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Detection and monitoring of the volcanic ash cloud top height applying the Global Navigation Satellite System Radio Occultation technique

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Large amounts of ash, aerosols and gases can be ejected from volcanoes during explosive eruptions into the troposphere, and occasionally into the stratosphere, affecting the atmospheric structure, human society and economy, and life on Earth in general both near and far away from the source. Detecting volcanic cloud top and bottom height at high vertical resolution has thus the following implications: 1) it is crucial for air traffic to know which altitudes are ash free, since an ambient ash density greater than 2 mg/m^3 is considered dangerous for the aircraft engines to fly in, and 2) it is strongly related to the mass ejected by the eruption, the type of ash particles and the optical properties of the ash cloud emitted, making the measurement of the could top height convenient for improving retrievals of the ash plume density. Accurate volcanic ash cloud detection and monitoring are, thus, important, yet deal with many challenges given by 1) the complex nature of volcanic eruption dynamics and their products, 2) the transport processes in the atmosphere as well as 3) the current technology limitations, e.g. weather dependence and coarse vertical resolution.

The Global Navigation Satellite System (GNSS) Radio Occultation (RO) technique, is characterized by high vertical resolution and accuracy as well as weather independency and offers now the possibility to complement other measurement techniques and help solve volcanic clouds monitoring issues with global coverage. To show the capabilities of this method, we selected several volcanic ash clouds detected with different algorithms from IASI, MODIS and SEVIRI and co-located them with GNSS RO profiles. For detecting the cloud top altitude we compared each selected RO bending angle profile in the volcanic cloud area to the monthly RO reference climatology profile extracted for the same location. The cloud top height is usually represented as a pronounced spike in the vertical bending angle anomaly structure. In some cases, the cloud top height detected with RO was validated by using the co-located Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) cloud top data from attenuated backscatter.

We show how this technique has been tested and proven capable of detecting atmospheric anomaly profiles and cloud top height for the 2011 ash-rich eruption of Puyehue volcano, Chile, and 2011 SO_2 rich eruption of Nabro volcano, Eritrea. We additionally show the preliminary setting of the neural network we are optimizing to detect the volcanic cloud top and bottom height and thus the cloud geometrical thickness. This will result in a highly improved volcano monitoring tool and more accurate hazard assessment.