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Solid Earth
Discussions
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Interactive comment on "Gravity modeling of the Alpine lithosphere affected by magmatism based on seismic tomography" *by* Davide Tadiello and Carla Braitenberg

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1_) The authors must make more explicit throughout the text what are the results from their work and what are from previous work, such as the velocity model, something that is not explained very clearly if it is theirs or if they used Kastle's et al. (2018) data.

Reply: Ok, we agree and have made a correction on the manuscript.

2) The authors stated that they obtained the gravity disturbance map for EIGEN 10 < N _ 2190, generally these combined models present a good performance up to 2159 (e.g. EGM2008 - Pavlis et al. 2012). Using the model up to such higher degree/order,

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isn't it very noisy? Justify your choice.

Reply: Our choice was to use the maximum degree and order offered by the model, leaving the choice of maximum expansion to the geodesists, authors of the model (Förste et al., 2014). In any case, we show the two maps of the expansion to 2190 and 2159, and you can see that they are almost indistinguishable. The difference between the two grid has the following statistics: min = -1.34 mGal, max = 1.41 mGal, mean = 0.002 mGal, RMS = 0.4 mGal . The field with expansion up to 2190 has values between -120 mGal and +183 mGal, with average 21.1 mGal, with RMS of 55.24 mGal. It can be seen that the difference is negligible. In any case, an expansion up to 2159 would not alter significantly the inverted density model, since the difference is small relative to the entire signal (see fig. 1).

3_) Regarding the Crustal conversion authors stated that: in this work, for distinguishing the sedimentary rocks velocity domain from the crystalline domain and therefore which of the two relations to use, it has been chosen the velocity value of 6km/s-1 at which the two curves intersect. This does not generate an artefact in the conversion to densities when passing from one curve to another? since the slope changes overwhelmingly?

Reply: The figure shows there is a slope change, the results are robust in relation to the choice of one or the other curves. On the other hand, it is not possible to use a single curve, since the experimental data show that the relation between density and velocity is different for sedimentary rocks and crystalline rocks. Before taking this choice, we have tested different relations, which did not significantly change the final results and conclusions. Looking at the velocity of sedimentary rocks, the only rocks that would have an overestimated density would be dolomite, since the other sedimentary rocks generally have velocity below 6 km/sec. For the crystalline rocks, there are limited rocks that have a velocity below 6 km/sec and are in danger of overestimating their density, by switching to Gardner's curve. For instance, only Quartzites, Andesites, Meta-Grauwacke, Serpentinites are in danger to be misplaced (Mooney 1995). Over the large area, we consider a choice must be made, and we used the choice of the intersection between the two curves.

4_) In section 4.4 Inversion of the gravimetric residual and model density correction: authors should add a final error estimate.

Reply: Several error sources intrinsically affected the presented 3D density model. A forward error propagation has not been performed during the calculation steps of the study, so it is hard to provide a quantitative error estimation of the final density model. However, some general aspects can be considered to understand which is the main sources of uncertainty and their effect during the modelling process. First of all, Moho discontinuity definition has a larger impact for the mid-long component of the gravimetric field and uncertainty of some kilometres of this surface can produce several mGal, significantly changing the modelled anomaly. Analyzing the proposed method, another critical error sources are the different equation used for the P-wave velocity-density transformation, the proposed equation reflected regional studies based on different input data acquired from different geological context. Other sources of error are the uncertainties affecting the tomographic velocity model used as input data for this study and the linear inversion algorithm based on the simple Bouguer plate correction. Apart from the mentioned uncertainties, we estimate the amount of correction on the crustal density model in the final iteration of the inversion and use this as a quantification of the uncertainty. For the crustal column, we obtain a maximum value of the final correction of 2 kg/m3. The final gravity residual has an RMS value of less than 2.7 mGal (see fig.2).

5_) Some references to geographic locations, basins, terrains, intrusive, etc. that are mentioned in the text should be added in the plant view of the final figures for clarity.

Reply: Thank you for the suggestion, the figure has been updated (see fig.3)

6_) When describing the methodology used in data processing, they should unify the verb tenses, it would be better in past, they mixed with the present simple.

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Reply: Ok, thank you for the suggestion.

7_) Specific comments over text and minor comments are in the attached pdf.

Reply: ok, all inserted in the text.

Reference: Förste, C., Bruinsma, S., Abrikosov, O., Flechtner, F., Marty, J.-C., Lemoine, J.-M., Dahle, C., Neumayer, H., Barthelmes, F., König, R. and others: EIGEN-6C4-The latest combined global gravity field model including GOCE data up to degree and order 1949 of GFZ Potsdam and GRGS Toulouse, in EGU general assembly conference abstracts, vol. 16., 2014.

