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

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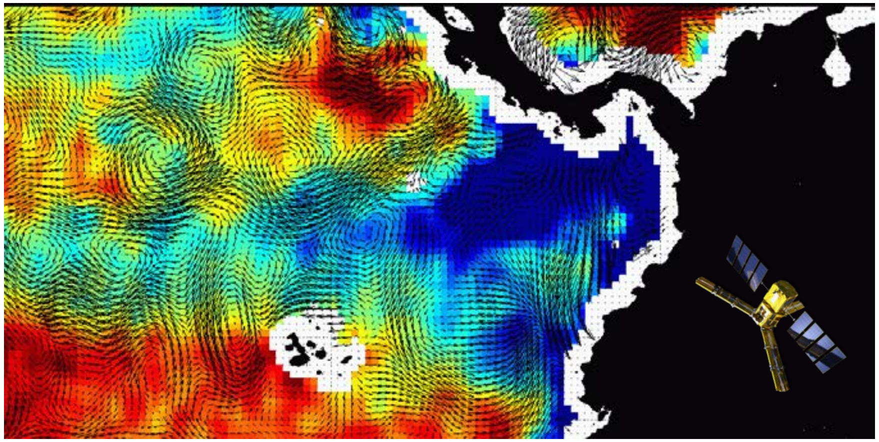
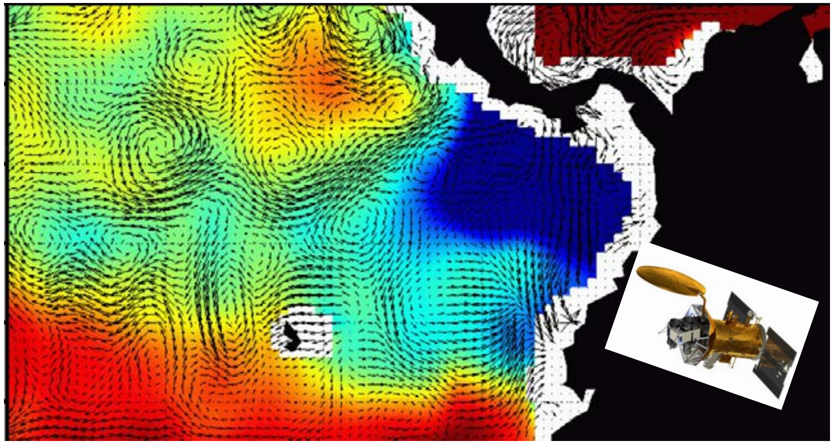
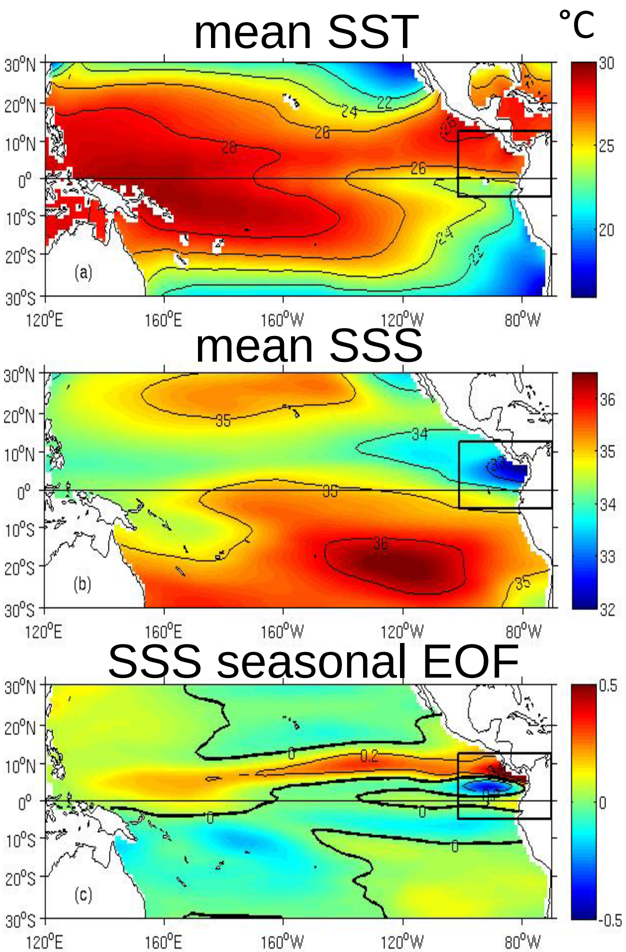




Why focus on SSS in the the Far Eastern Pacific Fresh Pool?



Delcroix et al., 2011

- 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)

Gaël Alory, Christophe Maes, Thierry Delcroix, Nicolas Reul, Serena Illig, 2012: **Seasonal dynamics of Sea Surface Salinity off Panama: the Far Eastern Pacific Fresh Pool.** Journal of Geophysical Research, Vol. 117, C04028, doi:10.1029/2011JC007802, 2012.

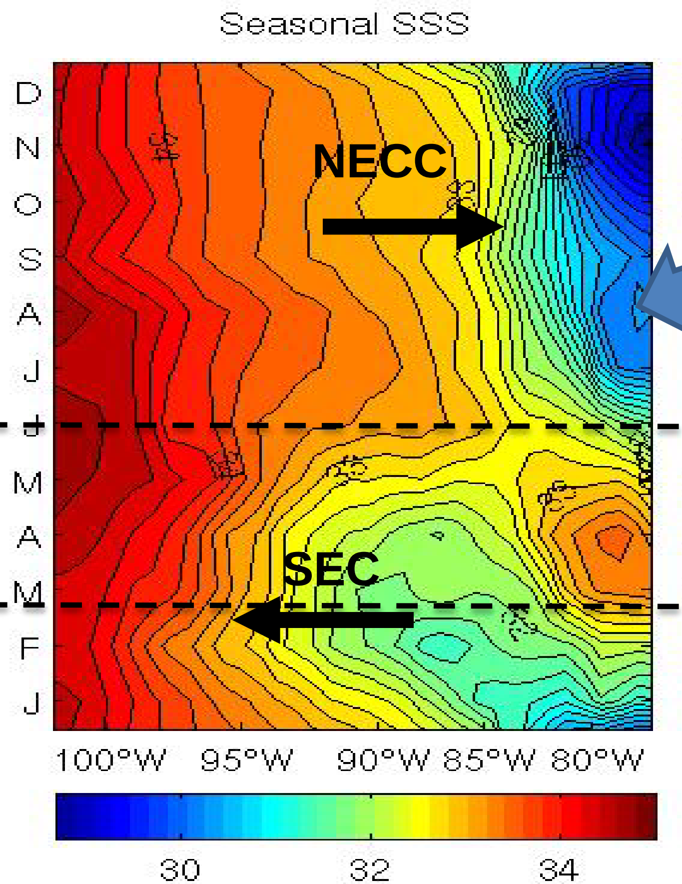
Main Mechanisms

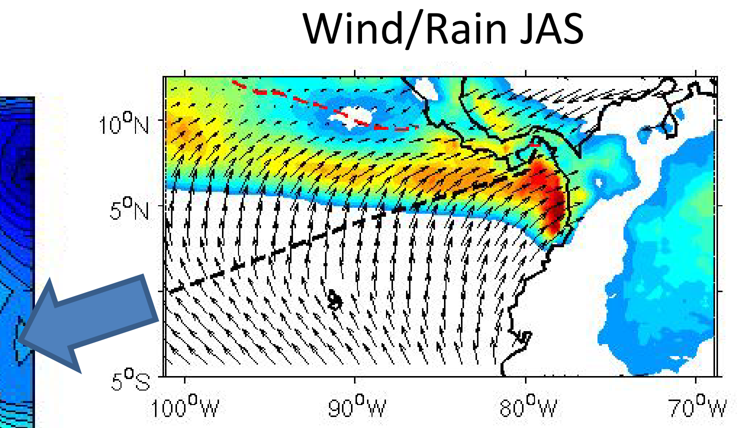
- Life cycle of the Fresh Pool along Panama-Tahiti ship track

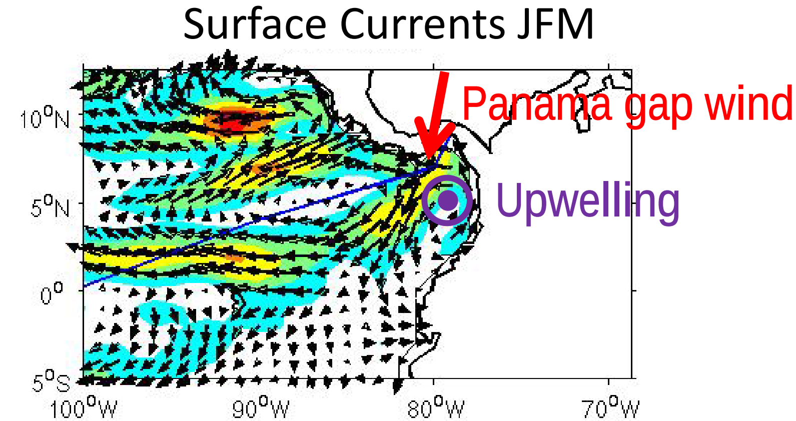
June-Dec: building

Apr-May: Destruction

Jan-Mar: westward stretching



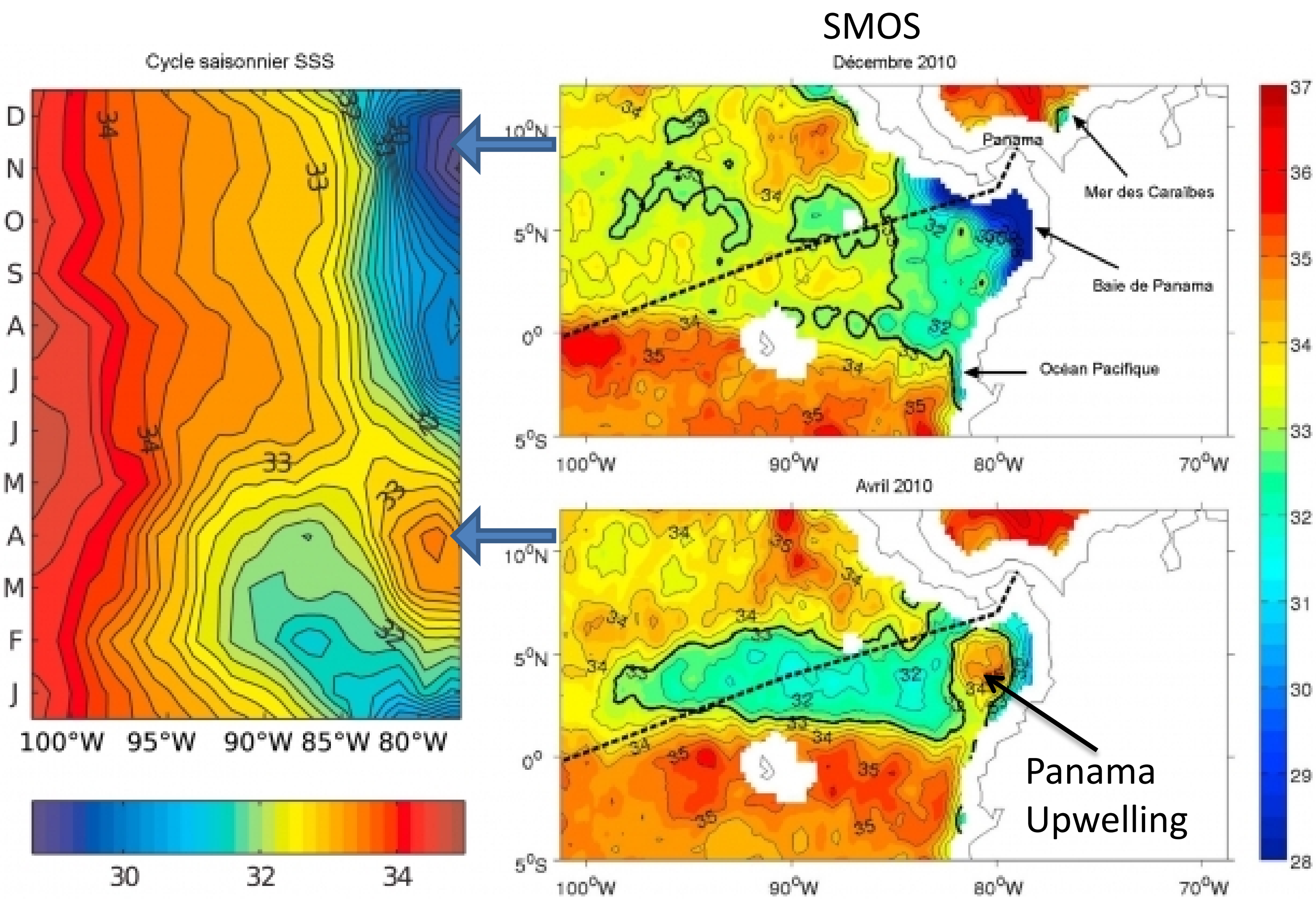




- Summer rain → building of Fresh Pool, SSS minimum
- Winter gap wind → Westward advection of Fresh Pool by SEC

