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esa

SMOS Sea Ice Thickness Product Description Document (PDD)

Document Version

Version	Date	Description	Author
1.0	25/10/2018	Draft of the Product Description Document	Xiangshan Tian-Kunze (AWI)
2.0	26/03/2020	Update	Xiangshan Tian-Kunze (AWI)

Applicable Documents

Abbreviation	Name	Description
ATBD	AWI_ESA_SMOS_ATBD_v1.0	Algorithm Theoretical Basis Document
RM_TN	AWI_ESA_SMOS_RM-TN_v1.0	ReadMe-first Technical Note

1. Purpose of this Document

The purpose of this document is to describe the content of the **SMOS Sea Ice Thickness Product.** The document contains a description of the product and its format. Information about scientific algorithms used to generate the product is available in the Algorithm Theoretical Baseline Document [ATBD].

2. SMOS Sea Ice Thickness Product

Table 1: Overview of SMOS Product

Parameter	Sea ice thickness
Spatial covergae	Northern hemisphere, poleward of 50°N, -180°E to 180°E
Spatial Resolution	12.5 km x12.5 km
Temporal Coverage:	since 15. Oct. 2010
Temporal Resolution	1 day
Data Format(s)	NetCDF v3
Platforms	SMOS
Version	v3.2

Rationale

The European Space Agency's (ESA) Earth Explorer SMOS satellite can detect thin sea ice, due to the large penetration depth of L-band in sea ice. Up to 1.5m ice thickness information can be derived from brightness temperatures measured by the L-band radiometer onboard of SMOS.

Methods

We retrieve sea ice thickness from daily averaged brightness temperature. The measured L-band brightness temperature mainly depends on the ice concentration, the molecular temperatures of the sea and the ice, and their emissivities (Menashi et al., 1993). The sea ice emissivity depends on the microphysical sea ice structure, but the inhomogeneities, like brine pockets and air bubbles, are much smaller than the SMOS wavelength of 21 cm (Kaleschke et al., 2010, Kaleschke et al., 2012). Therefore, we can consider sea ice as a homogeneous medium and neglect volume scattering. For the assumption of 100 % ice coverage, the sea ice emissivity mainly depends on ice thickness, ice temperature, and ice salinity (Kaleschke et al., 2010). Tian-Kunze et al. (2014) has further improved the retrieval algorithm of Kaleschke et al., (2012), based on a thermodynamic sea ice model and a three-layer radiative transfer model, which explicitly takes variations of ice temperature and ice salinity into account. In addition, ice thickness variations within the SMOS spatial resolution are considered through a statistical thickness distribution function derived from high-resolution ice thickness measurements from NASA's Operation IceBridge campaign. More details of the sea ice retrieval algorithm can be found in Tian-Kunze et al. (2014) and in the ATBD.

File Format

Daily mean SMOS sea ice thickness is given in NetCDF v3 format. Global attributes are given in Table 2. The variables are given as grid arrays as listed in Table 3.

Table 2: Global attributes from an example NetCDF file.

Attribute	Value
title	Daily gridded sea-ice thickness and auxiliary parameters from satellite L-band radiometry data
project	CS2SMOS PDS CR-1: SMOS Sea Ice Data Product Processing and Dissemination Tasks, supported by ESA
institution	Alfred-Wegener-Institut Helmholtz Zentrum für Polar und Meeresforschung (AWI), http://www.awi.de
contributor_name	Xiangshan Tian-Kunze, Lars Kaleschke, Robert Ricker, Stefan Hendricks
publisher_email	xiangshan.tiankunze@awi.de
platform	"ESA Soil Moisture and Ocean Salinity (SMOS) mission"
sensor	"Microwave Imaging Radiometer using Aperture Synthesis (MIRAS)"
source	SMOS v620 L1C brightness temperature
product_version	v3.2
Processing level	L3c
grid	NSIDC polar stereographic projection. http://nsidc.org/data/polar_stereo/ps_grids.html
tracking id	08533af0-7656-4f35-b0a8-7ae4081a2c9a
naming authority	de.awi
history	Product generated with SMOS sea ice thickness retrieval Algorithm v3.2

Attribute	Value
summary	This dataset contains Level-3 daily sea ice thickness products from satellite observations in the northern hemisphere. Northern hemisphere sea ice thickness coverage is limited to the winter month between October and April. 100% sea ice coverage is assumed, which leads to underestimation of sea ice thickness.
topiccategory	Oceans Climatology Meteorology Atmosphere
keywords	Earth Science > Cryosphere > Sea Ice > Ice Depth/Thickness, Earth Science > Oceans > Sea Ice > Ice Depth/Thickness, Earth Science > Climate Indicators > Cryospheric Indicators > Ice Depth/Thickness, Geographic Region > Northern Hemisphere, Vertical Location > Sea Surface, Institutions > AWI > Alfred Wegener Institute for Polar and Marine Research
id	awi-cs2smos-l3c-sithick-smos-nh_12p5_km_polstereo-YYMMDD-fv3p2
doi	none
Date_created	e.g. “Tue Mar 24 17:37:59 2020”
spatial_resolution	12.5 km grid spacing
time_coverage_duration	P1D
time_coverage_start	yyyy-mm-ddT00:00:00
time_coverage_end	yyyy-mm-ddT23:59:59
time_coverage_resolution	P1D
geospatial_bounds_crs	EPSG:3411
geospatial_lat_max	90.0
geospatial_lat_min	50.0
geospatial_lon_max	180.0
geospatial_lon_min	-180.0
geospatial_vertical_max	0.0

