Salinity Variability influenced by shelf-interior ocean interactions in the Northeast Pacific and Bering Sea

Scott Durski[1] and Alexander Kurapov[2]

[1]College of Earth, Ocean and Atmospheric Sciences, Oregon State University
[2]Coastal Survey Development Lab, NOAA

Outline

- Description of our project
- Results from preliminary study of the Northeast Pacific system
- Results from prior work on the Eastern Bering Sea and initial exploration of Satellite SSS products.

Project

Objectives:

- Understand the dynamical mechanisms driving **sea surface salinity variability** in shelf and offshore ocean regions **influenced by coastal processes and shelf-interior ocean exchange**
- **Assess seasonal and interannual variability** in the **satellite** SSS products in comparison to **in-situ** observations and **regional ocean model** outputs
- Develop benchmark cases in coastal and adjacent offshore areas, setting accuracy and sensitivity requirements for future satellite products

Focus Areas

- Northeast Pacific Ocean – variability driven by rainfall, terrestrial and river freshwater discharge, shelf-interior ocean eddy transport and coastal upwelling
- Bering Sea - river discharges, shelf currents, shelf-interior eddy exchange and seasonal sea ice formation and melt

NE Pacific: study shelf-interior ocean salinity fluxes and their effect on SSS, on seasonal and interannual temporal scales

Compare SMAP, regional ocean model, in-situ data (glider, Argo, ship CTD)

Regions:

- Offshore off British Columbia (precipitation: ~ 2 m/year, terrestrial discharges)

- Off Oregon (Columbia river plume)

- Offshore of Southern CA (a “reference region” with low precipitation and terrestrial discharge): *surprisingly large interannual variability (0.6 psu)*

