

Exploring the synergy of satellite altimetry, gravimetry, and salinity data in studying Arctic Ocean freshwater changes

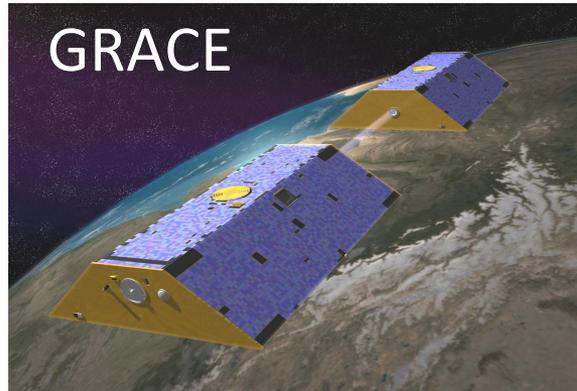
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Sea Surface Height
(SSH)



Ocean Bottom Pressure
(OBP)



Sea Surface Salinity
(SSS)



Motivation, rationales, and approach

Motivation & rationales:

- Arctic Ocean (AO) freshwater changes are important to ocean, climate, & BGC
- Satellite SSH-OBP have been used to infer column-integrated AO freshwater changes
 - But AO altimetry has limited sampling; GRACE has large footprint
- Satellite SSS have better sampling/resolution, but large uncertainties in the AO
 - AO SSS signals are large, so satellite SSS S/N ratio may be good in some regions
 - Lack of in-situ SSS in the AO poses a challenge to satellite SSS validation

Questions addressed:

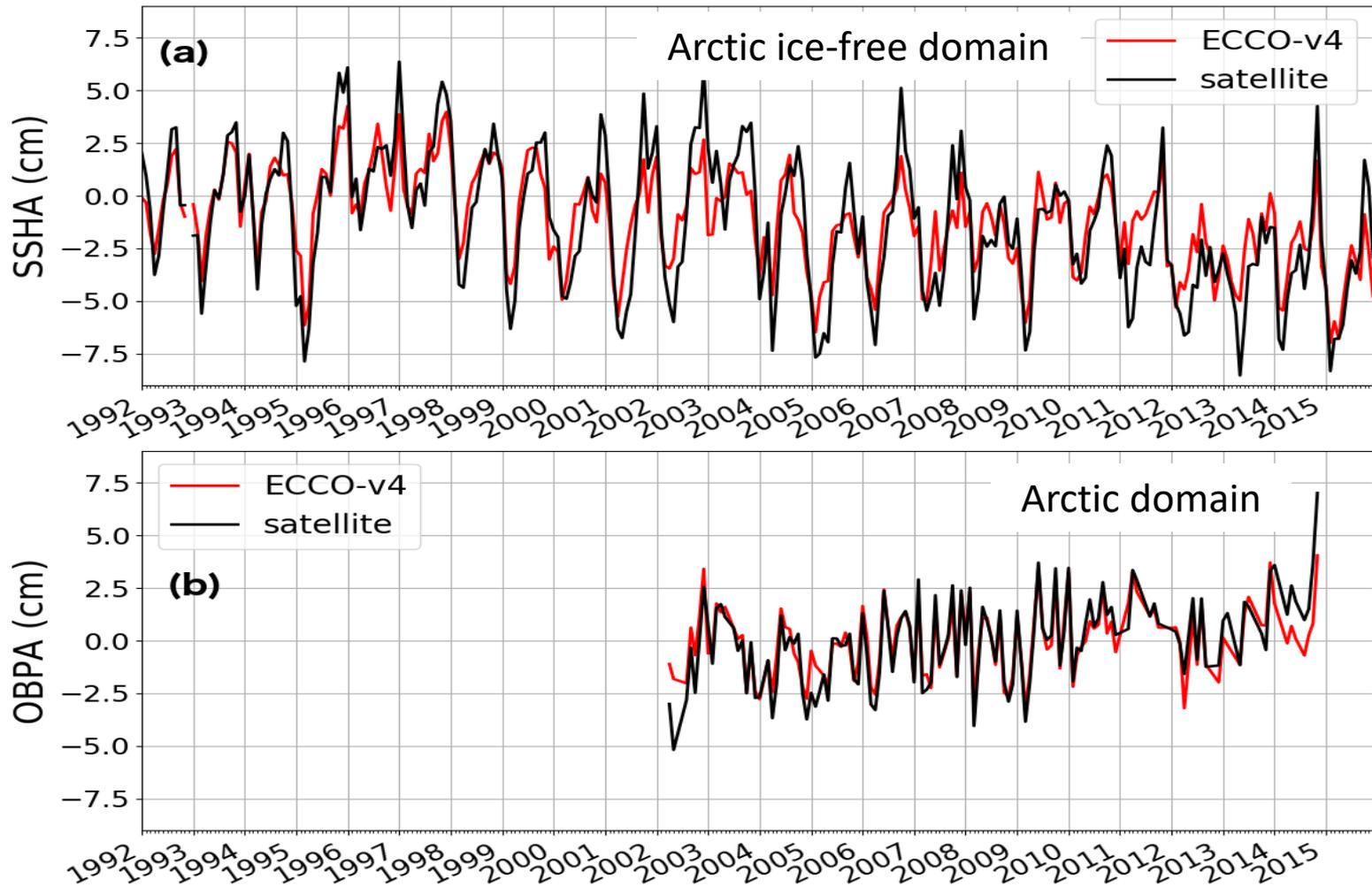
- To what extent Arctic SSS & SSH-OBP variations are coherent?
- Can satellite SSH-OBP data be used to evaluate satellite SSS?

