Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

SGD21-01 Room:301B Time:May 23 09:00-09:15

Evaluation of IGS reproduction precise ephemeris applying the analysis of Japanese domestic GPS network data (Part 3)

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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 (2011) evaluates IGS reproduction orbit analyzing about 90 GEONET and 5 NIED GPS network sites in Tokai-Izu area for the period during 1996 and 1999 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 are estimated. In the result the sites repeatabilities of Tokai-Izu sites applying the IGS reproduction orbit are improved especially for E-W and U-D components compared with those applying the IGS final orbit, although the improvement is not significant compared with the standard deviation of those repeatabilities.

In this study, we examine the systematic biases of the station coordinates between the reprocessed and the IGS final orbits, and we find that the coordinates applying the original final orbit deviate in north, east, and upward compared with those applying the reprocessed orbit although the difference is not significant compared with the uncertainties of site coordinate solutions. Then we examine the systematic discontinuity of the station coordinates between the periods of the different reference frames applied in the IGS final orbit, and find that the jump between ITRF94 and ITRF97 is far larger than that between ITRF96 and ITRF97, although the most jumps are not significant compared with the one sigma uncertainties.

Keywords: IGS reproduction precise ephemeris, systematic biases of site coordinates, systematic discontinuity of site coordinates

Japan Geoscience Union Meeting 2013
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SGD21-02 Room:301B Time:May 23 09:15-09:30

Development of a new precise positioning technique using multi-GNSS signals

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Geospatial Information Authority of Japan (GSI) is developing and standardizing a new precise positioning techniques which deal with multiple GNSS constellations, GPS, QZSS, GLONASS, and Galileo, in order to mainly encourage effective surveys at places where are currently difficult to carry out them by only GPS satellites. This project is composed of 1)Development of suitable analysis methods with multi-GNSS, 2)Evaluation of the methods, and 3)Standardization of the precise positioning techniques.

In FY 2012, we examined analysis methods to reduce Inter Frequency Bias and Inter System Bias. We will release the prototype of new software by integrating and expanding those ideas. In addition, we obtained multi-GNSS data using three kinds of GNSS receivers and compared baseline solutions with/without QZSS under various elevation cutoff angles.

This presentation shows results of FY 2012 and future plans from FY 2013.

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SGD21-03 Room:301B Time:May 23 09:30-09:45

Development of multi-GNSS precise orbit and clock determination tool MADOCA

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Japan Aerospace Exploration Agency (JAXA) is planning to conduct precise point positioning (PPP) experiment by using the LEX (L-band experiment) signal channel of QZSS (quasi-zenith satellite system). The target accuracy of the PPP is under 10 cm RMS. The area of the service is all over the Asia and Oceanian region including the Pacific Ocean side where user can receive broadcasting signals by QZSS satellites. The GNSS for the augmentation will be GPS, GLONASS, QZSS and Galileo. The PPP can provide the precise positioning service to many users in the broad regions without need of any ground stations. A lot of applications like precise farming, Tsunami detection, crustal deformation monitoring and GNSS meteorology are much expected by such PPP technique.

To generate the augmentation information for the PPP service, precise orbit and clock determination of GNSS satellites is necessarily required as well as ground GNSS reference station network. For these purposes, JAXA decided to newly develop a precise orbit and clock determination software for multiple constellation of GNSS from scratch in addition to extending multi-GNSS monitoring network (MGM-net). We call the software ”MADOCA” (multi-GNSS demonstration tool for orbit and clock analysis).

In this talk, we will provide the introduction of MADOCA including models and algorithms, technical features, implementation aspects, accuracy evaluation and future plan.

Keywords: GNSS, QZSS, PPP, LEX, orbit determination

Japan Geoscience Union Meeting 2013
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SGD21-04 Room:301B Time:May 23 09:45-10:00

An accuracy evaluation of GNSS positioning toward semi-real time seafloor geodetic observation

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GPS/Acoustic seafloor geodetic observation (hereafter GPS/A SGO) is quite important and useful for understanding of shallower part of the interplate coupling between subducting and overriding plates, because it is very difficult to resolve the coupling clearly based on onshore GPS network [Nishimura et al., 2005]. We typically conduct GPS/A SGO in specific ocean area based on repeated campaign style using research vessel. Therefore, we cannot monitor the temporal variation of seafloor crustal deformation in real time. The one of the technical reason of difficulty for the real time observation is limited by precise kinematic GPS positioning. We are strongly urged to detect the buoy or vessel position less than several tens millimeter for detecting seafloor crustal deformation precisely. For this purpose, in this time, GPS analysis based on reference site. If the precise kinematic GPS analysis will be possible in the offshore region, it should be promising method for real time GPS/A SGO with USV (Unmanned Surface Vehicle) and a moored buoy.

