
# SMOS sea ice thickness - a review and way forward

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14:00
Nairobi 3-4

# Low-frequency microwave radiometry for sea ice

←Hallikainen et al. (1976)

ESA SMOS sea ice studies

2007→

2010→

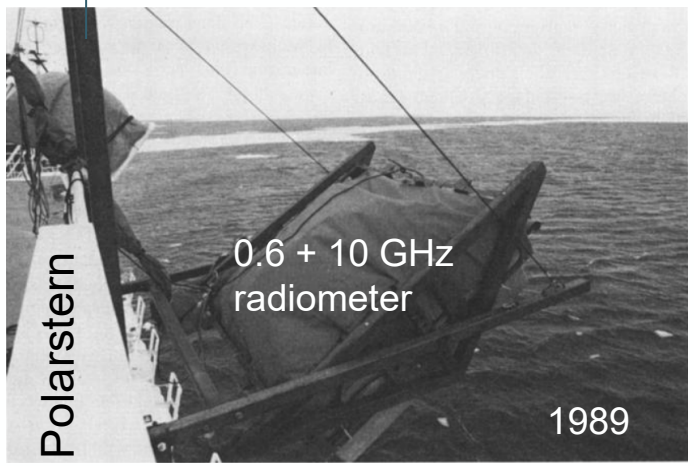
2011

ESA SMOSIce

2015→

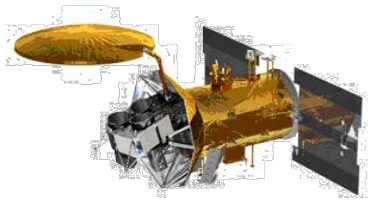
MOSAiC
ESA SMOS ESL

2019/20

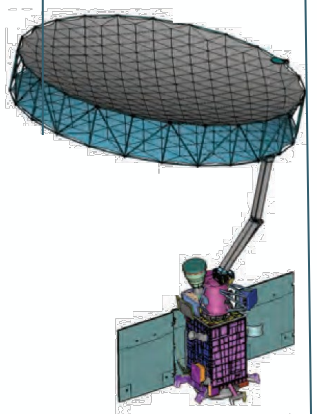



Menashi, J. D., St. Germain, K. M., Swift, C. T., Comiso, J. C., and Lohanick, A. W. (1993), Low-frequency passive-microwave observations of sea ice in the Weddell Sea, J. Geophys. Res.

