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## Problem 1

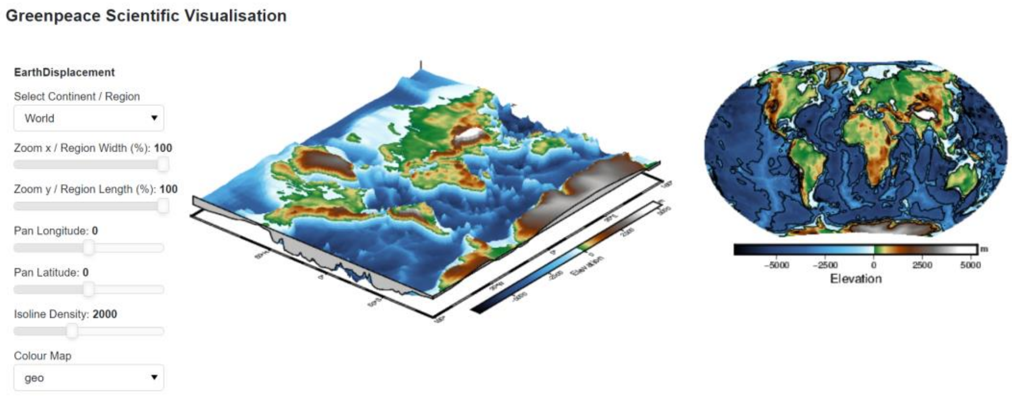


***Fig 1** – default 3D perspective and 2D isoline map of the world*

Scientific visualisation aims at collecting data and presenting data appropriately for exploration, with this instance adding a focus in comparing two techniques. Relief data from the PyGMT library was used to create two types of maps – a 3D perspective displacement map and a 2D isoline map, as seen in *Fig 1*, using scalar algorithms. This was combined with the panel library to create an interface with interactable widgets which were linked to events using params. Various sliders were included to enable high levels of functionality to allow versality data analysis and unique map curation.

