Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

SSS32-P01 Room:Convention Hall Time:May 20 15:30-17:00

A rainfall correction of the strainmeter for detecting a small short-term change (2)

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A present rainfall correction of the strainmeter for forecasting of the Tokai earthquake has a problem. The present rainfall correction has a effect that smoothes off a sharp change by the rainfall and holds down the peak of the rainfall noize, but it has a rainfall effect for a long time slowly. It is difficult to detect a small short-term change while such as the rainfall effect. It is desirable for a trend to be constant to detect the small short-term change.

We considered that the reply of the strainmeter by the rainfall is effect of the load by the rainfall. We tried to a rain fall correction of the volume strainmeter, a simple tank model of one level or two levels got a good result than the AR-method. (Kimura et al., 2011) This is because a tank model can express the increase of the outflow coefficient with the increase of the rainfall accumulation.

We retried to a rain fall correction of the strainmeter by the tank model of three levels which is used as Soil Water Index of JMA. We estimated many parameters of the tank model of three levels by the SCE-UA method. We could obtain a better result by using a complicated tank model about some observation station. We explain these results.

Keywords: Strainmeter, Rainfall correction, Tank model, SCE-UA method

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The removal of the postseismic crustal deformation from the GPS data

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JMA monitor the GPS data of GSI by spatial Monitoring (Kobayashi, 2007) for forecasting of the Tokai earthquake. This output is published as the JMA report of Earthquake Assessment Committee for Areas under Intensified Measures against Earthquake Disasters. Offset of the maintenance and earthquake and trend is removed from the GPS data. But JMA couldn't monitor the GPS data because of the postseismic crustal deformation which occured after the 2011 off the Pacific coast of Tohoku Earthquake (Mw 9.0). The postseismic crustal deformation may continue for several decades. It is necessary to remove the postseismic crustal deformation from the GPS data to monitor the phenomenon that is going to happen now. Therefore, we tried to estimate the parameters of the postseismic crustal deformation.

We use the combination of a logarithmic function and an exponential function as the postseismic crustal deformation. We estimate some parameters by the SCE-UA method so that the total of the difference at 30 day is minimized. We explain the result that removed the postseismic crustal deformation of the 2011 off the Pacific coast of Tohoku Earthquake (Mw 9.0) or the Tokachi-oki Earthquake in 2003 (Mw 8.0).

Keywords: GPS, postseismic crustal deformation, SCE-UA method

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Short-term Change of Permeability after Tohoku Region Pacific Coast Earthquake Observed at Rokko-Takao Station

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The 2011 off the Pacific coast of Tohoku Earthquake on March 11, 2011 caused the step-like increase of groundwater discharge by 250ml/s as well as the step-like changes of strain by about 10^{-7} at Rokko-Takao station. The magnitude of the atmospheric pressure admittance of groundwater discharge increased by 80% just after the earthquake compared with before the earthquake. The pressure admittance has been recovering to the original level in about one year after the earthquake. The station is located in the fracture zone of Manpukuji fault. It is considered that the change of the pressure admittance on the earthquake was caused by the increase of permeability due to outflow of plugging components such as mud from the fracture zone. In this study, we estimated the secular change of permeability of the fracture zone nearby the station and investigated the characteristics of re-plugging of the fracture due to accumulation of mud and so on.

Rokko-Takao station is located in the emergency evacuation road for the Shin-Kobe tunnel, and crosses Manpukuji fault with the east-west strike. In the station, three components strainmeter (ST1:N81^{o}W, ST2:N39^{o}E, ST3:N21^{o}W), three extensometers in the direction of N69^{o}E (EX2, EX3, EX4), the groundwater discharge meter and the groundwater level meter were installed. The observation has been performed continuously with the sampling intervals of 0.5 second and 10 minutes. We calculated the tidal strains by applying the tidal analysis program BAYTAP-G (Tamura et al., 1991) to the observed data of strain. Mukai and Otsuka (2008) reported that the tidal amplitudes of strain had been recovering secularly by a few % per year since 1995 Hyogoken Nanbu Earthquake. It was considered that the healing of the fracture zone caused increase of the Young's modulus and reduced the tidal amplitudes.

The ordinary seepage rate of groundwater at the station is about 550ml/s. The groundwater discharge rate increased to 800ml/s just after the earthquake. After the earthquake, the groundwater discharge rate decreased to 300ml/s in a few days and recovered to the original rate in a few months. Strain steps due to the earthquake at the station showed the positive dilatation about 10^{-7}, which was calculated by using the fault model of Geographical Survey Institute. The low discharge of groundwater during a few months after the earthquake might be caused by the decrease of pore pressure due to the extension of the surrounding crust. On the other hand, the rapid increase of groundwater discharge on the earthquake might be caused by the increase of permeability due to the outflow of plugging components such as mud from the fracture zone.

