Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS31-01 Room:304 Time:May 25 14:15-14:30

Seasonal load variations, cGPS displacements, and crustal rigidity in Iceland

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Annual-cycle displacements can be seen directly on the cGPS network in Iceland. Every year, the country is subject to heavy snowfalls during winter times. The snow accumulates mainly over the five ice-caps and the highland in the central part of the island before melting during spring. This snow is expected to apply an important load on the crust. Other load like atmospheric load and water reservoir load are also subject to annual variations. Previous studies have shown that the crust has an elastic response to these loads.

We analyzed the time-series of 110 cGPS Icelandic stations processed using over 100 worldwide reference stations. We detrended the data from its secular trends, mainly caused by plate spreading and glacial isostatic adjustments. Signals associated with earthquakes or volcanic activities were also removed. The annual and semi-annual components of the signal were estimated by finding their best fit to a sinusoid using least-square adjustments. In the end, only the stations with a good estimate of these components were kept.

Each of the three coordinates (East, North and Up) of the GPS time-series were analyzed. It appears that the Up coordinate is one with the clearer signal. It is also showing the biggest annual signal amplitude and is thus the more sensitive to annual load changes. By looking at it, we found that almost all cGPS stations show largest subsidence in April. The stations close to ice caps or to the central part of Iceland tends to have their maximum subsidence later than the station further away. It is also clear that the amplitude of the signal gets bigger the closer the station are to ice caps or to the central part of Iceland. These are indications that the snow load is the dominant load in the annual cycle in Iceland.

These data were inverted using the Green function assuming the Preliminary Reference Earth Model (PREM) to get a time-series of the load distribution. As expected, we found that load accumulate on the ice-caps especially on Vatnajokull, the biggest one.

We also had atmospheric pressure data, reservoir water-level data and an estimation of the snow load from a weather model. Using the same model as the inversion but in the direct way, we estimated the contribution of each of the load. We found that the atmosphere has a fairly homogeneous effect in Iceland with the maximum vertical amplitude of 2-3 mm and insignificant horizontal displacements. The reservoir water-level changes are only affecting nearby stations. The snow load data is in agreement with the inversion results: it is the main contributor to annual crust deformation in Iceland.

Having both the load data and the deformation data, we are also expecting to be able to get more information on the Icelandic crust rigidity. We will be able to find out if there is any relevant change in the crustal strength near the plate boundary or the center of the Iceland hot spot.

Keywords: GNSS, GPS, annual crustal deformation, seasonal changes, snow load, crustal rigidity

SSS31-02 Room:304 Time:May 25 14:30-14:45

Fault source modeling of the October 28, 2008 earthquake sequence in Baluchistan, Pakistan, using ALOS/PALSAR InSAR data

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The Quetta Syntaxis in the western Baluchistan, Pakistan, is formed as a result of oroclinal bend of the western mountain belt and serves as a junction for different faults. As this area also lies close to the left lateral strike slip Chaman fault, which is supposed to be marking the boundary between Indian and Eurasian plate, the resulting seismological behavior of this regime becomes even more complex. In the region of Quetta Syntaxis, close to the fold and thrust belt of Suleiman and Kirthar ranges and on 28 October 2008, there stroke an earthquake of magnitude 6.4 (Mw) which was followed by a doublet on the very next day. In association with these major events, there have been four more shocks, one foreshock and three aftershocks that have moment magnitude greater than 5.Here we use ALOS/PALSAR InSAR data sets from both ascending and descending orbits that allow us to more completely detect the deformation signals around the epicentral region. On the basis of these data sets, we propose a four-faults model that consists of two left lateral and two right lateral strike slips that also include some thrust slip. We have thus confirmed the complex surface deformation signals even from the moderate-sized earthquake. Intra-plate crustal bending and shortening seem to be often accommodated as conjugate faulting without any single preferred fault orientation. We also discuss two possible landslide areas along with the crustal deformation pattern.

Keywords: ALOS/PALSAR data, Earthquake, Crustal Deformation, Source Modeling, Conjugate Faulting

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(May 24th - 28th at Makuhari, Chiba, Japan)

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Possible repeating slow slip events beneath the Bonin Islands

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Continuous global navigation satellite system (GNSS) data including the global positioning system (GPS) is one of the most powerful tools available for observation of Earth's surface deformation. In particular, coseismic, postseismic, slow transient, and interseismic deformation have all been observed globally by GPS over the past two decades, especially in subduction zones.

Here, we are using the deformation data from GPS observations to understand the deformation due to the earthquakes, afterslip and slow slip events in subduction zones around Japan, where geodetic data coverage is particularly dense. We are focusing on Bonin (Ogasawara) Islands Arc to understand its characteristic, especially the possibility of repeating Slow Slip Events (SSE). Global positioning system (GPS) time series in Bonin Islands Arc reveal the possible existence of slow slip events (SSEs) at the boundary between the Philippine Sea plate and Pacific plate.

Using data from this dense geodetic network operated by GSI, there are several possible events look like SSE that have one-year recurrence, detected by stations in Hahajima and Chichijima islands. These SSEs were identified from January 1996 to October 2014 by GNSS time series offset monitoring and rupture modeling with a rectangular fault located on the subducting Philippine Sea Plate. The detected SSEs were found to have a variety of characteristic recurrence intervals, magnitudes, durations, and coincide or relate with other seismic activities.

Time-decaying constant of these slow slips are first estimated to obtain the northward, eastward and vertical components of the ground deformation. Several methods are used to estimate the fault parameter including depth, dip, slip, strike, and width to understand its consistency with the fault boundary geometry. This process is followed by modeling the rupture area during the events and calculating the magnitude of these events based on geodetic approach.

These results lead us to further understanding about sequence of slow slip events in Bonin Islands Arc as a part of Philippine Sea plate.

Keywords: Slow Slip Event (SSE), Bonin Islands Arc, Ogasawara, GNSS, GPS

SSS31-04 Room:304 Time:May 25 15:00-15:15

Plate Convergent Process and Block Motions in Mindanao, the Philippines

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Tectonics of the Philippine Archipelago is characterized by westward subduction of the Philippine Sea plate (PHS) at the Philippine Trench in the east, eastward subduction of the Sunda plate (SUP) in the west, and left-lateral strike-slip movement of the Philippine fault inland. Ohkura et al. (2015) used GPS campaign measurement data spanning 2010-2014 to make clear the plate locking distribution at the Philippine Trench and slip/locking pattern of the Philippine fault in order to estimate earthquake generation potential in Mindanao. The displacement rate field with respect to SUP shows that west-northwestward motions are dominant due to the convergence of PHS from the east but their spatial decay with increasing distance from the trench is not significant. Elastic deformation caused by a strong coupling at the PHS interface can not explain the observed displacement rates. Thus, they needed to introduce translations of multiple crustal blocks to interpret the observed deformation pattern. However GPS data in Mindanao are too sparse to conduct geodetic inversion analyses.

In this study, we introduce a Markov Chain Monte Carlo method (MCMC) into the simultaneous estimation of slip deficit distribution on the PHS interface, lateral slip along the Philippine fault and translations of multiple crustal blocks. MCMC can get posterior probability density function of unknown parameters from enormous number of forward calculations. In the modeling we represent configuration of the plate interface and fault segments of the Philippine fault by 64 and 4 rectangular elements, respectively. Slip deficit rates, lateral fault slip rates and block translation rates are searched by MCMC while the direction of slip deficit is fixed to that of the PHS-SUP relative motion.

Preliminary results show that southern portion of the PHS interface is strongly locked. But its contribution to the displacement rate field is as small as 29% of the observation at the maximum and the rest can be attributed to the translation of crustal block. Along the Philippine fault that is the major boundary between forearc and backarc blocks, slip rate changes from south to north even in Mindanao. While stronger locking is estimated in the southern segment, clear creep motion is detected in the north. Creep rate in the northern Mindanao is comparable to that detected in Leyte Island just north of Mindanao. Some segments of the Philippine fault are estimated to release strain stationary.

