The United Nations General Assembly Resolution on A Global Geodetic Reference Frame for sustainable development

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The United Nations General Assembly adopted its resolution, “A Global Geodetic Reference Frame for Sustainable Development”, on February 26, 2015, recognizing that Global Geodetic Reference Frame (GGRF) is essential fundamental infrastructure for social, economic and scientific activities. This resolution is the first resolution on the importance of a globally-coordinated approach to geodesy and urges Member States to jointly develop and maintain sustainable GGRF under globally-coordinated multilateral cooperation. The resolution includes six Operational Paragraphs which urge Member States to establish a Roadmap for the enhancement of GGRF, enhance technical assistance and capacity building on geodesy, and maintain and improve their geodetic infrastructure and so on. Working Group established by the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) for drafting the resolution also drafted the Roadmap and the Roadmap was adopted by UN-CCIM at its sixth session in August 2016. In the roadmap, the Working Group clarifies current issuers for maintenance of sustainable GGRF, then suggests the possible solutions and finally presents future vision for the further enhancement of GGRF on the five items indicated in the resolution, that is Geodetic Infrastructure, Data Sharing, Policies, Standards and Conventions, Education, Training, and Capacity Building, Communication and Outreach, and Governance. The Geospatial Information Authority of Japan (GSI) has contributed to drafting of the Roadmap as a member of the WG and will participate in the sub-committee and contribute to drafting of the implementation plan.
In the presentation, I will brief the resolution on Global Geodetic Reference Frame for Sustainable Development and current situation on International Terrestrial Reference Frame (ITRF) which is practical de-facto standard for GGRF.

Keywords: Global Geodetic Reference Frame (GGRF), the United Nations, GGRF Roadmap

SLR continuous observation at the Shimosato Hydrographic Observatory after 1982

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Satellite Laser Ranging (SLR) plays an important role for the Global Geodetic Observation System (GGOS). The Hydrographic and Oceanographic Department of the Japan Coast Guard (JHOD) has conducted the SLR observation at the Shimosato Hydrographic Observatory (SHO) since 1982. For 35 years, the SLR observation at the SHO made a great contribution to establishing a world geodetic system as a national geodetic system in Japan in 2002. The Shimosato station also observed crustal movements of the 2004 Kii Peninsula earthquakes and the 2011 Tohoku-oki earthquake. In addition, the Shimosato station also plays a role as the mainland reference point of the marine geodetic control network based on MGC2000. In this presentation, we review results of the SLR observation at the SHO. The fact that the SLR observation was continuously performed at the same point for 35 years is significant for not only a framework of a national geodesy in Japan but also a global geodetic framework. It is also valuable to discuss a framework of the future GGOS.

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Keywords: SLR, Laser ranging

Satellite Laser Ranging Network: Where Should a New Station Be Placed? [Part II] For Better Satellite Orbits

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Precise orbits of artificial satellites are not only useful for flight dynamics and geodetic products but also important for monitoring the phenomena of the changing Earth such as sea level rise and ice melting. Satellite Laser Ranging (SLR) is one of the most precise techniques to determine the orbits of satellites. About 35 SLR stations are being operational all over the world but the distribution of the current station network is not uniform. In particular, there are only 7 stations in the Southern hemisphere and there is no stations below 37 degrees latitude. It is found that this results in relatively less accurate orbit determination in the southern hemisphere.
A virtual station is added to the existing SLR network to evaluate the impact of a future station. The simulation procedure is similar to our previous study (Otsubo et al., EPS, 2016). Combining a simulated data set of a virtual station to the real existing data set, orbit determination procedures are simulated. For instance, assuming an active SLR station at Syowa (69S, 39E), the time-varying formal errors of Jason-2 and Cryosat are improved in the southern high latitude region by 20 to 30%.

Keywords: GGOS, Satellite Laser Ranging, Precise Orbit Determination

Time variation of solar radiation pressure acceleration acting on geodetic satellites