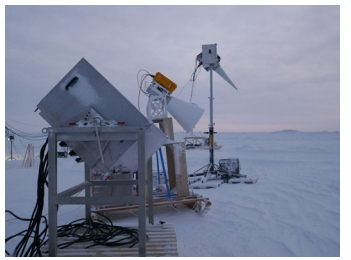
ESA SMOS



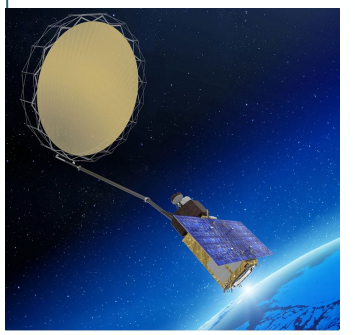
NASA Aquarius



NASA SMAP

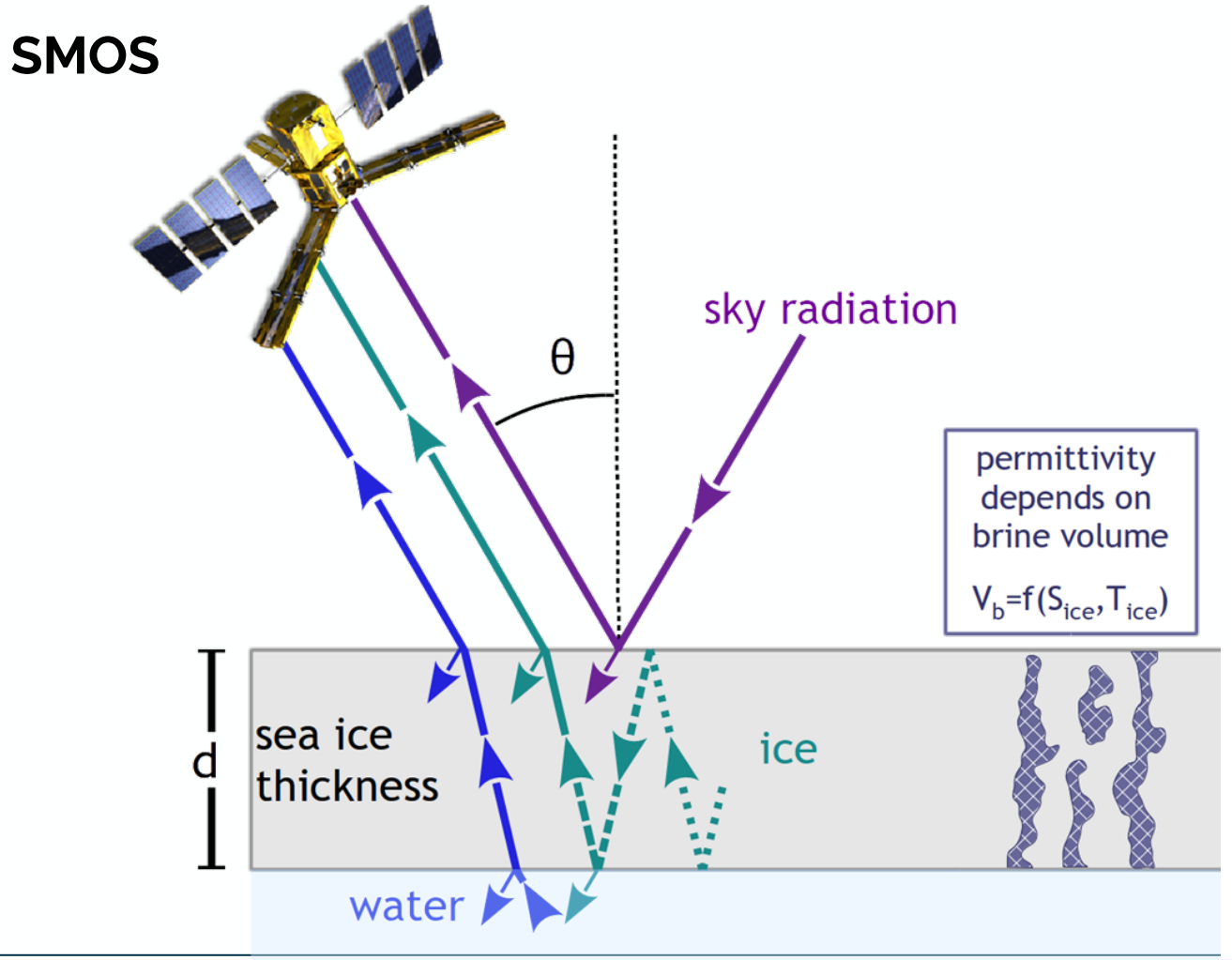


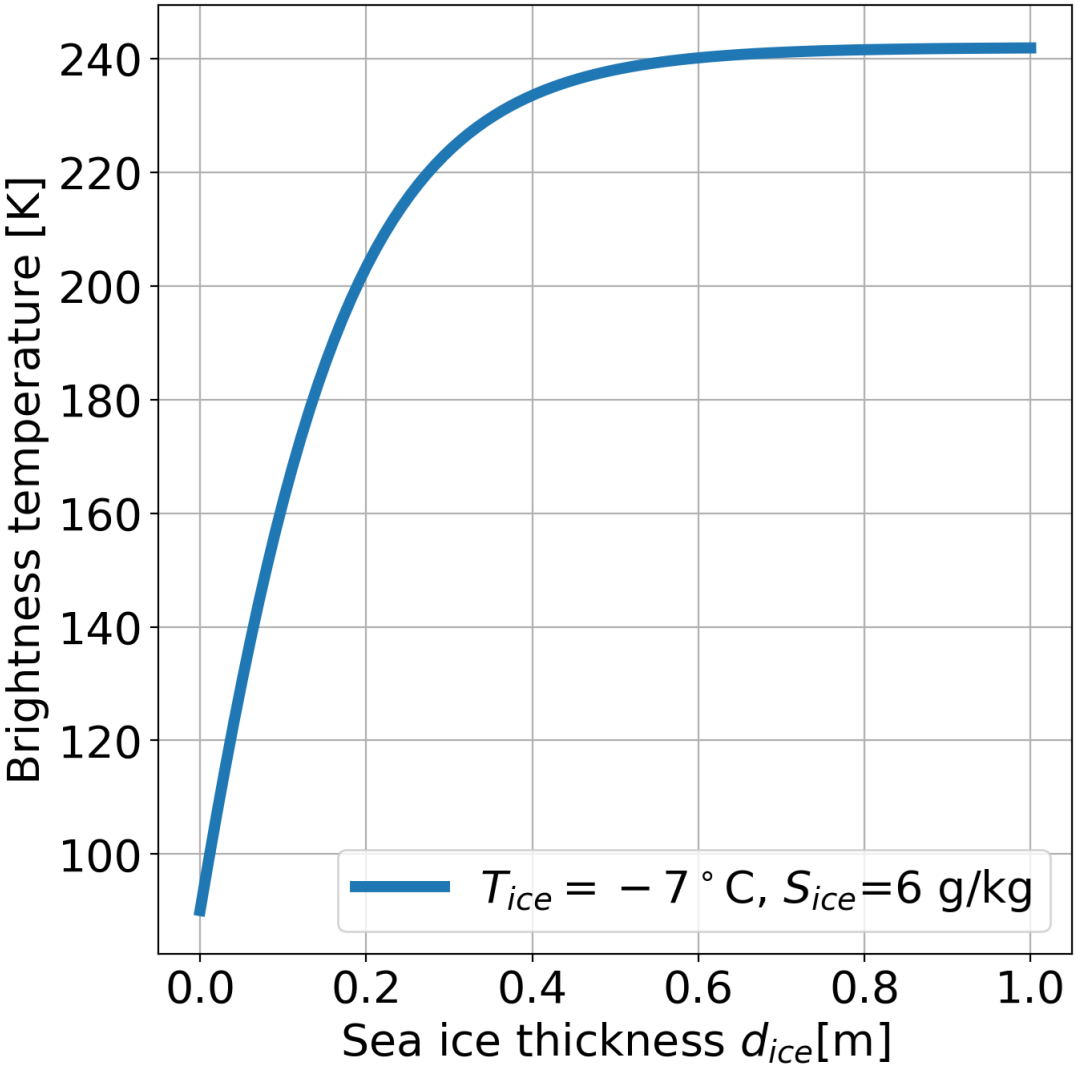
SMOS next/HR?
CryoRad?



Copernicus
Radiometer
CIMR

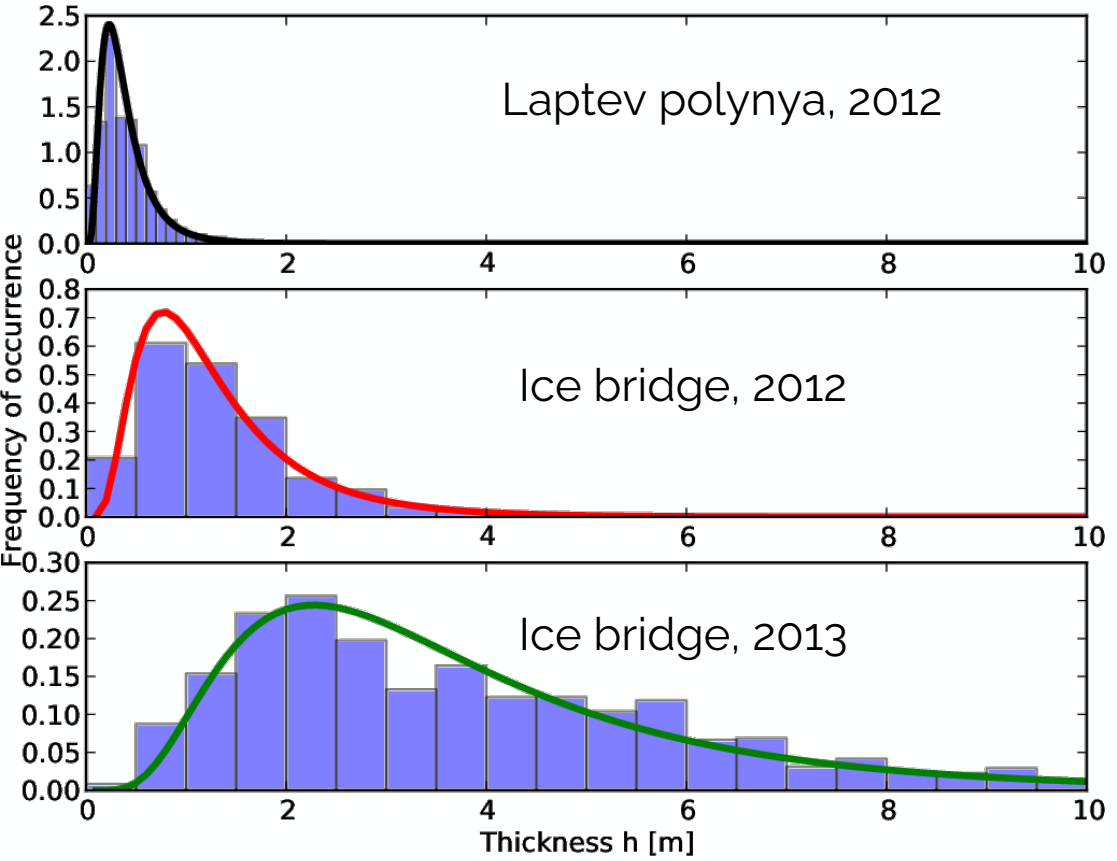
# How to measure sea-ice thickness from space

