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Evaluation of Arctic Ocean surface salinities from SMOS and the regional CMEMS Arctic reanalysis against in-situ datasets

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Outline

- Motivation
- Taking our own reanalysis as a reference
- Evaluation against the near-SSS from CORA5.1
- Evaluation against moorings in the Beaufort Sea
- Summary

Motivation

The Arctic cold halocline stratification is salinity-controlled.
Sea Surface Salinity (SSS) is a key indicator of the freshwater fluxes and an important variable to understand the changes the Arctic is facing.

However, salinity in-situ measurements are technologically challenging in ice-covered regions.

SSS retrieval by remote sensing represents a challenge as well:

- brightness temperatures measured by L-band satellites are less sensitive to salinity in cold waters.
- sea ice contaminates the brightness temperature

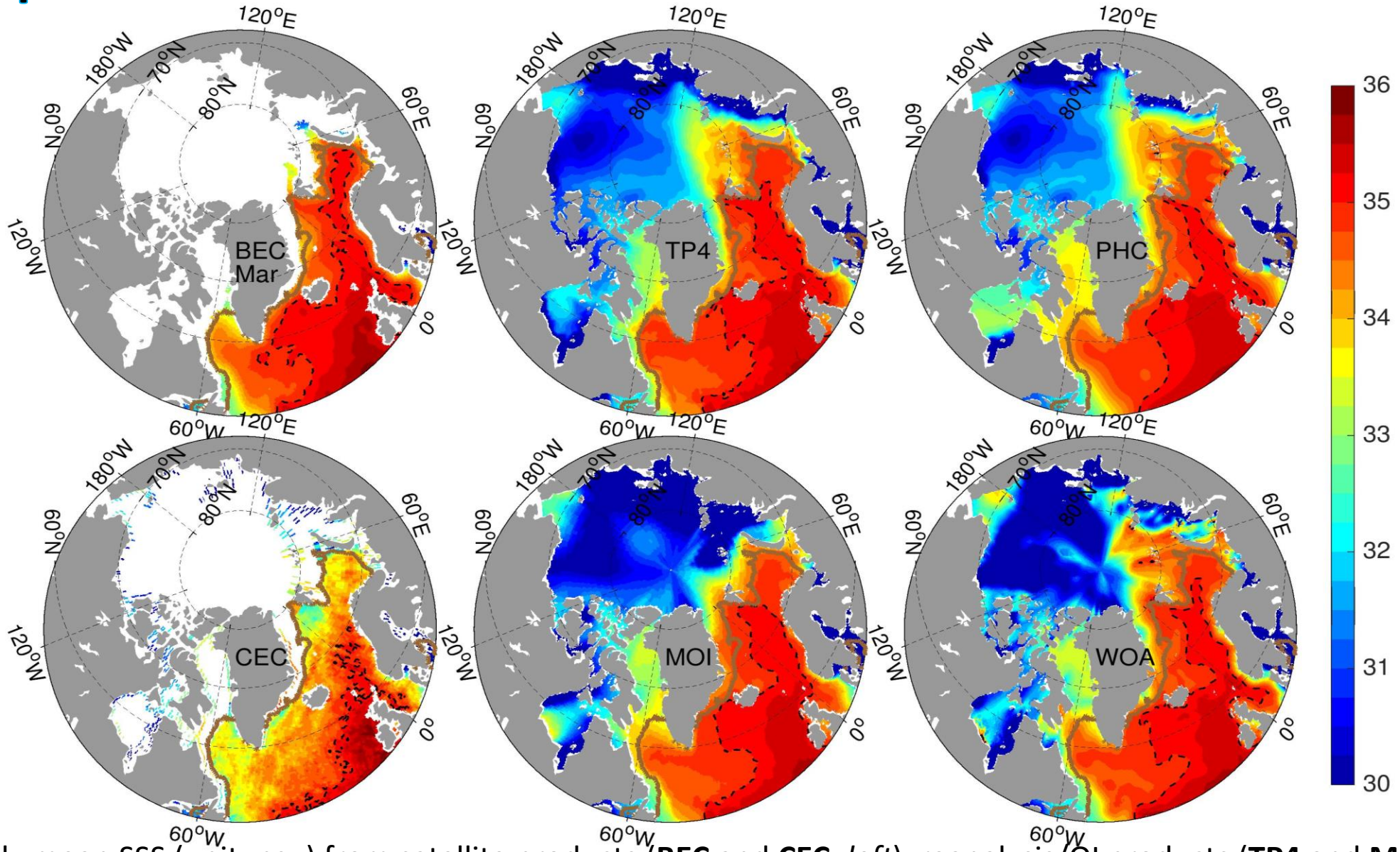
Table 1 Arctic Ocean surface salinities of 2011-2013:

Product name	Main source	Resolution	Release year	Provider	Website or CMEMS id
BEC	SMOS	9 days; 25 km	2018	*Barcelona Expert Centre, Spain*	http://bec.icm.csie.es
CEC	SMOS	9 days; 25 km zonal	2018	*Ocean Salinity Expertise Center (CECOS), IFREMER*	FTP: ftp.ifremer.fr
TP4	Reanalysis	Daily; 12~16 km	2015	*ARC MFC, CMEMS*	ARCTIC-REANALYSIS-PHYS-002-003
MOI	MV - In situ Objective Interpolation	7 days; 1/4x1/4°;	2016	*MOB MFC, CMEMS*	MULTIOBS_GLO_PHY_REP_015_002
PHC	In situ (1950-1994)	Monthly; 1x1°	2005	*Polar Science Center, University of Washington*	http://psc.apl.washington.edu/
WOA	In situ (1955~2012)	Monthly; 1/4x1/4°	2013	*NODC, NOAA*	https://www.nodc.noaa.gov/OC5/woa13/