Significance: improved satellite SSS retrievals complement satellite SSH-OBP data for AO research because of better sampling satellite SSS.

Approach:

- 1st step: examine relationship of SSS & SSH-OBP in ECCO-V4 ocean-ice state estimation (proof-of-concept)
- Ongoing work: quantify uncertainties of satellite SSH-OBP

Assessment of ECCO-v4 SSH, OBP, and salinity in the Arctic Ocean



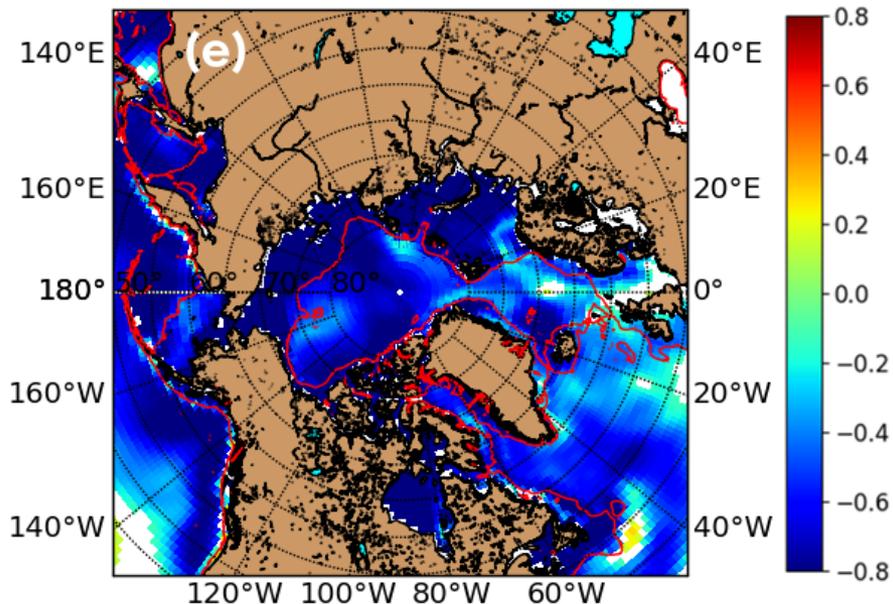
ECCO-v4 salinity also compared favorably with ice-tethered profiler data (not shown)

ECCO-v4 SSS & SSH-OBP are strongly anti-correlated over much of the AO (lower SSS ~ larger steric height)

