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Annual Research Report 2011

Focus on Flood Hazard in a Changing Climate

KIT - University of the State of Baden-Wuerttemberg and
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Imprint

CEDIM Annual Research Report 2011 - Focus on Flood Hazard in a Changing Climate

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Preface

The most prominent catastrophe in 2011 was the Tohoku earthquake East of Japan on March 11, 2011 with the Fukushima Daiichi nuclear accident as one of its consequences. This event was not only outstanding in terms of its high losses (about US$ 330 billion in economic terms), it also triggered an extensive political discussion in many countries about general safety issues regarding nuclear power plants. In Germany this caused a moratorium and finally led to the decision to abandon nuclear energy completely within eleven years.

In the CEDIM funding institutions, GFZ contributed actively to providing information to the public on the earthquake and KIT installed the Helmholtz-spanning Fukushima Task Force. CEDIM researchers from GFZ and KIT were involved significantly in these activities.

Within the CEDIM research community a new initiative, called Forensic Disaster Analysis, was born to address future large-scale disasters in a novel way. This is a notion that has been coined by the Integrated Research on Disaster Risk Initiative (IRDR) and which CEDIM combines with near-real time assessment. The core of this new style of analysis is to look at catastrophes with a particular focus on interactions between the natural impact, the societal structures, institutions and capacities, and the technical installations, facilities and infrastructures, that play a vital role in human society but may also aggravate disasters. This should allow us to identify the tipping points of disasters, i.e. the decisive points during the course of disasters that change or set new trajectories for their further development, and to identify the real loss and risk drivers with implications for disaster mitigation. Forensic Disaster Analysis in near-real time assures high visibility and intensive interaction with many researchers and practitioners. This new strategy has materialized already in 2011 with in-depth studies of the Tohoku earthquake and was initially implemented after the October 23, 2011 Eastern Turkey earthquake.

The scientific highlight of the past year is certainly the finalization of our 3-year project Flood Hazard in a Changing Climate. Merging high-resolution climate modelling, downscaled to the regional planning scale of a few kilometers, with hydrological modelling in three key areas the project succeeded in establishing the methodology to provide science-based, sound statements on the range of possible modifications to flood hazard patterns on the regional scale, calibrated with 30 years of observations and projected 30 years into the future. The scientific exploitation of the research results, but also their dissemination to a wider scientific community, to regional users, to ministries, and the Helmholtz community at large is a task to be addressed in early 2012.

As a novel component of CEDIM‘s work a closer cooperation has been established with the insurance industry. CEDIM became a member of the Willis Research Network in 2009 and continued to cooperate with Willis through 2010 and 2011. We organised a workshop on insurance needs in Karlsruhe in May 2011. Specific cooperation projects have been developed with SV Insurance on hail and earthquake risk, which allow for a better understanding of insurance needs, and for refining and tuning models for insurance applications. A strategic goal for the future is to enhance these capacities and to offer the CEDIM research community as a partner for the insurance industry.

CEDIM and its supporting institutions participate in several European FP7 projects (SYNER-G, WEATHER, MATRIX, REAKT, NERA, CONHAZ) with coordinating roles in some of them. The scientific topics that are covered include economic issues, socio-economic questions, flood risk, wind risk, earthquake risks, multi-risk assessment and strategic stakeholder interaction.

Another strategic target of CEDIM is to firmly establish it within the Helmholtz community. This ensures a sound financial basis for future work but also dissemination and stimulation of our scientific work. The new CEDIM research strategy is an integral part of the recently approved Helmholtz Portfolio Topic Earth System Knowledge Platform (ESKP) to which it has already started to contribute. With the future focus on Forensic Disaster Research embedded in many European projects, the Global Earthquake Model (GEM) and partnerships with the insurance industry we believe to be on the right track.

Friedemann Wenzel
Bruno Merz
Christoph Kottmeier

Vorwort

Die mit Abstand dramatischste Katastrophe des Jahres 2011 war das Tohoku Erdbeben mit einer Magnitude von 9 im Osten Japans am 11. März 2011, in dessen Folge sich auch die Unfälle im Kernkraftwerk Fukushima Daiichi ereigneten. Diese Katastrophe hebt sich nicht nur durch die große Zahl der fast 20.000, überwiegend dem Tsunami geschuldeten Toten und der hohen Verluste von ca. 330 Milliarden US-Dollar von anderen Erdbeben in hoch industrialisierten Ländern ab. Sie löste in vielen Ländern auch eine intensive politische Diskussion über Sicherheit von Kernkraftwerken aus, die in Deutschland zunächst zu einem Moratorium und schließlich zum Beschluss zum Ausstieg aus der Kernergie führte.

In den CEDIM tragenden Institutionen GFZ und KIT trug das GFZ entscheidend zur Information der Öffentlichkeit über das Erdbeben bei, am KIT wurde die mehrere Helmholtz-Zentren umfassende Task Force Fukushima eingerichtet. CEDIM-Wissenschaftler waren maßgelbich in diese Aktivitäten involviert.

Dieses Ereignis löste auch eine intensive Diskussion unter den CEDIM Forschern aus, wie in Zukunft große Katastrophen mit neuen Methoden adressiert werden könnten. Die Antwort, die wir gefunden haben, lautet ‚Forensic Disaster Analysis' - ein vom internationalen Forschungsprogramm Integrated Research on Disaster Risk Initiative (IRDR) geprägter Begriff, den wir in CEDIM um eine weitere Komponente erweitern: Das Herzstück dieser neuen Herangehensweise in CEDIM besteht in der zeitnahen Analyse von Katastrophen in interdisziplinären Teams. Dabei achten wir insbesondere auf die Interaktion zwischen dem Naturereignis, technischen Installationen wie zum Beispiel Infrastrukturen, und den gesellschaftlichen und sozialen Umständen, die zum eigentlichen Ausmaß der Katastrophe oft mehr beitragen als das Naturereignis selbst. Ziel ist es, die kritischen Risikofaktoren zu identifizieren, kaskadierende Effekte und Interaktionseffekte in Desastern zu verstehen, prognostische Fähigkeiten zum Ablauf zu entwickeln und Erkenntnisse und Lehren Wissenschaftlern und einer weiteren Nutzergemeinde zur Verfügung zu stellen. Die zeitnahe Analyse sollte dazu führen, dass es zu einer intensiveren Interaktion zwischen Forschung und Anwendung kommt als es bisher der Fall ist. Die ‚Feuertaufe' dieses neuen Konzepts erfolgte mit dem Erdbeben in der Osttürkei am 23. Oktober 2011, in dessen Folge die Forensic Earthquake Disaster Analysis Group in CEDIM aktiv wurde und eine Reihe von Berichten zum Erdbeben selbst, zu dessen Schäden, sozio-ökonomischen Auswirkungen und Rahmenbedingungen, sowie zu Wissens- und Verständnisdefiziten und Forschungsnotwendigkeiten publizierte.

Der wissenschaftliche Höhepunkt des vergangenen Jahres besteht im Abschluss unseres Dreijahresprojekts zu Hochwassergefahren unter den Bedingungen des Klimawandels. Die Kopplung von hochauflösenden Klimasimulationen mit einer Diskretisierung von wenigen Kilometern hochauflösenden hydrologischen Modellen in drei Schlüsselregionen der Bundesrepublik erlaubte es (a) Auswirkungen des Klimawandels auf Hochwassermuster auf Planungsskala (einige Kilometer) zu analysieren, (b) solche Prognosen sorgfältig mit 30 Jahren an Beobachtungen zu kalibrieren und (c) entsprechende Projektion in die Zukunft mit Ensemblemethoden zu leisten. Der wissenschaftliche Ertrag wird im vollen Umfang im Jahr 2012 zu ernten sein. Gleichzeitig kommt es uns darauf an, die entwickelten Methoden und Ergebnisse einer breiteren wissenschaftlichen Öffentlichkeit, vor allem aber auch regionalen Anwendern, Ministerien und Entscheidungsträgern nahe zu bringen.

Eine neue Komponente in der CEDIM Arbeit des vergangenen Jahres bestand in einer zunehmend enger werdenden Kooperation mit der Versicherungswirtschaft. CEDIM wurde im Jahr 2009 Mitglied des Willis Research Network und setzte die Zusammenarbeit mit Willis durch einen Workshop in Potsdam im Jahr 2010 und durch einen weiteren Workshop im Mai 2011 in Karlsruhe fort. Bei diesem Workshop wurden Prinzipien der Versicherungswirtschaft und Optionen wissenschaftlicher Arbeit im Kontext der neuen Regulierungsverfahren für diesen Wirtschaftszweig (Solvency II) diskutiert. Mit der SV-Versicherung verbinden uns mittlerweile Projekte zum Hagel und Erdbebenrisiko, die es uns erlauben, Anforderungen der Versicherer zu verstehen und unsere Modelle und Methoden auf diese Anforderungen hin auszurichten. Es bleibt ein strategisches Ziel, solche Zusammenarbeiten weiter zu entwickeln.

CEDIM und als juristische Körperschaften ihre finanzierenden Institutionen GFZ und KIT beteiligten sich, teilweise federführend, an mehreren europäischen FP7 Projekten (SYNER-G, WEATHER, MATRIX, REAKT, NERA, CONHAZ). Dabei bringen wir die ganze Bandbreite des CEDIM Wissensportfolios ein, so dass wir Themen wie Erdbeben, Hochwasser, Windrisiken, Multirisikoanalysen, aber auch ökonomische und sozio-ökonomische Implikationen bearbeiten können sowie vor dem Hintergrund unserer Erfahrungen im Desastermanagement auch neue Formen der Nutzerinteraktion.

Ein weiteres strategisches Ziel von CEDIM im Jahr 2011 war es, sich fest innerhalb der Helmholtz Gemeinschaft zu etablieren. Dies sollte auf der einen Seite eine nachhaltige Finanzierungsbasis schaffen, zugleich aber auch die Verbreitung unserer Ergebnisse fördern und der Stimulation unserer Arbeit durch die Interaktion mit mehreren Helmholtz Institutionen dienen. Die neue CEDIM Strategie – Forensic Disaster Analysis – ist ein integraler Teil des kürzlich bewilligten Helmholtz Portfoliothemas Earth System Knowledge Platform (ESKP), die sich eben etabliert. Mit diesem Schritt und der Einbettung von CEDIM in viele europäische Projekte, das Global Earthquake Model (GEM) und Partnerschaften mit der Versicherungswirtschaft glauben wir, auf dem richtigen Weg zu sein.

Friedemann Wenzel
Bruno Merz
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I. Research

Natural Risk and Climate Change

According to the fourth IPCC Assessment Report (AR4, 2007) it is “likely” that the number of extreme weather events such as winter storms and heavy precipitation will increase over Central Europe due to anthropogenic climate change. This means that protective measures may fail more frequently and that damage related to hydro-meteorological natural hazards will increase in the future. Additionally, a growing damage potential due to social and economic change (demographic change, change in land use, increasing values, and increasing cross-linked infrastructures) can be expected. In consequence, the risk as a product of hazard and vulnerability will increase significantly in the future.

The challenge of changing risks is met by the research focus within CEDIM “Natural risks and climate change”. Central to this research focus which started in 2008 are the projects on changing flood hazard in small and middle sized river catchments and the project studies on changing thunderstorm and hail hazard in Germany. In 2010 and 2011, parallel to finalizing the joint project “Flood hazards in a changing climate”, a follow-up project was implemented that focuses on the influence of the drivers of climate change, change in land use, and change in building values on the change in flood risk, first in the Mulde catchment and then also in the Elbe catchment.

In the following chapters the results of these three projects are presented with special focus on “Flood hazards in a changing climate”. A more detailed report for this project will be available for download from the CEDIM homepage www.cedim.de at the end of 2011.

Naturrisiken im Klimawandel

Nach dem vierten Sachstandsbericht des IPCC (2007) werden extreme Wetterereignisse wie Winterstürme oder Starkniederschläge über Mitteleuropa infolge des anthropogen bedingten Klimawandels „wahrscheinlich“ zunehmen. Diese Erhöhung der Gefährdung führt voraussichtlich dazu, dass Schutzmechanismen immer häufiger versagen und damit die mit hydro-meteorologischen Naturereignissen verbundenen Schäden zunehmen werden. Dieser Veränderung auf der Gefährdungsseite steht eine Veränderung der Vulnerabilität (Exposition und Schadenanfälligkeit) durch wirtschaftliche und gesellschaftliche Veränderungen (demographischer Wandel, Landnutzungsänderungen, Wertezuwachs, zunehmende Vernetzung von Infrastrukturen) gegenüber. In der Folge wird das Risiko als Produkt von Gefährdung und Vulnerabilität in Zukunft erheblich ansteigen.

CEDIM widmet sich diesem Themenkomplex im Forschungsschwerpunkt „Naturrisiken im Klimawandel“. Im Mittelpunkt stehen dabei seit 2008 die Arbeiten im Verbundprojekt zur Änderung der Hochwassergefährdung in verschiedenen kleinen Flusseinzugsgebieten, 2009 kamen Arbeiten über die Änderung der Gewitter- und Hagelgefährdung in Deutschland hinzu. Parallel zum Abschluss des Verbundprojektes „Hochwassergefahr durch Klimawandel“ in den Jahren 2010 und 2011 wurde ein Anschlussprojekt durchgeführt, in dem der Einfluss der Komponenten Klimawandel, Landnutzungsänderungen und Änderungen der Gebäudewerte auf die Änderungen des Risikos zunächst im Einzugsgebiet der Mulde und anschließend im gesamten Einzugsgebiet der Elbe untersucht wird.

In den folgenden Kapiteln werden die Ergebnisse der drei Projekte dargestellt, wobei das Projekt zur Änderung der Hochwassergefährdung durch Klimawandel den Schwerpunkt bildet. Ein ausführlicher Bericht zu diesem Projekt wird zum Ende des Jahres 2011 auf den Internetseiten von CEDIM (www.cedim.de) zum Herunterladen bereitgestellt.

Flood hazards in a changing climate

Gerd Schädler, Peter Berg, Doris Düthmann, Hendrik Feldmann, Jürgen Ihringer, Harald Kunstmann, Joachim Liebert, Bruno Merz, Irena Ott, and Sven Wagner

Introduction

The climate is changing all over the world, and due to the inertia in the climate system, the rate of change will be beyond the reach of any mitigation effort for the next few decades. Adaptation to the changing climate is thus the remaining option. However, not all regions of the world are affected to the same degree, and local assessments of changes are thus necessary to plan for adaptation of infra-structure in order to maintain current safety standards. Projected changes in temperature and precipitation make it plausible to assume an increase in the risk of extreme flood events. Global projections of future climate at global and regional scales have, however, large uncertainties, which must be assessed to provide a better and more informed basis for adaptation decisions.

Flood discharges are sensitive to changes in not only precipitation amounts and the distribution over the year, but also to changes in precipitation intensity and the timing of snow melt. There are several possible drivers for trends in flood frequency. Besides changes caused by land use and land cover shifts, river training works or the construction of dams and reservoirs, changes in flood discharges are certainly also due to changes in climate. While it is challenging to attribute changes in flood hazards to these drivers, this study will only address climate-induced changes. Longer records and inventories of historical flood events show distinct phases of increased and reduced flood frequency, i.e. there is a clear natural variability in the flood records. Such natural variability can further complicate the attribution of trends to the climate change phenomenon.

For the 20th century, temperature has increased at a higher rate in Germany than the global mean, with the largest increase in winter. Connected with these temperature trends are an increase in number of hot days (maximum temperature above 30°C) and a reduction of ice days (maximum temperature less than 0°C). Therefore, it is very likely that the potential evapotranspiration has increased in summer. Furthermore, duration and thickness of snow cover in winter are expected to decrease further. This will have an impact on the timing and amount of runoff due to snowmelt. For precipitation, the past changes in Germany are less clear, but in general slight increasing trends are found in winter over large parts, whereas in summer the trends are more heterogeneous with mostly no change or only a slight decrease. Trends for precipitation extremes are stronger, however the changes depend on the season and region studied.

Investigations of changes in flood discharges for 145 gauges in Germany over the period 1951 – 2002 have shown increases in the annual maximum flood for a third of the gauges in western and southern Germany (Petrow and Merz, 2009). In winter, increasing trends were found in a diagonal band from northwest to the southeast of Germany, whereas in summer there were decreasing trends for eastern Germany and increasing trends for southern Germany. Large natural variability makes it difficult to perform trend analysis, and there are only few gauges with significant trends in very long time series. However, more significant increasing trends are found if the time period being studied is restricted to the last 40 – 50 years.

For the 21st century, mean precipitation is expected to increase in the north and decrease in the south of Europe. This expectation is based on a climate projection from a GCM (Global Climate Models) ensemble study, carried out in connection with the AR4 IPCC-report (IPCC, 2007). It was also shown that the ensemble not only produces such a pattern over Europe, but that the individual members agree significantly on the sign of the changes in the north and south respectively. The transition zone between the increases and decreases in precipitation goes through central Europe, thus there are only weak changes and disagreement over the sign of the change for Germany. Whereas mean precipitation shows only weak changes for central Europe, there are significant changes to the distributions of precipitation intensities. These changes are such that there is a decrease in the weaker intensities, and a corresponding increase in the higher intensities. In other words, the precipitation events are becoming more intense. RCM (Regional Climate Model) studies

of Germany have shown that the variability of precipitation is increasing for the next few decades, with larger changes for extreme events than for more moderate events (Feldmann et al., 2011).

Investigations of changes in flood discharges using single model projections have shown heterogeneous results for extreme flood events in Germany. Such studies tend to be overconfident, as the change patterns from single climate projections can differ significantly. Larger projects have investigated changes in the river discharges using multi-model projections, including different GCMs, RCMs, HMs (Hydrological Models), and initializations. The general result from such studies is that the GCM and natural variability have a large impact on the results, followed by the RCM, HM and finally the emission scenario used, although the HM and RCM position in the scale differs between studies. The common use of the delta change approach (a method of imposing a GCM or RCM derived climate change signal on the observational record) and other bias correction techniques can have a large impact on the rank of uncertainties. In general, and for Germany in particular, there is a lack of such multi-model simulations of discharge assessments, however with this project and the ongoing BfG (Federal Institute of Hydrology) project KLIWAS (http://www.kliwas.de/), this is starting to change.

Objectives

Focusing on changes in flood discharge, this pilot study aims at promoting the use of ensembles combining climate and hydrological models for scenario based projections, in order to assess the uncertainties involved. The near future time period of study (2021 – 2050) was chosen such that it conforms with that of the planning horizons of local water resource management systems, i.e. at about 30 – 50 years. Three focus catchments of medium and small sizes were selected: Ammer, Mulde and Ruhr. Such smaller catchments have faster response times to meteorological events, and thus put high requirements on the meteorological input data. High resolution RCM simulations were therefore carried out.

The ensemble, built with global climate models, regional climate models and hydrological models, was constructed such that the main sources of uncertainty are sampled. From earlier projects there are clear results that the emission scenario has a small impact on the results for the near future. This is because the different scenarios of the IPCC start to differ significantly only after about year 2050. Thus only the A1B scenario is used in this project. Physical models of nature, such as GCMs, RCMs and HMs, are ultimately limited by our understanding of the physical processes. Differences between similar models and the way they are handled, e.g. GCMs, yield different descriptions of the world, and it is often not possible to determine which one is more correct. The main idea behind model ensemble studies is that multiple models will produce a distribution of plausible results, which encapsulates the “real world” result.

In this study, an ensemble which samples the uncertainty from each part of the chain from GCM to HM simulations, via RCMs, is constructed (see Fig. 1). Due to limited availability of sufficiently comprehensive GCM data and limited computing resources, the ensemble is based on only two GCMs (ECHAM5 and CCCma3 from the IPCC-AR4 ensemble). Also, to assess the natural variability (which is a known large source of uncertainty for the near future), three realizations of ECHAM5 are used. To downscale the GCM simulations, two RCMs (CLM and WRF) are used. Finally, three HMs (WaSiM, SWIM and PRMS) are used to model discharges for the three catchments (two models per catchment), which forms a ten-member ensemble per catchment. The investigation periods used are the 1971 – 2000 control period and the 2021 – 2050 future period, using the A1B scenario.

Results

A major task of the project was to carry out all of the simulations of the ensemble, starting from already available GCM simulations (see Fig. 1). The RCM simulations were the most time and computer resources consuming part of the ensemble, but the end result is a unique five member RCM climate ensemble at the high spatial resolution of seven kilometers for all of Germany. This ensemble forms the basis for the assessment of flood discharges through the use of HMs, but can later be applied to different climate change related topics.

To give an overview of the atmospheric driving data and changes thereof, a short summary of the main findings of the RCM simulations is presented below. However, since the focus of the project is on changes in discharge, the analysis presented here will have an emphasis on

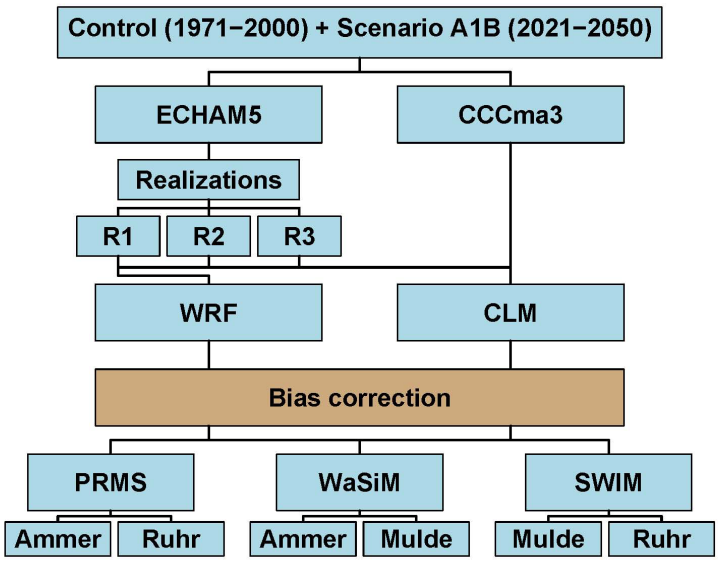

Fig. 1: Schematic of the model chain of simulations used in the project.

the HM results. More in-depth analysis of the atmospheric investigations can be found in the two papers Berg et al. (2011) and Wagner et al. (2011), as well as in the main report of the project (Schädler et al., 2011, available for download from www.cedim.de) which also includes more information on the HM results.

Temperature and precipitation

Mean temperature is found to increase significantly for Germany with an ensemble mean increase of 1.1°C, with larger increases in winter (1.4°C) than in summer (0.9°C). Since temperature is a continuous variable, there are no larger regional variations to the temperature signal over Germany, except for a small gradient of larger increases from west to east.

Changes in mean annual precipitation are found to follow the pattern of changes over Europe, described in the AR4 IPCC assessment (IPCC, 2007), for each member of the ensemble. However, for Germany, the annual changes are generally not significant as the country is situated in between regions of opposite changes; there is, however, a tendency for increasing precipitation in winter and decreasing precipitation in summer. Fig. 2 shows the annual mean precipitation changes in Germany for the ensemble mean as well as for two members with the strongest increase and decrease of precipitation, respectively. The different GCMs have an obvious impact on the results. Although driven by the same forcing data, the WRF and CLM RCMs produce different change patterns and amplitudes, which indicates a large sensitivity of the precipitation changes with regard to the RCM (Wagner et al., 2011).

Even though there is no significant change in mean precipitation, there are significant changes to the precipitation intensity distribution. Fig. 3 shows the difference between the probability distribution functions for the future and the control period, indicating a decrease in lower intensity precipitation and an increase in higher intensities. This means that the already intense precipitation events become more intense in the future. The characteristics of the change are similar for all ECHAM5-driven simulations, although the WRF simulation produces slightly larger amplitudes. The CCCma3-driven CLM simulation has a different change point, smaller amplitudes and a different behavior at weak intensities.

It turned out that a bias correction of the RCM temperature and precipitation was necessary. The method used performs corrections to the full distributions of precipitation intensities and temperatures, and is further described in Schädler et al. (2011). Bias corrections are commonly based on the assumption that the biases of the models are stationary, i.e. that the bias in the control period is the same as in the future period and should not have an impact on projected changes. The bias corrected RCM temperature and precipitation data, together with the other meteorological data, are then used to drive the HMs.

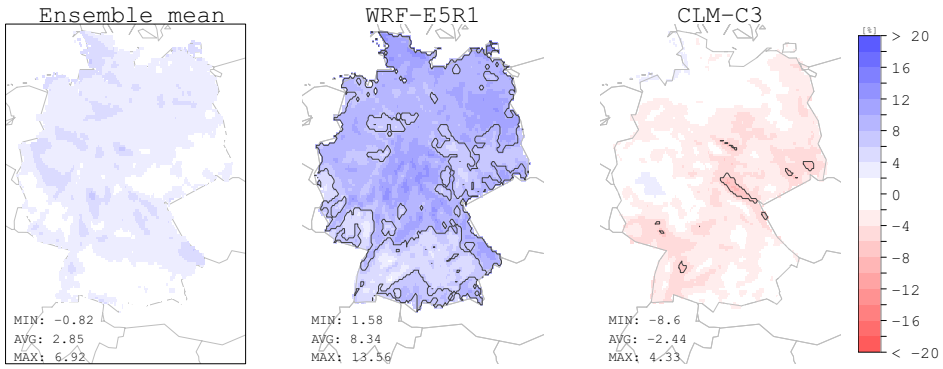

Fig. 2: Mean annual precipitation changes (%) for a selection of the ensemble members. The panels show: the ensemble mean (left), WRF driven by ECHAM5 (middle) and CLM driven by CCCma3 (right).

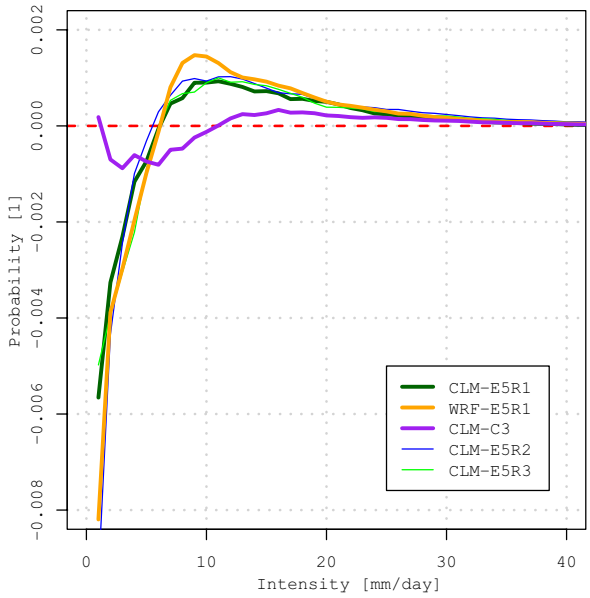

Fig. 3: Changes in the distribution of precipitation intensities displayed as the difference between scenario and control period probabilities for each of the climate ensemble members.

Flood discharges

Only a few exemplary results are presented here (mainly for the Wetter gauge in the Ruhr catchment); more information can be found in the final report. Here we present the results of control period simulations and investigations of the climate change of the mean maximum monthly discharge (MHQ) and the return values respective return periods.

The HMs were calibrated with the observed discharge data at several gauges in each catchment, while driven by observational meteorological data. The quality of the hydrological model calibration is characterized by appropriate criterion parameters (like NSE) evaluated for a uniform validation period (1971 – 2000). There was a comparable quality and good consistency between the HMs for the different catchments. For the climate change simulations, the models are instead driven by RCM simulated meteorological data, and Fig. 4 (left) shows an example of the control period MHQ results for the Ruhr catchment. Although the meteorological input is the same, the two HMs have an offset of several tens of m^3/s between each other, and also have varying biases in comparison with the observations. Noticeable is the different behavior in summer, although the meteorological model input is the same and the hydrological calibration shows comparable

results. This is related to the bias in the RCM humidity and radiation data, different observational data used for the calibration of the models, different methods and approaches to describe the complex water balance in the catchments and the pre-processing of the input data. However, the ensemble means follow the general shape of the observed annual cycle.

The relative changes between future and control in MHQ for the Ruhr catchment are in a very close agreement between the HMs (see Fig. 4 right). There are general increases in MHQ for most of the year. The ensemble spread is smaller in the winter half-year than in the summer half-year, indicating a higher likelihood of MHQ increases in winter than in summer, albeit with considerable uncertainty.

Fig. 5 shows the change (as ratio future/control) in MHQ in the Ruhr catchment for each of the ensemble members and the ensemble mean for the winter and summer half-years. The single members agree well on the sign of the change for winter, but are more divergent in summer. The HMs mostly produce similar and concurrent changes. The changes for the summer half-year are dominated by the large increases in MHQ for the WRF-driven simulations. In the meteorological analysis, WRF also produces a different climate change signal for precipitation than CLM, which might explain some of the differences in the HM results.

