

living planet symposium

BONN
23–27 May
2022

TAKING THE PULSE
OF OUR PLANET FROM SPACE



SMOS sea ice thickness - a review and way forward

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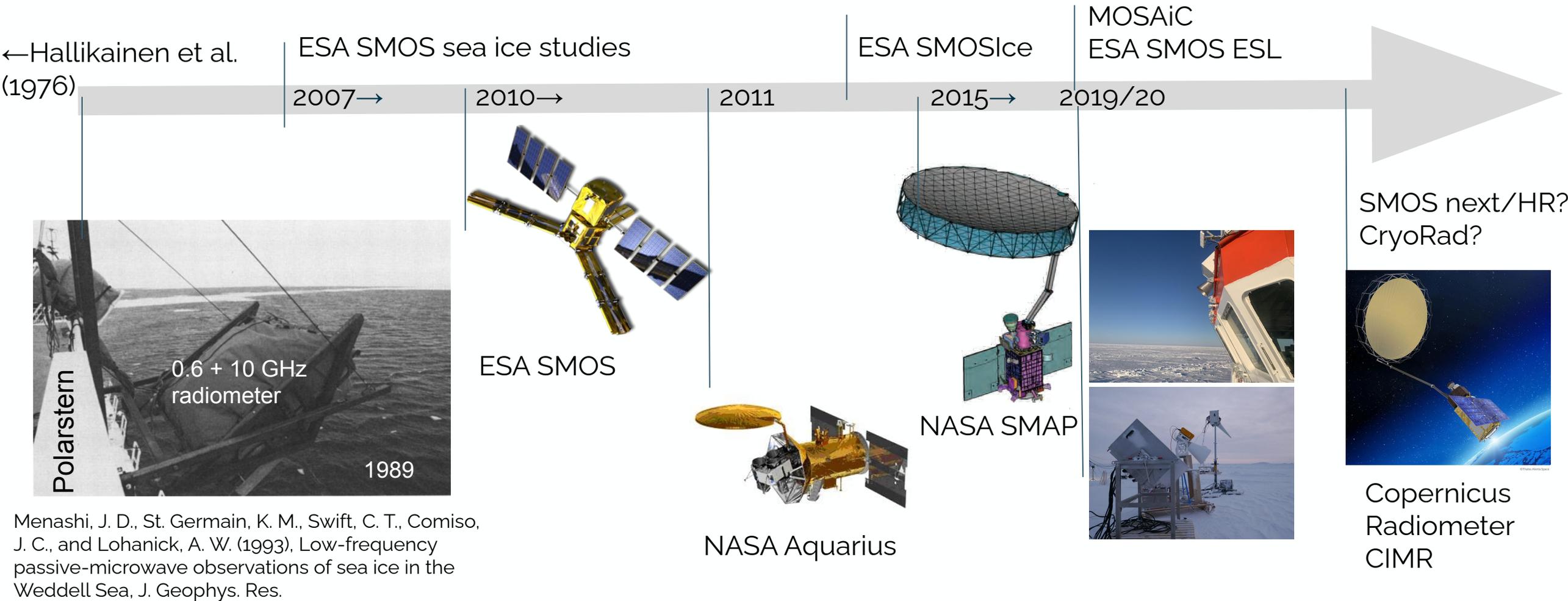
Raffaele Crapolicchio | Serco Italia SpA - for European Space Agency (ESA) | Italy

