Visualization Work Of The Earth's Mantle

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In the UK it is still not common for computational scientists to use 3D visualization to examine their data. Many groups now seem to be at a bottle neck in their work because of this lack of graphics. When the UKHEC formed, it set a goal of improving the use of graphics and to do this they have commissioned three case studies.........we present the first one here.

This work has been supported by SGI. An octane with 512 Mega Bytes memory, 16 GigaBytes of disk space and with texture memory has been borrowed from SGi, through the CSAR equipment loan scheme (see article on page .Url: www.csar.ac.uk/using/loan.shtml).

Case Study: *Seismic Tomography and Convection Modelling of The Earth's Mantle by The Terra Group*

The UK base of the Terra consortium is at the University of Liverpool and it is led by Dr. Huw Davies. They run computational simulations of the circulation of the Earth's mantle (the layer between the crust and core) on 512 processors of the Cray T3E for up to 12 hours. These results are then compared to seismic tomography images derived by the group.

Currently they can only analyse the results by producing a series of 2D projections, one for each layer of data. All 2D projections are inherently distorted and hence may be misleading. 3D views of the data would be an improvement but it is important that they can be interactively cut, isosurfaced and rotated.

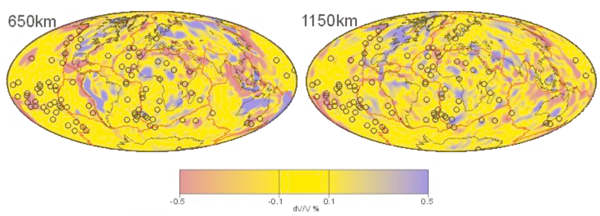

Figure 1: 2D projection of one depth layer - original visual analysis using seismic tomography data

We believe visualisation tools would speed up the analysis, shorten the time between runs and improve acceptance of the results from their peers. Papers have been rejected because of the inadequate nature of the visual presentation.

The mantle is a thick viscous liquid, usually modelled by finite element analysis, the ocean and atmosphere on the other hand are thin and flow easily between computational cells so are modelled by finite differences.

Data produced by finite difference is array data and relatively easy to visualize, but the data produced here was from finite element analysis which is cell data and much more complex to visualize. The simulation data is placed in computational cells in polar coordinate space with its inherent curved surfaces. Graphics renderers deal only with straight lines and are based on a cartesian coordinate system.

To convert the computational cells into visualization cells the coordinates must be converted from polar into cartesian coordinates and then each cell must be resampled to compensate for the curved nature of the original cells and make the new cell set tessellate. The data in the model is strongly related to other information, volcanic "hot spots", plate tectonic boundaries and coastlines. It is vital that this reference data is always visible and unambiguously displayed.

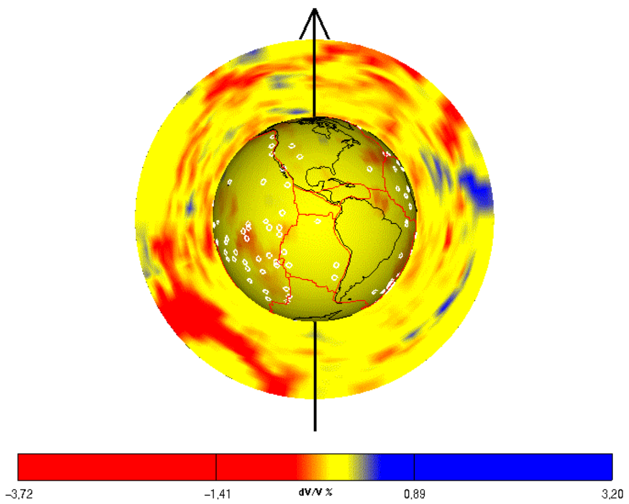

Figure 2: New 3D visualization of seismic tomography data.

Huw Davies has been pleased by the results of this visualization work. He works with researchers in the USA and they too are impressed, they have some 3D visualizations but not on data of this complexity or with this flexibility. The Terra group are keen to use the visualization tools on a permanent basis. The next case study will commence soon.

The simulation is high resolution and produces large data sets, which must be converted into its visualization cell set. The conversion resamples the cells and replaces each one with three to four cells. The size and structure make the resulting visualization difficult to display and slow to manipulate unless specialist graphics hardware is used on a machine with a large amount of memory. The Terra group have no specialist graphics hardware and they would prefer to spend any new computational resources on increasing the resolution of their simulation which ironically increases their visualization problems. Their expertise is in simulation not graphics and we are now considering the possibility of developing a visualization server as a part of the CSAR service.

These simulations are computationally expensive and the data is only analysed at the end of a run. If the computation goes down the "wrong" path resources are wasted. It would be useful if they could analyse results while the simulation is progressing and where appropriate alter parameters. This is called "computational steering" and with a visualization server could improve the system for the Terra group.