A statistical analysis of the ensemble results (consisting of different GCM-RCM-HM chains) showed that there is a large spread in the discharge statistics and therefore in the discharge change signal between the single members (Schädler et al., 2011). Differences could be attributed mainly to the GCMs and to natural variability during the winter half-year, but mainly to the RCMs during the summer half-year. The larger uncertainty attributed to the RCMs differs from earlier studies. The HMs have a similar uncertainty as the RCMs in winter, and GCMs in summer. The results are important pieces of information, since it shows that results from a single simulation can be quite misleading, and underlines the added value of ensembles.

Calculating return periods is a way of characterizing how often an event of a certain magnitude occurs on average and is used to characterize extreme events. Fig. 6 shows an example of the ensemble mean climate change signal in return periods for the Ruhr catchment, where the signal is strongest. The spread of the ensemble members is indicated by one standard deviation (shown as a shaded gray area in the figure). There is a clear tendency toward increasing discharges for all return periods longer than one year. In the summer half-year, the change is larger with about a 10 – 20% increase for all return periods, and with high agreement between the two HMs. The winter half year changes are slightly smaller, and the HMs diverge at longer return periods.

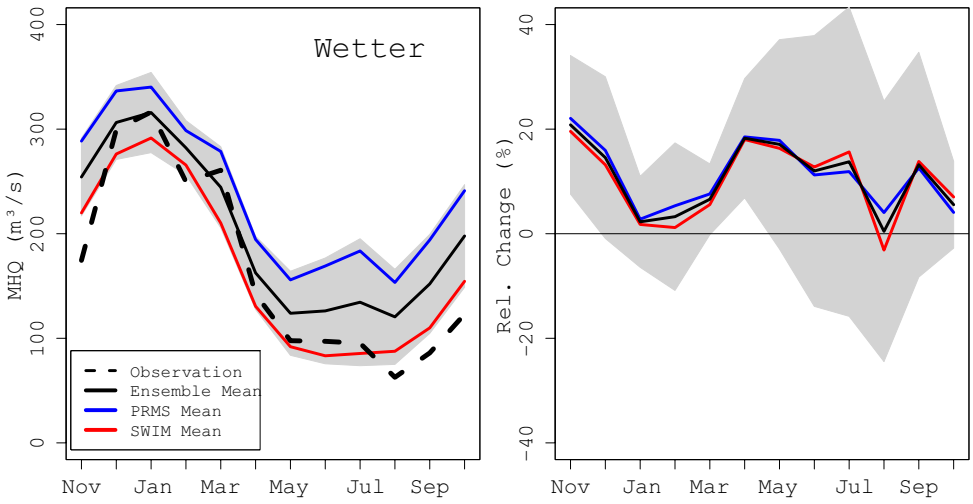

Fig. 4: Annual cycle of annual MHQ (left) in the control period and projected relative changes (right) for the Wetter gauge in the Ruhr catchment. The PRMS (blue) and SWIM (red) model ensembles (each with five members) are shown additionally to the full ensemble mean (black). The gray shaded area indicates the ensemble spread as one standard deviation of the ensemble.

The different catchments are subjected to differences in the annual cycles of meteorological variables, such as precipitation, and the catchments differ in topography, soil types, response times, etc. Therefore, they also show different responses to the climate change signals in the driving meteorological data. In comparison with the Ruhr, the Ammer and Mulde catchments are more variable in the response and show no significant changes for the period studied here. More detailed investigations are presented in Schädler et al. (2011).

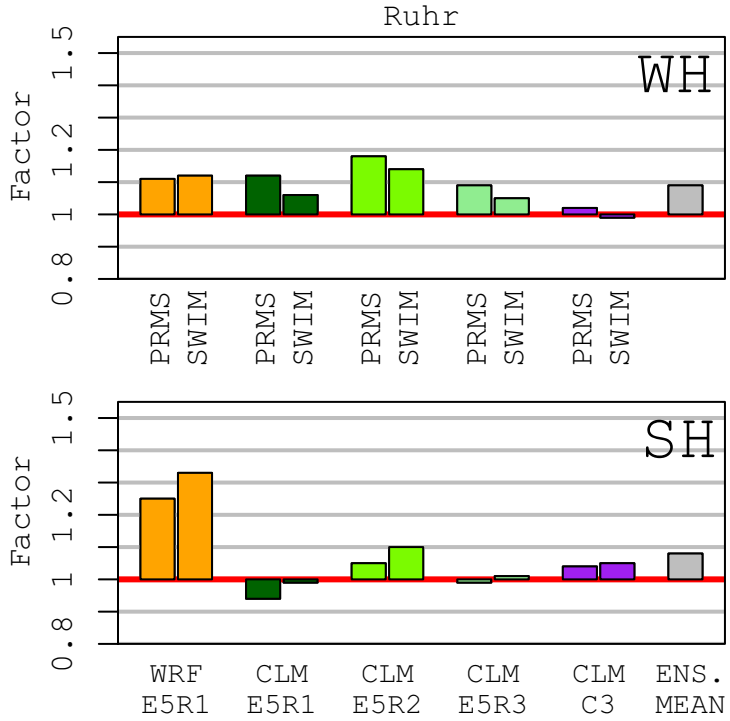

Fig. 5: Changes (scenario/control) of MHQ for the Ruhr catchment for each individual ensemble member, separately for the winter (WH) and summer half year (SH). The HM used is indicated between the two figures, and the driving data below the figures.

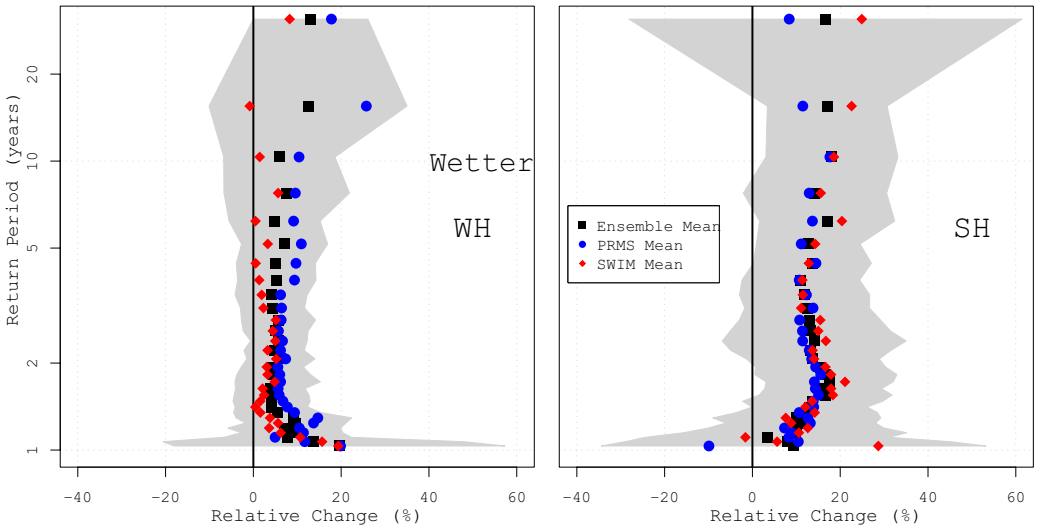

Fig. 6: Changes in discharge for a given return period for the Ruhr catchment in winter (left) and summer (right) half years. Denotations as in Fig. 4.

Discussion and outlook

The aims of this project were i) to assess if and how the flood discharges for medium to small size catchment areas in Germany will change in the near future (up to 2050), and ii) what uncertainty is associated with such a statement. We studied three catchment areas, two of them medium sized in low mountain ranges and a smaller one with more Alpine characteristics; such catchments react faster to heavy precipitation than large catchments and thus present a more immediate flood risk. To reproduce precipitation in a realistic manner (especially summertime convective precipitation), we used two non-hydrostatic RCMs at high spatial resolution (7 km). To quantify the uncertainty in the climate change signal, we used a ten member ensemble, in which the GCM-RCM-HM model chain was built with different GCMs, RCMs and HMs. Although the ensemble used is considered small in comparison with those used for weather prediction, it is one of the largest currently available RCM based ensembles at such a high resolution.

Although the climate change signal is weaker and the 30-year periods make it difficult to consider return periods longer than about 10 – 20 years, the near future period 2021 – 2050 was deliberately chosen for its planning relevance and its relative independence from uncertain scenario assumptions about future greenhouse gas emissions. Besides the more scientific result of showing the feasibility and added value of this kind of study, the results for the return periods considered here are of practical relevance to establish flood risk maps for planning and insurance purposes.

According to the ensemble results, the present day flood discharges remain at a constant level for the near future, or could even increase slightly, notably in the Ruhr catchment. However, single members show a much more pronounced signal. These results agree with observations of the past and seem to indicate that past trends will continue in the near future.

Increased sophistication and skill of the models (GCMs, RCMs and HMs) can reduce the uncertainties, but only to a certain point. There are many physical processes that are unknown, and probably will remain so for the foreseeable future. Multi-model ensembles enable to take this uncertainty into account, but it also requires the willingness and ability to deal with uncertain information.

It must be pointed out that this work was a pilot study combining the investigations of medium to small sized catchments with an ensemble of model chains including high resolution climate models. The study showed the feasibility and – considering the wide range of single results – also the necessity to perform this kind of work. It already indicates trends, but it could be put on a more firm basis and extended in several respects. Some of these are discussed below.

The ensemble: Although the results presented here already give an indication of the future prospects and are certainly much more informative and less error-prone than results obtained with only one single ensemble member, there is a need for a larger and more balanced ensemble. The ensemble used is essentially an ensemble of opportunity, restricted by the availability of suitable GCM data and the need to fit the computing time for quite expensive simulations into the project time frame. The consequence is that the ensemble is quite small and biased towards a specific GCM. A larger ensemble would provide a better basis for statistical analyses; this holds especially for extreme value statistics where a larger ensemble (possibly combined with longer time series) might provide more data in the higher percentiles and thus would allow studying longer return periods more accurately. The majority of the ensemble members are based on ECHAM5 as a driving GCM and CLM as RCM, so it would be important to have more GCMs and RCMs available. Although there are indications that ensembles with about 20 members already capture the main variability, this requires the ensemble to be well distributed. However, such information is not available *a priori* and can only be ascertained through a larger ensemble size. For GCMs, it can be expected that more datasets suitable for downscaling will be available in the future; for RCMs, apart from CLM and WRF, not many non-hydrostatic models necessary for the resolution used (high resolution seems to be a necessary, but not sufficient condition for realistic results at catchment scale) are available but this might be alleviated by using different setups and parameterizations in the available models. It will also be necessary to reduce the biases of the models. A large remaining problem is the required computing time, which considerably reduces the affordable ensemble size. Thus, the main goals should be to derive reliable information from small and possibly biased ensembles, to improve GCMs and RCMs, and to learn to deal with the remaining uncertainty.

Consequences for flood risk: The discharge at gauges varies considerably among the different ensemble members. However, discharge gives no direct information on the size of flooding areas, which is the relevant information in hazard assessments. Obtaining flood risk information requires the discharge information to be fed into hydraulic models, a step which was not included in the present project, but could be carried out with the available data.

Thus, the CEDIM-project “Flood hazards in a changing climate” has shown that there are still large scientific challenges ahead, but at the same time it could already provide valuable information for e.g. water management purposes about trends for the near future, including uncertainty margins. The data produced in the project can be used for further studies, and the methods be applied to other catchments.

References

Feldmann, H., Panitz, H.-J., Schädler, G., Kottmeier, Ch. (2011): Near future changes of heavy precipitation over complex terrain derived from high resolution RCM ensemble simulations, submitted to Int. J. of Climatology.

IPCC AR4 (2007): Climate Change 2007. Fourth Assessment Report of the Intergovernmental Panel on Climate Change Intergovernmental Panel on Climate Change, Fourth Assessment Report. Cambridge, UK and New York, USA : Cambridge University Press, 2007.

Petrow, T. and B. Merz (2009): Trends in flood magnitude, frequency and seasonality in Germany in the period 1951-2002, J. Hydrol. 371(1-4): 129-141.

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Publications

Berg, P., Panitz, H.-J., Schädler, G., Feldmann, H., Kottmeier, Ch. (2010): Downscaling climate simulations for use in hydrological modelling of medium-sized river catchments, in: M. Resch et al. (eds.), High performance computing on vector systems 2010, doi:10.1007/978-3-642-11851-7_12.

Berg, P., Panitz, H.-J., Schädler, G., Feldmann, H., Kottmeier, Ch. (2011): Modelling Regional Climate Change in Germany, in: W.E. Nagel et al. (eds.), High Performance Computing in Science and Engineering,10, doi:10.1007/978-3-642-15748-6_34.

Berg, P., Wagner, S., Kunstmann, H., Schädler, G. (2011): High resolution RCM simulations for Germany: Part I – validation, submitted to Clim. Dyn.

Berg, P., Duethmann, D., Liebert, J., Wagner, S. (2011): Uncertainty aspects of changes in flood hazard for medium size river catchments for the near future. Deutsches Komitee Katastrophenvorsorge e.V. (DKKV), 11. Forum Katastrophenvorsorge.

Liebert, J., Berg, P., Düthmann, D., Ihringer, J., Kunstmann, H., Merz, B., Ott, I., Schädler, G., Wagner, S. (2011): Wie ändern sich die Charakteristika von Hochwasserereignissen unter dem Klimawandel und mit welchem Unsicherheiten sind solche Aussagen behaftet?, Conference Publication acqua alta 2011 Hamburg, International Conference on Climate Impact, Flood Protection and Hydraulic Engineering, TuTech Verlag, ISBN 978-3-941492-38-7.

Schädler, G., Berg, P., Düthmann, D., Feldmann, H., Ihringer, J., Kunstmann, H., Liebert, J., Merz, B., Ott, I., Wagner, S. (2011): Flood hazards in a changing climate, www.cedim.de or http://www.cedim.de/download/Flood_Hazards_in_a_Changing_Climate.pdf

Wagner, S., Berg, P., Schädler, G., Kunstmann, H. (2011): High resolution RCM simulations for Germany: Part II – projected climate changes, submitted to Clim. Dyn.

Wagner, S., Berg, P., Duethmann, D., Liebert, J., Ott, I., Kunstmann,H. (2011)**:** High resolution regional climate simulations for hydrological impact studies in Germany, Geophysical Research Abstracts Vol. 13, EGU2011-10858, 2011, EGU General Assembly 2011.

Änderung der Hochwassergefährdung durch Klimawandel

In mehreren Studien wird für den prognostizierten Klimawandel von einer zunehmenden Variabilität von Niederschlag und Temperatur ausgegangen. Das könnte bedeuten, dass auch (extreme) Hochwasserereignisse wahrscheinlicher werden. Allerdings sind diese Modellaussagen mit deutlichen Unsicherheiten verbunden (IPCC, 2007).

Um eine Basis für diese wichtigen Fragestellungen zu geben, wird in dem CEDIM-Projekt „Flood hazards in a changing climate“ mit Hilfe eines Ensemble-Ansatzes untersucht, wie sich Starkniederschläge und Hochwasserereignisse unter dem Einfluss des Klimawandels ändern.

Die Quantifizierung der Unsicherheitsspannen der Ergebnisse, insbesondere aufgrund der notwendigen meteorologisch-hydrologischen Modellkette, basierend auf unterschiedlichen atmosphärischen Antriebsdaten, Regionalisierungsverfahren, Modellauflösungen und Modelltypen spielt dabei die zentrale Rolle. Hierzu werden Modellketten bestehend aus zwei globalen (GCM: ECHAM5 und CCCma3), zwei regionalen Klimamodellen (RCM: CLM und WRF) und drei hydrologischen Modellen (HM: PRMS, SWIM und WaSiM-ETH) für einen Kontrollzeitraum (1971 – 2000) sowie einen Zukunftszeitraum (2021 – 2050) basierend auf dem Emissionsszenario A1B für drei repräsentative Einzugsgebiete angewendet. Um den Einfluss natürlicher Klimaschwankungen abschätzen zu können, werden für ECHAM5 zusätzlich drei verschiedene Realisationen berücksichtigt. Für die drei betrachteten Einzugsgebiete (Ammer, Mulde und Ruhr) werden jeweils zwei verschiedene hydrologische Modelle angewendet. Damit steht für jedes Einzugsgebiet ein Ensemble aus zehn unterschiedlichen Simulationen zur Verfügung.

Die regionalen Klimasimulationen mit einer Auflösung von 7 Kilometern für Deutschland zeigen einen signifikanten Temperaturanstieg um 1,1°C. Dabei ist die Temperaturzunahme im Winter mit 1,4°C größer als im Sommer (0,9°C). Für den zukünftigen mittleren Jahresniederschlag werden von CLM und WRF sowohl zunehmende als auch abnehmende Tendenzen berechnet. In den derzeit verfügbaren regionalen und globalen Klimamodellen sind systematische Abweichungen zwischen Modellsimulation und meteorologischer Beobachtung vorhanden. Vor der Übernahme der meteorologischen Daten in die hydrologischen Modelle werden daher mit Hilfe von statistischen Analysen Korrekturen vorgenommen, in dieser Studie für Niederschlag und Temperatur.

Die Ergebnisse der hydrologischen Modellierung zeigen teilweise deutliche Unterschiede in den simulierten Abflüssen, beim Klimasignal sind die Unterschiede jedoch wesentlich geringer. Im Mittel ergibt sich für das untersuchte Ensemble in der näheren Zukunft eine gleich bleibende oder im Falle der Ruhr eine leicht zunehmende Hochwassergefahr. Die Ensemble-Simulationen führen zu einer großen Ergebnisvariabilität, welche die Unsicherheiten in der notwendigen Modellkette GCM-RCM-HM verdeutlichen. Die größten Unsicherheiten innerhalb der Modellkette liegen im Winterhalbjahr bei den globalen Klimamodellen und der natürlichen Klimavariabilität, im Sommerhalbjahr überwiegend bei den regionalen Klimamodellen.

Die Ergebnisse zeigen, dass Erkenntnisse aus einer einzelnen Modellkette sehr zufallsbehaftet sein können und damit u.a. sogar falsche Zukunftstendenzen bzgl. einer Hochwassergefahr aufzeigen können; sie unterstreichen nochmals die Notwendigkeit von Ensemblerechnungen.

Flood risk change and risk drivers - Case study „Vereinigte Mulde“

Florian Elmer, Jana Hoymann, Doris Düthmann, Sergiy Vorogushyn, Heidi Kreibich

Introduction

The observed increase in direct flood damages in recent decades may be caused by changes in the meteorological drivers of floods, changing land-use patterns and socio-economic developments. It is still largely unknown to what extent these factors contribute to future flood risk changes.

Hence, we established a risk model chain that takes multiple influences into account: from climate impact via hydrological and hydraulic modeling to damage and risk estimation while considering climate, economic and land-use changes.

Aims / Objective

Our first objective is to set up this model chain using the example of the meso-scale Vereinigte Mulde catchment in Germany (Fig.1).

Second, we model the development of potential damages to residential buildings in the study area over time (1990-2020) and transfer these damages to risk estimates. Third, based on selected scenarios, we analyze which drivers contribute to the change in flood risk and to what extent: Flood hazard change (change of the probability of events of a certain magnitude), land-use change (changes in residential area and the associated building stock composition) and changes in building values in terms of reconstruction costs for potentially affected residential buildings.

The study is intended to serve as a pilot application for macro-scale analysis and therefore provides a generic approach.

Project status and results

The first part of the project, an analysis of present and future flood risk change (1990-2020)

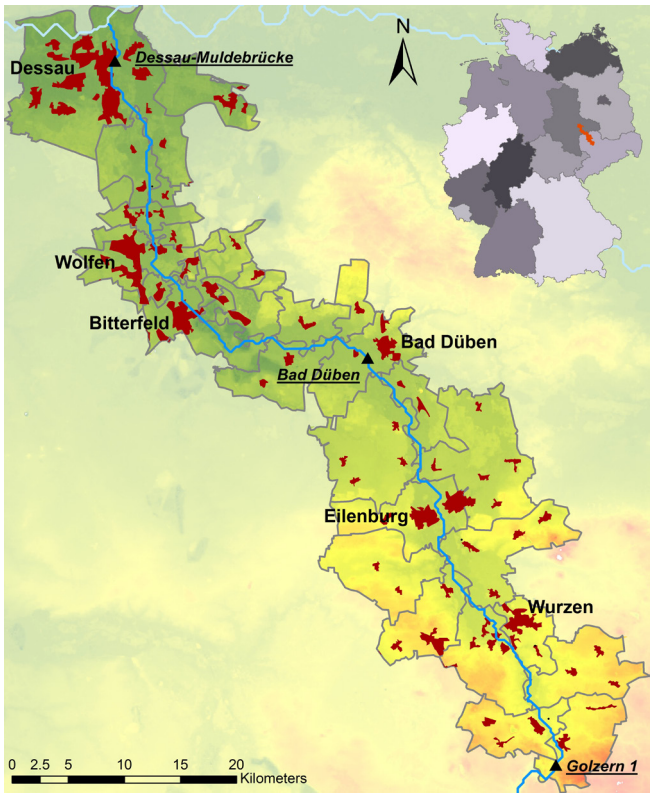

Fig.1: Study area “Vereinigte Mulde” with residential areas and gauges. The municipality borders as at 2000.

and its drivers at the Vereinigte Mulde River was completed in July 2011. The second project part, focusing on flood risk change in the Elbe basin (2000-2050), started in January 2011 and is still ongoing. The core results of the Mulde-project are presented in the following.

Methodology

The study uses state-of-the-art models (hydrology, hydraulics, land-use and damage estimation), model results (climatology) and methods (value calculation, disaggregation and extrapolation) for each chain link (Fig.2).

As climate input we obtained climate data from Deutsches Klimarechenzentrum (DKRZ) which have been dynamically downscaled from the ECHAM5 General Circulation Model (GCM) using the regional climate model (RCM) COSMO-CLM with a 0.2° horizontal resolution (DKRZ 2006, 2007). The ECHAM5 model run is based on the IPCC A1B emission scenario (IPCC 2000).

SWIM (Krysanova, Wechsung et al. 2000, Krysanova, Müller-Wohlfeil et al. 1998), a process-based semi-distributed model is used for hydrological modeling. It is set up for the Mulde catchment using the following spatial input data: a digital elevation model (DEM; 25m-DEM from BKG), land cover data (CorineLandCover - CLC) and soil data (BUEK 1000). In order to generate discharge data for the scenario period 2001 to 2020, the hydrological model is run using the bias-corrected RCM data.

To characterize the flood hazard we computed the extreme value statistics at gauges along the study reach. A set of probability distribution functions was fitted to four 50-year time windows in the period from 1941 till 2020, moved with the step of 10 years. Flood hazard in terms of discharges for selected recurrence intervals provide the input for modeling inundation scenarios. The recurrence intervals are also considered in the damage model as a parameter for loss estimation. Finally, they are taken into account to determine flood risk in terms of EAD.

The hydraulic simulations are carried out using the HEC-RAS (USACE 2010) model setup for the reach between gauges Golzern 1 and Dessau-Muldebrücke. Inundation scenarios were derived for return periods of 2, 5, 10, 20, 50, 100, 200, 500 and 1000 years based on extreme value statistics at gauge Golzern 1. The maximum simulated water stages were intersected with the DEM25 using the HEC-GeoRAS tool to obtain inundation depths. Flood protection measures are not taken into account due to the lack of consistent information on such structures.

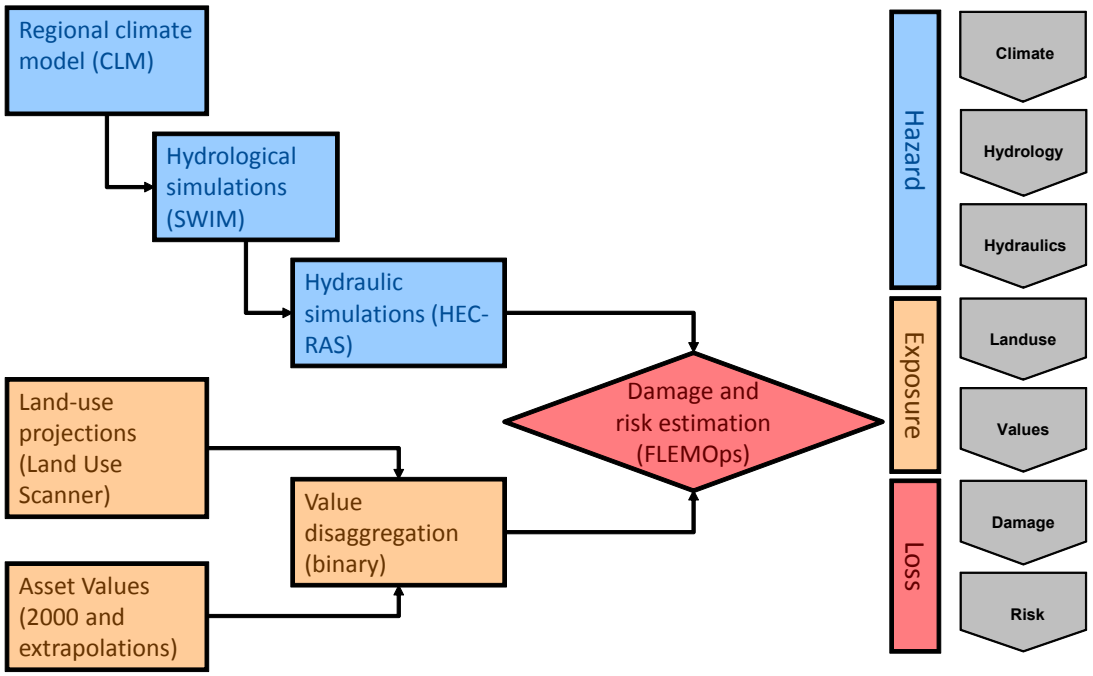

Fig.2: Flood Risk Chain – Chain links and models. Raster-based damage estimation, automated integration of input parameters.

Damage modeling for residential buildings requires information on spatial distribution, specific value of the building stock as well as information on building quality. Our survey uses land use data from CLC1990 and CLC2000 (Keil et al. 2005). Land-use projections for 2010 and 2020 were calculated with the Land Use Scanner model, applied to the entire Elbe basin (Hoymann 2010, 2011) and are based on IPCC emission scenarios and spatial planning policies:

- $A1^0$: Globalization with weak spatial planning policy
- $A1^+$: Globalization with very restrictive spatial planning policy
- $B2^0$: Differentiation with weak spatial planning policy
- $B2^+$: Differentiation with very restrictive spatial planning policy

A complete set of building values on the municipality level was created within the CEDIM framework by Kleist et al. (2006) for the year 2000 and were time adjusted for this study by using official indexed construction prices (BPI) (DESTATIS 2010) for 1990 and 2010 and a linear extrapolation of this index for 2020. The values are disaggregated, i.e. distributed to the respective land-use units by applying a binary disaggregation approach (Wünsch et al. 2009).

We use a modified version of the multi-factorial Flood Loss Estimation Model for the private sector (i.e. residential buildings) FLEMOps (Thieken et al. 2008, Elmer et al. 2010) to estimate flood damages to residential buildings. FLEMOps is derived from empirical damage data of 2158 residential loss cases in Germany and considers water level, building type and building quality and additionally the effects of flood magnitude (in terms of recurrence interval).

Flood risk is defined as the probability of a flood event times the resulting damage. In terms of expected annual damage (EAD) it is computed by integrating damage estimates from inundation scenario sets.

For the separation and quantification of the influence of different factors on the risk change, the risk influencing parameters (flood hazard associated with climate change, land use, building prices) were changed one-at-a-time. This results in three future scenarios, which were compared to the reference scenario.

Results

The maximum estimated flood damage of residential buildings for the study area is 467.1 million € for the most extreme inundation scenario (S9) under the conditions of $A1^0$ land use development in 2020. The estimated damages for the (high probability) inundation scenario S2 are one order of magnitude smaller (Fig.3).

Changes in EAD with time (Fig.4, black bars) and changes in damage estimations (Fig.3) show a similar pattern. Different land use scenarios seem to have a minor influence on overall changes.

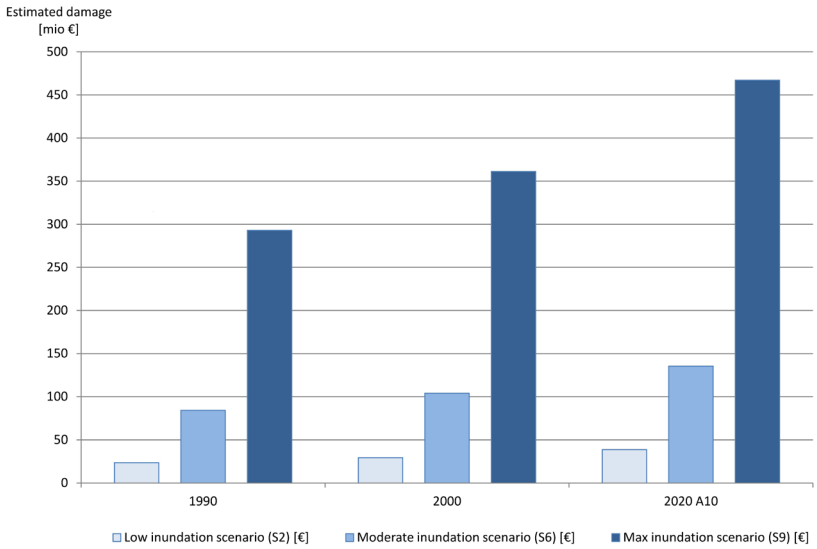

Fig.3: Absolute changes of estimated damage with time. $A1^0$ is the maximum land-use change scenario. Inundation scenarios S2, S6 and S9 correspond to recurrence intervals of 5, 100 and 1000 years in 2000.

