# Crossing the (shore) line: A geomorphometric database of volcanic islands

Elisa Klein, Emma Hadré, Sebastian Krastel, Morelia Urlaub

GEOMAR

## The Problem

1. A silent threat?

Volcanic islands are a source of various hazards, including sector collapses and their consequecial tsunamis. The accompanying seismic signals are usually too weak to be felt or registered by global tsunami warning systems, as these are designed to detect tsunamigenic earthquakes. Thus a better understanding of which volcanic islands are more prone to collapse is needed.

2. An ocean of secrets

While sattelites provide high resolution elevation information with resolutions in the metre-scale, only about 25% of the seafloor is mapped with shipborne bathymetric data <400m (1). Coastal areas are especially difficult to survey, often leading to a "coastal white ribbon" of a lack of data. This includes the submarine flanks of volcanic islands, which usually make up the majority of the volcanic edifice (Figure 1). Nevertheless, bathymetric data often presents the only available information below sealevel, especially in remote, uninhabited areas.

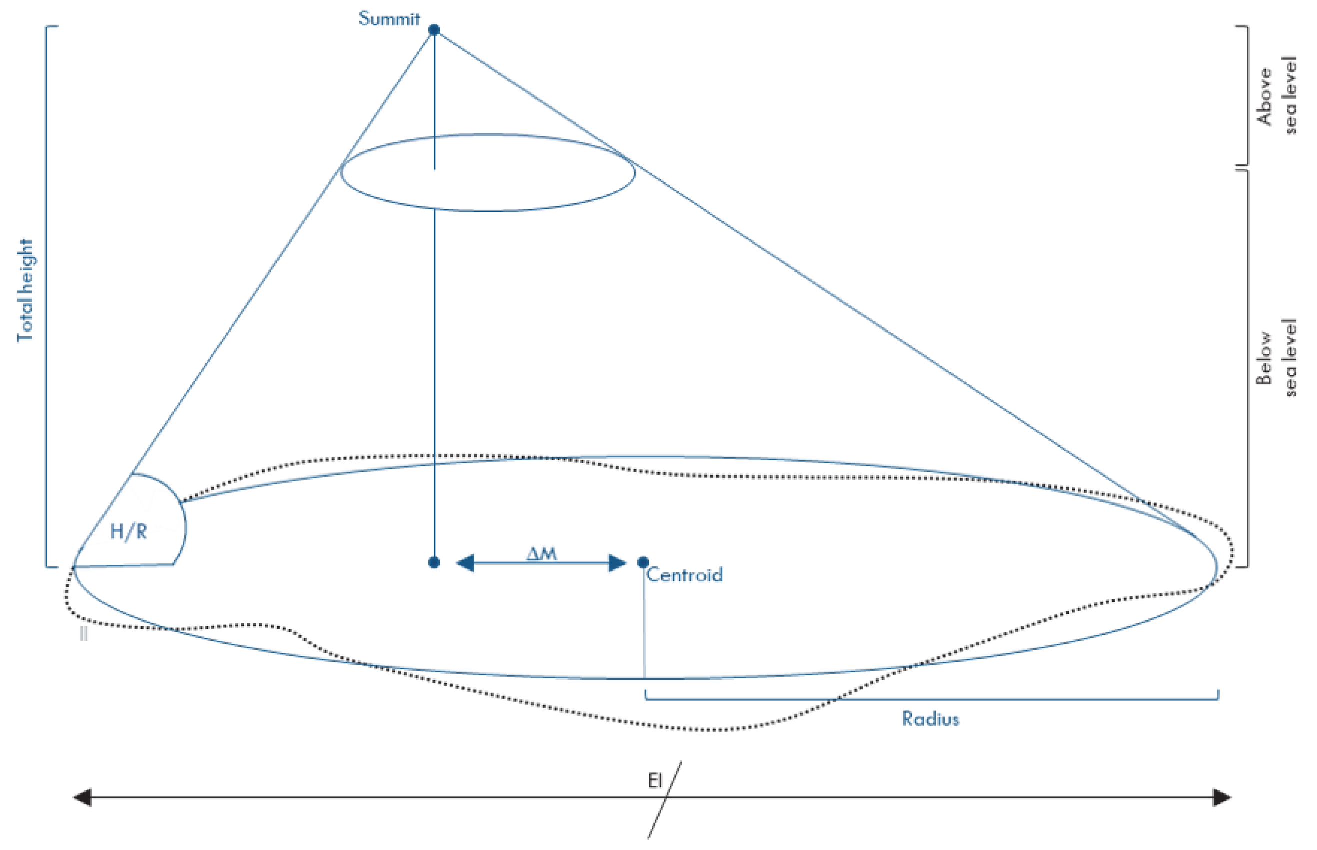


*Figure 2: Sketch of geomorphometric parameters. They include size, slope and asymmetry related parameters.*