- ***Uncertainties in the SSS from SMOS?***
- ***Any potential benefits from the SMOS SSS for TOPAZ4?***

Intercomparison

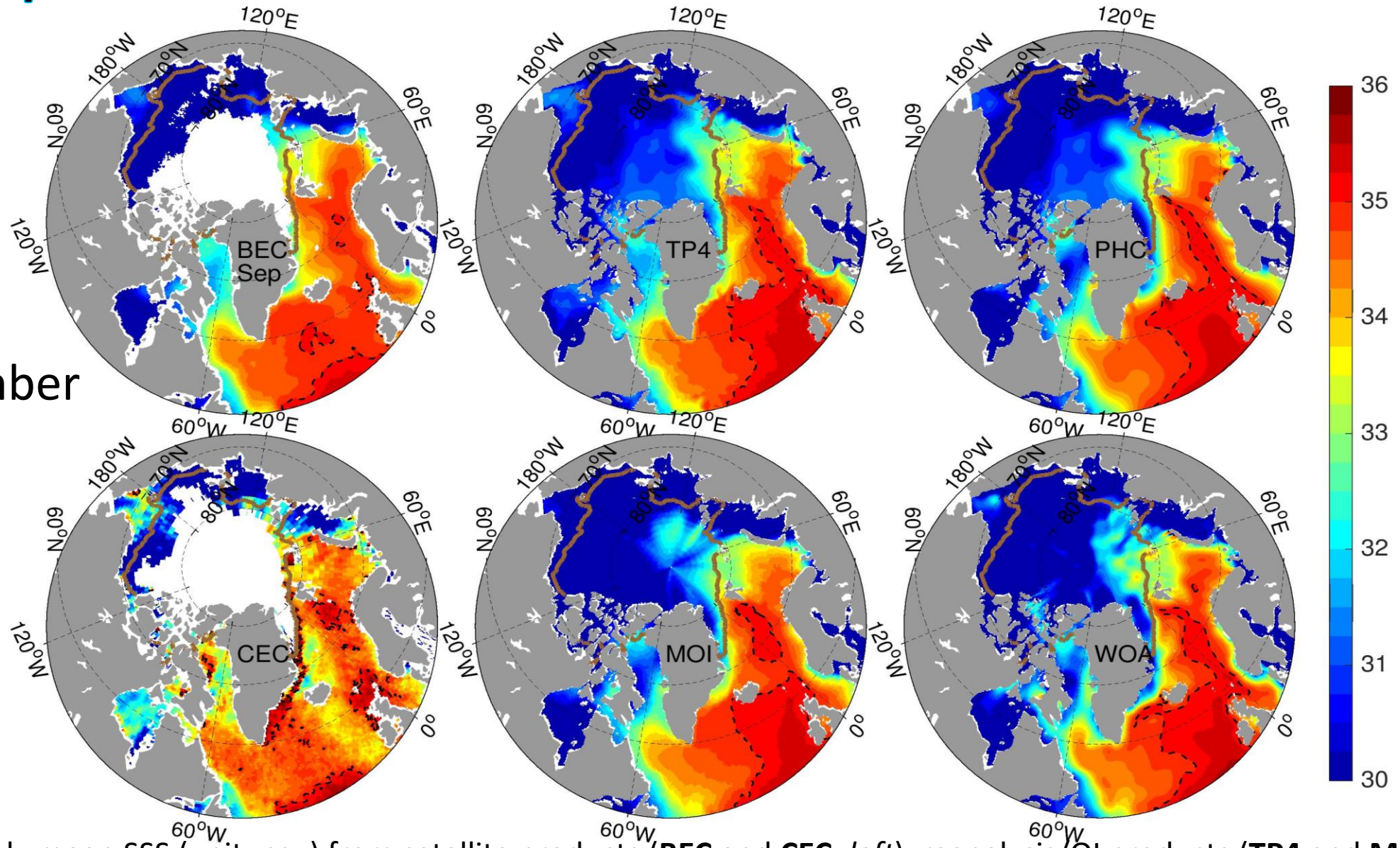
March



Monthly mean SSS (unit: psu) from satellite products (**BEC** and **CEC**, *left*), reanalysis/OI products (**TP4** and **MOI**, *middle*), and climatologies (**PHC** and **WOA**, right). Thick brown: sea ice edge in TP4; dashed black: 35 psu

