FINAL REPORT PROGRAM LEFE

Two pages to be written in English

Program LEFE/ IMAGO	**Project Title** REconstruction des Changements de Circulation Océanique Recents - Derniers Siècles - RECCORDS	**Year: 2019**

PI name, email and lab: Eva Moreno, eva.moreno@locean.ipsl.fr, LOCEAN Participating Laboratories : ISteP, EPOC, HNHP	Contribution to Other funding sources :

Context (2-3 lignes)

In 1990, A. Bakun hypothesized that the increase of greenhouse gases in the atmosphere and related global warming during the 20th century could be responsible for an intensification of upwelling and thus cooling of sea surface waters in these regions due to enhanced favorable winds along the coast. Since then, this hypothesis continues to be an important debate within the scientific community.

Objectives / scientific questions (2-3 lignes)

The aim of RECCORDS project is to test Bakun's theory in order to get a more accurate view of global upwelling patterns. Proxies of SSTs, surface productivity (TOC) and sediment grain-size measured in multi-tube cores were combined to characterize spatial and temporal trends in coastal upwelling off Peru, NW Africa and California.

Main results

Cores from major upwelling regions were analyzed for biomarkers, organic matter and sediment grain size distributions to investigate Sea Surface Temperature (SST) trends and variability and associated dynamical changes. Reconstructions of SSTs, surface productivity (TOC from rock eval) and grain size parameters, specially sortable silt in three upwelling systems over the past century were generated from three multi-core sediments: core ST11 off Pisco (Peru), core 11S off Mauritania (Canary system) and core C33 from off California. In addition, SSTs derived from alkenones were determined in three cores collected along a N-S transect in NW Africa: core 2S (19°N), 11S (21°N) and 24 S (26°N). Dating of all cores was performed using 210Pb.

Our first task was to evaluate the performance of sortable silt as a proxy of near bottom current intensity in upwelling systems, for the first time. As it is the case in bottom current that has been studied in contourites at depths >1000 m (McCave et al., 1995), hydrodynamic modeling experiments off Namibia have shown that the upwelling circulation enables the transport of particles of different grain-sizes up to the sand size but most transport on the upper slope (i.e. upwelled waters) is restricted to silt grain-size (Huhn et al. 2007) implying that upwelling variability should thus be captured by SS.

SS and percentage of the sortable silt fraction? (SS%) for these cores are shown in figure 1. Correlations between these two parameters were calculated to evaluate the ability of SS to reflect the flow speed history at each site (McCave and Andrews, 2019). The SS-SS% relationships show a strong Pearson coefficient (r>0.69), which indicates that the sediments are well sorted by bottom currents. However, wind transport can act in a similar way as bottom current and induces sediment sorting.

First results in the Peru, California and NW Africa upwelling systems indicate distinct trends (Figure 2). The impact of changes in upwelling indices was estimated in the form of linear relationship. In core ST11, off Peru, all our upwelling proxies suggest an intensification of the upwelling over the past 150 yrs and a notable increase since 1940. The SST cooling (about 1°C) and co-eval increasing TOC and SS suggest enhanced upwelling circulation. Similar results were found in core DIPAL C33 off California.

In core 11S, off Mauritania (NW Africa), the SST proxy shows a 1°C increase. Due to the fact that the core was collected at 1200 m water depth, the SS of core 11S is probably related to eolian transport. However, higher grain size was associated with a warming of surface waters and no significant change in surface productivity. Previous work off NW Africa over the 1981-2011 period indicates the wind actually intensified but sea surface warmed (Benazzouz et al. 2015).

Future of the project :

New funding from LEFE (RECCORDS2) for the years 2020-2021 was obtained for the analyses of new cores. This has enabled to better understand the link between grain-size in sediments and upwelling circulation and confirm our result off West Africa.

References

- Benazzouz, A., Demarcq, H. and González-Nuevo, G. 2015. Recent changes and trends of the upwelling intensity in the Canary Current Large Marine Ecosystem. In: Oceanographic and biological features in the Canary Current Large Marine Ecosystem. Valdés, L. and Déniz-González, I. (eds). IOCUNESCO, Paris. IOC Technical Series, No. 115, pp. 321-330. URI: http://hdl.handle.net/1834/9198
- Cropper, T. E. et al. Spatial and temporal seasonal trends in coastal upwelling off Northwest Africa, 1981–2012. Deep Sea Research Part I: Oceanographic Research Papers 86, 94-111, doi:https://doi.org/10.1016/j.dsr.2014.01.007 (2014).
- Huhn, K., Paul, A., Seyferth, M., 2007. Modeling sediment transport patterns during an upwelling event. Journal of Geophysical Research: Oceans 112.
- McCave, I. N. & Andrews, J. T. Distinguishing current effects in sediments delivered to the ocean by ice. I. Principles, methods and examples. Quaternary Science Reviews 212, 92-107, doi:https://doi.org/10.1016/j.quascirev.2019.03.031 (2019).
- McCave, I. N. et al. Sortable silt and fine sediment size/composition slicing: Parameters for palaeocurrent speed and palaeoceanography. Paleoceanography 10, 593-610, doi:10.1029/94PA03039 (1995).

