Newsletter

No. 11 Feb. 2018

European Gravity Service for Improved Emergency Management

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URUGUAYAN WATER STORAGE EXCESS DURING JUNE 2017.

EGSIEM Near Real-Time (NRT) Service

From April until the last available GRACE observations on June 29 2017, the ⁻¹⁰⁻¹⁰ EGSIEM near real-time (NRT) Service as well as the Hydrological Service underwent an operational test run. During this period, the full processing chain from gravity field computation at GFZ and TU Graz, over wetness index ⁻²⁰ derivation at GFZ, up to delivery of a combined flood indicator to ZKI at DLR was evaluated. Processing of the GRACE data proved to be more complicated than expected, as the degrading health of the satellite power supply resulted in changes to the satellite's attitude and instrument uptime, as well as data gaps in ^{-30⁻} Earth's shadow. These rapid variations of data characteristics required on-the-fly adaptions to the processing chain. Still, both analysis centres (ACs) were able to produce competitive daily gravity field solutions with a latency well below the ^{-40⁻} projected five-days. GNSS evaluation of the NRT time series showed that large scale water storage variations were captured (see cover picture and Fig. 1), though the quality of the historic GRACE time series could not be fully reached. For further information, please contact Dipl.-Ing. Andreas Kvas (<u>kvas@tugraz.at</u>).



FIG. 1: SUB-MONTHLY VARIABILITY FROM TUGS NRT GRAVITY FIELD SOLUTIONS.



FIG. 2: MEMBERS OF THE EGSIEM CONSORTIUM PRESENT AT THE KICK-OFF MEETING HELD IN BERN, JANUARY 2015.

Goodbye from EGSIEM

The EGSIEM project ended formally on the 31st December 2017 but as you can tell, we are still here. We will continue to provide access to <u>egsiem.eu</u> and as you can see from this edition of our newsletter, the work on understanding and improving the observation of the earth continues, thank you for your interest in EGSIEM and we hope to have assisted you in some way with our work.





Scientific Combination Service of Monthly Gravity Fields

The aims of the EGSIEM Scientific Service are the combination of global monthly gravity models from the individual EGSIEM ACs, the validation of the individual and the combined gravity field solutions and finally the provision of userfriendly Level-3 products. These goals were achieved within three specific tasks as design and concept, operation, and validation. First common processing standards for all EGSIEM analysis centers had to be agreed upon. Monthly gravity fields up to spherical harmonic degree and order 90 were computed within a specific work package (WP2) and provided for combination. University of Bern (AIUB), GFZ and TU Graz (ITSG) delivered according to the standards, GRGS provided preliminary monthly solutions up to degree and order 80 that were also included in the combination. The individual AC's contributions were validated in terms of signal and noise content. They were also compared to their corresponding predecessors to assess the improvements achieved within WP2 (see Fig. 3). The first combination of the individual contributions is performed at solution level applying variance component estimation to derive relative weights representative for the particular noise levels of the gravity fields. In a second step the derived weights are applied to a combination on normal equation level, correctly taking into account all correlations between the gravity field parameters of interest and the pre-eliminated orbit or instrument parameters.

The final product of the combination service are the monthly gravity fields combined on normal equation level. For ease of use they are transformed from spectral representation to global grids of Equivalent Water Heights (EWH), specifically smoothed for hydrological or oceanographic applications. De-aliasing products of short-periodic atmosphere and ocean mass variations are restored and degree 1 spherical harmonic coefficients derived from satellite laser ranging (SLR) are added to reconstruct full (non-tidal) signal content.

The validation of the combined monthly gravity fields reveals very low noise levels (as indicated by the smooth ocean areas in Fig. 4), while the geophysical signal content of mass variations is preserved. The very good performance of the EGSIEM combined confirmed gravity fields is bv comparison to the official GRACE SDS time-series (refer to Fig. 5). Within the frame of the EGSIEM project two years (2006/07) were processed and are publicly available. Currently, an effort is being made to prolong the time-series of Earth's gravity field models from 2004 to 2010. The final goal is to transform the EGSIEM scientific service to become a COmbination Service for Time-variable Gravity (COST-G) under the umbrella of the International Gravity Field Service (IGFS) of IAG.

GFZ

UNIVERSITÉ DU LUXEMBOURG



FIG. 3: MEDIAN DEGREE AMPLITUDES OF ANOMALIES IN EQUIVALENT WATER HEIGHT (TRUNCATED AT ORDER 29), REPRESENTING THE NOISE LEVELS IN THE SPHERICAL HARMONICS DOMAIN.



FIG. 4: RMS of anomalies in the spatial domain, smoothed by a 400 km Gauss filter. On the continents non-seasonal Hydrological mass variations are visible.



FIG. 5: MONTHLY RMS OF ANOMALIES OVER THE OCEANS. IT REPRESENTS THE PARTICULAR MONTHLY NOISE LEVELS IN THE SPATIAL DOMAIN OF THE **EGSIEM** COMBINATION AND THE OFFICIAL **GRACE SDS** GRAVITY FIELDS.

