Annual Crustal Deformation in Central Japan, Estimated from Wavelet Analysis of GPS Time-series Data

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#1. Introduction: The GPS time-series data from GSI/GEONET(Geographical Survey Institute/GPS Earth Observation NETwork) has revealed that crustal deformation apparently includes annual variations. It is controversial whether it is real crustal deformation or it is just fictitious. As a mechanism, which explains such annual variations, Heki(2001) has proposed snow loads, because the theoretical values of vertical movements caused by snow loads and the observation values by GPS are almost coincident in northeastern Japan. Murakami & Miyazaki (2001) have presumed that these would depend on the mutual interactions between the continental and oceanic plates. After these researches, the GPS time-series data have been re-analyzed and largely improved (Hatanaka et al., 2001). Here, we executed the wavelet decomposition analyses for these data obtained during the period from April 1996 to May 2002, and reexamined the annual crustal deformation in the Kanto and Chubu regions in central Japan (34.0N~38.0N; 135.5E~141.0E).

#2. Wavelet analysis: The north-south (NS), east-west (EW) and up-down (UD) components of the GPS time-series data were assumed to be mutually independent. We decomposed each of these NS, EW and UD components up to the 8th level by using the Daubechies wavelet family. Concretely, we decomposed the original time-series data to the approximation part, A1 and the detail part, D1. Following this, we decomposed A1 to the approximation part, A2 and the detail part, D2. We could continue the same procedures as above up to some desired level. We could recognize a seasonal variation clearly in the D8 part. We estimated both amplitudes and phases of annual crustal movements at 208 GPS sites in central Japan.

#3. Annual crustal movement: The average amplitude of horizontal components of annual crustal movements was estimated to be 3.0 mm, and their maximum 11.7 mm. The average of UD components was estimated to be 17.7 mm, and their maximum 78.4 mm. The phases of horizontal components were changed depending on the locations of GPS observation sites. Especially, the directions of the horizontal displacement vectors in the Pacific coastal area were shown to be opposite to those in the Japan Sea coastal area. In short, the horizontal displacement vectors in the coastal areas turn toward seaside in summer and toward inland in winter (Fig. 1). Although the phases of UD components regularly changed, their average amplitudes were different from year to year; the minimum of 15.5 mm in 1999 and the maximum of 21.7 mm in 2001. The crust was upheaved in summer and was subsided in winter. Since the phase of annual vertical movements coincides with that of annual tidal changes (Fig. 2), the mechanism of the annual crustal deformation should be related to the tidal force.

#4. Summary: It was revealed that the amplitude of annual crustal deformation in the coastal areas is larger than that in the inland areas. We indicated that the Japanese islands are contracting in winter and expanding in summer. It might be difficult to explain such crustal deformation by snow loads only. The annual horizontal crustal movements might be real crustal deformation, because they were strongly dependent on the location of GPS observation sites. In future, we will investigate the mechanism of the annual crustal deformation, considering the annual tidal force.

