Review Report

Vaes et al. - APWP-online.org: a Global Reference Database and Open-Source Tools for Calculating Apparent Polar Wander Paths and Relative Paleomagnetic Displacements, TEKTONIKA, 2024.

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1st Round of Revisions

Decision letter and author response

Dear Bram Vaes, Douwe van Hinsbergen, Joren Paridaens:

We have reached a decision regarding your submission to τεκτονικα, "APWP-online.org: a global reference database and open-source tools for calculating apparent polar wander paths and relative paleomagnetic displacements".

Our decision is to: Resubmit for Review

As you will in the online portal for your manuscript, Graeme Eagles, the Associated Editor (AE) handling your manuscript (see below for AE report to me), solicited two expert reviewers who have provided detailed and comprehensive, constructive comments on the paper. All agree that the manuscript is certainly suitable for Tektonika and well put together, but that some work is required to make it more accessible for a broader audience.

I now invite you to prepare a revised version of the manuscript. Ideally, we suggest trying to complete revisions in a couple of months, but we are flexible on timelines and just ask that you update us on any foreseeable delays.

Kind regards,
Craig Magee

General message to the Editor:

Dear Editor,

Thank you for these constructive reviews that invited us to clarify and improve several aspects of our manuscript. We have addressed each of the comments of the reviewers listed below and provide a tracked-changes version of the manuscript. In summary, we have expanded the documentation for the software by adding a *user manual* that provides a concise overview on how to use APWP-online.org. This should aid new users to get familiar with the tools and its functionalities/options, as well as its input and output files. Moreover, we improved the explanation of several buttons, input fields, and the purpose of the tool for each portal, and fixed some bugs. Regarding the manuscript, we have added a background section to explain the background of the methods used here as well as some of the key terms used throughout the paper and on the website, following the recommendations of reviewer #1. We have also clarified the terminology where needed and expanded the explanations of the screenshot figures in the captions.

AE report:

The recommendation regarding the submission to тєктоніка, "APWP-online.org: a global reference database and open-source tools for calculating apparent polar wander paths and relative
paleomagnetic displacements" is: Request Revisions

Two reviewers have seen the manuscript and engaged with it in depth. Both welcome its submission, variously describing it as timely, valuable, relevant, well-written, clearly laid out, and useful. Both reviewers recommended the manuscript could be accepted following modifications. A prominent point from each of them is the need for better documentation to help users of the software that the manuscript describes. One reviewer (Dupont-Nivet) suggests that this help should appear in the manuscript, suggesting software users would be able to use the manuscript as a kind of user manual for the software. The second reviewer (Tetley) suggests the documentation should appear as more extensive help menus in the online software. To me, additions to the software this would seem the more orthodox course of action. Dupont-Nivet also suggests that the manuscript should be written in a more accommodating style for non-paleomagnetists, who will make up the bulk of Tektonika's readership. As a non-paleomagnetist who occasionally needs to engage with the subject, I second this comment. As well as these points, each reviewer provides a fairly lengthy list of minor corrections and changes that the authors should carefully and responsibly consider and respond to.

Best regards,
Graeme Eagles

Thank you for these positive comments.

We completely agree that more extensive documentation was needed. For this reason, we have added a *user manual* that helps users to get acquainted with the software and its tools. The manual is directly available for download as PDF, both from the homepage as well as from the header of the website. As mentioned above, we have also added a background section that will help non-paleomagnetists better understand the paper. We note, however, that the tools presented here are technical and, in principle, meant for researchers that already have some background knowledge on the tectonics applications of paleomagnetism. We anticipate that the textbooks and background papers cited in the new background section will help non-paleomagnetist readers to find additional background information where needed.

Comments by Reviewer A (Guillaume Dupont-Nivet) and Authors' response

Dear Authors and Editor,

This paper introduces the online tool associated with the application of the methodology to process paleomagnetic data that has been proposed in 2 previous papers (one of which is not published but available on Earth arXive). The paper comes with example of applications that make it very clear what can be done with it. The methodology proposes a solution to a long standing and major problem in the statistical processing of paleomagnetic data, and as such is very timely and valuable. The application proposed in the present paper is extremely relevant as the new method requires complex computations that can not be easily done with standard software. As a result, this paper is bound to be highly cited and extensively used as a reference and guide for the usage of the online tool. For, this reason I think it will be the one that is used most and therefore should be clearly convey the content of the more theoretical companion papers Vaes et al., 2023 and 2022. For this I have made many suggestions, in particular to clarify the terminology and to be consistent in using it throughout the paper. This is a very well written paper, yet it is sometimes a bit technical and may not easily accessible to less experience users such as non paleomagnetists and students. I have used the tool to process a current project and managed to get valuable results easily. From that experience I drew a series of suggestions and comments. In general, the online tool does not offer online help menus, therefore the tool will rely mainly on that paper. As a result the paper should also make the connection clear with the specific options and windows online. The caption of the figures could be use for. I also have commented on deeper aspects of the fundamental method but these comments are more relevant to the other previous papers and do not affect my appreciation othat this paper should be published pending minor revisions.