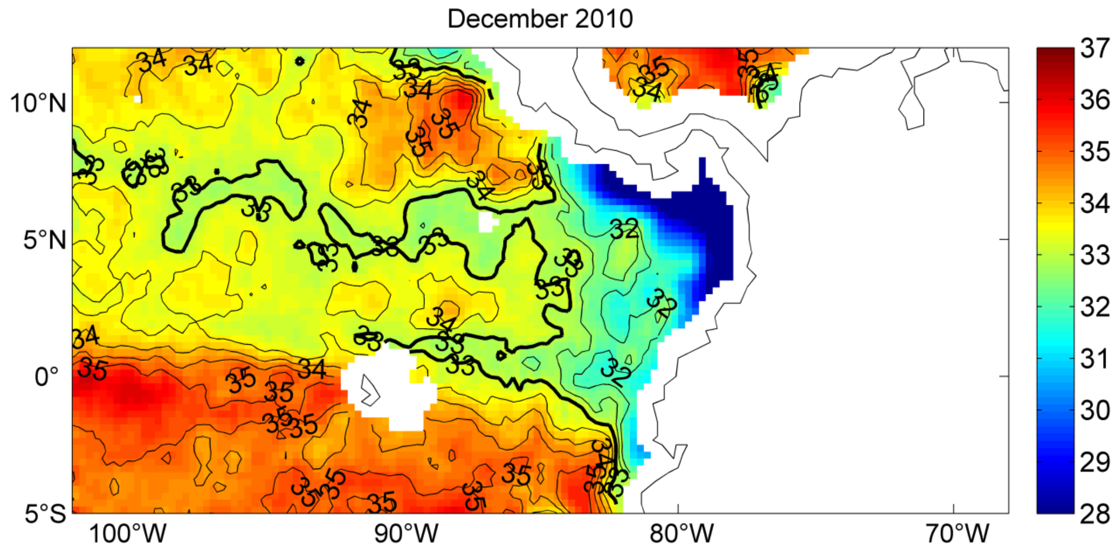
  Upwelling → destruction of Fresh Pool

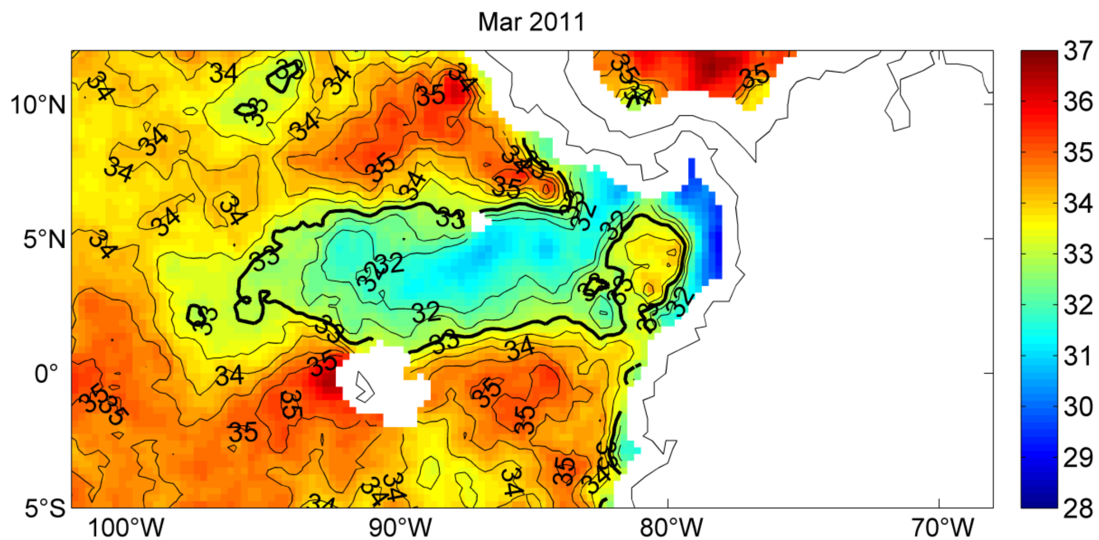
SMOS detection of the Upwelling in April 2010



