Interannual salinity in the Amazon plume and adjacent areas

With support from NASA PhO and Salinity Teams

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ENSO related interannual variations in atmospheric subsidence produce notorious variations of rainfall over the Amazon and the tropical Atlantic and lead to well-known variations in Amazon discharge as well as in ocean rainfall. If averaged over the affected tropical Atlantic area, the ocean rainfall variations have a comparable impact on the ocean surface freshwater flux as Amazon variations do (Grodsky et al., 2014).

The ocean rainfall has an almost immediate impact on underlying salinity in contrast to the land rainfall that leads to a delayed (next year) impact related to the Amazon hydrology.

Using syntheses of in-situ profile observations (JAMSTEC, SCRIPPS) we infer ENSO-related patterns of tropical Atlantic SSS variability related to ocean rainfall and Amazon discharge. Due to limited span of time series, similar analysis applied to satellite SSS (SMOS, AQUARIUS) doesn't separate the impacts of continental discharge and ocean rainfall.

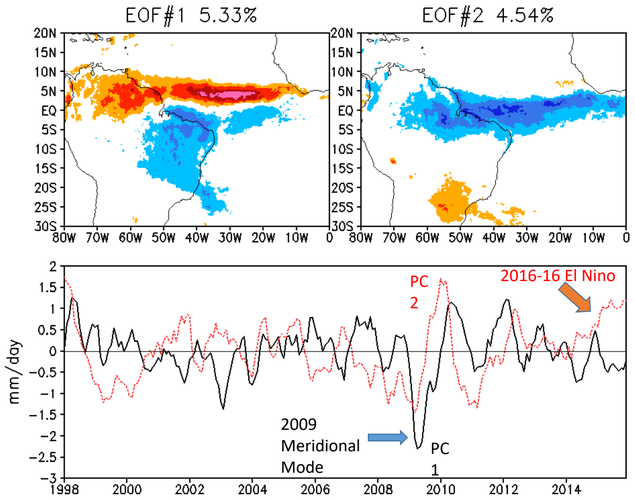

Figure 1. Interannual Tropical Atlantic rainfall is affected by the Atlantic Meridional Mode and ENSO teleconnections (the two are not completely separate). The Leading EOFs of anomalous monthly rainfall (based on TRMM merged microwave and IR rainfall, 3B42_V7) show a dipole-like pattern (EOF#1, due to the Atlantic Meridional SST mode) and homogeneous pattern of rainfall variations over the Amazon and the tropical Atlantic (EOF#2, due to the ENSO).

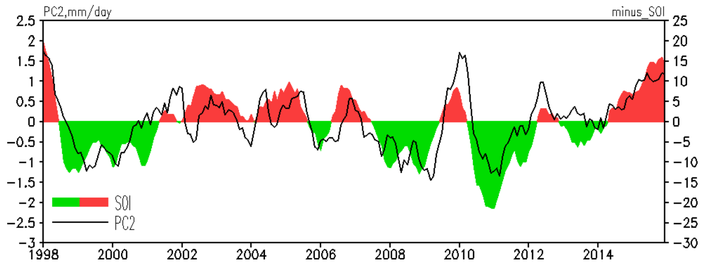

Figure 2. Time series of the second EOF (PC2) vary in-phase with the inverse SOI, i.e. decreased rainfall over the Amazon and the tropical Atlantic occurs during El Nino years.

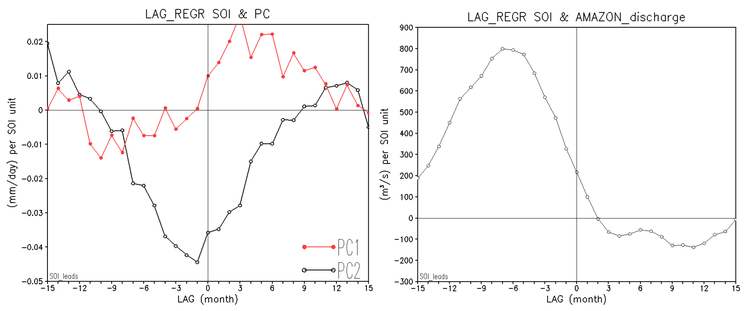

Figure 3. Lagged correlation of SOI with (left) rainfall (right) Amazon discharge.