First, we would like to thank the reviewer for his kind words and are happy to read that he obtained valuable results easily using our software. We have expanded the online help menus, added extra information per input field, and added a *user manual* on the website to accommodate the user in getting familiar with the tools. We have also improved the connection between the manuscript and the figures by expanding the captions of each figure. Finally, we have added a background section that explains APWPs and the computation of relative paleomagnetic displacements in more detail, to make it more accessible to nonpaleomagnetists and students.

I am appending a pdf with the detailed comment directly in the text. It is not going through your system, maybe beacause I am at the Istanbul airpoty. I will send it per email to theditor. Please make sure this is accessed by the authors.

Find below the details of the comments by line numbers and at the end my comments upon trying the tool.

With best regards,
Guillaume Dupont-Nivet

17. "Paleomagnetic displacements" could be many things. They can be defined in the fist sentence of the abstract. Then no worries throughout the paper.

We use this more general term as the 'tectonic' displacements derived from them – vertical-axis rotations or paleolatitudinal motions - are interpretations, as explained in the introduction. We have clarified this in the second sentence of the abstract to emphasize that the relative paleomagnetic displacements are determined from the comparison of two types of paleomagnetic poles.

40. Here it would be good to explain how the APWP provides a reference pole ofr that plate (plate ciruit allowing the use of other study-poles from other plates and the age windows that go with that.

The previous sentence already explains that the "reference direction or pole that represents a nearby stable tectonic plate is often provided by an APWP." The transfer of paleomagnetic poles

40. Sentence is too long. Cut after "APWPs,'. This is part must be very clear so the rest of the paper can be understood.

We have removed this sentence to improve the flow of the text and the clarity of the main messages.

42. Again cur that giant sentence after "A95,". So this one long sentence into 3.

We have also rewritten this sentence.

46. I find the statement a bit confusing. Not sure if this is the way Rowley put it. The poles that are used are "discordant" assuming bad statistics. They are statistically distinct if the classic approach is used, showing it is nonsense. To me it is more clear to say the statistics are wrong. You may add one or two sentences to clarify this as it is a major point.

Good point, we have emphasized that this result was obtained when using the conventional statistical approach. We note that we already made clear in the next sentence that this should be interpreted as a problem with the approach, not with the paleomagnetic data itself.

51-53. Some probem in that sentence, should be:

"the reference direction is a pole from the APWP that is computed from the mean of study-mean directions from the sable continent, whereas the observed direction from the realtively mobile part to be determined, is one study-mean pole instead computed from a collection of spot reading directions of the geomagnetic field (i.e., paleomagnetic sites)."

Corrected

56. "Site-level datapoints" and "study mean pole" to simplify and make that paper a hudnred times easier to read I would suggest always using the same terminology and to be consistent across different levels of sampling. Rather than using both "site-level datapoints" and "site-mean directions" or "study-mean pole" or "study-level datapoints" etc… I suggest having always the same. e.g. "samplemean", "site-mean", "study-mean" (that can be combined with

"directions", 'poles', "datapoints". I would also suggest defining those terms in a table or something and then sticking to them in the other papers and especially in the website that this paper is presenting. Very confusing throughout the paper is the use of "poles" and "paleopoles" for various "hierarchical levels". I would avoidn this and always mention if they are site-poles and study-poles. Would be also good somewhere to simply define wha a "pole" is, in fact a "Virtual Geomagnetic Pole" based on a "sample", "site-mean" or "study-mean" direction from a given location. It sounds like a nerdy comment as I read it again but I am sure it will improve not only the readibility, alleviate potential ambiguities and misunderstanding.

We agree that this could be confusing. We have therefore removed all instance of 'datapoints' and 'paleopoles' and improved the consistency in our use of different terms throughout the text. For terms that are not yet explained in the introduction, we have added a description in the new background section. Our new background section provides a more detailed explanation of how APWPs are computed from paleopoles, what a paleomagnetic site is, and how VGPs are derived from them.

61-68. Huge sentence has to be cut in two, maybe three to be digestable.

Corrected

66. 'e.g., by ocean basin reconstruction'. I would change to 'e.g., by retro-fitting marine magnetic anomalies' that is more precise and clearly indicates the referred methods.

Corrected

68. "parametrically resampled site-level data". I know exactly what you mean here because I know the technique but I am not sure this is obvious for all paleomagers. You could explain a bit or at least add a reference to the parametric resamling routine defined by Tauxe in the book coming with her software.

We have added this to the new background section.

70. "hierarchical level". Again I know hat you mean but this may not be obvious to all. This hierarchy could be defined in that table I suggested on the previous comment to define the various statistical level of sampling and means. I have also not found that in Vaes 2023 so certainly something that will help pass on the method.

We agree and have added a short explanation of the different hierarchical levels to the new background section. This problem of using different hierarchical levels is extensively discussed in Vaes et al. (2022), which is cited many times in this context. For more details we refer the nonspecialist reader to well-known textbooks. We note that this paper aims to present a new specialist tool and not provide a detailed review of statistical methods in paleomagnetism.

