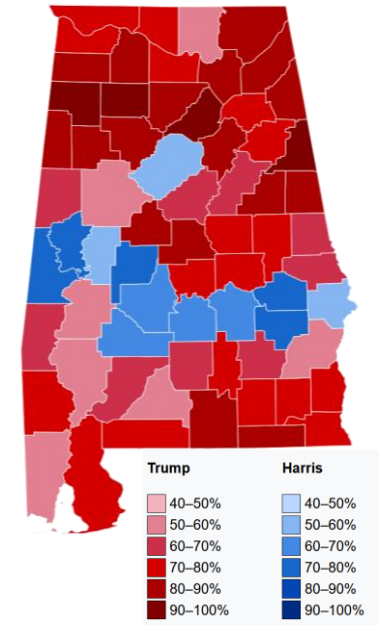


Unearthing Proprietary Software into Open-Source: Lessons learned from TopoChronia, a QGIS Plugin for Reconstructing Digital Elevation Models of the Last 500 Million Years

Florian Franziskakis¹, Christian V  rard,
S  bastien Castelltort, Gr  gory Giuliani

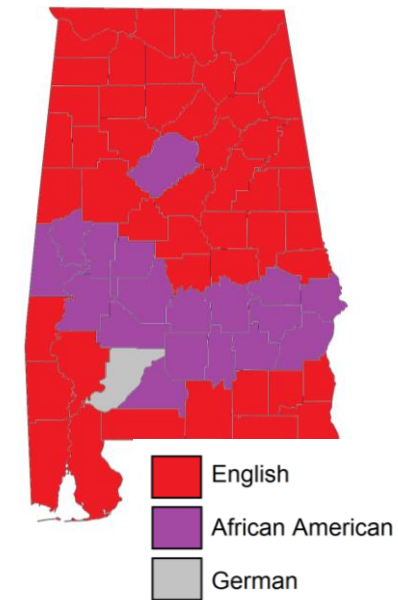
¹enviroSPACE Lab, Institute for Environmental Sciences, University of Geneva, florian.franziskakis@unige.ch

Palaeogeography ?

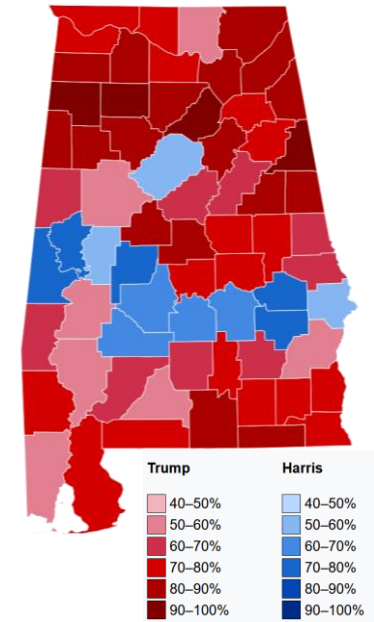


USA Presidential
Election Results
Alabama
2024

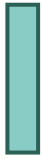
Palaeogeography ?



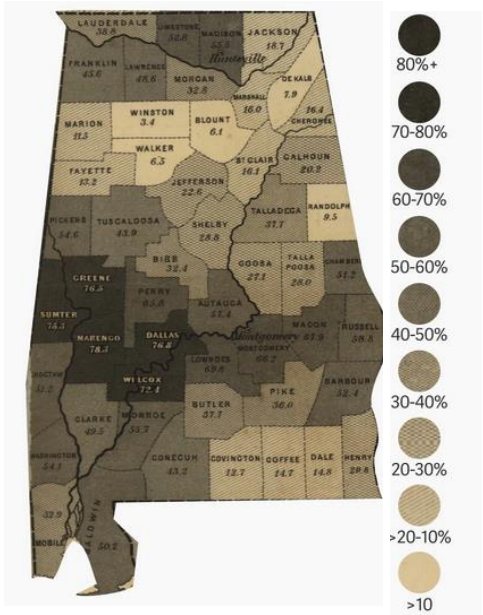
Largest Ancestry
Group
2016



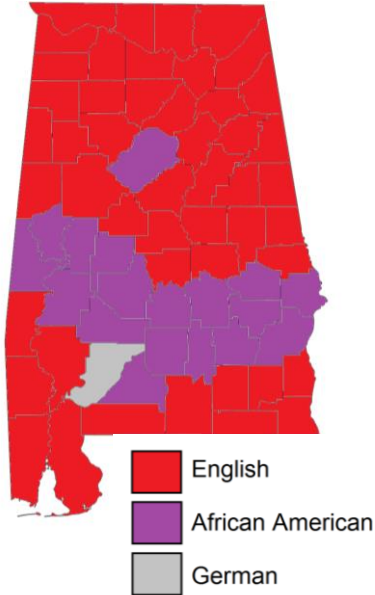
USA Presidential
Election Results
Alabama
2024



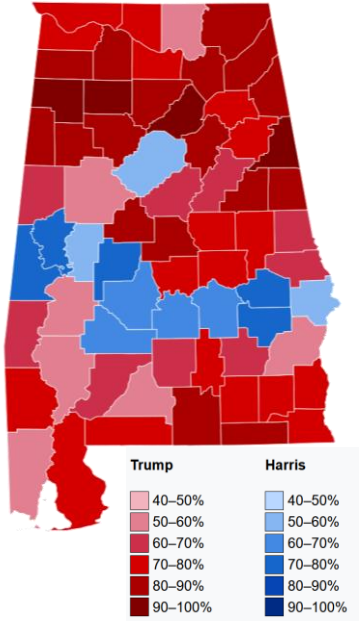
Palaeogeography ?



Slave Population (%)
1860

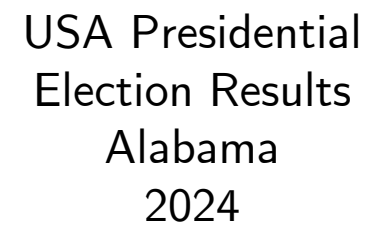
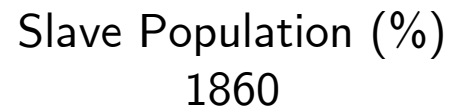


Largest Ancestry
Group
2016

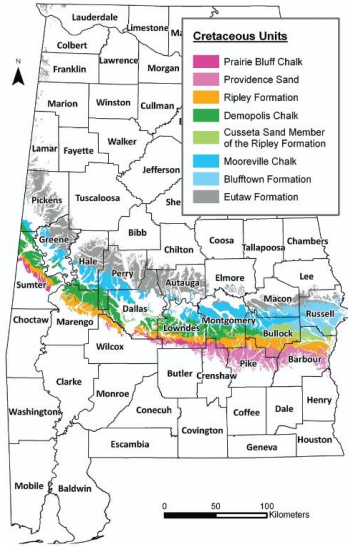


USA Presidential
Election Results
Alabama
2024

180



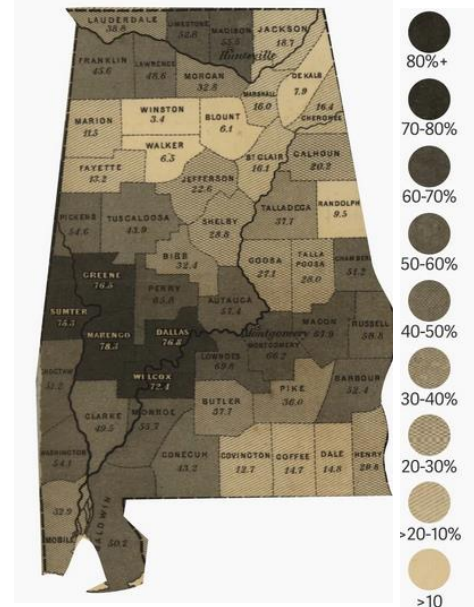
Palaeogeography ?



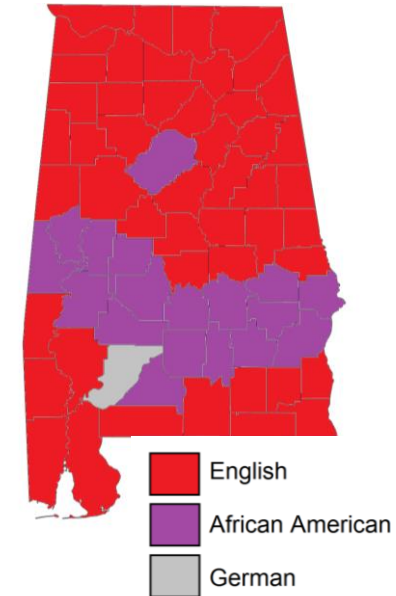
Cretaceous sediments
120 Ma



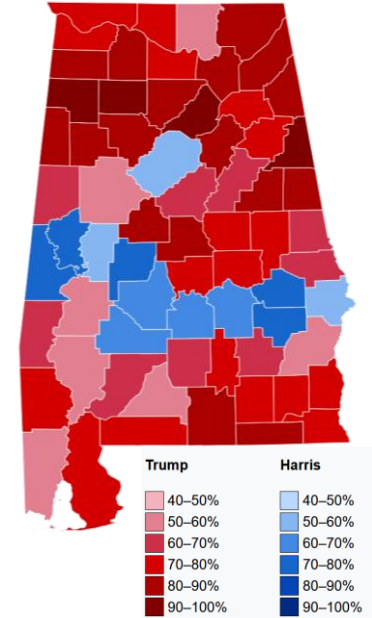
Fertile Blackland
Prairie Soil



Slave Population (%)
1860





Largest Ancestry
Group
2016



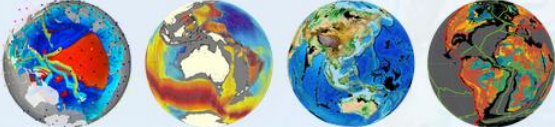
USA Presidential
Election Results
Alabama
2024

Plate Tectonics & GIS: GPlates

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GPlates

GPlates is a plate tectonics program. Manipulate reconstructions of geological and paleogeographic features through geological time. Interactively visualize vector, raster and volume data. PyGPlates is the GPlates Python library. Get fine-grained access to GPlates functionality in your Python scripts.



