Arctic+ Salinity

AO/1-9158/18/I-BG

Arctic+ Salinity

Polar Science Collocation Meeting

16 September 2021

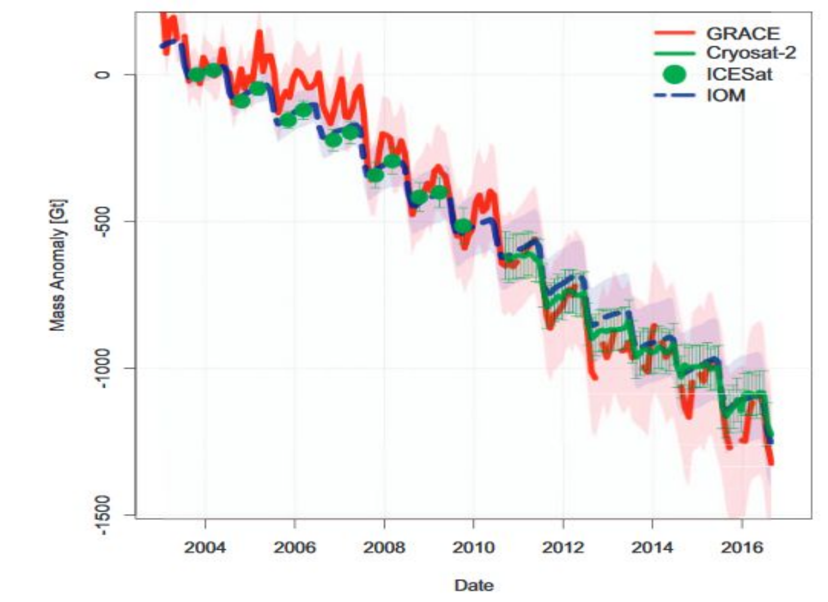
Carolina Gabarró, Justino Martinez, Antonio Turiel (BEC- ICM-CSIC)
Laurent Bertino, Roshin P. Raj, Jiping Xie (NERSC)
Rafael Catany, Manuel Arias (ARGANS)

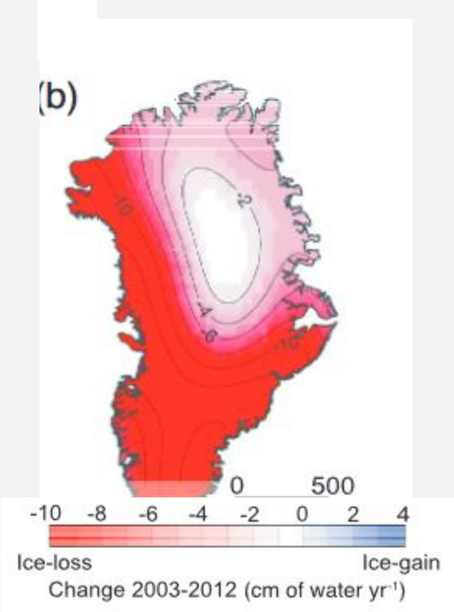
Arctic changes: Increase of freshwater

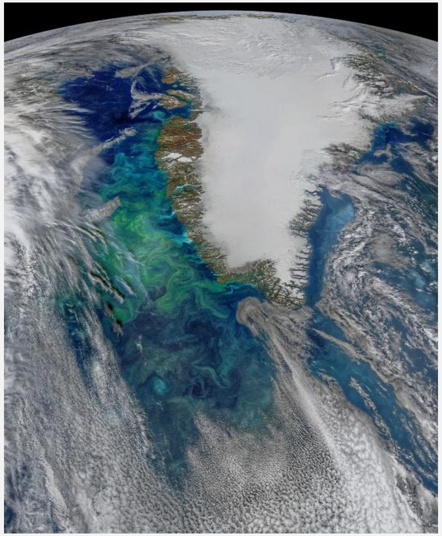
Arctic+ Salinity

Glaciers & Greenland | Sea ice | River discharge | P-E | Ocean Transport

- Ice mass loss from Glaciers & Greenland.







August 2019

Bamber et al. 2018

IPCC AR5, 2014

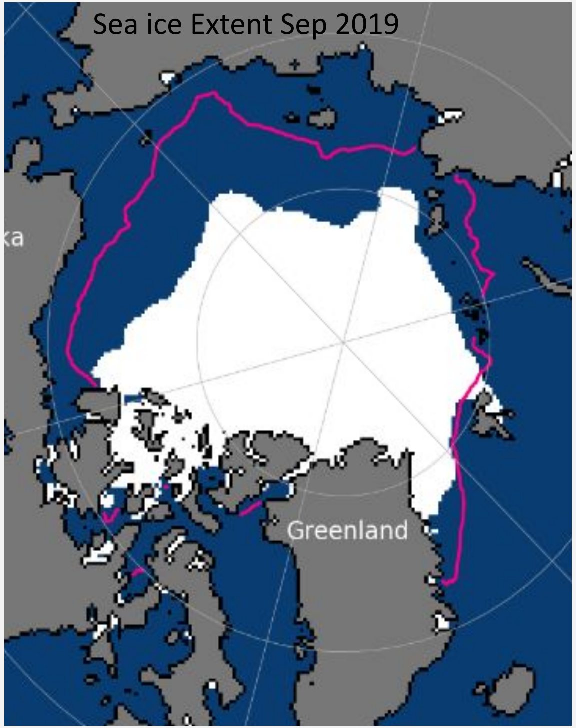
NASA

Arctic changes: Increase of freshwater

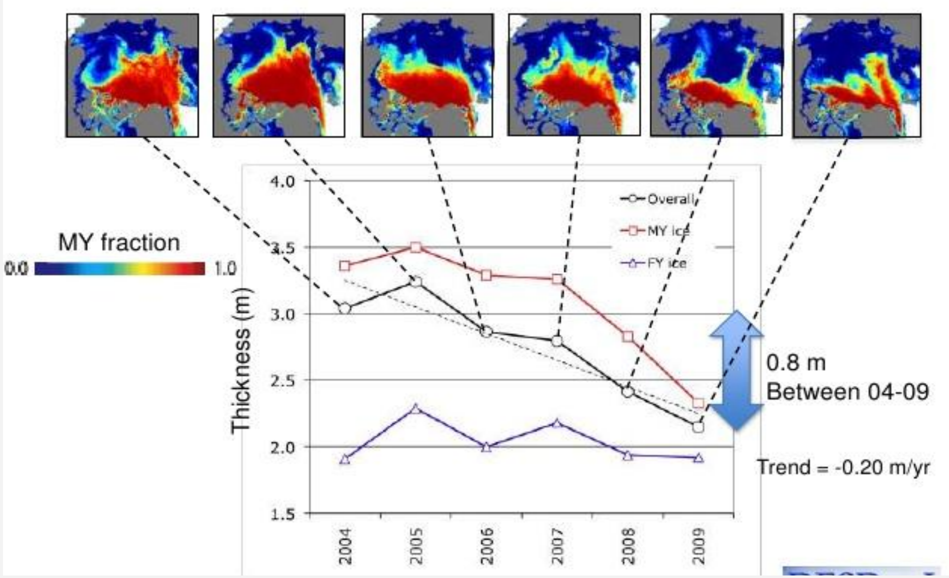
Arctic+ Salinity

Glaciers & Greenland | **Sea ice** | River discharge | P-E | Ocean Transport

- Sea ice decrease



NSIDC, 2019



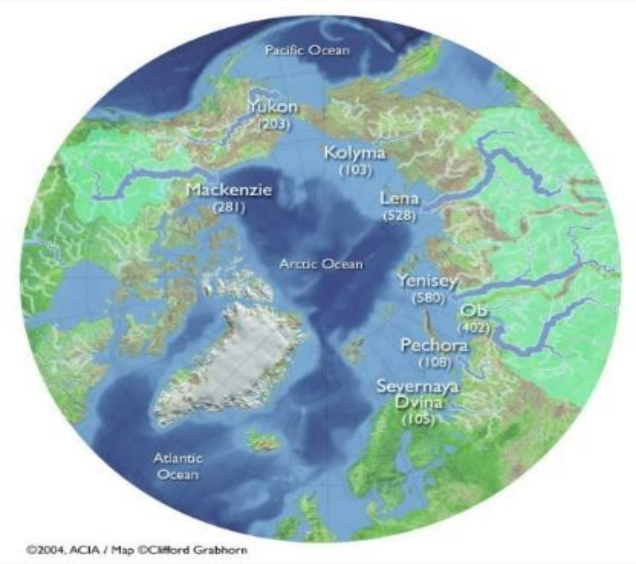
Kwok et al., 2009

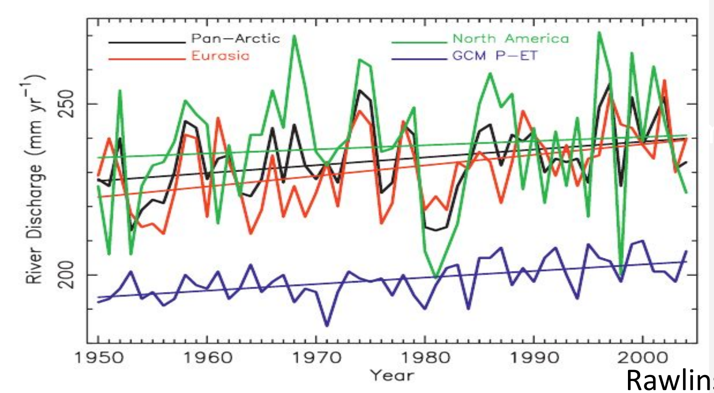
Arctic changes: Increase of freshwater

Arctic+ Salinity

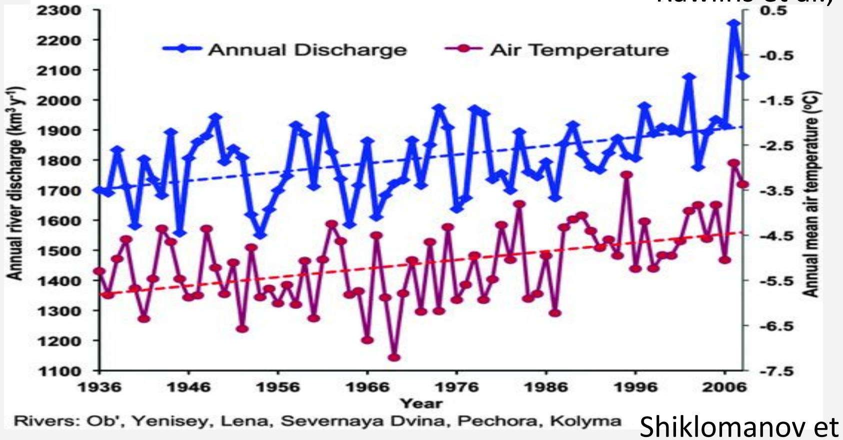
Glaciers & Greenland | Sea ice | **River discharge** | P-E | Ocean Transport

- 10% increment on river discharge with respect the mean in 1980-1989 (Arctic report card, 2015).





