Global salinity changes over the ARGO-era

Nikolaos Skliris and Robert Marsh
University of Southampton, Ocean and Earth Science, United Kingdom

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1. Long-term changes

The EN3 (v2a) global ocean dataset [1] (1950-2012) is used to investigate global ocean salinity changes. Salinity observations over 1950-2012 clearly suggest an amplification of the global water cycle with the spatial pattern of surface salinity multi-decadal change (Fig. 1) strongly resembling the climatological mean patterns of both surface salinity and surface freshwater flux. Large salinification of the upper layer North Atlantic subtropical gyre and freshening of the Western Pacific warm pool are highly correlated with the SST increase after the early 1970s (Fig. 2), and seem to be part of an accentuating contrast between Atlantic and Pacific Oceans water cycle components linked to the broad-scale surface warming . However, results show low correlations between reanalysis-derived surface freshwater flux components and EN3 salinity annual variations during the 1950s and 1960s (Fig. 2) when density of observations is very low.

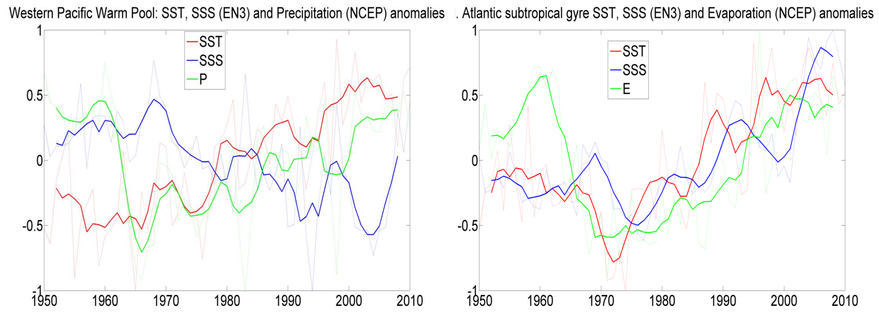

Figure 2: Normalised (by maximum absolute value) yearly anomalies (dashed lines) of SST (EN3), SSS (EN3) and respectively precipitation (GPCP v2.2) [2] and evaporation (NCEP/NCAR) [3], in the Western Pacific Warm Pool (left panel) and the subtropical gyre of the North Atlantic (right panel) 5-yr running means (solid lines) are also depicted

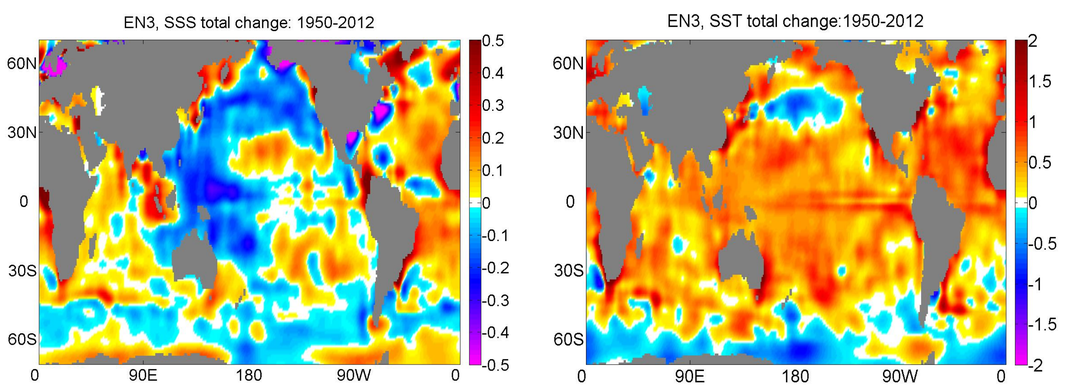

Figure 1: Linear trends in Sea Surface Salinity (SSS) (psu/63 yr) and SST (° C/63 yr) (EN3) over 1950-2012