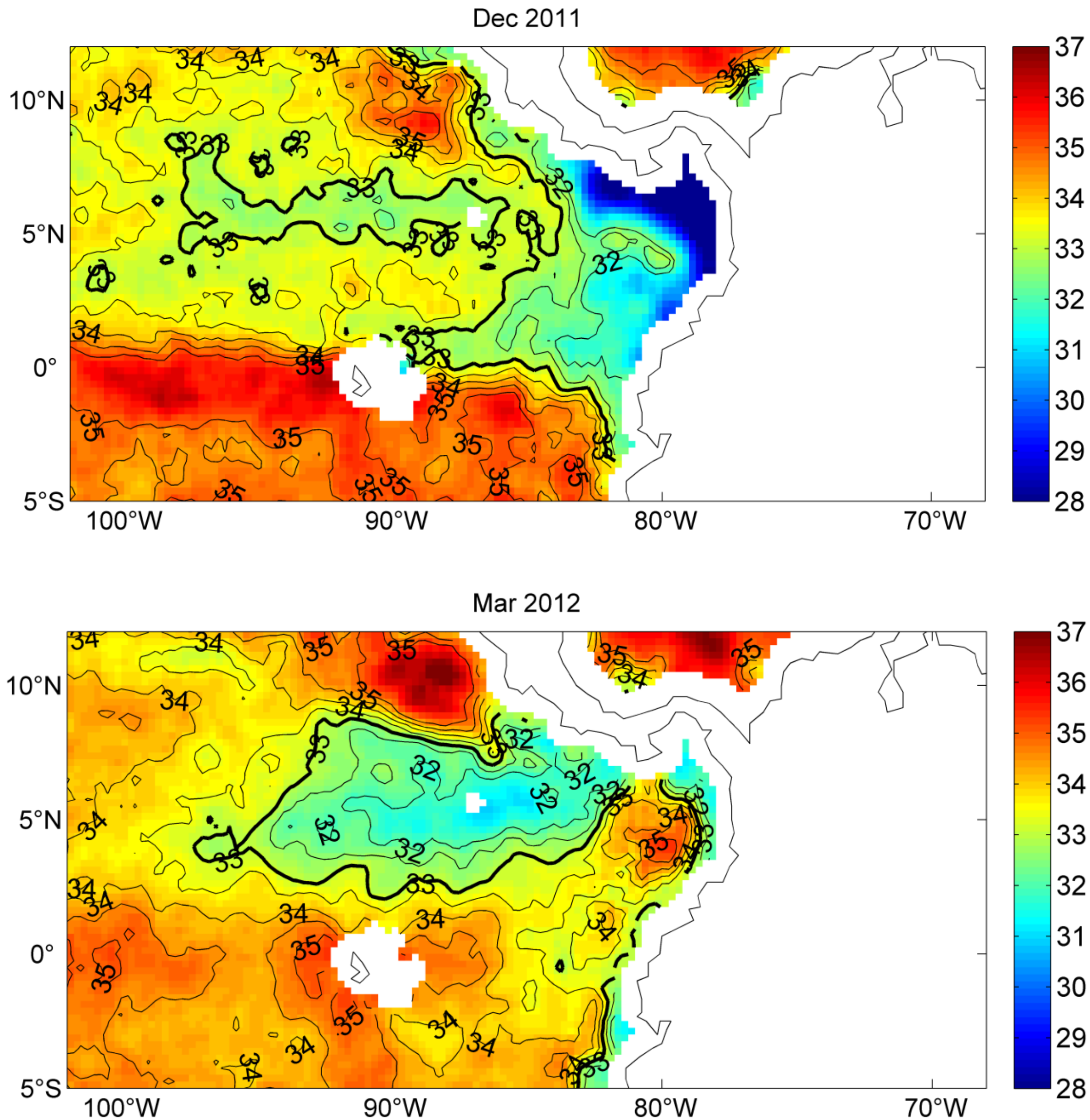
Alory et al, JGR, 2012

SMOS detection of the Upwelling in 2011

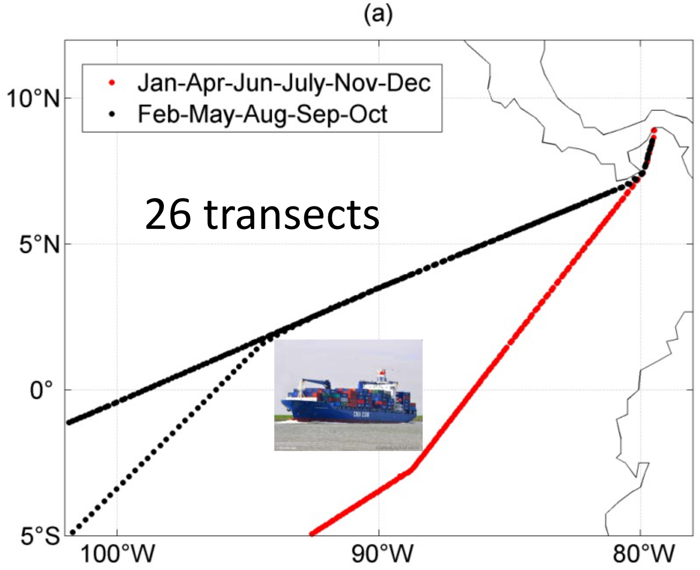


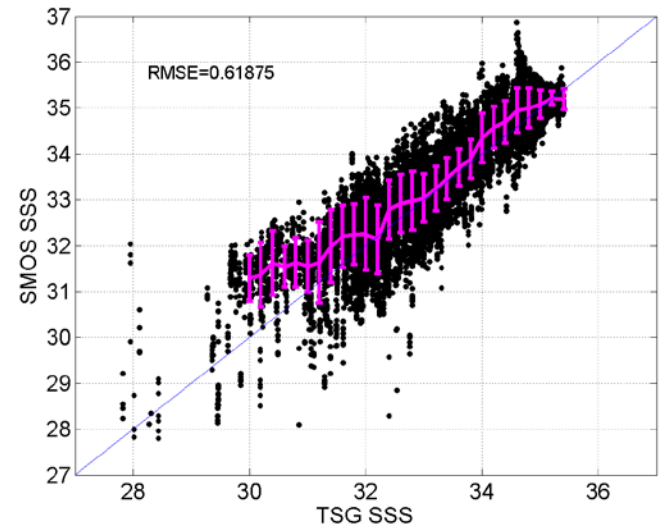


SMOS detection of the Upwelling in 2012



SMOS data validation with Matisse TSG 2010-2012

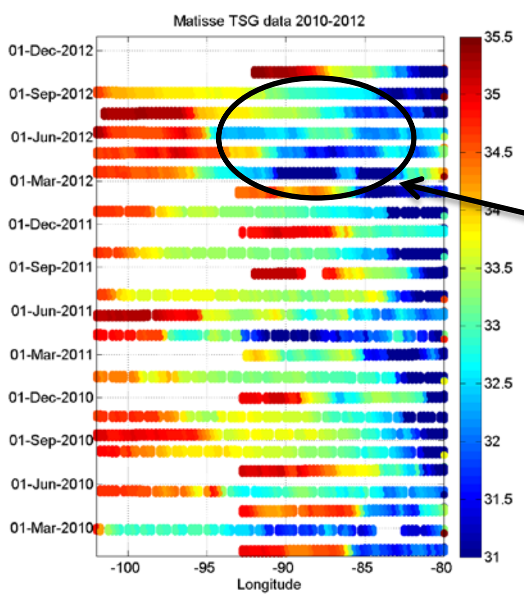




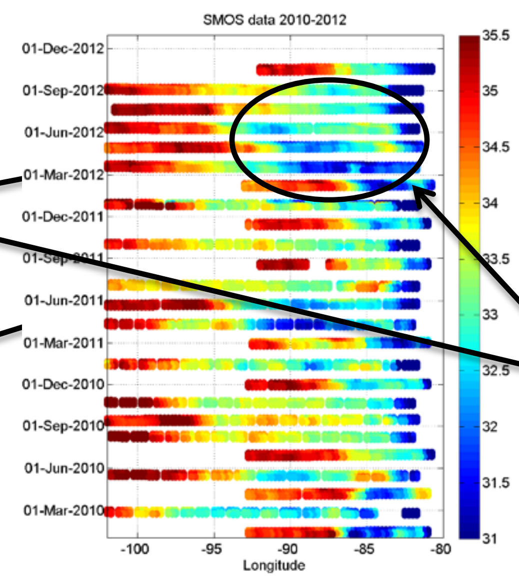
SMOS (±5 days average) & TSG products averaged at ¼° resolution :

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

TSG

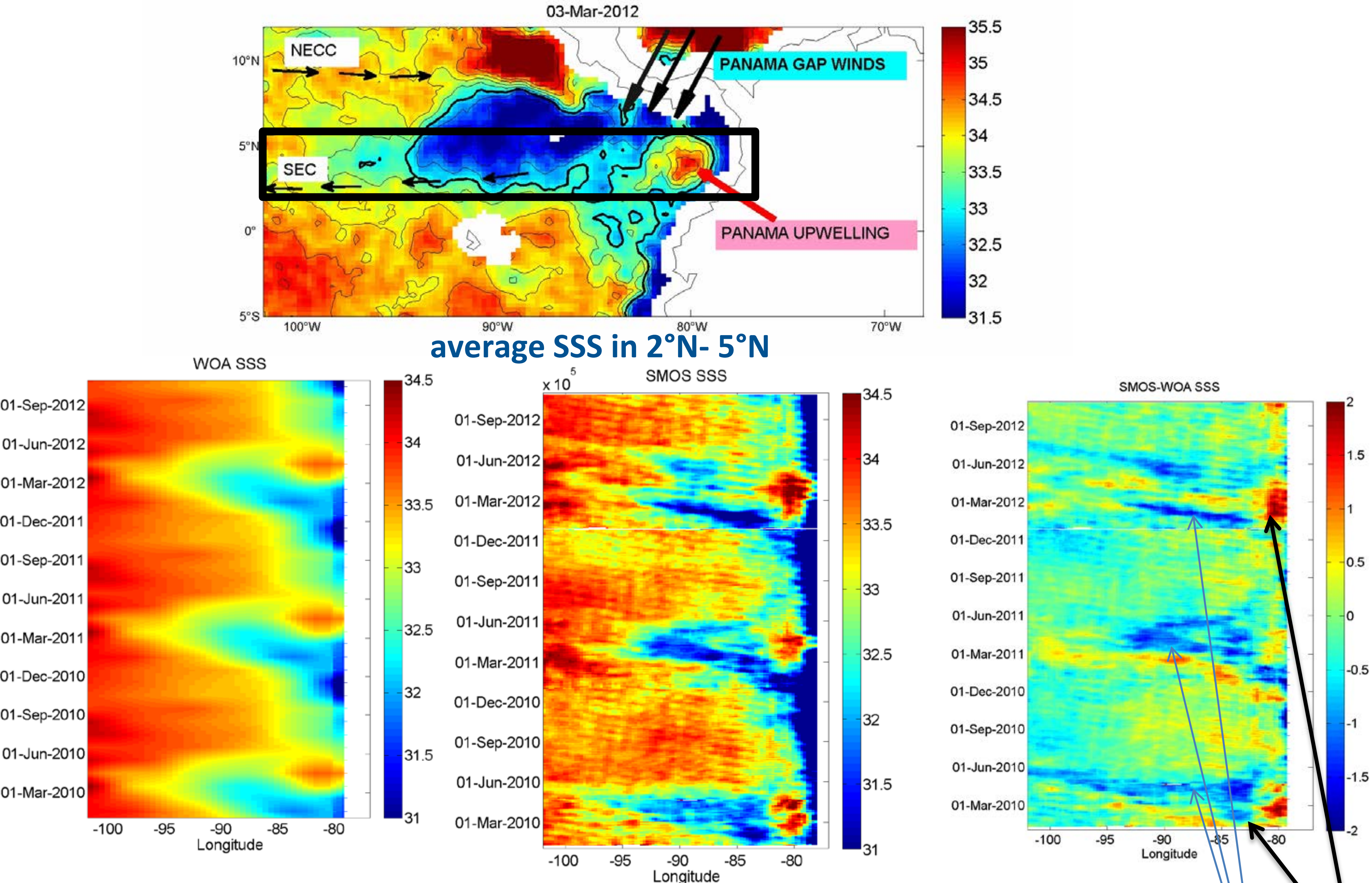


SMOS



Western borders of the freshpool well detected by SMOS in general

SSS Structure differences are nevertheless observed within the pool

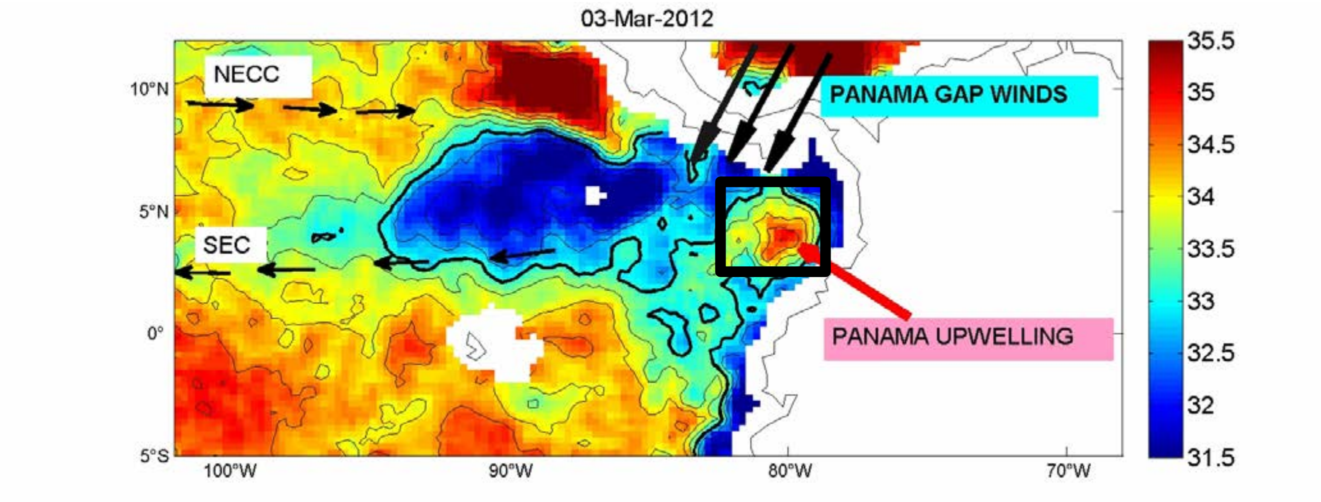


SMOS detects

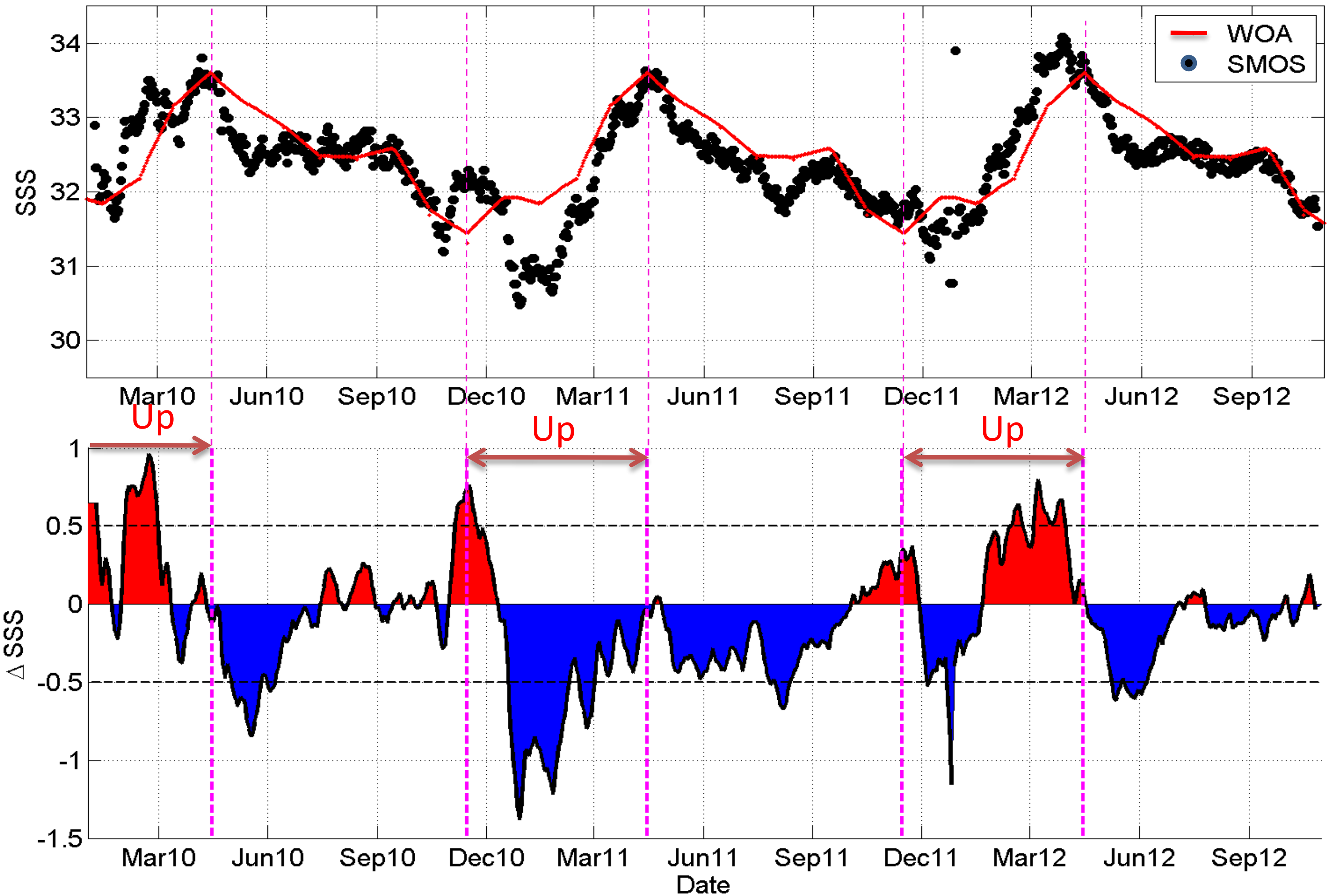
(i) Saltier surface waters in the panama upwellings than in the climatology in 2010 & 2012:

(ii) Fresher waters extending farther west at the surface of the FEPFP almost all years

Focus on the Upwelling Area



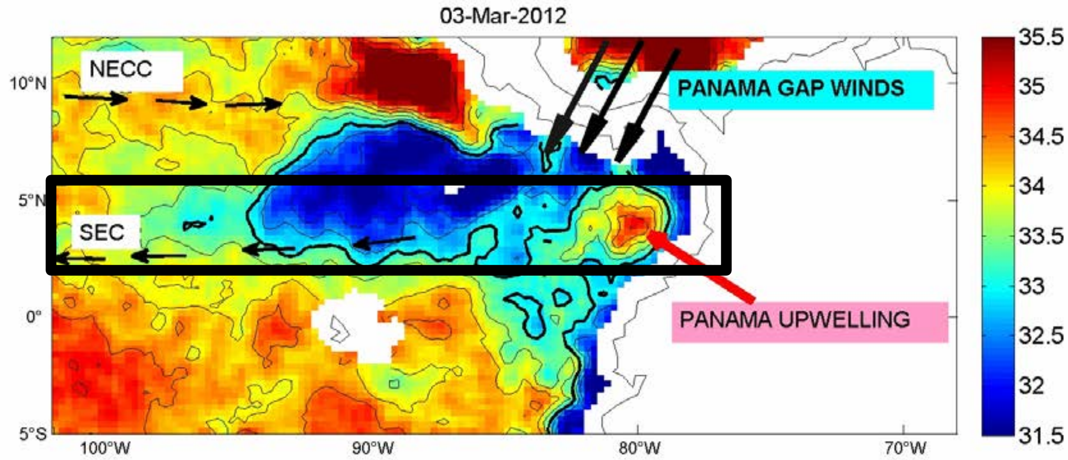
Median SSS in [1.75°N- 6.75°N; 79.25°W-82.75°W]

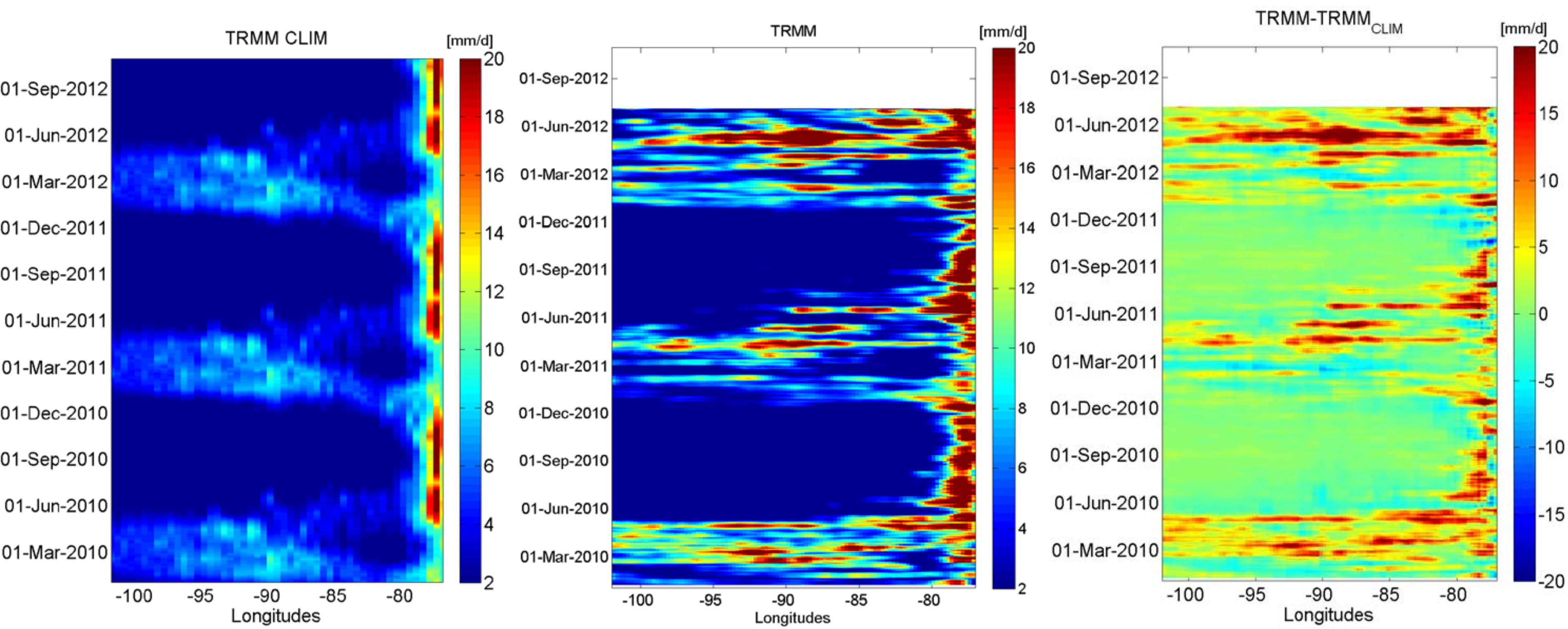


ΔSSS=SSS_{SMOS}-SSS_{WOA}. Apparently SMOS detects

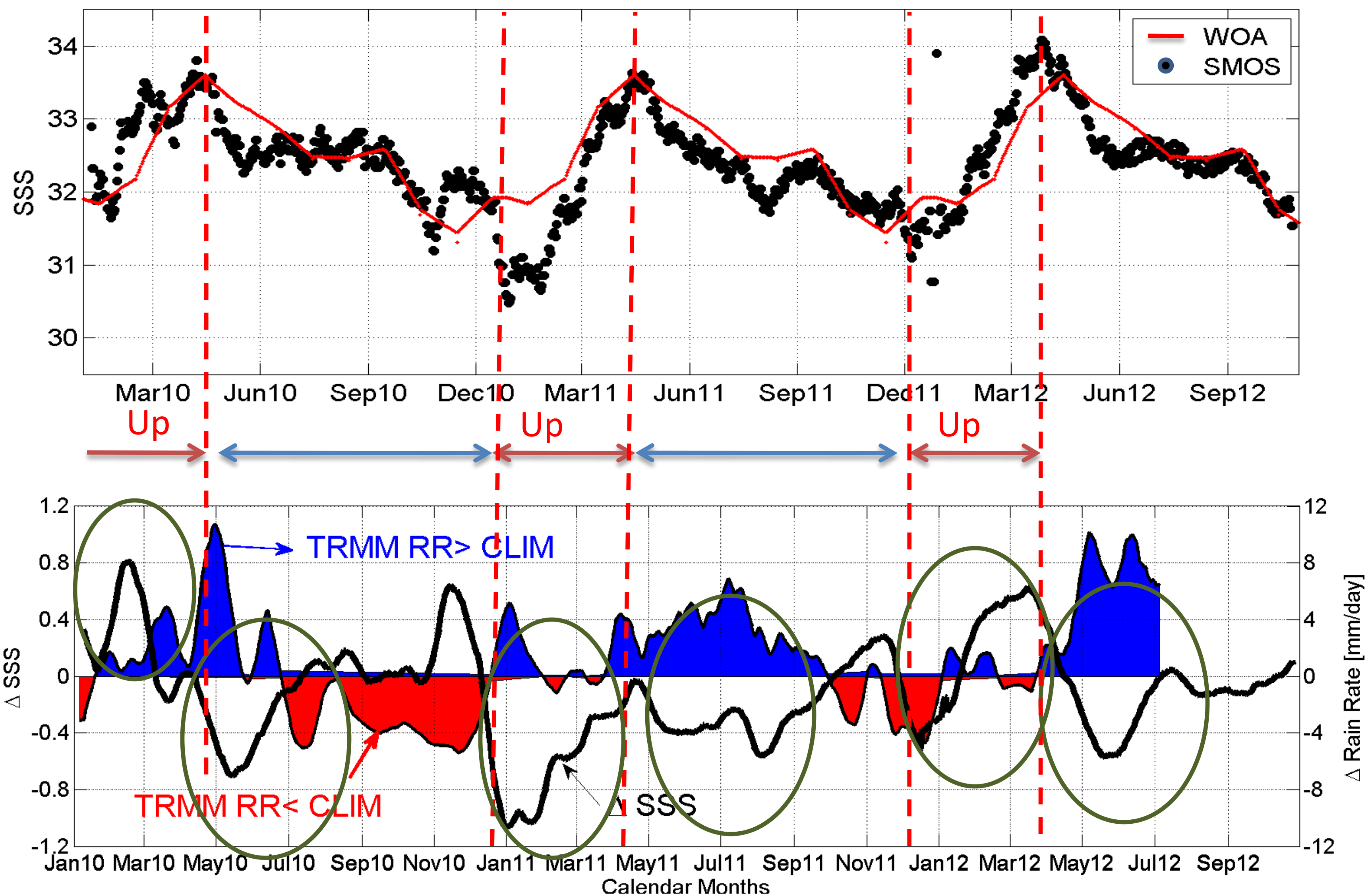
(i) a saltier surface waters in the panama upwellings than in the climatology in 2010 & 2012:

(ii) a longer lasting & more intense freshening season in winter 2010-2011 (or a weaker upwelling)


03-Mar-2012
NECC
PANAMA GAP WINDS
SEC
PANAMA UPWELLING
10°N
5°N
0°
5°S
100°W
90°W
80°W
70°W
35.5
35
34.5
34
33.5
33
32.5
32
31.5


TRMM CLIM
[mm/d]
TRMM
[mm/d]
TRMM-TRMM$_{CLIM}$
[mm/d]
01-Sep-2012
01-Jun-2012
01-Mar-2012
01-Dec-2011
01-Sep-2011
01-Jun-2011
01-Mar-2011
01-Dec-2010
01-Sep-2010
01-Jun-2010
01-Mar-2010
-100
-95
-90
-85
-80
Longitudes
20
18
16
14
12
10
8
6
4
2
20
15
10
5
0
-5
-10
-15
-20

