GGOS 2020

The Global Geodetic Observing System: Meeting the Requirements of a Global Society on a Changing Planet in 2020

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Reiner Rummel, Dork Sahagian, Chris Rizos, Jim Zumberge, Richard Gross, Tom Herring, Markus Rothacher, Gerhard Beutler

and many others

Anticipated Result

Two documents:

- **Strategy document:** short document for politicians, decision makers, funding agencies
- **Reference document:** long, comprehensive document with all the user requirements and details of GGOS in 2020 mainly for those actually doing the work

Overview GGOS 2020

GGOS 2020

Anticipated GGOS 2020 Schedule

- April 2006: Request for Strategy paper of the GGOS Steering Committee.
- July 2006: Initial Writing Team established.
- October 2006: First draft Reference document available for GGOS Workshop.
- January/February 2007: Reviewer team established
- February 2/17, 2007: Versions 0.15/0.16, respectively
- February 19-22, 2007: GGOS Retreat and GGOS 2020 SWT Meeting, Oxnard, California
- Strategy and Reference documents available in April 2007
- Hearing phase, including GEO, IGOS-P, IUGG, national authorities and space agencies
- Final documents available for IUGG, July 2-13, 2007, Perugia, Italy

Overview GGOS 2020

Modified GGOS 2020 Schedule

- ...
- Draft Reference Documents available on May 29, 2007 for internal IAG hearing
- Internal hearing phase, deadline June 22, 2007
- Comments reached up to July 2, 2007
- Editing finished by July 9, 2007: V0.18
- Submission to GEO ADC on July 10, 2007
- Hearing phase, including GEO, IGOS-P, IUGG, national authorities and space agencies up to September
- September 5, 2007: Deadline, hearing
- September 12-13, 2007: ADC meeting
- September 15-30, 2007: Final editing round

- October 15, 2007: Submission of Reference Document to GEO

Overview GGOS 2020

Status

- Reference document through internal IAG Hearing
- Most services, two Commissions, and a number of individuals provided comments
- Most comments very positive and constructive
- Editing nearly completed
- Next version (0.18) available on July 9, 2007
- A number of open issues remain

Status (Hearing results)

Key open issues:

- GGOS Products: What are these? Duplication? (Chapter 7)
- No comments on functional specifications – Do we all agree? (Chapter 7)
- Need for relativistic frame-formulation? (Chapter 8)
- Future treatment of Earth rotation? (Chapter 8)
- Design of future system and necessary infrastructure not clear enough specified, new and emerging technologies (Chapter 9)
- Too IAG-centric (Chapter 10)
- Too many recommendations, not focused enough, shopping list (Chapter 11)

Overview GGOS 2020 GGOS 2020

Contents of Reference Document

1. Introduction
2. The ways, means, and achievements of geodesy
3. Observing a dynamic planet: Geodesy's contribution to science (Rummel)
4. Geodesy's contribution to the functioning of a modern society (Rizos)
5. Earth observation: Serving the needs of an increasingly global society (Sahagian)
6. Geodesy: foundation for exploring the planets, the solar system and beyond (Zumberge)
7. Integrated user requirements and functional specifications for the GGOS (Gross)
8. The future geodetic reference frame (Herring)
9. The future Global Geodetic Observing System (GGOS) (Rothacher)
10. Towards GGOS in 2020 (Beutler)
11. Recommendations

Main Issues

GGOS 2020

There are two rather distinct meanings for "GGOS":

- the "observation system GGOS": the infrastructure consisting of many different instrument types, satellite missions, and data and analysis centers.
- the "organization GGOS": consists of components like Steering Committee, Science Panel, Working Groups, etc.;

Main Issues

GGOS 2020

There are two rather distinct meanings for "GGOS":