PC1 weakly correlates with SOI. PC2 lags SOI by a few months. Rainfall decreases by ~1.5 mm/day during strong El Nino events (SOI~-30).

Amazon discharge lags SOI by 6 to 8 months. Amazon floods next year (after La Nina). Amazon discharge variations reach ~10% of the mean discharge during strong ENSO years (SOI~30).

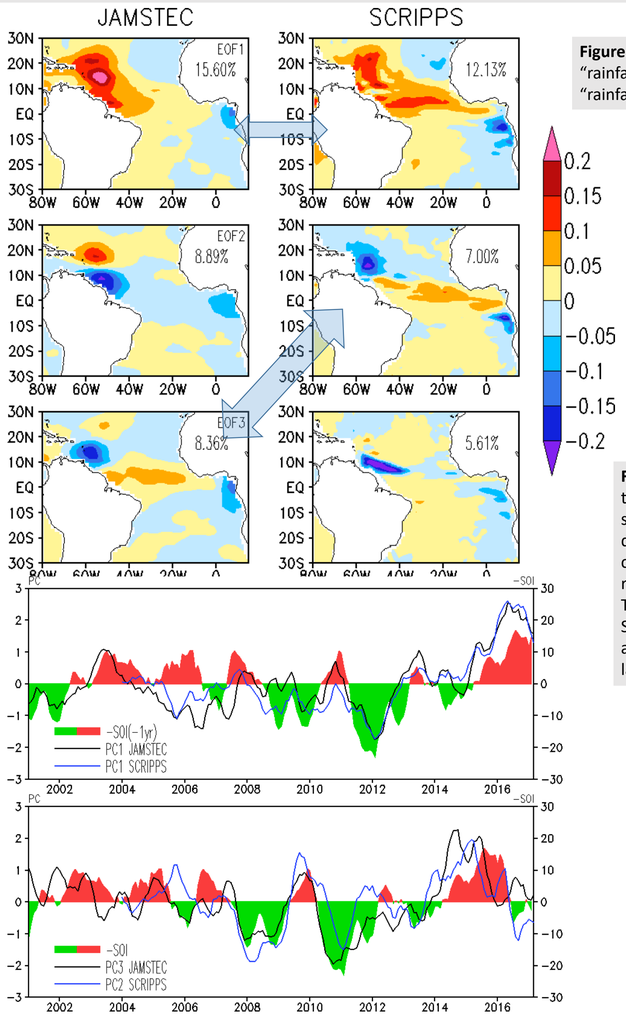

Figure 4. EOF analysis of near surface salinity from in-situ observation syntheses.

The leading EOF is consistent for the two analyses and show SSS response along the major Amazon plume export pathways. This response lags SOI by about 1 year and is related to variations in the Amazon discharge ("Amazon" EOF).

EOF2 (SCRIPPS) corresponds to EOF3 (JAMSTEC). The cross-Atlantic pattern of these EOFs is attributed to ocean rainfall. Its temporal variations occur mostly in-phase with the inverse SOI ("rainfall" EOF).

(See also lagged correlation in Figure 5).

