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Self-lofting and dynamical confinement of the Raikoke volcanic plume

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Recent research has provided evidence of the self-lofting capacity of smoke aerosols in the stratosphere and their self-confinement by persistent anticyclones (Smoke-Charged Vortices, SCV), prolonging the atmospheric residence time and radiative effects of wildfire emissions. By contrast, the volcanic aerosols - composed mostly of non-absorptive sulphuric acid droplets – were never reported to be subject of dynamical confinement. In this study, we use high-resolution satellite observations from various satellite instruments (TROPOMI, ALADIN, CALIPSO, OMPS-LP and EUMETSAT GNSS-RO) together with high-resolution ECMWF ERA5 reanalysis and meteorological radiosoundings to show that the eruption of Raikoke volcano in June 2019 produced a long-lived stratospheric anticyclone termed Vorticized Volcanic Plume (VVP). The primary VVP structure contained 24% of the total erupted mass of sulphur dioxide, circumnavigated the globe three times, and ascended diabatically by more than 13 km in three months through radiative heating of the confined aerosol plume. We argue that persistent anticyclonic formations act to maintain the volcanic plumes at high concentration thereby providing a high degree of radiative heating and upward thrust to volcanic plumes.

The mechanism of dynamical confinement has important implications for the planetary-scale transport of volcanic emissions, their stratospheric residence time, and atmospheric radiation balance. It also provides a challenge or “out of sample test” for weather and climate models that should be capable of reproducing such dynamical structures.