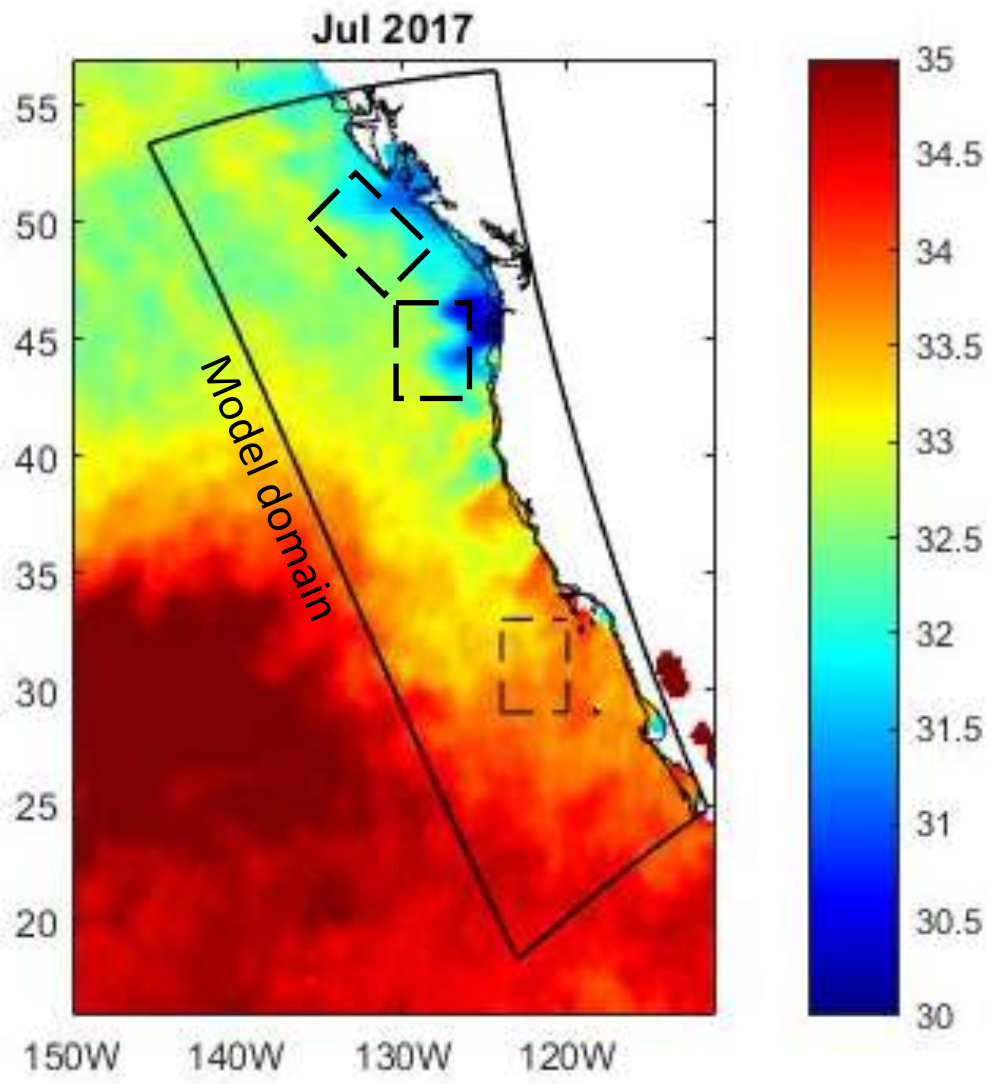


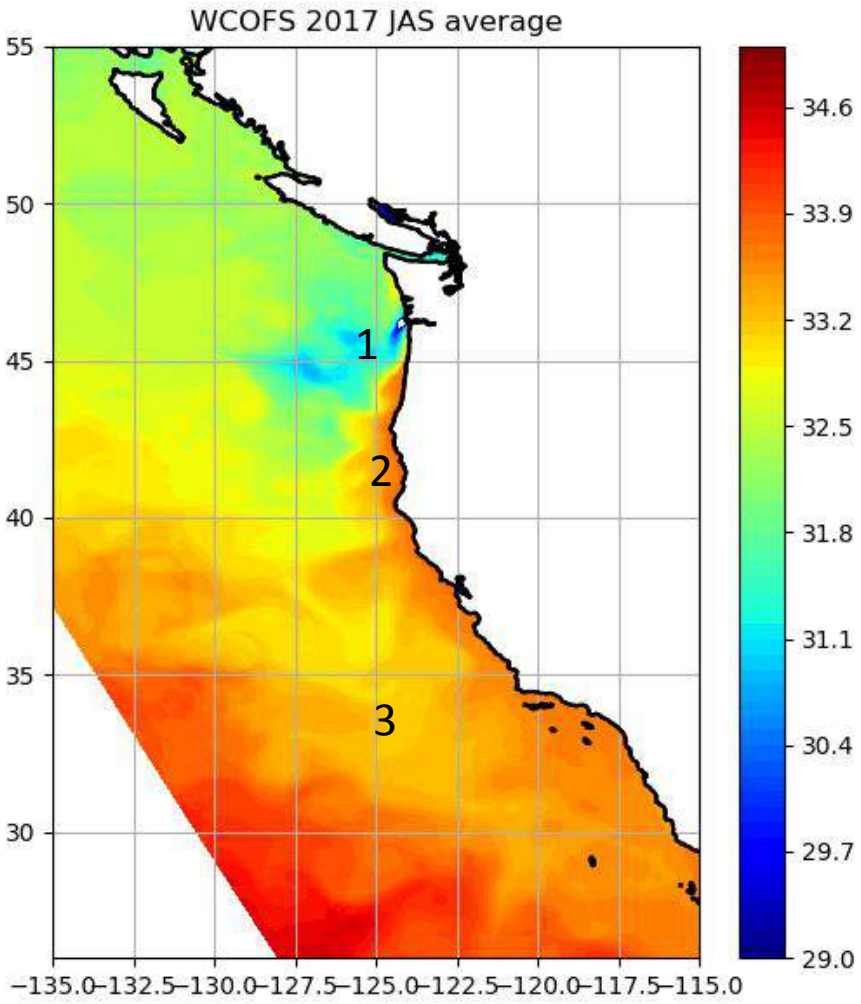
Image: Jul 2017 average SMAP (JPL L3)

Model:

- Regional Ocean Modeling System (ROMS)
- 2-km horizontal resolution / 40 terrain following layers
- Realistic atmospheric forcing, tidal and non-tidal boundary conditions
- River discharges (Columbia R., Fraser R., 15 small rivers in Puget Sound)

2009-2018 simulation (a free-run model, without data assimilation inside the domain)

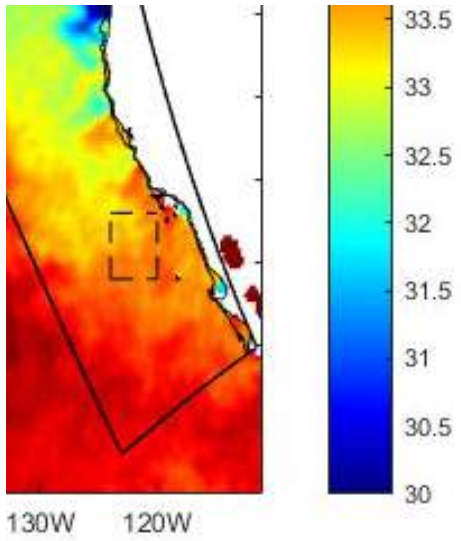
Summer 2017 average SSS

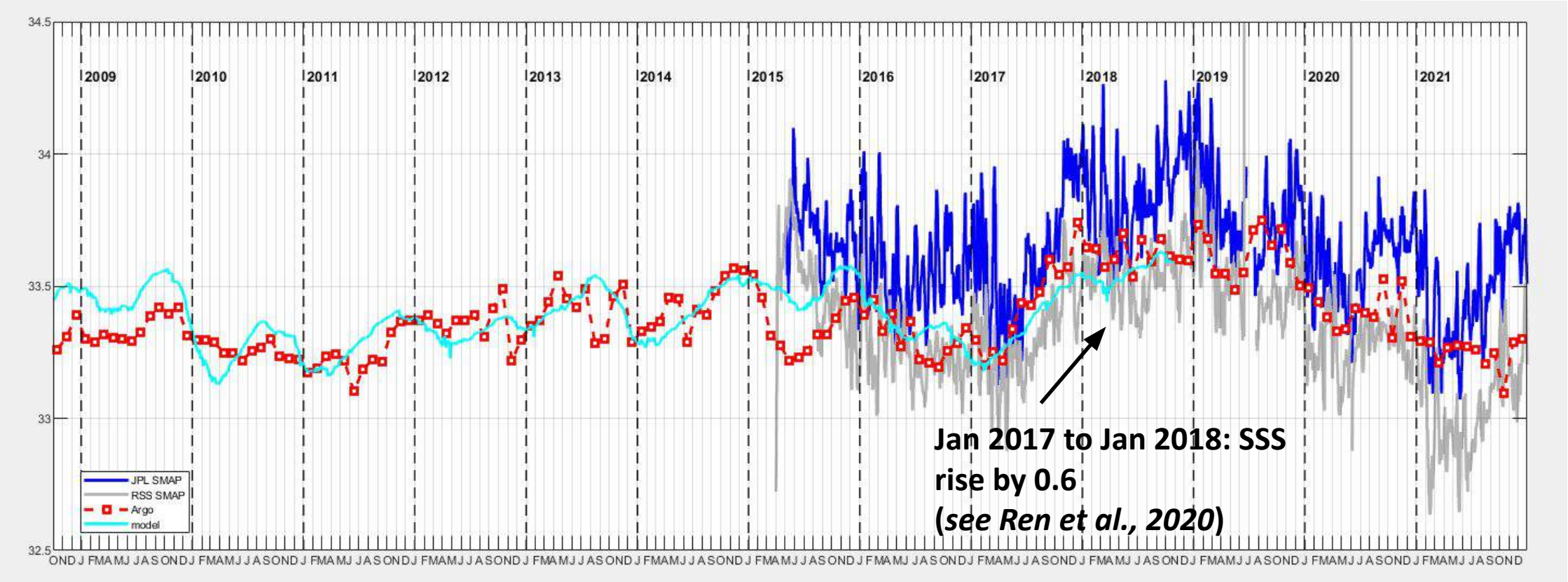


(1) Columbia R. plume
(2) Upwelling
(3) California Current System: subarctic water intrusion

