EGSIEM

European Gravity Service for Improved Emergency Management

HORIZON 2020

EO-1-2014: New ideas for Earth-relevant space applications
Research and Innovation action

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Dissemination and Exploitation of EGSIEM Products

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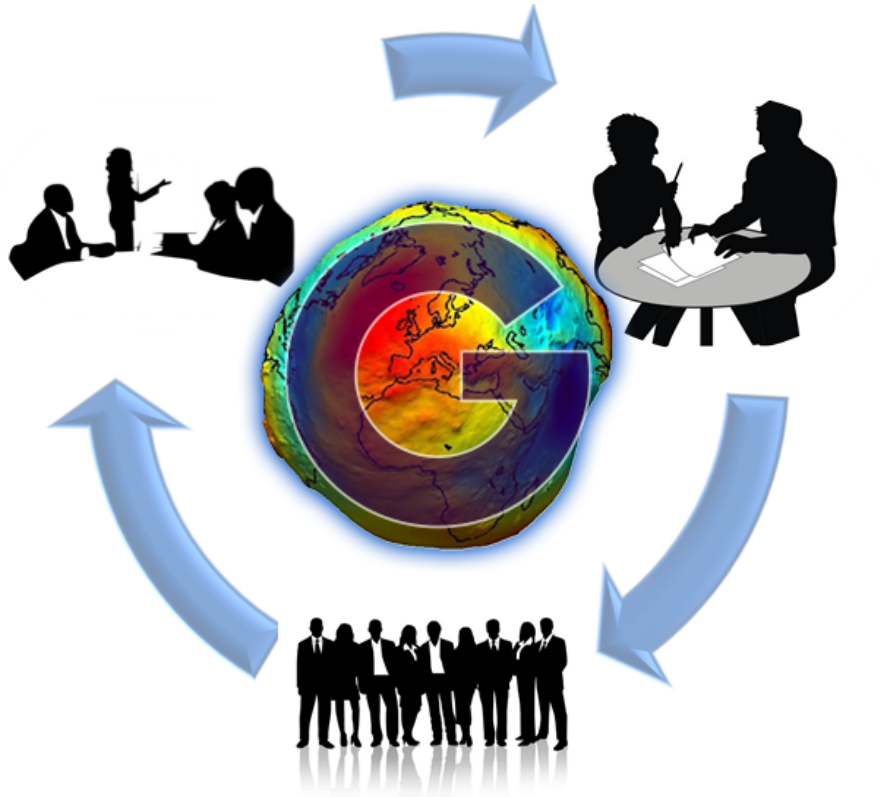

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1.Change Record

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Draft 3			

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2. Overview and Summary

This document provides our dissemination and exploitation (DE) concept and activities of the EGSIEM team during the project and the time beyond. The purpose of the plan is to ensure that the EGSIEM products including project information, concepts, research data, procedures and scientific publications achieved by the EGSIEM participants remain available and easily accessible to various scientific communities, commercial users, the public, decision makers and other potential users.

Given existing limitations before the start of the project, our efforts can be summarised into three key objectives: 1) to deliver the best gravity products for applications in Earth and environmental science research for a demonstration period of two years; 2) to reduce the latency and increase the temporal resolution of the gravity and therefore mass redistribution products; and 3) to develop gravity-based indicators for extreme hydrological events and demonstrate their value for flood forecasting and monitoring services. Each objective is associated to on of three dedicated services, namely the *scientific combination service*, the *near real-time and regional service*, and the *hydrological service*, which deliver project information and products as a service to various communities and the public.

