Newsletter EGSIEM

European Gravity Service for Improved Emergency Management

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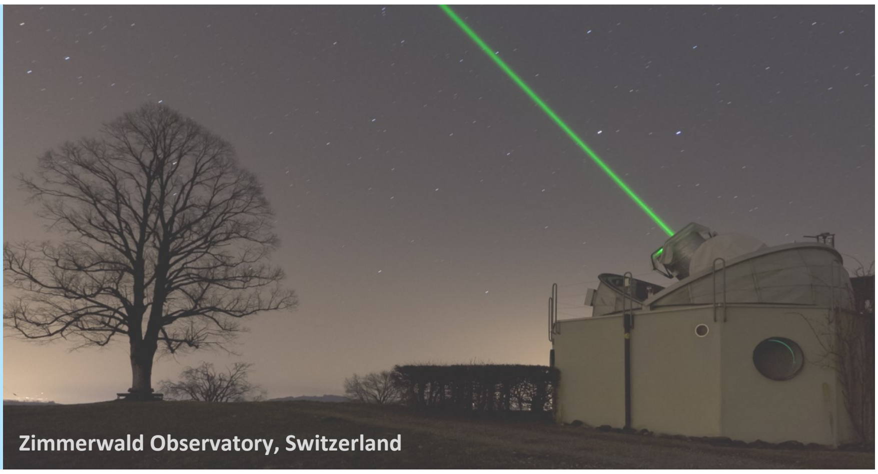
Inside this issue:

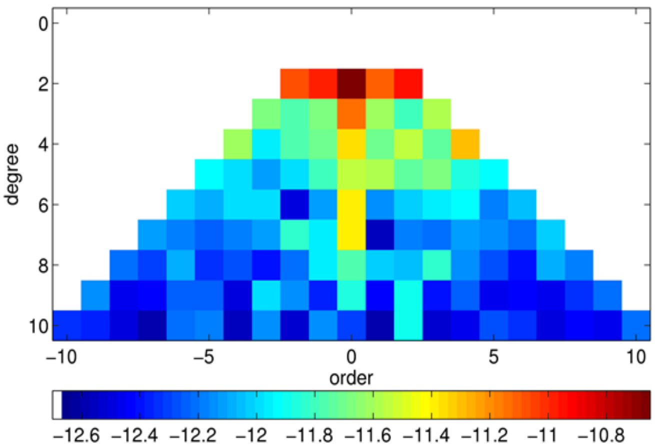


Zimmerwald Observatory, Switzerland

Expanding the Combination Service

The combination service is one of the three key scientific services of EGSIEM which aims to produce consistent, reliable and validated monthly gravity fields of the Earth. The key observable for monthly gravity fields is the inter-satellite range-rate between the two GRACE satellites that is observed with the stupendous accuracy of about 0.3 µm/s by the K-band instrument. However, this is not the only observable sensitive to temporal gravity variations. At large spatial scales monthly gravity field coefficients can be derived from the kinematic satellite orbits of Low Earth Orbiters (LEOs) that are determined by **GPS** observations alone. And for variations in Earth's oblateness (C20-coefficient) Satellite Laser Ranging (**SLR**) to spherical satellites is the most accurate technique to date.

It was therefore decided to open up the EGSIEM project to gravity field solutions derived from GPS and SLR.

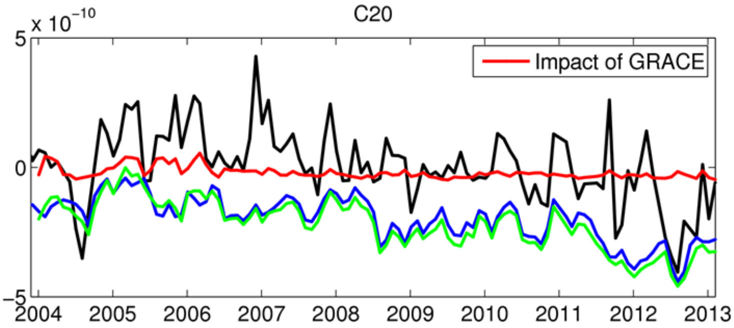


Contribution of SLR to the unit-less spherical harmonic coefficients of a GPS/SLR combined monthly gravity field.

