UA developing network to improve weather forecasting

September 22 2009

Flooding after a summer thunderstorm stops cars at the intersection of Drachman Street and Park Avenue in Tucson, Ariz., in July 2007. Credit: Copyright 2007 Ashley Coles.

An interdisciplinary team of University of Arizona researchers is building a network of soil moisture probes to improve short-term and seasonal weather forecasting.

The National Science Foundation has awarded the UA $5.45 million over four years to fund the project, known as the COsmic-ray Soil Moisture Observing System, or COSMOS.

Water in the soil, said COSMOS team members, exerts an important influence on the climate system, particularly regional precipitation.

The project will measure low-energy neutrons produced when cosmic rays hit the soil. The neutrons are then emitted from the land. The number of neutrons in air above the soil surface is inversely related to soil moisture.

"The project will generate data that may improve weather forecasts, particularly over a longer term-maybe up to two weeks in advance, instead of two to three days," said Marek Zreda, a UA associate professor of hydrology and water resources and principal investigator of the project.

A recent National Research Council report called for a national network of soil moisture measuring devices, said co-principal investigator Xubin Zeng, a UA professor of atmospheric sciences. The COSMOS project will help fulfill that need, the investigators said.

Up until now, measuring soil moisture at the relevant spatial scale was difficult. Researchers could take point soil measurements by digging up soil and drying it.

Such measurements cannot be repeated over and over for the same location, Zeng said.
"If you dig out a hole, you can take some measurements today," he said. "If you want to take measurements again, you have to dig a hole again."

Another method of detection requires burying wires in the soil and measuring electrical impulses.

Zreda said, "If you want to get soil moisture over a large area that is meaningful for atmospheric or hydrologic scientists, you would have to measure maybe hundreds of those points. That's very labor-intensive, time-consuming and expensive."

Scientists can also use satellite images to get average soil moisture for county-sized areas, but only to a soil depth of about one inch (2.5 cm).

The COSMOS project will fill the gap between point measurements and large-scale measures by deploying probes that can detect soil moisture within an area of approximately 90 acres (about 36 hectares). The sensors can assess soil moisture as deep as 2 feet (70 cm) in an area about 720 yards (about 660 m) in diameter.

In addition, the COSMOS project sensors provide soil moisture information quickly, said team member W. James Shuttleworth, Regents' Professor of hydrology and water resources.

"With these sensors you can get the information within an hour or so, via the Web, so it can go into weather forecasting," Shuttleworth said.

The probes will form a data-gathering network and will generate continuous, near real-time measurements.

The researchers will also investigate whether the cosmic-ray probes can distinguish between water in the soil and snow-and-ice moisture that sits above it. Satellites cannot accurately report the water content of frozen soil or snow-and-ice-covered soil, Zreda said.

Although the technology is not new, it has not been applied in this manner before, the researchers said.

Three probes, which look like white electric boxes mounted on poles, already are up and running in southern Arizona. They are located on Mount Lemmon near Tucson, at Biosphere 2 near Oracle, and along the San Pedro River near Sierra Vista. Data from the probes are available online at ace.hwr.arizona.edu/NeutronProbes/ .

The probes, which were designed by a former University of Arizona student, cost about $20,000. Zetetic Institute and Quaesta Instruments, LLC, both located in Tucson, and Hydroinnova of Albuquerque, N.M., were involved in designing and manufacturing the probes.

The team of scientists anticipates spending the first two years of the project installing and testing the probes on different types of terrain and vegetation. The team will use the elbow-grease method of digging holes to calibrate the probes. The researchers plan to test 50 probes across the continental United States.

To determine where the probes should be deployed, the team will hold a workshop in December at the American Geophysical Union meeting in San Francisco to solicit input from the larger scientific community.

A big part of the project will be working with other parts of the scientific community who could also use the data produced by the COSMOS project, Shuttleworth said. For example, ecosystem processes such as the activity of soil organisms, the growth of plants and the carbon cycle are all linked to soil moisture.

Once the testing phase is complete, the researchers hope to be able to expand the network substantially, Zreda said.

Zeng cited support from the UA's Water Sustainability Program, or WSP, as crucial to getting the project off the ground. WSP provided seed money through the Technology and Research Initiative Fund, or TRIF.

Chris Zweck, a UA hydrology and water resources research assistant professor, is also a principal investigator on the grant.

Source: University of Arizona (news : web)

Citation: UA developing network to improve weather forecasting (2009, September 22) retrieved 20 April 2024 from https://phys.org/news/2009-09-ua-network-weather.html

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