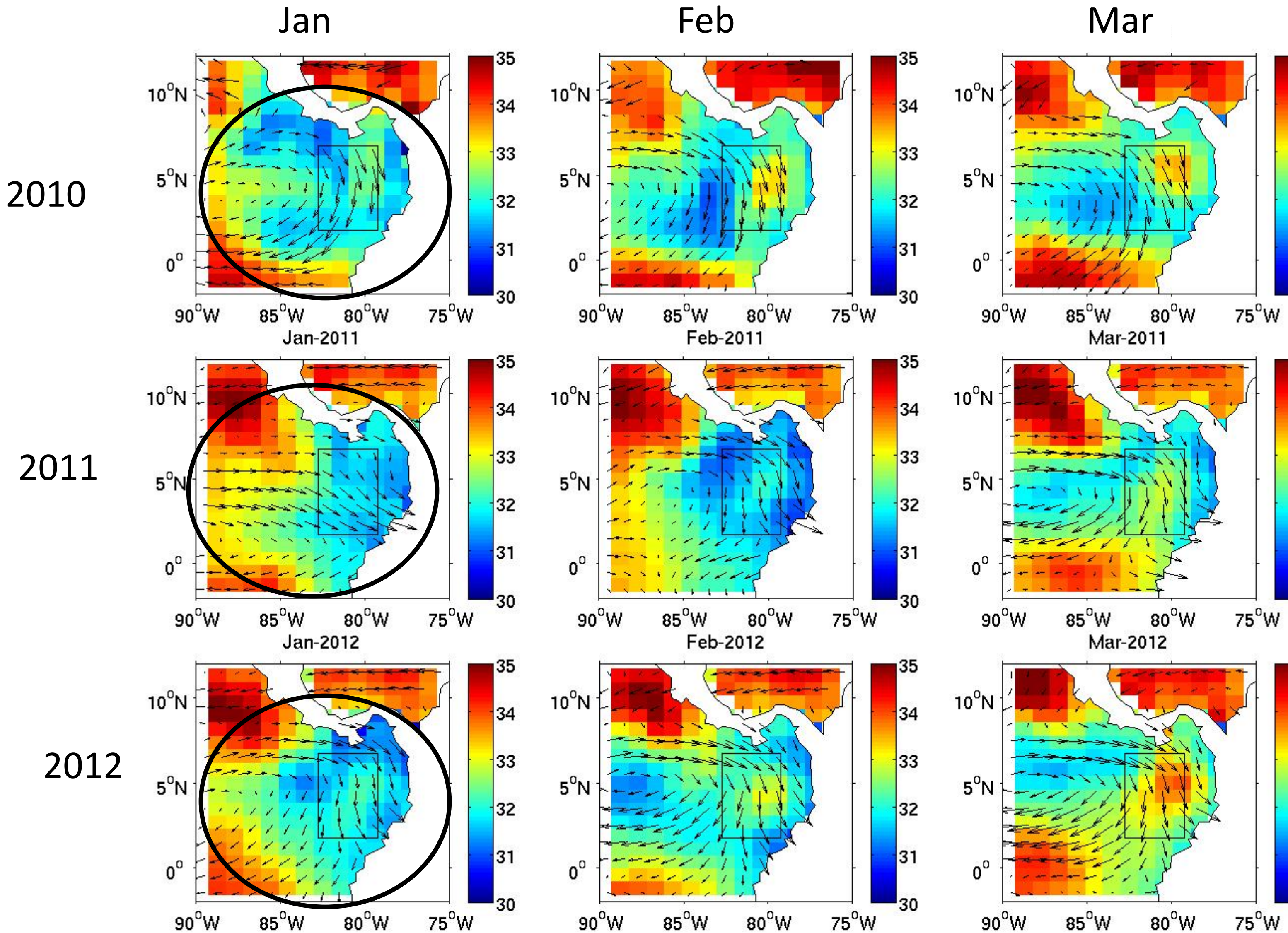
Median SSS & RR in [1.75°N- 6.75°N; 79.25°W-82.75°W]



Fresher SMOS SSS systematically found after SSSmax is reached corresponds to excess « local » precipitation with respect the climatology.

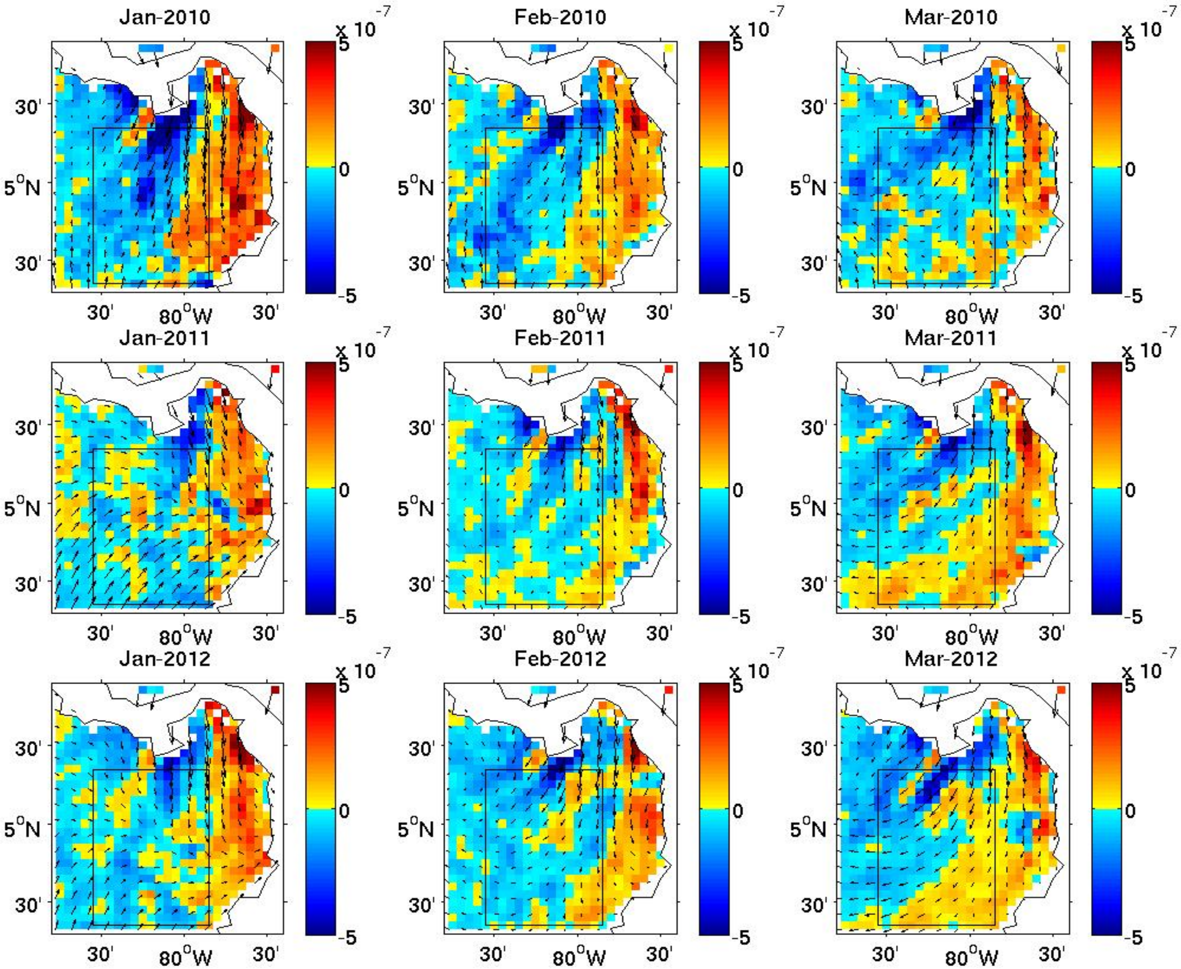
Stronger Upwellings in 2010 and 2012 but fresher in 2011

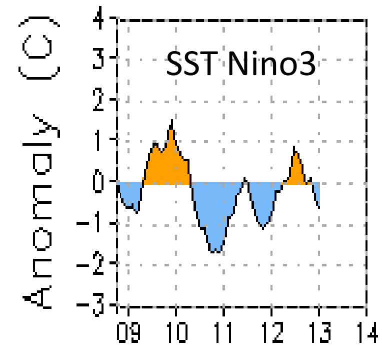
SSS SMOS + Oscar currents during the Upwelling periods



Clockwise circulation and SSS increase occur one month later in 2011

Wind and wind curl (ASCAT)

