Can satellite altimetry and gravimetry data be used to evaluate Arctic-Ocean satellite sea surface salinity? – insight from ECCO state estimation

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Motivation, rationales, and approach

Motivation & rationales:

- Changes of Arctic Ocean freshwater are important to ocean, climate, & BGC.
- Sea surface salinity (SSS) data are important to study Arctic freshwater changes, ocean-ice interaction, and interaction with the North Atlantic Ocean.
- Large uncertainties of L-band satellite SSS; but how bad is the S/N radio?
- Lack of in-situ salinity data to validate satellite SSS.
- SSH from altimetry & OBP from gravimetry can be used to infer column-integrated freshwater changes in the Arctic Ocean (e.g., Morrison et al. 2012)

Questions addressed: To what extent Arctic SSS & SSH-OBP variations are coherent? Can SSS-OBP data can be used to evaluate satellite SSS?

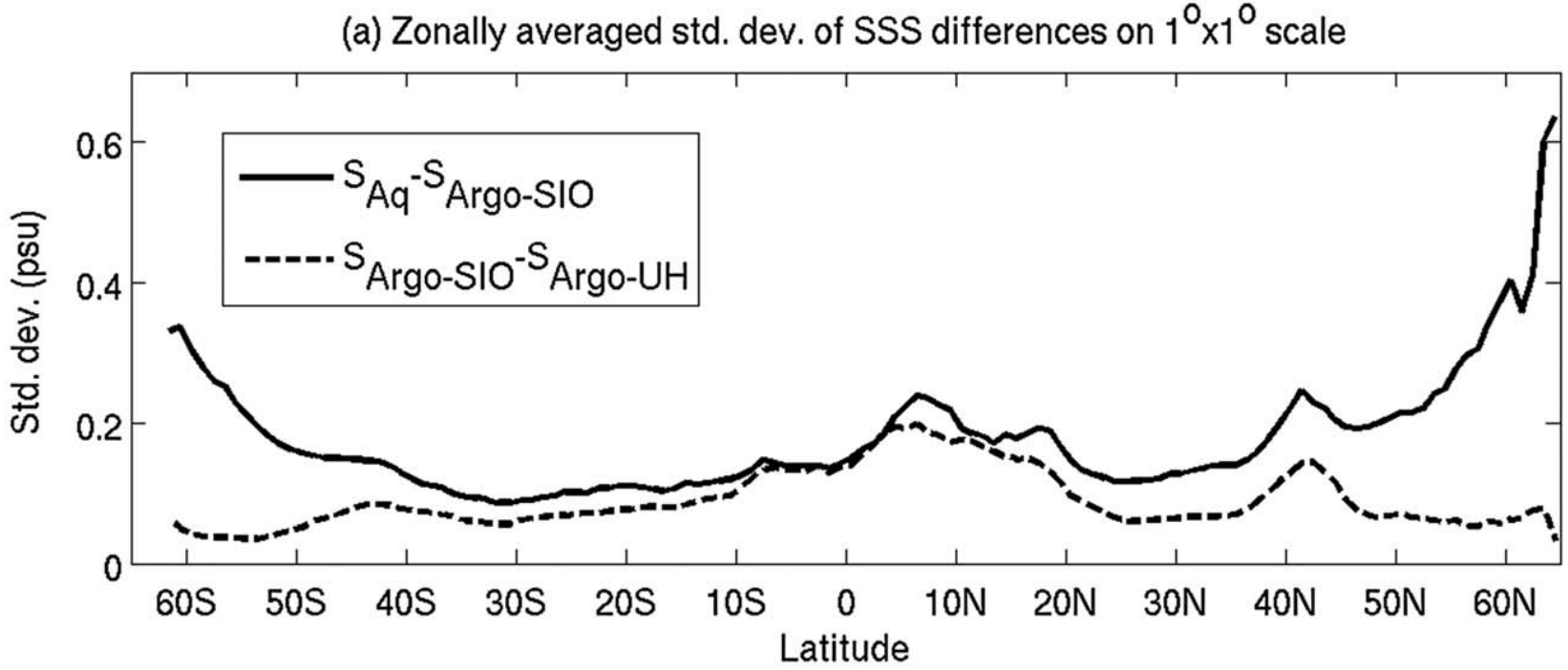
Significance: validated satellite SSS are complementary to SSH-OBP data to study Arctic freshwater changes due to better sampling (SMOS+Aquarius+SMAP).

Approach: Examine relationships of SSS & SSH-OBP in ECCO-V4 for a proof-of-concept study as a 1st step.

Uncertainty characteristics of L-band Satellite SSS:

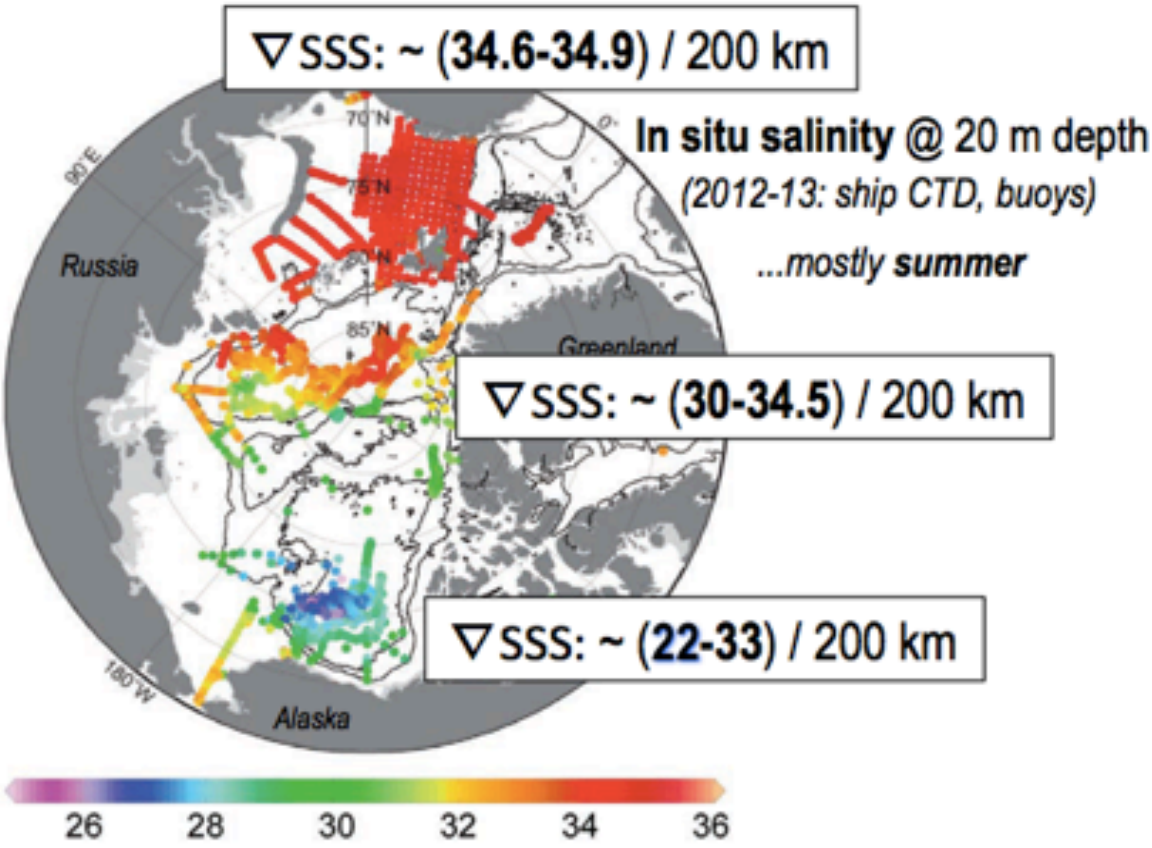
Tropics & subtropics ✓ high-latitudes ✘

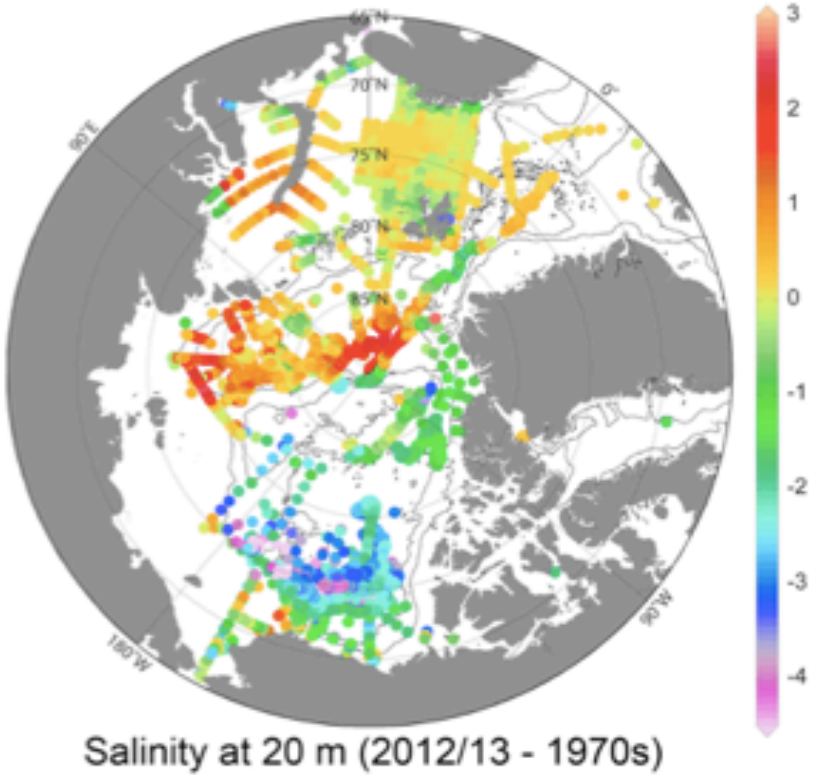
Zonally averaged STD of ΔSSS for (Aquarius V4.0 - Argo-SIO) & (Argo-SIO - Argo-UH)
(Argo-SIO & Argo-UH are two different "ground truth" datasets)



Lee (2016)

SSS signals in the Arctic Ocean are large!
So how bad is the S/N ratio for L-band satellite SSS?

