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Extremely fast retrieval of volcanic SO2 layer heights from UV satellite data using inverse learning machines

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Precise knowledge of the location and height of the volcanic sulfur dioxide (SO_2) plume is essential for accurate determination of SO_2 emitted by volcanic eruptions. So far, UV based SO_2 plume height retrieval algorithms are very time-consuming and therefore not suitable for near-real-time applications like aviation control. We have therefore developed the Full-Physics Inverse Learning Machine (FP_ILM) algorithm for extremely fast and accurate retrieval of volcanic SO_2 layer heights based on the UV satellite instruments Sentinel-5 Precursor/TROPOMI and MetOp/GOME-2.

In this presentation, we will present the FP-ILM algorithm and show results of the 2019 Raikoke eruption; a strong volcanic eruption which has emitted a huge ash cloud accompanied by more than 1300 DU of SO_2, which could be detected even two months after the end of eruptive event. We will also present first results of the recent Taal volcanic eruption on 13 January 2020 in Indonesia, which has injected a huge ash and SO_2 plume into the upper atmosphere, with plume heights of up to 20km.

The algorithm is developed in the framework of ESA's "Sentinel-5p+ Innovation: SO_2 Layer Height project" (S5P+I: SO2 LH), dedicated to the generation of an SO_2 LH product and its extensive verification with collocated ground- and space-born measurements.

The high-resolution UV spectrometer GOME-2 aboard the three EPS MetOp-A, -B, and –C satellites perform global daily atmospheric trace-gas measurements with a spatial resolution of 40x40km^2 at an overpass time of 8:30h local time. The UV spectrometer TROPOMI aboard the ESA Sentinel-5P satellite provides a much higher spatial resolution of currently 5.6x3.6km^2 per ground pixel, at an overpass time of 13:30h. In the future, also UV instruments aboard the Sentinel-4 (geostationary) and Sentinel-5 will complement the satellite-based global monitoring of atmospheric trace gases.