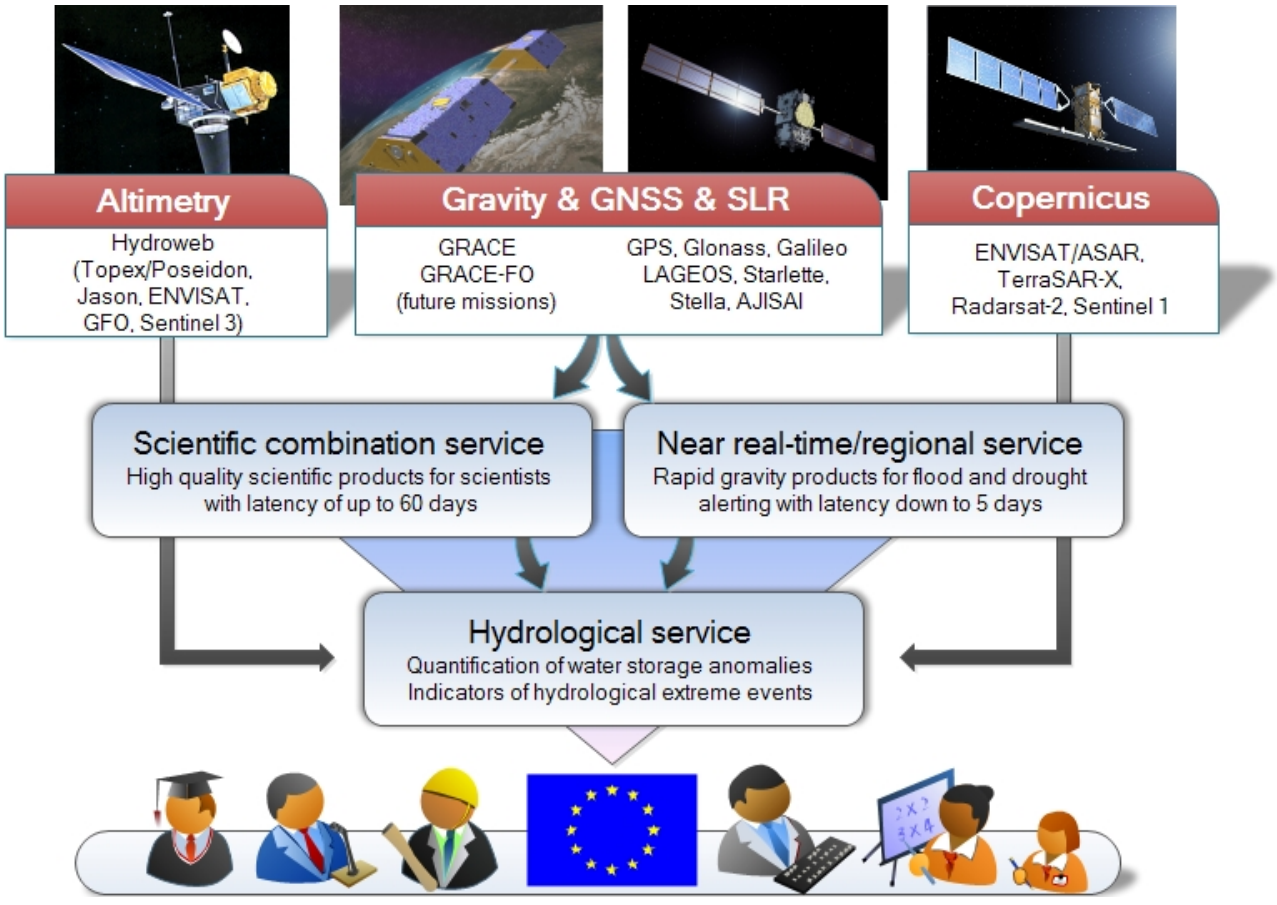

Figure 1: Dissemination and exploitation concept of EGSIEM products.

Figure 1 reflects the general work- and dataflow within EGSIEM. Each service is operating a platform including repositories and servers as an interface whereas each service aims at providing the best products and procedures based on available standards in the Earth gravity field, remote sensing and hydrological communities as follows:

- The products by the scientific combinaation service allows users to access monthly gravity field solutions based on a combination of solutions of various analysis centres. They primarly address scientists and experts as gravity field products are generally difficult to interprete.
- The near real-time (NRT)/regional gravity field service provides daily global solutions and daily regional solutions with an increased spatial resolution for a region of interest both based on data of the satellite mission GRACE. Likewise, these products are primarily used by scientists and experts.
- The hydrological service uses the products of the scientific service and especially of the near-real time service to derive gravitational-based wetness indices for the analysis and forecasting of hydrological extreme events. Wetness indices are provided as easy to interprete global and regional maps which can be used by decision makers, the public and the scientists alike.

All products are accessible via the EGSIEM project web portal (www.egsiem.eu) to make products findable, accessible, interoperable and re-usable in compliance with the FAIR Data Management guidelines in H2020. Dissemination is further supported by the EGSIEM plotter which allows users to easily access and compare the various products.

2.1 Exploitation of EGSIEM products

Exploitation measures support the user in selecting and properly pre-processing the data to fully exploit satellite gravity data 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. In the subsequent parts we outline the exploitation measures, activities to increase the steadiness and to secure the availability of products and services and future applications of the products. More information on the processing of the various products can be found in

- Deliverable 4.1: Concept of the Scientific service,
- Deliverable 5.1: Concept of NRT Service,
- Deliverable 5.4: Regional Solution Product Report,
- Deliverable 6.1: Hydrological Service Product Report and
- Deliverable 7.1: EGSIEM Project Website.

2.1.1 Complementary Data

The processing of GPS data is an inherent part of any Level-1B GRACE data processing needed to infer gravity field solutions. For this purpose high-quality information on GPS satellite orbits and GPS satellite clock corrections are required. A dedicated GNSS reprocessing campaing was conducted to provide up-to-date GPS products to the EGSIEM ACs also for the time period before EGSIEM started. Reference Frame Products covering GPS (1994-2001) and combined GPS+GLONASS (2002-2014) data, including a detailed summary on the analysis strategy, is available at

ftp://ftp.aiub.unibe.ch/REPRO_2015/

with a DOI identifier assigned to provided products.

2.1.2 Scientific Service

Based on the EGSIEM processing standards, the scientific service delivers the combined Earth's gravity field solutions and user-friendly L3 products covering two years of GRACE data from 2006 to 2007 which are made available under the project portal (www.egsiem.eu). Current efforts aim at prolonging the time-series from 2004 to 2010 and subsequently to the entire time-span of available data. Since the satellite mission GRACE has been subsequently decommissioned, preparations for the data processing of the successor mission GRACE Follow-On have been initiated.

Prior to the combination of gravity field solutions, each Analysis Center (AC) processed the GRACE sensor data including K-band range and range-rate measurents, star camera data, GPS high-low satellite-to-satellite tracking (SST) observations and accelerometer data. A variety of background models have been used by EGSIEM participants to generate their specific products. For the calculation of the combined solutions, a common denominator needed to be defined to allow for a controlled exchange and combination of the AC-solutions. The exchange of normal equations has been found to be this common denominator for which, for the first time in the gravity field community, the already existing Solution INdependent EXchange (SINEX) format has been established at all processing centres and used to exchange the normal equations of the various ACs in the EGSIEM consortium. Temporal gravity field solutions are calculated in terms of Stocke's coefficients and made available in terms of the GFC-fomat defined by the Internation Centre for Global Earth Models (ICGEM), which is a service of the International Association of Geodesy (IAG) and run by the GFZ Potsdam. Single AC solutions as well as the combined solution have been provided to the ICGEM where they are archived and partially have been assigned with a digital object identifier (doi).