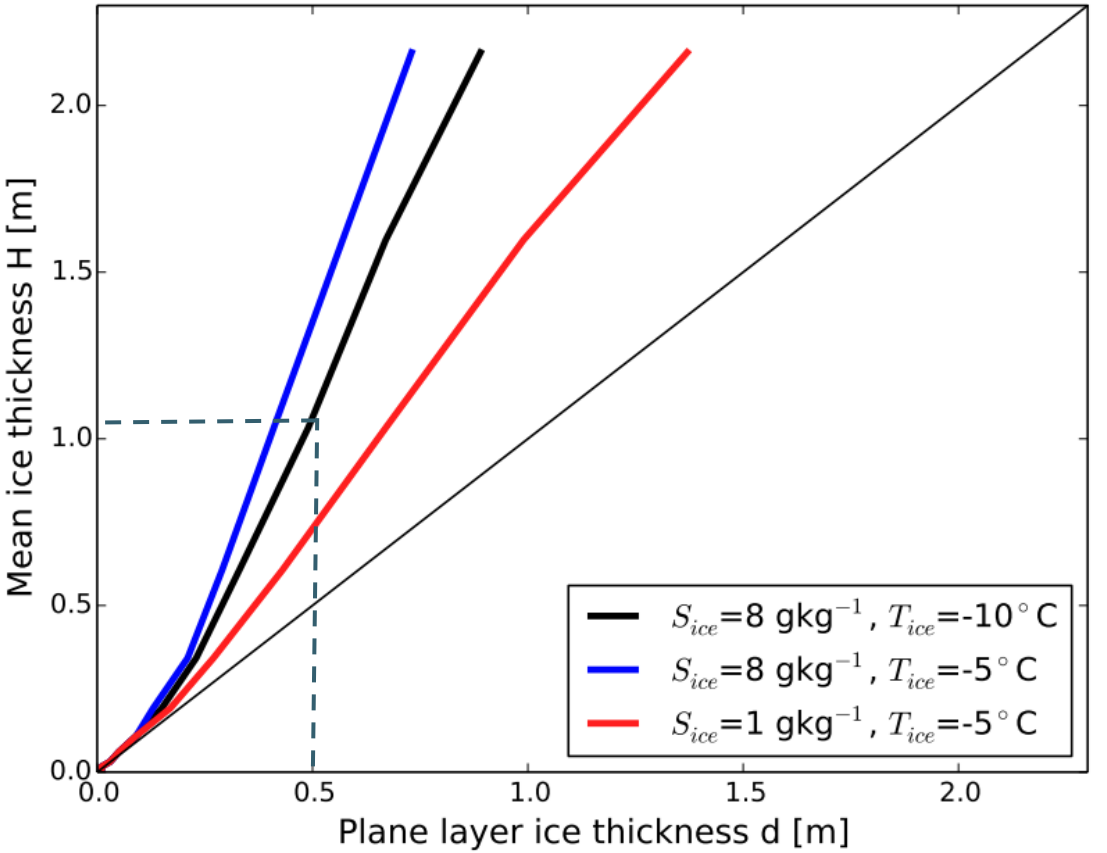


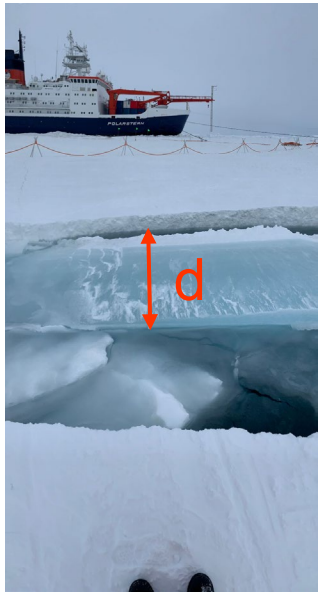




Sketch by A. Schmitt

# Parameterization: statistical thickness distribution



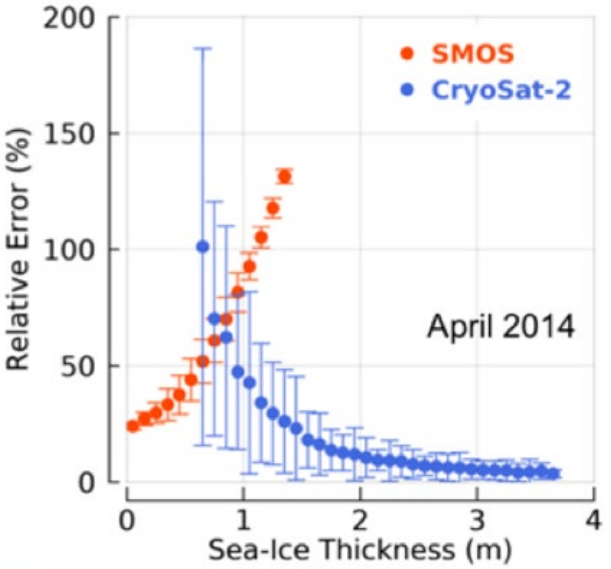



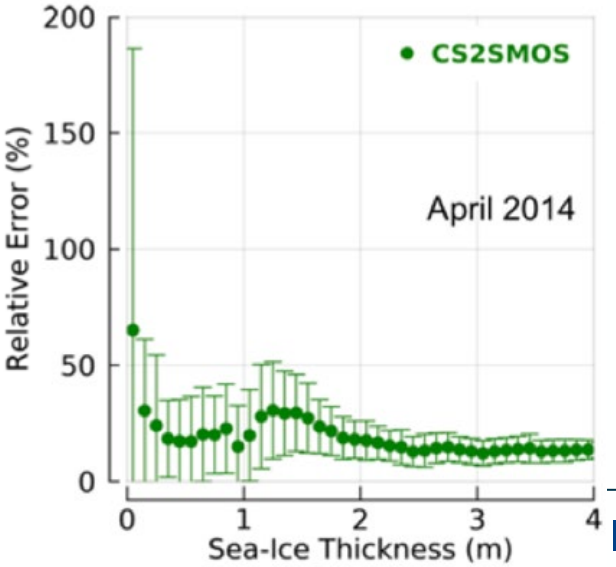



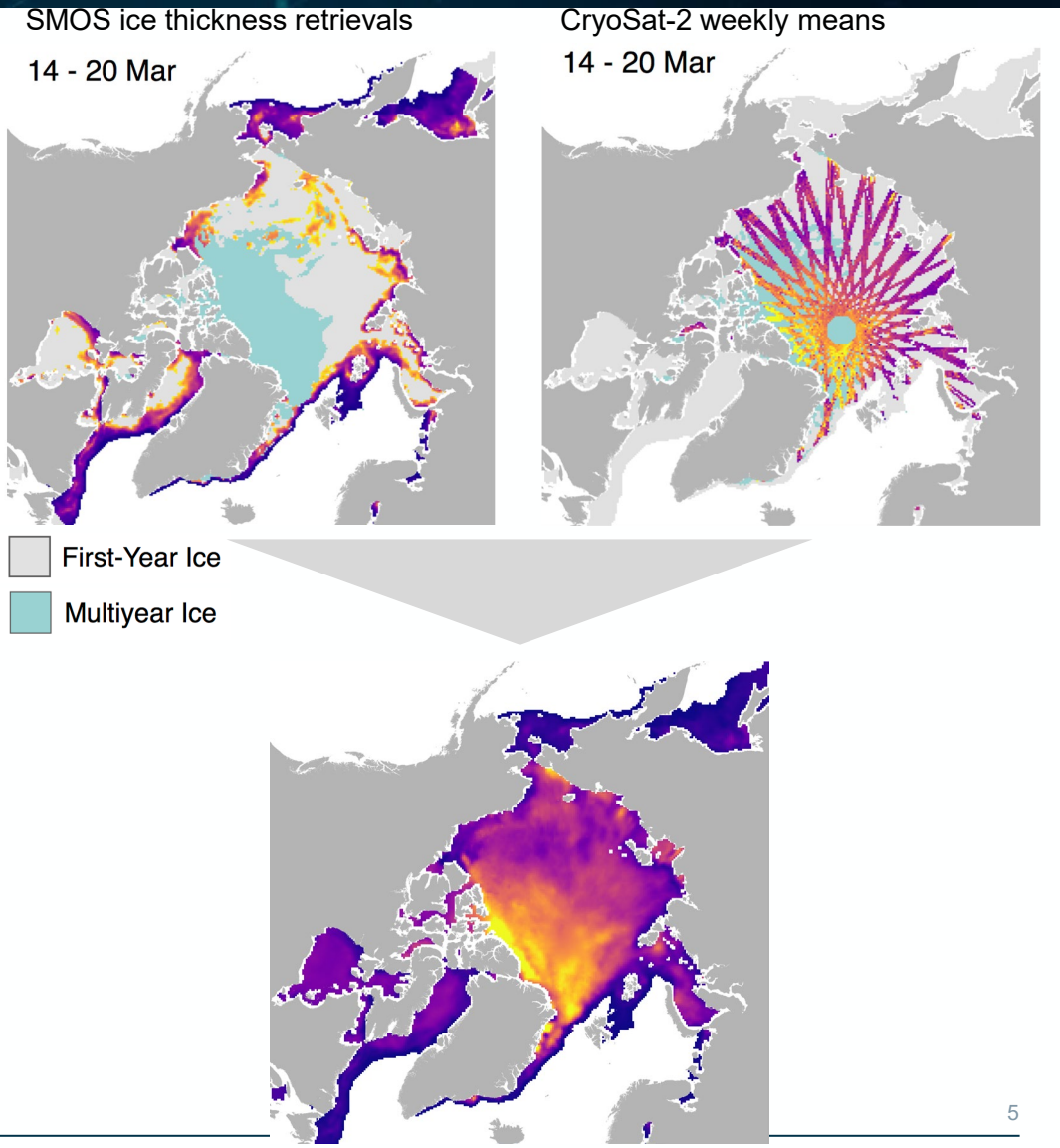

Tian-Kunze, X., Kaleschke, L., Maaß, N., Mäkynen, M., Serra, N., Drusch, M., and