Karlsruhe Institute of Technology

CEDIM

RESEARCH REPORT 2017 – 2020

Content

Imprint

CEDIM Research Report 2017 – 2020

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Cover picture: Riverbed of the Elbe in Magdeburg (Germany) on 8 July 2018 (Image credit: Marco Kaschuba).

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Preface

...and then Corona happened, and everything was different: most of the CEDIM team worked from home, meetings took place only via video, conferences and events were cancelled, and the finalisation of this research report has also been delayed significantly.

However, Corona has also occupied CEDIM in other ways, because a pandemic shows many parallels to natural disasters, which are normally our focus. In both cases, resilience concepts adjusted to local scale are crucial for the mitigation of impacts. Also in both cases, valid, up-to-date, and high-resolution data and information are the foundation for important decisions – be it on relief measures or on measures to prevent the spread of the corona virus. Therefore, CEDIM and Risklayer (CEDIM/KIT spin-off) teamed up with many volunteers to collect current Covid-19 case numbers on a sub-national level by means of crowd sourcing already this February. The numbers are processed using the CATDAT database and distributed via the new CEDIM/Risklayer Explorer (Chapter I). Compared to official statistics of the Robert Koch Institute (RKI), the information collected by CEDIM/Risklayer is more up-to-date and has a higher granularity – in particular for Germany, where it is partly available down to the municipal level (*"In order to be able to react rapidly to a regional corona outbreak, these data [KIT/Risklayer] are more suitable than those of the RKI."* – ZDF television channel on 03.08.2020). The interest in these data is considerable: besides the use in future research projects, they are processed by various media (ZDF, Tagesspiegel, MDR, etc.) and feed into the dashboard of the Johns Hopkins University; there was even a request from the Federal Government (BM Karliczek).

The Center for Disaster Management and Risk Reduction Technology (CEDIM) is an interdisciplinary research institute at Karlsruhe Institute of Technology (KIT) in the fields of disasters, risks, and security. CEDIM conducts research on the causes, the handling and prevention of natural and technical risks and develops new models and concepts for this purpose. In doing so, we exploit the synergy potential created by interdisciplinary cooperation at KIT and by strategic cooperation with national and international institutions, institutions of civil protection, and the insurance industry. Currently, ten KIT institutes are involved in CEDIM. The present report provides an overview of the research work and activities of CEDIM during the years 2017 to 2020.

In the past funding phase (2016 – 2019), the projects financed by CEDIM focused on the fields of energy, mobility, and information identified by the Overarching KIT 2025 Strategy (Chapter I). In all three of these fields, society is in urgent need for innovation, implying change and challenges for risk and security research – especially in the context of the Paris Climate Agreement, the energy transition in Germany, and changing mobility. The projects funded by CEDIM had the objective to investigate the resilience of existing and future energy and mobility systems using model analyses and case studies in test areas and to identify critical elements and processes that are decisive for failure of various systems. Major questions in risk and disaster research were addressed, ranging from hazards and systemic resilience to social impacts and risk management. These projects were complemented by research on rapid loss estimation after natural disasters and by modelling of hazard and risk from tsunamis. In addition to the existing internet platform www.wettergefahren-fruehwarnung.de, which was revised last year and is now available in English, the information portal www.risklayer-explorer.de was launched, on which the Covid-19 statistics are now available as interactive graphics. Furthermore, the CEDIM team was very successful in applying for third-party funded projects, which complement existing research activities in CEDIM neatly. They range from modelling of hazards and risks caused by severe wind gusts, floods, and hail to decision support systems and emergency logistics for urban areas to resilience of critical infrastructures.

The past two summers in Germany and Central Europe were characterized by exceptionally long and intense heat waves and a severe drought (Chapter II), unique for the period of instrument-based weather observation. The consequences of the heat and drought episodes, which are dramatically amplified by climate change, are manifold: increased mortality as a result of (hydro-)thermal stress, reduced transport capacity on waterways, restrictions in energy generation and industrial production, large-scale damage to forests and trees, and poor harvest in agriculture. In addition to the reduction of greenhouse gases, increased research activities on handling, adaptation and the development of strategies to deal with heat waves and droughts are needed urgently. For this reason, the topic "Effects of heat waves and droughts in Germany on society, the economy and ecology" was selected as a priority of the new research programme for 2020 to 2023. The results of this priority area will be presented in the next research report.

Forensic disaster analysis (FDA) in near-real time has also been a focus of CEDIM's work in recent years (Chapter II). The objectives of this ex-post research approach are: to assess a disaster directly after its occurrence, to estimate its consequences, to track its temporal development and to identify the main factors that determine its impact. As part of an FDA activity, CEDIM publishes reports with different foci in a timely manner, i.e. a few hours to days/weeks after the disaster has occurred. Since 2017, 7 FDA reports and 12 short reports on recent events were produced (Chapter II). The report on Hurricane Harvey and the associated large-scale flooding of Huston/USA in August 2017 received the greatest media attention, followed by over 1,500 citations, mainly in international media. In the aftermath of tropical cyclone Idai, which severely affected large parts of Southeast Africa in April 2019, CEDIM's damage estimates were also used by the World Bank to allocate aid funds. In addition, several hundred reports on extreme weather events, earthquakes and catastrophes worldwide were published on the Internet platforms www.wettergefahren-frühwarnung.de, earthquake-report.com, and CatNews operated by CEDIM employees.

In the recent years, several new collaborations were established with various research institutions or programmes (Chapter III), such as the University of Adelaide, the Institute for Environmental Studies (VU Amsterdam in the Netherlands) or the Swinburne University of Technology in Melbourne (Australia). A cooperation agreement between the World Bank and CEDIM is about to be concluded. Since 2019, CEDIM has been an official member of the Knowledge Action Network on Emergent Risks and Extreme Events (Risk KAN) of the World Meteorological Organization (WMO) and the German Committee for Disaster Reduction (Deutsches Komitee für Katastrophenvorsorge, DKKV). Since 2018, the CEDIM spokesman has also been a member of the advisory board of the SV SparkassenVersicherung foundation "Umwelt und Schadenvorsorge" (Environment and risk prevention), whose new scholarship programme (from 2020) is planned to integrate with the work of CEDIM. There are still close collaborations with the insurance sector, in particular with SV SparkassenVersicherung, for which CEDIM has developed risk models for hail, floods and earthquakes, and with the Willis Research Network (WRN), where CEDIM is involved in the development of hail risk models for Europe, Australia, and South Africa through a cooperation with NASA in a claimed "Flagship Project".

Another important pillar of CEDIM's success is knowledge transfer from research to the society (Chapter IV). This includes, of course, the numerous ISI-referenced publications by CEDIM scientists, the publication of FDA reports and short reports as well as the interactive internet platforms with very high access rates (Chapter V). CEDIM is involved in several sessions at the European Geoscience Union (EGU), has written numerous articles for the website Earth System Knowledge Platform (ESKP; www.eskp.de) of the Helmholtz Association and has been quoted frequently in articles of high-ranking media (e.g. The New York Times, Bloomberg, Die Zeit, FAZ, ARD, ZDF, SWR, Deutschlandradio and others). Through numerous invited presentations and participation in Science Slam/FameLab competitions, both important stakeholders and the public are informed about CEDIM's work.

Further highlights of the last years were:

- Visit of the then president of the Federal Agency for Technical Relief (Technischen Hilfswerks, THW) Albrecht Broemme in April 2018;
- An invitation of the CEDIM spokesman to the German Bundestag within the framework of the Future Forum on Public Safety and a presentation on "Resilience of a changing society" in June 2018;
- BMBF Number of the Week given by CEDIM: "192 billion US dollars damage caused by storms in 2017" in September 2017;
- News in the renowned journal Science about „These winemaking regions are most at risk from natural hazards" in May 2017.

In addition, CEDIM was also successfully evaluated in 2017.

Finally, we would like to thank all those who contributed in various ways to the success of CEDIM: first and foremost, of course, the highly motivated and committed staff of CEDIM, including many volunteers, the members of the Coordinating Committee, the CEDIM General Manager, the student assistants, and, of course, KIT as the supporting institution. Here, we would like to particularly thank Prof. Oliver Kraft (Vice President Research) for his support and Dr. Karl-Friedrich Ziegahn (Head of Division 4: Natural and Built Environment), who chaired the executive board of CEDIM from 2016 until his retirement in October this year. Many thanks to all of you.

Michael Kunz, Stefan Hinz,
Franz Nestmann, James Daniell

Vorwort

…und dann kam Corona und alles war anders: Die meisten CEDIM Mitarbeiterinnen und Mitarbeiter arbeiteten fortan im Homeoffice, Besprechungen fanden nur noch per Video statt, Konferenzen und Veranstaltungen wurden abgesagt, und auch die Fertigstellung dieses Forschungsberichts hat sich deutlich nach hinten verschoben.

Corona hat CEDIM aber noch auf andere Weise beschäftigt, denn eine Pandemie zeigt viele Parallelen zu Naturkatastrophen, die ja eigentlich im Fokus unserer Arbeiten stehen. In beiden Fällen sind angepasste Resilienzkonzepte auf lokaler Ebene für die Minderung der Folgen entscheidend. Und in beiden Fällen bilden möglichst valide, aktuelle und hoch-aufgelöste Daten und Informationen eine wichtige Grundlage für Entscheidungen – hinsichtlich Hilfsmaßnahmen oder Maßnahmen gegen die Ausbreitung des Coronavirus. Daher sammeln CEDIM und Risklayer (Spin-off CEDIM/KIT) gemeinsam mit vielen Freiwilligen via Crowd-sourcing seit Februar dieses Jahres aktuelle Covid-19 Fallzahlen auf subnationaler Ebene, bereiten diese mit Hilfe der Datenbank CATDAT auf und machen sie über den neuen CEDIM/Risklayer-Explorer zugänglich (Kapitel I). Gegenüber den offiziellen Zahlen des Robert Koch-Instituts (RKI) sind die von CEDIM/Risklayer gesammelten Zahlen aktueller und weisen eine höhere Granularität auf – insbesondere für Deutschland, wo sie zum Teil bis auf Gemeindeebene vorliegen (*„Um schnell auf einen regionalen Corona-Ausbruch reagieren zu können, sind diese Daten [KIT/Risklayer] besser geeignet als jene des RKI."* ZDF vom 03.08.2020). Das Interesse an diesen Daten ist erheblich: neben der Nutzung für zukünftige Forschungsprojekte werden sie von verschiedenen Medien verwendet (ZDF, Tagesspiegel, MDR u.a.) und fließen ein in das Dashboard der Johns Hopkins University; sogar von der Bundesregierung (BM Karliczek) kam eine Anfrage.

Das Center for Disaster Management and Risk Reduction Technology, kurz CEDIM, ist eine Disziplinen-übergreifende Forschungseinrichtung des Karlsruher Instituts für Technologie (KIT) auf den Themenfeldern Katastrophen, Risiken und Sicherheit. CEDIM forscht über die Ursachen, die Bewältigung und Prävention natürlicher und technischer Risiken und entwickelt hierfür neue Modelle und Konzepte. Wir schöpfen dabei aus dem Synergiepotential, das durch die interdisziplinäre Zusammenarbeit am KIT und durch strategische Kooperationen mit nationalen und internationalen Institutionen, Einrichtungen des Katastrophenschutzes und der Versicherungsindustrie entsteht. Derzeit sind zehn Institute des KIT an CEDIM beteiligt. Der vorliegende Bericht gibt einen Überblick über die Forschungsarbeiten und Aktivitäten von CEDIM in den Jahren 2017 bis 2020.

In der letzten Förderphase (2016 – 2019) erfolgte eine stärkere Fokussierung der durch CEDIM geförderten Projekte auf die in der Dachstrategie KIT 2025 identifizierten Profilschärfungsfelder Energie, Mobilität und Information (Kapitel I). Alle drei gesellschaftlichen Bedarfsfelder sind verbunden mit Implikationen und Herausforderungen für die Risiko- und Sicherheitsforschung – insbesondere auch vor dem Hintergrund des Klimaabkommens von Paris, der Energiewende in Deutschland oder dem Mobilitätswandel. Die durch CEDIM geförderten Projekte hatten zum Ziel, anhand von Modellanalysen und Fallstudien in beispielhaften Testgebieten die Resilienz bestehender und zukünftiger Energie- und Mobilitätssysteme zu untersuchen und dabei kritische Elemente und Prozesse zu identifizieren, die für das Versagen verschiedener Systeme maßgeblich sind. Dabei wurden wichtige Fragen der Risiko- und Katastrophenforschung von der Gefährdung über die systemische Resilienz bis hin zu den gesellschaftlichen Auswirkungen und den Umgang mit Risiken adressiert. Ergänzt wurden diese Projekte durch Forschungsarbeiten zur schnellen Schadenschätzung nach Naturkatastrophen und der Modellierung der Gefährdung und des Risikos durch Tsunamis. Neben der bereits bestehenden Internet-Plattform www.wettergefahren-fruehwarnung.de, die im vergangenen Jahr einen Relaunch erfahren hat und nun in Englisch verfügbar ist, ging im März dieses Jahres das Informationsportal www.risklayer-explorer.de online, über das nun auch die Covid-19 Fallzahlen als interaktive Grafiken zugänglich sind. Des Weiteren waren CEDIM Mitarbeiterinnen und Mitarbeiter sehr erfolgreich in der Beantragung von Drittmittelprojekten, die die bestehenden Forschungsaktivitäten in CEDIM sehr gut ergänzen. Diese spannen einen Bogen von der Modellierung der Gefährdung und des Risikos durch Starkwindböen, Hochwasser und Hagel über Entscheidungsunterstützungssysteme und die Notfalllogistik für urbane Gebiete bis hin zu Fragestellungen der Resilienz kritischer Infrastrukturen.

Die beiden vergangenen Sommer in Deutschland und Mitteleuropa waren geprägt von außergewöhnlich langen und intensiven Hitzewellen und einer Dürre (Kapitel II), die seit der instrumentellen Wetterbeobachtung einzigartig ist. Die

Folgen der durch den Klimawandel massiv verstärkten Hitze- und Dürreepisoden sind vielfältig: eine erhöhte Mortalität infolge der (hydro-)thermischen Belastung, verminderte Transportkapazität auf den Wasserstraßen, Einschränkungen bei der Energieerzeugung und der industriellen Produktion, großflächig geschädigte Wälder und Bäume und Ernteeinbußen in der Landwirtschaft. Neben der Reduktion der Treibhausgase sind verstärkte Forschungsaktivitäten hinsichtlich Umgang, Anpassung und Strategieentwicklung an Hitzewellen und Dürren dringend notwendig. Daher wurde das Thema „Auswirkungen von Hitzewellen und Dürren in Deutschland auf Gesellschaft, Wirtschaft und Ökologie" als Schwerpunkt für das neue Forschungsprogramm 2020 bis 2023 auswählt. Ergebnisse dieses Schwerpunkts werden im nächsten Forschungsbericht vorgestellt.

Forensische Katastrophenanalysen in nahe-Echtzeit (Forensic Disaster Analysis, FDA) bildeten auch in den vergangenen Jahren einen Schwerpunkt der Arbeiten von CEDIM (Kapitel II). Die Ziele dieses ex-post Forschungsansatzes sind es, unmittelbar nach dem Eintreten einer Katastrophe diese zu bewerten, die Folgen abzuschätzen, die zeitliche Entwicklung nachzuverfolgen und die wichtigsten Faktoren zu identifizieren, die für die Auswirkungen maßgeblich sind. Im Rahmen einer FDA-Aktivität verfasst und veröffentlicht CEDIM zeitnah, also wenige Stunden bis Tage/Wochen nach dem Eintreten einer Katastrophe, Berichte mit unterschiedlichen Schwerpunkten. Seit 2017 wurden sieben FDA-Berichte und 12 Kurzberichte zu aktuellen Ereignissen verfasst (Kapitel II). Die größte mediale Aufmerksamkeit erfuhr der Bericht zu Hurrikan Harvey und den damit verbundenen großflächigen Überschwemmungen von Huston/USA im August 2017, dem über 1.500 Zitierungen vor allem in internationalen Medien folgten. Im Nachgang des tropischen Wirbelsturms Idai, der im April 2019 weite Teile Südostafrikas schwer getroffen hat, wurden die Schadenschätzungen von CEDIM auch von der Weltbank verwendet, um Hilfsgelder zu allokieren. Zusätzlich wurden mehrere hundert Berichte zu extremen Wetterereignissen, Erdbeben und Katastrophen weltweit über die von CEDIM Mitarbeiterinnen und Mitarbeitern betriebenen Internetplattformen www.wettergefahren-frühwarnung.de, earthquake-report.com und CatNews veröffentlicht.

In den vergangenen Jahren wurden mehrere neue Kooperationen mit verschiedenen Forschungseinrichtungen bzw. Programmen etabliert (Kapitel III), etwa der Universität Adelaide, dem Institute for Environmental Studies (VU Amsterdam in den Niederlanden) oder der Swinburne University of Technology in Melbourne (Australien). Ein Kooperationsvertrag zwischen der Weltbank und CEDIM steht kurz vor dem Abschluss. Seit 2019 ist CEDIM offiziell Mitglied bei der Knowledge Action Network on Emergent Risks and Extreme Events (Risk KAN) der World Meteorological Organization (WMO) und dem Deutschen Komitee für Katastrophenvorsorge e.V. (DKKV).

Außerdem ist der CEDIM-Sprecher seit 2018 Mitglied des Kuratoriums der Stiftung "Umwelt und Schadenvorsorge" SV SparkassenVersicherung, dessen neues Stipendienprogramm (ab 2020) mit den Arbeiten von CEDIM vernetzt werden soll. Enge Verbindungen bestehen nach wie vor mit der Versicherungsindustrie, insbesondere mit der SV SparkassenVersicherung, für die CEDIM Risikomodelle für Hagel, Hochwasser und Erdbeben entwickelt hat, sowie mit dem Willis Research Network (WRN), bei dem CEDIM über eine Kooperation mit der NASA in einem sogenannten „Flagship Project" an der Entwicklung eines Hagelrisikomodells für Europa, Australien und Südafrika beteiligt ist.

Eine weitere wichtige Säule von CEDIM ist der Wissenstransfer von der Forschung in die Gesellschaft hinein (Kapitel IV). Dazu zählen natürlich die zahlreichen ISI-referenzierten Veröffentlichungen der CEDIM-Wissenschaftler/-innen, die Veröffentlichung der FDA Berichte und Kurzberichte sowie die interaktiven Internetplattformen mit sehr hohen Zugriffszahlen (Kapitel V). CEDIM ist beteiligt an mehreren Sessions bei der European Geoscience Union (EGU), hat vielfältige Artikel bei der Internetpräsenz Earth System Knowledge Platform (ESKP; www.eskp.de) der Helmholtz-Gemeinschaft verfasst und wurde und wird immer wieder in Beiträge hochrangiger Medien (z.B. The New York Times, Bloomberg, Die Zeit, FAZ, ARD, ZDF, SWR, Deutschlandradio u.a.) zitiert. Durch zahlreiche eingeladene Vorträge und Teilnahme an Science Slam/FameLab Wettbewerben werden sowohl wichtige Stakeholder als auch die breite Öffentlichkeit über die Arbeiten von CEDIM informiert.

Weitere Höhepunkte der letzten Jahre waren:

- Besuch des damaligen Präsidenten des Technischen Hilfswerks (THW), Herrn Albrecht Broemme im April 2018;
- Einladung des CEDIM-Sprechers in den Deutschen Bundestags im Rahmen des Zukunftsforums Öffentliche Sicherheit und Vortrag zum Thema „Resilienz einer Gesellschaft im Wandel" im Juni 2018;
- BMBF Zahl der Woche von CEDIM: „192 Milliarden US-Dollar Schaden haben Stürme 2017 angerichtet" im September 2017;

- Nachricht im renommierten Fachmagazin Science über „These winemaking regions are most at risk from natural hazards" im Mai 2017.

Außerdem erfolgte im Jahr 2017 die erfolgreiche Begutachtung des CEDIM.

Zum Schluss möchten wir allen einen großen Dank aussprechen, die in unterschiedlicher Weise zum Erfolg von CEDIM beigetragen haben: allen voran natürlich den engagierten und hoch motivierten Mitarbeiterinnen und Mitarbeitern des CEDIM einschließlich der vielen Freiwilligen, den Mitgliedern des Koordinierungsausschusses, der CEDIM Geschäftsführerin, den studentischen Hilfskräften und natürlich dem KIT als fördernde Einrichtung. Hier gilt unser Dank insbesondere Herrn Prof. Oliver Kraft (Vizepräsident Forschung) für seine Unterstützung und Herrn Dr. Karl-Friedrich Ziegahn (Leiter Bereich IV: Natürliche und gebaute Umwelt), der von 2016 bis zu seinem Eintritt in den Ruhestand im Oktober dieses Jahres den Vorsitz des CEDIM-Vorstands inne hatte. Vielen Dank Euch/Ihnen allen.

Michael Kunz, Stefan Hinz,
Franz Nestmann, James Daniell

I. Research

CEDIM Projects

Disaster information portal: CEDIM/Risklayer-Explorer

Andreas Schäfer
Geophysical Institute (GPI)
Risklayer GmbH

When natural disasters occur, information is key for both locals, scientists, news and the interested public. So far, there is only a small number of information agencies, most of them only working in a regional context. With CEDIM's long and on-going history of disaster analysis and new approaches like "Wettergefahren-Frühwarnung" and "Rapid Impact Modelling", the foundation is already given to facilitate CEDIM'S disaster information activities on one platform.
Partnering with the CEDIM-close start-up Risklayer, a web platform is currently under development to foster all these activities. The platform is made both for scientists and the interested public. Thus, providing a mixture of easy-to-read metrics and detailed reports and graphics to dig deeper into the topics. The platform employs a mixture of custom, manually generated content and automatically simulated and uploaded information. Both principles are already in use for the "Rapid Impact Modelling", where a combination of automatic smart algorithms provide initial metrics which can be later-on optimized using manual calibration techniques.
A primary goal of establishing a dedicated disaster information platform comes by merging different disasters types. Users can search the platform for on-going and past disasters and don't need to change the website when looking for different disaster types. In addition, search by location can provide the user with a complete overview of the wide variety of event in one country or region.

Similar, yet smaller sized platforms are provided, for example, by RSOE from Hungary or distributed over large number of US or European agency websites.
The platform is currently in a prototype phase, for which key systems and assets are already in place and getting tested. New features and content will be added subsequently. The development goals line out to subsequently add different disaster types and reporting features.

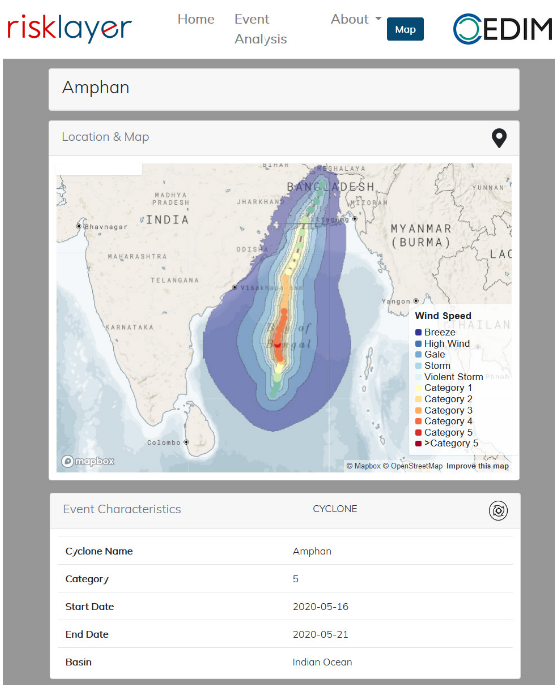

Fig. 1: Example of the disaster type Tropical Cyclone AMPHAN in the North Indian Ocean (16 – 21 May 2020).

