Holocene climate variability – a marine perspective

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Les scénarios climatiques du futur ont suscité un grand intérêt pour les études paléoclimatiques, notamment pour l'Holocène (les derniers 11.5 ka - période historique et riche en archives), dans le but d'identifier la variabilité naturelle du climat. Cependant, si pendant les périodes glaciaires, la température gouvernait l'essentiel de l'oscillation des signaux climatiques, pendant l'Holocène, du fait des faibles variations de température, il est nécessaire d'extraire les forçages à l'origine de la variabilité enregistrée. Cette variabilité a tout de même été suffisamment importante pour reverdir le Sahara. Dans ce contexte, nous tentons de caractériser les forçages de la variabilité de l'Holocène en analysant des séries climatiques reconstruites à partir d'indicateurs (proxies) tirés d'enregistrements marins de l'Atlantique Nord, de la Méditerranée, du Pacifique et de l'Océan Austral.

1: Holocene climate records from the Bay of Biscay (BoB)

The effect of global and regional climate forcing (e.g. orbital forcing, North Atlantic Oscillation – NAO; Fig. 1) and their subsequent control on marine ecosystem in the southeastern BoB were investigated on planktic and benthic foraminiferal assemblages, and stable isotopes in four sediment cores.

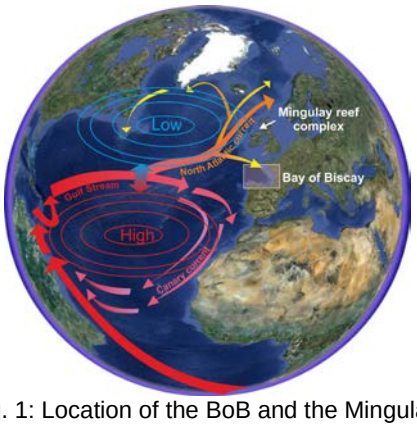

Fig. 1: Location of the BoB and the Mingulay reef complex within the NAO system and at the edge of the NA circulation.

Episodic long-term incursions of the warm and saline Iberian Poleward Current into the BoB are indicated by the intermittent presence of subtropical planktic foraminifer species *G. ruber*. The incursions seem to be triggered by negative NAO conditions [1;2] (PhD thesis J. Garcia, Angers Univ. 2010-2013, and [1]).

2: Changes in the NA circulation related to abrupt climate events

Deep-water cold corals collected in several key locations in the North Atlantic (e.g. Mingulay reef complex; Fig. 1) are used for detailed reconstructions of Holocene changes in surface circulation patterns. Deep-water corals provide novel and highly detailed paleoenvironmental records allowing reconstructions at centennial to decadal time-scale (Fig. 2; [3;4;5]).

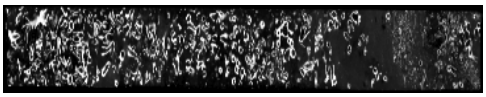

Fig. 2: CT scan image of a coral/sediment core section from the NE Atlantic

This multidisciplinary study combines macro and microfossil geochemistry. We aim to determine the changes in the reservoir age (from coupled U/Th and

^{14}C measurements on *Lophelia* fragments), and to obtain estimates of temperature changes from novel tracers such as Li/Mg (projects: ANR HAMOC, 'Jeune Equipe' (post doc), and PhD funded by NERC, UK).

3: Climate change and marine ecology at the Nile River prodelta

Changes in Holocene climate in the SE Levantine region were investigated by studying foraminifer assemblages and geochemical proxies measured on their tests. According to planktic data, several periods of environmental change are determined (Fig. 3). Those climate phases were mainly controlled by insolation changes, and the consequent ITCZ positioning controlling monsoon intensity and therefore Nile River runoff. After 6.4 ka, ICTZ migrated southward and other climatic systems such as the NAO took control (Project MADHO; MISTRALS PaleoMEX, 2012-2015).

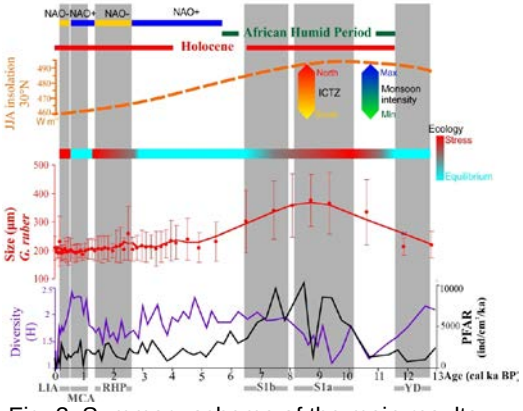

Fig. 3: Summary scheme of the main results of planktic foraminifera from the Nile prodelta.

4: ENSO variability

Past ENSO variability is analysed on records with seasonal resolution obtained in areas particularly sensitive to this climatic system [6]. Following a $\delta^{18}O$ and Ba/Ca calibration study on a bivalve species (fossil giant clam) collected in Papua New Guinea and Indonesia, we have reconstructed changes in ENSO intensity and frequency in response to different climate systems. Our results show that during the early Holocene (9–6 ka) the intensity of ENSO was reduced mainly in response to changes in insolation (project: ANR ElPaso, 2012-2015).

5: The Holocene in the Southern Ocean (SO)

The SO is of particular importance for the understanding of glacial-to-interglacial climate changes, because it constitutes the most effective CO_2 sink over the course of the Quaternary. We are analysing a sediment core from the western slope of the Kerguelen Plateau for changes in the production and burial of foraminifer tests as proxy in paleoclimate (project: SOforCO2, LEFE-CYBER, and PhD thesis J. Meilland, Univ. Angers (2012-2015).

Associated publications

[1] **Garcia J., Mojtahid M.**, **Howa H.,** Michel E., **Schiebel, R.**, Charbonnier C., Anschutz P., **Jorissen F.J.**, 2013. Benthic and planktic foraminifera as indicators of Late Glacial to Holocene paleoclimatic changes in a marginal environment. Acta Protozoologica, 52, 163-182

[2] **Mojtahid M.**, **Jorissen F.J.**, **Garcia J.**, Michel E., **Schiebel R.**, Eynaud F., Gillet H., Cremer M., **Howa H.**, 2013. High resolution Holocene record in the southeastern Bay of Biscay: global versus regional signals. Palaeogeography, Palaeoclimatology, Palaeoecology, 377, 28-44.

[3] **Douarin, M., M Elliot,** et al., 2013. Growth of North-East Atlantic Cold-Water Coral Structures during the Holocene: A High Resolution U-Series and ^{14}C Chronology Earth and Planetary Science Letters, 375, 176-187.

[4] **Douarin, M.,** D.Sinclair, **M Elliot,** et al., 2014. Fossil biodiversity at the Mingulay Reef Complex: a model of coral reef build-up. Deep Sea Research, 99, 286-296.

[5] Eagle, R. A., Eiler, J. M., Tripati, A. K., Ries, J. B., Freitas, P. S., Hiebenthal, C., Wanamaker Jr., A. D., Taviani, M., **Elliot, M.,** et al., 2013. The influence of temperature and seawater carbonate saturation state on ^{13}C–^{18}O bond ordering in bivalve molluscs. Biogeosciences, 10, 4591-4606.

[6] **Elliot, M.,** et al., 2013. Giant clam recorders of ENSO variability. PAGES news, 21: N° 2.