Karlsruhe Institute of Technology

Geophysical Institute, KIT-Department of Physics
Hertzstr. 16, 76187 Karlsruhe
www.gpi.kit.edu/index.php

Contact for alumni affairs: Kerstin.Dick@kit.edu

NEWSLETTER OF THE GEOPHYSICAL INSTITUTE

Issue 16, December 2019

DEAR GPI ALUMNI

The second half of 2019 went by rather quickly and on the following pages you will find a selection of our current research. I personally find the breadth and width for our small institute rather impressive and I am looking forward to seeing many more new exciting projects coming up in 2020.
As you might know KIT has been selected as one of the new excellence universities in Germany. We are currently exploring several opportunities how this program might help to strengthen GPI in the future and will keep you updated on these developments in the forthcoming Alumni letters.

We wish all our Alumni Merry Christmas and Happy New Year!

Andreas Rietbrock

TEACHING

By Ellen Gottschämmer

The demand for our English Master degree program in Geophysics is still rising, and we received 150 applications from 23 different nationalities for winter semester 2019/20. After a strict selection process based on the courses taken in previous studies and on the proficiency in English, more than 40 applicants were accepted. Not all of them managed to receive their visa in time or struggled with other difficulties, so we started with approximately 20 students in our three compulsory courses in Geophysics (Seismics, Seismology and Physics of seismic instruments) in October. Additionally, students need to choose several elective courses which are partly offered by GPI. However, students are also free to take content-related courses from other departments as electives if they wish.

A course which is suitable as elective was conducted for our master students at the end of last summer semester. Together with our students we spent four days in Thuringia where they could study effects of induced seismicity from mines and reservoir dams.

The lecture included field observations at Leibis Lichte dam, Merkers mine, a sinkhole area and several quarries. Additionally, students had to give presentations about scientific topics which were discussed in the group.

This lecture was not only valuable in terms of gaining new knowledge in Geophysics but also regarding group dynamics. This was especially obvious during our barbeque night where we could taste food prepared in the style of the home countries of our students (nine different countries in that case!).

In winter semester 19/20 there will be another in situ lecture conducted for the students in the Master program which can again be part of their electives: In February 2020 we will go to the Eifel volcanic fields where we will train them to install seismometers in the field, analyze seismic data and interpret it in the context of seismo-volcanic activity. Other electives offered by GPI this winter semester are high-frequency surface-wave methods by Yudi Pan, a lecture on geological hazards and risk by James Daniell and me, and the Black Forest observatory course by Thomas Forbriger, to name just a few of them.

In the Bachelor degree program in Geophysics 15 new students were enrolled in winter semester 19/20. The Bachelor program has undergone some changes, with a strengthening of both, Geophysics and Computing. A new lecture on linear inversion and a new seismological field course were included in the schedule, both of them will be conducted in the fifth semester. They replace the practical course in Physics and improve our students' theoretical and practical training in Geophysics.

Figure 1: In situ lecture in Thuringia on induced seismicity in summer 2019: visit to a quarry.

Figure 2: Seminar during the in situ lecture in Thuringia. Every student had to give a short presentation about a scientifiv topic which then was discussed in the group.

Figure 3: Barbeque during the in situ lecture in Thuringia
All photos: E.Gottschämmer

THE POWER Of LANGUAGES: A nuclear thought process into the world of data and literature

