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Annual Research Report 2012

Focus on Forensic Disaster Analysis in Near Real-Time

KIT - University of the State of Baden-Wuerttemberg and
National Research Center of the Helmholtz Association

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Content

Imprint

CEDIM Annual Research Report 2012 - Focus on Forensic Disaster Analysis in Near Real-Time

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Preface

Based on the damage experience from past catastrophes, such as the earthquakes of Haiti (2010) or Japan (Tohoku, 2011), CEDIM had already begun a discussion before 2012 on how those large extreme events could be addressed to obtain a better understanding of their causes and evolution. The resulting concept of near real-time "Forensic Disaster Analysis" (FDA) has now been implemented as CEDIM's new research strategy for the years 2012 to 2014. It constitutes the focus of CEDIM's current activities and of the following report.

The term "Forensic Investigations of Disasters" (FORIN) had already been coined in 2010 in connection with natural disasters by the international research programme IRDR ("Integrated Research on Disaster Risk"). Based on an in-depth analysis of the root causes of disasters, IRDR, with its forensic approach, follows up on the question of how natural hazards do – or do not – turn into disasters. In this context, the term "Forensic" means bringing together different methods from various scientific disciplines in order to gain a comprehensive understanding of the respective event. CEDIM's FDA-approach pursues the same goal. However, with its focus on near real-time disaster analyses by interdisciplinary teams, it adds a new component and is complementary to IRDRs FORIN. The term "near real-time" in CEDIM's FDA means that first reports and analysis results will be provided to end users from science, practice and other groups in only a few hours to days after a catastrophic event.

Besides gathering, critically evaluating and merging information from various data sources, for instance by internet inquiries, CEDIM also draws on its own models and analysis methods developed in recent years, as well as on its own operational systems such as the earthquake monitoring system GEOFON and the web-service "Wettergefahren-Frühwarnung". Eight projects were initiated by CEDIM in 2012 which deal exclusively with the development of new analysis methods for near real-time disaster investigations. They address a broad range of themes, ranging from the rapid analysis of an earthquake's rupture process and the rapid assessment of direct and indirect damages to rapid flood event analysis and making use of social media, for example Twitter, by means of "crowdsourcing".

Four event-triggered Task Force exercises were carried out in 2012 that have contributed to refining CEDIM's FDA-concept. These Task Force activities were related to the disastrous earthquake sequence near Ferrara in northern Italy at the end of May, the extreme drought and record heat in the US in spring and summer, the tropical cyclone "Saola" that struck the Philippines and Taiwan in July/August, and the superstorm "Sandy", which caused extreme damage in the Caribbean and at the East Coast of the United States in October and November. The crucial test of the new FDA-concept in its early stages had already occurred in October 2011 in relation to the Van earthquake in eastern Turkey.

The FDA-approach with interdisciplinary teams is supposed to cope with the complexity of loss events, hazards and risks, including diverse interactions and cascade phenomena, not only in natural but also in anthropogenic systems. CEDIM, with its broad spectrum of participating disciplines and its expertise gained in recent years, is well prepared for such a comprehensive approach. Thirteen different units of GFZ and KIT have contributed to CEDIM's work in 2012:

GFZ, Section 1.5 Geoinformatics
GFZ, Section 2.1 Earthquake Risk and Early Warning
GFZ, Section 2.4 Seismology
GFZ, Section 5.4 Hydrology
GFZ, Centre for Early Warning EWS
GFZ, Scientific Infrastructure and Platforms
KIT, Geophysical Institute
KIT, Institute for Industrial Production (IIP)
KIT, Institute for Nuclear and Energy Technologies
KIT, Institute for Meteorology and Climate Research
KIT, Institute for Technology and Management in Construction (TMB)
KIT, Institute of Photogrammetry and Remote Sensing
KIT, Institute of Economics.

In addition to the activities related to the new FDA-focus, CEDIM has continued its efforts within the framework of the Global Earthquake Model (GEM) as well as addressing the themes "Critical Infrastructure" and "Disaster Management". These activities were partly strengthened

by extending the research component dealing with the socio-economic consequences of disasters. “Natural Risks and Climate Change” has also been an important CEDIM theme in 2012, although it was not CEDIM´s main focus, as had been the case in the previous three years. Cooperations and joint projects with the insurance industry were as important in 2012 as before, especially for the strengthening of the socio-economic research component within CEDIM, and with regard to CEDIM’s research on hail-risk. CEDIM has also become a participant in new EU-FP7 projects that contribute to advancing the themes CEDIM is focusing on. Finally, the cooperation with the Fraunhofer IOSB also continued in 2012, and resulted in the common organization of the international ISCRAM-Conference (Intergrative and Analytical Approaches to Crisis Response and Emergency Management Information Systems) that will take place in May 2013 in Baden-Baden, Germany.

An important goal for 2013, in relation to CEDIM’s new “Forensic Disaster Analysis” concept, will be the further development of the partnerships with IRDR at the international level, and with the “Earth System Knowledge Platform” (ESKP) of the Helmholtz Research Field “Earth and Environment” at the national level. Both partnerships have been prepared already in 2012 and will be of high strategic importance for CEDIM in the future.

With such strategic partnerships, manifold cooperations, participation in large European projects within the framework of the FP7-Programme, contributions to the global initiative GEM, and especially with its new FDA research concept, we believe that CEDIM is well prepared for the coming challenges of risk research in 2013.

Jochen Zschau
Michael Kunz

Vorwort

Basierend auf den Schadenerfahrungen vergangener Katastrophen, wie beispielsweise der Erdbeben in Haiti (2010) oder Japan (Tohoku, 2011), wurde in den vergangenen Jahren innerhalb von CEDIM intensiv darüber diskutiert, wie die Ursachen und der Ablauf solcher großen und komplexen Ereignisse besser verstanden werden können. Die daraus entwickelte Idee der zeitnahen „Forensischen Katastrophenanalyse“ (FDA) wurde als eine neue CEDIM-Strategie für die Jahre 2012 bis 2014 etabliert und umgesetzt. Sie bildet den Fokus der derzeitigen CEDIM-Aktivitäten und damit auch des vorliegenden Berichts.

Der Begriff „Forensic Investigations of Disasters“ (FORIN) wurde bereits im Jahr 2010 durch das internationale Forschungsprogramm IRDR (Integrated Research on Disaster Risk“) geprägt. IRDR untersucht mit Hilfe des forensischen Ansatzes, unter welchen Bedingungen ein Extremereignis zu einer Katastrophe wird oder nicht. Forensisch bedeutet dabei, dass verschiedene Methoden aus unterschiedlichen Disziplinen zusammengeführt werden, um möglichst ein Gesamtbild des jeweiligen Ereignisses zu erstellen. CEDIM verfolgt in seinen Arbeiten ein ähnliches Ziel, ist aber mit seiner Fokussierung auf zeitnahe Katastrophenanalysen in interdisziplinären Teams komplementär aufgestellt. „Zeitnah“ bedeutet dabei, dass erste Berichte mit Analyseergebnissen bereits wenige Stunden bis Tage nach einem katastrophalen Ereignis Nutzern aus Wissenschaft und Praxis zur Verfügung gestellt werden.

Neben der Zusammenführung und kritischen Bewertung von frei zugänglichen, aber verteilten Informationen, z. B. aus dem Internet, greift CEDIM dabei auch auf eigene Modelle und Analysemethoden zurück. Berücksichtigt werden weiterhin eigene operationelle Systeme wie das Erdbeben-Monitoringsystem GEOFON oder der Webdienst „Wettergefahren-Frühwarnung“. Acht CEDIM-interne Projekte konnten 2012 ins Leben gerufen werden, die sich mit der Entwicklung von Methoden in nahe Echtzeit zur Unterstützung zeitnaher Katastrophenanalysen befassen. Sie reichen von der schnellen Analyse eines Erdbeben-Bruchprozesses über schnelle Schätzungen von direkten und indirekten Schäden, schnelle Hochwasseranalysen bis zur Nutzung sozialer Netzwerke, wie beispielsweise Twitter, durch die Methode des „crowdsourcing“.

Während vier Task Force Übungen im vergangenen Jahr konnte CEDIMs FDA-Konzept erprobt und weiter verbessert werden. Die CEDIM FDA Task Force war aktiv bei der katastrophalen Erdbebensequenz Ende Mai in Norditalien, der extremen Trockenheit und Hitze in den USA im Frühjahr und Sommer, dem tropischen Wirbelsturm „Saola“ im Juli/August mit seinen katastrophalen Auswirkungen besonders auf den Philipinen und in Taiwan, sowie dem Supersturm „Sandy“, der im Oktober und November in der Karibik und Nordamerika verheerende Schäden anrichtete. Die Feuertaufe des neuen Konzepts in seinen Anfängen erfolgte bereits beim Van-Beben im Oktober 2011 in der Osttürkei.

Mit der Herangehensweise in interdisziplinären Teams soll der Komplexität der Schadenereignisse und des Risikos durch Naturkatstrophen mit seinen vielfältigen Wechselwirkungen und Kaskadeneffekten sowohl in natürlichen als auch in anthropogenen Systemen Rechnung getragen werden. Dafür ist CEDIM mit seinem breiten Spektrum an beteiligten Disziplinen und der Expertise, die in den vergangenen Jahren entwickelt wurde, hervorragend ausgerüstet. Allein zu CEDIM‘s Arbeiten im Jahr 2012 haben 13 verschiedene Einheiten des GFZ und KIT beigetragen:

GFZ, Sektion 1.5 Geoinformatik
GFZ, Sektion 2.1 Erdbebenrisiko und Frühwarnung
GFZ, Sektion 2.4 Seismologie
GFZ, Sektion 5.4 Hydrologie
GFZ, Zentrum für Frühwarnung EWS
GFZ, Wissenschaftliche Infrastruktur und Plattformen
KIT, Geophysikalisches Institut
KIT, Institut für Industriebetriebslehre und Industrielle Produktion
KIT, Institut für Kern- und Energietechnik
KIT, Institut für Meteorologie und Klimaforschung
KIT, Institut für Technologie und Management im Baubetrieb
KIT, Institut für Photogrammetrie und Fernerkundung
KIT, Institut für Wirtschaftspolitik und Wirtschaftsforschung.

Neben den Aktivitäten im Rahmen des neuen Schwerpunkts „Forensische Katastrophenanalyse“ wurden die Arbeiten von CEDIM im

Rahmen des Globalen Erdbebenmodells GEM sowie zur Risikoanalyse kritischer Infrastrukturen und zum Desaster Management in 2012 weitergeführt und teilweise durch Forschungskomponenten zu sozio-ökonomischen Auswirkungen von Naturkatastrophen verstärkt. Auch „Naturrisiken im Klimawandel“ waren 2012 weiterhin ein wichtiges Thema für CEDIM, allerdings nicht mehr als CEDIM-Schwerpunkt wie in den drei Jahren zuvor. Die auch in 2012 fortgesetzten Kooperationen und gemeinsamen Projekte mit der Versicherungsindustrie waren wichtige Komponenten der Arbeit von CEDIM, insbesondere für die Forschungen zum Hagel-Risiko und für die Verstärkung der sozio-ökonomischen Forschungskomponente in CEDIM. Darüber hinaus sind 2012 neue EU-FP7-Projekte hinzugekommen, an denen CEDIM beteiligt ist und die dazu beitragen, die Arbeiten von CEDIM weiter voranzubringen. Schließlich organisiert CEDIM gemeinsam mit dem Fraunhofer Institut für Optik, Systemtechnik und Bildauswertung die internationale ISCRAM-Konferenz (Integrative and Analytical Approaches to Crisis Response and Emergency Management Information System) in Baden-Baden im Mai 2013.

Ein wichtiges Ziel für das Jahr 2013 im Zusammenhang mit dem neuen Ansatz der zeitnahen forensischen Katastrophenanalyse ist die Weiterentwicklung der Partnerschaften mit IRDR im internationalen Rahmen sowie mit der „Earth System Knowledge Platform“ (ESKP) des Helmholtz Forschungsbereichs Erde und Umwelt im nationalen Rahmen. Beide Partnerschaften sind von hoher strategischer Bedeutung für CEDIM.

Mit solchen strategischen Partnerschaften, CEDIM‘s vielfältigen Kooperationen, seiner Integration in eine Vielzahl europäischer FP7-Projekte, der Teilnahme an der globalen Initiative GEM und vor allem mit seinem neuen Forschungskonzept ist CEDIM auch im Jahr 2013 für die Herausforderungen der Risikoforschung bestens gerüstet.

Jochen Zschau
Michael Kunz

I. Research

Forensic Disaster Analysis

CEDIM embarked in 2012 on a new style of disaster research referred to as Forensic Disaster Analysis (FDA). Previously, efforts were focused on Forensic Disaster Investigations (FORIN) by the Integrated Research on Disaster Risk Initiative IRDR (www.irdrinternational.org) that was launched by the International Council for Science (ICSU), the International Social Science Council (ISSC) and the United Nations International Strategy for Disaster Reduction (UN-ISDR) in 2010. The IRDR working group FORIN follows an approach to studying natural disasters that aims at uncovering the root causes of disasters through in-depth investigations that go beyond the reconnaissance reports and case studies typically conducted after disasters.

CEDIM's new FDA-concept shares with IRDR's FORIN the goal of improving our understanding of how natural hazards do – or do not – become disasters. It also follows a comprehensive research strategy that takes into account not only the natural components of an extreme event, but also the related complex interaction's and cascading effects in and between the natural, social, economic and infrastructure systems. However, with its near real-time component that attempts to provide information and results within the first few hours to days of a disaster, the CEDIM-FDA system is different and complements the IRDR-FORIN activities. Time criticality is considered important as many pieces of information emerge within the first days that may later be obscured by the flood of new information. Also, potential user interest peaks in this initial stage, and initial hypotheses on loss evolution and its implications can be tested in the following days and, thus, may enhance our understanding of natural disasters within their respective socio-economic contexts.

The main scientific questions being addressed in CEDIM's Forensic Disaster Analyses are: What are the critical factors that control loss of life, of infrastructure, and of economy? What are the critical interactions between hazard – socio-economic systems – technological systems? What were the protective measures and to what extent did they work? Can we predict patterns of losses and socio-economic implications for future extreme events from simple parameters: hazard parameters, historical records, socio-economic conditions? Can we predict implications for recovery and rebuilding from these parameters?

To achieve answers to these questions CEDIM's FDA work is organized in two closely related work areas, the first one with a focus on the development of new near real-time methodologies and the second on event triggered FDA-Task Force activities. Eight research projects were started in 2012 with the focus on near real-time methodologies,

1. Rapid assessment of seismic slip distribution based on near field displacement wave forms,
2. ATMO forensic prediction and analysis,
3. Rapid flood event analysis in Germany,
4. Loss assessment for earthquakes,
5. Natural disasters and transportation systems- rapid indirect loss assessment,
6. Crowdsourcing-using social media for rapid damage assessment,
7. Methodology for a (rapid) assessment of the economic impact of natural disasters,
8. Development of a CEDIM database and implementation of case-based reasoning for analytical support.

FDA Task Force exercises were carried out for a number of disasters that have occurred recently. Both the near real-time methodology projects and Task Force exercises on superstorm Sandy 2012, the extreme drought in the US in 2012, tropical cyclone Saola 2012, the earthquakes near Ferrara in northern Italy 2012 and the Van earthquake in Turkey 2011, are the main focus of CEDIM's Annual Research Report 2012 and are presented in the next two chapters.

Whereas IRDR is the international strategic partnership in CEDIM's FDA activities, the Earth System Knowledge Platform (ESKP) of the Helmholtz Research Field "Earth and Environment" is the national one. Both are fundamentally important for CEDIM's new FDA focus, and, therefore, have their own chapters in this Annual Report.

Forensiche Katastrophenanalyse

Mit der Forensischen Katastrophenanalyse (FDA = Forensic Disaster Analysis) beschreitet CEDIM seit 2012 einen neuen Weg in der Katastrophenforschung. Dieser baut auf das FORIN (Forensic Disaster Investigations) - Programm der Integrated Research on Disaster Risk (IRDR)-Initiative von ICSU, ISSC und UN-ISDR auf und teilt mit ihm das Ziel, besser zu verstehen, unter welchen Bedingungen Naturgefahren zu Katastrophen werden und unter welchen Bedingungen nicht. Der umfassende Forschungsansatz, der nicht nur die natürlichen Komponenten eines Extremereignisses in Betracht zieht, sondern auch die an ein Ereignis geknüpften komplexen Wechselwirkungen und Kaskadeneinflüsse in und zwischen den natürlichen, sozialen, ökonomischen und infrastrukturellen Systemen, ist beiden Ansätzen, CEDIM-FDA und IRDR-FORIN, gemeinsam. Mit ihrer „Nahe Echtzeit"-Komponente, mit der Informationen und Ergebnisse innerhalb von Stunden bis Tagen nach Eintritt einer Katastrophe bereitgestellt werden, unterscheidet sich CEDIM-FDA aber von IRDR-FORIN und ist dazu komplementär. Die Tatsache, dass Informationen, die in den ersten Tagen entstehen, oft auch wieder durch die Flut späterer Informationen überdeckt werden, ist nur *ein* Argument für die Bedeutung der „Nahe Echtzeit"-Komponente, die Möglichkeit, Anfangshypothesen z.B. zur Schadensentwicklung testen zu können, ist ein anderes. Die Forschungsaktivitäten im Rahmen von CEDIM-FDA sind in zwei Arbeitsbereiche gegliedert, einer mit Schwerpunkt auf die Entwicklung von „Nahe Echtzeit"-Methodik und der andere auf Ereignis getriggerte Task-Force Aktivitäten. Die 2012 angefangenen Projekte zur Echtzeit-Methodik sowie von CEDIM durchgeführte Task-Force Übungen bei einer Reihe von Naturkatastrophen in Jahr 2012 sind Gegenstand der beiden folgenden Kapitel. Wegen der strategischen Bedeutung für CEDIM haben sowohl die internationale Partnerschaft mit IRDR als auch die nationale Partnerschaft mit der „Earth System Knowledge Platform" (ESKP) des Helmholtz-Forschungsbereichs „Erde und Umwelt" jeweils ein eigenes Kapitel in diesem Jahresbericht.

FDA – Projects

Rapid Assessment of Slip Distribution based on Near-Field Displacement Wave Forms

Andreas Höchner

Introduction

Seismology, being the study of earthquakes and the internal planetary structure, had its origins in a modern scientific sense about 150 years ago. The first time-recording seismograph was built in Italy by Cecchi in 1875, the first observation of a distant earthquake was made by Von Rebeur-Paschwitz in Potsdam in 1889 of a Japanese event (Peter M. Shearer, Introduction to Seismology, 2009). Since then, the development of much more powerful seismometers and of the theories of wave propagation and Earth structure generated a wealth of knowledge on the occurrence and nature of earthquakes. However, during recent decades, and especially since the advent of GPS (Global Positioning System), geodetic methods have become more prominent in supporting traditional seismological techniques. In the near field of large earthquakes, data from broadband seismometers are not straightforward to interpret due to clipping, tilting and hysteresis effects, while displacement time series from GPS receivers are still stable (as long as the antenna is not destroyed). Having observations as close to the source as possible enables faster estimation of earthquake magnitude. The direct relationship between slip at the rupture fault and displacement at the observing station allows good assessment of the slip distribution and, in the case of subduction events, for sea floor deformation, which is crucial information for tsunami early warning.

Aims / Objective

The goal of the project is the development of fast and stable methods using near-field displacement time series from GNSS (Global Navigation Satellite System) and accelerometers to infer slip distribution of large earthquakes in near real-time. In the case of subduction earthquakes, a semi-automatic processing should be possible since the geometry of the fault can be assumed to be given by the subduction plate interface. For other events, geometric information has to be obtained by seismological methods or geological analyses and thus manual processing is necessary.

Project Status

The core science team started working in April 2012. As an example, Figure 1 shows results obtained for the magnitude Mw=9.0 Tohoku earthquake of 2011. These results are based on post-processed GPS data from the Japanese GEONET array (real time data is not available publicly). However, all the processing is done

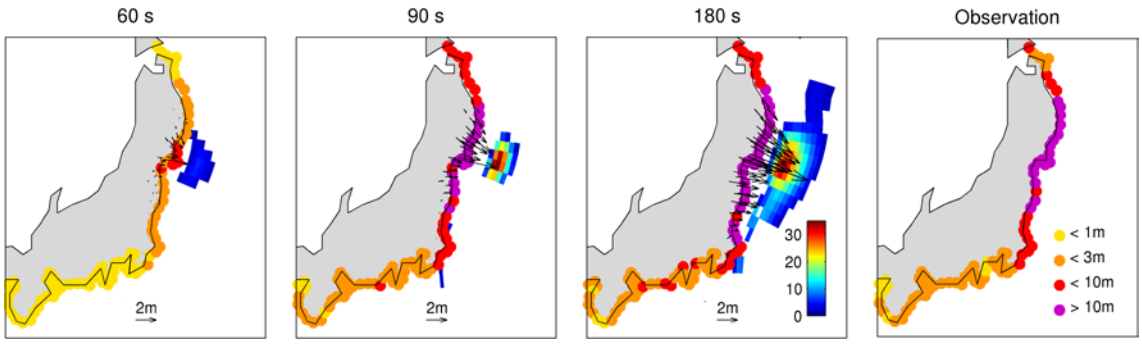

Fig. 1: Inverted slip distribution (colored rectangles) and predicted tsunami wave heights (colored coastline) based on GPS displacements (black arrows) for the Tohoku earthquake of 11.3.2011 offshore Japan. The first three panels show results (post-processed) based on data from 60, 90 and 180 seconds after beginning of the earthquake. The fourth panel shows observed maximum wave heights.

in exactly the same way as it would be done in real time in a warning center, i. e. with a delay of less than one minute. Here, the slip inversion is based on a static approach. This will be developed into a dynamic wave form inversion, which will further enhance results, especially if the observing stations are located further away and also for earthquakes of smaller magnitude.

Publications

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Daniell, J., Hoechner, A., Wenzel, F., Zschau, J. (2012): Ferrara Earthquake Sequence 20.5.2012 – 29.5.2012, Information as of 31 May 2012, updated version 1.6.2012, http://www.cedim.de/download/2012_May_EQ_Ferrara_report_v2.pdf

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Hoechner, A., Ge, M., Babeyko, A. Y.,Sobolev, S. V. (submitted 2012): Instant Tsunami Early Warning based on Real Time GPS – Tohoku 2011 case study; Natural Hazards and Earth System Sciences special issue: 'New challenges for tsunami science: understanding tsunami processes to improve mitigation and enhance early warning', nhess-2012-475.

Core Science Team

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ATMO Forensic Prediction and Analysis

Bernhard Mühr

Short Description

In addition to the routine forecasting and analysis activities of worldwide extreme weather events, "Wettergefahren-Frühwarnung" will develop a method to record, classify and evaluate winter storms in Germany, Central Europe and finally the whole of Europe.

For the scenario „winter-storm", practical and routine methodologies will be implemented until the end of the project (31/12/2014); these methods allow an a priori and a real-time assessment of possible damage (total loss) before and during a winter storm event over Europe.

Aims and Methods

From selected representative and reliable station measurement data (average wind speed and peak gusts) different weighted or unweighted storm indices may be calculated from past events. For these historic storms events GFS and/or CFS archived model data are also available, from which typical storm classes may be derived. A validation is done by the comparison of the storm classes and the measured storm indices. With the use of gust parameterizations that e. g. include the stratification of the atmosphere, a further improvement in the correlation between measured and model wind peak gusts may be achieved. Model analyses result in indices that include two variables: affected area and storm intensity.

Furthermore, a damage index will be developed through the use of insurance data; the index characterizes past storm events and includes the number of damaged houses, the number of fatalities or the total loss.

With the help of model forecast data, the index of an impending storm can be estimated prior to its arrival. Ensemble forecasts provide information on the most likely intensity and area affected, and thus the expected loss index. The closer a forecast storm gets, the greater is the

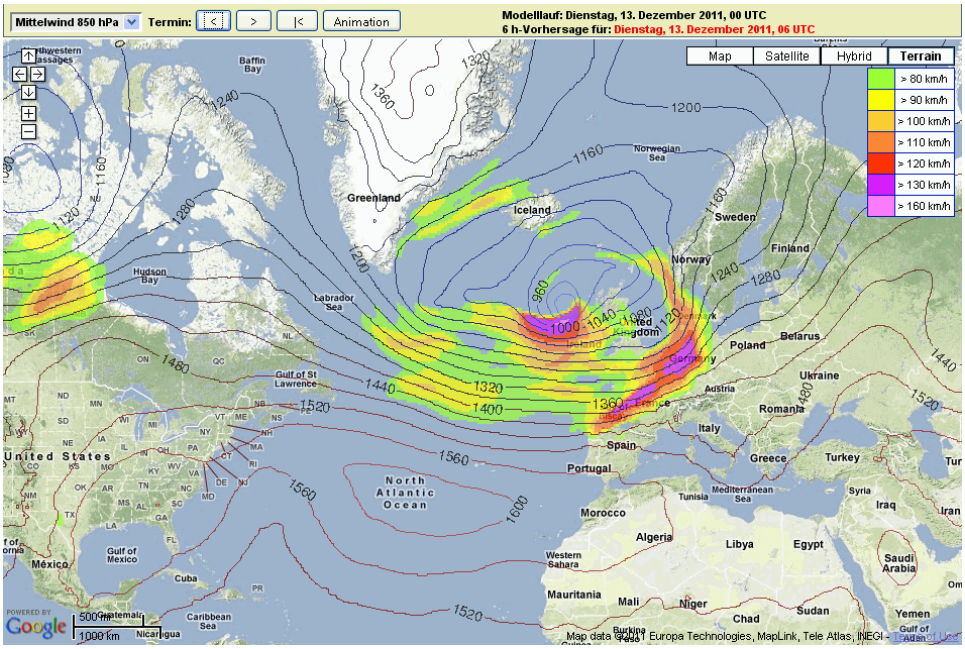

Fig. 1: Winter storm system "Joachim"; 850hPa Wind forecast (GFS Model), 13 December 2011
Image Credit: http://www.wettergefahren-fruehwarnung.de

significance and the better is the description of the oncoming storm scenario with the indices.

The calculations result in a „Wind-MOS" or „Storm-MOS" (model output statistics) that can describe a storm event with reasonable certainty and accuracy and carves out a damage function. Once the storm has arrived, the knowledge of the representative measured wind speed data on the one hand and the model-predicted wind speed on the other hand, the storm indices provide the appropriate damage index.

The data from all past and future storm events will be added to a database. The data set entries contain storm name, date of occurrence, affected region, model data, measured values and damage information.

Additionally, the "Wettergefahren-Frühwarnung" also provides information on meteorological or non-meteorological events (floods, volcanic eruptions, earthquakes) for all other participating projects within CEDIM FDA. The meteorological or climatological information include rainfall data or forecast rain amounts for flood estimation, climatological data, statements and charts or particular model forecasts of various important weather parameters, e.g. for areas that have been affected by earthquakes. The data can be collected within a short time for any global region, thus model forecasts(in low or high resolution) are available routinely over a longer or shorter period.

