Numerical modeling of crustal deformation and gravity change caused by glacier melting in Southeast Alaska

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Glacier melting caused by global warming is of great interest as a factor of sea level rise. Spatiotemporal variations in glacier melting have been monitored by geodetic observations such as altimetry, gravimetry and GNSS. However, since these observations contain various responses of solid earth, many devices are necessary in order to estimate glacier melting from observation data. As one of the devices, it is considered to construct numerical model of solid earth deformations caused by glacier melting. Because glacier melting involve variation of mass distribution in earth’ s surface and deformation of solid earth (GIA : Glacial Isostatic Adjustment), glacier melting cause various spatiotemporal deformations such as sea level change, crustal deformation, and gravity change. Therefore, in order to quantify the present spatiotemporal variations in glacier melting directly, it is necessary to improve numerical model regularly.

In Southeast Alaska that is the main area of this study, about 16 km^3/yr of glaciers melt at present (Larsen et al., 2007) and those melting speed may be accelerated these days (Arendt et al., 2002). GNSS stations has been installed in this area since the 2000s, and they observed large ground uplift of up to 3 cm/yr associated with GIA (Larsen et al., 2004). The spatial variation of the uplift was already modeled by Larsen et al. (2005) and Sato et al. (2012) numerically. On the other hand, absolute gravity values have been measured in this area sinse 2006, and absolute gravity changes of -4~-7 microGal/yr were detected (Sun et al., 2010). However, any previous studies have not considered the observed gravity changes in their numerical model, so the gravity variations are not reproduced quantitatively as of now.

Therefore, we numerically model spatiotemporal variations in crustal deformation and gravity change derived from GIA in Southeast Alaska as follows. Both of crustal deformation and gravity change are mainly composed of two effects: the elastic deformation due to the present glacier melting, and the viscoelastic deformation due to the past glacier melting. Gravity change is additionally caused by the time variation in the attraction effect due to the present glacier melting. We here estimate these effects expected at six absolute gravity points in Southeast Alaska, by numerically computing the spatiotemporal integral of the present-day ice melting model (Larsen et al., 2007) and the ice melting history model (e.g., ICE-6G; Peltier et al., 2015). We compare the estimated results with the data observed in Southeast Alaska until 2015, to discuss the present glacier melting in this area.

Keywords: glacier melting, glacial isostatic adjustment, Alaska, gravity change, crustal uplift

