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EDIM

Annual Research Report 2013

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

Helmholtz Centre Potsdam
GFZ German Research Centre for Geosciences

Content

Preface

Since more than two years, the scientific work of the Center for Disaster Management and Risk Reduction Technology (CEDIM) has focused on the forensic analyses of catastrophes in Near Real-Time (Forensic Disaster Analysis, FDA). This approach aims to estimate and evaluate the consequences of a disastrous event immediately after its occurrence, tracking their temporal evolution, and identifying the most important factors. Several models and methods generating Near Real-Time knowledge are being developed within various projects, e.g., assessing the extent of a disaster in terms of direct and indirect damage or the number of required emergency shelters. These methods are in turn supplemented by information distributed through the Internet via, e.g., social networks.

In 2013, several disasters were forensically analysed by the interdisciplinary team of CEDIM and the results presented online through various reports. Based on the knowledge of past extreme events, CEDIM scientists analysed the hydro-meteorological situation of the June flood in Germany, which was comparable to the severe floods of 2002 and 1954. They determined, using an indicator model, the resilience for each county and compared it with the occurred damage. For the severe tropical cyclone Phailin, that hit India in October, the work of CEDIM focused on the meteorological development of the storm and its impact upon infrastructure, in particular on traffic interruptions. Finally, a comprehensive FDA activity was conducted for the super Typhoon Haiyan/Yolanda in November, which exhibited the highest ever recorded wind speeds at landfall, causing devastating damage, resulting in thousands of victims in the Philippines. In the aftermath of this event, CEDIM provided within a few hours realistic estimates about damage and casualties. These estimates have been frequently cited by the international media (e.g., in a press release from Reuters). All the aforementioned FDA Task Force activities are described in detail in Chapter I.

In addition to the wide range of forensic analyses, CEDIM staff have also investigated other extreme events and disasters and have published their results in a timely fashion on www.cedim.de. Included amongst the considered events are the meteorite explosion over Russia in February, the severe hail events in Germany and Europe in July, the heat wave in Germany in July and August, the Bohol earthquake in the Philippines in October, and the winter storms over northern Germany at the end of the year (see also the articles in Chapter I).

Last year, CEDIM established an intensive dialogue with potential users of its reports, who included national and European disaster relief and aid organizations. The feedback from these organisations is important to CEDIM in order for it to address further users' needs in future FDA reports.

To improve the CEDIM FDA projects for Near Real-Time disaster analysis, automated information gathering from social networks was implemented and a disaster database was created to compare and evaluate differttent attributes across disasters. Following the recommendations of the CEDIM Advisory Board, the socio-economic component in the research was further strengthened: among other things, a research project for the rapid analysis of the efficiency of emergency assistance during relief activities was introduced. Another approach in the field of socio-economic research (see section FDA Research Projects) is the development of appropriate indicators for the timely identification of the needs for effective assistance, e.g., estimates of the required number of emergency shelters or expected support for reconstruction. In addition, CEDIM is incorporating the work of other groups at GFZ and KIT, such as the Post-Disaster Damage Mapping project, which is setting out to derive global vulnerability and exposure indicators of buildings through crowdsourcing or open data, and linking these to damage data mapped by the Humanitarian OpenStreetMap Team in the aftermath of catastrophes.

In addition to activities focusing on FDAs, CEDIM has continued in 2013 to concentrate the German efforts for the Global Earthquake Model (GEM). These efforts include the operation of the GEM Testing Centre for the evaluation of earthquake hazard and risk models, the development of a harmonized seismic risk model for Central Asia (the EMCA or Earthquake Model Central Asia initiative) and the preparation of a global dynamic exposure model for the assessment of the socio-economic vulnerability to earthquakes. Like in previous years, CEDIM has continued to expand upon the topics "Disaster Management" and "Critical infrastruc-

tures". Examples are the ongoing development of a large-scale flood risk analysis model for Germany and of decision support techniques for the protection of critical infrastructure.

CEDIM maintains close links with the insurance industry, especially with Willis Research Network (WRN) within the context of social vulnerability research and hail modelling for Europe, as well as with the SV Sparkassenversicherung, also in the field of hail-damage modelling, while cooperation with IRDR (Integrated Research for Disaster Reduction) has been intensified. In addition, last year, a Memorandum of Understanding between CEDIM and alpS (Innsbruck) was signed, stipulating regular exchanges in the form of workshops or joint projects. In May, CEDIM employees participated in the organization of the international ISCRAM Conference (Integrative and Analytical Approaches to Crisis Response and Emergency Management Information System). Finally, the cooperation with ESKP ("Earth System Knowledge Platform" of the Helmholtz Association) began. ESKP will publish short versions of CEDIM FDA reports on their homepage and will provide links to the original reports on the CEDIM site.

Overall, the manifold CEDIM activities during the last year were widely visible in numerous reports in the national and international media. The many users have proven the Near Real-Time FDA concept, CEDIM's new strategy of the past two years, to be successful and constructive. We are confident that the continuous improvements of the CEDIM strategy will lead to enhanced understanding of how and why extreme events turn into catastrophes. With our work, we hope to provide the knowledge to increase resilience to disasters around the world, to support disaster relief, and to prevent future events from becoming tragic catastrophes.

Jochen Zschau
Michael Kunz

Vorwort

Seit mehr als zwei Jahren liegt der Schwerpunkt der wissenschaftlichen Arbeiten des Centers for Disaster Management and Risk Reduction Technology (CEDIM) auf forensischen Katastrophenanalysen in Nahe-Echtzeit (Forensic Disaster Analysis, FDA). Ziel dieses Ansatzes ist es, direkt nach dem Eintreten einer Katastrophe diese zu bewerten, deren Folgen abzuschätzen, die zeitliche Entwicklung nachzuverfolgen und die wichtigsten Faktoren zu identifizieren, die für die Auswirkungen maßgeblich sind. Dazu werden in verschiedenen Projekten Modelle und Methoden entwickelt, mit denen in naher Echtzeit Wissen generiert wird, beispielsweise über das Ausmaß einer Katastrophe, über direkte und indirekte Schäden oder die Anzahl benötigter Notunterkünfte. Diese Methoden werden durch Informationen ergänzt, die unter anderem über soziale Netzwerke im Internet verfügbar sind.

Auch im vergangenen Jahr 2013 wurden mehrere Katastrophen durch das interdisziplinäre Team von CEDIM forensisch analysiert und deren Ergebnisse in Form verschiedener Berichte zur Verfügung gestellt. Für das schwere Juni-Hochwasser in Deutschland, das in der Ausdehnung und Gesamtstärke vergleichbar war mit den schweren Hochwasserereignissen von 2002 und 1954, analysierten CEDIM-Wissenschaftler die hydro-meteorologische Situation im Vergleich zu vergangenen Extremereignissen. Mit Hilfe eines Indikatormodells wurde für jeden Landkreis die Resilienz (die Fähigkeit, externe Störungen zu kompensieren) bestimmt und deren Zusammenhang mit den aufgetretenen Schäden hergestellt. Für den schweren tropischen Wirbelsturm Phailin, der im Oktober über Indien zog, fokussierten sich die Arbeiten von CEDIM auf die meteorologische Entwicklung des Supersturms und die Auswirkungen auf die Infrastruktur, vor allem auf Verkehrsunterbrechungen. Eine umfassende FDA-Aktivität wurde schließlich für den Super Taifun Haiyan/Yolanda initiiert, der im November mit den höchsten jemals beobachteten Windgeschwindigkeiten bei Landgang zu verheerenden Schäden und mehreren Tausend Opfern auf den Philippinen geführt hatte. Hier konnte CEDIM innerhalb weniger Stunden realistische Schätzungen zu Schäden und Opferzahlen abgeben, die auch von vielen internationalen Medien zitiert wurden (beispielsweise in einer Presseinformation von Reuters). All diese FDA-Task-Force-Aktivitäten sind in Kapitel I ausführlich beschrieben.

Neben den breit angelegten forensischen Analysen betrachteten CEDIM-Mitarbeiter einige weitere Extremereignisse und Katastrophen und stellten diese Informationen unmittelbar nach deren Eintreten auf der CEDIM-Website bereit. Dazu zählten die Explosion eines Meteoriten über Russland im Februar, die schweren Hagelereignisse in Europa im Juli, die Hitzewelle über Deutschland im Juli und August, das Bohol-Erdbeben auf den Philippinen im Oktober oder die Winterstürme über Norddeutschland am Ende des Jahres (siehe auch hier die Beiträge in Kapitel I).

Im vergangenen Jahr wurde außerdem ein intensiver Kontakt zu potentiellen Nutzern der CEDIM-Berichte aufgebaut, der zunächst vor allem nationale und europäische Katastrophenschutz- und Hilfsorganisationen umfasste. Das Ergebnis dieses Dialogs wird in Anpassungen der CEDIM-FDA-Berichte münden, um diese stärker nutzerorientiert zu gestalten.

In den CEDIM-FDA-Projekten, die sich mit der Entwicklung von Methoden zur Unterstützung von Katastrophenanalysen in Nahe-Echtzeit befassen, wurden weitere Fortschritte erreicht, etwa bei der automatisierten Informationsauswertung sozialer Netzwerke oder dem Aufbau einer Datenbank, durch die über verschiedene Attribute aktuelle mit vorangegangenen Katastrophen verglichen und bewertet werden können. Den Empfehlungen des Beratungsgremiums folgend wurde die sozio-ökonomische Komponente in den Forschungsarbeiten weiter verstärkt. Hinzu kam unter anderem ein Forschungsprojekt, das sich mit der Analyse der Effizienz von Katastrophenhilfe noch während der Hilfsaktivitäten befasst. Auch die Entwicklung geeigneter Indikatoren zur schnellen Identifizierung des Hilfsbedarfs, beispielsweise die Abschätzung der benötigten Notunterkünfte oder die Unterstützung beim Wiederaufbau, gehört zu den neuen Ansätzen im Bereich der Sozioökonomie (siehe Abschnitt FDA Research Projects). Neben den direkten CEDIM-Projekten werden außerdem Arbeiten und Methoden von anderen Gruppen am GFZ und KIT in die CEDIM-FDA-Aktivitäten eingebunden. Ein Beispiel ist das Post-Disaster Damage Mapping, bei dem globale Vulnerabilitäts- und Expositionsindikatoren von

Gebäuden durch Crowdsourcing oder offenen Daten gewonnen werden und im Nachgang einer Katastrophe mit Schadenskartierungen des Humanitären OpenStreetMap Projektes verknüpft werden.

Neben den Aktivitäten zum FDA-Schwerpunkt hat CEDIM auch im Jahre 2013 weiterhin die deutschen Anstrengungen im Rahmen des Global Earthquake Models (GEM) gebündelt. Dazu gehören der Betrieb des GEM-Testzentrums zur Evaluierung von Erdbebengefährdungs- und Risikomodellen, die Entwicklung eines harmonisierten seismischen Risikomodells für Zentralasien sowie die Vorbereitung eines dynamischen Expositionsmodells zur Einschätzung der sozio-ökonomischen Vulnerabilität gegenüber Erdbeben auf globaler Ebene. Wie in den Jahren zuvor, wurden auch die Themen „Katastrophenmanagement“ und „Kritische Infrastrukturen“ weiter bearbeitet, beispielsweise im Zusammenhang mit der noch laufenden Entwicklung eines großräumigen Hochwasserrisiko-Modells für Deutschland oder mit dem Fokus auf entscheidungsunterstützende Methoden zum Schutz kritischer Infrastrukturen.

Enge Verbindungen bestehen nach wie vor mit der Versicherungsindustrie, insbesondere mit Willis Research Network im Rahmen der Forschung zur sozialen Vulnerabilität und in der europäischen Hagelmodellierung, sowie mit der SV Sparkassenversicherung bei der Entwicklung eines Hagelschadenmodells. Die Zusammenarbeit mit IRDR (Integrated Research for Disaster Reduction) wurde weiter intensiviert und konkretisiert. Im letzten Jahr wurde außerdem ein Memorandum of Understanding zwischen CEDIM und alpS (Innsbruck) unterzeichnet. In Zukunft ist hier ein regelmäßiger Austausch in Form von Workshops oder gemeinsamen Projekten geplant. Bei der internationalen ISCRAM-Konferenz (Integrative and Analytical Approaches to Crisis Response and Emergency Management Information Systems) im Mai waren auch CEDIM-Mitarbeiter an der Organisation beteiligt. Schließlich wurde auch die Kooperation mit ESKP („Earth System Knowledge Plattform“ der Helmholtz-Gesellschaft) aufgenommen. ESKP wird in Zukunft die CEDIM-FDA-Berichte in verkürzter Form auf der Startseite Ihres Internetauftritts veröffentlichen und zu den Originalberichten auf der CEDIM-Website verlinken.

Insgesamt waren die CEDIM-Aktivitäten im vergangenen Jahr sehr vielfältig und aufgrund zahlreicher Berichte in nationalen und internationalen Medien auch weithin sichtbar. Das FDA-Konzept in naher Echtzeit als neue und zentrumsübergreifende Strategie von CEDIM hat sich in den vergangenen zwei Jahren als zielführend und erfolgreich erwiesen. Wir sind davon überzeugt, dass uns die weitere Entwicklung und Implementierung dieser Strategie in der Beantwortung der Frage, unter welchen Bedingungen extreme Naturereignisse zu Katastrophen werden, deutlich voranbringt und so zur Minderung der Schäden durch extreme Naturereignisse beitragen kann.

Jochen Zschau
Michael Kunz

I. Research

Forensic Disaster Analysis

„Forensic Disaster Analysis“ (FDA) in Near Real-Time, which started in 2012 as the major CEDIM activity, has remained CEDIM’s main focus also in 2013. The goal of the FDA is to enhance our understanding of the critical factors and interdependencies that control losses to life, infrastructure and to the economy as a result of natural extreme events, and from this to better predict implications for protective measures, response and recovery. As the term “Forensic” in FDA indicates, the related research follows a comprehensive strategy for disaster impact analysis that takes into account not only the natural components of an extreme event, but also the complex interactions and cascading effects within and between the natural, social, economic and infrastructure systems. With its Near Real-Time approach CEDIM FDA allows for the time criticality of the disaster related information flow as well as for the potential user interest, both being at a peak within the first days of a disaster.

The work within CEDIM’s FDA has remained organized into two closely related work areas; the first has its focus on the development of new methods for analysing natural disasters in Near Real-Time, and the second concentrates on applying these methods to real events. The latter includes an event-triggered rapid gathering and provision of disaster information useful for various stakeholders.

Besides the 8 research projects that had already been started in 2012 and continued in 2013:

1. Rapid Assessment of 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. Transportation Interruptions,
6. Crowdsourcing - Using Social Media for Rapid Damage Assessment,
7. Assessment of Indirect Losses and Economic Impacts,
8. Development of a CEDIM Database and Implementation of Case-Based Reasoning for Analytical Support.

Two new projects were initiated within work area 1 in the reporting year,

9. Causal Loss Analysis,
10. Information Gap Analysis: Near Real-Time Evaluation of Disaster Response.

The first one (9) attempts to create a method for rapidly identifying and estimating key indicators in the aftermath of a catastrophic event (geophysical or hydro-meteorological) that can provide a holistic view on post-disaster shelter, aid, recovery and reconstruction needs. The second one (10) has its focus on the development of a method for analysing the efficiency of disaster response in Near Real-Time.

Work area 2, event triggered task force campaigns, was in action in 2013 in response to the following cases, the

1. June Flood 2013 in Central Europe (Focus Germany),
2. Super Cyclone “Phailin” in India in October,
3. Super Typhoon Haiyan beginning of November in the Philippines.

In addition, FDA activities were also initiated, although not to the same extent as for the three cases above - for a number of natural events, such as

4. M=7.2 Bohol Earthquake of October 15 in the Philippines, and the
5. Winter storm Xaver in northern Europe beginning of December and a few others.

Of the five events above at least four were exceptional in some manner. The June flood 2013, in terms of spatial extent and magnitude, exceeded all previous floods in Germany since at least 1950. With wind speeds of up to 259 km/h the super cyclone Phailin was classified as a category 5 cyclone – the highest category on the Saffir-Simpson hurricane scale, and with a maximum sustained wind speed of 314 km/h and peak wind gusts of 380 km/h the super Typhoon Haiyan/Yolanda was one of the strongest tropical cyclones ever observed in history. Winter storm Xaver caused a severe storm surge hazard for the entire North Sea coastline

that resulted, for instance, in the second highest absolute water level recorded since 1825 at the tide gauge in Hamburg St. Pauli.

All events were analysed in Near Real-Time, and the results made public in special reports within a few days and continuously updated. Some of the results were later published or submitted for publication in scientific journals. Special summaries derived from the reports were also put on the web page of the Earth System Knowledge Platform (ESKP) of the Helmholtz-Association. Altogether 13 reports were accomplished, 2 for the June Flood 2013, 2 for super Cyclone “Phailin”, 6 for the Bohol earthquake, 2 for super Typhoon Haiyan/ Yolanda and 1 for Winter storm Xaver. They include among others information on the related hazards, on historical events, exposure and vulnerability, primary, secondary and indirect damage, social and economic impact as well as on loss estimates. As the reports are quite detailed, only three FDA Task Force missions are addressed here, and only a summary is given, respectively. The full reports are available from CEDIM’s webpage www.cedim.de. Their format differs slightly from the one of the 2012 reports, in particular as each report is now proceeded by one to two standardized information sheets that summarize the most important features of each event. This modification was a consequence of intensive interactions we had in 2013 with potential stakeholders on the national and European level. An example for such a standardized summary sheet is given in the following for the Philippines (Bohol) earthquake, report 6 (final report).

Forensische Katastrophenanalyse

Die 2012 von CEDIM begonnene forensische Katastrophenanalyse (FDA) in Nahe-Echtzeit war auch der Hauptfokus der CEDIM-Aktivitäten im Jahr 2013. Das Ziel ist geblieben, die kritischen Faktoren und Wechselwirkungen, die das Schadensausmaß bei Naturkatastrophen bestimmen, so verstehen zu lernen, dass daraus Implikationen für geeignete Schutzmaßnahmen abgeleitet werden können. Wie das Wort „forensisch“ ausdrückt, ist der wissenschaftliche Ansatz insofern umfassend, als er nicht nur das natürliche Extremereignis selbst adressiert, sondern auch komplexe Wechselwirkungen und Kaskadeneffekte innerhalb und zwischen den betroffenen natürlichen sozialen, ökonomischen und infrastrukturellen Systemen berücksichtigt. Die Nahe-Echtzeit-Komponente erscheint wichtig, da sowohl der katastrophenbezogene Informationsfluss als auch das potentielle Nutzerinteresse unmittelbar nach einer Katastrophe am größten sind.

Wie auch schon 2012 sind CEDIMs FDA-Aktivitäten in zwei Arbeitsbereiche gegliedert, im Bereich 1 mit dem Fokus auf methodische Entwicklungen, die Analysen in Nahe-Echtzeit ermöglichen, und im Bereich 2 mit dem Fokus auf die ereignisgetriggerte praktische Durchführung der Analysen.

Zu den bereits seit 2012 aktiven 8 Forschungsprojekten des Bereichs 1 sind 2013 zwei weitere hinzugekommen, so dass zurzeit 10 Forschungsprojekte zur Entwicklung von Nahe-Echtzeit-Methodiken durchgeführt werden. Die beiden neuen Projekte befassen sich mit Möglichkeiten, den Bedarf an Notunterkünften und anderen Hilfen unmittelbar nach einem katastrophalen Ereignis schnell erfassen zu können, sowie die Effizienz der Katastrophenhilfe in Nahe-Echtzeit zu analysieren.

Im Arbeitsbereich 2 wurden 2013 ereignisgetriggerte Task Force-Kampagnen in fünf Fällen durchgeführt. Drei bezogen sich auf extreme Sturmereignisse, eine auf die Juni-Flut in Mitteleuropa und eine weitere auf ein destruktives Erdbebenereignis. Alle Katastrophen wurden in Nahe-Echtzeit analysiert und innerhalb weniger Tage nach dem jeweiligen Ereignis in speziellen Berichten (insgesamt 13) auf der CEDIM-Webseite der Öffentlichkeit zugänglich gemacht. Auch die „Earth System Knowledge Platform (ESKP)“ der Helmholtz-Gemeinschaft war zu einem frühen Zeitpunkt einbezogen worden, so dass zielgerichtete Zusammenfassungen bzw. Extrakte auf die ESKP-Webseite gestellt werden konnten. Ausgesuchte Ergebnisse kamen auch in wissenschaftlichen Zeitschriften zur Veröffentlichung bzw. wurden zur Veröffentlichung eingereicht.

Als Folge einer intensiven Diskussion mit möglichen Stakeholdern auf nationaler und europäischer Ebene wurde für die Berichte ab 2013 ein neues Format gewählt, dass den ausführlichen „Reports“ u.a. eine ein- bis zweiseitige nach einem vorgegebenen Schema standardisierte Zusammenfassung voranstellt. Ein Beispiel hierfür wird im Folgenden für das Bohol-Erdbeben gezeigt (Report 6, letzter Bericht).

CEDIM Forensic Disaster Analysis Group &
CATDAT and Earthquake-Report.com

Philippines (Bohol) Earthquake – Report #6

02.11.2013 – Situation Report No. 6 – 14:00 GMT

Report Contributors:

Report & Socioeconomic Loss Analysis: James Daniell (Earthquake Report/KIT) & Armand Vervaeck (EQ Report); Shelter: Susan Brink & Friedemann Wenzel (KIT); Social Sensors: Joachim Fohringer, Silke Eggert (GFZ), Andre Dittrich, Christian Lucas (KIT); Disaster Response: Trevor Girard (KIT); Landslides: Bijan Khazai (KIT); Weather: Bernhard Mühr (KIT); Social Vulnerability: Chris Power (KIT), Werner Trieselmann (GFZ); Bohol Pictures and on-site data: Pieter Nierop, Julie Jaramillo & Maria Docoy-Boucher (Bohol, Philippines); General Help & Dissemination: Carlos Robles, Jens Skapski (Earthquake Report), Lee-Jerome Schumann (GFZ)

Official Disaster Name	Date	UTC	Local	CATDAT_ID
Bohol EQ	**15-Oct-2013**	**12:12:31**	**+8**	**2013-285**

Preferred Hazard Information:

EQ_Latitude	EQ_Longitude	Magnitude	Hyp_Depth (km)	Fault Mech.	Source	Spectra
9.86	**124.07**	**7.2Ms**	**12**	**Thrust**	**PHIVOLCS**	**Some avail.**

Duration: 30 secs

Location Information:

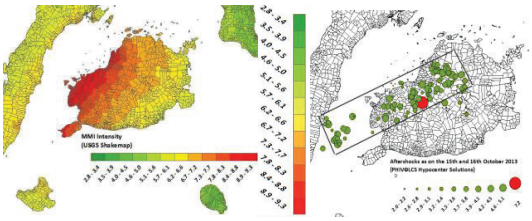
Country	ISO	Province	Most Impact	Building PF	HDI (2012)	Urbanity	Population
Philippines	**PH**	**Bohol**	**West Coast**	**Average**	**0.729**	**25%**	**1.3 million**
Philippines	**PH**	**Cebu**	**City**	**Good**	**0.761**	**66%**	**4 million**

Preferred Hazard Information:

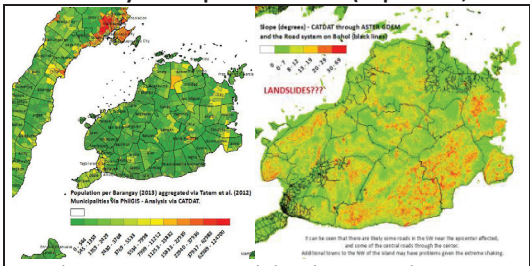
MSK-64	MMI	PEIS	**Key Hazard Metrics**
IX	VIII-IX	VII-VIII	(VIII-IX) Epicenter, Loon, Clarin, (VII-VIII) Tagbilaran City, West Bohol, (VI-VII) Cebu City, East Coast Cebu, East Bohol

Hazard Description (Intensities and Ground Motion)

Intensities reached VII on the PEIS scale – very well built structures received slight damage. Older buildings suffered great damage. There was also limited liquefaction. The damage seen corresponds to VIII and perhaps very isolated VIII-IX locations on the MMI scale. Over 3000 aftershocks have occurred, with magnitude 5 earthquakes continuing to pepper the region around Clarin, Loon and Tagbilaran on Bohol. The fault sense can start to be seen well from the PHIVOLCS data, with the fault break running at about WSW-ENE. At least 94 of these have been strong enough to be felt.



Vulnerability and Exposure Metrics (Population, Infrastructure, Economic)



Population, Barangays and the Elevation, Slope

The island of Bohol has a capital stock around $5-6 billion USD with approximately 1.3 million inhabitants. It is mountainous in nature and has the chance for many landslide. Cebu is a key tourist area in the Philippines with 2 million arrivals per year as of 2013. Still, the average income and GDP per capita is about the same as that of the whole of the Philippines. Bohol has a lower GDP per capita in comparison. The main industries are dominated by agriculture which could be affected.

What have been the 2 largest comparable damaging events in the past? None in this region.

Date - Name	Impact Size	Damage %	Social % or Insured %	Economic Loss
1990 Bohol	Mw6-6.8, VII PEIS	7000 homeless	6 deaths, 200 injured	154m PHP ($7m US)
1996 Bohol	Mw5.6, VI PEIS	Poorly built structures	No deaths	Minor

Preferred Building Damage Information: (Damage states will be filled in later when more info available)

Description: Many government, churches and private (over 66932 so far) The counting of buildings destroyed has not been undertaken with only a few houses included in the current count of **13249 destroyed and 53683 damaged.** Based on families displaced, this value could be up to at least 15-20000 destroyed. Loon has been particularly hard hit as well as Tubigon, Antequera, Carmen, Tagbilaran and others. See the pictures for locations of current counting.

Julie Jaramillo (all rights reserved)

Secondary Effect Information: For weather impacts see reports 1-5 & *http://www.wettergefahren-fruehwarnung.de/*

Type	Impact	Damage %	Social %	Economic %
Landslides	Many roads blocked, infrastructure damage	Minor	At least 20 deaths	1-5%

See below in the pictures for Barangays affected

Preferred Social Impact Information:

Type	Median	Accepted Range	Description	Source
Deaths	**230 incl. 8 missing**	May rise	Hypocenter played a major role in fatality estimation: 20 to 400 =various models	Daniell, CATDAT, Earthquake Report.
	***NB: The lowest death toll is currently 222 as 8 are missing.*			
Injuries	**976**	Approx. 1000	877 Bohol, 96 Cebu	NDRRMC
Sheltered Homeless	87000	Up to 105000	87146 currently in shelters	NDRRMC Data 02.11.2013
All Homeless	**368691**	**380906** peak	**368691 currently displaced – see below**	NDRRMC
Affected	**3.2m**	3.5m peak	Cebu, West Bohol, Negros	NDRRMC

*predicted

Preferred Current Economic Impact Information: $million int. event-day dollars

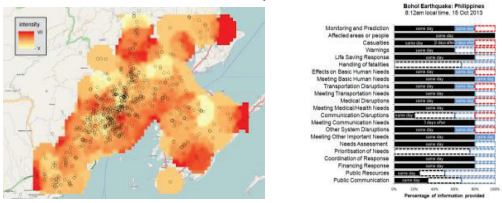
Type	Median	Accepted Range	Description	Source
Reconstruction Cost	$162m	$100m-$200m	Reconstruction costs have been estimated at 7 billion PHP	NDRRMC/Govt
Total Loss	$89.4m	$55m-121m	Total estimate (using rapid loss model combined with damage for range)	CATDAT/James Daniell
Insured Loss	<$2m	$1m-5m	Minor insurance takeout but some in Cebu	CATDAT
Aid Impact	$8m		EU: $3.3mn, AU: $3mn - $46.8mn desired.	NDRRMC

Direct Economic Damage (Total) - Summary

- There have been estimates of some components of the infrastructure damage being **2.2 billion PHP** (around 50 million USD).
- The rapid loss estimation of CATDAT/James Daniell, gives a total damage value coming out to between 55-100 million USD (up to 4.5 billion PHP) with a median 89.4 million USD (3.9 billion PHP).
- The reconstruction cost has been estimated by the government to be approx 7 billion PHP (162m USD)
- This is a significant percentage of the gross capital stock of the location, with a MDR approaching 2%.

Social Sensors & Disaster Response

- Analysis has been undertaken as to the social media response during the earthquake, and also the associated aid and disaster response after the disaster. See the main chapters for more info.



Source: Silke Eggert, Joachim Fohringer (GFZ); Trevor Girard (KIT)

Insured Loss Estimates:

Some public infrastructure damage occurred, and in addition there was minor damage to tourist facilities in various locations. It is still expected that the damage will be insignificant for the insurance industry. In addition no global impacts on supply chains.

Abridged Summary Description from full CATDAT description sources:

A catastrophic earthquake hit the densely populated area of Cebu, and the less densely populated island of Bohol with catastrophic consequences.

CATDAT Economic Index Rank:	8: Very Damaging	**CATDAT Social Index Rank:**	8: Destructive

This report was produced in conjunction with the CATDAT database, earthquake-report.com, NDRRMC, PHIVOLCS and USGS data. As shown below is full size documentation of the diagrams shown in the summary above. The data is current as of 2nd November 2013, 6:00am European Standard Time. For the current data, go to www.earthquake-report.com.

FDA Research Projects

Rapid Assessment of Slip Distribution Based on Near Field Displacement Wave Forms

Andreas Hoechner

Introduction

During recent decades, and especially since the advent of the GNSS (Global Navigation Satellite System), geodetic methods have become more prominent in supporting traditional seismological methods. In the near field of large earthquakes, it is not straight forward to interpret data from broadband seismometers due to clipping, tilting and hysteresis effects, even though 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 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

During the last year, there were no earthquakes which triggered an FDA (forensic disaster analysis) activity including a rapid assessment of the slip distribution.

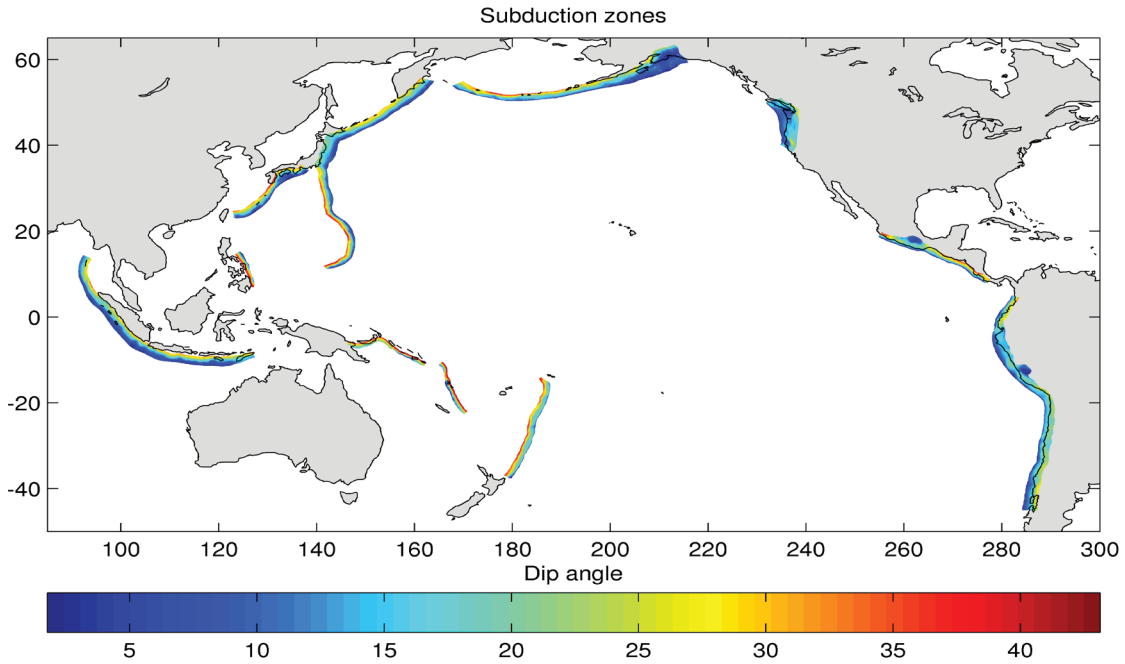


Fig. 1: Geometry of major subduction zones. The Hellenic arc and Makran will also be included.

For two test cases (Japan, Chile), a compilation was made of what could be provided (given that GNSS data can be obtained). The publication about Tohoku, which was submitted last year and published this year, generated a lot of attention in general media (radio interview for BBC, etc.). The geometry of the subduction zones as defined in the Slab 1.0 model (Hayes et al., 2012) has been adopted for the static inversion procedure (see Fig. 1).

Outlook

The geometry of some additional subduction zones, especially the Hellenic arc and the Makran, will be adopted based on the RUM model (Gudmundsson et al., 1998). For those regions where it appears promising, a sensitivity analysis concerning GNSS-based tsunami early warning will be conducted. The wave form inversion procedure should become available next year.

Core Science Team

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Section 2.1 Physics of Earthquakes and Volcanoes, GFZ

Publications

Hoechner A., Ge M., Babeyko A. Y. and Sobolev S. V. (2013): Instant tsunami early warning based on real-time GPS – Tohoku 2011 case study, Nat. Hazards Earth Syst. Sci., 13, 1285-1292.

Wang R., Diao F., Hoechner A. (2013): SDM-A geodetic inversion code incorporating with layered crust structure and curved fault geometry, Geophysical Research Abstracts Vol. 15, EGU2013-2411-1 (Poster presentation).

ATMO Forensic Prediction and Analysis

Bernhard Mühr

Short description and goals

Not only western and northwestern Europe are prone to winter storms, such events are also common in central Europe between October and March. They can be strong and sometimes cause significant loss and damage. “Lothar” and “Anatol” in 1999 or “Kyrill” in 2007 are well-known representatives of winter storms that affected Germany. And recently, in October 2013, the winter storm “Christian” swept across northern Germany and Denmark with wind speeds close to 200 kph, establishing a new all-time wind record for Denmark. In addition to the routine forecasting and analysis activities of worldwide extreme weather events and the activities in the CEDIM Forensic Disaster Analysis group, “Wettergefahren-Frühwarnung” will develop a method to record, classify and evaluate winter storms in Germany, central Europe and finally Europe as a whole.

For the scenario “winter storm”, practical and routine methodologies will be implemented before 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.

A winter storm can be described by a number of indices. Observed wind data (maximum average wind speed and gusts) from a selection of representative weather stations of the measurement network of the German Weather Service may be aggregated into a measured storm index. Due to changes in the location or the conditions of the measurement, some of the resultant time series have to be adjusted.

A second index, the model storm index, can be derived from model data. A data set with analysed and forecasted average wind speeds is available for past storm events. According to the number of grid points at which the model wind speed was over a predefined threshold, an individual storm index is calculated. The model output doesn’t provide information about

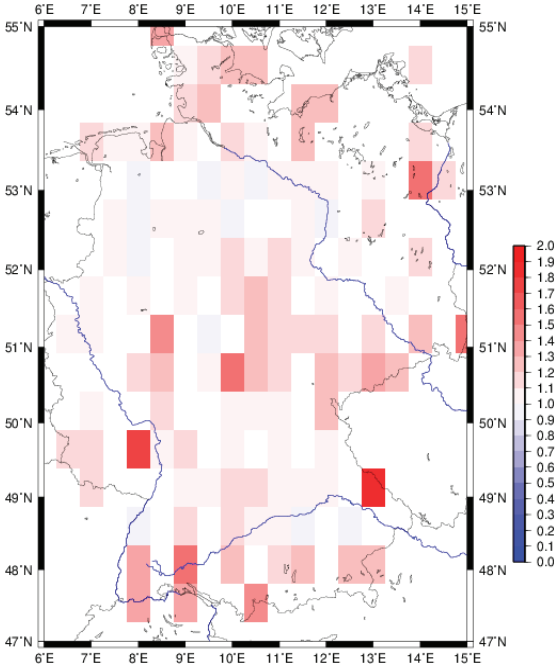

Fig. 1: Comparison of model wind gusts and measured wind gusts (station data) for 100 storm events between 1990 and 2013. Red colours indicate that the real (measured) wind gusts have been higher by a factor between 0 and 2 whereas blue colours show areas where the model overestimated the wind gust speed. Data source: CFS (Climate Forecast System) Reanalysis data and observed wind gust data (station network of the German Weather Service).
Image provided by Sarah Jäger (KIT, IMK)

wind gusts: these will be computed using the wind speed and the height of the planetary boundary layer. The model analyses result in a storm index that includes both affected area and storm intensity. A validation is done by the comparison of the model storm indices and the measured storm indices.

Furthermore, a storm 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.

So far we have identified 100 winter storms between 1990 and 2013 and calculated the model wind gusts. It turned out that the model wind gust speeds are generally too low compared to the observed at the related weather stations; only few areas show a slight overestimation (blue colours, Fig. 1).

Using this information the forecast model wind gust speed can be optimised and 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. Ensemble forecasts consisting of about 20 forecast members allow describing a storm scenario well in advance and with an increasing reliability and significance the closer the storm gets. Towards the end of 2014 we will be able to provide a storm damage estimation based on GFS (Global Forecast System) ensemble forecasts for central Europe with the option to extend it to the whole of Europe in a next step; using the WRF and/or COSMO models the results might be even more precise.

The data of 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. "Case-Based Reasoning" is another FDA project within CEDIM.

Additionally, the Wettergefahren-Frühwarnung contributes to all CEDIM FDA activities ahead, during and after a major event. Information will be provided as text, weather charts or data and will be part of all CEDIM reports. Furthermore, information provided on the Wettergefahren-Frühwarnung web pages are used by online and print media, news agencies, insurance firms and others. The information on the web pages is updated on a daily routine, with page impressions in the order of several thousand a day.

Core Science Team

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Publications

Articles and reports of about 1000 unusual and extreme weather events between 2004 and 2013 can be found 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 provide important information for disaster response activities including emergency management, financial appraisal and reconstruction planning. Further, closely monitoring and documenting the hydro-meteorological factors which control flood generation and development as well as evaluating flood impacts provides a valuable basis for the in-depth analysis and improved understanding of flood causes for floods and the key drivers for their impacts and consequences.

Aims/Objective

The Rapid flood event analysis project aims at the development of an operational flood event analysis system which enables the Near Real-Time acquisition and evaluation of event-related hydro-meteorological data from in-situ and remote sensors. The analysis system provides functionalities to evaluate the current flood situation, to assess hazard intensity and to estimate the current flood impact, particularly direct flood damage to private households and companies. This system supports the work of CEDIM's forensic disaster analysis Task Force. Another objective is the compilation of a consistent flood event catalogue which enables comparisons and categorizations of large scale flood events in terms of triggering processes and preconditions, critical controls and drivers for flood losses as well as the interplay of the natural hazard, technical facilities and society.

Project status

The prototype of the flood event analysis system is currently being tested. This is essential to work out the conceptual details, to test the methods and tools, and to refine the interfaces to the relevant data sources and diverse data providers, including the CEDIM projects 'Forensic ATMO' and 'Social Sensors'. The January 2011 flood was successfully used as a test-case for a 'simulated' Near Real-Time flood loss estimation using remote sensing data from DLR-ZKI (Schröter et al. 2013a, 2013b). The results of this test application, see example shown in figure 1, demonstrate the feasibility of the flood loss estimation approach thus implemented and confirm the value of satellite radar data for rapid flood impact evaluations. The spatial coverage, accuracy and resolution provided by Terra SAR-X StripMap-Scenes are promising. However, in operational applications the availability of these data is not guaranteed.

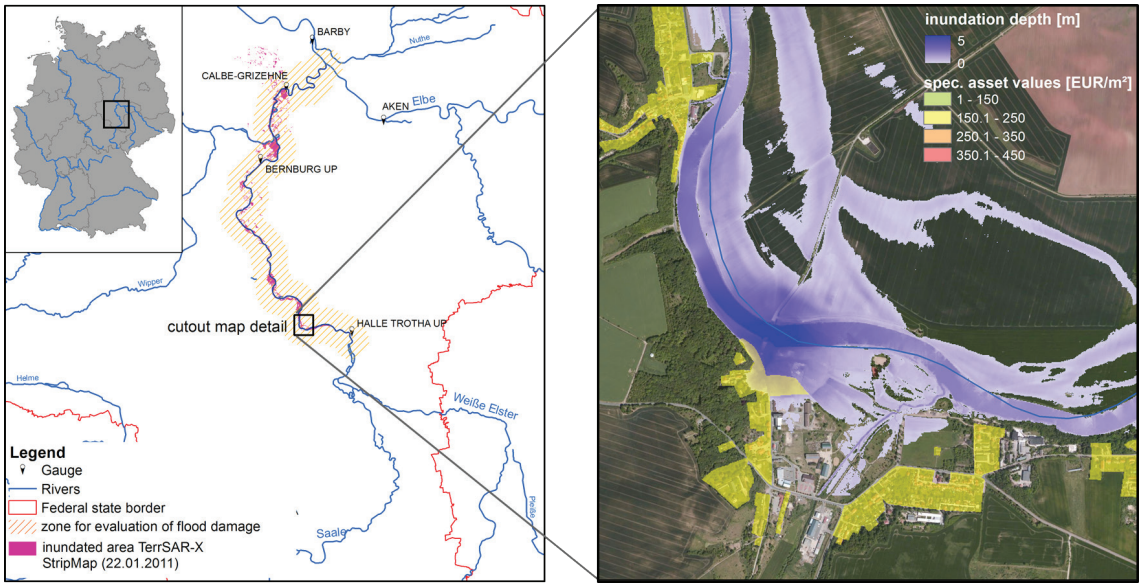

Fig. 1: Study area for January flood 2011 event analysis (left), exemplary detail of specific asset values of residential buildings and inundation depths derived from TerraSAR-X StripMap Scene (right).