Based on these backgrounds, we assess the precision and accuracy of the real time GPS positioning and the reliability of the communication path for conventional RTK-GPS. First, we assess the "StarFire^{TM}" global subscription service [Hatch and Sharpe, 2004], which is developed for the commercial purpose. It provides real-time accuracy typically better than 5 cm. Its globally corrected signal is available almost anywhere on the Earth's surface on land or sea via geostationary satellites. With this corrected signal, the precise real-time precise point positioning (real-time PPP) without the need for local ground base stations is realized. We assess the stability of kinematic solution based on the StarFire receiver compared with the daily positioning deduced from the GIPSY-OASIS II software version 6.1.2 (hereafter GOAII) from October 24th to 28th 2012. The standard deviation of the StarFire time series is generally nominal precision of the service. And also, obtained StarFire time series are good agreement with the GOAII daily positioning. But we cannot assess long-term stability of StarFire time series, because we only obtain 4 days observation data in static condition.

We also assess the communication path for conventional RTK-GPS positioning via satellite-based mobile phone service "WideStar II$^{(R)}$" operated by NTT DoCoMo. As a result, we basically succeeded to obtain the RTK-GPS solution stably via WideStar II even though we occasionally encountered the unexpected loss of the satellites communication.

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SGD21-05 Room:301B Time:May 23 10:00-10:15

GPS tide gauge using multipath signatures

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Sea level measurements are important for monitoring tsunami, sea level rise due to global warming, and estimation of the geoid height. Various government agencies or research institutes routinely observe the sea level with traditional tide gauges. Recently, satellite altimeters have also been used to monitor the sea level.

Tide gauges data include not only sea level information but also vertical crustal movements. It is impossible to isolate the former only with tide gauges, i.e. we need another instrument, e.g. GPS, to measure the latter. However, if we could measure sea level with GPS, we might be able to measure sea level free from vertical crustal movements. This new method may realize a denser network of sea level measurements.

Multipath implies interference of direct microwave signals from GPS satellites and those reflected by ground, sea surface, or buildings. Multipath causes cyclic changes in quantities such as SNR (signal-to-noise ratio) or L4 (geometry-free linear combination) phases. By analyzing these changes, we can infer heights of GPS antennas from reflecting surfaces. This has been applied for measurements of snow depths [Larson et al.,2009; Ozeki and Heki,2010] or soil moisture [Larson et al.,2008].Larson et al.[2013] recently reported that GPS can measure the sea level in the same way.

In this study we explore the possibility of measuring the sea level with GPS stations deployed for geodetic purposes. We compared results from the GPS tide gauges based on multipath observations and traditional tide gauges during the period from 2012/6/1 to 2012/7/31 at 39 coastal GPS stations. Among them, 37 GPS stations are called GPS-P stations, which are installed next to tide gauges in order to correct for vertical crustal movements by Geospatial Information Authority (GSI) of Japan. We will report that we can use some of these GPS stations as tide gauges although the measurement accuracies are less than those reported in Larson et al.[2013].

Keywords: GPS, GNSS, multipath, sea level change

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SGD21-06 Room:301B Time:May 23 10:15-10:30

Offset of zenith tropospheric delays and tropospheric delay gradients in GEONET F3 solution

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According to 'A Correction Method to Artificial Displacements on GEONET Coordinate Time Series' (Iwashita et al., 2009), GEONET (GNSS Earth Observation Network System), the dense GPS observation network in Japan, they showed there are jumps (offset) of the coordinate value which arises by artificial factors, such as a maintenance of a GPS observation apparatuses.

Although similarly offset is seen in tropospheric delays, and according to 'Calibration of error in solutions of baselines observed with mixed GPS receiver types' (Ochi, and Hatanaka, 2010), the difference of horizontal direction between L1 solution and L2 solution is less than a few mm. However, there are the systematic errors in vertical direction, and they showed offset amounts especially vary bigger when the estimate of tropospheric delays. It was checked that it is the important cause by which a gap of a phase center and the difference in the phase pattern of an antenna produce offset by a simulation.

In this research, we show offsets not only the systematic errors of tropospheric delays originate in the different model antenna exchange but the same model antenna exchange, radome, mount adjustment, and also in other maintenances.

