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Improved estimation of volcanic SO2 emissions from satellite observations and Lagrangian transport simulations: The 2019 Raikoke eruption case study

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Monitoring and modeling of volcanic aerosols is important for understanding the influence of volcanic activity on climate. Here, we applied the Lagrangian transport model Massive-Parallel Trajectory Calculations (MPTRAC) to estimate the total injected SO2 by the stratosphere reaching eruption of the Raikoke volcano (48N, 153E) in June 2019 and its subsequent transport. We used SO2 observations from the AIRS and TROPOMI satellite instruments together with a backward trajectory approach to estimate the altitude-resolved SO2 emission timeseries. Then we applied a scaling factor to the initial estimate of the SO2 mass and added an exponential decay to simulate the time evolution of the total SO2 mass. By comparing the estimated SO2 mass and the observed mass from TROPOMI, we show that the volcano injected 2.1±0.2 Tg SO2 and the e-folding lifetime of the SO2 was about 13~17 days. Further, we compared simulations that were initialized by AIRS and TROPOMI satellite observations with a constant SO2 emission rate. The results show that the model captures the SO2 distributions in the first ~10 days after the eruption. The simulations using AIRS nighttime and TROPOMI measurements show comparable results and model skills which outperform the simulation using a constant emission rate. Our study demonstrates the potential of using combined satellite observations and transport simulations to further improve SO2 time- and height-resolved emission estimates of volcanic eruptions.