Intercomparison

September



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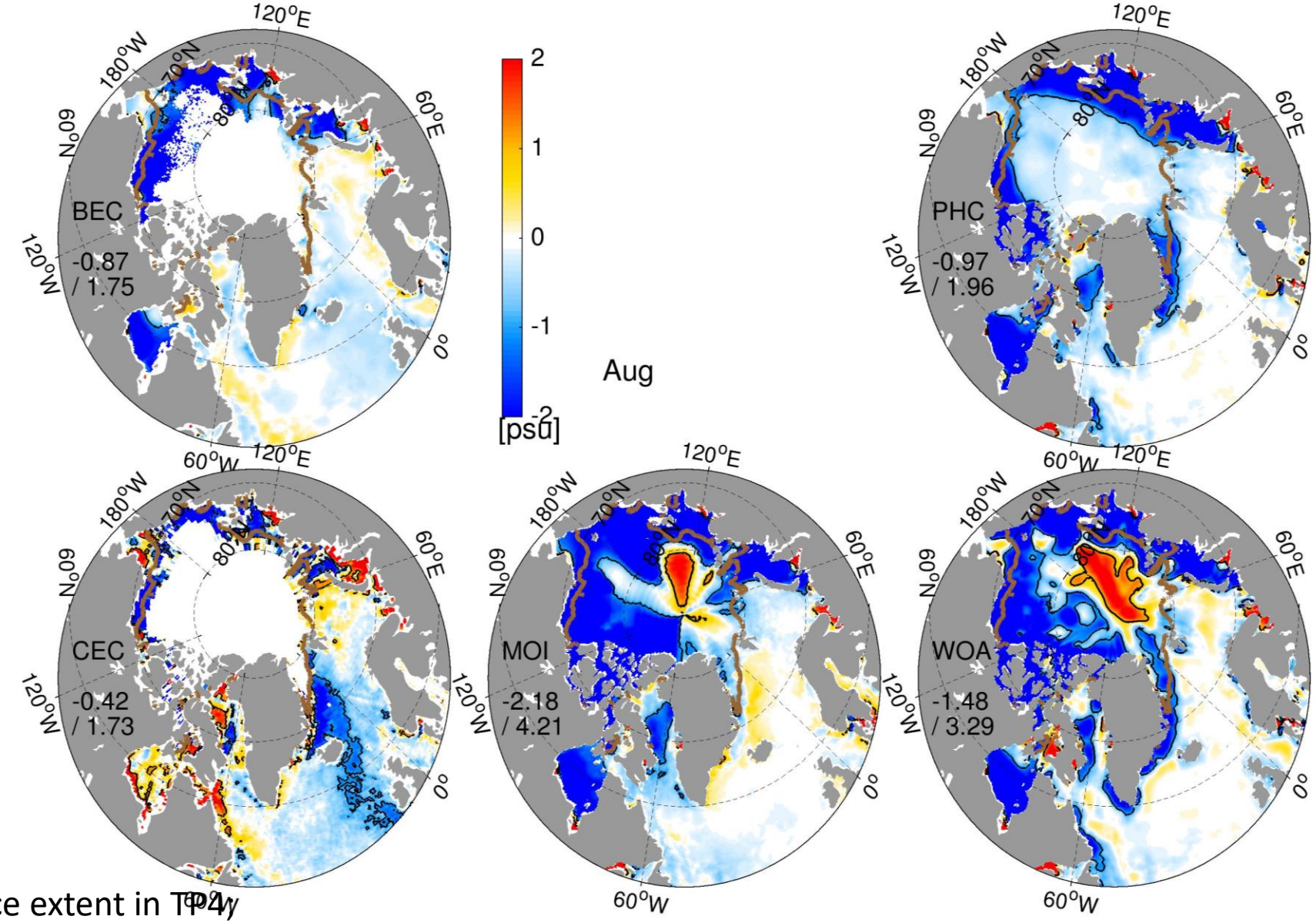
SSS Differences relative to TP4 in summer

