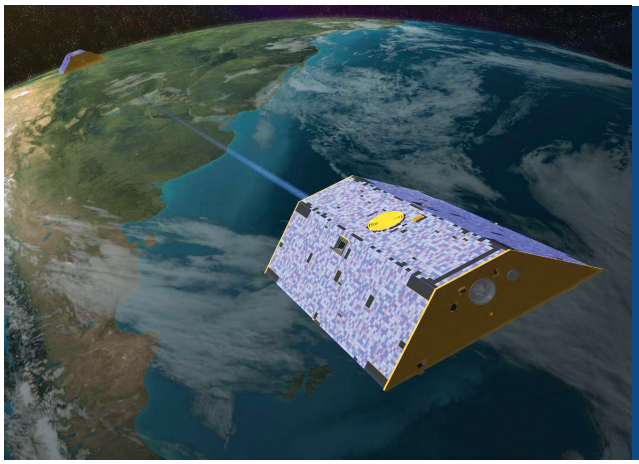
PASSAGE 2

How Do Scientists Study Ice Sheets?

NASA measures ice sheets

For decades scientists would estimate the changes in ice sheets by going to the ice sheets and making measurements with a variety of instruments. In the mid-1990s, a team at NASA had a very interesting idea. The idea was to "weigh" Earth's water by measuring its gravitational force. "Newton's laws tell us that anything that has mass will have a gravitational attraction," explains GRACE project scientist Michael Watkins. "The bigger the mass, the more gravity there is." This means that a mountain has more gravitational pull than a hill, and an ocean has more than a stream. Earth's gravity is not the same wherever you go. This distribution is called Earth's gravitational field.

"We realized, after decades of looking at satellite orbits, that if we could design a mission accurate enough to observe those small changes, we could actually watch the polar ice caps melt," says Watkins. His team suggested using satellites to measure changes in the gravitational field over time. This would help them see how



GRACE, twin satellites launched in March 2002, are making detailed measurements of Earth's gravitational field.

Image Source:
NASA / JPL-Caltech

quickly ice sheets were melting. If they could do this, they could track the motions of large masses of water on Earth. They then developed a satellite mission called GRACE, which stands for Gravity Recovery and Climate Experiment.

How GRACE works

Satellites are able to stay in orbit because of Earth's gravitational field. They respond to changes in Earth's gravity. For example, when a satellite flies over a high-mass area, like a mountain range or an ice cap, the increase in gravitational force causes it to be pulled towards the high-mass area and speed up. After the satellite passes the area, the gravitational force pulls in the opposite direction, slowing the satellite back down. If we can keep track of these changes in velocity, we can create a "gravity map" of Earth.

The best way to observe these minute changes in a satellite's speed is to observe one satellite with another. So GRACE scientists decided to launch two identical spacecraft. They follow each other 240 kilometers (140 miles) apart, going from pole to pole, 500 kilometers (310 miles) above Earth. They constantly measure the distance between each other by beaming microwave signals back and forth. Miniscule changes (as small as one-tenth the width of a human hair) can be detected across these 240 kilometers. The change in distance between the two satellites tells the scientists there is a change in mass below on Earth. This process produces a gravitational field map for the strip of Earth beneath the spacecraft, showing the concentration of mass in different places.

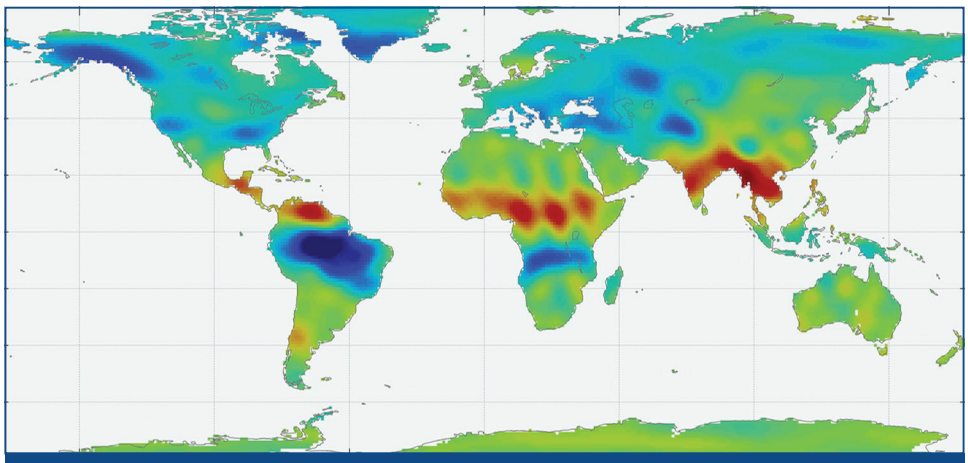
"Weighing" Earth's water and mapping its movements

Changes in the solid Earth are too slow to measure on a month-to-month basis. But water is always moving. Monsoons come and go, ice freezes and thaws, and seasons change. "If you actually look

at the gravitational field from one month to the next, what's changed the most is Earth's thin fluid layer—the oceans and rivers, the polar ice caps, the groundwater," says Watkins.

The GRACE satellites began orbiting in March 2002. They provide the first global coverage of Earth's gravity field from a single source. They circle Earth every 90 minutes, which is 15 times a day, taking 30 days to map Earth's entire gravitational field. The satellites effectively track Earth's shifting water resources more accurately and more comprehensively than ever before. Obtaining data like this from measurements taken on land would be impossible.

For the first time, scientists can see how fresh water is being distributed across the continents. They can see the directions in which it is moving and how long that movement is taking. NASA scientist Jay Famiglietti says, "When we start looking at the whole Earth, and thinking about how water moves from the ocean to the land and how those changes compare to changes in the great ice sheets, we see some very interesting things." GRACE has helped scientists understand much more about how water is stored on land and how it moves around Earth.



Monthly map created by GRACE. Blue areas are wetter than usual. Red areas are drier than usual.

Map Source: NASA

A remarkably accurate view from space

As the GRACE dataset grows, it is revealing long term changes in the Earth's water with more accuracy than ever before. In addition to tracking the movement of glaciers, the satellites are able to measure changes in ocean currents, river basins, reservoirs, aquifers, and ground water. "A lot of our infrastructure was built on the assumption that there were no long-term trends in water storage," says Famiglietti. "But GRACE shows that there are in fact changes, and that we have to deal with them."

PASSAGE 2

Stop and Think Questions

Based on the Text

1. What kinds of data are the scientists collecting? How does this compare to your answer to question 4 at the end of passage 1?

2. What methods are scientists using to collect their data? How does this compare to your answer to question 5 at the end of passage 1?

3. Explain how GRACE satellites are used to determine the distribution of fresh water on Earth.

Looking Ahead

4. What questions do you think the scientists are trying to answer with this data?