In Brief

From the ocean depths to the high desert, Layerscape is helping scientists visualize complex data about planet Earth in three-dimensional space and time. Oceanographers and earth scientists are using this free set of research tools to analyze data and share discoveries with researchers and the public as they work to understand the complex interconnections of our planet.

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Websites:

layerscape.org

worldwidetelescope.org

mbari.org

azgs.az.gov

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Expanding Earth Sciences Research with Layerscape

The Earth is a vast, complicated system comprised of an astonishing collection of interlocking components with intricate interconnections. Earth scientists worldwide are attempting to work out the enormous puzzle of how the Earth functions as a system. One of the key technical challenges facing earth scientists is the management of the flow—and particularly, the visualization—of research data. Microsoft Research has a technological solution to the issue: Layerscape.

Layerscape is a set of research tools, consisting of three main elements:

- The WorldWide Telescope visualization engine
- The website in support of the content generated by the user
- A data transfer tool for transferring data into Layerscape

The Layerscape data transfer tool is built on Microsoft Excel, meaning that data housed in existing Excel spreadsheets can be transferred into the Layerscape visualization engine with just a few clicks of a button. The link from Excel is dynamic; therefore, anytime a user changes the data in Excel, the updates will be rendered automatically in Layerscape.

The Layerscape visualization engine, Worldwide Telescope, harnesses a PC's graphics processor, which in turn enables scientists to visualize large amounts of data both in space and time. This feature opens up an endless number of possible applications, for example: visualizing historical surface temperature measurements, chlorophyll concentration, seismic activity, greenhouse gas diffusion, sea ice extent, wind patterns, ocean pH, insect biodiversity, aquifer storage, and geothermal heat flux. Additional uses might include tracking antelope migratory patterns or the movement of Saharan dust as it seeds plankton blooms across the surface of the Atlantic Ocean with nitrogen and iron. Layerscape can also be used to create abstract visualizations by simply using coordinate axes.

"Layerscape offers the opportunity to look at a whole range of variables and overlay them in space and, eventually, in time so you can see how these ocean landscapes change and respond to forces in the environment."

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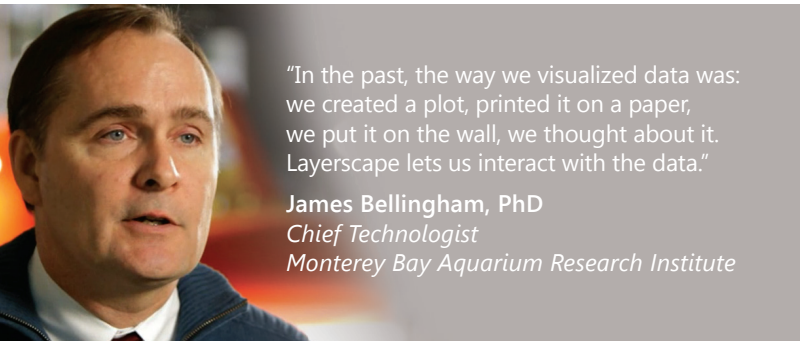
In addition to rendering data in three-dimensional space and time, Layerscape offers a free narrative view. Users can place their "virtual eye" anywhere they desire and connect together a sequence of perspectives and automated transitions that illustrate what the data is doing and the story that the user hopes to communicate. This type of storytelling is ideal for educational outreach, enabling researchers to communicate their results to both the scientific community and the general public.

Layerscape's early adopters include oceanographers and earth scientists who are using the technology to explore and visualize large,

complex data. In this case study, we'll explore how three members of the earth sciences community are using Layerscape to analyze and share data with researchers and the public.

EXTENDING SCIENTIFIC REACH THROUGH TECHNOLOGY

Researchers conducting ocean sciences research have traditionally spent a lot of time on the ocean recording first-hand observations. This approach accounts for most of what we know about the oceans today. The general consensus among the scientific community is that we have only scratched the surface. "We don't have many ships, and it's a very big ocean," says James Bellingham, the chief technologist



at the Monterey Bay Aquarium Research Institute (MBARI) and a self-described "techno-geek." The MBARI has found a technological solution to human limitations: robots.

Researchers send robotic autonomous underwater vehicles (AUVs) equipped with MBARI sensors into the ocean and the robots transmit observations (data) back to the team onshore via satellite. Not only are the AUVs able to access greater portions of the ocean, they are also more cost effective than human-staffed missions. Also, AUVs can return larger volumes and a wider variety of data than their human counterparts.

Layerscape has provided the team with a way to investigate the increased data sets returned by the AUVs. "Layerscape is becoming one of the tools that we use now for exploring these data sets, which are not just three-dimensional or four-dimensional, but they're many-dimensional, because there are many different parameters that we're looking at," Bellingham explains. "Sometimes we're really more interested in a story, and Layerscape helps us tell stories. We could put a data set in it and we can play it like it's a movie and see how organisms change."

TRACKING EARTHQUAKE ACTIVITY IN ARIZONA

Hundreds of miles from the ocean, the Arizona Geological Survey (AZGS) has been amassing data about a different piece of the geological puzzle: earthquakes. "There's a common perception that, 'Oh, we're not California—we don't have earthquakes in Arizona," observes Lee Allison, state geologist and director, AZGS. The agency has amassed volumes of information establishing the potential hazards posed by earthquakes. It has struggled to find a way to communicate the data, however. The team used Layerscape's demonstration tools to develop a presentation in minutes.

The presentation includes a timeline of earthquakes in Arizona and short video clips enticing viewers to go online for a more expansive experience. The team is now using Layerscape to develop a series of pre-packaged tours of iconic locations: a "Virtual Arizona Experience" for the state's Centennial.

The Arizona earthquake animation has given the geologic hazards community a way to show decision makers where and how frequently earthquakes have occurred over the years. This has caught the attention of many people in the state, Allison says.

ASSESSING THE HEALTH OF THE OCEAN

Just a few states away, faculty members in the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University are conducting research into Earth systems, ranging from how ocean currents affect ocean productivity, to the interactions between winds and ocean circulation, to how the circulation of the Earth's mantle drives undersea volcanoes. Mark Abbott, dean and professor, is studying how physical and biological properties affect sound transmission in the ocean.

Abbott regularly uses a wide variety of underwater sensors to gather data for analysis. His team collects terabytes of data per day. While the team can handle the volume, the complexity and variety of the data sets gathered from individual sensors can present issues. Layerscape can reduce the complexity and provide a clearer picture for researchers, Abbott says.

"I think Layerscape can understand how people and the environment interact," Abbott remarks. For example, Layerscape can identify areas where natural disasters—such as tsunamis, earthquakes, or coastal flooding—are more likely to occur. This critical information can help policymakers and citizens make informed decisions regarding infrastructure, such as where to locate future roads or homes. Another potentially critical feature is collaboration, which addresses one of the biggest challenges in earth sciences.

"Collaboration is absolutely essential. Nobody goes to sea by themselves," Abbott asserts. "Not only do they have a crew, there are other scientists, other technicians who bring their talents to bear on this very complicated system. They not only work within an institution, they work internationally and nationally. Having these tools that bring these different data sets together is part of it, but it also brings people together who have different knowledge and expertise."

CONNECTING THE WORLD

Scientists have a lot of work ahead of them to develop a deep understanding of our wonderful and mysterious planet. Technology must play a central role in helping the scientific community make progress, from ocean to desert and from the earth's core to the atmosphere and beyond. Microsoft Research is dedicated to supporting that progress by offering its technology solutions and exploring *with those scientists* which methods and tools we need to build next.