Keywords: MCMC, Philippine fault, Philippine Trrench, Mindanao, GPS observation

SSS31-05 Room:304 Time:May 25 15:15-15:30

Aseismic strike slip associated with the 2007 dike intrusion episode in Tanzania

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In July 2007, an earthquake swarm initiated Northern Tanzania near Lake Natron and lasted for about two months. Mt. Oldoinyo Lengai, which located near the seismicity, began to erupt effusively before about a month later, and increased eruption intensity on September when the swarm almost ceased. The explosive eruption continued until April 2008.

Calais et al. (2008), Baer et al. (2008), and Biggs et al. (2009) have already reported the deformation associated with the swarm using InSAR. However, they mainly used ENVISAT/ASAR(C-band) images and only used images acquired from descending pass. We use both ascending and descending passes of ALOS/PALSAR (L-band) images. In addition to InSAR data, we also employ the offset-tracking technique to detect the signals along the azimuth direction. Using InSAR and offset-tracking, we could obtain the full 3D displacement field associated with the swarm.

The inferred full 3D displacement indicates that the graben-like-subsiding zone was horizontally moving by ~48cm toward SSW. To our knowledge, the horizontal movement at the subsidence zone has never been identified. To explain the displacement, we performed the fault source modeling. The fault slip distribution indicates that the ratio of strike slip component is about 20% of total moment release. Aseismic strike-slip creep motion might have also been responsible for the horizontal motion area and the swarm activity. We also confirmed that the stress changes due to the dike intrusion were consistent with the inferred fault slip distributions.

Keywords: InSAR, dike intrusion, aseismic slip, East African Rift valley, relay ramp

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS31-06 Room:304 Time:May 25 15:30-15:45

Permeability change estimated by using frequency property of the atmospheric effect on groundwater discharge

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The Rokko-Takao station in the southern Hyogo prefecture passes through the fracture zone of Manpukuji fault. Groundwater discharge about 550ml/s regularly takes place at this station. The groundwater discharge showed rapid changes due to earthquakes, as well as seasonal changes due to precipitation. For example, the groundwater discharge increased by about 50% just after the 2011 off the Pacific coast of Tohoku Earthquake. Mukai and Otsuka (2014) constructed one-dimensional groundwater migration model, in which groundwater flows in the confined aquifer from a source to the station, and estimated permeability change due to the 2011 Tohoku earthquake by using the observational data of groundwater discharge and pore pressure. The permeability just after the earthquake was about 20% higher than that before the earthquake. It was considered that the increase of permeability due to the earthquake was caused by the seismic motion that loosed or swept mud in the crack in the surrounding crust.

Permeability change is expected to have influences on the atmospheric effect of groundwater discharge as well. In this study, we constructed one-dimensional groundwater migration model with periodic atmospheric loading on the confined aquifer, and estimated secular change of permeability by applying the model to the atmospheric effect of groundwater discharge observed at the Rokko-Takao station. The atmospheric effect admittance of groundwater discharge is expressed to be 'a$*\sqrt{}$(f)' when the atmospheric pressure varies with the frequency 'f'. Coefficient 'a' in this equation is proportional to '$\sqrt{}$(k$*$S)' that is square root of permeability 'k' and storage coefficient 'S'. Therefore, we can estimate permeability change by investigating the frequency property of the atmospheric effect for various periods.

We conducted frequency analysis by applying FFT to the groundwater discharge observed at the Rokko-Takao station and the atmospheric pressure observed at the Kobe local meteorological office in the range from 2001 to 2013, and calculated the atmospheric effect admittance of groundwater discharge with frequency domain. In this calculation, we obtained the frequency properties for 348 windows with size 2048 data (85.3 days), and the window was shifted from the former one by 240 data (10 days). After then, coefficient 'a' was estimated by applying the equation '$\sqrt{}$(f)' to the frequency property of the atmospheric effect admittance in the periodic band from 0.5 to 7 days, because there is high correlation between the groundwater discharge and the atmospheric pressure in that periodic band. The coefficient 'a' just after the 2011 Tohoku earthquake increased twice as high as that before the earthquake. This agrees to the conclusion of Mukai and Otsuka (2014) of based on time domain analysis. We could find the increase of the coefficient 'a', or permeability increase, after the great earthquake such as the 2004 off Kii Peninsula earthquake as well.

Precipitation as well as earthquakes have the influences on the coefficient 'a', which shows positive correlation with the seasonal change of accumulated precipitation during the almost period since 2011. It might be considered that pore pressure increase due to precipitation causes looseness or outflow of mud in the crack and permeability increase.

Keywords: permeability, groundwater discharge, atmospheric effect

Japan Geoscience Union Meeting 2015
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SSS31-07 Room:304 Time:May 25 15:45-16:00

How much was the interseismic strain released by the 2011 Tohoku-oki earthquake?

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In order to estimate the value of released strain at the 2011 Tohoku-oki earthquake with respect to interseismic accumulated geodetic strain in northeastern Japan, we analyze daily coordinates (F3 solutions) obtained from GEONET, operated by GSI. During the interseismic period, northeastern Japan had been under the EW contractional field with the order of ˜0.1 ppm/yr, affected by interplate coupling between Pacific plate and Okhotsk plate. On the other hand, the 2011 Tohoku-oki earthquake released these accumulated strain generating mainly EW extentional field. The value ran to several 10 ppm near the hypocenter. We assumed that the period between 1996 and 2002 is interseismic period and its strain rate reflects stable state. Then, we compared this maximum principal strain rate to coseismic released strain toward to interseismic principal strain axis at each area. Around the eastern Pacific coast, the coseismic strain released accumulated interseismic strain of 500-100 years. Back-arc region and northern part of central Japan are released the interseismic strain of 50-100 years and several-several decades by the coseismic event, respectively. In spite of the extentional field at almost all are at the earthquake, some local areas show contraction toward the interseismic principal axes. This is caused by the difference of the direction of interseismic principal axis and coseismic extensional direction, and this may imply a possibility that this strain field change triggered seismic activity in inland after the 2011 Tohoku-oki earthquake. As an example, Yonezawa area in Yamagata prefecture, which is activated seismicity after the 2011 event, became contractional field by the coseismic strain with respect to interseismic principal strain axis. Consideration of this strain change is important to consider the strain accumulation process for the next inland earthquakes in the future. In addition, this geodetic approach will provide independent information to the discussion of stress field change by the seismological data.

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS31-08 Room:304 Time:May 25 16:15-16:30

Characteristics of viscoelastic relaxation caused by the 2011 off the Pacific coast of Tohoku earthquake

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We are developing a 3-D viscoelastic model using the Finite Element Method to describe the postseismic deformation following the 2011 Tohoku-oki earthquake. A purpose of this presentation is to describe the characteristic of the viscoelastic relaxation. Our model is composed of an elastic crust and subducting plate, plus a linear (Maxwell) viscoelastic upper mantle wedge and mantle beneath the slab (oceanic mantle). The viscoelastic relaxation strongly depends on the viscosity of the upper mantle. The viscoelastic relaxation at oceanic mantle produces westward displacements and subsidence. On the other hand, the viscoelastic relaxation at mantle wedge produces eastward displacements and uplift. Therefore, observed westward displacement and subsidence at sea area are probably produced by the viscoelastic relaxation at oceanic mantle, and eastward displacement at the land area and uplift at the Pacific side are produced by the viscoelastic relaxation at mantle wedge. If the viscosity of the oceanic mantle is smaller than that of the mantle wedge, westward displacement and subsidence are dominant. On the other hand, if the viscosity of the oceanic mantle is larger than that of the mantle wedge, eastward displacement and uplift are dominant. Hence, the ratio of the viscosity between mantle wedge and oceanic mantle is important to quantitatively explain the observed displacements.

