Answers to reviewers's comments

Reviewer 1:

Review of paper by Colleoni et al.: *PALEOSTRIPv1.0 – a user-friendly 3D backtracking software to reconstruct paleo-bathymetries;* submitted to GMD (MS No. gmd-2021-78)

General comments:

This paper presents the rationale, methodology, physical/geophysical background and parameterization of new open-source software to calculate paleo-water depths in a 1D, 2D and 3D backtracking/backstripping procedure. The development of a relatively user-friendly open-source software for paleobathymetry is timely as the relevance for improved paleo-water depths for different time slices of the past geological history of ocean basins and continental margins is largely increased for urgently needed improved paleo-ice sheet and paleo-climate modelling results. Previously available software solutions have been lacking various aspects, such as full 3D flexural response, implementation of mantle-driven dynamic topography, sensitivity testing, open-access/open-source, and user-friendliness. All aspects are absolutely necessary to a research community-wide acceptance and usage of this software. The paper is well structured and written, and it contains the necessary and informative tables and figures. The methods and mathematical background are absolutely sound, and previously developed procedures are correctly cited. I recommend the paper to be accepted for publication after the following minor issues are addressed.

Specific comments and suggestions (numbers refer to line numbers of manuscript):

1) In general: Difference between backtracking and backstripping? I think that this is rather a semantic difference. In both approaches, the same fundamental principles and equation systems are used. It's only a matter which of the variables should be solved or kept constant first: Either assuming a fixed paleo-water depth and then solve for decompaction and subsidence, or implying an assumed subsidence and decompaction for obtaining a paleo-water depth. I suggest to generally use the term backstripping for either approach as this term is widely known and recognised in the geoscience community.

Many softwares in literature distinguish between backstripping and backtracking. Thus it is just a matter of terminology. Since we explicitly describe the differences within the manuscript between backtracking and backstripping, and also show the differences in the equations, we think it is more honest to distinguish between them. In PALEOSTRIP, it is not straightforward to perform a classical backstripping procedure since one cannot prescribe a paleo water depth history in this version of the software. The only way of doing backstripping is to deactivate the tectonic subsidence from the GUI and prescribe a water depth in the sea level tab of the GUI. In this version, the sea level tab does not allow to have a time-evolving

and spatially varying sea level history (only timeseries can be prescribed to have time-evolving values). With a few modifications, this can be done quite easily. But right now, the software is more dedicated to reconstruct paleo-water depths. Thus, we prefer keeping the terminology as it is for now and follow modern works terminology for basin analysis (e.g. Muller et al., 2018).

3) Introduction: I suggest to add the following two references as previous examples of 3D backstripping cases from the SW African and Brazilian margins to the Introduction: Dressel et al. (Marine & Petroleum Geology, 2015) and Dressel et al. (Tectonophysics, 2017).

Thank you very much for pointing out those references. We added them to the indicated paragraph.

2) Chapter 3: The authors describe with great clarity all necessary steps for backtracking/backstripping (decompaction, isostatic correction, thermal subsidence, sea-level, dynamic topography), but one important aspect is missing which is in particular important for polar continental shelves. That is the reconstruction of sediments that were eroded/truncated by grounded ice-sheet advances. Of course, reconstructing such eroded sediments above truncational unconformities or the seafloor (in case where dipping sequences pinch out) requires assumptions on pre-erosional sedimentation rates, but it would be useful if the authors could include a short paragraph on how this issue could be handled with their software.

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. As you mentioned, 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).

4) Chapter 3.4 Sea level correction: The first paragraph has some repetition regarding the short timescale, glacial/interglacial cycle driven sea-level changes. Should be partly rewritten.

We simplified this paragraph and reformulated it. See the track-changed version of this manuscript.

5) Chapter 4: The description of input data formats for 2D and 3D is not always very clear. For instance, is with 'regular array' a constant spacing of nodes meant? And can the x,y coordinates be different from horizon to horizon, or must x,y be the same for all horizons? Please clarify.

Thanks for pointing this out, it was indeed misleading. We reformulated the sentences. Coordinates must be strictly identical for all horizons. Input data must be on the same grid. Spacing between each x and y must be constant. For 3D grids, the spacing along the X

direction can differ from the spacing in the Y direction. But along the X direction, spacing must be constant. Same along the Y direction.

6) Chapter 6: I think it would be very useful to potential users of the software if the authors could make the input files of their two cases accessible, either as Supplementary Material or by providing URLs. Most new users to a software prefer to start with well tested working example files to become more familiar with the parameterization before preparing and loading their own data files. This would add to the acceptance and encouragement for a wider usage of PALEOSTRIP.

All input files of case studies shown in this article are distributed on GitHub alongside with PALEOSTRIP code. There is a specific zip file named "paleostrip_examples". Actually, Reviewer 2 found them and used them to test PALEOSTRIP without any issues.

Corrections of phrasing and spelling, and other minor issues:

7: 'to allow users to'

Done

12: '(e.g. the Shared Socio-economical Pathways by Riahi et al, 2017)'

Done

15: '..., although ...'

Done

37: '..., and thus the paleo-water depth ...'

