OHP Superconducting Gravimeter array

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Abstract

A global array observation with superconducting gravimeters is being developed under the support of OHP (Ocean Hemisphere Project). The array and a part of the resent observation results obtained from this array are introduced.

1. Superconducting gravimeter and an array observation

Superconducting gravimeter (SG) is a kind of relative gravimeters, which uses a magnetic force induced by the superconducting current as the force to support the proof mass instead of a metal spring of conventional gravimeters. The sensing unit of SG is kept at the cryogenic temperature of 45 K. Due to the smallness in both the thermal electronic and mechanical noises at the cryogenic temperature, SG has a capability to detect gravity signals existing such a wide bands from 20 s to 1.4 years in period with a high resolution of 0.1 nGal (1nGal=1E-12 m/s/s).

Under the support of OHP, Japanese SG group is developing an array of SGs. The SG sites are arranged so that the array widely covers the earth along the longitudinal directions. The data now available to use through the web site of OHP data center are, those obtained at the five sits of, from the north, Ny-Alesund, Svalbard, Norway (78.9N), Esashi in Japan (39.1N), Bandung, Indonesia (6.8S), Canberra (35.3S), and Syowa Station, Antarctica (69.0S). At each SG site, the gravity data are continuously acquired at the sampling rate of 1-s with several associated data. An advantageous point of this array observation is its longitudinal distribution of the sites on the earth. This is an important point to study many gravity signals such as, for example, the Earth's free oscillations, earth tides and the effect of the polar motion, which essentially imply a latitude dependency in their amplitude and phase.

2. Recent observation results

2.1 Seismic bands

An important observation results used the data obtained from this array is the discovery of an incessant excitation of the Earth's free oscillation (recently so call Earth's background free oscillations) by Nawa et al. (1997). They analyzed the 3-year MODE data (March, 1993 - December, 1995) obtained by SG016 at Syowa Station in Antarctica. Their frequency-time spectrogram clearly shows that mainly the fundamental spheroidal modes in a frequency range of 0.3 mHz to 5 mHz are incessantly excited, and the observed 30 spectrum lines agree with the eigenfrequencies expected from an earth model PREME. After this discovery, the existence of the oscillations has been confirmed by many researchers using the data from SGs and from the long-period seismometer networks (for example, Suda et al., 1998, Kobayashi and Nishida, 1998, Tanimoto, 1999). Kobayashi and Nishida (1999) studied the excitation mechanism related to atmospheric disturbances.

Compared the long-period seismometers, SG usually shows a low noise level at the frequency band lower than about 1.5 mHz (Nawa et al., 2000). This indicate that the SG records might be useful to study such low frequency signals as Coliolis coupled modes (Zurn et al., 2000) and/or to search unknown seismic waves coupled with the motions of the oceans. The observation of the back ground free oscillations of a planet is an important application to know the structure of the planet at where the study using the data from a seismometer network is difficult, although the existence of atmosphere is required.

2.2. Short-period gravity tides

As well known, tides show the strong frequency dependency in the diurnal band due to the resonant response of the fluid core to the diurnal tidal forces. This phenomenon (Free Core Resonance) gives us useful information related to the shape of the core-mantle boundary (CMB) and that for the physical parameters related to the strength of the coupling at CMB (for example, Sato et al., 1994). The observable parameters of this resonance, i.e. the eigen frequency, strength of the resonance and Q-value are to be global ones, therefore, we may determined precisely these parameters by stacking the data obtained from the OHP array rather than the determination used separately the data obtained from independent site. A preliminary analysis results by stacking will be presented at this symposium by Tamura et al..

The Love numbers and load Love numbers are considered as one of the Earth's parameters those are very well determined. However, Sato's et al. (this symposium), who analyzed the SG data obtained at Canberra, find out a systematic discrepancy of about 0.5% in magnitude between the observed gravimetric factors and theoretical ones. The discrepancy is to be significant compared with the formal errors of the observed gravimetric factors. Okubo (1987) pointed out a significant effect of the density of the fluid core at CMB on the estimated Love numbers. The observed discrepancy may be related to an uncertainty in the core density at CMB that is used to estimate the Love numbers and load Love numbers. Although we should carefully check their results, there is a possibility that we might constrain the core density by the tidal observations using the data from the OHP array.

2.3. Long-period gravity changes

SGs have enough stability to detect such long-period gravity signals induced by the annual and Chandler motions of the earth's rotation. For example, Sato et al. (2000) studied the effect of sea surface height (SSH) variations using the data obtained from the SGs installed at the three sites of Syowa, Canberra and Esashi, and they show that the observed annual signals are well recovered from the three effects of the solid tide, the polar motion and SSH. There is a possibility that the SG at Bandung detects an ocean oscillation related to ENSO like motion in the oceans, the strength of ENSO like oscillations becomes large as the latest event during the period of 1996 to 1997.

For long-period gravity changes, it is desired to detect the gravity changed due to the up-lighting motion of the ground related to a post-glacial rebound. The gravity signals of this phenomena are useful to study the rheological property of the earth. Both the Syowa and Ny-Alesund are located on a place at where this effect is expected to be large and the monitoring of the ground motions with VLBI and GPS are carried out at both sites. The collocation measurements with absolute gravimeters and VLBI were carried out at Ny-Alesund by two European groups at the 2 year interval (from 1998 to 2000). The measured gravity changes during the 2 years very consistent with those in the vertical displacement observed by VLBI (Hinderer, 2000). The continuous observation with the SG should provide an useful information to study this phenomenon.