Geophysical Research Abstracts
Vol. 15, EGU2013-8484, 2013
EGU General Assembly 2013

Ground-based microwave radar and optical lidar signatures of volcanic ash plumes: models, observations and retrievals

Luigi Mereu (1), Frank Marzano (1), Saverio Mori (1), Mario Montopoli (), Domenico Cimini (), and Giovanni Martucci ()

(1) Sapienza University of Rome, DIET, Italy , (2) CETEMPS, University of L'Aquila, Italy, (3) University of Cambridge, UK, (4) CNR, IMAA, Italy, (5) NUI Galway, Ireland

The detection and quantitative retrieval of volcanic ash clouds is of significant interest due to its environmental, climatic and socio-economic effects. Real-time monitoring of such phenomena is crucial, also for the initialization of dispersion models. Satellite visible-infrared radiometric observations from geostationary platforms are usually exploited for long-range trajectory tracking and for measuring low level eruptions. Their imagery is available every 15-30 minutes and suffers from a relatively poor spatial resolution. Moreover, the field-of-view of geostationary radiometric measurements may be blocked by water and ice clouds at higher levels and their overall utility is reduced at night.

Ground-based microwave radars may represent an important tool to detect and, to a certain extent, mitigate the hazard from the ash clouds. Ground-based weather radar systems can provide data for determining the ash volume, total mass and height of eruption clouds. Methodological studies have recently investigated the possibility of using ground-based single-polarization and dual-polarization radar system for the remote sensing of volcanic ash cloud. A microphysical characterization of volcanic ash was carried out in terms of dielectric properties, size distribution and terminal fall speed, assuming spherically-shaped particles. A prototype of volcanic ash radar retrieval (VARR) algorithm for single-polarization systems was proposed and applied to S-band and C-band weather radar data. The sensitivity of the ground-based radar measurements decreases as the ash cloud is farther so that for distances greater than about 50 kilometers fine ash might be not detected anymore by microwave radars. In this respect, radar observations can be complementary to satellite, lidar and aircraft observations. Active remote sensing retrieval from ground, in terms of detection, estimation and sensitivity, of volcanic ash plumes is not only dependent on the sensor specifications, but also on the range and ash cloud distribution. The minimum detectable signal can be increased, for a given system and ash plume scenario, by decreasing the observation range and increasing the operational frequency using a multi-sensor approach, but also exploiting possible polarimetric capabilities. In particular, multi-wavelengths lidars can be complementary systems useful to integrate radar-based ash particle measurement.

This work, starting from the results of a previous study and from above mentioned issues, is aimed at quantitatively assessing the optimal choices for microwave and millimeter-wave radar systems with a dual-polarization capability for real-time ash cloud remote sensing to be used in combination with an optical lidar. The physical-electromagnetic model of ash particle distributions is systematically reviewed and extended to include non-spherical particle shapes, vesicular composition, silicate content and orientation phenomena. The radar and lidar scattering and absorption response is simulated and analyzed in terms of self-consistent polarimetric signatures for ash classification purposes and correlation with ash concentration and mean diameter for quantitative retrieval aims. A sensitivity analysis to ash concentration, as a function of sensor specifications, range and ash category, is carried out trying to assess the expected multi-sensor multi-spectral system performances and limitations. The multi-sensor multi-wavelength polarimetric model-based approach can be used within a particle classification and estimation scheme, based on the VARR Bayesian metrics. As an application, the ground-based observation of the Eyjafjallajökull volcanic ash plume on 15-16 May 2010, carried out at the Atmospheric Research Station at Mace Head, Carna (Ireland) with MIRA36 35-GHz Ka-Band Doppler cloud radar and CHM15K lidar/ceilometer at 1064-nm wavelength, has been considered. Results are discussed in terms of retrievals and intercomparison with other ground-based and satellite-based sensors.