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New sea level polar maps combining Sentinel-3A, SARAL/AltiKa and Crysosat-2

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Context

- In the polar regions satellite sea level observations are limited by the sea ice. Thanks to a dedicated processing, sea level can however be estimated within fractures in the ice (leads).
- Some sea level maps emerged in the polar regions using **one satellite** (Armitage et al. , 2016, Rose et al., 2019).
- CNES studies in sea level in the polar regions resulted in **multi-mission** polar maps prototypes for the arctic (Prandi et al., 2021) and the southern ocean (Auger et al., 2022).

Arctic sea surface height maps from multi-altimeter combination

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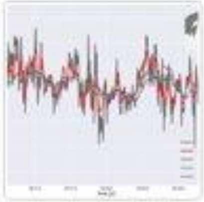


Data Descriptor | Open Access | Published: 02 March 2022

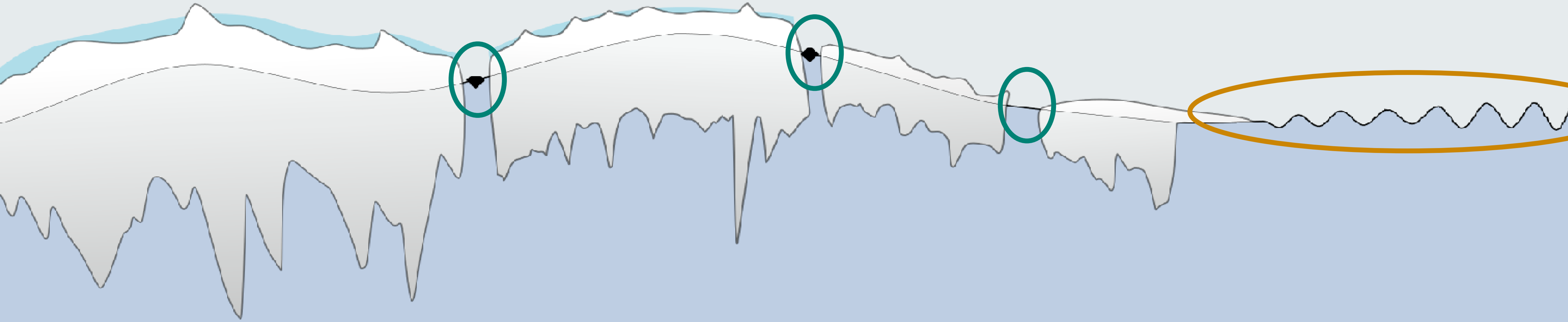
Southern ocean sea level anomaly in the sea ice-covered sector from multimission satellite observations

Matthis Auger, Pierre Prandi & Jean-Baptiste Sallée

Scientific Data **9**, Article number: 70 (2022) | Cite this article

Classification to select leads and open ocean

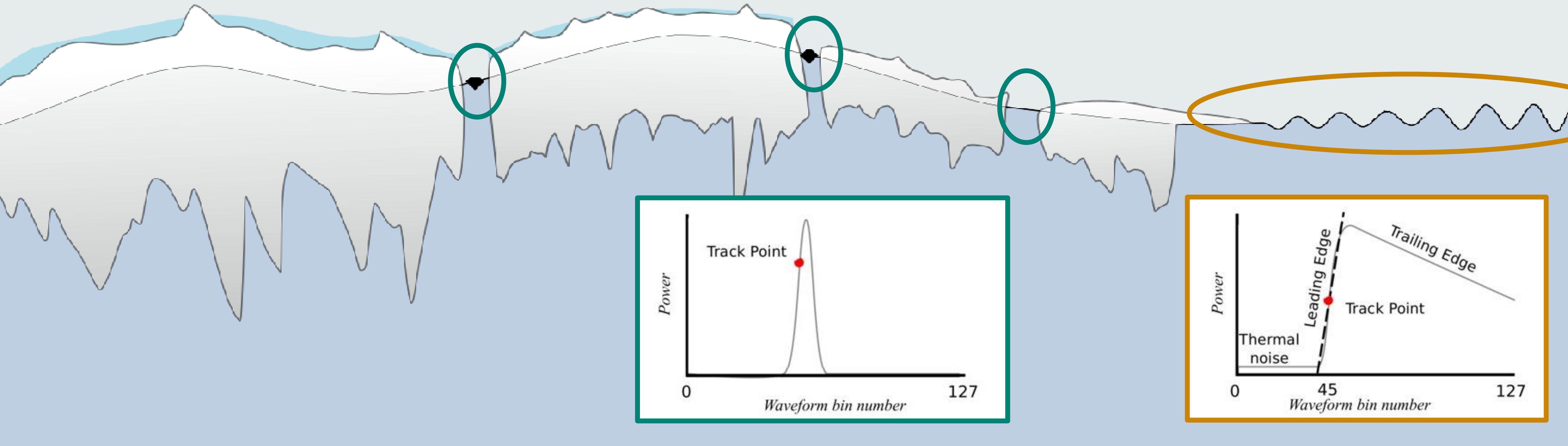
- Neural Net based (Poisson et al., 2018, Longépé et al., 2019)



From Quartly, 2019

Range estimation through retracking

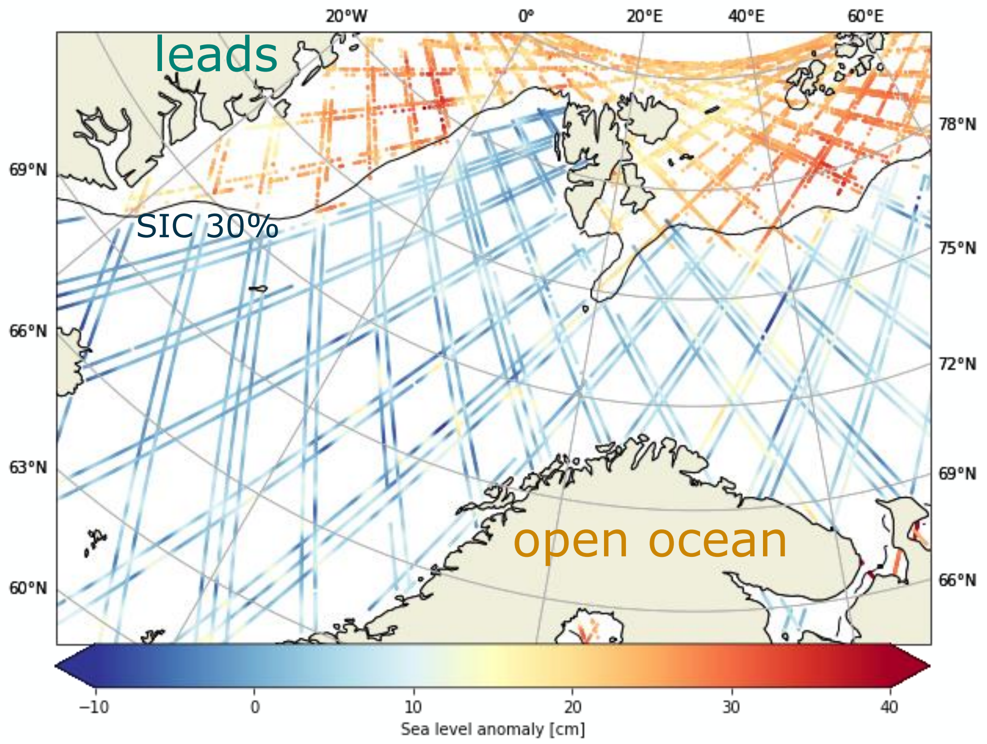
- Adaptive retracker (Poisson et al., 2018) on LRM (SARAL/AltiKa) able to process **both** specular and diffuse echoes,
- Empirical TFMRA retracker on SARM (Sentinel-3A and Cryosat-2) for specular echoes



