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The impact of Mount Etna's sulphur emissions to the atmospheric composition, aerosol properties and radiative transfer in the central Mediterranean: 14 years of statistic analysis using observations and Lagrangian modelling

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Volcanic eruptions influence tropospheric and stratospheric composition, the Earth's radiation budget from the regional to the global scale, and then the Earth's climate. While the impact of the strong explosive eruptions reaching the stratosphere is relatively well known, the influence of the more frequent weak volcanic activity, including passive degassing, on the tropospheric aerosol properties and on the radiation budget is still largely unknown. Most of the radiative effects of moderate eruptions are associated with changes of the aerosol size distribution, composition, and shape. Emission of primary particles, mainly ash, and secondary aerosols through gas-to-particle conversion of volatile sulphur compounds contribute to affect the aerosol properties.

Mount Etna's continuous degassing and episodic explosive eruptions is an important source of particles and gases for the Mediterranean atmosphere, with, e.g., ten times larger emissions of volatile sulphur compounds than the anthropogenic sulphur emissions in the Mediterranean area. The impact of Mount Etna on the atmospheric composition, the aerosol chemical, microphysical and optical properties, the clouds occurrence and properties, the radiative balance and the regional climate in the Mediterranean are not known and probably underestimated.

In this contribution, the downwind impact of Mount Etna's sulphur emissions in the central Mediterranean is estimated over the period 2000-2013 using long-term series of sulphur dioxide column and Ångströms exponent observations at the the ENEA (Ente Nazionale per l'Energia e l'Ambiente) Station for Climate Observations on the small island of Lampedusa (35.5°N, 12.6°E). These observations are linked to the information on the volcanic source, in terms of 1) the local dynamics, using a long series of trajectories and plume dispersion information obtained with the FLEXPART Lagrangian mode, and 2) the emission strength, using the long-term series of daily sulphur dioxide emission rates measured at Mount Etna with the FLAME network (a near-crater network of ground-based ultraviolet spectrophotometers, operated by the INGV - Istituto Nazionale di Geofisica e Vulcanologia). This statistical analysis has allowed, for the first time, the characterization of the impact of Mount Etna's sulphur emissions to the sulfur dioxide distributions and the aerosol microphysical/optical characterisation in the central Mediterranean. This impact is here presented and critically discussed. Finally, the radiative forcing of simulated Mount Etna's plumes is estimated for different optical properties and vertical distributions of the volcanic aerosols. We have found that the radiative forcing efficiency of Mount Etna's plumes can be as important as the efficiency related to the most frequent Saharan dust or pollution transport events, in the same area.