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

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Potential competing interests: No potential competing interests to declare.

This paper addresses one of the key challenges in geophysics: improving uncertainty estimation in Full-Waveform Inversion (FWI). The authors introduce a novel approach using Annealed Stein Variational Gradient Descent (ASVGD) to bring more reliability and precision to subsurface modeling. The idea of incorporating annealing into the optimization process is intriguing, and it feels like a thoughtful way to address the instability issues that often plague FWI. The potential applications—like seismic imaging and exploration—make this method both timely and highly relevant.

Key points:

- **Fresh Perspective:** Using ASVGD in FWI is a creative solution to a long-standing problem, and the authors make a solid case for its effectiveness.
- **Strong Foundations:** The technical depth of the method is impressive, and it's clear the authors have built their work on a robust theoretical framework.

Where It Could Be Stronger:

- **Testing on Real Data:** The results from synthetic datasets are interesting, but seeing this applied to real-world seismic data would be a game-changer for proving its practicality.
- **Comparisons Missing:** It's hard to judge how much better ASVGD is without seeing how it stacks up against other methods like MCMC or Bayesian approaches.
- **Scalability Questions:** FWI is computationally heavy as it is, so it would've been great to hear more about how this method handles large-scale problems.
- **Interpreting Results:** The uncertainty estimates are promising, but it's not entirely clear how these translate into decisions or actions for practitioners.

Conclusion: This paper is a great step forward in improving uncertainty quantification in geophysics. It's creative, well thought out, and has plenty of potential for real-world applications. That said, adding more validation with real data and comparing it to other techniques would make it even stronger. All in all, it's an exciting piece of work that opens up new possibilities for the field.