## The Results

So far, we included 47 volcanic islands in our database. The distribution of the parameters are shown in Figure 3. The islands on the x-axes are sorted descending by their total height in all subplots. Our study covers a great range of sizes of volcanic islands from Genovesa (Galapagos), with 78m the smallest island by elevation above sea level to the great Hawaiian Islands which reach more than 4000m a.s.l. The size parameters generally follow the law of high numbers, meaning that there are a few very large volcanic islands and a significantly higher number of smaller volcanic islands. This is a welcoming evidence that our chosen sample is representative.

## The Helpful GEBCO?

To adress the lack of high resolution bathymetry data on the submarine slopes of the islands, we investigated how well our method performs, when using the data of the General Bathymetric Chart of the Ocean (GEBCO) (5). This is a global dataset of 15 Arc second resolution (appr. 450m) which relies on predicted bathymetry from satellite measurements, where no shipborn information is available. For the comparison we calculated the deviation D of the parameters calculated with GEBCO from those derived from the high-resolution grids. Additionally we investigated the influence of the DEM and the Delineation of the results separately.The results are shown in Figure 4. In summary, 20 out of 24 parameters show <±2.5% median deviation, and quartiles <±10%. Only the slope parameters (Slmn, Slasl,mn, Slbsl,mn) and Hasl have systematic deviations greater than that. See (6) for more detailed information.

