

Assessment of salinity variability in the Bering Sea from satellite-based observations, **Argo floats** and a coupled ice-ocean model

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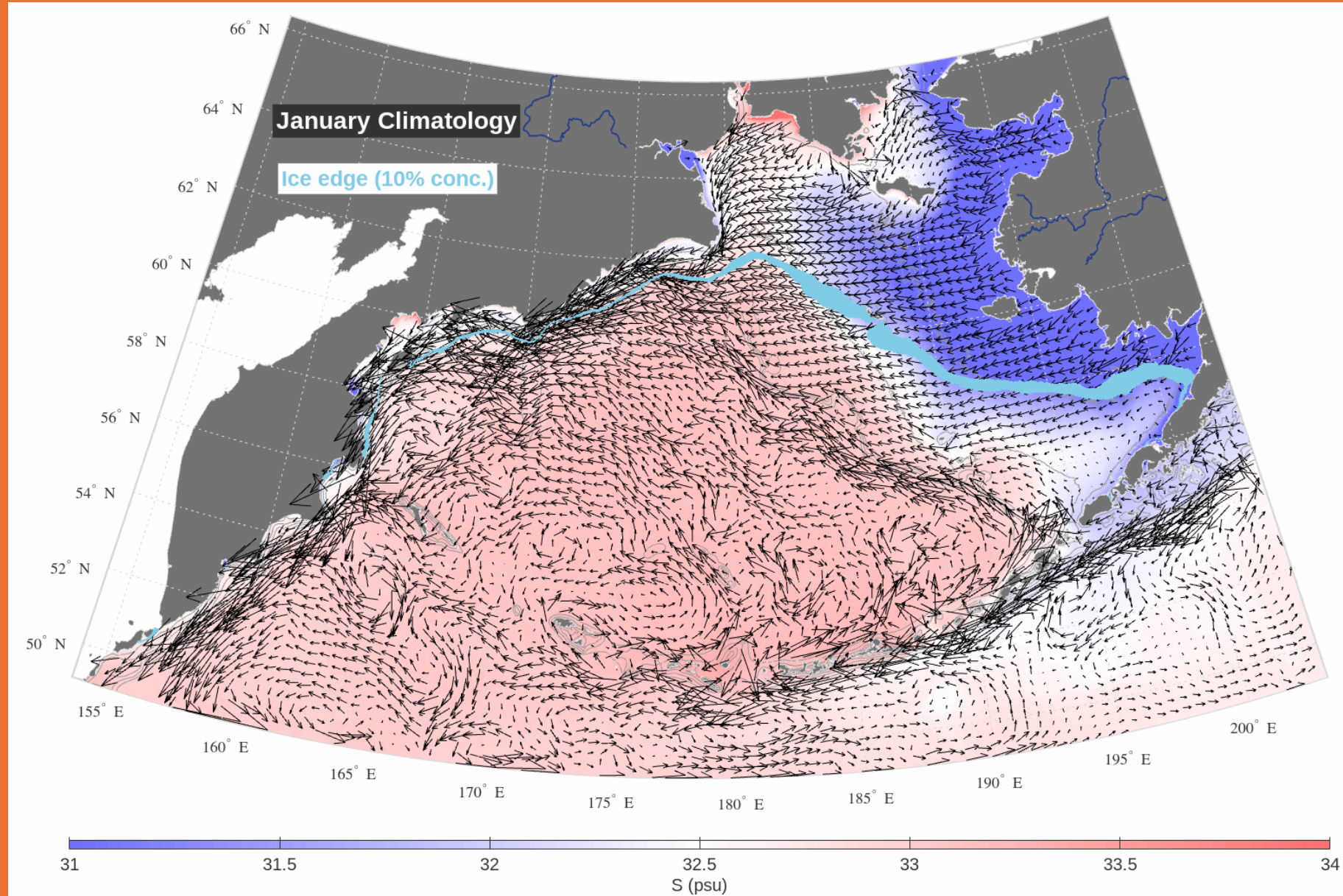
Salinity in the Bering Sea

Using satellite salinity and a high-resolution ocean model:

- 1) What can we learn about salinity dynamics on the broad eastern Bering sea shelf?
- 2) What can we learn about shelf-basin exchange

- Rivers (Yukon, Anadyr, Kukoskwim)
- Shelf-basin exchange (Anadyr current)
- Shelf-basin exchange (slope-flow eddies)
- Tidally-mixed flow through Aleutian passes
- Sea ice, formation and melt
- Arctic shelf exchange
- Pacific-shelf exchange (ACC) and Unimak Pass

Monthly average surface velocity vectors and surface salinity from the model simulation 2018-2025



Climatological mean surface salinity from 4 satellite products

Short Name: **RSS SMAP v6.0 RF**

Full Product Name: RSS SMAP Level 3 SSS Standard Mapped Image 8-Day Running Mean V6.0

Producer: Remote Sensing Systems (RSS)

Satellites / Sources: SMAP (L-band)

Spatial Res.: 0.25° (~40 km)

Temporal Res.: 8-day running (daily files)

Time Range: Apr 2015 – present

Salinity Accuracy: ~0.2 psu

Short Name: **BEC SMOS v4**

Full Product Name: BEC Arctic SMOS SSS L3 V4.0

Producer: Barcelona Expert Centre (ICM-CSIC)

Satellites / Sources: SMOS (L-band)

Spatial Res.: 25 km (LAEA polar)

Temporal Res.: 9-day running

Time Range: 2011–2015, 2018–2022

Salinity Accuracy: ~0.3–0.5 psu

Short Name: **CEC SMOS v2**

Full Product Name: SMOS Arctic SSS L3 V2 Maps

Producer: CATDS Expert Centre LOCEAN

Satellites / Sources: SMOS (L-band)

Spatial Res.: ~25 km (EASE2 polar)

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Time Range: Jul 2010 – Aug 2023

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Short Name: **OISSS v3**

Full Product Name: Multi-Mission Optimally Interpolated SSS Level 4 V3.0

Producer: ESR / IPRC Univ. Hawaii

Satellites / Sources: Aquarius + SMOS + SMAP + ARGO bias correction

Spatial Res.: 0.25° (~28 km)

Temporal Res.: 7-day running

Time Range: Aug 2011 – present

Salinity Accuracy: ~0.2 psu

Short Name: **CMEMSCNR daily**

Full Product Name: Multi Observation Global Ocean SSS and SSD

Producer: CNR (Italy)