Rawlins et al., 2010



Shiklomanov et al., 2013

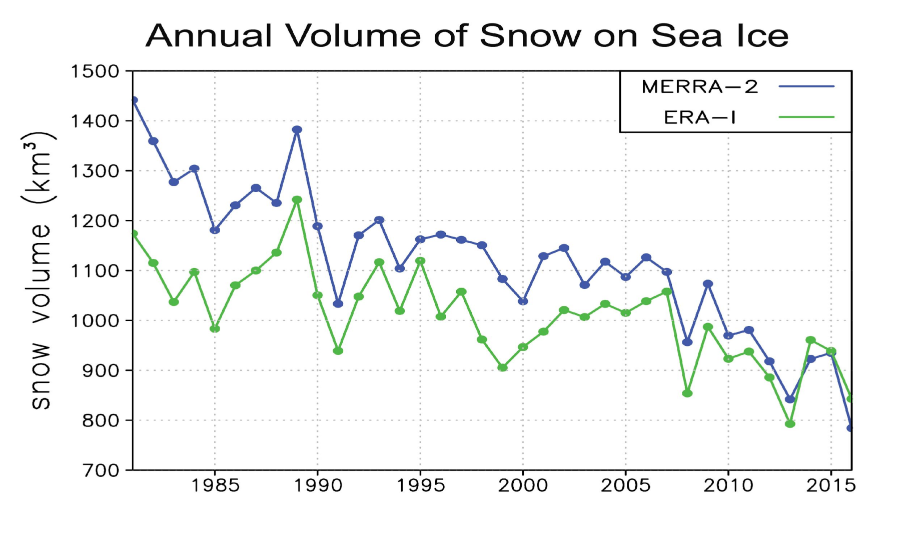
Arctic changes: Increase of freshwater

Arctic+ Salinity

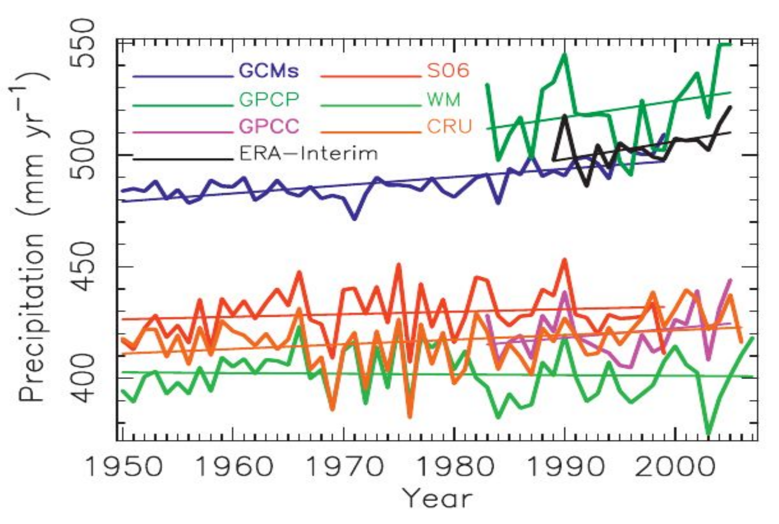
Glaciers & Greenland | Sea ice | River discharge | **P-E** | Ocean Transport

- **Less snow precipitation:** in summer a decrease of 40%
- **Increase of net precipitación at high latitudes in rain**:

McClelland et al 2006 y Haine et al 2015 state that it could increase 30% en 2100.



Stroeve, NSIDC, 2019



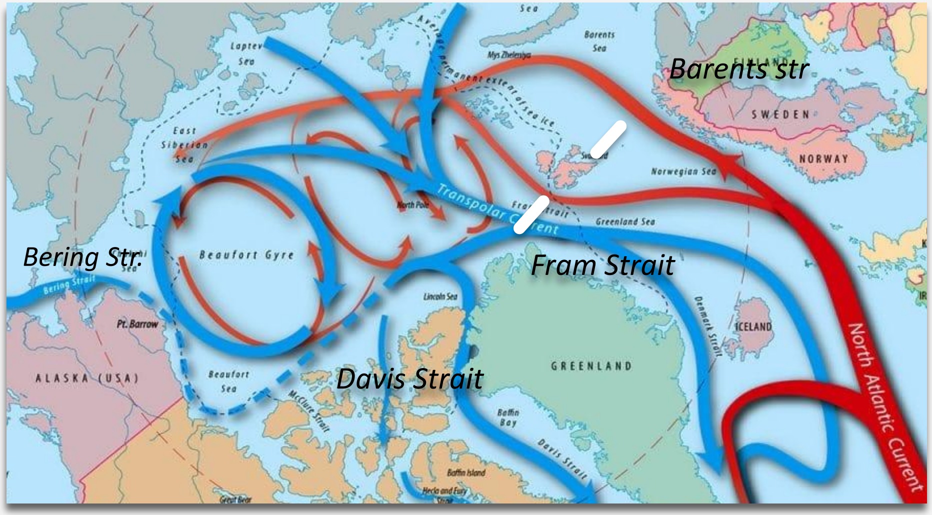
Rawlins et al., 2010

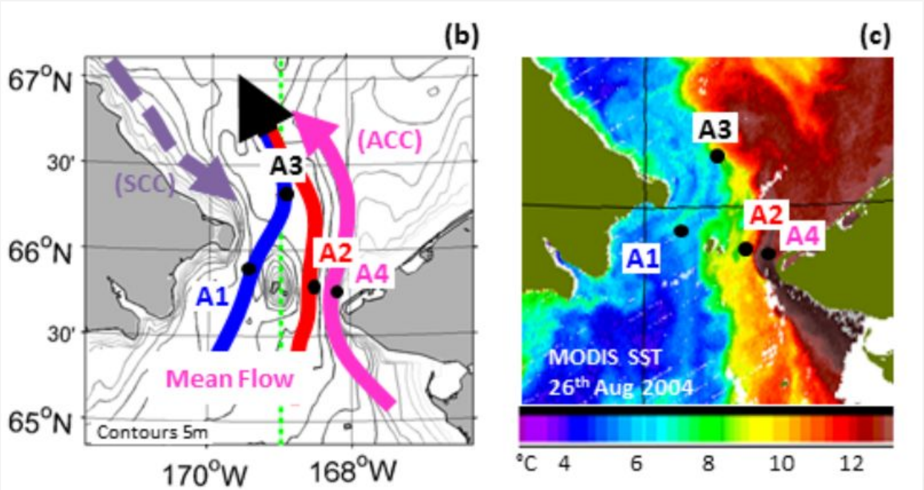
Arctic changes: Increase of fresh water

Arctic+ Salinity

Glaciers & Greenland | Sea ice | River discharge | P-E | **Ocean Transport**

- **Freshwater import increase by the Bering strait to Arctic** (Woodgate et al., 2017, Wang et al, 2016).
- Reduction of exported water by Davis strait