Krumpen, T.: SMOS-derived thin sea ice thickness: algorithm baseline, product specifications and initial verification, The Cryosphere, 8, 997-1018, 2014.

# 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



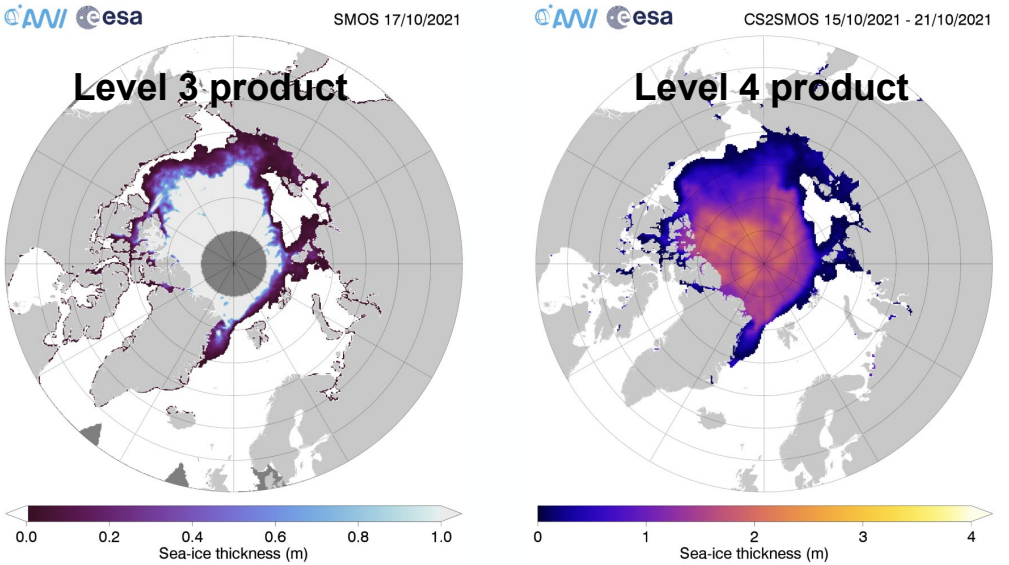




Ricker, R., et al (2017): A weekly Arctic sea-ice thickness data record from merged CryoSat-2 and SMOS satellite data

