ECOLA-13 : Characterization and analysis of circulation and mesoscale dynamics in the Eastern Tropical Atlantic Ocean using altimetry data - OSTST project: Alti-ETAO

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Objectives: The main objective of this project is to study the dynamics of the Eastern Tropical Atlantic Ocean (ETAO), especially at mesoscale (10 km -500 km) at different time scales: intra-seasonal to interannual. The project gathers scientists from different teams and laboratories (at LEGOS: ECOLA, OLVAC, CTOH, ECHOS; In Benin: CIPMA/UAC, IRHOB, In Ivory Coast: UA).

This project is structured around the following objectives:

- To determine the main characteristics of the mesoscale activity (eddies, etc.) and to study its role on the overlying atmosphere and on the regional ocean circulation, in particular on the transport from coastal zones towards the open ocean.

- Analyze how this mesoscale activity (forcing / formation, propagation, dissipation) is influenced by the variability of large scale currents (equatorial, tropical), equatorial waves and coastal dynamics (coastal currents, intermittent and permanent upwelling systems, coastal trapped waves, internal waves).

- Improve coastal altimetry capacities and data with regional and higher frequency spatio-temporal corrections for the ETAO region (tides and dynamic atmosphere, identification of mesoscale processes).

-Develop new diagnostics for vortex structure and their impact on large-scale dynamics, atmosphere and productivity, especially by combining altimetry with other observations (satellite and in situ).

Scientific Rationale and Methods:

Mesoscale activity (vortices, etc.) in the Eastern Tropical Atlantic Ocean (ETAO) (**Fig.1**) is poorly known. It interacts with a wide range of processes such as large scale circulation, equatorial waves and near-shore dynamics. In addition, the ETAO region, which drives the African monsoon, is one of the ocean regions worst represented in climate models, with warm biases of several degrees in sea surface temperature (SST), probably partly because of the misrepresentation of the effects of the mesoscale processes. In this project, we use the long time series of satellite altimetry data, both single missions and combined missions (T / P, ERS, JASON 1, 2, and 3, AltiKa, Sentinel 3, etc.) and also data from Coastal Altimetry (XTRACK) after validation, thanks to . These altimetry data are used in conjunction with other satellite data such as ocean surface wind (ERS, QuikSCAT, ASCAT), sea surface temperature (AVHRR, TMI), ocean color (SeaWiFS, MODIS / Aqua, MERIS, Sentinel3, GlobColour multi-mission product), surface salinity (SMOS), in situ data (PIRATA, etc.) as well as high spatial resolution modeling (NEMO model) with different configurations for the study area (1/4 °, 1/12 ° with and without tides, with and without rivers). The results of this realistic model for the ETAO region serve as a virtual laboratory to test the new mesoscale diagnoses and also to identify the possible limitations for their identification from altimetry observations. Finally we will assess whether future observations of the SWOT wide-swath sensor will overcome these problems.

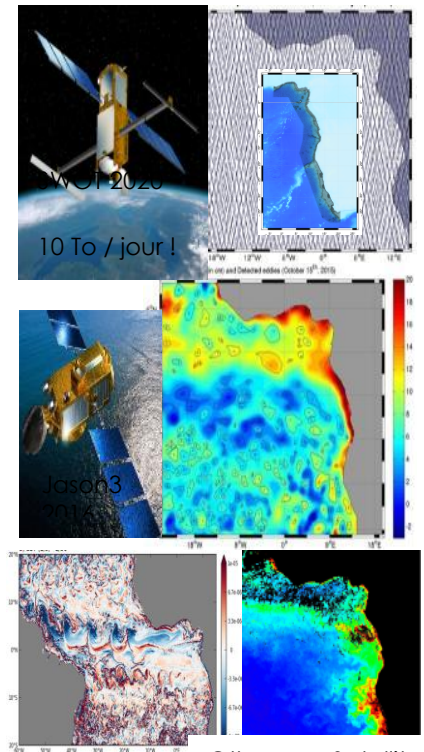

Fig.1 : ETAO region and data/model used in the OSTST project « Alti-ETAO ».