70. I suggest replacing requires' by "is achieved with". Other techniques may be used to do this.

Corrected

80. Do these case studies include the building of a new APWP?

Yes

91. "custom-provided collection" it is not clear from that sentence what this is. It should be define somewhere. Could be simply adding a sentence explaining the source of the data which is not so obvious from reading this paper alone.

Corrected

90-91. This sentence typically sounds ambiguous to me.

Corrected

92. "itself" should be "themselves if referring to the paleopoles. The "paleopoles" or "poles" are here site-poles and not study-poles if I understand correctly. Having a consistent tereminology defined in the paper would alleviate this.

We have removed this part of the sentence for clarity

92. "specify"

Corrected

93. 'the size'

Corrected

96. should clarify what the coordinate system of a plate is.

We have removed this part of the sentence for clarity

97. 'user-provided' or the euler poles providid by the software.

We have decided not to include this functionality for now, so we removed this sentence.

Page 4:

"each iteration"

This is explained more clearly now.

"pseudo-VGP" meaning?

We have replaced this by re-sampled VGPs to avoid confusion.

108. "the workflow" is not specifically described in Vaes et al., 2023, more the background theory.

We disagree that the workflow is not explained in this paper. Fig. 2 in Vaes et al. (2023) schematically shows the entire workflow of the computation of the global APWP, and we refer to reader to this paper for more details.

110. fig. 3 caption is quite limited. This would be a good place to explain how to work with these tools (as there is no help menu on the website and it is also not explained in the present manuscript). See comments above on how to use the different options and what to fill in the windows, what is pre-given in there and where to be careful to add specific user info. The easier it will be to use the more it will be used. Te current captio does not justify the figure. What is the purpose of showing these in particular? Taking time to write the details of how to use the tool in the caption would be useful later to add in a help menu on the website.

A detailed explanation of the tools and different options and buttons is now provided in the user manual. We have expanded the description of this figure to make it more useful and better linked to the text.

128. "pseudopole" is used in the previous part (as "pseud-pole")but only defined here. A table with all the defined terms would be really helpful, as commented above.

We have removed the previous instance such that this line gives the first mention of this term, which is defined here.

129. "paleopoles" I am guessing these are the reference VGP mentionned in the previous sentence?

No, these are the paleomagnetic poles listed in the reference database, as explained in the text. Reference VGPs do not exist, and we clarify the difference between a paleopole and VGP in the background.

133. "number of sites used by the original authors to compute that pole" and "Ns" in the next sentence

are different beasts I think. Yet they are very close leading to confusion. Again would be good havea table (to define Ns) but this will not be enough. The wording has to be carefully chosen to have the readers scratch their heads less.

The meaning of N_s is defined a few lines above (line 126 in the submitted manuscript). We think the explanation provided here is clear.

133. Why not use the original data for the poles? I guess it is not always available but this formats the data.

This is a good suggestion. Version 1.0 of APWP-online.org intends to use the approaches of Vaes et al. (2022, 2023) which rely on the parametric re-sampling of all the reference paleopoles behind the global APWP. We indeed plan to develop the option for adding custom reference databases by the user that include the original site-level paleomagnetic data instead of study-mean paleopoles. This requires a different workflow and lots of 'failsafes' in case the number of sites and its temporal coverage are not sufficient. For now, we prefer to present tools enabling the re-sampling approaches that were already developed and published.

134. "VGPs" refers here to poles equivalent to site-means (providing a snapshot of the field). Like the VGPs of the previous sentence but not to the pole referred in that sentence. Could be clarified easily.

We believe the reviewer may be confused regarding the meaning of a VGP, which is always computed for a single site, providing indeed a snapshot or 'spot reading' of the past field.

it is not obvious from what data pool these VGPs are drawn from. If that directions pool has a large scatter, will that scatter remain in the gathered data to compute the presudopole? Say you have 2 good studies that defined 2 very different reference poles. Do you first generate 2 datasets with respective mean directions? And then average those site-level directions? Then generate parametrically a new dataset based on the mean direction, K and N?

Admittedly, we do not see how this is unclear. As clearly stated, these "*VGPs are generated by parametric re-sampling of all paleopoles included in the reference database, whose age uncertainty range overlaps with that of the studied dataset.*" From *this pool* N_s VGPs are selected that fall within the time window around the age of the studied dataset. No VGPs or directions from different reference datasets are averaged first. Again, we refer to our previous publications for more technical background.

But then if you had a 3rd dataset with yet another far fetched direction, that would show the 2 first ones have not sampled the variability on the reference pole dataset. There should be a reference disctribution for the VGPs that define a reference pole. This should be different from the distribution related to secular variation as it integrate more sources of variability.