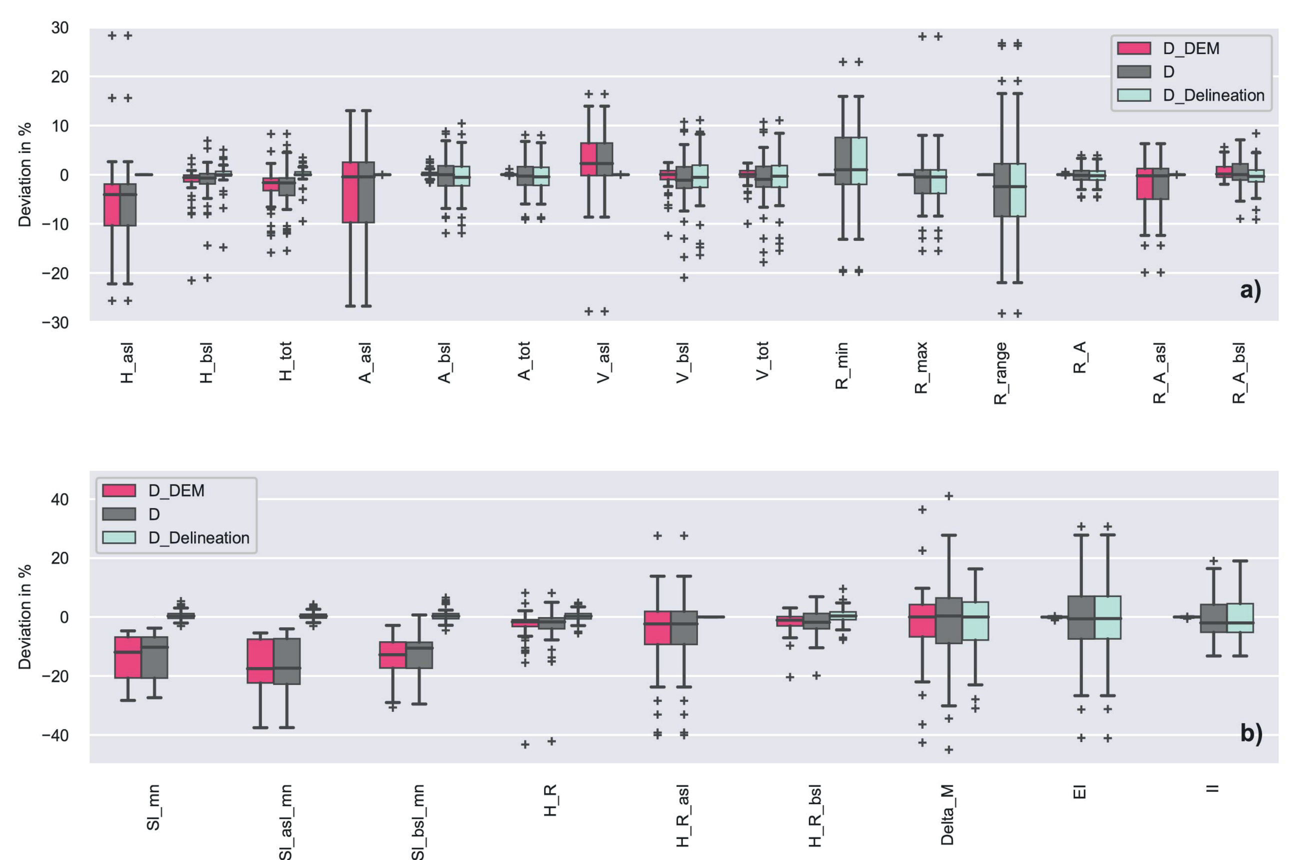


*Figure 4: Deviation of the geomorphometric parameters calculated with GEBCO from those derived from high-resolution grids. The total Deviation D is shown in grey, the influence of the DEM in pink and of the Delineation in light blue.*

