Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-01 Room:201A Time:May 23 08:30-08:45

Degree one motion of the inner core and Earth rotation

Chuichi Kakuta[1*]

[1]none

The Earth's inner core shows degree one hemispherical variation of anisotropy in the eastern hemisphere(40 degE-180 degE) and in the western hemisphere(180 degW-40 degE).The hemispheical difference may be explained by unequal growth of the inner core. Wen(2006) showed that the Earth's inner core radius enlarged locally beneath middle Africa by 0.98 to 1.75 kilometers from 1 December 1993 to 6 September 2003. In this report we add the gravitational torque of the outer core caused from the surface deformation of the inner core to the gravitational coupling between the mantle and the inner core.We express the form of the outer core to be a cylinder of elliptic cross section in the elliptic coordinate frame. The volume of the outer core is assumed to be the same volume as the outer core excluding the volume of the tangent cylinder of the inner core. By taking account of Wen(2006) results the semimajor axis of the outer core is assumed to be increase 100 m.. The elliptic form of the inner core also depends on the one dimensional gravitational coupling torque between the mantle and the inner core. We assume the outer core to be a rigid body. If the directions of the semimajor axes of the outer core and the inner core do not coincide, the axial gravitaional torque acts to restore the outer core and the inner core to the gravitaional equilibrium position. This torque relates to the figure of the inner core and the motion of the outer core is transferred to the motion of the mantle. The results show that the free oscillations of the mantle and the outer core, and that the free oscillation period of the mantle (92 years in the previous result) is shorter than the previous value,due to variations of the semimajor axis of the inner core.

Keywords: inner core, outer core, mantle, gravitaional torque, degree one motion, Earth rotation

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-02 Room:201A Time:May 23 08:45-09:00

Polar motion due to the 2010 earthquake in Central Chile and long-term polar motion due to earthquakes

Yuta Kobayashi[1*], Kosuke Heki[1]

[1]Dept. Natural His., Hokkaido Univ

Mass redistribution associated with earthquake faulting causes the shift of the Earth's rotation axis and changes in LOD (Length of day). In Chile, the great earthquake occurred on 27 February 2010. GRACE gravity observations showed a negative jump with the largest drop of ~5 micro gal, and this corresponds to ~8 cm shift of the Earth's inertial axis (Heki and Matsuo, GRL 2010). In the meetings in the last autumn, we reported our attempt to detect this polar motion by geodetic observations. Atmosphere and ocean are the main factors to excite polar motions. We tried to remove their contributions (both motion and mass terms) using NCEP data and ECCO model, respectively. However, the 2010 ECCO model was not available then, and we could not correct the oceanic contribution before and after the 2010 Chilean earthquake. Hence, the discussion on the polar motion was not adequate. In the present meeting, we hope we can correct for the oceanic excitation during 2010 and discuss the issue fully.

In addition to this topic, we will also discuss the excitation of long-term polar motion due to earthquakes. We calculated the earthquake-induced polar motion excitation. Seismic excitation of the polar motion is smaller than the observation by two-orders of magnitude, and in the opposite direction to the observed motion toward Greenland. It was pointed out that the seismic excitation has a strong tendency to move the pole towards ~140E (Chao et al., 1996, Spada, 1997). Large earthquakes in subduction zones generally makes dent in geoid, and move the pole (the north pole if the earthquake occurred in the northern hemisphere) toward the epicenter. The preferred direction would reflect the occurrence of such earthquakes in the northwestern (~140E, mid-latitude) and southeastern (antipodal to it) rims of the Pacific Ocean.

Keywords: The 2010 Chilean earthquake, polar motion, mass redistribution, earth rotation parameters

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-03 Room:201A Time:May 23 09:00-09:15

Ultra-rapid dUT1 measurement with high-speed network

Kensuke Kokado[1*], Shinobu KURIHARA[1], Ryoji KAWABATA[1], Kentaro NOZAWA[2], Daisuke TANIMOTO[2]

[1]GSI of Japan, [2]Advanced Engineering Service Co.,Ltd

UT1 (Universal Time 1) is essential data for orbit control of an artificial satellite, space exploration or analysis of GPS data. Although the UT1 value is calculated by international VLBI observations operated by International VLBI Service for Geodesy and Astrometry (IVS), it takes several hours or several days to obtain UT1 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 UT1 which is calculated using the observed UT1 value on VLBI observation. The final solution includes the prediction UT1 values, which accuracies decrease with time. Therefore, many users of the UT1 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 since 2007. In 2008, we introduced the system for quasi real-time estimation into an international VLBI session, and it enables us to obtain the UT1 results within a few minutes after the observing session of regular VLBI session. GSI became an IVS analysis center in April, 2010. Since then, we have improved the system and checked the qualities of the results. I will report our recent activities in my presentation.

