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Variability of the Atlantic meridional overturning circulation in the last millennium and two IPCC scenarios

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The variability of the Atlantic meridional overturning circulation (AMOC) is investigated in several climate simulations with the ECHO-G atmosphere-ocean general circulation model (AOGCM), including two forced integrations of the last millennium, one millennial-long control run, and two future scenario simulations of the 21^{st} century. 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 natural variability. The main mechanisms responsible for the AMOC variability at interannual and multidecadal time scales are described. At interannual timescales the AMOC is directly responding to local changes in the Ekman transport, associated to three different teleconnection indices: El Niño-Southern Oscillation (ENSO), the North Atlantic Oscillation (NAO), and the East Atlantic (EA) pattern. At multidecadal timescales the AMOC is largely controlled by convection activity south of Greenland. Again, the atmosphere is found to play a leading role on these variations. Positive anomalies of convection are preceded in 1 year by intensified zonal winds, associated in the forced runs to a positive NAO-like pattern.
Finally, the sensitivity of the AMOC to three different forcing factors is investigated. The major impact is associated to increasing greenhouse gases (GHG), given their strong and persistent radiative forcing. Starting in the Industrial Era and continuing in the future scenarios, the AMOC experiences a final decrease of up to 40% with respect to the preindustrial average, well below the range of natural AMOC variability simulated for the past millennium and the control simulation. This final weakening is associated with a reduced meridional density gradient and with decreased convection in the North Atlantic, both mainly responding to changes in the atmospheric water transport. Also, a weak but significant AMOC strengthening is found in response to the major volcanic eruptions, which produce colder and saltier surface conditions over the main convection regions. In contrast, no meaningful impact of the solar forcing on the AMOC is observed. Indeed, solar irradiance only affects convection in the Nordic Seas, with a marginal contribution to the AMOC variability in the ECHO-G runs.