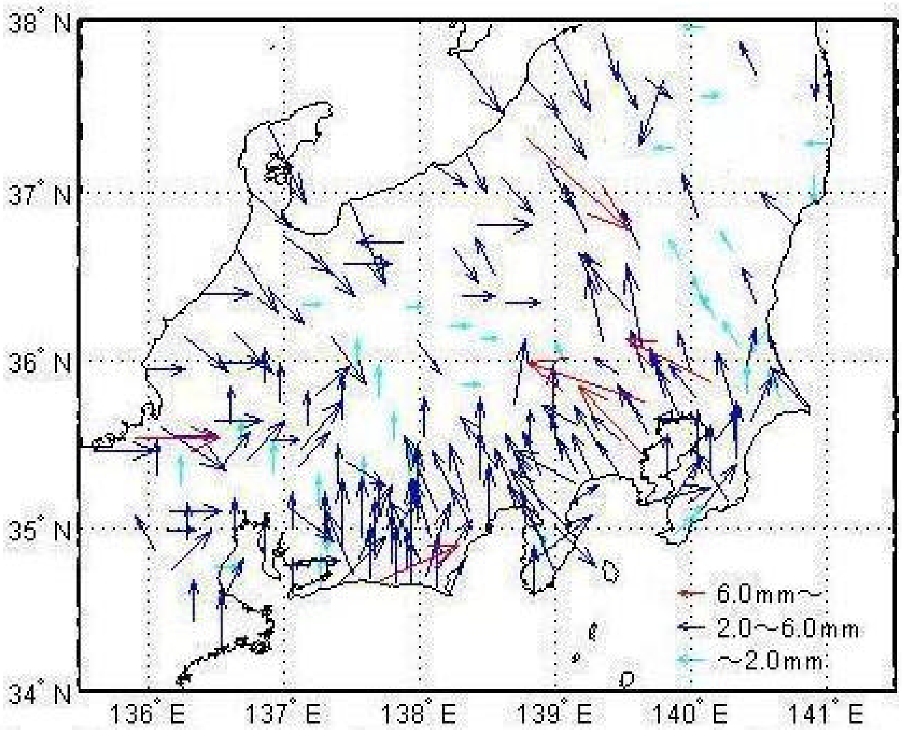

Figure1

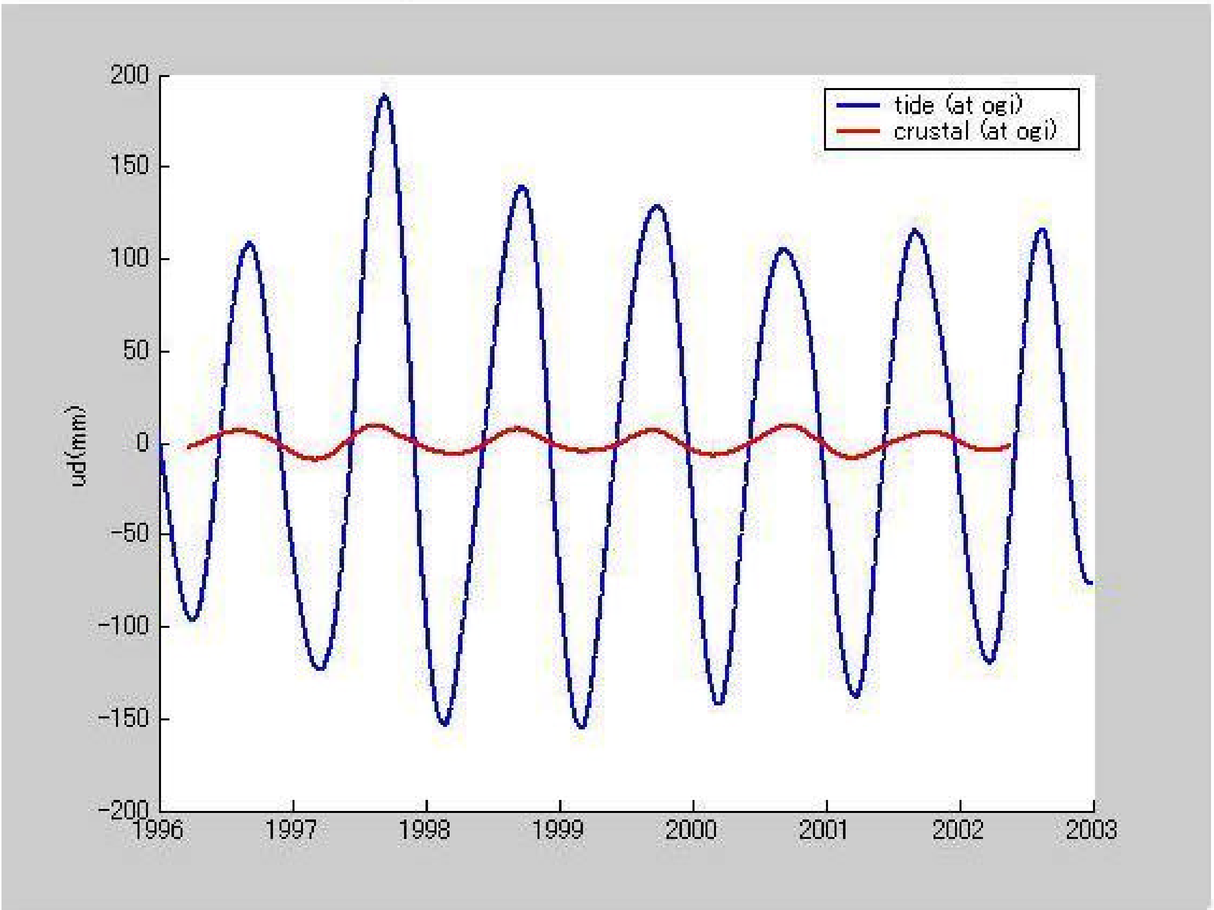

Figure2