Newsletter

## No. 9 Jun. 2017

European Gravity Service for Improved Emergency Management

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## **EGSIEM NRT Service** .

Since March 2002, the Gravity Recovery And Climate Experiment (GRACE) satellite mission has been churning out water storage anomaly data, which have been shown to be a unique descriptor of large-scale hydrological extreme events, such as floods and droughts. Nonetheless, efforts to assess the comprehensive information from GRACE on total water storage variations for near-real time (NRT) flood or drought monitoring or forecasting have been limited so far, primarily due to the coarse temporal (monthly to weekly) and spatial (>150.000 km<sup>2</sup>) resolution currently available, and the latency of standard products of about 2 months. Some 15 years later, as of 1 April 2017, the EGSIEM consortium launched its demonstrator near-real time (NRT) daily gravity field service. In comparison to the official GRACE gravity products, the NRT solutions not only increase the temporal resolution from one month to one day, but also reduce the current latency from two months to five days. Thus, the NRT service allows for the monitoring of extremes in total water storage variations as they happen, as opposed to a 'confirmation after occurrence', which has been the situation up until now.

#### **Global Daily Solution**

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Because the satellite data coverage within one day does not allow for a gravity field solution based on GRACE data alone, the computation of daily gravity maps employs a prediction – correction principle. Information obtained from geophysical models on the temporal behavior of the gravity field are used to predict the following day, which is subsequently improved with the available GRACE observations in a Kalman filter approach. Daily gravity field solutions are made available by the GFZ German Research Centre for Geosciences and

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Porto Maua Floods from the River Uruguay on 01 June 2017 (Courtesy: <u>floodlist.com</u>).



FIG. 1: GRACE BASED WETNESS INDEX AT 30 MAY 2017 - TOP: TUG SOLUTION AND BOTTOM: GFZ SOLUTION.

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### EGSIEM NRT Service (cont'd)

the Graz University of Technology (TUG), with each analysis center providing an independent solution. TUG focuses on improving global gravity field solutions, whereas GFZ implements tailored regional representations of the gravity field. Both analysis center approaches complement each other, providing global coverage. Additional processing converts the resulting gravity field solutions, expressed in terms of spherical harmonics coefficients, into a global 1° x 1° gridded map of total water storage anomaly (TWSA) in Equivalent Water Thickness (EWT) in cm.

#### NRT Global Test Run

The example below shows the NRT satellite gravity-based Wetness Index for 30 May 2017 as visualized on the Global Flood Awareness System (GloFAS) platform (<u>http://globalfloods.irc.ec.europa.eu</u>/). GloFAS employs a web-based visualization system to present a combined Wetness Index generated from the individual indices derived from the TUG and GFZ gravity solutions within EGSIEM. Blue tones represent wetter than normal conditions, while red tones represent drier than normal conditions. The index equals the departure of the gravity anomaly from the seasonal cycle expressed in units of standard deviation. The departure is the sum of the long-term trend (inter-annual variation) and the residual (intra-annual variation). Wetter than 'normal' conditions (2.5-3 times the standard deviation) are indicated for parts in Latin America, signaling 'El Niño` conditions, prompting flooding in southern Columbia and Uruguay (<u>https://disasterscharter.org/web/guest/home</u>). Hot-spots indicate ongoing drought-related humanitarian crises in Africa e.g. in Zambia, Angola and North-Western Africa.



FIG. 2: NRT GRACE-BASED WETNESS INDEX ON 30 MAY 2017 IN THE GLOFAS FORECAST VIEWER.

For more information about EGSIEM NRT service, GRACE daily solution and applications, please refer to **Ben T. Gouweleeuw** and **Andreas Güntner** at GFZ, Potsdam.

#### **Publication**

Gouweleeuw, Ben T., Andreas Kvas, Christian Grüber, 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*, in Hydrology and Earth System Sciences Discussions, pp. 1-23, DOI: <u>10.5194/hess-2016-653</u>.



## **GNSS Loading – A Validation Tool for GRACE Products**

As one of the key scientific services of the EGSIEM project, combined GRACE gravity products are generated using various monthly GRACE solutions from the EGSIEM Analysis Centers (ACs). To ensure the quality of the EGSIEM-generated gravity products, external validation using other derived observations is essential as they can help us to identify outliers, and more importantly increase user's confidence in the project's data products. Within the EGSIEM project, external validation of gravity products using GNSS (Global Navigation Satellite Systems) loading has been undertaken at University of Luxembourg. Through the elastic loading theory, we can use the mass variations, which are independently observed by GRACE, to predict surface displacements at the GNSS stations. Consequently, GRACE-derived displacements can be compared with GNSS-observed deformation. For the GRACE data processing, we have

adopted a standard data processing procedure, i.e. restoring degree one coefficients by ones from Swenson et al. (2008), replacing the imperfect  $C_{20}$ coefficients in GRACE with SLR results, adding back the AOD1B products and finally filtering the monthly field with a Gaussian filter with a radius of 500 km. Two different GNSS datasets have been used. One is the clean and de-trended daily ITRF2014 residuals provided by Dr. Paul Rebischung (IGN). The other is the raw GNSS dataset generated within the EGSIEM project by UBERN, which utilises the standard GNSS time series analysis procedure. To validate monthly GRACE products, we average the daily GNSS observations into monthly solutions. The correlation coefficient and WRMS -60 reduction have been used as criteria to evaluate the solution performance.



