30 Years (Almost) of Arctic Ocean Sea Level

OSTST 2022

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Introduction

Why studying Polar Sea level?

- Part of various ESA projects
- White spots on global sea level maps.
- The Arctic SL challenging

Scientific and technical challenging

- Seasonal/permanent ice cover
- Regional coverage (tide gauges/buoys/satellites)
- Satellite instruments
- Insufficient geophysical models
- Retracking

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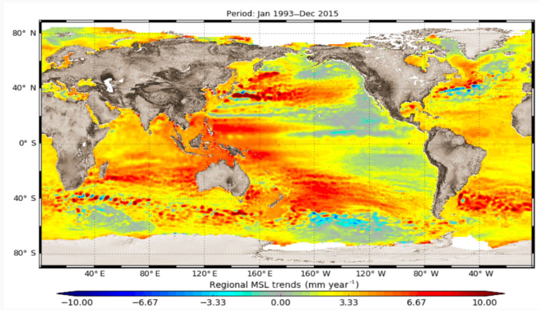

Figure 2: *SL CCI ECV v2.0 1995 - 2015*

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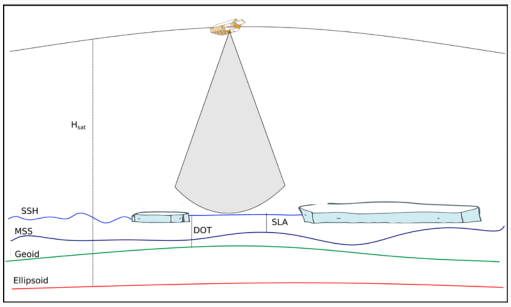

Scientific and technical challenging

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- Satellite instruments
- Insufficient geophysical models
- Retracking

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Arctic Sea level product 1991 - 2022

About

- New improved sea level record 1991 (Aug) up to 2022 (Jan)
- Satellites: ERS-1, ERS-2, Envisat, CryoSat-2
- Now includes monthly SLA/SLA (without DAC corr.)/DOT
- Constant work-in-progress

Improvements from the (Rose et al., 2019) DTU/TUM product

- Physical retracker everywhere, including SSB correction (Tran et al. (2012))
- CryoSat-2 data have been processed with the SARvatore service provided by ESA Research and Service Support (RSS), and later years Earth Console.
- CryoSat-2 lead detection + SAR/SIN/LRM offset improved
- ALES+ data from ERS-2/Envisat improved, especially lead detection algorithms
- SLA wrt. MSS DTU21 and DOT wrt. MDT DTU22
- Intermission bias is validated against Jason in ice-free North Atlantic

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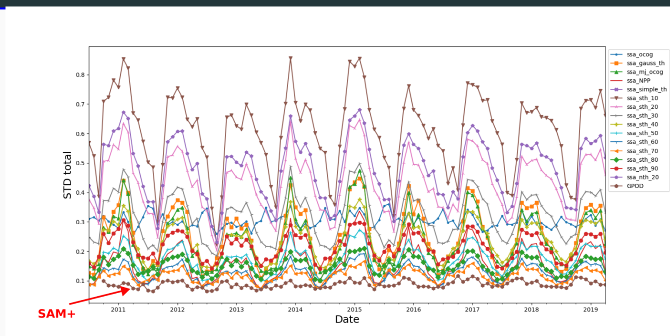
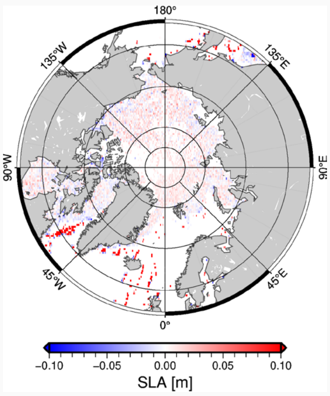
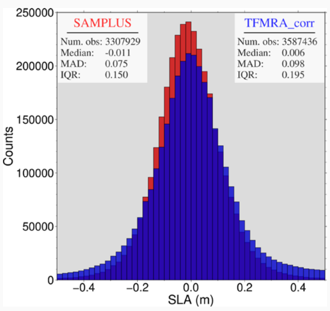
Note about CryoSat-2 processing

- From Cryo-TEMPO: SAM+ and TFMRA similar
- TFMRA monthly offsets
- Benefits from SSB







SAM+ PROC.