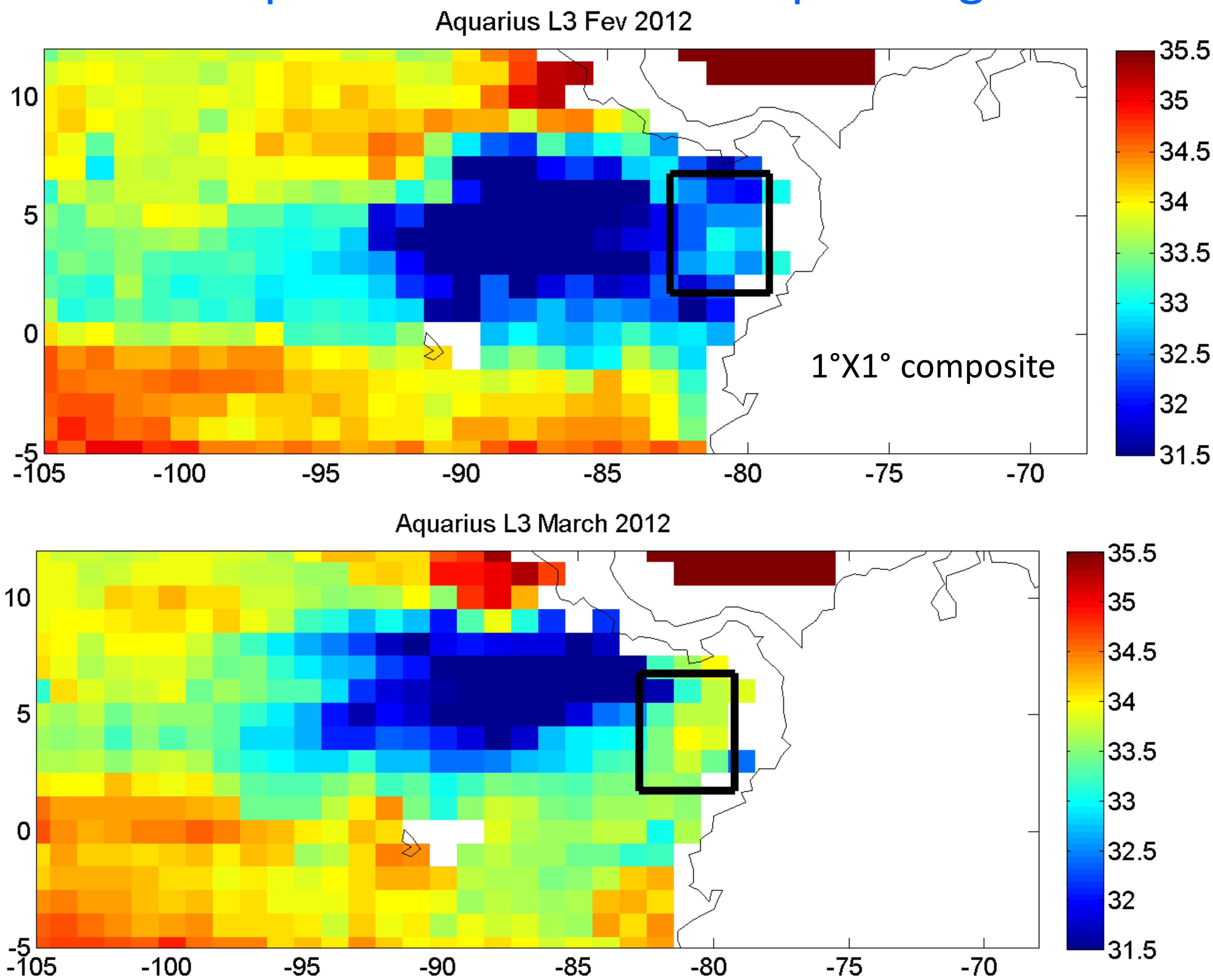


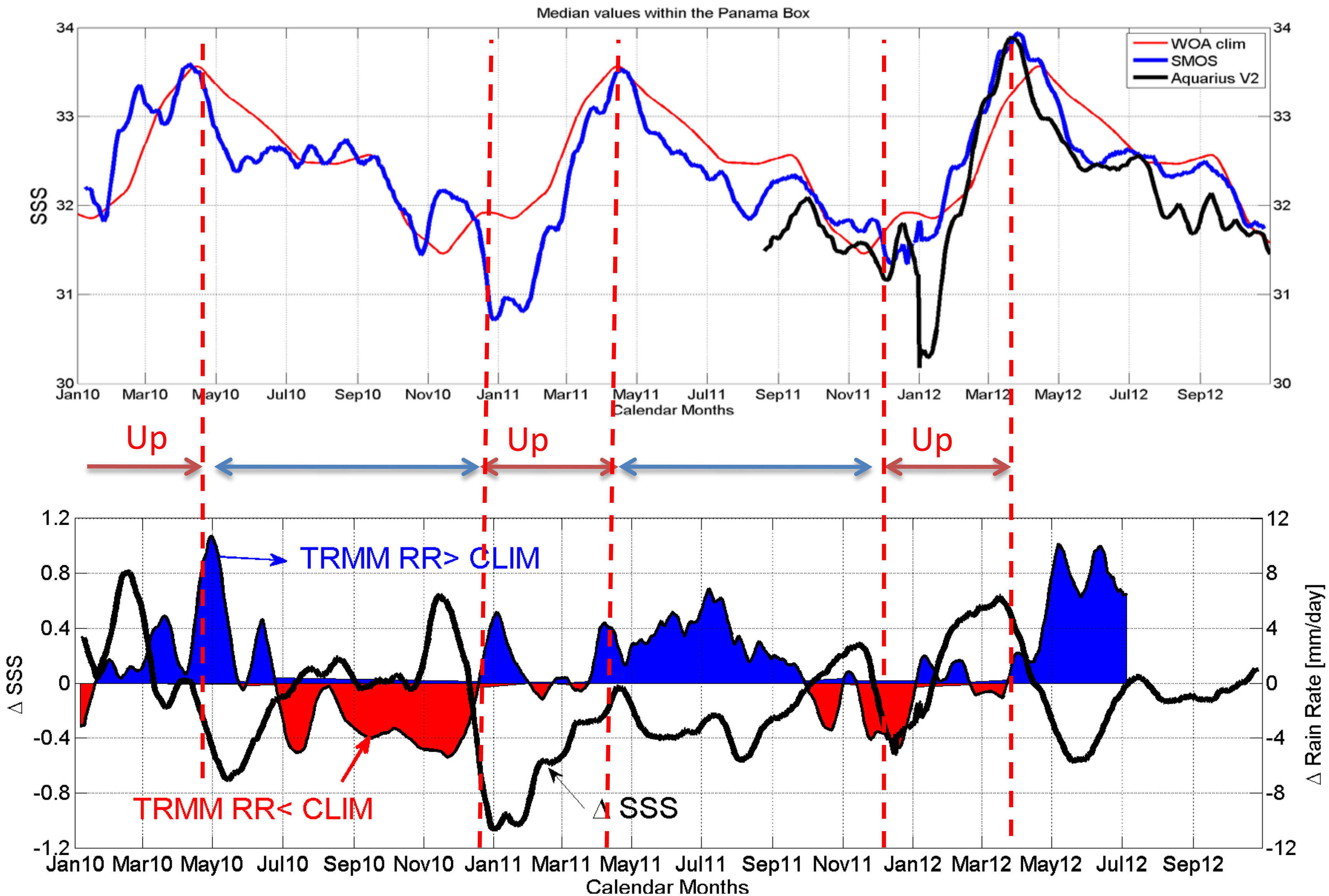


- Strongest gap wind and Ekman pumping in 2010 (due to Nino-related East Pacific warming?)

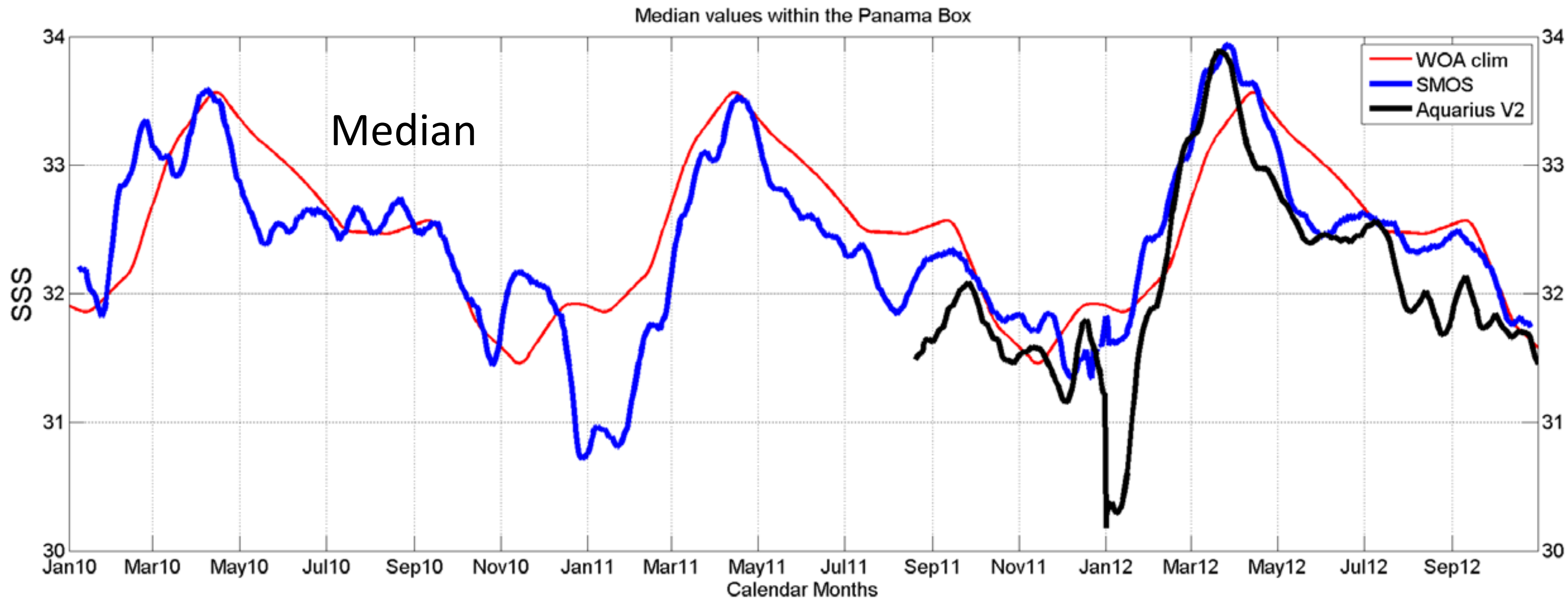
- Wind-driven upwelling in eastern Panama Bight not weaker in 2011 than 2012 but stronger westerlies in Jan 2011 driving eastward current=> might have blocked the westward extension of the pool

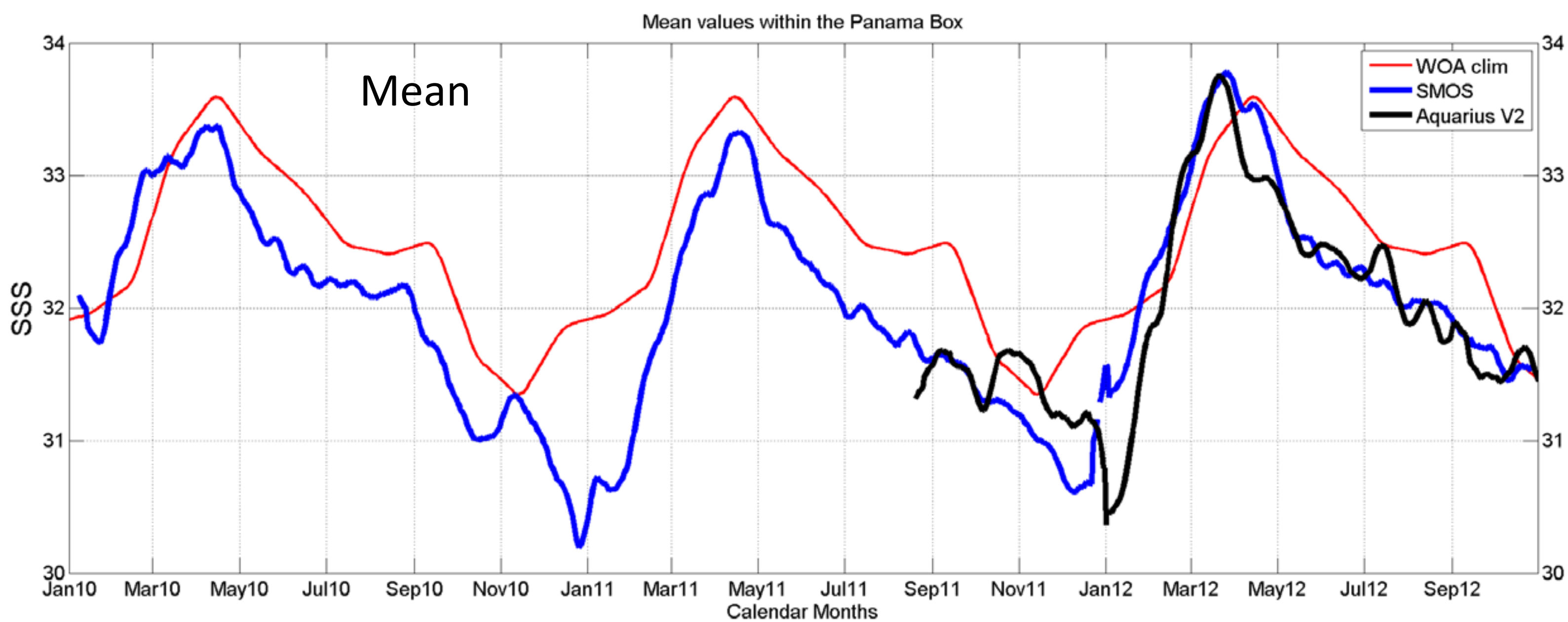
Aquarius sensus of the Upwelling





Aquarius Significantly fresher than SMOS at the beginning of the 2012 Upwelling (Jan 2012)


Median values within the Panama Box
Median
WOA clim
SMOS
Aquarius V2
SSS
34
33
32
31
30
Jan10
Mar10
May10
Jul10
Sep10
Nov10
Jan11
Mar11
May11
Jul11
Sep11
Nov11
Jan12
Mar12
May12
Jul12
Sep12
Calendar Months