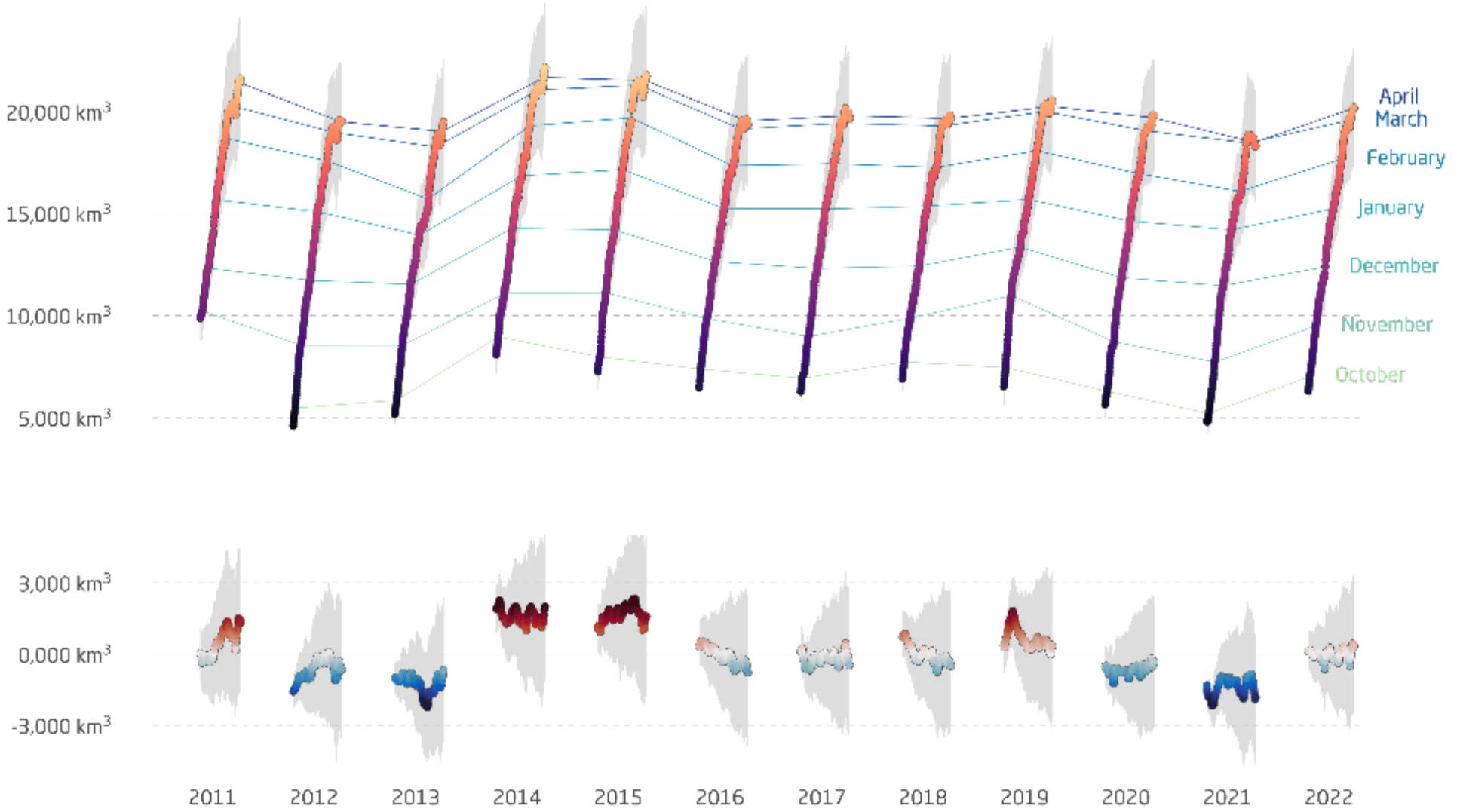
# 12th Arctic season finished
# 13th Antarctic season started