- SAM+ ver. (tides, SIC., SSB)
- Issues with impl. tides
- Diff. CryoSat baselines
- Limits to 65N
- Hamming not applied
- Offset from Aug. 2021

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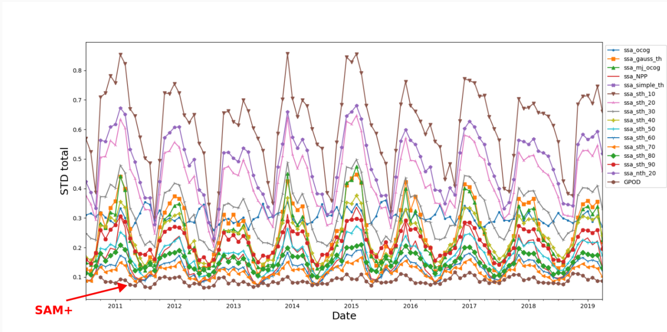

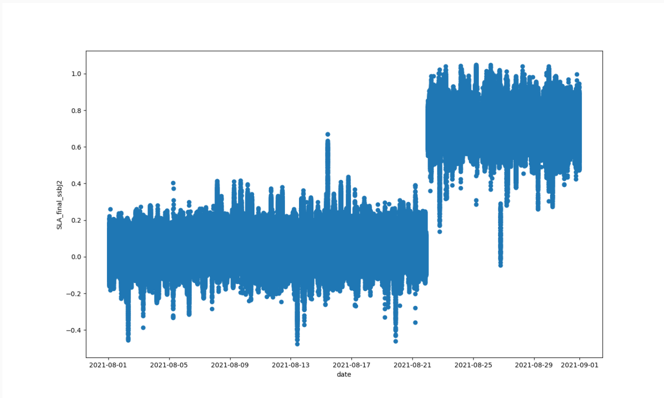

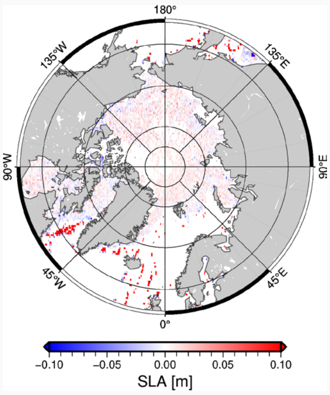

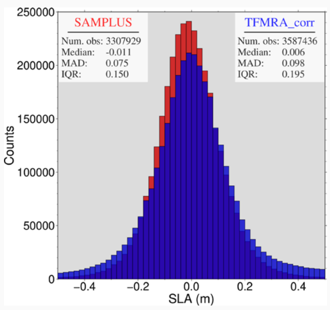

