TROPICAL ATLANTIC VARIABILITY FROM SATELLITE ALTIMETRY

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Abstract

Surface layer variability is investigated in the tropical Atlantic using altimetry between 1993 and 2010. This study focusses on the low frequency interannual variations. Empirical orthogonal functions and singular value decompositions are made on altimetry and other oceanic and atmospheric parameters in order to characterize this low frequency variability. Diagnosis on these decompositions are presented in this poster.

1. DATA SETS

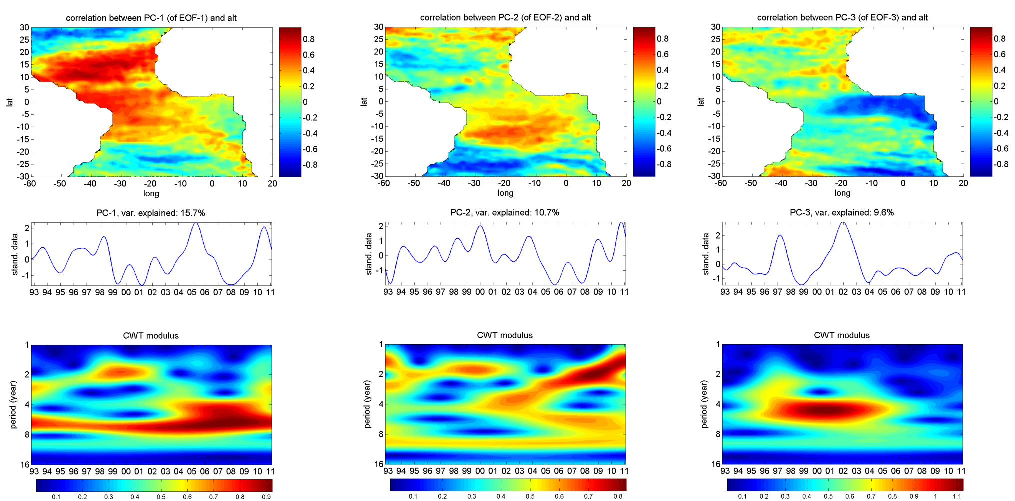
Absolute dynamic topography (ADT) were downloaded from the AVISO data center. They consist in 1/3°x1/3°x7 days resolution ADT maps (see www.aviso.oceanobs.com for more information). We use here the "reference" versions from October 1992 to January 2011.

The NCEP Reynolds Optimally Interpolated (OI) Sea Surface Temperature (SST) product used here from October 1992 to January 2011 consists of weekly SSTs on a 1 degree by 1 degree grid. The analysis uses both in-situ SSTs and satellite derived SSTs from the NOAA Advanced Very High Resolution Radiometer (AVHRR).

This study is also based on the ECMWF ERA-Interim 0.75° model results for wind stress and pressure fields (http://www.ecmwf.int/research/era/do/get/era-interim) from October 1992 to January 2011 (4-hours products).

All series have been low pass filtered to remove temporal scales < 13 months.