By James Daniell

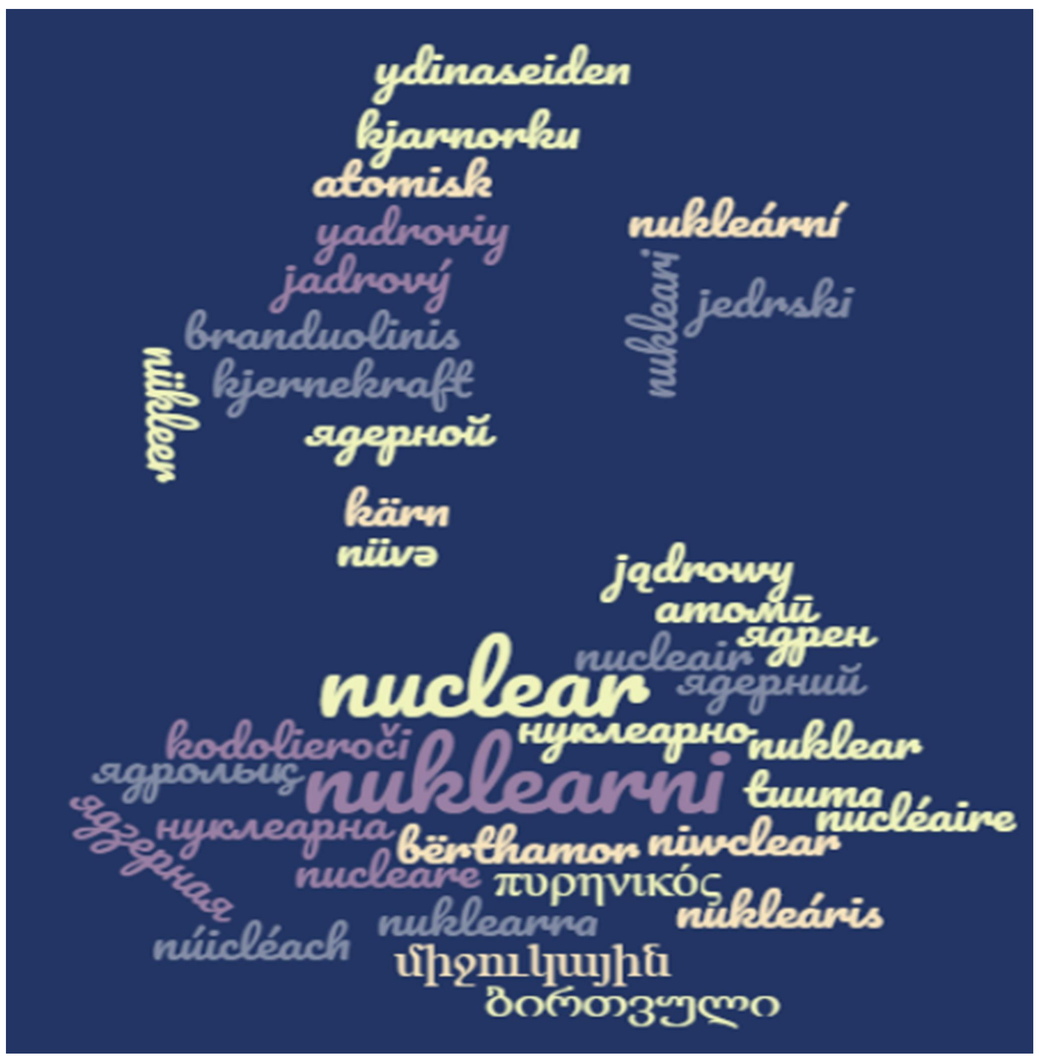
Instead of reporting on the 24-month update of NARSIS (a multi-hazard risk assessment of nuclear power plants across Europe, (www.narsis.eu**)**, I thought it would be a good idea to share the thought process across data searches in various countries to explore the existing literature.

Although the world of scientific articles is largely centralised around the English language; it is important to note that cutting-edge research; technical reports; and country and sub-country databases are usually in the local language! In the case of the NARSIS project, this meant searching in 45 languages to ensure that we had the local data for nuclear power plants, decommissioning, seismicity studies, earthquake hazard assessments and the other 80 types of hazards being explored.

In many cases, EU technical reports will be in English, but most of the good sources of information were the local information, which contained new insights and greater detail. In this way, the literature review provided a greater depth than before on EU hazards. Of course, Google Translate may not be perfect, but it improves day by day with AI and data correction, and DeepL and other services allow quick good quality translations good enough to understand each document quickly with good confidence.

