Towards a long-term, consistent record of anthropogenic and volcanic sulphur dioxide (SO_2) from IASI

B. Franco[(1)], L. Clarisse[(1)], J. Hadji-Lazaro[(2)], C. Clerbaux[(2,1)], and P.-F. Coheur[(1)]

[(1)]Université libre de Bruxelles (ULB), Spectroscopy, Quantum Chemistry and Atmospheric Remote Sensing (SQUARES)
Brussels, Belgium

[(2)]LATMOS/IPSL, Sorbonne Université, UVSQ, CNRS
Paris, France

Email: bruno.franco@ulb.be

ABSTRACT

Atmospheric sulphur dioxide (SO_2) is released primarily from anthropogenic activities, such as combustion of sulphur-rich fossil fuels and smelting, as well as natural sources like volcanic eruptions and quiescent degassing of volcanoes. Once in the atmosphere, SO_2 quickly oxidizes into sulfuric acid and sulphate aerosols, which contribute to both local and long-range air pollution. The altitude at which SO_2 is injected into the atmosphere is key, as it determines its lifetime and the extent of its environmental impact. In the low- and mid-troposphere, SO_2 contributes to acid rain and cloud modification, adversely affecting air quality and ecosystems. In the stratosphere, it forms sulphate aerosols cooling the Earth's surface by scattering solar radiation, potentially affecting global climate patterns for years. Polar-orbiting nadir satellite sounders have been providing valuable data on SO_2 vertical column densities (VCDs) for many years. In particular, the bi-daily global observations from IASI/Metop has been shown to provide reliable measurements of both low- and high-altitude SO_2.

We present here a general algorithm for retrieving both SO_2 plume heights and VCDs from IASI measurements. Compared to earlier work, the height retrieval has a better accuracy performance in the densest and most saturated part of fresh volcanic plumes, while the column product shows enhanced sensitivity, especially in the lower troposphere, but also higher up. Particular efforts were also made to improve consistency of the product, over the entire 2007-2024 period, and between the three different IASI instruments. We illustrate the robustness of this SO_2 retrieval algorithm on case studies of both volcanic and anthropogenic plumes, which we compare with the results reported in the literature. We present the entire 16-year IASI record of SO_2, focusing on the largest eruptions, most active volcanoes, and long-term trends over large anthropogenic SO_2 sources.