Further, the core science team contributed to the CEDIM FDA activities on Hurricane Sandy in November 2012 and the Central European Flood in June 2013. In particular, the June 2013 flood provided valuable experiences and insights into data availability issues and the performance of data acquisition and evaluation procedures under real conditions. The CEDIM FDA Task Force published a first event report on 4th of June - four days after the start of the event precipitation on 31st of May - including a snapshot of spatial flood hazard distribution and a classification of the flood hazard in terms of event severity in comparison to historical flood events (http://www.cedim.de/english/2408.php).

Outlook

Based on the experience gained from the test applications, future activities are aimed at integrating alternative information sources which allow estimating inundated areas and inundation depths and evaluating the flood impact in Near Real-Time. To this end the suitability of water levels from river gauges and/or hydraulic simulation models, information from social sensors as well as background information from official flood hazard maps will be investigated. Further steps are the implementation of the operational flood event analysis system and carrying forward the analysis of the June 2013 flood, including the estimation of direct flood losses to residential buildings on the national scale.

Core Science Team

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Publications

Schröter, K., Kreibich, H., Zwenzner, H., Merz, B. (2013a): Schnelle Hochwasserereignisanalyse in Deutschland, Wasserbaukolloquium 2013: Technischer und organisatorischer Hochwasserschutz -Bauwerke, Anforderungen, Modelle, Wasserbauliche Mitteilungen Heft 48, 163-172.

Schröter, K.; Kreibich, H.; Merz, B. (2013b): Rapid flood loss estimation for large scale floods in Germany. General Assembly European Geosciences Union (Vienna, Austria 2013).

Loss Assessment for Earthquakes

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

Introduction

For each earthquake worldwide over the past year, reporting of the potential impacts, analysis of the losses and rapid estimates of fatalities, damaged buildings and economic losses have been undertaken. The assessment of various components of hazard, vulnerability and exposure combined with the socioeconomic climate of the affected region allows for successful estimation of losses.

Aims/Objective

- To determine which events are interesting and are historically significant for forensic disaster analysis.
- To create a rapid loss estimate of the potential impacts, and to look at the evolution
- and key parameters which influence the earthquake losses.
- To create robust methodologies using socio-economic indicators and traditional empirical and analytical fragility functions.
- Exploration of not only shaking losses, but secondary effects such as landslide, liquefaction, tsunami and fire.

Project status

The loss estimation methodologies have been used in various studies in 2013 including the Pakistan (Arawan), Philippines (Bohol), China (Sichuan) and other major earthquakes. Anal-

ysis has been undertaken in conjunction with www.earthquake-report.com in order to provide the quickest possible information via a group of dedicated 24/7 reporting. Each earthquake has been examined for the last 12 months in terms of the socioeconomic impacts on the affected regions. Over 300 earthquakes have caused some form of damage and around 150 have been classified as having damage significant enough to be input into the yearly review of damaging earthquakes via CATDAT. So far, over 1500 deaths have occurred this year, and although analysis has been undertaken on a number of events, none of the hard-wired forensic disaster analysis criteria has been exceeded as yet. In May 2012, there was 1 such event – the Mirandola earthquake (subject to the final loss estimate) with around $17 billion reconstruction costs estimated.

In terms of historical statistics, this is a significant period of quiescence: there is usually an average of 3 events occurring per year (for the last 113 years) using the following criteria:

Absolute: Over 1000 deaths; 200 000 homeless (non-panic); Over $8.5 billion USD (2013) losses and/or all less damaging events (with structural damage) in Germany.

Relative: > 30 deaths with > 1 death per 100,000 pop.; > 0.8 % of country population to become homeless.; Over 3 % of Gross Domestic Product (GDP) Purchasing Power Parity adjusted (PPP) with losses > $30 million USD; Any interesting location, or extraordinary event.

During the doctoral thesis research of James Daniell, a process for rapid economic and social loss estimates has been created and tested over the past 4 years. This uses parsimonious modelling using intensity, historic damage and socio-economic parameters calibrated through time to create loss functions. This methodology will now be used by Susan Brink for homelessness, starting in October 2013. Historic events from the CATDAT Damaging Earthquakes Database (the 3rd annual report of which was distributed in January 2013 in conjunction with CEDIM) will be used to find the key parameters contributing to homelessness in order to give rapid assessments of shelter-seeking individuals, which may also help disaster relief organisations to better apportion aid and the level of support needed. The general format of the functions is shown in figure 1. The latest event explored is that of the 2013 Bohol earthquake in Philippines. Loss estimates using the first intensities coming out underestimated the death toll (predicting around 20 deaths), but once the intensity maps were updated to better repre-

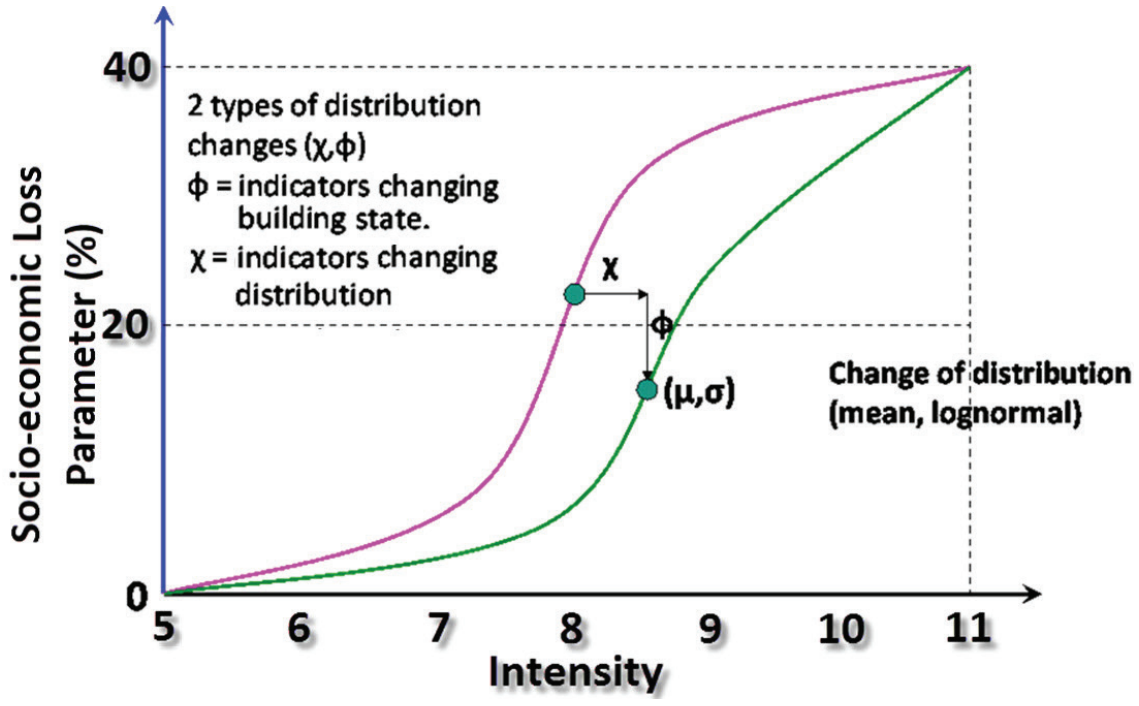
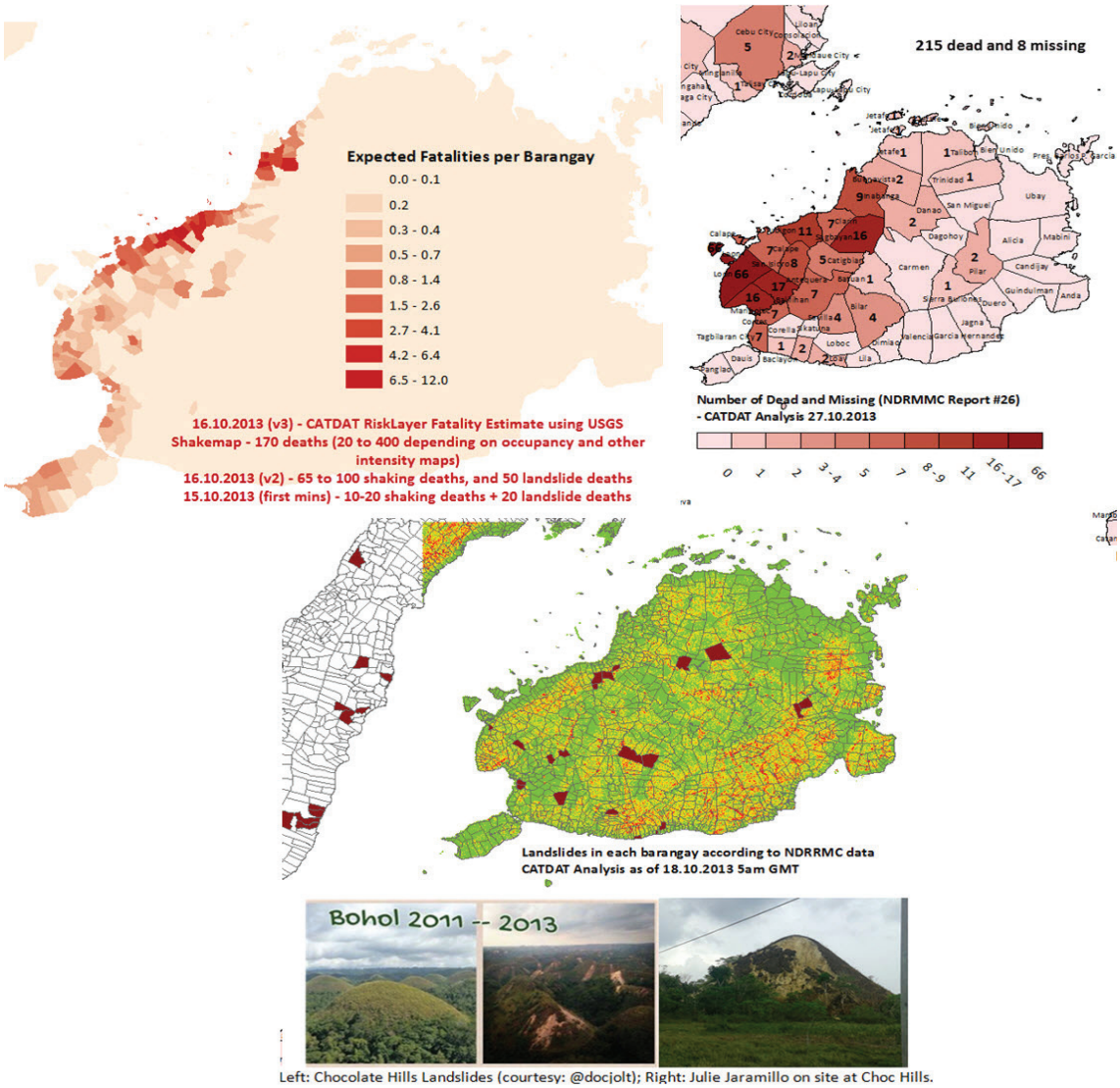


Fig. 1: The methodology for rapid socio-economic fragility functions (Daniell, 2013).

sent the intensities felt on Bohol (around 24 hrs after the event), death tolls of around 100 due to shaking were expected, with the final version of 170 shaking deaths resulting from using the PHIVOLCS intensity data. A 90 million USD loss and around a 160 million USD reconstruction cost using the rapid estimation were predicted. As of the 28 October 2013, 223 people have died (around 130-150 due to direct shaking effects) and around a 150-180 million USD reconstruction cost estimated. Six reports have been produced detailing the loss estimation, statistics and analysis of secondary effects such as landslides. A 2-page executive summary was constantly updated for easy viewing from partners, giving a quick and easy to read summary (see page 13). Examples of some of the diagrams can be seen in figure 2. Collaboration with the Crowdsourcing project as well as with Transportation Interruptions and CE-DIM Database CBR projects continues.

Outlook

The reports produced have previously contained many different analyses, generally focussing on the impacts of loss. The reports have also been published on ReliefWeb to help aid organisations with pre-mission planning. In the future a finer tuning of the reports to agencies such as Civil Protection agencies, International Relief Organizations, Development Organizations and Industry (Insurance, Tourism, global scale manufacturing, etc.) in order to provide useable post-disaster information, will be undertaken. In addition, learning through



Left: Chocolate Hills Landslides (courtesy: @docjolt); Right: Julie Jaramillo on site at Choc Hills.

Fig. 2: Some of the diagrams from the set of Bohol earthquake reports in October 2013; Left: CATDAT fatality rapid estimation using early intensity map; Middle: Fatalities as of 28 October 2013 in each location (223 dead and missing); Right: Landslide location map per barangay on Bohol.

this rapid post-disaster analysis, new research areas were discovered in locations where there is little or non-detailed census information. The rapid post-disaster analysis methodology will be extended to homelessness as well as tailoring the disaster reports and using the methodologies established currently to cover more loss types (man-made, etc.), emphasising insurance and other economic aspects, knowledge management, re-visiting forensic disaster analysis sites and processes and to enhance stakeholder interaction.

Core Science Team

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Publications

Daniell, J.E., Schäfer, A., Wenzel, F., and Khazai, B. (2013): Weltweite Verluste durch von Erdbeben induzierten Sekundäreffekte und deren Bedeutung für D-A-CH und das Versicherungswesen, Beitragsnr. 138, 13. D-A-CH Tagung für Erdbebeningenieurwesen und Baudynamik (D-A-CH 2013) C. Adam, R. Heuer, W. Lenhardt & C. Schranz (Hrsg.) 29.-30. August 2013, Wien, Österreich.

Daniell, J.E., B. Khazai, F. Wenzel (accepted 2013): Uncovering the 2010 Haiti Earthquake death toll, Natural Hazards and Earth System Sciences.(NHESS), Discussions, 1, 19131942, 2013. doi: 10.5194/nhessd-1-1913-2013.

Wenzel, F., J. Zschau, M. Kunz, J.E. Daniell, B. Khazai, T. Kunz-Plapp (2013): Near Real-Time Forensic Disaster Analysis, in: Comes, T., F. Fiedrich, S. Fortier, J. Geldermann, T. Müller (eds) Proceedings of the 10th International ISCRAM Conference – Baden-Baden, Germany, May 2013.

Wyss, M., Wenzel, F., & Daniell, J.E. (submitted 2013): How Useful is Early Warning and Can It Be Made More Effective? In Early Warning for Geological Disasters (pp. 369–379). Springer.

Daniell, J.E. (submitted 2013): Socioeconomic impact of earthquake disasters, in “Earthquake Hazard, Risk, and Disasters”, ed: Prof. Max Wyss, Earthquake and Seismic Hazards and Disasters. Elsevier.

Khazai, B., Daniell, J.E., Düzgün, S., Kunz-Plapp, T., Wenzel, F. (2013): Framework for Systemic Socio-Economic Vulnerability and Loss Assessment, In Framework for Systemic Socio-Economic Vulnerability and Loss Assessment, eds: K. Pitilakis, P. Franchin, B. Khazai, H. Wenzel.

Daniell, J.E., Vervaeck, A. (2013): The CATDAT Damaging Earthquakes Database – 2012 – Year in Review, CEDIM Research Report 2013-01, Earthquake Report OF Report, Karlsruhe, Germany.

Power, C., Daniell, J. E., Khazai, B., Oberacker, C. & Schaper, J. (2013): Socio-Economic Vulnerability and Integrated Risk Initiative: Status Report #2, GEM Willis Socioeconomic Resilience Project.

Transportation Interruptions

Kay Mitusch, Tina Bessel

Introduction

Following a winter storm, flood, or other natural disasters, the media often report the severe impacts on travellers, such as delayed trains or flights, missed connections, road traffic congestion or forced detours. The quantification of these impacts in physical and monetary terms is hardly ever reported, although the public and media would be interested in this information immediately after an event. The Chair of Network Economics, part of the Institute of Economics (ECON) at Karlsruhe Institute of Technology (KIT), is investigating the impacts of events causing a disruption of the transportation system.

Aims/Objective

Our goal is to develop a procedure to rapidly assess the indirect economic losses following a disruption of the transportation system. Therefore this project contributes to a better understanding of economic losses of events harming transport systems. We specifically aim to improve the accuracy and speed of indirect loss assessment by:

- identifying data requirements;
- finding innovative estimation methods for cases in which little data is available;
- classifying impacts of a disrupting event;
- determining affected parties;
- analysing possible methods of quantification and monetization of the impacts;
- assessing the indirect costs associated with a disrupting event.

Project status

We have studied the impacts on transport of the winter storm Daisy in Germany and of the eruption of the Islandic volcano Eyjafjallajökull. Both events happened in 2010, and we focused on the impacts on the German transport sector. From press releases and other internet resources, we collected information on all types of impacts caused by the events. We categorised the impacts to obtain an overview of the various dimensions. As an example, the winter storm Daisy caused snow drifts on the streets (direct impact). Therefore, cars had to drive more slowly (indirect impact), and some car drivers may have been too late for appointments (second-level indirect impact). We assessed the categorised impacts in respect of the possibilities to monetise 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. Otherwise it is virtually impossible to interpret the numbers presented.

Our recent activities focus on the central European flood in June 2013. For about two months during the joint FDA activities related to this event, we systematically monitored traffic reports that were broadcast somewhere in Germany. From these reports, we filtered all information on disruptions of road traffic caused by this flood event. Comprehensive data on the type, extent and duration of the disruptions was fed into a data base which provides a basis for further research.

Outlook

We are currently analysing possible methods to assess the disruptions collected in our database on the central European flood in June 2013. We aim to reduce all information of a disruption to a simple quantitative assessment that describes the severity of the disruption. All assessed disruptions in a certain area will form an indicator that will allow us to make a comparison of the impacts between different areas. Part of the results will be reported in an interdisciplinary joint paper of several CEDIM members about the impacts of the flood event.

The two case studies mentioned before showed that, depending on the type of event, different types of impacts can be expected within the transport sector. Future research will focus on developing appropriate methods for a fast quantification and assessment of the different impacts. We will need to collect more data from current or past events and undertake further case studies to verify and improve our procedures towards a more reliable rapid loss assessment.

Core Science Team

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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.

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

Crowdsourcing – Using Social Media for Rapid Damage Assessment

Joachim Fohringer, André Dittrich, Christian Lucas, Silke Eggert, Doris Dransch, Stefan Hinz

Introduction

Messages in social media can include a variety of observations on the impact of natural hazards. Especially messages from microblogs, such as Twitter, provide additional information, which is difficult or impossible to be detected by conventional sensors.

Our studies during the hurricane “Sandy” 2012, the floods in Central Europe 2013, and the earthquake at the Philippines 2013 (Fig. 1) have shown that Twitter messages incorporate useful information with respect to damage, such as flooded roads, damaged buildings or power outages. The damage information is provided either as text or photo. Information derived from Twitter messages can be used to quickly detect disastrous events, to complement traditional sensors or to validate damage scenarios.

Aims/Objective

The objective of the project is to acquire observations from eye witnesses in real-time from social media platforms and to provide it for rapid damage estimation. Storm, flood, and earthquake events are especially well regarded. The specific challenge in using social media as information sources is to automatically extract the relevant information from the huge amount of data. Our aim is to develop methods that determine quickly and reliably the relevance of each single message and to provide this information for further analysis and decisions.

Project status

We installed a prototype that quickly detects disastrous events from Twitter. This detection is performed on the basis of statistical tests and content analysis of twitter messages. For example, we detected the earthquake in the Philippines 2013 after just a few minutes from Twitter messages. After the event detection, a notification with a basic set of information is provided for a first overview. For further analyses of the disaster’s impact we extract relevant messages continuously during and after the event. To identify and rate the relevant information we developed a multi-level approach by filtering messages by suitable keywords, time, location and expert knowledge. Against the background of the floods in Central Europe in 2013 we extended our prototype with a web-based user interface to provide easy access to filtered messages from our database. This flood-focused interface allows an exploration of photos that are included in the Twitter messages. Flood experts can interpret photos and store relevant information, e.g. for deriving water levels, as additional attributes in the database. This enriched data than can be exported in standard geospatial data formats for further analysis.

Outlook

In a next step we will improve our detection and filtering methods. We want to enhance event detection and localization by adding a language processing component and spatial semantics. We also want to develop our methods towards automatic filtering and classification by using machine learning algorithms trained with manually labelled Twitter messages. Additionally, we will extend our prototype focused on floods to earthquake events.

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Publications

Dittrich, A., & Lucas, C. (2013). A step towards real-time analysis of major disaster events based on tweets. In T. Comes, F. Fiedrich, S. Fortier, J. Geldermann, & T. Muller (Eds.). Presented at the Proceedings of the 10th International ISCRAM Conference, Baden-Baden.

Dransch, D., Poser, K., Fohringer, J., & Lucas, C. (2013). Volunteered Geographic Information for Disaster Management. In C. Silva (Ed.), Citizen E-Participation in Urban Governance: Crowdsourcing and Collaborative Creativity (pp. 98-118). Hershey, PA: Information Science Reference. doi:10.4018/978-1-4666-4169-3.ch007.

Kunz, M., Mühr, B., Kunz-Plapp, T., Daniell, J. E., Khazai, B., Wenzel, F., Vannieuwenhuyse, M., Comes, T., Elmer, F., Schröter, K., Fohringer, J., Münzberg, T., Lucas, C., Zschau, J. (2013): Investigation of superstorm Sandy 2012 in a multi-disciplinary approach. Natural Hazards and Earth System Sciences, 13, pp. 2579-2598.

Kunz, M., Mühr, B., Schröter, K., Kunz-Plapp, T., Daniell, J., Khazai, B., Wenzel, F., Vannieuwenhuyse, M., Gomes, T., Münzberg, T., Elmer, F., Fohringer, J., Lucas, C., Trieselmann, W., Zschau, J. (2013): Near Real-Time Forensic Disaster Analysis: experiences from hurricane Sandy. General Assembly European Geosciences Union (Vienna, Austria 2013).

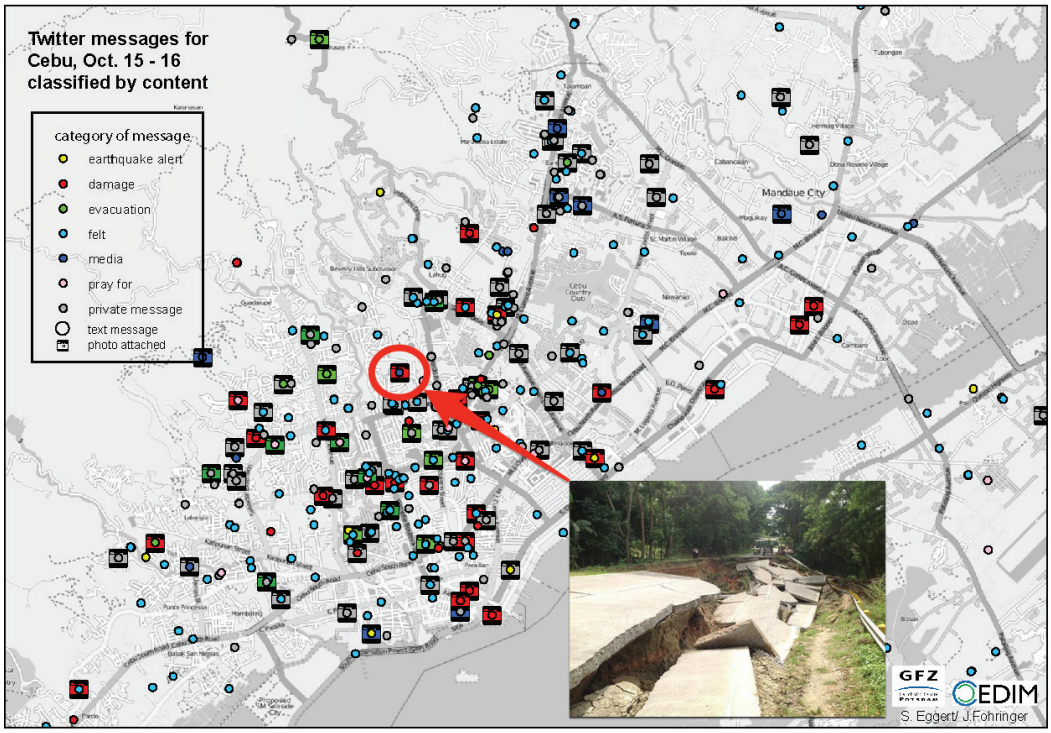

Fig. 1: Map of Cebu City in the Philippines with classified Twitter messages after an earthquake on 24 October 2013.

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

Stella Möhrle, Wolfgang Raskob

Introduction

Case-based reasoning (CBR) is a problem solving paradigm. In order to solve new problems, previously experienced problem situations are utilized. CBR makes use of similarity between problems and offers the possibility to quickly draw conclusions. The project "Development of a CEDIM database and implementation of case-based reasoning for analytical support" addresses the Near Real-Time characteristic of the Forensic Disaster Analysis (FDA) by providing a useful methodology, which can be applied by all institutes conducting first rapid assessments. Moreover, having a cross-sectoral task, the project supports the interdisciplinary quality of CEDIM. The establishment of a common database and the implementation of the CBR functionalities needs close collaboration between all experts.

Aims/Objective

The objectives are the development of a structured storage facility of different kinds of historic disasters and the implementation of CBR in the frame of FDA. Hence, attributes need to be gathered capturing general and event specific characteristics. Further, similarity functions need to be defined, which are dependent on the event and on the required information from the past. The application will be implemented and support Near Real-Time assessments gained from similar historic events.

Project status

Starting in 2012, the work focused this year on further improving individual aspects of the CBR system and the database. By means of expert discussions, the attributes were gathered and structured. Afterwards, the database was established and first historic events were integrated. The data model comprises earthquakes,

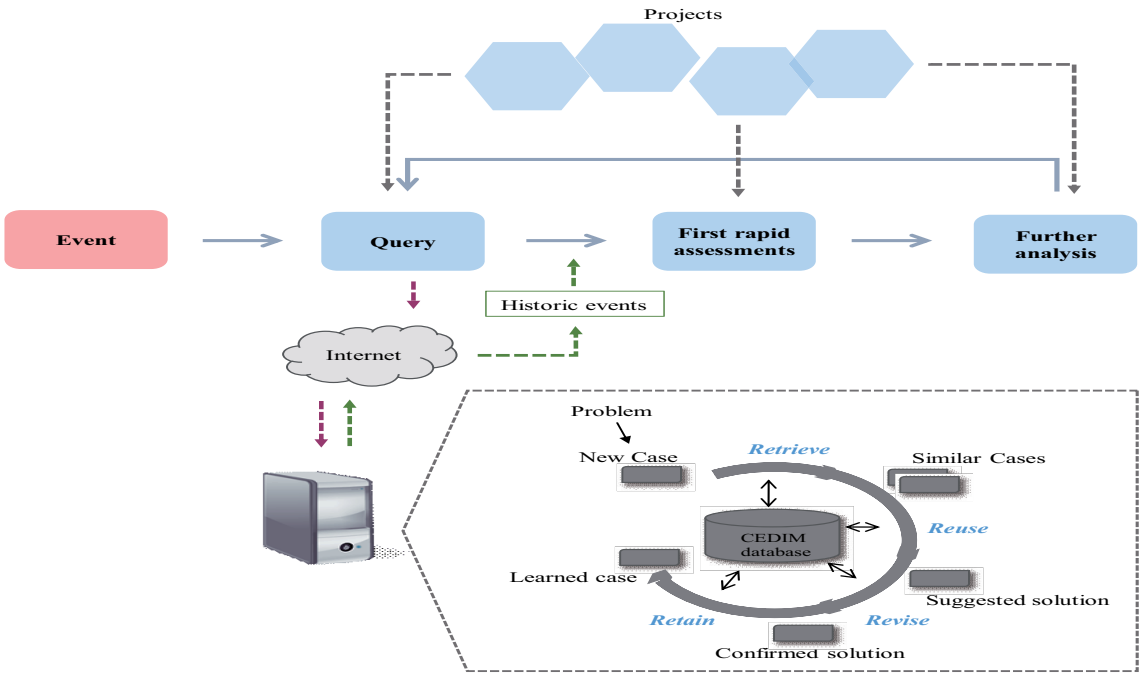

Fig. 1: The methodology CBR provides an analysis support for other participating project partners in order to conduct first rapid assessments. In the event of a disaster, members of the team can query similar historic events via a web interface. The CBR cycle illustrated is based on Aamodt, A. and Plaza, E. (1994): Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches.

floods and storms. Further, a new frame of the CBR application was set up. The application is programmed in Java. The focus here is on the development of a flexible application, which can be configured by XML files. The development is still ongoing. Parallel to this, approaches for the similarity calculations and technical implementations are under consideration.

Outlook

The CBR application will be developed further, including research activities on similarity calculations. The research is accompanied by discussions with experts and the implementation is realized in an iterative manner. The implementation concerns the CBR functionalities as well as the data in- and output during a current event. In the long term, the query should be implemented via a web interface.

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Assessment of Indirect Losses and Economic Impacts

Thomas Münzberg, Marcus Wiens, Frank Schultmann

Introduction

The increasing exposure and vulnerability of our modern interlaced societies against natural and man-made disasters intensifies the impact of hazards on people, buildings and infrastructure. Beside the resulting direct impacts, there are many indirect consequences that are not obvious at the beginning of a disaster. Forensic Disaster Analysis (FDA) allows the Near Real-Time assessment of economic impacts, be it direct or indirect damages that occur due to business and supply chain interruptions.

Aims/Objective

The objective of the project is the development of a method that enables the rapid assessment of indirect economic damages of a disaster. These indirect damages result from business and supply chain interruptions.

Project Status

Two particularly challenging objectives of the project are its Near Real-Time character on the one hand (quick assessment) and the difficulty of measuring indirect impacts on the other (indirect assessment). The problem with quick assessments is that during the first few hours of a disaster the situation is highly uncertain. Only little information about the magnitude of a disaster and its potential direct impacts are known in the beginning. The limited information that is available cannot be verified with respect to source or reliability. At the same time, the same reliability is drastically reduced due to widespread panic, shock and stress which prevail under disaster conditions. Therefore, flexibility is needed for quick updates and for the consideration of new data.

In 2013, the main focus of research was on an adaptable vulnerability framework that captures the specific characteristics of a system and considers the preferences of stakeholders and decision-makers. The contribution to disaster management, especially rapid assessment of economic impacts, is threefold: First, the interdependencies between the population and critical infrastructures were analysed and their respective vulnerability was determined. Linear input-output models were applied to estimate the industries' lost output and indirect effects resulting from supply chain disruptions. Additionally other sources of information, such as Twitter, the Internet or experiences of past events (Case-based reasoning) complemented the research. Second, a scalable and static indicator framework was applied to determine the size of damage at a given time. The model identifies the most important vulnerability drivers, taking into account the goals of the different stakeholders and decision-makers. Third, a scalable and dynamic model was proposed that allows for a more flexible assessment process.

This model is able to adapt changes in environmental factors and new available information, which are permanently up-dated and revised. The mechanisms involved are kept generally valid, so that the application of the framework is not limited to specific countries or a particular kind of disaster. The proposed framework was introduced at a workshop on exploring new directions for decisions in the internet age in Thessaloniki in 2013. At the workshop, the approach was illustrated for the case of Hurricane Sandy in 2012 to exemplify the Near Real-Time assessment procedure (Comes & Vannieuwenhuyse, 2013).

Outlook

This report is basically related to the conference paper of Comes & Vannieuwenhuyse, 2013 and the authors' preliminary work on this topic. In one future project the methodology of indirect assessment will be partly applied with the aim to identify key factors of industrial vulnerability of the metropolitan area of Stuttgart (Germany).

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Publications

Comes, T., Vannieuwenhuyse, M. (2013) ICTbased Near Real-Time decision support for disaster and crisis management. Workshop on Exploring New Directions for Decisions in the Internet Age, May 29-31, 2013. See http://ewgdssthessaloniki2013.files.wordpress.com/2013/05/ewg-dss_thessaloniki_2013_proceedings.pdf

Causal Loss Analysis

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

Introduction

Immediately after a hazard impacts a population, there are many important questions raised about the level of impact and the emergency response needs. Immediate response is often required before complete data are available. The causal loss analysis project focuses on creating methodologies to estimate and identify the key indicators and root causes in the immediate impact of a major event in terms of building damage and homelessness/shelter needs based on widely available data. This allows for the quantification of the scale of the disaster for response.

Aims/Objective

Historic catastrophic events (geophysical and hydro-meteorological) of the past 40 to 50 years will be analysed to understand the aggravating factors (socio-economic, regional building practices, weather, etc.) that affect the impact of a hazard. Using the parsimonious modelling approach, socio-economic fragility functions as per Daniell (2013) will be calculated and calibrated with a selected database of historic events from CATDAT to develop a standard relationship between the hazard intensity, loss and other regional data that are widely available (e.g. HDI, population density) and the total impact of the event. This project also has synergies with the CEDIM “Earthquake Loss Analysis” project. Such methods were used in quantification of losses post-disaster in the Bohol earthquake and Haiyan typhoon in 2013.

Analysis will be done on individual (and groups of) natural disaster events where data are available at a local scale in order to determine the influence of individual factors on disaster impacts beginning with shelter needs (building damage, homelessness, utilities, etc.). The key indicators then will serve as a proxy for the potential scale and impact of a disaster and the time aspect leading to a potential catastrophe.

Outlook

It is hoped that the “Causal Loss Analysis” project will identify some of the key indicators required for study in FDA in the Near Real-Time of a disaster. By identifying such indicators, this provides a focus for a holistic view of the shelter needs post-disaster as well as other potential insights on aid, recovery and reconstruction needs.

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Publications

Daniell, J.E. (2013): The development of socio-economic fragility functions for use in worldwide rapid earthquake loss estimation procedures, PhD Thesis (unpublished), Karlsruhe Institute of Technology.

Daniell, J. E.; Wenzel, F.; Khazai, B. (2012): The normalisation of socio-economic losses from historic worldwide earthquakes from 1900 to 2012, Paper No. 2027. In: Proceedings of the 15th World Conference of Earthquake Engineering, Lisbon, Portugal.

Khazai, B.; Daniell, J. E.; Franchin, P.; Cavalieri, F.; Vangelsten, B. V.; Iervolino, I.; Esposito, S. (2012): A New Approach to Modeling Post-Earthquake Shelter Demand in the Aftermath of Earthquakes: Integrating Social, Paper No. 2015. In : Proceedings of the 15th World Conference of Earthquake Engineering, Lisbon, Portugal.

Khazai, B.; Daniell, J. E.; Kunz-Plapp, T.; Wenzel, F.; Vervaeck, A.; Mühr, B. (2011): Shelter report for the Oct. 23 2011 Eastern Turkey Earthquake. CEDIM Forensic Earthquake Analysis Group. Available online at http://www.cedim.de/download/CEDIMForensicEQAGTurkeyVanEQ_Report3.pdf.

Information Gap Analysis: Near Real-Time Evaluation of Disaster Response

Trevor Girard

Introduction

The quality of a disaster response can affect how severely a society is harmed by a disastrous event. While an efficient disaster response can help to reduce casualties and suffering, a less efficient response may aggravate the situation. In order to include the disaster response as a potentially contributing factor to the overall disaster impact, a pilot study has been started to analyse disaster response in Near Real-Time. In contrast to the typical "lessons learned reports" from past disasters, such a Near Real-Time evaluation needs to be based on data which are produced immediately following the disaster.

Aims/Objective

The overall goal of the project is to develop a methodology for analysing disaster response in Near Real-Time. The methodology needs to be quantifiable so that comparisons can be made between disasters. The methodology also needs to be sufficiently tested following actual disasters to confirm the viability of the approach.

Project status

So far, a methodology for analysing disaster response in Near Real-Time has been developed and applied in the CEDIM FDA activities on tropical cyclone Phailin in India and the Bohol Earthquake in the Philippines. The analysis uses the information provided by the disaster management system within the first 0-5 days of the response. The data are collected from publicly available sources such as ReliefWeb and sorted under various categories which represent each aspect of disaster response. This process was carried out for 12 disasters and the information under each category was then compared. The comparisons resulted in the establishment of best practices under each category. It was observed that most disaster management systems produced information under almost every category and some produced information much quicker than others. Hence, categories without information, or with delayed information, represented potential deficiencies in response. Consequently, the categories could act as indicators for measuring the performance of disaster response. The two criteria (amount of data and timeliness) then allow for these indicators to be quantified. As illustrated in figure 1, each piece of critical information was separated into three types: basic data (who, what, where, when), analysis (how), and root causes (how come). A formula was then devised for calculating the value of each information type. The dotted lines identify where the information gaps are, and therefore indicate which aspects of the disaster response potentially require improvement.

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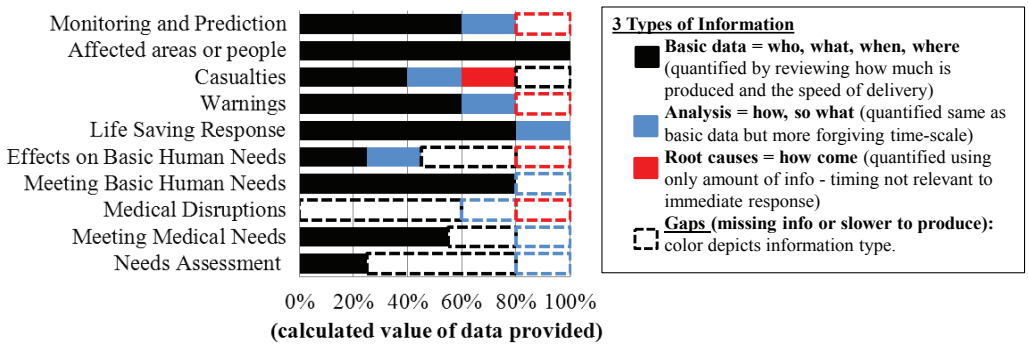

Fig. 1: Information Gap Analysis (using a select number of indicators) of the disaster response to Cyclone Phailin, India.

FDA Task Force Activities

Super Typhoon Haiyan/Yolanda

Michael Kunz, James Daniell, Bernhard Mühr, Trevor Girard, Bijan Khazai, André Dittrich, Joachim Fohringer, Christian Lucas, Tina Kunz-Plapp

Overview

With the highest wind speed ever observed during landfall, Typhoon Haiyan caused widespread destructions and several thousand fatalities in the Philippines on 7 and 8 November 2013. CEDIM decided to set an FDA task force into action on 9 November. Two reports have been compiled so far, the first one on 10 Nov., 11 UTC, the second three days later. CEDIM's estimates on destroyed buildings and fatalities have received major attention in the international media. At KIT, CEDIM researchers contributed to a charity event one week after Haiyan.

The following summary draws on the 2nd CEDIM report released on 13 Nov. 2013 and, thus, is based on the information that was available up to that day.

Hazard Information

In 2013, the tropical cyclone (TC) activity in the north-western Pacific was very high; in this year, four out of five typhoons of the highest category 5 occurred in this region. Storm Haiyan, referred to as Yolanda in the Philippines, formed on 3 October about 100 kilometres southeast of Micronesia. Following a west-

Fig. 1: Path of Haiyan/Yolanda and forecasted track (as from 10 November 2013, 06 UTC)
Source: JTWC imported into Google Maps.

northwesterly track, it was classified as a typhoon (10-min mean wind speed > 120 km/h) on 4 Nov. Within only 36 hours, Haiyan grew to a typhoon of the highest category 5 on the Saffir-Simpson hurricane scale. With warm waters of at least 26 °C, low wind shear, and excellent upper-level outflow conditions, Haiyan remained a category 5 storm until landfall. Shortly after reaching peak intensity on 8th Nov., Haiyan made landfall on the Philippine island of Samar near Guiuan (Fig. 1). With maximum sustained wind speed of 314 km/h and peak wind gusts of 380 km/h, it was one of the strongest TCs ever observed in history. The high wind speeds were comparable to an EF4-5 tornado, the related extraordinary storm surge comparable to a tsunami and torrential rain (locally around 500 mm) devastated several Philippine regions, particularly the provinces of Samar and Leyte. After landfall there was very little weakening at first and Haiyan kept its intensity as a typhoon of the highest category until 8th Nov. (06 UTC). Afterwards, the typhoon followed a more northerly track, lost its intensity, and made landfall in north-eastern Vietnam on 10 Nov. 2013 (21 UTC).

