

# Global Geodetic Observing System

## GGOS Days 2021 Report

October 11-13, 2021  
Video Conference



Global Geodetic  
Observing System

[ggos.org](http://ggos.org)

# Global Geodetic Observing System

## GGOS Days 2021 - Report

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## 1 Introduction

GGOS Days is the annual meeting of GGOS during which the different components of GGOS meet and **report on their activities** during the past year and their **plans for the coming year**. The meetings is focused on **strategic discussions** rather than on formal reporting. The different components of GGOS are: GGOS Consortium (large steering committee of GGOS), GGOS Coordinating Board (decision making body of GGOS), GGOS Bureau of Networks and Observations, GGOS Bureau of Products and Standards, all 3 GGOS Focus Areas as well as the GGOS Science Panel.

This year the GGOS Days was held as a **video conference** again, instead of the common face-to-face meeting due to travel restrictions by the COVID-19 crises and uncertain situation.

## 2 Logistics

Chair: **Basara Miyahara** (President of GGOS)  
Organizer: **Martin Sehnal** (GGOS Coordinating Office)

Dates: **Monday, October 11, 2021**  
**Tuesday, October 12, 2021**  
**Wednesday, October 13, 2021**

Duration: **2 hours** each day

Time: Every day it started at the same time

Time Zone	Country	Time
UTC		13:00-15:00
PDT	USA West Coast	06:00-08:00
EDT	USA East Coast	09:00-11:00
GMT-3	Argentina	10:00-12:00
CEST / SAST	Europe / South Africa	15:00-17:00
JST	Japan	22:00-00:00
AEST	Australia East Coast	00:00-02:00 (next day!!)

Recording: The entire virtual **conference was recorded**. Parts of the recording are available on the [GGOS YouTube Channel](#). All presenters and participants agreed to publish the recorded videos on the GGOS YouTube Channel.

Documents: Please find the current status reports of GGOS components and all presentation slides at **GGOS Cloud**: <https://cloud.ggos.org/index.php/s/wA76j5WorEj4eG8>

### 3 List of Participants

Members of the GGOS Consortium, GGOS Coordinating Board, GGOS Bureaus, GGOS Focus Areas, GGOS Science Panel, invited guests and all interested persons were highly welcome to attend this meeting. Over all three days **83 people attended this meeting**, with a maximum of 63 and a minimum of 56 each day.

Participant	Country	Day 1	Day 2	Day 3
Basara Miyahara	Japan	x	x	x
Allison Craddock	USA	x	x	x
Mike Pearlman	USA	x	x	x
Richard Gross	USA	x	x	x
Martin Sehnal	Austria	x	x	x
Detlef Angermann	Germany	x	x	x
Zuheir Altamimi	France	x	x	x
Thomas Gruber	Germany	x	x	x
Rolf Dach	Switzerland	x	x	x
Susanne Glaser	Germany	x	x	x
Sônia Costa	Brazil	x	x	x
Kevin Kelly	USA	x	x	x
Toshimichi Otsubo	Japan	x	x	x
Claudia Tocho	Argentina	x	x	x
Kosuke Heki	Japan	x	x	x
Soudarin Laurent	France	x	x	x
Jaakko Mäkinen	Finland	x	x	x
Markku Poutanen	Finland	x	x	x
Daniela Thaller	Germany	x	x	x
Sergei Rudenko	Germany	x	x	x
Abel Garcia-Castellano	Spain	x	x	x
Mariana Moreira	Portugal	x	x	x
Manuela Vasconcelos	Portugal	x	x	x
Laura Isabel Fernández	Argentina	x	x	x
Elizabeth Bradshaw	UK	x	x	x
Yusuke Yokota	Japan	x	x	x
Stanislava Valcheva	Bulgaria	x	x	x

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Participant	Country	Day 1	Day 2	Day 3
Hartmut Wziontek	Germany	x	x	x
Harald Schuh	Germany	x	x	x
Andrew Matthews	UK	x	x	x
Valente Cuambe	Portugal	x	x	x
Mattia Crespi	Italy	x	x	x
Michela Ravanelli	Italy	x	x	x
Diogo Avelar		x	x	x
Zinovy Malkin	Russia	x		x
Elena Martinez Sanchez	Spain	x	x	
Hansjörg Kutterer	Germany	x		x
Johannes Böhm	Austria	x	x	
Christoph Förste	Germany	x	x	
Ezequiel D. Antokoletz	Argentina	x	x	
Ignacio Parada	Chile	x	x	
Gabriel Guimarães	Brazil	x	x	
Robert Heinkelmann	Germany	x	x	
Arturo Villiger	Switzerland	x		x
Esther Azcue	Spain	x		x
Mathis Bloßfeld	Germany	x	x	
Sean Bruinsma	France	x	x	
Maik Thomas	Germany	x	x	
Axel Rülke	Germany	x	x	
Markus Rothacher	Switzerland	x	x	
João Salmim Ferreira	Portugal	x		x
Sultan Alshahrani	Saudi Arabia		x	x
Helena Ribeiro	Portugal		x	x
Yoshiyuki Tanaka	Japan		x	x
Ben Phillips	USA		x	x
Christopher Kotsakis	Greece		x	x
Riccardo Barzaghi	Italy		x	x
Larry Hothem	USA		x	x
Elena Yebes		x		