Mean values within the Panama Box
Mean
WOA clim
SMOS
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34
33
32
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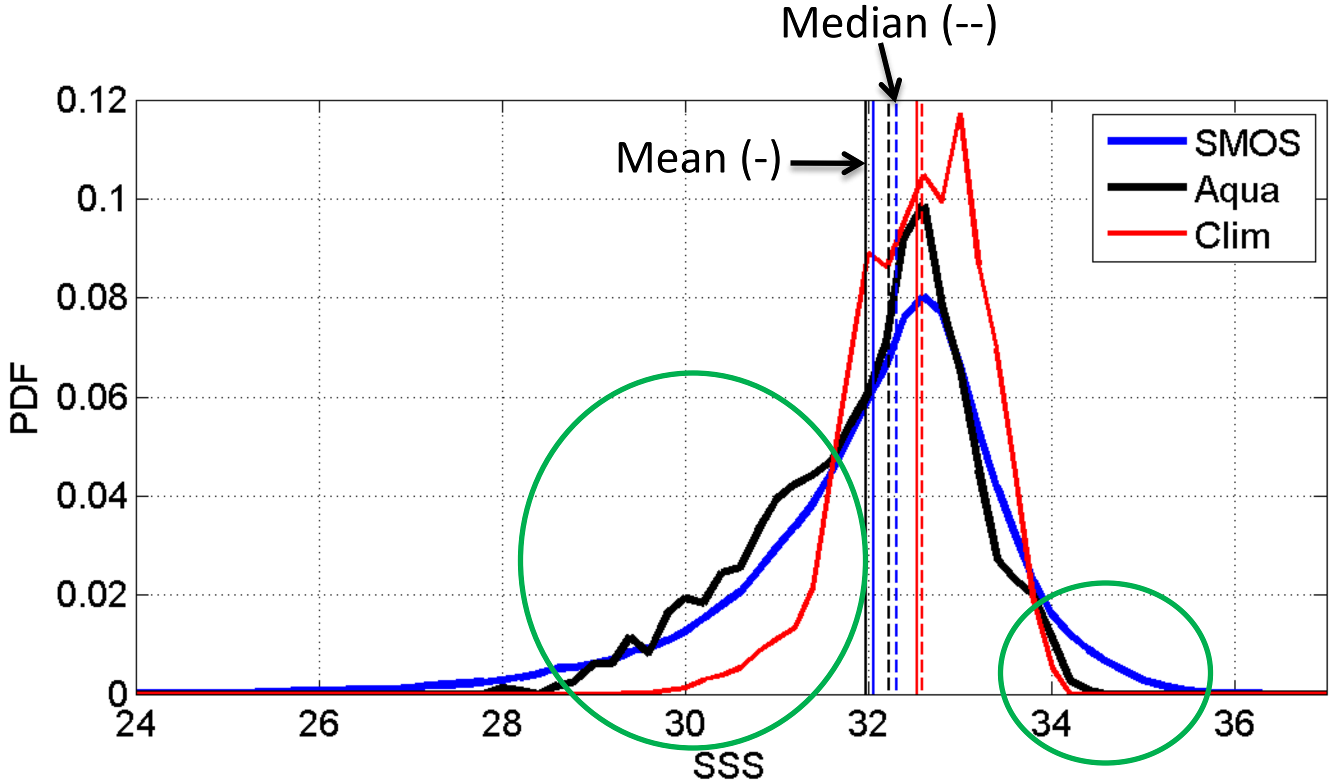
30
Jan10
Mar10
May10
Jul10
Sep10
Nov10
Jan11
Mar11
May11
Jul11
Sep11
Nov11
Jan12
Mar12
May12
Jul12
Sep12
Calendar Months

Data Distribution within the Panama Upwelling box



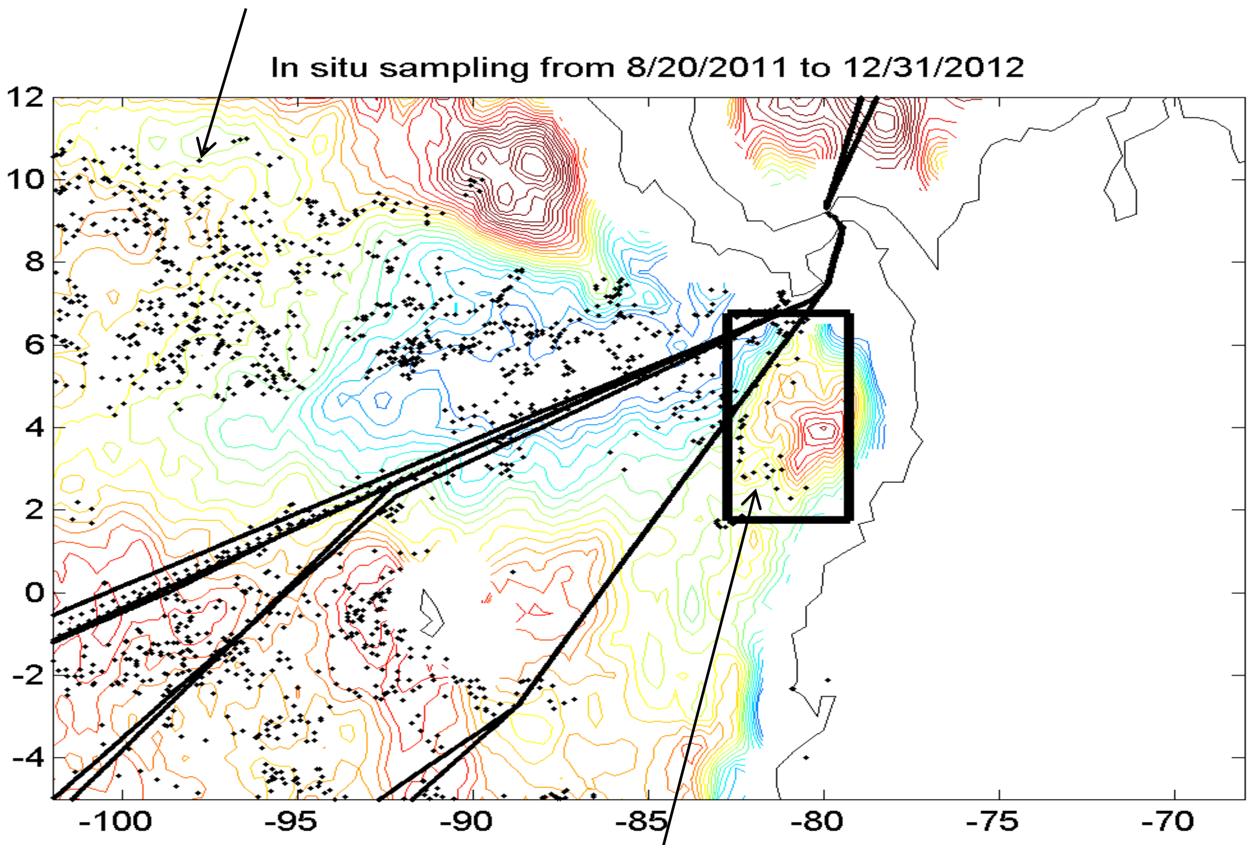
▪**SMOS and Aquarius SSS** histograms **exhibit** significant departure from normal distribution due to anomalous low-salinity measurements creating a negative skewness

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**:

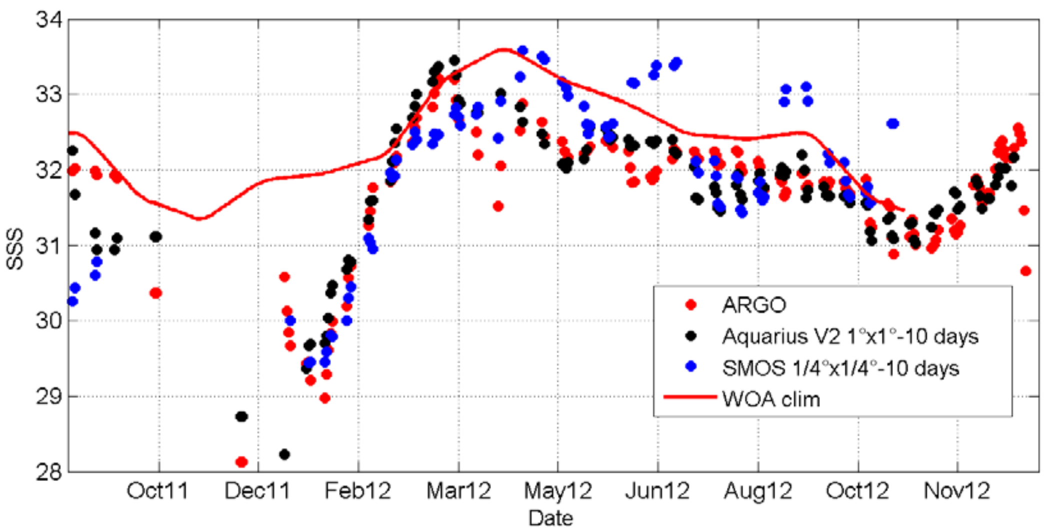
⇒Typical signature of tropical rain events (e.g. Bingham et al. JGR 2002)

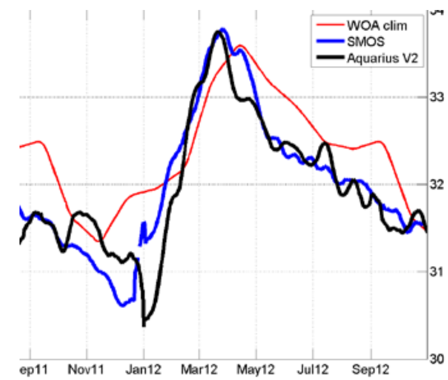
▪**SMOS** data exhibit an **higher density of high SSS events** >34 (upwelling signal ?)

ARGO floats in the upper 10 m

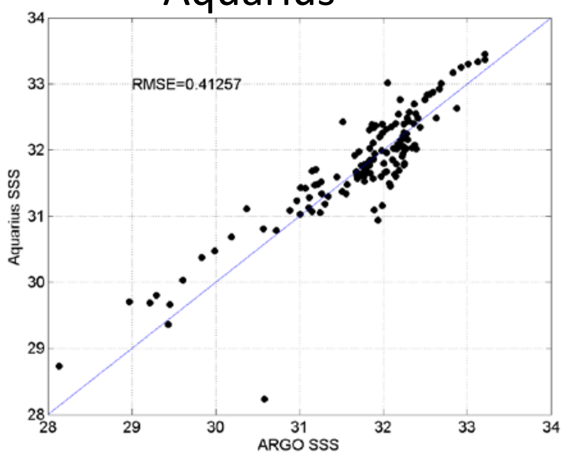


No ARGO floats & no TSG data in the center of the salty Upwelling

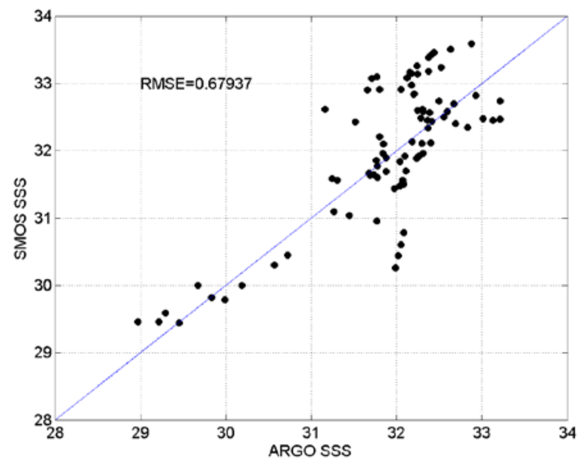




Aquarius



SMOS



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 repeatidely detected the SSS seasonal cycle of the Freshpool (building, westward streching & 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:

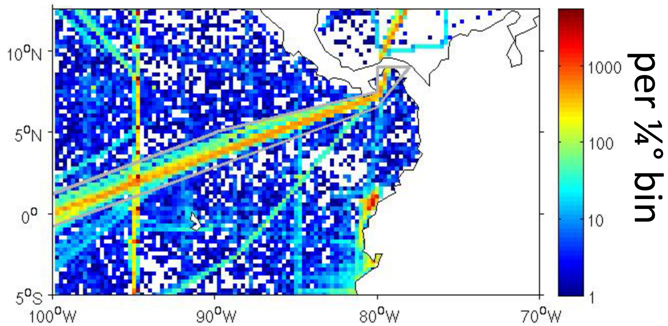
-both datasets show a much higher number of low SSS events than the climatology

- 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



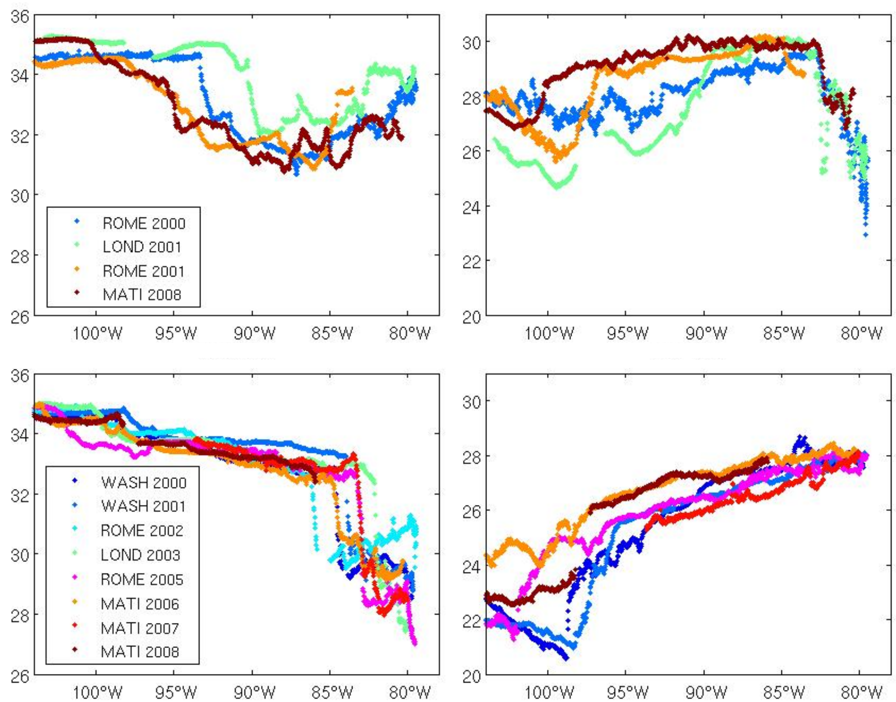
Well-sampled TSG line from Panama canal to Tahiti

SSS

SST

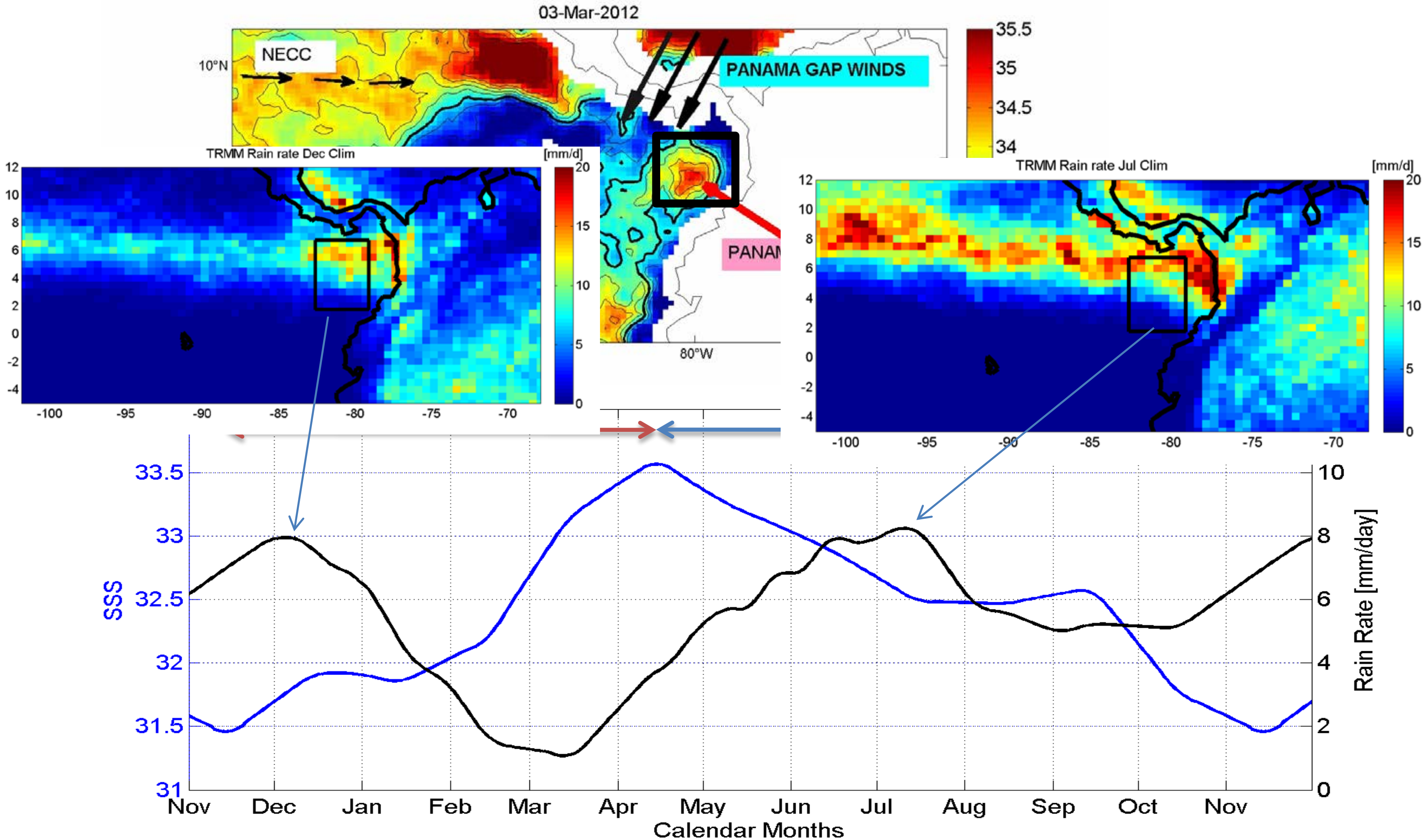
April →

Dec. →



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

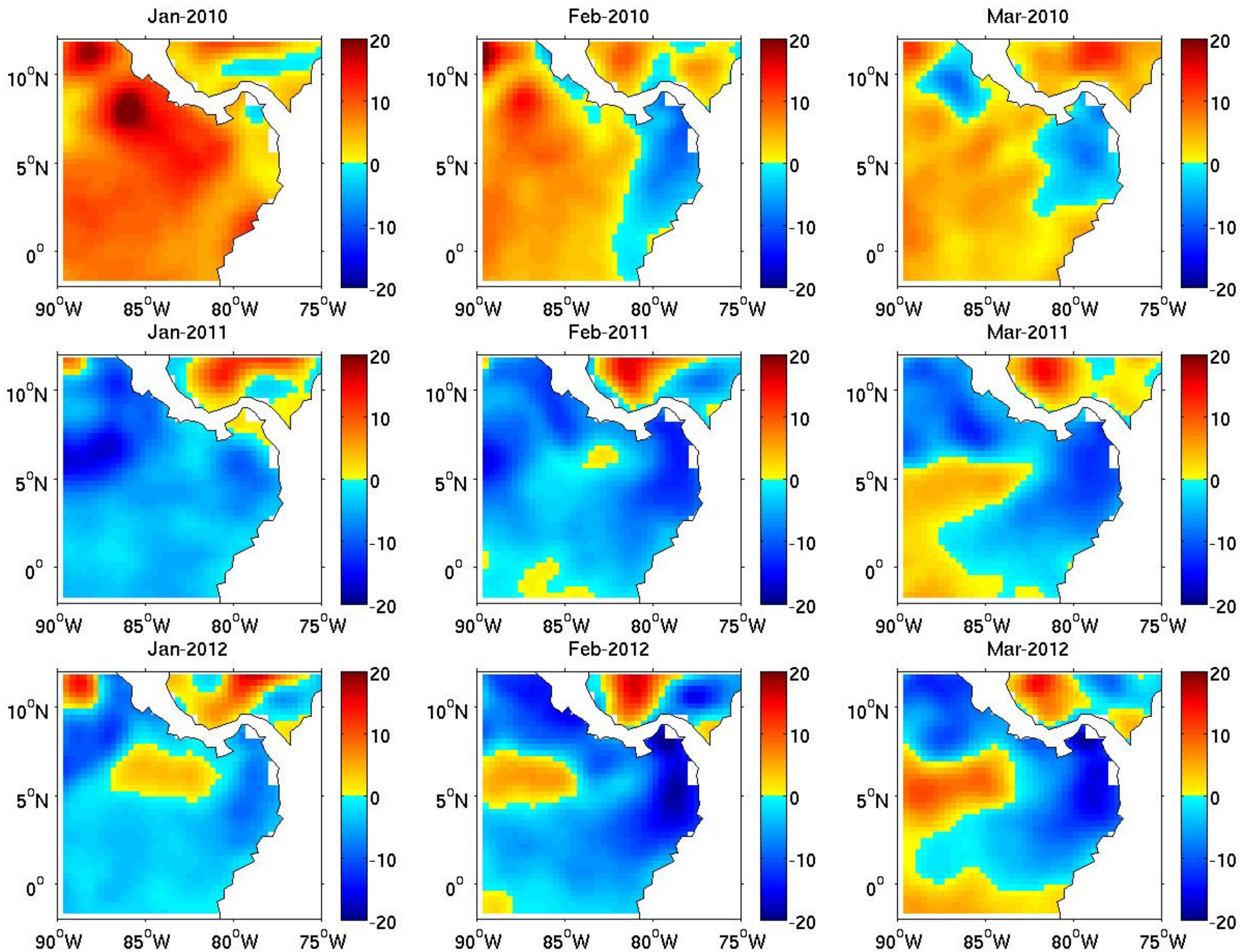


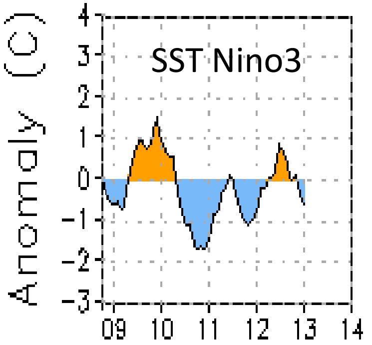
Cimatological SSS cycle from WOA in [1.75°N- 6.75°N; 79.25°W-82.75°W]

Minimum SSS (31.5) reached in Mid Nov

Max SSS (33.5) reached in Mid-Apr

Sea level anomalies (Aviso)





- Much higher sea level in 2010 (Nino) than 2011/2012

- Not much difference in sea level between 2011 and 2012