Geophysical Research Abstracts
Vol. 17, EGU2015-1910, 2015
EGU General Assembly 2015

A regime shift in the subpolar gyre strength due to a sudden transition in the North Atlantic climate during the Little Ice Age

Eduardo Moreno-Chamarro (1,2), Davide Zanchettin (1), Katja Lohmann (1), and Johann Jungclaus (1)

(1) Max Planck Institute for Meteorology, Ocean in the Earth System, Hamburg, Germany (eduardo.chamarro@mpimet.mpg.de), (2) International Max Planck Research School on Earth System Modelling, Hamburg, Germany

Recent paleoceanographic reconstructions of the subpolar North Atlantic variability during the last millennium describe oceanic conditions associated with a weaker subpolar gyre during the Little Ice Age (∼1400-1700) after a relatively strong phase during the Medieval Climate Anomaly (∼950-1250). However, mechanism(s) behind such a relatively rapid shift remains unclear. Here, we investigate the dynamics of the subpolar gyre and its role on driving the exchanges of heat and freshwater between the northern North Atlantic and the Arctic Ocean over the last millennium in an ensemble of three transient and an unperturbed-climate simulation performed with the Max Planck Institute-Earth system model for paleo-applications. In particular, we focus on the dynamics underlying a decadal-scale transition in the subpolar gyre from an initial strong to a later weak state, which is found in one of the last-millennium transient simulations and shows characteristic features similar to the reconstructed event.

Our results indicate that the simulated shift is triggered by a rapid increase in the sea-ice transport from the Arctic toward the subpolar North Atlantic, which causes a broad freshening of the Labrador Sea surface and, thereby, a shut-down in deep oceanic mixing. As a result, the subpolar gyre weakens. This in turn activates a series of long-lasting feedbacks relating oceanic and atmospheric circulation, sea-ice extent, and oceanic deep convection in the Labrador Sea that keep the North Atlantic in an anomalous state for about 250 years. A reorganization of the North Atlantic/Arctic ocean-atmosphere coupled system, sustained by internal feedbacks acting on multicentennial time scales, can therefore result in a new subpolar gyre state.

The simulated shift coincides in time with a two-decade-long cluster of relatively small volcanic eruptions which leads to prominent thickening of the Arctic ice cap previous to the shift. Sensitivity experiments will be performed to further investigate the role of the external forcing and of the background state on this climate shift. Preliminary results from an experiment initialized before the climate transition and excluding the volcanic cluster do not show such a rapid change in the subpolar gyre strength and, more generally, in the climate of the North Atlantic/Arctic region. Relatively small but very close volcanic eruptions can thus exert a cooling influence on the North Atlantic/Arctic climate similar to that found for much stronger but indeed rarer eruptions.