Sulphur dioxide (SO$_2$) is an important atmospheric constituent that plays a crucial role in many atmospheric processes. In the troposphere, SO$_2$ injection leads to the acidification of rainfall while in the stratosphere it oxidises to form a stratospheric HSO$_3^-$ haze that can affect climate for several years. The Infrared Atmospheric Sounding Interferometer (IASI) on the Metop satellite can be used to study volcanic emission of SO$_2$ using high-spectral resolution measurements from 1000 to 1200 cm$^{-1}$ and from 1300 to 1415 cm$^{-1}$ (the 7.3 and 8.7 um SO$_2$ bands). The scheme described in Carboni et al. (2010) has been applied to measure volcanic SO$_2$ amount and altitude for most eruptive events from 2008 to 2014, including large eruption such as Nabro and less intense events such as Etna lava fountains and the recent Bardarbunga eruption. The work includes a comparison with independent measurements. (The SO$_2$ column amounts from the 2010 Eyjafjallajökull plumes have been compared with Brewer ground measurements over Europe; (ii) the SO$_2$ plumes have also been compared with CALI/PSO backscatter profile. The results of the comparisons show that IASI SO$_2$ measurements are not affected by underlying cloud and are consistent (within the retrieved errors) with the other measurements considered. The series of analysed eruptions, between 2008 and 2012, show that the biggest contributor of volcanic SO$_2$ was Nabro, followed by Kasatochi and Grimsvötn. Our observations also show a tendency of the volcanic SO$_2$ to be injected to the level of tropopause during many eruptive episodes. For the eruptions observed, this tendency was independent of the maximum amount of SO$_2$ emitted (e.g., 0.2 Tg for Dallarisa compared with 1.6 Tg for Nabro) and of the volcanic explosive index (between 3 and 5).

**Retrieval scheme**

This SO$_2$ retrieval algorithm uses measurements from 1000 to 1200 cm$^{-1}$ and from 1300 to 1415 cm$^{-1}$ (the 7.3 and 8.7 um SO$_2$ bands) made by IASI (Carboni et al., 2012). Uses the detection scheme (Walker et al. 2012) applied to plots for the full eruption (Carboni et al., 2010).

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 information in the lower troposphere.

There are several advantages of the IASI retrieval:

1. IASI retrieval measurements do not rely on any 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) retrieval is not affected by underlying cloud (if the plume is within or below an all or cloudy layer that signal will be masked and the retrieval will underestimate the SO$_2$ amount, in the case of such a signal is a systematic (by the cloud function index).
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 atmosphere of the differences between the IASI and forward modelled spectra.

**Comparison with Brewer ground data**

Scatter plot of IASI SO$_2$ measurements, averaged within a distance of 20 km from the ground station, versus the daily SO$_2$ column amount measured from Brewer spectrometry (difference in the mean column relative to the individual ground stations). Black markers are the IASI average retrieved emissions on the standard deviation of the IASI data within the consideration time. The green markers are the peak column obtained from the Brewer data. The blue line indicates the best fit with error in the bracket.

**Height comparison with CALI/PSO**

Comparison with CALI/PSO. SO$_2$ plumes are presented with CALI/PSO to identify the location of volcanic plume (G. Thomas, personal communication). The height of the SO$_2$ plume from the IASI pixel closest to CALI/PSO track, are examined on the CALI/PSO satellite image. SO$_2$ column and 12-hour difference in time between the two measurements (i.e., the red box indicates only the two bartometers (retrieved here): some coincidences (close coincidence between SO$_2$ column and 12 hours) are observed but the quality of the data are limited. Note that for L-CLSPO/tropopause legal points and extension of SO$_2$, it only reaches the elevation of 40 km.

**Summary**

IASI retrieved values are consistent with the satellite CALI/PSO and ground measurements (Brewer). The IASI scheme has been used twice a day to follow the vertical distribution of SO$_2$ as a function of time, for different eruption types (e.g., VEI ranging between 1 and 5) and different latitudes. There is a tendency for volcanic SO$_2$ emissions to reach a point of injection close to the tropopause. The plume evolves down to the tropopause in the latitude latitudes, the eruptions of building height, large-original and enstratified is transported in the troposphere.