27.5.2022

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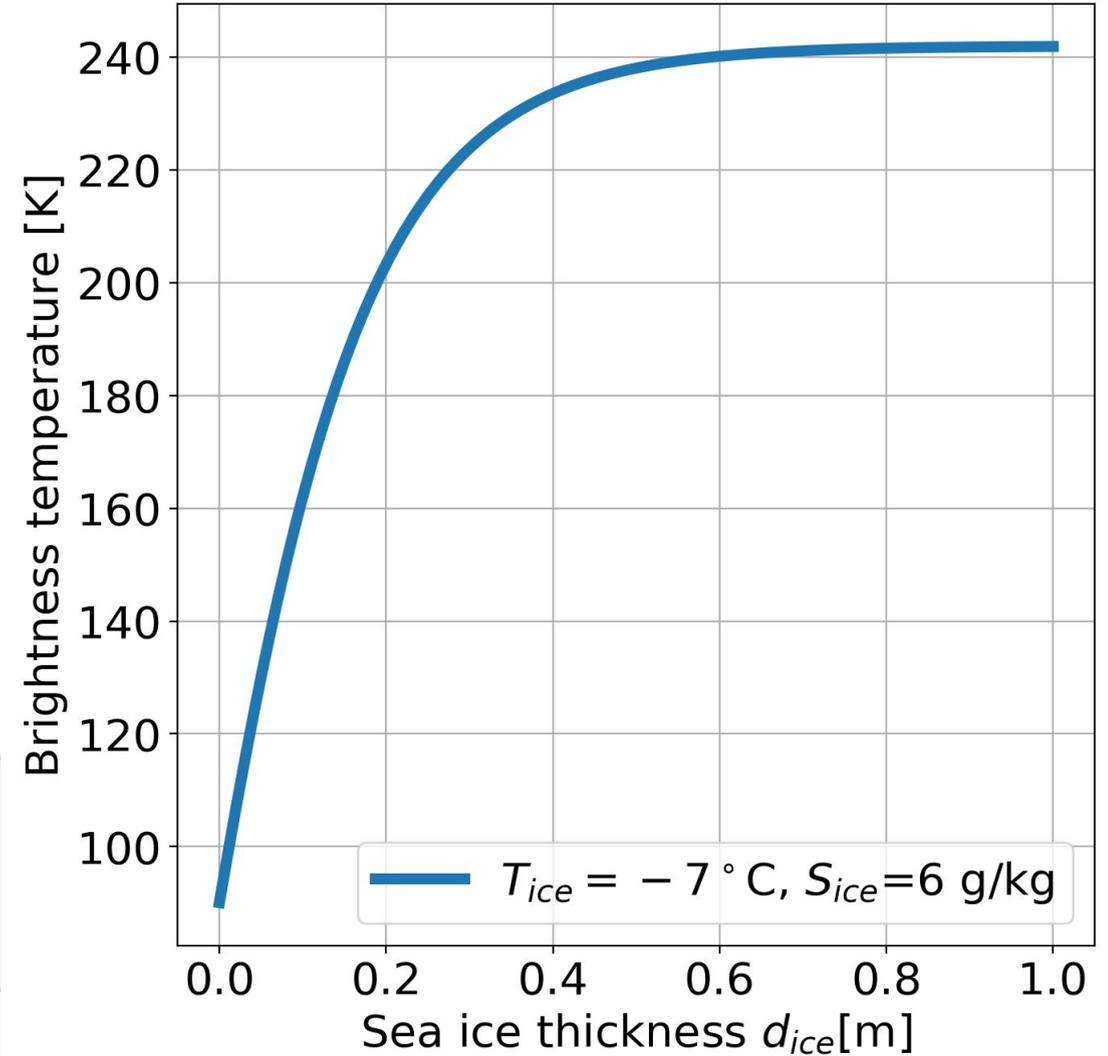
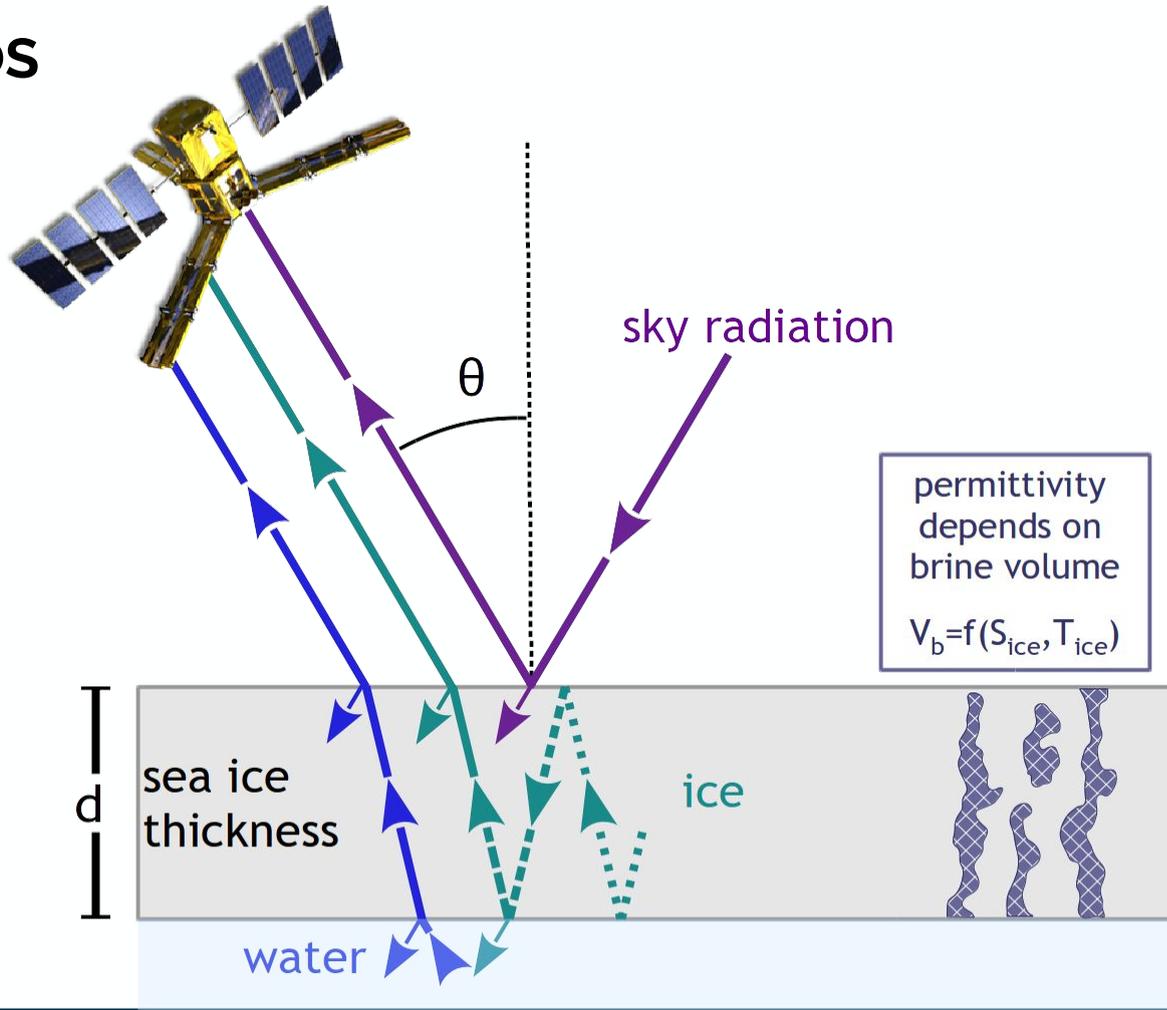
Nairobi 3-4

