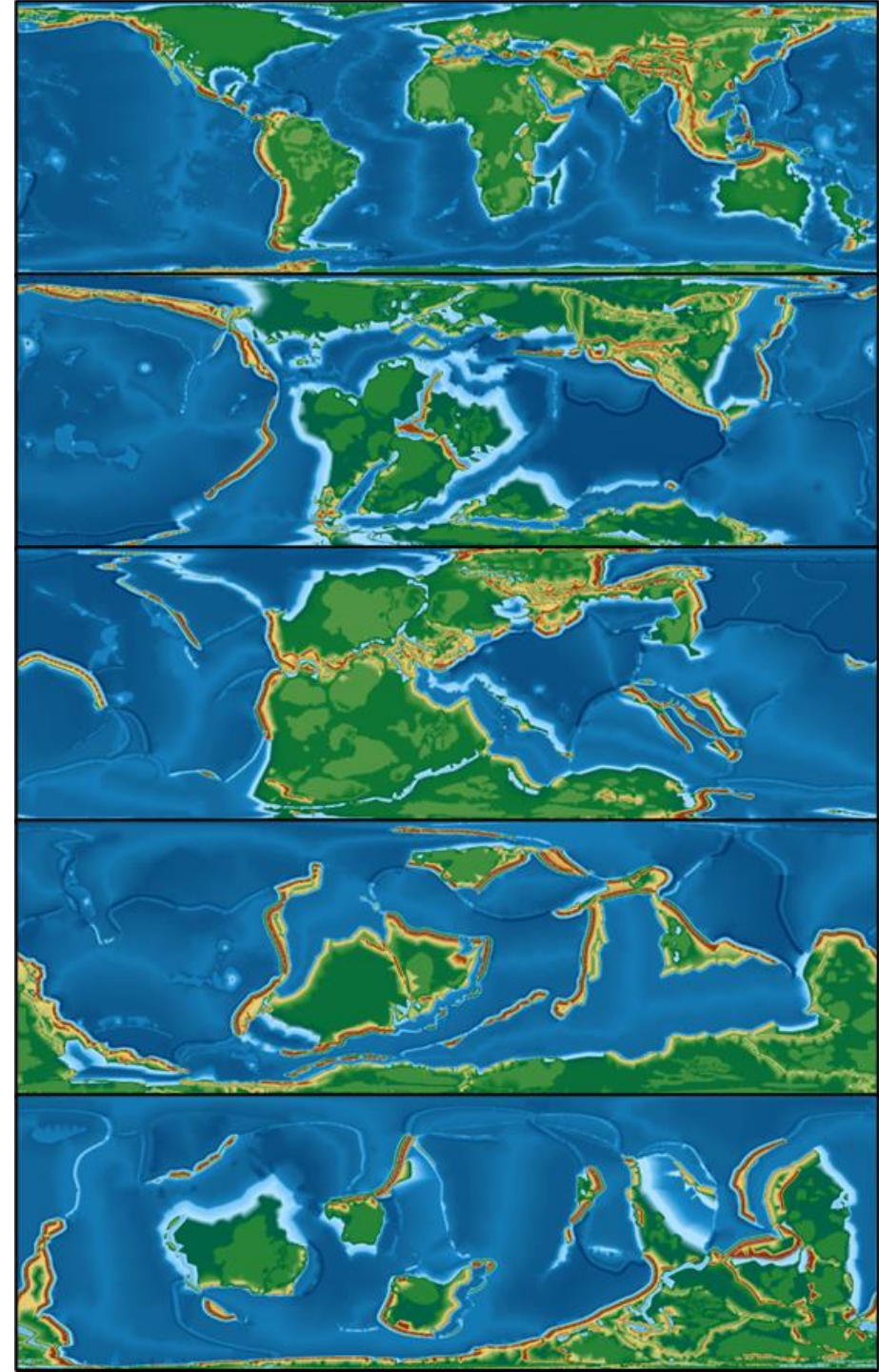


Comparing 545 Million Years of Sea-Level Change: New Insights from the TopoChronia QGIS Plugin

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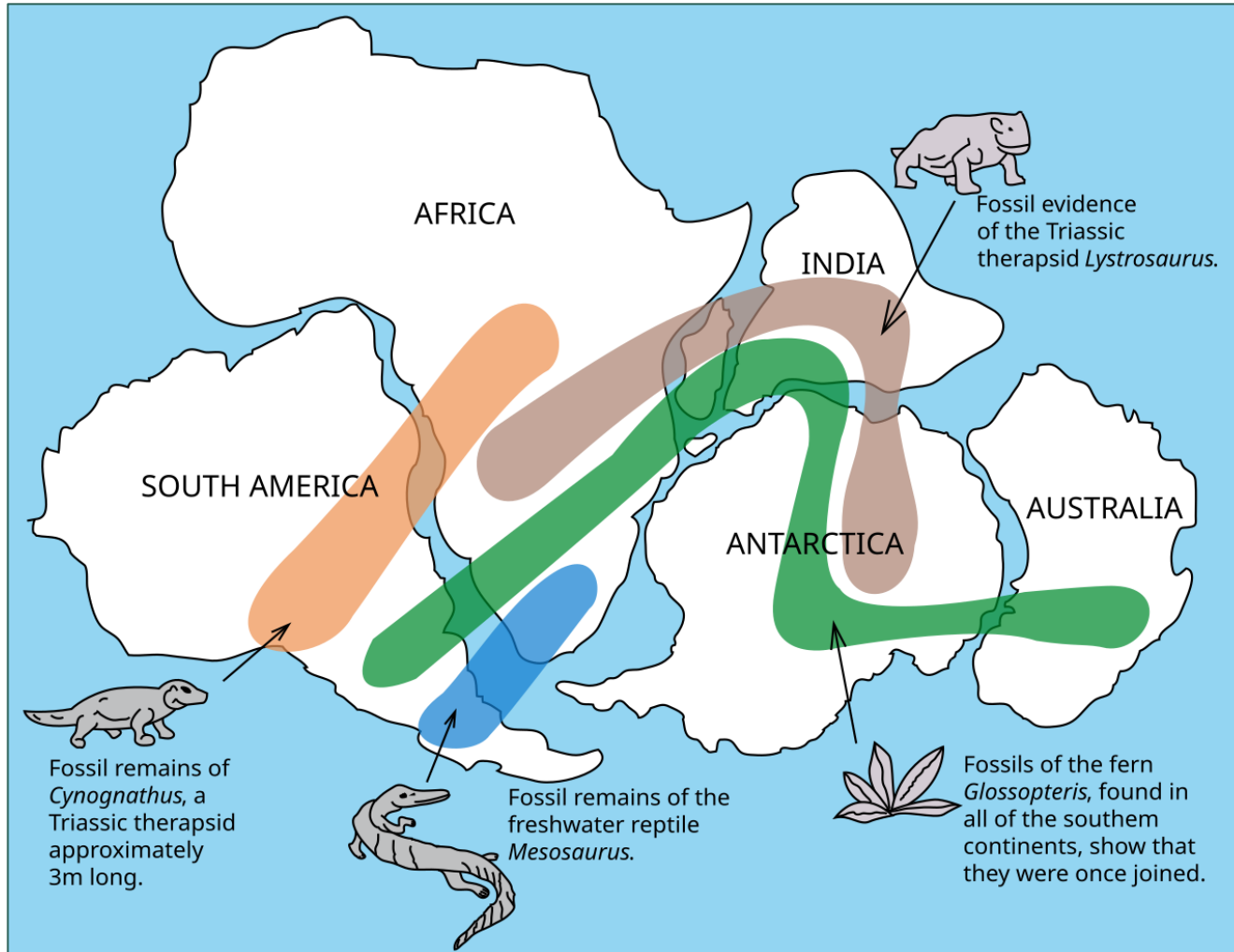
Continental Drift ?

“The Americas are torn away from Europe and Africa (...) by earthquakes and floods”

Abraham Ortelius
(16th century)



Continental Drift ?

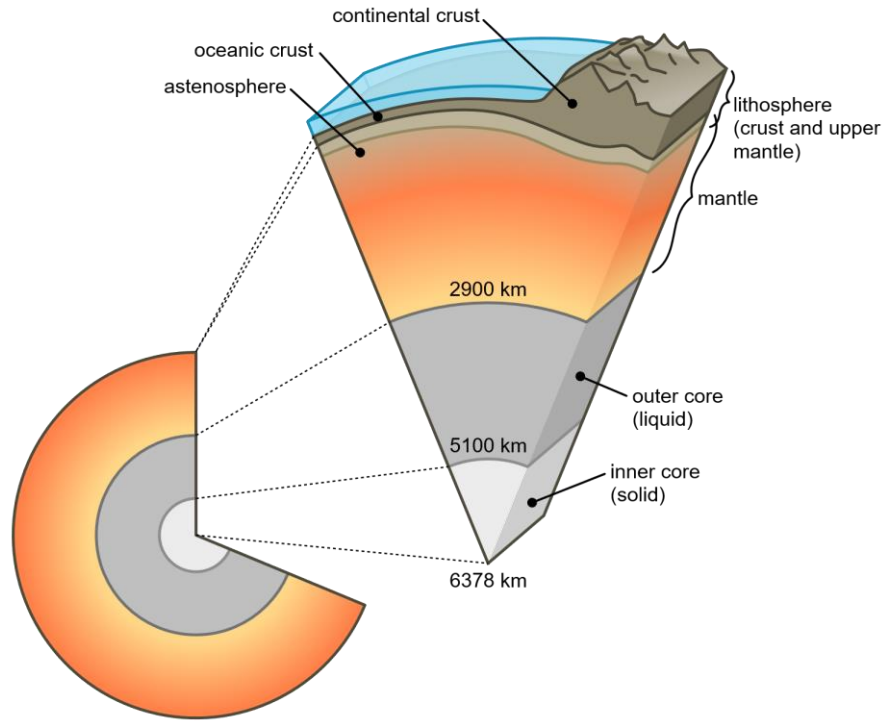


Shapes of continent are like the pieces of a puzzle with similar fossil records.

