Mass Balance and Present-day Antarctic Rebound and Gravity Change

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Two satellite missions, one designed to detect gravity change (Gravity Recovery and Climate Experiment, or `GRACE') and the other (ICESat) for determining changes in ice sheet elevation may soon provide a powerful new data set capable of determining mass changes within the Antarctic ice sheet. Wu et al. (2002) and Velicogna & Wahr (2002) have recently advocated that additional data from GPS crustal motions may be employed as a third independent data set, when combined with GRACE gravity and ICESat altimetry simultaneously, to constrain postglacial rebound (PGR). Here we examine the estimated signal and possible sources of error for the purpose of separating the ongoing ice mass change signature from that associated with past deglaciation. Bounds on the uplift signature now appear to be emerging from a number of recent GPS data sets obtained on solid bedrock across the Antarctic continent. During the past decade other information (on ice GPS, differential radar interferrometry, radar altimetry, etc.) have determined bounds on the total volume change of ice that contribute to equivalent sea level rise (ESL) during 1990-2000. The rate of positive ESL change due to the net mass imbalance of West Antarctica occurs at a rate of about 0.11 +- 0.026 mm/yr (Rignot & Thomas, 2002). East Antarctica is less well-deterrnined but appears to be near net balance. If valid, such comprehensive studies place bounds on the time rate of change in geoid that should be observable with GRACE. The ice mass loss from glaciers that feed into the Amundsen Sea produce secular geiod changes that are at the –1 to –1.5 mm/yr level over 800 – 1000 km wavelengths. Such a signal could be detected with GRACE gravity data over the projected 5-year mission lifetime. A PGR geoid change signal may be predicted from the variety of ice sheet reconstructions available, albeit, the undetermined regional mantle viscosity is a far more tricky issue at the present time. A preliminary estimate is made based upon our current modification of a model published by Denton et al. (1990) and "Fennoscandian" mantle viscosity profile and lithospheric thickness. The geoid changes are comparable in magnitude, but opposite in sign, to those of present-day mass wastage (MW) signal. The PGR signal has a substantially longer wavelength signal than does that produced by MW. The peak PGR uplift signature tends to be of order 4-8 mm/yr while the peak MW induced isostatic (elastic) uplift signal is 2-5 times smaller and of shorter wavelength.

References:

Denton, G.H., M.L. Prentice & L.H. Burckle, 1991, in Geology of Antarctica, (ed. R.J. Tingey), Oxford Univ. Press, N.Y., pp. 365-433.

Rignot, E. & R. H. Thomas, 2002, Science, 297, 1502-1506.

Velicogna, I. & J. Wahr, 2002, J. Geophys. Res. (DOI 10..1029/2001JB001735).

Wu, X., M.M. Watkins, E.R. Ivins, R. Kwok, P. Wang, & J.M. Wahr, 2002, J. Geophys. Res. (DOI 10.1029/2001JB000543).