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Observed connections of Arctic ozone extremes to Northern Hemisphere Climate

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Arctic ozone loses are much weaker and more variable than in the Antarctic due to enhanced planetary wave driving in the Northern Hemisphere. In dynamically quiescent winters, Arctic ozone abundances can be quite low, attributable to both weakened transport and chemical depletion. In dynamically active winters, Arctic ozone abundances can reach values similar to those of the pre-ozone depletion era. This extreme interannual variability in Arctic spring ozone has made it difficult to detect trends and in discerning possible climate impacts.

A recent study by Smith and Polvani (2014) probed whether Arctic ozone extremes could affect Northern Hemispheric climate in time-slice experiments with an atmospheric global climate model and prescribed ozone forcings. Smith and Polvani (2014) found a colder and stronger polar vortex in the simulations with low ozone anomalies. However to detect a robust tropospheric response, they had to impose an ozone forcing larger than has been observed historically. A following study by Calvo et al (2014) using an ensemble of simulations with a coupled chemistry dynamics climate model showed a robust coupled stratospheric/tropospheric response with observed historical ozone depleting substances. The simulations with low spring ozone anomalies relative to high ozone anomalies showed a poleward shift of zonal winds over the North Atlantic and precipitation, a positive phase of the North Atlantic Oscillation, and a response in surface temperatures in April and May.

In this work, we examine the observational record for evidence of the role of Arctic extreme ozone anomalies on the Arctic stratospheric and Northern Hemisphere tropospheric climates. Comparison of our results to previous modeling studies helps illuminate where models are useful in understanding stratospheric/tropospheric coupling and areas of further research. Lastly, we evaluate the potential for Arctic spring ozone in predictability for late spring Northern Hemispheric climate.