Section 1:

Introduction

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Satellite Laser Ranging: An Essential Component of the Global Geodetic Observing System

The Global Geodetic Observing System (GGOS) of the International Association of Geodesy (IAG) provides the basis on which future advances in the geosciences can be built. By considering the Earth system as a whole (including the geosphere, hydrosphere, cryosphere, atmosphere and biosphere), monitoring Earth system components and their interactions by geodetic techniques and studying them from the geodetic point of view, the geodetic community provides the global geosciences community with a powerful tool consisting mainly of high-quality services, standards and references, and theoretical and observational innovations.

Satellite laser ranging is an essential part of the geodetic enterprise, for both monitoring the Earth system and for enabling geoscientific research. The solid Earth is subject to a wide variety of forces including external forces due to the gravitational attraction of the Sun, Moon, and planets, surficial forces due to the action of the atmosphere, oceans, and water stored on land, and internal forces due to earthquakes and tectonic motions, mantle convection, and coupling between the mantle and both the fluid outer core and the solid inner core. The solid Earth responds to these forces by displacing its mass, deforming its shape, and changing its rotation. Satellite laser ranging can measure the change in the Earth's gravity caused by mass displacement, the change in the Earth's shape, and the change in the Earth's rotation. Consequently, satellite laser ranging can be used to study both the mechanisms causing the Earth's shape, rotation, and gravity to change, as well as the response of the solid Earth to these forcing mechanisms. As a result, satellite laser ranging can be used to gain greater understanding of the Earth's interior structure and of the nature of the forcing mechanisms including their temporal evolution.

The availability of accurate, routine determinations of the Earth orientation parameters (EOPs) afforded by the launch of the LAser GEOdynamics Satellite (LAGEOS) on May 4, 1976, and the subsequent numerous studies of the laser ranges to LAGEOS, has led to a greater understanding of the causes of the observed changes in the Earth's orientation. LAGEOS observations of the EOPs now span more than 43 years, making it the longest available space-geodetic series of Earth orientation parameters. Such long duration homogenous series of accurate Earth orientation parameters are needed for studying long-period changes in the Earth's orientation, such as those caused by climate change. In addition, such long duration series are needed when combining Earth orientation measurements taken by different space-geodetic techniques. They provide the backbone to which shorter duration EOP series are attached, thereby ensuring homogeneity of the final combined series.

Radar altimetric observations of sea level rely on satellite laser ranging, as well as GNSS and DORIS, to provide the accurate orbits of the altimetric satellites that are needed for cm-level sea level determination. Gravimetric satellite missions like GRACE and GRACE-FO rely on satellite laser ranging to provide the longest wavelength components of the gravity field (degree-2 and degree-3 zonals). The present altimetric and gravimetric satellites can measure total sea level change and its mass component, both of which are vital for understanding global climate change. An important goal of GGOS is to integrate the measurement techniques that monitor Earth's time-variable surface geometry (including ocean and ice surfaces), gravity field, and rotation into a consistent system for measuring ocean surface topography, ocean currents, ocean mass, and ocean volume changes. This system depends on both globally coordinated ground-based networks of satellite tracking stations as well as on an uninterrupted series of satellite missions. The ground-based networks of geodetic stations also provide the measurements used to determine the terrestrial reference frame that is needed for studying regional and global sea level change and ocean-climate cycles like El Niño, the North Atlantic Oscillation, and the Pacific Decadal Oscillation. Much of the future progress in ocean observation will depend ultimately on the ability of the global geodetic community to maintain the accurate and long-term reference frame required for Earth observation.

Satellite laser ranging is therefore an essential component of the IAG's Global Geodetic Observing System, providing critical satellite orbit observations, low-degree gravity field coefficients, Earth orientation parameters, and unique geocenter observations for the terrestrial reference frame. Continued improvements of these observations and contribution to the terrestrial reference frame will depend on technological innovation and adequate geographical coverage and co-location of SLR with the other geodetic measurement techniques of VLBI, GNSS, and DORIS. Implementing modern technology into a network of core geodetic sites with better geographic distribution and more uniform performance is a high priority of GGOS.

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Chair, Global Geodetic Observing System (GGOS)
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September 11, 2019

Chairmans' Remarks

I was honored to serve as chairman of the Governing Board of the ILRS for three terms, from 2013 to 2018. During this period, I was delighted to see a growing demand of high accuracy SLR data, not only from our usual customers, but also from new ones. The space surveillance and tracking (SST) network needs our high precision distance measurement (either from cooperative and non-cooperative targets) to complement the "usual" direction information as well as less precise RADAR telemetry; on the other hand, the optical and quantum communication research work makes use of the advanced timing facilities embedded in a SLR station. Other than that, after more than 50 years of development, SLR remains unequaled as a fundamental technique for the definition of the Terrestrial Reference Frame.

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Chairman, ILRS Governing Board (2013-2018)
August 2019

At the ILRS Governing Board Meeting held in Canberra in November 2018, I was elected as the new chairperson. Following the four predecessors, and as the first chairperson from Asia, I am thrilled to lead the ILRS. My term as chair is from January 2019 to December 2020.

We have successfully demonstrated our capability of yielding high-precision satellite tracking data since an early age, and it is truly exciting that more and more satellite providers are nowadays choosing to add laser reflectors on their missions. The number of ILRS targets is growing and has now reached nearly 100. On the other hand, the number of active laser tracking stations has been almost at the same level for a few decades. We need to strengthen the ILRS tracking network by increasing stations and/or making operations more efficient and thus contribute more to global-scale geodesy to its utmost precision.

The greatest assets of the ILRS are, in my view, challenging spirits and mutual stimulation. Having a variety of new applications of laser ranging technology/data, we should re-examine what we can potentially provide in the future and make our technical development more exciting. It will no doubt help attract more people from the outside and/or of a new generation.

I look forward to working with each institute and each individual member of the ILRS and also collaborating with related entities: other geodesy services, GGOS, IAG, and more.

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August 2019