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Ash fallout long term probabilistic volcanic hazard assessment for Neapolitan volcanoes: an example of what Earth Scientists can do with HPC resources

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The creation of hazard maps relative to volcanic phenomena requires taking into account the intrinsic complexity and variability of eruptions. Here we present an example of how HPC can allow producing a high resolution multi-source probabilistic hazard assessment due to tephra fallout over a domain covering Southern Italy.

The three active volcanoes in the Neapolitan area, Somma-Vesuvius, Campi Flegrei and Ischia, were considered as volcanic sources. For each one, we explored three explosive size classes (Small, Medium and Large) for Somma Vesuvius and Campi Flegrei, and one explosive size class (Large) for Ischia. For each size class, we performed 1500 numerical simulations of ash dispersion (total of 10500) using the Fall3D (V8.0) model over a computational domain covering Southern Italy with a 0.03° □ 0.03° (~3 km □ 3 km) resolution. Within each size class, the eruptive parameters have been randomly sampled from well-suited probability distributions and with different meteorological conditions, obtained by randomly sampling a day between 1990 and 2020 and retrieving the relative data from the ECMWF ERA5 database. This allowed exploring the intra-class variability and to quantify aleatoric uncertainty. The results of these simulations have been post-processed with a statistical approach by assigning a weight to each eruption (based on its eruption magnitude) and the annual eruption rate of each size class. For the case of Campi Flegrei, the variability in the eruptive vent position has also been explored by constructing a grid of possible vent locations with different spatial probability. By merging the results obtained for each source and size class we produced a portfolio of hazard maps showing the expected mean annual frequency of overcoming selected thresholds in ground tephra load. A disaggregation analysis has also been performed in order to understand which particular source and/or size class had the greater impact on a particular area.

The completion of this work, considering both numerical simulations and the statistical elaboration of the results has required a total of more than 5000 core hours and the processing of more than 2TB of data, an effort that wouldn't have been possible without the access to high level HPC resources.