

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

Action acronym: **EGSIEM**  
 Action full title: **European Gravity Service for Improved Emergency Management**  
 Grant agreement no: **637010**

**Deliverable 7.4  
Summer school Lecture Notes**

Date: 22. November 2017



The poster features the EGSIM logo at the top, a QR code on the left, and images of satellite instruments. The main text reads: 'International Autumn School The EGSIM Autumn School for Satellite Gravimetry Applications 11 – 15 September 2017 GFZ Helmholtz Centre, Potsdam, Germany'. A paragraph describes the school's focus on satellite gravimetry. A list of topics and speakers is provided, including 'Analysing GRACE Data – Torsten Mayer-Gürr/Ulrich Meyer' and 'GRACE Follow On Mission – Frank Flechtner'. The 'GRACE FOLLOW-ON' logo is also present. At the bottom, it lists the registration deadline (31st July 2017), the organizing institutions (GFZ and the German Federal Government), and the Horizon 2020 grant agreement number (637010).

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## 1.Change Record

<b>Name</b>	<b>Author(s)</b>	<b>Date</b>	<b>Document ID</b>
Draft 1	KC-G	08.11.17	D7.4_Lecture_Notes_v1
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## Table of Contents

1. Change Record .....	2
2. Terms.....	4
3. Summary.....	5
4. Advertisement.....	6
5. School Details .....	7
6. Lecture Notes .....	9
7. Acknowledgements .....	9
8. Annexes .....	10



## 2. Terms

The EGSIEM description of Action states that young scientists and students will be prepared for usage of EGSIEM products in a one-week summer school to be conducted in the third year of the project. The original text states that the school would provide...

“...half-day presentations (morning sessions) on the topics covered within the project and train the participants in the usage of the data (afternoon sessions). The presentations will be augmented by inviting high profile guests giving presentations on selected topics. Lecture notes will be prepared and distributed resembling also a comprehensive manual to the products. The notes will be made available on the website.”

This report will give a brief insight into the planning and preparation of the summer school, and provide weblinks to the presentations provided at the school.

### 3. Summary

As part of the overall dissemination and exploitation strategy of the EGSIEM project a summer school was envisaged from the very beginning of project planning. The school was designed to serve two main purposes i) to teach a broad-section of scientists how to use EGSIEM (and related) products, and ii) to learn how to produce and interpret gravity field data. The school was initially planned to take place in the second half of the final project year which we are pleased to confirm that it did, however, because of a delay in finding suitable premises (and additional funding) it was eventually launched as an **Autumn** school as it took place in September. Although funds had been set-aside within the original application to support lecturer travel it was decided that to encourage younger scientists to attend, the school itself would need to be free to all (though applicants would need to cover their travel and accommodation costs). In addition to students who applied to come to the school (there was a pre-selection process in place, which is common amongst such schools) it was also attended by two winners of the earlier EGSIEM competition whose travel and accommodation were paid for by the project.

## 4. Advertisement

The main instrument for advertising and disseminating information about the school was a dedicated subpage of the project website ([egsiem.eu/autumn-school](http://egsiem.eu/autumn-school)), this was initially published in March 2017.

In addition to displaying the project poster (this was updated when new information was available, ie revised lecturer list and indicative timetable) and application deadlines and details it was later used to disseminate practical information on travel and accommodation. In addition to the webpage the consortium was able to utilize some aspects of social media, and there were regular updates on Facebook and Twitter.

The school was advertised by the consortium to their students during lectures and was also featured in the IAG (International Association of Geodesy) Newsletter. What produced the most far-flung results were a series of emails which advertised the school and which were targeted at all known European Geodesy higher education centres (building on work undertaken by colleagues at Leibniz Universität Hannover), according to feedback gained from students the event was also featured on the ESA and IUGG websites.

When the definitive list of attendees was known the webpage was then superseded by an email distribution list for attendee specific information and a dedicated subpage was set up purely for attendees (students and lecturers) where they could access supporting information provided by the lecturers (software, practical information as well as presentations).

## 5. School Details

The Autumn School took place at GFZ, Potsdam from Monday, 11. until Friday 15. September. There were 46 students in total, this included the third and sixth placed [EGSIEM competition winners](#). Unfortunately the lady who was placed third overall was unable to attend owing to a clash with a graduation ceremony, the fifth-placed winner was invited but they also could not come so it was actually the sixth-placed winner who attended. Including the twelve lecturers and an additional EGSIM consortium member the total people attending was 59 (not including local support staff at GFZ Potsdam).



