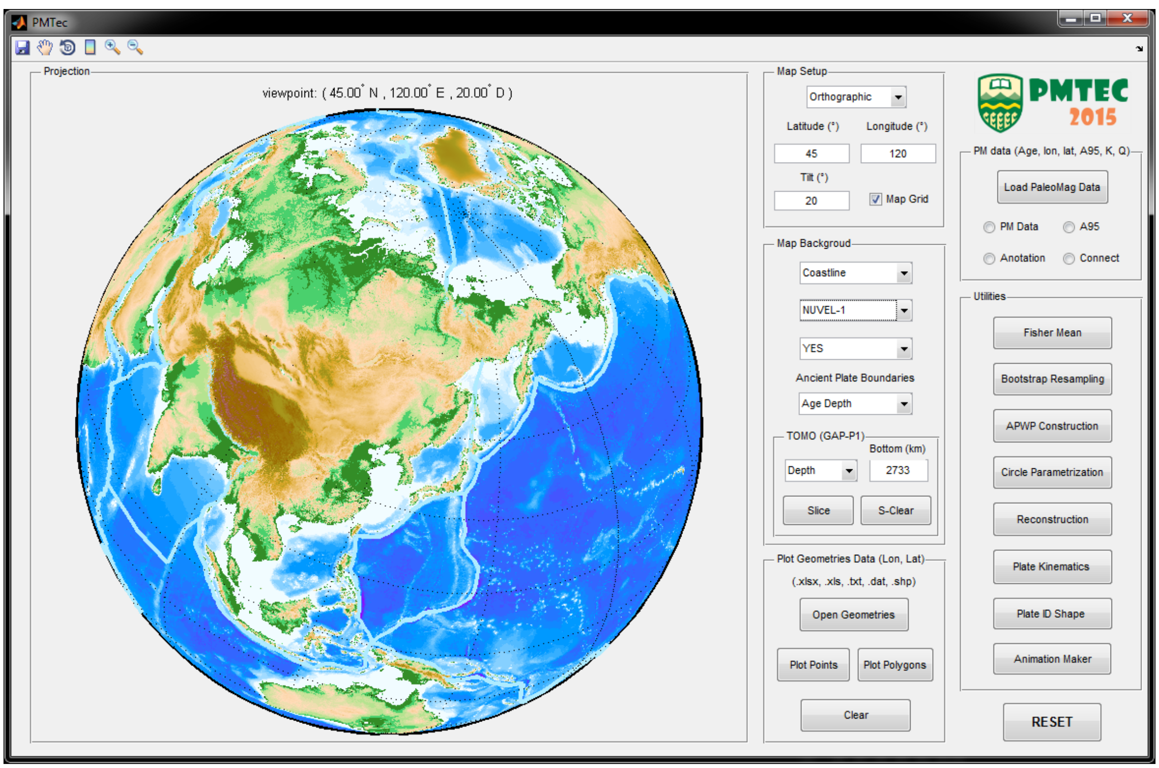
PMTec 2015

Graphical manual and tutorials



June 20th 2015

Preface

PMTec is a MATLAB based graphical users interface to perform tectonic plate reconstruction using paleomagnetic data. The main features of PMTec are 1) to construct apparent polar wander path (APWP) from paleomagnetic data, 2) to do absolute plate motion reconstructions using paleomagnetically derived Euler rotations (rotation poles and rotation angles) and 3) to visualize the geospatial data in the regular mapping projections.

PMTec, optimized on PC platform, is originally developed in MATLAB 2013a and has been tested in MATLAB 2014a. PMTec is presented both in p-files that run on all computer platforms (http://www.mathworks.com/help/matlab/ref/pcode.html) and executable files which do not require installation of MATLAB (run on PC and Linux systems). The source code could be provided on email request. Problems might occur on the releases earlier than 2012b when MathWorks started to update syntaxes for some built-in functions. Please feel free to email us (lwu2@ualberta.ca) any bug reports, comments and suggestions for PMTec which will be considered for the enhancement of the future releases.

PMTec is a freeware for plate tectonic research and teaching purposes. The toolbox package, together with the tutorial document and data can be downloaded from http://www.ualberta.ca/~vadim/software.htm. Users are allowed to redistribute the software. Any use of PMTec should be cited as:

Wu, L., Kravchinsky, V.A., Potter, D.K.. PMTec: A new Matlab toolbox for tectonic plate reconstructions from paleomagnetism. Computers & Geosciences

There are five tutorial sessions in this graphical manual, where we list in the tables all the input and out files for demonstration at the beginning of each session. Figures and captions are used to illustrate the main operation procedure (in magenta numbers) and the outcome plots and files so it is more intuitive for users to get familiar with the usage of PMTec. The major steps, corresponding to the numbers in the figures, are briefly described to clarify each operation.

Enjoy your experience with PMTec!

Sincerely,

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June 2015

Tutorial 1 Getting started

Table 1. Input and output files for tutorial 1

Input Files	Output Files
101_North_America.shp	×
APWPInd.xlsx	×

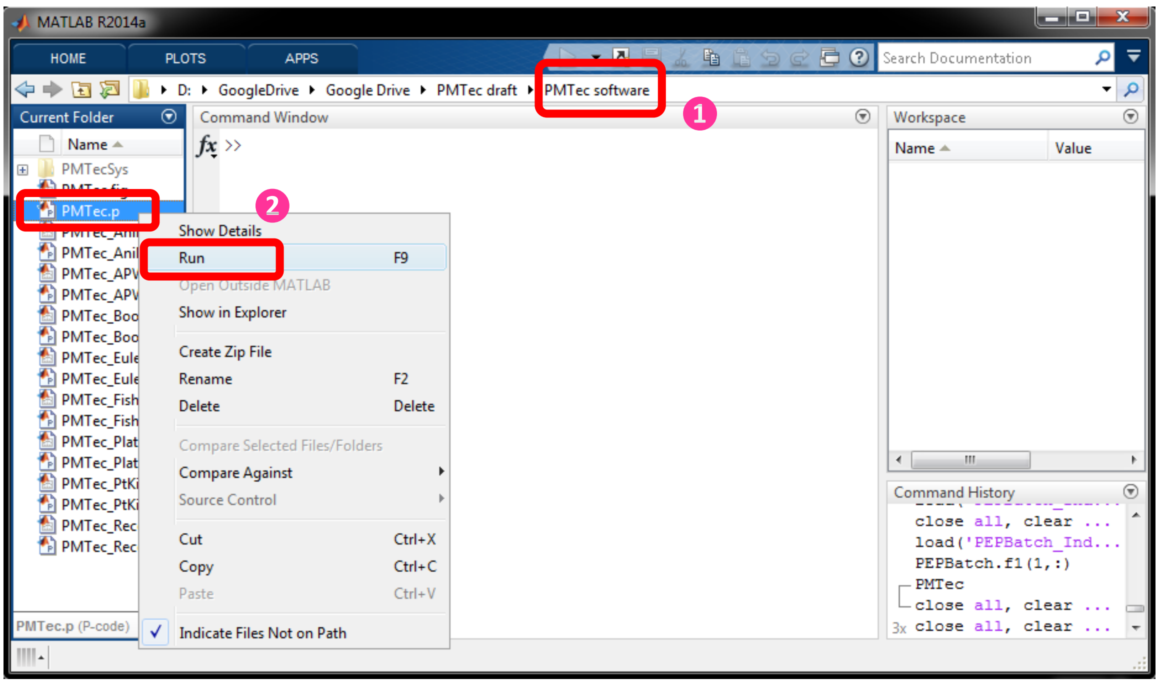

Figure 1. Launching PMTec and the component modules. The numbers in the figure shows the suggested operation steps.

Steps:

1. Go to the directory where the PMTec package is stored.
2. Run the selected module, i.e., PMTec in Figure 1.

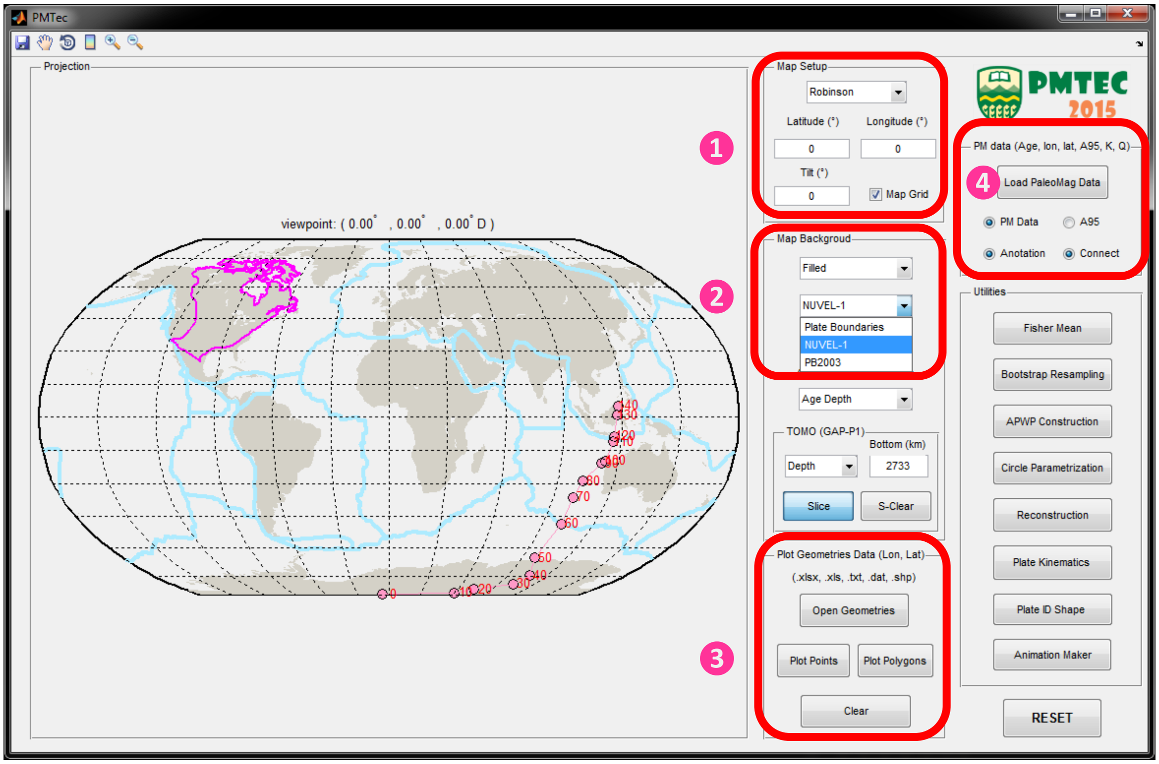

Figure 2. Robinson projection of the plotted background data coastline and plate boundaries. Also plotted are the loaded plate geometry of North America craton and apparent polar wander path of India [Torsvik et al., 2012].

