IAG's GLOBAL GEODETIC OBSERVING SYSTEM (GGOS) IN ITS INITIAL PHASE

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Introduction

The Global Geodetic Observing System (GGOS) was installed during the XXIII General Assembly of the International Union of Geodesy and Geophysics (IUGG) in Sapporo, Japan, July 2003, as the first and presently only Project of the International Association of Geodesy (IAG). IAG's Projects are, according to its bylaws, of broad scope and of highest interest for the entire field of geodesy. They serve as the flagship of the Association for a long period (decade or longer).

The initial phase of GGOS was set up directly after the Sapporo 2003 meeting by nominating the Project Board. The first meeting of the GGOS Project Board took place before the IAG EC Meeting at the EGU General Assembly, Nice, April 24, 2004. During this meeting the objectives were revised and the first structure was installed nominating initial chairpersons.

The Vision of GGOS

The vision of GGOS as IAG's flagship was discussed by the "Committee for the Realization of the New IAG Structure" during the years 2002-2003 and defined by the GGOS Planning Group. It may be highlighted as follows:

- GGOS integrates different geodetic techniques, different models, different approaches in order to achieve better long-term consistency, reliability and understanding of geodetic, geodynamic and global change processes.
- GGOS provides the scientific and infrastructure basis for all global change research in Earth sciences. In the frame of GGOS the Earth system is viewed as a whole by including the solid Earth as well as the fluid components, the static and the time-varying gravity.
- GGOS is geodesy's contribution to Earth sciences and the bridge to the other disciplines; it asserts the position of geodesy in geosciences.

The Mission of GGOS

Following these basic ideas, the mission of GGOS may be seen twofold, the coordination within geodesy and the representation of geodesy in public. The internal matters are summarized by the tasks

- to collect, archive and ensure accessibility of geodetic observations and models;
- to ensure the robustness of the three fields of geodesy: geometry and kinematics, orientation and rotation, and gravity field of the Earth;
- to identify geodetic products and to establish the requirements concerning its accuracy, time resolution, and consistency;
- To stimulate close cooperation between IAG services, to identify service gaps and develop strategies to close them.

If we look at the present situation in geodesy we may find some significant deficiencies with respect to the listed tasks. The robustness of the three fields of geodesy is not sufficiently exhausted due to some inconsistencies in the used models and provided products in the different

areas. The requirements concerning accuracy and time resolution should be similar for all parameters. However, while we get 10^{-9} for the geometric parameters (e.g., surface coordinates) we are far off this level in gravimetric parameters (geoid, gravity anomalies). Gaps in geodetic services are, e.g., a unified global height reference system (global vertical datum), vertical deformation models (tectonic, isostatic, loading, ...), time dependent sea level models from (satellite altimetry), free availability of terrestrial gravity data. A close cooperation of services is needed to use identical standards, models and parameters, to generate compatible products, and to coordinate common research fields of mutual interest.

The representation of geodesy in public means in particular

- to promote and improve the visibility of geodetic research;
- to achieve maximum benefit for the scientific community and for society in general.

It is obvious that geodesy is not well-known in society although geodetic products (surface coordinates, Earth orientation parameters, gravity potential) are used in surveying, cadastre, engineering, global spatial data infrastructure, rural and urban development, space-travel, navigation etc. We have to let people know that it's geodesy that provides the basis for these applications. We must publish more in popular literature, not only in scientific journals.

To achieve more visibility and influence we have to exchange data and information with geosciences and other sciences in an easily understandable way, and provide policy makers and publicists with the necessary information for their decisions and reports. This part of geodesy has widely been neglected in the past.

The objectives of GGOS

The specified objectives of GGOS may be derived from the tasks mentioned in its mission:

- GGOS aims at maintaining the stability of time series of geometric and gravimetric ***reference frames***;
- GGOS ensures the consistency between the different geodetic ***standards*** used in the geo-scientific community;
- GGOS aims at improving the geodetic ***models*** at the level required by the observations;
- GGOS focuses on all aspects to ensure the consistency of geometric and gravimetric ***products***;
- GGOS shall be established as an official partner in the United Nations' ***Integrated Global Observing Strategy, IGOS***,
- GGOS shall represent IAG in the inter-governmental ad hoc ***Group on Earth Observations, GEO.***

Table 1 gives some examples to demonstrate the necessity of looking seriously after the consistency of standards, models and reference frames in geodetic products. We have several options to define and to realize the parameters. As a matter of fact, there is no complete homogeneity in the use of these parameters. The origin, orientation and scale of reference frames is defined differently in geometric and gravimetric applications, and they are not always consistent. E.g., the models for reducing the effects of Earth tides are not identical in geometric and gravimetric products. While the permanent effect of Sun and Moon is normally included in gravity data and models, it is reduced in geometric parameters (e.g., coordinates). This means, that the basic formula h = H + N (ellipsoidal height = orthometric height + geoid height) is not fulfilled if we take h, H from geometric and N from gravimetric results.