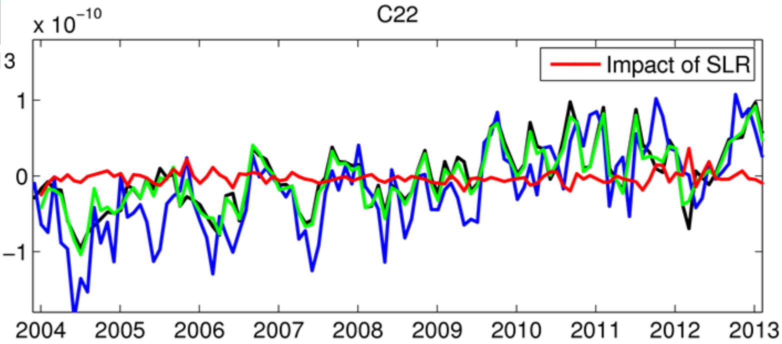
The advantages to the project are two-fold:

- the weakly determined C20-coefficients in the GRACE-derived monthly gravity fields are stabilized by **SLR**, and,
- in the probable case of failure of the GRACE mission before the launch of GRACE-FO (planned for 2017, see story on page 3 for more about the original GRACE mission) **GPS**-derived gravity fields of the orbits of other LEOs can be used to bridge the data gap.

Expanding the Combination Service (cont.)



*(Left) Monthly C20 values that are derived from GRACE observations alone (**black**) show large scatter that is much reduced in SLR only solutions (**blue**). The combination (**green**) is dominated by SLR, the impact of GRACE remains small (**red**).*

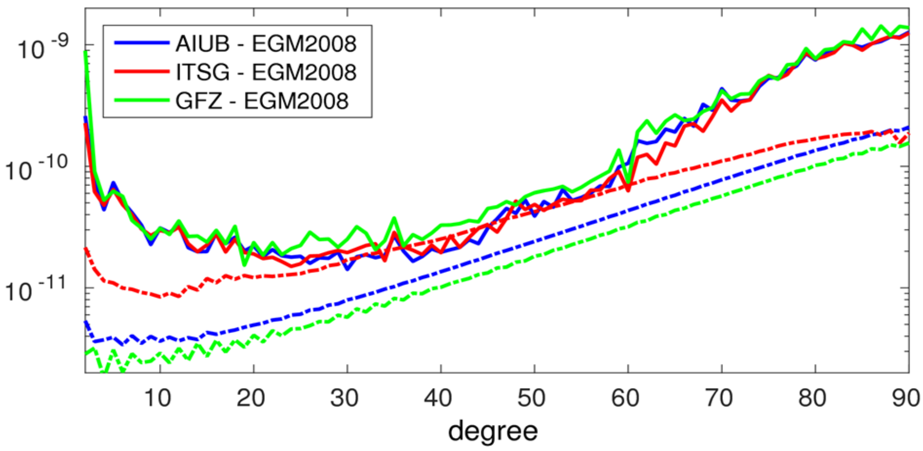


*(Right) In the case of C22 the role of GRACE and SLR is inverted, SLR (**blue**) showing a large scatter that is much reduced in GRACE solutions (**black**). Combined solutions (**green**) are dominated by GRACE, the impact of SLR solutions remains small (in **red**).*

Towards a first combination on normal equation level of the contributions of different ACs

In a first step the individual monthly gravity field contributions of the different Analysis Centers (ACs) are compared and combined at solution level. This effort is helpful for quality control and to derive empirical weights from the comparison of the individual monthly gravity fields to their arithmetic mean. The weighted combination of the gravity fields already shows a very significant reduction of noise compared to the individual fields. In step two the individual contributions are combined at the Normal Equation (NEQ) level. This is necessary to take into account all correlations between the gravity field parameters and the AC-specific orbit and instrument-parameters.

Prior to combination the individual NEQs are transformed to common a priori values. Afterwards relative weights for the combination have to be defined and at this point a principle problem is encountered. All ACs apply different noise models that lead to variable levels of the formal errors specific to each individual solution. A simple noise model results in optimistic formal errors, while a more complex noise model that is based, e.g., on empirical co-variances, leads to more realistic formal errors.