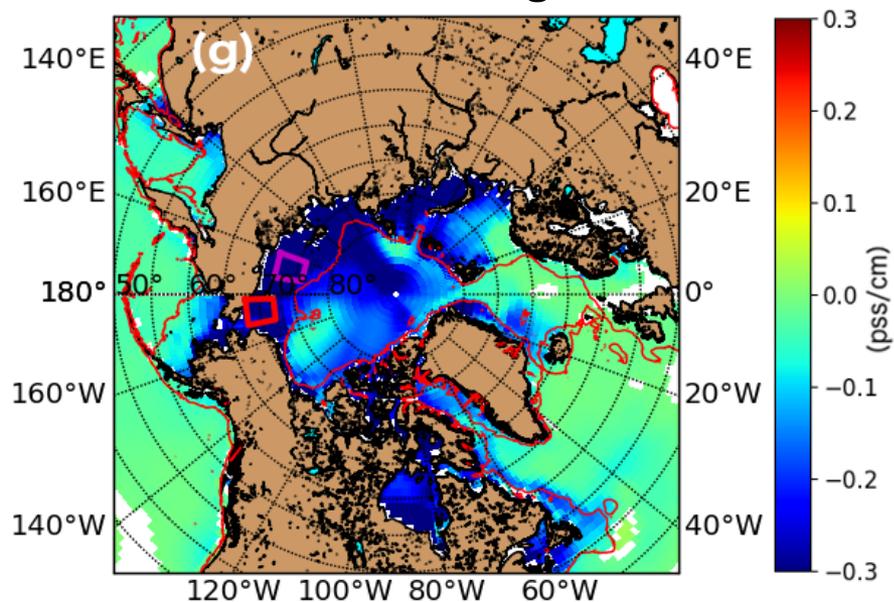
-> SSS is a good proxy for AO freshwater changes

