Annual Research Report 2014
Focus on Forensic Disaster Analysis in Near Real-Time

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Enhancing Resilience by Learning from Disasters
## Content

Preface .......................................................................................................................................................... 5
Vorwort .......................................................................................................................................................... 8

### I. Research ........................................................................................................................................... 11

FDA Research Projects ........................................................................................................................... 11

Rapid Assessment of Slip Distribution .................................................................................................... 11

Loss Assessment for Earthquakes ............................................................................................................ 13

ATMO Forensic Prediction and Analysis ................................................................................................ 17

Rapid Flood Event Analysis in Germany ................................................................................................ 19

Assessment of Indirect Losses and Economic Impacts ....................................................................... 21

An Approach for Quick Road Transport Modelling to Support Rapid Impact Assessment of Transport Interruptions ............................................................................................................. 23

Crowdsourcing – Using Social Media for Rapid Damage Assessment ................................................ 26

Development of a CEDIM Database and Implementation of Case-Based Reasoning for Analytical Support ................................................................................................................................. 28

Information Gap Analysis: Near Real-Time Evaluation of Disaster Response ..................................... 29

Causal Loss Analysis ............................................................................................................................... 31

User-oriented Visualization for CEDIM FDA Reports ......................................................................... 32

Global Dynamic Exposure .................................................................................................................... 35

FDA Task Force Activities ..................................................................................................................... 39

Iquique (Chile) Earthquake, 1. April 2014 ......................................................................................... 39

Super Typhoon “Hagupit”, Philippines ................................................................................................. 41

Disaster Management ............................................................................................................................ 46

Continuous Long-Term Simulations for Flood Risk Assessment - Mulde Case Study ............................ 46

The Web Service „Wettergefahren-Frühwarnung“ (Weather Hazards – Early Warning) ................. 49

The Challenge of Hail Hazard and Risk Modelling ......................................................................... 52
Vulnerability and Critical Infrastructures................................................................. 57

Decision Support Methods in the Field of Critical Infrastructure Protection (DSM CIP):
Overview.................................................................................................................. 57

DSM CIP: The RIKOV Project, Risks and Costs of Terrorist Threats Against
Public Rail Transport Systems – Continuation from 2013 ......................................... 60

Strategic Deterrence of Terrorist Attacks................................................................ 61

DSM CIP: The SEAK Project, Decision Support for Managing Disruptions
in Food Supply Chains – Continuation from 2013 ..................................................... 63

Business Continuity Management Against Food Supply Chain Disruptions.............. 65

DSM CIP: Modeling and Simulation of Critical Infrastructures Using
an Agent-Based Approach.......................................................................................... 67

DSM CIP: Understanding Resilience, Spatial-Temporal Vulnerability
Assessment – Continuation from 2013 .................................................................... 69

Regional Climate Change and the Industry’s Fragility – An Indicator-Based Approach .... 72

Global Earthquake Model.......................................................................................... 76

GEM Testing & Evaluation Center............................................................................... 76

Social Vulnerability and Integrated Risk Project in GEM.............................................. 78

II. Strategic Partnerships ......................................................................................... 82

Earth System Knowledge Platform ESKP................................................................. 82

Cooperation with Integrated Research on Disaster Risk (IRDR).................................... 83

Cooperation with the Insurance Industry................................................................. 84

Cooperation with alpS - Centre for Climate Change Adaptation .............................. 85

Stakeholder Interactions for Near Real-Time Forensic Analysis of Disasters .............. 86

III. Publications 2014 ............................................................................................ 88

Articles in Journals and Books.................................................................................. 88

CEDIM Reports......................................................................................................... 90

Conference Abstracts ............................................................................................... 90

Imprint ....................................................................................................................... 94
Preface

2014 was a relatively quiet year in terms of the occurrence of major natural disasters. In particular, regarding earthquake disasters, that year belongs to the longest period of quiescence since 1900, over two and a half years since the last major event. “Less than” 850 deaths and “only” around 6770 injuries have been counted in 30 death-bearing and 87 casualty-bearing earthquakes according to the CATDAT database to which CEDIM is contributing. As a consequence, CEDIM put its focus in 2014 more on the development of methods for the rapid analysis of catastrophes rather than on the forensic disaster analysis (FDA) itself in event triggered task force activities.

Nevertheless, two damaging events that occurred in 2014 were still investigated by CEDIM within the frame of their FDA activities. These were the Iquique (Pisagua) earthquake of April 1st in Northern Chile, with MW=8.2 the strongest earthquake in this area since 137 years and the super typhoon Hagupit that threatened the Philippines in the same region which typhoon Haiyan had devastated only one year before. Although both events, due to the relatively little damage and losses incurred, did not match CEDIM’s criteria for a full FDA activity, short FDA reports were published.

(1) The Iquique earthquake was of special interest for CEDIM, because, despite the size of the earthquake, it had only released a small fraction of the energy estimated to be stored in the subduction zone of the region, suggesting that in the future there is still the potential for a considerably larger event.

(2) Protective measures before landfall of super typhoon Hagupit had also attracted CEDIM’s interest. They were considered a best practice example, because the relatively low number of fatalities and the lower storm damage than previously feared was not only due to the decrease of the storms intensity before landfall, but to a great extent to the early and effective evacuation of more than 700,000 people.

Considerable progress has been made in the development of methods for earthquake disaster analysis in near real-time. This includes the ability of automatically imaging earthquake rupture processes from GPS and strong motion seismograms. The method has been finalized and published in 2014. The progress also includes the finalization of socio-economic fragility functions for use in world-wide rapid earthquake loss estimation procedures, and in particular the design of a social fragility function that estimates the number of displaced people after an earthquake. In addition, first steps were made to combine CEDIM’s rapid post-disaster analysis methodology with indicator methods to provide post-disaster vulnerability locations in combination with loss estimates.

With regard to atmospheric extreme events, CEDIM has put special emphasize in 2014 in the development of a system to predict in near real-time the severity of a storm in Germany in terms of loss and possible fatalities. The system is based on three indicators reflecting the wind speed, the affected area and the storm intensity, as well as the damage, total loss and fatalities. It is expected to become operational by the end of 2015. In addition, CEDIM has taken up again the problem of hail risk in Germany and has further developed in 2014 the ability of assessing not only the hazard but also the risk coming from hail. Given the result that there are strong indications suggesting an increase in the hail potential in Europe over past and future decades, damage from hail may become more and more important in Germany.

Like in the field of atmospheric extreme events CEDIM’s 2014 development activities in the area of flooding also had a regional focus in Germany. This involved the design of a novel approach for assessing flood risk in river catchments at large spatial scales (>10,000 km²) and in a spatially consistent way. The approach was developed by CEDIM in 2014 for the mesoscale catchment of the Mulde river (~6,000 km²) and has great potential to be transferred to other mesoscales of even large-scale catchments. It is currently being implemented for case studies in the Saale catchment and the German part of the Elbe catchment. With regard to a rapid flood event analysis in Germany the most important progress in 2014 has been the implementation of CEDIM’s flood event analysis approach in a database system which automatically retrieves and stores data from more than 100 online discharge gauges on a daily basis. Initiated by experiences coming from the flood in June 2013 in Germany, the system is currently being further developed for rapidly mapping inundated areas and inundated depths, including data provided by social media.
CEDIM is aware of the growing importance of social media with regard to providing information on the impact of natural extreme events. As before, the advancement of methods that make use of crowdsourcing for rapid damage assessment has, therefore, been a major concern of CEDIM’s activities also in 2014. Consequently, the above mentioned capability of deriving inundation depths from photos that were combined with tweets has been further strengthened in the year. The capability is part of CEDIM’s software package TENAS (Twitter Event Notification and Analysis Service), which by now monitors geo-referenced disaster related Twitter messages in real-time, on a worldwide 20 km x 20 km grid, 24 hours a day, and in more than 40 languages.

Closely related to this is CEDIM’s attempt to develop a user-oriented visualization platform. This work started in 2014 and aims as a first step at designing a prototype platform as a Weblog for event based information in near real-time. The envisaged format covers not only text and static figures, but also interactive maps, picture galleries and videos.

As in the years before, CEDIM in 2014 also addressed a wide range of disaster related risks for critical infrastructure. These included the risks and crisis management of food supply interruptions in Germany, in particular business interruptions related to food supply, as well as vulnerability and risks for health care and water supply due to power interruptions. The potential influence of climate change on the industry in Baden-Württemberg has also been a subject of these research activities, as well as cyber-risks, economic crime and risks to public rail transport systems due to terrorist threats. All of these investigations aim at contributing to the development of more efficient decision support methods that aid decision makers from different administrative levels of disaster and emergency management. Central to these activities two expert workshops with end-users were organized in 2014, one with a more general focus on the evaluation and management of risks, the other addressing management planning for food shortages and power outages at the local level.

Strategic partnerships have always been an essential component of CEDIM’s work. These partnerships have been extremely active in 2014. In the case of the Global Earthquake Model (GEM), for instance, the cooperation resulted in the first rigorous quantitative and comparative test of US earthquake hazard models, which helps to improve these hazard models over time. The testing of risk models is starting now. In the frame of the Willis Research Network of the global insurance broker Willis, CEDIM also contributed to the Social Vulnerability and Integrated Risk Program of GEM. This contribution was completed by the end of 2014 and resulted in the development of multiple comprehensive spatially enabled databases for building indicators and indices of social and economic vulnerability that are integrated with GEM’s Open Quake Platform. A special toolkit has been developed in collaboration with the GEM Modelling Facility that allows users to access the global and sub-national databases on the Open Quake platform for the building of social, economic or integrated risk indices. In addition, a multi-level risk and resilience scorecard has been developed in collaboration with GEM and implemented as a self-evaluation tool with both ward level and municipal representatives from Lalitpur (Nepal) in March 2014.

Besides cooperation with Willis in the frame of GEM, CEDIM in a close collaboration with the Willis CatNet team also contributed in 2014 to the improvement of the hazard component of the Willis European Hailmodel WEHM which estimates frequency, extent and severity of hail events. Hail modelling has also been an object of cooperation between CEDIM and the Sparkassenversicherung SV in 2014. In this collaboration, CEDIM is developing a novel and unique hail risk model for Germany based on a combination of radar, lightning and insurance loss data. One specific goal is the ability to estimate overall losses from hail in near real-time. As a new activity of the cooperation with the Sparkassenversicherung SV, the development of a tool for damage estimations related to widespread extreme flood scenarios was started in 2014.

Bilateral cooperations have also been enhanced in 2014 with ESKP, the “Earth System Knowledge Platform” of the Helmholtz-Association, IRDR, the “Integrated Research on Disaster Risk Program” of ICSU, ISSC and UNISDR as well as with alpS, the Centre for Climate Change Adaptation in Innsbruck, Austria. In addition, stakeholder interactions for near real-time forensic analysis of disasters have been advanced in 2014 with various organizations within both public and private sectors. These interactions aimed at identifying research fields of common interest.
The year 2014 has been an extremely active one with regard to CEDIM’s work. The various scientific results were published in 34 articles in journals and books, 38 conference abstracts and six CEDIM reports related to the years damaging events. We would like to sincerely thank all those who contributed to the results and express our hope and best wishes for successfully carrying on the CEDIM idea into the coming years.

Jochen Zschau
Vorwort


(1) Das Iquique-Erdbeben war von besonderem Interesse für CEDIM, denn trotz der Größe des Erdbebens war es nur ein kleiner Bruchteil der gespeicherten Energie, die hier durch das Beben freigesetzt worden war. Das deutet darauf hin, dass es in der Zukunft noch das Potenzial für ein wesentlich größeres Ereignis gibt.

(2) Insbesondere hatten auch die Schutzmaßnahmen vor dem Landgang von Supertaifun Hagupit das Interesse von CEDIM geweckt. Sie gelten als ein „Best-Practice“-Beispiel, weil die relativ geringe Zahl der Todesopfer die kleinern Sturmschäden als vorab vernommen von den Bevölkerungsgeschehen. Angesichts der starken Anzeichen für eine Erhöhung des Agelopentials in Europa über die vergangenen und zukünftigen Jahrzehnte, können Hagelschäden in Deutschland an Bedeutung gewinnen.


Wie bei den extremen Wetterereignissen hatten auch CEDIM’s Entwicklungsaktivitäten im Bereich Hochwasser im Jahr 2014 einen regionalen Schwerpunkt in Deutschland. Er betrifft die Bewertung des Hochwasserrisikos in großen Flusseinzugsgebieten (>10.000 km²). Ein neuer Ansatz hierzu wurde von CEDIM im Jahr 2014 für das mesoskalige Einzugsgebiet der Melde (≈ 6.000 km²) entwickelt, mit einem guten Potenzial, auch auf größere Flusseinzugsgebiete wie beispielsweise die Elbe (148.000 km²) erfolgreich angewendet zu werden. Mit Blick auf eine schnelle Hochwassereignisanalyse in Deutschland war ein wichtiger Fortschritt im Jahr 2014 die Implementierung des CEDIM-Hochwasser-Analyseverfahrens in ein Datenbanksystem, das
täglich und automatisch Daten von mehr als 100 Online-Pegelstationen abruft, speichert und hinsichtlich der statistischen Wiederkehrintervalle und der räumlichen Ausprägung bewertet. Angeregt durch Erfahrungen aus der Analyse des Hochwassers im Juni 2013 in Deutschland, wird das System aktuell für eine schnelle Kartierung von Überflutungsflächen und -tiefen weiterentwickelt. Dafür werden unterschiedliche Datenquellen wie beispielsweise Wasserstandsmessungen an Pegeln, Fernerkundungsdaten, aber auch Fotos und Informationen aus sozialen Medien erfasst und zu einem Gesamtbild zusammengeführt.

CEDIM ist sich der wachsenden Bedeutung der sozialen Medien für die schnelle Sammlung von Informationen über die Auswirkungen von natürlichen Extremereignissen bewusst. Wie schon zuvor war deshalb auch im Jahr 2014 die Weiterentwicklung von Methoden, die „Crowdsourcing“ zur schnellen Schadensbewertung nutzen, ein wichtiges Anliegen. Daher wurde die oben erwähnte Fähigkeit zur Ableitung von Überschwemmungstiefen aus Fotos, die mit Tweets kombiniert werden, in CEDIM’s Softwarepaket TENAS (Twitter Ereignisbeachtigung und Analyse Service) integriert. TENAS überwacht jetzt geo-referenzierte und Katastrophen bezogene Twitter-Nachrichten in Echtzeit, auf einem weltweiten 20 km x 20 km-Raster, 24 Stunden am Tag und in über 40 Sprachen.


Neben der Zusammenarbeit mit Willis im Rahmen von GEM hat CEDIM 2014 auch direkt mit


Jochen Zschau
I. Research

FDA Research Projects

Rapid Assessment of Slip Distribution

Andreas Höchner

Fig. 1: Seismic moment budget in northern Chile. The black line in the right panel shows the estimated accumulated moment since 1877 as a function of latitude, the blue line which has been released by earthquakes, and the red line that is expected to still be present.

Introduction

During recent decades, and especially since the advent of GNSS (Global Navigation Satellite System), geodetic methods have become more prominent in supporting traditional seismological methods. In the near field of large earthquakes, data from broadband seismometers and accelerometers are not straightforward to interpret as ground displacement due to clipping and tilting artefacts, while displacement time series from GNSS receivers are still stable. 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

A wave-form inversion method (Iterative Deconvolution and Stacking, IDS) working with broadband-, accelerometer- and GPS-data was developed and published [Zhang et al. 2014]. Application to coseismic signals from the Pisagua earthquake in 2014 shows promising results with very high spatial and temporal resolution of rupture propagation imaging.

During last year, there were no earthquakes having such an impact as to trigger a CEDIM forensic disaster analysis (FDA) activity. However, a large event, the Pisagua earthquake with magnitude Mw=8.2 occurred offshore Chile, which was of great scientific interest, since it took place in the so-called Northern Chile seismic gap. This region has been monitored closely in anticipation of a possible gap-closing event. Analysis of the data from this event at GFZ led to a publication in “Nature” with contributions from CEDIM members [Schurr et al. 2014]. One significant conclusion is that the Pisagua-earthquake released only a rather small fraction of the moment which is assumed to have been accumulated in the region and other large events are still likely to happen. This result was also presented at the AGU fall meeting in San Francisco [Hoechner et al. 2014].