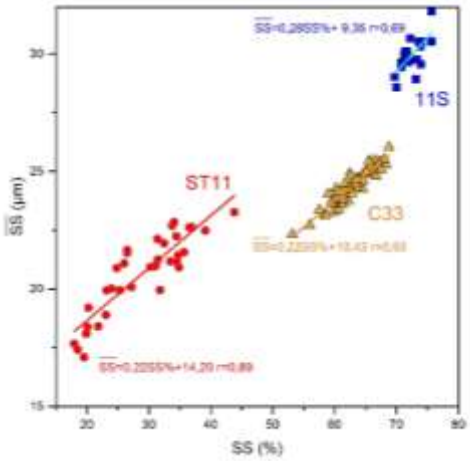

Figure 1

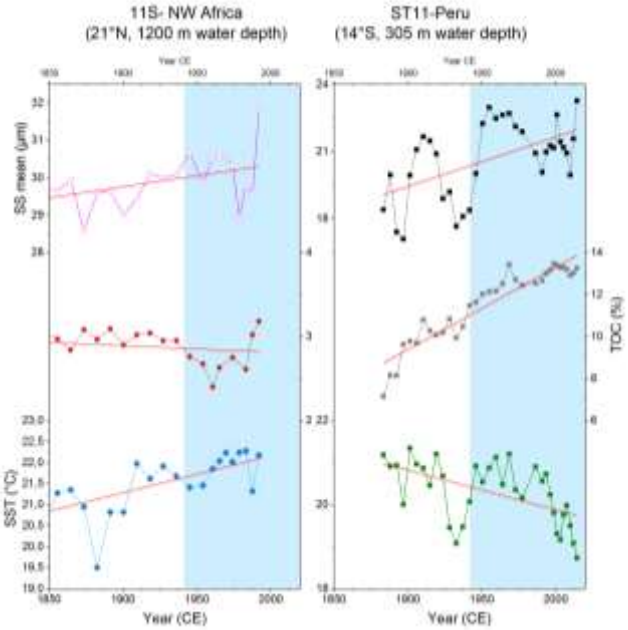

Figure 2

Figure 1: Relationship between sortable silt grain-size mean (SS) and percentage (SS%).

Figure 2: Downcore profile of alkenone SSTs, total organic carbon (TOC) and sortable silt mean grain size (SS) at the 11S site, off Mauritania and at ST11, off Peru since 1850.

Nombre de publications, de communications et de thèses

(citer au maximum 5 publications en lien direct avec le projet)

Alves Ana, 2019 - Master 1 Sciences de Terre et des Planètes, Environnement (STePE) voie Climat, Environnement, Applications & Recherches (CLEAR) - Université Paris-Saclay. Reconstitution des changements de circulation océanique récents dans les systèmes d'upwellings. Sous la direction d'Eva Moreno (LOCEAN).

Camille Guerrin, 2018/2019. Master 1 Science de la Mer et du Littoral-Université de Bretagne Occidentale. Etude de la variabilité du climat pré-industriel récent à partir des sédiments marins. Sous la direction de Marie-Alexandrine Sicre et Vincent Klein. _

Moreno Eva, Marie-Alexandrine Sicre, Ana Alves, Sabine Schmidt, Simon Puaud, François Baudin, Vincent Klein and Fanny Kaczmar (2019). Temporary evolution of the coastal upwelling in the eastern boundary currents from the Pacific and Atlantic oceans since the 17th century to the present day. 13th International Conference on Paleoceanography (ICP13). Sydney (Australia).

Sicre Marie-Alexandrine, Eva Moreno, Loic Barbara, Sabine Schmidt, Vincent Klein and Fanny Kaczmar (2019). Temporal evolution of coastal upwelling in Eastern boundary currents from before the 20th century using paleo-climate reconstructions. WIOMSA, 11th scientific symposium. Mauritius.