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Atmospheric Teleconnections of Northern Hemisphere cooling to the Southern Hemisphere midlatitudes, and implications for Southern Ocean ventilation

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Recent marine proxy studies, most notably by Anderson et al. (2009), show intensification of wind-driven upwelling in the Southern Ocean during Heinrich events, and suggesting the possibility of robust atmospheric teleconnections from the Northern Hemisphere affecting the Southern Hemisphere midlatitude westerlies. We explore the latter hypothesis using simulations of an AGCM coupled to a reduced-gravity ocean, and with reference to current thinking regarding extratropical-tropical atmospheric dynamical linkages. When we simulate a Heinrich-like event in our model (by cooling the North Atlantic), we find a significant strengthening of the southern midlatitude westerlies, in particular during the austral winter (JJA), and in the South Pacific. The other pronounced climate change is a marked southward shift of the tropical rainbelt, indicating alteration of the Hadley circulation. Our analysis indicates that the teleconnection can be broken into two parts: first, the northern hemisphere cooling shifting the ITCZ southwards with a pronounced effect on the Hadley circulation (Lindzen and Hou 1988), and then the altered Hadley circulation in turn affecting the southern midlatitude westerlies through the former's control of the southern subtropical westerlies and subsequent effect on the eddy-driven midlatitude westerlies (Lee and Kim, 2003). The seasonal (JJA) and regional (South Pacific) preference of the teleconnection's effects can be explained in terms of the peculiarities of the regional atmospheric dynamics. As an aside, we also find that the growth or decay of the Laurentide ice sheet can also generate this type of north-south teleconnection, although the dynamics are somewhat different.

With regards to possible implications for southern ocean ventilation and atmospheric CO2: we applied the wind changes we obtained in our AGCM 'Heinrich' simulation to a global biogeochemical model (the Minnesota Earth System Model for Ocean biogeochemistry), and found a $\sim$20ppm increase to the equilibrated atmospheric CO2 concentrations; the increase is substantially higher ($\sim$60ppm) if feedbacks from biology are turned off in the model. In short, we find the scenario as hypothesized by Anderson et al. (2009) to be quite plausible. Our study elucidates and emphasizes the central role of atmospheric teleconnections in the story, in particular the importance of tropical circulation mediating the intimate coupling between the northern and southern high-latitude climate through atmospheric circulation. More broadly, it underscores the control that the northern hemisphere has on southern midlatitude winds, in contrast to past paleoclimate suggestions that the magnitude and/or position of the southern midlatitudes was controlled by global temperatures.

References:
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