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Distinct tropical climate response to subpolar energy perturbations from the Northern or Southern Hemisphere

The energetics framework predicts how climatic asymmetry develops in response to interhemispheric differences in energy flux into the coupled ocean-atmosphere system. Indeed, the late 20th century anthropogenic aerosol emissions, mostly concentrated in the Northern Hemisphere (NH), forced an interhemispheric Hadley circulation that displaces the Inter-Tropical Convergence Zone (ITCZ) southward. Confusions arise, however, from recent climate model experiments that utilize realistic dynamical oceans, in which radiative perturbations over the Southern Ocean fail to significantly displace the ITCZ. Using a hierarchy of coupled models, here we demonstrate a previously unrecognized sensitivity that the tropical response is intrinsically distinct depending on whether the subpolar energy perturbation comes from the NH or Southern Hemisphere (SH). In response to a NH subpolar radiative cooling, the surface temperature response is blocked by the northward-displaced mean ITCZ and hence is strongly asymmetric about the equator. The SH subpolar radiative cooling, in contrast, is strongly damped by heat uptake due to the mean upwelling in the Southern Ocean. The resultant surface cooling penetrates across the equator, leading to a weak cross-equatorial gradient and little ITCZ shift. These results have important implications for projecting future changes in the tropical hydrological cycle as well as for interpreting tropical paleoclimate data.

Sarah Kang from the Ulsan National Institute of Science and Technology, Korea is guest of Bjorn Stevens (MPI-M).

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