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The response of the winter NAO to CO2, SST and sea ice changes

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The North Atlantic Oscillation (NAO) is the dominant winter mode of atmospheric circulation variability in the North Atlantic and European (NAE) region. It is therefore important to understand how the NAO may change in future in response to climate change. To examine changes in NAE region circulation, the control run of the Met Office Hadley Centre coupled climate model HadGEM1 is compared to climate change runs in which CO2 levels are fixed at twice or four times preindustrial levels. The model shows a clear response to CO2 forcing, but this response does not project onto the NAO. Instead, reduced sea level pressure is seen over the Arctic, related to sea ice melting and an associated strong warming here. Warming is seen at low levels in the Arctic (acting to reduce the pole-equator temperature gradient) and in the tropical upper troposphere (acting to strengthen the pole-equator temperature gradient). Zonal mean zonal wind change is consistent with this, with westerly anomalies in the upper troposphere around 30N and easterly anomalies closer to the surface at around 50N.

Motivated by the coupled model results, four runs are produced with the atmosphere-only version of the coupled model. The runs are forced with sea surface temperature (SST) and sea ice model fields taken from the control and 4xCO2 coupled model runs. One pair of runs has a 4xCO2 climate (with 4xCO2 run SSTs and CO2 levels) and the other pair of runs has a control climate (with control run SSTs and CO2 levels). Each pair of runs consists of one run forced with control run sea ice and one run forced with 4xCO2 run sea ice. The atmosphere model is found to be capable of reproducing the differences shown in the coupled model. Analysis of differences between the runs allow the changes due to sea ice and SSTs/CO2 levels to be examined separately. Results suggest that the upper level westerly zonal wind anomalies are due to the

changes in CO_2 and SSTs, while the sea ice change is largely responsible for the lower level easterly zonal wind anomalies.