Review Report

van der Linden, T.J.M. & van Hinsbergen, D.J.J., MORGen: an algorithm to compute spreading centre and transform geometries from simple initial plate boundaries and Euler rotations, TEKTONIKA, 2023.

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1st Round of Revisions

Decision Letter

Thomas van der Linden, Douwe van Hinsbergen:

We have reached a decision regarding your submission to τεκτονικα, "MORGen: an algorithm to compute spreading centre and transform geometries from simple initial plate boundaries and Euler rotations".

Our decision is to: Major Revision

We have received two reviews of your manuscript, and as you can see in the attached files, they are positive. Nevertheless, minor and major reviews are recommended. They both raised important questions (e.g. code documentation, limitations, applications) that need to be addressed before we can come to a final decision on your manuscript. At this point, we are returning the manuscript to you so that you can make the necessary changes and provide detailed answers to the reviewers.
We look forward to receiving your revised manuscript and responses to reviewers by December 18, 2022.

Comments by Reviewer 1 and Authors' replies

Section A: Overview of manuscript

A1) Overall evaluation, general comments & summary

A1.1) Reviewer's comments

A1.1.1) General evaluation and publication suggestion – Required:

Please use this space to describe, in your own words, the core subject of the submission and your overall assessment of its suitability for publication.

The MORGen algorithm is an innovative idea for the automated generation of mid-ocean ridge plate boundaries and associated isochrons, for subducted crust in particular, that are more continuous in their evolution thus avoiding abrupt ridge geometry changes (through time) that complicate the creation of topological plate boundaries and generating synthetic isochrons that are more physically plausible (transform faults following fracture zone curvature) and that complement present-day isochrons (based on real-world data).

I think the submission is suitable for publication with some minor revisions.

A1.1.2) What does the submission need to be publishable? (select as needed; comment for all cases)

- ☒ No changes required
- ☐ Rewriting
- ☐ Reorganising
- ☐ More data/figures
- ☐ Condensing
- ☐ Reinterpretation
- ☒ Other

Comments:

The submission seems fine for publishing in general. However, the source code to the algorithm could improve a little on the documentation (and do with a little restructuring) to make it easier

to follow and understand for the reader (see section A2.1 for more detail), particularly if the reader plans to run the source code with their own data.

A1.1.3) Can the submission be improved by reducing/adding any of the following? (select as needed; comment for all cases)

- ☐ Text
- ☐ Table
- ☐ Figures
- ☒ Supplementary material

Comments:

See section A2.1 regarding the source code.

A1.1.4) Please complete the following section if you recommend that the submission is NOT appropriate for publication (select as needed; comment if a box is selected)

- ☐ Quality is poor
- ☐ Research is not reproducible
- ☐ Other

Comments:

[Free form box]

A1.2) Author(s) Responses:

A2) Summary of main merits and main points of improvement

A2.1) Reviewer's comments

Please describe below in a few sentences (100 to 300 words) the main merits of the submission and suggestions for improvements.

The main merits I have found are...

The generation of mid-ocean ridge and associated isochron geometries using initial rift geometries, while ensuring the spreading centre (ridge-like) sections and transform faults match the spreading rotation pole as it changes through time. It would be interesting to see the mid-ocean ridge output of MORGen be used as input to the codes that compute paleo-age grids in self-closing plate polygons mentioned in this paper.

The source code makes very good use of the pyGPlates library. The authors have clearly spent time learning and understanding how to use the pyGPlates API to good effect (more than most researchers).

Thank you ☺

The main points of improvement I have found are...

There are a few minor issues with the source code in terms of readability/understandability, usability, and reproducibility of the results of the paper. None of them are showstoppers, but still worth mentioning.

- Readability/Understandability:
    - It might be helpful to have an explanation of each parameter in "MORGen_set_parameters.py" and an overview of each process/workflow in "MORGen_run_code.py".

      We added an explanation for each parameter. Adding the overview of each process/workflow would be nice, but is very time consuming and adds little gain, so we prefer to leave it as is.
    - And it would be useful to users if these processes/workflows (in "MORGen_run_code.py") were turned into functions with the various parameters becoming function arguments. This would allow users to import the Python module and call the functions from their own code. Perhaps this could ultimately be made into a public Python package that users can install

(eg, using "pip install ..."). But that's just a possibility for the future – it is not a trivial amount of effort and the algorithm/functions would need to be fairly robust (eg, automating the creation of topological boundaries is tricky to make robust).

We converted processes into functions. We agree that it would be nice to convert this tool into a Python package, but it is, as mentioned, outside of the present scope.

- Perhaps document how the variable 'feature_collection' changes throughout the different processes/workflows in "MORGen_run_code.py". For example, "tool 4 check for subduction" uses 'feature_collection' but its value depends on which previous processes/workflows have been activated (eg, if 'create_isochrons' and 'isochrons_from_boundary_topologies' have been turned on or not).

  In MORGen_run_code.py the workflows were converted to functions. This also enables tracking of changing variables.

  - This is another reason to turn these processes/workflows into independent functions with their own input parameters/arguments.
- The function get_ordered_features() is a bit hard to follow the logic.
  - Admittedly this is a very difficult part of the code to produce desired results (since usually this process of assembling sections for a topology is done *manually* within GPlates).
  - Also reversal of line sections may need to be considered when used with pygplates.GpmlTopologicalSection.create() in cases where a line section does not intersect both neighbouring sections (or excluded because not close enough). I noticed some topologies not filling the entire plate once neighbouring sections stopped intersecting each other.

This was a difficult part and we are aware it could be improved. It would be great if the current code could be used as a starting point for an element of a (community developed) tool set. As it is outside of the core code of MORGen we prefer to keep it as is for now.

- In points_to_transform() it might be more accurate to generate transform sections using a pygplates.FiniteRotation with axis at the Euler pole (and a small rotation angle), and then use it to transform the input point (already on transform) to a new point on the transform. But the current method seems fine too.

Since the current method is fine, we kept it as is.

- Functions with many levels of indentation (ie, many nested if/else and loops) would benefit from breaking up into several smaller functions to make the code easier to follow and reason about. For example, 'check_for_subduction_individual_isochrons()' sets 'isochron_feature' to be reconstructed in the next timestep/loop but it's hard to trace this through several levels of nested 'for' loops.

We agree the code would benefit from the proposed modifications. Implementing the changes and testing the result is time consuming, which is not possible due to time constraints. The main author currently has a full time job outside of academia.

