Programme LEFE/EVE	Project Title : Ti Ammo - Theoretical Investigations of the Atlantic Multidecadal to Millenial Oscillations	Années 2010–2013

Intermediate report □ Final report ☒

PI: Thierry Huck, LPO (UMR 6523) Participating Laboratories: LPO, LOCEAN, LSCE, NOCS (Southampton, UK)	Contribution to international projects: *THOR, EPIDOM* Other funding sources

Objectives & main results

The project aimed at deciphering the characteristics of the Atlantic multidecadal variability, separating the anthropogenic signal from the natural part, and understanding the physical mechanisms pacing the North Atlantic climate on decadal to millenial time scales. The original approach was to gather different groups using a hierarchy of models of various complexity and realism, each showing one aspect of the decadal variability in the Atlantic, to allow cross-discussions of its interpretation. This exercise led to 3 potential mechanisms of decadal-scale variability that could well all work together in reality. The project clearly strengthened the interactions between the involved scientists, allowing in-depth discussions of the assets and limits of each approach, and incitating further research in order to validate and test each mechanism.

A 20-yr variability was found pacing the Atlantic Meridional Overturning Circulation (AMOC) in a 1000-yr long control simulation of the IPSL-CM5 coupled model, associated with the propagation of same-sign temperature and salinity anomalies along the subpolar gyre up to the Nordic Seas, where interactions with sea-ice and atmosphere modulate the East Greenland Current and shift the anomaly sign (Escudier et al. 2012). A very similar damped mode was found through a linear stability analysis of the ORCA2° global ocean model, supporting an oceanic mechanism at the origin for this variability (Sévellec and Fedorov 2013a). In more idealized 2.5-layers shallow-water model allowing outcropping, a decadal mode of Gulf Stream variability was shown to be associated with the existence of the front: this low-frequency nonlinear mode propagates westward along the second layer outcrop line, with a velocity differing from Rossby waves and found analytically to to be independant of the beta effect (Sirven et al. 2013).

Historical and initialized IPSL-CM5 simulations have been sucessfully compared to reconstructions, showing a relatively good synchronization linked to the NAO variations and their signature in SST, as well as the triggering of the 20-yr cycle by the Agung volcanic eruption (Swingedouw et al. 2013a).

On millenial time scales, a natural oscillation of thermohaline origin was found in the intermediate complexity UVic climate model, that could be a prototype for the Dansgaard-Oeschger events. Reduced northward oceanic heat transport in the Atlantic basin during glacial times, compared to interglacial periods, seems to be the key to the existence of such instabilities (Arzel et al. 2012).

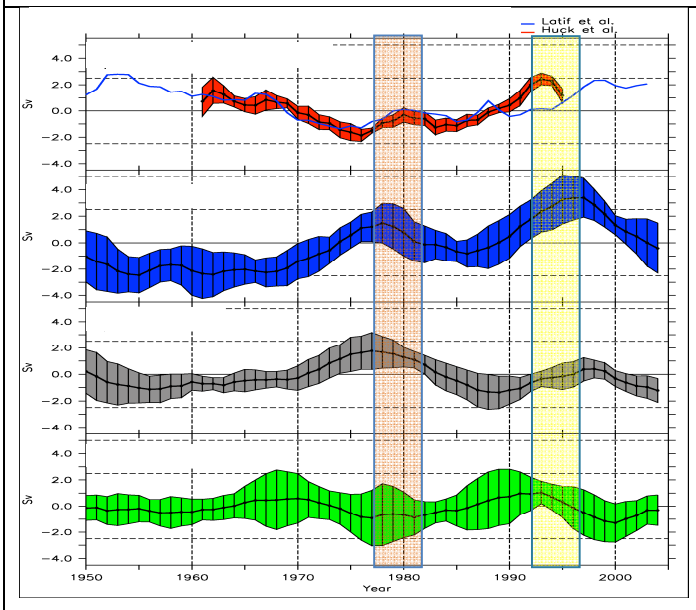

Figure 1: AMOC index at 48°N in a) 2 reconstructions (Huck et al. 2008, Latif et al. 2006), b) IPSL-CM5A model initialized with SST anomalies external forcing, c) historical simulation (external forcing included), d) control simulation. 5 members ensemble mean and error bar (color) are shown.

