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IAG NEWSLETTER

IAG Newsletter

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The IAG Newsletter is under the editorial responsibility of the Communication and Outreach Branch (COB) of the IAG. It is an open forum, and contributors are welcome to send material (preferably in electronic form) to the IAG COB (newsletter@iag-aig.org). These contributions should complement information sent by IAG officials or by IAG symposia organizers (reports and announcements). The IAG Newsletter is published monthly. It is available in different formats from the IAG internet site: http://www.iag-aig.org.

Each IAG Newsletter includes several of the following topics:

I. General information
II. Reports of IAG symposia
III. Reports by commissions, special commissions or study groups
IV. Symposia announcements
V. Book reviews
VI. Fast bibliography

General Announcement

COST-G: combination service for time-variable gravity fields

Overview

The International Combination Service for Time-variable Gravity Fields (COST-G) is the Product Center of the International Gravity Field Service (IGFS) for time-variable gravity fields. COST-G provides consolidated monthly global gravity models in terms of spherical harmonic (SH) coefficients and thereof derived grids by combining existing solutions or normal equations (NEQs) from COST-G analysis centers (ACs) and partner analysis centers (PCs).

The NASA/DLR GRACE satellite mission provided 15 years (2002–2017) of observations of the changing Earth masses in the Earth system, e.g. the ice masses in Greenland. Several analysis centers are engaged in the determination of these mass variations, many of them are Analysis or Partner Analysis Centers in COST-G. Its successor mission GRACE-FO, implemented and operated by NASA and the German Research Centre for Geosciences (GFZ), is now in space and continues to provide data of the same quality as GRACE.

Earth observation (EO) satellites yield a wealth of data for scientific, operational, and commercial exploitation. Observations, derived from the Gravity Recovery and Climate Experiment (GRACE) mission, and by GRACE-FO (Follow-on), deliver fundamental insights into the global water cycle, ice mass redistributions, ocean circulation and the solid Earth. For example, changes in continental water storage control the regional water budget and can, in extreme cases, result in floods and droughts that often claim a high toll on infrastructure, the economy and human lives.

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Objectives

Due to different processing strategies, individual solutions of the analysis centers may differ in terms of mass variation. COST-G aims at consolidating these monthly global gravity models in terms of spherical harmonic coefficients (Level 2) and derived grids (Level 3) by combining the solutions of the individual centers.

The COST-G ACs adopt different analysis methods but apply agreed-upon consistent processing standards to deliver time-variable gravity field models, e.g. from GRACE/GRACE-FO low-low satellite-to-satellite tracking (ll-SST), high-low satellite-to-satellite tracking (hl-SST) such as for ESA's Swarm mission, Satellite Laser Ranging (SLR).

COST-G recognizes and emphasizes the existence and acknowledges the contribution of every individual AC and PC. Their participation is a crucial and mandatory prerequisite to the consolidation of monthly global gravity fields within COST-G.

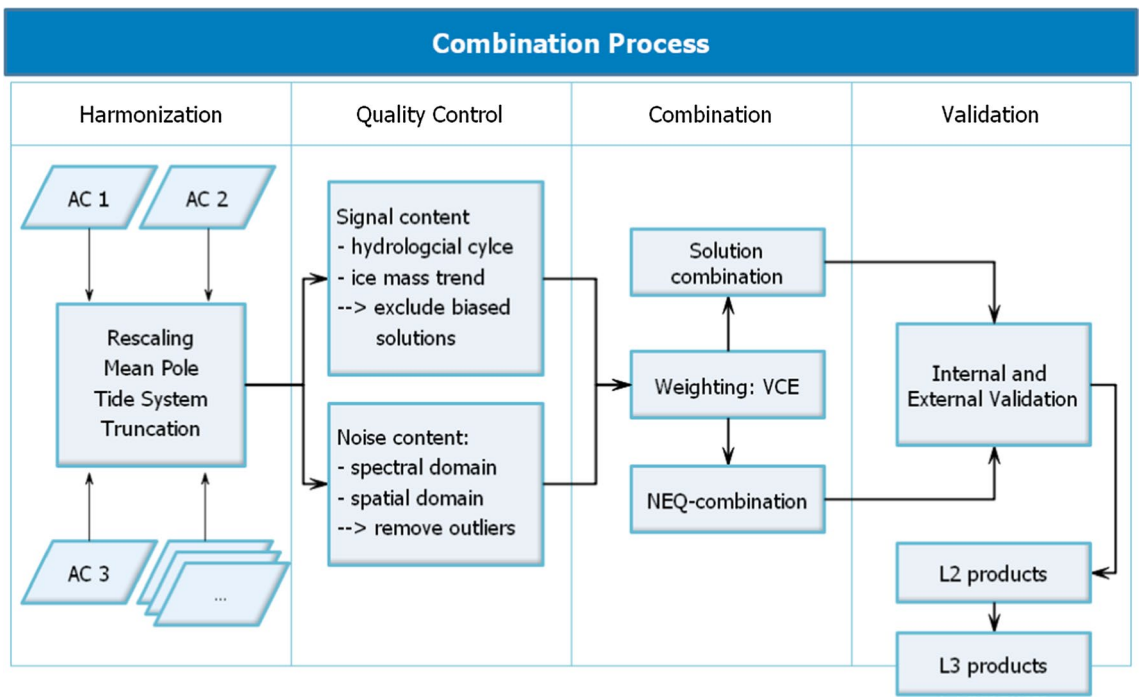
COST-G performs a quality control of the individual contributions before combination. COST-G provides:

