Uncertainty in satellite observed SSS variability in the subpolar North Atlantic

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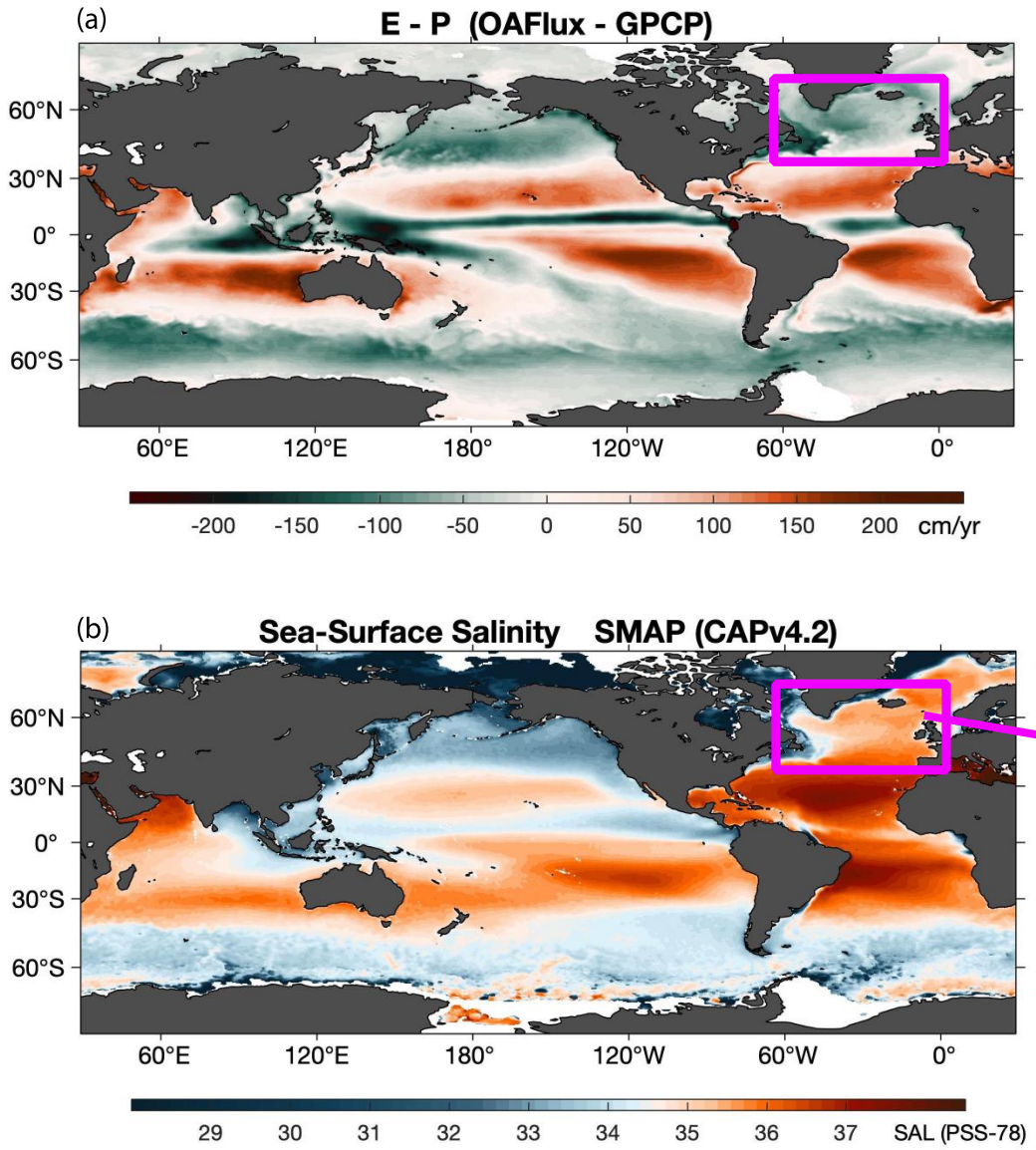
Subpolar North Atlantic

(47 – 70°N, 70°W – 0)

- High-latitude net precipitation region (*P* > *E*)
- Low SST but high SSS
- High salinity waters are transported by the North Atlantic Current from the subtropical gyre.
- Low salinity waters are carried into the region by boundary currents (such as the east Greenland Current and the Labrador Current).



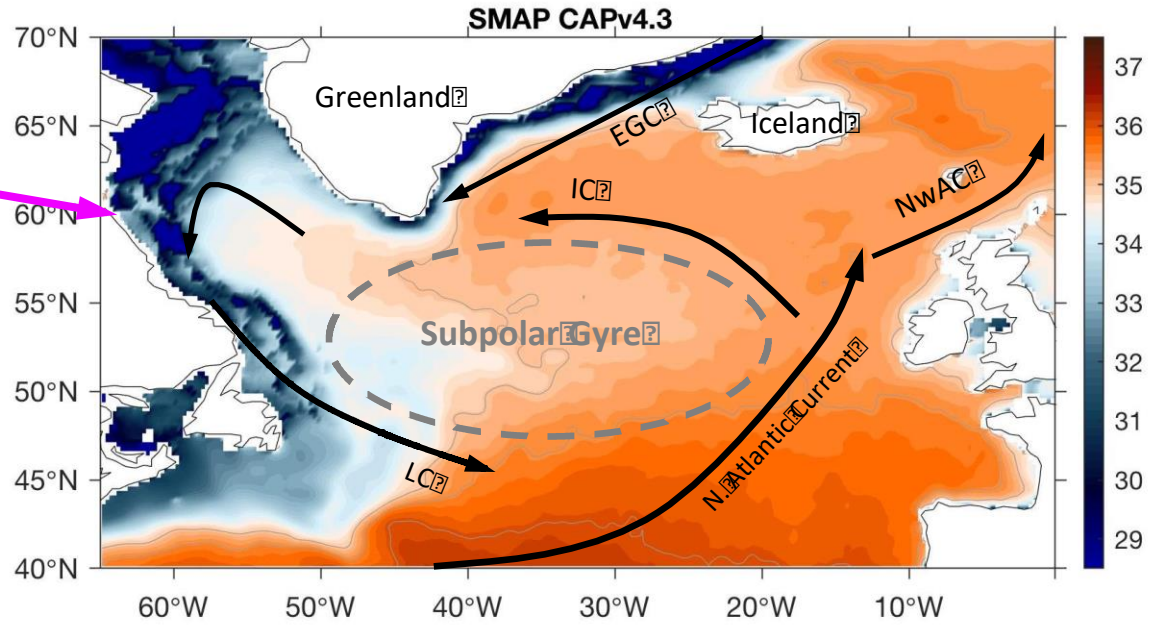
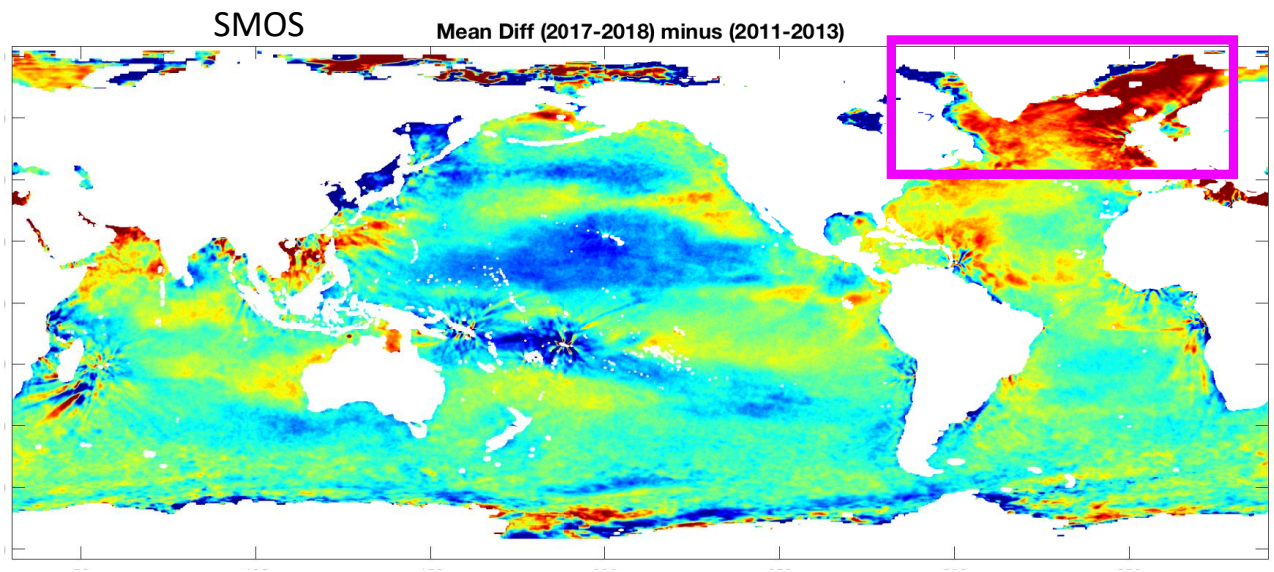


Figure taken from "**Intensification of the Global Water Cycle and Evidence from Ocean Salinity: A Synthesis Review**" by L. Yu, S. Josey, F. Bingham, & T. Lee.