Continents must have “drifted” from an original “supercontinent”

Alfred Wegener
(1912, 1915)

Plate Tectonics ?



Study of the Earth structure
through seismic waves:
layers with different physical and
chemical properties

1957 physiographic map of the North
Atlantic:
Oceanic floor is not flat !
Shallow ridges in the middle of the ocean

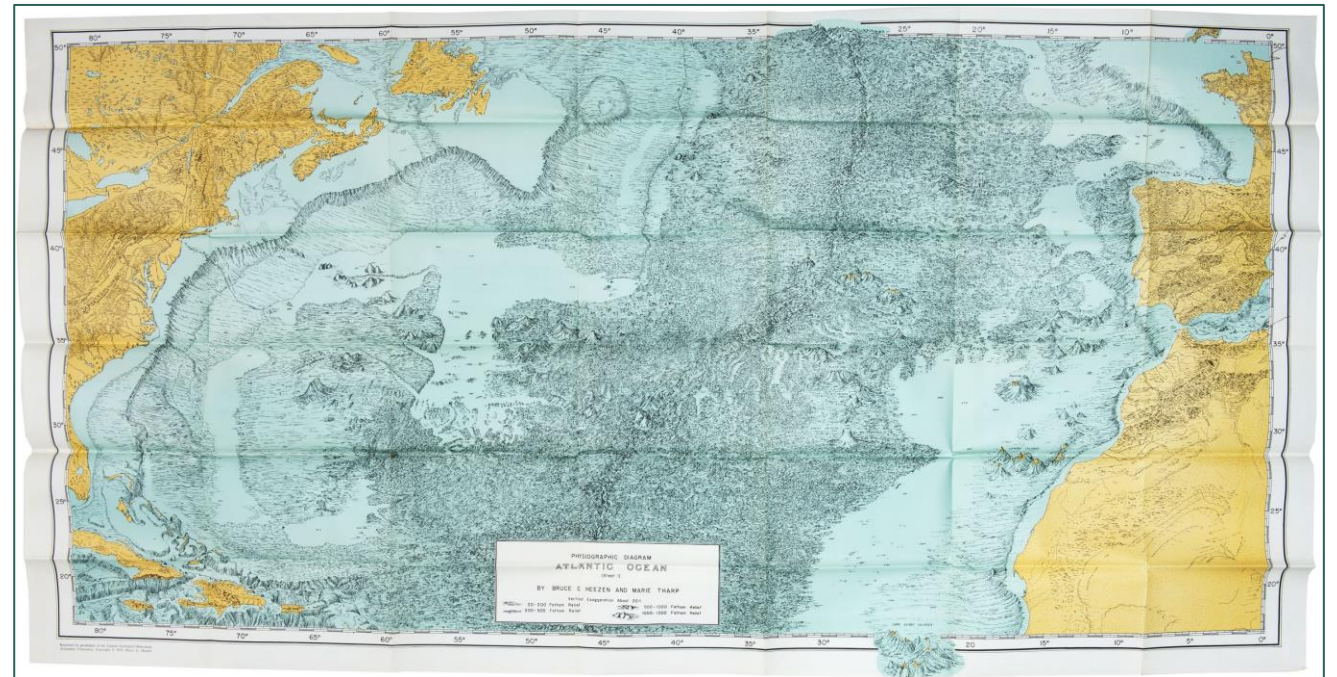
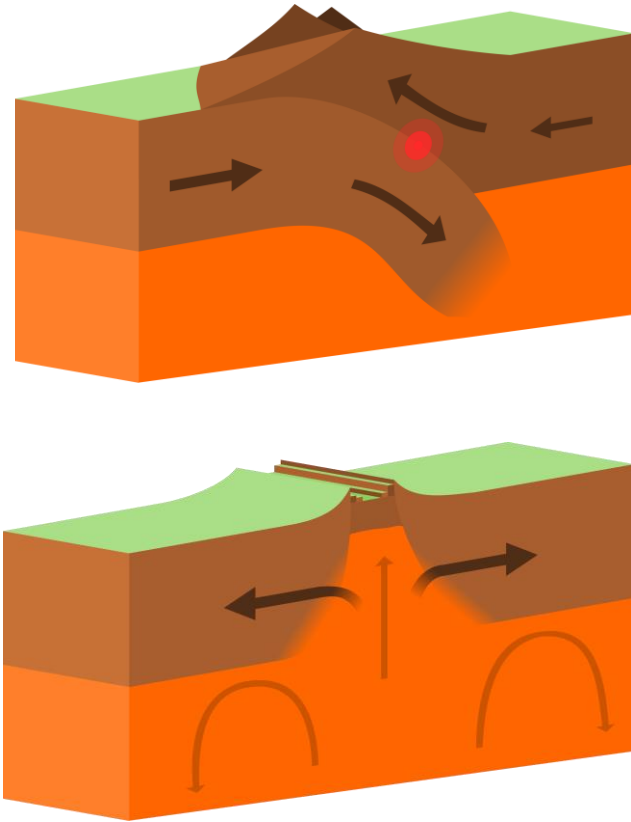


Plate Tectonics ?



The lithosphere moves on top of the asthenosphere.
Old crust is recycled back into the mantle at converging boundaries.
Newly erupted crust is formed at diverging boundaries

Plate Tectonics Controls on Geography/Topography

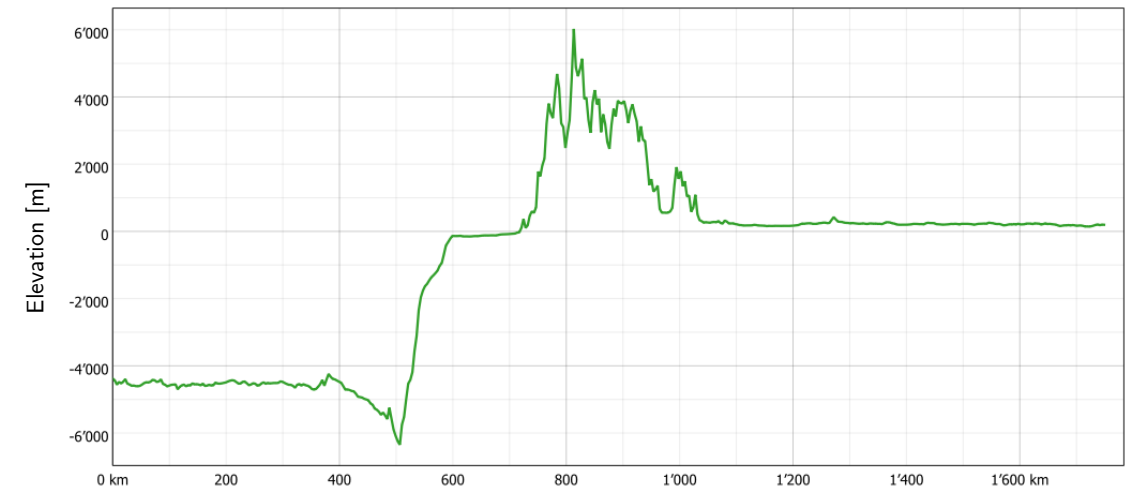
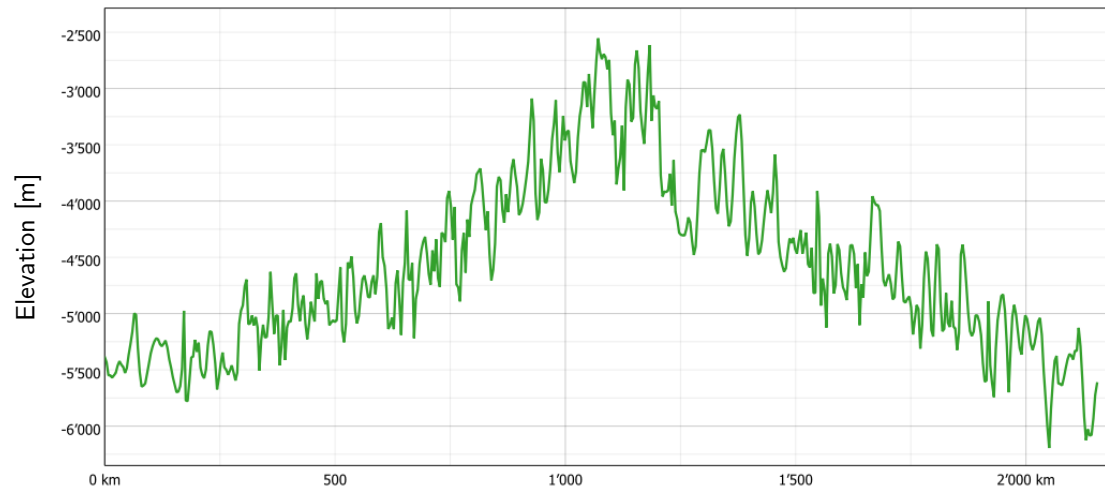
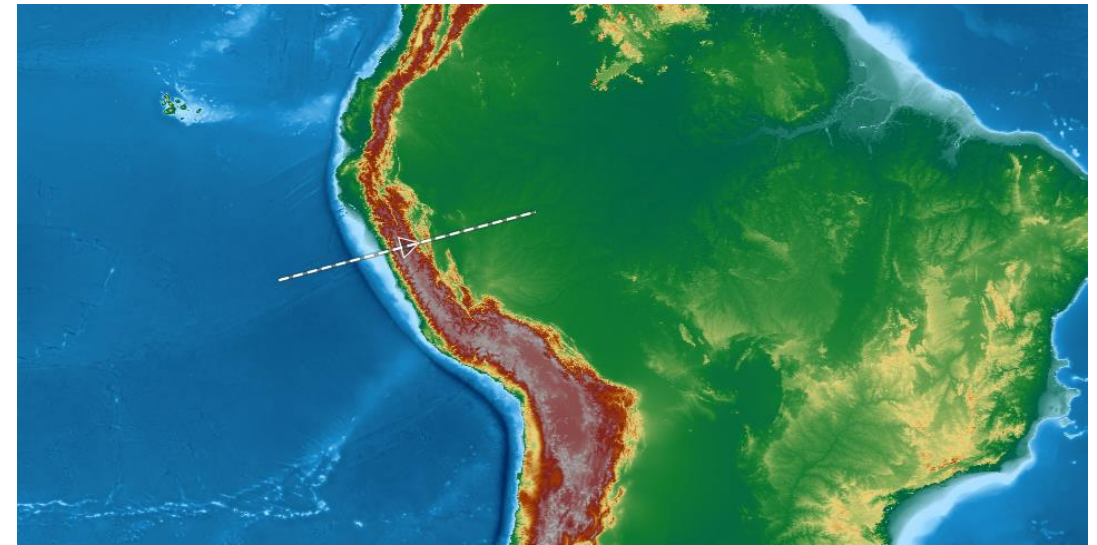
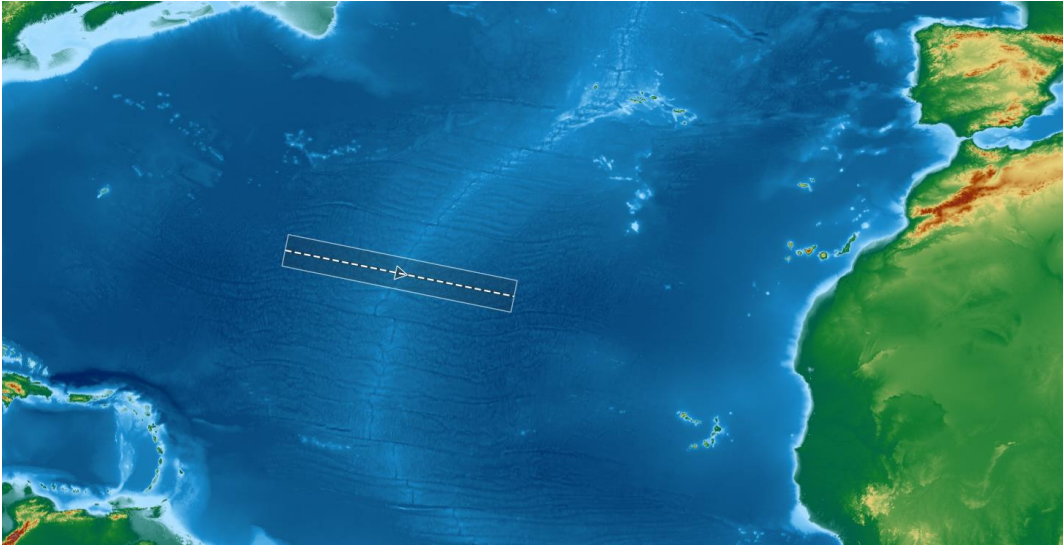
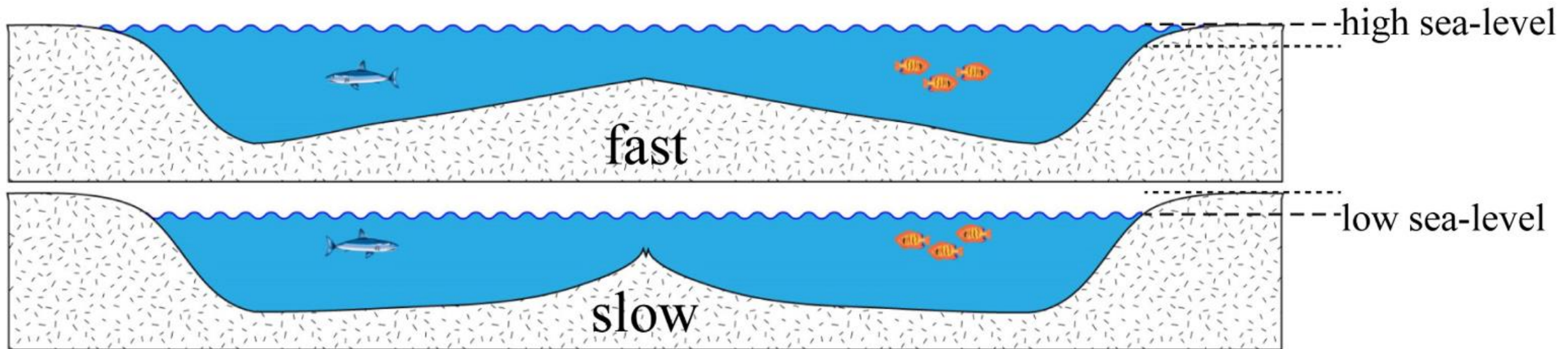