From Quartly, 2019

Importance of processing continuity

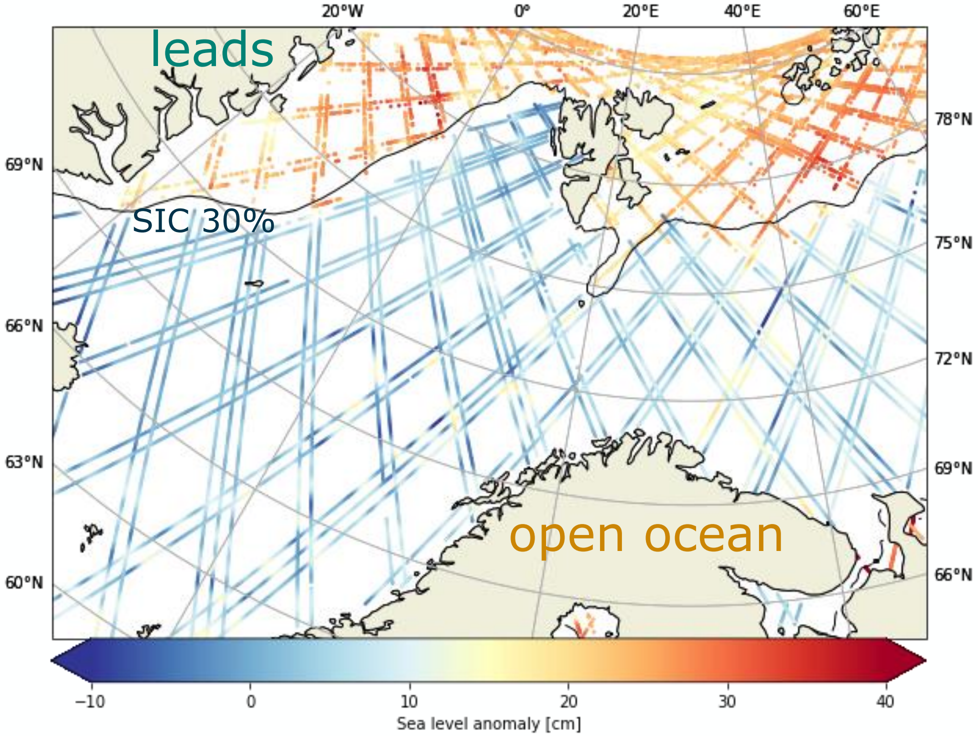
Empirical TFMRA retracker



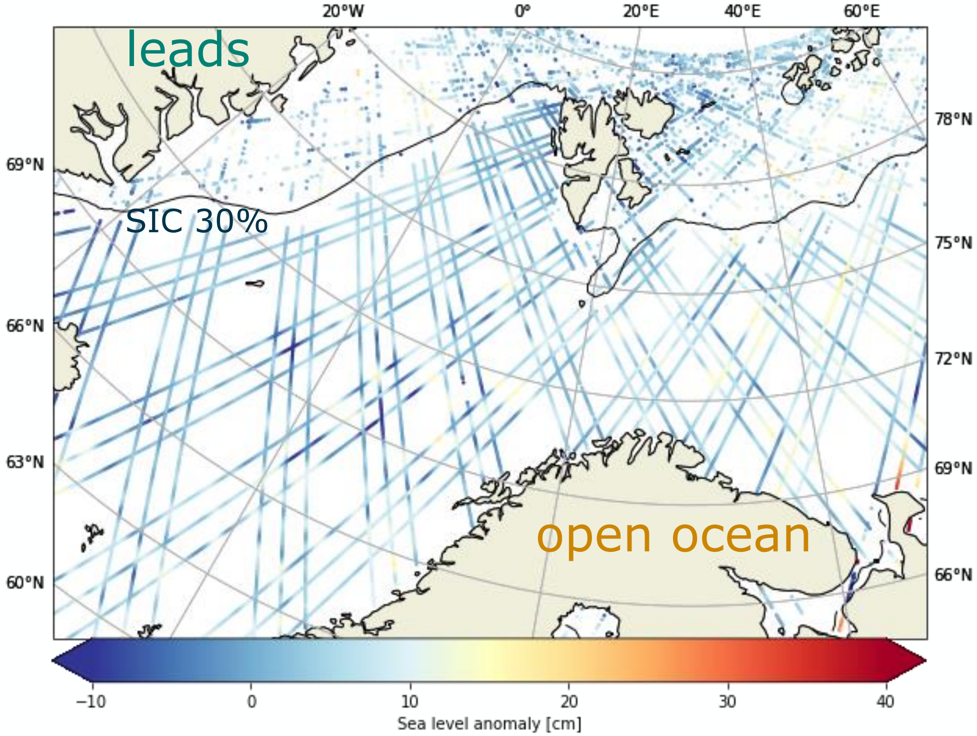
- In most polar ocean approaches, leads and open ocean echoes are retracked differently,,
- An empirical bias between both surfaces must therefore be estimated,
- This bias is highly uncertain,

