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Volcanic sulphur dioxide (SO_2) in atmosphere from IASI data: analysis of SO_2 amount and altitude for recent eruptions and volcanic degassing.

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Sulphur dioxide (SO_2) is an important atmospheric constituent that plays a crucial role in many atmospheric processes. In the troposphere its production leads to the acidification of rainfall while in the stratosphere it oxidises to form a stratospheric H2SO4 haze that can affect climate for several years. Volcanoes contribute about 1/3 to the tropospheric sulphur burden of which the majority is SO_2. However, the absolute amount of the annual SO_2 volcanic emission is both poorly constrained, and highly variable.
The uncertainty in SO_2 released arises for the stochastic nature of volcanic processes, very little or no surface monitoring of many volcanoes (so their contribution to annual emission is extremely uncertain) and from huge uncertainty in the contribution of volcanic sulphur emitted by quiescent (non-explosive) degassing.

Volcanic SO_2 retrievals from satellite data in the thermal infrared spectrum are based on two regions of SO_2 absorption around 7.3 and 8.7 μm.
The strongest SO_2 band is at 7.3 μm and is contained in a strong water vapour (H_2O) absorption band and is not very sensitive to emission from the surface and lower atmosphere. Above the lower atmosphere this band contains valuable information on the vertical profile of SO_2. Fortunately differences between the H_2O and SO_2 emission spectra allow the signals from the two gases to be decoupled in high resolution measurements.
The 8.7 μm absorption feature is in an atmospheric window so it contains information on SO_2 from throughout the column.

The development of an SO_2 retrieval algorithm that uses measurements from 1000 to 1200 cm-1 and from 1300 to 1410 cm-1 (the 7.3 and 8.7 μm SO_2 bands) made by the Infrared Atmospheric Sounding Instrument (IASI) (Carboni et al., 2012) on the MetOp satellite permits the quantification of SO_2 amount and the estimate of the plume altitude.

This retrieval scheme determines the column amount and effective altitude of the SO_2 plume with high precision (up to 0.3 DU error in SO_2 amount if the plume is near the tropopause) and can retrieve informations in the lower troposphere.

There are several advantages of the IASI retrievals:
(1) IASI makes measurements both day and night (so has global coverage every 12 hours),
(2) the IASI retrieval does not assume plume height but retrieves an altitude for maximum SO_2 amount (under the assumption that the vertical concentration of SO_2 follows a Gaussian distribution).
(3) IASI retrievals is not affected by underlying cloud (if the SO_2 is within or below an ash or cloud layer its signal will be masked and the retrieval will underestimate the SO_2 amount, in the case of ash this is a posteriori discernible by the cost function value)
(4) A comprehensive error budget for every pixel is included in the retrieval. This is derived from an error covariance matrix that is based on the SO_2-free climatology of the differences between the IASI and forward modelled spectra.

In this work we present the results for recent volcanic eruptions and we will demonstrate the potential to monitor quiescent degassing from some volcano.