A tsunami hazard assessment for the Makran region was made and presented at the AGU fall meeting [Zamora et al. 2014]. Of special interest is the consideration of recent findings suggesting larger maximum magnitude than previously assumed for this subduction zone.

Outlook

The IDS method will be developed further for automatic or semi-automatic processing similar to a moment tensor inversion.

The Makran hazard assessment will be published as a paper.

Core Science Team

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Publications

Hoechner A., Bedford J, Moreno M., Hainzl S., Dahm T. (2014): Coupling at the Northern Chile seismic gap and moment balance after the Mw=8.2 Pisagua event 2014, AGU fall meeting S33E-03


Fig. 2: Tsunami hazard Makran. Shown are probabilities of exceeding certain coastal water height levels somewhere in the Makran region (Iran, Pakistan) for different time periods.
Introduction

Worldwide, for each damaging earthquake that occurred last year, full reports have been created of the potential impacts, analysis of the losses and rapid estimates of fatalities, damaged buildings and economic losses. 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: specific indices have also been created.

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.
• The creation of indicators to aid post-disaster vulnerability analysis.

Project status

In conjunction with www.earthquake-report.com in order to provide the quickest possible information via a group of dedicated 24/7 reporting, loss estimation methodologies have been used in various studies in 2014.

In cooperation with Jens-Udo Skapski from Bochum University, and Armand Vervaeck from Belgium, the disaster database reveals over 380 damaging earthquakes as well as 10 rock-
bursts, with around 200 that have been classified as having damage significant enough to be input into the yearly review of damaging earthquakes via CATDAT. So far, 823-837 deaths, and around 6770 injuries have been counted in 30 death-bearing and 87 casualty-bearing earthquakes.

Although a number of events have been analysed, none of the hard-wired forensic disaster analysis criteria has been exceeded as yet. In May 2012, there was one such event – the Mirandola earthquake (subject to the final loss estimate) with around $17 billion reconstruction costs estimated. Follow-up for all events has been undertaken since 2010, with each of the disasters from 2011 (Tohoku, Christchurch and Van), from 2012 (Mirandola) and 2013 (Bohol) being followed in terms of loss and recovery metrics.

In terms of historical statistics, this is a significant period of quiescence, with 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 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 extraordinary event.

This is the longest period of quiescence since 1900 with over two and a half years since the last major event (Mirandola which was Dark

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Fig. 1: The period of quiescence in terms of Dark Red rated CATDAT events.

Fig. 2: The Level 1 Indirect Economic Loss Potential Index globally.
The indirect loss potential index in advance of an earthquake for a similar scale event is shown in the following diagrams.

**Outlook**

The reports produced have previously contained many different analyses with a focus on the impacts of loss generally and have been culminated in a fast 2-page format. The reports have also been published on ReliefWeb to help aid organisations with pre-mission planning in past disasters. In addition, learning through this rapid post-disaster analysis, new research areas were discovered in locations where there is little or non-detailed census information, including information fill-in processes, economic modelling and other demographic, social, political and environmental modelling. The rapid post-disaster analysis methodology will be combined with indicator methods to provide post-disaster vulnerability locations in combination with loss estimates.

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*

**Publications**


Daniell J.E., Schäfer A. [2014] “Making an Australian brick house more earthquake-resistant for $100 or less: Ideas, Practice and Loss
ATMO Forensic Prediction and Analysis

Bernhard Mühr

**Introduction**

The combination of several indices is used to implement a forecast system for winter storms that regularly affect Germany, Central Europe or other parts of the European continent. A winter storm can be described by a storm index that is based on wind speed data from measurements. Another index or indicator, the model storm index, is calculated from model data and includes both the affected area and the storm intensity. With the use of insurance data we develop a third index; this storm damage index includes information about damage, number of fatalities or the total loss that occurred with past storm events. A forecast system is planned to become operational to describe a winter storm scenario with reasonable certainty and accuracy well in advance; a probabilistic storm damage estimation will be provided.

**Short description**

To calculate a storm index we use measurement data from the station network of the German Weather Service (DWD). Of particular interest is the hourly mean of wind speed and the daily maximum wind speed (gusts). According to data availability and local station characteristics the selection of stations have to be done very carefully. This work has been continued to include storm data from the previous winter storm season.

Due to the lack of station data, data gaps or changes in the station location some of the time series have to be adjusted and homogenized.

The Global Forecast System (GFS) is a global numerical weather prediction system produced by the National Centers for Environmental Prediction (NCEP). The output data are freely and routinely available. This data set is used to derive a model storm index which considers both intensity and extension of a storm field affecting Germany. The storm index is calculated for storms that lie within a forecast period of 240 hours and is also applied on past storm events. For the latter we refer to archived GFS data and the closely related CFS reanalysis data (Climate Forecast System). Each individual past storm event is labelled with an adequate
Validation is achieved through the comparison of the model storm index and the storm index, based on measurements with respect to the stratification of the atmosphere; both the average wind speed and the height of the planetary boundary will be considered.

Since the beginning of 2015 the GFS data are provided with a horizontal resolution of 0.25 degrees (around 25 km) and covers Germany with forecast data at more than 800 grid points. We need to gain wider experience during the next few months with respect to the quality of forecast peak wind gusts and 10m-mean wind speed.

GFS ensemble forecast data are also available. We will be able to provide both deterministic and probabilistic forecasts about imminent winter storms. A storm scenario may be described well in advance and with decreasing uncertainty the closer the storm gets.

Once completed (towards the end of 2015) an operational forecast system will be prescribed for Germany that predicts the probabilities of storms, their intensities and resulting loss amount classes (damage assessment). In a further step - assuming the availability of relevant damage information from past storm events - this system can be expanded across Europe or to any other regions. Moreover, with the use of high-resolution forecast models (e.g. WRF and/or ICON) further improvement of damage assessment may be expected and should be verified by case studies of upcoming storm events.

All data about past and future winter storm events will become part of a database that is currently being developed in another CEDIM project: “Development of a CEDIM Database and Implementation of Case-Based Reasoning for Analytical Support”. The database entries give information about individual storm events and their characteristics such as name, date of occurrence, affected regions, intensity or damage. With the use of this database we can compare and search for storm events with similar or same attributes.

Core Science Team:

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Publications

Articles and reports of about 1000 unusual and extreme weather events worldwide since February 2004 can be found at:

www.wettergefahren-fruehwarnung.de
www.wettergefahren-fruehwarnung.de/Ereignis/archiv.html
http://www.wettergefahren-fruehwarnung.de/Ereignis/20131015_e.html
Rapid Flood Event Analysis in Germany

Kai Schröter, Heidi Kreibich, Dung Viet Nguyen, Stefan Lüdtke, Bruno Merz

Introduction

Flood disaster management, recovery and reconstruction planning benefit from rapid evaluations of flood events and expected impacts. The near real-time in-depth analysis of flood causes and key drivers for flood impacts requires a close monitoring and documentation of hydro-meteorological and socio-economic factors.

Aims/Objective

The aim of the rapid flood event analysis project is the development of a flood event analysis system which enables the near real-time evaluation of large-scale floods in Germany. The analysis system includes functionalities to compile event-related hydro-meteorological data, to evaluate the current flood situation, to assess hazard intensity and to estimate flood damage to residential buildings. Additionally, a German flood event database is under development, which contains various hydro-meteorological information in the future also impact information for all large-scale floods since 1950. This database comprises data on historic flood events which allow the classification of ongoing floods in terms of triggering processes and pre-conditions, critical controls and drivers for flood losses.

Project status

The flood event analysis system has been implemented in a database system which automatically retrieves and stores data from more than 100 online discharge gauges on a daily basis. The current discharge observations are evaluated in a long-term context in terms of flood frequency analysis. The web-based frontend visualizes the current flood situation in comparison to any past flood from the flood catalogue as shown in figure 1 for a period from August 2014 compared to the flood in August 2002. The regional flood data base for Germany contains hydro-meteorological data and aggregated severity indices for a set of 76 historic large-scale flood events in Germany. This data base has been used to evaluate the key drivers for the flood in June 2013 (Schröter et al., 2015).

The FDA activity on the flood in June 2013 in Germany also revealed useful methodological advancements of the flood event analysis system. This particularly concerns the rapid mapping of inundated areas and inundation depths.

![Fig. 1: Snapshot of the web-based frontend to the flood event analysis system. A flood situation in August 2014 (left) is compared to the flood in August 2002 (right) in Germany in terms of return periods.](#)
which are essential input variables for the estimation of flood damage and the consideration of uncertain and incomplete input information within rapid flood damage estimation procedures.

For the rapid inundation mapping the suitability of social media data was tested in collaboration with the CEDIM FDA project Crowdsourcing. The Elbe flood in June 2013 in Dresden was used as a test case to investigate whether photos posted by eye-witnesses on Twitter can provide relevant and useful information for flood inundation and inundation depth mapping. The 'Tweet explorer' developed within the Crowdsourcing project automatically filters the massive amounts of data and supports the extraction of inundation depth information from photos by flood experts. Concerning the rapid estimation of flood damage the potential of probabilistic modelling approaches has been investigated (Schröter et al., 2014). Bayesian networks crystallized as being the most suitable since they provide quantitative information about predictive uncertainty and offer a consistent framework for dealing with uncertain and incomplete observations.

**Outlook**

Future activities are aimed at extending the data interfaces of the flood event analysis system in order to automatically retrieve data from more river gauges and additional hydro-meteorological variables. Further, the integration of multiple data sources as for instance from satellite images, water level observations, the regional flood model for Germany or volunteered geographic data within a rapid inundation mapping procedure will be investigated. Probabilistic damage models will be developed further for regional applications.

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**Publications:**


Assessment of Indirect Losses and Economic Impacts

Hanns-Maximilian Schmidt

Introduction

The cascading impact of natural disasters on economic networks is a well-known fact and widely observable. However, when it comes to its quantitative assessment the analysis lacks high-resolution data on the economic structure, especially in developing countries. Most of the available figures are highly aggregated whereas natural disasters are likely to produce direct impacts on a local area. Obviously, indirect impacts and losses in other areas cannot be evaluated and interpreted without detailed information on the affected region’s economic network. Concerning this operationalization for near real-time forensic disaster analyses (FDA) the necessary data needed have to be either rapidly available or easily computed.

Aims/Objective

This project aims for a methodology for the rapid assessment of indirect economic losses due to natural catastrophes. Therefore, the main objective is to find an approach for the instant evaluation of regional economic structures and dependencies between interconnected areas. Additionally, once the local structure can be quantified, models need to be created for recalculating damages occurred alongside the catastrophe that is to be analyzed. For this purpose, different simulation models are to be tested.
In order to achieve this goal, we suggest the model structure shown in figure 1 for developed countries for which national input-output data are usually available at the statistical bureaus. The combination of tools for regionalizing these economic data and models for in-depth event analyses allows for some near real-time insights into the economy’s response in the case of a disturbance and into the overall economic damages.

If there are no basic economic data (national level) available – which seems to be the case in many developing countries – the regionalization needs to be done by using additional sources and approaches. The indicator-based model developed at the KIT-IIP (Merz 2011) can be used for this purpose as it is flexible and adaptable to different levels of aggregation concerning the input data. Therefore, even if there is no regionalization possible, in terms of recalculating the local input-output table, this procedure might still be a powerful tool for generating plausible scenario-based assumptions that can be used for further analyses.

Project status

The project started with an intensive literature review on different models and applications in early 2014. The mechanism suggested by Flegg & Webber (1997) combines employment statistics (on a national and regional level) and national input-output data for the purpose of calculating the regional input-output structure. Therefore, it seems to meet the requirements for analyzing regional impacts in developed countries. We implemented and tested their algorithm in MATLAB and applied it to Baden-Württemberg’s economy. Surprisingly, even for German counties regional data on economic structures are scarce. Due to this lack of data, the validation of the model is rather difficult. However, case studies for European counties (Flegg & Tohmo 2011; Kowalewski 2012) show that the model (and some further modifications) might still be a valid tool for analyzing sectorial interdependencies.

For developing countries the indicator-based model needs to be calibrated. We suggest that further case studies will demonstrate the potential use of that approach.

Outlook

In 2015, we will continue with the operationalization and validation of models for regionalizing official economic data provided. Additionally, we will identify compatible models for simulating damages and economic losses within the economic structure. In addition, the indicator-based model will be tested and improved in several case studies for South East Asia and official FDA events.

References


![Model structure](image.png)

**Fig. 1:** Model structure.
Methodik zur (schnellen) Abschätzung der ökonomischen Auswirkungen von Naturkatastrophen in Industrieunternehmen und über Supply Chains


An Approach for Quick Road Transport Modelling to Support Rapid Impact Assessment of Transport Interruptions

Kay Mitusch, Tina Bessel

Introduction

Recent natural disasters, such as the Central European flood in June 2013 and typhoon Haiyan in November 2013, caused severe negative impacts to traffic in the affected regions. In cases where damaged infrastructure leads to long-lasting transport interruptions, natural disasters have serious impacts on the economy and the society relying on these infrastructures.

Since 2010, the Chair of Network Economics, as part of the Institute of Economics (ECON) at Karlsruhe Institute of Technology (KIT), is investigating the impacts of events that are causing a disruption of the transportation system.

Aims/Objective

In the context of CEDIM’s near real-time FDA activities, suitable assessment methods are required for a rapid analysis of transport interruptions. A transport model for the affected regions would allow a more detailed analysis of transport interruptions and their impacts on economy and society, and hence improve impact assessments. Since a transport model isn’t quickly available for every region, latest
research at the Chair of Network Economics assessed the opportunities for developing an approach for quick road transport modelling to support rapid impact assessment of transport interruptions.

**Project status**

The research focus is on investigating possibilities and limits of activity-based (or agent-based) transport models, which would have to be set up relatively fast after a disaster has happened. For activity-based modelling of road traffic in FDA activities, the open-source software MATSim appeared to be suitable. The software is working with an iterative algorithm to calculate fast and dynamic road transport simulations, both for private and public traffic. Results can be easily and interactively visualised. As input data, the software is using:

- network data from Open Street Map (OSM), which is widely available for many regions and easy to find during a FDA activity, and
- population data on a disaggregated level.

Since it is usually difficult to find disaggregated population data rapidly during a FDA, possible methods for using aggregated data have been reviewed. Furthermore, first test simulations with MATSim have been set up for German regions affected by the Central European flood in June 2013 and for regions in the Philippines, which have been affected by typhoon Haiyan in November 2013.

**Outlook**

During the initial simulations, problems with simulation assumptions and some general issues have arisen as follows:

- A main problem with the first test simulations was the lack of reliable disaggregated population data. To compensate for the lack of data and to keep the setup of a simulation quickly manageable, many assumptions had to be applied. The reliance on many and sometimes inconsistent ad hoc assumptions have led to implausible simulation results.
- For the traffic simulations, the initially chosen level of transport demand is questionable. For instance, after typhoon Haiyan had hit the Philippines in November 2013, the city of Tacloban City has been severely damaged, including the destruction of many residential buildings. It is obvious that travel demand for the inhabitants has changed significantly. However, the actual level of travel demand directly after the disaster remains unknown.
- In the case of a completely destroyed city or region, it is questionable how relevant an impact assessment of traffic disruptions in general is. In most of these cases, the losses from transport disruptions are relatively small in comparison to the overall loss caused by the disaster.

To improve the approach for quick transport modelling during FDA activities, further research on suitable methods for disaggregating available population data is needed. Since every disaster event has different impacts, it is furthermore necessary to identify disaster events where an application of quick transport modelling is reasonable.

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Transportunterbrechungen


Seit 2010 untersucht der Lehrstuhl für Netzwerkökonomie am Karlsruher Institut für Technologie (KIT) die Auswirkungen von Katastrophen und Ereignissen, welche zu Unterbrechungen im Verkehrssystem führen. Im Rahmen der FDA-Aktivitäten von CEDIM werden aktuell Ansätze zur schnellen Modellierung des Straßenverkehrs untersucht, um die bisherige Methode zur Bewertung von Verkehrsunterbrechungen zu verbessern.

Der Fokus der Forschung liegt aktuell auf agentenbasierten Verkehrsmodellen, welche mit der frei verfügbaren Software MATSim erstellt und simuliert werden können. Für die mikroskopischen Verkehrssimulationen verwendet die Software Netzwerkdaten von ”Open Street Map”, welche für viele Regionen schnell abgerufen werden können, sowie räumlich aufgegliederte Bevölkerungsdaten. Da Bevölkerungsdaten meist nur auf einem zu hohen Aggregationsniveau vorliegen, werden zudem Möglichkeiten zur Verwendung aggregierter Daten bzw. Methoden zur räumlichen Aufgliederung aggregierter Daten analysiert.


