EGU22-12573
https://doi.org/10.5194/egusphere-egu22-12573
EGU General Assembly 2022

Exploring the North Atlantic response to anthropogenic aerosols through idealised single-forcing experiments in a model at two different resolutions

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Anthropogenic aerosols have been implicated as an important driver of North Atlantic variability. However, the exact mechanism of how aerosol affect the North Atlantic is not well understood and questions remain about the relative importance of aerosols compared to other forcings or internal variability. Therefore, to better understand how aerosols can drive the North Atlantic, we performed idealised experiments using a state-of-the-art coupled climate model (HadGEM3-GC3.1) by applying varying levels of North American and European anthropogenic sulphate aerosol emissions. Medium and (0.25° ocean, ~60km atmosphere) and low-resolution (1° , ~135km) versions of the model were used to assess how model differences may impact on the forced response. We show that the aerosol increases initially cool the North Atlantic SST by a combination of decreased surface shortwave radiation and increased turbulent heat loss. This surface cooling induces surface density anomalies and strengthening of the Atlantic Meridional Overturning Circulation (AMOC), leading to a lagged warming of the Subpolar North Atlantic. However, the AMOC response and subsequent warming is much stronger in the medium-resolution model, despite an overall stronger radiative forcing in the low-resolution model. We show evidence that this AMOC difference is consistent with differences in the sea ice response in a key region of the Subpolar North Atlantic. These results indicate that while surface temperature, sea ice and the AMOC are all sensitive to aerosol forcing in the HadGEM3-GC3.1 models, small regional differences between the model climatologies can significantly alter the pattern and magnitude of the large-scale response.