Measuring water from space

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(PhysOrg.com) -- Observations from satellites now allow scientists to monitor changes to water levels in the sea, in rivers and lakes, in ice sheets and even under the ground. As the climate changes, this information will be crucial for monitoring its effects and predicting future impacts in different regions.

Sea level rise in one of the major consequences of global warming, but it is much more difficult to model and predict than temperature. It involves the oceans and their interaction with the atmosphere, the ice sheets, the land waters and even the solid Earth, which modifies the shapes of ocean basins. Measurements from tidal gauges show that for most of the twentieth century, sea levels rose by 1.8 mm per year on average.

Since the 1990s, a number of altimeter satellites have been measuring the height of the ocean surface and this has dramatically improved our understanding of sea level rise. Currently, three altimeter satellites cover the entire globe every 10 to 35 days, and can measure the height of the sea surface to a precision of 1 to 2 cm.

These measurements show that since the start of 1993, sea level has been rising by 3.3 mm a year, almost double the rate of the previous 50 years. "It could be that we are seeing a decadal fluctuation, and in the near future the rate will fall again," says Anny Cazenave, from the Laboratoire d'Etudes en Géophysique et Océanographie Spatiale (LEGOS) in Toulouse, "but I do not think so. For several years now, the rate of rise has not changed significantly."

Melting ice fills the sea

Cazenave's team, and other groups, calculate that for 1993-2003, about half of the sea level rise was due to the oceans expanding as they became warmer, and the other half was due to shrinking land ice. Since 2003, ocean warming has had a temporary break but sea level has continued to rise. Now, about 80% of the annual sea level rise can be attributed to accelerated land ice loss from glaciers, Greenland and Antarctica. This has been revealed by a brand new satellite technique, called space gravimetry.

The GRACE mission comprises two satellites, launched in 2002, which measure how the Earth's gravity field varies with time. The gravity field depends on how mass is distributed on Earth, and affects the speed of satellites in orbit. By closely monitoring the speed of both satellites, as they orbit the planet, it is possible to measure the change in mass of water or ice in different regions.

The method has shown that the Greenland ice sheet is losing about 150 gigatonnes of ice each year, two thirds of which is large chunks of ice flowing rapidly into the sea. The combined effect of ice loss from Greenland and West Antarctica has contributed about 1 mm per year to the rising seas over the past five years.

Rivers run low

Using GRACE, Cazenave and others have also looked at changes in water storage in river basins. In the period from 2002-2006, they found that some basins, including the Congo and the Mississippi, have been losing water, but river systems in the boreal regions are gaining water.

Meanwhile, scientists at the European Space Agency, collaborating with

DeMontfort University in the UK, have begun to use data from the satellites that measure sea level, to assess lake and river levels on land.

Fresh inland water is much in demand, but those managing it suffer from a grave lack of information about how much of it there is. "The number of river gauges is diminishing every day, and many catchments are now entirely unmeasured," says Jérôme Benveniste of the European Space Agency's data processing centre ESRIN, in Frascati, Italy. "But we have 16 years' worth of data on river and lake levels. It's just a question of processing it all."

The work Benveniste is leading can recreate water levels in reservoirs, or lakes, and reconstruct the annual ebb and flow in large river basins like the Amazon.

Other teams are combining these surface water level measurements with gravimetry measurements from the GRACE satellites, to derive the amount of ground water stored in each catchment. "International cooperation is essential in achieving this goal, with global coverage and local validation of the data," says Benveniste. "At the moment, Europe is leading the field."

Source: European Science Foundation