SGD22-01 Room:303 Time:May 28 14:15-14:30

GGOS and contributing efforts in Japan

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The IAG's GGOS (Global Geodetic Observing System) project will be introduced and its impact on the geodesy of Japan and future prospects will be discussed. GGOS aims to provide a fundamental frame of reference with global geodetic observations by ground- and space-based techniques, and to address global problems and societal needs. In Japan, GGOS working group was established in 2013 to discuss Japan's active contribution to GGOS and construction of GGOS Core Sites etc. by strengthening inter-organizational collaboration and communication.

Keywords: GGOS (Global Geodetic Observing System), Space geodetic techniques, GGOS Core Sites

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

SGD22-02 Room:303 Time:May 28 14:30-14:45

The United Nation General Assembly resolution on Global Geodetic Reference Frame (GGRF) and the future vision

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The United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) decided on its third session held on July 2013 to submit draft resolution to the United Nation General Assembly which promotes international co-operation for maintenance of sustainable Global Geodetic Reference Frame (GGRF), acknowledging GGRF is the essential infrastructure for accurate positional reference for social, economic and scientific activities. A Working Group was established by UN-GGIM and developed the draft resolution. The resolution will be endorsed by the General Assembly on early 2015.

Geospatial Information Authority of Japan (GSI) has been participating the WG as a member of UNCE-GGIM from the first stage of the activity and contributed to the development of the draft resolution. The GSI are also participating the activity to develop roadmap for sustainable development and maintenance of GGRF. The background and the purpose of the resolution, current activity and future plan of WG for sustainable maintenance of GGRF of will be reported.

Keywords: The United Nation General Assembly resolution, geodetic reference frame, UN-GGIM, The United Nations Committee of Experts on Global Geospatial, Global Geodetic Reference Frame

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

SGD22-03 Room:303 Time:May 28 14:45-15:00

Precise ocean dynamic topography measurements by satellite altimetry

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A satellite altimeter is an instrument to measure a distance between the satellite and ocean surface from propagating delay time between transmitting and receiving pulse of a microwave. A sea surface height (SSH) with respect to a reference ellipsoid is then derived by determining satellite orbit precisely.

Satellite altimetry started observations since Seasat satellite launched in 1978 after the experimental operation of GEOS-3. At the time, since the accuracy of orbit determination exceeded several tens of centimeters, which is larger than an ocean-dynamic related signal of 10 cm, Seasat had a limitation to detect ocean dynamic topography. On the other hand, it provided valuable information to improve bathymetry and geoid as SSH variance induced by them exceeds an order of meters.

The launch of TOPEX/POSEIDON (T/P) in 1992 brought significant changes to oceanography. It was carefully designed to enable precise ocean dynamic topography measurements: it carried a dual frequency altimeter to evaluate ionospheric path delay and its altitude was set high for rapid changes of gravity fields not to affect orbit determination. These preparations resulted in improving a measurements accuracy of 2-3cm and T/P yielded many oceanic findings such as the distribution and propagation of mesoscale eddies. In addition, altimeters revealed global sea level rise (3mm/year) and its regional distribution, which are not an initial scope of altimetry mission, thanks to continual operations by several altimeters and careful cal/val activities. In the present, the precision of orbit determination drastically improves reaching up to 1 cm due to the improvement of geiod models by altimeters themselves and other gravity missions.

The next target of satellite altimetry is improving spatio-temporal resolution. Even if the current altimeter observes SSHs at a 7km interval, its measurements are only along satellite tracks and zonal intervals between adjacent tracks reach up to several tens and several hundreds of kilometers in the mid- and low-latitudes. It has also been reported that effective spatial resolution of along-track SSHs is roughly 100km due to an instrumental noise. Thus the current altimeters can't detect relative fine spatial phenomena such as coastal and submesoscale (10-100km) SSH variations. In order to tackle these problems, state-of-art satellite altimeters use high frequency (ka-band) microwave to improve footprints and/or have a function of 'SAR mode' to improve along-track spatial resolution (250m). The next-generation wide-swath altimeters, which observing concept is different from traditional nadir-type one, are also planned by NASA/CNES and JAXA named as SWOT and COMPIRA, respectively. They can measure 2-D SSHs based on an interferometric technique using two SAR antennas to be mounted. They are expected to depict ocean phenomena which spatial scale is less than 100km and drive greater innovation since the T/P era.