Core Science Team

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Publications

Available from 2004 – 2012 at:

www.wettergefahren-fruehwarnung.de
www.wettergefahren-fruehwarnung.de/Ereignis/archiv.html

Rapid Flood Event Analysis in Germany

Kai Schröter, Heidi Kreibich, Bruno Merz

Introduction

Rapid evaluations of flood events are needed for efficient responses both in emergency management and financial appraisal. Beyond that, closely monitoring and documenting the formation and development of flood events and their impacts allows for an improved understanding and in-depth analyses of the interplay between meteorological, hydrological, hydraulic and societal causes leading to flood damage.

Aims / Objective

The main objective is to develop a methodology for the rapid assessment of flood events. In the first place, the focus is on large scale floods in Germany. For this purpose an operational flood event analysis system is set up. This system has basic spatial thematic data available and supports data capture concerning the current flood situation. Further, it provides functionalities to evaluate the current flood situation, to assess the hazard intensity and to estimate the current flood impact. An additional component is a catalogue of historic flood events. This catalogue summarises information about the hydro-meteorological and hydrological situation before and during the flood event. It lists information about the hazard intensity as well as the impacts and coping strategies. Current flood events will be evaluated with regard to comparable historic events using the information from this catalogue.

The flood event analysis system will be used in two different ways. The first involves the near real-time retrieval and evaluation of flood event information for the rapid estimation of flood damage. For the moment, direct damage to residential buildings is assessed. This output supports the work of the forensic disaster analysis Task Force by providing rapid science based information about the flood hazard and its impacts.

The second way concerns the in-depth analysis of flood event data in terms of (a) processes and pre-conditions that lead to large scale flood events, (b) critical factors that control losses in large scale flood events and (c) critical interactions between the natural hazard, technical facilities and society.

Project Status

The conceptual design of the flood event analysis system has been set up. At present, a prototype is implemented using the PostgreSQL and PostGIS open source data base system. Currently, data are compiled and read into the data base. Furthermore, the interface to the CEDIM project ATMO is defined to feed in hydro-meteorological data in real time. 45 historic large scale flood events from the last 60 years have been identified. The research and compilation of information on these events is in progress.

Outlook

The operation of the flood event analysis system will be tested for the past flood event from January 2011, with a focus on the Elbe/Saale region. The performance of the approach will be evaluated and obstacles in the data flow will be uncovered. Further, requirements and potential for improving the information basis, as for instance by including hydrological and /or hydraulic model results as well as information from social sensors, will be addressed.

Core Science Team

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Section 5.4 Hydrology, GFZ

Publications

Schröter, K., Kreibich, H., Zwenzner, H., Merz, B. (submitted 2012): Schnelle Hochwasserereignisanalyse in Deutschland, Proceedings of the 36. Dresdner Wasserbaukolloquium 2013.

Loss Assessment for Earthquakes

Friedemann Wenzel, Bijan Khazai, James Daniell

Introduction

Rapid assessment of losses resulting from earthquakes to residential buildings, industrial facilities, infrastructures and the derivation of direct economic loss, and also downtimes of infrastructures and numbers of fatalities, casualties and homeless, is an important part of the CEDIM FDA activities. Building on earthquake-report.com as a real-time internet information tool and on the CATDAT data basis, the worldwide most comprehensive data base on earthquake loss allows not only rapid damage assessment but also comparison with previous events in the same region or of similar impact.

Aims / Objective

The scientific goals are:

(1) the understanding of loss patterns as they evolve during earthquake impact and the identification of the most significant driving factors for losses;
(2) the understanding of demand for shelters based on physical loss estimations but also on socio-economic circumstances;
(3) understanding the level of loss (direct and indirect), the characteristics of losses, the relationship between socio-economic parameters such as the human development index (HDI), the corruption index, the code compliancy index and others.

Project Status

Contribution to FDA cases: After two cases in 2011 – the March 11, 2011 Tohoku earthquake in Japan and the October 23, 2011 Van earthquake in Eastern Turkey – we analyzed in 2012 the Ferrara (Northern Italy) earthquake sequence between May, 20 and 29, 2012. It caused 'only' 24 fatalities but 15000 homeless people and more than a billion € direct economic loss (0.6 % of Emilia-Romagna's GDP), significant heritage losses as well as large industry and residential losses. The annual CATDAT Yearly Review of Damaging Earthquakes in 2011 is the second in this series and produced by James Daniell and with support of CEDIM. The purpose of these reports is to present the damaging earthquakes around the world of the past year, which were entered into the CATDAT Damaging Earthquake Database

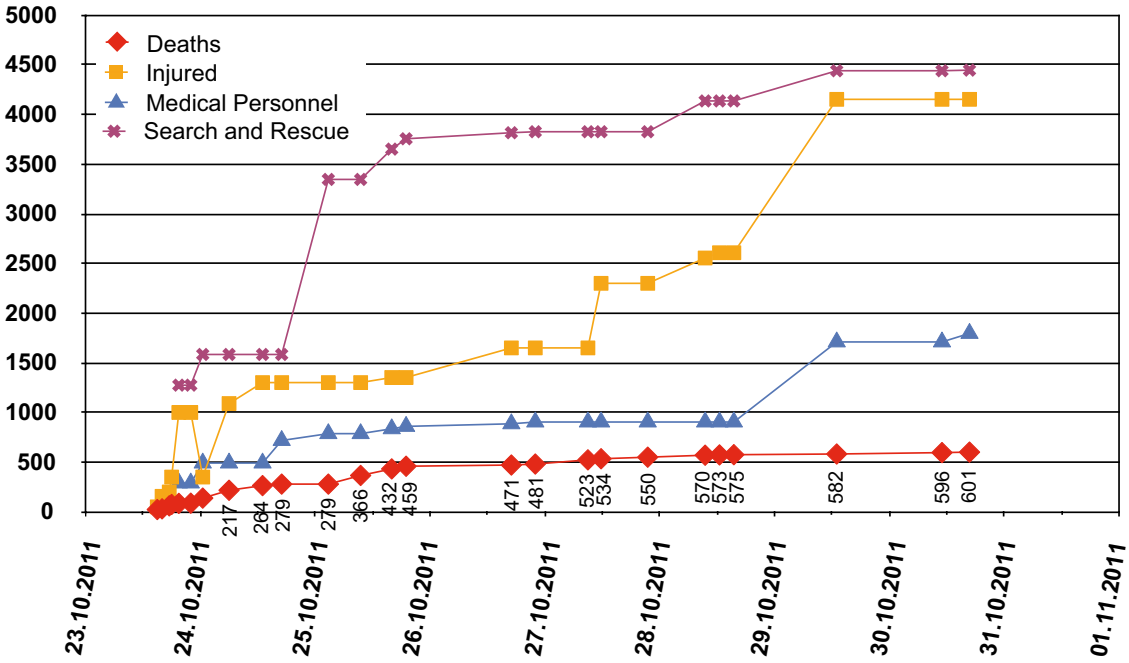

Fig. 1: Development of the numbers of fatalities, casualties, medical personnel and rescue personnel in the area during the Van October 23, 2011 earthquake.

in terms of their socio-economic effects. The report lists 133 damaging events, with 61 of them also causing casualties. Countries with the most damaging earthquakes were Japan (27); China (20); Turkey (18). The total fatalities were between 19985 and 20109, total homeless about 1.108 million, total economic losses were between $503 billion and $749 billion US, total insured losses: were $43.26 billion to $67.48 billion US. The series will be continued in 2012.

Outlook

In the future, methodologies will be refined as well as the inclusion of more loss parameters and indicators in addition to more publications.

Core Science Team

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Publications

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Natural Disasters and Transportation Systems – Rapid Indirect Loss Assessment

Kay Mitusch

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 both physical terms (in what way is traffic interrupted?) and in monetary terms (what is the social cost of the interruptions?) is, however, hardly ever done nor published, but often called for immediately after an event. The Chair of Network Economics (IWW), part of the Institute of Economics at Karlsruhe Institute of Technology (KIT), is investigating 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 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 innovative estimation methods in cases 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 categorized impacts were thereafter assessed in respect of the possibilities to monetize them. The comparison of our figures with other published figures showed that it is crucial to define the category of losses captured in the analysis since otherwise it is virtually 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, co-operations with the CEDIM projects related to crowd sourcing and to the modeling of the natural events may contribute to a faster assessment. While the modeling of the natural events may help to determine the extension 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. In future research, more information will have to be collected, from current or historical events, in order to verify and improve the procedures towards a more reliable rapid loss assessment.

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Publications

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

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Crowdsourcing – Using Social Media for Rapid Damage Assessment

Joachim Fohringer, Christian Lucas, Doris Dransch, Stefan Hinz

Introduction

Recently, data from social media provided via the Internet are judged as potential further data sources providing additional valuable information for disaster management. The benefit of information from "social sensors", as people who contribute information are often called, is manifold. The information is highly up-to-date. Eyewitnesses can document their observations directly and improve situational awareness. The information is contextual. People have local knowledge, are aware of their surroundings, and can make sense of situations; they filter, synthesize and interpret information accordingly. The information complements established observation systems. People may contribute information that cannot be measured by conventional sensors since the phenomenon is not measurable or such sensors are not available. Thus, information from social media can support rapid damage assessment after a hazard event by amending sensor data, confirming simulation data, or improving simulation output.

Aims / Objective

The aim of the project is to acquire observations by eyewitnesses in the form of text messages in real time from social media platforms for rapid damage assessment, especially for flood, earthquake, and storm events.

The volume of data from social media, such as Twitter, is very large and single messages cannot be assigned to particular hazard events easily. Thus methods have to be developed which facilitate extracting relevant observations. Our approach is to use filtering by suitable key words, such as earthquake or flood, as the basis for effective information extraction. Localization of messages dispatched by eyewitnesses is a further method to select relevant observations. We will enhance and adapt existing approaches for filtering and localization in order to extract suitable information for rapid damage assessment.

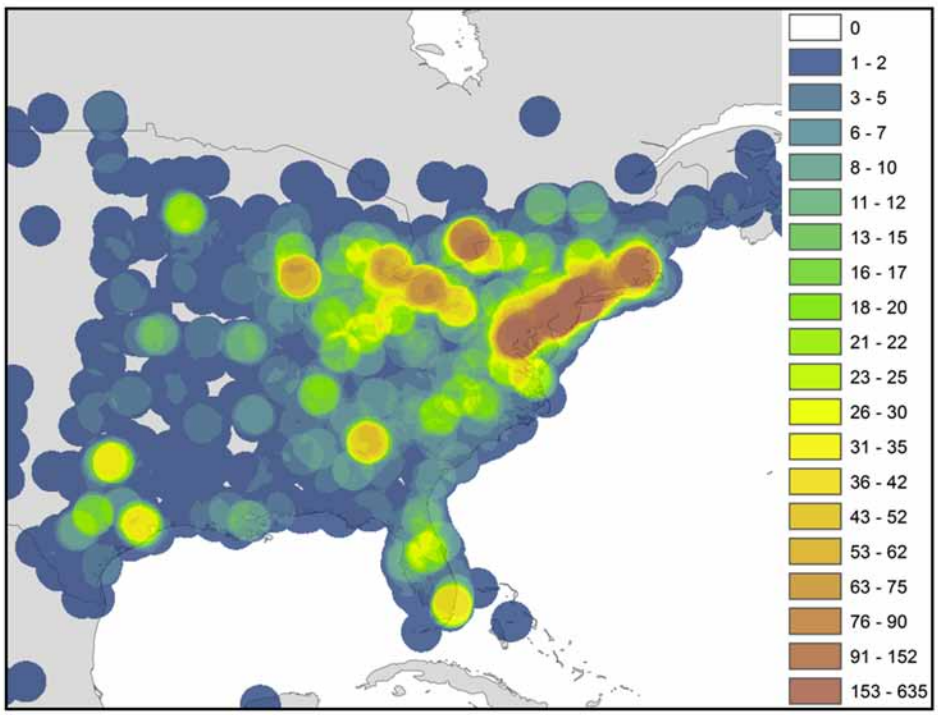

Fig. 1: Density Map of the located tweets with the keyword hurricane for the 10/30/2012, the day Sandy crossed the coastline of the states between New York and Washington DC

Project Status

We have developed a software prototype, which extracts messages containing disaster-related keywords (e.g. „earthquake“, „flood“, “storm”, etc.) from the social media platform „Twitter“ and stores them for evaluation in a database. These data serve as the basis for further processing to obtain information about the impact of a hazard, such as damage of transportation-infrastructures, water and energy supply or telecommunication-systems. The data can also be used to validate damage models.

For hurricane “Sandy” we collected more than 5 million text messages from Twitter to extract potential announcements of power outages and flooding in urban areas. We filtered localized messages, which are shown in a density map in Figure 1.

Outlook

Our next goal is to improve (a) localization of messages without explicit coordinates as well as (b) localization of investigated events. To localize messages (a) we will automatically derive coordinates from textual information, such as neighborhoods, addresses, or even vague descriptions of locations. Messages are filtered by their proximity to the event; because messages that are located close to the event include potential observations (relevant information). Relevant information is then used to draw conclusions about the intensity and impact of natural disasters.

To locate events we are currently developing an approach to perform a near real-time assessment by detecting significant increases of tweets compared to regular Twitter traffic for a specific region. On the other hand a decrease in tweets may indicate a collapse of the communication infrastructure and point to an area with severe impact.

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Methodology for a (Rapid) Assessment of the Economic Impact of Natural Disasters

Tina Comes, Frank Schultmann, Marjorie Vannieuwenhuyse

Introduction

Natural disasters can result in considerable economic costs, which can have important consequences for the affected regions and beyond. More important than the direct damages (e.g., destruction of buildings and physical infrastructures) are often the indirect damages that occur due to business and supply chain interruptions. As the interdependencies within and across modern supply networks are complex and information about them is typically limited, an assessment of indirect disaster impact is difficult.

Aims / Objective

This project aims at developing a method that enables the rapid assessment of indirect damages.

From a forensic disaster analysis perspective, the method has to fulfill several requirements. First, it must enable a quick implementation after any potential disaster and enable near real-time estimates of losses, even if only very little information about the disaster and its direct impacts is available. In addition, the method must enable comparisons with past disasters and hazard events to enable better preparedness and decision-making. As disasters are – for-

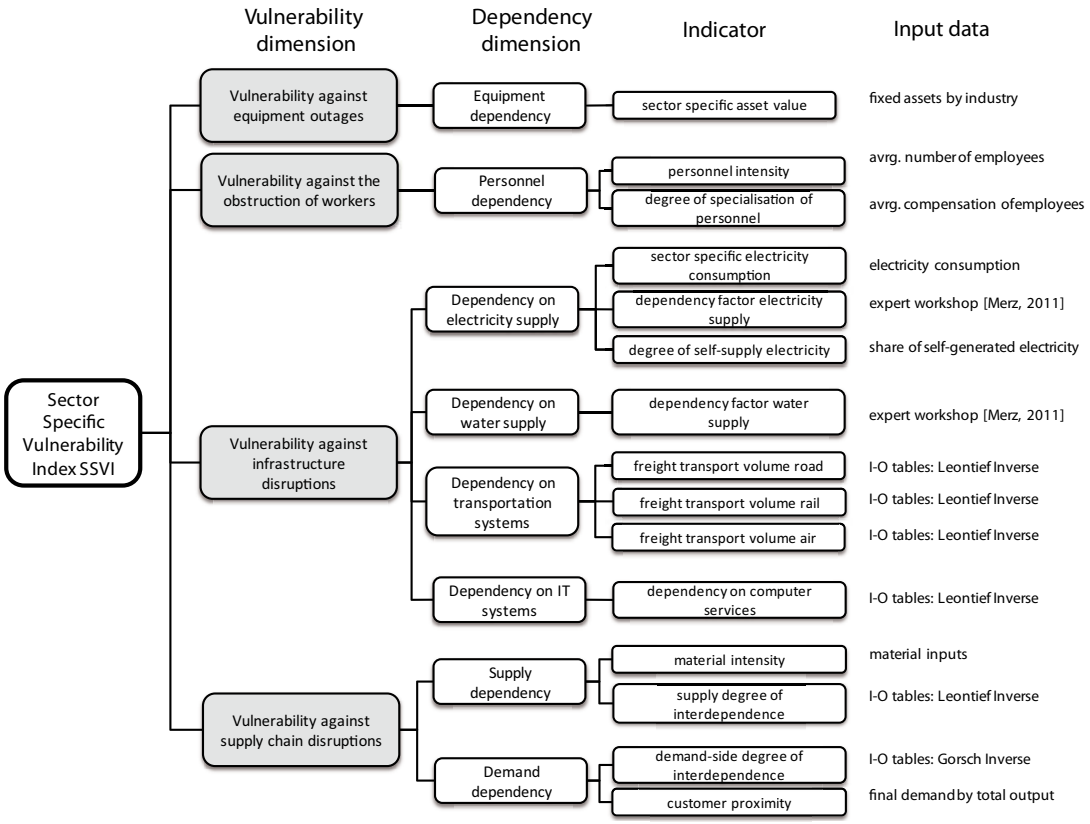

Fig 1: Sector Specific Vulnerability Index (national level)

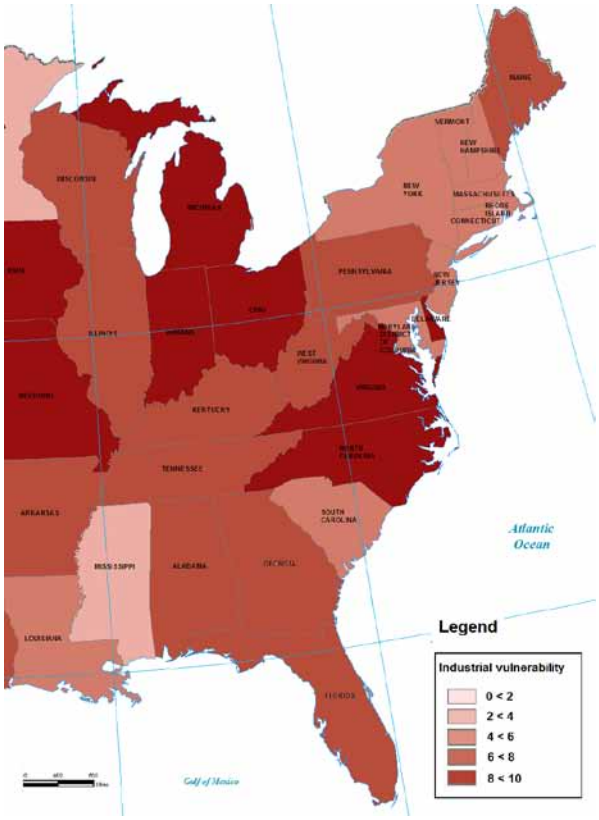

Fig 2: Industrial Vulnerability of Eastern U.S. against indirect disaster impacts, calculated in order to illustrate possible impacts of hurricane Sandy on the industry sector.

tunately – rare events, countries with different economic, cultural, social and infrastructural standards need to be compared. This implies the use of an economic damage assessment model based on few, universal and quickly available data.

Given these requirements, we chose an input-output approach that uses data available from the national statistical offices of every country. We focus on the assessment of business interruptions in the manufacturing sector, since the greatest proportion of economic losses occurs in this sector (Chang et al., 2007).

We use a linear input-output model to estimate the industries' lost output and indirect effects resulting from supply chain disruptions (Leontief, 1986; Okuyama, 2007). The method requires relatively little data and allows the release of first estimates based on uncertain information about the direct damages.

This method is completed by an indicator-based approach for assessing the vulnerability of each industrial sector against indirect costs (see Fig. 1). Vulnerability is a key factor, since it determines the capacity of businesses to cope with the direct and indirect impacts of disaster. The indicator-based method was chosen for its transparency and operational representation of vulnerability (Cutter et al., 2003). Additionally, due to their hierarchical structure, indicator approaches enable the efficient update of information as revisions of information are required only in the affected branches (as opposed to a complete update).

The extent of business interruptions, their effects on the industrial sectors, as well as the costs generated, mainly depend on the extent and duration of business interruptions and the recovery time (Webb et al., 2002). In order to take these factors into account, we use different scenarios. As the uncertainties, particularly in the immediate aftermath of the event, are fundamental (i.e. hard to quantify), we used scenarios which have been proven useful as a means of accounting for the severe uncertainties (Comes et al., 2011). To construct the scenarios in a systematic way, the indirect costs were split up into several sub-scenarios considering the overall disruption due to the event (across all sectors), the impact of power blackouts and the impact of disruptions of the transportation system.

The main advantage of such an approach is its adaptability to the data availability. The model can be run on the basis of minimal data at a national level and then regionalized for a more fine-grained scale. As further data become available, the model can be adapted to allow a more detailed assessment regarding the extent and the development of the disaster, or to consider other aspects such as the production strategies or the dependency on critical infrastructures of the concerned industry sectors or businesses, etc.

Project Status and Outlook

So far, the different model parts have been implemented and tested using the the case of hurricane Sandy. The Input Output model was coupled with regional estimations of the industrial vulnerability (see Fig. 2), and a greater focus was given to the dependency of industry sectors on power and IT infrastructures. The results were tested for different interruptions scenarios, and first estimates could be released prior to the landfall of Sandy.

In order to obtain more precise results, data on previous events have to be included in the model, especially for the generation of scenarios regarding the extent and duration of business interruptions. In order to improve the quick collection of information input for the model, we plan to develop a checklist for the diagnosis of disaster impact on the economy (extent and duration of business interruptions, supply chain relations, etc.) based on Case-Based Reasoning and Twitter reports.

The integration of the input-output model with the vulnerability indicator model still have to be improved, as well as their combination with scenarios and CBR. Finally, the model has to be tested with a sensitivity analysis and its results calibrated with data on the previous events in cooperation with the CBR workgroup, and validated based on expert workshops.

Core Science Team

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Literature

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Development of a CEDIM Database and Implementation of Case-Based Reasoning for Analytical Support

Stella Möhrle

Introduction

One important characteristic of the Forensic Disaster Analysis (FDA) is interdisciplinary. In order to provide near real-time and broad analysis of an ongoing disaster event, close collaboration of the experts involved is necessary. Moreover, data-based inference provides a useful methodology for all institutes conducting first rapid assessments. The project “Development of a CEDIM database and implementation of case-based reasoning for analytical support” addresses both issues. The project has a cross-sectoral task since several subprojects intend to use the database to be developed. Further, a methodology is introduced which utilizes similar past events in order to draw conclusions about a new and to a large extent unknown event.

Aims / Objective

The objectives are the structured storage of historical disasters and the implementation of case-based reasoning (CBR) within the framework of FDA. Of particular importance is the definition of a generic structure covering different kinds of disasters. Furthermore, the description of a specific event by means of attributes has to be defined on an appropriate level of detail, preserving a reasonable quality of information. In order to retrieve past events similar to the current disaster, a suitable similarity function has to be developed. For the reasoning step, the required information from past events used in other analysis tools has to be specified.

Project Status

By means of discussions with the experts involved, the first attributes describing a specific event and its consequences were defined. They became structured and a first relational database scheme was established. The scheme involves descriptions for earthquakes, floods and storms. The data modeling is an ongoing process. The challenges are how to attribute diversity, to ensure simple extensibility and to avoid redundancy. Moreover, further research on CBR was carried out. Additionally, considerations are made with regard to technical implementations for data in- and output in a current event and the implementation of CBR.

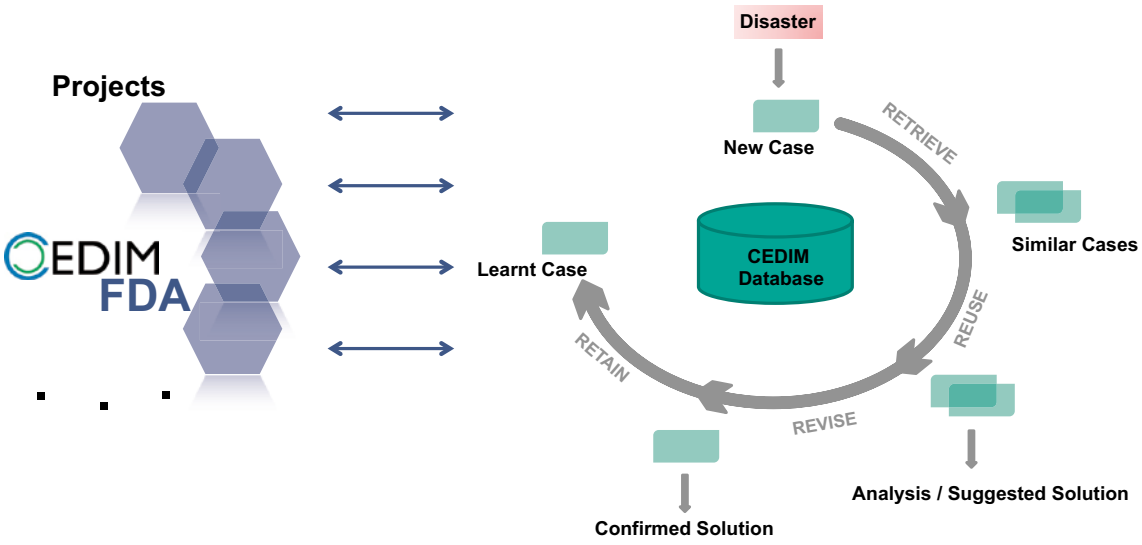

Fig. 1: The CEDIM database is a combination of existing databases and the methodology case-based reasoning provides an analysis support for other participating project partners. The CBR cycle illustrated is based on Aamodt, A. and Plaza, E. (1994): Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches

Outlook

The database scheme will be further developed, including the storage of different kinds of historical disaster events. Moreover, the CBR application for the FDA will be implemented, comprising the development of appropriate similarity measures. The research is accompanied by discussions with experts and tests in order to enhance the data model and the CBR application in an iterative manner.

Core Science Team

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Publications

Moehrle, S. (2012): Generic self-learning decision support system for large-scale disasters, 9th International Conference on Information Systems for Crisis Response and Management (ISCRAM 2012).

FDA – Task Force Activities

CEDIM Near Real-Time FDA Activity on Superstorm Sandy

Michael Kunz, Bernhard Mühr, Tina Kunz-Plapp, James Daniell, Bijan Khazai, Friedemann Wenzel, Marjorie Vannieuwenhuyse, Tina Comes,Thomas Münzberg, Florian Elmer, Kai Schröter, Joachim Fohringer, Christian Lucas, Jochen Zschau

Overview

Superstorm Sandy was the last tropical cyclone of the 2012 Northern Atlantic Hurricane season. From 24 to 30 October, it moved from the Caribbean to the US East Coast, causing widespread damage and almost 200 fatalities. Sandy was an extraordinary event due to its multihazard nature and several cascading effects in the aftermath.

From the hydro-meteorological perspective, most unusual was the very large spatial extent of up to 1,700 km, primarily due to an extratropical transition shortly before landfall at the U.S. East Coast. High wind speeds were associated with record breaking storm surges during high (astronomical) tide, leading to widespread flooding. Very unusual also was the storm track from the south to the north. Thus, Sandy hit a region in the U.S. that has rarely been afflicted by hurricanes in the past, but is densely populated and very vulnerable to such an unexpected event.