- The name 'isochron_features_after_subduction' initially confused me since I think of "after subduction" as meaning the time after which subduction has happened (as in a more recent time) but the code actually means at an older/larger time (as in a less recent time) - I would suggest changing the name to 'isochron_features_before_subduction' or even 'isochron_features_prior_to_subduction'. Also, not sure difference between 'include_subduction' and 'exclude_subduction' parameters. Actually, I just realized that 'include_subduction' refers to "after subduction" (as in it removes subducted isochrons), and 'exclude_subduction' means don't remove subducted isochrons. Perhaps this distinction could be documented.

Changed name of variable to isochron_features_not_subducted. Added description about difference between options include_subduction and exclude_subduction

- Perhaps remove unused code, such as code that initializes variables 'pole_at_time', 'pole1' and 'pole2' in function "make_isochron()" since it might confuse the reader as to its purpose (if they, like me, don't initially realize it's unused).

Unused code was removed. The specific example was left unchanged, as the function get_stage_poles() returns two poles, which is other cases are both used, just not in this case.

- It's worth mentioning, FYI, that the ideas for checking of isochrons for subduction, plate splits and ridge jumping is similar to new functionality in pyGPlates (introduced after version 0.28 used in this paper) that deactivates points in similar scenarios as they are incrementally reconstructed forward in time. The authors might be interested in taking a look if they plan to have a new version of their software in the future: https://www.gplates.org/docs/pygplates/generated/pygplates.reconstructedgeometrytimespan#pygplates.ReconstructedGeometryTimeSpan.DefaultDeactivatePoints

        - I'm not suggesting this should be noted in the paper, not at all. Just mentioning in case it might be useful.

    We agree that this is a nice option to include in a future version of MORGen, but for now we do not include it in the code.

- Running the source code:
    - Might want to create the "../data/temp/" directory at script start up to avoid error trying to write a file to that directory (due to directory not existing).

    Added
- Reproducibility:
    - I had trouble reproducing figure 4B/C (southern oceans). So then I tried setting 'isochrons_from_lines=True' (instead of False) for the southern oceans and it looked closer to the figure, but while the South America isochrons were nicely spaced apart the Africa isochrons were still bunched together. It might be worth running the source code again in case some parameters are out-of-date with respect to the paper.

    We did run the code on a clean installation with the correct result. I do recognise this issue though. Did you maybe use a rotation file of your own or multiple rotation files? Or maybe feature collections containing the same features? GPlates an get confused in those cases.

The code was updated on Bitbucket.

A2.2) Author's responses:

See between-the-comments responses above.

Section B: Detailed evaluation of manuscript

B1) Title and abstract

B1.1) Reviewer's comments

*These statements are a **guide** to what good* Titles *and* Abstracts include*. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Title* describes the main topic of the manuscript **accurately** — YES

The *Title* describes the main topic of the manuscript **succinctly** — YES

The *Title* includes **appropriate key terms** — YES

The *Abstract* includes a **clear aim and rationale** — YES

The *Abstract* supports the rationale with **sufficient background information** — YES

The *Abstract* includes a **well-balanced description of the methods** — YES

The *Abstract* describes the **main results sufficiently and adequately** — YES

The *Abstract* clearly describes the **importance/impact of the study** — YES

The *Abstract* clearly states the **conclusions of the study** — YES

The *Abstract* is **clear** and **well structured** — YES

Comments:

[Free form box]

B1.2) Author's responses

[Free form box]

B2) Introduction

B2.1) Reviewer's comments

*These statements are a **guide** to what good* Introductions *include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Introduction* provides **sufficient background and context** for the study — YES

The *Introduction* describes the **aim/hypothesis/rationale** clearly, providing **sufficient context** — YES

The *objective/hypothesis/rationale* **flows logically from the background** information — YES

The *Introduction* describes the study's **objective and approach** (last paragraph) — YES

The *Introduction* contains **relevant, suitable citations** — YES

The *Introduction* is **organized effectively** — YES

Comments:

[Free form box]

B2.2) Author's responses

[Free form box]

B3) Data and methods

B3.1) Reviewer's comments

*These statements are a **guide** to what good* Method *sections include and good practices for* Dataset *accessibility. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Methods* are described **concisely and with enough detail** for reproducibility — YES

Necessary information about **data sources/acquisition/processing** is included — YES

Data used are accessible via either supplementary files or links in the data availability statement — YES

The *Dataset and/or Methods* are **organized effectively** — YES

Comments:

[Free form box]

B3.2) Author's responses

[Free form box]

B4) Results

B4.1) Reviewer's comments

*These statements are a **guide** to what good* Result sections *include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Results* findings are **supported by data** — YES

The *Results* findings are presented **clearly and succinctly** — YES

The text in the *Result* section **cites tables and figures appropriately** — YES

The *Results* directly **relate to the study objectives** — YES

The *Results* present **data for all the approaches** described in the *Methods* section — YES

The *Results* **text belongs to the Results section**, not to *Introduction*, *Methods*, or *Discussion.* — YES

The *Results* section is **organised effectively** — YES

Comments:

There's a section 4 "Proof of concept" and I think there's a section 5 "Example applications", I'm not sure? So, in my mind, I'm lumping these together under the category of Results. Both these sections cover 3 different scenarios/applications of the algorithm. The southern oceans scenario differs in that it compares results with real world data - so it has a little crossover between "Proof of concept" and "Example application".

B4.2) Author's responses

We prefer to keep the distinction we had: we first show how the code operates on modern ocean basins where we know the 'real' ocean age grids from magnetic anomaly observations, where we can illustrate the 'successes' and shortcomings of the code (we reproduce the age grid well, albeit smoothened, but we cannot resolve issues like intra-oceanic ridge jumps for

instance), and then show some applications to scenarios that are reconstructed (Mediterranean region) or predicted (future east African breakup) to illustrate how the code makes the development of age grids simpler and straightforward without having to draw new plate boundaries for every change in (re)constructed Euler rotation.

B5) Discussion and conclusions

B5.1) Reviewer's comments

*These statements are a **guide** to what good* Discussions *and* Conclusions *include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Discussion* is **focused on the objectives** of the study — YES

The *Discussion* **addresses all major results** of this study, which are shown in *Results* — YES

The *Discussion* section makes **comparisons with other studies** that are relevant and informative — [YES] / [NO]

The *Discussion* section properly identifies all **speculative statements** — YES

The *Discussion* section presents the **implications of the study** persuasively — YES

The *Discussion* section **highlights novel contributions** appropriately — YES

The *Discussion* section **addresses the limitations** of the study appropriately — YES

The *Discussion* section is **organised effectively** — YES

The *Conclusions* are **consistent** with and **summarise** the rest of the manuscript — YES

The *Conclusions* are **supported by the data** in *Results* and **follow logically** from the *Discussion* — YES

The *Conclusions* are **clear and concise** — YES

Comments:

The conclusion section is brief but it does succinctly sum up the paper. Even so, I'm not sure if more discussion is warranted or not (perhaps as a separate Discussion section)? Perhaps a discussion item could be: highlighting that real-world isochron data complements synthetically generated isochrons and suggesting how the two could be combined (as in, take the subducted isochrons from MORGen and combine with present-day isochrons) in order to then generate better paleo age grids for example.