[!\[\]\(c03112ee263a906bbf549fae85097b06_img.jpg\) Latest GPlates release v2.5](#)
[!\[\]\(6a9335257ee4bae53722233b4f4983f7_img.jpg\) Latest pyGPlates release v1.0.0](#)
[!\[\]\(4cf4858f0f33d9147b4f89d7334365ec_img.jpg\) Latest GPlately release v1.3.0](#)

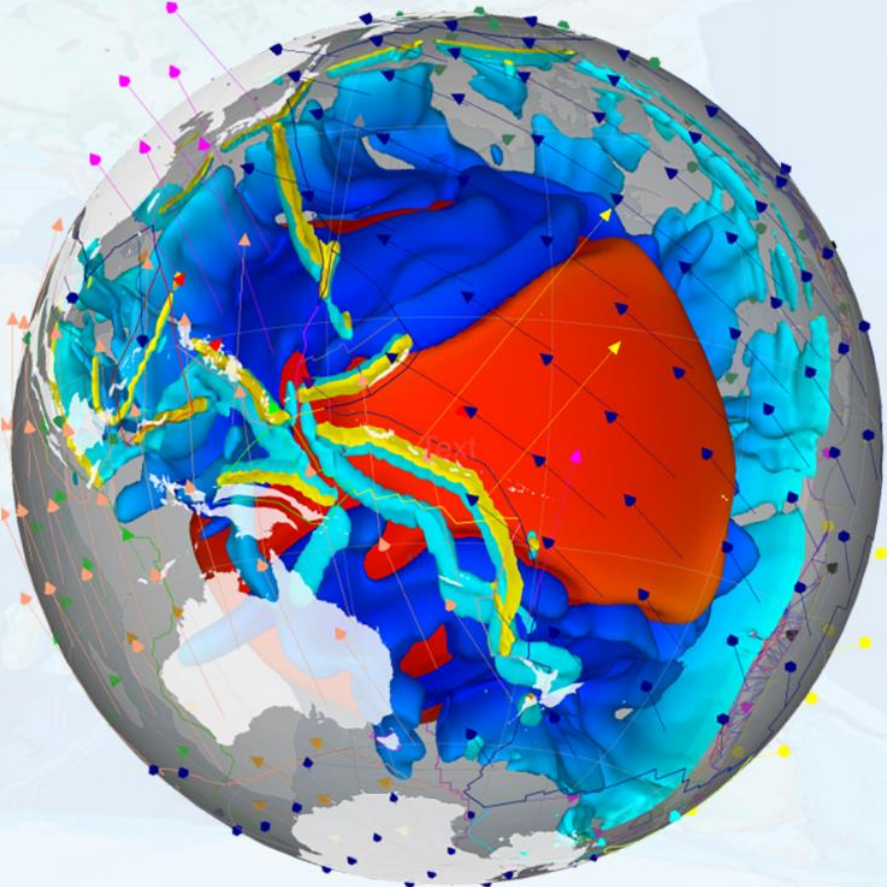


Plate Tectonics & GIS: PALEOMAP

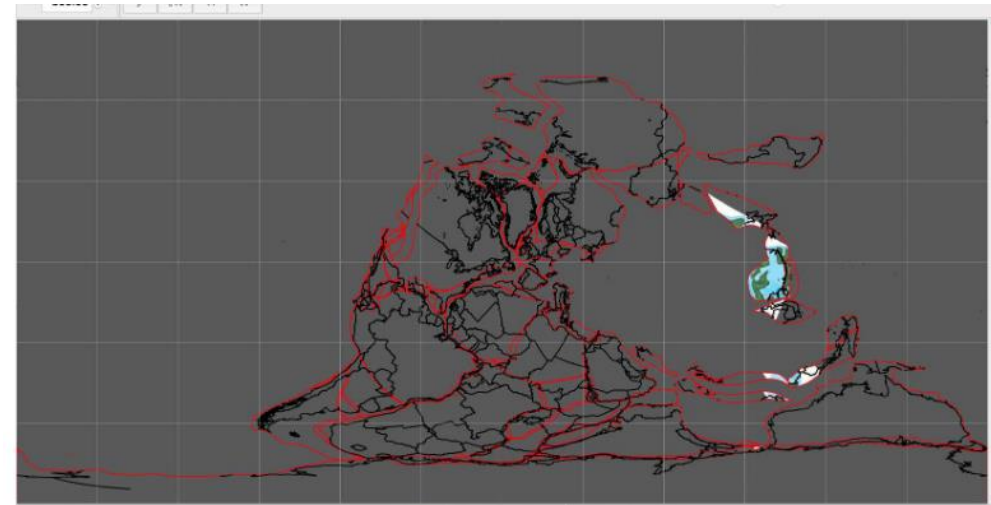
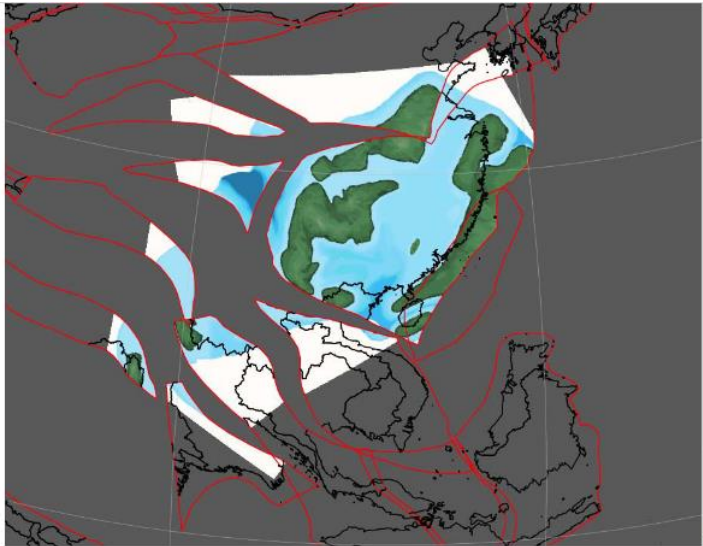
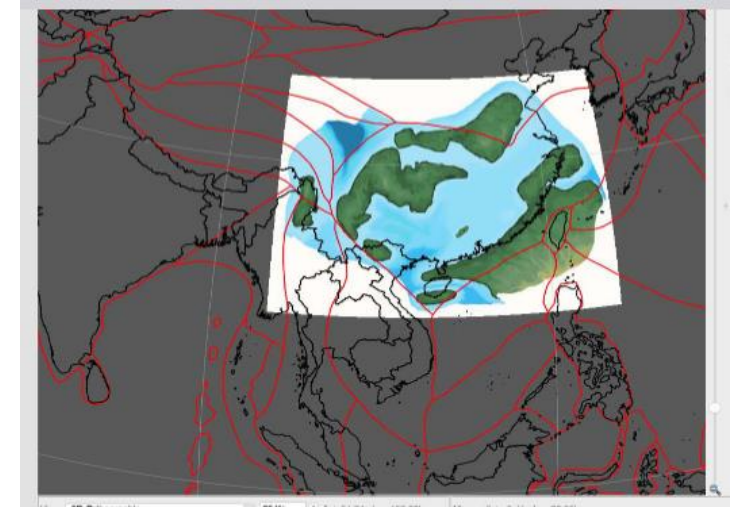
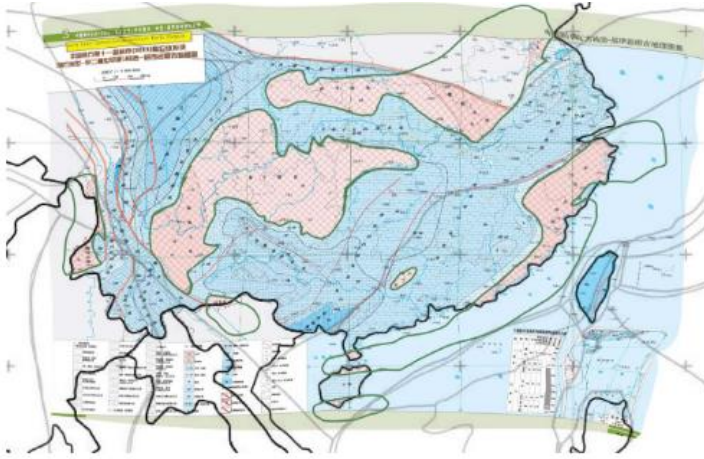