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Participant	Country	Day 1	Day 2	Day 3
Jose Antonio Tarrío	Chile	x		
Marie-Francoise Lalancette	France	x		
Edilberto Suárez Torres	Colombia	x		
Fuensanta G. Montesinos	Spain	x		
Toshiki Kumazawa		x		
Mario Moreno	Germany	x		
Patrick Schreiner	Germany	x		
E. Sinem Ince	Germany	x		
Benjamin Männel	Germany	x		
Kirsten Elger	Germany	x		
Assumpció Termens	Spain	x		
Ryan Hippenstiel	USA		x	
Sergio Rozas	Chile		x	
Juan Quilaleo	Chile		x	
Georgios S. Vergos	Greece			x
Léo Martire	USA			x
David Grzan	USA			x
Kangkang Chen				x
Attila Komjathy	USA			x
Jianliang Huang	Canada			x
Tilo Schöne	Germany			x
Jose Manuel Ferrandiz	Spain			x
Valentino Constantinou	USA			x
John Rundle	USA			x

### Statistics:

Participants in <b>total</b>	<b>83</b>	Participants from <b>Europe</b>	<b>49</b>
Participants of <b>day 1</b>	<b>63</b>	Participants from <b>North America</b>	<b>13</b>
Participants of <b>day 2</b>	<b>56</b>	Participants from <b>South America</b>	<b>9</b>
Participants of <b>day 3</b>	<b>56</b>	Participants from <b>Asia</b>	<b>6</b>
Participants participated <b>on all 3 days</b>	<b>34</b>		



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### 4 Group Photo



## 5 Schedule

### Day 1 - Monday, October 11, 2021 - General, Internal and External Activities

#### General:

- |        |  |
|--------|--|
| 5 min  | <b>Welcome and Instruction</b> (B. Miyahara)                                     |
| 10 min | <b>GGOS &amp; IAG Report</b> (B. Miyahara)                                       |
| 5 min  | <b>New GGOS Strategic Plan – Workshop 2022</b> (B. Miyahara)                     |
| 5 min  | <b>Recently finished IGS Strategic Plan – invited presentation</b> (A. Craddock) |
| 5 min  | <b>GGOS Days 2022</b> (B. Miyahara, D. Angermann)                                |

#### Internal Activities:

- |        |  |
|--------|--|
| 10 min | <b>GGOS Science Panel</b> (K. Heki)                              |
| 15 min | <b>GGOS Affiliate – New GGOS D-A-CH</b> (H.J. Kutterer)          |
| 10 min | <b>GGOS Affiliate – GGOS Japan Report</b> (T. Otsubo)            |
| 20 min | <b>GGOS Coordinating Office – New GGOS Website</b> (M. Sehnal)   |
| 20 min | <b>Working Group on “DOIs for Geodetic Data Sets”</b> (K. Elger) |

#### External Activities:

- |        |  |
|--------|--|
| 20 min | <b>GGOS External Relations</b> (A. Craddock) |
|--------|--|



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### Day 2 - Tuesday, October 12, 2021 - GGOS Bureaus

- 15 min      **ITRF2020 report – invited presentation** (Z. Altamimi)
- 45 min      **BNO - Bureau of Networks and Observations**
- Report about GGOS BNO – Part 1 (M. Pearlman)
- Working Group on Site Survey and Co-location (R. Hippenstiel)
- Standing Committee on PLATO (D. Thaller)
- 45 min      **BPS - Bureau of Products and Standards**
- Report about GGOS BPS (D. Angermann)
- Definition of Essential Geodetic Variables – EGVs (R. Gross)
- Committee on Contributions to Earth System Modeling (M. Thomas)

### Day 3 - Wednesday, October 13, 2021 - GGOS Focus Areas

- 30 min      **GGOS Focus Area: Unified Height System** (L. Sánchez, R. Barzaghi)
- 20 min      Report about GGOS BNO – Part 2 (M. Pearlman)
- 10 min      Short Break
- 10 min      **UN-GGIM Subcommittee on Geodesy update** (J. Bouman, B. Miyahara)
- ~~30 min      GGOS Focus Area: Geodetic Space Weather Research (M. Schmidt, E. Forootan)~~
- 15 min      **GGOS Focus Area: Geohazards**
- Recent Activities of GGOS Geohazards Focus Area** (J. LaBrecque, A. Craddock)
- ITU Focus Group on AI for Natural Disaster Management - invited presentation**  
(A. Craddock, J. Rudle, D. Grzan, A. Komjathy)
- 10 min      **General discussion / Any other Business** (All)

## 6 General Report

This year, due to the Corona pandemic, the GGOS Days 2021 were held as a completely virtual conference like last year. We tried to attract more participants through social media (Twitter and LinkedIn) and with the new GGOS website (blog and newsletter). We were very successful with this and a total of 83 people attended this conference, which is a new record. In 2020 we had 49 attendees (virtual conference) and the year before 21 attendees (hybrid conference) in total. We are very happy that so many people are interested in GGOS. With this short general report, we would highlight the main points from this meeting.

At the GGOS Days 2021 it was stated that the **GGOS Strategic Plan** should be renewed. Therefore, a strategic plan workshop will be held in Munich next year directly after the GGOS days. The IAG Service IGS had just completed the creation of the **new IGS Strategic Plan**, which was presented by Allison Craddock in an invited presentation.

The Panel supported Hansjörg Kutterer presented the GGOS Affiliate organization **GGOS D-A-CH**, newly founded in May 2021, and its future plans to strengthen activities in the German-speaking region (Germany, Austria and Switzerland). Toshimihchi Otsubo also presented update of GGOS Japan. GGOS D-A-CH and GGOS Japan had first bilateral meeting to start discussion on possibility of future collaboration among GGOS Affiliates. The **newly developed GGOS website** and the planned further developments were presented by Martin Sehnal. As outreach of importance and role of geodesy to non-geodesists, new pages on geodetic products were developed by the GGOS Bureau of Products and Standards (BPS) with support by GGOS Science Panel, GGOS Coordinating Office, the GGOS Bureau of Networks and Observations (BNO) and other colleagues. The pages were published in 2021 and are now available at new GGOS website. New pages on geodetic observation are also developed by Laura Sánchez with support by Martin Sehnal and will be published soon.