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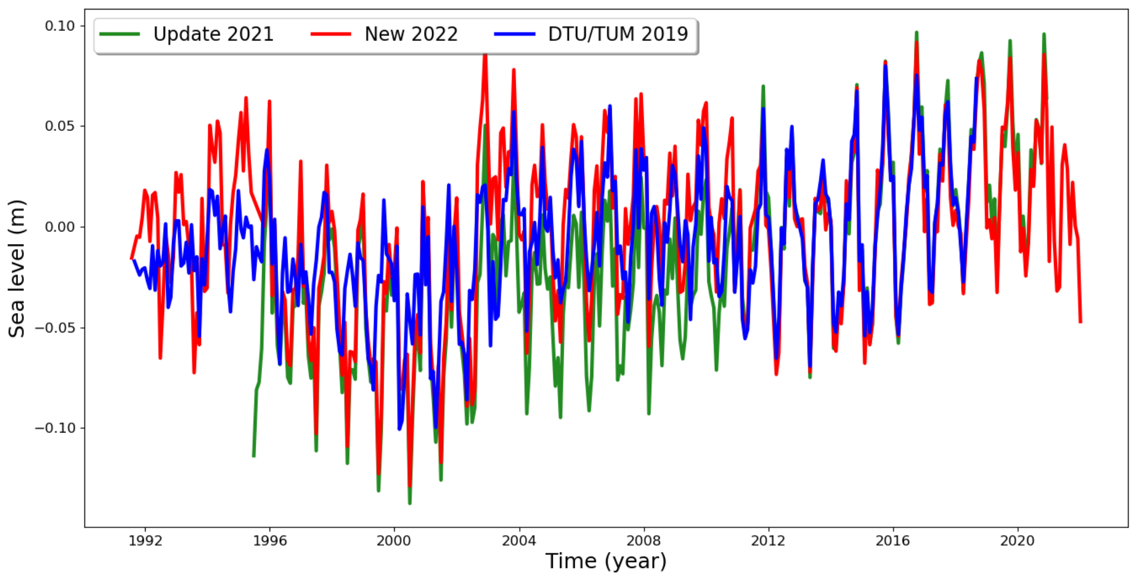
Comparing old (Rose et al., 2019) and new (2021) data set

Arctic Ocean



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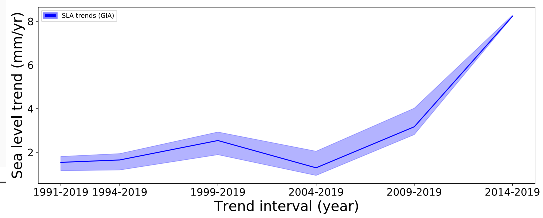
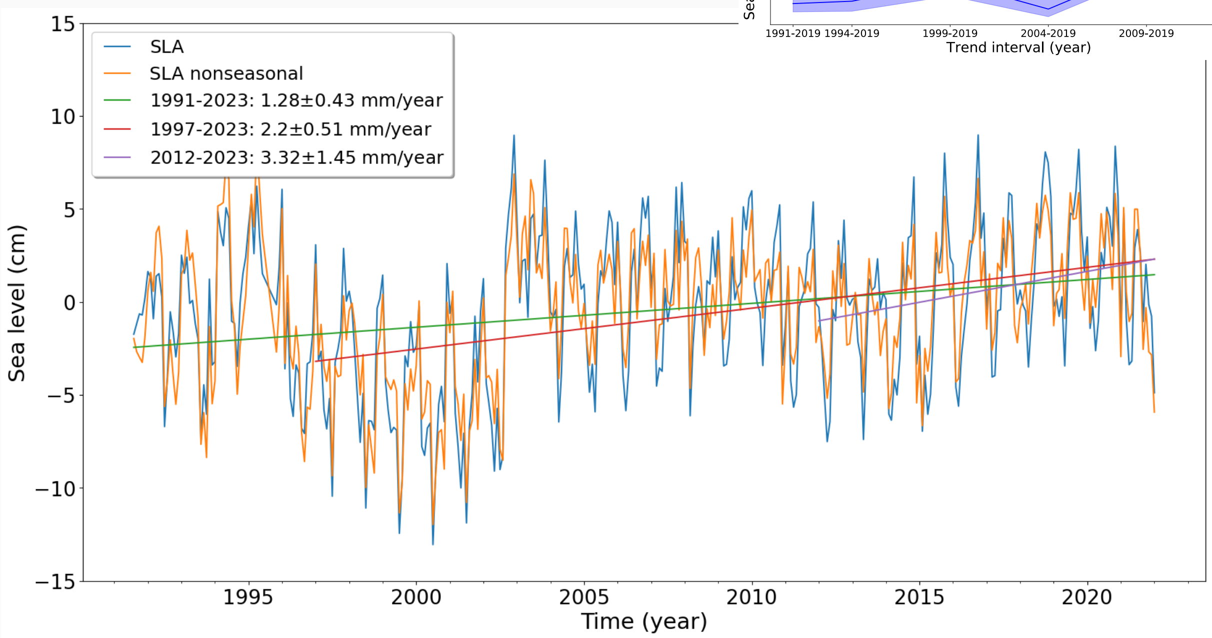
Arctic Ocean time series trend