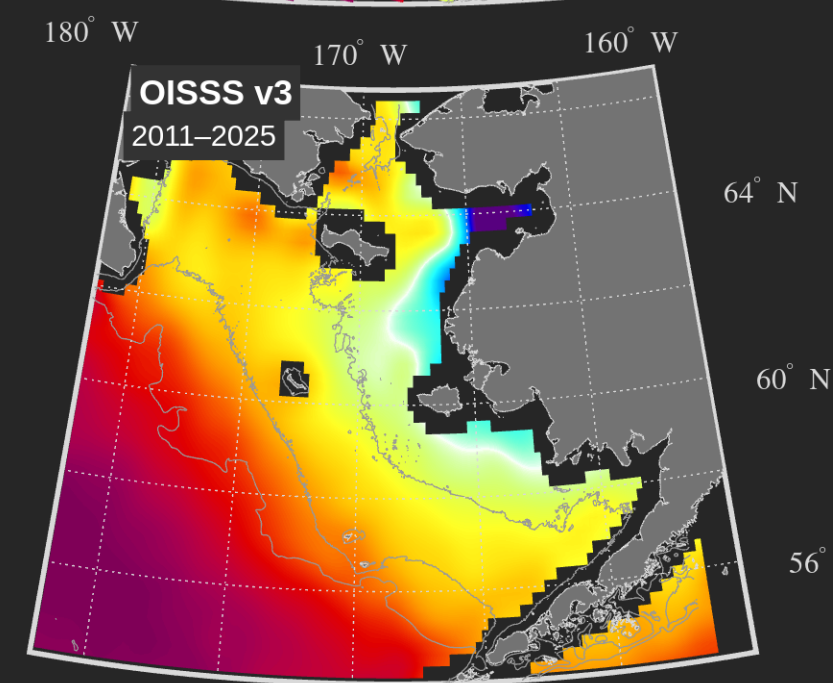
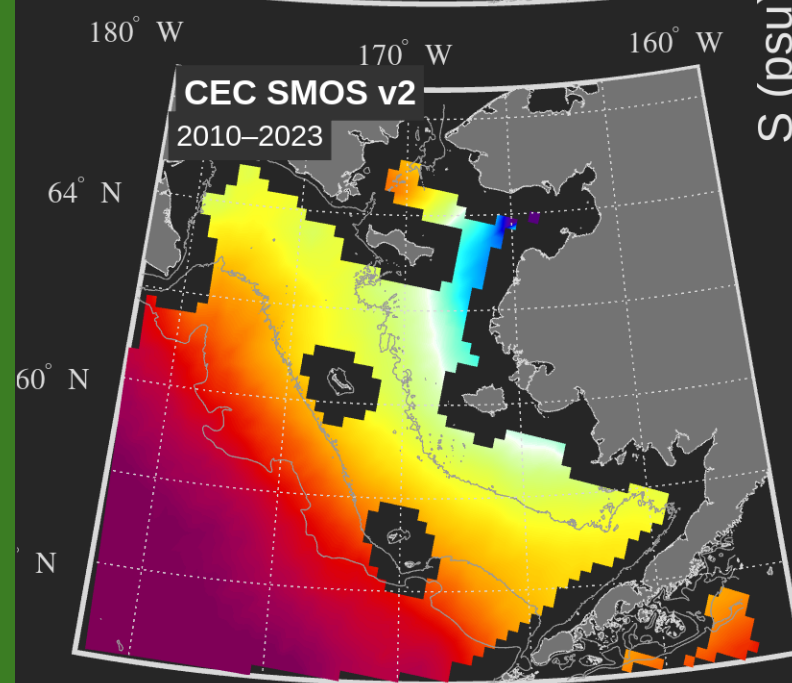
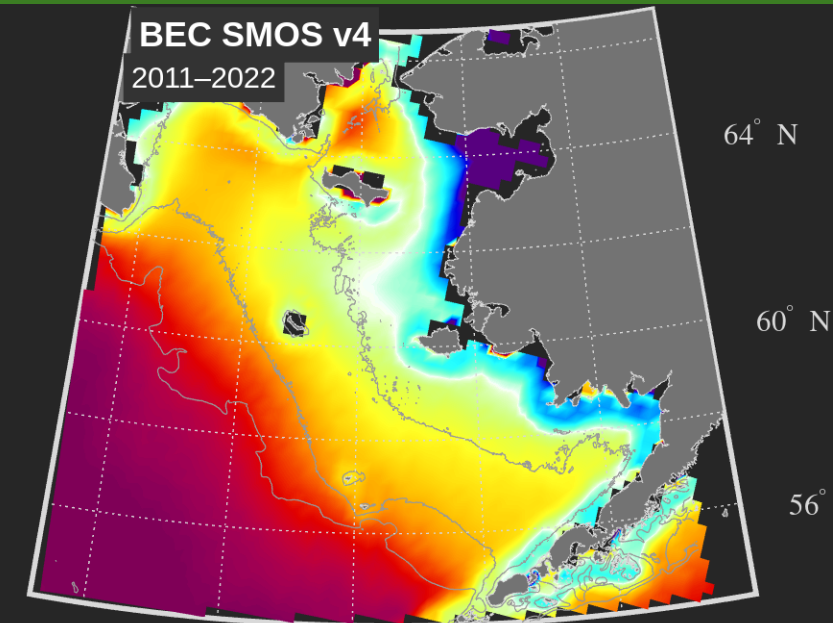
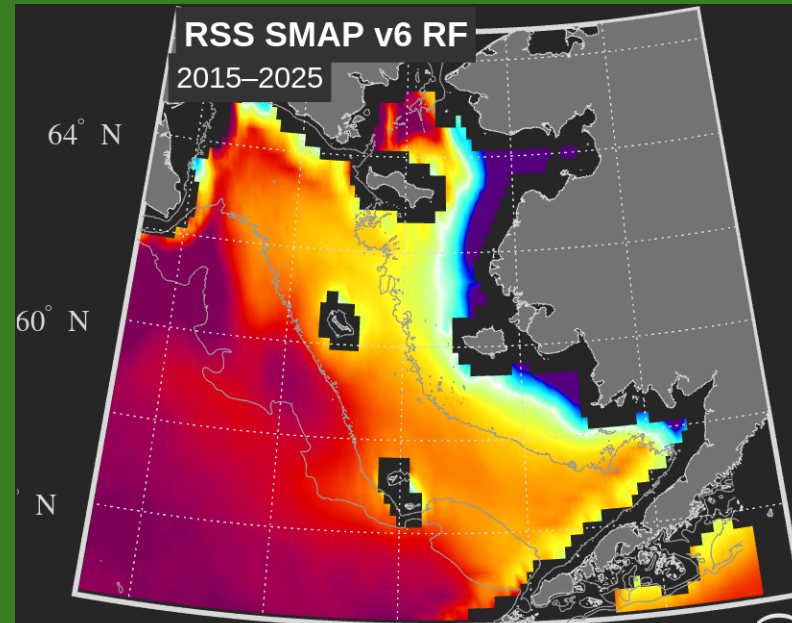
Satellites / Sources: SMOS + SMAP + in-situ + SST (OI)

Spatial Res.: 0.125° (~14 km)

Temporal Res.: Daily (L4 OI)

Time Range: 1993 – present

Salinity Accuracy: ~0.2–0.3 psu



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Full Product Name: SMOS Arctic SSS L3 V2 Maps

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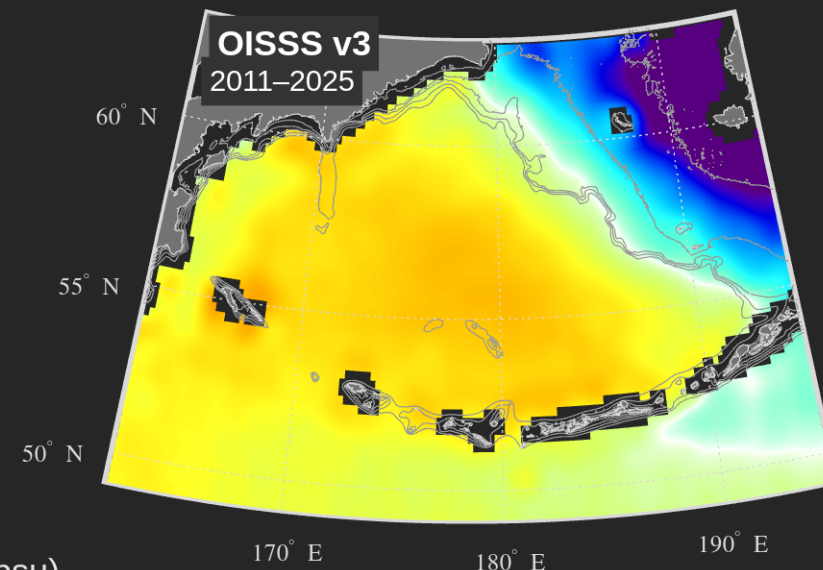
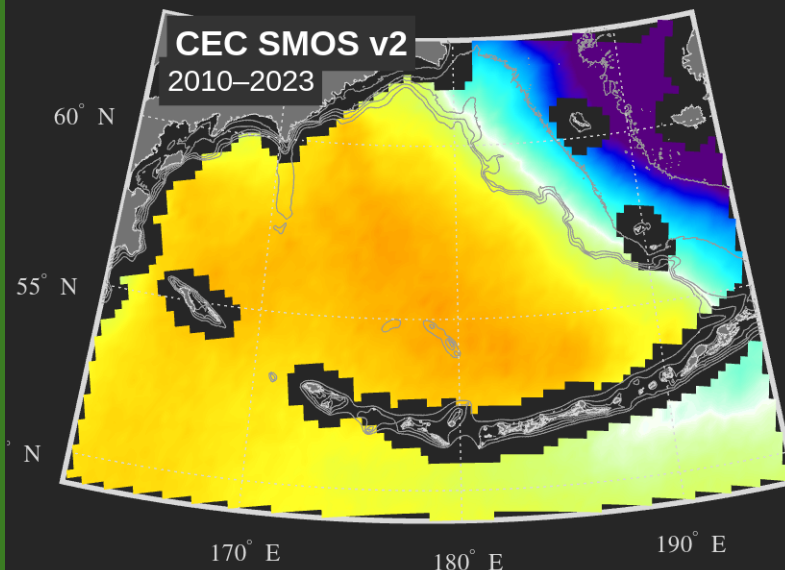
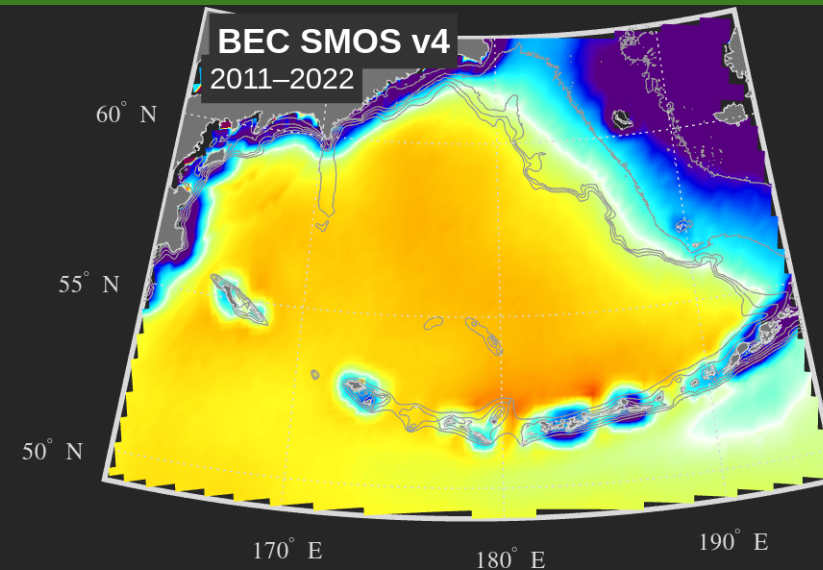
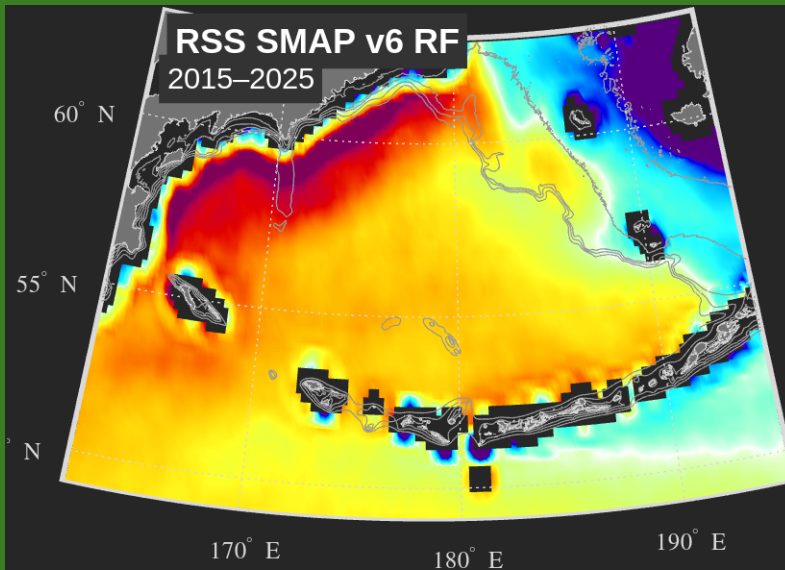
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31.5 32

