Refinement of the geoid model on the islands with sparse terrestrial gravity data

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SUMMARY

Summary. Croatia has more than five hundred islands majority of which has the surface smaller than one km square, while the largest island exceeds even 400 km squares. In accordance to the large differences of the islands' surfaces, 10 % of the islands are permanently inhabited while the rest of the islands record an increasing rate of the real estate transactions making them a subject of a great scope of the construction works, which reflects on higher demands for the geoid model on the islands to rely on. Since 2011, current Croatian geoid model have been implemented in the online service of national positioning system in order to allow the real time height transfer between ellipsoidal and orthometric heights. Its accuracy of +/- 3.5 cm was validated on the Croatian mainland stations while the estimation of its reliability on the islands was not possible due to the lack of gravity and levelling data on the islands. Regarding the new avenues that have occurred in the meantime such as more detailed bathymetric and gravity global models as well as new sparse terrestrial gravity data on the islands, the subtle gravity field modelling have been applied on the Croatian islands, within which the refinement of the geoid model for the islands and part of the Adriatic sea have been evaluated in this paper.

Key words. gravity field modelling, islands, geoid

DATA SET

ELEVATION DATA

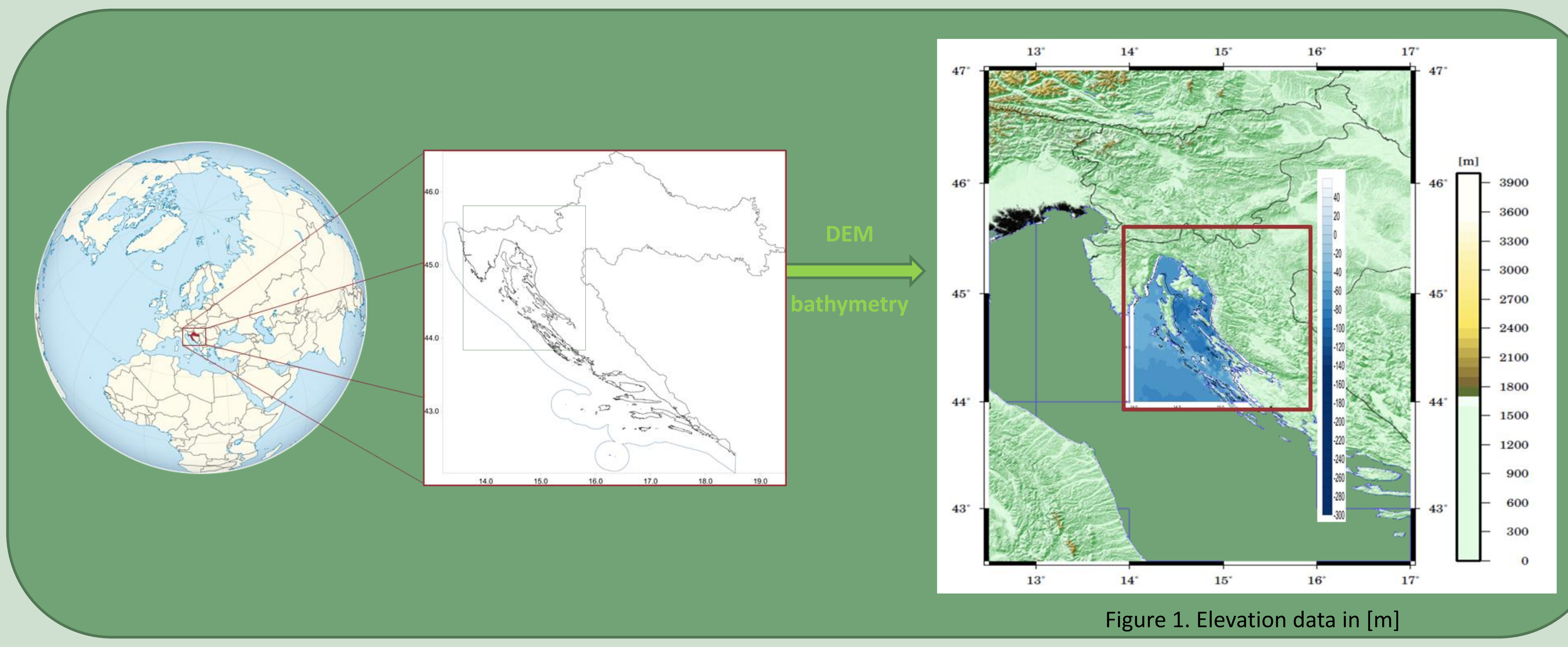

Figure 1. Elevation data in [m]

