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# The OpenEarth Framework (OEF) for the 3D Visualization of Integrated Earth Science Data

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Data integration is increasingly important as we strive to combine data from disparate sources and assemble better models of the complex processes operating at the Earth's surface and within its interior. These data are often large, multi-dimensional, and subject to differing conventions for data structures, file formats, coordinate spaces, and units of measure. When visualized, these data require differing, and sometimes conflicting, conventions for visual representations, dimensionality, symbology, and interaction. All of this makes the visualization of integrated Earth science data particularly difficult.

The OpenEarth Framework (OEF) is an open-source data integration and visualization suite of applications and libraries being developed by the GEON project at the University of California, San Diego, USA. Funded by the NSF, the project is leveraging virtual globe technology from NASA's WorldWind to create interactive 3D visualization tools that combine and layer data from a wide variety of sources to create a holistic view of features at, above, and beneath the Earth's surface. The OEF architecture is open, cross-platform, modular, and based upon Java.

The OEF's modular approach to software architecture yields an array of mix-and-match software components for assembling custom applications. Available modules support file format handling, web service communications, data management, user interaction, and 3D visualization. File parsers handle a variety of formal and de facto standard file formats used in the field. Each one imports data into a general-purpose common data model supporting multidimensional regular and irregular grids, topography, feature geometry, and more. Data within these data models may be manipulated, combined, reprojected, and visualized.

The OEF's visualization features support a variety of conventional and new visualization techniques for looking at topography, tomography, point clouds, imagery, maps, and feature geometry. 3D data such as seismic tomography may be sliced by multiple oriented cutting planes and isosurfaced to create 3D skins that trace feature boundaries within the data. Topography may be overlaid with satellite imagery, maps, and data such as gravity and magnetics measurements. Multiple data sets may be visualized simultaneously using overlapping layers within a common 3D coordinate space.

Data management within the OEF handles and hides the inevitable quirks of differing file formats, web protocols, storage structures, coordinate spaces, and metadata representations. Heuristics are used to extract necessary metadata used to guide data and visual operations. Derived data representations are computed to better support fluid interaction and visualization while the original data is left unchanged in its original form. Data is cached for better memory and network efficiency, and all visualization makes use of 3D graphics hardware support found on today's computers.

The OpenEarth Framework project is currently prototyping the software for use in the visualization, and integration of continental scale geophysical data being produced by EarthScope-related research in the Western US. The OEF is providing researchers with new ways to display and interrogate their data and is anticipated to be a valuable tool for future EarthScope-related research.