The amount of offset presumed the time series of the tropospheric delays contained in F3 solution by the least-squares method with seasonal variation and a long-term change.

Moreover, there are offsets in time series of tropospheric delay gradients estimated with the coordinate values and tropospheric delays in F3 solution.

We estimated offsets of tropospheric delays and tropospheric delay gradients and studied about their causes.

Keywords: offset, tropospheric delay, tropospheric delay gradient

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SGD21-07 Room:301B Time:May 23 10:30-10:45

Frequency dependent Love and Shida numbers determined from GPS and gravimetric data at Syowa Station, Antarctica

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With objective of monitoring variations in the Antarctic geosphere, we have been performing several geodetic measurements such as VLBI, GPS, DORIS, tide gauge, and superconducting gravimeter (SG), at/around Syowa Station, Antarctica. The tide always deforms everywhere on the Earth periodically in the wide frequency bands. To observe the tidal responses of geosphere, e.g., Love and Shida numbers, is useful for understanding the internal physical properties of the Earth. In this study, we computed tidal parameters from GPS and SG data during Jan. 2010 - Jan. 2013 by applying tidal analysis software BAYTAP (Tamura et al., 1991) and determined frequency dependent Love and Shida numbers at the period of 1/2 - 180 days.

Keywords: Love and Shida numbers, Tidal analysis

Japan Geoscience Union Meeting 2013
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SGD21-08 Room:301B Time:May 23 11:00-11:15

Vertical Deformation Detected by Precise Leveling around Tono Research Institute of Earthquake Science, Gifuin 2004-2012

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Introduction

Precise leveling network was established in the west part of Mizunami in March 2004, as a part of projects of Tono Research Institute of Earthquake Science (TRIES), to research the underground water flow, strain accumulation, ground deformation and gravities changes and their relations in shallow crust. Around TRIES, Japan Atomic Energy Agency (JAEA) has started the 1,000m shaft excavation project in April 2004. Precise levelings are carrying out once or twice every year until October 2012. Leveling route is about 10 km length with 10 benchmarks in 2004 and 50 in 2012. Closer errors of leveling are less than about 1 mm.

Vertical deformation

During the survey period of 8 years and 8 months from February 2004 to October 2012, subsidence is distinguished, and the maximum reached about 2 cm in October 2012. Generally, benchmarks detected 1-2 cm subsidences are locating close to the shaft excavation site and on its south side area. As it is referred a 2km away benchmark, the subsidence of 2 cm supports ground tilt of 10 micro-radian. It is suggested that it is not the slant quantity of influence upon the building now.

Groundwater level

Groundwater levels are monitored in observation wells of TRIES and JAEA, located at 100 m or 300 m south from the shaft excavation site. Drawdown of water head amounting to 70 m was detected in December 2010. When shaft reached at 120m depth, the groundwater inflow due to the shaft excavation suddenly increased to 300 ton/day. The groundwater level decreased approximately by 30m at the same time. The groundwater level was almost recovered to its level of before the shaft excavation when drainage was temporarily stopped in June 2005, but it decreased by resume of drainage again. After the shaft reached at 500m depth, the quantity of groundwater inflow is ranging around 700 ton/day. The groundwater risings due to the occurrences of the earthquake are observed. 13 m and 3 m rises were observed by 2011 M 9.0 Tohoku earthquake and in M 5.7 Mizunami earthquake on December 14, 2011.The groundwater level is descending after the earthquakes slowly.

Subsidence and ground water drawdown

The groundwater level decreased with rates of 10-30 m/year for the period in June 2005 to June 2007, and subsidence with rates up to 2-5 mm/yr was observed at the benchmarks locating close to the shaft excavation site and on its south side area. On the other hand, the observed subsidence is relaxed, when a groundwater drawdown is decreasing to less than 10 m/yr. After the co-seismic groundwater rises observed in March and December 2011, additionally, slight uplifts were observed in February 2012. The maximum subsidence was observed at the benchmarks in the south side of the shaft excavation site, not at the benchmarks close to the shaft excavation site.

On the south side of the shaft excavation site, 160,000m^3 of soil was cut and covered according to the construction of a park in 2004. Therefor it is considered that the influence of the construction is included in observed ground deformation in a part. The deformation by the construction should be discussed precisely in the next subjects.

Distribution and mechanism of subsidence

Distribution of subsidence is the important information to consider its mechanism. However, it is not able to clarify its spatial distribution of the subsidence yet, because benchmarks are limited to the shaft excavation point neighborhood. Authors set up benchmarks to the neighboring area newly in 2012 to clarify distribution of the subsidence more precisely.