Importance of processing continuity

Empirical TFMRA retracker



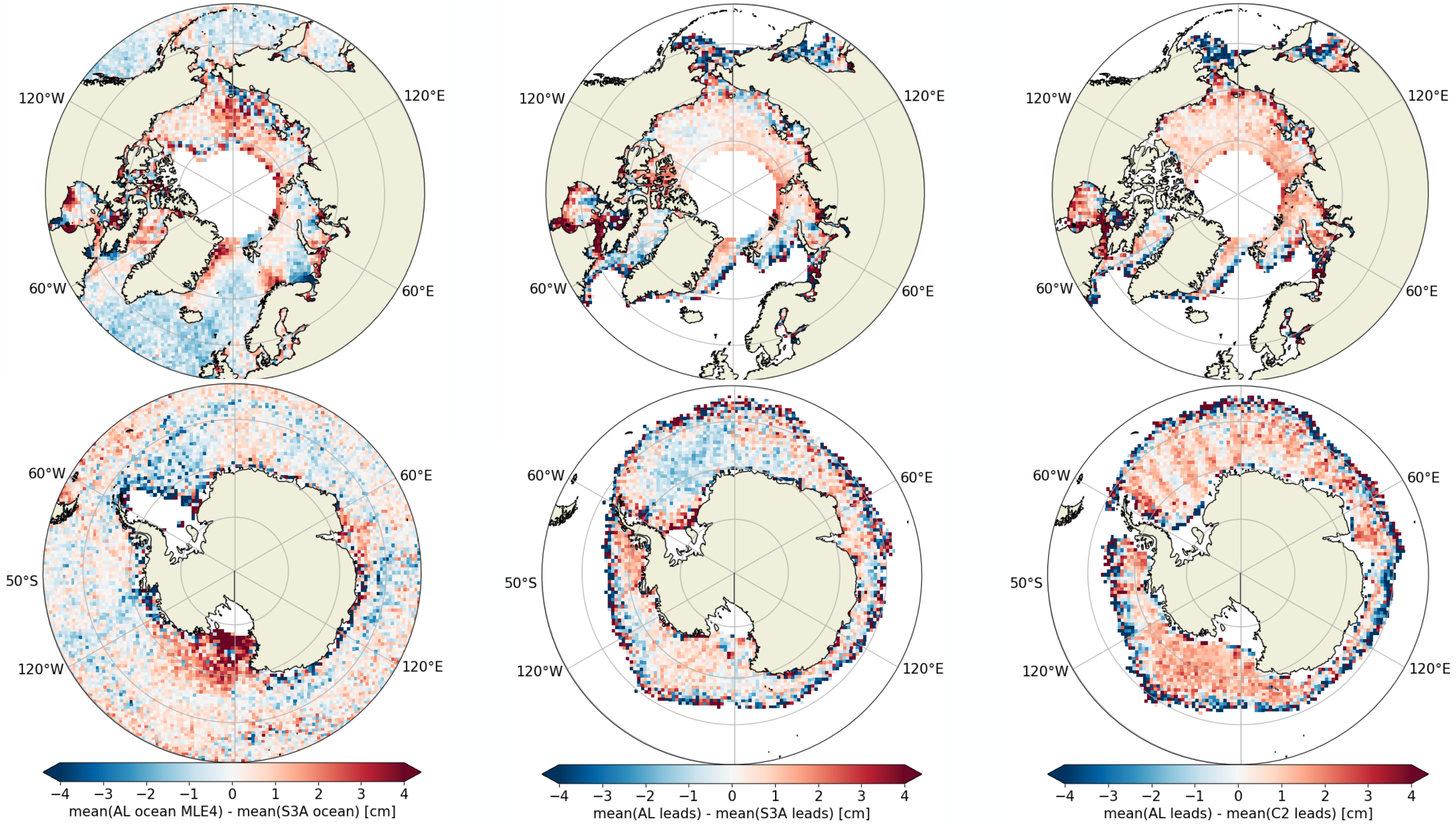
Physical ADAPTIVE retracker



- Here, the use of SARAL/AltiKa Adaptive retracking provides continuity between the two surfaces. It is used to cross-calibrate the other missions

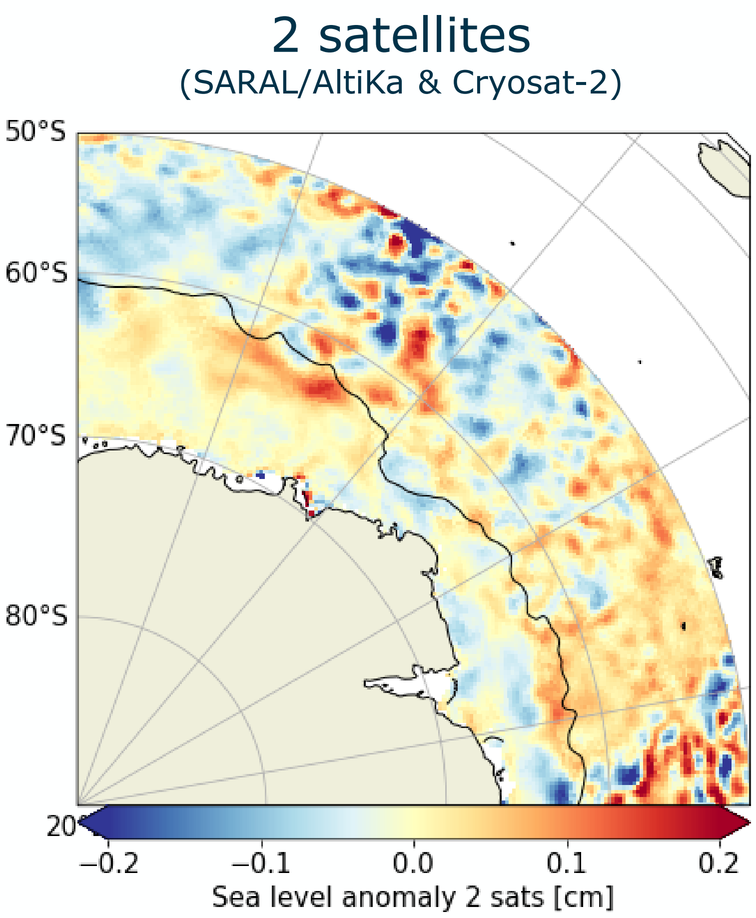
Inter-satellite consistency (once bias is removed)

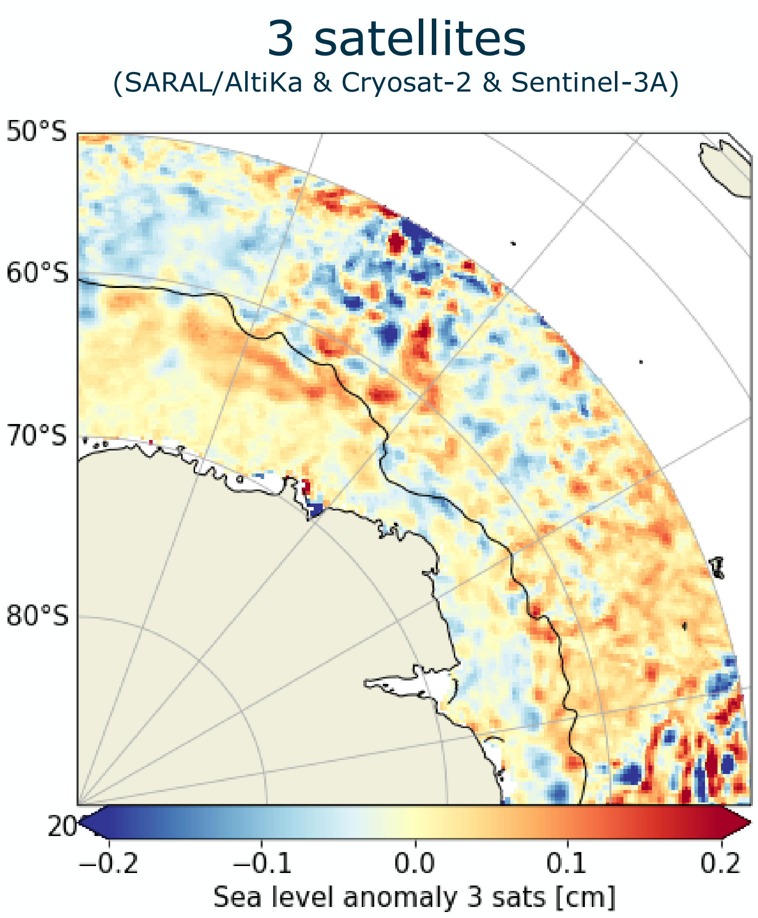
Altika – S3A (ocean) **AltiKa – S3A (leads)** **AltiKa – Cryosat-2 (leads)**



- Processing continuity on SARAL/AltiKa provides a consistent baseline for cross-calibration
- The three missions are consistent both in the Arctic and Antarctic regions.
- Most patterns are below 4cm.