Keywords: Satellite altimetry, Ocean Dynamic Topography

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SGD22-04 Room:303 Time:May 28 15:00-15:15

Strategies for Space Geodetic Data Analysis in the Coming GGOS Era

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The three pillars in geodesy, geometry, gravity and rotation, are expected to be more precise and accurate in the middle- to long-term plan proposed by the GGOS (Global Geodetic Observing System) project.

A number of issues are foreseen before achieving its goal, especially in a terrestrial reference frame, 1 mm accuracy in coordinates and 0.1 mm/year accuracy in velocity. It is getting more important for analysts to utilise the advantage of each geodetic technique. We point out the following issues:

- Precise modelling of satellites and quasars as well as terrestrial stations
- Combination and comparison of multiple analysis outputs
- Common parameters in multiple geodetic techniques
- Feedback from analysis centers to the global observation network
- User-friendly products and user-friendly interface

Keywords: GGOS, Space Geodesy

SGD22-05 Room:303 Time:May 28 15:15-15:30

Realization of ITRF and Problems in Plate Boundary Zone

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In the modern geodesy, the shape and it's time variations of the earth are presented by the International Terrestrial Reference Frame (ITRF), which gives the accurate coordinates of the observation sites of the space geodetic techniques.

The observations by GNSS also contribute to establish the ITRF models through the permanent GNSS sites (for instance, International GNSS Service (IGS) network sites), but the most important contribution of GNSS for the modern geodesy is the realization of ITRF. At any place on the earth we can observe easily the GNSS satellites using less expensive GNSS receivers and determine the accurate ITRF coordinates of the site by the analysis with the GNSS fiducial sites which coordinates are given by ITRF accurately. This is the realization of ITRF in the states of art.

Thus both the determinations of the ITRF model applying space geodetic techniques and the realization of the ITRF applying the GNSS receivers to determine the present accurate coordinates of any place on the earth are just two halves of the whole in the modern geodesy.

In this presentation we also discuss the most important problem that prevent the realization of ITRF, that is, the co-seismic and post-seismic motions of huge earthquakes (M8 or larger) that make it difficult to give the accurate coordinates of the GNSS fiducial sites in the moment after the earthquake especially for the sites in the plate boundary zones.

For instance, after the 2011 Great East Japan Earthquake the IGS reference frame stations in and around Japan, TSKB, MTKA, YSSK, DAEJ, and SUWN sites, move considerably both in co-seismic and post-seismic period, and change the site coordinates very largely and rapidly. Especially TSKB site is one of the very important core site of the IGS network for long time and the coordinates of the site change near one meter. Thus there arises very wide blank area of the ITRF reference frame sites in Eastern Asia after the earthquake.

Another case is the 2004 Great Sumatra-Andaman Earthquake. The earthquake makes it impossible to use NTUS IGS site in Singapore which was the only one reference frame site in Indochina area at that time for very large co-seismic and post-seismic movements. Because of the considerable post-seismic motion, there still exists very wide blank area of the reference frame sites in this area.

Keywords: ITRF, Realization of ITRF, GNSS, Huge earthquakes, Plate boundary zone

Japan Geoscience Union Meeting 2015
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SGD22-06 Room:303 Time:May 28 15:30-15:45

Abrupt changes in drift trend of the earth's geocenter and rotational pole in 2012-2014

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Positions of the earth's geocenter and rotational pole are constantly moved by mass redistributions on/in the earth. Such movements can be estimated via low-degree gravity field measurement by Satellite Laser Ranging (SLR). In this study, we investigate recent trends in geocenter motion and polar motion based on SLR analysis. We compute their linear changes for the following three periods: 1994-2002, 2003-2011, and 2012-2014. Here annually-average drift rates and directions are described as (rates, azimuth angle, elevation angle) for geocenter motion and (rates, azimuth angle) for polar motion, respectively. In 1994-2002, the obtained drift trends are (0.5mm/yr, -26 $^{\circ}$, 59 $^{\circ}$) for geocenter motion and (1.3mm/yr, -73 $^{\circ}$) for polar motion. Concerning polar motion, the good agreement with EOPs data by VLBI was confirmed. These trends are considered to be caused by Glacial Isostatic Adjustment (e.g. Wahr et al., 1993; Greff-Lefftz, 2000). In 2003-2011, the obtained drift trends are (0.8mm/yr, 111 $^{\circ}$, -61 $^{\circ}$) for geocenter motion and (5.4mm/yr, 14 $^{\circ}$) for polar motion. These trend shifts from 1994-2002 can be well explained by large-scale ice mass depletion in polar region started in 2000s (e.g. Chen et al., 2013; Dong et al., 2014). In 2012-2014, the obtained drift trends are (3.4mm/yr, -84 $^{\circ}$, 44 $^{\circ}$) for geocenter motion and (8.9mm/yr, -62 $^{\circ}$) for polar motion. We can see distinct departures in drift trends from 2003-2011. By analyzing other geodetic data and geophysical models, we have revealed that these trend shifts can be attributed to an abrupt stagnation of Greenland's ice loss after autumn of 2012.

