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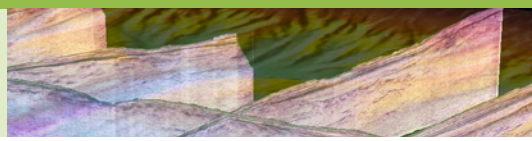
Presenting geoscience using virtual globes

Communicating geoscience data in a variety of contexts



James Navin and Michael de Hoog

Virtual globes have increased in popularity since the first online offerings appeared in 2004–05. Since its release in mid-2005, Google Earth has been downloaded over one billion times (Official Google Blog 2011), and there are now numerous virtual globe software applications available that cater to different audiences and industries.

As a platform for communicating and visualising geoscience data, virtual globes have a number of key benefits. These include:

- visualisation of data at a range of scales, from local to global
- three-dimensional representation of terrain, helping to locate and contextualise data
- overlay and visualisation of different datasets simultaneously
- interactivity, allowing users to freely explore the data
- the easy incorporation of large datasets associated with the geosciences.

Like many other organisations, Geoscience Australia is using virtual globes as an important visualisation tool. In a 'right tool for the job' approach, different virtual globe applications are used to meet different needs; these include NASA's World Wind, Google Earth and ESRI ArcGIS Explorer. This article focuses on the development of Geoscience Australia's 3D Data Viewer and its use within the agency to share information with external stakeholders.

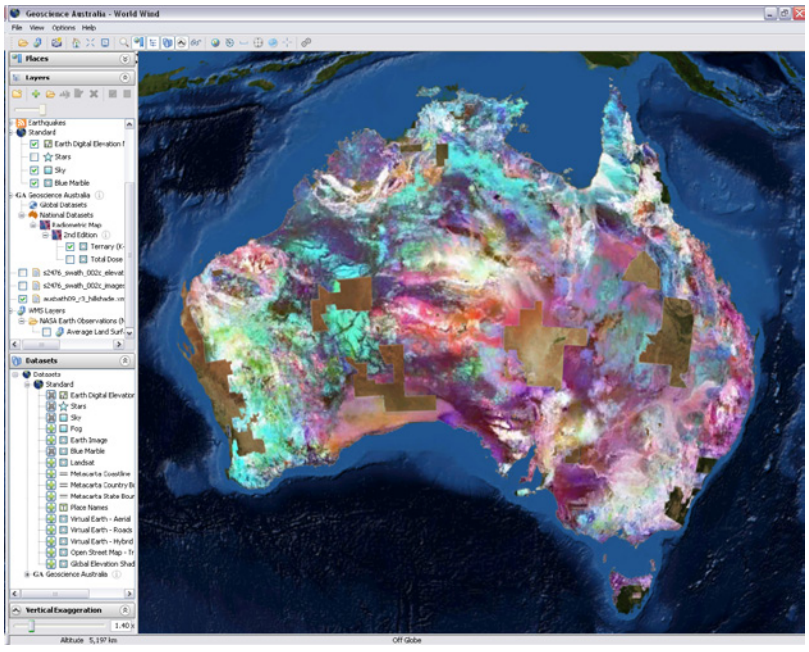


Figure 1. A screenshot of Geoscience Australia's 3D Data Viewer showing the Ternary layer of the 2nd Edition Radiometric Map of Australia.

Geoscience Australia's Virtual Globe

In February 2009, Geoscience Australia released the national Radiometric Map of Australia as eight data grids totalling 55 gigabytes. In the lead-up to the public release, the agency looked for an application that would provide external stakeholders with easy and intuitive access to images of the data at full resolution without the need for specialist software. The application also needed to allow users to compare each of the eight data grids with each other as well as with other national datasets, such as the national Gravity and Magnetic Anomaly maps. The application that best met the agency's requirements was the NASA World Wind Java Software Development Kit (SDK) which enabled the development of an agency-specific application built on the base World Wind components (figure 1).

Development on the 3D Data Viewer has continued since its release and it now supports a range of data types including:

- Raster images
- shapefiles (point, line and polygon)
- digital elevation models (DEMs) and digital surface models (DSMs), including high-resolution LiDAR-derived data
- earthquake data (recent and historic)
- seismic and airborne electromagnetic (AEM) survey data
- web map service (WMS) data layers.

A growing collection of Geoscience Australia's national and regional datasets are now available through the public version of the 3D Data Viewer (see below), which has been used by agency staff at a number of international conferences to present data and findings.

Uniform data presentation

A key advantage of using virtual globes for the visualisation of geoscience data is that they provide a uniform and familiar interface for interacting with data from a wide range of sources and disciplines. For example, topographic data can be viewed alongside geophysical survey data and remote sensing data, all of which can then be overlayed on a digital terrain model, and navigated and controlled in a uniform manner. This immediately makes data more accessible, which is important for communicating scientific data to a broad audience.