Keywords: Tohoku-oki Earthquake, Postseismic deformation, Viscoelastic relaxation

Japan Geoscience Union Meeting 2015
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SSS31-09 Room:304 Time:May 25 16:30-16:45

Crustal tectonic stress and poroelastic relaxation of the Mw 9.1 tohoku earthquake

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The Mw 9.1, Tohoku-oki earthquake has been investigated by many scientists. This earthquake produces changes in the state of strain and stress in the surrounding rupture area. Postseismic deformation following large earthquake including afterslip, viscoelastic relaxation, and pore fluid flow, further modify strain and stress near a fault. The migration of fluid after earthquake from high-pressure area to low-pressure area modify stresses and pore pressure near fault and cause pore pressure changes in the surrounding rocks. This pore pressure changes are a part of coulomb stress calculation for fault interaction analysis.

By using various input of slip model, we calculate undrained coseismic pore pressure and coulomb stress change due to the earthquake (King, Stein, & Lin, 1994; Cocco & Rice, 2002) and its poroelastic relaxation by using green's function proposed by (Kalpna & Chander, 2000). The strain and stress due to slip on the fault are calculated by using analytical expression of (Okada, 1992) and consider stress-strain relation for an isotropic form of Hooke's law, respectively. We find that pore pressure changes following the tohoku-oki earthquake is increased through relaxation in the dilatation region which further modified coseismic coulomb stress in surrounding region. We estimates the pore pressure variation from the first 50 days following the tohoku earthquake has change from 7.08 MPa to 2.62 MPa in the dilatation region, and in the compression region, it change from -9.37 MPa to -3.46 MPa.

Keywords: pore pressure, poroelastic relaxation, coulomb stress

SSS31-10 Room:304 Time:May 25 16:45-17:00

Change of groundwater behavior caused by 2011 Tohoku earthquake detected from pore pressure and gravity

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At the Kamioka mine, Gifu prefecture central Japan, several kinds of apparatus, such as seismometer, strainmeter, tiltmeter and laser extensometer, have been installed. We have been monitoring pore pressure and barometric pressure at this mine. Pore pressure remarkably decreased at the time of the earthquake, although the hypocentral distance of 2011 Tohoku earthquake is 528 km. This reduction of pore pressure was equivalent to 2-3 m decrease of groundwater level. It was the largest response during the observation period. The pore pressure reduction had continued for a few days. We anticipated the causes of the reduction were creation of new water path or permeability increase. We focused on Earth tide which can be assumed that it's effect is almost constant. We extracted Earth tidal response of pore pressure by the tidal analysis program BAYTAP-G (Tamaura et al., 1991). We compared it before and after the earthquake and the amplitude of M2 constituent reduction was seen from 22 to 16 Pa. O1 constituent also slightly responded to the Tohoku earthquake and these results indicate the rock property change. We estimated the hydraulic diffusivity to evaluate permeability of rock. From the analysis, adopting theory of linear poroelasticity and diffusion equation, we found that diffusivity increased about two fold after the Tohoku earthquake (Kinoshita et al., 2015). If these results are real, other instruments should also capture the change of diffusivity and groundwater behavior induced by earthquake.

The superconducting gravimeter have been installed at the same mine. This observation started in 2004 which is located 2.5 km apart from our pore pressure monitoring point. We analyzed gravity data by the same method as used for the pore pressure analyses. We suppose that if permeability of rock increases, gravity should be changed because gravity reflects the density of underground. The tidal response of gravity is clearer than that of pore pressure and we can compare the other constituents (Q1, M1, N2 constituents). While gravity analysis has difficulty because of large disturbance caused by heavy snow around this region in winter in the case of the Kamioka mine. Imanishi et al. (2014) indicates that the data of gravimeter has decreased after the Tohoku earthquake and it could not be explained only by the crustal deformation. It implies that the density change occurred. We will show the tidal analysis results of pore pressure and superconducting gravimeter, and report the hydraulic parameter change after the Tohoku earthquake.

Keywords: pore pressure, superconducting gravimeter, Tohoku earthquake, Earth tide

SSS31-11 Room:304 Time:May 25 17:00-17:15

Postseismic deformation of the 11 April 2011 Fukushima Hamadori (Mw=6.6) earthquake inferred from GPS observations

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The 2011 Fukushima Hamadori earthquake (Mw=6.6) is one of aftershocks of the 2011 Tohoku-oki earthquake (Mw=9.0). While the coseismic deformation field due to the Fukushima Hamadori earthquake is derived from InSAR measurements, leading to detailed slip distribution (Kobayashi et al., 2012; Fukushima et al., 2013), SAR data is not available to decipher postseismic deformation because the ALOS satellite terminated its operation right after the Fukushima Hamadori earthquake. GPS observations are thus the only way to delineate postseismic displacements of the earthquake. Here we try to detect the postseismic deformation of the Fukushima Hamadori earthquake and investigate the mechanism of it.

We assumed that the observed displacements are a combination of 1) rigid plate motion, 2) postseismic deformation of the Tohoku-oki earthquake, and 3) the triggered afterslip of the Fukushima Hamadori earthquake that results from fault creeps around the hypocenter of the mainshock, all of which are simultaneously estimated by solving an inverse problem. Because the postseismic deformation of the Tohoku-oki earthquake has prominent long-wavelength features compared with the spatial scale of this study, we approximated the deformation by either linear, quadratic, cubic, or quartic function. A statistical assessment indicates that the postseismic deformation of the Tohoku-oki earthquake is most appropriately represented by a cubic polynomial.

Our results indicate that, in the first six month, the afterslip is concentrated at the deeper and horizontal extension of the mainshock rupture and the shallowest part of the mainshock rupture. Of these, location of the slips in the horizontal extension of the mainshock rupture depends on the size of the fault we assume probably because of insufficient coverage of GPS sites.

We found that the observed displacement field during the first 12 months is inconsistent with the afterslip, invoking the need for assessing a contribution of viscoelastic relaxation. A preliminary analysis with a viscoelastic halfspace overlaid by a 25-km thick elastic layer indicates that a viscosity of 1×10^{18} Pa s, a very low value for a upper mantle viscosity, seems to be consistent with the observed postseismic displacements.

Keywords: Crustal deformation, GPS, Postseismic deformation, Normal faulting earthquake

SSS31-P01 Room:Convention Hall Time:May 25 18:15-19:30

Measurements of a precise pressure in the C0002 borehole observatory using a mobile pressure gauge

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[1]JAMSTEC

In the Nankai Trough region, several large interplate earthquakes with magnitudes of 8 have occurred repeatedly due to a subduction of the Philippine Sea Plate beneath the Eurasian Plate at a rate of 4-6 cm/year. In this area, we deployed a long-term borehole monitoring system (LTBMS) with pressure gauges (Paro-scientific Inc.8b7000-2 and 8b7000-1) into the C0002 boreholes during the IODP expedition 332 in 2010 to understand a seismogenic process of large interplate earthquakes. In the C0002 boreholes, seafloor pressure measurements are continuously conducted since the deployment. The precise pressure measurement such as the detection of long-term crustal deformation is important in order to obtain geophysical knowledge associated with the occurrence of large earthquakes. However, pressure measurements contain instrumental drifts in the sensors in addition to the pressure changes associated with a crustal deformations. Therefore a correction of the instrumental drift is necessary to estimate precise measurements of the crustal deformation. We developed a mobile pressure gauges equipped with pressure holding system for the correction. The mobile pressure gauge has a crystal water pressure meter (Paroscientific Inc. 410K) as a pressure sensor and is equipped with a pressure holding function due to a temperature control using a heater. Also, an electric valve control was adopted. These systems decrease a pressure variation throughout an observation. To estimate an accuracy of the pressure gauge, we measured a repeatability and hysteresis of the sensor. The repeatability of the sensor equipped with a pressure holding system is 1.3 hPa, while a repeatability of the sensors without a pressure holding system is 8.93. This indicates that the pressure holding system improves the accuracy of the sensors. In this March, a calibration of the C0002 pressure gauges is peformed in the KY15-05 by R/V Kaiyo (2015.3.9˜3.29). In this presentation, we show preliminary results of the cruise.