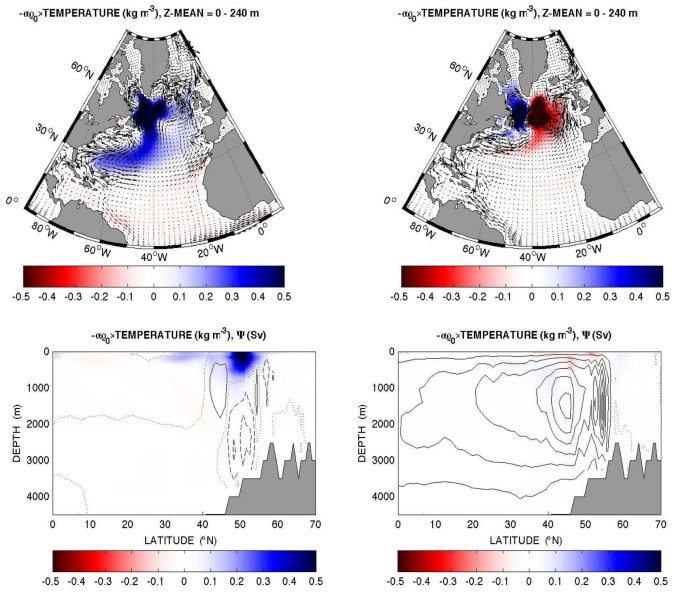

Figure 2: 24-yr oscillation in ORCA2° ocean model: spatial structure of the least-damped mode of the tangent linear model: anomalies of upper-ocean temperature and surface currents (top), meridional overturning and zonally-averaged temperature (bottom), for 2 phases 6 yr apart (left, right).

Main publications

Arzel, O., M. H. England, A. Colin de Verdière, T. Huck, 2012: Abrupt millennial variability and interdecadal-interstadial oscillations in a global coupled model: sensitivity to the background climate state. Clim. Dyn., 39, 259-275, doi: 10.1007/s00382-011-1117-y .

Arzel, O., M. England, 2013: Wind-stress feedback amplification of abrupt millennial-scale climate changes. Clim. Dyn., 40, 983-995, doi: 10.1007/s00382-012-1288-1 .

Escudier R., Mignot J., Swingedouw D., 2013: A 20-yr coupled ocean-sea ice-atmosphere variability mode in the North Atlantic in an AOGCM. Clim. Dyn., 40, (3-4) 619-636, doi:10.1007/s00382-012-1402-4.

Ferjani, D., T. Huck, A. Colin de Verdière, 2013: Influence of bottom topography on large-scale basin modes. J. Mar. Res., submitted.

Ferjani, D., T. Huck, A. Colin de Verdière, 2013: Influence of mean circulation on large-scale decadal basin modes. J. Phys. Oceanogr., submitted.

Herbette, S., A. Hochet, A. Colin de Verdière, T. Huck, 2013: Dynamics of dipolar gyres on the beta-plane. Geophys. Astrophys. Fluid Dyn., submitted.

Mercier, H., P. Lherminier, A. Sarafanov, F. Gaillard, N. Daniault, D. Desbruyères, A. Falina, B. Ferron, T. Huck, V. Thierry, 2013: Variability of the meridional overturning circulation at the Greenland-Portugal OVIDE section from 1993 to 2010. Prog. Oceanog., Special Issue "North Atlantic Subpolar Gyre", submitted.

Sévellec, F., A. V. Fedorov, 2013a: The leading, interdecadal eigenmode of the Atlantic meridional overturning circulation in a realistic ocean model. J. Climate, 26, 2160-2183.

Sévellec, F., A. V. Fedorov, 2013b: Model bias reduction and the limits of oceanic decadal predictability: importance of the deep ocean. J. Climate, in press.

Sirven, J., S. Février, C. Herbaut, 2013: Low frequency variability of the separated western boundary current in response to a seasonal wind stress in a 2.5 layer model with outcropping. J. Mar. Res., in revision.

Sirven, J., Tremblay B., 2013: Analytical study of an isotropic visco-plastic sea-ice model in idealized configurations. J. Phys. Oceanogr., submitted.

Swingedouw D., Mignot J., Labetoule S., Guilyardi E., Madec G., 2013a: Initialisation and predictability of the AMOC over the last 50 years in a climate model. Clim. Dyn., doi: 10.1007/s00382-012-1516-8, in press.

Swingedouw D., Rodehacke C., Behrens E., Menary M., Olsen S., Gao Y., Mikolajewicz U., Mignot J., Biastoch A., 2013b: Decadal fingerprints of fresh water discharge around Greenland in a multi-models ensemble. Clim. Dyn., doi: 10.1007/s00382-012-1479-9, in press.

PhDs

Ferjani, Dhouha, 2013: Variabilité décennale de la circulation océanique et modes de bassin : Influence de la topographie et de la circulation moyenne. Thèse de doctorat (PhD thesis manuscript), Université de Bretagne Occidentale, Brest, France. Funding: French Ministry for Research, 11/2009-05/2013, supervisors A. Colin de Verdière & T. Huck, LPO.