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Comment on esurf-2022-18

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Referee comment on "Initial shape reconstruction of a volcanic island as a tool for quantifying long-term coastal erosion: the case of Corvo Island (Azores)" by Rémi Bossis et al., Earth Surf. Dynam. Discuss., https://doi.org/10.5194/esurf-2022-18-RC1, 2022

Comment on: "Initial shape reconstruction of a volcanic island as a tool for quantifying long-term coastal erosion: the case of Corvo Island (Azores)" by Bossis et al. (in review).

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The proposed method described in this manuscript is attractive in potentially providing a straightforward way to quantify the spatial variation in long-term erosion rate around volcanic islands. This effectively continues observations of apparent erosional asymmetry observed at islands with persistent wind and wave directions that appeared as nautical charts became more accurate. Menard may be one of the originators and certainly wrote about this in his book (some historical background could be interesting in the introduction). By building on the work of Karátson et al. (2010), it benefits from their study of many stratovolcanoes. It uses trends in both subaerial and submarine slope elevations to estimate the original coastline position. The results presented suggest erosion has been greatest on the side of the island where waves dominate at the present day.

I had some questions about the assumed geometry. There is some evidence that sediments released by erosion are not fully exported into the deep basins around volcanic ocean islands, as assumed by Bossis et al., but instead accumulate on their uppermost flanks. Examples include:

- Short term development of the Capelinhos Surtseyan cone since its formation by a volcanic eruption in 1957/58 (Zhao et al., 2019). In this case, the original position of the coastline is known from aerial photographs taken during and immediately after the eruption. The platform slope break located using swath sonar is seaward of the position expected from the starting coastline position by 100 to several 100 m, even allowing for dip of material between IE and platform edge. (These distances may not seem important but the cone was small so they actually represent a large proportion of the original cone diameter.)
- Work carried out by Yu-Chun Chang and co-workers on the central Azores has involved comparing volcaniclastic turbidites containing evidence of shelf involvement (e.g., bioclastic particles) in sediment cores from basins near the islands (Chang et al., 2021a) with the volumes of landslide valleys in the uppermost submarine slope (Chang et al., 2021b). Between the landslides and the core sites, there are abundant sedimentary waves produced by sedimentary gravity flows (Chang et al., 2022). Chang and co-workers have found that only the largest landslide volumes correspond with the turbidite volumes, so the smaller landslides produce sedimentary gravity flows that deposit on the submarine slope without reaching the basin floor. This is also corroborated by their study of sedimentary fluxes. They used estimates of Quartau et al. (2012) of sediment released by island erosion (coastal and fluvial) and biogenic production on the shelf of Faial Island (Azores). Those estimates scaled to the portion of the island facing north have been compared with the depositional fluxes in the basin to the north of the island constrained using ^{14}C dates and volume modelling. They found that <10% of the sediment produced at the island has reached the basin over >ky timescales.
- Modelling of seismic refraction data collected around volcanic islands typically reveals low seismic velocities beneath the submarine slopes. While this could be caused by volcanic processes (e.g., lower bulk rigidity of lavas compared with intrusive rocks), they could also be due to widespread clastic deposits. Watts et al. (1997) show a seismic reflection image collected from data perpendicular to Tenerife, which shows some seabed-parallel reflections within the lower slope (you may need to see the original paper copy as the scan is poor).

I therefore recommend that Bossis et al. consider another reconstruction in which the ESB in their Figure 1 is moved landward by such an amount that the eroded volume equals a deposited volume on the submarine slope. This would assume that the particles released by erosion have prograded the uppermost slope. The result would be only one end-member of possible geometries because, if the upper slope were depositional, we might expect to see evidence of a landward ESB on eroded shelves of other islands but the evidence is unclear. For example, Santa Maria Island of the eastern Azores has many hardgrounds but it is difficult to see an ESB within them, although there is a break in slope beyond hardgounds to the north (Ricchi et al., 2020; Zhao et al., 2022). Mitchell et al. (2003) presented morphologic evidence that the upper submarine slope of the Anaga massif was eroded and not depositional, although that was based on lower resolution multibeam sonar data than is available elsewhere. In my opinion, the original slope position remains uncertain so I would recommend using the above adjustment to present alternative results that illustrate the effect of this uncertainty.

Volcanic ocean islands tend to be permeable structures so that a large proportion of rainfall penetrates the edifice, whereas runoff becomes focused within deep valleys. This leads to classical structures such as planezes (areas of the original volcano that are poorly eroded) with intervening deep valleys. This is acknowledged by the map in Figure 2 and mentioned in the text. Some of the introduction or other sections could explore this further, e.g., see articles and book by Ollier. I would think we would want only to use profiles over planezes that appear weakly eroded, to have the best chance of reconstructing the original geometry, rather than stack profiles as suggested on line 189. It would also be useful to have local geological knowledge to confirm the planezes are formed of laterally continuous volcanic units.