A special issue on "The Year in Climate Science Research: Water Cycle and Climate Change" by *The Annals of the New York Academy of Sciences*.

EGC: East Greenland Current; IC: Irminger Current;
LC: Labrador Current; NwAC: Norwegian Atlantic Current

Questions, Objective, and Method



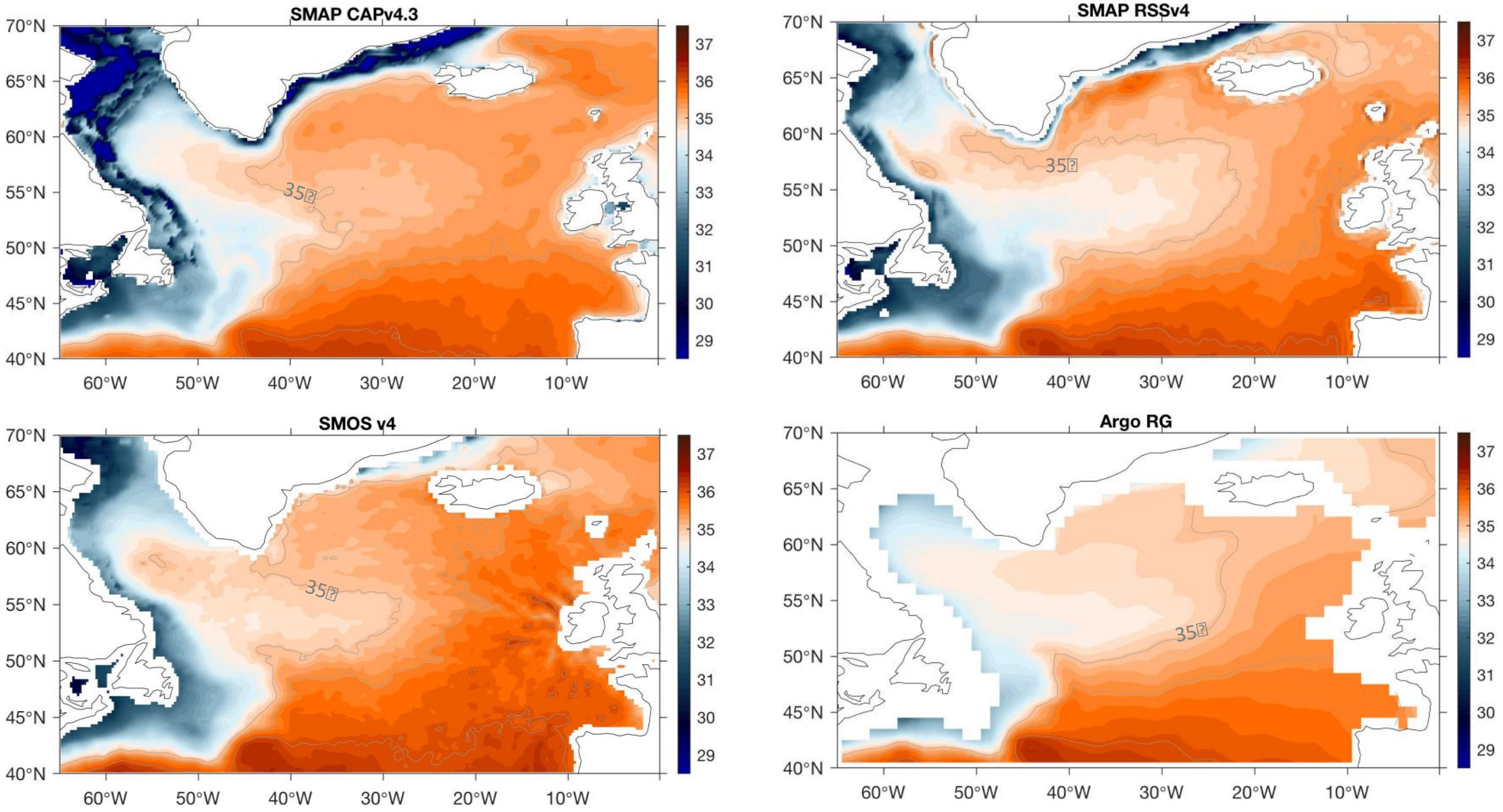
SSS products used in this analysis:

- SMOS v4
- SMAP CAP v4.3
- SMAP RSS v4
- Argo JAMSTEC
- Argo Scripps (Roemmich and Gilson)
- EN4

- The 10-year observations of SMOS reveal several large-scale changes of SSS pattern in all basins.
- Some signals, such as the SSS salinification in the subpolar North Atlantic, are in sharp contrast to the changes of the E-P pattern.
- The relationship between E-P and SSS is not linear. A better understanding of the inconsistency between E-P and SSS changes can help improve the understanding of the ocean-rain gauge concept.
- But first, are the SSS change signals real? How accurate are satellite SSS products in the subpolar North Atlantic?

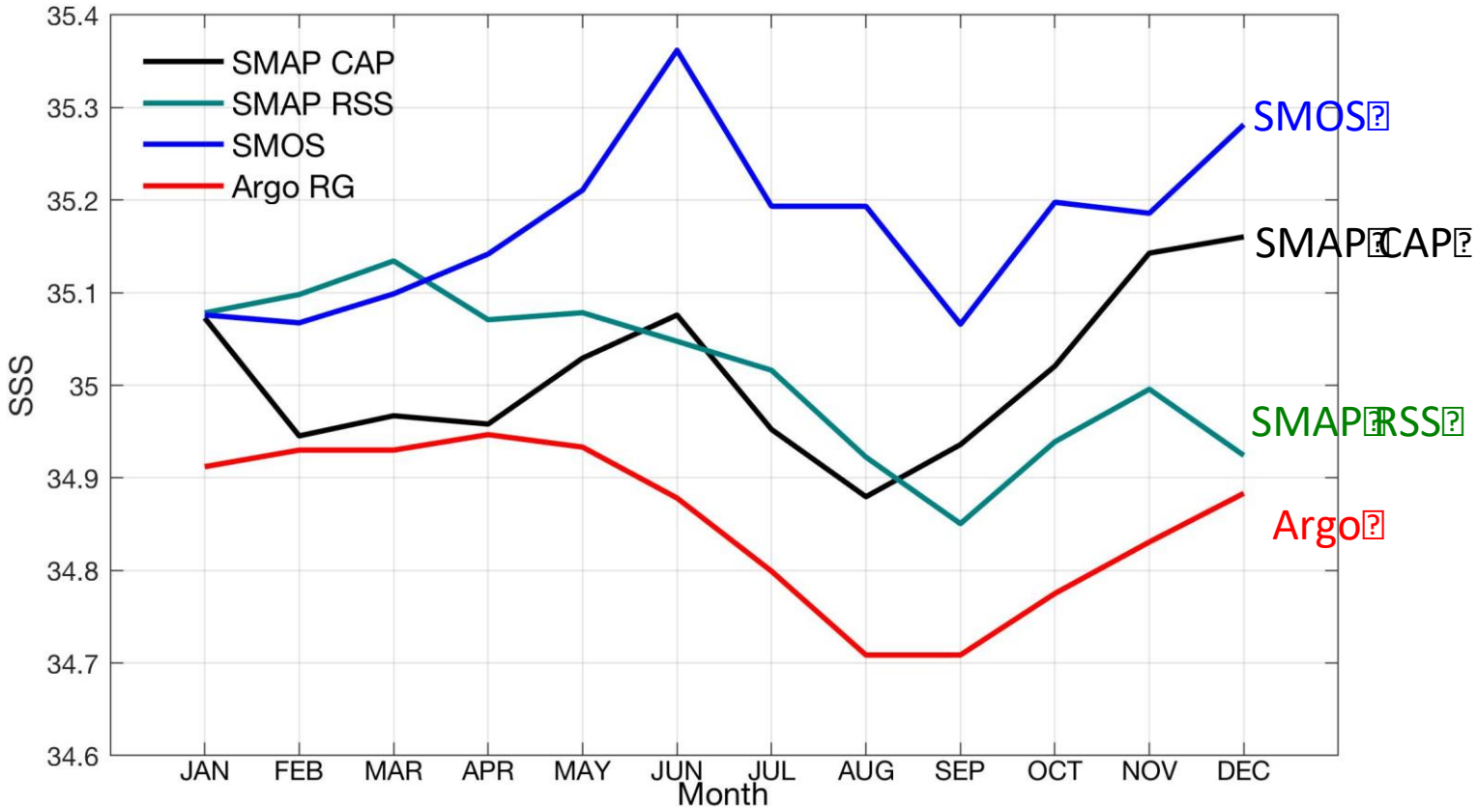
3-Year Mean SSS from 4 products: 2016-2018

Used all grids that have SSS values. Some grids have values only in summer.