Keywords: vertical deformation, precise leveling, groundwater level

Japan Geoscience Union Meeting 2013
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SGD21-09 Room:301B Time:May 23 11:15-11:30

VLBI2010 – Newly Established VLBI Station –

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The International VLBI Service for Geodesy and Astrometry (IVS) compiled the specification of the new geodetic VLBI observation in “Design Aspects of the VLBI2010 System (Petrachenco et al., 2009)”. It has a lot of differences from the current system; a 12-m diameter and fast moving (12 deg./sec for Az) antenna, continuous frequency coverage from 2 to 14 GHz, data sampling with four1 GHz bandwidth channels, and so on. The Geospatial Information Authority of Japan (GSI) is going ahead with the VLBI2010 project including the establishment of the antenna, the feed & receiver system, the up-down convertor, the data acquisition & storage system, and the hydrogen maser. In this presentation I describe the progress situation of the VLBI2010 project of GSI.

Keywords: Geodetic VLBI, VLBI2010, GGOS, IVS

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SGD21-10 Room:301B Time:May 23 11:30-11:45

Evaluation of domestic VLBI observation using simulation

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Evaluation of domestic VLBI observation using simulation

Keywords: VLBI, VieVS, simulation, VLBI2010, NetCDF, IVS

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SGD21-11 Room:301B Time:May 23 11:45-12:00

Optical responses and centre-of-mass corrections for the sub-cm laser ranging targets LARES and Starlette

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The target signature effects of small spherical satellites, LARES and Starlette are investigated. Otsubo and Appleby (2003, JGR) have already looked into the effects for larger satellites such as Ajisai and LAGEOS, where the system dependence of the centre-of-mass correction amounts to 5 cm and 1 cm, respectively. Recent enhancement in precision and repetition rate of the laser ranging technique makes it possible to study the effects for smaller target such as LARES and Starlette. Using the fullrate laser ranging data obtained at Herstmonceux, UK, this study reveals that the center-of-mass correction can vary within 128 to 135 mm for LARES, and 75 to 82 mm for Starlette. The result of Starlette indicates that the current standard value 75 mm is too small in general. This study has an impact on the scale of the terrestrial reference frame and the gravity constant (GM) of the Earth.

Keywords: space geodesy, satellite laser ranging

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SGD21-12 Room:301B Time:May 23 12:00-12:15

Spin parameters of LARES spectrally determined from Satellite Laser Ranging data

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Satellite Laser Ranging (SLR) is a powerful technique able to measure spin rate and spin axis orientation of the fully passive, geodetic satellites. This work presents results of the spin determination of LARES - a new satellite for testing General Relativity. SLR passes measured during one year from the launch were spectrally analyzed. Our results indicate that the initial spin frequency of LARES is f0=86.906 mHz (RMS=0.539 mHz). A new method for spin axis determination, developed for this analysis, gives orientation of the axis at RA=12h22m48s (RMS=49m), Dec=-70.4o (RMS=5.2o) (J2000.0 celestial reference frame), and the clockwise (CW) spin direction. The half-life period of the satellite's spin is 214.924 days and indicates fast slowing down of the spacecraft.

LARES has been placed on a similar orbit to Ajisai, but demonstrates different spin dynamics. The spin behavior of the two geodetic satellites Ajisai and LARES will be compared in this presentation.

Keywords: LARES, Satellite Laser Ranging, Spin

Japan Geoscience Union Meeting 2013
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SGD21-13 Room:301B Time:May 23 12:15-12:30

Combination of space-geodetic techniques on the observation level: estimation strategies for common parameters

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A multi-technique space-geodetic analysis software, named ”c5++”, has been developed over the recent years. The software provides consistent geodetic and geophysical models which can be accessed by single technique space-geodetic applications or can be used to combine several techniques on the observation level. Satellite Laser Ranging (SLR) and Very Long Baseline Interferometry (VLBI) stand-alone applications have been realized in the last two years. With the introduction of an option to utilize local-tie information as well as the possibility to estimate common parameters the software enables rigorous combination of space-geodetic techniques on the observation level. Moreover, the inclusion of GNSS as a third space-geodetic technique since 2012 has increased the choice of analysis strategies tremendously. Thus, we are discussing the advantage of estimating common parameters (clock, troposphere) and show how technique specific offsets/biases need to be treated in order to achieve optimum performance of this approach.

Keywords: VLBI, GNSS, GGOS, Space Geodesy, Combined Analysis