Qeios

Peer Review

Review of: "Annealed Stein Variational Gradient Descent for Improved Uncertainty Estimation in Full-Waveform Inversion"

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This paper was written very well. It is aiming at an innovative approach to estimate uncertainty for FWI by utilizing variational inference (VI) to replace the traditional sampling algorithm like MCMC at a more affordable computation cost. I like its multiscale idea and also the SNR clustering methods for post-evaluation.

I have the following suggestions to help improve this manuscript:

1) I agree with one of the reviewers from Rice University, please add **depth uncertainty** of the key shallow and deep horizons, which is one of the major objectives for the operator to use to mitigate drilling risks. It has been done by Cen H., Guo K., and Wang D. from Viridien in the 2024 IMAGE (https://imageevent.aapg.org/portals/26/abstracts/2024/4101084.pdf).

2) In the paper, you mentioned, "This deterministic sampling algorithm iteratively minimizes the Kullback-Leibler (KL) divergence between the chosen approximate distribution and the target density to ensure that the final set of particles is distributed according to the desired posterior distribution," please add a citation to support your idea. One reference I want to suggest is the Stein variational adaptive importance sampling published by Han J. and Liu Q. (https://auai.org/uai2017/proceedings/papers/217.pdf).

3) Since salt and sediment have a big contrast, I am not sure your multiscale idea is good for salt-related FWI inversion. Please add some discussion about this topic if possible. One related work that has been investigated in the geophysical community is salt reconstruction in full waveform inversion with a parametric level-set method by Kadu A., van Leeuwen T., and Mulder W. from Shell (https://arxiv.org/pdf/1610.00251).

Declarations

Potential competing interests: No potential competing interests to declare.

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