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Water. And When It Shifts, So Does Earth's Gravity.

By HENRY FOUNTAIN

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Much of Earth's mass is water, and that water doesn't stay in one place. It evaporates here, condenses there, freezes up north and melts down south. And because gravitational force changes with mass, as Earth's water goes, so goes its gravity.

Measurements of tiny changes in the Earth's gravitational field have given the clearest picture yet of where the water is going. The data, from the Gravity Recovery and Climate Experiment, a pair of satellites, show the seasonal changes in water distribution around the globe, particularly in the Amazon basin, the largest watershed on the planet.

"What we are trying to do is get a snapshot of how the water mass over the Earth changes from month to month," said Dr. Srinivas Bettadpur of the Center for Space Research at the University of Texas, which along with a research institute in Potsdam, Germany, operates the experiment, known by the acronym Grace.

Maps of the changes, published in the July 23 issue of the journal *Science*, show that

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gravitational force in the Amazon increases from February through May as rains bring billions of tons of water to the region. Gravity decreases from July through November as the basin dries out.

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"This is basically remote sensing," Dr. Bettadpur said. "You're measuring changes in mass on the Earth, and the thing that changes the most is water."

But it isn't remote sensing in the conventional sense, when a camera or other instrument on a satellite takes images or measurements of the surface. Grace's satellites are the instruments, Dr. Bettadpur said, and what is being measured is the distance between them.

The two identical spacecraft are in polar orbits about 130 miles apart. As they travel above different parts of the Earth, the varying gravitational pull alters the distance between them slightly. The satellites have a microwave link between them and are equipped with global positioning system receivers so the changes in distance can be precisely calculated.

Dr. Bettadpur said the maps and data from future studies would be useful to hydrologists, whose models of water distribution are often local or, at best, regional in scope. Grace, he said, will allow them to see the bigger picture. The water that falls in the Amazon, after all, has to come from somewhere else.

"What has happened is that mass and energy has gone from one part of the globe to another," Dr. Bettadpur said. "A hydrologist in the Amazon wouldn't notice that."

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