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ReadMe-first Technical Note (RM-TN)

Document Version

Version	Date	Description	Author
1.2	27/09/2019	Refers to CryoSat-2 SMOS Merged Product version v202	Robert Ricker (AWI)
1.1	19/10/2018	Revision after comments from ESA	Robert Ricker (AWI)
1.0	15/06/2018	Draft of the ReadMe-first Technical Note	Robert Ricker (AWI)

Applicable Documents

Abbreviation	Name	Description
ATBD	AWI_ESA_CS2SMOS_ATBD_v1.0	Algorithm Theoretical Basis Document
PDD	AWI_ESA_CS2SMOS_PDD_v1.2	Product Description Document

Read-me-first note for the release of theCryoSat-2/SMOS Merged Sea Ice Thickness (CS2SMOS)	
Product version	v202
Release date by ESA	*add date*
Author(s)	Robert Ricker
Further information	A detailed description of the processing algorithm can be found in the Algorithm Theoretical Basis Document (ATBD): *add link* Information about the data product ca be found in the Product description document (PDD): *add link* Information on how to access the CS2SMOS ice thickness data can be found here.
How to cite the data	1. Please cite: Ricker, R., Hendricks, S., Kaleschke, L., Tian-Kunze, X., King, J., and Haas, C.: A weekly Arctic sea-ice thickness data record from merged CryoSat-2 and SMOS satellite data, The Cryosphere, 11, 1607-1623, https://doi.org/10.5194/tc-11-1607-2017, 2017. 2. Include the following phrase into the acknowledgment: "The production of the merged CryoSat-SMOS sea ice thickness data was funded by the ESA project SMOS & CryoSat-2 Sea Ice Data Product Processing and Dissemination Service, and data from DATE to DATE were obtained from AWI."
Contact for helpline	For all issues related to data access, please contact ESA's HelpDesk at eohelp@esa.int
Comments to CryoSat-2/SMOS merged product	For questions and feedback, please contact: Robert.Ricker@awi.de Stefan.Hendricks@awi.de

1. Introduction

The read-me-first note provides information about improvements with regard to the previous releases, data caveats, and instruction about how to use auxiliary data and uncertainties contained in the product.

The current product version v202 is available from November 2010 to present and replaces product versions v200 and v201. v202 is continuously generated within the framework of the ESA project **SMOS & CryoSat-2 Sea Ice Data Product Processing and Dissemination Service**. The product is only available for the Northern Hemisphere from October to April.

2. Main Improvements and Changes in the current Data Set

The current version is v202. It is available since October 2019. The main changes in v202 compared to previous versions v200 (November 2010 to April 2016) and v201 (October 2016 to April 2019) are:

- The time coverage resolution has been changed from 7 days to 1 day, meaning that the weekly averaged product is updated every day from now on.

- We adapted the CS2SMOS processing to changes due to the update to CryoSat-2 sea ice thickness product version v2.2. Now the CryoSat-2 product can be used for Baffin Bay and Hudson Bay, since a new snow climatology is applied in the retrieval algorithm.

- We adapted the CS2SMOS processing to changes due to the update to SMOS sea ice thickness product version v3.2, which is now processed and provided by AWI.

- An ocean mask is applied to allow for a consistent land/ocean mask throughout the entire data record in order to overcome inconsistencies due to switches of the land masks in the OSI SAF ice concentration products.

- Changes in the NetCDF variable names, fulfilling CF 1.6 conventions (see also PDD).

- We now use different sea ice concentration products for the operational mode and for the reprocessing mode. In the operational mode, we use the operational OSI-401 ice concentration product, while in the reprocessing mode, the reprocessed OSI -430-b ice concentration product is used. Both are provided by OSI SAF.

3. Product Performance

CS2SMOS, CryoSat-2 and SMOS Ice Thickness Uncertainties

The uncertainties of the CryoSat-2 and SMOS sea ice thickness observations are crucial for the data merging and the interpolation. Figure 1 shows the relative uncertainties of CryoSat-2 and SMOS for November 2013 and April 2014. While the SMOS relative uncertainties are lowest for very thin ice, CS2 relative thickness uncertainties are smaller over thick ice and rise asymptotic towards thickness values < 1 m, which is due to the different methodical approach. The merged product (CS2SMOS) takes advantage of the complementary uncertainties. CS2SMOS merged ice thickness shows a significant reduction in the relative uncertainty with regard to the thickness uncertainties of the thin ice in the CryoSat-2 product, and the thick ice in the SMOS product.