Further reading

CEDIM/Risklayer-Explorer Website: http://www.risklayer-explorer.com.

CEDIM/Risklayer-Explorer

Wenn sich Naturkatastrophen ereignen, sind Informationen sowohl für Einheimische, Wissenschaftler, Nachrichten und die interessierte Öffentlichkeit von entscheidender Bedeutung. Bisher gibt es nur eine kleine Anzahl von Informationsagenturen, die meisten von ihnen und oft nur in einem regionalen Kontext arbeiten. Mit CEDIMs langer und kontinuierlicher Geschichte der Katastrophenanalyse und bestehenden Projekten wie „Wettergefahren-Frühwarnung“ und „Rapid Impact Modelling“ ist bereits die Grundlage gegeben, die Katastropheninformationsaktivitäten von CEDIM auf einer Plattform zu ermöglichen.

In Zusammenarbeit mit dem KIT Start-up Risklayer wird derzeit eine Web-Plattform entwickelt, um all diese Aktivitäten zu bündeln. Die Plattform richtet sich sowohl an Wissenschaftler als auch an die interessierte Öffentlichkeit. So bietet sie eine Mischung aus leicht lesbaren Metriken und detaillierten Berichten und Grafiken zur Vertiefung der Themen. Die Plattform befindet sich derzeit in einer Prototyp-Phase, für die bereits wichtige Systeme und Anlagen vorhanden sind und getestet werden. Neue Funktionen und Inhalte werden später hinzugefügt. Die Entwicklungsziele sehen vor, in der Folge verschiedene Katastrophentypen und Berichtsfunktionen hinzuzufügen.

Data processing of COVID-19 in the new CEDIM/Risklayer-Explorer

James Daniell, Andreas Schäfer
Geophysical Institute (GPI)
Risklayer GmbH

Johannes Brand
Institute of Geography and Geoecology (IFGG)

Since the beginning of the COVID-19 pandemic in Europe, CEDIM in collaboration with Risklayer GmbH, a spin-off at KIT, has been collecting and processing various data on the evolution of infected persons, fatalities, and other related information. Via interactive maps, multiple quality-checked data provide a quick overview on the number of cases as well as changes in mobility – in Germany on the district level (Landkreis), worldwide on the country level. Already in January 2020, CEDIM staff started collecting data on the case numbers of COVID-19 in China – initially in the context of a lecture of the Geophysical Institute (GPI). At the beginning of March, the first maps were published via Twitter (now daily). Since the end of March, the data have been presented using the recently launched CEDIM/Risklayer-Explorer. The data also feeds into the highly-cited statistics from the Johns Hopkins University. In Germany, various media such as ZDF, Tagesspiegel, mdr, BNN among various others use the CEDIM/Risklayer data for their presentations.

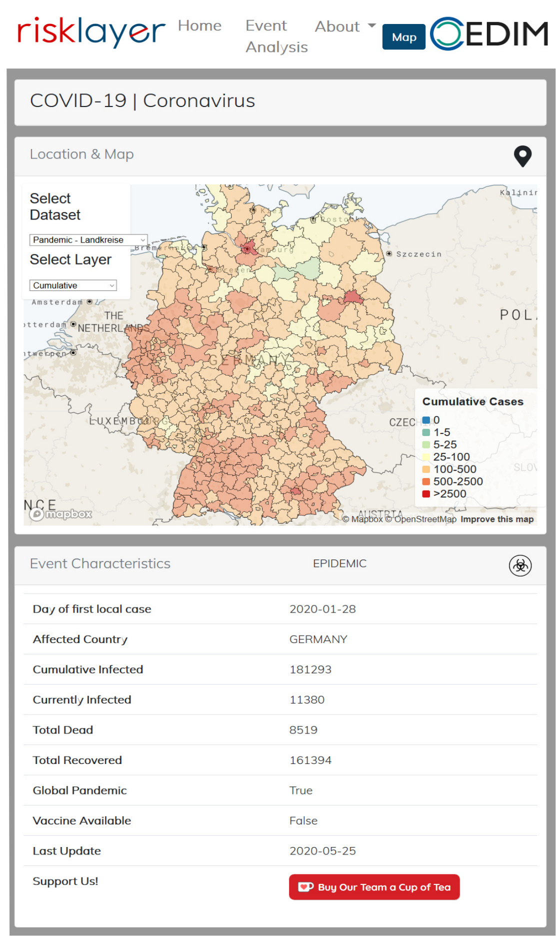

Fig. 1: CEDIM/Risklayer-Explorer with cumulative cases for Germany (as of 25 May 2020).

Further reading

Analysis of the German statistics at district level: http://www.risklayer-explorer.com/event/100/detail.

Further reading

Analysis of the statistics at global level: http://www.risklayer-explorer.com/event/6/detail.

Interactive illustrations at the "Tagesspiegel":
https://interaktiv.tagesspiegel.de/lab/karte-sars-cov-2-in-deutschland-landkreise.

Interview: Risikoanalyst über Corona

James Daniell, Risikoforscher in CEDIM, erklärt in einem Interview am 23. April 2020 mit Hendrik Lehmann vom „Tagesspiegel", warum Deutschland schlecht auf die Corona-Pandemie vorbereitet war – und was das Virus kosten könnte.

Herr Daniell, wie viel wird uns das Coronavirus kosten?
Das ist extrem schwer zu berechnen.

Warum?
Es gibt 81 verschiedene Arten von Naturkatastrophen. Erdbeben, Orkane, Vulkanausbrüche, Dürren. Und dann kommen Seuchen wie Ebola oder jetzt das Coronavirus dazu. Der maximale Schaden, den ein einzelnes Erdbeben auslösen könnte, läge derzeit bei 1,5 bis 2 Billionen US-Dollar, wenn es sich beispielsweise in Tokio ereignet, was nicht ganz unwahrscheinlich ist. Corona wird weit mehr Schaden verursachen.

Fig. 1: James Daniell berät Regierungen, Versicherungen und internationale Organisation beim Umgang mit Naturkatastrophen.

Aber Sie können nicht abschätzen, wie groß er sein wird?
Der Hauptunterschied bei Corona ist: Bei anderen Katastrophen sind mindestens 60 Prozent der Schäden an Objekten. Bei Corona aber gibt es kaum Schäden am Kapital. Die Hotels stehen ja alle noch – es ist nur keiner mehr drin. Die Flugzeuge sind alle heile – es fliegt nur keiner mehr damit. Wie hoch die Todesrate liegen wird, kann derzeit auch noch niemand verantwortungsvoll abschätzen. Die Folgen hängen völlig davon ab, wie gut die politischen Maßnahmen wirken. Aber in einigen Bereichen ist trotzdem schon sichtbar, wie massiv die Schäden sein werden.

Sie bezeichnen sich als Risikoingenieur. Klingt so, als konstruierten Sie Gefahren. Tun Sie das?
Am häufigsten führe ich Schnellschadenschätzungen direkt nach großen Katastrophen durch. Da fasst man möglichst schnell möglichst viele der Daten zusammen, die zu einer Katastrophe aufzutreiben sind: Verletztenzahlen genauso wie Schäden an Objekten. Dann kombiniert man sie mit Bevölkerungsdaten und Modellen. So versucht man, möglichst schnell die Kosten und ökonomischen Folgen abzuschätzen. Eigentlich verbringe ich die meiste Zeit mit Datenanalysen.

Für wen sind solche Katastrophenanalysen wichtig?
Banken, Rückversicherer und Versicherungsfirmen brauchen das, um einzuschätzen, in welcher Höhe mögliche Schadenssummen auf sie zukommen. Das Tohoku-Erdbeben 2011 vor Japan verursachte beispielsweise circa 400 Milliarden Euro an Schäden. Wir beraten aber auch Behörden und Regierungen, wie man Katastrophen besser managt. Für die Weltbank haben wir beispielsweise eine Datenbank aller Schulen weltweit aufgebaut, mit dem Ziel, abzuschätzen, wie viele Schulen pro Jahr durch Erdbeben zerstört werden. Nur so können Regierungen oder

Organisationen genug Gelder einplanen, um die Schulen wiederaufzubauen, die in Zukunft durch Beben zerstört werden.

Das Coronavirus kommt aber nicht aus dem Erdinnern. Es ist eine Katastrophe zwischen den Menschen. Kann man die Schäden trotzdem in manchen Bereichen schon beziffern?
Im Tourismus. Das gesamte globale BIP lag zuletzt bei ungefähr 80 Billionen US-Dollar. 2,5 Billionen an Einnahmen gab es allein durch Tourismus. Nimmt man indirekte Tourismuseinnahmen dazu, Hotels, Restaurants, Airlines, kommt man auf mindestens sieben Billionen US-Dollar, die weltweit umgesetzt werden. Davon wird mindestens ein Siebtel wegfallen, also eine Billion – wenn alles sehr bald besser wird. Danach ist aber die Frage: Wer wird jetzt ein Ticket buchen für eine Reise in einigen Monaten? Welche Rolle spielt die Angst? Vom Tourismus aus werden sich die Verluste in andere Wirtschaftszweige ausbreiten. Es wird nicht gut ausgehen.

Wie gut war Deutschland auf Corona vorbereitet?
Anscheinend nicht besonders gut. Es gibt hier offenbar kein modernes „Disaster Information Management System“, wie es andere Länder haben. Dadurch sind alle Daten nur sehr langsam verfügbar. Deswegen sammeln wir die Daten für Deutschland selbst, mithilfe von über 40 Freiwilligen und inzwischen ja auch mit der Tagesspiegel-Redaktion zusammen.

Ja, auch wir hatten zu Beginn Probleme mit den Testzahlen in Deutschland. Immer wieder beschwerten sich Leser, dass die Zahlen in ihrem Landkreis bereits viel höher seien als die gemeldeten.
Für Deutschland habe ich schnell gemerkt, dass da etwas extrem schiefläuft. Wie bei jeder Katastrophe bin ich von unten nach oben gegangen, von den Meldungen der Gesundheitsämter in den Landkreisen, über die Bundesländer bis zu den nationalen Meldungen. Da fiel schnell auf, dass die Summe der lokal gemeldeten Zahlen teils tausende Fälle über den Meldungen des Robert-Koch-Instituts (RKI) lag. Also haben wir angefangen, das Nacht um Nacht zusammenzutragen. Erst mit einem Kollegen, dann mit weiteren Freiwilligen. Jede Meldung wird dabei von mindestens drei Personen verifiziert.

Ob die Zahl für Deutschland nun einen Tag früher oder später steigt, sei kein großer Unterschied, entgegnen einige.
Nein! Es ist sehr wichtig, dass so schnell und so lokal wie möglich zu wissen. Denn der Trend in jedem einzelnen Kreis ändert das Verhalten der Leute. Wenn man sieht, dass im Landkreis nebenan die Fallzahl plötzlich in die Höhe schnellt, kann man vermeiden, dorthin zu fahren. Es ist wichtig, dass jeder die Daten kennt. Nur dann kann jeder seine Entscheidungen treffen. Wäre das früher verfügbar gewesen, hätte man noch besser reagieren können.

Inwiefern?
Man hätte vielleicht die Grenzverkehre sinnvoller einschränken können, statt spät und pauschal abzusperren. Zum Beispiel Richtung Basel, wo die Zahlen besonders stark nach oben gingen.

Wie müsste ein gutes System für Katastrophen funktionieren?
Man muss ein System haben, das sofort von allen Behörden genutzt werden kann, egal ob Polizei, Feuerwehr oder Entscheidungsträgern – von der kleinsten lokalen Ebene bis zur zentralen Planungsebene. Weil sowas im Katastrophenfall meist schlecht automatisch funktioniert, braucht man außerdem Menschen.

Wie ist es mit den weltweiten Zahlen?
Viele internationale Daten sind extrem intransparent und oft unprofessionell. Wenn man sich beispielsweise die Johns-Hopkins-Daten genauer anschaut, wird deutlich, dass die ihre Daten über Webseiten beziehen, die diese wiederum von anderen Webseiten beziehen. Am unteren Ende sitzen oft genau solche Leute wie wir, die das aus lokalen Quellen mühsam freiwillig zusammentragen. Weil die Quellen nicht sauber angegeben werden, ist aber manchmal gar nicht klar, wer diese Zuträger sind. Einer ist beispielsweise Carlos Robles, ein extrem talentierter 23-Jähriger in Mexiko, der das für die Webseite BNO News macht. Das weiß kaum jemand. Trotzdem beziehen sich Dutzende Medien weltweit über Umwege auf ihn.

Welche Länder haben gute Katastrophensysteme?
In den Philippinen gibt es so ein System von jedem Dorf bis hoch auf die nationale Ebene. In China ebenfalls. Sie bezahlen Menschen in jedem Dorf dafür, dass sie die neuesten Daten von Verletzten oder Schäden eintragen. In solche Infrastrukturen muss man investieren. Wir haben großes Glück, dass es so eine langsame Katastrophe ist.

Wieso ist COVID-19 eine langsame Katastrophe?
Die Infektionszeit ist im Vergleich zu anderen Seuchen recht lang. Die Todesrate ist niedrig. Man muss sich vorstellen, dass bei Ebola die Todesrate bei 30 bis 90 Prozent liegt, oder die Verbreitungsgeschwindigkeit bei Masern ein Vielfaches höher ist als bei SARS-CoV-2. Hätte Corona solche Eigenschaften, würden wenige Tage Verzögerung Tausende Tote mehr bedeuten. Bei Vulkanausbrüchen oder Erdbeben geht es noch viel schneller. Stellen Sie sich mal vor, jetzt kommt eine weitere „normale“ Katastrophe irgendwo in der Welt! Das ist recht wahrscheinlich. Aber wegen Corona kämen nicht mal Helfer ins betroffene Gebiet.

Gibt es in Deutschland so wenig Infrastruktur, weil es hier kaum Katastrophen gibt?
Die Menschen haben generell eine sehr schlechte Vorstellung von Risiken. Was heißt es, wenn einer von Tausend in Baden-Württemberg mit Corona infiziert ist? Klingt wenig. Aber wie viele Leute pendeln? Wie viele Menschen trifft man pro Tag? Wie hoch ist die Sterberate? Exposition, Vulnerabilität und Gefährdung? Das zusammen ist Risiko. Ich wünsche mir, dass diese Krise unser Bewusstsein für solche Zusammenhänge ändert.

Sie meinen, dass der Sinn der Menschen für Wahrscheinlichkeiten unterentwickelt ist?
Ja. Der Fakt, dass große Katastrophen nur sehr selten passieren, heißt eben auch, dass sie irgendwann passieren werden. Es ist beispielsweise überhaupt nicht ausgeschlossen, dass Deutschland ein schweres Erdbeben erlebt. Und Vulkanausbrüche könnten auch hier einiges lahmlegen.
Wo soll denn in Deutschland ein Vulkan ausbrechen?
Im Durchschnitt kommt es weltweit alle 200 Jahre zu einem riesigen Vulkanausbruch. Der Vulkan Tambora auf Indonesien ist das letzte Mal 1815 ausgebrochen. Der Ausbruch damals hat zwar nur bis zu 100.000 Menschen in direkter Umgebung getötet. Aber die Aschewolken zogen sehr weit. Sie führten in vielen Teilen der Welt zum „Jahr ohne Sommer“ 1816. Es gab Millionen von Hungertoten bei sehr viel weniger Menschen, die überhaupt auf der Erde gelebt haben. Das ist Risiko. Aber ich denke, mit dem Coronavirus fangen die Menschen langsam an, das zu verstehen.

Das Original-Interview ist am 23.04.2020 online beim „Tagesspiegel“ erschienen:
https://www.tagesspiegel.de/wissen/risikoanalyst-ueber-corona-wir-haben-grosses-glueck-dass-es-so-eine-langsame-katastrophe-ist/25767598.html.
Veröffentlichung mit freundlicher Genehmigung.

TAGESSPIEGEL RERUM COGNOSCERE CAUSAS

Effects of extreme events on EMI-Systems

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Introduction

The expected increase in extreme natural events and the considerable potential effects on society require an analysis of the effects of extreme natural events on present and future energy, mobility and information (EMI) systems. The network character of these systems allows disturbances and disruptions to spread far beyond the location of a natural disaster.

These cascade effects are further intensified by the strong globalization and networking of the world. In order to consider these aspects, the indirect effects of natural disasters are investigated within two sub-models. Taking into account global dependencies, the effects of natural disasters on supply chains on the one hand and the changed mobility demand of private households after a disaster on the other hand are examined.

Aims/Objective

This project has two subprojects. It seeks to investigate (i) the impacts of natural disasters on supply chain performance and (ii) the changed mobility behaviour of households in the aftermath of a disaster. Furthermore, recommendations on supply chain design, sourcing strategies and on mobility regulations will be given.

Project status

Subproject 1: Effects of extreme events on supply chains
For a detailed investigation, different vulnerability drivers for a supply chain have been identified and classified according to different types of risk. The aforementioned extreme events are part of the external supply chain risks, which cannot be influenced directly by, for example, a corporation or country. Furthermore, the vulnerability of a place or location is determined by structural conditions, such as social, economic, physical and environmental characteristics. With respect to the location, the analysis took into consideration that existing vulnerability analyses focus on regions with a high population density, which are not always identical to "economic hotspots". For example, critical infrastructure is very often located in remote areas and industrial districts are frequently clustered around tier 2 or tier 3 cities. As a second data source, deviations in delivery times and business closure times where extracted from supply chain reports, scientific papers and databases. Out of this, a delay-distribution was developed.
Subproject 2: Effects of extreme events on consumer mobility requests
Based on a literature review, information on general mobility behaviour could be obtained. In order to generate a more complete picture of mobility behaviour in everyday life, original mobility data records were evaluated in addition to literature research. Survey data from the German Mobility Panel (MOP) as well as from the *System repräsentativer Verkehrsbefragungen* (SrV) were investigated with a special focus on trip purposes and modal split for specified groups of persons as soon as the study area was more narrowly defined. Due to repeated flooding events in the recent past, the area of investigation was determined to be Dresden.
Because of the very thin data situation and the dependence on the event, research hypotheses were first formulated and later verified resp. refined by expert interviews. The expert interviews led to a further restriction of the study area to a particularly interesting district in Dresden. It is cut off from the rest of the city once a certain river level is reached. On the one hand, the aim is to find out how the district is integrated in everyday life in the city as a whole. On the other hand, the objective is to find out how mobility presents itself in the event of flooding. Building on this, the research hypotheses and questions were operationalized and a questionnaire was designed which was distributed to private households in the district of interest.

Outlook

Subproject 1: Based on the economic vulnerability indicators and the derived distribution of delays a regression analysis should shed light on the most influential factors on supply chain disruptions. In addition, it is necessary to validate the empirical results with supply chain experts.
Subproject 2: In the next step, the data set generated from the survey will be validated and evaluated in order to test the research hypotheses. After a description of the current status, an outlook for mobility behaviour in the future is to be given, which will depend on future technologies as well as on future extreme events.

Auswirkungen extremer Naturereignisse auf EMI-Systeme
Die zu erwartende Zunahme extremer Naturereignisse erfordern eine genaue Unter-

suchung möglicher Auswirkungen auf gegenwärtige und zukünftige Energie-, Mobilitäts- und Informationssysteme. Den genannten Systemen ist gemein, dass sie über einen Netzwerkcharakter verfügen. Diese Tatsache kann dazu führen, dass sich Störungen und Unterbrechungen weit über den Ort einer Naturkatastrophe hinweg ausbreiten und erheblichen Einfluss auf die Gesellschaft nehmen können. Diese sog. Kaskadeneffekte werden durch die starke Globalisierung und Vernetzung der Welt noch weiter verstärkt. Um diesen Aspekten Rechnung zu tragen, werden innerhalb von zwei Teilmodellen die indirekten Auswirkungen von Naturkatastrophen untersucht. Unter Berücksichtigung globaler Abhängigkeiten werden zum einen die Auswirkungen von Naturkatastrophen auf Supply Chains und zum anderen die veränderte Mobilitätsnachfrage privater Haushalte nach einer Katastrophe untersucht. Ein Hauptziel des ersten Teilprojekt ist es, wichtige Einflussfaktoren auf Verzögerungen innerhalb von Supply Chains zu identifizieren. Im zweiten Teilprojekt liegt ein Fokus auf Erkenntnisgewinne hinsichtlich Veränderungen im Mobilitätsverhalten nach Katastrophenfällen und der Abschätzung bzgl. dann vorherrschender Bedarfe in Bezug auf das Mobilitätsangebot.

Energy risks toward 2025: Disaster risk and resilience assessment of renewable and traditional systems

James Daniell, Andreas Schäfer
Geophysical Institute (GPI)

Energy systems are key to the recovery of a location post-disaster. Connectivity to internet, telephone systems, heat, cool, cooking, and many other processes are energy-system driven. Evacuation, business downtime and direct losses are all associated with energy systems. A change to the system, whether from natural disaster, terrorism or other effects can cause major delays and follow-on consequences for social and economic systems as seen through Tohoku earthquake 2011 in Japan. With the world becoming increasingly reliant on electricity through use of the internet, power systems and increased connectivity, a potential major outage during a disaster is a risk that will become more and more important to countries in the future.

A loss database has been developed to collect historical natural disaster events affecting power systems and power plants. 1258 events have been collected within CATDAT – one of the world's largest natural disaster database with over 60,000 entries, which has been built up by CEDIM staff in recent years – with energy system losses, but in addition an exposure assessment from past events has also been undertaken on today's global stock indicating that there are likely many more events that need to be analysed and collected (e.g Fig. 1 for hurricanes). In addition, PDNAs (post disaster needs assessments) and DALAs (disaster and loss assessments) have also been used to provide a relative loss ratio as a percentage of the total losses for the energy sector.

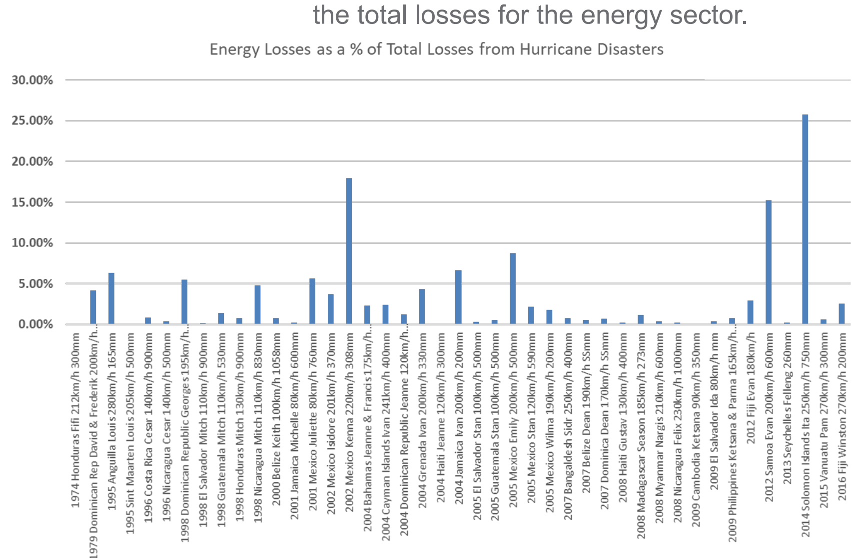

Fig. 1: Energy network losses in terms of economic losses as a percentage of total hurricane losses, including the maximum wind speed and rainfall associated with the events. It can be seen that higher wind speeds correlate to higher losses in the energy sector.

