Answers to reviewers's comments

Reviewer 2:

Review for Colleoni et al. (Geoscientific Model Development: gmd-2021-78):

PALEOSTRIPv1.0 - a user-friendly 3D backtracking software to reconstruct paleo-bathymetries

The authors present a MATLAB open-source software called PALEOSTRIPv1.0, which performs 1D, 2D and 3D backtracking of paleobathymetries. The robust and comparable calculation of paleobathymetries is an important factor in past climate reconstructions and providing the community with a widely accessible, comprehensive software package will prove incredible valuable step towards more detailed paleo-reconstructions.

For this review, I assessed the provided manuscript as well as the software package and manual attached to the software.

Overall, the manuscript is well written and gives a very detailed description of the process of calculating paleobathymetries. The example of the Ross Sea Embayment is clear and showcases the advantages of PALEOSTRIP clearly. Nevertheless, I like to advise the authors to amend some more information and resources for the profit of the users just starting working on paleobathymetric reconstructions, to avoid misconceptions and confusion. I detail these and some other comments below. Additionally, the text has some minor spelling and grammatical issues (especially when referring to software names), which should be rectified.

I recommend to accept the manuscript after minor revisions.

General comments on the manuscript:

1. *Backstripping vs. Backtracking: Throughout the manuscript, the authors reiterate that there is a difference between backstripping and backtracking without clearly defining and distinguishing both at the beginning of the manuscript. A paragraph laying this groundwork as well as explaining to the reader the different usage is warranted. A constant mentioning of these similar concepts confuses the reader. I suggest, the authors define the process they are calculating with PALEOSTRIP at the beginning of the manuscript and use only one to the terms in the remainder of the manuscript, to avoid confusion.*

We disagree with the reviewer's comment since the entire Section 3 is dedicated to explain, by means of equations and text (and even in the section title) that PALEOSTRIP performs backtracking. Reviewer 1 stated that he understood the difference well and also re-explained it very well in its own comments. We were very careful of using "backtracking" or "backtracked" throughout the manuscript to be consistent. Thus we estimate that no further clarification is needed here.

2. *What can PALEOSTRIP provide & what can't it provide?*

   For any paleobathymetric reconstruction, it is important to clearly define which geological environments can be reconstructed with a given method. The authors mention various caveats, that every geological reconstruction holds, throughout the manuscript, but a central paragraph briefly summarizing limitations and advantages of PALEOSTRIP for the reader can help convey various matters, that the users need to be aware of. More technical aspects might also be a good addition to the manual:

   - *Crustal Structure: Can PALEOSTRIP be used in areas underlain by oceanic crust or transitional crustal types, which might be common on wider continental margins? By including multiple β-factors and thermal subsidence various settings for the continental crust are available, which is great to reconstruct more complicated geological settings, but does this also translate to oceanic crust?*

We agree on this point and we inserted a new sub-section 3 in which we added a sentence mentioning that PALEOSTRIP does not backtrack sediments on oceanic crusts for now. This could be the object of a future release with the help of interested users.

   - *Dynamic Topography: Since PALEOSTRIP does not include a platekinematic component, the user needs to be careful to use appropriate dynamic topography models for the reconstruction time frame, since they are often related to a specific platekinematic model.*

Well, this recommandation holds for all input data. The present article is not focused on dynamic topography and we assume that the users are careful enough to choose appropriate input data for their reconstruction. Actually, as clearly stated in subsection 3.5, PALEOSTRIP does not provide any dynamic topography data. We just provided some regridded onto the Ross Sea sector for the sake of the case studies of this paper:"Note that Muller et al. 2018a is not implemented within PALEOSTRIP" .

We nevertheless added a sentence in subsection 3.5: "Maps of dynamic topography are inputs to PALEOSTRIP and the user is free to use any reconstructions. Note that inputs of dynamic topography require some post-processing to be adjusted to the area of interest before being passed through the GUI".

   - *Lithological parameters: Could you point the readers to resources, where they might find general values to compare their lithological parameters (especially the decompaction coefficient) to, or use in case the area they are working in has not been cored?*

In other commercial softwares, standard lithological parameters are implemented already within the softwares. However the approach of PALEOSTRIP is to provide the physical structure and let the users provide all input data related to lithological parameters. Most of the books about basin analysis (Allen and Allen, 2013, Wangen et al., 2010, and many others) or some key papers such as Kominz et

al., (2011) provide analysis and explanation on how to retrieve those parameters. So by doing a bit of bibliography, one might retrieve the necessary parameters. The use of lithological parameters in areas for which lithology is unknown is at the discretion of the users and might vary from area to area.