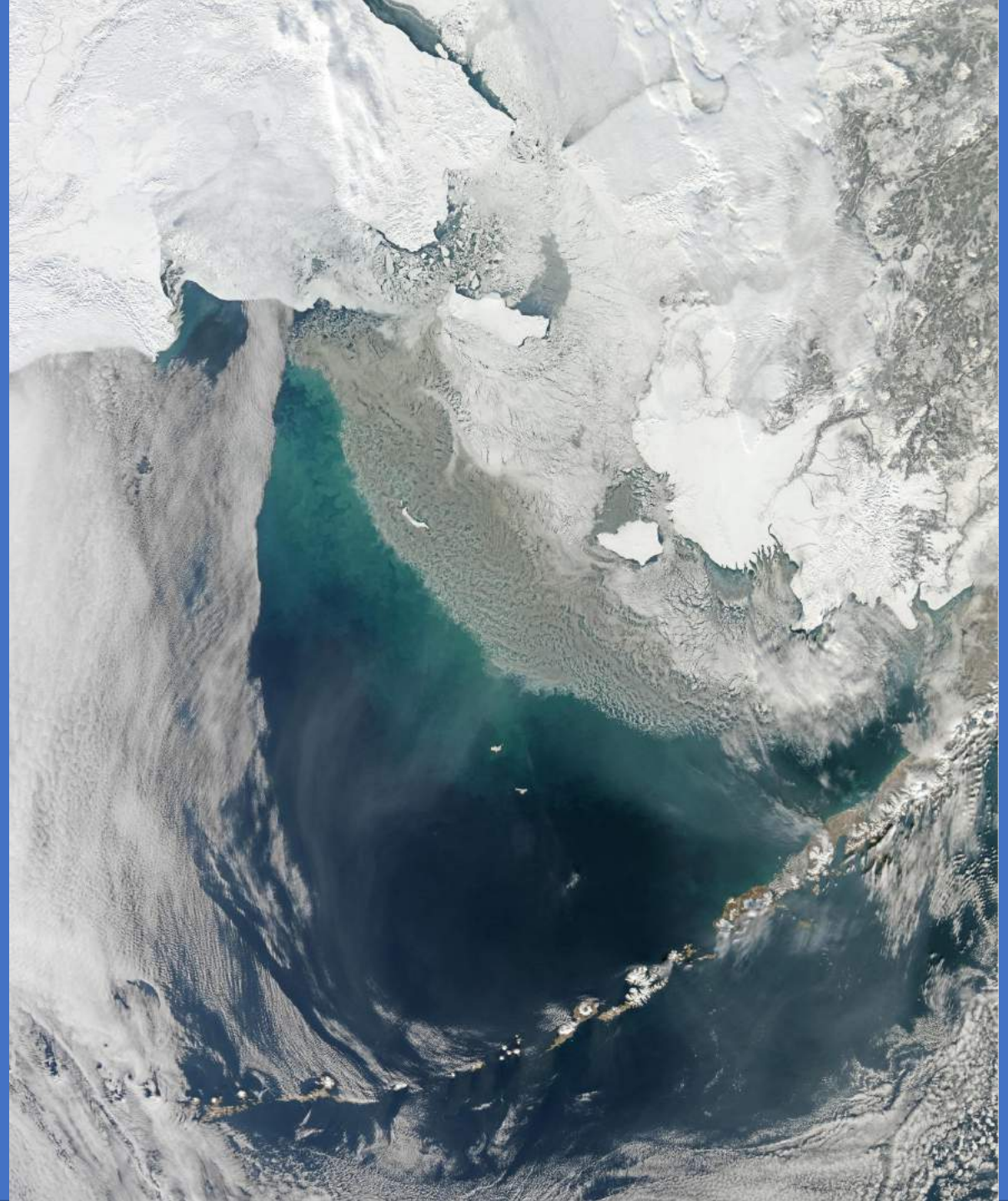
Area averaged time SSS series in the offshore S CA region:

JPL 8day running average V5.0
RSS 8day running average V5.0
Argo (BOA mapped product), monthly averaged
Model: daily average





