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# Newsletter EGSIEM

**European Gravity Service for Improved Emergency Management**

## Inside this issue:




Happy 15th Anniversary to the Revolutionary GRACE Satellites Pioneering Measurement of the Global Water Cycle from Space (Photo: [Nasa Earth @Twitter]).

## EGSIEM Level-3 mass grids

The major goal of EGSIEM is to provide high quality GRACE monthly gravity field solutions by combining the accumulated know-how of the European GRACE community. Typically these solutions are provided as sets of spherical harmonic coefficients which represent a monthly snapshot of Earth's time variable gravity field. For most geophysical applications however, the mass redistribution which caused the change in Earth's gravitational field measured by GRACE, is of greater interest. To derive mass changes from gravity, we can exploit the fact that most of the changes are concentrated in a very thin layer on the Earth's surface. Indeed, most of the gravity variations are caused by changes in water storage in hydrologic reservoirs, by moving ocean, atmospheric mass as well as changes in the cryosphere, and by mass exchanges between these Earth system compartments. When investigating water storage changes in river basins, atmosphere and ocean masses have to be removed, leaving only the land hydrological signal behind. For this signal separation, we rely on models, which represent the different geophysical sub-systems we want to reduce from our products. Apart from the EGSIEM GRACE solution in terms of spherical harmonic coefficients we provide gridded products providing monthly mass grids for these geophysical subsystems:

- **Land hydrology:** Corrected for Glacial Isostatic Adjustment (GIA), atmosphere and ocean mass variations. Representing terrestrial water storage in Equivalent Water Height (EWH).
- **Ocean:** Ocean Bottom Pressure (OBP), corrected for GIA and terrestrial water storage to reduce land leakage as non-tidal OBP variations.

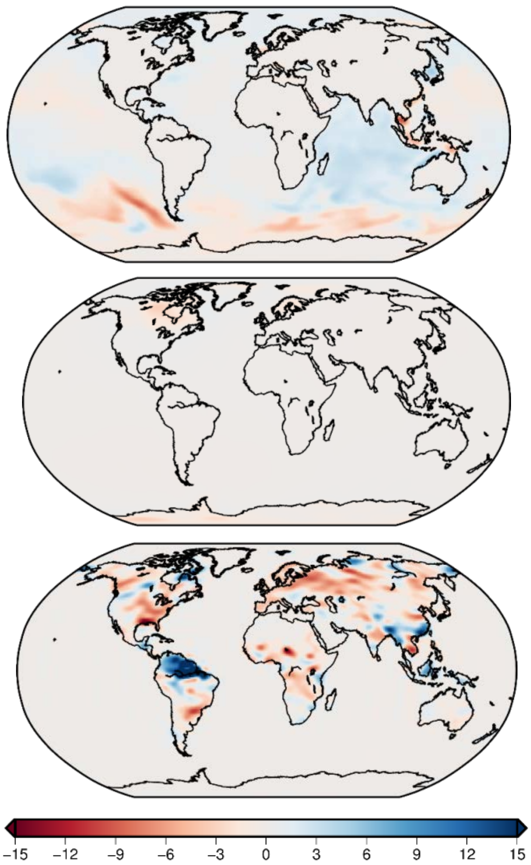


**Fig. 1:** Liquid water equivalent trend in cm/y from Top to Bottom: Ocean Bottom Pressure, GIA and Hydrology Signals.

# Global correction model for Glacial Isostatic Adjustment

The term Glacial Isostatic Adjustment (GIA) describes the response of the Earth due to changing ice-ocean load distributions on the Earth's surface. These redistributions result in deformation, as well as geopotential, rotation and stress changes. GIA is well known in northern Europe, where the absolute uplift reaches 1 cm/a near the city of Umeå, Sweden. Here, land is literally rising from the sea. GIA also leads to notable changes in Canada, Alaska, Greenland, Patagonia and Antarctica. The process generates a strong signal in many geodetic observations such as the GNSS stations and tide gauges, and of course, also in gravimetric applications such as GRACE (see Fig. 3). The GIA signal may thus overlap other signals of interest, e.g., from hydrology, the major target of EGSIEM. Fortunately, the GIA signal can be replicated via a physical model, a so-called GIA model. This generally consists of an ice history model that describes the load variation during (at least) the last glaciation, and an earth structure. A physical description of the GIA process and the corresponding sea-level variation combines these two models and at the same time calculates