Difference degree variances between individual monthly solutions of the 3 ACs and a long-time static gravity field. The corresponding formal errors are also given dash-dotted. At low degrees the difference degree variances are dominated by physical temporal gravity variations, starting from approx. degree 30 they are dominated by noise. Beyond degree 60 aliasing of slowly varying physical signal into resonant order 61 disturbs the picture. The formal errors of AIUB and GFZ are clearly optimistic.

Realistic formal errors result in a significantly higher a posteriori RMS and consequently in lower relative weights, independent of the actual quality of the gravity field coefficients in the NEQ. The variance factors computed from the intrinsic statistics of the NEQs therefore are only of limited use for the actual combination of the NEQs. To multiply with the weights derived by the comparison of the solutions first a weighting scheme has to be derived that leads to a fair contribution of all individual NEQs to the combination.

First tests in this direction were presented at EGU2016, April 18-22, Vienna.

Physik am Freitag Lecture

On Friday 11. March 2016 Prof. Dr. Adrian Jäggi of the Astronomical Institute, University of Bern gave a public lecture (in German) entitled *On Water, Ice and Satellites - what they and gravitational fields reveal to us about environmental changes*. The talk was part of the annual *Physik am Freitag* (Physics on Friday) lecture series hosted by the University and around 80 members of the public attended the lecture and a small drinks reception afterwards.

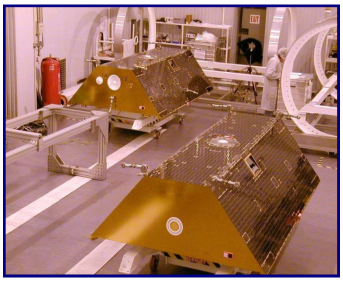
If you would like to read more about the lecture, see some more pictures of the event and be able to view the presentation then please take a look at http://egsiem.eu/.

EGSIEM Publication

AIUB-RL02: an improved time series of monthly gravity fields from GRACE data

The EGSIEM project is pleased to announce their latest publication, written by scientists at the University of Bern (Ulrich Meyer, Adrian Jäggi, Yoomin Jean & Gerhard Beutler).
Release AIUB-RL02 of monthly gravity models from GRACE GPS and K-Band range-rate data is based on reprocessed satellite orbits referring to the reference frame IGb08. The release is consistent with the IERS2010 conventions. Improvements with respect to its predecessor AIUB-RL01 include the use of reprocessed (RL02) GRACE observations, new atmosphere and ocean dealiasing products (RL05), an upgraded ocean tide model (EOT11A), and the interpolation of shallow ocean tides (admittances). The stochastic parametrization of AIUB-RL02 was adapted to include daily accelerometer scale factors, which drastically reduces spurious signal at the 161 day period in C20 and at other low degree and order gravity field coefficients. When compared to the official GFZ-RL05a and CSR-RL05 monthly models, the AIUB-RL02 stands out by its low noise at high degrees, a fact emerging from the estimation of seasonal variations for selected river basins and of mass trends in polar regions. Two versions of the monthly AIUB-RL02 gravity models, with spherical harmonics resolution of degree and order 60 and 90, respectively, are available for the time period from March 2003 to March 2014 at the International Center for Global Earth Models (ICGEM) or from ftp://ftp.unibe.ch/aiub/GRAVITY/GRACE

HAPPY BIRTHDAY GRACE !



Just over fourteen years ago (17.3.2002) the twin satellite system known as **GRACE** (*Gravity Recovery And Climate Experiment*) blasted off from the Plesetsk Cosmodrome (a site originally designed in 1957 to launch Inter-Continental Ballistic Missiles!) which lies some 800 km to the north of Moscow. Although the satellites weigh only 487 kilos each their influence on the fields of Geodesy and Hydrology have had considerable impact, far outstripping their initial planned duration of only 5 years. Since its launch, GRACE has observed a number of significant changes in the water cycle. GRACE revealed losses in the ice masses of Alaska, Antarctica and Greenland (the most dramatic loss of all). The gravity measurements revealed how much the melting glaciers are contributing to sea level rise by recording both ice lost from the land and the mass gained in the ocean. We look forward to the next chapter when the GRACE Follow-On (GRACE FO) mission is due to be launched next year.