Woodgate et al., 2017

Arctic changes: Increase of fresh water

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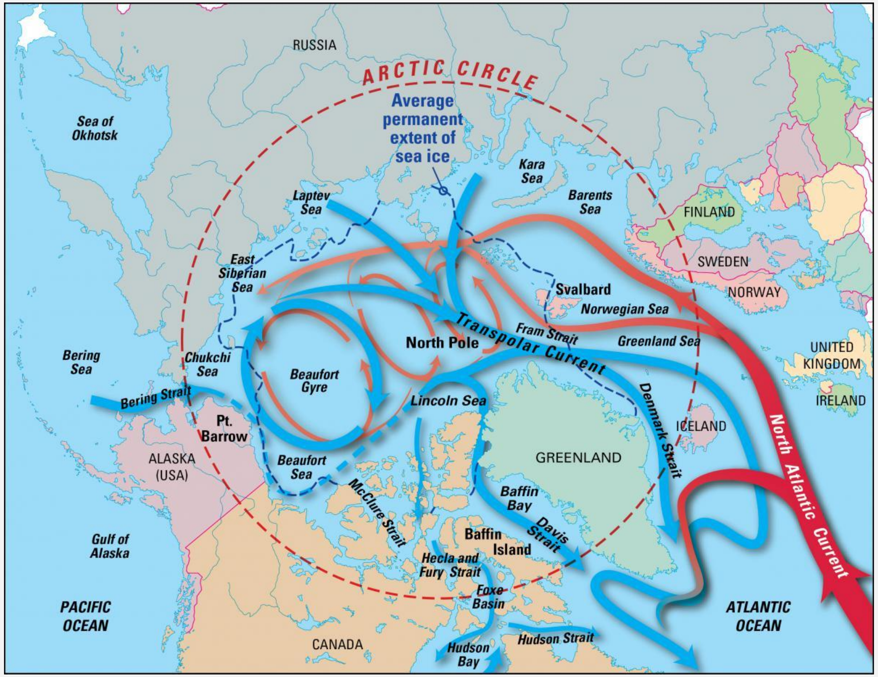
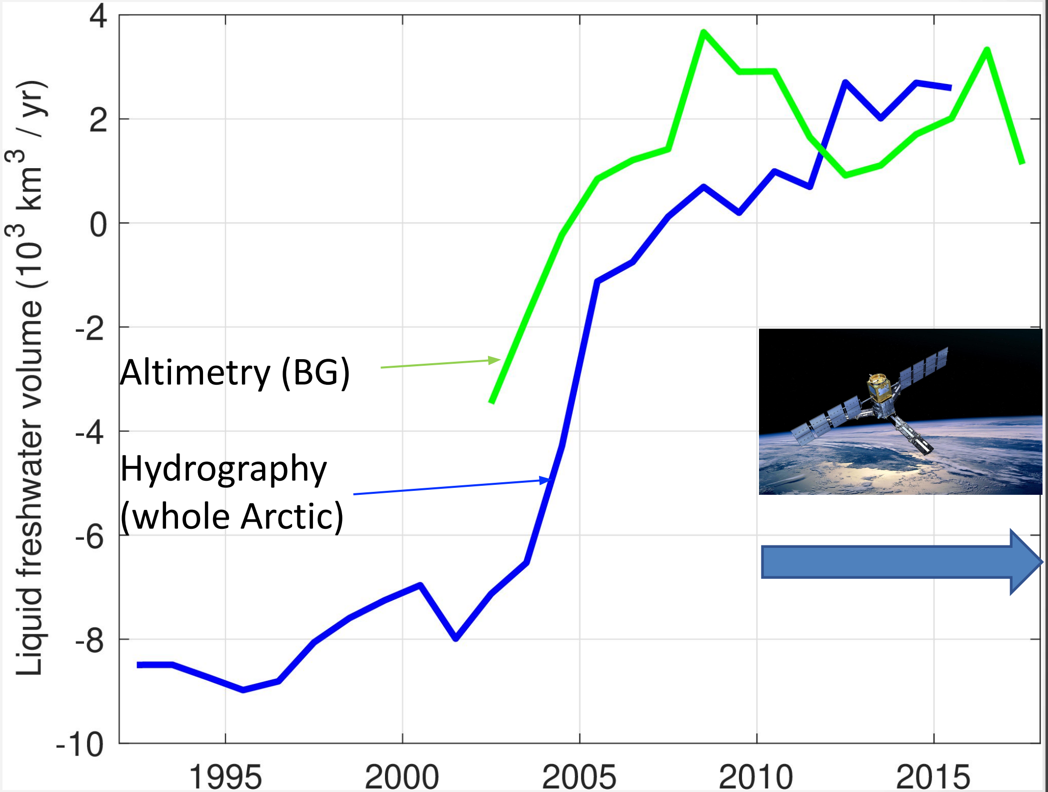
The SMOS context: 2010-2019 a decade of stable Arctic freshwater

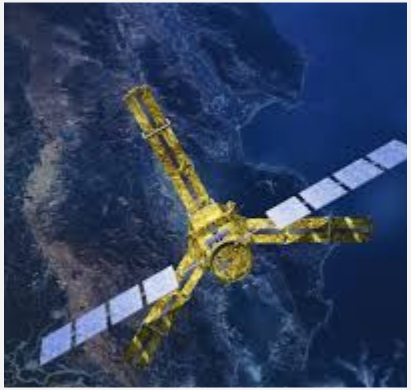


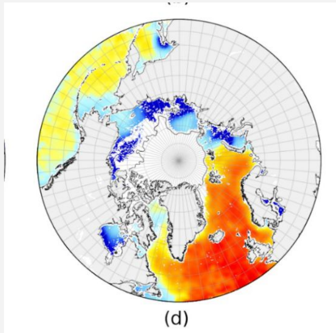


Solomon et al. (OS, 2021) https://doi.org/10.5194/os-17-1081-2021

Sea Surface Salinity Satellites Product- state of the art 2018

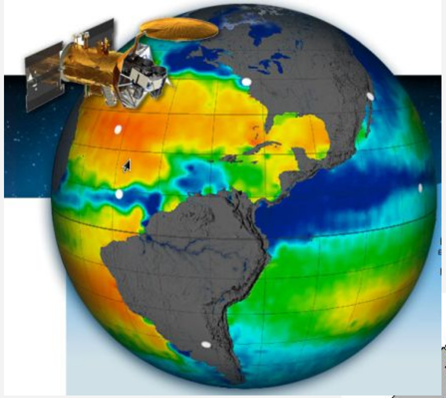
SMOS ESA
2009-now

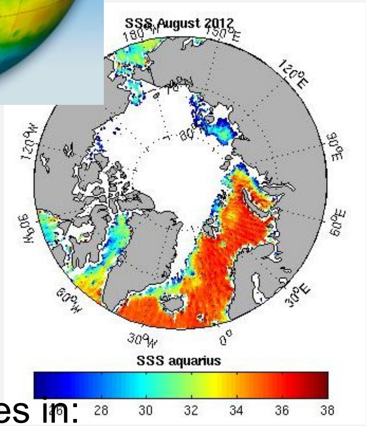




BEC dedicated product
Olmedo 2018

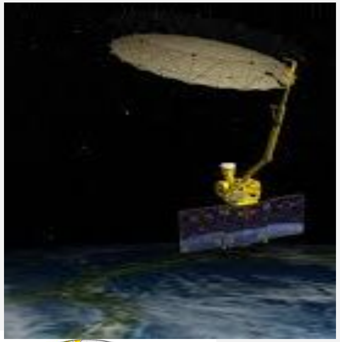
Aquarius NASA
2012-2015

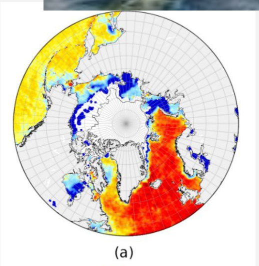




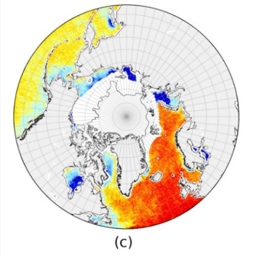
SSS high latitudes in:
https://nsidc.org/data/aq3_sss
Brucker, et al. 2015

SMAP NASA
2015 - now





JPL V4.2



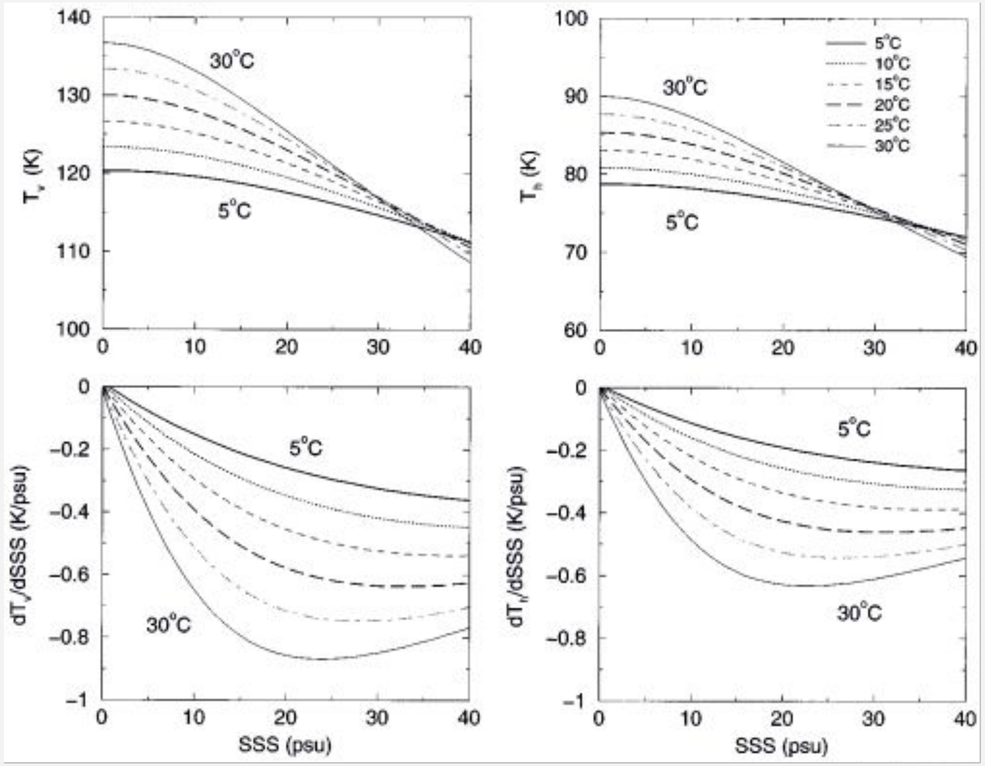
SMAP REMSS
V3.0

no Arctic
dedicated product

Challenges measuring Arctic Sea Surface Salinity

Arctic+ Salinity

- **Low sensitivity of TB to salinity at cold waters:** Therefore, the errors of the SSS at cold waters are larger than at temperate oceans.

