U.S. NAVAL RESEARCH LABORATORY

Improving Forecasts and Nowcasts at High Latitudes

Elizabeth Douglass, Robert Helber, Alexandra Bozec[2], Eric Chassignet[2], Julie McClean[3] and Alan Wallcraft[2]

2: Florida State University

3: Scripps Institution of Oceanography

OUTLINE

- Project description (what is an OSSE?)
- Current use of altimetry in data assimilation
- Suggested new approach to altimetry in numerical data assimilation at high latitudes

What is an OSSE?

Observed System Simulation Experiment

1. Produce a multi-year, high resolution "free" model run (forced with real atmosphere, no assimilation) – this is the Nature Run
2. Sample this output as your instrumentation would sample the real world
3. Use these data to assimilate into an experimental test case.
4. Compare these results to the Nature Run. Does your sampling/assimilation strategy allow you to accurately recreate the system?

An OSSE setup allows you to compare different sampling strategies and assimilation processes to determine the efficacy of your system – to answer the question of "how are we doing?"

Experimental Overview

Nature Run description	OSSE member setup
• Global model run, based on POP model • Very high horizontal resolution (nominally 8 km at the equator to 2 km at the poles) • 60 vertical levels • Forced by JRA-55 atmosphere • Run from July 2016 to December 2020 • Details in Fine et al. (2023)	• Regional HYCOM-based model • Region is the Arctic Cap (all longitudes, North of 40°N). • Initial and boundary conditions from GOFS 3.5. • Atmospheric forcing from Navy Global Environmental Model (NAVGEM). • Horizontal resolution is 1/12.5°, with 41 vertical levels. • Assimilative setup, where "data" are taken from Nature Run at times/locations/types of actual data.

Synthetic Profiles

The model assimilates SSH as a synthetic profile of temperature and salinity.

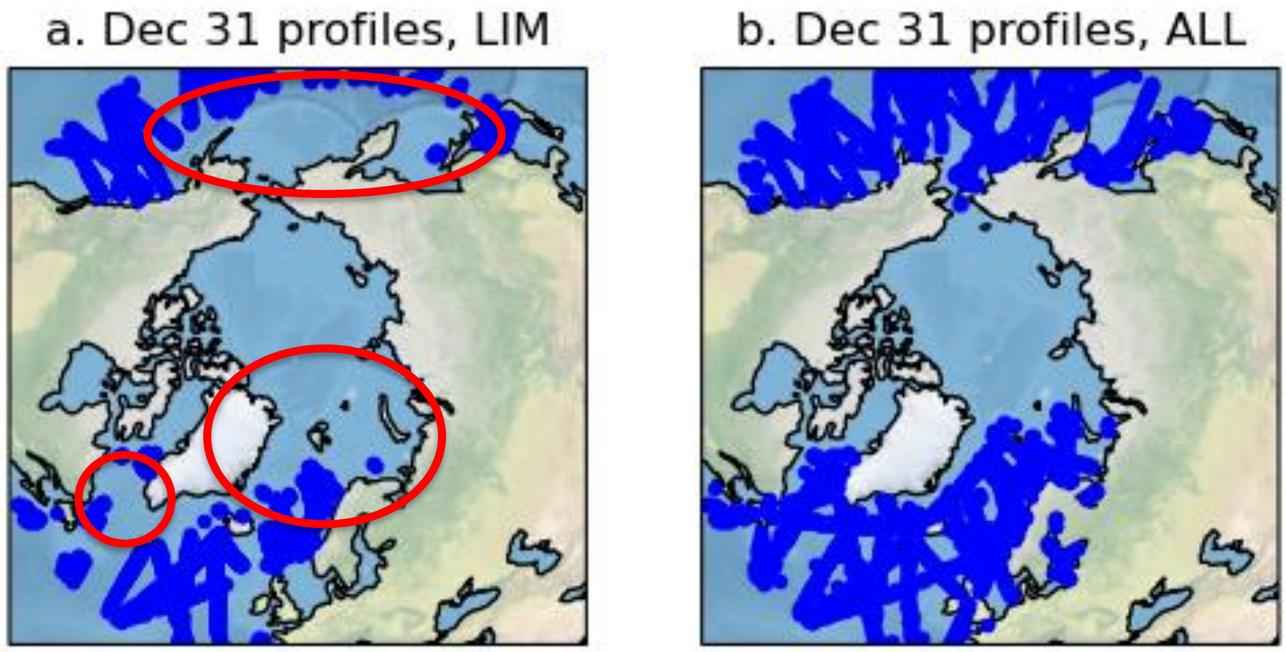
These are created using a method called ISOP, which uses covariances based on historical in situ data to evaluate a sea surface height anomaly and construct synthetic profiles of temperature and salinity most likely associated with that anomaly.