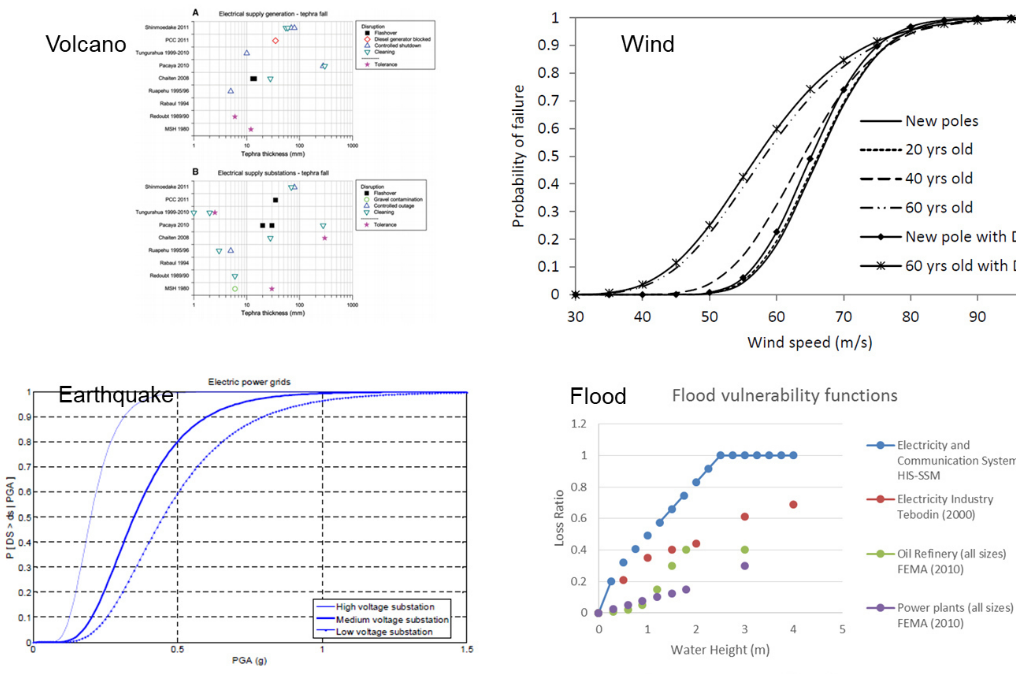

Fig. 2: Some vulnerability and damage functions for various hazards for electrical systems in the database (authors as per database).

Energierisiken der Zukunft: Resilienz erneuerbarer und konventioneller Energiesysteme

Eergiesysteme sind ein entscheidender Faktor für die Wiederherstellung eines Standortes nach einer Katastrophe. Die Verbindung zum Internet, zu Telefonanlagen, zum Heizen, Kühlen, Kochen und zu vielen anderen Prozessen wird durch das Energiesystem gewährleistet. Auch die Evakuierung, betriebliche Ausfallzeiten und direkte Verluste sind alle mit Energiesystemen verbunden. Eine Änderung des Systems, sei es durch Naturkatastrophen, Terrorismus oder andere Auswirkungen, kann zu erheblichen Verzögerungen und Folgen für die sozialen und wirtschaftlichen Systeme führen, wie man bei dem Tohoku-Erdbeben 2011 in Japan sehen konnte. In der Studie wurde eine Schadensdatenbank entwickelt, die historische Naturkatastrophenereignisse mit Auswirkungen auf Energiesysteme und Kraftwerke dokumentiert. Zusätzlich wurde eine Vulnerabilitäts-Datenbank zusammengestellt und weiterentwickelt. Die Expositionsabschätzung zeigt die Notwendigkeit einer integrierten Datenbank für Stromnetzpreise und Gebäudebestand, um die Analyse nach einer Katastrophe zu ermöglichen. Damit liefert diese Studie einen ersten Schritt in Richtung einer Risikomodellierung für den Energiesektor vor und nach verschiedenen Naturkatastrophen sowie eine globale Vernetzung der Energiesysteme, die zudem verschiedene Kapitalstockwerten berücksichtigt.

Rapid impact modelling

Andreas Schäfer
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Rapid impact modelling is an essential for the quick assessment of natural disasters within the first minutes and hours after their occurrence. Currently, rapid impact modelling can be applied to earthquakes, tsunamis and tropical cyclones. However, it is most relevant for the first two and frequently tested by a variety of earthquakes around the world during the last 2 years.

More than 800 earthquakes have been simulated to provide a quick overview of the imminent impact of earthquakes. Such models, called shakemaps are no novelty in the earthquake community. Services, as provided, for example, by the United States Geological Survey (USGS), publish shakemaps for most felt earthquakes within their area of interest. Other services like the INGV in Italy or JMA in Japan adopted this technology. For the people, both affected and interested, it is a primary source of information to understand the extent of a potential disaster. The Rapid Impact Modelling framework employed by CEDIM and its results distributed via the social media network CATnews on Twitter and Facebook uses small-scale high performance computation methods to quickly provide impact results. Such impacts are measured using the modified Mercalli intensity in case of earthquakes, a qualitative scale to identify the level of impact reaching from just being felt to damaging and disastrous conditions. For tsunamis or cyclones, quantitative scales like peak coastal wave heights and wind speeds are used. The resulting impact maps for earthquakes are usually hand calibrated using felt reports and testimonies from the affected locations combining in with social media crowdsourcing and information from the official agencies.

Within the last years, the public attention, both in- and outside social media, increased significantly. During the first iterations, impact maps had only been seen by a few hundred interested people. However, today with about 7.000 followers and a reach of often more than 10.000 people, the maps provided by rapid impact modelling are well received. In some cases, the reach goes well beyond 100.000 individuals and is shared by regional news agencies including: Qatar Day, Nevada Today, The Jakarta Post, India Times and our experts have been cited by New York Times, the Wallstreet Journal or National Geographic.

But not only public attention is a relevant part Rapid Impact Modelling. Especially during larger events, the results are utilized for rapid loss assessments. Instead of waiting for other agencies to provide geospatial information on earthquake intensities, Rapid Impact Modelling can provide the relevant inputs to assess direct losses and potential casualty numbers. Such results can then be used in FDAs and other scientific short-term reports about the disaster. The results of Rapid Impact Modelling are considered into the new Disaster Information Portal to not only provide map metrics on social media platforms, but also on a dedicated website built to inform about ongoing natural disasters.

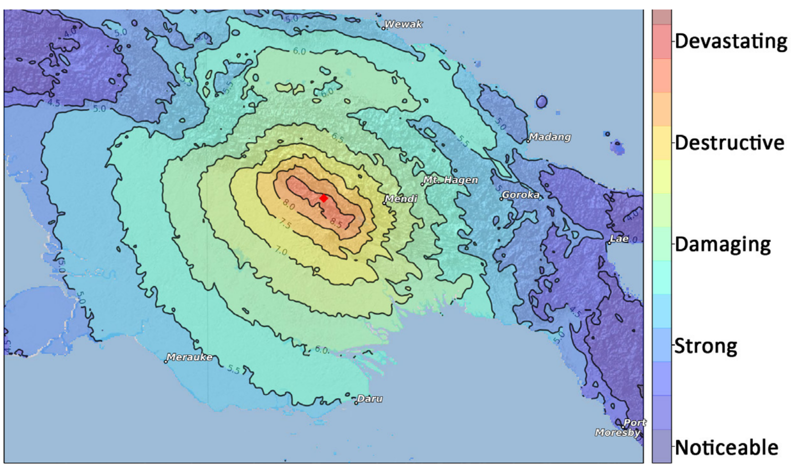

Fig. 1: ShakeMap of the 2018 Papua New Guinea earthquake (magnitude 7.5, 25 February 2018), which, together with its aftershocks, claimed 200 lives.

Schnelle Modellierung der Auswirkungen

Die schnelle Modellierung der Auswirkungen ist eine wesentliche Voraussetzung für eine zeitnahe Bewertung von Naturkatastrophen innerhalb der ersten Minuten und Stunden nach ihrem Auftreten. Derzeit kann die Modellierung der raschen Auswirkungen auf Erdbeben, Tsunamis und tropische Wirbelstürme angewandt werden. Am relevantesten ist sie jedoch für die ersten beiden und wurde in den letzten zwei Jahren häufig durch eine Vielzahl von Erdbeben auf der ganzen Welt getestet. Das von CEDIM eingesetzte Rapid Impact Modelling Framework und seine Ergebnisse, die bisher über soziale Medien wie Twitter und Facebook (CATnews) verbreitet werden und seit kurzem auch über den neuen CEDIM/Risklayer-Explorer zur Verfügung gestellt werden, nutzen kleinräumige Hochleistungsberechnungsmethoden, um schnell Ergebnisse zu den Auswirkungen zu liefern.

Further reading

CATnews on Facebook: https://www.facebook.com/catnewsde.

CATnews on Twitter: https://twitter.com/catnewsde.

CEDIM/Risklayer-Explorer: http://www.risklayer-explorer.com.

Resilience of cities in the course of time: Integrated resilience planning for smart power distribution systems

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Introduction

A better understanding of upcoming technological transformations and their impact on critical infrastructure systems and security of supply is one of the main drivers of our research. The transformation of the classical power system into a smart decentralized power system is one of the most prominent and societally relevant examples of such transformations – the ongoing increase of automation and power consumption illustrates it's increasing importance accompanied by a simultaneously increase of vulnerabilities. Furthermore, a drastic change of power consumption, e.g. by an increased usage of electric vehicles, may result in unforeseen loads that cannot be managed by the utility provider e.g. in terms of demand side management. Therefore, our research deals with the following topics: Assessing the impact of different power and information and communication technologies (ICT) network structures on the resilience of urban systems. Development of new risk-based power distribution mechanisms dealing with power scarcity in order to avoid large-scale blackouts and improve security of supply (Ottenburger et al., 2018b; Ottenburger and Münzberg, 2017). The methods that are used ground on modelling various critical infrastructures, power-, and ICT-infrastructures separately, but also new resilience measures. The key idea is to consider smart grid topology and power distribution mechanisms as model parameters. Thus, by varying these parameters for a specific region, e.g. an urban area, good structures and distribution mechanisms may be identified.

Urban resilience and power system

The concept of urban resilience encompasses various types of resilience dimensions such as the social, economic or physical infrastructure dimension. Critical infrastructure (CI) services such as the supply of electricity, drinking water, and health care provide vital services for the population, thus disruptions or failures of these services are hazardous and can lead to injuries or even losses of life, property damages, social and economic disruptions or environmental degradations. Therefore, CIs constitute a pivotal aspect in urban resilience considerations and establishing and implementing sophisticated continuity management concepts with respect to CIs can be regarded as one of the major building blocks for preserving or enhancing urban resilience. Most of the CIs like water supply, hospitals, pharmacies, and traffic and transport systems rely on electricity – the circumstance of massive dependencies of other CIs to the electrical power entitles the electrical power grid to be considered as a *high ranked* CI. The generation and supply of electricity is currently about to undergo a fundamental transition. Due to the integration of smart meters, the consumers in the classical sense will have the eligibility to consume, produce and distribute electricity. The therefor necessary smart

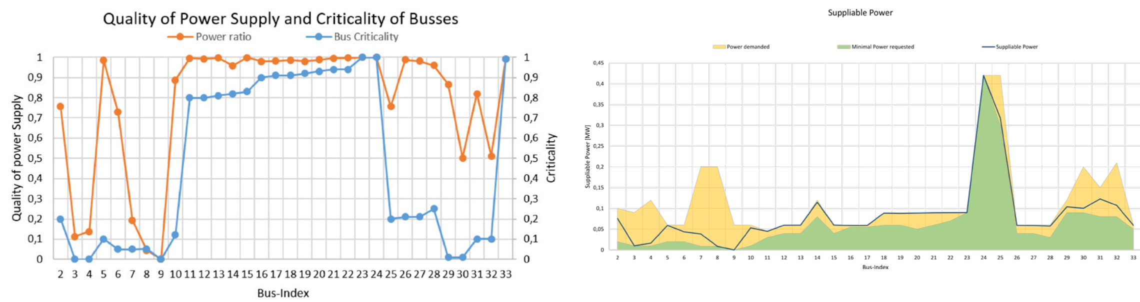

Fig. 1: First results of criticality based optimal power flows on the IEEE33 bus system for stationary load states.

meters are electronic devices that monitor electricity consumptions and generations and allow two-way communications with other meters. However, to keep a stable electricity supply it is important that in-feed and consumption form an equilibrium. A smart grid construed as a complex and highly automated power distribution grid fundamentally relies on a rigorous multi-layered distribution management system in order to maintain grid performance and reliability. The architecture of a distribution management system allows a partitioning into several locally arranged and interconnected operation centers which themselves may be considered as local distribution management systems. A precise and secure operation of an energy management system of a smart grid, that operates – due to grid stability issues – automatically in real-time, heavily depends on the degree of accuracy of the transmitted quantities of interest.

Criticality and degrees of freedom

In view of net neutrality, this project perceives criticality as a risk-comparing framework, which we split up into different subcategories. The type of the power shortage scenario, the different relevancies of CIs and the timely varying demands for critical services determine the possibly timely varying so-called *global criticality* of CIs in an urban area. *Global criticality* of a CI can be considered as a function depending on relevancies of all other CIs, global system variables and the CI's *local criticality*, where *local criticality* is a function describing the critical state of a CI, reflecting its internal state, current and expected demand, current and expected fulfillment of demand etc. *Global criticality* and local criticality are of course power shortage scenario dependent. In the case of normal performance states of CIs and no occurring or expected power shortage, global criticality reflects the different relevancies of CIs compared to each other – these values are called *initial criticality* of CIs – for more details we refer to (Ottenburger et al., 2018b; Münzberg und Ottenburger 2018).

Operationalizing criticality should start in the phase of designing grid extensions or developments both from the ICT- but also from the physical power infrastructure perspective. This project especially focuses on two topological degrees of freedom in the design of smart grids. One topological degree of freedom refers to decomposition of a smart grid into so-called micrograds which may be disconnected from the overall smart grid and operate autonomously in island mode. A smart grid subdivided into microgrids has the potential to restrict cascading effects and hence to be less vulnerable against disruptions. Cascading effects due to dysfunctionalities of certain components or propagation of malware throughout a smart grid might be prevented by disconnecting the affected microgrids from the overall smart grid. Although having isolated disturbed or dysfunctional microgrids from the smart grid of a city, CI dependencies may cause issues in other parts and reduce the resilience of the city as a whole. Another topological degree of freedom refers to different configuration options w.r.t. smart grid components, e.g. overlaying network structures to provide redundancies within a microgrid.

Obviously, the network topology of a smart grid has significant effects on urban resilience particularly referring to the adequate provision of vital services of CIs. Taking *initial criticality* into account during the smart grid design phase can be regarded as a first proactive measure in the sense of preparedness. The rationale of applying *initial criticality* could be to distribute CIs with high *initial criticality* on different microgrids, avoiding a concentration of highly relevant CIs in one microgrid, or to build redundancies for CIs with high *initial criticality.* An elaborated topology of smart grids increases urban resilience.

Resilience measure: Supply Index

Advanced Metering Infrastructures (AMIs) including smart meters allow fine-grained power distribution management strategies that go beyond the classical strategies like rolling blackouts. A main task is to develop resilient and fair power distribution strategies in times of power shortage by exploiting the advantages of an AMI and smart meters. Therefore, new resilience metrics, measuring security of supply that complement known measures like SAIDI (System Average Interruption Duration Index) are developed. Smart meter can be considered as an interface between a prosumer, e.g. a household, and the outer smart grid structure. An AMI that utilizes advanced smart meter technologies, allowing complex communication with distribution management system entities, enables a CI to transfer its current *initial criticality* into the distribution management system. The distribution management system, being aware of all the *initial criticality* values, the relevancies of all other CIs, global system variables etc., is able to compute the current *global criticality* for each CI (Ottenburger et al., 2018b). In the case of a power shortage, caused by dark doldrums or cyber-attacks, a system knowledge about a *global criticality* distribution can be used for identifying optimal power distribution mechanisms. Therefore, a so-called Supply Index SI is applied: Let $i \in I$ be an infrastructure, and $c_i \in [0,1]$ the global criticality of i:

$$SI = \sum_{i\in I} \widetilde{c}_l q_i \left(SP_i\right), \text{ where } \tilde{c}_l = \frac{c_i}{\sum_{j\in I} c_j}$$

is the *weighted global criticality* and q_i a certain linear function measuring the quality of supply (Ottenburger et al., 2018a).

The spectrum of optimal power distribution mechanisms that are applicable strongly depends on the topology of smart grids or in other words smart grid topology determines the range of possible optimal power distribution techniques and massively influences urban resilience. During a power shortage, optimal power flows or power distribution policies should target at distributing electricity in such a way that the severity of the impact of a possible decrease of the overall performance of all CIs in an urban area is *minimum*. In enhanced power distribution policies, where *global criticality* is applied, rolling black outs in terms of dynamically connecting different microgrids with each other, might also be an option.

The smart grid resilience framework - Optimal power flow applying SI and evolutionary algorithms

The development of the so-called Smart Grid Resilience Framework (SGRF) is part of an interdisciplinary project at KIT (IPD/IIP). The SGRF uses network topologies and power flow algorithms as model parameters that can be varied. First concepts on resilient power flow mechanisms were developed:

An infrastructure i may possess process flexibility or coping capacities that allow to specify a *power demand flexibility interval*

$\left[P^i_{D,min}, P^i_{D,max}\right]$, where $P^i_{D,max}$ is the power demand for *normal process* mode and $P^i_{D,\min}$ the power demand for at least running *some essential sub-processes*. There might be an infrastructure i that has criticality equal to 1 – in this case i has no power flexibility and thus demands a certain power value P^i_D.

In the case of power shortage, for example only 75 % of the normal power demand of all infrastructures is available, new resilient power distribution strategies in the energy management system of a smart grid are thinkable in order to avoid total blackouts – nevertheless, new distribution algorithms should not violate non-discrimination.

Before applying these new concepts on our distribution grid model of Karlsruhe, they are validated against simpler grid models e.g. standard IEEE-models:

For stationary load states optimal power flows on the IEEE33 bus system were calculated in a joint project with KIT-IAI – genetic algorithms were applied, in order to maximize SI while respecting fair distribution (Ottenburger et al., 2018a). Conclusively, the way we applied genetic algorithms can be considered as a possibility to specify the corresponding parameter in the Smart Grid Resilience Framework.

Summary

The ongoing transition of the power distribution system towards Smart Grids bears the chance to conceptually integrate principles of crisis prevention and management into power control mechanisms. Following this aspiration global criticality considered as a dynamic feature of CIs is a promising attribute that helps to bridge Smart Grids resilience and urban resilience in a sensible way. In cases of power shortages, where first, secondary, and tertiary controls are not able to stabilize the whole grid, global criticality as a further criterion can be applied for controlling the power flow in a Smart Grid in an urban resilient way and thus contribute to enhancing urban Continuity Management.

The proposed simulation framework, allowing the variation of parameters like Smart Grid topology and power distribution mechanisms, can be applied to specific urban systems. Simulation studies against power disruption scenarios that are considered to be plausible for that particular urban system can be conducted.

The outcomes of these studies would be

- an analytical view on Smart Grid infrastructure planning in terms of a selection of urban resilient Smart Grid design options and
- appropriate power distribution strategies or algorithms to deal with power shortage scenarios; these strategies or algorithms could be implemented in the EMS of a Smart Grid.

Resilienz von Städten im Wandel der Zeit: Integrierte Belastbarkeitsplanung für intelligente Stromverteilungssysteme

Ein besseres Verständnis der bevorstehenden technologischen Transformationen und ihrer Auswirkungen auf kritische Infrastruktursysteme und die Versorgungssicherheit ist eine der Haupttriebkräfte unserer Forschung. Die Transformation des klassischen Energiesystems in ein intelligentes dezentrales Energiesystem ist eines der prominentesten und gesellschaftlich relevantesten Beispiele für solche Transformationen – die kontinuierliche Zunahme der Automatisierung und des Energieverbrauchs verdeutlicht ihre zunehmende Bedeutung bei gleichzeitig zunehmender Verwundbarkeit.

Der fortschreitende Wandel des Stromverteilungssystems hin zu Smart Grids birgt die Chance, Prinzipien der Krisenprävention und des Krisenmanagements konzeptionell in die Mechanismen der Stromkontrolle zu integrieren. Diesem Bestreben folgend ist globale Kritikalität, die als dynamisches Merkmal von CIs betrachtet wird, eine vielversprechende Eigenschaft, die dazu beiträgt, die Belastbarkeit von Smart Grids und die Belastbarkeit von Städten sinnvoll miteinander zu verbinden. In Fällen von Stromknappheit, in denen erste, sekundäre und tertiäre Steuerungen nicht in der Lage sind, das gesamte Netz zu stabilisieren, kann die globale Kritikalität als ein weiteres Kriterium angewandt werden, um den Stromfluss in einem Smart Grid auf eine städtisch belastbare Weise zu steuern und so zur Verbesserung der städtischen KM beizutragen.

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Tsunami beach risk for tourism

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Tsunamis are among the most damaging natural disasters in human history. Not only the direct impact of recent tsunamis was tremendous, but also the indirect long-term effects in various business sectors. Especially the tourism industry is vulnerable to natural disasters and the 2004 Indian Ocean tsunami highlighted it through long-lasting decline of regional tourism activity. Thus, the potential risk to beach-tourism has been quantified in this study. However, in many cases, structural damage was not the key driver behind the sectorial losses of the tourism industry. Instead, business interruption and a reduction of tourist arrivals in the affected destinations lead to a majority of losses. Risk was defined as a culmination of direct and long-lasting indirect losses e.g. through business interruption and beach erosion. A global model of tsunami hazard was compiled on the basis of peak coastal amplitudes extrapolated to beach sites. It comprises more than 50 different strong-seismic and tsunami-genic sources globally. Here, each earthquake was computed as a heterogeneous rupture plane leading to a high variety of tsunami sources. Using the power of GPUs enabled the possibility to avoid the demand of high-performance computing and deployed the simulation on commonly available computing systems.

A global tourism and beach database has been assembled using various open, global and regional data sources on beaches. It was linked to a similar global hotel inventory as a base estimator of regional tourism activity. The model provides insight into the scale of monetary losses in the tourism sector. Not only previously known affected tourist destinations like Phuket or Hawaii show high risks, but also destinations like Bali or parts of the Eastern Mediterranean (Fig. 1).

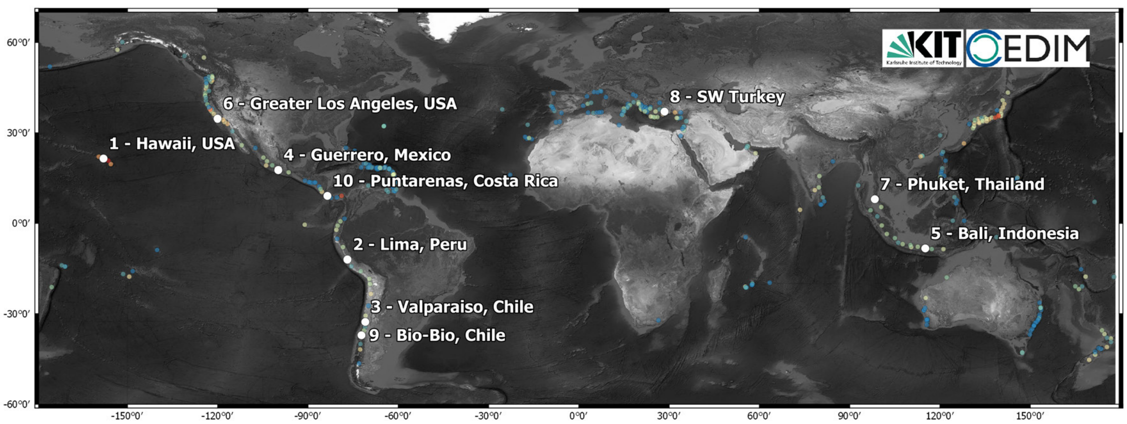

Fig. 1: Top ten locations on the global risk index for beach tourist destinations threatened by tsunamis.

