

Dear Reviewers and Editor(s),

Thank you for taking the time to review the manuscript and for managing the review process. Our detailed answers to the reviewers are provided in the interactive discussion.

We noticed that some comments from Reviewer 1, 2, and 3 raised similar issues. We gave specific attention to these issues and ran additional modelling to answer to the different points made by the reviewers.

In particular, we investigated:

- The influence of noise in the data (Appendices 3 and 5),
- The robustness of the inverted models to a poor starting model (Appendices 4 and 5),
- The influence of noise in the data with a poor starting model (appendix 5).

Information about this was added in Section 5.1.2:

“While analysing the influence of inaccurate knowledge of densities in detail is beyond the scope of this paper, it remains important to ensure that inversions are robust to small errors in density. For this, we refer the reader to Appendix 5 where we simulate errors in the knowledge of unit 4. Previous works using level inversion have investigated the importance of the starting model in the uncorrected case and assume that their conclusions hold. Likewise, we assume robustness of level set inversion to noise in the data as it was shown by previous works cited in Sect. 1. To confirm this and for completeness, we performed additional tests, using:

- data contaminated with noise relatively high compared to the amplitude of the uncontaminated data (Appendix 3: Robustness to noise);
- a degenerate starting model and data contaminated with noise (Appendix 4: Robustness to a degenerate starting model)
- a starting model affected by errors in the density of rocks units (Appendix 5: Robustness to errors in the density of rock units).

A detailed analysis of these tests is beyond the scope of this paper and we refer the reader to these Appendices for more detail. In the remainder of this article, we assume that our approach is robust to random noise and inaccurate starting models.”

In addition to the Appendices, we added one Figure in the body of the manuscript text, in Section “5.3. Improving the geological realism of a pre-existing model” to investigate the case where the starting model fits the geophysical data but is geologically inconsistent. Moreover, JG released unpublished material relating to Giraud et al. (2021) to enrich the discussion around the importance of prior information and the potential impact of noise onto level set inversion (Giraud, 2023). To complement the written material, we prepared an animated GIF showing the evolution of the inverted model together with geological inconsistencies when inversion with geological correction starts from the uncorrected case, for the first synthetic case (Giraud and Caumon, 2023).

Last, we have also proceeded with minor rephrasing in a few places of the manuscript when it was clarifying the meaning or improving the flow.

Best regards,

The Authors

#### References

Giraud, J.: Synthetic tests: unconstrained multiple level set inversions with errors in the starting model and noise in the data, 9 pp., <https://doi.org/10.5281/zenodo.7919381>, (2023).

Giraud, J. and Caumon, G.: Evolution of model and geological inconsistencies during inversion, , 1, <https://doi.org/10.5281/zenodo.7920886>, (2023).

Giraud, J., Lindsay, M., and Jessell, M.: Generalization of level-set inversion to an arbitrary number of geologic units in a regularized least-squares framework, *GEOPHYSICS*, 86, R623–R637, <https://doi.org/10.1190/geo2020-0263.1>, (2021).