So, if your bachelor, master's or PhD thesis looks across countries or needs research into a "new" topic then remember to do multi-language searches for key phrases relevant to your thesis to ensure you have the state-of-art research, not just the English state-of-art research on the topic.

.



As good as Google Scholar is (even when searching via 45 language phrases), unfortunately there are still a significant amount of missing reports and articles from various walks of conference proceedings, articles in foreign languages and technical reports, so use normal Google searches; keyword combinations, country codes to find those older and hard-to-find useful reports. **404! Error!**

Can’t access it directly as it is out of date? Get out Wayback Machine and try again. Still can’t access it, try MementoWeb. Still can’t access it, VPN the country of interest, bulletin board it via Academia, and the millions of other research portals or email the original authors. There is usually always a way in ascending order of time taken. And if you find a really sensational article where Google Translate doesn’t cut it, then ask a friend who speaks the language. In the institute we likely have around 10 languages at least covered, plus with our networks of tens more languages it is hard to think that there isn’t an important figure, or table of data from an article or report that can’t be cracked.

By the way, the NARSIS project is going well, we are leading WP1 on the multi-hazard assessment and have submitted the first 2 deliverables, 7 to go in the next 24 months from our side, but well on the way!

45th AG SEISMOLOGUE MEETING IN RASTATT

By Joachim R. R. Ritter

GPI was the local organizer for the 45th meeting of AG Seismologie, the yearly meeting of the German seismologists. Rastatt is a perfect place for seismologists, because damaging earthquakes occurred here, the latest one in 1933 which caused structural damage to houses and the collapse of about 1,500 chimneys. Rastatt is also the only city in Germany (at least to my knowledge) where there is a fountain which is dedicated to St. Alexius – in order to protect the city from earthquakes. The fountain was built in 1739 after strong earthquakes and an inscription tells it purpose.

Inscription at the St. Alexius fountain in Rastatt. It describes that the fountain was built by Margrave Ludwig Georg and his brother August Georg in 1739 and their master builder M. E. Röhrer in honor of St. Alexius as protector of the city against earthquake hazard. Photo: J. Ritter

The meeting started in the afternoon of Monday 23. Sept. with the working team on "*Seismological Analysis*". The audience was composed of 42 interested scientists and technicians. Mainly the representatives of the state seismological surveys reported on their recording networks and recent seismicity. This event was followed by a special meeting of the technicians who exchanged their experience with seismological instruments and measurements.

Participants of the working team on seismological analysis in Rastatt.

Photo: T. Plenefisch

The main AG Seismologie meeting with the scientific presentations started on Tuesday afternoon when more than 80 participants from 5 countries had arrived. During the meeting 28 talks and 17 posters were presented on themes covering all aspects in seismology from field experiments, models on seismic structures and sources as well as synthetic waveform modelling. A special block of talks covered the InSight mission to Mars in which several German institutes are involved. GPI researchers contributed with 5 presentations during the meeting. On Thursday afternoon the working team on "*Signals Generated by Wind Turbines*" met. More than 20 researchers discussed this problematic issue which receives more and more attention due to the increase of large wind turbines which may influence ground motion measurements.

Participants of the AG Seismologie meeting in front of the venue, the Bildungsstätte St. Bernhard .

Photo: J. Ritter

The meeting was characterized by a high scientific level and many fruitful discussions. In the evenings the St. Alexius bar in the basement of the venue was a perfect place for additional conversations and networking. Here the seismologists were in a very safe place protected by the saint responsible for the protection against natural hazards.

Karlsruhe Institute of Technology

Geophysical Institute, KIT-Department of Physics
Hertzstr. 16, 76187 Karlsruhe
www.gpi.kit.edu/index.php

Contact for alumni affairs: Kerstin.Dick@kit.edu

NEWSLETTER OF THE GEOPHYSICAL INSTITUTE

Issue 16, December 2019

TIDAL ANALYSIS – where geophysics, astronomy and oceanography meets

By Adam Ciesielski

Moving window tidal analyses of gravity recordings, investigated by Eva Schroth or Bruno Meuers, show a temporal variation of tidal parameters (fig. 1a and 1b). Since gravimetric parameters express Earth's body admittance to tidal forces, we don't expect them to vary within a few months.

