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Sea-studying satellite
By Cindy Stowell

Right now Galveston is 35 feet above sea level. In a hundred years, will it be underwater?

Because predicting changes in sea level is so complicated, no one knows for sure. But two satellites orbiting our planet right now will make those projections a lot easier.

The brainchild of Byron Tapley in UT's aerospace engineering department, the GRACE mission (Gravity Recovery and Climate Experiment), was launched in March 2002 to track changes in the Earth's gravitational field over the next five years. This knowledge will be converted into information about the position of the Earth's water. The study has already produced data 50 times more accurate than previous knowledge, said senior research scientists Srinivas Bettadpur and John Ries.

Tapley, Bettadpur and Ries are part of UT's Center for Space Research. Established in 1981, the center didn't concern itself with the planet's water supply initially, Bettadpur said.

"We started looking at navigation in space, then precise navigation and how to find a satellite to within a centimeter, then making good models to see what drives the satellites' motion," Bettadpur said.

The center became very good at modelling the path of satellites, which is determined by Earth's gravitational pull but also affected by smaller gravitational forces such as tides or lunar positions. Their success led them to wonder if they could do the reverse: use the satellite's location to determine the mass and composition of the land it's travelling over.

With this idea, the center designed an experiment which would measure particularly elusive changes in the Earth's gravity ˇ– changes from mass and movement of water.

Measuring these changes is critical in making predictions about the Earth's climate, said Bettadpur. For example, if a mass of warm water is heading towards a coastal area, that area will experience higher temperatures. If a large glacier is losing mass, that area's temperatures are increasing.

GRACE is born

In 1996, Tapley and colleagues in CSR wrote a proposal to NASA and Deutschen Zentrum für Luft-und Raumfahrt - the German counterpart of NASA - for the GRACE mission to study the changes in the Earth's gravity. This proposal was accepted the following year, and March 17, 2002, an unmanned rocket launched from Russia, carrying the two GRACE satellites into orbit.

The two satellites travel in the exact same polar orbit (meaning that they cross the earth in a primarily north-south direction, going across the North and South pole each orbit), and are approximately 220 kilometers apart. The satellites don't travel over the same parts of the planet for each orbit, so about every 30 days, the current orbit overlaps the one from 30 days before.

The two satellites are in constant communication with GPS satellites to determine their exact position. They are also in contact with each other. Every tenth of a second, a satellite sends a signal to the other to see if the two are moving closer together or farther apart, Bettadpur said.

Since a satellite is attracted to a large mass, such as a river basin where ground is saturated with water, the satellite accelerates quickly towards the basin along its orbit because of the greater pull of gravity. Once over the river basin, the satellite slows down, also because of the increased gravity, and only speeds up once the satellite is farther away from the gravitational attraction of the river basin, Bettadpur said.

Since there is a delay between when the two satellites cross over the same path, the satellites move closer and farther apart from each other.

By measuring their changing speed, the gravitational force required to cause those motions can be calculated. Because the satellites travel over duplicate areas each month, the changes in gravity are observed from one month to the next.

When other known effects like atmospheric pressure, temperatures and ocean topographies are taken away, you get the water movement, Bettadpur said.

The study can be seen in the August journal of "Science," which studied seasonal changes in South American river basins. Previously, it was impossible to see changes this small.

"The previous studies had a resolution of 5,000 to 10,000 kilometers where this study can see changes within a 400-kilometer distance," Bettadpur said.

Finding answers

While these findings are interesting, the real goal of the GRACE mission is to form and test models to predict changes in surface water and ocean levels. After only two years of data, the hydrological models agree well with the GRACE data, Bettadpur said. Hydrological models measure atmospheric and surface water.

"The ocean level models disagree enough to make it interesting."

This makes it likely that some effects are being accounted for incorrectly, said Don Chambers, another research scientist at CSR.

Many factors affect sea levels, including how much river water is diverted inland for drinking water and agricultural purposes, and the rate at which glaciers and ice on Antarctica and Greenland are melting.

"Many current models have the sea level change between falling a millimeter and rising three millimeters per year," Chambers said, but these models don't factor in melting ice and glaciers around the world.

By monitoring changes in the glacial and ice shelves, these scientists say GRACE can help produce models to predict sea-level change.

"We can see local weather, we can watch from space and we can measure the water accumulation in many places," Ries said. "But we've never had a direct measure of just how much water or ice is moving around. Now we are seeing it, and this has already indicated deficiencies in the models we relied upon to describe this."

More accurate models documenting climate changes will likely bring policy changes too.

Environmental groups say they welcome any new accurate information.

"Any study that can document the changes, and what is happening to our planet, can contribute to our global understanding," said Ken Kramer, Texas state director of the Sierra Club. "Any addition to that body of knowledge is certainly welcome."

Although the mission length is five years, the satellites may collect data for as long as 10 years, Bettadpur said.

Then the satellites, whose orbit is slowly collapsing on Earth, will crash into it.

By that point, questions about climatic and sea level changes will hopefully have become answers.