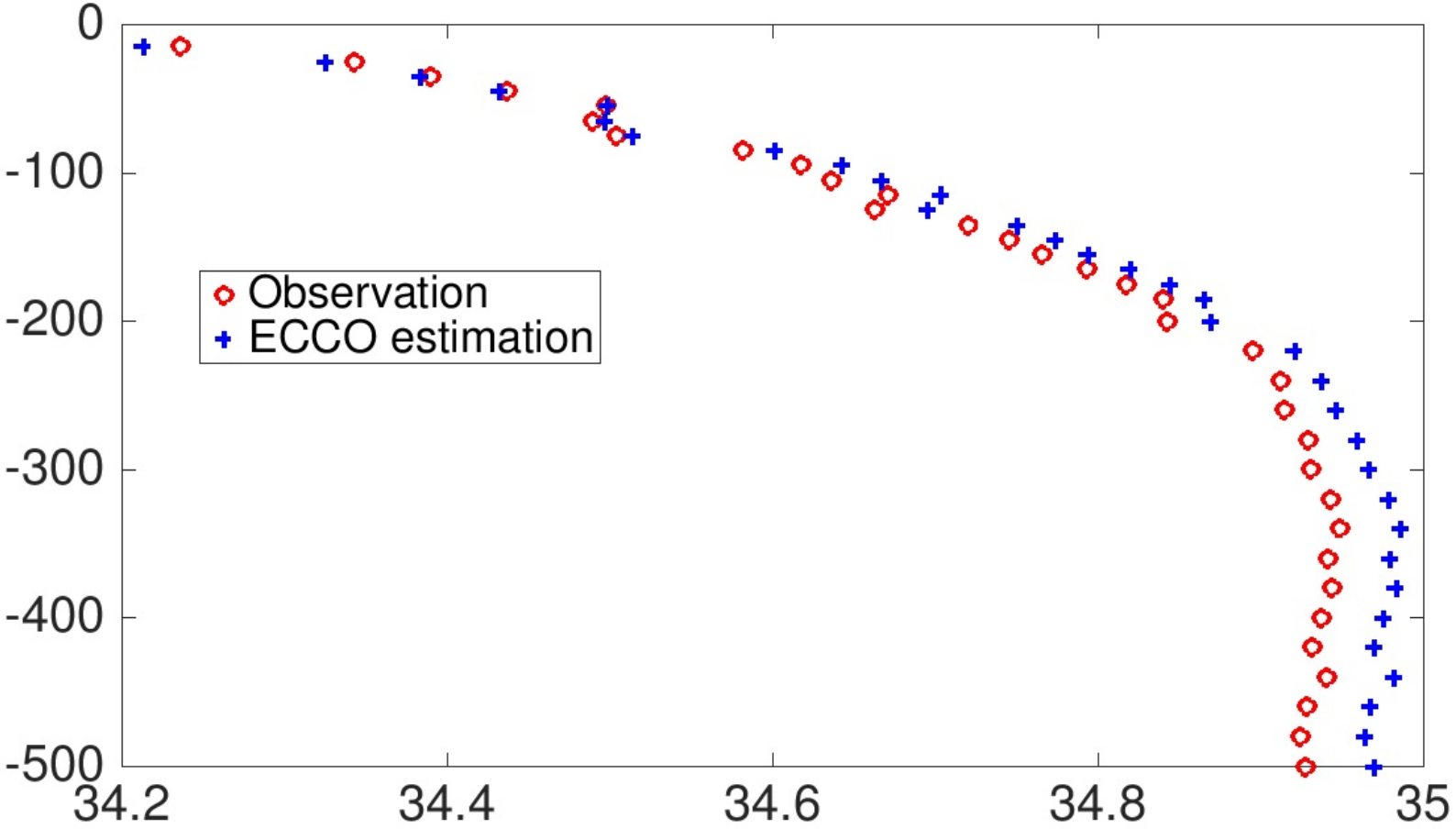




Timmermans et al. (2014) and NOAA Arctic Report Card 2013 Update.
Gradient estimates provided by Mike Steele of APL, University of Washington

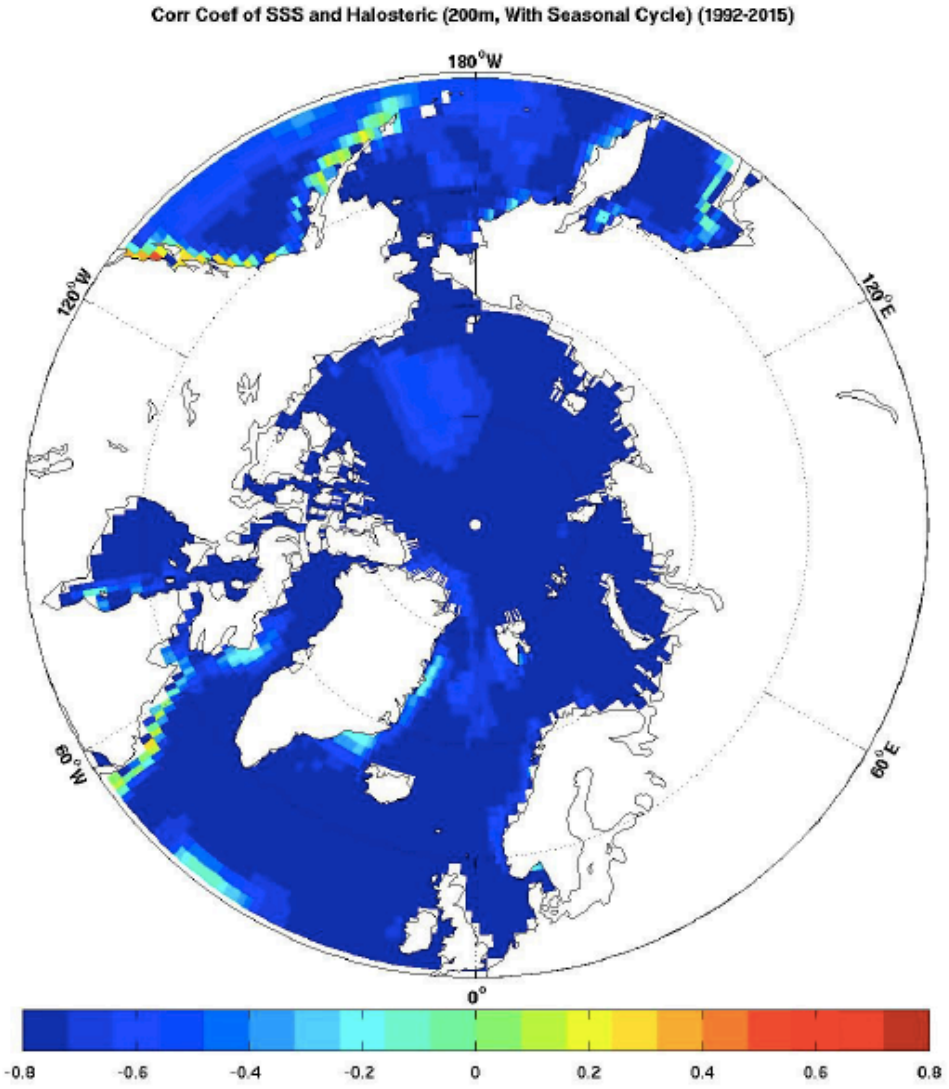
Comparison of time-mean salinity profile in the Arctic Ocean between Ice-Tethered Profiler data & co-located ECCO estimates