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Solar radiation pressure is one of the major error sources in satellite geodesy. Solar radiation pressure acting on a satellite varies in accordance with how sunlight illuminates its surface and how it is reflected. The cannonball model widely applied for spherical geodetic satellites rests on the following assumption: the satellite is a perfect sphere and the optical properties of its surface is spherical symmetry. Applying this model, a solar radiation pressure coefficient C_R is often adjusted as a scale factor. This study focuses on the time variation of the C_R solutions.
We use the geodetic analysis software "c5++" (Otsubo, 2016) to estimate the C_R coefficients of the six geodetic satellites: Ajisai, LAGEOS-1, LAGEOS-2, LARES, Starlette and Stella. Satellite laser ranging data for the past 20 years are analyzed where the C_R coefficients are estimated per 30 days.
An interesting behavior is observed in the time series of Ajisai’s C_R estimates. It ranges from 1.022 to 1.064, and shows a clear semiannual pattern maximizing in summer and winter. The 0.04 variation of Ajisai’s C_R value is equivalent to a 1.0 nm/s^2 difference in the acceleration acting on the satellite (Hattori, 2016).
Sengoku et al. (1995) constructed a solar radiation pressure model of Ajisai based on its surface materials. The C_R is predicted to vary in a range from 1.020 to 1.035 and show a dominant annual pattern with a maximum in summer. This does not agree well with our solutions above.
We attribute the reason of the discrepancy to the following two facts. One is that a 5-cm-height metallic ring is attached to one of the pole the satellite and the effective cross-section area becomes larger when the satellite is illuminated from inclined angles in summer and winter. This seasonal variation of the effective cross-section area results in a semi-annual variation of the C_R estimates. The other is that the difference of optical reflectivity between its equatorial region and the polar regions are found to be more than the difference between the two polar regions.

Keywords: satellite laser ranging, solar radiation pressure, Ajisai

SLR monthly gravity solutions using the C5++ software

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This study presents monthly gravity solutions up to degree and order 4 for the period 1993-2015 derived by Satellite Laser Ranging (SLR) data using the C5++ software [Otsubo et al., 1994]. Here, we apply the following modifications to the previous solutions by Matsuo et al. (2013). First, Range bias is estimated for per station and per satellite. Secondly, station coordinates are solved for using no-net-rotation constraints. Thirdly, non-tidal effects for atmosphere, ocean, hydrology are corrected using geophysical fluid models. Last, one-per-rev empirical accelerations are estimated in along-track and cross-track. Consequently, our new SLR solutions exhibited better consistency with those from Gravity Recovery And Climate Experiment (GRACE) than the previous solutions in the degree 3 and 4 components. The improvements of SLR gravity solutions provides further insight into the mass variability of the earth prior to the launch of GRACE in 2002.

Keywords: Time-variable gravity, Satellite Laser Ranging, Space geodesy

Activities of the Asia-Oceania VLBI Group for Geodesy and Astrometry (AOV)

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The Asia-Oceania VLBI Group for Geodesy and Astrometry (AOV) was established in 2014 as a subgroup of the International VLBI Service for Geodesy and Astrometry (IVS) in order to foster regional collaboration of VLBI. AOV coordinates six regional sessions in a year on regular basis by sharing resources of scheduler, stations, and correlators. AOV members are also enhancing their close collaboration by sharing information of recent activities in several face-to-face meetings. Successful broadband VLBI experiments with telescopes in Australia and Japan in August 2016 marked the start of VGOS in this region under the collaboration of AOV. We talk on the recent activities of the AOV.

Keywords: VLBI, IVS

The GSI contribution to the IGS

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Geospatial Information Authority of Japan (GSI) has started GNSS continuous observation in tracking stations since 1991. Five years later, GSI started operation of nationwide continuous observation system called GEONET (GNSS Earth Observation Network System), which now consists of more than 1300 stations.
Some stations of GEONET operated by GSI are registered as International GNSS Service (IGS) stations. GSI has participated in IGS since the establishment of the IGS and has played an important role as an operational data center and Regional Network Associated Analysis Center (RNAAC).
GSI operates 7 IGS stations including 6 stations in Japan, and SYOG station located in Antarctica. Some equipment satisfying IGS specification are installed at these stations, e.g. atomic clock to keep precise time stamp at each station. We have also participated in recently launched M-GEX project and RTS Service for further contribution to IGS. These data support the high-quality IGS products and construction of International Terrestrial Reference Frame, which also benefit us to conduct coordinate analysis of GEONET stations in Japan. We will continue to cooperate with IGS.
We show the GSI contribution to IGS from beginning of continuous GNSS observation.

