Remote sensing

Satellite-based gravitational surveys (*March 2002*)

Outside of tides, two fundamental processes shift mass in our planet, the convective motion of the mantle and lithosphere, and that of the oceans. A second-order means of mass transfer is that of water via the atmosphere, from sources of evaporated vapour to sites of precipitation and temporary storage (as soil moisture and in snow and ice). Any movement of mass should, theoretically, result in changes in the Earth's gravitational field. Exploiting that simple notion presents two practical challenges, sufficiently precise measurements of gravity and its continuous monitoring. Gravimeters used for surveys at the surface are now sensitive enough to give a reading for the mass of a person, provided he or she moves close enough to the instrument (gravity obeys an inverse-square law), but ground-based monitoring is so slow and expensive that continuous monitoring is impossible, except at permanent stations that check micro-gravitational changes near active volcanoes and fault zones. Variations in the height at which satellites orbit the Earth stem from changes in gravity. Although the inverse-square law of gravitational attraction smoothes out gravity anomalies at orbital altitudes, such measurements have been used for three decades to assess the shape of the Earth's surface, were it completely covered with water (the geoid). However, they are not accurate enough to do much more than that.

A project jointly funded by NASA and the German space agency DLR aims to improve the precision of satellite gravity measurements by more than 100 times that of the best to date (Adams, D. 2002. Amazing grace. *Nature*, v. **416**, p. 10-11; doi: 10.1038/416010a). The Gravity Recovery and Climate Experiment (GRACE), launched in March 2002, uses two satellites that follow the same orbit with a spacing of 220 km. Range finders on each measure their separation distance, and so their ups and downs as gravity varies, with far greater accuracy than any other method. Every month they will have gathered enough data to assess the global variation of gravity at their orbital height. That will produce movies of annual and longer term fluctuations, with sufficient detail even to track variations in the Gulf Stream and rises and falls in soil moisture and snow cover, as well as details that relate to deep ocean currents and mantle convection. Unfortunately, gravity and the drag of Earth's atmosphere limits GRACE's lifespan to a mere 5 years.

See also: http://www.csr.utexas.edu/grace/