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Numerous activities have been undertaken within EGSIEM to disseminate the data, products and findings allowing other potential users to exploit the data and the findings. Measures comprised the EGSIEM portal, an interactive tool for data access (EGSIEM plotter), scientific publications, user training and skill development aimed at young scientists and many activities to address the public like newsletters, open talks and usage of social media. Besides these efforts, procedures and standards have been developed by the EGSEIM project that are now recommended for use by the scientific community for the processing of GRACE-Follow On data.

EGSIEM Project Portal

The EGSIEM project website (www.egsiem.eu) was made available at the beginning of the project. It is the primary portal and repository to access EGSIEM data and documentation, it also acts as a platform for documents and the findings of project participants and beyond. The project webpage welcomes the user with the latest news about the project and provides general information about the background and work that has been achieved in the last three years. It also provides direct access to the data and the documentation which has been prominently placed in the center of the header menu. Data access is made available for experts via ftp and interestingly by the EGSIEM plotter to visualize EGSIEM products. The platform will be kept alive beyond the end of the project and will continue to serve as the primary access point for EGSIEM data and scientific publications for experts, scientists and potential users. Fig. 6 shows a screenshot of EGSIEM project website.



FIG. 6: EGSIEM PROJECT PORTAL (SCREENSHOT AT 14TH FEB. 2018).

EGSIEM Plotter

The EGSIEM consortium provides a professional webbased easy-to-use interface (<u>http://plot.egsiem.eu/</u>) to all kind of users, but focuses especially on potential scientists, commercial and public users. It allows users to estimate and visualize mass variations in the regions of interest and interpret the mass transport in the Earth system without complexity. The plotter comes with comprehensive documentation and a dedicated video tutorial guiding inexperienced users which is also available via EGSIEM YouTube social channel e.g. https://youtu.be/R8UODI81Jfl. The plotter web-portal allows users to take full advantage of high quality data produced by EGSIEM members and will enhance the productivity and effectiveness of the scientific community. The experiences gained from the EGSIEM consortium can be transferred to professional and scientists to improve visualization of GRACE Follow On mass variations. A preview of the EGSIEM plotter has been show in Fig. 7.



FIG. 7: EGSIEM PLOTTER PORTAL (SCREENSHOT AT 14TH FEB. 2018).







EGSEIM Dissemination continued

EGSIEM Autumn School

The EGSIEM Autumn School for Satellite Gravimetry Applications took place at GFZ Potsdam, Germany, in September 2017. In total, 45 attendees and 12 lecturers from 16 different countries enjoyed a very interesting week in the beautiful city of Potsdam (Fig. 8). In various lectures and practical exercises, participants learned how to use EGSIEM products and to handle the GRACE and future GRACE-FO datasets. Special focus was placed on geophysical applications and the easy access to data via the EGSIEM plotter. Presentations are available under: http://egsiem.eu/autumn-school



FIG. 9: THE WINNERS OF THE EGSIEM STUDENT CHALLENGE 2016 – LEFT TO RIGHT: B.Sc. PHILIPPA HIGGINS (TU-DRESDEN, GERMANY), B.Sc. JULIAN RODRIGUEZ VILLAMIZAR (TECHNICAL UNIVERSITY OF MUNICH, GERMANY), B.Sc. PEIZO CHENG RACHEL (TU-DELFT, NETHERLANDS) AND B.Sc. ALEXANDROS KAZANTZIDIS (UNIVERSITY OF THESSALONIKI – GREECE).

Teaser Lecture

In addition to the scientific lectures given to colleagues around the world members of the consortium also explained their work to the general public. These 'Teaser lectures' were aimed at people with no previous knowledge of Earth Observation and we would like to highlight here the presentation given by Prof. Adrian Jäggi, at University of Bern entitled "Von Wasser, Eis und Satelliten - und was uns die Schwerkraft über Umweltveränderungen verrät" (or, On Water, Ice and Satellites - what they and gravitational fields reveal to us about environmental changes), which was given within the framework of the "Physik am Freitag lecture series" in Bern, Switzerland on the 11th March 2016 (Fig. 10). He introduced Earth sciences such as geodesy, hydrology and geophysics and showed the Earth's gravity field and its application for monitoring natural hazards. Other such events included talks given by colleagues from Luxembourg on World Environment Day and from Hannover at Czech Space Day.



FIG. 8: GROUP PHOTO OF EGSIEM AUTUMN SCHOOL PARTICIPANTS.

EGSIEM Student Competition

During the EGSIEM Student Challenge, European students were asked to fill an online survey with twenty multiple-choice questions about gravity, hydrology and their application in emergency management. Around one hundred B.Sc. and M.Sc. students from various disciplines participated in the challenge. The second round began shortly after the first round, which thirty-seven B.Sc. and M.Sc. students successfully passed. In this round, students had been expected to provide written answers to another twenty questions. Four winners of the Challenge have been announced on the EGSIEM website and in the EGSIEM newsletter #9.