Keywords: munekane-h96nu@mlit.go.jp, Geocenter motion, Polar motion, Climate change, GGOS

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SGD22-07 Room:303 Time:May 28 15:45-16:00

GGOS Network and Syowa Station, Antarctica

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GGOS is one of the principal components of GEOSS. GGOS network station is defined to be equipped with DORIS, GNSS, VLBI and SLR at the same site. Although Syowa Station (SY) does not have SLR, operation of other instruments has been continuing for 15 years. Other than space geodesy programs, precise gravimetry and tidal observations have been done at the same site. I present mainly history of these observations and briefly describe perspective for future developments.

Geographically Syowa Station is located at 39?35′ E, 69?00′ S, in East Ongul Island at the mouth of Lutzow-Holm Bay, Eastern Antarctica. Geologically it is placed on the bedrock of metamorphic granitic gneiss of 500 myr in age. Sedimentary layer which induces unfavorable groundwater effect does not exist; this provides very stable geodetic observation environments.

Japanese Antarctic Research Expedition (JARE) is a long-term national project. NIPR organizes geodesy/geophysics program with one (+1-2 depending on season) winter-over geophysicist from NIPR, one summer-season surveyor from GSI, and one summer-season hydrographer from JHOD, every year for the maintenance including the above facilities.

Modern facility installation actually started from 1990 (JARE-32) by the construction of the gravity observation hut (GOH), and ended in 1997 (JARE-39) at the start of the regular VLBI observation. After this first-epoch, there were step-wise progresses to strengthen Syowa status every 7 year. To realize installation/start of SLR observation, now is a planning stage. We present history and current of each component below.

VLBI: Construction of an 11 m S/X band antenna, and installation of a front-end (including 22GHz) was made in 1989. Preliminary experiment between Syowa, Tidbinbilla and Kashima was made by CRL in 1990. Integration of a K4 back-end and H-maser was made in 1997. The first regular VLBI experiment (1998) was SYW. Syowa participated in the OHIG session under the coordination of IVS in 1999. Data processing has been done by the Bonn correlator afterwards. SYW session ended in 2004 and a K5 back-end was integrated.

Observation itself became a routine. Syowa-Hobart, Syowa-HartRAO, Syowa-O′ Higgins baseline solutions have been obtained regularly without severe problems. In 2015 February, OHIG96 session was finished normally.

Syowa IGS SYOG: Syowa participated in the SCAR GPS campaign at SYOW (geodetic marker No.23-16) during 1993-1999. In 1995, a permanent pillar was constructed by GSI. Data acquisition is being made by a Dorn Margolin T antenna placed at 28.933 m above asl.

Sporadic outlier solutions appeared frequently until 1999 when rubidium frequency standard was used, but change from rubidium to cesium solved this problem dramatically. Formal registration to IGS network (named SYOG) was made in 1999. Near-real-time data transfer of 30 s sampling raw data via Intelsat link to GSI, and then to IGS Center was realized in 2004. 1 Hz sampling by dual Trimble NetRS is continuing from 2008.

Syowa DORIS SYPB: The first generation SYOB was installed on a 10 m pylon tower in 1991. The tower might have been declined gradually WSW under the prevailing ENE winds; the tower was broken down in May of 1998 by a heavy blizzard. The second-generation

SYPB on a concrete pillar was installed in Feb. 1999. It has the best stability (<3 mm) among the DORIS network (>40) stations. Replacement of the beacon transmitter was made twice until 2012.

SLR: To satisfy the GGOS requirements, JARE-57 which departs Japan this year (November 2015), will make feasibility study to install the SLR site. Because of optical instruments, SLR favors non-cloudy condition. The initial stage may be to perform observations for one month in the summer season when day-time is 24 hours and weather condition is mild. Preparation for winter-over observation to accumulate return shot counts to obtain sub-cm variability of the geo-center location is considered.