GRAVITY DATA

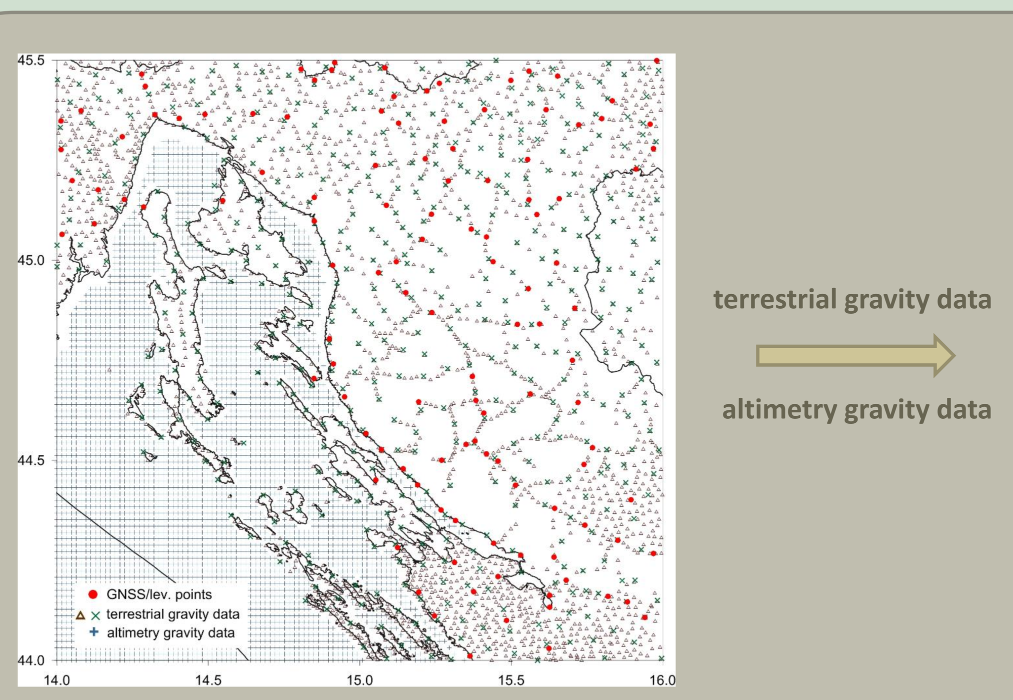

Figure 2. Gravity data

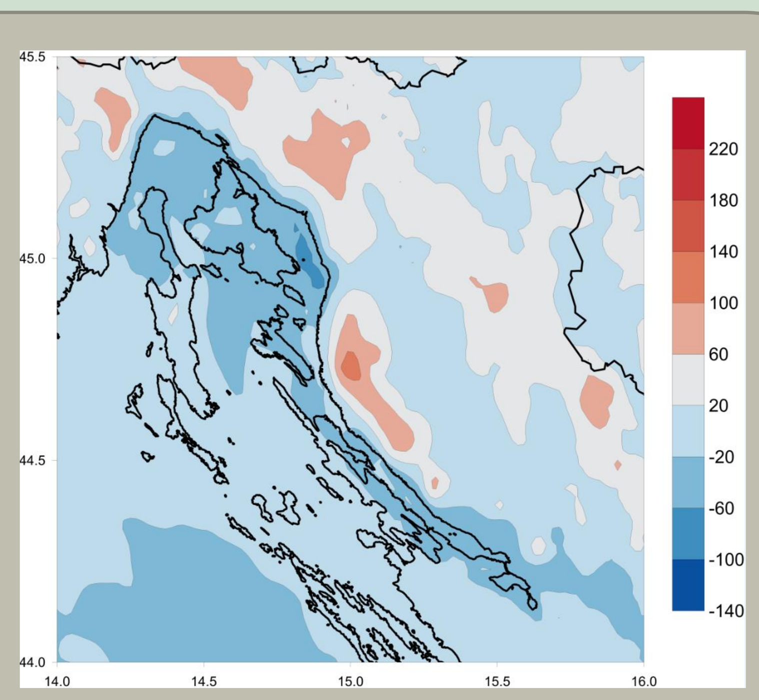

Figure 3. Free-air anomalies in [mGal]

Since the study area consists of both mainland and sea part, the combination of different global elevation models as well as combination of terrestrial and altimetry gravity set were required.