The EGSIEM 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 a service or centre under the umbrella of the IGFS at the next IAG Executive Board meeting on 8 April 2018. COST-G shall be primarily operated by UBERN which continues the activities of EGSIEM Scientific Combination Service and will deliver consolidated time-variable global gravity field models in terms of spherical harmonic coefficients (Level-2 products) and user-friendly Level-3 products by combining

solutions from individual analysis centers. GFZ will support the generation of the user-friendly L3 products derived from the GRACE/GRACE-FO satellite missions.

2.1.3 Near-Real Time (NRT) 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 analysis centres at GFZ and TUG are now able to deliver daily global or 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. Currently the service is put on hold as no new data is available due to the decommissioning of the GRACE satellites.

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

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 (L3 products) on their respective FTP servers and in case of TUG are already made available at the aforementioned ICGEM.

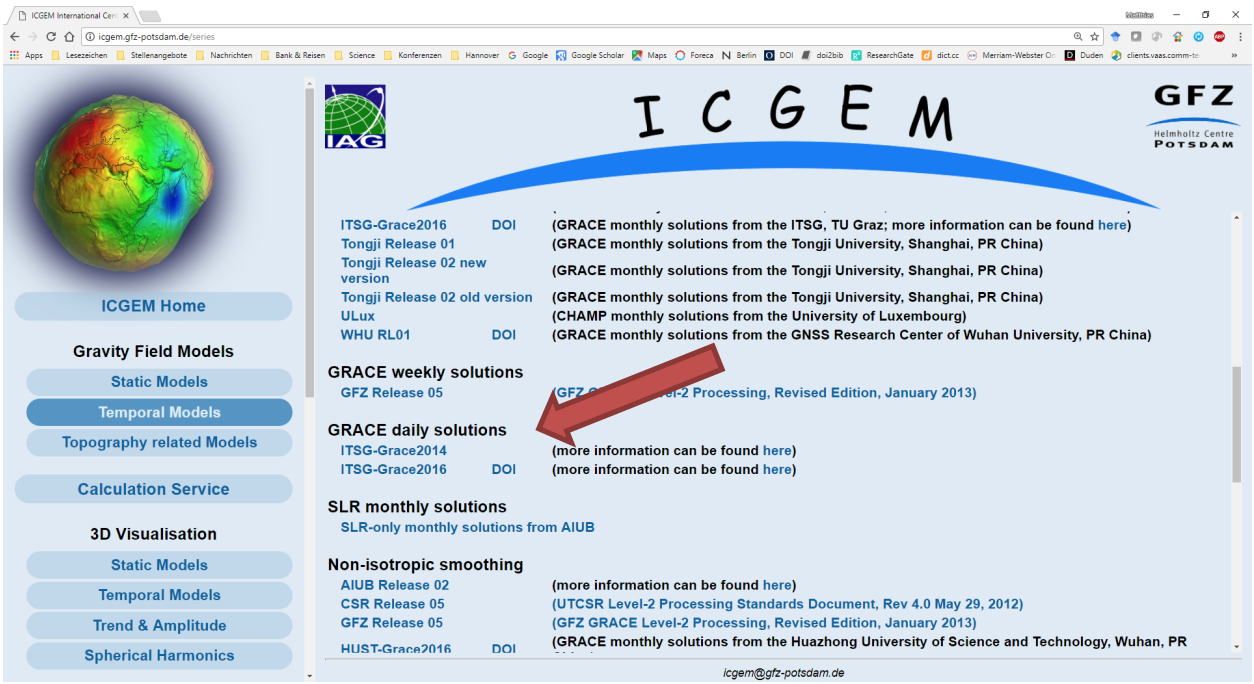

Figure 2: Time-variable models available at the ICGEM: among them the daily TUG solutions

We anticipate resuming the NRT operations as soon as the GRACE-FO data will become available in 2018 and we expect that through the expertise gained during the operational service test run, the NRT product can be further be improved.

Furthermore, the currently available NRT products based on GRACE data and the expected new products based on GRACE-FO data will be used in the framework of the Collaborative Research Centre 1128 “Relativistic geodesy and gravimetry with quantum sensors – modelling, geo-metrology, and future technology”. Within the sub-project C05 “Modelling of mass variations down to small scales”, an observation-driven inversion approach will be persued by combining the daily spaceborne gravitational data from GRACE and GRACE-FO and terrestrial gravimetry data with loading information derived from GNSS station movements in a Kalman filter approach based on a regional gravity field parameterisation. The project tackles the limited spatial resolution of daily spaceborne-only gravitational data which are nevertheless imperative to this project.

2.1.4 Hydrological Service

The gravitational wetness index derived by the EGSIEM consortium enables users to monitor (sub-)surface hydrological mass variations in near-realtime. 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 data sets have been made publically available: 1) retrospective data and 2) operational NRT data for the test period 01.04.2017 till 31.07.2017

The retrospective daily [1°x1°] degree grids of hydrological indices cover the period from 01.04.2002 till 31.12.2015. The following products are available:

- gravity-based GFZ wetness index,
- gravity-based TUG wetness index and
- gravity-based combined wetness index.

The retroperspective products are available to all potential users under ftp://ftp.gfz-potsdam.de/home/hydro/bingo/share/Retro**.**

An operational NRT test service was in use between 01.04.2017 – 31.07.2017 which has been put on hold like the NRT service with the decommissioning of the GRACE satellites. During the test phase, daily [1°x1°] degree grids of the following hydrological indices have been prepared:

- gravity-based GFZ wetness index,
- gravity-based TUG wetness index,
- gravity-based combined wetness index and
- wetness index bulletin.

The data are available to the scientific communities, climate experts and other potential users under ftp://ftp.gfz-potsdam.de/home/hydro/bingo/share/NRT. The concept and production chain of hydrological drought/flood indices can be used again once GRACE-FO data becomes available and it is expected that the service will resume then.