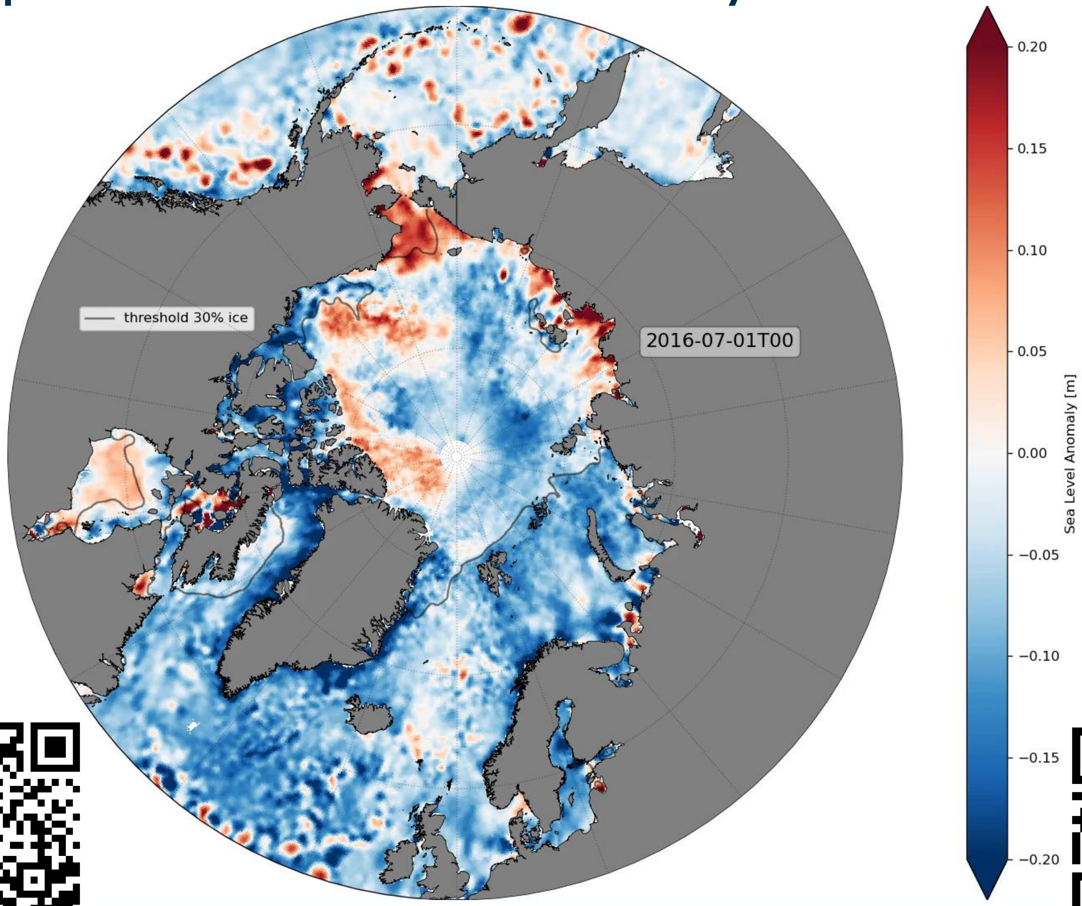
Multi-satellite combination

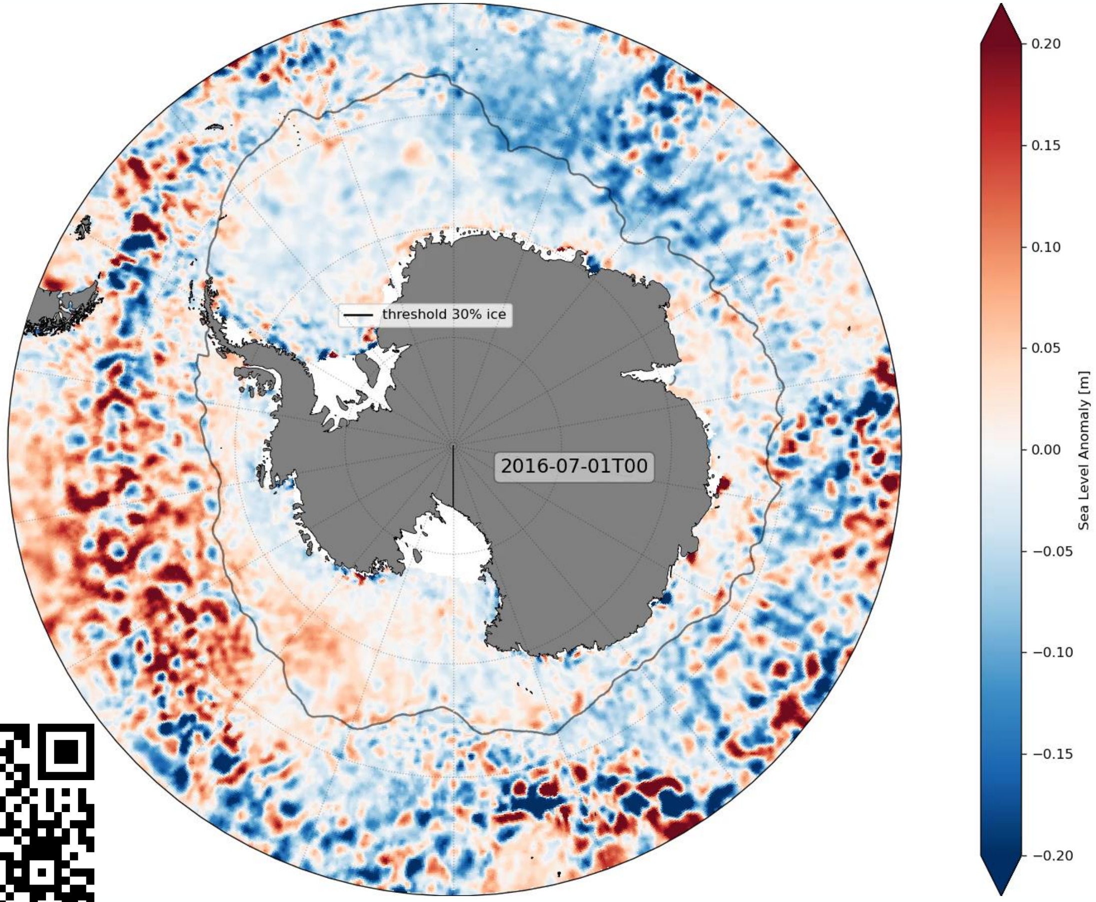




- Optimal interpolation scheme maps along-track data to 3 day/25 km grid
- Combining 3 satellites enables to map smaller oceanic features.