Based on monthly ECCO-v4 data from 1992-2015

SSS vs. SSH-OBP correlation



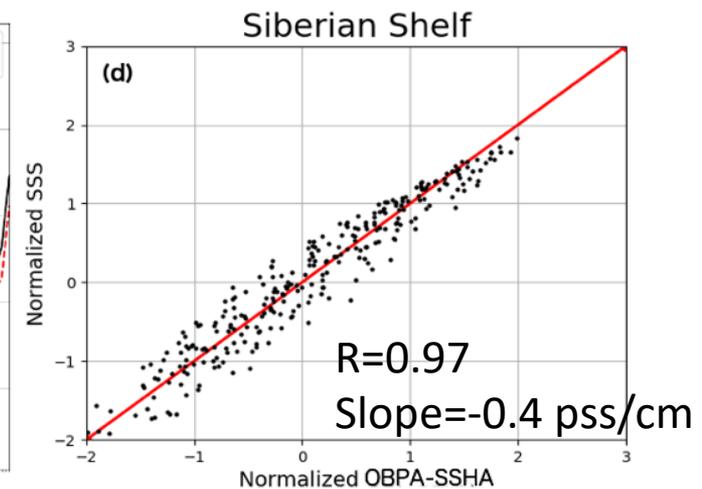
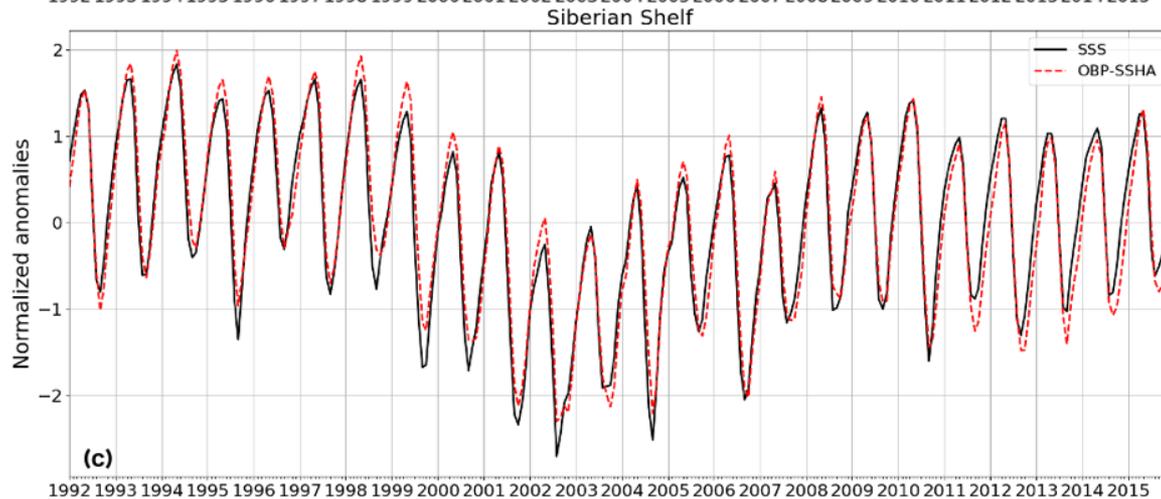
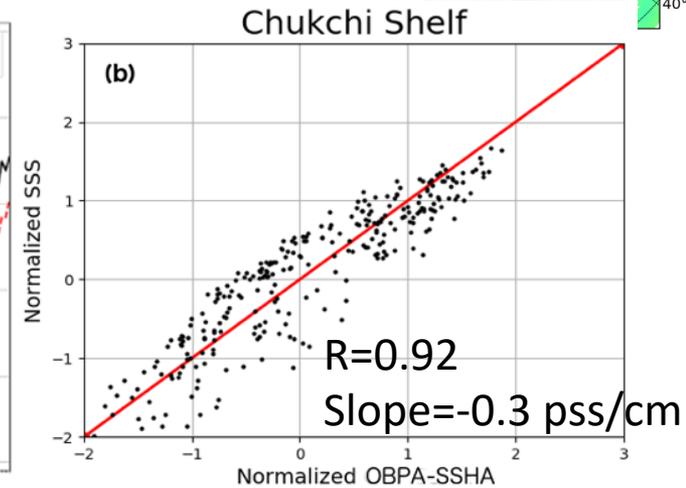
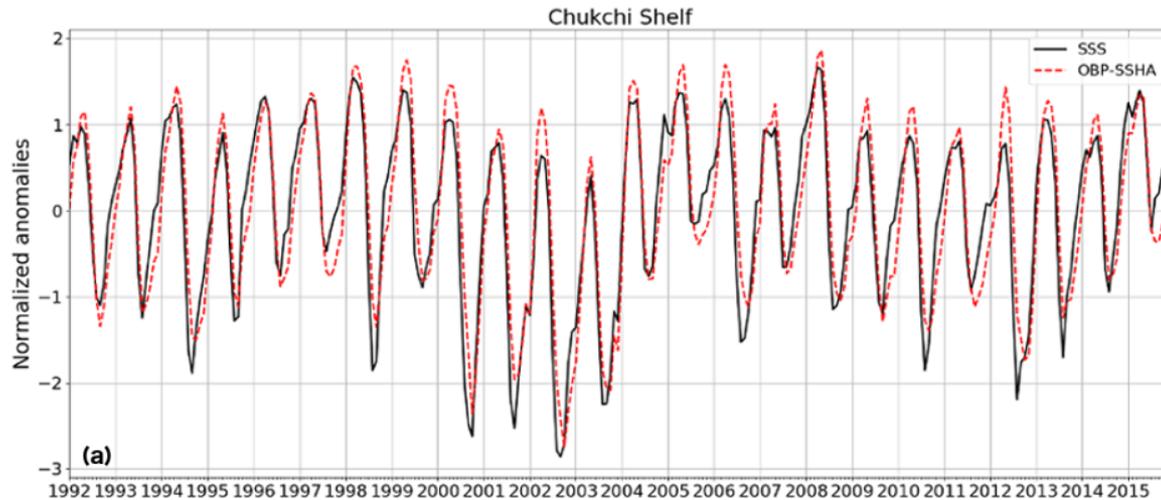
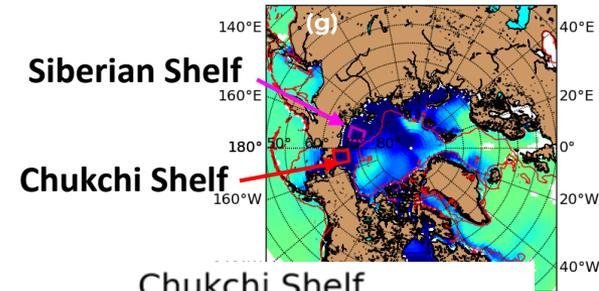
SSS vs. SSH-OBP regression