Seasonal cycle of SSS: What is the “right” seasonal cycle?

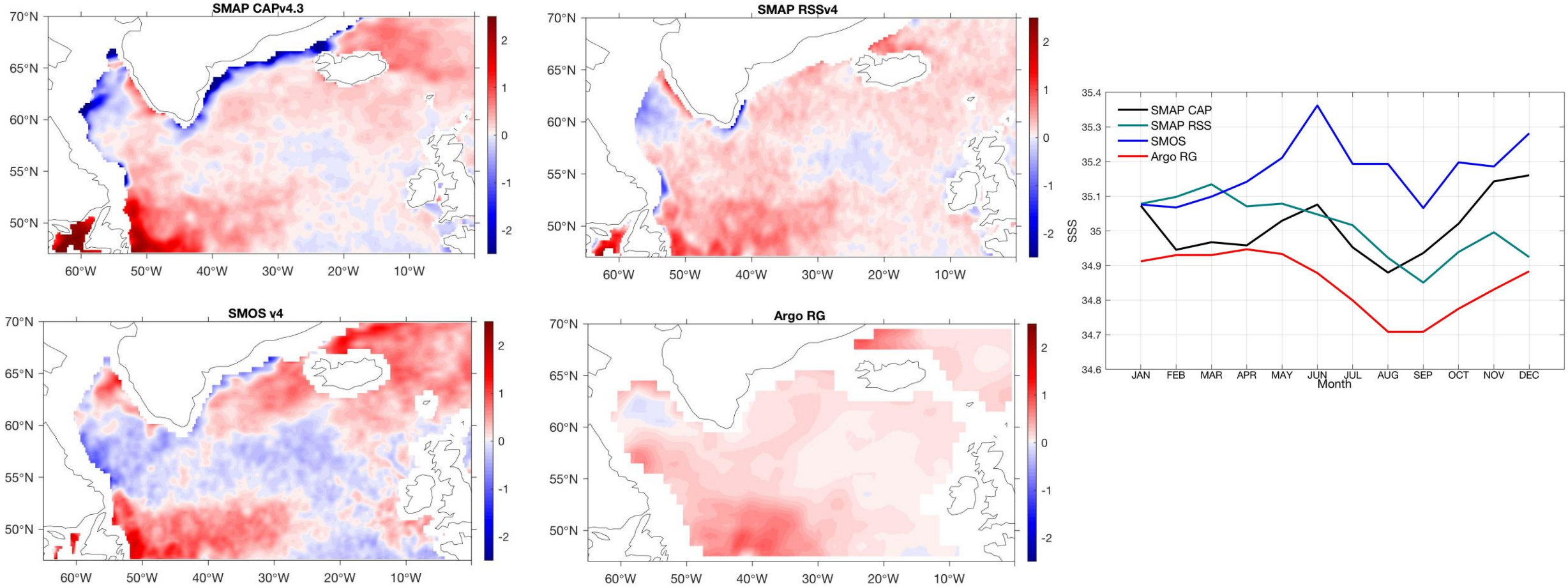
Averaged over permanent ice-free grid points in each product



- SMAP CAP and SMO have a similar semi-seasonal cycle:
  two maxima (Jun, Dec) and two minima (Feb, Aug or Sept)

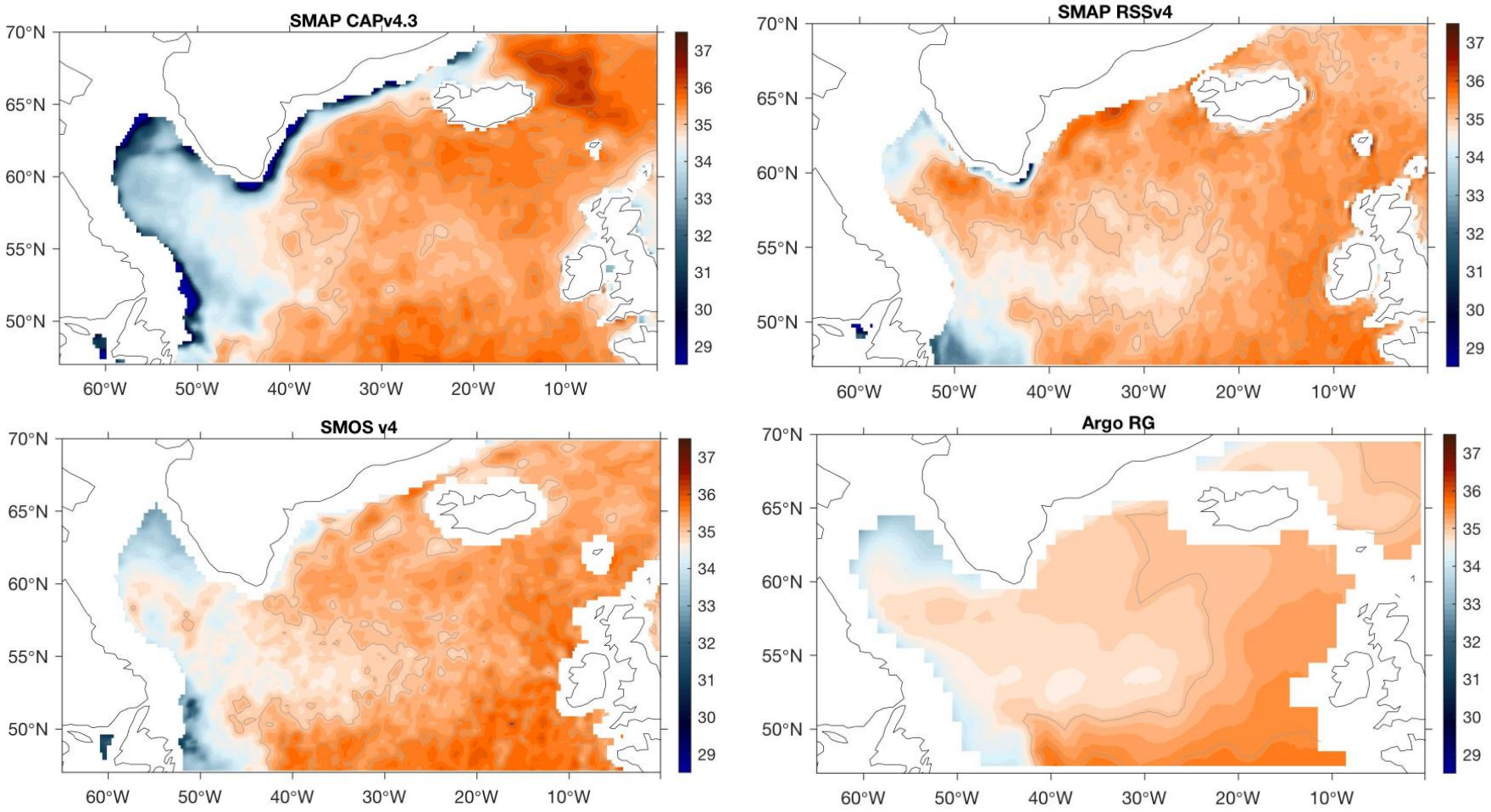
- SMAP RSS and Argo have a similar annual cycle:
  one maximum (Mar or Apr) and one minimum (Aug or Sept)