Attribute	Value
geospatial_vertical_min	0.0
references	1) Kaleschke, L., X. Tian-Kunze, N. Maass, M. Maekynen, and M. Drusch (2012), Sea ice thickness retrieval from SMOS brightness temperatures during the Arctic freeze-up period, Geophys. Res. Lett., 39, L05501, doi:10.1029/2012GL050916. (2) Tian-Kunze, X., Kaleschke, L., Maass, N., Maekynen, M., Serra, N., Drusch, M., and Krumpen, T., SMOS-derived sea ice thickness: algorithm baseline, product specifications and initial verification, The Cryosphere, 8, 997-1018, doi:10.5194/tc-8-997-2014, 2014 (3) Kaleschke, L., Tian-Kunze, X., Maass, N., Beitsch, A., Wernecke, A., Miernecki, M. and others, SMOS sea ice product: operational application and validation in the Barents Sea marginal ice zone, Remote Sensing of Environment 180 (2016), 264-273. doi: 10.1016/j.rse.2016.03.009 (4) Tietsche, S., Alonso-Balmaseda, M., Rosnay, P., Zuo, H., Tian-Kunze, X., and Kaleschke, L.: Thin Arctic sea ice in L-band observations and an ocean reanalysis, The Cryosphere, 12, 2051-2072, https://doi.org/10.5194/tc-12-2051-2018, 2018.

Table 3: NetCDF file variables

Variable	Long name	Unit	Type	Scale factor	Dimension
latitude	latitude coordinate	degrees_north	float	1.f	896 x 608
longitude	longitude coordinate	degrees_east	float	1.f	896 x 608
x	x coordinate of projection	km	float		608
y	y coordinate of projection	km	float		896
sea_ice_thickness	SMOS sea ice thickness	m	float	1.f	1 x 896 x 608
ice_thickness_uncertainty	sea ice thickness total uncertainty	m	float	1.f	1 x 896 x 608
saturation_ratio	ratio of retrieved ice thickness and	%	short		1 x 896 x 608

Variable	Long name	Unit	Type	Scale factor	Dimension
	maximal retrievable ice thickness				
TB	brightness temperature intensity (TBh+TBv)/2	K	float	1.f	1 x 896 x 608
TB_uncertainty	brightness temperature uncertainty defined as one standard deviation of TB devided by the sqrt(nPair)	K	float	1.f	1 x 896 x 608
Tsurf	SMOS derived snow surface temperature	K	float	1.f	1 x 896 x 608
Sice	Bulk ice salinity	psu	float	1.f	1 x 896 x 608
nPair	number of TBh and TBv pairs available		short	1.f	1 x 896 x 608
RFI_ratio	percent of RFI-contaminated measurements in total measurements	%	float		1 x 896 x 608
land	land_binary_mask		byte		896 x 608
time	hours since 2010-01-01 00:00:00	hour	double		1

Grid

Table4: Northern Hemisphere Grid Coordinates of NSIDC Polar Stereographic Grids (ref.: https://nsidc.org/data/polar-stereo/ps_grids.html)

X (km)	Y (km)	Latitude (deg)	Longitude (deg)	position
-3850	5850	30.98	168.35	corner
0	5850	39.43	135.00	midpoint
3750	5850	31.37	102.34	corner

3750	0	56.35	45.00	midpoint
3750	-5350	34.35	350.03	corner
0	-5350	43.28	315.00	midpoint
-3850	-5350	33.92	279.26	corner
-3850	0	55.50	225.00	midpoint

Data Sources

V620 L1C SMOS brightness temperature measurements are collected during one day and averaged and interpolated to build L3B daily brightness temperature in 12.5 km NSIDC polar stereographic grid. Two auxiliary data sets are used as boundary conditions in the retrieval: JRA55 reanalysis and Sea Surface Salinity from model outputs of MIT General Circulation Model from 2002-2009 (Tian-Kunze et al., 2014). Both auxiliary data sets are interpolated to 12.5 km grids to match the L3B brightness temperature.

File naming convention

Currently, the data is provided in NetCDF 3 classic format and the files are named as

SMOS_Icethickness_v3.2_north_<date>.nc

SMOS filename might be changed to the conventional name defined as following after the release of SMOS product for both Hemispheres which is expected for the winter season (2020/2021):

W_XX-ESA,SMOS,NH_12P5KM_NSIDC_YYMMDD_o_v(version number)_01_l3sit.nc (North)
W_XX-ESA,SMOS,SH_12P5KM_NSIDC_YYMMDD_o_v(version number)_01_l3sit.nc (South)

Changes in global attributes since 23.03.2020

Small mistakes are found in the global attributes of NetCDF files.

