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# Impact of the Ambae, Raikoke and Ulawun eruptions in 2018-2019 on the global stratospheric aerosol layer and climate

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Using a combination of satellite, ground-based and in-situ observations, and radiative transfer modelling, we quantify the impact of the most recent moderate volcanic eruptions (Ambae, Vanuatu in July 2018; Raikoke, Russia and Ulawun, New Guinea in June 2019) on the global stratospheric aerosol layer and climate.

For the Ambae volcano (15°S and 167°E), we use the Stratospheric Aerosol and Gas Experiment III (SAGE III), the Ozone Mapping Profiler Suite (OMPS), the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) and Himawari geostationary satellite observations of the aerosol plume evolution following the Ambae eruption of July 2018. It is shown that the aerosol plume of the main eruption at Ambae in July 2018 was distributed throughout the global stratosphere within the global large-scale circulation (Brewer-Dobson circulation, BDC), to both hemispheres. Ground-based LiDAR observations in Gadanki, India, as well as in-situ Printed Optical Particle Spectrometer (POPS) measurements acquired during the BATAL campaign confirm a widespread perturbation of the stratospheric aerosol layer due to this eruption. Using the UVSPEC radiative transfer model, we also estimate the radiative forcing of this global stratospheric aerosol perturbation. The climate impact is shown to be comparable to that of the well-known and studied recent moderate stratospheric eruptions from Kasatochi (USA, 2008), Sarychev (Russia, 2009) and Nabro (Eritrea, 2011). Top of the atmosphere radiative forcing values between -0.45 and -0.60 W/m$^2$, for the Ambae eruption of July 2018, are found.

In a similar manner the dispersion of the aerosol plume of the Raikoke (48°N and 153°E) and Ulawun (5°S and 151°E) eruptions of June 2019 is analyzed. As both of those eruptions had a

stratospheric impact and happened almost simultaneously, it is challenging to completely distinguish both events. Even though the eruptions occurred very recently, first results show that the aerosol plume of the Raikoke eruption resulted in an increase in aerosol extinction values, double as high as compared to that of the Ambae eruption. However, as the eruption occurred on higher latitudes, the main bulk of Raikoke aerosols was transported towards the northern higher latitude's in the stratosphere within the BDC, as revealed by OMPS, SAGE III and a new detection algorithm for $SO_2$ and sulfate aerosol using IASI (Infrared Atmospheric Sounder Interferometer). Even though the Raikoke eruption had a larger impact on the stratospheric aerosol layer, both events (the eruptions at Raikoke and Ambae) have to be considered in stratospheric aerosol budget and climate studies.