Satellite Measurements of Time-Variable Gravity: what might they tell us about the earth?

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Changes in the distribution of mass within the earth and on or above its surface can cause time-dependent fluctuations in the earth's gravitational field. These fluctuations are certain to be small over time periods of decades or less - many orders of magnitude smaller than the static field, for example. But many of them are large enough to be observable in existing and, especially, future satellite gravity measurements.

Existing satellite ranging data have been used in a number of studies to identify secular trends and seasonal variations in the very longest wavelength zonal gravity coefficients. These have been variously interpreted as due to the effects of post-glacial rebound and of present-day changes in polar ice mass (for the secular trends), and of the atmosphere (for the seasonal variations).

Future dedicated satellite gravity missions will cause a dramatic improvement in the spatial resolution and accuracy of the time-variable results. This is one of the primary scientific drivers behind GRACE, an approved 5-year NASA/DLR mission scheduled for a 2002 launch. It will be possible to use the gravity results from GRACEto address problems in a wide variety of disciplines, from oceanography to hydrology to glaciology to solid earth geophysics.

We will describe the GRACE mission and the possible scientific applications of the GRACE time-variable gravity measurements. Among our conclusions are: (1) GRACE will be able to detect monthly changes in water storage to accuracies better than 1 cm of water, averaged over a few hundred km and greater. These averages can be used, for example, to estimate precipitation minus evaporation over large river basins to accuracies of better than 1 cm/month (2) GRACE will be able to detect monthly changes in sea floor pressure to accuracies of about 0.1 mbar, averaged over 500 km and greater. These averages can be used with altimeter measurements to estimate changes in mid-latitude oceanic heat storage to accuracies of about 15\% in variance; and they can be used to estimate changes in mid-latitude currents at 2 km depth to accuracies of about 10-15\% in variance. (3) By the end of the 5 year mission, GRACE measurements of the post glacial rebound signal over Canada should result in substantial improvement in our knowledge of the Earth's viscosity profile.