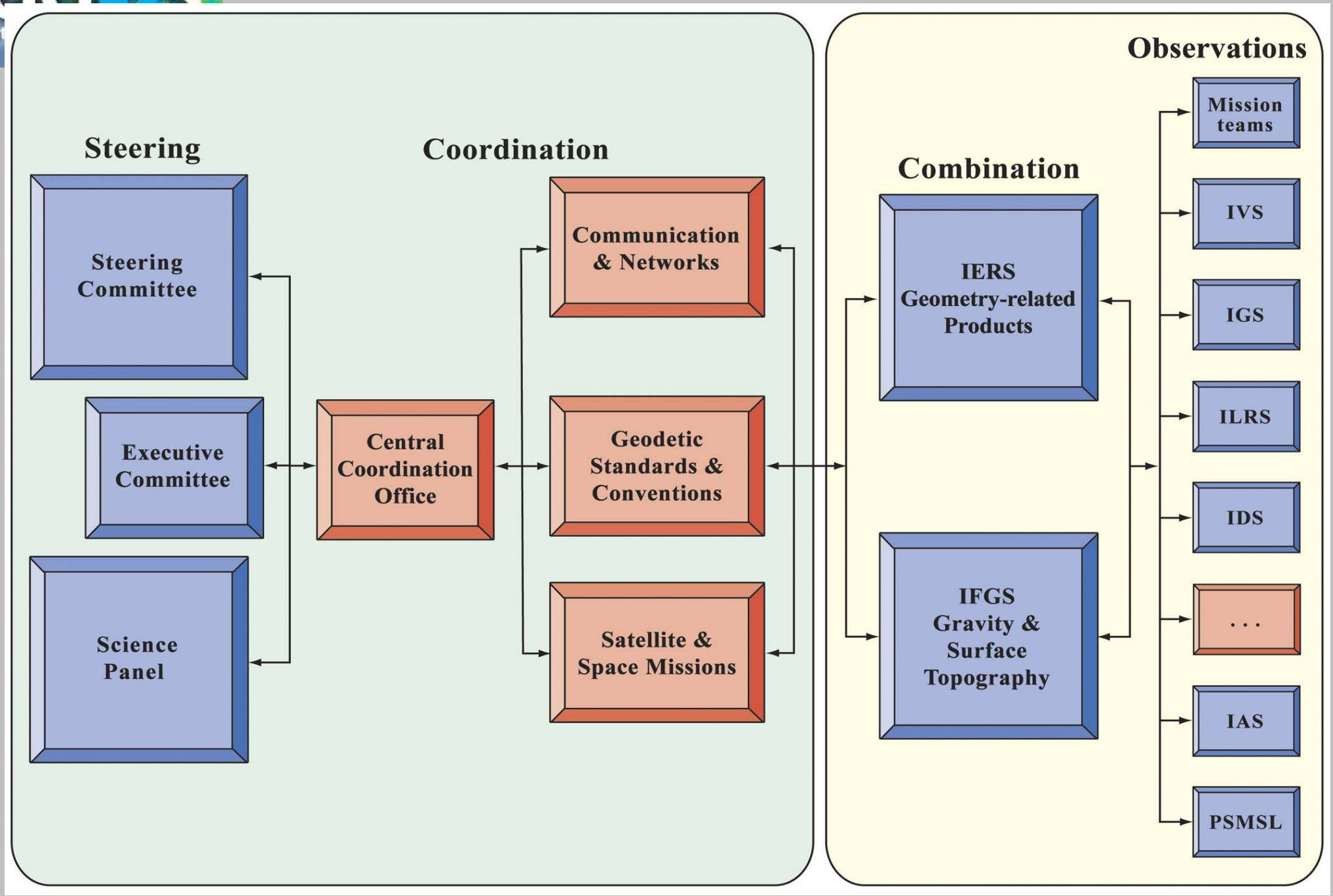
- the "observation system GGOS": The Services, networks, GNSS, satellites, moon, planets, quasars, ...
- the "organization GGOS": ?

Alternative views:

- GGOS integrates everything and is everything?
- GGOS more a federal government for the "Nation" of IAG Components (the individual states)?

