INTERACTIVE IMMERSION LEARNING

Flying through Weather Data onboard the GEOpod

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About 90 million people are gaming online in the United States, and most of them are student age. While the majority of the 2,000-plus online games are designed for entertainment, there are many that use this technology as effective supplements to traditional learning. Some include sophisticated visualizations that attempt to synthetically simulate real-world environments; but only a handful create an authentic experience by immersing the user in physical data, and these are generally limited to the use of canned data targeted for specific learning scenarios. However, 3D visualizations of real-time atmospheric data, including gridded model output, are commonplace in the meteorology community. The Integrated Data Viewer (IDV) developed at Unidata is an example of a framework that uses Java and VisAD to analyze and display 3D geoscience data (www.unidata.ucar.edu/software/idv).

With support from the National Science Foundation (NSF), a team of meteorologists and computer scientists at Millersville University have been working on the development of an interactive interface—a GUI plug-in—that offers an immersion-world experience within the IDV framework. The project, GEOScience Probe of Discovery (GEOpod), is an effort to provide users with the capability of navigating a virtual probe (the GEOpod) through a geophysical data volume while actuating virtual devices, all the while being guided by a tiered instructional design strategy. The goal is to create a design perspective that will appeal to "next-geners," who are adept at gaming, and motivate them to intimately explore the data volume and take away a better understanding of meteorological concepts resulting in enhanced learning and discovery. What distinguishes the GEOpod from other synthetic environments such as Virtual Thunderstorm—developed by Gallus et al. in 2005—is the use of numerical model output based on actual physics that exhibits technical accuracy, fidelity, and scientific soundness.

GEOpod on the Web: http://csheadnode.cs.millersville.edu/~geopod/index.html

The GEOpod provides a number of useful devices and features to facilitate and enhance the exploration process, while maintaining a clean, easy-to-use interface that is accessible to novices and experts alike. The user enters and navigates the data volume using the intuitive controls, a compass, and an autopilot system capable of traversing isosurfaces with high fidelity. The Geocoding system provides ground truth over the current location or for locating a point of interest by name. User-selected meteorological variables are continuously updated on a customizable display panel on the GEOpod dashboard. Virtual devices can be actuated by the click of an icon. The particle imager displays hydrometeor type and ice crystal habits based on inputs of temperature and relative humidity. A virtual dropsonde provides vertical profiles over the closest grid point and allows users to save multiple soundings. A grid-point displayer allows the user to view the underlying model grid framework. Using a noted-locations system, the user is able to annotate (and later view, edit, or save) parameter values at points of interest. In addition to autopilot, the user can fly manually and with variable speed to any point within the grid, or retrace the entire traverse, or save and send the full exercise to the instructor for replication and evaluation.

The overarching purpose of GEOpod is to create an interesting, friendly, and interactive environment for learning about our atmosphere. So, in addition to the system capabilities, GEOpod missions have been developed that serve as guided exercises for the user. Each mission includes a set of learning objectives and questions for assessment supported by a detailed

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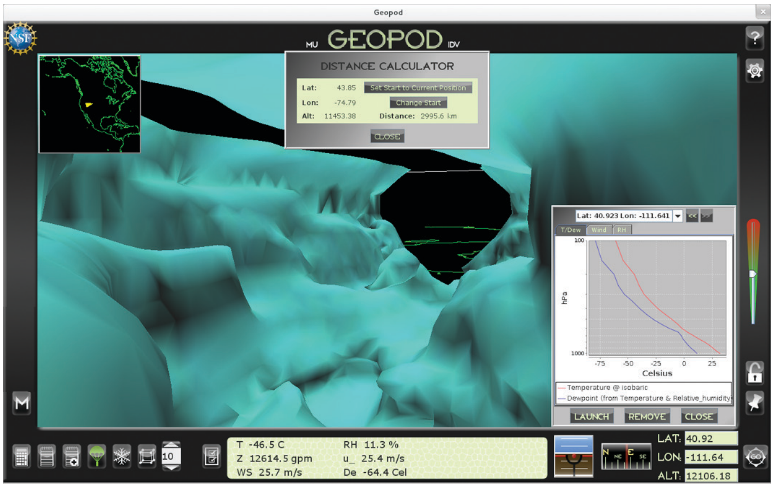

Fig. 1. GEOpod presentation of an isosurface of wind speed. The user can deploy the virtual dropsonde, call a distance calculator, change the variables displayed on the dashboard, turn the autopilot on and off, or actuate a particle imager.

assessment rubric that can be utilized by both instructor and student. Moreover, GEOpod provides a Mission Builder that gives the user the ability to create customized missions; a student invoking the GEOpod would click on a mission's icon to access preloaded exercises using current or archived gridded datasets.