Maps of sea level anomaly

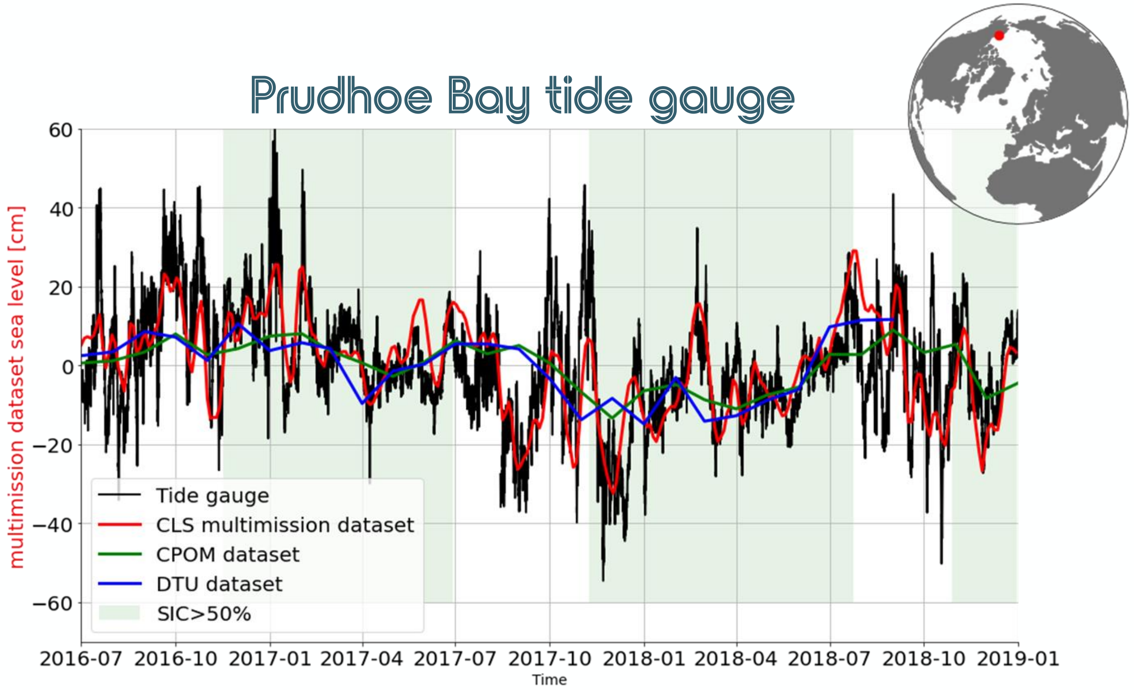


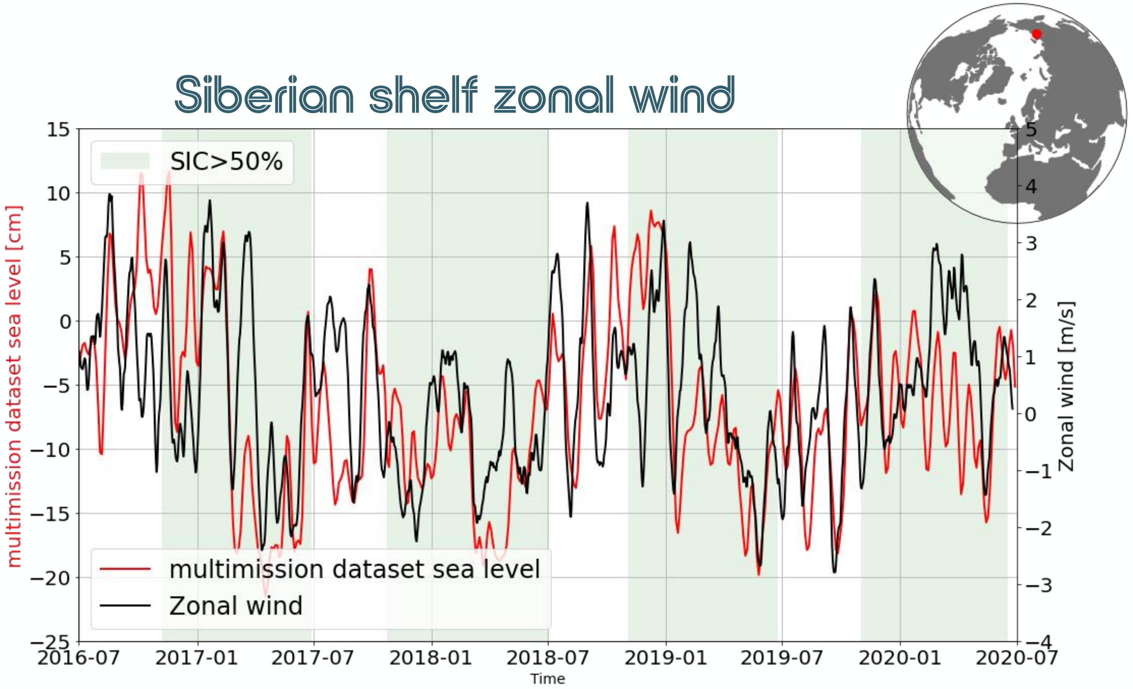


AVISO : doi.org/10.24400/527896/a01-2020.001
https://www.youtube.com/watch?v=vAOjmNPgQGs

AVISO : doi.org/10.24400/527896/a01-2022.010
https://www.youtube.com/watch?v=YrKXu2UZOPw