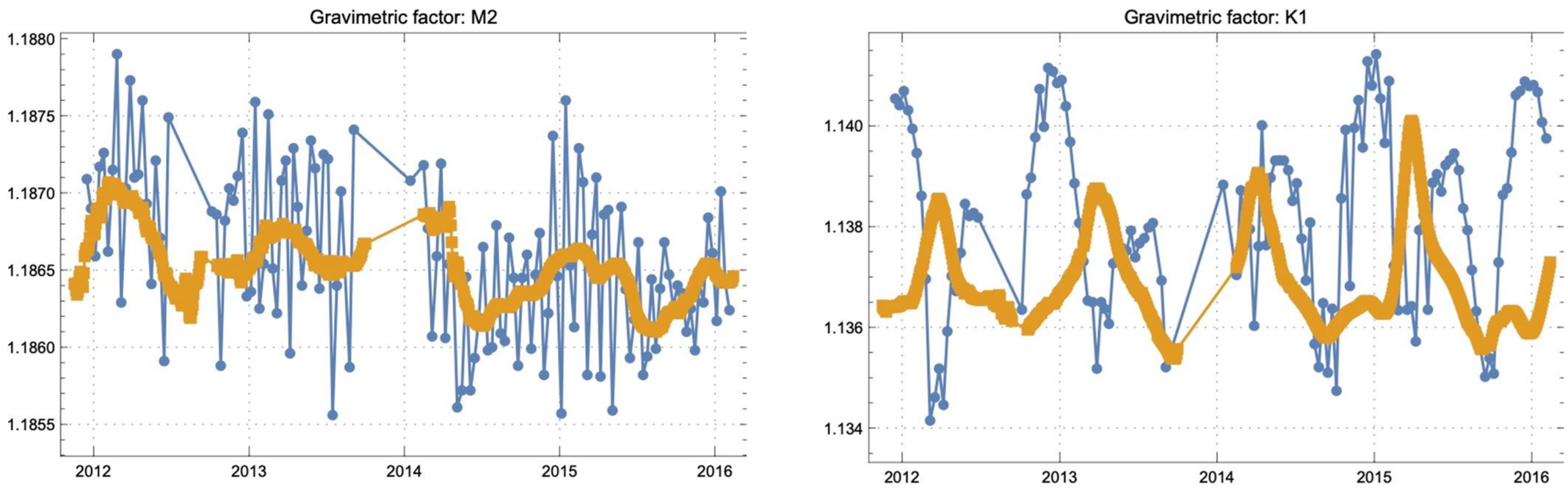


Figure 1a and 1b: Blue: Gravimetric factors obtained with SVD, currently developed approach, with no NDFW correction and using unfiltered pressure data. Orange (reference): gravimetric factors obtained by Eva Schroth.

Because of this inconsistency, we would like to improve the methods of tidal analysis, that the new model should be able to account for various effects that currently are not being considered. Original ETERNA (v.3.4) does not allow us to make a singular value decomposition (SVD) for the complete set of harmonics. Decomposition of tidal harmonics provides the opportunity to learn about the problem itself, and could answer questions: which contributions are essential in reproducing the tidal signal, is there a natural wave grouping apparent? Which time windows could be important in the tidal analysis? We already found out that there is a cross-talk present between harmonics (and groups) from different tidal species, which was surprising.

With the new approach, we are able to implement tidal simulation based on tidal catalogue data. The modified version of ETERNA: PREDICT, currently named "Predict Rigid", can compute synthetic time series for each harmonic as well as for any number of predefined groups Having rigid earth tide - which expresses forcing from celestial bodies - computed, we can calculate the Earth response as gravimetric factor (admittance) and phase (time offset) for each defined wave group. Currently we can allow any harmonic combination to form a group.

