An accessible solution for paleocoordinate calculation

Noa Scholz[1,2,3], Alejandro Rodríguez-Mena[1,2], Víctor Madarnás-Gómez[1,2], Antonio Monleón-Getino[1,2]

[1] BIOST3, Research Group in Biostatistics, Data Science and Bioinformatics, Barcelona, Spain.
[2] Department of Genetics, Microbiology and Statistics, Faculty of Biology, Universitat de Barcelona (UB), Barcelona, Spain.
[3] Institut de Recerca de la Biodiversitat (IRBio), Universitat de Barcelona (UB), Barcelona, Spain.
Corresponding author: E-mail: scholz@ub.edu (N. S.)

SUPPLEMENTARY TABLE 1

Supplementary Table 1. Comparison of representative existing paleocoordinate reconstruction tools and PACA.

Tool	GPlates Desktop Software[1]	'Palaeorotate' ('Palaeoverse' R package)[2]	PAMS paleolocation.org[3]	paleolatitude.org[4]	ODSN[5]	PACA (This Study)
Access	Desktop Software	R[6] or Rstudio[7]	Web Platform	Web Platform	Web Platform	Web Platform
Programming knowledge required	Not strictly required (optional via Python[8])	Yes	No	No	Yes	No
Learning curve	High	Low	Low	Low	High	Low
Batch data upload	Yes	Yes	No	Yes	Yes	Yes
Data input format	Specialized (.rot, .gpml, .gdal, .csv, .shp)	Tabular dataframe	Simple (single entry)	Excel/CSV	Command-line strings	CSV
Timespan (Ma)	2500–0 Ma (Depending on the GPM, practical use often limited to ~1000 Ma)	1100–0 Ma (Depending on the GPM)	~520–0 Ma	550–0 Ma	150–0 Ma	1100–0 Ma (Depending on the GPM)
GPMs utilized	Any in .rot format (or convertible to it)	PALEOMAP[9] GOLONKA[10] MERDITH2021[11] TorsvikCocks2017[12] MATTHEWS2016_pmag_ref[13]	PLATES Project[14]	Limited to paleomagnetic based GPMs[15-18]*	Wilson (1989) terranes[19]; rotations by Soeding[20] (maps compiled in Hay et al. (1999)[21])	PALEOMAP[9] GOLONKA[10] MERDITH2021[11] TorsvikCocks2017[12] MATTHEWS2016_pmag_ref[13]
Paleomap visualization and download	Yes	Other packages required	Yes	No	Yes	Yes
Uncertainty Calculation	Yes (via pyGPlates/ GPlately and post-processing in Python[8])	Yes (directly)	No	No	No	Yes (directly)

PAMS: Paleolocation Mapping Service. ODSN: Ocean Drilling Stratigraphic Network. PACA: Paleocoordinates Calculator. CSV: Comma-separated values format. GPM: Global Plate Model. * Models restricted to a specific set of APWP.

References for Supplementary Table 1

1. Müller, R. D. *et al.* GPlates: building a virtual Earth through deep time. *Geochem. Geophys. Geosyst.* **19**, 2243–2261 (2018).

2. Jones, L. A. et al. palaeoverse: a community-driven R package to support palaeobiological analysis. *Methods Ecol. Evol.* **14**, 2205–2215 (2023).

3. Urban, T. & Hardisty, F. Developing PAMS—a paleolocation web service (#1305). In *26th International Cartographic Conference Proceedings* 308 (2013).

4. van Hinsbergen, D. J. J. *et al.* A paleolatitude calculator for paleoclimate studies. *PLoS ONE* **10**, e0126946 (2015).

5. Ocean Drilling Stratigraphic Network (ODSN). ODSN Plate Tectonic Reconstruction Service. https://www.odsn.de/odsn/services/paleomap/paleomap.html (2011).

6. R Core Team. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing https://www.R-project.org/ (2023).

7. Posit team. *RStudio: Integrated Development Environment for R.* (Posit Software, 2025).

8. Python Software Foundation. *Python Language Reference*, Version 3.13. (2024).

9. Scotese, C. R. Tutorial: PALEOMAP paleoAtlas for GPlates and the paleoData plotter program. *PALEOMAP Project, Technical Report* (2016).

10. Wright, N., Zahirovic, S., Müller, R. D. & Seton, M. Towards community-driven paleogeographic reconstructions: integrating open-access paleogeographic and paleobiology data with plate tectonics. *Biogeosciences* **10**, 1529–1541 (2013).

11. Merdith, A. S. *et al.* Extending full-plate tectonic models into deep time: linking the Neoproterozoic and the Phanerozoic. *Earth-Sci. Rev*. **214**, 103477 (2021).

12. Torsvik, T. H. & Cocks, L. R. M. *Earth History and Palaeogeography*. (Cambridge Univ. Press, 2017).

13. Matthews, K. J. *et al.* Global plate boundary evolution and kinematics since the late Paleozoic. *Glob. Planet. Change* **146**, 226–250 (2016).

14. University of Texas Institute for Geophysics (UTIG). PLATES Project. https://www.ig.utexas.edu/research/projects/plates/

15. Besse, J. & Courtillot, V. Apparent and true polar wander and the geometry of the geomagnetic field over the last 200 Myr. *J. Geophys. Res*. **107**, 2300 (2002).

16. Kent, D. V. & Irving, E. Influence of inclination error in sedimentary rocks on the Triassic and Jurassic apparent pole wander path for North America and implications for Cordilleran tectonics. *J. Geophys. Res*. **115**, B10103 (2010).

17. Doubrovine, P. V., Steinberger, B. & Torsvik, T. H. Absolute plate motions in a reference frame defined by moving hot spots in the Pacific, Atlantic, and Indian oceans. *J. Geophys. Res.* **117**, B09101 (2012).

18. Vaes, B. *et al.* A global apparent polar wander path for the last 320 Ma calculated from site-level paleomagnetic data. *Earth-Sci. Rev.* **245**, 104547 (2023).

19. Wilson, K. M. *Mesozoic Suspect Terranes and Global Tectonics*. PhD thesis, Univ. of Colorado (1989).

20. Cox, A. & Hart, R. B. *Plate Tectonics: How It Works*. (Blackwell Scientific Publications, 1986).

21. Hay, W. W. *et al.* Alternative global Cretaceous paleogeography. In *The Evolution of Cretaceous Ocean/Climate Systems* (eds Barrera, E. & Johnson, C.) 1–47 (Geological Society of America, 1999).