Kirsten Elger presented progress of the GGOS Working Group on “DOIs for Geodetic Data Sets” and reported current situation, issues and possible ways to appropriately mint DOIs to geodetic data sets.

At the end of the first day, Allison Craddock presented the activities of GGOS in the field of external relations. In addition to existing collaborations, the new engagement in the **ITU Focus Group "AI for Natural Disaster Management"** was highlighted. Another invited talk on the geodetic contribution to this ITU Focus Group, as part of the **GGOS Focus Area Geohazards**, was given on the third day of the GGOS Days conference.

Two additional speakers were invited. Zuheir Altamimi presented the current status of **ITRF2020** and Johannes Bouman wanted to give a status report on the **UN-GGIM Subcommittee on Geodesy and its Global Geodetic Center of Excellence (GGCE)**. Unfortunately, Johannes was unable to give his presentation, but Basara Miyahara attempted to give a status update.

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On the second and third day of this conference, the **GGOS Bureaus** and **GGOS Focus Areas** presented their status reports with invited speakers from the committees and working groups. Full details are in the status reports from the GGOS components, which can be found in the appendix.

In the **GGOS Bureau of Product and Standards (BPS)** Detlef Angermann presented the intensive involvement in the development of the geodetic product pages of the GGOS website and the participation in the rewrite of the IERS Conventions in the function as Chapter Expert for the "General Definitions and Numerical Standards". Invited presentations by Richard Gross on the "Definition of Essential Geodetic Variables (EGVs)" committee and by Maik Thomas on the "Contributions to Earth System Modeling" committee rounded out the BPS report.

Mike Pearlman reported on progress within the **GGOS Bureau of Networks and Observations (BNO)**, in particular the contribution to the development of the GGOS website, the closer collaboration between ROSCOSMOS and ILRS and GGOS, and the response to the IAG questionnaire. Presentations by Daniela Thaller on the PLATO Committee and by Ryan Hippenstiel on the "Site Ties and Co-location" Working Group rounded out the BNO report.

Riccardo Barzaghi highlighted ongoing activities in the **GGOS Focus Area "Unified Height System"** presentation and showed the status of the first static solution for the IHRF.

Allison Craddock explained the plans and collaboration under the "GNSS enhancement to Tsunami Early warning Systems" (GTEWS) in the **GGOS Focus Area Geohazards**.

This conference concluded with a **lively discussion** on the **creation of new IAG services** for existing geodetic products such as "Altimetry Service", "Sea Level Service" or "Ice Mass Variation Service".

More information and details are in the **Status Reports of the GGOS components** and the presentation slides of the talks which are available at [GGOS Cloud](#). If you want to re-watch the recorded presentations, please visit the [GGOS You Tube Channel](#).

## 7 Appendix – Status Reports of GGOS Components

### 7.1 GGOS Bureau of Networks and Observations

**STATUS REPORT** 11/08/2021

#### **GGOS Bureau of Networks and Observations**

Mike Pearlman and many others

Center for Astrophysics

#### **Bureau**

##### Current Status and Progress:

- Bureau posters at AGU and IAG Symposium;
- Continued recruiting for the GGOS Affiliated Network;
- MOU completed with ROSCOSMOS for closer cooperation with ILRS and GGOS
- Monitored network status; projected network evolution for the reference frame based on input from current and expected future participants, estimate performance capability 5 and 10 years ahead;
- Letters/documentation to support stations, current/ new missions, and analysis centers;
- Reviewing IAG Questionnaire material for posting in the IAG website;
- Supported activities by the Standing Committees;

##### Plans:

- Continue advocating for the expansion and upgrade of the space geodesy network for the maintenance and improvement of the reference frame and other GGOS priorities; encourage partnerships to build and upgrade ground stations;
- Continue recruiting stations for the GGOS Affiliated Network;
- Continue monitored network status; project network evolution for the reference frame based on input from current and expected future participants,
- Continue the work of the Standing Committees;
- Letters/documentation to support stations, current/ new missions, and analysis centers, etc.

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- Provide the opportunity for representatives from the Services and the Standing Committees to meet and share progress and plans; discuss issues of common interest; meetings at EGU, AGU, GGOS Days, etc.;

### Services

- The Services continue to expand their networks as funding and conditions allow. Significant geographic gaps still exist. Technology updates continue as funding permits. Progress has slowed due to the pandemic.

### Standing Committees

- **Standing Committee on Performance Simulations & Architectural Trade-Offs (PLATO)**  
**(Daniela Thaller/BKG and Benjamin Maennel/GFZ)**

#### Current Status and Progress:

- PLATO-linked session at EGU 2021 with 16 contributions (G2.3 „New strategies for consistent geodetic products and improved Earth system parameters”)
- Annual meeting held May 18, online
- Examples of recently finished and ongoing studies
  - Simulation studies on possible extension of Australian SLR network (DGFI/TUM)
  - Simulation studies on differential LLR (IfE, Hannover)
  - Simulation studies on VLBI observation to Galileo satellites (TU Vienna)
  - Simulation studies on future GNSS constellation (GFZ, TU Berlin)

#### Plans:

- Re-activate pilot project on exchanging simulation data; SLR and VLBI simulations and subsequent processing results to be compared between software packages; period of CONT17 selected;
- Simulations to project the improvements in the ITRF related to network and station updates (depending on BNO and Services)
- Encourage additional groups to contribute to PLATO

