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One the role of dry processes for climate model biases and possible emergent constraints

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Common model deficiencies in representing the large-scale circulation include an equatorward bias in the location of the midlatitude westerlies and an overly zonal orientation of the North Atlantic storm track. Orography is known to strongly affect the atmospheric circulation and is notoriously difficult to represent in coarse-resolution climate models. Here we show that the effects of switching off the parameterization of drag from low-level orographic blocking in one climate model resemble the biases of the Coupled Model Intercomparison Project Phase 5 ensemble: An overly zonal wintertime North Atlantic storm track and less European blocking events, and an equatorward shift in the Southern Hemispheric jet and increase in the Southern Annular Mode time scale.
Experiments with a dry model with and without topography confirm that in the presence of topography, increased localized drag can shift the jet polewards.

This suggests that typical circulation biases in coarse-resolution climate models may be alleviated by improved parameterizations of low-level drag.

Simple models suggest that inter-model differences in the response to forcing, such as the jet shift in a warming climate, may be related to differences in present-day variability. If such a relationship holds in complex models and can be used as an emergent constraint remains unclear.

Here, we show that including topography and a more realistic surface drag in a dry model substantially changes its variability and response to forcing. No universal relationship between annular mode timescale and forced response is found.

In a high-top model, adding a stratospheric polar vortex in winter allows to reproduce a relationship between control climate jet latitude and jet shift found in complex climate models. Control climate jet latitude and the latitudes of maximum wind speed changes in CMIP models are strongly correlated in Southern Hemisphere summer, but hardly so in Southern Hemisphere winter. Our results suggest that the presence of the stratospheric polar vortex in winter acts to fix the latitudes of maximum windspeed changes independently from variations in the control climate jet latitude.