ECCO-v4 reproduces the structure <200 m well, which dominate the steric changes

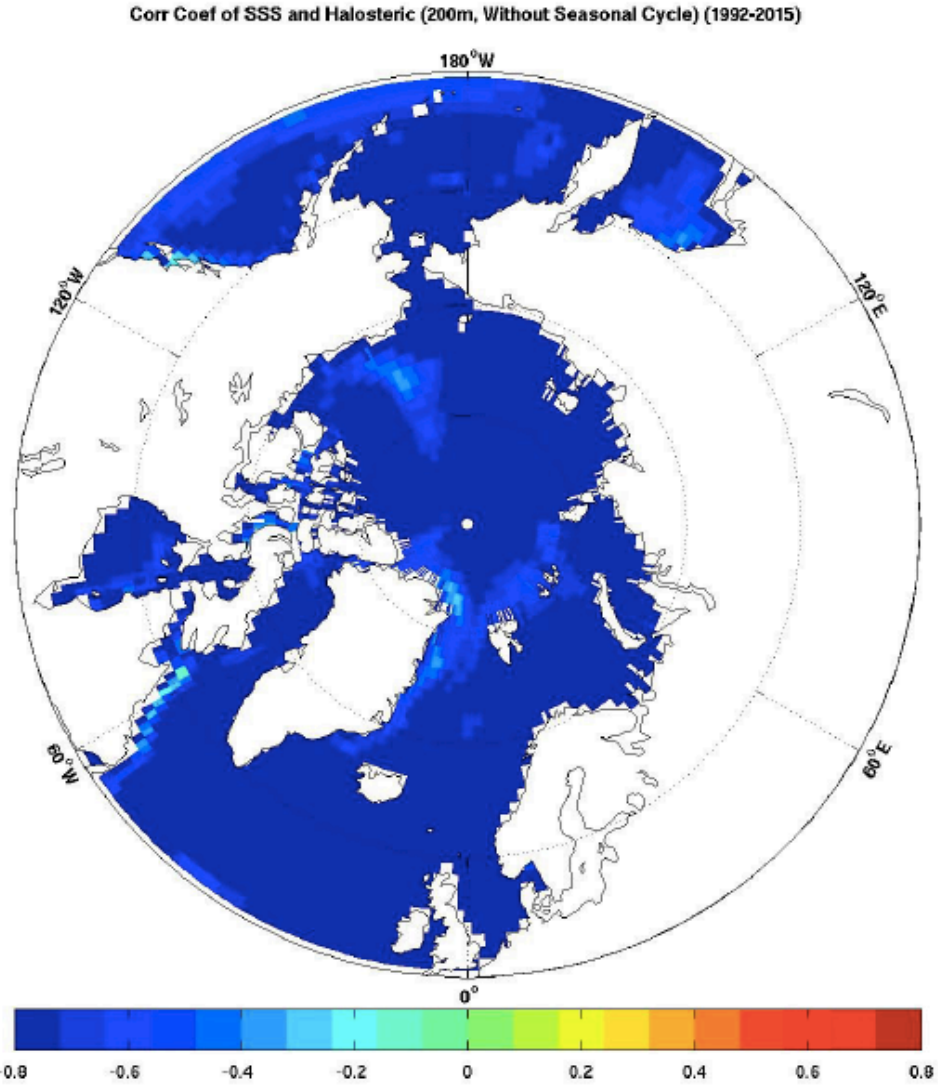


Courtesy of Ou Wang, JPL

Local correlation of SSS & 0-200 halosteric height: they are coherent over much of the Arctic Ocean