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- **Standing Committee on Data and Information (Nicholas Brown/GA, Sandra Blevins/NASA)**

### **Geoscience Australia (GA)**

#### Current Status and Progress:

- Geoscience Australia is leading a global initiative to identify and meet user requirements for **Findable, Accessible, Interoperable and Reusable (FAIR)** geodetic data. This initiative is paying particular attention to ensuring the new and emerging user base of positioning information (e.g. location based services and intelligent transport services) have FAIR geodetic data;
- In recent months, GA and its collaborators have conducted a user requirements survey across a range of industrial and societal user sectors of geodetic data to identify critical gaps in standards identified in which could inhibit the uptake of precise positioning products. There were over 100 responses covering data standards scalability issues, lack of encoded metadata; technology, security and block chain technology, performance for demanding positioning applications, understanding the meaning of FAIR – Findable, Accessible, Interoperable, and Reusable Data /Metadata;

#### Plans:

- Through a process of user consultation and engagement, provide user sectors (e.g. agriculture) with fit-for-purpose metadata profiles which meet their current and future requirements.
- Revise and expand the information model of GeodesyML to ensure the provided precise positioning data is FAIR.
- Progress GeodesyML development with assistance from the OGC Innovation Program.
- Develop, implement and test GeodesyML against current standard practice
- Welcome anyone who would like to assist in the development and refinement of GeodesyML to please contact us and get involved.

### **CDDIS**

#### Current Status and Progress:

- CDDIS is actively progressing in the implementation of ongoing tasks, including the following:
  - Reprocessing and re-ingest of data and derived products for all CDDIS geodetic techniques (DORIS, GNSS, SLR, VLBI). Re-ingest of most data sets covering all geodetic techniques are complete, and data product set re-ingest is underway. These granule-level metadata will be updated in the EOSDIS Common Metadata Repository (CMR);



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- Collaborating with the NASA ESESES MEaSURES team to receive, ingest, and archive new data product sets including GNSS geodetic displacement time series, daily PPP troposphere estimates, transient earthquake data, and others. All new data product sets ingested and archived at the CDDIS will have a CMR collection record, CDDIS landing page, and registered DOI;

### Plans:

- Enhance and update all collections metadata in EOSDIS Common Metadata Repository with the guidance of the NASA IMPACT Analysis and Review of CMR (ARC) Project team;
  - Continue work underway;
- **Standing Committee on Missions (Roland Pail/TUM, C.K. Shum/OSU)**

### Current Status and Progress:

- Activities were significantly hampered by pandemic;
- Evaluating contribution of current and near-term satellite missions to the GGOS 2020 goals;
  - Advocate the realization of future gravity field missions (see next slides (Joint ESA/NASA activities (MAGIC, Joint science study with China)
  - **e-motion** (ESA EE9; double pair);
    - **MOBILE** (ESA EE10; high-low track;
    - NASA Mass Change Designated Observable (*MCDO*) study;
    - ESA Next-Generation Gravity Mission (NGGM) study, *MAGIC* Phase A;
  - Contribute to set-up IAG Altimetry Service;

### Plans:

- Set-up of a new concept of the Standing Committee to increase participation by potential members;
- Work with the Coordinating Office to set up and maintain a Satellite Missions Committee section on the GGOS website;
- Advocate and support national and international space agencies in their processes towards future gravity missions, by providing material and taking part in studies that support their realization;
- Continue exchange with PLATO on joint interests and possible collaborations;

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- **IERS Working Group on Site Survey and Co-locations (Ryan Hippenstiel/NGS)**

Current Status and Progress:

- Developing deflection of vertical (DoV) measurement capabilities utilizing a robotic total station and camera, and conducted field testing for hopeful deployment on upcoming local tie surveys;
- Examining new technologies and procedures for ground surveys at space geodesy stations;
- Encouraging more frequent site surveys and new survey groups to support the stations.
- Group continues to grow based on submissions to ITRF2020. New/updated colleagues from Australia, New Zealand, and Spain have been added and contacts in Japan have been provided.
- A full tie survey at GGAO will be conducted in Spring 2022 when the new SLR installation is final.

Plans:

- Focus on gravity deformation of VLBI antennas;
- Examine new technologies and procedures for ground surveys at space geodesy stations;
- Encourage more frequent site surveys and new survey groups to support the stations.

### 7.2 GGOS Bureau of Products and Standards

**STATUS REPORT** 28-09-2021

#### GGOS Bureau of Products and Standards

D. Angermann <sup>(1)</sup>, T. Gruber <sup>(2)</sup>, M. Gerstl <sup>(1)</sup>, R. Heinkelmann <sup>(3)</sup>, U. Hugentobler <sup>(2)</sup>,  
L. Sánchez <sup>(1)</sup>, P. Steigenberger <sup>(4)</sup>

<sup>(1)</sup> Deutsches Geodätisches Forschungsinstitut, Technische Universität München (DGFI-TUM), Germany

<sup>(2)</sup> Institut für Astronomische und Physikalische Geodäsie (IAPG), Technische Universität München, Germany

<sup>(3)</sup> Helmholtz Centre Potsdam, German Research Centre for Geosciences (GFZ), Germany

<sup>(4)</sup> Deutsches Zentrum für Luft- und Raumfahrt (DLR), Oberpfaffenhofen, Germany

#### Present Status and Progress

This report summarizes the present status and progress of the GGOS Bureau of Products and Standards (BPS), including the following GGOS components associated to the BPS:

- Committee “Contributions to Earth System Modeling” (Chair: Maik Thomas)
- Committee “Definition of Essential Geodetic Variables (EGVs)” (Chair: Richard Gross)
- Working Group “Towards a consistent set of parameters for the definition of a new GRS” (Chair: Urs Marti)

The BPS comprises the staff members, the chairs of the associated GGOS components, as well as representatives of the IAG Services and other entities involved in standards and conventions.