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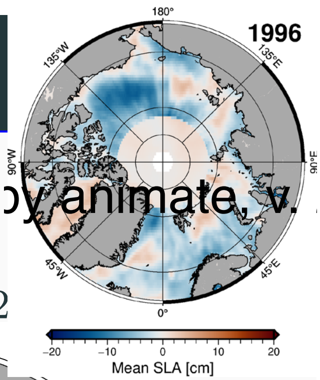
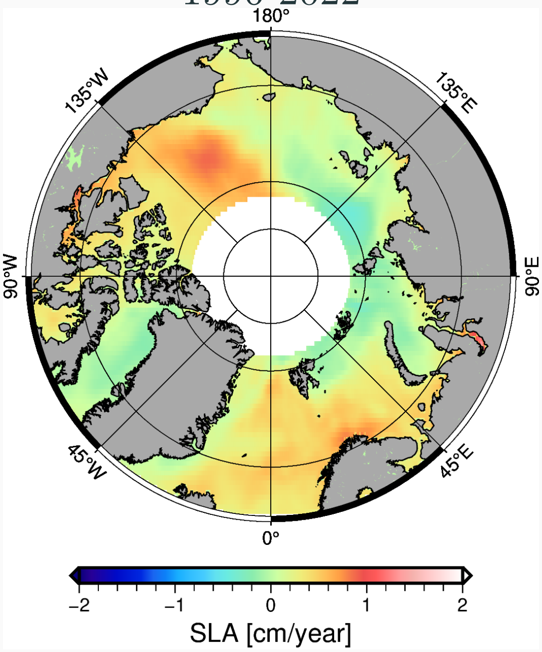
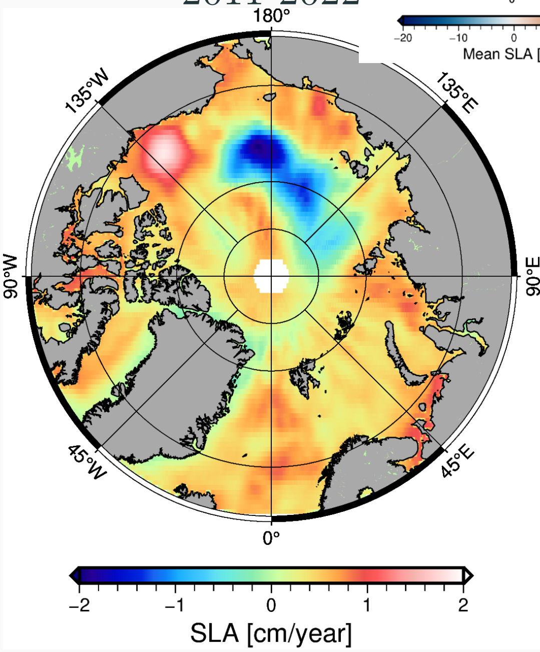
Arctic Ocean SLA trend maps



