Karlsruhe Institute of Technology

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NEWSLETTER OF THE GEOPHYSICAL INSTITUTE

Issue 12, December 2017

DEAR GPI ALUMNI

Another eventful year has passed by at GPI and finally I myself arrived in October 2017 as the ‘new’ Chair of Geophysics. I would like to take this opportunity to thank all GPI staff and visiting alumni for the warm and open welcome.
I am excited by the breadth of research being conducted reaching from near surface geophysics to mountain building processes, deep seismicity, normal modes amongst others and reaching out to hazard and risk assessments. I am looking forward becoming a part of this stimulating environment and contribute to the GPI research and teaching reputation. On the observational side, we are currently buying 100 new seismic stations which will consolidate our place as one of the leading observational seismology institutes in Europe. On the teaching side, we are establishing an international geophysics master program taught in English, which gives our students the best education to work later in industry and science as well as trying to attract high quality students from abroad.
With all the excellent work being done in 2017 we look forward to a productive and stimulating new year.

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

Andreas Rietbrock

TEACHING

By Ellen Gottschämmer

Presently, our Geophysics master program undergoes a transformation process: Starting in October 2018, the Geophysics master program will be entirely taught in English. We believe it to be important for our advanced students not only to understand geophysical terminology and technical terms but also to be able to express themselves and discuss geophysical topics in English.

This guarantees an optimum preparation for their future work in industry or science.

We will keep our strong focus on exploration and earthquake seismology, and will bring together theory and field experiments.
This provides our students the opportunity to cover the full range of geophysics from data acquisition to modelling, inversion and interpretation.

During their first year students take compulsory modules to guarantee a solid knowledge in different aspects of exploration and earthquake seismology. For their specializations students can choose additional modules from Geophysics or related subjects which allows them to focus individually. During their second year students will be integrated in one of the research groups working on their master thesis. We consider it as important to fully immerse into a project at a high level over an extended period.

The program will be open for students who hold a Bachelor degree in Geophysics, Physics, Mathematics, Geosciences or related sciences. Candidates must provide 20 credits each in Geophysics, Physics and Mathematics, as well as a proof of excellent English. Missing credits in Geophysics can individually caught up for during the first year. For immediate success students without background in Geophysics can take part in iBridge, an interactive convergence course covering the most important topics from exploration and earthquake seismology.

Several *in-situ* lectures are planned for 2018, some of them can be attended by Bachelor students as well: Early in the year, a lecture on 3D seismics will be held by Thomas Hertweck and Thomas Bohlen, including geophysical measurements at Bruchsal. At BFO, a three-day winter school will be run by Thomas Forbriger for all students who have taken part in his lecture on Physics of seismic instruments. In April 2018, an international summer school on Seismology and Geohazards will be conducted in cooperation with Bandung Institute of Technology and Australia National University at Bandung (Indonesia) and surroundings.
Lectures will be given by Andreas Rietbrock and Ellen Gottschämmer from GPI as well as by Australian and Indonesian seismologists, and ten students from GPI will be able to participate.

During summer term 2018, an *in-situ* lecture to the Eifel volcanic field will be organized and held by Joachim Ritter, and in August 2018, GPI students will have the chance to focus on seismic hazard during an *in-situ* lecture to the Apennines (Italy) conducted by Andreas Rietbrock, Joachim Ritter and Ellen Gottschämmer. *In-situ* lectures are taught in the field at the location which is being studied giving students the possibility to fully appreciate the objective and observe the whole range of parameters involved.

RAPID EARTHQUAKE IMPACT MODELLING

By Andreas M. Schäfer

Earthquakes are felt every daily all around the globe. In some cases, damaging effects cannot be avoided and it is difficult, especially during bigger disasters, to estimate the actual impact. First estimates of the earthquake intensity are important to estimate potential losses and the number of affected people. For this task, a system for disaster cartography has been developed to provide potential disaster impact maps within minutes after an event occurred. Such data can then be used e.g. for loss estimates, mitigation measures, awareness or media.

In case of an earthquake, only few data is available relatively quickly (e.g. time, hypocenter & magnitude), however with such little information, the system can compute the spatial extent of earthquake intensities. In the course of this, a Monte Carlo simulation computes several 1000s of potential permutations of that same earthquake to take uncertainties regarding depth, location and magnitude into account. The results are then calibrated through first observations and testimonies retrieved from EMSC, USGS or earthquake-report.com. The system has been calibrated by various recent and historic events and is under constant development providing an alternative (European) solution to USGS ShakeMaps and local agencies.