That is entirely correct. As explained by Vaes et al. (2022, 2023), the reference distribution of VGPs has a dispersion that is expected to be slightly larger than that purely related to secular variation, since it is affected by additional sources of noise such as age uncertainties, uncertain bedding corrections, errors in the relative plate circuit used to rotate the data to a single reference plate, etc.

136. "as specified by the user". Is there not a given number of iteration sufficient to determine the mean direction? Would be good to make sure users go beyond that number to define the pseudopoles.

Good suggestion, we have added this recommendation to the manual.

Related to this, and more findamental, this procedure appears to assume the reference pole directions are very well defined at least better than the study). What if the reference pole direction is not so well defined? Say there are only a few (e.g. 25) directions to define it. Or the reference pole is defined by a good number of directions (e.g. >200) but they are altogether scattered like hell (low K). There is an assumption here that the variability around the refernce pole is well sampled but anothr assumption could be it is not sampled enough and the mean could vary if more data was availabe.

Not sure that belongs to this paper but I have not found an answer in Vaes et al., 2022-23.

This is a very good point. A poorly defined reference pole (or direction) could result from a lack of (reliable) data or simply by choosing a too small time window for the APWP. We will add a warning when the reference pole is based on N<100 or is smaller than that of the studied dataset.

152. Fig. 4 caption very limited. Same comment as fig 3.

We have added a more extensive description to the caption

171. "and"not needed here

Corrected

176. See Butler 1992. Would be helpful to indicate chapter and appendices referred to here.

Added

Note for the reference line 390. Bob Butler's book is not edited anymore. But the content is available online on the UoA website. This could be mentionned here in the reference.

Good suggestion, we have added the link to the reference.

194. See my comments upon using the tool. I found not clear which parameters are absolutely necessary to run the tool. Would be good to specify what is needed and not. Also it seems some of the info is redundant:

- VGPs can be deerived from site-mean directions and site location and vice versa.

- Any 2 combination of K, n and a 95 is enough to get the thris parameter.

The tool would be more easy to use if only a minimum info can be included (e.g. k and n or a95 and n).

It would also check for errors and avoid the inclusion of biased datasets.

Good suggestion, we explain the mandatory input fields in the new user manual.

198. Sentences starting with 'For the global APWP,...'. It takes reading until line 203 two sentences later, to understand the context of that statement. I suggest starting with the sentence "The input file includes an optional…" and then explain why.

Corrected

243-244. "database coupled to the MagIC database". The format of the atabase is different, notably for the input of the paleomagnetic sample coordinates and the bedding corrections. Some data in the MagIC database is now provided with erroneous orientations. There seem to be a systematic error in coupling these databases that requires some attention before it propagates back into the online.org database…

We have removed this sentence.

286;'are minor since Eurasia did not rotate much' is a bit loose. I would say the Eurasian rotation with resepct to the north pole is minor (5-10%) relative to the rotations of NE and SW Japan.

We have specified that the rotation is less than 5 degrees.

305. "relative to Eurasia" is that relative to the APWP of Eurasia?

Yes, we have clarified this.

Why does that 'tightly' constrains teh timing and amount of rotation?

We have removed this part of the sentence.

I suppose the Eurasian APWP is, compared to NE and SW Japan; less well defined by fewer data with less good ages. Seems to me this would add some uncertainty.

This brings up the uncertainty on the ages. In the procedure it seems to mix up with the rest of the uncertainty (in space). But it is hard to judge from the output how much is contributed by ag uncertainty. I suppose sometimes given the age window, a 'bad' moint may be included that will shift the APWP and may introduce biases in the APWP. Slightly changing the age would include or exclude such point and make a difference in the results when there should not be. Also data used to define a reference pole may have very large age uncertainties and therefore affect a large span of time. These age issues are partly discussed in Vaes et al., 2023 but they are hard to grasp from using that

tool alone. The underlying assumption is often that the reference poles are defined by enough data to be confident on the age and directions

These are all important concerns. We note the Eurasian APWP here is simply the global APWP in Eurasian coordinates, which is defined by a lot of data. As mentioned above, we will implement warnings to show when the reference poles are less well defined then the individual data points used to determine the relative displacements. We note that data with very large age uncertainties are not present in the database that underpins the global APWP, because they were intentionally excluded in its computation. Indeed, the underlying assumption of any of these comparisons is that the reference pole/APWP is robust. Similar concerns may also be expressed for the individual paleomagnetic datasets compiled for the chosen terrane. All paleomagnetic analyses and their interpretations are, in the end, dependent on data quality and robustness. We foresee, however, that using the statistical methods applied here, based on (simulated) site-level paleomagnetic data rather than arbitrarily defined study-mean poles, generally leads to more robust results that may be interpreted as geologically meaningful.

325. To clarify sentence change 'and' to 'and because'

Corrected

331. Fig 8. caption could be expanded to explain how that portal window operates.

We have added an explanation to the caption.

353. Still not sure what "paleopole" refers to.

Replaced by study-mean pole.

351-358. Generally it seems from that sentence that users need to define an APWP to be able tocalculate rotations. But this only one option. It should be clear that one can only use simple sitemean and study-means to calculate rotations and paleolatitudes.