Plate Tectonics & GIS: Terra Antiqua

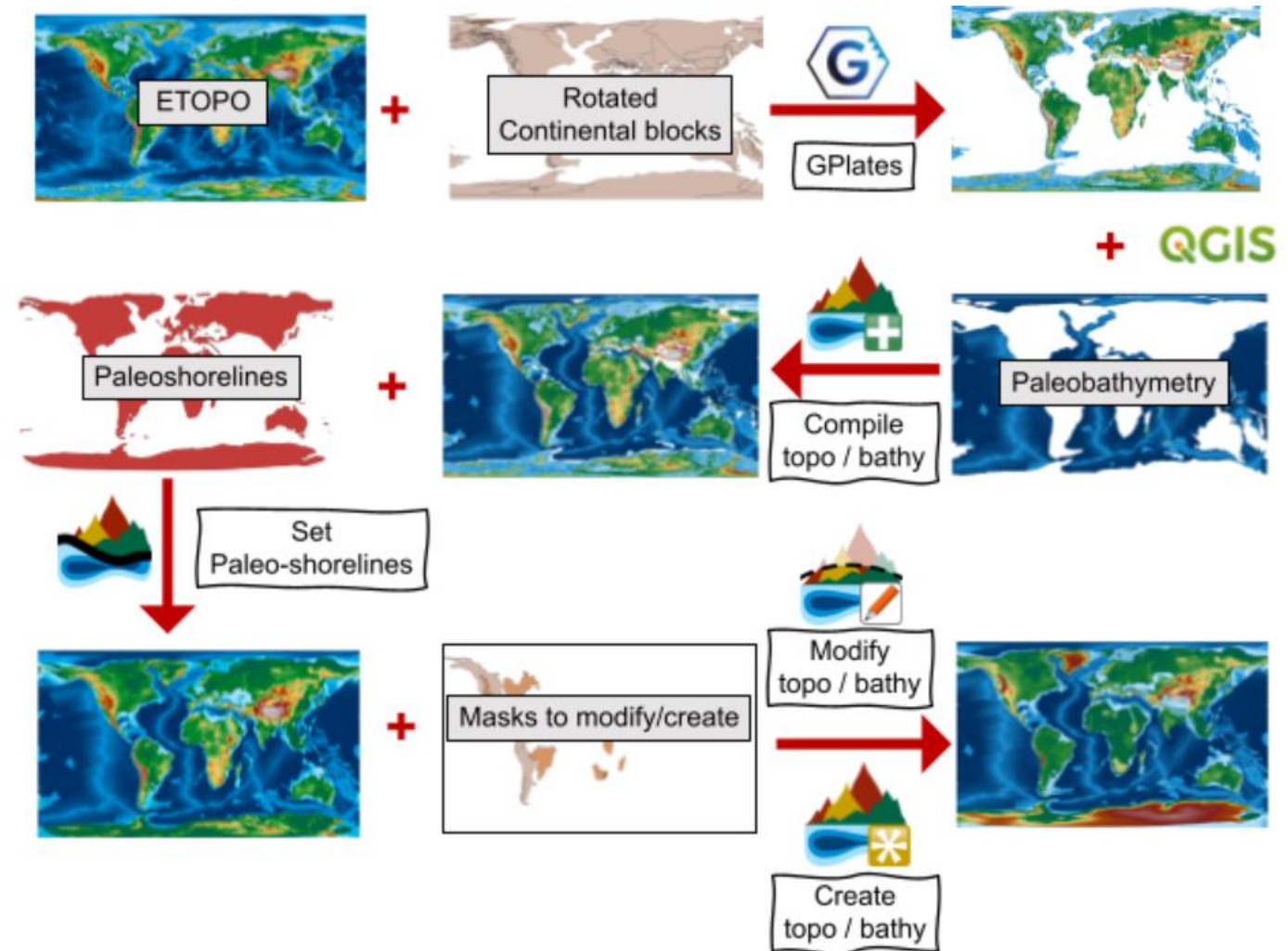
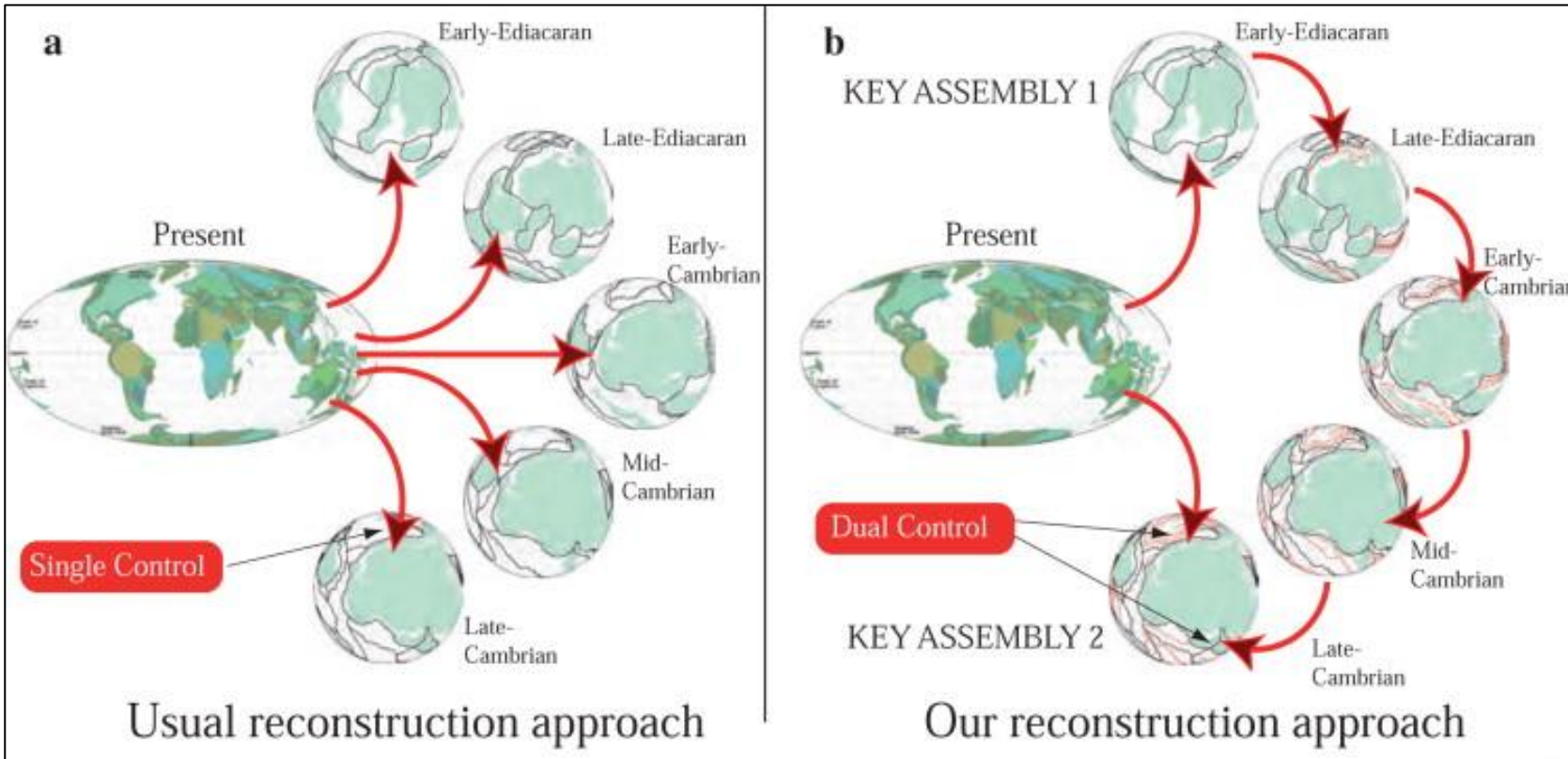


Plate Tectonics & GIS: PANALESIS



Covering 100% of the
Earth surface

600 – 000 Ma (v0)

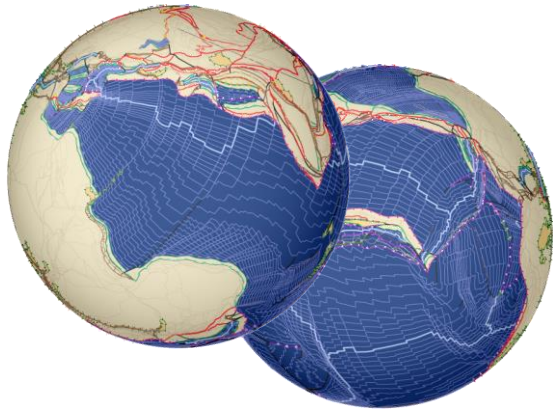
888 – 330 Ma (v1)

Dual control approach

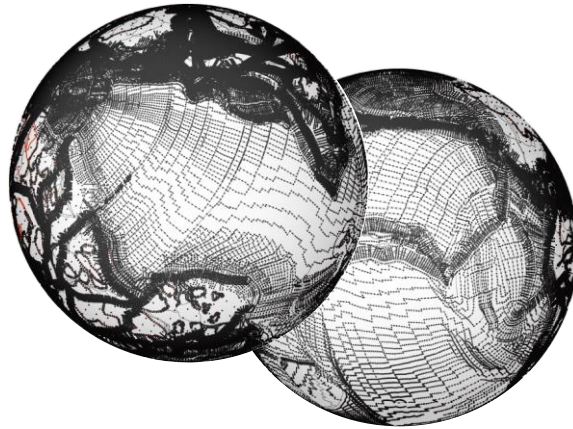
Drawn by hand (100k+
features!)