In the framework of the renewing of the GGOS website, the BPS supports the GGOS Coordinating Office regarding the representation of geodetic products. Two classifications for the products have been implemented: The first option according to the geodetic themes provides the classical geodetic view, whereas the second classification according to Earth system components and space may be preferred by users from other disciplines. The GGOS website provides a unique information platform for geodetic data and products, which should help to make them easier findable and more visible to other disciplines and society.

Furthermore, the BPS contributes to the re-writing of the IERS Conventions in the function as Chapter Expert for the “General Definitions and Numerical Standards”. The director of the BPS serves as IAG representative to ISO/TC 211 and UN GGIM “GGRF” Subcommittee on Geodesy (SCoG), mainly to the Working Group “Data sharing and development of geodetic standards”. The BPS also contributes to the activities of the Committee on Essential Geodetic Variables (EGVs) and to the two Working Groups on “DOIs for geodetic data” and “Towards a consistent set of parameters for the definition of a new GRS”.

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### Ongoing activities and planned actions

- Act as contact and coordinating point for homogenization of IAG standards and products
- Keep track of adopted geodetic standards and conventions across all IAG components, and initiate steps to close gaps and deficiencies, and provide recommendations
- Regularly update the BPS inventory on standards and conventions used for the generation of IAG products to incorporate the latest developments in these fields
- Contribute to the re-writing/revising of the IERS Conventions, mainly in the function as Chapter Expert for Chapter 1 “General definitions and numerical standards”
- Interact with external stakeholders in the field of standards and conventions (e.g., IAU, ISO, CODATA, UN-GGIM, GGCE, ...)
- Act as IAG representative to ISO/TC 211 and to the UN-GGIM Subcommittee on Geodesy (SCoG) Working Group “Data Sharing and Development of Geodetic Standards”
- Contribute to the GGOS components associated to the BPS and to the GGOS Working Group on Digital Object Identifier (DOI) for geodetic data and products to improve their discoverability
- Focus on the integration of geometric and gravimetric observations, and support the development of integrated products (e.g., GGRF, IHRF, atmosphere products)
- Contribute to organizational and coordination issues within IAG/GGOS and with external entities
- Contribute to the development of the renewed GGOS Website and to other GGOS outreach activities (publications, popular articles, brochures, etc.).
- Present BPS activities and results at conferences and workshops, and publish them in scientific journals

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STATUS REPORT

28-09-2021

### GGOS Committee on Earth System Modeling

Maik Thomas  
Helmholtz Centre Potsdam  
GFZ German Research Centre for Geosciences

#### Present Status and Progress

Recent activities of the committee related to further developments of data assimilation and AI algorithms, the explicit consideration of effects due to surface mass loading, and opportunities to provide realistic model error estimates have been continued. Main foci were placed on:

- Implementation of particle filter algorithms into stand-alone models and comparison with traditional Kalman filter approaches;
- Development and successful application of neural networks for downscaling of geodetic observations (focus on terrestrial water storage systems derived from GRACE/GRACE-FO);
- Consideration of lateral variations of the Earth's structure in elastic and viscoelastic solid Earth models.

Furthermore, opportunities for the synergetic combination of newly developed methods based on artificial intelligence with classical numerical model approaches have been discussed. However, this is a rather new and complex development with strategic relevance also for environmental and climate system sciences and will be an important topic for further investigations in the following years.

#### Planned Actions and Milestones

In the next year the activities will mainly concentrate on:

- Continuation of feasibility studies to investigate opportunities of constraining dynamically coupled model systems by geodetic monitoring data;
- Quality assessment of existing empirical and numerical ocean tide models in view of their application in geodetic data processing; discussion of opportunities for their improvement;
- Discussion and estimation of consequences of upcoming hardware developments for CPU intensive model simulations (high-performance computing vs. exascale modeling).

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### GGOS Committee on Essential Geodetic Variables

Richard Gross (NASA Jet Propulsion Laboratory)

#### Present Status and Progress

The GGOS BPS Committee on Essential Geodetic Variables was established in 2018 in order to define a list of Essential Geodetic Variables and to assign requirements to them. Essential Geodetic Variables (EGVs) are observed variables that are crucial (essential) to characterizing the geodetic properties of the Earth and that are key to sustainable geodetic observations. Examples of EGVs might be the positions of reference objects (ground stations, radio sources), Earth orientation parameters, ground- and space-based gravity measurements, etc. Once a list of EGVs has been determined, requirements can be assigned to them. Examples of requirements might be accuracy, spatial and temporal resolution, latency, etc. These requirements on the EGVs can then be used to assign requirements to EGV-dependent products like the terrestrial and celestial reference frames. The EGV requirements can also be used to derive requirements on the observing systems that are used to observe the EGVs. And the list of EGVs can serve as the basis for a gap analysis to identify observations needed to fully characterize the geodetic properties of the Earth. During GGOS Days 2017 it was agreed that a Committee within the GGOS Bureau of Products and Standards should be established in order to define the list of Essential Geodetic Variables and to assign requirements to them. This Committee was subsequently established in 2018 and consists of representatives of the IAG Services, Commissions, Inter-Commission Committees, and GGOS Focus Areas.