Seasonal differences: (May-June) – (Aug-Sep)



- SMAP CAP and SMOS have more SSS retrievals near the coasts, where the fresher waters locate.
- **The SSS seasonal lows are highly sensitive to the SSS retrievals associated with the Labrador Current and the east Greenland Current**

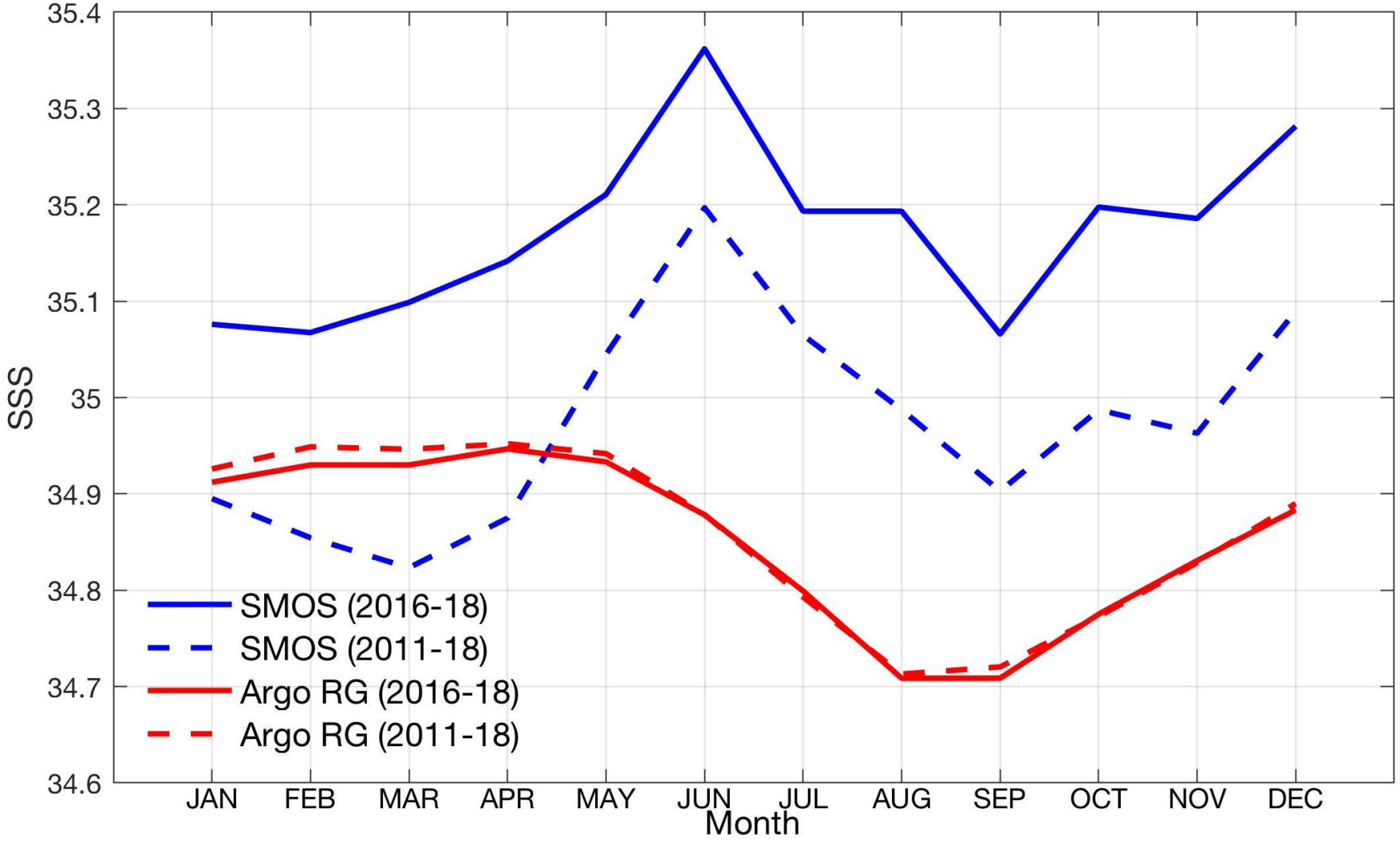
Comparison of SSS Mean in February



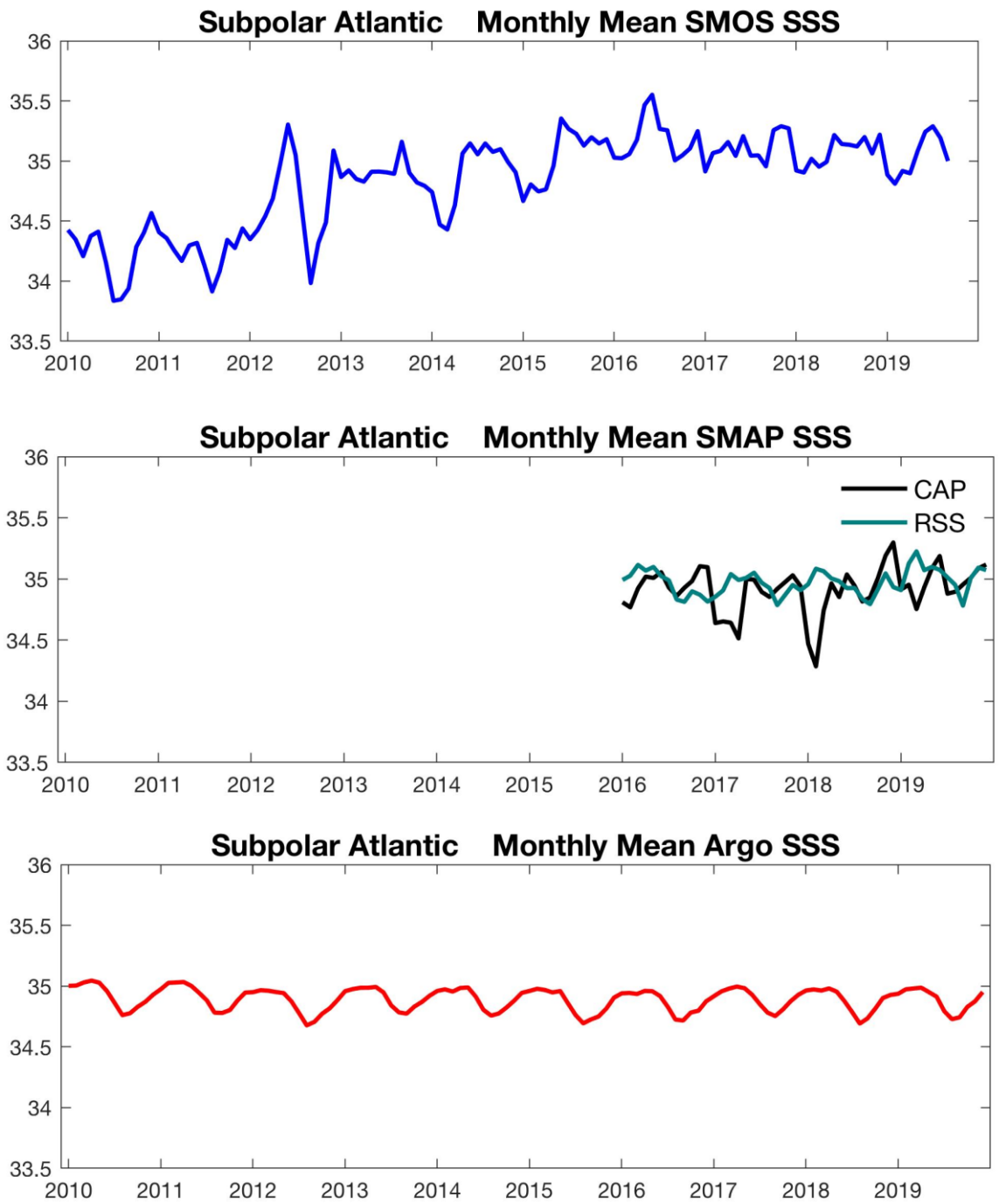
- SMAP CAP provides more low SSS retrievals near the Greenland coast and in the Labrador Sea.

Would the seasonal cycle be modified if using a longer average period?