- *Erosion and re-sedimentation: One crucial and difficult to quantify aspect of paleobathymetric reconstruction, especially in areas of polar continental shelves such as the example from the Ross Sea given here, is the removal of sediments by* advancing glaciers and potentially various stages of sedimentation prior to the current position. How does PALEOSTRIP deal with scenarios of multiple sedimentation cycles and how do the authors recommend users do account/correct/anticipate this process?

This is a very good point. PALEOSTRIP cannot handle erosion at this stage. This would imply a varying number of sedimentary layers during computation, which is not implemented in this version. How to deal with it? One needs to make some initial hypothesis about how much and from where sediments are eroded and add them artificially as a single additional layer during backward modeling. A very good description of the procedure is provided in "Physical principles of sedimentary basin analysis" by Magnus Wangen (2010), chapter 5, 5.4 Erosion. This could be a way of dealing with it while modifying PALEOSTRIP structure. We added this short explanation to the manuscript (a new subsection 3.6).

3. *Communication of new releases:* The authors mention various times throughout the manuscript as well as within the software manual that certain functionalities are likely to be developed in the future. How will the authors ensure, that they inform the community about new developments by themselves or other groups?

The updates will be the object of peer-reviewed articles in literature. Most of the functionalities that you are referring to will likely be developed within the next two years because this paper is funded by a national Italian project that will end in May 2023. However, because of the open source license, the philosophy is to let users free to implement their own developments within PALEOSTRIP and communicate them to the community or not. If there will be some interest to build a PALEOSTRIP community, many of those individual developments could be incoporated within PALEOSTRIP next releases. For now, those who are interested to follow some updates by our group can contact any of us directly.

Specific comments on the manuscript:

Abstract: Introduction:

The abstract should include a brief explanation, why paleobathymetries are important and how they connect to paleomodels.

This paper is really focusing on the description of the software. Thus we do not think it is important to add this sentence to the abstract. We prefer keeping it focused. The importance of paleo-bathymetric reconstructions is touched upon in the Introduction.

L24 tectonic setting might not encompass all the different factors listed here. To underline the importance of paleobathymetric reconstructions, it would be useful to add brief examples on the processes and give the reader a window of how much bathymetry can actually change within certain timeframes.

We added some references at the end of this sentence: "(e.g. Herold et al., 2008; Frigola et al., 2018; Müller et al., 2018a; Straume et al., 2020; Hochmuth et al., 2020)" to provide references for the readers about global paleogeography changes through different time periods.

L32/33 "overprinted information" what do the authors mean by this? Erosion and re-deposition?

We reformulated: "eroded and/or reworked", which is definitely more correct here. Thanks for pointing this out!

L40 and following: This is a great overview on what is currently available for backstripping/tracking. This paragraph would be a great opportunity to emphasize, where the current gaps are, that PALEOSTRIP is closing.

PALEOSTRIP's original contribution is mentioned in the next two paragraphs just after this one. We just think that no additional sentences are needed.

Model framework and requirements:

I tested download and installation of the software package and am happy to report, that there were no issues on MATLAB2020. The interface is well done and easy to navigate. The example data worked and I could re-calculate the steps presented in the manuscript.

L73: incompatibility with GUIDE this information might be more suitable for the manual.

We retain that it is important to have this info here so that at first glance, the reader can understand or not if his/hers operating system and software release is compatible with PALEOSTRIP without having to download the code and go through the Manual.

Coordinate Systems: The resources mentioned here should also be added to the manual.

Same here, this paper describes the software, this is the aim of such a journal. So all info useful to run the software should be mentioned here.

Input files: mention the examples attached to the software package.

Agreed. We added the following sentence: In the present study, the input data files associated to each case studies are zipped in paleostrip_examples.zip, available on GitHub at https://github.com/flocolleoni/PALEOSTRIPv1.0.

PALEOSTRIP: Backtracking:

This entire paragraph is a detailed and very clear overview on the different steps of paleobathymetric reconstruction and various consequences to the seafloor development. Several caveats the user needs to account for are mentioned throughout the text. As already detailed above, I would recommend a summary paragraph explaining the advantages and limitations of PALEOSTRIP to be included here.

As you reported, most of the caveats of the different aspects of PALEOSTRIP are discussed through the text. However, as you suggested, we inserted a new subsection 3.6 "Sediment erosion" and we inserted a sentence about applicability for oceanic crust at the end of the introductory paragraph of section 3: Note that the physics implemented does not allow the treatment of oceanic crust in this version. This can be done by adding a few more options in the GUI mainly for thermal subsidence (e.g., Muller et al., 2018b).