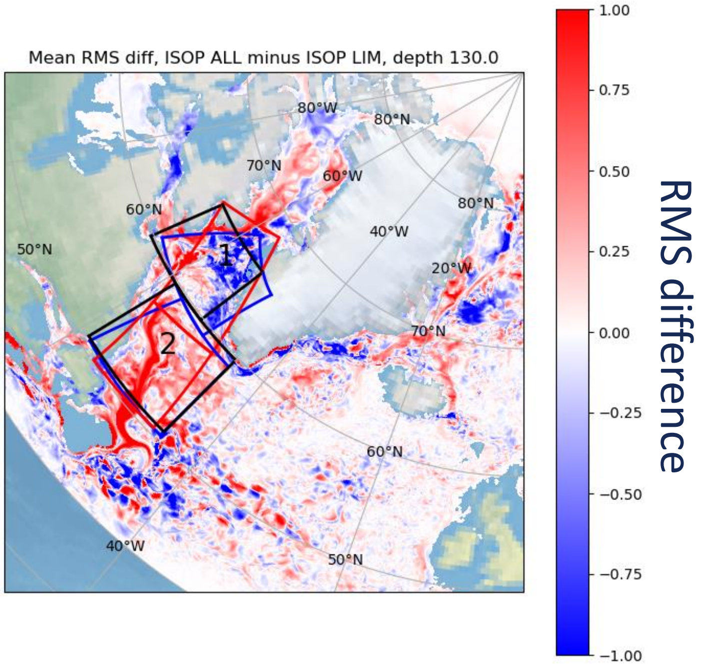
This method relies on the assumption that the region is stratified and most SSH anomalies are due to vertical displacement of the thermocline (an example would be an eddy passing through).

All profiles where the surface temperature is less than 3°C warmer than the temperature at 1000 m depth are discarded as “unstratified”. This is the “3° check”.

This figure shows how many profiles are discarded on a single day due to the 3°check.

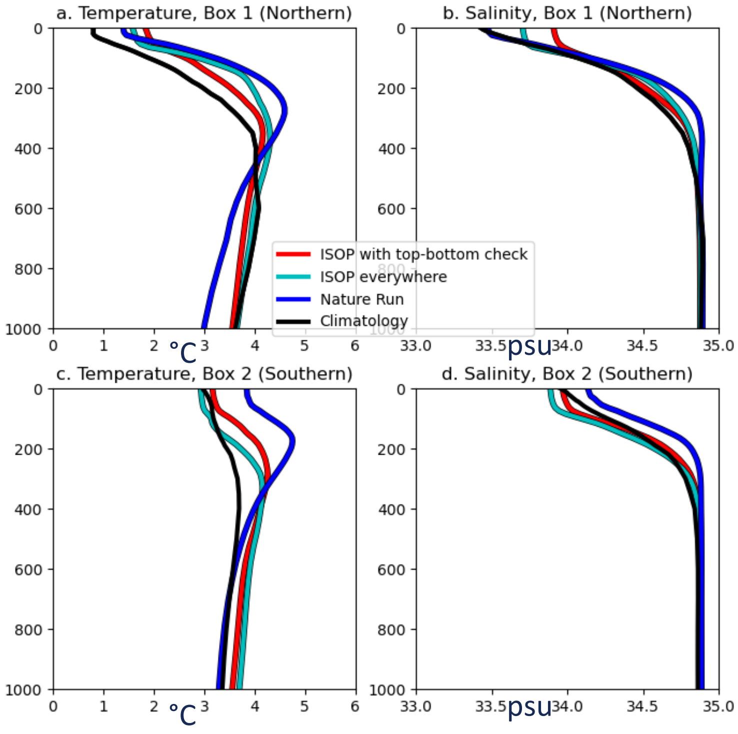
Note large regions where data are being discarded. Is useful information being discarded?