B5.2) Author's responses

We are careful to advocate that MORGen should be used to replace real isochrons. Using data is always better than using synthetic isochrons and MORGen is not developed to replace data, so real-world data do not complement synthetic isochrons, but the other way around. It is simply developed to overcome the laborious procedure in developing age grids of now-subducted ocean basins from estimated Euler poles in plate reconstructions. We illustrate this in sections 4.2 and 4.3. We don't really see what else to discuss.

B6) Figures, tables and citations

B6.1) Reviewer's comments

*These statements are a **guide** to what good* Figures *and* Tables *include and how they are presented. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

Tables and *Figures* are **ordered logically** and **numbered sequentially** — NO

Tables and *Figures* have **captions that explain** all their major features — YES

Tables and *Figures* have **captions that complement** the information in the main text — YES

Tables and *Figures* present data that **relate** to the study objective — YES

Tables and *Figures* present data that are **consistent** with and support the description of results — YES

Tables and *Figures* have **succinct and informative titles** — YES

Figures are **accessible** (elements are clearly labelled, accessible colour palettes, colour contrasts, font size legible, etc.…) — YES
Please, check our [Figure guidelines]

Figures with **maps or cross-sections** contain all **elements to be understood** (north arrow orientation, scale, visible coordinates, sufficient coordinate grid intercepts) — YES

Figures with **maps** have **sufficient location information** (in the map or caption) — YES

Cross-sections have clear labels for **scale and coordinates** at ends and within-section kinks — YES

All georeferenced elements are provided in common format (.shp, .geotiff, .kml) [in an open-access repository] — YES

Citations throughout are relevant, suitable, and comprehensive — YE

Comments:

I think figure 5 is missing.

You are right. There was a Figure 5 in an earlier version, which was removed late in the writing. Figures were renumbered.

Figure 4 might need a title.

We added titles to the subfigures and indicated a few elements in the figures to clarify the procedure

Figure 8 could benefit by stating what the blue and green lines are.

Added "Plate boundaries coloured blue, active mid ocean ridges coloured green" *to caption of what is now Figure 7.*

Text for the colour palette in figure 7 is a bit illegible.

The colour bar of what is now Figure 6 was enlarged.

In the figure 3 caption it mentions "Only the segments (drawn in black) in between the corresponding transform faults are stored", which applies to the spreading centres. It might also be worth mentioning that a similar clipping applies to the transform fault.

Added The transform segments are also clipped, so as to only exist between ridges segments

B6.2) Author's responses

[Free form box]

Section C: Additional comments

C1) Minor/line-numbered comments

C1.1) Reviewer's comments

At line 142 it says "*and the transforms drawn at the first time interval will exist throughout the lifetime of the ridge*". From reading the source code (specifically the function 'create_stepped_lines()') my understanding is that transforms are recalculated for each time

interval based on the changing stage pole. So I was a little confused by that. I see that later it does say "*but that the originally defined transforms will remain*" so I think this means the *point* at which each transform intersects the original curve remains the same, but of course the transform length and orientation will change. Perhaps the sentence at line 142 could be rewritten to more clearly express this?

Added the intersection points of the curve with the

C1.2) Author's responses

[Free form box]

C2) Other remarks

C2.1) Reviewer's comments

[Free form box]

C2.2) Author's responses

[Free form box]

Comments by Reviewer 2 and Authors' replies

Section A: Overview of manuscript

A1) Overall evaluation, general comments & summary

A1.1) Reviewer's comments

A1.1.1) General evaluation and publication suggestion – Required:

Please use this space to describe, in your own words, the core subject of the submission and your overall assessment of its suitability for publication.

Core subject of the submission is a python-based toolkit to generate mid-ocean ridge geometries from a given plate model (as comprised of Euler poles and the bordering continental domains and involving the GPlates software). As such, it will in theory be useful for those who generate (and modify) plate reconstructions. In general, I welcome any new tools and frameworks which can streamline the process of building plate tectonic reconstructions, which can also be used to rest reconstructions. I also commend and encourage open-source workflows. Overall the paper is well-written, a concise deliverable, and a succinctly written paper.

However, as they note in the abstract it based on "simple plate boundary inputs" and relies on assumptions including symmetric spreading, ridge-perpendicular spreading and curved break-up geometries (pseudo-COB). Their examples are from a more 'simple' configuration of two continents rather than multi-MOR - indeed the Scotia Sea region seems to be a complicating factor in their South Atlantic example without detailing why not. Granted that the Neotethys example is also more complex than the South Atlantic, it appears to still be a scenario of a single MOR system for each oceanic domain. As such, I am unsure how useful it will be for all global domains, especially for those that have intersections MORs, and multiple plates, such as the Pacific/Panthalassa.

The code simply reconstructs pseudo-isochrons for any MOR for which Euler rotations are known and an initial approximate geometry can be determined. If a reconstruction contains multiple MORs, then MORGen can reconstruct age grids for each MOR. The tool does not reconstruct ocean basins, it uses reconstructions of ocean basins (in terms of a set of Euler rotation poles and an approximate location and shape of plate boundaries) to develop an age grid.

Overall, I think it is suitable for the scope of Tektonika but before publication I recommend a

number of improvements. In particular, I think that a few more quantitative descriptors of the algorithm's case studies and more clear discussion of the limitations. By addressing these points I think this will maximise the legacy and contribution of the paper – the more clear the simplications, limitations (and conversely the outlook and potential applications) are disclosed, the easier it will be for another user to pick it up and adapt for their own oceanic region of interest. I also suggest a number of specific improvements to the figures and ask that some animations are included, either in the main manuscript or as supplementary material.

We will address these comments where given below.

Honestly, I have not been able to get the code to work myself; but that is most likely a function of my own limited python capabilities. I hope that another reviewer or the editorial team can check this. Else, I will ask a colleague to help me in the next round of review.

The other reviewer had it working.

A1.1.2) What does the submission need to be publishable? (select as needed; comment for all cases)

- ☐ No changes required
- ☒ Rewriting
- ☐ Reorganising
- ☒ More data/figures
- ☐ Condensing
- ☐ Reinterpretation
- ☐ Other

Comments:

A1.1.3) Can the submission be improved by reducing/adding any of the following? (select as needed; comment for all cases)

- ☒ Text - more
- ☐ Table
- ☒ Figures - more
- ☒ Supplementary material – potentially more

Comments: *Please see comments below*

A1.1.4) Please complete the following section if you recommend that the submission is

NOT appropriate for publication (select as needed; comment if a box is selected)

- ☐ Quality is poor
- ☐ Research is not reproducible
- ☐ Other

Comments:

A1.2) Author(s) Responses:

A2) Summary of main merits and main points of improvement

A2.1) Reviewer's comments

Please describe below in a few sentences (100 to 300 words) the main merits of the submission and suggestions for improvements.