Plate Tectonics & GIS: PANALESIS

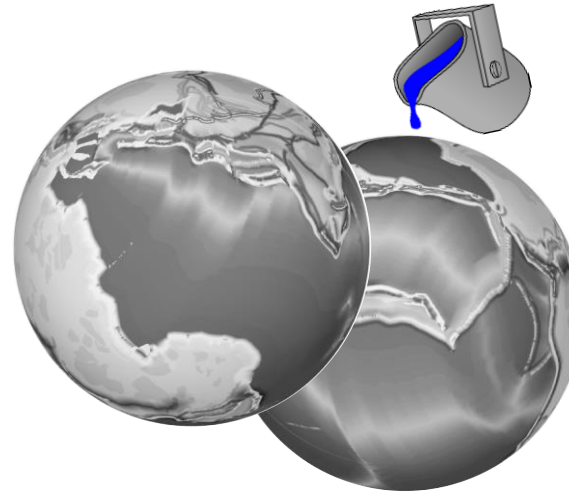
(1)
Geological Features



(2)
Profiles/Nodes



(3)
Palaeo-DEM



(4)
Palaeogeography



Automated, quantitative & synthetic palaeogeography

Reproducibility Crisis ?

32'000+ lines of code to translate

→ Cannot run old code

ArcGIS 9.x / 10.x

→ No LTS for these versions

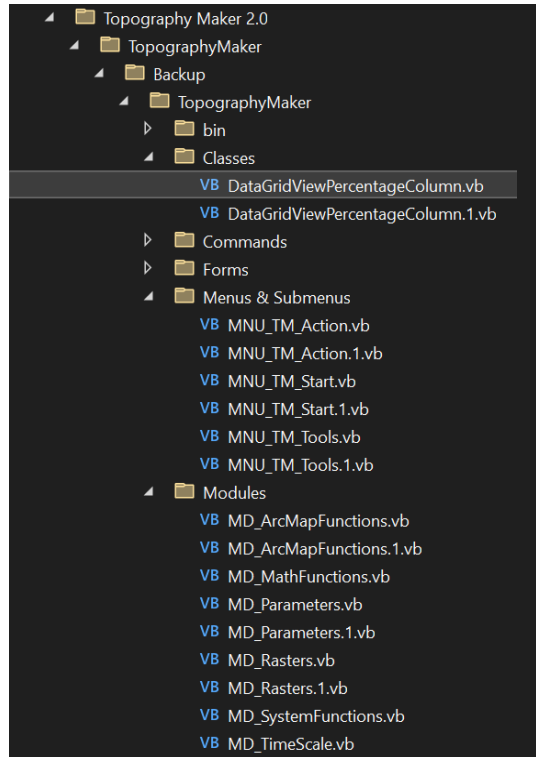
VB.NET language

→ Not familiar with language – does this even work for geospatial ??

Multiple untracked versions for input and output data, software & docs

→ Cannot compare results

Reproducibility Crisis ?



4DGeoSystems
Unravelling the Earth's Evolution

THE TOPOGRAPHY MAKER SOFTWARE
"USER MANUAL"

By: 4DGeoSystems (4DGS), Lausanne. Date: June 1st, 2013.

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Correct Water Load	23
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Contact	24

the starting position of the profile (being -0.3° from the feature) for a collision age of 000 Ma, and (m/2-Max) is +0.3° for an old collision.

The graphs below (Fig.6) show the evolution of the collision zone profile according to the age of the polyline feature on the plate tectonic model.

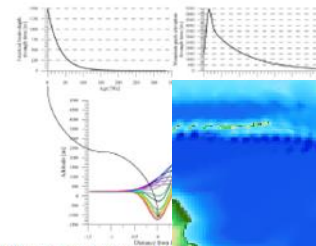


Figure 6 - Temporal evolution of synthetic profiles (show the evolution of the elevation according to the contact). Top-left inset for the foreland basin.

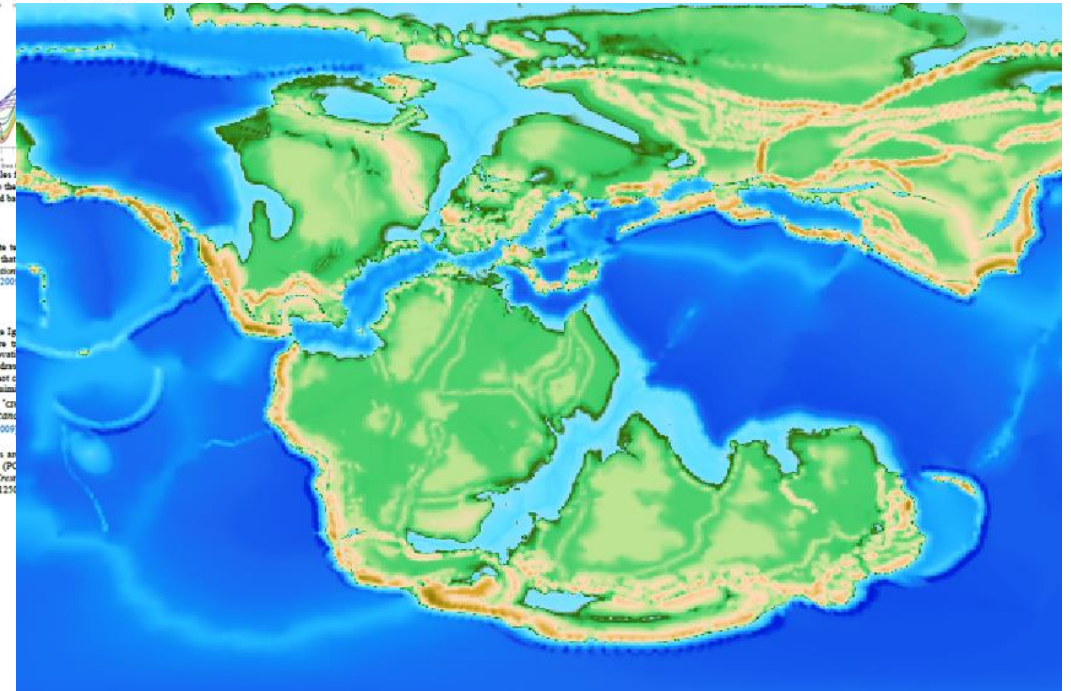
► Crustal area:

The crustal area defined as polyline on the plate tectonic model is drawn on the "General" section and changed to the "Average elevation" (Elevation statistical analysis of ETOPOL (Amante & Eakins, 2009)).

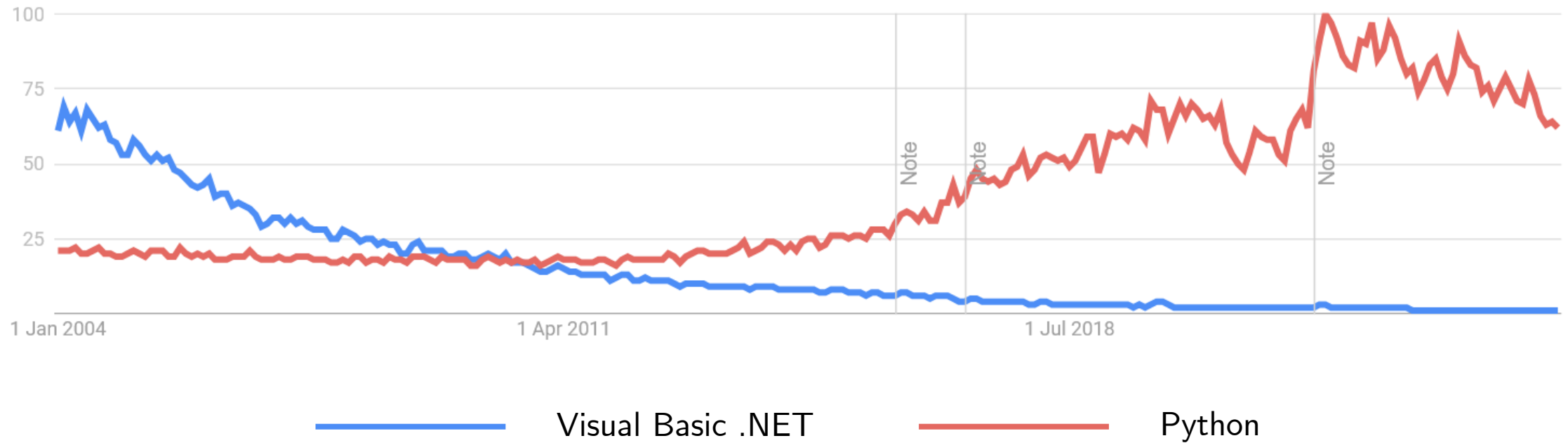
► Hot-Spot:

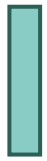
The active hot-spot, inactive seamount and Large Igneous Province (LIP) are drawn on the plate tectonic model as "point" in the "General" section. A buffer is drawn around the point (Note that the buffer is not circular). One point (at label position) is defined to minimize the elevation of the "volcano code" (Folcane values) on ETOPOL (Amante & Eakins, 2009) "crest" is set at -0.4°.