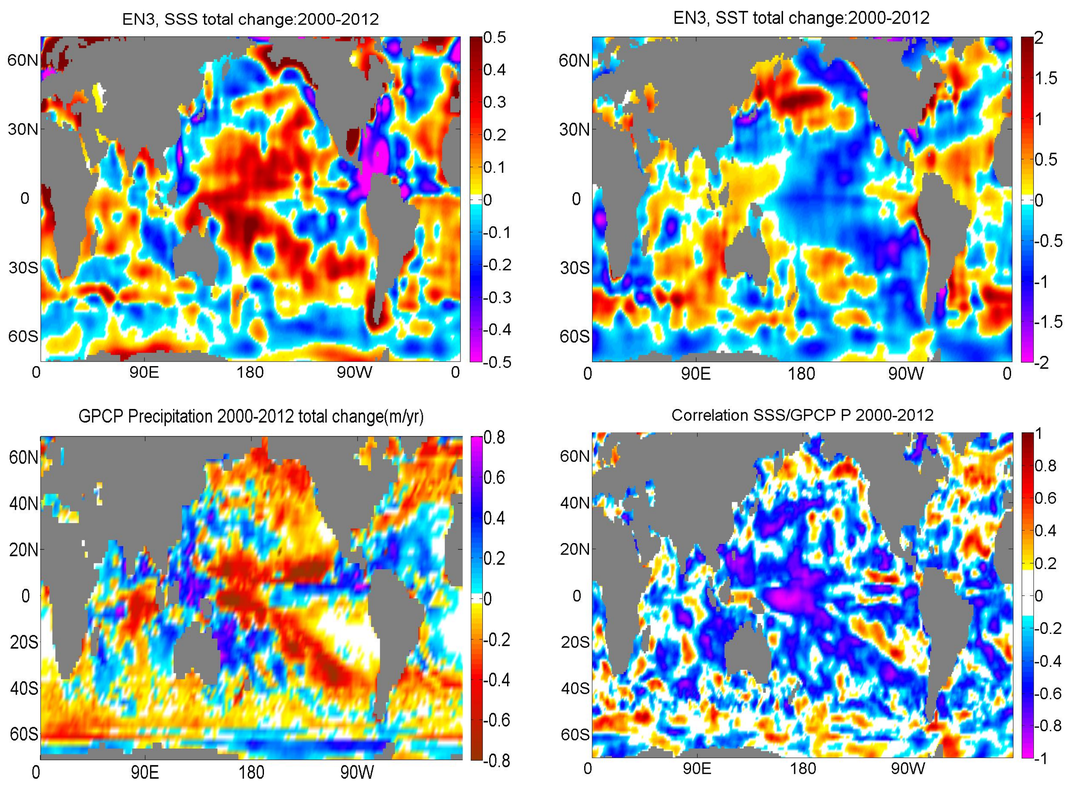

Figure 3: Linear trends in SSS (psu/13 yr), SST (° C/13 yr) (EN3), Precipitation (m/yr/13 yr) (GPCP) and correlation between Precipitation and SSS over 2000-2012

2. Salinity changes over the ARGO-ERA

The Argo array of profiling floats, started in 2000, has dramatically increased data coverage for salinity for the global ocean after 2003 allowing for more reliable estimations of global salt content. Over 2000-2012 increasing (decreasing) salinity trends are found in most of evaporation- (precipitation-) dominated regions, indicating a further intensification of the hydrological cycle (Fig. 3). Results show robust and spatially coherent correlation patterns between annual precipitation and surface salinity anomaly timeseries in most of the tropical regions (Fig. 3). However, as opposed to the long-term multi-decadal trend, the upper layer salinity contrast between Atlantic and Pacific Oceans is now reducing with possible implications for the Atlantic Meridional Circulation (AMOC). Furthermore the global average upper ocean salt content is increasing following a global precipitation decrease (Fig. 4) whilst a reversal of the SST trend and strong surface cooling take place in large parts of the global ocean (see top right panel in Fig. 3).