- Combined gravity field solutions in SH coefficients (Level-2 products) derived from a weighted combination of individual contributions generated by the different ACs,
- Spatial grids and other high-level products (Level-3 products) of the Combined Solutions for hydrological, oceanic, and polar ice sheets applications.

Services

COST-G combines the gravity field solutions of various analysis centers (ACs). Currently, solutions are provided for GRACE, GRACE-FO and Swarm. The combination procedure consists of four major steps:

1. Harmonization: the various solutions are transformed to a common system
2. Quality control: the signal content as well as the noise content is evaluated in order to eliminate biased solutions and/or outliers.
3. Combination is performed on two levels:
   a. Solution level, i.e. the spherical harmonic coefficients are combined using variance component estimation (VCE); details can be found in Jean et al. (2018)
   b. Normal-EQuation-level (NEQ), i.e. the normal equations of the analysis centers are combined; details can be found in Meyer et al. (2019)
4. Internal and external validation ensure the quality of the product



Evaluation of models

Evaluation of the models is performed in a two-stage process by the validation center and the product evaluation group.

Validation Centers focus on a noise assessment of the derived solutions. Tasks of the VC include:

- Evaluation of the noise of the solutions over dedicated areas of low variability
- Evaluation of the quality of the solutions through comparison with external data sets such as altimetry
- Validation through LEO satellite orbit tests

The Product Evaluation Group focuses on the assessment of the signal contribution. Tasks of the PEG include assessing COST-G products for studying mass variations related to:

- Terrestrial water storage over non-glaciated regions
- Bottom pressure variations in the oceans
- Ice mass changes in Antarctica and in Greenland

Public outreach

The Level-2 products are made available through the International Center for Global Earth Models (ICGEM, http://icgem.gfz-potsdam.de).

The Level-3 products by the Information System and Data Center (ISDC, https://isdc.gfz-potsdam.de).

The products can be visualized at the COST-G Plotter (http://cost-g.org/) and the Gravity Information Service (GravIS, http://gravis.gfz-potsdam.de).

Data policy

Access to global gravity field models, derived products, once offered by the center, shall be unrestricted for any external user.

References

Jäggi A. et al. (2020) International Combination Service for Time-Variable Gravity Fields (COST-G). In: International Association of Geodesy Symposia. Springer, Berlin, Heidelberg. https://doi.org/10.1007/1345_2020_109

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Staff

COST-G is hosted by the AIUB Bern.

- Chair of the Directing Board: Adrian Jäggi
- Vice-Chair of the Directing Board: Frank Flechtner
- Analysis Center Coordinator: Ulrich Meyer

The staff is allocated part-time and responds to queries on a best-effort basis.

Point of contact

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Matthias Weigelt

Obituary

Erik Wilhelm Grafarend (1939–2020)

On 8 December 2020, Prof. Dr.-Ing.habil. Dr.tech.h.c.mult. Dr.-Ing.e.h.mult. Erik W. Grafarend, professor emeritus at the University of Stuttgart, died at the age of 81.