Crowdsourcing – Using Social Media for Rapid Damage Assessment

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

Introduction

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

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 real-time observations from eyewitnesses from a diverse range of Social Media sites. These observations are used to provide rapid damage and impact estimation. Additionally, other related, digitally accessible, platforms can be exploited to gather relevant (background) information on an event to semantically enrich Social Media data. Within our approach, we are aiming at different natural disaster events such as storms, floods, volcanic eruptions, and earthquakes.

The specific challenge in using social media as an information source is to automatically extract the relevant information from the huge amount of data. Therefore, our goal is to develop algorithms that are able to a) handle the massive amount of data in real-time, b) filter the incoming data stream for disaster-relevant content and c) provide quick and reliable information for further analysis and decisions.

Project status

Our developments are twofold: The TENAS software (Twitter Event Notification and Analysis Service) monitors geo-referenced Twitter messages based on a world-wide grid (20x20 km) in real-time and operates day and night. The software is able to robustly detect significantly high tweet volumes for any area around the world compared to a weekly updated three month moving average baseline. The subsequent analysis of the tweets’ textual content identifies disaster related terms in more than 40 languages and classifies the event accordingly, e.g. as earthquake, thunderstorm, tornado, etc. Within minutes after the start of a detected event, an automatic e-mail alert is sent to the subscribers of the service.

In a next step the Observation Explorer Software allows for exploring Twitter feeds related to a specific event. It filters tweets on the basis of disaster related keywords as well as event related features such as time, geolocation, spatial entities, e.g. catchments. It also screens for photos related to tweets. The idea is to enable scientists or decision-makers to extract information from single tweets that is relevant for their tasks, in our case rapid damage estimation. We evaluated our Observation Explorer in a case study, the flood event in Dresden in 2013. Scientists derived inundation depths from photos that were combined with tweets we have filtered out from some 880,000 tweets (Fig. 1). The inundation depths thus derived

Fig. 1: Inundation depths derived from photos provided via Twitter during the flood 2013 in Dresden.
are used as model input for rapid damage estimation.

Outlook

The next steps concerning TENAS are a) the extension of language capabilities, b) the optimization of the taxonomy-based classification algorithm, and c) using TENAS as trigger for automatic distributed searches in other digital platforms such as Flickr, Instagram, or Facebook. Complementing the broad approach of TENAS, we are working on methods to automatically classify single Social Media messages into specific classes (e.g. damage report, evacuation, alarm, cry for help, etc.) and geo-reference messages without explicit geographical coordinates, based on the textual content and context knowledge. Both aspects will enable us to retrieve more detailed on-site information and hence provide better situational awareness for an event. The Observation Explorer will be customized to other natural hazards; the filtering of relevant information will be improved.

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Publications


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

Stella Möhrle, Wolfgang Raskob

Introduction

The project CEDIM Forensic Disaster Analysis (FDA) is concerned with near real-time analyses of disasters and their impacts. The implementation of case-based reasoning (CBR) should provide an IT-based support for near real-time assessments of current disaster events. CBR makes use of similarities between events and offers the possibility to quickly draw first conclusions about a current event, in particular when little information is available. Since the approach is not limited to a certain type of disaster, the project aims at developing a structured storage facility for historic earthquake, flood, and storm events and applying CBR for analytical support.

Aims/Objective

Within the FDA, inferring from similar past events should support the understanding of a new and to a large extent unknown disaster. Conclusions relate primarily to the categorization of the current event and the assessment of possible damages. The contribution comprises the establishment of a common database and the implementation of CBR within the framework of FDA. Attributes need to be defined in collaboration with experts capturing general and event specific characteristics. Furthermore, intelligent and flexible similarity functions need to be specified and developed to limit the space of possibly interesting events.

Project status

The focus of this year was on implementing CBR and defining similarity functions, respectively. So far, functions depend on the attribute type. The application is flexible and enables an ad-hoc configuration. This applies to the choice of attributes for the retrieval step and whether exact matches are requested or not. Furthermore, importance values of attributes are set individually. The development of a web interface is ongoing where experts can set up their query and configure the similarity function. Furthermore, they can select which information is needed from historic events for further analyses.

Outlook

The application and web interface will be programmed further, including research activities on similarity functions. Among other work, the generic functions need to be adapted to the attributes. Research will be accompanied by an exchange with experts and the application will be expanded and improved iteratively.

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Publications


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

Trevor Girard

Introduction

During a disaster situation the public will need to make critical decisions/actions regarding what to do, where to go, how to get there, and so on. A key hypothesis is that the more informed the public is, the better decisions/actions they are able to make, resulting in reduced disaster impacts. This research project investigates the dynamic information needs of disaster affected populations and analyzes how well informed the public is during disasters.

Aims/Objective

The purpose of the research project is to identify key indicators for measuring how well informed the public is during disasters. The indicators are limited to those which can be observed as communication is happening. By doing so, the indicators can be analyzed as disaster situations unfold, deficiencies can be identified, and recommendations can be made to potentially improve communication while the response is still underway. The end goal of the research is to improve the ability of communicators to inform disaster affected communities.

Project status

A classification scheme has been developed to categorize the information provided to the public during disasters. Under each category is a set of typical questions that the information should answer (result of best observed practice review), as shown on the right of figure 1. For example, under the category 'Life Saving Response', the questions which should be answered are who is doing what (Evacuation, SAR), when and where, and the amount of the affected communities’ needs being covered by these actions (coverage). Review of what questions remain unanswered acts as the first indicator identified in figure 1, referred to as an 'Information Gap Analysis'. The remaining indicators identified in figure 1 are also potential candidates for being observed in near real-time.
Outlook

A case study is planned to be carried out in the Philippines in 2015 in areas affected by typhoons Haiyan and Hagupit. A major purpose of the case study is to confirm, through interviews with disaster affected communities, what their information needs were during the typhoons, what information they actually received and how they received that information. Comparisons can then be made with what information the disaster management system produced and how they disseminated that information. The case study will help to confirm the validity of the indicators identified so far and potentially identify others.

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Publications

Forensic Disaster Analysis

Causal Loss Analysis

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

Introduction

The relationship between a hazard and its impacts on the infrastructure, environment and population is complex and varies across events. In particular the medium and long term social impacts of a disaster can be very difficult to estimate even after an earthquake or wind storm has passed and the physical damage is known. Vulnerable population, response efforts and many other factors influence the severity of the social impacts leading to difficulties for estimation and preparedness efforts.

Aims/Objective

The Causal Loss Analysis project studies population displacement after a disaster event to understand the root causes that lead to large numbers of displaced persons, lengthy displacements and high shelter demand. This project analyzes historical events to understand the factors that are associated with severe population displacement.

The first objective of the project is to determine to what extent data on historic events could be used to determine the relationship between the impact of the event and the number of displaced persons. Using methodology developed by Daniell (2014), the CATDAT database of historical earthquakes is analyzed to develop a standard relationship between hazard intensity and population displacement. This research has led to the development of a social fragility function that can provide an initial estimate of the number of displaced people after an earthquake.

Although there is a clear relationship between the physical intensity of an earthquake or other hazard and the population displacement caused by the event, there are many other factors that can aggravate or reduce the severity of the population displacement in an event. The second objective of the Causal Loss Analysis Project is to determine the root causes that can increase the probability, severity or length of disaster population displacement.

The Causal Loss Analysis project includes a thorough review of the literature addressing population displacement in historic events to generate an understanding of both the types of disaster population displacement and the factors that have been associated with it in past events. This has led to the development of an initial framework to represent the severity of population displacement and an index to measure vulnerability to displacement in disaster events.

Finally, in depth analysis of individual case studies of historic disaster events complements the historic earthquake data analysis and literature review. The analysis aims to identify additional factors that are root causes of population displacement as well as to analyze and quantify the indicators, their interactions and their impact on population displacement.

Project status

Ongoing.

Outlook

It is hoped that the Causal Loss Analysis project will identify some of the key indicators required for FDA analysis in the near-real time of a disaster. By including these root causes of population displacement in the analysis, the FDA process will be able to more comprehensively estimate post-disaster shelter demand.

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Publications


to understand risk driving factors." Proc., 2nd IRDR Conference. Beijing, China.


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**Causal Loss Analysis**

Das Causal Loss Analysis-Projekt befasst sich mit historischen Naturkatastrophen um Faktoren zu identifizieren, die die Schwere des Desasters beeinflussen. Hierbei liegt der Fokus vor allem auf der Untersuchung der Verdrängung der Bevölkerung sowie den Bedürfnissen der Opfer. Das Projekt beinhaltet einen Überblick zu Literatur, die sich mit Katastrophenerfahrungen und deren Auswirkungen befasst, um Faktoren zu erkennen, welche in der Vergangenheit mit der Dislokation der Bevölkerung assoziiert wurden. Zusätzlich wurden im Rahmen des Projektes quantitative Analysen historischer Ereignisse durchgeführt, um zusätzliche Faktoren zu ermitteln, welche die Verdrängung der Bevölkerung beeinflussen sowie um festzustellen, in welchem Umfang die Bevölkerungsdislokation nach einer Katastrophe vorhergesagt werden kann.

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**User-oriented Visualization for CEDIM FDA Reports**

Silke Eggert

**Introduction**

In times of a natural disaster fast and up-to-date information is crucial to quickly understand the catastrophe and its possible impact. One aim is to identify the root causes of the event to derive implications for a long-term risk reduction. Comparison of recent events with historic disasters can help understanding why one event was disastrous while another caused almost no damage. CEDIM introduces the concept of Forensic Disaster Analysis (FDA) while incorporating a real-time component to impact assessment.

The FDA report readership mainly consists of four groups: civil protection/disaster management, media, scientists and general public. The readers’ demand on rapidity and type of information as well as their level of knowledge is very heterogeneous. Especially for the first two groups information in near real-time is essential while others focus on in-depth analysis. To better serve the users’ needs and improve communication in times of a disaster, CEDIM started the project "User Oriented Visualization".
Aims

Evaluate our readers’ needs concerning information after natural disasters.

Adapt the data visualization as well as the report layout and format according to the reader’s needs.

Project status

In the first phase, we followed two approaches. (a) Learn more about the FDA reports readers and gain insight into their needs and wishes. (b) Test and evaluate new methods and approaches of data visualization and presentation.

Motivation

To improve the two aspects mentioned above (a) reader oriented presentation of results and (b) comparison of events, we want to develop a new platform. It should (a) let the reader search the database interactively for historical events and (b) present FDA results more concisely and better focused on the reader’s state of knowledge. The working title is “Event Explorer”.

Figure 1 shows a schematic structure of the Event Explorer. A database with information on recent and historic events, starting from a simple base map to detailed analysis will be the basis for the Event Explorer. The results of all FDA projects will be included as well as external data, users can access and search the database via a graphical interface [see Fig. 1].

Implementation

The Event Explorer will mainly focus on three user groups: media, disaster management and (re)insurance/research. These groups reflect the participants in the FDA survey [see Fig. 2].

The central point is to improve the presentation of FDA analyses to make it more suitable for individual users. The FDA reports so far are a classic mixture of text and figures published and updated whenever a considerable collection of information is available. The format is PDF but many readers tend to move away from the desktop workstation and are more interested in real-time updates for mobile devices. Key facts should therefore be identified easily and maps should be more interactive to fit the individual needs. Figure 3 shows the main user needs expectations of the FDA reports. That is why FDA results will be edited according to the users’ needs and users’ state of knowledge as, for example, journalists are interested in a different type of analysis than people working for insurance.

From the scientific point of view, the Event Explorer will act as an internal database for interdisciplinary results. To improve the analysis for future events, the Event Explorer enables searches for similar events and compare results with historic events.

The first prototype is designed as a blog. From the FDA point of view it is very convenient to handle: new results can be added as soon as they are available to keep the event page up-to-date. The format covers not only text and static figures but also allows interactive maps, picture galleries and videos. The reader will be provided with up-to-date information and can follow the blog via RSS-feed to stay informed. Keywords and tags let the user search for related events, results or methods. The format is independent from any device and adaptable for desktop PC, smartphone or any other device.
Outlook

For the future, the underlying database will be defined more precisely such as ‘What type of information is needed for what type of disaster?’, ‘What results are mandatory to obtain a complete view?’ and ‘What extra information is available?’. Results obtained from the user survey will also be incorporated into the prototype because according to their profession, users gave different ideas and input for the design. The prototype will also be tested in different environments and with different users.

Finally, a user-oriented visualization of FDA results will increase the spread of disaster analyses and will make it a valuable contribution to the further use of CEDIM results.

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Global Dynamic Exposure

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Introduction

In the Global Dynamic Exposure (GDE) project we use crowd-sourced and open geographic/geospatial data from the OpenStreetMap (http://www.openstreetmap.org/) project and additional available open data. Using these data, which are extended and updated permanently by a continually growing number of volunteers on the one hand and local or even countrywide governmental organizations on the other hand, we are deriving a permanently updated global exposure model.

We also provide guidance supporting the “crowd” by not only geographic data collection, but also by deriving information required to improve our exposure and vulnerability indicators. Because of the immense number and variety of buildings and their locations, exposure- and vulnerability-related data cannot be compiled by a small or local group.

Furthermore, the dynamic aspect of risk, namely rapid urbanization in emerging countries, requires monitoring of exposure and vulnerability indicators, again a task that can only be achieved when distributing the work onto many shoulders.

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 exists in high quality.

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 3, these indicators can be computed for many buildings if sufficient data exists in OpenStreetMap. Once a target area is fully captured in OpenStreetMap, further changes in the dataset indicate the change in 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 minutely. After every update, indicators for buildings affected by recent updates are 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 (http://hot.openstreetmap.org/), a quick responding crowd-sourced post-disaster mapping effort, is providing information about the status of buildings and roads in the aftermath of a disaster. These data are retrieved mainly from open (at least for this particular purpose) 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.
To spread the idea of volunteering as a scientist, engineer or “ordinary mapper” we provide the infrastructure for near real-time updated visualization of multi layer exposure maps on a global scale.

**Project status**

After finishing the proof-of-concept phase we became aware of the immense amount of information contained in our basic dataset in some parts (i.e. regions) and the lack of data in others (see Fig. 2). Therefore we decided to search for planned or initiated projects for building mass imports into the OpenStreetMap database, and offered our guidance for selecting available information and choosing appropriate tags (see below in support of planned and ongoing mass building imports).

Since our global OpenStreetMap database is up, running reliably and being updated minutely, we are now working on the infrastructure for real-time re-calculation of exposure data. Also, we have introduced algorithms for new exposure and vulnerability indicators and implemented them in the continuously running distributed computation system.

**OpenBuildingMap**

We extended the OpenBuildingMap (http://www.openbuildingmap.org/) by numerous layers of newly derived or calculated indicators (i.e. ground area, floor space, power infrastructure). We try to address two main goals in this project:

- create a visualisation of the calculated indicators
- stimulating mappers worldwide to capture building properties that are usually not visible in the generic maps (see Building Property Editor for Mobile Devices below)

Also we worked with the community to improve the quality and speed of the tools used to import and extract OpenStreetMap data. We put effort in creating a tool chain to visualize the progress of the completeness of OpenStreetMap data for certain regions.

**Support of planned and ongoing mass building imports**

Together with local mappers, we work on the import of building outlines and building occupancy information in different locations on the world (Cologne, Germany; Palermo, Italy; Helsinki, Finland; Lecce, Italy; Portland, OR, U.S.A.).

For these mass imports we created translation tables for all of the imported occupancy types. Those tables provided the respective tags in OpenStreetMap for the data import but also the respective taxonomy tags for exposure assessment. These imports are mostly performed manually as otherwise they would need considerable advance preparation for data quality reasons.

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![Fig. 2: OpenStreetMap worldwide node density distribution as of June 2013.](image)

Visualization based on work of Martin Raifer (“tyr_asd”), © cc-by-sa - source data © OpenStreetMap contributors, ODbL.
Our former proof-of-concept static map is now included in the near real-time updated Open- 
BuildingMap.

Derived from our Haiyan/Yolanda typhoon proof-of-concept damage map we created the infra-
structure to deploy similar maps for future events in short time.

