Geophysical Research Abstracts
Vol. 18, EGU2016-15105-1, 2016
EGU General Assembly 2016

Doppler radar retrievals from lava fountaining paroxysms generating tephra plumes at Mt. Etna

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Etna volcano is one of the most active European volcanoes. Between January 2011 and December 2013, a new crater called the New South East Crater (NSEC) was built during 46 eruptive episodes characterized by lava fountaining generating tephra plumes that reached up to 10 km (a.s.l). A 23 cm-wavelength Doppler radar (VOLDORAD 2B), located about 3 km from NSEC at the Montagnola station and integrated into the INGV-OE instrumental network, has been continuously monitoring the explosive activity of Mt. Etna's summit craters since 2009. We have studied these paroxysms by analyzing the radar echoes and Doppler signals coming from adjacent volumes of the fixed beam probing the lava fountains close to the eruptive crater, in combination with thermal and visible imagery.

The range gating (150 m-deep probed volumes along-beam) allows us to discriminate the active summit craters and to roughly estimate the lava fountain width. The backscattered power, which is related to the erupted tephra mass load in the beam, and Doppler velocities help to mark the transition from Strombolian activity to lava fountaining, providing onset and end times of the fountain. Both radar parameters directly provide a proxy for the mass eruption rate, which is found to follow the time variations of tephra plume height. Oscillations of the echo power during lava fountaining indicate a pulsatile behavior likely originating in the magmatic conduit or deeper reservoir. Ejection velocities retrieved from positive along-beam velocities measured near the emission source, are found to range from 140 to almost 350 m/s during the climax. Maximum along-beam Doppler velocity components from fallouts allow us to infer maximum particle sizes (pluri-decimetric) in agreement with field observations. The mode of power spectral distribution could further be used to constrain the mean diameter of proximal fallout. A reliable quantification of the source mass loading parameters requires more stringent constraints on the complete particle size distribution erupted during the paroxysms and confrontation with independently validated measurements from other sensors such as radar and satellite.