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

SGD24-01 Room:105 Time:May 25 09:00-09:15

A study on Antarctic ice-sheet mass changes using satellite data

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Total ice sheet on Antarctica is said to consist of about 90 % of the earth's entire Ice sheet, which is equivalent to almost 60 meters of sea level rise. Nevertheless, because of the difficulties of in-situ observations, it has been difficult to estimate the mass change rate of the whole of Antarctic ice mass. GRACE (Gravity Recovery and Climate Experiment) has been observing time-variable gravity fields and succeeded to estimate the mass change rate for the whole of Antarctica, which was difficult to conduct by other means. However the GRACE observation is the total mass change of the earth including the Glacial Isostatic Adjustment (GIA) and therefore, suffers from the discrepancy between GIA models. In addition, the uncertainties of lower degrees of Stokes coefficients have particularly large impacts in Antarctica.

On the other hand, ICESat (Ice, Cloud, and land Elevation Satellite) is a satellite with GLAS (Geo-science Laser Altimeter System), which can observe ice-sheet elevation changes. In principle, the combination of GRACE and ICESat can yield comparisons between ice-sheet mass change estimates and volume change estimates. Nevertheless, ICESat datasets of 90 days have 180 days of interval time, and therefore, not appropriate to compare with monthly GRACE data. Equipped with RA2 radar system, EnviSat (Environmental Satellite) is useful to compensate ICESat data, for its datasets are available in 35-day repeat cycle from the same period as GRACE. Although the precision of EnviSat RA2 is not as high as ICESat GLAS, continuous observation of height changes in a longer period are considered useful. In this study, therefore, we used EnviSat data as well as GRACE and ICESat, to estimate the Antarctic ice-sheet mass change rates as a whole. In addition, we divided Antarctica into 27 drainage systems, and compared the results of EnviSat with those of GRACE.

The Antarctic ice-sheet mass change rates from GRACE show mass decrease of -174 ˜ -48.4 Gt/year in total, which is consistent with previous studies. GRACE and ICESat are in good agreements in their spatial patterns, and a large mass/volume decrease can be seen in Amundsen Sea Sector (ASE) and Antarctic Peninsula (AP). Due to the scarce measurement densities, the spatial patterns of volume changes from EnviSat does not agree well with those of GRACE or ICESat. Nevertheless, the time-series of volume changes from EnviSat show good agreements with mass changes from GRACE for the whole of Antarctica as well as some of the drainage systems, especially in the regions where the slope magnitude is low. This study shows by making use of EnviSat data, the volume changes in shorter time-scale can be detected for the whole off Antarctic as well as its regions.

Keywords: Satellite geodesy, GRACE, ICESat, EnviSat, Altimeter, Antarctic ice sheet mass change

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SGD24-02 Room:105 Time:May 25 09:15-09:30

Gravity field determination around Syowa station, Antarctica, by combining GOCE and in-situ gravity data

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GOCE (Gravity field and steady-state Ocean Circulation Explorer) satellite launched in March 2009 by ESA (European Space Agency) aims at improving static gravity fields, in particular at short wavelengths. In addition to its low-altitude orbit (250km), the sensitive gravity gradiometer installed is expected to reveal 1 mgal gravity anomaly and 1cm geoid at the spatial resolution of 100km (half wavelength). On the other hand, due to instrumental drifts, lack of reference points, and other reasons, the accuracy of in-situ gravity data (land, surface ship and airborne gravity data) is decreasing toward the longer wavelength more than several tens km. In particular in Antarctica where very few gravity reference points are available, the long wavelength accuracy and/or consistency among the data sets are quite limited. The Japanese Antarctic Research Expedition (JARE) has been conducting in-situ gravity measurements around the Japanese Antarctic stations for a long period. These measurements also suffered from such influences and they cause large errors in the long wavelength gravity fields, and, consequently, errors in geophysical and geodetic applications. This study aims at improveing the accuracy of the JARE gravity data using GOCE gravity models (level 2 EGMs). There are three different approaches for estimating the GOCE gravity models, namely, direct solution (DIR), time-wise solution (TIM) and space-wise solution (SPW). Among these, TIM never uses any a-priori information other than GOCE. Therefore we mainly employed TIM models (RL 1-3). We also employed EGM2008 as a reference. In this talk, we present the comparisons between the gravity models and each of in-situ gravity data sets, and a preliminary result of the improved gravity field around Syowa station, Antarctica.