For more information on the concept and the products, the reader is referred to:

- Deliverable 5.1: concept of NRT service,
- Deliverable 5.2: NRT service product report,
- Deliverable 5.3: Operational NRT service product report and
- Deliverable 5.4: regional solution product report.

Having the wetness index products available allows their deployment for hydrological applications. Despite the early stage for such applications, the products have already been used for a hydrological analysis of flooding events, in which we were able to identify two main groups of events:

- The daily wetness index can monitor flood peaks in locations of high water volume, e.g., the Bangladesh delta floods of 2004 and 2007 which are 20 times larger in volume than a basin-wide Danube flood despite its geographically small area (~150.000 km^2). These events did not show any lead time, i.e. water storage build-up and flood occurrence are not collocated.

- Large basin-wide flooding in the Danube basin in 2006 and 2010 have a water storage build-up component due to e.g. melting snow among others and have been picked up with lead times prior to peak flow at the basin outlet of 43 days (over 6 weeks) and 37 days (over 5 weeks), respectively. The lead time length depends on the choice of a predefined threshold, which is a river basin and gauge location charasteristic. We also found lead times that are critically reduced or even negative prior to peak flow in the Upper Danube for 2006, 2010, and 2013. Smaller, regional floods in 2005, 2009, 2013 and 2014 have not been picked up as they have no water storage build-up component and were triggered by torrential rain in sub-basins of the Danube.

The findings require further investigation, but it is evident that the index is a valuable source of information for operational early warning services and it suggests that in some cases not only flood monitoring but also flood and possibly drought forecasting may be feasible. Furthermore, the gravitational wetness indexes might be assimilated into other climate forecasting system and indicies.

The value of these wetness index products for early tasking of SAR satellites has been explored and demonstrated within the EGSIEM project by DLR which operates three dedicated flood services:

1. It operates a fully automated flood service for TerraSAR-X data with a resolution of 40 m (WideScanSAR mode) up to 3m (StripMap mode). TerraSAR-X/TanDEM-X satellites must be tasked, which is done on a global scale for activations of the International Charter.
2. Parallel to TerraSAR-X flood service DLR operates MODIS flood service, which is a fully automated large-scale flood mapping service with 250 m resolution. The optical MODIS instrument acquires data systematically with a high revisit interval (daily coverage). By using the MODIS Flood Service for triggering the on-demand TerraSAR-X Flood Service,

the probability for detailed flood mapping with high resolution SAR data can be increased.

3. The third in the row of the DLR's fully automatic flood services is the Sentinel-1 flood service. This service is best suited for systematic large-scale flood monitoring with a high resolution (20 m) and a repeat frequency of 6 days.

All flood services are accessible via interactive web clients (DLR internal use). Results appear to be very good in flat terrain whereas classification errors in the SAR data can occur in urban areas and for flooded vegetation. The primary concern currently is the sufficiently early tasking of the satellites as e.g. the International Charter is generally activated when a flood is already occurring. The delay may be reduced based on monitoring/forecasting with gravitational wetness indices as has benn shown for the Danube basin (see above).

Further, medium resolution inundation depth maps and flood volume estimation have been derived for two historic flood events in the Ganges-Brahmaputra Delta (2006) and the Mekong Delta (2007) based on SAR satellite data, DEMs and in-situ water level data. The experimental results have proven to be useful in the comparison to hydrologic model results and GRACE data and the method can be automated for each Sentinel-1 data set. So far there is no plan for future operational use, but it may be reconsidered once GRACE-FO data becomes available.
For easy accessibility, an interactive web client based on the TerraSAR-X/Sentinel-1 flood service has been created and combined with the EGSIEM daily GRACE-based wetness index. This client shows daily global results of the Sentinel-1 and TerraSAR-X flood service together with the EGSIEM daily GRACE-based wetness index in the same view. Currently, the client is only available internally to DLR, but it shall be used and integrated into the operational ZKI workflow. The further integration is currently pending due to the lack of daily GRACE-based wetness indices, but it can be fully deployed as soon as GRACE-FO based operational wetness indices become available.