Steps:

1. Select the desire map projection type and specify the viewpoint in degree (lat, lon, tilt).
2. Load background data such as coastline and plate boundaries.
3. Load and visualize geometry data in form of individual points or polygons.
4. Load and visualize paleomagnetic data.

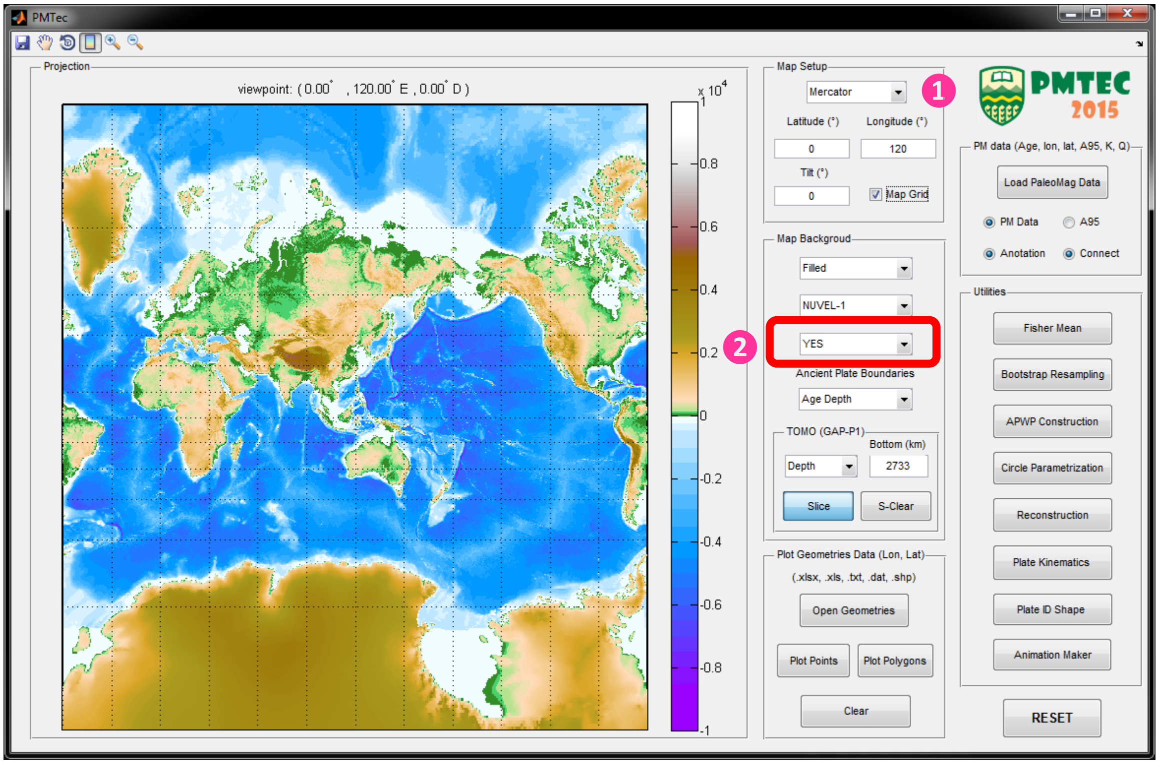

Figure 3. Mercator projection of topographic data by reduction factor of 4 to the TOPO2 model with the color bar.

Steps:

1. Select the desire map projection type and specify the viewpoint in degree (lat, lon, tilt).
2. Load background topography model TOPO2.

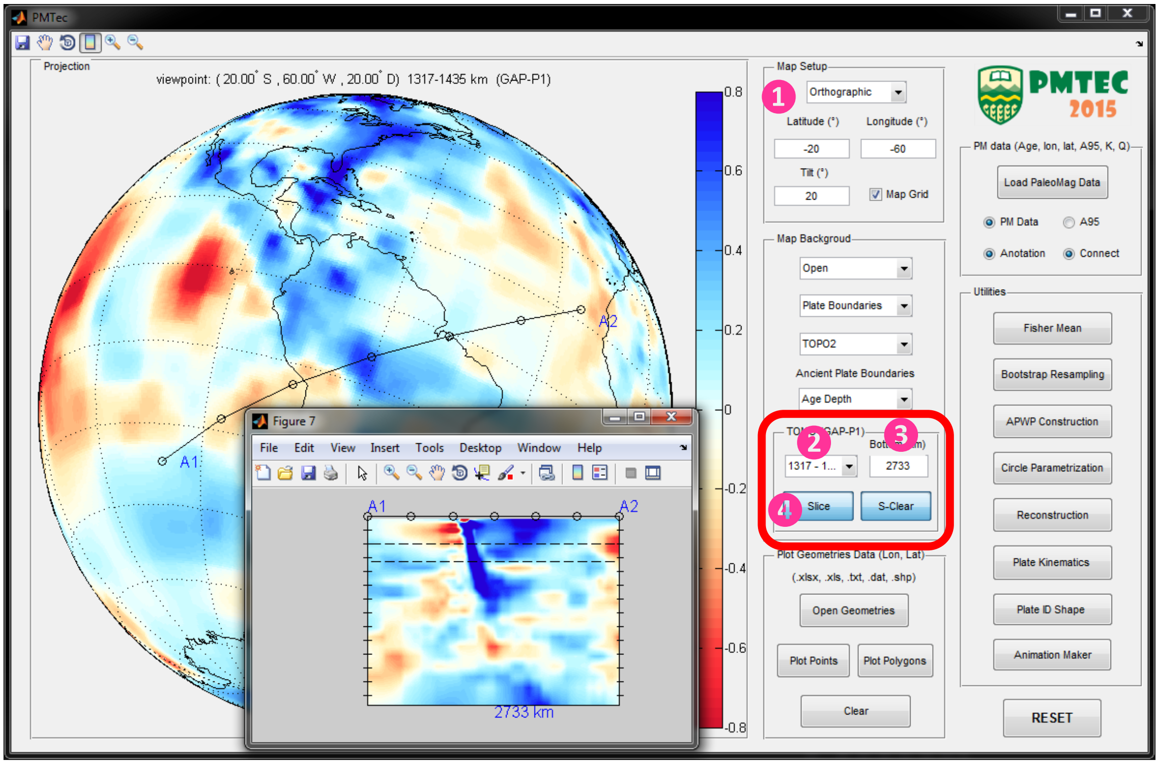

Figure 4. Orthographic projection of the P-wave tomography of Obayashi et al. [2006] at depth of 1317-1435 km with the default grid of 0.5°×0.5°. The inset figure is the cross-section along the specified seismic profile A1-A2 where all the points along the profile share the same azimuth with respect to each meridian. The magenta crosses and the numbers along the profile A1-A2 show the marker points separating the profile into ten segments with equal spherical distance.

Steps:

1. Select the desire map projection type and specify the viewpoint in degree (lat, lon, tilt).
2. Plot the plan view tomography model at selected depths.
3. Specify the bottom depth for the cross-section visualization.
4. Specify the seismic profile A1-A2 for the vertical cross section visualization.

Tutorial 2 APWP construction

Table 2. Input and output files for tutorial 2

Input Files	Output Files
EuroPoles.xlsx	APWP_Euro.mat

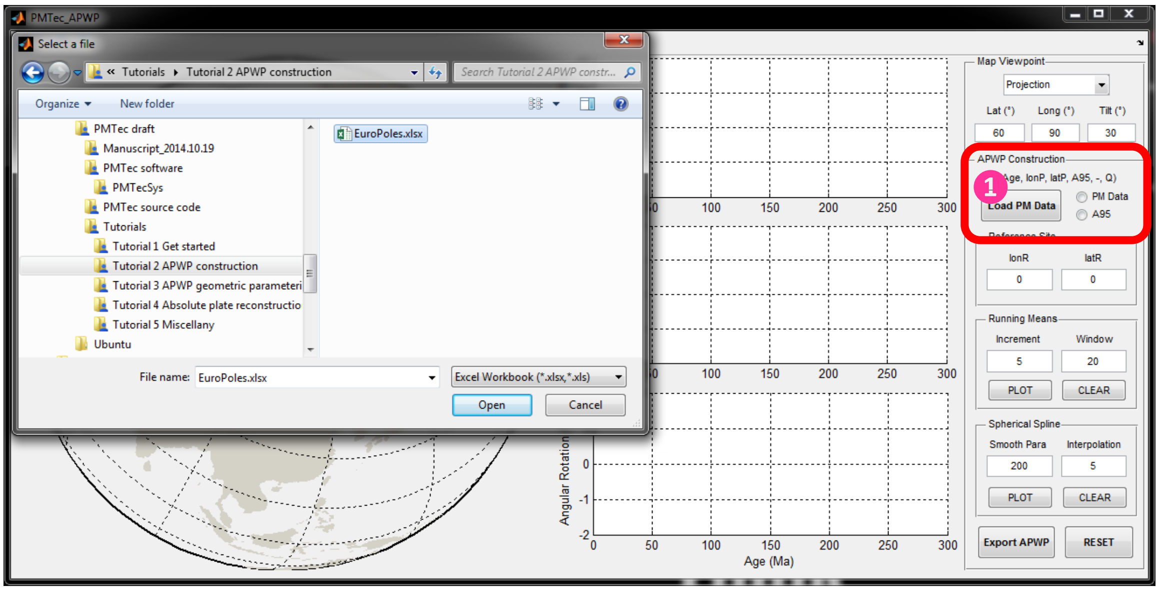

Figure 5. Initializing module PMTec_APWP and loading of paleomagnetic data of stable Europe [Torsvik et al., 2001] for the APWP construction.

Steps:

1. Load paleomagnetic poles for data processing, which should be evaluated according to Voo90 grading scheme [Van der Voo, 1990].