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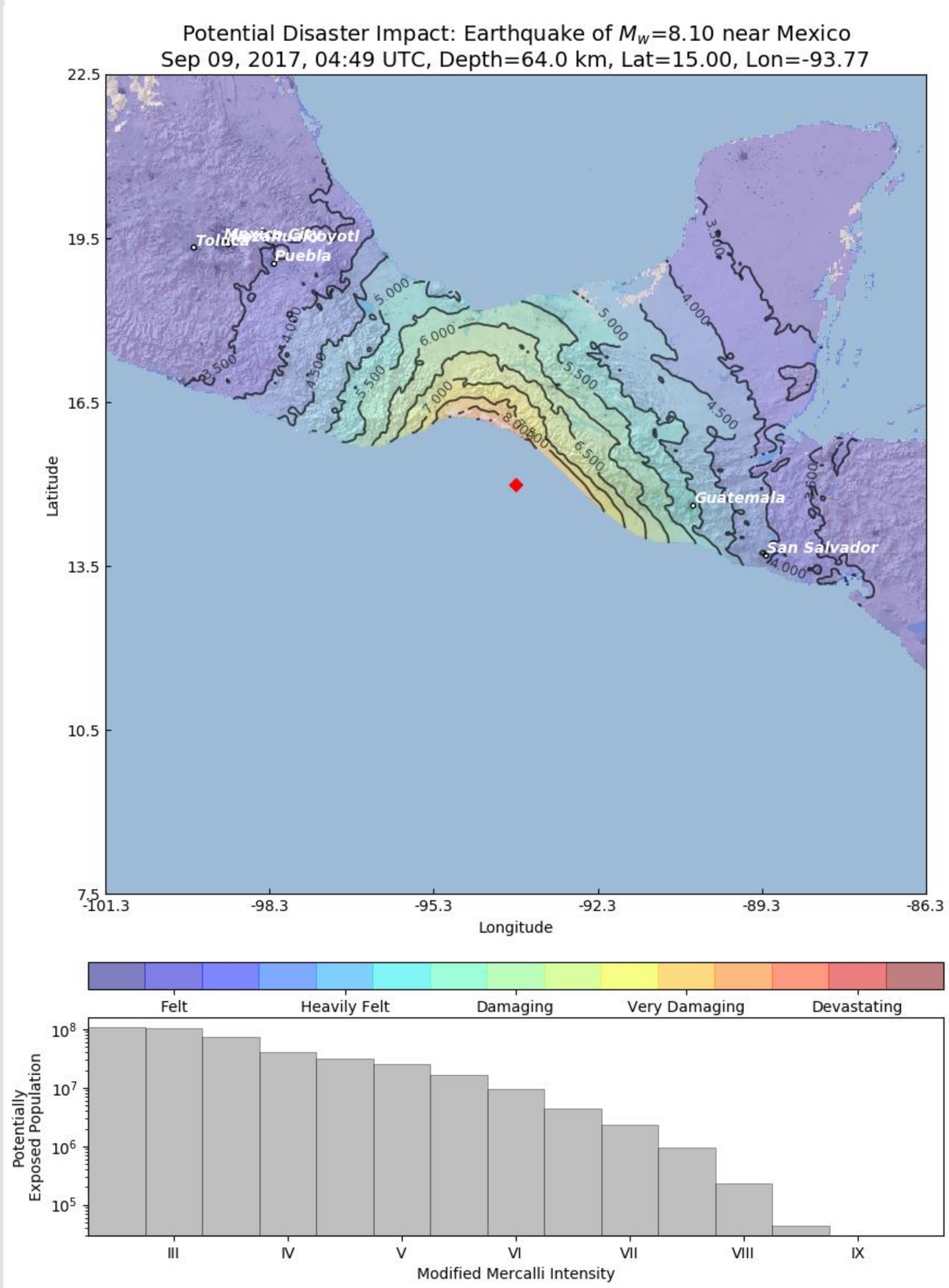
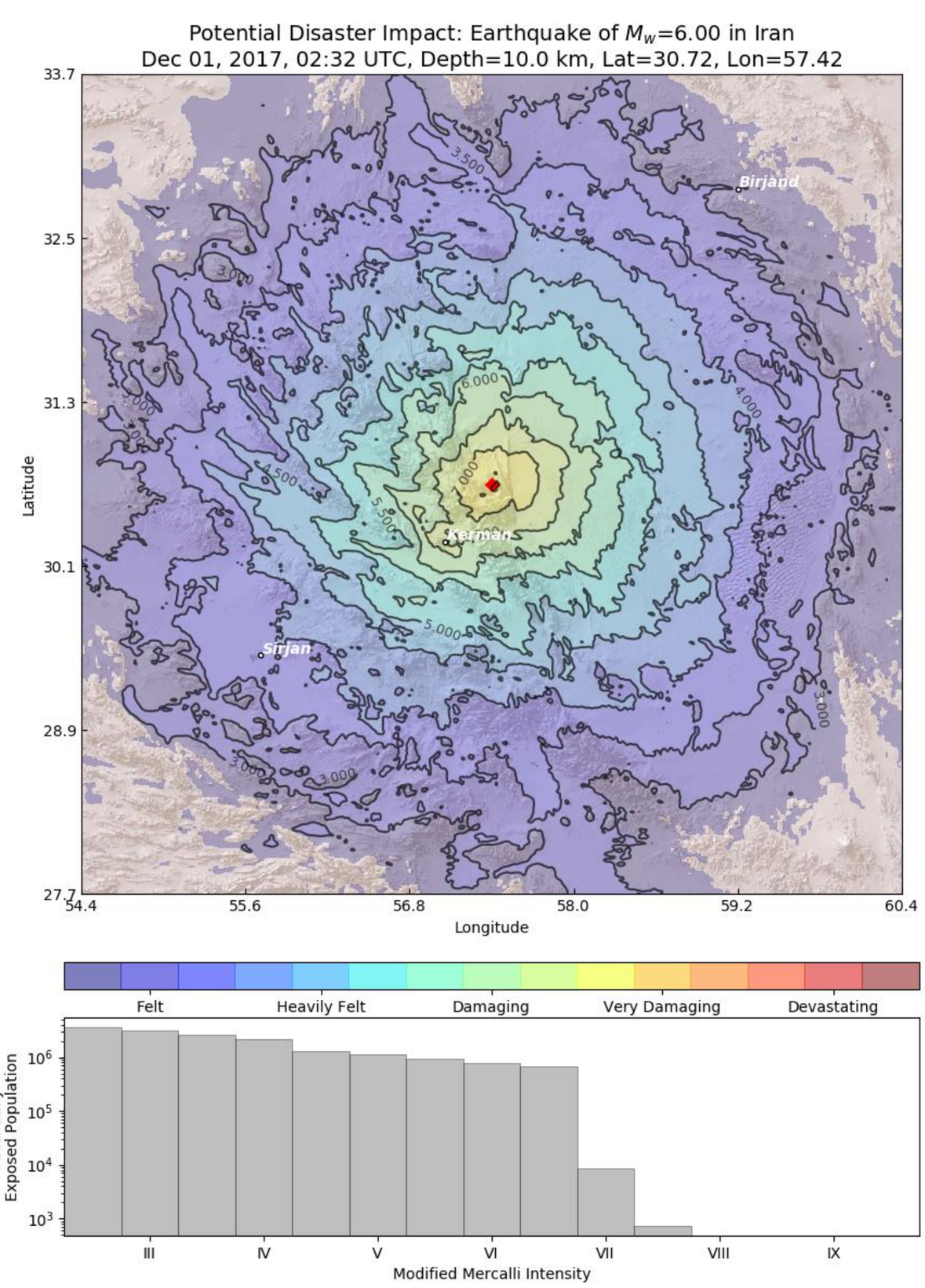
The final maps are shared in social media, Facebook (https://www.facebook.com/catnewsde/) & Twitter (https://twitter.com/CATnewsDE) and used e.g. by earthquake-report.com or CEDIM. In social media, posts reach, in some cases, several ten thousand people. Currently, the system is operational for earthquakes globally. During the September, 2017 Mexico earthquake a first attempt to apply the same methodology to tsunamis was successful. Future installments will focus on casualty estimates and the modelling of volcano disasters (ash fall) and hurricanes.