Done

45: 'trends'

Done

50-51: '... of the geodynamical open-source software GPlates (https://www.gplates.org/). It benefits from geodynamical corrections related to kinematic, ...'

Done

55: '...areas to constrain climate ...'

We actually chose a different formulation: "...areas that will be prescribed as boundary conditions within climate and ice sheet models". This is more correct than the previous formulation or the one you suggest here.

71: 'operating system'

Done

81: ‘operating system’ and ‘provide the PALEOSTRIP code’

Done

84: ‘Coordinate system’

Done

101: I suggest to add ‘... on the thermal subsidence as well as erosion ...’

Agreed and done.

Equation (1): Shouldn’t it be $\rho_m+\rho_w$ in the last term?

No, this term is correct. This $\rho_m-\rho_w$ *represents mass substitution, here water by water.*

111: Add abbreviation ‘... sea level (SL) variations ...’ to refer to term in equation.

Agreed and done.

123+125: ‘right-hand side’

Thank you for pointing this out! Done.

128: ‘... are explained following ...’

Done

187: ‘... grid point results are independent from each other.’

Done

206: Remove the a before ‘2d and 3D ...’

Done

210: ‘by means of’

Done

211: Remove one of the two in.

Done

212: ‘also allow to use’ (remove s)

Done

222: ‘the stretched lithosphere thins due to cooling’

We reformulated with “the stretched lithosphere constricts due to cooling”

247: ‘larger time elapsed since’

Done

258: Add ‘On a long time scale, sea level ...’

Done

259: ‘... and on shorter time scales, due to ...’

Done

258-267: There are some repetitions in this paragraph. Please rewrite.

We did simplify this paragraph. See the track changes in the manuscript.

290: ‘... dynamic topography occurs at long wavelength ...’

Done

308: ‘PALEOSTRIP’

Done

324: It says 90% in Fig. 4a. Please be consistent.

We corrected it. Correct value is 90%. Thanks for pointing this out!

330: Please clarify if *dx* and *dy* must be identical for all horizons polygons.

We clarified the introductory paragraph of Section 4 (see our answer to your previous general comment at the beginning of this review). And we further simplified the other paragraphs. We hope this is more readable in the new revised text.

331: It is not clear what is meant with scattered data as opposed gridded data. Do you mean data on an irregular grid as opposed to data on a regularly spaced grid?

*Scattered data means that points are unstructured and are not written in a file following a classical NX*NY structure but treated as independent single points. When data is treated as scattered, this takes more computational time, but this also allows one to input either structured gridded data, or irregular polygon data (that can’t really be read as a rectangular grid because some of the grid points would be empty).*

345: Add sentence: ‘Depths are related to present regional sea level.’

Done

349: Add ‘... is the age of horizons at the base of the layers and ...’

Done

368: ‘The match between ...’

Done

377: Why are results better than with Flex-Decomp? Do you have a short explanation?

Yes. This is because TAFI is an isostasy scheme and we implemented it within PALEOSTRIP to test different ways of computing isostasy. However, the regridding of the loads is done by PALEOSTRIP in both cases. This explains why PALEOSTRIP finite difference isostasy and TAFI isostasy show only minor discrepancies. Flex-Decomp applies a different reggriding method of the loads, which mostly explains the discrepancies observed with PALEOSTRIP.

We added “Re-interpolation of the load is performed by PALEOSTRIP in both cases” to the description of TAFI impacts on backstripping.

381: ‘The match between ...’

Done

385: ’... also extract 2D transects or 1D wells from 3D ...’

Done

386: ‘we provide two case studies’

Done

389: ‘Both cases are taken ...’

Done

392: ‘... Ross Sea paleo-bathymetry ...’

Done

396-397: Shouldn’t it be ‘DSDP Site 273’ on the western Ross Sea shelf?

Many thanks!...initially we used DSDP site 270 to provide a case study but we ultimately decided on site DSDP 273. We corrected it here and in the caption of Figure 8.

414: ‘... depth of the mid-Miocene unconformity ...’

Done

419-424: According to Fig. 4 in De Santis et al. (1999), the unconformity RSU4 and other unconformities pinch out to the seafloor due to glacial erosion. How have the eroded sediments been taken into account? See also my comment above.

See our answer to your general comment above about erosion treatment within PALEOSTRIP.

436: Add ‘It can process paleobathymetries for ...’

Done

439: ‘allow users to insert’

Done

440: Remove a before ‘minor work’

Done

Figures:

Fig. 4a & caption: The text (line 324) says 80%. Please correct.

Thanks for pointing this out! We corrected the main text. The Figure’s caption is correct.

Fig. 4b & caption: It is not clear if the squared grid is absolutely required. How about a rectangular grid, e.g. in cases of long but narrow continental shelves?

We apologize...we realise that the figure can be misleading. Actually, the grid is rectangular in the sense that PALEOSTRIP builds it based on Xmin and Xmax and Ymin and Ymax. So in the case of an elongated area, the corresponding grid will be rectangular and elongated in the direction of the largest width.

Fig. 8 caption: Change to ‘DSDP Site 273’.

Many thanks, we corrected it.

Fig. 9 caption: What are the references for the RSU-4 and basement grids?

References are from the ANTOSTRAT project. We added them to the caption and to the main text (Subsection 6.2).