Plate Tectonics Controls on Geography/Topography

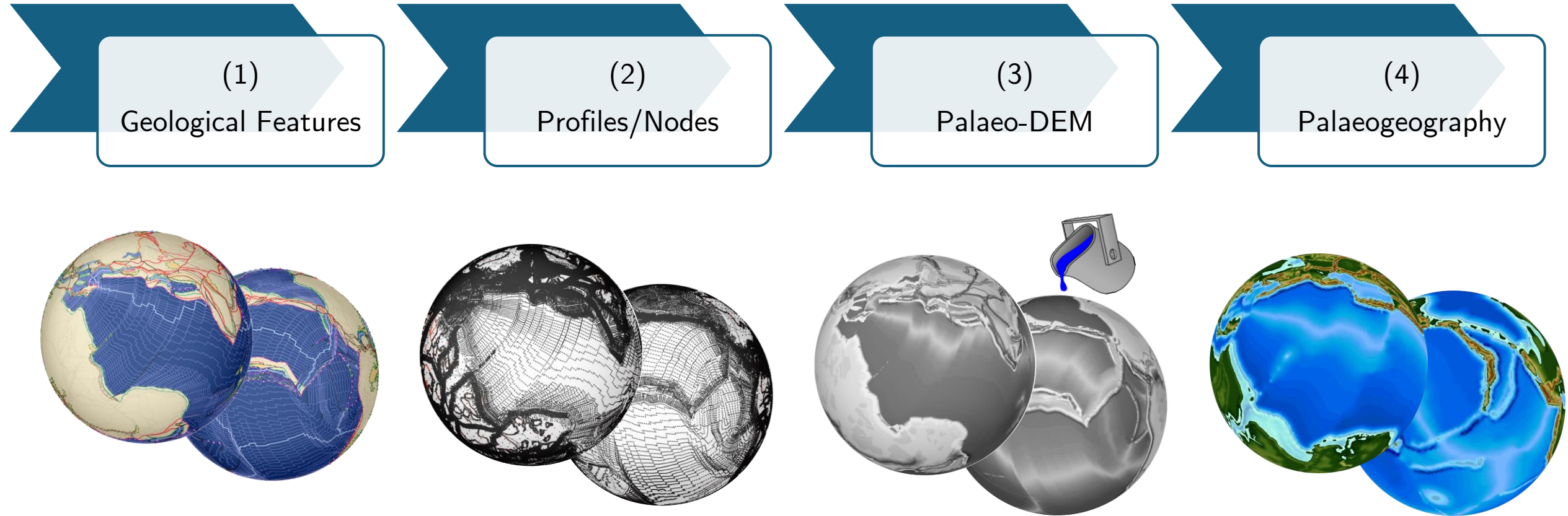


■ Plate Tectonics Controls on Geography/Topography

Can we reconstruct the deep-time Earth topography and geography using plate tectonic models ?