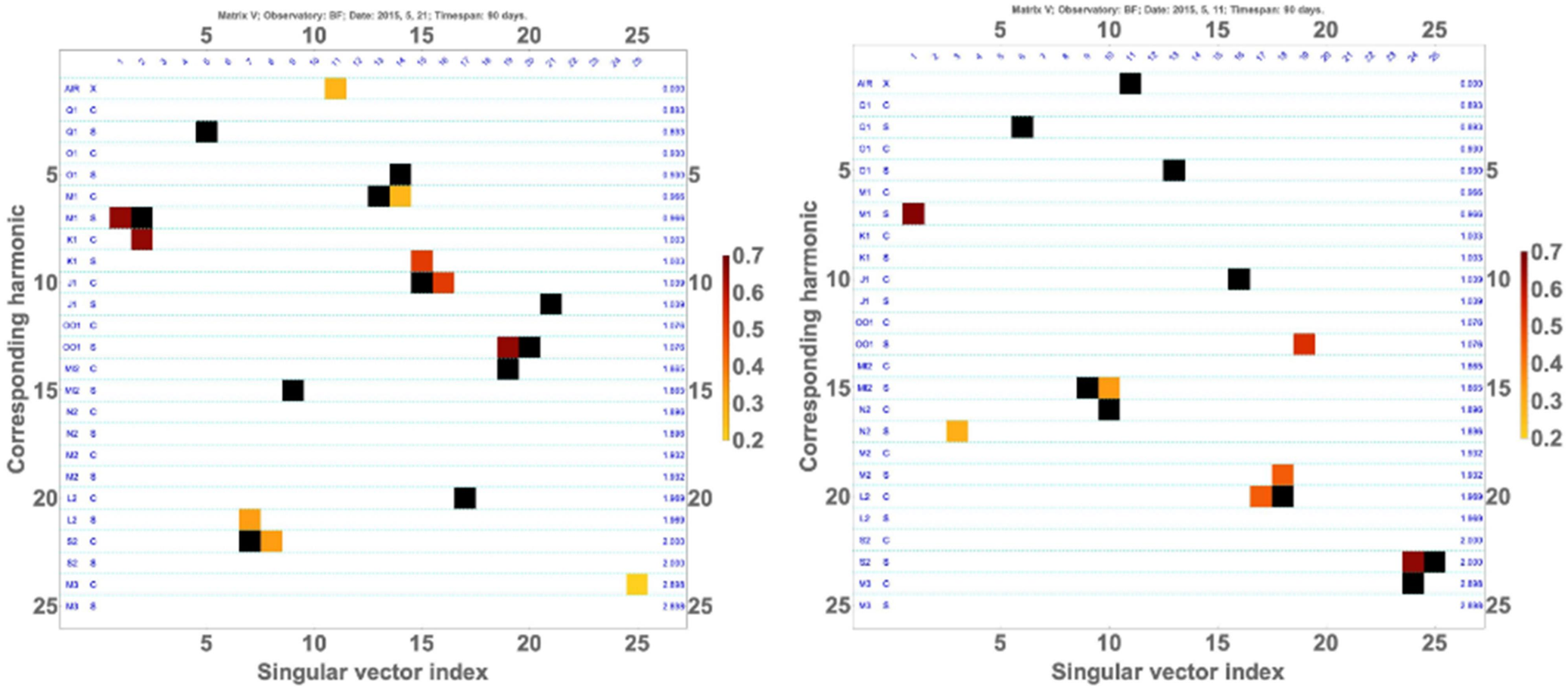


Fig: 2a and 2b:
Full rank matrix V, which shows a linear combination of harmonics in SVD space, being a result of SVD from 90 days of rigid earth tide time series. Coefficients above 0.71 are black, below 0.2 are white. Pleas note, that all vectors form an orthonrmol basis.