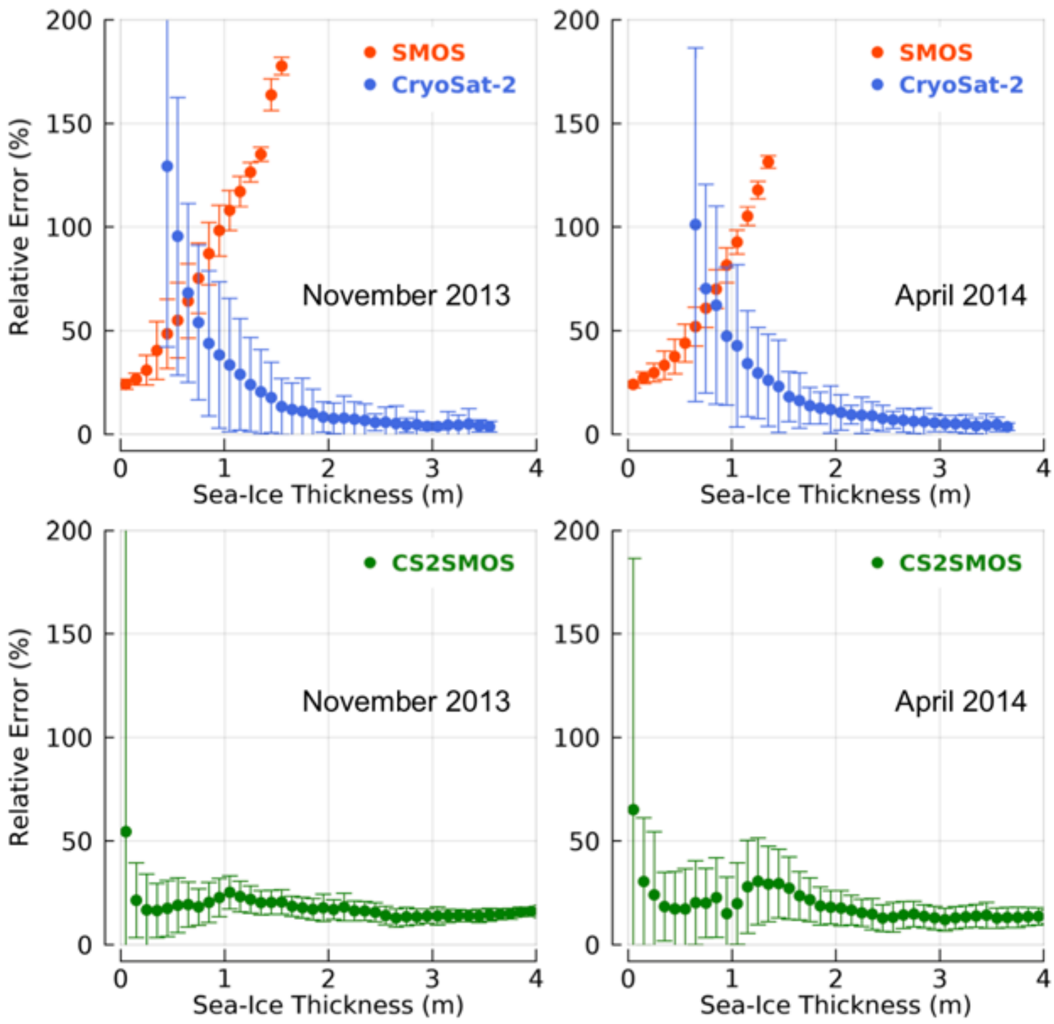

Figure 1: Binned Relative uncertainties for November 2013 and April 2014. Error bars indicate the standard deviation of relative uncertainties within the 10 cm bin width.

Differences between CS2SMOS v200-operational and v200-reprocessd

Since the background field in the operational mode only includes the two weeks prior the target week, we expect differences when comparing the operationally processed data with the reprocessed data, which use the full background field, including two weeks prior and two weeks after the target week (see ATBD). Figure 2 shows the difference (reprocessed product subtracted from operational product) for the week March 4, 2019 – March 10, 2019. Differences are in the same order for other weeks.