Low-frequency microwave radiometry for sea ice



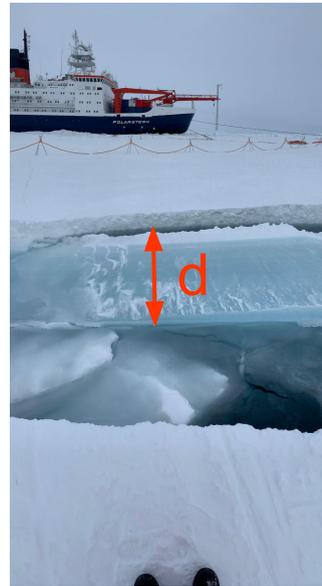
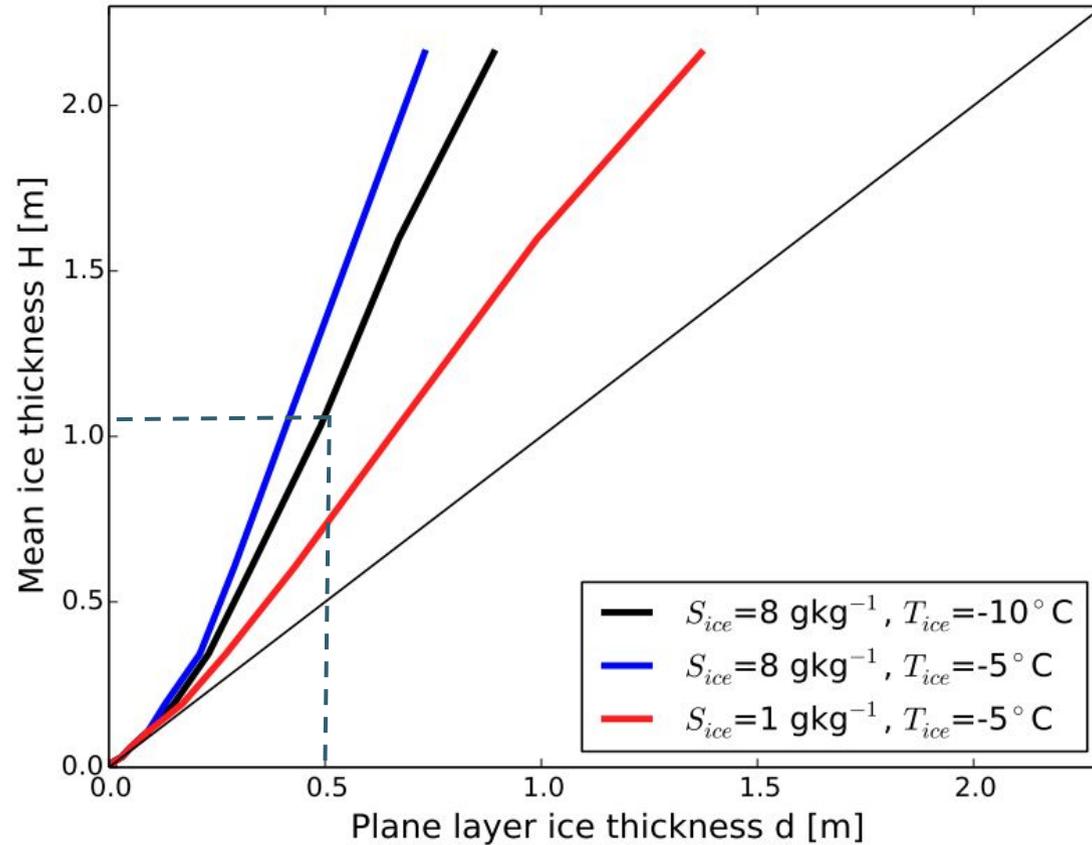
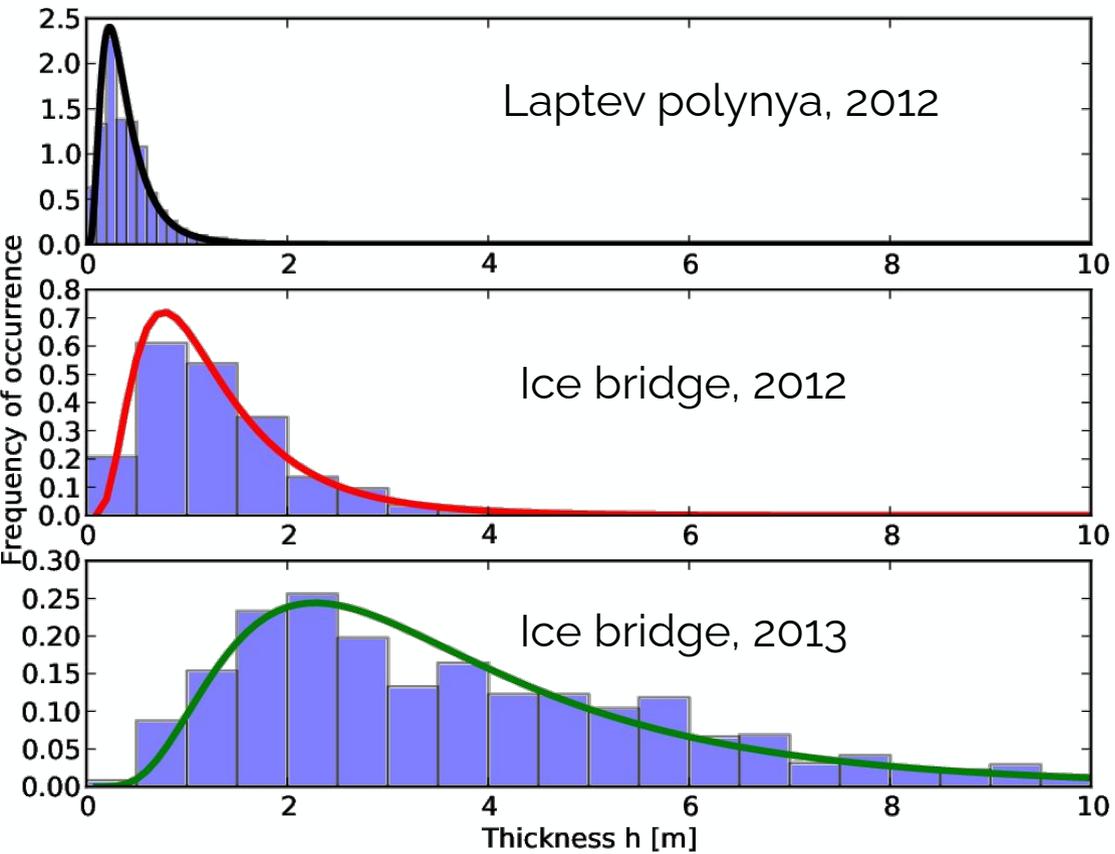
How to measure sea-ice thickness from space

SMOS



Sketch by A. Schmitt

Parameterization: statistical thickness distribution

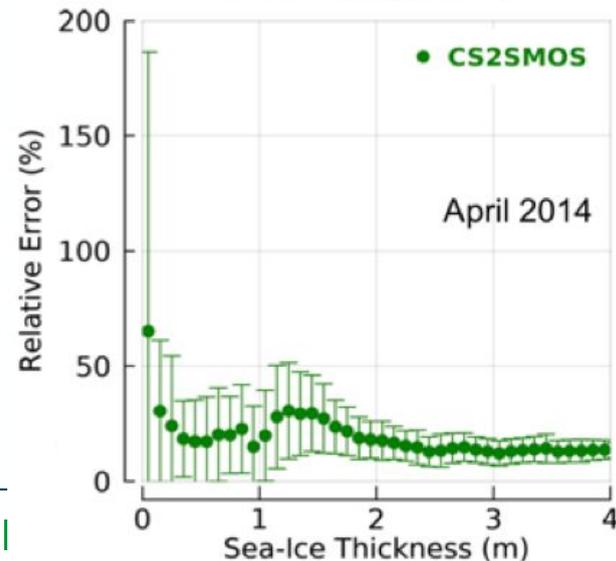
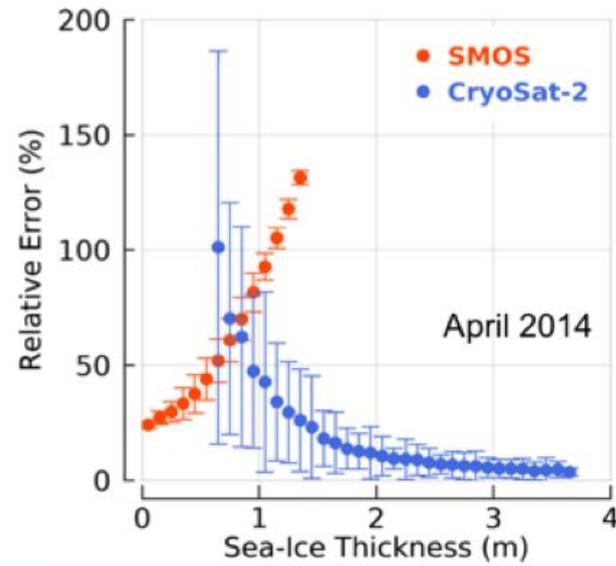


Tian-Kunze, X., Kaleschke, L., Maaß, N., Mäkynen, M., Serra, N., Drusch, M., and Krumpen, T.: SMOS-derived thin sea ice thickness: algorithm baseline, product specifications and initial verification, *The Cryosphere*, 8, 997-1018, 2014.

