

Exporting Reconstructions to ArcGIS

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Aim

The aim of this tutorial is to illustrate the workflow for a task that will be fairly common to GPlates users who also use ArcGIS.

The scenario is:

1. we are working with data in ArcGIS,
2. we want to reconstruct these data according to one (or several different) plate reconstruction models, at one (or several different) times.
3. we want to load the reconstructed data back into ArcGIS, for further

analysis or to make maps with consistent symbology.

This tutorial gives step by step instructions on how to achieve this. Since the workflow is generally applicable to data stored in shapefiles, it can also be followed using open-source GIS software such as QGIS.

Background

A major advantage of GPLates over viewing reconstructions within ArcGIS is the ability to dynamically visualise the reconstructions through time, rather than as a series of static images. On the other hand, the ability to produce high quality maps with detailed symbologies, bounding boxes, labels, etc, is greater within ArcGIS or GMT. GPLates loads shapefiles and provides a range of options to export reconstructed shapefiles, allowing users to experience the best of both worlds.

Shapefile Prerequisites

Shapefiles can be loaded directly into GPLates. The coordinate system of the data is assumed to be geographic (Longitude/Latitude). So, data stored in a shapefile with projected coordinates (e.g. UTM, Lambert Conic) needs to be reprojected. Similarly, data stored within geodatabases needs to be transferred to a shapefile.

The speed with which GPLates reconstructs shapefile data depends on the number of vertices within the geometries. Thus, if large shapefiles are slow to reconstruct, it is worth considering whether the level of detail contained within the geometries is strictly necessary (for example, polygons/polylines can often be simplified to remove vertices along straight-line segments). Using a 64-bit version of GPLates also improves performance.

Options for exporting reconstructed shapefiles

The options for exporting files offer a lot of flexibility, although this means the export dialogue takes some getting used to.

To access the Export dialogue, select the menu item 'Reconstruction -->

Export'.

The first window looks like this:

Export

☒ Export Time Sequence of Snapshots ☐ Export Single Snapshot Instant

Time Range

Animate from: 250.0000 Ma

to 0.0000 Ma

with an increment of 1.0000 My per frame.

by swapping the start and end times.

Export Data

At each time step, GPlates will create the following files:

Data	Format	Filename
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Target directory: C:\Users\jega4792\Documents

Animation Options

☒ Finish exactly on end time.

Export Progress

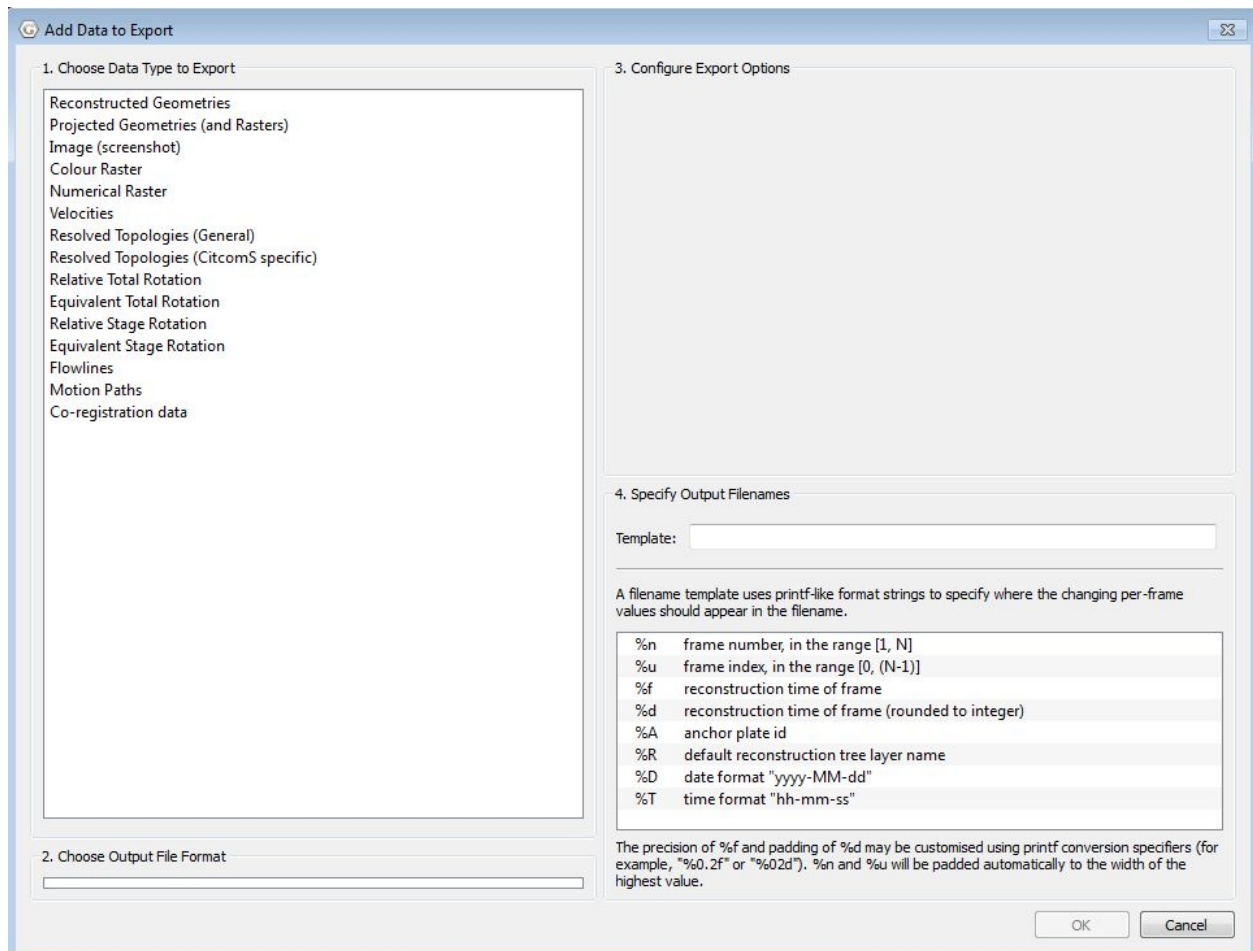
Ready for export.

250.00 Ma 0/251 (0%) 0.00 Ma

The main dialogue gives the option to export reconstructed features at a single time, or at multiple times (e.g. to create an animation for use outside GPlates). This is also where we select the directory into which the exported

files will be saved.

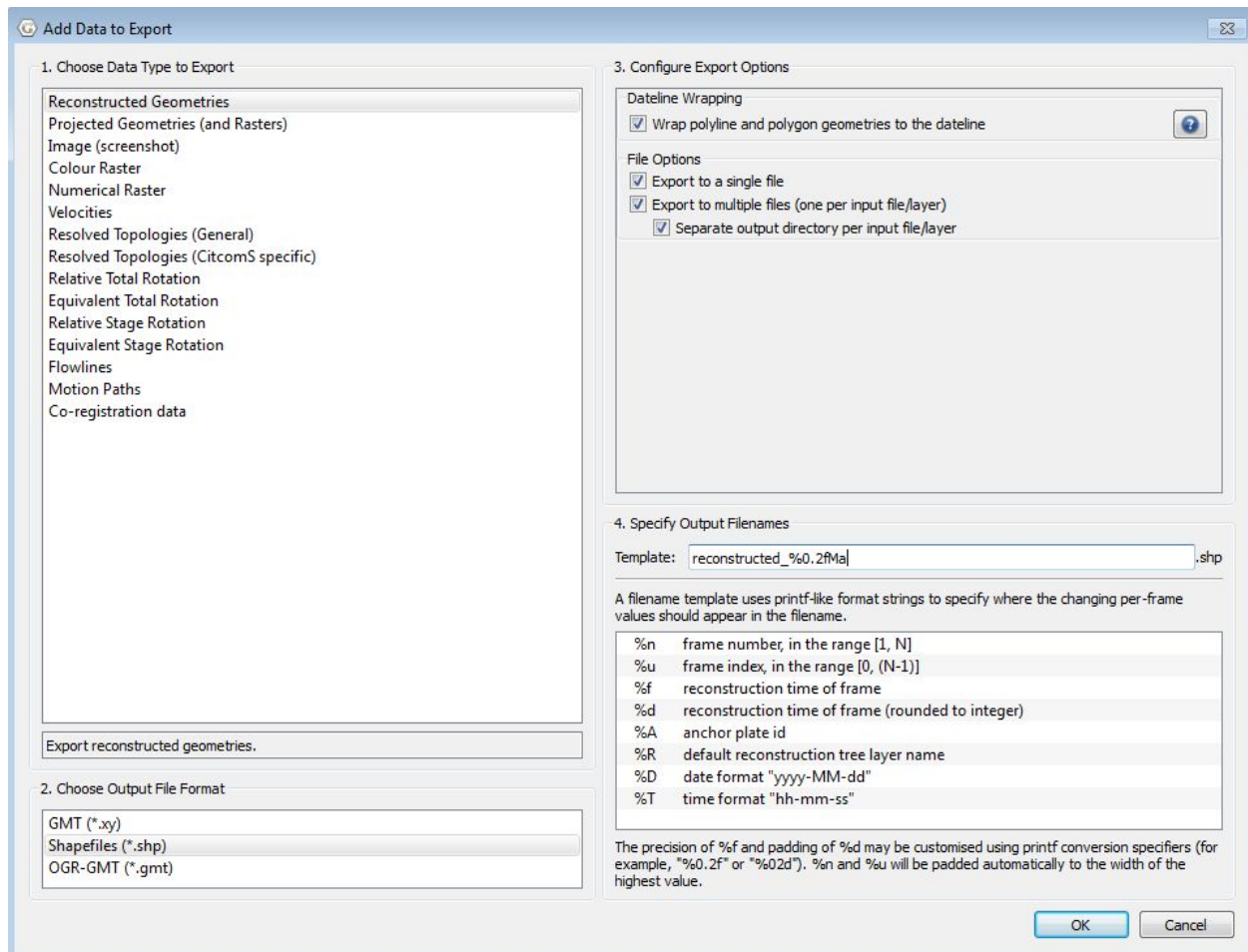
To specify that we want to export shapefiles (or any other file type), we need to select the 'Add Export...' option. This will bring up a second dialogue window:



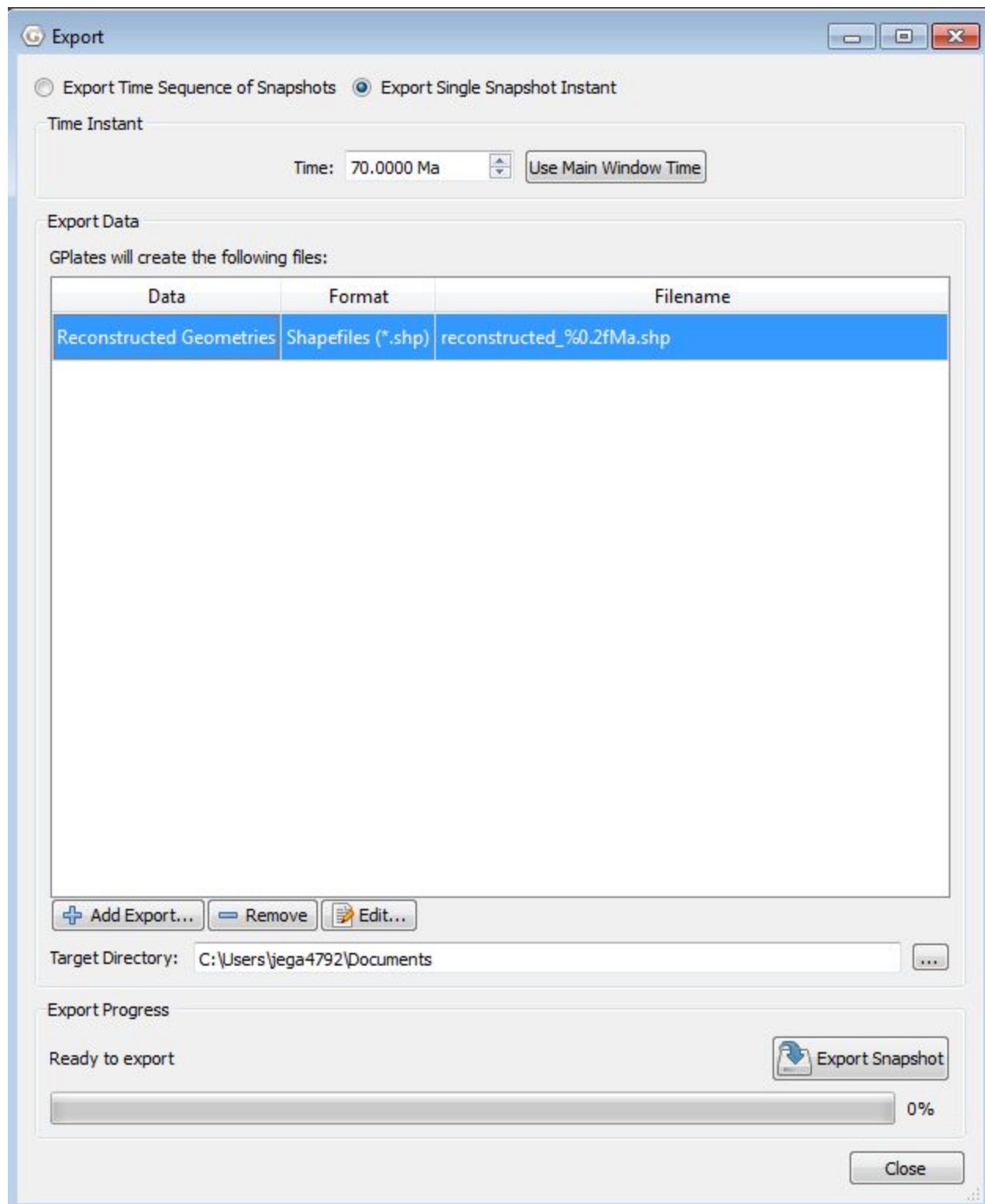
Within this dialogue we can specify many different export types.

1. For a basic shapefile export, select 'Reconstructed Geometries' from the list in panel #1.
2. A list of available file types will appear in panel #2 the lower left, from which we select 'Shapefiles (*.shp)'.
3. Next, panel #3 shows export options specific to shapefile export. For example, where polygons are reconstructed such that they cross the dateline (-180/+180 longitude), it is generally necessary to select the 'Wrap to dateline' option so that the geometries display correctly in ArcGIS. Other options allow us to

4. In panel #4, you can specify some options to customise the output filenames (which will be based on the names of the input files, but with extra information incorporated such as the reconstruction time).



Once you are happy with your export options, click 'OK' and you'll return to the main Export dialogue. You'll see the added export item in the list of Data to be exported. You can add as many additional export items to this list as you want. For example, you could choose to export both shapefiles and GMT .xy format files for the same reconstructed geometries, by going through the 'Add Export...' dialogue twice.



When you are ready to export, click on 'Export Snapshot' and the files will be saved. If you are exporting files for a sequence of times, the progress bar will show how quickly this is happening.

After export is complete, the Export dialogue window will stay open. This gives you the flexibility to have both the Export and Layer Manager windows open, turn layers on/off in the layer manager to modify what will or will not be exported, and re-export with one click.

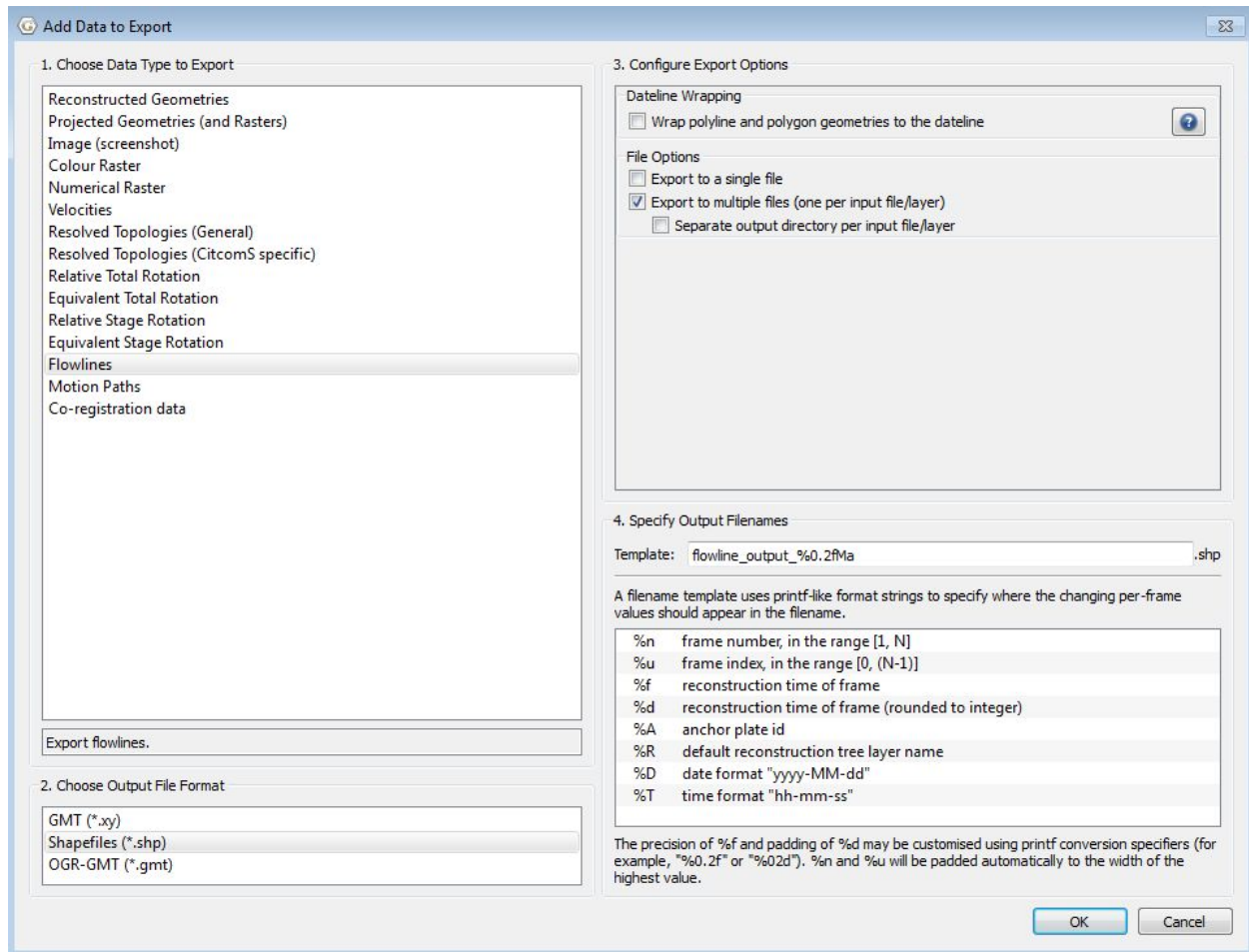
Important Note: Only visible shapefiles will be exported. For example, if seven shapefiles are loaded but only two are displayed (ie ticked in the layer manager window), then only these layers will be exported.