Keywords: GOCE, Gravity Model, Antarctica, Syowa Station

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SGD24-03 Room:105 Time:May 25 09:30-09:45

Towards improvement of geoid model in Japan by GOCE data: Case study of Shikoku area

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The performance of the recently released global geopotential models (GGMs) based on 2, 8 and 12 months of data collected by the Gravity field and steady-state Ocean Circulation Explorer (GOCE) is evaluated using geoid undulations and free-air gravity anomalies over Japan. The evaluated GOCE and related GGMs include; direct solution (DIR, release 1, 2 and 3), time-wise solution (TIM, release 1, 2 and 3), space-wise solution (SPW, release 1 and 2) and Gravity Observation Combination (GOCO, release 1 and 2). Further evaluations are carried out in each of the four Japanese main islands. The performance of EGM2008 and GOCE-related GGMs over Japan is generally comparable indicating possible improvement of geoid model in Japan by GOCE data at the end of the mission. The comparisons over the four main islands reveal that EGM2008 performs better than GOCE and related GGMs in Hokkaido, Honshu and Kyushu. However, GOCE and related GGMs perform better than EGM2008 in Shikoku. GOCO02S, GOCE-DIR3 and GOCE-TIM3 have the best and similar performance in Shikoku. Given that GOCE-TIM relies exclusively on GOCE data, it is considered for geoid determination in Shikoku for further assessment. To evaluate the actual improvement of the geoid model in Shikoku area by GOCE-TIM3, the geoid over Shikoku is determined from EGM2008 and a combination of GOCE-TIM3 with EGM2008 (GOCE-TIM3/EGM2008). In both cases the same terrestrial gravity data sets are used and all the necessary reductions are applied. The Stokes-Helmert scheme in a modified form is adopted for the computations. The first improvement of geoid model over Japan by GOCE data is evident in Shikoku.

Keywords: Geoid model, Gravity, EGM2008, GOCE, Shikoku

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SGD24-04 Room:105 Time:May 25 09:45-10:00

Search for geoid height changes due to the Tohoku Oki earthquake (Mw9.0) by satellite altimeter Jason-2

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On March 11, 2011, The Tohoku Oki earthquake (Mw9.0) occurred, and the accompanying crustal deformations and gravity changes detected by SAR, GPS, and GRACE have been reported (e.g., Matsuo and Heki, 2011). While these results are very important to reveal the mechanism of the earthquake, if we detect coseismic changes of geoid height over the ocean, we can exploit the data to constrain the earthquake mechanisms immediately above the epicenter because the co-seismic geoid height changes would be one of the few near-field data for the earthquake offshore. However, no successful report of the detection of coseismic geoid height changes have been reported yet.

Geoid height changes link with mean sea surface height changes, and one of the most useful ways to calculate them is to use satellite altimeter. In this study, we used GDR (Geo Physical Record) SSHA (Sea Surface Height Anomaly) data of satellite altimeter Jason-2 and searched for geoid height changes due to the Tohoku Oki earthquake. Although we don't think about sea bottom changes, water load and so on, we estimated the geoid height changes by the fault model reported by Geospatial Information Authority of Japan before this research. Then, it is expected that coseismic geoid height was changed to 3.5cm at most at latitude 38 degrees north and longitude 144 degrees east. And the Jason-2 pass 238 is running around this point, so that it is possible to observe those changes by Jason-2 (measuring precision of 2 ~3cm). The biggest problem to search the geoid height changes is how to eliminate sea surface height changes due to ocean tide, oceanic currents and so on. In this study, we use SSH (Sea Surface Height) data from JCOPE2 (Japan Coastal Ocean Predictability Experiment) oceanic circulation model in order to correct those sea surface height changes, and this experiment is provided by JAMSTEC (Japan Agency for Marine-earth Science and Technology). Jason-2 GDR SSHA data and JCOPE2 SSH data have similar trends of these changes. We thought the differences between those two data suggest the geoid height changes and we compared these differences.

We stacked and compared these differences of each year (2009~2011) and there is the about 20 cm peak around latitude 38 degrees north in pass 238 data across the earthquake. But it is far from the theoretical value. And although we applied High Pass Filter on this result, we couldn't get any useful information about the geoid height changes.

This study has room for us to consider contributions for the geoid height changes by sea bottom changes, water load and so on. In point of fact, many kinds of changes which must not be ignored have been found: the local more-than-10m sea bottom changes by the fault model reported by Geospatial Information Authority of Japan, about 5m mean sea surface changes around latitude 38 degrees north in Jason-2 pass 238 obtained by Jason-2 observation, and so on. Our future works are to consider these things. Furthermore, to check the noise properties on other passes, we are going to use SSHA data of Jason-1, the conventional model of Jason-2.