32.5

33

33.5

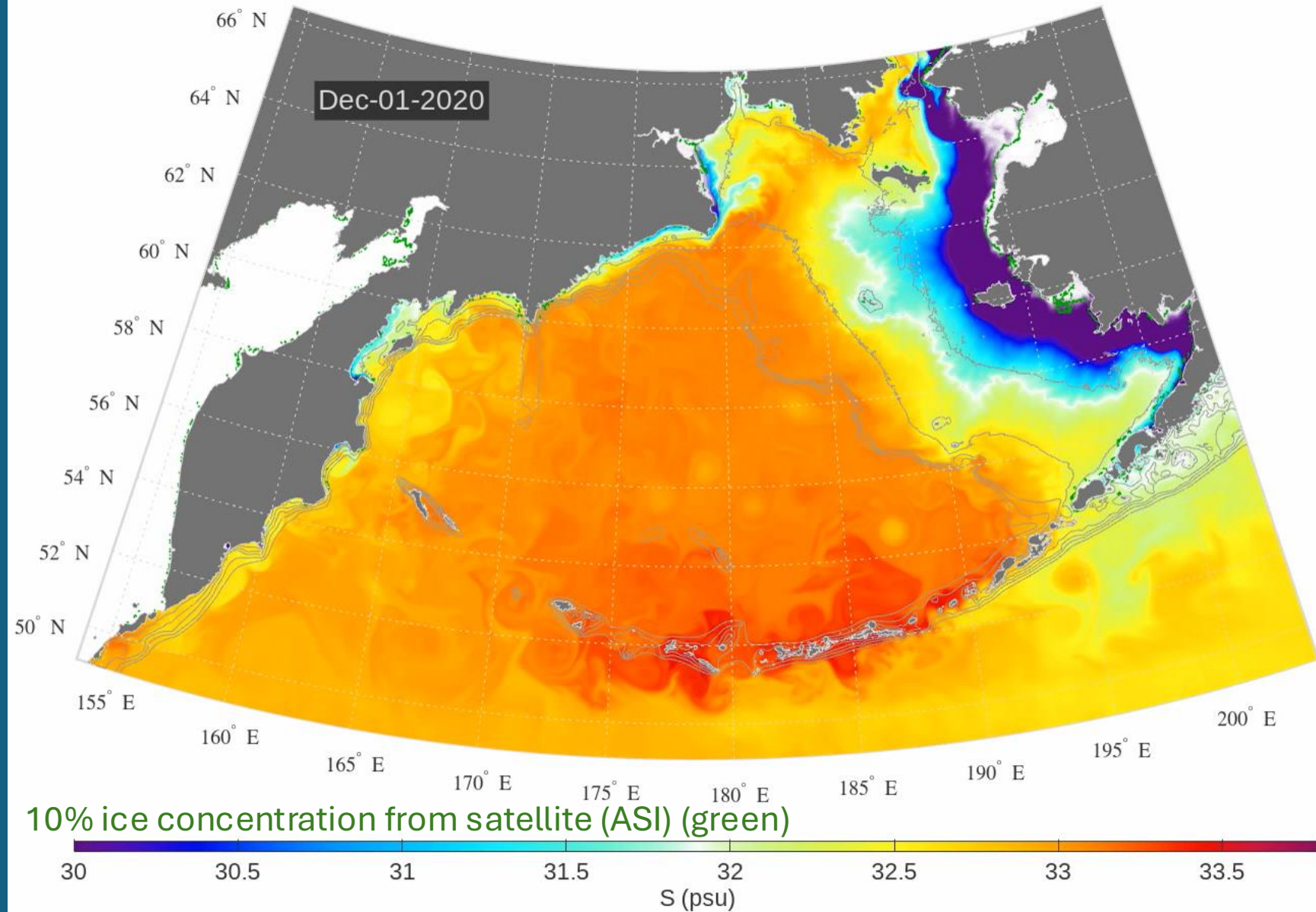


Model Setup

- ROMS
- 2km horizontal res.
- 45 vertical levels
- TPXO Tides (6 const.)
- ERA5 Atm. Forcing
- GLoFAS Rivers+runoff
- HYCOM GLB[vyE] BCs and nudging along boundaries
- 'In-house' single category ice model modified from Hedstrom-Budgell

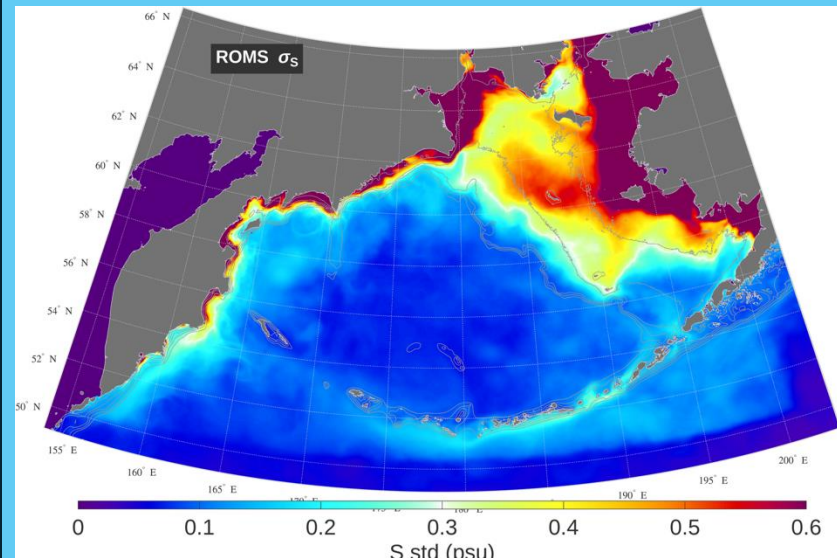
7-year simulation July 2018 through October 2025

Modeled SSS and sea ice concentration

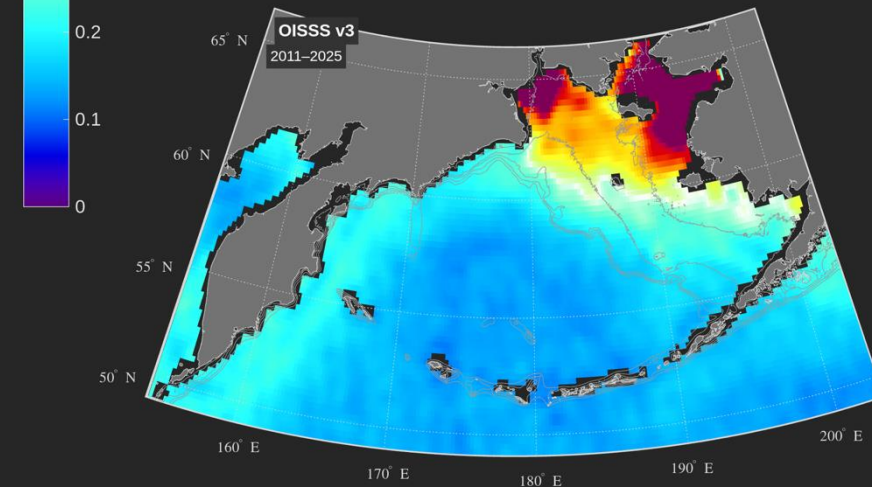
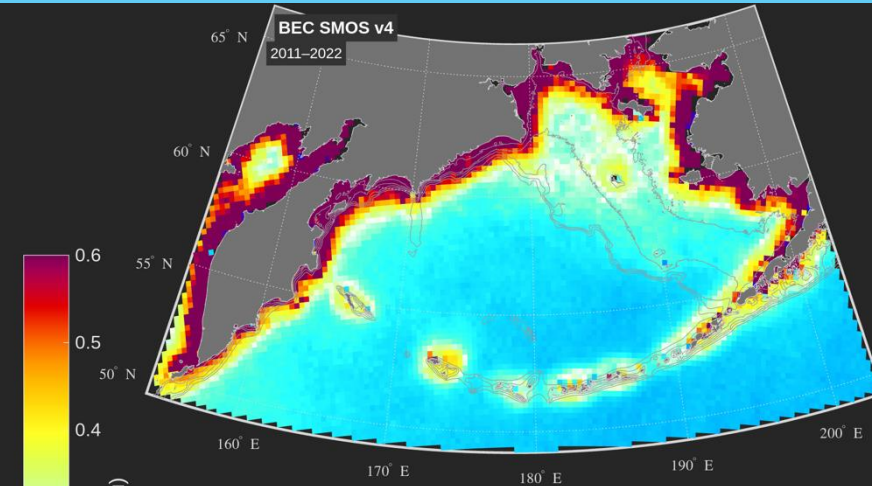
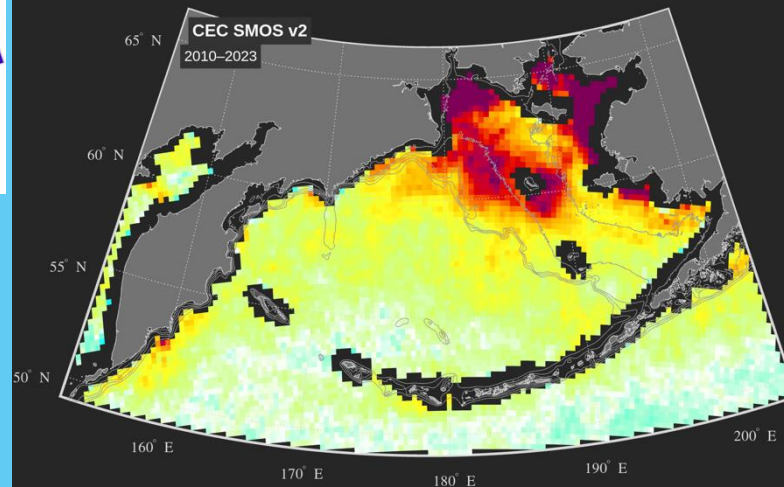
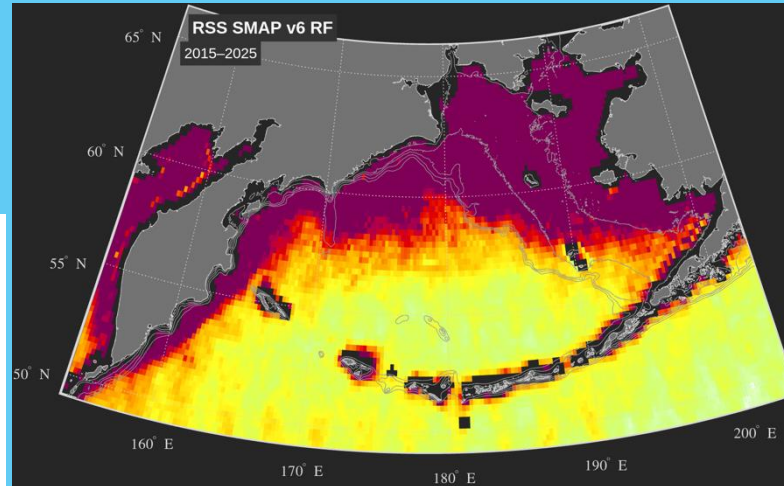


