

The Once and Future Battles of Thor and the Midgard Serpent: The Antarctic Circumpolar Current and Glacial/Interglacial Climate*

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*Abstract from 2011-2012 AAPG Foundation Distinguished Lecture presentation.

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The vast Southern Ocean region surrounding the Antarctic continent is the only place in the global ocean where water upwells from more than two kilometers to the surface before sinking again. The deep of the Southern Ocean holds the key to the rate of warming of our atmosphere, because enormous amounts of heat and carbon can be stored in this ocean reservoir. In paleoclimate model simulations, wind position and the overturning of deep water in the Southern Ocean explain some of the more puzzling features of glacial-interglacial carbon dioxide cycles, including the tight correlation between atmospheric carbon dioxide and Antarctic temperatures, the lead of Antarctic temperatures over carbon dioxide 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 carbon to accumulate in the deep ocean. Warm climates like the present have poleward-shifted westerlies that flush respired carbon dioxide 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 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, slowing the rate of warming of the atmosphere.