Keywords: Syowa Station, DORIS-SYPB, IGS-SYOG, IVS OHIG session, IAGBN(A)#0417, SLR

Japan Geoscience Union Meeting 2015
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SGD22-08 Room:303 Time:May 28 16:15-16:30

Local Tie Survey at the Ishioka Geodetic Observing Station

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[1]GSI of japan

The Geospatial Information Authority of Japan (hereafter GSI) has constructed a new geodetic observing facilities in Ishioka city, where is 17km northeast from the site of the GSI in Tsukuba city. A new VLBI antenna and two GNSS CORS were completed in the site. Moreover, we plan to construct a gravity observing point. We call the site iGOS (Ishioka Geodetic Observing Station).

The new VLBI facilities including antenna in the site are fully compliant with the VGOS (VLBI Global Observing System) concept, which is advocated by the International VLBI Service for Geodesy and Astrometry (IVS). It tries to achieve 1mm position and 0.1mm/yr velocity accuracy, continuous measurements, and turnaround time to initial geodetic results of less than 24 hours in order to satisfy the requirements of GGOS.

The site will take over the role of constructing and maintaining the geodetic reference frame of Japan from Tsukuba VLBI station after establishing strong tie relation between the two sites. In order to achieve this aim, measuring local tie vector at the site is also very important. We conducted survey to estimate tie vector between the reference point of the VLBI antenna (the intersection of the azimuth and the elevation axis) and GNSS observing points in January 2015.

We implemented local tie survey (angle and distance measurement, GNSS, and leveling) by using a conventional method that used some pillars for local tie survey as we had carried out at the other GSI's VLBI antenna sites. Furthermore, we tried some new method which aimed to estimate the reference point of the antenna with better accuracy. I will talk about the overview of iGOS and the preliminary result of the local tie survey.

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SGD22-09 Room:303 Time:May 28 16:30-16:45

Recent Status of the VGOS Network in the World

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The International VLBI Service for Geodesy and Astrometry (IVS) is promoting VGOS (VLBI Global Observing System), a new VLBI system to be the VLBI component of the GGOS, to achieve 1-mm position accuracy on global scales, continuous measurements of station positions and Earth orientation parameters, and turnaround time to initial results of less than 24 hours.

VLBI antennas of the VGOS network are required to have fast slewing speed (12 degrees per second) and broadband receiving system (frequency of 2-14 GHz). VLBI antennas compliant with VGOS have been constructed in four countries, and seven countries have plans of VGOS construction. Moreover many experiments related with VGOS are carried out to realize VGOS observation in these stations.

In March 2014, GSI has constructed a new VLBI antenna fully compliant with VGOS in Ishioka, Japan, which is the first VGOS antenna in the Asian countries.

We will talk on the current status of the VGOS network in the world and the operation of the Ishioka VGOS antenna.

Keywords: VLBI, GGOS, VGOS

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SGD22-10 Room:303 Time:May 28 16:45-17:00

On a wide-band bandwidth synthesis II

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1. Introduction

Bandwidth synthesis of wideband observation data exceeding a band width of 10 GHz has been studied since last year. We are now investigating the correction of phase characteristics in a band, inter-band delay correction, and ionospheric delay correction on a wide-band bandwidth synthesis.

2. Phase correction in a band

Total band width is at most 1 GHz in a conventional band-width synthesis. In the wide-band observation system discussing here, each band has a bandwidth of 1GHz or wider. Therefore phase correction in a band corresponds to the phase correction in the conventional band-width synthesis. In the wide-band system phase calibration signals (PCAL signals) are also injected at a frontend like a conventional system. However PCAL signals may not have good performance at higher frequencies such as 10 GHz or higher, so that we are investigating a realistic method as follows.

1) Obtain phase data from cross spectrum of a strong source and apply them as reference phases like PCAL signals for phase calibration in a band.

2) Time variation is compensated by using a couple of true PCAL signals in a band.

3. Inter-band correction

A wide-band bandwidth synthesis, instrumental delays among different bands should be compensated. In case of an observation on a short baseline like a 100 km distance, the effect of ionospheric delay is very small. Hence an inter-band correction is considered as follows.

1) Observed VLBI delay is determined by each band by using a strong source data. In this case, phase correction in a band is carried out in advance.

2) Inter-band delay obtained this way is applied to a wide-band bandwidth synthesis. Set inter-band phase difference zero in this case.

