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Investigating the model-dependent uncertainty of volcanic ash dispersal forecasts

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Accurate modelling of volcanic ash dispersal and deposition is a challenging goal for volcanology. In particular, forecasts of tephra dispersal have a key role in the assessment of the associated hazard and impact mitigation. In order to produce robust forecasts of this phenomenon in case of explosive events occurring at Mt. Etna (Sicily, Italy), the Istituto Nazionale di Geofisica e Vulcanologia has set up an automatic web-based procedure based on a multi-model simulation approach. Each day five numerical models, named FALL3D, HAZMAP, PUFF, TEPHRA and VOL-CALPUFF, produce forecasting maps of aerial ash concentration and tephra deposit generated by hypothetical explosive events at Mt. Etna. By adopting the same initial meteorological dataset provided by an external mesoscale model, the numerical codes produce, for each eruptive scenario assumed, time-varying maps of ash concentration at different vertical atmospheric levels, maps of ash concentration vertically integrated over the domain, and maps of cumulative ground deposition. Model outcomes are then integrated to produce synthetic maps to be used as early-warning information for aviation and airport operations. Such a multi-model approach allows to quantify the model-dependent uncertainty characterizing the modelling capability. In fact, the five numerical codes, based on different modelling approach (e.g. Eulerian vs Lagrangian), different physical formulations of the process, as well as different numerical algorithms, allow us to obtain independent representations of the phenomenon. Quantitative comparisons between different model results were performed estimating key variables of ash dispersal and deposit. Some of the most important variables are the plume height, the main dispersal axis of the cloud, the ash cloud aerial extension and shape, as well as the tephra ground deposition at specific locations. Comparisons were extended over a time period of several months and allowed analytical comparisons between the models as a function of the eruptive and meteorological conditions assumed. Statistical analyses were also carried out to discriminate between casual random and systematic differences between these models. Such differences were then interpreted in terms of the specific features of each model so to gain crucial insights on the strengths and weaknesses of different models.