#### Planned Actions and Milestones

The planned tasks of the Committee on Essential Geodetic Variables are to:

- Develop criteria for choosing from the set of all geodetic variables those that are considered essential;
- Develop a scheme for classifying EGVs;
- Within each class, define a list of EGVs;
- Assign requirements to each EGV;
- Document each EGV including its requirements, techniques by which it is observed, and point-of-contact for further information about the EGV;
- Perform a gap analysis to identify potential new EGVs;
- Define a list of geodetic products that depend on each EGV;
- Assign requirements to the EGV-dependent products;
- Hold workshops to engage the geodetic community in the process of defining EGVs, determining their dependent products, and assigning requirements to them.



# Global Geodetic Observing System

## GGOS Days 2021 - Report



STATUS REPORT

29-09-2021

### GGOS WG “Towards a consistent set of parameters for the definition of a new GRS”

Urs Marti

Federal Office of Topography swisstopo, Wabern, Switzerland

#### Present Status and Progress

The main task of this WG is to define a consistent set of parameters and formulas for the definition of a new conventional Global Reference System (GRS). This includes the geometry (size and shape of a reference ellipsoid), the gravity field (normal gravity field of this ellipsoid), physical heights, terrestrial time and Earth rotation.

This new definition becomes necessary because since the introduction of GRS80 (Moritz, 1980) the knowledge in Geodesy has improved a lot (e.g. GNSS, gravity space missions) and the use of the parameters became inaccurate and inconsistent over time. The problem of the permanent Earth Tide was not yet a topic at the epoch of the definition of GRS80. A new set of parameters was published by Groten in 2004 but was not widely introduced in Geodesy. Another source of parameters are the IERS conventions, which do not strictly apply GRS80.

The acceptance of the IAG Resolution Nr. 1 in 2015 which defines the potential at Sea Level ( $W_0$ ) even increases the inconsistency in the geodetic parameters of the conventional GRS (in GRS80,  $W_0$  is a derived quantity).

The new set of parameters is based on the four fundamental parameters:  $W_0$  (Potential at Reference Level),  $J_2$  (dynamic form factor, “flattening”),  $GM$  (geocentric gravitational constant) and  $\omega$  (angular velocity of the Earth). All these quantities are well observed and monitored by various geodetic space techniques. (This implies, that the semi major axis of the ellipsoid will be a derived parameter).

Most of the defining parameters change with time. This includes seasonal variations and long-term trends. These changes are important and must be considered for the consistency with the ITRF (e.g. ellipsoidal heights). Nevertheless, in order to keep things simple for the user, this time variability will not be treated in the published definition of a new GRS. All quantities will be fixed to the epoch 2010.0. This is the epoch at which the  $W_0$  of the IAG resolution Nr. 1 is defined.

All calculations will be done in the zero tide system. Only at the very end, conversion formulas to mean tide and tide-free will be given for all quantities. In order to keep things simple, some very minor terms in this conversion will be neglected.

#### Planned Actions and Milestones

A draft of the paper with the calculation of the parameters is available. It has to be finished and discussed in the WG. It follows more or less the structure of the papers by Moritz (1980) and Groten (2004).

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The calculation of a new set of parameters is one thing. The main problem will be to convince the users to adopt such a system as a new global reference. Many users don't see the necessity to replace GRS80, as they just see it as a conventional model for the conversion of geocentric coordinates or for the calculation of gravity anomalies. Main concerns are the danger of confusion and the necessity to update many software packages. This discussion has still to be lead.

Another question to be answered is the necessity to define a conventional global gravity field model. For many applications (e.g. global height system, reference for local geoid determination), the assignment of such a standard model would have some advantages. For different application we would need a low-resolution satellite-only model and a high-resolution combined model.

### 7.3 GGOS Focus Area Unified Height System (FA-UHS)

**STATUS REPORT**

2021-09-01

#### **GGOS Focus Area Unified Height System (FA-UHS)**

Laura Sánchez

Deutsches Geodätisches Forschungsinstitut, Technische Universität München (DGFI-TUM)

#### **Present Status and Progress**

The GGOS Focus Area “Unified Height System” (GGOS-FA-UHS, formerly Theme 1) was established at the 2010 GGOS Planning Meeting (February 1 - 3, Miami, Florida, USA) to lead and coordinate the efforts required for the establishment of a global unified height system that serves as a basis for the standardisation of height systems worldwide. Starting point was the results delivered by the IAG Inter-Commission Project 1.2 Vertical Reference Frames (IAG-ICP1.2-VRF), which was operative from 2003 to 2011. During the 2011-2015 term, different discussions focussed on the best possible definition of a global unified vertical reference system resulted in the IAG resolution for the Definition and realisation of an International Height Reference System (IHRF) that was approved during the 2015 General Assembly of the International Union of Geodesy and Geophysics (IUGG) in Prague, Czech Republic. In the term 2015-2019, actions dedicated to investigate the best strategy for the realisation of the IHRF (i.e., the establishment of the International Height Reference Frame – IHRF) were undertaken. In particular, a preliminary station selection for the IHRF reference network was achieved and different computation procedures for the determination of potential values as IHRF coordinates were evaluated.

At present, we are preparing a special issue on Reference Systems in Physical Geodesy to be published in the Journal of Geodesy. This special issue includes the scientific description of the best available strategies for the geoid modelling as well as key contributions for the establishment of the IHRF/IHRF and the IGRS/IGRF (International Gravity Reference System and Frame). Paper submission started in October 2019 and was closed in May 2020. We received 22 manuscripts; 18 of them are already published, two were rejected, and the other two are still under review.