• In continental areas, magmatic provinces are "volcanoes" are experimentally decreasing (PC "crest", elevation are varying between (Crest "volcanoes", between (Folcane_20Max) = 1250

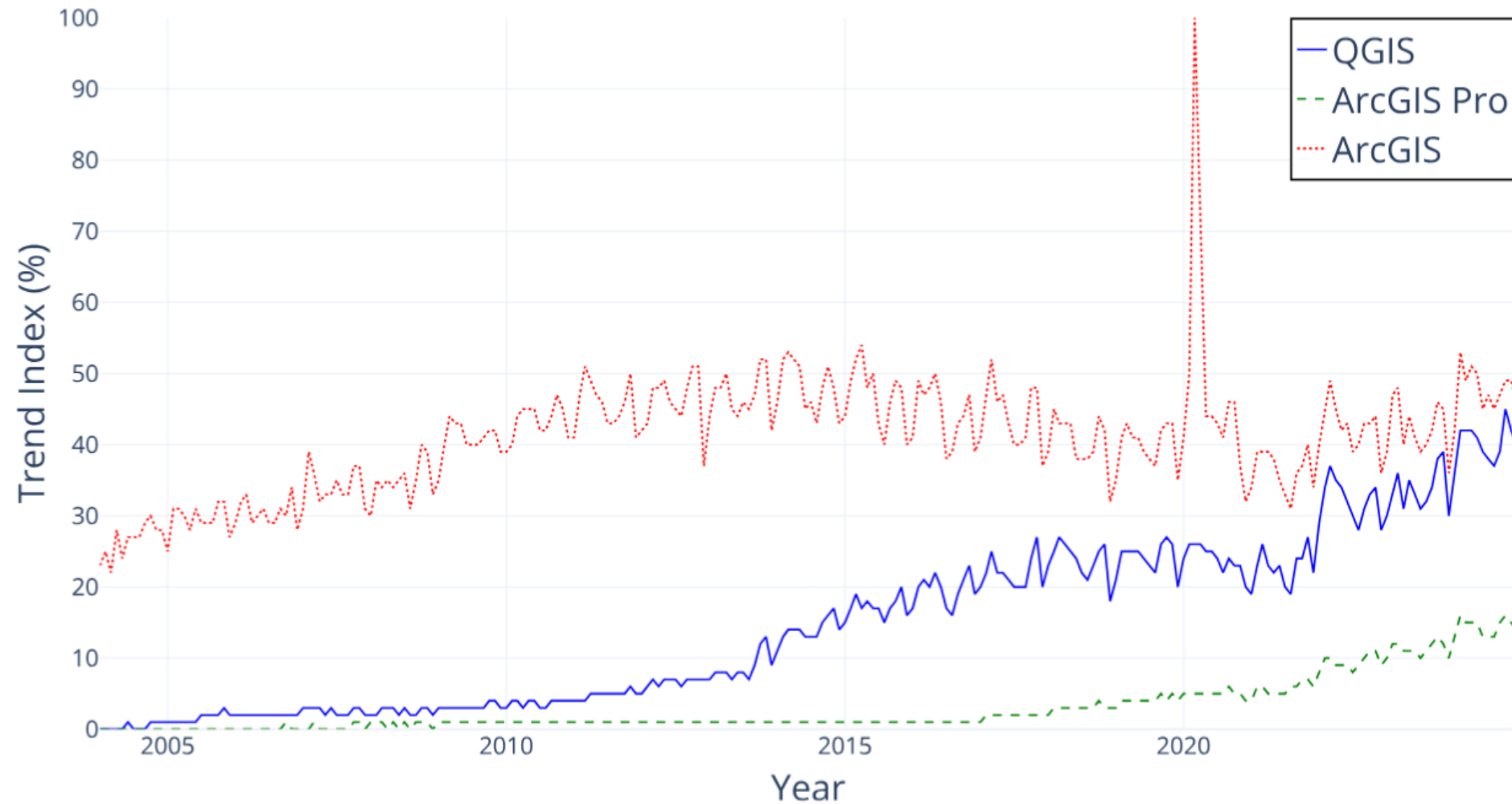


Programming Language ?

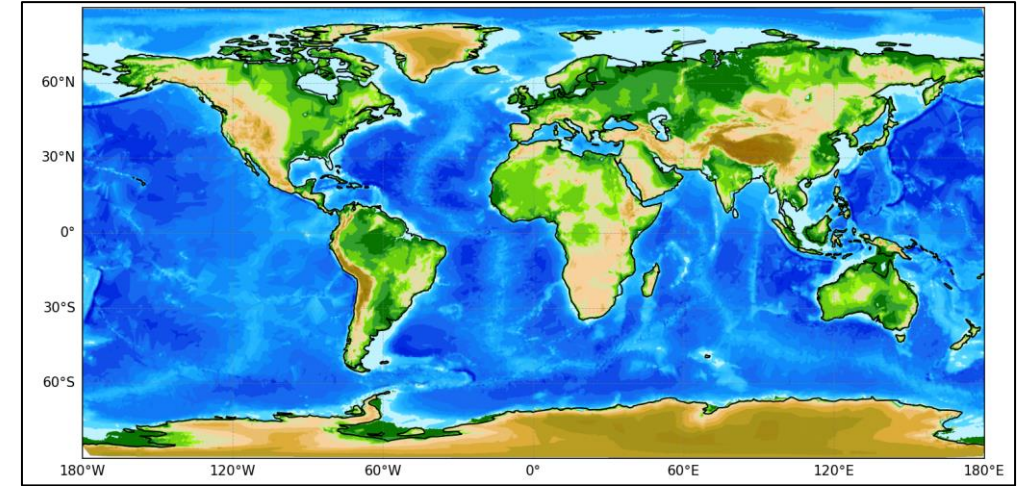
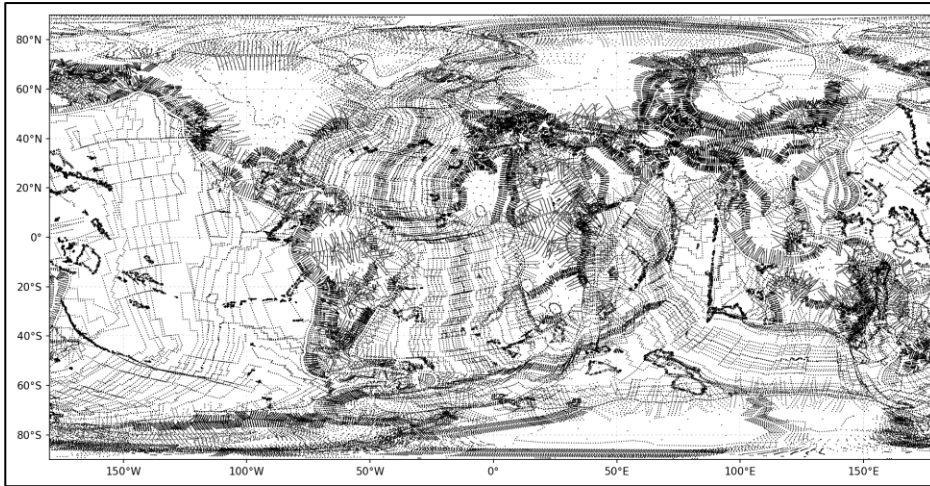




GIS Software ?