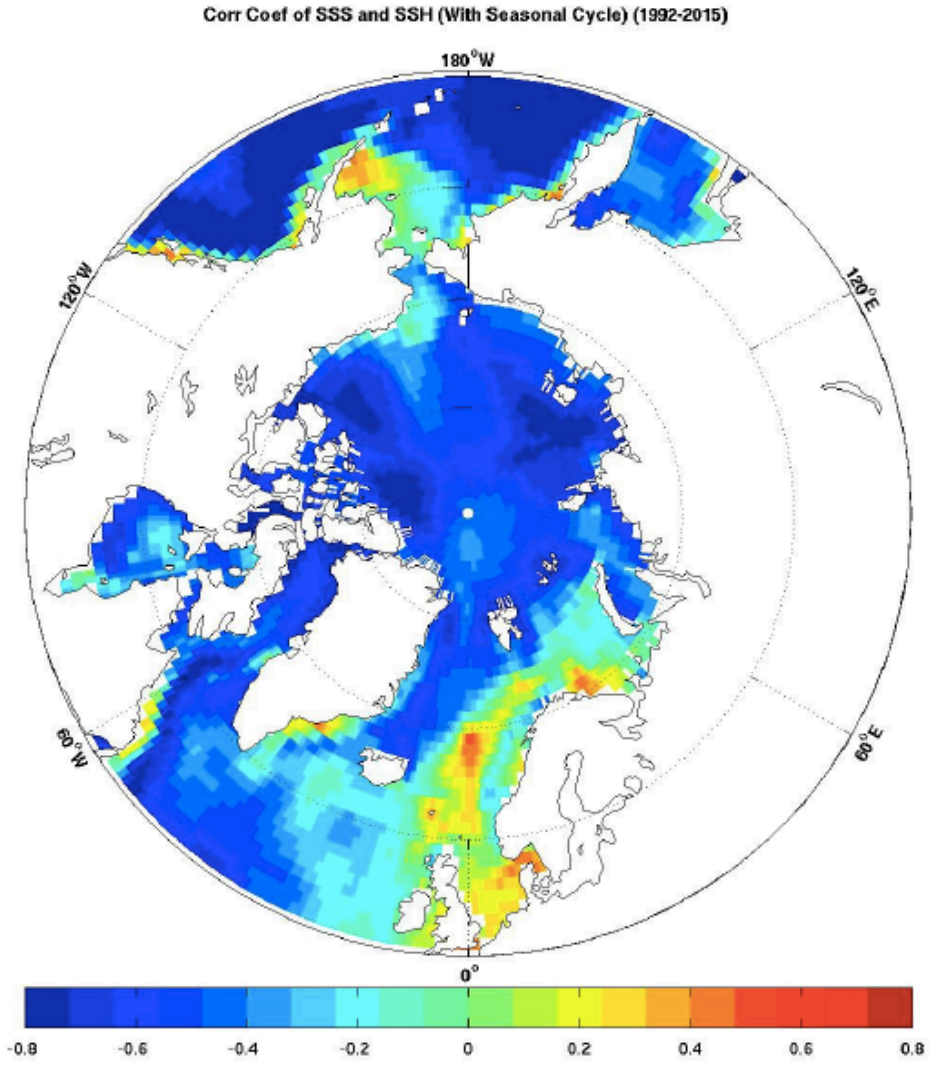


With Seasonal Cycle

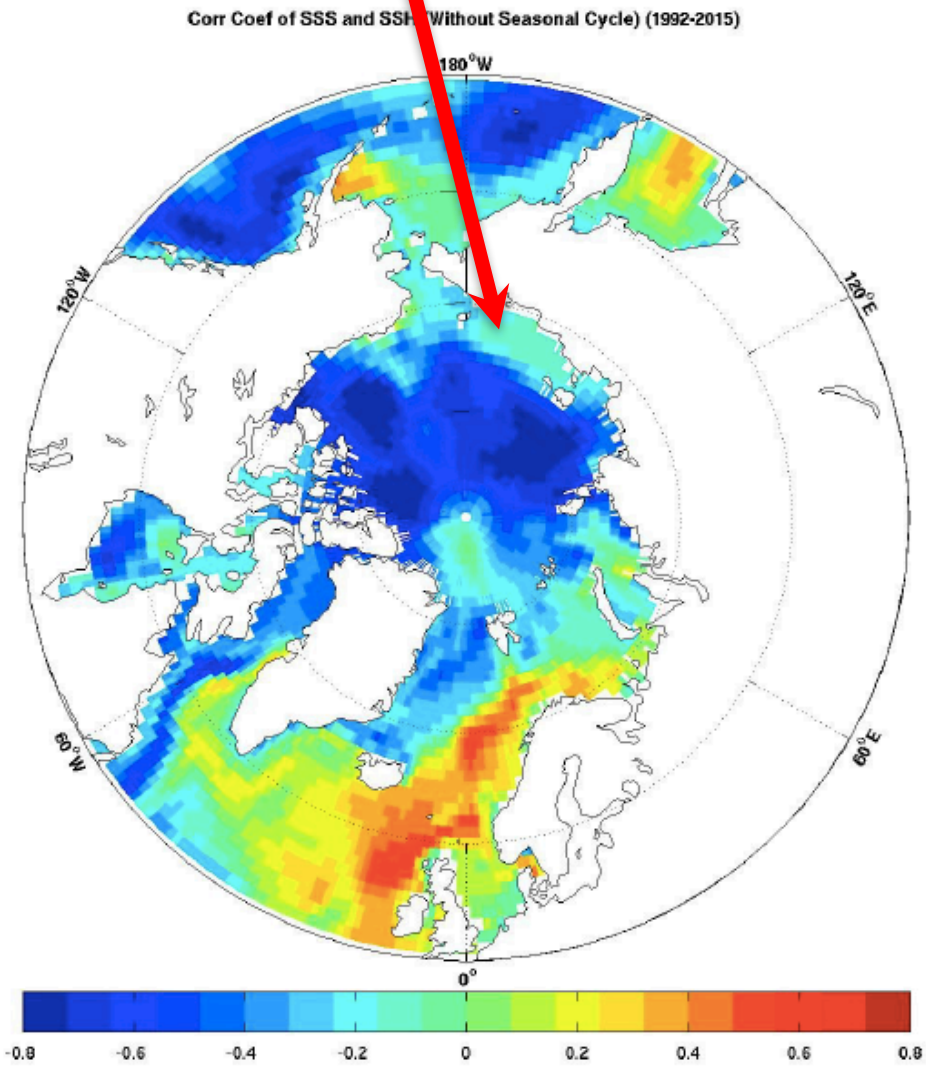


Without Seasonal Cycle

Local correlation of SSS & SSH:
poor correlation around the Arctic shelves
(because of barotropic coastal Kelvin waves, unrelated to SSS)