Other data types that can be exported as shapefiles

The text above applies to a situation where we already have some data in a shapefile, and want to create a shapefile containing a reconstructed version of the same data. GPLates can also support a number of feature types beyond those that shapefiles are capable of storing, that can be used to visualize the time-dependent evolution of plate reconstructions and plate boundaries. These include

- flowlines and motion paths that illustrate how points move through time according to a given reconstruction model. These features can be created from scratch within GPLates in a few simple steps, as described in the 'Flowlines and Motion Paths' tutorial.
- topological plate boundaries (Mid-ocean ridges, subduction zones), which GPLates dynamically resolves into plate polygons. The sample data provided with GPLates contains a set of such dynamic plate boundaries from 0 - 200 Ma from the global plate tectonic reconstruction model of [Seton et al \(2012\)](#).

Using the same export dialogues, resolved topologies and flowlines can be exported at a single reconstruction time, or a series of times. For example, to add a flowline export (and assuming you have flowline layer(s) active within GPLates), select the Flowline option from the 'Add Data to Export' dialogue.



Included Files

[Click here](#) to download the data bundle for this tutorial.

This data bundle includes the following files:

Coastline shapefiles of Australia and Antarctica:

AusAnt_Coastlines.dbf

AusAnt_Coastlines.prj

AusAnt_Coastlines.sbn

AusAnt_Coastlines.sbx

AusAnt_Coastlines.shp

AusAnt_Coastlines.shp.gplates [XML Document]

AusAnt_Coastlines.shp [XML Document]

AusAnt_Coastlines.shx

Polygons defining the present-day extent of continental crust on the Australian and Antarctic plates:

AusAnt_PlatePolygons.dbf

AusAnt_PlatePolygons.prj

AusAnt_PlatePolygons.sbn

AusAnt_PlatePolygons.sbx

AusAnt_PlatePolygons.shp

AusAnt_PlatePolygons.shp.gplates [XML Document]

AusAnt_PlatePolygons.shx

Flowlines file for Exercise 2:

Flowlines_Tutorial_4.3.gml

Rotation files:

Global_EarthByte+AusAnt_Powell_1988_Model

Global_EarthByte+AusAnt_RoyerSandwell_1989_Model

And a folder named 'MoreRotationFiles'.

This tutorial dataset is compatible with GPlates 1.5.

Exercise 1: Australia-Antarctica at 160 Ma

As an example of the above workflow, use the reconstructions of Mesozoic-Cenozoic rifting between Australia and Antarctica. A number of different studies have proposed reconstruction models for how Australia and

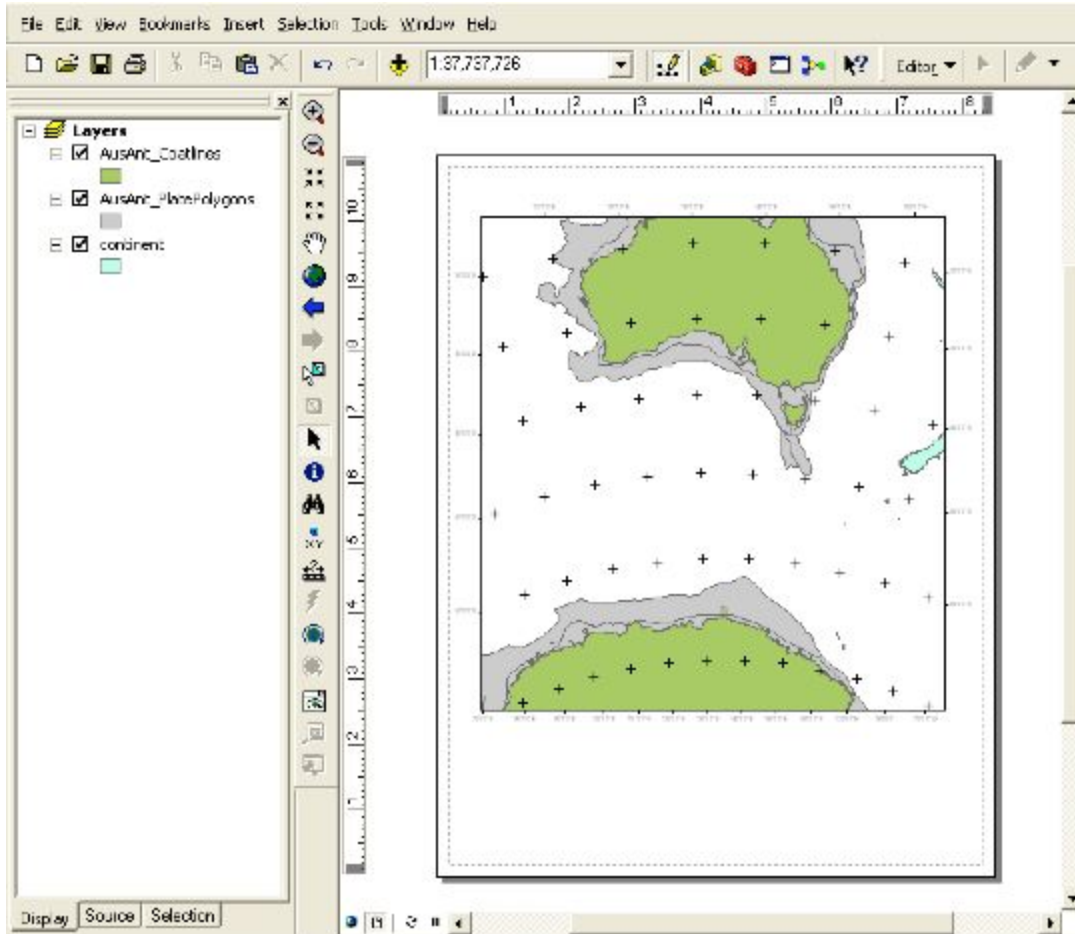
Antarctica have moved apart since the onset of rifting in the Jurassic. In this example we'll show how to take some geological data for Australia and Antarctica in ArcGIS, reconstruct these data using different reconstruction models within GPlates, then export the results back to ArcGIS to make some high-quality map visualisations.

The starting point are polygons shapefiles (provided in the tutorial data bundle). Files are provided that define:

1. Coastlines of Australia and Antarctica.
2. Polygons defining the present-day extent of continental crust on the Australian and Antarctic plates. The polygons delimit the boundary between oceanic crust and the outermost crust of the continent-ocean transition (COT) interpreted from geological and geophysical data from the Australian southern margin (Blevin and Cathro, 2008) and the Antarctic margin (Leitchenkov et al, 2007; Close et al, 2009).