The main merits I have found are...

Concise problem and workflow

Open source (including dependencies)

The main points of improvement I have found are...

Quality and content of figures

Definitions and terminology

Quantification of misfit for case study

Clear discussion of limitations

A2.2) Author's responses:

[Free form box]

Section B: Detailed evaluation of manuscript

B1) Title and abstract

B1.1) Reviewer's comments

*These statements are a **guide** to what good* Titles *and* Abstracts include*. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Title* describes the main topic of the manuscript **accurately** — [YES]

The *Title* describes the main topic of the manuscript **succinctly** — [YES]

The *Title* includes **appropriate key terms** — [YES] /

The *Abstract* includes a **clear aim and rationale** — [YES]

The *Abstract* supports the rationale with **sufficient background information** — [YES]

The *Abstract* includes a **well-balanced description of the methods** — [YES]

The *Abstract* describes the **main results sufficiently and adequately** — [YES]

The *Abstract* clearly describes the **importance/impact of the study** — [YES]

The *Abstract* clearly states the **conclusions of the study** — [NO]

The *Abstract* is **clear** and **well structured** — [YES]

Comments:

I like the acronym

B1.2) Author's responses

[Free form box]

B2) Introduction

B2.1) Reviewer's comments

*These statements are a **guide** to what good* Introductions *include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box*

checked with NO, or to comment on any other matter.

The *Introduction* provides **sufficient background and context** for the study — [YES]

The *Introduction* describes the **aim/hypothesis/rationale** clearly, providing **sufficient context** — [YES]

The *objective/hypothesis/rationale* **flows logically from the background** information — [YES]

The *Introduction* describes the study's **objective and approach** (last paragraph) — [YES]

The *Introduction* contains **relevant, suitable citations** — [YES]

The *Introduction* is **organized effectively** — [YES]

Comments:

Line 43. define half spreading rate for non-experts (i.e. equivalent of one flank)

MORGen is aimed at a specialist audience that has already produced plate reconstructions using GPlates or other software and is therefore expected to be familiar with concepts such as half spreading. Moreover, the context is given in this sentence: "Assuming symmetric spreading, spreading centres migrate at half-spreading rate away from the adjacent plates". No change to text

Line 45. would have thought that COBs/COTs (despite their uncertainties) rather than present-day coastlines would be a better proxy for the configurations

Changed 'coastlines' to 'margin shapes (e.g., ocean-continent transitions)'.

Line 45/47 - clarify "present-day" coastlines rather than paleo-coastlines

Sentence rewritten into margins, see above. Comment no longer relevant.

Line 50 consider defining "full-plate" for non-experts also Line 194 for "self-closing"

We added to l. 50: "full-plate reconstructions, i.e. plate reconstructions that infer rigid plates and plate boundaries covering the whole Earth's surface, also for lithosphere that has been lost to subduction (Gurnis et al., 2018)" , *and to l. 194:* "self-closing plate polygons, i.e., gradually changing surface plates are defined from evolving intersecting plate boundaries"

Line 55 and more generally. The user also has to choose other elements such as the length of MOR segments and the direction of the transform/FZ offset (e.g. stepping left or right - see also comment below line 86).

As explained in the text, length of segments has a standard value and can be set manually. Is this comment relevant for the cases of interest? The left or right stepping follows from the geometry and the Euler pole. No change to text

Line 56 - consider clarying which may be an "...artificially abrupt..." because with an Euler pole shift, whether intentional or not, it could be a re-configration of the plate boundaries (e.g. reorg event) in which case the ridges would jump on relatively instantaneous times? The next sentence does clarify a scenario for a more simple case of "Atlantic" style ridge jumps but I'm not sure it really represents what we see from the modern Pacific plate (or indeed elsewhere in the Central and North Atlantic). I see that this point is referred to again around lines 98-106 but again I think the tectonic setting (i.e. large and/or ocean basin, or area with lots of subduction zones and back-arc spreading) are more complex than the "natural examples" (Line 157) you show.

Figure 1. Is not "terminology" per se

It is the terminology used in this paper, as indicated. No change made.

Line 64 - define "topologically closed" for non-experts

Rewritten to: “which is especially inconvenient if the model contains topologically closed plate boundaries, in which gradually evolving plate shapes are determined from intersecting, moving plate boundaries (Gurnis et al., 2018), as each Euler pole shift then requires to also recreate topologies”.

Line 66. Please give some examples of the statistics or analyses

We added “and substantiate that the algorithm is effective in paragraph 1.3”. The introduction is not the appropriate place to give results and analyses.

Line 67. replace "show" with "introduce" or "detail" or similar - you are not just showing it

Replaced “show” with “introduce”

Line 69. "Euler pole shifts"

Added “s”

Line 73. does this algorithm work forwards or backwards in time? e.g. "using only initial ridge/rift

geometry as input" initial rift geometry isnt the final as a final rift geometry and which in turn can be oblique to break-up geometry. Example being the Northeast Atlantic in which breakup was oblique to rift axes.

MORGen models forward (like all paleo-age grids are made forward in time, see e.g., Karlsen et al., 2020). We explicitly explain how the obliquity of a rift axis to a divergence direction leads to a stepped ridge-transform system such as referred to by the reviewer. No changes made to the text.

Introduction. Somwhere early on, I would clearly state that the algorithm (or at least this version of it) is more for simple/single MOR systems with two divergent plates and assumes symmetric spreading.

MORGen works with multiple plates and multiple MOR systems. It also is able to deal with subducting plate boundaries. We believe the text is clear on the aims and the applications. No change to text

Line 80, or nearby. Rifts also propagate rather than appear - how does your algorithm account for this.

We do not. MORGen is not aimed at reconstructing intracontinental deformation (to do that, our group has developed reconstruction protocols elsewhere), but to develop pseudo-isochrons in ocean floor. Rift behaviour is not relevant to do that. We made no change to the text.

Line 83 "using the rift (after it has developed into continental plate boundaries)" please explain this further, Are you refering to a defined boundary i.e. not a diffuse zone (c.f. deforming plate models which more appropriately capture rift dynamics)?

In GPlates rifts are represented by lines, not by diffuse zones. If they are defined as diffuse zones, MORGen will use a line in the center as the rift to approximate the continental break-up zone, and develop pseudo-isochrons from that point onward. Changing this line in a zone as narrow as a rift has barely any influence on the resulting age grid. No change to text

Line 86 and later. How are the (lateral) lengths of your steps calculated? I see that the MOR lengths are calculated but not the steps.

