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Simulated evolution of the Atlantic meridional overturning circulation in the last millennium and two IPCC scenarios. Modes of variability and forced response.

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A number of climate simulations with the ECHO-G model, including two forced integrations of the last millennium, one millennial-long control run and two future scenario simulations of the 21st century are employed to analyse the variability of the Atlantic Meridional Overturning Circulation (AMOC). This constitutes a new framework in which the AMOC response to future climate change conditions is addressed in the context of both its past evolution and its unforced scales of variability. The forced runs evidence a weakening of the MOI beginning in the industrial era that deepens in intensity in the future scenario simulations, accounting for a final decrease of up to 40 % with respect to the mean preindustrial value.

Two different mechanisms are found operating at interannual and longer timescales, both involving atmospheric forcing. In the high-frequency (periods < 10 yr), the AMOC is directly responding to local changes in the Ekman transport, that is linked to various wind regimes at different latitudes, some of them specifically related to ENSO and NAO variability. In the low frequency (periods from 11 to 400 yr) the AMOC is characterized by a propagating mode in which maximum overturning events are preceded by the irruption of positive density anomalies in the sinking regions south of Greenland, that act to enhance the deep water formation in the Irminger Sea. These changes in convection tend to occur during positive NAO phases, and seem to be ultimately forced by strong zonal wind-stress and increased evaporation.

In addition, the different aspects of the externally forced variability are investigated, with emphasis on the AMOC response to both the volcanic and the greenhouse gas forcing. In the ECHO-g simulations, the AMOC exhibits no significant response to solar variability.