MODIS volcanic ash retrievals vs FALL3D transport model: a quantitative comparison

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Abstract
Satellite retrievals and transport models are the main tools to monitor the volcanic clouds evolution. Because of the harmful effects of fine ash particles on aircrafts, the real-time tracking and forecasting of volcanic clouds is key for aviation safety. Together with the security reasons also the economical consequences of a disruption of air traffic must be taken into account. The airport closures due to the recent Icelandic Eyjafjallajökull eruption caused millions of passengers to be stranded not only in Europe, but across the world. IATA (the International Air Transport Association) estimates that the worldwide airline industry has lost a total of about 2.5 billion of Euros during the disruption. Both security and economical issues require reliable and robust ash cloud retrievals and trajectory forecasting. The intercomparison between remote sensing and modeling is required to assure precise and reliable volcanic ash products. In this work we perform a quantitative comparison of ash particle size and total ash mass retrieved from Moderate Resolution Imaging Spectroradiometer (MODIS) retrievals of volcanic ash cloud mass and Aerosol Optical Depth (AOD) with the FALL3D air dispersal model. MODIS, aboard the NASA-Terra and NASA-Aqua polar satellites, is a multispectral instrument with 36 spectral bands operating in the VIS–TIR spectral range and spatial resolution varying between 250 and 1000 m at nadir. The MODIS channels centered around 11 and 12 µm have been used for the ash retrievals through the Brightness Temperature Difference algorithm and MODTRAN simulations. FALL3D is a 3-D time-dependent Eulerian model for the transport and deposition of volcanic particles that outputs, among other variables, cloud column mass and AOD. Three MODIS images collected the October 28, 29 and 30 Mt. Etna volcanic during the 2002 eruption have been considered as test cases. The results show a general good agreement between the retrieved and the modeled volcanic clouds in the first 300 km from the vents. Even if the modeled volcanic cloud area is systematically wider than the retrieved area, the ash total mass is comparable and varies between 35 and 45 kt and between 20 and 42 kt for FALL3D and MODIS respectively. The mean AOD values are in good agreement and approximately equal to 0.8. When the whole volcanic clouds are considered the ash areas and the total ash masses, computed by FALL3D model are significantly greater than the same parameters retrieved from the MODIS data, while the mean AOD values remain in a very good agreement and equal to about 0.8. The volcanic cloud direction in its distortal part is not coincident for the 29 and 30 October 2002 images due to the difference between the real and the modeled local wind fields. Finally the MODIS maps show regions of high mass and AOD due to volcanic puffs not modeled by FALL3D.

References
Costa et al., 2006; Folch et al., 2009
Corradini et al., 2008, 2009, 2010
Dixon et al., 2005
FALL 3D
MODIS
Ash Mass
FALL3D
MODIS
Ash Optical Depth (0.55 µm)

First 300 km from the vents: the retrieved and modeled ash clouds are essentially collocated; the MODIS retrieval highlight regions of high AOD and total ash mass not captured by FALL3D; the total ash mass varies between 30 and 45 kt and between 35 and 60 kt for MODIS and FALL3D respectively; the mean AODs are in good agreement and equal to about 0.8

Whole image
As expected the FALL3D modeled masses are significantly greater than those retrieved from MODIS data (in the plume distal part the ash signal is too low to be detected by MODIS); the mean AOD remain in good agreement and equal to about 0.8. The directions of the retrieved and modeled clouds in their distal parts are not coincident. This is probably due to the difference between the real and the modeled local wind fields.

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Conclusions

THE MT. ETNA 2002 ERUPTION

Mt. Etna (37°73’N, 15°00’E) is a stratovolcano located in the eastern part of Sicily (Italy), is one of the major erupting volcanoes in the world. Etna’s general quiescent state is periodically interrupted by explosive crises, during which significant emissions of gases and ash occur. Ash fallout periodically reaches the surrounding areas affecting the local population and disrupting the nearby Catania, Sigonella, and Reggio Calabria airports.

The Mt. Etna 2002 eruption began on the evening of 28 October with a swarm of earthquakes recorded by the Italian National Institute of Geophysics and Volcanology (INGV). The seismic swarm preceded and accompanied the explosive activity in the NE and S volcano flanks and strombolian activity in the summit area. The explosive activity increased during the following days reaching a paroxysm between 28-31 October, with a fairly sustained plume rising to about 7 km a.s.l. and a fairly sustained eruptive column that rose to about 7 km a.s.l. Ash fallout caused many problems to the surrounding population and infrastructures, including the closure of the Catania Fontanarossa (27 October) and the Reggio Calabria (31 October) airports. Plumes of ash and dust were directed towards the western coastline, causing a light fall-out in Libya (700 km far from Mt. Etna) during the subsequent days.

In this work the 29, 30 and 31 October 2002 images captured between 12:45 and 12:48 UTC respectively, by MODIS-Aqua (29 and 30 October) and MODIS-Terra (31 October), have been considered as test cases.

The volcanic dust optical properties with log-normal size distribution and particle density equal to 2500 kg/m³ have been considered.

The MER and plume column height derive from Andronico et al., 2009 and Corradini et al., 2009. This work has been accepted for publication:


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