New Method to Measure Snow, Soil Moisture With GPS May Benefit Meteorologists, Farmers

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(PhysOrg.com) -- A research team led by the University of Colorado at Boulder has found a clever way to use traditional GPS satellite signals to measure snow depth as well as soil and vegetation moisture, a technique expected to benefit meteorologists, water resource managers, climate modelers and farmers.

The researchers have developed a technique that uses interference patterns created when GPS signals that reflect off of the ground -- called "multipath" signals -- are combined with signals that arrive at the antenna directly from the satellite, said CU-Boulder aerospace engineering sciences Professor Kristine Larson, who is leading the study. Since such multipath signals arrive at GPS receivers "late," they have generally been viewed as noise by scientists and engineers and have largely been ignored, said Larson, who is leading a multi-institution research effort on the project.

In one recent demonstration, the team was able to correlate changes in the multipath signals to snow depth by using data collected at a field site in Marshall, Colo. just south of Boulder, which was hit by two large snowstorms over a three-week span in March and April of 2009. Published in the September issue of Geophysical Research Letters, the snowpack study built on a project Larson and her colleagues have been working on that is funded by the National Science Foundation to measure soil moisture using GPS receivers.

The new study on snow and vegetation moisture will be presented at the fall meeting of the American Geophysical Union being held in San Francisco Dec. 14 to 18.

Larson's group is the first to use traditional GPS receivers -- which were designed for use by surveyors and scientists to measure plate tectonics and geological processes -- to assess snowpack, soil moisture and vegetation moisture. The team hopes to apply the technique to data collected from an existing network of more than 1,000 GPS receivers in place around the West known as the Plate Boundary Observatory, a component of NSF's Earthscope science program.

"By using the Plate Boundary Observatory for double duty, so to speak, we hope this will be a relatively inexpensive and accurate method that can benefit climate modelers, atmospheric researchers and farmers throughout the West," said Larson.

Study collaborators, all from Boulder, include CU-Boulder's Eric Small and Mark Williams, John Braun from the University Corporation for Atmospheric Research, Ethan Gutmann from the National Center for Atmospheric Research and Valery Zavorotny and Andria Bilich from National Oceanic and Atmospheric Administration.

The most recent effort by the team has been conducted in cooperation with Munson Farms of Boulder. The new experiment is designed to analyze how the GPS signals traveling through alfalfa, corn and grass correlate with the amount of water in the vegetation. Small and CU-Boulder students have been cutting and weighing both wet and dry vegetation and matching the sample weights with comparative GPS multipath signal changes using a receiver set up at the farm.

The team is collaborating with Bob Munson, owner of Munson Farms and a former antenna engineer at Ball Aerospace & Technologies of

Boulder. Munson holds more than 30 patents related to antenna design, including one of the most widely used antennas for GPS applications like vehicle navigation and recreational applications.

"With this system, the GPS antenna allows us to see across a whole field, unlike individual moisture sensors that are sometimes set up to measure only small, specific areas," Munson said. If a farmer relied on data from only a single soil moisture sensor that happened to be in a particularly dry pocket of his crop field, for example, it could have a negative effect on the timing and quality of the harvest, he said.

Originally developed in the 1970s for military use, GPS technology is in wide use today, telling drivers and hikers their exact position on the planet and providing directions to their destinations by gathering at least four signals simultaneously from the 31 GPS satellites now orbiting Earth.

Braun, who received his doctorate from CU-Boulder in 2004, also is interested in observing water vapor in the atmosphere by measuring the delay of GPS signals as they propagate through the atmosphere. "Water scarcity is going to be a problem for the western United States in the coming century," he said. "Having improved observations of water in all of its phases is going to be an important step as we monitor changes in the environment, which is the most intriguing part of this project for me."

Larson helped to pioneer the use of GPS as a tool to measure the movement of tectonic plates and the crustal deformation associated with earthquakes as a graduate student at the University of California-San Diego in 1980s. "Even then we knew that the data were corrupted by ground reflection, which was really irritating," she said. "But it was only recently that we began to think maybe there was a way to use these ground reflections to our benefit."

All of the team's research efforts revolve around the water cycle, said Larson. "We want to know if the water is in the ground, in the snow or in the vegetation, and how much is evaporating into the atmosphere, since it will ultimately be returned to the Earth's surface through precipitation events."

Source: University of Colorado at Boulder (news : web)

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