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

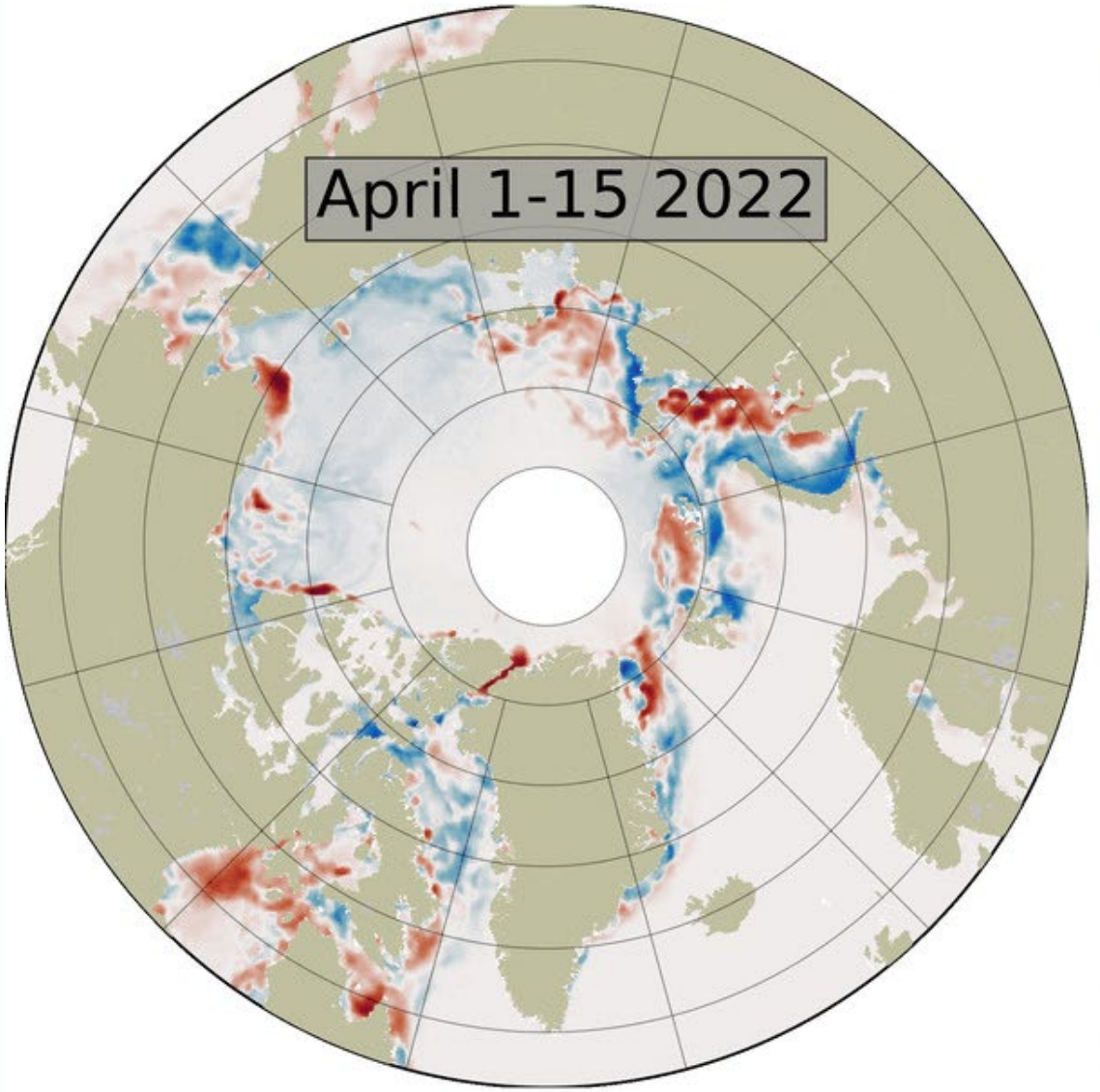



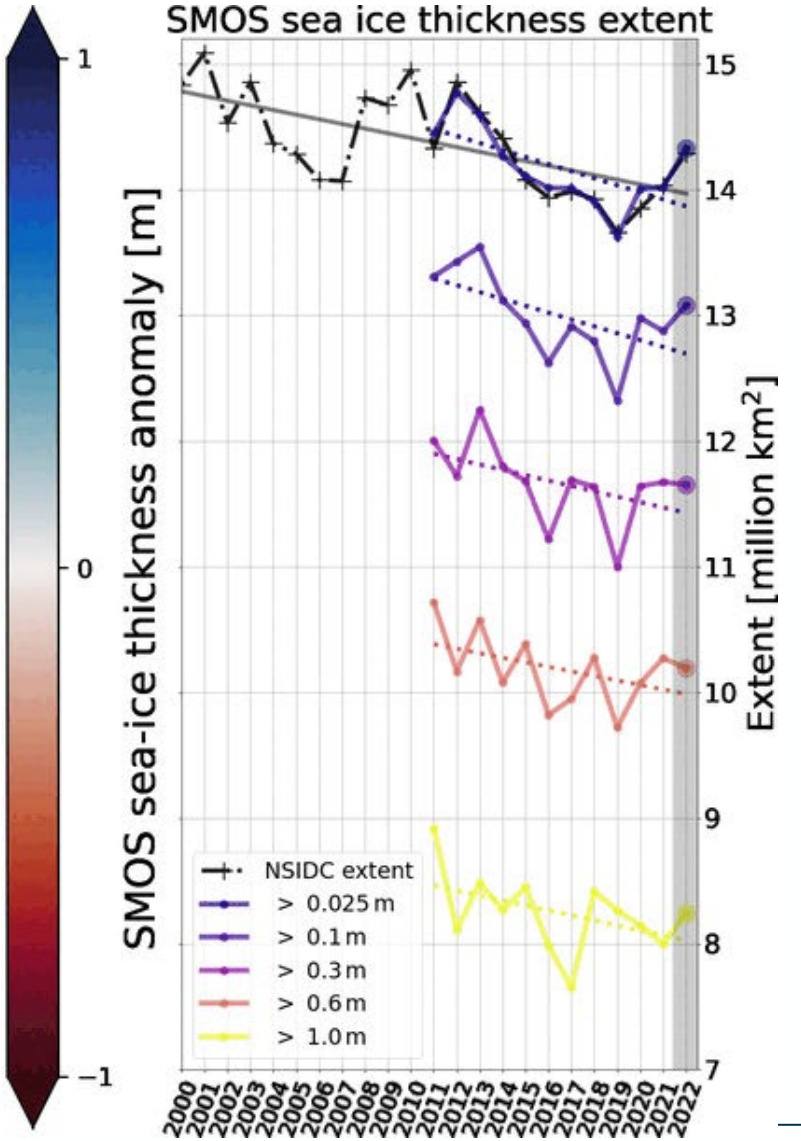

- SMOS L3 sea ice algorithm **v3.3** based on L1C **v724**
- SMOS & CS2 L4 algorithm **v204** based on CryoSat2 **baseline E**