This section is not about the algorithm. To answer the question: the MOR lengths are set as a variable, the step lengths follow from the provided curve and Euler pole and there is no rule for step length. This is clear from the described procedure. No change to text

Figure 2. Updated fracture zone set of Matthews et al. 2011. This figure and location is also an opportunity explain why this site is chosen as a case study. Fracture zones are clear but the white thin plate boundaries should be thickened (and/or change in colour) and please also delineate the subduction zones from the MOR/transforms. Mention that green and continental

domains (?) and what source they are from.

Fracture zone set and continents and COBs are from Seton et al., 2012 and references therein.

Added information to caption.

Line 91 and elsewhere - statements are little too generalised e.g. "and are generally perpendicular to the spreading direction (Atwater and Macdonald, 1977). A typical shape of a mid-ocean ridge" please include some recent plate kinematic statistics e.g. Seton et al. 2020 https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020GC009214

I think the figrues in the Seton et al. paper are also important regarding obliquity, spreading rate, age-grid misfit - these are parameters revelant to the "analsyes" you mention above but also in explaining the use and limitations of the algorithm.

We added reference to Seton et al. (2020). We find a detailed comparison of statistical properties not relevant: MORGen is NOT intended, as explicitly and repeatedly mentioned in the paper, to replace reconstructions of real ocean floor, but to make reconstructions of subducted ocean floor from estimated Euler poles in deep-time plate reconstructions less laborious and smoother. In absence of evidence to the contrary, all such oceans reconstructed previously assumed symmetric spreading perpendicular to ridges, for obvious reasons. Hence, so does MORGen. Even if in some percentage of cases, spreading in modern oceans is asymmetric or oblique, there is no point in adding such percentages to synthetic reconstructions with MORGen, and further detailed statistical analysis is therefore not useful.

Line 110. Would include arrows on FIgure 2 to clearly show a few of the S features you refer to. If it becomes too messy, you could have a duplicate back and white panel which identifies these features more. And is also an opportunty to address some of the analyses and spreading characteristics which the Seton paper mentions.

We added arrows to the figures.

B2.2) Author's responses

B3) Data and methods

B3.1) Reviewer's comments

*These statements are a **guide** to what good* Method *sections include and good practices for* Dataset *accessibility. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Methods* are described **concisely and with enough detail** for reproducibility — [NO]

Necessary information about **data sources/acquisition/processing** is included — [NO]

Data used are accessible via either supplementary files or links in the data availability statement — [YES]

The *Dataset and/or Methods* are **organized effectively** — [YES]

Comments:

Method section. Mention which version/build of GPlates and python and GMT.

MORGen was written using GMT version 6, pyGPlates revision 28 for Python 3.7. Details added to Computer code availablity*.*

Line 117. What are the vector output data?

Added: 'as line and polygon features, non-raster data'.

Line 120. Are they global grids? At what resolution/increments?

Added "using standard time increments of 5 or 10 Myr and at a spatial resolution of 0.5 degree. Both are variables that can be set by the user"

Line 123. "defined" rifts, or similar. See deforming comment above. Rifts do appear to focus before

breakup-so perhaps it is OK to simplify to a dicrete line but it should be mentioned.

We indicate here that we represent a rift as a smooth curve. No change made.

Line 127. Clarify which part of the Atlantic Ocean

Added: southern Atlantic.

Line 131. Is this a case with just two plates? e.g. South America and Africa? Or all relevant plates e.g. for the "Atlantic" this may include North America, Greenland, Eurasia, Africa, Antarctica etc. Not clear if you are specifically including the Southern Ocean (as a geographic domain).

Not relevant here. We explain the procedure, not the geography. No change to text

Line 139. "user-defined" what - something in missing

Added “time interval”

Line 140. 10 Ma means an absolute time i.e. at 10 Million years ago, I think you should write 10 Myrs (i.e. a period of 10 million years, relative to the absolute time of interest).

No, the reviewer is mistaken. The unit of time in years is ‘annum’ (a) and a million years is mega-annum, (Ma). 10 million years ago is written as 10 Ma ago. Geological jargon has removed the ‘ago’, but that’s grammatically incorrect. ‘yr’ is not a unit of time, but an invention of Nature. No change made.

Line 143. "If initial rifts are perfectly perpendicular to the initial divergence direction," ... what if they are not - perfect doesn't exist in nature...

We are explaining here how the procedure works. The second part of the sentence reads ‘transforms will have a non-zero length’. We clarified: “In the exceptional case that initial rifts are perfectly perpendicular”.

Line 143 "will exist throughout the lifetime of the ridge" is this perhaps a limitation of the code?

Changed to “the intersection points of the curve with the transforms”.

Line 151. "if within" rather than "in

Changed “in” to “within”

Figure 3. This figure and corresponding text are really important to explaining how the algorithm works. In order to ensure the use and maximuse the potnential of this paper is it possible to make an animation/movie of this. I think seeing the time-dependent development which really help the reader. Especially so that they can visualize how to implement it into a region that is perhaps more complex than the examples shown in the paper (via static images).

Making animations and online tutorials is a good suggestion, but not possible due to time constraints: the lead author has a fulltime job outside of academia.

Line 188-193. If I understand correctly the main workflow of MORGen uses an plate model as an input (i.e. with Plate IDs and associated Euler rotations defined) and MORGen generate the resultant geometry which can be returned into the evolving topologicall-closed plate polygon. However is this additional option is more an iterative application whereby MORGen can be used to also update the associated Euler rotations? Or perhaps not? Maybe your answer to my half-stage rotation question, below, will explain this point. My point is that I am wondering to what extent MORGen can be used at the phase of plate reconstructions where we are still

testing kinematics and finite rotations rather than computing the resultant geometries, age-grids etc.

MORGen is not intended as a tool to estimate Euler rotations, but to develop age grids given a set of Euler rotations and an initial shape. That said, it will become clear quickly whether the reconstruction contains 'errors' such as unintended obliquity on inferred transform faults. This may turn out to be a useful spin-off, but MORGen is not required to spot such 'errors'. No change made.

Line 191. When I make MORs in GPlates I (and I think several others) choose the "half-stage rotation" element in GPlates, and digitise the boundary accordingly. Could you briefly expand on how MORGen compares to this work flow? I think I understand conceptually but does your workflow render that option unnecessary or does enable the half-stage rotation to be implemented but it calculates the geometry?

We already indicated in the text, on the next page 'The MORGen algorithm can also create its own isochrons at set time intervals based on the computed mid-ocean ridges. We thereby assume symmetric spreading, by means of half stage rotation'. So our approach is in this respect similar to the standard approach in Gplates.