Table 5: Correction in the global attributes

	untill 22. 03. 2020	Since 23.03.2020
product_version =	“3.1";	"3.2";

id =	awi-cs2smos-l3c-sithick-smos-nh_12p5_km_polstereo-YYMMDD-fv3p1	awi-cs2smos-l3c-sithick-smos-nh_12p5_km_polstereo-YYMMDD-fv3p2
history	Product generated with SMOS sea ice thickness retrieval Algorithm v3.1	Product generated with SMOS sea ice thickness retrieval Algorithm v3.2

3. Sample data record

Figure 1 shows an example of SMOS sea ice thickness map in the Arctic, on 19 November, 2018.

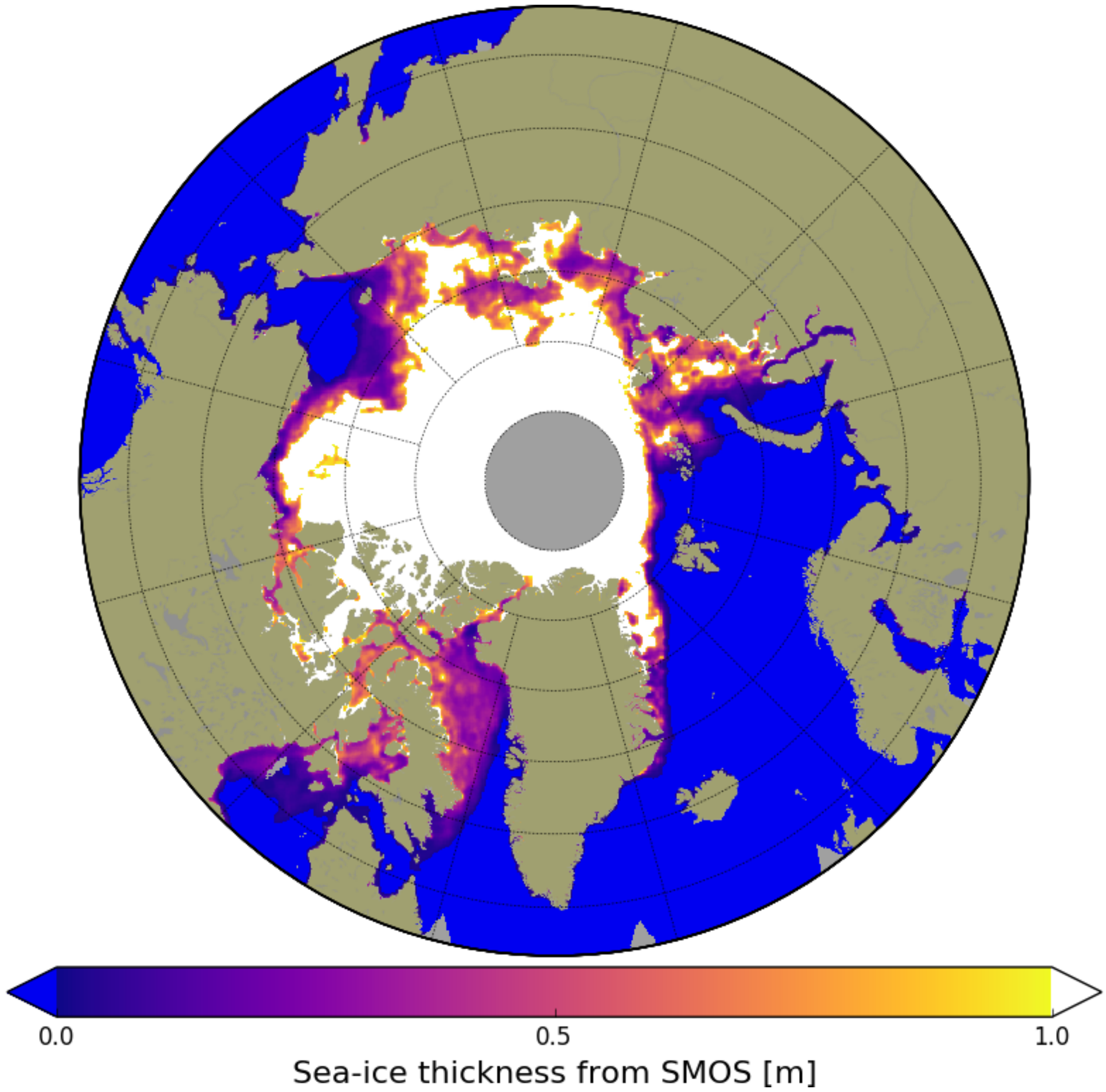

Fig. 1. Sea ice thickness map in the Arctic, 2018.11.19

References

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Tietsche, S., Alonso-Balmaseda, M., Rosnay, P., Zuo, H., Tian-Kunze, X., and Kaleschke, L.: Thin Arctic sea ice in L-band observations and an ocean reanalysis, The Cryosphere, 12, 2051-2072, https://doi.org/10.5194/tc-12-2051-2018, 2018.