In collaboration with other community partici-
pants we developed a proof-of-concept mobile building property editor (see Fig. 1) for any HTML5 capable device. The goal is to have a simple to use tool for adding building property 
data into the OpenStreetMap project and to di-
rect volunteers to focus onto easily recogniz-
able data that helps the Global Dynamic Expo-
sure project.

By adding additional hardware to the GDE da-

table system we extend the number of expo-
sure indicators computed by the system on the global scale.

The increasing amount of open data in the public, esp. in the OpenStreetMap database, 
requires us to put more effort into the optimiza-
tion of the distributed calculation system to be kept updated with the changes in our source dataset(s).

We develop the possibilities to face the chal-

lange of motivating numerous locally depend-
ent experts ("crowd" of earthquake engineers 
and scientists) to interpret the datasets and add algorithms for processing the data of their regions of knowledge. We consider this our major task for improving the quality of the Global Exposure Model.

We will improve the capabilities of the dam-
age map system to show layers from various sources which may contain almost arbitrary geospatial data.

To attract volunteering developers we will clean our so far proof-of-concept code of this project and made it available on a public open source collaboration platform.

We will create a platform where the results of our calculation are available for browsing and download either as dynamic up-to-date set or a periodically dumped release.

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Fig. 3: Color-coded exposure indicators derived from OpenStreetMap data of Catania (east cost of Sicily, Italy). From top left to bottom right: Predominant landuse, occupancy type of building, number of storey of building, number of buildings, bridges and tunnels, and finally, electrical power related information. Source data © OpenStreetMap contributors, OdbL.
Introduction

The $M_W$ 8.2 Iquique earthquake (also called Pisagua earthquake) struck Northern Chile on 1st April 2014 northwest of Iquique. It was the strongest earthquake in this area for the last 137 years. With a hypocentral depth of 34 km and located about 96 km offshore of the harbor city of Iquique it belongs to the type of subduction thrust earthquakes along the Chilean coast.

The Northern Chile seismic gap

The event occurred in a region of historic seismic quiescence, the Northern Chile seismic gap. The earthquake ruptured a part of the gap close to its northern end, where the Nazca plate subducts eastward beneath the South American plate at a rate of ~65 mm/yr. The last significant earthquakes occurred in 1868 and 1877. Since then the region has been quiet and built up stress along the segment for the last 140 years. The two neighboring segments to the north and south of the seismic gap broke in 2001 and 1995, causing magnitude 8.4 and 8.1 earthquakes respectively (Fig. 1). A recent increase in seismicity had occurred just before the $M_W$ 8.2 event, including an $M_W$ 6.7 event and three $M_W$ 6.2 events in March. The remaining unbroken parts of the seismic gap now pose an increased seismic hazard with the potential to host an earthquake of magnitude larger than 8.5.

Historic seismicity

Since population is sparse due to the Atacama Desert, most earthquakes in Northern Chile cause minor human losses. Economic losses, mainly for the mining industry are higher. Past damaging events:

<table>
<thead>
<tr>
<th>Date</th>
<th>Magnitude</th>
<th>Casualties</th>
<th>Damage</th>
<th>Economic Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>7.2</td>
<td>5 dead 5000 homeless</td>
<td>1000 houses damaged</td>
<td>ca. $1M USD</td>
</tr>
<tr>
<td>1911</td>
<td>7.1</td>
<td>20 dead</td>
<td>Damage to nitrate industry</td>
<td>major</td>
</tr>
<tr>
<td>1877</td>
<td>8.8</td>
<td>ca. 2500 dead</td>
<td>Major damage, tsunamis</td>
<td>major (also war)</td>
</tr>
</tbody>
</table>

Table 1: Major historic earthquakes along the Chilean subduction zone.

2005 saw a major $M_w$ 7.8 earthquake killing 11 people and causing landslides in the region of Iquique, however this was an intermediate depth earthquake at 100km depth. 1981 also saw a minor $M_w$ 5.8 earthquake with 10 deaths. (CATDAT)

Human and economic losses

At least 15 people died due to the shaking and later building collapse. Around 1000 persons became homeless while 90,000 in total were affected by evacuation. Damage to buildings and infrastructure was mostly minor but reached up to southern Peru. Major damage was observed mainly in Huara and Altophospicio, cities near to Iquique. The event generated a small tsunami of 1-2 m height which did not cause any major damage, a fact also due to the sparsely populated nature of the Chilean coast in that area. Few roads were closed by landslides. The mining industry reported modest economic losses in the order of $10m.

Because of the relatively little damage and losses incurred, the Iquique earthquake did not match the criteria set for a CEDIM Forensic
Disaster Analysis but since the event is of major scientific interest, a short report was published and a study with contributions from CEDIM members was published in Nature [Schurr et al.].

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Publications


http://www.cedim.de/download/Short-report_IQUIQUE_2.pdf

http://www.eskp.de/wissenschaftler-untersuchen-vor-und-nachbeben-in-chile/
**Erdbeben “Iquique”, Chile**


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**Super Typhoon “Hagupit”, Philippines**

Bernhard Mühr, Tina Bessel, Trevor Girard, Susan A. Brink, Bijan Khazai, Tina Kunz-Plapp, Sven Baumstark

**Introduction**

Nearly one year after super typhoon “Haiyan” devastated the Philippine city of Tacloban and caused several thousand casualties, another very strong typhoon headed for the central parts of the Philippines during the first week of December 2014. The name of the typhoon was “Hagupit”, on the Philippines known as “Ruby”. “Hagupit” was the fourth tropical storm system of the 2014 season in the north western Pacific that reached highest category and super typhoon status. On 6 December 2014 “Hagupit” made landfall. Due to early and effective evacuation of more than 700,000 people and because of a significant decrease in the storm’s intensity, the number of fatalities and the storm damage was lower than previously feared. Nevertheless, fierce winds and torrential rain of about 400 mm within 24 hours ensured considerable damage, floods and landslides: at least 18 people were killed.

Two days before landfall there was a realistic scenario that “Hagupit” could hit the same area as “Haiyan” did a year ago (Samar and Leyte, including the city of Tacloban) as a category 4 typhoon. While approaching the Philippines “Hagupit” lost intensity and finally missed the previously battered areas. CEDIMs FDA group decided to put a minor FDA activity into effect.

On 29 and 30 November “Hagupit” developed from a low pressure area that was identified just north of the equator in the area of the Federated States of Micronesia. Warm ocean water and favourable atmospheric conditions fed thunderstorm clusters that became organized.
The tropical depression was called “22W” by the Joint Typhoon Warning Center (JTWC). On the same day the depression grew into a tropical storm and was named “Hagupit” by the Japanese Meteorological Agency (JMA). On 2 December 2014 “Hagupit” strengthened into a typhoon and became the eleventh typhoon over the western Pacific Ocean in the 2014 season. “Hagupit” made its way through Micronesia and headed from near Palau towards the central Philippines and reached super typhoon status on 3 December 2014. A super typhoon has 1-min sustained winds of at least 241 kph. The typhoon showed maximum intensity on 04 December 2014 between 00 and 15 UTC with sustained winds of 287 kph. At 15 UTC the storm centre was 500 km southeast of Samar (PH) at 11N 131E. According to JMA the central pressure was 905 hPa.

During the next 36 hours while approaching Samar “Hagupit” decreased. According to PAGASA, the Philippine national weather agency, the typhoon made landfall on 6 December 2014 at 13:15 UTC near Dolores on eastern Samar. At the time of landfall, “Hagupit” was rated a category 3 typhoon on the Saffir-Simpson Hurricane Wind Scale with maximum sustained winds of 201 kph.

The storm field covered an area with a diameter of about 500 kilometres. Due to friction, the typhoon showed further weakening and made its way across the Philippines with a propagation speed of around 10 kph as a category 2 storm on 7 December 2014. “Hagupit” made its second landfall near Cataingan on the island of Masbate.

On 8 December 2014 the typhoon was downgraded into a tropical storm and had its closest approach to the metropolitan area of Manila at around 17 UTC when the storm center passed the capital 90 km to the south. On 9 December 2014 the storm entered the South China Sea travelling to the west to southwest and finally dissipated on 11 and 12 December 2014. Remnants of the storm affected Vietnam.

Forecasting and Impacts of Super Typhoon “Hagupit”

On 3 December 2014 some forecast models still calculated a track to the northeast on which “Hagupit” would have missed the Philippines altogether.

On 4 December 2014 it was feared that “Hagupit” would make landfall as an upper category 4 typhoon near the island of Leyte and close to the city of Tacloban. Moreover, “Hagupit” would still affect Manila as a category 2 typhoon; at this time gusts of as much as 380 kph were predicted over open waters.

In contrast to the first forecasts that “Hagupit” could hit the Philippines as a super typhoon with a similar strength to that of “Haiyan” a year ago, the storm showed significant weakening from 5 December 2014 onwards. Despite a sea surface temperature of about 29°C, increased

Fig. 2: Track of Super-Typhoon HAGUPIT, 6 hourly timestep (Analysis 29 Nov - 09 Dec and forecast 09 - 12 Dec 2014). Red numbers represent the storm’s category (Cat 1 – Cat 5) according to the Saffir-Simpson Hurricane scale (TD – Tropical Depression, TS – Tropical Storm). Data source: Joint Typhoon Warning Center.
vertical wind shear made “Hagupit” lose intensity rapidly.

Due to a relatively slow shift along its track, Hagupit was responsible for intense rainfall which caused landslides, flooding and falling debris. 72-hour rain amounts were 433 mm in Catbalogan (Samar), 420 mm in Masbate City (Masbate), 406 mm in Borongan (Samar) and 292 mm in Tayabas (Luzon); Manila International Airport did not get extremely heavy precipitation, recording a mere 44 mm of rain.

Figure 2 shows predicted rain amounts during a period of 144 hours while “Hagupit” crossed the Philippine islands between 5 and 11 December 2014. Along the path of the typhoon rain amounts exceeding 300 mm had been expected as well as resulting flooding and landslides.

Impacts on Transportation Systems and Lifelines

Typhoon Hagupit had some minor impacts on the transportation system. Vessels, rolling cargoes and motorbancas have been stranded due to bad weather conditions. Between 7 and 9 December 2014, a total of 245 domestic and 33 international flights were cancelled. Several roads were reported not passable because of flooding, landslides, fallen trees and toppled electric posts, some bridges were closed due to high water levels.

Power interruptions were experienced in 20 provinces in six regions, most of them occurring in the provinces of Samar and Leyte. In the telecommunication sector some networks were down but had been restored largely within two days.

Disaster Preparedness and Social Impacts

Before affecting the Philippines, storm and typhoon warnings have been issued for parts of Micronesia (Woleai, Yap) on 2 December 2014 followed by tropical storm warnings for parts of the Republic of Palau (Kayangel, Koror). From December 4th - 8th the Philippine National Disaster Risk Reduction and Management Council (NDRRMC) issued an average of four Weather Bulletins per day, or one every six hours. On 6 December 2014 public storm warning signal#3 (highest warning level) was issued for parts of Regions VIII and V. The emphasis was on storm surges and “big waves”, a term not used during typhoon “Haiyan”.

“Hagupit” affected more than 4.000.000 people, 18 people died, 916 were injured. The evacuation focused on the eastern coast of the Philippines although evacuations occurred throughout the affected area. The large evacuation before “Hagupit” has been credited to improved preparedness as a consequence.
<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thursday, 4 December 2014, 10:51 UTC</td>
<td>Email-notification with preliminary information and advice of a possible FDA activity; FDA distribution list</td>
</tr>
<tr>
<td>Thursday, 4 December 2014, 21:00 UTC</td>
<td>Advance warning on website Wettergefahren-Frühwarnung</td>
</tr>
<tr>
<td>Friday, 5 December 2014, 09:00 UTC</td>
<td>Update of warning on website Wettergefahren-Frühwarnung</td>
</tr>
<tr>
<td>Friday, 5 December 2014, 11:36 UTC</td>
<td>Information of CEDIM FDA group members by email</td>
</tr>
<tr>
<td>Friday, 5 December 2014</td>
<td>Preliminary CEDIM activities began; checking and categorizing information about the typhoon</td>
</tr>
<tr>
<td>Saturday, 6 December 2014, 09:30 UTC</td>
<td>Update of warning on website Wettergefahren-Frühwarnung</td>
</tr>
<tr>
<td>Saturday, 6 December 2014, 13:15 UTC</td>
<td>Landfall of “Hagupit” near Dolores in Eastern Samar province, Philippines</td>
</tr>
<tr>
<td>Saturday, 6 December 2014, 13:51 UTC</td>
<td>Email to all members on CEDIM FDA distribution list. Decision was made that a full FDA activity was not considered inevitable due to significant decrease of storm</td>
</tr>
<tr>
<td>Sunday, 7 December 2014, 09:30 UTC</td>
<td>Update of warning on website Wettergefahren-Frühwarnung</td>
</tr>
<tr>
<td>Sunday, 7 December 2014, 13:35 UTC</td>
<td>Latest information sent by email to CEDIM FDA group</td>
</tr>
<tr>
<td>Sunday, 7 December 2014, 21:30 UTC</td>
<td>First analysis on typhoon’s evolution on website Wettergefahren-Frühwarnung</td>
</tr>
<tr>
<td>Monday, 8 December 2014, 11:00 UTC</td>
<td>Final warning on website Wettergefahren-Frühwarnung</td>
</tr>
<tr>
<td>Tuesday, 9 December 2014, 11:00 UTC</td>
<td>Report 1 on CEDIM website (in English)</td>
</tr>
<tr>
<td>Tuesday, 9 December 2014, 23:00 UTC</td>
<td>Extensive analysis about Hagupit (meteorological information, historical context, impact) on website Wettergefahren-Frühwarnung (in German)</td>
</tr>
<tr>
<td>Tuesday, 9 December 2014, 23:00 UTC</td>
<td>FDA activity ended</td>
</tr>
</tbody>
</table>

Table 1: Timeline of the FDA activity concerning “Hagupit”.

A total of 290,670 damaged houses were reported with 42,466 totally damaged. According to latest situation report of NDRRMC, the overall cost of damages were about 100 Million US$, of which 29 Million US$ was related to infrastructure damage and 71 Million US$ to agriculture.
Forensic Disaster Analysis

Super Typhoon “Hagupit”, Philippinen


Der tropische Wirbelsturm hatte für mehr als 4 Millionen Einwohner der Philippinen direkte Auswirkungen. Sie wurden in umfangreichen und frühzeitigen Evakuierungsmaßnahmen in insgesamt 327 Schutzräumen gebracht. Im Gegensatz zum Taifun „Haiyan“, der noch ein Jahr zuvor rund 7000 Todesopfer gefordert hatte, blieb die Zahl der Toten (18) und Verletzten (916) vergleichsweise klein. Die Schadenssumme beläuft sich auf rund 100 Millionen US$, davon entfallen 71 Millionen US$ auf Schäden in der Landwirtschaft, der Rest auf Schäden an der Infrastruktur.

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Publications


Disaster Management

Continuous Long-Term Simulations for Flood Risk Assessment - Mulde Case Study

Daniela Falter, Kai Schröter, Nguyen Viet Dung, Sergiy Vorogushyn, Heidi Kreibich, Yeshawettesfa Hundecha, Heiko Apel, Bruno Merz

Introduction

There is an increasing need for spatially consistent flood risk assessments at the large scale (>10,000 km²), since currently available approaches have several shortcomings. Flood risk assessments often use the return periods of flood flows or precipitation as a proxy for the probability of damage. Moreover, risk mapping is often undertaken assuming a uniform return period across large river basins, which may lead to a vast overestimation of risk at large spatial scales.

Aims/Objective

The project aims at developing a novel approach for assessing flood risk in river catchments in a spatially consistent way. The approach is based on a set of coupled models representing the complete flood risk chain, including a large-scale multisite, multivariate weather generator, a hydrological model, a

Fig. 1: Input data, components and interactions of the RFM model chain.
two-way coupled 1D-2D hydrodynamic simulation model and a flood loss estimation model. Long time series of spatially consistent meteorological fields are generated and transformed, through the subsequent models, into long time series of flood damage. This allows the derivation of flood risk estimates directly from the simulated damage.