Though Sandy was not the most severe storm event in terms of wind speed and precipitation, the impacts were enormous. More than 20 million people on the U.S. East Coast were affected by power outages that lasted several days to weeks. Furthermore, some places suffered for several days from fuel supply shortage. CEDIM estimates direct damage of up to 90 billion US$. In addition, indirect losses could contribute to additional losses, which would make Sandy the second costliest U.S. hurricane in history.

The CEDIM Forensic Disaster Analysis (FDA) Task Force made an effort to obtain a comprehensive and holistic overview of the causes, hazardous effects and consequences associated with Sandy immediately after landfall at the U.S. coast on 30 October 2012. This was done in an interdisciplinary way by collecting and compiling scattered and distributed information from available databases and sources via the Internet, by application of CEDIM models and

Fig. 1: Track of Hurricane Sandy from 24 to 30 Oct. 2012. Indicated are storm category according to the Saffir-Simpson Hurricane Scale, minimum pressure and maximum 1-minute sustained wind speed (in knots). Data source: National Hurricane Center.

methodologies for near real-time analyses developed in recent years, and by expert knowledge. Two reports were drawn up: the first one of 30 October 2012 was made 20 hours after Sandy had crossed the U.S. East Coast, the second one 10 days later. In addition, the main findings are summarized in a fact sheet by Willis Research Network (WRN; accessible via homepage) and published in an International Journal (Mühr et al., 2013).

Meteorological Overview

Sandy was added to the list of 2012 tropical storm systems on 22 October, 15:00 UTC; it was tropical storm #18 so far this year in the North Atlantic region. After crossing Jamaica as a Category 1 hurricane (119 – 153 $km \cdot h^{-1}$) on the Saffir-Simpson Hurricane Scale with a 1 to 5 rating, it moved over the eastern parts of Cuba while reaching the maximum intensity (see Fig. 1). On 25 October at 06:00 UTC, the hurricane had 1-minute sustained winds of 175 $km \cdot h^{-1}$ with gusts in excess of 204 $km \cdot h^{-1}$, making Sandy a category 2 hurricane. Heavy precipitation led to widespread flooding in the very south of the Dominican Republic as well as in the south-western tip of Haiti; rainfall amounts were between 200 and 250 mm. After passing over the Bahamas on 26 October, Sandy made a right turn towards the northeast and started to lose strength. Some hours before entering the U.S. mainland, the hurricane intensified again and showed mean wind speeds of approximately 150 $km \cdot h^{-1}$ (see satellite image of Fig. 2). During landfall on 30 October around 00:00 UTC, the center pressure was 940 hPa, which is a new record for hurricanes making landfall north of Cape Hatteras. Several regions in the U.S. received rain amounts between 100 and 200 mm, with a maximum in the vicinity of the Chesapeake Bay (319 mm). Sandy gave rise to the wettest days that have ever been recorded in October at Baltimore/ Washington Intl. Airport as well as at Dulles Int. Airport. The intrusion of cold air near the surface from the northwest led to heavy snowfall especially in mountainous areas of Tennessee, Kentucky, North Carolina, West Virginia and Virginia, with snow depths of up to 1 m. During the next two days, the storm traveled further northward and finally dissolved near Lake Erie.

Fig. 2: Satellite image, 28 October 2012, 17:45 UTC. Image Credit: NASA GOES Project

Storm Surge and River Flood at the U.S. East Coast

The high wind speeds of Sandy caused storm surges that advanced from south to north along the affected coastlines of Virginia, Delaware, New Jersey, New York, Connecticut, Rhode Island and Massachusetts. North of the landfall location in New Jersey and New York, the highest and often record-breaking water levels occurred (see Fig. 3). However, the impact and magnitude of the storm surges differed strongly due to the geophysical characteristics and the complex interplay of multiple factors. At New York City and Long Island, for example, a combination of shift in the wind direction, minimum sea level pressure accompanied by maximum gusts, and the full moon high (astronomical) tide all at the same time caused the most extreme storm surge. This concurrence of reinforcing effects did not happen to the full extent at other affected coastal areas, thus resulting in lower storm surges. According to our analyses, the observed water levels at the tidal gauges from northern Virginia to Rhode Island exceeded recurrence intervals (Tn) of 10 years. Even Tn > 100-year events were recorded at a single gauges (e. g., at the southern tip of Manhattan), where unprecedented water levels occurred.

By contrast, fluvial flooding in the Mid-Atlantic region turned out to be only a minor hazardous event, despite very high rainfall totals. First, river flows before Sandy were mainly below normal conditions, so the flood wave started from very low initial discharge levels. Second, the accumulation of snow in the headwater regions led to an attenuation and lag in runoff.

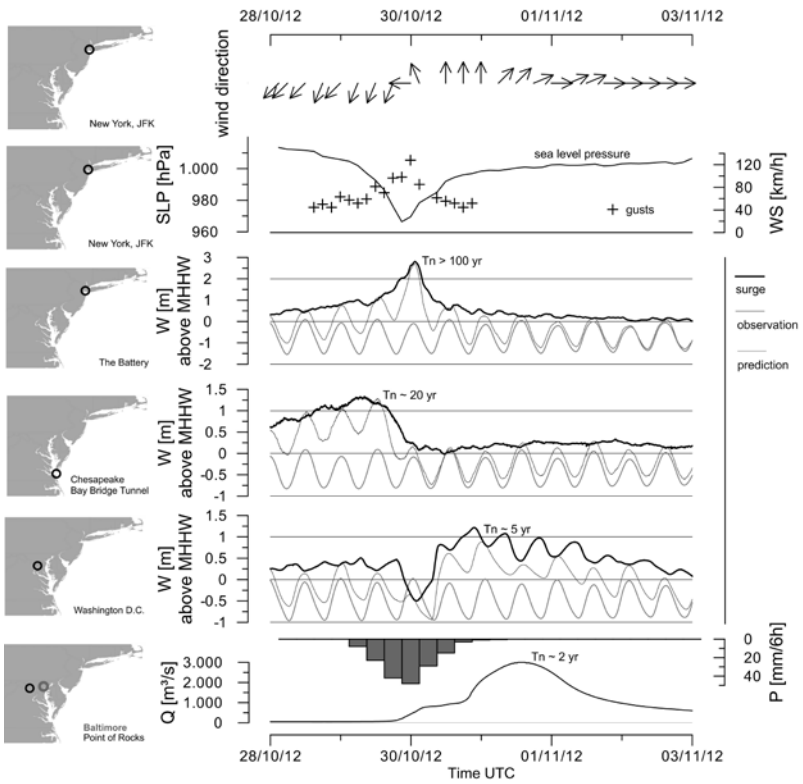

Fig. 3: Evolution and magnitude of the associated hazardous effects (from top to bottom: wind directions and peak gusts at JFK Intl. Airport; storm surge at New York, Chesapeake Bay Inlet and Washington D.C.; Precipitation at Baltimore/Washington Intl. Airport and discharge of the Potomac River at Point of Rocks).

What made Sandy an Extraordinary Hazard Event

Nearly all tropical cyclones in the North Atlantic turn onto an east-northeasterly track before they get anywhere close to the U.S. mainland. However, the particular meteorological situation from October 28 onwards led to a significant shift of Hurricane Sandy. In combination with an Atlantic low pressure system, an extended high pressure system over the continent blocked Sandy and forced it on a west-northwest track towards New Jersey and New York. Since recording began, Sandy was only the third hurricane that made landfall in New Jersey. According to the Hurricane Probability Project, the probability for landfall during the hurricane season in New Jersey is only 1 %, whereas it is 51 % for Florida.

High sea surface temperatures (SST), well above the mean, helped to maintain the storm's intensity over several days. The deviation from the long-term mean SST was 2–4 K on 27 October off the U.S. East Coast. Warm water provided more latent heat, which is the source of energy for hurricanes, and intensified the tropical low, while there was no or only little wind shear, which is destructive for those systems.

Near the U.S. coast, Sandy interacted with a huge upper level trough (low pressure system in the mid troposphere). At its eastern edge, the trough provided additional forcing, which resulted in further strengthening of the storm. While approaching the trough, Sandy grew rapidly; temporarily it had a horizontal extension of a record breaking 1,700 km (see Fig. 2). Just before landfall, the transition from a tropical into an extratropical cyclone began. Shortly after landfall, Sandy turned into a cold-core-low and completed the extratropical transition. With both tropical and extratropical characteristics during landfall, Sandy became somewhat capricious and dangerous.

Social Impacts and Fatalities

Cuba and Haiti were the hardest hit countries in the Caribbean in terms of number of affected people. During the passage of Sandy on 25 October, at least 70 people have been killed in the Caribbean. With 100,000 ha of destroyed crops by strong winds in Cuba and 90,000 ha of devastated cropland by heavy rain and flooding

in Haiti, in both countries the risk of food insecurity is severely increased and is expected to have also a medium-term effect on livelihoods (IFRC, 2012b).

In Cuba, eleven people died and 3 million people suffered direct or indirect impacts (International Federation of Red Cross and Red Crescent Societies, IFRC 2012b and d). In total, 243,000 houses, 2,601 schools, and 615 health centers were damaged or destroyed by strong winds as well as subject to flooding. An estimated number of 1 to 1.5 million people were hampered in access to safe water (IFRC, 2012b; ECHO, 2012).

In Haiti, strong wind, heavy rainfall and subsequent overflowing of rivers in the West and Southwest of Haiti killed at least 54 people (OCHA, 2012a and b, ECHO 2012), destroyed or damaged 27,000 houses and emergency shelters of 5,298 families. Some other factors also aggravated Sandy‘s impact there. First, Hurricane Sandy struck a country that is still recovering from the devastating earthquake in 2010 with 350,000 people still living in camps for internally displaced persons (OCHA, 2012b). Second, after the passage of Hurricane Isaac in August 2012 and Hurricane Sandy in October 2012 resulting in destruction of agricultural crops in at least 60 communities, 450,000 to 1.5 million people are at an increased risk of malnutrition. Third, damage to medical facilities (including 22 cholera treatment centers), problems in restocking because of interrupted transportation, and poor sanitary conditions have increased the risk of waterborne diseases such as cholera, which was highest after the major earthquake. In the first five weeks after Sandy, approximately 13,000 new cases and 65 deaths were reported (Ministère de la Santé Publique, Republique d‘Haiti), which represents a slight increase in disease spread compared to the weeks before.

In the Eastern U.S., 131 people died because of Sandy, most of them in New York, New Jersey and Pennsylvania (LA Times, 2012). Of the 53 fatalities in the State of New York, 43 occurred in New York City (NYC), 20 of them on Staten Island (Tagesspiegel 2 Nov.). In comparison with historic events for the States of New York, New Jersey and Pennsylvania, Sandy is among the three most fatal events of recorded history of hurricane deaths. For New Jersey it is the deadliest hurricane event ever.

Electric Power Outages in the US

Power systems are a critical infrastructure because of their essential role in sustaining social and economic systems. Due to their networked characteristics, consequences of disruptions may propagate widely. A combined total of 8.7 million customers, which equates to 21.3 million people, were left without power from peak outages of Hurricane Sandy on 29 and 30 October, but also from the subsequent

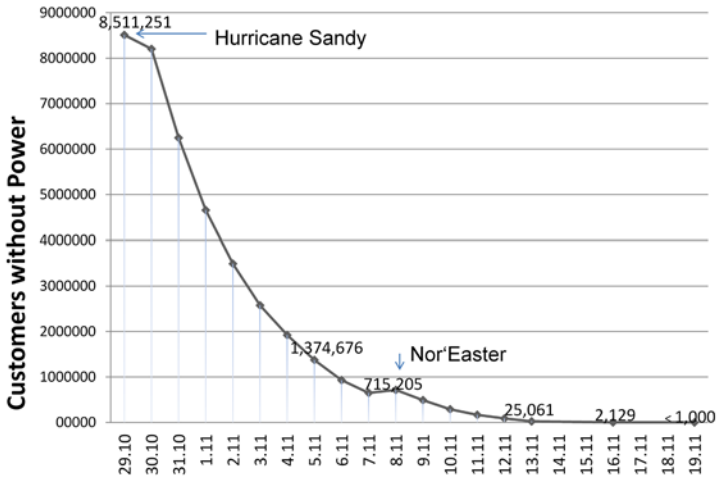

Fig. 4: Time series of power outages from Hurricane Sandy between 29 and 30 Oct. and the Nor’easter on 7 Nov. for affected customers in the U.S. (Customer outages are compiled from specific situation reports obtained from the U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability from 29 Oct. to 19 Nov.).

Nor'easter Storm on 7 November (150,276 customers affected; US Department of Energy DOE, 2012a and b; see Fig. 4). Power outages stretched across 21 States and affected residents of some of the most populated cities in the U.S., including the lower part of Manhattan.

One week after impact, 84 % of the power had been restored with about 1.37 million customers (mostly in New York and New Jersey) still waiting to get back on the grid. Despite widespread power outages, the duration was not unusually long compared to other major hurricanes in the U.S. Hurricanes Katrina, Rita and Wilma in 2005 and Ike in 2008 all resulted in longer outages in Louisiana (18 days for Katrina), Texas (23 days for Katrina), Mississippi and Florida (Fahey, 2012).

Nevertheless, nearly two weeks without power, heat and other provisions, exceeds the limits of citizens' self-helping capacities, and imposes a severe hardship on the sick, elderly, handicapped and poor. There are heightened risks from fire and carbon monoxide poisoning as people use generators, or other gasoline-, propane-, or charcoal burning devices inside their homes for heating, as observed in former comparable incidents (Platz, 2007). The combined power outage and severe weather conditions due to the drop of temperature down to 0 °C further stresses the affected population.

Economic Impacts: Estimation of Direct Losses

Direct losses were estimated by considering destroyed and damaged buildings in addition to other sectoral losses such as agriculture, infrastructure, education and health as a proportion of capital stock and GDP (Daniell et al., 2011; Daniell, 2012). We developed loss functions based on previous impacts of hurricanes as a function of wind speed, storm intensity and flooding as well as the current damage reported from IFRC and national agencies.

According to this analysis, losses in the Caribbean were greatest in Cuba, with around 5.5 % of GDP. The damage followed the storm track closely, with over 20 % of houses losing roofs particularly due to the high wind speeds. In some sections of the Holguin and Santiago de Cuba provinces, the percentage of damaged buildings reached over 80 % as compared to the total building stock. Some of this was related to the vulnerability of building stock, yet more to variable wind speeds and flooding from storm surge (as seen in Guama) and rainfall (seen in Songo-La Maya). Haiti has also seen major damage through the combination of river flooding and fluvial flash flooding, with over 6,000 buildings destroyed and 21,000 buildings damaged.

New York direct losses have totaled around 32.8 billion US$ for repairs and restoration. An estimated 305,000 houses were damaged or destroyed in the State of New York (information as of 26 November 2012), causing around 9.7 billion US$ in damage (see Fig. 5). The large amount of damage is related to the massive exposure in this region (New York and New Jersey have 5 trillion US$ capital stock). New York City has stated direct economic losses of 13.3 billion US$, and indirect losses of 5.7 billion US$ (Newsday, 2012). New Jersey has released figures for losses to housing, transit systems, infrastructure, tourism and coastlines at 29.4 billion US$. Damage before this was quoted as being 34 % from New York, 30 % from New Jersey, 20 % from Pennsylvania and 16 % from

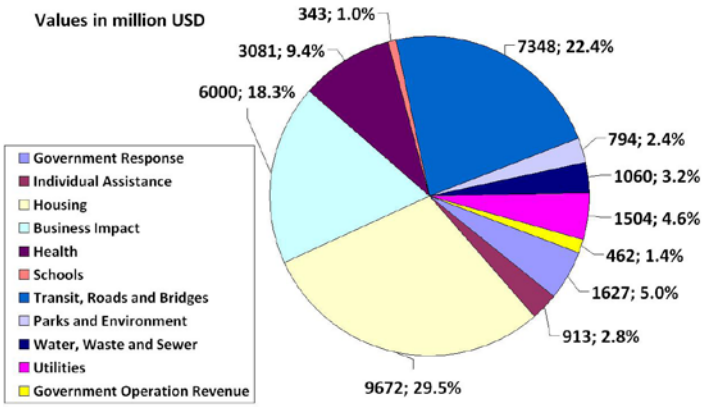

Fig. 5: A breakdown of direct losses in New York State (in million US$ and %) reported by Cuomo (2012).

Tab. 1: Direct Economic Losses by historic hurricanes that have affected the U.S. (CATDAT Database Daniell, 2012).

Hurricane (Year)	Direct Economic Losses in the U.S. (in billion US$ 2012)
Katrina (2005)	127.8
Sandy (2012)	78-97*
Andrew (1992)	42.7
Ike (2008)	31.3
Wilma (2005)	23.9

remaining states using the EQECAT estimate. Using this total system, losses in Pennsylvania would hit around 19 billion US$, with an additional 15 billion US$ from other states, leaving a total of up to 97 billion US$ damage from this event (see Tab. 1), given the fact that New York and New Jersey loss estimates have fitted this model well.

Estimation of Indirect Losses

Natural disasters often result in important indirect losses that have grown considerably due to the increasing interrelatedness of today's globalised supply networks and the growing dependence of modern societies on critical infrastructures (Comes and Schultmann, 2012). In particular, the interruption of the most essential infrastructures such as electric power or transportation can cause cascading effects throughout further infrastructure systems. To estimate indirect losses, we used two approaches: on the one hand we estimated the costs of the power outages based on a comparison with previous power blackouts and on the other hand, we estimated the indirect losses based on a sector-specific model that takes the indirect vulnerability of industrial sectors into account.

According to the study of Zimmermann et al. (2005), we assessed the costs for the power outages in the aftermath of Sandy based on GDP per capita and the number of people affected. The GDP per capita per day, averaged from Pennsylvania, New York and New Jersey, is 160.89 US$. Using a linear recovery function from 20 million people affected on 29 October, to 2 million on 7 November, losses are about 3.2 billion US$ for the first day, and 17.7 billion US$ for the following ten days of blackout.

In order to assess the sector specific vulnerability, we used in addition an indicator-based approach for the transparency and operational representation of vulnerability. The 14 U.S. States affected by Sandy play a key role in the manufacturing sector, accounting for 26.5 % of the added value created in this sector in the whole U.S. economy. A linear input-output model was used to estimate the potential impacts of Sandy on different business interruption scenarios of the U.S. economy (see Fig. 6). As the uncertainties, particularly in the immediate aftermath of the event, are hard to quantify, we considered different scenarios (Comes et al., 2011). For their construction in a systematic way, the indirect costs were split up into several sub-scenarios considering the overall disruption due to the event, the impact of power blackouts and the impact of disruptions to the transportation system.

The overall impact depends to a large degree on assumptions made about the disaster recovery. Assuming that the disruptions of the manufacturing sector lasted for two days in the 14 States, the costs would approximate 9.4 billion US$ for the two days of the storm. However, the time needed for the industrial sector to recover must be considered, which extends the time for utilities to recover. Depending on the recovery scenario, the indirect costs estimated by the model for 10 days following the storm range from 1.4 to 5.6 billion US$, which gives a total between 10.8 and 15.5 billion US$.

Concluding Remarks

Hurricane Sandy was a storm system with special meteorological characteristics. It caused widespread damage from the Caribbean to the U.S. East Coast. Especially in New York, New Jersey and Pennsylvania, Sandy resulted in a relatively high death toll compared to historic events. We estimated direct damage of up to

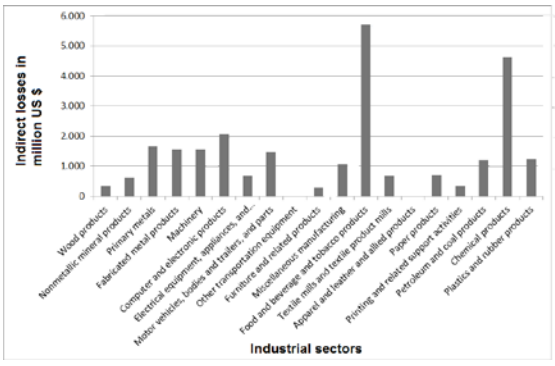

Fig. 6: Assessment of indirect industrial losses due to Sandy.

90 billion US$. In addition, indirect losses due to critical infrastructure failures (electricity, transportation) could contribute to additional losses on top, which would make Sandy the second costliest U.S. hurricane in history.

It is shown that the impact of Sandy was driven by the superposition of different extremes (high wind speeds, storm surge, heavy precipitation) and by cascading effects. Research on how the impacts are amplified by multi-hazards rather than by single extremes may help to better assess potential losses of events such as Sandy. The impact of Sandy on the longer term and the indirect losses are difficult to estimate due to the complex interrelations between socio-economic and technical systems; our estimates range between 10.8 and 15.5 billion US$ using a sector-specific vulnerability model and approximately 20 billion US$ by comparison with past events. Therefore, further analysis of recovery scenarios considering diverse uncertainties related to the response of the economy (from individual business continuity plans to outsourcing decisions, replacement of suppliers or longer term price developments), the duration of recovery of the critical infrastructure systems and potential policy interventions will be important.

An important field for further research is the communication of uncertainty. The CEDIM reports are also meant to be a means to assess risks and losses so as to enable prioritization of risk management. Therefore, it is crucial to document how the situation could potentially evolve and to highlight potentially harmful developments as early as possible. All these scenarios are, however, prone to uncertainty to an extent which is so overwhelming that the use of standard methods to characterize the probability of each scenario cannot be applied. Alternative methods to assess and communicate the risks, particularly for the early stages of the disaster, should be further investigated.

Tracking power outages and estimating downtimes requires a combination of simple models and a crowd-sourcing tool, which should be brought closer together than we managed to do with Sandy. The distribution of losses to different sectors of the economy is done with a simple input-output model and, given the data sparseness at an early stage of the analysis, the right thing to do. An equally simple model allows defining an industrial vulnerability parameter for states (and potentially other administrative units) that immediately indicates where aggravating impact has to be expected even if the state is less affected in terms of hazard and current loss numbers.

Although we find our working hypothesis was essentially confirmed, we learnt that linking methods and models has more potential than is currently exploited, and more systematic utilization of historic data bases might hold the key for uncertainty estimation in direct and - more importantly - indirect loss predictions.

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Supersturm Sandy

Ende Oktober 2012 entwickelte sich in der Karibischen See Hurrikan Sandy, der letzte tropische Wirbelsturm der Hurrikan-Saison 2012 im Nordatlantik. Auf seinem Weg nach Norden forderte Sandy über 200 Todesopfer und verursachte massive Schäden in einem der ärmsten (Haiti) und einem der reichsten (USA) Länder der Erde mit sehr unterschiedlichen Auswirkungen und Schadenmustern. Die Schäden in Höhe von rund 100 Mrd. US$ waren vor allem eine Folge der Überlagerung und Verstärkung verschiedener hydro-meteorologischer Phänomene (multihazard) und nachfolgender kaskadierender Effekte wie beispielsweise großflächige Stromausfälle an der Ostküste der USA.

Außergewöhnlich aus hydro-meteorologischer Sicht war vor allem die großräumige Ausdehnung des Sturms von bis zu 1 700 km als Folge der außertropischen Umwandlung unmittelbar vor Erreichen der Ostküste der USA (New Jersey). Die hohen Windgeschwindigkeiten und die gleichzeitig auftretenden hohen (astronomischen) Tiden führten zu einer außergewöhnlichen Sturmflut und massiven Überflutungen. Ein umfangreiches blockierendes Hochdruckgebiet über Kanada zwang Sandy auf eine ungewöhnlichen Zugbahn, die sich fast geradlinig von Süden nach Norden erstreckte. Damit wurde in den USA eine Region getroffen, in der Wirbelstürme nur sehr selten auftreten, die aber aufgrund der hohen Besiedlungs- und Industriedichte eine erhebliche Vulnerabilität aufweist.

Obwohl Sandy von der Intensität her nicht zu den stärksten Ereignissen gezählt werden kann, waren die Auswirkungen enorm. In der Karibik hinterließ der Wirbelsturm über 300 000 beschädigte oder zerstörte Gebäude, über 80 Menschen verloren ihr Leben. Insbesondere in Haiti, das noch immer an den Folgen des verheerenden Erdbebens von 2010 leidet, waren die Auswirkungen erheblich. Durch die Zerstörung landwirtschaftlicher Nutzflächen in 60 Kommunen sind aktuell 450 000 bis 1,5 Millionen Menschen von Hunger bedroht. An der Ostküste der USA litten über 20 Millionen Einwohner während mehrerer Tage bis hin zu Wochen unter Stromausfällen. Ökonomische Schäden durch Sandy konnten mit Hilfe verschiedener vereinfachter Modelle und Methoden, die im Rahmen von CEDIM Projekten entwickelt wurden, abgeschätzt werden. Danach ergeben sich direkte Schäden für die Karibik von rund 4,2 Mrd. US$, für die USA zwischen 78 und 97 Mrd. US$. Indirekte Schäden durch Stromausfälle und Betriebsunterbrechung liegen in der Größenordnung zwischen 10,8 und 15,5 Mrd. US$. Damit geht Sandy nach Hurrikan Katrina im Jahr 2005 wohl als der zweitteuerste tropische Wirbelsturm der USA in die Geschichte ein.

Die CEDIM Forensic Disaster Analysis (FDA) Task Force begann ihre Analysen von Hurrikan Sandy unmittelbar nach dessen Erreichen der Ostküste der USA mit dem Ziel, einen möglichst umfassenden Überblick über die Ursachen, die Wechselwirkung der verschiedenen Ereignisse und deren Auswirkungen zusammenzustellen. Dazu wurden von CEDIM verteilte Informationen aus dem Internet und aus verschiedenen Datenbanken zusammengestellt und analysiert sowie eigene Methoden und Modelle angewendet. Über die CEDIM-Webseite erfolgte die Veröffentlichung von zwei Berichten: der erste 20 Stunden, nachdem Sandy die Ostküste der USA getroffen hatte, der zweite zehn Tage später. Die wichtigsten Ergebnisse aus diesen Berichten sind auch von Willis Research Network (WRN) zusammengefasst worden; sie wurden außerdem zur Veröffentlichung in einer wissenschaftlichen Zeitschrift (NHESS) eingereicht.

Analysis of U.S. Extreme Drought and Record Heat 2012

Bernhard Mühr, James Daniell, Bijan Khazai, Michael Kunz, Tina Kunz-Plapp, Marjorie Vannieuwenhuyse

Introduction

During spring and summer 2012, the continental U.S. experienced record heat and extreme drought causing considerable losses in the agricultural sector in the U.S. In August and September CEDIM researchers analyzed the drought while it was still ongoing and while impacts on agriculture could be only estimated. Two reports were released on CEDIM's website www.cedim.de. The first report focused on the meteorological and climatological aspects of the drought and heat. The second report included updated information on meteorological parameters, but also loss estimations, comparisons with other historic droughts, and reflections on social vulnerability to drought. In this CEDIM annual research report, the most relevant results of our analysis are summarized.