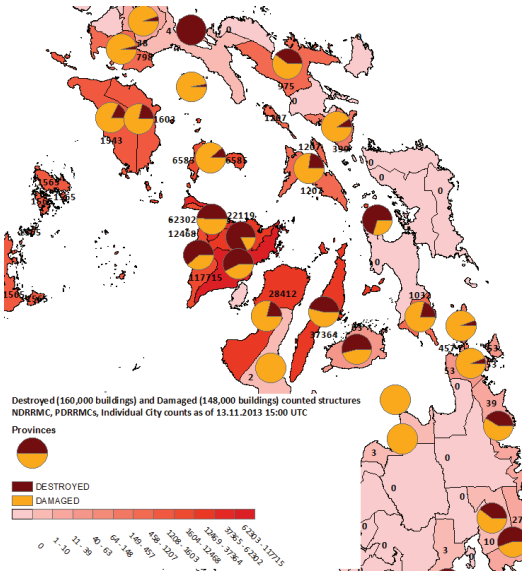

Fig. 2: An early view as of 13 November 2013 of the Province level destroyed and damaged building counts as quantified by various municipalities provincial disaster response offices (PDRRMC) and national data (NDRRMC) showing over 300,000 buildings currently counted with damaged (it is expected this is about 30 % of the final total to be counted given that the Eastern Visayas data is currently not in).

Social Impacts

Homeless data have been collected from National/Provincial Disaster Risk Reduction and Management Council (NDRRMC/PDRRMC) reports throughout the region, news articles, comments on specific towns and other sources of data. In the 1st FDA report, the homeless total was calculated to be 2.1 million long-term homeless and 6 million short-term homeless using the socioeconomic fragility function method (Daniell, 2013). In the 2nd FDA report, the number of short- and long-term homeless was estimated to be 2.1 and 4.7 million, respectively. In total, more than 14 million people were expected to be affected by the storm (Fig. 2 shows some of the modelling methods).

As of 12 December 2013, around 4 million people are still homeless, with around 2.9 million predicted to be long-term homeless, given the housing destruction. Fatalities were not modelled as part of the study, but the death and missing toll is currently around 8,000.

Damage Estimates

CEDIM, through the same rapid methodology, estimated that the final total could be around 400,000 buildings destroyed and around 600,000 buildings damaged adding up to 1,000,000 structures needing repairing or reconstruction as part of the economic loss calculations. Damage to buildings was assessed afterwards on the basis of available information from different networks, for example, the PDRRMC and NDRRMCs (provincial and national disaster management councils) and through the work of the Humanitarian OpenStreetMap Team (HOT) in certain locations like Tacloban and Roxas City. For the region most affected, Northern Leyte with the city of Tacloban, the destruction was initially canvassed at 70-80 % of homes destroyed or severely damaged. When considering damage on municipality level, it was obvious that only a few of the municipalities were able to return final loss statistics within a week.

Although counting continues, as of 12 December 2013, around 600,000 houses have been deemed to be destroyed or severely damaged, and around 600,000 houses also damaged making a total of 1.2 million buildings damaged.

Direct economic costs were estimated given the capital stock and gross domestic product (GDP) of the disaster path and the destruction seen in locations of Leyte, Cebu and Aklan.

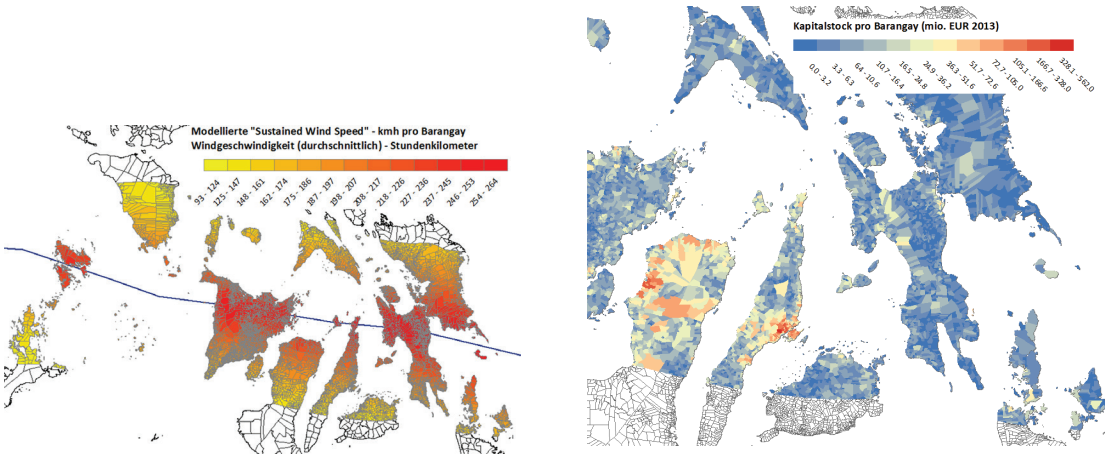

Fig. 3: The modelled wind speed combined with historic damage functions and Capital stock and GDP were used to create the economic loss estimate in addition to the storm surge (Daniell, 2013).

Using the 70-80 % destroyed rate for certain parts of Leyte, northern Cebu and parts of Aklan and Iloilo, the mean damage ratio (MDR) comes to around 30 % for Leyte. In other locations like Aklan or Samar, an MDR of 15 % is likely, based on the initial estimates of house destruction. In less affected regions, MDRs of 1-5 % were calculated based on the economic vulnerability functions.

Reconstruction costs in the order of $9.5 billion in total were estimated from CATDAT as a first estimate for all affected regions (Fig. 3). Plantations and crop losses (sugar cane and rice) can be expected to be huge, and industry losses in the affected regions will probably be at least 40 % of the GDP – around $4.1 billion in total. It can be expected that the damages are in the order of 14 times larger compared to Typhoon Bopha ($1.04 billion), which hit the Philippines in 2012.

The extent of the impact of TC Haiyan was examined using the historic economic losses from the past 63 seasons of typhoons and tropical storms. Whereas total loss from Haiyan

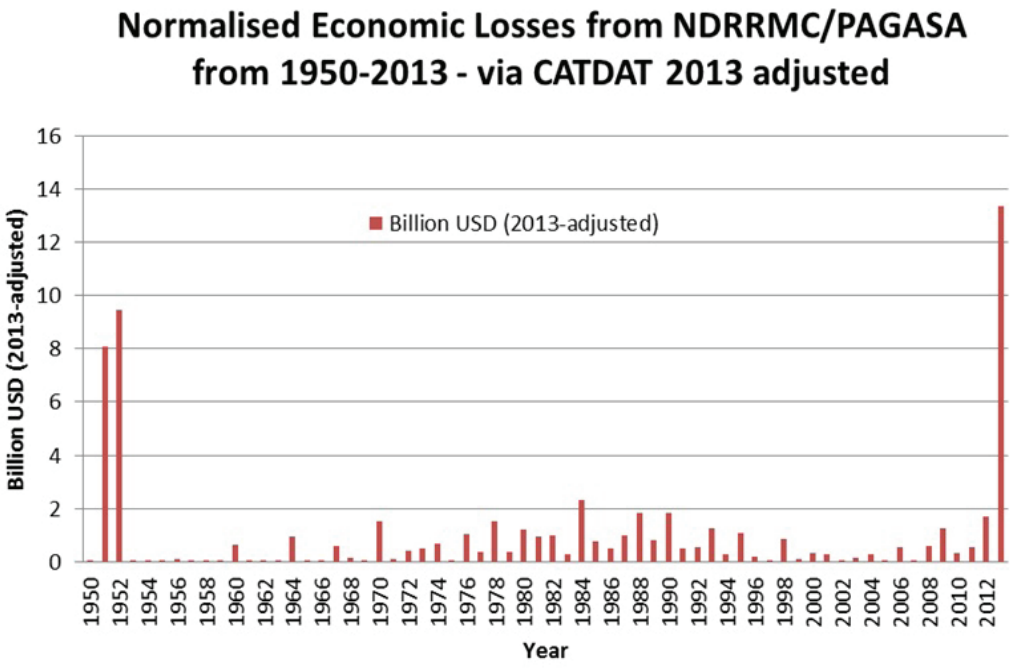

Fig. 4: Normalized Economic Losses from 1950-2013 for Philippines typhoons (CATDAT).

was estimated around $14 billion, no historic typhoon season between 1950 and 2012 has exceeded a total of $2.5 billion. In this analysis, only inflation adjustment was considered. When adjusting for the population increase through time to calculate a predicted "as if today" scenario of historic typhoons for the exposure of today, Haiyan still is the largest event even when reproducing these historic typhoons (Fig. 4).

Social Sensors

Social networking services like Facebook, Google or Twitter allow easy and rapid sharing of various kind of information to obtain insight into the mood of the population and the extent of damage from the perspective of eyewitnesses. Between 4 and 12 Nov., 5,159 Twitter messages, so called tweets, localized in the region of interest and containing one or more specified keywords from the field of "cyclonic storms" were extracted.

Four categories were set up: damage, evacuation, call/pray for help/donations for the victims and not relevant. Messages most interesting for rapid hazard estimation make up about 10 % of all messages: tweets on evacuations and damage can be used for rapid disaster assessment. Most of the messages were counted in the categories of damage or call/pray for help/donations for the victims (Fig. 5). In contrast, the topic of evacuation was only present in very few messages.

Conclusion

Typhoon Haiyan/Yolanda was one of the most severe tropical cyclones in history. The damage pattern resembles other phenomena – a tsunami near the coast, and a severe tornado but with a spatial extent of more than 100 km. In the first two reports, CEDIM researchers described the situation that was very confusing at the beginning (note that officials reported on around 100 fatalities two days after the storm) and estimated the damages and number of homeless based on historic events and by application of simplified models. In the next step, it is intended to analyse at a deeper level the evacuation process and the shelters on a local or municipal scale.

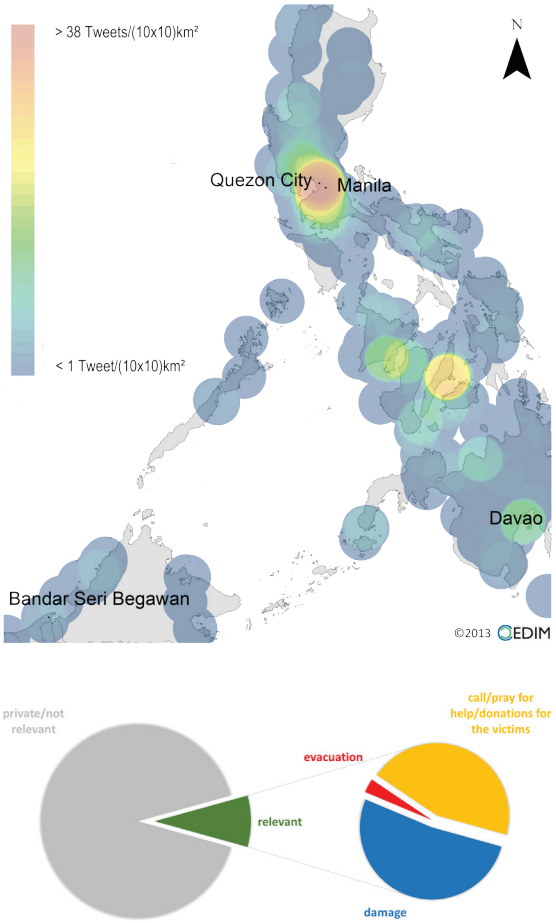

Fig. 5: Spatial distribution of tweets on national level. Two hotspots of Twitter activity Manila and Cebu City are marked clearly (upper) and Shares of categorized messages (lower).

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References

Daniell, J., Mühr, B., Kunz-Plapp, T (2013): Super Typhoon Haiyan/Yolanda – CEDIM FDA Group Report No. 1, 11 Nov. 2013, 7 p.

Daniell, J., Mühr, B., Girard, T., Dittrich, A., Fohringer, J., Lucas, C., Kunz-Plapp, T (2013): Super Typhoon Haiyan/Yolanda – CEDIM FDA Group Report No. 2, 13 Nov. 2013, 25 p.

See also
http://www.cedim.de/typhoon-haiyan.php

Super Taifun Haiyan/Yolanda

Mit den höchsten Windgeschwindigkeiten, die während des Auftreffens eines tropischen Wirbelsturms auf Land je beobachtet wurden, führte Taifun Haiyan am 7./8. November 2013 zu schwersten Verwüstungen auf den Philippinen. Für diese Katastrophe wurde eine CEDIM-FDA-Aktivität gestartet, aus der bisher zwei Berichte hervorgingen, die am 10. bzw. 13. November veröffentlicht wurden. Die Schätzungen von CEDIM zu Opferzahlen und beschädigten Gebäuden fanden eine hohe Aufmerksamkeit in den internationalen - vor allem britischen – Medien. Am KIT fand wenige Tage nach der Katastrophe eine Benefizveranstaltung zugunsten der Universität Tacloban statt, auf der CEDIM-Wissenschaftler berichteten.

CEDIM Near Real-Time FDA Activity on Super Cyclone “Phailin”, Bay of Bengal, India

Bernhard Mühr, Daniel Köbele, Tina Bessel, Joachim Fohringer, Christian Lucas, Trevor Girard, Werner Trieselmann

Introduction

In the middle of October 2013, a very strong cyclone developed over the Bay of Bengal. Super cyclone 02B Phailin showed average wind speeds of up to 259 km/h, making the storm a category 5 cyclone - the highest category on the Saffir-Simpson hurricane scale. The Indian Meteorological Department (IMD) classified Phailin as “Super Cyclonic Storm”, which is the highest category of the IMD tropical intensity scale. Phailin became one of the strongest tropical cyclones ever recorded over the North Indian Ocean.

The track led towards the northeast of India, where the tropical cyclone made landfall in the federal state of Odisha and caused enormous damage. In view of the cyclone’s strength, the track and the history of deadly tropical cyclones in the Bay of Bengal area, a CEDIM FDA activity was advised.

Evolution of tropical cyclone Phailin

Phailin originated from a tropical disturbance that moved westward over the Andaman Sea. On October 9, 2013, the cloud complex formed a closed cyclonic circulation near the archipelago of the Andaman and Nicobar Islands and then intensified into a tropical storm. At this time, many forecast models were in agreement that the tropical storm would make its way during the following days over the Bay of Bengal into a west-northwesterly direction, heading for the east coast of India. The numerical weather models predicted only a moderate intensification and the system should arrive as a category 1 tropical cyclone named Phailin at the Indian mainland. But on October 10, 2013, the tropical storm strengthened in an unexpectedly and almost unprecedentedly rapid fashion into a fully developed category 5 tropical cyclone east of the Andamans.

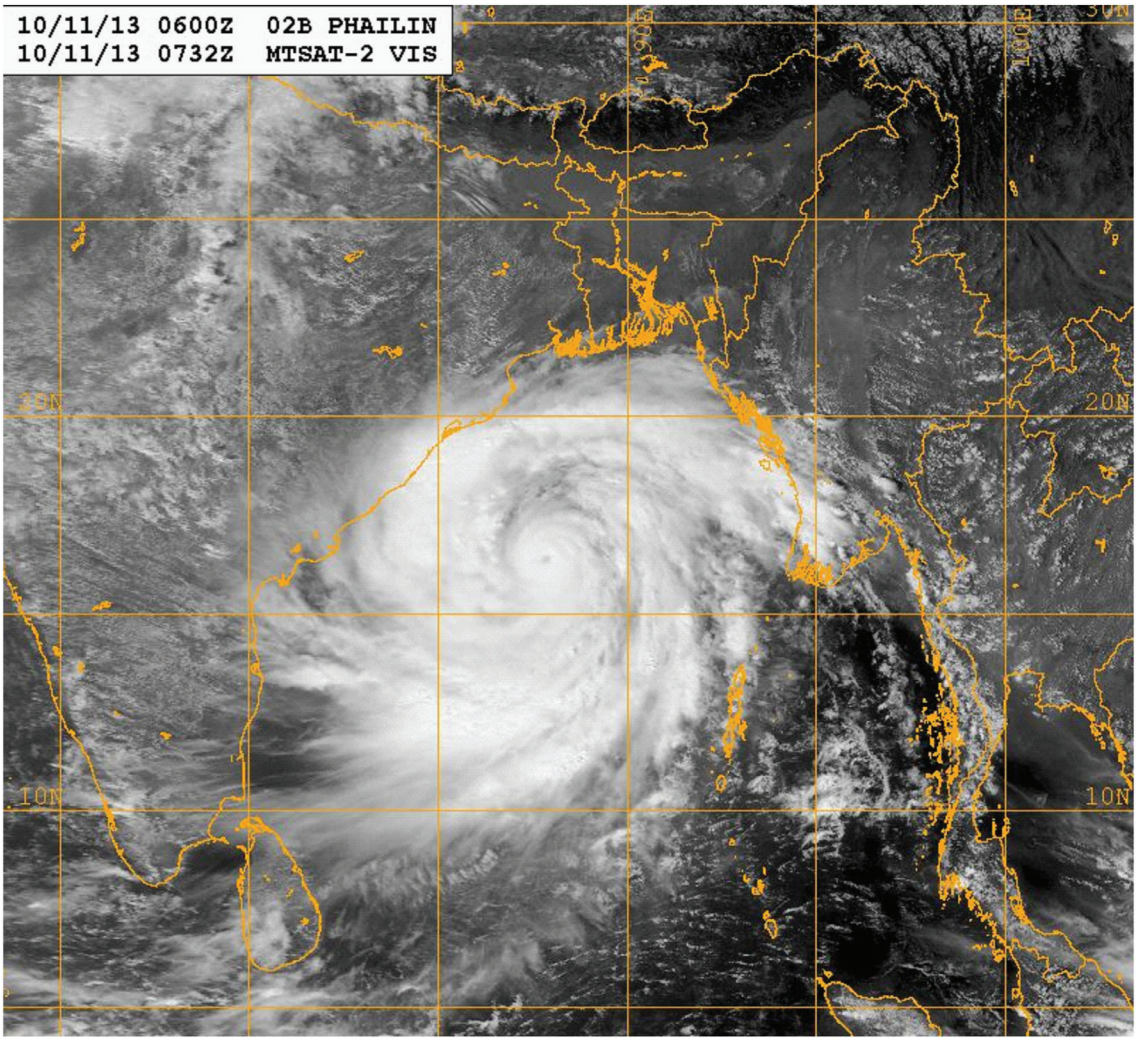

Fig. 1: Satellite Image (Visible), 11 October 2013, MTSAT-2.
Image Credit: http://www.nrlmry.navy.mil

On October 12, 2013, the centre of Phailin crossed the coastline at 15:45 UTC south of the city of Brahmapur in the Indian federal state of Odisha. At that time, Phailin was still a category 4 cyclone. The mean wind speeds taken from satellite observations were about 120 kt (222 km/h). The weather station in Gopalpur observed a gust of 185 km/h at the storm's northern eyewall. Before the weather station failed at 17:10 UTC, a minimum air pressure of 937.4 hPa was measured. After landfall, the former super cyclone weakened rapidly into a category 2 tropical cyclone. Phailin moved in a northerly direction towards the Himalaya and on October 13, the cyclone was identified as only a tropical depression over the North East of India.

Facts that made Phailin extraordinary

Intensity (central pressure, wind speeds):
Phailin showed its maximum intensity between October 11, 12 UTC, and October 12, 00 UTC in the middle of the Bay of Bengal. With maximum 1 min-sustained winds of 140 kt (259 km/h) and gusts as strong as 170 kt (315 km/h), Phailin was classified as a category 5 super cyclone. Phailin equalled the typhoon Usagi, which was previously the world's strongest tropical cyclone of the 2013 season over the western Pacific. Phailin was the first super cyclone in the Indian Ocean since 2007 and one of the strongest ever observed in this area. Only Gonu in 2007 was a stronger cyclone (145 kt, 269 km/h).

According to satellite observations (NOAA) Phailin had a minimum central pressure of 910 hPa on October 10 and 11, one of the lowest

pressures ever observed in the territory of the North Indian Ocean. However, these observations are uncertain as buoy measurements and reconnaissance flights are not available in the region for verification. The Joint Typhoon Warning Center (JTWC) issued a minimum central pressure of 914 hPa, and the value of 918 hPa was given by the Naval Research Laboratory (NRL).

Rapid Development:
The mean wind speed on October 10, 2013, 00 UTC, was 55 kt (102 km/h). Only 24 hours later, this had increased to 135 kt (250 km/h). Thus, within only one day the tropical storm grew into a category 4 tropical cyclone, which is the second highest category according to the Saffir-Simpson hurricane scale. This was not expected by most of the model forecasts.

Extent:
During its maximum intensity, Phailin had an enormous extent. On satellite images the outer cloud bands are spiralling as far as over Sri Lanka and the southern tip of India in the south and over northern Bangladesh and even the Himalaya at the northern edge of the storm. The storm's circulation covered nearly the entire Bay of Bengal and affected an area roughly 2,500 km in diameter. The storm centre, the eye, is clearly visible until landfall, indicating the symmetrical structure and strength.

CEDIM FDA Activity

Because of the storm intensity while making landfall in a pretty densely populated Indian area and because of India's history concerning deadly cyclones, CEDIM put an FDA alert into effect. Table 1 gives an overview of CEDIM activities before, during and after the tropical cyclone Phailin. CEDIM was able to get information about the twitter activity around Phailin´s landfall, as well as information about loss and damage, and presented an information gap analysis.

Loss and Damage

The tropical cyclone Phailin left enormous damage in India. While in the coastal areas of the federal states of Odisha and Andhra Pradesh fierce winds and a storm surge were the main problems, torrential rainfall caused flooding and landslides in the interior of Odisha and Andhra Pradesh, as well as in the states of Jharkhand, Bihar and Chhattisgarh.

Over 12 million people have been affected by cyclone Phailin in Odisha and Andhra Pradesh state respectively. The number of disaster-hit villages across 20 districts has risen to more than 18,000. The worst affected districts in Andhra Pradesh state are the Visakhapatnam and Srikakulam districts, and in Odisha state the Ganjam, Barhampur, Puri, and Khurdha districts.

At least 46 people died – a small number, compared to similarly strong events in the past. Due to one of the largest evacuations in Indian history, the storm event didn't cause more fatalities. The IMD issued warnings days ahead of Phailin´s landfall, so more than 1.5 million people were brought to safety.

More than 250,000 houses have been either partially or fully damaged. Crop areas with an accumulated size of more than 600,000 ha have been destroyed. Phailin caused widespread power outages and cut off water supply. Main highways have been affected by uprooted trees, eroded streets and congestion. The railway infrastructure suffered severe damages and more than 165 trains were cancelled. Service at Biju Patnaik airport in Bhubaneswar was disrupted and the majority of flights were cancelled on October 12.

The Indian power ministry stated that cyclone Phailin has caused substantial damage to local power transmission lines in the coastal districts of Odisha and Andhra Pradesh. In several districts, the power supply has been switched off by the authorities. In the Ganjam district, Odisha, more than 3,000 villages have been affected by the black-out. No damages have been reported to high tension wires and power generation units. More than 7,000 telephone towers have been destroyed, but most of them have been restored within two days. In the meantime, telecommunication operators have shared their infrastructure to provide a mobile network.

Vehicle movement on National Highway 5, which connects Kolkata to Chennai and runs along the Eastern coast, came to a standstill on October 12. Trucks and cars could be seen lined up along the highway since all movement towards the cyclone area had been restricted by the state administration. After the landfall of Phailin, countless streets were blocked due to uprooted trees and thousands of toppled transmission towers along the highways. Many vehicles have been toppled by strong winds and

Table 1: Timeline of the FDA activity concerning Phailin

Thursday, 10 October 2013, 09:00 UTC	Advance warning on website Wettergefahren-Frühwarnung
Thursday, 10 October 2013, 22:38 UTC	Email notification with preliminary information and advice of a possible FDA activity; FDA distribution list
Friday, 11 October 2013, 08:30 UTC	Warning on website Wettergefahren-Frühwarnung
Friday, 11 October 2013, 09:35 UTC	FDA pre-alert by sending sms to FDA distribution list.
Friday, 11 October 2013, 13:11 UTC	Email sent to FDA distribution list containing preliminary information
Saturday, 12 October 2013, 09:43 UTC	FDA alert by sending sms to FDA distribution list. All FDA participants were put on the alert.
Saturday, 12 October 2013, 11:27 UTC	Email sent to FDA distribution list containing available information about cyclone and FDA activity
Saturday, 12 October 2013, 12:30 UTC	Warning on website Wettergefahren-Frühwarnung
Saturday, 12 October 2013, 15:15 UTC	Phailin made landfall near Gopalpur (Odisha, India)
Sunday, 13 October 2013, 10:00 UTC	Final warning on website Wettergefahren-Frühwarnung
Monday, 14 October 2013, 08:30 UTC	Warning ended on website Wettergefahren-Frühwarnung
Tuesday, 15 October 2013, 21:15 UTC	Extensive analysis about Phailin (meteorological information, historical context, impact) on website Wettergefahren-Frühwarnung (in German)
Monday, 21 October 2013	Report 1 on CEDIM website (in English)
Thursday, 24 October 2013	Report 2 on CEDIM website (in English)
Thursday, 24 October 2013	FDA activity ended

suffered severe damages. Although, most main connections had been restored, clearance of debris on the roads and rebuilding of eroded streets was still ongoing.

Paradip port, one of the largest ports in India, has been cut off for several days since two connecting roads caved in and there was no access to the 10 km long channel to the port. Three days after Phailin hit the coast, cargo handling, vessel movement and rail movement have resumed.

Information Gap Analysis

The chart below (Fig. 2) is the result of an analysis of the information produced within the first 4 days following landfall. The information was obtained from ReliefWeb (http://reliefweb.int/disaster/tc-2013-000133-ind), and was retrieved as it was released. All information obtained was categorized under the headings listed on the left side of the graph. Three types of information have been identified as Basic Data, Analysis, and Root Causes. 'Basic data' makes up the majority of the information and answers the questions of who, what, where, and when. 'Analysis' describes results of inquiry or measurement, such as explaining how disruptions occurred, or identifying levels of needs met or outstanding. 'Root Causes' identify why aspects of the disaster occurred. For example, the number of low casualties observed in the aftermath of cyclone Phailin was identified as being the result of a good warning system and excellent coordination between agencies which successfully evacuated almost one million people prior to landfall. This type of information is very important to disaster risk reduction activities, which attempt to learn from past failures and success by understanding the root causes of each.

The Basic Data are quantified by reviewing how much is produced and how fast each piece of information is provided. Therefore, each of the who, what, where, and when types of information, unique to each category, is measured based on how fast it is produced. The Analysis information is also quantified in this way but with a more forgiving time-scale as it will understandably take a little longer to produce. The Root Causes are quantified using only the amount of information, as the timing of this information is not relevant to the immediate disaster response.

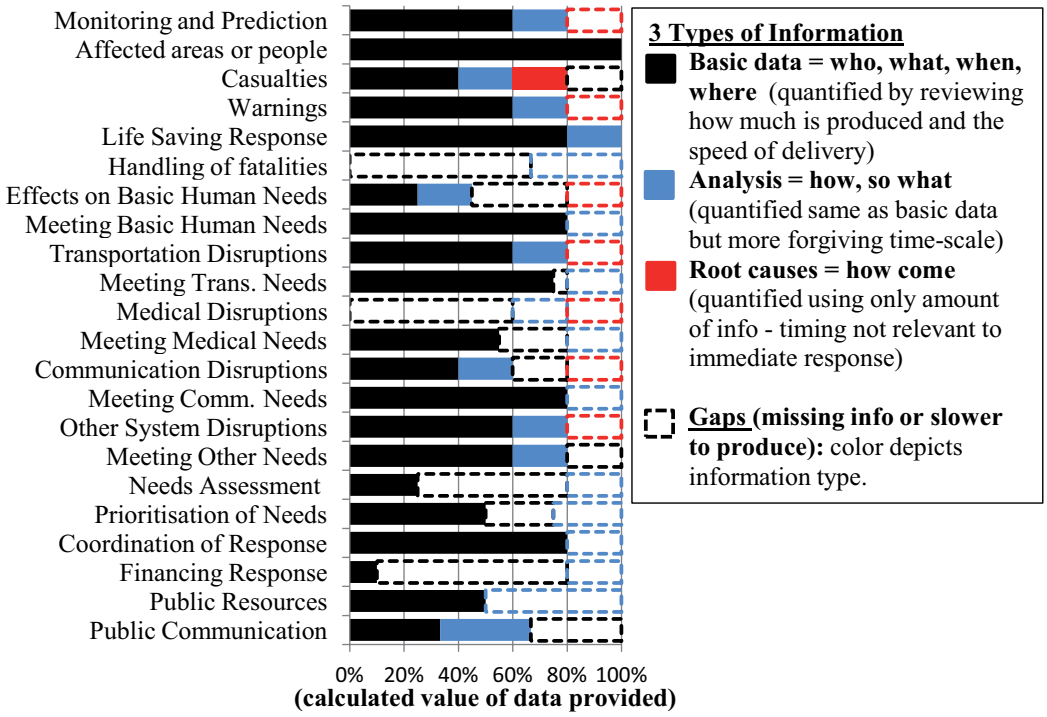

Fig. 2: Information Gap Analysis (Information as of 16 Oct 2013) of Super Cyclone Phailin, India.
Image Credit: CEDIM

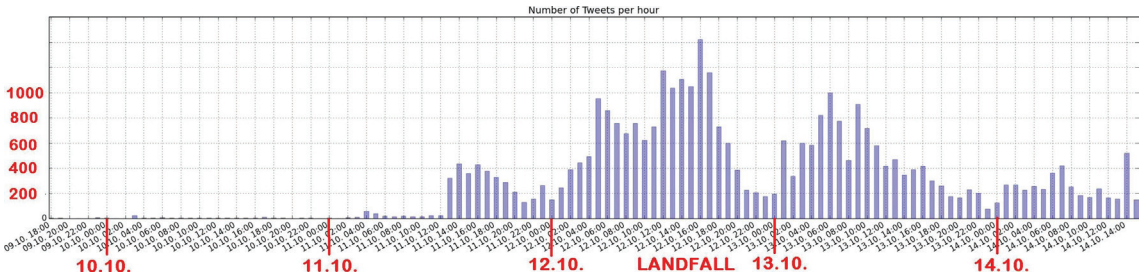

Fig. 3: Number of tweets per hours containing one of the keywords “phailin” and “cyclone” from October 9, 18 UTC, until October 14, 16 UTC

Twitter based Damage Assessment

To get rapid information on what eye-witnesses report from the affected area, we analysed twitter messages related to the cyclone “Phailin”. Twitter messages (tweets) with various keywords such as “cyclone”, “Phailin”, “shelter”, “storm” or “power outage” have been recorded for a period of 72 hours from the day before Phailins landfall on October 11. During the hour of landfall on October 12, around 16 UTC, 25 event related tweets per minute were counted and analysed.

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Publications

B. Mühr, D. Köbele, T. Bessel, J. Fohringer, C. Lucas: Super Cyclonic Storm 02B “Phailin” – information as of 15 October 2013, 1st report, http://www.cedim.de/download/CEDIM-Phailin_Report1.pdf,11 pages.

B. Mühr, D. Köbele, T. Bessel, J. Fohringer, C. Lucas, T. Girard: Super Cyclonic Storm 02B “Phailin” – information as of 24 October 2013, 2nd report, http://www.cedim.de/download/CEDIM-Phailin_Report2.pdf,16 pages.

B.Mühr, D.Köbele: Tropischer Wirbelsturm Superzyklon “Phailin” - Indien, http://www.wettergefahren-fruehwarnung.de/Ereignis/20131015_e.html.

Superzyklon “Phailin”, Golf von Bengalen, Indien

Wenngleich tropische Wirbelstürme im nordwestlichen Pazifik oder im Atlantik häufiger vorkommen, so zählt auch der Golf von Bengalen zu den bevorzugten Wirbelsturmgebieten der Welt. 26 der 35 Wirbelstürme, die weltweit die meisten Todesopfer forderten, gingen in den Anrainerstaaten Indien, Bangladesh oder Burma an Land. Am 9. Oktober bildete eine tropische Störung über der Andamanensee eine geschlossene Zirkulation aus, die sich zum Tropensturm Phailin intensivierte. Entgegen der meisten Prognosen nahm Phailin eine rasante Entwicklung und reifte innerhalb von 24 Stunden zu einem Zyklon der Kategorie 4 heran. Nur wenig später war die höchste Kategorie 5 erreicht. Die Windgeschwindigkeiten betrugen in Böen mehr als 300 km/h und Phailin wurde zu einem der stärksten tropischen Wirbelstürme, die je im Golf von Bengalen tobten. Die Historie, die enorme Ausdehnung, die prognostizierte Zugbahn und die Intensität, mit der Phailin im Indischen Bundesstaat Odisha an Land gehen sollte (Kategorie 4), machten eine FDA-Aktivität erforderlich. In Indien gelang es dank eines funktionierenden Warnmanagements, mehr als eine Million Menschen rechtzeitig in Sicherheit zu bringen und die Zahl der Todesopfer gering zu halten. Vor nur 14 Jahren hatte mit dem Odisha Cyclone ein vergleichbar starker Wirbelsturm in derselben Region mehr als 9.000 Todesopfer gefordert. Die Schäden, die Phailin in den Bundesstaaten Odisha und Andhra Pradesh anrichtete, waren gleichwohl enorm.

Wie die Analyse zeigt, verfügt Indien mittlerweile über ein funktionierendes Warnmanagement und konnte dem Sturm und seinen Folgen wirkungsvoll begegnen.

Über die Zugbahn und die Intensität des Wirbelsturms, sowie die betroffenen Gebiete und entstandenen Schäden gibt der CEDIM Report *http://www.cedim.de/download/CEDIM-Phailin_Report2.pdf* Auskunft.

June Flood 2013 in Central Europe – Focus Germany

Kai Schröter, Bijan Khazai, Bernhard Mühr, Florian Elmer, Tina Bessel, Stella Möhrle, André Dittrich, Tina Kunz-Plapp, Werner Trieselmann, Heidi Kreibich, Michael Kunz, Jochen Zschau, Bruno Merz

Overview

Starting on 31 May 2013, a large-scale flood event developed in Central Europe, primarily affecting south and east Germany and its neighbouring countries. Long lasting periods of heavy rain in combination with extremely adverse preconditions, most notably large areas of sodden soils, caused an extreme flood which in terms of spatial extent and magnitude exceeded all previous floods in Germany since at least 1950.

New record water levels occurred particularly in the Danube and Elbe catchments. Along the Elbe the region downstream of the Saale inflow was most affected. On the Danube in Passau the highest inundation levels were observed since the historical flood of 1501. Large-scale inundation occurred as a consequence of levee breaches near Deggendorf (Danube), Groß Rosenburg (Saale) and Fischbeck (Elbe).

The June flood 2013 once again revealed that complete flood protection is not possible. Inundations caused severe damage to buildings, infrastructure and agricultural lands. First estimates of total damage in Germany amount to approx. 12 Billion € which is comparable to the 2002 flood – the most expensive natural hazard experienced so far in Germany.

The CEDIM Forensic Disaster Analysis (FDA) Task Force closely monitored the development and evolution of the June 2013 flood right up to the impacts on people, transportation and economy. This activity was carried out by collecting and compiling scattered and distributed information available from diverse sources including in-situ and remote sensors, the internet, media and social sensors as well as by applying CEDIM's own rapid assessment tools.

Two reports were issued: the first focused on the preconditions, meteorology and hydrology and a comparison with major floods from the past (Schröter et al. 2013), the second on impact and disaster management (Khazai et al. 2013).

The first report was released on 4 June and updated twice, on 8 and 20 June. The second report was published on 13 June and updated on 27 June. Based on the data gathered during the FDA activity, additional in-depth analyses of causes and key drivers for the impacts are currently carried out. Three scientific publications are in preparation, bringing into focus the hydro-meteorological particularities of the flood event in Germany in comparison to major historic floods, a methodology for rapid large-scale estimation of direct damage to residential buildings, and the analyses of impacts, disaster responses and resilience in affected regions. Parts of the CEDIM-FDA analyses contributed to a joint paper with the Potsdam Institute for Climate Impact Research (PIK) on the comparison of the extreme floods of 2002 and 2013 in the German part of the Elbe River basin (Conradt et al., 2013).

Hydro-Meteorology

During May 2013, Central Europe was already under the influence of a persistent low pressure system, which created very favourable conditions for flooding. A quasi-stationary upper level low pressure area covering large parts of Germany, France, Switzerland and northern Italy (Fig. 1) and its associated surface low pressure systems were responsible for exceptionally wet weather conditions during the weeks previous to the most intense rainfall starting on 31 May until 4 June 2013. The month of May received 180 % of the long-term monthly mean precipitation, making it the second wettest month of May since 1881.

As a consequence the infiltration capacity of the soils was significantly reduced favouring the formation of direct runoff. Further, in many rivers in the Saale and Mulde catchment as well as in some tributaries of the Danube, the flow conditions on 31 May 2013 were already above the mean annual flood level.

According to the German Weather Service the general weather situation between 18 May and 3 June was classified as "Trough Central Europe (TrM)" or "Low Central Europe (TM)"

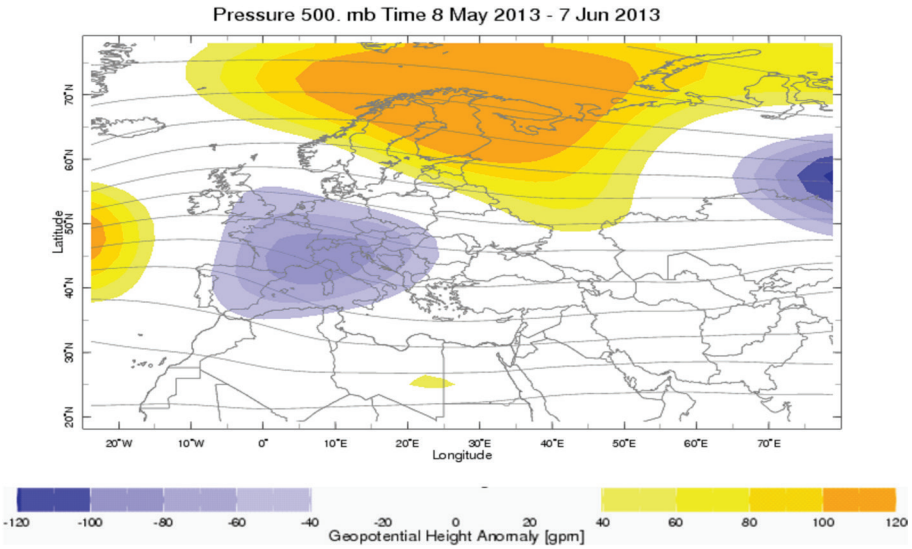

Fig. 1: Deviation of the 500 hPa geopotential level (30 day average from 8 May to 7 June 2013) from the long term mean 1981-2010 (source: http://iridl.ldeo.columbia.edu).

(DWD 2013). Both such pressure circulations are frequently associated with widespread heavy rain. From 29 May until 2 June the pressure pattern TM resulted in a steady transport of unstable air of subtropical origin. This air mass was forced in a wide sweep over northeast Europe into Central Europe and precipitated in long periods of heavy rain.

Heavy precipitation developed particularly in the northern (windward) areas of the Central Uplands and the northern Alps. In eastern Germany, precipitation was additionally strengthened by convection and accompanied by thunderstorms. The map of 4-day precipitation totals from 30 May 6 UTC until 3 June 2013 6 UTC shows extensive areas in which precipitation of more than 125 mm were reached (Fig. 2). Noticeable are the south of Saxony, smaller areas in the east of Thuringia as well as southern Bavaria. In Baden-Wuerttemberg the heaviest precipitation was concentrated in an area of the northern Black Forest as well as in the Swabian Jura.

Return periods of 3-day precipitation totals mostly do not exceed 25 years but do so in some regions in western Saxony and at the northern fringe of the Alps. In terms of 7-day precipitation totals, the event is more exceptional: large parts of Saxony as well as numerous patches in Bavaria and Thuringia exhibit return periods above 100 years.

In Germany, all major river basins showed flooding including the Weser, upper Rhine, Elbe and Danube catchments. The catchment areas of the Danube and Elbe were particularly affected by flooding. Along the Elbe the superposition of the flood waves from the Elbe, Mulde and Saale catchments caused new record water levels downstream of the Saale inflow. In the Danube catchment in Passau the conflux of the flood waves from the Danube and the

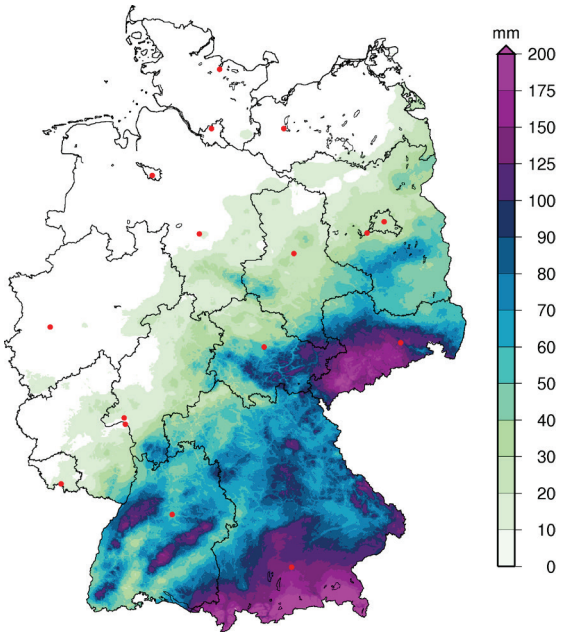

Fig. 2: 4-day (96 hours) precipitation totals from 30 May 6 UTC until 3 June 2013 6 UTC, interpolation (1x1 km) based on station measurements (data source: REGNIE data sets of the German Weather Service (DWD)).