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

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Crustal Deformation in the Southwestern Ryukyu Arc Estimated from GNSS data

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1. Introduction

The south-western Ryukyu arc is characterized by back-arc spreading and a fast plate convergence rate (12.5 cm/year). In this region, few large earthquakes are reported though a fast plate convergence rate. Well-known large earthquake in this region is the 1771 Yaeyama earthquake (M_W 8.0) with a devastating tsunami. On the other hands, slow seismic and aseismic events are often reported. For example, biannually repeating slow slip events (SSEs) are reported by Heki and Kataoka (2008), and they reported that SSEs occur on a subducted plate interface under Iriomotejima Island. Crustal deformation during several years in this region is proposed to be expressed by rigid block rotation models by Nishimura et al. (2004), Nakamura (2004), and so on. They propose that the Ryukyu region is divided to three blocks, and each block is moving independently. But boundaries are different from each other. Nishimura et al. (2004) proposed that the Yaeyama region (Iriomotejima, Ishigakijima, and some other islands) and the Miyakojima region are moving on the same block. On the other hand, Nakamura (2004) proposed that these two are on different blocks. These studies used the GEONET GNSS data operated by Geospatial Information Authority of Japan. But this region consists of remote islands, so we can't discuss detailed internal deformation.

2. GNSS data

In this study, we use 13 stations in total. 8 stations are GEONET GNSS stations located in the Yaeyama region and the Miyakojima region. And one station is located in the south of Miyakojima Island, which is operated by the Japan Coast Guard. This station has not been used for scientific analysis. And the other 4 stations are new ones we set up, which are located in Iriomotejima Island (Funauki and Oohara), Kuroshima Island, and Kohamajima Island. We estimate daily cordinates of the GNSS stations using GIPSY 6.2 with strategy of Precise Point Positioning. Next, we calculate moving average to remove errors due to the artificial offsets and the weather condition. In time-series data of 4 new stations from 2010 to 2013, we can recognize 4 deformation episodes suggesting SSE in all station's data.

3. Rigid block rotation models

We compare displacements calculated from the model of Nishimura et al. (2004) with observed one from 2010.24 to 2012.69, and we find that they have an obvious difference. The observed displacements direct counterclockwise compared with calculated one, and displacement pattern suggests displacement direction changing counterclockwise and increasing displacement rate in western stations. This may mean that a rigid block rotation in this region changed after the previous study. Therefore, we examine how good rigid block rotation can explain the observed displacement and estimate Euler vectors for the rigid block rotation. Displacement calculated from the best-fit rotation model can reproduce the observed one. The estimated Euler pole located at (128.089^{o}E, 29.095^{o}N) with angular velocity of 6.675 rad/Myr. And we examine baseline change which is independent with rigid block rotation to study internal deformation in this region.

4. Conclusion

We analyze GNSS data in the south-western Ryukyu arc. This region is characterized by a fast plate convergence rate (12.5 cm/year) and frequent slow slip events (SSEs). Because this region consists of remote islands with a few GNSS stations, we set up new 4 GNSS stations to examine detailed crustal deformation. We compare observed and calculated displacement using the proposed rigid block rotation models and find that they have an obvious difference. We also report a result for a rigid block rotation estimated from the observed displacement and a change of baseline lengths in this region to examine internal deformation.

Acknowledgements

We thank the Geospatial Information Authority of Japan and the Japan Coast Guard for providing GNSS data.

Keywords: Ryukyu trench, GNSS, Rigid block rotation

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Crustal deformation around Kikaijima

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1. Introduction

Philippine Sea plate is subducting under Eurasian plate from the Ryukyu trench where is located at the east side of Ryukyu arc. On the other hand, there is back arc spreading at west side of Ryukyu arc. It was thought that the region of the back arc spreading is weak strength of crust, so, Interplate coupling is weak, too. However, I have experienced that the 2011 Tohoku-Oki Earthquake and the 2004 Sumatra-Andaman Earthquake, where are the same situation with the Ryukyu arc. It means to examine the possibility that the M9 class earthquake occurs in all subduction zones with a plate having similar tectonics background.

2. Collision with Amami plateau and high-speed uplift of Kikai-jima

Amami plateau, which is one of the world's largest scales, subducts under the Ryukyu arc from the Ryukyu trench, and Amami plateau make that Kikai-jima is high-speed uplift. Previous coastal terrace studies reveal that Kikai-jima is 2 mm/yr uplift. These evidences suggest strong interplate coupling and occurrence time of a large earthquake is about 1,000 years time scale. In addition, historical M8 class earthquake occurred around the Amami-Oshima in 1911, and seismic activity is high.

3. Tilt direction and uplift velocity at the Kikai-jima observed by leveling, and GNSS observation

A traverse line of Kikai-jima, Oshima, Amami-Oshima, Yokoate-jima can be established only more than 100km in the Ryukyu arc. A GNSS observation in Yokoate-jima (uninhabited island) was started in October 2013. Baseline change rate between Yokoate-jima and Amami-Oshima is about - 3.8×10^{-8} /yr, which is same level baseline change between Amami-Oshima and Kikai-jima (-2.5×10^{-8} /yr). However, still have a short observation period (only 8 months). On the other hand, tilting in the Kikai-jima is observed by leveling. The direction and amount of tilt are forward to the trench axis and about 10^{-7}/yr, which is in comparison with this leveling result (April, 2014) and the previous result (September, 1997). These results suggest strong plate coupling on the Ryukyu trench. However, strong plate coupling is difficult to explain both vertical and horizontal deformation components. It is may have an effect of collision of the Amami plateau.

Keywords: Leveling, Kikai Island, Interplate coupling, GNSS Observation

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SSS31-P04 Room:Convention Hall Time:May 25 18:15-19:30

Strain rate field in Kyushu district estimated from GPS velocity data

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Kyushu district is one of the areas where unique crustal deformation is detected in Japan. For major tectonic characteristics, the Philippine Sea plate subducts and repeatedly generates M7 class earthquakes with a recurrence interval of about 20-30 years at the Hyuga-nada area (Yoshioka, 2007). In the Bungo Channel, slow slip events have occurred at intervals of about 6-7 years (Ozawa et al., 2013). These differences of tectonic process may be responsible for the frictional property of the plate interface (Hirose and Maeda, 2013). Moreover, back-arc spreading at the Okinawa Trough (Nishimura and Hashimoto, 2006) also brings about complicated tectonics. Takayama and Yoshida (2007) investigated some tectonic factors using GPS velocities obtained from 1998 to 2002. Then, they suggested that there was a velocity gap of about 5 mm/yr in the EW component along N32^o where subsequent M5-6 class earthquakes occurred. However, clear active faults are not distributed there and the process of stain budget is unrevealed, indicating that the present-day crustal deformation began to develop in the recent geological age. Additionally, inelastic deformation (Noda and Matsu'ura, 2010) with high temperature is also expected, since many active volcanoes exist in this region. Therefore, it is important to estimate the influence of the inelastic behavior attributed to heterogeneity in the crust and upper mantle on the deformation field quantitatively. It is thought that the quantitative understanding of strain rates leads to the assessment of seismic potential such as locking depth of faults and estimating the future crustal deformation. In this study, we estimated the strain rate field in Kyushu district using GPS velocities.

We estimated site velocities using GEONET F3 solution, daily coordinates of continuous GNSS sites, derived from the Geospatial Information Authority of Japan (Nakagawa et al., 2009). According to a conventional method of processing for GPS time series, we removed annual and semiannual variations, and offsets caused by earthquakes and GPS antenna replacement. Next, using the method proposed by Shen et al. (1996), we calculated strain rates by forming crossover area within a 50 km diameter every one GPS observation site, assuming uniform deformation in each crossover area. Finally, we determined a rigid motion and strain rates in the whole area simultaneously by the method of least squares, and then, we obtained strain rate distribution interpolated every 20 km. We set the same period as shown in Takayama and Yoshida (2007), when few unsteady events occurred. From estimated strain rate field, following characteristics were derived.