SGD24-05 Room:105 Time:May 25 10:00-10:15

Postseismic gravity changes of the 2010 Chilean earthquake from GRACE gravimetry

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The Earth's gravity field is known to change after earthquakes. The changes occur instantaneously in the earthquake (coseismic gravity change) and/or slowly after the earthquake (postseismic gravity change). The coseismic gravity change was first observed after the 2003 Tokachi-oki earthquake by an array of superconducting gravimeters (Imanishi et al., Science 2004). Using the data of GRACE (Gravity Recovery And Climate Experiment) satellites, which is the twin satellite launched in 2002 to measure gravity field and its changes, Han et al. (Science, 2006) observed the two-dimensional distribution of coseismic gravity changes associated with the 2004 Sumatra-Andaman earthquake. In the present study, using the GRACE data, we try to detect co- and postseismic gravity changes of the 2010 Chile (Maule) earthquake. We found coseismic gravity decrease and its slow recovery. The coseismic gravity changes were mostly negative, and the maximum decrease was about 4 microgal. The postseismic gravity recovery had a time constant of about a year. The coseismic changes are already reported by Heki and Matsuo (GRL 2010).

Three mechanisms are known for postseismic gravity changes: afterslip, viscous relaxation of the upper mantle, and pore water diffusion. Afterslips would change the gravity in the same sense as the coseismic changes, and viscous relaxation would take a few years or more. These two mechanisms cannot explain the observed postseismic gravity changes, and consequently the pore water diffusion seems the most likely mechanism. Similar postseismic gravity changes were found after the 2004 Sumatra-Andaman earthquake (Heki and Ogawa, GRL 2007), and they suggested that the diffusion of supercritical pore water is responsible for the changes. In addition, the 2004 Sumatra-Andaman and the 2010 Chile earthquake show common features in the amount, time constant of the postseismic gravity changes. I also compared the 2011 Tohoku-oki earthquake, but the time elapsed after this earthquake is not long enough (the GRACE data available only up to 2011 October) to enable detailed discussion on the postseismic gravity changes. One unique point in the Tohoku-oki event is that the postseismic gravity increase occurs in the same region as the coseismic increase. In spite of such differences, overall tendency of the co- and postseismic gravity changes of the 2011 Tohoku-oki earthquake is similar to the other two earthquakes. Recently, its coseismic gravity change is published by Matsuo and Heki (GRL, 2011).

Keywords: coseismic gravity changes, postseismic gravity changes, 2010 Chile earthquake

SGD24-06 Room:105 Time:May 25 10:15-10:30

Determination of earth gravity field from SLR analysis

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Determination of earth gravity field is newly implemented in our geodetic analysis software "c5++" (Otsubo, et al, JPGU, 2011). Satellite laser ranging (SLR) data are used to retrieve the gravity field, and its sensitivity is dependent on the SLR targets, especially in its altitude. Although the two LAGEOS satellites arecommonly used for terrestrial reference frames and earth orientation parameters, the low SLR satellites such as AJISAI, STARLETTE and STELLA are more sensitive to the earth gravity. Combining those multiple satellites, the long-term trend and the periodical variation will be presented for the J2 term and low degree/order terms up to 2 or 3.

Keywords: satellite laser ranging, earth gravity field, space geodesy

SGD24-07 Room:105 Time:May 25 10:45-11:00

Development of a gravity gradiometer system for submarine gravity prospecting 2

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Gravity surveys are useful in profiling the underground density structure. We propose a hybrid gravity survey method using gravimeters and gravity gradiometers to detect submarine ore deposits. This paper describes the development of a submersible gravity gradiometer for this purpose. As compared to a gravimeter, a gravity gradiometer is sensitive to localized density structure, and hence it is well suited to survey on concentrated source such as ore deposits. The required resolution is estimated to be finer than approximately 10E (=$1\text{x}10^{-8}/s^2$), considering typical dimensions of submarine ore deposits and survey altitude from the seafloor. To attain the required resolution, we newly developed a gravity gradiometer comprising two vertically-separated accelerometers with astatic reference pendulums. Because any common noise to the gravity sensors, such as translation acceleration and thermal drift, is canceled by taking the differential signal, the gravity gradiometer is preferable as an onboard instrument in the underwater vehicle.

The instrument should be installed on a gimbal to reduce rotational motion when the gradiometer is mounted in an underwater vehicle to survey around the seafloor. We have demonstrated a one-dimensional forced gimbal on which the orientation is precisely controlled to be vertical referred to both a fiber-optic gyroscope and a tiltmeter. Laboratory measurements show that the gravity gradiometer attains the required resolution and the forced gimbal reduces expected rotational disturbances to required level. By combining the gravity gradiometer with a two-dimensional gimbal based on this experiment, detectability of the typical ore deposit can be obtained.

A sea trial observation is scheduled in Suruga Bay using an AUV in September, 2012. Details of the design, the instrument performance, and the trial plan are presented.

