SUPPLEMENTARY MATERIAL VOLCANICA

Supplementary Material for:

Lava flow hazard assessment on Bioko Island (Equatorial Guinea): A probabilistic approach using Q–LavHA

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Brauner et al. (2025) should be cited if this material is used independently of the article.

Documentation

All files and data created and calculated for this study, except the original digital elevation model and the slope map, can be found on www.zenodo.org (see Section 7 in the main article). All geospatial data sets are projected in the coordinate reference system EPSG:32632 - WGS 84 / UTM zone 32N.

List of files

Raster files

- dem.tif
- kde.tif
- Georeferenced historical maps:
  - bioko1.tif
  - bioko2.tif
  - bioko3.tif
  - bioko4.tif

Generated vector files

- vent_locations.shp (point)
- 1923_river.shp (line)

Q–LavHA – model parameters and output

- parameters
- output:
  - GIS files (∗.tif)
  - High-resolution maps (∗.pdf)

The listed files are described in detail below.

Digital elevation model

File name: dem.tif
Structure: Raster

The primary data source was a X-band TerraSAR-X (TSX) / TanDEM-X (TDX) synthetic aperture radar image product (Level 1B) with a nominal resolution of 3 m. The derived DEM (level 3 product) has a nominal resolution of 12 m and a relative height accuracy of 2 m for flat terrain and 4 m for slopes greater than 20°. The original DEM is not publicly available, but might be shared on request for future collaborations upon request. The primary radar imagery and DEM was provided by the German Aerospace Center (DLR, 2021) based on the proposal DEM_GEOL3419.

NOTE: The provided DEM is not the original DEM. We filled sinks with the ArcGIS 10.8.1 Fill (spatial analyst) tool, and resampled the DEM to 30 m / pixel.

Kernel Density Estimation

File name: kde.tif
Structure: Raster

We calculated a probability density function with the Kernel Density Estimation tool in `SAGA 7.8.2` (GIS) using the locations of the previously mapped vents (vent_locations.shp). Referring to Connor et al. [2019], the Kernel shape has only minor implications on the PDF so we followed their recommendation and chose a Gaussian kernel shape. Our kernel bandwidth is based on a study of Schmidt et al. [2022]. They used the SAMSE (Summed Asymptotic Mean Squared Error)

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bandwidth estimator and calculated anisotropic bandwidths of 2913 m and 3087 m for their KDE for the vents on Bioko. In accordance, we chose a bandwidth of 3000 m for this study.

Georeferenced historical maps

File name: bioko1.tif; bioko2.tif; bioko3.tif; bioko4.tif

Structure: Raster

We georeferenced historical maps [Instituto Geográfico Nacional 1981a; b; c; d] in `QGIS 3.22.10`.

Vent locations

File name: vent_locations.shp

Structure: Vector (point)

Attribute table header:

X – Easting [m]

Y – Northing [m]

We mapped vents manually using QGIS® 3.10.14. Referring to Tibaldi [1995], we distinguished between vents as discrete eruptive centers and monogenetic cones, which may comprise one or multiple vents.

Location of rivers

File name: 1923_river.shp

Structure: Vector (line)

Attribute table header:

name – Name of river

We mapped the rivers at the SE flank of Pico Basile in order to identify the 1923 eruption site. Therefore, we used the georeferenced maps (bioko2.tif and bioko4.tif) as a reference.

Q-LavHA

To assess the lava hazards on Bioko Island we used the probabilistic model `Q-LavHA` by Mossoux et al. [2016]. We simulated scenarios to assess the hazard for the entire island (multi-vent), and we simulated single-vent scenarios to identify the 1923 eruption site.

Parameters

For both, multi- and single-vent scenarios, we used the original DEM as a topography input. For single-vent scenarios the model simulated N = 1500, and for multi-vent scenarios N = 500 flows per vent. For the multi-vent scenarios, the model simulated a vent every 300 m and weighted them based on the probability density function (KDE.tif). We normalized the KDE to 1 as input requirement. We only simulated vents for vent opening probabilities of >0.0001 (~0.01 %).

Multi-vent scenarios

The length setting of the simulated flows is Euclidean (as the bird flies) and varies between 3–12 km. The height settings are set to Hp = Hc + 4 m, with the 'H16' and 'Probabilities to the square' options activated. A detailed description of every option can be found in Mossoux et al. [2016]. We simulated scenarios for flows between 2–8 m. For the reference map, we used averaged values (L = 7.5 km and Hc = 5 m) as discussed in the main manuscript.

For multi-vent scenarios, the naming convention for the created outputs (GIS + high-resolution maps) indicates the elevation corrective factor (Hc) and length parameter for each scenario using the format lX_hY (X in [km]; Y in [m]. For example: l3_h2.tif »> L = 3 km and Hc = 2 m.

Single-vent scenarios

For the single-vent scenarios, the model simulated a vent at:

V1: 474995.7 E 394855.4 N

V2: 474195.2 E 393945.8 N

V3: 473030.9 E 393332.4 N

V4: 473701.4 E 391845.8 N

The length is set to 20 km so the simulated flows are reaching the coast / limits of the DEM. The height settings are set to Hp = Hc + 4m, with the 'H16' and 'Probabilities to the square' options activated. A detailed description of every option can be found in Mossoux et al. [2016]. To identify the 1923 eruption site, we set Hc = 2 m. Accordingly, the provided the GIS output files are labeled: V1.tif, V2.tif, V3.tif, and V4.tif.

Furthermore, we tested the effect of variable flow heights for a vent at 474200.3 E 396241.3 N at Hc = 2 m; 8 m; and 20 m. Accordingly, we labeled the GIS output files VX_h2.tif, VX_h8.tif, and VX_h20.tif.

Output

We provide the original model output in ∗.tif format for GIS and ∗.pdf format, following the naming convention as described above.

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