The figure below shows these files displayed in ArcGIS:

(Note: To change the projection, click: View → Data Frame Properties ... → Projected Coordinate Systems → World → Mercator (World) → OK)

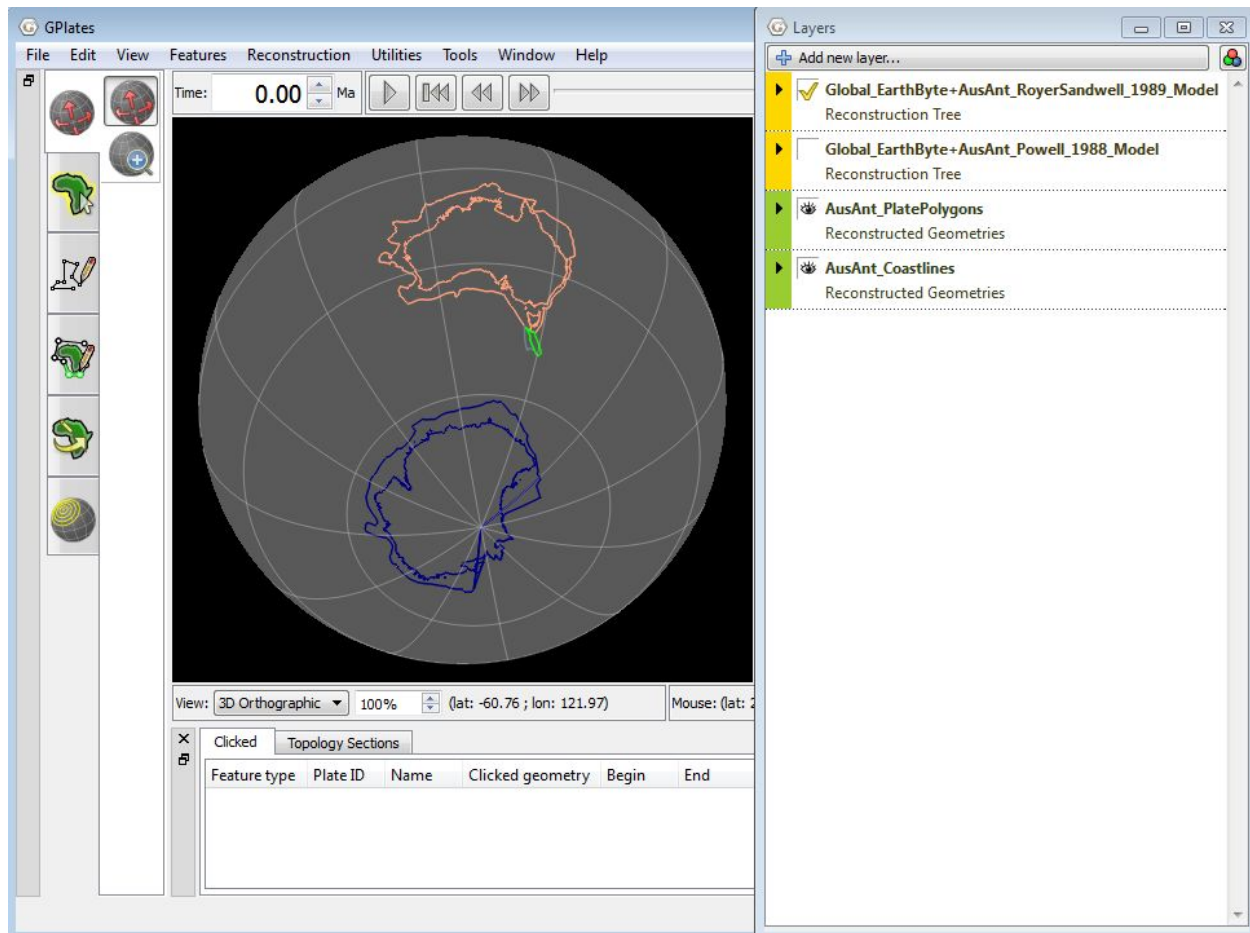


Within ArcGIS, we can confirm that the geometries have PLATE IDs assigned - these are the integer values in the PLATEID1 column of the attribute table that are either 801 (Australia) or 802 (Antarctica). These values correspond to the PLATE IDs defined in each of the rotation files (.rot) discussed below.

To reconstruct these data, load the shapefiles into GPlates, along with a rotation file that describes the plate motions. If we load several different rotation files, we can compare the reconstructions and relative motions predicted by different studies. Rotation files for several alternative reconstruction models are provided. To begin with we will concentrate on two of these reconstruction models, based on studies by Powell et al (1988) and Royer and Sandwell (1989).

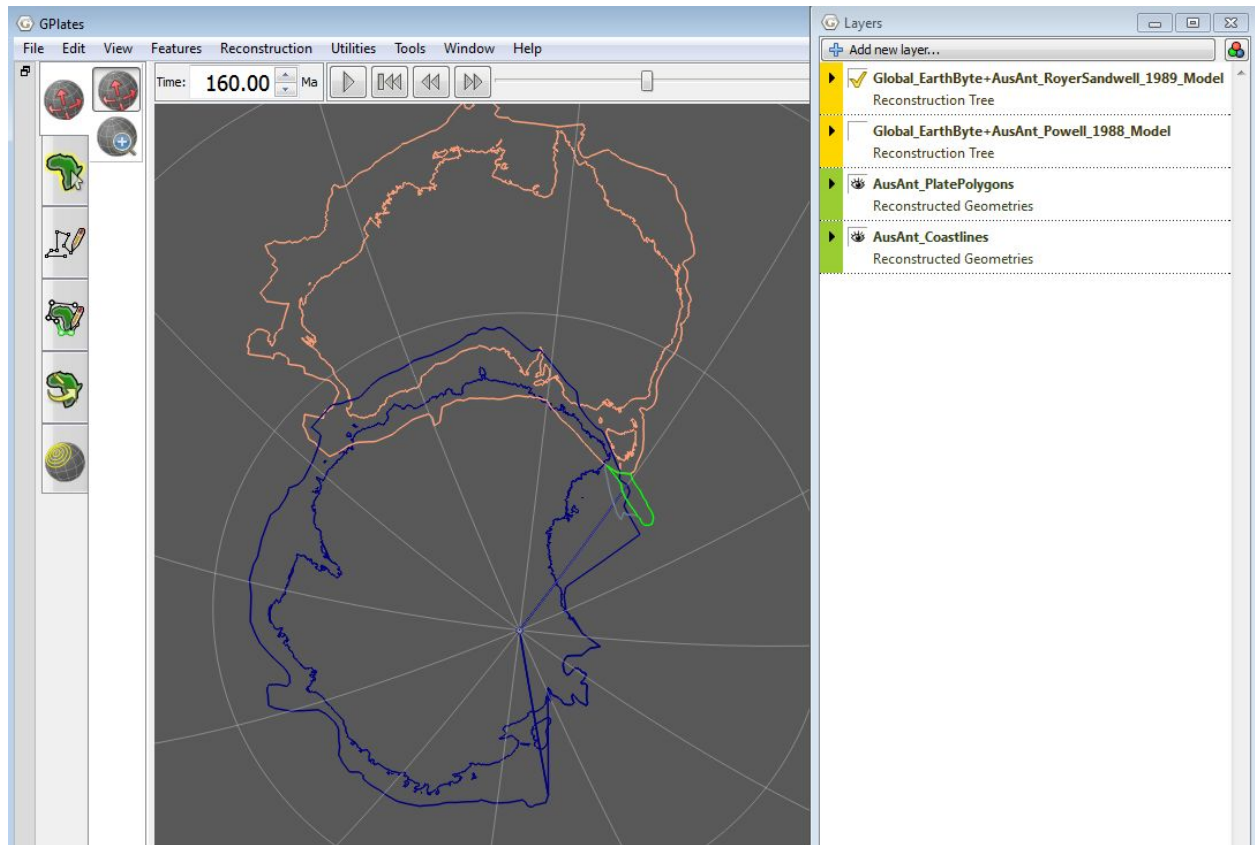
Open GPlates, and load in the shapefiles together with the rotation files (*.rot) with filenames corresponding to Powell and Royer and Sandwell. In the layer manager, the geometry layers appear in green and the rotation files appear in yellow. Only one of the rotation file layers will be ticked, denoting that this is the 'active' rotation file. We can switch between rotation