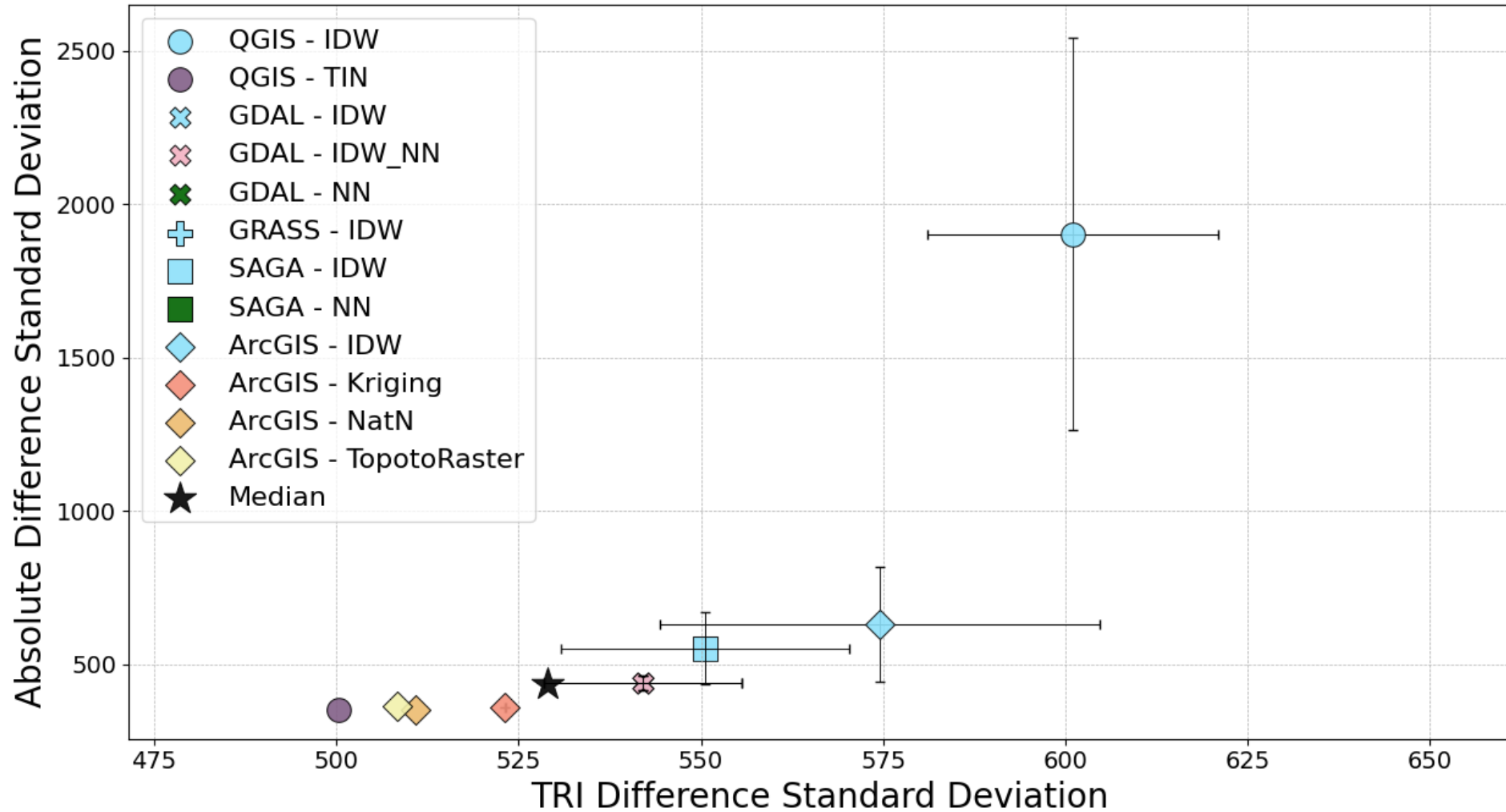


Reproducibility Challenge: Interpolation Method



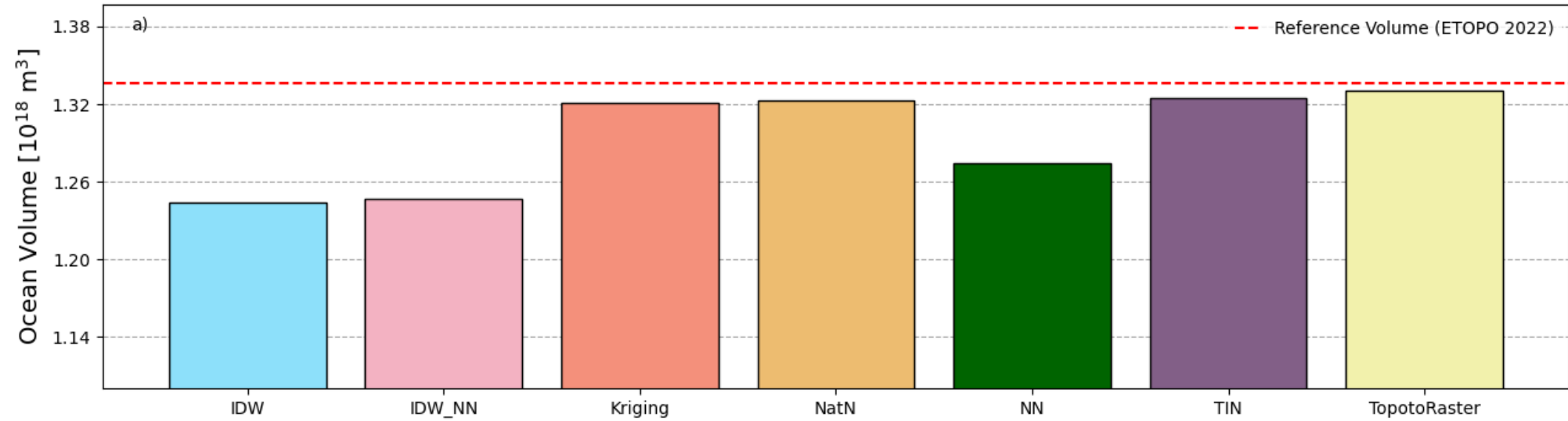
- (1) What is the best method to interpolate a raster at the global scale depicting topography (oceans + continents) based on irregular nodes ?
- (2) Are open-source solutions performing better than the ArcGIS Natural Neighbour method?

Reproducibility Challenge: Interpolation Method

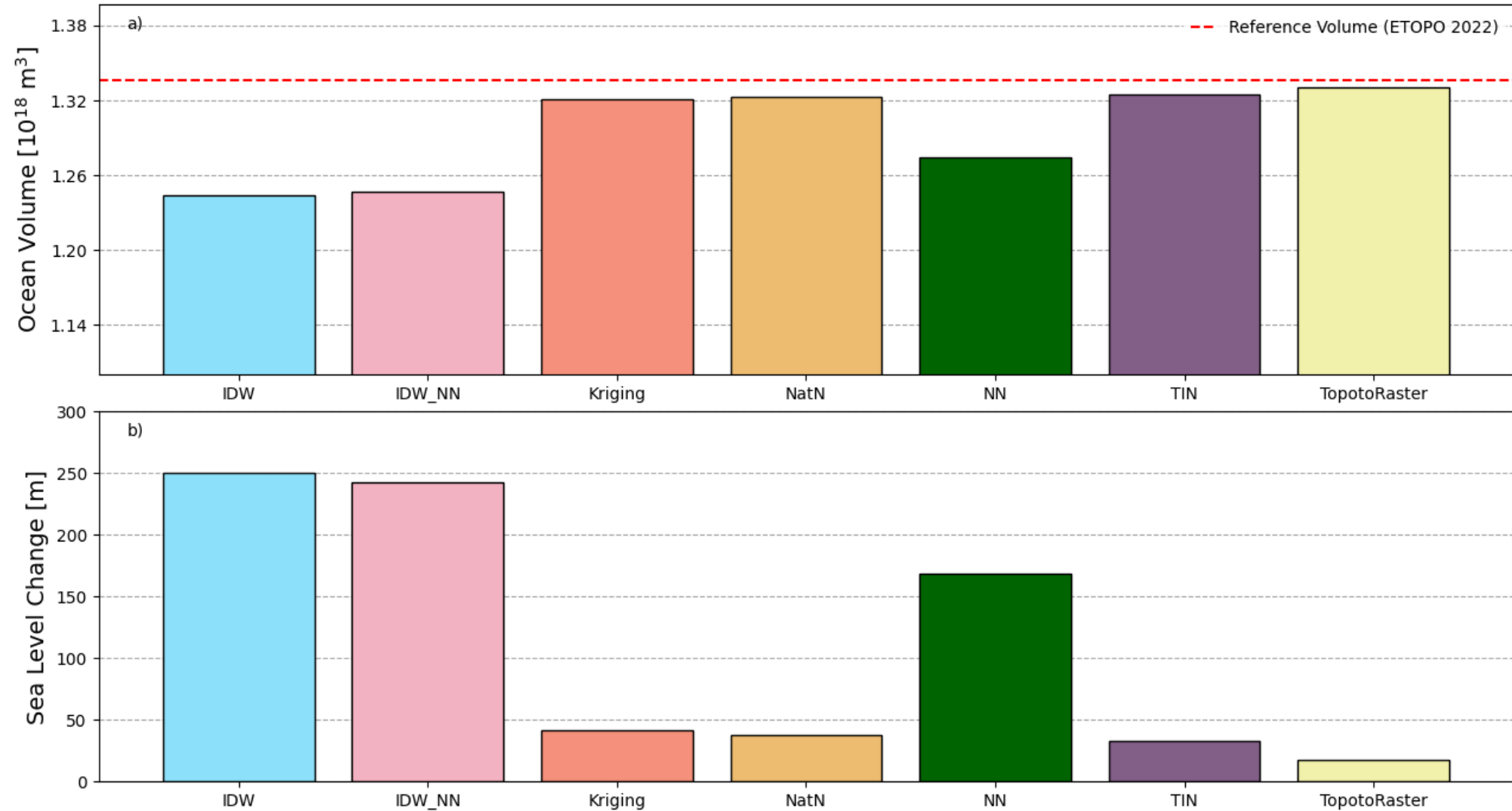


TRI = Terrain Ruggedness Index

Reproducibility Challenge: Interpolation Method



Reproducibility Challenge: Interpolation Method



Lessons Learned

Transition to open source: mentality before technicality.

