Far Eastern Pacific Fresh Pool surface salinity variability observed by SMOS and Aquarius sensors over the period 2010-2012

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Why focus on SSS in the Far Eastern Pacific Fresh Pool?

- Between 2 climate relevant features: Eastern Pacific warm pool and equatorial cold tongue
- Minimum in SSS (<33: Far Eastern Pacific Fresh Pool) and maximum seasonal variability
- Strong air-sea-land interactions in this region: monsoon, gap winds... (e.g. Xie et al. 2005, Fiedler and Talley 2006, Kessler 2006)
- Potentially active role of salinity stratification on regional climate (de Boyer Montegut et al. 2007)
- Good test ground for new SSS satellite products (SMOS, Aquarius)

Main Mechanisms

- Life cycle of the Fresh Pool along Panama-Tahiti ship track
  - June-Dec: building
  - Apr-May: Destruction
  - Jan-Mar: westward stretching

- Summer rain $\rightarrow$ building of Fresh Pool, SSS minimum
- Winter gap wind $\rightarrow$ Westward advection of Fresh Pool by SEC
  Upwelling $\rightarrow$ destruction of Fresh Pool

Wind/Rain JAS
Panama gap wind
Upwelling
SMOS detection of the Upwelling in April 2010

Panama
Upwelling

Alory et al, JGR, 2012
SMOS detection of the Upwelling in 2011
SMOS detection of the Upwelling in 2012
SMOS data validation with Matisse TSG 2010-2012

SMOS (±5 days average) & TSG products averaged at ¼° resolution:

Errors (differences) = 0.6 psu rms (0.5 std) = 10 times < seasonnal variability

Western borders of the freshpool well detected by SMOS in general

SSS Structure differences are nevertheless observed within the pool
SMOS detects
(i) Saltier surface waters in the panama upwellings than in the climatology in 2010 & 2012:
(ii) Fresher waters extending farther west at the surface of the FEPFP almost all years.
Focus on the Upwelling Area
ΔSSS = SSS_{SMOS} - SSS_{WOA}. Apparently SMOS detects
(i) a saltier surface waters in the panama upwellings than in the climatology in 2010 & 2012:
(ii) a longer lasting & more intense freshening season in winter 2010-2011 (or a weaker upwelling)
Fresher SMOS SSS systematically found after SSSmax is reached corresponds to excess « local » precipitation with respect to the climatology.

Stronger Upwellings in 2010 and 2012 but fresher in 2011.
Clockwise circulation and SSS increase occur one month later in 2011
- Strongest gap wind and Ekman pumping in 2010 (due to Nino-related East Pacific warming?)

- Wind-driven upwelling in eastern Panama Bight not weaker in 2011 than 2012 but stronger westerlies in Jan 2011 driving eastward current => might have blocked the westward extension of the pool
Aquarius sensus of the Upwelling

Aquarius L3 Fev 2012

Aquarius L3 March 2012

1°X1° composite
Aquarius Significantly fresher than SMOS at the beginning of the 2012 Upwelling (Jan 2012)
- SMOS and Aquarius SSS histograms exhibit significant departure from normal distribution due to anomalous low-salinity measurements creating a negative skewness.

Satellite obs are much more negatively skewed than the climatological data with a much higher number of low SSS events (below 31) than the clim:

⇒ Typical signature of tropical rain events (e.g. Bingham et al. JGR 2002)

- SMOS data exhibit an higher density of high SSS events >34 (upwelling signal ?)
ARGO floats in the upper 10 m

In situ sampling from 8/20/2011 to 12/31/2012

No ARGO floats & no TSG data in the center of the salty Upwelling
Aquarius more accurate (rmse ~0.4) than SMOS (rmse~0.7)
=>but small validation data set & not in the major upwelling zone
Conclusions

- SMOS data (1/4°, 10 days) and Aquarius (1°, 10 days) data have been analyzed from 2010 to 2012 to investigate seasonal & interannual SSS variability in the Far Eastern Pacific Fresh Pool.

- Each year, SMOS repeatedly detected the SSS seasonal cycle of the Freshpool (building, westward stretching & destruction by upwelling).

- SMOS data comparisons with regularly sampled TSG data reveal an rms difference of ~0.6 psu.

- Compared to the climatology, SMOS systematically detected a fresher pool during the rainy season, associated with local excess precipitation as shown by TRMM data.

- SMOS also detected a saltier upwelling in 2010 & 2012. Fresher upwelling in winter 2011 is potentially due to stronger westerlies in Jan 2011 driving a longer-lasting eastward current which might have trapped the freshwater toward the coast. Variability in the Gap wind Strength is not the source for that process.

- Averaged SMOS & Aquarius data compare well within the upwelling area:
  - both datasets show a much higher number of low SSS events than the climatology
  - Compared to Argo float upper level data, Aquarius data are more accurate (rmse ~0.4) than SMOS data (rmse~0.7) which are in general too salty (roughness effect?)

=> However in situ data do not sample the major upwelling zone but only its surroundings and it is difficult to conclude.
Current knowledge about SSS in this area
Main SSS data source: Voluntary Observing Ships

1950-2009 obs. density

Well-sampled TSG line from Panama canal to Tahiti

Transect snapshots

- Steep SSS fronts (up to 4 pss/1°) at Fresh Pool west/east boundaries with seasonal displacement >1000 km
- Not always related to SST fronts
Climatological SSS cycle from WOA in [1.75°N-6.75°N; 79.25°W-82.75°W]

Minimum SSS (31.5) reached in Mid Nov
Max SSS (33.5) reached in Mid-Apr
- Much higher sea level in 2010 (Nino) than 2011/2012
- Not much difference in sea level between 2011 and 2012