# SMOS & CryoSat2 Arctic Sea Ice Volume Time Series



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



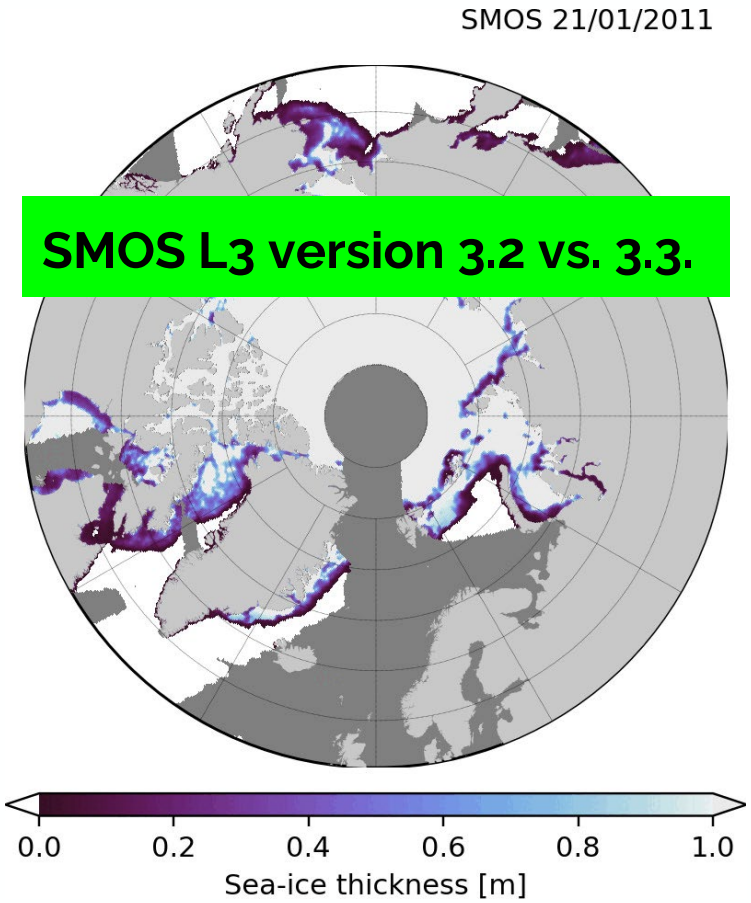



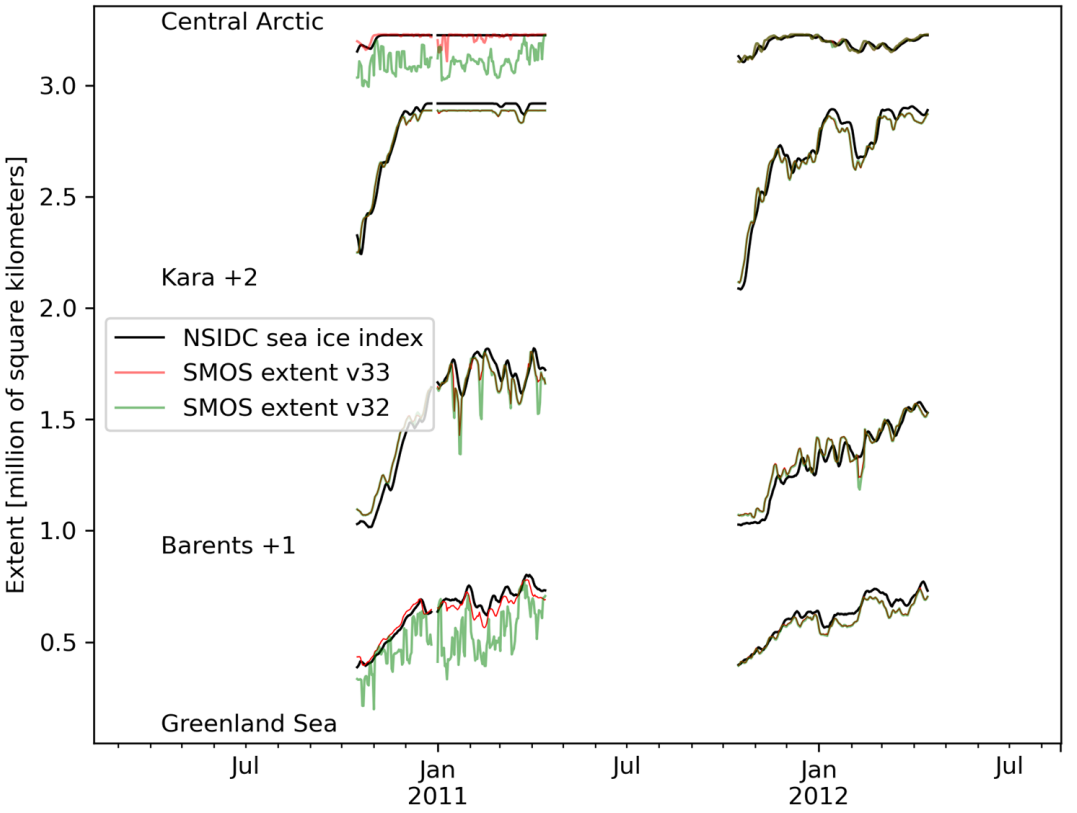

- 12 yrs SMOS data at the end of the freezing season
- SMOS sea ice thickness extent >0.025m agrees with NSIDC sea ice index based on SSMIS
- Upward trend over the past 4 years
- Long-term trend shows declining Arctic sea ice
- Negative trend is consistent for ice up to 1m

# 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.

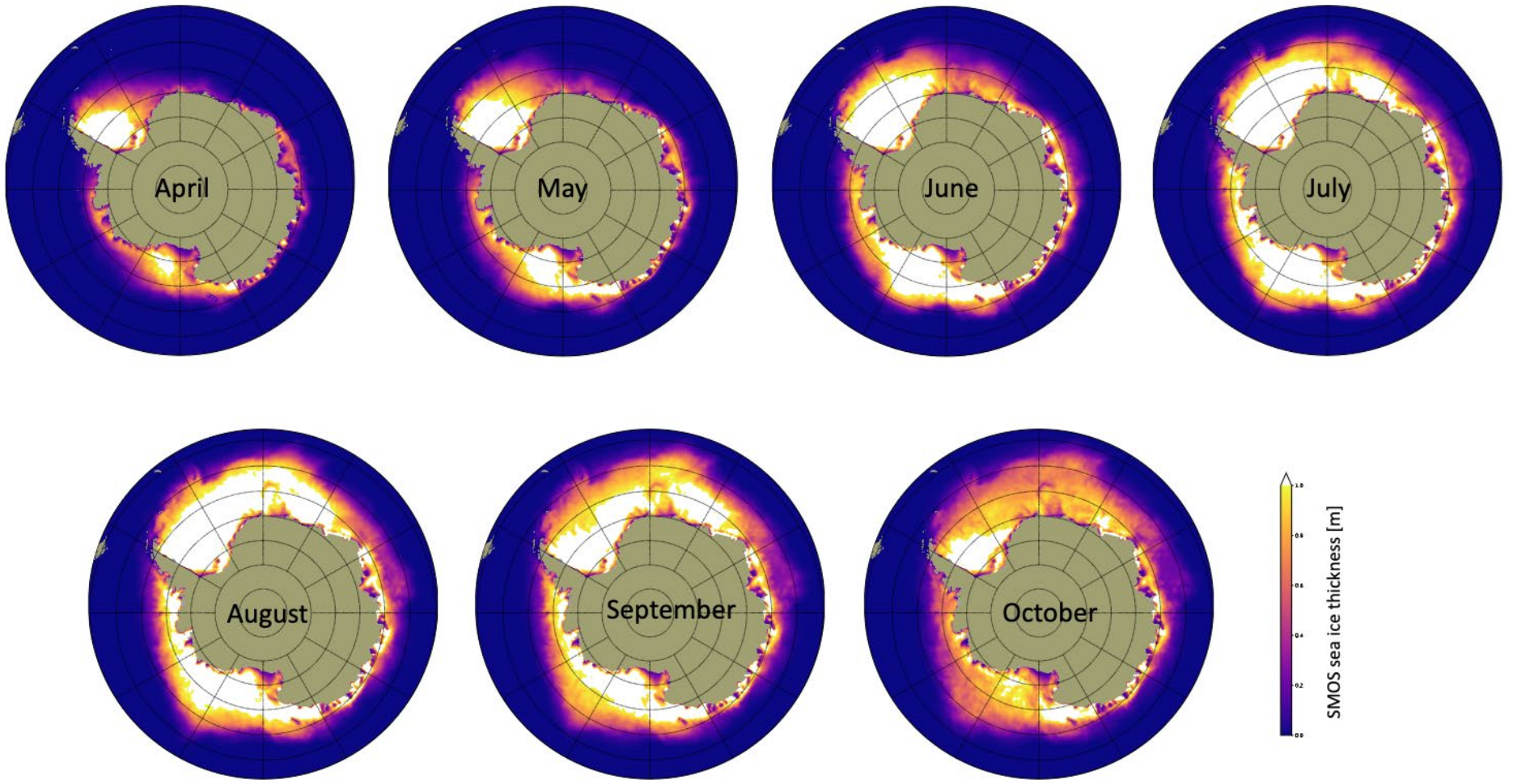
RFI-related data gaps filled e.g. in the Atlantic.