The main volcano ("Pico") of Pico Island (Azores) has a steep upper flank but low gradient lower flanks (Mitchell et al., 2008). It is effectively a hybrid - stratavolcano upper with some shield-like or at least lower gradient lower parts. Many of the Galapagos volcanoes also have steep upper flanks (Mouginis-Mark et al., 1996). Other volcanic ocean islands can be found with other shapes. There have been various ideas for the different gradients and profiles of oceanic volcanoes published over the years, though erupted lava viscosity and the thermal insulating effect of lava tubes has been invoked to explain low gradients of Hawaiian volcanoes (Greeley, 1987). This worries me also about the current analysis, as it poses the question of whether the geological process could have been systematically different for the lower subaerial flanks (now not accessible to inspection as they have been removed by erosion) compared with the upper flanks that remain. This implies uncertainty in the original subaerial profile.

The method assumes that the submarine parts of the island have exponential forms. Exponential forms were originally noted by Gee et al. (2001). However, there is no theoretical explanation for this form. Lee et al. (1994) talked of earthquake shaking as leading to curved-upwards profiles. Cassalbore et al. (2020) reviewed the work on sediment waves commonly found around volcanic islands, suggesting that sedimentary gravity flows have created them. Without a theoretical basis for the exponential form, it is difficult to know if we should expect the original form to have been exponential. Indeed, "constructional" flanks tend to have a change in slope near their base (Gee et al., 2001; Mitchell et al., 2002).

The abstract mentions that the derived coastal erosion rates are consistent with short-term rates. This would not be expected, because rates measured over different timescales are affected by episodicity of erosion (Gardner et al., 1987). There is some admission of this effect, though it would be nice to explore how the rates could fit in with schemes developed to address episodicity of process. Erosion rates tend to decline with increasing timescale over which it is measured logarithmically (Sadler & Jerolmack, 2014) - it would be nice to see how the inferred erosion rates here fit in with such a scheme, e.g., by comparing with modern rates over known timescales.

The text could be substantially shortened, which would allow the authors to incorporate more information on the geology of Corvo, a geological map and various constraints, e.g., better description of the dates and their significance. In my opinion, the study would be better updated by extending the step of terrain analysis, taking account of geological and geomorphological structure. The Karátson et al. (2016) study of Gran Canaria has some good ideas for this.

Detailed suggestions:

Line #

8 ... to determine when erosion started.

15 surface area or surface volume?

23 It seems strange to open the article's introduction with so many publications on modern erosion rates when the subject of the article is really long-term rates.

35 I would change the emphasis in this paragraph and others to erosion and sediment transfer for volcanic islands specifically. It is not clear how the results of this study will affect those broader global issues, so why mention them? It is better to use the introduction effectively to raise issues that can be returned to in the discussion in the light of the new results.

70 In local instances, pyroclastic deposits are important.

78 The logic here is not correct. If the ages are unknown, we cannot say that coastal erosion began at the same time.

97 There have been some other reconstructions of volcanic islands that may be cited also. For example, Urgeles et al. (1998) reconstructed La Palma prior to its large landslides, quantifying their volume. Mitchell et al. (2003) attempted to reconstruct the pre-erosion structure of the Anaga massif of Tenerife. As noted below, it shows similarities to the erosion of Corvo.

101 extension -> extent

116 Please cite Sunamura (2021) here.

134 These are quite old articles to cite for the LGM level and some more recent articles have suggested that a deeper level was reached (e.g., see Yokoyama et al., 2000).

- This is not the resolution of the data, rather it is the spacing of grid nodes. For much of the Earth, there are no bathymetry soundings to constrain depths.In the case of Corvo, there may be only old hydrographic soundings (single-beam) from widely spaced survey lines that contributed to the grids used.

- This seems an important assumption, which ought to be explored more earlier.

272-278. In my opinion, Karátson et al. took a better approach. Ignoring the geometry of subaerial erosion as done here could prevent the method from being widely accepted.

315-319. Please outline the constraints on these ages, e.g., the radiometric method (Ar-Ar of K-Ar). Also locate dated samples on the map and discuss their significance (e.g., how well they are likely to constrain a particular unit and show its extent).

350 Please provide a map showing survey lines of data contributing to the EMODnet grid, or at least consider that the surveying was not continuous around the island.

- It is interesting that the centre in Figure 3 also appears to be roughly centred within the ESB. Such a structure was found for the Anaga massif (Mitchell et al., 2003).
- The apparent minor discrepancy in Figure 5 (right panel) between the proposed IE and the ESB could be explained if the ESB is not the erosional shelf break to the NW, rather the uppermost slope has prograded due to sediment deposition there.
- Presenting uncertainties in this way gives the impression they are random uncertainties, but a large part of them is likely due to using profiles over planezes and eroded areas together, i.e., it includes systematic errors.

Table 3 - are these wave data or model outputs?

- How representative are modern wave predictions for the long period of erosion of Corvo?
- Perhaps instead: We have adapted the Karátson et al. method ....
- I would not put this in the conclusions or abstract given that we don't have "paleo" wave direction data.

Bossis, R., Regard, V., and Carretier, S., in review, Initial shape reconstruction of a volcanic island as a tool for quantifying long-term coastal erosion: the case of Corvo Island (Azores): Earth Surf. Dyn. Disc., doi:10.5194/esurf-2022-5118.

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