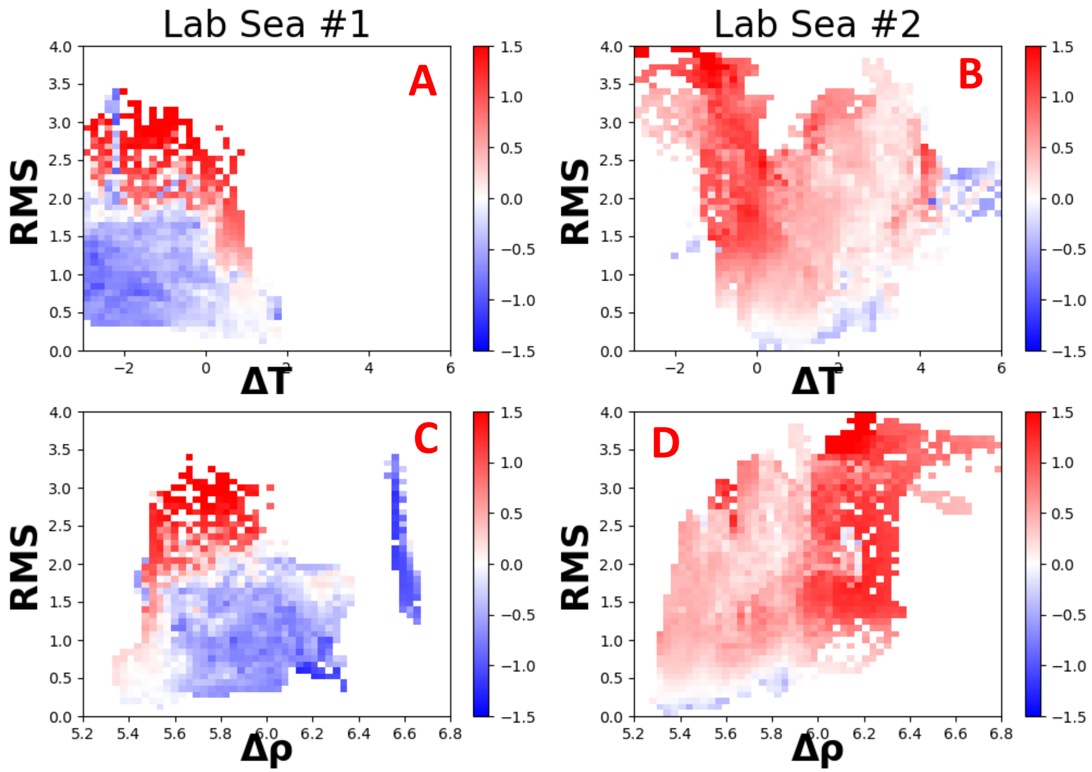


Two OSSEs were performed: one that implemented the “3° check” (ISOP LIM), and one that didn’t (ISOP ALL).

The DIFFERENCE between the OSSEs’ difference from the Nature run is shown. If the contouring is BLUE, using ISOP everywhere meant RMS got smaller (i.e. results closer to truth). If RED, using ISOP everywhere meant RMS got bigger.



- This example shows how ISOP affects profiles
- The cyan profile is from the run where ISOP is applied.
- In both cases (northern and southern box) the ISOP-adjusted temperature profile is closer to climatology; however, in the southern box, climatology does not resemble the Nature Run.
- If the climatology doesn't match reality, ISOP can't help you!



Is there a threshold of T_{sfc}-T_{1000} over which we should not use a profile?

Figures A and B demonstrate almost no relationship between ΔT and RMS. The lowest RMS differences are at ΔT of <2°C.

Figures C and D demonstrate that if anything, RMS increases with $\Delta\rho$.

So if thresholds don't work, what does?