Fournier et al. 2018 (in revision)

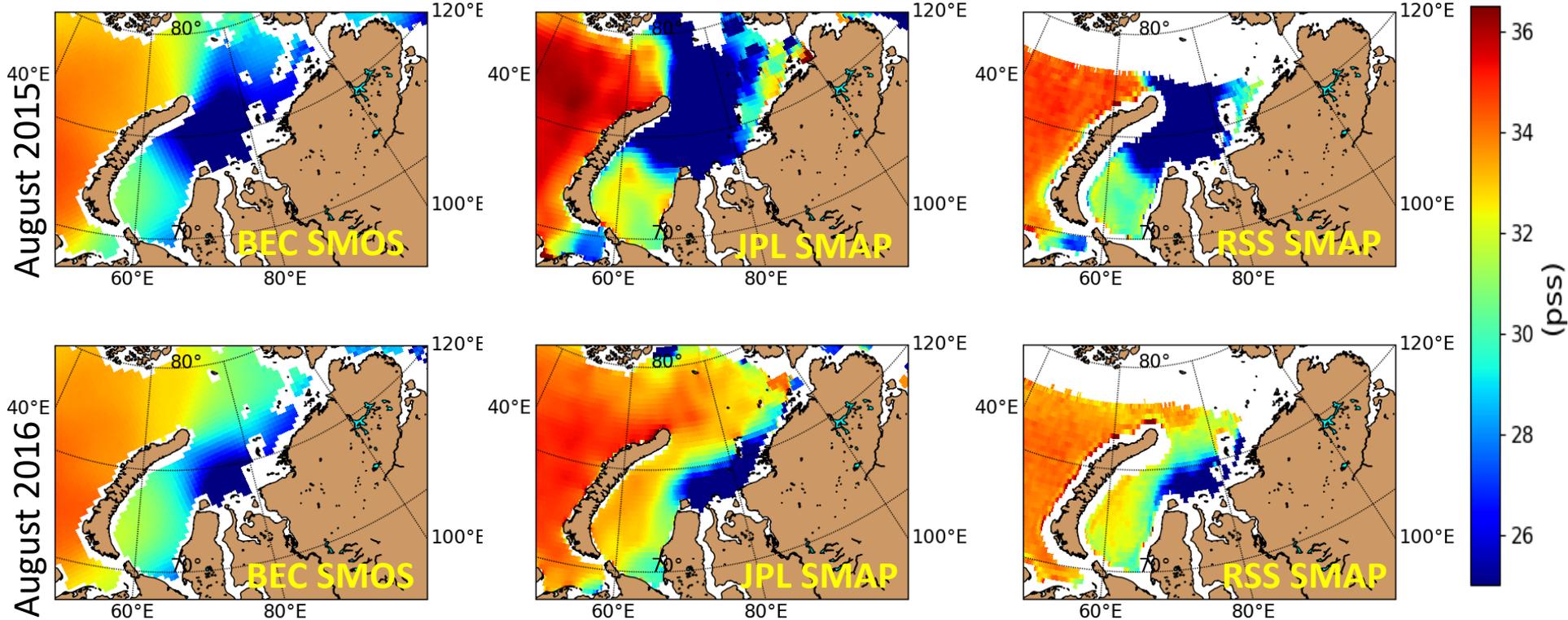
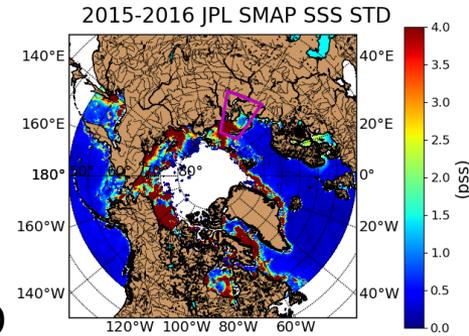
SSS & SSH-OBP relationships in the Chukchi Shelf and Siberian Shelf

