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

SGD23-P01 Room:Convention Hall Time:May 25 10:45-12:15

Green's function in the non-integer dimensional space: the fractional Laplacian for the fault zone

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Generally, the crust materials have a various scale of the discontinuous property. Since the effect of the discontinuity can be described quantitatively by the non-interger property of the space (e.g., Fractal geometry), we consider the Green's function in the non-interger space. Especially, we take up the fractional Laplacian as follows:

(-¥Laplacian)$^{a/2}$ $f(r)$=-$g(r)$ (1)

where a is the order of the differentiation and the real number. When a=2, this is the ordinary Laplacian, therefore, f is, for instance, the volumetric strain or the trace of the stress tensor and so on; g is the perturbative force. Except when a is an even number, the distance dependence of the Green's function is given by the Riesz potential:

$G \sim r^{a-2}$ (2)

From this relationship and the Laplacian of the dimension D, we obtain

D+a=4 (3)

except when a is an even number. For instance, when a=1 and 3, we have $G \sim 1/r$ and $G \sim r$, respectively. These are the well-known results in the thee-dimensional and the one-dimensional space. Note that since a is the real number, Eq. (3) shows that the dimension D can also take a non-interger values. For instance, when a=1.5, i.e., D=2.5 dimensional space, the Green's function take the form: $G \sim r^{-0.5}$.Since a itself is defined as the order of the differentiation, the larger number of a means that the problem, described by the fractional Laplacian, becomes more non-local. Eq. (3) shows that the order of the differential is inversely proportional to the number of the dimension of the space. In fact, as the D grows larger, the problem becomes more local. This is a phenological interpretation of Eq. (3).Our conclusions are as follows: (1) In the discontinuous space such as a fault zone, the order of the fractional differentiation has a relationship with the number of the dimension of the space. (2) This relationship determines the concrete form of the distance dependency for the Green's function in the non-integer dimensional space.

Keywords: non-integer dimension, Green's function, Fractional Laplacian, Fault zone

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SGD23-P02 Room:Convention Hall Time:May 25 10:45-12:15

Crustal deformation monitoring in the Asia-Pacific region

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Geospatial Information Authority of Japan (GSI) has been operating continuous GPS observation in the Asia-Pacific region and analyzing the data combined with IGS data obtained in the region. Purpose of the observation and analysis is to monitor crustal deformation in the region and establish regional reference frame consistent with ITRF. In order to establish analysis strategy for estimating enough stable coordinates for the purpose, we performed past data analysis and evaluate the stability of the estimated coordinate of the network composed of long baselines up to several thousand kilometers. This time series also includes gaps caused by events such as earthquakes. Therefore, we also evaluate detection capability of this analysis for crustal deformation.

Keywords: Asia-Pacific region, GPS, Long baseline, Crustal deformation, Bernese

Japan Geoscience Union Meeting 2012
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SGD23-P03 Room:Convention Hall Time:May 25 10:45-12:15

Ultra-rapid EOP measurement with e-VLBI system

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Earth Orientation Parameter (EOP) is essential data for orbit control of an artificial satellite, space exploration or analysis of GPS data. Although the EOP values are calculated by international VLBI observations operated by International VLBI Service for Geodesy and Astrometry (IVS), IVS needs a lot of time (from several hours to several weeks) to obtain EOP values, because it takes a lot of time to process the VLBI data.

Although we conduct some data analysis, we use the final solution of EOP which is calculated using the observed EOP values on VLBI observation. The final solution includes the prediction EOP values, of which accuracies decrease with time. Therefore, many users of the EOP solution require submission of observed UT1 value as soon as possible after the observation.

Geospatial Information Authority of Japan (GSI) has implemented a number of experiments for quasi real-time estimation of UT1 value, which is one of parameters of EOP, since 2007. We introduced the system for quasi real-time estimation into an international VLBI session, and it enabled us to obtain and submit the UT1 results within a few minutes after the observing session of regular VLBI session. In 2011, we have implemented test observation on East-West and South-North baseline and succeeded in ultra-rapid measurement of XY coordinate of polar motion as well as UT1. We will report our recent activities in the presentation.

Keywords: VLBI, UT1, EOP, e-VLBI

Japan Geoscience Union Meeting 2012
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SGD23-P04 Room:Convention Hall Time:May 25 10:45-12:15

Fully automated multi-baseline VLBI analysis with c5++

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Automated processing of UT1 single baseline session has been demonstrated by Hobiger et al. (2010) and is currently applied to regular INT2 sessions as well as ultra-rapid test sessions. We have extended the concept of fully unattended session analysis to multi-baseline sessions and applied it successfully to three station EOPs experiments. Thereby the ambiguity resolution is the crucial part which needs to be handled by a robust and straightforward algorithm before the estimation of the geodetic target parameters could start. Based on our software c5++, we will present a simple multi-baseline ambiguity resolution approach and demonstrate its effectiveness. Moreover we discuss results from real-time EOP estimation experiments and give an outlook how this would affect VLBI2010 operation.