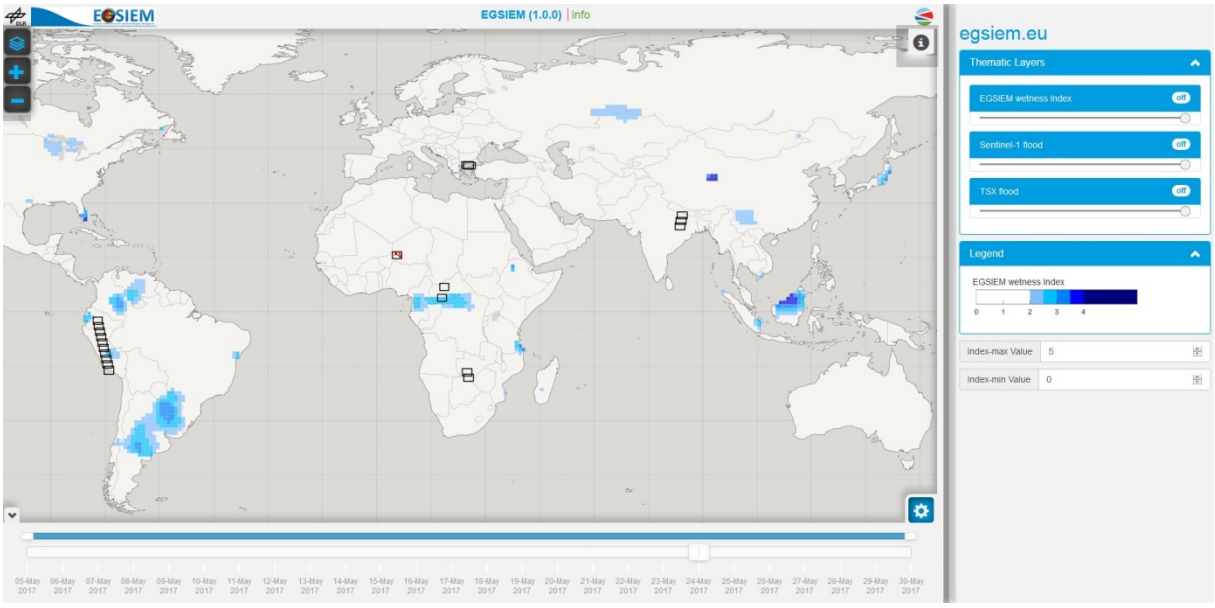

Figure 3: Interactive web client showing TerraSAR-X/Sentinel-1 flood service in combination with the EGSIEM daily GRACE-based wetness index.

2.2 Dissemination of EGSIEM products

Numerous activities have been undertaken within EGSIEM to disseminate the products and findings allowing others 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 aiming at young scientists and many activities to address the public like newsletters, press releases and via the social media. Besides, procedures and standards have been developed by the EGSEIM project that are now recommended for use by the scientific community for the processing of the GRACE-FO data. The latter is not further discussed her and the interested reader is referred to the following documents for more information:

- Deliverable 2.1: Processing Standards and Models,
- Deliverable 4.1: Concept of Scientific Service,
- Deliverable 5.1: Concept of NRT Service and
- Deliverable 5.4: Regional Solution Product Report.

2.2.1 EGSIEM portal

The EGSIEM project website (www.egsiem.eu) was made available at the beginning of the project. It is the primary portal to access our data and documentation but also acts as a platform for documents and findings of project participants and beyond.

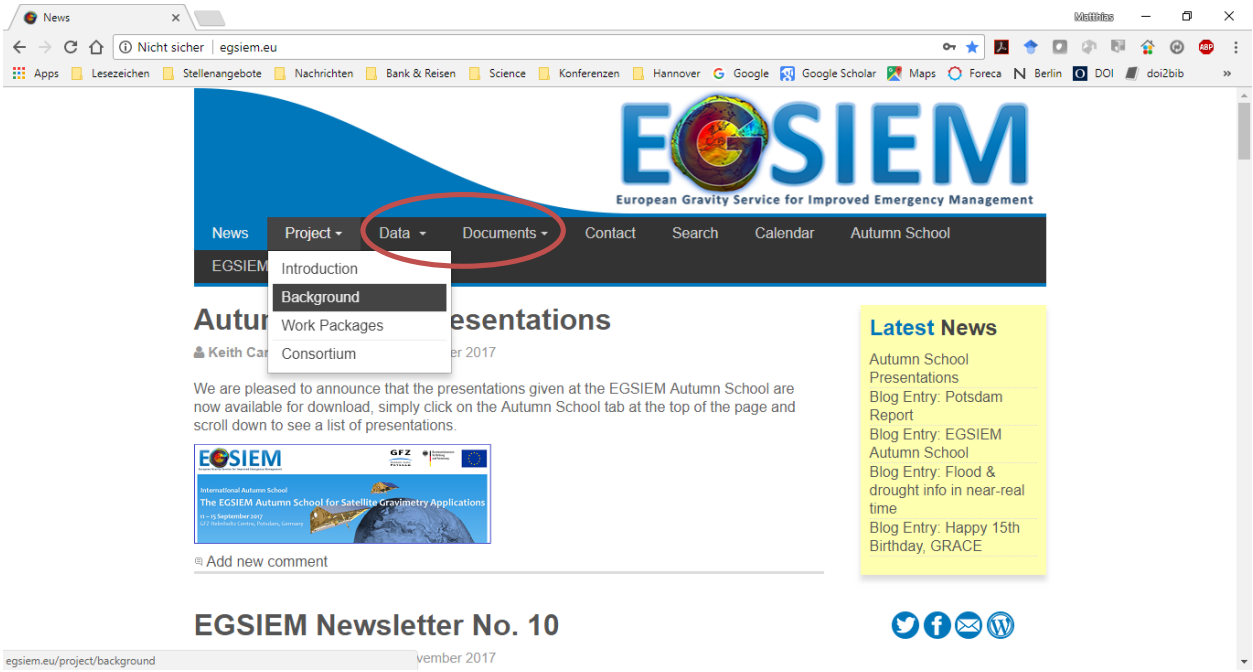

Figure 4: The EGSIEM portal with the data and documentation section highlighted

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. More important is the direct acces to the data and the documentation which has been prominently placed in the center of header menu. Data access is made available via ftp (for

experts) and more interestingly by the EGSIEM plotter (see below). The platform will be kept alive beyond the project and will continue to serve as the primary access point.

2.2.2 EGSIEM plotter

The EGSIEM consortium provides a professional web-based easy-to-use interface (http://plot.egsiem.eu/) to all kind of users but focuses especially on potential commercial and public users. It allows users to estimate and visualize mass variations in the regions of interest and interprete the mass variations without complexity.

The plotter comes with comprehensive documentation and a dedicated video tutorial guiding inexperienced users which is also available via https://youtu.be/R8UODI81JfI. The plotter web-portal allows to users to take full advantages of the high quality EGSEIM products and enhance the productivity and effectiveness of the scientific community.

