Quantifying the impact of moderate volcanic eruptions on the stratosphere

To cite this version:
Fabrice Jégou, Gwenaël Berthet, T Lurton, D Vignelles, Nelson Bègue, et al.. Quantifying the impact of moderate volcanic eruptions on the stratosphere. LEFE-CHAT workshop, 2015, Aussois, France. hal-01337346

HAL Id: hal-01337346
https://hal.univ-reunion.fr/hal-01337346
Submitted on 30 Jun 2016

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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 (OCS), 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 a major volcanic eruption, called ‘background’ periods. Surprisingly, the radiative impact of the background stratospheric aerosols over the last decades, 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 SiroPeLÉs project eight stratospheric balloons were launched from the Karage base (Sweden) in summer 2009. A number of in-situ aerosol counters (OTAC), a UV-visible remote sensing spectrometers for the aerosol extinction (SALOMON) and a photopolarimeter (microALHAD) 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(G8N, 153°E) located in the Kuril Islands which injected ash and an estimated 1 Tg of sulphur dioxide into the upper troposphere and lower stratosphere.

Kelud eruption (13 February 2014)

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.

Perspectives

The climate effects of volcanic eruptions are well understood. Then effects are due to the production of a layer of sulfate aerosols in the lower stratosphere, which is characterized by nucleation, inactivation, the plasma plume, and spread to the easterly. For these climate effects to be substantial, the aerosols must remain in the atmosphere for an extended period of time. The time scale before which the aerosols are removed by the climate system is characterized by the so-called volcanic aerosol residence time (VART). There is a great deal of uncertainty about the VART of volcanic aerosols, depending on the depositional mode of the eruption, its altitude and several other factors. The VART is a function of the chemical composition of the aerosol, its size distribution, and the atmospheric conditions at the time of the eruption. Measurements of aerosol properties, such as optical depth, aerosol optical depth, and aerosol mass concentration, can be used to estimate the VART of volcanic aerosols. These measurements can be obtained by satellite observations or by ground-based observations. The VART of volcanic aerosols is typically in the range of a few months to a few years. Recent studies have shown that the VART of volcanic aerosols can be significantly longer than previously thought, which has important implications for understanding the impact of volcanic eruptions on climate. The VART of volcanic aerosols is an important parameter for understanding the climate effects of volcanic eruptions.