

Geosci. Model Dev. Discuss., referee comment RC1
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Comment on gmd-2021-187

Anonymous Referee #1

Referee comment on "Blockworlds 0.1.0: a demonstration of anti-aliased geophysics for probabilistic inversions of implicit and kinematic geological models" by Richard Scalzo et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-187-RC1>, 2021

Overview

The manuscript presents a method for addressing the problem of defining a geological model on a regular grid and its effects on forward as well as inverse geophysical modeling. The problem being that structural geological models consisting of planes and surfaces loose definition when exported to a regular grid for geophysical modeling, and consequentially that this has an effect on physical modeling. This problem is termed an "aliasing problem".

What is the main contribution?

The new contribution in this work lies the construction of an anti-aliasing function that captures the forward geophysical response more accurately than a regular grid discretization. The anti-aliasing function is then applied in the context of structural models construction using kinematic models. Using a synthetic case study, the effect of aliasing, and hence anti-aliasing is studied.

Discretization of continuous geological models, in particular structural models is an important problem and the anti-aliasing method is an interesting idea, that has merit for a publication.

General perception

The manuscript suffers however from unfocused writing and presentation. The main contribution is the anti-aliasing function. There is no new methodology in kinematic modeling and Bayesian inverse modeling using McMC. It is unclear to me why the Authors decided to focus specifically on kinematic models, or on a rather complex example of McMC. It would be sufficient to study the effect of anti-aliasing on the misfit function or likelihood model. To illustrate their proposals, a series of models (not just from kinematics) could have been constructed, and the method tested, without the need to perform inversions. Instead, examples and effect of the anti-aliasing function are described mathematically, but not using examples.

I suggest therefore that the manuscript be rewritten with the anti-aliasing method be more thoroughly studied and evaluated on examples that better show the strength and limitation of the anti-aliasing function, outside the context of inversion first, then only apply inversion as an illustration case, but in my view this is not needed. This would also mean considerably shortening the introduction, which discusses all kind of matter tangential to the anti-aliasing problem and have more to do with inverse modeling, which is not the main contribution of this work.

Comments on the technical matter

- The presentation of the main idea, section 2.3 is unfocussed, it takes 3 paragraphs of meandering thoughts about inverse modeling to get to the main point/contribution. The presentation then is not very clear; it is never explained what the reasoning is behind Eq (2)-(4). Then suddenly, line 205, a "training appears", yet there is not yet any motivation as to why this is done. My suggestion is to write more structured and intentional, first explaining the intent of what is going to be done and why, then only the how. From what I understand, the anti-aliasing function is a proxy regression models that is fitted on a dataset created within a single voxel. It would be better to say this first.
- Please refrain discussing from what "might" be done, unless evidence is shown. Line 218
- Line 220: "Should", is it or isn't it? Otherwise please omit.
- Paragraph starting at 221: this whole section reads as non-committing, do you in fact have solution for voxels of varying size or for curvi-linear coordinates, or is this mere conjecture?
- Anti-aliasing for implicit models. This looks interesting, but I believe it is no longer studied later, so this would not be a contribution unless it is fully worked out and illustrated.
- Line 243: how is Eq (6) an "expansion". If it is an expansion, what are the higher order

terms?

- Where does Eq (9) come from?
 - Line 250: "it should be accessible to implicit models based on co-kriging, and could be spot-checked only for cells lying near interfaces". It should or it is? This very terse sentence needs expanding, what is the role of co-kriging here? If your sentences contain "should" and "could" then perhaps they should be omitted, or moved to discussion/future work.
 - Line 253, what maximization is carried out? What is the function being maximized?
 - Where does (10) come from?
 - Line 256: true but a sphere has the simplest possible curvature
 - Line 261: a folded surface has no curvature?
 - The section 243 – 265 discusses the possibly main issues with the contribution, in my view needs to be worked out with real examples of folding with different variation in curvature and how the authors plan to address it. Can you anti-alias a complex banded iron formation?
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- Line 258 – 273: this needs extensive examples and illustrations
 - Section 3.1 needs figures to explain parameters and relations to geometry

I will not be reviewing the next section on inverse modeling in detail, since these are not new contributions. My recommendation is to work out better the anti-aliasing idea, illustrated with more cases, understanding the extent of applicability, then resubmitted, possibly omitting inversion.

A final comment lies in understanding the amount of approximation relative to other errors. To me what is presented seems relevant when you have very well constrained problems, e.g. gravity inversion with simple geological structures. Once you increase the complexity of the models, then the posterior uncertainty increases as well, hence the approximation become much less relevant. In addition, one would also need to compare the error discretizing with data and model error. Why would you need to anti-alias when there are uncertainties orders of magnitude larger? Knowing this would be a considerable contribution.