

The Once and Future Battles between Thor and the Midgard Serpent: The Southern Hemisphere Westerlies and the Antarctic Circumpolar Current

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Global climate model simulations of the interactions between the Southern Hemisphere Westerlies and the Antarctic Circumpolar Current detail the role of the Southern Ocean in partitioning carbon between the ocean and atmosphere. The coupling of climate, Westerly Wind position and the overturning of deep water in the Southern Ocean explains some of the more puzzling features of glacial-interglacial CO₂ cycles, including the tight correlation between atmospheric CO₂ and Antarctic temperatures, the lead of Antarctic temperatures over CO₂ at terminations and the shift of the ocean's $\delta^{13}\text{C}$ minimum from the North Pacific to the Southern Ocean. Cold glacial climates seem to have equatorward-shifted westerlies which allow more respired CO₂ to accumulate in the deep ocean. Warm climates like the present have poleward-shifted westerlies that flush respired CO₂ out of the deep ocean.

In global warming simulations of future climate, poleward-intensified westerlies maintain a robust deep water overturn around Antarctica even as rising atmospheric greenhouse gas levels induce warming that reduces the density of surface waters in the Southern Ocean. These results imply that the future poleward-intensification of the Southern Hemisphere Westerlies may prop open the Southern Ocean door to the deep ocean, allowing the ocean to remove relatively more heat and anthropogenic carbon dioxide from the atmosphere.