Keywords: ore deposit, gravity survey, gravity gradiometer, gimbal, AUV

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SGD24-08 Room:105 Time:May 25 11:00-11:15

Hydrological gravity response detection using a gPhone -aboveground, and 100- & 300-m belowground-

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Inland water fluctuations are one of the most important source of disturbance for gravity monitoring which monitors density change of the underground. We have proposed the gravimeter array method as the technique of removing the disturbance due to inland water fluctuations. Namely, the effect of rain-/snow-fall should be cancelled using two continuous gravimeters with a free water plane between them. We have performed three gravity observations; aboveground (Ontake volcano), 100-m deep belowground (Mizunami Underground Laboratory (MIU)), and 300-m deep belowground (MIU). Although the data of 300-m deep are still under analysis, we have succeeded in approximately 1 ~ 4 microGal of gravity responses due to inland water variations in the data of both aboveground and 100-m deep belowground. However, the data of 100-m deep belowground also contained unknown gravity variations (real signal from the deep part of crust or non-linear spring sensor behavior). Our absolute gravity measurements have doubled as a calibration tool for the gPhone and a detector of rainfall response itself (Tanaka et al., 2011, JPGU abstract). However, even the rainfall over 20 mm/hour could not be detected with the usual operation policy (100 drops/hour, 10-second drop interval). Based upon the foregoing, the following strategy is realistic as gravity monitoring: (1) two relative continuous gravimeters both above- and belowground are in charge of detections of the response of inland water fluctuations. (2) absolute gravity measurements are repeatedly carried out to calibrate the sensor-drifting of relative gravimeters when atmosphere and ocean are under calm conditions.

Acknowledgements: This work is supporting by a promotion grant for the establishment of the underground research facility of the Agency for Natural Resources and Energy, Minister of Economy, Trade and Industry. We wish to thank the JAEA for cooperation of observations (especially H. Asai (now at Maeda Corp.), Y. Horiuchi, K. Kumada, and S. Hashizume). T. Tanaka and Y. Asai also wish to thank ERI for support of the special cooperative research grant 2010-B001.

Keywords: continuous gravity measurement, gravimeter, inland water variations, groundwater, rainfall, snow depth

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SGD24-09 Room:105 Time:May 25 11:15-11:30

Long-term slow slip events along the Ryukyu Trench as seen from high-precision continuous gravity observations

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Long-term slow-slip events (SSEs) have been observed in many plate-boundary zones along the circum-Pacific seismic belt. Previous studies have revealed that high-pressure fluids supplied from the subducted oceanic plate can generate SSEs. SSEs in different areas have different recurrence intervals. In general, the tectonic stress accumulation rates and the frictional properties on the plate boundaries control the intervals. Therefore, their differences are considered to cause the differences in the intervals. However, variations in fluid pressure will also change the intervals, because they affect the effective normal stress. Variations in fluid pressure are predicted by the earthquake-cycle model based on the fault valve behavior of Sibson (1992). So far, variations in fluid pressure associated with SSEs have not been detected by field observations. If a massive fluid pressure change occurred, gravity change could be observed since the corresponding density redistribution in the underground occurred. In the Tokai district in Japan, the SSE occurred during the years from 2000 to around 2006, and gravity changes in 2004-2009 that could be explained by a fluid pressure variation were detected (Tanaka et al., 2010). However, the quality of the data was not good due to the lower temporal resolution of the campaign data and the observation period did not cover the whole cycle of the SSE. So, a clear evidence of fluid-pressure change has not been obtained yet. In this study, we conduct a continuous gravity measurement using absolute gravimeters and a superconducting gravimeter in Ishigakijima and Iriomotejima Islands along the Ryukyu Trench where SSEs have occurred twice a year (Heki and Kataoka, 2008) to observe a transient gravity change during the whole cycle of an SSE. Such a continuous measurement to elucidate processes of an SSE has never been carried out in the world due to technical difficulties. In this presentation, we will report an observation result obtained by absolute gravimeters.

Keywords: slow slip, subduction zone, gravity, crustal deformation, geodesy, seismology

SGD24-10 Room:105 Time:May 25 11:30-11:45

Continuous gravity observation using a gPhone-109 at a hot spring area of Hachijojima, Japan

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[1]AIST

Gravimeter is a useful tool for detecting subsurface mass variations. For elucidating groundwater variations in hot spring area, we carried out continuous gravity observation with a gPhone-109 in the Nakanogo gravity observation hut of Hachijojima (GOH) at the period from November 2011 to February 2012. We also measured absolute gravity values with a FG5-217 gravimeter for a drift correction of gPhone gravimeter. In addition to gravity measurements, we collected data of atmospheric pressure, rainfall, soil moisture and the monitoring well (e.g. water level and temperature) in the vicinity of GOH. A preliminary result is that, in the late of December 2011, we detected gravity decrease of an approximately 5 microGal that occurred about 3 days after groundwater temperature decrease of the monitoring well of an approximately 1 degree Celsius. In addition to the case, several small gravity changes of microGal level are observed in the observation period. Therefore we will compare gravity changes with estimated precipitation effects and/or observed sea level changes for extracting a gravity signal related to mass variations of a hot spring reservoir.

