Symposium 5. Global Geodetic Observing System (GGOS): the metrological basis for the monitoring of the System Earth

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Abstract:
The Earth is constantly changing its geometrical shape, rotation and gravity field. These changes are measured by various geodetic techniques and provided through geodetic products. The Global Geodetic Observing System (GGOS) closely works with the IAG Services to generate geodetic products as well as to maintain globally consistent and common reference frames as the metrological basis for monitoring the System Earth. Such high-quality geodetic products can be generated only with uniformly distributed ground and in-space geodetic observations, analysis with common standards and conventions, and a consistent representation and parameterization of the relevant quantities. It is also important to understand the behavior of atmosphere, ionosphere, thermosphere, hydrosphere and cryosphere and the interaction between them, hence they all may be a major source of uncertainty in geodetic products. GGOS is addressing these challenges together with the IAG Services, Commissions and Inter-Commission Committees. In addition, as geodetic products are also underpinning human activities and help us in tackling various societal challenges, GGOS collaborates with the United Nations, the Group on Earth Observations, and other stakeholders to cope with these challenges. In this symposium, we solicit contributions on status, progress and plans for the GGOS-related activities to generate high-quality geodetic products, including long-term consistent and stable reference frames, as well as to address scientific and societal challenges.

Symposium 5, Session 1: Geodetic infrastructure for Earth System Monitoring

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Abstract:
The Global Geodetic Observing System (GGOS), with the support of the IAG Services, provides measurements of the static and time time-varying gravitational field, Earth rotation, and the shape of the Earth surface using geodetic and gravimetric instruments located on the ground and onboard spacecraft. Advances in technology, integration of results from different techniques, and improvements in modeling capabilities have placed us at the threshold of making very significant advances for science and societal benefit. We are at the stage now where measurements need to become more accurate than a part per billion in order to advance our understanding of the underlying processes that are causing global change. Mass transport in the global water cycle, sea level, and climate change, and crustal deformation associated with geohazards are examples of particularly demanding applications of geodetic and gravimetric measurements. All these measurements require a common reference frame with the same precision across techniques, based on the Global Terrestrial Reference Frame System and the Unified Height System. Fortunately, technology that is now being implemented and envisioned has stepped up to meet these needs. GGOS is designed to assimilate the individual observations and deliver models in a consistent frame with the highest precision possible. In this session we solicit contributions on global geodetic observing system components including single techniques as well as multidisciplinary approaches.

This session solicits contributions focusing on aspects of:

- Advances in Space Geodesy improvement of the reference frame and for measurements of Earth dynamics
- Recent Progress and Results from the IAG Geodetic Services
- New technology applicable to Space Geodesy
- New space geodetic satellites
- Status, progress, and plans of the Space Geodetic networks Xx

Keywords:
Space Geodetic techniques, GGOS Bureau of Networks and Observations, VLBI, SLR, GNSS, DORIS, IAG Geodetic Services.

Symposium 5, Session 2: Gravity observations and networks in the framework of GGOS

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Abstract:
The gravity field of the Earth contains useful information spreading over a broad range of values, from g (103 Gal) to 10-6 g (1 µGal). All these different components are observable with very different methodologies. The very long wavelength components are effectively estimated by observing the orbits of high satellites. The medium wavelengths, down to 100km, are basically observed from LEO satellites (e.g., the dedicated gravity mission of GRACE and GOCE) and, for the ocean's areas, by inverting radar-altimetry. Finally, the short components, down to 1km, are achieved by aerial and ground observations. Furthermore, at isolated permanent stations, absolute gravity and its variation are measured at few µGals accuracy.

In the last years, the methodologies and the techniques for gravity observations have been sharply improved. Particularly, portable absolute gravimeter and cold atom interferometry opened new perspectives in gravity filed observations. As an example, intense activities have been promoted in order to establish a new International Gravity Reference System to substitute the outdated IGSN71. Global Geodetic Observing System (GGOS) of the International Association of Geodesy (IAG) has promoted these activities with supporting the IAG Gravity Services.

