Geophysical Research Abstracts,
Vol. 11, EGU2009-9967, 2009
EGU General Assembly 2009

Estimation of volcanic eruption characteristics using satellite-based observations and coherent trajectory ensembles

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Volcanic eruptions and unrest are among the main natural hazards, which influence nature, human beings and climate. Large amounts of ash, rock fragments and trace gases can be emitted into the atmosphere. One of these trace gases is sulphur dioxide (SO2) which is a good indicator for volcanic ash clouds and can be detected by several satellite instruments such as GOME-2 (Global Ozone Monitoring Experiment) and OMI (Ozone Monitoring Instrument).

These satellite-based observations provide a global and daily monitoring of total SO2 columns of volcanic or anthropogenic origin. However, the measurements only deliver a two-dimensional snapshot of the SO2 distribution i.e. SO2 plumes. By combining satellite observations of increased SO2 concentrations and a newly developed backward trajectory ensemble modelling technique, information on volcanic eruption characteristics and SO2 plumes can be derived.

Relevant parameters such as the location of the emission source, the moment of the eruption as well as the emission or plume height are estimated from the observations. The method uses geolocations and observation times of enhanced SO2 values from satellite-based measurements, meteorological analyses from the European Centre for Medium Range Weather Forecast (ECMWF) and the Lagrangian kinematic trajectory model FLEXTRA. The sensitivity of the retrieved parameters versus the initialisation parameters of the inversion (observation time, longitude and latitude) was tested for significance.

Different case studies for recent volcanic eruptions are presented: (1) the eruption of Mount Etna, Italy in May 2008, (2) Hawaiian effusive eruptions in 2008 and (3) the eruption of Mount Okmok, Alaska in July 2008.

In order to evaluate the presented method the derived source terms were used to initialize forward integrations of the 3D Eulerian chemical transport model POLYPHEMUS and the 3D Lagrangian particle dispersion model FLEXPART. The resulting SO2 plumes were finally compared to observations.