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APPLIED GEOPHYSICS

By Thomas Bohlen, Thomas Hertweck and Yudi Pan

Research

Research activities within the Applied Geophysics group are (still) concentrating on the further development and application of full-waveform inversion (FWI). FWI leads to a significantly improved spatial resolution of velocity models plus the possibility to jointly invert for consistent multiple physical model parameters (P- and S-velocity, anisotropy, attenuation, density) which can improve the petrophysical characterization.

During the last year we made continuous progress in various aspects such as software development (C++ code modularization), higher-order optimization and pre-conditioning, inversion for second-order model parameters such as attenuation and anisotropy, and applications of FWI to land and marine field data.

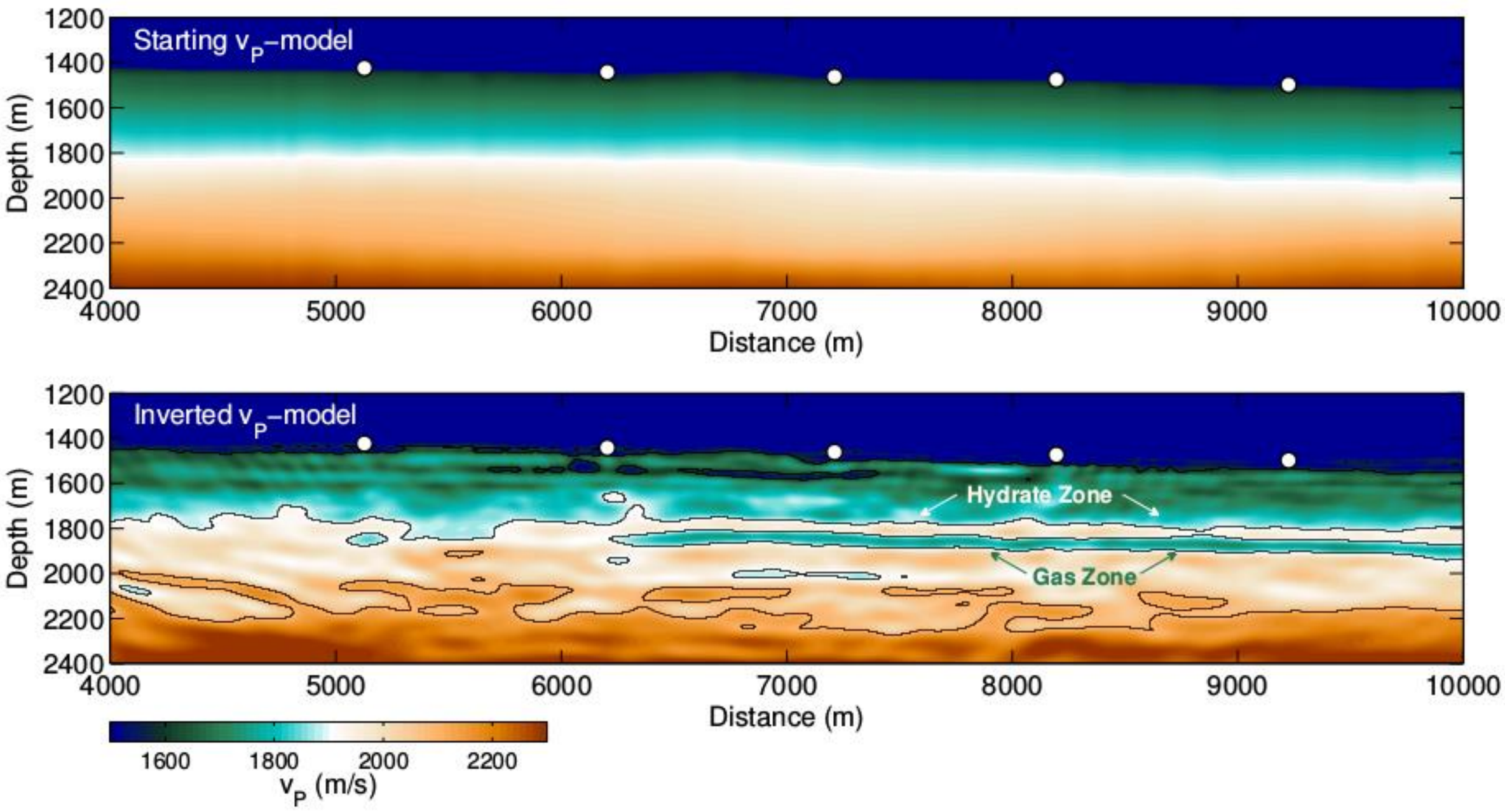
In the SUGAR project, we applied 2D acoustic and elastic FWI successfully to marine wide-angle OBS data and were able to detect and quantify the occurrence of gas hydrates and free gas in the Black Sea. In a cooperative project with PGS, 2D acoustic and elastic FWI was applied to industry streamer data acquired over deep-water salt bodies. We recently discovered that FWI must consider elastic effects (P- to S-wave conversion) in complex salt environments even in marine environments (streamer recordings) in order to be successful.