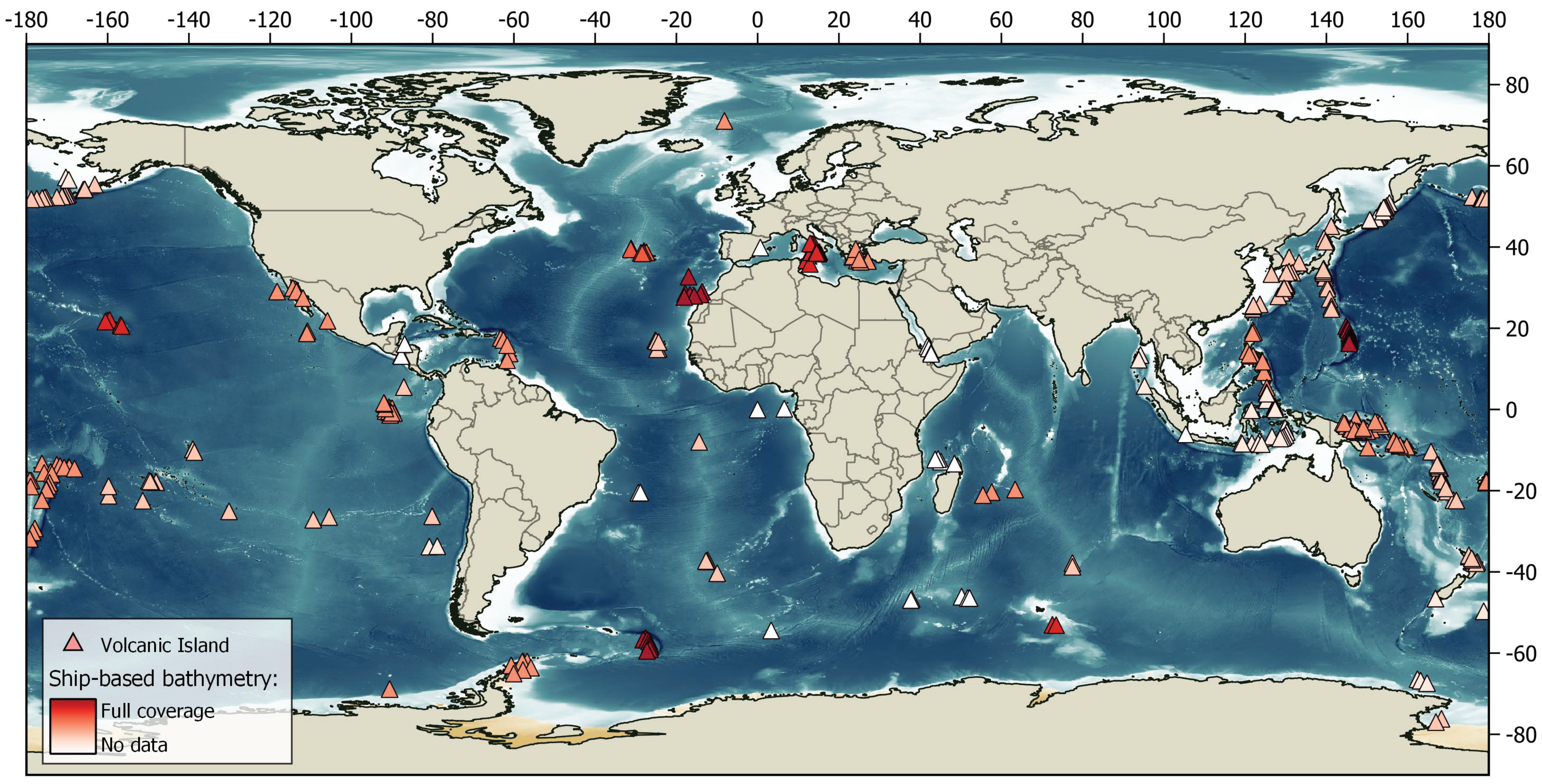


*Figure 1: A world map of marine volcanos (triangles). The submarine flanks of the volcanic islands are often not well covered with ship-based bathymetry (light colors). The dark red triangles, representing full coverage, are rare.*

## The Idea

We are creating a database of geomorphometric information derived from Digital Elevation Models (DEMs) from online plattforms, such as GMRT (2) that cover the entire volcanic edifice from summit to seafloor. First, we need to define the outline of the volcanic base. We use a semi-automated approach, where the 3-degree slope contour line is used and modified by hand where necessary (3). For the extraction of the geomorphometric parameters, we use our algorithm created with the free software QGIS and Python (inspired by (4)). The 24 parameters consist of three main categories: size (height, area, volume, radius), slope (from the DEM and H/R) and shape or asymmetry parameters (Fig. 2). All the information is gathered in a database, which can be analysed statistically, to find correlations between the geomorphology and the instabilty of volcanic islands.

