Response for review of the manuscript egusphere-2025-497 “Improving the Gravity Anomaly Map of French-Belgian Hainaut using Multi-Scale Fusion of New Gravity Acquisitions and Legacy Data in an Adaptive and Open-Source Gravimetric Processing Workflow”

XXX : Anonymous Referee #1
XXX : Authors

This paper mainly presents the acquisition and processing of a new gravity campaign MoreGeo, and how it is combined with existing gravity data in the region to obtain an improved gravity anomaly map. A short discussion was provided in the end regarding how this gravity anomaly map can be used to indicate geological structures. The topic is within the scope of the journal. However, at the current version, the manuscript reads to me more like a technical report documenting the data processing steps. For example, the authors used large content explaining the different types of correction applied (latitude, Bouguer, free-air, terrain correction and weighted least squares), which are already very well-established concept in literature. I would strongly recommend the authors to focus on their own innovative work. What is even more problematic is that these corrections are repeated here but not explained in a clear way, and there are some major mistakes. The figures are commonly difficult to read and presented without providing sufficient explanation and discussion. A large amount of reference are missing, i.e., equations or concepts are given without any references. Please find below a list of detailed comments:

Authors would like to thank you for your detailed comments and for the time you have spent commenting this submission, which further motivates its revision. Authors will reorganise the text to reduce the amount of information and improve the way it is presented.
With regard to the section devoted to processing and, in particular, gravimetric corrections, authors feel that it is appropriate to include it in the article, given its involvement in the gravimetric processing that authors have carried out. However, authors admit that its current form requires major modifications and that certain parts can be moved to the appendix. Necessary references will be added and concepts that are more than established in the literature will be synthesised or simply quoted, in accordance with your comments. With regard to the figures, authors will pay particular attention to their legibility, their number and their discussion in the text, also in accordance with your comments.

1. P1L30 and throughout the whole manuscript: please correct the citation form
- The citation form will be corrected throughout the manuscript.

2. P2Figure1: a) the text within the submap is totally invisible; b) for the same region, colors (gravity anomaly values) in the big map and the submap are different. This needs further explanation.
- The submap legend will be enlarged to make it visible. The big map and the submap come from different authors, which is why the colorbars don't quite match. This will be explained in the text.

3. Throughout the paper, the author uses density value (e.g., 2.67 in Figure 1 caption) without unit. But sometimes the density value is used as 2.67 and sometimes as 2670. Please add the unit and keep consistency.
- The density value of 2.67 will be used throughout the text.

4. P2L37: “The gravity data used to ...available in public databases”. Please provide references and where to access the data
- The DOI for the reference (Verbeurgt et al., 2019) (https://doi.org/10.24414/j0dx-9n36) and the WMS link for the reference (BRGM, 2023) (http://geoservices.brgm.fr/geologie) will be added to the bibliography which permit to access the data.

5. P3Figure2: Again this figure is really difficult to read, especially the text in Fig2a, the boreholes in Fig2c are invisible, and the caption of Fig2d wrote seismic line L1903. What is L1903 and where is it in Fig2d? This is not explained
- The legibility of this figure will be improved, either by increasing the font size or by placing a larger version in landscape format in the appendix. The location in the Fig2d section of the seismic section

L190. will be better explained on the map in Fig2c.

6. P3L76: “gravity anomaly that should be observed along these lines based on a density model and a geological model...” why gravity anomaly needs geological model?

- The idea behind this former work was to demonstrate the inconsistency between the former gravity anomaly map from (Everaerts and De Vos, 2012) and the interpretation of the 2012 seismic sections (Dupont, 2021). This highlighted the need to resample the gravity anomaly more finely in the area and probably to redesign the regional deep geological model (P3L80).

