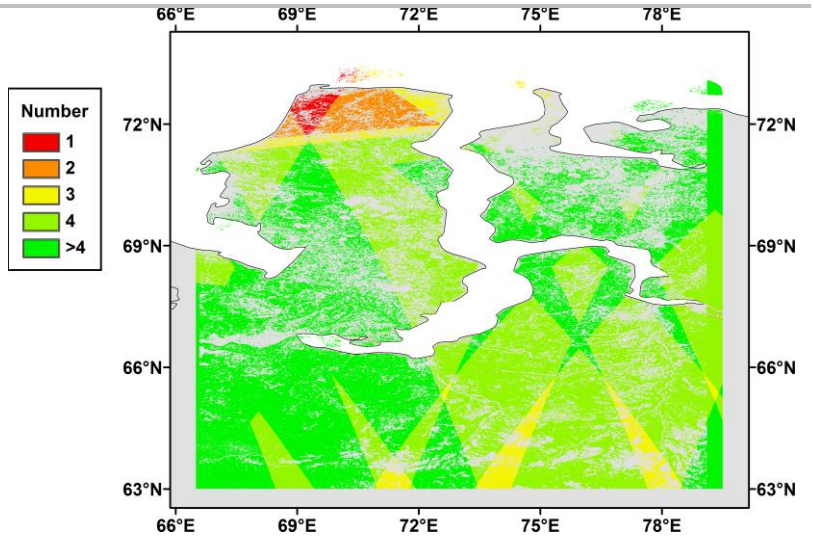

Figure 4
Quality indicator map corresponding to the SSM product shown in Figure 3.

4 Known issues

4.1 Limited ENVISAT ASAR data coverage

The availability and quality of the weekly SSM products is dictated by the availability and abundance of ASAR observations. The number of ASAR measurements available per week over the regional sites varies between zero to almost daily (in the most favorable cases). Users of the product are recommended to make use of the quality indicator maps in order to assess the suitability of the product for their applications.

4.2 Masking limitations

While masking based on the SSM sensitivity was always possible, the masking based on fraction of open water bodies was subject to spatial coverage of the Permafrost project's 150 m Water Body (WB) product. The WB product covered at least the extent of the regional sites as defined by the Permafrost project's Observation Strategy. However, the SSM product was produced areas larger than that definition. Masking for open water bodies was therefore not possible for minor parts of Ob Estuary (along eastern border of SSM maps) and Central Yakutia (along eastern and northern borders of SSM maps). For the Mackenzie site the open water body masking was only possible for a swath from the southeast to the northwest of the region as highlighted in see Figure 5. Users are recommended to be aware of this and look at the mask map provided for each region. The Laptev Sea Coast and Alaska sites were masked for open water bodies in their entirety.

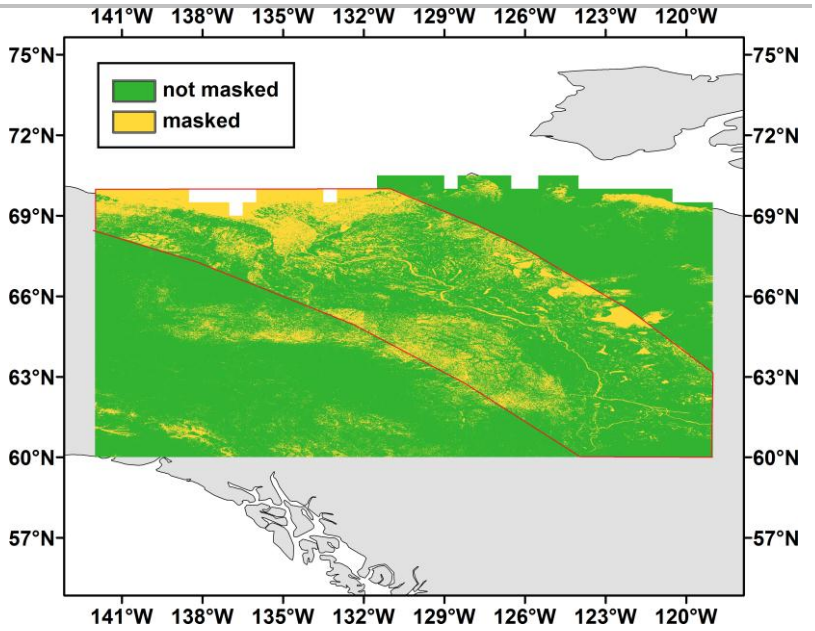

Figure 5
SSM mask map for the Mackenzie regional site. Masking for open water bodies was possible within the area indicated by the red polygon.

4.3 Artifacts

There are some artifacts in the SSM product which cannot be explained by ASAR data coverage or the applied masking:

- Lines with contrasting SSM values transecting the maps along the swath borders of certain ASAR tracks, affecting all sites except Central Yakutia. This is an artifact introduced by the NEST software during the geocoding processing step.
- Some minor artifacts due to artifacts in the SRTM30 DEM influencing the radiometric calibration during the geocoding process. This has been observed, e.g., for the Alaska site at latitude 66N longitude 150W.
- For some of the Mackenzie site maps there are slight oscillations in the estimates along the parallels (e.g. for the 2007 and 2008 maps). This is most probably due to the radiometric calibration applied during the pre-processing of ASAR datasets.

5 Data access and contact information

The SAR Surface Soil Moisture (SSM) version 2 product can be accessed via PANGAEA (http://doi.pangaea.de/10.1594/PANGAEA.780111) and should be cited as:

Sabel, Daniel; Park, Sang-Eun; Bartsch, Annett; Schlaffer, Stefan; Klein, Jean-Pierre; Wagner, Wolfgang (2012): Regional surface soil moisture and freeze/thaw timing remote sensing products with links to geotiff images, Institute of Photogrammetry and Remote Sensing, TU Vienna, doi:10.1594/PANGAEA.779658

In: DUE Permafrost Project Consortium (2012): ESA Data User Element (DUE) Permafrost: Circumpolar Remote Sensing Service for Permafrost (Full Product Set) with links to datasets. doi:10.1594/PANGAEA.780111

The product is alternatively stored on the Institute of Photogrammetry and Remote Sensing (TU Wien) FTP server which can be accessed via the DUE Permafrost data portal (www.ipf.tuwien.ac.at/permafrost). The dataportal includes a WebGIS for visualization. Login information is available on request.

For login access to the dataportal, contact Annett.Bartsch@tuwien.ac.at.

For questions about the product, contact Daniel.Sabel@tuwien.ac.at or Annett.Bartsch@tuwien.ac.at.

For ESA's technical officer, contact Frank.Martin.Seifert@esa.int.

Additional information on the ESA DUE Permafrost project can be found at the web - site: http://www.ipf.tuwien.ac.at/permafrost

6 References

Wagner, W., Lemoine, G. and Rott H. (1999): A Method for Estimating Soil Moisture from ERS Scatterometer and Soil Data. Remote Sensing of Environment 70(2): 191-207.

Pathe, C., Wagner, W., Sabel, D., Doubkova, M. and J. Basara (2009): Using ENVISAT ASAR Global Mode Data for Surface Soil Moisture Retrieval

Over Oklahoma, USA, IEEE Transactions on Geoscience and Remote Sensing, 47(2): 468 – 480.