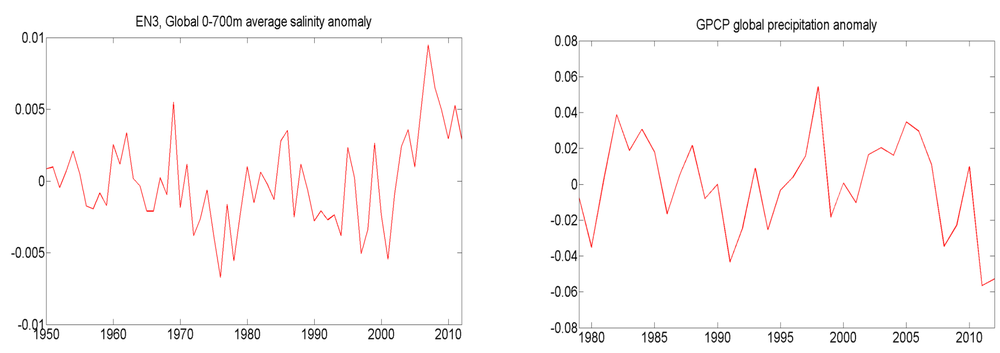

Figure 4: Yearly averaged global mean 0-700m layer salinity anomaly (psu) (left panel) and global mean ocean precipitation (GPCP) anomaly (m/yr) (right panel) over 1950-2012

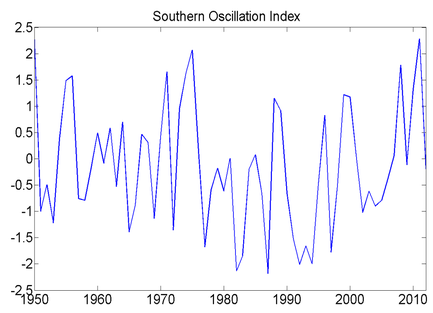

Figure 5: Yearly averaged Southern Oscillation Index (SOI) over 1950-2012

3. Surface salinity and ENSO decadal variability

The recent ocean surface changes are shown to be partially associated with strong decadal variability related to the El-Nino - Southern Oscillation (ENSO). Southern Oscillation Index (SOI) variations (Fig. 5) show a decreasing trend over roughly the first half of the 1950-2012 record followed by a stronger positive trend over the last 20 years. The spatial patterns of correlations between SOI and SSS, SST, and Precipitation timeseries show an out-of-phase oscillation with coherent opposite variation patterns between the central and westernmost parts of the tropical Pacific Ocean (Fig. 6). There is a clear ENSO imprint on the variability of all three parameters over 2000-2012, a period characterised by a progressive increase of La Nina events, showing consistent cooling and saltening trends in the Central Pacific. A pronounced freshening associated with increasing SOI is also found in the tropical western North Atlantic over the same period.

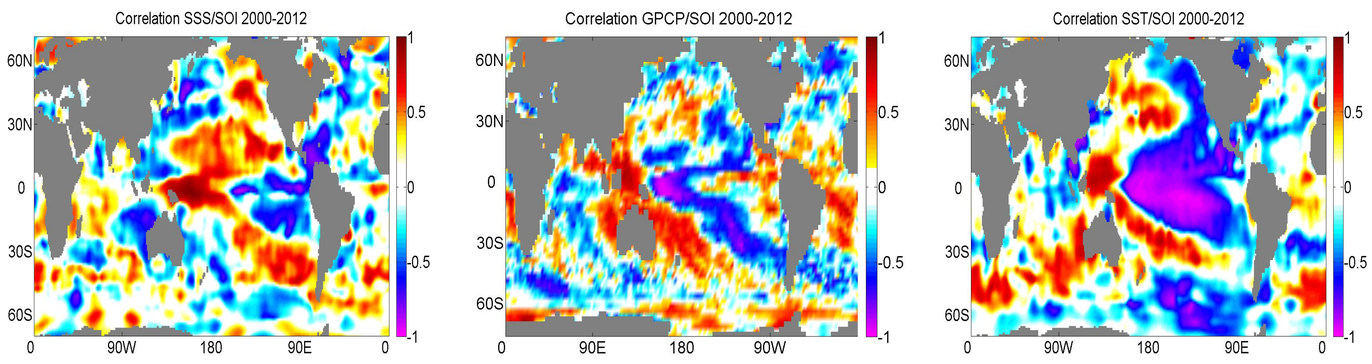

Figure 6. Spatial patterns of correlation between Southern Oscillation Index (SOI) and SSS (EN3), Precipitation (GPCP) and SST (EN3) annual timeseries over 2000-2012.

4. Conclusions

- Long-term (63-year) significant trends in surface salinity are likely associated with an amplification of the water cycle
- Over decadal timescales such as 2000-12, natural variability can largely dominate some regional trends, notably in the tropical Pacific
- Corresponding changes in the Atlantic-Pacific salinity contrast, of possible relevance for the AMOC, are observable at decadal timescales

References

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