**Fig. 5.1** Maps showing origin of EGSIM Autumn School Entrants with European detail (to the right)



The School was attended by a wide-range of attendees from different geographical and disciplinary backgrounds (of the 46 students, 28 were currently studying Geodesy, 12 were from a hydrological background 3 came from physics and 1 engineering). As you can see from Figure 5.1 the majority of attendees came from Europe, but some students came from further afield.

**DELIVERABLE 7.4**Summer School  
Lecture Notes

In Table 5.1 (below) you can see the format of the school.

DATE	Morning		Afternoon		Evening
<b>Monday</b> (11. September)	<b>Arrivals</b>		<b>Registration &amp; Welcome</b> Jäggi/Flechtner 14:00-15:00	<b>GPS &amp; GRACE Intro</b> Adrian Jäggi - Ulrich Meyer 15:00 – 17:30	<b>Ice Breaker</b> All 18:00
<b>Tuesday</b> (12. September)	<b>GRACE Analysis</b> Torsten Mayer-Gürr		<b>Modelling the Hydrological Cycle (Hydrology I)</b> Andreas Güntner		<b>Assimilation of GRACE data into hydrological models (Hydrology II)</b> Annette Eicker 19:00-20:30
	<b>Lecture</b> 09:30-11:00	<b>Practical</b> 11:30-13:30	<b>Lecture</b> 14:30-16:00	<b>Practical</b> 16:30-18:00	
<b>Wednesday</b> (13. September)	<b>Ice sheet signals</b> Martin Horwath		<b>GIA</b> Holger Steffen		<b>GNSS Loading</b> Tonie van Dam 19:00-20:30
	<b>Lecture</b> 09:30-11:00	<b>Practical</b> 11:30-13:30	<b>Part I-Introduction</b> 14:30-16:00	<b>Part II-Observations</b> 16:30-18:00	
<b>Thursday</b> (14. September)	<b>Remote Sensing</b> Hendrik Zwenzner		<b>GRACE FO</b> Frank Flechtner 14:00-15:00	<b>Cruise</b> All 16:00-19:00	
	<b>Lecture</b> 09:00-10:30	<b>Practical</b> 11:00-13:00			
<b>Friday</b> (15. September)	<b>EGSIEM Tools</b> Stéphane Bourgogne & Matthias Weigelt		<b>Departures</b>		
	<b>Lecture</b> 09:00-10:30	<b>Practical</b> 11:00-13:00			

**Table 5.1** Timetable of the EGSIM Autumn School

As one can see, the timetable was arranged broadly thematically to allow a logical progression for students who may not have been specialists in all fields covered by the school. Such an approach was only possible because of the flexibility of the invited lecturers, for which we would like to thank them, and for their time and enthusiasm.

In addition to the scientific events there were two free social events to encourage students to mingle and get to know each other and their chosen disciplines. The first was a drinks reception given on Monday evening and the second was a cruise on the lake surrounding Potsdam.



## 6. Lecture Notes

The presentations given at the Autumn School are available at the following urls

Presenter	Title	URL
Jäggi	Precise Orbit Determination of Low Earth Orbiters using the Global Positioning System	<a href="http://www.egsiem.eu/images/static/Autumn-School/Presentations/Jaeggi.pdf">www.egsiem.eu/images/static/Autumn-School/Presentations/Jaeggi.pdf</a>
Meyer	GRACE mission, gravity field determination and EGSIM scientific combination service	<a href="http://www.egsiem.eu/images/static/Autumn-School/Presentations/Meyer.pdf">www.egsiem.eu/images/static/Autumn-School/Presentations/Meyer.pdf</a>
Mayer-Gürr	GRACE Analysis	<a href="http://www.egsiem.eu/images/static/Autumn-School/Presentations/Mayer-Guerr.pdf">www.egsiem.eu/images/static/Autumn-School/Presentations/Mayer-Guerr.pdf</a>
Güntner	Modelling the Hydrological Cycle	<a href="http://www.egsiem.eu/images/static/Autumn-School/Presentations/Guentner.pdf">www.egsiem.eu/images/static/Autumn-School/Presentations/Guentner.pdf</a>
Eicker	Assimilating GRACE Data into Hydrological Models	<a href="http://www.egsiem.eu/images/static/Autumn-School/Presentations/Eicker.pdf">www.egsiem.eu/images/static/Autumn-School/Presentations/Eicker.pdf</a>
Horwath	Ice Sheet Signals	<a href="http://www.egsiem.eu/images/static/Autumn-School/Presentations/Horwath.pdf">www.egsiem.eu/images/static/Autumn-School/Presentations/Horwath.pdf</a>
Steffen	Glacial Isostatic Adjustment - An introduction	<a href="http://www.egsiem.eu/images/static/Autumn-School/Presentations/Steffen.pdf">www.egsiem.eu/images/static/Autumn-School/Presentations/Steffen.pdf</a>
van Dam	Surface Mass Loading of the Solid Earth: Theory and Examples	<a href="http://www.egsiem.eu/images/static/Autumn-School/Presentations/van_Dam.pdf">www.egsiem.eu/images/static/Autumn-School/Presentations/van_Dam.pdf</a>
Zwenzner	Remote Sensing	<a href="http://www.egsiem.eu/images/static/Autumn-School/Presentations/Zwenzner.pdf">www.egsiem.eu/images/static/Autumn-School/Presentations/Zwenzner.pdf</a>
Flechtner	Status of the GRACE Follow On Mission	<a href="http://www.egsiem.eu/images/static/Autumn-School/Presentations/Flechtner.pdf">www.egsiem.eu/images/static/Autumn-School/Presentations/Flechtner.pdf</a>
Weigelt	Practical: EGSIM Plotter	<a href="http://www.egsiem.eu/images/static/Autumn-School/Presentations/Weigelt.pdf">www.egsiem.eu/images/static/Autumn-School/Presentations/Weigelt.pdf</a>
Bourgogne	EGSIM Plotter	<a href="http://www.egsiem.eu/images/static/Autumn-School/Presentations/Bourgogne.pdf">www.egsiem.eu/images/static/Autumn-School/Presentations/Bourgogne.pdf</a>
All of the above are available at: <a href="http://www.egsiem.eu/autumn-school/">www.egsiem.eu/autumn-school/</a>		