2. EOF ANALYSIS

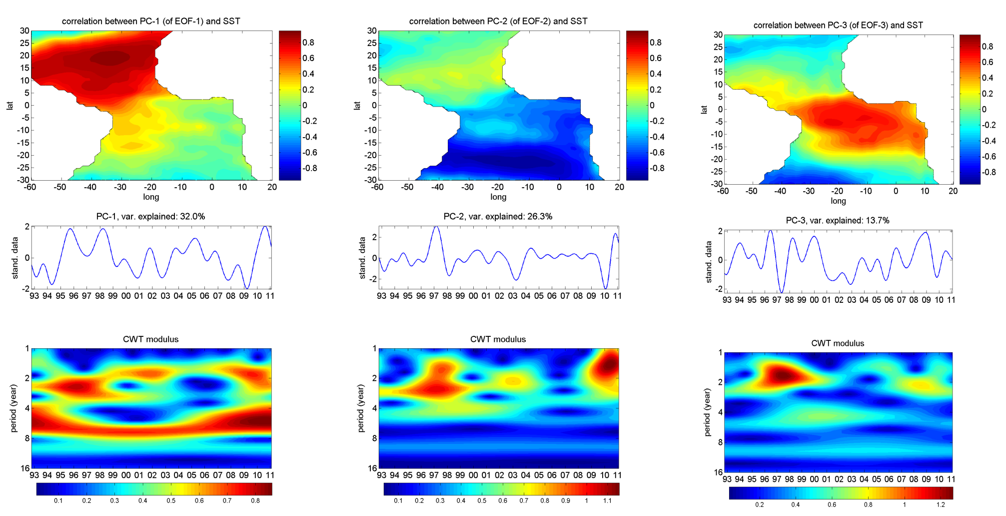


The first 3 Empirical Orthogonal Functions (EOFs) of the ADT low-pass filtered series represent ~37% of the total variance. They show interannual variability superimposed to lower modes (~ 5 to 6-years). Their spatial patterns generally offer meridional contrast between alternatively positive and negative structures.

The spatial structure associated with EOF1 (15.7%) is maximum between 5 and 15°N. Globally it corresponds to an opposition in terms of variability between the 15°N-15°S area and the poleward latitudes. The principal component and wavelet analysis indicates that this signal was prevailing during the last part of the series, in 2004-2010.

The second EOF (10.7%) spatial extrema are located in the south-western tropical Atlantic with 2 opposite cores around 10 then 25°S. The temporal characteristics show interannual fluctuations perhaps superimposed to low frequency variability. However the time series are not long enough to state on these decadal periods.

The signal associated with the 3rd EOF (9.6%) clearly depicts variability in the Gulf of Guinea. This signal peaks in 1997 then 2002 and corresponds to an intensification of the usual upwelling signal which occurs every year during boreal summer in that region.

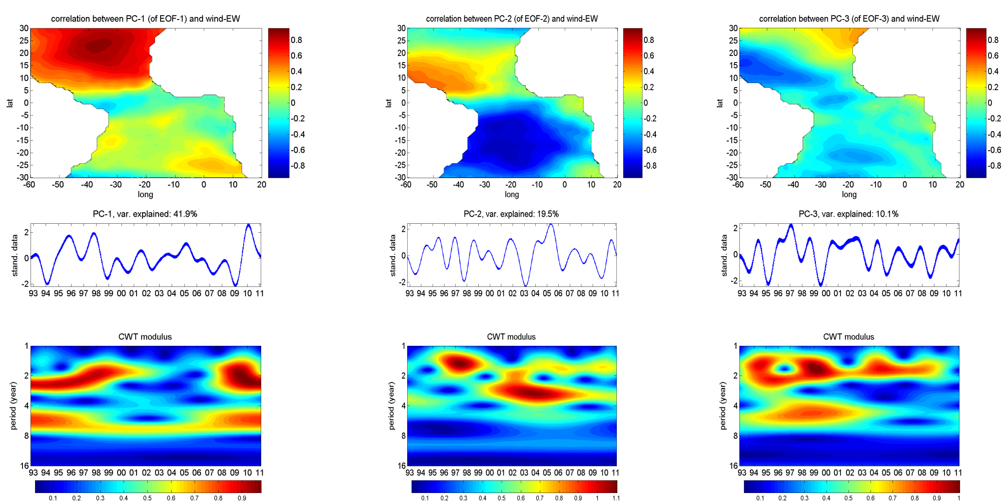


3 EOFs computed on the SST data explained 71% of the variance.

EOF1 (32%) is maximum between 5 and 15°N. Globally it corresponds to an opposition in terms of variability between the 15°N-15°S area and the poleward latitudes as was the altimetric EOF1 spatial structure..The principal component incorporates both year to year and longer scales fluctuations. as also evidenced by the wavelet analysis. The signal peaks (warm SSTs at 20°N x 30 – 40°W) during mid 1995, 1998, and 2010.