In our project called WAVE we are modularizing the FWI workflow (modules for forward modelling and the optimization) and completely re-implement the FWI workflow using C++ and the library LAMA developed by our project partner Fraunhofer SCAI Sankt Augustin.

Quite intensive research is also conducted to improve our established 2D elastic FWI workflow for shallow seismic field data in order to increase its robustness (e.g., to avoid cycle skipping) and to allow for reliable reconstructions of models of attenuation and seismic anisotropy. An application of multiparameter FWI on real-world data collected in Jülich proves the feasibility of characterizing near-surface aquifers by means of FWI.

In our collaboration with mathematicians at the KIT within the CRC 1173 (wave phenomena) we derived an improved formulation for visco-elastic FWI which we will apply to near-surface data for attenuation inversion.

Finally, we also explore the potential of transferring the FWI technology developed in the geophysical community and the corresponding knowledge and experience to ultrasonic imaging, which is widely used in medical cancer screening and in non-destructive testing of materials.



Acoustic full-waveform inversion result of a seismic profile using hydrophone data of 5 OBS stations (white circles) revealing possible hydrate and gas deposits. Photo: Laura Gaßner, GPI.

Teaching

Over the last nine months, we have worked on various lectures given by the Applied Geophysics group. In summer semester 2017, we introduced a new lecture specifically on full-waveform inversion. Students did not only learn about the theory of FWI but also implemented their own FWI solution in Matlab and presented their results during our work group seminar.

During the lecture-free period in autumn 2017 we revamped the material for the lecture on 'reflection seismics' and converted it to English in preparation for an official change to make our MSc programme more international in the future. As part of this revamp, we also updated the material with latest information from the industry. In addition, we worked on two entirely new lectures for winter semester 2017/18 (currently ongoing): Firstly, a lecture on 'near-surface seismics and ground penetrating radar' where students learn about near-surface investigations and also acquire and process their own shallow seismic data. Secondly, a new in-situ lecture on 3D seismics which will, at least partly, take place in the field during a commercial 3D land seismic data acquisition near Karlsruhe early 2018. We look into making such an in-situ lecture on reflection seismics a regular event, possibly organised in cooperation with other German universities.

In summer semester 2018, as the case stands, we will yet again introduce two new lectures: A lecture on 'seismic modelling' which will nicely complement lectures on seismology, tomography, inversion, theory of seismic waves and reflection seismics. And another lecture on 'seismic data processing' where students can play with a real seismic data set in order to process it from field tape to final migration. Furthermore, we will start to revamp the lecture on 'theory of seismic waves' to also convert it to English.

In a nutshell, a lot of updates are on the way which on the one hand keep us quite busy but on the other hand make our lectures more attractive and implement teaching related to practice.

WIND TURBINES AND SEISMIC EMISSIONS – TremAc and WINSENT

By Toni Zieger and Joachim Ritter

GPI is currently involved in two projects, TremAc and WINSENT, which investigate seismic emissions from wind turbines (WT). These emitted seismic signals are studied concerning their wave properties, their attenuation depending on different geological underground properties and their influence on seismological recordings. The influences of WT type and design, wind conditions or coupling to the ground are also included. For WINSENT, a test area is currently deployed on the Swabian Alb (SW Germany), with two large WTs and four ca. 100 m high masts for wind and environmental measurements. Our focus is on the seismic emissions of the WTs measured continuously in three shallow boreholes with intermediate-band seismometers (0.05-100 Hz). The seismic waveforms will be available in real-time and analysed by the GPI seismologists. In addition, there will be field campaigns with surface measurements in the vicinity of the WTs in order to study attenuation and directional effects of wave propagation.