Keywords: VLBI, UT1, EOP, High-speed network, ultra-rapid

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-04 Room:201A Time:May 23 09:15-09:30

Results of Geodetic VLBI Observations by Compact Antennas

Ryoji Kawabata[1*], Shinobu KURIHARA[1], Jiro KURODA[1], Misao Ishihara[1], Kensuke KOKADO[1], Ryuichi ICHIKAWA[2], Hiroshi TAKIGUCHI[2], Kazuhiro TAKEFUJI[2], Moritaka KIMURA[2], Yasuhiro KOYAMA[2], Atsutoshi ISHII[3], Yasuko MUKAI[3], Daisuke TANIMOTO[3], Kentaro NOZAWA[3]

[1]GSI of Japan, [2]NICT, [3]AES

The Geospatial Information Authority of Japan (GSI) has carried out experiments of geodetic VLBI observations by using a compact antenna with a diameter of about 1.5 m, in collaboration with the National Institute of Information and Communications Technology (NICT). The compact antenna can be removed from its basement which is also available for the basement of GPS antenna. Thus we can directly compare the results of VLBI observation with those of other geodetic technique. Moreover the compact antenna is so portable that it enables us to carry out VLBI observations everywhere. Hence we study the compact antenna as a new generation of VLBI techniques.

Large antenna with a diameter over 30 m is necessary for us to obtain high precision geodetic results with the compact antenna. We carried out geodetic observations by using two compact antennas, first prototype at NICT Kashima Space Research Center and second prototype at GSI, and two large antennas, Kashima 34 m and Tsukuba 32 m. Then we obtained geodetic results of seven observations since December 2009. These observations include a wideband observation on 12 November 2010 in which we directly sampled intermediate frequency signals (500 MHz bandwidth) of S and X band with a sampling rate of 2 Gbps in order to obtain a higher precision result. We will report on the results of experiments of the compact antenna.

Keywords: VLBI, geodesy, compact antenna

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-05 Room:201A Time:May 23 09:30-09:45

VLBI2010 and GGOS

Shinobu Kurihara[1*], Jiro Kuroda[1], Misao Ishihara[1], Kensuke Kokado[1], Ryoji Kawabata[1]

[1]GSI of Japan

The International VLBI Service for Geodesy and Astrometry (IVS) had been considering the next generation VLBI system named ”VLBI2010”. The IVS approved the specification of the VLBI2010 system in the IVS General Meeting held in France in March 2009, and the member organization of IVS proceeded in working toward VLBI2010. VLBI2010 is necessary for the Global Geodetic Observation System (GGOS) proceeded with the International Association of Geodesy. In this report, I’ll talk about the outline of VLBI2010, the situation of the effort for VLBI2010 in the world and the relationship with GGOS.

Keywords: VLBI, VLBI2010, IVS, Global, IAG, GGOS

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-06 Room:201A Time:May 23 09:45-10:00

Combining different types of data for inverse ill-posed problems

Peiliang Xu[1*]

[1]Kyoto University

Data assimilation theory for geophysical inverse problems

Peiliang Xu
Disaster Prevention Research Institute
Kyoto University

The method of generalized cross-validation (GCV) has been widely used to determine the regularization parameter, because the criterion minimizes the average predicted residuals of measured data and depends solely on data. The data-driven advantage is valid only if the variance?covariance matrix of the data can be represented as the product of a given positive definite matrix and a scalar unknown noise variance. In practice, important geophysical inverse ill-posed problems have often been solved by combining different types of data. The stochastic model of measurements in this case contains a number of different unknown variance components. Although the weighting factors, or equivalently the variance components, have been shown to significantly affect joint inversion results of geophysical ill-posed problems, they have been either assumed to be known or empirically chosen. No solid statistical foundation is available yet to correctly determine the weighting factors of different types of data in joint geophysical inversion. We extend the GCV method to accommodate both the regularization parameter and the variance components. The extended version of GCV essentially consists of two steps, one to estimate the variance components by fixing the regularization parameter and the other to determine the regularization parameter by using the GCV method and by fixing the variance components. We simulate two examples: a purely mathematical integral equation of the first kind modified from the first example of Phillips (1962) and a typical geophysical example of downward continuation to recover the gravity anomalies on the surface of the Earth from satellite measurements. Based on the two simulated examples, we extensively compare the iterative GCV method with existing methods, which have shown that the method works well to correctly recover the unknown variance components and determine the regularization parameter. In other words, our method lets data speak for themselves, decide the correct weighting factors of different types of geophysical data, and determine the regularization parameter. In addition, we derive an unbiased estimator of the noise variance by correcting the biases of the regularized residuals. A simplified formula to save the time of computation is also given. The two new estimators of the noise variance are compared with six existing methods through numerical simulations. The simulation results have shown that the two new estimators perform as well as Wahba estimator for highly ill-posed problems and outperform any existing methods for moderately ill-posed problems. More details on this topic can be found in Xu et al. (2006, J Geodesy, 80, 69-81), Xu (2009, Geophys J Int, 179, 182-200) and Shen, Xu and Li (2011, submitted).