The authors wish to express their deep gratitude to the Tokyo Electric Power Services Corporation and to Hachijo Town local government for providing generous and courteous support to our field survey team. This study was supported by the competitive research fund of the Ministry of the Environment.

Keywords: hot spring, geothormal power, groundwater, monitoring

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Absolute gravity measurement in coastal region of East Antarctica ? A preliminary report -

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We have started a project to implement absolute gravity measurements with GPS measurements on several outcropped areas along Prince Olav Coast and Soya Coast which locate in East Antarctica in the framework of the 53rd Japanese Antarctic Research Expedition (JARE53). The objectives of the measurements are precise determination of gravity field of Antarctic region and estimation of crustal movements associated with Glacial Isostatic Adjustment (GIA).

We planned to carry out the absolute gravity measurements with a portable absolute gravimeter A10 at 9 outcropped areas including Syowa Station during initial phases of the project. However, because of logistic restriction in JARE53 due to the impossibility of Icebreaker Shirase to come alongside Syowa Station, we have conducted the measurements at only just two areas, i.e. Syowa Station and Langhovde. Although the number of measured sites were much reduced, absolute measurements with A10 in the outcropped areas of Antarctica was the first trial of JARE and a lot of know-how were obtained through the measurements. The experiences including logistic preparation will bring many benefits to the next measurements in Antarctica.

The tentative absolute gravity value at Langhovde was 982 535 584. 57micro-Gal and its standard deviation was 2.4micro-Gal. In the presentation, we will show the outline of our project. We also show details of the measurements at Langhovde and Syowa Station and preliminary results of relative gravity measurements around the absolute gravimetric sites.

Keywords: absolute gravity measurement, GPS measurement, gravity field of Antarctic region, Glacial Isostatic Adjustment, A10

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SGD24-P02 Room:Convention Hall Time:May 25 13:45-15:15

Frequency corrections of 10MHz atomic clocks in absolute gravimeters (A10 and FG5) at Syowa Station, Antarctica

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Absolute gravity values are estimated by precisely observing the drop distance and time of falling bodies in absolute gravimeters. Since the drop time is mostly observed with 10 MHz atomic clocks, the accurate clock frequency is needed in advance to estimate the absolute gravity values. However, the frequency of atomic clocks in absolute gravimeters often shifts slightly from 10 MHz, and some clocks have the time variation in the frequency. Therefore, in order to estimate the precise absolute gravity values, the correction for frequency values of the atomic clocks are needed, by comparing the clock frequencies with a reference clock.

We thus estimated the precise frequency values of 10 MHz atomic clocks in absolute gravimeters at Syowa Station in Antarctica during the 53rd Japan Antarctic Research Expedition (JARE53). We tested the following clocks: (1) Rubidium clock in the A10 absolute gravimeter (SN: #017), (2) Rubidium clock in the FG5 absolute gravimeter (SN: #210), and (3) the spare Rubidium clock for these absolute gravimeters. And we utilized the following clocks as references of 10 MHz signals: (4) Cesium clock and (5) Helium maser. First, we displayed the sine signals of a test clock and a reference clock in an oscilloscope, and recorded the movements of the sine waves with movie cameras. We then calculated the frequency difference between the test and reference clocks with the movie analyses. We conducted the above processes periodically for two months in January and February 2012, and finally we estimated the time variation in the absolute frequency values of the tested atomic clocks.

According to the results, the frequency of the Rubidium clock in the A10 gravimeter (No. 1) shifts by about +0.15 Hz from 10 MHz, and it changes in terms of time at a constant rate of -0.0018 Hz/day. These frequency shifts imply the artificial absolute gravity shifts by +30 micro-gal and -0.36 micro-gal/day respectively, which are larger than the gravity accuracy of the A10 gravimeter (~10 micro-gal). On the other hand, the frequency shifts of the FG5 and spare Rubidium clocks (No. 2 and 3) are smaller than +/- 0.002 Hz (+/- 0.4 micro-gal for gravity), which are significantly smaller than the gravity accuracies of the A10 and FG5 gravimeters.

We will utilize these results for the correction of absolute gravity values observed in Antarctica. And in the coming poster presentation, we will show and discuss the final results of the observed absolute gravity values in Antarctica.

