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Salinity and water cycle - sea surface salinity changes: Constant or changing trend or mean regime shift

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For years the average global surface salinity (SSS) was assumed to be almost in steady state, but several recent studies have demonstrated the presence of significant changes at scales ranging from regional to global. Antonov et al. (J. Geophis. Res., 2002) and Boyer et al. (Geophis. Res. Lett., 2005) showed that surface waters in subtropical regions are generally becoming saltier while high-latitude waters are getting fresher. Durack & Wijffels (J. Climate, 2010) found that SSS increases are found in regions dominated by evaporation while freshening occurs in precipitation-dominated regions. They proposed that the great similarity in the spatial pattern of salinity change to the mean salinity field was a consequence of an intensification of the global hydrological cycle. The question we want to address in the present study is whether these SSS changes are due to: 1) a regime shift in which the SSS has moved from one equilibrium state to another (maybe even several regime shifts); 2) a constant SSS trend (no new equilibrium has been achieved); 3) a varying SSS trend (not only is SSS changing but the rate of change varies); or 4) a combination of the above. Smith & Aretxabaleta (Nonlin. Process. Geophys., 2007) and Aretxabaleta & Smith (Comput. Geosci., 2011) presented a procedure to objectively separate the different components (regimes) of a Gaussian Mixture Model using the Expectation-Maximization methodology to distinguish between the mean states of the distributions and then analyze the covariance in each regime. In this study, we apply this procedure to the global SSS to separate not only the means (regimes) but also the trends. The procedure uses a non-subjective method (Bayesian Information Criterion) to extract the optimal number of means and trends present in the data. The SSS data used includes the historical database and recent ARGO data. The available global SSS data from the SMOS (Soil Moisture and Ocean Salinity of the European Space Agency) satellite (launched in 2009) is included as a reference. A future goal is that satellite data from SMOS and the upcoming Aquarius (NASA) mission will help determine if the estimated means and trends are realistic once the data sets become long enough.