Modeling the stratospheric aerosol with a chemistry climate model: the example of Mt. Pinatubo

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The eruption of Mt. Pinatubo, in the Philippines, represents the largest eruption of the 20th century. Mt. Pinatubo erupted on 15 June 1991, injecting between 17 Tg and 20 Tg of sulfur dioxide into the stratosphere. Observations showed that the sulfate aerosol resulting from the volcanic SO_2 reached altitudes of up to 30 km, and spread fairly uniformly to both hemisphere. The evolution of the volcanic aerosol and the climate impact of the eruption was extensively observed by satellite- and ground-borne instruments, providing a great opportunity for testing the ability of the model to simulate stratospheric aerosol.

We simulated the dispersal of the volcanic aerosol from Mt. Pinatubo and its climate effects with the NASA Goddard Earth Observing System Chemistry Climate Model (GEOSCCM), coupled to the GOCART aerosol module and the StratChem stratospheric chemistry module. We show that the interaction of sulfate with longwave radiation is essential to simulate the observed evolution of the aerosol from the eruption. In our simulations, we inject the SO_2 from Mt. Pinatubo between 16 km and 18 km altitude. The absorption of mostly longwave radiation by the volcanic aerosol induces self-lofting of the volcanic aerosol to the altitudes where it was observed. The radiative interaction of the volcanic aerosol is also responsible for the transport of the volcanic cloud across the equator and, eventually, for its transport to the southern hemisphere.

Our simulations show that the heating due to the volcanic aerosol enhanced both the tropical upwelling and, subsequently, the extratropical downwelling. The enhanced circulation explains the negative ozone anomaly in the tropics and the positive ozone anomaly at southern midlatitudes observed after the eruption.