Hazard Profile: Heat and Drought

Temperature

After a record-breaking hot spring, the heat persisted in the U.S. and North America through summer 2012, and the extraordinary warm weather continued through July and August 2012. This was mainly due to the persistent large-scale flow pattern above North America and in the Northern hemisphere. Frequently, a long wave mid and upper troposphere ridge filled with very warm air developed above the North American continent and remained quasi-stationary at the same position. The planetary frontal zone was pushed back very far into the north of North America. This predominance of high pressure patterns resulted in very long lasting and stable general weather situations that made very warm air masses of southern origin advance to and remain in the U.S. It brought much sunshine, few clouds, hardly any precipitation, and very high temperatures with a few short interruptions only. Together with the past and extraordinarily hot year 2011, the temperature statistics exhibit a heat episode that has never been observed before in the U.S. The twelve-month period from August 2011 to July 2012 saw record heats in 24 states. All over the U.S., this was the hottest twelve-month period ever measured. About 132 million inhabitants were directly affected by the heat.

In consequence, monthly average temperatures were surpassed in June and July, and long-time records were broken. Temperatures in June exceeded the U.S.-wide average by about 2 °F (about 1.2 K). While temperature deviations along the coasts tended to be negative, high positive anomalies occurred especially in the Great Plains and the Midwest. The state of Colorado saw the hottest June on record with a deviation of +6 °F (about +3 K). In seven other states, June 2012 was listed under the top ten of the hottest June months. All over the U.S., 170 old records of daily high temperature were equaled or broken.

In July, many high-temperature all-time records were tied or surpassed, mainly in the eastern part of the U.S. A new all-time record of highest temperature was measured at 173 places. In 32 states, July 2012 was listed under the top ten of hottest months of July, e. g. Virginia experienced the hottest July on record. The significant positive deviation from long term average temperature in July was up to 8 °F (about 4.5 K). The average temperature for the contiguous U.S. was 3.3 °F (1.9 K) above average and made the July 2012 the all-time warmest month on record since 1895. (Fig. 1)

In 2012, the United States recorded the third-warmest summer since monitoring began. Nationwide, the average temperature of the three summer months of June, July and August exceeded the long term mean by 2.3 °F (1.4 K). Slightly negative temperature deviations could only be found in the southeast and in the very northwestern U.S. The rest of the country experienced large positive temperature anomalies, most notably the western United States, the Great Plains, the Midwest and much of the northeast. In 16 U.S. states, the summer 2012 lined up with the top 10 list of the hottest summers since 1895. Wyoming and Colorado even recorded the hottest summer since records began; at Denver (CO) the old record average temperature (1954) of the climatological summer was surpassed by 2 °F (1.2 K).Only the "Great Dust Bowl Summer" of 1936 (+0.2 °F)

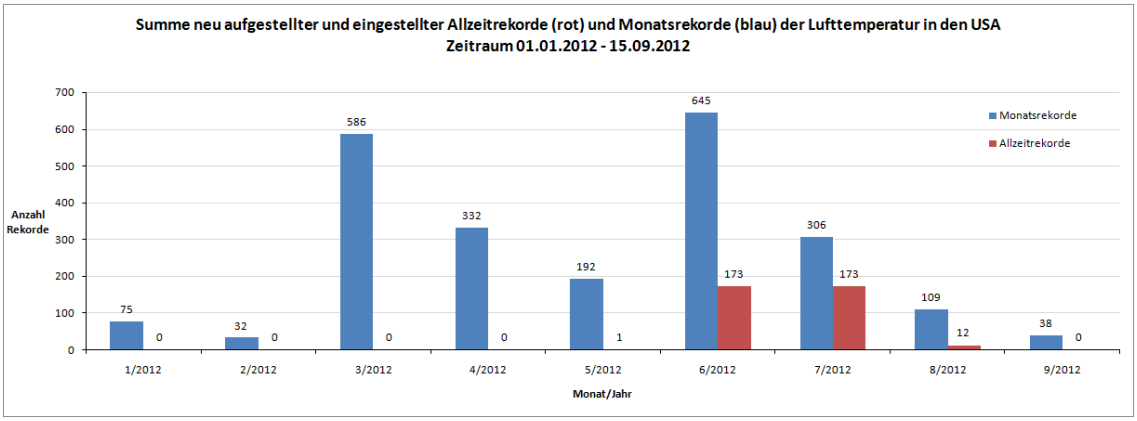

Fig. 1: Number of new or tied records per month (January 1st to September 15th, 2012). Red: All time records. Blue: Monthly records. Image Credit: Wettergefahren-Frühwarnung; Data source: NOAA/NCDC Records

and the last year's summer months (+0.1 °F) were slightly warmer. Summer 2012 continued the series of unusual warm months that already began in record-breaking warm spring 2012 with the extremely hot July being of particular impact.

Precipitation

Due to the persistent general weather situation, extreme heat in many parts of the U.S. was accompanied by longer-term sparse or lacking precipitation. Passing troughs with large-scale precipitation brought relief to some regions only. Sunshine, dry and hot air, and wind stimulated evaporation and resulted in a high precipitation deficit that was still growing at the beginning of August at many places.

From mid-August onwards greater heat waves no longer occurred but nevertheless widespread, above-normal temperatures were recorded until September. The relatively persistent large-scale circulation patterns over the North American continent continued, often with only little or no associated rainfall but prevailing windy weather.

Regarding the long term precipitation average, the continental U.S. can look back overall to almost average rainfall during the summer 2012. But this hides the fact that the precipitation pattern could not have been more variable throughout the U.S. Colorado, Wyoming, and Nebraska passed the driest summer on record. In Missouri, Illinois, Iowa, South Dakota and New Mexico the summer 2012 managed to jump into the top-10 list of the driest summer months. At Joplin (MO), no drop of rain was measured in July. The last time this happened was in the year 1946. At Springfield (MO), 8.3 mm monthly precipitation was measured, the driest July since 1953. Also at Sioux Falls (SD), precipitation was measured to be only 6.1 mm; normally, precipitation in July would amount to about 78 mm. Quite different, however, was the situation in Louisiana and Mississippi, where the summer 2012 is found to be in the top-10 of the wettest summers due to Hurricane „Isaac". In Florida hurricane "Isaac" and tropical storm "Debby" caused the wettest summer since records began.

Fifth largest drought since 1895

In July 2012, the percentage of areas that were at least moderately affected by the drought had increased to 75 % according to the Palmer Drought Severity Index. The area affected by extreme drought had increased to more than twice the value from June to July. The state of Maine experienced the fifth-driest July since the beginning of observations. Judging from the three-month precipitation amount, the months from May to July have to be considered record-dry in Nebraska, Kansas, and Arkansas. The last great drought occurred more than 50 years ago, in December 1956.

In many regions sparse or no rain and high evaporation rates exacerbated the already severe drought situation in the U.S. in the course of the summer. Even though the area affected by at least moderate drought (according to the Palmer Drought Severity Index) decreased by 2 % to 55 %, the percentage with at least severe drought increased further to 39 % and the area with extreme drought enlarged by 2 % (overall 6 %). Based on these numbers the

2012 drought is still the fifth-largest since 1895 and the worst drought for 56 years.

The largest drought so far in the U.S. happened in the 1930s, when most of the country's area was dry and events such as the "Great Dust Bowl Summer" in 1936, including dust storms and major erosion damage, became possible. Due to major river flooding that occurred in several states last year (e. g. Mississippi, Ohio, Missouri, a multi-year and sustainable drought period has not yet been established.

Impact of the Drought

According to the statements of the U.S. Department of Agriculture in September 2012, the 2012 drought was the "most severe and extensive drought in at least 25 years" and was "seriously affecting U.S. agriculture, with impacts on the crop and livestock sectors and with the potential to affect food prices at the retail level" (USDA 2012). As of August 17, 1,692 counties across 36 states in the U.S. had been legally declared primary natural disaster areas as the drought continued to cover 62 % of the contiguous U.S.. Mainly the states of Kansas, Nebraska and Oklahoma were suffering from the dry conditions, but also most of the West and even some areas in the Pacific Northwest as well as Northern Mexico were seriously affected by the drought. The situation in the Midwest (cornbelt) and the Great Plains (the breadbasket) was highly critical.

Estimation of economic impact

To gauge the economic impact the drought in the U.S. could have, first a drought score was calculated using the data from the U.S. Drought Monitor and assigning a value in percentage per county. Based on this drought score the possible impact of the drought (mean damage) was estimated state-wise for the exposed assets (crops, livestock) using a logarithmic damage ratio function (for more details see the second report on the drought).

This procedure resulted in the following estimates for livestock: Using a mean loss ratio of 15 % of the total value of the 2012 livestock for Level 4 drought-affected counties (in terms of percentage of a county) and a value of 1 % for Level 3, there was a potential $3.27 billion loss in the livestock section, whereby most losses in livestock would occur in the central United States. For the crops section, a potential for $3.6 billion loss was estimated using a mean loss ratio of 33 % of the total value of the 2012 crop for Level 4 drought- affected counties (in terms of percentage of a county) and a value of 2 % for Level 3. It can be seen from Figure 2 that most losses would also occur in the central United States. Using these rough percentages, crop and livestock loss could be equal to around $7 billion out of a total of $296 billion, thus about 2–3 % of the total productive sector.

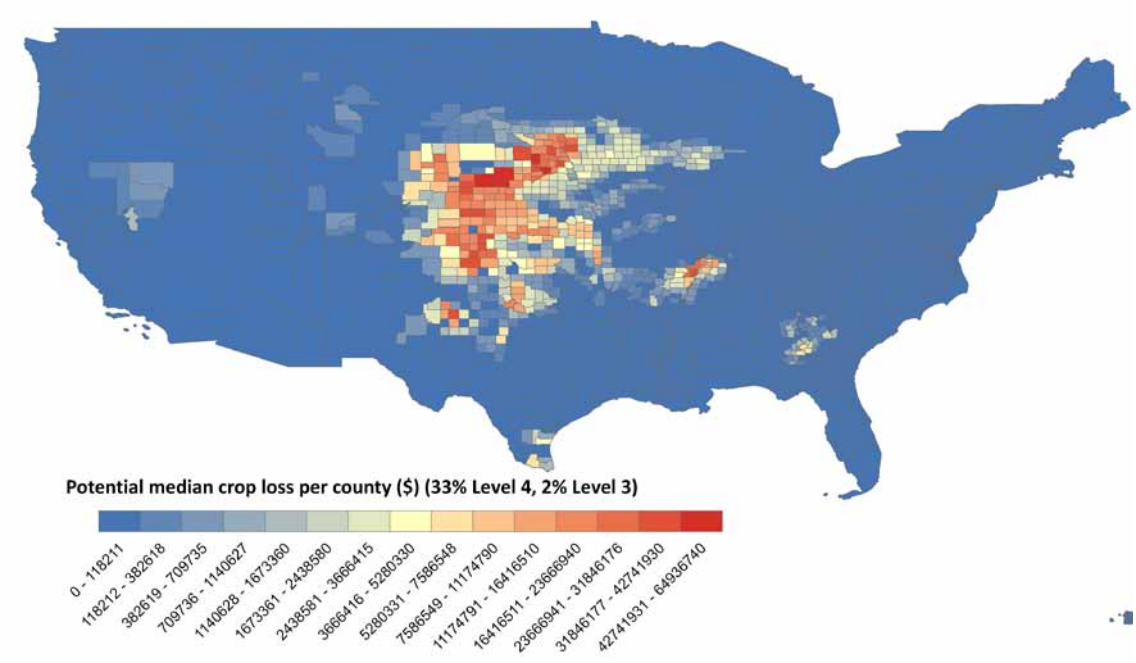

Fig. 2: Crop potential losses of production per county

However, since in the U.S. 7 % of the total production was under Level 4 drought and 15 % was under Level 3 in September 2012, assessing different levels of loss could give very different values, especially if the drought lasted more than a year and affected yearling and/or crop production in the future. Different scenarios could be played out such that if all Level 4 affected production is lost this would then total losses of around $21 billion for the U.S., and would also cause many add-on effects in terms of lost farms, houses and livelihoods.

Comparing the 2012 drought to the 16 droughts that have occurred since 1980 and have caused more than 1 billion US$, our estimations of damage in agricultural industry of U.S. $7 billion may appear to be merely average in terms of an AAL (Annual Average Loss) sense in the last 31 years ($6.9 billion U.S. [2012 adjusted from NCDC data]), However, in terms of years this would be the 7th highest loss since 1980 (after years 1980, 1988, 1996, 1998, 2002, 2011). The highest losses from droughts since 1980 occurred in 1988 (76.6 billion U.S.) and 1980 (55.6 billion U.S. [both values 2012 adjusted])

It is important to mention that we used a simple method to estimate the loss, and therefore a number of effects are not considered that have an influence on the total economic impact of the 2012 drought, including comparison of different crop types in terms of losses. Some additional effects may include:

- impacts of high corn prices that reduces livestock production compared to previous years; the global financial crisis and housing crisis in the U.S. has already placed the economy on a knife-edge;
- impacts of low water levels in parts of the Mississippi affecting trade and commerce;
- possible decrease in wealth of farm equipment as it may be expected that some farmers are forced to sell;
- long-term effects on next year's production.

Social vulnerability to drought

Given the same level of drought exposure in two different counties of the U.S., the impact of the drought will not be the same in both but rather commensurate with each county's social capacity to anticipate, cope with and respond to drought. To estimate the aggravating effect of different levels of social vulnerability to drought, we adopted the basic principles of the generic Social Vulnerability Index of Cutter et al. (2003) and built an modified index for social vulnerability to drought. The following five indicators were selected for the composition of a modified Social Vulnerability Index for Drought (SoVD): (1) Median Age, (2) Per Capita Income, (3) Race and Ethnicity, (4) Agricultural Production, and (5) Agricultural Employment.

The five indicators were populated with state-level data available from the U.S. 2010 Census. As the weight given to each indicator determines the final relative value rankings in the index, two scenarios were used; all indicators are valued equally under Scenario 1, but in Scenario 2 the demographic indicators (median age, per capita income, and race and ethnicity) are given 50 % of the weight, while the agricultural productivity and employment component are given the other 50 % of the weight. Comparing the two scenarios, it turned out that the top three states regarding social vulnerability to drought – California, Texas and Iowa – were robust to the change in weights of the indicators. However, some states such as New Mexico are much more sensitive to changes in weight, ranking very high in social vulnerability to drought under the equal weight scenario 1 (4th position) and moving downwards in ranking (19th) position under scenario 2, indicating that agriculture is a less important dimension for social vulnerability in this State.

We estimated the potential aggravated impact of the 2012 droughts in the U.S. by considering how the overall impact to areas experiencing extreme (Level 3) and exceptional (Level 4) droughts are amplified by the aggravating factors of the social vulnerability index. Thus, first a drought intensity score per state was obtained as the weighted sum of percentage of area affected by Level 4 drought (weight of 0.75) and percentage of area affected by Level 3 drought (weight of 0.25). The aggravated drought impact was then obtained by multiplying the drought intensity score by an indirect impact factor, based on the indicators representing the social vulnerability to droughts of each state (SoVD).

In the resulting relative ranking of the states on the Drought Risk Index (Fig. 3), it can be seen that for states such as Kansas and Nebraska both the social vulnerability against drought as well as the drought levels, i. e. the actual areas affected by droughts are high, giving these states their high rankings in the aggravated drought impact score. On the other

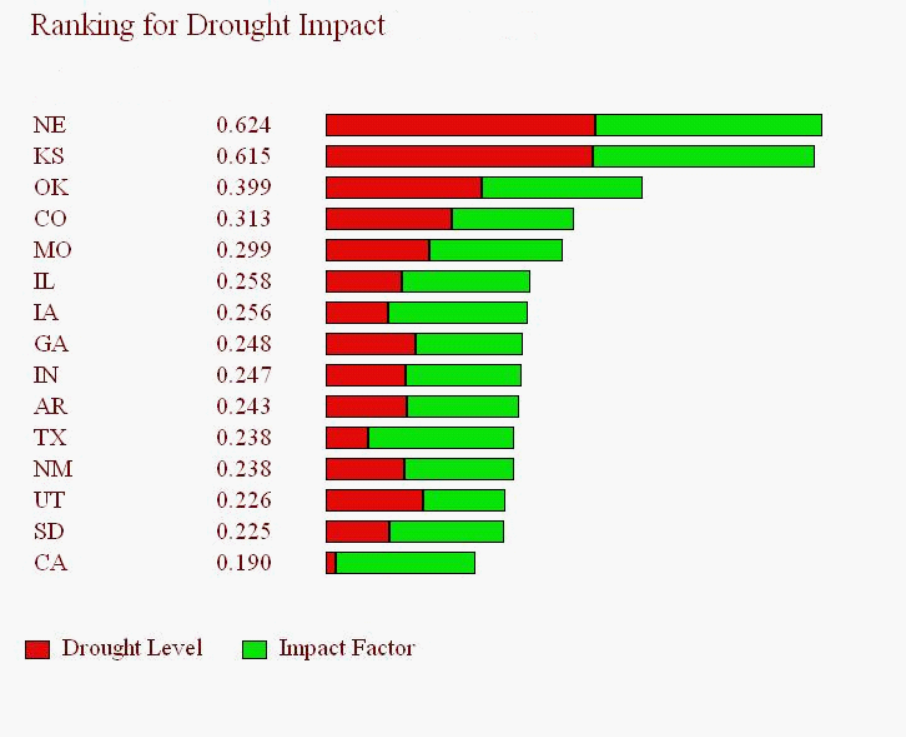

Fig. 3: Results for aggravated drought impact ranking for 15 states using scenario1 for the impact factor social vulnerability SoVD. Red: drought level (drought intensity), green: impact factor as given by social vulnerability index.

hand, states such as California, Texas and Iowa have very high levels of social vulnerability to droughts, but were / are not impacted as high as some other states in the 2012 drought as their drought level is much lower.

Summary

July 2012 was the hottest July on record in the U.S., with the summer (June to August) ranking 3rd since 1895. The most extreme drought occurred in the Great Plains. According to our rapid estimations of economic losses based on the situation in September 2012, we expected that the losses due to drought would not surpass the historic losses from droughts in 1988 and 1980. Considering the social vulnerability to drought, we identified those states where social vulnerability to drought is high and could therefore lead to an aggravated overall drought impact.

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Analyse der U.S. Dürre und Rekord Hitze 2012

Rekordtemperaturen und Trockenheit bestimmten im Frühjahr und Sommer 2012 und bis in den Herbst hinein in weiten Teilen der USA die Witterung. Die anhaltende Trockenheit sorgte für beträchtliche Verluste in der Landwirtschaft. Im August und September analysierten CEDIM-Forscher die Dürre und schätzten ihre möglichen Schäden ab. Die Analysen wurden in zwei Berichten auf der Webseite www.cedim.de veröffentlicht. Der erste Bericht bezieht sich vor allem auf meteorologische und klimatische Aspekte, im zweiten Bericht waren darüber hinaus Schadenschätzungen und Betrachtung sozialer Verwundbarkeit gegenüber Dürre enthalten. Im vorliegenden Jahresbericht sind die wichtigsten Ergebnisse zusammengestellt, die sich wie folgt zusammenfassen lassen: Der Monat Juli 2012 war der heißeste gemessene Monat in den USA seit 1895. Der Sommer insgesamt (Juni bis August) liegt auf Platz 3 der seit 1895 gemessenen Werte. Einige Staaten verzeichneten den trockensten Sommer seit Beginn der Aufzeichnungen, vor allem im Mittleren Westen und in den Staaten der Great Plains entstand ein extremes Niederschlagsdefizit. Gemäß den ersten Schätzungen im September 2012 zu den ökonomischen Auswirkungen der Dürre ist zu erwarten, dass die Schäden – trotz der Temperaturrekorde – unter den Schäden aus den großen Dürren in den Jahren 1980 und 1988 liegen werden. Zudem wurden die Staaten identifiziert, die eine besonders hohe soziale Verwundbarkeit gegenüber Dürre haben und bei denen sich daher die Auswirkungen der Dürre insgesamt verstärken könnten.

Analysis of Tropical Cyclone “Saola”, Philippines and Taiwan

Bernhard Mühr, Michael Kunz

Introduction

The Philippines and Taiwan belong to the areas mostly affected by Tropical Cyclones (TC). Each year, Taiwan is hit by several TCs, leading frequently to flooding, landslides and damage to infrastructure and agriculture. Rugged terrain, a dense population, an important industrial sector with many high tech-companies and well developed infrastructure, makes the island vulnerable not only to earthquakes but also to typhoons, which often approach from the Philippine Sea. The CEDIM report on Saola focuses on the meteorological aspects and summarizes information about precipitation and the forecasted track.

Hazard Profile: Development and Prediction of Storm Track

Saola appeared as a tropical depression on 28 July 2012 at 4.4 N 127.1 E, approximately 600 km east of the Philippine capital Manila. Successively intensifying, Saola moved first in a north-westerly, afterwards in a northerly direction. On 30 July 2012, 06 UTC, maximum mean wind speed was 65 kt (120 km/h) and Saola was classified a category 1-typhoon. Even though the centre of Saola passed the northern Philippine main island of Luzon at a distance of several hundred kilometers, the convective cloud bands of the TC gave rise to intensive precipitation and high wind speed.

Maximum intensity was reached on 1 August between 06 and 18 UTC, with mean wind speeds of 90 kt (167 km/h), equivalent to category 2.

According to most of the weather forecast models, the track of Saola’s centre was expected to move at a distance of between 100 to 200 km off Taiwan’s northeast coast and, afterwards, to move towards China in a north-westerly direction. However, in the evening of 1 August, the TC changed onto another track. After a

short tilt to the south, the centre of the storm hit the north-eastern coast of Taiwan on 2 August 03:20 Local Time – still being a category 2 storm. At this time, the propagation speed of the storm was very slow. Saola then moved over the conurbation of Taipei heading north, and afterwards with an increasing westerly component towards the mainland of China.

The unexpected direction and low propagation speed of Saola may be a result of the interaction with TC Damrey, a typhoon that was active at the same time several hundred kilometers far away from Saola.

Impact of Saola

Philippines

Even if – compared to Taiwan – rain totals of Saola on the Philippines were much lower (e. g. Baguio 242 mm within 24 h), they also resulted in large-scale flooding, leading to approx. 30 fatalities. Over the northern and central parts of the country, more than 2,700 houses were damaged or destroyed; approximately 1,200 people needed shelter, more than 500,000 inhabitants were affected. Schools were closed and more than three provinces experienced electricity blackout.

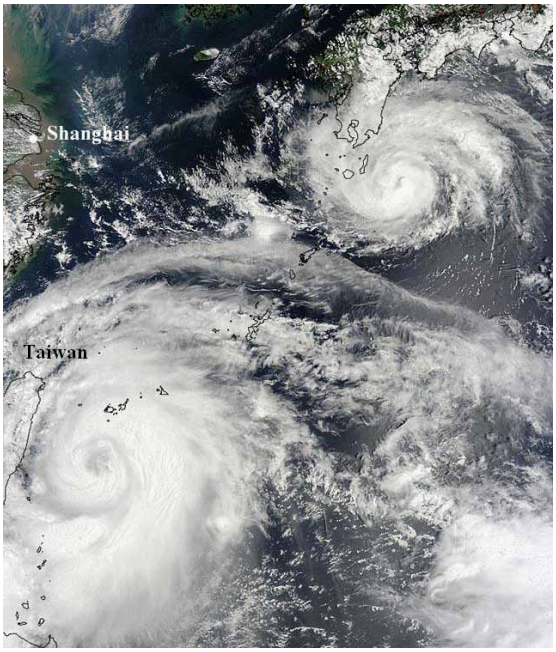

Fig. 1: Satellite image, 1 August 2012, MODIS, Terra-Satellite; Image Credit: http://earthobservatory.nasa.gov/

Taiwan

Due to the low propagation speed of Saola, the precipitation totals were very high, in particular over the mountain areas. In several regions, more than 100 mm of rainfall was recorded within one hour. All over the northern and western parts of the island, daily precipitation was in excess of 200 mm and for some (larger) areas even more than 500 mm. The highest total of 1216 mm within 2.5 days was registered at the station of Taipingshan. By contrast, a small area in the southwest of Taiwan remained almost dry.

According to available press reports (Associate Press, Voice of America), the high precipitation and related extremes claimed the lives of five people. A great number of flights were cancelled at the international airport of Taipei, the railway traffic was interrupted over the whole island. As a precautionary measure, large amounts of water were released from all seven large water reservoirs to avoid breaking of dams. The Ministry of Defense mobilized 48.000 soldiers to help with mitigating the impacts of the TC and to organize supporting measures.

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Taifun Saola, Philippines und Taiwan, 31. Juli – 3. August 2012

Der tropische Wirbelsturm „Saola“ war Ende Juli/Anfang August 2012 über dem tropischen Westpazifik unterwegs und richtete besonders auf den Philippinen, in Taiwan sowie in Teilen Chinas schwere Schäden an. Insgesamt kamen mindestens 45 Menschen ums Leben. Saola, ein Taifun der Wirbelsturmkategorie 2, vollführte vor der Nordostküste der Insel eine Drehbewegung um seine eigene Achse und verringerte auf diese Weise seine Zuggeschwindigkeit für einige Stunden erheblich. Möglicherweise stand diese von den Modellen im Vorfeld nicht prognostizierte Änderung von Zugbahn und Zuggeschwindigkeit in Zusammenhang mit dem Taifun „Damrey“ einige hundert Kilometer weiter im Norden und einer durch diesen ausgelösten Modifikation der Höhenströmung. Daraus resultierten enorme Niederschlagsmengen; innerhalb von knapp drei Tagen wurden Regenmengen von mehr als 1000 mm gemessen, in der Spitze fielen zwischen dem 31.07. und dem 02.08. in Taipingshan 1783 mm, davon 1213 mm innerhalb von 21 Stunden. Über die Zugbahn und die Intensität des Sturms sowie die betroffenen Gebiete und entstandene Schäden gibt der CEDIM Report https://www.cedim.de/download/FDA_Report_Saola_v1.pdf Auskunft.

Earthquake Sequence, 20th and 29th of May 2012, Ferrara, Italy

Jochen Zschau, James Daniell, Andreas Höchner, Friedemann Wenzel, Silke Eggert

Introduction

Two strong earthquakes with their accompanying aftershocks struck the Emilia-Romagna region in Northern Italy, the first on Sunday 20.05.2012 (M=6.1) and the second on Tuesday 29.05.2012 (M=5.8), affecting mostly the provinces of Ferrara, Bologna, Modena and Reggio nell'Emilia. A foreshock of the whole series with magnitude 4.1 occurred approximately three hours before the first main event.

CEDIM has drafted a short earthquake report on 31.05.2012 (updated 01.06.2012) as an exercise for its FDA (Forensic Disaster Analyses) - Task Force activities under development. The present report is practically a summary of this.

