The Global Geodetic Observing System (GGOS) - its Role and its Activities

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The Global Geodetic Observing System (GGOS) has been organized under the International Association of Geodesy (IAG) since 1999 to work with the IAG components to provide the geodetic infrastructure necessary for monitoring the Earth system and global change for both scientific research and to help give us the opportunity to make intelligent decisions for societal benefit. Observations include those of the Earth's shape, gravity field and rotational motion, and those such as precision satellite orbits to support space based systems (such as altimetry and gravity sensors). GGOS contributes to the emerging Global Earth Observing System of Systems (GEOSS) not only with the accurate reference frame required for many components of GEOSS but also with observations related to the global hydrological cycle, the dynamics of atmosphere and oceans, and natural hazards and disasters.

GGOS advocates for implementation of core and co-location network sites to satisfy GGOS requirements, monitors the present state of the networks and projects their future status, and supports and encourages maintenance and improvement in the infrastructure critical for the development of data products essential to GGOS.

GGOS is focused on the IAG Services and the products they derive on an operational basis for Earth monitoring making use of various space geodetic observation techniques such as VLBI, SLR/LLR, GNSS, DORIS, altimetry, gravity satellite missions, etc. GGOS builds upon existing observing and processing systems of the IAG, supporting its goal of obtaining products of highest possible accuracy, consistency, and temporal and spatial resolution, which should refer to a consistent reference frame, stable over decades in time. To achieve these important IAG goals, GGOS supports the fundamental requirement that common standards and conventions are used by all IAG components for the analysis of the different geometric and gravimetric observations.

In this talk, we will discuss the role of GGOS, its current status and structure, and plans as we move forward.

Keywords: Space Geodesy, VLBI, SLR, GNSS, Gravity , Co-located geodetic measurements

International and Japanese Activities of Satellite Laser Ranging for Global Geodesy

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For more than 50 years, the Satellite Laser Ranging (SLR) technique has played a key role in geodesy and orbital dynamics. SLR data have been used continuously to to study the dynamic Earth, the Earth-Moon system, and fundamental constants, and to provide a better understanding of our global environment.

In cooperation with the IAG’s (International Association of Geodesy) Global Geodetic Observing System (GGOS), space and ground based techniques are working together to develop and improve data products that rely on their combination of strengths and unique capabilities. A good example is Terrestrial Reference Frame (TRF), which is the basis for our metric measurements of global change, including the detection and monitoring of small global-scale signals. The TRF is a product of the combination of SLR with GNSS (Global Satellite Navigation System), VLBI (Very Long Baseline Interferometry) and DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) combined into a product of accurate fiducial station positions and velocities. SLR uniquely provides the reference frame origin and with VLBI, its scale. Laser ranging is also now an emerging tool for accurate time transfer between clock in the Earth and in space.

One great strength of SLR lies in the use of optical wavelengths. It can yield a high-precision, unambiguous two-way distance between a ground station and a satellite, and its measurement is not affected by ionosphere and less affected by troposphere. SLR systems are operating at sub-centimeter precision. Newer technologies, already implemented at some of the stations, are approaching 1 mm precision.

The number of SLR targets is increasing rapidly. In addition to the spherical geodetic satellites, laser reflectors are being carried on altimetry, gravimetry, Earth observation, navigation, and space engineering satellites. The ILRS presently tracks about 90 satellites.

Since the late 1960s when Tokyo Astronomical Observatory (current National Astronomical Observatory of Japan) tested SLR at Dodaira, Japanese stations have participated in the international SLR community. Three SLR stations, Shimosato, Koganei and Tanegashima, are being operated in Japan. In addition, JAXA (Japan Aerospace Exploration Agency) has launched a number of SLR satellites including the 30-year-old Ajisai satellite, which is still being tracked for orbit dynamics and Earth science. The Japanese SLR community and space geodesy community hope to explore new challenges in SLR observations, data analysis and satellite missions so as to effectively yield the global-scale geodetic products in cooperation with International Laser Ranging Service.