Tsunamis könnten Tourismusbranche jährlich mehrere hundert Millionen Dollar kosten

Tsunamis gehören mit zu den verheerendsten Naturkatastrophen in der Geschichte der Menschheit. Nicht nur die direkten Auswirkungen der jüngsten Tsunamis waren gewaltig, auch die indirekten Langzeitfolgen in verschiedenen Wirtschaftssektoren können erheblich werden. Vor allem die Tourismusindustrie ist anfällig für Naturkatastrophen, und der Tsunami im Indischen Ozean im Jahr 2004 machte dies durch den lang anhaltenden Rückgang der regionalen Tourismusaktivitäten deutlich. Basierend auf dem Simulationsmodell „TsuPy", das am GPI entwickelt wurde, wurde ein Tsunami-Risikoindex für alle Reiseziele auf der Welt erarbeitet, indem alle bedeutenden Reiseziele in Bezug auf mögliche Verluste für die Tourismusbranche in Folge eines Tsunami untersucht werden. Dadurch könnten die Top-10-Reiseziele in Bezug auf mögliche Verluste für den Strandtourismus durch Tsunamis ermittelt werden. Zudem wurde deutlich, dass im Schnitt alle zehn Jahre mehr als eine Milliarde Dollar an wirtschaftlichen Verlusten in der Tourismusbranche durch Tsunamis verursacht werden.

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Vulnerability and resilience of critical road infrastructure as exemplified by Chile

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Introduction

The road infrastructure system as one of the most fundamental parts of the critical transportation network infrastructure is designed to connect urban centres, provide regional coverage, and support basic necessities for rural areas.
A key function of road networks is to ensure the accessibility to vital resources in everyday life but also in emergency situations. Since its functions are crucial for all aspects of human life, a failure of the road infrastructure could cause serious consequences. Natural hazards, such as earthquakes, floods or wildfires threaten the road infrastructure and thus the society depending on this infrastruc-ture (Keller & Atzl, 2014; Zio, 2016). To analyse the vulnerability of road infrastructure, a database of the road network is required. The crowdsourced dataset OpenStreetMap (OSM) provides a valuable alternative to proprietary data. However, the issue of quality and completeness needs to be ad-dressed when using volunteered geographic information.

Aims/Objective

The project is a joint research project between the IPF and Institute of Regional Science (IfR). Within the IPF subproject, a generic, multi-scale concept is being developed to analyse the vulnerability of critical road infrastructure. One main objective of this subproject is to evaluate the applicability of open data like OSM to critical infrastructure research. Furthermore, in collaboration with the IfR, the influ-ence of social parameters on the road infrastructure is investigated.

Project status

In Guth et al. (2019), we developed a generic concept to analyse the accessibility of emergency facili-ties in critical road infrastructure for disaster scenarios. We applied our concept to the 2017 wildfires in Chile and Portugal.
We followed a modular approach: The basic module evaluates the accessibility of emergency facilities by calculating an accessibility index. Other modules enable the calculation of a grid-based index and the generation of a degraded network based on a natural disaster scenario. OSM serves as a free-to-use and worldwide available database for the road network and the emergency facility location. The multiple-scale concept is applicable worldwide and, at the same time, adaptable to local road conditions.
Concerning the applicability of OSM data on critical infrastructure research, we found that OSM data often lacks information important for routing or contains errors. On the one hand, speed information is rarely available. Therefore, we developed a framework to estimate average speed in road networks using fuzzy control from the OSM data (Guth et al., 2020). The parameters road class, road slope, road surface and link length were used to obtain average speed information. This framework was then linked as a module to the generic concept explained above.

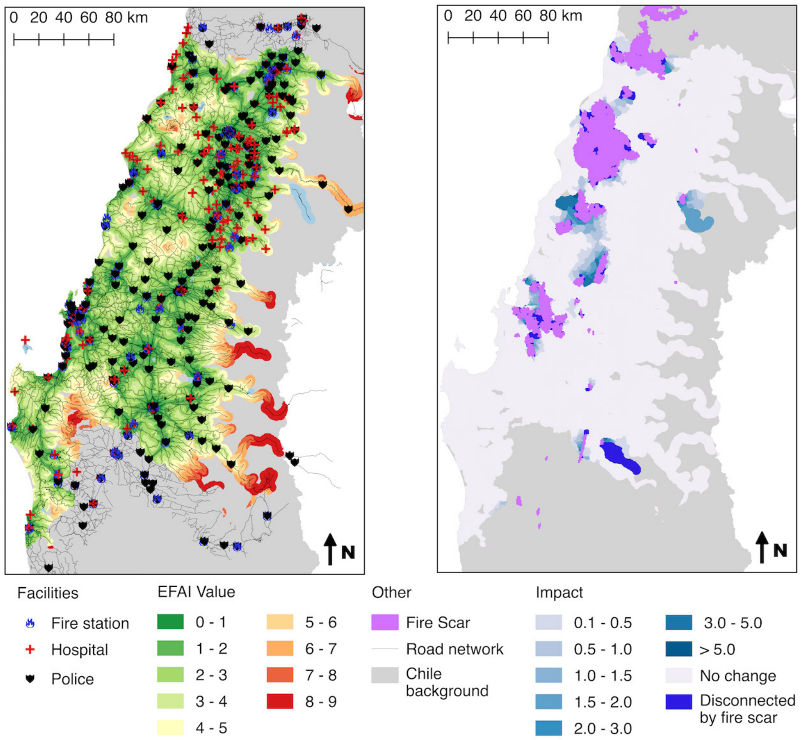

Fig. 1: Impact of the 2017 wildfires on the Maule and BioBìo region in Chile (Guth et al., 2019).

On the other hand, OSM road class errors hinder routing. Especially on a small scale, only an upper level road network is used, errors in road classes can lead to considerable detours or disconnections. Therefore, we are currently developing an additional module that detects classification errors which would lead to gaps in a high-level network.

As a result, the concept provides a valuable and data-sparse decision aid tool for regional planners and disaster control. All the data is readily available because of the usage of OSM. It can be used in different stages of the disaster risk management cycle. In the mitigation and preparation phase, plac-es with poor accessibility can be identified.

In the short-term response phase after a disaster, the quick identification of critical and disconnected road network parts assists disaster control in planning a possible reaction strategy.

Outlook

Due to the modularity of the developed concept, it can be adapted to new challenges and extended based on new information. The accessibility analysis can be extended to include a network scan to obtain network vulnerability. Additionally, the vulnerability towards specific natural hazards can be evaluated using risk maps on specific topics like wildfires, floods and more.

Vulnerabilität und Resilienz der kritischen Infrastruktur am Beispiel von Chile

Im Rahmen des KRITIS-Projekts analysieren das Institut für Photogrammetrie und Fernerkundung (IPF) und das Institut für Regionalwissenschaft (IfR) die Vulnerabilität der Straßeninfrastruktur. Im IPF-Teilvorhaben wird ein generisches Konzept zur Analyse der Vulnerabilität von Straßeninfrastruktur auf mehreren Maßstabsebenen entwickelt. Das Konzept ist weltweit anwendbar und kann gleichzeitig an regionale Gegebenheiten angepasst werden. Als Datengrundlage für das Straßennetzwerk werden die weltweit, offen verfügbaren OSM Daten angewendet. Zusätzlich werden Methoden entwickelt um diese Daten zu veredeln und mögliche Fehler zu korrigieren. Konkret wird ein Framework entwickelt, welches die Durchschnittsgeschwindigkeit auf Straßen aus verschiedenen OSM-Parametern schätzt. Zusätzlich wird ein Modul zugeschaltet, welches das Straßennetzwerk auf Fehler in der Klassifizierung prüft und diese gegebenenfalls korrigiert.

Das resultierende Konzept ermöglicht die Abschätzung des Einflusses eines Katastrophenszenarios auf das Straßennetzwerk. Es bietet damit eine Entscheidungshilfe für Regionalplaner und für das Katastrophenmanagement. Durch die Modularität des Konzeptes kann es in Zukunft beliebig erweitert werden.

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The contribution of tsunami evacuation analysis to disaster management in Chile – Importance of human behaviour and the criticality of the road network

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Introduction

Well-organized and rapid evacuation is crucial to save lives in disasters. Especially, in rapid-onset disasters like tsunamis, it is essential that the affected population is able to perform evacuation without official guidance (Shuto, 2005; León, Mokrani, Catalán, Cienfuegos, & Femenías, 2018). This is important as failures in the road infrastructure and the breakdown of communication systems, due to a preceding earthquake, might hinder official support (Herrmann, 2015; León & March, 2016; León et al., 2018). This was highlighted not only during the Indian Ocean Earthquake and Tsunami 2004, but also during the Maule Earthquake and Tsunami in Chile 2010 (Elnashai, et al., 2010; Kadri, Birregah, & Châtelet, 2014). According to official reports, 12.8 million people were affected socio-economically during the latter, and 521 people lost their lives (CEPAL, 2010). The relatively low fatality rate in Chile, despite the high magnitude of the earthquake (8.8 Mw) and tsunami – 800 km of the coastline were affected (Elnashai, et al., 2010) – might be ascribed to awareness among the Chilean population. Thus, human behaviour is a key issue to minimize the impact of natural disasters.

Aims/Objectives

The project is a collaboration between IfR and the Institute of Photogrammetry and Remote Sensing (IPF). Within the research focus of the IfR, the aim is to analyse human behaviour meticulously, focussing on an event-based past scenario (the Maule Earthquake and Tsunami 2010) and a hypothetical future scenario of a tsunami in Chile. A case study was chosen in order to give realistic insight to evacuation behaviour.

Beside demonstrating the value of the integration of knowledge and experience of the local population, this study aims to point out the contribution of a detailed evacuation analysis to evacuation planning. The analysation and evaluation format chosen in the case study, might additionally be valuable for evacuation

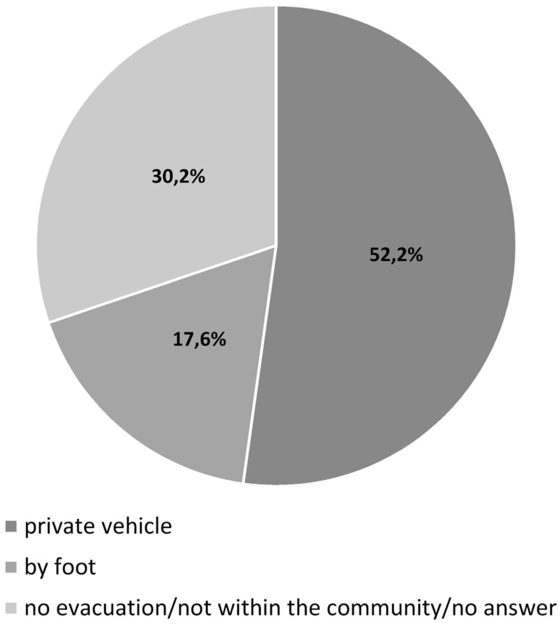

Fig. 1: Transport medium choice in the Maule earthquake and tsunami 2010.

planning in countries with different socio-economic background.
In order to give a holistic perspective on evacuation, the research focus of the IPF is on the vulnerability of critical road infrastructure. The latter plays an important role in evacuation.

Results and conclusion

The social science data was collected in form of standardized questionnaires for the affected population and expert interviews. Experts from different areas like disaster management, urban and regional planning and sociology and disaster psychology were interviewed. In order to get a holistic picture on evacuation, the data collected was enriched by a GIS-based simulation, evaluating the shortest path to the nearest evacuation zone within the research area. A further analysis also took into account the walking speed of different age groups (Yosritzal, Purnawan, & Putra, 2018) and the timely distance to the evacuation zones.
The joint research project, bundling up different perspectives is extremely valuable for complex issues like evacuation. The combination of both perspectives gave interesting results: The excessive use of cars during evacuation in the past event (Fig. 1) resulted in congestion of street sections and hindered evacuation. This might also pose a problem in the future, highlighting transport medium choice indicated by the respondents. However, a GIS-based simulation, calculating walking speeds and the shortest path to the nearest evacuation zones, demonstrated that evacuation by foot, as recommended by disaster management, can become critical due to the distance to the evacuation zone (see Fig. 2).
These results give rise to fundamental changes in disaster management, especially changes in the evacuation infrastructure, pointing out the road network and the accessibility of evacuation zones. Additionally, disaster management might raise the awareness of the population within educational programmes, regarding transport medium choice. These changes might improve the accessibility of evacuation zones in a timely manner, and in last consequence save lives.

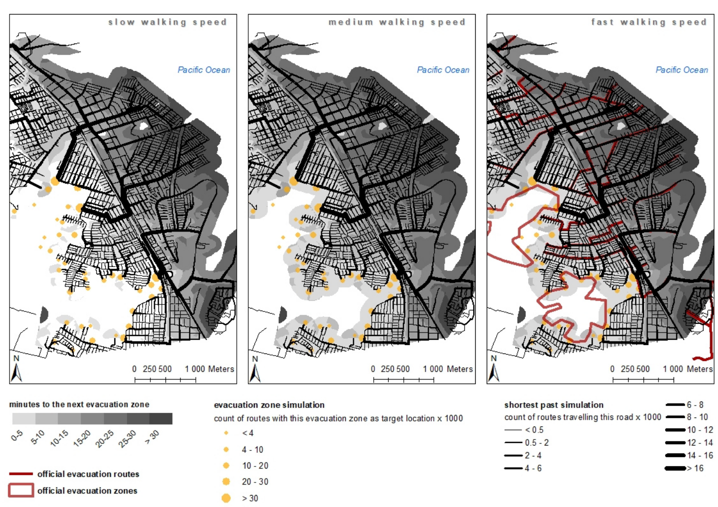

Fig 2. Simulation of evacuation for different walking speeds (based on Yosritzal et al., 2018) using the shortest path to the nearest evacuation zone.

Die Bewertung von Evakuierungsszenarien als Beitrag zum Risikomanagement in Chile – Die Bedeutung menschlichen Verhaltens und die Vulnerabilität des Straßennetzes

Im Rahmen des KRITIS-Projektes untersucht das Institut für Regionalwissenschaft (IfR) und das Institut für Photogrammetrie und Fernerkundung (IPF) das menschliche Verhalten in Katastrophenszenarien, sowie die Vulnerabilität der Straßeninfrastruktur. Ziel des IfRs ist es anhand einer Fallstudie in Chile, am Beispiel eines Tsunamiereignisses, das Evakuierungsverhalten der betroffenen Bevölkerung zu untersuchen. Das Evakuierungsverhalten wird sowohl anhand eines vergangenen Ereignis (Maule Erdbeben und Tsunami 2010), als auch anhand eines möglichen zukünftigen Ereignisses analysiert. Mittels Fragebögen und Experteninterviews werden sozialwissenschaftliche Variablen erhoben, die einerseits Einfluss auf das Evakuierungsverhalten haben, als auch Rückschlüsse auf das vergangene und zukünftige Evakuierungsverhalten erlauben. Durch die Befragung der betroffenen Bevölkerung soll weiteres die Bedeutung lokalen Wissens und der Erfahrung der betroffenen Bevölkerung für das Risikomanagement betont werden. Weiteres soll durch das gemeinsame Projekt und die Kombination verschiedener wissenschaftlicher Perspektiven deren Beitrag zu einer holistischeren Betrachtungsweise eines Phänomens, hier am Beispiel einer Evakuierung, betont werden.

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The web service “Wettergefahren-Frühwarnung“ *(Weather Hazards – Early Warning)*

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Overview

The internet service “Wettergefahren-Frühwarnung” provides information on imminent or just occurring unusual or extreme weather events worldwide; of particular interest are those weather events that are ruinous and associated with heavy losses. Permanent availability, daily updated (warning) information, editorially enhanced reports of extreme or unusual weather events that are enriched by images, diagrams, maps and measured values, are the hallmarks of the internet project. Routine operation started on 1 February 2004 and has since been continuously maintained. Since the beginning of 2019, all of the information is only available in English.

Handling and evaluation of extreme weather events

It is neither the task of “Wettergefahren-Frühwarnung” to issue detailed and minute-by-minute updated warnings for a country or county nor to pronounce codes of conduct. It’s the national weather services that are responsible for those warnings. The key aspect of “Wettergefahren-Frühwarnung” are extreme weather events, especially when they are associated with an extensive potential of damage. The main focus is on Europe and Africa.
Textual notes about forthcoming extraordinary events are made usually a few days before their arrival and include general information on the nature of the extreme event, the intensity and the course. Typically, a short warning text supplemented by informative forecast maps, indicate the affected areas and what they have to expect. These alerts are updated daily. Upon the occurrence and during the extreme weather event the information becomes more detailed, and sometimes preliminary analysis and assessments can be carried out already. A few days after the event a detailed editorial article finalizes the activities; the articles contain the main findings of the event and are enriched with data, maps, illustrations and figures. The information provided is based on web and literature research, own illustrations and calculations. Additionally, the comparison with similar events from the past always brings valuable insights.

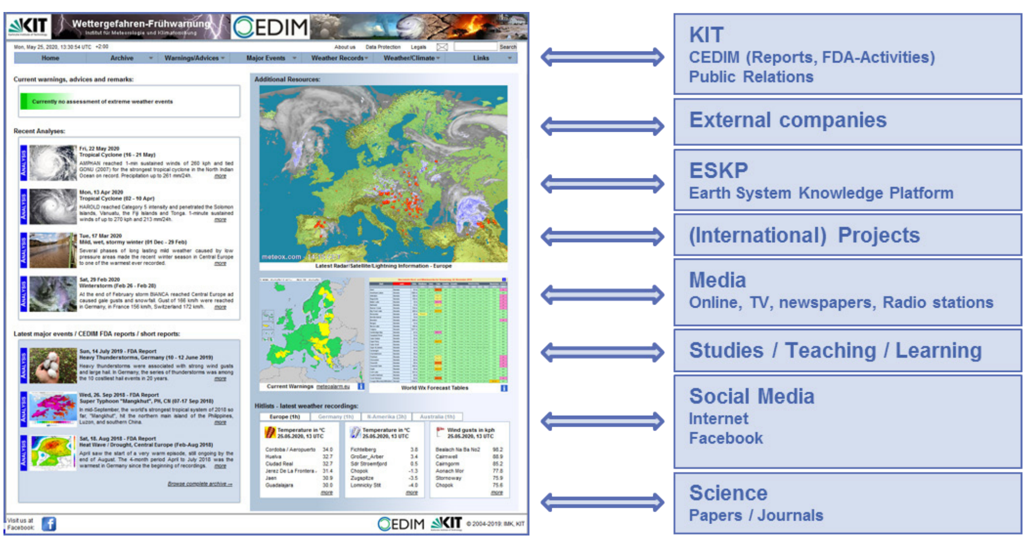

Fig. 1: Interconnections between “Wettergefahren-Frühwarnung” and different users and stakeholders.

Archive of extreme weather events worldwide

Since activities began in 2004, "Wettergefahren-Frühwarnung" was concerned with over 1000 extreme weather events that occurred all over the world. All warnings, special notes and detailed reports can be found in an ever-growing archive. This archive with its comprehensive, consistent and high-quality articles and reports is unique.

Additional information and research

The websites of "Wettergefahren-Frühwarnung" not only offer alerts, warnings reports, but also give all the necessary information to evaluate extreme or unusual weather events. This additional information includes e.g. wind and storm scales, national and international records of temperature, precipitation and other parameters as well as climatological data and maps. This information is constantly checked, expanded and updated. For some 2800 German, European and non-European cities daily point forecasts are calculated. The predicted weather parameters that are derived from the models for individual cities, are clearly arranged in tables for Germany, Europe, and the other continents. The forecast period is 4 days. If single forecast values are beyond the defined thresholds, the corresponding warning level can be highlighted by a colour backing.
As part of the project "Wettergefahren-Frühwarnung", further research work is carried out in the background. These include, for example, the implementation of a storm warning system for Germany and Europe, which enables an early assessment of the storm's loss potential. Precipitation information is calculated and archived in map form with high spatial and hourly resolution. Especially the repeated heat and drought of the last years in large parts of Europe makes the routine calculation and presentation of a drought index useful.

"Wettergefahren-Frühwarnung" as part of CEDIMs FDA activities

"Wettergefahren-Frühwarnung" plays an important role in CEDIMs disaster research concept known as Forensic Disaster Analysis (FDA) where natural disasters and their impact will be analysed in near real time and in an interdisciplinary manner. "Wettergefahren-Frühwarnung" contributes to all CEDIM FDA activities ahead, during and after a major event and comes up with preliminary and precise weather information and reliable forecasts, which are always available and may be updated several times daily. "Wettergefahren-Frühwarnung" gives advice and assist with articles and reports on extreme events thus making it a quick and uncomplicated cooperation between the various institutions of CEDIM.

Further reading

http://www.wettergefahren-fruehwarnung.de

Webservice „Wettergefahren-Frühwarnung"

Seit nunmehr fast 16 Jahren stellt die Internet-Plattform „Wettergefahren-Frühwarnung" umfassend und aktuell Informationen zu extremen oder außergewöhnlichen Wetterereignissen weltweit zur Verfügung. Das Hauptaugenmerk liegt dabei auf den Wettervorgängen in Europa und seit 2019 auch auf Afrika und insbesondere dann, wenn sie mit einem großen Schadenpotential einhergehen. Zum Angebot zählen redaktionell aufbereitete Artikel und Analysen, die teilweise mit eigenen Karten, Tabellen und Diagrammen vervollständigt werden. Weit mehr als 1000 Analysen extremer Wetterereignisse weltweit und in gleichbleibender Form und Qualität machen das Archiv zu einer einzigartigen Fundgrube. Seit Anfang des Jahres 2019 werden sämtlichen Informationen ausschließlich in englischer Sprache angeboten. Neben der routinemäßigen Überwachung der weltweiten Wettervorgänge und der Analyse extremer Wetterereignisse stellt „Wettergefahren-Frühwarnung" viele weitere Produkte und Informationen bereit, die ständig erweitert und aktuell gehalten werden; dazu gehört beispielsweise auch die Berechnung und Implementierung von Sturm- und Trockenheitsindices.

Im Rahmen des CEDIM-Konzeptes der forensischen Katastrophenanalysen (CEDIM Forensic Disaster Analysis, FDA) spielt „Wettergefahren-Frühwarnung" eine wichtige Rolle, indem es sämtliche FDA-Aktivitäten und beteiligten Institute durch Bereitstellung von Texten, Daten, Informationen und Grafiken ereignisnah unterstützt.

Third Party Funded Projects in CEDIM

Convective wind gusts (ConWinG)

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Institute for Hydromechanics (IfH)

Introduction

Convective wind gusts are triggered by thunderstorms and occur almost exclusively during the warm summer months in Germany. Due to falling precipitation and cooling processes in a convective cloud, a local downdraft (downbursts) is generated, which is deflected horizontally after hitting the surface, generating a divergent horizontal flow near the ground. Usually affected by high wind speed is only a small area of a few square kilometres. Convective gusts can also be caused by gust fronts of mesoscale thunderstorm complexes when the downdrafts of several thunderstorm cells merge into a continuous area of high horizontal wind speeds. Convective wind gusts can cause considerable damage to the natural and built environment. However, guidelines for the design of wind loads on buildings or structures currently consider characteristics of turbulent gusts only, but not convective gusts This is mainly due to the fact that their intensity, spatial extent and probability of occurrence are not well understood.

Aims/Objective

The interdisciplinary DFG-project "Convective Wind Gusts (ConWinG)" between IMK-TRO and IfH aimed to improve the basic knowledge about the spatio-temporal characteristics of convective gusts and their interaction with built structures and the associated damage potential.