A complete usability study designed and carried out by an external instructional technology expert was conducted in the second year of the GEOpod project to ensure system functionality and utility. The results of this study were highly favorable and aided in refining the system. GEOpod has been piloted in classroom settings and student reactions have been overwhelmingly positive. A formal survey designed by the project's external evaluator was conducted in a 200-level introductory meteorology course (ESCI 241, "Meteorology") in the fall of 2011. This is the first required course for majors in the meteorology curriculum, but can be taken by students from other sciences as part of their general education requirement. A large majority of the students surveyed indicated that GEOpod enhanced their learning of a concept or phenomenon in a significant way. This strong response was impressive considering that the students were exposed to GEOpod for such a short time in a single course. Students' open-ended responses revealed their enthusiasm for the GEOpod technology and its potential usefulness as a learning tool in their meteorology courses. Students remarked that the technology was not only visually compelling, but also helpful in deepening their understanding of a topic. Further evaluation of GEOpod is planned following its implementation in upper-level meteorology courses and in applied settings such as student forecasting for the Millersville University Campus Weather Service.

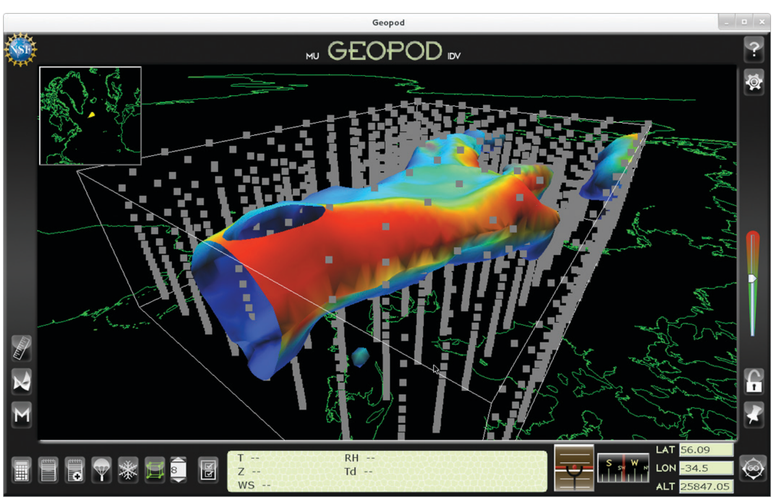

Fig. 2. A GEOpod display of *u*-wind at 16 m s^{-1} colored with potential vorticity (PV) and a perspective taken from outside the model domain to show the gridding utility. A user can point and click any grid point and the GEOpod will "fly" to that location within the domain. The values of PV units (1 unit = 10^{-6} m^2 s^{-1} K kg^{-1}) range from −1 (dark blue) to 10 (red). Orange is in the 8.2 to 8.9 range.

The GEOpod project is in its final year (2009–12). Friendly users will be tapped to test further enhancements to GEOpod made during the summer and the plug-in will become available to the community as open-source software thereafter. For those interested in experiencing GEOpod, a short course (the AMS Short Course on Interactive Immersion Learning: Flying through Data Onboard the GEOpod) will be offered at the 93rd AMS Annual Meeting in Austin, Texas, on Sunday, 6 January 2013. Information on the short course and registration can be found at http://

annual.ametsoc.org/2013/index.cfm/programs-and-events/short-courses.

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FOR FURTHER READING

Gallus, W. A., C. Cervato, C. Cruz-Neira, and G. Faidley, 2006: A virtual tornadic thunderstorm enabling students to construct knowledge about storm dynamics through data collection and analysis. *Adv. Geosci.,* **8,** 27–32.