Keywords: VLBI, analysis software, EOP

Japan Geoscience Union Meeting 2012
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SGD23-P05 Room:Convention Hall Time:May 25 10:45-12:15

Development of the space-time information justification verification system of the GNSS satellite using VLBI correlation

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We challenged the new GNSS justification observation to verify the space-time information using CUDA GPU. For this purpose we have to develop the two-dimensional FFT search software for the VLBI-type delay and delay rate using very long FFT chip data longer than 32M points. It consumes very long time such as 2.6sec for 1 line of FFT even using Core i7 CPU. Thus we developed CUDA GPU FFT technology and got the dramatically improved results of 0.0141sec. We also developed the 2D visual verification software from many kinds of GNSS satellite group by calculating the orbit of GNSS and we successfully linked with CUDA FFT system. Using this system we succeeded to verify the GNSS justification.

Keywords: CUDA, GNSS, VLBI, Correlation processing, FFT, GPU

Japan Geoscience Union Meeting 2012
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SGD23-P06 Room:Convention Hall Time:May 25 10:45-12:15

Radio Environment Survey for the Development of Wideband Receiver Antenna of VLBI2010 Specification.

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The VLBI2010 specification, which is under the development in the international geodetic VLBI community as the next generation observation system, is targeting to improve the measurement precision by increasing sensitivity through wide radio frequency observations. VLBI group of NICT has developed 2.4m diameter radio telescope with wide band receiver system (MARBLE), and we are going to use it for 10km baseline validation and for a tool of time-frequency transfer over the long distances. Furthermore, upgrading of MARBLE for the new VLBI antenna of Antarctica is being considered.

However wideband receiver system has disadvantage of vulnerability to radio frequency interference (RFI) such as increasing number of base stations of mobile phone. We have made radio environment survey at Kashima and Koganei sites, where MARBLE1 and 2 are placed, with another type of wideband receiver system. Its results indicated that radio frequency range lower than 3GHz was suffered from strong interference of mobile phone, wireless LAN, ground-TV broadcasting and so on. Thus VLBI systems of VLBI2010 specification need workaround to avoid these radio signals. MARBLE systems at NICT are suffered from these RFI and we are going to introduce high-pass-filter (HPF) to cut radio signal below 3GHz. This paper will present the results of radio environment survey and will show some test observation results after the workaround of the RFI.

Keywords: VLBI2010, Wideband Receiver, Radio Frequency Interference

Japan Geoscience Union Meeting 2012
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SGD23-P07 Room:Convention Hall Time:May 25 10:45-12:15

Variations in the equatorial flattening of the inner core

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The inner core shows degree one hemispherical variations between the eastern hemisphere and the western hemisphere, and beneath the middle Africa. In the cylindrical coordinate frame of which axis is coincide with the rotation axis,deformation of the inner core is expressed as variations of the equatorial flattening of the inner core. Here we discuss gravitational coupling between the inner core and the mantle associated with deformation of the equatorial flattening of the inner core. The motion of the outer core is characterized by a velosity potential. The velosity components must vanish at infinite distancs and the normal velocity at any point of the surface on the ICB (the inner core boundary) must be equal to the velosity of the surface at that point normal to itself. Heat flow due to phase changes from the fluid to solid is assumed to be distributed as an axially symmetric around the rotation axis. The flow generates a thermal wind and relative rotation of the inner core. The density gradient in the eastern and western hemispheres in the top 400 km of the inner core induces the equatorial flattening to be 1.69 x 10 -5. This value shows about 2.8 times larger than Szeto and Yu's value 6 x 10 -6 (1997).The local variations of the equatorial flattening can excite the mantle and inner core libration (Bufffett,1996; Zu et al.,2000;and Aurnou and Olson,2000).

Keywords: inner core, equatorial flattening, mantle, gravitational coupling, outer core, libration

Japan Geoscience Union Meeting 2012
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SGD23-P08 Room:Convention Hall Time:May 25 10:45-12:15

Evaluation of coordinate correction parameter of the 2011 off the Pacific coast of Tohoku Earthquake

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The 2011 off the Pacific coast of Tohoku Earthquake with a moment magnitude of 9.0 occurred on 11 March, 2011. Remarkable crustal deformation associated with the earthquake was observed by the GPS-based control stations in an extensive area of eastern Japan. Geospatial Information Authority of Japan (GSI) suspended the publication of survey results of control points located in eastern Japan on 14 March, 2011, because these control points largely moved and the survey results needed to be revised.