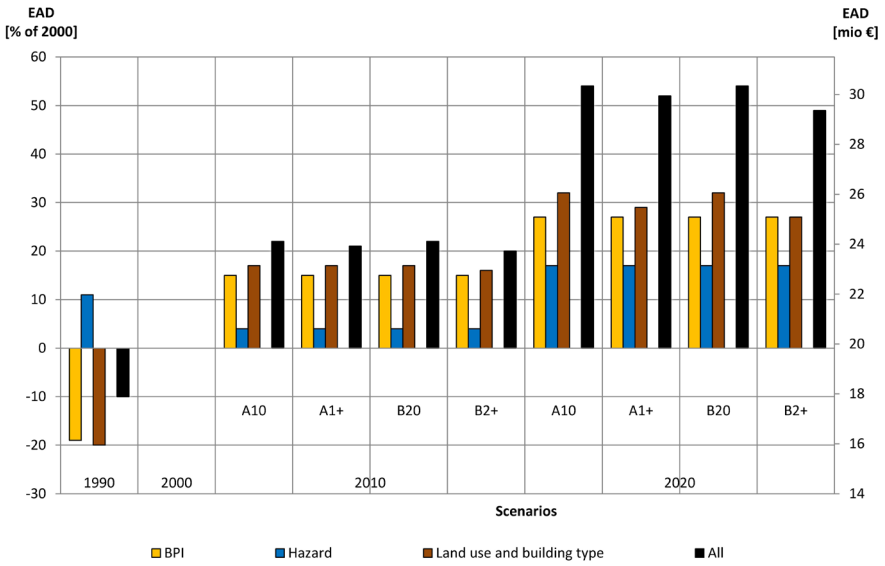

Fig.4: Overall flood risk change compared to single parameter risk change. EAD – left axis gives % of change compared to 2000 risk estimates, right axis gives EAD in mil. € for the study area.

The separation of influences on risk change shows that all three drivers contribute significantly to risk increase (Fig.4, colored bars).

Based on the linear BPI extrapolation, risk in 1990 is only 81% of the risk in 2000. The increase is 27% from 2000 to 2020 for our test case.

Climate induced hazard change leads to changes in damage risk of 17% maximum from 2000 to 2020. But the hazard shows strong fluctuations. The influence of climate change on risk development cannot be reliably interpreted for this region, but the flood hazard fluctuations hint at the magnitude of the influence of climate change.

The influence of changes in land use and building stock composition is even slightly stronger than the influence of building price development in our analysis (20% from 1990 to 2000 and max. 32% from 2000 to 2020). This parameter can be influenced by regional and national (land-use) policies. Risk increase can be lowered by 3 to 5% (2000 to 2020) when applying strict regulations of settlement development (+-scenarios).

Outlook

The ongoing CEDIM-project “Flood risk change in the Elbe basin” uses these methods and follows a similar approach to the pilot project (but with slight modification) and extends the analyses to a larger scale. The time frame of this follow-up study is extended further into the future (2000 - 2050). This allows for a large-horizon analysis and quantification of the influence of climate driven hazard changes. Additionally, the project applies an ensemble approach by incorporating several climate model combinations and focuses more on uncertainty quantification along the whole risk chain.

References

Deutsches Klimarechenzentrum (DKRZ) (2006): Climate Simulation with CLM, Scenario A1B run no.2, Data Stream 3: European region (CLM_A1B_2_D3). CLM regional climate model runs forced by the global IPCC scenario runs (archive.dkrz.de:/ut/k/k204095/prism/experiments/A1B_2). Creation date: 09/11/2006.

Deutsches Klimarechenzentrum (DKRZ) (2007): Climate Simulation with CLM, Climate of the 20th Century run no.2, Data Stream 3: European region (CLM_C20_2_D3). CLM regional climate model runs forced by the global IPCC scenario runs (archive.dkrz.de:/ut/k/k204095/prism/experiments/C20_2). Creation date: 29/01/2007.

Elmer, F., Thieken, A. H., Pech, I., and Kreibich, H. (2010): Influence of flood frequency on residential building losses, Nat. Hazards Earth Syst. Sci., 10, 2145-2159.

Hoymann, J. (2011): Accelerating urban sprawl in depopulating regions: a scenario analysis for the Elbe River Basin, Regional Environmental Change, 11, 73-86.

Hoymann, J. (2010): Spatial allocation of future residential land use in the Elbe River Basin, Environment and Planning B: Planning and Design, 37, 911-928.

Intergovernmental Panel on Climate Change (IPCC) (2000): Summary for Policymakers: Emissions Scenarios, IPCC SPECIAL REPORT.

Keil, M., Kiefl, R., and Strunz, G. (2500): CORINE Land Cover 2000 – Europaweit harmonisierte Aktualisierung der Landnutzungsdaten für Deutschland, Deutsches Zentrum für Luft- und Raumfahrt e.V. Deutsches Fernerkundungsdatenzentrum, Oberpfaffenhofen, Abschlussbericht zum F+E Vorhaben UBA FKZ 201 12 209 UBA - FB 000 826, 83.

Kleist, L., Thieken, A. H., Köhler, P., Müller, M., Seifert, I., Borst, D., and Werner, U. (2006): Estimation of the regional stock of residential buildings as a basis for a comparative risk assessment in Germany, Nat. Hazards Earth Syst. Sci., 6, 541 - 552.

Krysanova, V., Muller-Wohlfeil, D. I., and Becker, A. (1998): Development and test of a spatially distributed hydrological water quality model for mesoscale watersheds, Ecol. Model., 106, 261-289.

Krysanova, V., Wechsung, F., Arnold, J. G., Srinivasan, R., and Williams, J. (2000): SWIM (Soil and Water Integrated Model), User Manual, 239p..

Statistisches Bundesamt (DESTATIS) (2010): Preise. Preisindizes für die Bauwirtschaft – Februar 2010, Fachserie 17, Reihe 4, Wiesbaden.

Thieken, A. H., Olschewski, A., Kreibich, H., Kobsch, S., and Merz, B. (2008): Development and evaluation of FLEMOps - a new Flood Loss Estimation Model for the private sector, in: Flood Recovery, Innovation and Response, edited by: Proverbs, D., Brebbia, C. A., and Penning-Rowsell, E., Wit Transactions on Ecology and the Environment, Wit Press, Southampton, 315-324.

US Army Corps of Engineers (USACE) (2010): HEC-RAS River Analysis System User's Manual, US Army Corps of Engineers, Davis, USA-Version 4.1, 790 pp..

Wünsch, A., Herrmann, U., Kreibich, H., and Thieken, A. (2009): The Role of Disaggregation of Asset Values in Flood Loss Estimation: A Comparison of Different Modeling Approaches at the Mulde River, Germany, Environmental Management, 44, 524-541.

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Publications

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Gericke, A., Elmer, F., Berg, P., Düthmann, D., Hundecha, Y., Brucher, D., Vorogushyn, S., Apel, H., Teisselmann, F., Hoymann, J., Merz, B., Kreibich, H. (2011): Änderung des Hochwasserrisikos im Elbe-Einzugsgebiet (Poster, Abstract). Fachsymposium „Wasserbezogene Anpassungsmaßnahmen an den Landschafts- und Klimawandel in Deutschland." Großräschen/Lausitz, 22. - 24. Juni 2011.

Kreibich, H., Elmer, F., Merz, B. (2011): Veränderungen des Hochwasserrisikos und Konsequenzen für das Risikomanagement (Talk,

Abstract). Fachsymposium „Wasserbezogene Anpassungsmaßnahmen an den Landschafts- und Klimawandel in Deutschland.“ Großräschen/Lausitz, 22. - 24. Juni 2011.

Änderung des Hochwasserrisikos am Beispiel der Vereinigten Mulde

Als Ursache für den in den vergangenen Jahrzehnten beobachteten Anstieg der direkten Hochwasserschäden sind Änderungen der meteorologischen Ursachen von Hochwasserereignissen, Änderungen der Landnutzung und sozio-ökonomische Entwicklungen wahrscheinlich. In welchem Maße diese Faktoren zu Änderungen des Hochwasserrisikos in der Zukunft beitragen können, ist noch weitgehend unbekannt.

Wir untersuchen die Änderung des Hochwasserrisikos im Sinne jährlich zu erwartender Schäden an Wohngebäuden im Einzugsgebiet der Vereinigten Mulde für den Zeitraum 1990 bis 2020 und analysieren die Ursachen dieser Veränderungen. Zu diesem Zweck wurde eine „Risiko-Modellkette“ aufgebaut, die, beginnend mit Klimaszenarien über hydrologische Modellierung, hydraulische Modellierung sowie Szenarien zu Landnutzungs- und Werteänderungen zahlreiche Einflüsse berücksichtigt, und in Schadens- und Risikoabschätzungen einfließen lässt.

Nach unseren Berechnungen betrug das Hochwasserrisiko im Jahr 1990 90% des Risikos im Jahr 2000 und steigt bis 2020 weiter auf 154% (extremes Szenario) des 2000er Wertes. Die Quantifizierung der „Treiber“ der Risikoänderung zeigt, dass Werteakkumulation in gefährdeten Gebieten und Preisentwicklung die Hochwassergefahr laut den definierten Szenarien am stärksten beeinflussen. Klimabedingte Änderungen der Hochwassergefahr sind ein wichtiger, aber, für die relativ kurze Zeitspanne der Untersuchung, nicht der dominierende Faktor für Risikoänderungen im Untersuchungsgebiet.

Derzeitige Forschung fokussiert auf ein größeres Gebiet und eine längere Zeitperiode. Außerdem werden die Unsicherheiten der Modellkette durch die Anwendung eines Ensemble-Ansatzes untersucht.

Hail Risk and Climate Change (HARIS-CC)

Michael Kunz, Susanna Mohr, Marc Puskeiler

Introduction

In the last few years, damage caused by severe hailstorms increased significantly over Europe. In the federal state of Baden-Württemberg, for example, nearly 40% of the total damage to buildings by natural hazards is related to large hail (Kunz et al., 2010). Within the project HARIS-CC (Hail Risk and Climate Change), long-term changes in the convective potential of the atmosphere are quantified using observational data and an ensemble of high-resolution regional climate models (RCM). This work is complemented by an area-wide assessment of the hail hazard and risk in Germany (and Europe).

Aims / Objective

Due to their local-scale extent and a lack of appropriate monitoring systems, hailstorms and their impacts are not captured accurately and uniquely by a single observation data set. This hampers statistical analysis on the spatial variability of these phenomena and the finding of observational evidence for changes in extreme events on the regional scale. A way of overcoming these constraints, which is pursued in HARIS-CC, is to combine data sets from different appropriate observation systems. To obtain complementary information regarding hail occurrence, hailstorm tracks and intensity over a longer period, radar reflectivity, satellite data, and flash counts are combined with damage data from insurance companies. Another approach links thunderstorm occurrence and probability to larger-scale atmospheric conditions as expressed by various convective parameters and large-scale weather patterns. The main purposes of these studies are to determine the spatial distribution and intensity (re-

lated to the probability) of severe hailstorms over complex terrain including identification of the relevant pre-convective flow conditions and to examine whether any evidence exists that suggests an increase in the frequency and intensity of thunderstorms in recent and future decades.

Project status

Statistical analyses of long-term time series of various convective parameters determined at sounding stations over Europe in general show an increase in the convective potential in the last two decades (Mohr and Kunz, 2011). This is the case in particular for parameters reflecting atmospheric properties of the lowest layers, where a significant positive trend in the humidity can be observed. While the potential for thunderstorm development was lower in the 60s and 70s, it increased significantly in the 90s. Both the magnitudes and the directions of the observational trends are confirmed by reanalyses (ERA-40 of the European Centre for Medium Range Forecast, ECMWF), which were additionally downscaled using the regional climate model CCLM (Figure 1; simulations were performed by the IMK working group „Regional Climate and Water Cycle“, see CEDIM project „Flood Risk in a changing Climate“). First results based on an ensemble of high-resolution RCMs suggest no further increase in the convective potential for the future (2021-2050 vs. 1971-2000).

A similar picture emerges from the examination of large-scale weather types, which were determined from both reanalysis and RCM realizations (Kapsch et al., 2011). Four out of the 40 different weather types are related with an increased likelihood of damage-related hail events. These four types have slightly (but statistically significant) increased during the period 1971 - 2000. In cooperation with the University of Exeter, a stochastic model was developed that estimates the number of hail damage days using all weather types. The results suggest that the number of hail days will further increase in the next decades, but only slightly (approx. 10 %).

In cooperation with the SV SparkassenVersicherung AG, analyses of the hail climatology and damage effects on buildings were performed for the federal states of Baden-Wuerttemberg, Hesse and Thuringia. Appropriate methods were developed to connect three-dimensional radar data provided by the German Weather Service (DWD) with hail damage to buildings. It is found that both the 0°C level and the vertical extent of high reflectivity are important factors for damaging hail to develop

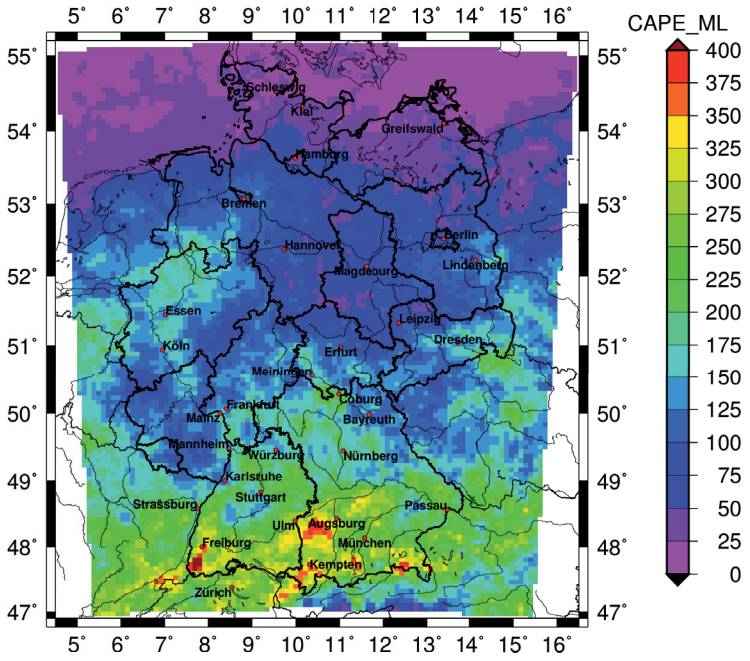

Fig. 1: Trend of the 90% percentiles of the annual distribution of the convective available potential energy (CAPE) between 1971 und 2000 from CCLM runs initialized by ERA-40 reanalysis. A positive trend indicates an increase in the convective potential.

and to reach the ground. First results show a high spatial variability in the number of “hail day estimates” for areas of 10 km x 10 km size. Maxima are found, for example, south of Stuttgart and north of Frankfurt, whereas hail occurs only rarely over northern and eastern Germany.

Outlook

In the next step, it will be examined to what extent inclusion of various atmospheric indicators (e.g. convective energy, moisture flux convergence, large-scale weather situations, etc.) using logistic regression will improve the predictive skills for hail. The most suitable methods will be transferred to an ensemble of high-resolution RCMs to estimate the hail potential for the next decades.

From the intersection of radar data, model data and insurance data, a comprehensive event catalogue of past significant hail events including their tracks and intensities will be created and processed by appropriate statistical methods. These studies will provide important information about the spatial distribution in the frequency and intensity of hailstorms and, thus, enables identification of regions highly exposed to hail. Based on the event catalogue, a hail damage model will be designed to estimate total losses of single severe events and expected losses for certain probabilities (return periods).

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Publications

Kapsch, M.-L., Kunz, M., Vitolo, R., Economou, T. (2011): Long-term variability of hail-related weather types in an ensemble of regional climate models; submitted to J. Geophys. Res.

Kunz, M., Puskeiler, M. (2010): High-resolution assessment of the hail hazard over complex terrain from radar and insurance data. Meteor. Z., DOI:10.1127/0941-2948/2010/0452.

Kunz, M., Sander, J., Kottmeier, Ch. (2009): Recent trends of thunderstorm and hailstorm frequency and their relation to atmospheric characteristics in southwest Germany. Int. J. Climatol. 29, 2283-2297, doi: 10.1002/joc.1865.

Mohr, S., Kunz, M. (2011): Trend analysis of convective indices relevant for hail events in Germany. Submitted to Atmos. Res.

Kunz, M., Puskeiler, M., Mohr, S. (2011): Millionenschäden durch Hagelschlag - Zufall oder konkrete Ursache? Symposium Stiftung Umwelt und Schadenvorsorge, 30-31 March 2011, Stuttgart.

Kunz, M., Puskeiler, M., Mohr, S. (2011): Assessment of the hail hazard from a combination of radar and insurance data. EGU General Assembly 2011, 3-8 April 2011, Vienna, Austria.

Kunz, M., Handwerker, J., Mohr, S., Puskeiler, M., Mühr, B., Schmidberger, M., Langner, R. (2011): Meteorological analysis of the extraordinary hailstreak on 26 May 2009. 6th European Conference on Severe Storms, 3-7 Oct 2011, Palma de Mallorca, Spain.

Mohr, S., Kunz, M. (2011): Trend analysis of meteorological parameter relevant to hail from soundings and reanalysis data. 6th European Conference on Severe Storms, 3-7 Oct 2011, Palma de Mallorca, Spain.

Mohr, S., Kunz, M. (2011): Trend analysis of convective indices relevant for hail events in Germany. EGU General Assembly 2011, 03-08 April 2011, Vienna, Austria.

Puskeiler, M., Kunz, M. (2011): Assessment of the hail hazard from a combination of different meteorological datasets and insurance data. 6th European Conference on Severe Storms, 3-7 Oct 2011, Palma de Mallorca, Spain.

HARIS-CC

Im Projekt HARIS-CC (HAil RISk and Climate Change) werden Änderungen der Hagelgefährdung und des Hagelrisikos in Deutschland aus einem Ensemble hoch-aufgelöster regionaler Klimaprojektionen quantifiziert. Grundlage ist dabei eine umfassende Hagelstatistik der vergangenen Jahre für Deutschland, die aus verschiedenen Datensätzen erarbeitet wird.

Global Earthquake Model

Global Earthquake Model GEM

Jochen Zschau

The Global Earthquake Model GEM is a public/private partnership for the assessment and communication of earthquake risk worldwide and sets out to support decisions and actions that reduce earthquake losses. Globally, more than 150 institutions are contributing to this initiative.

The activities of CEDIM in this framework are considered to be a major contribution to the GEM process. They have their focus on

1. cross-border harmonized earthquake risk assessment in Central Asia,
2. methods for rigorously testing the GEM model and its components against observations, and
3. the further development of an earthquake risk monitoring tool that integrates data coming from remote sensing with those from ground-based observations.

The work is partly motivated by the lack of any earthquake risk map of Central Asia despite the extremely high level of risk in the region, and it includes the development, application and comparison of new hazard and risk assessment methodologies. It is further motivated by the need to more rigorously test widely applied seismic hazard and risk models against observations, especially when one considers the seemingly poor performance of most (if not all) earthquake hazard maps for a number of recent catastrophic events. So far, testing has only started for earthquake forecast models in the framework of the international project CSEP (Collaboratory for the Study of Earthquake Predictability) on which the related CEDIM activities are based. Moreover, none of the worldwide earthquake vulnerability and risk models account for the dynamic nature of earthquake risk, which is visible in the increasing vulnerability and risk levels of many parts of the world. A vulnerability and risk monitoring tool that can continuously monitor such changes is, at this time, not in place.

CEDIM is carrying out the **Risk Assessment for Central Asia** within the framework of GEM's regional program EMCA (Earthquake Model Central Asia) coordinated by GFZ. Since its official start in April 2011, the organizational structure for the program has been finalized, and has as partners representative institutions from Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, as well as a Scientific Advisory Board accompanying the work. The Central Asian Institute for Applied Geosciences (CAIAG) founded by GFZ Potsdam and the Government of Kyrgyzstan in 2002, has a special role with respect to facilitating the logistics. In addition, a special application-oriented cooperation could be initiated with AKDN, the Aga Kahn Development Network, and a cooperation agreement has been formulated with NORSAR (Norwegian Seismic Array) which is following a similar goal in parts of the region.

The present focus of EMCA's scientific work lies mainly in

- the establishment of a new attenuation relationships for macroseismic intensity in the region,
- the provision of a hazard map, based on the new "site approach" methodology,
- data gathering for improved hazard mapping, as well as for vulnerability analysis,
- field studies of earthquake site effects,
- experimental work for testing the performance of our newly developed "street view" omnidirectional camera method for inventory classification and vulnerability analysis in Central Asia, and
- capacity building.

For **Testing and Evaluating (T & E)** Models of the Earthquake Risk Chain, a GEM - T & E-Centre is currently being established at GFZ in Potsdam. Two international workshops, one in February 2011 in London and another in October 2011 in Potsdam, have contributed considerably to the development of this concept. This not only includes the provision and application of tools and software systems for retrospective testing to help improve the GEM hazard and risk model during its development stage, but also pseudo-prospective and pro-

spective testing of many GEM components individually. The core science team started working in Sept./Oct. 2011.

CEDIM's work for Developing an **Earthquake Risk Monitoring Tool** is part of the EMCA project (see above), and is also involved in one of the ten GEM global component projects, GEM IDCT (Inventory Data Capture Tools), that addresses the inventory and damage data development needs of the GEM user community. This project specifically intends to develop tools for integrating data coming from satellite remote sensing with those obtained from ground-based observations. GFZ takes the responsibility of developing open-source software protocols for the processing of satellite images. The international project consortium is led by ImageCat (London).

More details on all three activity areas of CEDIM within the framework of GEM can be found in the three following reports.

Globales Erdbebenrisiko-Modell GEM

Die Arbeiten von CEDIM im Rahmen des globalen Erdbebenrisiko-Modells GEM konzentrieren sich auf drei Hauptaufgaben,

1. eine grenzübergreifende harmonisierte Erdbebenrisiko-Abschätzung für Zentralasien,
2. methodische Entwicklungen zum Testen aller Komponenten eines Erdbebenrisiko-Modells sowie ihres Zusammenwirkens für die Abschätzung der Erdbebengefährdung und des Erdbebenrisikos, und
3. die Weiterentwicklung eines Tools zur quasi-kontinuierlichen Überwachung von Risikoveränderungen.

Die Erdbebenrisiko-Abschätzung für Zentralasien erfolgt im Rahmen des vom GFZ koordinierten GEM-Regionalprogramms EMCA (Earthquake Model Central Asia), die methodischen Entwicklungen zum Testen von Erdbebenrisikomodellen sind Aufgabe des am GFZ im Aufbau befindlichen GEM-T&E-Zentrums, und die Möglichkeiten, schnelle Erdbebenrisiko-Veränderungen zu erfassen, werden sowohl im EMCA-Projekt als auch in dem GEM IDCT-Projekt (Inventory Data Capture Tools) vorangebracht.

EMCA (Earthquake Model Central Asia): the GEM regional-program for Central Asia

Dino Bindi, Stefano Parolai, Matteo Picozzi, Marco Pilz, Massimiliano Pittore, Sergey Tyagunov, Shahid Ullah, Marc Wieland, Jochen Zschau

Introduction

In developing uniform and open standards to calculate and communicate earthquake risk worldwide, feed-backs to the global components of GEM (Global Earthquake Model) from regional programs can provide enriching contributions to the process of definition of standards, as well as constraints for their applicability. While standards defined at a global scale have to be flexible enough to adapt to very different local situations, regional programs allow for addressing the issue of seismic risk for a specific region by fully exploiting the resources available and finding ad-hoc strategies. The interaction between global and regional components is therefore desirable in order to merge the global standards into the regional studies and transfer the experiences and solutions thus gained that can define standards which better suit a vast range of applications.

Among several regional projects, the German Research Centre for Geosciences GFZ coordinates the effort of establishing a risk model for Central Asia (EMCA project, http://www.emca-gem.org). The target area includes Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. The project aims at providing new assessment of both the seismic hazard and vulnerability of the building stock that will be considered to generate a risk model. Star-

ting from a consortium of GFZ and Central Asian Institutes (COSERICA) established during a previous project (CASCADE), various partners have been identified in the different countries, considering both the seismological and engineering communities. The project started in April 2011 and has a duration of three years. It includes tasks for both hazard and vulnerability assessment, taking into consideration the role played by local site amplification effects for hot spot urban areas. The hazard and risk computations will be performed using the OpenQuake platform developed by the Model Facility component of GEM. In order to achieve a mitigation of the seismic risk by improving the awareness and preparedness of local institutions, training courses are foreseen on different topics and a close involvement of Emergency Situation Departments will be promoted. Furthermore, strong connections with other projects developing infrastructures and tools (e.g. early-warning/rapid response) are established (e.g. PROGRESS).

Aims

EMCA aims at producing a new risk model for Central Asia by developing both the hazard and vulnerability components. Furthermore, in order to develop reliable urban risk scenarios for a few test sites, which fully exploit the vulnerability assessed over a high resolution spatial scale, the variability of site effects is estimated empirically using both earthquake and noise recordings. In the following, both the targets and the approach followed to develop the different tasks of EMCA are outlined.

Vulnerability

A workshop held in Almaty (Kazakstan) on October 1996 (Khalturin and Tucker, 1997) on the "Strategies for urban earthquake risk management for the Central Asian Republics" pointed out that the seismic resistance of Soviet-era buildings was significantly lower than was officially proclaimed. However, given the high rate of urbanization in many Central Asian cities, detailed inside and outside assessments of buildings using traditional civil-engineering approaches can hardly cope with the spatio-temporal development in current cities. As a result, building inventory and thus information on structural vulnerability of the building stock, is often out-of-date, spatially fragmented or highly aggregated. The EMCA project aims at providing an update of the building inventory and its vulnerability for Central Asian cities. Vulnerability data sets of different countries will be first harmonized, attempting a uniform reclassification of the building stock in terms of the EMS98 scale. During the project, the possibility of developing a harmonized vulnerability classification scheme for Central Asia will

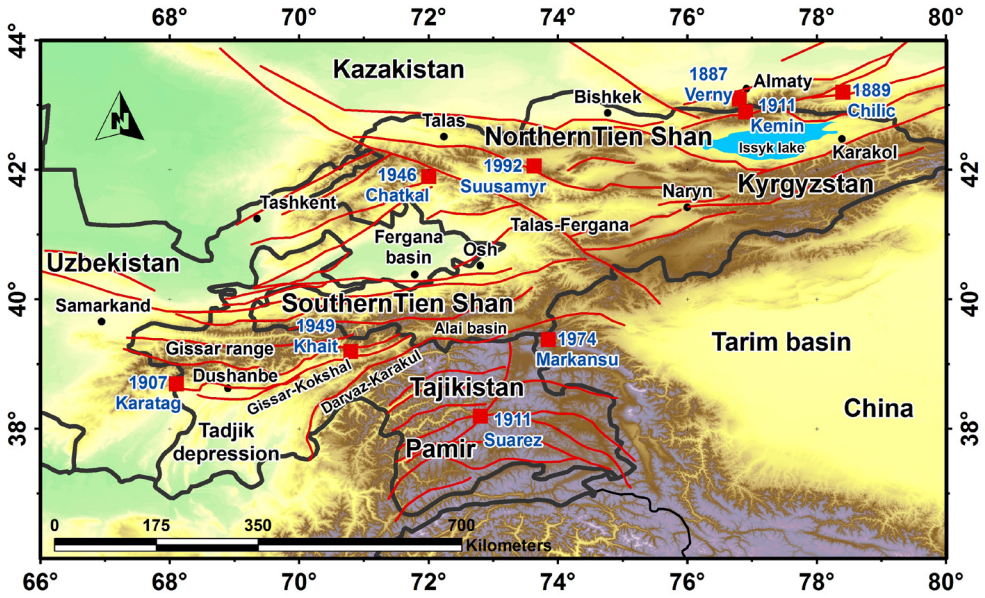

Fig. 1: Target area for EMCA project. The epicenters of the main earthquakes (red squares and labels) and the main active faults (red lines) are indicated.

be evaluated. In order to provide an efficient approach that allows seismic risk monitoring, and considering the rapid growth of the main Central Asian urban areas, a multi-source evaluation of structural vulnerability based on satellite remote sensing and ground-based omni-directional imaging will be applied and tested. In this context, first medium-resolution satellite images are analyzed with latest image processing techniques to delineate a city into areas of homogeneous urban structure types on a district level (Wieland et al., 2011). These analyses provide an initial estimate of value and distribution of crucial vulnerability indicators, such as predominant building-type, period of construction, and urban growth rate. The results of this first analysis stage are then used to calculate a path through the city for a rapid survey of a representative part of the building stock using an omnidirectional imaging system driven around with a car. Using automated image processing techniques, as well as manual expert guided rapid screening techniques, for each building successfully located the acquired images provide both vulnerability relevant features and the estimate of the most likely vulnerability class on the EMS-98 scale. Then, dominant vulnerability class thus identified can be associated with the corresponding homogeneous urban structure type, which in turn is used for extrapolating the high-resolution vulnerability information to the district level, and therefore provide a detailed vulnerability classification for the complete city. Globally available low-cost data-sources are preferred, so analyses and capture tools are developed on an open-source basis to allow for a high degree of transferability and usability following the general requirements of GEM.