Within TremAc, new results were obtained by analysing WT-induced signals near Landau and Pfinztal (close to Karlsruhe). The results were published in the Journal of Seismology with the title “Influence of wind turbines on seismic stations in the upper rhine graben, SW Germany” (2017, in press, https://doi.org/10.1007/s10950-017-9694-9), see also the figure with power spectral densities. New measurements will be conducted at a single WT near Ingersheim (close to Stuttgart) and at a wind-farm near Wilstedt (close to Bremen). These datasets will be compared and combined with infrasound measurements (Institute for Soil and Rock Mechanics (IBF) at KIT and University of Stuttgart) and medical interviews with residents by experts in environmental medicine (Universities of Bielefeld and Halle). The seismic wave generation and propagation is also compared with mechanical analyses of the WTs (Institute for Steel & Lightweight Structures (VAKA) at KIT) and numerical wave propagation simulations (IBF at KIT). In an accompanying study with Thomas Forbriger and Tobias Friederich (Master Thesis) we demonstrated how WT can be located with a semblance analysis of the WT emitted signals near Landau.

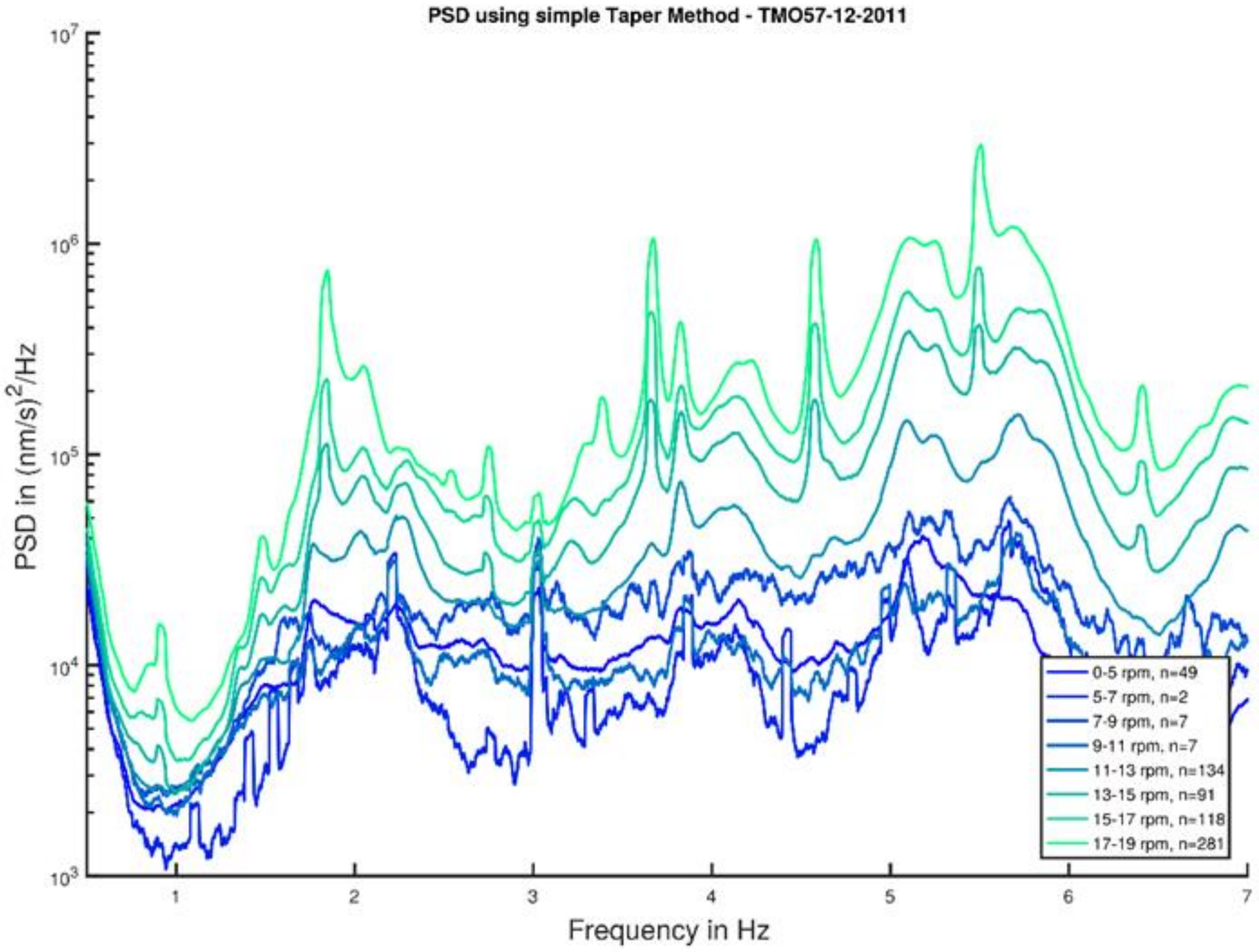


Fig.: Power spectral density plot for seismic station TMO57 near Bellheim, Pfalz. The different spectra are colour coded with respect to the rotation frequency (rpm: rotations per minute) of a near-by wind turbine. The overall increase of the spectra with rpm is mainly due to the coincident increase in wind speed which increases the background noise. However, there are also clear frequency peaks which result from a coupling of the swinging WT and the ground. n is the number of stacked single spectra, the time period is December 2011.

Fig. Our fearless technician Werner Scherer on the nacelle of a wind turbine in more than 100 m height above the ground. This wind turbine is located in Pfinztal where we conducted long-term measurements.
Photo: GPI

PhD at GPI

Mr. Trevor Girard

In January 2017 Mr. Trevor Girard successfully defended his PhD thesis

Title: *Barriers to Communicating Disaster Response Information to the Public During Disaster Situations*

Supervisors :
Prof. Dr. Louise K. Comfort (University of Pittsburgh)
Prof. Dr. Friedemann Wenzel (KIT)