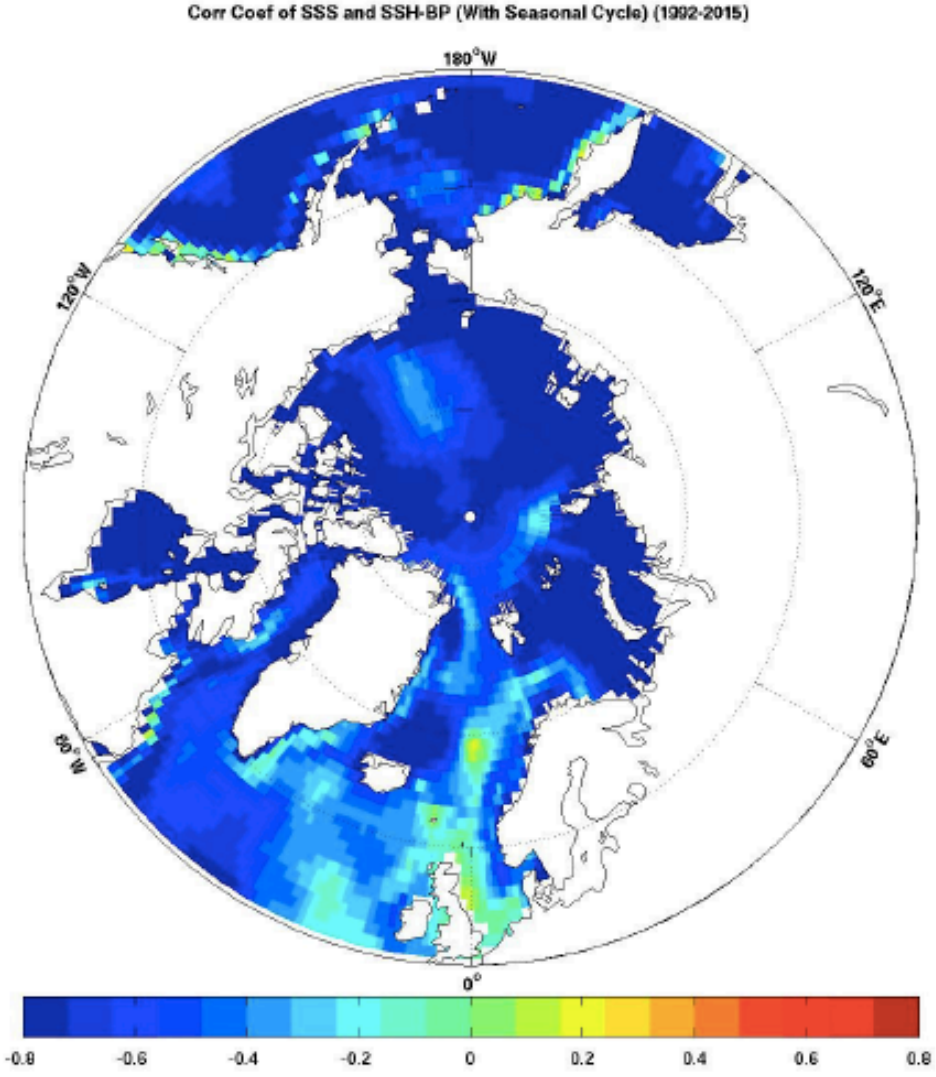


With Seasonal Cycle

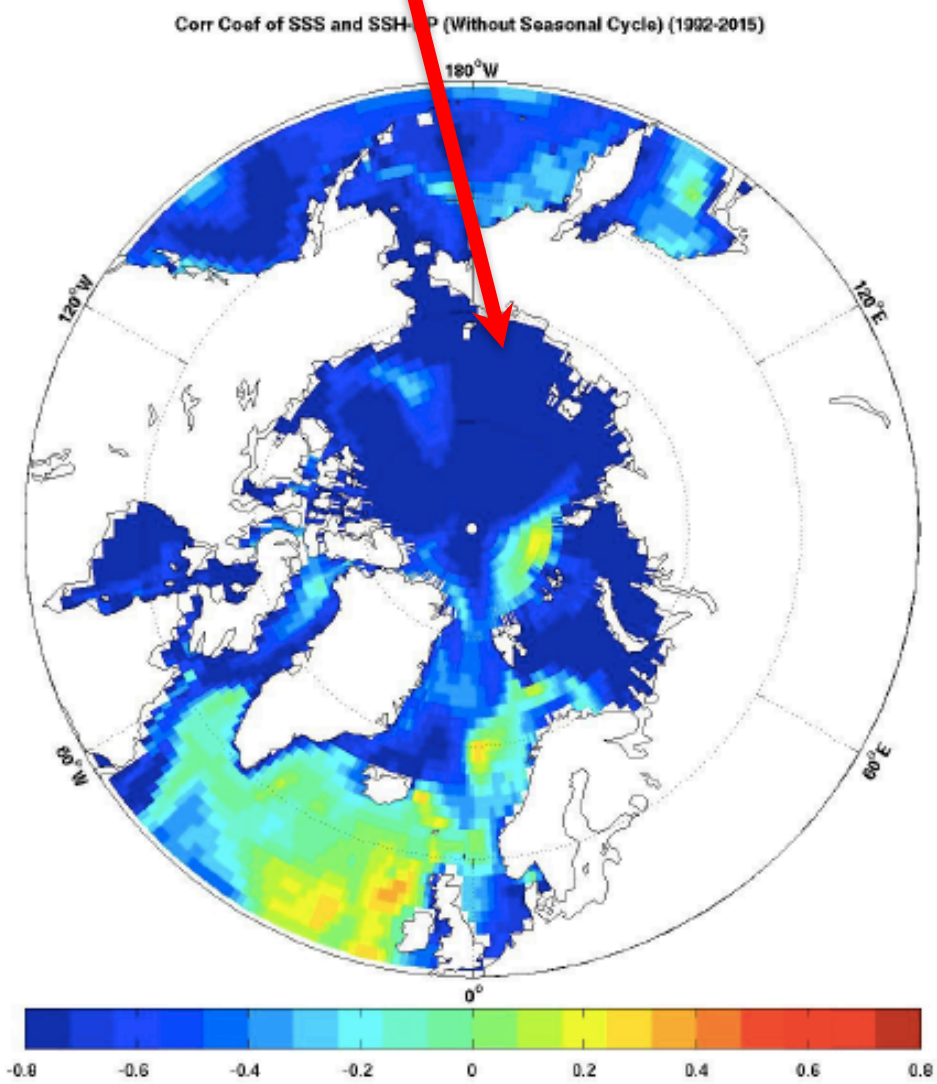


Without Seasonal Cycle

Local correlation of SSS & SSH-OBP: much strong correlation around the shelves (because barotropic wave signals have been removed)