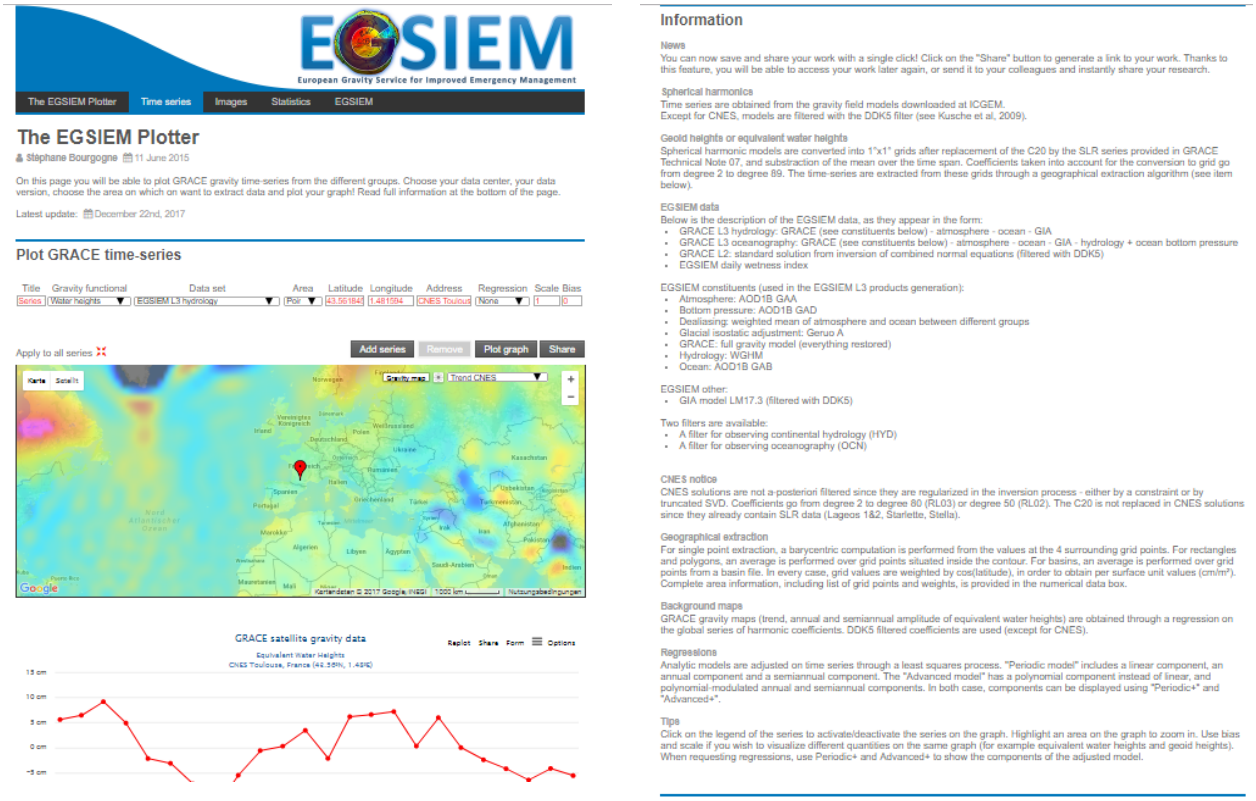

Figure 5: The EGSIEM plotter (left) with a time series for one point in Toulouse, France and its comprehensive documentation (right)

2.2.3 Scientific Publications

The scientific papers and EGSIEM research data have been made visible through repositories to potential users. Numerous presentations have been given in the Earth science conferences e.g. IAG General Assembly, IUGG and AGU and EGU and so on by EGSIEM consortium participants.

Journal Paper

Jäggi A, Weigelt M, Flechtner F, Güntner A, Mayer-Gürr T, Martinis S, Bruinsma S, Flury J, Bourgogne S, Meyer U, Jean Y, Sušnik A, Grahsl A, Cann-Guthauser K, Dach R, Li Z, Chen Q, van Dam T, Gruber C, Poropat L, Gouwleeuw B, Kvas A, Klinger B, Lemoine J-M, Biancale R, Zwenzner H, Bandikova T, A. Shabanloui (2018): European Gravity Service for Improved Emergency Management (EGSIEM) - from concept to implementation. Journal of Geodesy, in preparation

Sušnik A, Grahsl A, Arnold D, Villiger A, Dach R, Jäggi A (2017): GNSS reprocessing results in the framework of the EGSIEM project. Journal of Geodesy, submitted

Jean Y, Meyer U, Jäggi A (2017): Combination of GRACE monthly gravity field solutions from different processing strategies. Journal of Geodesy, submitted

Ben T. Gouweleeuw, Andreas Kvas, Christian Gruber, Animesh K. Gain, Thorsten Mayer-Gürr, Frank Flechtner, and Andreas Güntner (2017), Daily GRACE gravity field solutions track major flood events in the Ganges-Brahmaputra Delta, Hydrology and Earth System Sciences Discussions, pp. 1-23, doi: 10.5194/hess-2016-653

Klinger, B. and Mayer-Gürr, T. (2016). The role of accelerometer data calibration within GRACE gravity field recovery: Results from ITSG-Grace2016. Advances in Space Research 58, 1597–1609. DOI: 10.1016/j.asr.2016.08.007.

Conferences

Ben T. Gouweleeuw, Andreas Kvas, Christian Gruber, Thorsten Mayer-Gürr, Frank Flechtner, and Andreas Güntner (2017), A daily wetness index based on satellite gravity for flood and drought forecasting in the Danube basin, XXVII Conference of the Danubian countries on hydrological forecasting and hydrological bases of water management, 26-28 Sep., 2017, Golden Sands, Bulgaria.

Ben T. Gouweleeuw, Andreas Kvas, Christian Gruber, Thorsten Mayer-Gürr, Frank Flechtner, and Andreas Güntner (2017), A daily wetness index from satellite gravity for NRT global monitoring of floods and droughts, IAG Workshop: Satellite Geodesy for Climate Studies, Bonn, Germany.