QGIS plugin & other tools = great documentation in general.

Need supporting documentation in some cases (external libraries !!).

Has anyone created a guide or referenced QGIS equivalent tools from ArcGIS ?

ChatGPT (and other LLMs) very useful for decoding code. Very bad at generating code.

“Earth-like” (sphere) processing capabilities in QGIS would be great ! Does it exist already ?

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/>

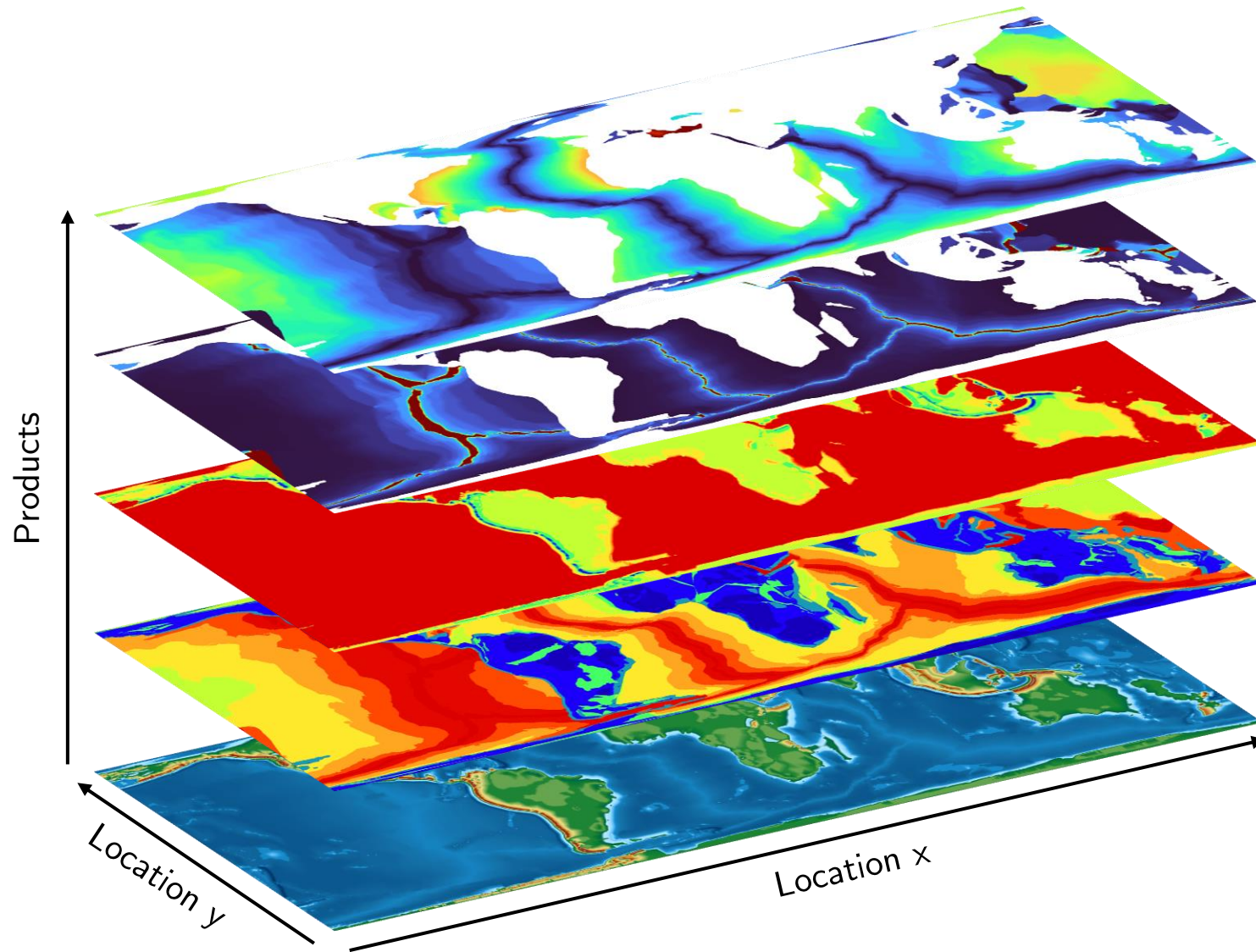


https://github.com/florianfranz/topo_chronia/releases/tag/v1.0.0-beta



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

Palaeo Data Cube: Multi Collection



Sea floor ages

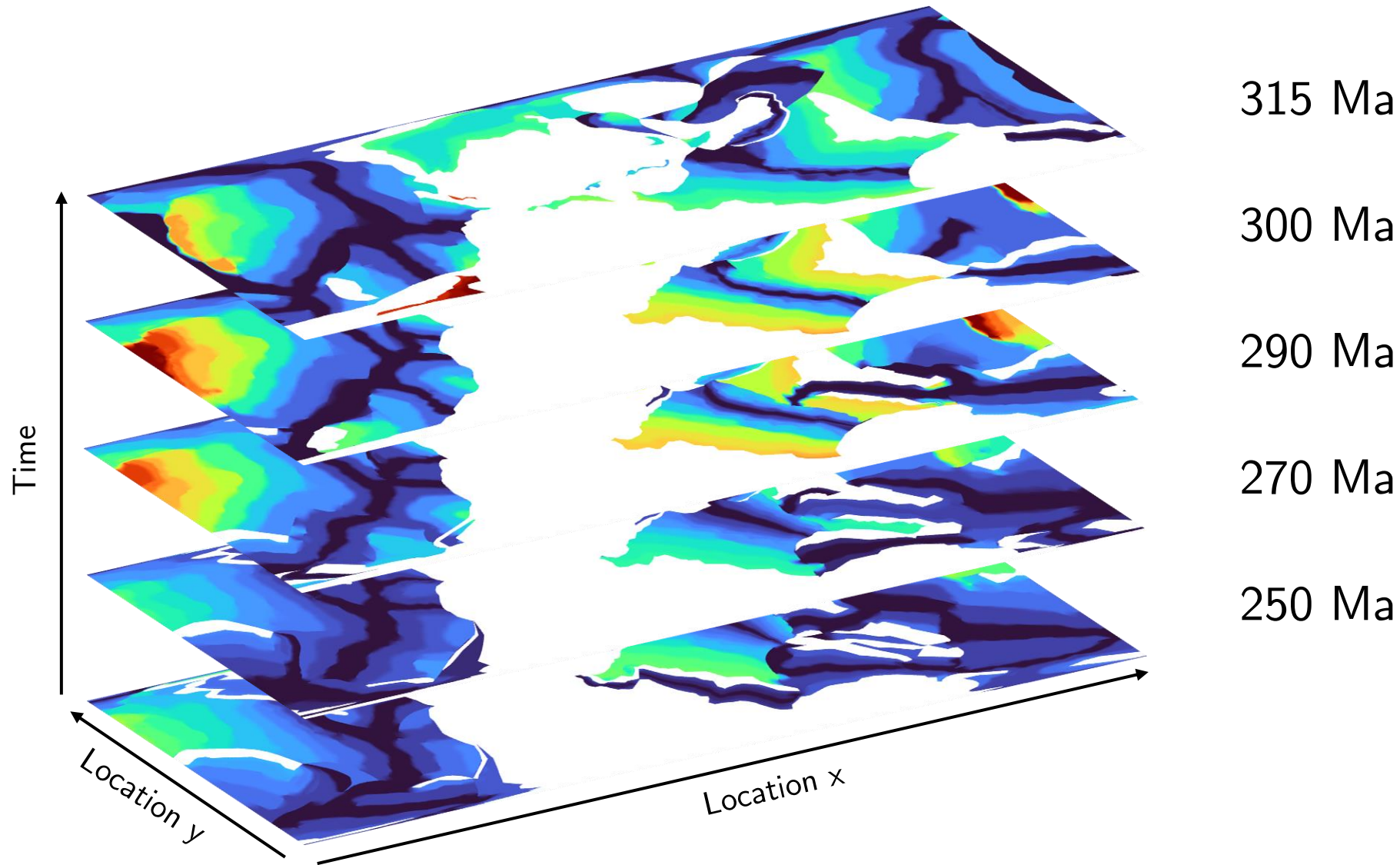
Hydrothermal penetration depth

Crustal thickness

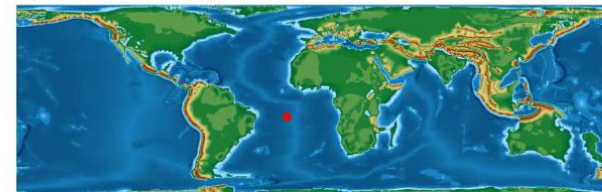
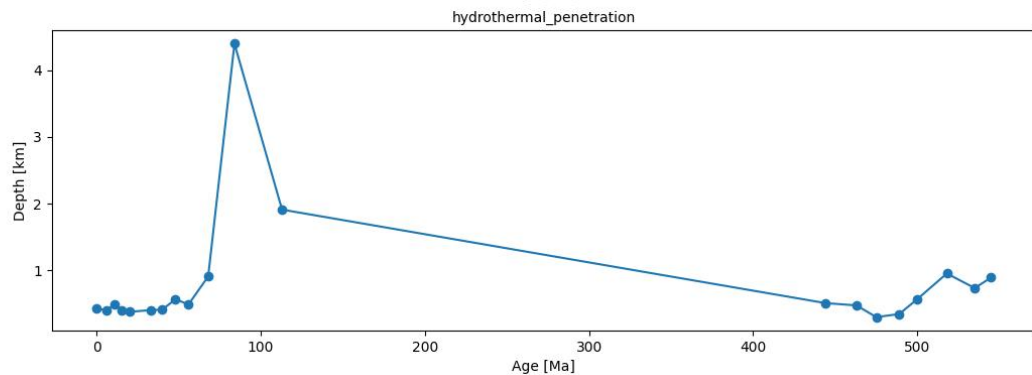
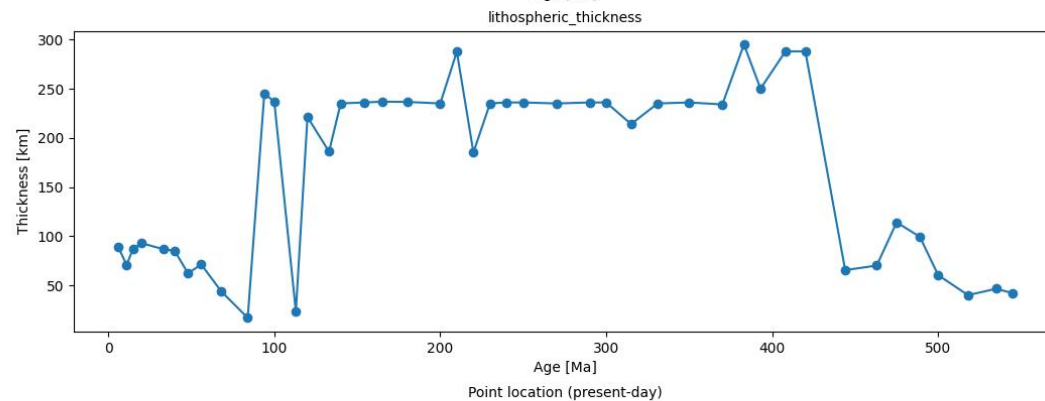
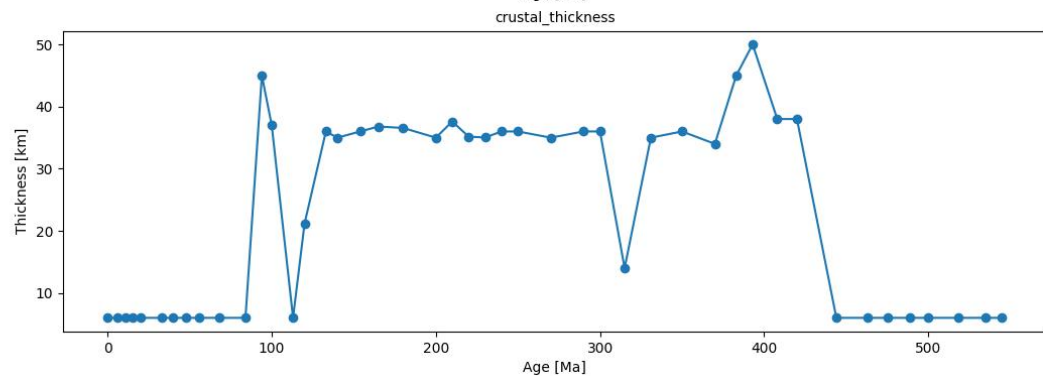
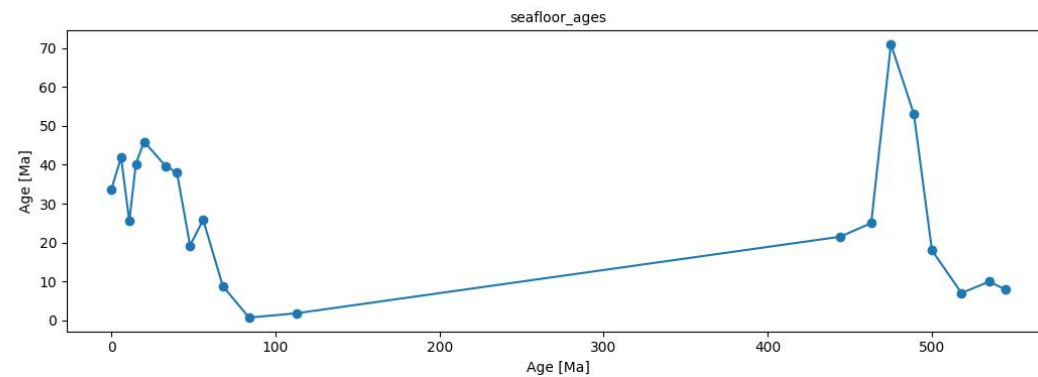
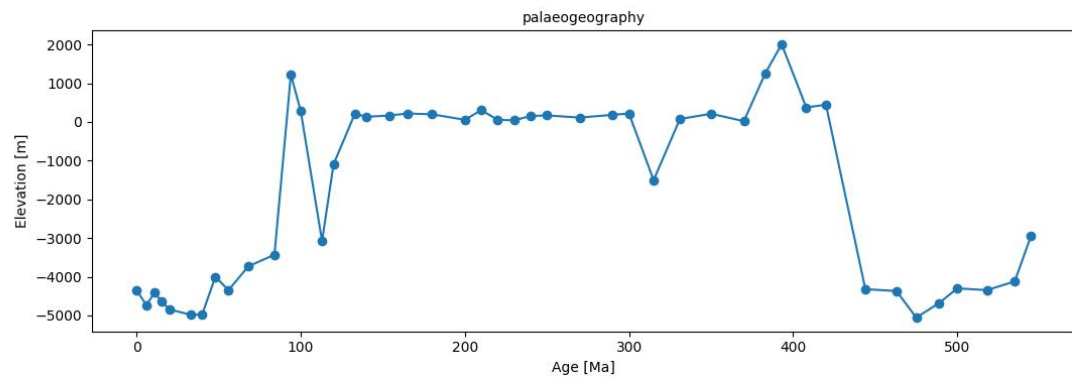
Lithospheric thickness

Palaeogeography

Palaeo Data Cube: Time Series



Palaeo Data Cube: Multi Collection Time Series



Palaeo Data Cube: Implementation



+



+



5 image mosaics (1 per product)
225 maps (45 images per mosaic)
~10⁹ pixels

1 catalog, 5 collections (1 per mosaic)
Items linked to GeoServer via WMS
“Fake” time (YYYY) & geological age

