Toward a satellite-based Upwelling Index for the West African Upwelling: a preliminary study

S. Marullo[1], P.M. Ruti[1], D. Iudicone[2], O. Cavalieri[1], A. Lazar[3], P. Marchesiello[4] , F. D'Ortenzio[5] and I. Polo[3]
Contact: salvatore.marullo@casaccia.enea.it

[1]Progetto Speciale Clima Globale, Ente Nazionale per le Nuove Tecnologie, l'Energia e l'Ambiente, Roma, Italy; [2]Stazione Zoologica "A. Dohrn", Italy, Napoli; [3]LOCEAN, Paris, France; [4] IRD, Brest, France;[5] Laboratoire d'Oceanographi de Villefranche, CNRS a nd Université Pierre et Marie Curie, Villefrache sr Mer, France

INTRODUCTION

At present standard upwelling indexes for the monitoring of coastal upwelling are based on estimate of the wind intensity or wind stress intensity (Ekman transport) along the coast. More complex indexes include the estimate of the Sea Surface Temperature (SST) and/or the wind-driven vertical turbulence.

The actual intensity of the Ekman-like upwellings circulation can be modulated by e.g., the interaction with large scale circulation and the coastal wind, changes in the vertical stratification induced by anomalies in coastal freshwater discharge (runoff). A more direct estimate of the circulation could therefore be useful.

Among the several satellite-based remote sensing of the ocean circulation, altimetric data are the most suitable to monitor the variability of the surface circulation. In particular for the upwelling phenomenology, (wind-induced) geostrophic coastal currents could be a priori monitored.

Here we propose investigate the possibility of improving our monitoring capability of the upwelling intensity via the inclusion of altimetry-based informations in the definition of indexes. Focus on the relationship existing between the oceanic response and the wind intensity also from remote locations.

A comparative analysis is done on both data and model outputs.

The study is done in the context of the CNES-NASA ANETUS Project and EU AMMA Project.

DATA and METHODS (Test year: 2002)

- Optimally interpolated Sea Surface Temperature from AVHRR (night passes only)
- Maps of Sea Level Anomalies merged (T/P or Jason-1 + ERS-1/2 or Envisat) + Mean Sea Level Height from Rio et al., 2004
- Surface winds from ECWMF operational analysis
- Model OPA-ORCA05 global model (1/2° resolution) interannual simulation (1992-2000) forced with ECMWF fields

INDECES DEFINITION:

- SST index: difference between coastal SST and zonal mean over the tropical Atlantic at the same latitude (fig.1)
- Ekman Index: offshore ekman transport computed using surface winds
- Slope index using altimeter data

MONSOON SNAPSHOT

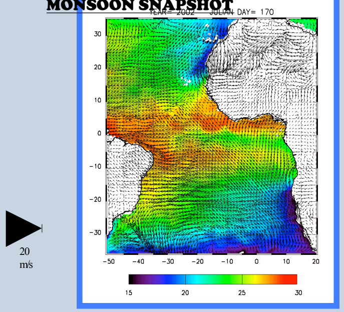


Figure 2: ECMWF surface wind and AVHRR SST Optimally interpolated map.

DATA ANALYSIS

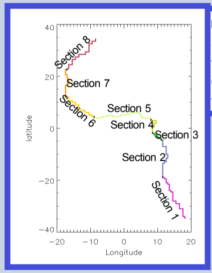


FIGURE 1: coastal lines sections used to compute upwelling indices time series

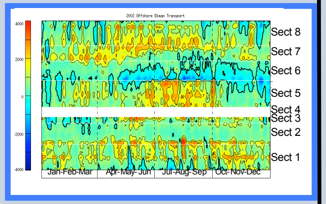


FIGURE 3: Offshore Ekman transport along the Atlantic Africa coasts. Contour line interval is 1000. the thick line represents the zero

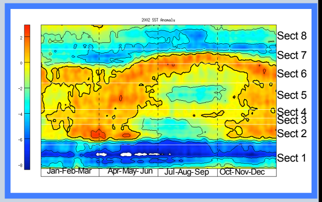


FIGURE 4: Sea surface temperature anomaly (respect to the SST average at the same latitudet he same day) averagedalong the Atlantic Africa coasts. Contour line interval is 2 °C. the thick line represents the zero

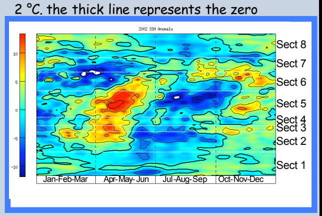


FIGURE 5: Sea surface height anomaly (respect to the SSH average at the same latidude the same day) averagedalong the Atlantic Africa coasts. Contour line interval is 5 cm. the thick line represents the zero