Seismic Hazard

After the collapse of the Soviet Union, several studies improved the probabilistic hazard assessment in Central Asia (CA). Between 1991 and 1997, a new general seismic zoning (GFZ-97) of Northern Eurasia was proposed (Ulomov, 1999) and included as contribution to the

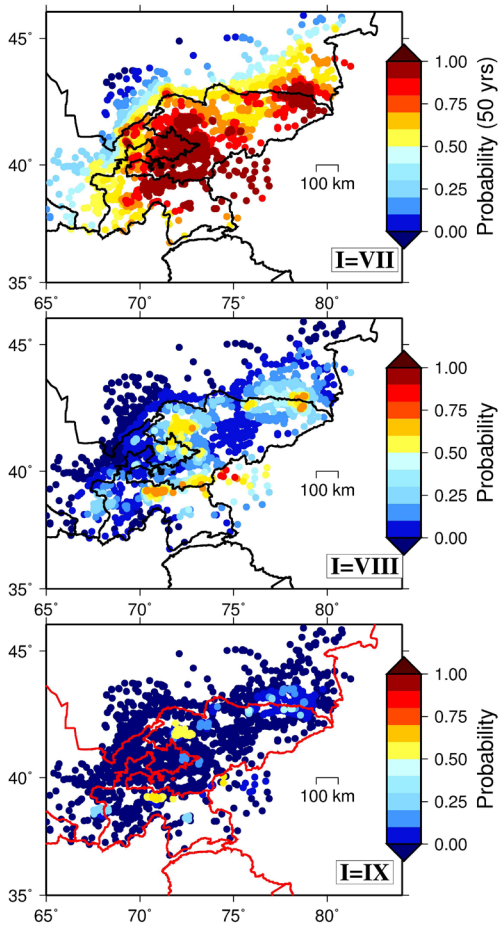

Fig. 2: Probability of exceedance, for an exposure time of 50 years, obtained for the different localities and different intensities (VII, VIII and IX from top to bottom, respectively).

Global Seismic Hazard Assessment Program (GSHAP) (Giardini, 1999). The probabilistic hazard was estimated in terms of intensity and converted to peak ground acceleration (PGA) by Ulomov (1999) using the Aptikaev and Shebalin (1988) relationship. Later, some studies attempted to improve the GSHAP at a more local scale, such as the probabilistic assessment performed for Kyrgyzstan (Abdrakhmatov et al., 2003), for Tashkent and Bishkek (Erdik et al., 2005), and Almaty (Mikhailova et al., 1996). The EMCA project aims at updating the hazard map for Central Asia (CA) by exploiting all the available up-to-date catalogs and data for the area (e.g. acquired from the previous project like CASRI and further updated within EMCA) and taking into consideration the standards and tools provided by GEM. The hazard computations will follow a multi-step approach, starting from the assessment in terms of seismic intensities using zone-less approaches, and then moving gradually to a fully probabilistic assessment based on seismic zones by the implementation of logic-tree strategies that allow for the handling of the epistemic uncertainties. Therefore, the available intensity data points have been considered for deriving an Intensity Prediction Equation (IPE) for CA (Bindi et al., 2011), considering about 6000 intensity data points from 66 earthquakes encompassing the surface-wave magnitude range 4.6 to 8.3. The calibrated IPE has been used to produce a seismic hazard map (Bindi et al., manuscript submitted) following an approach entirely based on the seismic histories available at different locations (D'Amico and Albarello, 2008). The advantage of this approach is that the hazard assessment is mainly guided by the observed seismic histories at each site without requiring, for example, the introduction of any seismic zonation. Then, the estimated probabilities of exceedance can be used as a robust term of comparison for other methods, like the standard Cornell-Mc Guire approach to PSHA, which require much more information to construct the inputs. In particular, the comparison between the results presented in this study with those coming from the application of the Cornell-McGuire approach could allow evaluation of the impact of the assumed *a-priori* information on the final results.

Capacity building

During the project scientists from Central Asia will be trained in the use of the tools for seismic hazard and risk assessment that will be adopted in GEM (OpenQuake/OpenGem platform). These tools are obtained under the general consensus of a large international seismological/engineering community and will allow Central Asian institutes to adopt analysis that are representing the state of the art at international level. Furthermore, they will also learn the use of advanced methods for vulnerability estimation based on remote sensing data (acquired both by satellite and panoramic cameras). The training period will also offer a unique opportunity for exchanging information between scientists of different countries.

Time schedule

The EMCA project develops over three years. The first year (2011) is mainly dedicated to construct the relationships among the partners, to the acquisition of updated catalogs and data, and to perform the quality check on acquired information. Field survey for site effect and vulnerability assessment, as well as training courses for capacity building, will be performed. The second year (2012) will be mainly devoted to developing the hazard and vulnerability models. New acquisition campaigns for site effects and vulnerability will be performed and the capacity building program further developed. Finally, in the third year (2013) all the derived models will be combined to compute a new risk model and the results will be disseminated through the Central Asian community.

Project status

All the different components have been developed during the first year of the project. Regarding the hazard component, an assessment of CA has been performed in terms of intensity using an attenuation relationship calibrated ad-hoc for the area and following an approach based on the intensity history observed at each site. In parallel, actions have been taken for gathering the input catalogs needed for performing a PSHA study, as well as to collect information to improve the knowledge of the building stock characteristics in CA. The analysis of the measurements previously performed in Bishkek about both site effects and vulnerability already produced several results that can be exploited to run scenario studies on urban risk damage assessment over a very detailed spatial scale. The methodologies under development will be applied to other important towns like Dushanbe, where the remote sensing data for vulnerability classification are under acquisition. In September 2011 a field campaign on building inventory data capture using om-

nidirectional cameras has been carried out in Dushanbe. Within ten days of fieldwork 1TB of image data has been captured along a pre-calculated path of 175 km length. The image capturing path has been calculated in advance, on the basis of an analysis of medium-resolution satellite images of the city. Analysis of the captured omnidirectional image streams is currently in progress using automated image processing techniques as well as manual expert guided screening techniques. The campaign to evaluate the spatial variability of site effects in Dushanbe will be performed in 2012.

In June 2011, a temporary seismic network consisting of 22 stations was installed in the city of Karakol (Kyrgyzstan) for recording earthquake activity. Two of the stations had been installed in the Terskey Ala-Too Range with the aim of having a reference station for the site effect estimation analysis. Moreover, single-station noise recordings were collected at nearly 50 sites, aiming at assessing local site amplifications by analyzing both earthquakes extracted from the data streams acquired continuously by the network, as well as from the single-station noise measurements.

Outlook

The activities foreseen for 2012 are related to both data analysis and acquisition. In particular, the remote sensing data acquired for Dushanbe will be analyzed to classify the vulnerability of the building stock, following the approach applied for Bishkek. On the other hand, the seismic and fault catalogues will be exploited to prepare the input files for the probabilistic hazard assessment using the OpenQuake software. Regarding the site effects, the single-station noise results, once their reliability was assessed by their comparison with the earthquake data, will be used to produce the first fundamental resonance frequency map for Karakol. Moreover, a spatially improved site response distribution will be obtained taking advantage of new clustering and correlation analyses. Based on the correlation of seismic noise recordings, these data sets will be used to perform a tomographic 3D inversion for obtaining images of the shear-wave velocity structure. These shear-wave velocity images are of particular interest for earthquake engineering purposes. Finally, a new experiment will be set up in Dushanbe, where a dense urban network (about one hundred measurement points) will be installed for recording earthquakes and to evaluate site effects.

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Publications

Bindi. D., S. Parolai, A. Oth, K Abdrakhmatov, A. Muraliev, and J. Zschau (2011): Intensity prediction equations for Central Asia, Geophysical J. International, 187, 327–337.

Bindi D., K. Abdrakhmatov, S. Parolai, M. Mucciarelli, G. Grünthal, A. Ischuk, N. Mikhailova, J. Zschau (2011): Seismic hazard assessment

Earthquake Model Central Asia EMCA: GEM Regionalprogramm für Zentralasien

Bei der Entwicklung einheitlicher und frei zugänglicher Vorgehensweisen zur Berechnung des weltweiten Erdbebenrisikos im Rahmen des Globalen Erdbebenmodells (GEM) können insbesondere regionale Programme wertvolle Beiträge zur Definition von Standards sowie zu deren praktischer Umsetzung liefern. Im Rahmen mehrerer regionaler Projekte koordiniert das Deutsche GeoForschungsZentrum hierbei den Aufbau eines Erdbebenrisikomodells für Zentralasien (EMCA-Projekt) unter Berücksichtigung der vorherrschenden seismischen Gefährdung als auch der Vulnerabilität. Das gesamte Projekt erstreckt sich über drei Jahre. Der Fokus liegt dabei auf den zentralasiatischen Ländern Kasachstan, Kirgistan, Tadschikistan, Usbekistan und Turkmenistan.

Da für die genannten Länder kein einheitliches Klassifikationsschema zur Bewertung der Vulnerabilität vorherrscht, liegt ein erster Fokus der Arbeit in der Harmonisierung der Datensätze und einer Neuklassifikation auf Grundlage der EMS98-Skala. Um mit dem raschen Wachstum vieler zentralasiatischer Städte Schritt halten zu können, werden auch neuartige Fernerkundungs- und räumliche Bildbearbeitungsmethoden eingesetzt und getestet. Da insbesondere im Rahmen von GEM ein Interesse an weltweit einsetzbaren, kostengünstigen Datenquellen besteht, werden die Verfahren auf Open Source Basis erstellt, womit ein hohes Maß an räumlicher Übertragbarkeit und Benutzerfreundlichkeit gegeben ist.

Um darüber hinaus verlässliche Risikoszenarien für einige exemplarische Untersuchungsgebiete erstellen zu können, welche die detaillierten Ergebnisse der Vulnerabilitätsstudien vollständig ausnutzen, werden für diese Untersuchungen auch lokale Standorteffekte miteinbezogen. Außerdem sollen die Karten für die Erdbebengefährdung in Zentralasien in einem mehrstufigen Verfahren unter Ausnutzung aller verfügbarer Datensätze und unter Verwendung der GEM-Standards auf den neuesten Stand gebracht werden.

Während der gesamten Projektlaufzeit werden außerdem Wissenschaftler aus Zentralasien mit dem Einsatz von Handwerkszeug für die Bewertung der seismischen Gefährdung, die auch innerhalb von GEM zum Einsatz kommen (OpenQuake / OpenGem), vertraut gemacht.

Während des ersten Projektjahres (2011) wurde eine neue Begutachtung der seismischen Gefährdung hinsichtlich der erwarteten Intensitäten vorgenommen. Desweiteren wurde begonnen, Informationen über die Gebäudesubstanz in Zentralasien und über die Vollständigkeit der vorliegenden Erdbebenkataloge, die für weiterführende PSHA-Studien benötigt werden, zu sammeln. Im September 2011 wurde eine Messkampagne zur Einschätzung des Bauwerkbestandes in Duschanbe (Tadschikistan) durchgeführt. Darüberhinaus wurde im Juni 2011 in Karakol (Kirgistan) ein temporäres seismisches Netzwerk für die Aufzeichnung der Erdbebenaktivität aufgebaut und nahezu 50 Messungen des seismischen Rauschens durchgeführt.

Im kommenden Jahr sollen die in Duschanbe gewonnenen Daten für eine Klassifikation der Gebäudevulnerabilität verwendet werden. Ergänzend dazu ist dort die Installation eines dichten seismischen Netzwerks geplant. Die Erdbebenkataloge werden weiter ausgewertet werden, um mit ihnen PSHA-Studien durchzuführen. Die in Karakol gewonnenen Daten werden zur Charakterisierung der Standorteigenschaften eingesetzt; hierbei sollen insbesondere neuartige Korrelations- und Tomographieverfahren zum Einsatz kommen.

in Central Asia: outcomes from a site approach, submitted to Soil dynamics and Earthquake Engineering.

Pittore, M., Wieland, M., Bindi, D., Parolai, S., Zschau, J. (2011): Towards a rapid, integrated, multi-scale assessment of earthquake risk: a case study in Central Asia, Geophysical Research Abstracts, 13, EGU Joint Assembly.

Wieland, M., Pittore, M., Parolai, S., Zschau, J., Moldobekov, B., Begaliev, U. (2011): Estimating building inventory for rapid seismic vulnerability assessment: towards an integrated approach based on multi-source imaging, Soil dynamics and Earthquake Engineering, submitted.

Wieland, M., Pittore, M., Parolai, S., Zschau, J. (2011): Rapid multi-scale assessment of seismic vulnerability: an integrated approach based on multisource imaging, Geophysical Research Abstracts, 13, EGU Joint Assembly.

Wieland, M., Pittore, M., Parolai, S., Zschau, J.

(2011): Estimating building inventory for rapid seismic vulnerability assessment in Bishkek, Kyrgyzstan: an integrated approach based on multi-source imaging and GIS, Proceedings of GISCA 2011, Almaty, 19.-20.05.2011.

GEM IDCT (Inventory Data Capture Tools)

Marc Wieland, Massimiliano Pittore, Stefano Parolai, Jochen Zschau

Introduction

The global component projects of GEM (Global Earthquake Model) aim at developing global uniform databases, tools and standardized methods as input to the model. The IDCT (Inventory Data Capture Tools) project is one of ten global component projects and addresses the inventory and damage data development needs of the GEM user community. The inventory and damage data captured by the tools, which are developed within the IDCT project, function as input to the Global Exposure and Global Consequences databases that support the seismic risk module of GEM. The IDCT project focuses on state-of-the-art methodologies and techniques in satellite remote sensing, GIS and data extrapolation and integration. Furthermore, the use of crowd-sourcing as a possible approach to inventory data capturing is addressed. Ground-based direct observation methodologies are developed as additional data gathering tools, which can be used to enhance and validate information derived from remote sensing. The project has a duration of 30 months. The project consortium is led by ImageCat and consists of partners from BGS, CAR, GFZ, OpenGeo, Stanford University, University of Nottingham, University of Pavia and WAPMERR. GFZ leads the project task IT 1b: Open source remote sensing software protocols.

Aims / Objective

The project aims at providing a globally applicable set of tools, protocols and guidelines for capturing building inventory data. The core of the project is the remote sensing analysis that allows for a rapid, flexible and scalable inven-

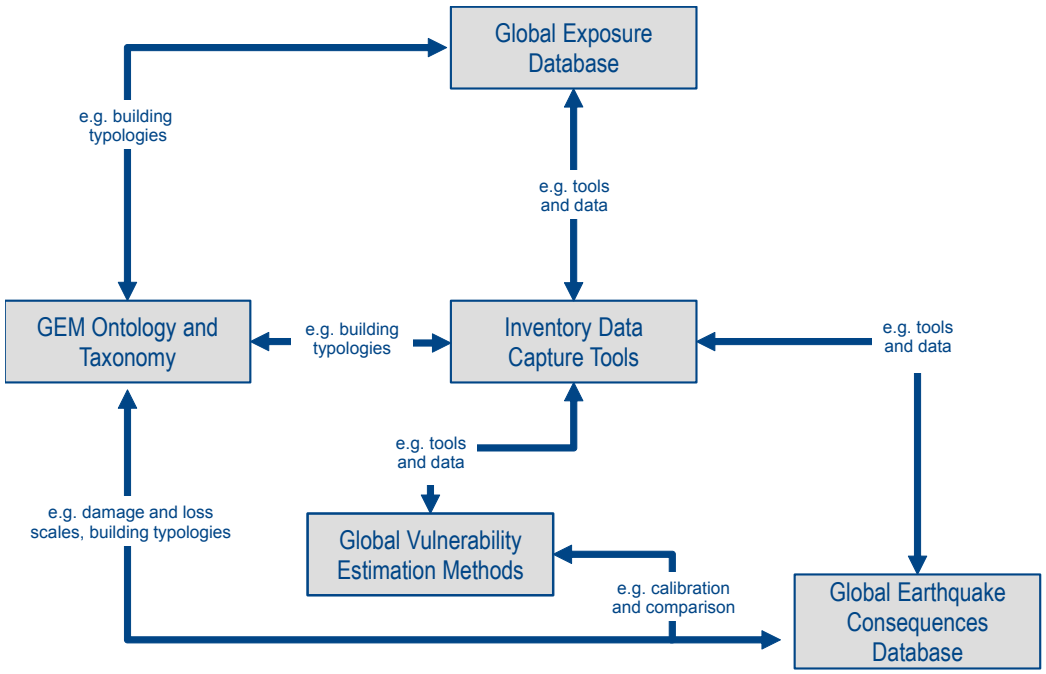

Fig 1: Inventory Data Capture Tools in the global components of the GEM Risk Module (source: GEM Report 2009/2010).

tory data capturing to fit the needs of GEM's end users. The main goals of the IDCT project are 1.) to provide tools that enable the capture and transfer of high-resolution inventory or damage data into either the Global Exposure and Global Consequences databases, and 2.) to develop tools for integrating data coming from remote sensing with data provided by direct observation methods.

In the context of this project the task IT 1b: Open source remote sensing software protocols, which is led by GFZ, aims at producing software protocols for the pre-processing and processing of satellite images using existing open source software. Several subtasks are involved under IT 1b including the generation of a conceptual framework for tool development that involves setting up a list of software functions to be supported in the remote sensing tools and evaluate and test existing open source software with the aim of deciding which software package to support within IDCT.

Project status

Within the task IT 1b, led by GFZ, a list of decision criteria to be taken into account during the software evaluation has been developed. Six initially selected software packages have been tested in greater detail following the defined list of decision criteria. Testing involved both availability checks of decision criteria and performance checks. To allow for a quantitative comparison of the results of the software testing, a decision analysis spreadsheet has been set up. The decision about which open-source software IDCT will support has been decided based upon the initial software evaluation: this is to be QGIS in a combination with GRASS.

Remote sensing protocols for the main pre-processing tasks comprising a detailed sequence of instructions and menu options for QGIS/GRASS have been developed and tested. The pre-processing protocols allow us to format the remotely-sensed imagery ready for input to tools IT1a (Brec-4-GEM remote sensing processing tool) and IT2 (GIS-4-GEM GIS processing tools). These protocols include amongst other pre-processing techniques, image pan-sharpening, layer-stacking, co-registration and geo-referencing.

Outlook

The activities foreseen for 2012 are related to further testing and improving the pre-processing protocols and including them into a comprehensive user-guide. Testing and improving will also include applying the protocols to several pilot studies which have been selected during the initial project phase. Some processing requirements for building attribute extraction will also be addressed and tested for their feasibility using QGIS/GRASS.

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Pittore, M., Wieland, M., Bindi, D., Parolai, S., Zschau, J. (2011): Towards a rapid, integrated, multi-scale assessment of earthquake risk: a case study in Central Asia, Geophysical Research Abstracts, 13, EGU Joint Assembly.

Wieland, M., Pittore, M., Parolai, S., Zschau, J., Moldobekov, B., Begaliev, U. (2011): Estimating building inventory for rapid seismic vulnerability assessment: towards an integrated approach

based on multi-source imaging, Soil Dynamics and Earthquake Engineering, submitted.

Wieland, M., Pittore, M., Parolai, S., Zschau, J. (2011): Rapid multi-scale assessment of seismic vulnerability: an integrated approach based on multisource imaging, Geophysical Research Abstracts, 13, EGU Joint Assembly.

Wieland, M., Pittore, M., Parolai, S., Zschau, J. (2011): Estimating building inventory for rapid seismic vulnerability assessment in Bishkek, Kyrgyzstan: an integrated approach based on multi-source imaging and GIS, Proceedings of GISCA 2011, Almaty, 19.-20.05.2011.

IDTC Inventory Data Capturing Tools

Als eine von insgesamt zehn globalen Komponenten des Globalen Erdbebenmodells (GEM) ist es die Aufgabe des IDCT (Inventory Data Capturing Tools) Projektes Werkzeuge, Richtlinien und Protokolle zur Erfassung von Daten des Gebäudeinventars zu entwickeln. Diese Daten sollen als Input für die Global Exposure und Global Consequences Datenbanken verwendet werden, welche ihrerseits das Risikomodul von GEM unterstützen. Neben bodengestützen Beobachtungs- und Analysemethoden und der Verwendung von sogenannten Crowd-sourcing Ansätzen liegt ein Schwerpunkt des IDCT Projektes auf der Nutzung von Satellitenfernerkundung zur Analyse des Gebäudeinventars. Die Aufgabe des GFZ im Rahmen des IDCT Projektes liegt vorrangig bei der Erstellung von Open Source Fernerkundungs-Software Protokollen. Dies umfasst in erster Linie Protokolle zur Beschreibung von Vor-prozessierungsschritten von Satellitenbildern. Innerhalb dieser Aufgabe wurde bisher nach einer detaillierten Evaluierungs- und Testphase durch das GFZ ein für das IDCT Projekt geeignetes Open Source Softwarepaket ermittelt (QGIS/GRASS). Für dieses Softwarepaket wurden dann die entsprechenden Protokolle zur Vor-prozessierung von Satellitendaten erstellt und getestet. Im kommenden Jahr sollen diese Protokolle weiter verfeinert und getestet werden. Ferner sollen die Protokolle um grundlegende Prozessierungsschritte (z.B. NDVI Analyse) erweitert werden. Die Protokolle gehen dann in ein ausführliches Benutzerhandbuch speziell für die innerhalb des IDCT Projektes anvisierten Aufgaben ein.

GEM Testing & Evaluation Center

Danijel Schorlemmer, Jochen Zschau

Introduction

The Global Earthquake Model (GEM) is developing the first homogeneous hazard and risk model for the entire globe. Such a model is assembled from data, known physical properties, statistical descriptions of physical phenomena, and assumptions – often called expert opinion. Over the past decade, independent testing of seismic rate models became standard through the Collaboratory for the Study of Earthquake Predictability (CSEP) and its importance was further emphasized by the L'Aquila earthquake and its legal aftermath. The Testing & Evaluation component of GEM is building on these developments and taking the role of an independent evaluator for the most important parts of GEM by operating a dedicated Testing Center at GFZ.

Aims / Objective

The T&E component will work together with the model builders to make GEM and its components as testable as possible. It will provide tools and software systems for retrospective testing to help improve the model during its development stage, it will pseudo-prospectively and prospectively test many components of GEM, and it will work on testing high-impact assumptions of GEM. The following tasks for the first year have been identified as having a major impact on GEM:

- Implementing zonation testing in the CSEP testing center software
- Testing the SHARE seismicity rate model
- Develop a prototype testing chain for the OpenQuake system of GEM

- Implementing a prototype (proof-of-concept) of a ground-motion prediction testing center to test intensity-based GMPEs
- Developing prototype tests for hazard model testing
- Retrospective hazard testing of the SHARE model in the intensity and strong motion domain
- Collaborating with the Global Consequences Database component to characterize the current and future dataset for testing risk models
- Setting up a testable hypothesis for testing M_{max}.

Project status

The core science team started working in September/October 2011. Concepts for most tasks have been developed and are put up for review. Development of the Testing Center is underway.

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GEM T&E Zentrum

Das Global Earthquake Model (GEM) entwickelt das erste globale homogene Gefährdungs- und Risikomodell. Solch ein Modell wird aus Daten, bekannten physikalischen Eigenschaften, statistischen Beschreibungen physikalischer Phänomene und Annahmen zusammengesetzt. Während des letzten Jahrzehnt wurde das Testen von Erdbebenratenmodellen durch das Collaboratory for the Study of Earthquake Predictability (CSEP) ein Standardverfahren zur Qualitätsüberprüfung. Diese Entwicklung wurde noch verstärkt durch das Erdbeben von L'Aquila und sein juristisches Nachspiel. Die Testing & Evaluation Komponente von GEM baut auf diesen Entwicklungen auf, übernimmt die Rolle eines unabhängigen Evaluators der wichtigsten Teile von GEM und entwickelt ein Testing Center am GFZ, um verschiedene Teile von GEM unabhängig zu testen. Der Fokus des ersten Jahres liegt auf der Entwicklung der notwendigen Softwareerweiterungen und der Entwicklung eines Prototypen für das Testen von durch Erdbeben verursachter Bodenbewegungen. Die T&E Komponente wird Hilfsmittel für retrospektives Testen zur Verfügung stellen und pseudo-prospektives und prospektives Testen durchführen. Darüber hinaus arbeitet T&E an der Entwicklung testbarer Hypothesen für gängige Annahmen in Gefährdungs- und Risikomodellen. Der Hauptaugenmerk liegt hierbei auf dem Testen der maximalen Magnitude an einzelnen Verwerfungen.

Vulnerability and Critical Infrastructures

Decision Support Methods in the Field of Critical Infrastructure Protection (DCM CIP)

Thomas Münzberg, Stella Möhrle, Friedmar Fischer, Tim Müller, Wolfgang Raskob, Tina Comes, Michael Hiete, Frank Schultmann

Introduction

When disaster strikes, the reliable functionality of critical infrastructure (CI) systems (e.g. electricity supply, supply of drinking water and food, telecommunication and transport systems) may be of vital importance for society and economy. For this reason, official civil protection authorities and providers of CI aim at both the prevention of and preparedness for service disruptions. Therefore, risk and crisis management tools should facilitate the development of robust solutions for the protection and safety of citizens and customers.

The current research on decision support tools for CI protection takes the results of the SIMKRIT-project (06/2009-12/2009) and the KRITISKONZ-project (06/2010-12/2010) into account (see CEDIM annual reports of 2009 and 2010). The SIMKRIT-project aimed at exploring the interdependencies of CIs whereas the KRITISKONZ-project developed a basic approach for an integrated decision support system for large scale disasters which affect CIs. Both projects have highlighted that especially the detection and understanding of disaster impacts on infrastructures whilst considering complex interdependencies and supply cross links are challenging in the prevention and mitigation of CI disruptions. Decision makers who have to respond to supply disruption incidents are additionally faced with a lack of resources and information.

Aims / Objective

The DSM CIP-project combines assessment of CI with decision support capabilities that will enhance the capacity of both the official authorities and private CI providers to deal with such large disaster events.

Therefore the DSM CIP-project aims at following an integrated approach that is oriented towards the decision making processes in CI protection (CIP). This requires us to

- gather information to get an overview about existing decision support tools in risk and crisis management with an emphasis on CIP,
- analyze essential decision making processes for that context,
- define end-user specific decision circumstances (e.g. area of responsibility, cooperation between official agencies and private partners),
- define the end-users' needs, and
- evaluate promising decision support tools regarding the fulfillment of the end-user needs and system integration possibilities.

Furthermore, the project should intensify partnerships with potential users and issue-related research groups to enhance the critical mass of researchers interested in CIP inside CEDIM and finally to raise funds in national and international research frameworks (e.g. National Security Research or FP7 Security Research).

Project status

As a first step decision support tools that are used especially for CIP have been analyzed. Literature reviews were carried out, and individual interviews with decision makers have been performed (police, fire brigade, civil/disaster protection management). In a second step, the end-user needs in this decision making process had to be explored (see Fig. 1). This was achieved by reviewing relevant literature and performing interviews with the relevant people.

One of the methods investigated in more detail focuses on knowledge data bases enhanced by case based reasoning (CBR). Machine learning methods have been derived allowing for a quick identification of best suitable countermeasures based on knowledge from the data base. For the strategic management of large scale crisis situations, the methodology

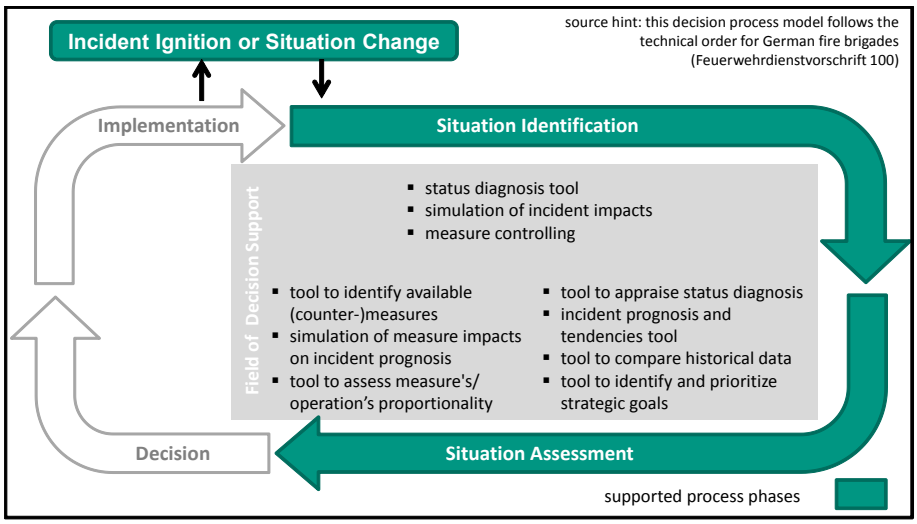

Fig. 1: Suggested field of application for decision support tools in responding to supply breakdown incidents.

of System Dynamics has been evaluated. In particular, the generation of dependency maps and the question of whether such information was suitable for decision making has been discussed with end users.

