Weather in a Tank

March 17 2010, by Morgan Bettex

The Weather in a Tank curriculum includes several dye-stir experiments, shown here, that are designed to help students understand how Earth's atmosphere and oceans work. Photo: John Marshall, EAPS

In recent years, U.S. undergraduates have shown an increasing interest in introductory meteorology, oceanography and climate classes. But many students find it difficult to grasp the non-intuitive nature of rotating fluids, which is critical to understanding how weather systems and climate work. Part of the problem, it turns out, is that instructors usually have to teach these abstract concepts using only equations or computer simulations because of the limited resources available for lab experiments.

That may be about to change, thanks to the work of two educators from the Department of Earth, Atmospheric and Planetary Sciences. For nearly a decade, Lodovica Illari, an EAPS senior lecturer, and John

Marshall, professor of atmospheric and oceanic sciences, have been developing an undergraduate weather and climate curriculum that's now being adopted by dozens of schools — and could have a wide impact on science education at many levels.

Known as "Weather in a Tank," the experiment-based curriculum was designed by Illari and Marshall in 2001 after they began offering an introductory weather and climate class that would also fulfill their students' lab requirements.

Since 2006, the curriculum has been tested in a project funded by the National Science Foundation (NSF), which involves MIT and five other universities. The intent was to bridge the gap between real-world weather phenomena and the theories and equations that describe those phenomena. Illari says that we should think of lab experiments as the third leg of a three-legged pedagogical stool that includes observation and theory.

Demonstrating fluid behavior

The centerpiece of Weather in a Tank is the equipment: an acrylic tank atop a rotating turntable on a portable cart. Experiments conducted in the rotating tank demonstrate the fluid dynamics of geophysical systems — how the motion of water and air influences Earth's climate.

About the price of a high-end laptop, according to Illari, the equipment can help explain a range of topics related to the atmosphere, oceans and climate, including how Earth's rotation creates weather systems that play a role in keeping the tropics warm and the poles cool.

To simulate these processes, a bucket of ice is placed in the center of the rotating tank of water. The ice creates a range of temperatures inside the cylindrical tank — colder near the bucket, warmer farther away. This temperature gradient is analogous to that of Earth, which is colder near the poles. As the turntable rotates, its motion causes eddies, or small currents, inside the tank. A few drops of food coloring can help students see this.

Because of the temperature gradient, the eddies act like atmospheric weather systems. They carry warm water from the edge of the tank (which simulates the equator) toward the bucket of ice at the center. Simultaneously, they carry cold fluid from the bucket (which simulates the poles) toward the periphery of the tank. Students can then change certain parameters, such as the rotation rate, and see how those changes affect the eddies' circulation at different latitudes. About a dozen of these experiments have been developed, along with associated curriculum materials.

Making the abstract real

Illari cautions that the Weather in a Tank curriculum isn't designed to avoid difficult equations or computer simulations. Instead, it's meant to provide lab experiments that help students understand firsthand the processes that the equations and simulations describe. "We think it's a mistake to give students the phenomena without the tools to understand," she says.

To date, about 25 colleges and universities have either asked for equipment plans, built their own turntables or bought the portable system from the manufacturer that made the original prototype.

Todd Ellis, a meteorology professor at SUNY Oneonta who has used the equipment in his classes, says that teaching fluid dynamics can be hard because the topic is very theoretical and uses complicated math to describe unusual phenomena. While these concepts aren't difficult for oceanography or meteorology majors, they can be tricky for non-majors learning about the equations for the first time.

Ellis agreed that nothing compares to observing how fluids behave in real time. “We spend so much time letting the computers do the figures, and it’s so easy to lose track that these are real substances — that the oceans and atmospheres are fluids,” he says. “You can partly lose the forest for the trees when you always rely on computers to tell you what’s going to happen.”

When the NSF project concludes in July, Illari plans to enhance the curriculum by adding experiments. She also intends to try to drum up interest in it among high schools and other educational institutions.

Illari is already at work with EAPS principal research scientist Chris Hill and other collaborators on another NSF-funded project, which will use cloud computing — the outsourcing of computational tasks to networked servers — to help people conduct virtual experiments on their computers. The goal of the Cloud-Computing Infrastructure and Technology for Education (CITE) project is to bring the Weather in a Tank curriculum to a larger audience by allowing schools to incorporate the tank experiments into their online curricula. A prototype is currently being tested in MIT undergraduate and graduate courses.

Provided by Massachusetts Institute of Technology

Citation: Weather in a Tank (2010, March 17) retrieved 27 April 2024 from
https://phys.org/news/2010-03-weather-tank.html