Work in progress!

Conclusion

Academic example of efforts put into transition to open source solution.

Open science: often theorized, not so many examples of practice

Encouraging trends for adoption of open source solutions

Idea: take users by the hand by showing them equivalent open tools and performance

Welcome any ideas for improving data sharing (Paleo Data Cube)

Presentation tomorrow (academic track): 11:00 Room PA01

Image sources

Slide 2-6:

- (i) Cretaceous sediments: Ikejiri et al., 2013,
- (ii) Blackland Fertile Prairie Soil: Prior & Wong, 2020,
- (iii) 1860 Census Data: Map Showing the Distribution of the Slave Population of the Southern States of the United States (1861), by E. Hergesheimer and Th. Leonhardt, U.S. Coast Survey. Public domain via Wikimedia Commons,
- (iv) Largest Ancestry Group: Alabama ancestry map, based on U.S. Census Bureau data. Public domain via Wikimedia Commons,
- (v) 2024 Alabama Presidential Election Results: Alabama Presidential Election Results 2024" by ZackCarns. Public domain via Wikimedia Commons

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- V  rard, C. (2019). Panalesis: Towards global synthetic palaeogeographies using integration and coupling of manifold models. *Geological Magazine*, 156(2), Article 2. <https://doi.org/10.1017/S0016756817001042>
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