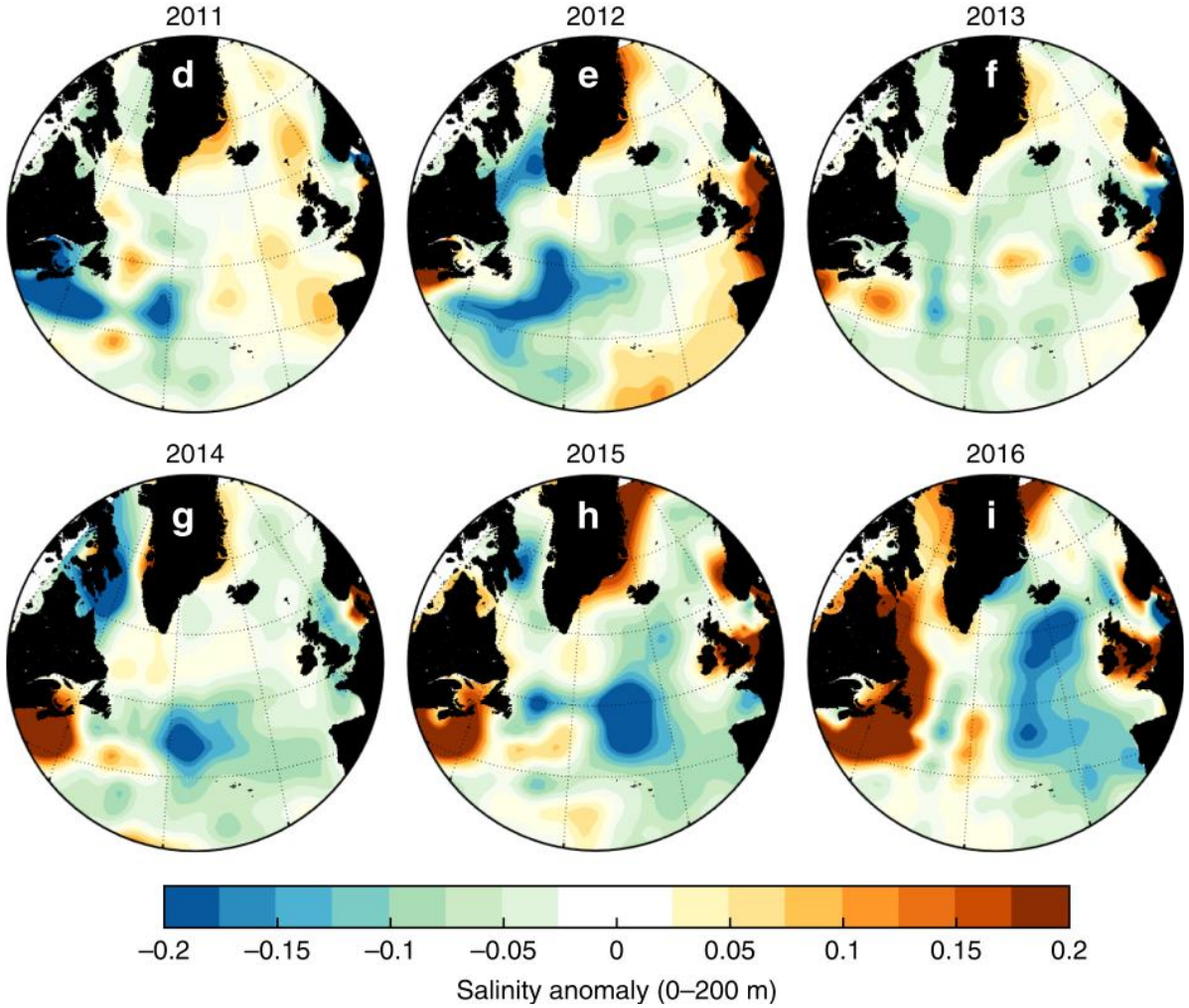
8-year Mean (2011-18) vs 3-year Mean (2016-18)



Interannual Variability

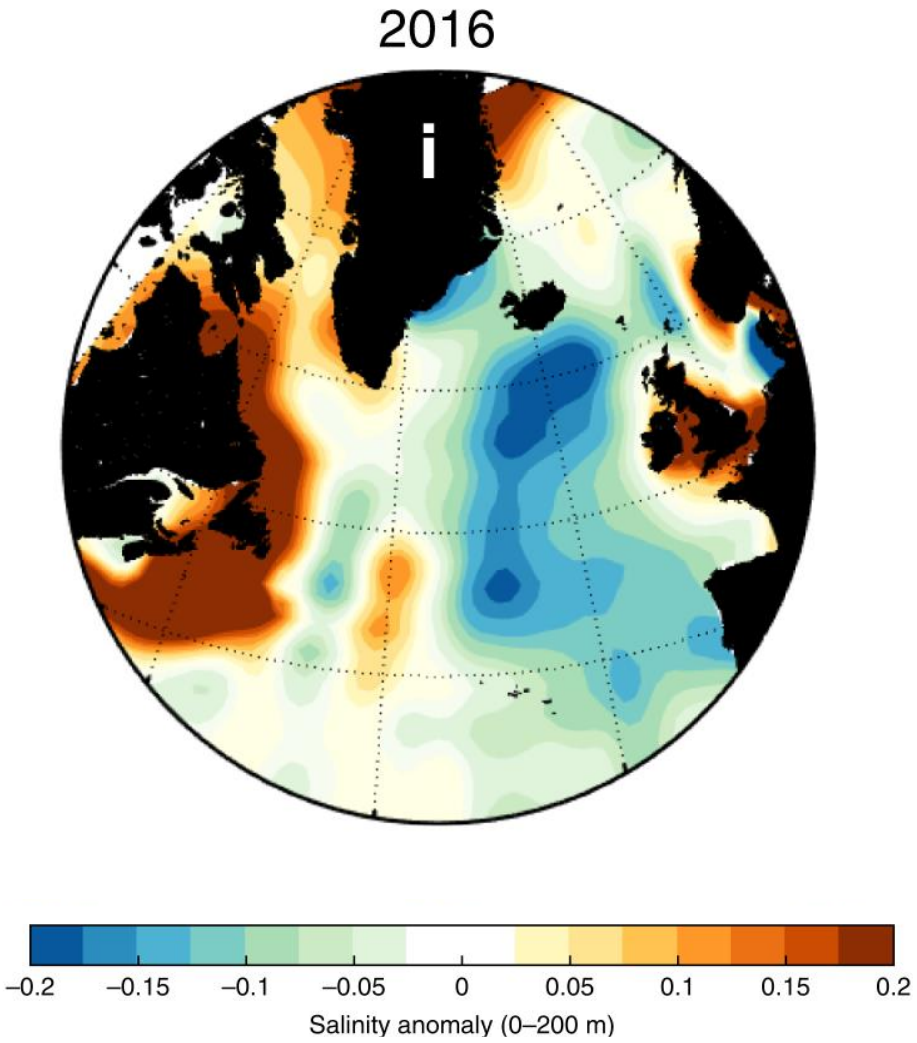


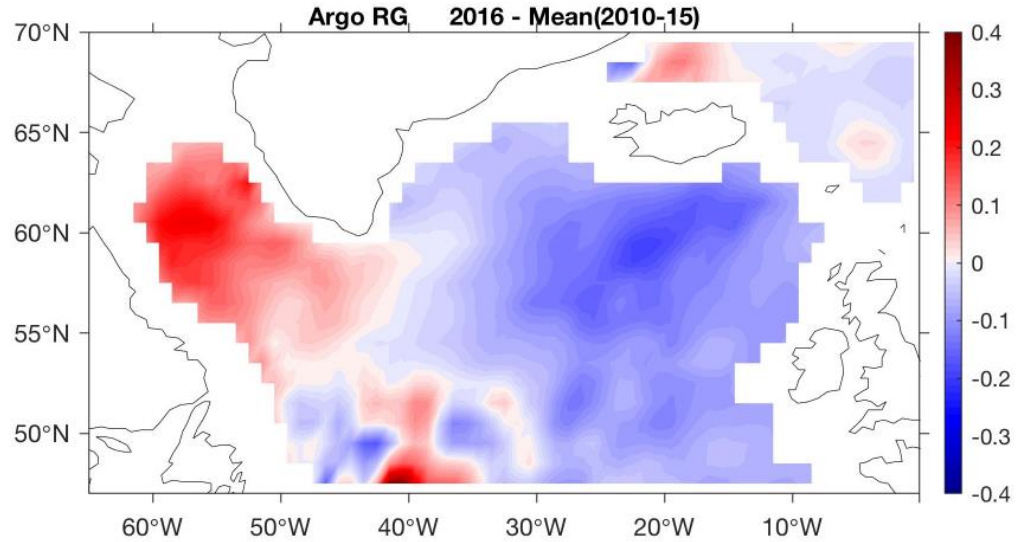
The eastern subpolar North Atlantic underwent extreme freshening during 2012 to 2016 with a magnitude never seen before in 120 years of measurements - *Holliday et al. (2020)*

