Geophysical Research Abstracts
Vol. 18, EGU2016-17976, 2016
EGU General Assembly 2016

Precursory volcanic CO_2 signals from space

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Identification of earliest signals heralding volcanic unrest benefits from the unambiguous detection of precursors that reflect deviation of magmatic systems from metastable background activity. Ascent and emplacement of new basaltic magma at depth may precede eruptions by weeks to months. Transient localized carbon dioxide (CO_2) emissions stemming from exsolution from depressurized magma are expected, and have been observed weeks to months ahead of magmatic surface activity. Detecting such CO_2 precursors by continuous ground-based monitoring operations is unfortunately not a widely implemented method yet, save a handful of volcanoes. Detecting CO_2 emissions from space offers obvious advantages – however it is technologically challenging, not the least due to the increasing atmospheric burden of CO_2, against which a surface emission signal is hard to discern.

In a multi-year project, we have investigated the feasibility of space-borne detection of pre-eruptive volcanic CO_2 passive degassing signals using observations from the Greenhouse Gas Observing SATellite (GOSAT). Since 2010, we have observed over 40 active volcanoes from space using GOSAT's special target mode. Over 72% of targets experienced at least one eruption over that time period, demonstrating the potential utility of space-borne CO_2 observations in non-imaging target-mode (point source monitoring mode). While many eruption precursors don't produce large enough CO_2 signals to exceed space-borne detection thresholds of current satellite sensors, some of our observations have nevertheless already shown significant positive anomalies preceding eruptions at basaltic volcanoes.

In 2014, NASA launched its first satellite dedicated to atmospheric CO_2 observation, the Orbiting Carbon Observatory (OCO-2). Its observation strategy differs from the single-shot GOSAT instrument. At the expense of GOSAT's fast time series capability (3-day repeat cycle, vs. 16 for OCO-2), its 8-footprint continuous swath can slice through emission plumes, providing momentary cross sections. While GOSAT measured approximately circular ∼10.5km diameter single-shot footprints, OCO-2 can provide hundreds more soundings per area at single kilometer scale footprint resolution. In this contribution, we summarize the approach and progress made over the past 5 years of CO_2 satellite observations, and their application toward detecting volcanic CO_2 eruption precursors.