Retrieving Aerosol Parameters from Advanced Visible and Near Infrared Radiometer (AVNIR) multispectral images of Mount Etna's aerosol plume.

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Abstract

Two multispectral images acquired on 28 March 1997 and 23 May 1997 by the Advanced Earth Observation Satellite (ADEOS) sensor AVNIR will be analysed in each of the four multispectral channels to retrieve aerosol optical thicknesses. The 28 March image provides the opportunity to retrieve optical parameters above snow, unvegetated basaltic lava flows and East Sicilian coastal waters. The heterogeneity of the plume can be clearly seen and could provide an insight into short term changes in rates of emission by Etna's active craters and near-source topographic effects.

The 23 May image provides a useful comparison by showing two distinct plumes; a relatively homogeneous plume from the southern complex of the Bocca Nuova, Voragine and Southeast craters and a distinctive 'beaded' plume from the Northeast crater. Analysis of the separate plumes will allow remotely sensed data to help categorise the differing eruptive activity of the two sites. Proximal and distal sections through the plume may also provide insight into temporal evolution of the aerosol phase.

Introduction

On 17 August 1996 the Advanced Earth Observing Satellite (ADEOS) was launched containing several remote sensors, including the Advanced Visible and Near Infra-red Radiometer (AVNIR). The AVNIR sensor contains four multispectral bands and one panchromatic band with at NADIR spatial resolutions of sixteen and eight metres respectively.

Two multispectral images have been obtained dated 28 March 1997 and 23 May 1997. In the 28/03/97 image a cloud free plume can be observed travelling south east over snow at the summit, then old basaltic lava flows and then out over the Ionian Sea. This provides an opportunity to derive aerosol parameters, primarily optical depth, over three spectrally different but well defined backgrounds which will enable the suitability of these backgrounds to volcanic aerosol retrievals to be studied.

The second image, 23/05/97, captured substantially more orographic cloud though the summit area still remains clear. Two distinct plumes can be observed, one emanating from the central Bocca Nuova and Voragine complex and the Southeast crater, and one from the Northeast crater. The plume generated by the Northeast crater has a pulsed nature with a periodicity of 40 s (for a wind speed of 5 m s^{-1}) while the primary plume can be seen to be much more consistent. The volcanic activity at the time of the images involved 'Strombolian' explosive activity at the Bocca Nuova and Southeast crater with quieter floor vent degassing from the Voragine and Northeast craters. The two plumes merge at 4 km from the summit.

Methodology

The images are to be atmospherically corrected using the minimum digital count level algorithm (Kawata, 1997). This method of estimating atmospheric optical thickness was developed specifically for the AVNIR sensor. First the minimum digital count level, (DC_{min}) is found for each of the four multispectral bands (i). The $DC_{min}(i)$ is then converted into the minimum radiance, ($PR_{min}(i)$). Then an appropriate meteorological range V(i) is then found for a given minimum radiance which is passed to MODTRAN code to calculate the atmospheric optical thickness for each band.

Once the atmospheric optical thickness is calculated for the non aerosol atmosphere the measured at-satellite radiance can be seen to contain contribution from the land/ocean surface and the volcanic aerosol. The true background signal can be calculated by removing the atmospheric contribution in an area of the image not contaminated by the volcanic aerosol. From this an approximate optical depth of the aerosol can be calculated. With this optical depth, the plume height, calculated using the brightness temperature, and the solar zenith angle, the extinction of incoming solar radiation on the background can be modelled. The subsequent albedo will be imposed iteratively until convergence criteria are met.

A routine for calculating the aerosol optical thickness, particle size and single scattering albedo will be developed to utilise a the pair of images (Kaufman, 1990). Both AVNIR and the Ocean Color and Temperature Scanner (OCTS) will be used to retrieve aerosol parameters, and SO_2 burden retrievals will also be attempted using OCTS. A simultaneous retrieval of both aerosol parameters and SO_2 gas burden would enable the generation of an accurate tropospheric volcanic box model.

Discussion

Aerosol parameters such as optical depth, mean scattering radius and single scattering albedo enhance understanding of the chemistry of volcanic plumes. The nature of volcanic hazards dictate remote measurement of gases and aerosols. An understanding of plume chemistry is therefore vital in utilising any remote measurements made. The inherent reactivity associated with high temperature release, and the presence of multiphase reactive conditions necessitate modelling of such conditions if realistic conclusions are to be drawn from spectroscopic and radiometric measurements at distances of kilometres from the vent. The investigation of Mount Etna is partly involved in a larger remote sensing project the EU Framework IV Environment and Climate Programme, aimed at mitigating volcanic risk in Europe with Mt. Etna, Europe's largest volcano and Mt. Versuvius, potentially Europe's most dangerous volcano. It is hoped that the aforementioned methodology can be used in both European and other volcanoes as a source of information directly related to the individual volcanoes volcanic activity.

References

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