This session solicits contributions on gravity observation techniques and methodologies covering the entire spectrum of gravity values and on the impact that gravity can have on the GGOS core network.

This session solicits contributions focusing on aspects of:

- Ground and airborne gravity observation techniques and methodologies
- Satellite gravity observation techniques and methodologies
- Establishment of the International Gravity Reference System
- Gravity and GGOS core network

Keywords: absolute gravity observations, relative gravity observations, satellite gravity missions, International Gravity Reference System

Symposium 5, Session 3: Standardized geodetic products for a reliable System Earth observation

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Abstract:
The generation of geodetic products is making use of various geometric and gravimetric observation techniques located on the ground and in space. In order to fully benefit from the ongoing technological improvements of the observing systems, it is essential that the data analysis and product generation is based on the definition and application of common standards and conventions and a consistent representation and parameterization of the relevant quantities. This is of crucial importance to obtain highly accurate and consistent products for the time-varying gravitational field, Earth rotation and the shape of the Earth surface, as well as for the generation of highly precise and long-term stable geodetic reference frames as a fundamental basis. Towards this aim, a key objective of IAG's Global Geodetic Observing System (GGOS), with support of the IAG Services, is the integration of the "three pillars" geometry, Earth rotation and gravity field, and to provide consistent products for Earth system studies and monitoring global change phenomena. This session will focus on recent activities towards the development of common standards and the generation of integrated products. Furthermore, this session will provide the platform to present and discuss the activities towards the definition of Essential Geodetic Variables (EGVs) that are crucial to characterizing the geodetic properties of the Earth and that are key to sustainable geodetic observations.

This session solicits contributions focusing on aspects of:

- Development of common standards for the generation of consistent geodetic products
- Integration of geometric and gravimetric observations
- Developments towards enhanced IAG/GGOS products needed for Earth sciences
- Activities towards the definition of Essential Geodetic Variables (EGVs)

Keywords:
GGOS Bureau of Products and Standards, standards and conventions, geodetic products, integration of geometric and gravimetric observations, Essential Geodetic Variables (EGVs)

Symposium 5, Session 4: Geodetic space weather research

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Abstract (Description of the Session, about 200 words):
Space weather means today an own, very up-to-date and interdisciplinary field of research. It describes physical processes in space mainly caused by the Sun's radiation of energy. The manifestations of space weather are multiple, for instance, the variations of the Earth's magnetic field or the changing states of the upper atmosphere, in particular the ionosphere, the plasmasphere and the thermosphere. The impacts and risks of space weather are gaining more and more importance in politics and sciences, since our modern society is highly depending on space-borne techniques, e.g., for communication, navigation and positioning.
The observation data of space-geodetic measurement techniques such as GNSS (terrestrial and space-borne), satellite altimetry, VLBI, SLR and DORIS provide valuable information on the state and dynamics of the upper atmosphere. Furthermore, geodesy has a long history and large experience in developing and using sophisticated analysis techniques and modelling approaches. As a conclusion, geodesy means an appropriate scientific field for space weather research. Within the GGOS FA-GSWR – installed in 2017 into the IAG structure – geodesy is going another step forward by treating the magnetosphere, ionosphere, plasmasphere and thermosphere as the components of a physically coupled system ranging from the Sun to the Earth's surface. Consequently, interdisciplinary research has to start with processes and events on the Sun, continuing with the effects on the geosphere and, finally, considering the impact on (geodetic) applications and systems.
In summary, Geodetic Space Weather Research has to be based on the use and combination of all space geodetic observation methods and Sun observations, real-time modelling, the development of deterministic and stochastic forecast approaches as well as assimilation strategies.