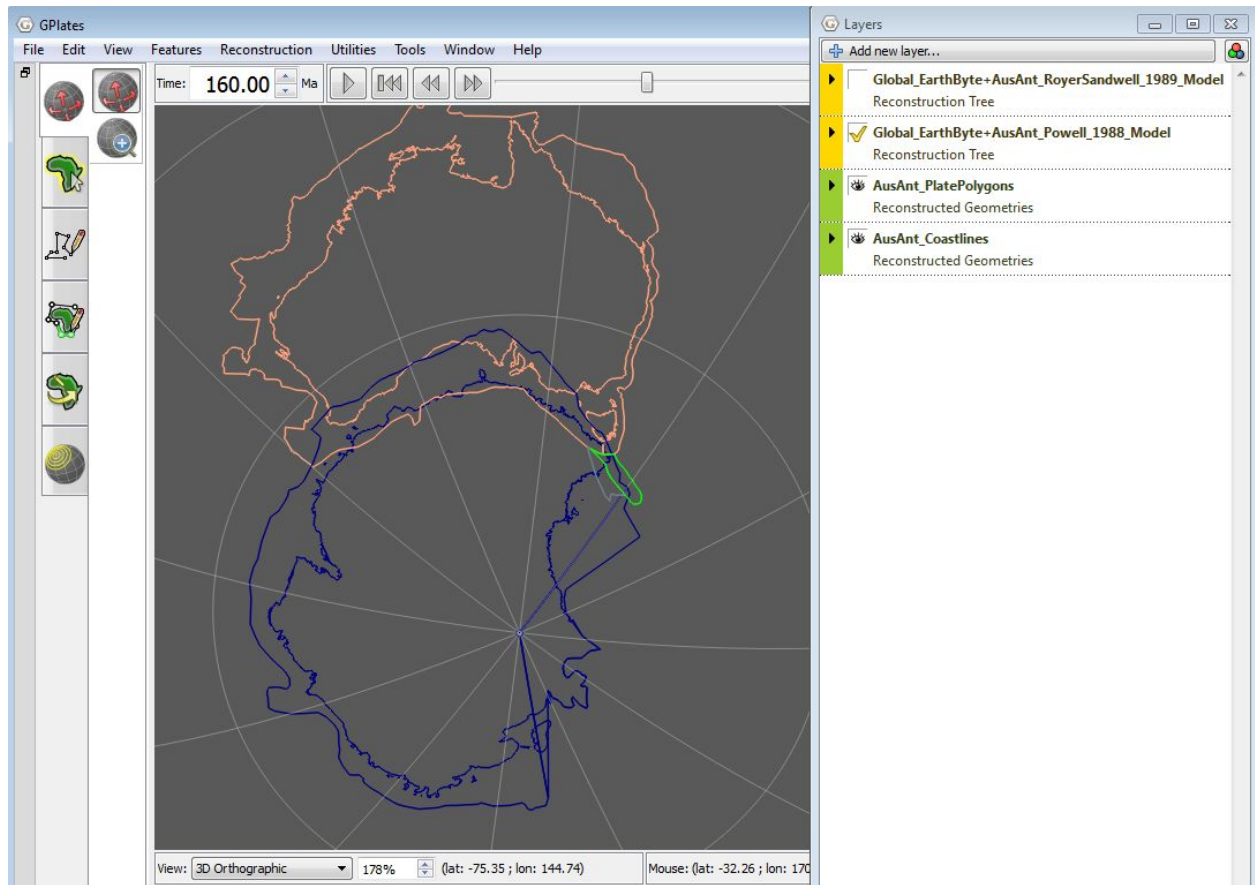
files by clicking on the tick boxes.



To compare the plate configurations predicted by different models at the beginning of rifting, select 160 as the reconstruction time. Note that as well as both plates moving together, both Australia and Antarctica will move significantly relative to their present location since the rotation file is tied to an absolute reference frame (Steinberger and Torsvik, 2008). If we are only interested in relative motions, we can fix one of the plates. For example, select 'Reconstruction --> Specify Anchored Plate ID...' then enter 802 so that Antarctica remains in its present position and we can concentrate on the relative motion of Australia.

By alternating between the two reconstruction files, we can see that the two rotation models predict a similar amount of closure when the plates are reconstructed back together prior to rifting, but the lateral juxtaposition differs by >200 km.





Note that both reconstructions produce a significant overlap (several hundred kms) between the present day extent of continental crust on the two plates. Such large overlaps are a common feature of reconstruction that restore the plates to their position prior to rifting and large-scale crustal extension that results in present-day passive margins. The overlaps provide a simple proxy for the amount of extension predicted by each reconstruction, which should be broadly comparable with estimates from geophysical studies of margin architecture.

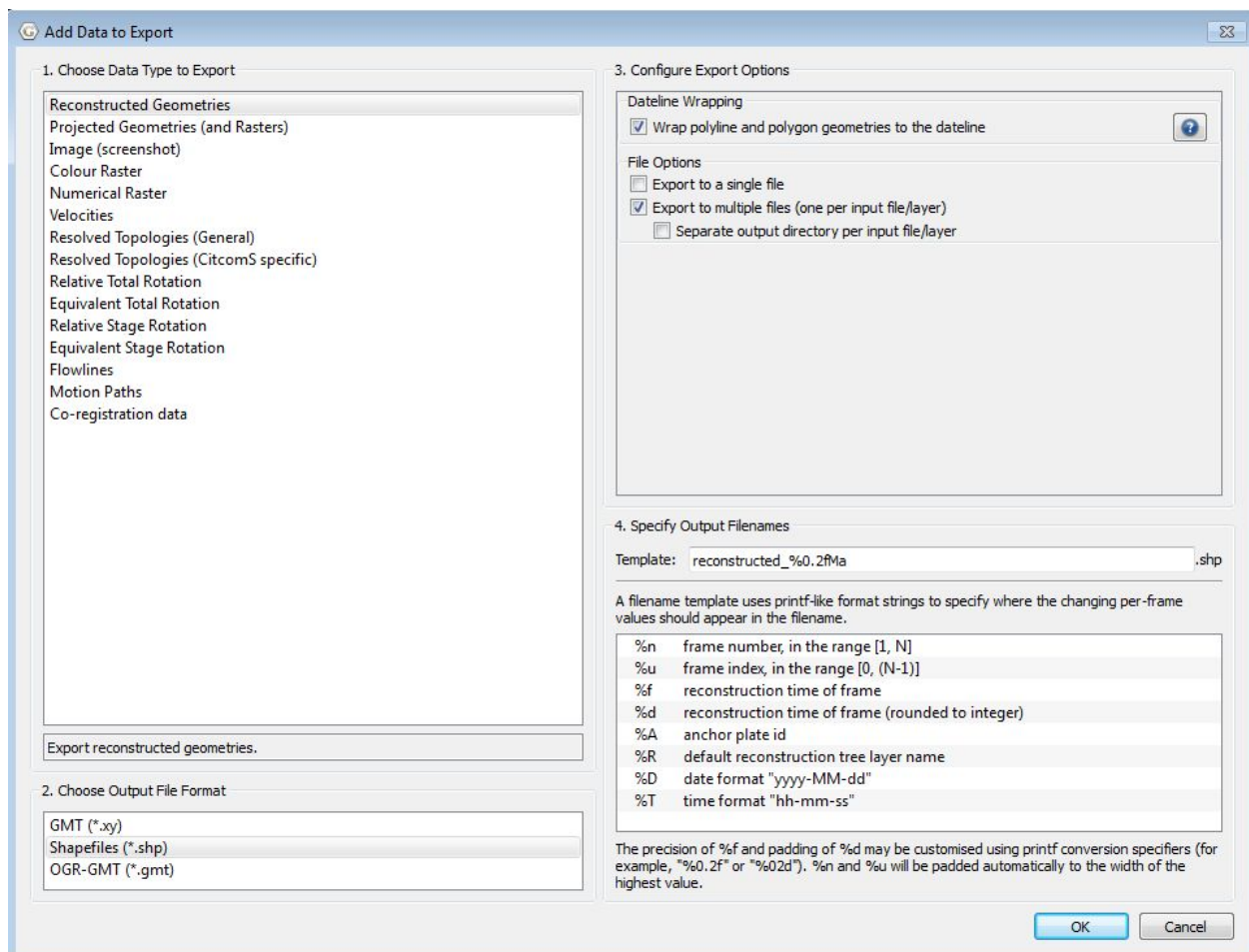
Next we will export the reconstructed geometries into new shapefiles. To do this,

