Geophysical Research Abstracts
Vol. 16, EGU2014-13060, 2014
EGU General Assembly 2014

A perfect-model analysis of the processes behind AMOC initialization in IPSL-CM5A-LR

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We use a perfect model framework to explore how the IPSL-CM5A-LR climate model initialises a series of AMOC peaks (two maxima and minima) from a previous control run. To this end, we impose a nudging in sea surface temperature and salinity over the sea-ice free regions. Two sets of nudged simulations are launched starting respectively 15 and 25 years before the first AMOC maximum, to compare the performance of the different initialization times. In each of the sets three different starting conditions are considered, corresponding to strong, weak and intermediate AMOC states. Understanding the maximum time required to achieve a proper AMOC initialization, as well as the sensitivity to the particular starting conditions is crucial for designing decadal prediction strategies.

The second AMOC peak is well reproduced by the two ensembles, both in terms of timing and magnitude. This is due to the correct initialization of the North Atlantic convection, which is a key driver of the bi-decadal AMOC variability in the IPSL model. However, a rather different picture arises for the first AMOC peak. While nudged simulations beginning only 15 years before are unable to capture it, those starting 25 years before do represent the increase but underestimate its magnitude. In all cases, North Atlantic convection is correctly initialized, which suggests that other important processes, not adequately represented in the nudged runs, are behind the development of this AMOC peak. A main candidate, requiring a good initialization of subsurface density profiles, is the westward propagation across the basin of thermal Rossby waves, already found to excite an interdecadal AMOC damped oscillation with the ocean component of the IPSL model. In a final step, we explore the role of this particular mechanism to explain the occurrence of the first AMOC peak, and therefore its misrepresentation in the nudged runs.