Seismotectonics and Historical Seismicity

The main shocks as well as the major aftershocks show similar reverse thrust type source mechanisms and their locations indicate that they may have activated the so-called Mirandola fault. The Mirandola blind thrust has been previously identified as a potential source for a M_w 5.5 earthquake (Valensise and Pantosti, 2001, Burrato 2003). Lavecchia et al., however, argue in a paper that came out in late 2012, that both mainshocks with their aftershocks were not focused around the basal thrust of Mirandola but rather around the neighbouring Quarantoli thrust for the May 29 event and the Ferrara Basal thrust for the May 20 event (see also Fig. 1). All three faults belong to the Ferrara Arc that was formed as a result of the NS-convergence between the African and Eurasian tectonic plates at a present rate of roughly 1 cm/year.

The earthquakes occurred in the Po plain, which is seismically not very active by Italian standards, the hazard is assumed to be low to moderate, but exposure is very high. In 1346, a magnitude 5.8 earthquake took place approximately at the location of the 29 May 2012 event. From 1561–1574, a series of 4 events was felt with intensity greater than 7 in the region of the 2 recent events, with the largest being the November 1570 event of a very shallow depth and magnitude 5.5 (EMS=7.5) occurring about 40 km east of the 20 May 2012 event, close to Ferrara (INGV, Website, 2012). A rep-

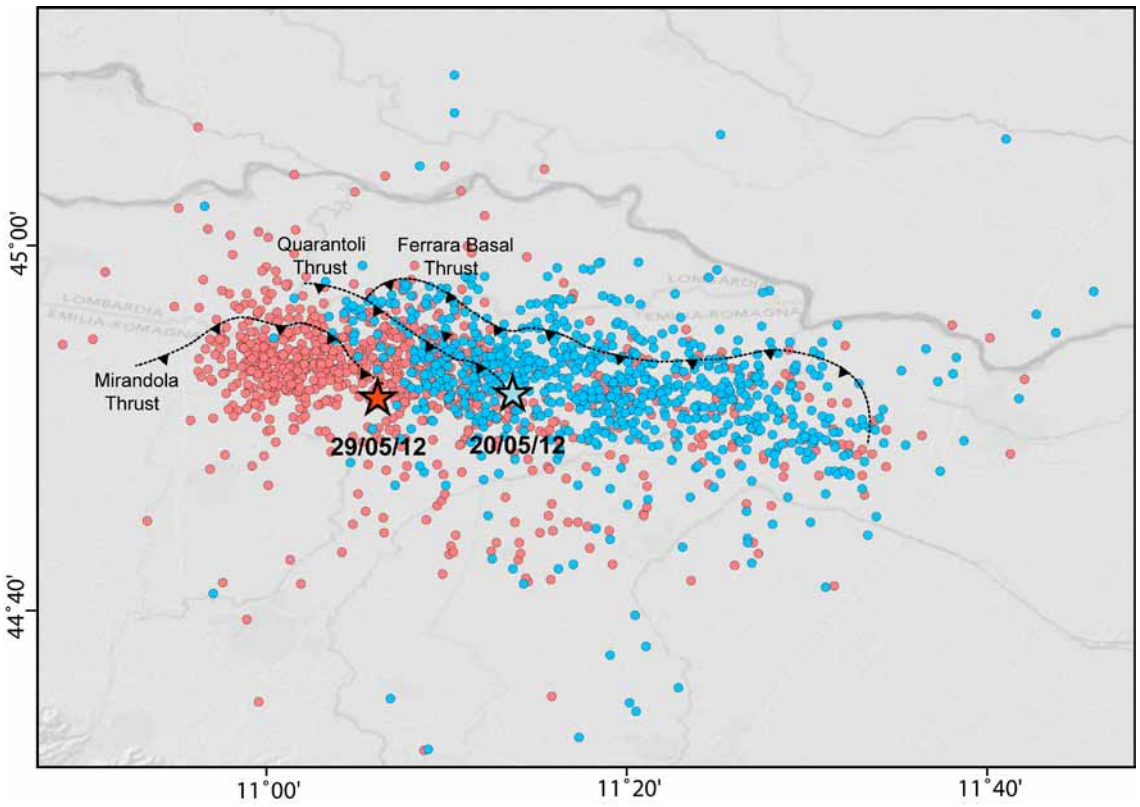

Fig. 1: Location of the two earthquake sequences of Ferrara in Northern Italy 2012 (Locations from the GEOFON archive of GFZ, fault lines from Laveccia et al. (2012))

etition of this event could lead to even greater damage than that of the recent earthquakes depending on the proximity of its epicenter to the city of Ferrara.

Ground Shaking and Losses

In both cases, felt intensities exceeded the value of 7 on the Modified Mercalli Scale, whose highest value is 12. Intensity 5 was experienced over the entire Eastern Po plain. Shaking was also felt in Switzerland, Slovenia and France.

The impact of the 20 May event was 7 fatalities, around 50 injured, 6000 homeless and 400-500 million € losses (0,3 % of Emilia-Romagna's GDP). The 29 May event resulted in 17 fatalities, 350 injured, 9000 homeless and losses most probably exceeding those of the first event (>500 million €).

Besides residential and cultural heritage losses, there was significant damage to industry. For example, losses to the cheese, ham and other agricultural industries in the region are estimated to be as high as 500 million €. This includes about 550.000 wheels of Parmesan that were destroyed, worth about 220 million €. In response to the losses from these earthquakes, the Italian government raised the petrol tax by 2 cents per litre, to fund recovery.

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Ferrara Erdbebensequenzen am 20. und 29.05.2012 in Norditalien

Am 20. und 29. Mai 2012 wurde Norditalien durch zwei starke Erdbeben erschüttert. Die Beben mit Magnituden 6,1 (20. Mai) und 5,8 (29. Mai) richteten erheblichen Schaden in den Provinzen Ferrara, Bologna, Modena und Reggio nell'Emilia an. Beide Hauptbeben sowie die größeren Nachbeben zeigen Herdmechanismen vom Typ Aufschiebung („reverse thrust") und legten als Quellregion zunächst die Mirandola-Verwerfung nahe, eine an der Oberfläche mit Sedimenten bedeckte Struktur des Ferrara Bogens. Jüngste Analysen zeigen aber, dass das Beben vom 29. Mai eher der benachbarten Quarantoli-Verwerfung und das vom 20. Mai der Ferrara-Aufschiebung zugeordnet werden muss, die wie die Mirandola-Verwerfung auch zum Ferrara-Bogen gehören. Alle drei Aufschiebungsstrukturen sind als Folge der NS-Konvergenz zwischen der Afrikanischen und Eurasischen Platte von gegenwärtig 1 cm/Jahr entstanden. Die Region ist, gemessen an anderen Gebieten Italiens, seismisch nicht besonders aktiv, hat aber eine Reihe von Ereignissen mit Erschütterungsintensitäten > 7 in der historischen Vergangenheit aufzuweisen, das stärkste in 1570 mit einer Intensität 7.5 (EMS), nur etwa 40 km östlich des Bebens vom 20. Mai 2012, nahe bei Ferrara.

24 Todesopfer, ca. 400 Verletzte, 15.000 Obdachlose und ca. 1 Milliarde € wirtschaftliche Verluste sind die Schadensbilanz für die beiden Beben von 2012 zusammengenommen. Neben kulturellen Denkmälern und Wohngebäuden waren auch wichtige Industriezweige der Region betroffen, insbesondere die landwirtschaftliche Industrie, für die ein Schaden von ca. 500 Millionen € entstand. Allein 550.000 Parmesan-Räder wurden durch die Beben zerstört. Sie hatten einen Wert von 220 Millionen €.

Van Earthquake (Eastern Turkey), 23. October 2011

James Daniell, Bijan Khazai, Friedemann Wenzel, Tina Kunz-Plapp, Bernhard Mühr, Armand Vervaeck, Michael Markus, Mustafa Erdik

Introduction

The M_w 7.2 Van Earthquake (Eastern Turkey) of 23 Oct. 2011 served as a test case for the aforementioned forensic approach. A timeline of the disaster and a summary of the key outputs will be presented. The time-criticality of such analysis should not be understated, and the methodology used existing data to formulate hypotheses and key questions that needed to be solved within the timescale of hours.

Aims / Objective

1. To undertake a test case for Forensic Disaster Analysis from a “Dark Red” rated event.
2. To produce a series of reports on topics from seismology to socio-economic loss estimation.

Project Status

1. The Initial Process to produce the first Report

For the 23rd October, 2011 Van earthquake event, alerts of major earthquake activity came first from earthquake-report.com including tweets, an increase in logins from Turkey and data from KOERI, SARBIS, EMSC and USGS. The full process leading to the initial report can be seen in the diagram below. There was a great difference in initial hypocenter information coming from the different agencies, making losses difficult to calculate. This type of problem is common and given that the hypocenter location is the most significant parameter for loss information, the estimates from ELER, PAGER, WAPMERR, CATDAT-EQLIPSE showed a large range of losses.

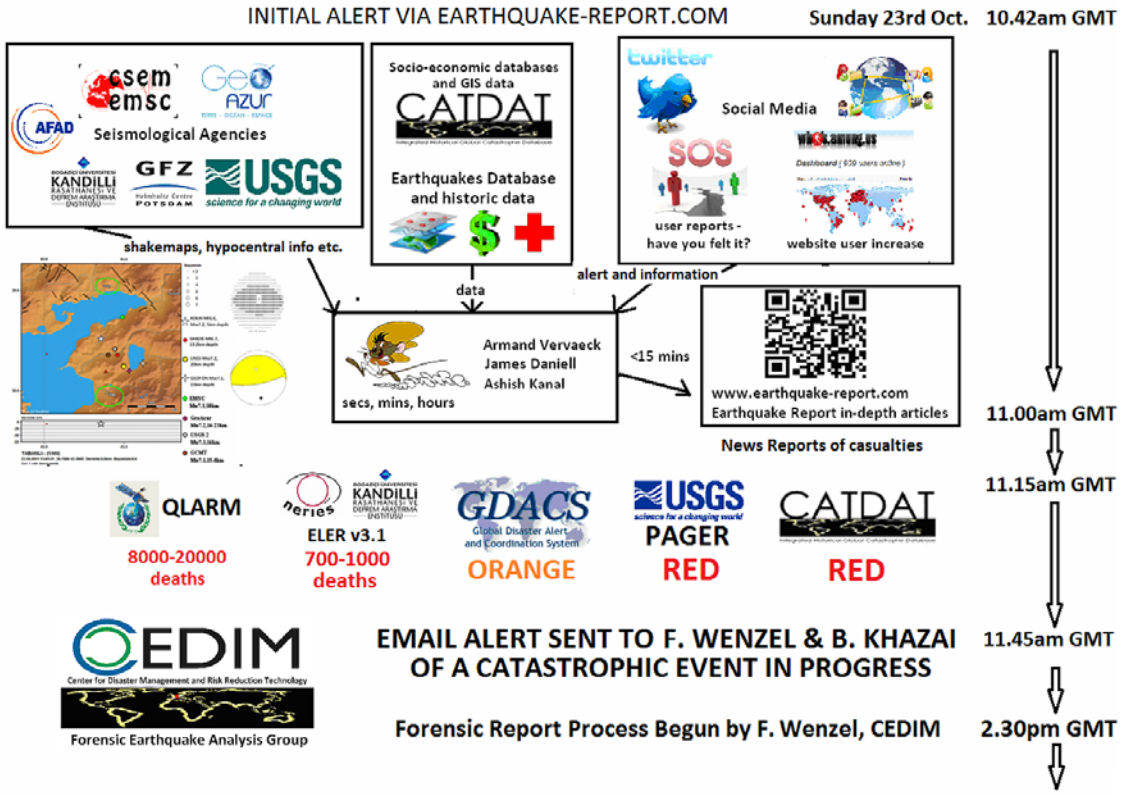

Fig. 1: The initial process used in this instance for the production of the first report

After the email alert was sent giving the level of the disaster, an initial report was compiled by F. Wenzel, checked overnight by J. Daniell and was published the following morning. Within hours of the process being instigated, other members of CEDIM were emailed to check their availability for input. The first report consisted of the event situation, some extra information on the seismology of the area, rapid earthquake loss estimates from various sources and the socio-economic status of the region summarizing and using Earthquake Report collected data.

2. The Outputs from the Van Test Case

Our team consisted of two seismologists, three engineers, a social scientist, an economist, an earthquake reporter and a meteorologist. Four reports were produced:

- 1st Report – Wenzel, Daniell - seismology, initial loss analysis, setting.
- 2nd Report – Daniell, Wenzel, Khazai, Kunz-Plapp, Vervaeck, Mühr - comprehensive report on losses (insurance, socio-economics, seismology, weather etc.), and a situation update
- 3rd Report – Khazai, Daniell, Kunz-Plapp, Wenzel, Vervaeck, Mühr - Shelter Impact dedicated report and continued work on losses including shelter prognosis and in comparison to previous Eastern Turkish Earthquakes.
- 4th Report – Daniell, Khazai, Kunz-Plapp, Wenzel, Mühr, Markus, Vervaeck, Erdik – A comprehensive report (27 pages) including much additional socio-economic loss analysis, comparison with historic East Turkey earthquakes, social vulnerability.

These reports are all available for download from the CEDIM website, www.cedim.de. Given the short time available to produce reports and the limited impact of the earthquakes (644 dead versus around 19,000 dead in Tohoku), the decision was made after the 4th report to only undertake additional work and research through the work of J. Daniell on earthquake-report.com, and to revisit the impacts in 2012 when more details had come available.

3. The Van Earthquake Test Case

The Van earthquake in 2011 hit at 10:41 GMT (13:41 Local) on Sunday, October 23rd, 2011. It was a M_w 7.1–7.3 event located at a depth of around 10 km, with the epicentre located directly between Ercis (pop. 75,000) and Van (pop. 370,000). Much difference in the original hypocenters was seen, with a preferred result coming from KOERI. Since then, the CEDIM Forensic Analysis Group (using a team of seismologists, engineers, sociologists and meteorologists) and www.earthquake-report.com has reported on and analysed the Van event. In addition, many damaging aftershocks occurring after the main event were analysed, including a major aftershock centered in Van-Edremit on November 9th, 2011, causing many additional losses. The epicentral region was probably exposed to 0.4–0.5 g with Van exposed to 0.15 g and Ercis exposed to about 0.2 g. The Van earthquake occurred in one of the poorest regions of Turkey, having an extremely different socio-economic status to that in the western provinces in the country. The Van Province has much inequality between the rural and urban centers, with an average HDI (Human Development Index) around that of Bhutan or Congo. The province of Van has around 1.035 million people as of the last census, however, it was estimated that as many as 1.35 million could live in the province (Van City has an official population of 370,000, yet over 600,000 were estimated to live there).

From the CATDAT Damaging Earthquakes Database, major earthquakes such as this one have occurred in the year 1111, 1267, 1715, 1896 causing major damage and having a magnitude of around 6.5–7. In the year 1648, Van was again struck by a M=6.7 quake killing around 2000 people. In 1881, a M=6.3 earthquake near Van killed 95 people. Again, in 1941, a M=5.9 earthquake affected Ercis and Van killing between 190 and 430 people. 1945–1946 as well as 1972 again brought damaging and casualty-bearing earthquakes to the Van province. In 1976, the Van-Muradiye earthquake struck the border region with a M=7, killing around 3840 people and causing around 51,000 people to become homeless. Comparative earthquakes were studied to look at the relative impact of this quake.

The earthquakes are estimated to have caused 604 deaths (23 October) and 40 deaths (9 November); mostly due to falling debris and house collapse. In addition, between 1.5 billion TRY to 4 billion TRY (approx. 800 million USD – 2.2 billion USD) is estimated as total economic losses with a median of 1.1 billion USD. This represented around 25 to 66 % of the provincial GDP of the Van Province (approx. 3.3 billion USD) as of 2011. Other estimates of 1.2 billion USD

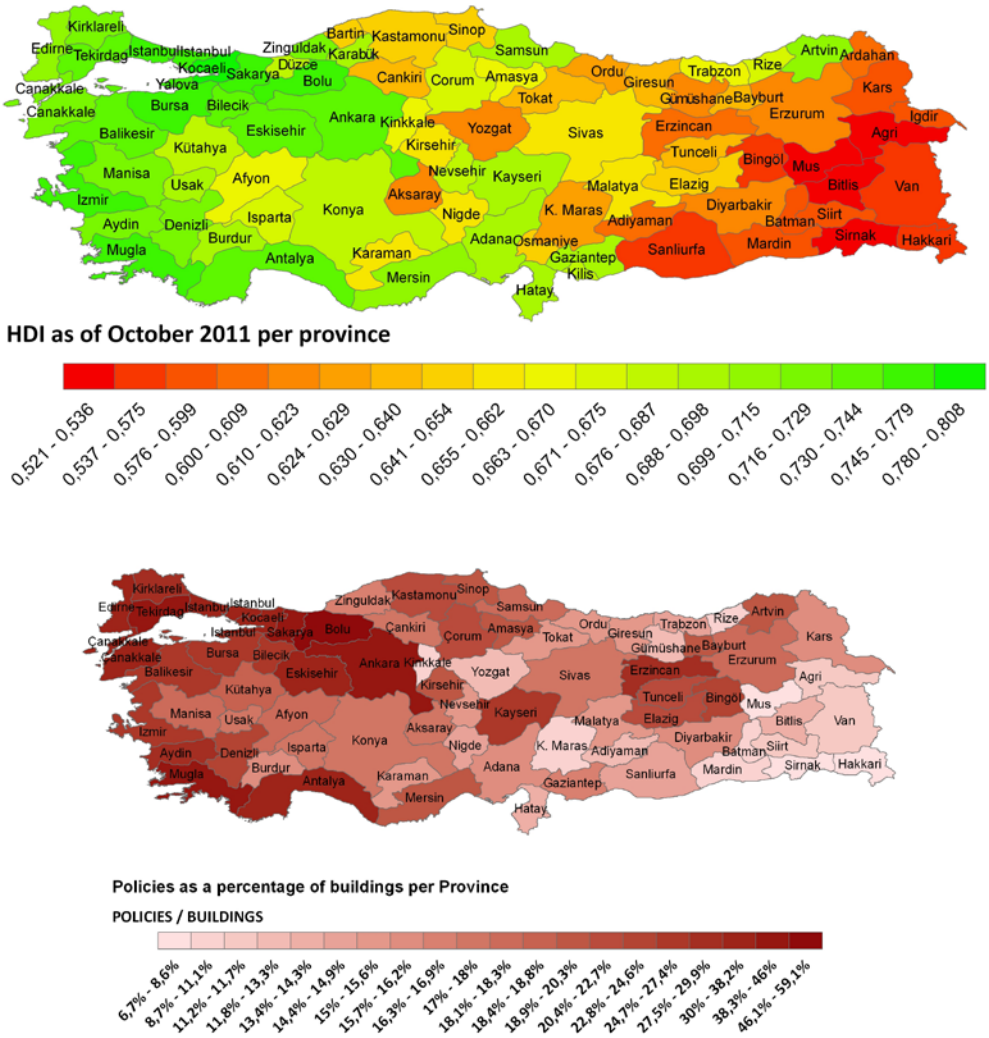

Fig. 2: Human Development Index in each province from CATDAT as of October 2011 (upper) ; TCIP (Insurance) policies as a percentage of buildings per province (lower)

direct losses with 0.3 billion USD indirect losses have been made in Erdik et al., March 2012. For Van Province (Ercis and Van cities) which was much more affected by this quake, for the 64,081 buildings registered, 7312 of them have TCIP insurance for earthquakes, equivalent to 11.4 % with a 814,670TRY (453,000 USD) premium. Based on the 814,670 TRY premium, there is an exposure of approximately a 400 million TRY (222 million USD. Final insurance losses totalled around $30–70 million. In addition, in-depth analysis was undertaken as to shelter needs.

Outlook

The reports produced as described in the test case of the Van Earthquake of 23rd October 2011 were tuned to agencies such as Civil Protection agencies, UN Organizations (OCHA relief web), International Relief Organizations, Scientific and Professional Organizations (EERI), Development Organizations and Industry (Insurance, tourism, global-scale manufacturing, etc.) in order to provide useable post-disaster information. In addition, learning through this rapid post-disaster analysis, new research areas were discovered in locations where there is little or non-detailed census information. Future work by the CEDIM Forensic Disaster Group includes further developing a network of interested people and groups to cover more perils (man-made, etc.), emphasising insurance and other economic aspects, knowledge management, re-visiting forensic disaster analysis sites and processes and to enhance stakeholder interaction.

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Van Erdbeben (Ost Türkei), 23. Oktober 2011

Das Magnitude 7,2 Van Erdbeben (Ost-Türkei) vom 23. Oktober 2011 diente als Testszenario für das Vorgehen während einer zeitnahen forensischen Katastrophenanalyse. Präsentiert wird die Zeitabfolge der Katastrophe und eine Zusammenfassung der Schlüsselelemente. Der Zeitfaktor solcher Analysen ist nicht zu unterschätzen. Der Methodologie entsprechend wurden dafür bereits existierende Daten genutzt, um eine Hypothese und Schlüsselfragen zu formulieren und diese innerhalb von Stunden zu lösen.

Die innerhalb von zwei Wochen nach dem Erdbeben erschienenen vier CEDIM-Reporte thematisieren verschiedene Aspekte, wie zum Beispiel sozio-ökonomische Verlustanalysen, Schutzräume, Vergleiche mit historischen Erdbeben in der Ost-Türkei und sozialeVulnerabilität. Die größten Auswirkungen des Bebens betrafen die Bevölkerung mit über 250.000 Obdachlosen und einem ökonomischen Verlust von ca. 30 % des lokalen BIP.

Die CEDIM-Reporte über das Van-Erdbeben vom 23. Oktober 2011 wurden Zivilschutzeinrichtungen, UN-Organisationen (OCHA), Hilfsorganisationen, wissenschaftlichen und professionellen Organisationen (EERI), Entwicklungsorganisationen und der Industrie (Versicherung, Tourismus, etc.) zur Verfügung gestellt, damit diese brauchbare Informationen für den Zeitraum nach dem Erdbeben erhalten. Zusätzlich wurden durch den Lernprozess während der Katastrophenanalyse neue Forschungsbereiche entdeckt, in denen nur wenig oder keine detaillierten Erhebungen existieren.

Global Earthquake Model

Jochen Zschau

CEDIM's engagement in the Global Earthquake Model GEM, a public/private partnership for the assessment and communication of earthquake risk worldwide, has continued throughout 2012. Contributions were made in four of the following five scientific programme activity areas of GEM:

1. *Global components,*
2. *Regional Programmes,*
3. *Testing & Evaluation Facility,*
4. *Socio-Economic Vulnerability,*
5. *Model Facility.*

The Earthquake Model Central Asia (EMCA), a programme for cross-border harmonized earthquake risk assessment in Central Asia, was brought forward by CEDIM as one of GEM's *Regional Programmes*. It includes contributions to the development of a tool for rapidly capturing building inventory data, made as part of GEM's ongoing *Global Component "Inventory Data Capture Tool (IDCT)"*. Whereas these activities together with the further growth of GEM's *Testing & Evaluation Facility* at the GFZ in Potsdam were continuations from the years before, setting up GEM's *Socio-Economic Impact Model* was instigated by CEDIM only in 2012.

Major results in the frame of CEDIM's Earthquake Model Central Asia (EMCA) programme that were achieved in 2012, include a new, harmonized earthquake catalogue for Central Asia with an accurate reevaluation of magnitudes and locations of historical events, and a harmonized seismic zonation model for the region that was agreed upon by local experts of all five countries involved, Kyrgyzstan, Kazakhstan, Tajikistan, Turkmenistan and Uzbekistan. As an extension of similar work by CEDIM in Bishkek and Karakol in Kyrgyzstan, equivalent site effect experiments were set up in 2012 in Dushanbe and Korogh in Tajikistan. They involved seismic monitoring networks as well as single station noise measurements and seismic noise array measurements. The collection of exposure and vulnerability data, especially for the major cities of the region, was carried on with the goal of achieving a level of aggregation compatible with the spatial resolution of the site response studies. Accordingly, high-resolution remote sensing images were collected for the main cities in Central Asia and panoramic-camera images were acquired for the cities of Osh and Yalabad in Kyrgyzstan and for Khorog in Tajikistan. Based on the newly developed vulnerability monitoring tool (see report 2011) that combines remote sensing with panoramic-camera images, a vulnerability model (building vulnerability) was completed for Bishkek, the capital of Kyrgyzstan. It is currently being compared with equivalent results obtained on the basis of classical methods. All activities were carried out in close interaction with local scientists, practitioners and decision makers.

GEM's Testing & Evaluation Center has been established at the GFZ in Potsdam and has been in operation since September/October 2011, with the aim of developing tools for retro- respectively, pseudo-prospectively and prospectively testing all major components of the earthquake risk assessment chain and applying them to the components of GEM's earthquake risk model(s). Specific testing targets are high impact assumptions, often based on expert opinions.

CEDIM's first truly prospective tests for intensity prediction equations (IPEs) revealed the unexpected result that for the case of Italy a recent global IPE was clearly superior to eight other tested regional IPEs. This supports the idea that IPEs may be formulated globally, at least for regions with the same tectonic setting. Another testing target in 2012 has been the maximum magnitude Mmax which usually enters into probabilistic hazard calculations. It appears that this quantity is not testable, at least when its determination is based on seismicity data alone. Its usefulness for hazard assessments is, therefore, now debatable.

A project on Social and Economic Impacts in the Global Earthquake Model (GEM) was initiated in 2012, funded partly by GEM and partly by the Willis Research Network and carried out by CEDIM under the coordination of the GEM Secretariat. The project will develop indices

for social vulnerability, disaster resilience and indirect losses as well as the accompanying data bases and tools that support the use of the indices. It is envisaged to integrate both the indices and tools into GEM's risk assessment platform. So far, the focus of activity was on the harmonization of globally available data for this purpose as well as on the implementation of a worldwide country-level indicator system.

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

Globales Erdbebenrisiko-Modell

CEDIM's Engagement im Rahmen des globalen Erdbebenrisiko-Modells GEM wurde auch in 2012 aufrecht erhalten. Es beinhaltet zwei Aktivitätsfelder, die aus 2012 fortgeführt wurden,

- die grenzübergreifende harmonisierte Erdbebenrisiko-Abschätzung für Zentralasien,
- Arbeiten zum Testen und Evaluieren aller Komponenten des Erdbebenrisiko-Modells,
- sowie eine in 2012 neu gestartete Initiative zur Integration sozio-ökonomischer Erdbebenfolgen in das GEM Risikomodell.

Auf allen drei Gebieten konnten wichtige Fortschritte erzielt werden. Sie beziehen sich im Fall des Regionalprogramms Zentralasien (EMCA) auf einen neuen harmonisierten Erdbebenkatalog für die Region, ein grenzübergreifendes seismisches Zonierungsmodell, Modelle zu lokalen seismischen Standorteffekten für eine Reihe großer Städte Zentralasiens und den Aufbau einer Datenbasis für die Vulnerabilitätsanalyse mit Hilfe des im Projekt neu entwickelten Vulnerabilitäts- und Risiko-Monitoring-Tools (siehe Jahresbericht 2011). Das Vulnerabilitätsmodell für die Hauptstadt von Kirgistan, Bishkek, konnte abgeschlossen werden.