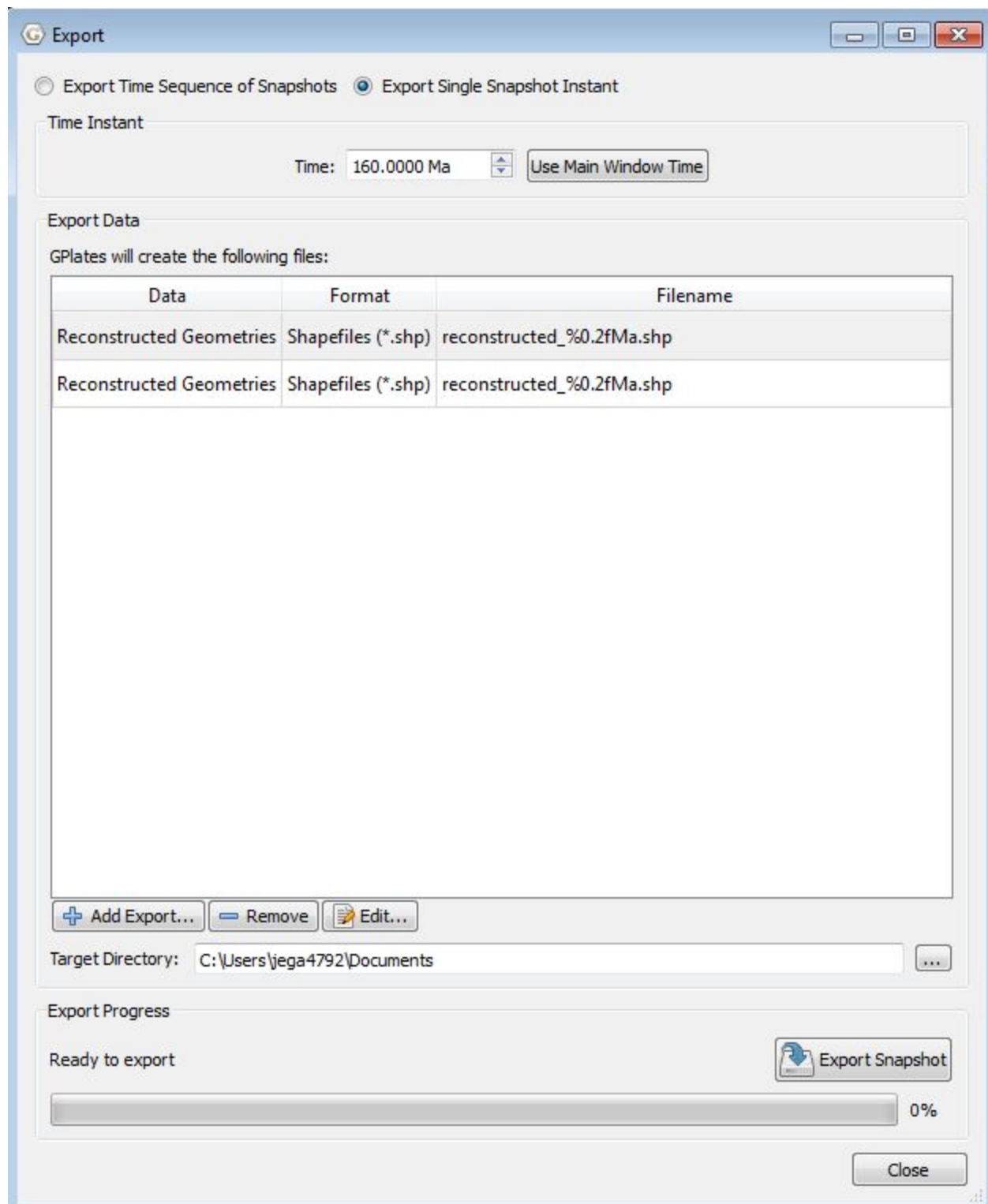
- select the menu item 'Reconstruction --> Export'.
- Select 'Export Single Snapshot Instant'
- Click on 'Use Main Time Window' so that the time switches to 160.
- Click on 'Add Export...'
- Select 'Reconstructed Geometries', the 'Shapefile (*.shp)'
- Tick the 'Wrap features to Dateline' tickbox
- Deselect 'Export to a single file'
- Select 'Export to multiple files' (this means the reconstructed plate

polygons will be in a separate shapefile from the coastlines, the same as the input files)

- Deselect 'Separate output directory per input layer' (this is optional, it depends whether you want your reconstructed files in different folders or all together).
- Finally, in the main Export dialogue, specify the Target directory that you want to save the reconstructed files to. Give this folder a name that matches the currently active

The dialogues should look like this:





Click on 'Export Snapshot'. Check that the shapefiles that you just exported exist in the folder you specified.

Next, export a second set of reconstructed features using an alternative reconstruction model. Change the active reconstruction layer in the layer manager, and change the target directory in the export dialogue so that you export the new files to a different directory (again with a name consistent with the reconstruction model that is currently active).

Now that we have the reconstructed shapefiles, we can load them directly back into ArcGIS.

How we display the results is entirely up to you. Some possible examples are shown below. We could plot just one reconstruction, or plot alternative reconstructions side-by-side, or superimposed.