The second EOF (26.3%) presents an opposition between the northern and southern parts of the basin, around the mean position of the Intertropical Convergence Zone (ITCZ). This structure has been sometimes named 'dipole' structure in the litterature. Here, the 2 parts of the basin are not equivalent in terms of intensity, the southern one being more energetic. This North-South opposition peaks in 1997 then 2003 and 2010.

The signal associated with the 3rd EOF (13.7%) is linked with variability in the Gulf of Guinea. Again the temporal characteristics show interannual fluctuations (especially in 1996-1998) perhaps superimposed to low frequency variability..

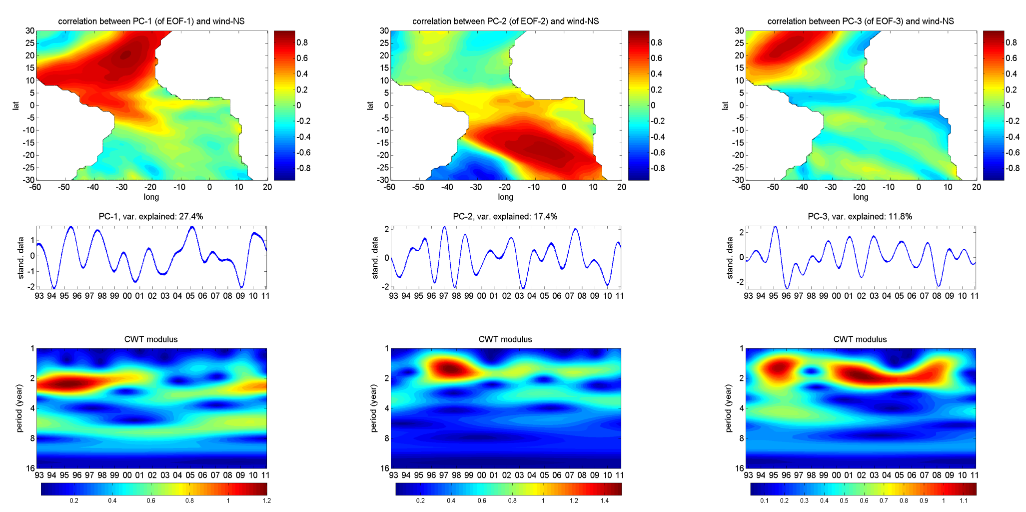


Concerning the wind, the first 3 EOFs computed on the East(West (EW) wind stress component explained 71% of the variance.

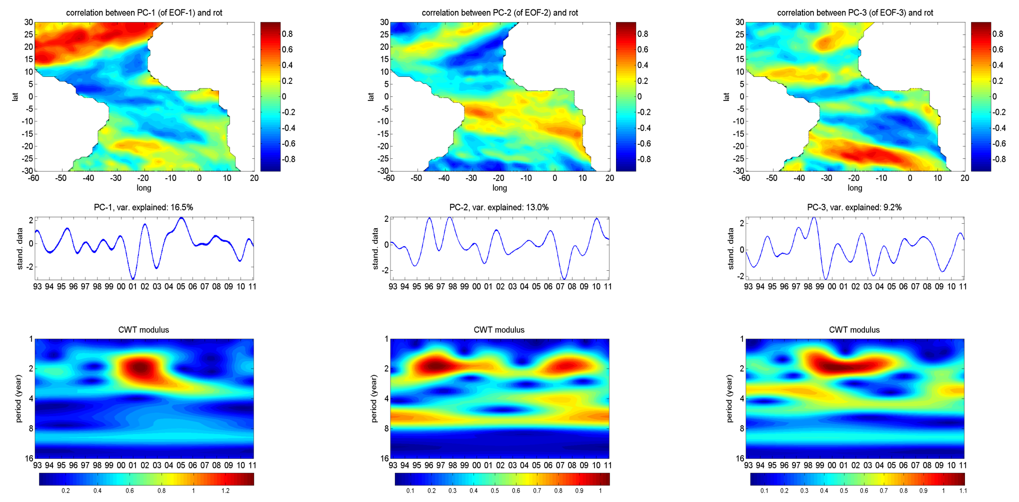
EOF1 (42%) presents extrema in the northern and southern parts of the basin. The northern hemisphere offers the strongest variability with important trade wind fluctuations between 20 and 30°W and 15 and 30°N. Following this scheme, the winds intensify in late 1995, 1997 and 2009.