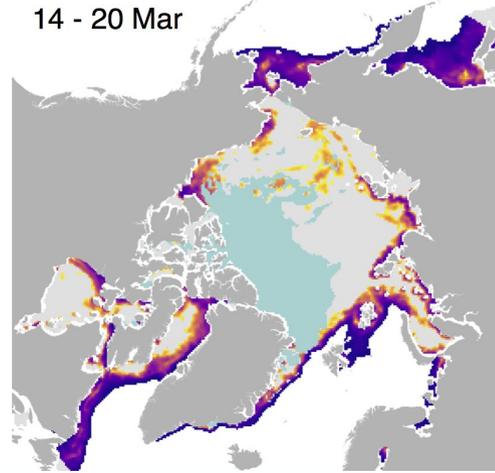
Level 4 product: SMOS and CryoSat2 combined

- Taking advantage of the complementary thickness retrievals, derived from the CS2 altimeter and the SMOS radiometer
- Weekly Arctic-wide sea-ice thickness fields with reduced relative uncertainties

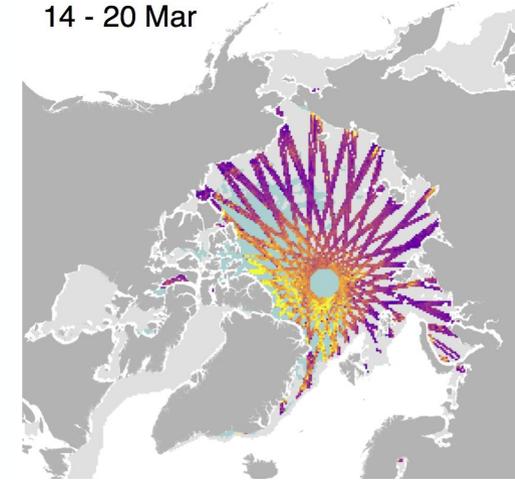
Ricker, R., et al (2017): A weekly Arctic sea-ice thickness data record from merged CryoSat-2 and SMOS satellite data



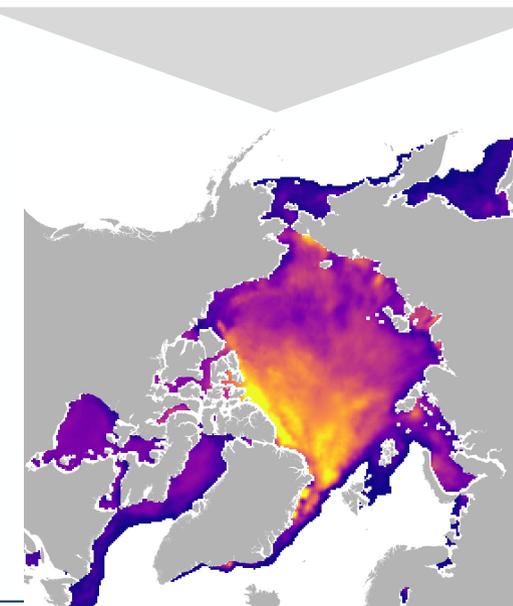
SMOS ice thickness retrievals



CryoSat-2 weekly means

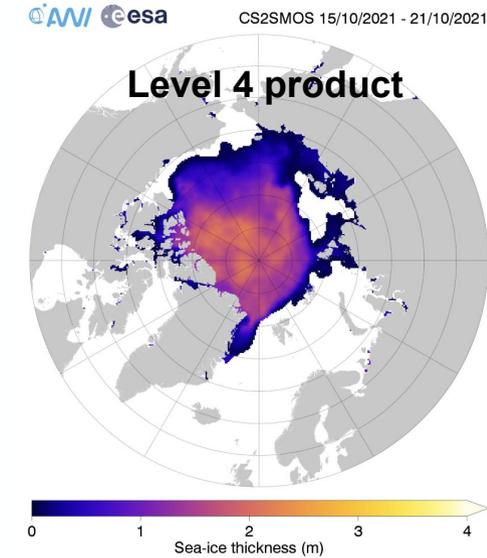
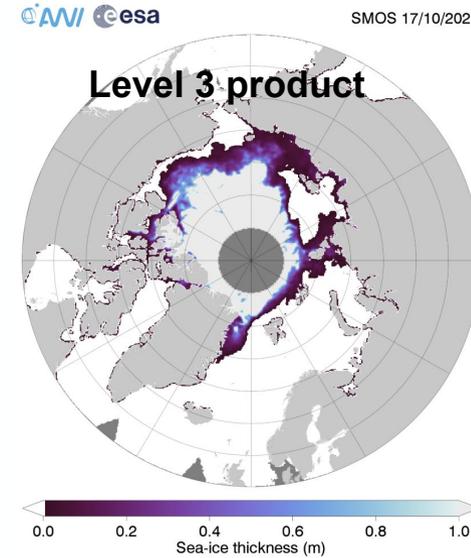
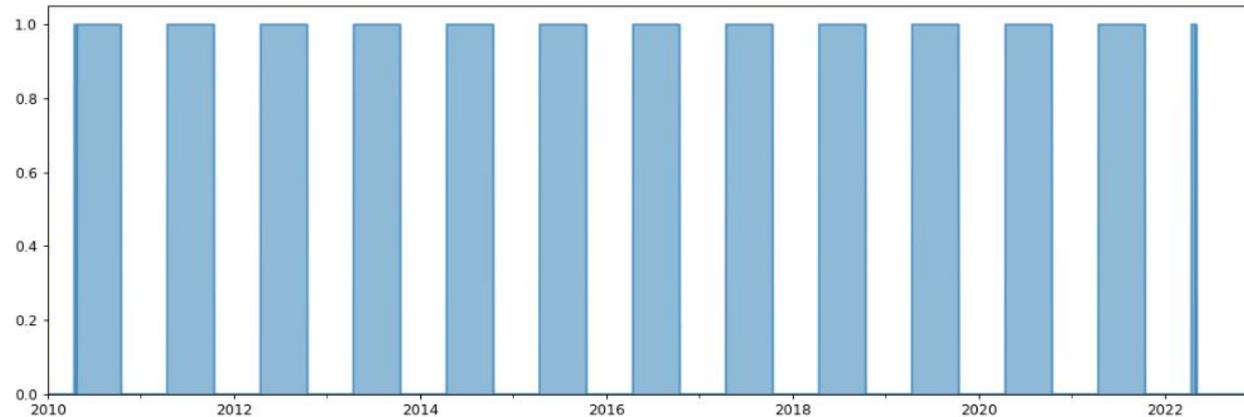
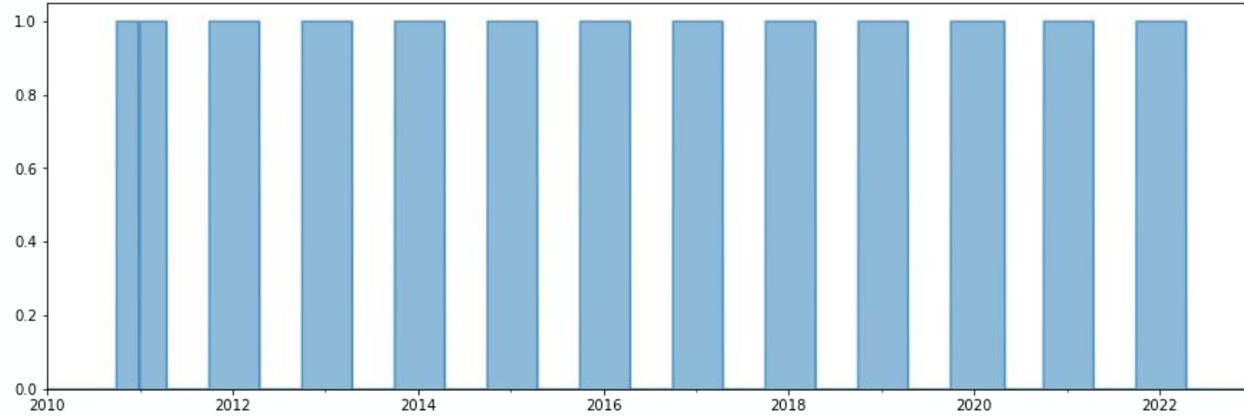