We have changed the order of the sentences to make this clear.

390. Bob Butler's book is not edited anymore. But the content is available online on the UoA website. This could be mentionned here in the reference.

Added, see reply to comment related to line 176.

I tried the software to process a new dataset from Ethiopia. Here some remarks.
In "Calculations" The standard options are preset in the various windows ("Input Dataset" "Number of iterations", etc…) It is not obvious what the other options are for. I suggest having a help button or window diretly next to these windos so one can learn what can be done changing these parameters.

Agreed, all of the buttons and functionalities are now explained in the user manual.

The Referecen plate could be chosen automatically based on the data location.

We prefer the user to think about the choice or reference plate instead of automatically assigning one.

In the results some options are not working upon clicking on them: "these settings" and the icon with 3 horizontal lines

Fixed

The option to calculate from an APWP does not work yet. There is warning sign but still the website starts computing. Then you can not stop it from running.

Fixed

In the input data, it is not clear what is efectively needed and what is only optional. I mean if you have the site location and the pole, you do not need the mean direction. Or you could only provide the mean direction and the software can calculate the poles. Lithology, f and p_std are optional. i tried without the site mean directions but it does not work, so this info is required. I suggest indicating which are necessary input and which are optional.

All of input and whether it is required or optional is explained in the user manual.

Careful that users understand these are for poles (study means) and not sites means.

This is clearly stated both in the paper and in the user manual.

Careful that users understand they still have to show thier actual data, sites and poles with uncertainties.

We do not see how users could believe that any paleomagnetic analysis is complete without showing the newly obtained or compiled paleomagnetic data itself. However, we have added a reference to paleomagnetism.org indicating that all actual data can be plotted and analyzed there.

Paleolatitude difference is labelled "L" in the data file. That could be confused with Latitude.

True, but we specifically choose this latter differentiate it from the 'p' used for 'poleward transport' by Butler (1992).

Would be good to offer a plot of the poles on a strrereographic projections (showing reference pole and observed poles with theiruncertainties)

In the output fimes give the expected direction at the site from the calculated reference pole

We agree that both these additions would be useful but refer to the existing and widely-used tools on paleomagnetism.org for these purposes. We have added the reference direction at the given location to the output file.

Recommendation: Revisions Required

We thank the reviewer for his positive comments and detailed suggestions for improving both the manuscript and website.

Comments by Reviewer B (Michael Tetley) and Authors' response

The paper presents an online paleomagnetic data analysis toolkit based on previously published opensource methods (from the same author) to quantitatively calculate APWP's and rotational information from paleomagnetic pole data. The manuscript presents the online interface and describes its core functions. In addition, the manuscript provides two example cases for the use of these online tools in paleomagnetic analyses.
All in all, this paper is well written, clearly laid out and contains appropriate figures to support the text. The tools provided at APWP-online.org are of great use to the current community, and could be of even greater use to the wider community if they can be made compatible with the existing ecosystem of paleomagnetic data community tools.
I recommend this manuscript for publication with the incorporation of the moderate additions and corrections listed below.

General comments:
Section 2: Tools
Although summarized in the paper, a little more clarity on the methods is required for the website (apwp-online.org) which, although online, must be treated in the same way as any community software release - requiring clear, detailed and easy-to-access documentation. Although not every developer's favourite task, complete documentation is absolutely required. Currently, the site provides only fairly basic user documentation for both the APWP Tool (https://apwponline.org/#!/apwptool), and the RPD Tool (https://apwp-online.org/#!/rpdtool). For a community release like this I would expect to see more detail in the 'WHAT' and 'HOW' sections of each method. I acknowledge and appreciate the principles behind the creation of a clean and simple UI here, however the technical details should be available on the website directly and not only via access to publications.

A 'Getting started'-style user guide for both the APWP and RPD tools should also be provided to walk new users through the processes. If the point of this tool is to make life easier for pmag/apwp users (which it absolutely does) - then you want these users to both understand and enjoy the experience! This is particularly important for users wishing to upload their own data - clear and easy to find content on the main pages (i.e. not hidden in hamburger menus) providing guidance on how to use the data templates would be very helpful (I only found the template as it was mentioned here in the paper).
We completely agree that more complete documentation was needed and have therefore added a *user manual* to the website. The manual can be downloaded directly from the home page or the website's header. We also increased the visibility of key content on the interface

and added a clear download link for the template input file. Finally, we note that the complete source code is openly available on Github, accessible from the About page.

Are there plans to provide support for the native outputs from existing databases (excluding MagIC which is mentioned) such as PINT (http://www.pintdb.org/), GPMDB (http://gpmdb.net/) or PALEOMAGIA (https://paleomagia.it.helsinki.fi/)? It wouldn't require much work relative to the huge benefit to the community (really just some variable (i.e. column) mapping). I do note that only the

MagIC database of all the existing paleomagnetic databases is mentioned/cited in this manuscript - this is a little surprising as they together have formed the primary sources of community paleomagnetic data for decades. I think some mention of these would not only be appropriate, but helpful here - as you can (in principle) generate compatible data inputs for APWP-online.org directly from all of these databases.