At the present time the software is able to compute SVD of tidal groups or harmonics (fig. 2a and 2b), along with resolution and information density matrix, though the latter was not studied in detail yet. The analysed observations from BFO in terms of moving window analysis serve as a kind of benchmark tests (fig 1a and 1b). Since there are similarities in terms of long-period pattern, the obtained parameters differ and show much more variation than the results obtained using ETERNA. Although the computation principle is the same, the mismatch is not surprising. Many features are still missing, like proper filtering of data. Additionally, the new approach still lacks in regularization, as well as ETERNA does. We plan to implement additional penalty terms to study the effects of so-called “radiation tides” and the fixed ratio between tidal harmonics of degree 2 and 3. The work is supervised by Thomas Forbriger (Black Forest Observatory) and Andreas Rietbrock. A student assistant from the Institute of Physics, Daniel Hollarek, also contributes to the project.

Figure 3: Doodson-Légé Tide Predicting Machine at the National Oceanography Centre, Liverpool.

Additionally, thanks to KIT-KHYS “Networking Grant”, I was able to set up new connections with exceptional researchers working on Tidal Analysis and FCN (NBFW). During my scientific visit at Royal Observatory of Belgium (ROB) and at the National Oceanography Center (NOC, Liverpool), I presented my work and learned from experts there. Planetary scientists at ROB were preliminary interested in the new robust approach to tidal analysis on Earth, while oceanographers at NOC showed interest in the new, more flexible approach to wave grouping and the application of singular value decomposition.

The poster presenting singular value decomposition of full rank rigid earth tide matrix (1200 harmonics) computed for 1-year time series can be found here: *https://presentations.Copernicus.org/EGU2019-16895_presentation_pdf.*

Figure 4: View form the office at the Royal Observatory of Beldium, Brussels
All photos: A. Cielsielski

WAVE-TOOLBOX For HARDWARE-INDEPENDENT FULL WAVEFIELD SIMULATION AND INVERSION

by Tilman Steinweg

End of 2019 we concluded the WAVE project, a BMBF-funded project that has started in 02/2016. The central part of the project dealt with the development of new hardware-independent code for seismic wave simulations and full-waveform inversion (FWI) on high-performance computing (HPC) systems and heterogeneous clusters utilizing CPUs, GPUs and accelerators.

Throughout the project the applied geophysics group collaborated with partners from the Fraunhofer Institute for Algorithms and Scientific Computing (SCAI), the Department of Computer Science at the Humboldt University (HU) in Berlin and the German company TEEC Geophysics in Isernhagen.

The group developed a matrix-vector formulation of the explicit time-domain finite-difference (FD) method on discontinuous staggered grids. This formulation allows a scientific developer to hide and outsource most of the low-level parallel computing issues to the HPC library LAMA (developed by Fraunhofer SCAI) and the graph partitioner Geographer (developed by HU Berlin). Consequently, it makes maintenance of any end-user software relatively easy and it allows scientific developers to focus on the actual geophysical problems rather than spending time on their most efficient implementation.

The components of the WAVE toolbox are written in an object-orientated C++ style. Due to their modular structure, they can easily form part of a library. This approach allows to directly call the forward solver from other applications, for instance full-waveform inversion or reverse-time migration. We implemented acoustic, (visco-)elastic and electromagnetic wave equations in 2D and 3D on the same code base. The code runs seamlessly on both CPUs, GPUs and accelerators without modifying any of the actual geophysical parts. Performance benchmarks using both CPUs and GPUs on the supercomputer JUWELS (Jülich) proved the high efficiency and flexibility.

Figure 1: Performance tests of the WAVE toolbox were performed on JUWELS, a supercomputer at the Jülich Supercomputing Centre (JSC) with a total of 122,768 CPU cores and 224 GPUs.

The WAVE toolbox has been applied successfully in several Master thesis projects covering the 2D elastic FWI of land seismic data in the presence of surface topography by Daniel Krieger, 3D elastic FWI of shallow seismic surface waves by Mark Wienöbst and 2D elastic FWI for nondestructive testing by Jonas Müller (see Figure below).

