

Joint inversion of the lithospheric density structure in the North China Craton based on GOCE satellite gravity gradient data and surface gravity data

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The presented manuscript brings a joint two-step inversion of terrestrial gravity data and gravity gradiometer data from the GOCE mission. The authors start with simulated tests and continue with the applications in the area of the North China Craton. Besides the comments below, the paper is well structured and clearly follows the topic so that it can be recommended after a **major revision**. The most important issues include: i) clarifying the synthetic tests in Table 1 and 2 and settings of the colorbar spans (Figure 2 and 3), ii) the discussion of the long wavelengths with respect to the kernel (tensor component) and the far zones, iii) proof-reading by a native or an experienced speaker (some complex sentences need to be revisited).

General comments

- Terminology - the paper denotes the gravity anomaly/gradient data sets that were reduced for multiple effects as "remaining" gravity anomaly/gradient. Using a term that is commonly used in gravimetry would be more appropriate (e.g., "corrected" for the effect of " etc.)
- Throughout the paper: "resultant data" → "resulting data"?
- Figures - on the top of the colorbars is a slash followed with a unit (probably coming from the panels with densities). Can it be removed (it is confusing)?
- In the text, white spacing is often missing when Figures are mentioned, look for "...(*Fig...*)"
- IMPORTANT: Figures 2,3 have different colorbars for the input and the output. Please, update them to have the same colorbar span.

Detailed comments (line(s))

- 14 *Inconsistency* - do you mean a difference in the data representation (geometry)?
- 19 *performed* → applied to?
- 20 *observation quantity* → observations?
- 23-24 *high heat flux* ... could add a reference to this sentence?
- 36-38 please reformulate or leave this sentence " *The **most** direct and effective approach...*" because the following one repeats it in other words. Btw, the non-uniqueness of the gravity-based inversions make the gravity data not the easiest means for understanding the subsurface.

- 38 *variations* - this little implies time variations. Please, reformulate.
- 38 "*laws*"? Gravimetry does not study the laws behind measurements but it uses the laws to study phenomenas in the region of interest. Please reformulate
- 49 Note ... gravity data contains all the frequencies about the whole Earth, but the high frequencies of the deep structures are just strongly attenuated due to the distance. If we would substantially improve S/N of the gravimeters, we could infer hi-freqs from the very deep density contrasts - the signal is there, just masked out by the signal of the closer masses. The point is however that the data contains it all but due to the attenuation and the errors we do not have access to it.
- 55 a typo "*can expands*"
- 56 leave out the end of the sentence (repetition): "..., *which promotes ...*"
- 57 shorten the sentence (repetitions), e.g. "Joint inversion of the gravity and gravity gradient data can enhance the reliability of the inversion result."
- 60 "*rare*"? (please reformulate), search for the topic, e.g. https://scholar.google.cz/scholar?hl=cs&as_sdt=0%2C5&q=joint+gravity+and+gradient+inversion&btnG=
- 62 shorten "... *realized the inversion combining gravity and gravity gradient*" → inverted gravity and gravity gradient?
- 71 it should be EGM2008
- 71 "*in the case of*"
- 72 leave out "*in local areas*"
- 75 remove "*calculations*"
- 75 correct to "*coefficients*"
- 76 remove "*actual*"
- 77 correct to "*advantage*"
- 78 remove "*actual*"
- 81 rather "*GOCE satellite gravity gradients data along the orbit*" than "*on orbit GOCE*"
- 88 "... *on the topography...*" (remove "*surface of the topo...unit*")
- 98 remove "*at the first process*" ... clear from the context
- 104 remove "*at the second process*" ... clear from the context
- 104 Start a new paragraph with "*By considering ...*"

