Increased Uncertainties of Salinity Variability from Multiple Objective Analyses Since 2016

Chao Liu[1], Xinfeng Liang[1], Rui M. Ponte[2], Don P. Chambers[3]

1. School of Marine Science and Policy, University of Delaware, Lewes, DE, United States
2. Atmospheric and Environmental Research, Lexington, MA, United States
3. College of Marine Science, University of South Florida, St Petersburg, FL, United States

BACKGROUND

❖ Argo and Ocean Observations

Historical measurements of ocean salinity are very sparse in space and time;

The global Argo program has become a major component of the Global Ocean Observing System.

❖ Underlying Issues

The salinity sensors are subject to drift over time;

Errors in the Argo salinity measurements are found responsible for 40% of the non-closure of the sea level budget since 2016.

❖ Goals

Assess the uncertainties of salinity variability from various objective analyses and their spatiotemporal characteristics;

Examine if there is a geographical preference of the "errors" after 2016

MEAN SALINITY: Splitting After 2015

- ❖ Most products exhibit a rapid increase in the 0-200 m global ocean from 2015 onwards;
- ❖ However, such increase is opposite to the implied salinity change from sea level budgets;
- ❖ Inconsistency of the timeseries is more evident since 2015, and it is also more apparent in the 700-2000 m layer.

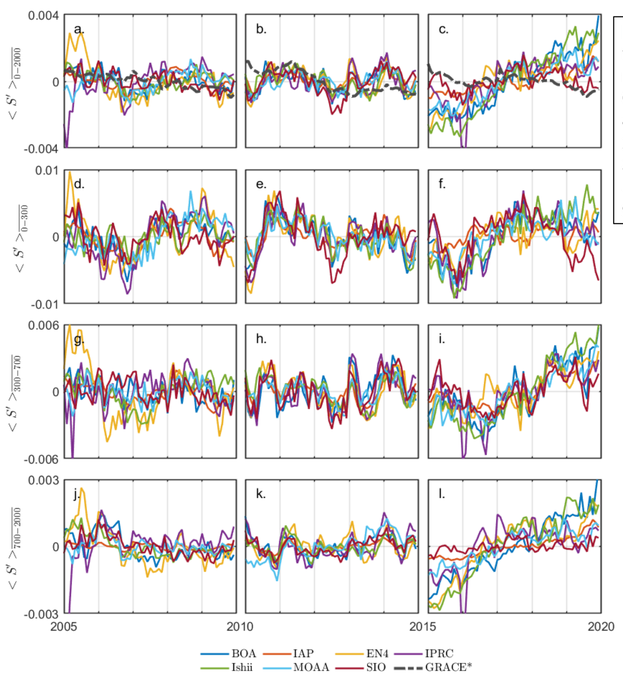
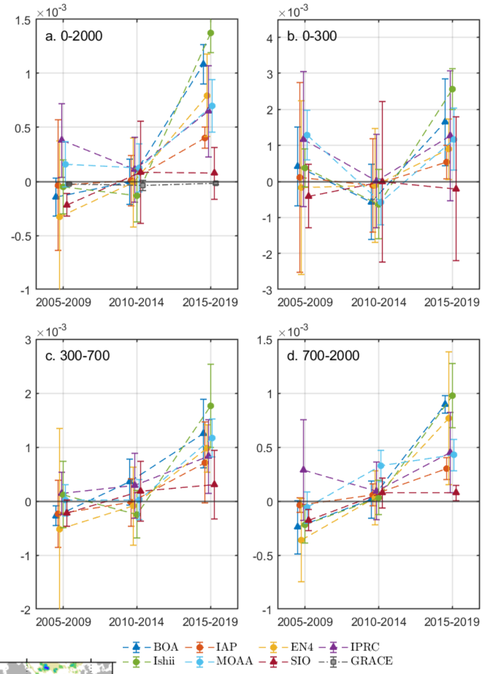


Figure 1. Monthly timeseries of global mean salinity anomaly (<S'>) in vertically averaged layers (0-300m, 300-700m, 700-2000m). The *implied salinity** anomaly is also given. (Unit: g/kg)

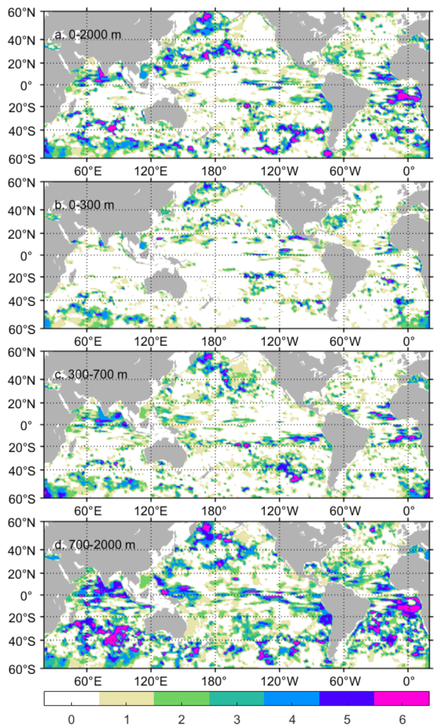
Implied Salinity Calculated from the *Gravity Recovery and Climate Experiment*.