Keywords: Absolute gravimeter, 10MHz atomic clock, Rubidium clock, Cesium clock, Helium maser, Antarctica

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Improvement of the calculation system of the terrain corrected gravity anomaly using 1m mesh DEM and its application

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One of the purposes of the research of gravity anomaly is to obtain information on subsurface structure. The information enables to estimate the basement structure and the location of active faults, so the information of gravity anomaly is the basic one in the field of earth sciences and disaster prevention.

To use the data of gravity anomaly, we have to carry many correction processes. The terrain and the density data are required to correct the gravity data. However if their data include any errors, we cannot obtain the certain information of gravity anomaly. Therefore it is important to use accurate terrain data to obtain precise gravity anomaly data.

Honda and Kono(2005) developed and applied the 50m mesh terrain data that include land area and sea area seamlessly as the terrain data for the terrain correction. Recently the 1m mesh terrain data measured by Airborne Scanning Lidar are available. In the Noto peninsula, the 1m mesh DEM are developed by Hokuriku Electric Power Company. The development of the calculation system of the terrain correction using the 1m mesh DEM improves the accuracy of gravity anomaly distribution, leading better understanding of subsurface structure.

In this study, the main purposes are to improve the terrain correction calculation system with the 1m mesh DEM, and to obtain a higher accuracy distribution of gravity anomaly in the northern Noto peninsula. We compare and consider the difference between existing gravity anomaly distribution and improved one.

Keywords: Gravity anomaly, Terrain correction, 1m mesh DEM, Noto peninsula

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Japan Gravity Standardization Net and Tohoku Region Pacific Coast Earthquake

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The Geospatial Information Authority of Japan (GSI) carried out hybrid gravity survey (absolute observation + relative observation) to detect gravity change caused by Tohoku Region Pacific Coast Earthquake in Sendai, Hachinohe, and Ohsyu area. GSI surveys Sendai and Hachinohe area every 5 years. Because crust change of those areas are very active. Fortunately we carried out gravity survey in Sendai and Hachinohe half year earlier than Tohoku Region Pacific Coast Earthquake. By comparing gravity of last year and this year, we find gravity change in absolute observation.

We inspect change of Japan Gravity Standardization Net (JGSN75 and 96) that have been provided from GSI.

Although, land subsidence was detected in those areas, gravity value decreases at some observation station. We intend to inspect those gravity changes by using formularization of gravity change that is bases on dislocation theory(Okubo, 1994).

We will report results of gravity change of JGSN and model calculation.

Keywords: Gravity, Gravity Standardization Net, Tohoku Region Pacific Coast Earthquake

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Miniaturization of absolute gravimeter by means of the throw-up method

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When carrying out the field survey of movement of magma in a volcano, change of gravity acceleration provides very important information. We are studying miniaturization of an absolute gravimeter.

Absolute gravimeters are equipment which can measure gravity acceleration in the accuracy of 8 to 9 digits. They can observe not only static gravity field but also groundwater flow and movement of magma which provide significant information of volcanic activities. Absolute gravimeters are accurate, but the equipment is too large and heavy for field observation. As a result, for volcanic observations, a gravity value is usually measured by an absolute gravimeter at a reference point of foot, and then a gravity value of an observation point can be obtained from the gravity difference of a reference point and an observation point measured with the relative gravimeter. Therefore such an observation is troublesome, and time resolution was bad. Furthermore it is dangerous to observe at reference point when a volcano erupts. In order to improve these situations, Araya et al. (2007) has developed a compact absolute gravimeter. If this equipment put to volcanic body, we will find out information when the volcano is active. By observing with absolute gravimeters which are arranged simultaneously as a multi-point network, we will be able to analyze magma activity as 2D gravity changes. By installation to a deep borehole or the deep sea of a plate subduction zone, the seismic activity and plate motion of the deep underground can be investigated using gravity. In conclusion, miniaturization of absolute gravimeters will enable various applications and offer the different observation techniques. Since the present equipment had the problem in rapid measurements because of a fall method, I am studying throw-up method.

Our new equipment throws up a corner cube mirror approximately 3mm high by a flexure-based piezoelectric actuator. It generates small vibration because of short raising distance without using a motor. Current equipment took time to lift the corner cube 10cm up to the release point. By the new one with the throw-up mechanism consecutive measurements become possible within a short time. The equipment need to throw vertically without rotating the corner cube mirror.