Outlook

The work on an integrated system supporting decision making processes for CIP will continue for at least further two years. It aims at fulfilling the objectives defined above, in particular at obtaining feedback from potential end users at each stage of the development. A strategic partnership with Fraunhofer IOSB has been established in 2011 that will strengthen that research area in CEDIM.

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Entscheidungsunterstützung zum Schutz kritischer Infrastrukturen bei Katastrophen

Kommt es zu Katastrophen, öffentlichen Notständen oder Unglücksfällen, sind die Verfügbarkeit und die Funktionsfähigkeit von Kritischen Infrastrukturen wie die der Elektrizitäts-, Wasser- und Nahrungsmittelversorgung, Informations- und Telekommunikationstechnik oder des Verkehrswesens entscheidende Einflussgrößen. Die Fragen, wie diese Infrastrukturen zu schützen sind und wie ihre Ausfälle beherrscht werden können, beschäftigen die Behörden und Organisationen mit Sicherheitsaufgaben (BOS) sowie die Betreiber derartiger Strukturen.

Werkzeuge des Risiko- und Krisenmanagement helfen diesen Entscheidungsträgern, verhältnismäßige Maßnahmen zu treffen, um negative Wirkungen auf Kritische Infrastrukturen zu beherrschen und deren Ausfälle zu bewältigen. Vor diesem Hintergrund werden Methoden der Entscheidungsunterstützung anwendungs- und endnutzerorientiert weiterentwickelt.

Bisher wurden die grundlegenden Entscheidungsfindungsprozesse im Risiko- und Krisenmanagementbereich zum Schutz von Kritischen Infrastrukturen analysiert und die damit verbundenen Herausforderungen für die Entscheidungsträger formuliert. Auf dieser Grundlage werden die methodischen Arbeiten der Entscheidungsunterstützung vorangetrieben, dass sowohl die Anwendungs- als auch die Endnutzerorientierung sichergestellt wird.

Natural disasters and transportation systems – the identification of critical road infrastructures

Carola Schulz

Introduction

Today's globalized society is highly dependent on reliable infrastructure systems like transportation, energy, water and telecommunication. The failure of these systems may have large economic and societal consequences. The identification and protection of critical infrastructures (CIs) within these sectors have found increasing support in the political field and research, e.g. in the European Directive 2008/114/EC. This doctoral dissertation project focuses on the road network and the identification of critical road infrastructures. Critical road sections are those whose failure would entail large costs to society.

Aims / Objective

The objective of this project is to contribute to the current European, national and regional endeavors in the identification of CIs. So far, it appears in the literature that, the identification of hot spots in transportation networks has predominantly been based on dimensionless indices. Input-output models are typically used to evaluate the long-term economic effects associated with an infrastructure disruption. This thesis focuses on the short- and medium-term monetized economic effects on road users who are affected by the closure of road sections. The economic effects associated with each road section's disruption serve as a basis for an indicator of criticality.

The effects of a road infrastructure disruption on trip makers and their behavior must be estimated by the use of a transport model, which can be based on various types of submodels. Using a logit-based approach, changes in trip making decisions like destination or modal choice can be evaluated and monetized. This thesis builds on such a concept, and suggests a new monetized loss calculation methodology based on a single measure that captures changes on various trip making decision levels, and also accounts for the duration of disruptions. Starting with the disruptions of single road sections, the thesis further introduces a systematization of the effects of simultaneous failures of multiple road sections. With this, it offers a reinterpretation of the criticality assessment depending on the combinations of affected links.

Project status

The methodology is applied to the case study area of Baden-Wuerttemberg and its motorway network. An extract version of VALIDATE (a transport model provided by PTV AG) and a newly developed logit model provide the modeling basis.

The short-term indirect losses with regard to an individual road section's closure range between 2,000 Euro and 2 million Euro per day. The short-term indirect losses include all the costs (including time-, distance-based and external costs) associated with circumventing the disrupted road section. In the medium-term, in case the disruption takes longer than ca. 3 days, people are likely to also adjust other transport related decisions, like the choice of destination. In this case, the indirect losses decrease by about 10 %. There is no standard threshold in respect of indirect losses above which a section can be considered to be critical. The thesis discusses various approaches to classifying the sections. Figure 1 shows the indirect short-term losses for five preset classes. The most critical sections are located on the A8 motorway south of Stuttgart. This means that on these sections a large number of vehicles is forced to take a detour which takes a lot of time (e.g. traffic jams on alternative roads) and/or causes high operating costs due to a longer distance to drive. Sections with better alternative routes and/or less vehicles on them entail less indirect costs by their closure and are therefore less critical.

Furthermore, the thesis combines the estimated indirect losses with a qualitative and a quantitative measure of susceptibility to failure. The results of this risk assessment reveal that the most critical links, solely based on the indirect loss ranking described above, are not necessarily the links with the highest level of risk. Figure 2 shows the flood risk with respect to indirect losses. The probabilities of flooding are

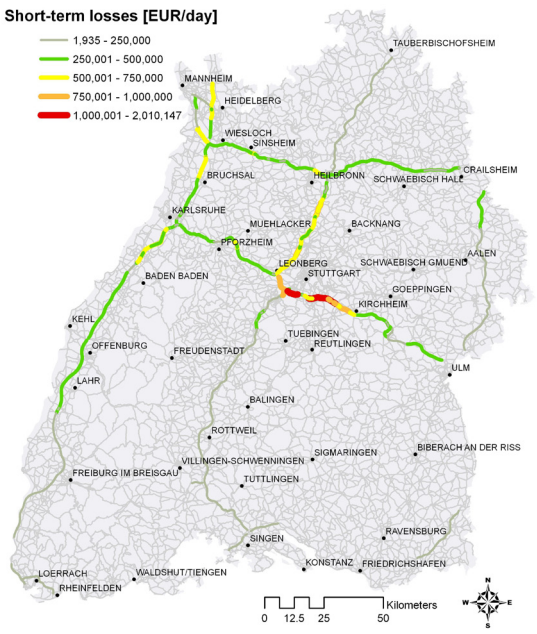

Fig. 1: Indirect short-term losses with regard to a complete road section's closure.

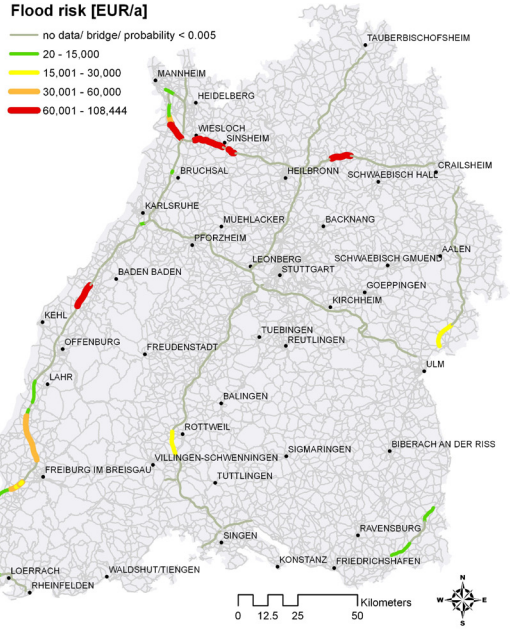

Fig. 2: Indirect flood risk.

based on the geographical information system ZÜRS Geo and have been provided by the German Insurance Association (GDV). Most of the road sections with high risk levels are located along the River Rhine. The section with the highest risk, with an expected indirect loss risk due to flooding of about 108,000 Euro/year, is situated south of Mannheim.

Two road-disrupting scenarios of an earthquake and a flood in Baden-Wuerttemberg, both developed in cooperation with other CEDIM member Institutes, demonstrate the applicability of the methodology in the context of multiple, simultaneous failures. In both scenarios, the results reveal complementary characteristics of the affected road sections. Accordingly, the indirect losses as a sum of the individual failures exceed the overall indirect losses associated with an event of simultaneous failures. Hence, in respect of the specific type of hazard addressed in the scenarios, the criticality of the links under consideration is rather overestimated. This means that an assessment of indirect losses and criticality against the background of a specific disrupting event may distort the results of the criticality assessment based on the indirect loss potential of individually closed sections.

Furthermore, the indirect losses in the scenarios turn out to be marginal compared to the physical damage associated with these events, depending on the seriousness of damage assumed. Even if indirect losses, in certain situations, may contribute to the overall losses to only a negligible extent, their assessment might still be valuable for reconstruction decisions.

Outlook

Future activities related to this thesis' findings could focus on a systematic incorporation of simultaneous failures in the identification of CIs. This also implies that realistic combinations of road links need to be analyzed which requires more profound data on possible hazards.

Moreover, a closer examination of the impact of road disruptions on the supply of essential goods and their underlying logistic processes could extend the perspective and understanding of indirect losses and CIs.

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Publications

Schulz, C. (2011): The identification of critical road infrastructures – the case of Baden-Wuerttemberg. Dissertation at the Karlsruhe Institute of Technology. Oral exam 6.12.2011. Publication expected in January 2012.

Naturkatastrophen und Verkehrsinfrastruktur - Identifikation kritischer Straßenverkehrsabschnitte

Die globalisierte und vernetzte heutige Gesellschaft ist sehr stark auf funktionierende Infrastruktursysteme angewiesen. Der Ausfall bestimmter Infrastrukturen in den Infrastruktursektoren wie Energie und Verkehr kann weitreichende Folgen für die Wirtschaft und Gesellschaft haben. Die Identifikation und der Schutz solch kritischer Infrastrukturen haben deshalb in der Forschung und v.a. in der Politik sehr viel Aufmerksamkeit und Unterstützung bekommen, z.B. durch die Europäische Richtlinie 2008/114/EC. Der Forschungsbeitrag dieser Arbeit liegt im Themenkomplex der kritischen Infrastrukturen mit dem Schwerpunkt Verkehr und der Identifikation kritischer Straßenverkehrsabschnitte. Als kritisch werden solche Abschnitte bezeichnet, deren Unterbrechung große gesellschaftliche Schäden nach sich ziehen würden.

Methodisch basiert diese Arbeit auf einem Nested Logit Ansatz, der eine monetarisierte Bewertung von Entscheidungsänderungen auf jeglichen Stufen der Verkehrsentstehung (Erzeugung, Zielwahl, Verkehrsmittelwahl, Routenwahl) erlaubt. Darüber hinaus schlägt die Arbeit eine Charakterisierung und Systematisierung von gleichzeitigen Mehrfachausfällen von Infrastrukturen in Bezug auf deren Kritikalität vor.

Zur Demonstration der Methodik dient das Straßennetz von Baden-Württemberg. Ein Ausschnitt des Verkehrsmodells VALIDATE der Firma PTV AG wird dabei zunächst mit einem eigens entwickelten Logit Modell zur Zielwahlmodellierung verknüpft. Für jeden Autobahnabschnitt in Baden-Württemberg werden die indirekten Schäden kurzfristig (nur Routenwahländerung) und mittelfristig (mit Zielwahländerung) aufgrund einer Vollsperrung des Abschnittes berechnet und anschließend in Kritikalitätscluster eingeteilt. Die indirekten kurzfristigen Schäden pro Abschnitt liegen zwischen ca. 2 Tausend und 2 Mio Euro pro Tag, die mittelfristigen liegen wegen der dann möglichen Anpassungen etwa 10 % darunter.

Die Ergebnisse der Berechnung werden zudem mit einem qualitativen und einem quantitativen Ausfallwahrscheinlichkeitsmaß der einzelnen Abschnitte verknüpft, um das indirekte Schadensrisiko zu verdeutlichen. Es stellt sich dabei heraus, dass kritische Abschnitte nicht unbedingt die Abschnitte mit der höchsten Ausfallwahrscheinlichkeit sind. Zwei verschiedene Szenarien, ein Erdbeben -und ein Hochwasserereignis, dienen dazu, die Effekte von gleichzeitigen Mehrfachausfällen im Kontext der Bestimmung kritischer Infrastrukturen näher zu untersuchen. In beiden Szenarien liegt eine Komplementarität der betroffenen Straßenabschnitte vor, das heißt, dass die Summe der Einzelausfälle größer ist als die Höhe der Schäden bei gleichzeitigem Ausfall. Das bedeutet, dass im Falle solcher Ereignisse die indirekten Schäden bzw. die Kritikalität der einzelnen Abschnitte im Vergleich zur Betrachtung der Einzelausfälle überschätzt werden.

Zukünftige Arbeiten könnten auf dieser Arbeit aufbauend speziell die Mehrfachausfälle näher und systematischer untersuchen sowie die Auswirkungen auf Güterflüsse in den Vordergrund der Betrachtung stellen.

Natural disasters and transportation systems – rapid indirect loss assessment

Carola Schulz

Introduction

Following a winter storm, an earthquake, or other events affecting transport systems, the media often report the severe impacts on travelers. The quantification of these impacts in monetary terms is, however, hardly ever done nor published, but often called for immediately after an event. In 2010, the Institute for Economic Policy Research has started to investigate the impacts of events causing a disruption of the transportation system.

Aims / Objective

The overall goal is to substantiate and extend common methodologies of indirect loss assessment towards a rapid loss estimation.

Therefore this project contributes to a better understanding of economic losses of events harming transport systems. This project specifically aims to:

- identify the data requirements and find innovate estimation methods in the case of low data availability
- classify the impacts of a disrupting event
- determine the parties concerned
- analyze possible methods of quantification and monetization of the impacts
- assess the indirect costs associated with a disrupting event

Project status

So far, two historic events were studied: the winter storm Daisy in Germany and the eruption of the volcano Eyjafjallajökull in Iceland. Both events happened in 2010 and we focused on the effects on transport in Germany. We started by collecting all types of effects caused by the events and categorizing them in order to obtain an overview of the various dimensions of the impacts. Press releases or other resources on the internet were used to gather the necessary information. The impacts thus categorized were then assessed in respect of the potential for monetization. The comparison of our figures with other published figures showed that is it crucial to define the category of losses captured in the analysis since otherwise it is virutally impossible to interpret the numbers presented.

Outlook

The most time consuming activity in the loss assessment has been the search for data. In this respect, cooperation with CEDIM projects related to crowd sourcing and to the modeling of natural events may contribute to a faster assessment. While the modeling of natural events may help to determine the extent of an event (e.g. which geographic areas are affected by extraordinarily high snow levels and for how long), crowd sourcing may assist in assessing the effects of an event on the transportation system and its users (e.g. number of cancellations of flights).

The two case studies showed that depending on the type of event, different types of impacts can be expected. The collected impacts and their categorization are still incomplete and need to be complemented with information from other historical events. Conducting more of these kinds of studies will help to verify and improve the procedure for a more reliable rapid loss assessment.

Core Science Team

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Naturkatastrophen und Verkehrsinfrastruktur - Erhebung und Schätzung indirekter Schäden

Nach einem Sturm, einem Erdbeben oder ähnlichen Ereignissen, die Verkehrssysteme zum Erliegen bringen können, wird in den Medien oft über die Unannehmlichkeiten der betroffenen Reisenden berichtet. Eine monetäre Quantifizierung der durch die Verkehrseinschränkungen hervorgerufenen gesellschaftlichen Schäden wird jedoch nur selten vorgenommen und veröffentlicht, obwohl kurz nach solch einem Ereignis diese Zahlen von großem Interesse wären.

Seit 2010 untersucht der Lehrstuhl für Netzwerkökonomie am Institut für Wirtschaftspolitik und Wirtschaftsforschung unter der Leitung von Prof. Dr. Kay Mitusch die Erhebung und Schätzung solcher indirekter Schäden. Zwei Fallstudien über den Ausbruch des Eyjafjallajökull und den Sturm Daisy wurden exemplarisch in zwei Bachelorarbeiten bearbeitet, um Erkenntnisse über die notwendigen Daten, Arten von indirekten Schäden und Möglichkeiten der Monetarisierung und Verwertung für eine Abschätzung der indirekten Schäden zu erlangen.

Es stellte sich heraus, dass die Suche nach Daten die meiste Zeit in Anspruch nahm. Hierbei könnte zukünftig eine Zusammenarbeit mit weiteren CEDIM Projekten, wie Crowd Sourcing und Modellierung von Naturereignissen, weiterhelfen, um schneller einen Überblick über das räumliche Ausmaß sowie die Stärke und Art der Betroffenheit zu bekommen. Die Durchführung weiterer Fallstudien ist angedacht, um das Verfahren und die Erkenntnisse zu testen und anzureichern.

Publications

Mitusch, K., Friedrich, H., Schulz, C.(2011): Wetterereignisse und Verkehr – am Beispiel von Sturm Daisy 2010. 6. ExtremWetterKongress 2011, Hamburg.

Mitusch, K., Friedrich, H. (2010): Wenn die Natur verrückt spielt: Auswirkungen von Naturereignissen auf die Volkswirtschaft und Tourismus-Unternehmen – am Beispiel vom Ausbruch des Eyjafjallajökull 2010. 60. DRV-Jahrestagung 2010, Agadir, Marokko.

Weather Extremes: Assessment of Impacts on Transport Systems and Hazards for European Regions

Tina Comes, Christian Trinks

Introduction

Records of reinsurance companies clearly highlight the rising damages caused by the consequences of climate change, and in particular of natural catastrophes and extreme weather events. While many studies focus on climate protection (CO_2 mitigation in transport), research on the vulnerability of the transport sector to climate driven effects, namely extreme weather events, has arisen only recently. So far, little knowledge has been developed on the economic costs of climate change and extreme weather driven damages to transport, and even less evidence is available on the options, costs and benefits of adaptation measures. National adaptation programs of EU Member States, the US, Canada, New Zealand and the 4th assessment report of the IPCC provide only indicative measures and global fields of action. Thus, European studies addressing local conditions are necessary. Another crucial branch of research is concerned with the role of transport systems for crisis or disaster management. In the related literature, the term “emergency operations” spans a number of topics including logistics, traffic planning and institutional issues. The major tasks under these topics are the transport of emergency vehicles and search-and-rescue teams, medical evacuation, and distribution of goods and local medical aid. In this field of research European evidence is already available.

The WEATHER project (Weather Extremes: Assessment of impacts on Transport Systems and Hazards for European Regions) aims at analyzing the economic costs of more frequent and more extreme weather events on transport and economy. On the basis of this analysis, the project explores the benefits and costs of suitable adaptation and emergency management strategies for reducing the impact of extreme weather events in the context of a sustainable policy design. The research is carried out by an international team of eight European research institutes. The project runs for 30 months, from November 2009 until April 2012. WEATHER is funded by the 7th RTD framework program of the European Commission and is supervised by the Directorate General for Research. The details of the project are described on the project website containing work package descriptions and current results (www.weather-project.eu).

Aims / Objective:

The WEATHER project approaches the topic of extreme events and their impacts on transport systems from an economic perspective. Its core objective is to „determine the physical impacts and the economic costs of climate change on transport systems and identify the costs and benefits of suitable adaptation and emergency management strategies“.This general objective is detailed by 7 sub-goals:

1. Develop a dynamic model on the causal relations between the severity and frequency of extreme events, the functionality of critical sectors and social welfare;
2. Detailed assessment of the vulnerable elements and damage costs in transport systems;
3. Work out efficient and innovative mechanisms of managing disastrous events, focusing on maintaining the function of transport systems;
4. Identify appropriate and efficient adaptati-

on strategies for transportation infra-structures and services to ease the impacts of extreme events in the future;
5. Clarify the role of governments, companies and industry associations;
6. Check the applicability of theoretical concepts of vulnerability assessment, crises prevention and adaptation strategies with practical experiences and local conditions;
7. Dissemination of project findings to a wider audience to fostering the debate on the costs and implications of more frequent and severe weather conditions on transport systems.

Project status

The work packages „Vulnerability of transport systems“ and „Crisis management and emergency strategies“ have been completed successfully. The results of both work packages are available on the project website (www.weather-project.eu).

Outlook

The final reports for the work packages „Weather trends and economy-wide impacts“ and „Adaptation options and strategies“ are scheduled for September and October 2011. The project ends in April 2012.

Core Science Team

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Publications

Trinks, Ch., Hiete, M., Comes, T., Schultmann, F. (submitted): Extreme weather events and road and rail transportation in Germany. International Journal of Emergency Management.

Trinks, Ch., Hiete, M., Schultmann, F. (2011): Impacts of Extreme Weather Events on Road and Railway Transport Infrastructures in Southwest Germany, TIEMS Workshop 2011, Alès.

Trinks, Ch., Hiete, M., Schultmann, F. (2011): Management of weather-induced emergencies in transport, Stiftung Umwelt und Schadenvorsorge Symposium 2011, Neuhausen auf den Fildern.

Trinks, Ch., Hiete, M., Schultmann, F. (2010): Auswirkungen extremer Wetterereignisse auf die Transportsysteme in europäischen Regionen, DACH Meteorologentagung 2010, Bonn.

Projekt WEATHER

Das EU-Projekt WEATHER soll einen Beitrag zur Erweiterung des aktuellen Wissens über die Auswirkungen von extremen Wetterereignissen auf Wirtschaft, Gesellschaft und insbesondere auf die verschiedenen europäischen Verkehrssysteme leisten. Als Ausgangspunkt dienen die vorhandenen Klimaszenarien und deren Implikationen für bestimmte Regionen in Europa. Dabei werden der Analyse der Auswirkungen auf Wirtschaft und Gesellschaft sowie der Wechselbeziehungen zwischen Verkehr und anderen Sektoren ökonomische Wachstumsmodelle zugrunde gelegt. Die Vulnerabilität der einzelnen Transportsysteme wird hinsichtlich der Infrastruktur, dem Betrieb und der Intermodalität beurteilt. Best Practices im Notfallmanagement werden einerseits mit Hilfe der zahlreichen weltweiten Schadensfälle und andererseits mit der Sammlung von Anpassungsoptionen im Transportsektor gegenüber häufigeren und / oder extremeren Wetterereignissen identifiziert. Ein besonderer Schwerpunkt des Projektes liegt auf der Quantifizierung der zu erwartenden Schäden, Notfall- und Anpassungskosten sowie der Vorteile aus Anpassungsaktivitäten und einem verbesserten Notfallmanagement. Darüber hinaus werden die politischen Instrumente identifiziert, die zur Implementierung der empfohlenen Maßnahmen und zur Demonstration des Wettbewerbspotentials sowie der Innovationskraft eines europäischen Leitmarktes für Notfall- und Anpassungstechnologien geeignet sind. Die Toolbox des Projektes umfasst u. a. Literaturrecherche, Experteninterviews, Workshops, Kostenrechnungsmodelle und Fallstudien.

Systemic Seismic Vulnerability and Risk Analysis for Buildings, Lifeline Networks and Infrastructure Safety Gain (Syner-G)

Bijan Khazai, Tina Kunz-Plapp, James Daniell, Friedemann Wenzel

Introduction

Syner-G is a European Collaborative Research Project focusing on systemic seismic vulnerability and risk analysis of buildings, lifelines and infrastructures. The systemic vulnerability and the associated increased impact have not been considered so far in a rigorous and unified way for all kinds of systems. The overall objective of Syner-G is to increase the understanding of the vulnerability of various societal elements at risk belonging to a system (city, region, lifeline network, etc.) and to propose appropriate methods and tools to consider inter-element and intra-systems interdependencies, including socio-economic features. Emphasis in Syner-G is placed on the early emergency relief and recovery period where the rapid provisioning of food, water, shelter and emergency healthcare services are the most important interventions. Thus, the socio-economic vulnerability and losses in Syner-G are primarily focused in analyzing the performance of two sectors: temporary public shelter and emergency healthcare services.

Aims / Objective

A primary focus in Syner-G is to further develop appropriate fragility relationships for the vulnerability analysis and loss estimation of all elements at risk, for buildings, building aggregates, utility networks (water, waste water, energy, gas), transportation systems (road, railways, harbors) as well as critical facilities such as hospitals. This sets up the foundation for the main thrust in Syner-G which is the development of a systemic framework and methodology which accounts for intra-relations between the components of each system, and inter-relations between the systems making up the infrastructure. Within the Syner-G project, CEDIM is leading the work package on socio-economic loss and vulnerability (WP4).

Project status

In considering socio-economic vulnerability and losses in Syner-G a model has been developed to evaluate systemic performance metrics, such as casualties, fatalities and displaced population that are of interest to emergency

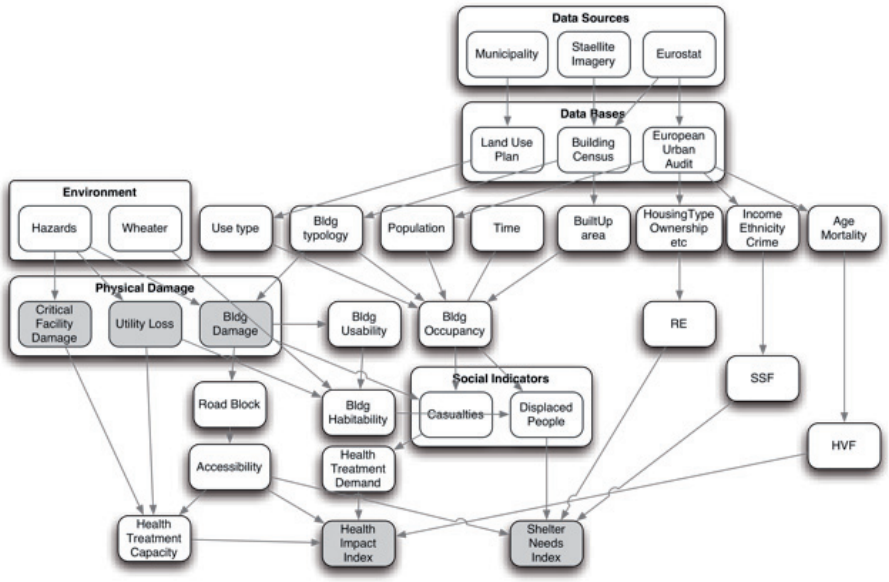

Fig. 1: Methodology for computing socio-economic losses in Syner-G (Source: Cavalieri et al., 2012).

managers in planning response measures to an earthquake (Figure 1). These quantities, assessed at the urban/regional scale, are then used as the necessary input into a Multi-criteria Decision Analysis (MCDA) model developed for assessment of impact on the regional healthcare system and for shelter needs planning. A main input into the MCDA tool is a system of indicators which posits socio-economic vulnerability in relational terms with respect to both shelter and healthcare systems. Consequently, a set of indicators have been developed for the socio-economic models by first performing a thorough literature review in each of the two sectors and then using the Principal Component Analysis technique to reduce the variables to a set of uncorrelated indicators representing most of the variation in the data. To harmonize the indicators for application at the European level, the EUROSTAT Urban Audit data at the sub-city district level was used as the basis for data analysis. In addition to WP4, research scientists at CEDIM are involved in exploring the potential of vulnerability assessment by optical satellite imagery under another activity of Syner-G. Here a report has been produced which provides a synthesis of the most applicable methodologies for extracting parameters used in vulnerability analysis in Europe.

Outlook

The methodological component of the project has been completed and presented in the second year plenary workshop in Orleans, France, on 2-4 November, 2011. In the final year of the project, the aim is to validate and benchmark the socio-economic model and indicators using observed data on building usability and shelter needs collected after the 2008 L'Aquila earthquake. Another goal for this last stage is to implement the full methodology in two case studies: Thessaloniki and Vienna. Finally, the methodology is currently being implemented within the MAE-Viz platform, which is an open source and unrestricted access software tool used in earthquake loss estimation (Figure 2). An important contribution in the software development is the integration of an open source Multi-criteria Decision Analysis tool developed by IKET at KIT which is currently being embedded in the MAE-Viz platform.

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Publications

Cavalieri, F., Franchin, P., Khazai, B., Gehl, P., (2012): Quantitative assessment of buildings habitability based on physical damage and functional interaction with infrastructural systems, Earthquake Engineering and Structural Dynamics, Accepted for Publication.