1996-2022



2011-2022



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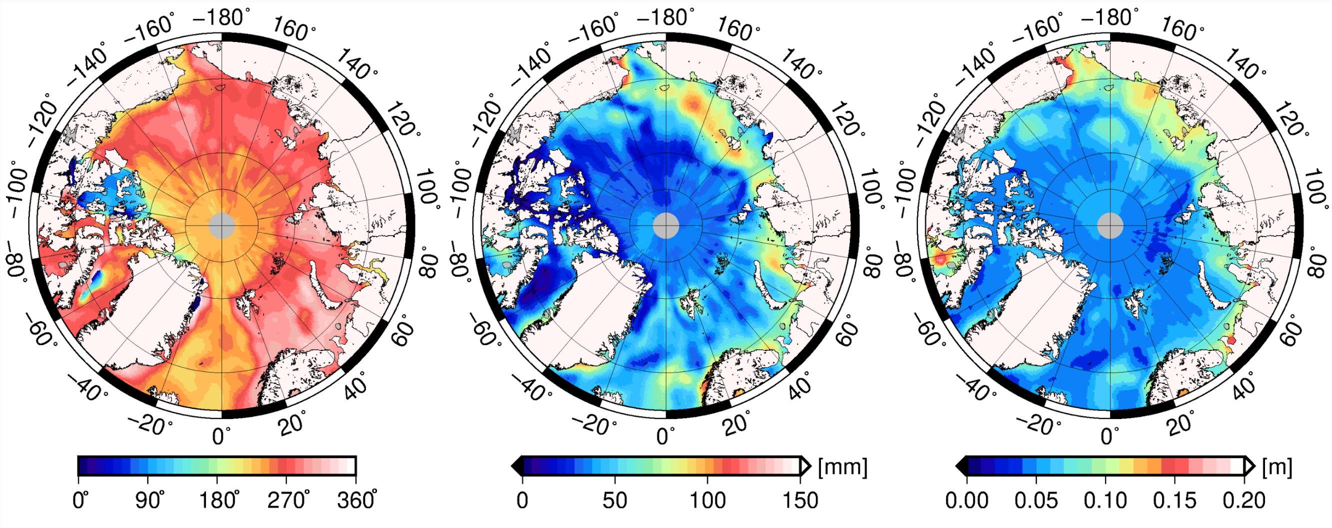
Arctic Ocean annual/inter-annual variability

Phase | Amplitude | Inter-annual variation



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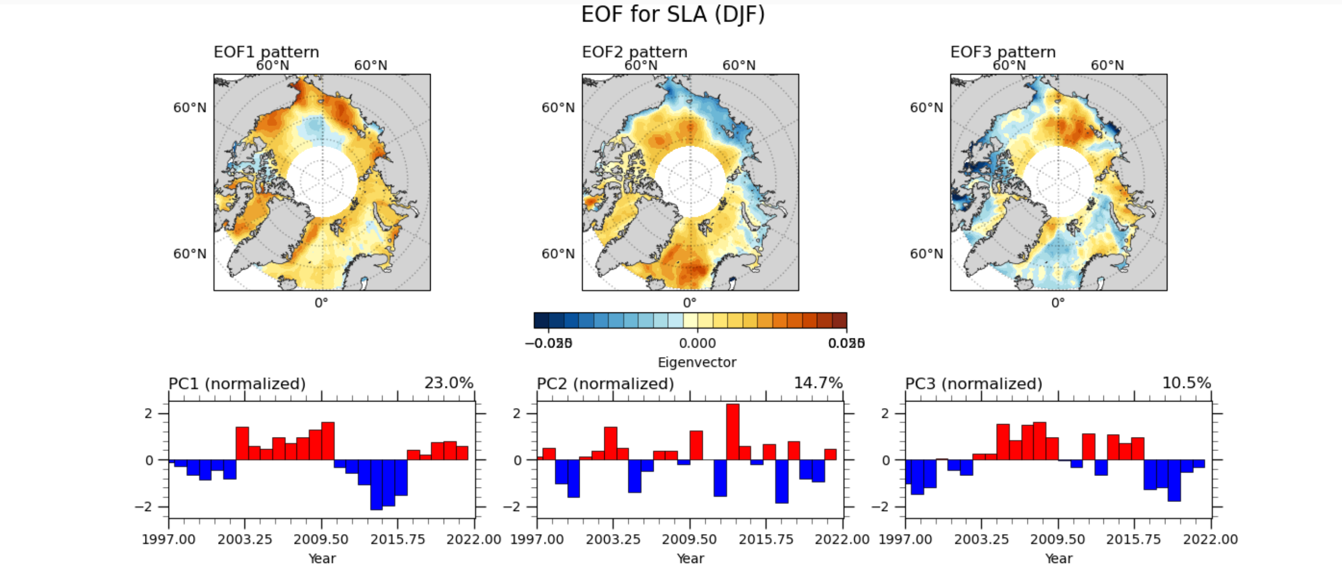
EOF Analysis (DJF)