Table 1: Examples for inconsistencies in geodetic standards, models, products.

	Geometric parameters	*Gravimetric parameters*
Definition of origin ... of orientation ... of scale	centre of network: X_0, Y_0, Z_0 rotation axis: X_P, Y_P, DUT c	centre of mass: C_{10}, C_{11}, S_{11} axis of inertia: C_{12}, S_{12} GM
Models for tides ... for deformation	tide free geometric only	zero tide dynamic
Product reference ... update	ITRF, GRS80 regularly	variable episodic

The Scientific Rationale of GGOS

The Global Geodetic Observing System shall have the *central theme* "Global deformation and mass exchange processes in the System Earth" which includes all the activities of GGOS in the future:

- The study of all global patterns of tectonic deformation;
- Investigations on global patterns of all types of height changes;
- Deformation due to mass transfer between solid Earth, atmosphere, and hydrosphere including ice, of geodynamic as well as of anthropogenic origin;
- Quantification of angular momentum exchange and mass transfer.

The list is not meant to be final and will be further developed.

Geodesy is capable of providing information on the mass exchange between all elements (components) of the Earth's system by observing

- deformation of the solid Earth (geometry and kinematics) by precise positioning,
- water circulation in oceans, ice covers, atmosphere, solid Earth by satellite radar and laser altimetry, atmospheric sounding, gravity),
- mass exchange between the atmosphere, the hydrosphere and the biosphere via the angular momentum by observing variations of Earth rotation and the gravity field.

Recent Activities of GGOS

The activities of GGOS within the geodetic community is done continuously by interaction closely with the IAG Services. There are twelve services which are cooperating more and more intensively in order to overcome inconsistencies in standards, models and parameters as well as to close gaps in service products. While the geometric services (International Earth Rotation and Reference Systems Service, IERS; International GPS Service, IGS; International Laser Ranging Service, ILRS; International VLBI Service, IVS; International DORIS Service, IDS) are working together very closely, there may be some improvement of cooperation within the gravimetric services (International Gravity Field Service, IGFS; International Gravimetric Bureau, BGI; International Geoid Service, IGeS; International Centre for Earth Tides, ICET) and between both.

With respect to the representation of geodesy in international bodies, GGOS started some important activities during the last two years. It submitted a concept note for a "Dynamic Theme" within United nations' Integrated Global Observing Strategy (IGOS) and was encouraged to develop a proposal for a new theme following the IGOS-P regulations and

coordinate the proposal preparation with the geohazard theme, the ocean theme and the water cycle theme.

IAG has become a participating organization in the intergovernmental ad-hoc Group on Earth Observations (GEO) and nominated the GGOS Chair Christoph Reigber as its representative to the GEO plenary. GGOS participated in the development of a 10-year implementation plan for a Global Earth Observing System of Systems (GEOSS) by working with ten members in the five corresponding subgroups.

Some regional activities were also started to support GGOS:

- In the USA the Project "Inter-Service Data Integration for Geodetic Operations" (INDIGO) will enable improved performance, accuracy, and efficiency in support of NASA's Earth science and inter-national user community by developing and providing uniform access to heterogeneous space geodetic data systems;
- The EU project on "Geodetic And Geohazard Observing Systems (GAGOS)" of the European Partners in GGOS (EPIGGOS) has the main goal to identify necessary adaptations of the existing infrastructure (including data management) and new deployments for the assessment of in-situ capabilities in Earth observation systems.

Conclusion

There are two principal aspects in the mission of GGOS:

1. "Internally" to guarantee the reliability of geodetic products by ensuring the consistency of standards, parameters, models and reference systems used in the three fields of geodesy: Earth geometry, Earth orientation, and Earth gravity field.
2. "Externally" **t**o promote and improve the visibility of geodetic research and results, to represent geodesy in international bodies, and to achieve maximum benefit for the scientific community and for society in general.