

# Review of “Quantitative Sub-Ice and Marine Tracing of Antarctic Sediment Provenance (TASP v0.1)”

## Letter

Dear Editor,

I greatly appreciate the opportunity to review this paper. I also thank the authors for preparing this manuscript.

This manuscript presents a method by which to validate the flow paths of paleo ice sheet models by seeding chemical tracers and comparing the evolution of the tracers with those measured in depositional environments. This technique is used to establish patterns of erosion and ice flow trajectories in Antarctica. In my assessment, this is a notable contribution to the field.

Despite my favorable view of the manuscript’s general intent and ambition, I believe that several matters must be addressed in the manuscript before publication. Particularly, I believe that substantial reorganization is needed. These matters are presented in detail below.

In my opinion, this manuscript likely falls between *major revisions* or *reject-resubmit*.

Below I outline my general comments about the manuscript, along with specific comments. My text is in normal font, while quotations from the manuscript are in italics.

I wish the authors the best in revising the manuscript and moving forward with this work.

## General comments

- I believe that the paper requires significant restructuring and more focused aims. For instance, the last paragraph of the introduction is about geographic area, rather than a traditional description of a knowledge gap and the paper’s objectives. Furthermore, substantial space in the paper is occupied with the neodymium isotope map, where as the objective set forth in the abstract and title of the paper is about the TASP model. Despite taking up a substantial amount of the manuscript, this dataset is not mentioned in the discussion. While the editor is in a better place to comment on this, the inclusion of this apparently novel dataset and some of the conclusions from the paper might make the manuscript more than a model description.
- I found few citations of other work that applies “tracers” be it airplanes, human bodies, erratic boulders or debris to examine or validate glacier flow. The best of my knowledge much of this work is focused on the alpine environments. However, I encourage the authors to examine the work of Guillaume Juvet and David Egholm, amongst others, that may provide context to the methods and findings presented here.
- The subject of the paper is well intentioned. However, the complexity and assumption of the processes at work is substantial, between erosion location, iceberg rafting, bottom currents... is there enough input data for these modules to be robust? Also, it was somewhat unclear to me the timestep and timescale of the model. There seems to be a mismatch between timescales between erosion of sediment and its introduction into the ocean and deposition. Can this be improved upon or discussed?
- Is there a table of parameters/variables/model functions somewhere?

- The description of model components (i.e. Section 4.2) include a mix of model description, model implementation, results and discussion in one section. I recommend the authors find a way to separate the presentation of these themes.
- It seems like sensitivity tests of some type were conducted (i.e. Figure 5), however, no I did not find how this done. Also, I am curious about factors such as how grid size was determined and if this impacts model outputs.

## Specific comments

Given my comments above, the specific comments here are not comprehensive and are generally representative of large issues with the manuscript.

- **Ln 391–403** How is sediment from erosion accumulated in the ice and transported? all of it is entrained and advected with the basal velocity?
- **Ln 415–445** There are two methods presented and one is recommended because it is better? Can the methods be compared? or possibly better, one method removed?
- **Ln 442–445** *This approach does not account explicitly for detritus transport in subglacial hydrological networks, but these are unlikely to deviate significantly from ice flow vectors at the spatial scales of interest here.* In many glaciers, subglacial networks are how most of the sediment is transported from the glacier. Furthermore, subglacial drainage networks follow the hydraulic potential, which can deviate significantly from ice flow vectors. If this statement is included, then a citation supporting it is certainly needed.
- **Figure 5** What is the misfit against? If I understand the model correctly, then shouldn't this figure be presented at the end after the sediment has passed through other modules, including the ice rafting and bottom current?
- **Ln 489–495** These are contemporary trajectories, it seemed. How well do they represent the distribution of tracers? Also the model was run 354 times.. however, by varying what? Parameters? is this a sensitivity test? Why was the model not run continuously from 1993 to 2019?
- **Ln 510** *It is not realistic to assume that the volume of debris dropped by an iceberg remains constant over time... Transport of iceberg rafted debris (IBRD) over many hundreds of kilometres is possible (Dowdeswell et al., 1995), but typically transport is more local.* This paragraph is a bit strange in the sense that it starts by discussing temporal variability and ends by discussing spatial variability.
- **Section 4** I did not find out how detritus is transferred to the “ocean transport” module from the ice flow model.
- **Ln 575** Superglacial debris... this seems like a poorly constrained process in this location. I am also curious how this debris is linked to the ice flow model. Englacial debris will move faster than the subglacial debris, will this create issues as englacial debris from the model is transferred to the ocean.
- **Ln 649–650** *As suspended particles will not be deposited uniformly over a given flow pathway, deposition over a streamline must be approximated.* What is the difference between a flow pathway and a streamline?
- **Ln 717–720** I am having a very hard time establishing what was done here. *This method makes no attempt to account for travel distance along a gravitational transport pathway* isn't this somehow the aim of the model? *always be approximately perpendicular to the coast (on the shelf).* Doesn't it need to follow the steepest descent, regardless of the coasts?
- **Ln 785** *There may be some relationship with the pathways of Ross Sea Bottom Water export, although the spatial match is not perfect (Orsi and Wiederwohl, 2009).* Spatial match between what and what? Also, I would not expect any match to be perfect, please clarify.

- **Figure 10** How is "best match" determined? I did not find comments about model parameterization or inversion that would have resulted in this.
- **Figure 12** There is a lot going on in this figure. Can it be improved upon?
- **Ln 955** *will permit application to simulations of palaeo ice sheets.* Simulations of what? something is missing in this sentence.