Spatial distribution of sea level changes around Japan revealed by GPS, satellite altimetry, and tide gauge data

Shogo Kuga[1]; # Kosuke Heki[2]

[1] Dept. Earth Sci., Hokkaido Univ.; [2] Div.Earth Planet. Sci., Hokkaido Univ.

Sea level rise due to global warming has been threatening the world, and precise geodetic measurement of on-going sea level change rate is important also from social point of view. Quantitative assessment of individual factors influencing the sea level has not been adequate, and total sea level change predicted as the sum of the factors is 0.7+/-1.5 mm/year. So the prediction does not even tell whether the sea level will rise or drop. It is uncertain, either, if melting of the polar ice is contributing to the eustatic sea level rise. In fact, recent discoveries of secular thickening of ice sheets in East Antarctica and inland of Greenland by ERS-1/2 radar observations (Davis et al. 2005; Johannessen et al., 2005) even suggest that ice polar ices are mitigating sea level rise. On the other hand, observations of the sea level by two methods show that it is rising, i.e. tide gauges indicate 1.5 mm/yr, and Topex/Poseidon and Jason altimeters show 2.8 mm/yr average sea level rise. Altimetry also revealed that sea level changes are quite non-uniform, which is due largely to the thermal expansion of sea water. In Japan, active crustal deformation hampered application of tide gauge data to eustatic sea level change studies. They are instead utilized as indicators of vertical crustal movement. In this study, following the method of Heki (2004), we added vertical crustal velocities of nearest GPS points to tide gauge data, and obtained absolute sea level changes relative to the geocenter. We used about one hundred tide gauge data, which yielded the average sea level rise in Japan of 1.9 +/- 0.25 mm/yr. This value is smaller than the sea level rise from satellite altimetry (2.8 mm/yr) and is larger than worldwide tide gauge average (1.5 mm/yr). Our study suggests that tide gauges in active areas like Japan can contribute to the eustatic sea level change studies if vertical crustal movement components are removed using GPS data. Sea level changes around Japan are not uniform, but have standard deviation as large as 2.4 mm/yr; sea levels in eastern Hokkaido and east coast of the Northeast District tend to go up while those in the Tokai area and southwest Shikoku show significant drop. Such tendencies are, however, not fully consistent with those suggested by satellite altimetry. Our method assumes that sea level trends in tide gauge records are constant over the time windows of both of the tide gauge and the GPS data. This is not the case for many of the tide gauge/GPS pairs, i.e. tide gauges often have time spans longer than a few tens of years while GPS points have only a decade of data. This might be responsible for some inconsistency between sea level changes by tide gauges and altimeters.

Cazenave, A. and R. Nerem, Present-day sea level change: observation and causes, Rev. Geophys., 42, RG3001, 2004.

Church, J. et al., Changes in Sea Level, in Climate Change 2001: The Scientific Basis, contribution of WG01 to the 3rd assessment report of the Intergovernmental Panel of Climate Change, edited by J.T. Houghton, pp.639-693, Cambridge Univ. Press, 2001.

Heki, K., Space geodetic observation of deep basal subduction erosion in northeastern Japan, EPSL, 219, 13, 2004.

Davis, C.H. et al., Snowfall-driven growth in East Antarctic ice sheet mitigates recent sea-level rise, Science, 308, 1898, 2005.

Johannessen, O.M. et al., Recent ice-sheet growth in the interior of Greenland, Science, 310, 1013, 2005.