Line 199. Not sure what "forward reconstruction" refers to

We clarified: "forward construction in time, starting from an approximate initial curvilinear ridge geometry"

Line 201. Plate ID changing of the MOR or the isochron or other?

Isochrons. Text clarified.

Line 196-210. I find this really hard to conceptualize without an example - a figure (and ideally an animation) would be helpful

We added a new Figure, in which we illustrated the two options discussed in the text.

Line 204 Does MORGen cookie cut to the part of the isochron that intersects with the subduction zone?

It cuts using the pyGPlates function partition_into_plates. No changes to text

Line 211. How does this compare to the TracTec Karlsen method? And do you mask continental domains?

Karlsen's method works better, and MORGen was not intended to improve that method, but to provide input for Karlsen's method. We already wrote in the text: For better results, the mid-

ocean ridges features generated by MORGen could be used as input for algorithms that are better at creating age grids, such as Karlsen et al. (2020), Williams et al. (2021).”

B3.2) Author’s responses

[Free form box]

B4) Results

B4.1) Reviewer’s comments

*These statements are a **guide** to what good* Result sections *include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Results* findings are **supported by data** — [YES] /

The *Results* findings are presented **clearly and succinctly** — [YES]

The text in the *Result* section **cites tables and figures appropriately** — [YES] /

The *Results* directly **relate to the study objectives** — [YES] /

The *Results* present **data for all the approaches** described in the *Methods* section — [NO]

The *Results* **text belongs to the Results section**, not to *Introduction*, *Methods*, or *Discussion.* — [YES]

The *Results* section is **organised effectively** — [YES]

Comments:

Line 227. "initial rift geometries" again, is that the break-up geometries (e.g. COB-esque delineations?)

It is whatever the user puts in as initial geometry. We explained how we approximate rifts and MORs in detail earlier in the paper.

Figure 4 are these all at present-day? Clarify the timsteps of the isochrons shown in this figure. Include a colour scale for panel D.

We added headings and labels to the figure. The colour scale is not relevant here, this just serves as an example of the procedure, and the absolute ages are not the point of this figure.

Line 273. "as they should in most places." ambiguous

Removed: ‘as they should’

Line 274. "sea floor structure" what specifically is meant here?

Changed to “fracture zones and isochrons”

Line 275 "locally suboptimal match" please clarify/quantify

We clarified: “Minor mismatches may have an underlying geological reason, reflecting small-scale relative motions between the conjugate sea floor of the Weddell Sea and the South American plate that was recently inferred by van de Lagemaat et al. (2021)”.

Line 281. "similar results "Any quantitative values you can include?

Added “as illustrated in Figure 7C”. We rearranged Figure 7 to make the panels larger and added labels.

Line 281. when is this ridge jump?

We clarified that this concerns the Malvinas plate and that the ridge jump model is a simplification, since the Malvinas plate likely had a protracted period of time as a plate separated from both SAM and AFR (according to Marks and Stock, 2001, reference added to the reference list).

Line 283. Any particular reason why it was not included? It is shown in Figure 7 and by including that region, which is the highest area of variability it skews the colour map to that region and makes the actual area of the case study all red. Please mask and adjust. Adjust to include same projection and domain as

The map is all read because there are no major mismatches between the Seton, data-based model from which the Euler rotations were determined, and the reproduction by the MORGen algorithm computed from a single initial rift. We include the mismatch with Scotia to illustrate that there, we obtain major mismatches since we did not include a reconstruction for the Scotia region in the MORGen example here. Difference like that would be a real worry for a paleo-age grid, or e.g. a bathymetry computed from that, the mismatches of 10 Ma or less, not so much.

Figure 2 (or vice-versa) - they focus on very different scales of the region, and are used as a comparison tool for quality of the output - so they should be consistent. Looks some some figures are exports from GPlates directly but some are externally plotted – please be consistent for the ones showing/discussing the same region.

Some figures come from GPlates and illustrate input reconstructions or features (fracture zones, plate boundaries, COBs) and the externally plotted figures give computed age grids. There is no reason for these figures to be the same format or made by the same program. We made no change.

Figure 7. "Present-day" age grids. Also, I cannot read the scale - please also include a scale with clear tick marks.

Scale adjusted and "present day" added

Figure 8. What are the blue markings? No Euler poles are shown. Please also indicate ages for some of the isochrons as it is hard to see where the MOR is at 170 Ma and what the ages are.

We Added "Plate boundaries colored blue, active mid ocean ridges colored green." We added some isochron ages where relevant. Euler poles are located far outside of the geographic area portrayed at the figure, but are obvious from changes in transform orientation.

B4.2) Author's responses

B5) Discussion and conclusions

B5.1) Reviewer's comments

*These statements are a **guide** to what good* Discussions *and* Conclusions *include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Discussion* is **focused on the objectives** of the study — [YES] /

The *Discussion* **addresses all major results** of this study, which are shown in *Results* — [NO]

The *Discussion* section makes **comparisons with other studies** that are relevant and informative — [NO]

The *Discussion* section properly identifies all **speculative statements** — [NO]

The *Discussion* section presents the **implications of the study** persuasively — [NO]

The *Discussion* section **highlights novel contributions** appropriately — [NO]

The *Discussion* section **addresses the limitations** of the study appropriately —[NO]

The *Discussion* section is **organised effectively** — [YES]

The *Conclusions* are **consistent** with and **summarise** the rest of the manuscript — [YES]

The *Conclusions* are **supported by the data** in *Results* and **follow logically** from the *Discussion* — [YES]

The *Conclusions* are **clear and concise** — [YES]

Comments:

Line 334. Laborious used 5 times - perhaps a synonym can be found for a couple of their instances?

Replaced twice by 'time-consuming'.

Abstract and Line 334 - seafloor roughness is not shown - or do you mean bathymetry?

We removed 'seafloor roughness' from the text, it was not important enough to clarify.

B5.2) Author's responses

[Free form box]

B6) Figures, tables and citations

B6.1) Reviewer's comments

*These statements are a **guide** to what good* Figures *and* Tables *include and how they are presented. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

Tables and *Figures* are **ordered logically** and **numbered sequentially** — [YES]

Tables and *Figures* have **captions that explain** all their major features — [NO]

Tables and *Figures* have **captions that complement** the information in the main text — [NO]

Tables and *Figures* present data that **relate** to the study objective — [YES]

Tables and *Figures* present data that are **consistent** with and support the description of results — [NO]

Tables and *Figures* have **succinct and informative titles** — [[NO]

Figures are **accessible** (elements are clearly labelled, accessible colour palettes, colour contrasts, font size legible, etc.…) — [NO]
Please, check our [Figure guidelines]

Figures with **maps or cross-sections** contain all **elements to be understood** (north arrow orientation, scale, visible coordinates, sufficient coordinate grid intercepts) — [YES]

Figures with **maps** have **sufficient location information** (in the map or caption) — [YES]

Cross-sections have clear labels for **scale and coordinates** at ends and within-section kinks —/ [NO]

All georeferenced elements are provided in common format (.shp, .geotiff, .kml) [in an open-access repository] — [YES] / [NO] N/A

Citations throughout are relevant, suitable, and comprehensive — [YES]

Comments:

Please see Figure comments in above sections.