♦ As for the elevation data, the Shuttle Radar Topography Mission digital elevation model was combined with the Smith&Sandwell global bathymetry model. Digital elevation data were used for the whole integration data area, meaning the area between 43.5°-46°N and 13.5°-16.5°E. Due to signal scattering, the SRTM tiles had some voids that needed to be filled before proceeding to geoid calculations. Therefore, all the voids have been replaced by the interpolated value to get more reliable elevation values at SRTM gaps. Values of the heights on the data area vary between -250m depth at the lowest maritime parts of North Adriatic to the 1678 m as maximum in the steep mountinous areas on the coastline (see Figure 1).

♦ As for the gravity data, terrestrial gravity dataset defined in IGSN71 on the mainland was combined with the BGI gravity data also given in IGSN71 gravity reference system on the sea area. The terrestrial satellite altimetry gravity dataset consisted of 2664 distinct gravity points, disributed irregularely over the mainland and islands, while the satellite altimetry gravity dataset was overtaken grided in 1x1 arc minute resolution.

♦ Along with elevation and gravity data, also a long wave gravity information model was needed. Based on apriori evaluated best fitting Global Geopotential model, the EGM2008 was used as a reference model .

GEOID COMPUTATION

The research was made on the Croatian part of North Adriatic area, between 14°-16°E and 44°-45.5°N, covering the computation area of 35 000 km^2. The integration area was wider for a cap size of 0.5°. Geoid was computed in resolution 30"x30", corresponding to 1 km resolution in reality. The Least square modified Stokes' (LSMS) method with Additive Corrections was applied. Final computed geoid model gave undulation values in 43 200 regularely grided points.

Orientation and the validation of the computed geoid model were made using a GNSS/levelling points. Kotsakis and Sideris systematic parameter model was used for the 7-parameter fitting procedure, made on 112 GNSS/levelling points and resulting with the RMS of ± 4.2 cm, ranging from -7 cm minimum values to +14 cm maximum values.

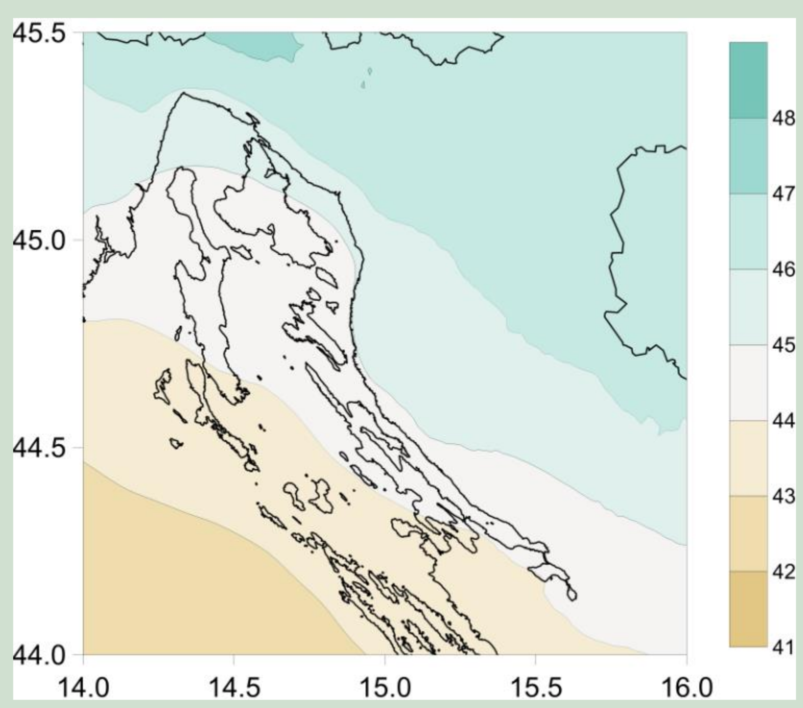

Figure 4. Geoid model of islands [m]

RESULTS

	26 GNSS/lev pts [cm]	7 GNSS/lev pts on the islands [cm]
min	-0.088	-0.005
max	0.130	0.082
rms	±0.052	±0.034

Table 1. Validation on complete 26 GNSS/lev. points and separately for the islands only, in [cm]

After the computed geoid model was fitted to the national height system, the external accuracy assessment had to be made in order to validate the fitting accuracy. The absolute external accuracy assesment was made on 26 GNSS/levelling points which were not used in the fitting procedure, of which 19 of them were on the mainland and 7 on the islands.

Centralized statistics for the complete external accuracy assesment resulted with ± 5.2 cm, while observing only validation on the islands the RMS dropped to ± 3.4 cm. These results imply on a possible future implementation of a geoid model as a reference vertical datum on the islands. Regarding the great number of the islands without connection to a national reference vertical system, this results prove that kind of solution could provide reliable and accurate height information.

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