The second EOF (19.5%) presents an opposition between the north-western and south-western parts of the basin, around the mean position of the ITCZ. This North-South opposition is merely associated with interannual fluctuations.

The signal associated with the 3rd EOF (10.1%) addresses variability in the northern part of the tropical Atlantic, and during the first part of the series, 1993-2001.



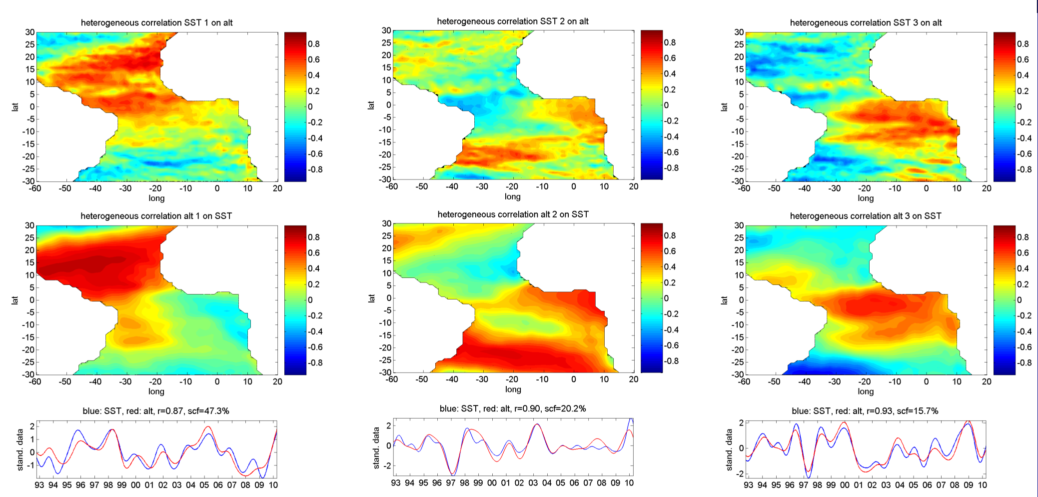
The first 3 EOFs computed on the North-South (NS) component of the wind stress enter for ~57% of the total variance. They indicate alternative strenghtening of the northward or southward trades on an interannual base..



The first 3 EOFs computed on the wind stress curl (Ekman pumping) represent ~39% of the total variance. They present interannual fluctuations occuring in different periods.
For instance, EOF1 shows extrema between 2000 and 2005 in the northern hemisphere, and EOF2 3 in 1998-1999 in the southern one.