Die in 2012 durchgeführten Arbeiten zum Testen von Komponenten des GEM-Risikomodells unterstützen die These, dass globale IPEs („intensity prediction equations") auch regional anwendbar sind und, wie für den Fall Italien gezeigt, bessere Ergebnisse liefern können als regional vorhandene IPEs. Sie machen zudem deutlich, dass die in probabilistische Gefährdungsabschätzungen eingehende Maximalmagnitude nicht testbar ist und daher einen kritischen Faktor in Gefährdungsabschätzungen darstellt.

In dem neuen Projekt zu sozio-ökonomischen Erdbebenfolgen werden Indizes für soziale Vulnerabilität, Katastrophen-Resilienz und indirekte Verluste entwickelt sowie begleitende Datensätze und Tools, die die Anwendung der Indizes unterstützen sollen. Für diesen Zweck konnte CEDIM in 2012 ein weltweites Indikatoren-System auf Länderebene erarbeiten.

Earthquake Model Central Asia (EMCA): Towards an Integrated Assessment of Seismic Hazard, Exposure and Vulnerability on Regional Scale

M. Pittore, M. Wieland, D. Bindi, S. Parolai, M. Pilz, S. Ullah, J. Stankiewicz, T. Boxberger, A. Saponaro, S. Tyagunov, B. Moldobekov, S. Orunbaev, U. Begaliev, P. Yasunov, A. Ishuk, R. Ibrajimov, J. Nyazov, A. Dusheev

Several activities have been carried out with a strong focus on the assessment of seismic risk in Central Asia. A critical step towards this overarching goal is the careful and uncertainty-aware analysis of the exposed assets (for instance, the building inventory), also known as the exposure model, and the susceptibility of such assets to seismic ground shaking (the vulnerability model). When such assessments are carried out in Central-Asia, the lack of available information or its poor geographical distribution calls for new tools and methodologies to be developed.

Seismic Hazard Assessment

Some of the main ingredients for a robust seismic hazard assessment are particularly the availability of a reliable earthquake catalog for the area under investigation, and a seismic zonation model that can combine of the existing geophysical and geological information in a harmonized and comprehensive way. For this reason, during the second year of the project a first version of the earthquake catalog for Central Asia was prepared after having accurately re-evaluated the magnitude and the location of historical events. While for most of the events the available magnitude and location data were confirmed, in a few cases a new estimation of the magnitude from intensity values was assigned. Figure 1 exemplifies the case of the 1911 Kemin earthquake which, according to different catalogs, has a magnitude ranging from M_s 7.8 to 8.4. The moment magnitude estimated from intensity assignment is 7.6, with a 5 % confidence interval equal to half of magnitude unit.

For the seismic zonation model, it was remarkable that while for every country a zonation model was available, when these were compared in the areas of overlap very often the models did not fit. It was clear that different strategic decisions were taken in the past by different expert groups in each country regarding the extension of the source area on the assignment of the possible maximum magnitude. It was only after an expert meeting held in June 2012 in Bishkek (Kyrgyzstan), that a harmonized model for seismic zonation for the

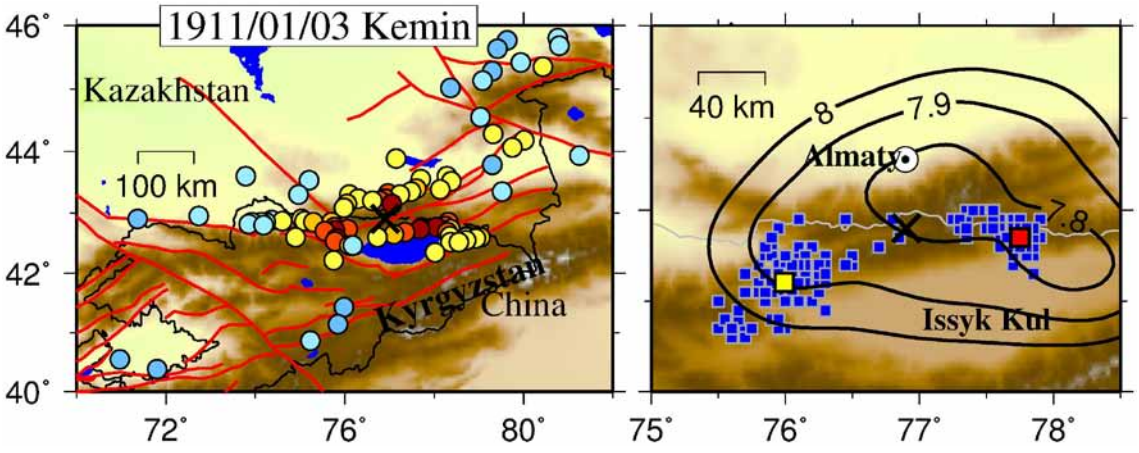

Fig. 1: Left Distribution of the intensity assignments for the 1911 Kemin earthquake, in terms of MSK-64 scale. Right: bootstrap solutions (squares) for the intensity epicenter. The black contour lines indicate the solutions for the intensity magnitude.

whole Central Asian countries was defined; this will provide the base for the future Probabilistic Seismic Hazard Assessment in the area.

In order to increase the spatial resolution of seismic hazard risk assessment for specific hot spots, site effects studies are necessary to evaluate the variability of the ground shaking due to an earthquake over a short distance. Following the work carried out previously in Bishkek and Karakol (Kyrgyzstan), a new large site effect estimation experiment was set up in Dushanbe and Korogh in Tajikistan. A network of 45 seismological stations was installed for a total of nearly 6 months in the urban area of Dushanbe in order to record local, regional and teleseismic events. After 3 months some of the stations have been moved to different sites to increase the number of points where site effects can be estimated. During this experiment single station noise measurements have been carried out at different sites aiming, by applying the approach of Ullah et al., (2012), to improve the spatial resolution of the site response. Additionally, seismic noise array measurements have been carried out at characteristic sites.

Similarly, but using a smaller number of instruments, a site-effect experiment was carried out in the mountain town of Korogh. The results are expected to provide important information in different geological and social (urban/rural) environments.

Seismic Exposure and Vulnerability Assessment

The collection of exposure and vulnerability data for Turkmenistan, Tajikistan and Kyrgyzstan continued, with different levels of aggregation, for consideration of the regional hazard- and risk-assessment of relevant urban hot-spots (mostly the capitals and prominent cities for each country). The enlargement of the data set was made possible by a closer cooperation with local partners and new in-situ investigations. In particular, panoramic-camera images have been collected for Osh and Jalalabad (Kyrgyzstan) and Khorog (Tajikistan). In cooperation with the GFZ´s Centre for Early Warning, high-resolution remote sensing images have been acquired for the main towns of all Central Asian countries and will be analysed in order to obtain information about the vulnerability of the building stock at a level of aggregation compatible with the spatial resolution of the site responses. The analysis of the remote sensing and panoramic camera data previously collected in Bishkek, performed with innovative tools (see Pittore and Wieland, 2012), led to the assessment of the vulnerability for the town, highlighting for instance how the areas of recent expansion (in particular, those located in the south-western part of the town) are also particularly vulnerable and exposed to the highest levels of seismic hazard, as depicted in Figure 2. The comparison of these results with a vulnerability model of Bishkek as obtained with classical methods, is currently under way.

Moreover, within the GEM global component IDCT (Inventory Data Capture Tool), particular care has been devoted to selecting the proper FOSS (Free, Open-source Software) environment for GIS (Geographical Information System) management and data processing. This proved critical to streamline the data acquisition and management phase for the composition of the exposure model, a critical component of the vulnerability assessment phase.

Capacity Building and Networking

For a transnational harmonization of seismic risk assessment, it is of paramount importance that all partners share a similar background and are up-to-date on the cutting-edge methods for seismic hazard and vulnerability analysis. Furthermore, involving possible end-users it is essential when gathering the important input during the preparation phase to illustrate how the final results can find an application in the countries involved. In this regard, during the second year of the project, two meetings were held with the Minister of Emergency Situations in Kyrgyzstan and a meeting with the Minister of Emergency Situations of Kazakhstan.. The meetings confirmed the strong interest of these Central-Asian countries in modern seismic hazard and risk assessment methods. The partner countries confirmed moreover their availability in considering the resulting findings in the future seismic risk mitigation actions. In order to create a common background among the participants of the EMCA project, focused training activities were organized both in Germany and in Central Asia. The capacity-building activities addressed several techniques of practical use, ranging from the software OpenQuake/OpenGEM to the application of modern open-source GIS software for seismic risk analysis. The strong commitment to foster the use of FOSS solutions among the regional partners, although less effective in the short term due to the steeper learning curve required, is believed to be preferable over a longer term perspective. It will indeed allow the adoption of a common set of high-level procedures that will be shared

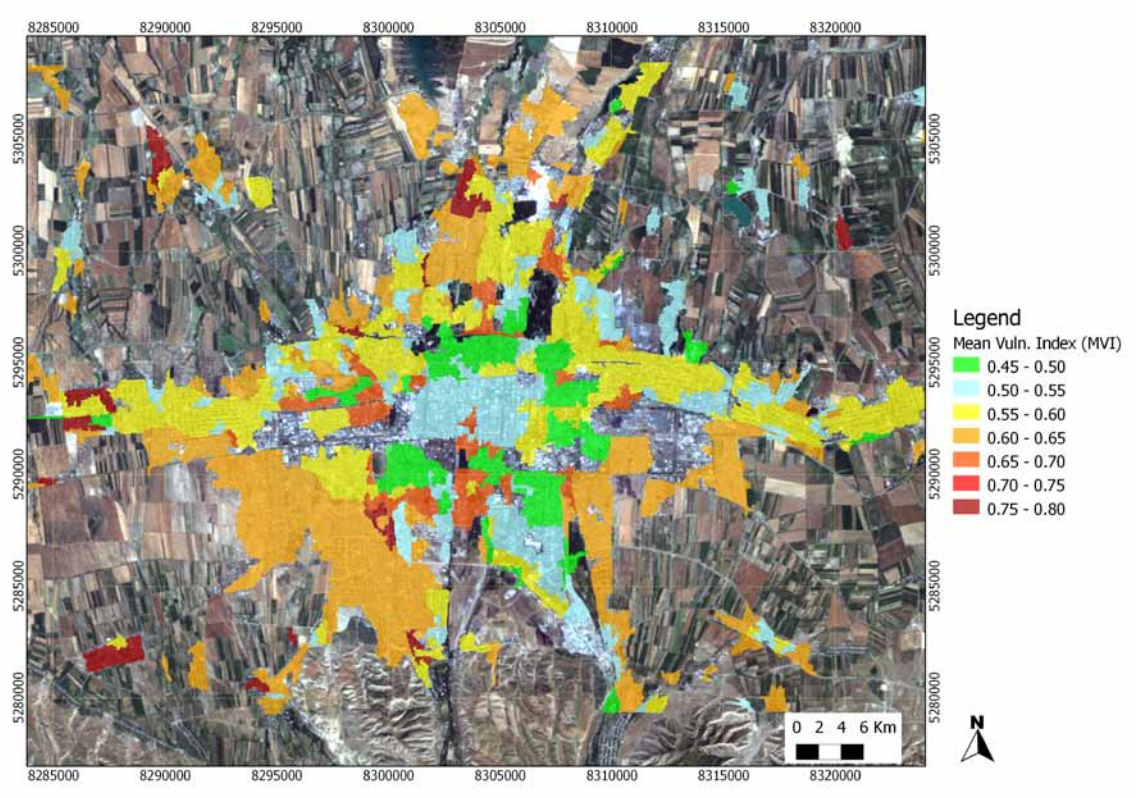

Fig. 2: Geographical distribution of seismic vulnerability in Bishkek (KG), in terms of Mean Vulnerability Index (MVI)

among the participants, and will streamline the development of a wider community of practitioners interested in the broader panorama of geo-risk mitigation and resilience-improvement methodologies.

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Publications

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EMCA: ein GEM Regionalprogram für Zentral Asien

CEDIM führte verschiedene Aktivitäten im Rahmen der globalen seismischen Risikoanalyse in Zentralasien durch. Voraussetzung zur Erreichung dieses übergeordneten Ziels ist eine sorgfältige Analyse exponierter Werte (zum Beispiel des Gebäudebestandes) und deren Verwundbarkeit im Falle von Erdbeben unter Berücksichtigung von Unsicherheiten. Eine oft mangelhafte, veraltete und räumlich sehr heterogen verteilte Datengrundlage erfordert die Entwicklung von neuen Werkzeugen und Methoden zur Expositions- und Verwundbarkeitsanalyse. Im Rahmen der Aktivitäten wurden vorhandene Daten auf verschiedenen Aggregationslevels durch enge Kooperation mit lokalen Partnern gesammelt und entsprechend internationaler Standards aufgearbeitet. Ferner wurden vor Ort Untersuchungen mit omnidirektionaler Kamera in verschiedenen Zentralasiatischen Städten durchgeführt. Für Bishkek, Kirgistan konnten durch die Analyse der Bilddaten in Verbindung mit Satellitendaten bereits Rückschlüsse auf die Verwundbarkeit des Gebäudebestandes gezogen werden. Bezüglich seismischer Gefährdungsanalysen konnte im Rahmen des Erbebenmodels Zentralasien (EMCA) in enger Kooperation mit lokalen Partnerinstitutionen eine harmonisierte transnationale seismische Zonierung erstellt werden. Ferner wurde ein detaillierter Erdbebenkatalog der Region kompiliert. Für manche Regionen wurden des Weiteren seismische Mikrozonierungen durchgeführt um lokale Verstärkungseffekte der Bodenbewegung zu analysieren. Trainingskurse in Deutschland und Zentralasien für Wissenschaftler aus der Region wurden organisiert, um die enge Zusammenarbeit weiter zu stärken und den Wissensaustausch zu fördern. Treffen mit den jeweiligen Ministerien für Katastrophenvorsorge und Bevölkerungsschutz (Ministry of Emergency Situations) von Kirgistan und Kasachstan bestätigten das große Interesse der Zentralasiatischen Staaten an modernen seismischen Gefährdungs- und Riskoanalysen und an einer weiteren Forschungskooperation.

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 a standard through the Collaboratory for the Study of Earthquake Predictability (CSEP) and is 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 works together with the model builders to make GEM and its part as testable as possible. It provides tools and software systems for retrospective testing to help improve the model during its development stage, it tests pseudo-prospectively and prospectively many components of GEM, and it works on testing high-impact assumptions of GEM. The following components have been identified as primary targets for testing:

1. Seismicity rate models
2. Develop a prototype testing chain for the OpenQuake system of GEM
3. Implementing a ground-motion prediction testing center to test intensity and ground-motion prediction equations
4. Developing prototype tests for hazard model testing
5. Collaborating with the Global Consequences Database component to characterize the current and future dataset for testing risk models
6. Setting up a testable hypothesis for testing Mmax

Project Status

The core science team started working in September/October 2011.

Seismicity Rate Testing

For seismicity rate model testing, the T&E effort uses existing CSEP testing capabilities. These were extended to accept seismicity rate models that are defined on arbitrary zones (polygons).

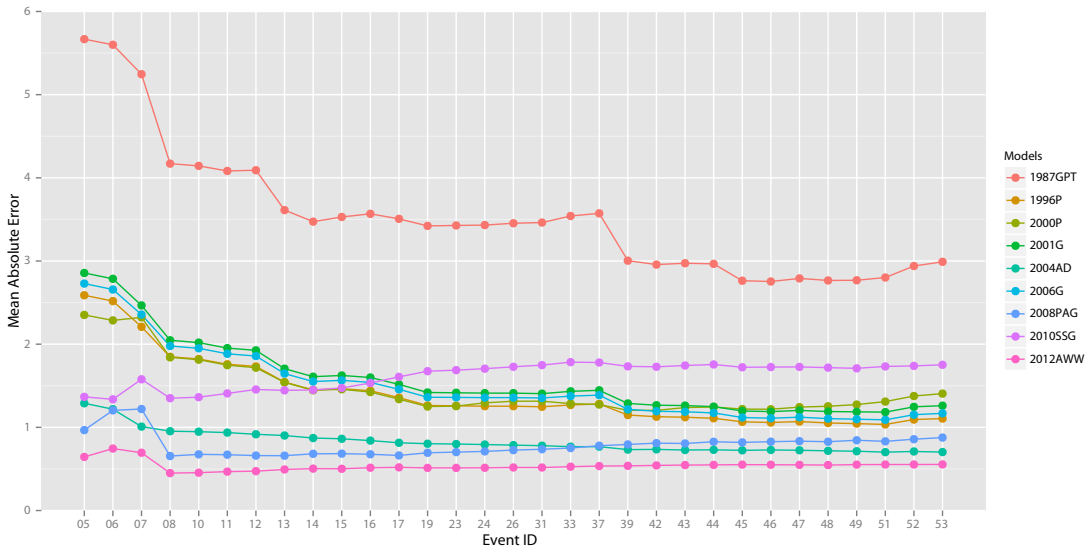

Fig. 1: Cumulative mean absolute error of Italian Intensity Prediction Equations. The model with the smallest error (2012AWW) is the only global model in this set. The very influential model for Italian seismic hazard (1987GPT) exhibits the largest errors.

This extension is operational but the GEM seismicity rate models are still under development.

Currently, we are working on quantifying the impact of location uncertainties of earthquakes on test results to solidify our testing metrics.

Ground Motion Testing

In the domain of testing ground motions, we developed various metrics and results visualizations for testing Intensity Prediction Equations (IPE). As a case study, we applied the methods to 8 IPEs valid for Italy and a recent global one. Additionally, we performed a suite of sensitivity tests (Determination of maximum intensity, various intensity sources as input). This test was carried out in a truly prospective sense, i.e. the models were created using data prior to the observations used for testing; the observational data was unknown. The results show that the global model performs best, followed by an Italian model from 2004 (see Fig. 1). Interestingly, the models used for seismic hazard assessment in the 1990s in Italy do not perform well compared to the global model. The upside of this result is that IPE may be formulated globally or at least covering the same tectonic setting. Additionally, no significant spatial residuals have been detected, rendering the distance to the epicenter the key quantity.

This experimental setup is now implemented in the GEM Testing Center at GFZ Potsdam. In addition, further data sources like USGS “Did You Feel It?” are introduced so that IPE tests for almost any region on Earth can be conducted in an automated fashion.

We have implemented the tests for Ground-motion Prediction Equations (GMPE) and currently conducting a case study on almost 20 GMPEs for Japan. This will soon be augmented by a case study on Taiwan to compare GMPEs for a similar tectonic setting.

Maximum Magnitude

We designed experiments to test for the estimate of a maximum magnitude as given for zones or faults in seismic hazard assessment. This experiment is designed to rely only on earthquake catalog information: Can a maximum magnitude be proven wrong with high power without observing an earthquake of even higher magnitude. The results clearly show that no test with sufficiently high power can be carried out in a reasonable time frame. Even almost meaningless low-power results will need several centuries of observations. Another equally important conclusion is that no useful estimate of a maximum magnitude can be derived from seismicity alone.

Outlook

We will introduce the GMPE work to the GEM testing center for regional and global prospective testing of GMPEs. After this, we will start testing efforts on hazard, combining earthquake rate forecasts and GMPEs. We plan to revisit the maximum magnitude problem by including geologic information (moment rate) and also investigating the testability of tapered magnitude distributions.

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Publications

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Social and Economic Impacts in the Global Earthquake Model (GEM)

Bijan Khazai, James Daniell, Julia Schaper, Friedemann Wenzel

Introduction

A project on Social Vulnerability and Resilience was initiated in 2012. The work for this project is being led by the Center for Disaster Management and Risk Reduction Technology (CEDIM) under the coordination of the GEM Secretariat. Both GEM and the Willis Research Network provide support for the project. The project directly supports GEM's mission of producing a holistic global earthquake risk model that integrates metrics of social vulnerability and disaster resilience with the on-going activities of hazard and physical risk.

Aims / Objective

The goal of the project is to facilitate the development and implementation of the tools and assessment standards for measuring earthquake risk holistically, via the development of indices and accompanying databases of social vulnerability, resilience, and indirect loss vulnerability to earthquake impacts. The project comprises five tasks, which can be divided into development of indices and accompanying databases and development of tools that allow users to interact with / use the indicators. Both the indices and tools will be integrated into GEM's risk assessment platform. The socio-economic database and indices are being developed at three different assessment scales: Country level (for the globe); Provincial level (for the Asia-Pacific region); and Municipal level (for Japan and Philippines).

Project Status

The initial focus has been on implementing a country-level indicator system for the world that builds upon existing methods and metrics defined within the field. Thus far, 1583 socio-economic variables have been compiled and geo-coded for 197 countries worldwide using 44 different publically available sources. A major effort thus far has been harmonizing the globally available data and evaluating them for relevance to the resilience and vulnerability indices, internal consistency and completeness. A literature review to identify the most significant variables representing social vulnerability, resilience and economic vulnerability has been carried out. Sensitivity analysis measures are also being conducted to check robustness of data. Preliminary principal component analyses (PCA) have been used to investigate the statistical relevance of the variables selected from the literature review. First results were used to eliminate highly correlated variables and thus start the indicator selection refinement.

Soziale und ökonomische Auswirkungen im Global Earthquake Model (GEM)

Das Projekt „Social Vulnerability and Disaster Resilience“ in GEM befasst sich mit der Entwicklung und Implementierung von Methoden, Messsystemen und Werkzeugen zur holistischen Auswertung von Erdbebenrisiken. Ziel des Projekts ist es, die Implementierung von Indikatoren, Indizes und Abschätzungsstandards zu ermöglichen, um die soziale Vulnerabilität, Resilienz und indirekte ökonomische Vulnerabilität von Bevölkerungen in Bezug auf Auswirkungen von Erdbeben zu ermessen.

Das Projekt umfasst fünf Aufgaben, welche in zwei Gruppen aufgeteilt werden können: die Entwicklung von Indizes und begleitenden Datenbanken und die Entwicklung von Werkzeugen, welche es dem Nutzer ermöglichen, die Indikatoren individuell zu verwenden. Sowohl die Indizes wie auch die Werkzeuge werden in die GEM risk assessment platform integriert. Die Arbeit für dieses Projekt begann in 2012 und wird vom Center for Disaster Management and Risk Reduction Technology (CEDIM) geführt, unter der Koordination vom GEM Sekretariat. GEM wie auch das Willis Research Netzwerk stellen dem Projekt Unterstützung zur Verfügung. Das Projekt unterstützt die Mission von GEM ein holistisches, globales Erdbebenrisikomodell zu erstellen, welches integrative Messmethoden von sozialer Vulnerabilität und Disaster Resilienz mit den laufenden Aktivitäten zur Gefährdungs- und physischen Risikoanalyse verbindet.

Another goal of the project is the development of a tool that allows users to combine their local knowledge and data with the GEM data sets and indices described above, in order to develop their own (composite) index or indices. A tool building workshop was held on October 24, 2012 between scientist from IIP, IKET and GPI at KIT and the GEM Modeling Facility to discuss and develop the requirements for the indicator toolkit.

Outlook

The harmonized database for the global level indicator construction is expected to be completed by the end of February 2013. The target for collection of data, exploratory and statistical analysis for sub-national and municipal level is set for the end of September 2013. By the same time, a Social Vulnerability Index and Disaster Resilience Index at the global level will be developed. A 'blue print' for developing the Indicator Toolkit will be developed by the end of May 2013.

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Publications

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Vulnerability and Critical Infrastructures

Measuring Disruption Impacts and Facilitating Disaster Risk Management in the Field of Critical Infrastructure Protection

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Introduction

The long-term blackouts caused by the hurricane "Sandy" clearly highlighted how severe the consequences of electricity disruptions can be. Additionally, the recent short-term blackouts in German urban areas such as Munich and Frankfurt show that energy systems are vulnerable and prone to failure – even if conditions are less extreme. Together, increasing severity of consequences and growing vulnerability imply that Critical Infrastructure (CI) disruptions will be one of the key challenges in emergency management.

The CEDIM-project 'Decision Support Methods in the Field of Critical Infrastructure Protection (DSM CIP)' will develop methods and tools supporting official civil protection authorities and CI providers to prepare for and manage CI disruptions such as power outages, drinking water pollutions or supply chain failures. The research on DSM CIP refers to two former CEDIM projects 'SIMKRIT' (06/2009-12/2009) and the 'KRITISKONZ' (06/2010-12/2010) (see CEDIM annual reports of 2009 and 2010).

Aims / Objective

In recent years, activities within the framework of the DSM CIP project were mainly devoted to analyzing the most important CIP risk and crisis management processes and end-user requests. Further to this, the partnership with potential users and issue-related research groups was intensified. In 2012, the project aimed at widening the development of a toolbox by focusing on methods for analyzing CI interdependencies, predicting and displaying consequences of CI disruptions / impacts and on methods to facilitate the selection of appropriate counter-measures. These new tools are designed to support risk and crisis managers of CI providers and Emergency Management Authorities (EMA) to minimize the likelihood and impact of CI disruptions (i.e. the risk) and to strengthen the mitigation abilities in response, relief and recovery.

Project Status

To model and to simulate CI interdependencies after a disastrous incident, we focused on two approaches: System Dynamic (SD) modeling and Agent-based Modeling and Simulation (ABMS) to analyze CI interdependencies in case of disruptions and to model the behavior of the entire system of different CI services. Ultimately, we aim at deriving and evaluating mitigation strategies.

SD is a method to understand complex systems and to analyze the evolution of a system over time. By modeling the system interactions and feedback loops it is possible to understand a system's behavior. In the DSM CIP project, SD was used to display the impacts of CI disruptions and to identify potential cascading effects. Based on the German Strategy of CI protection, the interdependencies of CI sectors and their branches were used to develop a very first simplified SD model and to simulate the dynamic consequences of different kind of incidents (Münzberg, Comes, & Schultmann, 2012).

ABMS is an important approach to explore and analyze complex and large-scale systems such as CI Networks since it allows a large number of interacting autonomous agents. Initially, a comprehensive literature study was conducted to gain an overview of the current status of frameworks that facilitate agent modeling and which would be appropriate for our purpose. The main parameters considered in the selection of appropriate frameworks were: performance capability, primary domain, programming language and availability of sufficient support-

ing documentation. The most promising frameworks are currently being tested and analyzed by building simple models.

Additionally, Multi-Criteria Decision Analysis (MCDA) components were used to identify and evaluate (counter-)measures. This implies the development of multi-criteria models to visualize CI disruption-triggered vulnerabilities of different supply regions of municipalities and to facilitate the understanding of disruption impacts in urban areas.

The current research focused on both generic as well as concrete disruption scenario approaches. Generic approaches take into account CI disruptions caused by different natural as well as man-made disasters e. g. hurricanes, floods, earthquakes and industrial accidents. This approach contributes efforts mainly on the total system of CIs. Disruption scenario approaches only focus on a single CI sector. The DSM CIP frame combined both approaches. Special issues on disruption scenario approaches are blackout-related CI protection researches due to the fact that power systems are nowadays typically operated closer to their stability limits by applying new utilities and the ongoing system transformation process.