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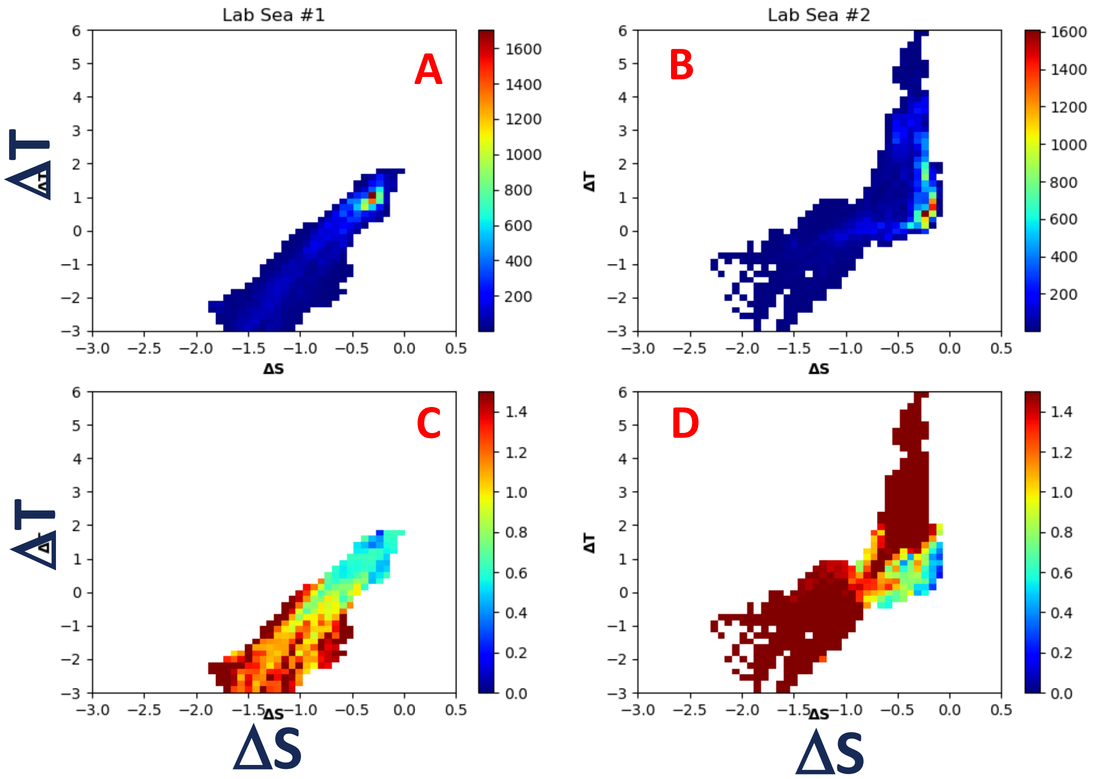
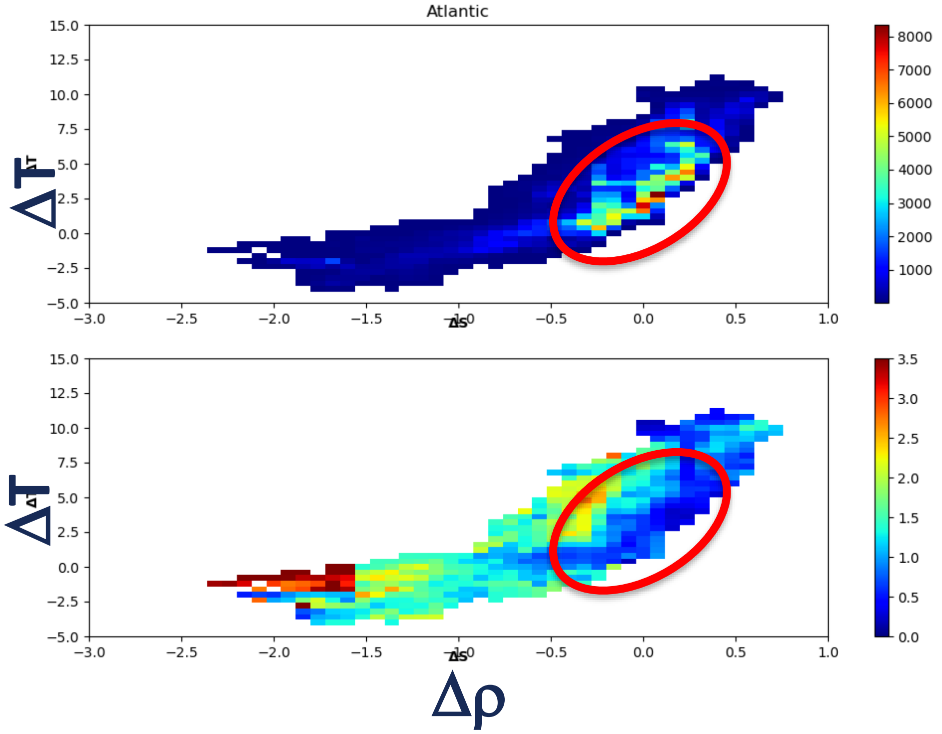


Consider the problem in T/S space.