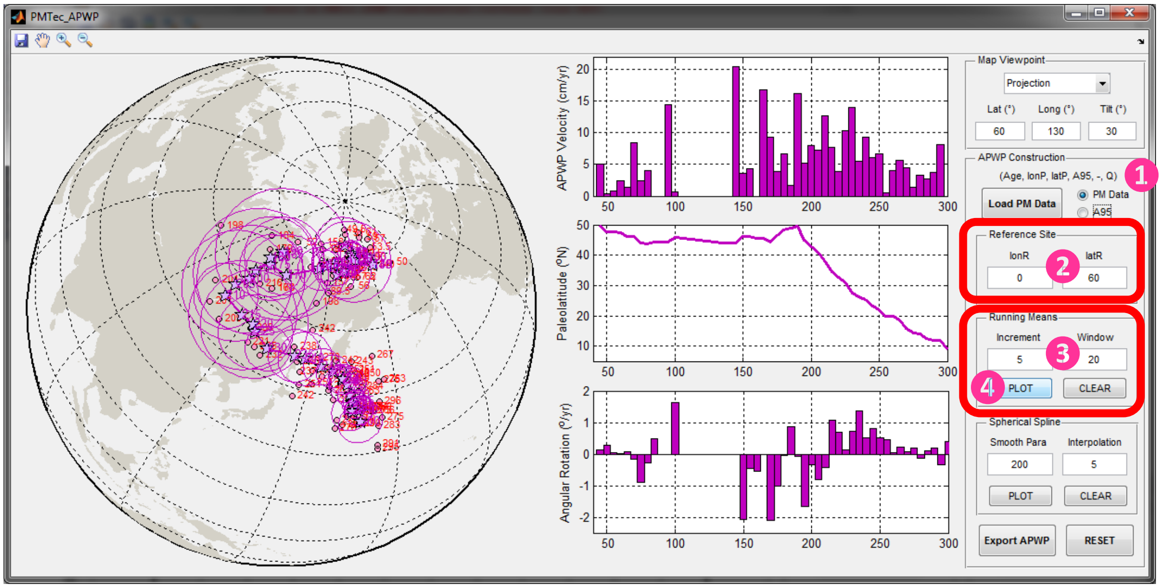

Figure 6. Orthographic projection of the running means (purple pentagons and line) and the corresponding uncertainties A_{95} (purple circles) with the time window of 20 Myr and 5 Myr's increment of the resulting path. The kinematics for the specified reference site (0 °E, 60 °N) are calculated and plotted in the right panel: APWP translation velocity (upper), paleolatitude variation for the reference site (middle) and the azimuthal rotation speed (lower). The imported paleomagnetic poles (pink dots) and annotations (red fonts) are displayed for reference.

Steps:

1. Specify the visibility of paleomagnetic poles and corresponding uncertainty regions.
2. Specify the reference site for APWP kinematics calculation.
3. Specify the output age increments and sliding time window for the running means calculation.
4. Plot and clear the computed running means path and the related kinematics.

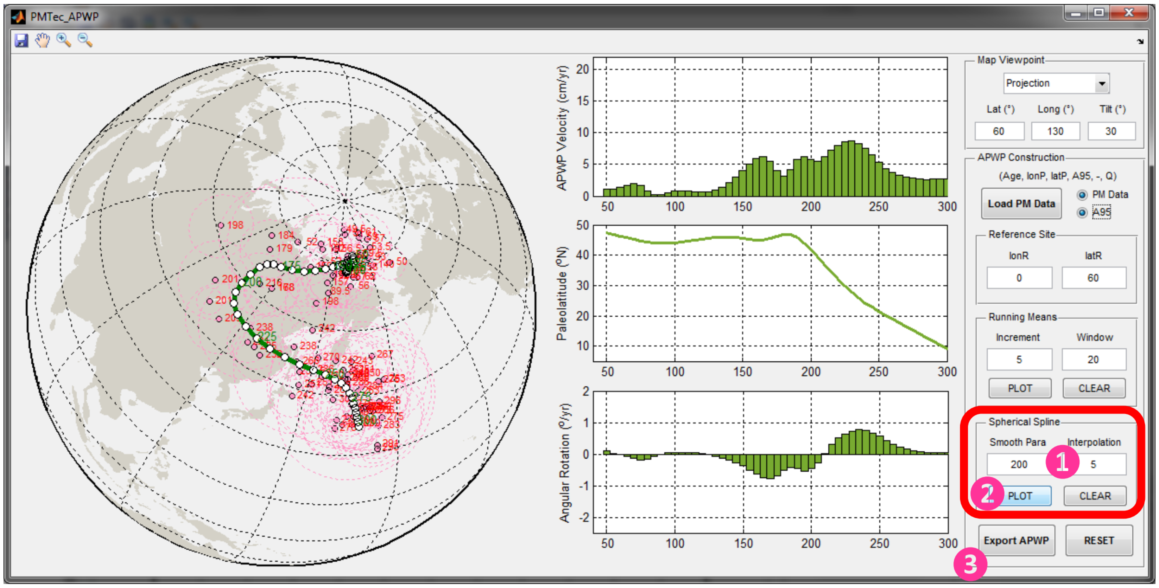

Figure 7. Orthographic projection of the spline path (white dots and green line) with the smoothing parameter of 200 and 5 Myr's increment of the resulting path. Also shown are the kinematics for the same reference site (0 °E, 60 °N). The imported paleomagnetic poles (pink dots), uncertainties A_{95} (pink dashed circles) and annotations (red fonts) are displayed for reference.

Steps:

1. Specify the smoothing parameter and the output interpolations increment for the resulting spline path.
2. Plot and clear the computed path path and the related kinematics.
3. Export the calculated running means and spline paths, both of which are needed before the exportation.

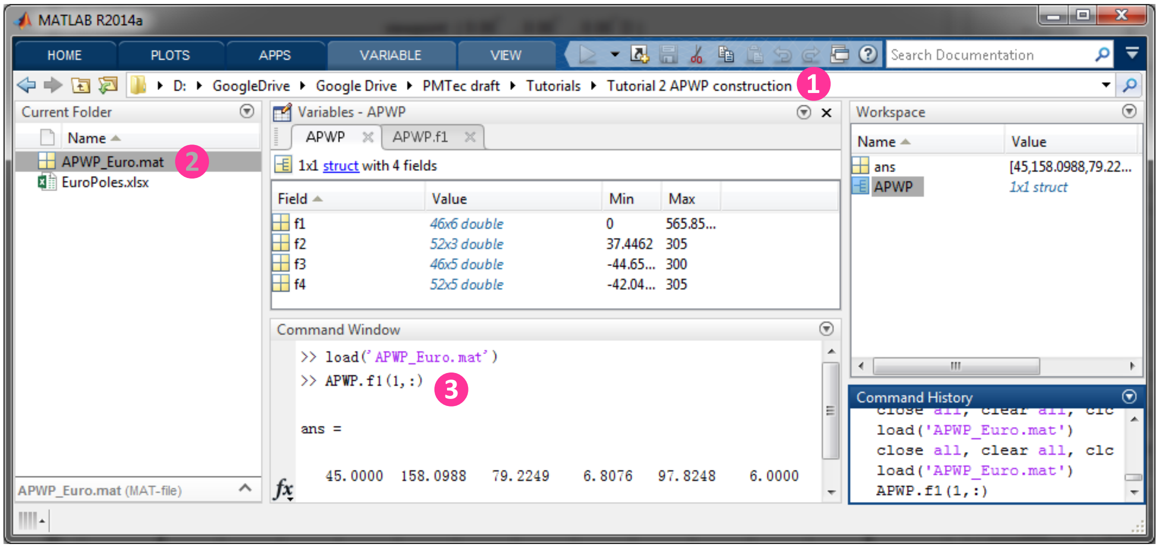

Figure 8. Access of the exported APWP constructions file 'APWP_Euro.mat'. The fields of variable of 'APWP' are shown in the variables window. In the command window, we provide a sample command to access data in the first row of the field 'f1': APWP.f1(1, :).

Steps:

1. Go to the directory where the output APWP file 'APWP_Euro.mat' is stored.
2. Load the APPW file 'APWP_Euro.mat'.
3. Access the data using the suggested command in Figure 8 caption.

Tutorial 3 APWP geometric parameterization

Table 3. Input and output files for tutorial 3

Input Files	Output Files
APWPInd.xlsx	PEPSingle_ind
FitCtrl_Ind.txt	PEPBatch_Ind.mat

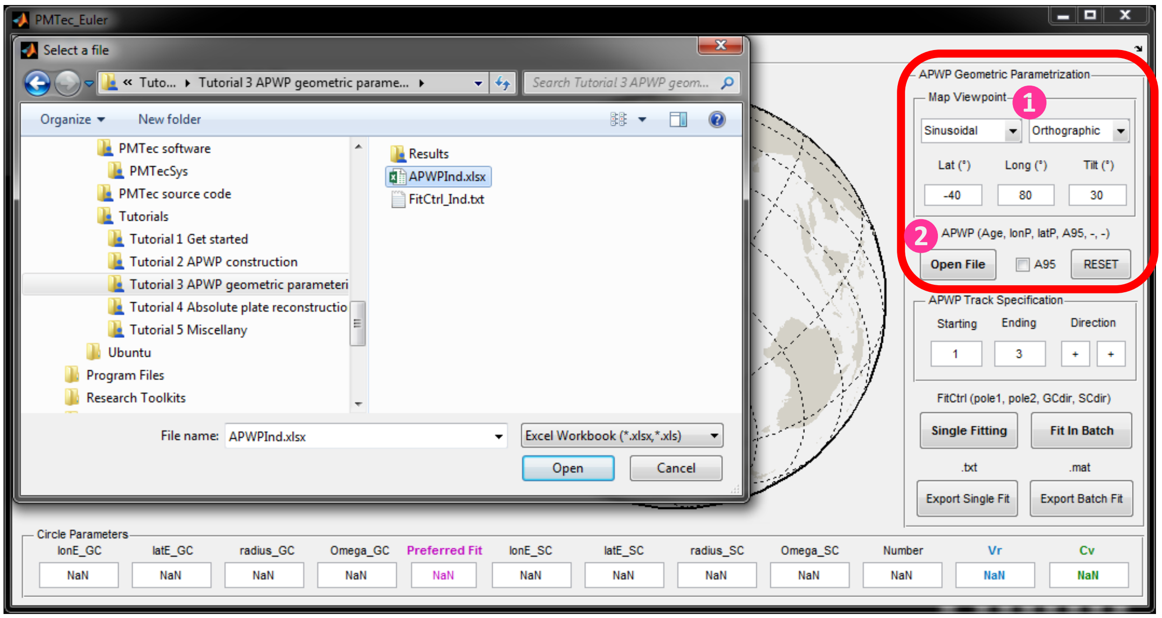

Figure 9. Importation of Indian APWP (0-140 Ma) presented by Torsvik et al. [2012] after the specification of the projection type and viewpoint for great circle fitting (left) and small circle fitting (right). The ages of the poles will be automatically annotated for the reference (Figure 10).