(1) A high strain rate region with the maximum shear strain rate of about 120 nanostrain/yr was recognized along N32^o, whose width was about 50 km.

(2) The crustal shortening of about 30-210 nanostrain/yr in the northern part and the central part of Kyushu district indicated the direction of ESE-WNW on the Pacific side. On the back-arc side, the magnitude of those shortening decreased and those directions were rotating counterclockwise.

(3) The crustal shortening in the southern part of Kyushu district indicated the direction of ENE-WSW and the highest shortening rate was 130 nanostrain/yr on the back-arc side.

The result (1) suggests that the fault locking ranges from 0 to 5 km in depth, assuming the fault slip (5 mm/yr) of infinitely long fault in the EW direction under high strain rate region. As for results (2) and (3), it is necessary to consider the effects of plate subduction and back-arc spreading into the analysis. For the future, we will calculate strain or strain rate released by earthquakes (moment release) and conduct the quantification of inelastic behavior ongoing in Kyushu district by comparing strain budget.

This study was carried out under a contract with METI (Ministry of Economy, Trade and Industry) as part of its R&D supporting program for developing geological disposal technology.

Keywords: crustal deformation, strain rate, high strain rate region, inelastic deformation, Kyushu district, Philippine Sea plate

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A Method of Field Research Incorporating the Results of the Surveying by GSI and MLIT - Gravity Profiles as an Example -

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1. Introduction

To reduce the natural disasters such as earthquakes or landslides, it is essential to the studies of earth science involving field works. Thereupon, it is necessary to acquire geographic location information about these survey sites. In recent years, it has been progressing to publicize digitized geographic information from the Web site established by Geospatial Information Authority of Japan (GSI), Ministry of Land, Infrastructure, Transport and Tourism (MLIT) or many municipalities. As a result, it is possible to obtain positional data of the land (longitudes and latitudes) and elevations from the mean sea level of the reference point. These services, in many cases, can be utilized in academic research.

To make various corrections in gravity surveys, geographic information of latitude, longitude and altitude values are required on the measurement points. Therefore, in this study, the process of using those public digitized information of triangulation points and benchmarks is described to perform gravity survey.

2. Target area

Gravity measurement survey line of interest is about 5.8 Km leading from Sanjodori, Sakai-ku to Tono-cho, Kita-ku, Sakai City, Osaka. This line has been crossed in Uemachi Fault. At the center of the line, there is a growing gravity anomaly.

3. Acquisition of geographic information

Measurement of gravity was performed on the triangulation point or the benchmark. The latitude, longitude and elevation values were obtained from the numerical information provided on the above-mentioned web site is used. They can be relatively easily obtained but there is each site-specific use restrictions. The values obtained information of the point or the benchmark is used for illustration of the measurement point and correction of gravity value.

4. Result

Accuracy is good when used the results of the survey on the triangulation point or the benchmark, as compared with the case of digitizing to enter the latitude or longitude value and reading the elevation values from topographic maps (Ryoki (2011), Ryoki and Nishitani (2013), Ryoki (2014)). Then, the time, it takes for data aggregation work, can be greatly reduced. In particular, since the error of the elevation values becomes to be within the range defined by the grade of each reference point, the homogeneity of the data has been secured.

5. Conclusion

Marks of the metal, that are triangulation points or benchmarks of public survey to manage by municipalities and survey of the city district for urban regeneration by MLIT, are found relatively easily in site. It is also possible to measure gravity, etc. on that point. Thus, these usage has been found to be highly convenient in the field research. Through this study, use of triangulation point or benchmark has been shown to be effective to efficiency improvements and uniformity of accuracy in field research, such as earth science.

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Ryoki, K. (2014): Correction of Gravity Measurements Utilizing GSI Maps and its Application in the Southern part of Uemachi Fault Zone, *Abstracts*, Japan Geoscience Union Meting 2014, SSS26-P02.

Keywords: gravity structure, digital geographic information, Uemachi Fault, Mikunigaoka Subsuface Peak, high-density intrusive rock, efficiency of measurement

Japan Geoscience Union Meeting 2015
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The observation of the electromagnetism pulse to capture crustal movement

KUNIHIRO, Hidemitsu[1*]

[1]JYAN meeting for the study

I observe a direct wave of the FM broadcast for foretelling an earthquake and perform a study to examine crustal movement from the abnormal phenomenon of the electric wave.

The electric wave observation performed continuous observation and data analysis for a long term, but I pursued a cause and discovered that I approximately synchronized with high and low tide of the ebb and flow, and an abnormality pulse occurred in data among them because pulsing abnormality of the electromagnetism often occurred.

However, I understood that there was much abnormality before and after an earthquake when I analyzed it more because ebb and flow had abnormality not to synchronize approximately 20%.

Therefore as a result of I added earthquake statistics to 80% and the remaining async part which synchronized for ebb and flow, and having inspected a comparison, high and low tide of the ebb and flow and the plus and minus direction of the abnormality pulse synchronized, and the abnormality of the async understood that the most occurred before and after an earthquake.

Therefore, the electromagnetism pulse became the circumstantial evidence to connect ebb and flow and an earthquake.

It is this cause and mechanism, but the Inland Sea using observation data has a big ebb and flow, and, as for the differences between high tide and ebb tide, there are 2-3 meters, and the huge weight change of approximately 5 billion tons is up only in west Seto.

Furthermore, in the poking each other investigation with earthquake statistics, the high and low tide of the ebb and flow shows the thing that is very likely to be it as crustal movement and earthquake trigger because an earthquake of approximately 60% occurs in the vicinity of the ebb tide of the big tide.

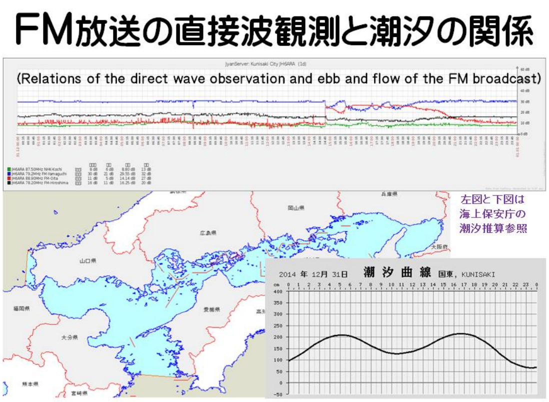
In addition, in the origin of the electromagnetism pulse, a gravity change of the ebb and flow gives impacts such as pressure or the extension in the earth crust, and an electromagnetism pulse occurs by whit destruction or friction when the earth crust becomes by compression or extension in the vicinity of boundary.

Because I form an electromagnetic field and am emitted to the air when this electromagnetism reaches by electromagnetic induction to the surface of the earth from the earth crust, a clear change appears for the synchronization of the ebb and flow like a change to an observation graph.

Therefore, if perform this electromagnetism pulse in an observation network in the long term, understand crustal movement, and provide important data foreseeing an earthquake; think that is observed.

I show each observation or data for the study.

Keywords: Foretelling an earthquake, Crustal movement, Earthquake trigger, Electromagnetism, Abnormality, earthquake



Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS31-P07 Room:Convention Hall Time:May 25 18:15-19:30

Gravity survey around the Medeshima Hills in the Sendai Plain, northeast Japan

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Our seismic and gravity survey carried out across the Sendai Plain in 2013 (Watari 2013) shows concealed active fault beneath the Sendai Plain. The concealed fault dislocates not only Pre-Tertiary basement rocks but also Miocene and Pleistocene sediments. Pre-existed bouguer gravity data suggest that the concealed active fault continue toward north via eastern foot of Medeshima Hills. However, the relationship among the concealed active fault, concealed fault of Nagamachi-Rifu active fault system, and Kagitori-Okubushi tectonic line is not so clear. To evaluate the active fault beneath alluvial plain, the length and relationship of these active faults provide essential information.