Good suggestion. We have added a paragraph to the new background section in which we refer to the 3 most important databases for paleomagnetic poles (MagIC, GPMDB, PALEOMAGIA) and recommend its use as a starting point for building a compilation. We do not intend to provide a means of directly supporting output from those databases as input for APWP-online.org. These databases aim to provide a complete overview of study-mean paleomagnetic poles for certain tectonic plates and terranes, which likely also include paleomagnetic poles that suffer from common artefacts such as remagnetization or inclination shallowing. We therefore prefer the user to carefully build its own compilation – using clear and objective selection criteria - rather than facilitating the possible unintentional inclusion of lower-quality paleomagnetic data that may be present in these databases.

Manuscript specific comments:

Abstract (and other locations): Is 'study-mean paleomagnetic pole' the same as a VGP? If so, it would be helpful to make this connection prior to the mention of VGP's in section 2.1

No, it is not. A virtual geomagnetic pole (VGP) is obtained from a single paleomagnetic 'site', whereas the study-mean paleomagnetic pole represents the estimate of the paleomagnetic pole position, computed as the mean of a set of VGPs. We explain this now in the background section that we have added to the main text (section 2).

Line 31: 'remanent magnetization'

Corrected

Line 91: Can you provide a little more explanation of what exact comprises 'a custom-provided collection of paleopoles rather than from those paleopoles itself' (themselves) ?

We have changed this sentence to make it clearer. More background on the approach is now provided in section 2.

Line 92: 'specific' should be 'specify'

Corrected

Line 100-101: I think the 'iterations' need to be explained better here - what does each iteration do? Does having more iterations generate a higher accuracy result? (i.e. is this a downhill simplex or optimisation algorithm that will converge to higher accuracy results with more iterations)

With 'iterations' we refer to each parametric re-sampling of VGPs from the collection of paleomagnetic poles that are provided as input, essentially corresponding to a parametric bootstrap iteration. We have added an explanation in the background section.

Figure 3: The figure caption should include a brief description of what we are looking at here as well as any parameters entered into the website form for calculations. E.g. 'Overview of the APWP tool showing APWP for xx calculated from the following parameters 'Window length=x', 'Number of iterations=x' etc

We have expanded the caption of this figure following these suggestions.

Lines 112-114: I'm not sure exactly what this means - is it the tool allows you to reproduce the APWP of Vaes et al. (2023) using the reference database provided in the Reference database portal? Some rewording here would make this clearer.

We have clarified these lines

Line 121: 'The second tool featured on APWP-online.org

Corrected

Figure 4: More detail in caption as per Figure 3 comment above.

We have expanded the description of the caption

Line 171: Remove 'and

Corrected

Line 210: 'hovering'

Corrected

Line 231: 'APWP-online.org'

Corrected

Line 248: will be reviewed and evaluated against the reliability criteria ?

Corrected

Line 300: 'the'

Corrected

Figure 8: N.B. This image does not correspond with the current version of APWP-online.org. I presume the image presented in the manuscript is an update that has yet to go live.

We have replaced figure 8 with an image of the latest version of the website.

Line 351: N.B. The terms 'APWP Portal', 'RPD Portal' and 'Reference Database portal' do not correspond with either the APWP-online.org main (top) menu or the page titles. Again this may just be a version issue.

We have changed these terms throughout the text to ensure consistency with the website.

Line 359: The 'Reference Database portal' is referred to here as the 'Global Database portal'. In fact he whole conclusion mixes references to all of the above - please check them for consistency.

Corrected

APWP-online.org specific comments

Potential bug: If you attempt to upload a user-supplied dataset and receive an error message related to missing required column, when you attempt to upload this file again (having corrected the error) it does not work. You do not get a new error message unless the page is refreshed.

Fixed

Typo: On both APWP and RPD pages 'Calculations will run locally on your own machine'
Corrected
Recommendation: Revisions Required
We thank the reviewer for his positive feedback and helpful suggestions.

2ⁿᵈ Round of Revisions

Decision letter and authors' response

Dear Bram Vaes, Douwe van Hinsbergen, Joren Paridaens:
Apologies for the delay, but we have reached a decision regarding your submission to τεκτονίκα, "APWP-online.org: a global reference database and open-source tools for calculating apparent polar wander paths and relative paleomagnetic displacements".
We decided to send the revisions back to review because, as Editors, we felt the need to obtain their expert opinion again - and are very thankful for it! Both reviewers, and we, agree that the revisions have greatly improved the manuscript. However, one reviewer highlights some inconsistencies between the website and the manuscript and we encourage you to fix these before publication.

If you have any questions, please do not hesitate to contact us.

Kind regards,
Craig Magee and Graeme Eagles

Dear Editors,
Thank you for giving us the opportunity to further improve the manuscript and website. We have used the suggestions of reviewer B to clarify/correct some sentences in the text and to solve some issues with the webtools, see below. Finally, we updated all screenshot figures in the manuscript and manual such that they are consistent with the current version of the web application.

