Supplementary Material for

How to mitigate flood events similar to the 1979 catastrophic floods in lower Tagus

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Accuracy of the Digital Elevation Models:

Spatial resolution and spatial accuracy are two of the most important issues in scientific disciplines that deal with geographical data, and therefore, need accurate cartographic results that fit the purposes of a particular study. In this sense, the quality of global DEMs has been frequently studied to assess their wide range of applications. Most of these studies consist of comparing the obtained data from DEMs and a set of reference data generally called control points. To evaluate DEM precision in the area under scope, 206 leveling benchmarks from the official high accuracy altimetric network of the Portuguese Geodetic System (RNGAP), located in the study area or in the immediate vicinity, were used as control points. This network is referred to the mean sea level in Cascais until the last day of 1938 (Cascais Helmert 38). In terms of accuracy, its relative error is rated at 0.1mm/100m (1ppm). Direção Geral do Território (DGT) provides, through a web feature service (WFS), all data related to the RNGAP (http://mapas.dgterritorio.pt/geodesia/geodesiamarcasnivelamentowms.html).

As it is shown in Table S1, where the main general characteristics of the freely available DEMs under consideration are presented, the horizontal and vertical references differ for some of them. To maintain the consistency of the different data, it was necessary to convert all data sets to the same reference frame to develop this analysis. Therefore, the WGS84 and the EGM96, were adopted as the horizontal and vertical reference systems, respectively. On the other hand, the altitudes of the leveling benchmarks are referred to the geoid model for Portugal mainland (GeodPT08) (https://www.dgterritorio.gov.pt/geodesia/modelo-geoide) (Catalao and Sevilla, 2009).

DEM	*CRS*	*Elipsoid*	*Height datum*	*Spatial Resolution*	*Absolute Vertical Accuracy*	*Absolute Horizontal Accuracy*	*Reference*
ESRI-DEM	Cartographic	GRS80	ETRS89	30 m	± 20 m	< 30 m	ESRI Portugal (2009)
ASTER GDEM	Geographic	WGS84	EGM96	30 m	± 20 m	< 30 m	ASTER (2009)
SRTM DEM	Geographic	WGS84	EGM96	30 m	±16 m	< 20 m	Farr and Kobrick, (2000)
COP DEM GLO-30	Geographic	WGS84	EGM2008	30 m	< 4 m	< 6 m	Fahrland et al., (2020)

Table S1. Original characteristics of the evaluated Digital Elevation Models.

Considering as altimetric error, the difference between the altitudes of each leveling benchmark and the pixel value, at the same location, in each DEM, the root mean square error (RMSE) (Eq. S1) for those differences was calculated (Table S2). The lower RMSE was obtained for the Copernicus DEM and as such, this was the altimetric model assumed as the most accurate on the study area.

DEM	***ESRI***	***ASTER***	***SRTM***	***Copernicus***
RMSE (m)	*4.81*	*5.91*	*4.42*	*3.81*

Table S2. Statistical analysis of the altitude difference between leveling benchmarks and analyzed DEMs.

Equations:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(S_i - O_i)^2}{N}} \qquad \text{(S1)}$$

where *S* is the DEM value, *O* is the official altimetric value, subscript *i* refers to the different points under consideration and *N* is the total number of data.

References:

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