The Bering Sea



Aqua/MODIS March 2-3 2011

A Changing Bering Sea

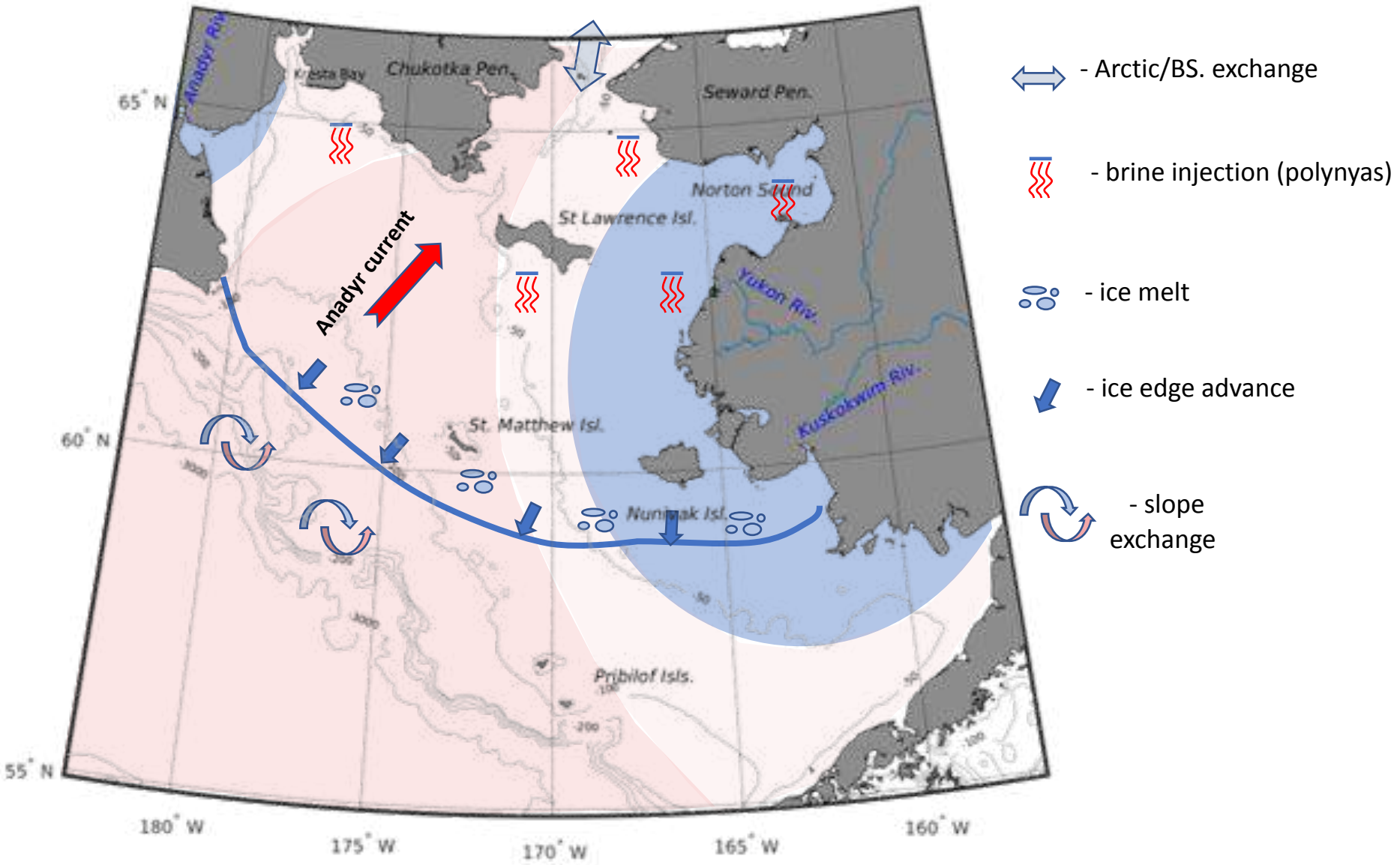
The maximum extent of seasonal ice advance has been greatly diminished in several recent years, having many impacts:

- Greatly altered shelf stratification structure through summer: Ice freeze/melt cycle leads to the formation of a bottom cold pool that acts as a refuge for species like pollock on the central BS shelf which migrate northward along with pacific cod in low ice winters
- Changed characteristics of water exported to the Arctic
- Coastal erosion: The sea ice typically protects coastal communities from the damage caused by winter storms.
- Ecosystem shifts: Under-ice algae promote a rich ecosystem supporting fatty fish through marine mammals and an abundant benthic community all of which are severely stressed by lack of sea ice cover
- Increased Northern Bering Sea shipping and fishing traffic

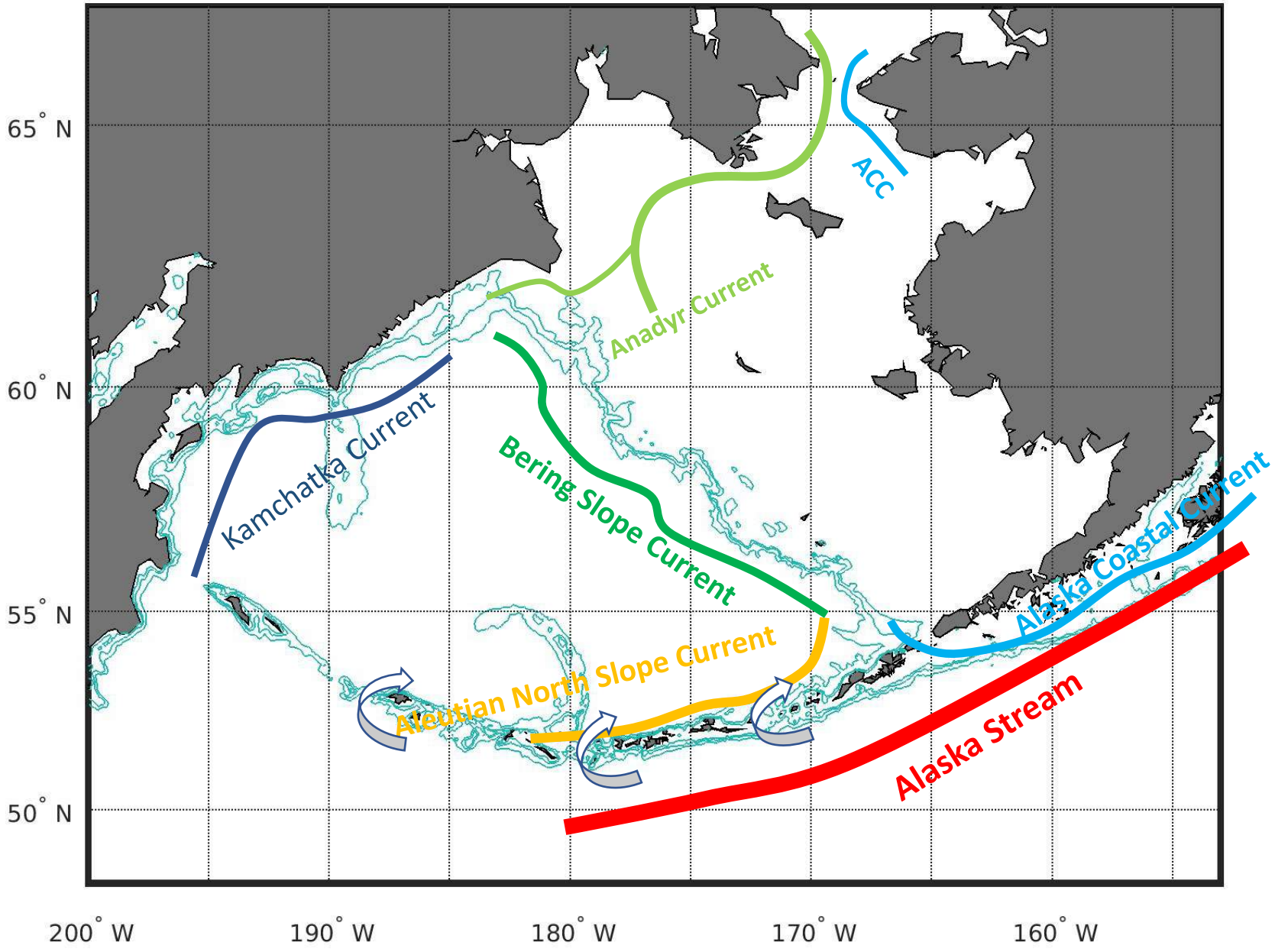
These recent low ice years are expected to be typical years by 2040.

