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Ground-based Radar Estimation of Mass Flow Rate during 2015 Etna Explosive Eruption

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Volcanic plumes are generated when explosive eruptions discharge of tephra, a mixture of pyroclasts and gas into the atmosphere. Generally the volcanic explosive eruptions are characterized by their mass flow rate (MFR, sometimes also called mass flux or mass eruption rate), a useful parameter to initialize the atmospheric dispersion models. Direct estimation of MFR is rather difficult immediately after and during the eruption, but ground-based Doppler microwave radars, either fixed-pointing or scanning, can offer the possibility of monitoring 24 hours a day, in all weather conditions, at a fairly high spatial resolution and every few minutes after an eruption.
The eruption of the Mt. Etna volcano on 3-5 December 2015 has been analysed applying different approaches in order to retrieve the main features of the eruption, such as the mass concentration, mean tephra diameters and mass flow rate. In this case study both the fixed-pointing L-band and scanning X-band radars as well as Thermal Infrared Camera are considered. Parametric thresholds help to retriever from X-band data the gas thrust region of the explosive eruption, useful to define the tephra volume of interest and the vent effective surface. The methodologies, here implemented and derived from ground-based data, are the TPA (Top Plume Approach), MCA (Mass Continuity Approach), SFA (Surface Flux Approach) and NSA (Near Source Approach).
The retrievals of MFR are compared in order to highlight the different sensitivity of each approach during the eruption activity. Other volcanic tephra characteristics are deduced and compared with those derived from numerical eruption models in order to stress the potentiality of each approaches ingesting the ground-based radar data. Results show that the radar-based methods provide estimates in a relatively good agreement among them. The inter-comparison with collected tephra deposits provides a good consistency in terms of Total erupted mass and volume. Other case studies should be analysed in order to verify and improve the various approaches in estimating eruptive features.