Inn River produced the highest inundation levels since the historical flood of 1501. The June 2013 flood turned out to be the most severe flood event in terms of spatial extent and magnitude of flood peaks in Germany since at least 1950. More than 45 % of the German river network was considered to be affected by flood peak discharges exceeding a statistical return period of five years. According to a preliminary statistical analysis of observed flood peak discharges, return periods above a 100-year event occurred along the Elbe River stretch from Dresden (Saxony) to Wittenberge (Brandenburg), in the Mulde catchment, as well as along the Danube downstream of Regensburg (Bavaria) and along the tributaries Isar and Inn (including Salzach).

Large-scale inundation occurred as a consequence of levee breaches near Deggendorf (Danube), Groß Rosenburg and Fischbeck (Elbe). Further focal points of adverse effects caused by this flood event were Passau (Danube), Halle (Saale), Magdeburg (Elbe) (Fig. 3) .

Comparison to historic events

The June flood 2013 ranks among a number of large-scale floods (Uhlemann et al., 2010) experienced during the last 60 years in Germany. Concerning seasonality, meteorological conditions, spatial extent and magnitude the recent flood is particularly comparable to the past floods of August 2002 and July 1954.

The hydrological preconditions are compared in terms of the 30-day Antecedent Precipitation Index (Fig. 4, top panel) clearly shows the large amounts of precipitation accumulated over wide areas of Central Germany during the month of May 2013. In August 2002 regions of moist preconditions are localized to the northern edge of the Alps covering the south of Baden-Wuerttemberg and Bavaria and to some patches in west Saxony and northern Germany. Prior to the flood of July 1954, areas of moist preconditions are even more narrowed, concentrating on the northern edge of the Alps. The comparison of event precipitation

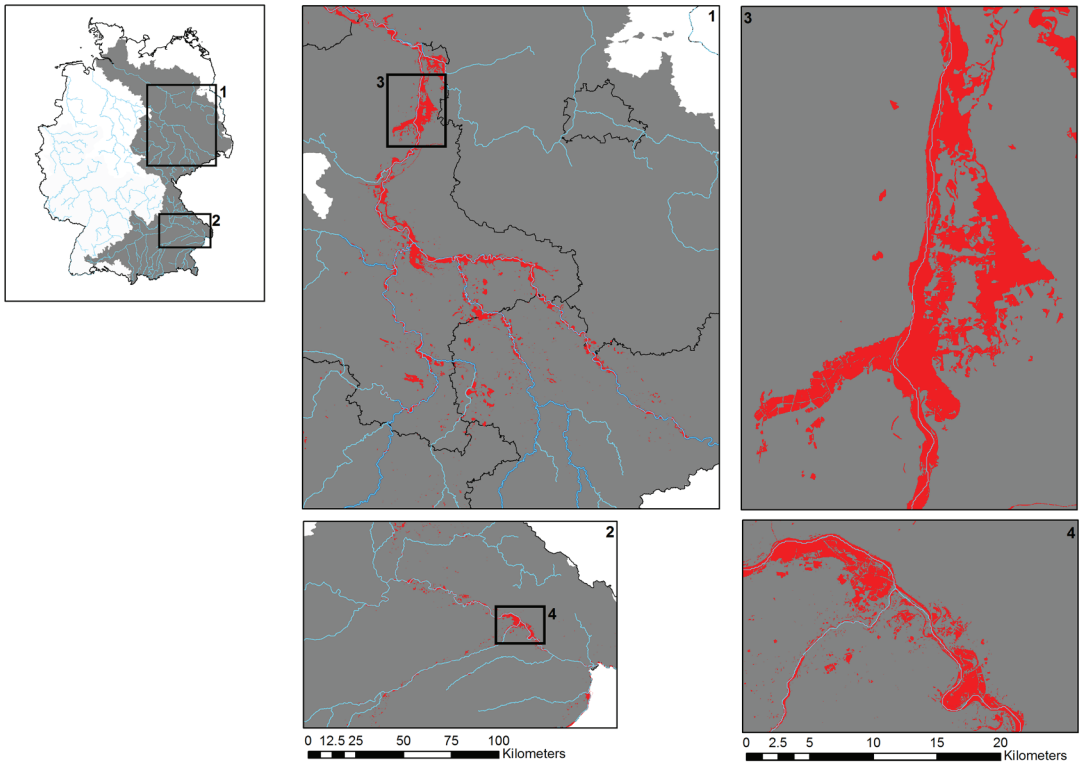

Fig. 3: Inundated area in the German parts of the Danube and Elbe River basins in June 2013. Maximum flood extent (red) derived from satellite images:
1) Inundated areas in the Elbe basin
2) Inundated area in the Danube basin (1:2,000,000)
3) Inundated area after the dike breach at Fischbeck/Elbe,
4) Inundated area after dike breach at Deggendorf/Donau (1:300,000). acquisition 20 June 2013.

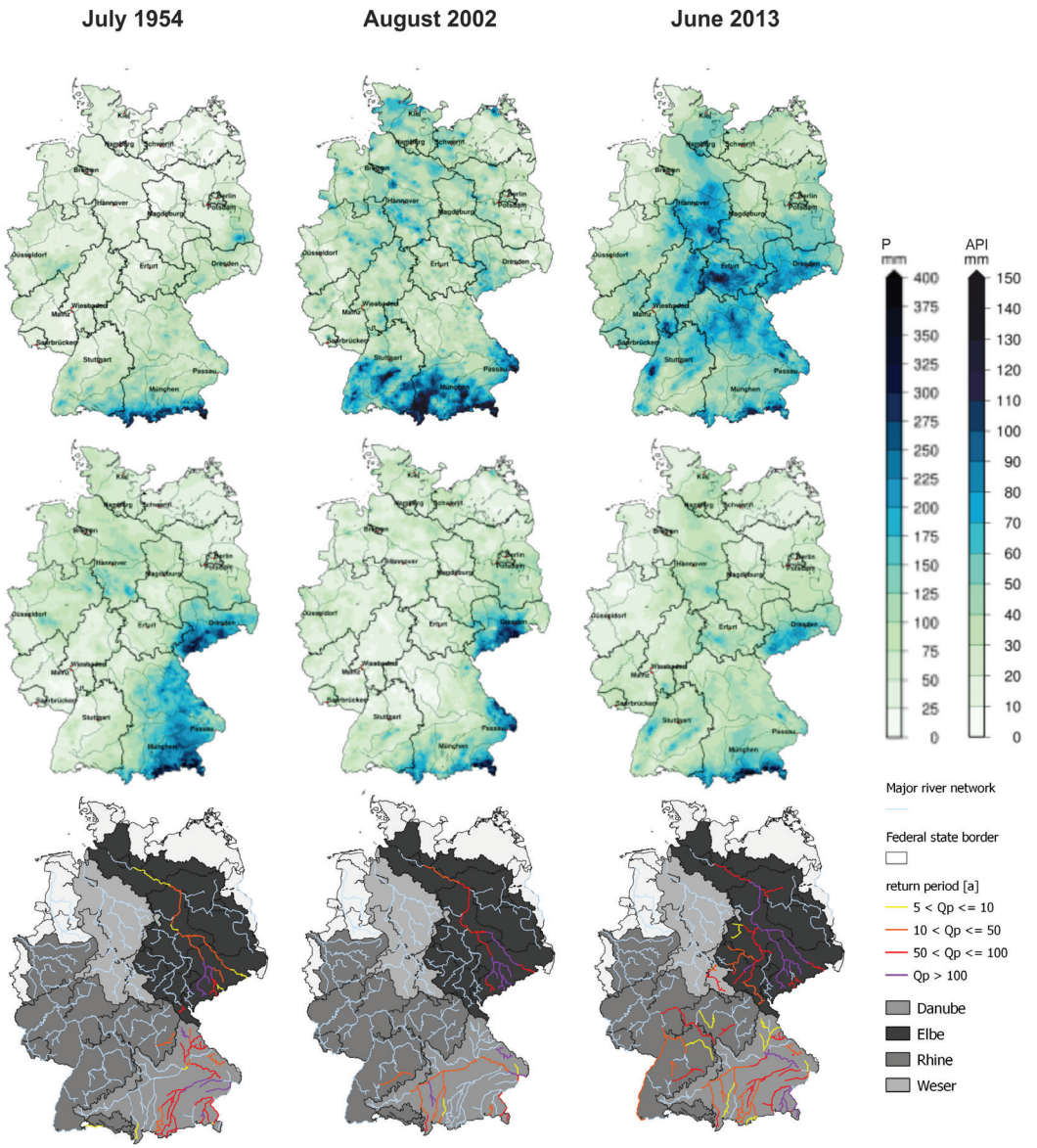

Fig. 4: Comparison of large scale floods from July 1954, August 2002 and June 2013 in terms of 30 day Antecedent Precipitation Index (top), 7 day precipitation totals (middle) and statistical return periods of maximum peak discharges (bottom). Data sources REGNIE data sets of the German Weather Service (DWD), gauge data made available by Water and Shipping Management of the Fed. Rep. (WSV) prepared by Federal Institute for Hydrology (BfG) and environmental state offices of the federal states, status of data acquisition 20 June 2013.

based on 7-day event precipitation totals (Fig 4 mid panel) reveals that rainfall amounts and spatial extent were far less in June 2013 than in August 2002 or July 1954.

However, in terms of spatial extent and magnitude of flood peak discharges, the June 2013 flood exceeds these previous record floods: the recent flood produced higher flood peak discharges in larger parts of the river network in Germany (Fig. 4 bottom panel). In June 2013 all southern tributaries plus the northern inflows Naab and Regen of the Danube contributed to the flood. In the Elbe catchment, as a major difference with previous floods, also the Saale catchment was affected and significantly contributed to the extreme stream flow in the Elbe River in June 2013.

Impact and disaster management

General impact

The June 2013 floods had severe impacts on people, transportation and the economy. Numerous levee breaches, e.g. in Bavaria and

along the Elbe, resulted in large-scale regional floods. In many areas, often thousands of people were forced to leave their apartments, homes and towns due to evacuation measures. The key areas affected were along the Danube and Elbe and their larger tributaries. The flood event claimed 8 lives in Germany and the total number of deaths in all affected countries is 25. A minimum of 52,500 people have been affected by evacuations in the catchment areas of the Elbe and the Danube. Despite similar flood intensities in these regions, CEDIM analyses show differential impacts in terms of both evacuations and transport disruptions (direct and indirect in essential sectors such as residential buildings, business premises, and agriculture were not investigated during the FDA). For example, almost 80 % of those evacuated were in Saxony and Saxony Anhalt. Likewise, four of the five districts (Landkreis) that experienced over 200 hours of flood-related congestion and disruptions also came from these two Federal States.

Transport infrastructure

In order to obtain accurate information on road traffic, ongoing traffic reports from police sources in Germany were monitored from 31 May until 4 June 2013, recorded daily from 6 am to 12 am at 3-hour intervals and filtered for correlations to the flood event. In the FDA evaluation

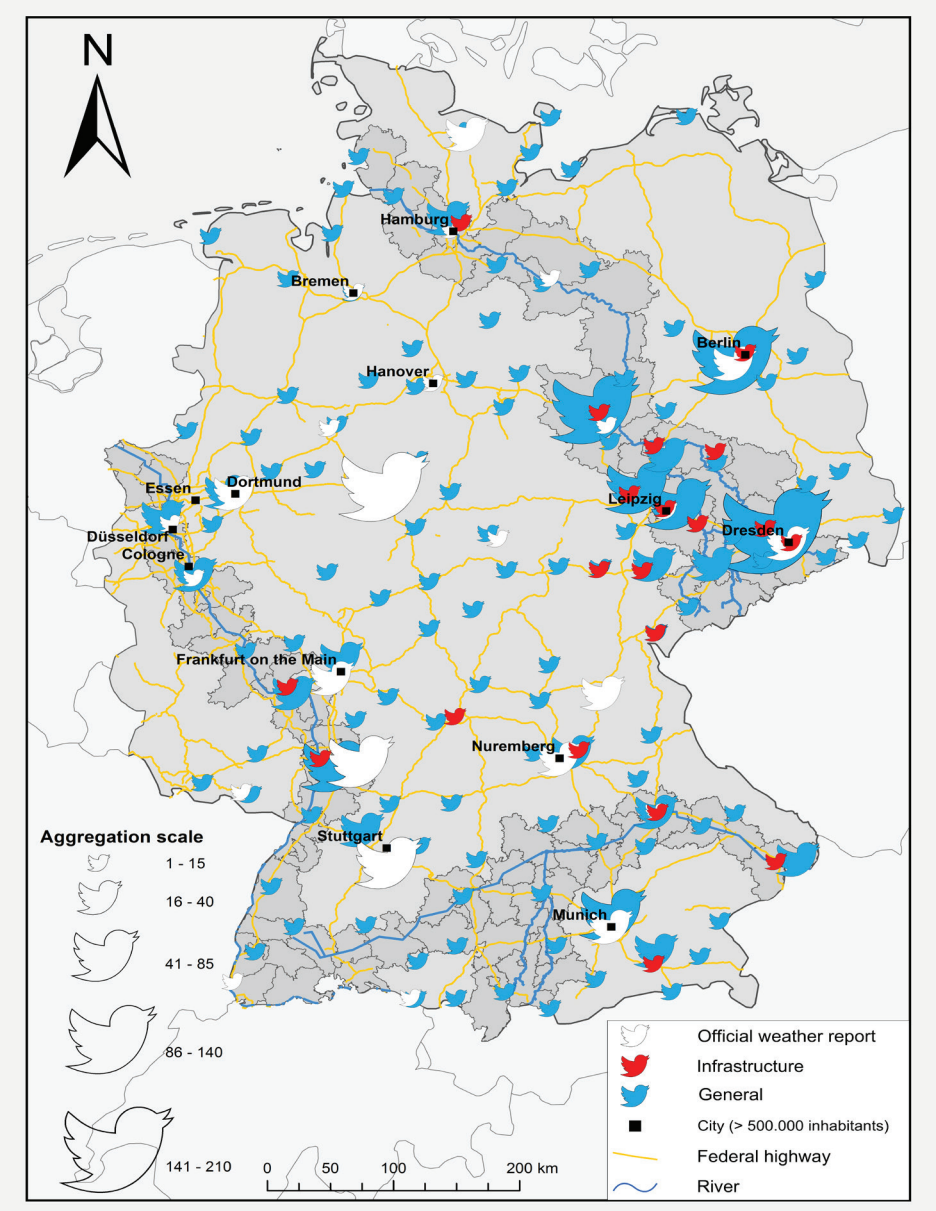

Fig. 5: Twitter messages on the impact of the floods per day for the week of 31 May – 6 June 2013.

the causes and types of traffic obstruction as well as the number and duration of disruptions which can be traced back to the flood event were considered for the interregional transportation network consisting of federal highways and interstate highways.

The main cause of disruptions (over 80 %) was overland flooding of transportation routes, whereas landslides and fallen trees contributed to the other 20 %. Almost 46 % of traffic obstructions recorded were roads that had been closed in both directions. The full closure of a road completely interrupts the flow of traffic on the routes affected, and hence probably results in the greatest amount of indirect damages in comparison with other types of obstructions. In total, traffic obstructions lasting at least 4,800 hours were recorded in the first four days. On average, a single disruption lasted for approximately 20 hours.

Crowdsourcing using Twitter messages

To complement the situational and damage analysis in this FDA, 1,874 event-related Tweets (Twitter messages) from 656 users whose content included references to the ongoing flood event and contained geographic coordinates were recorded from 31 May 2013 to 7 June 2013. These messages were mapped and analysed with a list of event-related keywords, and categorized according: (1) General news containing references to the floods; (2) Official weather reports and predictions; and (3) Messages that report on affected infrastructure. The development over time of the Twitter messages shows a clear clustering of event-related messages in and around the districts that were particularly affected (Fig. 5). In other areas of Germany, the floods as a topic are only visible in isolated instances. After a short maximum period of Twitter interest in the rest of Germany, it falls markedly towards the end of the week. In the affected districts, it continues to remain an important topic, especially in the area around the southern section of the Elbe (Leipzig, Dresden), and from Thursday onwards in Magdeburg. This FDA shows promising applications in the use of Twitter messages to analyse trends and retrieve concrete information to complement the structured data collected by other means.

Evacuations

The number of evacuations in districts that fell in the catchment of the Lech, Elbe, Mulde, Danube and Rhine were recorded between 31 May 2013 and 07 June 2013. In Saxony, Saxony-Anhalt, Lower Saxony, Bavaria, Brandenburg and Baden-Württemberg, approximately 52,549 people and 650 animals were affected. Over 90 % of the evacuations were in Saxony (26,992 people) Saxony-Anhalt (11,669 people) and Bavaria (9,600). A children's home in Wittenberg housing approximately 70 children, a nursing home in Salzlandkreis, and hospitals in Jerichower district, Anhalt-Bitterfeld and Magdeburg affecting 486 patients were among facilities that had to be evacuated The district of Anhalt-Bitterfeld was the worst affected, with over 10,000 people affected by the evacuation measures, followed by 8,670 in Sächsische Schweiz – Osterzgebirge and over 6,500 in Nordsachsen and Deggendorf. In many administrative districts, people saw to it that they obtained private accommodation, however, large-scale temporary shelter provisions also had to be provided. Alone in the Meißen district, approximately 300 from the 1,542 people who left their homes were housed in temporary accommodations. Of the 8,670 affected people in the district Sächsische Schweiz-Osterzgebirge, 372 people were located in emergency shelters.

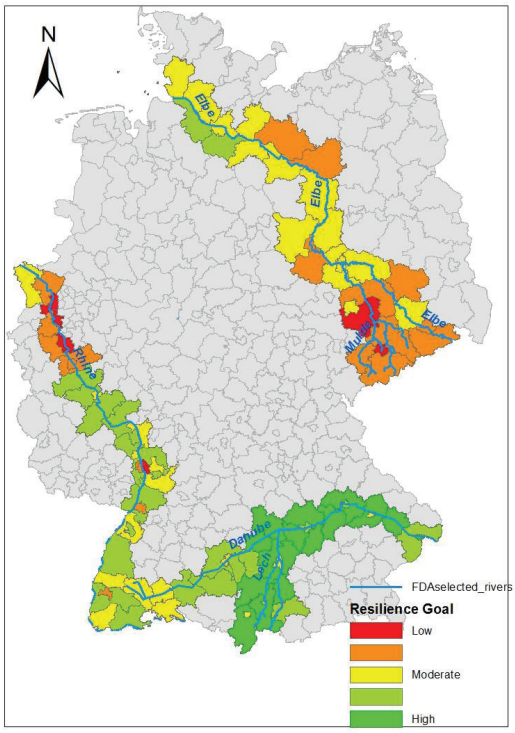

Fig. 6: Potential Resilience Index of the administrative districts along the rivers transporting floodwaters.

Resilience

Based on social, economic and institutional indicators compiled from the German Federal Statistical Office (Destatis) and using results from published studies (e. g. Fekete, 2009) that utilized household questionnaires following the August 2002 floods, the potential resilience (the ability to compensate for external hazards) of affected areas in the catchment of the Lech, Elbe, Mulde, Danube and Rhine were analysed on the district level. The potential resilience indicator is supplemented with information on the number of people affected by evacuations per district and the length and type of transportation disruptions as two measures of the flood impact. Combined with the information on the magnitude of the event (maximum return period of discharge per district), an index is calculated that allows for a preliminary comparison of the potential resilience of the different districts and the observed flood impacts. These results show a high potential resilience in the districts along the Bavarian Danube and Lech, high to moderate potential resilience in districts along the upper Rhine and Lower Elbe and moderate to low potential resilience for districts along the Lower Rhine, Elbe and Mulde (Fig. 6). Even though the pattern is not entirely distinct, the districts with a higher potential resilience index seem to have suffered less impact in terms of institutions of required evacuation measures, and duration of transportation disruptions (with exceptions such as Deggendorf where levee breaches led to massive evacuations). More in-depth studies on the degree of preparedness and effectiveness of crisis management during the 2013 floods in affected districts are needed to support the evaluation of factors and trends of (flood) resilience in Germany through further research, and can ultimately help improve resilience.

Concluding Remarks and Outlook

The June 2013 flood was driven by the combination of extremes of different hydro-meteorological factors, most notably initial soil moisture and catchment wetness, precipitation and concurrently responding sub-catchments. Overall, the June 2013 flood turned out to be the most severe flood event in Germany in terms of spatial extent and magnitude since at least 1950.

The impact analyses focused on transport interruption, evacuations and the evaluation in terms of potential resilience. The preliminary comparison of flood impacts characterized by transportation disruption, evacuations and event magnitude and potential resilience based on social, economic and institutional indicators at the district level shows that districts with a higher potential resilience index appear to have suffered less impacts. However, in-depths studies of this relationship are needed to advance the application of indicator-based evaluations for rapid flood impact assessments and to support the improvement of resilience.

CEDIM's Near Real-Time FDA activities aim to understand the evolution of disasters and to rapidly assess their impact even if information may be scarce or unclear. This requires new methods and tools. An operational flood analysis system for large scale flood events in Germany is currently developed within the ongoing CEDIM research project on forensic disaster analysis. Hence, the methodological developments and implementation of the system are still in progress. The FDA activity on the June 2013 flood provided valuable experiences and insights into data availability issues and the performance of data acquisition and evaluation procedures under real conditions.

Numerical weather prediction models provided reliable forecasts on rainfall amounts and spatial distribution with lead times of several days, thus the formation of a potentially exceptional hydro-meteorological event has been detected at an early stage. In contrast, the decentralized and limited availability of online measurements of water levels and discharges via the different federal state authorities poses a great challenge for the comprehensive acquisition of local information on the flood situation in near real time. These data are fundamental for the evaluation and classification of flood event severity and spatial extent.

Further, the rapid availability of information about inundation extent and depths is crucial for a data driven estimation of flood losses. In this regard, CEDIM established cooperation with partners from science (Center for Satellite Based Crisis Information, DLR) and consultancies (JBA Risk Management) which provide inundation extents based on satellite imagery and inundation depths using hydraulic models respectively. The goal is to combine data from various sources and use the results as input for flood loss estimation models. The CEDIM research project on Crowdsourcing for rapid damage assessment works on tools for the evaluation of twitter messages, which represent an additional real-time information source.

Concerning the reporting on ongoing events, CEDIM FDA intends to supplement “traditional” event reporting with the publication of graphical abstracts. These abstracts summarize the key findings of ongoing analyses in an intelligible and easy to understand way, enable the quick presentation and communication of real-time analyses of the event, and thus improve the usability of the added value for disaster management. Graphical templates for rapid event visualization are currently developed using the 2013 flood event as an example.

Follow-up questions to the Near Real-Time FDA activity are currently investigated within the preparation of three scientific publications.

These cover (1) the exceptionality of the June 2013 flood from a hydro-meteorological perspective, (2) the analysis of differential flood impacts despite lack of comparable flood intensities in different regions using a resilience indicator framework, and (3) a methodology for a data-based estimation of direct damage to residential buildings in near real time.

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References

Conradt, T., Roers, M., Schröter, K., Elmer, F., Hoffmann, P., Koch, H., Hattermann, F.F. and Wechsung, F. (2013): Vergleich der Extremhochwässer 2002 und 2013 im deutschen Teil des Elbegebiets und deren Abflusssimulation durch SWIM-live. Comparison of the extreme floods of 2002 and 2013 in the German part of the Elbe River basin and their runoff simulation by SWIM-live. Hydrologie und Wasserbewirtschaftung 57, 241 – 245 (doi: 10.5675/HyWa_2013,5_4).

DWD 2013: Wetter und Klima - Deutscher Wetterdienst -- Klimainfos, [online] Available from: http://www.dwd.de/bvbw/appmanager/bvbw/dwdwwwDesktop?_nfpb=true&_pageLabel=_dwdwww_spezielle_nutzer_hobbymeteorologen_klimainfos&T19607331211153463365254gsbDocumentPath=Content%2FOeffentlichkeit%2FWV%2FGWL%2F2013%2FMai%2FWetterklassifikation.html (Accessed 29 October 2013), 2013.

Fekete, A. (2009): Validation of a social vulnerability index in context to river-floods in Germany. Nat Hazards and Earth Syst Sci 9: 393 - 403.

Khazai, B., Bessel, T., Möhrle, S., Dittrich, A., Schröter, K., Mühr, B., Elmer, F., Kunz-Plapp, T., Trieselmann, W., Kunz, N. (2013): CEDIM FDA-Report No. 2 Update 1, June Flood 2013 Flood in Central Europe – Focus Germany, Impact and Management: Information as of 20 June 2013: http://www.cedim.de/download/FDA-Juni-Hochwasser-Bericht2-ENG.pdf.

Merz, B., F. Elmer, M. Kunz, B. Mühr, K. Schröter, and S. Uhlemann, 2014: The extreme flood in June 2013 in Germany. La Houille Blanche, 1, 5-10. DOI 10.1051/lhb/2014001

Schröter, K., Mühr, B., Elmer, F., Kunz-Plapp, T., Trieselmann, W. (2013): CEDIM FDA-Report No. 1 Update 2, June Flood 2013 Flood in Central Europe – Focus Germany, Preconditions, Meteorology, Hydrology: Information as of 20 June 2013, http://www.cedim.de/download/FDA_Juni_Hochwasser_Bericht1-ENG.pdf.

Uhlemann, S., Thieken, A. H. and Merz, B.: A consistent set of trans-basin floods in Germany between 1952–2002, Hydrol Earth Syst Sci, 14(7), 1277–1295, doi:10.5194/hess-14-1277-2010, 2010.

Juni-Flut in Mitteleuropa – Fokus Deutschland

Ab dem 31. Mai 2013 entwickelte sich ein großräumiges Hochwasserereignis in Mitteleuropa, welches vorwiegend Süd- und Ostdeutschland sowie seine benachbarten Länder traf. Die extremen Ausmaße sind die Folge starker Niederschläge auf bereits gesättigte Böden. Hinsichtlich der räumlichen Ausdehnung und des Ausmaßes übertrifft das diesjährige Hochwasser alle Hochwasserereignisse in Deutschland seit 1950.

Insbesondere im Einzugsgebiet der Donau und der Elbe waren Rekordpegelstände zu verzeichnen. Die Region flussabwärts der Saale war am stärksten betroffen. An der Donau in Passau wurden die höchsten Überflutungspegel seit dem Hochwasser im Jahre 1501 gemessen. Zudem verursachten Deichbrüche bei Deggendorf (Donau), Groß Rosenburg (Saale) und Fischbeck (Elbe) großflächige Überschwemmungen.

Das Hochwasser im Juni 2013 zeigt einmal mehr, dass ein vollständiger Schutz vor Hochwasser nicht möglich ist. Die Überschwemmungen verursachten schwere Schäden an Gebäuden, Infrastruktur und Landwirtschaft. Nach den ersten Schätzungen beläuft sich der Gesamtschaden auf ungefähr 12 Milliarden Euro. Dieser ist mit dem Schaden des Hochwassers aus dem Jahr 2002 vergleichbar, welches bis dahin das teuerste Naturereignis in Deutschland war.

Die CEDIM Forensic Disaster Analysis (FDA) Task Force beobachtete eingehend die Entwicklung des diesjährigen Hochwassers bis hin zu den Auswirkungen auf die Bevölkerung, den Transport und die Wirtschaft. Informationen wurden aus unterschiedlichen und verteilten Quellen gesammelt und ausgewertet. Die Task Force griff auf In-situ- und Fernerkundungssensoren, das Internet und (soziale) Medien zurück und setzte von CEDIM entwickelte Werkzeuge zur schnellen Abschätzung ein.

Zwei ereignisnahe Berichte wurden veröffentlicht: Der erste blickt auf die Vorbedingungen, die Meteorologie und Hydrologie sowie auf den Vergleich zu großen Hochwasserereignissen aus der Vergangenheit (Schröter et al. 2013), der zweite Bericht betrachtet die Auswirkungen und das Katastrophenmanagement (Khazai et al. 2013), besonders im Hinblick auf eine indikatorbasierte Resilienz-Analyse in den betroffenen Gebieten. Die daraus resultierenden Ergebnisse wurden in direktem Zusammenhang zu den Informationen über die Gebiete und Regionen gesetzt, die von Evakuierungsmaßnahmen betroffen waren. Der erste Bericht wurde am 4. Juni veröffentlicht und am 8. und 20. Juni aktualisiert. Der zweite Bericht wurde am 13. Juni veröffentlicht und am 27. Juni aktualisiert. Die während der FDA-Aktivität gesammelten Daten werden für weitere tiefergehende Analysen bezüglich der Hauptursachen für die Entstehung des Hochwassers und dessen Auswirkungen verwendet. Drei wissenschaftliche Veröffentlichungen sind in Vorbereitung: Sie thematisieren die hydro-meteorologischen Besonderheiten des Hochwassers 2013 im Vergleich zu früheren großen Hochwasserereignissen, sowie eine Methodik zur schnellen, großflächigen Abschätzung von direkten Schäden an Wohngebäuden und Analysen hinsichtlich der Auswirkungen, Katastrophenbewältigung und Resilienz in den betroffenen Gebieten. Teile der CEDIM-FDA Analysen sind in einem gemeinsamen Artikel mit dem Potsdam-Institut für Klimafolgenforschung (PIK) veröffentlicht, in welchem die extremen Hochwasserereignisse 2002 und 2013 im Elbeeinzugsgebiet in Deutschland verglichen werden (Conradt et al. 2013).

Disaster Management

Post-Disaster Damage Mapping

Danijel Schorlemmer, Jochen Zschau

Introduction

The Post-Disaster Damage Mapping is part of the Global Dynamic Exposure project. In this project we interpret and visualize crowd-sourced and open geographic data and provide guidance to what is called the crowd in data collection. Because of the immense number and variety of buildings, exposure- and vulnerability-related data cannot be compiled by a small group. Furthermore, the dynamic aspect of risk, namely rapid urbanization, requires monitoring of exposure and vulnerability indicators, again a task that can only be achieved when distributing the work onto many shoulders. For the data platform we use OpenStreetMap (www.openstreetmap.org) and additional open data. This project has just started but first results based on the already existing global OpenStreetMap dataset show the potential of this approach.

Aims/Objective

The objective of the Global Dynamic Exposure project is to provide a high-resolution (on the building-by-building level) and dynamic (low latency) exposure model for the world. It will build upon the Global Exposure Database for the Global Earthquake Model (GED4GEM) and augment it where crowd-sourced and open data exist in high quality. As a showcase, we have derived exposure indicators based on the GEM Taxonomy 2.0 from OpenStreetMap data for Berlin, Germany (see Fig. 1). The exposure and vulnerability indicators are derived from geographic data (e.g. building footprint, land use), building properties (e.g. type of building, occupancy), and semantic interpretation (e.g. regional types of architecture, cultural habits). As can be seen in figure 1, these indicators can be computed for many buildings if sufficient data exist in OpenStreetMap. Once a target area is fully captured in OpenStreetMap, fur-

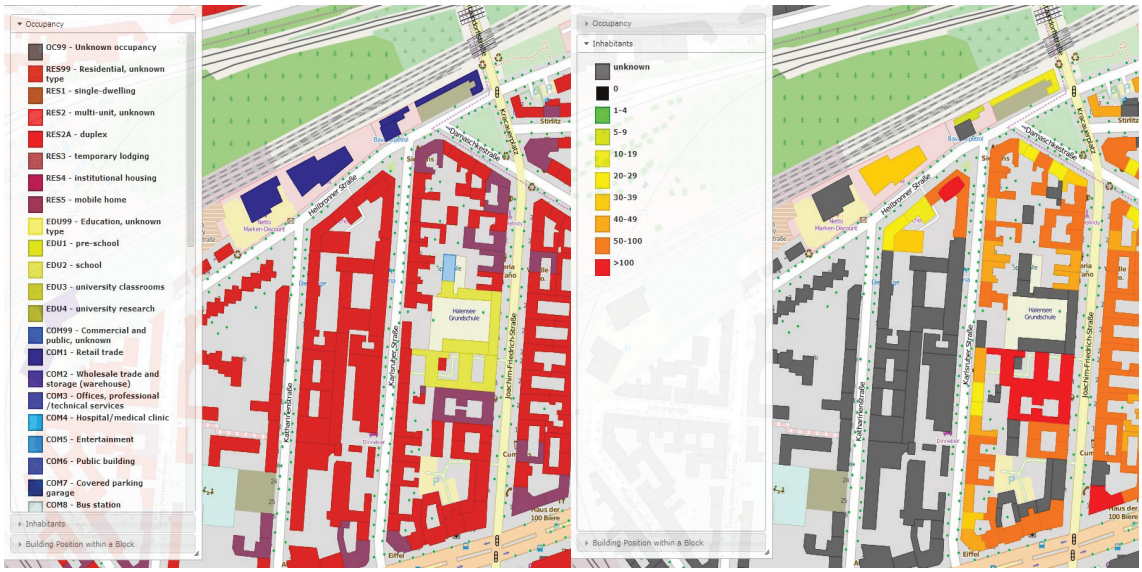

Fig. 1: Exposure map of Berlin, Germany. (Left) Occupancy type per building derived from predominant land use, building properties, building occupancy types, and information about points of interest (shops, restaurants, day care, etc.). (Right) Estimated number of inhabitants per building derived from building footprint size and number of stories. Missing number of stories per building result in not-computed number of inhabitants, displayed as gray buildings. Data and basic map tiles © OpenStreetMap contributors.

ther changes in the dataset indicate the change of building stock or the process of urbanization.

To keep up with the dynamic of crowd-sourced data collection, our system updates our OpenStreetMap replica database every 30 seconds. After each update, indicators for affected buildings will be newly computed to provide low-latency dynamic exposure data.

This dynamic aspect of data collection is of interest in our parallel project, the Post-Disaster Damage Mapping. Here, the so-called Humanitarian OpenStreetMap Team (hot.openstreetmap.org), a crowd-sourced post-disaster mapping effort, is providing information about the status of buildings and roads in the aftermath of a disaster. These data is retrieved mainly from aerial imagery but also from mappers on the ground.

Combining the exposure and vulnerability data of buildings prior to a natural disaster with the post-disaster damage status will provide a new dataset for better understanding risk but also the societal impact of a catastrophe.

Project status

The project is in a proof-of-concept phase. We developed the basic infrastructure for database replication and for low-latency updates for the areas of Germany and Japan. The regional limitation is caused by the available computational resources. We developed a proof-of-concept computation for a set of exposure/vulnerability indicators. We also implemented a proof-of-concept post-disaster map for the Haiyan typhoon destruction (see Fig. 2).

OpenBuildingMap

We developed the OpenBuildingMap (www.openbuildingmap.org) that overlays various building properties onto the regular map as provided by OpenStreetMap. This service aims at stimulating mappers worldwide to capture building properties that are usually not visible in the generic maps. It also serves as a tool for analysing data and their distribution, and for identifying data errors.

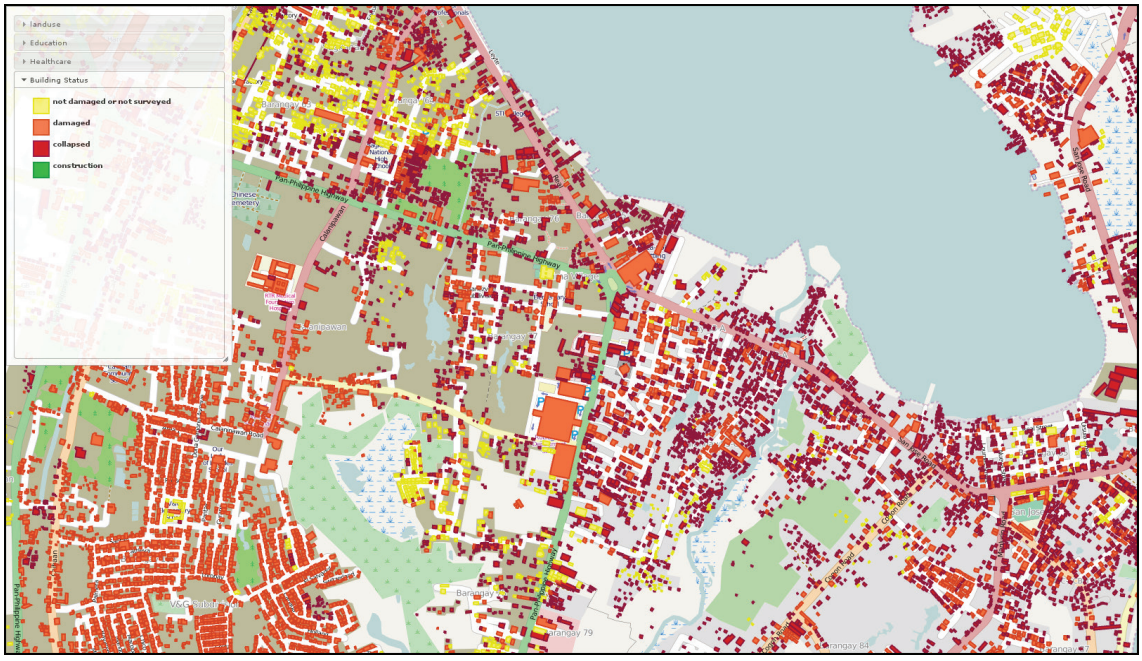

Fig. 2: Post-disaster damage map of the area of Tacloban, Philippines showing the impact of the Haiyan typhoon. The building stock data was collected during a pre-disaster action of the Humanitarian OpenStreetMap Team (HOT) when this area was identified as being likely hit by the typhoon. Further HOT actions were mapping the damage status from post-disaster aerial imagery. Data and basic map tiles © OpenStreetMap contributors.

Building import for Cologne

Together with local mappers, we worked on the import of building outlines and building occupancy information. We created a translation table for all occupancy types in Cologne. This table provides the respective tags in OpenStreetMap for the data import but also the respective GEM Taxonomy tags for exposure assessment. The import is performed manually for data quality reasons and is still underway.

OpenExposureMap

As a proof-of-concept, we computed several exposure indicators from OpenStreetMap building data based on the GEM Taxonomy 2.0. The occupancy type (see Fig. 1) is derived in a 3-step approach. First the underlying land use is considered, then explicit building occupancy properties, and finally additional points of interest (shops, restaurants, etc.). From the building outlines, we computed the position of a building within a block; from the number of stories and size of the building footprint we estimated the number of inhabitants. This exposure map is only infrequently updated with data from OpenStreetMap (no real-time map).

Haiyan damage map

We created a proof-of-concept dynamic map displaying the damage status of buildings in the Philippines region hit by the Haiyan typhoon. These data were collected by volunteers of the Humanitarian OpenStreetMap Team from aerial imagery.

Outlook

As soon as computational resources become available, all maps will be extended to cover the entire world. Fast computers will allow us to also keep the exposure map updated on a minute-by-minute basis. The major task in the future will be the development of the software platform that will allow us to introduce numerous, locally dependent, interpretations of OpenStreetMap data and open data in terms of exposure and vulnerability indicators. Besides the crowd-sourced data collection of OpenStreetMap, we will introduce a crowd-sourced interpretation of these data, hereby using the “crowd” of earthquake engineers and scientists. Motivating and guiding these two growing “crowds” will be the challenge for the next few years.

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Post-Disaster Damage Mapping

Das Post-Disaster Damage Mapping baut auf das Global Dynamic Exposure Projekt auf. In diesem Projekt werden global Vulnerabilitäts- und Exposure-Indikatoren von Gebäuden durch Crowdsourcing gewonnen. Diese werden aus geographischen Daten (z. B. Gebäudegrundriss), Gebäudeeigenschaften (z. B. Nutzung) und semantischen Interpretationen (z. B. regionale Baustile) abgeleitet. Als Basis dient das OpenStreetMap Projekt (www.openstreetmap.org), zu dem abertausende freiwillige Helfer beitragen. Nach großen Naturkatastrophen werden die Zerstörungen der Gebäude, der Landschaft und des Verkehrsnetzes mit Hilfe von Luftbildern von Freiwilligen erfasst und kartiert. Die Kombination dieser Kartierungen mit der vorher berechneten Exposure eröffnet neue Details über die Zerstörungen.

Seismic Characterization of the Chelyabinsk Meteor's Terminal Explosion

Sebastian Heimann, Álvaro González, Rongjiang Wang, Simone Cesca, Torsten Dahm

Introduction

On 15 February 2013 at 03:20 UTC the terminal explosion (airburst) of an exceptionally large meteor in the region of Chelyabinsk, Russia, produced a powerful shock wave, which caused unprecedented damage to people and property.