Erik Wilhelm Grafarend was born in Essen on 30 October 1939. After completing his studies in Mine Surveying (1964) at the University of Clausthal-Zellerfeld, Erik Grafarend pursued a rapid geodetic career with a doctorate (1966) and a second degree in physics (1968) at the same university. He moved to the University of Bonn where he habilitated in 1970 and received the Venia Legendi for the subject "Theoretical Geodesy"; the habilitation thesis was entitled "*The Accuracy of a Point in Multidimensional Euclidean Space*". In 1971, at the young age of 32, he became an adjunct professor at the Institute for Theoretical Geodesy at the University of Bonn. This was followed in 1975 by an appointment to the chair of "Astronomical and Physical Geodesy" at the University of the Federal Armed Forces in Munich. In 1980, Prof. Grafarend was appointed successor to Prof. Karl Ramsayer at the University of Stuttgart, where he headed the Institute of Geodesy until 2005. Since his retirement in 2005, he continued to be active in geodesy as a researcher and, in particular, as a book author.

Prof. Grafarend's research activities were by no means limited to the actual dedication of his chair. Known for his extraordinarily broad interest, even curiosity, he covered a thematically wide spectrum of geodesy: physical geodesy, estimation theory, statistics, geodetic network design, satellite geodesy, differential geometry, map projections, geokinematics, earth rotation, inertial navigation, reference systems.

The diversity of his research is documented on the one hand in an extensive oeuvre of around 350 publications in relevant scientific journals and conference proceedings. On the other hand, Erik Grafarend has left a series of substantial books to geodetic posterity, amongst others "*Map projections: cartographic information systems*", "*Applications of linear and nonlinear models: fixed effects, random effects, and mixed models*". His most recent book projects include Gravitation and the editorship of the "*Encyclopedia of Geodesy*". Beyond its diversity and size, Erik Grafarend's oeuvre is characterised by a creative power that has an almost artistic quality.

The geodetic work of Prof. Grafarend was highly recognised throughout his life. He was the first recipient of the prestigious Bomford Prize of the International Association of Geodesy in 1975. He has received numerous honorary doctorates and professorships from universities at home and abroad: Royal Institute of Technology in Stockholm (1989), TU Darmstadt (1996), TU Budapest (1998), University of the Federal Armed Forces in Munich (2000), University of Tehran (2002), University of Navarra in Pamplona (2014). He was a member of various learned societies: the German Geodetic Commission of the Bavarian Academy of Sciences, the Leibniz-Sozietät der Wissenschaften zu Berlin, the Finnish Academy of Sciences, the Hungarian Academy of Sciences, the Austrian Geodetic Commission.

In various functions in committees of national and international geodesy, Prof. Grafarend showed leadership. Within the DVW, he founded Working Group 7 "Experimental, Applied and Theoretical Geodesy"; for him, the name was the programme. As head of AK7, he founded the successful Geodetic Week, initially as an independent event with a special focus on young scientists, later established within InterGeo. In international geodesy, Erik Grafarend was clearly visible and, at conferences, also audible. In 1980 he was a founding editor of the journal *manuscripta geodaetica*, forerunner of the *Journal of Geodesy*. In the IAG he chaired various Special Study Groups and was elected President of the IAG Section IV "*General Theory and Methodology*" in 1983.

International networking has always been a special concern for Prof. Grafarend, but also a matter of course. He spent shorter and longer teaching and research stays in Columbus, Tehran, Wuhan, Sydney, Bandung, Uppsala, Stockholm and, regularly, Helsinki. Numerous top international scientists of the younger generation were motivated by him to conduct research with him in Stuttgart, among other things through funding from the Alexander von Humboldt Foundation. In recognition of his merits in promoting international scientific cooperation, he was awarded the Werner Heisenberg Medal of the Humboldt Foundation in 2000.

With Prof. Erik W. Grafarend we are losing a beacon of geodesy. He was an outstanding scientist whose interests and productivity knew hardly any boundaries, and whose contributions are inseparably linked to the development of modern geodesy. Nationally and internationally, he was valued as a colleague, as a teacher and, for many who knew him, as a friend. The beginnings of his scientific career could well have steered him into geophysics or physics. By a stroke of luck, geodesy became his home.

Nico Sneeuw, Stuttgart