Seasonal sea ice

Bering Sea shelf salinity processes



Bering Sea Circulation

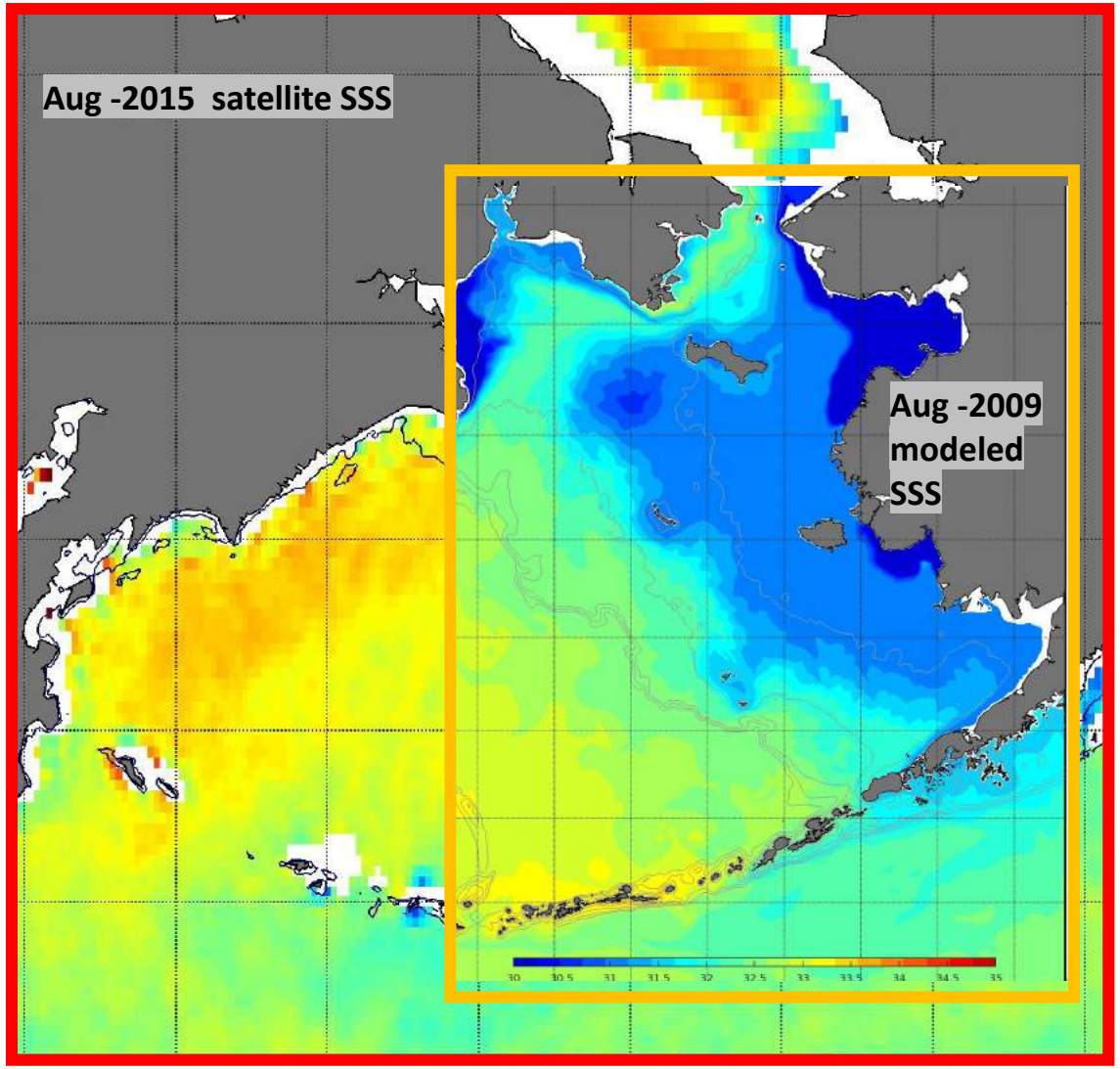


Bering Sea model

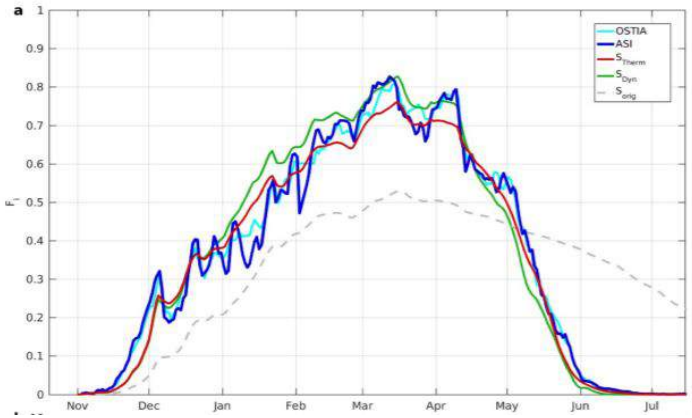
- The Regional Ocean Modeling System (ROMS)
- ~2 km horizontal resolution, 45 vertical s-levels.
- Boundary and Initial conditions from global HYCOM (~9 km res.) + tidal model
- Freshwater river inflow from monthly USGS gauge data and climat. for Yukon, Anadyr and Kuskokwim rivers.
- Northern flow boundary conditions adjusted for consistency observed Bering Strait transport estimates.
- Single category ice model **with refinements** for Bering Sea application
  - thermodynamics
  - wind/ocean drag
  - salinity conservation
- Simulations planned for 2009 through present