Legend:
 First-Year Ice (light grey)
 Multiyear Ice (teal)



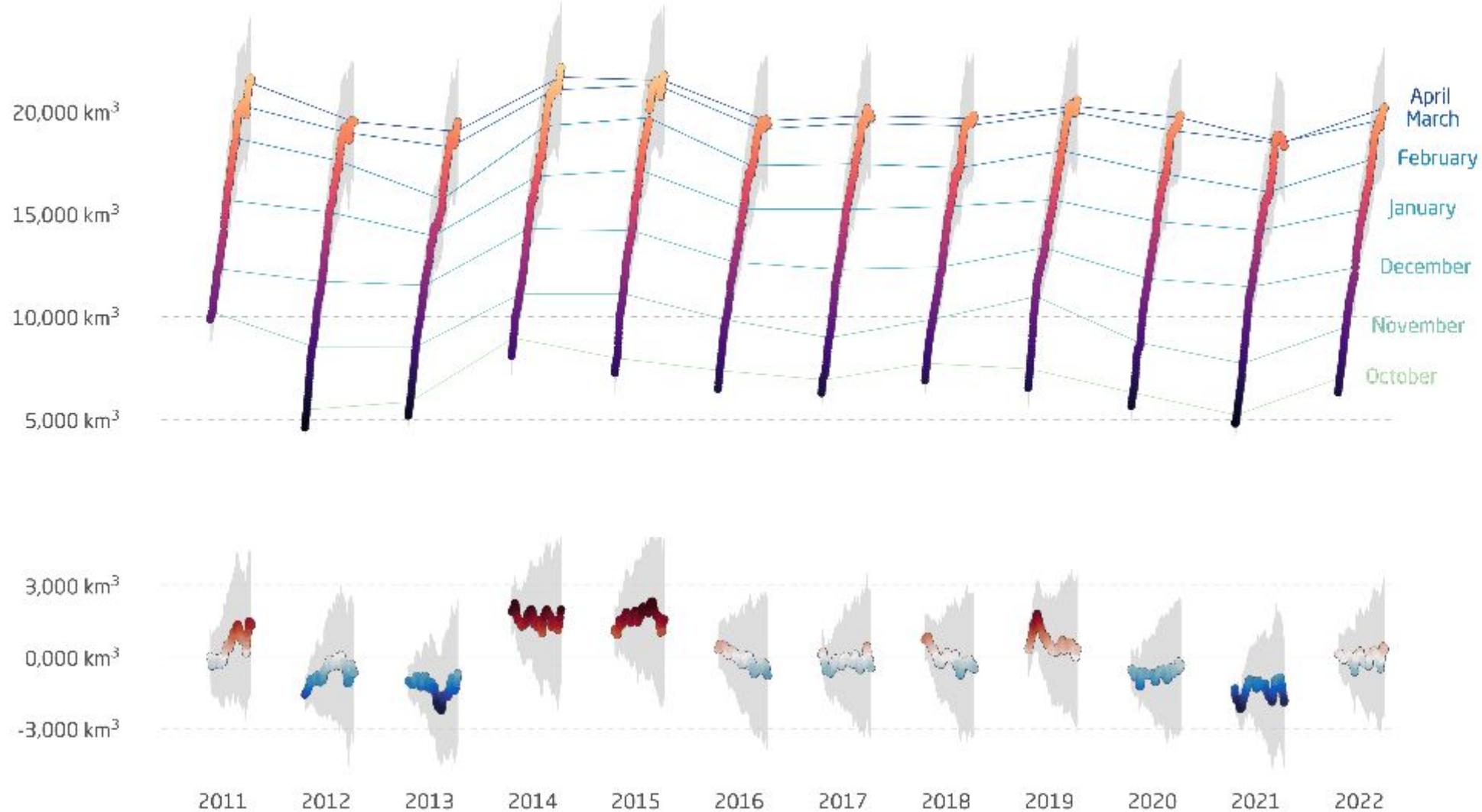
12th Arctic season finished 13th Antarctic season started

Available SMOS L3 sea ice thickness products version v3.3 based on L1C v724 for the northern (top) and southern (bottom) hemisphere winter periods.



- SMOS L3 sea ice algorithm **v3.3** based on L1C **v724**
- SMOS & CS2 L4 algorithm **v204** based on CryoSat2 **baseline E**