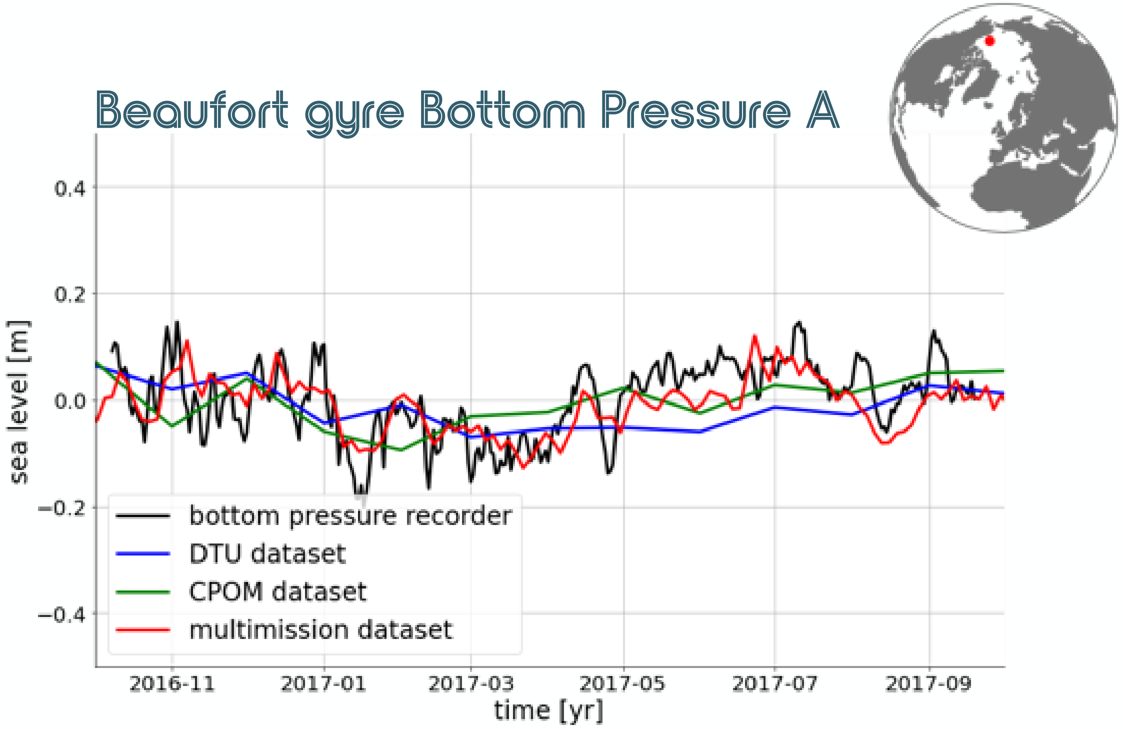
Validation against in-situ

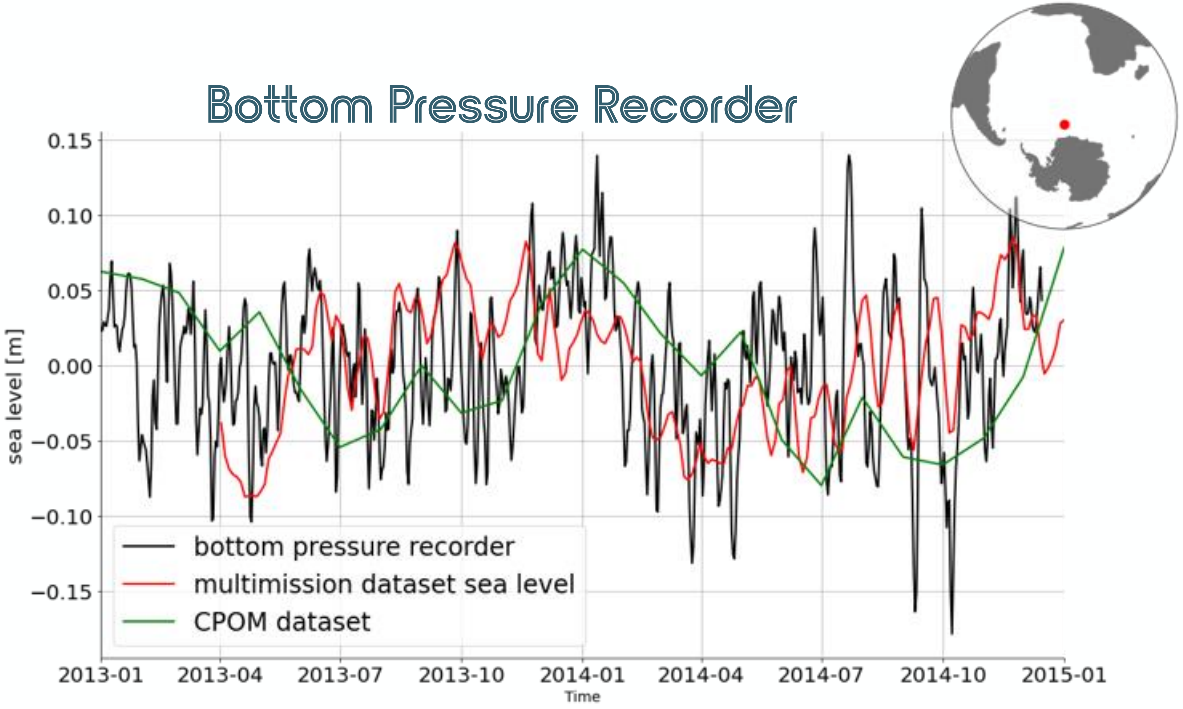




- Few in-situ data in the ice-covered polar regions. Only Prudoe bay tide gauge in the ice-covered Arctic region provides valid hourly data. Great correlation with the altimetric dataset.
- In the Siberian shelf region, sea level is mostly driven by the wind. Positive zonal wind producing cross-shelf sea level accumulation.

