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# Reconstruction of $SO_2$ emission height time-series and plume age using a combination of satellite imagery, volcanic tremor and back trajectory modelling at Mt. Etna

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While much work has focused on detection of volcanic gas emissions from space, relatively little progress has been made on examining volcanic processes using satellite measurements of volcanic plumes. In theory, much information can be derived regarding the temporal evolution of an eruption from a single image of an eruption plume. This information could be used to constrain models of magma chamber emptying, and comparison with InSAR measurements of syn-eruptive deflation. The over-arching goal of the work presented here therefore is $SO_2$ flux time-series reconstruction using satellite imagery of $SO_2$ in volcanic plumes. One of the major sources of uncertainty in the determination of $SO_2$ abundances from satellite imagery is the plume height, and so we have focused on the development of a robust procedure that allows us to make accurate reconstructions of plume height time series.

Starting from satellite images of $SO_2$ emitted from Mt. Etna, Italy, we identified specific pixels where $SO_2$ was detected and utilized the HYSPLIT Lagrangian back-trajectory model in order to retrieve the emission height and time of the eruption column over the volcano. The results have been refined using a probabilistic approach that allows calculation of the most probable emission height range.

Previous work has highlighted that volcanic tremor is strongly connected to eruption intensity, and therefore, potentially to plume height. We therefore examined the relationship between volcanic tremor measured on Etna with our derived plume height time series. We discovered a relatively good agreement between the time series, suggesting that the physical processes controlling both the distribution of $SO_2$ in the atmosphere and the intensity of volcanic tremor are strongly coupled, through the explosivity of the eruptive activity.

The synthesis of volcanic tremor and derived plume heights is a novel new approach, and opens the possibility of more quantitative analysis of $SO_2$ amounts in satellite imagery, and deeper insights into the volcanological processes driving eruptive activity.