Through the use of open data standards, such as Web Map Service (WMS), Web Feature Service (WFS) and GeoSciML, this uniform data presentation can be taken a step further: virtual globe applications become further decoupled from the data they are displaying and become data agnostic. This is uniform data presentation from a producer's perspective. Rather than preparing data specifically for use in Software Package A and then separately for use in Software Package B, data can be prepared once and then delivered over a standard interface to any number of consuming software packages.

Most of the popular virtual globe applications on the market today support open data standards to some extent. The 3D Data Viewers support for WMS includes a WMS Browser tool that allows users to browse for and select data layers from WMS servers around the world. It also includes a WMS Server Search tool that allows users to discover WMS servers that contain data layers of interest. Once added to the 3D Data Viewer, WMS layers are treated in the same way as any other layer: they can be turned on and off, opacity can be altered, and vertical 'draw order' can be changed. This consistency of the user experience ensures that WMS data can be added and used seamlessly alongside data and imagery from other sources.

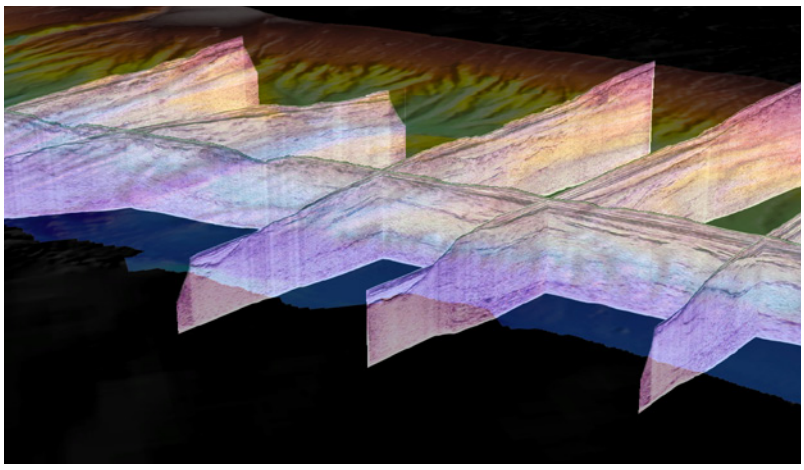


Figure 2. The 'curtain image' layer showing offshore seismic survey slices from Geoscience Australia's Southwest Margin project.

Subsurface in a virtual world

Much of geoscience is concerned with gathering, analysing and interpreting data about processes and structures that occur beneath the surface of the earth. This data can come from a range of sources and often requires specialised and expensive software to view. Communicating this data in a way that is intuitive and accessible can be challenging.

A number of techniques for visualising subsurface data in virtual globes have developed recently. One technique is to generate a two-dimensional representation of the data as viewed 'top-down' and to project this data onto the surface of the globe. This has the advantage that the data can be manipulated in the same way as other image-based data, but it can be difficult to convey the three-dimensional nature of the data. A second approach is to display the data in some way above the globe's surface. This approach has the benefit that the three-dimensional nature of the data can be conveyed, but suffers from a disconnect between where the data is displayed in the digital world and the real-world location of the features.

A more compelling representation of subsurface data can be obtained by visualising it in the correct location beneath the surface of the virtual globe (figure 2). Geoscience Australia has been working to add features to the 3D Data Viewer to support the visualisation of subsurface data.

Recent innovations

A recent addition to the 3D Data Viewer is support for the display of survey data collected as two-dimensional slices into the Earth's surface. Examples of this type of data include 2D seismic and airborne electromagnetic (AEM) survey data. These data are displayed using a 'curtain image' layer type that defines survey paths as a series of latitude and longitude coordinates with a top and bottom slice depth. From this information a simple mesh is generated that represents the data slice. The actual survey data is projected onto the mesh from a pre-computed image tile cache, with appropriate resolution image tiles selected based on the distance of the user from the survey slice.