Poor signal-to-noise ratio in satellite products and/or weak sub-seasonal variability in the model?

ROMS (2018-2025)



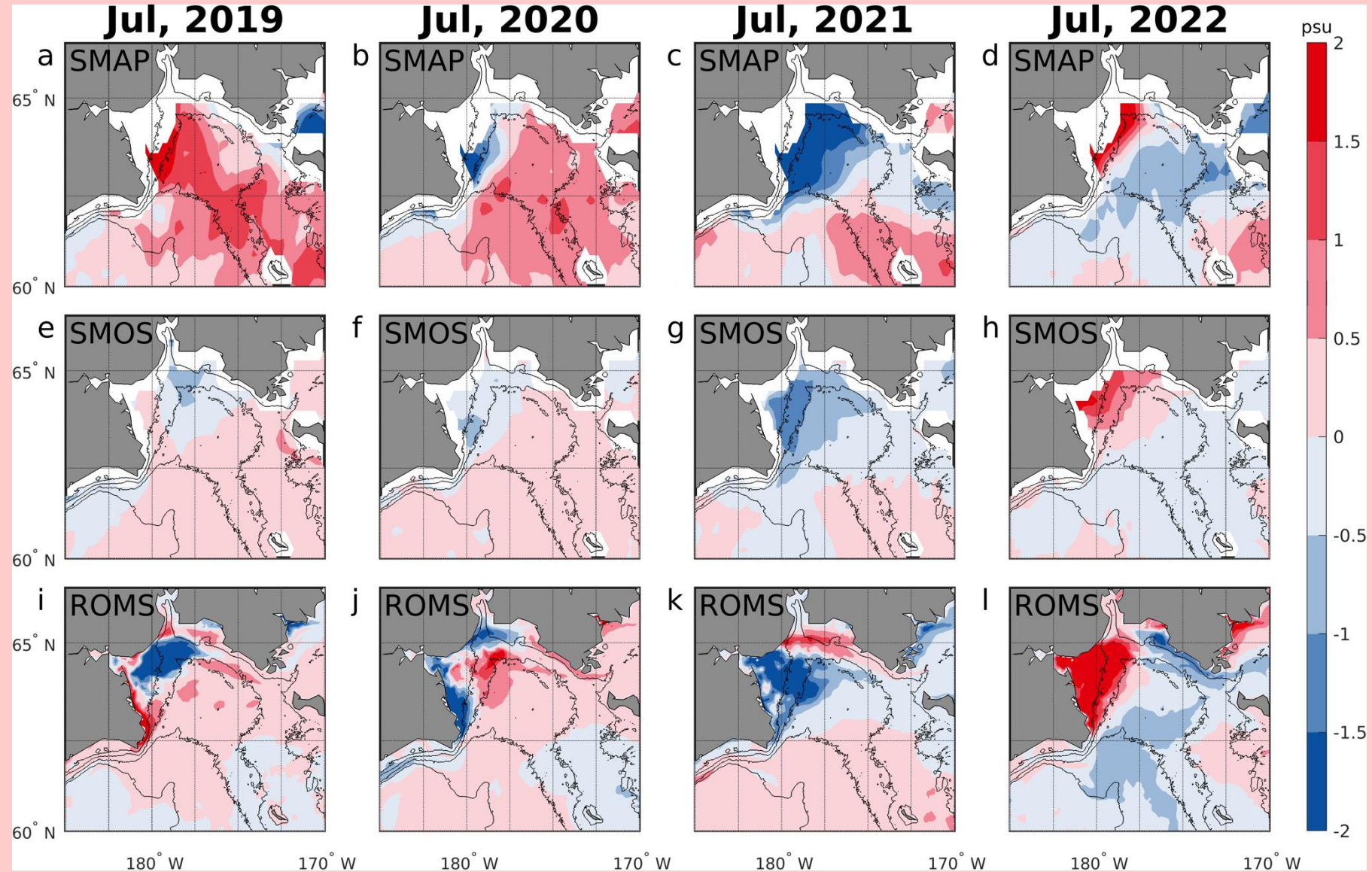
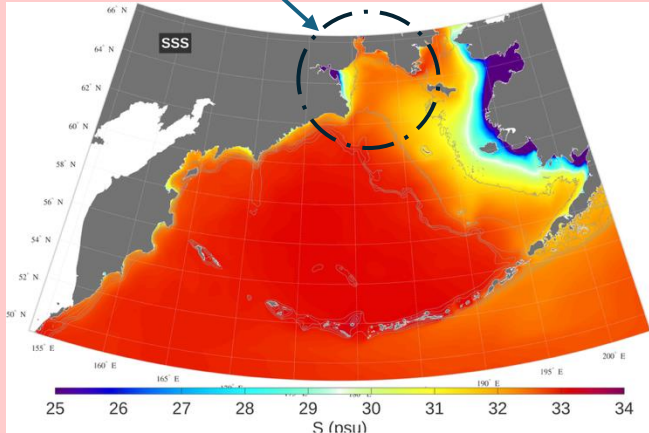
Subseasonal variability in SSS (0-0.6 psu)



Can we find SSS anomalies that are consistent across products?

Monthly SSS anomaly

The Gulf of Anadyr



Previous attachment

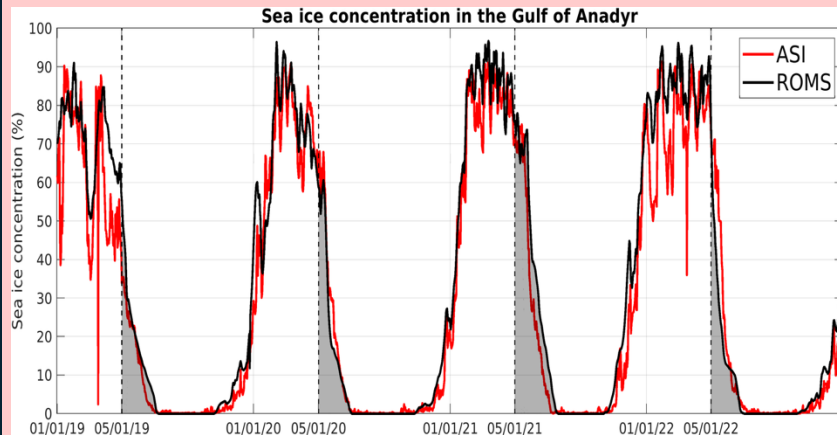
New in JGR Oceans

Sea Surface Salinity Variability in the Gulf of Anadyr: Inferences From Satellite Observations and a Coupled Ice-Ocean Model