## 7. Acknowledgements

In addition to the support of the European Commission the EGSIM project would also like to thank the generous assistance provided by the German Federal Ministry of Training and Research and the German Research Centre for Geosciences, without whom the School could not have taken place in its final format.

## 8. Annexes



**Photo 8.1** Group Photo of EGSIM Autumn School Attendees (Photo Credit GFZ Potsdam)



**Photo 8.2** Social Event on the Thursday evening of the Autumn School (Photo Credit, Prof. Annette Eicker)

**DELIVERABLE 7.4**

Summer School  
Lecture Notes



This autumn school, held in the historic surroundings of the Telegrafenberg site, will educate students and young researchers in state of the art Satellite Gravimetry Applications, and prepare them for the usage of those products being developed within the framework of the EGSiEM project. Presentations from key members of the EGSiEM consortium will be augmented by guests giving presentations on selected topics.

Organisation of the autumn school is jointly managed by the EGSiEM project and GFZ. This event has received partial support from the European Union's Horizon 2020 research & innovation programme under grant agreement No. 637010, and generous funding from the German Federal Ministry of Education and Research.

The European Gravity Service for Improved Emergency Management (EGSIEM) Project consists of the following partners:

DATE	Morning	Afternoon	Evening
Monday	Arrivals	Registration & Welcome Reception	Ice Breaker at 18:00
Tuesday	GRACE Analysis	Hydrology I	Workshop I 18:00-20:00
Wednesday	Sea Level Signals	GLA	GRACE Learning 18:00-20:00
Thursday	Remote Sensing	GRACE FO	Open Air Meeting
Friday	GRACE Data	Dissemination	Departures

**International Autumn School**

**The EGSiEM School for Satellite Gravimetry Applications**

11 – 15 September 2017  
GFZ Helmholtz Centre, Potsdam, Germany

The EGSiEM Autumn School will be held at:

Haus H, Helmholtz Centre Potsdam  
GFZ German Research Centre for Geosciences  
Telegrafenberg  
14473 Potsdam, Germany  
Tel.: +49 (0)331 288-0

**Adrian Jäggi**  
Universität Bern  
Global Positioning Systems

Precise Orbit Determination (POD) with GPS has for 20 years been used as one of the standard techniques to derive satellite trajectories in low Earth orbit (LEO). Since the launch of dedicated gravity missions, GPS is not only used as key tracking system for LEO POD and as a necessary prerequisite to analyze dedicated measurements such as GRACE inter-satellite K-Band data, but also for extracting the long wavelength part of the Earth's gravity field. The lecture gives an introduction into the analysis of GPS data for LEO POD and presents different orbit determination strategies.

**Ulrich Meyer**  
Universität Bern  
Introduction to GRACE

One of the main goals of the GRACE mission over the past 15 years has been to observe the medium to short wavelength part of the Earth's gravity field and its temporal variations, and additionally to measure the twin satellites' orbits (the inter-satellite range is measured with micrometer accuracy). This lecture gives an overview of the GRACE mission and data processing, and offers a first glimpse of the main products available, and their application.

