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Beyond the bipolar seesaw: toward a process understanding of interhemispheric coupling

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The thermal bipolar ocean seesaw hypothesis was advanced by Stocker and Johnsen (2003) as the 'simplest possible thermodynamic model' to explain the time relationship between Dansgaard–Oeschger (DO) and Antarctic Isotope Maxima (AIM) events. Here, we combine palaeoclimate observations, theory and general circulation model experiments to advance from the conceptual model toward a process understanding of interhemispheric coupling and the forcing of AIM events. We present four main results: (1) Changes in Atlantic heat transport invoked by the thermal seesaw are partially compensated by opposing changes in heat transport by the global atmosphere and Pacific Ocean. This compensation is an integral part of interhemispheric coupling, with a major influence on the global pattern of climate anomalies. (2) A change in cross-equatorial heat advection is commonly assumed to explain Atlantic Ocean temperature anomalies in the thermal seesaw. We suggest that wind driven deepening of the South Atlantic thermocline contributes, in addition to the change in advection, to explain the speed and spatial pattern of the temperature changes in the South Atlantic and the storage of heat at depth. (3) We support the role of a heat reservoir in interhemispheric coupling but argue that its location is the global interior ocean north of the Antarctic Circumpolar Current (ACC), not the commonly assumed Southern Ocean. (4) Energy budget analysis indicates that the process driving Antarctic warming during AIM events is an increase in poleward atmospheric heat and moisture transport following sea-ice retreat and surface warming over the Southern Ocean. Sea-ice retreat is itself driven by eddy-heat fluxes from the global ocean heat reservoir across the ACC, amplified by sea-ice–albedo feedbacks. Our results underline the coupled role of the ocean and atmosphere in signal propagation linking DO and AIM events.

Reference:

Stocker, T. F., & Johnsen, S. J. 2003. A minimum thermodynamic model for the bipolar seesaw. Paleoceanography, 18, 11–1.