Seasonal variation of vertical crustal deformation in southeast Alaska

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Many glaciers and ice fields in southeast Alaska have been rapidly retreating since the end of the Little Ice Age (from the mid-14th century to the mid-19th century). Recently, rapid uplifting caused by the deglaciation is detected by GPS observations in this region with the maximum rate reaching ˜30 mm/yr (Larsen et al., 2004, GJI). Therefore, this region is the best place in the world to study ongoing glacial isostatic adjustment (GIA) and its mechanism, by means of monitoring crustal deformation caused by global warming. GPS time series, however, contains some other effects except uplifting by global warming, such as interplate interaction, snow and atmospheric loading, ground water level, and excess path delay in atmosphere, which prevent from accurate estimation of secular uplift rate.

Consequently, it is important to reveal the cause of seasonal variation in GPS time series, and we examine amplitudes and phases of the seasonal variation at each GPS site. We use GPS data obtained at 35 sites of Plate Boundary Observatory for the period from January 2006 to October 2008.

GPS data are processed with the Precise Point Positioning (PPP) strategy implemented in GIPSY-OASIS II ver.5 software (Zumberge et al., 1997, JGR) to determine the site coordinates. We then fit a function consisting of linear, annual and semiannual terms to GPS time series by estimating coefficients of each term by least-square method. As a result, vertical components show conspicuous seasonal variations, while nothing in horizontal ones at all stations. Stations with large annual amplitudes (˜11 mm at the maximum) are located near the glaciers and ice fields in south and southeast Alaska. Phases of the annual components are almost identical among most of stations, and the maxima occur around October.

The spatial distribution of the amplitudes of the annual variations demonstrates some correlation with that of mass change estimated by GRACE (Luthcke et al., 2008, J. Glaciol.). The correlation coefficient between the elevation and the loading converted from mass change by GRACE is ˜2.2 mm/kPa, which is consistent with the value of 1.5 mm/kPa estimated for Tohoku district, northeast Japan by Heki (2001, Science). It is suggested that the seasonal variation in vertical crustal deformation in southeast Alaska can be mainly attributed to snow loading in winter. For the future work, we will numerically reproduce the deformation based on observed snow data to investigate, and will examine another possibility for the seasonal variation.