Steps:

1. Select the desire map projection type and specify the viewpoint in degree (lat, lon, tilt).
2. Load paleomagnetic poles.

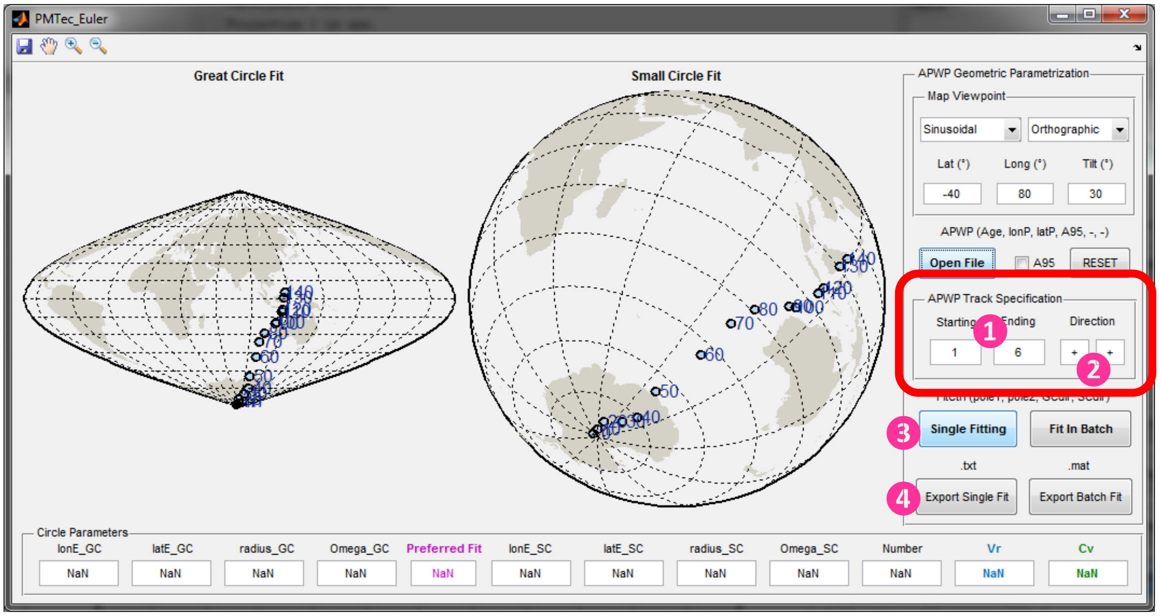

Figure 10. Specification of the APWP track confined between the ending poles inclusively and the rotation directions (backward in time) both for great circle and small circle fitting.

Steps:

1. Specify the starting and ending poles for circle modelling. Users also need to specify the rotation directions for great circle (left) and small circle fitting (right). Positive sign should be assigned to the counterclockwise rotation during reconstruction which is backward in ages.
2. Fit the specified APWP track with great circle and small circle modelling.
3. Export the circle fitting results for a single APWP track.

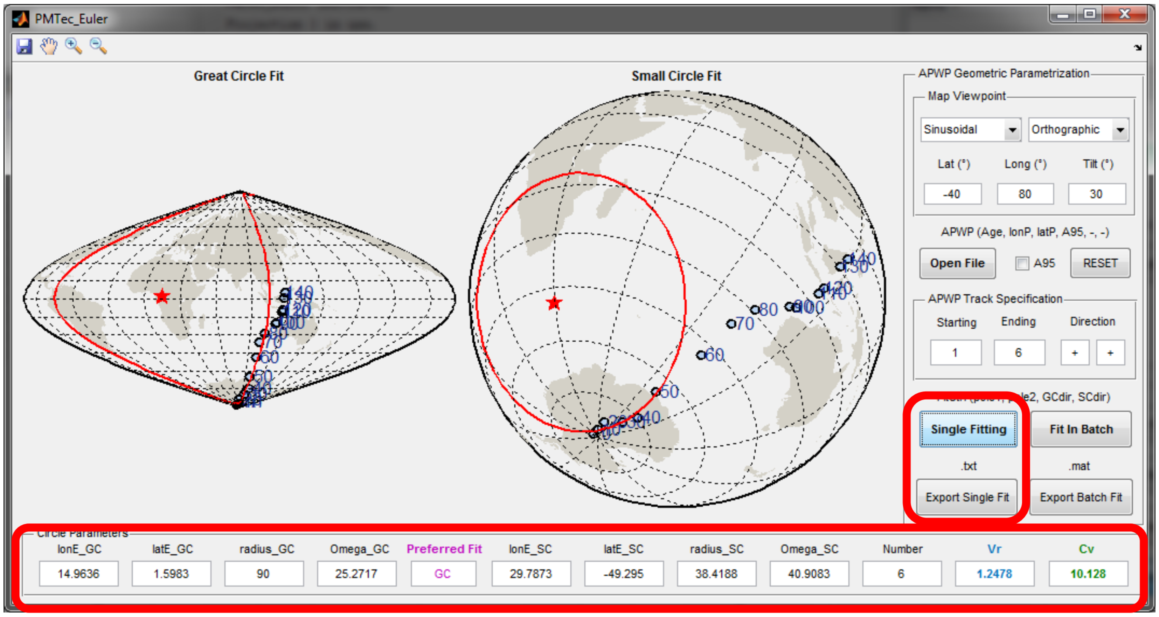

Figure 11. Single fitting for the specified APWP track (0-50 Ma). The results of both great circle and small circle modelling are shown in the bottom row with the recommendation of the 'preferred fitting code' by comparing the value of variance ratio (Vr) and the critical value (Cv) at 95% confidence level.

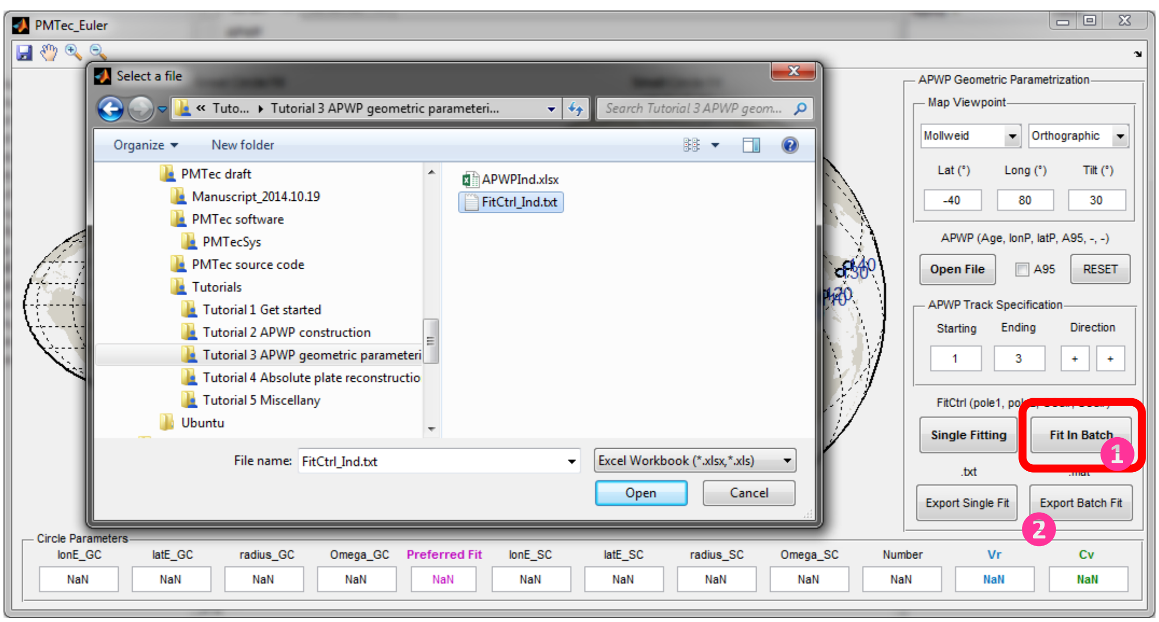

Figure 12. Great circle and small circle modelling to several APWP segments with the importation of the fitting control file 'FitCtrl_Ind.txt' (prepared according to Wu and Kravchinsky [2014]), whose data organization is hinted above the button.

Steps:

1. Load the fitting control file 'FitCtrl_Ind.txt' arranged in the format of (pole1, pole2, GCdirS, SCdirS), where pole1 and pole2 represent the starting and ending poles, and GCdirS and SCdirS represent the rotation signs for great circle and small circle modelling.
2. Export the circle fitting results for specified APWP tracks.