—- Replies to some of the specific comments in the text:

Reviewer #1: You should name it gravity disturbance (Gd) alone from now on because the term Bouguer implies the concept of a plate with constant thickness (in my opinion).

Reply: it would be wrong to call it gravity disturbance because the Gd is not corrected for the effect of topography. The Bouguer field in the first and very crude approximation is corrected for the only Bouguer plate, on top of which the topographic correction applied. To make it clear, we added a sentence in paragraph 3.2:

“This Bouguer field corresponds to the classical complete Bouguer anomaly, that includes both the topographic correction on top of the Bouguer plate correction, with the difference that we consider the entire Earth, and do not limit the topographic corrections to the Hayford radius of 167 km.”

Reviewer #1: Please justify why You selected this upper limit, as in general working at higher degrees may induce to some "noisy results"

Reply: we have added a sentence in paragraph 3.2:

“The choice of the upper degree is justified by the fact that the authors of the model consider this maximum degree as adequate, and statistical evaluations have been made by the authors up to this degree (Förste et al., 2014a).”

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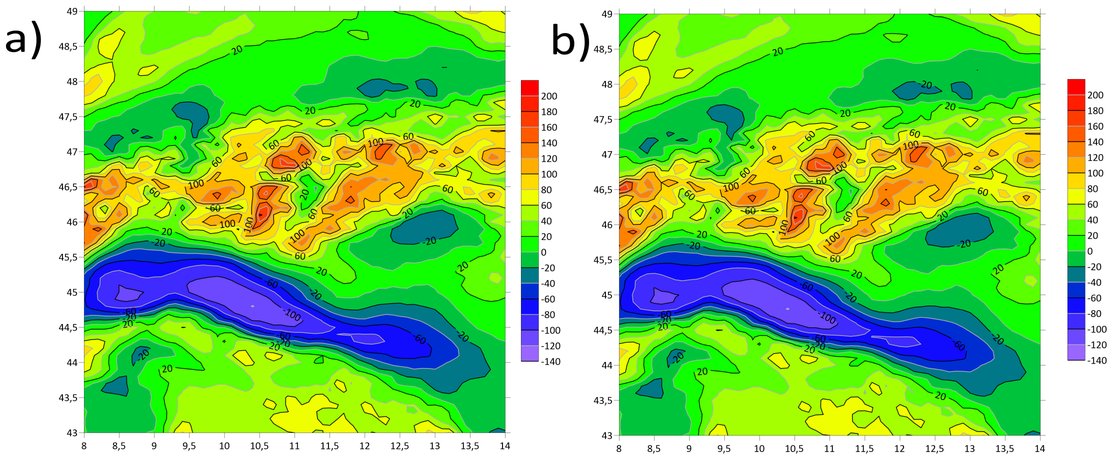

Fig. 1. a) Gravity disturbance of EIGEN6c4 calculated with maximum degree and order N up to 2190, b) Gravity disturbance of EIGEN6c4 calculated with N up to 2159.

