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New insights into the relationship between mass eruption rate and volcanic column

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Understanding the relationship between the mass eruption rate (MER) and volcanic column height is essential for both real-time volcanic hazard management and reconstruction of past explosive eruptions. Using 134 eruptive events from the new Independent Volcanic Eruption Source Parameter Archive (IVESPA, v1.0), we constrain bespoke empirical MER-height relationships for four measures of column height: spreading level, sulfur dioxide height, and two measures of top height, from direct observations and as reconstructed from deposits. These relationships show significant differences, and we discuss implications for their applications in ash dispersion forecasting and modelling volcanic climate impacts. The roles of atmospheric stratification, wind, and humidity remain challenging to detect across the wide range of eruptive conditions spanned in IVESPA, ultimately resulting in empirical relationships outperforming analytical scaling relationships and the Geneva 1-dimensional (1D) volcanic plume model accounting for atmospheric conditions. However, when excluding the IVESPA events with the highest uncertainties, the 1D model progressively outperforms the empirical MER-height relationship. Our findings highlight persisting challenges in constraining the MER-height relation and reinforce the need for improved eruption source parameter databases documenting uncertainties, as well as improved physics-based models.