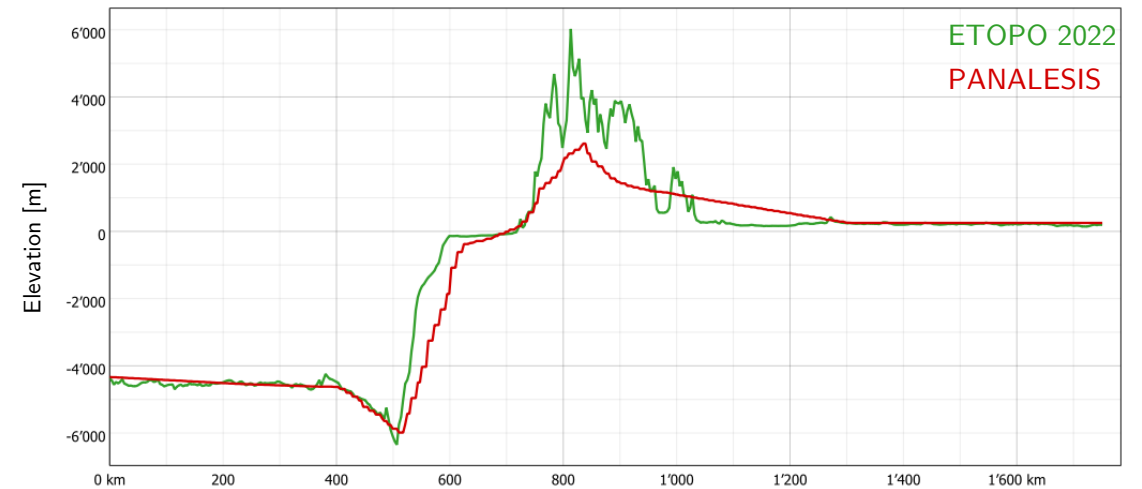
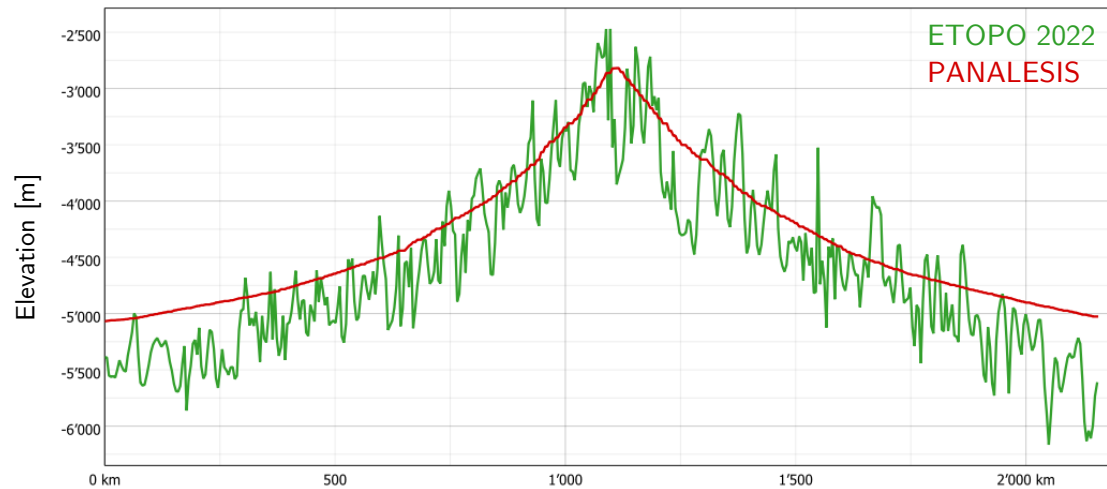
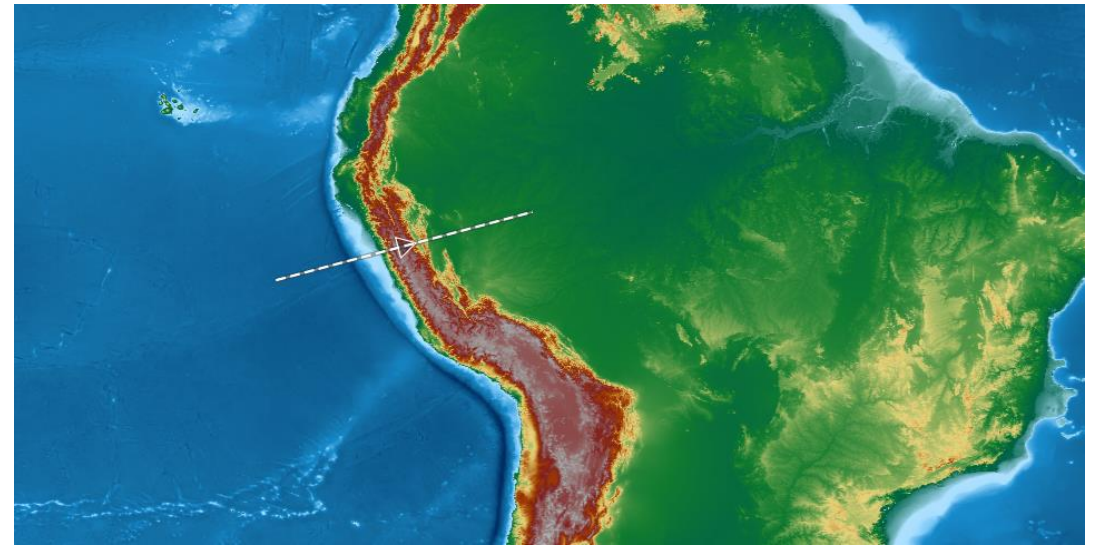
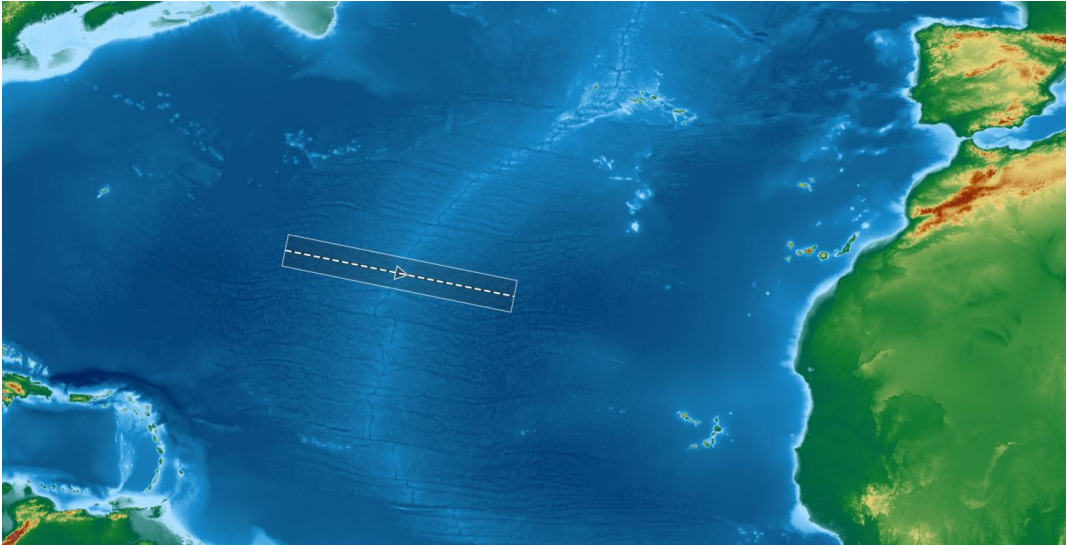
Can we estimate sea-level variations based on past topographic reconstructions ?

Palaeogeography: Approach



PANALESIS: Automated, quantitative & synthetic

Synthetic Topography



TopoChronia QGIS Plugin



TopoChronia: Digital Elevation Models of the Earth Past based on the PANALESES Plate Tectonic Model