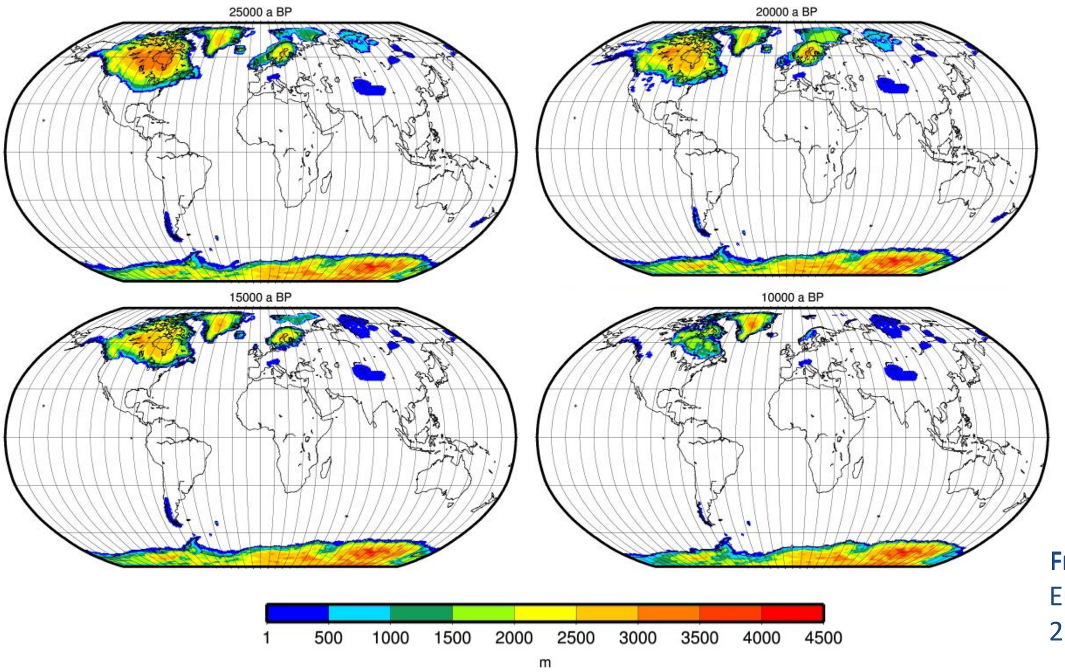


**FIG. 2:** GLOBAL ICE THICKNESS AT FOUR SELECTED TIMES OF MODEL LM17.1 (UNIT IN METER).

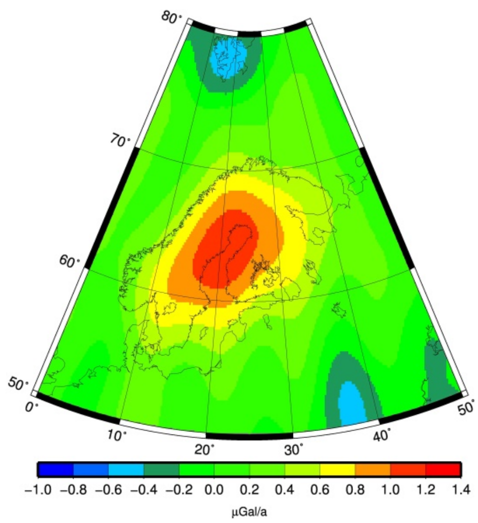


**FIG. 3:** MASS TREND SIGNAL IN NORTHERN EUROPE FROM GRACE (FILTER: GAUSSIAN 285KM, DATA: 2012-2016).

corresponding ocean load changes due to the glaciation (water is taken from the oceans to generate the ice sheets described in the ice history model). Research has shown that the ice model is the major part of a GIA model that needs to be known as accurate as possible. Currently available corrections for GRACE are based on the global ICE-5G ice model (Peltier 2004) of the last glaciation. The model is globally self-consistent when it comes to the sea-level equivalent, i.e. the amount of ocean water stored in the ice sheets during the glaciation. The model has been criticized though as some parts may not be well explained with ice physics. Therefore, we follow a different approach in the work for EGSIEM: Instead of using a global model such as ICE-5G, we combine regional, mainly thermodynamically-driven ice history models to a global one. The current model for EGSIEM is called LM17.1 and is based on the GLAC ice history for northern Europe, North America, Greenland and Antarctica (provided by Lev Tarasov, Memorial University of Newfoundland, Canada), IJ04 for Patagonia (provided by Erik Ivins, JPL, USA), ICE-6G for New Zealand (Peltier et al. 2015, doi:10.1002/2014JB011176), and ANU-ICE for Iceland and High Mountain Areas (provided by Anthony Purcell, Australian National University, Australia). Global snapshots of ice thickness can be found in Fig. 2. This model has 52 time steps covering the last 240,000 years and a spatial resolution of 0.5 degrees in longitude and latitude. The sea-level equivalent of this model is 111.7 m 25,000 years ago. As recent studies suggest that perhaps up to 10 m of ocean water were covered in groundwater and lakes as an alternative water reservoir, this model presents a reasonable first approximation. The calculated gravity anomaly will be used as GIA correction for EGSIEM products (see Fig. 3).

For more information about GIA models, applications and the correction model for GRACE, please refer to Dr. Holger Steffen, Lantmäteriet, Sweden.

# The EGSIEM student challenge 2016| The Winners

In autumn 2016, EGSIEM launched "The EGSIEM Student Challenge", a europe-wide student competition, which provided a unique opportunity for young scientists to explore the worlds of geodesy, hydrology, flood/drought monitoring and emergency management. The groups targeted were university students, both undergraduates and graduates, and residents of the European Economic Area (EEA). The EGSIEM student challenge was divided into two rounds, the first round consisting of 20 multiple-choice questions opened on the 1st October 2016, and the second round with 20 written questions started on 15th Nov. and closed on $15^{th}$ Dec. 2016. In the course of the 45 day registration period a total of 102 individuals registered themselves for the EGSIEM challenge. The valid number of registered participants was 92 (10 incomplete or ineligible entrants). Young scholars and students from 15 countries and 51 institutes successfully registered themselves for the challenge. In total 63 registered participants participated in the 1st round challenge. Among them, 37 participants answered the twenty questions correctly within the given timeframe. We are delighted to announce the four successful winners as follows:

**1st Winner**
**B.Sc. Philippa Higgins**
Institute of Hydrology and Meteorology, TU-Dresden - Germany

Philippa is an environmental engineer specializing in hydrogeology. She has a focus on groundwater management, and research interests in groundwater resources assessment and modelling, climate-surface water-groundwater interactions and climate change impacts and adaptation. She is currently studying her M.Sc. in groundwater and global change, through the Erasmus Mundus Program. Prior to her studies, Philippa worked in the Australian Office for Water Science and at the Australian Department of Climate Change.

**2nd Winner**
**B.Sc. Julian Rodriguez Villamizar**
ESPACE, Technical University of Munich
Munich – Germany

Julian graduated with a B.Sc. in Geomatics and Land Surveying Engineering from the Universidad Politécnica de Madrid. He is a M.Sc. student at the TUM in the ESPACE program. In parallel to the master studies, he is working at the DGFI and at the Institut für Astronomische und Physikalische Geodäsie as a researcher assistant. He performed research on hydrocarbon localization by multispectral and hyperspectral sensors, including an investigation on atmospheric corrections using on-scene techniques and radiative transfer models. His current research interests include geophysical phenomena in a global and regional scale with focus on ionosphere and gravity.

**3rd Winner**
**B.Sc. Peizo Cheng Rachel**
UNESCO-IHE, Inst. for Water Education
Delft – Netherlands

Rachel's current research interests includes the analysis of spatial and temporal relationship between surface and subsurface soil moisture, evaluation of remotely sensed soil moisture and/or groundwater products for practical application, improving groundwater budgets by inclusion of remotely sensed data especially in developing regions with sparse in-situ data networks. She is particularly interested in these topics within the context of climate change, sustainable water management and flood risk management.

**4th Winner**
**B.Sc. Alexandros Kazantzidis**
Dep. of Geodesy & Surveying, Aristotle University of Thessaloniki – Greece

Alexandros is a M.Sc. student at the Aristotle University of Thessaloniki, School of Rural and Surveying Engineering. Currently, he is working on his diploma thesis under the supervision of Professor Dimitrios Tsoulis. The topic of his thesis is the application of numerical integration techniques for satellite orbit determination. During a diverse and exciting 5-year curriculum he has grown a special interest in geodetic courses, such as gravimetry and satellite geodesy. He is also interested in programming languages. He is working at the time with Python and Matlab. After his M.Sc., he would like to continue with graduate studies and explore the many aspects and applications of Geodesy.