August

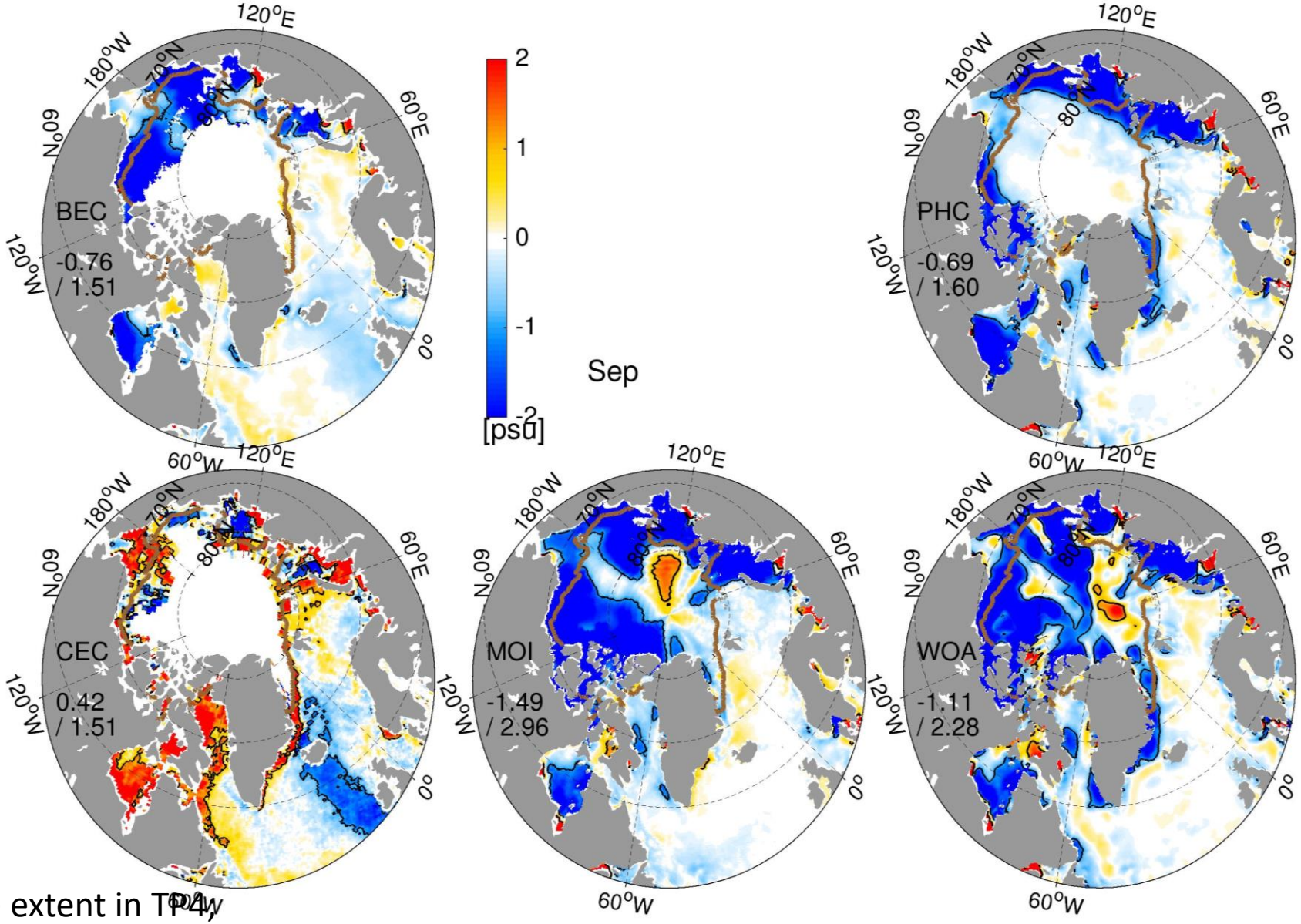


Thick brown: sea ice extent in TP4

Black line: ±1 psu

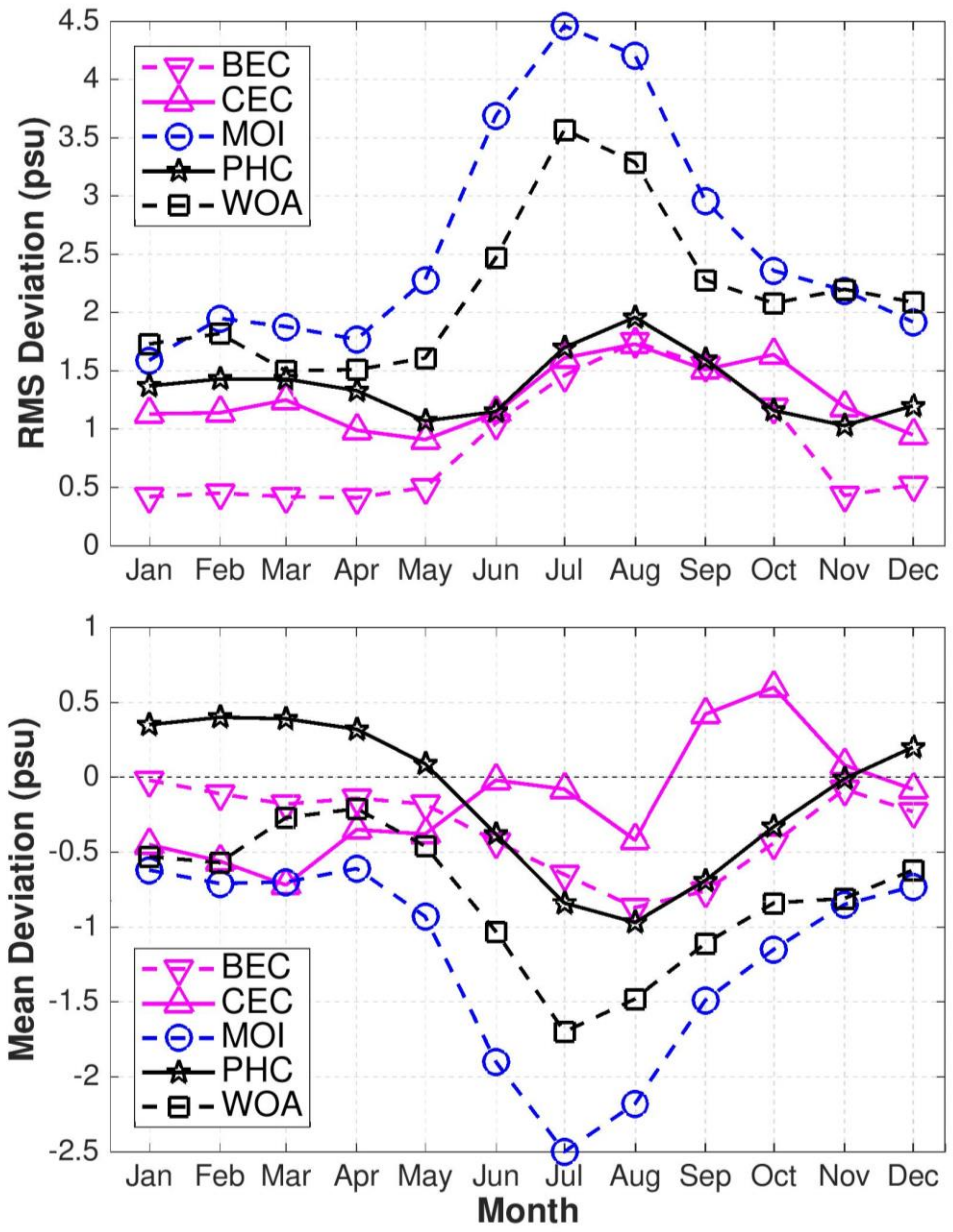
SSS Differences relative to TP4 in summer

September



Thick brown: sea ice extent in TP4,

Black line: ±1 psu



Whole Arctic RMS differences (upper) and biases (bottom) for the monthly SSS against TP4