B6.2) Author's responses

[Free form box]

Section C: Additional comments

C1) Minor/line-numbered comments

C1.1) Reviewer's comments

C1.2) Author's responses

[Free form box]

C2) Other remarks

C2.1) Reviewer's comments

What are the long-term plans for this code? Will there be improvements made to it?

Line 365 include builds/version numbers here

C2.2) Author's responses

[Free form box]

2nd Round of Revisions

Decision Letter

We have reached a decision regarding your submission to τεκτονικα, "MORGen: an algorithm to compute spreading centre and transform geometries from simple initial plate boundaries and Euler rotations".

Our decision is: Revisions Required

As you can see below, we have two reviews regarding the first review round on your manuscript and a third new review (Reviewer C). We look forward to receiving the authors' answers to specific queries the reviewers raised and a revised version of the manuscript accommodating Reviewer C requests.

Comments by Reviewer 1 and Authors' replies

I have read the rebuttal comments and the revised paper. Unfortunately, I am neither satisfied with the revised status of the manuscript nor the rebuttal comments. I feel that the authors have by-and-large dismissed my comments, with the large majority having short replies followed by "no change." As with the many other papers I have reviewed in my career, my often detailed comments come from a place of constructive commentary, genuine interest, my own expertise, and the wish to see open, accessible and forward-progressing science. The current paper is not accessible to non-specialists (as also admitted by the authors) and is not the best version it could be. Considering the short and dismissive nature of the previous round of replies I decline to respond to them individually. Furthermore, I find it irrelevant where the lead author works - good, peer-reviewed science does not depend on your external deadlines or interests outside of academia. Finally, I ask the reviewers to reconsider their dismissive tone for future reviews. I leave this with the editors for their final decision as to whether this suits Tektonika's scope and vision.

We are surprised by the reaction of reviewer 1. We appreciate the time and effort spent on the careful review. However, the suggestions we did not follow had, as we respectfully explained in the rebuttal letter, little to do with improving MORGen or the article but rather were requests to write an article with a different scope, deviating from MORGen itself. Because also reviewer C has now made clear that we did not make the purpose of MORGen sufficiently clear, we have rewritten the abstract and introduction to explain this better.

Comments by Reviewer 2 and Authors' replies

We thank reviewer 2 for their contributions and their appreciation of our work. Below we describe what changes to the code were made in response to their comments.

'Most of my review comments involved changes to the source code to make it easier to understand and use (and some suggestions for future improvements, ie, after the paper is published). I can appreciate that implementing and testing these changes would be time consuming. So it is fine for this to be done as a future improvement. Although it's good that the authors have converted the workflows to functions (in MORGen_run_code.py) – just as a side note, there are a few parameters not yet captured as function arguments (ie, they are still global variables, like 'rotation_model', 'on_intermediate', etc). But it is fine as a starting point, perhaps of a community-driven toolkit (as the authors mentioned).

Thank you for the appreciation of the changes to the code that we made in response to your comments. We have now also updated the code to not use global variables and to explicitly import all variables and functions.

In regard to my difficultly reproducing figure 4B/C (southern oceans), where the authors asked if I had used my own data files... I don't recall exactly, but I'm pretty sure I would have used the data supplied with the source code. In any case, it's possible I may have changed some variables prior to doing this (so I might not have been running with a clean installation).

Thank you for this information. To be sure, we have checked reproducing the images with a clean installation and were successful.

I was able to run the code on my system, although would have appreciated it if an environment .yml file was provided for me to use (and would encourage you to add this to your code repo).

Thank you for the suggestion. We added an environment yml to the repository.

Comments by Reviewer 3 and Authors' replies

We thank (new) reviewer C for their appreciation and comments. Below we answer their questions and detail the corresponding modifications to the manuscript.

I found the manuscript generally well written and clear, and appreciated that you acknowledge and address some of the tools' limitations (for example those related to assumptions of symmetric spreading). I was able to run the code on my system, although **would have appreciated it if an environment .yml file was provided** for me to use (and would encourage you to add this to your code repo).

Thank you for the suggestion. We added an environment yml to the repository.

The comments below illustrate that the main aim of MORGen was insufficiently clear from the text, and we therefore rewrote the abstract, and much of the introduction to clarify. Because of the large amount of changed text, we do not include it here, but rather refer to the manuscript.

I find one very significant omission in this manuscript, and this is what I have chosen to focus the review on: **you need to discuss the overlaps of this tool with other open-software in existence.** I believe that the manucscript would greatly benefit from answering the question: "as a user, when and why would I choose to use this tool and not others to automate the generation of isochrons?".

Even though MORGen contains an option to create isochrons and age grids, this should not be considered its main feature. We wrote in lines 311-317 of the reviewed version that other tools, including one mentioned by the reviewer, can be used to produce isochrons and age grids from the MOR features created by MORGen. The text was changed to contain references to articles mentioned by the reviewer and references therein.

The original text, lines 314-317 of reviewed version:

For better results, the mid-ocean ridges features generated by MORGen could be used as input for algorithms that are better at creating age grids, such as Karlsen et al. (2020), Williams et al. (2021).

was changed to include all of the gridding algorithms we are currently aware of, lines 377-379 of the revised version with tracked changes:

For better results, the mid-ocean ridges features generated by MORGen could be used as input for algorithms that are better at creating age grids, such as Karlsen et al. (2020); Merdith et al. (2019); Seton et al. (2012); Williams et al. (2021).

Partial overlap between tools is not an issue, and in fact it is often helpful to have more than one option to do a certain task, but having used alternative open code myself in

the past I struggle to come up with a reason why I would choose this new tool instead – you should make that clearer to me, and other modellers out there.

MORGen was developed to support tectonic modellers in drawing mid-ocean ridge features consisting of spreading centres and transforms with changing Euler pole locations through time, taking away the necessity to redraw these ridge features every time the Euler pole changes location. **In our efforts to develop paleogeographic reconstructions, we found that there was no tool that was able to create mid ocean ridge features with geometries adjusted to changes in Euler pole, and for that reason we developed the MORGen tool, that provides a simple solution. In the core task of MORGen, there is no overlap with other tools.**

The code I'm referring to in the following paragraphs can be found here:

(Don't let the repository name fool you, it's not just about generating age grids, or about doing so in present – note isopolate.py):

https://github.com/EarthByte/presentday-agegridding

and alongside this
paper: https://www.sciencedirect.com/science/article/pii/S1674987120301432?via%3Dihub

Thank you for the suggestions, we incorporated these as mentioned above.

