Measuring volcanic emissions using satellite thermal infrared spectrometer

Elisa Carboni, University of Oxford

Sulphur dioxide (SO2) is an important atmospheric constituent that plays a crucial role in many atmospheric processes. Volcanic eruptions are a significant source of atmospheric SO2 and its effects and lifetime depend on the SO2 injection altitude. Measurements of volcanic SO2 emissions can offer critical insight into the current and near-future activity of volcanoes, however, the majority of active volcanoes lack regular ground-based monitoring. Different satellite spectrometers are now used to observe SO2 emissions from space. One such instrument, the Infrared Atmospheric Sounding Interferometer (IASI) has been used to successfully quantify SO2 emissions and altitudes from several eruptions since 2007.

In this study, we exploit the spectral range of IASI, from 1000 to 1200 cm−1 and from 1300 to 1410 cm−1 (the 7.3 and 8.7 μm SO2 absorption bands), to study volcanic SO2 in 3 ways: 1) The IASI-A dataset was analysed using a rapid linear retrieval algorithm as a global survey tool to show that IASI observations detect SO2 emissions from anthropogenic sources, volcanic eruptions and certain persistently degassing volcanoes over the IASI time series. 2) We apply the iterative optimal estimation retrieval scheme to measure both the SO2 amount and altitude of volcanic plume from explosive and effusive eruptions, from 2008 up to the more recent Calbuco and Bárđabunga eruptions. Comparison with Brewer ground measurements and CALIPSO backscatter profiles show that IASI SO2 measurements are not affected by underlying cloud and are consistent (within the retrieved errors) with the other measurements. Our observations also show a tendency for volcanic SO2 to be injected to the level of the tropopause during many of the moderately explosive eruptions observed. 3) The iterative retrieval is used over Ecuador, Northern Kamchatka and Sicily to explore how trends in SO2 emissions observed by IASI compared to reported changes in the level of volcanic activity. The IASI retrieval is able to quantify tropospheric SO2 from multiple volcanoes in the regions across the period sampled. Over Sicily, Etna IASI showed the most persistent signal during both active and quiescent periods. Over Ecuador, Tungurahua showed a strong correlation in relative emission rates between quiescent and active periods when comparing IASI and with ground-based and OMI datasets. Over Kamchatka, IASI detected clear peaks in SO2 emissions coincident with reports of elevated volcanic activity. This is the first long-term satellite survey over the Kamchatka region and highlights the value of infrared satellite spectrometers, such as IASI, in regions where short wavelength observations are limited.