This session solicits contributions focusing on aspects of:

- Combination of ground- and space-based geodetic observation techniques (including terrestrial GNSS, satellite altimetry, radio occultations, VLBI, DORIS) with Sun observations (including EUV, X-ray, magnetic field from ACE, DSCOVR, Stereo, etc.)
- Modeling upper atmosphere (e.g. ionosphere and thermosphere) parameters such as the electron and the neutral density including (near) real-time approaches and forecast procedures
- Coupling processes between magnetosphere, ionosphere, plasmasphere and thermosphere
- Improvement of empirical and physical models, e.g. for ionosphere, plasmasphere and thermosphere key parameter

Keywords:
MIT system, upper atmosphere monitoring and modelling, (near) real-time modelling, coupling processes, validation procedures, development of forecast models, further development of empirical and physical models

Symposium 5, Session 5: Assimilation of geodetic observations in the modelling of the Atmosphere, Cryosphere and Hydrosphere

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Abstract:
Significant advances have been made in the past few decades in geodetic observations of the Earth system. Since 1993, satellite altimeter has provided high-precision and high-resolution continuous observations of global sea surface height (SSH) change. Altimeter SSH observations have been widely used in modern data assimilating ocean general circulation models (OGCMs) to improve the ocean state estimation. Since the launch of the GRACE satellite gravity mission in 2002, and GRACE Follow-On (GFO) in 2018, satellite gravimetry has offered a revolutionary tool for measuring large scale mass variations in the climate system, including terrestrial water storage change, ice mass change of polar ice sheets and mountain glaciers, and ocean mass change with unprecedent accuracy. Assimilating GRACE/GFO mass change observations provide a means for improving the estimation of water mass transport and redistribution by atmospheric and land surface models. Ice elevation changes observed by satellite laser altimeter (e.g., from ICESat 1/2 and CryoSat) and GRACE/GFO observed ice mas change can also help improve the modeling of the cryosphere. In addition, loading deformation observed by the global GNSS networks offers the potential to help improve regional mass load estimation by the climate models. We invite contributions from all related areas in assimilation of geodetic observations in the modelling of the atmosphere, ocean, hydrosphere and cryosphere.

This session solicits contributions focusing on aspects of:

- Assimilation of geodetic observations in the modelling of the atmosphere, ocean, cryosphere and hydrosphere
- Data analysis and uncertainty assessment of geodetic observations and model outputs
- Assimilation techniques and filtering algorithms
- Applications of geodetic data assimilating models

Keywords: Assimilation, Geodetic Observation, Modeling, Altimeter, GRACE, Atmosphere, Ocean, Hydrosphere, Cryosphere

Symposium 5, Session 6: Geodesy contributions to address societal challenges

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Abstract:
Geodesy is a science that underpins human activities and helps us in tackling various societal challenges. For example, an accurate and globally consistent Global Geodetic Reference Frame (GGRF) is essential fundamental infrastructure not only for science but also for society. Recognizing its importance, the United Nations adopted its General Assembly Resolution on "A global geodetic reference frame on sustainable development. The Global Geodetic Observing System, GGOS is the central interface of IAG to science and society and has been working closely with IAG Services, the UN Subcommittee on Geodesy, Group of Earth Observation, and other stakeholders to promote geodesy and GGRF as a basic infrastructure. For example, GGOS together with IAG participates in discussion on development of the Geodetic Center of Excellence which was adopted by the UN to be established in Germany under the umbrella of the UN to sustain GGRF. GGOS is also working on urgent common issues in geodesy that are related to societal challenges. For example, DOIs are extremely useful to make data findable, accessible, interoperable and reusable and helps society to fully utilize digital data. Therefore, GGOS established Working Group on Geodetic Dataset and had active discussion with representatives from IAG services to figure out what the data DOIs should be. In this session, the recent progress on GGOS activities including collaboration between GGOS and stakeholders will be presented and discussed.

This session solicits contributions focusing on aspects of (3-6 items):

- Development of sustainable Global Geodetic Reference Frame (GGRF)
- Global and Regional collaboration to sustain GGRF
- Recent progress from the UN, GEO and other stakeholders
- Common challenges in geodesy that are related to societal issues

Keywords: GGOS, Global Geodetic Reference Frame (GGRF), the UN Subcommittee on Geodesy, societal challenges, DOIs for geodetic data set