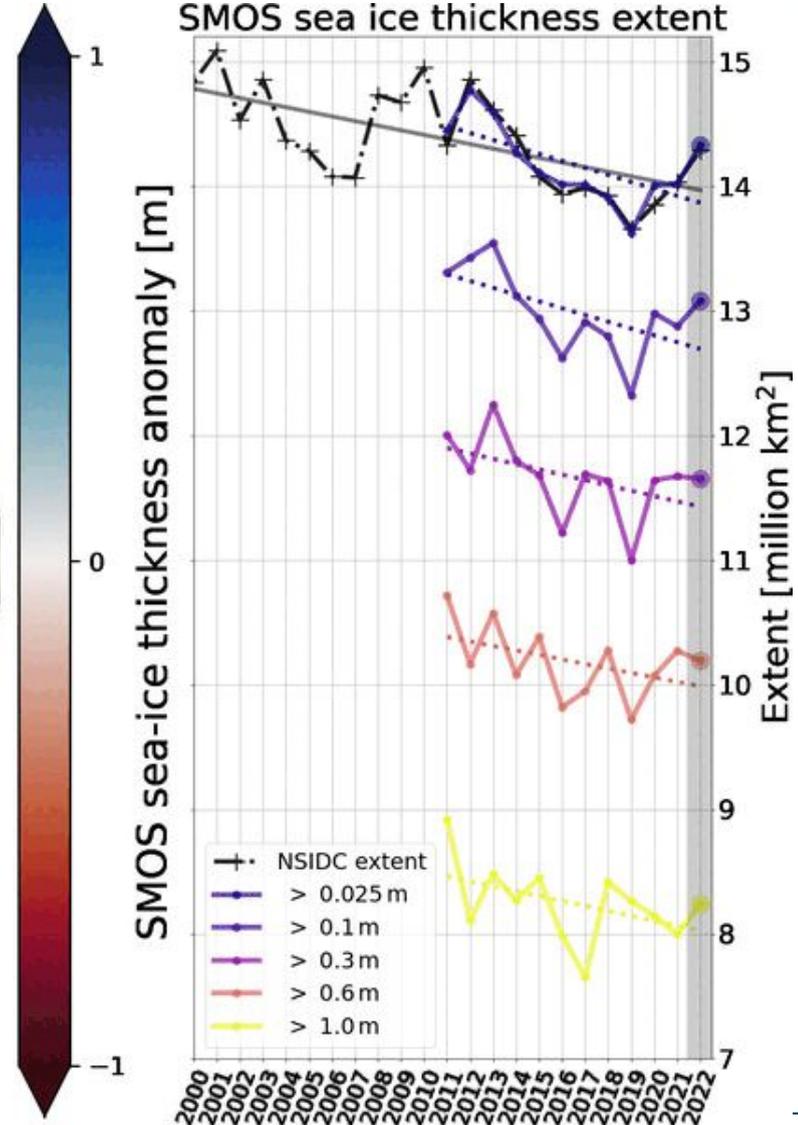
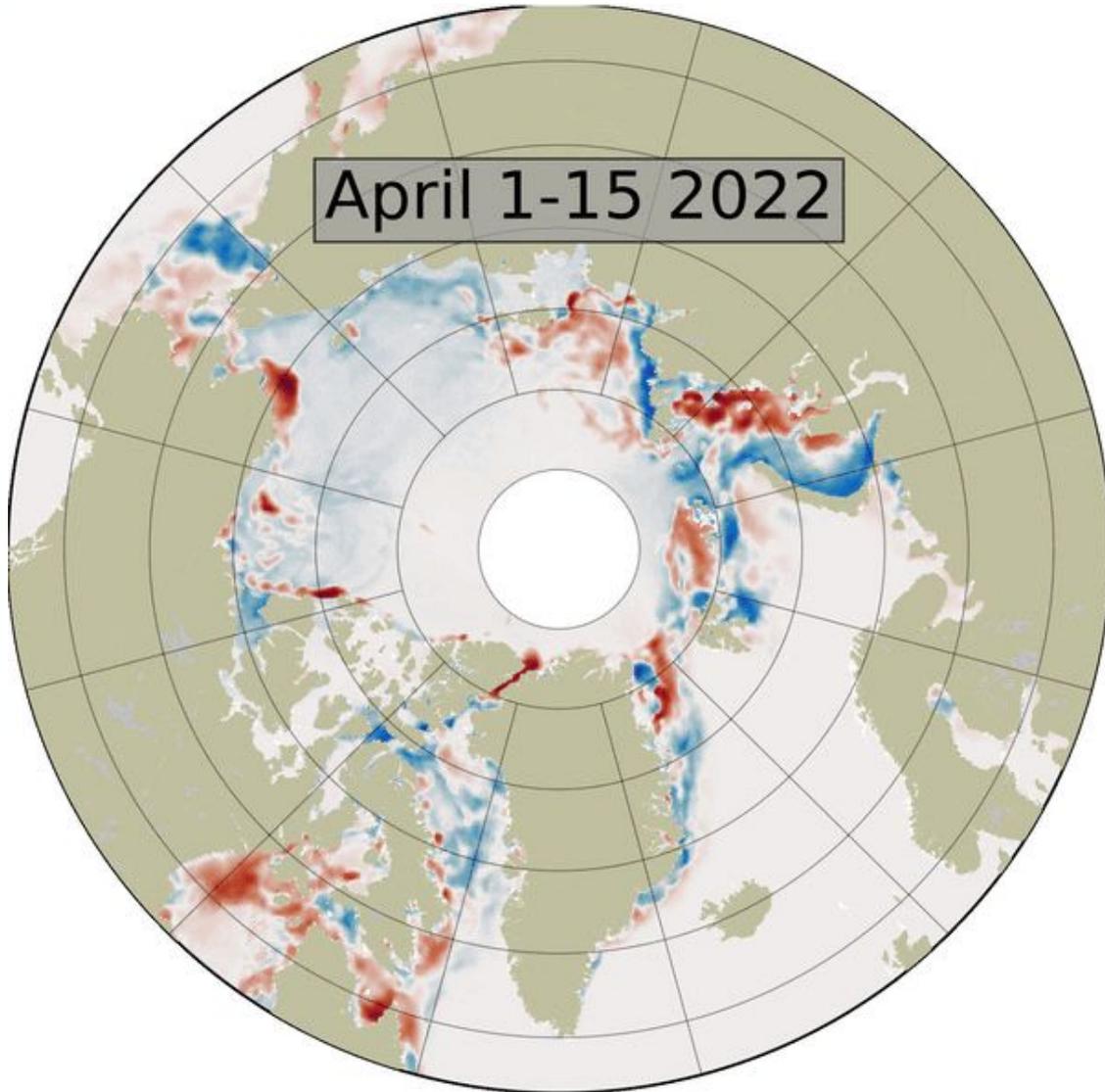
SMOS & CryoSat2 Arctic Sea Ice Volume Time Series



→ LPS22 presentation of Stefan Hendricks



SMOS L3 sea ice thickness extent at the end of the season

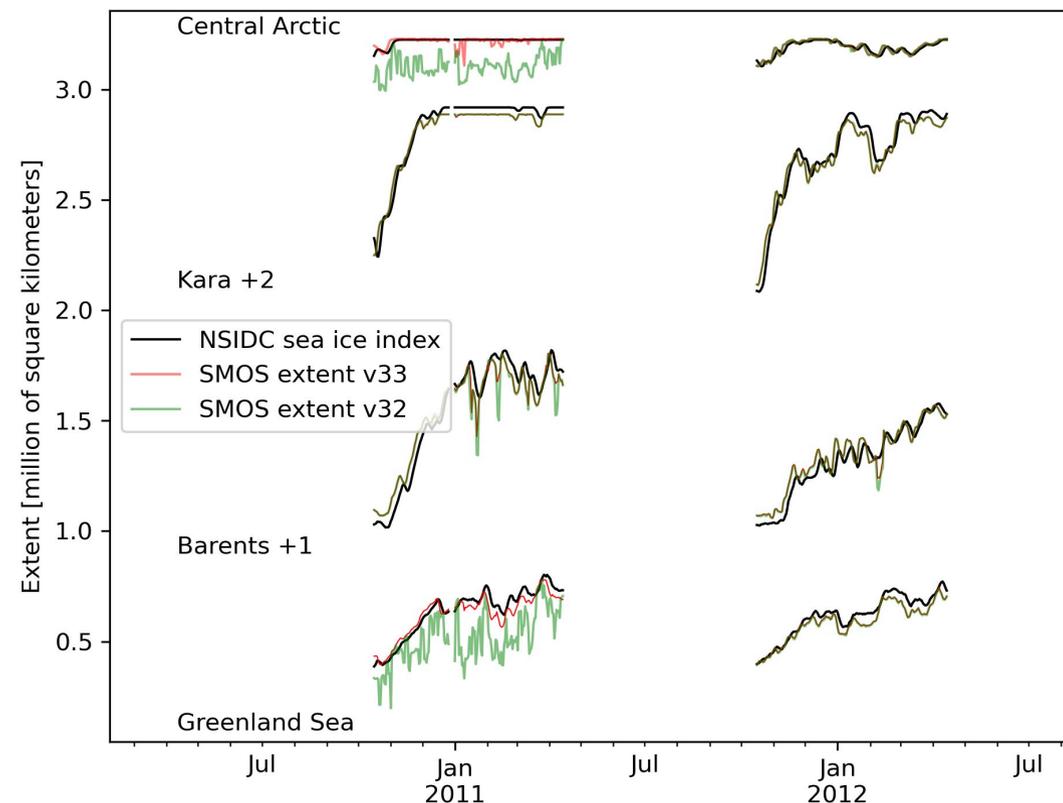
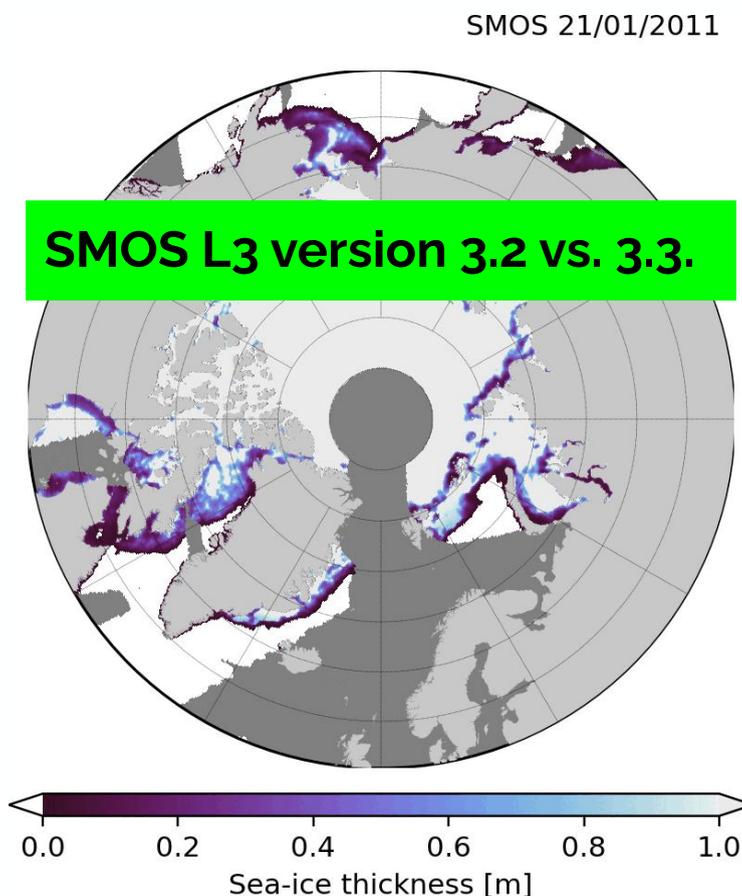