To use your tool, I need a plate model in GPlates-compatible format. That means that, at its minimum, I will have a rotation file, and some plate shapes. I may not have rift axis, so to use your tool I first need to draw them. This is of course fine, and I could simply extract them from the plate shapes. But since I'm doing some drawing, I could also use my plate shapes and draw some MORs. And whilst that is two lines instead of one per plate, the result of interpolating between MOR and rift lines using Earthbyte's isopolate.py tool is, in my view, superior. And, if instead of two lines I drew a few per plate, at a few instants through time, then I can even carry out interpolations without the assumption of symmetric spreading or rift-perpendicular spreading. Geometries seamlessly morph from MOR to COB, whilst respecting the orientation of small and great circles about rotation poles.

Indeed a plate model in GPlates-compatible format is needed. At its minimum the model should consist of a rotation file with one Euler pole and a file with one linear feature of type *MidOceanRidge*. It is of course possible to use other functions to create the initial linear feature. It is also possible to make more complex plate models. The core function of MORGen converts this curved linear feature (still of type *MidOcenanRidge*) into a feature consisting of spreading centres and transforms. The abstract and introduction were changed to clarify this.

Your tool "projects" shapes in the paleo > future direction. Earthbyte's instead interpolates between two points in time. So whilst they are fundamentally different, as a plate modeller and first-hand user of both, I would like to have a clear picture of when could I use yours that I couldn't use already existing code. Initially, I thought that perhaps yours is more intended as a predictive tool, whereby someone can project geometries into the future and draw plates using those projections as guides…. except that your tool requires rotation poles, therefore it requires an existing plate model and is not trying to help build one. So, to me, the main difference seems to be that with MORGen I only need an idea of rift axis geometries, and with Earthbyte's code I need that, and also some idea of MOR/paleoMOR geometries (which are part of plate models already, and therefore easy to use as input). Is that right?

It is correct that MORGen turns an idea of a rift axis (or continent-ocean boundary) into a MOR/paleoMOR geometry consisting of spreading centres and transforms. The abstract and introduction were changed to clarify this.

Is MORGen's main selling point it's ability to save some manual drawing? Are there other benefits I'm not seeing with respect to workflows that use interpolation? Where do you think it overlaps with existing code? Does that matter? Why? (or why not?).

MORGen's main selling point is its ability to save laborious manual drawing, as is written in lines 263-266 (of reviewed version): *South America-Africa motion is described using 17 Euler poles since approximately 140 Ma. In the same period Antarctica-Africa motion is described with 32 Euler poles, signalling a total of 47 Euler pole shifts. The 'traditional' approach thus required redrawing the ridge-transform system 47 times and defining self-closing plate boundaries after each shift.* This is to illustrate that shifts in Euler poles occur frequently and that each single shift necessitates a redrawing of the MOR. MORGen does this redrawing based on the changed Euler pole, specifically for ancient oceans that have been lost to subduction, and whose opening relies on the estimated relative rotations between continents or arcs that remain in the geological record.

Other benefits include:

1. An option to create boundary topologies, as is written in lines 204-210 of the reviewed version, lines 267-274 of the revised version with tracked changes, here cited in the revised version, including the added references: *There is also an option to let MORGen create plate boundary topologies. This option checks the plate boundary features per plate id for cross cutting and sorts the features in the right order to create a boundary topology. Boundary topologies may subsequently be used for further processing, such as input for the codes that compute paleo-age grids in self-closing plate polygons, i.e., gradually changing surface plates are defined from evolving intersecting plate boundaries (Karlsen et al. (2020); Merdith et al. (2019); Seton et al. (2012); Williams et al. (2021)).*

2. An option to create pseudo-isochrons and check those pseudo-isochrons for subduction or ridge jumps, see lines 211-214 of the reviewed and lines 275-287 of the revised version with tracked changes: *The MORGen algorithm can also create its own pseudo-isochrons at set time intervals based on the computed mid-ocean ridges. We thereby assume symmetric spreading, by means of half stage rotation. The algorithm can check pseudo-isochrons for subduction, formation of new plates and ridge jumps. This is done in three steps: (1) forward construction in time, starting from an approximate initial curvilinear ridge geometry; (2) assigning plate IDs to pseudo-isochrons at the reconstructed location (isochron features located in multiple plates are cut at this step); (3) check whether the plate ID of a pseudo-isochron has changed since the previous step. If the plate ID is unchanged, the feature continues its life as it is. If the plate ID has changed since the previous step there are two options (a) if the pseudo-isochron intersects a subduction zone feature, it is assumed to have subducted; (b) if it does not intersect a subduction zone, it is assumed to have changed to another plate, either by a ridge jump or by the break-up of an originally larger plate and the plate ID property is modified (**Error! Reference source not found.**).*

I look forward to a revised version of the manuscript with some discussion on these questions. Best of luck with your work.

2nd Round of Revisions

Decision Letter

Thomas van der Linden, Douwe van Hinsbergen:
We have reached a decision regarding your submission to τεκτονικα, "MORGen: an algorithm to compute spreading centre and transform geometries from simple initial plate boundaries and Euler rotations".

Our decision is: MINOR Revisions Required

Dear authors, thank you for the effort in responding the queries from the reviewers and making the proper changes in the manuscript. Before we can finally accept the paper, there are a few minor revisions needed, basically regarding typos and two figure captions. Please see the changes needed below and in the attached file (where they are highlighted in red, nevermind what is highlighted in blue):

(line numbering of the "Manuscript+final+version.docx" file):
- line 15: "forms" instead of "form";
- line 15: remove "much of";
- line 51: "Classically" instead of "Clasically";
- lines 99, 100, 103, 106: "Section" instead of "paragraph";
- line 123: "South Atlantic Ocean", instead of "Atlantic Ocean";
- Figure 2 caption: Instead of "in black", write "Balck lines: fracture zones". Same for "in white". Is this figure the white lines are FAR TOO THIN to be seen;
- line 140: "thus" should be moved to the beginning of the phrase;
- Figure 7 caption: was not updated with the new figure.

We hope to be hearing from you soon!

Acceptance Letter

Thomas van der Linden, Douwe van Hinsbergen:

We have reached a decision regarding your submission to τεκτονικα, "MORGen: an algorithm to compute spreading centre and transform geometries from simple initial plate boundaries and Euler rotations".

Our decision is to: Accept Submission