A recent milestone is the publication of an extensive guideline for the realisation of the IHRF, including:

- Strategy for the appropriate handling of permanent tide effects in the determination of IHRF coordinates in the mean-tide system
- Strategy for the determination and evaluation of IHRF coordinates depending on the data availability (specially surface gravity data and topography models)
- Strategy to improve the input data required for the determination of IHRF coordinates
- Strategy for the IHRF station selection in regional and national densifications
- Strategy to ensure the usability and long-term sustainability of the IHRF

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The authors of this paper represent the main IAG entities working on physical height systems and geoid modelling: GGOS FA-UHS, IAG Commission 2, IAG ICCT, IGFS:

Sánchez L., Ågren J., Huang J., Wang Y.M., Mäkinen J., Pail R., Barzaghi R., Vergos G.S., Ahlgren K., Liu Q.: *Strategy for the realisation of the International Height Reference System (IHRF)*. Journal of Geodesy, 95(3), 10.1007/s00190-021-01481-0, 2021

### Planned Actions and Milestones

The planned activities of the FA-UHS may be summarised as follows:

- (1) Based on the procedure described by Sánchez et al. (2021), to coordinate with regional/national experts in gravity field modelling the computation of a first IHRF solution;
- (2) To refine standards, conventions, and guidelines to support a consistent determination of the IHRF at regional and national levels;
- (3) With the support of the IAG Commission 2, the International Gravity Field Service (IGFS) and the Inter-Commission Committee on Theory (ICCT) to promote the study of quality assessment in the determination of potential values and determination of potential changes with time. In this way, following working/study groups play a main role to achieve the GGOS-GA-UHS objectives:
  - IAG Commission 2 working group *Error assessment of the 1-cm geoid experiment*, chaired by T Jiang (China) and VN Grigoriadis (Greece).
  - IAG ICCT study group *Geoid/quasi-geoid modelling for realisation of the geopotential height datum*, chaired by J Huang (Canada) and YM Wang (USA).
  - GGOS-FA-UHS and IGFS working group *Implementation of the International Height Reference Frame (IHRF)*, chaired by L Sánchez (Germany) and R Barzaghi (Italy).
- (4) In agreement with the IGFS and the IAG Commission 2, to design a strategy to install an operational infrastructure within the IGFS to ensure the maintenance and availability of the IHRF in a long-term basis. Aspects to be considered are:
  - Updates of the IHRF definition and realisation according to future improvements in geodetic theory and observations.
  - Regular updates of the IHRF according to new stations, coordinate changes with time, improvements in the estimation of reference coordinates and modelling of the Earth's gravity field, etc.
  - Support in the realisation and utilisation of the IHRF/IHRF at regional and national level.
  - To guarantee an organisational and operational infrastructure to ensure the sustainability of the IHRF.

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### 7.4 GGOS Focus Area Geohazards

STATUS REPORT

2021-10-13

#### GGOS Focus Area Geohazards

John LaBrecque

Center for Space Research, University of Texas at Austin

#### Present Status and Progress

The Geohazards Focus Area is working to support the [IUGG 2015 Resolution #4](#) as discussed and reported upon by the [GTEWS 2017 workshop](#). The GTEWS 2017 Workshop Report is the peer reviewed version of the initial report by [the APRU](#). The Focus Area activities implement the [GGOS 2020 recommendation 5.8](#) to “promote the development of GNSS seismology particularly for early warning and disaster assessment”.

The Focus Area fully supports the GATEW Working Group that is aligned to these same goals via a call for participation. The [GATEW Working Group](#) was formed in response this [call for participation](#) issued by the GGOS Chair (Dr. Kutterer). The GATEW WG currently numbers 18 exceptional institutions from 12 countries. The GATEW WG was central to the success of the GTEWS 2017 workshop. The current pandemic crisis impacted the Geohazards Focus Area. This Focus Area had announced the GTEWS 2020 meeting as a sequel to GTEWS 2017. GTEWS 2020 was a collaboration with the IUGG, APRU, Tohoku University, UCDAVIS. 2020 Planning and preparations for GTEWS Principals Organizational Meeting –the ongoing pandemic imposed delay is being used to further develop the community vision. Current planning is for a meeting of Principals during the Fall of 2022.

Planning is underway for a Meeting of Principals to begin the review and the interim, we determined that it is best to move forward with the first recommendation of the [GTEWS 2017 workshop](#) i.e., the establishment of a Consortium to oversee the development and operation of a GNSS enhancement to Tsunami Early Warning for the Indo-Pacific and Caribbean Basins. Starter funds have been identified in support of a meeting of principals to develop a [GTEWS Consortium](#) to encourage the shared use of real time multi-GNSS data and processing software within cloud computing environment. It is believed that rapid progress can be made with minor investment.

The concept of a meeting of principals to discuss the GTEWS Consortium is endorsed by the GGOS Coordinating Committee, the IAG President, the IUGG Commission on Geophysical Risk and Sustainability.

The GEO workplan for 2020-2022 establishes the Geodesy4Sendai Community Activity. Geodesy4 Sendai is the optimal forum for the GTEWS Consortium. I am working with Allison Craddock to recommend that GEO include the GTEWS\_Consortium as a community activity within the Geodesy4Sendai initiative. The IUGG has offered about \$20,000 in support of this meeting. These funds will serve as starter funds in planning the meeting of principals to include a broadened support community of agencies and institutions.

#### Planned Actions and Milestones

During the coming months, the GATEW Working Group will conduct virtual meetings with small subgroups to discuss support for GTEWS Consortium its goals, strategies, timelines and membership composition including those government agencies responsible for disaster risk management.

