

## Acceleration and deceleration of ice thickness variations in Greenland from ICESat laser altimetry (2003-2009)

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The laser altimeter mission ICESat, launched by NASA in January 2003, measures the Earth's surface elevation with a precision of several cm. ICESat has performed campaign observation of about 90 days a year between September 2003 and October 2009. The spatial resolution of the measurement in Greenland is about 20 km in average. In this study, we analyze acceleration/deceleration of ice thickness variations in Greenland from ICESat elevation data. We employ Plane fitting method (e.g. Zwally et al., 2011) to correct topographic effect coming from gaps of repeat-track paths, and fit the time-series of surface elevation variations with a linear combination of linear and quadratic terms by least-squares method at every 700m interval. The quadratic trend signal thus extracted represents accelerated/decelerated variations.

The obtained linear variation suggests significant ice thinning trend in southeastern and western Greenland. Their thinning rates attain to about 1.5-2 m/yr. On the other hands, inland area shows ice thickening trend with a rate of 0.3 m/yr. Assuming the firn density as 700 kg/m<sup>3</sup> in ice thinning area and 300 kg/m<sup>3</sup> in ice thickening area, we obtain the total ice loss rate of about -200 Gt/yr, which is equivalent to about 0.55 mm/yr sea level rise. This agrees well with GRACE gravimetric estimate.

Next we focus on the quadratic variation. Western Greenland shows significant negative quadratic variations, suggesting acceleration of ice thinning rate. Such trend is particularly noticeable in Jakobshavn glacier and Qaanaaq area. On the other hands, southern Greenland shows different behaviors: negative quadratic variations (accelerated ice thinning) in Helheim glacier and Kangerdlugssuag glacier, and positive quadratic variations (decelerated ice thinning) in other coastal area. We speculate that accelerated ice thinning in the above outlet glaciers reflects recent global warming, while decelerated ice thinning in other coastal area of southern Greenland does anomalous precipitation of Arctic Oscillation with positive phase during the winter of 2007-2008.

Keywords: Greenland, Ice thickness variation, Climate change, Space geodesy, ICESat, GRACE