https://github.com/florianfranz/topo_chronia



<https://topo-chronia.readthedocs.io/en/latest/>

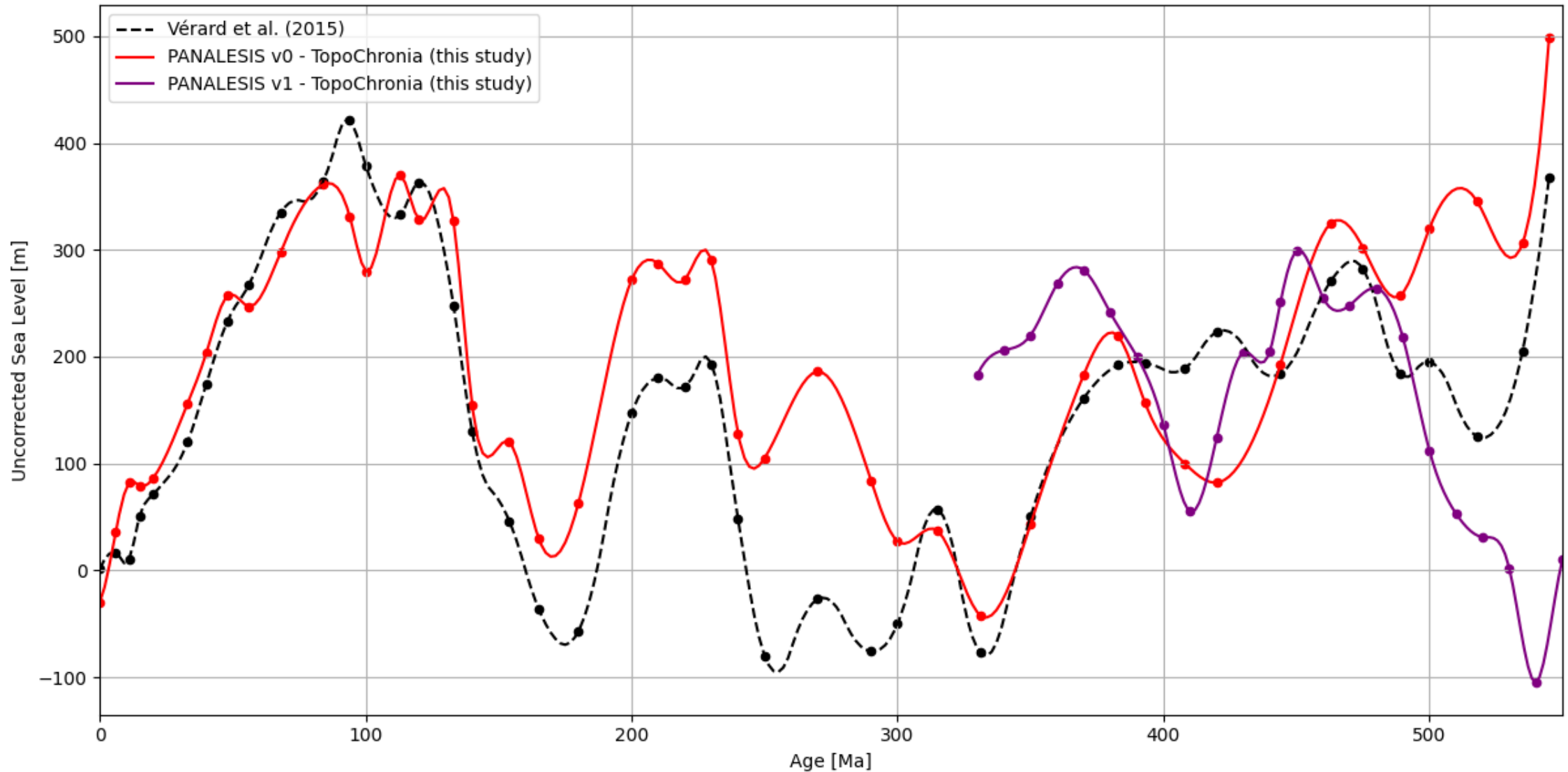


https://github.com/florianfranz/topo_chronia/releases/tag/v1.0.0-beta

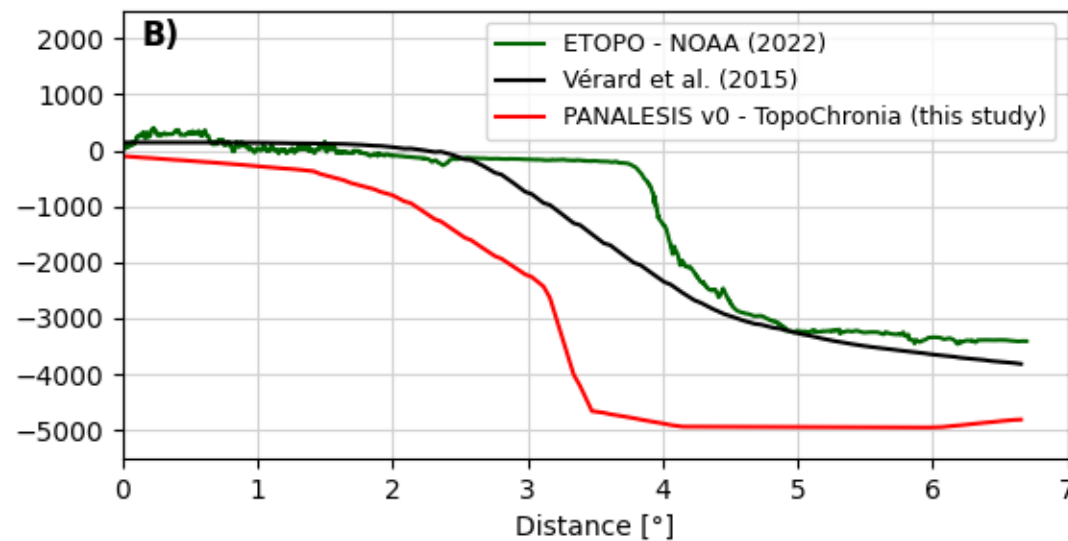
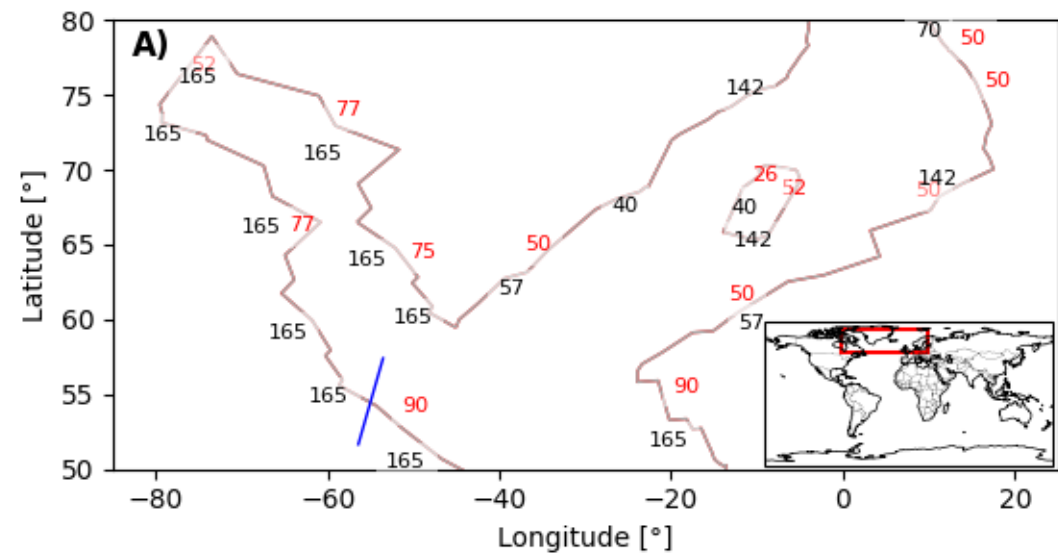
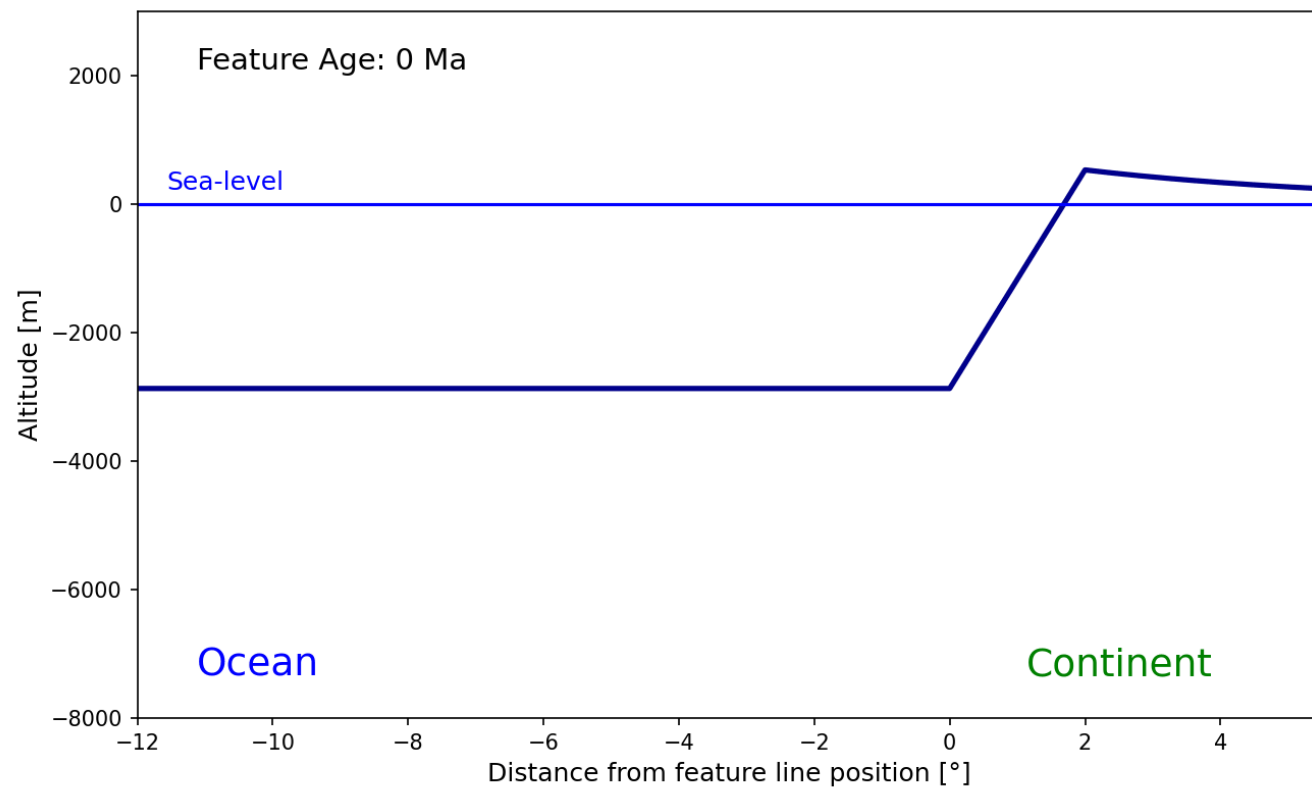


<https://github.com/openjournals/joss-reviews/issues/8108> (in review)