Validation against in-situ

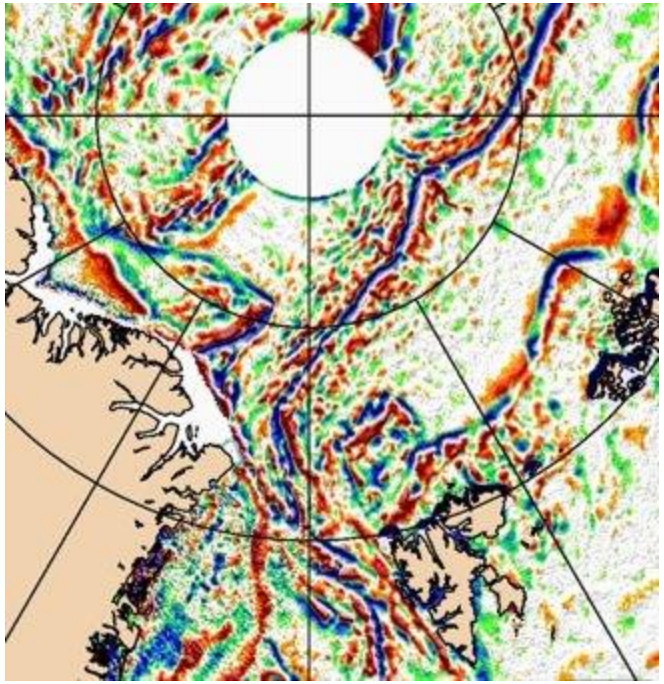




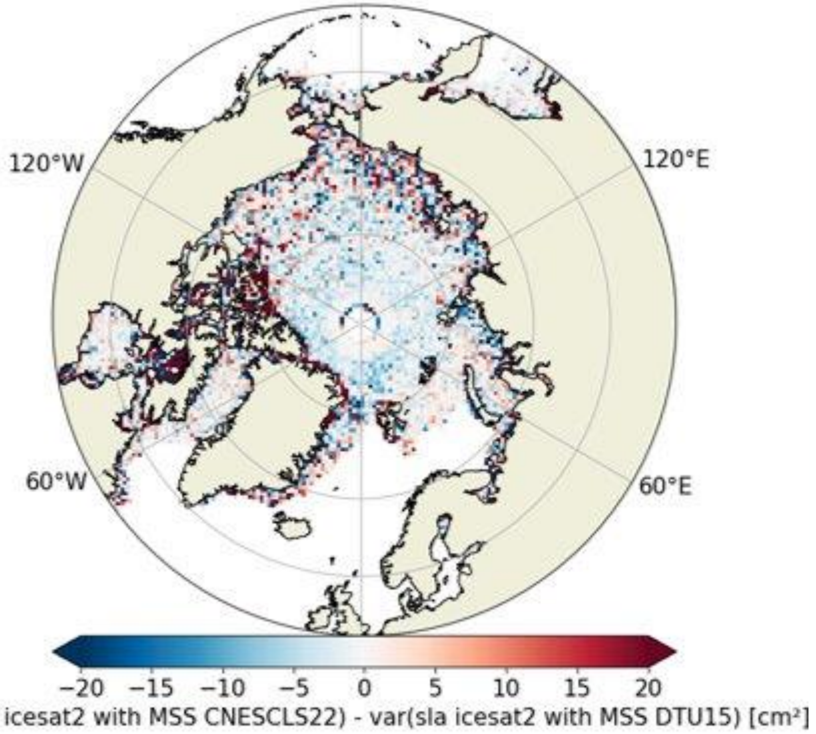
- In polar regions, ocean mass represents large part of the sea level variations.
- Bottom pressure recorder are valuable in-situ data to compare to altimetry sea level.
- Great correlation with the multimission sea level both in the Arctic and Antarctic regions.

In the new MSS CNESCLS22

Small scales features

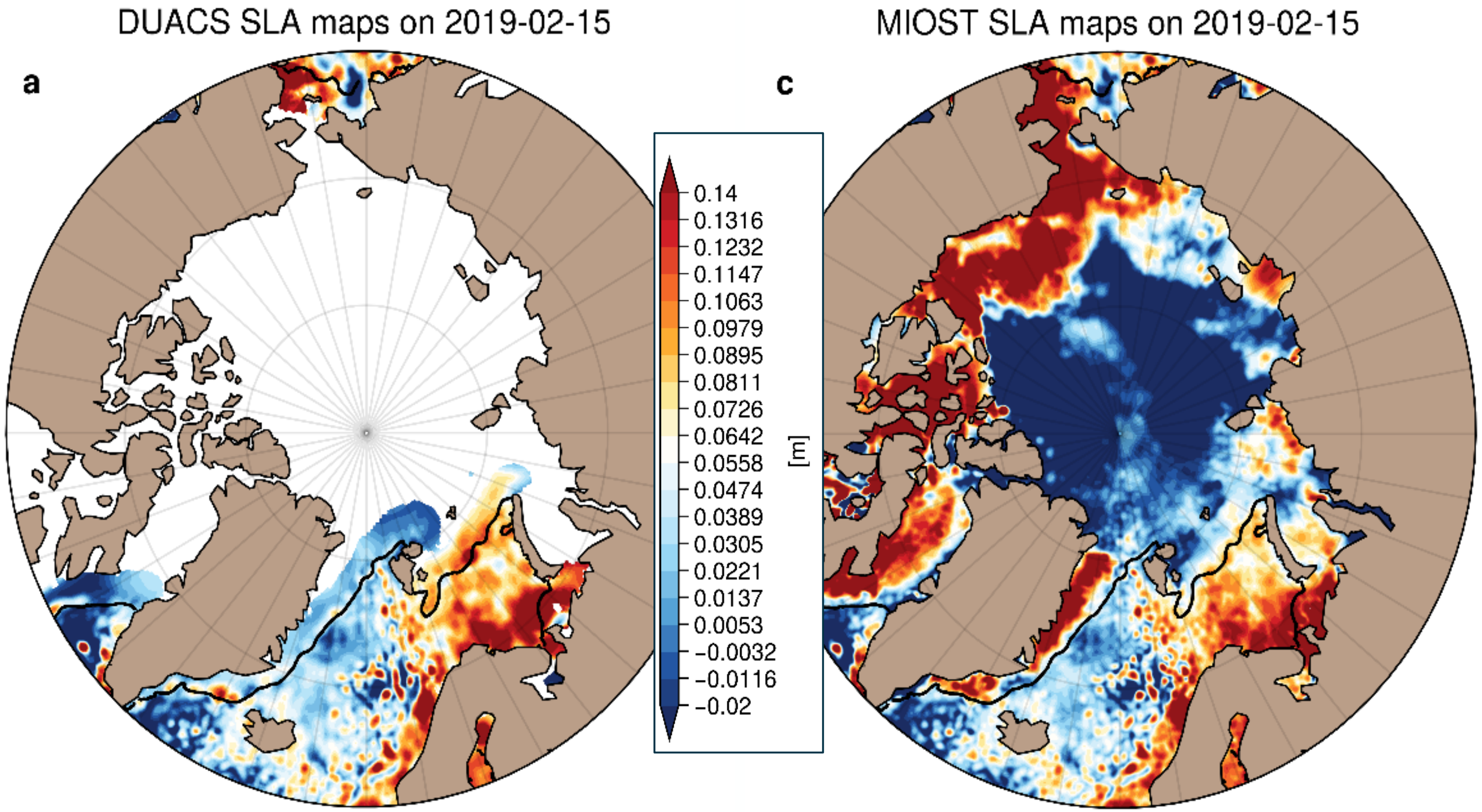


Var(SLA icesat-2 w/ MSS CNES/CLS22) - Var(SLA icesat-2 w/ MSS DTU15) [cm^2]
(50km boxes for 10/2018 to 06/2020)



- Leads data were ingested in the new MSS CNESCLS22 and successfully combined with open ocean MSS.
- Improvements of the Arctic small scales features compared to DTU15.