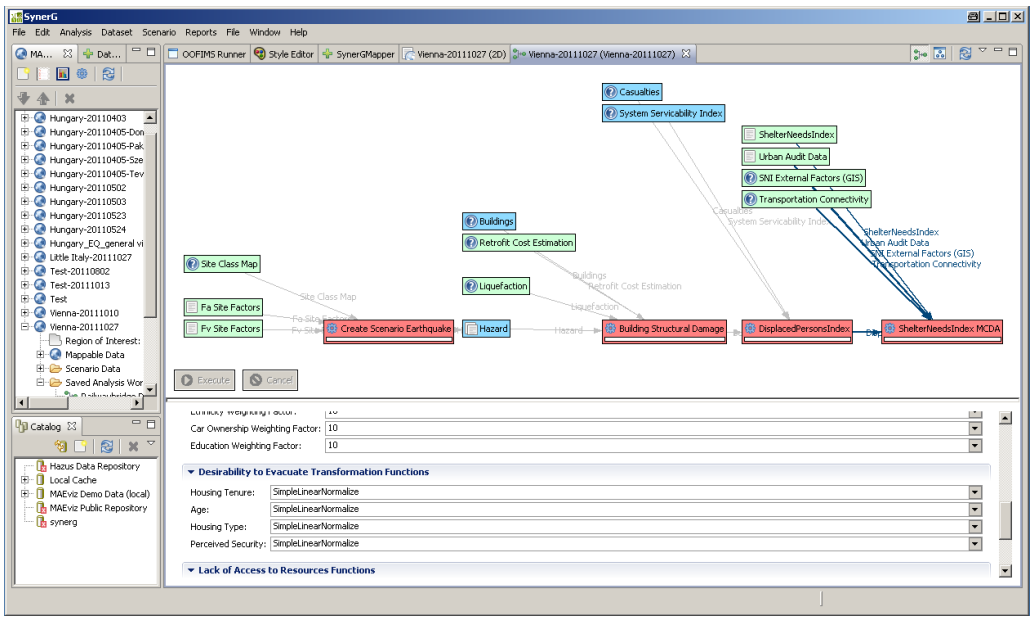

Fig. 2: Screen-shot in MAE-Viz for computing social losses according to Syner-G methodology.

Cavalieri, F., Franchin, P., Khazai, B., Gehl, P., (submitted): Quantitative assessment of socio-economic performance measures accounting for seismic damage to buildings and functional interaction with infrastructural systems at the urban scale, 15th World Conference on Earthquake Engineering, Lisbon, Portugal.

Khazai, B., Vangelsten, B., Duzgun, S, Braun, J., Daniell, J., (2011): Emergency Shelter Provision in the aftermath of Earthquakes: Integrating Social Vulnerability in Systemic Seismic Vulnerability Analysis, EGU 2011., Geophysical Research Abstracts Vol. 13, EGU2011-7374.

Kunz-Plapp, T., Khazai, B., Daniell, J., (2011): Social Impacts of Earthquakes on Health and Health Care Systems: Integrating Social Vulnerability in Systemic Seismic Vulnerability Analysis, EGU 2011. Geophysical Research Abstracts Vol. 13, EGU2011-7561.

Khazai, B., Kunz-Plapp, T., Daniell, J., (submitted): Social Impacts of Earthquakes on Health and Health Care Systems“, Abstract 3161, 15th World Conference on Earthquake Engineering, Lisbon, Portugal.

Khazai, B., Vangelsten, B., Franchin, P., Esposito, S., (submitted): Emergency Shelter Need Modeling in the aftermath of Earthquakes“, Abstract 2105, 15th World Conference on Earthquake Engineering, Lisbon, Portugal.

Syner-G

Das Forschungsprojekt Syner-G (http://www.vce.at/Syner-G) wurde im November 2009 von der Europäischen Kommission im Rahmen ihres FP7 Umweltprogrammes gebilligt. Das allgemeine Ziel von Syner-G ist es, das Verständnis der Vulnerabilität verschiedener gefährdeter Elemente eines gesellschaftlichen Systems (Stadt, Region, Versorgungsnetze, etc.), zu verbessern und einen europäischen Vergleichsrahmen für gesellschaftliche als auch für physikalische seismische Vulnerabilität zu etablieren. Zentraler Beitrag von Syner-G ist die Entwicklung eines systemischen Bezugsrahmens und einer Methodik, die sich aus den Beziehungen zwischen den Komponenten eines jeden Systems (*Intrarelationen*) und den Beziehungen zwischen den Systemen, die die Infrastruktur ausmachen, ergeben (*Interrelationen*). Ziel ist die Formulierung einer Systemfunktion, die die Beurteilung des Systemstatus als Funktion des Status seiner Komponenten erlaubt. Innerhalb des Syner-G Projekts leitet CEDIM das Arbeitspaket zu sozioökonomischen Schäden und Vulnerabilität (WP4). In diesem Arbeitspaket sollen die Abhängigkeiten und Schadensfolgen in physikalischen Systemen (Gebäude, Versorgungs- und Verkehrsnetzwerkskomponenten, kritische Einrichtungen) hinsichtlich ihrer Konsequenzen für die Gesellschaft und Wirtschaft in Form messbarer Indikatoren und sozioökonomischer Schadenswerte übertragen werden, so dass auf dieser Basis Regelwerke entwickelt und Entscheidungen getroffen werden können. Hinsichtlich der sozioökonomischen Vulnerabilität und der Schäden wurden neue Methoden entwickelt, um soziale Schäden hauptsächlich auf die Leistung von zwei Sektoren, nämlich die der temporären öffentlichen Unterkünfte und der Gesundheitsdienstleistungen zu erzeugen. Das sozioökonomische Modell wird in L’Aquila validiert und in Thessaloniki und Wien angewendet.

Vulnerability Wiki (VuWiki)

Antje Wegner, Bijan Khazai, Christian Bűscher, Tina Kunz-Plapp, Sandra Laskowski

Introduction

The term vulnerability is used in various disciplines and contexts ranging from disaster management and reduction to ecology, public health or climate change and adaptation. Within the last 20 years such a multitude of ideas about how to conceptualize and measure vulnerability has been discussed and published that one can hardly keep track of the developments. The challenge for newcomers, practitioners and even experienced researchers to derive appropriate methods, indicators and criteria for a specific vulnerability assessment

is broadly acknowledged and described in documents such as the UNU publication „Measuring the Un-measurable“ edited by Birkmann (2006).

The project “Vulnerbility Wiki” (short VuWiki) was initiated by an interdisciplinary group of researchers at Karlsruhe Institute of Technology who meet regularly at the Social Vulnerability Seminar to discuss theoretical concepts within vulnerability research. The Seminar led to development of a strong network of young researchers with common inter-disciplinary interests in various institutes across KIT. The many viewpoints on vulnerability assessments among the Seminar participants ultimately led to formulating a need for an ontology model of vulnerability studies, which contains rules and processes that incorporate the diverse methods for assessing vulnerability of disasters. Research funding to pursue this concept was made possible through a Startup Grant (STUB) in the “Geosphere and Risk” Competence Field as part of “bottom-up” efforts for promoting trans-disciplinary research development at KIT in January 2011.

Aims / Objective

The aim of the VuWiki project is to provide researchers and other stakeholders in the field of disaster vulnerability assessment an ontology and taxonomy framework for the explicit description of vulnerability assessment methods. The ontology is implemented in a semantic wiki which allows the classification and annotation of vulnerability assessment methods that have already been applied in empirical research. The aim is not at “synthesizing” any kind of holistic and comprehensive model for vulnerability, but to develop a uniform ontology that allows the annotation of key categories and properties of vulnerability studies so that they can be made comparable and easily accessible at a glance. The approach in the VuWiki project consists of three parts:

(a) Survey of vulnerability assessment studies: an extensive review of vulnerability assessment studies was carried out by the inter-disciplinary research group. The survey was not limited to standard, widely known methods, but also set out to identify modern, integrated multidisciplinary approaches that fill the gaps identified in the review. The 50 vulnerability assessment methods surveyed also provided the content for populating the wiki in the last stage of the project.

(b) Ontology and taxonomy development: through numerous sessions our group developed the structure of the vulnerability ontology collaboratively and revised it by doing “test-cases” with respect to selected studies and discussing the “fit” of the terminological structure to the content which should be organized by it. This iterative process led to a formal semantic classification system with respect to domains such as Vulnerable Systems (i.e., vulnerability of what), Vulnerability Drivers (i.e., vulnerability to what), Reference Frameworks (i.e., spatial and temporal scale of assessment, target users) and Methodological Approaches (i.e., both operational and theoretical approaches) (see Fig. 1).

(c) Semantic Interface and Wiki Development: Right from the beginning we pursued the idea to develop a semantic wiki in implementing the ontology. Although wikis are convenient for storing and retrieving individual information, their content is often weakly structured. On the other hand, a semantic wiki enables the organization of content through an ontology, which could be understood as a hierarchical representation of concepts and their interrelations in a certain knowledge domain. Additionally semantic wikis offer features like automatically-generated lists, semantic annotations of the wiki, and addition of semantic information by templates just to name a few.

Project status

The startup project commenced in March 2011 and will formally end by December 31, 2011. A semantic wiki has already been created (www.vuwiki.org). The user can search, browse or organize the content and add new vulnerability studies guided by a semantic form, which is a step-by-step form for capturing information and semantically encoding it at the same time (see Fig. 2). Over 50 empirical vulnerability assessments and methods will be compiled in the wiki in the coming months according to the ontology model developed for vulnerability studies.

Outlook

The semantic structure and content of the ontology model was validated and evaluated through a number of workshops. We quickly recognized that a vulnerability ontology model is an adaptation process that is dynamic and will continue to grow with more input from the community. Like in most taxonomic approaches in vulnerability research or social science in general, we

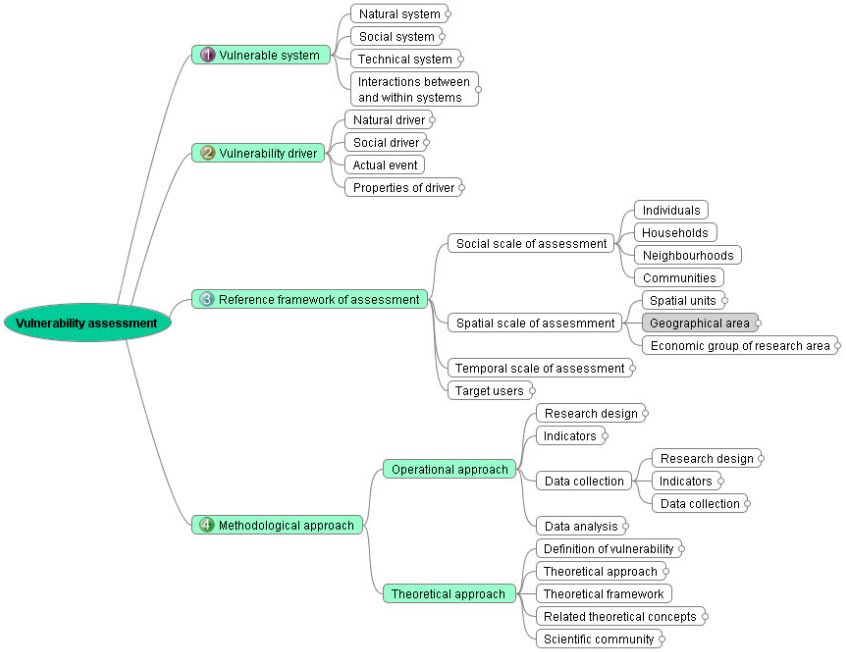

Fig. 1: Ontology for vulnerability assessment depicting the four main domains. Each branch can be expanded to view the full ontology using an interactive mapping program implemented in the wiki.

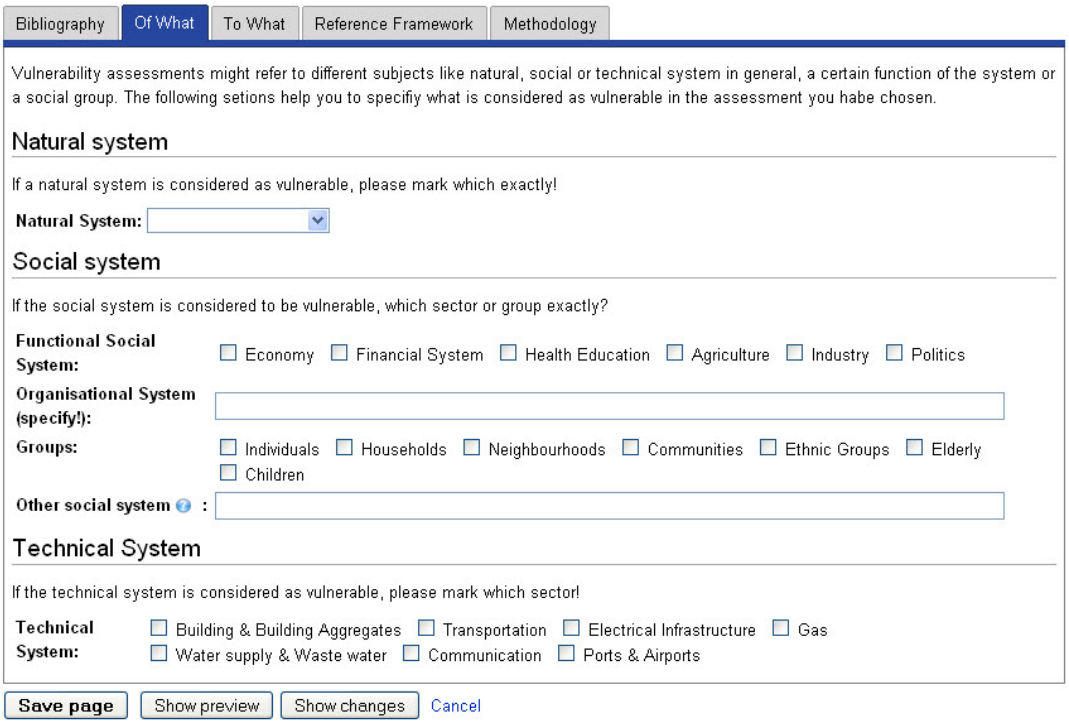

Fig. 2: Screen capture of the semantic form implemented in the wiki to capture content based on the vulnerability ontology for a new vulnerability study.

will always encounter some difficulties in „classifying“ all potential objects by a predefined set of categories and properties. Nevertheless the aim of the project was to provide an initial ontology framework for vulnerability studies and implement this in a collaborative platform. This provides a good starting point for organizing structured discussions regarding the different approaches to vulnerability assessment.

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Publications

Abstract will be submitted to the 32nd International Geographical Congress in Cologne.

Vulnerability Wiki

Vulnerability Wiki (VuWiki) ist eine kollaborative Wissensplattform basierend auf dem Semantic Media Wiki, die eine Vielzahl von „Vulnerability Assessments“ anhand eines semantischen Begriffsnetzwerkes (einer sogenannten Ontologie) strukturiert. So bietet Vuwiki Forschern und anderen Akteuren in der Katastrophen- und Vulnerabilitätsforschung einen schnellen Einstieg in das bisher wenig strukturierte Themengebiet und ermöglicht es gleichzeitig, Messmethoden und Ergebnisse vertiefend zu diskutieren. Dabei stehen die folgenden vier Leitfragen im Vordergrund: Was ist das vulnerable System? Welche Auslöser und Ursachen von Vulnerabilität werden betrachtet? Was ist der (räumliche und zeitliche) Referenzrahmen des Vulnerability Assessments? Welche Methoden werden zu Messung genutzt und auf welchem theoretischen Fundament basiert das Assessment? Diese zentralen Fragen, die in der Ontologie weiter ausdifferenziert sind, wurden von einer interdiszplinären Forschungsgruppe am KIT im Rahmen eines Start-UP Projektes erarbeitet. Ausgangspunkt für die Erarbeitung der Ontologie bildet die Sichtung und intensive Diskussion vorliegender empirischer Studien. Anhand von Testfällen wurde anschließend die Passfähigkeit überprüft und die Ontologie überarbeitet. In das Wiki sind derzeit 50 empirische Assessments eingepflegt. Die einfache Erweiterung des Wikis durch andere Nutzer unterstützt ein Formular, in dem der jeweilige Nutzer strukturiert und mit gezielten Fragen durch die Ontologie geführt wird und so neue Assessments hinzufügen kann.

Disaster Management

Socio-economic Analysis of the March 2011 Tohoku Earthquake

James E. Daniell, Friedemann Wenzel, Bijan Khazai, Armand Vervaeck

Introduction

From 2 minutes immediately after the earthquake, earthquake-report.com and CEDIM have followed the socio-economic effects of the earthquake using Japanese and international sources with additional historical input from the CATDAT Damaging Earthquakes Database. In addition, regular updates of the expected social (deaths, injuries, homeless) and economic (insured and total) loss from the worldwide rapid earthquake loss estimation software (EQLIPSE) were given, based on the ground shaking and tsunami effects, and then later refined to account for more complex effects. The interesting thing about the earthquake was the combination of losses from cascading effects – the earthquake triggering the tsunami triggering the powerplant disaster. Comparisons were also made with past earthquakes.

Aims / Objective

The aim of this project was to analyze a major earthquake from the initial impact through the entire loss collection process for the last 8 months. The methodologies in EQLIPSE were used to create fast socio-economic estimates within the first few minutes after the quake and as information became available further analysis was undertaken to refine the loss estimates. The socio-economic effects of this earthquake accounted for approximately 15% of all-time economic losses as shown through CATDAT and the largest ever single economic loss from an earthquake. In addition, earthquake-report.com provided a most useful tool by reporting the earthquake „as it happened“, including in-depth loss reports.

Creating accurate rapid earthquake loss estimates of socio-economic parameters has inherent problems and is extremely reliant on the hypocentral information. The initial estimate (first 15 minutes) of moment magnitude was 7.9, creating a very different estimate of potential losses than the final estimate ($5-50 billion total). In addition, it was unknown at that point that a tsunami had been triggered.

The problem was exarbercated because at the time when the Mw8.8-9.0 was given, no existing intensity prediction equations or GMPEs were valid for this Japanese scenario. Thus, the JMA instrumental intensity based on PGV was the best proxy for the intensity estimate of the shaking. A model was then used to fit this as best possible given the source information. In this case various IPEs in Japan, such as Bakun (2004), were used. However, it was found that the Honshu model of Bakun (2004), rather than the offshore model, actually fitted better to the JMA instrumental intensity for a M9 event. The building inventory has been collected as part of the EQLIPSE building inventory from various census data and other sources. In addition, the sectoral and socio-economic data in CATDAT indicated the industrial and other exposure elements.

There were 46954 shaking deaths in Japan in the CATDAT Damaging Earthquakes Database from 1900-2010 before the 2011 Tohoku Earthquake. Of these, most occurred in the 1923 Great Kanto EQ (28560 shaking deaths), 1927 Tango EQ (3110), 1943 Tottori EQ (1325), 1945 Mikawa EQ (2306), 1948 Fukui EQ (4618) and 1995 Kobe EQ (4823). Casualty estimation modeling using these events as well as all fatal and non-fatal earthquakes has given the base in the same methodology as per PAGER. In addition, the use of the seismic code index, other social vulnerability and building practice indicators and other normalization strategies ensures that the casualty model is calibrated to today's conditions. For example, it would be inaccurate to simply use casualties from a 1970 earthquake, as 80% of the Japanese building stock has been built since 1970.

As further building damage statistics collected by Japanese agencies became apparent, and the extent of shaking, tsunami heights and the nuclear powerplant problems became availa-

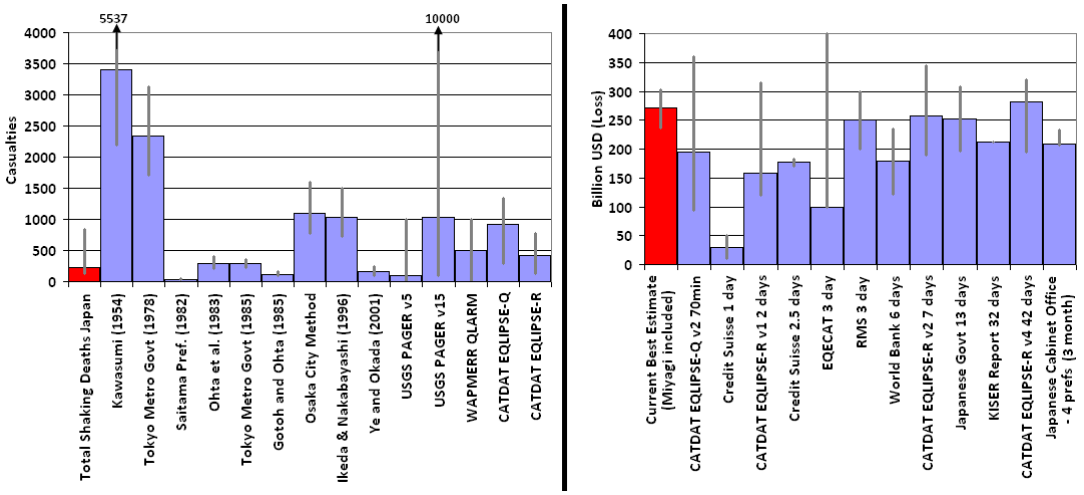


Fig. 1: Loss estimates from various casualty models for the 2011 Tohoku EQ (left); direct loss estimates from various economic models and summaries for the earthquake and tsunami (without powerplant losses) (right).

Table 1: Building damage statistics for the 2011 Tohoku EQ disaggregated for tsunami and earthquake.

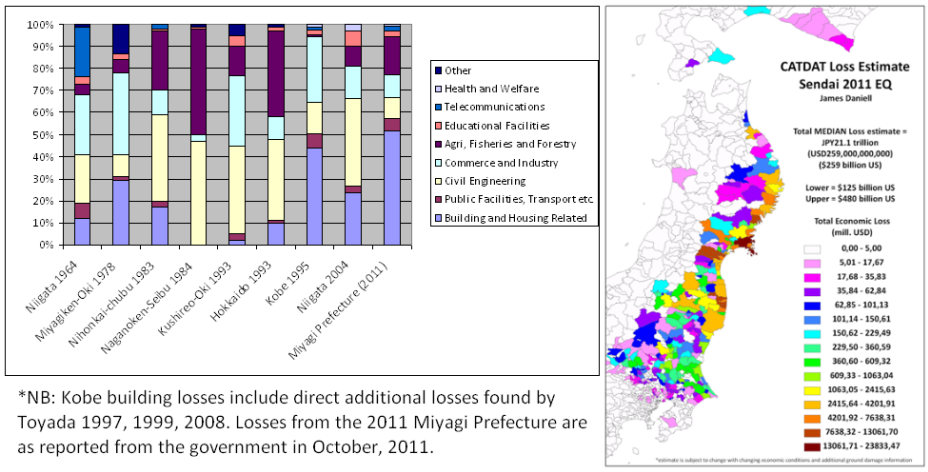
Buildings	Uninhabitable/Destroyed	Partially Destroyed	Partially Damaged
Tsunami (39%)	92168-104967	51322-103986	23892-72885
Earthquake (49%)	12813-26285	74253-127408	539595-590416
Powerplant (12%)	35466+		

ble, then additional loss modelling could take place to estimate the potential economic losses as well as casualties from various methods. A synopsis of these estimates is shown in comparison to other rapid earthquake loss estimation packages (PAGER, QLARM etc.) as well as government and company estimates (Fig. 1).

In addition, work was undertaken to separate the impacts of the earthquake, tsunami and powerplant incident in terms of social and economic modeling. Using the intensity relationships created in the buildings from non-coastal municipalities (since nearly all damage in these inland municipalities must be earthquake related), results in the following stastistics for tsunami and earthquake losses (Table 1).

As of 28 October 2011, 15829 have been killed and 3724 are missing (19553 in total). Of the 19553, around 600 are assumed to have died from earthquake-related stress and chronic disease. Around 230 are likely earthquake-collapse related as calculated from 133 non-coastal deaths and additional coastal municipality deaths. Around 250 could be related to other causes such as fire, landslides etc. Around 94% of deaths are tsunami related. Over 20 different casualty estimation models (mostly Japanese) were examined. PAGER, QLARM and EQLIPSE all performed reasonably well, given the uncertainty in the number of shaking deaths, 5 months after the event.

The initial direct losses in EQLIPSE are built via normalization of various parameters of historic earthquakes in CATDAT to 2011 conditions using population and dwelling changes, vulnerability changes, and community wealth changes as per Daniell and Love (2010). Within 70 minutes, the estimate was 11000-21000 deaths and $100-500 billion total loss. In addition, this uses the HNDECI index for each historic earthquake. Sectoral analysis from past Japanese earthquakes gave a predicted ratio for the initial loss. Historically in such events, 20-30% of direct economic loss was residential based, with estimates ranging from 25-55% in other



*NB: Kobe building losses include direct additional losses found by Toyada 1997, 1999, 2008. Losses from the 2011 Miyagi Prefecture are as reported from the government in October, 2011.

Fig. 2: Sectoral loss distribution from historic Japanese earthquakes in terms of direct economic losses (left); CATDAT EQLIPSE-Q v2 70min economic loss (only EQ and Tsunami) (right).

Table 2: Final loss estimates for the 2011 Tohoku EQ disaggregated for tsunami, powerplant and earthquake using Japanese and CATDAT data as of 18th October.

In Billion USD	Earthquake	Tsunami	Powerplant
Direct Loss Inland	77	0	58-71
Direct Loss Coastal	48-81	112-145	
Total Direct Loss	**125-158 (42%)**	**112-145 (39%)**	**58-71 (19%)**
Possible Indirect Loss	*69-132*	*64-113*	*51-91*
Total Economic Loss	***194-290 (41%)***	***176-258 (36%)***	***109-162 (23%)***

forms of industry, infrastructure and commercial losses. These relationships are based on historic large Japanese earthquakes, some of which are shown below. In EQLIPSE, the income level and historic losses to residential buildings were calculated based on potential losses in each municipality, as seen in the example loss diagram (Figure 2).

A number of rapid earthquake loss estimation software packages exist worldwide (PAGER, QLARM, EXTREMUM) and have been shown to create reasonable estimates of loss in quick time after a disaster. CATDAT EQLIPSE aims to integrate a higher level of socio-economic analysis and historic earthquake data into rapid loss calculations through its dynamic nature. In the case of the 2011 Tohoku earthquake and tsunami, it is difficult to ever know the final discretization of earthquake and tsunami losses; however, the possible outcome is about 39% economic losses due to tsunami ($127 billion) and 43% due to the earthquake ($144 billion), with about 18% due to the Fukushima disaster ($59 billion). The data from Miyagi prefecture released by the prefecture has shown these percentages to be realistic. On the other hand, approximately 94.5% of the deaths are expected to be tsunami related, with only a small percentage (1.2%) expected to be due to earthquake shaking. Direct losses are in the order of $335 billion with indirect losses around $260 billion expected with all impacts combined. From historical quakes and looking at business interruption, for the $280 billion direct economic loss from this earthquake, around $110 billion to $220 billion in extra indirect losses could be expected for the earthquake and tsunami. Further analysis will be needed over the coming years (Table 2).

EQLIPSE is in production currently and much work is still required for automation of the process. Further details of the socio-economic

functions included in EQLIPSE will be calibrated and then disseminated in future papers. In addition work with CATDAT and earthquake-report.com will continue.

Project status

This project continues to be a test case for the rapid earthquake loss estimation procedure, EQLIPSE. The direct effects of the earthquake, tsunami and powerplant incident are still being counted, even 8 months after the disaster. Given the extent of the disaster, the indirect effects of this disaster will be felt for years to come, and further analysis will continue to be undertaken.

Outlook

The work undertaken within this project formed a good pre-test case for the "CEDIM Forensic Earthquake Analysis Group" showing the power of earthquake-report.com, EQLIPSE (PhD methodologies) and CATDAT and the type of work that needs to be undertaken to create remote analysis of a disaster. Results have been presented online, at ReliefWeb, EGU (European Geophysical Union) and AEES (Australian Earthquake Engineering Society) Conferences.

Since then, the first test case for the "CEDIM Forensic Earthquake Analysis Group" was undertaken on the October earthquake in Eastern Turkey.

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Publications

Daniell, J.E., Khazai, B., Wenzel, F., Vervaeck, A. (2011a): The CATDAT damaging earthquakes database, Nat. Hazards Earth Syst. Sci., 11, 2235-2251, doi:10.5194/nhess-11-2235-2011, 2011.

Daniell, J.E., Vervaeck, A. (2011b): The 2011 Tohoku Earthquake – CATDAT Situation Reports 1-41, Earthquake-Report.com.

Daniell, J.E., Wenzel, F., Vervaeck, A. (2011c): The Socio-economic effects of the 2011 Tohoku earthquake, Geophysical Research Abstracts Vol. 13, EGU2011-14270.

Daniell, J.E.; Vervaeck, A.; Wenzel, F. (2011d): A timeline of the Socio-economic effects of the 2011 Tohoku Earthquake with emphasis on the development of a new worldwide rapid earthquake loss estimation procedure, Australian Earthquake Engineering Society 2011 Conference, Nov 18-20, Barossa Valley, South Australia.

Daniell, J.E. (2011e): Open Source Procedure for Assessment of Loss using Global Earthquake Modelling software (OPAL), Nat. Hazards Earth Syst. Sci., 11, 1885-1899, doi:10.5194/nhess-11-1885-2011, 2011.

Daniell, J.E. (2011f): The CATDAT Damaging Earthquakes Database – 2010 – Year in Review, CEDIM Research Report 2011-01, Earthquake-Report OF Report, Karlsruhe, Germany.