Fournier et al. 2018 (in revision)



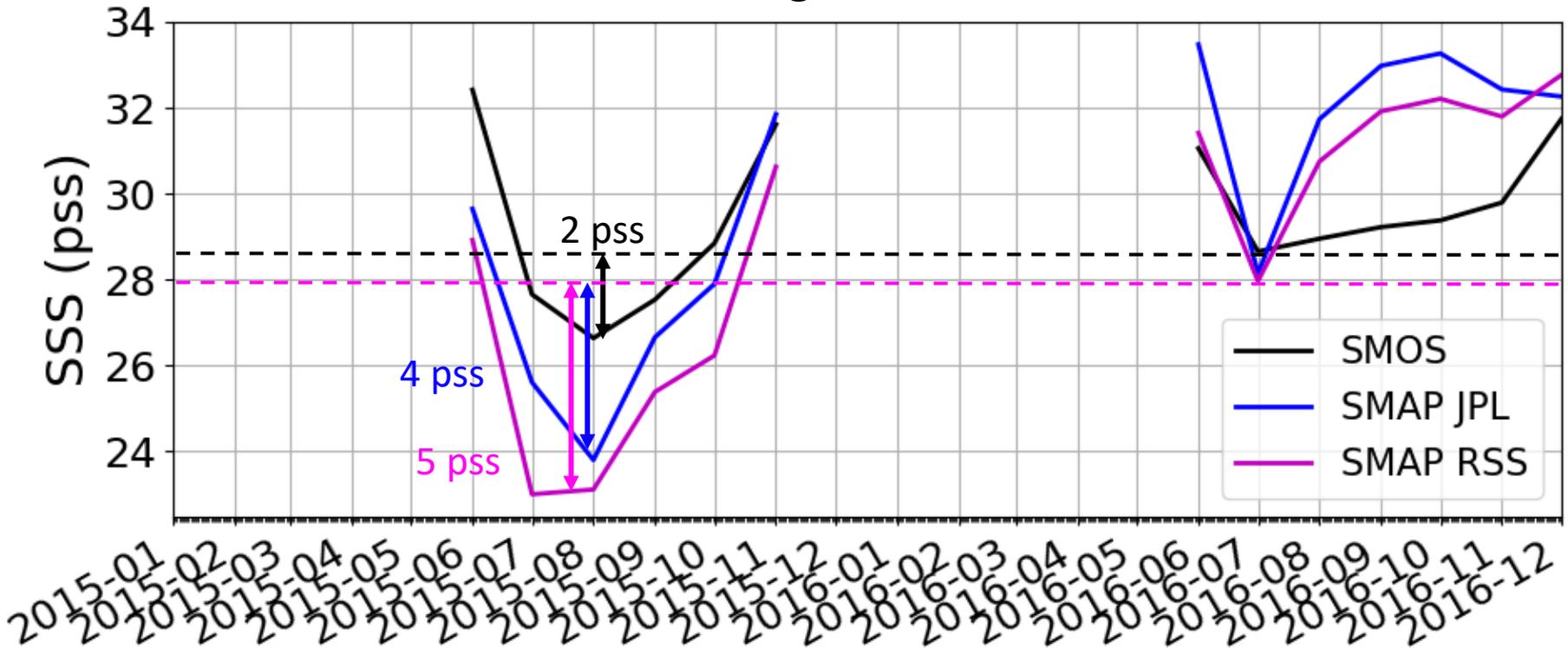
Kara Sea case study – 3 SSS products showed much lower SSS in summer 2015 than in summer 2016

- SMAP SSS from Jet Propulsion Laboratory (JPL)
- SMAP SSS from Remote Sensing Systems (RSS)
- SMOS SSS from Barcelona Expert Center (BEC) with de-bias in the AO



But the magnitude of the 2015 freshening differs significantly between SMAP & SMOS. Which one is right?