The pressure admittance of the groundwater discharge in 2010 was estimated to be +3.4ml/s/hPa, which was positive in case that decrease of the atmospheric pressure caused the increase of groundwater discharge. This admittance shows that groundwater is drawn from the fracture zone by decrease of the atmospheric pressure. We estimated the variations of the pressure admittance by applying BAYTAP-G to the groundwater discharge observed since March 12, 2011. In this calculation, we obtained the pressure admittances for four terms. Each term was 90 days and was shifted by 67 days from the previous term. The pressure admittance just after the earthquake was estimated to be +6.1ml/s/hPa. We considered that this large pressure admittance was caused by the increase of permeability as mentioned in case of the increase of groundwater discharge on the earthquake. The pressure admittance has been decreasing to +4.0ml/s/hPa at the end of 2011. It is suggested that the plugging of the fracture due to accumulation of mud and so on caused the short-term decrease of permeability. This plugging of the fracture might be beginning to the long-term healing process of the fracture zone shown by analysis of the tidal strain.

Keywords: groundwater discharge, strain, permeability, The 2011 off the Pacific coast of Tohoku Earthquake

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In-situ calibration for various multi-component borehole strainmeters

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Geological Japan, AIST has constructed fourteen observatories in and around expected focal zones of the Nankai and Tonankai earthquakes to monitor groundwater and borehole strain for prediction research of Nankai and Tonankai earthquakes. The Ishii's multi-component borehole strainmeter or the Gladwin Tensor Strain Meter (GTSM) was deployed at each observatory. Moreover, the Ishii's analog multi-component strainmeter or the Sacks-Evertson-Sakata multi-component strainmeter was deployed near some active faults. Here I represent the results of in-situ calibration for the various multi-component borehole strainmeters, and evaluate the results.

The in-situ calibration for the borehole strainmeter, tidal response of the borehole strainmeter and theoretical tide are used which is the same method of Matsumoto et al. (2010). Oceanic tidal loading of the theoretical tide is calculated by green's function at arbitrary depth for a surface point load (Kamigaichi, 1998) and the modified GOTIC2 program which can apply the green's function to the calculation of theoretical strain. The calibration coefficients are evaluated by long-period surface wave data observed by the borehole strainmeter and diagonal and/or non-diagonal elements of the calibration matrix.

All calibration coefficients for the eleven Ishii's strainmeters and one GTSM are reasonable, further calibration is needed for other three GTSMs. The results of in-situ calibraton for the Ishii's analog multi-component strainmeters or the Sacks-Evertson-Sakata multi-component strainmeters are also evaluated.

Keywords: strainmeter, in-situ calibration

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Vertical crustal deformation in Kii Peninsula from 1972 to 2009 deduced from leveling data

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Leveling data for the period from 1972 to 2009 in Kii Peninsula, Japan, were investigated to characterize unsteady vertical deformation. We estimated the steady vertical deformation rate at each GEONET GPS station by averaging the daily coordinates for the periods from January 1997 to January 2000, and between January 2007 and January 2010, avoiding the period of the large earthquakes.

First-order leveling surveys have been conducted repeatedly every several years since the 1970s. We determined crustal displacements by comparing leveling data from successive surveys. We subtracted subduction-related steady component derived by the GPS from the distribution of vertical crustal displacements during periods between leveling surveys. If any episodic events have not occurred, they should show little spatial variation around zero vertical displacement. However, the residual data clearly show uplift on the southern Kii Peninsula for the period from 1972.0 to 1979.6. The uplift is slightly left for the period from 1979.6 to 1983.5. It suggests that the after slip of the 1944 Tonankai earthquake and/or the 1946 Nankai earthquake remains until the early 1980s. Unsteady vertical deformation is not seen in the period from 1983.5 to 2009.0. At least a long-term slow slip event equivalent to that of Bungo channel or Tokai does not seem to occur in Kii Peninsula since 1972.

Keywords: leveling, vertical crustal movement, Kii Peninsula

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In-situ calibration of NIED Hi-net tiltmeter data

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At every Hi-net observatory operated by National Research Institute for Earth Science and Disaster Prevention (NIED), a high-sensitivity accelerometer (tiltmeter) is installed in a borehole sensor capsule accompanied by a high-sensitivity velocity seismometer. Horizontal components of the sensor have been used as a tiltmeter and the recorded ground tilt data is useful to monitor crustal activities such as slow slip events in southwest Japan [e.g., Obara et al., 2004]. In this study, we present the results of in-situ calibration of the ground tilt data [Matsumoto et al., 2010].