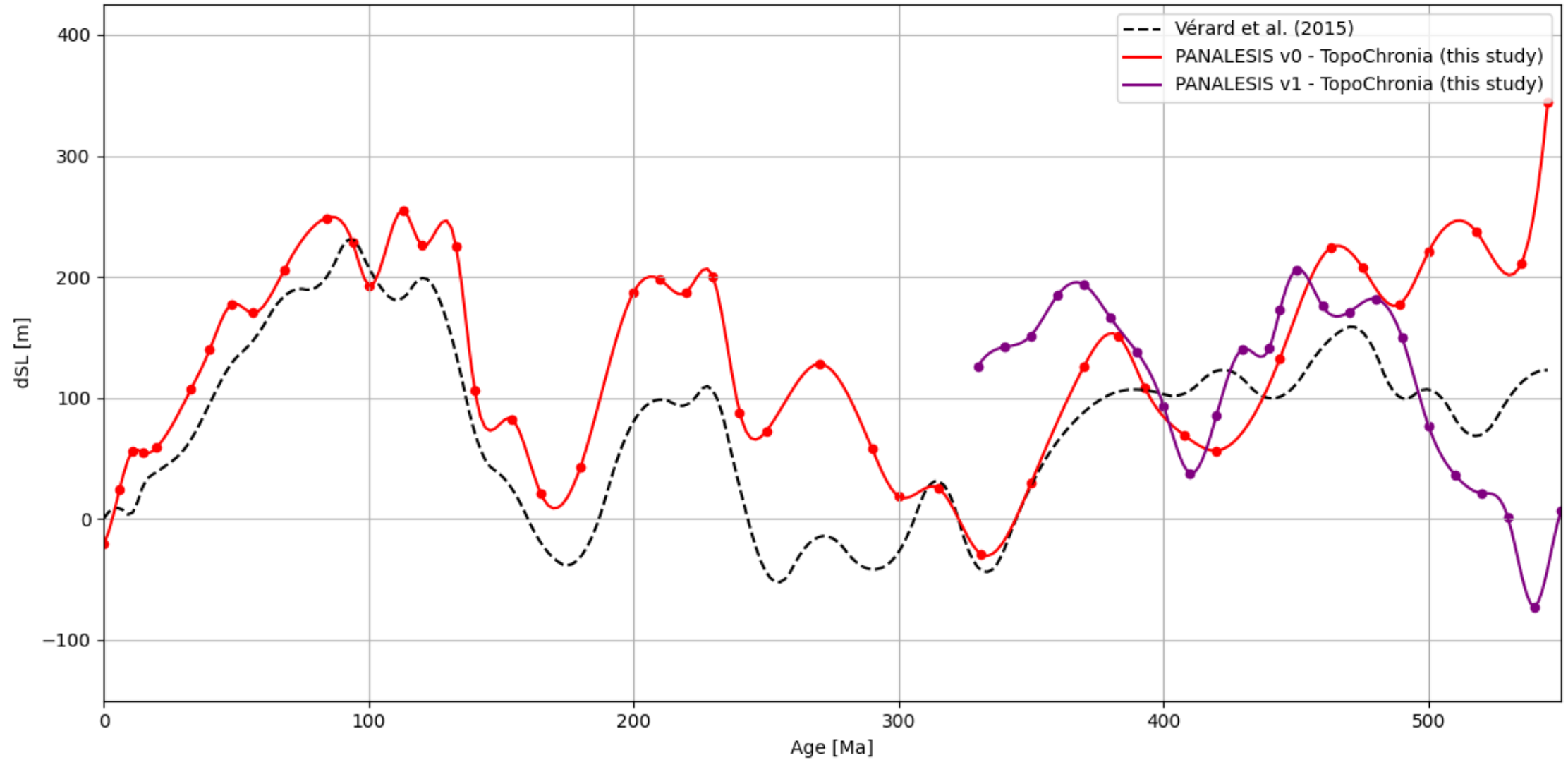
Uncorrected Sea-Level



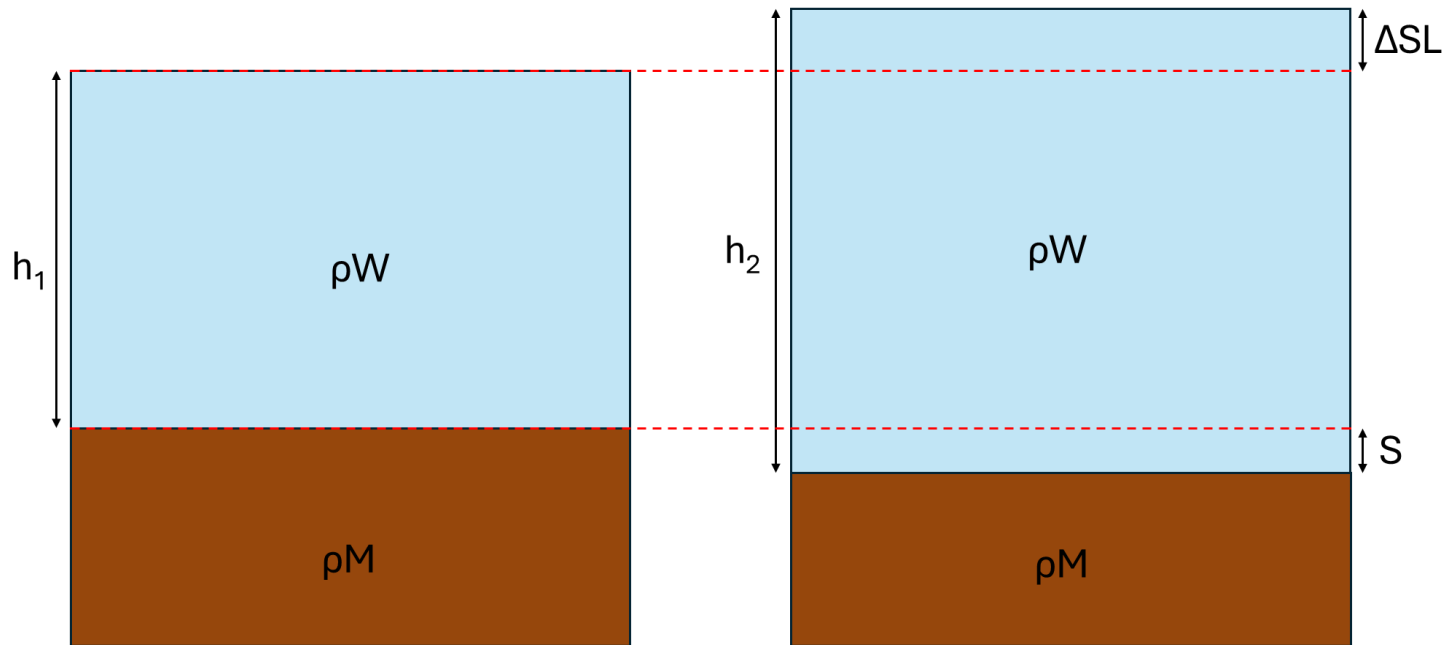
Uncorrected Sea-Level



Corrected Sea-Level



Water Load Correction



Vérard et al. (2015):

$$\Delta SL = 0.55 \times (h_2 - h_1)$$

Now (Airy):

$$\Delta SL = \left(\frac{\rho M - \rho W}{\rho M} \right) \times (h_2 - h_1)$$

$$\Delta SL \cong 0.69 \times (h_2 - h_1)$$

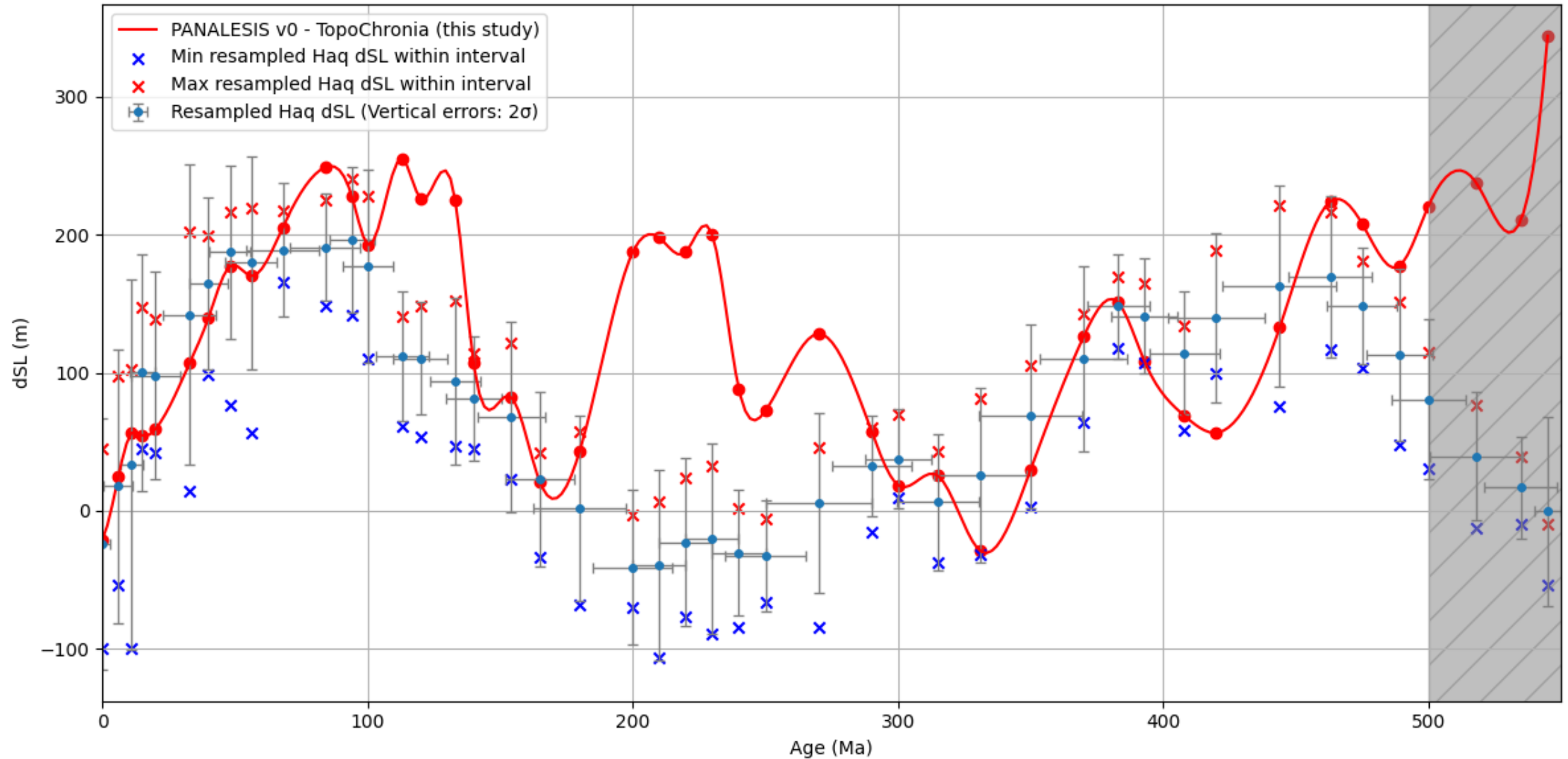
$$\rho M = 3300 \text{ [kg/m}^3\text{]} ;$$

$$\rho W = 1027 \text{ [kg/m}^3\text{]} ;$$

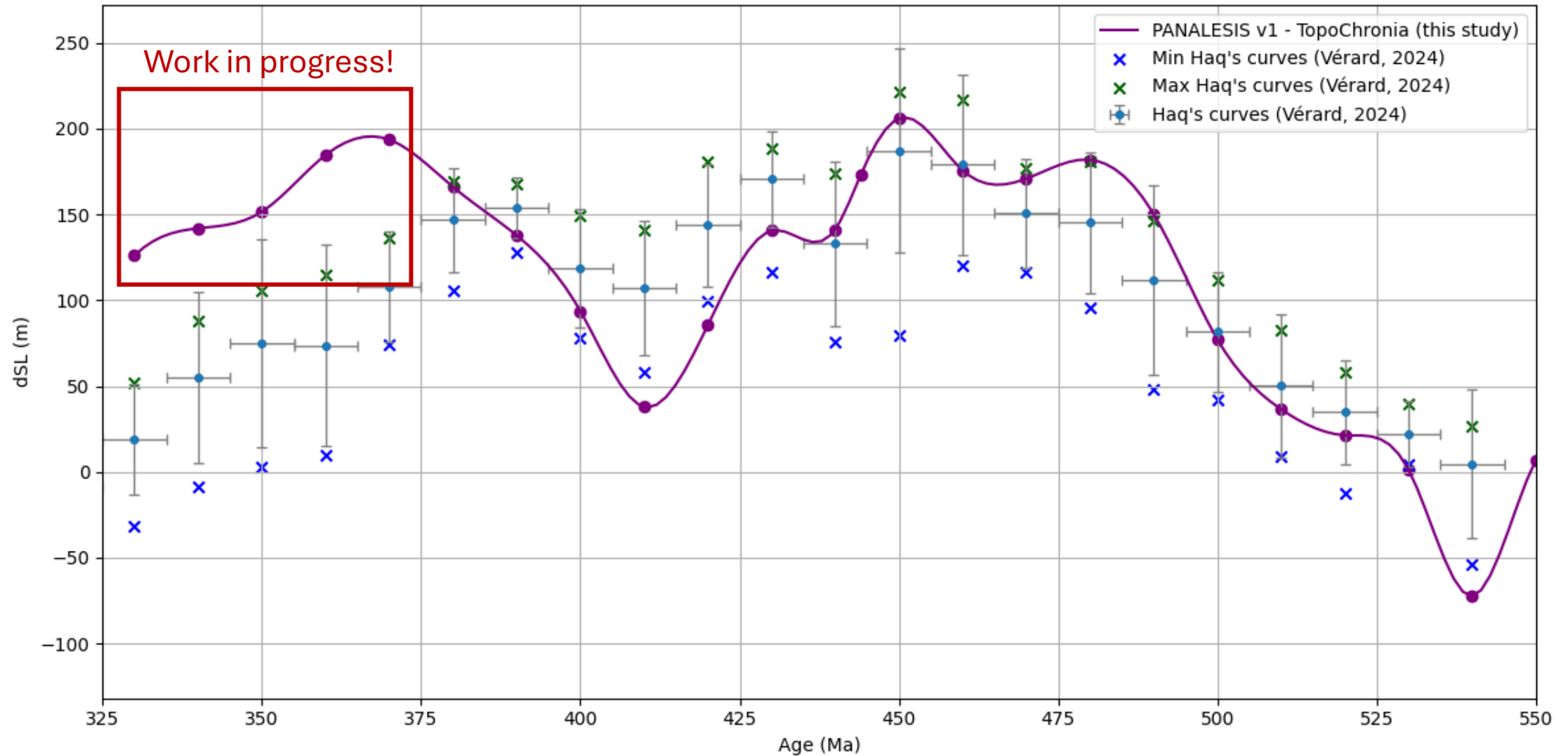
$$h_1 = \text{original water column height [m]} ;$$