Characteristics of convective wind gusts in Germany

An event catalogue for Germany was created and statistically evaluated using observational data of the German Weather Service (DWD; 1992 – 2014). The identified samples allowed for the identification of various gust features, such as their temporal and spatial variability, return periods, and gust factors (Mohr et al., 2017). The results show that the probability of occurrence of convective gusts increases in the north-to-south direction; local-scale spatial patterns, for example due to the influence of orography, could not be identified. Based on the spatial distribution of the gust maxima, it can be concluded that strong convective gusts in excess of 30 m/s may occur everywhere in Germany.

Fig. 1: Damage during a microburst in Framersheim on 7 July 2015 (Image credit: Susanna Mohr).

Interaction with urban structures

Based on various wind-channel experiments, it has been shown that the vertical velocity at eaves height as well as the volume flux into the street canyon depend on the ratio of the building height *H* to the downburst diameter *D* – the larger *H/D*, the higher the vertical velocity and the larger the volume flux into the street canyon (Richter, 2017). The maximum horizontal velocities within the canyon correspond to the vertical downdraft velocity. These high velocities are conserved over a longer distance for larger *H/D*. For a street canyon interrupted by crossings, the conservation of high velocities additionally depends on the building density – the lower the density, the faster the decrease in velocity. The turbulence intensities are, furthermore, smaller within the canyon compared to open terrain conditions. The wind loadings in such conditions differ from those of an atmospheric boundary layer (turbulent conditions). Especially the loadings acting on the roofs within the impingement centre exceed the specifications provided by DIN standards.

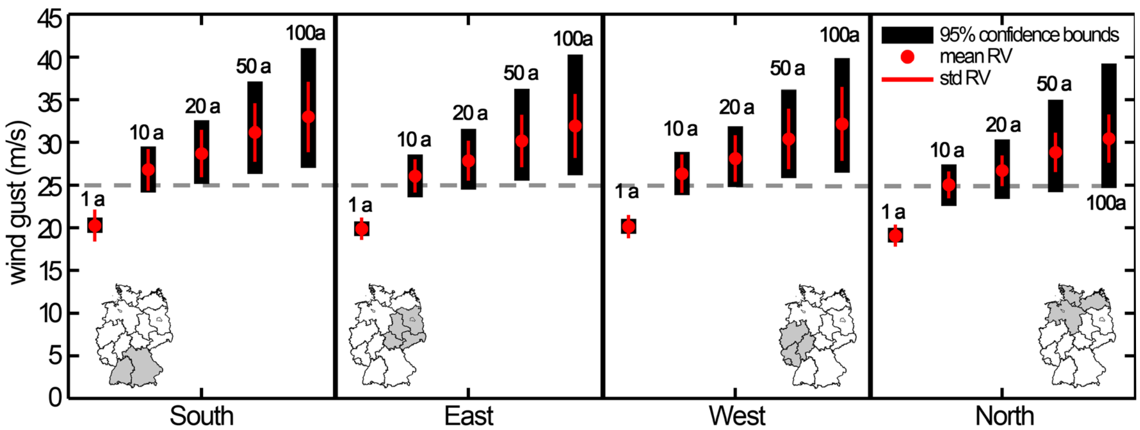

Fig. 2: Mean return values of convective gusts (RV) for various return periods (1, 10, 20, 50 and 100 years) in four regions in Germany (grey area). Red lines indicate the standard deviation of all stations within the respective region and black bars represent the mean 95 % confidence intervals representing statistical uncertainties of the used extreme value method (Mohr et al., 2017).

Sommerliche Starkwindereignisse in Deutschland

In Rahmen des interdisziplinären DFG-Projekts *ConWinG* zwischen Hydromechanikern und Meteorlogen wurde verschiedene charakteristische Merkmale konvektiver Böen wie die zeitliche und räumliche Variabilität, Wiederkehrperioden und Böenfaktoren basierend auf einem Ereigniskatalog für Deutschland (1992 – 2014) statistisch untersucht (Mohr et al., 2017). Des Weiteren wurde die Interaktion dieser Phänomene mit gebauten Strukturen experimentell im Windkanal untersucht, um die Auswirkungen und Veränderungen der Geschwindigkeiten – speziell in Straßenschluchten und Kreuzungen – und das damit verbundenen Schadenpotential durch die Windlast besser zu verstehen und zu quantifizieren (Richter, 2017; Richter et al., 2018).

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Dams and seismicity – Technologies for risk reduction: From rigid constructions to smart solutions (DAMAST)

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Together with other KIT institutes and EIFER, CEDIM forms the scientific part of the international consortium in the project *Dams and Seismicity – Technologies for risk reduction: From rigid constructions to smart solutions* (DAMAST). This project funded by the federal ministry of education and research within the framework of "International Partnerships for Sustainable Innovations" (CLIENT II). The target country is Georgia and in a first funding phase the Enguri Dam in the southwest of the Caucasus is the subject of the investigations.

Water reservoirs are of great importance for the Caucasian countries now and in the long-term: they are crucial for energy self-sufficiency, irrigation, water supply, but also for passive flood protection. Earthquakes, but also induced seismicity, which can be caused by a change in pore pressure and stress conditions, e.g. due to changes in water level, heavy precipitation, sedimentation, landslides, endanger the safe operation and safety on the utility's premise, but also the safety and security of supply for the population.

In a first phase of the DAMAST project, CEDIM is developing a holistic concept for a smart early warning system, which, on the basis of real-time measurement data, will on the one hand consider preventive measures for local dam safety, taking into account the regional impacts on the supply system and against the background of an energy system, which, in the long term, will be largely based on hydro-power (today, the hydropower plant at Enguri covers 38 % of the Georgian electricity supply). On the other hand, emergency measures to protect the population are also covered.

Fig. 1: The 277 m high arch dam of the Enguri dam in Georgia (Image credit: KIT/AGW).

Further reading

http://www.damast-caucasus.de
https://www.bmbf-client.de/projekte/damast

DAMAST: Technologien für den sicheren und effizienten Betrieb von Wasserreservoiren

Weltweit entstehen im Zuge der Einrichtung einer klimafreundlichen Energieversorgung neue Staudämme. Vielerorts gefährden natürliche oder induzierte Erdbeben insbesondere im Zusammenwirken mit anderen Extremereignissen wie Starkniederschlägen oder Hangrutschungen die Sicherheit eines Staudamms und damit auch die ortsansässige Bevölkerung. Im Projekt DAMAST, ein vom Bundesministerium für Bildung und Forschung im Rahmen der „Internationalen Partnerschaften für nachhaltige Innovationen" (CLIENT II) gefördertes Projekt, untersuchen deutsche, georgische und armenische Partner am Beispiel des Enguri Staudamms im Kaukasus die zugrundeliegenden Prozesse sowie sicherheitsrelevante Parameter von Wasserreservoiren.

Der Forschungsteil des CEDIM widmet sich der Konzeption eines modularen Frühwarnsystems, indem eine Gefährdungsanalyse für verschiedene Extremereignisse bzw. kritische Wirkfaktoren an dem Stausee erfolgt und Informationen aus den aufgebauten Überwachungssystemen hinsichtlich der relevanten Schlüsselparameter integriert werden. Zusätzlich sollen auch Notmaßnahmen zum Schutz der Bevölkerung untersucht werden.

Flood risk model SparkassenVersicherung (FLORIS-SV)

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Introduction

Severe flood events, such as those at the Elbe and Danube rivers in 2002 and 2013, frequently cause damage amounting to several billion Euros, and accordingly, are thus responsible for approximately one-third of the economic losses natural disasters in Germany have caused in the last decades (Schröter et al., 2015). To estimate the damage expected with a certain probability, CEDIM in cooperation with the SV SparkassenVersicherung, has developed a novel flood risk model (FLORIS). This model accounts for both pluvial flood events that result from persistent rainfall over large areas (which will be described here), and fluvial floods caused by short-term, local-scale convective precipitation. FLORIS is the outcome of a collaboration between the Institute of Meteorology and Climate Research (IMK-TRO), which developed a stochastic rainfall model, the Institute for Water and River Basin Management (IWG), which performed hydrological and hydraulic simulations, and the Geophysical Institute (GPI)/Risklayer GmbH, which quantified new vulnerability/fragility curves to estimate the flood risk ultimately.

Rainfall simulations

To estimate heavy rainfall that has the potential to cause severe flooding, area-wide measures of the amount of precipitation are required over an extended period, from several decades to centuries. However, reliable precipitation observations are available only as point measurements at individual stations, which are not distributed spatially homogeneously, and cover only a few decades. Hence, when using these data, it remains unclear whether extreme rainfall amounts have been recorded already throughout their entire possible range.
Therefore, a new method to generate a large number of high-resolution (1 x 1 km²) precipitation fields stochastically has been designed (Ehmele, 2018; Ehmele and Kunz, 2018). The two-dimensional Stochastic Precipitation Model, SPM2D, is based on the linear theory of orographic precipitation (Kunz, 2011), but includes further processes relevant to precipitation totals, such as fronts and embedded convection. The SPM2D is driven by a limited set of relevant meteorological variables, such as wind, humidity, stability, and large-scale lifting, for which seasonally dependent probability dis-

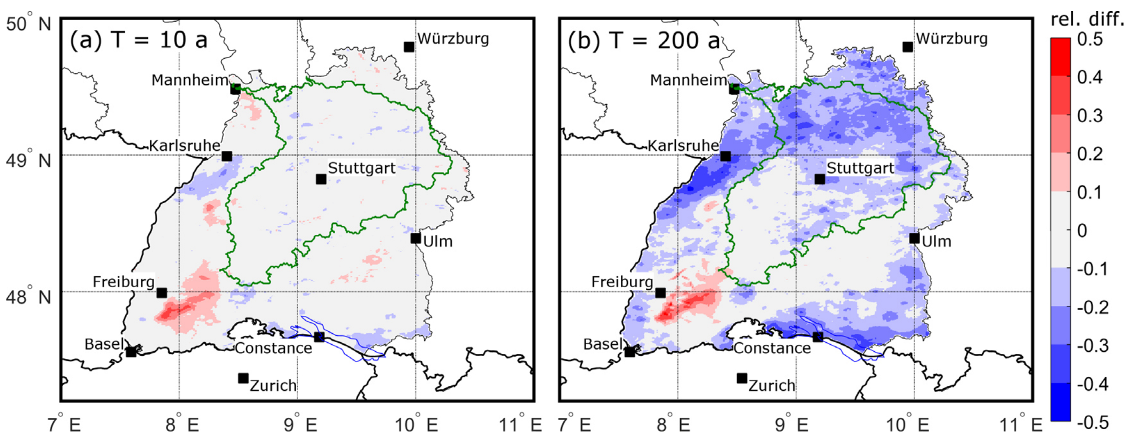

Fig. 1: Relative difference of the precipitation amounts for return periods of (a) 10 years, and (b) 200 years, according to a Gumbel distribution fitted to the observations and the SPM2D. The Neckar catchment is shown as green contour (Ehmele and Kunz, 2017).

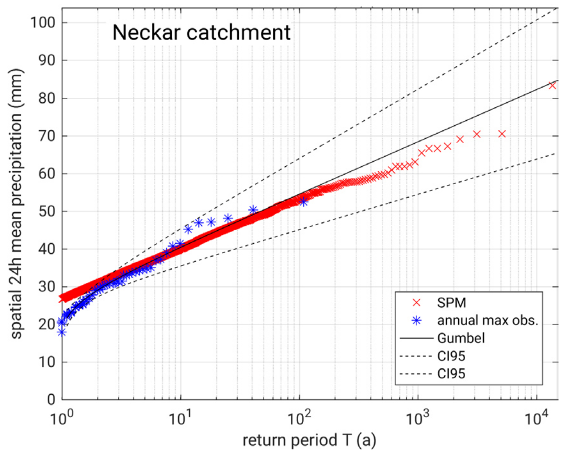

Fig. 2: Daily rainfall totals (areal means) as a function of return period T based on the annual maximum series of observations (REGNIE totals from DWD, blue), the corresponding Gumbel distribution including the 95 % confidence intervals (black), and the annual SPM series (red) for the Neckar catchment (Ehmele und Kunz, 2017).

tributions are determined from vertical profiles obtained from radiosondes (temperature, moisture, wind) and precipitation measurements (ground stations). The solution of the model equations in Fourier space allows thousands of events to be simulated in stochastic mode with significantly less computation time compared to standard numerical weather models.
Despite the precipitation processes' simplified parameterizations, the SPM2D generates realistic precipitation fields. The differences in the observations are largely in the range of only a few percent, both for larger regions or single catchments even for longer return periods (Fig. 1 and 2).

Hydrology & Hydraulic

In the second step, the IWG converted the stochastic precipitation events into stochastic flood scenarios by calculating the potential runoff and return periods per river basin using the corresponding flood hazard maps (Hochwassergefahrenkarten, HWGK). While current flood models quantify the risk separately for single catchments, this approach does so for flooding that occurs simultaneously in several catchments, which has the potential to increase total economic losses substantially.
The analysis of historical events has shown that the return periods of runoff in sub-catchments differ significantly from those in the catchment overall. For example, the effects of a 100-year event in an individual sub-basin may exceed those of a 500-year event in an entire catchment area. This is the principal reason why an event-based approach is required to examine pluvial flood events and estimate their related damage realistically.

Risk assessment

Finally, a comprehensive analysis of the exposure and vulnerability of the underlying portfolio of building data was conducted. A variety of innovative data gap filling methods were applied, including various OpenStreetMap methods and a comprehensive collection of information necessary for vulnerability and damage analyses. These includes the buildings' type and use, the number of stories or height, as well as any existing hydraulic engineering measures used to reduce flood risk (e.g. retention basins).

To associate the stochastic rainfall events and the related water levels with the damage caused, historical events were examined worldwide and more than 200 possible damage functions were tested (Fig. 3). In addition, the behavior of river floods and flash floods, which differ considerably, particularly in duration, flow characteristics, and debris content, was analyzed. In this way, the potential damage and the associated return period for each event were determined to generate PML curves (probable maximum loss) and damage tables. With these, it is possible to quantify the risk of a 200-year event (PML200) that the insurance industry requires according to the European insurance directive Solvency-II.

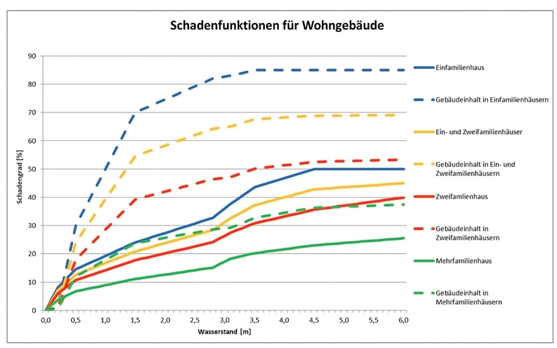

Fig. 3: Damage function (degree of damage as a function of the water depth) for different residential buildings based on the simulated water heights at the building.

Hochwasserrisikomodell SparkassenVersicherung (FLORIS-SV)

Im Rahmen des Projekts FLORIS (Flood Risk – Hochwasser-Risiko) hat CEDIM in Kooperation mit der SV SparkassenVersicherung ein Hochwasserrisikomodell entwickelt, mit dem das Risiko, also der zu erwartende Schaden für eine bestimmte Wahrscheinlichkeit, für mehrere gleichzeitig betroffene Einzugsgebiete realistisch abgeschätzt werden kann. Am IMK-TRO wurden die meteorologischen Bedingungen im Vorfeld und während schwerer Hochwasser analysiert und quantifiziert und die Ergebnisse in ein stochastisches Niederschlagsmodell überführt. Auf Basis der so gewonnenen Daten wurden anschließend am IWG hydrologische und hydraulische Simulationen durchgeführt, aus denen schließlich das Hochwasserrisiko mit den durch Risklayer GmbH neu entwickelten Vulnerabilitätskurven für ein vorgegebenes Portfolio an Gebäudebestandsdaten abgeschätzt werden kann.

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The increasing risk of a highly vulnerable industry globally to natural disasters and climate change – A global risk index for wine regions (WINE)

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Geophysical Institute (GPI), Risklayer GmbH

Further contributors: Trevor Daniell, Katherine Daniell, Michael Kunz, Tina Kunz-Plapp, Bijan Khazai, Trevor Girard, Timea Barta, Jan Becker, Susanna Mohr

Winemakers around the world lose billions of dollars in lost revenue, grapes and building stocks every year due to natural disasters. A multidisciplinary European-Australian research team of engineers, seismologists, meteorologists, scientists and wine lovers from Karlsruhe Institute of Technology (KIT), Risklayer GmbH in Germany, Australian National University, Griffith University, University of Adelaide, University of New South Wales in Australia; as well as Greece and UCL in UK has set out to examine just how much this is, and the total risks associated with the wine industry and how to improve and mitigate these with respect to different natural disasters and climate change by developing a global risk index for wine regions. "WineRisk" is an initiative started to assess and mitigate risk to wineries from natural hazards and other perils. The "WineRisk" website summarizes the results of the study and presents solutions for wine regions: www.winerisk.com. The wine regions of Mendoza and San Juan in Argentina are exposed to the highest risks due to extreme weather and natural hazards worldwide. Kakheti and Racha in Georgia come in at number 2, followed by Southern Cahul in Mol-

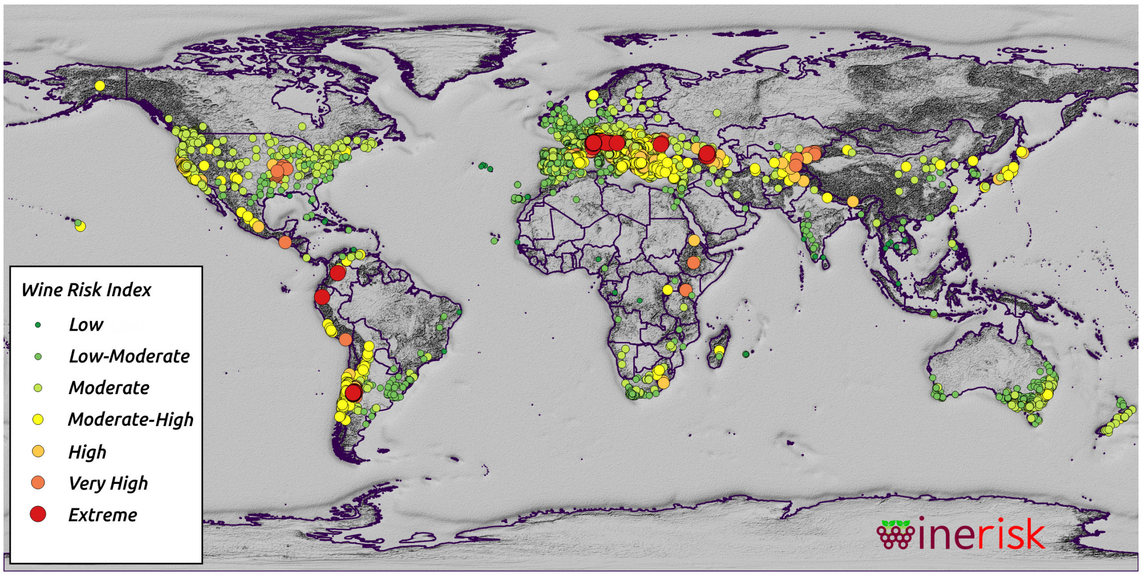

Fig. 1: Global combined wine risk index from natural hazards.

dova (number 3), Northwest Slovenia (number 4), and Yaruqui in Ecuador and Nagano in Japan (number 5). The study covers more than 7,500 wine regions in 131 countries. There is no wine region in the world that is not exposed to extreme weather or natural disasters. Events, such as frost, hail, floods, heat, drought, forest fires, and bushfires as well as earthquakes make worldwide wine industry lose more than 10 billion US$ every year according to conservative estimations. These losses result from damaged assets, losses of production, and lost profit.

In addition to cold waves and frost, hailstorms also have a major impact on wine – especially for European winemakers. Traditional wine countries like France and Italy have seen huge losses in the past five years due to hail and frost, with many losses being recorded in the regions of Burgundy and Piedmont. The hail losses from 2012 to 2016 in some vineyards totalled 50 to 90 percent of the value of the crop and caused long-term damage to many old vines. It is not just Europe that is affected by hail. All over the world, winegrowing regions are affected by at least one hail event per year, which can cause damage to the single vintage or to multiple vintages depending on the growth phase of the vines. Hail nets can save the crop in most cases, given a large hail event – Cost-benefit analyses generally show that the premium wines should be the ones covered by hail nets, with insurance or other cheaper methods used for other wines.

Earthquakes have the ability to knock out the infrastructure of entire wine regions for a number of years. In the past years, earthquakes struck Chile, New Zealand, and the USA, among other smaller events causing damage around the world. Over 125 million litres of wine were lost in Chile in 2010, mainly due to the failure of steel tanks. Earthquake-resistant design could have saved many millions of litres. Earthquakes also cause large losses to buildings, tanks, barrels, equipment, and chemicals. Even small earthquakes do not only cause financial loss, but also historical loss by destroying tasting rooms and rare wine collections. A few dollars investment in stabilization mechanisms, such as quake wax, zip ties or bolts, can often save millions of dollars loss. In addition, natural disasters are associated with losses of jobs and tourism.

Global climate change will have both positive and negative effects on wine industry, according to the study. Researchers expect a general shift of wine-growing regions southward and northward, while some wine regions closer to the equator may be lost. Many wines may indeed improve. The English, Canadian, and Northern China wine regions will likely increase production markedly and continue to improve their market share and quality of production. It can be expected that many wineries will master climate changes by changing grape varieties or harvest times. In addition, they will profit from new grape strains, innovative technologies to optimize production and reduce damage due to biological pathogens and insects, and new methods to overcome extreme weather events. The study also covers problems, such as bushfires causing smoke taint to vines. However, smaller-scale studies are required before the results can be included globally in the index. In addition, the effects of floods on vines are being explored. Nevertheless, a major volcanic eruption would likely cause the largest global impact to the wine industry, examples being the Laki eruption of 1783/84 or the Tambora eruption in 1815 which caused the famous "year without a summer" in 1816. Atmospheric changes, lack of sunlight, and global transport problems could cause major issues not only for the wine industry, other food security issues would likely be more important.

Despite all these hazards, the wine industry continues to grow and diversify. Through detailed natural hazard analysis, research can help winemakers and governments alike to prepare adequately for the natural hazards that they face and to reduce losses.

Wein und das damit verbundene Risiko durch Naturkatastrophen und den Klimawandel: Ein globaler Risikoindex für Weinregionen

Winzer auf der ganzen Welt verlieren jedes Jahr Milliarden von Dollar an Einkünften, Trauben und Lagerbeständen durch Naturkatastrophen. Ein multidisziplinäres europäisch-australisches Forschungsteam aus Ingenieuren, Seismologen, Meteorologen, Wissenschaftlern und Weinliebhabern vom KIT, der Risklayer GmbH in Deutschland, der Australian National University, der Griffith University, der University of Adelaide, der University of New South Wales in Australien sowie aus Griechenland und der University College London in Großbritannien hat sich vorgenommen, zu untersuchen, wie hoch dieser Verlust ist und welche Gesamtrisiken mit der Weinindustrie verbunden sind und wie diese im Hinblick auf verschiedene Naturkatastrophen und den Klimawandel durch die Entwicklung eines globalen Risikoindex für Weinregionen verbessert und gemildert werden können. „WineRisk" ist eine Initiative, die gestartet wurde, um das Risiko für Weinkellereien durch Naturkatastrophen und andere Gefahren zu bewerten und zu mindern.

Further reading

WineRisk Website: http://www.winerisk.com.

KIT-Presseinformation 051/2017: Naturkatastrophen kosten Winzer jährlich Milliarden https://bit.ly/2ZK4Wj2.