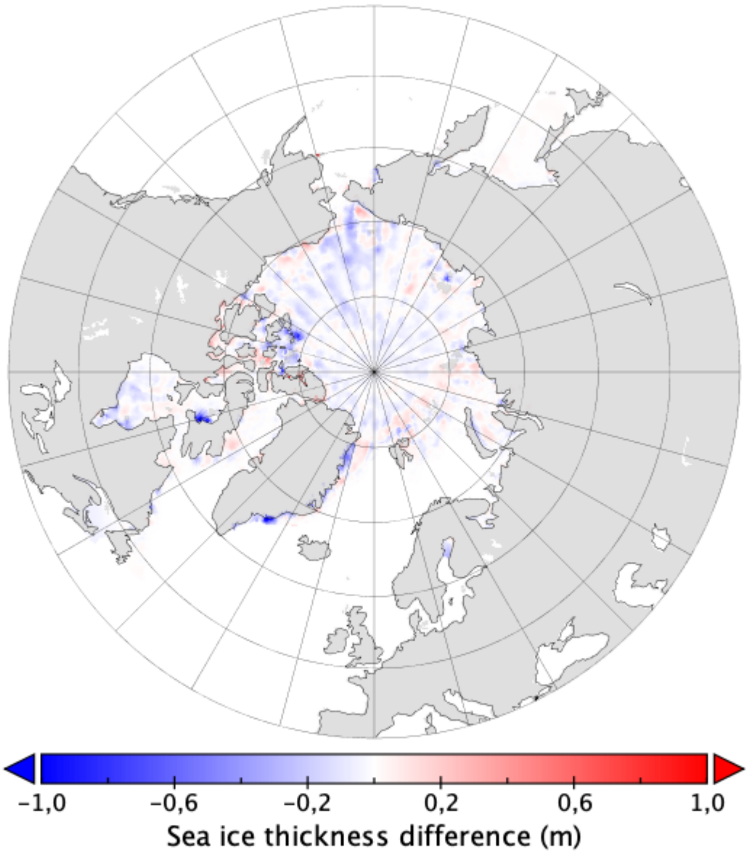

Figure 2: Thickness difference between operational and reprocessed product for the week March 4, 2019 – March 10, 2019.

Differences between CS2SMOS v202-reprocessed and v201-reprocessed

Due to changes caused by the CryoSat-2 sea ice thickness retrieval version switch from v2.1 to v2.2, and SMOS sea ice thickness retrieval version switch from v3.1 to v3.2, we expect impacts on the merged CS2SMOS product version v202. Figure 3 shows the differences for the week March 4, 2019 – March 10, 2019. Table 1 presents the mean monthly differences between both product versions.

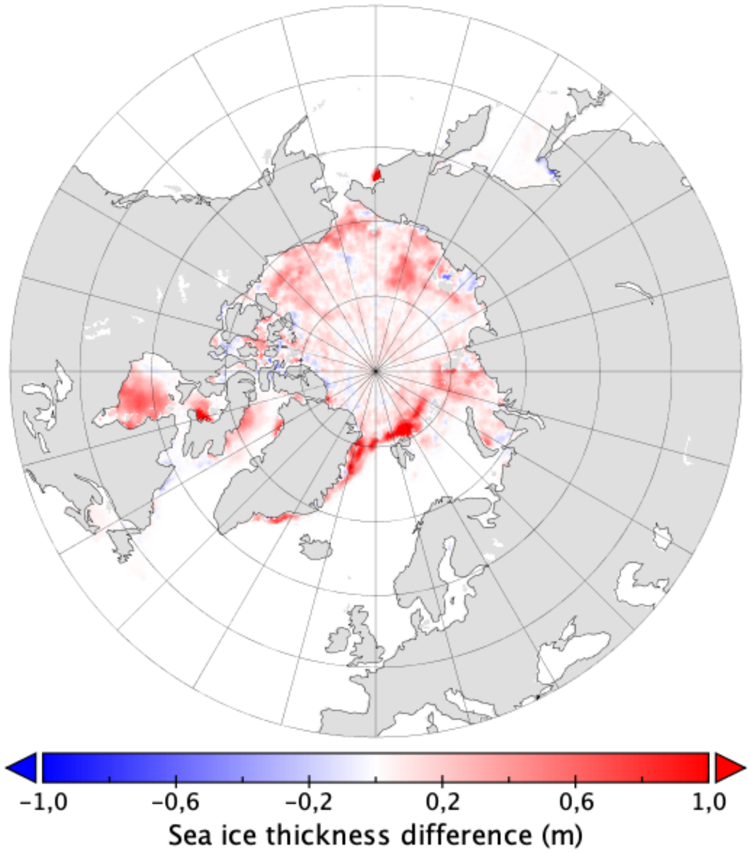

Figure 3: Thickness difference in meters between product v202 (r) and product v201 (r) for the week March 4, 2019 – March 10, 2019.

Table 1: Mean monthly sea ice thickness from 2010 to 2019 for different product versions.