$$h_2 = \text{final water column height [m]} ;$$

Comparison: v0 vs Haq's curves



Comparison: v1 vs Haq's curves



Comparison: Summary

	TopoChronia v0 0 - 500	TopoChronia v1 330 - 540	Vérard et al. 2015 UNIL 0 - 500
Mean	60.1594	42.7190	47.1240
Median	37.7314	27.4410	41.1070
Max	243.5463	111.0964	138.3365
Min	1.3245	3.3149	5.3841

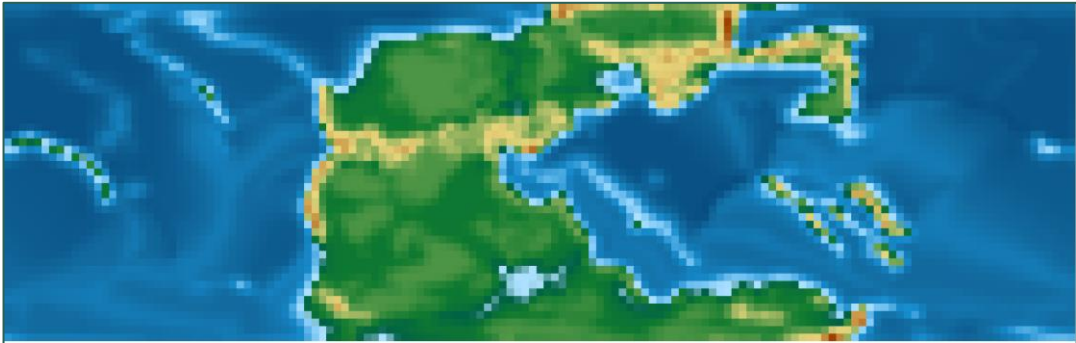
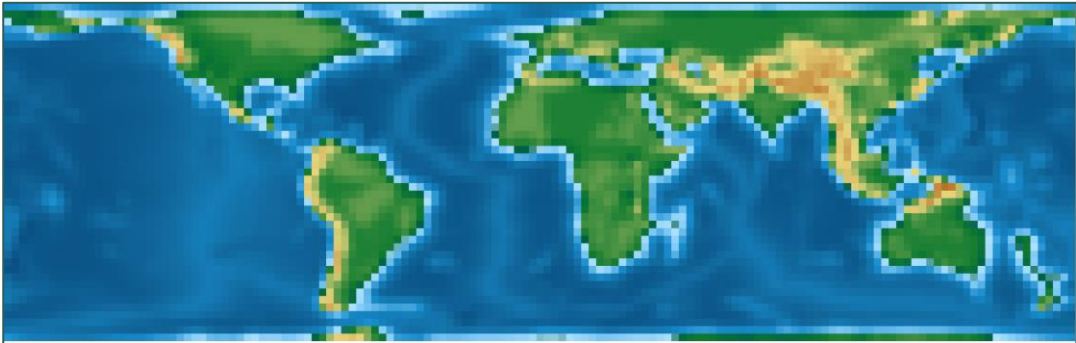


Climate Models: Resolution

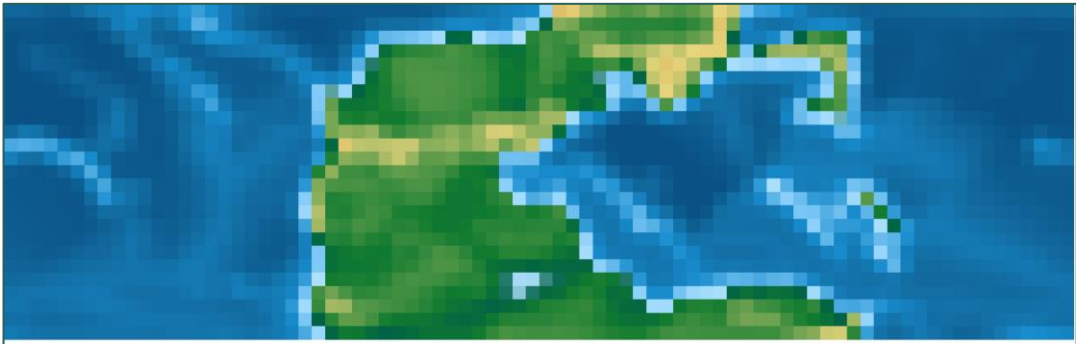
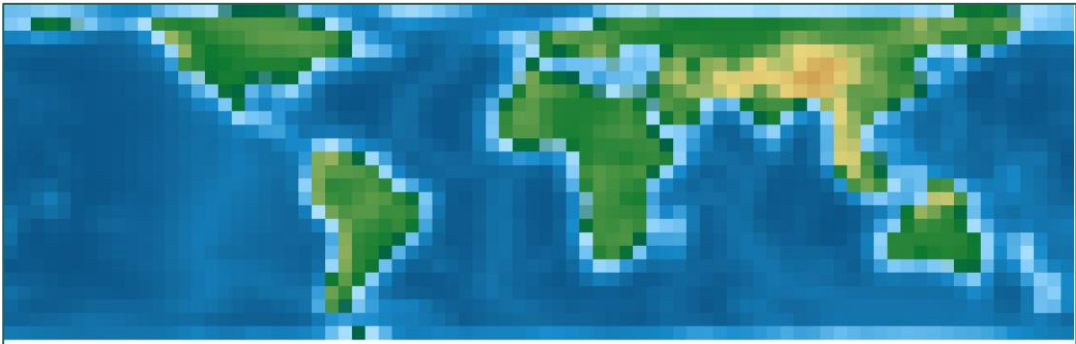
TopoChronia
(10 x 10km)



MITgcm
(280 x 280km)



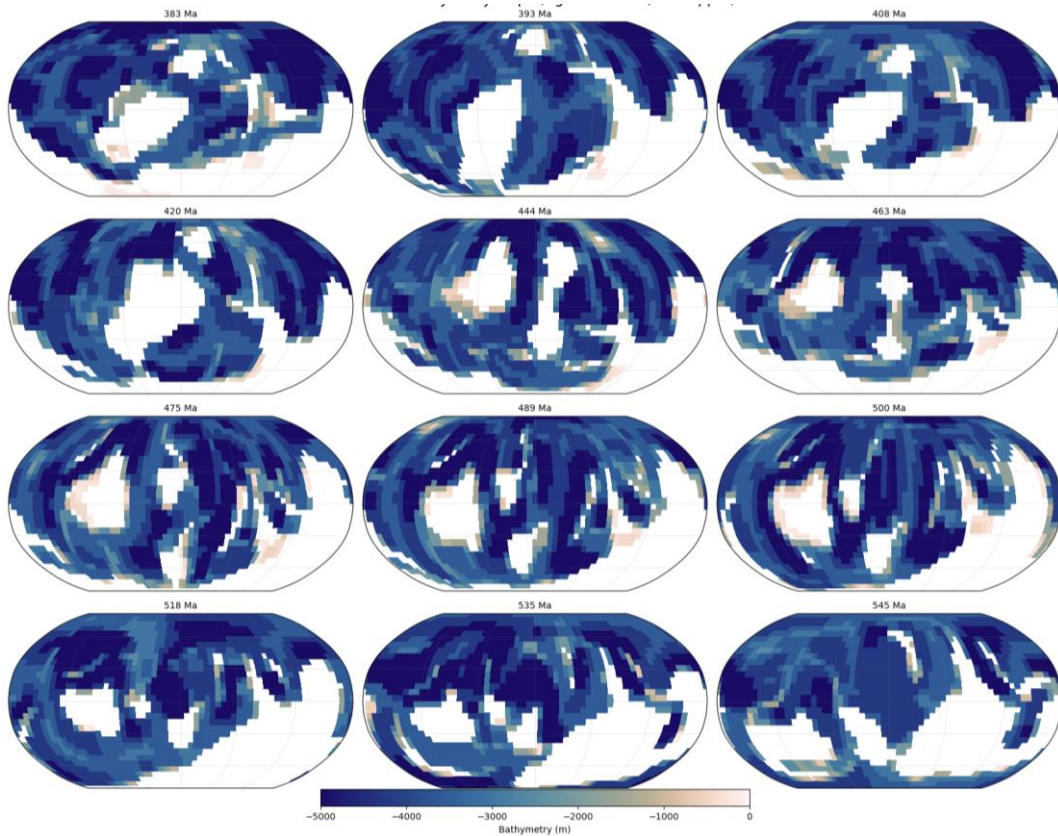
PLASIM-GENIE
(500 x 500km)