The most desirable method to revise the survey results of control points is to conduct observations at all the control points in order to improve the accuracy of the coordinates. However, it is not realistic because the number of control points which were affected by the earthquake was more than 40,000.

Crustal deformation associated with the earthquake was relatively uniform, so GSI carried out observations at about 2,000 control points, and revised the coordinates of the other control points by calculation using coordinate correction parameter.

In this presentation, we will report the method of calculation and the result of evaluation of coordinate correction parameter of the 2011 off the Pacific coast of Tohoku Earthquake.

Keywords: the 2011 off the Pacific coast of Tohoku Earthquake, survey results, coordinate correction parameter

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SGD23-P09 Room:Convention Hall Time:May 25 10:45-12:15

Simultaneous Observation of GPS and Radiosonde

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Bangladesh is one of the countries of very heavy rain in the world. National mean of annual rainfall is as large as 2000 mm and the rainfall exceeds 5000 mm/yr locally in the northeastern part of the country. In this study we compare precipitable water estimated from fixed continuous GPS observations (GPS-PW) with that obtained from radiosonde measurements (sonde-PW) and also with the daily precipitation at the surface. GPS observations were conducted at Bangladesh Meteorological Department in Dhaka (DHAK) and Sylhet (SYLT) for about 100 days from May to August, 2011. SYLT is located about 200 km northeast of DAHK. GPS data were processed with the precise point positioning method of GIPSY-OASIS II Ver.6.0, and zenith tropospheric wet delay (ZWD) was estimated every five minutes together with three components of coordinates. The ZWDs were converted to GPS-PWs by using a constant coefficient of 0.16 and then averaged to produce an hourly mean. Radiosonde systems were provided by International Met Systems. iMet 1-AA radiosondes were launched at 0000UTC at DHAK, and iMet 1-AB radiosondes were launched at 0600UTC and 1200UTC for one week in the beginning of May. GPS-PW and sonde-PW are consistent with each other at SYLT; the difference of them is about 2.6 mm in rms. On the other hand sonde-PW is systematically larger by about 10 mm than GPS-PW at DHAK. Since two GPS-PW estimates at DAHK and SYLT are very similar, the difference is smaller than 5 mm in rms, we need to check sonde-PW measurements at DAHK. GPS-PW time series at two sites show an increase of about 20 mm in the first one month during the pre-monsoon and then remain almost flat at around 60 mm during the monsoon. This change represents a transition from the pre-monsoon season to the monsoon season. GPS-PW shows spike-like peaks synchronizing to the rainfall.

Vertical component of the coordinates at DHAK shows a subsidence of about 4 cm in about three months. The subsidence may be caused by a decrease of groundwater level near DHAK (Steckler et al., 2010). The term of GPS observation corresponded to a rainy season from pre-monsoon to monsoon but there is a time-lag between rainfall and increase of groundwater level. We interpret that ground uplift that occurred in the dry season before the observation turned to a delayed subsidence. In contrast no subsidence was observed at SYLT. It can be explained that heavy rainfall at SYLT throughout the year preserves a high groundwater level without a significant fluctuation. Steckler et al. (2010) have reported annual variation of vertical component with amplitude larger than 6 cm near DAHK. The subsidence of about 4 cm in three months at DAHK may show a partial seasonal variation. Observations in longer time span are needed to quantify seasonal to annual variation.

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SGD23-P10 Room:Convention Hall Time:May 25 10:45-12:15

Diagnosis of troposphere-induced positioning errors using high-resolution numerical weather model

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In the routine analysis of GEONET, positioning errors caused by the tropospheric delay have been occasionally observed, which make the crustal deformation monitoring a difficult task. In the case study, we found that the characteristic positioning errors observed in the routine analysis of GEONET were reproduced using numerical weather model and the induced mechanism of errors was clarified.

In this research, we investigated which the numerical weather model is useful for diagnosis of troposhpere-induced positioning errors in various typical weather conditions such as seasonal rain front, typhoon, extratropical cyclone, and so on. For this purpose, we used the numerical weather model with 1.5km horizontal resolution and 30-minute temporal resolution computed by the Weather Research and Forecasting (WRF) model while assimilating JMA meso-scale analysis data. We produced simulated GPS observation datasets using Satellite Positioning System Simulator (SPSS) developed by GSI with the numerical weather model data. Then, we analyzed simulated GPS data by the PPP method using GIPSY-OASYS ver.6.1 to estimate positioning errors due to troposheric delay. In presentation, we will report on these results.