The intensified partnerships with end-users and other research groups allowed for application for further research grants. Two further projects could also be realized, one focusing on simulation- based decision support for incidents of food shortages (SEAK) and one on socio-economic analyses of terrorism counter measures in local public transport (RIKOV). Both started in Winter 2012/13 and are funded by the German National Security Research Framework.

Outlook

The CEDIM-project ‘Decision Support Methods in the Field of Critical Infrastructure Protection (DSM CIP)’ will be continued (or is being continued) and aims at fulfilling the objectives by widening the research methods. The two new projects SEAK and RIKOV provide the opportunity to advance DSM CIP regarding specific disaster scenarios. The research on CI modeling and simulation via SD and ABMS as well as on MCDA-methods will be intensified and applied to an integrated approach for supporting decision making processes for CIP.

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Auswirkungen von Versorgungsausfällen und Entscheidungsunterstützung für den Schutz Kritischer Infrastrukturen

Die Bewältigung und Beherrschung ausgefallener oder beeinträchtigter Kritischer Infrastrukturen (KRITIS) stellen Betreiber und Behörden und Organisationen mit Sicherheitsaufgaben vor ernsthafte Herausforderungen. Die durch Hurrikan ‚Sandy‘ verursachten langanhaltenden und großflächigen Stromausfälle in Nordostamerika zeigen die Aktualität der Problematik auf. Um dieser zu begegnen werden Methoden zur Entscheidungsunterstützung entwickelt. Einen Schwerbunkt bilden Analysewerkzeuge zur Vermeidung und Minderung von KRITIS-Ausfällen. Ferner sollen beim Ausfall von Versorgungsinfrastrukturen geeignete Maßnahmen zur Wiederherstellung initiiert werden.

Aufbauend auf den bisherigen Arbeiten wurden erste systemdynamische und agentenbasierte Modelle entwickelt, um Interdependenzen aber auch die kaskadierende Ausbreitung von Versorgungsausfällen innerhalb des KRITIS-System zu simulieren. Zusätzlich wurden erste Multi-Kriterielle Entscheidungsmodelle (MCDA) entwickelt, um die Auswahl von (Gegen-) Maßnahmen zur Vermeidung, Minderung und Vorbereitung gegen Versorgungsausfälle zu erleichtern. Diese Arbeiten werden basierend auf verschiedenen Bedrohungsszenarien weitergeführt, um sowohl die Endnutzerorientierung als auch die Anwendung auf bestehende Risiko- und Krisenmanagementprozesse sicherzustellen.

Publications

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WEATHER project: Policy Instruments and Transport Adaptation

Tina Comes, Christian Trinks, Frank Schultmann

Introduction

Levina and Tirpak (2006) understand adaptation to climate change as “a process by which strategies to moderate, cope with, and take advantage of the consequences of climatic events are enhanced, developed, and implemented”. Regarding transport systems, the overall aims of adaptation are the mitigation of impacts by reducing the exposure and increasing the resilience. The latter can be achieved by improving the adaptive capacity of transport modes. The WEATHER project examined the adverse impacts of extreme weather events on the European transport system and confirmed the common perception of their increase. Nevertheless, adaptation of transport systems to extreme weather events is not common practice due to the fact that impacts of extreme weather events on transport systems are not yet perceived as recurring irregular shocks. The four major transport adaptation areas identified in the WEATHER project are planning and general protection, infrastructure technology, vehicle technology and system operations. In order to foster adaptation in transport systems in European regions, authorities can set up two basic policy systems: regulations or incentives.

Regulation and Governance vs. Incentives

The available policy instruments to increase the application of certain climate change adaptation strategies are in general regulations or incentives. Regulations are designed and controlled by public authorities and include principles, rules, or laws regarding adaptation, that must be followed by e.g. transport operators. Regulation relies on setting up sanctions for certain undesired behavioral alternatives (Bressers and Klok, 1988). Incentives are understood as rewards for the voluntary implementation of certain adaptation measures, but also as penalties for not initiating adaptation activities. The main characteristic of incentives is that penalties or rewards and the behavior of the regulated parties are proportional (Bressers and Klok, 1988).

Types of Adaptation

Adaptation policies have to address the different effects of climate change on the European transport sector that cut horizontally across different policy sectors and vertically across different levels of government, that are uncertain and concern a broad range of non-state actors who often lack capacities to adapt (Bauer et al., 2011). In terms of designing policy instruments to foster climate change adaptation, it is crucial to distinguish the available strategies. Strategies focused on by the present research were in particular:

- Technical adaptation,
- Soft adaptation,
- Anticipatory adaptation,
- Reactive adaptation,
- Autonomous adaptation,
- Planned adaptation,
- Private adaptation, and
- Joint adaptation.

In addition to these established concepts new concepts emerged in the recent past. In particular, no-regret, safety margins, and reversible strategies have been developed. By identifying measures that provide net-benefits regardless of climate change effects the no-regret strategy avoids the problem of uncertainty (Hallegatte, 2009). Cheap safety margins can be produced by including climate change adaptation features in already pursued strategies (Hallegatte, 2009). Reversible strategies are flexible in terms of either heightening the efforts or postponement in case new information becomes available. Good examples for reversible strategies are classic risk transfer instruments, such as insurance.

Policy Conclusions on Major Adaptation Areas

The decision about appropriate policy instruments to foster transport planning and general protection activities is influenced by the particular risk and the scale of probable damages. Regarding, for instance, the increasing risk of storm surges and flooding in coastal and river side regions, policy makers are seeking the highest level of protection for inhabitants, property and infrastructure assets in terms of efficiency and effectiveness. To ensure an immediate and broad change of planning behavior appliance standards, building codes and settlement obligations can be set up or existing ones can be adapted by including an additional climate change related safety margin. These instruments are falling into the category of regulatory instruments and may impose higher costs of regulation (e. g. substantive compliance costs) for the regulated parties as well as sufficient enforcement resources for the regulator. Issues of general protection (e. g. evacuation in case of emergency, driving under extreme weather conditions, emergency management strategies) can be additionally addressed by initiatives including information, education, training, social planning and organization (Trinks et al., 2012).

The hot spots in terms of infrastructure adaptation are road and rail infrastructure, inland waterways and sea ports. The decision about policy instruments must take into account the operator (government ownership, private ownership, Public Private Partnership) and the exposure of the particular transport infrastructures. Climate change related investments for state-owned infrastructures can be required by adapted building codes and technology standards, including a detailed definition of exposure of the regulated transport infrastructures to avoid unnecessary investments. In that case, the regulator and the regulated party are identical. In general, private transport infrastructures and PPPs can also be regulated by directives. In both cases pure directives are imposing substantial costs of regulation on the infrastructure operators and may alienate the support of the transport sector for climate change adaptation but, at the same time, guarantees a substantial change in behaviour by the mean of formal enforcement. An alternative strategy is to combine directives with incentives, such as tax exemptions / reductions in the case of verified transport infrastructure adaptation activities, public benefit charges in the absence of certain transport infrastructure adaptation activities, capital subsidies, grants, subsidized loans to support certain transport infrastructure adaptation activities (Trinks et al., 2012).

Private industries are the main developers of innovative vehicle and information technologies. Thus, an increasing demand for innovative vehicle and information technology is the main reason to encourage such activities. The introduction of (voluntary) certification and labeling systems related to the reliability / safety of vehicles and ICT systems under extreme weather conditions could be a selling point to increase demand and transparency in the market. Possible regulatory instruments are climate change related procurement regulations, obligations or appliance standards for vehicles and ICT systems considering certain specifications, such as driver assistance technologies. Furthermore, public RTD funding schemes related to climate change adaptation of vehicles and ICT systems can be set up (Trinks et al., 2012).

Within the field of transport service operation, different policy instruments can be applied to foster climate change adaptation. Again, mandatory or voluntary certification and labeling systems related to the reliability / safety of transport services under extreme weather conditions inform and support the customer decision for a particular transport mode. Furthermore, knowledge about impacts of extreme weather events on transport can be improved by mandatory data mining systems and disclosure programs collecting and publishing information about weather-induced delays for each mode of transport. In that context, the implementation of a threshold for the maximum level of weather-induced delays per transport mode

and penalties for exceeding it might be useful. Regarding support and information, the initiation of campaigns raising the climate change awareness in using and operating transport systems, such as training in driving under extreme weather conditions and emergency exercises for the operator's staff, should be taken into consideration. However, the implementation of common risk management procedures plays a significant role in terms of harmonizing the methods used for identifying and managing risks among the different actors involved in the development and operation of European transport systems (Trinks et al., 2012).

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Publications

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WEATHER Projekt

Im Rahmen des EU-Projektes WEATHER wurde u. a. untersucht, welche Politikinstrumente geeignet sind, Anpassungsaktivitäten in europäischen Transportsystemen anzustoßen. Dabei konnten vier grundsätzliche Anpassungsfelder identifiziert werden: Planung und allgemeine Schutzmaßnahmen, Infrastruktur, Fahrzeugtechnik und Betrieb des Transportsystems. Zur Steuerung entsprechender Anpassungsaktivitäten stehen den staatlichen Akteuren entweder sanktions- oder anreizbasierte Instrumente zur Verfügung.

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

Bijan Khazai, James Daniell, Julia Schaper, Friedemann Wenzel

Introduction

The SYNER-G research project (http://www.vce.at/SYNER-G/index.htm) was approved in November 2009 by the European Commission in the framework of its Environment Programme – Call FP7-ENV-2009-1. The main contribution of SYNER-G is the development of a systemic framework for vulnerability analysis and loss estimation which accounts for intra-relations and inter-relations of all elements at risk, including buildings, utility networks, transportation systems, and critical facilities. Poor linkages between damage to physical systems and resultant social consequences remain a significant limitation with existing hazard loss estimation models. CEDIM researchers are leading the work package on socio-economic loss and vulnerability (WP4). The overall objective of this work package is to transfer the interdependencies and consequences of losses in physical systems to their consequences on society as measurable indicators and values of socio-economic losses upon which policy and decision-making can take place.

Aims / Objective

One of the aims in the SYNER-G project is to develop a unified approach for modeling social losses caused by earthquake damage which integrates social vulnerability into the physical systems modeling approaches. Contributing to the challenge of integrating social vulnerability with physical damage/performance models is the fact that social vulnerability is a fundamentally relative and complex phenomenon which cannot be directly observed and measured. The integrated approach proposed in SYNER-G provides a framework to link the degree of damage and performance of physical systems to vulnerabilities and coping capacities in society to assess: (1) Impacts on displaced populations and their shelter needs, and (2) Health impacts on exposed populations and their health-care needs.

Project Status

The shelter need model in SYNER-G provides a methodology and indicator based system to obtain shelter demand as a function of the habitability of buildings (defined by a household's tolerance to the loss of power, gas and water for different levels of building damage and weather conditions); and a set of key socio-economic indicators influencing a population to leave their homes and seek or not seek public shelter. Accordingly, the shelter model simulates a households' decision-making and considers physical, socio-economic, climatic and spatial factors in addition to modelled building damage states. The integrated shelter needs model developed in SYNER-G is based on a multi-criteria deci-

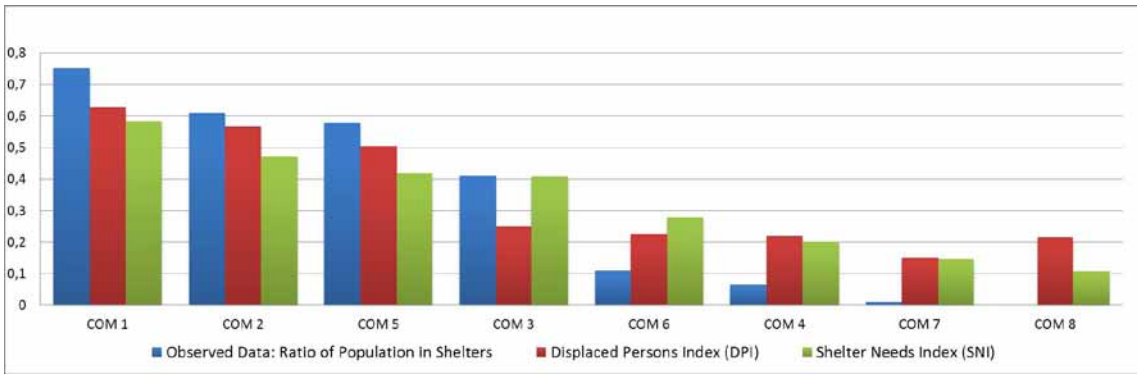

Fig. 1: Ratio of actual population in shelters (Observed data) shown against the ranking of displaced persons and shelter needs in the 8 COMs after the 2009 L'Aquila earthquake

sion theory (MCDA) framework which allows the bringing together of parameters influencing the physical inhabitability of buildings, with social vulnerability (and coping capacity) factors of the at-risk population as well as external factors to determine the desirability to evacuate and seek public shelter. To operationalize the shelter model, appropriate indicators from the EU Urban Audit Database have been selected using Geographically Weighted Regressions (GWR) combined with expert judgment. Vulnerability factors deduced from the EU Urban Audit have been validated by applying the model using data from the M=6.3 earthquake that struck L' Aquila, Italy in April 2009. Figure 1 shows how the modeling approach can be used to capture the actual shelter demand conditions (given as the observed number of people in shelter camps normalized by total population in different Mixed Operations Centres (COM) which had the overall coordinating role in their own territories for all rescue and shelter provision operations after the L'Aquila earthquake.

Similarly, the health impact model developed in SYNER-G presents a new method for integrating social vulnerability in modeling health impacts caused by earthquake damage. To link social impacts of health and health-care services to a systemic seismic vulnerability analysis, a multi-criteria decision model has been developed and appropriate social indicators for individual health impacts and for health care impacts were identified based on literature research, and tested using available statistical data. The results were used to develop a health impact model that describes the processes and links between socio-demographic, environmental, epidemiological and health behaviour parameters to increased short-term health impacts. Furthermore, healthcare system's parameters are integrated in a healthcare capacity model to assess secondary impacts on the overall health care delivery to the affected population.

Outlook

The SYNER-G project has been extended for a period of five months till the end of April 2013. The final workshop for SYNER-G will be held at ISPRA on March 21-22, 2013. Currently the validation studies and implementation of the various methodologies are being finalized in Thessaloniki, Vienna and Italy. The prototype software in the SYNER-G project –is also being finalized. One plug-in in the SYNER-G software is the Java-based MCDA software developed at KIT (IKET) for the socio-economic impact analysis.

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SYNER-G

Der hauptsächliche Beitrag des EU SYNER-G Projekts ist die Entwicklung eines systemischen Rahmenplans für die Vulnerabilitätsanalyse und Schadenabschätzung. Dieser bezieht interne Zusammenhänge und Wechselbeziehungen aller Risikoelemente, einschließlich Gebäude, Nutznetzwerke, Transportsysteme und lebenswichtige Einrichtungen, mit ein. CEDIM-Wissenschaftler leiten das Arbeitspaket über sozio-ökonomische Schäden und Vulnerabilität. Dieses hat das Ziel, Wechselbeziehung und Konsequenzen physischer Systemschäden auf Konsequenzen in der Gesellschaft mittels messbarer Indikatoren und Schadensermessungen sozio-ökonomischer Natur zu übertragen. In Bezugnahme hierauf sollen Verfahrensweisen entwickelt und Entscheidungen getroffen werden. Im Speziellen soll der integrative Ansatz einen Rahmenplan erstellen, der den Grad der Zerstörung sowie das Verhalten physischer Systeme in Beziehung zu Vulnerabilitäten und Bewältigungskapazitäten in der Gesellschaft setzt, um Folgendes zu ermitteln: (1) die Auswirkungen auf vertriebene Bevölkerungen und ihre Unterkunftsbedürfnisse, und (2) die Gesundheitseinflüsse auf exponierte Bevölkerungen und ihre Gesundheitsversorgnungsbedürfnisse. Um das Modell zu operationalisieren wurden angemessene Indikatoren aus der EU Urban Audit Datenbank ausgewählt und Geographically Weighted Regressions (GWR) durchgeführt. Das Unterkunftsmodell wurde mit Hilfe von sozio-ökonomischen Daten und Daten über Notunterkünfte vom M=6,3 Erdbeben in L'Aquila, Italien, im April 2009, validiert.

Publications

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Integrated Earthquake Risk Assessment for the Himalayan Region (IERA – Himal)

Bijan Khazai, Julia Schaper, James Daniell, Friedemann Wenzel

Introduction

In November 2012 a one year research project was approved for funding in the “Research Bridge” Nature, Technology and Society of the Karlsruhe Research Partnership (HEiKA). The strong synergy potentials and complementary expertise for interdisciplinary research between CEDIM and the South Asia Institute (SAI) directly supports HEiKA’s mission of bundling specific competences to address cross-sectional questions. Specifically, the proposed research project combines the experience in scientific modeling of earthquakes and their socio-economic impacts at CEDIM with the deep insight into human-environmental interactions and Himalayan development studies available at the SAI. The competences and expertise of the involved institutions – CEDIM and SAI – allows bridging the gap between natural and social sciences in the emerging field of disaster mitigation and risk reduction. The strategic aim beyond the one year phase is to extend the research to the larger context of disaster risk and multi-hazard management in the Himalayan region by including affiliated institutions, e. g. the Heidelberg Center for the Environment (HCE) and the KIT Climate and Environment Centre.

Aims / Objective

The aim of the project is to develop an integrated framework of risk and vulnerability to better understand human-environmental interactions in the context of extreme natural hazards and socio-economic development. The key feature of the proposed study in one of the most seismically active and landslide-prone regions in

IERA – Himal

Das Kooperationsprojekt IERA – Himal untersucht auf unterschiedlichen Maßstabsebenen die Interkonnektivität und Auswirkungen von extremen Erdbeben und Massenbewegungen auf Mensch-Umwelt-Systeme am Beispiel von Nepal. Die Kombination aus wissenschaftlicher Modellierung der direkten physischen Gefährdung (z.B. Zerstörungsanfälligkeit von Gebäuden) und der sozio-ökonomischen Vulnerabilität im Kontext demographischer Entwicklung und dynamischer Urbanisierungsprozesse steht im Zentrum der integrativen Analyse. Detaillierte multitemporale Untersuchungen des urbanen Raums von Kathmandu auf Basis von Fernerkundungsdaten, Kartierungen und empirischer Sozialforschung dienen als kleinräumiges Testfeld zur Ableitung aussagekräftiger Gefährdungsindikatoren auf regionaler und nationaler Ebene. Dabei werden auch historische Extremereignisse zur Identifizierung systemischer Gefährdungen und Risiken zur Modellbildung herangezogen. Mit den daraus abgeleiteten Indikatoren und Standards zur Bewertung von Naturgefahren und zur Messung sozio-ökonomischer Vulnerabilität und Resilienz wird im Rahmen des Projekts ein interdisziplinärer Analyserahmen für die Untersuchung systemischer Risiken im Himalaya entwickelt.

the world is to move from classical approaches in modeling risk into a more systemic and integrative approach accounting for interactions between hazards, engineered systems and society. Given the systemic vulnerability and the low level of preparedness of exposed populations in the Himalaya, we seek to understand how natural hazards as drivers affect regional livelihoods within the context of rapid population growth and urbanization. An indicator-based vulnerability and resilience index will be developed for Kathmandu Valley, based on detailed case studies using state-of-the art remote sensing technique, probabilistic multivariable modeling and field surveying. The results allow for a socio-economic comparison of places and their relative potential for harm or loss. The key findings will result in the development of a framework for integrated earthquake risk assessment.

Project Status

The project integrates the assessment of direct physical damage (i.e. damage to housing stock) and the socio-economic dimensions of specific vulnerability taking into account dynamic interactions among hazards and development processes such as urbanization and rapid population growth. Dynamic vulnerability scenarios of the urbanized area of Kathmandu valley will be generated using multi-temporal satellite imagery, remote sensing and change detection techniques. To better understand the interactions between nature, society and the built environment, the dynamic vulnerability scenarios will be generated by in-depth investigations of five Himalayan earthquakes. Furthermore, indicator systems of social vulnerability and resilience will be developed based on conceptual frameworks and assessment standards in the field and combined with the physical earthquake risk analysis. The integrated approach will focus on the development of a comprehensive assessment methodology for the evaluation of earthquake risks in the Himalayan region, based on a detailed investigation in one case study area. Within the pilot phase of the project, the approach will be implemented on a local scale of the Kathmandu Valley.

Outlook

The IERA-Himal project will commence in January 2013 through the close collaboration and involvement of one PhD student fromt KIT and one PhD student from Heidelberg University. The project will be supervised at SAI by Prof. Dr. Marcus Nuesser and at KIT by Dr. Bijan Khazai.

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Natural Risks and Climate Change

Hail Risk and Climate Change (HARIS-CC)

Michael Kunz, Susanna Mohr, Marc Puskeiler, Heinz Jürgen Punge

Introduction

Damage caused by severe hail increased substantially over several regions of Central Europe during the last two to three decades. In the federal state of Baden-Wuerttemberg, for example, nearly 40 % of the total damage to buildings by natural hazards is related to large hail (Kunz et al., 2010). Due to their local-scale extent and a lack of appropriate monitoring systems, hailstorms and their impacts are not captured accurately and comprehensively by operational observation systems, which hamper statistical analysis of these events. The challenges are to assess the hail potential by combining different observations and to estimate hail probability by appropriate proxy data (i. e. indirect climate data) in order to find evidence for long-term changes.

Hail Hazard Assessment

In cooperation with the SV SparkassenVersicherung AG, analyses of hailstorm tracks, their climatology and related damage to buildings were performed for the federal states of Baden-Wuerttemberg, Hesse and Thuringia. Based on the vertical extent of high reflectivity obtained from three-dimensional radar data, footprints and tracks of hailstorms have been reconstructed for a period of 7 years. The results reveal a high spatial variability in hail probability, which is due to the superposition of large-scale climatology (e. g. a north-to-south gradient in static stability) and local-scale flow dynamics. Most of the hot spots in hail probability are found in the lee of low mountains ranges, for example, in the region south of Stuttgart (downstream of the Black Forest) or east of Harz and Bergisches Land. Semi-idealized model simulations with the weather prediction model COSMO of the German Weather Service showed that convergence lines resulting from flow around the mountains and gravity waves are most relevant for the spatial distribution of hail events. Based on the reconstruction of past hail events, a hail model will be developed in the next step.

Hail Probability and Climate Change

Statistical analyses of long-term time series of specific convective parameters from both observations and model data (reanalyses) show positive trends towards higher convective potential, with a distinct north-to-south gradient over Europe and Germany. To take into account the different mechanisms most relevant for the formation of hailstorms, a specific parameter, the potential hail index (PHI), has been developed. The PHI is quantified by using a logistic regression model and combines convective indicators and large-scale weather patterns. Applied to an ensemble of high-resolution simulations from regional climate models (amongst others those performed within the former CEDIM focus “Flood Hazard in a Changing Climate”), an increase in PHI was found for the past decades and is projected for the future. This means that the convective potential over Germany – in particular over south Germany – will further increase in the future (2021 to 2050), though only slightly.

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Publications

Kapsch, M.-L., Kunz, M., Vitolo, R., Economou, T. (2012): Long-term variability of hail-related weather types in an ensemble of regional climate models, J. Geophys. Res., Vol. 117, D15 107, DOI:10.1029/2011JD017185.

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HARIS-CC

Im Rahmen des Projekts HARIS-CC (HAil RISk and Climate Change) werden durch die Kombination verschiedener Beobachtungsdaten vergangene Hagelzugbahnen rekonstruiert und statistisch analysiert. Dabei zeigt sich insbesondere auf der Leeseite der Mittelgebirge in Deutschland eine Häufung der Hagelereignisse, die unter anderem auf strömungsdynamische Vorgänge zurückgeführt werden kann. Änderungen der Hagelwahrscheinlichkeit in Deutschland und Europa werden aus einem Ensemble hoch-aufgelöster regionaler Klimaprojektionen quantifiziert. Aus verschiedenen Stabilitätskriterien und Großwetterlagen wird mit Hilfe eines logistischen Regressionsmodells ein hagelpotentieller Index (PHI) abgeleitet, der das aktuelle Hagelpotential der Atmosphäre wiedergibt. Angewendet auf ein Ensemble verschiedener hoch-aufgelöster regionaler Klimamodelle nimmt den Analysen des PHI zufolge das Hagelpotential in der Zukunft (2021 bis 2050) leicht zu.

Disaster Management

The Web Service “Wettergefahren – Frühwarnung”

Bernhard Mühr

Outline

The internet service „ Wettergefahren-Frühwarnung“ provides information on imminent or just occurring unusual or extreme weather events worldwide; of particular interest are those weather events that are ruinous and associated with heavy losses. Permanent availability, daily updated (warning) information, editorially enhanced reports of extreme or unusual weather events that are enriched by images and measured values, are the hallmarks of the internet project.

Routine operation started on 1 February 2004 and has been maintained continuously ever since. In 2007, the „Wettergefahren-Frühwarnung“ became part of CEDIM.

Several thousand page impressions a day and nearly daily Facebook activities give proof of the success of this web portal.

The Weather Warnings of „Wettergefahren – Frühwarnung“

It is neither the task of „Wettergefahren-Frühwarnung“ to issue detailed and minute-by-minute updated warnings for every county nor to pronounce codes of conduct. Current warnings of thunderstorms in summer, of heat in summer, of wind gusts, of impairment of visibility due to fog or slipperiness by snow or ice in winter are also not part of „Wettergefahren-Frühwarnung“; although all these events might indeed be loss-incurring, it is the German (DWD) or other National Weather Services that are responsible for such warnings.

The key aspect of „Wettergefahren-Frühwarnung“ are extreme weather events, especially when they are associated with an extensive potential for damage. The main focus is on Europe. Forecasts from both global and regional weather forecast models as well as the experience of the responsible person on duty serve as a basis for decision. Textual notes about forthcoming extraordinary events are made, usually a few days before their arrival and include general information on the nature of the extreme event, the intensity and the course. Typically, a short warning text supplemented by informative forecast maps, indicate the affected areas and what they have to expect. These alerts are updated daily; in some cases and if necessary several times daily.

At the onset and during an extreme weather event, the relevant information becomes more detailed, and sometimes preliminary analysis and assessments can be carried out simultaneously. One to three days after the event a detailed editorial article finalises such activities; the articles contain the main findings of the event and are enriched with data, maps, illustrations and figures. The handling and evaluation of extreme weather events that are affecting other continents is done in an analogous way.

In 2012, „Wettergefahren-Frühwarnung“ analysed 78 unusual or extreme weather events that occurred all over the world. Among all these events some are outstanding: In February, an extreme cold spell affected Central Europe and lasted for about 14 days. Many new temperature records were set, e. g. at Ueckermünde in north-eastern Germany, where the temperature dropped to -28.7 °C. Furthermore, the extreme drought and heat in the U.S. as well as Hurricane Sandy have been of special importance and caused FDA activities within CEDIM. And finally, 2012 ended with extreme high temperatures in central Europe around Christmas, whereas eastern parts of Europe suffered from temperatures below -30 °C.