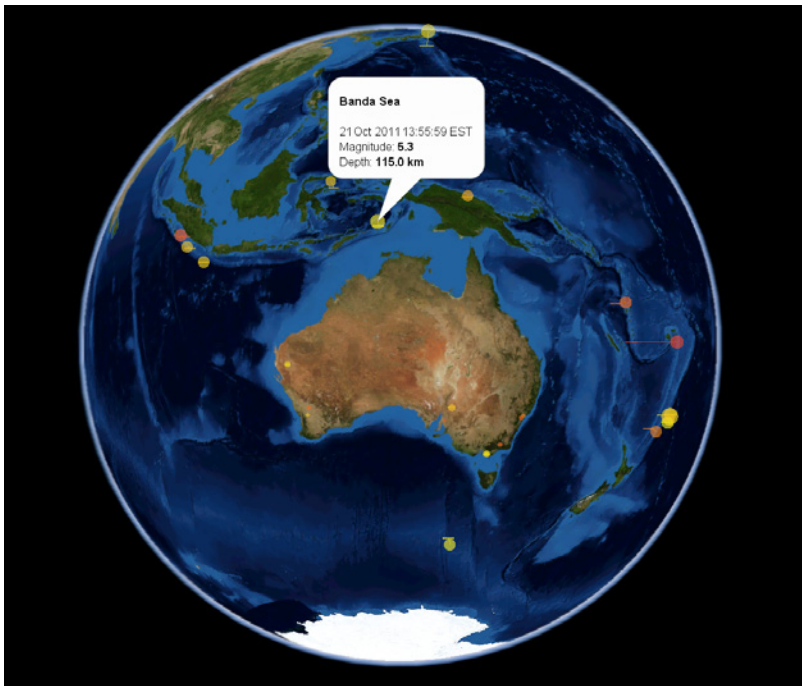


Figure 3. Recent earthquke activity as shown within Geoscience Australia's 3D Data Viewer.

This approach is similar to quad-tree tiling or 'pyramiding' techniques used to display high resolution surface imagery in many virtual globe and 2D web mapping applications. The use of a pre-computed tile cache rather than the source data has a number of benefits for the display of this type of data:

- The size of the tile cache is often smaller than the source data, due to the use of compressed formats such as JPEG and ZIP. This makes the transmission of the data faster and less network intensive.
- Tiles are pre-computed, so selecting an appropriate tile to use is very fast and requires minimal processing. This aids in delivering an engaging interaction for the user.
- Tiles are stored in common image formats, so specialised software is not required by the user to load the data.

Another feature that has been added to the 3D Data Viewer is a recent earthquakes layer (figure 3). This layer connects to an RSS feed of recent earthquake activity published by Geoscience Australia. The RSS feed contains the location, depth, magnitude and timestamp of earthquakes that have occurred within the last seven days. The 3D Data Viewer connects to this feed and

visualises earthquakes as a sphere located on the Earth's surface at the earthquake epicentre, scaled by magnitude and coloured by age. In addition, a 'tail' is added that extends subsurface data down to the earthquake hypocentre. This visualisation gives a clear overview of recent earthquake activity so users can immediately differentiate deep, recent, high-magnitude quakes from older less significant ones. Users can access more information by hovering the mouse over specific earthquakes and clicking to link to detailed earthquake information pages.

Making the world go around

A feature that is becoming more common in virtual globe applications is the ability to record 'fly-throughs' and output them in a video format for later playback and distribution. The 'pre-recorded' nature of these animations has a number of attractive features:

- a visually compelling method to illustrate spatial data
- presentation of data in a choreographed way to communicate specific information or ideas
- movies can be embedded in presentations and combined with other content in longer movies
- easy distribution on the internet.

Geoscience Australia has developed high quality animation capabilities for its virtual globe application in a standalone tool that is maintained alongside the 3D Data Viewer. This tool (the 'Animator') bridges the gap between GIS/scientific visualisation tools and traditional 3D animation software. It has the same core functionality as the 3D Data Viewer (such as support for large geoscience datasets, data layering and global to local navigation) and adds features such as key framing, motion graphs and composition guides that are common in professional 3D animation tools. The agency has used this tool to produce high quality animations of geoscience data for use at conferences, in communications with the public and for its education program (figure 4). Examples of movie outputs are available from the multimedia section of the Geoscience Australia website.

Figure 4. A still taken from a recent animation produced with the 'Animator' tool. This animation featured high-resolution LiDAR digital surface model and 25 centimetre aerial photography.

Conclusion

Virtual globes are powerful tools for communicating geoscience data to a varied and potentially non-technical audience. The increasing popularity of these tools ensures that many users are already familiar with this type of global interaction, enabling easy interaction with the data.

Geoscience Australia has developed a virtual globe application targeted for use with geoscience data. The 3D Data Viewer is being used to provide access to a growing number of the agency's national and regional datasets. It provides support for the display of a range of data, including subsurface data such as seismic and AEM survey data. Its companion tool, the Animator, provides support for creating high quality animated fly-throughs of geoscience data. These animations are used to communicate geoscience information in a variety of contexts. Development on both the 3D Data Viewer and Animator is ongoing, with the focus being on adding features to support the visualisation of geoscience data in all its forms.

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For more information

email ausgeomail@ga.gov.au

Related articles/websites

World Wind 3D Data Viewer (Geoscience Australia website)

www.ga.gov.au/products-services/maps/interactive-3d-models/world-wind-3d-data-viewer.html

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