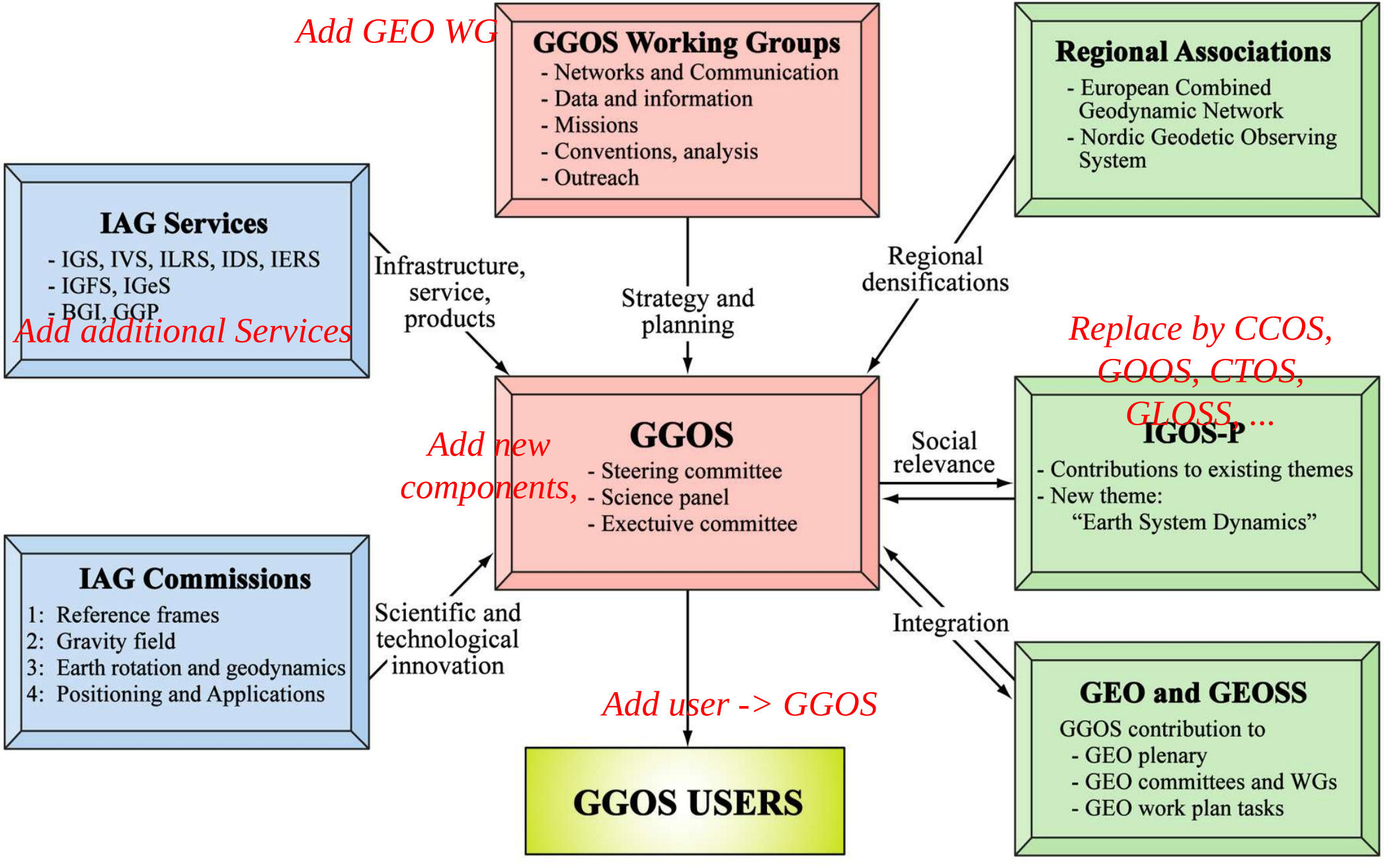
Main Issues

GGOS 2020



Main Issues

GGOS 2020



Recommendations

GGOS 2020

Recommendation 1.1:

Recognizing that

geodesy has an large potential to help meeting the challenge in reaching sustainable development for a global society on a changing planet

it is recommended that

IAG and GGOS actively engage in improving the framework conditions for fully utilizing the potential of geodesy for Earth observation through a transition of the observing system from research to operational, identifying and promoting sufficient infrastructure and human resources for GGOS, and in facilitating, in the frame of GEO, international agreement on global geodetic reference frame.

Recommendations

GGOS 2020

Recommendation 1.2:

Recognizing that

society to a large extent is not aware of the vital role played by geodesy for realizing a sustainable development, and that

educational aspects are extremely important (because they have the greatest implication on societal behavior) in order to prepare future generations to make use of the full benefits of geodesy

it is recommended that

IAG and GGOS make dedicated outreach efforts to science and society at large with the goal to promote geodesy's role in reaching sustainable development and to integrate this role of geodesy appropriately into education.

Recommendations

GGOS 2020

Recommendation 3.1:

Recognizing that

the combination of geodetic measurements from GGOS will require new definitions of a terrestrial reference system and a consistent realizations of this system

it is recommended that

particular attention be paid in GGOS to the development of these new reference systems.

Recommendations

GGOS 2020

Recommendation 4.1:

Recognizing that

a stable and accurate geodetic reference frame must underpin Spatial Data Infrastructures, to ensure that all geo-referenced data used by a wide range of community groups and government agencies is unambiguously linked to the geodetic foundation

it is recommended that

ITRF be employed as the global geodetic reference frame for SDI, and that

the ITRF be maintained and made accessible with an operational core ensuring ITRF with the accuracy, long-term stability, and accessibility required by SDI applications.