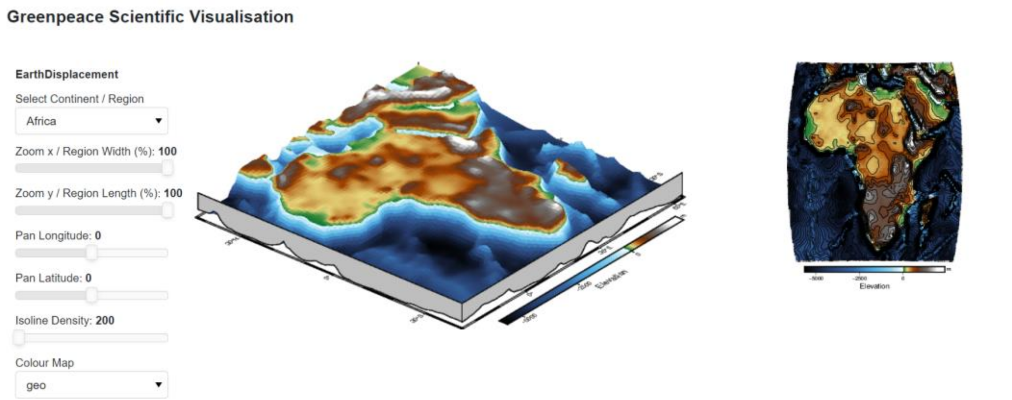


**Fig 2** – *adjustable number of isolines. Isoline density of 200 with Africa as the region*

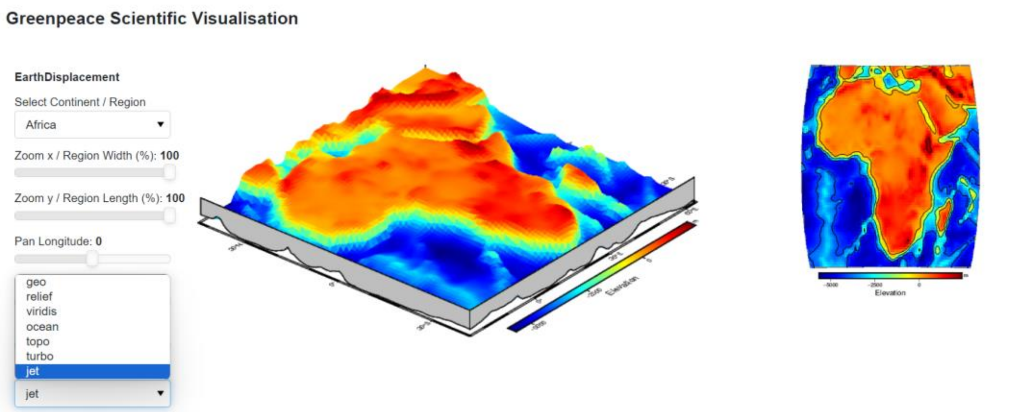


**Fig 3** – *chosen colour mapping. Jet colourmap with Africa as the region*

Many choices made align with the ideas from Jain in [1], and the visualisation pipeline from lecture 2 [2] was kept in mind. The 3D perspective displacement map and isolines map were kept separate to allow the appropriate comparison between the two. The 3D perspective model includes a colourmap on top of a 3D representation showcasing the exact topology, with colours assisting in visualising certain heights and depth. The 2D isoline model involves contour lines which refer to a height level at a certain interval; colour contour lines indicate a steep area whereas sparse contour lines indicate a flat area. These maps allow analysts to read off values based on the colour or isoline. A global spherical view was left for the public visualisation application, as it does not add much for the context of scientific analysis. Instead we can directly view close areas in a flat 2D or 3D perspective to gather the data required.

The number of isolines for the 2D map can be adjusted with its respective slider, as seen in *Fig 2*. This allows better comparisons between geographical features and analysing data with increased precision in assessing terrain variation. This results in figures that are tailored to this current exploratory analysis.

Assessing visualisations in different colour mapping provides alternative perspectives to help reassess hypotheses. Hence functionality was added to adjust the colour schemes of the maps with a dropdown tool, as seen in *Fig 3*. This includes geo, relief, cividis (for colourblind individuals), ocean, topo, turbo and jet colour schemes, creating a large variety of options in which scientific analysis can take place due to this visualisation. The default colourmap is geo so that areas are recognisable, however this is intended to be changed during analysis. As outlined by lecture 3 [2], rainbow colourmaps are not always desired.

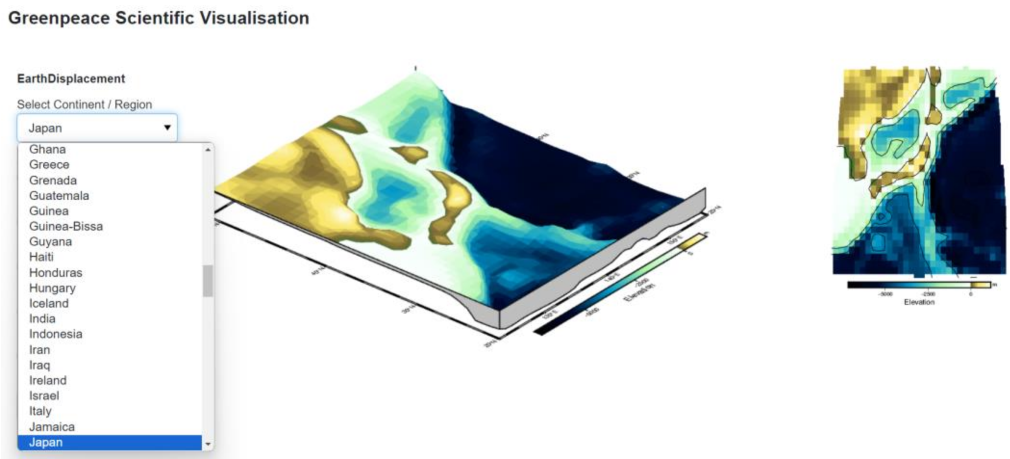


**Fig 4** – *dropdown option of the regions from the adapted database. View of Japan with the relief colourmap and an isoline density of 500*

A variety of views, including a world view, continents and the majority of country views were integrated. Examples of a few options are seen in *Fig 4*. This was implemented through cleaning the dataset from [3]. This functionality allows analysts to swiftly find the area they intend to analyse, rather than panning over the world map view. Once selected a region, both the perspective and isoline maps are updated so they are displaying a visualisation of the same area. This enables an easier comparison between the two methods.