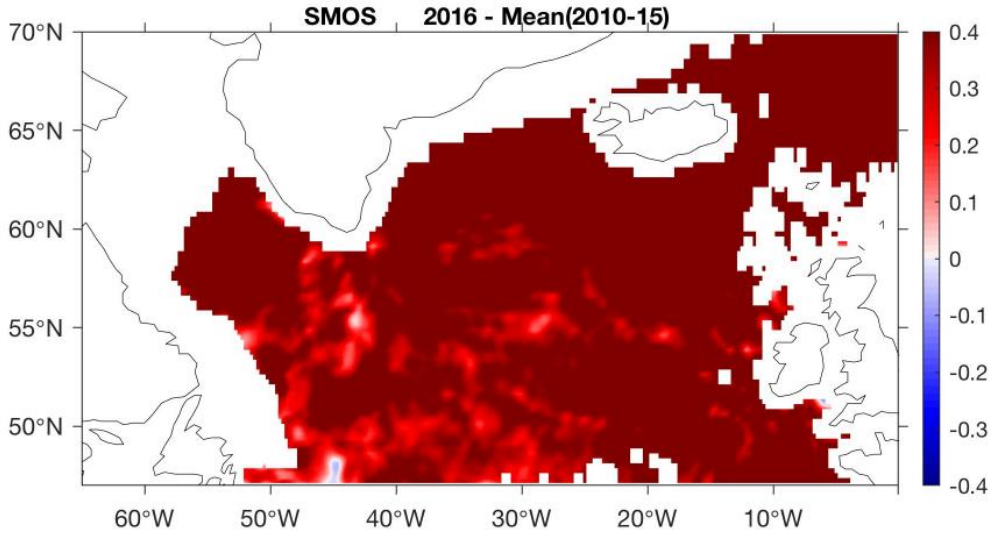


Can we see that from SMOS and SMAP SSS products?