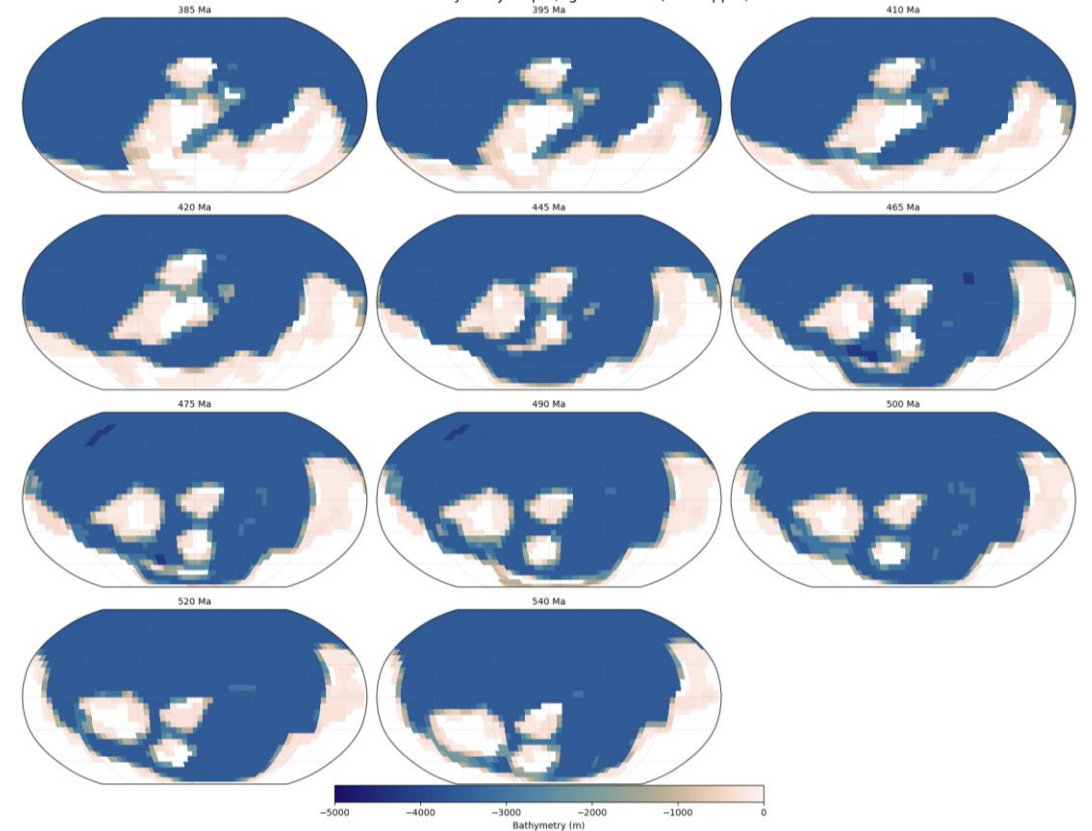
000 Ma (present-day)

250 Ma (Triassic)

Climate Models: Influence of Palaeogeography

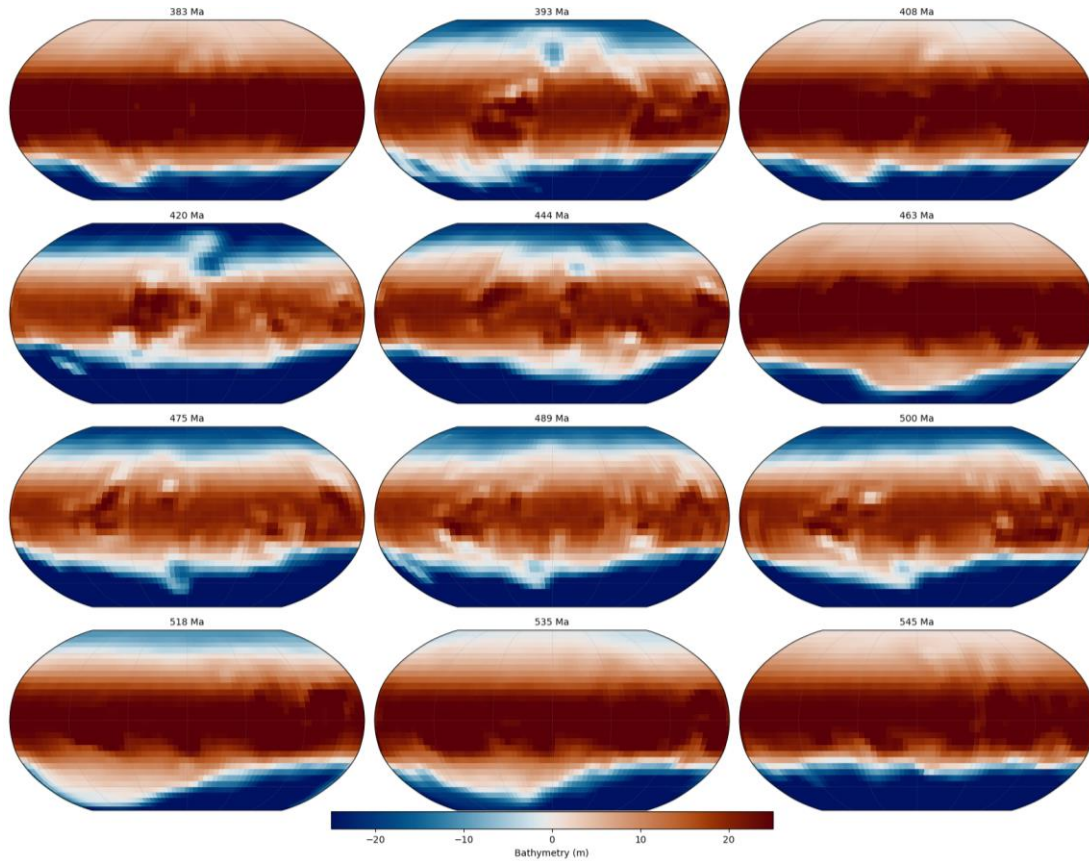


PANALESIS

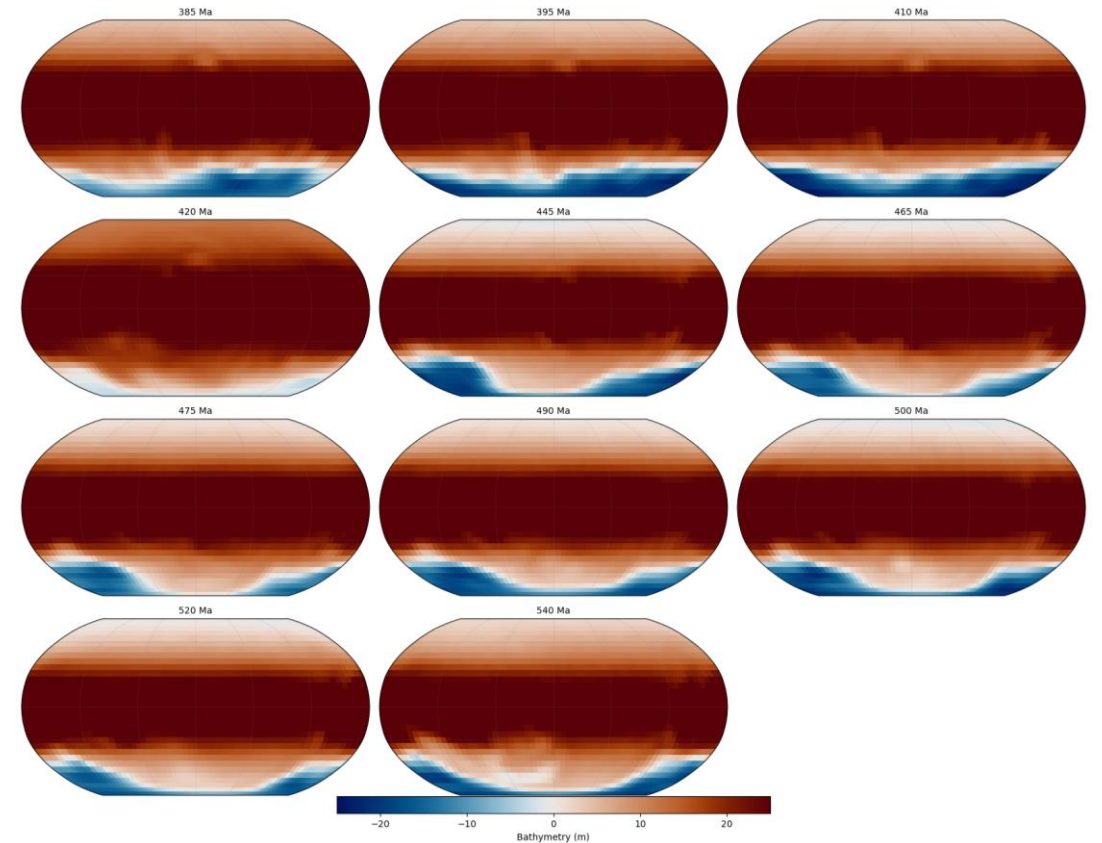


PALEOMAP

Climate Models: Influence of Palaeogeography



PANALESIS



PALEOMAP



Conclusions

Example of reproducibility crisis: software, input and outputs changed with time.

New results differ from previously published ones, still performs quite well.

Ongoing efforts to open software and data with community standards.

Palaeogeography is key for long-term climate simulations of the Earth's past.

Long-term feedback mechanisms between climate and geography yet to explore.

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Image sources

Slide 2: Theatrum Orbis Terrarum by Abraham Ortelius (1572), via Wikimedia Commons.

https://commons.wikimedia.org/wiki/File:Theatrum_Orbis_Terrarum,_by_Abraham_Ortelius,_World,_1572.jpg

Slide 3: Snider-Pellegrini Wegener fossil map, based on USGS materials, via Wikimedia Commons.

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