Keywords: inverse problems, data assimilation

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-07 Room:201A Time:May 23 10:00-10:15

Development of a compact absolute gravimeter (6)

Akito Araya[1*], Yoshiaki Tamura[2], Tsuneya Tsubokawa[3]

[1]Earthquake Res. Inst., Univ. Tokyo, [2]National Astronomical Obs., Mizusawa, [3]Shin-ei Keisoku

Absoute gravimeters can measure gravitational acceleration with an accuracy of 10{sup}-9{/sup}, and are useful for detecting crustal deformation and transfer of underground fluid, especially expected for diagnosing volcanic activity.

We have developed a prototype of a compact free-fall absolute gravimeter by means of new fringe-signal processing, correction of ground vibration using an active control of the reference mirror, and miniaturizing a free-fall mechanism. We are working on further reduction of its size and improvement of portability in the field. The details of the improvements, the performance including accuracy, and its practicality will be presented.

Keywords: geodesy, gravity, absolute gravimeter, laser interferometer, free fall

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-08 Room:201A Time:May 23 10:15-10:30

Compact and highly sensitive tiltmeter

Akiteru Takamori[1*], Alessandro Bertolini[2], Riccardo DeSalvo[3], Toshihiko Kanazawa[1], Masanao Shinohara[1], Akito Araya[1]

[1]ERI, Univ. of Tokyo, [2]Universita di' Pisa, [3]California Institute of Technology

The details of a novel compact tiltmeter will be reported as well as the results of test observations.

Keywords: tiltmeter, folded pendulum, optical transducer, ocean bottom, borehole

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-09 Room:201A Time:May 23 10:45-11:00

Towards the Utilization of QZSS for GPS surveying: Test observation at Tsukuba Baseline Field

Hiromichi Tsuji[1*], Hiroshi Yarai[1], Tomoo Toyoda[1], Tomohiro Yahagi[1], Kenji Yoshida[1], Yuki Hatanaka[1], Hiroshi Munekane[1], Satoshi Kogure[2], Jiro Yamashita[2], Motoyuki Miyoshi[2], Hiroaki Tateshita[2], Yaka Wakabayashi[2], Tomoji Takasu[3]

[1]GSI of Japan, [2]JAXA, [3]TUMSAT

Geospatial Information Authority of Japan (GSI) and Japan Aerospace Exploration Agency (JAXA) jointly conduct a test observation of Quasi Zenith Satellite System (QZSS) at Tsukuba Baseline Field of GSI. This is one of the first technical evaluations of GPS availability enhancement of QZSS.

We obtained GPS and QZSS data using JAXA's GNSS receivers manufactured by JAVAD at 14 stations for 24 hours. GPS baseline solutions with/without QZSS will be compared under various elevation cutoff angles using RTKLIB software developed by Tokyo University of Marine Science and Technology and GAMIT software modified by GSI.

Towards the early realization of multi-GNSS surveying environment, GSI will take necessary steps in collaboration with JAXA, including a new 4 year R&D project for multi-GNSS analysis method from 2011FY.

Keywords: QZSS, GPS augmentation, surveying

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-10 Room:201A Time:May 23 11:00-11:15

Development and availability of a new positioning technique using GPS augmentation information from QZS-1 'Michibiki'

Toshihiro Yahagi[1*], Kenji Yoshida[1], Tomoo Toyoda[1], Hiroshi Yarai[1], Hiromichi Tsuji[1], Yuki Hatanaka[1], Hiroshi Munekane[1], Yuki Kuroishi[1]

[1]GSI of Japan

The first satellite of the Quasi Zenith Satellite System (QZSS) named 'Michibiki' was launched on September 11th 2010 successfully. Michibiki has a unique orbit in order to stay long hours above Japan region and provide services even under non-open sky environment like urban areas and mountainous regions. Michibiki transmits two types of signals. Ones are completely compatible and interoperable with existing and modernized GPS signals (L1-C/A, L1C, L2C and L5). By transmitting those signals, Michibiki is expected to improve GPS satellite constellation by working as an additional GPS satellite. And the others are Michibiki's original signals, L1-SAIF and LEX, which are used for broadcasting augmentation messages.

GSI has developed a new precise positioning technique by using the augmentation parameters on the LEX signal. The goal of this method is the realization of cm-level positioning by a single-frequency GPS receiver with about 15minites observation. The parameters on LEX signal are generated from real-time data collected by the GPS Earth Observation Network system (GEONET). We carried out experimental surveys by using data from Michibiki and drafted the geodetic surveying specification to encourage a use of this technique in Japan.

This presentation shows the details of the new developed technique, evaluation results of experimental surveys and drafting specification.

Keywords: QZSS, GPS augmentation, surveying

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-11 Room:201A Time:May 23 11:15-11:30

Comparison of Ka-band Rainfall Attenation Measurement between radio interferometery and Nowcast data for WINDS satellite

Hirokazu Sato[1*]

[1]Yokohama National University

A rain attenuation on the Ka band has been measured with weather data by Japan Meteorogical Agency and with their own rainfall meters.

We have developed Ka band radio interferometer to measure the complex fringe data of WINDS satellite radio wave.

We compared the estimated rainfall attenation with the NowCast data of Japan Meteorological Agency and conventional data of rain attenuation.