**Project status**

The approach is based on a set of coupled models representing the complete flood risk chain, namely RFM (see Fig. 1). As an example, the approach is applied to the mesoscale catchment Mulde (ca. 6,000 km²), located in east Germany. 10,000 years (100 realizations of a 100-year period) of spatially consistent meteorological time series are generated and used as input to the model chain, yielding spatially consistent river discharge series, inundation patterns and damage values. This results in a unique data set of more than 2,000 flood events, including detailed spatial information on inundation depth and damage at a resolution of 100 m. On this basis flood risk curves and risk indicators, such as expected annual damage (see Fig. 2), can be derived for a range of spatial scales, from the grid cell to the catchment scale.

The novel flood risk approach thus developed is based on long-term continuous simulation and has a number of advantages:

1. Spatially coherent patterns of catchment meteorology, hydrology and floodplain processes,
2. Holistic representation of flood risk processes,
3. A genuine representation of damage probability, and hence, flood risk.

**Outlook**

The approach has great potential to be transferred to other mesoscale but also large-scale catchments. It is currently being implemented for case studies in the Saale catchment and the german part of the Elbe catchment. Moreover, dike breach process modelling and its implementation in the flood risk model chain is planned. This process has an important impact on flood impacts but is not yet considered in the hydrodynamic model components.

![Figure 2: 1) Distribution of Expected Annual Damage to residential buildings in the Mulde catchment at the subbasin scale. 2a) – 2d) Comparison of total damage (a, c) and discharge return period (b, d) spatial distributions among subbasins (x-axis) and different flood events (coloured lines) for two different levels of total catchment damage.](image-url)
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Section 5.4 Hydrology, GFZ

Publications


Kontinuierliche Langzeitsimulationen zu Flut-Risikobewertung - Multi-Case Studie

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

Bernhard Mühr

Overview

The key aspect of the internet service “Wettergefahren-Frühwarnung” is extreme weather events, especially when they are associated with a high potential for loss and damage. The main focus is on Europe, but severe natural disasters on other continents are also considered and investigated. The web platform “Wettergefahren-Frühwarnung” has been operational for more than eleven years now and has become a flagship of CEDIM. Permanent availability, daily updated information, automatically calculated forecasts worldwide, editorially enhanced reports of extreme or unusual weather events and a comprehensive and ever-growing archive of nearly 1000 events are the hallmarks of the project. Additionally, “Wettergefahren-Frühwarnung” is a pillar in CEDIM’s strategy of interdisciplinary research in analyzing natural disasters in near real-time. And in the context of ATMO Forensic Prediction and Analysis, an operational forecast system for winter storms in Germany will be developed.

Notable extreme weather events in 2014

51 unusual or extreme weather events have been identified and analyzed by “Wettergefahren-Frühwarnung” in the course of the year 2014. According to the goals and the mission of “Wettergefahren-Frühwarnung” which puts the focus on Europe, 22 of the events affected European countries or countries bordering the Mediterranean Sea.

Apart from super typhoon “Hagupit” that crossed the Philippines and required a minor CEDIM FDA activity (see this issue), some of the extreme weather events are particularly worth mentioning:

1.) Heavy snowfall and extreme cold spell in North America beginning of 2014

Strong winds, heavy snowfall and extreme low temperatures struck parts of Canada, the Midwest, the northern Plains and the north eastern states of the US. Minimum temperatures of around -40°C and blizzard-like conditions caused severe impairment and at least 20 deaths. Several arctic blasts until early March made the winter 2013/2014 extremely cold with negative temperature anomalies exceeding 5K in parts of the north eastern half of North America.

2.) Severe flooding in Balkan States, May 2014

While in many parts of Europe spring 2014 turned out to be exceptionally dry, lots of stations in south east Europe recorded rain amounts about two and a half to three times the usual amount. In mid May, another quasi-stationary upper low pressure system over south east Europe caused persistent and intense rainfall that finally led to extreme floods in the Balkans. Bosnia and Herzegovina and Serbia experienced a hundred year flood, at least 44 people were killed.

3.) Heat wave and severe thunderstorms in Central Europe, June 2014

Right during Pentecost 2014, hot air of African origin was responsible for the first heat wave of the year in Central Europe. High temperatures were well above 35°C at many places, numerous temperature records for the first decade of June or even for the entire month were broken. In Germany, Rheinau-Memprechtshofen in the valley of the river Rhine experienced 37.7°C: similarly high temperatures did not occur in the rest of the year throughout the country. The heat-wave ended with severe thunderstorms that developed over Benelux, France and parts of Germany. In North Rhine-Westphalia the thunderstorms were accompanied by extreme wind gusts that reached 144 km/h in Düsseldorf and were responsible for severe damage: 7 people died. One tree out of four was buckled or uprooted, railway traffic was disrupted, and on the streets there were 300 km of traffic jams.

4.) Intense rain, thunderstorms and flooding in the western and central Mediterranean Sea, autumn 2014

A series of high impact weather events battered eastern Spain, southern France, southern Switzerland and Italy. Due to constant moisture supply from the nearby Mediterranean Sea and


Sturmtief "Elon"

Wetterlage und Entwicklung

Im Verlauf der ersten Januarwochen 2015 stellte sich über West- und Mitteleuropa eine zonales Zirkulationsmuster mit sehr windigem Wetter ein. Am 06.01. und an den Folgetagen verlagerte sich ein langwelliger Trog über den Nordatlantik ostwärts. Das zugehörige Bodentief "Christian", das am 06.01. über dem östlichen Nordatlantik die Rolle des steuernden Zentraliefs einnahm erreichte am 07.01. mit einem Kerndruck knapp unter 940 hPa westlich von Island seinen Höhepunkt. Im Zusammenspiel mit einem sich aufbauenden Bodenfroh, das bis zum 09.01. einen Kerndruck von 1045 hPa aufwies, entstand über Mitteleuropa ein beachtlicher Druckgradient.

Fig. 1: Screenshot of "Wettergefahren-Frühwarnung": Analysis of winter storms "Elon" and "Felix" in Western and Central Europe, January 2015.
Image credit: http://www.wettergefahren-fruehwarnung.de.
favorable meteorological conditions, thunderstorms and areas with heavy rain were able to regenerate and led to enormous rain amounts.

And the end of September Montpellier received 250 mm of rain within 3 hours - a new record. The long-term monthly rain average for September is only 80 mm. According to Météo-France it had not rained that much in 11 years in the region and a state of disaster was declared.

In early November an intense cyclogenesis caused heavy rain between the western Mediterranean Sea and the Alps. France, Italy and Austria received several 100 mm of rain within a short time resulting in landslides and flooding. An extraordinary rain amount of nearly 700 mm (689 mm within 48 hours) occurred in north-eastern Italy at Malga Valine. At higher elevations of the Alps gale-force winds were measured, Chamrousse (F) reported wind gusts of even more than 200 kph. Further to the south, between Tunisia and Sicily, the low pressure system “Quendresa I” became a so-called “Medicane” and caused considerable damage on Malta and on Sicily.

A few weeks later, during another heavy rain event. 361 mm of rain fell within 12 hours at Passo de Giovi north of Genoa (Italy), Genoa itself observed 459 mm within a week (November 9-16) which is four times the usual amount for November. Entire districts were under water, landslides made roads and railroad tracks impassable. An extraordinary high water level of Lake Maggiore and Lake Lugano (Switzerland) required the highest warning level.

**FDA – Forensic Disaster Analysis**

Meteorological aspects play an important role before, during and after a natural disaster event, regardless of what type of disaster. On the one hand, meteorological extreme events are the most common natural disasters that occur globally; on the other hand, there are many interactions and inter-dependencies of local meteorological conditions that impact the social, economic and infrastructure sectors during or after non-meteorological events. The project “Wettergefahren-Frühwarnung” supports all FDA activities by the preparation of text, data, information or graphics. When appropriate, FDA activities are initiated or the leading role is taken.

Cooperation with and assistance of other projects inside and outside of CEDIM.

For example, projects such as Rapid Flood Event Analysis, Transportation Interruption or Database and Implementation of Case-Based Reasoning for Analytical Support all benefit from “Wettergefahren-Frühwarnung” activities. For these projects data is generated and made available. For a rapid flood analysis own high-resolution model forecast data might be calculated or measurement data will be provided and also the project of transport interruption may use forecast or measurement data on a daily routine.

Other duties include a close cooperation with external companies, e.g. insurances, for which information and products are made available. In addition, some work has to be done in the media sector (Television, radio broadcasting, newspapers or news agencies), but also other scientific institutions take advantage of particular products.

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**Publications**

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

Der Web-Service “Wettergefahren-Frühwarnung”

Seit mehr als 11 Jahren informiert die Internet-Plattform “Wettergefahren-Frühwarnung” tagesaktuell über bevorstehende ungewöhnliche oder extreme Wetterereignisse, vor allem dann, wenn sie mit einem großen Schadenpotenzial einhergehen. Das Informationssystem umfasst einerseits Warnungen und Hinweise bereits einige Tage vor Eintritt des Ereignisses und andererseits redaktionell aufbereitete und mit Texten, Tabellen, Grafiken und Daten versehenen Artikel, die nach Ende der Wetterereignisse verfasst werden. Das einzigartige
The Challenge of Hail Hazard and Risk Modelling

Michael Kunz, Heinz Jürgen Punge, Manuel Schmidberger, Susanna Mohr, Elody Fluck

Overview

The recently published damage statistics of Munich Re for the year 2013 reveal a surprising finding: The costliest natural catastrophe worldwide - ranked by insured losses - was a hailstorm event in Germany. On 27/28 July, two supercell thunderstorms – one that moved over the central parts, the other over southwest Germany – with hailstones of up to 8 cm diameter caused insured losses of 3.1 bn € (economic loss: 3.1 bn €). This example illustrates the large damage potential related to hail events, which is still underestimated both by the public and the insurance industry. In the context of CEDIM, different projects are currently carried out at IMK-TRO/KIT with the aim to better understand hail probability, hail risk and possible trends. This article gives a brief overview of the main results.

Hail Hazard Assessment

The assessment of the hail hazard is challenging mainly for two reasons: The areas affected by hail, referred to as hail streaks, are usually very small, and direct observational data are...
Disaster Management

not available. To tackle this problem, appropriate methods that estimate hail probability and intensity from indirect data, so-called proxies, have to be developed and implemented. Most suitable are observations from remote sensing instruments such as radar, satellite, or lightning sensors having a large area under constant surveillance. These data sets can be complemented by additional information from regional climate models (RCM) that are available for longer periods.

For the area of Germany, we derived hail signals from three-dimensional radar data from the German Weather Service (DWD) radar network, filtered additionally with lightning observations and tracked with a specific algorithm. The result is a unique high-resolution radar-based event set consisting of around 10,000 individual hail streaks. The analyses reveal that the spatial distribution of the hail events is the result of a superposition of large-scale climatology and local-scale flow dynamics (Fig. 1). A surprising finding is that most of the hail maxima are located downstream of the low-mountain ranges. Additional simulations with the numerical weather prediction model COSMO-DE of DWD confirm that flow convergence at lower levels emerging downstream of the mountains play a major role in the spatial distribution of the hail events.

To estimate the hail probability across Europe, we employed satellite-derived infrared brightness temperature as proxy for hail. Overshooting of air masses atop thunderstorm anvil clouds (overshooting top, OT) with low cloud top temperatures has proven to be a reliable indicator of severe thunderstorms including hail. In combination with hail reports archived by the European Severe Weather Database (ESWD), the OT observations are used to build a “climatology” of hail events in Europe. Highest OT frequencies found in regions adjacent to the Alps, the Pyrenees and near the Massif Central confirm the relation between topography and hailstorm frequency (Fig. 2).

Hail Risk Modelling

Risk modeling in general requires large event samples over a long-term period. This applies in particular for the estimation of the probable maximum loss of a 200-years event (PML200), which insurers need to provide in the context of regulatory directives such as Solvency II. The hail risk models developed at KIT for the insurance industry (SV SparkassenVersicherung AG, Willis Re, Tokio Millennium) are based on stochastic event sets for which track properties such as length and width, duration, orientation and intensity are generated from statistical distribution functions derived from past observed events.

The recently developed HARIS-SV hail loss model is based on the Gutenberg-Richter recurrence law known from earthquake modeling. This approach combines return periods of hailstorms with historical hailstone sizes from ESWD on a 10 x 10 km2 grid. The stochastic event set is created from polygons that are randomly constructed from the radar-derived event set. These polygons are the basis for the calculation of the PML for a given portfolio. Additionally, hazard and vulnerability are combined with a damage function to separate different damage classes for every building object class. Expected damage is obtained from the accumulation of the mean damage ratio for a specific portfolio. The model works efficiently and also predicts realistic overall losses for single events such as that of 28 July 2013.

The recently introduced Willis European hail model (WEHM) uses a satellite-based historical event set to define the spatial extent and intensity of hail events, also complemented by ESWD hail reports. More than 1 million individual events are simulated with the help of stochastic methods. Thereby an accurate representation of the relationship of event length, width and severity was implemented in the model. The final stochastic hail event catalogue

Fig. 2: Spatial distribution of the stochastic hail event centroids derived from overshooting top satellite data at a resolution of 0.5° x 0.3° between 2004 and 2011 (Punge et al., 2014).
(hazard module) is the first with a spatial event distribution that is based on a single homogeneous observation source over Europe. The risk part of WEHM, including the description of appropriate damage function, was developed at Willis Re. The WEHM is currently used by more than 20 insurance companies.

**Long-Term Variability of Hail Events**

The temporal variability of hailstorms over long time periods is examined using a logistic hail model (multivariate analysis). This approach combines different meteorological parameters relevant for thunderstorm and hailstorm development (e.g., convection energy, moisture content, large-scale weather conditions). The result of the logistic hail model is a new index, referred to as potential hail index (PHI), which describes the potential of the atmosphere for the formation of hailstorms. Based on regionalized ERA-40 reanalyses over past decades, PHI shows a distinct north-to-south gradient in Germany with maximum in the south. The analyses confirm that the hail potential of the atmosphere increased between 1971 and 2000, even though statistical significance is below 95% at most of the grid points. According to an ensemble of seven RCMs (including those from the former CEDIM project Flood Hazard in a Changing Climate), it can be expected that the potential for hail events will rise slightly in the future (2021-2050), particularly in Northwest and Southern Germany (Fig. 3).

**Conclusions**

In recent years, hail damage in Europe has increased substantially. In several regions such as Southern Germany, Switzerland, or Austria, hail causes the major share of insured losses by natural hazards to buildings and agriculture. Despite the considerable damage potential, hail risk is still underestimated by the public and the insurance industry. Only a few hail models are currently available in the insurance market.

In cooperation with the insurance industry, different hail risk models are developed at KIT. Apart from the quantification of risk measures such as the PML200, the hail hazard assessments also provide new scientific insights. One example is the increased hail frequency found downstream of low mountain ranges, which can be plausibly explained by flow characteristics prior to hail events.

The question whether the series of severe hailstorms over the last couple of years in Europe is the result of a changing climate or natural variability alone cannot be answered directly. However, our climate model analysis gives some indications that suggest an increase in the hail potential of the atmosphere over past and future decades.

Besides the various research activities in the context of hail, it is planned to combine our hail detection methods in future with information provided by the CEDIM crowd sourcing project. This should help to better estimate hail sizes, which are directly related to damage, and to support CEDIM FDA activities where hail plays a major role.

**Acknowledgement**

We acknowledge our cooperation partners SparkassenVersicherung AG, Willis Re, and Tokio Millennium for funding of the projects. We thank DWD, ESWD, and Siemens BLIDS for the provision of valuable data sets and James E. Daniell from GPI/KIT/CEDIM for various support for the HARIS-SV hail risk model.
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References


Conferences


Herausforderung Hagelmodellierung


Vulnerability and Critical Infrastructures

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

Thomas Münzberg, Stella Möhrle, Wolfgang Raskob

Introduction

Critical Infrastructure Protection (CIP) covers all activities that ensure a continued supply of vital services and products for the population. This includes all coping measures to mitigate and to minimize the consequences of CI disruptions before and during disasters as well as to recover from the effects to get back to a satisfying supply status.

With the focus on disaster management and emergency planning, the CEDIM project ‘Decision Support Methods in the Field of Critical Infrastructure Protection (DSM CIP)’ promotes the development of decision support methods and analysis approaches for numerous CI-related threats. In 2014, we were able to build on the successes of the previous years and further improved our research activities on various decision support methodologies, such as case-based reasoning, multi-criteria decision analysis, indicator-based vulnerability analysis, and agent-based simulation.

