Insights into tephra total grain-size distribution from field data analysis

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The Total Grain-Size Distribution (TGSD) of tephra deposits is crucial for hazard assessment and provides fundamental insights into eruption dynamics. TGSD is controlled by magma and wall-rock fragmentation processes, and has a primary control on the plume sedimentation processes and mass and particle size distribution in the eruptive plumes. Typically it is calculated by integrating deposit grain- size at different locations and the result of such integration is strongly affected not only by the number, but mostly by the spatial distribution and distance from the vent of the sampling sites. The minimum sampling distance required to accurately sample particles of different sizes was here assessed through dedicated numerical simulations of tephra dispersal. Results reveal that, depending on wind conditions, a representative grain-size distribution of tephra deposits down to ~100 μm can be obtained by integrating samples collected at distances from less than one tenth up to a few tens of the column height. The statistical properties of representative TGSDs were calculated by fitting the data with a few general distributions given by the sum of two log-normal distributions (bi-Gaussian in Φ-units) and the sum of two Weibull distributions, and a generalized log-logistic distribution for the cumulative number distributions. All these distributions adequately fit the datasets, which are often bimodal. Fitting results of the cumulative number distribution show two different power law trends for coarse and fine fractions of tephra particles, respectively. The main parameters of the bi-Gaussian fitting correlate with height of the eruptive columns and magma viscosity, allowing general relationships to be used for estimating TGSD generated in a variety of eruptive styles and for different magma compositions. Moreover finer particles are characterized by a fractal exponent correlated with eruption intensity, whereas coarser particles have a different exponent with an opposite trend. The results shed light on the complex processes characterizing magma fragmentation and represent the first attempt to assess TGSD on the basis of pivotal physical quantities such as magma viscosity and eruption intensity.