Geophysical Research Abstracts
Vol. 19, EGU2017-8581-1, 2017
EGU General Assembly 2017

Mechanisms of decadal variability in the Labrador Sea and the wider North Atlantic in a high-resolution climate model

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A necessary step before assessing the performance of decadal predictions is the evaluation of the processes that bring memory to the climate system, both in climate models and observations. These mechanisms are particularly relevant in the North Atlantic, where the ocean circulation, related to both the Subpolar Gyre and the Meridional Overturning Circulation (AMOC), is thought to be important for driving significant heat content anomalies. Recently, a rapid decline in observed densities in the deep Labrador Sea has pointed to an ongoing slowdown of the AMOC strength taking place since the mid 90s, a decline also hinted by in-situ observations from the RAPID array. This study explores the use of Labrador Sea densities as a precursor of the ocean circulation changes, by analysing a 300-year long simulation with the state-of-the-art coupled model HadGEM3-GC2. The major drivers of Labrador density variability are investigated, and are characterised by three major contributions. First, the integrated effect of local surface heat fluxes, mainly driven by year-to-year changes in the North Atlantic Oscillation, which accounts for 62% of the total variance. Additionally, two multidecadal-to-centennial contributions from the Arctic are quantified; the first associated with freshwater exports via the East Greenland Current, and the second with changes in the Denmark Strait Overflow. Finally, evidence is shown that decadal trends in Labrador Sea densities are followed by important atmospheric impacts. In particular, a delayed winter NAO response appears to be at play, providing a phase reversal mechanism for the Labrador Sea density changes.