Aims / Objective

Our long-term strategy aims at developing an integrated decision aiding system that supports decision makers from different administrative levels of disaster and emergency management. For this purpose, our research activities address various decision support approaches in order to manage different threat scenarios in different CI sectors.

Project status

In the last year, we have expanded our research activities in the ongoing projects which focus on

- the development of a CEDIM database and the implementation of case-based reasoning (CBR),
- a simulation-based decision support to manage food shortages (SEAK),
- facilitating the selection of security measures in the context of terrorist threats.

Fig. 1: Participants in the two-day expert workshop ‘disaster management planning for food shortages and power outages’ at the National Research Center of the Karlsruhe Institute of Technology.
against public rail transport systems (RIKOV),

- the modeling of CI interdependencies through agent-based simulation (HGF Portfolio Security Research), and

- vulnerability assessments to manage the impact of CI disruption.

In 2014, CBR has been further implemented within CEDIM’s Forensic Disaster Analysis (FDA) activity (see ‘Development of a CEDIM Database and Implementation of Case-based Reasoning for Analytical Support – Continuation from 2013’). Further, an agent-based model focusing on healthcare and water supply infrastructure is being developed (see ‘Modeling and Simulation of Critical Infrastructures using Agent-Based Approach’). Within the SEAK project, the decision support framework for food shortages has been further enhanced based on three threat scenarios (see ‘The SEAK Project: Decision Support for Managing Disruptions in Food Supply Chains – Continuation from 2013’). Within the RIKOV project, a knowledge database, a risk assessment approach, and a decision support method for prioritizing security measures in counterterrorism have been developed. (see ‘Risks and Costs of Terrorist Threats against Public Rail Transport Systems – Continuation from 2013’). Further, our research on measuring CI disruption impacts has been expanded by temporal considerations (see ‘Understanding Resilience: Spatial-Temporal Vulnerability Assessment– Continuation from 2013’).

To support the research, we continuously improved our cooperation with end-users by offering several workshops. Embedded in the RIKOV project, we conducted an expert workshop in April 2014 on the evaluation and management of risks, with 27 participants.

A further two-day expert workshop was organized at the end of October 2014. The workshop addressed disaster management planning for food shortages and power outages at the local level. For this purpose, all city departments responsible for disaster management and health in Baden-Württemberg, as well as representatives from the regional councils in Baden-Württemberg and from the relevant German federal authorities were invited. In a synergistic way, we focused on research activities from the two HGF-projects on agent-based modelling and vulnerabilities assessments as well as on the BMBF-project SEAK. The large number of experts allowed us to conduct various surveys and discussions to improve our methodological approach and the practical implications of the research activities. The results will be analyzed and several publications are foreseen for 2015. In addition, the cooperation with end-users such as fire brigades and disaster management authorities has been strengthened for upcoming research projects.

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Funding Body</th>
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<tbody>
<tr>
<td>Development of a CEDIM Database and Implementation of <strong>Case-based Reasoning</strong> for Analytical Support – Continuation From 2013</td>
<td>Center for Disaster Management and Risk Reduction Technology (CEDIM)</td>
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<tr>
<td>RIKOV Project: Risks and Costs of <strong>Terrorist Threats</strong> against Public Rail Transport Systems – Continuation From 2013</td>
<td>German Federal Ministry of Education and Research (BMBF), German National Security Research Framework</td>
</tr>
<tr>
<td>SEAK Project: Decision Support for Managing Disruptions in <strong>Food Supply Chains</strong> – Continuation From 2013</td>
<td>German Federal Ministry of Education and Research (BMBF), German National Security Research Framework</td>
</tr>
<tr>
<td>Modeling and Simulation of Critical Infrastructures using <strong>Agent-Based Modeling</strong> – Continuation From 2013</td>
<td>Helmholtz Association of German Research Centers (HGF)</td>
</tr>
<tr>
<td>Critical Infrastructure Disruption: Decision Support Through <strong>Vulnerabilities Assessments</strong> – Continuation From 2013</td>
<td>Helmholtz Association of German Research Centers (HGF)</td>
</tr>
</tbody>
</table>

Table 1: Projects within the DSM CIP activities in 2014 and its funding bodies.
Outlook

The individual DSM CIP activities will continue. The existing synergies between the projects will be expanded aiming to integrate new components. In addition, new projects focusing on additional CI related threats and the management of disruption effects are envisaged.

Publications


Methoden der Entscheidungsunterstützung zum Schutz Kritischer Infrastrukturen (DSM CIP)

DSM CIP: The RiKoV Project, Risks and Costs of Terrorist Threats Against Public Rail Transport Systems – Continuation from 2013

Lijun Lin, Stella Möhrle, Wolfgang Raskob

Introduction

The project RiKoV is part of the national research program Research for Civil Security - Security Economics and Security Architecture, initiated and financed by the Federal Ministry of Education and Research (BMBF).

Aims/Objective

The research aim of RiKoV is the investigation - exemplarily for all critical infrastructures - to what extent a holistic risk management approach can enhance the protection of public railway transportation systems against terrorist attacks. For this purpose, the following subsidiary aims will be pursued:

1. the analysis of historic events and the identification of plausible attack scenarios of public railway transportation,
2. the provision of a method for the analysis and assessment of terrorist risk against public railway transportation systems,
3. the provision of decision support methods for the identification and prioritization of suitable security measures considering costs and socio-political aspects to reduce the risk, and
4. the provision of decision support tools for the implementation of security measures and concepts.

The methods and tools so developed will be implemented in demonstrations.

Project Status

We focused this year on the development of a knowledge database for the structured storage of identifiable scenarios and historic attacks, the development of a risk assessment approach, and a decision support method for prioritizing security measures. For this purpose, all the attributes relevant to describe terrorist attack events were collected and analyzed. Afterwards, a database was established and filled with data from historic events and scenarios defined within this project. Furthermore, a risk assessment approach was developed, which takes threat, vulnerability, and consequences of terrorist attacks into account. In the decision-making process for prioritizing security measures, the method of case-based reasoning (CBR) and a multi-criteria analysis approach (MCDA) were used. The implementation of CBR should provide an IT-based support for preselecting security measures for current attack scenarios with the usage of information of the knowledge base. MCDA supports the prioritization of retrieved security measures in a multi-criteria manner by means of attribute trees, which contain all relevant criteria for assessing security measures. The methods and the decision tree were evaluated during the expert workshop in April this year.

The CBR application and MCDA tool were set up. They are programmed in Java.

Outlook

The CBR application will be tested and the implementation process continues. The CBR application and MCDA tool will be added to the KIT demonstration. Finally, all software products will be integrated into an overall RiKoV demonstration, which will be tested using realistic scenarios.

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Publications


RIKOV Projekt: Risiko und Kosten von terroristischen Handlungen gegen öffentliche Schienentransport Systeme - Fortsetzung von 2013


Strategic Deterrence of Terrorist Attacks

Sascha Meng, Marcus Wiens, Frank Schultmann

Introduction and objective

Since 9/11 terrorist threats are much more present in the European countries’ preventative security and intelligence strategies. However, research and management of adversarial risks is still dominated by methods which do not sufficiently account for the terrorists’ motives and for the strategic component of the interaction between offender and defender. In this research project we analyze the interplay between conventional risk analysis and game-theoretic reasoning in the context of adversarial risks. Part of this work is conducted in the context of the accompanying research project RIKOV.

Project description and outlook

The potential shortfall of conventional risk management approaches lies in the problem that history-oriented projections can also be anticipated by terrorist offenders so that they optimally adapt to this defense-system. As a result, the system’s vulnerability and the offender’s intention are both partly endogenous. The game-theoretic analysis contributes to a more robust defense-system in at least three ways: Firstly, it urges the researcher to investigate possible intentions and motivations of the offender by carving out a clear motivation structure of potential ‘types’ of offenders. Secondly, game-theoretic reasoning takes some kind of
Vulnerability and Critical Infrastructures

"illusion of control" from the defending institution by compelling the important insight that there are inevitably natural limits to risk reduction due to limited resources. In the end, the most vulnerable parts are the system’s limits. Although potential offenders will not be able to infer the optimal defense strategy they will be able to make an appropriate guess about the defender’s limits. In other words: The offender will not know what the defender will choose but he knows quite well which strategies the defender cannot choose. Rational offenders will take this into consideration so that some kind of endogenous vulnerability emerges. This problem cannot be tackled by improved decisions of the defender alone but rather by a society-wide agreement on higher budgets or higher thresholds of acceptance. Third, game-theory puts more strength on forward-looking procedures instead of backward-looking, history-oriented heuristics. As we know from crime reduction, too adaptive defense strategies run the risk of just reacting to events and thus forcing defenders into the passive role of a tortoise-hare-trap. This can quickly lead to heavy loss of resources and to a significant damage in reputation as the defense appears bustling and ineffective at the same time. In summary, the complementation of conventional approaches by game-theoretic analysis allows for a strategic and dynamic stress-test on the assumptions and the system’s parameters. We apply this methodology in the RIKOV project which is funded by the Federal Ministry of Education and Research. Here it provides the user with hints (‘warnings’) about potential blind spots in his defense system.

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Publications


Stategische Abschreckung von Terroranschlägen

SEAK focuses on three relevant threat scenarios which may lead to a food shortage or a FSC disruption: (i) a drop out of manpower, (ii) a heat wave, and (iii) a failure of the IT system. The selected scenarios in particular operate as cases for the proposed decision support framework by describing consequences within the supply networks, implications for the food supply, and the information needs of the actors involved. In 2014, additional experts—now 30 in total since 2013—from the private sector (e.g., food logistics companies) and from public authorities (e.g., federal state agencies) were interviewed to obtain information related to food supply shortages (scenario relevant aspects, decision-makers in charge, distribution of responsibilities, etc.). In particular, possible countermeasures and information needs of the key players involved (“Landkreise und kreisfreie Städte”, “Regierungsbezirke”, “Bundesländer”, “Bund”, private sector) were identified during an expert workshop (“Notfallplanung für Lebensmittellücken”) at KIT with more than 25 representatives from public authorities of different administrative levels from Baden-Württemberg and one from the Federal Office for Agriculture and Food (BLE). The workshop evaluation is still ongoing. Based on results from this and one further internal workshop, a catalogue with possible countermeasures—dependent on the three scenarios—is being assembled for public authorities. Another important finding from the expert workshop was that local authorities are in charge of managing food shortages and FSC disruptions within their area of responsibility.
While food distribution via FSCs is organised supra-regionally (partly even supra-nationally). Hence, a supra-regional instance or instrument to coordinate activities by the authorities may be necessary. This challenge needs to be resolved for a successful and efficient disaster management.

Since 2014, we have been working on the three threat scenarios described above in two ways (see Fig. 1). Firstly, we use them to investigate the overall quantitative system under disruptions or states of failure. The objective is to observe how the system behaves when various input parameters are changed according to the scenario conditions. Therefore, impact factors were extracted for each scenario. They are coupled with the quantitative system in order to ensure their compliance with the input parameters of the system. Secondly, we developed various sub-scenarios (within the three threat scenarios). The sub-scenarios specify concrete decision problems that may arise in companies and authorities. This twofold usage of scenarios – from a holistic and from specific perspectives – offers two benefits: (i) the (overall) quantitative system is considered under several states of failures so as to understand how robustly and resiliently the overall FSC network reacts to disturbances and (ii) the definition of sub-scenarios allows the investigation of independent use cases to demonstrate the applicability of decision support methods.

Outlook

The second year of the SEAK project again illustrates the great synergies between the CEDIM institutes involved in the field of critical infrastructure protection (CIP). In SEAK’s upcoming research, a problem oriented concept for a decision support framework will be developed based on the results obtained so far. One realisation could be a “how-to” guideline or manual for decision-makers. A more methodical, quantitative approach is e.g. to apply multi-criteria decision analysis (MCDA) such as the multi-attribute value theory (MAVT) or the analytic hierarchy process (AHP). Figure 2 illustrates the problem structuring by a general attribute tree. The “overall goal” is the securing of food supply. The task is to fill the tree by concrete “criteria” (= “indicators”) and “alternatives” (= “countermeasures”) depending on the (sub-) scenario under investigation, i.e. the respective outcome of the system modelling (see Fig. 1) and additional information if required. Generic criteria are e.g. costs and supply service level; weights of criteria are gained by e.g. expert evaluation. Possible alternatives for public authorities are provided by the catalogue resulting from the two workshops (see above). Finally, the resulting decision support will be tested and validated via a table-top exercise.

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Business Continuity Management Against Food Supply Chain Disruptions

Frank Schätter, Marcus Wiens, Frank Schultmann

Introduction

Widespread research articles focus on decision-making in the immediate aftermath of hazardous events which affect a society and its logistical structures. Humanitarian logistics in particular is a prominent domain in this regard where the objective is to replace such affected structures temporarily. These approaches focus on situations where pre-existing logistical structures are severely disrupted and decision-makers such as governments, military, aid agencies, donors, non-governmental organizations and companies require decision support in order to implement robust logistical compensation structures that additionally hedge against various conditions of the uncertain decision situation. In turn, our approach complements the research on logistic resilience and business interruptions. Here pre-existing logistical structures have to be secured against the risk of sudden breakdowns in critical parts of the transport infrastructure.
**Objectives**

KIT-IIP works on a decision support methodology that concentrates on a decision situation where business continuity management is required to keep alive the functioning of threatened logistical structures due to a hazardous event. Decision-makers are companies themselves as operators of these logistical structures, particularly those whose businesses refer to the critical infrastructure sectors of food, water, health care, and energy. KIT-IIP cooperates with the SEAK project partner 4flow GmbH to develop a case study that applies the decision support methodology for business continuity management. A case study is developed dealing with a flu epidemic scenario in Berlin that triggers a high ratio of staff absence in a food retail company.

**Project status and outlook**

The SEAK project develops decision support concepts to prevent a hazard-affected society from possible food shortages due to food supply chain disruptions. In the course of the project heat waves, blackouts of the IT-system and staff absence have been mentioned by experts as primary risks for food shortages due to business interruptions. Based on these categories, the SEAK project consortium has defined nine threat scenarios indicating the possibility of food shortages due to, inter alia, disruptions of transport and production chains or destructions of inventory. For each threat scenario, a narrative description of the underlying decision situation has been formulated as a basis on which to develop and test innovative decision support concepts. The considered case study focuses on the decision problem of a retailer who is confronted with the problem of staff absence in a sales district. The inherent restrictions are firstly the ratio of available staff and secondly the uncertain evolution of local demands. The decision-makers are located at the management level of the food retailing company that supervises staff reallocations and has the competence to close stores in cases of necessity. To process the decision problem of staff distribution, an optimization model has been implemented where the optimal solution (distribution of available staff) depends on different demand distributions, highlighting demand shifts of the population. Each demand distribution is denoted as a scenario specification: the overall aggregation of these solutions across all scenarios leads to a set of alternatives that can be taken as actions to solve the decision problem. Testing the objective function of each alternative under all scenario specifications within the optimization model provides the basis to explore the robustness of each alternative to uncertain conditions. The application of the optimization model is work-in-progress; the conception of the case study has been submitted to the Humanitarian Technology Conference in 2015.

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**Wiederaufbau des Handelswesens zur Bewältigung von Versorgungsenpässen**

Introduction

In order to simulate power outages and their impact on Critical Infrastructures (CIs), we are using the agent-based modeling (ABM) approach – a flexible computer-aided method. The agents are autonomous and independent from other operating units. They have the ability to decide which action they take either to react to actions of other agents or to new conditions within their environment.

Aims/Objective

The objectives of the work are the study of CI behavior during power outages and investigate measures to optimize measures supporting decision-making.

Project status

To represent different CIs and their interdependencies, a relational model is being developed focusing on healthcare and water supply infrastructure. The ABM model represents CI elements as agents whose properties are stored in a database. The ABM framework is coupled to a database which allows storing and reading information related to particular simulations. It is further coupled to a Geographical Information System (GIS) allowing the visualisation of the simulation for particular geographical locations.

To consider the practical applicability of our approach, we decided together with our project partners DLR and the research centre Jülich, that the city of Karlsruhe will be our test case. Consequently, we have started to collect data concerning different elements of healthcare and water supply infrastructure in Karlsruhe. The data collection comprises characteristics and key parameter of the water supply chain and health care facilities such as hospitals, mental hospitals, dialysis practices, other smaller hospitals, and care facilities. Further to this, we are collecting potential management measures related to the above mentioned infrastructures: other options are those related to the operator and civil protection authority.