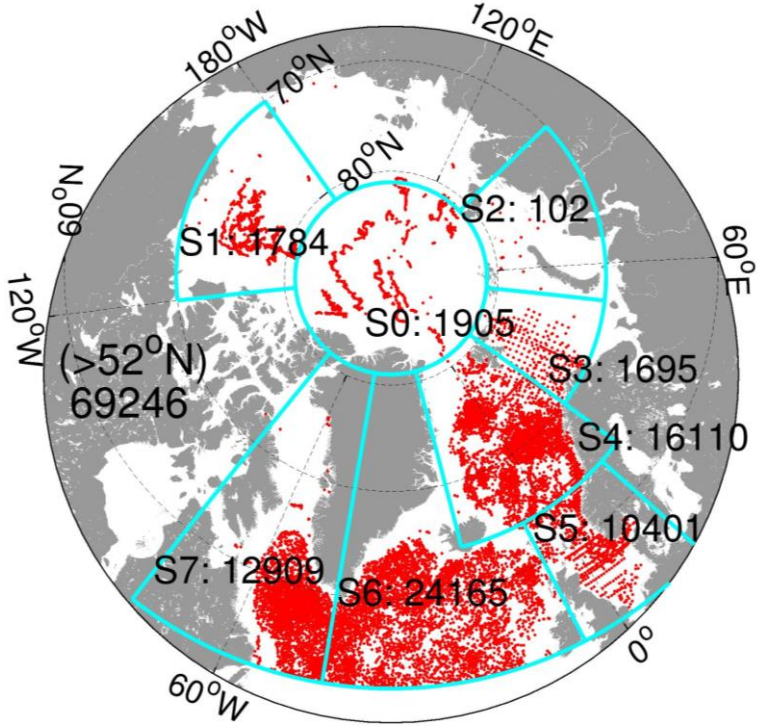
- In the Arctic Ocean (>60°N) for the period of 2011-2013;
- BEC is closest to TP4: 0.5 psu in winter but 1.5 psu in summer;
- Seasonality of CEC differences is weakest;
- MOI and WOA are furthest from TP4 in terms of RMS deviation and bias.

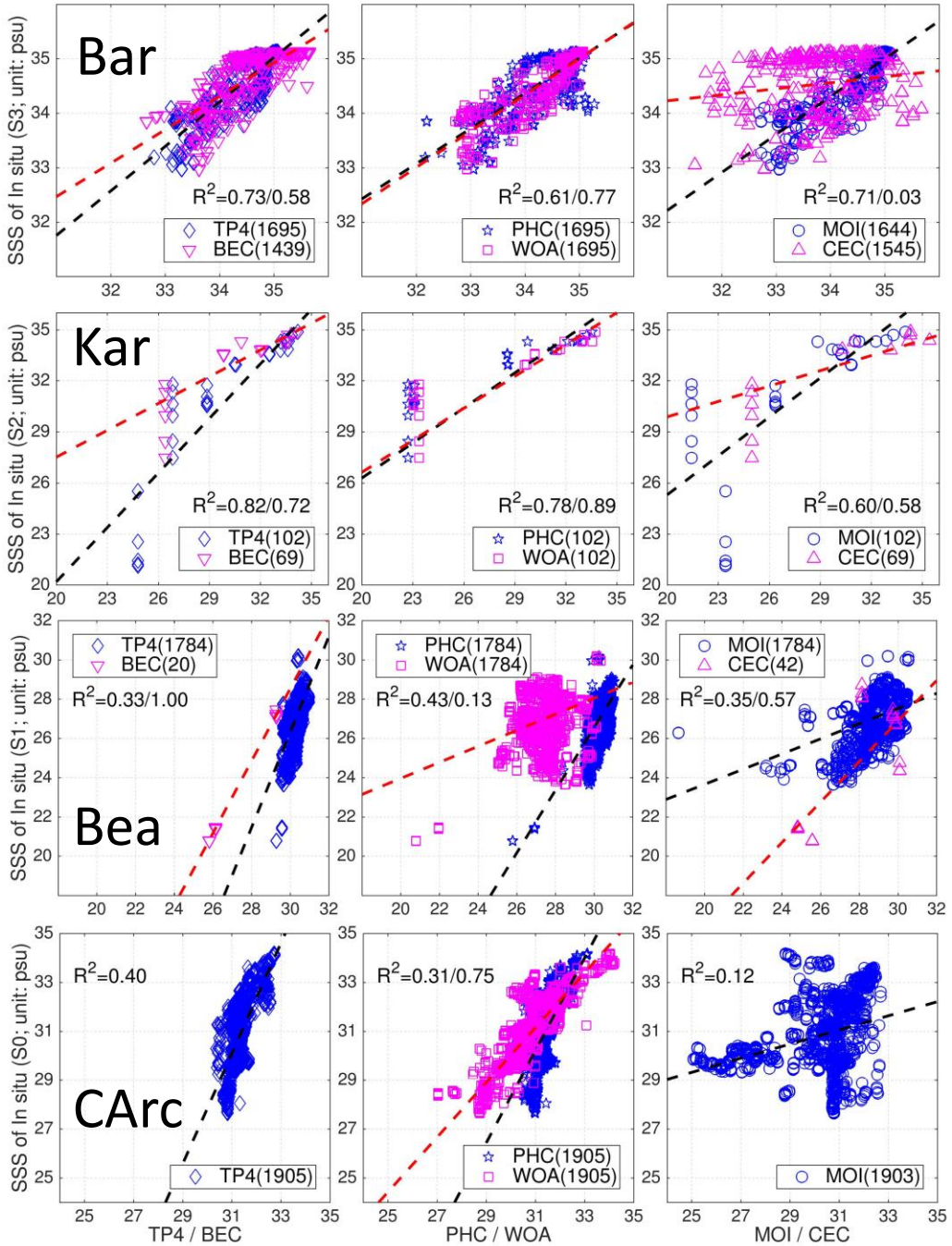
Against *dependent* in situ data:

- ***SSS from CORA5.1 assimilated in TP4***

Scatterplot of SSS in the central Arctic

- Barents Sea: all SSS products consistent except CEC.
- Kara Sea: BEC and CEC both too fresh for low salinities (<32psu)
- Central Arctic & Beaufort Sea: ITP only;
- SMOS not available in Centr. Arc.;

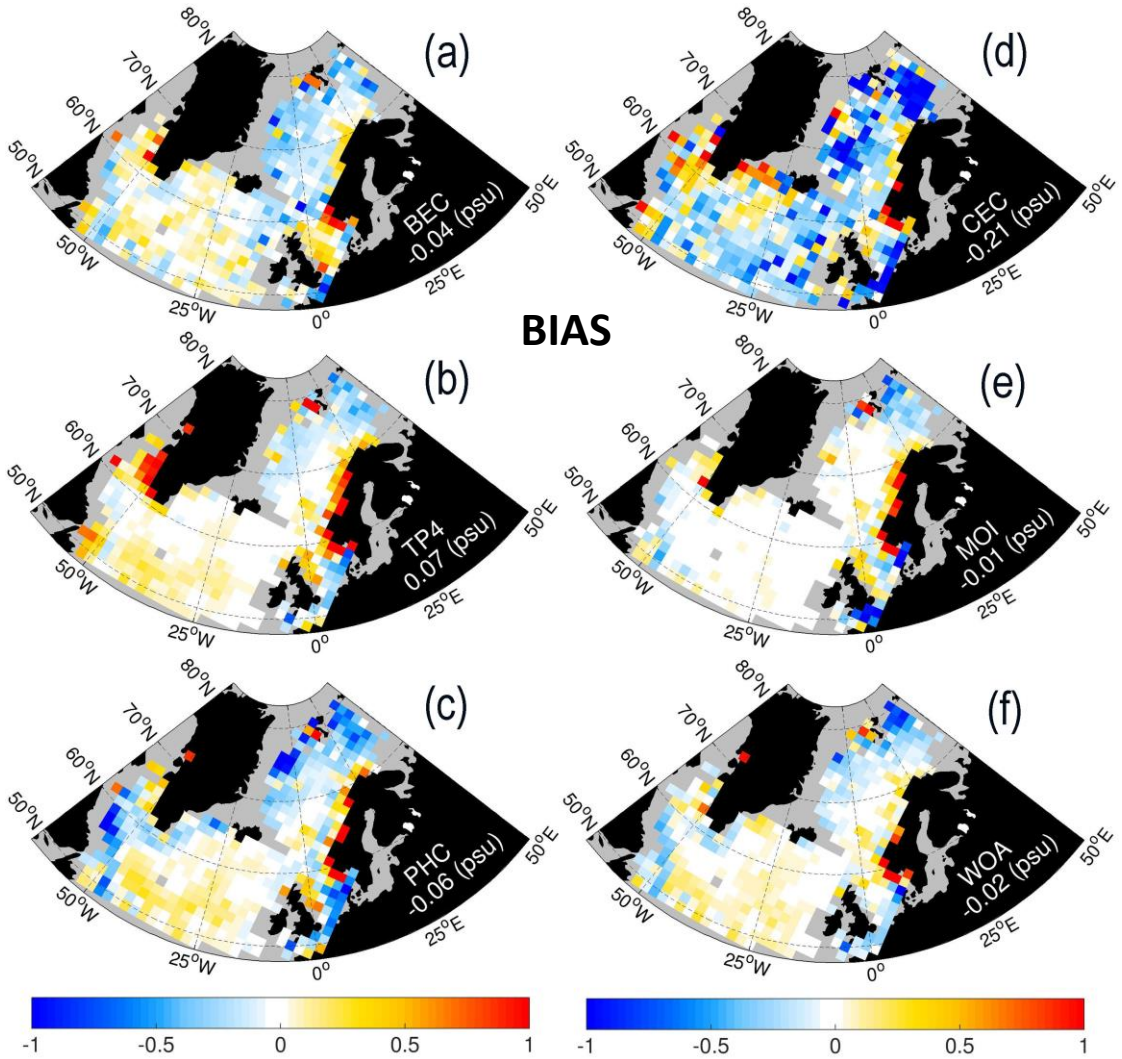


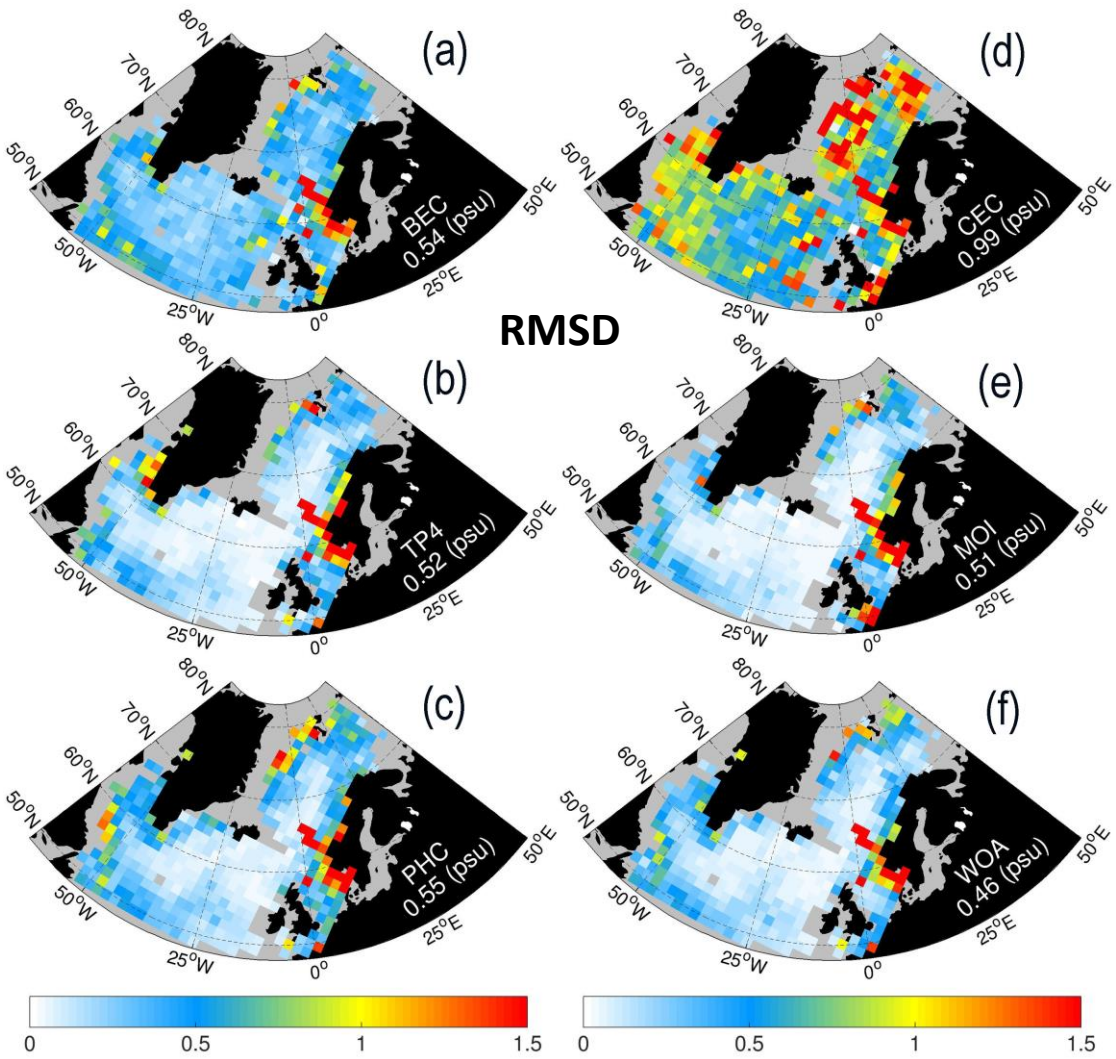


SSS Misfits relative to CORA5.1 in the eight regions (2011-2013).

Region	Bias (psu)						RMSD (psu)					
	BEC	CEC	TP4	MOI	PHC	WOA	BEC	CEC	TP4	MOI	PHC	WOA
CArc	-	-	.48	-.52	.48	***-.11***	-	-	1.25	1.78	1.28	***.70***