Recommendations

GGOS 2020

Recommendation 4.2:

Recognizing that

geodesy plays a vital role with respect to sustainable development, the provision of community services, support for many vital industries, security and emergency management, mapping and navigation, and others

it is recommended that

the link between ``scientific geodesy'' and ``practical (or operational) geodesy'' be strengthened, and made explicit so that national geodetic agencies are reminded of the mutual benefits of these two parts of geodesy, and of the fundamental contribution of geodesy to their mission.

Recommendations

GGOS 2020

Recommendation 4.3:

Recognizing that

geodesy and GGOS are relevant to an number of international and national scientific and professional sister organizations of IAG, including, but not restricted to ISPRS, FIG, IAIN, IEEE, and IUGG

it is recommended that

the IAG continue to work closely with these organizations by promoting the GGOS vision and its activities.

Recommendations

GGOS 2020

Recommendation 4.4:

Recognizing that

there is a rapid technological development integrated into professional applications of geodesy

it is recommended that

GGOS embrace new geoinformation/geodetic technologies such as DInSAR, GNSS-RTK, structural monitoring systems, and multi-sensor precision navigation systems, in an integrated manner to address different spatial and temporal user requirements for high accuracy geometric information that is unambiguously tied to a rigorous geodetic framework.

Recommendations

GGOS 2020

Recommendation 5.1:

Recognizing that

the global geodetic reference frame is a fundamental contribution to global Earth observation, and that this frame in many cases enables Earth observations with the required accuracy

it is recommended that

GGOS maintain a formal representation in existing Earth observing coordination committees (international bodies and commissions), and establish links to relevant committees as appropriate.

Recommendations

GGOS 2020

Recommendation 5.2:

Recognizing that

real-time or low-latency access to GNSS observations is increasingly important for applications in numerical weather predictions, space weather predictions, early warnings, and other societal application

it is recommended that

existing and future ground-based GNSS sites installed by geodesists be connected in near-real time to GNSS data and analysis centers thus enabling these non-geodetic applications, and that

future geodesy missions using GNSS receivers be radio occultation-compatible, whenever possible, and that the corresponding subsequent data processing can be done outside the geodesy mission.

Recommendations

GGOS 2020

Recommendation 5.4:

Recognizing that

detailed knowlegde of the Earth's gravity field is important for circulation models

it is recommended that

that GGOS establish proper contacts and interfacing to the Earth system modeling community with the goal to discuss improvements of the gravity field representation in circulation models.

Recommendations

GGOS 2020

Recommendation 5.6:

Recognizing that

geodetic observations are fundamental for monitoring the global hydrological cycle on global to local scales

it is recommended that

GGOS develop a global water cycle service that provides information on changes in the water storage on land, in ice sheets and in the ocean on a routine basis, potentially through assimilation of the geodetic observations in a Earth system model consistently treating the three pillars of geodesy.

Recommendations

GGOS 2020

Recommendation 5.7

Recognizing that

GNSS can potentially contribute to the near-real time determination of the seismic magnitude and associated displacement field of particularly great earthquakes

it is recommended that

GGOS promotes the development of GNSS seismology particularly for early warning purposes.

Recommendations

GGOS 2020

Recommendation 6.1

Recognizing that

planetary geodesy, radio science, interferometry (including imaging VLBI, astrometric VLBI, and Earth-Space VLBI), and inter-planetary navigation all require an accurate geodetic foundation, and that

although the performance of GGOS is not a limiting factor in all of these applications, future requirements will be more demanding, especially those imposed by inter-planetary navigation, and in some cases exceeding present-day capabilities of GGOS

it is recommended that

GGOS be developed in order to meet these future requirements, that in particular

GGOS allow the real-time determination of Earth orientation accurate to ≤3 mm, and that

GGOS enable calibrations of troposphere delay and ionosphere accurate to ≤3 mm and ≤2 TEC units, respectively.

Recommendations

GGOS 2020

Recommendation 7.1

Recognizing that

it will often not be possible to implement the desirable observing system

it is recommended that

GGOS set up, together with relevant user groups, threshold and target values in terms of accuracy, spatial and temporal resolution, latency, and integrity, for the quantities to be observed or derived from geodetic observations.