THE 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?*

Prof. Dr.-Ing. Jakob Flury

1 - Mapping the Earth has always fascinated me, whether it were hiking maps of interesting landscapes, or maps about global change and geophysical processes. At the university and in the field, it was more about the particular beauty and challenge to learn how an instrument works, and how to squeeze out its best performance. Now, as a researcher and teacher, it is a privilege and fun to work with the excellent sensor data from satellite missions such as GRACE, and to interpret the signals we see. And when we are mapping gravity changes and investigating related signals in the satellite sensors, it is often about new things that have not been studied or seen in this particular way before. Geodesy is a rather small field, but offers tons of interesting things to do and see.

2 - I lead the Hannover contributions to EGSIEM - but that is a rather small role, compared to the actual research work done by the group members. We study whether and how to integrate new insight from the satellite sensor data analysis into the processing chain for the improved estimation of gravity and mass variations. In addition, we develop and coordinate outreach activities such as those described by Tamara.

3 - It is the collaboration of Europe's leading experts on this field. When you attend to the very concise and effective discussions between the EGSIEM scientists at the General Assemblies and progress meetings, you can see the research ideas developing and progress taking place - that is very rewarding.

Leibniz Universität Hannover

Institute of Geodesy

www.uni-hannover.de **www.ife.uni-hannover.de**

Dr.-Ing. Tamara Bandikova

1 - I am fascinated by the whole field of satellite geodesy, which focuses on observation of the Earth (and other celestial bodies) from space using various measurement techniques. It is a task of the geodesists to develop such measurement techniques as well as data processing strategies. For this reason, the geodesists represent an inevitable part of the satellite mission development and operation team. Being a geodesist you stand with your feet solidly on Earth, but fly with your head in space, which for me is a great feeling.

2 - For the whole last year, I was involved in both scientific and public relation activities. I was the editor and graphical designer of the EGSIEM Newsletters and EGSIEM brochure. I also created a concept of a European-wide student competition, The EGSIEM Challenge, which will be launched later this year. Regarding the scientific work, I analyzed the GRACE satellite sensor data and worked on improvement of their accuracy. Although I had a wonderful year in EGSIEM, I am no longer part of it. Starting from April this year, I do my PostDoc research at the NASA/Caltech Jet Propulsion Laboratory in Pasadena, CA.

3 - The exciting new way of using GRACE gravity field data for forecasting and monitoring of large-scale floods and droughts is truly something which was unthinkable at the beginning of the GRACE mission 14 years ago. This is only possible thanks to the improved data quality and processing strategies. Also, the EGSIEM Challenge will be a great opportunity to bring the science closer to the general public, especially to the young generation and to increase the awareness about the importance of Earth observation.

Dr.-Ing. Akbar Shabanloui

1 - Since childhood I was interested in the Earth system, its environments and space. As a high school student, I learned in physics class about the history of Johannes Kepler, Isaac Newton and their laws about the orbital mechanics and classical (Newtonian) mechanics and in chemistry the orbiting of electrons around the protons. I was wondering how orbital dynamics repeat themselves as a natural pattern from micro level in chemistry to macro level in astronomy. Therefore, observing satellite orbits with sensors, modeling them with mathematical tools and finally determining the orbits based on observations has always excited me. Geodesy is a discipline that fuses many of my interests about the Earth, environment and space.

2 - At EGSIEM, I am responsible for the quarterly EGSIEM newsletter, public relations activities and GRACE-sensor analysis.For this year, I am preparing some outreach activities such as a competition for students around Europe in the context of EGSIEM. It gives European students opportunities to be familiarized with the challenges in satellite geodesy and the benefit of geodesy for understanding and managing the Earth system.

In addition, I developed a GUI software for analyzing/visualizing the monthly solutions of GRACE products from different analysis centers with different settings. This software gives scientists opportunities to test and visualize different settings on GRACE data/products to see, without complexity, if those settings might improve the estimated mass transport in the target region.

3 - I am excited to have joined the EGSIEM project and to have the opportunities to work with a lot of experts in the gravity field community in order to find out if these activities may help to improve the management of emergencies e.g. droughts and floods in Nature.

MEET EGSIEM

European Geosciences Union, Vienna
April 17th-22nd, 2016

ESA Living Planet Symposium, Prague
May 9th-13th, 2016

COSPAR Scientific Assembly, Istanbul
July 30th-August 7th, 2016

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