To reveal the continuity of northern extension of the concealed active fault, we executed gravity survey in the southern part of Sendai Plain, from Medeshima Hills to the right bank of Natori River. The total number of gravity stations is 232, using LaCoste & Romberg D-type gravimeter and G-type gravimeter. The interval of gravity stations is 200 m.

The result of our gravity survey shows no steep gradient of bouguer gravity associated with the concealed active fault in the northern area of Medeshima Hills, indicating that the active concealed fault is terminated in this area.

Keywords: gravity survey, concealed active fault, subsurface structure, continuity of active fault

SSS31-P08 Room:Convention Hall Time:May 25 18:15-19:30

Block Modeling of The Sunda Block Using GPS Velocities in South East Asia

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The Sunda block in Southeast Asia has its own independent block rotation. It covers most of Southeast Asia including Indo-China Peninsular, Sumatra, Borneo, Java, and the shallow waters that lies in between. The GPS network data in Southeast Asia derived by campaign and continuous observations are used in this study to simultaneously estimate the Euler rotation parameters of the Sunda block, and the elastic deformation due to the slip deficit on the block boundaries. In order to see the precise block rotation of the Sunda block, all effects contained in the data such as elastic deformations due to the inter-plate coupling in the southern boundary of the block have to be removed. We used the method devised by Meade (2009) and elastic deformation rates are computed for each fault segment assumed in a homogeneously elastic half-space using triangular dislocation elements to accurately represent complex fault system geometry. The Zone between 110^{o}E to 116.5^{o}E in the southern plate boundary of the Sunda block indicates interpolate coupling, while that between 107^{o}E to 110^{o}E shows postseismic slip after the 2006 interplate earthquake with M7.7. The optimum Euler pole parameters of the Sunda block are estimated as follows: the latitude of 24.629 $\pm$ 1.962 ^{o}N, the longitude of 117.369 $\pm$ 0.788 ^{o}E, and the angular velocity of 0.692 $\pm$ 0.066 ^{o}/Myr. This study excludes the effect of elastic deformations due to the slip deficit on the block boundaries in estimating the Euler rotation parameters, while the previous studies estimated the parameters by assuming the block rotation only.

Keywords: Sunda block, Euler rotation, GPS velocities

SSS31-P09 Room:Convention Hall Time:May 25 18:15-19:30

Abnormal strain distribution in Hokkaido, Japan, inferred from the 2003 Tokachi-oki earthquake

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To extract the abnormal strain distribution caused by heterogeneous subsurface structure in Hokkaido, Japan, we compared observed coseismic crustal deformation with theoretical crustal deformation of the 2003 Tokachi-oki earthquake (M8.0). Observed data is extracted by the difference of the daily coordinates, which is provided by GSI (F3 solutions), before and after the event. Theoretical data is calculated from dislocation model (Okada, 1992), which assumes deformation in uniform elastic half-space, using fault parameters provided by GSI. The observed coseismic displacement is explained by calculations well, except for several areas. Dilations are also roughly agreed with each other. However, several areas show deformation excess and deformation deficit with respect to theoretical model. Especially, in Hidaka region, which is high seismic velocity region (kita et al., 2012), corresponds to deformation excess area, and Kamuikotan region, which has thick sediment layer, corresponds to deformation deficit area. These results might imply the effect of the heterogeneous subsurface structure around the region.

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

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Modeling of the time series of the postseismic deformation in Yamagata, Japan, after the 2011 Tohoku earthquake.

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Using daily coordinate time series provided by GSI (F3 solutions), we estimate the effects of the postseismic deformation in Yamagata, Japan after the 2011 Tohoku earthquake (M9.0). We assumed that the most of postseismic signals are caused by afterslip and viscoelastic relaxation. These postseismic deformations are often modeled by logarithmic and exponential (or power-low) temporal change, respectively. We approximated observed daily postseismic deformation by these theoretical models. As a result, the logarithmic theoretical time series, which assumes afterslip, is fitted the observations well between just after the earthquake and ~100 days after the event, and exponential theoretical, which assumes viscoelastic relaxation with Maxwell body, time series explain data after ~100 days after the earthquake. Estimated time constants are ~8 days (afterslip) and ~1000 days (viscoelastic relaxation), respectively. This result is consistent with other previous studies at the eastern pacific coast in Tohoku region. Combined model consists of summation of logarithmic and exponential signals also explain the time series. Distribution of the amplitude of the viscoelastic relaxation might be reflecting heterogeneous viscoelastic structure beneath the study area.

Keywords: postseismic deformation, tohoku earthquake

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

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Revisiting Interplate Coupling Beneath the Tohoku District Based on Geodetic Observations

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Many studies have been carried out into the distribution of interplate coupling between the subducting Pacific and overriding continental plates based on observations of the surface displacement rate field using satellite geodesy. In such studies, the degree of coupling has generally been expressed in terms of the back-slip (or slip deficit) at the plate interface. In some cases, seismological rather than geodetic data have been used to investigate the spatiotemporal variation of the back-slip distribution. Although it is difficult to resolve the back-slip distribution at the plate interface off the coast of the Tohoku District along the direction normal to the trench based only on terrestrial observations, it can be constrained to some extent in the direction parallel to the trench.

Iinuma et al. (2010, 114th Meeting of the Geodetic Society of Japan) proposed a method for monitoring the spatiotemporal variation of interplate coupling based on calculating the spatial gradient of the surface displacement rate field within belt-like zones along the direction perpendicular to the trench axis. They suggested that the gradient of the horizontal component of the displacement rate depends mainly on the strength of the interplate coupling in shallow (<40 km) regions of the offshore plate interface, and that the sign of the vertical displacement rate gradient indicates the presence or absence of interplate coupling at deeper (>50 km) regions of the plate interface beneath the land. Thus, the spatiotemporal variation of interplate coupling can be monitored based on the temporal change in the trench-parallel distribution of the displacement rate gradient. Based on an analysis of small repeating earthquakes, Uchida et al. (2013, Fall Meeting of the Seismological Society of Japan) reported that there is a strong correlation between the temporal change in the displacement rate gradient and the slip rate.

Application of this monitoring method to geodetic data before the availability of satellite geodesy data may enable us to estimate the state of interplate coupling by calculating the displacement rate gradient along the direction perpendicular to the trench axis based on leveling and triangulation surveys. Therefore, in this study, leveling survey data were used to estimate the degree of interplate coupling beneath the Tohoku District for approximately the past 100 years.

The spatial gradient of the vertical displacement rate along an observation line from Ayukawa to Sendai via Rifu was calculated from leveling survey data recorded by the Geospatial Information Authority of Japan since 1900. Fifteen sets of vertical displacement rate field data were used to calculate the spatial gradient along the direction perpendicular to the Japan Trench. The results for recent decades were compared with the vertical displacement rate gradient estimated from GPS observations, and were found to be in reasonably good agreement. It can therefore be concluded that the degree of interplate coupling at deeper regions of the plate interface can be assessed even for periods before the introduction of global navigation satellite systems, based on leveling survey data alone. The results indicated that there were clear cycles in the strength of this coupling, interspersed with large interplate events such as the 1936 and 1978 Miyagi-oki earthquakes. Before these events, strong coupling existed in deeper regions, but disappeared after the main shock occurred. The results of similar investigations for observation lines from Kamaishi to Yokote via Kitakami, and Iwaki to Aizu-Wakamatsu via Koriyama will be presented at the meeting.