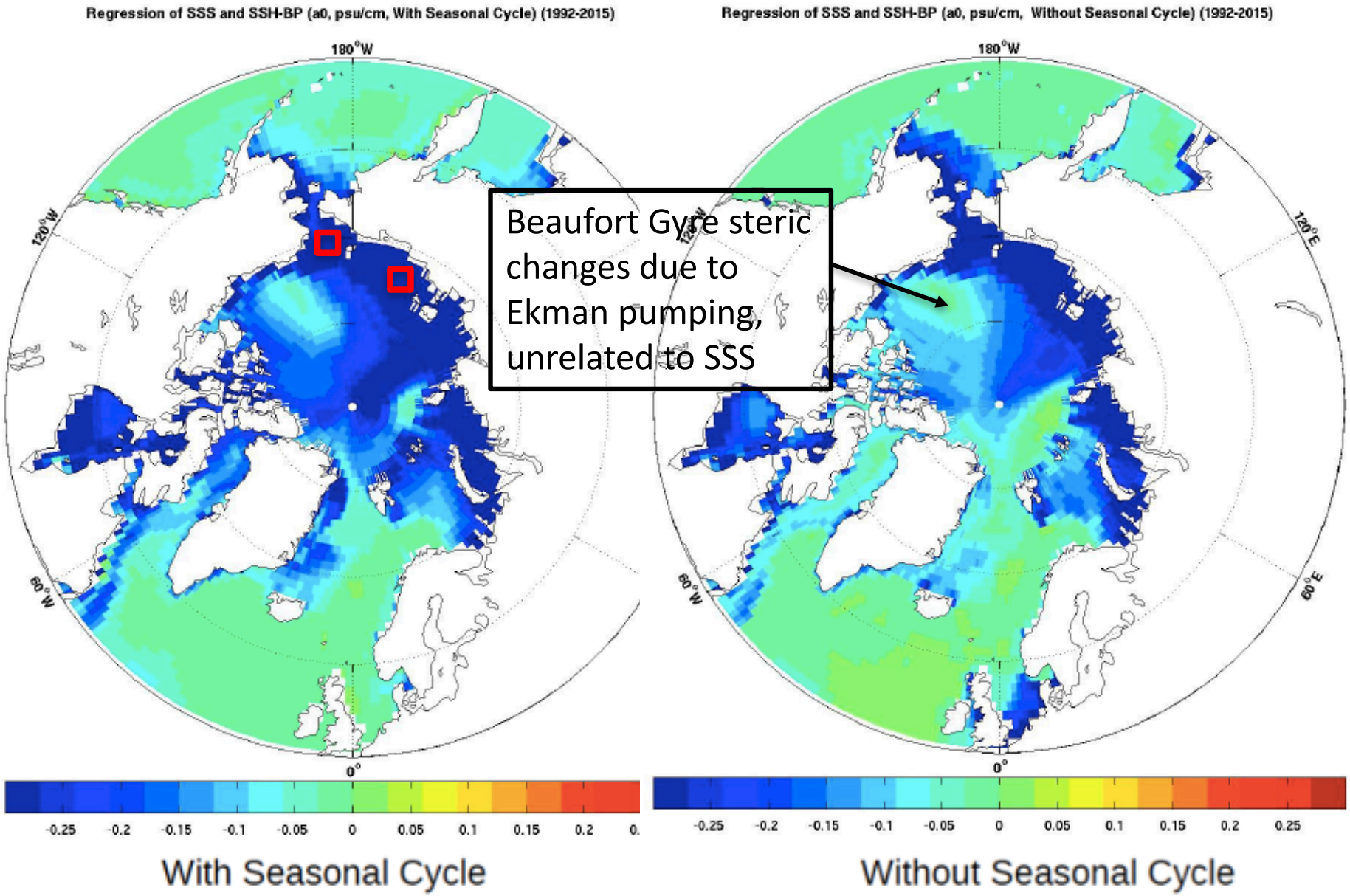


With Seasonal Cycle



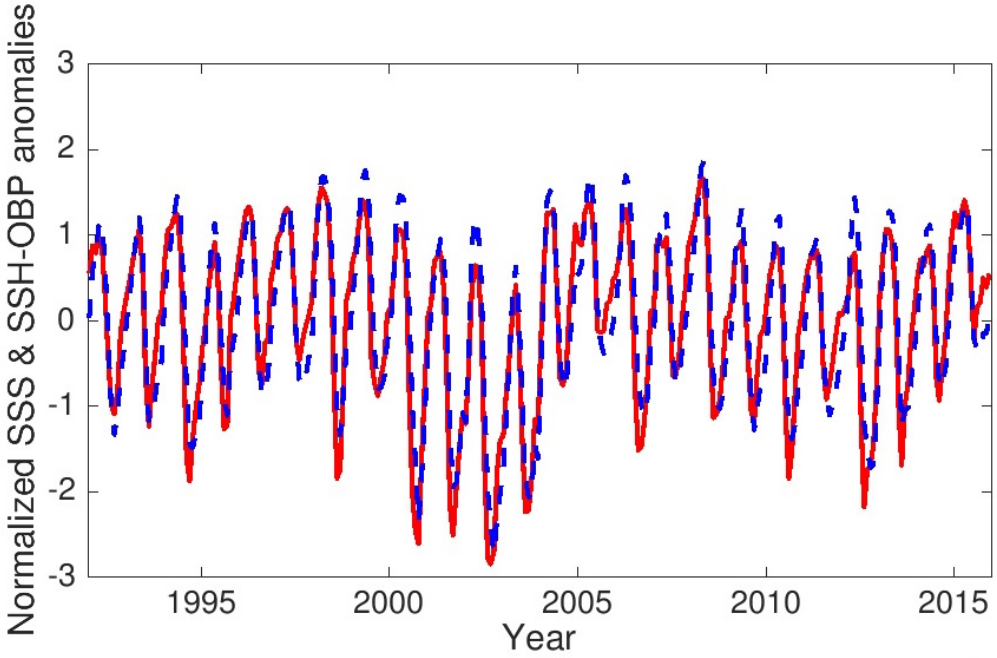
Without Seasonal Cycle

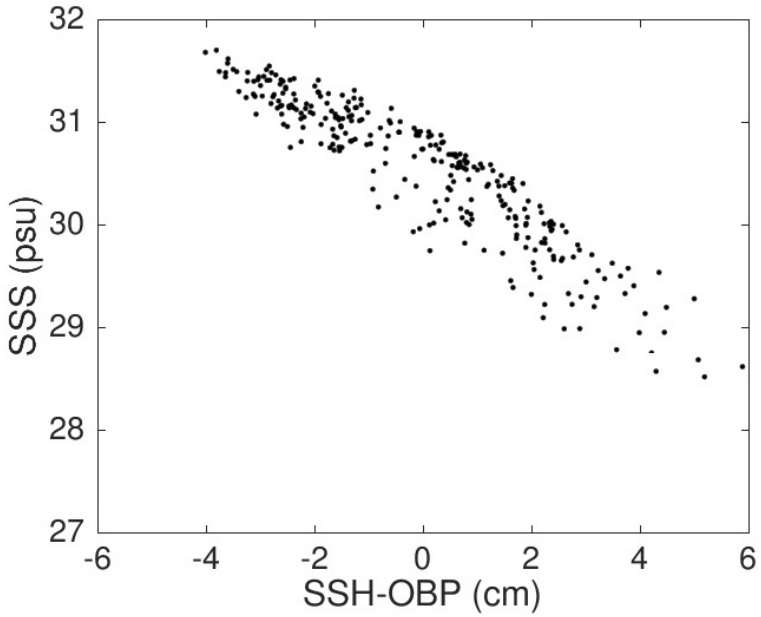
Linear regression slope for SSS vs. SSH-OBP (in psu/cm): good “calibration” sensitivity around the shelves ~ 0.3 psu/cm



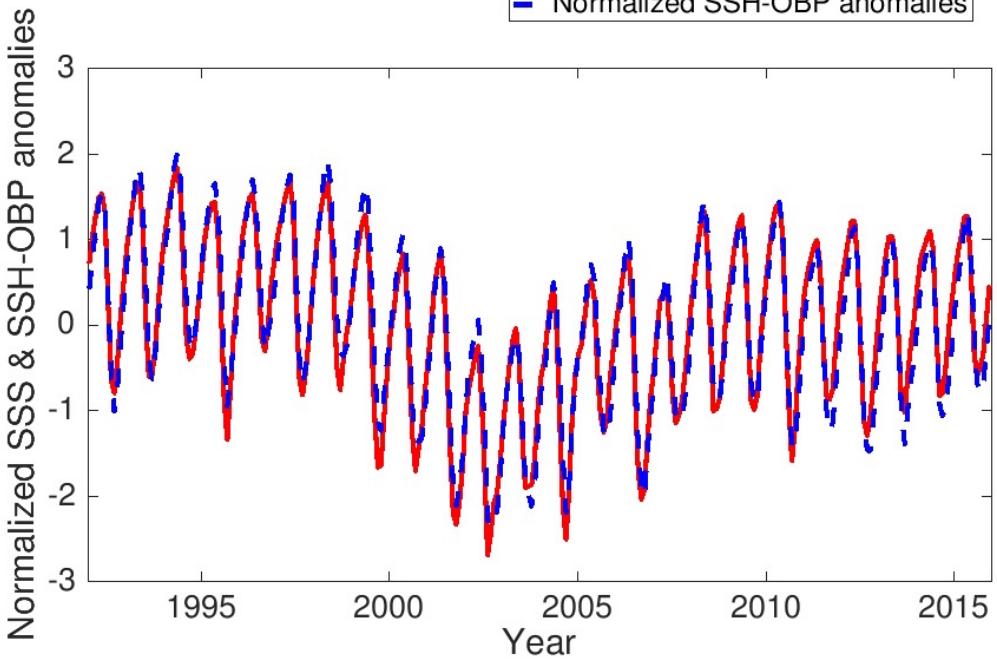
SSS & SSH-OBP relationships in Chukchi Shelf and Siberian Shelf