- 12 yrs SMOS data at the end of the freezing season
- SMOS sea ice thickness extent >0.025m agrees with NSIDC sea ice index based on SSMIS
- Upward trend over the past 4 years
- Long-term trend shows declining Arctic sea ice
- Negative trend is consistent for ice up to 1m

SMOS sea ice data evolution and quality control

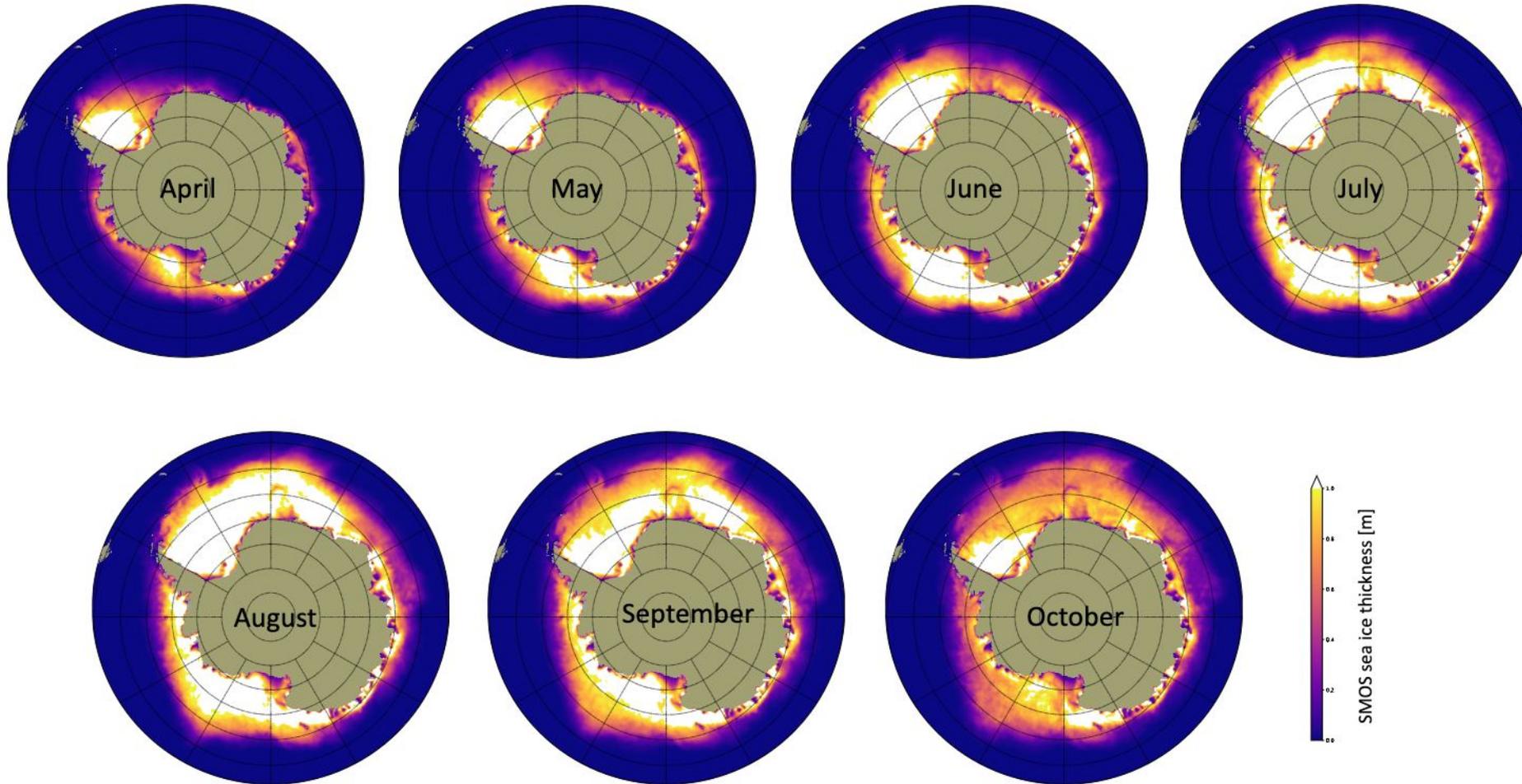
Substantial gain in coverage due to improved RFI flags in L1C data version v724 compared to previous L1C version v620.

RFI-related data gaps filled e.g. in the Atlantic.



L. Kaleschke and X. Tian-Kunze, "SMOS Sea Ice Thickness Data Product Quality Control by Comparison with the Regional Sea Ice Extent," 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS, 2021, pp. 1110-1113, doi: 10.1109/IGARSS47720.2021.9553630.