3) Get inter-band phase difference from a cross spectrum after wide-band bandwidth synthesis.

4) Do wide-band bandwidth synthesis again by using inter-band phase difference obtained by step 3).

4. Ionospheric delay correction

Ionospheric delay is inversely proportional to the square of the frequency, so that it affects phase characteristics in a band at lower frequencies (less than about 4 GHz). It also affects an inter-band delay. We are now investigating whether the method described below can be applied to true data.

1) Get phase correction data and inter-band correction data for a certain scan as reference data.

2) Get phase deviation from the reference data obtained by step 1) for another scan and assume it as an ionospheric correction.

5. Summary

As described above, we are investigating a practical method regarding phase correction in a band, inter-band correction, and ionospheric delay correction. As for a short baseline observation, we have already succeeded in a wide-band bandwidth synthesis. This result and ionospheric correction will be presented.

Keywords: VLBI, wide-band bandwidth synthesis

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SGD22-11 Room:303 Time:May 28 17:00-17:15

SLR technical issues and challege confronting GGOS goal

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SLR(Satellite Laser Ranging), one of the space geodetic technology of GGOS, measures TOF (Time of Flight) of photons. It has a principle to measure an absolute value of the distance directly from the earth station to the satellite using the electromagnetic wave of the visible wavelength domain. These are unique aspect of SLR.

Since high accuracy demand of GGOS goal statement in that station position to be accurate equal or better than 1mm and its rate to be ˜0.1mm/yr, and SLR raw data measurement always corrected with bias by station procedure, we must investigate all the error factors those affect such precision and make sure accuracy by calibration method. The error of precision and accuracy of 1mm and 0.1 mm/y holding every bias and sum total of the factors means that variation of error factor each should be checked out

with submillimeters order. International Laser Ranging Service(ILRS) has held conference and working group meeting for solving such problems regularly and shared a common problems, lesson learned by each organization solution.

The error source is not only come from ground station, but others namely, space segment design and the propagation. As a whole system the problem of the network play a key role. The one example of network quality control method using the data obtained by global SLR network produces orbit analysis and fitting orbit to each observation every day or sub-daily.

According to the resuluted O-C of each orbit determination, outlier station will be warned and/or trend analysis can be done in cm level. These do big contribution for everyday use of SLR to find the bias source of station such as a clock, a laser, signal strength dependence of the detector and stability. The precision of the state of the world station has achievee a submillimeter by a progess of laser technology, development of the electronics and software, however bias and its stability has rarely reach 1mm and the average network performance have to be more precise. In the space segment, a satellite equipped with large number of retroreflector cube designed in the 1970 years level was aim of a cm order, but not for sub-millimeter. A pulse width deterioration by the target effect has an

order of a few mm to few cm some cases significantly affect an argument for CoM (Center of Mass) correction. A sub-millimeter order to overcome this will be challenge to design a new satellite. It is under discussion of the pulse reply pulse from the single cube as well as a single photon receiver v.s multi-photon one should be used.

As for monitoring the bias between SLR and other technique such as VLBI, and GPS for the colocation of each technique in GGOS, the demand to measure the three dimensional position among each technique reference point with accuracy of by a submillimeter meter continuously will be another challenge to elliminate a systematic error. The challenge of new technology and procedure for managing accuracy of 1mm level, Japan and the world present conditions toward GGOS will be reviewed.

Keywords: SLR, bias error, calibration

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SGD22-12 Room:303 Time:May 28 17:15-17:30

Present situation of GNSS and recent activities of IGS

FURUYA, Tomoaki[1*] ; KAMAKARI, Yuki[1] ; MANDOKORO, Motomu[1]

[1]GSI of Japan

As of 2015, many Global and Regional Navigation Satellite Systems are deployed: GPS, QZSS, GLONASS, Galileo, and BDS.

The International GNSS Service (IGS) is committed to providing the highest quality data and products as the standard for GNSS and RNSS in support of Earth science research, multidisciplinary applications, and education. To pave the way for a future provision of high-quality data and products for all constellations, the IGS started the Multi-GNSS Experiment (MGEX) in 2011. The MGEX project is expected to transition into a Multi-GNSS Pilot Project within the next couple of years. In addition, the IGS launched the Real-Time Service (RTS) in 2013. The RTS is a GNSS orbit and clock correction service that enables precise point positioning (PPP) and related applications, such as time synchronization and disaster monitoring, at worldwide scales.