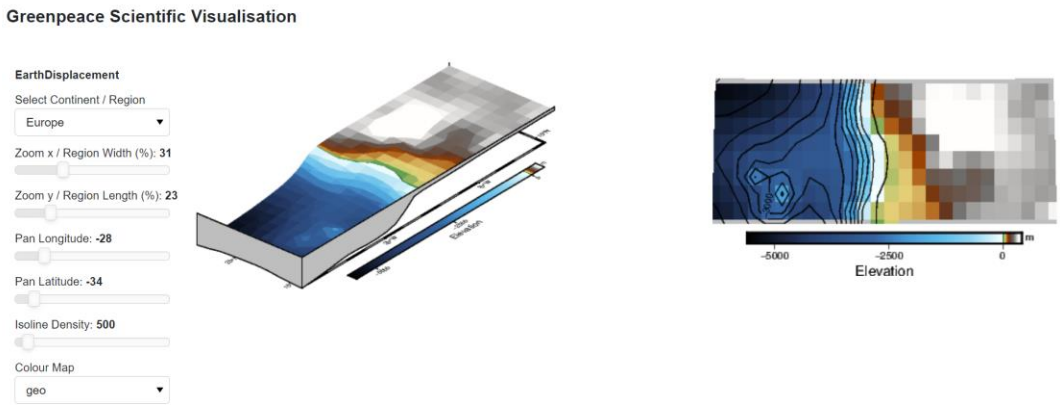


**Fig 5** – *functionality to pan around the regions and zoom in up close. Maps of West Wales, with clear isolines and colourings for possible analysis*]

Zoom and panning functionalities were implemented to allow analysis of any specific area of the world as demonstrated in *Fig 5*. A visualisation is appropriately created if the x and y zoom or the longitudinal and latitudinal sliders are adjusted, to create images of any exact areas of interest. The addition of this highlights the usefulness of the region selection functionality in swiftly generating a visualisation of countries and smaller areas, instead of requiring the user to zoom in from the world view.

A final option is added to allow the analyst to change the resolution of data used, with the potential of creating images in 10k.

**Evaluation of Methods**

Through assessing the techniques, we can see that the 2D isoline map provides a clear representation that can be used to interpret and collect data easily. However, this model lacks depth perception, so instead we must interpret how close the isolines are to one another. Hence if a user would like to quickly understand the overall physical structure and look of regions, the 3D perspective model excels.

