Glacial melting in Asian high mountain ranges derived by GRACE gravimetry

K. Matsuo[1] and K. Heki[1]

[1]*Department of Natural History Sciences, Hokkaido University*

Tectonic uplift associated with the collision and convergence between the Indian and the Eurasian Plates formed the Tibetan Plateau and Asian high mountain ranges, such as Himalaya, Karakoram, Kunlun, Pamir and Tien-Shan, since the middle Eocene (~50 Ma). These extreme reliefs block the wet summer monsoon from the Indian Ocean and the winter westerly, resulting in the development of extensive mountain glacier system in this region. As a result, Asian high mountain glacier system forms the largest store of water ice in middle and low latitude regions known as the "Third Pole" of the Earth after the North and South poles (Qiu, 2008). In recent years, rapid shrinking of mountain glaciers due to recent global warming has been reported in many parts of the world. According to the results of field observations 1961-2003 compiled by Dyurgerov and Meier (2005), the largest glacial loss goes on in southeastern Alaska (53.8 Gt/year), and the second in the Asian high mountains around Tibetan Plateau (30.7 Gt/year) and the third in Patagonia (16.9 Gt/yr).

A system of twin satellites Gravity Recovery and Climate Experiment (GRACE), launched in 2002 to measure time-variable gravity field with monthly time resolution, enabled direct measurement of mass loss rates over extensive mountain glacier systems. Such observations revealed glacial loss of 115 Gt/yr in Alaska (Tamisiea et al., 2005) and 27.9 Gt/yr in Patagonia (Chen et al., 2007), which indicates the duplation of ice loss rate from 1961-2003 due to accelerating warming.

In this study, we focus on Asian high mountain glacier system, and try to estimate current ice loss rate there using GRACE time-variable gravity data sets during 2003-2009. As a result, we obtained 47±12 Gigaton (Gt) yr^{-1} as the average ice loss rate in this region, equivalent to ~ 0.13 ± 0.04 mm yr^{-1} sea level rise. This is twice as fast as the average rate over ~ 40 years before the studied period, and agrees with the global tendency of accelerating glacial loss. Such ice loss rate varies both in time and space; mass loss in Himalaya is slightly decelerating while those in northwestern glaciers show clear acceleration. Uncertainty still remains in the groundwater decline in northern India, and proportion of almost isostatic (e.g. tectonic uplift) and non-isostatic (e.g. glacial isostatic adjustment) portions in the current uplift rate of the Tibetan Plateau. If gravity increase associated with ongoing glacial isostatic adjustment partially canceled the negative gravity trend, the corrected ice loss rate could reach 61 Gt yr^{-1}.