The vertical distribution of volcanic plumes measured by IASI

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Sulphur dioxide (SO2) is an important atmospheric constituent that plays a crucial role in many atmospheric processes. For example, the current hiatus in global warming has been suggested to be caused by low volcanic activity. Volcanic eruptions are a significant source of atmospheric SO2 and its effects and influence depend on the SO2 injection altitude. In the troposphere SO2 injection leads to the acidification of rain while in the stratosphere it contributes to form a greenhouse H2SO4 haze that can affect climate for several years. The InfraRed Atmospheric Sounding Instrument (IASI) on the Metop satellite can be used to study volcanic emission of SO2 using high-spectral resolution measurements from 1000 to 1200 cm⁻¹ and from 1300 to 1410 cm⁻¹ (the 7.3 and 8.7 μm SO2 bands). The scheme described in Carboni et al. (2012) has been used to measure volcanic SO2 altitude and amount for most explosive eruptions from 2008 to 2014, including large eruption such as Nabro and less intense events such as Etna lava fountains and the recent Bardabunga eruption. The work includes a comparison with independent measurements. The SO2 column amounts from the 2010 Eyjafjallajökull plumes have been compared with Brewer ground measurements over Europe. (i) The SO2 plumes heights have been compared with CALIPSO backscatter profile. The results of the comparison show that IASI SO2 measurements are not affected by underlying cloud and are consistent (within retrieval errors) with the other measurements considered. The series of analysed eruptions, between 2008 and 2012, show that the biggest contributor of volcanic SO2 was Nabro, followed by Katla and Grimsvötn. Our observations also show a tendency of the volcanic SO2 to be ejected to the level of tropopause during explosive eruptions. For the eruptions considered, this tendency was independent of the maximum amount of SO2 erupted (e.g., 0.2 Tg for Dalafilla compared with 1.6 Tg for Nabro) and of the volcanic explosivity index (between 3 and 5).

Retrieval scheme

The SO2 retrieval algorithm uses measurements from 1000 to 1200 cm⁻¹ and from 1300 to 1410 cm⁻¹ (the 7.3 and 8.7 μm SO2 bands) made by Carboni (Carboni et al., 2012). Uses the detection scheme (Walker et al. 2012) applied to pixels by the cost function value). (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 SO2 amount (under the assumption that the vertical concentration of SO2 follows a Gaussian distribution). - If SO2 retrievals are not affected by underlying cloud if the SO2 altitude is below an ash or cloud layer its signal will be masked and the retrieval will underestimate the SO2 amount; in the case of 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 model on the SO2 retrieval (determined by the climatology of the differences between the IASI and forward modelled spectra).

In each plot the y axis are the vertical levels in km. The colour represents the total mass of SO2 in Tg dark-red represent values over 2 Tg.

Every column of the plumes comes from an IASI map (one every 12h). Red triangles in the bottom line indicate the presence of a fresh plume connected with the volcano. Black triangle indicate the presence of an old plume overpassing the volcano. The notes that the plume for different eruptions have different color-scales and cover different time ranges. Black lines are the mean and standard deviation of the tropopause. VEI (Volcanic Explosivity Index) is a qualitative scale of eruption magnitude. The VEI indicates here are from the Smithsonian Institution Global Volcanism Programme (http://volcano.wr.usgs.gov/).

Acknowledgments

This work has been supported by escaping SO2 lead to a maximum on 15 June (3.5 Tg). Etna is included in the retrieval. A special thanks to EODG and SMASH (ESA) projects. Carboni, E. Grainger, R. Walker, J. Duticha, A. Smith, M. Koukouli, and D. Balis. The CALIPSO data are prewashed with SEVIRI to identify the location of volcanic plume (G. Thomas personal communication). The CALIPSO data are prewashed with SEVIRI to identify the location of volcanic plume (G. Thomas personal communication). The CALIPSO data are prewashed with SEVIRI to identify the location of volcanic plume (G. Thomas personal communication).