**FIG. 3:** EGSIEM-GENERATED TWO-YEAR MONTHLY GRAVITY FIELDS AGAINST THE ITRF2014 RESIDUALS AT 626 GNSS STATIONS. NOTE: SUBPLOTS FOR EGSIEM SOL D90, AIUB, GFZ, GRGS AND ITSG2016 SHOW THE DIFFERENCES OF WRMS REDUCTION W.R.T. EGSIEM NEQ D90.

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#### Validating Monthly GRACE Products

An experimental set of two-year (2006-2007) monthly gravity fields have been generated by the four ACs. Their combinations both at the solution level and the normal equation (NEQ) level have been performed at AIUB within the frame of the Scientific Combination Service (see <u>Newsletter No. 6</u>). Fig. 3 presents a comparison of the EGSIEM-generated two-year gravity fields vs. the ITRF2014 residuals in terms of WRMS reduction. The combined solution on the NEQ level up to degree 90 shown in the top left displays the high positive WRMS reduction indicating its good agreements with GNSS. The other five subplots illustrate differences of WRMS reduction w.r.t. the combined NEQ level of degree 90. Similar performances are found on the combined solution level up to degree 90. Improvements of the combined solutions w.r.t. the individual solutions except ITSG2016 can be observed as well. The combined solutions show similar performances to ITSG2016. Further tests on the combined scenarios are still underway at UBERN.

#### Validating Daily NRT GRACE Products

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Within EGSIEM, two daily GRACE products have been generated by GFZ and TUG as NRT gravity services. These daily gravity fields are validated against daily GNSS time series. While for daily fields, interpolated degree-1 coefficients are used as no daily degree-1 coefficients are available yet. In addition, no filtering is required for daily fields as they have been stabilized during data processing. Cross-validations against hydrological models using the GNSS loading have also demonstrated the good quality of these two daily GRACE products, which has been enabled for their NRT service test run from 1st of April. For more information, please contact Qiang Chen (Qiang.CHEN@uni.lu).

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## - EGSIEM GRACE Plotter

The EGSIEM projects allows you to visualize results, thanks to its dedicated tool: the EGSIEM plotter. You can visit us at <u>plot.egsiem.eu</u>. The portal gives users different possibilities: First of all, users extract GRACE gravity or equivalent water heights time series over the region (point or region) of your interest or predefined hydrological basin. The portal offers the user different functionalities to visualize monthly gravity fields results from several analysis centres e.g. as geoid, spectral analysis.



FIG. 4: EWT FROM EGSIEM GRACE PRODUCTS, FILTERED WITH DDK (LEFT), EWT FOR AMAZON BASIN GRGS-RL03 (RIGHT).

#### EGSIEM Autumn School for Satellite Gravimetry Applications 11-15 Sep. 2017 | Potsdam, Germany

The EGSIEM Autumn School for Satellite Gravimetry Applications will take place from 11– 15 September in Potsdam, Germany. It offers a unique opportunity to international students in Geodesy, Hydrology and other disciplines to participate. There is no registration fee for the Autumn School, however, students will be expected to cover their own travel, accommodation and other expenses, more information about local logistics are available at (see Tab. 1): egsiem.eu/autumn-school.

Applications should consist of a one page pdf file (including a short CV, your contact details and motivational text) to be sent via email to <u>info@egsiem.eu</u>.

The registration deadline is: **31<sup>st</sup> July 2017** 

## MEET EGSIEM

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IAG-IASPEI General Assembly Kobe, Japan Jul. 30 – Aug. 4, 2017



IAG Workshop: Satellite Geodesy for Climate Studies Bonn, Germany Sep. 19 - 21, 2017

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#### TAB. 1: EGSIEM AUTUMN SCHOOL LECTURE PLAN.

DATE	Morning	Afternoon		Evening		
		GPS & GRACE Introdu	ction			
Monday	Arrivals	Adrian Jäggi/		Adrian Jäggi/		Ice Breaker
(11. September)		Ulrich Meyer		All		
Tuesday	GRACE Analysis	Hydrology I		Hydrology II		
(12. September)	Torsten Mayer-Gürr	Andreas Güntner		Annette Eicker		
Wednesday	Ice sheet signals	GIA		GNSS Loading		
(13. September)	Martin Horwath	Holger Steffen		Tonie van Dam		
Thursday	Remote Sensing	GRACE FO Se		cial & Networking Event		
(14. September)	Hendrik Zwenzner	Frank Flechtner		All		
	EGSIEM Tools					
Friday	Stéphane Bourgogne /	Departures				
(15. September)	Matthias Weigelt					

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- <u>https://twitter.com/EGSIEM</u>
- www.facebook.com/egsiem
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