- Non seasonal and detrended SLA
- Correlation Arctic Oscillation, Atlantic Oscillation and Pacific Decadal Oscillation tested

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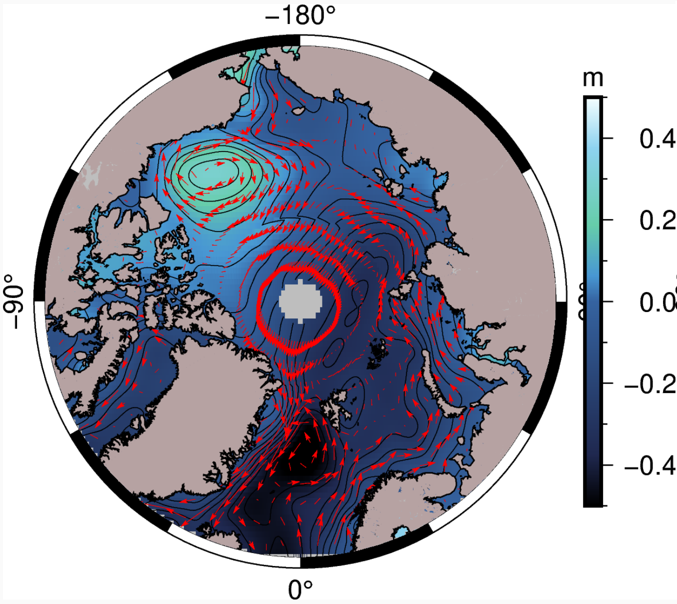
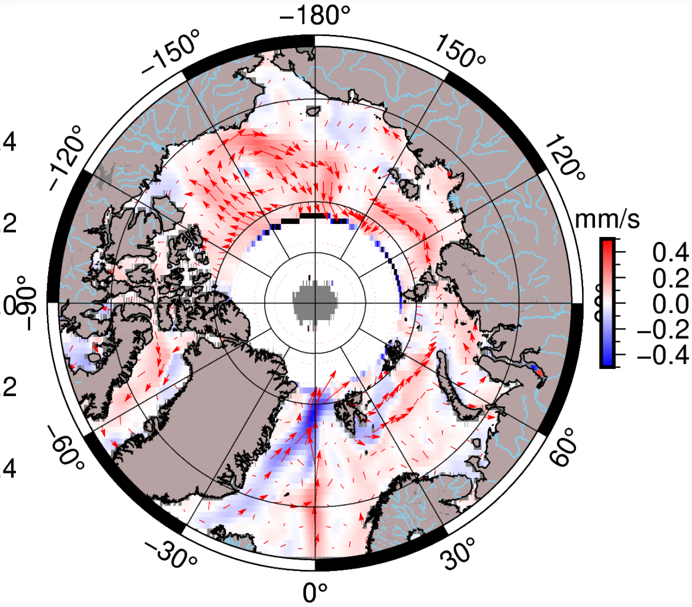
Geostrophic Circulation (Arctic)



1995-2021
Background (Mean DOT)