Ben T. Gouweleeuw, Andreas Kvas, Christian Gruber, Thorsten Mayer-Gürr, Frank Flechtner, Mehedi Hassan, and Andreas Güntner (2017), A daily wetness index from satellite gravity for near-real time global monitoring of hydrological extremes, EGU General Assembly, Vienna, Austria.

Ben T. Gouweleeuw, Andreas Kvas, Christian Gruber, Maike Schumacher, Thorsten Mayer-Gürr, Frank Flechtner, Jürgen Kusche, and Andreas Güntner (2016) (Invited), Towards near-real time daily GRACE gravity solutions for global monitoring of hydrological extremes, AGU Fall Meeting,

San Francisco, USA.

Ben T. Gouweleeuw, Andreas Kvas, Christian Gruber, Maike Schumacher, Thorsten Mayer-Gürr, Frank Flechtner, Jürgen Kusche, and Andreas Güntner (2016) (Invited), Towards near-real time daily GRACE gravity solutions for global flood and drought monitoring, GSTM, 5-7 Oct., 2016, Potsdam, Germany.

Ben T. Gouweleeuw, Andreas Güntner, Animesh K. Gain, Christian Gruber, Frank Flechtner, Andreas Kvas, and Thorsten Mayer-Gürr (2016), Evaluation of GRACE daily gravity solutions for hydrological extremes in selected river basins, EGU General Assembly, Vienna, Austria.

Ben T. Gouweleeuw, Andreas Güntner, Adrian Jäggi, Matthias Weigelt, Tonie van Dam, Zhao Li, Frank Flechtner, Christian Gruber, Thorsten Mayer-Gürr, Sandro Martinis, Sean Bruinsma, Jakob Flury, Stephane Bourgogne (2015), European Gravity Service for Improved Emergency Management - a near-real time and daily satellite gravity product service for early warning of flood and drought, Earth Observation for Water Cycle Science 2015, ESA/GEWEX 20-23 Oct., 2015, ESRIN, Frascati, Italy.

Klinger, B., Mayer-Gürr, T., Kvas, A., Zehentner, N., Ellmer, M. and Behzadpour, S. (2017). The role of accelerometer data calibration within the ITSG-Grace2016 release: impact on C20 Coefficients, EGU General Assembly 2017, Vienna, Austria. Geophysical Research Abstracts Vol. 19, EGU2017-14534.

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Ellmer, M., Mayer-Gürr, T., Klinger, B., Kvas, A., Zehentner, N. and Behzadpour S. (2016). Gravity Field Processing At TU Graz, Asia Oceania Geosciences Society 13th Annual Meeting, Beijing, China.

Klinger, B., Mayer-Gürr, T., Behzadpour, S., Ellmer, M., Kvas, A., and Zehentner, N. (2016). The new ITSG-Grace2016 release, EGU General Assembly 2016, Vienna, Austria. Geophysical Research Abstracts Vol. 18, EGU2016-11547.
URL: https://pure.tugraz.at/portal/files/3643450/2016_04_Klinger_etal_EGU2016_ITSG_Grace2016.pdf.

Mayer-Gürr, T., Jäggi, A., Meyer, U., Jean, Y., Susnik, A., Weigelt, M., van Dam, T., Flechtner, F., Gruber, C., Güntner, A., Gouweleeuw, B., Kvas, A., Klinger, B., Flury, J., Bruinsma, S., Lemoine, J.-M., Zwenzer, H., Bourgogne, S. and Bandikova, T. (2016). European Gravity Service for Improved Emergency Management - Status and project highlights, EGU General Assembly 2016, Vienna, Austria. Geophysical Research Abstracts Vol. 18, EGU2016-14970.

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Meyer U, Jean Y , Arnold D and Jäggi A (2017) EGSIEM combination service: combination of GRACE monthly K-band solutions on normal equation level, EGU General Assembly 2017}, Vienna, Austria,

Meyer U, Y Jean , Arnold D and Jäggi A (2017) Combination of monthly gravity field solutions on Normal
Equation Leve, IAG Scientific Assembly, Kobe, Japan

Meyer U, Jean Y , Arnold D and Jäggi A (2017) Combination of monthly gravity field solutions – transition from an EGSIEM prototype service into an IAG service, IAG Scientific Assembly, Kobe, Japan

Meyer U, Jean Y , Arnold D and Jäggi A (2017) The EGSIEM combination service for monthly gravity fields, IAG Workshop Satellite Geodesy for Climate Studies, Bonn

Meyer U, Jean Y, Bentel K, Arnold D and Jäggi A (2017) GRACE satellite gravimetry to assess global hydrology and ice melt, 15th Swiss Geoscience meeting, Davos

Meyer U, Jean Y, Arnold D and Jäggi A (2017) EGSIEM: scientific combination service for monthly gravity
fields, IGS Workshop, Paris

Poropat L, Bergmann-Wolf I, Flechtner F and Dobslaw H (2016): Validation of EGSIEM gravity field products with globally distributed in situ ocean bottom pressure observations, (Geophysical Research Abstracts, 18, EGU2016-12478, 2016), General Assembly European Geosciences Union (Vienna 2016). http://gfzpublic.gfz-potsdam.de/pubman/item/escidoc:1503924

Jäggi, A., M. Weigelt, F. Flechtner, A. Güntner, T. Mayer-Gürr, S. Martinis, S. Bruinsma, J. Flury, S. Bourgogne; 2015: European Gravity Service for Improved Emergency Management - a new Horizon 2020 project to serve the international community and improve the accessibility to gravity field products. EGU General Assembly 2015, Vienna, Austria, 12 - 17 April, 2015.