- Figures A and B demonstrate that in both regions, MOST profiles fall within a relatively small range of T/S behavior.
- Figures C and D demonstrate that the minimum RMSE (difference between a profile and the Nature Run ground truth) occurs in the range where most profiles fall.
- As long as we check whether ΔT and ΔS are within our accepted range, we can assume RMSE values will be comparatively small.

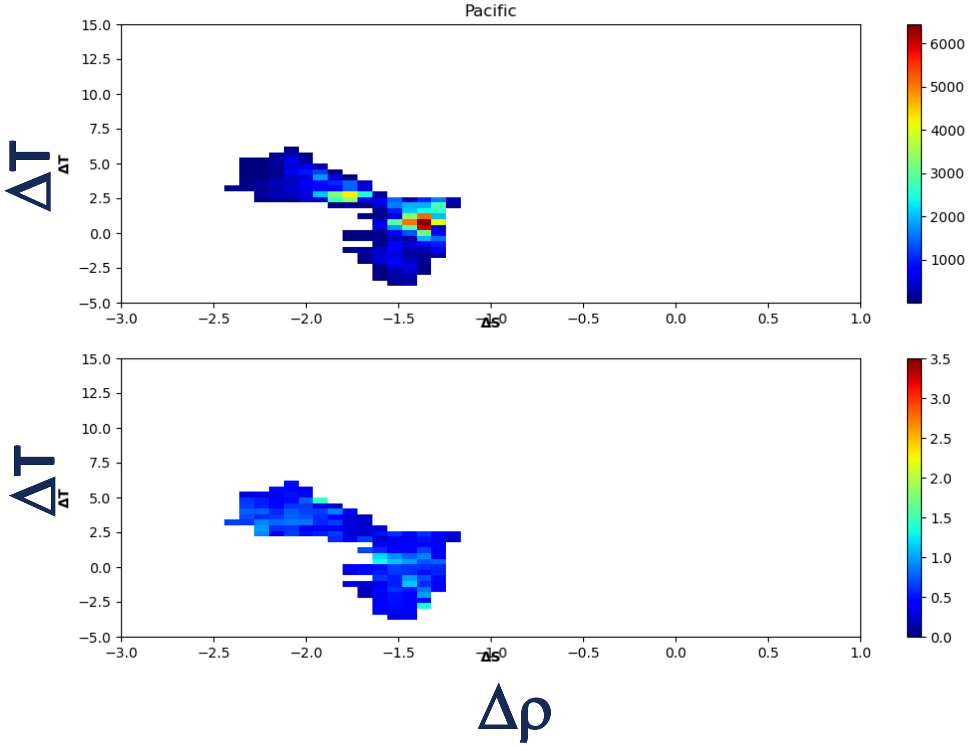
Full Atlantic



Does the relationship seen in the Labrador Sea extend to the full Atlantic?

- As in the Labrador Sea, the majority of points fall within a small range, and the range in which those points fall (red circle in top figure) is the range with the smallest RMS errors (red circle in bottom figure)
- As long as we check whether ΔT and ΔS are within our accepted range, we can assume RMS errors will be relatively small.

Full Pacific



What about the Pacific?

- Note that the ΔT/ΔS ranges are not the same in the Pacific as the Atlantic; ΔS is consistently between -1 and -2 PSU, while in the Atlantic ΔS was often close to 0
- The color scales on the RMS plot are the same as the Atlantic plot, demonstrating that the RMS in the Pacific is consistently smaller

CONCLUSIONS

- We used an OSSE format to demonstrate that data are being discarded unnecessarily
- We demonstrated that a “threshold” format, whether based on temperature or density, is not a good way to determine whether a synthetic profile will be accurate or not
- We demonstrated that there is potential to develop a threshold based on the relationship between temperature and salinity, which could help us move forward in utilizing high latitude data more effectively
- We demonstrated that if the climatology is inaccurate, the results will be inaccurate, and moving forward we continue to develop up-to-date climatologies for high latitude regions