Keywords: absolute gravimeter, throw-up method, miniaturization, gravity, volcano, magma

SGD24-P06 Room:Convention Hall Time:May 25 13:45-15:15

Gravity tectonic map of Kofu district

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The low gravity anomaly of the Kofu basin is a part of large low gravity anomaly belts which exist in the east side of Itoigawa-Shizuoka Tectonic Line which goes Fujigawa north and reaches the Suwa basin. The west edge and southeast edge of the basin are a steep slope, and correspond to reversed fault structure. Gravity is the minimum not in the lowlands along Fujikawa but in the steep range of hills of several kilometer west, and especially near the Kajikazawa town which is an exit of the south of a basin is having structure where the low density substance is collapsed under the hill. The regional gravity basement of Kofu basin correlates with topographical feature. In detail, the deepest part deeper than -2000m above sea level does not exist in the central part of the basin, but in the west edge, which corresponds to the foot of Minami-Alps.

Keywords: Kofu basin, gravity tectonic map, Itoigawa-Shizuoka tectonic line, Bouguer anomaly, gravity basement

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

SGD24-P07 Room:Convention Hall Time:May 25 13:45-15:15

A Gravity Measurement at the Reference Station of Osaka City University and its Variation

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The gravity exploration is a useful method in pushing forward basement structural analysis for city disaster prevention. The comparison measurement of the gravity value was obtained on the station according to the transfer in Osaka City University, and reported on the change of passing year from the measurement value before this time.

A presented gravity reference station (A station) is in front of the entrance of the Faculty of Science. A new gravity reference station (B station) is in the general education district north end. The gravity values at the temporary reference station in Kinki Polytechnic University (C station) and in Hattaso Geoscience Institute (D station) were also measured respectively. C station was used by Ryoki (2010) and Ryoki (2011). The standard station for the comparison of the gravity values was Kyoto FGS. The gravimeter was LaCoste & Romberg G-308.

The gravity values on the reference stations were obtained; A station:979707.69 mgal, B station:979707.91 mgal, C station:979688.49 mgal, D station:979699.18 mgal. These values were determined from 979707.68 mgal which was measured absolutely in Kyoto FGS on May 12, 2003 (Geographical Survey Institute, 2004).

The gravity value on A station measured March or April, 1973 was 979721.86 mgal in 1930 Potsdam system (Nakagawa and Satomura, 1973).This value was converted to 979708.03 mgal in 1967 gravity system. Moreover, it was 797707.59 mgal in the measurement on July 30, 1981 (Ryoki, 1982). When the value in 1981 and the value in 1973 are compared based on the measurement value in 2011, the gravity value is -0.10 mgal and + 0.34 mgal. The height is -0.092 m (after Ryoki(1982) and Mitamura(2011)).

The height in A station is 0.092 m rises from about 1981 to present, and the gravity value is 0.10 mgal increases. A rise of 0.092 m makes a gravity effect of almost -0.03 mgal in Free-Air reduction. But the measurement value increases. An increase in the height is thought to be a result which considered how to cope with the ground subsidence in the whole area of Osaka plains, and yet an increase in the gravity value in A station is a problem which should be examined more in detail including the activity signs such as Uemachi Fault Zone.

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Keywords: gravity station, KyotoFGS, reference method, ground subsidence, basement structure, gravity survey

Japan Geoscience Union Meeting 2012
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SGD24-P08 Room:Convention Hall Time:May 25 13:45-15:15

Gravity observation using a superconducting gravimeter at Ishigakijima, Japan

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We have started gravity observation using a superconducting gravimeter (SG) at the VERA Ishigakijima Station, National Astronomical Observatory Japan, with the aim of detecting possible gravity changes associated with the slow slip events taking place in the Iriomotejima/Ishigakijima region. The gravimeter (serial number CT36) used in this project was in operation at the Inuyama Observatory, Nagoya University for about ten years. We have chosen to refurbish and reuse the instruments to move them to Ishigakijima island. Refer to Tanaka et al. (this session) for the objectives of the whole project, and Ikeda et al. (this session) for the preparation of the instruments at Inuyama and Tsukuba.

Installation work of the SG at Ishigakijima took place from January 30 through February 4, 2012. The gravimeter pier in the VERA Ishigakijima Station is 2m x 1.5m wide, about half of which is occupied by the SG. The other half of the pier is reserved for future regisration of an absolute gravimeter. The three granite blocks as the gravimeter base are placed on the pier with rubber sheets inserted underneath them, and are anchored to the pier using L-shaped angles. We have not fastened the refrigerator support frame to the pier but simply adjusted it for the alignment with the Dewar. The gravimeter is housed inside a plastic cover so that airflows from the air-conditioner do not hit it directly. Gravimeter controllers as well as data acquisition equipments are placed outside the pier. We have built a new hut next to the building where an air-cooled compressor is housed. We have installed a soil moisture gauge outside the building, and several meteorological sensors such as a rain gauge will be added in the near future.

