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Quantifying the impact of moderate volcanic eruptions on the stratosphere


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It is expected that the aerosols in the stratosphere, are predominantly sulfates resulting from natural or anthropogenic sources of precursor gases mainly: carbonyl sulfide (COS), sulfur dioxide (SO2). Sulphate aerosols are regarded as the main constituent of the “Junge layer” between the tropopause and about 30 km. This assumption is regularly challenged by detection of solid aerosols with aircraft and balloon measurements. The direct injection of gaseous SO2 into the stratosphere by major volcanic eruptions is likely to generate significant amounts of sulfate aerosols that can stay for several years. Recently, Vernier et al. (2011) have shown from satellite measurements that moderate eruptions modulate the aerosol content during periods not influenced by major volcanic eruptions, called “background” periods. Surprisingly, the radiative impact of the background stratospheric aerosols over the last decade, has been found to be significant with a counterbalance to global warming (Solomon et al., 2011).


Sarychev eruption (12 June 2009)

In the framework of the StratoPELÉS project eight stratospheric balloons were launched from the Esrange base (Sweden) in summer 2009. A number of in-situ optical aerosol counters (OTAC), a UV-visible remote sensing spectrometer for the aerosol extinction (SAALMON) and a photopolarimeter (microADHAR) provided information on the nature and size distribution of the stratospheric aerosols. The observations highlighted high amounts of aerosols in the lower stratosphere. These observations have been explained by the eruption in June 2009 of the Sarychev volcano(48°N, 159°E) located in the Kuril Islands which injected ash and an estimated 1 Tg of sulphur dioxide into the upper troposphere and lower stratosphere.

Perspectives

The climate effects of volcanic eruptions are well understood. Few effects are due to the production of a large cloud of aerosols in the lower stratosphere, which induces surface cooling and, to a lesser extent, the decrease of the stratospheric temperatures. For the climate effects in general, aerosols most remain in the stratosphere for an extended period of time. The aerosol layer in the lower stratosphere (15–30 km) is commonly referred to as the “Junge layer”. By work at the time of the eruption, it has been found that aerosols from the eruption are transported to the mid and upper stratosphere. The WACCM-CARMA model could be used to investigate the origin of these solid aerosols and the inter-annual efficiency of the dynamical barriers.

Future campaigns are also in discussion to better estimate the Asian Tropopause Aerosol Layer (ATAL) observed by the CALIPSO satellite. Future campaigns to quantify the variability of the stratospheric aerosols in the tropics are envisaged in the Reunion Island region. These observations are also the opportunity to verify the presence of solid aerosols up to the mid stratosphere. The WACCM-CARMA model could be used to investigate the origin of these solid aerosols and the inter-annual efficiency of the dynamical barriers.

Future eruptions in Asia are the main concern for stratospheric aerosol studies. The response of the stratosphere to the Sarychev eruption is symbolized by the red triangle. The black dotted lines are tropopause. The good agreement between the WACCM-CARMA model and the observations gives evidence that moderate stratospheric eruptions control the variability of the Junge Layer. Moderate eruptions like the Sarychev eruption have the potential to increase the background aerosol loading by a factor 2 to 10.