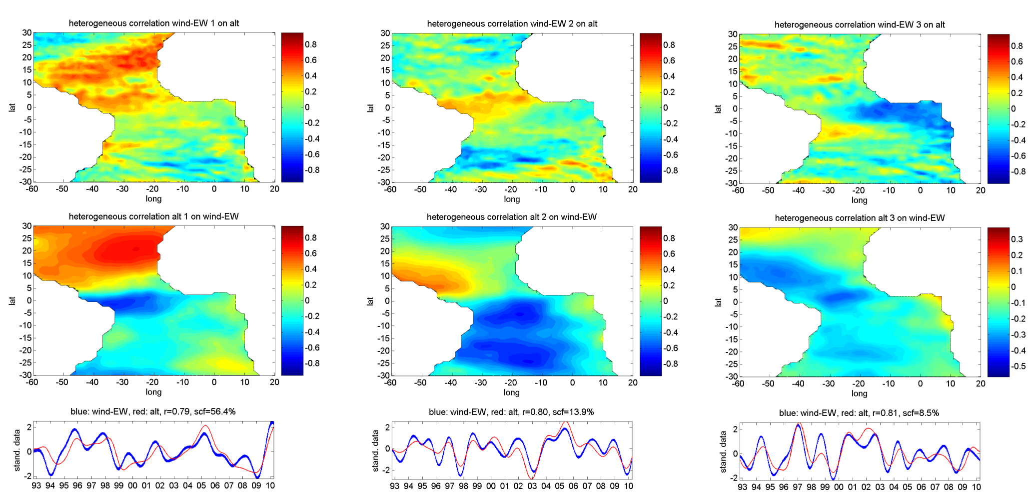
3. SVD ANALYSIS

The Singular Value Decomposition (SVD) technique is used to investigate the relationship between the altimetry and the other fields. The SVD results are presented using heterogeneous maps. The square covariance faction (scf) gives the amount of cross-covariance extracted by the SVD and the correlation coefficient (r) gives the coupling between the expansion coefficients of both variables.



The first SVD (SST vs altimetry) shows a strong positive coupling of the variables between 0°N to 20°N and a weak negative coupling elsewhere.

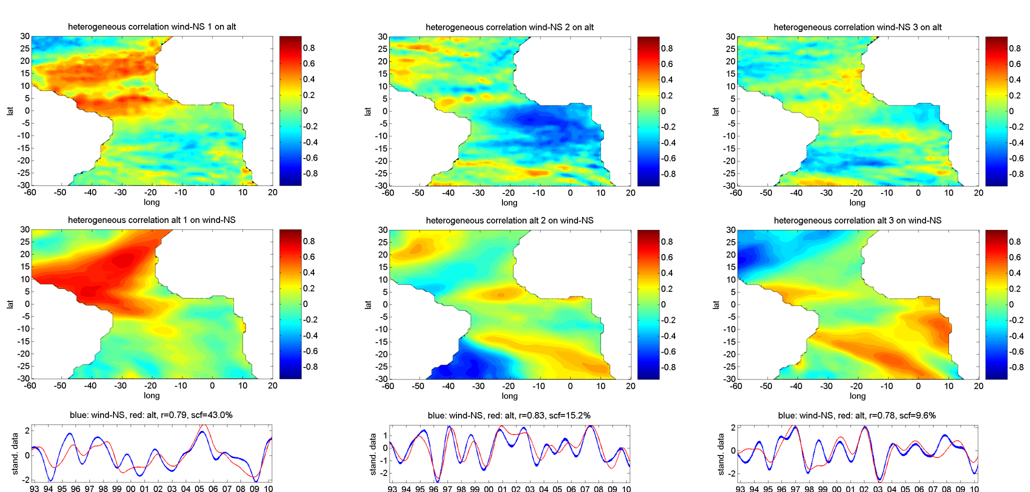
The second SVD shows broadly a positive coupling in the southern hemisphere while the 3rd SVD exhibits positive coupling in the Gulf of Guinea.



The first SVD (EW wind stress vs altimetry) shows a strong positive linkage between the fields in the northern hemisphere while there is a negative relationship in the western part of the equator.

For the second SVD, the relation between the altimetry expansion coefficient and the wind data seems to show a broadly dipole-like behavior separated by the equator.

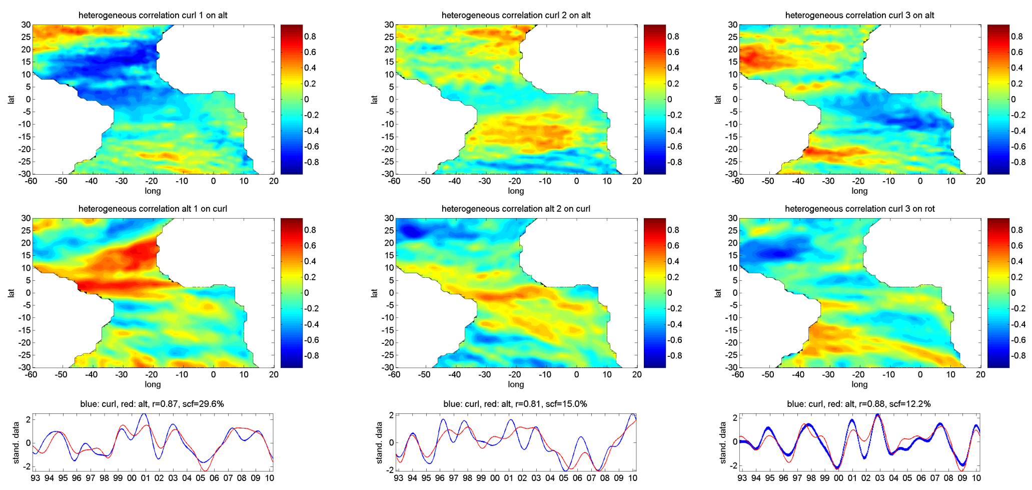
The third SVD shows a weak negative relationship between the wind expansion coefficient and the altimetry fields observed in the Gulf of Guinea.