A VIEW FROM THE TREND: Large Spread In the Deep

Figure 2. 5-year trends of global mean salinity in vertically averaged layers and their uncertainties (2σ). The Implied salinity trend is also given. (Unit: g/kg/year)



- ❖ Globally, the 2010-2014 period has the lowest spread of the estimated 5-year trend between the products;
- ❖ The spread substantially increased in the 2015-2019 period, and is at least comparable to 2005-2009, when the spatial coverage of Argo was much lower;

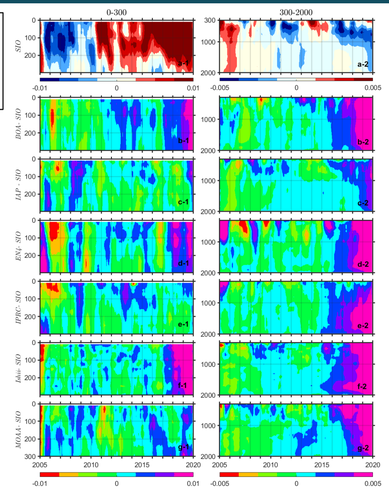


- ❖ All examined products show strong positive trends during 2015-2019 when the ocean is supposedly freshening;
- ❖ This discrepancy is most apparent between 20-60°S and 700-2000 m (see Figure 3).

Figure 3. Regions of possible overestimations of salinity trends over 2015-2019. Spatial map of the number of products that have trends falling outside of SIO's 2σ interval over 2015-2019. It is constructed when an estimated salinity trend over 2015-2019 is out of SIO's uncertainty in each cell.

SPATIAL DISTRIBUTION: A Common Cause?

Figure 4. a) Mean salinity anomaly over 25-60°S as a function of depth and time over 2005-2019. b-f) Residuals of anomaly after subtracting SIO from the other products. (Unit: g/kg)



- ❖ SIO is chosen as a reference for its trend is the closest to the implied salinity change;
- ❖ Traces of a positive bias are found in the residuals between SIO and other products, particularly below 300 m;
- ❖ In the SIO analysis, a strong freshening is evident along the ACC region, yet all other products have large positive residuals.

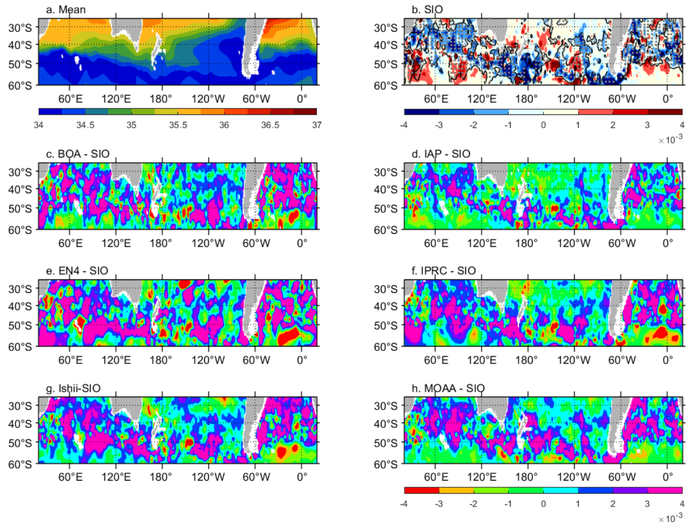


Figure 5. Mean salinity, 5-year trend, and residuals of the trend over 25-60°S between 700-2000 m over 2015-2019. (Unit: g/kg & g/kg/yr for the left and right columns, respectively.)

CONCLUSIONS

- ❖ Spreads on both the anomaly timeseries and the trends have substantially increased after 2015 between various objective analyses;
- ❖ A consistent increase of salinity is observed in most products after 2015. However, it is likely not real for being inconsistent with other measurement;
- ❖ Most objective analyses show a strong positive bias against the implied salinity change after 2015, which could result from sensor drifts.