A decision support framework for improving cross-border area resilience to disasters (INCA)

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In the INCA project, funded by the German Research Foundation (DFG) and the French National Research Agency (ANR), the crisis scenario of a long-term power failure in the German-French border region is investigated. First, direct and indirect consequences of a power failure for the population are collected by scenarios. The selected situation represents a stress test for the supply system and brings the emergency program to its limits, as energy backup generators are only designed for a short-term usage. Hence, the main aspect is the efficient identification and treatment of casualties by finding an optimal distribution of the remaining medical resources. A special focus is on the cross-border cooperation of authorities who are responsible for crisis management as well as the forces involved in crisis management. In past crisis it was observed, that volunteers no longer act as members in voluntary aid organizations, but spontaneously come together and offer their know-how. As a result, the usual coordination is limited or completely eliminated such that this trend requires analysis. It will be investigated in coordination processes for the inclusion of voluntary spontaneous helpers to act in a structured way since their different backgrounds, experiences and motivations are seen as a huge potential for strengthen the resilience in a disaster.

To achieve these goals, an agent-based model is developed, as this method is suitable for mapping the complex interplay of the individuals and the dynamics of their behaviour. Agent-based modelling is particularly well-suited for depicting a crisis scenario, as each actor has limited information that he gains by sharing with other agents. Additionally, not all alternative courses of action are known and not all resulting effects are predictable due to the complexity. Nevertheless, decisions must be taken under uncertainty and the project will support this process from a scientific point of view. Here, special features of the cross-border region as culture and language, which may facilitate or complicate crisis cooperation, are considered so that solution approaches can be derived that accurately represent the peculiarities of the border region and take into account positive factors of so-called border identity. The solution of the model should be robust despite changes in the scenario, since crises and their course are not known in advance. The current state of the agent-based model was presented at the INFORMS Annual Meeting in Seattle in October 2019.

In order to gain a deeper understanding of the border region, an empirical study will also be conducted to measure cross-border social capital as a success factor for cooperation in the event of a crisis. This data will be used to show the influence of different languages and cultural backgrounds, which play a crucial role in cross-border cooperation. By comparing the data collected separately for each of the both countries, Germany and France, with the data collected in the border region, it is possible to examine the specific features of the border region.

INCA – Ein Entscheidungsunterstützungs-Framework zur Stärkung der Katastrophenresilienz in Grenzgebieten

Ziel des interdisziplinären und transnationalen Projekts INCA, das von der Deutschen Forschungsgemeinschaft (DFG) und der französischen Agence nationale de la recherche (ANR) gefördert wird, ist die Erhöhung grenzüberschreitender Resilienz urbaner Systeme gegenüber exogenen Gefahren, wie beispielsweise extremen Naturereignissen und/oder dem Zusammenbruch kritischer Infrastrukturen wie eines langfristigeren Stromausfalls in der deutsch-französischen Grenzregion. Der methodische Kern des Projekts ist ein agentenbasiertes Modell, mit dem sich die Reaktion der betroffenen Bevölkerung, die Intervention der Akteure des Bevölkerungsschutzes sowie das Verhalten freiwilliger Helfer analysieren lassen. Auf Basis sozio-ökonomischer Daten und klar definierter Szenarien soll es so möglich werden, Schwachstellen grenzüberschreitenden Krisenmanagements zu identifizieren, die Koordination und Kooperation zwischen den Stakeholder-Gruppen zu verbessern und so zu einer erhöhten Resilienz urbaner Systeme in Grenzregionen beizutragen.

Competence Center for Applied Security Technology (KASTEL)

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Introduction

The far-reaching integration of IT technology into the world of life and work enables a multitude of innovative applications and services. In so-called Smart Environments, networked sensors and actuators form the basis for the automation of everyday processes, more comfort and the efficient use of resources such as energy or water. Modern production facilities are highly interconnected. Embedded systems communicate independently with each other, planning systems from the cloud, calculate order steps and machine allocations, plant operators monitor and control from a distance, maintenance personnel carry out configuration changes worldwide. In the networked world, the protection of production plants no longer ends at the building or factory premises. Via the network connections, attackers can penetrate and manipulate the systems, malicious code infections can completely paralyze large areas, causing immense physical damage and danger to life and limb. Not just since Stuxnet, Duqu, Flame and Havex reports, it's clear that production facilities are targets for cyber-attacks. The associated ubiquitous collection, storage and processing of data, however, particularly affects the core area of personal lifestyle and organizational performance. Thus, the collected data can be used to draw conclusions about activities, interests and preferences of persons or about processes in organizations. One of the great challenges of Smart Environments is therefore the protection of the privacy of individuals and the business secrets of organizations.

Objectives

The main objective of KASTEL is to develop methods and concepts for secure IT systems of the future as a university-based competence centre. The focus here is on a holistic approach and application orientation. To this end, various aspects of Smart Environments, which are characterized by a variety of networked sensors and actuators, will first be investigated. Networked production (industry 4.0) is also considered to be an application case in the economy. Furthermore, the security of networked critical infrastructures will be investigated. This is achieved by bundling the outstanding skills of twelve working groups in the field of IT security in one centre.

Thereby a hypothesis is, that security in modern and complex systems can only be reliably ensured if the requirements placed on a system are consistent from design to implementation and quality assurance. Practically observable attacks on systems are usually due to a lack of security concepts or to errors that only occurred during implementation because the security design intended was not implemented consistently.

Therefore, KASTEL is developing a system theory for the continuous adaptation to strategic, evolving attackers, as well as to tools and methods that consider security, implement security consistently and make security verifiable. The primary focus of the Institute of Industrial Production (IIP) within KASTEL is on economic risk management. Risk management generally comprises a systematic analysis of internal organisational risks and the development of measures to reduce risks for the purpose of long-term protection of the organisation and the society. The handling and control of IT risks requires not only that organizations have the necessary technologies and processes available, but also that these are economically sensible and feasible. Economically oriented risk management is therefore becoming increasingly important due to the ever-stronger linkage of industrial value chains in terms of information technology and the associated growing effort required to protect these structures from attacks and technical errors. Economic risk management refers not only to the economic efficiency of IT risk management, but also to the economic consequences of a failure of IT systems (e.g. business interruption). With a view to the development of scalable and quantifiable safety concepts, it is possible to consider material and immaterial consequences in the risk assessment. In addition, an economic risk analysis also considers the behaviour of the actors as well as the opportunity costs of risk-reducing measures and thus the conflicting objectives of security investments. The following project objectives of IIP in KASTEL can be derived from this:

- Categorization of attacker profiles and identification of attack strategies to enable targeted defence against external attackers (external offenders)
- Identification of internal system attackers (internal offenders) as well as analysis and design of internal organisation incentives for risk reduction
- Description of requirements for an internal safety culture to reduce “negligence and human error” as sources of danger
- Assessment of direct/indirect material and immaterial damage
- Quantification of cyber risk
- Holistic, value based decision support for cyber security relevant investments in safeguards, insurances and hedges

In order to guarantee the practical relevance of the developed solutions and to secure the technology transfer, an exchange with companies takes place. The methods and tools developed are to be further adapted by this linkage and extended by functions, which permit an approximation to the requirements and complexity of real systems. Furthermore, the technology transfer in the security sector is intended to strengthen the economy.

Project Status

As one of three competence centres for IT security research in Germany, KASTEL will be established on a permanent basis.

The research team around IIP is going to intensify their research in the area of cyber risk management on a broad basis. Thereby collaborations with economic partners as well as international research institutes shall be strengthened. First results are already presented in international research journals and conferences. The research group has started to develop a framework for the holistic assessment of cyber risk as well as first quantitative assessment approaches. An industrial demonstrator was developed for this purpose, which can be used for simulations and analysis. By transferring the knowledge gained by the in-depth research to organizations and society, the research can help increase cyber security. In particular, participation in corporate network initiatives and in research transfer companies should prove to be particularly relevant. Thereby, among other things an innovative Key Performance Indicator (KPI) system shall be developed to increase the research impact.

Kompetenzzentrum für angewandte Sicherheitstechnologie (KASTEL)

KASTEL ist eines von deutschlandweit drei Kompetenzzentren für Cybersicherheit, die vom Bundesministerium für Bildung und Forschung (BMBF) im März 2011 initiiert wurden. Unter dem Motto „Nachvollziehbare Sicherheit in der vernetzten Welt“ stellt sich KASTEL den Herausforderungen, die durch eine fortschreitende Vernetzung bisher isolierter Systeme entstehen.

Das IIP beschäftigt sich im Rahmen von KASTEL mit ökonomischem Risikomanagement. Risikomanagement allgemein umfasst die systematische Analyse organisationsinterner Risiken sowie die Entwicklung von Maßnahmen zur Risikoreduktion zum Zwecke des langfristigen Schutzes der Organisation. Ökonomisches Risikomanagement bezieht sich dabei nicht nur auf die Wirtschaftlichkeit des IT-Risikomanagements, sondern auch auf die wirtschaftlichen Folgen eines Ausfalls von IT-Systemen (z. B. Betriebsunterbrechung). Mit Blick auf die Entwicklung skalierbarer und quantifizierbarer Sicherheitskonzepte ist es möglich, materielle und immaterielle Konsequenzen in der Risikobewertung zu berücksichtigen. Zudem berücksichtigt eine ökonomische Risikoanalyse auch das Verhalten der Akteure sowie die Opportunitätskosten risikoreduzierender Maßnahmen und damit die Zielkonflikte von Sicherheitsinvestitionen.

New approach to reactor safety improvements (NARSIS): KIT multi-hazard assessment

James Daniell, Andreas Schaefer, Friedemann Wenzel, Ann-Kathrin Edrich, Eric Haecker, Anna Neuweiler
Geophysical Institute (GPI)

NARSIS coordinates the research efforts of eighteen partners encompassing leading universities, research institutes, technical support organizations (TSO), nuclear power producers and suppliers, reactor designers and operators from ten countries. The project aims at making significant scientific updates of some elements required for the Probabilistic Safety Assessment (PSA), focusing on external natural events such as earthquake, tsunami, flooding, high speed winds etc.

The NARSIS project has now been running for a year, and the first set of deliverables and milestones have been produced as part of the effort of the consortium. Datasets have been collected, methodologies tested, the state of the art has been researched, and various criteria and plans developed. The 1-year plenary meeting was held from the 18th to the 20th of September at the Karlsruhe Institute of Technology with over 40 members joining the 3 days of discussions, presentations, working groups and activities.

A large amount of literature and models have been reviewed as part of this attempt to define a state-of-art in multi-hazard analysis for Nuclear Power Plants (NPPs) in the first year led by KIT as Work Package Lead. Many methodologies, software packages and datasets have been developed globally over the last decades for both probabilistic and deterministic hazard analysis of natural catastrophes. These tools have fed the production of potential external hazard scenarios and return periods for NPPs as part of PSA and Screening analysis.

A huge amount of external hazards from natural catastrophes exist – over 70 as determined by the ASAMPSA_E project of geophysical, meteorological, extra-terrestrial, biological, hydrological and climatological origin with various combinations of these events possible. Each hazard type interaction (coincident, causally correlated, mutually exclusive, direct) needs to be examined in a multi-hazard assessment.

A large number of historical single and multi-hazard events have been reviewed as part of this work, including large events such as the Tohoku 2011 earthquake and tsunami which will have a long lasting impact on the nuclear industry. Over 60 natural hazard events have been identified affecting in some ways NPPs in Europe. In most cases however the damage was not extensive. However, many more events not affecting NPPs have been identified from history. In fact, for earthquakes, 30 % of all fatalities have not been from shaking but from secondary effects such as tsunami or landslide. Similarly, we often see for tropical cyclones that storm surge and rainfall cause more fatalities than the pure wind losses themselves.

A review of the stress tests for European NPPs including various discussions with stakeholders shows the key design parameters for earthquake, flood and precipitation, using the national and individual plant reports for each of the available NPPs in Europe. The multi-hazard aspects however, are not touched upon in nearly all cases, thus the need for this project. NARSIS takes benefit of the recent ASAMPSA_E project, which aimed to examine in detail how far the PSA methodology is able to identify any major risk induced by the interaction between a NPP and its environment, and to derive some technical recommendations for PSA developers and users.

For the key hazards identified to affect NPPs across Europe, earthquakes, tsunami and wave, extreme weather effects (heat wave/cold spell, hail, precipitation etc.), and flooding, empirical data for Europe has been collected and examined as well as a discussion of empirical events collected from various scientific papers, projects and industry briefs. Methodologies have been put forward for the state-of-art assessment in deterministic or probabilistic methodologies for the perils be it via extreme value statistics of empirical data, with Monte Carlo simulation to produce a stochastic event set; or PSA using historical regression of disaster data via physical hazard zones and lognormal relations (or forms of it).

Key input parameters, datasets and metrics have been examined for each of the main types, as well as how uncertainty is examined as part of the analysis framework. A review of such hazard curves and combination methodologies is thus made for singular and secondary hazards. The step from single to multi-hazard analysis and the review of various frameworks suggests that this field is rapidly evolving with a significant increase in literature associated with multi-hazard in the last 5 years (in part due to the Tohoku event).

Various methodologies such as multivariate analysis and multi-hazard combinations of curves have been undertaken by many authors at a global, regional and local scale. With respect to NPPs, it can be seen from the stress test review and some other details that correlated hazards have rarely been used as part of design, however using the frameworks found, and has allowed for an Explorer software tool to be produced.

Further reading

http://www.narsis.eu

Neuer Ansatz zur Verbesserung der Reaktorsicherheit

In dem Projekt NARSIS werden die Forschungsanstrengungen von achtzehn Partnern gebündelt, zu denen führende Universitäten, Forschungsinstitute, technische Support-organisationen, Hersteller und Lieferanten von Atomstrom, Reaktorkonstrukteure und -betreiber aus zehn Ländern gehören.

Das Projekt zielt darauf ab, wesentliche wissenschaftliche Aktualisierungen einiger Elemente vorzunehmen, die für die probabilistische Sicherheitsbewertung (Probabilistic Safety Assessment) erforderlich sind, wobei der Schwerpunkt auf schweren Naturkatastrophen wie beispielsweise Erdbeben, Tsunami, Überschwemmungen oder Hitze-/Kältewellen liegt.

Scalable emergency logistics for urban areas as public-private emergency collaboration (NOLAN)

Marcus Wiens, Florian Diehlmann, Markus Lüttenberg, Frank Schultmann
Institute for Industrial Production (IIP)

Introduction

Emergency care falls within the remit of the public sector. Nevertheless, private companies have a large number of resources (including skills) at their disposal which can be very helpful in providing care to the needy population in the event of a crisis. In the NOLAN project, the option of a public-private partnership in crisis management is being systematically explored for the first time.

Project Status

The 2nd NOLAN expert workshop took place in May 2019. Dialogue partners from the private and public sectors reported on their experiences. Furthermore, current interim results of the project partners were presented and concrete aspects were worked out in small groups, which represents important input data for the modelling in the project. The project focus in 2019 was on collaboration in the area of emergency logistics with methods from the area of Operations Research and on game-theoretical modelling of the incentive structure of a public-private emergency collaboration. At project meetings in Dresden, Karlsruhe, and Berlin, further steps were defined in the project and interim results were recorded. Some of these interim results of particular interest for Critical Infrastructure providers (e.g. referring to the water and fuel scenario of NOLAN) were presented by Marcus Wiens at the European Disaster Management Congress in Berlin. Other conferences, such as the Fuel Safety Conference in Bonn or the closing event of the KIRMIN project, also funded by the BMBF in the field of safety research, were also attended by the project consortium. The exchange with the representatives there provided the team with further insights.

In cooperation with international researchers and project partners, work continued on various publications in the field of crisis management.

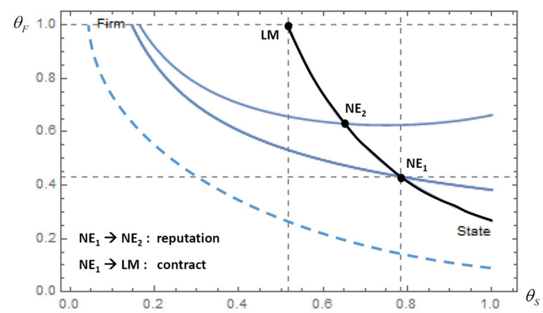

Fig 1: The graph shows so-called reaction-functions and Nash-equilibria (NE) as they are analysed in game-theoretical models. The incentives of public and private actors determine the scope of cooperative equilibria of a Public-Private Emergency Collaboration (PPEC).

NOLAN: Skalierbare Notfall-Logistik für urbane Räume als Public-Private Emergency Collaboration

Die Notfallversorgung fällt in den Aufgabenbereich der öffentlichen Hand. Dennoch verfügen private Unternehmen über eine Vielzahl an Ressourcen (inkl. Kompetenzen), die bei der Versorgung der notleidenden Bevölkerung im Krisenfall sehr hilfreich sein können. Im Projekt NOLAN wird erstmalig die Option einer öffentlich-privaten Partnerschaft im Krisenmanagement systematisch erforscht. Die Projektpartner sind in den Bereichen Risiko- und Krisenmanagement, Notfalllogistik, Supply Chain Management und öffentlichem Recht ausgewiesen und untersuchen zusammen mit Dialogpartnern aus dem privaten und öffentlichen Sektor die Möglichkeiten zur effektiven und praxistauglichen Gestaltung einer „Public Private Emergency Collaboration“ (PPEC). Ziel des Projektvorhabens ist es, die Versorgungssicherheit einer städtischen Bevölkerung mit lebensnotwendigen Gütern in Krisenlagen zu verbessern. Dabei sollen Konzepte für eine effiziente Kooperation von privaten Akteuren der kommerziellen Versorgungsketten (insb. Einzelhandel, Logistik, KRITIS-Betreiber) mit den staatlichen Akteuren erarbeitet werden. Das Projekt soll dazu beitragen, das öffentliche Krisenmanagement beim Ausfall von Versorgungsketten zu verbessern.

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Resilience of critical transport infrastructures exemplified by waterways (Preview)

Rebecca Wehrle, Marcus Wiens, Frank Schultmann
Institute for Industrial Production (IIP)

Introduction

Around 2.5 million containers are transported annually on the German waterways. On the one hand, the waterways are of outstanding importance for the functioning of the economy. On the other hand, the infrastructure of the artificial federal waterways, including canals and locks, is outdated. Floods or possible terrorist attacks also pose a threat to the waterway infrastructure. Furthermore, it is not known what consequences the failure of individual critical elements of this system may have for other transport infrastructures, the economy and the population in the affected regions.
The PREVIEW project pursues the central goal of increasing the resilience of the waterway infrastructure in Germany. To this end, five consortium partners are investigating the possible effects of the failure of critical waterway infrastructure on other transport infrastructures, on logistics, on neighbouring industries and on the population of neighbouring regions as part of a holistic risk management approach. The consortium includes BAW (Bundesanstalt für Wasserbau), Hochschule Karlsruhe, antwortING Beratende Ingenieure PartGmbB, 4flow Research, and IIP as project partners. The project is funded by the Federal Ministry of Education and Research and is located in the fields of civil security research (www.sifo.de).

Aims/Objective

The aim of the PREVIEW project is to increase the resilience of the waterway infrastructure in Germany. Therefore, the damage effects and consequences will be analysed and processed on the basis of the three safety scenarios of natural events, technical or human failure and hostile attacks. For the first time, the entirety of the hazards for the population as well as for transport and economy will be analysed. The resulting findings will be used to draw up contingency plans in order to effectively counter these hazards.
The results of the project will be incorporated into a simulation model, which illustrates possible hazardous situations using the example of the West German canal network. This enables end users to visualize the vulnerability of the infrastructure, the local communities and industries. Logistic models also make it possible to assess the economic impact of damage events in canals. The results benefit the end users and can then be transferred to the entire waterway infrastructure.

Project Status

The PREVIEW project started in September 2018. During the three-year term of the project, IIP scientists focus on scenario development, the assessment of damage consequences and the interdependences of critical infrastructures. A further task is the integration of the partial work into a holistic risk framework. Therefore, scenarios have been developed and validat-

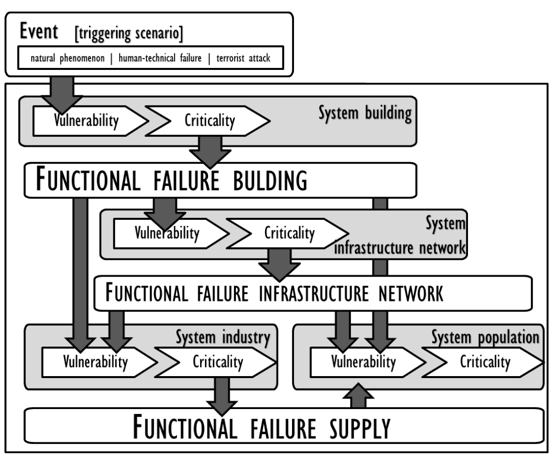

Fig. 1: Risk framework.

ed. Furthermore, a holistic risk framework has been constructed.
Activities that contributed to the previous results include a three-day excursion to the model region to the West German canal network as well as an expert workshop. This supported the interdisciplinary and practice-oriented exchange between project partners and experts from science and industry as well as a continuous flow of information between the parties involved does.

Outlook

In the next steps, the project partners focus on their own area of expertise, taking into account the developed risk framework and corresponding interfaces. The employees of KIT-IIP will deepen the economic assessment of damage consequences as well as the analysis of interdependences of critical infrastructures. Therefore, experts will be interviewed and another expert workshop will be held in 2020.

Fig. 2: Excursion to the West German canal network in March 2019 (Image credit: IIP/KIT).

Resilienz kritischer Verkehrsinfrastrukturen am Beispiel der Wasserstraßen

Auf den deutschen Wasserstraßen werden jährlich rund 2,5 Millionen Container transportiert. Einerseits sind die Wasserstraßen für das Funktionieren der Wirtschaft von herausragender Bedeutung. Andererseits ist die Infrastruktur der künstlichen Bundeswasserstraßen, einschließlich der Kanäle und Schleusen, veraltet. Hochwasser oder mögliche Terroranschläge stellen ebenfalls eine Bedrohung für die Wasserstraßeninfrastruktur dar. Zudem ist nicht bekannt, welche Folgen der Ausfall einzelner kritischer Elemente dieses Systems für andere Verkehrsinfrastrukturen, die Wirtschaft und die Bevölkerung in den betroffenen Regionen haben kann.
Das Projekt PREVIEW verfolgt das zentrale Ziel, die Belastbarkeit der Wasserstraßeninfrastruktur in Deutschland zu erhöhen. Zu diesem Zweck untersuchen fünf Konsortialpartner im Rahmen eines ganzheitlichen Risikomanagement-Ansatzes die möglichen Auswirkungen des Versagens kritischer Wasserstraßeninfrastrukturen auf andere Verkehrsinfrastrukturen, auf die Logistik, auf benachbarte Industrien und auf die Bevölkerung benachbarter Regionen. Dem Konsortium gehören die BAW (Bundesanstalt für Wasserbau), die Hochschule Karlsruhe, antwortING Beratende Ingenieure PartGmbB, 4flow Research und das IIP als Projektpartner an.

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PREVIEW Project Website: https://preview-projekt.baw.de/de.

Integrated solutions for sustainable development in the Mekong Delta (ViWaT)

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Stefan Norra
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The endangered delta

In the Mekong Delta in southern Vietnam, about 18 million people live in an area that is about the size of Baden-Württemberg in Germany. Climate change and other human-induced influences are putting a heavy strain on this economically significant region of Vietnam, which is why the existence of the Mekong Delta is now threatened.

The intensive use of groundwater in recent decades has thus led to a sharp drop in groundwater levels and to a sustained landfall of up to several centimetres per year. The annual sea-level rise of about two to three millimetres caused by climate change is added to these factors. Another problem is strong erosion in the coastal areas. One of the causes is the construction of barrages in the neighbouring countries, especially in China and Laos, which contain sediments and thus restrict their transport to the Mekong Delta. This and the loss of the protective mangrove forest mean that, in parts, the coastal areas are eroded up to 50 meters from the sea each year. But the banks of the canals and rivers are also damaged by erosion. The existing water management of the surface waters is regulated with the help of hundreds of locks and weirs and serves as a basis for diverse land use (including rice cultivation, fruit cultivation, fish farming and shrimp farming) with their different demands on the salinity of the water. The combined effect of climate-induced seawater rise and local land subsidence poses an enormous threat to these systems. An additional burden on the regional availability and quality of existing freshwater resources is the largely untreated wastewater.