Reference to the 2010-2015 mean

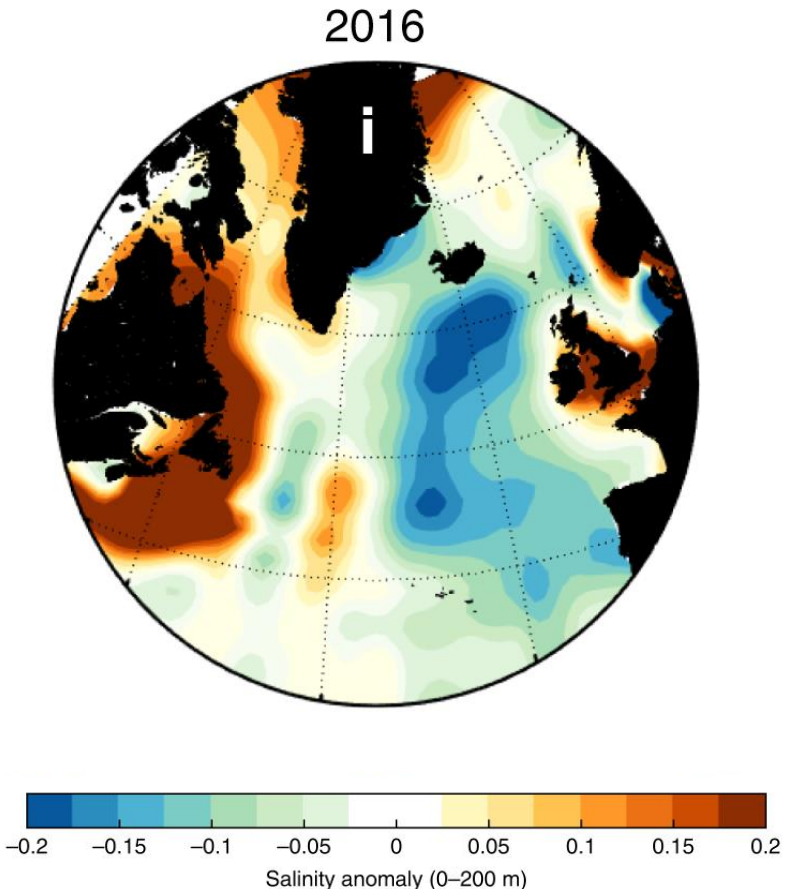


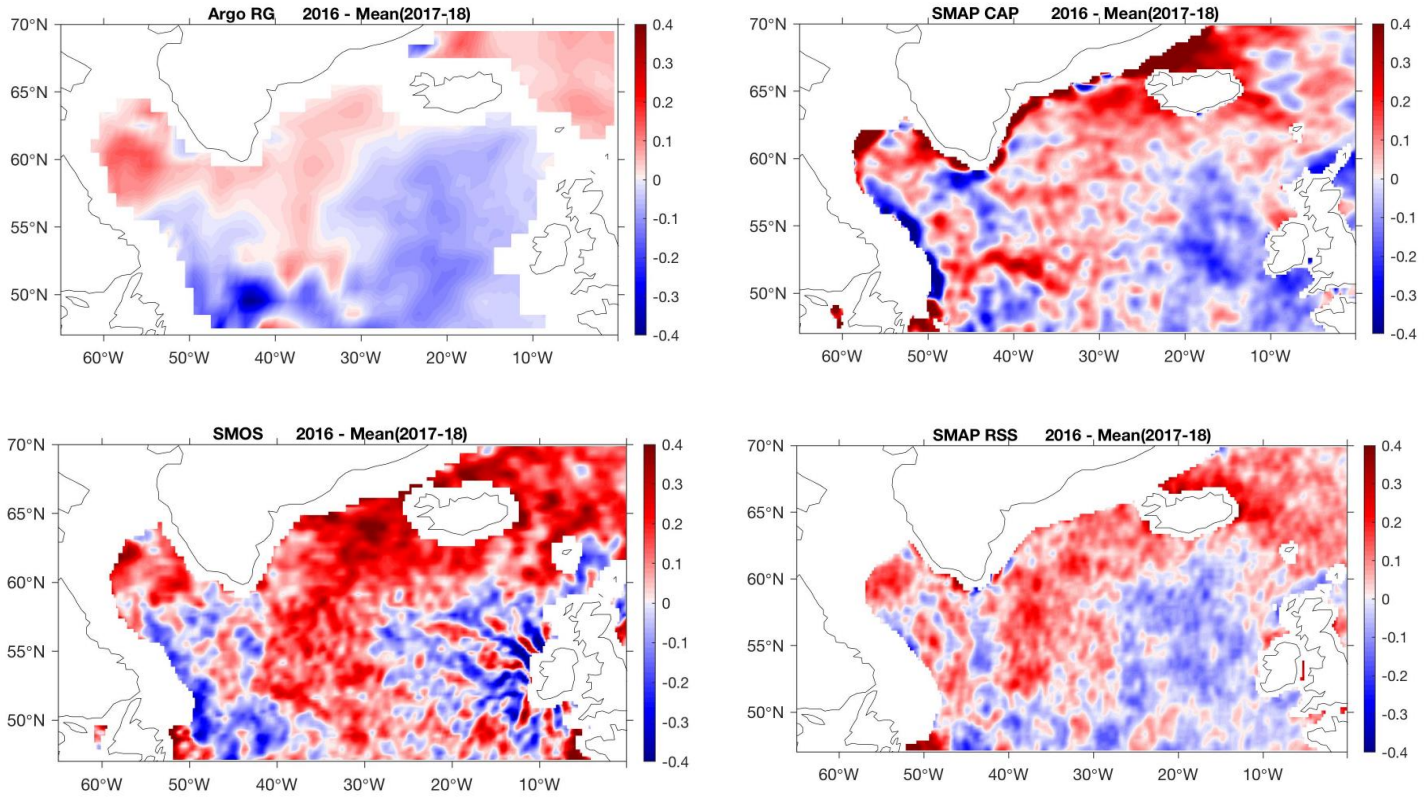




Reference to the 2005-2016 mean

Reference to the 2017-18 mean

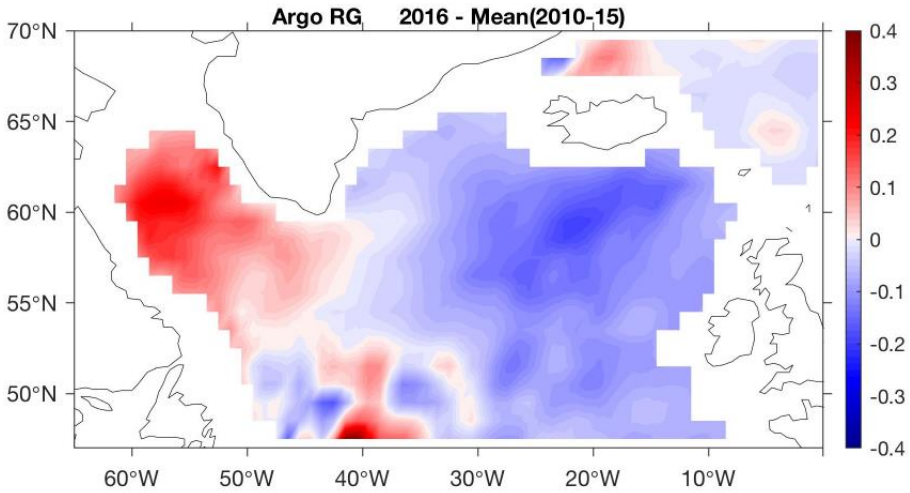


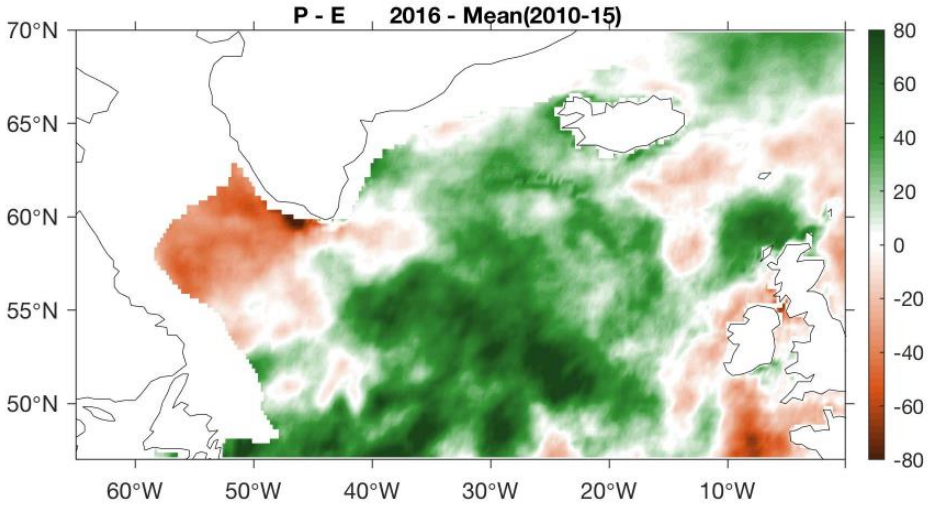


Reference to the 2005-2016 mean

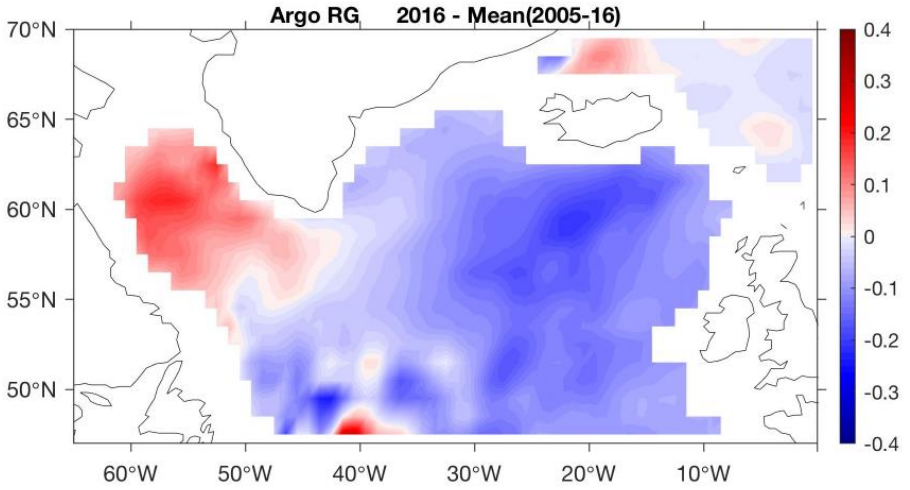
Changes in P – E Flux

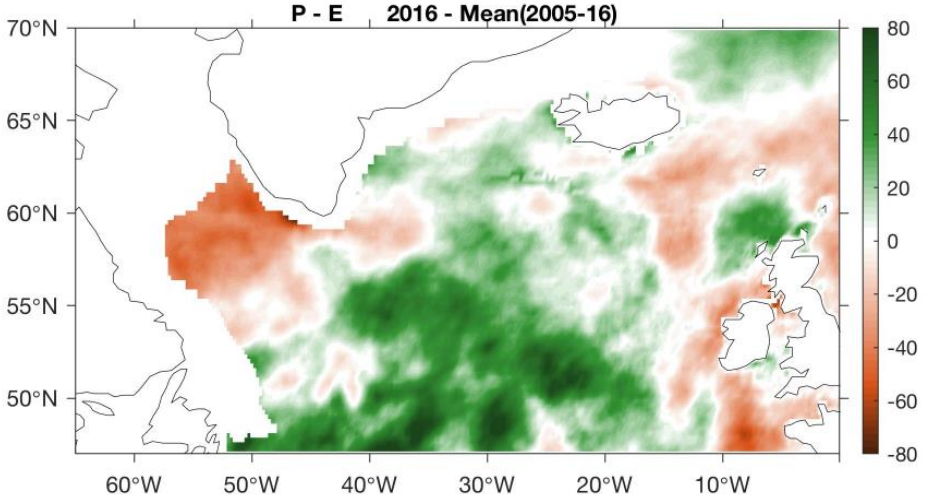
Reference to
the 2010-15 mean





Reference to
the 2005-16 mean

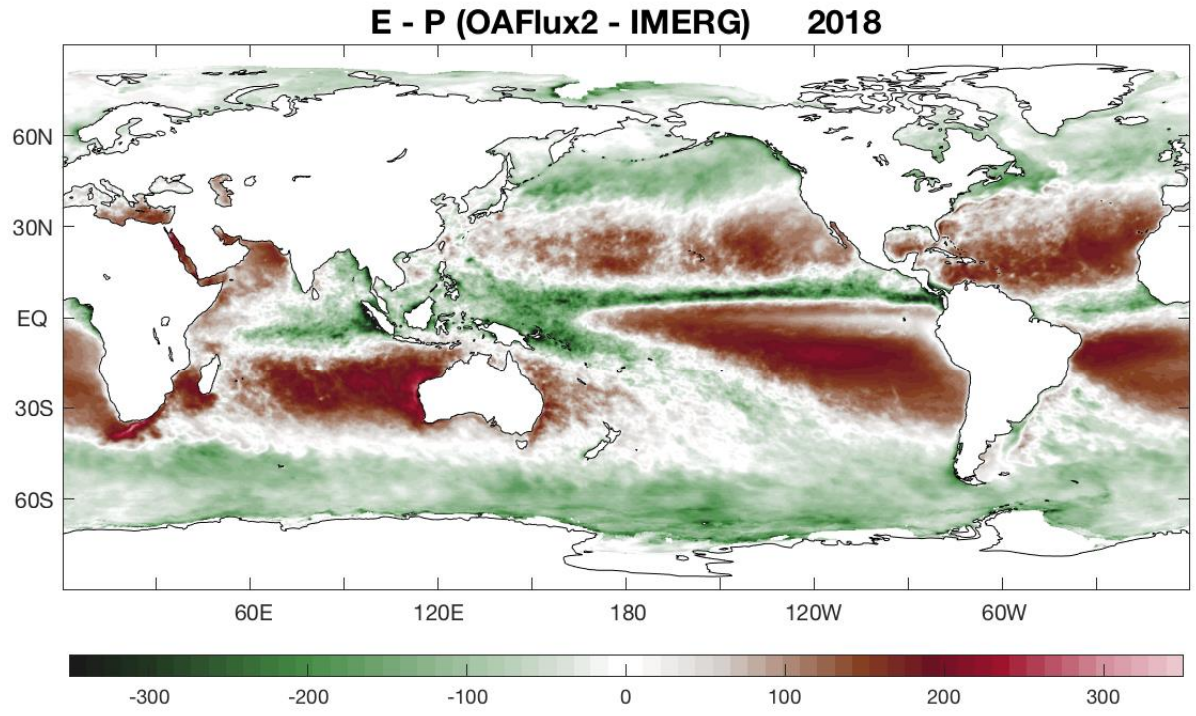




Atmospheric freshwater input is a major source of the upper-layer freshening in the subpolar North Atlantic.