Results

The main properties of eddies have been determined in the ETAO region using altimetry data (**Fig.2**). The tropical zones (1 and 3) have 60% more vortices than the equatorial zone (2). The vortices are

formed in the eastern part of the basin and spread westward with a faster speed to the equator. Eddy lifetimes can be up to 140j in the tropics (1 and 3) (**Fig.2**). The application of the vortices/waves criterion developed for the project shows that 10% of the detected structures are waves. The seasonal cycle of eddies in the study area can be as much as ± 50% of the average value for properties (radius, Eddy Kinetic Energy) related to the seasonal cycle of ocean circulation .

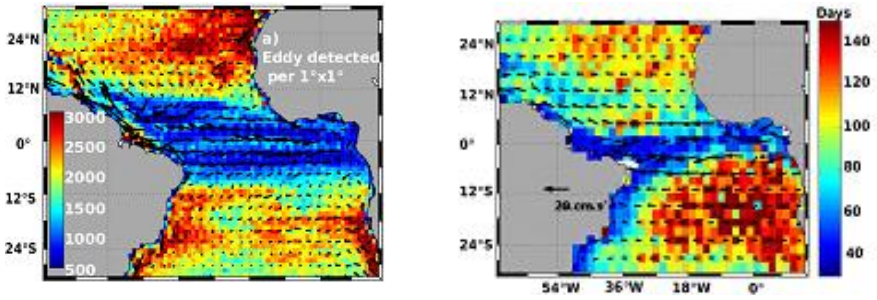

***Fig.2** : Distribution spatiale des propriétés moyennes des tourbillons sur la période 1993-2015 : (a) nombre de tourbillons détectés (b) durée de vie des tourbillons (jours)*

Strong and distinct SSS signatures in the equatorial band and around large river plumes, captured by in situ observations and also visible by SMOS, have been attributed to the meridional and equatorial interannual modes, and their driving processes have been identified using the NEMO 1/4° model (Awo et al., 2018).

A theoretical model on equatorial Kevin wave dynamics (Morel et al., 2018) has been developed and successfully applied to the Equatorial Atlantic ocean (July-October 2009 observations), explaining several feature of the effect of Kelvin waves on the development of temperature anomalies along the equator.

The XTRACK coastal altimetry data have been systematically validated with tide gauge data available in the study area, confirming the good consistency of XTRACK data north of 23°S (**Fig.3**). Spectral analyses over time along the coast show a dominance of the seasonal cycle, followed by semi-annual and intra-seasonal periods. South of 23°S, the temporal variability of the XTRACK and tide gauge data is different, probably related to the tide and DAC. These hypotheses are tested with the tide and DAC modeling at very high resolution (< 1km) using the Tugo-m barotropic model developed at LEGOS (Dieng et al., 2019).

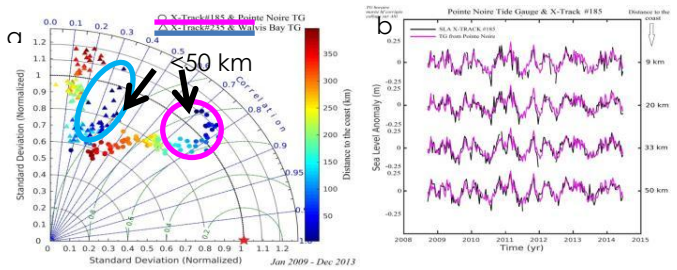

***Fig.3** :(a) Taylor diagram (cor-relation, standard deviation quadratic error) ; reference : TG SLA for Pointe Noire (4.78°S, 11.83°E), Walvis Bay (22.95°S, 14.50°E) (b) Comparison of SLA time-series from TG and X-Track at different distances from the coast along of the track around Pointe Noire TG.*

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