MUSICA Retrieval of Vertical Concentration Profiles of SO_2 Using the IASI Satellite Instrument

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ABSTRACT

The MUlti-platform remote Sensing of Isotopologues for investigating the Cycle of Atmospheric water (MUSICA) project, funded by the European Research Council, initiated the development of a comprehensive processing framework for satellite spectral data. Specifically, MUSICA works with Infrared Atmospheric Sounding Interferometer (IASI) radiances, measured under cloud-free conditions, to derive vertical profiles of different atmospheric properties and chemical composition. For examples: atmospheric temperature; water vapor; ratios between water vapor isotopologues; and, trace gases including greenhouse gases (methane and nitrous oxide). In accordance with the FAIR (findable, accessible, interoperable, reusable) principles, all MUSICA IASI data products are freely available together with their observation specific averaging kernels and uncertainty covariances. Recently, peroxyacetyl nitrate (PAN), acetic acid and acetone from biomass burning events, and sulfur dioxide (SO_2) from volcanic eruptions have been included in order to account for their significant spectroscopic signals in cases of these natural disasters.

Assessments of the MUSICA IASI SO_2 retrieval and its data products with other datasets are the focus of our study. The availability of individual averaging kernels in MUSICA IASI data products allows quantitative inter-comparison with other SO_2 data products for future studies. Potential candidates for inter-comparison include: in-situ measurements, groundbased remote-sensing Brewer data, satellite data from Microwave Limb Sounder Instrument (MLS), and, possibly Tropospheric Monitoring Instrument (TROPOMI) aboard Sentinel-5 Precursor (S5P) SO_2 products.

Here, we present the MUSICA IASI SO_2 retrieval. A particularity is the use of a logarithmic SO_2 concentration scale. This facilitates a reliable detection of the altitude where the SO_2 plume is situated, because it is retrieved directly from the spectral signal and no a priori assumptions of SO_2 plume height are required. We document the superiority of this retrieval setup compared to a retrieval on a linear SO_2 concentration scale.

In addition, we empirically demonstrate MUSICA IASI's capabilities of carrying out SO_2 retrievals from different volcanic eruptions using quality controlled, but still preliminary results of SO_2 profile data from three different eruptions: effusive (Raikoke, 2019, 48°N), explosive (La Palma, 2021, 29°N), and extremely explosive (Hunga Tonga-Hunga Ha'apai, 2022, 20°S). The measured amounts of SO_2 and the SO_2 plume heights are different for the three events. Here, we show that the MUSICA IASI data product is able to correctly capture these differences.