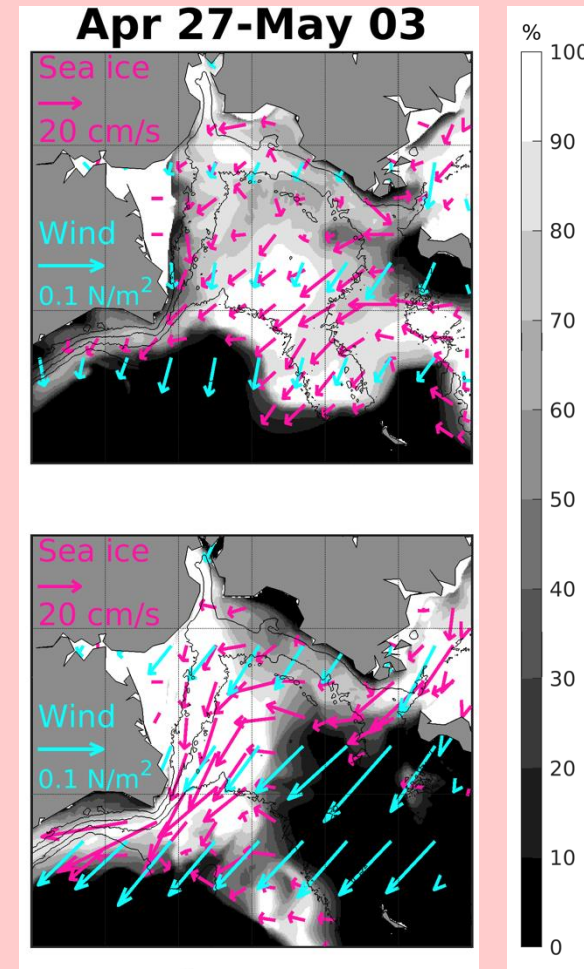
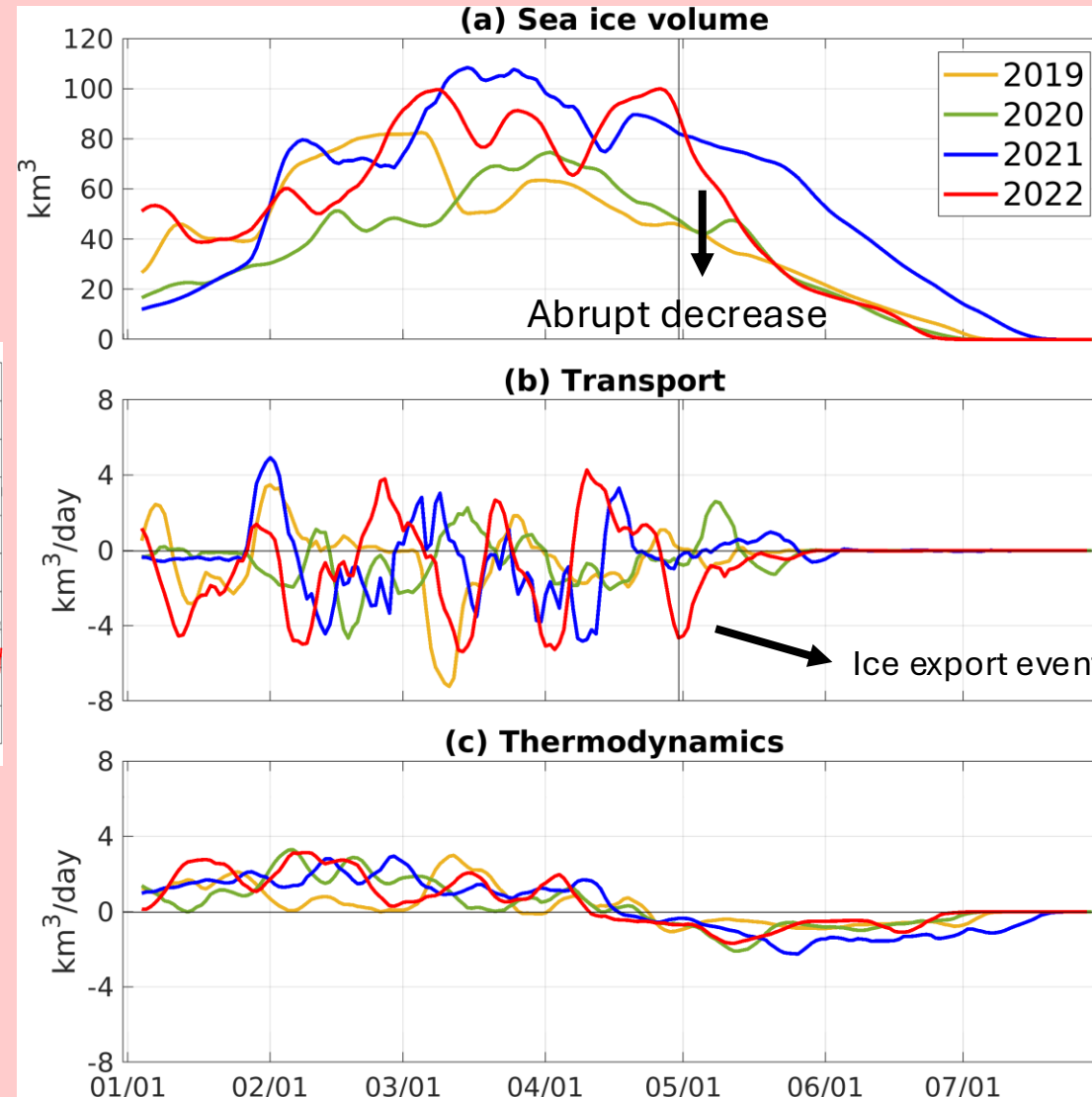
Jung et al. (2026)
DOI: 10.1029/2026JC024005

AGU
PUBLICATIONS

Fresh anomaly resulted from late-winter persistence of ice in the Gulf of Anadyr, due to winds that were anomalously favorable for retention.



Shaded area: Sea ice concentration after May 1st



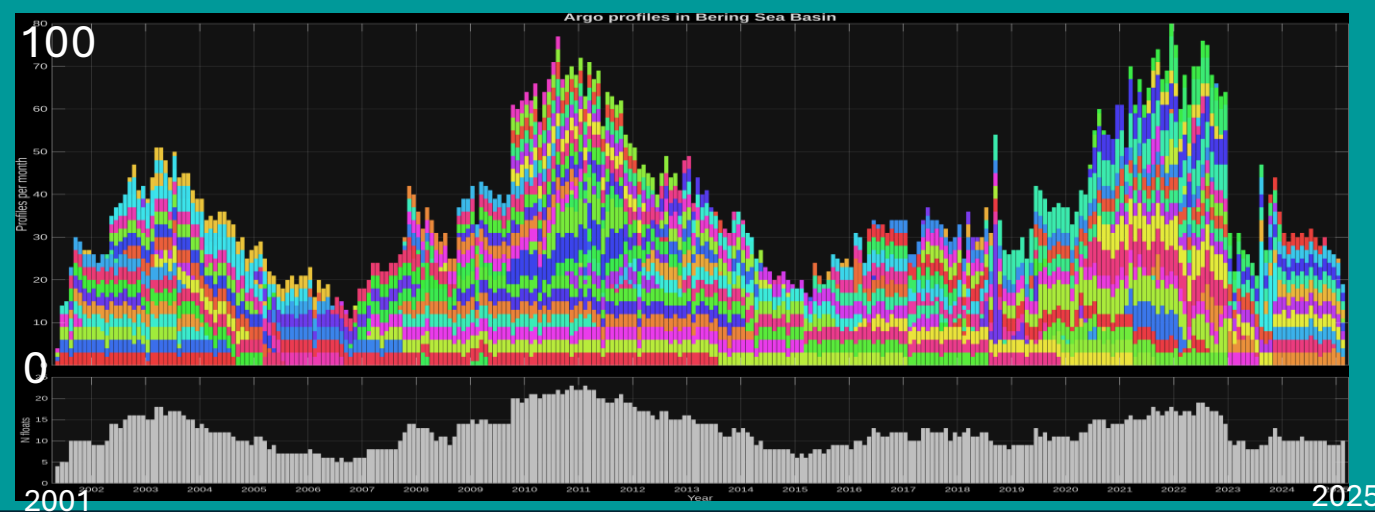
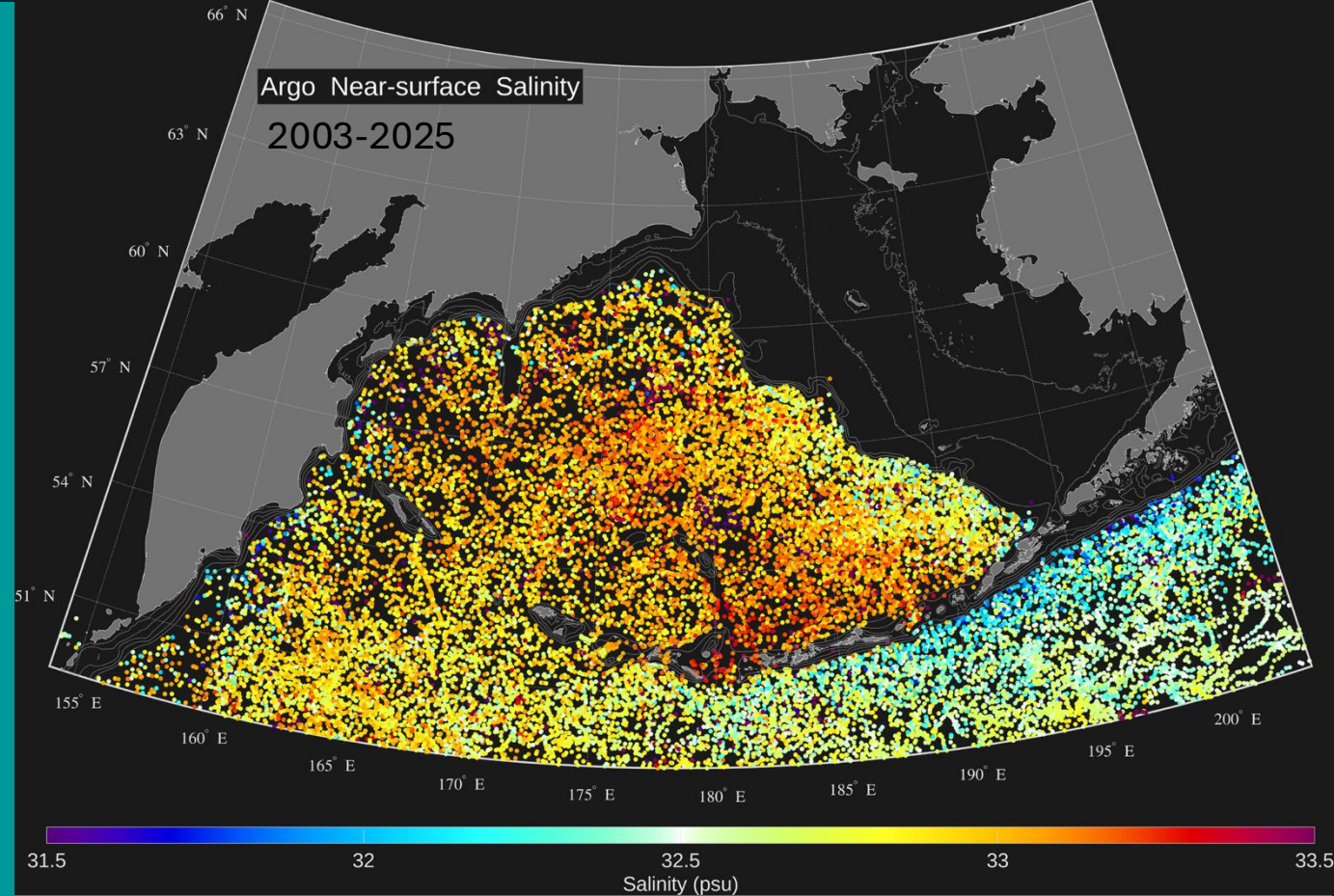
Depth averaged salinity in the Gulf of Anadyr remained anomalously low through October 2021

