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Volcanic carbon dioxide emissions: observations from space using GOSAT FTS SWIR data

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Recent advances in satellite-borne measurements of atmospheric CO_2 have resulted in smaller field of views, approaching the domain size necessary to detect and quantify emissions from strong stationary sources. Volcanoes are highly variable but continuous emitters, with a large number of sites available world-wide. The application of such observations is both in improving the currently very poorly understood global CO_2 source strength estimates for volcanoes, as well as in volcano monitoring, because volcanic CO_2 emissions before eruptions are the potentially earliest indicators of unrest available. Early detection of anomalies permits ground-based monitoring at the best place and time because in times of crisis, the time is extremely short for decisions, validation and response.

The rationale for using CO_2 as an early unrest indicator is complex: Among the first potential signals of ascending magma is the exsolution of volatiles contained in magma induced by dynamic depressurization, crystallization, and temperature variations. The three most abundant gas species in these emissions are usually water (H_2O), Carbon Dioxide (CO_2), and Sulfur Dioxide (SO_2). SO_2 monitoring methods are widespread, using COSPEC, mini-DOAS, SO_2 cameras, and space-borne SO_2 data. However, since H_2O and SO_2 are frequently scrubbed out by near-surface processes, they may be obscured unless the magma is already near the surface. SO_2 is most useful for volcanoes that erupt frequently and have a dry chimney for easy gas escape. CO_2 is more difficult to measure remotely than SO_2 because the atmospheric background concentration of CO_2 is so much higher than for SO_2. Nevertheless, CO_2 is important because it is the first gas to exsolve from magma (together with helium), and it is minimally affected by scrubbing and other near-surface processes. CO_2 monitoring has been attempted by ground-based CO_2 flux monitoring and by crater plume CO_2 measurements using ground-based open-path FTIR and airborne closed-path IR measurements.

The Japanese GOSAT has been operational since January 2009, producing CO_2 total column measurements at a repeat cycle of 3 days and a field of view of 10km. GOSAT has thus the potential to provide spatially integrated data for entire volcanic edifices. In target mode, repeat observation requests have a great potential to detect volcanic anomalies. We present data of target mode observation requests on a number of selected volcanoes world-wide, using GOSAT FTS SWIR data. Where available, we compare these to SO_2 data from the Ozone Monitoring Instrument (OMI) and ground-based SO_2 sensors. We also compare NIES Level 2 retrieval products with alternative processing by NASA, where available in volcanic areas.