FIG. 10: TEASER LECTURE BY EGSIEM PROJECT COORDINATOR PROF. ADRIAN JÄGGI GIVEN AT THE UNIVERSITY OF BERN ENTITLED: "VON WASSER, EIS UND SATELLITEN - UND WAS UNS DIE SCHWERKRAFT ÜBER UMWELTVERÄNDERUNGEN VERRÄT".





GFZ









Exploitation of EGSIEM Products

Exploitation measures support the user in selecting and properly pre-processing data to fully exploit satellite gravity data and products for their specific application. They answer the increasing demand to simplify data access and to provide reliable and well validated products with comprehensive documentation and information. Here we outline the exploitation measures and activities to increase the steadiness and to secure the availability of EGSIEM products, services and future applications of the products.

Scientific Service

Based on the EGSIEM processing standards, the scientific service delivers the best combined Earth's gravity field solutions and user-friendly L3 products covering two years of GRACE data from 2006 to 2007, these have been made available under the project website (see Data). For the calculation of the combined solutions, a common denominator needed to be defined to allow for a controlled exchange and combination of the Analysis Centres (AC) solutions. For the first time in the gravity field community, the already existing Solution INdependent EXchange (SINEX) format has been established, and has been used to exchange the normal equations of the various ACs in the EGSIEM consortium. Single AC solutions as well as the combined solution have been provided to the ICGEM where they are archived and have partially been assigned with a digital object identifier. The Scientific Service shall be continued as part of IAG's International Gravity Field Service (IGFS). It is intended that the International COmbination Service for Time-variable Gravity fields (COST-G) will be formally established as the Product Center of the International Gravity Field Service (IGFS) for time-variable gravity fields. (see Fig. 11) . COST-G shall be primarily operated by the University of Bern (Switzerland) which continues the activities of the EGSIEM Scientific Combination Service and will deliver consolidated time-variable gravity field models.



The International Gravity Field Service - IGFS

IGFS is a unified "umbrella" IAG service, which: (i) Coordinates collection, validation, archiving and dissemination of gravity field related data (ii) Coordinates courses, information materials and general public outreach relating to the earth's gravity field, (iii) Unifies gravity products for the needs of GGOS – the Global Geodetic Observing System.

IGFS coordinates the servicing of the geodetic and geophysical community with gravity field-related data, software and information. The combined data of the IGFS entities data include both satellite-derived global models, terrestrial, airborne, satellite and marine gravity observations, earth tide data, GPS leveling data, digital models of terrain and bathymetry, ocean gravity field and geoid from satellite altimetry.

IGFS Data and Products

FIG. 11: INTERNATIONAL GRAVITY FIELD SERVICE (IGFS) AS HOST PLATFORM FOR THE FUTURE COST-G PRODUCT CENTRE.





Exploitation of EGSIEM Products

Near Real Time and Regional Service

Hydrological applications using GRACE data proved that it is possible to derive gravitational based wetness indicators that allow users to quantify catchment anomalies. However, reducing the latency from 60 to less than five days and increasing the temporal resolution to daily for a low degree Earth's gravity field solution has been a prerequisite to establish a prototype monitoring service. The EGSIEM consortium realized this within the near-real time (NRT) service. In terms of operational processing, the ACs at GFZ and TUG are now able to deliver daily global and regional gravity field solutions within less than the projected five days latency in a fully automated manner including computation, internal evaluation and distribution. For the operational test period from 01.04.2017 to 31.07.2017 the consortium successfully ran the service in real-time. In the run up to the NRT service operational test run, the whole GRACE time series from 2002 up to 2017 was successfully processed. The resulting post-processing solutions of both GFZ and TUG are publicly available as gridded water storage products at:

- TUG: <u>ftp://ftp.tugraz.at/outgoing/ITSG/EGSIEM/NRT/grids</u>
- GFZ: <u>ftp://egsiem@gfzop.gfz-potsdam.de</u>

The service is currently on-hold due to the decommissioning of GRACE.

Hydrological Service

The gravitational wetness index derived by the EGSIEM consortium enables users to monitor (sub-)surface hydrological mass variations in near-real time (see Fig. 12). At the beginning of the project no such service existed. The primary effort of this service was therefore the reliable and robust derivation of the wetness index from the products provided by the NRT. Two types of datasets for the EGSIEM test period have been made available at:

- retrospective data under <u>ftp://ftp.gfz-potsdam.de/home/hydro/bingo/share/Retro</u>
- operational NRT data under http://ftp.gfz-potsdam.de/home/hydro/bingo/share/NRT



FIG. 12: INTERACTIVE DLR WEB-CLIENT SHOWING TERRASAR-X/SENTINEL-1 FLOOD SERVICE COMBINED WITH EGSIEM GRACE-BASED WETNESS INDEX.

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SPAR 2018

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Vienna, Austria Apr. 8 - 13, 2018 COSPAR 2018

EGU 2018

Pasadena, California, USA Jul. 14 - 22, 2018

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