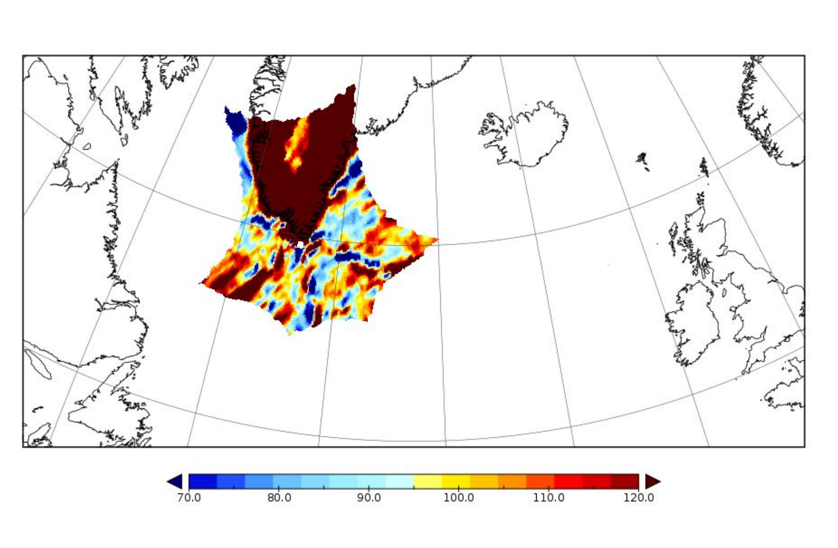


from Yueh et al, 2001, IEEE TGRS 39(5): 1049-1059

Challenges measuring Arctic Sea Surface Salinity

- **Low sensitivity of TB to salinity at cold waters:** Therefore, the errors of the SSS at cold waters are larger than at temperate oceans.

- **Land-sea contamination (LSC) and ice–sea (ISC) contamination:** The presence of a sharp discontinuity in brightness temperature due to the transition between sea and land or between sea and sea ice induces a contamination of the signal which is especially important in the case of SMOS although it is also present in SMAP and in its predecessor, Aquarius.



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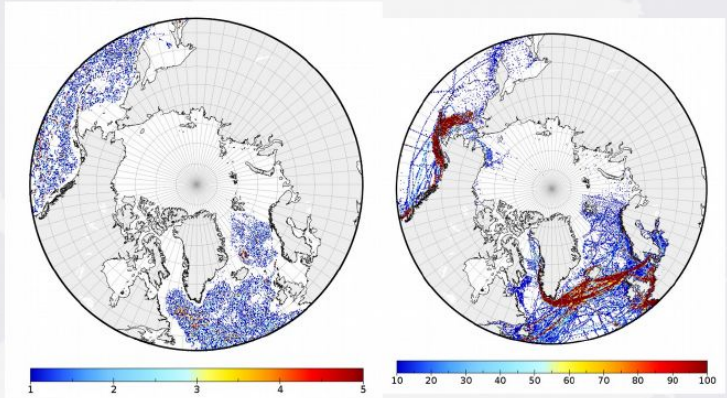
- **Lack of in-situ measurements:** Limitation for validation: Measurements are not equally distributed and lack of data in some regions. Limitation to carry out the temporal bias correction: since the method uses a daily reference of SSS, based in in situ.



left: Number of in-situ measures provided by delayed ARGO profilers.
Right: Number of measures by TSG provided by CEMES .
Data are grouped in a 0.25°x0.25° grid and comprise the whole period 2011-2017.

Challenges measuring Arctic Sea Surface Salinity

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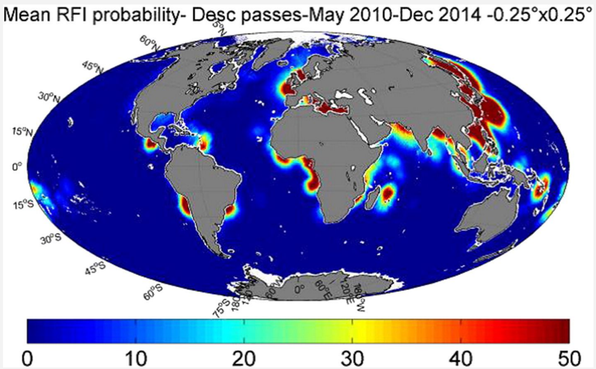
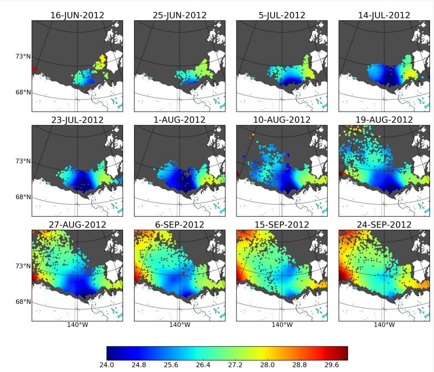
- **RFI: few effect on Arctic region**



Measuring Arctic Sea Surface Salinity

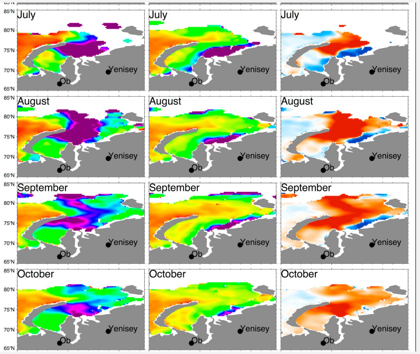
Arctic+ Salinity

SMOS - BEC v2.0



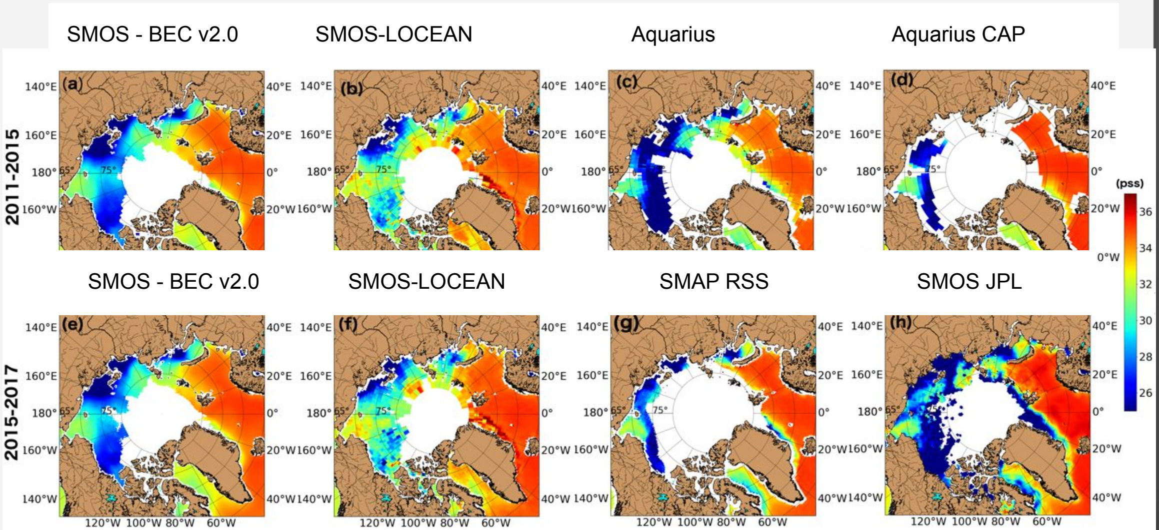
Olmedo et al., 2018

SMAP - JPL



Tang et al., 2018

Fournier et al. 2019 showed consistency between the different satellite products for describing large-scale SSS dynamics



Arctic+ Salinity

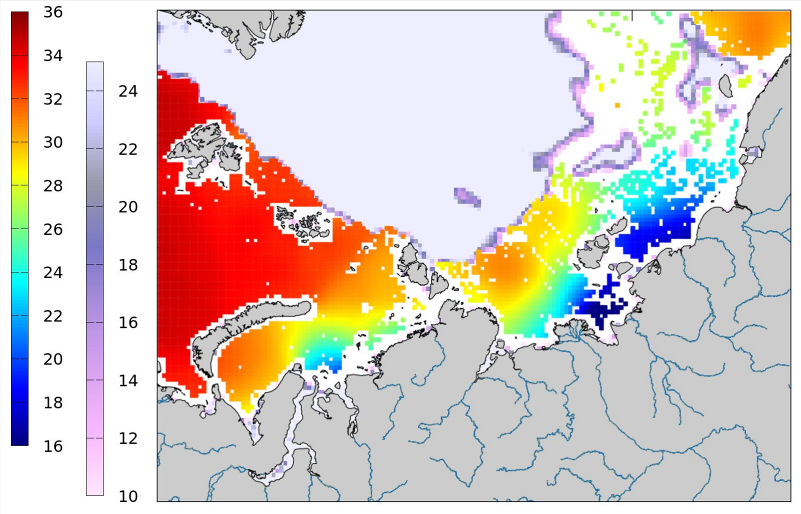
ESA initiative to improve the Arctic SMOS SSS products

Objective of Arctic+ Salinity ESA project

Objectives:

- **Produce an enhanced regional ARCTIC SSS product**
  - Increased number of valid retrievals within the Arctic region
  - Usability of the polar grid (EASE v2.0)
  - Better effective spatial resolution
  - Satellite (SMOS) data only, to minimize error uncertainty due to external data sources
- **Assimilation into TOPAZ models**
- Impact Assessment analysis
  - Correlation between SSS and CDOM in Arctic rivers
  - FWF regional analysis
  - Salinity trend changes