According to official news reports, glass windows were shattered in over 7,300 buildings and falling debris hurt more than 1,600 people. The explosion produced the strongest atmospheric infrasound signal ever recorded (Le Pichon et al., 2013) and ground shaking comparable (at low frequencies) to that of an earthquake of magnitude Mw 4.8 (Heimann et al., 2013).

In GFZ Section 2.1 an ad-hoc working group formed in the days after the event to analyse the seismic signal of the Chelyabinsk meteor's explosion. This report is a short summary of the results of this work, which has been published in (Heimann et al., 2013).

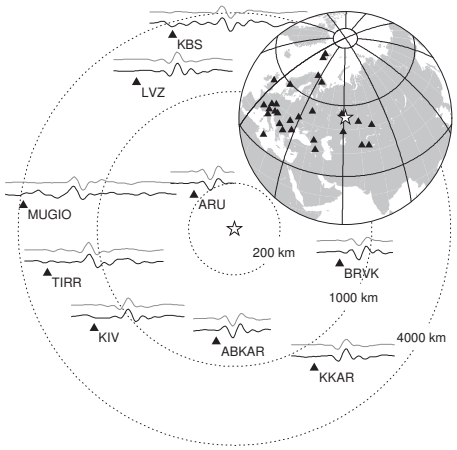

Fig. 1: (from Heimann et al. 2013) Examples of waveform fits at different distances and azimuths around the meteor explosion. Triangles, seismic stations used for the analysis. Black traces, observed seismograms. Gray traces, synthetic ones. Star, explosion source.

Shock wave and ground shaking

Strong atmospheric shock waves can be generated by explosive fragmentation of a meteoroid when the pressure caused by atmospheric drag exceeds its internal strength (Edwards et al. 2008). The resulting explosion (airburst) is accompanied by a sudden increase in the meteor luminosity. The acoustic wave produced by the Chelyabinsk meteor's terminal explosion caused the damage around the explosion source and could be registered as an infrasound signal on a planetary scale (Le Pichon et al., 2013). It also generated Rayleigh waves which could be identified at seismic stations at least 4,000 km away from the source.

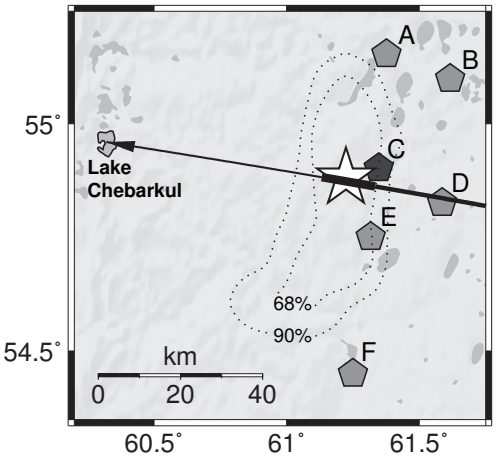

Fig. 2: (from Heimann et al. 2013) Seismic source, terminal meteor trajectory, and distribution of shockwave damage. Star, our optimally fitting epicentre, with contours indicating the confidence regions (for unconstrained origin time); pentagons, the most damaged population centres (Russian Ministry of Internal Affairs, 2013): (A) Chelyabinsk, (B) Kopeysk, (C) Korkino, (D) Etkul', (E) Yemanzhelinsk, and (F) Yuzhnouralsk. Lakes are shown in gray (after Lehner and Döll, 2004). The arrow depicts the terminal part of the approximate meteoroid ground path. Past Korkino (black pentagon), the meteor had its brightest flare (coincident with the seismic explosion source), after which it faded abruptly and eventually vanished (thin trace).

Source inversion by full waveform fitting

We adapted a full waveform fitting approach to determine the source parameters of the Chelyabinsk seismic source, modelling it as a point-like isotropic explosion and using broadband seismic recordings at epicentral distances between 220 and about 4,100 km. The epicentral location could be found to be at 54.88 N, 61.22 E with an accuracy of about 20-40 km using seismic recordings only. The explosion altitude could be determined to be at about 21-24 km by constraining the time of the explosion using an independent source (Yeomans, 2013). The moment magnitude of the explosion was about Mw 3.6. When modelling the source with an underground explosion, a much higher moment magnitude of Mw 4.8 would be required to produce the observed ground shaking.

Conclusions

The Chelyabinsk meteor was recorded in dozens of casual or surveillance videos, providing an exceptionally well documented example for such an explosion. Our results show that distant seismic recordings agree remarkably well with local meteor observations, and herald the potential for characterizing future large meteors with scarce direct data. That most of the seismic energy was released from a terminal explosion highlights the danger posed by such phenomena and we hope that this study will help to increase public awareness.

References

Edwards, W. N., D. W. Eaton, and P. G. Brown (2008). Seismic observations of meteors: Coupling theory and observations, Rev. Geophys. 46, RG4007, doi: 10.1029/2007RG000253.

Le Pichon, A., L. Ceranna, C. Pilger, P. Mialle, D. Brown, P. Herry, and N. Brachet (2013). The 2013 Russian fireball largest ever detected by CTBTO infrasound sensors, Geophys. Res. Lett. 40, 3732–3737, doi: 10.1002/grl.50619.

Yeomans, D. (2013). Fireball and Bolide Reports, National Aeronautics and Space Administration, http://neo.jpl.nasa.gov/fireballs/ (last accessed 15 June2013).

Publication

Heimann, S., González, Á., Wang, R., Cesca, S., Dahm, T., (2013), Seismic characterization of the Chelyabinsk meteor‘s terminal explosion, Seismological Research Letters, Vol. 84, No. 6, 1021-1025, doi: 10.1785/0220130042.

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Seismische Betrachtung der Explosion des Chelyabinsk Meteors

Am 15. Februar 2013, 03:20 UTC explodierte nahe der Stadt Tscheljabinsk ein Meteor und erzeugte dabei das stärkste Infraschallsignal seit Beginn der Aufzeichnungen. Die Druckwelle war derart stark, dass Rayleighwellen angeregt wurden, welche noch in 4000 km Entfernung registriert werden konnten. Eine spontan gebildete Arbeitsgruppe in Sektion 2.1 am GFZ widmete sich in den Tagen nach dem Ereignis der Auswertung dieses außergewöhnlichen seismischen Signals und die Ergebnisse wurden in Heimann et al. 2013 veröffentlicht.

Large-Scale Flood Risk Model for Germany

Daniela Falter, Kai Schröter, Dung-Viet Nguyen, Sergiy Vorogushyn, Yeshewatesfa Hundecha, Heidi Kreibich, Heiko Apel, Falko Theisselmann, Bruno Merz

Introduction

Damage from floods has dramatically increased during recent decades and flood risk is expected to rise continually in response to global change which is caused by climate change impacts, anthropogenic changes in river catchments as well as increasing vulnerability. Regional flood risk assessment approaches are needed for instance for national risk policy developments, (re-) insurance industry and large-scale disaster management planning. However, large-scale coherent risk assessment methods for areas in the order of several 10,000 km^2 are still in its infancy.

Aims/Objective

The project aims at developing a Regional Flood Model (RFM) for a spatially coherent flood risk assessment based on continuous long-term simulations covering the whole of Germany. RFM consists of a chain of models representing all relevant processes from flood generation to damage, see figure 1. The continuous and coupled simulation of rainfall-runoff processes, 1D hydrodynamic river network simulation including representation of the dike system, 2D hydrodynamic simulation of hinterland inundation and flood loss estimation at relatively high spatial resolution is a novel approach to consistently analyse the large-scale picture of flood risk (Falter et al. 2013a submitted).

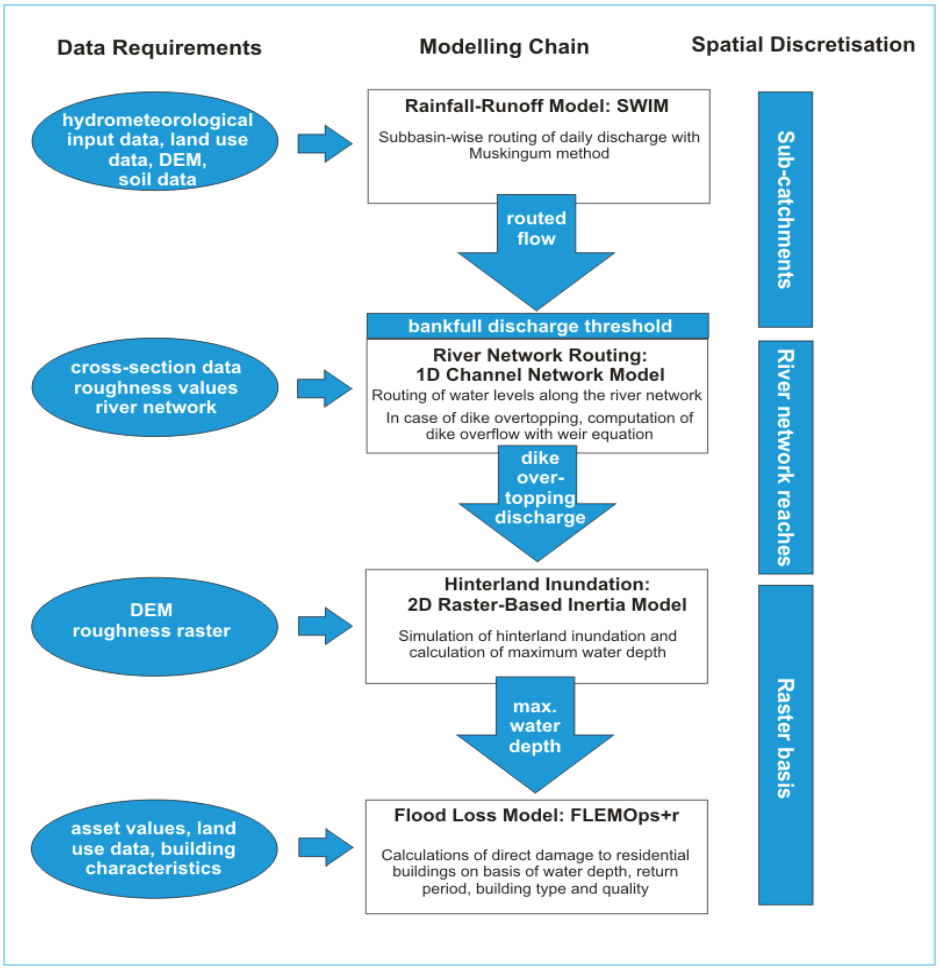

Fig. 1: Components and data requirements of the Regional Flood Model RFM.

Project status

The RFM is developed and applied to the German part of the Elbe catchment including around 2,700 km of river network and an area of 80,000 km^2. A proof of concept study with continuous simulations over a period of 14 years (1990-2003) has been undertaken successfully. As uncertainties are introduced with each module along the model chain, results were evaluated, where possible, with observed data. Due to the continuous simulation approach, no limitation on event sets is necessary as usually proposed by other studies. Additionally, the creation of hydrographs of possibly unrealistic shapes is not needed. The relatively high spatial resolution of 100 m of the 2D-flood inundation model has the potential to provide adequate inundation depths and extents for detailed flood loss estimations (Falter et al. 2013b). The computational burden for continuous 1D-2D coupled simulations has been partly relieved by implementing the efficient 2D flood propagation code for the NVIDIA GPU environment (Vorogushyn et al. 2013). The results are promising and indicate that future efforts should be directed towards the refinement of the hydraulic model set-up. Improved representations of overbank cross-sections and bankfull depth by using high resolution DEMs and terrestrial surveys have high potential to reduce the uncertainties in hydrodynamic simulations and thus further improve simulations of inundation depths and loss estimates.

Outlook

RFM, firstly applied to the Elbe catchment, can be transferred to other large basins in Germany and elsewhere. RFM has the potential to provide a spatially consistent, large-scale picture of flood risk and will as such provide an important tool for regional risk analyses and transboundary risk management and cooperation.

The coupled chain of hydrological and hydraulic simulation models provides the basis for further enhancement in view of Near Real-Time applications providing discharge and water level information for ongoing flood events. This area wide information is highly relevant for the developments concerning the rapid analysis of large-scale floods in Germany.

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Publications

Falter, D., Dung, N.V., Vorogushyn, S., Schröter, Hundecha, Y., Kreibich, H., Apel, H., Theisselmann, F., Merz, B. (2013a) Continuous, large-scale simulation model for flood risk assessments: proof-of-concept, submitted to Journal of Flood Risk Management.

Falter, D.; Vorogushyn, S.; Lhomme, J.; Apel, H.; Gouldby, B.; Merz, B. (2013b): Hydraulic model evaluation for large-scale flood risk assessments. Hydrological Processes, 27, 9, 1331-1340.

Vorogushyn, S., Dung, N.V., Falter, D., Apel, H. (2013): Benchmarking of a 2D flood inundation model implemented in a GPU environment. In: Klijn, F. and Schweckendiek, T. (eds.), Comprehensive Flood Risk Management. Research for policy and practice. Proceedings of the 2nd European Conference on Flood Risk Management FLOODRisk2012, Rotterdam, The Netherlands, 19-23 November 2012, pp. 523-526, Taylor&Francis, Group, London, ISBN 978-0-415-62144-1.

The Web Service „Wettergefahren-Frühwarnung“ (Weather Hazards – Early Warning)

Bernhard Mühr

Overview

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 since been continuously maintained – “Wettergefahren-Frühwarnung” will celebrate its 10th anniversary in February 2014. 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 be loss-incurring, it’s the German (DWD) or other National Weather Services that are responsible for those warnings.

The key aspect of „Wettergefahren-Frühwarnung“ is extreme weather events, especially when they are associated with an extensive potential for damage. The main focus is on Europe.

Forecasts of 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.

Upon the occurrence and during the extreme weather event the information becomes more detailed, and sometimes preliminary analysis and assessments have been carried out already. One to three days after the event a detailed editorial article finalizes the 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.

Comprehensive archive of extreme weather events

During the last 10 years, the internet project „Wettergefahren-Frühwarnung“ was concerned with some 800 unusual or extreme weather events that occurred all over the world since its beginning on 1 February 2004. All warnings, special notes and detailed reports can be found in an ever-growing archive. This archive, with its comprehensive, consistent and high quality articles and reports, is unique, at least in the German language area. 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 German, European and non-European cities. The predicted weather parameters that are derived from the models for individual cities are 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 cor-

Fig. 1: Screenshot of “Wettergefahren-Frühwarnung”: Article in new web design.
Image Credit: http://www.wettergefahren-fruehwarnung.de

responding warning level can be highlighted by a colour backing.

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 forecast parameters meet 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

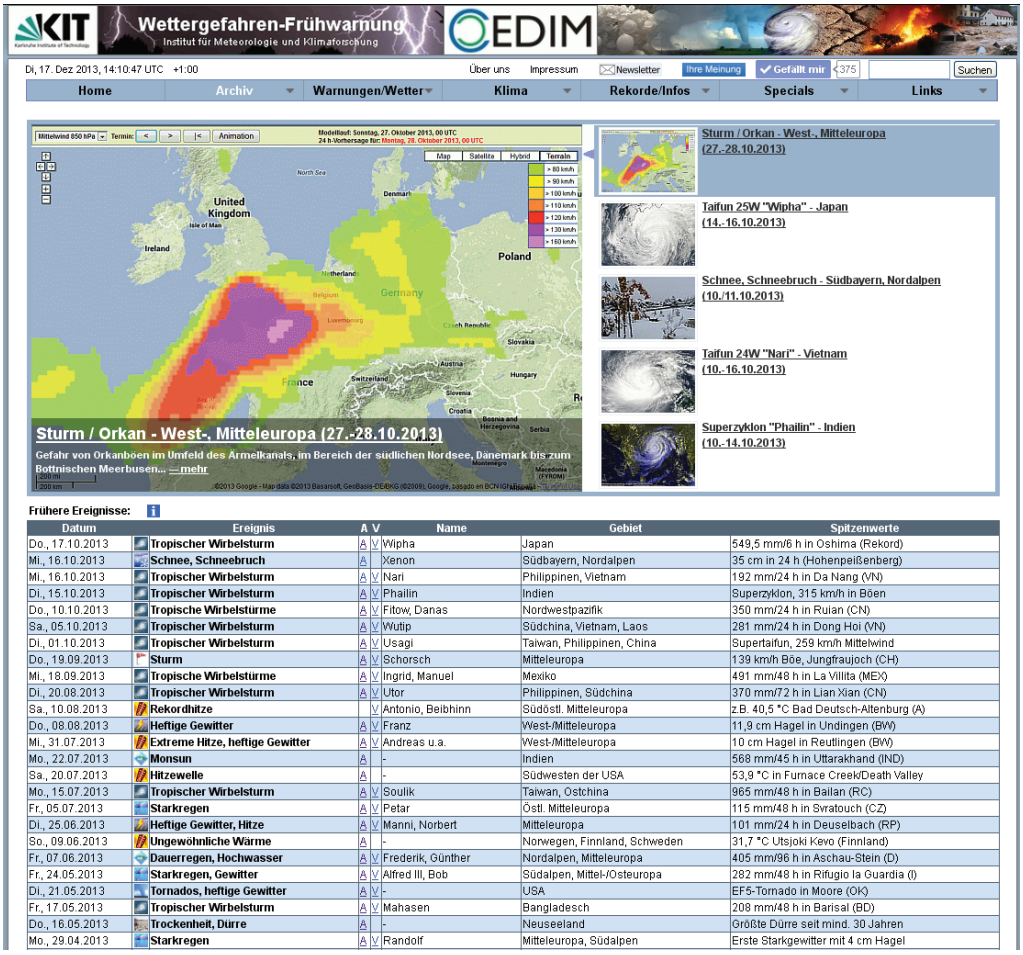
In addition to daily monitoring and assessment of global weather events since its beginning in 2004, “Wettergefahren-Frühwarnung” also creates its own special maps and images. In recent years, increasingly complex codes have been developed that now produce many hundreds of weather charts and forecast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



Datum	Ereignis	A	V	Name	Gebiet	Spitzenwerte
Do., 17.10.2013	Tropischer Wirbelsturm	A	V	Wipha	Japan	549,5 mm/6 h in Oshima (Rekord)
Mi., 16.10.2013	Schnee, Schneebruch	A		Xenon	Südbayern, Nordalpen	35 cm in 24 h (Hohenpeißenberg)
Mi., 16.10.2013	Tropischer Wirbelsturm	A	V	Nari	Philippinen, Vietnam	192 mm/24 h in Da Nang (VN)
Di., 15.10.2013	Tropischer Wirbelsturm	A	V	Phailin	Indien	Superzyklon, 315 km/h in Böen
Do., 10.10.2013	Tropische Wirbelstürme	A	V	Fitow, Danas	Nordwestpazifik	350 mm/24 h in Ruian (CN)
Sa., 05.10.2013	Tropischer Wirbelsturm	A	V	Wutip	Südchina, Vietnam, Laos	281 mm/24 h in Dong Hoi (VN)
Di., 01.10.2013	Tropischer Wirbelsturm	A	V	Usagi	Taiwan, Philippinen, China	Supertaifun, 259 km/h Mittelwind
Do., 19.09.2013	Sturm	A	V	Schorsch	Mitteleuropa	139 km/h Böe, Jungfraujoch (CH)
Mi., 18.09.2013	Tropische Wirbelstürme	A	V	Ingrid, Manuel	Mexiko	491 mm/48 h in La Villita (MEX)
Di., 20.08.2013	Tropischer Wirbelsturm	A	V	Utor	Philippinen, Südchina	370 mm/72 h in Lian Xian (CN)
Sa., 10.08.2013	Rekordhitze		V	Antonio, Beibhinn	Südöstl. Mitteleuropa	z.B. 40,5 °C Bad Deutsch-Altenburg (A)
Do., 08.08.2013	Heftige Gewitter	A	V	Franz	West-/Mitteleuropa	11,9 cm Hagel in Undingen (BW)
Mi., 31.07.2013	Extreme Hitze, heftige Gewitter	A	V	Andreas u.a.	West-/Mitteleuropa	10 cm Hagel in Reutlingen (BW)
Mo., 22.07.2013	Monsun	A		-	Indien	568 mm/45 h in Uttarakhand (IND)
Sa., 20.07.2013	Hitzewelle	A		-	Südwesten der USA	53,9 °C in Furnace Creek/Death Valley
Mo., 15.07.2013	Tropischer Wirbelsturm	A	V	Soulik	Taiwan, Ostchina	965 mm/48 h in Bailan (RC)
Fr., 05.07.2013	Starkregen	A	V	Petar	Östl. Mitteleuropa	115 mm/48 h in Svratouch (CZ)
Di., 25.06.2013	Heftige Gewitter, Hitze	A	V	Manni, Norbert	Mitteleuropa	101 mm/24 h in Deuselbach (RP)
So., 09.06.2013	Ungewöhnliche Wärme	A		-	Norwegen, Finnland, Schweden	31,7 °C Utsjoki Kevo (Finnland)
Fr., 07.06.2013	Dauerregen, Hochwasser	A	V	Frederik, Günther	Nordalpen, Mitteleuropa	405 mm/96 h in Aschau-Stein (D)
Fr., 24.05.2013	Starkregen, Gewitter	A	V	Alfred III, Bob	Südalpen, Mittel-/Osteuropa	282 mm/48 h in Rifugio la Guardia (I)
Di., 21.05.2013	Tornados, heftige Gewitter	A	V	-	USA	EF5-Tornado in Moore (Ok)
Fr., 17.05.2013	Tropischer Wirbelsturm	A	V	Mahasen	Bangladesch	208 mm/48 h in Barisal (BD)
Do., 16.05.2013	Trockenheit, Dürre	A		-	Neuseeland	Größte Dürre seit mind. 30 Jahren
Mo., 29.04.2013	Starkregen	A	V	Randolf	Mitteleuropa, Südalpen	Erste Starkgewitter mit 4 cm Hagel

Fig. 2: Screenshot of “Wettergefahren-Frühwarnung” - Comprehensive archive consisting of 800 reports about extreme weather events worldwide since 2004.
Image Credit: http://www.wettergefahren-fruehwarnung.de

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 modelling, flood calculations), thus making it a quick and uncomplicated cooperation between various institutions of CEDIM.

In April 2010, the eruption of the Islandic Eyjafjallajökull volcano attracted attention; in March and April 2011, the nuclear disaster in Fukushima, Japan, dominated the headlines in May 2011 before an Icelandic volcano, the Grimsvötn, again emphatically drew attention. And 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. In 2012 super typhoon “Saola”, that made landfall in Taiwan, required a FDA activity. In spring, summer and even autumn 2012 the United States suffered from a record breaking heat wave and a disastrous drought in most of the country; and by the end of the year, hurricane “Sandy” had a tremendous impact on the eastern parts of the United States. In 2013 the major weather events were the unusual and extreme cold spell in March in many parts of Central Europe, the Danube and Elbe flooding at the end of May and early June, heavy thunderstorms with hailstones of historic size (14.1 cm in diameter) in Germany in July and August. Additionally, in October, a tropical cyclone of the highest category 5 occurred in the Bay of Bengal and made landfall in India (“Phailin”). By the end of October the winter storm “Christian” mainly affected the coastal areas of Denmark and Germany with wind speeds close to 200 kph. In November another category 5 typhoon devastated parts of the Philippines (“Haiyan”). For both tropical cyclones a CEDIM FDA activity was put into effect. On 6 December, the

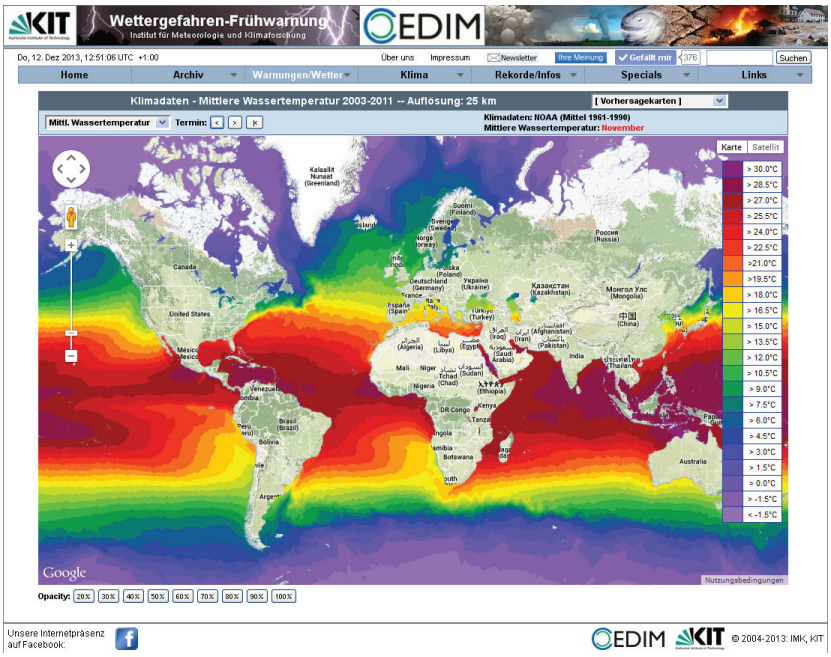


Fig. 3: Screenshot of "Wettergefahren-Frühwarnung" - Additional maps and information, e.g. average sea surface temperature.
Image Credit : http://www.wettergefahren-fruehwarnung.de

intense winter storm "Xaver" threatened parts of Northern Germany and required a FDA activity since Hamburg could have experienced a major storm surge.

In most cases Wettergefahren-Frühwarnung provides high-resolution forecast maps for many weather parameters within 1 to 2 days which allows detailed and reliable predictions about the future weather conditions, wind direction, rainfall, etc. in the affected areas.

In the case of an imminent extreme weather event "Wettergefahren-Frühwarnung" plays an important role in whether or not to put a CEDIM FDA Alert into effect and provides preliminary data and information. Lots of interview inquiries by newspapers or radio and TV stations have to be handled and there is a close cooperation with the press offices of KIT Karlsruhe and GFZ Potsdam.

Cooperation with external companies

The extensive information "Wettergefahren-Frühwarnung" offers, 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 on about 800 extreme weather events worldwide. Furthermore, the German and other private weather services benefit from "Wettergefahren-Frühwarnung". Some cooperations have been organized by now, others are on the way.

Further Plans and Goals

Ensemble forecasts

Potential ensemble forecasts are desirable to improve the forecast skill and to provide a bandwidth of possible weather scenarios and their damage. Depending on time and computer resources, ensemble forecasts will be implemented and calculated on a daily basis.

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, too.

Flyer/ Brochure

On the Internet and at all kinds of events (conferences, etc.), there is generally a great interest in the activities of weather hazard early warnings. Additional information material, available and distributed during events, could help to increase the awareness level considerably. Thus the creation of a flyer or a brochure appears very helpful and important but hasn’t been done so far.

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Publications

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

Webservice “Wettergefahren-Frühwarnung” (Weather Hazards - Early Warning)

Der Webservice “Wettergefahren-Frühwarnung” stellt Informationen zu bevorstehenden oder gerade auftretenden ungewöhnlichen oder extremen Wetterereignissen weltweit zur Verfügung. Von besonderem Interesse sind dabei die Ereignisse, die mit einem großen Schadenspotential einhergehen. Das Hauptaugenmerk liegt auf den Wettervorgängen in Mitteleuropa. Auch extreme Ereignisse wie eine Hitzewelle in Australien oder ein heftiger Monsun in Südostasien bleiben nicht unberücksichtigt. Der Routinebetrieb begann am 1. Februar 2004 und wurde seitdem kontinuierlich aufrechterhalten.

Ständige Verfügbarkeit, tägliche Aktualisierung der (Warn-)Informationen, redaktionell aufbereitete und mit Fotos, Abbildungen und Messdaten angereicherte Artikel sind die Markenzeichen des Internet-Projektes. Alle Warnungen, Informationen und ausführlichen Analysen fließen in ein ständig wachsendes Archiv ein, das mittlerweile Berichte zu mehr als 800 extremen Wetterereignissen weltweit umfasst und zumindest im deutschsprachigen Raum seinesgleichen sucht. Mehrere 1000 Seitenzugriffe täglich und nahezu tägliche Facebook-Aktivitäten belegen den Erfolg des Projektes.

Darüber hinaus ist “Wettergefahren-Frühwarnung” fester Bestandteil aller CEDIM FDA (Forensic Disaster Analysis)- Aktivitäten vor, während und nach einer größeren Naturkatastrophe. Die Informationen werden als Text, in Form eigener Abbildungen und Daten bereitgestellt und gehen in alle CEDIM-Berichte ein. Auch Online- und Print-Medien, Nachrichtenagenturen, Hörfunk- und Fernsehanstalten, Versicherungen und andere nutzen die dargebotenen Informationen intensiv.

Extreme Weather Events Analysed by “Wettergefahren-Frühwarnung” (Weather Hazards - Early Warning)

Very Intense Winter Storm “Christian” South Western North Sea to Central Baltic Sea

Bernhard Mühr, Daniel Köbele

Introduction

Intense winter storms are common in north-western Europe as well as in parts of central Europe in autumn and winter each year. Some of them are responsible for significant damage and loss and claim fatalities.

During 28 October 2013 one of the strongest winter storms ever observed crossed southern England, the southern North Sea, parts of the Netherlands, northern Germany, Denmark and southern Sweden. The winter storm was named “Christian”; storm gust speeds exceeded 150 kph in a narrow corridor of roughly 200 km in width. In Denmark a new all-time wind gust record was set: 193 kph at Kegnaes Fyr. Nearly all of the forecast models were far from predicting wind gusts of nearly 200 kph and due to the relatively small extent of the area with damaging winds a FDA activity was not put into effect.

Evolution of winter storm Christian

At the beginning of the last third of October 2013 the large-scale circulation pattern still was classified as meridional, but from 25 October onwards the circulation changed and culminated in a strong westerly flow that propagated from the north western Atlantic Ocean eastward and finally extended over western and central Europe. At the northern edge of the forming frontal zone, “Burkhard” became the central low pressure system with its centre around Iceland. On the western side of “Burkhard” polar air masses were forced towards the south and thus the horizontal temperature contrasts intensified rapidly generating a well-defined frontal zone.

A shallow low pressure system called “Christian” and originating in the waters around Newfoundland approached the hyper baroclinic zone. With a strong pressure drop near the surface, “Christian” moved towards Europe and finally grew into an intense winter low on 28 October. “Christian” moved with its centre across central England, the North Sea and the Kattegat into south-eastern Sweden; on 29 October it could be analysed over north-western Russia. Within only 3 days the low travelled 5,000 kilometres from Newfoundland all the way into the southern Barents Sea. “Christian’s” small but very intense storm area affected southern England, the southern North Sea, northern France, the Netherlands, the very north of Germany, southern and eastern Denmark and south-eastern Sweden. The evolution of “Christian” was not that of a classical polar front cyclone (theory of Bjerknes), but corresponded to the conceptual model of a Shapiro-Keyser cyclone. Most likely this low pressure system was associated with a so-called “sting-jet”, which made hurricane force wind gusts of well over 150 kph possible.

Detailed information on the theories of a Shapiro-Keyser-cyclogenesis and the evolution and the impact of a sting-jet can be found in the article on

http://www.wettergefahren-fruehwarnung.de/Ereignis/20131031_e.html

Extreme wind gusts and new wind records

On 28 October 2013, 06 UTC, “Christian” was located over south-eastern England and had a central pressure of 976 hPa. In the morning hours, hurricane-force wind gusts occurred around the English Channel in southern England and northern France (Needles (Isle of Wight) 159 kph; Cap Griz Nez 147 kph), and even further inland at Heathrow 113 kph. At 12 UTC, the low pressure system had its centre over the German Bight and a centre pressure of 967 hPa, which was the lowest in the life cycle of “Christian”. From the late morning hours until the evening, the sting-jet developed and brought violent wind gusts with speeds exceeding 150 kph. In the Netherlands the wind blew strongest on the West Frisian Isles, where Vlieland took a wind gust of 152 kph. With further intensifying the storm reached the East Frisian Islands, towards evening the North Frisian

Islands and Schleswig-Holstein. The strongest gust in the monitoring network of the German

Weather Service (DWD) was observed at St. Peter-Ording at the North Sea coast of Schleswig-Holstein: 172 kph. In St. Peter-Ordings history it has never been so windy before. Private weather stations recorded wind gusts of even 191 kph on Helgoland and Borkum. And Hamburg airport got hurricane force wind gusts of 119 kph.

In the early evening ”Christian” entered the south and east of Denmark and caused an extreme wind gust of 193 kph at Kegnaes Fyr which set a new all-time national wind record for Denmark. At Copenhagen the top winds were 128 kph. The strongest wind gust ever recorded in the DWD monitoring network along German coasts was 184 kph, when winter storm “Anatol” devastated Denmark and northern Germany on 3 December 1999.

Loss and Damage

“Christian” was one of the most powerful winter storms in recent years and claimed at least 14 deaths. Severe storm damage, many uprooted trees and power outages occurred, mainly in Great Britain, northern France, northern Germany, Denmark, southern Sweden, Estonia and Latvia. Railway traffic was partially disrupted also in Hamburg, where the train service was very limited after the storm. At London’s Heathrow airport more than 100 flights were cancelled.

Some official wind recordings of 28 October 2013:

Vilsandi (EST)	*193 kph*
Kegnæs Fyr (DK)	*181 kph*
Røsnæs Fyr (DK)	*169 kph*
St. Peter-Ording (D)	*172 kph*
Kiel-Leuchtturm (D)	*169 kph*
Glücksburg-Meierwik (D)	*159 kph*

Needles (Isle of Wight) (GB)	*152 kph*
Vlieland (NL)	*147 kph*
Cap Griz Nez (F)	*130 kph*
Halmstadt Swedish Air Force (S)	*126 kph*
Boulogne sur Mer (F)	*124 kph*
Southampton (GB)	*120 kph*

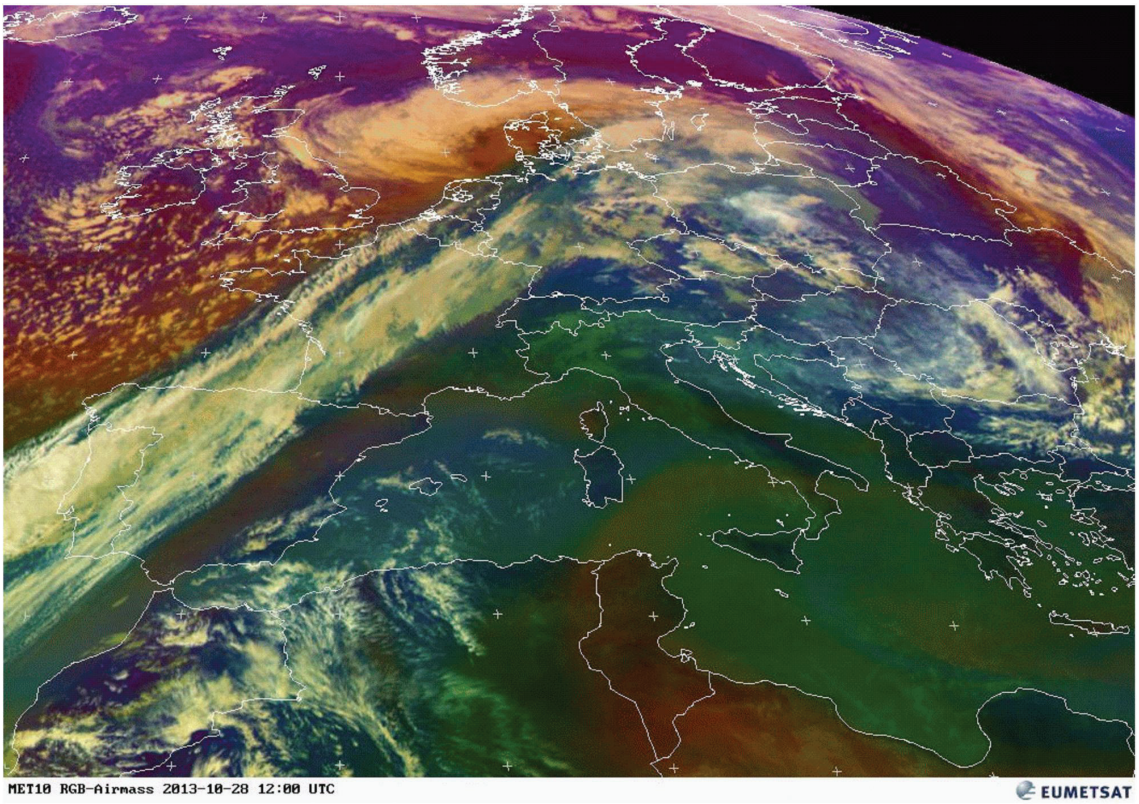

Fig. 1: Satellite Image (RGB airmasses), 28 October 2013, 12 UTC.
Image Credit: Eumetsat

Wintersturm "Christian", Süd-West Nordsee bis Zentral Ostsee

Winterstürme und Orkane sind besonders im Nordwesten Europas und im nördlichen Mitteleuropa von Oktober bis März nichts Ungewöhnliches. Sie richten immer wieder große Schäden an Gebäuden und Infrastruktur an und fordern Todesopfer.

Während des 28. Oktober 2013 überquerte das Tiefdruckgebiet „Christian" Teile Nordwest- und Mitteleuropas. Es war mit einem flächenmäßig zwar kleinen aber überaus intensiven Starkwindfeld verbunden, in dem die Windgeschwindigkeiten in Böen mehr als 150 km/h erreichten. Böen dieser Größenordnung waren von fast allen Wettervorhersagemodellen nicht progostiziert worden und allein aus dem Bodendruckgradienten lassen sich solch hohe Windgeschwindigkeiten nicht erklären. Höchstwahrscheinlich bildete das Orkantief einen so genannten "sting jet" aus, eine Theorie, der seit dem "Great Storm of 1987" rund um den Ärmelkanal nachgegangen wird.

Die maximalen Böen erreichten in Deutschland an den offiziellen Stationen des Messnetzes des Deutschen Wetterdienstes Geschwindigkeiten bis 172 km/h in St. Peter-Ording an der schleswig-holsteinischen Nordseeküste; dort war es seit Beginn der Messungen noch nie so windig. Einen neuen Allzeit-Landesrekord für Dänemark stellte die Station Kegnæs Fyr auf, wo der Orkan in Böen mit 193 km/h tobte. Von Süd-England bis Südschweden kam es zu massiven Sturmschäden, teilweisen Stromausfällen und erheblichen Behinderungen im Flug- und Eisenbahnverkehr. Durch „Christian" verloren mindestens 14 Menschen ihr Leben.

Weitere und ausführliche Informationen zum Orkantief „Christian" sowie zur Theorie des „sting-jets" gibt der Artikel auf Wettergefahren-Frühwarnung: http://www.wettergefahren-fruehwarnung.de/Ereignis/20131031_e.html.

Severe Thunderstorms and Large Hail in Central Europe – 4-7 August 2013

Bernhard Mühr

Overview

Violent storms raged in early August 2013 across western and central Europe, producing severe damage by hail, storm and heavy rains with flooding. Particularly affected were parts of France and the south-eastern half of Germany. In Baden-Wuerttemberg a hailstone with a diameter of 14.1 cm was found near Undingen on the Swabian Alb; in central France hailstones reached 11 cm. The thunderstorms were accompanied by locally gale-force winds.

Evolution

From 4 to 7 August 2013 the conditions over western and central Europe were very favourable for the development of severe thunderstorms in terms of mesoscale convective systems (MCS) and supercell storms. Small surface low pressure systems formed along a quasi-stationary cold front; ahead of the front and in the elongated trough convergence lines emerged and upper level short wave troughs labilized the troposphere triggering widespread deep convection.

The prelude to the multi-day storm situation was made by a MCS that organized itself over northern Switzerland and propagated across southern Baden-Württemberg, the Swabian and Franconian Alb to the Czech Republic. In Sigmaringen 30 people were injured by strong wind gusts in a camp of tents.

On 5 August heavy thunderstorms developed over central France, causing hail with diameters of 7 cm in Puy-de-Dome. Vichy reported wind gusts of 135 kph, in Lurcy-Lévis peak gusts reached 149 kph.

Thunderstorms that developed over the Vosges mountains on 6 August organized into a squall line that moved from the southern Palatinate and the middle Upper Rhine Valley across the south of Hesse, Baden-Wuerttemberg and Bavaria towards Eastern Germany and into the Czech Republic. The passage of the squall

Fig. 1: A thunderstorm approached Karlsruhe on 6 August 2013, 16:19 CEST, and brought wind gusts of up to 111 kph.
Image Credit: Bernhard Mühr

line was associated with hurricane force wind gusts. The weather station on top of the Wasserkuppe (Hesse) measured a wind gust of 140 kph; gale force winds of 119 kph occurred on the Weinbiet (Palatinate), Rheinstetten near Karlsruhe reported gusts of 111 kph.