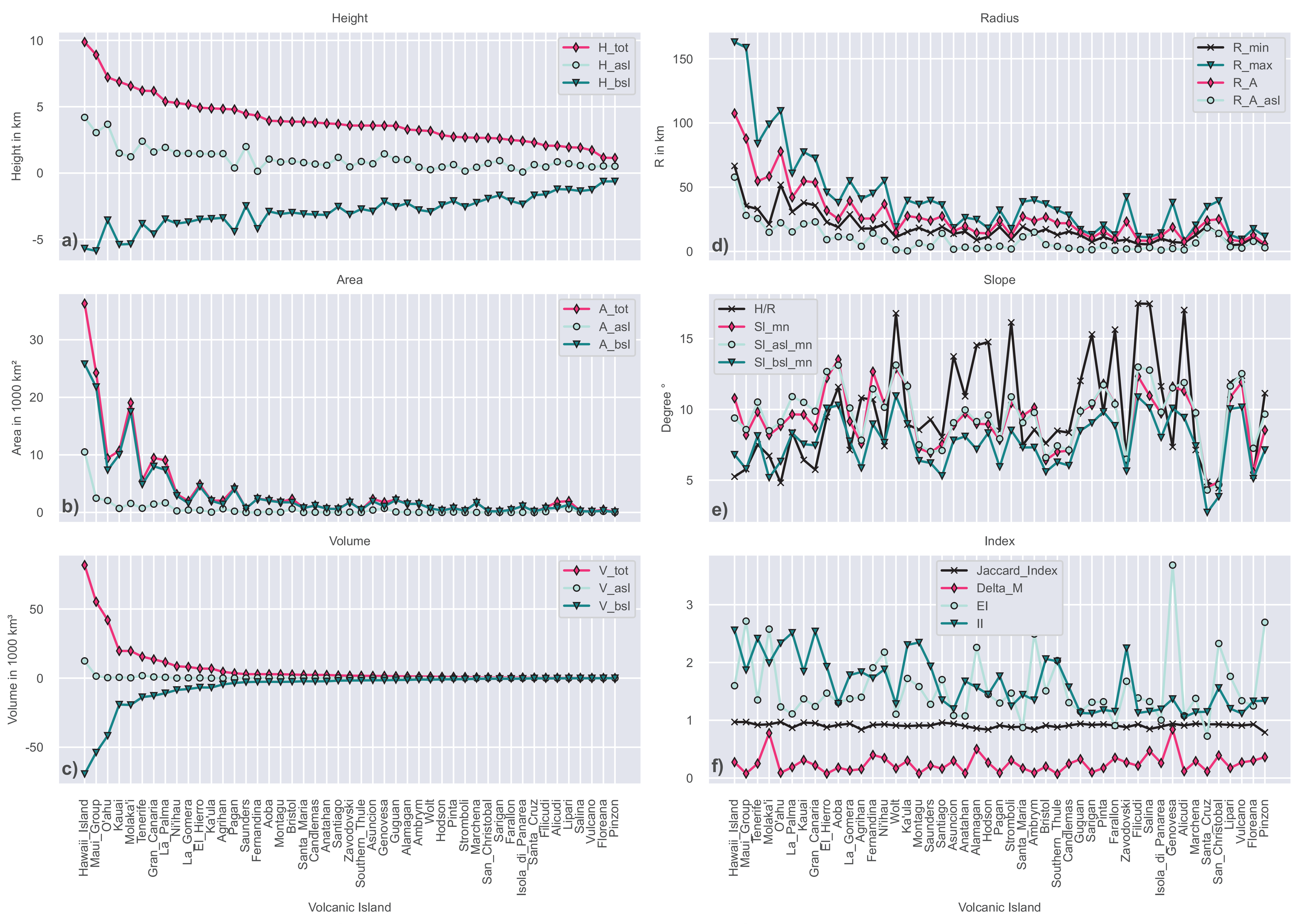


*Figure 3: An overview of the geomorphometric parameters of 47 volcanic islands sorted by their total height.*

## The Future

With the confirmation that most of the parameters can reliably be calculated from the world-wide, low-resolution grid of GEBCO, we will be able to expand our database significantly. We are currently investigating how to integrate coastal volcanos, like the Etna in Sicilly, which are only partially sourrounded by water.

With a more extensive database a probablistic approach to finding correlations between the geomorphology and the instability of volcanic islands become more reliable. We are planning on making the database publically available upon its completion, so that it can be implemented into existing hazard assesments in the future.

## References

*(1) [Dataset] National Oceanographic Centre (2023). A quarter of the ocean floor is now mapped. Publisher: National Oceanographic Centre*

*(2) Ryan, W. B. F., Carbotte, S. M., Coplan, J. O., O'Hara, S., Melkonian, A., Arko, R., et al. (2009). Global Multi-Resolution Topography synthesis: GLOBAL MULTI-RESOLUTION TOPOGRAPHY SYNTHESIS. Geochemistry, Geophysics, Geosystems 10, n/a–n/a. doi:10.1029/2008GC002332*

*(3)Van Wees, R., Tournigand, P.-Y., O'Hara, D., Grosse, P., Kereszturi, G., Campforts, B., et al. (2021). The role of erosion in the morphometry of composite volcanoes. other, pico. doi:10.5194/ egusphere-egu21-14500*

*(4) Grosse, P., van Wyk de Vries, B., Euillades, P. A., Kervyn, M., and Petrinovic, I. A. (2012). Systematic morphometric characterization of volcanic edifices using digital elevation models. Geomorphology 136, 114–131. doi:10.1016/j.geomorph.2011.06.001*

*(5) [Dataset] GEBCO Bathymetric Compilation Group 2021 (2021). The GEBCO 2021 Grid - a continuous terrain model of the global oceans and land. doi:10.5285/ C6612CBE-50B3-0CFF-E053-6C86ABC09F8F. Type: dataset*

*(6) Klein, E., Hadré, E., Krastel, S. and Urlaub, M. (2023). An evaluation of the General Bathymetric Chart of the Ocean (GEBCO) in shoreline-crossing geomorphometric investigations of volcanic islands. Front. Mar. Sci.(in press)*

*This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 948797)*