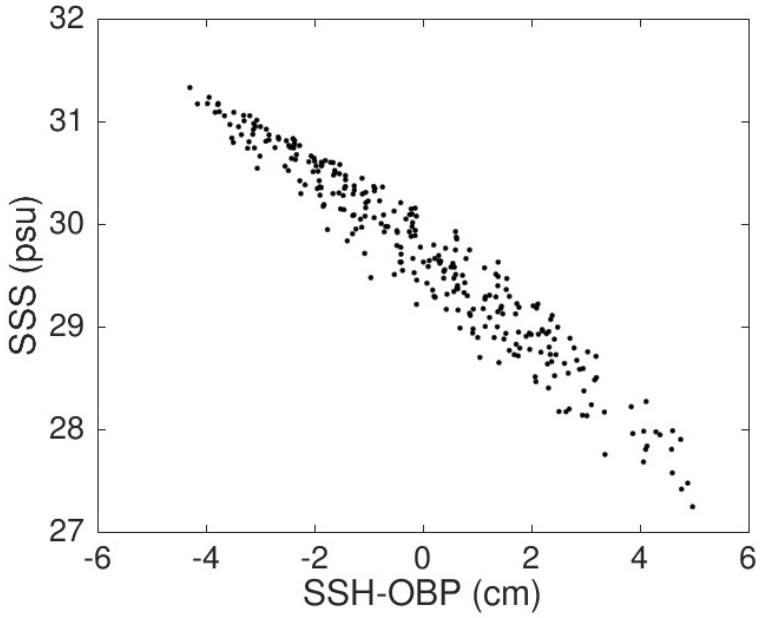
Chuckchi Shelf





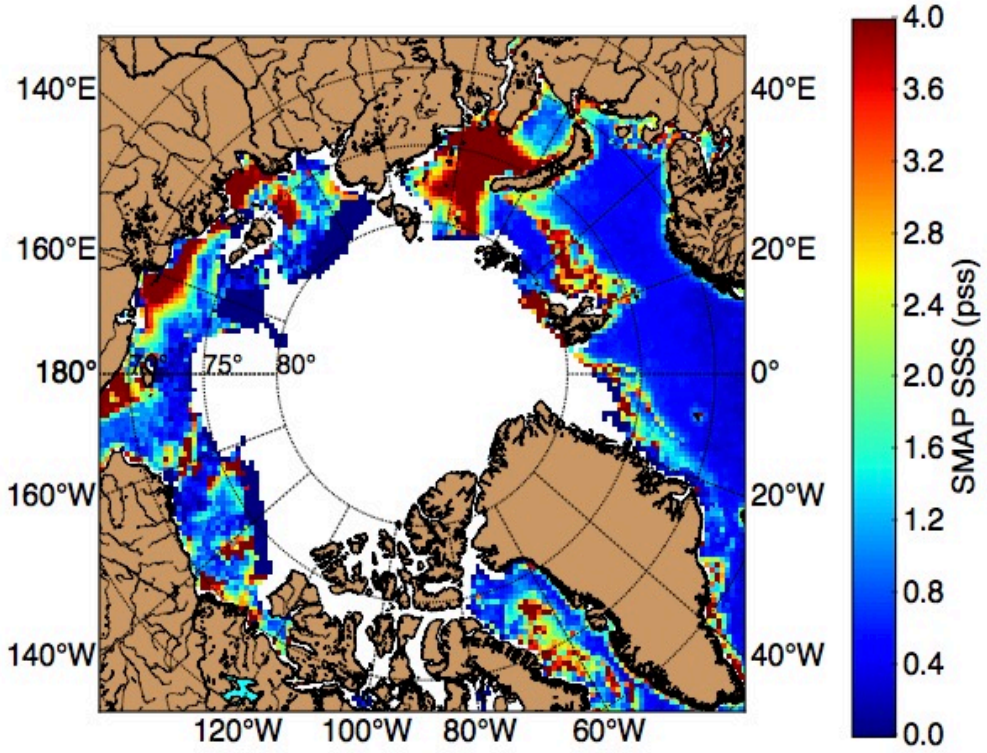
Siberian Shelf



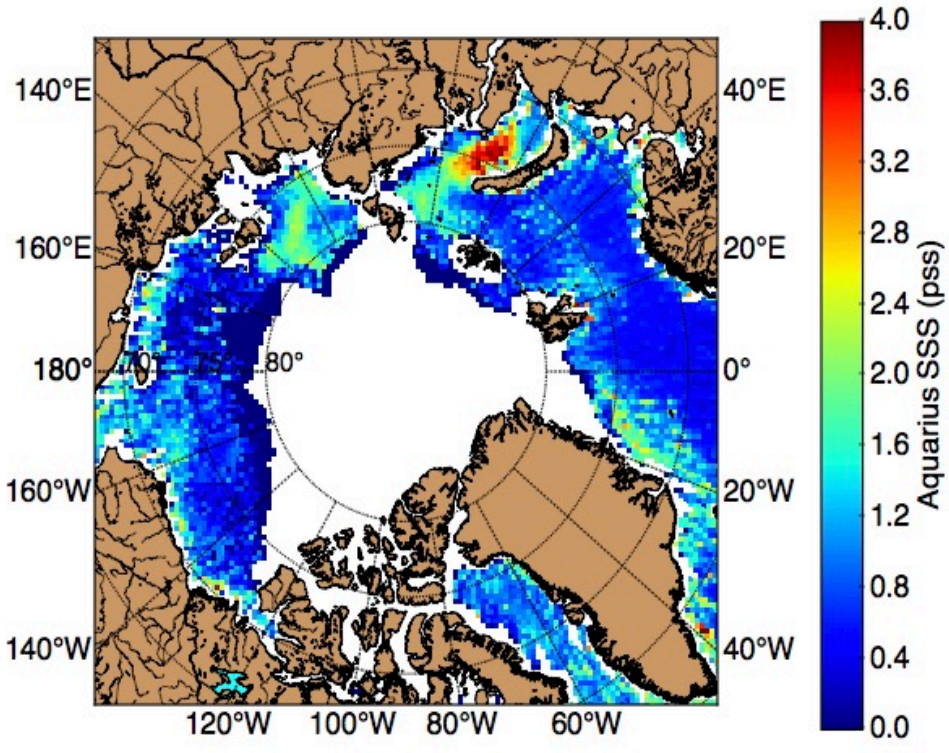


Standard deviation of Arctic SSS from Aquarius & SMAP: large differences in magnitudes!

Aquarius (2011-2015)



SMAP (2015-2017)



Ongoing work: use altimetry-gravimetry data to evaluate satellite SSS and improve Arctic Ocean SSS retrievals.

Summary

- ECCO ocean-sea ice state estimation product illustrates the strong relationship of SSS and SSH-OBP variations around Arctic shelves.

- This relationship could be used to evaluate satellite SSS in the Arctic Ocean using altimetry-gravimetry data and improve SSS retrievals.