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Polar amplification as a preferred response in an idealized aquaplanet GCM

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An aquaplanet atmospheric general circulation model (GCM) coupled to a mixed layer ocean is analyzed in terms of its polar amplified surface temperature response to a 2xCO2-like forcing and in terms of the phase space trajectory of the relaxation of a free perturbation to equilibrium. In earlier studies concerned with linear stability of the same system we have shown that the least stable mode of the linearized surface budget operator has a polar amplified shape. We demonstrate that this shape of the least stable mode is responsible for the polar amplified shape of the response to a uniform forcing and for the manner in which the system relaxes back to equilibrium. Based on GCM and simple energy balance model results it is argued that the decay timescale of this mode is determined by the sensitivity of the net top-of-the-atmosphere radiation to surface temperature while its shape (and thus the degree of polar amplification in a climate change experiment) is determined by the sensitivity of poleward heat transport to low- and high-latitude temperatures by the faster timescale atmospheric dynamics. This implies that the underlying mechanisms for the polar amplification may be obscured when studying feedbacks during the slow evolution of climate change or considering only the new equilibrium state after introduction of a steady forcing.

Reference:

Langen P.L. and V.A. Alexeev, Polar amplification as a preferred response in an idealized aquaplanet GCM, Climate Dynamics, in press.