BG	4.03	3.18	3.29	1.63	3.29	***.42***	4.23	3.70	3.47	2.22	3.43	***1.37***
Kar	-1.76	***-.44***	-.97	-2.96	-3.30	-2.93	2.16	2.57	***1.70***	3.68	3.87	3.62
Bar	***-.14***	-.70	-.14	-.21	-.29	-.25	.45	1.17	***.34***	.42	.51	.44
Nordic	-.09	-.20	.12	.11	***-.02***	***.02***	.91	1.21	.89	.86	.94	***.84***
NWS	-.07	.06	.20	***.01***	.02	.07	1.47	1.52	1.42	1.44	1.39	***1.30***
Irm	***-.01***	.15	***.01***	***-.01***	-.09	.05	.25	.66	.14	***.12***	.28	.16
Lab	.05	.34	.04	***-.03***	-.23	-.03	.31	.88	.33	***.22***	.43	.27

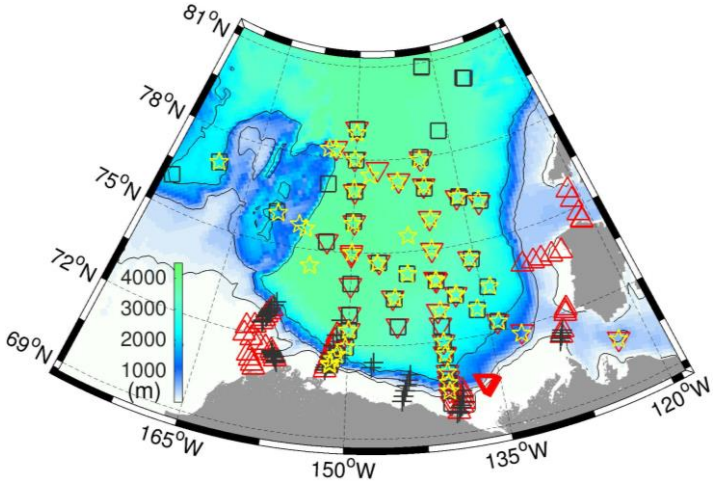
SSS deviations of the six products against CORA 5.1