Keywords: WINDS, Rainfall Attenation

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-12 Room:201A Time:May 23 11:30-11:45

Mass loading contribution for seasonal variation of GPS time series in southeast Alaska

Masaki Akatsuka[1], Yusaku Ohta[1*], Satoshi Miura[1], Tadahiro Sato[1], Jeffrey T. Freymueller[2]

[1]RCPEVE, Tohoku University, [2]GI, UAF

We assess contributions of mass loading effects to GPS time series seasonal variation in southeast Alaska.

In southeast Alaska shows very rapid uplift, with peak rates exceeding 30 mm/yr based on the mainly campaign GPS observation, which are mainly caused by GIA due to the effects of past and present-day ice melting [1]. The almost continuous sites, however, clearly shows the strong seasonal variation in vertical components. It may be interfered with precise vertical velocity estimation. In this study, we consider well-known mass loading for the GPS time series correction, which contain atmosphere, snow and soil moisture loading effect.

We re-analyzed the PBO (Plate Boundary Observatory) GPS data in and around Alaska region using PPP (Precise Point Positioning) approach implemented in GIPSY-OASIS II Ver. 6.0. We applied VMF1 mapping function and reproduced JPL precise orbit and clock products (flinnR products). Obtained GPS vertical component time series clearly show seasonal variation. The Green's function approach is adopted to calculate site displacements from various mass loads [2]. We used the NCEP/NCAR reproduced product as atmospheric pressure data for loading calculation. Mass redistribution from variations of snow cover (snow water equivalent, SWE) and soil moisture is derived from the assimilated model of GLDAS (Global Land Data Assimilation System [3]). Compared with GPS and synthetic displacement time series generated by all loading component, both time series are basically agreement with each other. The synthetic time series, however, underestimate seasonal variation amplitude. The mass loading can explain only 30 % of annual signal amplitude. The one of the inconsistency reason include the inaccurate GLDAS SWE data set because of GLDAS SWE amount is not consistent with ground observation result.

[1] Larsen et al. (JGR, 2005)
[2] Farrell (Rev. Geophys. Space Phys, 1972)
[3] Rodell et al. (Bull. Amer. Meteor. Soc., 2004)

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-13 Room:201A Time:May 23 11:45-12:00

Performance Comparison of High-Rate GPS Receivers for Seismology

Takuji Ebinuma[1*], Teruyuki Kato[2]

[1]The University of Tokyo, [2]Earthquake Research Institute

High-rate GPS observations with higher than once-per-second sampling are getting increasingly important for seismology. A number of reports have shown that high-rate GPS receivers are capable of capturing the ground vibration due to earthquakes. Unlike a traditional seismometer which measures short period vibration using accelerometers, the GPS receiver can measure its antenna position directly and record long period seismic wave and permanent displacements as well. The high-rate GPS observations are expected to provide new insights in understanding the whole aspects of earthquake process.

The ground vibration due to an earthquake is composed of a wide spectrum of frequencies. In general, the seismic energy in frequency spectrum decreases toward higher frequency, and the corner frequency is around several to tens of hertz depending on the earthquake magnitude. In order to grasp such a wide frequency range, the GPS receiver is required to provide higher data sampling rate. The receiver also needs to maintain lock to the GPS signals under high acceleration and high jerk environment due to the earthquake.

In this study, we investigated dynamic characteristics of the high-rate GPS receivers capable of outputting the observations at up to 50Hz. This higher output rate, however, doesn't mean higher dynamics range of the GPS observations. Since many GPS receivers are designed for low dynamics applications, such as static survey, personal and car navigation, the bandwidth of the loop filters tend to be narrower in order to reduce the noise level of the observations. The signal tracking loop works like a low-pass filter. Thus the narrower the bandwidth, the lower the dynamics range. In order to extend this dynamical limit, high-rate GPS receivers might use wider loop bandwidth for phase tracking. In this case, the GPS observations are degraded by higher noise level in return.

In addition to the limitation of the loop bandwidth, higher acceleration due to earthquake may cause the steady state error in the signal tracking loop. As a result, kinematic solutions experience undesirable position offsets, or the receiver may lose the GPS signals in an extreme case.

In order to examine those effects for the high-rate GPS observations, we made an experiment using a GPS signal simulator and several geodetic GPS receivers, including Trimble Net-R8, NovAtel OEMV, Topcon Net-G3A, and Javad SIGMA-G2T. We set up the zero-baseline simulation scenario in which the rover receiver was vibrating in a periodic motion with the frequency from 1Hz to 10Hz around the reference station. The amplitude of the motion was chosen to provide up to 10G acceleration to emulate high frequency and high acceleration earthquake motion.

The simulation results showed that the amplitude was too small when the frequency was higher than 5Hz, and kinematic solutions were buried under the noise level. The jerk was also too high in such high frequency region, and no receiver was capable of maintaining signal lock. Many receivers lost signal under the acceleration higher than 4G. We also found that the accuracy of high-rate GPS observations was independent of sampling rate of the receivers, and the 50Hz sampling rate provides better resolution to the kinematic solutions.