Daniell, J.E. (2011g): The Worldwide CATDAT Damaging Earthquakes and Damaging Volcanoes Databases: Socio-economic trends, values and analysis including 2010, Geophysical Research Abstracts Vol. 13, EGU2011-4909.

Daniell, J.E., Gibson, G. (2011h): A review of all Australian Damaging Earthquakes and their contribution to knowledge of earthquake risk in Australia, Geophysical Research Abstracts Vol. 13, EGU2011-4934.

Daniell, J.E., Khazai, B., Slingby, A. and Wenzel, F. (2011i): A Country-by-Country Building Inventory and a Building Vulnerability Index for use in different Natural Disaster applications Geophysical Research Abstracts Vol. 13, EGU2011-4948-1.

Daniell, J.E., Wenzel, F. and Khazai, B. (2011j): The Economics of Earthquakes since 1900: The Hybrid Natural Disaster Economic Index, Historical Loss Conversion, Future Impacts and Insurance Takeout, Geophysical Research Abstracts Vol. 13, EGU2011-4923.

Daniell, J.E., Wenzel, F., Khazai, B. (2011k): Die Kosten historischer Erdbeben : Ökonomische Analyse der weltweiten Erdbebenschäden seit 1900, DKKV Paper, DKKV 2011 Conference, Potsdam, Germany. (Student Prize)

Daniell, J.E., Wenzel, F., Khazai, B., Vervaeck, A. (2011l): A Country-by-Country Building Inventory and Vulnerability Index for Earthquakes in comparison to historical CATDAT Damaging Earthquakes Database losses accepted, Australian Earthquake Engineering Society 2011 Conference, Nov 18-20, Barossa Valley, South Australia.

Khazai, B., Daniell, J.E., Wenzel, F. (2011m): The March 2011 Japan Earthquake – Analysis of losses, impacts, and implications for the understanding of risks posed by extreme events, Technikfolgenabschätzung – Theorie und Praxis 20. Jg., Heft 3, November 2011.

Vervaeck, A., Daniell, J.E. (2010-2011): Over 400 earthquake loss estimation related articles on earthquake-report.com related to the rapid loss estimation procedures and calibration of data since 12/2010, earthquake-report.com.

Sozioökonomische Analyse des Tohoku-Erdbebens

Ab 2 Minuten nach dem Erdbeben in Japan am 11. März 2012 haben earthquake-report.com und CEDIM die sozio-ökonomischen Auswirkungen des Erdbebens anhand von aktuellen Informationen aus japanischen und internationalen Quellen und verfolgt und mit historischen Vergleichen aus der CATDAT Damaging Earthquakes Database ergänzt. Außerdem wurden regelmäßig die erwarteten sozialen Verluste (Tote, Verletzte, Obdachlos gewordene) und ökonomischen Schäden (versicherte Schäden und Gesamtschäden) aktualisiert, die mit Hilfe der Software EQLIPSE zur schnellen, weltweiten Abschätzung von Erdbebenfolgen bereitgestellt wurden und die zunächst auf Basis der Bodenerschütterung und der Effekte des Tsunamis berechnet und später mit der Berücksichtigung komplexerer Effekte verfeinert wurden. Für die Bestimmung der Schäden war hierbei aus wissenschaftlicher Sicht das Zentrale die Kaskade von katastrophalen Effekten: das Erbeben löste den Tsunami aus - der Tsunami die katastrophalen Schäden in den Kernkraftwerken. Dennoch konnten auch historische Vergleiche mit Erdbeben der Vergangenheit für die Analyse herangezogen werden.

Bestehende Programme zur weltweiten, schnellen Abschätzung von Erdbebenschäden (PAGER, QLARM, EXTREMUM) haben gezeigt, dass sie kurze Zeit nach einem Erdbeben angemessene Schätzungen zu Schäden liefern. CATDAT EQLIPSE hat zum Ziel, sozioökonomische und historische Analysen auf einer höheren Ebene und mit einem dynamischen Ansatz in Schnellschadensschätzungen zu integrieren. Im Fall des Tohoku Bebens 2011 und des Tsunamis wird es schwierig sein, endgültig die jeweiligen Anteile der durch das Erdbeben verursachten und der durch den Tsunami verursachte Schäden zu ermitteln. Dennoch kann man derzeit davon ausgehen, dass etwa 39% der ökonomischen Schäden durch den Tsunami (127 Milliarden US$) und etwa 43% durch das Erdbeben (144US$) verursacht wurden, und etwa 18% den katastrophalen Folgen der Schäden in Fukushima (59US$). Betrachtet man jedoch die Anzahl der Todesopfer, dann sind etwa 94,5% der Toten dem Tsunami geschuldet, und nur ein relativ kleiner Anteil (1,2%) kann direkt dem Erdbeben zugeordnet werden. Für das Erbeben und seine Auswirkungen insgesamt werden die direkten Schäden in Größenordnung von 335US$ geschätzt und die indirekten auf etwa 260US$.

Die direkten Effekte des Erdbebens, Tsunamis und der Auswirkungen des Kernkraftunfalls werden auch acht Monate nach der Katastrophe noch immer ausgewertet. Angesichts des Ausmaßes dieser Katastrophe werden die indirekten Schäden noch in den nächsten Jahren zu spüren sein. Weitere Analysen hierzu werden unternommen werden.

The web service „Wettergefahren - Frühwarnung“

Bernhard Mühr

Routine Operation of „Wettergefahren-Frühwarnung“

The online information service „Weather hazards – early warning“ (Wettergefahren–Frühwarnung) provides information about current or future extreme or unusual weather events all over the world on a daily basis.

Between January 2011 and October 2011 nearly 70 events have been investigated, editorial articles produced to describe their development, progress and impacts in detail.

The number of page impressions for “Wettergefahren-Frühwarnung” increased in 2011: several thousand visitors are now visiting the webpages every day; also national weather services or private companies inform themselves regularly as do insurances or the media.

Real-Time Service / Forensic Disaster Analysis

During 2011 several natural disasters with heavy impacts occurred; they all provided a good opportunity to put the idea of „Real-Time Forensic Disaster Analysis“ into practice and to implement a close, quick and easy cooperation across several institutes.

For instance, in May 2011 the Icelandic volcano “Grimsvötn” began to erupt. Similar to the volcano Eyjafjallajökull in the previous year, this eruption also caused major problems for the European air traffic. “Wettergefahren-Frühwarnung” provided specific high resolution weather forecast maps for the Islandic area within a few hours.

Much more serious consequences resulted from a major earthquake and a subsequent tsunami in the Pacific Northwest in March 2011; the tsunami flooded many coastal areas in northern Honshu (Japan) and triggered the nuclear disaster in Fukushima. On “Wettergefahren-Frühwarnung” a special page was implemented immediately on which a daily weather report for the disaster region was provided. Within 24 hours a forecast of trajectories was made available allowing at least a rough estimate about the direction of displacement and velocity of a possible radioactive cloud. Additionally, a high-resolution weather forecast model (WRF) was put into operation within a few hours. Its data, generated routinely four times

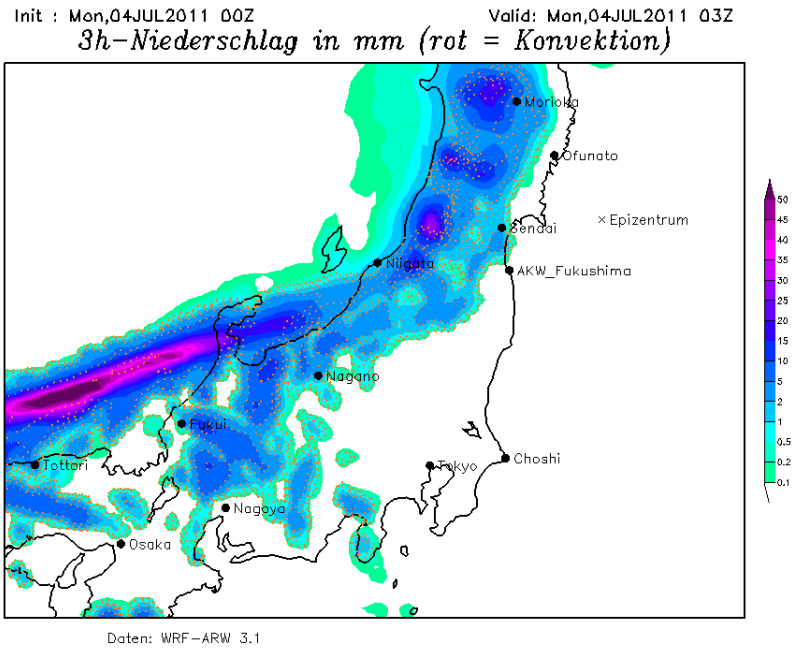

Fig. 1: High-resolution precipitation forecast map for Japan.

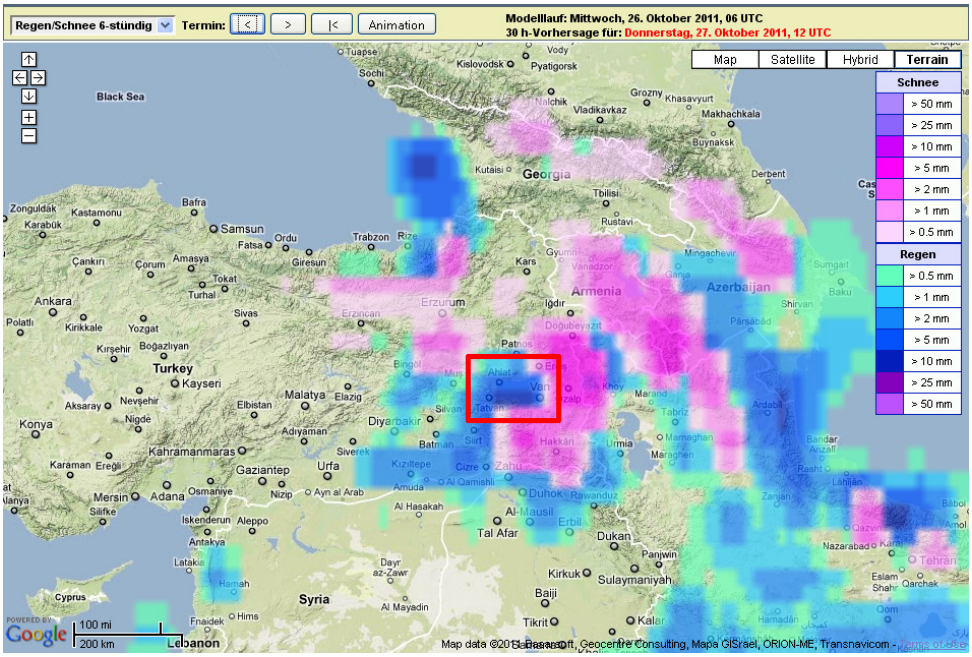

Fig. 2: Rain/snow precipitation forecast for eastern Turkey.

daily, were integrated into the RODOS-System (Real-time On-line DecisiOn Support), which is run at the Institute for Nuclear and Energy Technologies (IKET) at the KIT.

In October 2011 a major earthquake shook eastern Turkey. Within a short time, a climatological overview of the Van/Ercis region could be provided and was made available for the public together with reports from the CEDIM Forensic Earthquake Analysis Group.

Thailand was hit by devastating floods twice this year. The “Wettergefahren-Frühwarnung” informed on the causes and the chronological progress of the enormous rainfall and made a significant contribution with illustrations to an article in an important online news magazine.

Outlook

To provide weather forecasts in case of a severe event for any region of the world in quasi-real time and in almost any resolution, the WRF model will be run operationally. The hardware requirements have been fulfilled already with the acquisition and installation of a new powerful server.

Any data that might be required as input for other projects within CEDIM (rain, snow, wind, …) can also be provided.

With the new server it is also possible to carry out ensemble forecasts that can give detailed information about the probability of occurrence of severe events and their intensity.

Moreover, there is a need fot a new design for the webpage and its navigation and also for an English version.

Note: The „Wettergefahren-Frühwarnung“ project is operated independently from the official warning sites of the national weather services and without guarantee. Rules of conduct and recommended actions for individuals, businesses or authorities are not included in the warnings.

Web addresses:

www.wettergefahren-fruehwarnung.de
www.vorhersagezentrale.de

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Das Internet-Projekt „Wettergefahren – Frühwarnung“

Seit dem Jahr 2004 informiert der Internet-Informationsdienst „Wettergefahren-Frühwarnung“ tagesaktuell über bevorstehende oder gerade auftretende ungewöhnliche und extreme Wetterereignisse weltweit, deren Entstehung, Verlauf und Auswirkungen in ausführlichen redaktionellen Artikeln erläutert wird.

Die Zugriffszahlen des Internetangebots von „Wettergefahren-Frühwarnung“ nahmen im Jahr 2011 weiter zu, mittlerweile sind es mehrere 1000 Besucher täglich; regelmäßig informieren sich auch staatliche und private Wetterdienste, Versicherungen und Medien auf den Webseiten. Mit einem privaten Wetterdienstleister wurde eine Kooperation vereinbart.

Im Jahr 2011 traten einige herausragende und folgenschwere Naturkatastrophen auf; sie alle boten eine gute Gelegenheit, den Gedanken der „Real-Time Forensic Disaster Analysis“ in die Praxis umzusetzen und institutsübergreifend rasch und unkompliziert zusammenzuarbeiten.

Als Beispiel sei das Tohoku Erdbeben vor Honschu (Japan) im März 2011 genannt, dessen nachfolgender Tsunami viele küstennahe Bereiche im Norden Honschus überschwemmte und die Reaktorkatastrophe in Fukushima auslöste. Bei Wettergefahren-Frühwarnung wurde sofort eine Sonderseite zu dem Ereignis eingerichtet, auf der ein täglich aktualisierter Wetterbericht für die Unglücksregion bereitgestellt wurde; innerhalb von 24 Stunden stand eine Trajektorienprognose zur Verfügung, die zumindest grob Auskunft über die Verlagerungsrichtung und -geschwindigkeit einer möglichen radioaktiven Wolke Auskunft gab. Zudem konnte innerhalb weniger Stunden ein hochaufgelöstes Wettervorhersagemodell (WRF) für Japan in Betrieb genommen werden. Dessen routinemäßig 4 Mal täglich erzeugten Daten flossen in das am Institut für Kern- und Energietechnik (IKET) am KIT betriebene Echtzeit-Entscheidungshilfesystem RODOS (Real-time On-line DecisiOn Support) ein.

Im Oktober 2011 erschütterte ein heftiges Erdbeben den Osten der Türkei. Auch hier konnten innerhalb kurzer Zeit sowohl eine ausführliche klimatologische Übersicht als auch aktuelle Wetterberichte bereitgestellt und zusammen mit Berichten der CEDIM Forensic Earthquake Group der Öffentlichkeit zugänglich gemacht werden.

Um in Zukunft in quasi-Echtzeit für jedes Gebiet auf der Welt bei Bedarf Wetterprognosen in nahezu beliebiger Auflösung bereitstellen zu können, soll das WRF-Modell routinemäßig in Betrieb genommen werden. Zudem können dadurch auch beliebige Daten bereitgestellt werden, die als Eingangsdaten für andere Projekte innerhalb von CEDIM benötigt werden (Regen, Schnee, Wind,...). Ensemble-Prognosen erlauben eine Auskunft über die Eintrittswahrscheinlichkeit bestimmter Ereignisse und ihrer Intensität. Darüber hinaus bedarf die Wettergefahren-Frühwarnung eines neuen Designs; eine englische Version ist wünschenswert.

Internet-Adressen:

www.wettergefahren-fruehwarnung.de
www.vorhersagezentrale.de

Risk communication with interactive web-based maps

Doris Dransch

Introduction

Conveying scientific findings on hazard exposure and risk assessment to non-experts is a crucial task since it enables people to act adequately to hazards and their effects. Natural hazards have a strong spatio-temporal component; therefore maps can play a decisive role in risk communication. Traditionally, the investigation and design of hazard and risk maps has been guided predominately by the needs of risk-management experts and their particular focus, less by the needs of non-experts. To design effective maps for non-experts we have to consider specific constraints and challenges derived from investigations in psychology and sociology.

Aims / Objective

Our research work aims at 1) identifying concepts for effective risk communication developed in psychology and sociology and 2) to incorporate the concepts into interactive map-based information systems on the internet to improve risk communication to the public.

Project status

In an extensive literature survey we identified several challenges and concepts that address the main issues for effective risk communication to non-experts. They can be divided into three main groups:

1) Challenges related to risk perception: The perception and framing of risk is quite different in the case of experts and non-experts. Experts deal with suspected hazards, exposure, vulnerability, risk and describe them by qualitative and quantitative measures. Non-experts frame risks in a more personal way and in a broader social context. They are interested in the implications of hazards to their daily life. They tend to believe risk messages when they can confirm them through interaction with other people. Furthermore, non-experts often do not perceive risks correctly; they overestimate hazards with high societal regard, and in contrary, underestimate hazards with low societal regard.

2) Challenges related to communication: Effective risk communication has to be designed for the most important target group, the primary audience. The communication's objectives have to be defined thoroughly, and the media designed accordingly. Finally, an adequate source and media to deliver information has to be used. The audience's choice of an information source is determined by its availability and accessibility, the effort and money which is necessary to contact it, and the experience the person already has with the source and its credibility.

3) Challenges related to information presentation: A suitable form of information presentation is crucial for effective risk communication. Vivid presentation may improve memorability and amplify the emotional involvement of a person. Information may be described as vivid if it is emotional interesting, concrete and imagery-provoking, and proximate either in a sensory or spatiotemporal way. Thus, localized hazard information, e.g. pictures showing former disasters in the home community, is remembered longer than more impressive pictures from other areas. Vivid information has greater influence on decision making than non-vivid information. Reducing and adapting the complexity of a message to the particular audience is another vital aspect for risk communication. The more user-oriented and interactive the communication material, the better the information is understood. The wording of a message also influences its interpretation and the conclusions derived from it. Positive wording leads to risk-averse behavior, negative wording causes

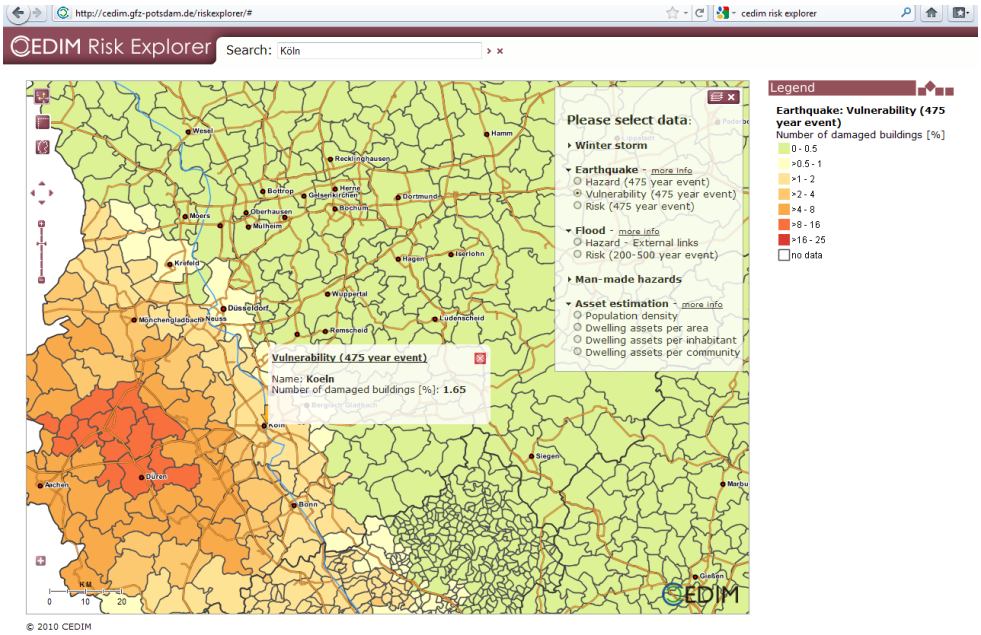

Fig. 1: CEDIM Risk Explorer: Risk information for a selected municipality.

risk taking. Another relevant issue is the formulation of a risk's probability: non-experts prefer relative frequency as measure for this. Finally, showing a risk in comparison with others help to improve a person's assessment of risks.

We related the more general results from the literature review to the focus of our research. For our main audience, the non-experts, we formulated the following communication objectives and related tasks: 1) improve risk perception by increasing risk knowledge and risk assessment, 2) support a personal risk framing by creating a personal view, 3) establish credibility by informing objectively and through consistent information. To support these objectives we developed methods for map-based information presentation and chose technologies to allow good information accessibility. The concepts of vividness, suitable complexity, comparability, interactivity, and personal message framing were implemented in the CEDIM Risk Explorer and the Natural Disaster Networking Plattform NaDiNe. CEDIM Risk Explorer is a map-based information system on the Web. It presents interactively hazard-, vulnerability- and risk-maps of Germany which have been developed in CEDIM. The Risk Explorer for

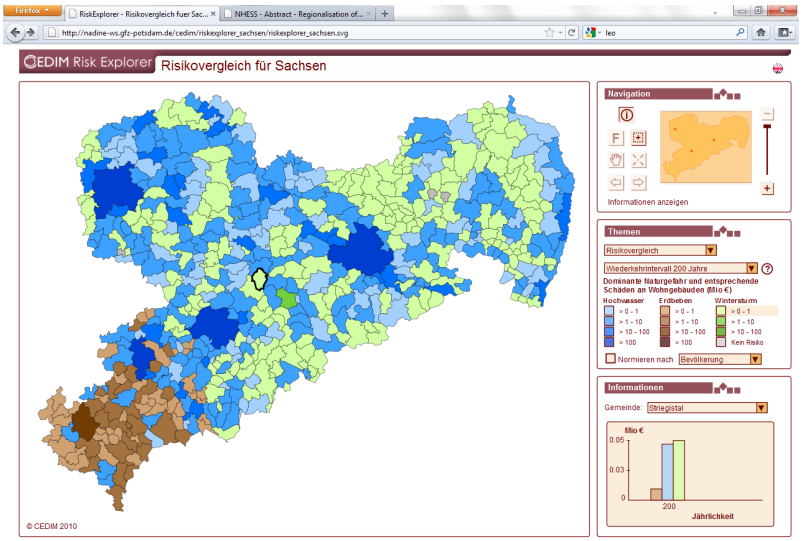

Fig. 2: CEDIM Risk Explorer: Comparison of earthquake, flood, and storm risk.

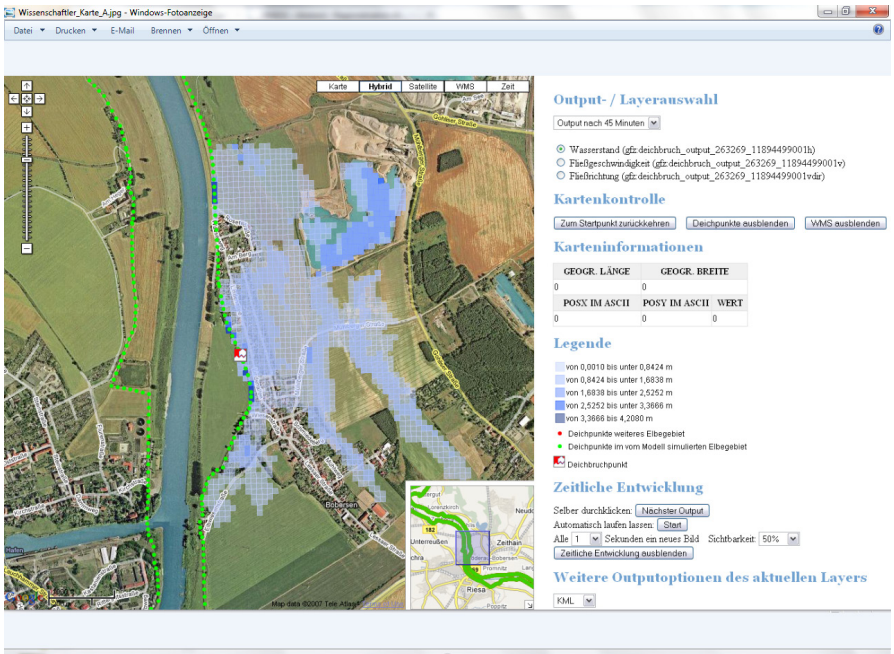

Fig. 3: NaDiNe: Presentation of exposure to flood and dike breach.

Saxony additionally allows the comparison of interactive risks related to flood, earthquake, and winter storms. The data for Risk Explorer are stored in a PostGIS spatial data base and is made available using the WebMapService component of the server software Geoserver and Open Layers Client. The Risk Explorer for Saxony is developed using Scalable Vector Graphics (SVG). NaDiNe makes simulation models for flood damage assessment available as well as the internet-based information brochure for flood damage prevention which was developed at German Research Center for Geosciences. NaDiNe is implemented using Webservices and Google maps.

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Risikokommunikation mit webbasierten interaktiven Karten

Die erfolgreiche Kommunikation risiko-relevanter Information an die Öffentlichkeit ist Voraussetzung für bewusstes Handeln der Bevölkerung im Kontext von Naturgefahren und Risiken. Karten und damit verbundene Informationssysteme können den Raum- und Zeitbezug von Naturgefahren und Risiken zeigen, sie sind daher eine geeignete Kommunikationskomponente. Um den Erfordernissen der Kommunikation mit der Öffentlichkeit gerecht zu werden, haben wir Konzepte zur Risikowahrnehmung, Risikokommunikation und Informationspräsentation untersucht und sie in den von uns entwickelten web-basierten Karten und Informationssystemen CEDIM RiskExplorer und NaDiNe operationalisiert.

Publications

http://www.cedim.de/riskexplorer.php
http://nadine.helmholtz-eos.de/intro_de.html

Dransch, D., Rotzoll, H., Poser, K. (2010): The contribution of maps to the challenges of risk communication to the public International Journal of Digital Earth, 3(3) 292 – 311., http://www.tandfonline.com/doi/abs/10.1080/17538941003774668

Fig. 4: NaDiNe: Internet-based flood damage prevention brochure.

Security2people

Security Research Program sponsered by the Federal Government

Wolfgang Raskob and Stefan Möllmann

Introduction

The project SECURITY2People (Secure IT-Based Disaster Management System to Protect and Rescue People) is part of the German Security Research initiative and aims at exploring the needs for and the structure of an integrated disaster management system with simulation, decision support and interoperability as key elements. It will be applicable

for all types of emergencies and at all levels of disaster management. Operators of critical infrastructures and organizations dealing with security issues are also seen as potential users of that system. The goal is to create a system suitable for emergency planning, training and mission support.

Aims / Objective

The key objective of the project is to explore the needs of the various end users by analyzing the current situation in the emergency management in North Rhine-Westphalia (NRW). To facilitate the interaction with the end users, a demonstrator has been developed to present the potential features of an integrated decision support system for a specific scenario.

As basis for the demonstration and evaluation, an example scenario was implemented focusing on a large crisis situation in the area of NRW affecting Cologne and its surroundings. A large scale frontal zone with high wind speeds and heavy precipitation resulted in many car accidents, a crash of an air plane at the Cologne Bonn Airport, mass panic at an exhibition hall and finally a power blackout in the southern areas of Cologne, which could result in a gas dispersion. In particular the potential release of a pollutant from an industrial area was the focus of a workshop presenting the demonstrator to the end users.

An open source portal was used as the technological platform to implement the demonstrator, which combines simulation, decision support and common operational picture (COP) components (see Fig. 1).

Input to the demonstrator are resources such as police and rescue forces provided by a tailored version of the GESI emergency management simulation system, a detailed resources simulation system provided by CAE. Further, external data such as simulation of a release of pollutants can be integrated into the Demonstrator and visualized, together with the resources in the Common Operational Picture of the Portal.

For supporting decision making, a knowledge data base has been set up that contains “historic” large scale disaster events and their management options. The current incident is compared with those of the data base and a machine learning algorithm provides a ranked list of potential measures that might be applicable for the current event. This includes also measures to be taken on a more strategic basis. To test the applicability of the measures, a Key Performance Indicator (KPI) approach has been selected to calculate the time or resources required for relief measures applied on a current disaster site. In this way, a fast and consistent decision making framework has been established to support decision making on the operational (usage of the KPI mainly) or stra-

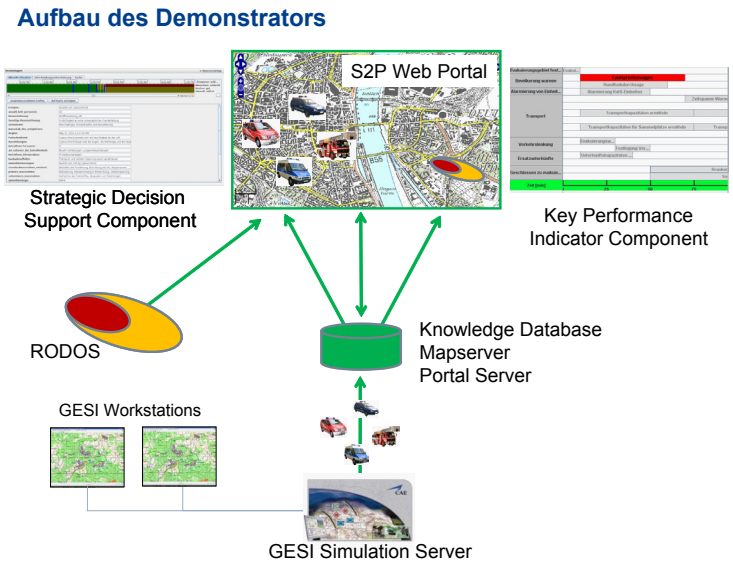

Fig. 1: Demonstrator layout with the various components and the connection to simulations such as GESI and RODOS.

tegic level (usage of the knowledge data base and strategic decision making).