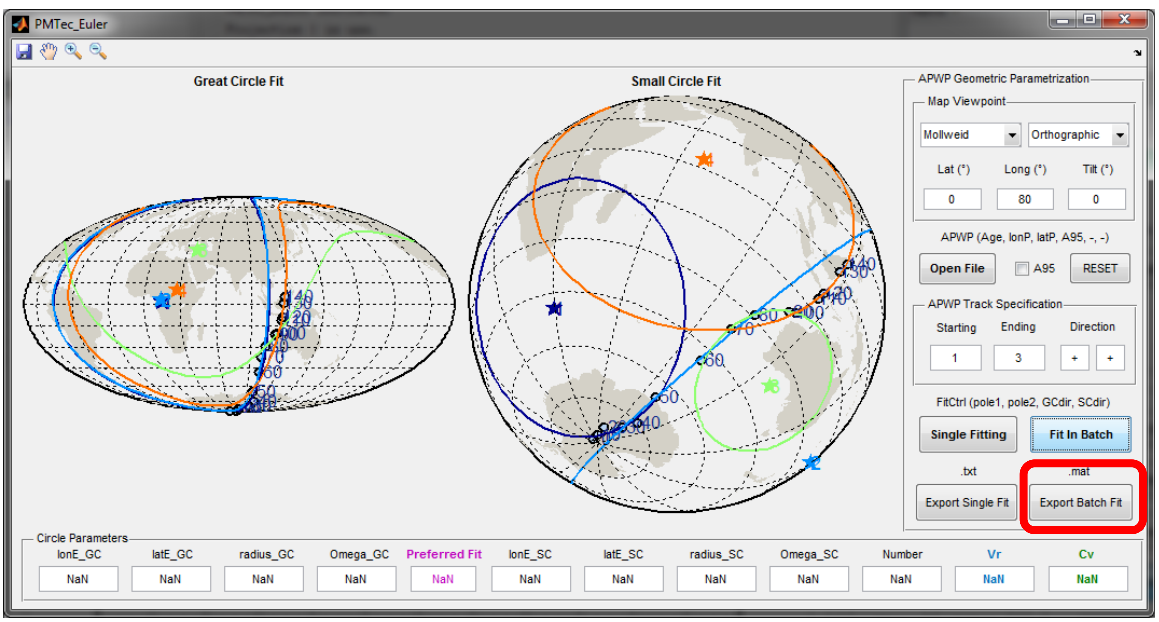

Figure 13. Visualization of the APWP parameterization in batch which can be exported as 'PEPBatch_Ind.mat' (see Figure 14).

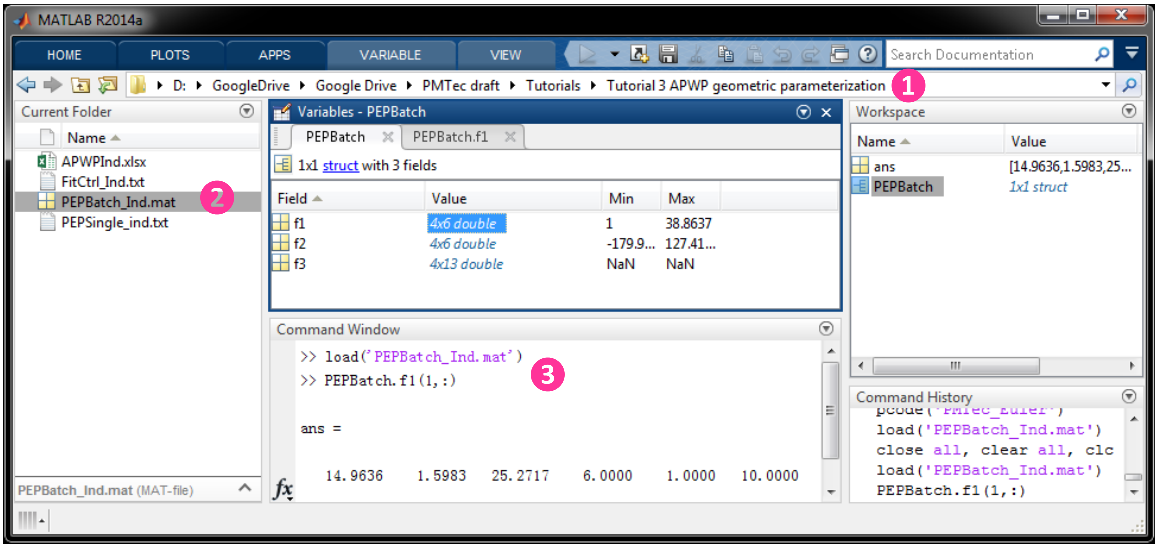

Figure 14. Access of the exported circle batch fitting file ‘PEPBatch_Ind.mat’. The fields of variable of ‘PEPBatch’ are shown in the variables window. In the command window, we provide a sample command to access data in the first row of the field ‘f1’: PEPBatch.f1(1, :).

Steps:

1. Go to the directory where the output circle fitting file ‘PEPBatch_Ind.mat’ is stored.
2. Load the circle fitting file ‘PEPBatch_Ind.mat’.
3. Access the data using the suggested command in Figure 14 caption.

Tutorial 4 Absolute plate reconstructions

Table 4. Input and output files for tutorial 4

Input Files	Output Files
APWPInd.xlsx	RecSt_Ind.mat
PEP_Ind.txt	BootAPWP.mat
ContInd.xlsx	BootEuAPWPnew.mat
ContAus.xlsx	StrucEuAPWP.mat
ContEAnt.xlsx	BootEuGC.mat
FiniteInd.xlsx	BootEuSC.mat
FiniteInd.xlsx	BootEuNewRG.mat
FiniteInd.xlsx	BootRec.mat
APWPboot_Ind.mat	BootRecRG.mat

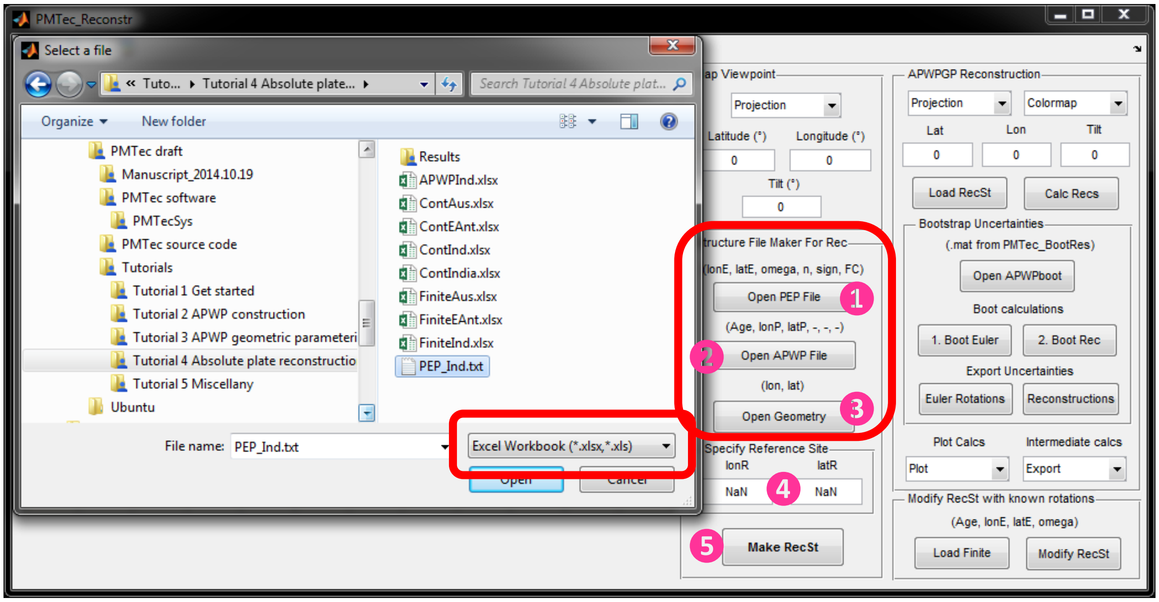

Figure 15. Importation of paleomagnetic Euler pole (PEP) file ‘PEP_Ind.txt’, APWP file ‘APWPInd.xlsx’ and the plate geometry file ‘ConInd.xlsx’. The recognized file format for each import is hinted.

Steps:

1. Load the paleomagnetic Euler rotations in the designated format (Figure 15), which can be calculated in Module PMTec_Euler.
2. Load APWP in the designated format (Figure 15).
3. Load plate geometry in the designated format (Figure 15).
4. Specify the reference site.
5. Make the reconstruction file ‘RecSt.mat’.

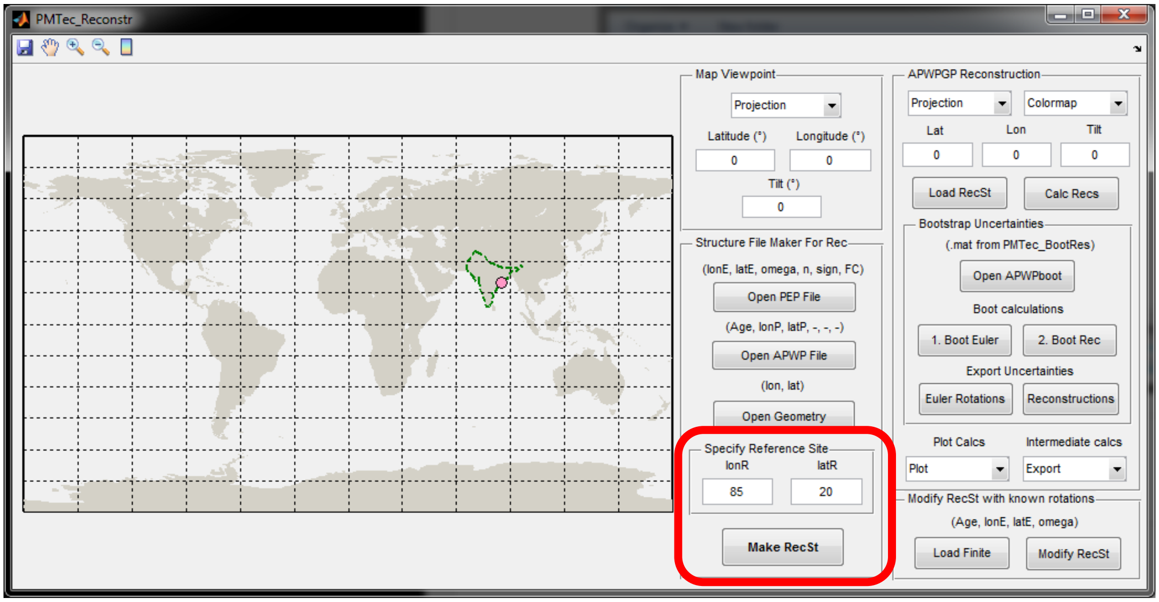

Figure 16. Map projection of the imported plate geometry (green dashed line) with the automatically selected reference site (first data point in the geometry file). Users can also specify reference site manually before making the reconstruction file 'RecSt_Ind.mat'.