Our experiment suggested that, in the given environment and receiver sets, higher sampling interval was recommended to measure the ground motion in higher resolution. On the other hand, the dynamic characteristics of the signal tracking loop put a limit on the frequency and the acceleration of the antenna motion, and it would be quite difficult to capture the ground vibration with higher than 5Hz in frequency and 4G in acceleration. We will further continue our experiments to find the optimal configurations of the high-rate GPS receivers to monitor seismic events.

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-14 Room:201A Time:May 23 12:00-12:15

Evaluation of real-time PPP performance with IGS real-time precise ephemerides

Tomoji Takasu[1*]

[1]Tokyo Univ of Marine Science and Tech

PPP (precise point positioning) is a precise positioning technique by using carrier-phase observables of GNSS satellite signals. Compared to general baseline analysis, PPP has a merit that it does not need any reference station. Conventionally, PPP is utilized in post-processing mode which needs precise ephemeris provided by IGS (International GNSS service). IGS had been have the activity to provide its products in real-time as RTPP (real-time pilot project) since about 10 years ago. The RTPP already started to broadcast the real-time ephemeris products via Internet with RTCM ver.3 SSR (state space representation) format and NTRIP (Networked Transport of RTCM via Internet Protocol). The ephemerides contain not only for GPS but also for GLONASS. The performance of PPP much depends on the quality of used ephemerides and has not been well evaluated. In this study, we continuously collected IGS real-time ephemeris via Internet for about half year and evaluated real-time PPP performance with such IGS real-time products. For the experiment, we used RTKLIB version 2.4.0 which provides real-time and post-processing PPP modes. The evaluation results include accuracy of solutions, convergence time, comparison between with GPS only and with GPS/GLONASS.

Keywords: Precise Point Positioning, IGS, precise ephemeris, real-time

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-15 Room:201A Time:May 23 12:15-12:30

A GNSS-R system based on software defined radio

Thomas Hobiger[1*], Amagai Jun[1], Aida Masanori[1], Tadahiro Gotoh[1]

[1]NICT

The remote sensing community has an increasing interest in analyzing GNSS reflections as they provide valuable information about the physical characteristics of the reflection area. This technology operates usually with two antennas in order to monitor direct and reflected signals. One up-looking (RCHP) and one down-looking (LHCP) antenna is deployed at the same site and analysis of the differential delay and/or the cross-correlation function w.r.t. to delay and Doppler shift allows to deduce the physical properties of the scattering surface. In order to develop a GNSS-R off-the-shelf system RHCP and LHCP L1 active patch antennas are utilized together for this purpose. Signals are sampled directly in the RF and sent to a PC over a Gigabit ethernet connection. This allows us to implement the system as a software radio using readily-available, low-cost RF hardware and commodity processors. Field tests are carried out on a 60m high telecommunication tower located NICT's headquarter in Koganei, Tokyo.

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-16 Room:201A Time:May 23 12:30-12:45

Evaluation of IGS reproduction precise ephemeris applying the analysis of Japanese domestic GPS network data (Part 2)

Seiichi Shimada[1*]

[1]NIED

International GNSS Service (IGS) revised the conditions to calculate GPS precise ephemerids after 1400 GPS week (November 5, 2006) and 1410 GPS week (January 14, 2007). IGS recalculates precise ephemerides for the weeks before 1410 GPS week applying the same conditions with those after 1410 week (IGS reproduction ephemeris).

Shimada (2010) evaluates IGS reproduction orbit analyzing about 90 GEONET and 5 NIED GPS network sites in Tokai-Izu area for the period during 1997 and 1998 with about 15 IGS network sites in and around Eastern Asia applying the IGS reproduction orbit and the IGS final orbits and comparing the site coordinates repeatability of the Tokai-Izu sites obtained using those two orbits. In the analysis site coordinates, zenith delay parameters, tropospheric gradients, and ambiguities of Tokai-Izu and IGS sites, orbit parameters, and the EOP parameters are estimated. By the comparison there is very little difference between the repeatabilities applying those two orbits. The little difference may be caused by the orbit relaxation approach in the analysis adopting the ITRF2005 site coordinates and velocities (Altimimi et al., 2007) for the IGS fiducial sites, and the approach makes very little difference between those two improved orbits.

Therefor in this study we fix those two orbits and analyze the same datasets with the same conditions but fixing orbits, and compare the site repeatabilities of the Tokai-Izu sites applying the IGS reproduction and final precise ephemerides. In the result the averages and standard deviations of the sites repeatabilities of Tokai-Izu sites applying the IGS reproduction orbit are 2.0 +- 0.9 mm, 2.6 +- 0.8 mm, and 6.4 +- 1.3 mm for N-S, E-W, and U-D components respectively. On the other hand, those applying the IGS final orbit are 2.1 +- 0.9 mm, 3.0 +- 0.8 mm, and 7.1 +- 1.2 mm respectively. Judging with the standard deviation the difference is not significant, but especially for E-W and U-D components the repeatabilities of the reproduction orbit seem to improve compared with those of the final orbit.