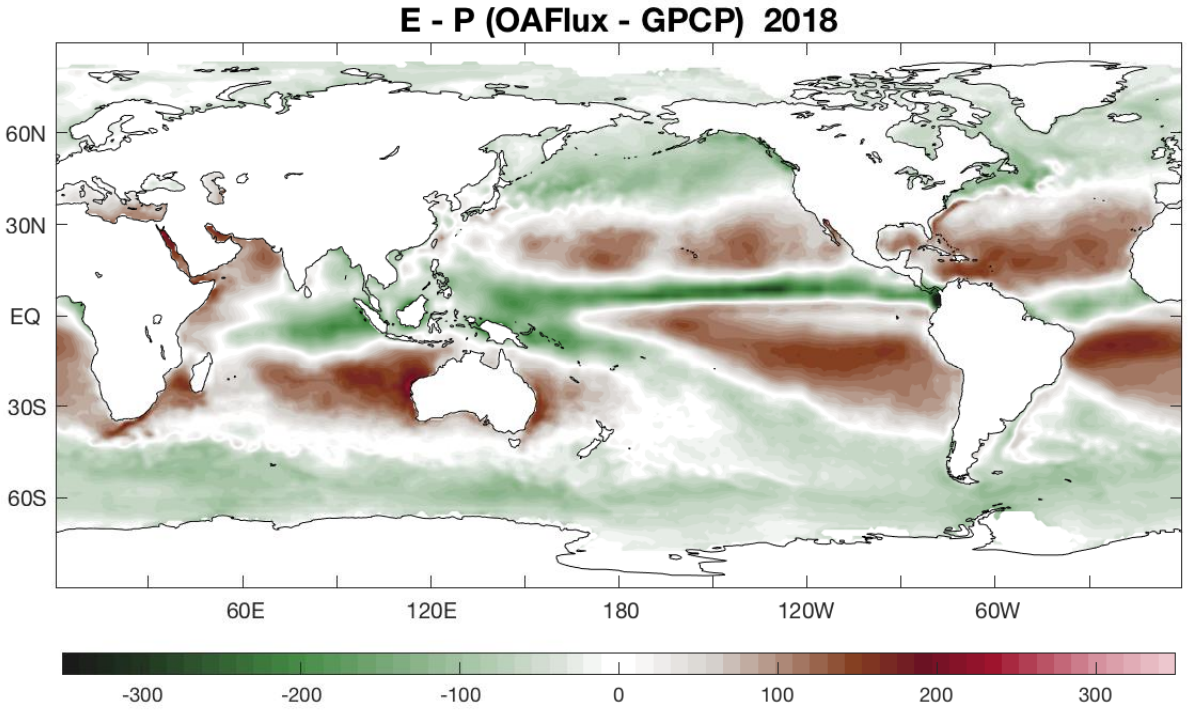
Ongoing: New High-resolution E-P product

New



0.25 X 0.25 spatial resolution, daily

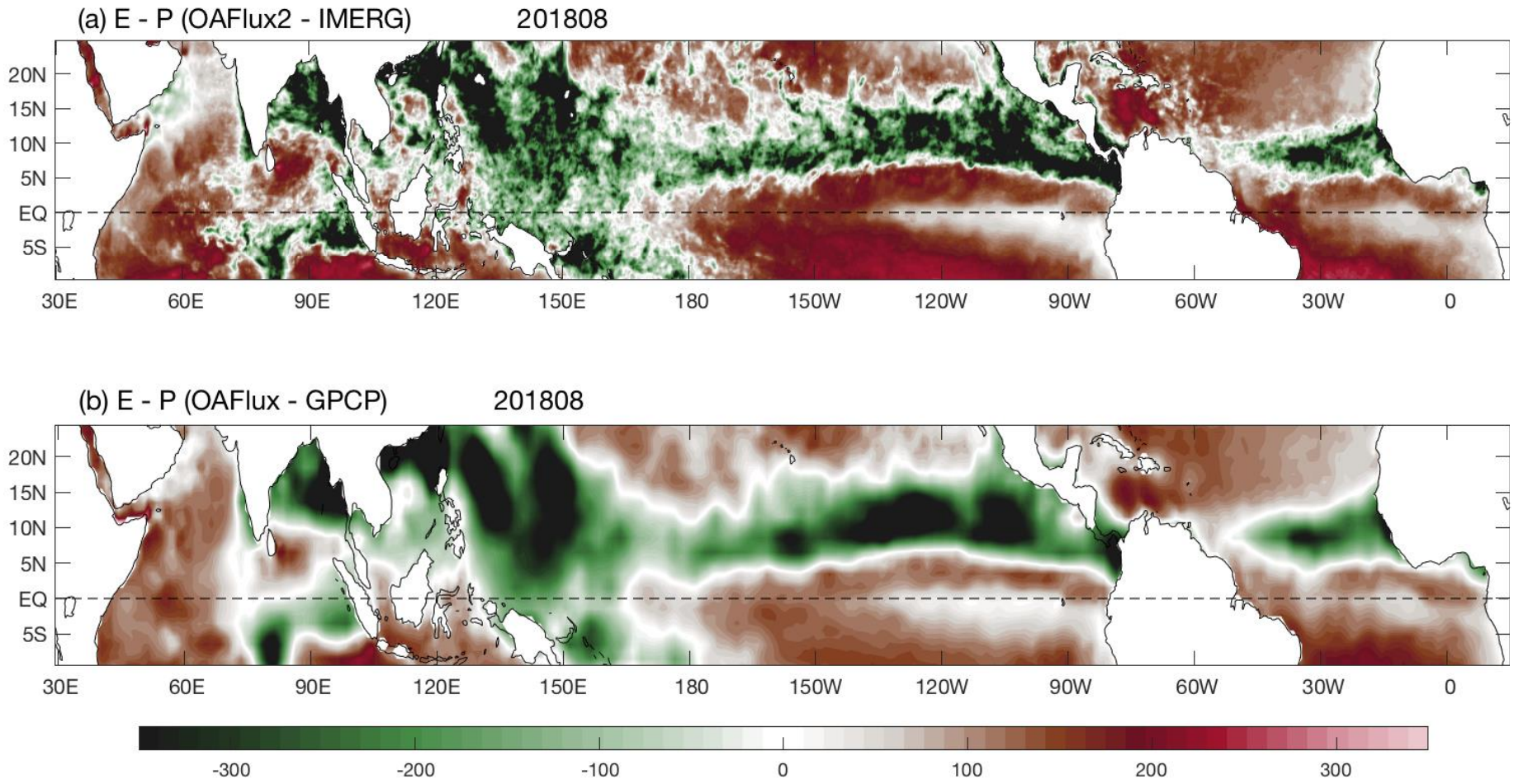
Existing



1x1 spatial resolution, monthly

Differences in monthly mean E-P fields: Resolution matters!

Narrower (E-P) minimum zone and more spatial variability



Summary

- We evaluated the mean and variability of 6 SSS products in the subpolar North Atlantic.
- Mean: The products differ in the low SSS retrievals near the Greenland coast and in the Labrador Sea
- Seasonal Cycle: The products differ vastly in seasonal pattern. It is not yet clear whether SSS possesses a semi-annual cycle (SMAP CAP and SMOS) or annual cycle (SMAP RSS and Argo)
- Internannual Variability: SMOS has a major drift
- The 2016 extreme freshening event: SMOS is not able to depict the event. The change of the P-E pattern indicates that atmospheric freshwater input is a major source of the low-salinity event.
- A new high-resolution E-P product is in preparation. This product provides greater details about freshwater variability from meso and frontal scales to basin scales, allowing the examination of the response of SSS to the E-P forcing on various scales.