In the afternoon of 6 August 2013 a huge supercell thunderstorm formed over the Black Forest and moved north-eastwards along the northern edge of the Swabian Alb. This supercell followed by further intense storms produced 8 cm hailstones near Balingen and Bernloch. Around 15:40 CEST in Undingen, south of Reutlingen, hailstones had diameters of up to 12 cm with the largest having a diameter of an inconceivable 14.1 cm.

Heavy thunderstorms also affected central France, where Mont Verdun in the Loire Department experienced 11 cm hail, the country's largest since 25 May 2009.

On 7 August the strongest storms shifted slowly eastward. Along the cold front that stretched from western Germany across Luxembourg and France into Spain, the thunderstorm activity was very subdued. The focus was in southeastern France, where thunderstorm complexes again brought 5 cm hail. Towards evening the storm widened into southern Switzerland and into the Piedmont, but major damage didn't occur.

The hail events of July and August 2013 in Germany caused tremendous damage and became a Billion Euro weather disaster.

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Publications

B.Mühr, D.Köbele: Heftige Gewitter - West-/Mitteleuropa, http://www.wettergefahren-fruehwarnung.de/Ereignis/20130808_e.html.

Heftige Gewitter und Hagel in Mitteleuropa, 4.-7. August 2013

Heftige Gewitter suchten Anfang August 2013 Teile West- und Mitteleuropas heim und verursachten schwere Schäden durch Riesenhagel, Orkanböen und Starkregen mit Überschwemmungen. Besonders betroffen waren einige Landesteile Frankreichs sowie die Südosthälfte Deutschlands. In der Nähe von Undingen auf der Schwäbischen Alb fiel ein Hagelkorn mit einem Durchmesser von 14.1 cm; es war der größte jemals in Deutschland gefundene Hagelstein. In Zentralfrankreich erreichte die Hagelkörner Durchmesser bis zu 11 cm. Die Hagelereignisse von Juli und vom August 2013 verursachten in Deutschland einen Schaden in Milliardenhöhe.

Record Heat, Severe Thunderstorms and Large Hail in Central Europe - 26-30 July 2013

Bernhard Mühr

Overview

An extreme heat wave with maximum temperatures much above 35 °C affected large parts of central Europe towards the end of July 2013. In Rheinfelden (Baden-Wuerttemberg), the thermometer was at 38.6 °C: the European 'leader' was Banja Luca in Bosnia and Herzegovina with 41.6 °C. The heat was followed by a derecho that developed over France and had wind gusts of up to 165 kph. In northern and southern Germany supercell thunderstorms brought heavy damage from large hail with a diameter of up to 12 cm in Sehnde in Lower Saxony and up to 10 cm in Reutlingen close to the Swabian Alb. Considering the long term central European weather conditions, the hailstones were exceptionally large. The diameters are at the top

of the list of maximum hail sizes ever observed in Germany.

Evolution

As of 25 July, a massive warm air advection began over south-western Europe. The 20 °C isotherm in the 850 hPa level (about 1,500 m above ground) advanced into the south of France and northern Italy. During 26 and 27 July the extremely warm air entered southern and central Germany. The profile of the Stuttgart radiosonde showed an impressive temperature of 24.4 °C in the 850 hPa-level – the highest value since 20 August 2012 (25.2 °C).

Until 27 July, the long wave trough remained quasi-stationary over the eastern Atlantic off the European coast and increased its amplitude to the south. Embedded short wave troughs influenced only western Europe. Further to the east, massive warm air advection supported a broad high pressure ridge over the European continent that extended at its greatest extent up to the northern tip of Scandinavia. As of 28 July, several more prominent shortwave troughs propagated north-eastwards on the eastern edge of the upper level long wave trough, allowing slightly cooler air from the Atlantic to enter the continent. The hottest air retired to the eastern Alps and the nearby eastern and south-eastern Europe. A fast moving short wave trough, that was located over Portugal on 28 July, was then analysed over Slovakia on 30 July, finally displacing the subtropical hot air from central Europe.

During the maximum heat, the high pressure influence of high pressure over Central Europe

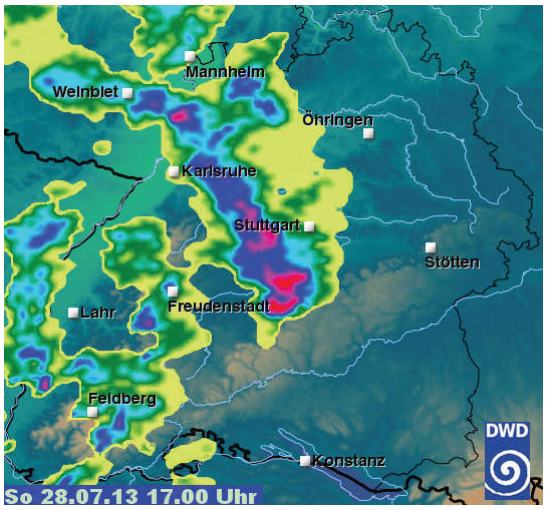

Fig. 1: Radar image, 28 July 2013, 17 CEST. Image Credit: DWD (German Weather Service)

prevented the development of showers and thunderstorms. The hot air close to the ground was mostly too dry to permit deep moist convection. Over western Europe however, on 25 July severe thunderstorms had already arisen in the transition region between the moist subtropical airmass and the cooler air from the Atlantic. The series of thunderstorms began in the night 25/26 July as in the lee of the western Pyrenees just off the south-western French Atlantic coast over the Bay of Biscay where an organized thunderstorm complex developed. In western France wind gusts up to 115 kph were recorded; at Saint-Sulpice-et-Cameyrac they reached 101 kph. Fleury-les-Aubrais reported hail with 4 cm diameter.

An even bigger and more intense storm system occurred the following night, 26/27 July, over France. This system grew into a mesoscale convective complex (MCC) and in the early morning hours of 27 July the storm arrived in Belgium and in the very west of Germany. Due to a significant surface wind shear a squall line formed ahead of the MCC and embedded supercell storms brought large hail. In the department of Lot-et-Garonne hailstones with a diameter of 5-7 cm were observed. In France, the squall line achieved the status of a Derecho (a continuous squall line), stretching at least 400 km and causing widespread convective wind gusts of over 93 kph. Poitiers measured a hurricane force wind gust of 131 kph while in Pauillac gusts even reached 165 kph. On 27 July the MCC and associated supercell storms caused significant damage from flooding and large amounts of hail in Liège, Belgium. Another long lasting supercell storm travelled from North Rhine Westphalia across Lower Saxony and Saxony-Anhalt almost to Berlin. Along its path hail was common. At Sehnde (Lower Saxony) hail occurred with diameters of up to 12 cm.

On 28 July a thunderstorm formed around 16 CEST ahead of an eastward propagating cold front over the central Black Forest. The storm grew into a supercell thunderstorm, gained further intensity on its way into a north easterly direction along the Swabian and Franconian Alb and above all produced very large hail. Hailstones with diameters around 10 cm caused severe damage to buildings, cars, plants and agriculture mainly in the Tübingen/Reutlingen area south of Stuttgart.

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Publications

B.Mühr, D.Köbele: Extreme Hitze/Heftige Gewitter - West-/Mitteleuropa, http://www.wettergefahren-fruehwarnung.de/Ereignis/20130731_e.html.

Rekordhitze mit schweren Gewittern und Hagel in Mitteleuropa - 26.-30. Juli 2013

Eine extreme Hitzewelle mit Höchsttemperaturen jenseits von 35 °C erfasste gegen Ende Juli 2013 große Teile Mitteleuropas. In Rheinfelden (Baden-Württemberg) machte das Thermometer erst bei 38.5 °C Halt, den europäischen Hitzerekord stellte Banja Luca in Bosnien und Herzegowina mit 41.6 °C auf. Der Hitze folgte ein sogenanntes Derecho, eine umfangreiche Gewitterzone, die sich über Frankreich entwickelte und mit Orkanböen bis 165 km/h verbunden war. Auch in Nord- und in Süddeutschland traten heftige Gewitter auf; die Superzellen brachten außerordentlich großen Hagel mit Durchmessern bis zu 12 cm in Sehnde (Niedersachsen) und bis zu 10 cm in Reutlingen am Rande der Schwäbischen Alb. Der Großhagel führte zu schweren Schäden und die Hagelkörner zählen zu den größten, die jemals in Deutschland beobachtet wurden.

F5/EF5 Tornado in Moore, Oklahoma

Bernhard Mühr

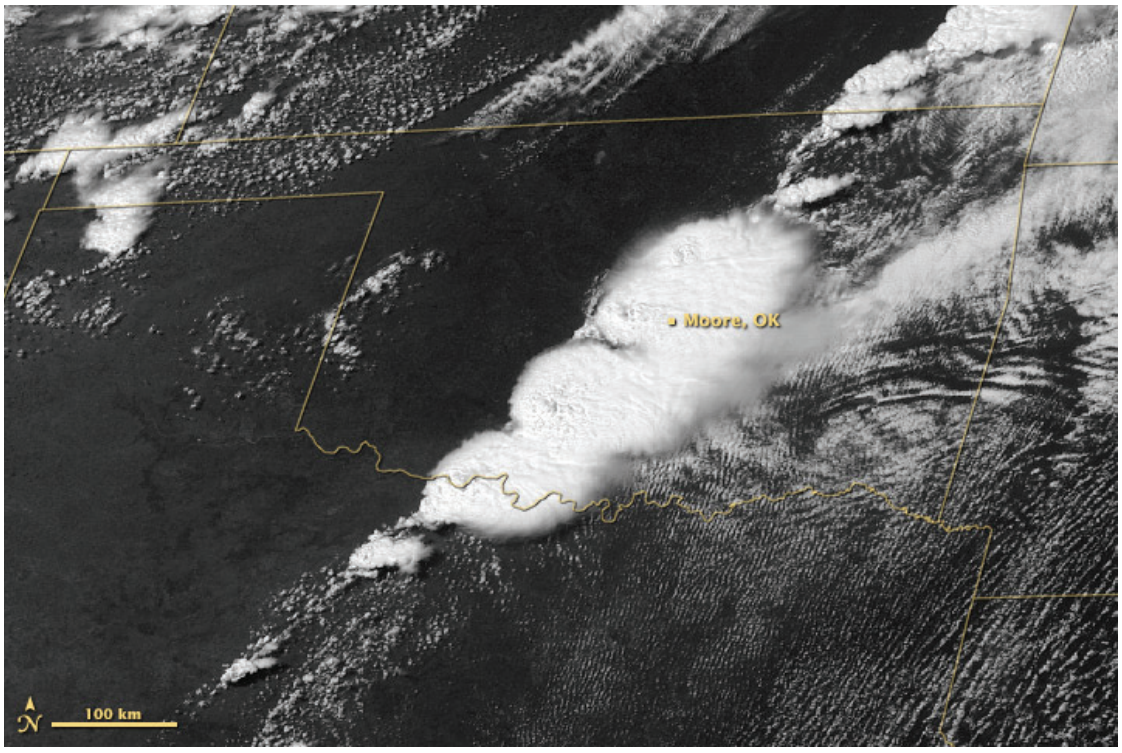

Fig. 1: Satellite image, 20 May 2013.
Image Credit: NASA Earth Observatory

Overview

In mid-May 2013 violent thunderstorms occurred in the Midwest and the Great Plains of the United States. Heavy rain and wind gusts, large hail and tornadoes caused major damage, primarily in a strip from northern Texas and Kansas to Illinois. Particularly affected was the State of Oklahoma, where an EF5 tornado made its way through Moore, a suburb of Oklahoma City. At least 24 people died in the storms.

Evolution

As of 18 May, the conditions over the Great Plains were favourable for the development of strong thunderstorms, including supercells and tornadoes. In an area between northern Texas and South Dakota thunderstorms formed, accompanied by large hail and strong wind gusts; some tornadoes appeared in Kansas. On 19 May, the area with heaviest thunderstorms, including an observed EF4 tornado over Oklahoma, slowly propagated eastward. The severe weather situation culminated on 20 May, when between northern Texas, Oklahoma and Illinois the area of the largest atmospheric instability overlapped with sufficient vertical wind shear thus producing organized thunderstorms and several supercells with violent tornadoes.

A tornado of the highest category devastated the densely populated Moore area in the immediate vicinity of the capital of Oklahoma City. The tornado brought havoc around 15:00 local time (22:00 CEST) and left a path of destruction and widespread damage. The tornado made touchdown for about 50 minutes and shifted north-eastwards with a maximum diameter of approximately 2 kilometres and an average speed of about 40 kph. The tornado didn't even spare schools and hospitals.

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Publications

B.Mühr, D.Köbele: Tornados, heftige Gewitter - USA, http://www.wettergefahren-fruehwarnung.de/Ereignis/20130521_e.html.

F5/EF5 Tornado in Moore, Oklahoma

Tornados treten in den Vereinigten Staaten bevorzugt im Frühjahr auf. Vor allem in den Gebieten zwischen Mississippi und Rocky Mountains richten die kleinräumigen Wirbelstürme gelegentlich enorme Schäden an. Verläuft ein Tornado der höchsten Kategorie und mit Geschwindigkeiten bis zu 500 km/h durch bewohntes Gebiet, bleibt kein Stein auf dem anderen.

Eine solche Tornadolage stellte sich auch im Mai 2013 ein; vom 18. bis zum 20. Mai waren die Bedingungen zur Bildung schwerer Gewitter über den Great Plains überaus günstig. Einige entwickelten sich zu Superzellen und brachten Hagel, Sturmböen und Tornados hervor. Die heftigsten Gewitter tobten insbesondere zwischen Nordtexas und Illinois. Dabei erfasste ein Tornado der höchsten Kategorie die Ortschaft Moore, einen Vorort von Oklahoma City, und hinterließ dort eine Schneise der Verwüstung. Mindestens 24 Menschen kamen in den Trümmern ums Leben.

6th Coldest March on Record in Germany

Bernhard Mühr

Overview

Primarily the north, the east, and the central parts of Germany witnessed an unusually cold March in 2013. A north-easterly flow of very cold polar air led to a number of new records of minimum temperatures. Several low pressure systems caused extensive snowfall and made the month one of the snowiest ever in parts of Germany. A monthly average temperature of

+0.2 °C corresponds to the 6th coldest March since records began in 1881. Some weather stations recorded the coldest March ever, e.g. at Cottbus since 1889, with a monthly average temperature of just -1.1 °C.

Evolution

Several stable north-east weather patterns in the second and last third of March were responsible for the exceptional cold. Very cold continental air of polar origin was forced into Central Europe and caused severe night frosts and sometimes record cold minimum temperatures especially in the north, centre and east of Germany. High air pressure over northern Europe, stretching from Greenland to the North Sea and to Scandinavia and low pressure in the south from the Azores to the Mediterranean, are favourable for a north-easterly flow pattern across Central Europe. On the southern and south-eastern edge of the north European high pressure area very cold polar air from Arctic climes moved directly into Central Europe and Germany. This large scale pressure pattern occurred several times in March 2013.

The absolute minimum temperature of the month was reached at Deutschneudorf-Brüderwiese in the Ore Mountains, when -21.3 °C was recorded. Quickborn in Schleswig-Holstein measured -18.8 °C on the 12th and set a new March record. Wiesenburg, located west of Potsdam, registered an impressive 15 days with maximum temperatures below 0 °C.

March 2013 was not only exceptionally cold but also very snowy, especially in the north-eastern half of the country. Berlin observed a 20 cm snow pack, which was the highest in the last third of March since 1892. Lübeck-Blankensee observed a snow depth of 36 cm on 12 March. On the same day Hamburg airport saw 28 cm of snow, which was a new record for March and 18 cm at Frankfurt airport also set a new record.

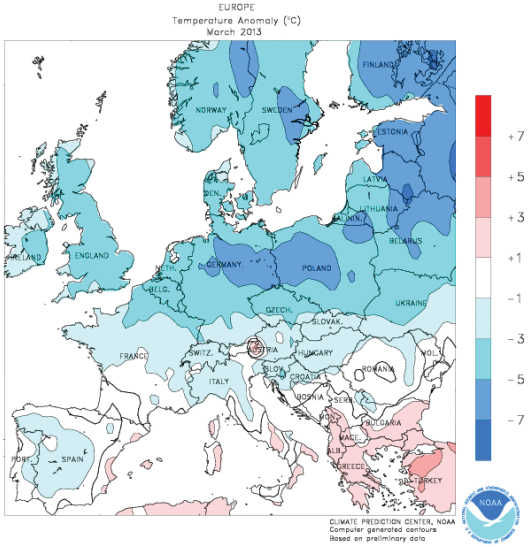

Fig. 1: Deviation of the monthly mean temperature in March 2013 over Europe.
Image Credit: Climate Prediction Center

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Publications

B.Mühr, D. Köbele: Ungewöhnlich kalter März und Aprilbeginn - Deutschland, http://www.wetter-gefahren-fruehwarnung.de/Ereignis/20130409_e.html.

6. Kältester März seit Beginn der Aufzeichnung in Deutschland

Der März 2013 verlief ungewöhnlich kalt in Mitteleuropa, besonders tiefe Temperaturen traten im Norden, Osten und in der Mitte Deutschlands auf. Die häufige Zufuhr kontinentaler und kalter Luftmassen aus dem Nordosten führte zu zahlreichen neuen Rekorden der Tiefsttemperatur, in Quickborn in Schleswig-Holstein beispielsweise wurden -18.8 °C registriert. Als kältester Ort trat Deutschneudorf-Brüderwiese im Erzgebirge mit -21.3 °C in Erscheinung. Mit einem deutschlandweiten Flächenmittel von +0.2 °C reiht sich der März 2013 auf Platz 6 der kältesten Märzmonate seit 1881 ein.

In Teilen Mitteleuropas kam es zudem zu intensiven Schneefällen und mancherorts erreichte die Schneedecke Rekordhöhen. In Hamburg (28 cm) oder in Frankfurt/Main (18 cm) lag der Schnee in einem März noch nie so hoch.

Vulnerability and Critical Infrastructures

Risk Management Strategies in Logistics and Infrastructure Networks (RM-LOG)

Kay Mitusch, Tina Bessel, Li Zhang

Introduction

Catastrophes, whether natural disasters or terrorist attacks, may have serious impacts on the infrastructure and population. A complete infrastructure failure could hinder the supply of necessary goods and services and paralyse production. For instance, this was the case when Rhine navigation was suspended in January 2011. Therefore, the ability to professionally handle and respond to such disasters is crucial for a highly networked economy, such as Germany. In a collaborative project together with other scientists and logistic experts, including practitioners, the Chair of Network Economics, part of the Institute of Economics (ECON) at Karlsruhe Institute of Technology (KIT), is investigating the feasibility of different risk management strategies in transport and logistics systems.

Aims/Objective

The aim of the project is to develop feasible risk management strategies for the public sector as well as for private companies. They should be enabled to develop a greater emergency preparedness and better responses in cases of possible catastrophes. The following issues are explored in greater detail:

- To what specific consequences could a catastrophe lead to?
- How should private companies design and operate their logistics systems to be best equipped against catastrophes, both preventively as well as reactively?
- Which infrastructural investment strategies should and could the government take to ensure a robust transportation system in case of catastrophe?

Project status

Various risk management strategies have been assessed by evaluating the impact of potential catastrophes on transport and logistics systems. For this evaluation, we have constructed possible catastrophe scenarios and developed new quantitative as well as qualitative models.

For instance, we have applied a traffic model based on the open source project MATSim to reproduce the traffic load of the German trunk road network on an average day. We have then quantified the different impacts on this network in two catastrophe scenarios, namely a parallel breakdown of five motorway bridges and an extensive snow storm. Subsequently, we have evaluated three cost-equivalent infrastructural investment strategies, both from a private economic and from a societal perspective. To be specific, we analysed the investment strategies of (a) constructing new motorways, (b) expanding existing motorways, and (c) expanding motorways which were congested in our modelled scenarios. With regard to possible catastrophes resulting in a complete infrastructure failure, the creation of network redundancy in form of alternative gateways or corridors is advisable.

Outlook

From the models thus developed, we will extract the most effective and cost-efficient risk management strategies as recommendations for various stakeholders of transport and logistics systems, such as industrial and logistics companies, infrastructure operators and government institutions. The strategies suggested will be published as part of the final project report.

Core Science Team

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Publications

Zhang, L., Schröder, S., Brock, M., Hayden, C. (2012): Assessment of the interaction between congestion and carriers' route decision: a case study, Proc. 5th Int. Symposium on Transportation Network Reliability, Hong Kong, 2012.

Scholz, A.B., Zhang, L., Gizzi, F., Jäkel, K. (2012): Risk management in the European air freight system – An institutional economic approach, Aviation Transport Research Society World Conference, Tainan (Taiwan), 2012.

Liedtke, G., Friedrich, H. (2012): Generation of logistics networks in freight transportation models, In: Transportation, Springer, 2012, p. 1-17.

Brock, M., Zhang, L., Hayden, C., Matteis, T., Gross, W. (2012): A Comparison of Regular and Disrupted Operations for Route Planning in Freight Transportation, Proc. Int. Disaster and Risk Conference, Davos, 2012, pp. 94-98.

Schröder, S., Zilske, M., Liedtke, G., Nagel, K. (2011): Der Transport-Service-Provider in einem Multiagentenmodell, In: Wirtschaftsverkehr 2011, Modelle – Strukturen – Umsetzung, Dortmund, Verlag Praxiswissen, 2011, ISBN-13: 978-3-86975-041-5.

Liedtke, G., Friedrich H., Babani J. (2011): Identifikation von Tourtypen in Fahrzeugtagebüchern, In: Wirtschaftsverkehr 2011, Modelle – Strukturen – Umsetzung, Dortmund, Verlag Praxiswissen, 2011, ISBN-13: 978-3-86975-041-5.

Zhang, L., Matteis, T. (2011): Congestion Costs and Infrastructure Development: A Simulation Case Study, Infraday, Berlin, 2011.

Risikomanagement-Strategien in Logistik- und Infrastrukturnetzwerken (RM-LOG)

Katastrophenereignisse können einen erheblichen Einfluss auf Infrastrukturen und die Bevölkerung eines Landes haben. Ein großflächiger Infrastrukturausfall könnte zu Behinderungen im Güterverkehr und zu Verzögerungen in Produktionsabläufen führen. Aus diesem Grund ist eine professionelle Handlungs- und Reaktionsfähigkeit gegenüber möglichen Katastrophen für eine eng vernetzte Wirtschaft von entscheidender Bedeutung. Der Lehrstuhl für Netzwerkökonomie am Institut für Volkswirtschaftslehre (ECON) unter der Leitung von Prof. Dr. Kay Mitusch untersucht in einem gemeinsamen Projekt mit anderen Wissenschaftlern, Experten und Praktikern aus der Logistikwirtschaft die Realisierbarkeit verschiedener Risikomanagement-Strategien in Logistik- und Infrastrukturnetzen aus unternehmerischer und gesamtwirtschaftlicher Sicht.

Im Rahmen dieses Projektes wurden verschiedene Katastrophenszenarien entwickelt und die Auswirkungen der potentiellen Katastrophen auf Transport- und Logistiksysteme untersucht. Mithilfe der Open-Source-Software MATSim wurde die Verkehrslast des deutschen Bundesfernstraßennetzes für einen durchschnittlichen Tag modelliert und die Auswirkungen von zwei Katastrophenszenarien auf der Basis dieses Verkehrsnetzes bewertet. Des Weiteren wurden drei kostengleiche Investitionsstrategien in Infrastruktur analysiert. Für den Fall einer Katstrophe, welche zu einem umfangreichen Infrastrukturausfall führen könnte, ist es empfehlenswert Netzwerkredundanzen in Form von alternativen Korridoren zu schaffen.

Aus den im Projekt entwickelten Modellen werden die effektivsten und kostengünstigsten Risikomanagement-Strategien für verschiedene Akteure im Transport- und Logistikbereich abgeleitet. Die vorgeschlagenen Strategien werden im Projektendbericht veröffentlicht.

Decision Support Methods in the Field of Critical Infrastructure Protection (DSM CIP): Overview

Thomas Münzberg, Stella Möhrle, Wolfgang Raskob

Introduction

The management of critical infrastructure (CI) disruptions includes all measures to predict (infrastructure) failures, to mitigate or minimize CI disruption consequences and to recover to normal business. For all these fields of decision making, the CEDIM project 'Decision Support Methods in the Field of Critical Infrastructure Protection (DSM CIP)' promotes the development of supporting methods and analysis approaches for numerous CI related threats. In 2013, the activities of this research field were expanded by newly funded projects including the primary responsibility for preparing and hosting the '10th International Conference on Information Systems for Crisis Response and Management' (ISCRAM 2013) in Baden-Baden, Germany.

Aims/Objective

The long-term strategy aims at integrating various decision support approaches in order to manage different threat scenarios in different CI sectors. Such a system should contain numerous decision support methods to assist decision makers from the private and governmental sector. Therefore, CEDIM has and will intensify its activity to draw up new projects with the focus on different decision support methods.

Project status

The DSM CIP research activities are based on the two former CEDIM projects 'SIMKRIT' (06/2009-12/2009) and 'KRITISKONZ' (06/2010-12/2010) (for both projects see CEDIM annual reports 2009 and 2010). Results of 'SIMKRIT' and 'KRITISKONZ' have fostered current projects like

- the development of an integrated management system that is applicable for all types of emergencies and at all levels of emergency management ('Security2People'),
- the development of a CEDIM database and the implementation of Case-based reasoning (CBR),
- the modelling of CI interdependencies through agent-based simulation, and
- the measurement of disruption impacts

to support disaster risk management and analytical support (see CEDIM annual report 2012).

The development of a CEDIM database and the implementation of CBR were continued in the context of CEDIM's Forensic Disaster Analysis (FDA) activity in 2013 (see 'Development of a CEDIM Database and Implementation of Case-based reasoning for analytical support – continuation from 2012'). The activities on agent-based simulation for modelling CI interdependencies have already started at the end of 2012 and were increased in 2013 (see 'Modelling and Simulation of Critical Infrastructures using Agent-Based Approach'). Further, research on measuring disruption impacts has been carried out. With the help of a multi-indicator approach, spatial vulnerabilities of different regions which are affected by CI disruptions were assessed (see 'Critical Infrastructure Disruption, Decision Support Through Assessing Spatial Vulnerabilities').

In winter 2012/13, two new CIP research projects have been started. Both are financially supported by the German national security research framework. The SEAK project focuses on simulation-based decision support to manage food shortages (see 'The SEAK Project, Decision Support for Managing Disruptions in Food Supply Chains'). The RIKOV project aims at facilitating the selection of security measures within the framework of terrorist threats against public rail transport systems.(see 'The RIKOV Project, Risks and Costs of Terrorist Threats against Public Rail Transport Systems').

The 'KritisF&E' project started at the beginning of 2013. It is financially supported by the German Federal Office of Civil Protection and Disaster Assistance (BBK; an office within the remit of the Federal Ministry of the Interior) and a cooperation between the Cologne University of Applied Sciences and the Karlsruhe Institute of Technology. 'KritisF&E' provides a holistic overview of current CIP research projects and an in-depth analysis with respect to still existing research gaps (see 'The KritisF&E Project, Review on Critical Infrastructure Protection re-

Article / Project Name	Funding Body
Development of a CEDIM Database and Implementation of **Case-based Reasoning** for Analytical Support – Continuation From 2012	Center for Disaster Management and Risk Reduction Technology (CEDIM)
The RIKOV Project, Risks and Costs of Terrorist Threats against Public Rail Transport System	German Federal Ministry of Education and Research (BMBF), German National Security Research Framework
The SEAK Project, Decision Support for Managing Disruptions in Food Supply Chains	German Federal Ministry of Education and Research (BMBF), German National Security Research Framework
The KritisF&E Project, Review on Critical Infrastructure Protection related Research Projects	German Federal Office of Civil Protection and Disaster Assistance (BBK)
Modelling and Simulation of Critical Infrastructures using an **Agent-Based Approach**	Helmholtz Association of German Research Centers (HGF)
Critical Infrastructure Disruption: Decision Support Through **Assessing Spatial Vulnerabilities**	Helmholtz Association of German Research Centres (HGF)

Table 1: Projects in the context of DSM CIP in 2013 and its funding bodies.

lated Research Projects'). It has also strengthened our partnership with end-users like the German Federal Office of Civil Protection and Disaster Assistance (BBK).

In addition to this variety of project activities mentioned above, CEDIM hosted the '10th International Conference on Information Systems for Crisis Response and Management' (ISCRAM 2013). Since 2004, ISCRAM invites top researchers and practitioners working in the area of information systems and crisis management to strengthen the connection between science and end user so as to support better crisis planning, response, mitigation, recovery, and training. This year, the main topic was holistic crisis management. The ISCRAM 2013 took place in Baden-Baden, Germany. The Fraunhofer Institute of Optronics, System Technologies and Image Exploitation, chaired the conference. CEDIM representatives were responsible for the conference's programme and organisational chair.

Outlook

The individual DSM CIP activities will be continued and expanded if possible. The synergies between the current projects will be intensified, with the aim of integrating single components into a decision support system in the field of CIP.

Therefore, new projects focusing additional CI related threats and management as well as other methods of decision support will continue to be of great interest.

Publications

Moehrle, S. (2013): Modeling of countermeasures for large-scale disasters using High-level Petri Nets, Proceedings of the 10th International Conference on Information Systems for Crisis Response and Management (ISCRAM 2013), Baden-Baden 2013.

Moehrle, S. (2013) Towards a decision support system for disaster management, Proceedings of the European Safety and Reliability Conference 2013 (ESREL 2013), Amsterdam, Netherlands, 29. 9 – 2.10. 2013.

Methoden der Entscheidungsunterstützung zum Schutz kritischer Infrastrukturen (DSM CIP)

Der Schutz Kritischer Infrastrukturen (KRITIS) umfasst sowohl die Bereiche Vorhersage, Vorbeugung und Minimierung von KRITIS-Ausfällen als auch die anschließende Wiederherstellung des Normalzustandes nach einem Schadensereignis. Hierfür werden im Rahmen der CEDIM-Aktivität „Entscheidungsunterstützung zum Schutz Kritischer Infrastrukturen (DSM CIP)“ Methoden und Analyseansätze erforscht, die in unterschiedlichen KRITIS-Sektoren Anwendung finden und sowohl private wie auch behördliche Entscheidungsträger unterstützen. In mehreren Projekten werden Methoden des fallbasierten Schließens, der multikriteriellen Entscheidungsanalyse, der Indikatoren-basierten Vulnerabilitätsanalyse und der agentenbasierten Simulation erforscht und weiterentwickelt. Diese Projekte spiegeln unterschiedlichste Bedrohungsszenarien wie terroristische Anschläge im öffentlichen Nahverkehr, Lebensmittelengpässe oder langanhaltende und großflächige Stromausfälle wider. Langfristig sollen alle untersuchten methodischen Ansätze zu einem umfassenden Entscheidungsunterstützungssystem integriert werden. Ferner wurde im Jahr 2013 die weltweit renommierteste Konferenz für Informationssysteme, Krisenbewältigung und -management ISCRAM 2013 in Baden-Baden federführend vorbereitet und ausgerichtet.

DSM CIP: The RIKOV Project, Risks and Costs of Terrorist Threats Against Public Rail Transport Systems

Lijun Lin, Sascha Meng, Stella Möhrle

Introduction

Past terrorist attacks against public railway transportation systems (PRTS) – as in Tokyo (1995), Madrid (2004), London (2005) or Mumbai (2006) – have shown their vulnerability. Such attacks often cause many casualties, considerable economic damage, and sometimes even unpredictable political consequences.

RIKOV intends to investigate – ideally for all critical infrastructures - to what extent a holistic risk management approach can enhance protection of public railway transportation systems against terrorist attacks. The project is part of the national research programme Research for Civil Security - Security Economics and Security Architecture, initiated and financed by the Federal Ministry of Education and Research (BMBF). The project started in November 2012 and will end in October 2015.

Aims/Objective

Research aims of RIKOV are (i) the analysis of terrorist threats against critical infrastructure using the example of public railway transportation systems, (ii) the identification and prioritisation of suitable security measures considering cost and socio-political aspects and (iii) the provision of decision support for the implementation of security measures and concepts. To achieve these aims, interdependencies between risks, security measures and costs are systematically assessed, serving as the basis for decision-making. This holistic approach considers terrorist attack scenarios with intelligent and rational adversaries and proactively acting public railway operators with a security concept for their system. Based on risk assessment, including the analysis of historical events, the identification of plausible scenarios, and the selection of appropriate security measures, an innovative approach to enhance protection of public railways transportation systems will be provided.

Project Status

An analysis of historical terrorist attacks against PRTS was carried out. Highly vulnerable key elements of PRTS to terrorist attacks were identified as well as weapons of attack, which are now or will be in future plausible and relevant. The result is a matrix that shows all

(target x weapon) - combinations that will be taken into account for further research. This matrix considers experiences and opinions of experts (public security authorities, project partners) and decision-makers (PRTS-operators and public authorities). In the next step, scenarios were identified to enable scenario-based risk analysis and risk evaluation. Those scenarios will be stored in a structured way in a knowledge database, which also will contain historical events.

Further, existing literature on risk analysis methods was reviewed. Various different risk analysis methods exist but none of them satisfactorily considers the key characteristic of terrorist attacks: intelligent adversaries. Therefore, a new risk analysis approach by using a risk function which takes threat, vulnerability, and consequences into account, needs to be developed to obtain robust results for the decision-making process.

The (target x weapon)-combinations resulted in a list of possible security measures. Multicriteria decision analysis (MCDA) will be used to support the decision-making process by prioritising security measures. That method allows the evaluation of measures with respect to effectiveness, costs, and social, political, and legal aspects. It supports problem structuring by means of attribute trees and helps to understand the decision-making process. The development of a MCDA tool for the evaluation/ prioritisation of security measures has started.

Outlook

RIKOV will be continued and aims at fulfilling the objectives by broadening the range of research methods. The knowledge database will be used within the framework of Case-based reasoning (CBR), which is a methodology that utilizes similar historical attacks in order to draw conclusions about current scenarios. The security measures thus obtained serve as input for the strategic decision support. An attribute tree will be defined, which contains all important aspects (criteria) to evaluate individual security measures or sets of measures. Results of the risk analysis and decision support methodology will be validated by means of expert workshops.

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Publications

Lin, L., Brauner, F., Münzberg, T., Meng, S., Moehrle, S., Raskob, W. (2013): Prioritization of security measures against terrorist threats to public rail transport systems using a scenario-based multi-criteria method and a knowledge database. In 8th Security Research Conference, Berlin, September 17th – 19th.

RIKOV Projekt: Risiken und Kosten terroristischer Bedrohungen des schienengebundenen öffentlichen Personenverkehrs

Das Verbundprojekt „RIKOV“ hat zum Ziel, einen umfassenden, ganzheitlichen Ansatz für das Risikomanagement und die strategische Planung in kritischen Verkehrsnetzen zu entwickeln. Die Institute des KIT beschäftigten sich in dem Projekt schwerpunktmäßig mit der Entwicklung eines robusten transparenten Risikomanagementsystems. Hierzu werden Methoden des Wissensmanagement wie Wissensdatenbanken, fallbasierte Systeme, szenariobasierte multikriterielle Entscheidungsunterstützung und Indikatorenmodelle untersucht.

DSM CIP: The SEAK Project, Decision Support for Managing Disruptions in Food Supply Chains

Andreas Motzke, Frank Schätter

Introduction

Natural and man-made disasters such as Hurricane Sandy in 2012 or the walk-out in Spain 2008 highlighted difficulties in providing food to the population. Particularly in the early phases of an event, uncertainties are overwhelming such as sparse or lack of information about demand levels, available supply and resources, or the status of infrastructures. To respond to disruptions in the food supply chain, actions by food and retail industries (maintaining or resuming their services) as well as the Emergency Management Authorities (EMA) are required to ensure the supply of goods to the population.

The SEAK project is part of the topic Securing Food and Food Supply Chains of the German security research programme, initiated and financed by the Federal Ministry of Education and Research (BMBF). SEAK project partners are the Karlsruhe Institute of Technology (KIT), the Technical University of Darmstadt, and the logistics consulting company 4flow. The project started on 1 January 2013 and will end on 31 December 2015.

Aims/Objective

The main research aim of SEAK is the improvement in the security and reliability of the food supply in Germany, in particular if disturbances take place. This aim should be achieved by a decision support framework which enables (i) an increased understanding and transparency of food supply in Germany, (ii) the analysis of highly relevant scenarios implying disruptions in the food supply chain, and (iii) an improved decision support for crisis and risk management. Therefore, scenario techniques, decision support methods, and logistical and transport simulation models are combined. SEAK focuses on three appropriate threat scenarios which may lead to a food +shortage or a food supply chain disruption. In particular, the three selected scenarios operate as examples for the proposed decision support framework by describing consequences within the supply networks, implications for the food supply, and the information needs of the key players involved. To ensure that the results of the project are useable, companies, agencies, and ministries are integrated within the entire project runtime.

Project Status

To identify relevant incidents which lead to food shortages or disruptions in the food supply chain, a literature review of historical events has been performed, resulting in a table consisting of eight categories and 15 relevant events. Based on these results, relevant decision-makers in charge of managing supply chain disruptions and their consequences have been identified. Several experts from public authorities and from the private sector have been interviewed to obtain information related to food supply shortages (e.g. scenario relevant aspects, decision-makers in charge, distribution of responsibilities, possible countermeasures) as well as further contacts, literature, and data. From the findings of the literature review and the results of the expert interviews, three narrative threat scenarios have been developed that imply disruptions of the food supply chain and can be seen as highly relevant incidents for the purpose of SEAK. These three scenarios are (i) a heat wave, (ii) a drop-out of manpower, and (iii) a failure of the IT system. For each narrative threat scenario a general description has been developed. Additionally, relevant drivers and consequences for each scenario have been identified during two workshops. Furthermore, relevant data have been collected (i.e. from agencies, companies, literature) within a quantitative system analysis. Therefore, economic actors have been identified (producers, logisticians, retailers) as well as physical locations and the commodity flows of the actors. To facilitate a common understanding within the interdisciplinary project, a glossary containing approximately 100 SEAK-related terms with their definitions has been assembled.

Outlook

The first year of the SEAK project illustrates the large synergies between the CEDIM institutes involved in critical infrastructure protection (CIP). To facilitate the response planning for food supply disruptions and to strengthen the

coping capacities of all supply chain actors, the scenario description will be improved by identifying quantitative drivers and interdependencies between the drivers. The analysis and use of the results from logistical simulations and models will be an ongoing issue. Moreover, current decision processes are investigated and implications for the decision support are derived. Therefore, uncertainties that will be revealed by these scenarios are considered. Based on these requirements, a problem-oriented concept for a decision support framework will be developed. Finally, the framework will be tested and validated by a table-top exercise.

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Publications

Münzberg, Th.; Berbner, U.; Comes, T.; Friedrich, H.; Gross, W.; Pfohl, H.-C. & Schultmann, F. (2013): Decision Support for Critical Infrastructure Disruptions: An Integrated Approach to Secure Food Supply. In: Comes, T.; Fiedrich, F.; Fortier, S.; Geldermann, J. &rMüller, T. (eds.) 10th International Conference on Information Systems for Crisis Response and Management (ISCRAM 2013), Baden-Baden.

SEAK Projekt: Entscheidungsunterstützung zur Bewältigung von Versorgungsengpässen

Die zuverlässige Versorgung der Bevölkerung mit Lebensmitteln ist eine zentrale Aufgabe - gerade bei langanhaltenden und weitflächigen Großschadensereignissen. Ein wirkungsvolles Risiko- und Krisenmanagement trägt daher sowohl zur Vermeidung als auch zur Verringerung der Auswirkungen eines Versorgungsengpasses bei und verknüpft das Vorgehen von Behörden und Unternehmen sinnvoll. Das durch das Bundesministerium für Bildung und Forschung (BMBF) im Rahmen des Nationalen Sicherheitsforschungsprogramms geförderte Projekt SEAK („Entscheidungsunterstützung zur Bewältigung von Versorgungsengpässen“; das Akronym „SEAK“ rührt her vom ursprünglichen Projekttitel: „Simulationsbasierte Entscheidungsunterstützung für das Akteursübergreifende Krisenmanagement bei Störungen der Lebensmittelversorgung“) befasst sich deswegen mit der Beherrschung und Bewältigung von Lebensmittelengpässen. Hierzu wird ein simulations- und szenariobasierter Ansatz zur Entscheidungsunterstützung verfolgt, mit dem einerseits Ausfälle und Störungen in Lebensmittelwarenketten nachvollzogen und andererseits die Ursachen und Wirkungen von Schadensereignissen abgebildet werden können. Simulationen und Modelle aus der Logistik werden erstmals für das Management von Versorgungsengpässen mit Methoden der Entscheidungsunterstützung und der Szenariotechnik kombiniert. Diese Kombination bildet die Grundlage für einen Rahmen zur Entscheidungsunterstützung, der die beteiligten Akteure aus der Privatwirtschaft sowie der öffentlichen Gefahrenabwehr vernetzt und ihnen eine Möglichkeit zur gemeinsamen Reaktionsplanung bietet.

