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THE USE OF TIMS DATA TO ESTIMATE THE SO_2 CONCENTRATIONS OF VOLCANIC PLUMES: A CASE STUDY AT MOUNT ETNA, SICILY

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TIMS data were acquired over Mount Etna, Sicily, on July 29, 1986 (Bianchi et al. 1990). The volcanic activity at that time was characterized by the steady effusion of gas from the Bocca Nuova (BN), Chasm, and Southeast craters. The Northeast crater, quiet at the time of the TIMS overflight, was the site of Strombolian eruptive activity between July 31 and September 24, 1986 (SEAN 1986).

In aerial photographs of the Etna summit region acquired during the TIMS overflight, the SO_2-rich plume is visible due to the scattering of sunlight by the entrained aerosols. In the TIMS imagery, the plume is revealed by the strong absorption of SO_2 between 8 and 9 μm. This absorption feature falls within the first three channels of TIMS, with the strongest absorption falling within Channel 2. Following decorrelation processing, the plume is visible in color-composites of TIMS channels 2, 3, and 5.

To estimate the concentration of SO_2 within the plume, the LOWTRAN 7 radiative transfer code was used to model to radiance spectra measured by TIMS. Inputs to LOWTRAN included ground temperature and emissivity, vertical profiles of atmospheric temperature and humidity, and the vertical position of SO_2 within the plume. The ground temperatures and emissivity spectra were derived from the TIMS measurements through the use of a curve-fitting algorithm (Warner and Levandowski 1990, Realmuto 1990). Emissivity spectra recovered outside of the plume were applied to the ground beneath the plume where appropriate. The ground temperature estimates were modified interactively by fitting LOWTRAN-generated radiance values to those measured in TIMS channels 4, 5, and 6, the channels that were not strongly affected by the presence of SO_2 in the atmosphere. The atmospheric pressure, temperature, and humidity profiles were recorded by radiosondes launched from Trapani, which is located approximately 220 km west of Mount Etna.

To evaluate the accuracy and precision of the estimation procedure, SO_2 concentrations were recovered over the same piece of ground using the data from three successive TIMS overflights. The flights were separated by intervals of approximately 15 minutes. Assuming that the gas output of the volcano was constant during the course of the flights, the concentration of SO_2 in the chosen portion of the plume was 26.3 ± 4.1 mg/m^3. This estimate compares favorably with SO_2 concentrations of 22.84 ± 2.3 and 57.1 ± 5.7 mg/m^3 measured near the rim of BN crater in 1978 and 1979, respectively (Jaeschke et al. 1982). Assuming a plume width of 1 km and a wind speed of 5 m/s, the

SO_2 concentrations derived from the TIMS data correspond to flux rates ranging between 5400 and 7600 tons/ day. These SO_2 flux rates are within the range of published flux rates from Mount Etna (cf. Haulet et al. 1977, Zettwoog and Haulet 1978, Malinconico 1979), but the TIMS-derived flux rates are higher than the average flux rates published in the literature.

The sensitivity of the estimation procedure to variations in the inputs to the LOWTRAN code was also evaluated. The estimation procedure was most sensitive to ground temperature; a 10 degree (Celsius) variation in ground temperature translated into a 50% change in the estimation of SO_2 concentration. Changes in the vertical distribution of SO_2 within the plume resulted in 20% changes in the estimates of concentration. Replacing the ground emissivity with a uniform value of 0.95 resulted in a 10% change in the estimates of concentration. The substitution of a climatological atmospheric profile (mid-latitude summer) for theTrapani radiosonde measurements resulted in a 20% change in the estimates of SO_2 concentration.

The TIMS data provided a near-instantaneous measurement of SO_2 concentration of the plume in the summit region of Mount Etna. Data such as these could aid in the study of temporal and spatial variations in the SO_2 content of the plume. It is recommended that future TIMS flights over venting volcanoes be accompanied by ground support crews. These personnel could collect ground temperature and emissivity measurements as well as launch radiosonde balloons. Despite the fact that the Mount Etna TIMS mission was not supported by a ground crew, the SO_2 concentrations derived from the TIMS data were in good agreement with published values. The availability of ancillary data can only improve the accuracy of the TIMS estimation procedure.

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