Keywords: IGS reproduction precise ephemeris, site coordinates repeatability

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-P01 Room:Convention Hall Time:May 23 14:00-16:30

True polar wander of a quasi-fluid planet with a fossil shape: Effect of strain energy due to tidal deformation

Yuji Harada[1*]

[1]Shanghai Astronomical Observatory

Elastic strain energy stored in lithospheres of solid planets and satellites affect evolution of these rotation axes, especially true polar wander (hereafter ”TPW”). If we suppose an ideal planet without a lithosphere which completely behave as fluid body, its figure always keeps hydrostatic state. In this case, its spin pole finally coincides with the principal axis of its moment of inertia tensor. It is because this state minimizes the rotational energy. On the other hand, in the case of more realistic planet with an elastic lithosphere, one previous research pointed out a possibility that its spin axis and principal axis are not coincident each other. This remarkable argument is concluded solely because of the fact that huge amount of strain energy is accumulated in a lithosphere due to tidal stress by long-term polar motion. Thus, a pole position is settled at the different place in order that this position minimizes total energy including not only rotational energy but also strain energy.

The content treated in the previous study shown above, however, is just a difference of paleo-pole positions before and after TPW. In other words, the previous study did not handle secular time variation of a spin pole location from an initial state to a final state.

In the present study, therefore, temporal variation of a paleo-pole position due to TPW is formulated and calculated based on the strain energy as mentioned above in the previous study. Especially, the quasi-fluid approximation is suitable to deal with large-scale and long-term variation of a paleo-pole position. Thus, an orientation of a paleo-rotation axis in each time step is estimated in here by following the conventional formulation with the quasi-fluid approximation for TPW, and simultaneously by taking total energy minimization into account. In practice, this procedure is physically same as to incorporate elastic torque due to tidal deformation of a lithosphere into the Liouville equation including the quasi-fluid approximation. In this study, like the previous one, only one symmetric surface load is regarded as a driving force of TPW for the sake of convenience. In this calculation, the variable parameters are defined as follows: a location of emplacement, duration of formation, and maximum of intensity of a load. The result with strain energy is compared with that without strain energy.

As a result, the case with the strain energy indicates different characteristics from that without the strain energy in the following points. First, the paleo-poles under the steady states are different each other even in the cases for same parameters. These results have no contradiction to the previous results concerning just the final condition. Second, also in the cases for same parameters, time scales when the paleo-poles reach the static limits are different. These results demonstrate the fact that strain energy within a lithosphere effectively weakens influence of a load on TPW. Although such influence has already been pointed out by the previous results just in the case of the steady state, the present results further revealed similar effect also on a characteristic time scale of TPW. Strictly speaking, however, it is impossible to estimate this exact time scale only by reducing an effective size of a load. This is because secular variation in strain energy induced by TPW inevitably occurs after variation of a load itself as driving force. This delay results from visco-elastic readjustment of centrifugal bulge in response to long-term polar motion.

In conclusion, the present results imply that strain energy is not necessarily negligible in terms of physical interpretation for realistic TPW of the planets and satellites in the solar system, especially characteristic time scales and time variation between the initial and final state of the spin axis.

Keywords: fossil shape, quasi-fluid approximation, polar wander, elastic lithosphere, tidal deformation, strain energy

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-P02 Room:Convention Hall Time:May 23 14:00-16:30

Research on the parallel processing of VLBI USB samplers by using virtualization OS

Toru Kajiwara[1*], Fujinobu Takahashi[1], Tetsuro Kondo[2]

[1]Yokohama National University, [2]Kashima Space Research Center

K5/VSSP(Versatile Scientific Sampling Processor)32 sampler can beconnected by USB. It is used for VLBI(Very Long Baseline Interferometry) observation. In the normal operation only one sampler can operate by one PC. To improve the problem, we introduce the latest Multi-virtual OS technology. We installed four virtual OSs in one PC. And we operated one sampler by one virtual OS, respectively. We have succeeded in the realize the geodetic VLBI observation of 16ch/8Mbps and 16Mbps by using only one PC with our multi-virt system. We will report our analysis of the experiment by using the correlation processing.

Keywords: virtualization, VLBI, sampler, correlation processing

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-P03 Room:Convention Hall Time:May 23 14:00-16:30

Development of space geodetic analysis software c5++, Part-2

Toshimichi Otsubo[1*], Thomas Hobiger[2], Tadahiro Gotoh[2], Toshihiro Kubooka[2], Hiroshi Takiguchi[2], Mamoru Sekido[2], Hiroshi Takeuchi[3]

[1]Hitotsubashi University, [2]NICT, [3]JAXA

New analysis software ”c5++” is being developed at NICT, Hitotsubashi Univ and JAXA for high-precision geodesy/navigation data such as SLR (Satellite Laser Ranging) and VLBI (Very Long Baseline Interferometry).

This software is oriented for combining multiple types of observations, which is getting common in geodetic analyses and other purposes. The ”c5++” software is equipped with the combination procedure such as ”VLBI+SLR” data set at the observation level.