Towards global products

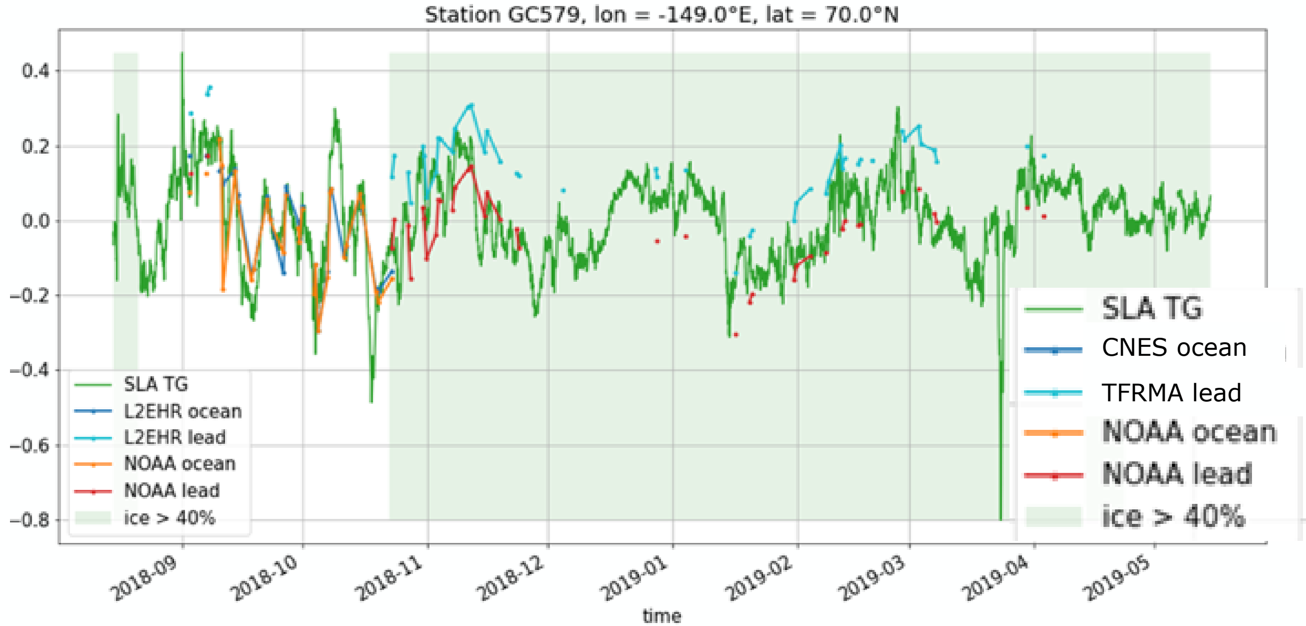


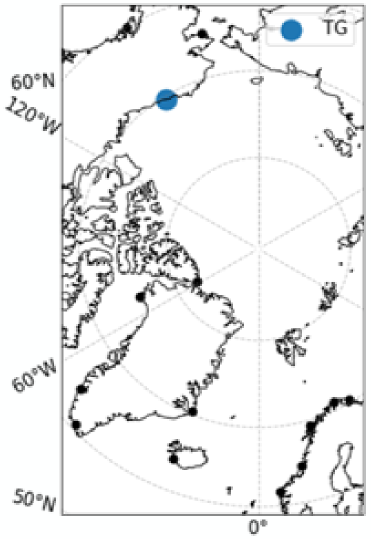
- Leads data were integrated in a new global product (doi.org/10.24400/527896/a01-2022.009).
- Differences of corrections remain between the leads and open ocean sea level (wet tropo, SSB) are still to be assessed.

New SAR physical retracking on Sentinel-3A

- SAR physical retracking was developed by NOAA processing both specular and diffuse waveforms at 80Hz.
- Consistent with current TFMRA retracking in the ice-covered region.
- More leads are observed (+3% boxes of 25km/1day).
- The processing looks continuous at tide gauges.

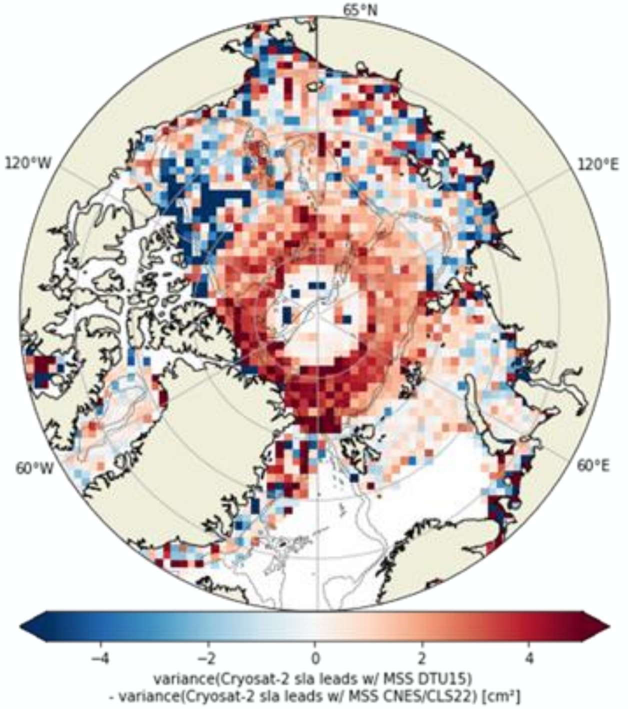
→ Encouraged to use for new version



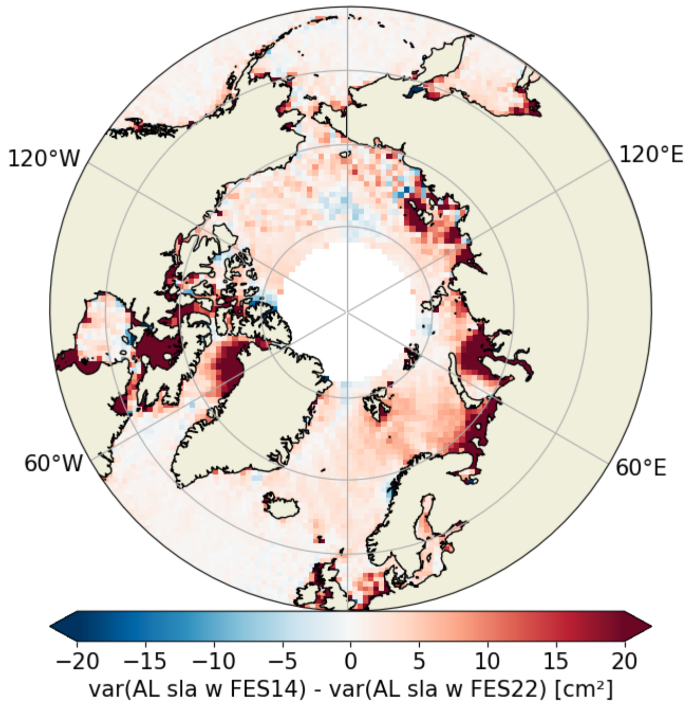


Upcoming version of the product

Var(sla leads Cryosat-2 w/ MSS DTU15) - Var(sla leads Cryosat-2 w/ MSS CNESCLS22)



Var(sla SARAL w/ FES14) - Var(sla SARAL w/ FES22)



Using the same processing with :

- new L3 data using NOAA SAR physical processing.
- Updated L4 input parameters for optimal interpolation.
- Improved geophysical corrections.

Conclusion

- Multi-satellite sea level polar maps were produced both over the open ocean and the ice-covered region. SLA from the three satellites are consistent and validation of the maps are made with in-situ data.
- Processing continuity is privileged to get continuous sea level between leads and open ocean. A new physical SAR solution was developed and should be used for new version of the product.

Perspectives

- CNES demo product : Use the current processing integrating new SLA using newly developed SAR physical retracker.
- Copernicus operational product : Initiate production of specific L2/L2P NTC upstream in 2024 with the aim of producing operational CMEMS-SLTAC SLA in the ice-covered regions.
- Interest of an extension of the product backwards (ESA's FDR4ALT) and forwards including new missions.