In the meridional wind/altimetry SVD 1, a strong positive relationship between the variables is observed from 0° to 20°N, as already noticed in the zonal wind SVD 1.

For the second SVD, the 2 correlation maps are quite identical with a weak coupling between the wind expansion coefficient and the altimetry field.

In SVD 3, no clear patterns can be observed.

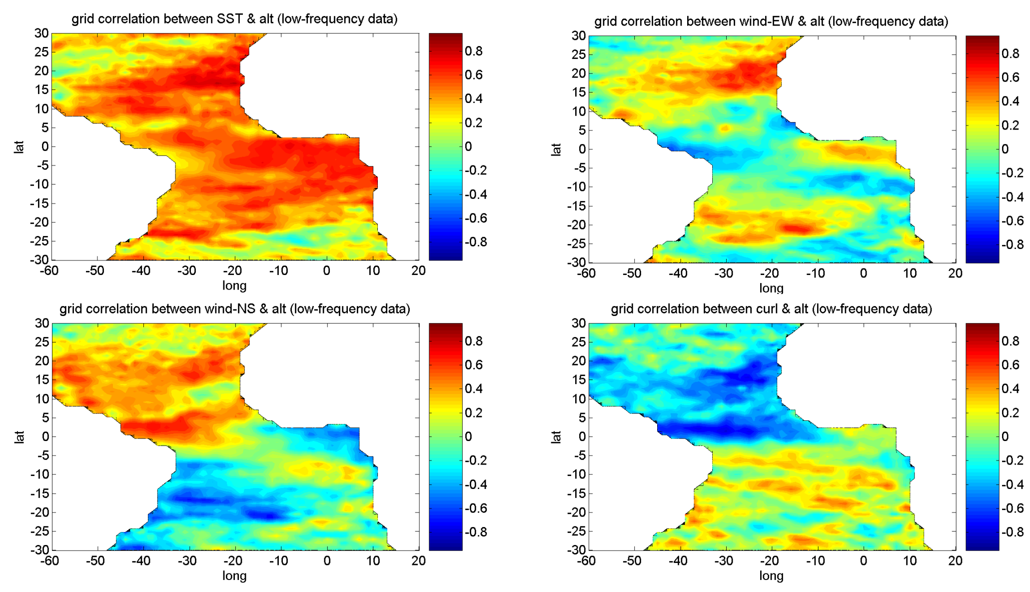


The wind stress curl and altimetry fields in SVD 1 are generally anti-correlated with the strongest correlation observation from 0 to 20°N.

In SVD 2 no clear relationship can be observed while in SVD 3 an inverse relationship is seen around 15°N and 55°W.

4. CORRELATIONS

For information the gridded correlation between the altimetry field and the other fields are displayed.



CONCLUSION

Low frequency variabilities of different variables: altimetry, Sea Surface Temperatures and wind stresses, have been investigated in the tropical Atlantic ocean.

Empirical Orthogonal Function analysis performed on the different fields generally evidence interannual vaiability with sometimes lower frequencies superimposed.

The relationship between altimetry and the other fields through Singular Value Decomposition will help to investigate how the altimetry can be linked to other climate fields or indexes as the El Nino Southern Oscillation, the North Atlantic Oscillation...

ACKNOWLEDGEMENTS

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