The physical models in Earth rotation, site displacement, satellite acceleration and propagation delay are being updated so that it has full compatibility with the newly-released IERS Conventions 2010.

The first outcome from this software is a rapid UT1 analysis from VLBI data. The poster contains the actual results from this project.

Keywords: space geodesy, satellite laser ranging, very long baseline interferometry

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-P04 Room:Convention Hall Time:May 23 14:00-16:30

Construction of GEONET quasi-real-time analysis system

Hideki Kojima[1*], Isao Kageyama[1], Toshihiro Yahagi[1], Tomoaki Furuya[1], Yukiko Furuya[1]

[1]GSI of Japan

GSI has processed the GPS kinematic analysis with GEONET 1 Hz sampling data when a large earthquake occurs. The purpose of this analysis is to obtain the detailed behavior of land deformation caused by the earthquake with high time resolution. This method also has an advantage in terms of the time until we can get results. Because of processing data with epoch-by-epoch, compared to the GEONET routine analyses which need at least 6 hours data set, it enables us to start the analysis flexibly. Meanwhile, we need to be careful when we use it that the accuracy and reliability is relatively worse than the GEONET routine analyses.

A current problem is that we spend long hours until starting process because of some steps like deciding the area, choosing GEONET stations and setting appropriate parameters. We have carried out those steps manually and could not fully utilize the advantages. So we establish a new strategy to kick off the analysis automatically by using the information from the JMA Earthquake Early Warnings system. This new method has been applied since March 2011 and made us possible to get results within 1 hour in the fastest case.

Keywords: GEONET, GPS

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-P05 Room:Convention Hall Time:May 23 14:00-16:30

Monitering of atmospheric precipitable water using GPS and microwave radiometer

Mikito Tanaka[1*], Takao Tabei[1], Yuji Ohhigashi[2], Fumie Murata[1]

[1]Faculty of Science,Kochi University, [2]Mitsubishi Electric Tokki Systems

Temporal variations of precipitable water (PW) from fixed continuous GPS observations are compared with those from microwave radiometer (MR) observations and radiosonde measurements. All data were collected at the same site (Kochi University) for about one month in June 2010. GPS data were processed with the precise point positioning method of GIPSY-OASIS II ver.6.0 using precise satellite orbits and clocks, Vienna mapping function, and Onsala ocean loading correction coefficients. Zenith wet delay was estimated every five minutes after resolving phase ambiguities and then converted to GPS-PW by multiplying a constant coefficient. No significant difference was recognized ($<$ 1 %) even when time-variant coefficients expected from hourly surface temperature measurements were used. The MR measured zenith brightness temperatures of the atmosphere at 23 GHz and 36 GHz frequencies every ten seconds. We have newly calculated conversion coefficients from the brightness temperature to PW based on the GPS-PW estimates. Correlation coefficient between GPS-PW and MR-PW is as high as 0.974 after abnormal MR measurements at the rain fall are excluded. Since the MR is highly mobile and capable of real-time measurements, it is applicable to the direct monitoring of water vapor disturbance in an urban area where infrastructure has been highly developed and GPS is no longer an effective observation tool.

Next we investigate effects of satellite orbit information and mapping function on the GPS atmospheric delay estimation. We processed one-year GPS data at Kochi (GEONET 0083) using the final precise orbits and Vienna mapping function and also using the ultra-rapid orbits and Global mapping function. Two time series of zenith wet delay from different combination of sattelite orbits and mapping function are consistent with one another within 2.36 mm in rms. Atmospheric delay and resultant PW estimated from quasi-real-time GPS data processing are highly reliable and applicable to the wide variety of atmospheric studies.

Keywords: GPS, precipitable water, radiosonde, radiometer, mapping function

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-P06 Room:Convention Hall Time:May 23 14:00-16:30

Numerical simulation of positioning errors using high-resolution numerical weather prediction model

Masayoshi Ishimoto[1*], Hiroshi Munekane[1], Tomokazu Kobayashi[1]

[1]GSI of Japan

We observed characteristic positioning errors at GPS stations around Sakura-jima in Kagoshima Prefecture, Japan. The directions of these errors are usually same and observed in summer. In this research, we try to clarify that the source of these errors is troposhperic delay or not by comparing observed positioning errors with those simulated using high-resolution numerical weather prediction model. For this purpose, we used the numerical weather model with 1km horizontal resolution and 1-hour temporal resolution computed by Cloud Resolving Storm Simulator (CReSS) developed by Nagoya University while assimilating JMA meso-scale analysis data and SST 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 ver.5.0 to estimate positioning errors due to troposheric delay.

We found that the simulated positioning errors are correlated with the observed ones, which suggests that the errors of GPS observation around Sakura-jima are caused by tropospheric noise. In presentation, we will report on these results and the relation between positioning errors and weather condition.