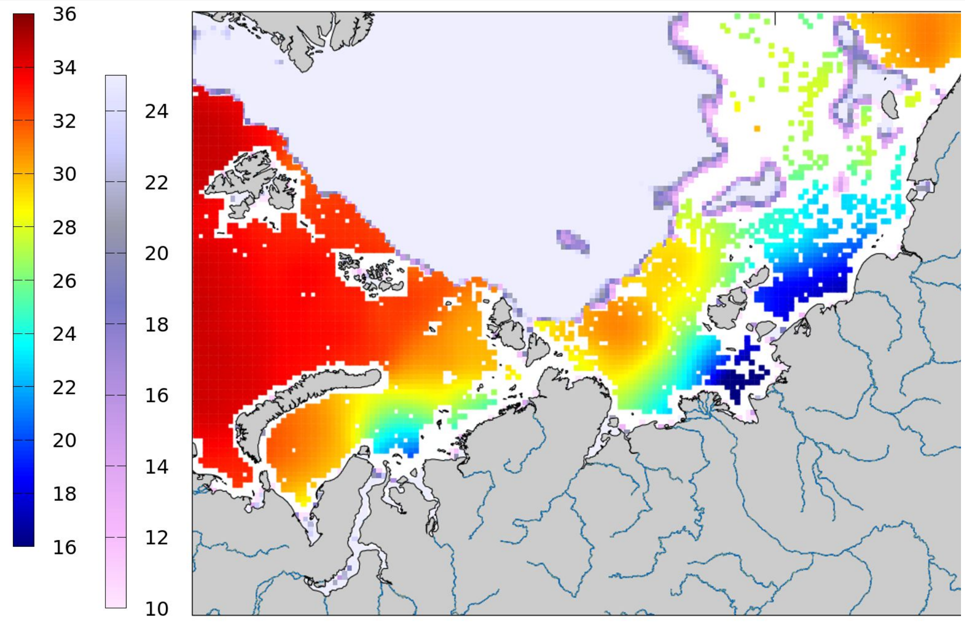
BEC v2



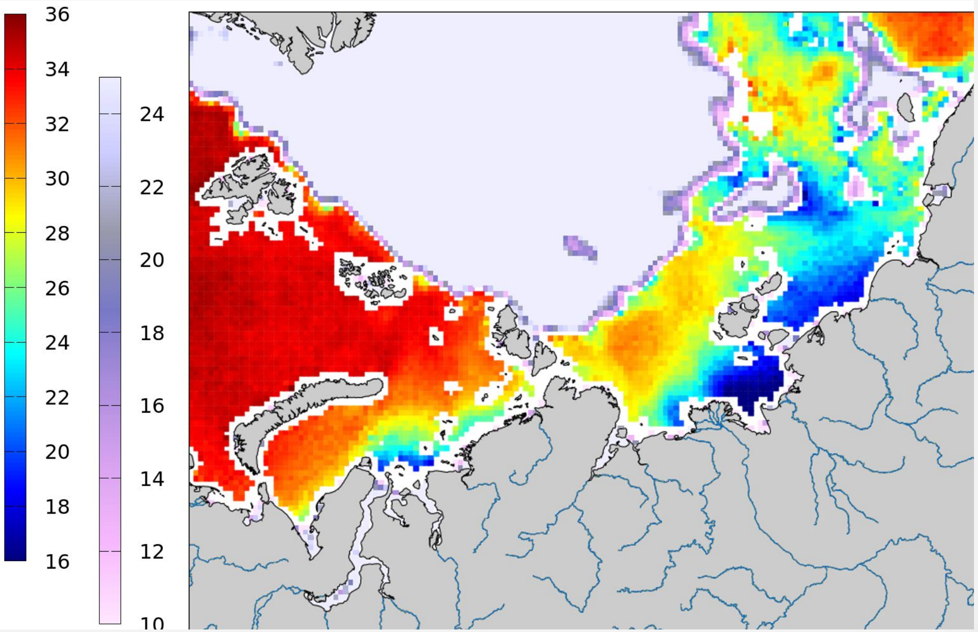
New enhanced product

Arctic+ Salinity

BEC v2



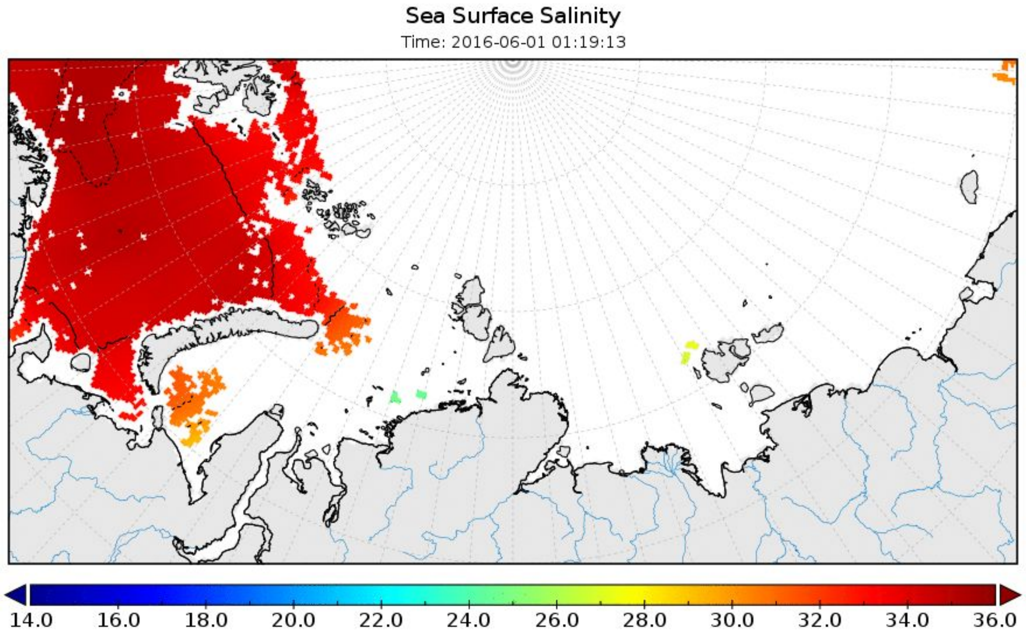
BEC v3.1



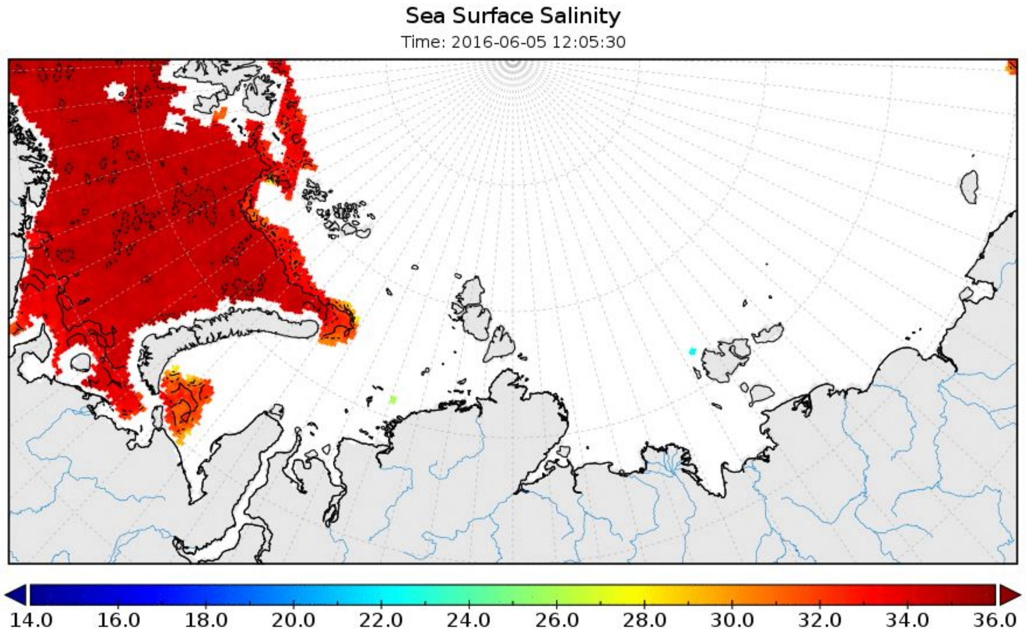
New inversion Algorithm

Arctic+ Salinity

BEC v2 (with Optimal Interpolation)



BEC v3.1



Data Processing Sea Surface Salinity in Arctic Ocean

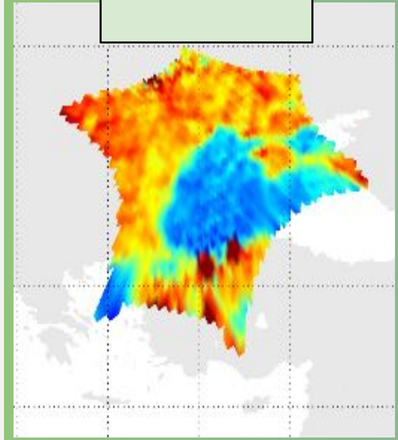
Arctic+ Salinity

- **Advanced algorithms at L2 and L3** have been **developed** to improve the SSS accuracy and resolution
- **SSS product**: **daily 9-day maps, at 25 Km (EASE-2), from 2011-2019**

Products are freely distributed from BEC webpage:

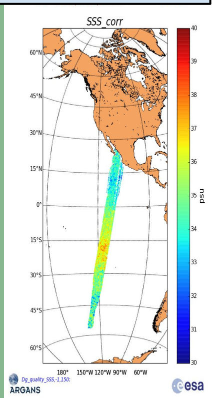
FTP service
http://bec.icm.csic.es/bec-ftp-service/

