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Improving the ash dispersal forecasting of Etna explosive eruptions by using the VAPOR radar monitoring system

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The volcanic plume modelling needs to know accurately and timely the Mass Discharge Rate (MDR) and Particle Size Distribution (PSD) of the pyroclastic material that, during an explosive eruption, rises from the volcanic vent up to the upper stratosphere and then is dispersed by wind from tens to thousand kilometres far from the volcano. MDR and PSD are key parameters for initializing ash dispersal models, as well as an accurate wind field, and then to simulate realistically the time-space path of the volcanic cloud, which contaminating the atmosphere may disturb seriously the air traffic. Up today, the direct measurement of volcanic and atmospheric parameters during an eruption is not easy to achieve.

Etna volcano made more then 200 ash-plume eruptions in the last 35 years, which caused several problems to the operations of nearest airports and airspace. This fact represents at the same time a problem and a resource for improving the observation and prediction system of volcanic plumes.

Compared to other remote sensing techniques able to detect only the outer surface of the ash clouds, radars can probe the inside plume for 3D measuring of MDR and PSD. A novel radar system, named VAPOR (Volcanic Ash and Plume Observation by Radar), is now operative on Etna volcano, offering better sensitivity than weather radars and a capability to measure plumes in optimal view conditions.

The radar monitoring system consists of two devices, a Doppler-radar at S-band located near the summit vents, and a transportable polarimetric Doppler-radar at X-band to observe the plume from different sites on the volcano slopes. Radar signals are processed in real-time to obtain the values of velocity and backscattered power of the volcanic particles, moreover we are working to develop algorithms for the volcanic parameter inversion, where reflectivity measurements should be used to obtain some volcanic quantities such as ash concentration and fall rate using a given or derived PSD.

During first tests on the field VAPOR radars have achieved very good results, promising to be integrated in the monitoring system of Etna ash-emitting eruptions, which is aimed mainly to improve the forecasting of the airspace contaminated by volcanic ash for improving the air traffic management and the aviation safety.