Prior model domain

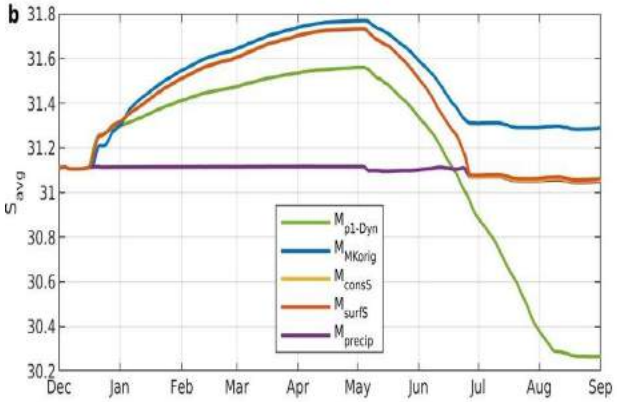
Planned model domain



Fractional shelf ice coverage

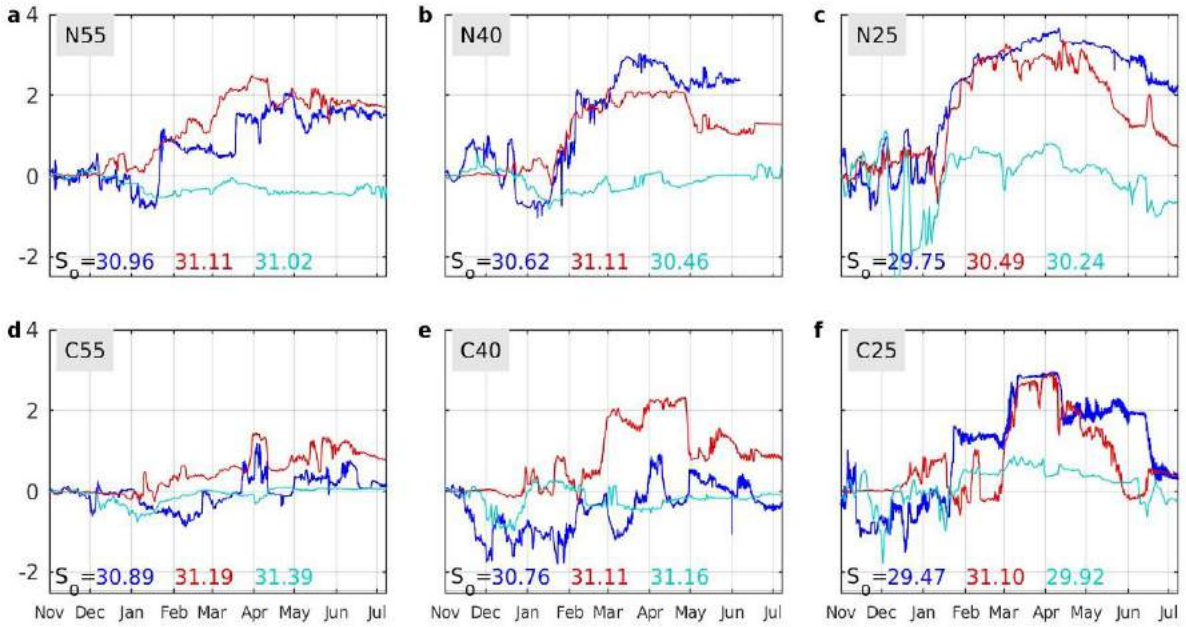


Depth-averaged salinity



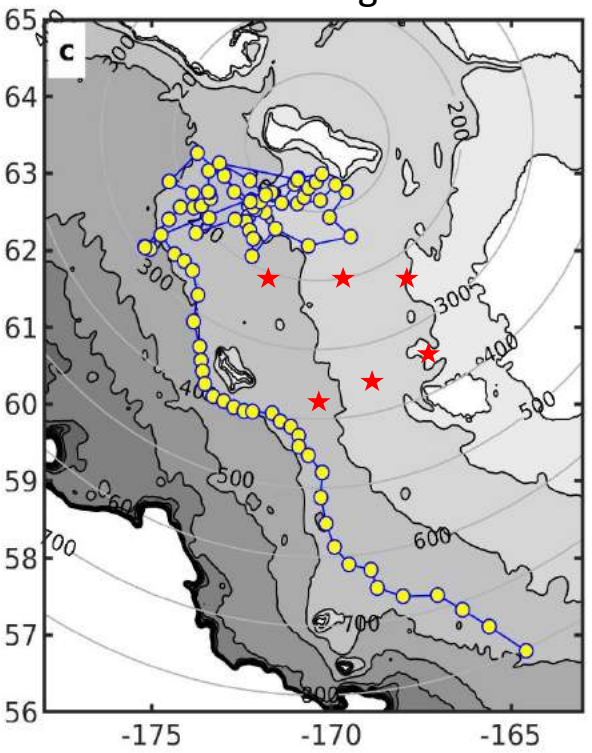
Results from Previous Work: Model-Observation comparisons

Model improves on capturing changes in shelf salinity due to brine rejection and sea ice melt.

