The Effect of Stratospheric Water Vapor in Large Volcanic Eruptions on Climate and Atmospheric Composition

Parker Case[1], Allegra N. LeGrande[2, 3], Kostas Tsigaridis[2, 3]

1: Columbia College, Columbia University, New York, New York, USA
2: NASA Goddard Institute for Space Studies, Columbia University, New York, New York, USA
3: Center for Climate Systems Research, Columbia University, New York, New York, USA

Large, explosive volcanic eruptions that inject material into the stratosphere have a significant impact on atmospheric composition and climate. Understanding and generalizing these effects is crucial to the development of climate models. Previously, volcanic forcing was crudely parameterized in all climate models which may be a source of large error in past-climate simulations. Here we investigate how water vapor, in addition to sulfur dioxide, from volcanic eruptions affect atmospheric chemistry and climate using NASA's atmospheric general circulation model GISS Model-E2. Three simulations were considered: a control run with no eruption, a run with a summertime dry eruption of 18 Tg of SO_2, and a run with a summertime eruption containing 150 MT of water vapor in addition to 18 Tg of SO_2.These amounts roughly approximate the mass of water and SO_2 injected during the 1991 Mt. Pinatubo eruption. They were also injected at the same geographic location, directly into 10-layers of the lower to mid stratosphere. Each simulation was set in a pre-industrial atmosphere and monthly averages from the control were subtracted from the data in order to avoid signals from anthropogenic and meteorological effects, respectively. Comparing the dry and wet eruptions, there is a quicker forming but shorter lived sulfate aerosol population from the eruption containing water vapor. It was also observed that the aerosols spread more evenly between the Northern and Southern hemispheres when water was added to the eruption, compared to the dry eruption which was mostly contained in the Northern hemisphere. These differences more rapidly increase sulfate aerosol optical depth and cause a climatic effect of a quicker, shorter-lived decrease in surface temperatures and increase in stratospheric temperatures. The quicker signal from the wet eruption matches observations more closely than that of the dry eruption. This understanding will help in generalizing the climatic effects of volcanoes and reduce the error introduced in historical climate model simulations−leading to a better understanding of our changing climate system.