SO₂ AND ASH VOLCANIC PLUME RETRIEVALS FROM THE 24 NOVEMBER 2006 Mt. ETNA ERUPTION USING MSG-SEVIRI DATA: SO₂ VALIDATION AND ASH CORRECTION PROCEDURE

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Estimation of the daily trend of sulfur dioxide and ash from the thermal infrared measurements of the Spin Enhanced Visible and Infrared Imager (SEVIRI), on board the Meteosat Second Generation (MSG) geosynchronous satellite, has been carried out. The SO₂ retrieval is validated vicariously by using satellite sensors and with ground measurements. The 24 November 2006 tropospheric eruption of Etna volcano is used as a test case. MSG-SEVIRI is an optical imaging radiometer characterized by 12 spectral channels, a high temporal resolution (one image every 15 minutes), and a 10 km² footprint. The instrument’s spectral range includes the 7.3 and 8.7 μm bands (channels 6 and 7) used for SO₂ retrieval and the 10.8 and 12.0 μm (channels 9 and 10) split window bands used for ash detection and retrievals. The SO₂ column abundance and ash are retrieved simultaneously by means of a Look-Up Table least squares fit procedure for SO₂ and using a Brightness Temperature Difference algorithm for ash. The SO₂ retrievals obtained using different satellite sensors such as AIRS and MODIS have been carried out and compared with SEVIRI estimations. The results were validated using the permanent mini-DOAS ground network system (FLAME) installed and operated by INGV on Mt. Etna. Results show that the simultaneous presence of SO₂ and ash in a volcanic plume yields a significant error in the SO₂ column abundance retrieval in multispectral Thermal Infrared (TIR) data. The ash particles with high effective radius (from 1 to 10 μm) reduce the top of atmosphere radiance in the entire TIR spectral range, including the channels used for the SO₂ retrieval. The net effect is a significant SO₂ overestimation. To take this effect into account a novel ash correction procedure is presented and applied to the retrieval.

SO₂ and Ash retrievals

The TOA simulated Radiances (Rₗ) needed for SO₂ and Ash retrievals, have been computed using MODTRAN 4 RTM, varying the AOT and the particles effective radius [Wen and Rose, 1994].

SO₂ retrieval validation

The SO₂ retrieval is validated vicariously by means of a Look-Up Table least squares fit procedure for SO₂ and using a Brightness Temperature Difference algorithm for ash. The results were validated using the permanent mini-DOAS ground network system (FLAME) installed and operated by INGV on Mt. Etna. Results show that the simultaneous presence of SO₂ and ash in a volcanic plume yields a significant error in the SO₂ column abundance retrieval in multispectral Thermal Infrared (TIR) data. The ash particles with high effective radius (from 1 to 10 μm) reduce the top of atmosphere radiance in the entire TIR spectral range, including the channels used for the SO₂ retrieval. The net effect is a significant SO₂ overestimation. To take this effect into account a novel ash correction procedure is presented and applied to the retrieval.

Test Case: 24/11/2006 Mt. Etna eruption

Mt. Etna is located in the eastern part of Sicily (Italy) and is one of the major degassing volcanoes in the world. From September to December 2006, many eruption episodes occurred. The 24 November 2006 eruption started at about 6:00 GMT and ended at about 17:00 GMT. It took place at the SE crater located in the southern flank of Mt. Etna. The wind was blowing from the NNW direction creating major problems for the “Fontanarossa” International Airport of Catania which was subsequently closed to air traffic.

Instrument used for SEVIRI SO₂ validation

Ground Instruments

FLAME network of scanning DOAS instruments

The Etna FLAME network was deployed in 2003 and consists of 5 scanning ultraviolet spectrometers used to automatically measure the flux of SO₂ emitted from Mt. Etna. Each station consists of an Ocean Optics S2000 spectrometer, a scanning mirror, and a PC. Data are collected and analyzed in real-time, with results sent via GSM modem to the observatory.

The spectrometer measures between 285 and 380nm, with a resolution of 1.1nnm. Data analysis is performed using a custom-built DOAS-style retrieval with artificial clear-sky background spectrum.

Satellite Instrument

AIRS: image 12:20 GMT

MODIS: image 12:20 GMT

References


CONCLUSIONS

- Results show the importance of the ash correction on SEVIRI SO₂ retrieval at 8.7 μm; the total mass corrected by the ash influence, can be less than half the values retrieved without the correction.
- The MODIS SO₂ and ash retrievals are in good agreement with the SEVIRI estimations.
- The SO₂ retrieval is significantly underestimated. The main reason is due to the use of the 7.3 μm SO₂ absorption feature; in case of tropospheric eruptions (our case), the 7.3 μm band is severely affected by atmospheric water vapor absorption.
- The FLAME network SO₂ flux is significantly lower than the flux retrieved by SEVIRI. The lowest values occur in concomitance with ash emission.
- The plume vertical cross section reconstructed by means of Flame network data tomography, suggest that UV radiation is attenuated by ash, thus inhibiting the ground detection of SO₂.
- A possible cause of a SEVIRI SO₂ overestimation is the presence of water vapor particles in the volcanic plume, that was not modeled in the atmospheric correction simulations.