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Understanding the circulation response to major eruptions: The importance of stratospheric warming

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Observations suggest that major volcanic eruptions induce a poleward shift of the extratropical jet, associated with warmer winters in parts of Northern Eurasia and North America. However, studies of this phenomenon with comprehensive models have not led to a strong consensus, particularly as to any effect in the Southern Hemisphere. Furthermore, the mechanism by which volcanic aerosols in the tropical stratosphere may modify the tropospheric jets is not yet clear.

This study examines the impact of Pinatubo-like shortwave and longwave forcings in a hierarchy of atmospheric general circulation models. Volcanic aerosols scatter incoming short radiation, thereby cooling the surface, but also cause an in situ warming of the stratosphere, primarily due to long wave absorption. We find that surface darkening alone has little effect on the circulation, while stratospheric warming alone decisively shifts the extratropical jet poleward in both summer and winter hemispheres. Further study with more simplified models demonstrates that the response to stratospheric warming does not hinge on planetary or gravity waves, nor moist or radiative processes, but it does involve both zonal mean and eddy circulation feedbacks. The timescales, seasonality, and structure of the various responses provide insight into the mechanism. These findings have implications for interpretation of comprehensive multimodel studies.