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2.2.4 User training and skill development

2.2.4.1 EGSIEM Autumn School

The EGSIEM Autumn School for Satellite Gravimetry Applications took place at the German Research Center for Geosciences (GFZ) in Potsdam, Germany, from September 11th till 15th. In total, 45 attendees and 12 lecturers from 16 different countries enjoyed a very interesting week in the beautiful city of Potsdam. In various lectures and practical exercises, participants learned how to use the EGSIEM products and to handle the GRACE and future GRACE-FO datasets. Special focus was on geophysical application and the easy access to the data via the EGSIEM plotter. The EGSIEM Autumn School presentations are available to the public and potential users under: http://egsiem.eu/autumn-school

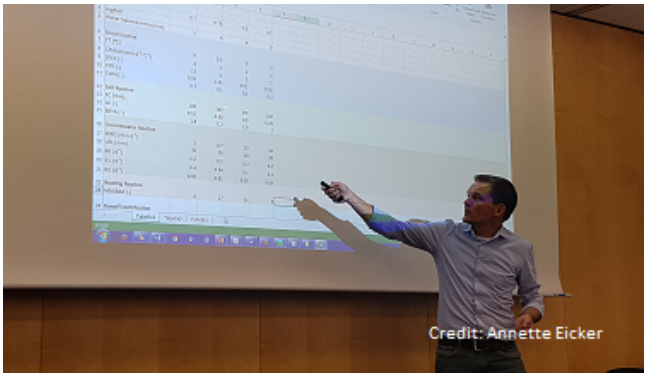

Figure 6: Impressions from the EGSIEM Autumn School including social activities (boat trip on the river Havel, Potsdam) which allowed participants to get into face-to-face dicssuions with lectures and fellow participants.

2.2.4.2 EGSIEM Student Competition

The first round of the EGSIEM Student Competition was launched on 01.10.2016 and closed on 10.11.2016. European students could participate and 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 of the EGSIEM Student Challenge began on 15.11.2016 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. This involved some online study, but also incorporated some textbooks which should already be familiar to students in the Geodesy, Hydrology, Geophysics fields. The deadline to submit theirs answers to the questions of the second round EGSIEM student challenge was 15.12.2016. Four winners of the EGSIEM Student Challenge have been announced on 10.01.2017 on the EGSIEM website and in the EGSIEM newsletter no. 9.

2.2.5 Public Relation Activities

Many public relation actives have been implemented during the EGSIEM project period such as:

1) **Newsletters:** Regular (every three month) release of EGSEIM newsletter issues provide an overview on the project progress, data products, recent results and announce upcoming EGSIEM relevant events. Each issue presented a mix of the latest development, general information on the topic and ongoing activities or was used to introduce the various members of the project as shown in the example below.

Figure 7: Examples of the newsletter which have been published quarterly

2) **Teaser lectures:** Several lectures were given to the public by various EGSIEM members. Teaser lecture addressed all levels interested people, such as pupils, students and interested laypeople.

Exemplary we mention the presentation given by the coordinator, Prof. Adrian Jäggi, at University of Bern entitled "Von Wasser, Eis und Satelliten — und was uns die Schwerkraft über Umweltveränder-ungen verrät", which was given within the framework of the "Physik am Freitag lecture series" in Bern, Switzerland. He introduced Earth sciences such as geodesy, hydrology and geophysics and showed to get to know the gravity field of the Earth and its application for monitoring natural hazards. A follow-up lecture has been organized in spring 2018 in the frame of the lecture series L'Horizon at the Gymnasium Bern Kirchenfeld, which is one of the larger grammar schools in the city of Bern, Switzerland.

3) **Social Media:** Activities on social media e.g. Facebook and Twitter have been used to post updates on new project findings, publications, technical details and reports, hot stories and other relevant news.

2.2.6 Further activities

Teatime event at Helmholtz Centre, Brussels, on March 15th, 2017

The Helmholtz-Centre Potsdam, GFZ German Research Centre for Geosciences and SwissCore invited various experts from the European Commisssion and ESA to the Helmholtz Brussels Office to a Teatime Event "GRACE-FO – the launch of a new chapter in our knowledge of the Earth's gravity field". Since mass transport data and applications are highly relevant for the development of research and innovation programmes in the EU, the U.S.A., and worldwide as demonstrated in the EGSIEM project, the intention of this meeting was to provide information on the technological background and scientific success and application potential of the Gravity Recovery and Climate Experiment (GRACE) satellite mission and to make aware on its Follow-on mission (GRACE-FO), which is due for launch early in 2018.

Service Level Agreements

To ensure a wide-ranging project which will benefit from European expertise from outside of the consortium we have concluded several Service Level Agreements: TU Dresden, Federal Agency of Cartography and Geodesy (BKG), the Space Research Institute of the Austrian Academy of Sciences, the University of Worclaw, the Hafen City University of Hamburg. The main purpose of the majority of these SLAs has been to initiate activities similar to the Scientific Combination Service for Satellite Laser Ranging (SLR). These activities were coordinated by

DGFI-TUM, who was already associated to EGSIEM via TUM (Technical University of Munich) since the very beginning of the project.

Meeting with the Copernicus Climate Change Service (C3S), Brussels, on November 29th, 2017
A meeting between EGSIEM representatives and the head (J.N. Thépaut) and deputy-head (D. Dee) of the C3S took place at the premises of the Helmholtz Office in Brussels. The main agenda point was to discuss ways to better integrate the monitoring of mass transport from Space in the Copernicus Services. The availability of one consolidated gravity product, i.e. one of the main objectives of the EGSIEM project, was appreciated by the C3S representatives as a very important and necessary first step. Future activities have been identified to focus on better anchoring mass transport in the Essential Climate Variables (ECVs) of the Global Climate Observing System (GCOS).