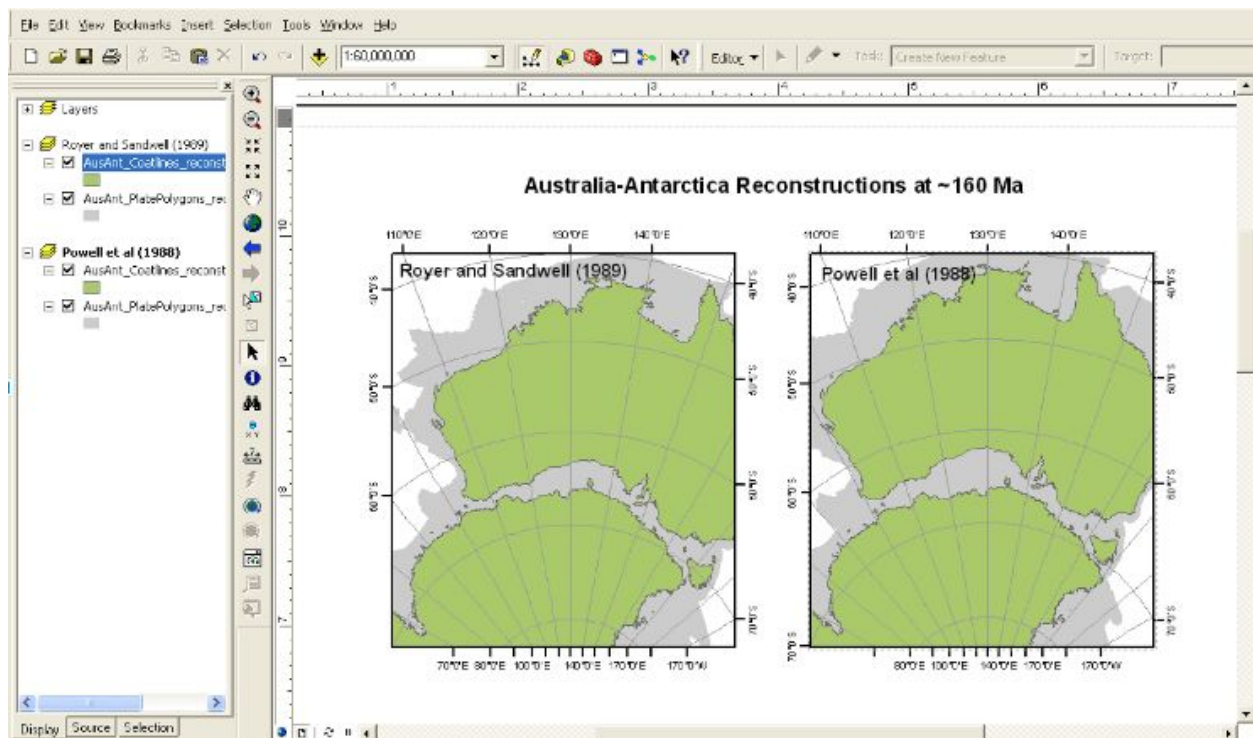


Figure 1. A Side by side comparison

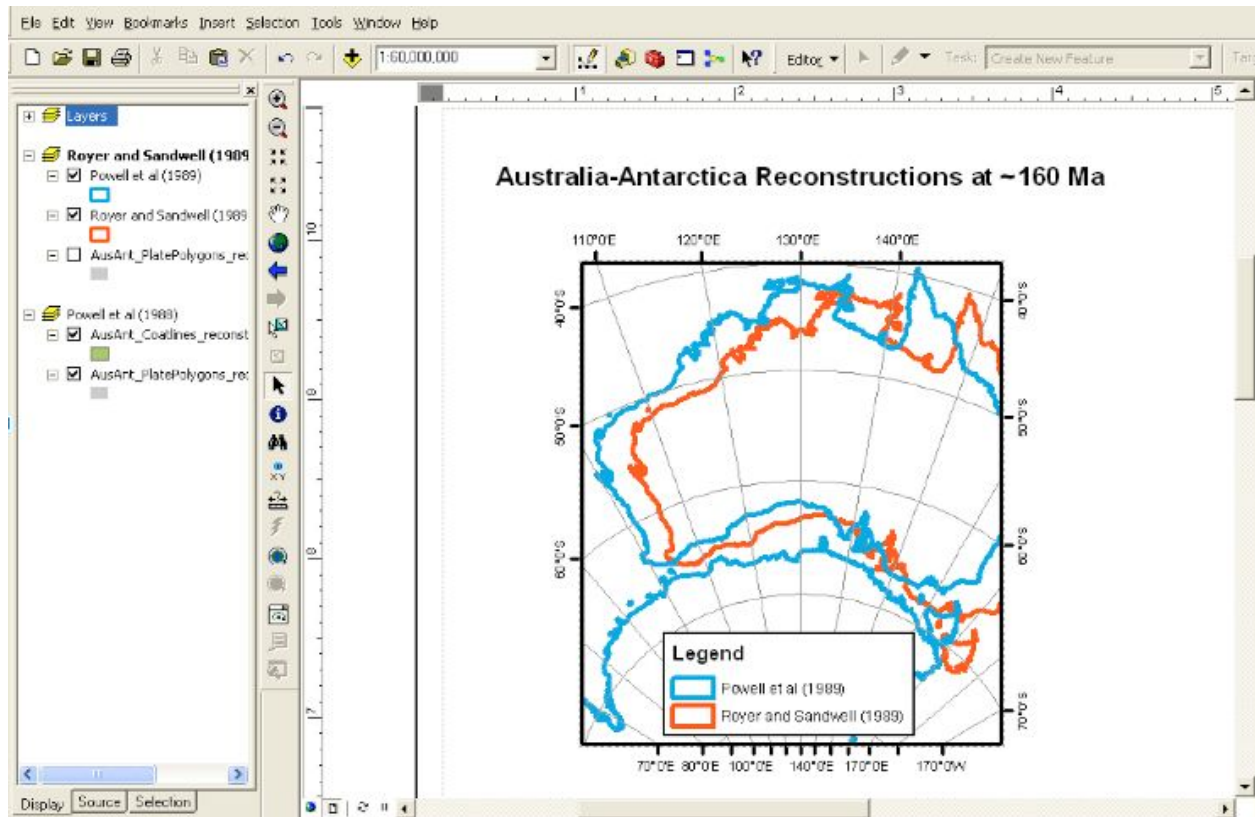


Figure 2. Comparing reconstructions by superimposing alternative configurations.

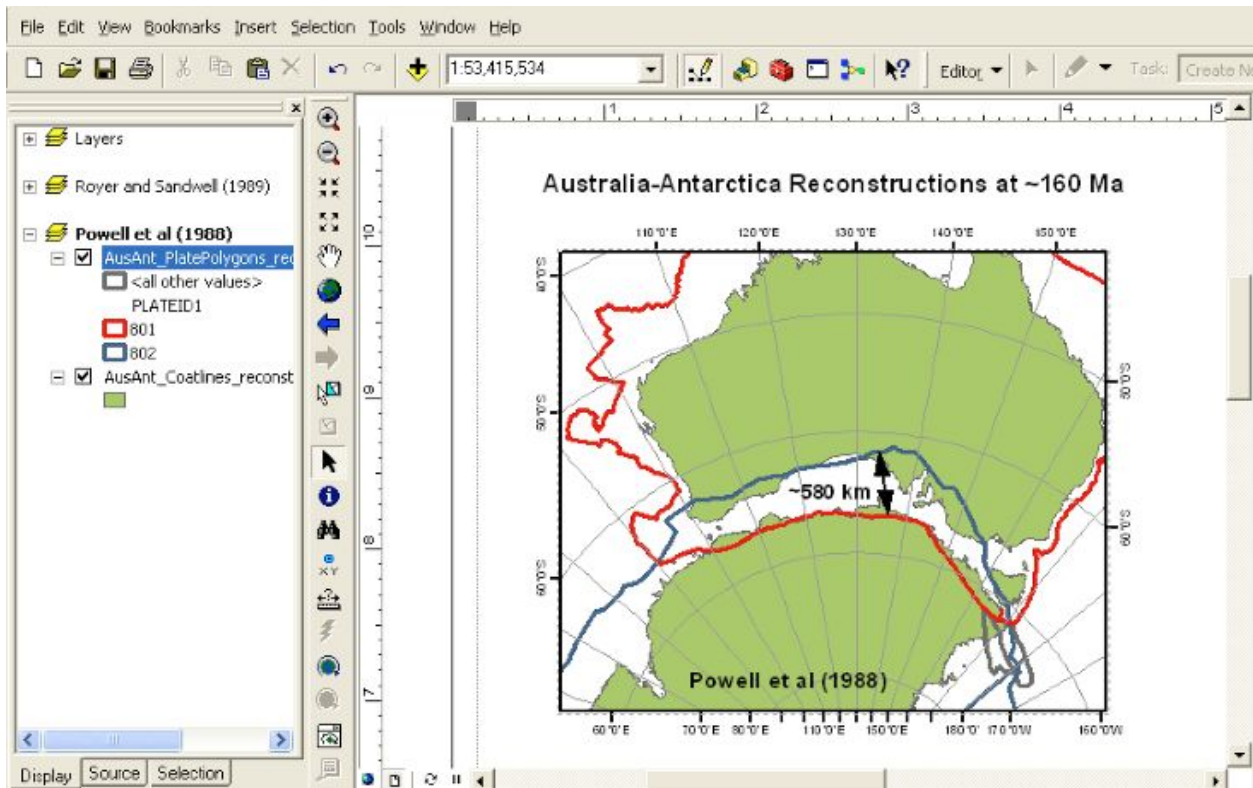


Figure 3. Analysing the amount of crustal extension predicted by a reconstruction model. The red line is the (maximum) present day extent of continental crust within the Australian Plate, the Blue line is the equivalent line for the Antarctic plate. Plotting these data in ArcGIS and measuring the amount of overlap, we can observe that the reconstruction model proposed by Powell et al (1988) predicts up to ~600 km of extension of continental crust prior to breakup and the onset of seafloor spreading.

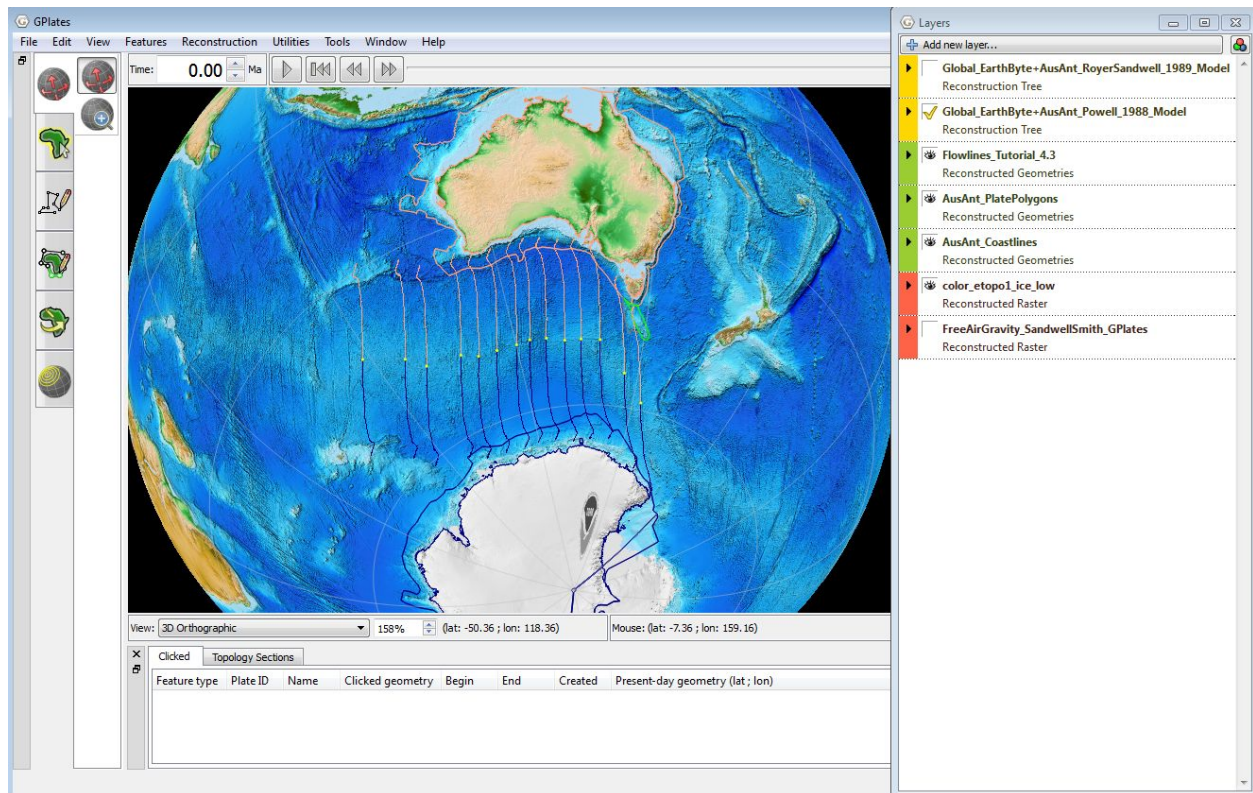
Exercise 2: Illustrating the Rifting History in ArcGIS

In this section we will continue with the previous example, and go through two further ways to work seamlessly between GPlates and ArcGIS