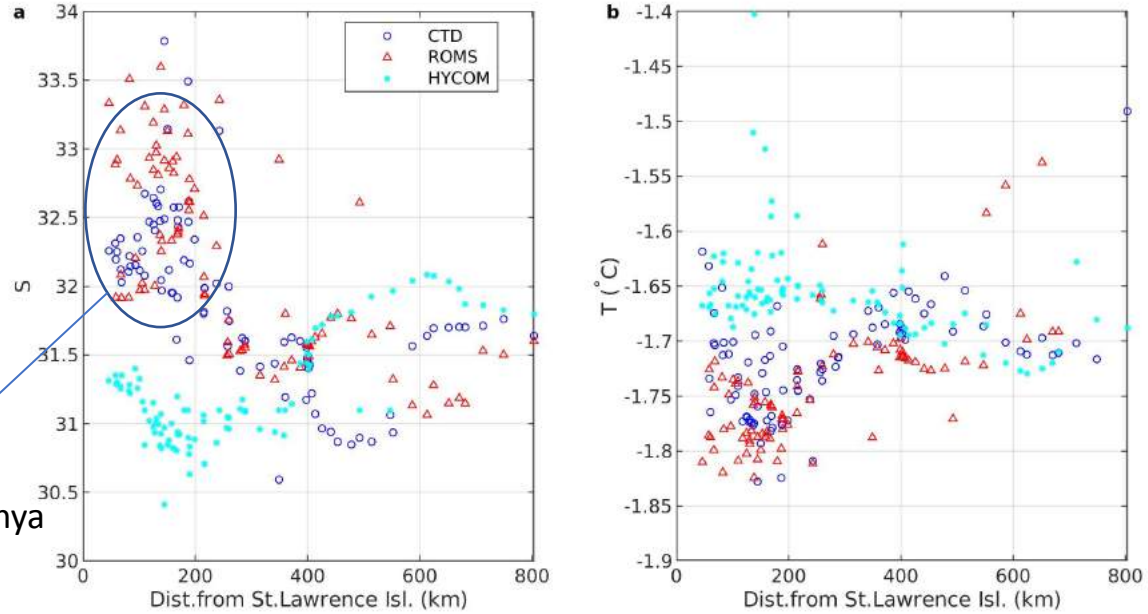


Salinity time-series at BEST shelf moorings (red stars)