Comments by Reviewer A (Guillaume Dupont-Nivet) and Authors' response

Dear authors and editor,

I must congratulate the authors for an excellent revisions. I have read the revised version and the manual and have no additional comments. I am glad to read the "background" section added and the clarification of the terminology throughout the manuscript, responding nicely to my comments and those of the second reviewer. Instead of a table I requested, I welcome the alternative to show the key terms in italic and, especially, the addition of the user manual that will be widely used and may be modified along with the software. That manual remains very succinct on the background, making this paper more relevant beyond making another paper notifying the existence of the software. It is the perfect step into understanding what one is doing with the software, without having to read and understand in detail Vaes et al., 2022, 2023 and the PhD thesis that remains arduous and requires some level of specialisation. As such I am convinced this manuscript has gained in importance, along with readability. It even mentions the undelrying limitations of the parametric resampling vs. using actual data, that remains a topic of fascinating research for the years to come that will necessarily improve the methods and clarify the sources of uncertainty in paleomagnetic data and its many applications.

Best regards, Guillaume Dupont-Nivet
Recommendation: Accept Submission

We appreciate the reviewer's kind words and would like to express our thanks once more for the detailed and constructive review that greatly improved both the manuscript and web application.

Comments by Reviewer B (Michael Tetley) and Authors' response

Thank you to the authors for their re-submitted manuscript. Much of the paper has been greatly improved since the initial submission and the updated website looks great. In particular the addition of the "Background" section has addressed many of the comments from my first review, and the new User Manual is exactly what was needed to guide users through the process of using the tool. The key issue that remains is adequate website testing and continuity between the website and the written material (both the manuscript and the user manual). Please find below a list of minor grammatical/text changes and some more detailed bug reports/fixes required for the website that need to be addressed prior to publication. Many of these issues are small in isolation, but together demonstrate that testing of website has not been comprehensive enough, resulting in a bit of an (at times) frustrating user-experience. I would strongly suggest that the authors find some external testers (who are not familar with the website) to help them get this over the line.

In particular, some recurring themes are:
- Any website UI screenshots/images/plots included in the manuscript and/or user manual must match the live website at both review and time of publication.
- Any website products (maps, downloads etc) explicitly mentioned in the manuscript and/or user manual must match the live website at both review and time of publication.
- Any website functionality explicitly mentioned in the manuscript and/or user manual must be both present (e.g. the missing data template) and fully functional at both review and time of publication I think this is a great open-source tool for the community and absolutely should be published as soon as the above quality control issues are addressed and rectified - this is important as a 'hard to follow' tool, or, a tool that isn't completely working and/or reliable will end up not being used... and this would be a shame for APWP-online.org as this is great work.

We thank the reviewer for his positive feedback. We appreciate the thorough testing of the website by the reviewer and have addressed all issues raised here. The website is and has been tested by several external users now, as well as by a group of paleomagnetism students, but we acknowledge that there are always things to improve and bugs that have gone unnoticed.

L 157: "will significantly increase computation time" or "will significantly slow down computation speed".

Rephrased

L 210: It would probably be a little more accurate not to use the word "few". Perhaps "With age uncertainties of up to ten million years" or "With age uncertainties of less than 10 million years".

Corrected

L 214: Does the word "right" in this sentence mean the correct file, or the one on the right? Maybe it can be simplified: "This can be done by choosing an uploaded file under …"

Corrected

L 215: Needs rewording: "hence consisting of a collection of study-mean poles whereby relevan parameters such as age, age uncertainty range, number of sites and the Fisher (1953) precision parameter K are provided." Perhaps it could say something like: "as all reference study-mean poles require age, age uncertainty range, number of sites and the Fisher (1953) precision parameter K".

Corrected

L 224: "has no uncertainty" should be "does not have a calculated uncertainty"

The geographic pole simply has no uncertainty, the position of the geographic pole is defined as having a latitude of 90 degrees. We have added this to the text.

L 250: Unfortunately, I could not find any template download link (e.g. the 'Download the sample input file' button as seen in Figure 3.and Figure 4.) on either the APWP Tool or RPD Tool pages - the only available options there are loading either of the two Japan datasets or the combined Japan dataset. Neither Figure 3 nor Figure 4 are representative of the live site layout. This really should be either the first option under the 'Download' list (before the demo data files) and/or in the 'LOAD INPUT FILES' hamburger menu.

We understand the confusion of the reviewer here. The demo files are meant to serve as an example input file. We have now clarified this by changing the name of the download link to 'Example input file' and have updated the manual accordingly. We have also updated the screenshot figures 3, 4 and 5.

L 252: Should 'should contain' be 'must contain'?

Corrected

L 259: "only sediment-derived datasets that were corrected for inclination shallowing using this correction method and that satisfied the criteria proposed by Vaes et al. (2021) were used.

Corrected

L 269: "are easily inspected".

