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# Earth System Montoring by Satellite Gravimetry

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Before the advent of satellite gravimetry, ``Gravity'' has been a tool to determine the Earth's shape. Also, gravity anomaly defined as deviations from reference gravity model has been useful to explore a resource and/or a geological structure. Further, gravity has played a role as data sources for precise determination of geoid. Satellite gravimetry started at the time of the launch of Sputonik in 1957. Artificial satellite's orbit is disturbed by the Earth's spatial inhomogeneous gravity fields. Precise measurement of the trajectory enabled us to infer global gravity fields. Four parameters of geodetic reference system, i.e., radius, GM, dynamical flattening and angular velocity, were also precisely determined after the launch of artificial satellite. It should be noted as an early contribution from Japan to satellite gravimetry that Kozai (1959) discovered the Earth has a pear-shaped gravitational potential. Ever since, gravity field model has improved its spatial resolution. Secular changes in gravity fields were discovered in early 1980's, and interpreted as an effect of postglacial rebound. In 1990's, seasonal changes in low order coefficients in gravity fields were detected and interpreted as caused by redistributions of surficial fluid such as atmosphere and ocean. So far, the gravity field inferences based their foundation on the precise determinations of artificial satellite's orbit.

Setting aside satellite altimetry, novel gravity field inference in the next decades will rely on satellite-to-satellite tracking(SST) and/or satellite gravity gradiometry. The CHAMP(CHAllenging Minisatellite Payload) satellite launched on July 2000 in collaboration of US and Germany is an low Earth orbit satellite at an altitude of 450 km, and delivering data sources derived by high-low SST that enable to determine the Earth's temporal changes in gravity field; http://op.gfz-potsdam.de/champ. In March 2002, two low Earth orbite satellites are going to be launched, which is known as GRACE(Gravity Recovery And Climate Experiment). GRACE is expected to provide us with three orders of magnitude more precise gravity field in low order gravity fields less than 40 degrees (Dickey et al. 1997). GOCE(Gravity Field and Steady State Ocean Circulation Explorer) now planned in ESA is going to be equipped with full tensor gravity gradiometer, and they focus upon finer spatial resolution gravity fields than CHAMP and GRACE. Expected applications of those gravity data include constraints into mantle(lithosphere) dynamics. Moreover, in conjunction with altimeter data from JASON launched on December 2001, we could expect a more improved geoid model and thus more precise inference of global ocean circulation.

A fundamental difference of CHAMP and GRACE from forgoing artificial satellites for space based gravimetry is that these satellites aim to detect ``temporal'' changes in Earth's gravity. GRACE is going to deliver spherical harmonics coefficients of gravity every one months. In other words, they are going to directly measure a global mass redistribution on a time seasonal time scale by space-based instrument. Meanwhile, redisribution of atmospheric mass is independently measured as ground pressure changes, and further objective analysis data is available as well. Hence, within the precision of reliable spatio-temporal scales of these independent data, we can monitor the global scale changes in mass distribution other than the atmosphere. Roughly speaking, therefore, we can infer a global water redistribution as an integrated quantity. They may provide a breakthrough for a remote sensing of water circulation in hydrology, snow and glacilogy.