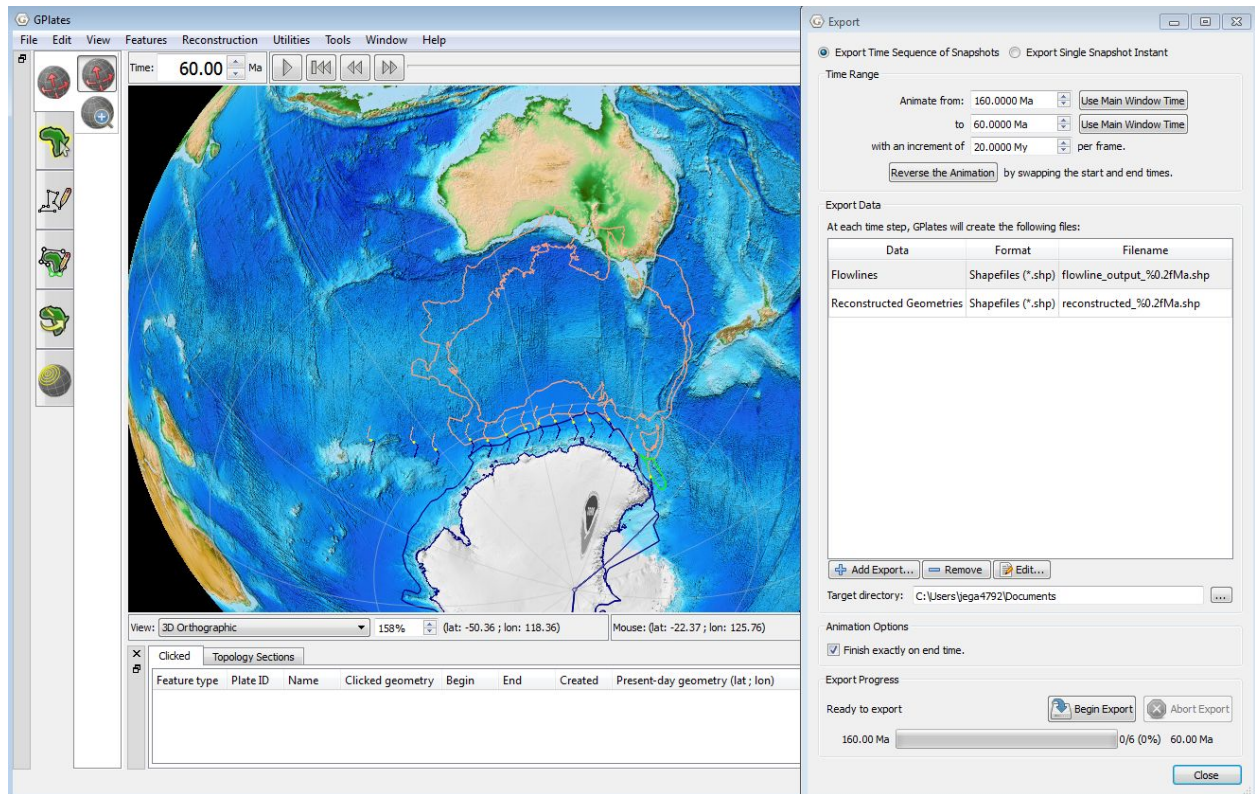
1. creating and exporting to ArcGIS features that contain information about plate motions through time, such as motion paths and flowlines.
2. creating time sequence ArcGIS maps.

Firstly, we need to make flowline features in GPlates. The process is described in the '[Flowlines and Motion Paths](#)' tutorial. Alternatively, you can load the flowlines provided as part of the sample data for this tutorial. If you do want to make your own flowlines, you may find it useful to load a dataset from the GPlates sample data that delineates the present-day

spreading ridge in the South East Indian Ocean, such as the isochrons or the raster of free air gravity.

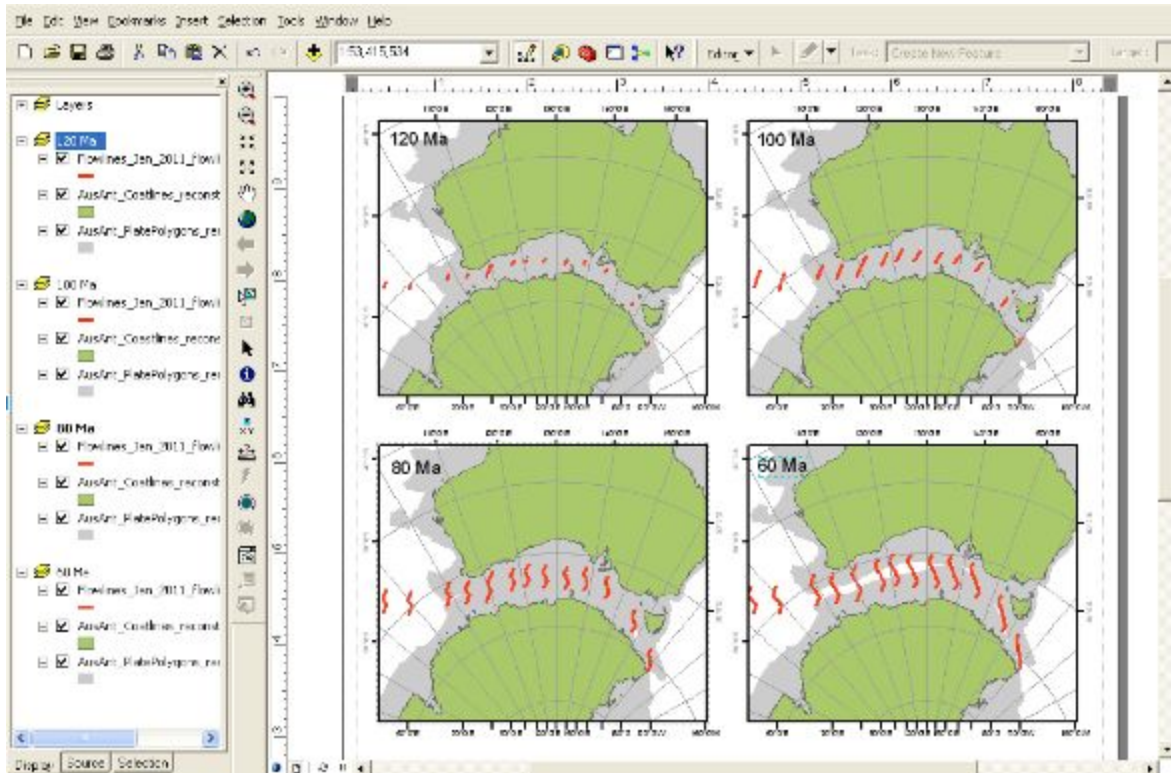


Go to the 'Reconstruction --> Export...' dialogue window. Select 'Export time sequence of snapshots', then add two export items to the export list - 'reconstructed geometries' and 'flowlines'. The list should end up looking like this:



Specify a Target directory for the output files, then click on 'Begin Animation'.

Now, go to ArcGIS and load the reconstructed shapefiles. By default, each shapefile will contain the reconstruction age as part of the filename. By loading the geometries for different reconstruction ages into different data frames, we can construct a single page in the ArcGIS layout view with different data frames for different times. The image below is an example showing four different time snapshots.



The figure with the flowlines illustrates the details of the extension direction predicted by the reconstruction model, and how this evolves through the reconstruction sequence. The Powell et al (1988) reconstruction predicts initial NNE-SSW extension, followed by NNW-SSE extension.

Additional Exercises

The examples only scratch the surface of investigating different reconstructions. Rifting between Australia and Antarctica is one part of the wider story of Gondwana breakup. There are many other ways that we can use GPlates to investigate some of the different reconstructions for this, and use ArcGIS to make maps that communicate these differences. Aside from the two examples compared above, many other authors have studied Australia-Antarctica relative motions. Several additional rotation files are provided in the sample data for this tutorial. Try loading up these different rotation models and see how different they are.

1. Investigate the amount of continental extension implied by different reconstructions. Consider the amount of overlap between the outer limit of the Continent-Ocean Transitions for different models. We can compare the amount of overlap with independent estimates of

continental extension during rifting (e.g. Veevers and Eittreim, 1988; Espurt et al, 2009, 2012; Williams et al, 2011), on the basis of which we should expect the COTs to overlap by several hundred kilometres. How well do the different reconstruction models compare?

2. What are the implications for the size of greater India? The example data for this tutorial deliberately concentrates on reconstructions of Australia and Antarctica, but this configuration (together with the Antarctica-India configuration prior to rifting) is a fundamental constraint on the size of greater India before it collided with Eurasia (see Ali and Aitchison, 2005). To investigate this question further using GPlates, consider using [this data pack](#) provide with the paper of Gibbons et al (2012).
3. What are the implications of different reconstructions for the juxtaposition of Paleozoic and older geological units in Australia and Antarctica? See papers Williams et al (2012), White et al. (2013).

When comparing different reconstructions, it is important to understand exactly what geological and geophysical observations have been used as constraints. GPlates is reconstruction software, and is agnostic of how well or poorly constrained the rotation files you load are.

You can read more about Australian-Antarctic reconstructions in several papers on the [Earthbyte publications page](#).