The added value of this approach with using a knowledge databases in the center is the enormous potential when combined with machine learning components. Such algorithms will solve a problem in a better way when the number of cases increases. In this way the continuous application of the system increases its performance.

Project Status

The year 2011 was devoted to completing the Demonstrator described above. In particular, the Key Performance Indicators, the knowledge data base and the machine learning components have been explored and integrated into the system.

The two CEDIM institutes concentrate on the development of simulation and decision support capabilities on both the strategic and the operational/tactical levels.

Outlook

The demonstrator was presented in a large workshop to receive feedback from the end users. Based on their comments, the project will focus on the interoperability of the system components as well as the integration with existing systems.

The two CEDIM institutes will continue to work on their individual components, introducing also a system for automatic context-sensitive provision of information.

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SECURITY2People

Das Projekt SECURITY2People ist Bestandteil des Programms zur Sicherheitsforschung des BMBF und hat das Ziel die Grundlagen für ein ganzheitliches, IT-basiertes System zur Unterstützung im Krisenmanagement zu erarbeiten. Dieses soll Behörden übergreifend auf allen Hierarchieebenen für jede Art von Katastrophenereignis eingesetzt werden und verschiedene Komponenten zur Lagedarstellung und Entscheidungsunterstützung enthalten. Um die tatsächlichen Anforderungen aus der Praxis des deutschen Bevölkerungsschutzes optimal zu berücksichtigen, wird das Projekt auf Basis eines fiktiven Szenarios in NRW unter Einbeziehung verschiedener BOS aus der Region durchgeführt. Der bislang entwickelte Systemdemonstrator basiert auf einem Webportal, an welches das Simulationssystem GESI des Projektpartners CAE angebunden ist. Im weiteren Projektverlauf wird ein besonderer Schwerpunkt auf dem Thema Interoperabilität liegen. Dies bedeutet zum einen, dass die eigenen Komponenten stärker miteinander verknüpft werden sollen und zum anderen, dass die Anbindung etablierter Systeme demonstriert werden soll.

Die Institute des KIT beschäftigen sich in dem Projekt schwerpunktmäßig mit der Unterstützung des Krisenmanagements auf operativ-taktischer und strategischer Ebene. Hierzu werden Methoden des Wissensmanagement wie selbstlernende System, Wissensdatenbanken, multikriterielle Entscheidungsunterstützung und Expertensysteme untersucht.

II. Partnerships

Cooperation with the Insurance Industry

Willis Research Network

CEDIM became a member of the Willis Research Network (WRN) in 2009 and continued to cooperate with Willis Research through 2010 and 2011. WRN (www.willisresearchnetwork.com) is a subsidiary of Willis, the global insurance and reinsurance broker. The network is a partnership between the insurance industry and academia. Founded in 2006, WRN has entered long-term partnerships with 30 of the world's leading research institutions from the US, Great Britain, Japan and Italy. CEDIM is the first German partner in the network. Being an active partner in the WRN will increase CEDIM's national and international interaction with insurance industry.

After the WRN launch event in June 2010 in Potsdam, we organized a workshop with an insurance expert from WRN in May 2011 in Karlsruhe. During this workshop, basic principles of the insurance industry were discussed, in particular the options for scientific research within the context of new regulation schemes (Solvency II).

Kooperation mit der Versicherungswirtschaft: Willis Research Network

Die Kooperation mit Willis Research Network (WRN), hat sich weiter verstetigt. Das WRN ist eine Partnerschaft zwischen Willis – dem weltweiten Versicherungsmakler – und der akademischen Welt. Es wurde 2006 gegründet und besteht heute aus ca. 30 Forschungseinrichtungen aus den u.a. USA, Großbritannien, Japan und Italien. CEDIM ist damit erster Partner von WRN in Deutschland. Mit der Zusammenarbeit mit WRN wird die systematische Interaktion von CEDIM mit der Versicherungswirtschaft auf nationaler und auf globaler Ebene weiter ausgebaut.

Nach dem Einführungsseminar von WRN in Deutschland in 2010 in Potsdam führte CEDIM die Kooperation u.a. in einem Workshop mit einem Experten von WRN im Mai 2011 fort.

Bei diesem Workshop wurden Prinzipien der Versicherungswirtschaft und Optionen wissenschaftlicher Arbeit im Kontext der neuen Regulierungsverfahren für diesen Wirtschaftszweig (Solvency II) diskutiert. Langfristiges Ziel auch dieser Aktivität ist es, die Vernetzung und Interaktion von CEDIM mit der Versicherungswirtschaft zu intensivieren.

www.willisresearchnetwork.com

Other Cooperation with the Insurance Industry

During the last two years, specific cooperation projects have been developed with SV Insurance (SV Sparkassenversicherung) on hail and earthquake risk, which allow understanding insurance needs and refining and tuning models for insurance applications. It is important to mention also the cooperation with the Deutsche Hagelversicherung.

For several years now KIT has collaborated via CEDIM with the Universität Stuttgart in a joint PhD program „Umwelt und Schadenvorsorge“ by the „Stiftung Umwelt und Schadenvorsorge“, the foundation of the SV Sparkassenversicherung. This PhD program was started to address research gaps in prediction of extreme events and prevention of loss from natural hazards. At the moment one PhD candidate in CEDIM is funded by this program. Her research is focused on the changes in hail probability due to climate change.

The Stiftung Umwelt und Schadenvorsorge held a Symposium on hail and thunderstorms

and related risks in March 2011. The symposium was part of a seminar series “natural hazards: novel ways of prevention and risk management”. CEDIM members were actively involved in the preparing the event, as well as giving presentations on their research.

Weitere Zusammenarbeit mit der Versicherungsindustrie

Darüber hinaus hat sich vor allem im Bereich Hagel- und Erdbebenrisiko im Jahr 2010 die Interaktion und Kooperation mit der Versicherungswirtschaft verstärkt. Mit der SV-Versicherung verbinden uns mittlerweile Projekte zum Hagel und Erdbebenrisiko, die es uns erlauben, Anforderungen der Versicherer zu verstehen und unsere Modelle und Methoden auf diese Anforderungen hin auszurichten. Als weitere projektspezifische Zusammenarbeit ist auch die Kooperation mit der Vereinigten Hagelversicherung zu nennen. Bereits seit mehreren Jahren kooperiert das KIT über CEDIM mit der Universität Stuttgart im Rahmen der Ausbildung und Förderung von Doktoranden im Kolleg „Umwelt und Schadenvorsorge“ der Stiftung Umwelt und Schadenvorsorge der SV Sparkassenversicherung. Derzeit wird in diesem Kolleg eine Doktorandin aus CEDIM gefördert, die sich in ihren Forschungsarbeiten mit der Veränderung von Hagelwahrscheinlichkeit im Zuge des Klimawandels beschäftigt.

CEDIM beteiligte sich zudem aktiv an der Vorbereitung und Durchführung des Symposiums „Hagel - Blitz -Tornado: Millionenschäden in Minuten“ der Stiftung Umwelt und Schadenvorsorge am 30./31. März 2011, bei dem mehrere CEDIM-Mitglieder ihre Forschungsarbeiten vorstellten. Das Symposium fand im Rahmen der Seminarreihe „Naturgefahren: neue Wege der Prävention und des Risikomanagements“ der Stiftung statt.

SFB/TR Extreme Events

On March 31, 2011 the research group who prepares the installation of a Collaborative Research Center on natural extreme events submitted a proposal to the DFG. The collaborative team consists of the following institutions: KIT, Potsdam University, ETH-Zurich, PIK, Max-Planck Institute, GFZ. The project has been initiated and discussed in CEDIM and a broader partnership has been established that covers also other institutions. In particular, the March 11, 2011 Tohoku earthquake indicated that extreme events, and specifically the interaction with technical facilities and installations and societal structures, are an issue that until now has not been researched sufficiently. Cascading and interaction effects are not very well known and are not underpinned by good models. The tipping points in this interaction are widely unknown and therefore not understood. The investigation of these items for earthquakes but also for other disaster types, such as the hydrometeorological events understood as changing through variable climatic conditions, are at the core of the proposal. Methodologies for developing scenarios that can be used for stress testing societal institutions, technological installations and critical infrastructure are to be studied. The current status of the proposal is pending as there are negotiations in hand between Deutsche Forschungsgemeinschaft (DFG) and Schweizer Nationalfond (SNF) on how to properly handle evaluation and financing issues.

EU-FP7 Projects

GFZ and KIT as CEDIM supporting institutions are part of a number of FP7 projects in the context of disaster and risk, in some of them as coordinators or work package leaders. The network of European research infrastructures for earthquake risk assessment and mitigation (NERA) began in November 2010, is financed for four years and builds on a number of previous FP6 projects. GFZ and KIT are involved in earthquake monitoring, hazard assessment and risk to infrastructures, including socio-economic implications. The project on new multi-hazard and multi-risk assessment methods for Europe (MATRIX) aims at the development of multi-risk assessment methodologies. The coordinator is Professor Jochen Zschau (GFZ). KIT participates by assessing storm risks and by developing a new dissemination strategy to stakeholders. The project started in October 2010 and is funded for three years. The project strategies and tools for real-time earthquake risk reduction (REAKT) started in September 2011. It deals with earthquake, hazard, vulnerability, risk, early warning and operational forecasting. GFZ and KIT contribute by being part of the project management team (Professor Jochen Zschau) and serving as work package leaders.

Cooperation with Fraunhofer Institut für Optik, Systemtechnik und Bildauswertung (Fraunhofer IOSB)

Fraunhofer IOSB (Fraunhofer Institute of Optronics, System Technologies and Image Exploitation) and CEDIM developed an agreement on a strategic partnership for the forthcoming years starting in 2011. The aim of the cooperation is the generation of synergies between both institutions. Fraunhofer IOSB is very strong in the field of information management, automatic recognition of objects, and real-time information systems. CEDIM develops methodologies for risk assessment, early warning, real-time damage and loss prognoses and risk management. It is planned to jointly prepare the 2013 conference of ISCRAM (International Community on Information Systems for Crisis Response and Management, www.iscram.org). The chair of the conference will be Professor Jürgen Beyerer (Fraunhofer IOSB and Professor for Interactive Real-Time Systems at KIT). A scientific project goal is the development of decision support tools for the protection of critical infrastructures, where we can build on joint experience in the protection of railway systems.

III. Publications 2011

Articles in Journals and Books

Bendimerad, F., Khazai, B., Zayas, J. (2011) Mumbai DRRMP Validation and Implementation Work Outputs, Earthquake and Megacities Report No. TR-1 1-12, Municipal Corporation of Greater Mumbai (MCGM) Project BW 600330 and 09526, March 2011, 46p.

Berg, P., Panitz, H.-J., Schädler, G., Feldmann, H., Kottmeier, Ch. (2011): Modelling Regional Climate Change in Germany, in: W.E. Nagel et al. (eds.), High Performance Computing in Science and Engineering,10, doi:10.1007/978-3-642-15748-6_34.

Berg, P., Wagner, S., Kunstmann, H., Schädler, G. (2011): High resolution RCM simulations for Germany: Part I – validation, submitted to Clim. Dyn.

Bindi D., Abdrakhmatov, K., Parolai, S., Mucciarelli, M., Grünthal, G., Ischuk, A., Mikhailova, N., Zschau, J. (2011): Seismic hazard assessment in Central Asia: outcomes from a site approach, submitted to Soil dynamics and Earthquake Engineering.

Bindi, D., Parolai, S., Oth, A., Abdrakhmatov, K., Muraliev, A., Zschau, J. (2011): Intensity prediction equations for Central Asia, Geophysical J. International, 187, 327–337.

Cavalieri, F., Franchin, P., Khazai, B., Gehl, P. (2012): Quantitative assessment of buildings habitability based on physical damage and functional interaction with infrastructural systems, Earthquake Engineering and Structural Dynamics, Accepted for Publication.

Daniell, J.E. (2011e): Open Source Procedure for Assessment of Loss using Global Earthquake Modelling software (OPAL), Nat. Hazards Earth Syst. Sci., 11, 1885-1899, doi:10.5194/nhess-11-1885-2011, 2011.

Daniell, J., Khazai, B., Wenzel, F. (2011): Uncovering the 2010 Haiti Earthquake death toll, DPM-Mar-2011-0034, Disaster Prevention and Management (submitted).

Daniell, J.E., Khazai, B., Wenzel, F., Vervaeck, A. (2011a): The CATDAT damaging earthquakes database, Nat. Hazards Earth Syst. Sci., 11, 2235-2251, doi:10.5194/nhess-11-2235-2011, 2011.

Daniell, J.E., Vervaeck, A. (2011b): The 2011 Tohoku Earthquake – CATDAT Situation Reports 1-41, Earthquake-Report.com.

Elmer, F., Hoymann, J., Düthmann, D., Vorogushyn, S., Kreibich, H. (2011): Drivers of flood risk change. Submitted to NHESS – under Review.

Heneka, P., Hofherr, T. (2011): Probabilistic winter storm risk assessment for residential buildings in Germany., Natural Hazards, 56, 815-831.

Hiete, M., Merz, M., Comes, T., Schultmann, F. (2011): Trapezoidal Fuzzy DEMATEL method to analyse and correct for relations between variables in a composite indicator for disaster resilience, OR Spectrum, (DOI) 10.1007/s00291-011-0269-9.

Hiete, M., Merz, M. & Schultmann, F. (2011): Scenario-based impact assessment of a power blackout on healthcare facilities in Germany, International Journal of Disaster Resilience in the Built Environment, Vol. 2, pp. 222-244.

Hiete, M., Merz, M. & Schultmann, F. (2011): Critical Infrastructure Protection in Germany: Accounting for Inter-infrastructure Dependencies and Facilitating Public-Private Cooperation, he CIP Report, Center for Infrastructure Protection and Homeland Security, 9(2), pp. 18-22.

Ingram, J.C., Khazai, B. (2012): Ecological Dimensions of Disaster Prevention, Integrating Ecology and Poverty Reduction, Ecological Dimensions. Ed. Ingram, J.C., DeCelrck, F., Rumbaitis del Rio, C., 1st Edition, Springer, 2012.

Kapsch, M.-L., Kunz, M., Vitolo, R., Economou, T. (2011): Long-term variability of hail-related weather types in an ensemble of regional climate models; submitted to J. Geophys. Res.

Khazai, B., Bendimerad, F. (2011): Megacity Indicator Systems (MIS) for DRM in Greater Mumbai, in Mumbai Disaster Risk Management Master Plan (DRRMP). Ed. Bendimerad,

F., Daclan J.M., Dagli, W., Zayas. J., Earthquake and Megacities Initiative, Final Technical Report, No. CR-1 1-0, 31, Municipal Corporation of Greater Mumbai (MCGM) Project BW 600330 and 09526, March, 2011, 429 p.

Khazai, B., Bendimerad, F. (2011): Risk and Resiliency Indicators, Earthquake and Megacities Report No. TR-1 1-03, Municipal Corporation of Greater Mumbai (MCGM) Project BW 600330 and 09526, March 2011, 103p.

Khazai, B., Daniell, J. E., Apel, H. (2011): Risk Analysis Course Manual: For Instructors, Global Facility for Disaster Risk Reduction and Recovery (GFDRR), The World Bank, 218p.

Khazai, B., Daniell, J.E., Wenzel, F. (2011): The March 2011 Japan Earthquake – Analysis of losses, impacts, and implications for the understanding of risks posed by extreme events, Technikfolgenabschätzung – Theorie und Praxis 20. Jg., Heft 3, November 2011.

Khazai, B., Merz, M., Schulz, C., Borst, D., (2011): An Integrated Indicator Framework to Compare Regional Vulnerability to Indirect Industrial Losses from Disasters, Natural Hazards (submitted).

Kreibich, H. (2011): Do perceptions of climate change influence precautionary measures?. International Journal of Climate Change Strategies and Management, 3, 2, 189-199.

Kreibich, H., Seifert, I., Thieken, A. H., Lindquist, E., Wagner, K., Merz, B. (2011): Recent changes in flood preparedness of private households and businesses in Germany. Regional Environmental Change, 11, 1, 59-71.

Merz, M. (2011): Entwicklung einer indikatorenbasierten Methodik zur Vulnerabilitätsanalyse für die Bewertung von Risiken in der industriellen Produktion, KIT Scientific Publishing, Karlsruhe, 295p.

Mohr, S., Kunz, M. (2011): Trend analysis of convective indices relevant for hail events in Germany. Submitted to Atmos. Res.

Motamed, H., Khazai, B., Ghafory-Ashtiany, M., Amini-Hosseini, K. (2011): An Automated Model for Optimizing Budget Allocation in Earthquake Mitigation Scenarios, Natural Hazards, Accepted for Publication.

Schulz, C. (2011): The identification of critical road infrastructures – the case of Baden-Wuerttemberg. Dissertation at the Karlsruhe Institute of Technology. Oral exam 6.12.2011. Publication expected in January 2012.

Sokolov, V., Wenzel, F. (2011): Influence of ground-motion correlation on probabilistic assessments of seismic hazard and loss sensitivity analysis. Bull. Earthquake Engineering, 9, 5, 1339-1360.

Trinks, Ch., Hiete, M., Comes, T., Schultmann, F. (submitted): Extreme weather events and road and rail transportation in Germany. International Journal of Emergency Management.

Vervaeck, A., Daniell, J.E. (2010-2011): Over 400 earthquake loss estimation related articles on earthquake-report.com related to the rapid loss estimation procedures and calibration of data since 12/2010, earthquake-report.com.

Wagner, S., Berg, P., Schädler, G., Kunstmann, H. (2011): High resolution RCM simulations for Germany: Part II – projected climate changes, submitted to Clim. Dyn.

Wieland, M., Pittore, M., Parolai, S., Zschau, J., Moldobekov, B., Begaliev, U. (2011): Estimating building inventory for rapid seismic vulnerability assessment: towards an integrated approach based on multi-source imaging, Soil Dynamics and Earthquake Engineering, submitted.

CEDIM Reports

CEDIM Forensic Earthquake Analysis Group (2011): Shelter report for the Oct. 23 2011 Eastern Turkey Earthquake, Status Report October 26, 2011.

CEDIM Earthquake Forensic Disaster Analysis Group (2011): Comparing the current impact of the Van Earthquake to past earthquakes in Eastern Turkey., Status Report Nov 2nd, 2011.

Daniell, J.E. (2011f): The CATDAT Damaging Earthquakes Database – 2010 – Year in Review, CEDIM Research Report 2011-01, Earthquake-Report OF Report, Karlsruhe, Germany.

Daniell, J.E. (2011): The CATDAT Damaging Volcanoes Database, CEDIM Research Report 2011-01, Karlsruhe, Germany.

Schädler, G., Berg, P., Düthmann, D., Feldmann, H., Ihringer, J., Kunstmann, H., Liebert, J., Merz, B., Ott, I., Wagner, S. (2011): Flood hazards in a changing climate, Project Report.

Conference Abstracts

Berg, P., Duethmann, D., Liebert, J., Wagner, S. (2011): Uncertainty aspects of changes in flood hazard for medium size river catchments for the near future. Deutsches Komitee Katastrophenvorsorge e.V. (DKKV), 11. Forum Katastrophenvorsorge

Daniell, J.E. (2011g): The Worldwide CATDAT Damaging Earthquakes and Damaging Volcanoes Databases: Socio-economic trends, values and analysis including 2010, Geophysical Research Abstracts Vol. 13, EGU2011-4909.

Daniell, J.E., Gibson, G. (2011h): A review of all Australian Damaging Earthquakes and their contribution to knowledge of earthquake risk in Australia, Geophysical Research Abstracts Vol. 13, EGU2011-4934.

Daniell, J.E., Khazai, B., Slingby, A., Wenzel, F. (2011i): A Country-by-Country Building Inventory and a Building Vulnerability Index for use in different Natural Disaster applications Geophysical Research Abstracts Vol. 13, EGU2011-4948-1.

Daniell, J.E., Vervaeck, A.; Wenzel, F. (2011d): A timeline of the Socio-economic effects of the 2011 Tohoku Earthquake with emphasis on the development of a new worldwide rapid earthquake loss estimation procedure, Australian Earthquake Engineering Society 2011 Conference, Nov 18-20, Barossa Valley, South Australia.

Daniell, J.E., Wenzel, F., Khazai, B. (2011k): Die Kosten historischer Erdbeben: Ökonomische Analyse der weltweiten Erdbebenschäden seit 1900, DKKV Paper, DKKV 2011 Conference, Potsdam, Germany. (Student Prize).

Daniell, J.E., Wenzel, F., Khazai, B. (2011j): The Economics of Earthquakes since 1900: The Hybrid Natural Disaster Economic Index, Historical Loss Conversion, Future Impacts and Insurance Takeout, Geophysical Research Abstracts Vol. 13, EGU2011-4923.

Daniell, J.E., Wenzel, F., Khazai, B., Vervaeck, A. (2011l): A Country-by-Country Building Inventory and Vulnerability Index for Earthquakes in comparison to historical CATDAT Damaging Earthquakes Database losses accepted, Australian Earthquake Engineering Society 2011 Conference, Nov 18-20, Barossa Valley, South Australia.

Daniell, J.E., Wenzel, F., Vervaeck, A. (2011c): The Socio-economic effects of the 2011 Tohoku earthquake, Geophysical Research Abstracts Vol. 13, EGU2011-14270.

Gericke, A., Elmer, F., Berg, P., Düthmann, D., Hundecha, Y., Brucher, D., Vorogushyn, S., Apel, H., Teisselmann, F., Hoymann, J., Merz, B., Kreibich, H. (2011): Änderung des Hochwasserrisikos im Elbe-Einzugsgebiet (Poster, Abstract). Fachsymposium „Wasserbezogene Anpassungsmaßnahmen an den Landschafts- und Klimawandel in Deutschland." Großräschen/Lausitz, 22. - 24. Juni 2011.

Guse, B., Castellarin, A., Merz, B. (2011): Improving flood frequency analysis by integration of empirical and probabilistic regional envelope curves. European Geosciences Union, General Assembly 2011, 3.-8. April 2011, Vienna, Austria, Geophysical Research Abstracts, Vol. 13, EGU 2011-10517.

Khazai, B., Bendimerad, F. & F. Wenzel (2011): Resilience Indicators for Mainstreaming Disaster Risk Reduction in the City of Mumbai, Geophysical Research Abstracts Vol. 13, EGU2011-7528.

Khazai, B., Kunz-Plapp, T., Daniell, J., (submitted): Social Impacts of Earthquakes on Health and Health Care Systems, Abstract 3161, 15th World Conference on Earthquake Engineering, Lisbon, Portugal.

Khazai, B., Vangelsten, B., Duzgun, S, Braun, J., Daniell, J. (2011): Emergency Shelter Provision in the aftermath of Earthquakes: Integrating Social Vulnerability in Systemic Seismic Vulnerability Analysis, Geophysical Research Abstracts Vol. 13, EGU2011-7374.

Khazai, B., Vangelsten, B., Duzgun, S., Braun, J., Daniell, J. (2011): Social Impacts of Emergency Shelter Provision in the aftermath of Earthquakes: Integrating Social Vulnerability in Systemic Seismic Vulnerability Analysis. European Geosciences Union, General Assembly 2011, 3.-8. April 2011, Vienna, Austria, Geophysical Research Abstracts, Vol. 13, EGU 2011-7374.

Khazai, B., Vangelsten, B., Franchin, P., Esposito, S., (submitted): Emergency Shelter Need Modeling in the aftermath of Earthquakes, Abstract 2105, 15th World Conference on Earthquake Engineering, Lisbon, Portugal.

Kreibich, H., Elmer, F., Merz, B. (2011): Veränderungen des Hochwasserrisikos und Konsequenzen für das Risikomanagement (Talk, Abstract). Fachsymposium „Wasserbezogene Anpassungsmaßnahmen an den Landschafts- und Klimawandel in Deutschland.“ Großräschen/Lausitz, 22. - 24. Juni 2011.

Kunz, M., Handwerker, J., Mohr, S., Puskeiler, M., Mühr, B., Schmidberger, M., Langner, R. (2011): Meteorological analysis of the extraordinary hailstreak on 26 May 2009. 6th European Conference on Severe Storms, 3-7 Oct 2011, Palma de Mallorca, Spain.

Kunz, M., Puskeiler, M., Mohr, S. (2011): Assessment of the hail hazard from a combination of radar and insurance data. EGU General Assembly 2010, 3-8 April 2011, Vienna, Austria.

Kunz, M., Puskeiler, M., Mohr, S. (2011): Millionenschäden durch Hagelschlag - Zufall oder konkrete Ursache? Symposium Stiftung Umwelt und Schadenvorsorge, 30-31 March 2011, Stuttgart.

Kunz-Plapp, T., Khazai, B., Daniell, J., (2011): Social Impacts of Earthquakes on Health and Health Care Systems: Integrating Social Vulnerability in Systemic Seismic Vulnerability Analysis“, Geophysical Research Abstracts Vol. 13, EGU2011-7561.

Liebert, J., Berg, P., Düthmann, D., Ihringer, J., Kunstmann, H., Merz, B., Ott, I., Schädler, G., Wagner, S. (2011): Wie ändern sich die Charakteristika von Howchwasserereignissen unter dem Klimawandel und mit welchem Unsicherheiten sind solche Aussagen behaftet?, Conference Publication acqua alta 2011 Hamburg, International Conference on Climate Impact, Flood Protection and Hydraulic Engineering, TuTech Verlag, ISBN 978-3-941492-38-7.

Mitusch, K., Friedrich, H., Schulz, C. (2011): Wetterereignisse und Verkehr – am Beispiel von Sturm Daisy 2010. 6. ExtremWetterKongress 2011, Hamburg.

Mohr, S., Kunz, M. (2011): Trend analysis of convective indices relevant for hail events in Germany. EGU General Assembly 2010, 03-08 April 2011, Vienna, Austria.

Mohr, S., Kunz, M. (2011): Trend analysis of meteorological parameter relevant to hail from soundings and reanalysis data. 6th European Conference on Severe Storms, 3-7 Oct 2011, Palma de Mallorca, Spain.

Pittore, M., Wieland, M., Bindi, D., Parolai, S., Zschau, J. (2011): Towards a rapid, integrated, multi-scale assessment of earthquake risk: a case study in Central Asia, Geophysical Research Abstracts, 13, EGU Joint Assembly.

Puskeiler, M., Kunz, M. (2011): Assessment of the hail hazard from a combination of different meteorological datasets and insurance data. 6th European Conference on Severe Storms, 3-7 Oct 2011, Palma de Mallorca, Spain.

Slingsby, A., Daniell, J., Dykes, J., Wood, J. (2011): Sharing insights on the impact of natural disasters using Twitter. European Geosciences Union, General Assembly 2011, 3.-8. April 2011, Vienna, Austria, Geophysical Research Abstracts, Vol. 13, EGU 2011-9171.

Trinks, Ch., Hiete, M., Schultmann, F. (2011): Impacts of Extreme Weather Events on Road and Railway Transport Infrastructures in Southwest Germany, TIEMS Workshop 2011, Alès.

Trinks, Ch., Hiete, M., Schultmann, F. (2011): Management of weather-induced emergencies in transport, Stiftung Umwelt und Schadenvorsorge Symposium 2011, Neuhausen auf den Fildern.

Wagner, S., Berg, P., Duethmann, D., Liebert, J., Ott, I., Kunstmann,H. (2011): High resolution regional climate simulations for hydrological impact studies in Germany, Geophysical Research Abstracts Vol. 13, EGU2011-10858, 2011, EGU General Assembly 2011.

Wenzel, F., Sokolov, V. (2011): Correlated Ground Motion - Influence on Loss Estimates. European Geosciences Union, General Assembly 2011, 3.-8. April 2011, Vienna, Austria, Geophysical Research Abstracts, Vol. 13, EGU 2011-1816.

Wieland, M., Pittore, M., Parolai, S., Zschau, J. (2011): Rapid multi-scale assessment of seismic vulnerability: an integrated approach based on multisource imaging, Geophysical Research Abstracts, 13, EGU Joint Assembly

Wieland, M., Pittore, M., Parolai, S., Zschau, J. (2011): Estimating building inventory for rapid seismic vulnerability assessment in Bishkek, Kyrgyzstan: an integrated approach based on multi-source imaging and GIS, Proceedings of GISCA 2011, Almaty, 19.-20.05.2011.

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