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Estimating the volume of tephra deposits: a new simple strategy

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Volume determination of tephra deposits is necessary for the assessment of the magnitude, dynamics and hazards of explosive volcanoes. Several methods have been proposed during the last forty years that include the analysis of crystal concentration of large pumices; integrations of various thinning relationships; and the inversion of field observations using analytical and computational models. Regardless of their strong dependence on tephra-deposit exposure and distribution of isomass/isopach contours, empirical integrations of deposit-thinning trends still represent the most widely adopted strategy due to their practical and fast application. The most recent methods involve the best-fitting of thinning data using various exponential segments or a power-law curve on semi-log plots of thickness (or mass/area) versus square root of isopach area. The exponential method is mainly sensitive to the number and the choice of straight segments, whereas the power-law method can better reproduce the natural thinning of tephra deposits but is strongly sensitive to the proximal and distal extremes of integration. We analyze a large dataset of tephra deposits and propose a new empirical method for the determination of tephra-deposit volumes that is based on the integration of the Weibull function. The new method shows a better agreement with observed data reconciling the debate on the use of the exponential versus power-law method. In fact, the Weibull best-fitting only depends on three free parameters, can well reproduce the gradual thinning of tephra deposits and does not depend on the choice of arbitrary segment or of arbitrary extremes of integration. Nonetheless, due to the typical large uncertainties investigated in our study (mainly due to availability of data, compilation of isopach maps and discrepancies from empirical best fits), volume and magnitude of explosive eruptions cannot be considered as single values regardless of the technique used. It is crucial to assess such an uncertainty even adopting multiple techniques.