- 120 the sentence "Since" does not make sense, please update
- 121 *undetermined* is related to a number of data but you rather want to emphasize that the problem is ill-conditioned right?
- 140 "*which is expressed ...*" repeats the first part of the sentence (remove it)
- 143 "is comprehensive" not clear what you mean (please reformulate)
- 146 "?" "...while a very small value may lead to a large ...the model and the data, thus providing unrealistic ..."??
- 147 introduce the L-curve method before you write it is used
- 167 Reformulate the sentence and see Martinec, Z. (2014). Mass-density Green's functions for the gravitational gradient tensor at different heights. *Geophysical Journal International*, 196(3), 1455-1465. ... not all gradients have the kernel with the properties as you describe (what you describe is related to the radial derivatives)
- 176 IMPORTANT. You use some damping function to revert the kernel behaviour. Why do you use the same for all the gradients if their kernels behave differently?
- 202-228 Consider leaving the whole paragraph on PCG since this method is well described and established in the community. The paper is already quite long, here is the potential to shorten it.
- 230 remove "*further*"
- 231 "..., which is relatively simple" → "equipped with density values"
- 231 sentence is bit cumbersome → e.g., "The densities are different at each layer to study the role of the initial values in the joint inversion."
- Table 1 IMPORTANT. Could you add the real densities used in the model. The table gives just the initial values but not true ones so the reader cannot compare the result with the truth.
- 266 You claim "that is almost identical to the true model". If I have not overlooked something, I did not find the true values so the claim cannot be checked by the reader. As said above, updating Table 1 with true values would help. Note "almost identical" is soft characteristics - it is more convenient to use RMS or so.
- 276 concluded → given in Table 2
- 278 "... a more precise initial model" and/or more data, right?
- Table 2 - update with true value
- 296-288 - the last sentence might be left out, not clear what it brings.

- 300 ...*decomposed into two integrated ...* → is composed of two steps?
- 317 ~~directly~~
- 319 ~~remaining~~
- 321 ~~on an overall basis~~
- 331 we constructs
- 335 What is meant by "outer" iterations. Are there any inner iterations so that these two have to distinguished in the paper?
- Figure 5: the red line is hardly visible, maybe not needed in this figure
- Figure 6: density ~~distribution~~ variation (it is not a full value right?)
- Figure 6: "~~(a) 10 km depth ...~~" ... km is well visible from each panel, no need to repeat it in the caption.
- ~~of the satellite~~ ... clear from the context
- 359 ~~IMPORTANT of the European Space Agency~~. The webpage is not maintained by ESA and ESA is not responsible for that.
- 359 update to *These data sets have*
- 360 cite normal gravity with "Mortiz, H. (1980). Geodetic reference system 1980 (GRS80). Bulletin Geodesique, 54".
- Figures 7,8,9: delete (a)...(d) ...clear from the panels
- 384 replace "*deducting*"
- 389 "*In order to directly...*" should continue with a second part, but the sentence is not complete probably.
- Section 3.4 Please be aware of the paper that investigates this effects: Importance of far-field topographic and isostatic corrections for regional density modelling 2016, W Szwillus, J Ebbing, N Holzrichter Geophysical Journal International 207 (1), 274-287
- Figure 9: update the caption, it is not clear what the panel (e) is showing (a 3D map or Tzz as written in the title?)
- Figure 10 the same for (g), update unit in the colorbar of this panel (g). Shorten the caption as the caption repeats all the same (you can put "anomalous gravity gradients Txx, Tyy ...etc" into one sentence)
- 421: You probably mean the gravity effect of the layer bounded by topo and Moho, right? The sentence implies to calculate the gravity effect of the Moho surface.
- Figure 11: shorten the caption - lot of repetitions.

- Section 3.6 - the text implies that this correction is due to the masses below the area of interest. This is was recently studied by Szwillus et al. (2016) showing the importance of lateral masses. Please mention this problem.
- EGM2008
- 442: what is meant by "*relatively minor*"? - the magnitudes are up to 1.5 E, which quite large
- Figure 12: remove "(a)...(d)" ...clear from the panels
- 445: not clear what the sentence tries to tell (what official website, why this is linked with the accuracy/reliability of the data?)
- Figure 13: caption can be shortened, gradients clear from the panels directly
- 455: "*outer iterations*"?
- Figure 14: unit is missing in the y-axis
- 470: "*negative density anomalies*" → negative density contrast/residuals?
- 481-482: sentence wording, also ~~characteristics~~
- 489: ~~clearly~~ obvious
- 505: simplify (does not make sense) "... demonstrate persistently present significant differences ..."
- Figure 15: simplify the caption (km is obvious from the panels directly)
- 619: at the given website `goce.mka.zcu.cz` data cannot be browsed (how?), just it can be downloaded? Please change the sentence if true.