Recommendations

GGOS 2020

Recommendation 7.2

Recognizing that

the user requirements with respect to geodetic observations and products will evolve over time

it is recommended that

GGOS maintain a database of user requirements and a list of products to be provided by GGOS in order to meet these evolving requirements.

Recommendations

GGOS 2020

Recommendation 7.3

Recognizing that

the global geodetic reference frame and ready access to this frame plays a crucial role for many scientific, professional and societal applications

it is recommended that

GGOS pay particular attention to improving access to the global reference frame with low latency and high spatial resolution as well as the long-term stability of the frame.

Recommendations

GGOS 2020

Recommendation 8.1

Recognizing that

users in many applications increasingly require access to a geodetic reference frame with high spatial and temporal resolution in order to be able to detect 'anomalous' motion of an object with respect to the reference frame

it is recommended that

GGOS develop a future reference frame approach based on a reference frame model with, in principle, infinite spatial and temporal resolution, and that

this reference frame be based on a dynamic Earth system model that predicts the motion of all points on Earth surface as well as variations in the gravity field of the Earth system and the rotation of the solid Earth.

Recommendations

GGOS 2020

Recommendation 8.2

Recognizing that

the future geodetic reference frame approach, in order to meet the demanding user requirements, will have to be based on model prediction

it is recommended that

GGOS promote the development of an integrated Earth system model, which can be used to predict the geodetic quantities in a self-consistent framework, and that

both forward-modeling and inversion methods are developed to predict geodetic quantities and to invert geodetic observations for the forcings, respectively.

Recommendations

GGOS 2020

Recommendation 9.1

Recognizing that

the currently implemented global geodetic infrastructure is not sufficient to provide a monitoring of Earth's shape, gravity field and rotation meeting most of the user requirements and to sustain the global geodetic reference frames required for many scientific and societal applications

it is recommended that

the global geodetic infrastructure not only be maintained at the current level but also be augmented, in order to close major spatial and technological gaps, with (1) a global network of core stations on all continents, thus filling in the major spatial gaps in the ground networks, (2) absolute and superconducting gravimeters at a global network of reference sites, in particular the core stations, and (3) two additional dedicated SLR satellites, that

...

Recommendations

GGOS 2020

Recommendation 9.1 (cont.)

it is recommended that

...

an operational core system be built up and maintained with the necessary infrastructure for an operational geodetic Earth system service providing quantitative information on changes in ice sheets, sea level, water cycle, and climate, as well as for hazards, disasters, and resource management application, and that

the operational core include at least (i) the global geodetic networks for the determination and monitoring of the geodetic reference frames, including Earth rotation, (ii) continuous gravity satellites missions for the monitoring of mass transport, (iii) continuous satellite missions for the monitoring of ice sheet, sea surface height, and lake level variations, and (iv) continuous satellite missions for the imaging of the solid Earth's surface.

Recommendations

GGOS 2020

Recommendation 10.1:

Recognizing that

all IAG Commissions, Services and Inter-Commission Committees contribute to the realization of GGOS, which shall be IAG's geodetic observing system resulting in unique geodetic products, constants, conventions, and procedures for science and society

it is recommended that

IAG, with all of the above mentioned entities, provide the scientific basis for GGOS, and that

GGOS be an IAG entity at the highest organizational level in IAG.

Recommendations

GGOS 2020

Recommendation 10.2:

Recognizing that

the terrestrial technique-specific entities represented by the IAG Services are the basis of IAG's GGOS, and that their products are prerequisites for the realization GGOS

it is recommended that

the work of the technique-specific entities, based on the state-of-the-art observational and analysis tools, be continue, and that funding for these technique-specific Services be secured on a long-term basis.

Recommendations

GGOS 2020

Recommendation 10.3:

Recognizing that

uninterrupted geodesy-related space missions are required for the generation of the best possible time-varying gravity field, and the monitoring of sea- and ice-surface topographies, and that today there is no consistent plan for deploying geodesy-related space missions

it is recommended that

GGOS, in close partnership with the space agencies, develops a plan for uninterrupted series of geodesy-related space missions based on scientific and societal needs, and that

GGOS have an specific entity developing these scenarios.

Recommendations

GGOS 2020

Recommendation 10.4:

Recognizing that

the results of the technique-specific entities (the IAG Services) are compared, validated, and combined to generate unique, technique-independent geodetic products (celestial, terrestrial, (and, to a lesser extent) gravitational reference frames, constants, etc.), that

this work is taken care of by the IERS for the geometry-related products

it is recommended that

the work of the IERS be continued based on state-of-the-art validation and combination techniques, and that

funding for these activities be secured on a long-term basis.

