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Thesis abstract

Interhemispheric asymmetry of global warming: the role of ocean dynamics

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Global surface air temperature is increasing due to rising greenhouse gases. This warming has occurred at a faster rate in the Northern Hemisphere (NH) than the Southern Hemisphere (SH) and the asymmetry of warming between hemispheres is predicted to continue throughout the 21st Century. Several factors contribute to this interhemispheric asymmetry, including the greater proportion of land in the NH and the northward transport of heat by the ocean. This thesis focuses on the role of ocean dynamics in setting the warming asymmetry, using several modelling approaches.

First, the impact of the Antarctic Circumpolar Current (ACC) on the interhemispheric warming asymmetry is investigated. The role of the ACC is isolated by comparing warming experiments in a global coupled climate model with and without a land barrier across Drake Passage (DP). With DP closed, the asymmetry in sea surface temperature (SST) warming is reduced, due to the presence of a subpolar gyre, and a lower Antarctic sea ice extent.

Second, the asymmetry of warming is examined when moving from coarse (1°) to eddy-permitting (0.25°) ocean resolution. We use an idealised coupled model with a 60° sector ocean domain, comprising one basin with Atlantic-like bathymetry and an ACC channel. A larger high latitude SST asymmetry develops in the 0.25° model than the 1° model, both in control runs and in warming scenarios. The larger warming asymmetry in the 0.25° model is caused by stronger boundary current heat transport and reduced NH sea ice. The SH warming is less sensitive to the resolution change, since eddy heat transport differences between the models are small compared with mean flow heat transport differences. When SH westerly winds are enhanced, the warming asymmetry increases, with greater upwelling of cool water in the Southern Ocean and greater warming in the NH.

Finally the impact of realistic bathymetry is explored in the sector climate model. The Atlantic-like sector model is compared with a flat bottom rectangular model in similar experiments. The Atlantic and rectangular models have similar control climates, however the rectangular models have a stronger subpolar gyre in the NH in the absence of bathymetry. In warming experiments, the rectangular models develop warming and cooling regions in the NH, while the Atlantic models have no significant cooling regions. The Atlantic models exhibit greater sensitivity of ACC transport to wind forcing.

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