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Hierarchical Bayesian modelling of mobility metrics for hazard model input calibration

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In this work we present a method to constrain flow mobility input parameters for pyroclastic flow models using hierarchical Bayes modeling of standard mobility metrics such as H/L and flow volume etc. The advantage of hierarchical modeling is that it can leverage the information in global dataset for a particular mobility metric in order to reduce the uncertainty in modeling of an individual volcano, especially important where individual volcanoes have only sparse datasets. We use compiled pyroclastic flow runout data from Colima, Merapi, Soufriere Hills, Unzen and Semeru volcanoes, presented in an open-source database FlowDat (https://vhub.org/groups/massflowdatabase). While the exact relationship between flow volume and friction varies somewhat between volcanoes, dome collapse flows originating from the same volcano exhibit similar mobility relationships. Instead of fitting separate regression models for each volcano dataset, we use a variation of the hierarchical linear model (Kass and Steffey, 1989). The model presents a hierarchical structure with two levels; all dome collapse flows and dome collapse flows at specific volcanoes. The hierarchical model allows us to assume that the flows at specific volcanoes share a common distribution of regression slopes, then solves for that distribution. We present comparisons of the 95% confidence intervals on the individual regression lines for the data set from each volcano as well as those obtained from the hierarchical model. The results clearly demonstrate the advantage of considering global datasets using this technique. The technique developed is demonstrated here for mobility metrics, but can be applied to many other global datasets of volcanic parameters. In particular, such methods can provide a means to better contain parameters for volcanoes for which we only have sparse data, a ubiquitous problem in volcanology.