In the face of this significant pressure, the Vietnamese government has begun to redesign water and land use in the Mekong Delta. Various existing research and planning results as well as planned activities at the Vietnamese and international level are already contributing to this.

One joint project - three sub projects

The Karlsruhe Institute of Technology (KIT), together with research groups from the Ruhr University Bochum (RUB) and the University of Witten/Herdecke (IEEM), launched the interdisciplinary joint project ViWaT-Mekong to make another strong contribution to the sustainable improvement of water and land use in the Mekong Delta, which is funded by the Federal Ministry of Education and Research (BMBF) under Client II.

The work of ViWaT-Mekong focuses in particular on coastal protection, sustainable water management and regional water and land use planning. These topics are coordinated in three independent research associations that combine engineering, economics, geoscientific and planning disciplines.

ViWaT-Engineering (KIT) focuses on the topics of coastal protection and land reclamation, landfall, water dynamics and the identification of sustainable water resources. The aim of the group is the development of effective coastal protection measures and the assessment of local water availability and quality with regard to the use of alternative water resources to reduce landfall.

Fig. 1: Buildings in the Mekong-Delta endangered by coastal erosion (Image credit: Wendy Gonzalez Otero, KIT).

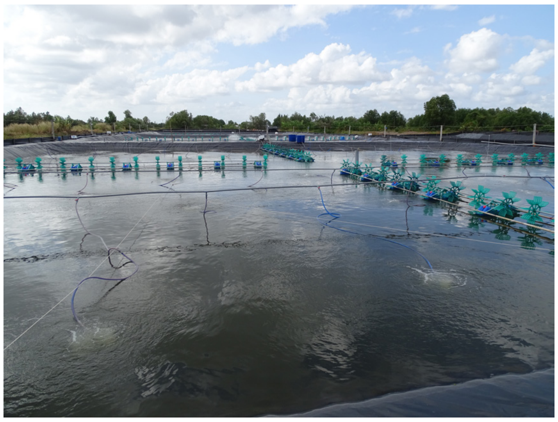

Fig. 2: Water intense shrimp farming in the southern Mekong Delta (Image credit: Nicolas Börsig, KIT).

ViWaT-Planning (RUB) is about sustainable regional water and land use planning. The group develops assessment tools for integrated water and land use planning as well as recommended measures to avoid problems and conflicts concerning water quantity and quality management.
ViWaT-Operation (IEEM) focuses on water supply and wastewater treatment. The aim is to develop a replicable, financially and ecologically sustainable concept for micro-waterworks and aquaculture wastewater treatment.

Holistic problem solutions

Through the interdisciplinary cooperation of German research institutions and industry partners with Vietnamese partner institutions from politics, science and administration, the ViWaT projects contribute to finding sustainable and holistic solutions to the challenges of the Mekong Delta. The concepts, technologies and instructions developed in the project are intended to help protect land and water resources and thereby preserve the Mekong Delta habitat for future generations as well.
For the industrial partners involved, the project offers the opportunity to expand their know-how in the areas covered, to develop new products and technologies, and to open up new markets based on the close cooperation with the Vietnamese partners.

ViWaT: Integrierte Lösungen für eine Nachhaltige Entwicklung im Mekong-Delta

Das Mekong-Delta in Vietnam ist einem zunehmenden Verlust von Land- und Süßwasserressourcen ausgesetzt. Dieser ist zum einen durch den Klimawandel, zum anderen durch den Menschen verursacht. Um einen weiteren starken Beitrag zur nachhaltigen Verbesserung der Wasser- und Landnutzung im Mekong-Delta zu leisten, wurde vom KIT zusammen mit Forschungsgruppen von der Ruhr-Universität Bochum (RUB) und der Universität Witten/Herdecke (IEEM) das interdisziplinäre Verbundprojekt ViWaT-Mekong ins Leben gerufen. Die Arbeiten von ViWaT-Mekong befassen sich insbesondere mit den Schwerpunktthemen Küstenschutz, regionale Wasser- und Landnutzungsplanung sowie nachhaltigem Wassermanagement. Diese Themen werden in drei eigenständigen Forschungsverbünden koordiniert, die ingenieur-, wirtschafts-, geowissenschaftliche und planerische Fachbereiche vereinen.
ViWaT-Engineering (KIT) fokussiert sich auf die Themen Küstenschutz und Landrückgewinnung, Landsenkung, Wasserdynamik sowie die Identifizierung nachhaltig nutzbarer Wasserressourcen. Ziel des Verbundes ist die Entwicklung einer wirksamen Küstenschutzmaßnahme sowie die Bewertung der lokalen Wasserverfügbarkeit und -qualität hinsichtlich der Nutzung von alternativen Wasserressourcen zur Minderung der Landsenkung.

Further reading

http://www.viwat.info
https://www.bmbf-client.de/projekte/viwat

Worldwide hail hazard assessment for Willis Tower Watson

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Institute of Meteorology and Climate Research (IMK)

CEDIM has been a member of the Willis Research Network (WRN) since 2009, a network of excellence funded by Willis Towers Watson, a global risk management, insurance brokerage and advisory company. WRN cooperates with CEDIM by funding a Willis fellow (full position) in the working group “Atmospheric Risks” (IMK-TRO) on the topic of hail risk estimation and modelling. Sparked by the large financial risks associated with hail around the globe, there is a raising awareness and many new efforts to understand this thunderstorm peril in particular.

For many years, KIT has relied on automated thunderstorm detection algorithms developed by Kris Bedka and his group at the NASA-Langley research center. Overshooting cloud top (OT) detections of severe convective storms from geostationary weather satellites have been combined with other convection-related data sources such as convective indices from reanalysis, radar reflectivity, and reports of hail to estimate the hail climatology of hail for entire continents, including Europe and Australia. The same data sources have also been used to construct stochastic hail event sets used by Willis Towers Watson to compute the financial risks associated to hail hazard for specific insurance portfolios. KIT has been working closely with the Willis Towers Watson’s Sydney office to coordinate these activities for Australia, where hail is a prominent hazard (Fig. 1), along with wild fires and tropical cyclones.

In 2019, this cooperation has been taken to the next level: Within the NASA Disasters Program, NASA teams up with Willis Towers Watson, KIT and partners in Brazil and Argentina. This project seeks to mitigate hail disasters over South America by aiding development of new satellite-based severe storm nowcasting tools by regional partners and developing climatologies to improve societal understanding of hail frequency. To this end, additional satellite products are evaluated, such as the low earth orbit

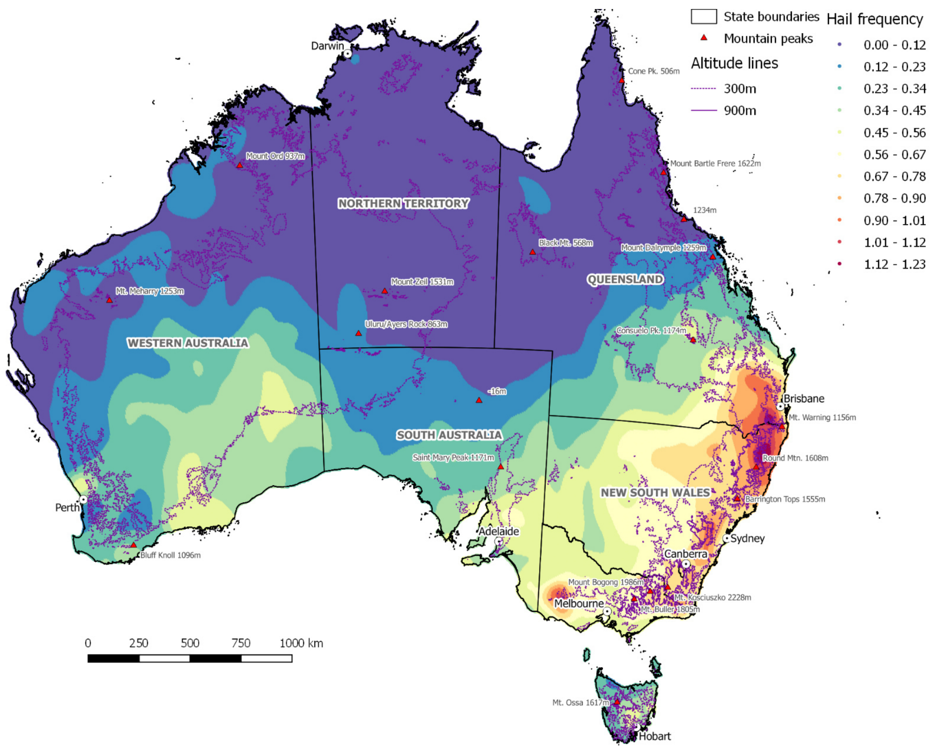

Fig. 1: Estimation of the annual occurrence of hail fall in Australia based on a combination of storm detection from geostationary satellite images and ground based radar, hail reports, reanalysis and soundings. The data was furnished by the Bureau of Meteorology, NASA Langley Research Center, ECMWF and the NOAA-NCDC.

Global Precipitation Measurement (GPM) mission operating a precipitation radar alongside a Microwave Imager, both capable of identifying potential hail signals in the atmosphere, and high resolution optical imagery can be used to identify hail streaks by their impact on vegetation. The next generation of geostationary imagers, already available for the Americas, also carries a lightning detector and scans at higher frequency to track storms much more closely.

As a first step, KIT has tested NASA-Langley's most recent OT detection algorithm with the European METEOSAT satellite imagery to develop a hail climatology for South Africa. This is another region frequently affected by hailstorms, often generating large amounts of losses, and so it is important for insurers to have a risk model at hand to estimate the potential for such losses in advance.

Weltweite Hagelgefährdungmodellierung für Willis Tower Watson

CEDIM ist seit 2009 Mitglied des Willis Research Network (WRN), einem Exzellenznetzwerk, das von Willis Towers Watson, einem globalen Risikomanagement-, Versicherungsmakler- und Beratungsunternehmen, finanziert wird. WRN kooperiert mit CEDIM durch die Finanzierung eines Willis Fellow zum Thema Hagelrisikoeinschätzung und -modellierung. Ausgelöst durch die großen finanziellen Risiken, die mit Hagel rund um den Globus verbunden sind, gibt es ein wachsendes Bewusstsein und viele neue Bemühungen, insbesondere diese Unwettergefahr zu verstehen.

Seit vielen Jahren verlässt sich das KIT auf automatisierte Algorithmen zur Erkennung von Gewittern, die am NASA-Forschungszentrum in Langley entwickelt wurden. Die Erkennungen schwerer Gewitterstürme von geostationären Wettersatelliten über Overshooting Tops (OT) wurden mit anderen konvektionsbezogenen Datenquellen wie konvektiven Indizes aus Reanalysen, Radarreflektivität und Hagelberichten kombiniert, um die Hagelklimatologie von Hagel für ganze Kontinente, einschließlich Europa und Australien, abzuschätzen.

Im Jahr 2019 ist diese Zusammenarbeit auf die nächste Stufe gehoben worden: Im Rahmen des NASA-Katastrophenprogramms arbeitet die NASA mit Willis Towers Watson, KIT und Partnern in Brasilien und Argentinien zusammen. Mit diesem Projekt sollen die Auswirkungen von Hagelereignissen über Südamerika gemildert werden, indem regionale Partner bei der Entwicklung neuer satellitengestützter Nowcasting-Tools für schwere Stürme unterstützt und Klimatologien entwickelt werden, um das gesellschaftliche Verständnis der Hagelhäufigkeit dort zu verbessern.

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Event based identification and assessment of bridge conditions based on radar sensors in combination with intelligent algorithms (ZEBBRA)

Chris Michel, Sina Keller
Institute of Photogrammetry and Remote Sensing (IPF)

Introduction

The safety and availability of critical transport infrastructures like bridges is highly dependent on the monitoring of these infrastructures. Damages of the building structure are difficult to detect in an early stage, which is why the actual condition of a bridge often remains uncertain. Traditionally, directly contacting sensors such as strain gauges are used to measure the structures behaviour under static and dynamic loads. These sensors require time-intensive and complex installation which decreases monitoring repetition rates. In recent years, remote sensing techniques such as ground based interferometric radar (GBR) have shown great potential as alternative monitoring techniques.

Aims/Objective

The objective of the joint research project ZEBBRA is the development of a non-invasive, mobile and innovative measurement and method approach to detect and analyse the condition of bridges during operation combined with an evaluation of the bridges' condition. The ZEBBRA project is funded within the scope *Forschung für die zivile Sicherheit 2012 bis 2017* in the specific topic civil security and infrastructure.

Within the project part of the IPF, a monitoring approach for bridges based on GBR is developed. The objective is to detect changes or damages of the bridge structure. In contrast to traditional sensors, the GBR is capable of remotely measuring the displacement of several bridge points at the same time (Fig. 1). As it reaches a sampling frequency of up to 200 Hz, the vibration of the bridge due to vehicles passing over it can be observed (Fig. 2). The GBR-based monitoring approach is then evaluated and compared to directly contacting sensor data.

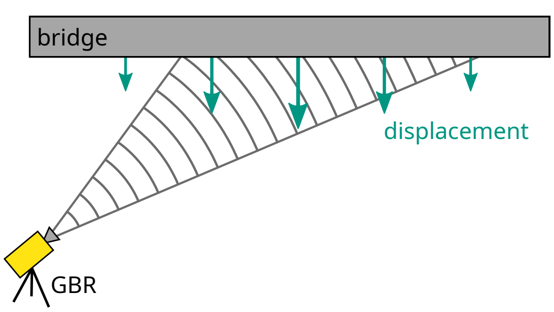


Fig. 1: Schema of the GBR-based monitoring approach at a bridge.

Project Status

In order to extract information about the bridge behaviour from its vibration, the GBR measurements need to pass through several processing steps. Vertical displacements of the bridge, for example, are useful information when analysing the changes of the bridge behaviour.

At first, disturbances of external sources such as vehicles passing through the signal are removed. Afterwards, several corrections are applied. This includes among others the correction of dynamics of atmospheric parameters such as temperature and relative humidity as well as a projection of the line of sight measurements to a common coordinate system.

The results of these processing steps are long continuous time series. Relevant information is then extracted from these time series for further analysis. This is accomplished with traditional signal processing and new machine learning algorithms.

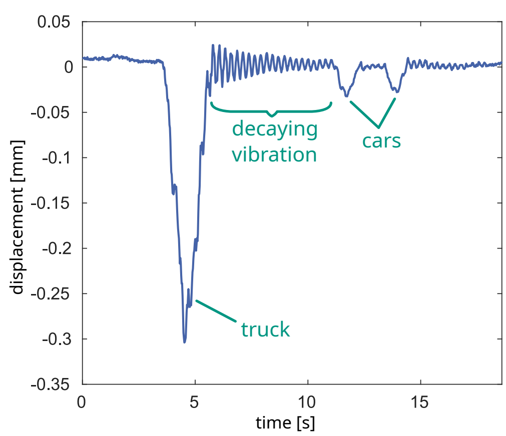


Fig: 2: Exemplary vertical displacement of a selected bridge point extracted from the GBR data during vehicle crossings.

Outlook

We aim to further improve the accuracy and reliability of the radar processing steps, thus making the measurement approach applicable for a wide range of situations at different types of bridges. A next step is to implement an automatic extraction of the vibration parameters for comparison to the model.

Eventbasierte Zustandserfassung und –bewertung von Brücken basierend auf Radar-Sensorik in Kombination mit intelligenten Algorithmen

Das Gesamtziel des ZEBBRA-Projektvorhabens stellt die Erarbeitung eines non-invasiven, mobilen, innovativen Mess- und Methodenansatzes zur Erfassung und Analyse des Brückenzustands („Zustandskonzept“) während des „laufenden Betriebs“ mit einer Bewertung dieses Zustands dar. Das ZEBBRA-Verbundvorhaben wurde im Rahmen des Programms „Forschung für die zivile Sicherheit 2012 bis 2017“ im Themenfeld „Zivile Sicherheit – Verkehrsinfrastruktur“ beantragt. Schädigungen der Brückenstruktur äußern sich in Änderungen des Schwingungsverhaltens der Brücke, weshalb dieses hochgenau mittels bodenbasierten Radars gemessen werden soll. Die Entwicklung eines Methodenkonzeptes zur Erfassung der Brückenschwingung mittels GBR-Daten übernimmt im ZEBBRA-Verbundvorhaben das Institut für Photogrammetrie und Fernerkundung (IPF). Datengrundlage stellen Messungen an drei verschiedenen Brückenbauwerken dar. Die radarbasierten Messdaten werden in mehreren Prozessierungsschritten verarbeitet, um möglichst genaue Ergebnisse, die frei von externen Einflüssen sind, zu erhalten. Anschließend müssen relevante Ereignisse wie z. B. verschiedene Fahrzeugüberfahrten auf der Brücke in den Daten detektiert und die Schwingungsparameter extrahiert werden. Im Vergleich zu konventioneller Sensorik wie Dehnungsmessstreifen und zu an einem Brückenmodell simulierten Daten sollen die GBR-Messungen evaluiert werden. Die GBR-Datenauswertung wird so robust wie möglich implementiert, sodass der Überwachungsansatz bei unterschiedlichen Szenarien und unterschiedlichen Brückenbauwerken eingesetzt werden kann.

II. FDA Activities

Overview

Near real-time Forensic Disaster Analyses (FDA)

For several years, CEDIM researcher have been conducting near real-time Forensic Disaster Analyses (FDA). While near real-time here means a time horizon of hours to days after the occurrence of a disaster, forensic refers to the combination and merging of methods and findings from different disciplines with the aim of describing and understanding disasters and their main drivers as comprehensively as possible. This approach originally was developed by IRDR (Integrated Research on Disaster Risk) within its program FORIN (Forensic Investigation of Disasters).
In case of an FDA activity, a team of researcher evaluates a disaster immediately after its occurrence, estimates the direct and indirect impacts, traces the temporal evolution and identifies the most important factors decisive for the overall impact. The main results of these investigations are summarized in FDA reports, which have different focuses and scientific depth. The FDAs apply methods and models developed in CEDIM projects and incorporates expert knowledge pooled and bundled in CEDIM. The rapid damage estimation (losses, affected persons), for example, uses a model that incorporates various data from comparable historical disasters and relevant infrastructure and population data and metrics (building inventory, Human Development Index HDI, gross domestic product, education level, etc.). The central component of this loss estimation procedure is the catastrophe database CATDAT, one of the world's largest natural catastrophe databases with more than 60,000 entries developed by CEDIM researcher in recent years.
Over the last four years, the Forensic Disaster Analysis Task Force has published near real-time reports (7 FDA and 12 Short reports) on various disasters such as tropical, extratropical, or convective storms, heavy precipitation, flooding, heat wave, and drought. Twenty-nine different authors from 8 different institutes within the KIT and 3 external organizations worked jointly on these reports.

Further reading

https://www.cedim.kit.edu/english/2863.php

FDA Reports

Hurricane Harvey, USA (August 2017)

James Daniell, Bernhard Mühr, Andreas Kron, Mitra Jahanbazi, Mariana Bartsch, Wolfgang Raskob, Christina Wisotzky, Timea Barta, Michael Kunz, Jan Wandel, Florian Becker, Christian Latt, Susanna Mohr

Overview

Hurricane Harvey was a Cat. 4 storm with peak wind gusts of 260 km/h when it made landfall on 26 August 2017 near Rockport in the US state of Texas (Fig. 1). The atmospheric environmental conditions prevented a rapid weakening and withdrawal of the tropical storm, which led to catastrophic flooding in the large Houston area. Harvey ranks among the 10 most expensive natural disasters worldwide. CEDIM investigated the meteorological conditions responsible for Harvey's exceptional properties and was the first institution to publish a reliable estimate of damage caused by flooding, winds and storm surges while the event was still ongoing. The CEDIM FDA on Hurricane Harvey attracted considerable media attention and produced approximately 1,000 citations in 94 countries.

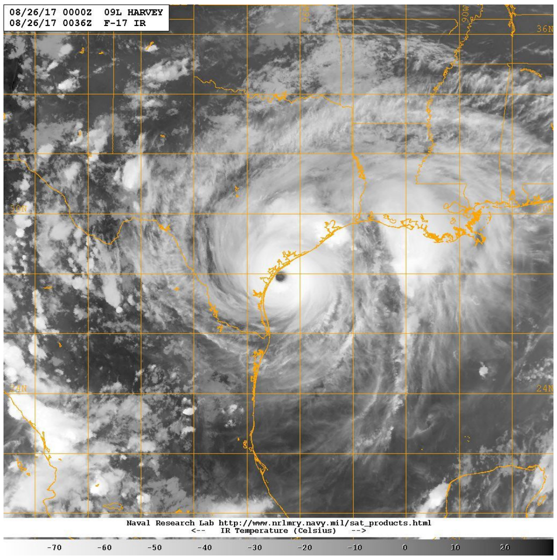


Fig. 1: Satellite image showing Harvey shortly before landfall on 26 August 2017 (Image credit: GOES NOAA).

Meteorological background

Harvey arose from a tropical wave west of West Africa on 13 August 2017 and travelled fastly westwards across the tropical Atlantic. Before entering the Caribbean, Harvey was classified as a tropical storm for the first time on 17 August 2017. While crossing the Lesser Antilles and moving over the Caribbean Sea, Harvey decreased and nearly dissipated. Due to very favourable ambient conditions – sea surface temperatures of 30–31 °C and low wind shear – Harvey reawoke and intensified into a category 1 hurricane in the evening of 24 August 2017. Just 24 hours later and immediately before arriving at the shoreline of Texas, Harvey strengthened into a Cat. 4 hurricane.

Harvey crossed San Jose Island and Aransas Bay and came ashore around 03 UTC on 26 August close to the city of Rockport. With landfall, the hurricane became quasi stationary south west of Victoria. At this time close to peak storm intensity, Harvey led to hurricane force winds in the coastal areas of Texas between Corpus Christi and Port Lavaca. Recorded maximum wind gusts were 212 kph in Port Aransas. Around 18 UTC on 26 August Harvey lost his hurricane status.

As large parts of the hurricane were still over the ocean, moist and warm air masses continued to feed the system. On 27 and 28 August, an elongated band of rain affected Houston; like a string of pearls embedded convectively enhanced rain areas were responsible for extreme rain rates and were supplied by a steady flow of warm and moist air from the Gulf of Mexico. Rainfall totals in Harris County were as high as around 1000 mm within four to five days. For example, the station Clear Creek recorded 326 mm within 6 hours (27 August 2017) and accumulated storm rain amount (25–29 August 2017) was 1199 mm (cf. Fig. 2).

Flooding

The very large rain totals caused severe flooding of large parts of the Texas-Gulf Region. At 22 gauges, the historic water level record has been exceeded, the maximum at San Bernard River near Sweeny with an observed water level 11 ft higher than the former record. In an effort to limit the scope of the disaster, the US Army Corps of Engineers decided to release water from two overfilled reservoirs, Addicks and Barker, although this put downstream areas at further risk. These two dams were tagged by their owner with an “extremely high risk of catastrophic failure” label. Some media reported this failure potential as an explanation of water releasing during Hurricane Harvey, since water level was rising rapidly, increasing the risk of collapse. Corps on the other hand explained the action of water releasing as an attempt to control flood levels at surroundings.