DSM CIP: The KritisF&E Project, Review on Critical Infrastructure Protection Related Research Projects

Thomas Münzberg, Stefan Wandler, Evgenia Deines

Introduction

Critical infrastructure protection (CIP) has become an expanding topic in recent years. Numerous research programmes at national, European and international levels have initiated research projects related to predicting and minimizing the consequences of critical infrastructure disruptions. This has resulted in an increased number of scientists interested in CIP. Today, the CIP community has an impressively wide range of research disciplines and directions. The outcome of the research provides policy-maker and practitioner alike with proven scientific solutions and new thoughts. Their benefit is clearly visible e. g. in technical improvements, more secure technologies or advanced sophisticated methods for risk and crisis management. However, there exists so far no systematic review on the benefit of CIP-related research for the field of civil protection and disaster management. To fill this gap, the German Federal Office of Civil Protection and Disaster Assistance commissioned the project 'Review of Critical Infrastructure Protection related Research Projects (KritisF&E)'. The project is conducted through cooperation between the Institute of Rescue Engineering and Disaster Management (IRG) at the Cologne University of Applied Sciences (lead contract) and the Accident Consequence Group (UNF) at the Karlsruhe Institute of Technology.

Aims/Objective

The project 'Review of Critical Infrastructure Protection related Research Projects (KritisF&E)' aims at providing an overview of nationally and internationally funded CIP research projects. This overview should illustrate the individual project benefit in the disaster management discourse and should extract current research gaps. The results of 'KritisF&E' will assist in the definition of new topics in upcoming calls, reports on the state of the current research, and will help to identify potential synergies in past and future research topics.

Project status

From February to October 2013 the UNF and the IRG reviewed and evaluated research projects related to CIP. The work focused on current and former work programmes in the period from 2005 to 2013 and with the key focus on national and European activities. In a second step, relevant and representative international research projects related to CIP were added. All project data were stored in a knowledge base.

In order to illustrate a systematic overview, each research activity was documented through a descriptive specific project summary. This summary was derived from publicly available project documents. Each project summary provides a project description including e. g. project partners, methods thus developed, results, and a brief evaluation of the project's benefits in civil protection and disaster management. Therefore, a comprehensive template was developed and performance indicators were defined. As the target groups for this information are the German ministries and their offices, the project summaries had to be prepared in the German language.

Projects were additionally reviewed and briefly evaluated regarding critical infrastructure and disaster management related topics such as e. g. management, simulation and modelling, vulnerability assessment, interdependency analysis or capacity building. The scientific methods used and developed within these research projects were considered when developing the summary description of the project's objectives and benefits. Hence, 'KritisF&E' made it possible to highlight the wide range of methods and approaches applied to individual problems in the CIP research.

The role of UNF in 'KritisF&E' was on the one hand to support the lead contractor in assuring the scientific quality of the project and on the other hand to perform the review and evaluation of research projects related to interdependence analyses, simulation and modelling. Therefore, UNF reviewed systematically all relevant work programmes on national and Euro-

pean levels and documented more than 30 CIP research projects.

The resulting presentation of the 'KritisF&E' project is intended to take place at a workshop organized by the German Federal Office of Civil Protection and Disaster Assistance in Bonn, Germany.

Outlook

It is under discussion whether the results of the project in terms of the final report and the individual project summaries will be made available to the public. One possibility is the publication via the information centre for civil protection and disaster management ("Fachinformationsstelle") at the German Federal Office of Civil Protection and Disaster Assistance.

'KritisF&E' strengthened our research network within the German Federal Office of Civil Protection and Disaster Assistance as the end-user at the strategic level of CIP and civil protection in Germany, and with the IRG as a reliable partner for application-orientated research in the field of disaster management. The extracted knowledge provides an ideal basis for the CEDIM approach on DSM CIP and especially its research direction on agent-based simulation and modelling.

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KritisF&E Projekt

In den letzten zehn Jahren wurde eine Vielzahl von Forschungsprojekten zum Schutz von Kritischen Infrastrukturen (KRITIS) durchgeführt. Viele dieser Projekte wurden in Rahmen von nationalen und internationalen Forschungsprogrammen gefördert und haben einen wesentlichen Beitrag bspw. hinsichtlich des technischen Fortschritts, verbesserter Sicherheitstechnologien oder neuartiger Methoden des Risiko- und Krisenmanagements geleistet. Ein umfassender Überblick über die Projekte, die einen Mehrwert im Bevölkerungsschutz und insbesondere beim Schutz von Kritischen Infrastrukturen erreicht haben, existiert jedoch noch nicht.

Das vom Bundesamt für Bevölkerungsschutz und Katastrophenhilfe geförderte Projekt ‚KritisF&E' hat nun erstmals versucht, einen derartigen Überblick zu erarbeiten. In einer Kooperation zwischen dem Institut für Rettungsingenieurwesen und Gefahrenabwehr an der Fachhochschule Köln und der Forschergruppe Unfallfolgen des Karlsruher Institut für Technologie wurden relevante Projekte auf nationaler, Europäischer und internationaler Ebene systematisch erfasst, übersichtsartig dokumentiert und nach ihrem Mehrwert im Bevölkerungsschutz evaluiert.

Als Ergebnis des Projektes steht eine Studie zur Verfügung, die relevante Projekte zum Schutz Kritischer Infrastrukturen standardisiert erfasst und ihren jeweiligen Mehrwert für den Bevölkerungsschutz beschreibt. Mit einem derartigen Überblick können der derzeitige Forschungsstand dargestellt, die Entwicklung zukünftiger Forschungsförderungen unterstützt und potentielle Synergien bisheriger Forschungsprojekte erkannt werden.

DSM CIP: Modelling and Simulation of Critical Infrastructures Using an Agent-Based Approach

Evgenia Deines, Stefan Wandler

Introduction

Critical infrastructures (CIs) are highly interconnected. Hence, the disruption of one CI may negatively affect other CIs. To protect CIs it is necessary to study their interdependencies and the overall complex system behaviour. For this purpose we use an agent-based approach. Agent-based modelling and simulation (ABMS) allows the analysis of complex systems comprised of individual, autonomous interacting "agents". Agents represent particular components of CIs. They have the decision-making capability and can react to events triggered by other agents which in turn influence the behaviour of other agents. The most important characteristic of ABMS is the modelling flexibility, i.e. an agent-based model can be coupled with other modelling methods such as system dynamics or can be enhanced by adding decision support methods, e.g. MCDA (Multi-Criteria Decision Analysis).

Aims/Objective

We aim at a better understanding and analysis of CI Interdependencies and their behaviour in cases of large-scale and long-term power blackouts. This objective will be achieved by developing an agent-based model representing the complex system of critical infrastructures. Simulating the model will facilitate the analysis of CIs, their impacts on each other and on the entire system. Furthermore, the agent-based model will be coupled with a Geographical Information System (GIS) resulting in visualization of the cascading effects on the geographical space for better observation and monitoring of the power blackout propagation.

Project status

All CIs interact with the energy system so that a failure in the electrical power infrastructure can have serious impacts on other CIs. Therefore we have started with power grid modelling, focused on the high- and medium-high-voltage

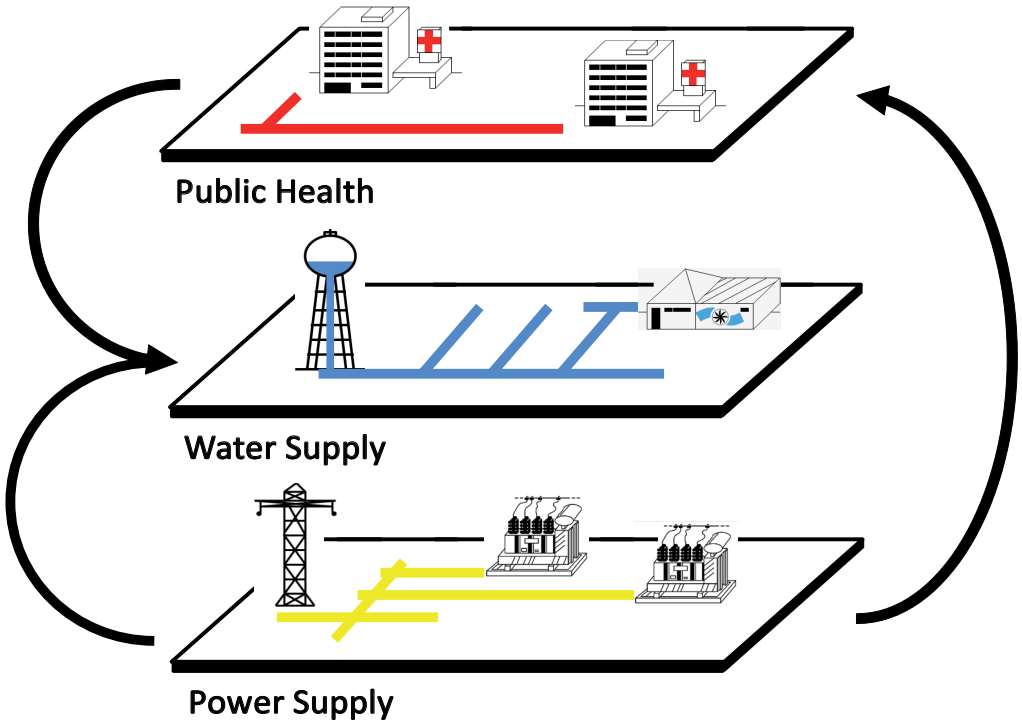

Fig. 1: Interdependencies among the three sectors: public health, water supply and power supply.

network. The power grid is a complex system composed of many non-identical components connected to each other. It includes power generation, transmission and distribution facilities. The increased use of renewable energy sources implies changes in the behaviour of energy systems that will be especially considered in addition to conventional power generation. We adopt an agent-based framework for simulating and representing our model and use Java as object-oriented programming language for implementation. In the model, agents represent the components of the power grid such as power plants, generators, transformers, substations, etc. Individual behaviours and internal organizations as well as collaboration between agents are specified. Information about agents, their attributes and structural relations are stored in the relational database which is accessed by the agent-based framework. The generic model is being continually developed and enhanced by adding new agents into the model and determining additional behavioural and decision-making rules to the agents.

Outlook

Initially, the model will be run with artificially generated data within a virtual environment. The model will be continually developed and improved by collecting real data and making agents more intelligent and realistic, e.g. by adding MCDA components. Other critical infrastructures such as water supply, health care systems and communication networks will be embedded in the model and coupled with each other. In addition, simulation scenarios have to be determined and created. Simulation results will include datasets, time series charts of changing parameters at runtime and the visualization of model components on the geographical space within which agents interact. Simulating the collective behaviour of agents will promote the understanding of CIs interdependencies.

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Agentenbasierte Simulation der Entscheidungsunterstützung von interdependenten kritischen Infrastrukturen

Die kritischen Infrastrukturen bilden zusammen ein hoch komplexes miteinander verkoppeltes System. Störungen oder sogar Ausfälle von einigen Komponenten einer kritischen Infrastruktur können somit negative Auswirkungen auf andere kritische Infrastrukturen haben. Um dieser Problematik zu begegnen nutzen wir einen agentenbasierten Ansatz zur Entscheidungsunterstützung. Die Agenten haben die Fähigkeit mit anderen Agenten zu interagieren, um damit auf Ereignisse reagieren zu können.

Dies führt zur Entwicklung von Modellen, die einerseits die Interdependenzen der kritischen Infrastrukturen widerspiegeln, als auch deren Verhaltensweisen in Notsituationen und damit eine Entscheidungsunterstützung durch geeignete Tools wie zum Beispiel Multi-Criteria Decision Analysis (MCDA), zur Abschwächung der Auswirkungen, bieten. Als zu Grunde liegendes Szenario wird von einem langanhaltenden und großflächigen Stromausfall ausgegangen.

Zurzeit wird ein generisches Modell des Stromnetzes entwickelt, um die Verknüpfungen zu anderen kritischen Infrastrukturen untersuchen zu können. Die Agenten repräsentieren in diesem Fall die einzelnen Komponenten. Die Eigenschaften und strukturellen Beziehungen werden direkt im agentenbasierten Framework definiert bzw. über relationale Datenbanken eingelesen. Es wird angestrebt die Agenten mit mehr Fähigkeiten auszustatten und das Modell sukzessive mit weiteren kritischen Infrastrukturen zu ergänzen.

DSM CIP: Critical Infrastructure Disruption, Decision Support Through Assessing Spatial Vulnerabilities

Thomas Münzberg

Introduction

Critical Infrastructures (CIs) are facilities and organizations, which ensure the functionality of essential services and goods. A disruption of a CI may have severe impacts for society, economy, and industry. To limit the consequences of CI disruptions, disaster management authorities and CI providers aim at minimizing negative impacts as well as managing the effects of CI disruption. To support this, spatial vulnerability analyses should provide an understanding of regional vulnerabilities arising from a CI disruption.

Aims/Objective

The assessment of vulnerabilities of different regions regarding a CI disruption should facilitate the understanding of decision makers from disaster management authorities and CI providers of the consequences of CI disruptions. Such an assessment should provide a framework to identify CIs at a local level, to consider the individual criticality of CIs, and to take the CIs' localization into account. The result should facilitate the comparison of vulnerabilities of different regions and illustrate the impact of single CIs on the vulnerability of a region.

Project status

The general framework for the spatial assessment of vulnerabilities against a CI disruption uses an indicator approach, which was first published by Münzberg, Müller, Möhrle, Comes, and Schultmann (2013) at the 10th International Conference on Information Systems for Crisis Response and Management' (ISCRAM 2013) in Baden-Baden, Germany. The assessment was performed for the problem of a load reduction which is an emergency procedure that might be implemented in cases of electricity grid instabilities. To keep the stability of electricity grids, some consumers are dropped from the electricity grid. This is achieved by decoupling so-called 'supply regions' that reduces the grid's load. If one supply region is selected for load reduction, decision-makers need to understand what kind of and how many CIs may be affected by a power outage. This improves the understanding of potential impacts of such a decision.

A general framework of assessing the vulnerabilities of supply regions was developed. The framework consists of eight steps:

- Analytical selection of criteria and attributes to assess the vulnerability of the supply regions to power outages;
- Definition of a hierarchical criteria framework (see layer 1 of Fig. 1);
- Definition of normalization functions;
- Integration of weighting factors (see layer 2 of Fig. 1);
- Aggregation to prioritise supply regions;
- Visualisation of results (see layer 4 of Fig. 1);
- Sensitivity analysis concerning changing weights and attribute values accompanied by an update of the criteria framework, and
- Decision support by means of the assessment.

The eight steps (see Fig. 1) provide a clear and well-structured framework to assess vulnerabilities against power outages. It takes the criticality of the CIs as well as the localization of CIs into account and illustrates the level of vulnerability of each supply region. It enables a decision-maker to rank supply regions regarding the level of vulnerability and to support the planning of load reduction schedules. Hence, the spatial vulnerability assessment for the load reduction problem bridges the gap between the interests of electricity grid providers (e.g. ensuring grid stability) and the interests of disaster management authorities (e.g. protecting CIs from power outages). To ensure applicability and end-user orientation, the framework was applied to the city of Mannheim in cooperation with the Mannheim Municipal Fire Department. The framework is also adaptable to other kinds of CI disruptions.

Outlook

To manage the effects of CI disruptions, the CIs may maintain limited coping capacities. These capacities may buffer the negative effects and reduce the vulnerability for a limited period of

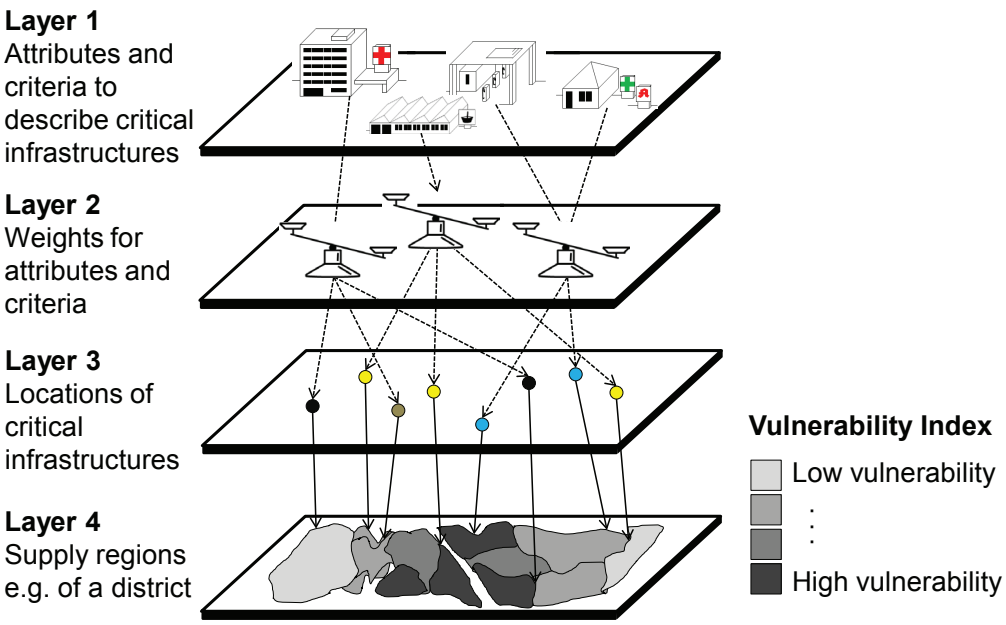

Fig. 1: Layer illustration of the framework to assess spatial vulnerabilities against a CI disruption.

time. Therefore, dynamic considerations of vulnerability are needed. These considerations will be included in upcoming researches. Assessing dynamic aspects of vulnerabilities may allow analysis of the performances of coping strategies. This is a particularly interest aspect for forthcoming research activities.

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Publications

Münzberg, Th.; Mueller, T.; Möhrle, S.; Comes, T. & Schultmann, F. (2013): An Integrated Multi-Criteria Approach on Vulnerability Analysis in the Context of Load Reduction. Proceedings of the 10th International Conference on Information Systems for Crisis Response and Management (ISCRAM 2013), Baden-Baden 2013.

Unterbrechungen von kritischen Infrastrukturen - Entscheidungsunterstützung durch Vulnerabilitätsanalysen

Fallen Kritische Infrastrukturen (KRITIS) aus, stehen sowohl Betreiber als auch Behörden und Organisationen mit Sicherheitsaufgaben vor der Herausforderung, die daraus resultierenden Konsequenzen zu beherrschen und zu bewältigen. Die Analyse regionaler Vulnerabilitäten kann dabei helfen, die negativen Wirkungen von KRITIS-Ausfällen zu verstehen und ihre Konsequenzen zu mindern. Ziel derartiger Analysen ist es, durch ein systematisches Vorgehen eine Gewichtung der verschiedenen KRITIS-Sektoren und -Branchen zu ermöglichen und unter Berücksichtigung ihres Standortes die Vulnerabilität von einzelnen Regionen eines Kreises oder einer kreisfreien Stadt gegenüber einem KRITIS-Ausfall messbar zu machen. Das Vorgehen für eine regionale Analyse von Vulnerabilitäten wurde zunächst anhand des Praxisproblems der Lastreduzierung - eine Notfallmaßnahme zur Stabilisierung von Elektrizitätsnetzen - für Stromausfälle entwickelt. Hierdurch wird es möglich, Versorgungsregionen hinsichtlich ihrer Vulnerabilität zu vergleichen und darzustellen, inwieweit welche KRITIS-Einrichtung Einfluss auf die Vulnerabilität einer Versorgungsregion hat. Da die meisten KRITIS-Einrichtungen über Bewältigungskapazitäten wie bspw. unterbrechungsfreie Notstromversorgungen für Stromausfälle verfügen, besteht Forschungsbedarf bei der Berücksichtigung zeitlicher Entwicklungen. Die Einbindung dynamischer Effekte in die Messung der Vulnerabilität spielt damit eine zentrale Rolle kommender Forschungen.

Global Earthquake Model

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 components 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 centre 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 characterise the current and future dataset for testing risk models
6. Setting up a testable hypothesis for testing Mmax

Project status

Seismicity Rate Testing

For seismicity rate model testing, the T&E effort uses existing CSEP testing capabilities. We computed and analysed test results for the 3-month model experiment in California. All seven models of this experiment forecast seismicity for the following 3-month period. We identified the best operating model and provided guidance on how to improve the models based on detailed residual analyses.

Also for the region of California, we tested the Uniform California Earthquake Rupture forecast (UCERF2) and the forecast of the National Seismic Hazard Mapping Project (NSHMP) and compared their performance with the suite of models of the Regional Earthquake Likelihood Models (RELM) project. The best-performing RELM model showed better performance than UCERF2 and NSHMP for various testing periods, prospective as well as retrospective. The differences between the models became more significant with longer testing periods (up to 40 years retrospectively).

We also developed a high-resolution global testing experiment that will cover various earthquake forecast models, in particular the seismicity rate models developed for GEM.

Ground Motion Testing

This experimental set-up for testing intensity prediction equations is implemented in the GEM Testing Center at GFZ Potsdam. In addition, further data sources like the 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 conducted a case study on almost 20 ground-motion prediction equations (GMPE) for Japan. The results show that better preforming GMPEs exist than are currently used in seismic hazard assessment. Overall, the

performance differences are less pronounced compared to the IPE experiment. Automatic testing of GMPEs poses serious problems because data preparation can become arbitrarily complex and metadata about GMPEs are often improperly specified. Such tests will only be possible in collaboration with GMPE authors and hazard modellers.

Maximum Magnitude

We showed in the previous year that maximum magnitude estimates cannot be tested within a reasonable time frame. Even almost meaningless low-power results will need several centuries of observations. This year we focused on assessing the possibilities of estimating maximum magnitudes. We investigated estimates from seismicity catalogues, historic earthquake catalogues, paleoseismic records, strain rates, and geologic information such as fault length. We came to the conclusion that none of the methods mentioned can provide estimates of maximum magnitude without making assumptions that basically completely predetermine the results.

Hazard testing

We convened a hazard testing workshop at the USGS in Golden, Colorado. We are currently setting up tests of the National Seismic Hazard Map (released 1996) for the US against the collection of earthquake shaking information for the last 17 years.

Outlook

We will move from testing the components of seismic hazard (rates, IPEs, GMPEs) to testing hazard and risk directly. The hazard test is outlined briefly above. For the risk test, please see the remarks in the section about Post-Disaster Damage Mapping.

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Publications

Zechar, J. D., Schorlemmer, D., Werner, M. J., Gerstenberger, M. C., Rhoades, D. A., Jordan, T. H. (2013): Regional Earthquake Likelihood Models I: First-Order Results, Bull. Seismol. Soc. Am., 103(2A), 787-798.

Holschneider, M., Zöller, G., Clements, R. A., Schorlemmer, D. (in revision): Can we test for the maximum possible earthquake magnitude?, J. Geophys. Res.

Schneider, M., Clements, R., Rhoades, D., Schorlemmer, D. (submitted): Likelihood- and Residuals-Based Evaluation of Medium-Term Earthquake Forecast Models for California.

Mak, S., Clements, R., Schorlemmer, D. (submitted): Evaluating Intensity Prediction Equations for Italy.

Schorlemmer, D., Clements, R., González, A. (2013): The Testability of Maximum Magnitude. Invited talk at: JpGU Annual Meeting, 2013 May 21, Chiba, Japan.

Schorlemmer, D., Schneider, M. (2013): Evaluation of USGS Earthquake Forecast Models. Invited talk at: SSJ Annual Meeting, 2013 October 8, Yokohama, Japan.

‘GEM Testing & Evaluation Center’

Das Global Earthquake Model (GEM) entwickelt das erste weltweit homogene Gefährdungs- und Risikomodel für Erdbeben. Innerhalb von GEM arbeitet das Testing & Evaluation-Projekt daran, die verschiedenen Bestandteile dieses Models zu testen. Zu den wichtigsten zählen die Erdbebenratenmodelle, Modelle zur Vorhersage der durch Erdbeben hervorgerufenen Bodenbewegungen, die resultierenden Gefährdungs- und Risikomodelle und ausgewählte weitreichende Annahmen, die in den Modellen verwendet werden. Dazu gehört das Konzept der maximalen Magnitude von Beben in bestimmten Gebieten. Alle Tests werden im GEM Testing Center am GFZ-Potsdam durchgeführt.

Social Vulnerability and Integrated Risk Project in GEM

Bijan Khazai, James Daniell, Christopher Power, Christopher Oberacker, Chris Burton

Introduction

At the core of the Global Earthquake Model (GEM) is the development of state-of-the-art modelling capabilities that can be used worldwide for the assessment and communication of seismic risk. Holistic evaluation of seismic risk in GEM centres on the development of tools, validated data and methods that draw from the GEM hazard and risk module on seismic hazard, exposure, predicted mortality and property loss, and from models of social vulnerability and economic vulnerability. The Social Vulnerability and Integrated Risk Project is a two-year project which began in September 2012 and is a collaborative effort between the GEM Foundation and CEDIM (KIT) with involvement from the Willis Research Network. Bijan Khazai from KIT is leading the project, which is coordinated by GEM's Christopher Burton. There are several PhD and masters students contributing to the project from both institutions.

Aims/Objective

The goal of the project is to integrate Open Source software tools, spatially-enabled and open databases, and indicators and indices with GEM's on-going activities on hazard and physical risk to address the differential susceptibility of populations to the adverse impacts of earthquake events in a holistic manner that accounts for both physical risk and the social circumstances at a given place. One of the key outcomes of the project is development of multiple comprehensive, spatially enabled databases for building indicators and indices of social and economic vulnerability. These are scaled at the national level for the whole world, sub-national level for the Asia-Pacific region, and sub-municipal levels for Quezon City and Kathmandu, based on open and publicly available sources. The databases will be used for the purpose of integrated risk assessments within the Integrated Risk Toolkit of the OpenQuake

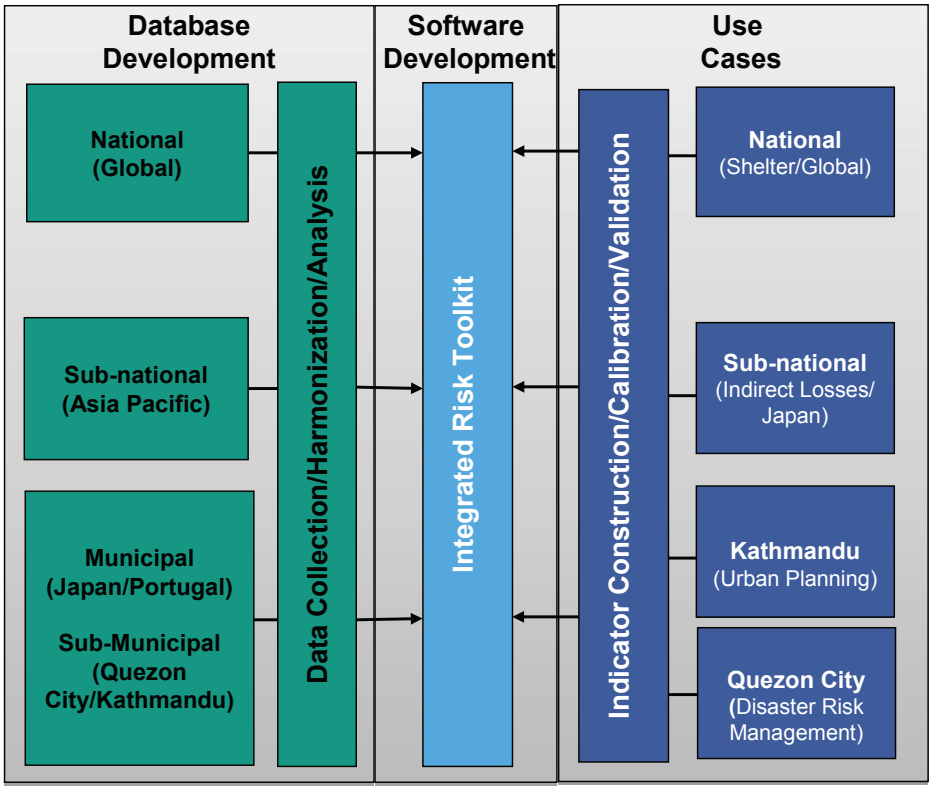

Fig 1: Overview of the different project components in the Social Vulnerability and Integrated Risk Project of GEM.

Platform. In the GEM Social Vulnerability and Integrated Risk Project, a set of "Use Cases" will demonstrate the development of particular indicator frameworks which are tested and validated (either statistically or through stakeholder interaction) for a set of defined contexts (i.e., shelter needs, indirect loss potential, urban growth, local-government preparedness planning etc) (Fig. 1).

Project Status

At present the work completed includes the data collection, harmonization, construction, and analysis of the country level (global coverage) portion of the socio-economic database that is sourced from free and publicly available global data sources. The determination of the most applicable indicators for social and economic vulnerability assessment was accomplished through a two-step approach using expert opinion and factor analysis illustrated in figure 2.

The expert opinion portion focused on identifying indicators of social and economic vulnerability most in use in the literature through a survey of 440 studies and an in-depth analysis of 35 key references. Next, a series of workshops was held in which researchers working in social and economic vulnerability sciences developed a taxonomy for structuring the identified indicators, and judged the applicability of each indicator to the social and economic vulnerability of populations based on a-priori knowledge and the extant literature (Fig. 3).

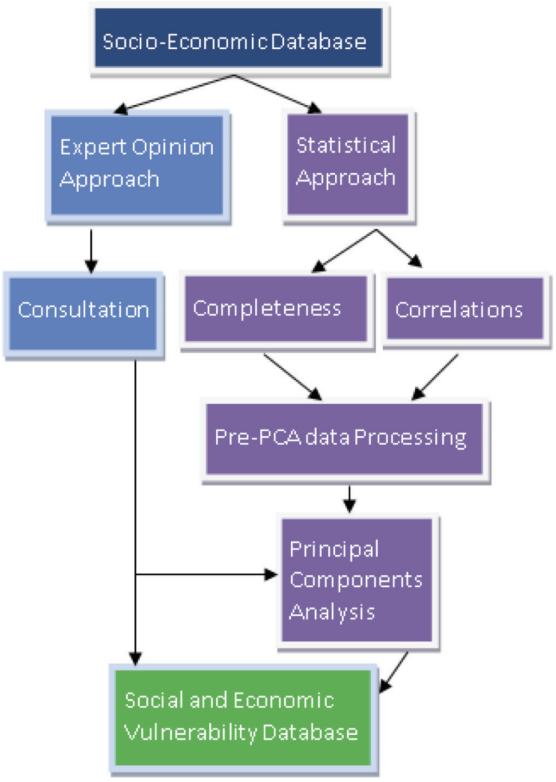

Fig 2: Overview of the steps in the methodology towards the creation of the more parsimonious database, labelled "Social and Economic Vulnerability Database".

In a second step, the factor analysis approach included examining the correlation structure between the indicators and the use of a series of Principal Component Analyses (PCA) to reduce the variables and identify the main underlying drivers of social and economic vulnerability. Within this context, analyses were performed that investigated the completeness, correlation structure, consistency and bias of the data. The end result was the coupling of the expert and multivariate statistical methods for the formation of a parsimonious database of 367 indicators from among 1,494 indicators representing 197 countries and sourced from 44 publicly available sources. The indicators were structured and classified using a broad taxonomy of themes and sub-themes that includes characteristics of populations, economies, health, education, governance, and infrastructures. The selected indicators are highly amenable to socio-economic vulnerability, and provide a harmonized and structured input national-level database required for constructing indices or developing an integrated risk assessment using the Indicator Toolkit within OpenQuake. In addition to the global country-level database, the Sub-national level socio-economic database for Asia- Pacific region is currently under progress and a final set of indicators and accompanying databases are proposed for 21 countries.

Furthermore, municipal level socio-economic databases were compiled for use cases in Quezon City and Kathmandu. The Kathmandu use case is being developed as part of a collaborative effort between the South Asia Institute at Heidelberg University, CEDIM at KIT, and the National Society for Earthquake Technology (NSET) in Kathmandu and focuses on an integrated seismic risk model for Kathmandu linked to seismic risk modelled in OpenQuake that considers the effect of social vulnerability at the geographical sub-municipal level (L3). In addition to quantitative socio-economic databases, a "score-card" is being developed and tested through workshops with stakeholders in Kathmandu which consists of a series of evaluation

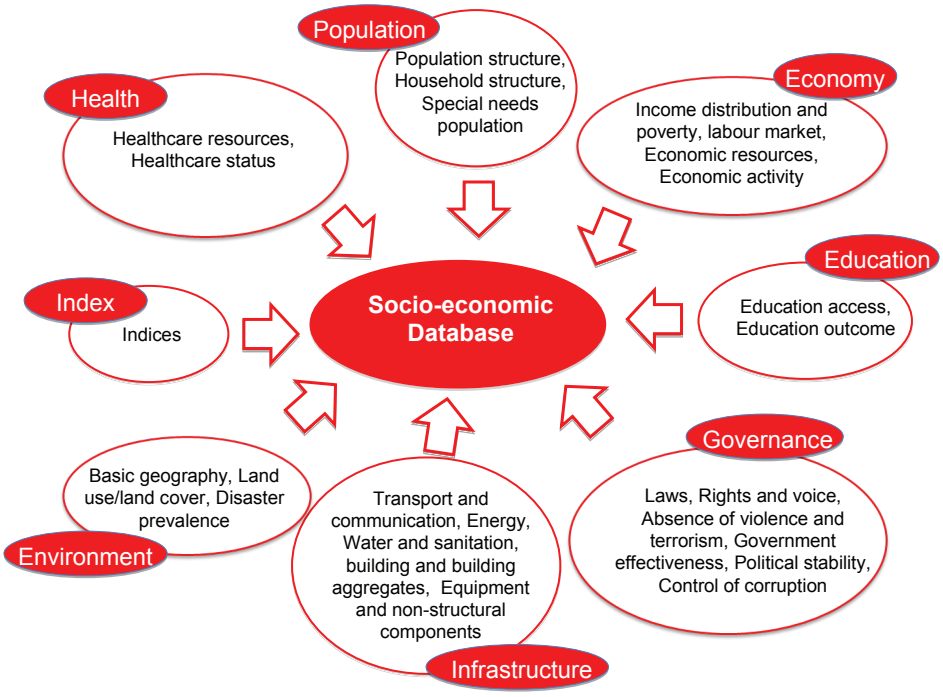

Fig 3: Themes and respective subthemes of the socio-economic database, italicised labels are the themes and the labels below are the subthemes.

criteria designed to cover the policy & planning, engineering, informational, organisational, financial, social and environmental aspects of disaster resilience in Kathmandu not readily captured through publicly available data.

The Quezon City use-case is also being finalized and is based on a collaborative effort between CEDIM at KIT and the Earthquake and Megacities Initiative (EMI), and the Quezon City Government with participation of local and national stakeholders. The use case is structured around efforts to establish a disaster risk reduction and management system within the city and to institutionalize DRRM protocols, policies, procedures, and functions within the Quezon City government. The goal of the indicators is to identify concentrations of the highest impact areas at the geographical sub-municipal level in Quezon City with a focus on the decision-making needs of local government authorities in Quezon City. The selection of social vulnerability and coping capacity indicators and their respective weights in Quezon City is a fully participatory process and implemented through workshops with 40 stakeholders from 21 city offices and organizations in Quezon City.

Concluding Remarks and Outlook

Further development of the databases for integrated risk assessment aims to statistically analyse and determine the key socio-economic vulnerability indicators for countries of the Asia-Pacific region at a sub-national level (e. g. Provincial). Differences and similarities between the key indicators of socio-economic vulnerability are be discussed and investigated. Results will be completed and reported in December 2013. Two additional case studies are also currently underway: 1) The first will be established at the national level (L1) and proposes a framework of social vulnerability indicators to better articulate the potential of being displaced and seeking public shelter after a damaging earthquake; and 2) A second example will be developed to consider aspects of the private sector such as the insurance and reinsurance industries. Here, a database developed for Japan at the sub-national level (L2) of geography will be used for the development of vulnerability indices to assess the potential for indirect economic loss. Finally, a “mock-up” of the Indicator Toolkit has already been developed, and work is underway at the GEM Modelling Facility in Pavia in developing the software.

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References

Khazai, B., Daniell, J., Power, C., Burton, C., Wenzel, F., Bendimerad, F. (2013) Monitoring Changes in Global Social Vulnerability and Integrated Risk Indicators through Time; Input to GAR15 – HFA Thematic Review for Indicator PFA/C12. Abstract for Input Paper Accepted.

Anhorn, J., Khazai, B., Schaper, J., (2013) Open Space Suitability Analysis for Emergency Shelter After An Earthquake – Kathmandu Case Study, Submitted to NHESS.

"Social Vulnerability and Integrated Risk" in GEM

Das Projekt "Social Vulnerability and Integrated Risk" in GEM integriert OpenSource Software, OpenDatabases und Indikatoren mit GEMs laufenden Aktivitäten im Bereich der Gefahren und Risiken. Im Projekt soll die Entwicklung von sozialen und ökonomischen Vulnerabilitäts-Indikatoren und die Verknüpfung mit Risikobewertungen innerhalb eines "Integrated Risk Toolkits" erreicht werden. Für das im Projekt entwickelte "Integrated Risk Toolkit" wird eine statistisch robuste, geographische Datenbank für die Daten der sozialen und ökonomischen Vulnerabilitäts-Indikatoren auf nationaler (weltweit), subnationaler (asiatischer Pazifikraum) und regionaler Ebene (Japan, Quezon City und Kathmandu) entwickelt.

EMCA & Co.: Towards Harmonized Seismic Risk in Central Asia

Massimiliano Pittore, Marc Wieland, Dino Bindi, Shahid Ullah, Marco Pilz, Kevin Fleming, Jochen Zschau, Stefano Parolai

Introduction

Even a cursory glance at the global model of seismic hazard provides a hint as to the reasons why Central Asia is such an important region for research into earthquake hazard, and of such concern for the local administrations. Countries such as Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan share not only a long and fascinating cultural history, but also a high level of exposure to seismic risk and other natural hazards, such as landslides and floods. Of particular importance is the Ferghana valley, an area measuring around 300 by 70 km, situated between the mountain system of Tien-shan, in the north, and the Gissar-alai system in the south, where more than 11 million people of different countries and ethnic groups live side by side within a delicate geopolitical environment (Pittore et Al, 2012).

GFZ is involved in a number of projects focusing on Central Asia within the broad framework of disaster risk reduction (DRR). In particular, EMCA (Earthquake Model Central Asia), coordinated by GFZ, is the regional component of the Global Earthquake Model (GEM) initiative, and aims to provide a comprehensive risk assessment for the entire region, working in partnership with local institutions and building upon global standards, tools and approaches developed within the broader range of GEM activities. Similarly, the PROGRESS (Potsdam Research Cluster for Georisk Analysis, Envi-

ronmental Change and Sustainability) project is tackling seismic risk from the exposure point of view within the context of early warning systems. Meanwhile, more recently the SENSUM (Framework to integrate **S**pace-based and in-situ s**ENS**ing for dynamic v**U**lnerability and recovery **M**onitoring), an FP7-SPACE project, intends to boost the application of remote sensing and geo-spatial information management for vulnerability assessment and post-earthquake recovery monitoring.

Understanding and evaluating the impact of seismic events on the exposed communities is the major challenge we are confronted with. A reliable assessment of seismic risk is indeed essential to efficient prevention and mitigation measures, and a basic component of the next generation of Earthquake Early Warning (EEW) systems. In the following, a brief overview of current activities and advancements related to risk assessment in Central Asia is provided.

Seismic hazard estimation

In the framework of EMCA, new assessments of seismic hazard in Central Asia are ongoing, in terms of MSK64 intensity. The intensity prediction equations developed for the area (Bindi et al., 2011) has been exploited to evaluate the probability of exceedance of any given intensity value over a fixed exposure time following the Site Approach to Seismic Hazard Assessment (SASHA) . The evaluation is mainly based on the seismic history available at different locations without requiring any a-priori assumption about seismic zonation, allowing to test the influence of the latter when standard PSHA procedure are applied. The seismic catalogue compiled within EMCA by the Kazakhstan National Data Center-Almaty (KNDC), under the supervision of N. Michaelova, has been also considered to apply the spatially smoothed seismicity approach for PSHA. The computed models confirm that Central Asia is exposed to high seismic hazard, in particular Kyrgyzstan (intensity VIII), Tajikistan (Intensity VIII and IX), the western part and the Gazli area in Uzbekistan (VIII and IX), and western Turkmenistan (intensity VIII and IX close to Ashgabat).

Exposure modelling

Within the possible assets categories we focus on residential buildings, since most of the fatalities due to earthquakes happen when the buildings collapse. Creating an inventory of the types, amount and spatial distribution of such assets exposed to seismic hazard is therefore the scope of exposure modelling. Due to high urbanization rates and an increasingly high spatio-temporal variability in many Central Asian cities, local authorities are often unable to keep track of the building inventory.