MODEL ANALYSIS

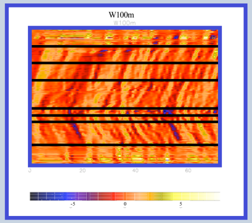
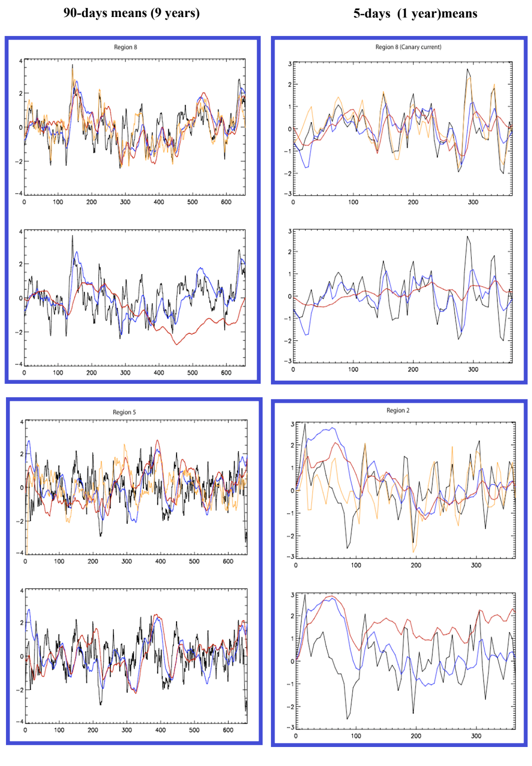


FIGURE 4: Vertical velocity at 100m along the african shlef (1992). Regions are the same as in the data analysis. **Waves from the Equator dominate the upwelling in most of the western Africa.**

TIME SERIES OF ANOMALIES (NO SEASONAL CYCLE, NORMALIZED TITH THE RMS).

Upper panels: BLACK: W100M; RED: SSTI; BLUE: SLAI; YELLOW: BAKUN INDEX (SSTI and SLAI signs have changed in order to evidentiate the correlations with the Bakun index)

Lower panels: Black: W100m; Blue: SLAI; red: time integral of W100m (cumulative)



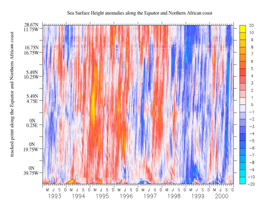
WAVES FROM THE EQUATOR

The figureshows the hovmoller diagrams for the SSH anomaly along the Equator and the Northern African coast, for the period from 1993 to 2000.

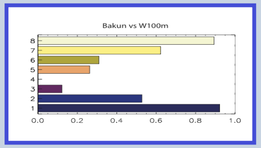
Both, positive and negative signals appears along the year, not showing relation to the seasonal upwelling and downwelling signals.

The propagation velocity from the figure has been estimated to be around 1.4 and 1.6 m/s.

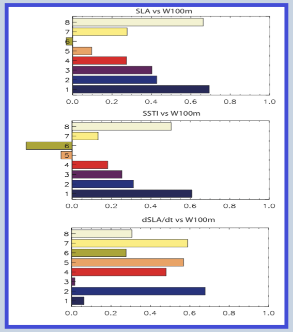
Although some propagation signals show a continuity from the equator to the african coast, the mayority of the kelvin wave signals starts at the african coast and propagates until the end of Guinea Gulf.



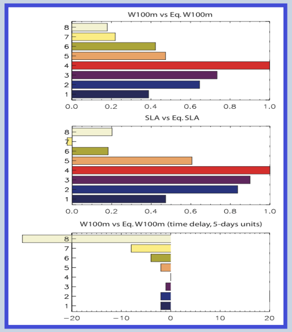
CORRELATIONS (90-DAYS LOW PASS FILTER)



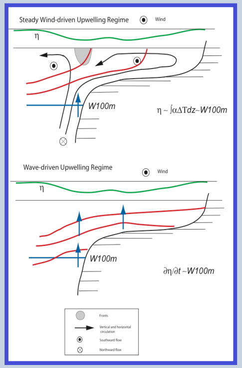
Bakun is a good proxy far from the Equator



SLAI is better then SSTI; but dSLAI/dt is better whne closer to the Equator



Why the upwelling (W100m) is correlated with the SLAI at mid-latitudes and with its time derivative elsewhere? A scenario



CONCLUSIONS

1. The coastal upwelling has a clear signal in altimetric SSH and SST anomaly. This is evident in both data and model simulation.
2. This preliminary analysis indicates the usefulness of remote sensing data, and inn particular of altimetric data, to derive upwelling indices for the Atlantic Africa coasts.
3. The combined analysis of model simulations and data shows that part of the signal is forced locally by winds and part is forced by remote signals via Kelvin Wave.

Acknowledgements

The authors wish to thank AMMA and ANETUS projects

The altimeter products have been produced by the CLS Space Oceanography Division.

NCEP data have been provided by the NOAA-CIRES Climate Diagnostics Center, Boulder, Colorado, from their web site at http://www.cdc.noaa.gov/.

The ECMWF data have been obtained from the ECMWF data server at http://data.ecmwf.int/data/.