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Simulated inter-hemispheric phasing for an abrupt Northern Hemisphere warming

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Recent high-resolution paleoproxies suggest that the abrupt Greenland warming seen in Dansgaard–Oeschger (DO) events was followed about 200 years later by a shift from warming to cooling in the Antarctic temperatures.

Here, we investigate the dynamics of DO-like events using a coupled ocean-atmosphere-sea ice general circulation model with idealized geometry. Rather than exploring the potential forcings of DO event, our focus is specifically on the processes controlling the Southern Hemisphere (SH) response to an abrupt warming event in the Northern hemisphere (NH). Starting from a cold, glacial-like state, an abrupt NH warming is forced via an eccentricity-related incoming solar radiation perturbation lasting 100 years. In connection with a reduction of the northward cross-equatorial ocean heat transport (COHT), a robust multi-decadal/centennial phasing between the two hemispheres, similar to the reconstructed one, emerges in the model.

The reduced COHT is mainly due to a weakening of the subtropical cell (STC) in both the Atlantic-like and Pacific-like basins, itself forced by a northward shift of the Intertropical Convergence Zone and associated weakening of the NH trade winds. Although the meridional overturning circulation (MOC) also weakens (due to sea ice melt and freshening of the ocean surface), its contribution to the decreased COHT is secondary. In the SH, the reduced northward COHT drives an anomalous subsurface accumulation of heat that extends into the mid-latitudes. There, it gets released, causing ocean and atmosphere surface warming and sea ice retreat. This heat release continues even after switching off the NH forcing, prolonging the high-latitude SH warming beyond that seen in the NH.

Factors influencing the phasing timescale will be discussed, including the impact of the length and meridional distribution of the applied forcing. Our results highlight the potential role of global coupled ocean-atmosphere processes, rather than the often-invoked Atlantic MOC, in controlling inter-hemispheric connections.