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Multifrequency radar imaging of ash plumes: an experiment at Stromboli

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Volcanic ash emissions in the atmosphere are hazardous to aviation while ash fallout affects people and human activities and may cause damage to infrastructures and economic losses. In the framework of the French Government Laboratory of Excellence ClerVolc initiative, an experiment was carried out on Stromboli volcano (Italy), between 28 September and 4 October 2015. The aim was to retrieve various physical properties of the ash plumes, especially the mass loading parameters which are critical for the modelling of ash dispersal. We used a complementary set of cutting edge techniques recording in different bands of the electromagnetic spectrum. The innovative instrument setup consisted in three radars, hyperspectral thermal infrared and dual-band UV cameras, a mini DOAS-Flyspec and a multigas sensor. A drone equipped with differential GPS was flown near the ash plumes with several sensors including SO_2, CO_2 and particle counter.
We mainly focus on radar measurements of over 200 ash plumes and present some preliminary comparisons at three frequencies. The BASTA Doppler radar at 95 GHz, originally designed for atmospheric studies, was deployed at about 2.2 km in slant distance from the eruptive craters. It was configured to observe volumes above one of the active craters with a spatio-temporal resolution of 12.5 m and 1 s. From the same location, a 1.2 GHz volcano Doppler radar (VOLDORAD) was recording the signature of ballistics and small lapilli at 0.15 s in 60 m-deep volumes. In addition, a commercial 24 GHz micro rain Doppler radar (MRR) simultaneously recorded activity from the Rochette station, at 400 to 650 m from the active craters with a sampling rate of 10 s and a resolution of 25 m. The latter was pointing almost perpendicularly to the other radar beams. Reflectivity factors were measured inside the ash plume above the source vent by the BASTA radar (3 mm wavelength) spanning -9 to +21 dBZ. Fallout could sometimes be tracked during several minutes within the beam, providing additional constraints on particle sizes and sedimentation process from ash clouds. Furthermore, proximal deposits were analyzed by sieving samples collected near the craters and processing data from a laser disdrometer. Ash samples constantly show a unimodal distribution ranging from 44 microns to 1 mm (more rarely 2 mm), with a mode in the range 0.1-0.3 mm. This is expected to be representative of the coarse content of the ash plumes generated by Strombolian explosions at Stromboli, i.e. mainly coarse ash, and will be used to constrain inversions of the radar signals.