L1



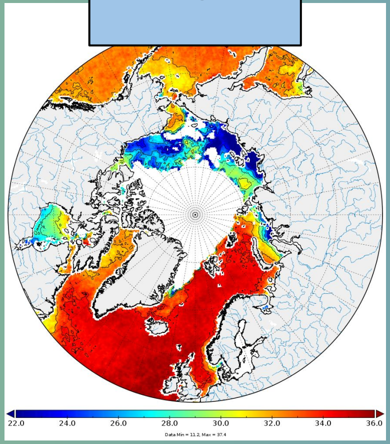
Brightness Temperatures

L2



Sea Surface Salinity swath

L3

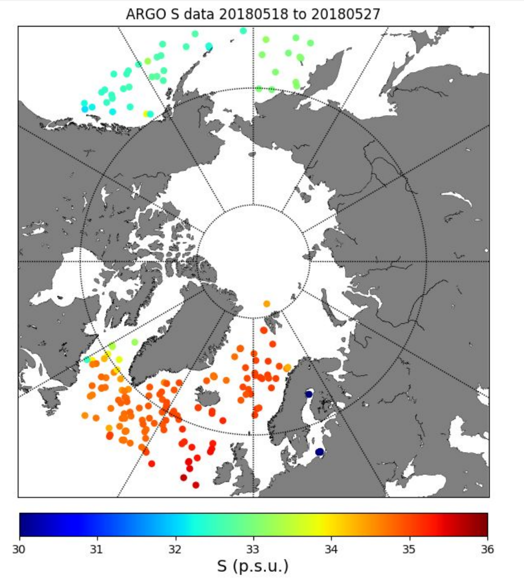


Sea Surface Salinity maps

Validation Assessment - ARGO & TARA

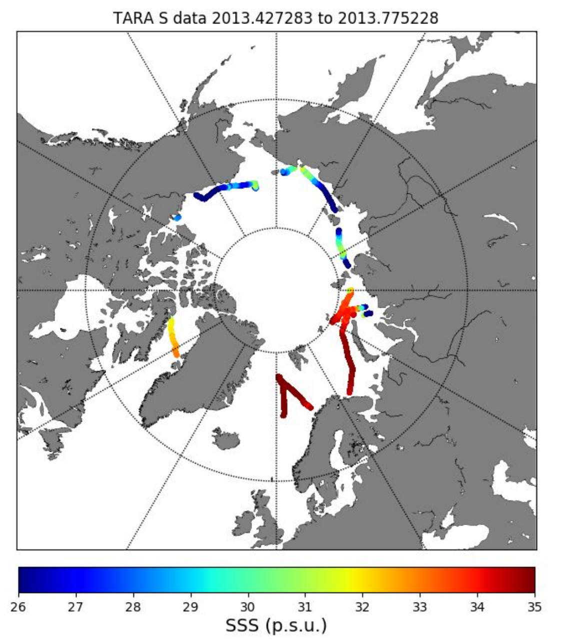
Arctic+ Salinity

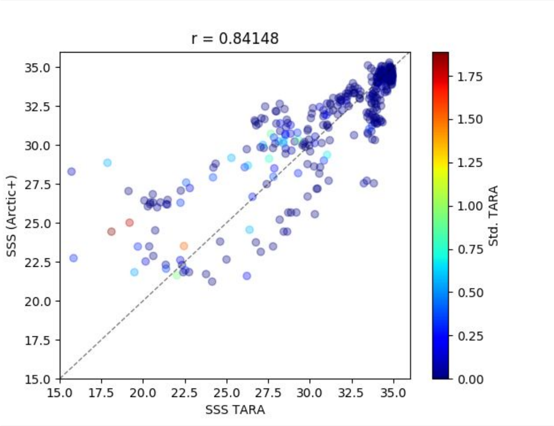
ARGO: few measurements in Arctic Basin



Averaged 2011-2018 (SSS V3.1 - ARGO)
Mean (SSS_SMOS - ARGO)= 0.02
STDD (SSS_SMOS - ARGO)= 0.39
RMSD (SSS_SMOS - ARGO) = 0.39
Correlation (SSS_SMOS - ARGO) = 0.9

TARA ship sailing in the Arctic Ocean from Jun-Oct 2013. Thermosalinograph at -11m



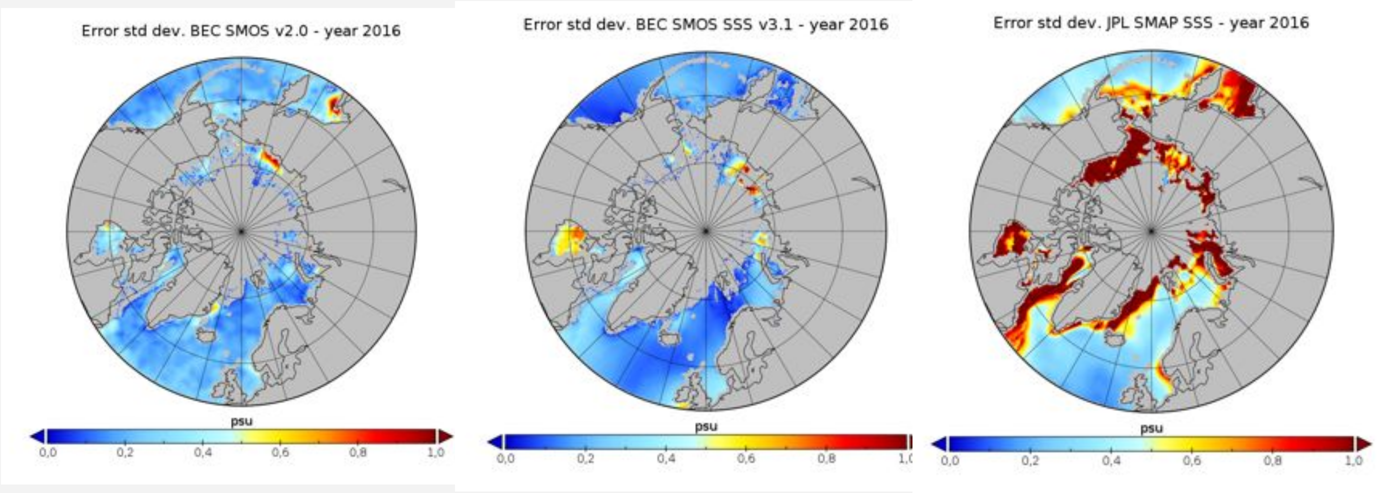


Large variability in different oceans

Validation Assessment - Correlated Triple Collocation

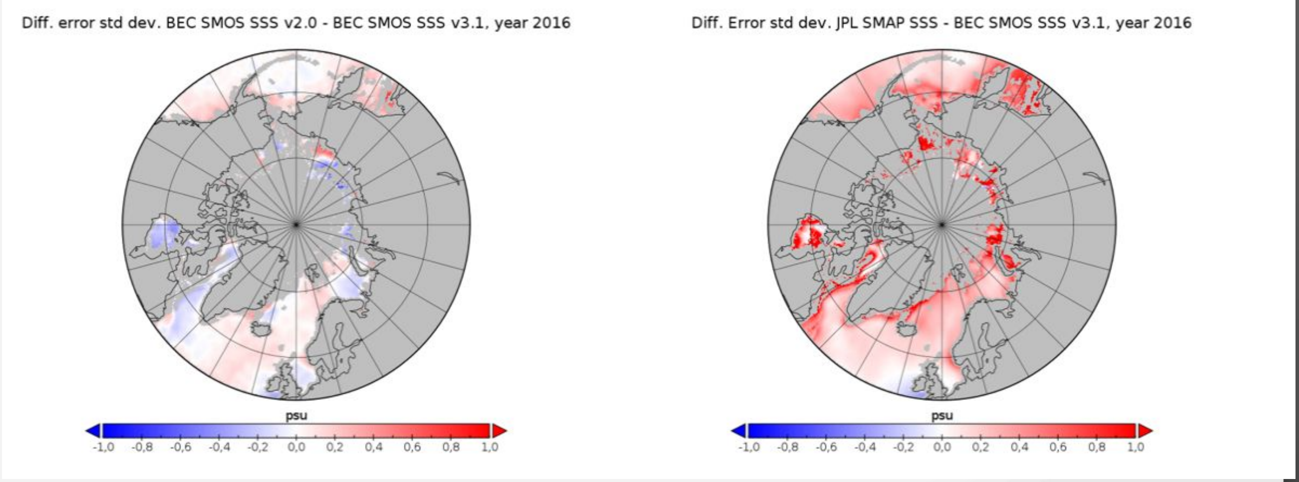
Arctic+ Salinity

González-Gambau et al., 2020 is an adaptation of TC to use same source (correlated errors). Provide estimates of the measurement error variances of three systems.



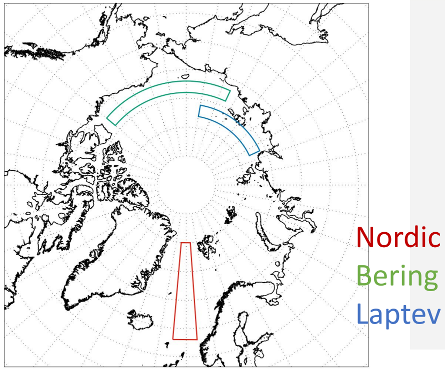
- BEC v3.1 has the smallest error, except in some specific regions where BEC v2.0 is better (Hudson Bay, east coast of Greenland, and Kara Sea).

- JPL 4.2 is in all cases the product with the greatest error.