7. P4L85: “improving the mapping of the anomaly in a sub-regional sense has many other advantages. For example, it would help to better constrain any future modelling of the geothermal reservoir outside the seismic lines.” Please provide some explanation why gravity anomaly mapping can constrain geothermal modeling, it is not clear

- The link between gravity anomaly mapping and geological modelling for geothermal energy is introduced in P2L55 but I agree a reminder would be appropriate here, specifying that this would help to constrain the location of karstified levels and those of massive anhydrites within the deep reservoir.

8. P4L113: what is “WALCORS GNSS network”, explanation or reference needed

- Authors will add reference about WALCORS GNSS network.

9. P4L116: isn’t “location of the stations” and “their distribution” the same thing?

- This line will be modified as “...defining the location of the profiles on the surface of the study area and the spatial distribution of the stations within them.”.

10. P4L120 and throughout the paper: the term EPSG:XXXX is used a lot but without explanation or references.

- The definition of the acronym EPSG will be added at the first mention in the text.

11. In P4L127: what is acquisition parameters, here it is written “As far as the acquisition parameters are chosen, the most important...” then in P5L133, it is written “Other acquisition parameters…”

- The acquisition parameters are all the parameters mentionned in this part, between P4L127 and P4L137.

12. P5L145-155, this section is difficult to understand.

- A reorganisation and refomulation of this part will be carried out.

13. Figure 3: what is the X and Y axis? Unit?

- The unit is in meter due to the CRS Lambert 72 mentionned in both axes. This is also the reason why there is no graphic scale on the maps where this indication appears on the X and Y axes. To prevent any confusion, an explanation will be added in the text when this map style appears.

14. P6L170 “The table below provides a summary by profile number.” I did not see any table

- Indeed, there is a problem between two versions of the document. The final version should no longer contain a summary table. This sentence will be deleted.

15. P6L175 “three areas along the seismic lines could not be covered by the gravimetric survey.” where are the three areas

- Few details on the location of these zones will be added.

16. P7L185 “These were implemented using notebooks written in Python 3. A Python module containing all the functions developed and used in these processes was also created.” Are the notebooks written by the authors or from others? If it is the latter case, references are needed

- All notebooks were written by authors, this comment will be added.

17. P7L192 “The model used in this paper is from (Longman, 1959).” Why to use such an old tide model, there are more recent ones and is this old model still suitable?

- Although there are more recent models (Hartmann & Wenzel (1995) or Tamura (1987)), it is all a question of the accuracy of the correction. Some recent paper (Trabanco, Jorge and Rogério Rodrigues Amarant (2016). Calculation of the tide correction used in gravimetry. Revista Brasileira de Geofísica.) evaluate that for the longman tide model, “some computer programs adopt equivalent values and do not yield significant results”. Compared to the initial target of 100 µGal, the longman tide model seems correct but this still needs to be investigated and commented on.

18. P7L196 “Figure 4 shows the range of this correction, which is between -0.2 and 0.1 mgal...” However, in Fig4, there are clearly values larger than 0.1 mgal

- That's true. This is due to confusion over the references used between the text and the figure. The text refers to the absolute tide correction range over all the survey, whereas the figure illustrates this range minus the value at the base station used for the corrections, which shifts the range window by +30µgal. This confusion will be corrected.

19. P7L199 “This panel also illustrates the 7-day period required to produce this profile.” How can this information be seen in Fig 4a

- 7 is a error, 5 days is the actual time required to produce this profil and this can be seen by the 5 sets of green lines only on FIG4a. Nevertheless, this information is not considered necessary and will be removed.

20. P7L201 and throughout the paper: what is et?

- Indeed, there is a typo in the text, 'et' = ‘and’ in French, it will be corrected.

21. Equation 1-9: are these equations developed by the authors or from others, references are required in the latte case

- These equations were written by authors.

22. P10L185 “Although it’s much better than the previous one”, Why Fig 8b result is now better, please add some explanation. Also why Figure 9 is also better than Fig8b

- Some explanation about this comment will be added.

23. Equation 11-12, 21-23, 29 reference missing

- References will be added.

