EGSIEM Level-3 mass grids

The major goal of EGSIEIM 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 EGSIEIM 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.**
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 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.
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 1st October 2016, and the second round with 20 written questions started on 15th Nov. and closed on 15th 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

Philiippa 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 include 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 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:

1. Analysing GRACE Data – Torsten Mayer-Gürr/Ulrich Meyer
2. Glacial Isostatic Adjustment – Holger Steffen
3. GPS & Orbit Determination – Adrian Jäggi
4. GRACE Follow On Mission – Frank Flechtner
5. Ice Sheet Signals – Martin Horwath
6. The EGSIEM Plotter – Stéphane Bourgogne/Matthias Weigelt
7. Remote Sensing – Hendrik Zwenzner
8. GNSS Loading – Tonie Van Dam
9. 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

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