2011-2020 anomaly
wrt. 1995-2021 mean
Background (Current speed)

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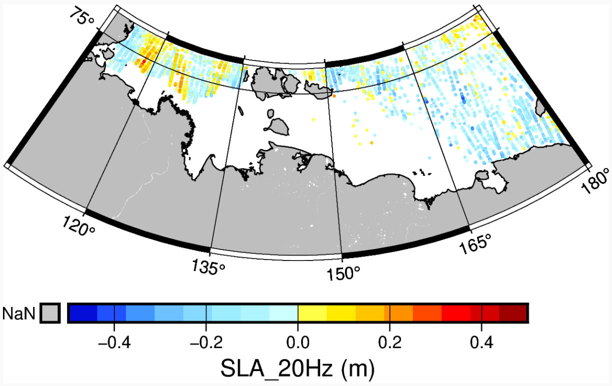
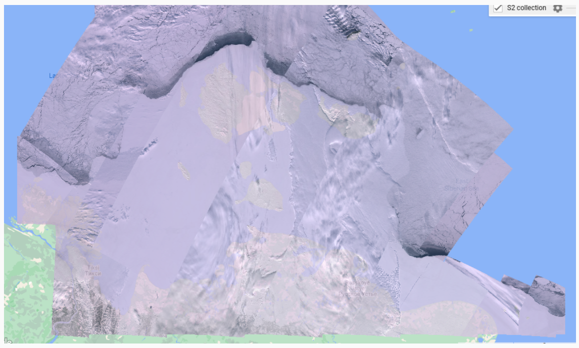
Russian Shelf

- Russian shelf area is historical a difficult area for altimetry with very little in-situ observations
- Models are used over satellite observations
- With CryoSat-2 it is now possible to see oceanic features not possible before





Sentinel 2, 2017, April 18th

- The seasonal signal in the tide gauges (ex. left fig.) are captured, but the trend is not. For more on this see Ludwigsen et al. (2020).
- Figure (top) show the inter-annual SLA variability
- Clear signal around the large river outlets

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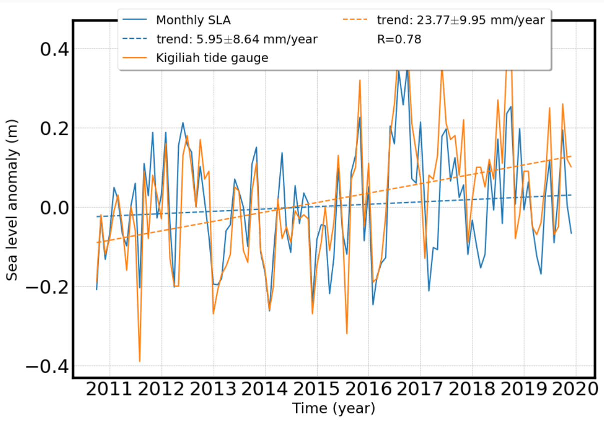

