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Empirical and analytical determination of eruptive parameters

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The determination of eruptive parameters (e.g. plume height, erupted volume, mass discharge rate, duration, grain-size distribution) is crucial to the interpretation of the activity and therefore the hazard assessment of any given volcano. Characterization of tephra deposits allows for most eruptive parameters to be constrained, even though some parameters of recent eruptions can be more accurately derived from direct observations and satellite retrievals (e.g. plume height). In particular, the distribution of tephra thickness and mass per unit area around the volcano (isopach and isomass maps) is necessary for the estimate of erupted volume, whereas the distribution of the largest clasts (isopleth maps) is typically used for the estimate of column height and wind speed at the time of the eruption. Both isopach/isomass maps and isopleth maps can also be used for the determination of the eruptive vent location and the classification of the eruptive style. The mass eruption rate and the duration of the sustained phase can be calculated from a combination of these parameters. Indications on fragmentation mechanisms can also be inferred from the study of particle size. Eruptive parameters can be inferred by applying empirical, analytical and numerical models and through the inversion solutions of analytical models. These empirical and analytical models need to be thoroughly analyzed and the associated assumptions and limitations need to be investigated in order to assess the variability of resulting eruptive parameters. This is crucial not only because these eruptive parameters are used to characterize volcanic eruptions but also because they are used as input to numerical models and to construct potential activity scenarios for hazard assessment. In addition, tephra deposits cannot be uniquely characterized especially when associated with old eruptions and were affected by erosion and reworking. Here we apply different models to different eruptions, both recent and prehistoric, in order to assess the variation of results. Our study confirms how the empirical extrapolation of poor data sets can be misleading. We also analyze in detail the application of inversion techniques on the model TEPHRA for the derivation of erupted mass and plume height and discuss advantages and limitations. We found that the choice of parameter ranges can significantly affect the final result and therefore requires critical analysis. As an example, empirical and analytical models could be used first to constrain the order of magnitude of a given parameter (e.g. erupted mass and plume height) and to reduce the variation range considered in inversion calculations. In addition, inversion techniques applied on mass/area data give an excellent constraint on the eruption mass but not on the column height. It is also worth stressing that studies of poorly-exposed deposits have shown how the method of Carey and Sparks (1986) gives good results for the determination of plume height even when the position of the vent is not well known. Inversion techniques applied on grainsize also give better results than inversion techniques applied on mass/area data on the determination of column height. In conclusion, empirical, analytical and numerical models should all be critically used to obtain independent results and better quantify the level of uncertainty on the eruptive parameters.