Using **Argo** salinity and a high-resolution ocean model:

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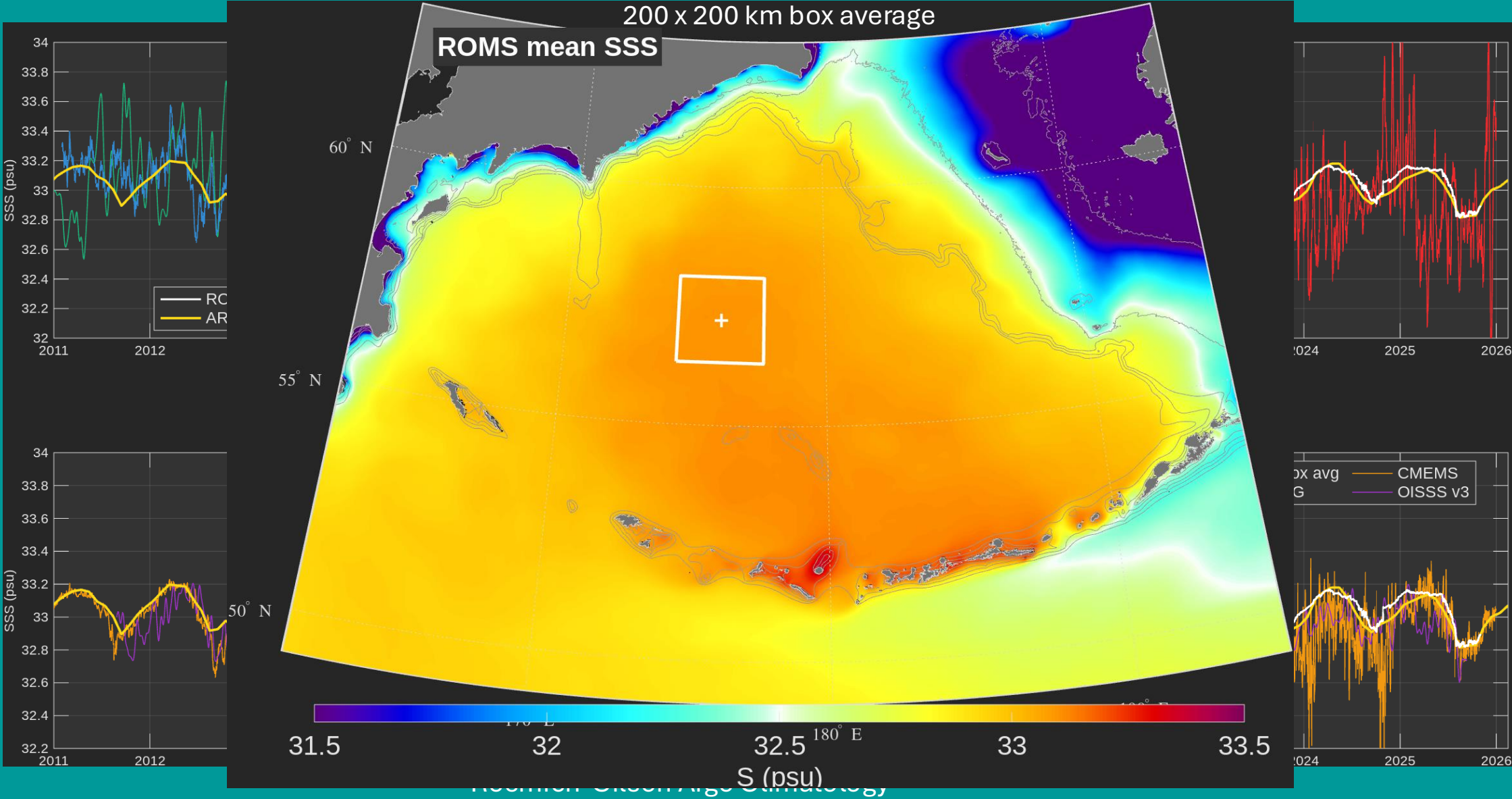
Typically, ~30 profiles a month in the Bering Sea basin from about 12 Argo floats.

Horizontal resolution ~ 300-400 km

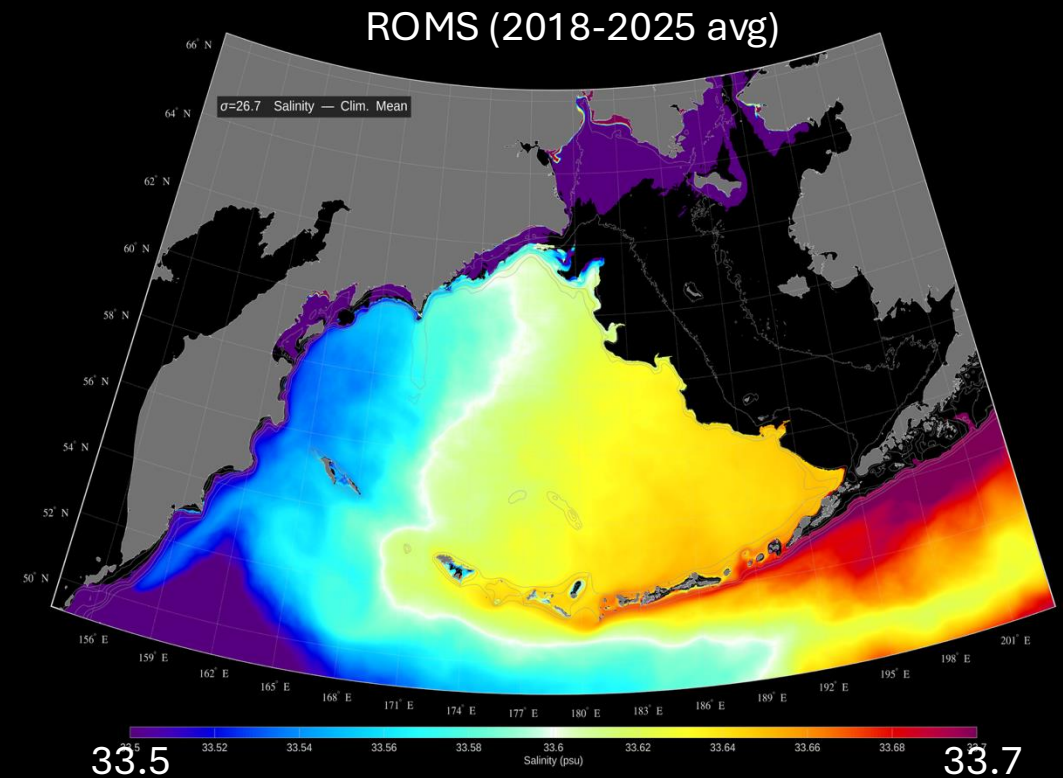
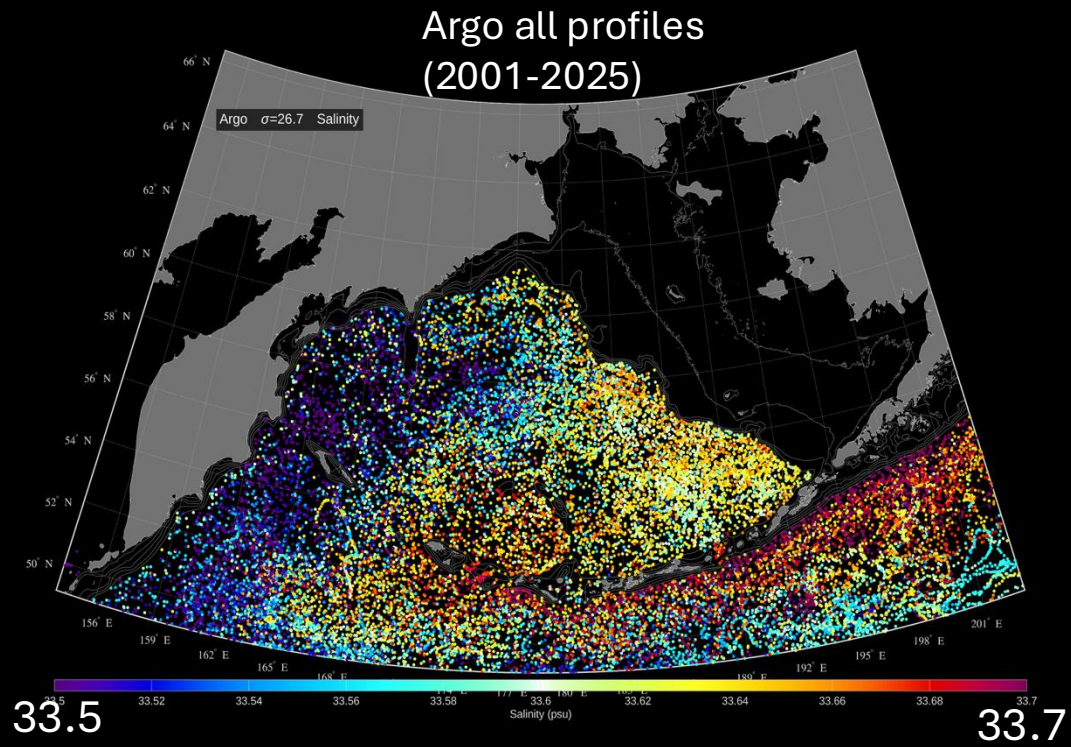


