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Connections between climate sensitivity and the extratropical circulation

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The dry dynamical core represents one of the simplest possible numerical models for studying the response of the extratropical circulation to climate change. In the model, the circulation is forced by relaxing temperature to a notional "equilibrium" using linear damping. The linear damping coefficient plays an essential role in governing the structure of the circulation. But despite decades of research with the dry dynamical core, the role of the damping coefficient in governing the circulation has received relatively little scrutiny.

In this work, we systematically vary the damping coefficient in a dry dynamical core in order to understand how the amplitude of the damping influences extratropical dynamics. Critically, we prove that the local climate feedback parameter is proportional to the damping coefficient – that is, the damping timescale is a measure of climate sensitivity for the dry atmosphere. The key finding is that the steady-state extratropical circulation responds to changes in this climate sensitivity.

Longer damping timescales (i.e. higher climate sensitivities) lead to a less dynamically active extratropical circulation, stronger and more persistent annular modes, and equatorward shifts in the jet. When perturbed with climate change-like forcings, changing the damping timescale can also change the dynamical response to the forcing. We argue that understanding the response of the circulation to climate change is critically dependent on understanding its climate sensitivity, and consider how climate sensitivity might be inferred from its effect on the circulation in the dry model and more complex general circulation models.