24. P12L323 where does “These 111 loops” coming from

- These loops are pairs of acquisitions made at the same station in different periods and were used to reposition the 5 periods in relation to a reference period. The number of loops is not important. This section will be reworded.

25. P13Fig10b, where do these numbers coming from? Also there are 80 equations in Fig10, why in L346 you wrote “these 84 equations”, there are no explanations

- These numbers come from drift relationships between periods for the MoreGeo survey (P13L340 and shown in FIG10a). This is probably a typo, 80 is the correct number of relationships kept after filtering.

26. P13L344: Reference to “graph traversal algorithm” missing

- Reference will be added.

27. P14Fig11, a) the authors claimed that this figure is gravity measurement and used the symbol g which is for absolute gravity. The values of gravity on Earth surface cannot be around 4300 mGal. Please check. b) it is not a good idea to change colors for representing base 1/2/3 between figures, this could be confusing. c) there is no purple color in fig 11b

- All these comments will be taken into account by authors, the figure and its legend will be corrected.

28. P15L397 What is “outdoor correction”

- This typo will be replaced by free-air correction.

29. P17L460, if equations are provided, then they should be explained, what are all the symbols in Fig14? They are not explained

- As proposed by referee no. 2, this point should be deleted from the text because no use is made of it afterwards.

30. P20 The X and Y axis of Fig16 and 15 are not consistent

- The X and Y axes in FIG16 and FIG15b are different because the grids are georeferenced in different CRS. In particular, the Pseudo-Mercator projection has been used for the regional terrain correction elevation grid, as the Lambert 1972 projection, which is generally used in Belgium, would lead to excessive distortions. Nevertheless, the authors will add the unit [m] and comments on this subject.

31. P22 Figure19 not properly explained, what are the cyan color dots

- The authors will take care to improve the comprehensibility of this figure.

32. P24L628, where did the " ge, k and e2" come from? It was not in equation26

- These notations come from an earlier version of the document and have been replaced by A, B and C for ease of reading. This typo will be corrected.

33. P25 Equation 27 is wrong, please check the reference. Also the statement following eq27 cannot be true, the effect of atmospheric correction would not be in the order of ugal according to the h

- The authors will correct this error. 10e-5 * h and 10e-9 * h^2 have been replaced by 10-5h and 10-9h^2 respectively when writing the Word equations.

34. P25 Equation28: form g to gravity anomaly, the normal gravity should be removed

- Authors will replaced g by Instrumental measurement in the P25 Equation28.

35. P26L677 "which is 12 cm, corresponding to a maximum error of about ±37 µgal" how is the 37 uGal obtained?

- This value, which was also announced during the presentation of the 1x1 m^2 Walloon DTM for 2013-2014 (P20L522), comes from the owner of the data, the Service Public de Wallonie (SPW) (https://geoportail.wallonie.be).

36. P28Figure26, the authors wrote that this is the raw collection of data for the three surveys. However, there is a mix of usage between absolute gravity value g (value ranging around 981100) and likely gravity anomaly/disturbance (value -15 to 2).

- Indeed, and this is illustrated expressly to show one of the difficulties of having fused the different data sets. However, your comment will be added in the figure label to avoid any confusion.

37. P29Figure27, also Figure28: These values in the figure cannot be gravity disturbance, they should be absolute gravity values

- Absolutely, authors will replace gravity disturbance with absolute gravity in these figures.

38. P32Figure30: it is difficult to read any information from the figure, please make it more clear

- The figure will be enlarged and moved to the appendix to make it visible.

39. P32L839, where does the "R^2" coming from?

- A commentary on the R^2 calculation will be added to the text. It is from the average of the squared differences between the observed anomaly and the anomaly simulated by equivalent sources.

40. P33 L865 writes that Fig31 presents the Bouguer anomaly but in the figure it is written gravity disturbance. Please check and correct the usage between gravity, gravity anomaly and gravity disturbance throughout the paper.

- These notions will be checked and corrected throughout the paper.