In October 2014, we participated in the organisation of the workshop “emergency planning for bottlenecks in food distribution and black-
outs”. Day two of the workshop focused on representatives of civil protection authorities and health offices in Baden-Württemberg. The aim of this workshop was to provide information for building emergency plans, to identify vulnerabilities in crisis management, and to evolve and assess concrete measures for the perpetuation of health care during a blackout. As part of the workshop, we developed a questionnaire that was mainly related to decision making, e.g. how the participants would react in different crisis situations.

Outlook

The ABM model will be enhanced by adding further CI components and implementing their behaviors. For example, it is planned to integrate fuel supply or a model of an airport, in cooperation with our project partner DLR. Various scenarios, including decision-making structures and measures, will be simulated, taking into account also the increased use of renewable energy. The simulation results will be analyzed and the appropriate strategies to mitigate the consequences to the CI and the population during power blackouts will be tested.

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Introduction

The disruption of Critical Infrastructures (CIs), which supply the population with vital services and products, can lead to severe situations that request advanced activities from disaster management authorities and CI providers. To support these activities, we focus on the development of vulnerability models which allow for the consideration of time-dependent and spatial impacts of CI disruptions. The project on decision support through vulnerability assessments is based on the example of a power outage that affects all kinds of CIs in all districts of a city.

Aims/Objective

The vulnerability model should support local disaster management authorities and CI providers with a more accurate forecast of the spatial-temporal impacts of a power outage as one example of a CI disruption. Often, the individual impacts on single infrastructures are well known. However, a comprehensive view of the functionality of CI sectors as well as a common picture of the time-dependent effects are missing. In addition, the effects of alternative business continuity measures on the overall resilience of a city should be determined based on the spatial-temporal vulnerabilities of its districts.

Project status

In our previous work on a general framework for the spatial vulnerability assessment, we used a static indicator-based approach to measure the impacts of a power outage. The results of the framework enable decision makers to compare individual vulnerabilities of districts by taking into account the locations of CIs. In particular, the selection of the most appropriate districts to conduct the load shedding procedure was facilitated. Due to such a procedure, some consumers are decoupled from the grid to ensure network stability in times of network imbalances.

In 2014, we built the scientific basis to elaborate this model including temporal considerations. For this purpose, we reviewed current research results that focused on temporal assessments of CI disruption impacts and on methodological approaches which expand indicator-based models taking into account time-dependent effects (Münzberg, Wiens, and Schultmann, 2014a). Based on this result, we concentrated our activities on the relevancies of CIs, the temporal impacts of coping capacities such as emergency power units with different sizes of fuel tanks, and day-time referenced dependencies of CIs on electricity. Other aspects issued in 2014 were the different types and numbers of CIs in a city and its relevance in providing a population with vital services and products. In Germany, there is an official definition of the CI sectors and branches that is determined from a federal perspective. At the local level of a city, there is no common or official definition of CIs that represent a city system. Also missing is a clear overview of which CIs are most relevant in providing critical services and products and, hence, should have a higher priority in supplying CIs with electricity than others. To overcome this problem, we carried out an expert survey in three steps. In the first step, we tested a questionnaire in which a small number of experts with practical experience were asked to define a priority value for CIs. For this purpose, we defined a set of CIs which was derived from the official federal definition of CI sectors which present facilities at the local level. The survey was embedded in an invited talk to an expert audience of the Program at the German Annual Trade Fair for Fire Brigades, Fire Protection and Disaster Management (Münzberg, Wiens, Schultmann, 2014b). In addition, experts were asked to add missing CIs.

In the second step, the questionnaire was adjusted based on the findings from the first step. The new questionnaire was given to experts that participated in our workshop on ‘disaster management planning for food shortages and power outages’. The experts were representatives from the local disaster management and health authorities of cities, districts, and regional governments in Baden-Württemberg which are in charge of disaster planning in their area of responsibility.
In a next step we considered different degrees of coping capacities of the CIs. To cope with a power outage, typically the CIs have emergency power units with fuel tanks of different sizes. These enable CI providers to delay the adverse effects and to ensure a continued business for a limited time. The more capacity is consumed, the less is the ability to cope with the abnormality and, hence, vulnerability increases. Based on the aggregation methodology from our previous work, it is possible to estimate district specific vulnerability profiles. These profiles display the increase vulnerability, taking into account the localization of CIs, their relevancies and their coping capacities. Decision-makers are able to conduct sensitivity analyses by changing the capacities and assessing the differences in the vulnerability profiles. This allows a comparison of the impact of different strategies and an assessment of district resiliencies. For this purpose, we developed a framework (Münzberg, Wiens, and Schultmann, 2014c). Methodologically, we used the results of temporal vulnerability analysis and predefined, time-depending protection target levels. This allows decision makers to assess how well alternative coping strategies perform and satisfy predefined goals.

Another issue in 2014 was the enhanced link to practitioners and end-user cooperation. Based on the outcome from the expert workshop, conducted in autumn 2014, we enhanced our end-user orientation and addressed several scientific issues to the practitioners. In addition, our approaches and model results were presented in several invited talks including the annual trade fair for fire brigades, fire protection and disaster management (Münzberg, Wiens and Schultmann, 2014), already mentioned above, and the PMR-Conference 2014 which is an international conference for professional mobile radio and control rooms (Münzberg, Wiens, and Schultmann, 2014d). In addition, we contributed peer-reviewed scientific papers to end-user orientated events such as the 62nd Annual Expert Meeting of the German Fire Protection Association (vfdb) (Münzberg, Wiens, and Schultmann, 2014e) and the 14th Forum on Disaster Preparedness of the German Committee for Disaster Reduction (DKKV) (Münzberg, Wiens, and Schultmann, 2014f).

**Outlook**

In 2015, we will analyze, compare, and verify the results of the various surveys. This will provide more insight in the decision-maker’s perception of the relevancies of CIs on a local level. Another interesting field for research is to consider the varying dependence of the CI on electricity with time. The dependence of a CI on electricity changes over time according to the business undertaken during a day. We assume that the vulnerability of a CI is higher at a time of the day in which this dependency reaches the highest degree. To include this aspect, we will complement our research activities by including standardized load profiles that are usually applied in the load management of electricity grids.

This approach allows for an assessment of the performances of different coping strategies. The next step would be to systematically include this into disaster management planning. For this purpose, we will investigate several business continuity measures that could define different strategies.

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Publications


Regional Climate Change and the Industry’s Fragility – An Indicator-Based Approach

Hanns-Maximilian Schmidt, Karoline Fath, Marcus Wiens, Julian Stengel, Frank Schultmann

Introduction

The IPCC’s “Fifth Assessment Report: Climate Change 2013” provides scientific evidence for the ongoing environmental changes that come along with climate change. Concerning our society and the industrial sector in particular, the efforts to mitigate or adapt to these incontrovertible challenges are subject to the decision-makers’ risk assessment and their individual and collective risk perception. In order to support risk response and strategies for adaptation on the municipal level in Baden-Wurttemberg (BW), we designed an indicator-based approach that considers regional characteristics of climate change as well as the (regional) economic structure. Therefore, we combined high-resolution climate projections (A1b scenario) for BW provided by the Institute of Meteorology and Climate Research (IMK-TRO) at the KIT with economic indicators derived from the Federal Statistical Office and from input-output analysis for the specific region. The overall goal is to raise the awareness of the stakeholders concerning regional climate change.

The project KLIMOPASS is funded by the Ministry of the Environment, Climate Protection and the Energy Sector Baden-Wurttemberg and coordinated by the Landesanstalt für Umwelt, Messung und Naturschutz Baden-Württemberg (LUBW). Our sub-project was processed from October 2013 until July 2014.

Indicator Framework for the Stuttgart Metropolitan Area

The Stuttgart Metropolitan Area includes 480 communities in 20 rural districts with more than 5 million people living there. Within the urban areas, e.g. Stuttgart, Heilbronn, Tübingen, etc., are situated some highly specialized industries. In particular, automotive companies and their suppliers play an important role regarding the employment. As the IMK-TRO’s data show, climate change is likely to affect this highly industrialized region. It forecasts a decrease in cold and frost days of more than 28 percent for the period from 2021 to 2050, whereas the number of hot days might rise to 96 percent. Days of high precipitation are also likely to increase by 21 percent compared to the reference period 1971 – 2000.

When it comes to the physical impacts of climate change and extreme weather events on

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<thead>
<tr>
<th>Category</th>
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<td>Fixed Assets</td>
<td>Specific assets</td>
<td>Dependency on operating materials</td>
</tr>
<tr>
<td>Staff</td>
<td>Personnel intensity</td>
<td>Dependency on personnel</td>
</tr>
<tr>
<td></td>
<td>Degree of staff specialization</td>
<td>Share of staff members with college degree</td>
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<tr>
<td>Infrastructure</td>
<td>Specific energy use</td>
<td>Energy consumption per revenue</td>
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<td>Dependency on energy</td>
<td>Decrease in productivity per loss</td>
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<tr>
<td></td>
<td>Specific water use</td>
<td>Water use per revenue</td>
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<td>Dependency on water</td>
<td>Decrease in productivity per loss</td>
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<td>Use of transportation</td>
<td>Diversification of transportation modes used</td>
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<td>Key Sectors</td>
<td>Sector’s importance for the supply chain</td>
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<td></td>
<td>Specific material cost</td>
<td>Measuring specialization of manufacturing processes</td>
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industry, there are four vulnerable assets to be observed: fixed assets and equipment (machinery, buildings), staff working in administration or production, infrastructure (transportation services) and economic interrelations along the supply chain that might lead to cascading effects. Within these categories we identified 10 economic indicators. Most of them can easily be drawn from official economic data whereas the factors concerning the dependency on energy and water are deducted from literature. As there are no data available for BW, the indicators state the nation-wide average for each of the 16 industrial sectors. Moreover, the indicator “Key Sector”, which indicates that a sector plays an important role as a supplier and purchaser of goods at the same time, is drawn from the regionalized input-output table for BW that we performed as suggested by Flegg & Thomo (2011). However, by using the entries of an online address database for companies in Germany we were able to assign the industries’ vulnerability indices (as a weighted sum of all indicators) to the communities. Obviously, our indicator composition focuses on the industry’s fragility. Any factors concerning resilience of the given systems are explicitly excluded as we did not want to underestimate certain aspects. The indicators were normalized on a scale from 0 to 1 and equally weighted. All of them and their short descriptions are listed in table 1.

The results clearly show that the industries suffer from different circumstances that drive their fragility towards climate change impacts. As figure 1 indicates, the fragility drivers seem to differ between the sectors according to the chosen indicators. While the chemical industry is highly driven by its dependency on water and energy and its importance for other industries, the automobile industry, for example, is quite vulnerable due to its high degree of specialized staff working in the facilities. The energy and water supply sector, however, shows a strong dependency on its static and highly exposed infrastructure and fixed assets.

Additionally, we defined climatic indicators for the area on a municipal level that were derived from changes in the climate projections over time. The high-resolution climate data (raster width: 7 km) provided by the IMK-TRO includes the following attributes for the time span from 2021 to 2050:

- Number of ice and frost days
- Number of hot days
- Number of days with high precipitation
- Maximal wind velocities

These indicators were used to define scenarios and were added to the sectorial results in order to raise the resolution of the local analysis. For each community we calculated the average change of the indicator between the two periods (1971 – 2000 and 2021 – 2050). Moreover, we added some general information on the specific regions including population densities, sum of industrial buildings etc. in order to introduce a certain weighting regarding the socio-economic attributes of the communities. This
procedure was recommended at a stakeholder workshop that we conducted in May 2013.

Results and Outlook

The high-resolution data we calculated from general, climatic and industrial indicators can easily be visualized by geographical information systems. These maps give a detailed overview on the industry’s fragility on a community level. They allow stakeholders like urban planners or companies to become aware of the projected circumstances within their region and might support climate change policies and knowledge transfer. Figure 2 gives an example of what these maps look like.

In our case study, including 480 communities, we demonstrate that the indicator-based approach is an easily comprehensible and valid tool for quick identification and analysis of hot spots of climate change impacts in highly industrialized areas. Moreover, the indicator composition and the widely available input data used allow for an application of this method to other urban regions throughout Germany and Europe. However, for developing countries one needs to define new indicators that can be adjusted to the data available. Therefore, we are looking forward to further improvement of the methodology and further case studies in other regularly affected regions.

![Fig. 2: Hot days projection (left) and the Fragility Index (right).](image)

Core Science Team

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References


Publications

Project Completion Report to be published in 2015 on the following website: http://www.lubw.baden-wuerttemberg.de.

Regionaler Klimawandel und die Fragilität der Industrie - Eine Indikatorbasierte Annäherung


Hierfür wurden unterschiedliche Szenarios und Gewichtungen eingeführt, um die Verwundbarkeit der regionalen Industrie hinsichtlich einer steigenden Anzahl an heißen und trockenen Tagen, Eis- und Frosttagen sowie der sich verändernden maximalen Windgeschwindigkeiten und Niederschlagsintensitäten zu messen und ihnen vergleichbare Werte zuzuordnen. Die Ergebnisse zeigen, dass durch die allgemein hohen Anforderungen der im Land weit verbreiteten und im Raum Stuttgart besonders geballten Automobil- und Elektroindustrie sowie durch die besondere Verwundbarkeit der Wasser- und Energieversorgung einzelne Regionen besonders vom Klimawandel betroffen sein könnten. Energie-, wasser- und personalintensive Unternehmen werden demnach die Auswirkungen am deutlichsten spüren. Auf Gemeindeebene bedeutet dies auch, dass gerade Ballungsräume mit zunehmender Spezialisierung betroffen sein werden. Im betrachteten Raum weisen die Stadt Stuttgart und ihr unmittelbares Umland eine besondere Vulnerabilität gegenüber dem Klimawandel auf, die sich aus der Aggregation aller Vulnerabilitätsindikatoren ergibt.

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 parts as testable as possible. It provides tools and software systems for retrospective testing to help improving the model during its development stage, it tests pseudo-prospectively and prospectively many components of GEM, and it works on testing high-impact assumptions of GEM. The following components have been identified as primary targets for testing:

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

Project status

Seismicity Rate Testing

We finished the work on seismicity rate testing for the region of California. Investigating a suite of 3-month forecasting models revealed useful strategies for aftershock sequence forecasting and decision support for an aftershock hazard modeler. The test of the Uniform California Earthquake Rupture forecast (UCERF2) and the forecast of the National Seismic Hazard Mapping Project (NSHMP) showed good performance when compared to the suite of forecasts from the Regional Earthquake Likelihood Models (RELM) project. One RELM model showed consistently the best performance. As a consequence, the main features of that winning model are now becoming part of UCERF and NSHMP.

We have investigated the possibilities of improving forecasts by creating ensemble models. The focus of this study was on multiplicative hybrids using the RELM models as the input models. We found that many two-model or three-model hybrids have an appreciable information gain per earthquake relative to the best individual model. Larger information gains are obtained when the contributing models involve markedly different concepts or data.

For the upcoming tests of the Global Earthquake Activity Rates (GEAR) model, we have prepared the forecast definition and have been working on the implementation for this experiment.

Ground Motion Testing

We have investigated the Euclidean Distance-Based Ranking (EDR) method for selecting and ranking ground-motion prediction equations (GMPEs) by Özkan Kale and Sinan Akkar. We found that the presented score is not proper and have documented this fact in a comment on the original paper.
Hazard Testing

Many researchers have worked on site-specific testing of hazard estimates and several scores and strategies for result interpretation were published. We have investigated the power of such statistical tests with sobering results. Under best available conditions (longest datasets) one still needs to observe a seven times higher hazard to reject the modeled hazard with a comparatively low power of 90%. The results of this work clearly demands that hazard estimates be tested on a large collection of sites.

To move into testing hazard models, we have undertaken a case study and tested the suite of National Seismic Hazard Mapping Project (NSHMP) models of the US. Unlike previous studies by others, we have used three different datasets as observations: Crowd-sourced intensity reports (“Did You Feel It?” by the USGS), ShakeMaps, and strong-motion recordings. We were able to show that the US hazard models are improving over time. This is the first rigorous, quantitative, and comparative test of US hazard models. We were also able to show that all three datasets deliver essentially the same result, allowing us in the future to test hazard models in regions for which strong-motion data are not available and only derived data like ShakeMaps or intensity reports exist.