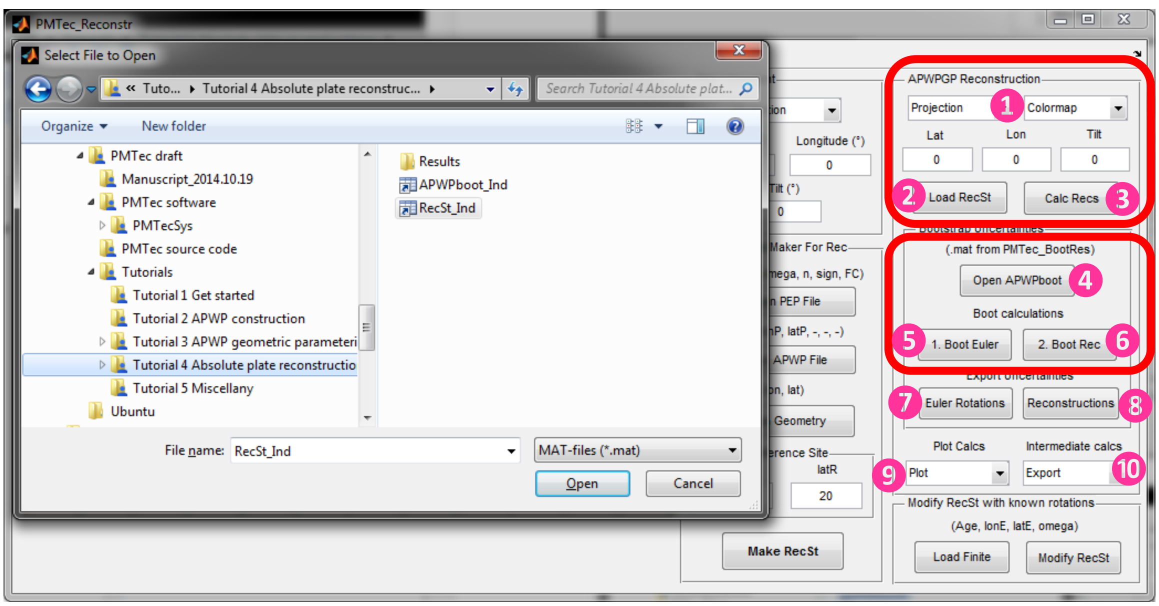

Figure 17. Map projection setup for the intermediate reconstruction process where all the reconstructions are calculated and visualized (Figure 18) using the button 'Calc Recs' after loading 'RecSt_Ind.mat'. The structure file 'APWPboot_Ind.mat' should also be loaded before the calculation of the bootstrap uncertainties both for Euler rotations and reconstructions, which must be done in the suggested sequence.

Steps:

1. Select the desired map projection type and viewpoint.
2. Load reconstruction file ‘RecSt.mat’.
3. Perform the absolute calculation to the reference site.
4. Load bootstrapped APWP file ‘APWPboot.mat’ which can be produced from the module PMTec_BootRes.
5. Calculate the bootstrapped Euler rotations.
6. Calculate the bootstrapped reconstructions.
7. Export the bootstrapped Euler rotations.
8. Export the bootstrapped reconstructions.
9. Visualize the bootstrapped Euler rotations, bootstrapped reconstructions and reconstructed plate contours.
10. Export all the intermediate calculations.

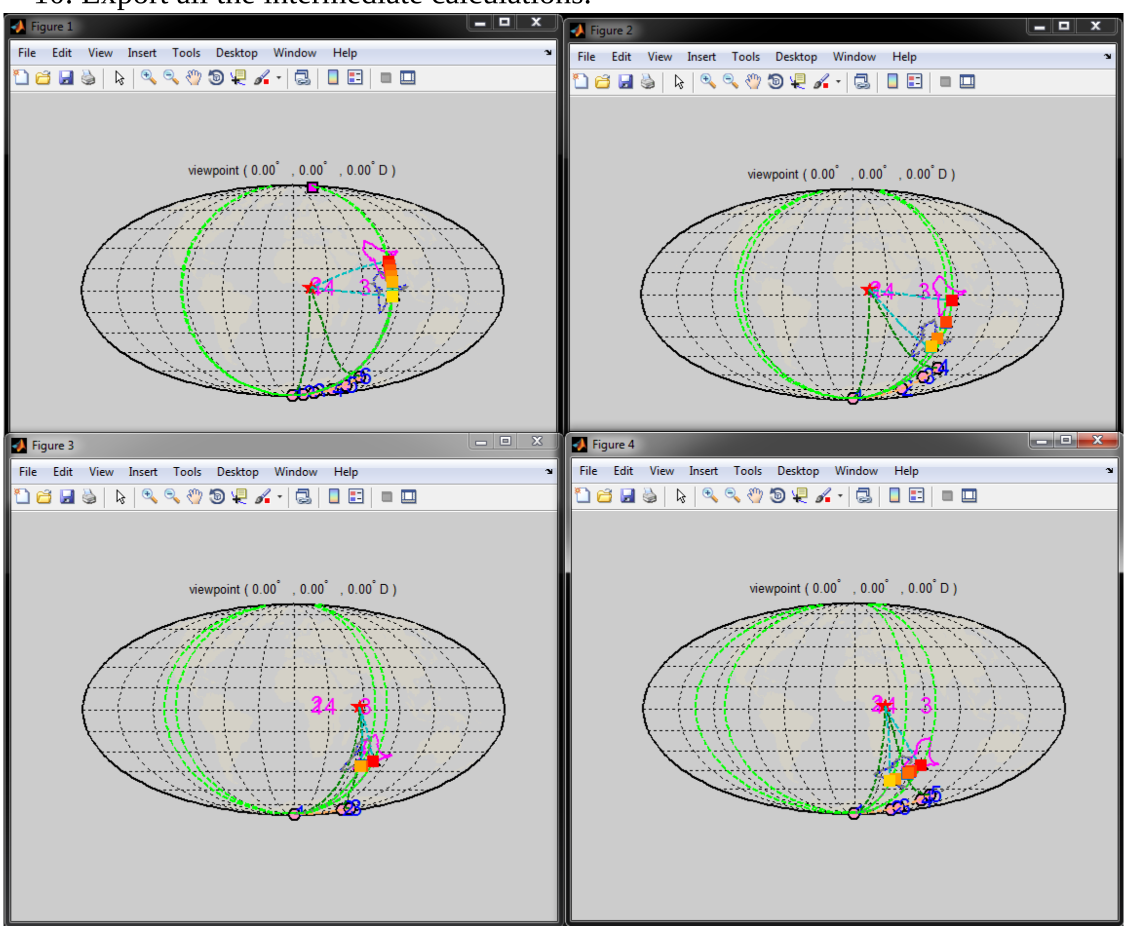

Figure 18. Map projection of the intermediate reconstructions.

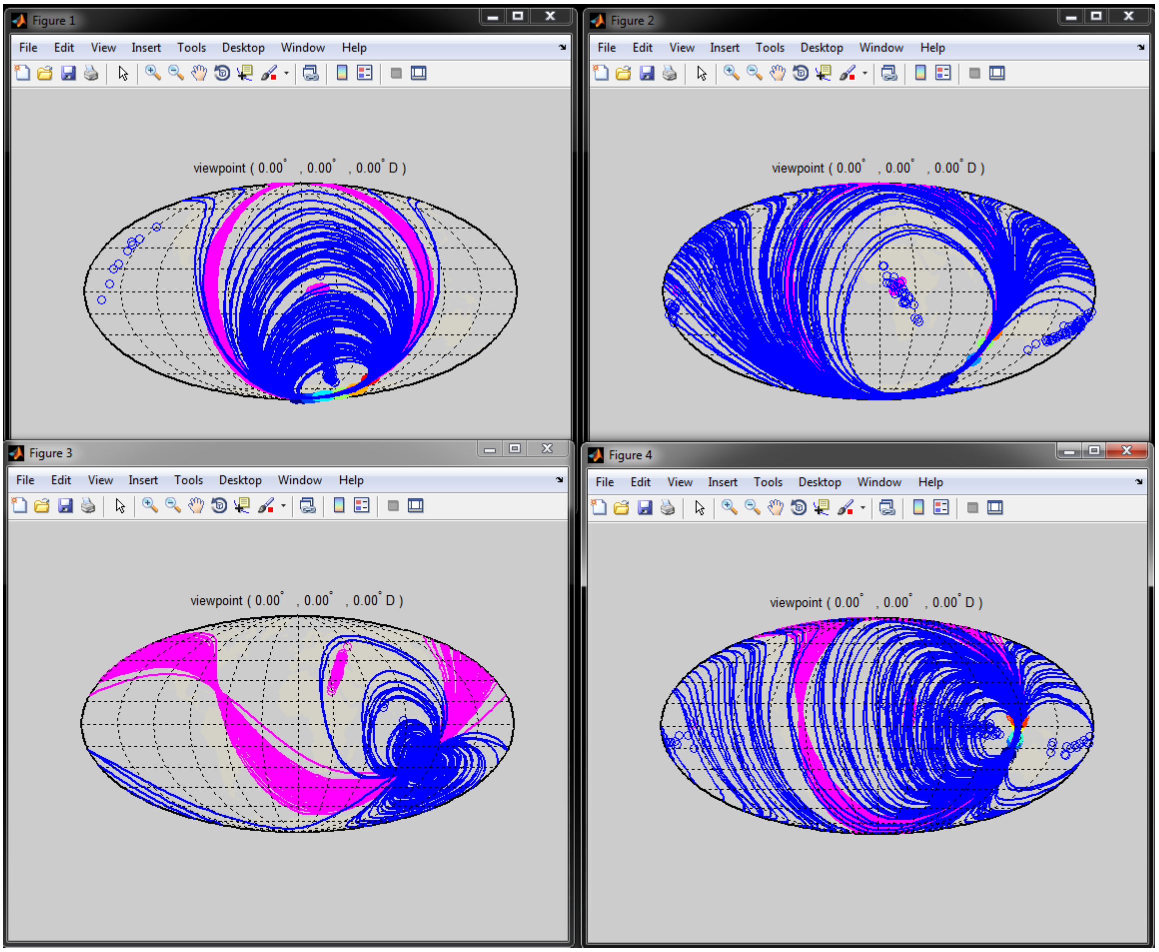

Figure 19. Map projection of the great circle (magenta solid line and dots) and small circle (blue solid line and dots) modelling to the bootstrapped paleomagnetic poles (in color) for the same APWP segments.