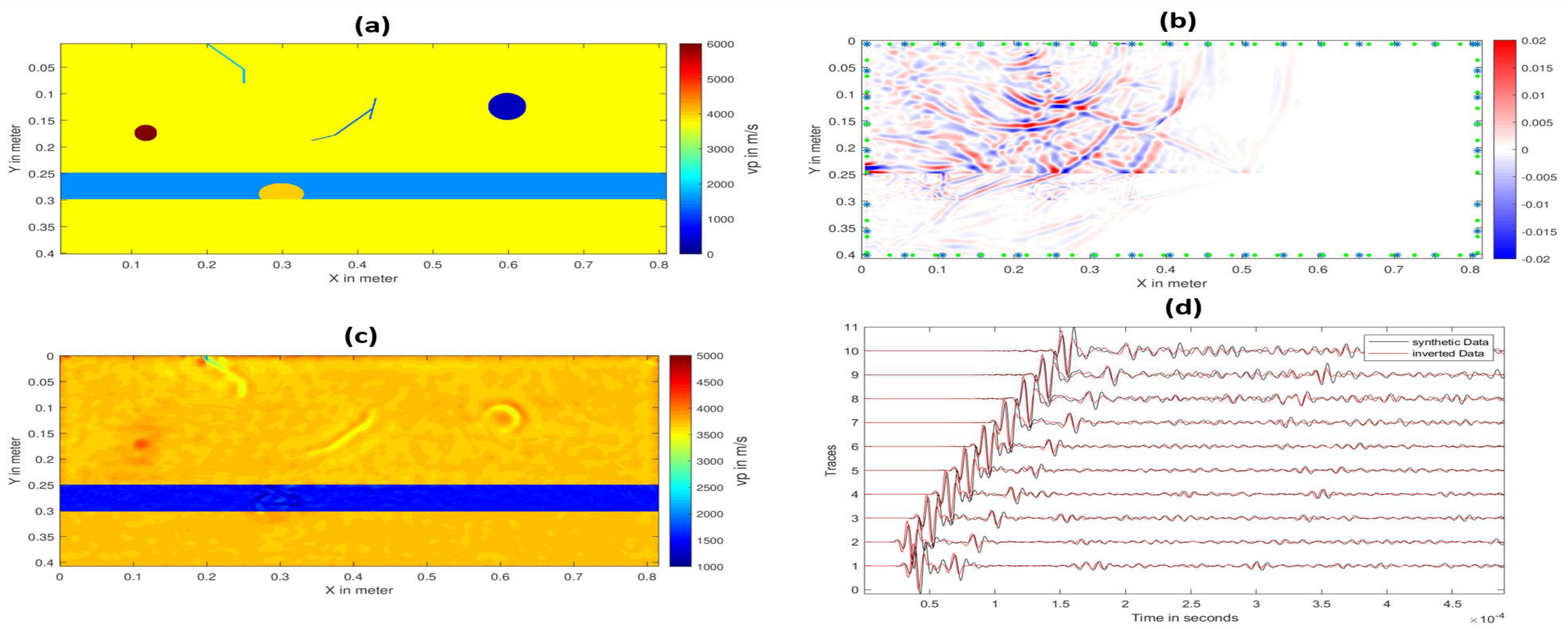


Figure 2: Application of the WAVE toolbox to explore the potential of elastic FWI for non-destructive material testing. This project is conducted in co-operation with Fraunhofer Institute for Nondestructive Testing (IZFP) Saarbrücken. (a) 2D true model of a concrete block which contains a water filled pipe, a round air hole, a round hole filled with quartz and two differently shaped cracks. (b) Snapshot of the wavefield after t = 0.154 ms showing the high complexity of wave phenomena. Blue asterisks are sources while green dots represent receivers. (c) Final reconstruction of the 2D FWI, assuming an initial model containing only the water filled pipe. (d) Seismogram fit of the synthetic data for the true model shown in a) and the reconstructed model shown in b).

The software of the WAVE-Toolbox, including Fraunhofer's LAMA library and HU's graph partitioner, will be made available at the end of 2019 as open-source software components on https://github.com/WAVE-Toolbox.

PhD at GPI

In November 2019 M.Sc. **Danhua Xin** successfully defended her PhD thesis.

