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Quantitative analysis of the variability of volcanic shields' morphometry

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Shield volcanoes are described as low angle edifices that have convex up topographic profiles and are built primarily by the accumulation of successive lava flows. This generic view of shields' morphology is based on a limited number of monogenetic shields in Iceland or Mexico and a small set of large oceanic islands (Hawaii, Galapagos). Here, the morphometry of 77 large Holocene shield volcanoes, as identified by the Global Volcanic Network database, is analysed quantitatively from SRTM DEMs using the MORVOLC algorithm. This algorithm enables to quantify in a systematic and comparable way the size, aspect ratios, and transversal and plan shape of each shield and, if present, its summit caldera. An additional set of 8 volcanoes identified as stratovolcanoes but known to be dominantly built up by accumulation of basaltic lava flows are documented for comparison (e.g. Mt Cameroon, Etna, Cumbre Vieja on La Palma). Results show that there is a large variation in shield size (volumes range from $\sim$1 to >1000 km3), elongation, profile shape (height/base diameter ratios range from 0.01 to 0.1) and in the average and maximum flank slope gradients. Analysis of the obtained quantitative database enables to identify a set of key morphometric descriptors which include volume, average ellipticity, maximum slope gradient interval, height-to-base ratio, size of the summit plateau or caldera, number of secondary peaks/vents and slope vs elevation profile. Using these criteria, a new classification scheme is proposed. It highlights the control of the magma feeding system – either central, along a linear structure, or diffuse – on the resulting volcano morphology. Genetic relationships and evolutionary trends between contrasted morphological end-members can be highlighted within this new scheme. Additional findings are that the Galapagos-type morphology with a central deep caldera and steep upper flanks are characteristic of other shields like Nyamulagira . A series of large oceanic shields (Karthala, Aoba, Stanta Isabel) have slopes systematically much steeper than the low gradients (<4-8°) generally attributed to large Hawaiian-type shields. Finally, the continuum of morphologies from flat shields to steeper complex volcanic constructs considered as stratovolcanoes call for a revision of this oversimplified distinction, taking into account the lava/pyroclasts ratio and the spatial distribution of eruptive vents.