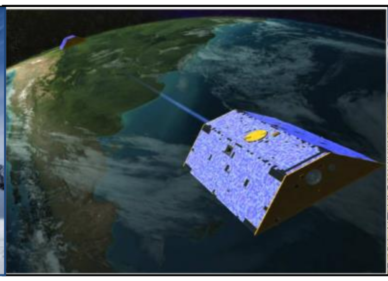
Theme: Mass transport

Estimation of the maximum spatial resolution achievable from GRACE satellite data


Research context

Satellite gravimetry missions, like GRACE and GRACE Follow-On, deliver information about mass transport in the Earth's system since 2002. This information is of high importance for various Earth sciences, including hydrology, climatology, and ice sheet studies.

Spherical harmonic expansion is a commonly-used tool when GRACE (and GRACE Follow-On) data are converted into estimates of mass anomalies at/below the Earth's surface. Traditionally, monthly sets of spherical harmonic coefficients are computed up to degree L_{max} = 60 or 96, which corresponds to the spatial resolution of 200 to 300 km (in terms of half-wavelengths). We hypothesize that such a choice may result in a substantial loss of high-frequency information contained in the original data. Polar areas, where the Signal-to-Noise (S/N) ratio of GRACE data can be particularly high, is a matter of a special concern. This is because of: (i) a high density of satellite groundtracks; (ii) relatively short time intervals between satellite visits, which makes measurements of (residual) rapid mass variations more representative; (iii) a relatively large angle between ascending and descending groundtracks, which makes the sensitivity of measurements more isotropic; and (iv) the fact that long-term changes (e.g., linear trends) are frequently the primary focus, which allows noise in the data to be largely averaged out.

Purpose of the research

The major research objective is to estimate the maximum spatial resolution achievable from GRACE satellite data. In other words, to find the maximum degree L_{max} of the spherical harmonic expansion that allows the information content of the original satellite data to be fully preserved even in the scenarios with the highest S/N ratio.

Methodology

The research will be based on numerical simulations. It is envisioneed that the major steps will be:

1. To generate realistic high-resolution realizations of signals associated with long-term mass changes in polar areas (e.g., Greenland). To that end, altimetry-based elevation changes can be used (after a proper scaling).
2. To generate realistic realizations of noise in GRACE-based spherical harmonic coefficients that describe long-term mass changes. Available estimates of noise in the original GRACE data can be used at this stage.
3. To prepare realistic realizations of noisy data (signal+noise) in the form of sets of spherical harmonic coefficients up to different maximum degrees L_{max}.
4. To perform a statistically-optimal inversion of noisy datasets into mass anomalies and select the maximum degree L_{max} at which a convergence of the results is observed.

In the course of the project, the student will have an opportunity to gain/expand/apply his knowledge in:

- satellite gravimetry
- statistics and inverse theory
- programming

A sussessfully completed study may culminate in the preparation of a manuscript for a high ranked scientific journal.

Further information and project supervisor:

- Dr. Pavel Ditmar (TU Delft, GRS, email: p.g.ditmar@tudelft.nl)