Validation Assessment - Power Density Spectra (PDS)

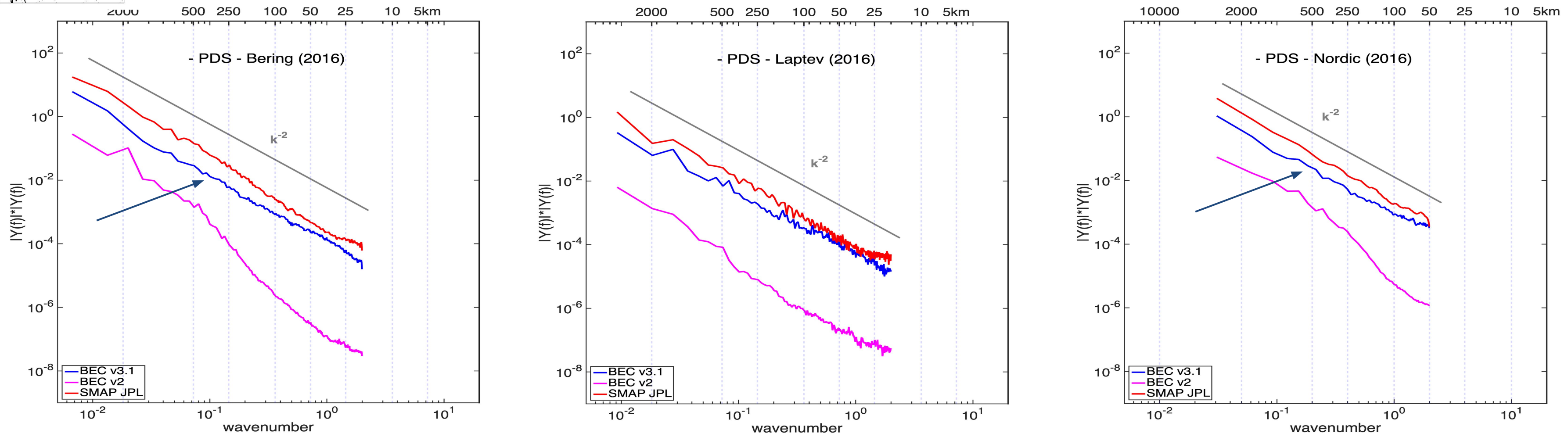
Arctic+ Salinity



Power density Spectra (PDS) :

➢ permits obtaining information about the effective spatial resolution

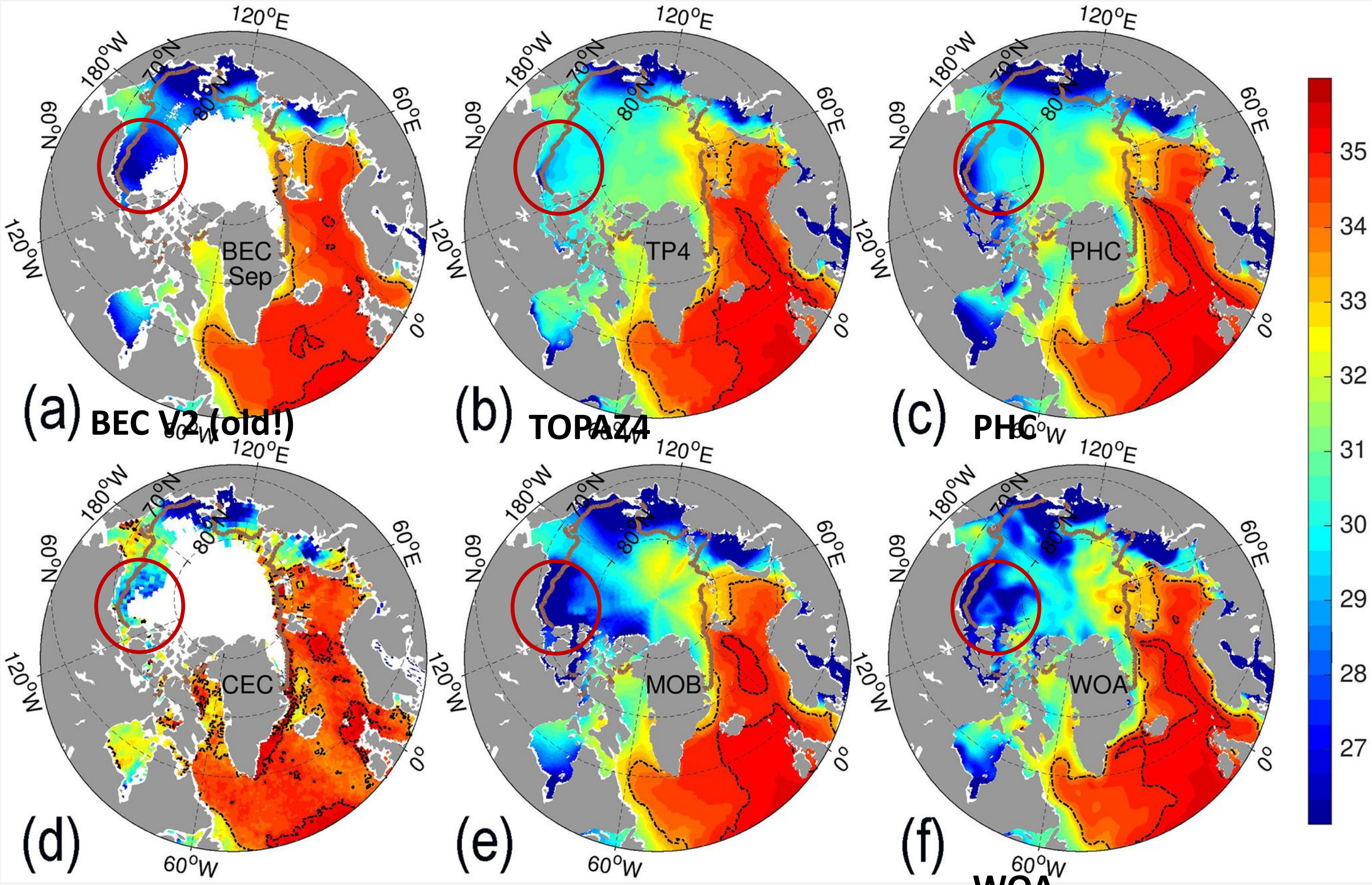
Mean for year 2016



- SSS v3.1 & SMAP, up to 50 km wavelength, 25 km resolution
- SSS v2.0 , up to 250 km wavelength, poor resolution -> OA

Starting point: Model biases, climatologies

Arctic+ Salinity



BEC V2 (old!)

TOPAZ4

PHC

LOCEAN v3 (old!)

GLO_PHY_REP_015_002

WOA

Sep.

Xie et al. OS 2019
https://doi.org/10.5194/os-15-1191-2019

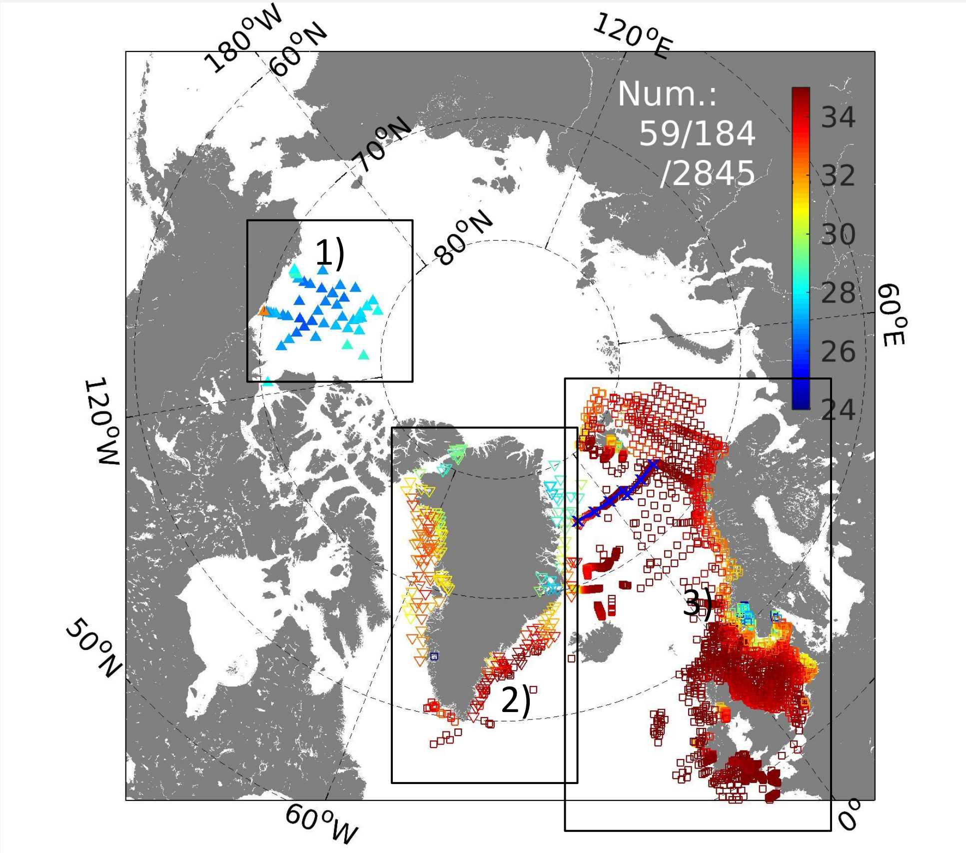
TOPAZ too saline where it should be fresh:

- Beaufort Sea
- E. Greenland Sea
- Hudson Bay

TOPAZ4 assimilated BEC V2 and V3 products

Arctic+ Salinity

Period June-December 2016



Validation against independent SSS from in situ profiles

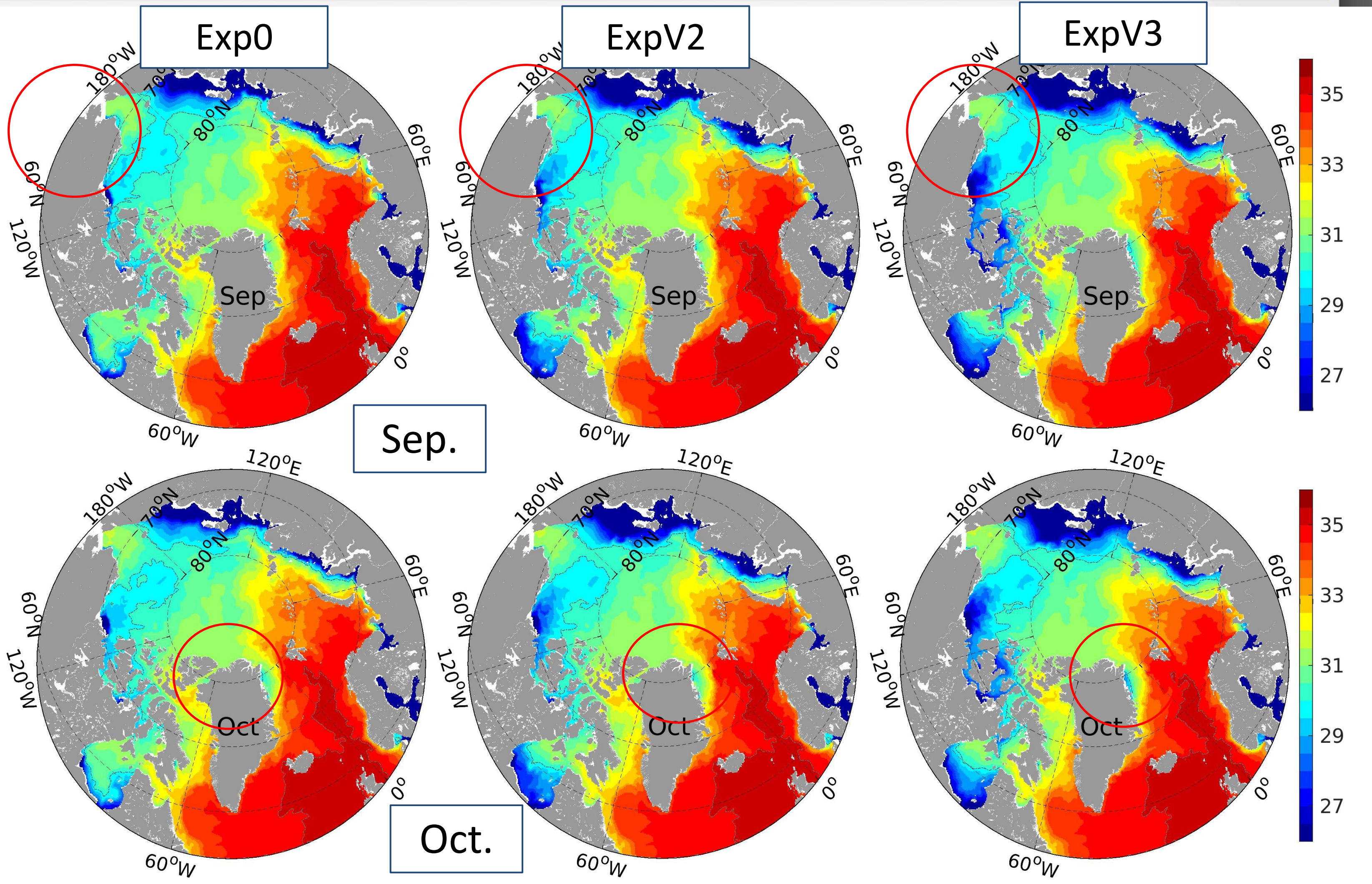
1) Beaufort Gyre: BGEP, WHOI
   - Bias reduced by 16%(V2) and 29% (V3);
2) Ocean Melt Greenland: OMG, NASA
   - Bias reduction 17.3% (V3); increases by 2% with V2
3) North Sea – Barents Sea: ICES
   - Bias reduction 20% (V3), increases by 10% with V2.

TOPAZ4 assimilated BEC V2 and V3 products

Arctic+ Salinity

TOPAZ SSS Sep - Oct

- Beaufort Sea: fresher
- October: wider freshwater (<30 psu) east of Greenland in ExpV3



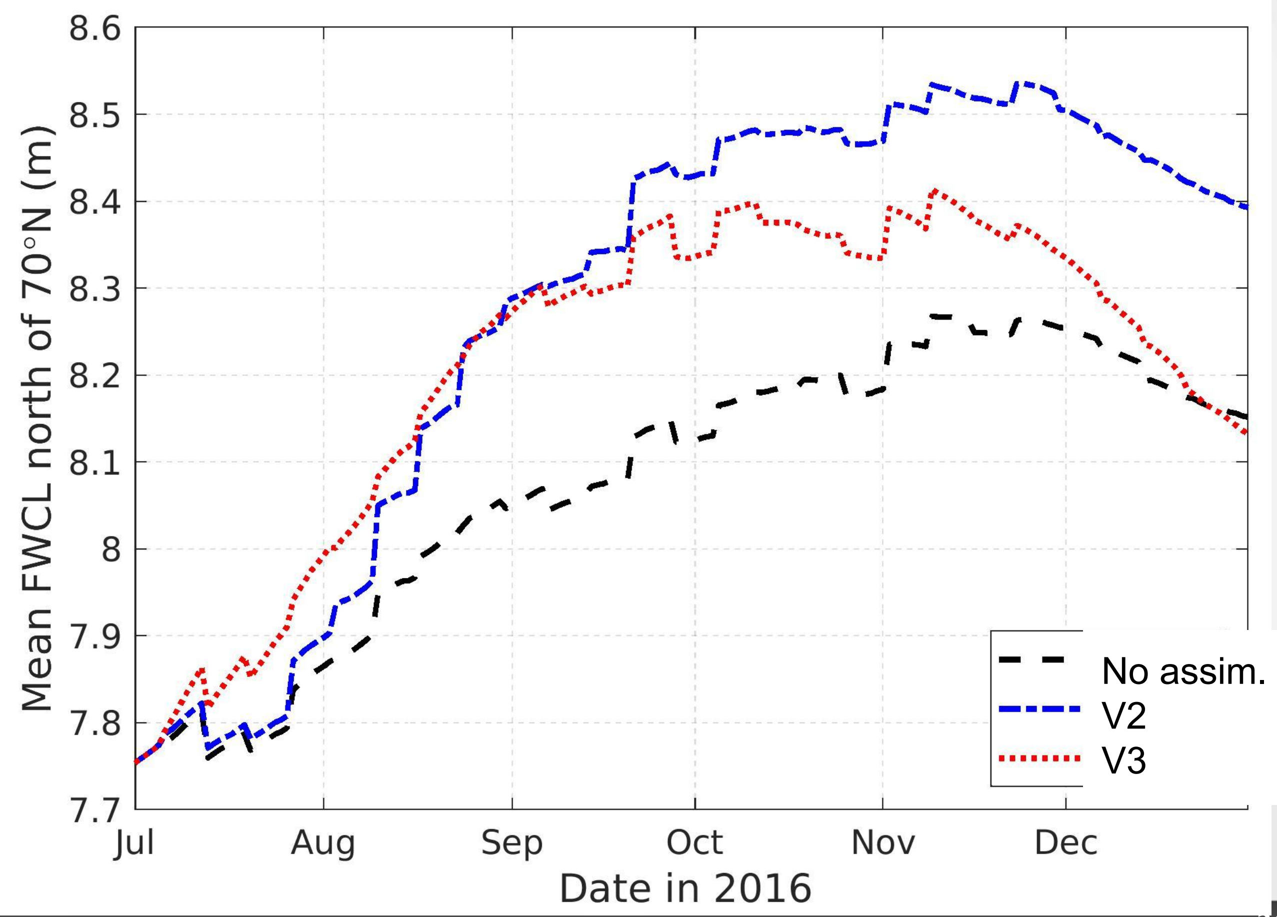
TOPAZ4 assimilated BEC V2 and V3 products

Arctic+ Salinity

Spatially averaged Freshwater Content

Arctic-wide average North of 70N

- Different results of FWC in the 3 runs:
  - Timing (earlier)
  - Amplitude (stronger)
- To be confirmed with independent data…



Conclusions & Future work

Arctic+ Salinity

Conclusions

- BEC v3.1 SSS is able to **resolve finner scales, about 25 km** (similar to SMAP), while BEC v2 SSS resolve poorly scales under 200 km.
- BEC v3.1 SSS has lower errors than BEC v2 SSS and SMAP JPL.
- BEC v3.1 SSS has **less data gaps** than BEC v2 SSS.
- BEC v3.1 SSS better **suited to study oceanographic processes (river discharges, currents..).**
- **Assimilation of Arctic+ SSS v3.1 into TOPAZ system, resulted beneficial for most test sides.**
- TOPAZ4b reanalysis is ongoing (1991-2020) for CMEMS (December release) which assimilates the BEC V3 product from 2013 to 2020.

Future work:

- Aim to study the FWF variability in Beaufort
- Aim to study the North Atlantic cold blob
- Study the Greenland melting
- Collaborate with SASSIE NASA project

Arctic+
Salinity

THANKS FOR YOUR ATTENTION

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BEC
Barcelona Expert Center
NERSC