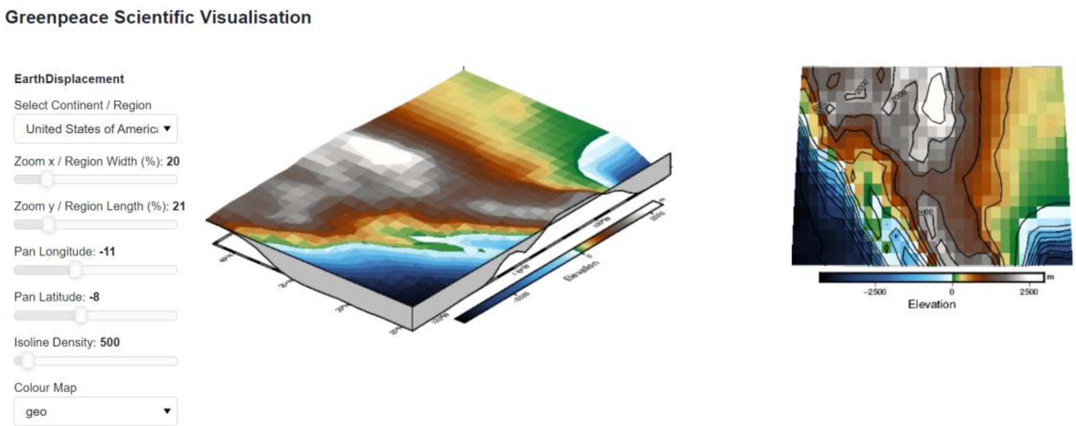


**Fig 6** – *West America coastline as an example of a rapid change in environment in 2D*

Moreover, the isoline model works well for regions that are flatter. However if there is a steep incline or a rapid change in elevations – such as in *Fig 6* – it may be difficult to carry out scientific analysis and analyse the region quickly and efficiently. Similarly, since this is a 2D representation from a birds eye view, overlapping areas with differing elevations cannot be mapped. On the other hand, a 3D perspective representation is able to capture realism through utilising a sense of depth, creating an immersive visualisation of the data more similar to our human perception. This is particularly useful to understand complex terrains with their diverse data.

A downside to 3D perspective representations however is that such complex terrains may be too visually cluttered or distort elevations when working with large volumes of data. This can lead to wrong assumptions of the environment. Data size can be reduced if possible and colourmaps can be changed to assist visualisation clarity. Changing colourmaps can add a sense of versatility to capture many different features appropriately, such as those specific to features of the ocean. However, with colourmaps there is an added sense of subjectivity as we all process colour differently.

In this implementation, the default colourmap can result in colours close to white being misinterpreted as just below 0m or close to 5000m, hence alternative colourmaps are provided in this instance. This mistake is more difficult to make with isolines. Also, although the squares may appear grainy on the isoline map unlike the smooth shapes in the perspective map, the isoline appear very clear and are highly detailed. For close-up details, the isoline map still prevails.

To conclude, 3D perspective maps (with their colourmaps) can capture detail of complex environments and provide a sense of immersion, however they may be more difficult when interpreting data in comparison to 2D isoline maps, and in some cases the environment if there is distortion or clutter. Isoline maps are strong when analysing simple environments, as the details can be clearly displayed and are simple to understand. However, if there are overlapping or complex terrains, this cannot be captured and so 3D perspective maps should be referred to.

**Problem 2**

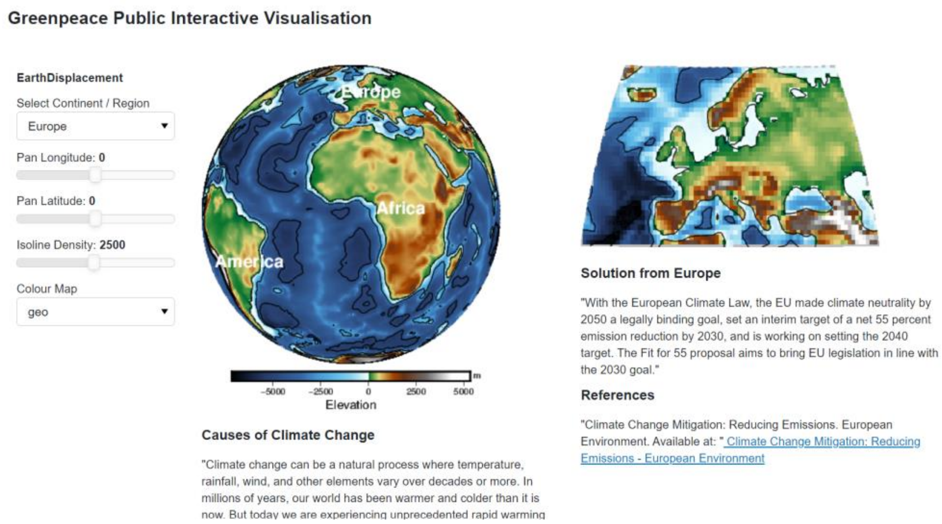


**Fig 8** – *a global view of Earth detailing causes and effects of climate change, and a isoline map solutions with current solutions from each continent. Emphasis on ocean data with relief and how this links to climate change*

