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An integrated study of SO_2 degassing from Tungurahua volcano, Ecuador

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Tungurahua is a 5023 m-high stratovolcano in Ecuador, with an estimated long-term mean SO_2 output of 1458 $\pm$ 2026 t/day. Since 2006, gas emissions from Tungurahua have been continuously monitored by UV DOAS spectrometers installed as part of the Network for Observation of Volcanic and Atmospheric Change (NOVAC) programme. The SO_2 emissions from the volcano have also been observed and characterised by the satellite-based UV spectrometer OMI (Ozone Monitoring Instrument). Tungurahua is therefore an ideal location for comparing ground- and satellite-based estimates of volcanic SO_2 emissions. Although OMI SO_2 retrievals for continuous tropospheric degassing are not yet validated, the dataset represents a large and mostly untapped resource for volcano monitoring, particularly in remote or inaccessible regions.

This novel study seeks to improve agreement between the DOAS and OMI datasets for Tungurahua, and gain new understanding of why differences in the two estimates of SO_2 degassing arise. Uncertainties affecting comparison between the datasets include: the different natures of the quantities measured (flux vs column concentration); the impact of local atmospheric and meteorological conditions (e.g. clouds masking volcanic plumes; humidity and temperature promoting rapid loss of SO_2 via oxidation to sulphate or by various wet/dry deposition processes; wind dispersal of plumes); and differences in the spatial and temporal resolution of measurements. We present a novel numerical modelling-based study of volcanic SO_2 emissions from Tungurahua using the atmospheric chemistry/transport model REMOTE, which has already been successfully applied to modelling post-emission SO_2 dispersion from volcanoes in Nicaragua and Indonesia. We also investigate the use of derived fluxes from instantaneous satellite scenes to provide better agreement with ground-based gas emission measurements.

Total daily atmospheric SO_2 burdens for the REMOTE and OMI datasets are compared, and we use REMOTE's treatment of atmospheric chemical reactions, wind dispersal, and cloud cover, as well as additional OMI data products (effective reflectivity and aerosol index) and ground-based observatory records to interpret the variation in agreement between the two datasets. A key aim is to identify whether any of the above sources of uncertainty are dominant, and to investigate potential means of correcting for these. Additionally, we seek to produce a detailed assessment of errors in each dataset.