Improving GLAS data using GRACE

This document serves as a brief synopsis of the following article:

Wahr, J., D. Wingham, C. Bentley. 2000. A method of combining ICESat and GRACE satellite data to constrain Antarctic mass balance. *Journal of Geophysical Research* 105 (B7): 16,279-16,294.

A primary use of the Gravity Recovery and Climate Experiment (GRACE), launched on 17 March 2002, is to measure changes in sea surface height over time; however, GRACE also has the potential to help improve the reliability of Greenland and Antarctic ice sheet mass balance measurements from GLAS. GRACE measures the Earth's geoid, or gravity field. A geoid is a surface of constant gravitational potential lying close to the mean sea level. The geoid lies close to the ellipsoid (the simplest model of the shape of the Earth); departures from this shape on the order of ± 100 m are due to variations in the Earth's density and topography.

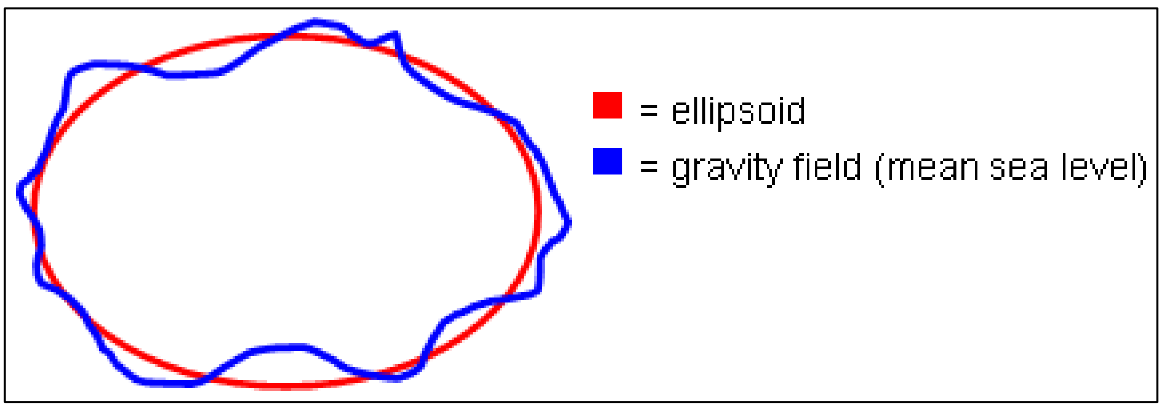

Figure 1. Variations from Geoid

One of the principal error sources in estimating mass-balance using GLAS data is inadequate knowledge of postglacial rebound (PGR). What is PGR? Because the solid Earth is an elastic body, it is still adjusting to the accumulation and subsequent melting of ice that occurred during and after the last ice age. Reduction of ice loads over Greenland and Antarctica since the last ice age is causing a gradual uplift of the Earth's crust underlying these areas; thus, you cannot separate crustal uplift from actual changes in ice surface heights in the GLAS altimetry data. Mass balance and sea level rise calculations are confounded by PGR as a result (~0 to -0.3 mm/yr in sea level estimations).

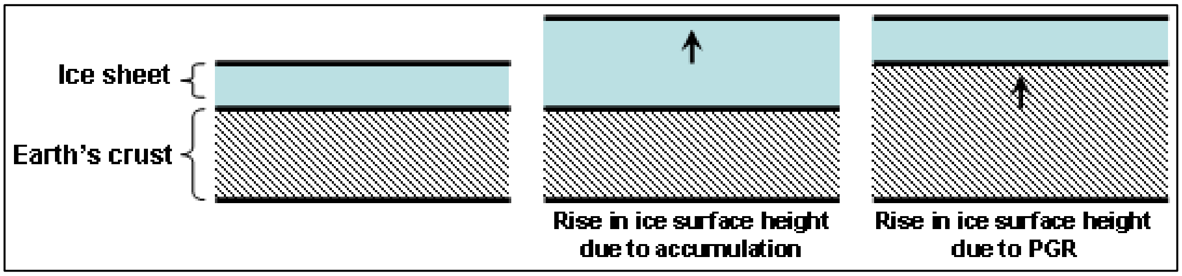

Figure 2. Postglacial Rebound

Crustal uplift due to PGR increases the gravitational field. Because PGR effects two independent measurements (altimetry and the geoid; GLAS and GRACE), we can use both measurements to factor out PGR and improve mass balance calculations, as follows:

1. Infer the geoid change caused by the difference in two GLAS mass balance estimates. Remove this geoid change from the GRACE data. The residual gravity field is assumed to be entirely caused by PGR.
2. Calculate the amount of crustal uplift due to the PGR estimate in step #2.
3. Remove this crustal uplift from the GLAS altimetry data. The residual altimetry is used to determine a better mass balance estimate.

Step #1 introduces other GLAS measurement errors into the procedure. Some error in mass balance will remain.

In summary, the contribution of GRACE to GLAS shows some improvement in altimetry measurements, but the improvement is marginal in the short term (five-year range) due to interannual accumulation and compaction variation that also compound results; however, as follow-on missions are flown and more data are collected, errors from these fluctuations are reduced and the impact of using GRACE to correct for PGR is more significant.

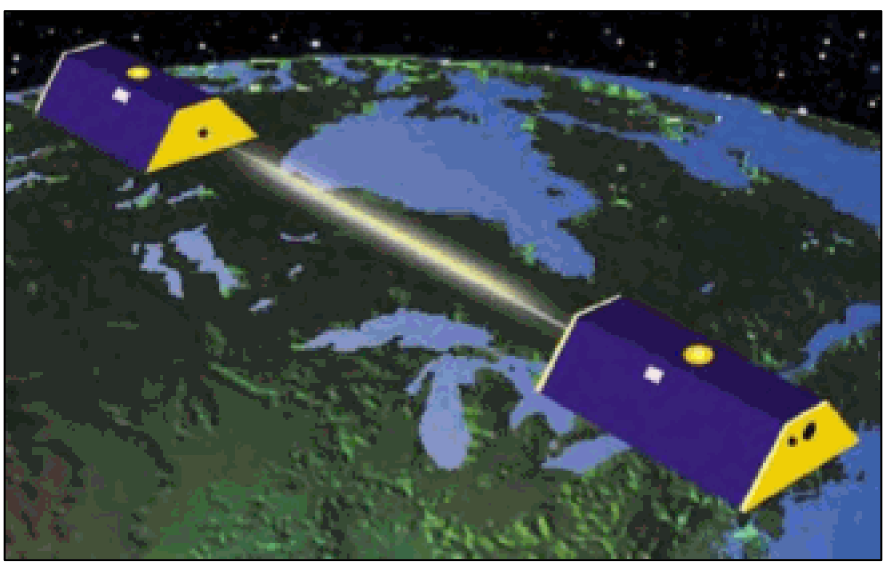

Figure 3. GRACE Mission