Keywords: Iinterplate coupling, The 2011 Tohoku-oki Earthquake, Leveling Survey, GPS

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(May 24th - 28th at Makuhari, Chiba, Japan)

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Coulomb's static stress changes induced by the 2011 Tohoku-Oki earthquake: a case of spherical earth

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Some studies indicated that seismicity around a main shock is activated where the Coulomb's static stress changes (ΔCFF) are positive (e.g. King *et al.,* 1994; Stein, 1999). ΔCFF is defined as ΔCFF=$\Delta\tau+\mu\Delta\sigma$, where $\Delta\tau$ is the shear stress change on the fault (positive for the inferred slip direction), $\Delta\sigma$ is the normal stress change to the fault (positive for fault unclamping) and μ is the apparent friction coefficient. The failure is promoted if the ΔCFF is positive. Okada's (1992) theory on coseismic internal deformation in a homogeneous semi-infinite media has been widely used to calculate ΔCFF. Using this theory, Toda *et al.* (2011) estimated the ΔCFF induced by the 2011 Tohoku-Oki earthquake. Their results showed that the broad area over epicentral distance of several hundreds kilometers undergoes the stress changes larger than 0.1 bar. It should be considered whether Okada's (1992) theory can be directly applied to the calculation of such a broad deformation field. In other words, it is necessary to estimate the effect of the Earth's curvature and stratification on the deformation field. However, the method of theoretical calculation of coseismic internal deformation in a spherically stratified earth has not been entirely established because previous works assumed an incompressible earth (Piersanti *et al.,* 1995) or oversimplified the gravity (Pollitz, 1996). We have realized the theoretical calculation of coseismic internal deformation in a spherically stratified earth without such unrealistic approximation. We applied our method to the preliminary computation of the volumetric strains caused by the 2011 Tohoku-Oki earthquake and found that the discrepancies of the volumetric strains for the conventional half-space from those for a spherically stratified earth exceed 30 per cent at the epicentral distance of about 200 km. It is expected that there are discrepancies of the same order among the ΔCFF for the two earth models.

In this presentation, we apply our method to calculation of ΔCFF induced by the 2011 Tohoku-Oki earthquake and discuss the difference between those for a spherically stratified earth and for a half-space.

Keywords: Coulomb's static stress change, 2011 Tohoku-Oki earthquake, spherical earth, internal deformation

SSS31-P13 Room:Convention Hall Time:May 25 18:15-19:30

Travel time changes of the ACROSS signal detected by the TRIES borehole network associated with the Tohoku Earthquake

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[1]Tono Research Institute of Earthquake Science, ADEP

The 2011 off the Pacific coast of Tohoku Earthquake (M9.0, March 11, 2011) caused large change of observed data, such as groundwater level, strain and stress, in Tono Research Institute of Earth Science (TRIES),which located approximately 600km away from the epicenter. In addition, significant changes in travel time of the seismic ACROSS signal transmitted from the TOKI station (JAEA Tono Geoscience Center) were detected at many Hi-net stations (Kunitomo et al.,2014a). In this study, we analyzed the ACROSS signal observed by the borehole network of TRIES distributed in the range of about 9 km from the Toki station, and discuss the seismic velocity change caused by the Tohoku Earthquake. The observation stations, SBS110, JRJ, TRIES, TGR165, TGR350, TOS, BYB, are distributed in the range about 1 - 9 km apart from the seismic ACROSS station (TOKI). Analysis period is two years, from April 2010 to March 2012. We calculated the Green's functions from the transfer functions every day by the data processing of ACROSS (Kunitomo et al.,2014b), and estimated temporal change in the travel time of S-wave by the cross spectral method. S-wave travel time showed a step-like delay at the all observation stations at the time of the 2011 off the Pacific coast of Tohoku Earthquake. The delay times which depend on the observation station, are 1 to 7 ms at SV wave and 1 to 3 ms at SH wave. Travel time delay can be divided into two types, short-term delay and long-term delay. The short-term delay recovers exponentially in about 2 to 3 weeks, on the other hand, the long-term delay remains even after one year. The short-term delay is different by observation station, and it is estimated to represent the change in the vicinity of the observation station. The delay times of SH waves are large in the stations, TRIES, TGR165, TGR350 near Mizunami Underground Research Laboratory (MIU). The long-term delay, except the stations near MIU, has generally become larger with increasing distance from the ACROSS station, and it is estimated to represent the change in broad area.

Keywords: seismic velocity change, crustal movement, seismic ACROSS, the 2011 off the Pacific coast of Tohoku Earthquake

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS31-P14 Room:Convention Hall Time:May 25 18:15-19:30

High resolution seismic and magnetic mapping of Kucukcekmece Lagoon (Istanbul), Turkey

ALP, Hakan[1*] ; BOYCE, Joe I.[2] ; SUTTAK, Phil[2] ; OKSUM, Erdinc[3] ; KARABULUT, Savas[1] ; ISCAN, Yeliz[1] ; OZCEP, Ferhat[1]

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To understand the submarine features of the Kucukcekmece Lagoon, a total of 42 km high resolution seismic reflection data and total field marine magnetic data were collected and processed. The results were interpreted together with bathymetric data in detail. Total magnetic intensity distribution identifies several north-northwest trending (340-350^0) magnetic lineaments (L1-L5) that are aligned with strike-slip faults mapped from offshore seismic data. Analytic signal depth estimates indicate magnetic source bodies at ~100 m depth within the Thrace Basin Cenozoic sediments. Further analysis of the magnetic field data would provide information on faults kinematics and depth. Stratigraphically, parallel reflection pattern of the lagoon indicate initial deposition under low-energy conditions. From place to place, some whiteout areas are interpreted as gas charging area. Structurally, three main fault zones, FZ1, FZ2 and FZ3 are mapped with strike-slip character in NW-SE orientation. These faults delimit the lagoon from eastern and western coast where the bathymetry decreases from 10m to 5m and is characterised by two linear NW-SE directed feature on the seafloor morphology. The direction of active faults of the lagoon are also well matching with onland NE-SW oriented ridges and lineaments toward northern part of the lagoon and southern coast area. The right lateral displacement at the coast line of the lagoon in the northern Sea of Marmara and strike-slip character of FZ1, FZ2 and FZ3 are thought that these fault zones maybe related with the North Anatolian Fault Zone (NAFZ). In terms of reducing the high seismic risk posed with increased urbanization of the densely populated Istanbul, it becomes significant to monitoring or identification of the continuities of these faults in current sediments represented at the shallow parts of the seismic sections.

Keywords: High resolution seismic data, Marine Magnetic data, Istanbul, Tectonic, Faults

Japan Geoscience Union Meeting 2015
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Focal mechanisms prove the right-turn of slab beneath Kii Peninsula

MASE, Hirofumi[1]*

[1]none

(Please refer to the figure. Names of the slab, topography of seabed, etc are naming only of here.)

Curve cr is the leading edge where the seismic activity disappears (1). I interpret it as the substantial edge of the slab. Mantle that heads eastward(the red arrow) in the Chugoku region pushes the edge of the slope that inclines to the northwest, of the Nankai slab. Therefore, the edge always receives the right-turn-force (2). Earthquakes occur on the surface of the slab and in it. I want to prove the right-turn by those focal mechanisms and to clarify details of the right-turn-force.

I thankfully used the monthly report(3)(4) of The Meteorological Agency for the focal mechanisms.

If fault type of the earthquake is typical, mechanics in the vicinity can be clearly understood. If it is thrust-type or normal-type, the direction of pressure or tension is understood respectively. However, judgment is required because settling-force with small material in exactly under or pushing-up-power from exactly under dresses thrust-type or normal-type respectively. On the other hand, it is necessary to judge whether the first power is pressure or tension about the lateral-type.

I grouped the earthquakes into A, B, C, D, E and F by enclosing them in the short dashed line.

The green arrow in A is average tension axis in the vicinity. I understand this area is the state of expansion because it ties and stops the Nankai slab of heading-eastward-tendency.

The gray arrows in B and C are average tension axises of normal-type in the vicinity. Tension element of the direction of gyration-radius of the red arrow might be the cause of normal-type. The southern part of B receives the power of the purple arrow (from the southwest) as the reaction that the leverage point receives.