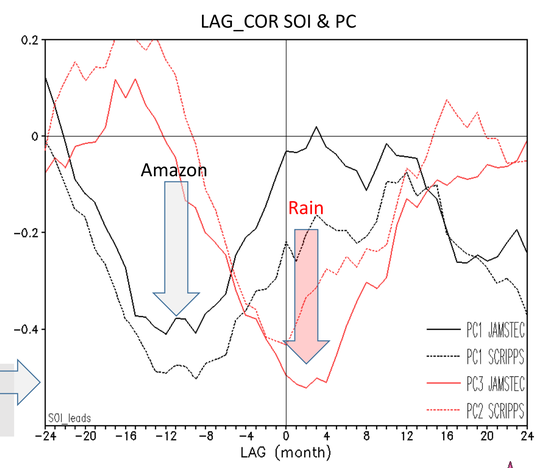

Figure 5. Lagged correlation of SOI with "Amazon" PC and "rainfall" PC. "Amazon" PC lags SOI by about 1year while "rainfall" PC vary in-phase with SOI.

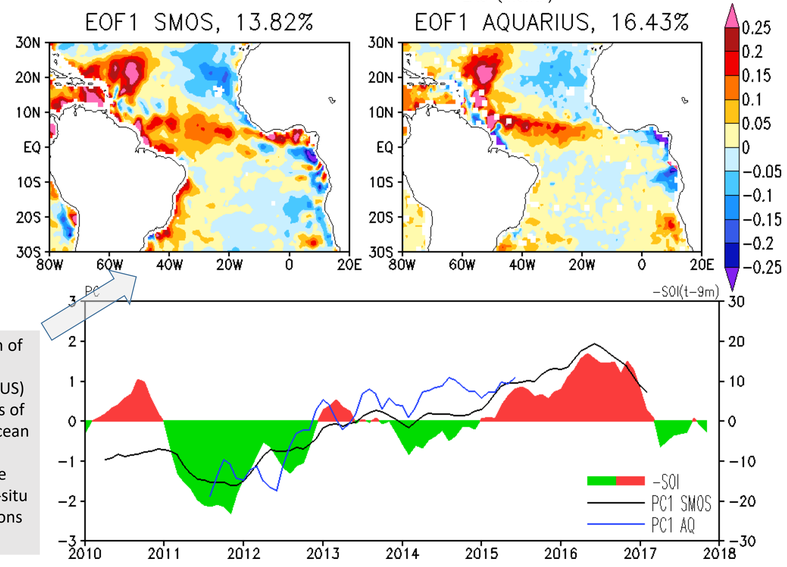

Figure 6. Due to limited span of time series, EOF analysis of satellite SSS (SMOS, AQUARIUS) doesn't separate the impacts of continental discharge and ocean rainfall.
The major pattern of satellite SSS resembles EOF1 from in-situ analysis. Its temporal variations lag SOI by about 9 months.

Conclusions

- Based on in-situ profile data syntheses, ENSO explains about 20-25% of monthly anomalous near-surface salinity variance in the tropical Atlantic.
- ENSO affects rainfall over the Amazon and the tropical Atlantic. The ocean rainfall has almost immediate impact on underlying salinity in contrast to the Amazon rainfall that leads to a delayed (next year) impact related to the Amazon hydrology.
- EOF analysis of in-situ data reveals the leading EOF of SSS which temporal part lags behind SOI by about 1 year. It reflects variations in the freshwater balance due to ENSO-induced variations of the Amazon discharge (Amazon mode, 10-15%).
- It also reveals the cross-Atlantic tropical pattern which temporal variability occurs in-phase with the inverse SOI (rainfall mode, 7-8 %)
- Due to limited span of time series of satellite SSS (SMOS, AQUARIUS) , EOF analysis doesn't separate the impacts of continental discharge and ocean rainfall. The major pattern of satellite SSS resembles EOF1 from in-situ analysis. Its temporal variations lag SOI by about 9 months.

Grodsky, S.A., G. Reverdin, J. A. Carton, and V.J. Coles (2014), Year-to-year salinity changes in the Amazon plume: Contrasting 2011 and 2012 Aquarius/SACD and SMOS satellite data, *Remote Sensing of Environment*, **140**, 14-22, http://dx.doi.org/10.1016/j.rse.2013.08.033