Keywords: GNSS, IGS

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SGD22-13 Room:303 Time:May 28 17:30-17:45

Contribution of DORIS to GGOS

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DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite), which is a Doppler satellite tracking system developed for a precise determination of satellite orbits and a precise positioning of ground stations, is one of the space geodetic techniques constituting the GGOS (Global Geodetic Observing System). DORIS system is composed of receivers on board the altimetric satellites and of an international network of ground stations. Each ground station consists of a dual-frequency 2036.25 MHz and 401.25 MHz transmitter (a DORIS beacon) including USO (Ultra Stable Oscillator), UPS (Uninterruptible Power Supply) and a remote control system through IRIDIUM on the inside, and an omnidirectional antenna and a set of meteorological sensors on the outside. Since the DORIS beacon transmits signals automatically, it is easy to operate and to maintain the DORIS ground station. The international network of about 60 ground stations deployed by CNES (Centre National D'Etudes Spatiales) and IGN (Institut national de l'information geographique et forestiere) since 1986 and recently supported by IDS (International DORIS Service), is global, dense and homogeneous, and thus unique among the different techniques that contribute to the ITRF (International Terrestrial Reference Frame).

The only DORIS station belonging to Japan is located at Syowa station, Antarctica. To make the DORIS popular, we report the current Syowa DORIS system, its operation and its co-location with other space geodetic techniques.

Keywords: DORIS, IDS, GGOS

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SGD22-P01 Room:Convention Hall Time:May 27 18:15-19:30

VLBI observation of multi-geostationary satellites in a same antenna beam II

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1. Introduction

On a VLBI observation of multiple geostationary satellites received in the same antenna beam, it is unable to separate each satellite independently by using a conventional processing system. In order to get each satellite delay we have improved the correlation software and delay search software to get observed delay. Improved software was evaluated by using laboratory experiment data and true observation data as well. We could confirm that expected results were obtained.

2. Improvement of the software

The software correlator (K5 correlation processing software) was developed for geodetic VLBI system. It is therefore assumed that white noises from a quasar are received and processed. On the other hand multiple narrow band signals are received in case of a geostationary satellite observation. In this case a so-called "delay resolution function" shows a comb-like form unlike the case of white noises. In case of receiving signals from multiple satellites the delay resolution function becomes a combination of functions for multiple satellites, and it is impossible to separate to each delay resolution function. However if frequencies differ among satellites, it becomes possible to get a delay resolution function independently by filtering at either correlation processing or delay search processing. Hence filtering function was implemented in the correlation software and the delay search software. In addition, envelope interpolation function is also implemented in the delay search software for processing a comb-like form delay resolution function.

Two kinds of filtering method are possible for correlation processing; one is filtering on the time domain and the other is on the frequency domain. We have adopted the frequency domain filtering considering from reasons such as ease of both implementation and change of filtering characteristics. It has also been adopted to the delay search software.

3. Evaluations

In order to evaluate the function and performance of revised software, data processing was carried out by using laboratory experiment data and true observation data. A laboratory experiment was carried out using four signal generators (SGs) and a 4-ch sampler as follows. Two pairs of SGs simulate two satellites and signals are mixed each other. They are then fed to two input channels of the sampler through coaxial cables with different lengths. An extra cable is applied between two pairs of SGs to simulate the path difference of satellites. Sampled data are processed by revised software. By using a filtering function, delays for simulated two satellites are successfully separated. Two cases of filtering, one is at correlation processing and the other is at delay search processing, are compared. Observed delays are well-coincided with each other. The comparison was also carried out by using true observation data, and it was confirmed that both results are well-coincided. It is also compared between the two delay search methods; one is a conventional way and the other is an envelope interpolation. Daily variation can be seen in the difference between delays obtained by two methods, and peak-to-peak variation reaches a few hundred nanoseconds. More detailed evaluation should be made through the determination of satellite orbit.

4. Summary

A filtering function was implemented in the correlation software and the delay search software to get delay for each geostationary satellite independently under the condition that multiple satellite signals are received simultaneously. An envelope interpolation function is also implemented in the delay search software for processing delay resolution function when it shows a comb-like form. According to evaluations by using both laboratory experiment data and true observation data, it is confirmed that improved software shows an expected performance. As for more detailed evaluation, it is necessary to carry out the determination of satellite orbit.

Keywords: VLBI, geostationary satellite