Visualisation aimed towards the general the public requires simplicity and a combination of information and scientific visualisation. Instead of allowing the creation of numerous unique maps and access to every data piece, which is suitable for scientists, more general ideas are conveyed (in relation to climate change in this instance). These are conveyed through a 3D spherical world map as a global visualisation method and a 2D isoline map, to provide joint scientific and information visualisation as seen in *Fig 8*. Gestalt laws [2] are used here to organise ideas so they are clear for communication with the public, ensuring the pair of figures have their text directly underneath.

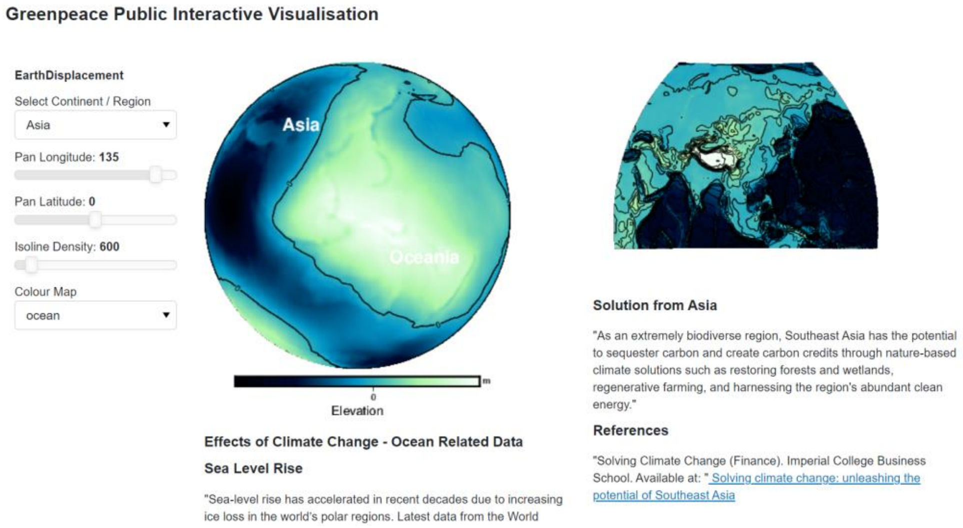


**Fig 9** – *changing visual maps (including adjusted dataset and colourmap) based on user interaction*

The 3D spherical map was made interactive to aid visualisation of the Earth's oceans. By adjusting the respective sliders, the longitude and latitude of the globe can be changed in increments of 45 for simplicity, which is important for clarity of ideas as outlined in lecture 7 [2]. This adds incentive to engage to find out more information related to the causes and effect information below the global map.