Outlook

The first phase of GEM has ended. However, we are looking forward to the second phase in which we will work on automating the testing processes and improving decision support capabilities. Together with the Global Dynamic Exposure project, we are working towards quantitative risk testing. Finally, we aim to open our infrastructure for external experiments.

Core Science Team

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Publications

Papers


Presentations


Schorlemmer, D: Collaboratory for the Study of Earthquake Predictability, Invited talk at the Conference on Operational Earthquake Forecasting, Varenna, Italy, June 2014.
Social Vulnerability and Integrated Risk Project in GEM

Bijan Khazai, James Daniell, Christopher Power, Susan Brink, Johannes Anhorn, Christopher Burton

Fig. 1: Snapshot of the visualization of the Integrated Risk Modelling Toolkit on the OpenQuake platform.

Introduction

At the core of the Global Earthquake Model (GEM) is the development of state-of-the-art modeling capabilities that can be used worldwide for the assessment and communication of seismic risk. The socio-economic vulnerability and integrated risk working group is working on the implementation of methods, metrics, and tools for holistic evaluation of earthquake risk, such as indexes for social vulnerability, resilience, and indirect loss. The two year Socio-economic Vulnerability and Integrated Risk Project began in September 2012 as a collaboration between CEDIM (KIT) and the GEM Foundation and the Willis Research Network (WRN). The project is led by Bijan Khazai from KIT and is a part of the Social Vulnerability and Integrated Risk Program of GEM coordinated by Christopher Burton.
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 of 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.

Project status

The CEDIM Socio-economic Vulnerability and Integrated Risk Project was completed in December 2014 and the results are to be presented at the 2015 GEM Reveal. One of the key outcomes of the project has been the development of multiple comprehensive, spatially enabled databases for building indicators and indices of social and economic vulnerability that are integrated with the Open Quake Platform (Power et al., 2015). These are scaled at the national level for the globe, sub-national level for the Asia-Pacific region. Another major accomplishment has been the design and development of an Integrated Risk Modelling Toolkit in collaboration with the GEM Modelling Facility (Khazai et al., 2014). The Toolkit has recently been released as an extension for Quantum GIS and allows users to access the Global and Sub-National databases on the Open Quake platform for the development of social, economic, and integrated risk indices (Fig. 1). Moreover, the software tool will allow users to manipulate and interact with all of the data, which may be inputs to both physical earthquake risk and social vulnerability models.

To demonstrate the potential of the databases and the tool, two use cases were developed by the Social Vulnerability and Integrated Risk working group. One of these is an indicator framework for quantifying the potential for indirect economic losses from earthquakes developed by James Daniell (Daniell et al., 2015). The framework is based on a comprehensive review of existing literature and methods associated with indirect losses, and utilizes indicators from the Global and Sub-national databases to operationalize a ranking of indirect loss potential world-wide and for Prefectures in Japan. A second framework and index was produced by Susan Brink for population displacement following disasters which provides a simple way of representing the multiple aspects of population displacement and the factors that aggravate them using a comprehensive review of the existing literature (Brink et al., 2015). The Sub-national database in GEM has been used for operationalizing the framework for es-

![Six dimensions of the Multi-level Risk and Resilience Scorecard with a spider chart showing implementation at both the Municipal and Ward levels.](image-url)

Fig 2: Six dimensions of the Multi-level Risk and Resilience Scorecard with a spider chart showing implementation at both the Municipal and Ward levels.
imating vulnerability to disaster displacement of Prefectures in Japan.

Besides the development of quantitative indicators for estimating social and economic vulnerability that can be computed from publically available databases, a key thrust in the project has been an alternative approach focusing on qualitative information for the production of relevant indicators and targets representative of key functional and organizational areas for urban resilience, based on a participatory assessment process with local government officials. The result has been development of a Multi-level Risk and Resilience Scorecard in collaboration with GEM, the South Asia Institute (SAI) of Heidelberg University and the National Society for Earthquake Technology (NSET) (Khazai, et al., 2014). The Scorecard was implemented as a self-evaluation tool with both Ward-level and Municipal representatives from Lalitpur in March 2014 and empowered these stakeholders to quantitatively assess resilience parameters based on their experiential knowledge and perception of the city’s disaster resilience along six dimensions (Fig. 2).

To extend and deepen CEDIM’s collaboration with GEM and build on the existing experiences and capacities developed, a project concept has been discussed with GEM and a proposal submitted to the GEM Governing Board. In particular, the proposed project aims to go beyond result-oriented monitoring and evaluation tools by developing, and testing under various contexts, a Participatory Multi-level Resilience Assessment and Management Framework, Handbook and Scorecard Tool.

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References


Soziale Verwundbarkeit und integriertes Risiko in GEM

II. Strategic Partnerships

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 centers in this field take part in the initiative that is jointly coordinated by Helmholtz Centre Potsdam GFZ, German Research Centre for Geosciences GFZ and Helmholtz Centre Geesthacht, Centre for Materials and Coastal Research HZG. The coordination office is located at GFZ. In cooperation with the participating Helmholtz centres, ESKP provides the latest research findings and news about ongoing events in the three focal areas (1) natural hazards, (2) climate change, and (3) transport of substances and pollutants. Thus, ESKP is an important partner for CEDIM in disseminating results of the Forensic Disaster Analysis to the media and the public and as such significantly increases the distribution of the results. With its expertise on natural hazards and risks, and in particular with the current focus on Forensic Disaster Analysis in near real-time, CEDIM is an important partner for ESKP.

Aims / Objective

ESKP communicates scientific results and knowledge on environmental processes, the Earth system, its dynamics and risks achieved in the eight Helmholtz Centers in a way that enables society to mitigate hazardous developments and react adequately to present and future environmental changes. By editing and providing knowledge in an appropriate way, ESKP aims to support the dialogue between science, politics, economy, education and the public. In each Helmholtz centre an ESKP staff member is established as a partner for scientists to ensure the knowledge transfer from the eight centers and its integration into ESKP.

Project status

The bilingual Helmholtz knowledge platform www.eskp.de was launched in May 2014. CEDIM researchers contributed in several ways to the platform and used it to disseminate research results.

In the case of CEDIM FDA Task Force activities, CEDIM provided the FDA reports with an additional summary to ESKP, making the CEDIM reports accessible for a wider audience than may be reached via the CEDIM website alone. When the platform was still under construction, CEDIM provided the first FDA reports to ESKP after Typhoon Haiyan in November 2013 with a focus on rapid loss assessments and rapid mapping of damage in the City of Tacloban. In the course of the year 2014, CEDIM researchers analyzed a number of events in short CEDIM summaries outside FDA activities and provided them to ESKP: other examples were the Typhoons Hagupit and Rammasun that hit the Philippines in December 2014 and in July 2014 respectively, the thunderstorms in North-Rhine-Westphalia, Germany, in July 2014, and the floods in Eastern Europe in May 2014. Reports on past events such as Hurricane Sandy...
Strategic Partnerships

in 2012 and the floods in Germany 2013 were included retrospectively on the portal to foster collaboration and knowledge transfer in the topic natural hazards on www.eskp.de.

CEDIM researchers have complemented the reports on ongoing or recent events by short articles that explain basic knowledge on natural hazard processes such as hail, thunderstorms, tropical storms, or earthquakes, and on related topics such as storm hazard in Germany, risk assessment, early warning systems, and the relationship between urbanization and disasters.

In addition, the interactive CEDIM Risk Explorer is accessible via www.eskp.de.

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Research

Cooperation with Integrated Research on Disaster Risk (IRDR)

Since 2012, CEDIM has been cooperating with the program “Integrated Research on Disaster Risk” (IRDR, www.irdrinternational.org), an initiative of the International Council for Science (ICSU), the International Social Science Council (ISSC) and the United Nations International Strategy for Disaster Reduction (UNISDR). Having coined the term “forensic disaster investigations”, the IRDR initiative identified forensic investigations of disasters (FORIN) as one of its key activities that “aims to uncover the root causes of the disasters through in-depth investigations that go beyond the typical reports and case studies conducted after disasters” and to “help build an understanding of how natural hazards do—or do not—become disasters.” (IRDR Strategic plan 2013-2017, http://www.irdrinternational.org/wp-content/uploads/2013/04/IRDR-Strategic-Plan-2013-2017.pdf).

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

In 2014, two CEDIM researchers attended the 2nd IRDR Conference in June in Beijing, China and participated in the FORIN session. The session included an introduction to FORIN and two presentations covering FORIN investigations conducted by researchers in other institutions. In addition, the CEDIM researchers gave two presentations on research conducted by CEDIM. The first presentation summarized the CEDIM FDA project detailing methods and giving examples of the output of some FDA investigations. The second presentation discussed in detail one of the CEDIM FDA projects. Following these presentations there was a question and answer session during which participants discussed each individual project and the relationship between FDA and FORIN.
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 more than 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 still is the only German partner of the network since 2009. As a partner of the WRN, CEDIM staff gather experience in the cooperation with the insurance industry and has learned about their needs and research priorities. WRN cooperates with CEDIM by funding Willis fellows at the working groups “Atmospheric Risks” (IMK/KIT) on the topic of hail risk modeling and “Vulnerability and Risk” (GPI/KIT) related to earthquakes.

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 compounded nature of earthquake events through consideration of factors related to socio-economic vulnerability and development of global and sub-regional socio-economic databases. Uses cases in Japan, Kathmandu (Nepal) and Quezon City (Philippines) are also developed for the application of the indicator tools for various contexts and different scales of geography.

In the first project, CEDIM still works on the hazard component of the Willis European Hail model WEHM which estimates frequency, extent and severity of hail events (see the article “The Challenge of Hail Hazard and Risk Modelling” earlier in this annual report). The model is based on overshooting top data from METEOSAT Second Generation (MSG) satellite as a proxy for hail. This method leads to a unique, spatially homogeneous event data set covering continental Europe. The risk component of the model is done by Willis. Currently the WHEM model is used by more than 20 insurance companies. A close collaboration on a day-to-day basis quickly developed between the Willis CatNat team in London and KIT atmospheric risks group fostered further development and improvement of the WEHM. Model specifications were continually reviewed based on needs and available data.

References


Punge, H.-J., A. Werner, K. Bedka, and M. Kunz, 2014: Hail hazard distribution in Europe: Analysis based on the overshooting cloud top (OT) proxy & application in a catastrophe risk model. 1st European Hail Workshop, 25–27 June 2014, Bern, Switzerland


Sparkassenversicherung SV

Within the framework of the project HARIS-SV (Hail Risk SV), IMK developed a novel and unique hail model for the SV Sparkassenversicherung insurance company. This 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 (see the article “The Challenge of Hail Hazard and Risk Modelling” in this annual report). Currently, the hail model is further improved and calibrated by considering adjusted hail-size distributions and different damage functions based on loss experiences of past hailstorms. Furthermore, a modified version of the HARIS-SV model is developed that allows for estimating overall losses in near-real time, which can be used in the case of a CEDIM FDA activity where hail is important.
In 2014 a new 3-year project was established between CEDIM and the SV within the project FLORIS-SV (Flood Risk SV Sparkassenversicherung). This project aims at estimating damage related to widespread extreme flood scenarios based on stochastic modelling of precipitation processes and resulting floods. A special focus will be put on events that occur simultaneously in different catchment areas, thus leading to extreme loss situations. In the first step, the area under investigation is restricted to the federal state of Baden-Württemberg, where the SV portfolio is large. Involved in the project are IMK-TRO (WG Atmospheric Risks), IWG (Abt. Numerical Models in Hydraulic Engineering and Dep. Hydrology), and James E. Daniell.

References


Cooperation with alpS - Centre for Climate Change Adaptation

The alpS – Centre has been established as a K1-Centre of the Austrian Competence Centre Programme for excellent Technologies and as such is an independent, non-university research and development platform with its focus on natural hazards, risks and climate change adaption in Innsbruck, Austria.

After the first meeting in November 2013 in Innsbruck and the agreed „Memorandum of Understanding“ both CEDIM and alpS acknowledge the similarities in the scholarly pursuits of the institutions and the desire to promote inter-institutional cooperation, scientific, technical and cultural exchange, and mutual understanding. Since then, the cooperation was intensified in terms of projecting and scheduling a joint workshop in 2015 on the exchange of experience, students and staff, and establishment of joint research and development programmes concerning Disaster Risk Reduction, Risk Management and Climate Change Adaption.
Stakeholder Interactions for Near Real-Time Forensic Analysis of Disasters

Introduction

The Forensic Disaster Analysis (FDA) research in CEDIM requires innovative approaches 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 organizational 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, a series of engagements were planned with carefully selected group of stakeholders to map their needs and identify exchange and interaction processes.

Aims/Objective

Stakeholder interactions were planned and carried out among both public and private sectors, including civil protection, humanitarian aid, insurance/re-insurance and scientific organizations. The two overarching goals of these activities were to (a) engage both scientists and stakeholders in a dialogue to discover the needs of potential FDA beneficiaries in the context of CEDIM’s FDA mission, and (b) provide input to further develop and improve FDA tools/methods for obtaining meaningful parings of FDA research outputs and end user uptake.

The results (positive or negative) of interaction with each of the stakeholders were 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 analyses and modeling results into relevant outputs that could better serve the needs of the respective stakeholders.

Project Status

From July 2013 until May 2014 CEDIM researchers held nine workshops/meetings with key representatives of several organizations within both public and private sectors. These include meetings with the Federal Office of Civil Protection and Disaster Assistance (BBK) on July 5, 2013; USAID Office of Foreign Disaster Assistance (OFDA) on August 2, 2013; European Commission – Humanitarian Aid and Civil Defense (DG-ECHO) on September 9, 2013; German Red Cross (DRK) on September 22, 2013; Technische Hilfswerk (THW) on October 17, 2013; Google Crisis Response and Google Earth Engine on December 17-18, 2013; Guy Carpenter on January 30, 2014, UNESCO Natural Disaster Reduction (SC/DRR) on March 6, 2014 and Griffith University (Crisis Communication) on May 5-7, 2014. Prior to each meeting a background document is prepared where areas of common interest related to FDA activities are documented and used as a basis for developing the meeting agenda and steering the discussions. Several research themes were identified to be of potential interest to stakeholders based on these engagements and have been selected for follow-up. These include: near real-time evaluation of public communication of disaster impacts (USAID); near real-time prognosis of causality, displaced persons and economic losses (DG ECHO/JRC); near real-time shelter needs evaluation (German Red Cross).

Concluding Remarks and Outlook

The initial set of stakeholder interactions have resulted in a set of recommendations for structuring the FDA reports which represent a wide spectrum of views. For example, while some users thought that the FDA reports were too long and text heavy, others saw the reports as “not going deep enough”. Similarly, among the different sectors we engaged with were some who thought that 10 days was an appropriate interval for releasing the reports, while others reported that they would need information on likely impacts within several hours of the first day. In general, representation of key information through a one page summary and graphical abstract was recommended and taken up by CEDIM in structuring the report. Furthermore, the use of a web-based application and platform for uploading and sharing geospatial information from the FDA investigations such as GeoNode is currently being discussed at CEDIM.

Overall, it was agreed that more of CEDIM’s own analysis should be captured in the FDA reports and that follow-up reports beyond the initial period are desirable. Ideally these should
Strategic Partnerships

be combined with on-site investigations and based on clear areas of contribution in targeted partnerships. Currently, research into public communication of disaster impacts - including a field investigation following Typhoon Haiyan - is being planned in the Philippines and targeted engagements with stakeholders on site have been sought.

References

III. Publications 2014

Articles in Journals and Books


Mak, S., Clements, R.A. and Schorlemmer D. (2014): Comment on “A New Procedure for Selecting and Ranking Ground-Motion Prediction Equations (GMPEs): The Euclidean Distance-Based Ranking (EDR) Method” by Ozkan Kale and Sinan Akkar,


CEDIM Reports


Conference Abstracts


Hoechner A., Bedford J, Moreno M., Hainzl S. and Dahm T. (2014): Coupling at the Northern Chile seismic gap and moment balance after the Mw=8.2 Pisagua event 2014, AGU fall meeting S33E-03.


Imprint

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Cover picture: High Speed Train “Shinkansen” in vulnerable urban environment in Japan (PhoTones works #4675)
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