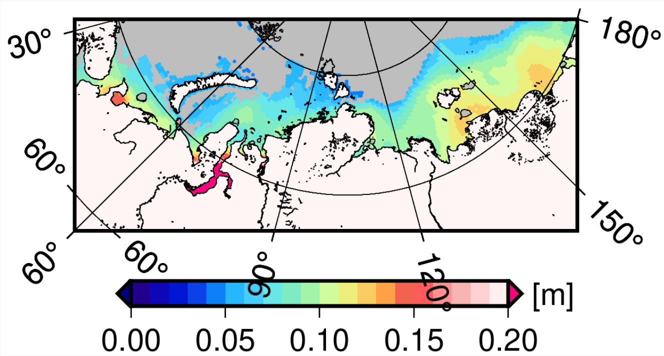

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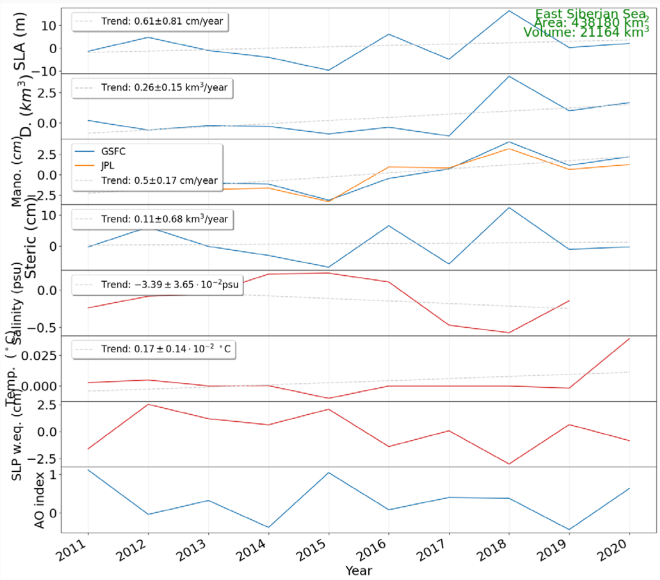
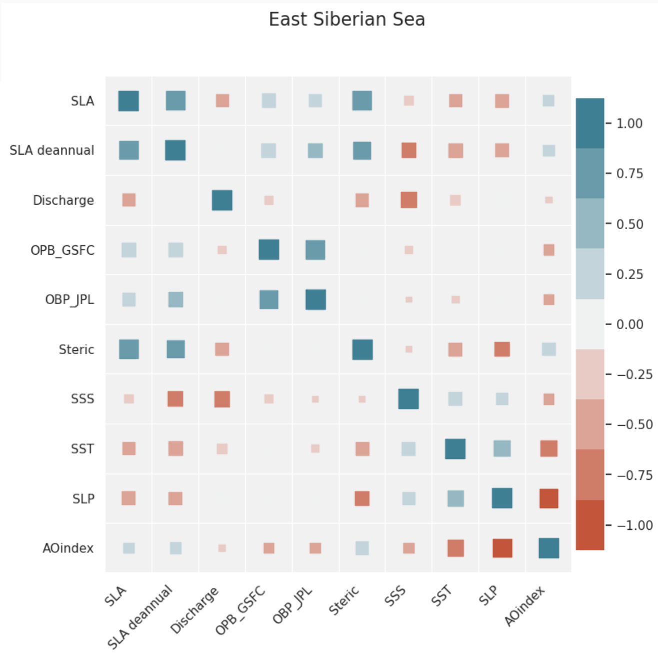
Russian Shelf (East Siberian Sea/Kolyma)





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Summary

- New improved SLA/DOT product (Soon available online)
  - More variability in ERS-2/Envisat data (better data coverage)
  - Physical retracking of CryoSat-2 (SAMOSA+) including SSB
  - Better Mean Sea Surface model
- CryoSat-2 have improved the possibilities for studying oceanography in the Polar Oceans
- There are still challenges for Polar Ocean sea level processing
- Missing validation data sets
- Look out for CryoTEMPO product

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Thank You for Listening!

Special thanks to...

- ESA-RSS (Research and Service Support), and in particular B. Abis and G. Sabatino, the for their assistance in processing the data with G-POD (`http://gpod.eo.esa.int/`)
- Earth Console

C. A. Ludwigsen, O. B. Andersen, and S. K. Rose. Assessment of 21 years of Arctic Ocean Absolute Sea Level Trends (1995–2015). *Ocean Science Discussions*, pages 1–18, 2020. ISSN 1812-0806. doi: 10.5194/os-2020-87.

S. K. Rose, O. B. Andersen, M. Passaro, C. Ankjær, and C. Schwatke. Arctic Ocean Sea Level Record from the Complete Radar Altimetry Era : 1991-2018. *Remote Sensing*, 11:1672, 2019. doi: 10.3390.

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