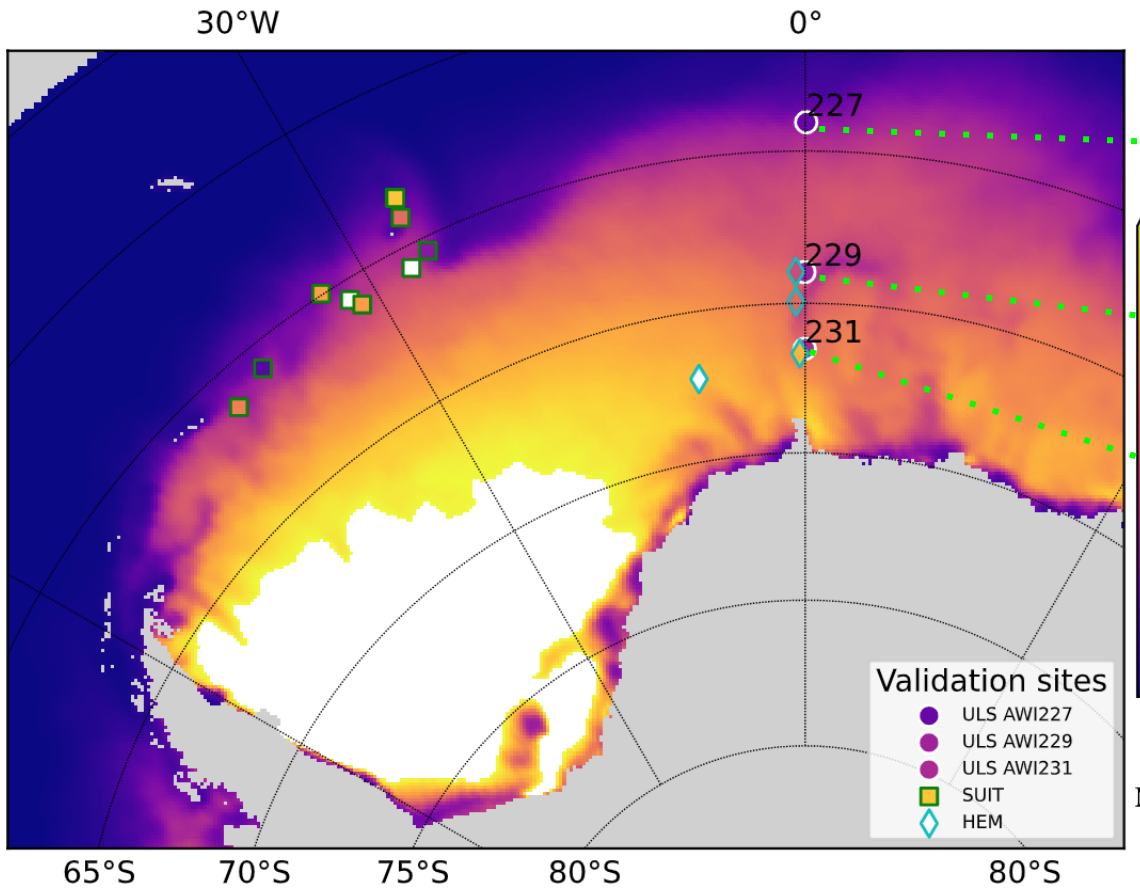

L. Kaleschke and X. Tian-Kunze, "SMOS Sea Ice Thickness Data Product Quality Control by Comparison with the Regional Sea Ice Extent," 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS, 2021, pp. 1110-1113, doi: 10.1109/IGARSS47720.2021.9553630.

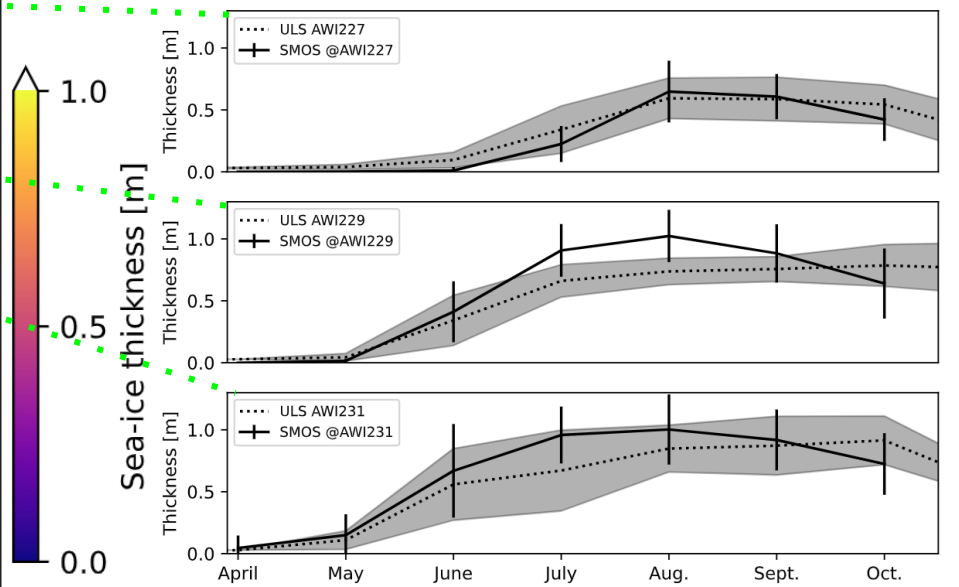
# Antarctic thin sea ice thickness from SMOS 2010-2020

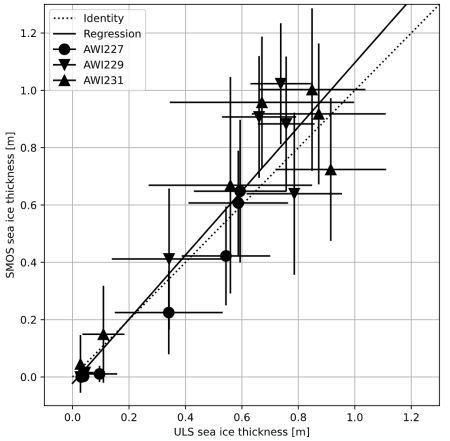



Tian-Kunze, X., Kaleschke, L. (2021): SMOS-derived sea ice thickness in the Antarctic from 2010 to 2020. https://doi.org/10.1594/PANGAEA.934732

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




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

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±32 | 49±38 | 21 | 0.94 | +3 | 14 |

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

# Summary and way forward

- 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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