In order to define a harmonized, regional description of the most common building typologies for Central Asia, and to facilitate the transfer of knowledge on how to derive such vulnerability functions following the newly established standards of the GEM, a workshop on exposure and vulnerability assessment in Central Asia was organized by GFZ in April 2013 at the Central Asian Institute for Applied Geosciences (CAIAG) in Bishkek. The workshop brought together experts from Kyrgyzstan, Tajikistan, Uzbekistan, Turkmenistan and Kazakhstan, all of which are also involved in EMCA, as well as experts from the global components on exposure and vulnerability assessment. Existing building typologies from the different countries were evaluated and a set of building types that are representative of the countries participating in EMCA were agreed upon.

Table 1 shows the proposed building types, at two levels of details. In average, almost half of the exposed stock (44%) in urban areas is composed by masonry buildings, mostly unreinforced. Another 30% of the stock is represented by precast concrete large panel buildings. The rural environment is clearly dominated by non-engineered, earthen buildings, usually associated with high levels of seismic vulnerability.

Building reports have been compiled for each identified building type following a standardized characterisation by means of the building taxonomy proposed within GEM. For each typology, a description of the most likely structural features has been created based on joint technical discussions. The workshop has set an important milestone in the roadmap towards an integrated and harmonized exposure and vulnerability model for Central Asia, and has provided a good opportunity for high level capacity building.

In order to provide a time- and cost-efficient approach to estimating exposure and vulnerability at different scales over large areas, the use of satellite remote sensing in combination with ground-based omnidirectional imaging has been tested and applied. Free-of-cost, me-

Table 1: Proposed two-levels description of buildings stock in Central Asia.

code	description	subcode	description
EMCA-1	Load bearing masonry wall buildings	1,1	Unreinforced masonry -buildings with walls of brick masonry, stone, or blocks in cement or mixed mortar (no seismic design) - wooden floors
		1,2	Unreinforced masonry - buildings with walls of brick masonry, stone, or blocks in cement or mixed mortar (no seismic design) - precast concrete floors
		1,3	Confined masonry
		1,4	Masonry with seismic provisions (e.g. seismic belts)
EMCA-2	Monolithic reinforced concrete buildings	2,1	Buildings with monolithic concrete moment frames
		2,2	Buildings with monolithic concrete frame and shear walls (dual system)
		2,3	Buildings with monolithic concrete frames and brick infill walls
		2,4	Buildings with monolithic reinforced concrete walls
EMCA-3	Precast concrete buildings	3,1	Precast concrete large panel buildings with monolithic panel joints - Seria 105
		3,2	Precast concrete large panel buildings with panel connections achieved by welding of embedment plates - Seria 464
		3,3	Precast concrete flat slab buildings (consisting of columns and slabs) - Seria KUB
		3,4	Prefabricated RC frame with linear elements with welded joints in the zone of maximum loads or with rigid walls in one direction - Seria 111, IIS-04
EMCA-4	Non-engineered earthen buildings	4,1	Buildings with adobe or earthen walls
EMCA-5	Wooden buildings	5,1	Buildings with load-bearing braced wooden frames
		5,2	Building with a wooden frame and mud infill
EMCA-6	Steel buildings	6	

dium-resolution multi-spectral satellite images are used to subdivide urban environments into areas of relatively homogeneous urban structure types. The resulting segments are used as strata to identify representative sample areas for a detailed per-building analysis of the exposed building stock with an omnidirectional camera system and high-resolution satellite images. The processing of the acquired and georeferenced satellite and omnidirectional images allows for the extraction of several building attributes (e.g., building location, footprint area, building height) which indirectly relate to buildings' physical vulnerability. The approach has so far been successfully applied to some of the main urban areas in Kyrgyzstan (Bishkek, Osh, Jalalabad) and Tajikistan (Dushanbe, Khorog).

Vulnerability assessment

Possible approaches for physical vulnerability assessment of buildings stock can be divided into three main categories: expert-based, empirical or analytical, but hybrid solutions are applied as well. In Central Asia, most used are the empirical approaches based on the MSK and the EMS98 scales, which define different grades of damage as discrete, categorical variables. EMS-98 in particular provides qualitative relationships between damage grades and macroseismic intensity which can be then converted into damage probability matrices, and used to model the buildings fragility.

A preliminary vulnerability assessment for the city of Bishkek in terms of EMS-98 scale has been computed. In order to efficiently deal with data coming from multiple imaging sources, at varying scales and with different uncertainties, a novel Bayesian approach for data integration and vulnerability assessment was developed (Pittore & Wieland, 2012). The application of Bayesian networks allows to integrate available information about the buildings in a sound but intuitive probabilistic framework. It therefore allows for each building successfully characterised by both omnidirectional and satellite imaging, to generate the posterior probability distribution of its vulnerability. Furthermore, statistical models can be seamlessly mixed with expert judgement without losing consistency. Several activities has been started in Central Asia to address the development of analytic fragility curves for the buildings stock, in collaboration with international partner institutions.

Application to Early Warning and Rapid Response

The task of providing decision-makers with a useful early warning in case of an earthquake is very challenging. In contrast to other natural hazards, characterized often by a creeping onset, such as landslides or floods, earthquakes almost always strike without any real warning. In a regional early warning application scheme, especially in Central Asia, the high spatial density of seismic sources and their closeness to important urban areas define strict upper bounds on the expected time available for emergency actions after issuing a warning. An alternative on-site application scheme is therefore suggested, where EW systems are more geared towards Rapid Response (see also Frühwarnsystem Für Bishkek, this issue). Within this operational context, reliable, spatially-detailed loss scenarios would be released immediately before, or in the immediate aftermath of an earthquake (Picozzi et al.,2013). This in turn would provide timely information to better coordinate and optimise the deployment of search and rescue teams and the management of other emergency measures.

The development of a catalogue of loss scenarios is planned for the most prominent towns in Central Asia, starting from the capitals (Bishkek, Dushanbe, Almaty, Tashkent, Ashgabat). For each target town, a set of seismic events compatible with the local hazard will be created, and used as a basis for the stochastic simulation of the expected macroseismic intensity field (accounting for site amplification effects where possible). The set of stochastic realizations are then used to estimate the probability distribution of physical loss (in terms of buildings collapses, or extended structural damage) over the spatial extension of the selected urban environment.

Towards multi-hazard risk assessment

Another aspect of hazard and risk research in Central Asia which will play a greater role in future activities involves multi-hazard and risk assessment. By this, we mean a process by which not only one type of hazard is considered but the various spatial and temporal interactions that may arise at the hazard, exposure and vulnerability levels. For example, earthquake triggered landslides are one of the classic cases of a multi-hazard event.

In fact, earthquake-triggered landslides are an example of where the triggered event, i.e., the landslide, is more devastating than the trigger itself. In Tajikistan for instance, in 1949 flows in loess probably triggered by a combination of the main shock, aftershocks, and heavy rainfall killed an estimated 15,000 people, and a rock avalanche triggered by the main shock buried the town of Khait, killing at least 3,000 people. Remarkably, only few earthquake-induced landslides reactivate older landslides; most are in materials that have not previously failed.

However, the number of earthquakes with almost complete data sets on the occurrence of secondary effects is still small, and one of the most pressing research needs is for complete landslide inventories for many more events in a wider variety of environments. Whereas many additional inventories in all regions are needed, data from seismically active regions of e.g. Central Asia are especially desirable.

Such additional data, coupled with the increasing use of GIS, can be used in a multi-risk view of exposure which may involve, for example, the encroaching of human settlements and infrastructure into areas more susceptible to different hazards. Considering vulnerability, the situation arises where, for example, a structure weakened by an initial event is further damaged by subsequent events. In the end, this should lead to additional refinements of existing models and, therefore, to our ability to minimize damage and loss of life from seismically generated landslides. Activities focusing on multi-hazard risk assessment are currently ongoing within project MATRIX, in Germany, and in Central Asia in partnership with local institutions.

Conclusions

Central Asia is acknowledged as one of the most hazardous areas in the world, in consideration of the several natural hazards threatening the region. On the one hand, this is paired with unique geological and geophysical conditions which makes it an optimal and stimulating laboratory for researchers. On the other hand, scientists ought to consider as well the significant threat to the exposed population and economical infrastructure, and provide local end-users with knowledge and information about the expected risk and its evolution, in order to undertake better prevention and mitigation actions. In this short article we presented some of the latest research activities carried out at

the Center for Early Warning in the framework of several projects, which aim at better understanding the complex nature of seismic risk in Central Asia and provide innovative solutions for its reliable and efficient estimation. A prospective application in the field of Earthquake Early Warning was introduced along with a discussion on the next extension to multiple hazards. The results are encouraging and the feedback from local partners and end-users stimulate further efforts.

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References

Bindi D, K. Abdrakhmatov, S.Parolai, M.Mucciarelli, G. Grünthal, A. Ischuk, N. Mikhailova, J.Zschau (2011a) Seismic hazard assessment in Central Asia: Outcomes from a site approach, Soil Dynamics and Earthquake Engineering 37 (2012) 84–91.

Bindi, D, Parolai, S, Oth, A, Abdrakhmatov, K, Muraliev, A, Zschau, J. (2011b). Intensity Prediction Equations for Central Asia, Geophysical Journal International, 2011;187(1):327–37. doi:10.1111/j.1365-246X.2011.05142.x.

Cornell CA (1968). Engineering seismic risk analysis. Bulletin of the Seismological Society of America, 58(5):1583–606.

D'Amico V, Albarello D. (2008). SASHA: a computer program to assess seismic hazard from intensity data. Seismological Research Letters, 79(5), 663–71.

Frankel, A. (1995). Mapping seismic hazard in the Central and Eastern United States, Seismological Research Letters. 66(4), 8–21.

Riznichenko, Yu.V. (1959). On quantitative determination and mapping of seismic activity, Annals of Geophysics, 12, 227–237.

Evans, S.G., Roberts, N.J., Ischuk, A., Delaney, K.B., Morozova, G.S. and Tutubalina, O. (2009) Landslides triggered by the 1949 Khait earthquake, Tajikistan, and the associated loss of life, Engineering Geology, vol. 109, pp. 195-212.

Erdik M, Rashidov E, Safak, Turdukulov A. (2005) Assessment of seismic risk in Tashkent, Uzbekistan and Bishkek, Kyrgyz Republic. Soil Dynamics and Earthquake Engineering; 25:473–86.

Giardini D (1999):The global Seismic Hazard Assessment Program (GSHAP)—1992/1999. Annali di Geofisica, 42(6), 957–74.

Mushketov DI.(1933) Opyt seysmicheskogo rayonirovanija S.S.S.R. Tr. Seismol. Inst. Akad. Nauk S.S.S.R., 33, 1–17.

Picozzi, M., D. Bindi, M. Pittore, K. Kieling, and S. Parolai (2013) "Real-time risk assessment in seismic early warning and rapid response: a feasibility study in Bishkek (Kyrgyzstan)," J. Seism., DOI 10.1007/s10950-013-9381-4.

Savarensky E. F. (1968): On the prediction of earthquakes. Tectonophysics, 6(1), 17–27.

Stock C, E. G. C. Smith (2002): Adaptive Kernel Estimation and Continuous Probability Representation of Historical Earthquake Catalogs, Bulletin of the Seismological Society of America, Vol. 92, No. 3, pp. 904–912.

Ulomov V. I. (1999): The GSHAP Region 7 working group. Seismic hazard of Northern Eurasia. Annali di Geofisica 42:1023–38.

Seed, H. B. (1968): Landslides During Earthquakes Due to Soil Liquefaction, American Society of Civil Engineers, Journal of the Soil Mechanics and Foundations Division, 94, 1053–1122.

Keeper, D. K. (1984). Landslides caused by earthquakes. Geological Society of America Bulletin, 95(4), 406-421.

EMCA - Reduzierung des seismischen Risikos in Zentralasien

Zentralasien zählt zu den am stärksten gefährdeten Erdbebenregionen der Welt. Darüber hinaus ist die Region durch einen hohen Grad an Exposition und Verwundbarkeit gekennzeichnet. Vor allem die Erfassung der Dynamik des städtischen Raumes stellt eine große Herausforderung für verlässliche und aktuelle Risikoabschätzungen der Region dar. In mehreren Projekten konzentriert sich das Zentrum für Frühwarnung des GFZ auf die verschiedenen Komponenten der Risikoabschätzung in Zentralasien. Dieser Artikel stellt einen kurzen Überblick über die aktuellen Forschungsaktivitäten dar und beleuchtet deren Anwendung im Rahmen von Frühwarn- und Rapid-Response-Systemen, sowie deren Weiterentwicklung im Zusammenhang von Multi-Gefährdungs-Risikoabschätzungen.

II. Strategic Partnerships

Stakeholder Interactions for Near Real-Time Forensic Analysis of Disasters

Introduction

The Forensic Disaster Analysis (FDA) research in CEDIM requires a systematic approach for ab-initio engagement with stakeholders with clear definitions of mutual needs and processes of engagement and interaction. For this purpose it is necessary to understand the operations and organisational characteristics of the respective stakeholders, what their needs are and the extent to which FDA can contribute to them. To support and structure the sharing of information at the time of an event, within the framework of the Helmholtz Earth System Knowledge Platform (ESKP) a study has been conducted with a carefully selected group of stakeholders to map their needs and identify processes of engagement.

Aims/Objective

The aim of this project is to organize stakeholder interactions along topical Focus Groups representing both public and private sectors; including civil protection, humanitarian aid and disaster relief, international development, tourism and the insurance/reinsurance sectors. The scientific task of this study consists in: (a) understanding the transfer conditions of scientific knowledge to the stakeholders, (b) developing strategies and best practice cases based on this, and (c) developing implementation instruments (e.g., guidelines, cooperation agreements) to support the engagement with stakeholders. This includes the understanding of the science processes relevant for Near Real-Time Forensic Disaster Analysis (FDA) and the organizational constituent conditions under which stakeholders work, ensuring that the FDA works are operationalised and relevant to be used beyond the academic domain. The results (positive or negative) of interaction with each of the stakeholders are documented in a form that includes the detailed contacts, the essentials of the discussions, the identified user needs and reflections on the interactive processes and protocols to transfer FDA analysis and modelling results into relevant outputs that could better serve the needs of the respective stakeholders.

So far this year researchers from CEDIM have held a number of meetings with key representatives of several organizations within the civil protection and humanitarian aid sector.

Concluding Remarks and Outlook

Follow-up activities with stakeholders require utilizing the information gathered to better structure FDA outputs such that they are more relevant, and to further develop research concepts together with stakeholders so that they serve mutual needs and interests. In the next period, engagement is being sought with key representatives of development organizations and the Insurance and Re-insurance sectors.

Earth System Knowledge Platform - ESKP

Introduction

The „Earth System Knowledge Platform -ESKP“ is part of the Helmholtz Association's Portfolio process in the Research Field Earth and Environment. The eight centres 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. In cooperation with the participating Helmholtz-Centres, the latest research findings and news about ongoing events will form the topical content.

Aims/Objective

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 scientific knowledge in context with a special focus on adaptation strategies
- Feedback to science about knowledge gaps and stimulation of respective research initiatives

Cooperations

ESKP is linked to all scientific programmes, 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 centre as a competent partner for science and knowledge transfer. CEDIM is projected as a main contributor of content about natural hazards, their impacts and consequences. The CEDIM focus area “Forensic Disaster Analysis in Near Real-Time” analyses ongoing events and thus contributes to ESKP-content. CEDIM employees also provide background information on disaster sources, processes, receptors and consequences. Via ESKP, CEDIM has direct access to a broad network of experts in disaster risk analysis.

Special summaries derived from the reports were also put on the web page of ESKP of the Helmholtz-Association.

Project status

The ESKP-website will go online in the first quarter of 2014 and thereby will enter the operational stage. In this stage, background information will be improved and complemented with new information step by step. CEDIM FDA activities from the year 2013 are online on the ESKP test website. Preliminary work and collaboration has begun.

Cooperation with the Insurance Industry

Willis Research Network

The Willis Research Network (WRN), formed in 2006 by the global insurance broker Willis, is a network of currently 50 of the world's leading research institutions. It aims to provide an open forum for the advancement of the science of extreme events through close collaboration between universities, insurers, reinsurers, catastrophe modelling companies, government research institutions and non-governmental organizations. CEDIM has become the first German partner of the network in 2009. As a partner of the WRN, CEDIM staff gather experience in the cooperation with insurance industry partners and has learned about their needs and research priorities. This experience can be expected to foster further cooperation with insurance companies both on the national and international scale. WRN cooperates with CEDIM through the working groups "Geological Hazards and Risks" at GPI/KIT on social vulnerability related to earthquake and "Atmospheric Risks" at IMK/KIT on the topic of hail research.

The Social Vulnerability and Integrated Risk Project in GEM which is co-funded by Willis will deliver indicator methods and an open source software that will be integrated into the GEM OpenQuake Platform. The indicators and the indicator toolkit (software) can be used worldwide to explore the compounding nature of earthquake events through consideration of factors related to socio-econmic vulnerability and development of global and sub-regional socio-economic databases. User case studies in Japan, Kathmandu (Nepal) and Quezon City (Philippines) are also developed for the application of the indicator tools for various contexts and different geographic scales.

Within the second project, CEDIM works on the hazard component of a Pan European Hail model that allows estimation of the frequency, extent and severity of hail events. The model is based on overshooting top data from the METEOSAT Second Generation (MSG) satellite as a proxy for hail. This method leads to a unique, spatially homogeneous event dataset covering continental Europe. From stochastic modelling of the frequency, length, width, and severity of hail events, a large event set for hail storms expected to occur within several thousand years is created. This event set can in turn be combined with insurance portfolios in order to estimate return periods of loss events for the insurers. A further aim of the project is to improve the understanding of the relationship between the strength of convection and the formation of hail and local probabilities of hail, including identification of the most relevant meteorological processes.

References (2013)

Anhorn, J., Khazai, B., Schaper, J., (2013): Open Space Suitability Analysis for Emergency Shelter After An Earthquake – Kathmandu Case Study, Submitted to Natural Hazards and Earth System Sciences.

Burton, C., Silva V., Khazai, B., (2013): Social Vulnerability and Integrated Risk Assessment within the Global Earthquake Model - Portugal Case Study, Tenth U.S. National Conference on Earthquake Engineering, Anchorage, Alaska, July 21-25, 2014.

Khazai, B., Daniell, J., Power, C., Burton, C., Wenzel, F., Bendimerad, F. (2013): Monitoring Changes in Global Social Vulnerability and Integrated Risk Indicators through Time; Input to GAR15 – HFA Thematic Review for Indicator PFA/C12.

Punge, H.J., Bedka, K., Kunz, M., Werner, A. (accepted 2014): A new physically based stochastic event catalog for hail in Europe. Submitted to Natural Hazards and Earth System Sciences.

Punge, H.J., Bedka, K, Stephenson, D. B. , Kunz, M., Puskeiler, M, Werner, A (2013): A new stochastic event catalogue for hail in Europe. European Conference on Severe Storms (ECSS), 3-7 June 2013, Helsinki, Finland.

Punge, H.J., Werner, A, Bedka, K, Kunz, Puskeiler, M (2013): A climatology of severe convection based on IRW overshooting cloud top detection and its application for a European risk model for hail. DACH, 2-6 Sept. 2013, Innsbruck, Austria.

Sparkassenversicherung SV

In Southern Germany the total damage caused by severe hail reaches a magnitude that is only exceeded by large-scale winter storms. Current examples of such events are the hailstorms at the end of July 2013, which caused insured losses in the order of 2.7 bn € – more than the two floods in 2002 and 2013.

Despite the high loss potential of hail, there are currently only a few hail models available in the insurance market, most of them based on damage data. To improve the robustness and reliability of hail damage estimates, CEDIM/IMK developed a novel and unique hail model for the SV SparkassenVersicherung AG insurance company. The CEDIM hail model considers several thousands of footprints from past hailstorms in Germany, estimated by combining radar data from the German Weather Service (DWD) with lightning data from Siemens and insurance loss data. The hazard part of the model shows several interesting features, for example, a systematic increase in the number of hail days from the north to the south or the location of several hail hot spots downstream of low mountain ranges. To quantify the almost robust recurrence curves, the relevant intensity parameters are simulated by randomization over a long-term period. In the final version, the CEDIM hail model allows the quantification of probable maximum loss (PML) or to estimate damage from single events.

Stiftung Umwelt und Schadenvorsorge

For several years now KIT and CEDIM have collaborated with the University of Stuttgart in a joint PhD programme which is funded by the "Stiftung Umwelt und Schadenvorsorge" of the SV SparkassenVersicherung AG. At the beginning of 2013, the CEDIM candidate Susanna Mohr finished her PhD with the title "Änderung des Gewitter- und Hagelpotentials im Klimawandel" (Changes in the thunderstorm and hail potential due to climate change). In her thesis, she investigated long-term changes in atmospheric stability related to thunderstorm and hail probability. Based on an ensemble of high-resolution regional climate models, she further quantified the hail potential and long-term changes over Germany by developing and applying a logistic hail model.

References (2013):

Mohr, S. (2013): Änderung des Gewitter- und Hagelpotentials im Klimawandel. Wiss. Ber. Instit. Meteorol. Clim. Res., No. 58, KIT Scientific Publishing, Karlsruhe, 246 p.

Mohr, S., Kunz, M. (2013): Trend analysis of convective indices relevant for hail events in Germany and Central Europe; Atmos. Res., 123, 211-228, DOI: http://dx.doi.org/10.1016/j.atmosres.2012.05.016.

Mohr, S., Kunz, M. (2013): Changes in the hail potential over past and future decades: Using a logistic hail model. Submitted to J. Geophys. Res.

Mohr, S., Kunz, M (2013): Changes of Thunderstorm and Hail Potential in Climate Change. European Conference on Severe Storms (ECSS), 3-7 June 2013, Helsinki, Finland.

Mohr, S., Kunz, M (2013): Änderung des Gewitter- und Hagelpotentials im Klimawandel. DACH, 2-6 Sept. 2013, Innsbruck, Austria.

Cooperation with Fraunhofer Institute of Optronics, System Technologies and Image Exploitation

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

At ISCRAM 2013, we celebrated the 10th Anniversary of the ISCRAM series of conferences, which started in 2004 in Belgium. Although important topics such as “decision support”, “complexity and interoperability”, “human factors”, “training and gaming” have remained in the conference programme, new topics have emerged over time such as “Social Media”, “Humanitarian Relief Logistics”, “Visual Analytics for Crisis Management”, and “Critical Infrastructures”. This clearly demonstrates that the ISCRAM community is developing continuously and tries to find answers to new challenges. This is in line with the activities of CEDIM related to the modelling of Critical Infrastructures and Forensic Disaster Analysis.

About 250 researchers attended the conference and roughly 150 papers were presented. More than 20 different topics were discussed and plenary sessions conducted to tackle important issues such as the question of how to bridge the gap between science and practice. Looking at the feedback, the conference has been a success and the effort of the organising organisations was highly appreciated. It also strengthened KIT, Fraunhofer and CEDIM in the ISCRAM community.

III. Publications 2013

Articles in Journals and Books

Anhorn, J., B. Khazai, J. Schaper (Submitted 2013): Open Space Suitability Analysis for Emergency Shelter After An Earthquake – Kathmandu Case Study, Natural Hazards and Earth System Sciences (NHESS).

Bubeck, P.; W. J. W. Botzen, H. Kreibich, J. C. J. H. Aerts (2013 online first): Detailed insights into the influence of flood-coping appraisals on mitigation behaviour. Global Environmental Change.

Conradt, T., Roers, M., Schröter, K., Elmer, F., Hoffmann, P., Koch, H., Hattermann, F.F., and Wechsung, F. (2013): Vergleich der Extremhochwässer 2002 und 2013 im deutschen Teil des Elbegebiets und deren Abflusssimulation durch SWIM-live. Comparison of the extreme floods of 2002 and 2013 in the German part of the Elbe River basin and their runoff simulation by SWIM-live. Hydrologie und Wasserbewirtschaftung 57, 241 – 245 (doi: 10.5675/HyWa_2013,5_4).

Daniell, J.E. (submitted 2013): Socioeconomic impact of earthquake disasters, in "Earthquake Hazard, Risk, and Disasters", ed: Prof. Max Wyss, Earthquake and Seismic Hazards and Disasters. Elsevier.

Daniell, J.E., B. Khazai, F. Wenzel (accepted 2013): Uncovering the 2010 Haiti Earthquake death toll, Natural Hazards and Earth System Sciences.(NHESS), Discussions, 1, 19131942, 2013. doi: 10.5194/nhessd-1-1913-2013.

Daniell, J.E., Schäfer, A., Wenzel, F., and Khazai, B. (2013): Weltweite Verluste durch von Erdbeben induzierten Sekundäreffekte und deren Bedeutung für D-A-CH und das Versicherungswesen, Beitragsnr. 138, 13. D-A-CH Tagung für Erdbebeningenieurwesen und Baudynamik (D-A-CH 2013) C. Adam, R. Heuer, W. Lenhardt & C. Schranz (Hrsg.) 29.-30. August 2013, Wien, Österreich.

Dransch, D., K. Poser, J. Fohringer, C. Lucas (2013): Volunteered Geographic Information for Disaster Management. In C. Silva (Ed.), Citizen E-Participation in Urban Governance: Crowdsourcing and Collaborative Creativity (pp. 98-118). Hershey, PA: Information Science Reference. doi:10.4018/978-1-4666-4169-3.ch007.

Falter, D., Dung, N.V., Vorogushyn, S., Schröter, Hundecha, Y., Kreibich, H., Apel, H., Theisselmann, F., Merz, B. (2013a): Continu-ous, large-scale simulation model for flood risk assessments: proof-of-concept, submitted to Journal of Flood Risk Management.

Falter, D., S. Vorogushyn, J. Lhomme, H. Apel B. Gouldby, B. Merz (2013b): Hydraulic model evaluation for large-scale flood risk assessments. Hydrological Processes, 27, 9, 1331-1340.

Heimann, S., González, Á., Wang, R., Cesca, S., Dahm, T., (2013): Seismic characterization of the Chelyabinsk meteor's terminal explosion, Seismological Research Letters, Vol. 84, No. 6, 1021-1025, doi: 10.1785/0220130042.

Hoechner A., Ge M., Babeyko A. Y., and Sobolev S. V. (2013): Instant tsunami early warning based on real-time GPS – Tohoku 2011 case study, Natural Hazards and Earth System Sciences (NHESS),13, 1285-1292.

Holschneider, M., Zöller, G., Clements, R. A., Schorlemmer, D. (in revision): Can we test for the maximum possible earthquake magni-tude?, Journal of Geophysical Research.

Khazai, B., Daniell, J.E., Düzgün, S., Kunz-Plapp, T., Wenzel, F. (2013): Framework for Systemic Socio-Economic Vulnerability and Loss Assessment, In Framework for Systemic Socio-Economic Vulnerability and Loss As-sessment, eds: K. Pitilakis, P. Franchin, B. Khazai, H. Wenzel.

Khazai, B., Daniell, J., Power, C., Burton, C., Wenzel, F., Bendimerad, F. (2013): Monitoring Changes in Global Social Vulnerability and In-tegrated Risk Indicators through Time; Input to GAR15 – HFA Thematic Review for Indicator PFA/C12. Abstract for Input Paper Accepted.

Khazai, B., T. Kunz-Plapp, C. Büscher, A. Wegner (accepted 2013): VuWiki: An ontology-based semantic wiki for vulnerability assessments, International Journal of Disasters Risk Science.

Komendantova, N., R. Mrzyglocki, A. Mignan, B. Khazai , B. Wenzel (accepted 2013): Evaluating stakeholder perceptions in multi-hazard and multi-risk decision support models, International Journal of Disaster Risk Reduction.

Kreibich, H., K. Schröter, P. Bubeck, S. Parolai, B. Khazai, J. Daniell, M. Kunz, H. Mahlke, T. Lakes (submitted 2013): A review of multiple natural hazard risks in Germany, Natural Hazards and Earth System Sciences (NHESS).

Kunz, M., Mühr, B., Kunz-Plapp, T., Daniell, J. E., Khazai, B., Wenzel, F., Vannieuwenhuyse, M., Comes, T., Elmer, F., Schröter, K., Fohringer, J., Münzberg, T., Lucas, C., Zschau, J. (2013): Investigation of superstorm Sandy 2012 in a multi-disciplinary approach. Natural Hazards and Earth System Sciences (NHESS), 13, 2579-2598, doi: 10.5194/nhess-13-2579-2013.

Mak, S., Clements, R., Schorlemmer, D. (submitted 2013): Evaluating Intensity Prediction Equations for Italy.

Merz, B., H. Kreibich, U. Lall (2013): Multi-variate flood damage assessment: a tree-based data-mining approach. Natural Hazards and Earth System Sciences (NHESS), 13, 1, 53-64.

Mohr, S. (2013): Änderung des Gewitter- und Hagelpotentials im Klimawandel. Wissemschaftliche Berichte des Instituts für Meteorologie und Klimaforschung des Karlsruher Instituts für Technologie, No. 58, KIT Scientific Publishing, Karlsruhe, 246 pages.

Mohr, S., Kunz, M. (2013): Trend analysis of convective indices relevant for hail events in Germany and Central Europe; Atmospheric Research, 123, 211-228, doi:10.1016/j.atmosres.2012.05.016.

Mohr, S., Kunz, M. (submitted 2013): Changes in the hail potential over past and future decades: Using a logistic hail model. Submitted to Journal of Geophysical Research.

Picozzi, M., D. Bindi, M. Pittore, K. Kieling, and S. Parolai (2013): Real-time risk assessment in seismic early warning and rapid response: A feasibility study in Bishkek (Kyrgyzstan), Journal of Seismology, 17, 2, 485-505, doi: 10.1007/s10950-013-9381-4.

Power, C., Daniell, J. E., Khazai, B., Oberacker, C. & Schaper, J. (2013): Socio-Economic Vulnerability and Integrated Risk Initiative: Status Report #2, GEM Willis Socioeconomic Resilience Project.

Punge, H.J., Bedka, K., Kunz, M., Werner, A. (submitted 2013): A new physically based stochastic event catalog for hail in Europe. Submitted to Natural Hazards and Earth System Sciences.

Schneider, M., Clements, R., Rhoades, D., Schorlemmer, D. (submitted 2013): Likelihood- and Residuals-Based Evaluation of Medium-Term Earthquake Forecast Models for California.

Schröter, K., Kreibich, H., Zwenzner, H., Merz, B. (2013a): Schnelle Hochwasserereignisanalyse in Deutschland, Wasserbaukolloquium 2013: Technischer und organisatorischer Hochwasserschutz -Bauwerke, Anforderungen, Modelle, Wasserbauliche Mitteilungen Heft 48, 163-172.

Vorogushyn, S., Dung, N.V., Falter, D., Apel, H. (2013): Benchmarking of a 2D flood inundation model implemented in a GPU environment. In: Klijn, F. and Schweckendiek, T. (eds.), Comprehensive Flood Risk Management. Research for policy and practice. Proceedings of the 2nd European Conference on Flood Risk Management FLOODRisk2012, Rotterdam, The Netherlands, 19-23 November 2012, pp. 523-526, Taylor&Francis, Group, London, ISBN 978-0-415-62144-1.

Wyss, M., Wenzel, F., & Daniell, J.E. (submitted 2013): How Useful is Early Warning and Can It Be Made More Effective? In Early Warning for Geological Disasters (pp. 369–379). Springer.

Zechar, J. D., Schorlemmer, D., Werner, M. J., Gerstenberger, M. C., Rhoades, D. A., Jordan, T. H. (2013): Regional Earthquake Likelihood Models I: First-Order Results, Bull. Seismol. Soc. Am., 103(2A), 787-798.

CEDIM Reports

Daniell, J., B. Mühr, T. Kunz-Plapp (2013): Super Typhoon Haiyan/Yolanda – Report 10.11.2013 – Situation Report No. 1 – 12.00pm GMT, http://www.cedim.de/download/CEDIM_TCHaiyan_Rep1.pdf.

Daniell, J., B. Mühr, T. Girard, A. Dittrich, J. Fohringer, C. Lucas, T. Kunz-Plapp (2013): Super Typhoon Haiyan/Yolanda – Report 13.11.2013 – Report No. 2, Focus on Philippines – 18:00 GMT, http://www.cedim.de/download/CEDIM_FDA_Haiyan_Rep2.pdf.

Daniell, J.E., A. Vervaeck (2013): The CATDAT Damaging Earthquakes Database – 2012 – Year in Review, CEDIM Research Report 2013-01, Earthquake-Report OF Report, Karlsruhe, Germany.

Daniell, J.E., A. Vervaeck, S. Brink, F. Wenzel, J. Fohringer, S. Eggert, A. Dittrich, C. Lucas, T. Girard, B. Khazai, B. Mühr, C. Power, W. Trieselmann, P. Nierop, J. Jaramillo, M. Docoy-Boucher, C. Robles, J. Skapski, L.-J. Schumann (2013): Philippines (Bohol) Earthquake – Report 1-6,.02.11.2013, https://www.cedim.de/english/2442.php.

Khazai, B., T. Bessel, S. Möhrle, A. Dittrich, K. Schröter, B. Mühr, F. Elmer, T. Kunz-Plapp, W. Trieselmann, M. Kunz (2013): June 2013 flood in Central Europe - Focus Germany; Report 2 – Update 1: Impact and management, http://www.cedim.de/download/FDA-Juni-Hochwasser-Bericht2.1.pdf.

Kunz, M., B. Mühr, K. Schröter, T. Bessel, S. Möhrle, T. Münzberg, S. Brink, H.-M. Schmidt (2013): Winterstorm Xaver, 06 Dec 2013 – Report No. 1, Situation Report – 19:00 CET, http://www.cedim.de/download/CEDIM-XaverRreport1.pdf.

Mühr, B., D. Köbele, T. Bessel, J. Fohringer, C. Lucas (2013): Super Cyclonic Storm 02B Phailin - Report 1 with information as of 15 October 2013, http://www.cedim.de/download/CEDIM-Phailin_Report1.pdf.

Mühr, B., D. Köbele, T. Bessel, J. Fohringer, C. Lucas, T. Girard (2013): Super Cyclonic Storm 02B „Phailin“, Report 2 – 24 October 2013, http://www.cedim.de/download/CEDIM-Phailin_Report2.pdf.

Schröter, K., B. Mühr, F. Elmer, T. Kunz-Plapp, W. Trieselmann (2013): June 2013 Flood in Central Europe - Focus Germany; 1 Report 1 – Update 2: Preconditions, Meteorology, Hydrology, http://www.cedim.de/download/FDA_Juni_Hochwasser_Bericht1-ENG.pdf.

Conference Abstracts

Burton, C., Silva V., Khazai, B., (2013): Social Vulnerability and Integrated Risk Assessment within the Global Earthquake Model - Portugal Case Study, Tenth U.S. National Conference on Earthquake Engineering, Anchorage, Alaska, July 21-25, 2014.

Comes, T., Vannieuwenhuyse, M. (2013): ICT-based Near Real-Time decision support for disaster and crisis management. Workshop on Exploring New Directions for Decisions in the Internet Age, May 29-31, 2013.

Dittrich, A., & Lucas, C. (2013): A step towards real-time analysis of major disaster events based on tweets. In T. Comes, F. Fiedrich, S. Fortier, J. Geldermann, & T. Muller (Eds.). Presented at the Proceedings of the 10th International ISCRAM Conference, Baden-Baden.

Elmer, F., Schröter, K., Mühr, B., Kunz-Plapp, T., Trieselmann, W., Kreibich, H., Kunz, M., Merz, B. (2013): Das Hochwasser im Juni 2013 in Deutschland – Vorbedingungen, Auslöser und Ablauf. 13. Forum Katastrophenvorsorge, Hamburg, 11–12 December 2013. (Poster)

Fohringer, J., S. Eggert (2013): Microblogging als Informationsquelle für schnelle Schadensschätzung nach Naturkatastrophen, 13. Forum Katastrophenvorsorge (Hamburg, 2013).

Gerl, T. M., H. Kreibich, M. Bochow (2013): Urban structure mapping using high-resolution remote sensing data for modelling flood losses in Dresden, Germany. General Assembly European Geosciences Union (Vienna, Austria 2013).

Khazai, B., Bessel, T., Dittrich, A., Schröter, K., Mühr, B., Elmer, F., Kunz-Plapp, T., Trieselmann, W., Kunz, M. (2013): Das Hochwasser im Juni 2013 in Deutschland – Auswirkungen und Bewältigung. 13. Forum Katastrophenvorsorge, Hamburg, 11–12 December 2013. (Poster)

Kreibich, H., K. Poser, I. Pech, M. Müller (2013): Flood information from affected people - gains and uncertainties. General Assembly European Geosciences Union (Vienna, Austria 2013).

Kunz, M., B. Mühr, K. Schröter, T. Kunz-Plapp, J. Daniell, B. Khazai, F. Wenzel, M. Vannieuwenhuyse, T. Gomes, T. Münzberg, F. Elmer, J. Fohringer, C. Lucas, W. Trieselmann, J. Zschau (2013): Near Real-Time Forensic Disaster Analysis: experiences from hurricane Sandy. General Assembly European Geosciences Union (Vienna, Austria 2013).

Lin, L., F. Brauner, T. Münzberg, S. Meng, S. Möhrle (2013): Prioritization of Security Measures against Terrorist Threats to Public Rail Transport Systems using a Scenario-based Multi-Criteria Method and a Knowledge Database, Future Security Conference , Berlin 2013.

Moehrle, S. (2013): Towards a decision support system for disaster management, Proceedings of the European Safety and Reliability Conference 2013 (ESREL 2013), Amsterdam, Netherlands, 29. 9 – 2.10. 2013.

Moehrle, S. (2013): Modeling Of Countermeasures for Large-scale Disasters Using High-level Petri Nets, Proceedings of the 10th International Conference on Information Systems for Crisis Response and Management (ISCRAM 2013), Baden-Baden 2013.

Münzberg, T., U. Berbner, T. Comes, H. Friedrich, W. Gross, H.-C. Pfohl, F. Schultmann (2013): Decision Support for Critical Infrastructure Disruptions: An Integrated Approach to Secure Food Supply, Proceedings of the 10th International Conference on Information Systems for Crisis Response and Management (ISCRAM 2013), Baden-Baden 2013.

Münzberg, T., T. Müller, S. Möhrle, T. Comes, F. Schultmann (2013): An Integrated Multi-Criteria Approach on Vulnerability Analysis in the Context of Load Reduction. Proceedings of the 10th International Conference on Information Systems for Crisis Response and Management (ISCRAM 2013), Baden-Baden 2013.

Punge, H.J., Bedka, K, Stephenson, D. B. , Kunz, M., Puskeiler, M, Werner, A (2013): A new stochastic event catalogue for hail in Europe. European Conference on Severe Storms (ECSS), 3-7 June 2013, Helsinki, Finland.

Punge, H.J., Werner, A, Bedka, K, Kunz, Puskeiler, M (2013): A climatology of severe convection based on IRW overshooting cloud top detection and its application for a European risk model for hail. DACH, 2-6 Sept. 2013, Innsbruck, Austria.

Schorlemmer, D., Clements, R., González, A. (2013): The Testability of Maximum Magnitude. Invited talk at: JpGU Annual Meeting, 2013 May 21, Chiba, Japan.

Schorlemmer, D., Schneider, M. (2013): Evaluation of USGS Earthquake Forecast Models. Invited talk at: SSJ Annual Meeting, 2013 October 8, Yokohama, Japan.

Schröter, K., Kreibich, H., Merz, B. (2013b): Rapid flood loss estimation for large scale floods in Germany. General Assembly European Geosciences Union (Vienna, Austria 2013).

Schröter, K., H. Kreibich, K. Vogel, C. Riggelsen, F. Scherbaum, B. Merz, B. (2013): Comparing flood loss models of different complexity. General Assembly European Geosciences Union (Vienna, Austria 2013).

Schröter, K., Elmer, F., Mühr, B., Nied, M. and the CEDIM FDA Task Force (2013): June flood 2013 - A Hydro-Meteorological déjà vu? 4th Water Research Horizon Conference (WRHC), 25-26th June 2013, Berlin.

Vorogushyn, S., Dung, N.V., Falter, D., Apel, H. (2013): Benchmarking of a 2D flood inundation model implemented in a GPU environment. In: Klijn, F. and Schweckendiek, T. (eds.), Comprehensive Flood Risk Management. Research for policy and practice. Proceedings of the 2nd European Conference on Flood Risk Management FLOODRisk2012, Rotterdam, The Netherlands, 19-23 November 2012, pp. 523-526, Taylor&Francis, Group, London, ISBN 978-0-415-62144-1.

Wang R., Diao F., Hoechner A. (2013): SDM-A geodetic inversion code incorporating with layered crust structure and curved fault geometry, Geophysical Research Abstracts Vol. 15, EGU2013-2411-1 (Poster presentation).

Wenzel, F., J. Zschau, M. Kunz, J.E. Daniell, B. Khazai, T. Kunz-Plapp (2013): Near Real-Time Forensic Disaster Analysis, in: Comes, T., F. Fiedrich, S. Fortier, J. Geldermann, T. Müller (eds) Proceedings of the 10th International ISCRAM Conference – Baden-Baden, Germany, May 2013.

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