For the in-situ calibration of the borehole tiltmeters, we compare observed amplitudes and phases of M2 and O1 tidal constituents with theoretical ones. From the observed tilt data, we extracted these tidal amplitudes and phases using the BAYTAP-G software [Tamura et al., 1991]. The parameters of theoretical tidal constituents are estimated by a modified version of the software GOTIC2 [Matsumoto et al, 2001]. In order to compute the precise ocean tidal loading effect on the borehole tiltmeters, we use Green's function applicable to arbitrary depths due to surface point loading [Kamigaichi, 1998] and the GOTIC2 program with this Green's function modified by Kamigaichi.

We calibrated ground tilt data at 31 Hi-net stations in Shikoku. The observed amplitudes and phases of M2 and O1 tidal constituents are obtained by averaging the estimated values for a 90-day time-window incremented at one day. Ratios of the observed amplitudes to the theoretical ones range from 0.7 to 1.5, and are consistent with the results of Matsumoto et al. [2010] where tiltmeters operated by Geological Survey of Japan, AIST, in Kii Peninsula were calibrated. Differences between observed and theoretical phases are smaller than 20 degrees, and we can confirm the validity of azimuths of borehole sensors estimated by Shiomi et al. [2003] based on teleseismic waves. However, the NS component at MISH station shows relatively large differences between observed and theoretical tidal constituents: amplitude ratio is 0.4 and phase difference of M2 constituent is 50 degrees. A possible cause of this discrepancy is that the accuracy of the calculated ocean tidal loading effect on this station is not sufficient because this station is located on the Sadamisaki peninsula, which has very complicated coastlines.

Keywords: ground tilt data, in-situ calibration, Hi-net

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Search for Creep Signals along the Sagaing Fault Using ALOS/PALSAR Interferometry

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Sagaing fault is known as a ˜1000 km continental transform fault between the India and Sunda plates, and it is one of the great right-lateral strike-slip faults of Southeast Asia. As slip rate is the important aspect of Sagaing fault, during the past 30 years, seismologists did their best to estimate the slip rate in order to get a close value. The value of slip rate estimated from 35.4 mm/yr by Curray et al. (1982) to 18.5 mm/yr suggested by Myint Thein et al. (1998) changes by different seismologists. Since GPS become useful around 21st century, Vigny et al. (2003) used two years GPS observations to estimate 18 mm/yr of elastic deformation across the central Sagaing fault, and Meade (2007) estimated the rate using GPS observations in a block model which suggests that the strike-slip rate between the Indian and Southeast Asian Plate is 17 and 49 mm/yr at across the central and northern Sagaing fault, respectively.

Whereas InSAR is a powerful technique to map the Earth's surface deformation, to our knowledge, no previous studies have been performed along the Sagaing fault, presumably because shorter-wavelength SAR data did not allow preserving interferometric coherence over the densely vegetated regions. The L-band ALOS/PALSAR, however, could keep good coherence even in vegetation, so that we can map out the surface deformation if the fault is deforming with detectable amplitude. As a preliminary study, we applied InSAR technique to such PALSAR data pairs that span 2-3 years if the fault is undergoing creeping signals like found along the San Andreas Fault in the US west coast.

Keywords: creeping signals, right-lateral, strike-slip, slip rate, InSAR

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Crustal deformation in and around Beppu-Shimabara Graben by continuous dense GPS Network

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Beppu-Shimabara Graben located in central Kyushu. In this area, there is north-south extension field. It is important to study the crustal defoamation in this area to research tectonics in Kyushu district. We started 20 continuous GPS observation added to GEONET sites from 2009 in and around Beppu-Shimabara Graben.

GPS data observed at our stations, GEONET and 15 IGS sites are analyzed by Bernese GPS Software Ver. 5.0 (Dach et al., 2007) with IGS precise orbit and Earth rotation parameters. We can get daily coordinates of the sites (Nakao, et al., 2010).

Displacement velocities, which are coefficient of linear trend, are estimated by least squares method.

When these velocities, which are relative to 960688 GEONET site, plotted, clear boundary can see. 960688 GEONET site is located in the northern part of Kyushu. The displacement velocities of northern part from this boundary, where fixed site 960688 is located, are almost zero. On the other hand, those of southern part are from several to 10 mm. This boundary is from the northern part of Beppu Bay to Uki City in Kumamoto Prefecture via Aso Volcano. There are a lot of active faults on this boundary. The western part of this boundary seems the south boundary of Beppu-Shimabara Graben. However, the eastern part is not the south boundary but the north boundary.

There is the clear boundary of crustal deformation in Beppu-Shimabara Graben..