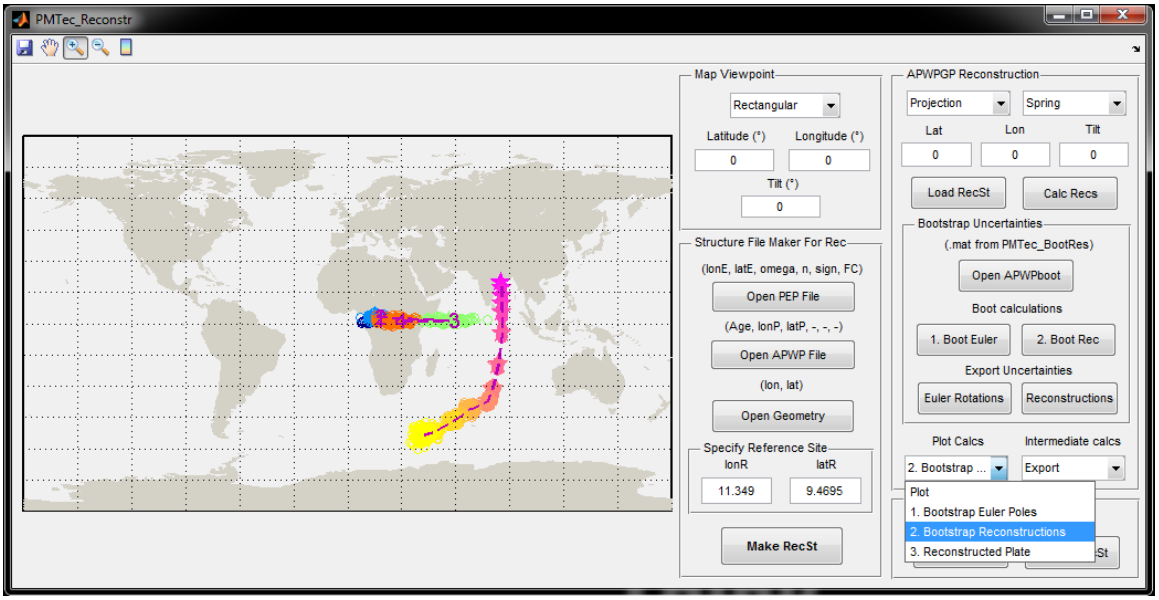

Figure 20. Plotting of the reconstructions and the corresponding uncertainties, including bootstrap Euler poles, bootstrap reconstructions and reconstructed plates. Colormap can be specified before the plotting.

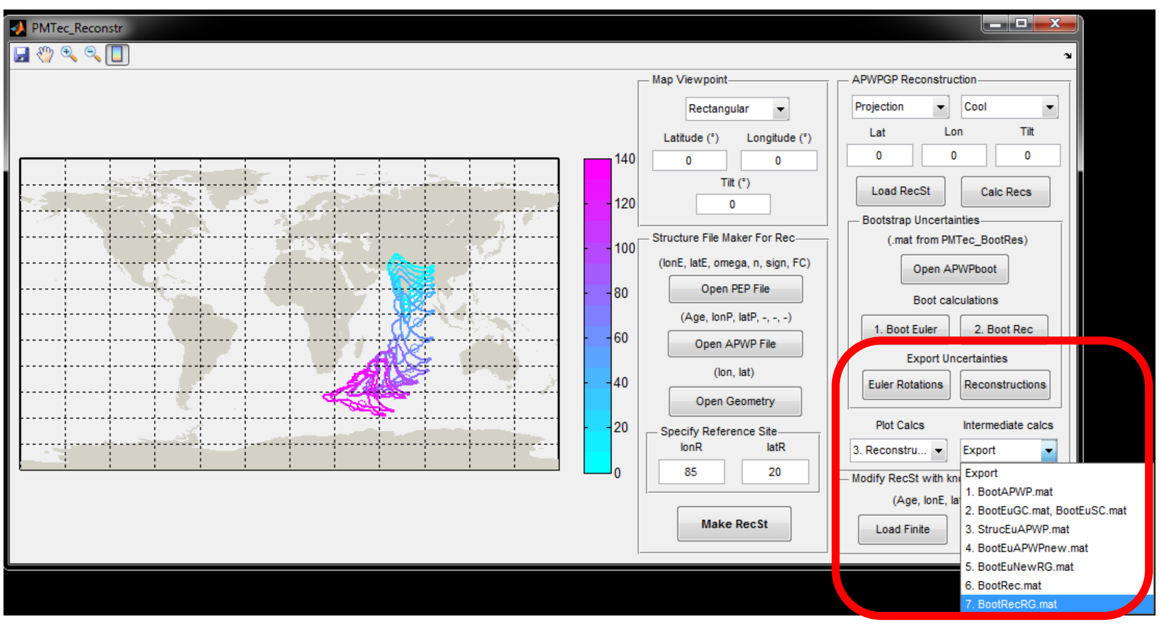

Figure 21. Exportation of the estimated uncertainty region for Euler rotations and reconstructions. All the intermediate calculations can also be exported using the pop-up menu.

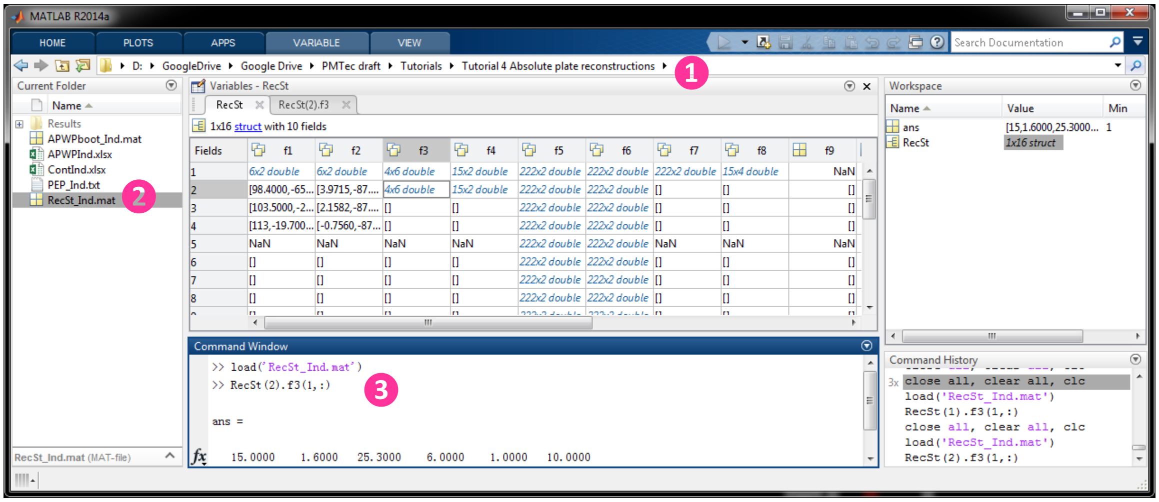

Figure 22. Access of the reconstruction file 'RecSt_Ind.mat'. The fields of variable of 'RecSt' are shown in the variables window. In the command window, we provide a sample command to access data in the first row of the second element in the field 'f3': RecSt(2).f3(1, :).

Steps:

1. Go to the directory where the output reconstruction file 'RecSt_Ind.mat' is stored.
2. Load the reconstruction file 'RecSt_Ind.mat'.
3. Access the data using the suggested command in Figure 22 caption.

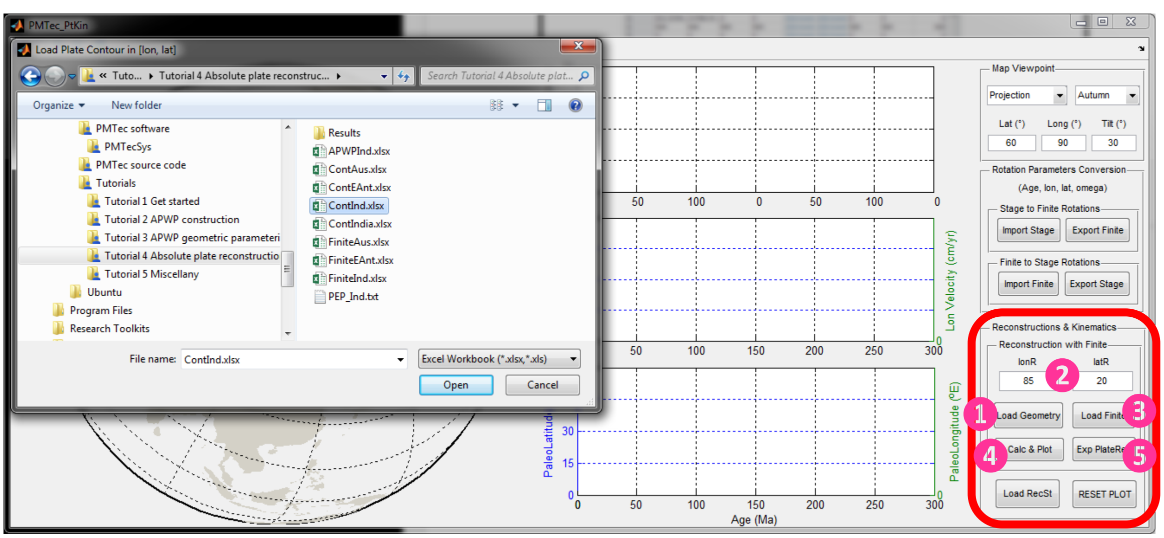

Figure 23. Reconstructions and the corresponding kinematics calculated from the known finite rotations for a certain plate geometry. The demonstration finite rotations are presented by Mitchell et al. [2012]. Animation files ‘PlateRec.mat’ can be made during the process using the button ‘Exp PlateRec’. The plate kinematics can also be derived, plotted and automatically saved in the loaded reconstruction files ‘RecSt.mat’.

Steps:

1. Load the geometry file in format of (lon, lat).
2. Specify the reference site of interest.
3. Load finite rotations file arranged in format of (age, lon, lat, omega), where omega is the rotation angle.
4. Calculate and visualize the kinematic parameters for the reference site.
5. Export the calculations to the animation file ‘PlateRec.mat’.

