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Real-time detection of volcanic plume H_2O, CO_2 and SO_2 as a precursor to 2006 Mt. Etna eruptions.

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Mount Etna, in southern Italy, is well known for its uninterrupted open-vent degassing activity from the summit craters, making the volcano the largest point source of volcanogenic volatiles on Earth. Notwithstanding a substantial improvement of our understanding of degassing rates and mechanisms over the past two decades, analytical limitations still hamper the quantitative evaluation of the total volatile budget from the volcano. In contrast with the routine sensing of volcanic SO_2 by UV-spectroscopy (Allard, 1997; Caltabiano et al., 2004), only a few spot determinations of CO_2 emissions from Mount Etna have been reported to date (Allard et al., 1991; Aiuppa et al., 2006), while H_2O emissions are virtually unconstrained. Also, volcanic gas measurements are most often taken discontinuously, limiting their potential as precursors of volcanic eruptions. Here, we describe the very first simultaneous detection of H_2O, CO_2 and SO_2 in Etna's quiescent volcanic plume, performed by operating a Multi-component Gas Analyzer System (Multi-GAS) which integrates an infrared LICOR spectrometer and a specific electrochemical sensor for SO_2 (Aiuppa et al., 2006; Shinohara et al., 2006). The Multi-GAS is permanently installed on the rim of Etna's Voragine (central) crater, and allows the real time continuous observation of volcanic plume composition with a high acquisition frequency (4 daily measurement cycles and 9s acquisition step). We document significant modifications of the volcanic gas plume composition from CO_2-poor and H_2O-rich (e.g., $CO_2/SO_2 \approx 0.5$; $CO_2/H_2O \approx$

0.01) to CO_2-rich (e.g., $CO_2/SO_2 \approx 25$; $CO_2/H_2O \approx 0.5$), and relate the emission of a CO_2-rich plume in June-July 2006 to the accumulation of volatile-rich magmas in the shallow volcano plumbing system, leading to resumption of eruptive activity since July 14. Similar pre-eruptive peaks of the CO_2/SO_2 plume ratio occurred in the days/hours before the occurrence of short-lived strombolian eruptions at South-East crater in September-December 2006, testifying for the potential of volcanic gas measurements as short-term precursors of even-mild explosive events at Etna. By combining our observed composition with SO_2 emission rates, we finally attempt at a very first characterisation of H_2O emissions from the volcano, and provide a refinement of previous CO_2 budget evaluations.