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The role of erosion in the morphometry of composite volcanoes

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Volcanoes are extremely dynamic landforms. They grow by the accumulation of eruptive products and intrusions and degrade by a range of erosion processes such as superficial runoff, chemical and physical weathering, fluvial and glacial incision, and mass movements. In this study, we aim at documenting and quantifying the morphology of natural composite volcanoes using a range of morphometric indices, to better understand the factors that control erosion rates and patterns.

In addition to standard morphometric indices, including edifice ellipticity and irregularity, computed by the MORVOLC algorithm, a fractal dimension tool is developed to quantitatively report the shape complexity of stratovolcanoes. A convex hull approach is used to derive minimal erosion volumes and estimate erosion rates, considering available geochronological constraints. Morphometric parameters are derived from digital elevation models (DEMs) for a few exemplary stratovolcanoes of contrasted ages from the same volcanic region. To analyse the potential bias induced by the selected DEMs and the identification of the volcanic edifice outline, we also conduct a sensitivity analysis. The morphometric parameters are similarly extracted using the freely and globally available ALOS 30m (AW3D30), SRTM 30m (SRTMGL1), and ASTER 30m (GDEM 003), and compared to values obtained with the TanDEM-X 12m. The subjective user-drawn edifice outlines are compared to outlines generated by available algorithms, i.e. NETVOLC and MBOA, and their impact on the accuracy of morphometric indexes is quantified.

Our results highlight that erosion increases edifice irregularity and fractal dimension. Preliminary trends between volcano fractal dimension, eroded volume, and age suggest that fractal analysis has the potential to be used as a relative age determination tool. The proposed morphometric characterisation paves the way for a comparison between natural volcanoes and controlled lab experiments reproducing the degradation of pristine volcanic cones by surface runoff to be developed later in our project.