Geophysical Research Abstracts
Vol. 18, EGU2016-2083, 2016
EGU General Assembly 2016

Simulated Atlantic Meridional Overturning Circulation in the 20$^{\mathrm{th}}$ century with an ocean model forced by reanalysis-based atmospheric data sets

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Global ocean hindcast simulations for the period 1871–2009 have been run with the ocean-sea ice component of the Norwegian Earth System Model (NorESM-O), forced by an adjusted version of the Twentieth Century Reanalysis version 2 data set (20CRv2 data set), as well as by the commonly used second version of atmospheric forcing data set for the Coordinated Ocean-ice Reference Experiments phase-II (CORE-II) for the period 1948–2007 (hereafter CORE.v2 data set). The simulated Atlantic Meridional Overturning Circulation (AMOC) in the 20CR and the CORE simulations have comparable variability as well as mean strength during the last three decades of the integration. The simulated AMOC undergoes, however, distinctly different evolutions during the period 1948–1970, with a sharply declining strength in CORE but a gradual increase in 20CR. Sensitivity experiments suggest that differences in the wind forcing between CORE and 20CR have major impact on the simulated AMOCs during this period. It is furthermore found that differences in the air temperature between the two data sets do contribute to the differences in AMOC, but to a much lesser degree than the wind. An additional factor for the diverging AMOC in the two decades following 1948 is the inevitable switching of atmospheric forcing fields in 1948 in the CORE.v2-based runs due to the cyclic spin-up procedure of the ocean model. The latter is a fundamental issue for any ocean hindcast simulation. The ocean initial state mainly influence the actual value but to a lesser degree also the temporal evolution (variability) of AMOC. It may take about two decades for the AMOC to adjust to a new atmospheric state during the spin-up, although a dynamically balanced ocean initial state tends to reduce the adjustment time and the magnitude of the deviation, implying that an ocean model run with atmospheric forcing fields extending back in time, like 20CRv2, can be used to extend the reliable duration of CORE-type of simulations.