Month	SIT v200/v201 (m)	SIT v202 (m)	Difference (v202 – v201/v200)
Nov	1.09	1.04	-0.05
Dec	1.12	1.08	-0.04
Jan	1.17	1.15	0.02
Feb	1.25	1.25	0.00
Mar	1.34	1.35	0.01
Apr	1.37	1.39	0.02

Product validation

For Validation, we use ULS ice draft data from moorings that have been deployed at four different sites in the Beaufort Sea within the BGEP project (Woods Hole Oceanographic Institution (WHOI), Krishfield and Proshutinsky, 2006). Data are sampled at 2s intervals. Ice draft is converted to ice thickness by multiplying the draft by 1.1 (Rothrock et al., 2008). Table 2 provides the position of the moorings in the Beaufort Sea and information about the ULS record periods. They cover the SMOS and CryoSat-2 periods (A, B, D). For the comparison of the merged CS2SMOS ice thickness and the ULS ice thickness measurements, open water sections within the ULS data set have been removed. Afterwards, the filtered data were averaged over 24 h to obtain daily mean effective ice thickness for each ULS (A, B, D). In the last step, daily retrievals are averaged weekly on a 25 km EASE2 grid to cover the same period as the weekly CS2SMOS products. Since the positions of the moorings are steady, one pixel for each ULS (A, B, D) is retrieved per week and is then compared with the gridded weekly mean of the CS2SMOS ice thickness.
Figure 4 shows the positions of the moorings and the corresponding differences to the SIT CDR. Mean differences (MD) are calculated by subtracting ULS ice thickness from satellite ice thickness. Considering the entire ULS data set as the reference, the MD is -0.02 m, while the root mean square deviation (RMSD) is 0.34 m. This shows an improvement compared to the previous product version v200/v201 (MD = -0.1 m, RMSD = 0.36 m).

Table 2: Mooring sites with ULS measurements used in this document.

Mooring Site	ULS record periods	Location
A	08/2003 – 10/2016	150.0°W 75.0°N
B	08/2003 – 09/2005 09/2006 – 09/2009 10/2010 – 10/2016	150.0°W 80.0°N
D	09/2006 – 10/2016	140.0°W 74.0°N

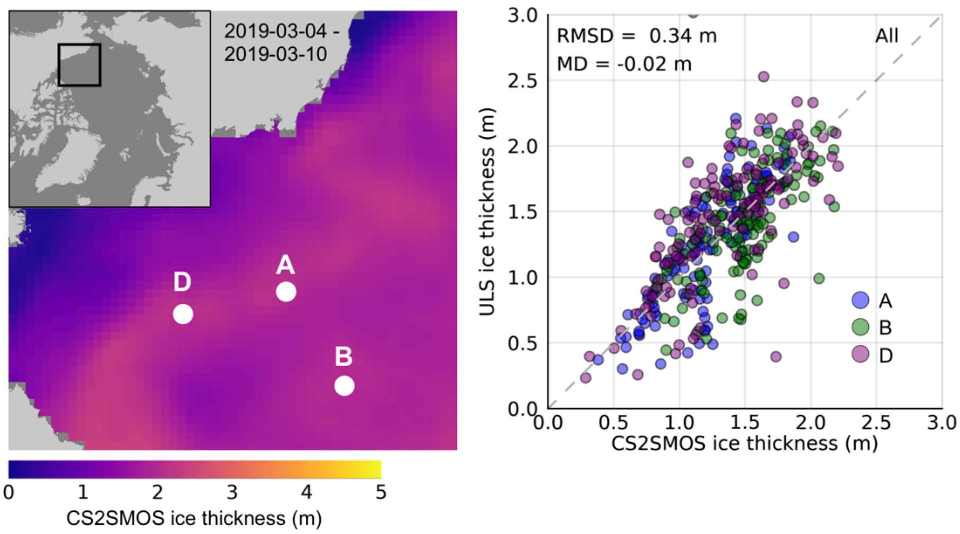

Figure 4: Overview of the ULS locations (left panel), and scatter plot between ULS and CS2SMOS ice thickness over the period Nov 2010 – Oct 2016. The RMSD represents the root mean square deviation. MD represents the mean difference between CS2SMOS and ULS ice thickness.

4. Caveats

Major caveats are listed below:

Issue	Product Version	Status
Underestimation of SMOS ice thickness when ice concentration is lower than 100%	202	open
Fundamental calibration of CryoSat- 2 range retracking algorithm required	202	open

5. Future algorithm evolution

We want to investigate the capability of expanding the processing to the Southern hemisphere. Moreover, we will aim to improve the retrieval algorithm. In particular, we will investigate the possibility to apply a multiyear ice concentration product to better distinguish between first-year and multiyear sea ice.

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