Kara-Sea averaged SSS time series

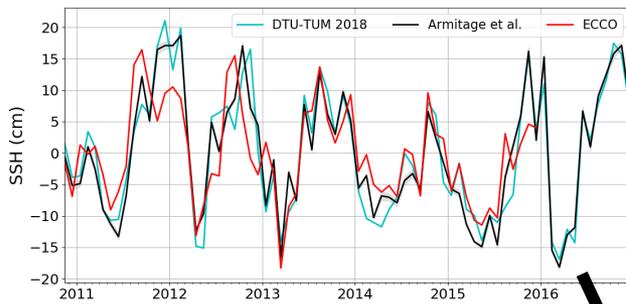


Ongoing work: use SSS vs SSH-OBP regression from ECCO-v4, together with satellite SSH-OBP to evaluate satellite SSS.
Uncertainty Quantification (UQ) important!

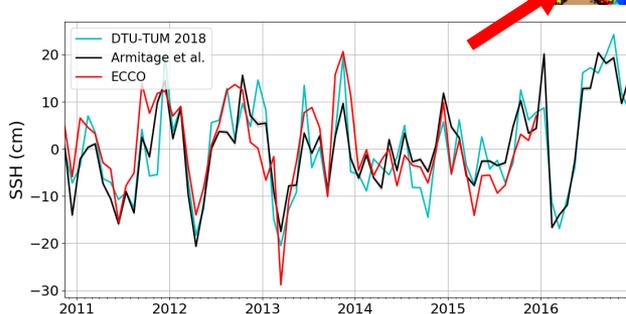
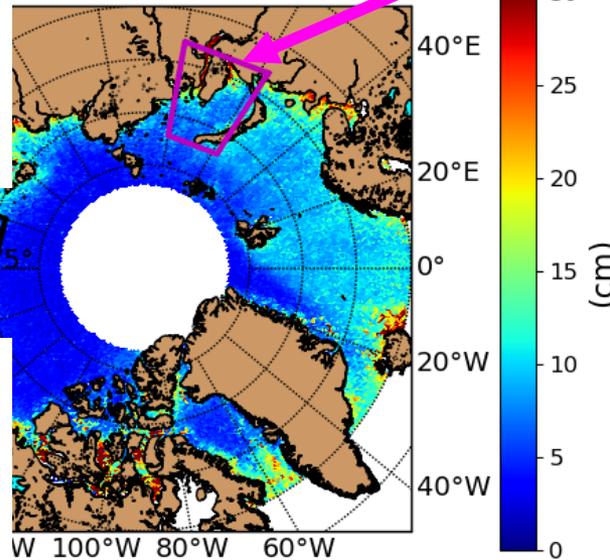
Examples of evaluating the consistency of Arctic SSH products in the AO

Dynamic Ocean Topography (DOT) (Armitage et al. 2018)
DTU-TUM v2 2018 (Anderson & Piccioni 2016)