Recommendations

GGOS 2020

Recommendation 10.5:

Recognizing that

the geodetic products resulting from space missions (including SLR data, terrestrial and airborne gravity measurements) must be compared, validated, and combined to result in unique geodetic products (mainly), which have to be, moreover, consistent with the geometry-related products, and that

the IAS addresses one aspect of this problem, namely that of sea surface topography based on the data of all altimetry missions available

it is recommended that

the IAS as a mission-independent altimetry service be deployed and incorporated into GGOS, and that

funding for the IAS be secured on a long-term basis.

Recommendations

GGOS 2020

Recommendation 10.6:

Recognizing that

full utilization of the gravimetric space missions requires long time series based on all relevant techniques

it is recommended that

the IGFS develop a plan to generate mission-independent gravity-products, which also include terrestrial and airborne data, that

an entity realizing this plan (inside or outside the IGFS) be identified, or, if not existing, be created, and that

long-term funding for this entity be secured.

Recommendations

GGOS 2020

Recommendation 10.7:

Recognizing that

in order to ensure consistency of observations, data processing, modeling and products across the three pillars of geodesy at a level of better than 10^{-9}, adherence to common geodetic standards and conventions is crucial

it is recommended that

a GGOS entity responsible for the geodetic Standards and Conventions be created (named "GGOS Bureau of Standards and Conventions"), that

this entity keep track of and make available a detailed and concise list of geodetic conventions, constants, and procedures, and that

this catalogue include the IERS conventions.

Recommendations

GGOS 2020

Recommendation 10.8:

Recognizing that

currently there is a large number of more or less independent technique-specific ground tracking networks (and products) in GGOS, and that

coordination of these networks is not sufficient

it is recommended that

the IAG Services operating the technique-specific networks create, in cooperation with the IERS, a GGOS Communications and Networks Entity with the objective of this entity to design the networks (minimum number and distribution of core stations, co-location of techniques, etc.) and scope the operation (communication and data flow between networks and from stations to regional and global data centers) of the network as a whole.

Recommendations

GGOS 2020

Recommendation 10.9:

Recognizing that

the full implementation of GGOS and particularly of an operational core system requires broad international support for GGOS as organization

it is recommended that

IAG continue its active role in GEO, IGOS-P and other relevant organizations, and that

IAG and GGOS continue the dialog on the association of GGOS with an appropriate United Nations' agency (UNESCO).

Recommendations

GGOS 2020

Recommendation 10.10:

Recognizing that

GGOS is based on a wide range of contributing organizations, institutions, space agencies, services, and systems, and that

GGOS has a wide range of users and stake holders

it is recommended that

GGOS establish a central coordinating entity (named here ``GGOS Central Coordinating Office'') with the task to maintain an overview on GGOS contributors and users and their requirements as well as to support the GGOS decision making entities in the day-to-day business, and that

funding for this entity be secured on a long-term basis, preferably through the respective United Nations' agency.

Recommendations

GGOS 2020

Recommendation AI.1:

Recognizing that

the fundamental role for geodesy and the geodetic geodetic observation system for Earth observation in general and GEO in particular necessitate the continuous commitment of many national and regional institutions, organizations and governments to GGOS

it is recommended that

the GEO Plenary consider a resolution recommending to the GEO member countries to maintain, and if necessary, increase their support of the operational maintenance of the infrastructure of GGOS at a level appropriate to meet the requirements of the SBAs addressed by GEO.

Recommendations

GGOS 2020

Recommendation AI.2:

Recognizing that

the implementation of GGOS on the basis of the findings and recommendations resulting from the GGOS 2020 Process requires a continuous dialog engaging all stakeholders inside and outside of IAG

it is recommended that

a conference of the GGOS stakeholder organizations be organized in 2008 to further develop the findings and recommendations of the GGOS 2020 documents (the Reference Document and the GGOS strategy document) into key elements for the implementation plan of GGOS, and that

the GGOS 2020 documents serve as the basis for discussion and decisions at this conference.

Recommendations

GGOS 2020

Recommendation AI.3:

Recognizing that

the proposed new entities of GGOS are essential for progress towards the full implementation of GGOS

it is recommended that

the GGOS Bureau of Geodetic Standards & Conventions and the GGOS Coordination Office be established through a call for proposals immediately after the GGOS stakeholder conference.