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Sensitivity tests and ensemble hazard assessment for tephra fallout at Campi Flegrei, Italy

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We present the results of a statistical study on tephra dispersion in the case of reactivation of the Campi Flegrei volcano. We considered the full spectrum of possible eruptions, in terms of size and position of eruptive vents. To represent the spectrum of possible eruptive sizes, four classes of eruptions were considered. Of those only three are explosive (small, medium, and large) and can produce a significant quantity of volcanic ash. Hazard assessments are made through dispersion simulations of ash and lapilli, considering the full variability of winds, eruptive vents, and eruptive sizes. The results are presented in form of four families of hazard curves conditioned to the occurrence of an eruption: 1) small eruptive size from any vent; 2) medium eruptive size from any vent; 3) large eruptive size from any vent; 4) any size from any vent.
The epistemic uncertainty (i.e. associated with the level of scientific knowledge of phenomena) on the estimation of hazard curves was quantified making use of alternative scientifically acceptable approaches. The choice of such alternative models is made after a comprehensive sensitivity analysis which considered different weather databases, alternative modelling of the possible opening of eruptive vents, tephra total grain-size distributions (TGSD), relative mass of fine particles, and the effect of aggregation. The results of this sensitivity analyses show that the dominant uncertainty is related to the choice of TGSD, mass of fine ash, and potential effects of ash aggregation. The latter is particularly relevant in case of magma-water interaction during an eruptive phase, when most of the fine ash can form accretionary lapilli that could contribute significantly in increasing the tephra load in the proximal region. Relatively insignificant is the variability induced by the use of different weather databases.
The hazard curves, together with the quantification of epistemic uncertainty, were finally calculated through a statistical model based on ensemble mixing of selected alternative models, e.g. different choices on the estimate of the total erupted mass, mass of fine ash, effects of aggregation, etc.
Hazard and probability maps were produced at different confidence levels compared to the epistemic uncertainty (mean, median, 16th percentile, and 84th percentile).