### 7.5 Focus Area: Geodetic Space Weather Research

STATUS REPORT

29.09.2021

#### Focus Area: Geodetic Space Weather Research

Michael Schmidt (1), Ehsan Forootan (2)

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(2) Geodesy and Earth Observation Group, Aalborg University, Denmark, [efo@plan.aau.dk](mailto:efo@plan.aau.dk)

#### Present Status and Progress

The following items should be mentioned here:

- Following the decision made at the splinter meeting of the FA-GSWR at the IUGG 2019 General Assembly in Montreal, the scientific content of the FA-GSWR was officially extended by the magnetosphere and their coupling processes such that the FA deals with the Magnetosphere – Ionosphere and Plasmasphere – Thermosphere (MIT) system and the mutual couplings.
- One single GGOS Joint Study Group (JSG), associated with the Inter-Commission Committee on Theory (ICCT) of the IAG and denoted as ICCT-JSG T 0.27, and three Joint Working Groups (JWG), directly associated with the FA-GSWR, have been implemented within the FA-GSWR.
- Setup and performance of the Session G5.1 “Ionosphere, thermosphere and space weather: monitoring and modelling” within the Geodesy Division at the virtual EGU 2021 General Assembly, April 19 to 30, 2021. Several presentations in this session have been given by members of the JSG and JWGs of the FA-GSWR. The convener of the session was Ehsan Forootan, Michael Schmidt a co-convener.
- Performing a joint virtual splinter meeting with the chairs and vice-chairs of the working groups of the Sub-Commission 4.3 “Atmosphere Remote Sensing” of IAG’s Commission 4 “Positioning and Applications” and the chairs and vice-chairs of the JSG and the JWGs of the FA-GSWR at April 26, 2021 on the status and the future steps of the FA-GSWR.
- Setup and performance of the Session 5.4 “Geodetic Space Weather Research” within the Symposium 5 “Global Geodetic Observing System (GGOS): the metrological basis for the monitoring” at the virtual IAG 2021 Scientific Assembly, Beijing, China, June 28 to July 2, 2021. The session consisted of an oral part with 6 presentations and a poster part with 7 additional e-posters. The convener of the session was Michael Schmidt, Ehsan Forootan a co-convener.
- The JSG and the JWGs of the FA-GSWR have achieved the following important results and have acquired noteworthy knowledge during the reporting period:



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JSG 1 (ICCT-JSG 0.27) “Coupling processes between magnetosphere, thermosphere and ionosphere electron density modelling”; Chair: Andres Calabia Aibar (China), Vice-Chair: Munawar Shah (Pakistan), Research Coordinator: Binod Adhikari (Nepal), 17 group members

Current activities: (1) working through a common platform to increase the communication and to prepare a spreadsheet with interests of each group member, (2) increase international cooperation to break the existing isolation, (3) elaboration of a proposal for an International workshop on MIT Coupling (IWMTIC2021): Prospects, Challenges, and Opportunities in Kathmandu, Nepal, 2022,

More information on the activities of JSG 1 can be found at the website: <https://www.researchgate.net/project/IAG-JSG1-Coupling-processes-between-magnetosphere-thermosphere-and-ionosphere-MTI>

JWG 1 “Electron density modelling”; Chair: Fabricio dos Santos Prol (Germany), Vice-Chair: Alberto Garcia-Rigo (Spain), 18 group members

Current activities: (1) provision of the final results of the first campaign regarding the accuracy of ionospheric models using a fair database, (2) creation of a simulated case scenario to perform the second campaign of data quality evaluations.

JWG 2 “Improvement of thermosphere models”; Chair: Christian Siemes (The Netherlands), Vice-Chair: Kristin Vielberg (Germany), 9 group members

Current activities: virtual group meeting in September 2021, (1) ongoing data and model comparison of accelerometer-derived mass densities, (2) planned comparison of POD-derived mass densities

JWG 3 “Improved understanding of space weather events and their monitoring by satellite missions”; Outgoing Chair: Alberto Garcia-Rigo (Spain; till 30<sup>th</sup> September, 2021), Incoming Chair: Haixia Lyu (China; from 1<sup>st</sup> October, 2021) Vice-Chair: Benedikt Soja (Switzerland), 11 group members

Current activities: (1) correlation between space weather products and perturbed ionospheric electron density or VTEC, jointly performed with JWG 1, (2) a set of four historical representative space weather events were selected to be analyzed, including storm-related periods in 2013, 2015, 2017 and 2018, performed together with JWG 1.

- During the Corona pandemic and the related lockdowns many papers have been written in the reporting period on topics related to the JSG and the JWGs of the FA-GSWR.
- In the same manner significant progress has been made in third-party funded national and international projects, which are often strongly coupled to the objectives of the JGS and the JWGs of the FA-GSWR.

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### Planned Actions and Milestones

- Continuation of the work on the definition and selection of the essential geodetic variables (EGV) in the framework of the scientific work within FA-GSWR.
- The main topics of the FA-GSWR are again included in the description of the PICO Session G5.1: Ionosphere, thermosphere and space weather: monitoring and modelling of the Geodesy Division of the European Geosciences Union (EGU) General Assembly (GA) 2022. The main convener of this session will be Ehsan Forootan, co-conveners of the Session G5.1 are Benedikt Soja, Kristin Vielberg and Michael Schmidt. Deadline for submitting abstracts will be January 12, 2022; the EGU GA 2022 will take place from April 3 to 8, 2022 in Vienna, Austria.
- Planning of a splinter meeting of the FA-GSWR during the EGU GA 2022 in Vienna.
- The 2nd International Symposium of IAG Commission 4 “Positioning and Applications” was originally planned for September 7 – 11, 2020 with a special conference part dedicated and organized by the FA-GSWR; due to the Corona pandemic the symposium was postponed to September 2022.
- JSG 1 as a part of the ICCT (Inter Commission Committee on Theory) will organize a session at the 2022 Hotine-Marussi symposium.