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-P07 Room:Convention Hall Time:May 23 14:00-16:30

Ka-band Data Analysis of Phase Variation from WINDS Satellite Signals Interferometer System

Tetsuya Katayama[1*], Takuya Shinno[1], Fujinobu Takahashi[2]

[1]Yokohama National University, [2]Yokohama National University

Japanese Super Internet Satellite WINDS sends Ka-band signals. Ka-band is influenced by rainfall and meteorological phenomenon because its wavelength is very short. We constructed the interferometer system that receives signals and thermal noise from the WINDS and measure and research the influence of rainfall and meteorological phenomenon on WINDS signals. The interferometer system receives the radio wave from the WINDS with two antennas and performs the correlation processing. Using the VLBI-type fringe stopping method to practical use, we got the amount of phase variation of the correlation. We analyzed the phase variation by comparing that to meteorological variation such as temperature and atmospheric pressure and discussed the influence of meteorological phenomenon on WINDS signals and tropospheric propagation.

Keywords: WINDS, Ka-band, interferometer, correlation processing, phase, meteorological phenomenon

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-P08 Room:Convention Hall Time:May 23 14:00-16:30

The accuracy evaluation of attitude of buoy using GPS receivers

Yukihito Osada[1*], Yusaku Ohta[1], Motoyuki Kido[1], Hiromi Fujimoto[1]

[1]Tohoku Univ., Graduate school of science

We observed the seafloor crustal movement using the ship, towed buoy and moored buoy. On these platforms, there is the important information to monitoring an attitude. It is a key point to determine the position of the acoustic transducer from the position of a GPS antenna after a correction for the motion of the surface platform for the improvement of accuracy on seafloor geodesy. There are two methods on the measurement of attitude. One thing is the combination of GPS and inertial navigation system (RLG and MEMS). Another is the multi antennas GPS receiver. In this presentation we carried out the accuracy evaluation of attitude using the multi antennas GPS receivers.

We use three GNSS receivers (Sigma@Javad GNSS, PolaRx2@septentrio, and GRX1200+@Leica Geosystems) for the accuracy evaluation. Basic test is the static test. We carried out the basic test for PolaRx2@ receiver on June 2006 and for Sigma receiver on October 2010. The following was obtained by this examination. The resulted accuracy is comparable to the catalog accuracy. The results of power spectrum density for the Sigma receiver was about one order smaller at the noise level than those for the PolaRx2 receiver, and there was a good correlation between the variability and DOP. However, because we did not carry out these observations at the same time, it is difficult to do a detailed comparison of receivers. Therefore, it is scheduled that using all receivers will carried out the static observation and the moving observation for the accuracy evaluation.

Keywords: GPS, attitude

Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SGD021-P09 Room:Convention Hall Time:May 23 14:00-16:30

Ocean tidal observation with GPS buoy around Lutzow-Holmbukka, East Antarctica

Yuichi Aoyama[1*], Koichiro Doi[1], Kazuo Shibuya[1]

[1]National Institute of Polar Research

With the objective of measuring the ocean tide around Lutzow-Holmbukka, East Antarctica, we have been developing GPS buoys. In 2005, the first GPS buoy was installed on sea surface at Nishi-no-ura, the shore of East Ongul Island, where the ocean bottom pressure has been regularly observed as tide gauge data at Syowa Station. This GPS buoy consisted of a dual frequency GPS receiver and antenna (Lexon-GGD160T & GrAnt; Javad Inc.), the buoy with a float (Zeni-light buoy Co., Ltd.) and two Pb batteries (12V24Ah). Several continuous ocean tidal observations could be conducted for 5 - 7 days without its maintenance. Aiming to perform the continuous ocean tidal observation for a few months, we modified the GPS buoy and examined its performance in 2008. We applied a hybrid power system which was combination of the electric double layer capacitor (30VA, PowerSystems Co., Ltd.) and the Pb battery (12V24Ah) to a second generation of the GPS buoy and we attached 20W solar panel on its float. The dual frequency GPS receiver and antenna (DL-V3 and GPS-702-GG; NovAtel Inc.) ware incorporated into the GPS buoy. This GPS buoy was installed on the offing of Benten Jima which is located on about 20 km distance from Syowa Station, at the end of September, 2008. Due to malfunction of the charging to the Pb battery, the power supply of GPS was maintained by the electric charge and discharge to the capacitor. The 30VA capacity of the capacitor and 20W power generation of the solar panel were too short to perform the continuous GPS measurement. Therefore the ocean tidal observation by the GPS was intermittent. Polar day and fine weather in austral summer enabled the comparatively continuous observation. The instantaneous positions of the GPS buoy which were synchronized with the ocean tide were determined from GPS data obtained during Nov. - Dec., 2008 by adopting the kinematic precise point positioning analysis with GPS Tools. The ocean tidal analysis with BAYTAP-G was applied to the time series of the instantaneous GPS position data during Nov. - Dec., 2008.

We still continue to improve the GPS buoy. We plan to install the several GPS buoys around Lutzow-Holmbukka and to conduct the continuous ocean tidal observations in order to study the geoid and the ocean tide in this area.

Keywords: GPS bouy, Ocean tidal observation, Antarctica