L 269: I loaded the supplied 'Demo - North East Japan' and separately the 'Demo - South West Japan' datasets to test this. The APWP is produced quickly and with no problems, but there are no info popups at all when hovering the mouse over the path using Google Chrome Version 122.0.6261.129 (Official Build) (arm64) on a Macbook Pro. Please can you check this. I also do not have a 'Add Reference APWP' button visible, so could not test this behaviour. Is this behaviour expected for this dataset? If so, please update the main text to reflect this. Downloading data works well.

We have removed this sentence since this functionality is not working properly after the removal of the open-source package used for this feature.

L 283: "an APWP"

Corrected

L 288: Can you please elaborate on how the specific outputs from APWP-online.org can be used on the paleomagnetism.org website? As a quick and simple test, I uploaded my APWP-online-org generated APWP for South-west Japan using the "Geography Portal". I was able to upload the data no problem, but was not able to visualise the APWP (i.e. the map stayed blank). Please either 1) include some basic directions on how the specific outputs from APWP-online.org can be directly used (without

modification) on paleomagnetism.org (which is a great idea!) - or remove this reference from the paper.

Good point. The output from APWP-online.org contains many more columns with statistical parameters than required for the Geography Portal on paleomagnetism.org. This is why uploading the CSV output file does not work directly. However, the relevant columns (pole latitude, pole longitude, 95% confidence region and age) are easily extracted from the output file (simply by copying the file and removing additional columns), such that it can be uploaded to the Geography Portal without much effort. We have added some directions using this output on paleomagnetism.org in the manual. Since APWP-online.org has very specific tools that only cover a fraction of what paleomagnetic analyses often involve, we feel it is useful to refer to paleomagnetism.org for additional tools and visualization.

L 296: "the most recent version of the global APWP (in the coordinate frame of all major tectonic plates), the paleomagnetic database and the global plate circuit which together underpin the computation of the APWP may be accessed and downloaded."

Corrected

L 329: ".. structural geological data. By placing their…"

Corrected

L 381-382 "relative" used twice - consider rewording.

Corrected

L 382: "currently a part"

Corrected

L 384: Remove "that" and "because"

Corrected

L 402: remove "locally"

Corrected

APWP-online.org website suggestions/bugs

Loading data

Every time you click the "Load in demo data" it will add the same demo data again. So you can end up with many copies of 'Demo - South West Japan' and 'Demo - North East Japan'. There needs to be a check in place to stop this from happening if the same data are already loaded. Additionally, once loaded, these data remain for all future sessions - even if you close the window/browser or do a hard refresh (SHIFT + refresh). These data need to be removed from memory at the end of a session - I would suggest adding either an 'End Session' button that does this, or an alert/popup when leaving to tell the user that they will lose their loaded data. Further to this, perhaps a 'Start new session' button would also be helpful which would

remove any previously loaded from the browser cache all in one go (not having to do it manually per dataset).

We have fixed this bug: now the demo data can only be loaded once. The website shows 'Demo data is loaded'. We note that the functionalities requested by the reviewer already exists. All datasets can be removed under the hamburger menu next to 'Load input files'. In addition, all locally stored data can be deleted under the About page, by clicking 'Delete all locally stored data'. We have clarified these functions in the updated manual.

Both the paper and the manual suggest that the data template can be easily found - I unfortunately can not find this ('Download the example input file') on either the APWP Tool or RPD Tool main pages - either in the main body, or within any of the hamburger/shore more menus. The live website does not reflect Figures 3 or 4.

See reply above. We have edited the name of the download links to make this clear and have updated figures 3, 4 and 5 to reflect the live website.

Re: L 275: If I generate an APWP (using the South-west Japan demo data for example) with the APWP Tool, save the resulting CSV to my computer, then attempt to load that APWP using the downloaded CSV in the RPD tool it fails with the following error: "The column "slat" is required but not present". Note: If I load the South-west Japan demo data from the website (and not upload it myself), the RPD tool works perfectly. At an absolute minimum, the RPD tool must be able to accept inputs generated by the APWP tool 'out of the box'.

We thank the reviewer for his thorough testing of the functionalities of this tool. This should indeed work and we have changed the output format of the APWP tool to make sure that the required columns ('slat' and 'slon') for the RPD tool are present.

The map of the generated APWP that does appear does not have any visual geographical components as depicted in Figure 3 - it is blank.

The open-source package used to plot the geographical components has recently become unavailable. We are looking for a different way to plot a basemap under the computed APWP, but for now leave it

blank. We have updated Fig. 3 to match the current stage of the website.

Recommendation: Revisions Required

We thank the reviewer again for his positive feedback and helpful suggestions for improving the text and webtools.

Acceptance letter

Bram Vaes, Douwe van Hinsbergen, Joren Paridaens:

We have reached a decision regarding your submission to тектоніка, "APWP-online.org: a global reference database and open-source tools for calculating apparent polar wander paths and relative paleomagnetic displacements".

Our decision is to: Accept Submission