As of this writing, we are aware of electronic problems in the gravimeter system, including noise contamination associated with the operations of the VLBI antenna. Further adjustment of the instruments is needed to improve the quality of recordings. We will characterize the first data obtained at Ishigakijima, and also introduce gravity data to be acquired in the next slow slip event, which is predicted to take place in March 2012.

Keywords: superconducting gravimeter, slow slip, Ishigakijima

SGD24-P09 Room:Convention Hall Time:May 25 13:45-15:15

Refurbishment of the SG-CT36 at University of Tsukuba for a new challenging observation at Ishigakijima, Japan

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We started a superconducting gravimeter observation to elucidate relationships between slow slip events and gravity changes at Ishigakijima near Ryukyu trench, southwestern Japan in February 2012 (Tanaka et al., and Imanishi et al., this meeting). Before the installation of the superconducting gravimeter (CT36) at Ishigakijima, we refurbished the CT36, installed at the Inuyama observatory of Nagoya University originally, so that the system can operate reliably at such a remote island. Specifically, for the planed observation, we replaced compressor for the coldhead from 'water-cooled' type to 'air-cooled' type. In addition, at University of Tsukuba, we warmed up the Dewar to room temperature to remove the 'clogs' inside it. This has resulted in eliminating strange behaviors in the temperature and tilt controls of the gravimeter, as well as solving the problem in transferring liquid helium into the Dewar.

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Keywords: superconducting gravimeter, liquid helium, slow slip

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Gravity changes at Hachijo island caused by the displacement of the Kuroshio current

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A three-year research project has been begun since fiscal year 2010 (FY2010). The final goal is to develop a reliable monitoring system that can detect small effects on a hot spring caused by geothermal exploitation (Yasukawa et al., 2011). We have started gravity monitoring by means of continuous measurement and time-lapse measurement for the project at southern Hachijo Island, where a 3.3 MWe geothermal power station has been in continuous operation since March, 1999 and several hot spring wells were drilled. We aim to detect a change in groundwater and hot spring water level with a resolution of 10 cm with continuous gravity measurement (Nawa et al., 2011). Roughly it is equivalent to a resolution of 1 microGal. On Hachijo Island we must distinguish local gravity changes occurring in connection with hydrothermal process of hot spring, from those of geothermal power generation, groundwater, and tidal current around the island. Regarding the tidal current the displacement of the Kuroshio current may cause gravity change on Hachio island.

We set a new type of metal spring sensor gravity meter gPhone-119 at the gallery of the broadband seismic station HJO of the F-net networks operated by NIED, in 2010FY creating a continuous 34-day record. Removing tidal component and air-pressure response from the continuous record we detected the gravity variation whose amplitude is about 20 microGal. The displacement of the Kuroshio current was reported by Japan Coast Guard that the current axis was northwest off the island at first then moved to southeast off the island during the period. Observed gravity change is reproduced by calculating the effect of the dynamic topography of the Kuroshio current. Removing the tidal current effect from the observed record we can evaluate the local gravity changes occurring in connection with hydrothermal process of hot spring and others.

The authors wish to express their deep gratitude to NIED (National Research Institute for Earth Science and Disaster Prevention) and to Hachijo Town local government for providing generous and courteous support to our field survey team. This study was supported by the competitive research fund of the Ministry of the Environment.

Keywords: Hachijo island, Kuroshio current, gravity change, gPhone, dynamic topography

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Gravity changes around Ito campus, Kyushu University by using hybrid gravity measurement

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Ito campus, Kyushu University is located in the western end of Fukuoka city, Northern part of Kyushu, Japan. There are 30 wells in order to monitor the groundwater level. Repeat gravity measurements using Scintrex CG-3M gravimeter around Ito campus were conducted before construction of the campus. The seasonal gravity changes were observed and there were good correlation between the gravity changes and groundwater level changes. We started the repeat gravity measurement using Scintrex CG-5 gravimeter since 2009. We established 12 observation points, because almost observation points of previous study were destroyed by the construction of the campus.

The A10 absolute gravimeter (Micro-g LaCoste Inc.) was introduced in order to monitor the gravity changes at base observation points since 2008. We observed seasonal gravity change (Maximum change was 25 micro gal), and we compared with the groundwater level changes. There are good correlation between the gravity changes and the groundwater level changes. We calculated the effect of groundwater level changes using Gwater-1D (Kazama et al., 2010). As a result of the calculation, we can explain the gravity seasonal changes were caused by the groundwater level changes.

The gravity changes of the base observation were removed from each observation point. We can see the good correlation between the gravity changes and the groundwater level change in the almost observation point. The effect of the construction of the campus awaits future studies.

Keywords: A10 absolute gravimeter, Hybrid gravity measurement, Groundwater level change, Gravity changes