**Torsten Mayer-Gürr**  
TU Graz  
GRACE Data

One of main products of the GRACE mission are the monthly gravity field solutions in terms of spherical harmonics. These products are not easy to handle and to interpret. This lecture explains some properties of the solutions. It will also give an overview on how to process the data for mass transport interpretation. This includes filtering and gridding, and the transformation in terms of total water storage or equivalent water heights. In the practical MATLAB software will be developed to compute such results.

**Andreas Güntner**  
GFZ  
Modelling the hydrological cycle

This lecture will give an overview of the components of the global water cycle and an introduction into the concepts of hydrological modeling. Focus is given to illustrating different water storage compartments and the value of time-variable gravity data to quantify their dynamics. During practicals students will use a hydrological model to experience the interplay of water fluxes and water storage dynamics as influenced by model parameterization. The basic principles of model calibration as a strategy of turning the model structure and model parameters in a way that simulation results correspond to observations will be conveyed within a calibration exercise.

**Annette Eickert**  
HCU Hamburg  
Assimilating GRACE data into hydrological models

Data assimilation (DA) is a tool for integrating observations into numerical models in order to provide more realistic model results. We will introduce the concept of data assimilation for integrating GRACE observations into hydrological models. The approach allows us to improve the model results, but also delineate GRACE observations into individual hydrological storage compartments and increase the spatial and temporal resolution of water storage estimates. The methodological concept of the ensemble Kalman filter method of DA will be introduced and the associated challenges discussed.

**Martin Horwath**  
TU Dresden  
Ice Sheet Signals

The lecture introduces processes related to ice sheet changes, ranging from local glaciological phenomena to global sea level fingerprints. These processes add up as prominent signals in GRACE satellite gravimetry. They also affect a wealth of complementary geodetic observations. The lecture illustrates how a combination of geodetic techniques, together with glaciological and geophysical modeling, leads to an improved understanding of ice sheet processes. Exercises will give participants access to current results and challenges.

**Holger Steffen**  
Lantmateriet  
GIA

Glacial isostatic adjustment (GIA) describes the response of the Earth in terms of deformation as well as stress, rotation and geopotential changes due to changing ice-ocean load distributions on the Earth's surface. The lecture will give an overview of the determination, observation and modelling of GIA from the initiation of the first measurements about 300 years ago in Fennoscandia to the most recent advances thanks to satellite-geodetic techniques.

**Tonie van Dam**  
Uni du Luxembourg  
GNSS Loading

The Earth responds elastically to surface mass loading. Many publications have demonstrated that GNSS is capable of observing these displacements. GNSS combined with GRACE observations allows us to refine the mass load at a finer scale in regions where GNSS is sufficiently spatially dense, and by analysing the horizontal motions, we can determine where the load is located. In this session, we will review elastic loading theory. We will demonstrate the theory that allows us to compare GRACE and GNSS observations. We will also review the literature that compares GNSS and GRACE to outline the limitations and the benefits of these comparisons.

**Hendrik Zwenzner**  
DLR-ZKI  
Remote Sensing

This lecture and practical will present an overview of different space-based earth observation techniques and mechanisms currently in use. Special focus will be placed on the application of SAR satellite data for flood mapping. Examples from the rapid mapping service of DLR's Center for satellite-based Crisis Information (ZKI) will be presented and discussed during this session.

**Frank Flechtner**  
GFZ  
GRACE FO Mission

The GRACE Follow On (FO) mission, due for launch early 2018, will continue providing time-variable estimates of the Earth's gravity field for a period of up to five years at a precision and temporal sampling equivalent to that achieved with GRACE. The FO will provide quick look (<24h) products for enhanced operational use for water resource management and will demonstrate inter-satellite interferometry in LEO for future gravity missions. The talk will focus on the mission status and will also give an outlook on potential Next Generation Gravity Missions.

**Matthias Weigelt**  
LU Hannover  
EGSIEM Tools

Dissemination is an essential part of the EGSiEM project therefore we developed the EGSiEM plotter which allows easy but powerful access to GRACE data. Users can be overwhelmed by the number of available solutions and preprocessing possibilities on offer. The EGSiEM plotter simplifies these variables considerably. Individual & combined solutions are available for various applications which automatically consider various preprocessing steps.

**Stéphane Bourgoigne**  
géode & cie  
The EGSiEM Plotter

The GRACE mission allows us to monitor mass transfers and water variations all over the globe. We have designed and built a tool to instantly visualize the results by simple clicks on a web page: The EGSiEM Plotter. We will explore the full possibilities of the tool together with the students, and discover how mass distribution is changing rapidly over the Earth, either in a periodic fashion (monsoons, seasonal effects over equatorial areas...), or in a secular fashion (ice melt at the poles).

**Fig. 8.2 EGSiEM Autumn School Flyer**