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Accurate prototype remote sensing of correlated carbon dioxide and sulfur dioxide emissions at Mt.Etna

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Volcanic carbon dioxide (CO_2) and sulfur dioxide (SO_2) emissions have a direct as well as indirect impact on climate and air quality. Moreover these two gases, and in particular their ratio, are tracers for dynamic processes inside volcanoes. Hence they can give direct information about volcanic activity.
Semi-continuous in-situ measurements of CO_2 and SO_2 have been conducted for only a decade, demonstrating the great potential of such data. More than once it could be shown that the CO_2/SO_2 ratio increases and then drops before an eruption. However, in-situ measurements are linked with great effort and risk due to the difficult environment, which might also result in sheer impossibility.
Remote sensing of volcanic emissions allows for monitoring a volcano's activity from a safe distance to the volcano and thus generally under less difficult ambient conditions. This means in turn less effort and cost, even employing a more cost intense instrument. Further, remote sensing enables sampling of cross sections of the entire plume thus, suffering less from representativeness errors than the in-situ technique.
Remote sensing of SO_2 is already well developed, whereas the measurement of CO_2 is challenged by the high background concentration and therefore required high accuracy in order to measure little concentration enhancements in the volcanic plume. To overcome this challenge, we employed combined direct sunlight spectroscopy for SO_2 and CO_2. Two spectrometers (a UV-spectrometer for SO_2 and a FTIR-spectrometer for CO_2) were coupled into the beam of a common sun tracker. The whole setup was installed on a mobile platform, which allowed for sampling plume cross sections in a stop-and-go pattern. Measurements were conducted during a three-week campaign at Mt.Etna, Sicily. We measured enhancements of the averaged CO_2 mixing ratio up to 0.5–1 ppm (2.5×10^{19} molec cm^{-2} CO_2 column enhancement) and SO_2 column enhancements up to 4×10^{18} molec cm^{-2}. CO_2 and SO_2 emissions showed a strong correlation and their emission ratios were in the range of 5-15. For comparison in-situ data, obtained by multigas and optical measurements, will be presented.
Although CO_2 mixing ratio enhancements could be clearly detected, we were close to the detection limit. As an outlook we will discuss further, necessary research to improve the accuracy of the CO_2 measurement to a level which allows for the construction of a stable and risk reduced monitoring network for CO_2/SO_2 ratios.