Keywords: GGOS, Satellite Laser Ranging

Performance Aspects of the Next Generation Lunar Retroreflector

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The ability of the Next Generation Retroreflector (NGR) (a.k.a. The Lunar Laser Ranging Array Retroreflector for the 21st Century and/or MoonLIGHT) depends heavily upon a detailed thermal simulation to assure that the NGR will perform according to the requirements of the nominal design. This performance objective is to assure 80% of the peak return at all times during a lunation (assuming the NGR is pointed correctly at the earth). There are three phases in addressing this issue: Phase 1 consists of using a rigorous Solar/Orbital/Optical/ Thermal/Optical (SOOTO) simulation. This has been described briefly in earlier presentations. The SOOTO is used to evaluate the effects of the reflectivity, emissivity and conductivity of various elements of the NGR, to allow the selection (where feasible) of these parameter to obtain the design performance. Phase 1 will be the primary focus of this talk, illustrating some initially surprising results. Phase 2 addresses the effects of angular offsets of the back faces of the CCR and the effects of the phase shifts due to Total Internal Reflection. This allows the optimization of the angular offsets of the back faces of the CCR and the orientation of the CCR. Phase 3 consists of incorporating the Phase 2 results and re-evaluating the effect of the parameters studied and selected in Phase 1. Further, several other topics will be briefly reviewed: The new design to address the second landing site, the effects of break-through in solid CCRs, detailed simulations of the effects of atmospheric propagation and the testing of a candidate for a low visible absorption high thermal infrared emissivity coating.

Keywords: Lunar Laser Ranging, Next Generation Retroreflector, Solar/Orbital/Optical/Thermal/Optical Simulation

VGOS development for Ishioka 13-m antenna

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The Geospatial Information Authority of Japan (GSI) constructed a new VLBI facilities in Ishioka. It is designed for the next-generation VLBI system called VGOS, which is promoted by the International VLBI Service for Geodesy and Astrometry (IVS) in order to meet the requirements of Global Geodetic Observing System (GGOS). In addition to the VGOS facilities, Ishioka has GNSS Continuously Operating Reference Stations and a gravity measurement facility in order to contribute to GGOS as a core observatory.
Since February 2015, the Ishioka 13-m antenna observed legacy S/X sessions with Tsukuba 32-m to obtain accurate positions of the new site. Then, Ishioka has started the international observations dedicated for Earth rotation measurement taking over the role of Tsukuba 32-m from the beginning of 2017. In parallel with these legacy observations, we have carried out several broadband observations compatible with VGOS frequency setup. From August to September 2016, we installed a new signal chain including QRFH (Quadruple-ridged flared horn), up-down converters, and high speed digital samplers at Ishioka in order to participate in VGOS Trial sessions which were broadband observations coordinated by IVS. Several experimental broadband observations with Kashima 34-m of NICT and Hobart 12-m of AuScope were also performed, and the compatibility of equipment between Ishioka and other overseas stations was confirmed. We report on the recent development of VGOS equipment and results of the legacy and broadband sessions for Ishioka.

GGOS and the Gravity Field Studies

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During the IUGG General Assembly in Prague 2015, the IAG adopted two Resolutions; No. 1 (R1) for the definition and realization of an International Height Reference System (IHRS) and No. 2 (R2) for the establishment of a Global Absolute Gravity Reference System (GAGRS). As ITRF is the realization of ITRS, IHRF and GAGRF are the realization of IHRS and GAGRS, and they should be visible outcomes of GGOS. IAG R1 describes that the vertical coordinate of a point P is given by the difference between the gravity field potential at the point and at the geoid (W0). This procedure is nothing but the precise geoid determination. IAG R2 describes the direction to establish GAGRS and its meanings, and it looks more directly related to the gravity field studies. In addition, International Geodynamics and Earth Tide Service (IGETS), which is a service of IAG, have officially started during the IUGG in Prague. IGETS is expected to monitor temporal variations of the Earth gravity field. It is an important conponent of GGOS. In this talk, by reviewing the IAG resolutions and the role of IGETS, GGOS and the gravity field studies are discussed.

Keywords: International Height Reference System, Global Absolute Gravity Reference System, International Geodynamics and Earth Tide Service , Earth Gravity Field

The Contribution of Global Geodetic Observations to Understanding Dynamic Earth Processes

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The Earth is a dynamic system—it has a fluid, mobile atmosphere and oceans, a continually changing global distribution of ice, snow, and water, a fluid core that is undergoing some type of hydromagnetic motion, a mantle both thermally convecting and rebounding from the glacial loading of the last ice age, and mobile tectonic plates. In addition, external forces due to the gravitational attraction of the Sun, Moon, and planets also act upon the Earth. These internal dynamical processes and external gravitational forces exert torques on the solid Earth, or displace its mass, thereby causing the Earth's figure, rotation, and gravitational field to change. Geodetic observing systems, both space-based and ground-based, provide the measurements of the Earth's figure, rotation, and gravitational field that are used to study these dynamical processes and the response of the Earth to them. Geodetic observations also provide the metrological foundation for Earth observations and provide the means to determine mass transport in the Earth system. Geodetic observations are therefore a cornerstone of the Earth observing systems needed for scientific research and societal applications. In this presentation, selected examples of the contribution of geodetic observations to understanding the dynamic Earth system will be presented.

Keywords: GGOS