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The Circulation Response to Volcanic Eruptions

Proxy data suggests that large tropical volcanic eruptions induce a poleward shift of the North Atlantic jet stream in boreal winter. This warms Europe in the winters following an eruption, despite the global cooling impact of volcanic aerosols. There is far from universal agreement on this effect in model integrations, however, and its mechanism, and the possibilities of a corresponding jet shift in the Southern Hemisphere or in the summer season have received little attention.

Using a hierarchy of simplified atmospheric models, I will explore the impact of stratospheric aerosols on the extratropical circulation. In particular, the models allow the separation of the dominant shortwave (surface cooling) and longwave (stratospheric warming) impacts of volcanic aerosol. It is found that stratospheric warming associated with the long wave effect shifts the jet poleward in both the summer and winter hemispheres. The circulation response to stratospheric warming provides a test of our ability to isolate dynamical mechanisms, as opposed to merely describing them. We find that the response to stratospheric warming is fairly generic, in that it does not depend critically on the boundary conditions (e.g., the planetary wave forcing) or atmospheric physics (e.g., the treatment of radiative transfer and moist processes). It does, however, fundamentally involve both zonal-mean and eddy circulation feedbacks. The time scales, seasonality, and structure of the response provide further insight into the mechanism, as well as its connection to modes of intrinsic natural variability.