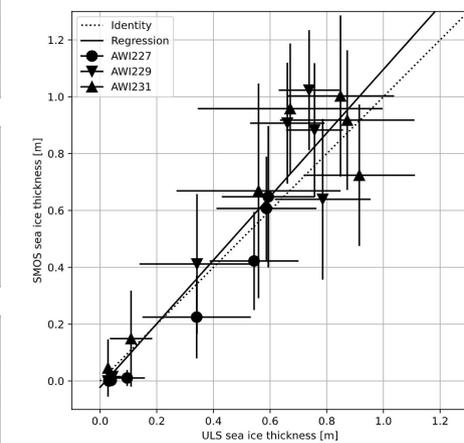
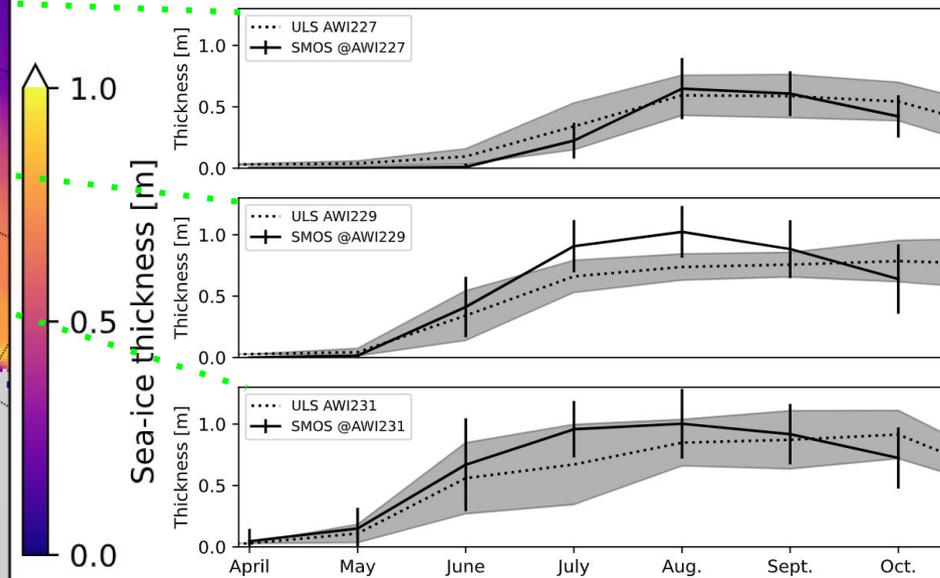
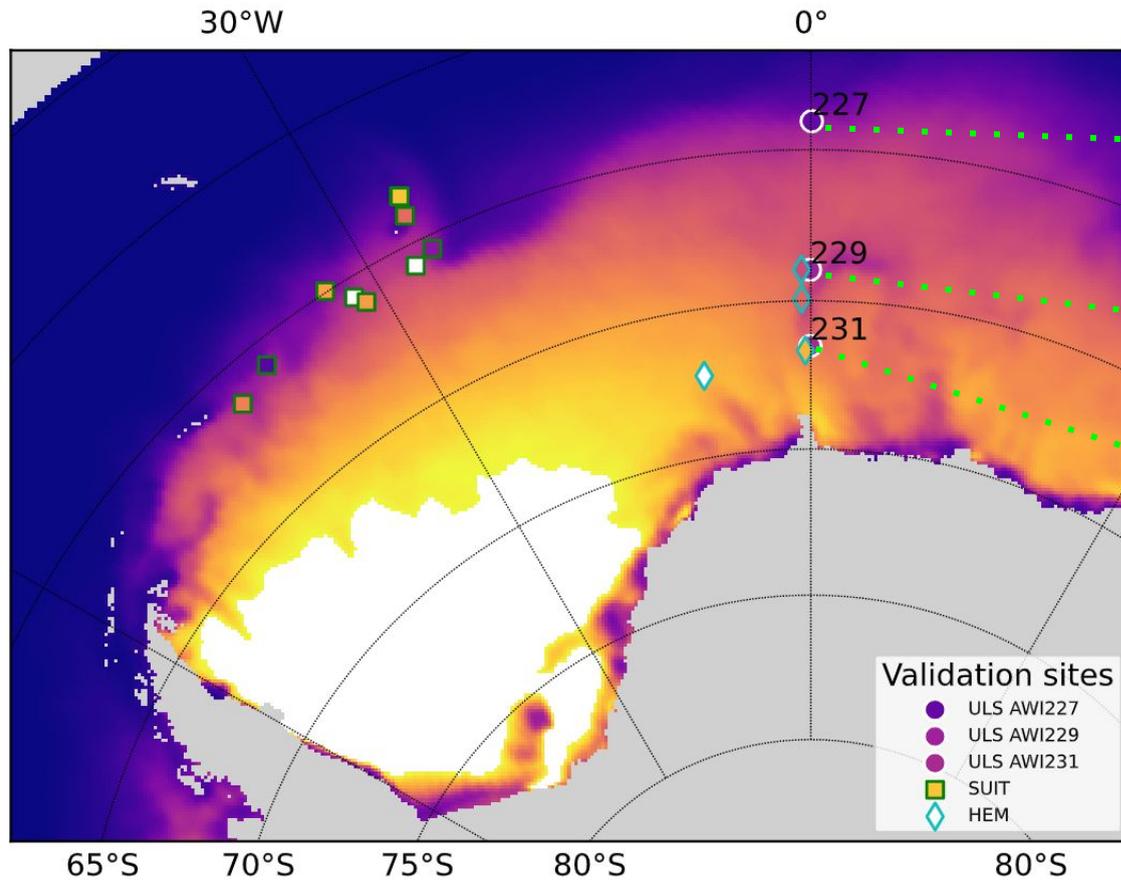
Antarctic thin sea ice thickness from SMOS 2010-2020



Tian-Kunze, X., Kaleschke, L. (2021): SMOS-derived sea ice thickness in the Antarctic from 2010 to 2020. <https://doi.org/10.1594/PANGAEA.934732>



Validation with upward-looking sonar (ULS) < 1m



Mean deviation and RMSD of SMOS and ULS sea-ice thickness. Monthly climatological mean data for three ULS stations.

Time period	ULS $\mu \pm \sigma$ (cm)	SMOS $\mu \pm \sigma$ (cm)	N	R	MD(cm)	RMSD (cm)
Apr. - Oct.	46 \pm 32	49 \pm 38	21	0.94	+3	14

Overview of validation data. The background shows the SMOS sea-ice thickness averaged from April to October over the years 2010-2020.

Same numbers for v3.2 (L1C v620) and v3.3. (L1C v724).

- Complementary sensor synergy has been proven successful: ESA's SMOS low-frequency radiometry together with CryoSat-2 altimetry can be used to measure the sea ice thickness with reduced uncertainty and better data coverage
- SMOS L3 sea ice thickness data v3.3 based on L1C v724 data
→Sea ice thickness extent
- SMOS and CryoSat2 L4 sea ice thickness data v204 based on baseline E
→Sea ice volume
- SMOS L3 product for Antarctic sea ice initially validated and operational soon
- Field campaigns such as MOSAiC are necessary for process studies, parameterizations and validation to further improve EO methods
- Ongoing work in ESA-funded project SMOS Expert Support Laboratories (ESL) for further algorithm evolution and improvement of data quality
 - Evolution of L3 & L4 sea ice algorithms
 - Continuing MOSAiC data analysis
 - New metrics for enhanced quality monitoring
 - Extended triple collocation (ETC) for validation
 - More synergy: increasing sampling & grid resolution by including Sentinel-3

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