The purpose of his research was to investigate the people, agencies and communication channels that comprise the typical disaster communication system. He carried out quantitative surveys and qualitative interviews with disaster affected individuals and government officials in the Philippines (Typhoons Haiyan and Hagupit) and Nepal (Gorkha Earthquake). His proposed disaster communication model incorporates the unique characteristics of a disaster message (content, treatment, channel and meaning) and the complex network (actors and strategies) required to successfully relay that message.

By Joachim Ritter

We congratulate Toni Zieger and Michael Grund on receiving a networking grant from the KIT Karlsruhe House of Young Scientists (KHYS). The grant money is for travelling to a new international research partner.

Feedback

If you have any comments, questions or remarks, please do not hesitate to contact us. We appreciate your feedback.

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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:

Hartmann G., Barth A., Ross J. O., Grünberg I. & Frei M., Pilger, C.: Verification of the North Korean Nuclear Explosions 2006, 2009, 2013, and 2016. In: Ceranna, L. & Bönnemann, C. (Eds.) Monitoring Compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT), Geologisches Jahrbuch Reihe B, 105, Schweizerbart Science Publishers, Stuttgart., (2017).

Gottschämmer E., Pontius M., Busch N., Bohlen T.: Erdbebenregistrierung mit Seismmometern, Plus lucis, (3), 12 – 17, 2017.

Gottschämmer E., Heck A., Schneider N., Bergmann A., Bohlen T.: Zerstörungsfreie Materialuntersuchung: Gleichstromgeoelektrik, Plus lucis, (3), 23-29, 2017.

Schäfer A. M., Daniell J. E., Wenzel F.: The smart cluster method, Journal of Seismology 21, 4, 965-985, 2017.

Schäfer A. M., Wenzel F.: TsuPy: Computational robustness in Tsunami hazard modelling, Computers & Geosciences 102, 148-157, 2017.

Newman J. P., Maier H. R., Riddell G. A., Zecchin A. C., Daniell J. E., Schäfer A. M., van Delden H., Khazai B., O'Flaherty M.J., Newland C. P.: Review of literature on decision support systems for natural hazard risk reduction: Current status and future research directions. Environmental Modelling & Software, 96, 378-409, 2017.

Murnane R. J., Daniell J. E., Schäfer A. M., Ward P. J., Winsemius H., Simpson A., Tijssen A., Toro J.: Future scenarios for earthquake and flood risk in Eastern Europe and Central Asia. Earth's Future 5, 7: 693-714, 2017.

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A very Merry Christmas to all
of those who celebrate Christmas
and to all of you a very
Happy New Year
2018