Number of Argo profiles and number of Argo floats in the Bering Sea Basin by month

Comparison of central basin SSS from satellites, Argo and the model



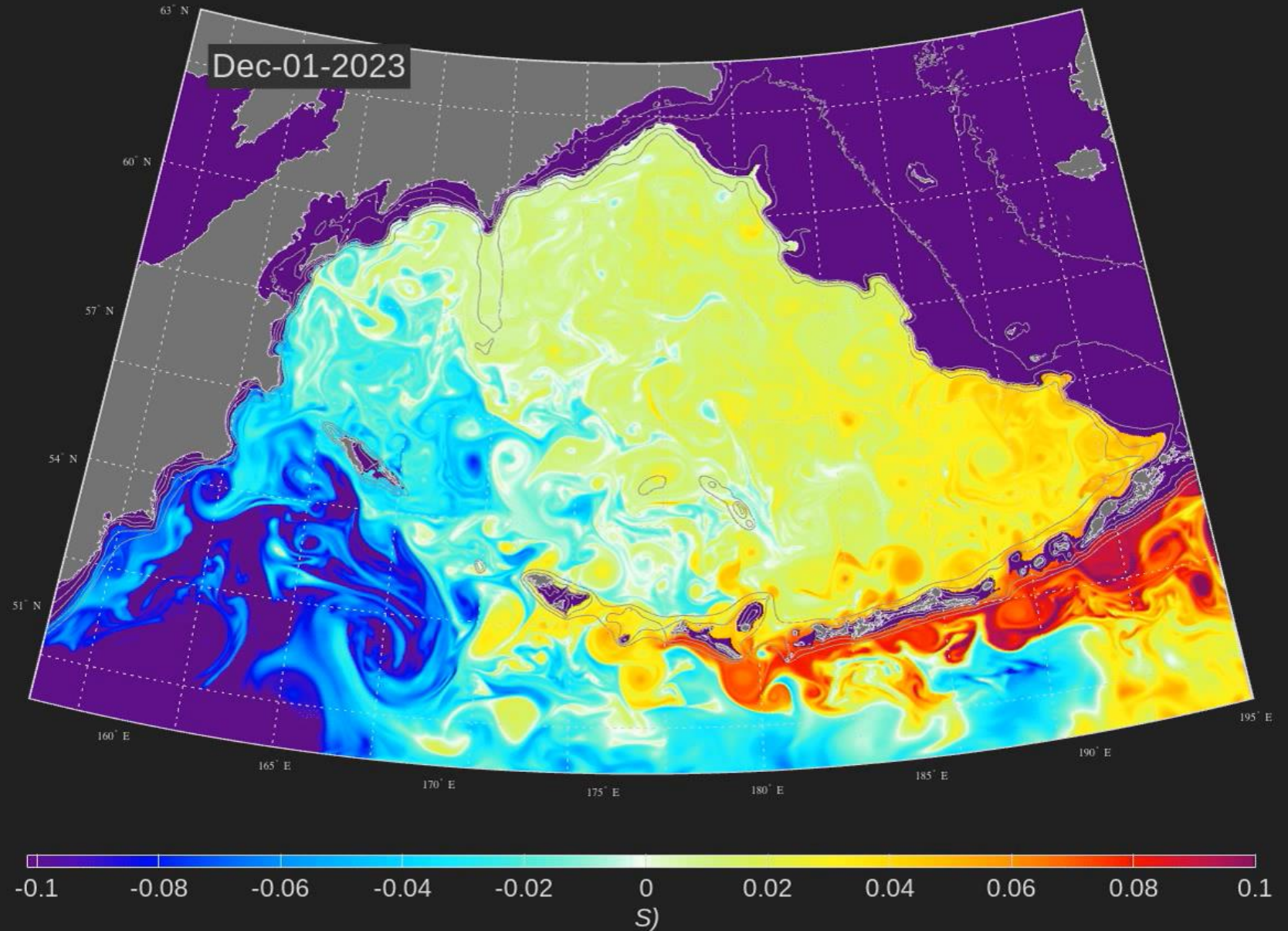
Looking deeper, Salinity on the $\sigma_{26.7}$ isopycnal



Fresher water along the Koryak and Kamchatka coasts in Argo and the model

Moderately low salinity $\sigma_{26.7}$ water is often associated with North Pacific Intermediate Water (NPIW), a relatively oxygen-rich water mass that is ventilated by cold winter water in the Sea of Okhotsk

Winter freshening of the $\sigma_{26.7}$ isopycnal by shelf slope exchange processes

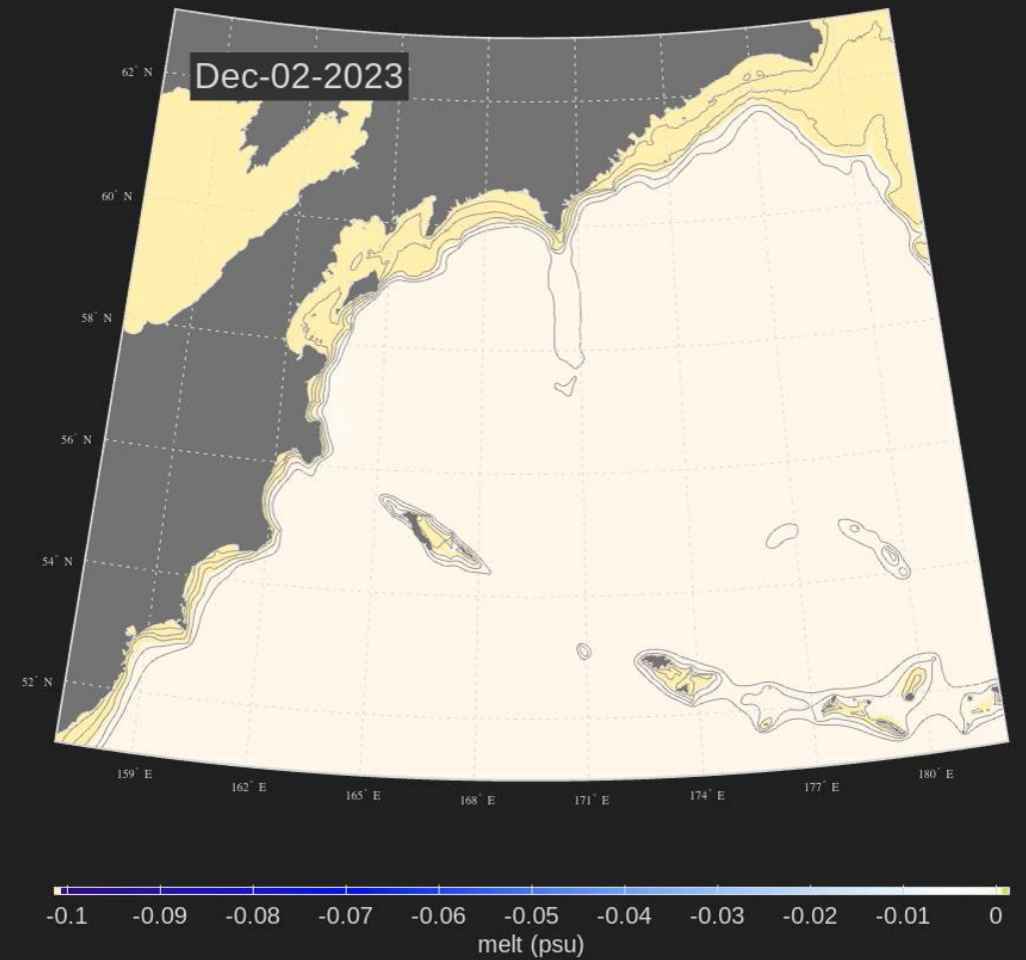


What is the source of the anomalously fresh water along the Koryak and Kamchatka coasts?

In the Sea of Okhotsk, very cold brine injected waters from sea ice formation are considered the source waters for the ventilation of the NPIW (appears as a fresh anomaly due to the very cold temperatures)

Sea ice Brine and Melt tracers are added to the model, provided through the surface boundary. Their magnitudes equal the salinity flux due to formation and melt respectively.