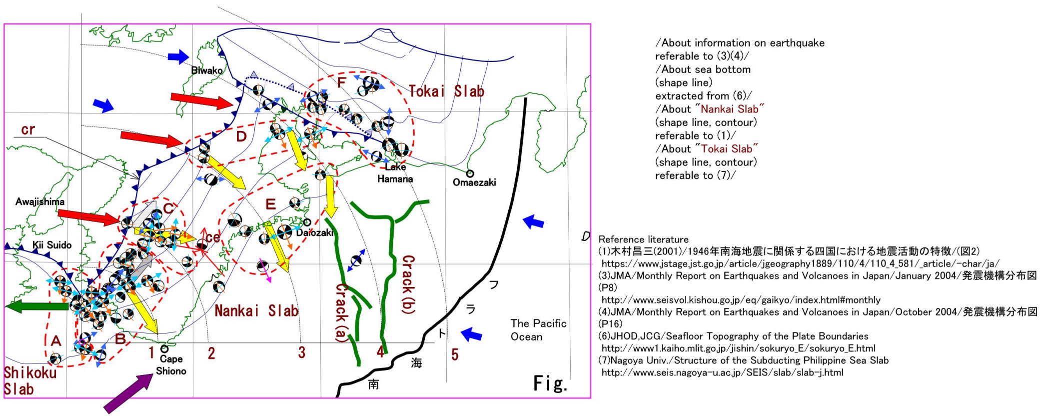
The yellow arrow in B, C, D and E is the average pressure axis in the vicinity. The yellow arrow in C seems to incline outside circular arc 2, and to have collided with E group, like the direction of the red arrow. Though the yellow arrow on circular arc 4 in D and E inclines internally than the tangent, other yellow arrows harmonize with the circular arc.

Because power to induce the overall right-turn of the Nankai slab exists widely in each place as mentioned above, it becomes grounds of the right-turn.

Though the part that rubs against the Tokai slab cannot do a smooth turn without along circular arc 5, I think that the Crack(b) reflects externals of the Nankai slab. Destruction by impossible turn occurred between, in south and north, from the Trough to Lake Hamana, in east and west, from circular arc 5 to circular arc 4. The stagnated material will form mountains.

Though there are a lot of normal-type ones in F group, the tension-axial-directions are various. I think that earthquakes that occurred because mantle pushed up(5) the Tokai slab from the under exist considerably among these.

(1)KIMURA(2001)/https://www.jstage.jst.go.jp/article/jgeography1889/110/4/110_4_581/_article/-char/ja/
(2)MASE(2014)/JpGU2014/SSS29-P10
(3)JMA/Monthly Report/January 2004/(P8)
(4)JMA/Monthly Report/October 2004/(P16)
(5)MASE(2012)/JpGU2012/SCG67-P06



SSS31-P16 Room:Convention Hall Time:May 25 18:15-19:30

The 2014 Bungo slow slip

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Introduction

The seismic activities off Shikoku Island are different from those off the Kyushu Island. M8 class earthquakes have occurred repeatedly off the Shikoku Island with time interval of about 150 years and M7 class earthquakes repeatedly occurred off the Kyushu Island with a recurrence interval of about 20 to 30 years. The Bungo channel area is flanked by Shikoku and Kyushu Islands and seems to be a transient area. In this Bungo channel area, slow slip events repeatedly occurred in 1997, 2003, 2009. Short-term slow slip events occurred in a low frequency area with a time interval of around half a year. Under this circumstance, the GNSS network in Japan detected a transient in 2014, which suggest occurrence of a slow slip event in a long-term slow slip area. In this study, we estimated interplate aseismic slip on the Philippine Sea plate by time dependent inversion.

Analytical Procedure

We adopted a fault patch based on the plate surface model estimated by Hirose et al (2008). We used 155 GPS sites in the Bungo slow slip area. We estimated a linear trend for the data for a period between January 2007 and January 2008 and removed the estimated linear trend from the original data. Misumi GNSS site is used as a reference point. We estimated time evolution of aseismic interplate slip using the above detrended data for the period between January 2014 and January 2014.

Results

The processed time series show a small transient for early 2014 and large transient from around July 2014. The time dependent analysis shows aseismic slip on the plate interface beneath the Bungo channel area. The estimated moment magnitude is around 6.3. Since the moment magnitude of previous long-term slow slips is around 7.2, the current event is very small. This kind of small size of slow slip event occurred in 2006. There are no clear explanations about the relationship between Mw7 class slow slip and M6 class slow slip in the long-term slow slip area.

Keywords: Bungo channel, Slow slip

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Rainfall correction of strainmeter data in consideration of the flow from the upper reaches (1)

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Kimura et al.(2015) showed that the flow from the upper reaches was important for the rainfall correction of the strainmeter. Therefore, Meteorological Research Institute(MRI) started the research by plural technique about the rainfall correction of the strainmeter in consideration of the flow from the upper reaches.

At first, I try the rainfall correction of the strainmeter by the introduction of the upper precipitation data of the mountain. Higashiizu-Naramoto is located in the foot of Mt. Amagi, and comes under influence that the rainfall of the mountain flows in as groundwater. The strainmeter data at Higashiizu-Naramoto was corrected only using precipitation data at Inatori(130m above sea level) Amedas(Automated Meteorological Data Acquisition System) until now. After incorporating the precipitation data of Amagisan(1,070m above sea level) AMEDAS for this, an improvement effect was provided.

In addition, MRI try the rainfall correction of the strainmeter by the observation of the river water level. Shimada-Kawane is located near the Minari River,and and comes under influence that the rainfall of the upper reaches as flow of the river. Therefore MRI install a ultrasonic type level gauge on the river.

In this announcement, I explain these summaries.

Keywords: strainmeter, rainfall correction, the flow from the upper reaches

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Crustal Deformation caused by the Earthquake of Northern Nagano Prefecture using InSAR analysis of ALOS-2/PALSAR-2 data

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ALOS-2, was launched on May 24, 2014, has an L-band SAR (PALSAR-2) in the same way as ALOS/PALSAR. PALSAR-2 is of help to understand of a ground surface state, and its interferometric coherence is highly effective for the crustal deformation observation.

An earthquake of M6.7 occurred near the northern Nagano prefecture on November 22, 2014. The maximum seismic intensity of this earthquake was 6-Lower. We analyzed the crustal deformation caused by this earthquake from ALOS-2/PALSAR-2 data interferograms. In this study, we used September 19, 2014 ? November 28, 2014 for ascending orbit (path:126, frame:720, right looking) and October 2, 2014 ? November 27, 2014 for descending orbit (path:25, frame:2840, left looking), and able to get a good interference result. Microwave from the satellite is irradiated from the west-southwest and west-northwest sky, incident angle in the around of the epicenter is approximately 39 and 37 degree, respectively. As the result, the eastern area from epicenter shows up to 8 fringes (=95.2 cm) crustal deformation toward the satellite in the radar-line-of-sight direction. Furthermore, Kamishiro fault has been longitudinal from north-northeast to south-southwest in the vicinity of the epicenter, and phase discontinuous line has been confirmed along the fault trace.

Some of PALSAR data were prepared by the Japan Aerospace Exploration Agency (JAXA) via the Geospatial Information Authority of Japan (GSI) as part of the project “ALOS-2 Domestic Demonstration on Disaster Management Application” of the SAR analysis of earthquake Working Group. Also, we used some of PALSAR-2 data that are shared within PALSAR Interferometry Consortium to Study our Evolving Land surface (PIXEL). PALSAR-2 data belongs to JAXA. We would like to thank Dr. Ozawa (NIED) for the use of his RINC software. In the process of the InSAR, we used Digital Ellipsoidal Height Model (DEHM) based on “the digital elevation map 10m-mesh” provided by GSI, and Generic Mapping Tools (P.Wessel and W.H.F.Smith, 1999) to prepare illustrations.

Keywords: InSAR, Crustal deformation, ALOS-2/PALSAR-2, earthquake in northern Nagano prefecture