# EGSIEM CONSORTIUM INTRODUCES ITSELF

**Interview questions:**

*1 - What interests you about Geodesy?*
*2 - Describe your role in EGSIEM?*
*3 - What is the one aspect of EGSIEM you are most interested in?*

## Dr. Holger Steffen
EGSIEM Associate Member
Lantmäteriet, Sweden

**1** – Sciences are interdisciplinary. I am actually a geophysicist by training, but had, thanks to GRACE, the chance to branch into the field of geodesy. From all the different disciplines, I like - guess what - gravimetry the most as it ties geophysics and geodesy. Gravimetry helps not only in unravelling the secrets of the inner Earth such as the composition of the crust and flow paths of water, it also delivers using absolute gravity measurements and GRACE important insights into the process of Glacial Isostatic Adjustment (GIA).

**2 –** I am involved via a so-called Service Level Agreement in EGSIEM. My task is to provide a global model of GIA. GIA is one of the processes generating partly large signals of mass changes in selected parts of the world, which make it difficult to identify a hydrological signal of interest. At Lantmäteriet, we have decades of experience with GIA observation, modelling, and correction in the Nordic countries of Europe. We eventually expand our area of interest now to the whole globe.

**3 –** The combined gravity field solution. When I started using GRACE data in 2007, I already had the option to select between 5 different solution centers, and this number increased since then. Analyses lead to, of course, different results although some common signals were evident, but it was hard to find the one for my purposes. The combined solution is expected to be the best one.

## Dr. Krzysztof Sośnica
EGSIEM Associate Member
Wrocław University, Poland

**1** – Accuracy. It is amazing that geodesy is able to measure distances of thousands of kilometers between continents, ground stations and satellites, and even ground stations and the Moon with the accuracy of single millimeters. As a result, we are able to describe the geometry, gravity and rotation of whole planets with extraordinary precision. The main goal of the very first observations of artificial satellites was to connect geodetic networks on various continents with the accuracy of 1 meter. Today, the geodetic obervations are better by three orders of magnitude.

**2** – One of the fundamental EGSIEM products are the monthly GRACE gravity field solutions. However, GRACE is insensitive to the geocenter motion. The Earth's oblateness derived from GRACE is affected by disturbances with a period of about 160 days. Therefore, geocenter and Earth's oblateness need to be derived from Satellite Laser Ranging (SLR) to geodetic spherical satellites. My role is to provide SLR-based gravity field products as a contribution to the combined SLR solutions.

**3** – GRACE products provide gravity field parameters which are, however, greatly correlated. The combination of GRACE and SLR solutions should reduce these correlations, and thus, help to separate between the gravity signals included in different coefficients. Such an analysis, with the goal of deriving uncorrelated gravity signals, is very interesting.

# 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 for international students in Geodesy, Hydrology and other disciplines.

This autumn school is being generously supported by the Helmholtz Centre Potsdam GFZ Research Centre for Geosciences and the German Federal Ministry of Education and Research (BMBF).

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 will shortly be available at 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 info@egsiem.eu.

The registration deadline is: **31st July 2017**

The following topics will be covered in the EGSIEM Autumn School:

- Analysing GRACE Data – **Torsten Mayer-Gürr/Ulrich Meyer**
- Glacial Isostatic Adjustment – **Holger Steffen**
- GPS & Orbit Determination – **Adrian Jäggi**
- GRACE Follow On Mission – **Frank Flechtner**
- Ice Sheet Signals – **Martin Horwath**
- The EGSIEM Plotter – **Stéphane Bourgogne/Matthias Weigelt**
- Remote Sensing – **Hendrik Zwenzner**
- GNSS Loading – **Tonie Van Dam**
- Hydrology – **Annette Eicker/Andreas Güntner**

# MEET EGSIEM

**Fourth Swarm Science Meeting**
**Banff ,Alberta, Canada**
Mar. 20 - 24, 2017

**European Geosciences Union**
**Vienna, Austria**
Apr. 23 - 28, 2017

# KEEP IN TOUCH

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**Contact:**
EGSIEM, Astronomical Institute
University of Bern
Sidlerstrasse 5
3012 Bern
Switzerland
info@egsiem.eu