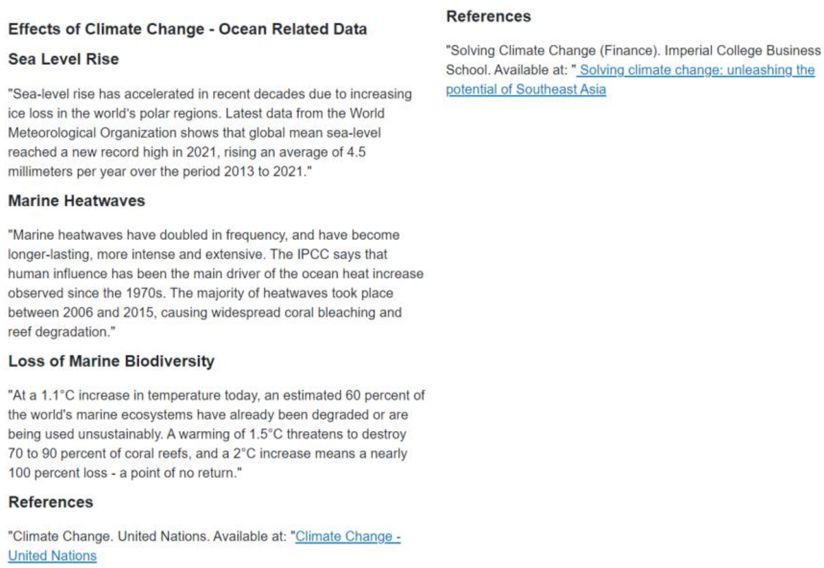


**Fig 10** – *changing textual information based on user interaction*

Adjusting the colourmap to "ocean" uses a geoid dataset from the PyGMT library to update the map of the globe and help users understand the sea level in different areas. This also updates the causes and effects of climate change to be relevant to the ocean, as seen in *Fig 10*. This specific textual information assisting user understanding by matching visual ideas with text and data.

Selecting the colourmap also updates the colouring on the isoline map accordingly. Although there is lower sensitivity to the colour blue, as outlined in lecture 9 [2], this is still fitting here due to the use of ocean data and as we are communicating general ideas to the public. Similar to before, a colourblind-friendly colourmap for land is provided ensuring that as many people as possible can utilise the visualisation appropriately.

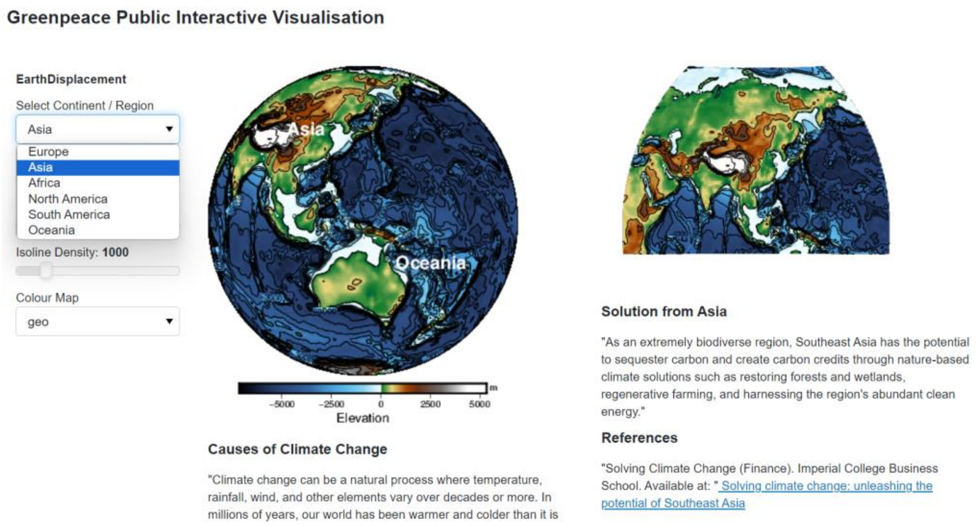


**Fig 11** – *further changing visual and textual information with map 2 through adjusting the continent*

Six continents can be chosen as seen in Fig 11. Few colourmaps are continents are integrated also for simplicity and to ensure there is just enough data. Selecting a different continent adjusts the information displayed underneath the isoline map for information visualisation of solutions. Functionality is also provided to adjust the contour lines in increments of 200 for scientific visualisation. Isolines are updated on both maps. This allows users to find out further information regarding sea level and understand areas which may be affected, such as the potential melting of the North Pole which would affect Europe. This links together scientific data and textual information, providing a cohesive framework to communicate causes, effects and solutions are related to climate change and facilitate understanding.

**References**


[1] Jain, R., 'Checklist for good graphics - The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modeling'.
[2] Koulieris, G. (2023), Visualisation Lectures, *Advanced Computer Graphics and Visualisation*.
[3] Bounding boxes for countries - Humanitarian Data Exchange. *Bounding boxes for countries*. Available at: [https://data.humdata.org/dataset/bounding-boxes-for-countries/resource/aec5d77d-095a-4d42-8a13-5193ec18a6a9](https://data.humdata.org/dataset/bounding-boxes-for-countries/resource/aec5d77d-095a-4d42-8a13-5193ec18a6a9)