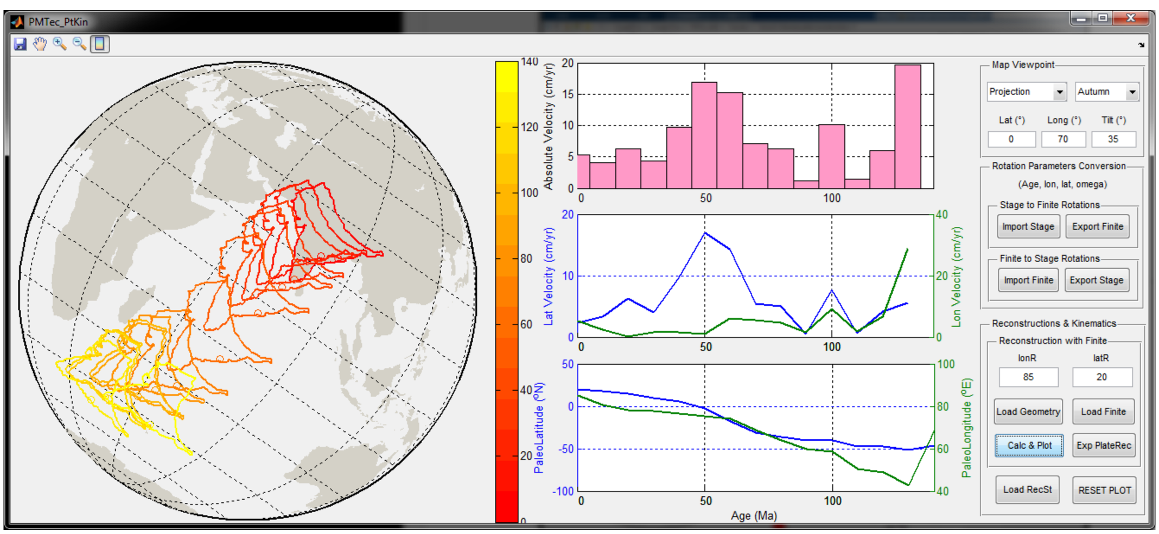

Figure 24. Orthographic projection of the reconstructed absolute motion of India since 140 Ma using the finite rotations of Mitchell et al. [2012]. The kinematics for the reference site (85 °E, 20 °N) are also computed and plotted.

Tutorial 5 Miscellany

Table 5. Input and output files for tutorial 5

Input Files	Output Files
PlateRec_Aus.mat	PlateRec_Ind_WK14.mat
PlateRec_Aus.mat	movie_forward.gif
PlateRec_Aus.mat	movie_rec.gif
RecSt_Ind.mat	

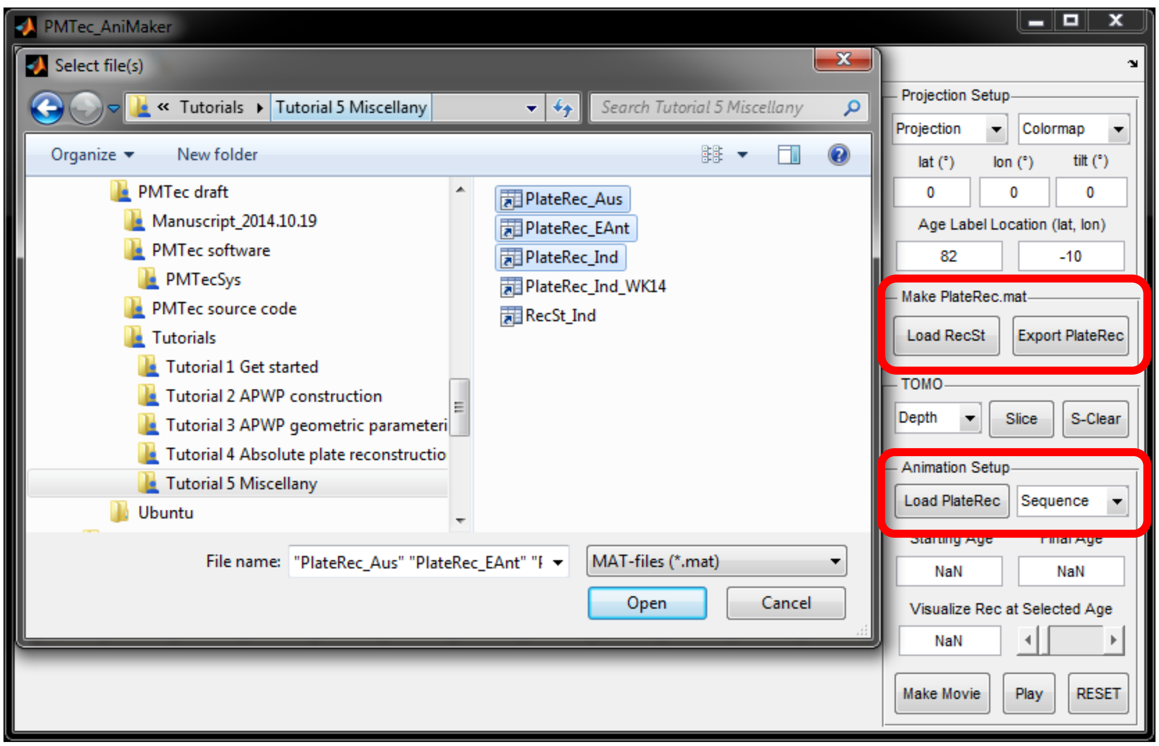

Figure 25. Load of topographic data for visualizing the reconstructions, where multiple selection of files are supported. The visualization sequence, either forward motion or reconstructions, can be selected using the pop-up menu. The animation file 'PlateRec_Ind_WK14.mat' is made from the reconstruction file 'RecSt_Ind.mat'.

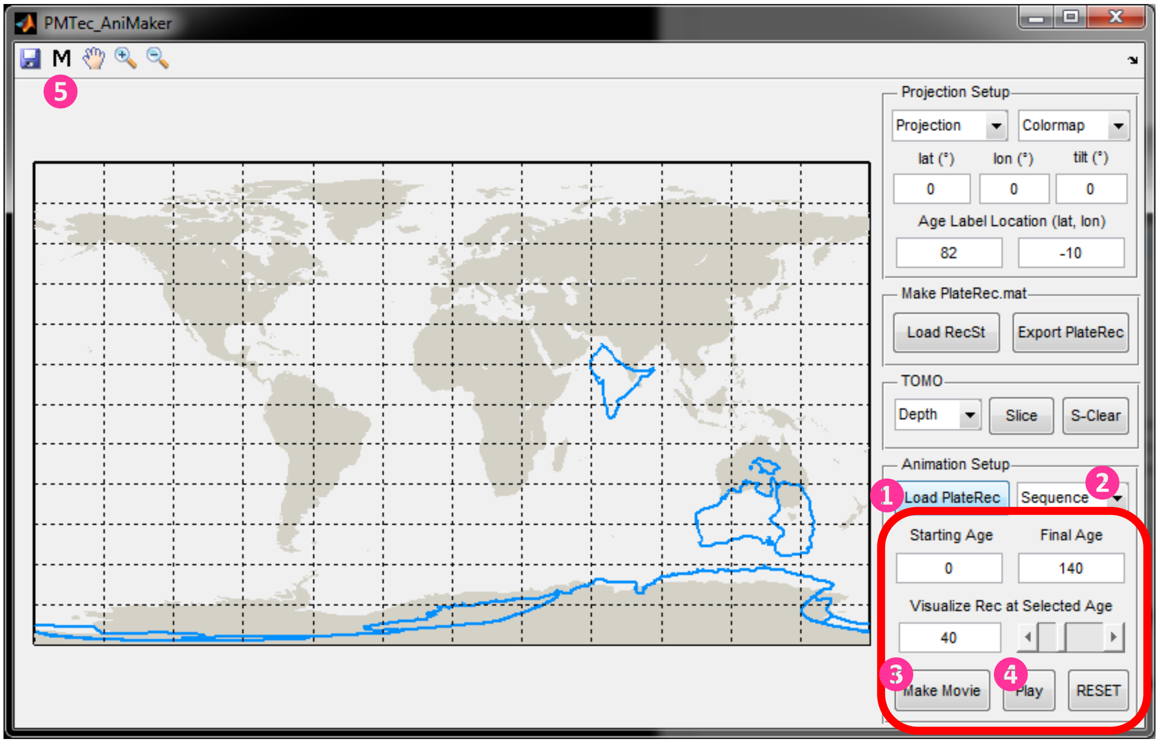

Figure 26. Animation production and play under the module of PMTec_AniMaker. The slider bar and the text box to its left specify the age for the reconstructions. The character 'M' in the toolbar panel saves the movie in the format of *.mov or *.gif.

Steps:

1. Load the animation file(s) 'PlateRec.mat'.
2. Specify the animation sequence: backward reconstruction or forward plate motion.
3. Make animation.
4. Play animation.
5. Save the animation in the format of *.mov or *.gif.

References:

Mitchell, R. N., T. M. Kilian, and D. A. Evans (2012), Supercontinent cycles and the calculation of absolute palaeolongitude in deep time, Nature, 482 (7384), 208–211.

Obayashi, M., H. Sugioka, J. Yoshimitsu, and Y. Fukao (2006), High temperature anomalies oceanward of subducting slabs at the 410-km discontinuity, Earth and Planetary Science Letters, 243 (1), 149–158.

Torsvik, T. H., R. Van der Voo, J. G. Meert, J. Mosar, and H. J. Walderhaug (2001), Reconstructions of the continents around the north atlantic at about the 60th parallel, Earth and Planetary Science Letters, 187 (1), 55–69.

Torsvik, T. H., et al. (2012), Phanerozoic polar wander, palaeogeography and dynamics, Earth-Science Reviews, 114 (3–4), 325–368.

Wu, L., and V. A. Kravchinsky (2014), Derivation of paleolongitude from the geometric parametrization of apparent polar wander path: Implication for absolute plate motion reconstruction, Geophysical Research Letters, 41 (13), 4503–4511.

Van der Voo, R. (1990), Phanerozoic paleomagnetic poles from Europe and North America and comparisons with continental reconstructions, Reviews of Geophysics, 28 (2),167–206, doi:10.1029/RG028i002p00167.