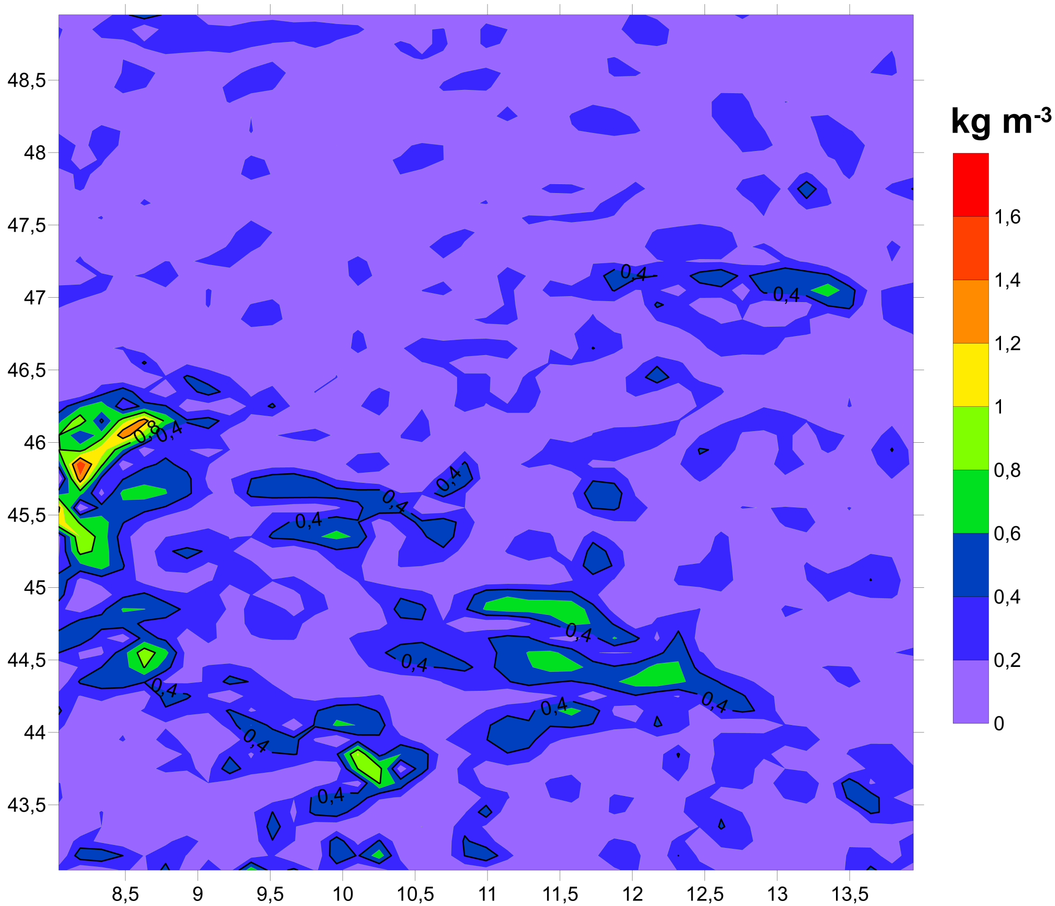

Fig. 2. RMS map of the last density correction for the crustal column, obtained from the final iteration of the gravity inversion algorithm.

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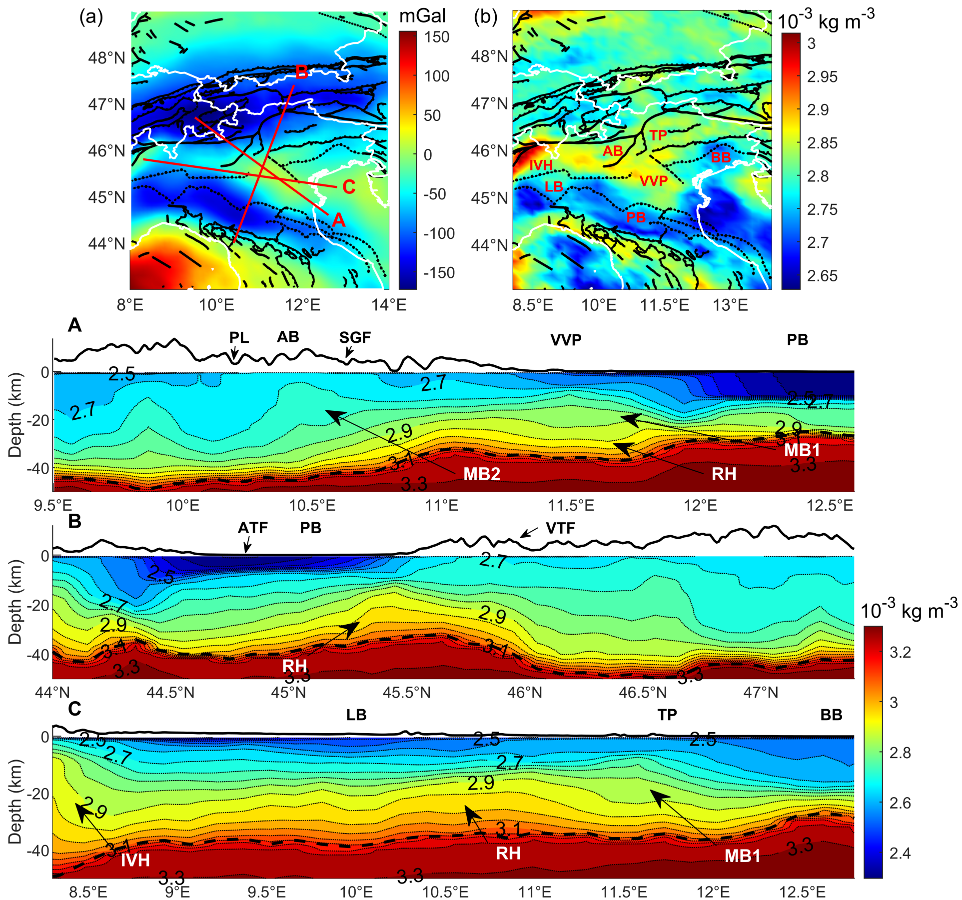

Fig. 3. Rev. Figure 12 – a) Bouguer gravity disturbance (Fig. 3c), b) Average density map (Fig. 11). Sections across the 3D density model for illustration. A) A section oriented NW-SE centered on the Vicenza