Title: *"*Compatibility of Seismic Hazard and Risk Calculations with Historical Observations*"*

Supervisors:
Prof. Dr. Friedemann Wenzel (KIT)
Prof. Dr. Erdik Mustafa Bogazici University, Istanbul

With focus on the Shanxi Rift Region in Eastern China the Dissertation develops a new methodology to check modelled hazard against the historic earthquake catalogue for various return periods. Fragility models for residential building stock and an exposure model on a 1 x 1 km grid for entire China were derived. The highlight is finally a method to compare results of engineering-based loss models (using the open source package Capra) and historic observations using the CATDAT data base with two metrics: Individual scenarios among them the 2008 Wenchuan event, and a more statistical quantity, the loss exceedance curve for a suite of return periods.

RECENT PUBLICATIONS

In this section we would like to inform those of you who are still active in Geophysics about recently published peer-reviewed journal papers authored by current members of GPI:

Zieger T., Lerbs N., Ritter J.R.R., Korn M.: Seismic Recordings for SMARTIE1: Seismic Monitoring And Research of Wind Turbine Induced Emissions 1. GFZ Data Services. Other/Seismic Network. doi:10.14470/K37563128245, 2019.

Hing-Ho T., Daniell J. E., Wenzel F., Wilson J.L.: A Universal Approach for Evaluating Earthquake Safety Level Based on Societal Fatality Risk. Bulletin of Earthquake Engineering, BEEE-D-18-00543R1, https://doi.org/10.1007/s10518-019-00727-9, 2019.

Karlsruhe Institute of Technology

Geophysical Institute, KIT-Department of Physics
Hertzstr. 16, 76187 Karlsruhe
www.gpi.kit.edu/index.php

Contact for alumni affairs: Kerstin.Dick@kit.edu

NEWSLETTER OF THE GEOPHYSICAL INSTITUTE

Martin van Driel, Savas Ceylan, John Francis Clinton, Domenico Giardini, Hector Alemany, Amir Allam, David Ambrois, Julien Balestra, Bruce Banerdt, Dirk Becker, Maren Böse, Marc S. Boxberg, Nienke Brinkman, Titus Casademont, Jérôme Chèze, Ingrid Daubar, Anne Deschamps, Fabian Dethof, Manuel Ditz, Melanie Drilleau, David Essing, Fabian Euchner, Benjamin Fernando, Raphael Garcia, Thomas Garth, Harriet Godwin, Matthew P. Golombek, Katharina Grunert, Celine Hadziioannou, Claudia Haindl, Conny Hammer, Isabell Hochfeld, Kasra Hosseini, Hao Hu, Sharon Kedar, Balthasar Kenda, Amir Khan, Tabea Kilchling, Brigitte Knapmeyer-Endrun, Andre Lamert, Jiaxuan Li, Philippe Lognonné, Sarah Mader, Lorenz Marten, Franziska Mehrkens, Diego Mercerat, David Mimoun, Thomas Möller, Naomi Murdoch, Paul Neumann, Robert Neurath, Marcel Paffrath, Mark P. Panning, Fabrice Peix, Ludovic Perrin, Lucie Rolland, Martin Schimmel, Christoph Schröer, Aymeric Spiga, Simon Christian Stähler, René Steinmann, Eleonore Stutzmann, Alexandre Szenicer, Noah Trumpik, Maria Tsekhmistrenko, Cédric Twardzik, Renee Weber, Philipp Werdenbach-Jarklowski, Shane Zhang, and Yingcai Zheng: Preparing for InSight: Evaluation of the Blind Test for Martian Seismicity. Seismological Research Letters, 90 (4), 1518-1534, 2019.

Dahm T., Wörner G., Ritter J.R.R.., Walter T.: Vulkanismus in der Eifel. Wissenschaftliche Einschätzung, Bewertung aktueller Prozesse und Forschungsbedarf, Mitteilungen der Deutschen Geophysikalischen Gesellschaft, 2/2019, 5-15, 2019.