Seasonal variation of ocean bottom pressure, geoid height, and earthquake occurrences: comparison between GRACE and ECCO

Takeshi Kataoka[1]; Kosuke Heki[2]

[1] Nat. Hist. Sci. Hokkaido Univ.; [2] Dept. Natural History Sci., Hokkaido Univ.

Monthly gravity fields of the Earth in terms of Stokes' coefficients have been available with degree/order complete to 100 or so, as the level-2 data of the GRACE (Gravity Recovery and Climate Experiment) satellite since 2002. Such data contributed much to our knowledge of time-varying gravity field, including seasonal variation of land hydrology and secular variation of the ice mass due to global warming. Their application also includes physical oceanographic studies of seasonal variation of sea water mass, for example, in the Mediterranean Sea (Fenoglio-Marc et al., 2006).

Large earthquake that occur in the Nankai and Sagami Troughs are known to concentrate in autumn and winter with statistical significance (Ohtake and Nakahara, 1999). In order to clarify its mechanism, we have been investigating seasonal changes in ocean bottom pressure (OBP) due to the changing mass of the overlying sea water and their influence on Coulomb failure stress (CFS) at the faults (Heki and Kataoka, 2006). ECCO (Estimating the Circulation and Climate of the Ocean) is a data-assimilated global ocean circulation model driven mainly by wind stress, and it gives half-daily OBP values in the entire ocean areas. OBPs near the Japanese Islands are found to show seasonal variations with peaks in summer, which is qualitatively consistent with the concentration of earthquakes in autumn/winter. However, although coastal tide gauges show seasonal sea surface height variations of 20-30 cm (2-3 kPa change in OBP if barotropic), OBP in ECCO showed seasonal variation amplitudes of only a few hundreds of Pa in the Pacific Ocean side. This is, by an order of magnitude, too small to account for the observed seasonality in seismicity. Large variations seen generally in tide gauges on the Pacific side seem to come from thermal steric variation or baroclinic changes and are irrelevant to the concentration of earthquakes in autumn/winter.

On the other hands, OBPs in ECCO have seasonal variation amplitudes comparable to those in tide gauges in the Japan Sea side, where concentration of earthquakes in autumn and winter is not known. If such a large change is real, it is above the detection level of GRACE, and we could see seasonal change in gravity/geoid height in the Japan Sea. In this study, we try to detect this in the GRACE monthly gravity data. In addition to isotropic Gaussian filter for spatial averaging (Wahr et al., 1998), we also try to use a filter to suppress longitudinal stripes (Swenson and Wahr, 2006). We also discuss the correction of land hydrology and snow loads in nearby land areas, such as the Japanese Islands, and Korean Peninsula.

References

Fenoglio-Marc, L., J. Kusche, and M. Becker, Mass variation in the Mediterranean Sea from GRACE and its validation by altimetry, steric and hydrologic fields, Geophys. Res. Lett., 33, L19606, doi:10.1029/2006GL026851, 2006.

Heki, K. and T. Kataoka, Seasonality of ocean bottom pressures and earthquake occurrences: a new approach using the ECCO model, Fall Meeting of Seismological Society of Japan, 2006.

Ohtake, M. and H. Nakahara, 1999, Seasonality of great earthquake occurrence at the northwestern margin of the Philippine Sea Plate, Pure Appl. Geophys. 155, 689-700.

Swenson, S. and J. Wahr, Post-processing removal of correlated errors in GRACE data, Geophys. Res. Lett., 33, L08402, doi:10.1029/2005GL025285, 2006.

Wahr, J., M. Molenaar, and F. Bryan, Time variability of the Earth' s gravity field: Hydrological and oceanic effects and their possible detection using GRACE, J. Geophys. Res., 103, 30205-30229, 1998.