

Response to Reviewers

We sincerely thank the reviewers and the editor for their thorough evaluations and insightful comments. We have revised the manuscript according to the suggestions provided. Below, we address each point raised by the reviewers and indicate how we have incorporated the corresponding changes into the revised manuscript.

Reviewer 1 Comments and Responses

1. Comment 1:

1. The paper would benefit from a deeper methodological justification and explanation of the Bayesian formulation applied to seismic inversion.

2. Response 1:

We have significantly revised Sections 2 and 2.1 to clearly describe the Bayesian inference framework used in seismic inversion. We cite relevant works (Tarantola, 2005; Bosch, 2004; Izzatullah et al., 2021) and clarify the role of prior, likelihood, and posterior distributions. The updated text better reflects the established foundations upon which our study is built.

3. Comment 2:

2. Please include a more explicit and structured discussion comparing the methods.

4. Response 2:

We have extended Section 6 (Discussion) to provide a more structured comparison of the four methods (MH, HMC, MALA, and Lip-MALA), addressing their strengths and weaknesses in terms of velocity and density estimation, convergence, and computational efficiency. This comparison now explicitly aligns with both synthetic and real data results.

5. Comment 3:

3. Add a clearer geological description of the study area for the real data section.

6. Response 3:

In Section 5.3, we added a paragraph describing the geological context of the Eastern Basin of Venezuela, highlighting its clastic sedimentary setting with alternating sandstones and shales, and the types of pore fluids. This strengthens the link between seismic behavior and elastic properties.

Reviewer 2 Comments and Responses

7. Comment 1:

1. The manuscript lacks contextual depth and does not articulate a clear research question.

8. Response 1:

We have revised the Introduction to include a clear research question and a specific objective that motivates the comparison of MCMC methods in seismic inversion. This addition clarifies the scientific purpose of the study and highlights its relevance to real-world exploration scenarios.

9. Comment 2:

2. Add a more realistic test or improvement to one of the algorithms.

10. Response 2:

We have added a new Section 5.3 describing a two-dimensional inversion using real data from the Eastern Venezuela Basin. This addition provides a more realistic and complex scenario, strengthening the validation of the methods and their practical implications.

11. Comment 3:

3. The discussion should be extended to include practical implications and future applications.

12. Response 3:

We extended the Discussion section (Section 6) to address the trade-offs between accuracy and computational cost. We also added a paragraph discussing when each algorithm might be best applied in operational settings, such as real-time decision-making or full-field studies with limited data.