CTD and mooring locations



Influence of St. Lawrence polynya

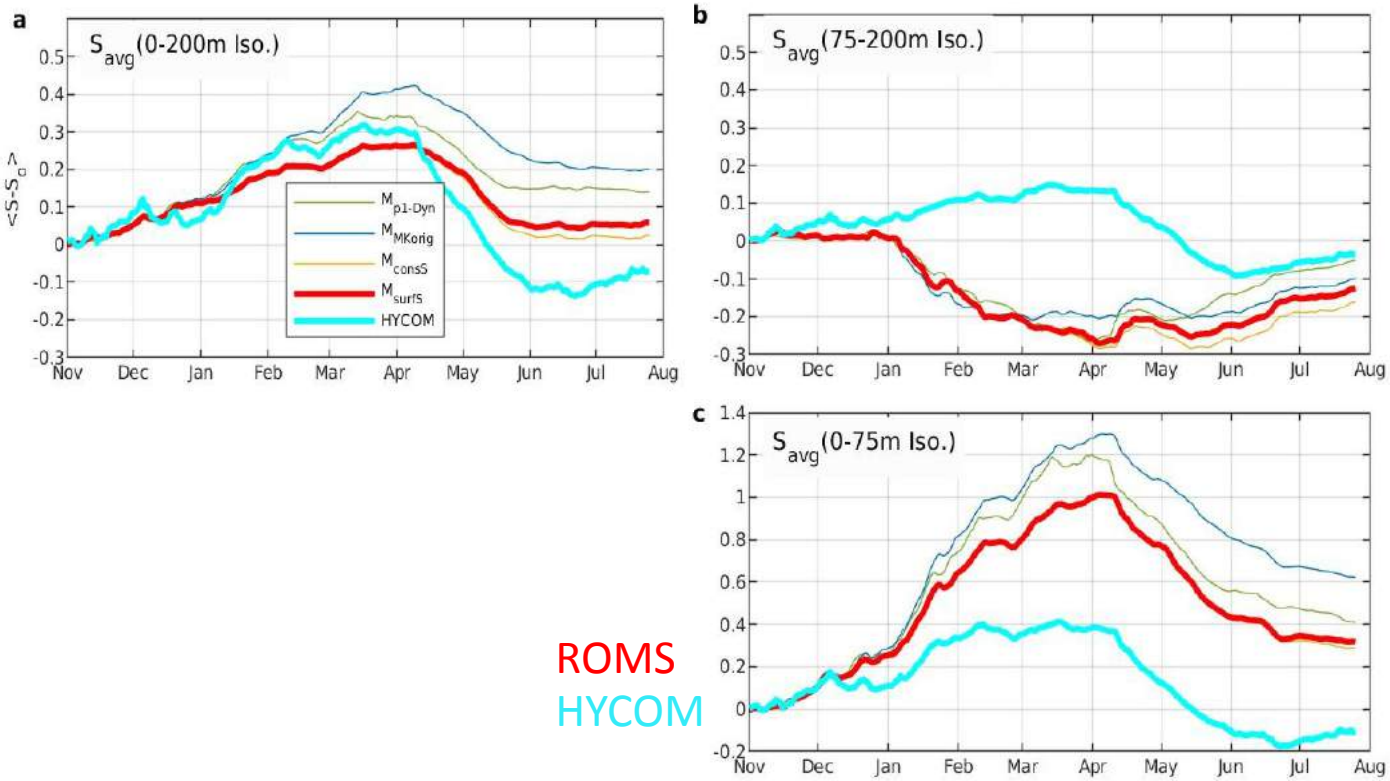


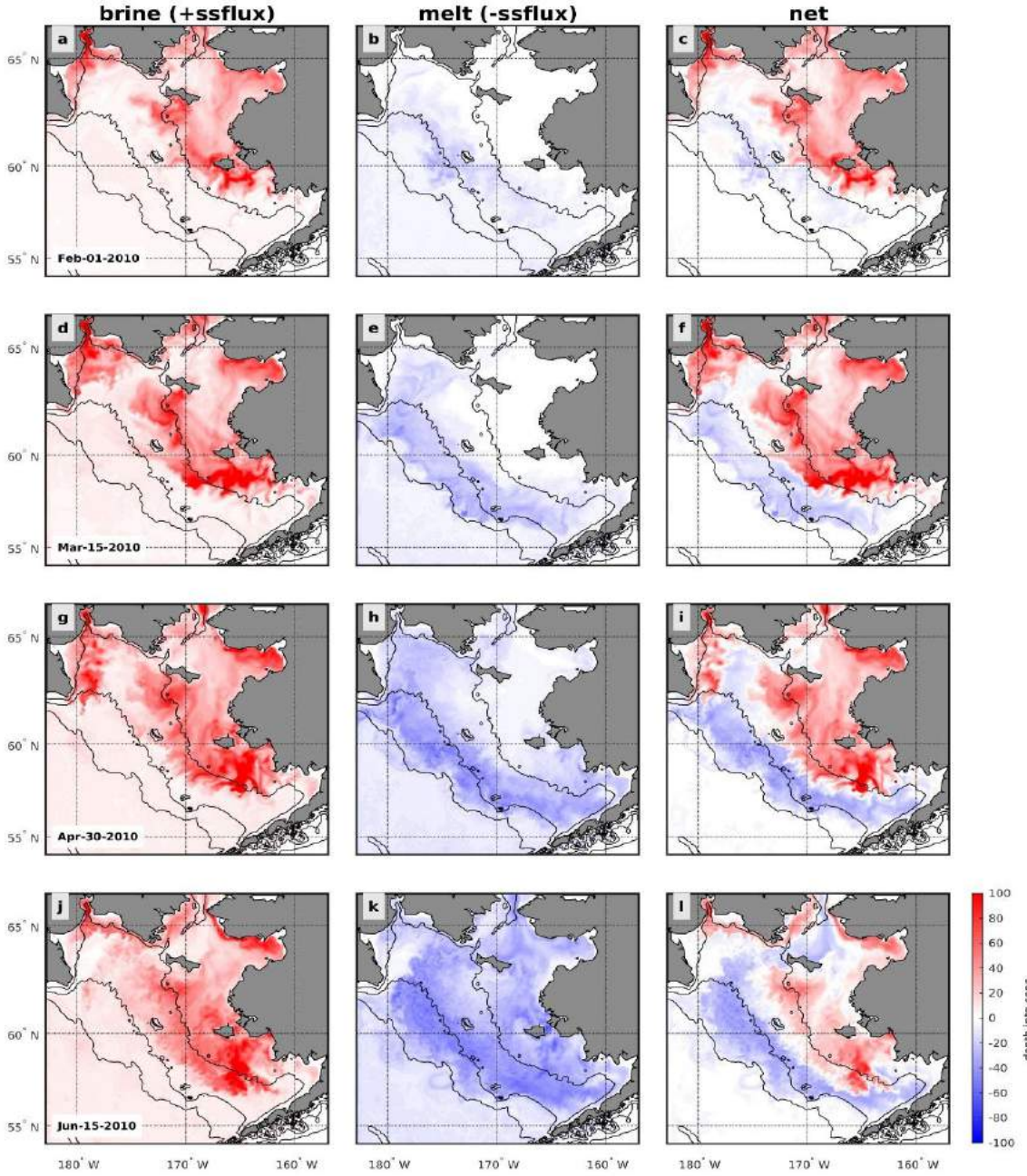
Depth averaged S and T at PSEA CTD profile locations, Mar-April 2010. (yellow dots)

Results from Previous Work: Shelf salinity budget

The model suggests that over a winter season with typical sea ice coverage, salinity on the eastern Bering Sea shelf tends to be redistributed. The inner shelf becomes saltier, while the outer shelf becomes fresher.

Volume-averaged salinity change

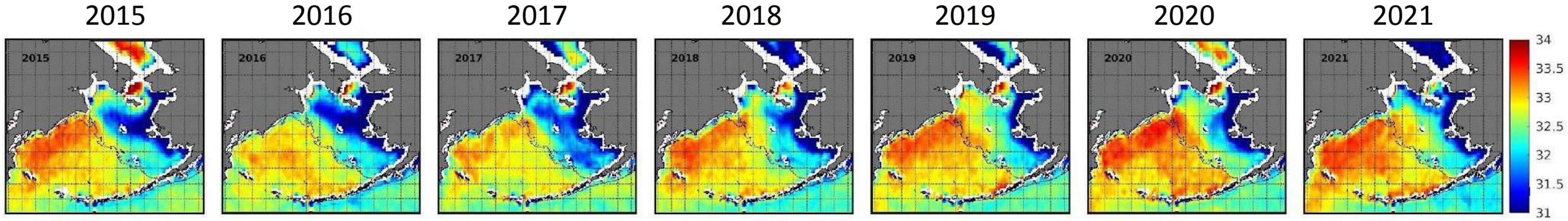




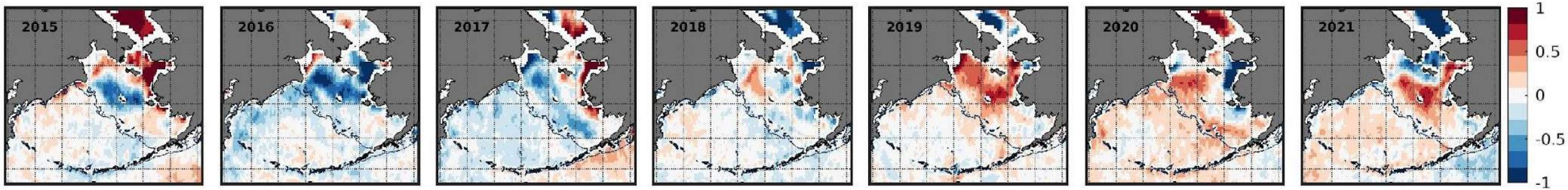
Trend in Bering Sea salinity from satellite estimates

Salinity tends to be increasing both in the basin and on the shelf

August-September averaged SMAP SSS (RSS L3 v5.0)



Difference from 7-year average of August-September averaged SSS



Summary for NE Pacific

- SMAP captures interannual variability in the S CA region, in particular the event of higher salinity anomaly in 2017. The regional model shows it too (and may provide insight on the mechanism).
- Differences between JPL and RSS products (2021: 0.3)
- Approximately fortnightly variability in the 8-day running average product. Why?

Summary for Bering Sea

- SMAP shows trend in sea surface salinity both on the eastern Bering Sea shelf and in the basin over the past 6 years
- Intercomparisons with observations and model will help elucidate the causes for this trend.