Keywords: GEONET, IGS, GNSS

Verification of accelerated vertical crustal movements in the Tohoku region prior to the 2011 Tohoku-Oki earthquake by reanalysis of GEONET data using Precise Point Positioning

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Homogeneous coordinate time series data over a decade from GNSS analysis is essential for investigation of various phenomena preceding massive earthquakes such as the Tohoku-Oki earthquake. Kurokawa (2016) found a significant difference between vertical velocities obtained from GNSS and those from tidal record during 2003~2011. This suggests that the long-term homogeneity of the GNSS result is questioned. Routine processing of GEONET, the GNSS continuous observation network in Japan, currently adopts the network analysis strategy (F3 solution). However, such strategy may generate bias in analysis result because the combination of baselines has changed in response to the increase of the number of stations. In this study, we reanalyze the daily coordinate of 30 GEONET stations along the coast of Tohoku region for the last 20 years by using Precise Point Positioning method (PPP) in order to get rid of bias due to network analysis. We compare the velocities obtained from the F3 solution and our PPP result. In the horizontal components, the differences are about 1~1.5 mm/yr before the Tohoku-Oki earthquake. In the vertical component, large differences of about 2~3 mm/yr are found before 2003, and gradually decrease to smaller than 0.5 mm/yr just before the Tohoku-Oki earthquake. Even if the difference is small, there exist systematic differences in many cases. We estimate the vertical acceleration before the Tohoku-Oki earthquake. Our PPP result shows no significant change along the Japan Sea coast, and accelerated subsidence along the Pacific coast (about -0.3 mm/yr^2). This result is consistent with the horizontal acceleration indicated by Mavrommatis et al. (2014) and the accelerated subsidence by Kurosawa (2016). Furthermore, this suggests that the construction of a network for the F3 solution is one of the causes of the common mode error, because Mavrommatis et al. (2014) and Kurokawa (2016) eliminated such errors by using spatial filtering technique.

Keywords: Precise Point Positioning, accelerated vertical crustal movements, GEONET

Implementation of Domestic Comparison of Absolute Gravimeters Ishioka Geodetic Observing station and construction of Japan Gravity Standardization Net 2016 (JGSN 2016)

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Geospatial information authority of japan (GSI) has held the Domestic Comparison of Absolute Gravimeters (DCAG) annually since 2002 with several domestic organizations which own absolute gravimeters. By comparing with the results of the FG5 absolute gravimeters, which is operated by the National Institute of Advanced Industrial Science and Technology (AIST) and routinely participate in the International Comparison of Absolute Gravimeters supported by BIPM, we could expect to confirm the consistency of our equipment with international standard.
While DCAG had been held at a hotel located in Mt. Tukuba area until 2015, it was done at GSI's new Ishioka Geodetic Observing Station (Ishioka city, hereinafter referred to as Ishioka station) in 2016. Since Ishioka station has a special room for DCAG as described later, it is expected that we can conduct DCAG much more precisely under better environment.
The gravity measurement facility of Ishioka station is very unique in several respects. It is firmly coupled to the support layer with a plurality of concrete piles and its base plate is isolated from the building in order to reduce the effect of ground vibration. It is designed to set up six absolute gravimeters simultaneously on each points which have precise coordinates decided by GNSS and leveling before the construction. Since Ishioka station also has the VLBI facility, we can utilize the distributed hydrogen maser 's signal to minimize clock errors between absolute gravimeters. Of course, we can expect less artificial noise because of its suburban location. Thanks to those improvements, we successfully achieved good results in the latest DCAG within the range of instrumental error.
GSI has released a new Japan Gravity Standardization Network (JGSN) 2016 in March 2017 for the first time in 40 years. It was composed of both absolute and relative gravity measurement data carried out by GSI between 2002 and 2016. On the course of its measurements, we used our FG5 calibrated by DCAG to determine the absolute gravity values. DCAG obviously played a key role in making JGSN2016 highly reliable and consistent with the global gravity standards.
We will report the results of past DCAG and its contribution to the JGSN2016.

Keywords: Japan Gravity Standardization Net 2016 (JGSN2016), Absokute gravity measurement, Domestic comparison of Absolute Gravimeters

On-site Frequency Measurements of a Rubidium Oscillator for Gravimeters

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It is important for precise gravity measurement to calibrate the frequency of a rubidium oscillator as a time frequency standard. We demonstrate simple on-site frequency measurement by using a time frequency calibration tool (FT-001A) with a GPS common view method. We equipped one at F-net IGK station, Ishigaki, Japan and measured frequency variation of the internal rubidium oscillator of gPhone gravimeter (S/N 133). As a result, we could measure its frequency with uncertainty of approximately 10^{-12} (0.01 mHz) on the gravity station 2,000 km apart from AIST Tsukuba where UTC(NMIJ) is maintained.