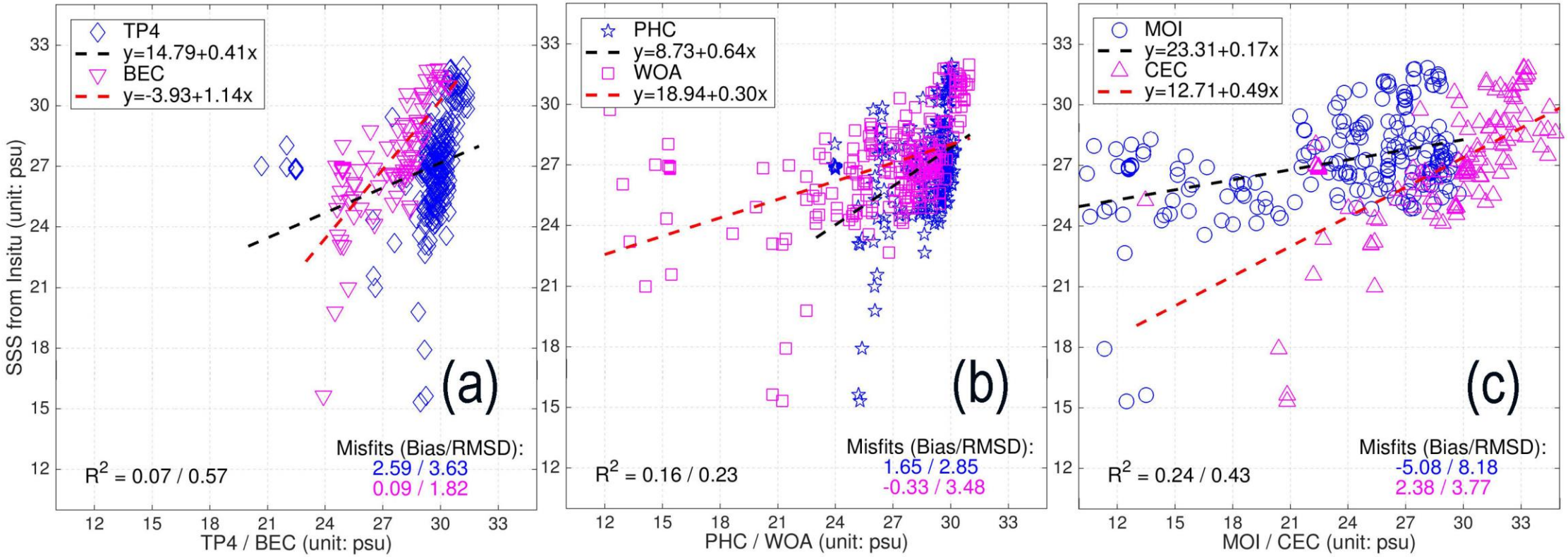


- 100x100 km boxes; Gray mask if less than 10 observations.
- West coast of Greenland and Norwegian coast should benefit most from assimilation

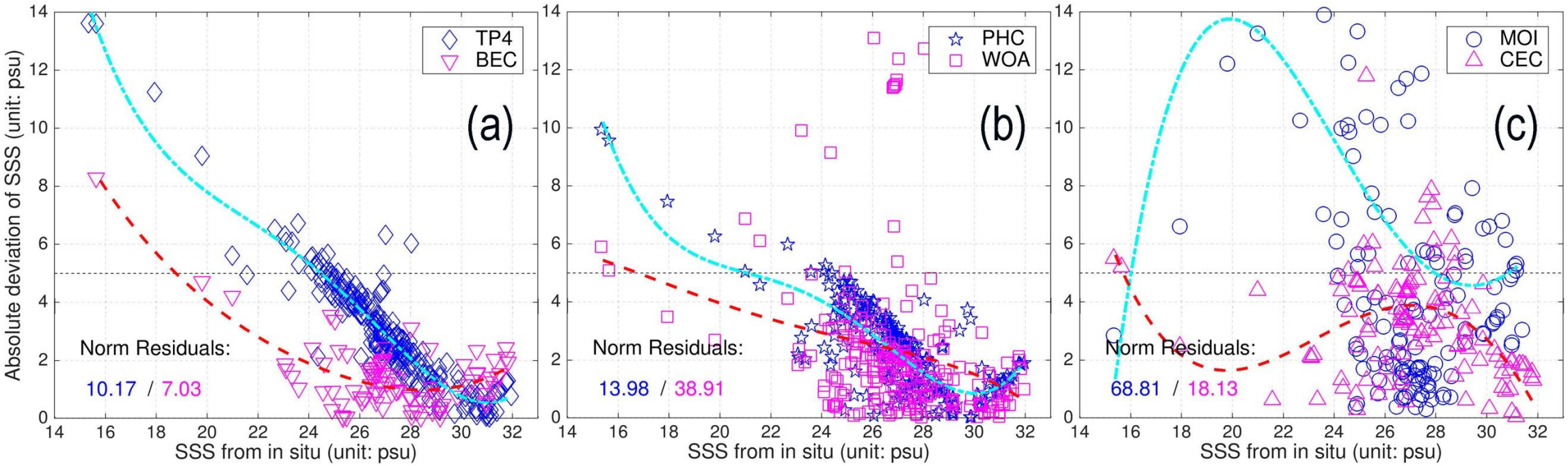
- ***Independent in situ data from BGEP & CLIVAR***



- Scatterplots of SSS against in-situ observations in Beaufort Sea during the summer months of 2011-2013.
- Freshwater is a common challenge for all products in the Beaufort Sea.



Scatterplots of SSS uncertainty compared to the in-situ observations in Beaufort Sea as a function of the observed salinity.



- Fitted by 4th order polynomial function, residuals are indicated on each panel;
- SSS uncertainties decrease with increasing salinity

Summary

- All Arctic SSS products disagree below sea-ice and in the marginal ice zone, especially in summer.
- BEC has least deviation to our model: 0.5 psu in winter months but 1.5 psu in summer months.
- Against CORA data in the central Arctic, both BEC and CEC show a significant saline bias (>3 psu) equivalent with TP4 and PHC, but WOA13 has lower misfits with the ITP SSS.
- Against independent Insitu SSS in the Beaufort Sea, BEC has smallest - saline - bias (~0.1 psu) with smallest RSMD of 1.8 psu.
  - TOPAZ will start assimilating BEC SSS from Nov. 2019.

Ocean Science: https://doi.org/10.5194/os-2018-163(in review)

Thank you for your attention!

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