Comprehensive Archive of Extreme Weather Events

„Wettergefahren-Frühwarnung“ has been concerned with some 700 unusual or extreme weather events that have occurred all over the world since its inception on 1 February 2004. All warnings, special notes and detailed reports can be found in an ever-growing archive. The

articles are presented as a table and, since 2009, a Google-maps application is also available that can be used to detect all the locations and areas with various extreme weather events in a fast and convenient way.

Automatically Calculated Forecasts (Tables and Maps)

Daily point forecasts are calculated for some 2800 individual cities, clearly arranged in tables for Germany, Europe, and the other continents. The forecast period is 4 days. If single forecast values are beyond the defined alarm thresholds, the corresponding warning level can be highlighted by a color backing.

world every 6 hours. The combination of the maps and the well known and popular Google-maps application allows a completely new and convenient navigation. Allegedly threatened areas or cities can be identified immediately. The maps give information about rainfall, areas and values of temperature deviations, convection indices, wind at several levels, snow accumulation and much more.

Additional Information

The webpages of „Wettergefahren-Frühwarnung“ not only offer alerts and warnings reports, they also give all the necessary information to evaluate extreme or unusual weather events. This additional information includes e.g. wind and storm scales, national and international

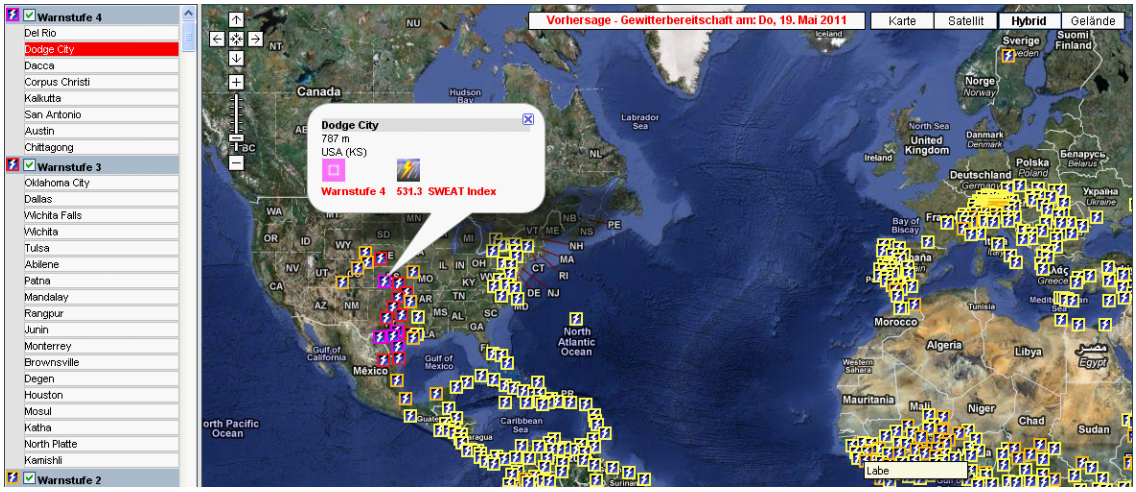

Fig. 1: Screenshot of “Wettergefahren-Frühwarnung” Warning maps indicating thunderstorm activity.
Image Credit: http://www.wettergefahren-fruehwarnung.de

In addition to the tabular presentation for each continent, „Wettergefahren-Frühwarnung“ provides an alternative with a Google-maps application. The maps show all the cities whose forecasted parameter meets the alert criteria according to their color-coded alert level. A click on the city gives the relevant information about the warning parameters and the alert level respectively.

New Methods of Visualisation

In addition to daily monitoring and assessment of global weather events since the beginning in 2004, „Wettergefahren-Frühwarnung“ also creates its own special maps and images. In recent years, increasingly complex codes have been developed that now produce many hundreds of weather charts and forecast maps for the entire

records of temperature, precipitation and other parameters as well as climatological data and maps. This information is constantly checked, expanded and updated. Special reports e.g. about the extraordinary summer of 2003 in Europe, the volcanic eruption of the Eyjafjallajökull volcano or the nuclear power plant disaster at Fukushima complement the information.

Real-Time Service / Forensic Disaster Analysis“

In case of a disaster, „Wettergefahren-Frühwarnung“ comes up with early and precise information on events and reliable weather forecasts, which are always available and updated several times daily. „Wettergefahren-Frühwarnung“ gives advice and assists with articles and reports on extreme events. High-resolution

model data also serve as input data for other models (e. g. radioactivity dispersion modeling, flood calculations), thus making it a quick and uncomplicated cooperation between various institutions of CEDIM.

In April 2010, the eruption of Islandic Eyjafjallajökull volcano attracted attention; in March and April 2011 the nuclear disaster in Fukushima, Japan, dominated the headlines; in May 2011 an Icelandic volcano, the Grimsvötn, emphatically draw attention. In all these cases, high-resolution forcecast maps for many weather parameters were available within 1 to 2 days and allowed detailed and reliable predictions about the future weather conditions, wind direction, rainfall, etc. in the affected areas. Also the earthquake in eastern Turkey (October 2011) led to an exemplary, easy, quick and result-oriented cooperation between different actors operating at CEDIM, which resulted in a number of highly regarded reports.

Cooperation with External Companies

The extensive information offered by „Wettergefahren-Frühwarnung is used by all kinds of media, many scientific institutes in Germany or other countries and insurance or tourism companies. In particular, they make use of the comprehensive information that is available in the archive of about 700 extreme weather events worldwide. Furthermore, the German and other private weather services benefit from „Wettergefahren-Frühwarnung“. Some further specific co-operations have already been organized and others are on the way.

Further Plans and Aims

New Design and improved navigation.

Each successful internet project requires not only permanent availability and maintenance, but also must be characterized by high-quality content, a modern design and intuitive navigation. Other pillars of success are new products and new forms of presentation, which should be introduced from time to time: soon there will be a relaunch of „Wettergefahren-Frühwarnung“, featuring a new design.

Currently there is no English version of „Wettergefahren-Frühwarnung“ available. Such a version would be desirable and could help very much to increase attention outside Germany.

Flyer/ Brochure

On the Internet and at all kinds of events (conferences, etc.), there is generally great interest in weather hazard early warning activities. Additional information material, available and distributed during such events, could help to increase the awareness level considerably: thus the creation of a flyer or a brochure appears to be very helpful and important.

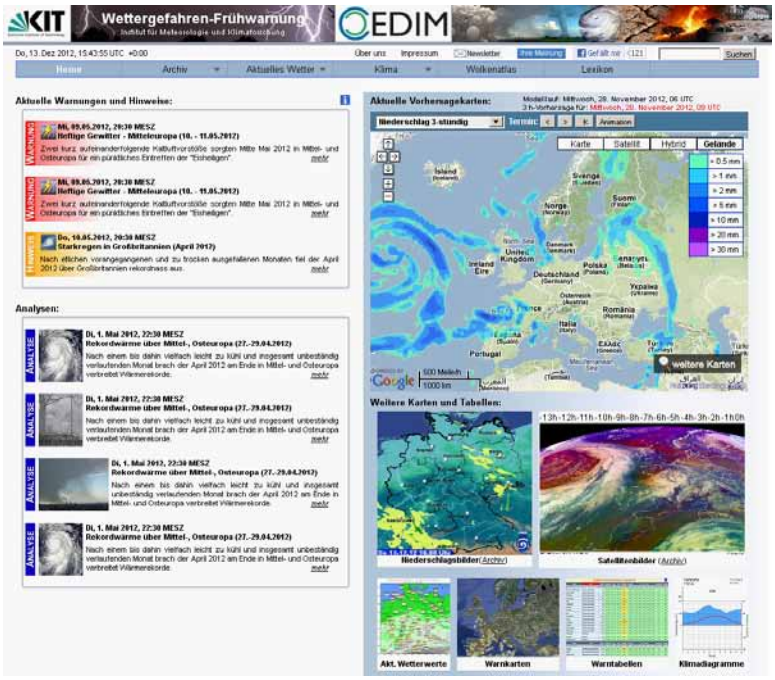

Fig. 2: Screenshot of «Wettergefahren-Frühwarnung» - New design coming soon
Image Credit: http://www.wettergefahren-fruehwarnung.de

More Information

CEDIM - ATMO Forensic Prediction and Analysis, Scenario „Winter Storm“ (see page 12)

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Publications

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

Web Service „Wettergefahren-Frühwarnung“

Der Internetdienst „Wettergefahren-Frühwarnung“ informiert über bevorstehende oder gerade auftretende außergewöhnliche oder extreme Wetterereignisse weltweit, ein besonderes Interesse gilt dabei schadenträchtigen Wetterlagen. Ständige Verfügbarkeit, täglich aktualisierte (Warn-) Informationen, redaktionell aufbereitete und mit Abbildungen und Messwerten angereicherte Analysen extremer oder ungewöhnlicher Wetterereignisse sind die Markenzeichen des Internetprojektes.

Der Routinebetrieb begann am 1. Februar 2004, im Jahre 2007 wurde die „Wettergefahren-Frühwarnung“ Bestandteil von CEDIM. Mehrere 1000 Seitenzugriffe pro Tag belegen u. a. den Erfolg des Internet-Projektes.

Die „Wettergefahren-Frühwarnung“ beschränkt sich auf die extremen Wetterereignisse, besonders, wenn diese mit einem Schadenpotential verbunden sind. Der Schwerpunkt liegt auf den Vorkommnissen in Europa. Als Entscheidungsgrundlage dienen eigene Wettervorhersage –Modellrechnungen verschiedener globaler und regionaler Modelle. Sämtliche Warnungen, Hinweise und alle ausführlichen Analysen können in einem ständig wachsenden Archiv eingesehen werden, das bereits mehr als 700 umfangreiche Artikel zu Wetterereignissen aller Art umfasst.

Die Wettergefahren-Frühwarnung zeichnet sich durch Aktualität, innovative Darstellungsformen, umfangreiche und qualitativ hochwertige Informationen, Karten und Tabellen aus; ihr kommt bei allen CEDIM-FDA-Aktivitäten eine wichtige Rolle zu und ist Ansprechpartner für Medien aller Art, wissenschaftliche Institutionen und andere Einrichtungen.

SECURITY2People

Wolfgang Raskob, Stefan Möllmann

Introduction

Within the German Security Research initiative, the integrated project SECURITY2People (Secure IT-Based Disaster Management System to Protect and Rescue People) aims at exploring the needs for and the structure of an integrated disaster management system that is applicable for all types of emergencies and at all levels of emergency management, from the local to the Federal Government. Having started in mid-2009, the project has ended in November 2012.

Aims / Objective

The key objective of the project was to explore the needs of the various end users by analysing thoroughly the current situation in the emergency management in North Rhine-Westphalia

(NRW). To facilitate the interaction with the end users, a demonstratration has been developed to present the potential features of an integrated decision support system for a specific scenario.

As a basis for the demonstration and evaluation, a fictitious scenario was created 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 several workshops in which the demonstratration was presented to a group of potential end users, mainly employees of various governmental institutions and relief organisations in NRW.

Project Status

The year 2012 was devoted to completing several components of the overall demonstratration. The work focused on the following:

Knowledge data base: The knowledge data base contains historic events and measures that have been carried out to manage those events. Furthermore, it may also contain scenarios that have been created during exercises. The knowledge data base is extended by a case- based reasoning (CBR) algorithm that allows the adaptation of the existing scenarios to the current one. This feature is important as input to the strategic decision support.

Key Performance Indicators: This component serves for the estimation of resources required for a particular action. An action is subdivided into individual processes (e. g. evacuation into alerting, movement of busses, movement of inhabitants, transportation out the area and others) for which resource and timing indicators can be defined. Based on simple formulas, the timing and resources for that action can be calculated thus indicating if a proposed action is feasible under the given circumstances.

Multi-criteria Analysis: This component allows the evaluation of different strategies based either on facts or on preferences of the decision-making team. It supports also the structuring of the problem and provides transparent information on how decisions have been made. To analyse the stability of decisions, it allows performing a sensitivity analysis of the selected

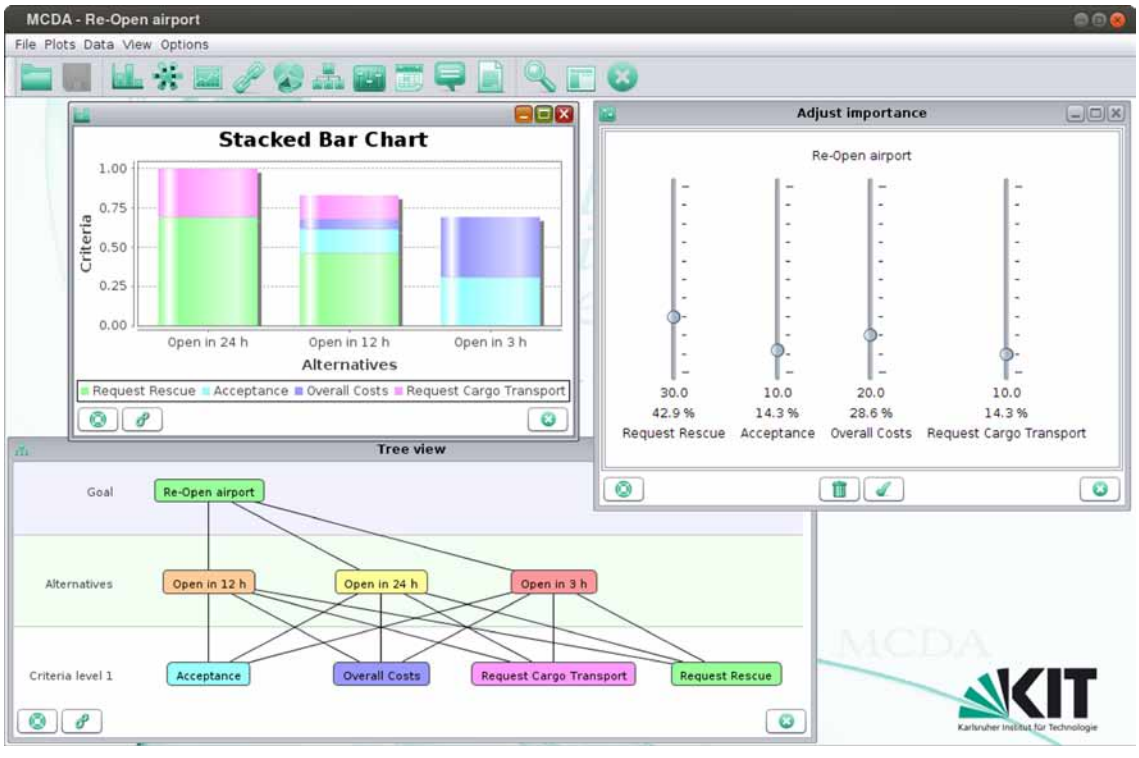

Fig. 1: Visualisation of the multi-criteria component

preferences indicating where further discussion/clarification is needed. This component is applicable mainly in the later phase supporting strategic decision making.

Strategic decision support: This component displays the on-going emergency on a timeline. The time line shows specific events where management is necessary. This is indicated via traffic light colors. Based on the information from the event and the information in the knowledge data base, an assessment is made with the help of the CBR component whether the situation is still fine (green), actions recommended (yellow) or mandatory (red). Based on the ranking from the CBR component, one strategy can be selected and the feasibility of that strategy can be estimated via the Key Performance Indicator component.

Social media component: This component facilitates the efficient gathering of information from Twitter to complete the decision makers' understanding of the situation.

Outlook

The project ended in November 2012, however, IKET will continue to work on individual components, in particular the knowledge data bases, the case-based reasoning and the multi-criteria analysis within the framework of further CEDIM projects.

Acknowledgement

The project SECURITY2People is funded by the Federal Ministry of Education and Research (BMBF) under its Research Program for Civil Security, which is part of the High-Tech Strategy for Germany.

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Publications

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SECURITY2People

Das Projekt SECURITY2People war Bestandteil des Programms zur Sicherheitsforschung des BMBF und hatte das Ziel, die Grundlagen für ein ganzheitliches, IT-basiertes System zur Unterstützung im Krisenmanagement zu erarbeiten. Dieses soll von Behörden übergreifend auf allen Hierarchieebenen und für jede Art von Katastrophenereignis eingesetzt werden und enthält verschiedene Komponenten zur Lagedarstellung und Entscheidungsunterstützung. Die Institute des KIT beschäftigten sich in dem Projekt schwerpunktmäßig mit der Unterstützung des Krisenmanagements auf operativ-taktischer und strategischer Ebene. Hierzu wurden Methoden des Wissensmanagement wie Wissensdatenbanken, selbstlernende Systeme, multikriterielle Entscheidungsunterstützung und Expertensysteme sowie soziale Medien untersucht.

Das Projekt endete im November 2012. Das IKET wird die Entwicklung der untersuchten Methoden und Ansätze in weiteren CEDIM-Projekten fortführen.

II. Strategic Partnerships

The "Earth System Knowledge Platform – ESKP" – an Initiative of the Helmholtz Research Field Earth and Environment

Project

The „Earth System Knowledge Platform - ESKP" is part of the Helmholtz Association's Portfolio process in the Research Field Earth and Environment. The eight centers in this field take part in the initiative that is jointly coordinated by Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences and Helmholtz-Zentrum Geesthacht, Centre for Materials and Coastal Research (HZG). The coordination office is located at GFZ.

The intended purpose of ESKP is to communicate scientific results and knowledge in a way that enables society to mitigate hazardous developments and react adequately to present and future environmental changes. The Helmholtz-Association possesses tremendous research resources in the earth and environmental sciences as well as knowledge about the Earth system and its changes. The Earth System Knowledge Platform integrates and activates this knowledge base.

Hence, the basic aims of ESKP are:

- The articulate presentation of scientific knowledge that is already available in the participating Helmholtz-Centres, to target groups (governmental departments / authorities, policy/decision makers, media, the public);
- the setting of scientific knowledge in context with a special focus on adaptation strategies;
- feedback to science about knowledge gaps and stimulation of respective research initiatives.

ESKP is linked to all scientific programs, portfolio topics and platforms in the Helmholtz Research Field Earth and Environment. The organizational structure consists of a small, decentralized team of scientists and technicians. An ESKP staff member is always on location in each center as competent partner for science- and knowledge transfer.

CEDIM is projected to be a main contributor of content about natural hazards, its impacts and consequences. CEDIM will benefit from the background information on earth system processes provided by ESKP and will also have direct access to a broader network of experts in disaster risk analysis.

ESKP is presently in an early stage of development. Exploratory discussions with all participating centres (including CEDIM-staff) have been completed and results are integrated in the ESKP-concept and strategy.

Cooperation with Integrated Research on Disaster Risk (IRDR)

In 2012 CEDIM started to cooperate with the program "Integrated Research on Disaster Risk" (IRDR, www.irdinternational.org), an initiative of the International Council for Science (ICSU), the International Social Science Council (ISSC) and the United Nations Office for Disaster Reduction (ISDR). Having coined the term "forensic disaster investigations", the IRDR initiative identified forensic disaster investigations (FORIN) as one of its key activities "that aims to uncover the root causes of the disasters through in-depth investigations that go beyond the typical reports and case studies conducted after disasters" and to help "build an understanding of how natural hazards do – or do not – become disasters." (http://www.irdrinternational.org/about-irdr/scientific-committee/working-group/forensic-investigations/).

With its focus on near real-time disaster analysis to identify major risk drivers, CEDIM's new research activity Forensic Disaster Analysis (FDA) is complementary to the one of IRDR which is based on a more long-term analysis. An important aim of the cooperation with IRDR FORIN is to build the necessary links between near real-time FDA work in CEDIM and the IRDR's long-term forensic disaster analysis program FORIN.

In 2012, CEDIM researchers participated in two advanced FORIN seminars (March 2012 in Taipei, and December 2012 in Orange County, California) that focused on the general approach of FORIN and on the template to conduct FORIN studies using the four general methods critical cause analysis, longitudinal analysis, meta-analysis, and scenarios of disasters. In the seminars, CEDIM researchers presented the first results obtained during the FDA activities after the Van earthquake in October 2011 and Hurricane Sandy in October 2012 and outlined how the FORIN methodologies could be applied within CEDIM FDA. Currently, further opportunities how to implement the cooperation are being developed.

Cooperation with the Insurance Industry

Willis Group Holdings plc is a major global insurance and reinsurance broker. Through the Willis Research Network (WRN), founded in 2006, it partners with a network of currently 50 of the world's leading research institutions. WRN operates through the organization of common workshops with participation of their clients, the financing of staff hosted at the partner institutions as Willis research fellows (WRF), and regular individual work meetings between WRN staff and the partners. CEDIM has been a member of WRN since 2009, and is active in the Natural Hazard and Risk section, the largest of the four „pillars" of the WRN.

CEDIM is the first German partner in the network, and intends to be a hub of the network for central Europe. As a partner in WRN, CEDIM staff gather experience in the cooperation with insurance industry partners and has learned about their needs and research priorities. This experience is expected to foster further cooperation with insurance companies both on the national and international scale.

In 2012, the activities of CEDIM in WRN focused on two areas:

- Earthquake research: WRN supports the development of the Global Earthquake Model (GEM) in CEDIM. The cooperation is described in the dedicated sections on GEM (page 46).
- Hail research: WRN cooperates with the working group "Atmospheric Risks" of IMK at KIT on hail research. As hail damage is a major insurance risk in many parts of the world and Europe in particular, research on this topic is a focus area of WRN. CEDIM has solid expertise in this area through its research group on the topic at IMK-TRO.

In 2012, CEDIM recruited a Willis Research Fellow to work at IMK-TRO on hail climatology and hail modelling for Europe. The project started in June for an unlimited period (but minimum of 3 years). Ongoing topics include the analysis of satellite-derived overshooting cloud top (OT) detection for hail quantification and cooperation on an OT-based risk model. Ultimately, a combination of different hail-related data sets available at IMK-TRO will be used to define continent-scale hail frequency and variability and to assess prevailing atmospheric conditions.

Sparkassenversicherung SV

During the last two years, two CEDIM projects have been carried out in cooperation with and funded by the building insurance company SparkassenVersicherung SV, Stuttgart:

The project EQRIS-SV has developed a comprehensive earthquake catastrophe model specifically adapted to the SV portfolio.

The project HARIS-SV aims at assessing hail probability in a high spatial resolution based on the combination of different appropriate data sets (e.g. radar and lightning data; see also "Hail Risk and Climate Change")

Stiftung Umwelt und Schadenvorsorge

For several years now KIT and CEDIM have collaborated with the Universität Stuttgart in a joint PhD program "Umwelt und Schadenvorsorge", which is funded by the "Stiftung Umwelt und Schadenvorsorge" of the SV Sparkassenversicherung. The current CEDIM PhD candidate investigates long-term changes in atmospheric stability related to thunderstorm and hail probability. Based on an ensemble of various regional climate model data (including model runs from the former CEDIM focus "Flood Hazard in a Changing Climate"), the hail potential for future decades (2012 to 2050) is quantified by using a logistic regression model (see also "Hail Risk and Climate Change").

EU-FP7 Projects

CEDIM with both supporting institutions, GFZ and KIT, has continued to contribute to the following EU-FP7 projects:

NERA – Network of European Research Infrastructures for Earthquake Risk Assessment and Mitigation. Involvement: Earthquake monitoring, hazard assessment and risk to infrastructures, including socio-economic implications;

MATRIX – New Multi-Hazard and Multi-Risk Assessment Methods for Europe. Involvement: risk harmonization and comparison, test site Cologne, storm risk assessment, strategy of dissemination to stakeholders, Project Coordinator (Jochen Zschau);

*REAKT – Strategies and Tools for Real-Time Earthquake Risk Reduction. S*erving as work package leaders, Member of Project Management Team (Jochen Zschau);

NERA will terminate by the end of 2014, MATRIX in Sept. 2013 and REAKT in September 2014.

Apart from the three projects above, there are some EU-projects with the involvement of only one of the two supporting institutions of CEDIM, either GFZ or KIT. Only those projects are mentioned below where the goals are closely related to those of CEDIM. These projects are:

SHARE – Seismic Hazard Harmonization in Europe. This project was set up as a European contribution to the Global Earthquake Model GEM. GFZ was particularly involved in harmonizing the earthquake catalogue for the hazard map of Europe. SHARE terminated at the end of 2012.

SYNER-G – *Systemic Seismic Vulnerability and Risk Analysis for Buildings, Lifeline-Networks and Infrastructure Safety Gain*. KIT is involved by leading the work package on socio-economic losses and vulnerability. SYNER-Gs final workshop will be in March 2013.

ConHaz – Costs of Natural Hazards-ConHaz. GFZ lead the work package on direct costs and production processes. The project ended in January 2012.

WEATHER – Weather Extremes. Assessment of Impacts on Transport Systems and Hazards for European Regions. KIT has been involved in studying the role of governance and incentives as well as the development of innovative emergency management strategies, the project ended in April 2012.

CEDIM is also part of two new EU-FP7 projects that started in 2012, early 2013 and follow goals that closely agree with CEDIM's mission:

SENSUM – Framework to Integrate Space-Based and In-Situ Sensing for Dynamic Vulnerability and Recovery Monitoring. The coordinator is GFZ (Massimiliano Pittore). The project will allow CEDIM to continue the development of the innovative tool for vulnerability- and risk monitoring that has been started within the EMCA (Earthquake Model Central Asia) regional project (see also special chapter on EMCA). The SENSUM project will last for two years until the end of 2014.

FUTUREVOLC – The Iceland Supersite: a Volcanological Monitoring System and European Network for the Future. GFZ contributes to the main goals of the project, establishing an integrated volcanological monitoring procedure through European collaboration, developing new methods for evaluating volcanic crises, increasing scientific understanding of magmatic processes and improving delivery of relevant information to civil protection and authorities. The project will last until March 2016.

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

The 10th ISCRAM Conference (International Conference on Information Systems for Crisis Response Management), organized by KIT and Fraunhofer IOSB, will be held from May 12 to 15 2013 in Baden-Baden. ISCRAM 2013 will focus on Holistic Crisis Management, which aims at the interdisciplinary development and design of information systems. This emphasis intends to enable better crisis planning, response, mitigation, recovery, and training by using integrated approaches that combine organizational, behavioral, technical, economic and environmental aspects.

Among the many topics of interest for crisis management ISCRAM 2013 focuses inter alia on the modeling and simulation of critical infrastructure disruptions and their consequences for disaster management and recovery. This is inline with the activities of CEDIM related to the modeling of critical infrastructures. Further key topics that should be addressed from a holistic perspective include the use of information and communication technologies, sensor techniques and sensor data fusion for early warning, crowdsourcing and crowd tasking, social media, healthcare, humanitarian challenges, intelligent systems and many more important issues that will be announced in the first call for papers.

Key Dates

- Deadline for full paper submissions - December 1th, 2012
- Deadline for work-in-progress paper, practitioner papers, posters - January 15th, 2013
- Deadline for doctoral student colloquium papers - February 15th, 2013

Further information can be found in the Conference website http://iscram2013.org.

III. Publications 2012

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