Effect of volcanic aerosol on the stratospheric quasi-biennial oscillation as revealed with a coupled chemistry-climate model

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Effect of volcanic aerosol on the quasi-biennial oscillation (QBO) in the equatorial stratosphere is investigated with the coupled chemistry-climate model (CCM) of Meteorological Research Institute (MRI), which includes full stratospheric photochemistry for Ox-HOx-NOx-ClOx-BrOx species. The dynamical module of MRI CCM employs spectral T42 truncation and 68 layers extending from the surface to 0.01 hPa (about 80km), wherein the vertical spacing is 500m in the stratosphere. Hines gravity wave (GW) drag is incorporated with enhanced GW source in the tropics to spontaneously reproduce the QBO in zonal wind.

Using MRI CCM, we made the past 25-year simulation from 1979 to 2004 under the CCMVal REF1 scenario. The REF1 scenario includes anthropogenic and natural forcings based on changes in sea surface temperatures, trace gases such as CFCs, solar variability, and stratospheric aerosol. The two major volcanic eruptions are taken into account (El Chichon in 1982 and Pinatubo in 1991) by prescribing observed surfate aerosol surface area densities, effective radius and optical thickness to calculate its chemical and radiative effect.

Results of the simulation exhibit that in the equatorial stratosphere perturbations of diabatic heating, temperature and upwelling due to volcanic aerosol are realisitically reproduced. Stratospheric ozone is decreased by heterogeneous reactions on the volcanic aerosol surface, although its decrease is slightly overestimated.

The period of the simulated QBO is elongated and the amplitude falls, primarily due to direct radiative heating of volcanic aerosol. To investigate the mechanism of the QBO modulation by volcanic aerosol forcing, relation between momentum budget and diabatic heating rate in the equatorial stratosphere are analyzed.