Melt tracer on the $\sigma_{26.7}$ isopycnal

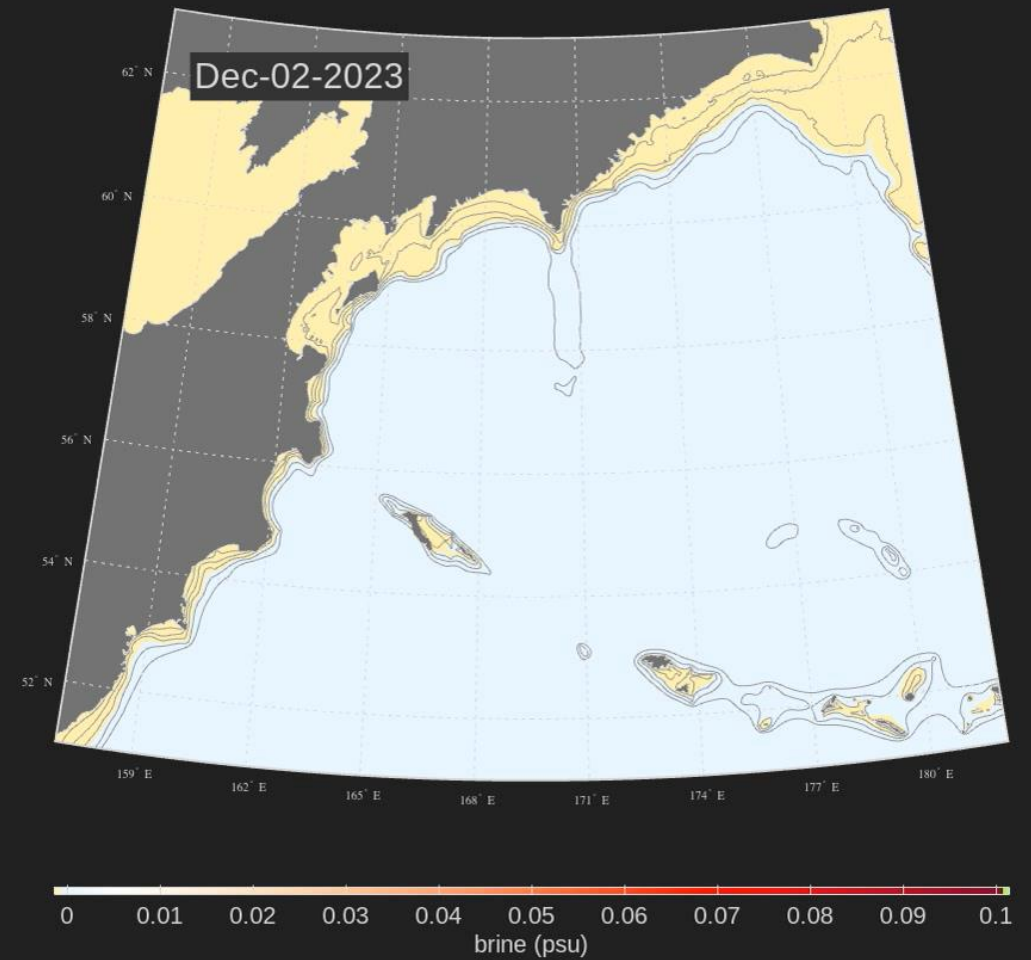


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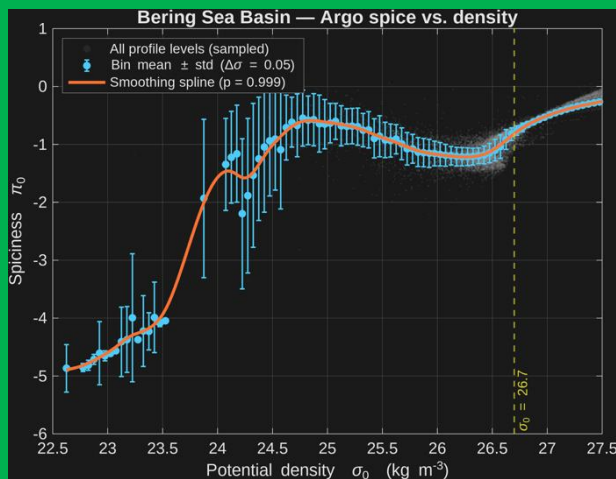
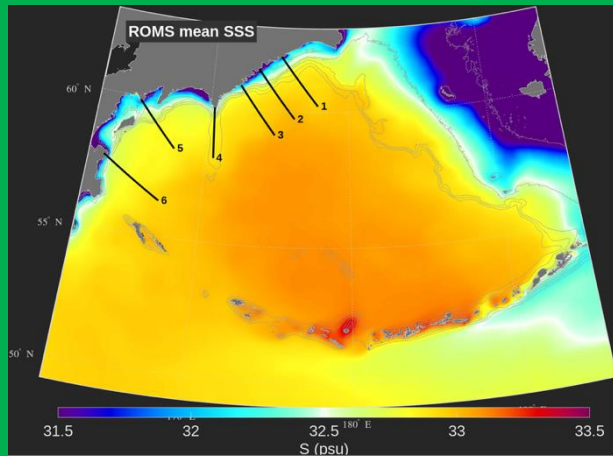
Sea ice Brine and Melt tracers are added to the model, provided as a flux through the surface boundary with magnitudes equal to the salinity flux due to ice formation and melt respectively.

Brine tracer on the $\sigma_{26.7}$ isopycnal

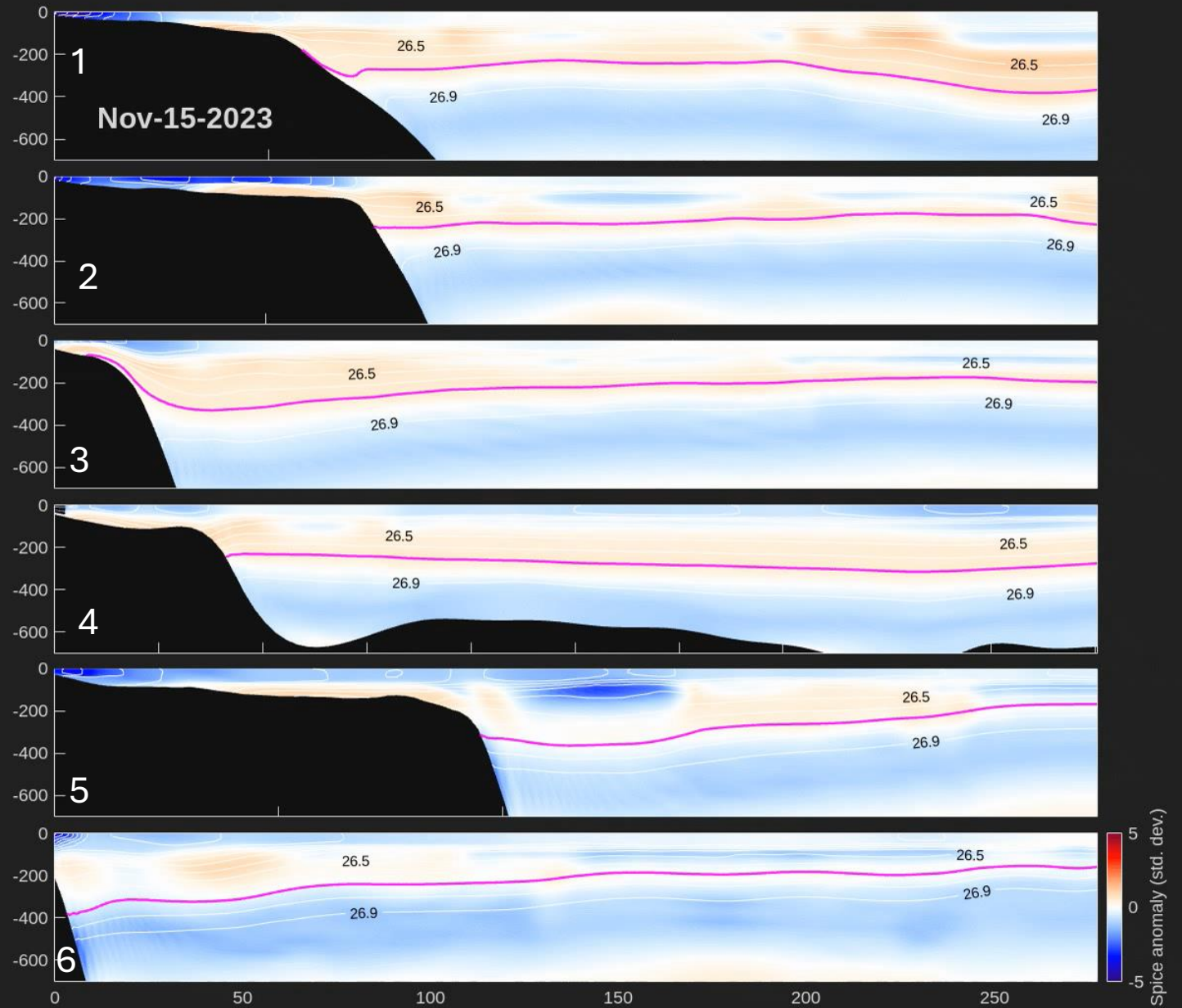


Entrainment along the slope associated with strong winter/spring downwelling events can be observed in the model on transects by examining the normalized spice

$$\text{anomalies } \pi' = \frac{\pi(\sigma_\theta) - \pi_A(\sigma_\theta)}{\text{std}(\pi_A(\sigma_\theta))}$$



mean and std of salinity as a function of density from all basin Argo profiles



Summary

Technical

- Application of the current generation of salinity satellite products to high latitude environments at 'coastal' scales is most likely to succeed where and when strong anomalies provide a signal that clearly exceeds the noise

Scientific

- Interannual variability in summer salinity in the Gulf of Anadyr can result from retention- or export favorable wind patterns in late spring
- A high resolution coupled ice ocean model suggests that the gradient in salinity on the $\sigma_{26.7}$ surface in the Bering Sea Basin may be partially sustained by shelf export of meltwater that subducts during stormy downwelling spells during the winter and spring.