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Climate impact of volcanic aerosol in the stratosphere and upper troposphere – CALIPSO observations from 2006-2015

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We have investigated the climate impact of volcanic eruptions in the period 2006-2015, and found that the volcanic perturbations of the stratospheric aerosol is stronger and lasts longer than previously thought. Recent studies (Ridley et al., 2014, Andersson et al., 2015) show that a large portion of volcanic climate impact stems from aerosol in the LMS (lowermost stratosphere). Although the LMS holds >40% of the stratospheric mass (Appenzeller et al., 1996) it is generally neglected in estimations of the stratospheric AOD (aerosol optical depth). In the past decade the stratospheric aerosol load was perturbed by a number of volcanic eruptions. We cover that period by using the CALIPSO level 1b night-time data to study the volcanic influence on the global and regional climate. CALIPSO data were averaged to a resolution of 180 m vertically and 1×1° horizontally, cleaned from ice clouds by means of the depolarization ratio (Vernier et al., 2009), and a method was developed to remove polar stratospheric clouds (PSC). This approach enables identification of aerosol also at low altitudes (currently using 4 km minimum altitude) and in the Antarctic region (60 to 90°S) where PSCs are frequent during winter.

In the current study, we estimate the total stratospheric AOD and radiative forcing and find that significant fractions of volcanic aerosol were located below the static tropopause after volcanic eruptions. Volcanic aerosol was generally observed down to the dynamic tropopause, and detected down to potential vorticities of 1.5-2 PVU (almost 1 km below the static tropopause). Hence, the dynamic tropopause was found to better enclose the volcanic aerosol. Furthermore, large concentrations of aerosol from the Kasatochi eruption (Aug 2008) is found to linger in the extratropical UT (upper troposphere) for several months after the eruption. Sulphate-rich volcanic aerosol transported from the LMS may influence cirrus clouds in the extratropical UT, inducing an indirect radiative impact that cause further climate impact from volcanic eruptions. A decrease in cirrus reflection in northern midlatitudes over the years 1999-2013 has been linked to subsiding volcanic aerosol from the stratosphere that increased the extratropical UT aerosol concentrations (Friberg et al., 2015). Also, based on IAGOS-CARIBIC observations we find that the stratosphere is the strongest source of sulphate aerosol in the extratropical UT during winter and spring. Hence, volcanic eruptions perturbing the stratosphere were generally evident down to a dynamic tropopause of 1.5-2 PVU (almost 1 km below the static tropopause) and the connected radiative effects may not have been limited to the stratosphere.

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