rmsd DOT-DTU=4.22
rmsd DOT-ECCO=5.43
rmsd DTU-ECCO=3.79



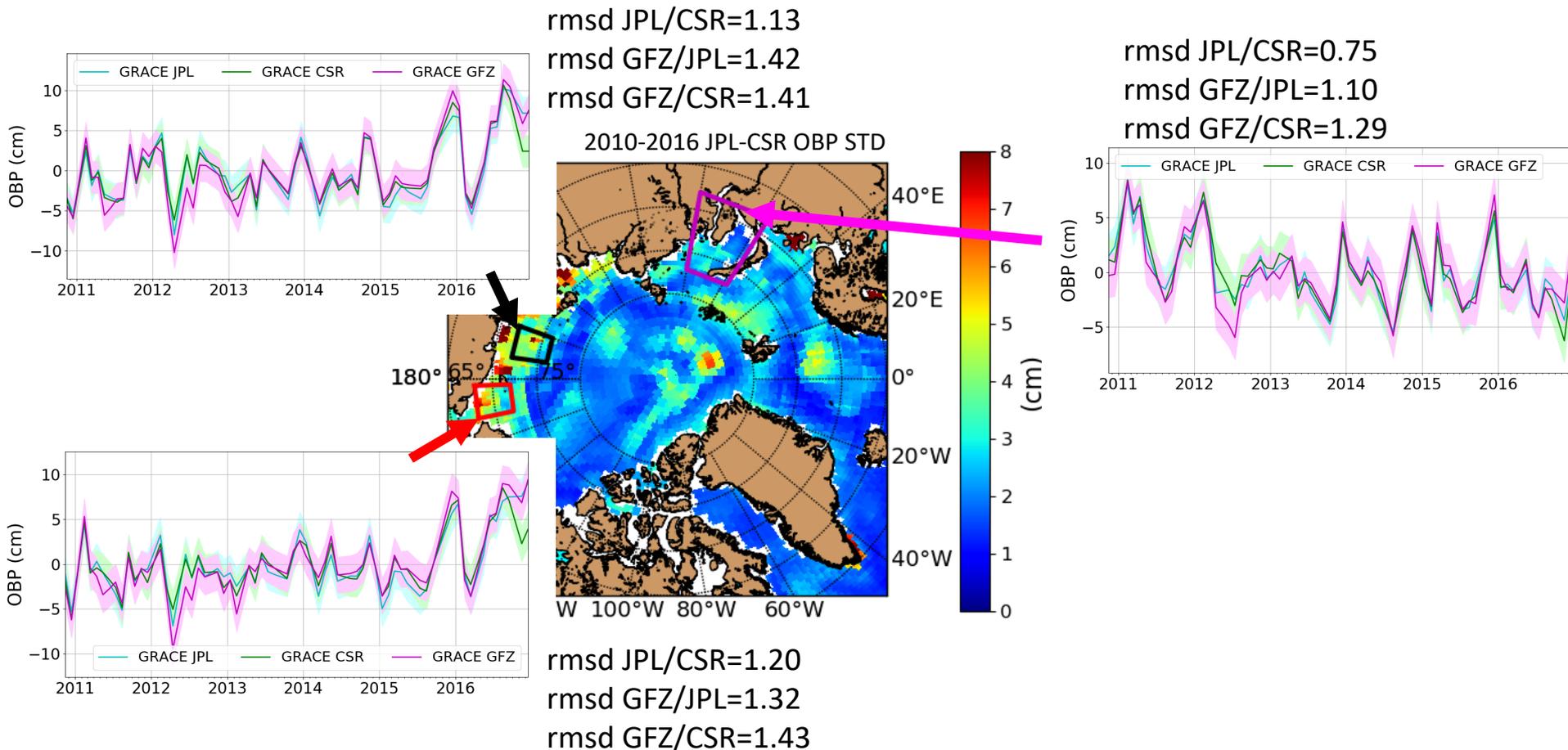
rmsd DOT-DTU=3.09
rmsd DOT-ECCO=6.05
rmsd DTU-ECCO=5.23



rmsd DOT-DTU=5.11
rmsd DOT-ECCO=7.01
rmsd DTU-ECCO=6.11

Examples of evaluating GRACE OBP product consistency: RL05 spherical harmonics

- JPL RL05 spherical harmonics
- CSR RL05 spherical harmonics
- GFZ RL05 spherical harmonics



Summary

- ECCO-v4 shows strong anti-correlation of SSS vs SSH-OBP
-> SSS is a good proxy for Arctic-Ocean freshwater changes
- This relationship is exploited to evaluate uncertainties of satellite SSS using satellite SSH-OBP, alleviating the difficulty due to the paucity of in-situ SSS
- Ongoing work of uncertainty Quantification (UQ)
 - for SSS vs. SSH-OBP regression coefficients (e.g., time-scale dependence, effect of ice masks)
 - for satellite SSH-OBP (RL05 so far, RL06 & GRACE-FO to be included)
- Need inputs from the GRACE & altimetry communities (products, UQ, etc.)



