Changes of gravity and pressure caused by 2003 Tokachi-Oki Earthquake recorded by GGP-Japan Network

GGP-Japan Group[1]

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Earthquakes are, in a sense, rearrangement of the mass distribution in the Earth, and give rise to permanent changes in Earth's gravity potential. Therefore, small changes in gravity values will be observed around source regions before and after earthquakes, including the effect of vertical displacement of lands. Sun and Okubo (1993, 1998) developed a method for calculating the magnitude of gravity changes caused by earthquakes based on the dislocation theory. It was shown that their method reproduced well the result of the gravity survey conducted before and after the great Alaskan earthquake (1964). However, no continuous gravity observation has been successful in detecting the gravity changes by earthquakes.

The Superconducting Gravimeter (SG) is ideal for detecting earthquake-induced gravity changes because of its high sensitivity and stability. There are three SG stations in Japan (Esashi, Matsushiro and Kyoto) that constitute a gravimeter array as a part of the GGP-Japan Network. On September 25, 2003 the Tokachi-Oki earthquake (M8.0) took place not very far from the array. This is a rare opportunity for investigating how the SG network records the possible gravity changes by the earthquake because of the magnitude, the mechanism and the geometry of the earthquake source. Theoretical calculations (Sun, personal communication), with a point source assumed, predict that gravity increase as large as 0.60 uGal (Esashi), 0.11 uGal (Matsushiro) and 0.06 uGal (Kyoto) is expected. This is large enough to be detected by the highly sensitive sensors of SGs.

All the three stations have produced normal recordings of gravity for this event without sufferring from serious instrumental problems. Preliminary analysis of the data has shown that gravity increase as large as approximately 2 uGal (Esashi) and 1 uGal (Matsushiro) is observed. These results are not in good agreement with the theoretical prediction. The data from the Kyoto station require special treatment because the thermal levelers were disabled then, and the method of precise correction for the tilt of the instrument is now under investigation. Although the reason why the theory and the observation do not agree quantitatively is not well known, the effect of underground water may be partly (or mostly) responsible, because there was considerable amount of rainfall in the mainland of Japan a few days before the earthquake.

The Tokachi-Oki earthquake has provided an interesting set of data also on the mechanical coupling between the solid Earth and the atmosphere. Quasi-periodic (approx. 20s) oscillations in atmospheric pressure were observed in duration of several minutes almost everywhere in Japan. They are acoustic (infrasonic) waves in the atmosphere which were excited when large amplitude Rayleigh waves propagated along the surface of the solid Earth. The GGP-Japan Network is the network of precise barometry as well as of superconducting gravimetry, and is capable of recording such atmospheric phenomena. Some examples of atmospheric signals of interest will be shown.