PALEOSTRIP Grid Interpolation:

The various details described here are very convoluted. This paragraph might profit from a careful re-write. During the final editing, Fig. 4 needs to be as close as possible to the describing text to convey the information needed.

Reviewer 1 also pointed out some confusing statement. We simplified it and we hope that the new version of this section is clearer.

PALEOSTRIP validation:

Although the reader can quickly refer to DeSantis et al. 1999, it would be practical, to reiterate how the used lithological parameters have been measured on DSDP 273 (logging along core, discreet samples...).

This paper is not a sedimentological description of the cores, but a description of the functionalities of a software. We thus think that this is not useful to the aim of this specific paper.

L369 and following: The authors compare PALEOSTRIP and Flex-Decomp pointing out a good fit and some understandable discrepancies. What would be considered a good fit and what kind of error margins can be assumed for this kind of reconstruction? A brief overview on potential error sources and error margins should be added to aid with maximum/minimum scenarios and raise awareness in the user community.

Uncertainties on edges influence on flexural isostasy is very well known (e.g. Wickert et al., 2016 provide some description on how to treat the load at the edge of a flexural grid) but only sediment cores can constran paleo-altitude or paleo-depths. Thus good reconstructions should result from the tuning of your flexural parameters (and of the other processes constrained by sediment core records. If the user doesn't have any observations to constrain

his/hers backtracked depths, then a statistical approach, performing ensembles of reconstructions varying the parameters within defined ranges (e.g., Monte Carlo, Latin Hypercube) is the only way of calculating statistical uncertainty and providing a measure of how good your backtracking is.

Potentially all the processes that are parameterized within PALEOSTRIP are a source of uncertainties, even the input paleodata by the users. There is no way to provide ad-hoc ranges of uncertainties for those processes since it will depend on the input data and on the area considered for backtracking.

Case study: example of the Ross Sea

Figures:

The example of the Ross Sea illustrates the different processes of the software package and does not draw on specialist knowledge of the region. Although, this manuscript is not designed to interpret the paleobathymetry of the Ross Sea, a little bit more detail to the results might be useful to fully see the physical settings at play. In my opinion, this does not necessarily require a lot of additional text, but can be conveyed with some changes to the attached figures (see comments to figures below)

As you point out this paper is not focusing on Ross Sea paleo-bathymetric reconstructions. Thus we did not modify the main text. But we improved the clarity of the captions of the figures to allow a better understanding.

General comment:

Some of the figures use red and green, which might create inaccessibility issues for visually impaired readers.

We acknowledge your suggestion. Those figures are direct PALEOSTRIP outputs and this colorscale is the PALEOSTRIP default colorscale. We wanted to illustrate the functionalities of the software. Contours are also provided on the Figures and we believe the readers might appreciate the differences even without colors.

Fig. 2: With a clear definition of backtracking vs. backstacking, the caption can be decluttered.

Agreed. We simplified the caption since it was clearly representing backtracking.

Fig. 3: Clear conceptual figure! I suggest to add this diagram to the manual as well.

Thanks!

Fig. 4: This figure immensely helped with my understanding of the paragraph on *PALEOSTRIP Grid Interpolation.* In the final edit, this figure needs to be set as closely as possible to this crucial paragraph.

Thanks!

Fig. *5:* Colour scale and km-scale are difficult to see on the blue background. Users unfamiliar with the Ross Sea might profit from indicating the basement highs, which are emerging in the reconstruction.

We put both scales in a white box to improve readability. Since we are not using any Ross Sea bathymetric highs in the main text, this is not relevant info to add to this figure.

Fig. *6:* Axis description on panel A differs from other panels and should be homogenized for better comparability.

Done.

Fig. *9/10/11*: Please change the used colour scale to be able to differentiate between both ends (currently both high and low end of the scale saturate in the red). Given, that the text states, that a certain portion of the embayment becomes subaerial, this should easily be visible in Fig. 10 & 11 (maybe use same colour scale as in Fig. 5?).

Actually, only the island in the uppermost right corner of the figure is above sea level. All the rest is below sea level. Those figures differ from Fig 5. They are PALEOSTRIP output figures and the colorscale is PALEOSTRIP default colarscale. We now indicate all this in the captions of Fig. 9, 10 and 11: "Layout is from PALEOSTRIP plotting GUI and the colorscale is the default colorscale impemented within PALEOSTRIP and has been saturated below -4000 meters and above 200 meters for the need of this figure. The island located on the uppermost right corner is the only location with elevation above sea level".