Critical infrastructure and production affected by Harvey

Oil & gas production: The Texas-Gulf-Region is a very important deliverer of natural gas and oil. Starting on 25 August, 23.2 % of the natural gas production and 21.5 % of the oil production in Gulf of Mexico were shut-in as a precaution in anticipation of the storm. By 28 August, 43.2 % of total Texas Gulf Coast refining capacity, and 11.8 % of the total US refining capacity were shut-down. Port Arthur refinery has been greatly affected by flooding with capacity reduced to 40 %.

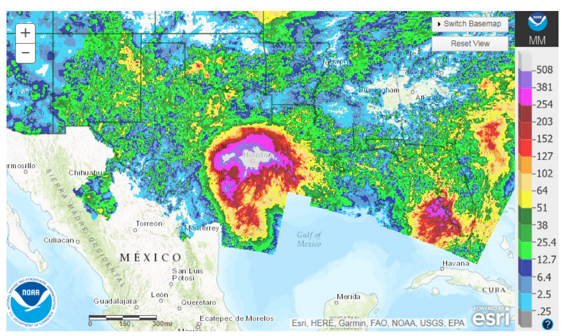


Fig. 2: 7-day observed precipitation prior to 29 August 2017 (12 UTC; Image credit: water.weather.gov/precip*).*

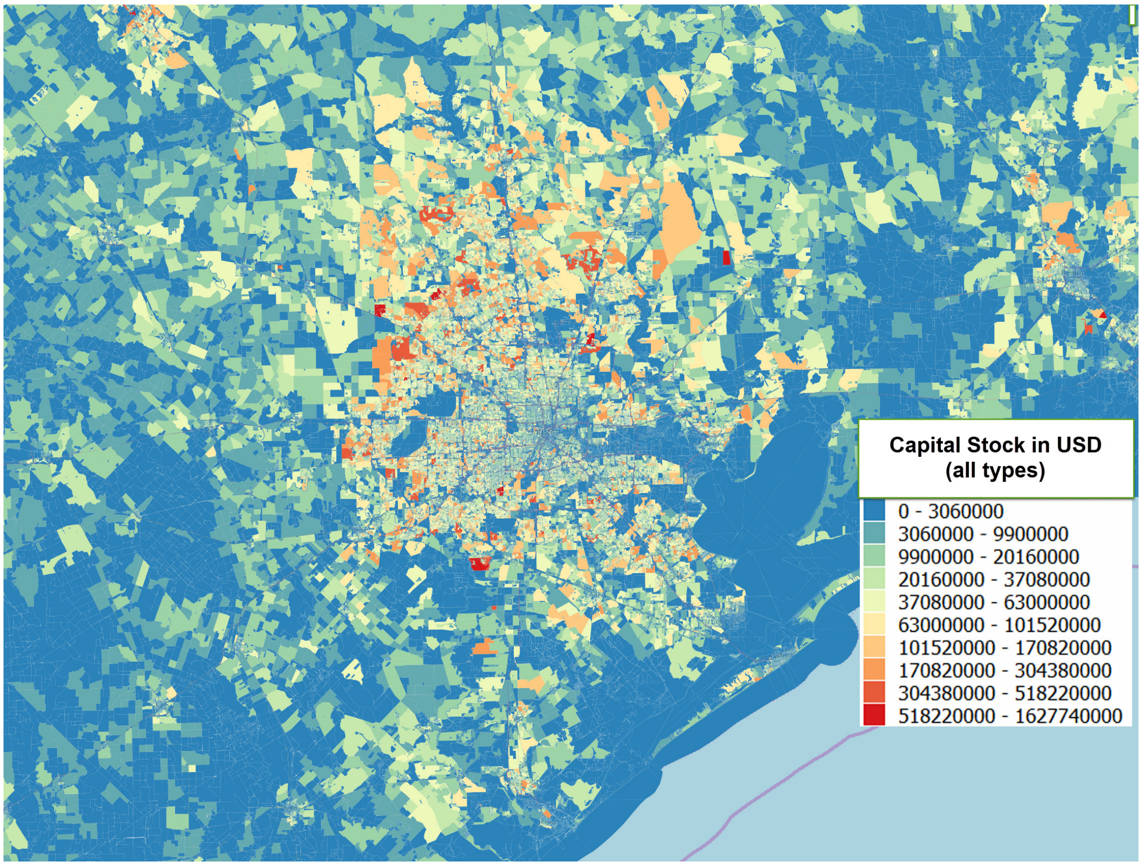


Fig. 3: Example of capital stock per census unit for the loss analysis in Houston (CATDAT).

Power grid: In the morning of 27 August, 258,137 customer power outages across Texas (about 2 % of total customers) were reported. The number increased to 306,058 (about 2.6 %) and 5,381 (< 1 %) in Texas and Louisiana on Sunday, but was slightly reduced to 274,086 (2.3 %) and 1,031 (< 0.2 %) on the next day.

Traffic: Up to 700 roads in the Houston area were closed according to the crowd sourced map of Marc Dempsey from the Houston Chronicle. On a two-lane Texas highway, a massive sinkhole had formed and finally collapse making the highway impassable.

Harbour and ship channels: Ports in that area were partly closed or opened with restriction. The Galveston Ship Channel (which is the busiest in the country) was closed on 25 August. Several cruise ships got stuck in the Gulf of Mexico.

Airports: Both of Houston's major airports were closed — along with six others in the area, including Corpus Christi (CRP). Houston's George Bush Intercontinental (IAH) was closed to all flights except for military and relief flights. Nearly 4000 flights were cancelled in total.

Other infrastructure: Three hospitals and several elderly care centres in Houston were evacuated. Houston University was closed till 30 August 2017 and used as accommodation. In addition, several school districts, and many stores, restaurants and theatres were closed.

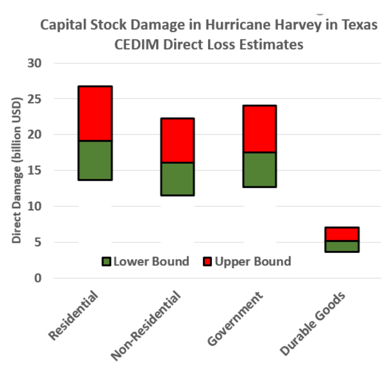


Fig. 4: Direct loss estimates for hurricane Harvey for Texas showing error bounds for the median estimate as of 29 August 2017.

Major damage and loss estimation

Flooding has occurred in many places around Houston, but also on other river reaches outside of the city. Two dams and a few levees have been breached, but much of the damage was to infrastructure, government equipment, cars, commercial and industrial facilities and of course private homes. Around $ 267 billion (bn) in stock was assumed to be damaged to some degree.
Loss modelling has been undertaken for flood as well as wind in order to get an understanding of the magnitude of the event and the possible range of losses. The hazard data was derived from rainfall observations, and similarly flow data was used to calibrate return periods in each subcatchment, which was then used to derive the losses from the National Flood Hazard Map layers depending on which zonation and river flow data were used. The derived flood maps were then plotted on block census data (Fig. 3), which had been converted with residential and non-residential capital stock estimates. In addition, government capital stock has been derived and various portions in transportation networks, buildings and other components have been examined. A total exposed value to flood waters and high winds upwards of $ 267 bn has been estimated out of a total of $ 4.54 bn. Flood and wind vulnerability functions have been derived on the basis of HAZUS and other datasets.
The flood losses were estimated between $ 38 bn and $ 75.3 bn (Fig. 4), while the wind modelling gave a loss between $ 3.55 bn and $ 4.94 bn. This was also compared to historic losses within CATDAT in order to provide a reasonable loss estimate such as for the events Allison in 2001 and Katrina in 2005.

Hurrikan Harvey, USA (August 2017)

Hurrikan Harvey war ein tropischer Wirbelsturm der Kategorie 4 mit Spitzenwindböen über 260 km/h, als er am 26. August 2017 in der Nähe von Rockport im US-Bundesstaat Texas an Land ging (Abb. 1). Die meteorolgischen Umgebungsbedin gungen verhinderten die sonst übliche rasche Abschwächung des Sturms bei Landfall, was zu katastrophalen Überschwemmungen im großen Gebiet von Houston führte. Harvey zählt zu den 10 teuersten Naturkatastrophen weltweit. Eine CEDIM FDA Task Force untersuchte die meteorologischen Bedingungen, die für die außergewöhnlichen Eigenschaften von Harvey verantwortlich waren, und veröffentlichte als erste Einrichtung eine zuverlässige Schätzung der Schäden durch Hochwasser, Starkwindböen und Sturmfluten während das Ereignis noch andauerte. Die CEDIM FDA zu Hurrikan Harvey erzeugte eine sehr hohe mediale Aufmwerksamkeit mit über 1.000 Zitaten in 94 Ländern.

Further reading

KIT-Presseinformation 118/2017: Harvey eine der bisher teuersten Naturkatastrophen, https://bit.ly/2Myoyis.

Hurricane Irma, Caribbean & USA (September 2017)

James Daniell, Bernhard Mühr, Antonios Pomonis (Athens), Andreas Schäfer, Susanna Mohr, Bernhard Mühr, Sadeeb Ottenburger, Michael Kunz, Jan Wandel, Florian Becker, Christian Latt

Overview

One of the strongest tropical cyclones ever observed raged along its path through the Caribbean, over the Bahamas and in the southeast United States in August and September 2017. Irma has been in the highest category 5 longer than any other hurricane in the satellite era since 1966 (2.75 days). With average wind speeds of almost 300 km/h, the hurricane crossed several islands of the Lesser Antilles and causing devastating damage with a storm surge of 2.5 m. On Barbuda and Saint Martin more than 90 % of the buildings and facilities were damaged or completely destroyed, leaving hardly any inhabitable islands. The total

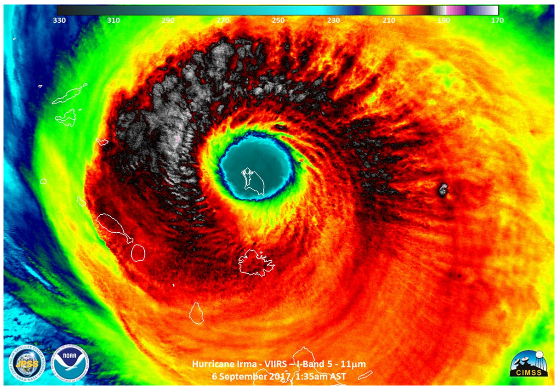


Fig. 1: Satellite image showing Irma's directly over Barbuda on 6 September 2017, the eye's diameter is roughly 55 km (Data source: CIMSS).

damage caused by Irma amounts to billions of euros, and the hurricane claimed at least 132 lives. It was the first time in 166 years that two Atlantic category 4-hurricanes, Harvey and Irma, made landfall in the United States in the same year, they both came along with sustained winds of 210 km/h.

Meteorological background and storm track

Like most Atlantic September hurricanes Irma emerged from a Tropical Disturbance, that was immediately off the coast of Guinea-Bissau on 27 August 2017. On 1 September Irma intensified rapidly and within 12 hours it passed all steps from a Tropical Storm to a major Cat. 3 hurricane. Average wind speeds increased from 111 km/h to 185 km/h. On 4 September 2017 Irma made its way over an area with increased sea surface temperatures (29 °C) and thus higher heat, which encouraged Irma's further development. Sustained wind speeds increased to 213 km/h making Irma a hurricane of the second highest Cat. 4. At this time, Irma appeared fairly symmetric as a very well organized tropical cyclone with a well pronounced eye and spiralling rain band features. One day later, favourable conditions for intensification of tropical cyclones (sea surface temperatures of more than 29 °C, low vertical wind shear, and increasing ambient humidity) led to a rapid decrease in the central pressure, which dropped from 943 to 916 hPa within just 24 hours. Correspondingly, sustained eye wall winds increased 296 km/h making Irma an extremely dangerous Cat. 5 hurricane and one of the strongest Atlantic hurricanes ever. Irma kept its intensity during 06 September 2017 when crossing several islands of the Lesser Antilles and Puerto Rico with the southern eye-wall touching the island and Hispaniola (Fig. 1).

While moving northwestward (Fig. 2), Irma slight weakening continued on 08 September 2017. Around 06 UTC Irma was an upper Cat. 4 hurricane. Irma's rain bands covered large parts of eastern Cuba and were responsible for torrential rain falls. After the eye-wall replacement, the eye was twice as large as the old one and had an extraordinary diameter of 72 km. With the new eye and further increased sea surface temperatures Irma strengthened again and once more became a Cat. 5 hurricane for some hours. While traveling away from the northern coast of Cuba and heading for the Florida Keys on 09 September, Irma passed over very warm waters with temperatures of more than 30 °C. These high sea surface temperatures enabled Irma to re-strengthen again into Cat. 4.

On day later, Irma made two last landfalls, first in the Florida Keys as a Cat. 4 and then near Naples as a Cat. 3 hurricane.

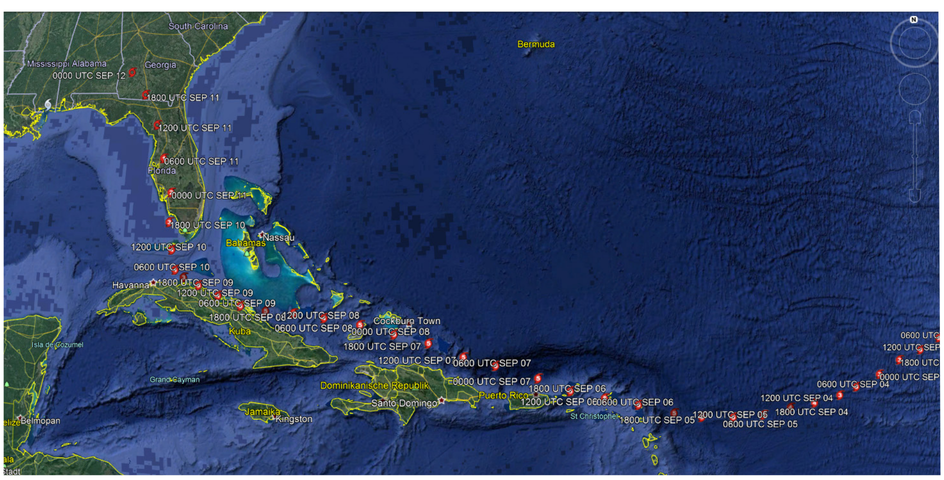


Fig. 2: Western part of the track and intensity of Irma (3 – 12 September 2017; Data source: National Hurricane Center).

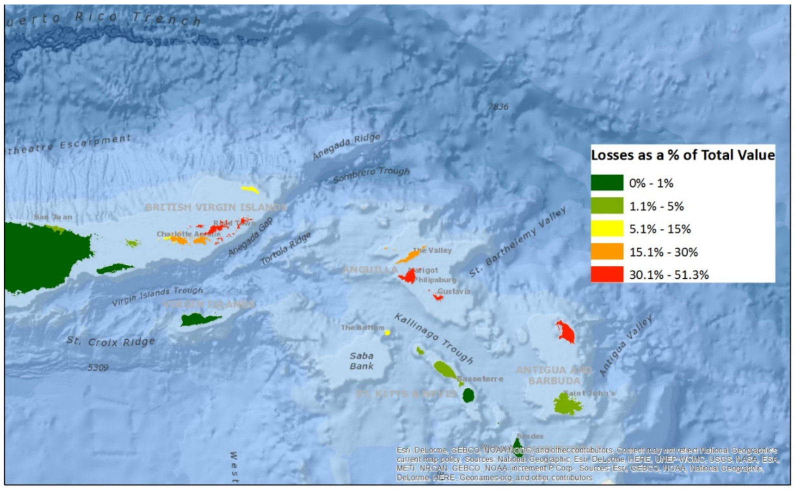


Fig. 3: Relative loss per administrative division in the Caribbean as of 8 September 2017.

The city of Naples observed the highest wind gust of 228 km/h, Marco Island reported 209 km/h. Following a northern track over western Florida, Irma lost hurricane status on 11 September 2017 around 12 UTC. On 13 September 2017, satellite images showed the remnants of Irma over the Midwest. The clouds stretched from Missouri to the southern tip of Lake Michigan.

Along its track Irma brought rainfall totals frequently of more than 150 mm. Satellite data indicate the largest rain totals over Cuba and the greatest amounts were observed in Guantanamo, the easternmost province of Cuba, where Irma dumped 406 mm of rain. Over the US, Irma unloaded the most rain east of the storm's centre in an area between Fort Myers, Tampa, Orlando and West Palm Beach with more than 200 mm; around 400 mm were reported from Fort Pierce on the eastern side of Florida. Also far northeastern Florida received rain amounts exceeded 200 mm.

Impacts

Irma had a great impact on coastal areas due to storm surge. Many locations and tidal gauges observed highest values on record. Especially affected were north eastern Florida, coastal Georgia and coastal South Carolina. With Irma moving northwards over western Florida, on the western side of the storm strong and persistent winds blew onshore from south easterly to north easterly directions. High tides in combination with storm surge pushed sea water towards the coast; the concave shaped coastline and the flat areas along the Atlantic coast between Jacksonville, Florida, and Savannah, Georgia, is particularly vulnerable to flooding. Moreover, runoff due to torrential rains exacerbated the flooding situation.

The first island of the Lesser Antilles hit by Irma was Barbuda (Fig. 1). The impact of Irma on the island and its buildings and infrastructure was calamitous. About 90 % of the islands buildings and facilities were damaged leaving a barely habitable surrounding. Fallen trees and power poles disrupted electricity supply and telecommunication. In addition to disastrous wind gusts, the storm surge of 2.5 meters above normal caused serious damage. Similar damage occurred in St. Barthelemy, St. Martin/St. Maarten, on British and American Virgin Islands, Turks and Caicos Islands, and the southern Bahamas as well as in parts of Cuba.

In Florida, Irma caused one of the largest natural disaster-related power outages in the U.S. history. On 11 September, 6.5 million households were knocked out, nearly 15 million people were without power. On 8 September, Florida's two nuclear plants – Florida Power & Light's turkey point, St. Lucie, both along Florida's Atlantic Coast – shut down in anticipation of hurricane-force winds.

One of the biggest evacuation ever was ordered – according to the Florida Division of Emergency Management (DEM), an estimated 6.3 million people were ordered to evacuate. Floridians have begun to evacuate the state *in bulk*, resulting in a traffic jam that stretched approximately 780 miles from Miami to Chattanooga, Tennessee. This type of near-standstill conditions has not been seen since Hurricane Floyd in 1999 – making a trip that would normally take 5-6 hours ran nearly double. The Florida Department of Transportation reported that the traffic load of many stretches of interstate were quadruple compared to the normal

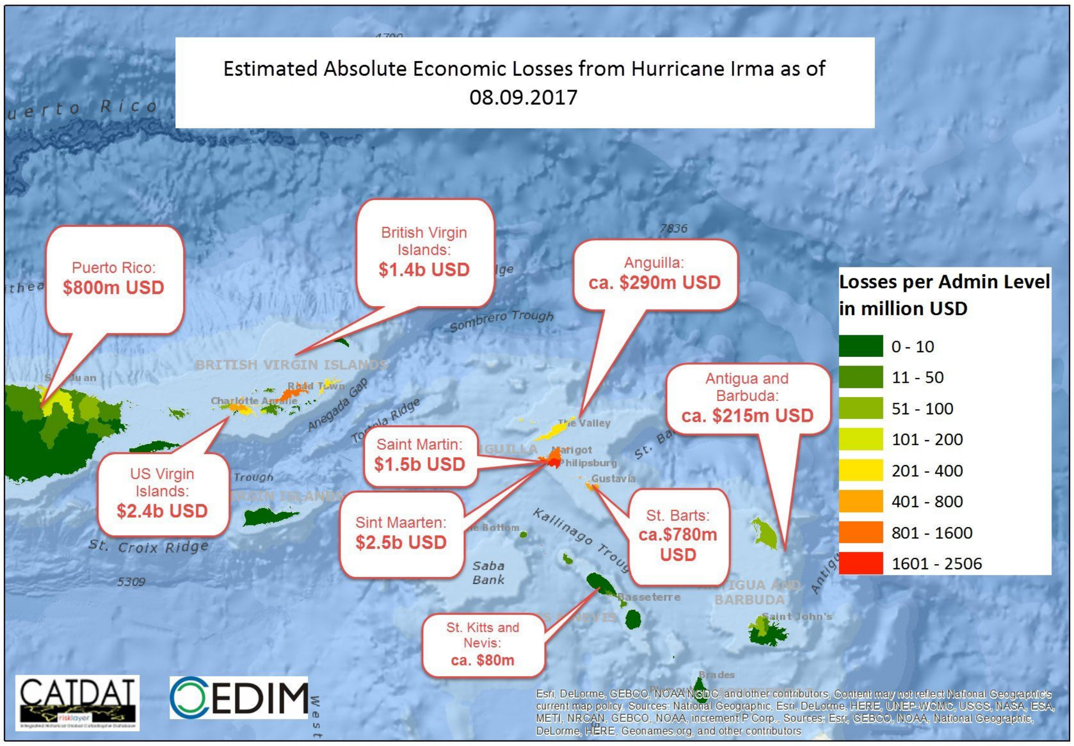


Fig. 4: Estimated absolute economic losses from hurricane Irma in the Caribbean as of 8 September 2017.

head count. According to live traffic data from Google Maps, road-going evacuees had mostly cleared out of Southern Florida by late Friday afternoon (8 Sept), with heavy congestions emerging in the middle of the state instead.

Loss modelling

For the Caribbean, Irma represents the worst storm of all times. The losses were upwards of 100 % of the gross domestic product (GDP) in Sint-Maarten and Saint Martin; St. Barts; British Virgin Islands and also very high in Virgin Islands (US and UK). Loss modelling including residential, non-residential, infrastructure, equipment and goods was undertaken for the Caribbean after a review of damage data and past events within the CATDAT database as per past FDA loss assessments (Fig. 3). Wind speeds were derived from station data (where stations did not go offline or become damaged), as well as the best track data from various platforms. CATDAT was used to fill the GDP, capital stock and building typology data for each of the island states, based on statistical agency data from each nation.

In total, around $ 10 billion with a significant range in damage across countries totalling around $ 600 billion in assets is seen (Fig. 4). A range of $ 6.7-15.8 billion exists. The loss modelling indicates that although Barbuda had the highest relative loss, the absolute losses were dominated by Saint Martin/Sint Maarten and Virgin Islands (GB and US).

Hurrikan Irma: Karibik und USA (September 2017)

Einer der stärksten je beobachteten tropischen Wirbelstürme wütete im August und September 2017 entlang einer Zugbahn durch die Karibik, über den Bahamas und im Südosten der USA. Irma gehörte so lange wie kein Hurrikan zuvor im Satellitenzeitalter der höchsten Kategorie 5 an. Der Hurrikan überquerte mit mittleren Windgeschwindigkeiten von fast 300 km/h mehrere Inseln der Kleinen Antillen und richtete dort zusammen mit einer 2.5 Meter hohen Sturmflut verheerende Schäden an. Der Hurrikan überquerte mit mittleren Windgeschwindigkeiten von fast 300 km/h mehrere Inseln der Kleinen Antillen und richtete dort zusammen mit einer 2.5 Meter hohen Sturmflut verheerende Schäden an. Auf Barbuda und Saint Martin wurden jeweils mehr als 90 % der Gebäude und Einrichtungen beschädigt oder völlig zerstört. Viele Inseln waren kaum noch bewohnbar. Die gesamten Schäden Irmas belaufen sich auf einen Milliardenbetrag; mindestens 132 Menschen kamen zu Tode.

Further reading

KIT-Presseinformation 127/2017: Irma verheerendster Karibik-Sturm aller Zeiten, https://bit.ly/2Y1RO6l.

Drought & heat wave, Germany (as of August 2018)

Bernhard Mühr, Susanne Kubisch, Andreas Marx (UFZ), Johanna Stötzer, Christina Wisotzky, Christian Latt, Fabian Siegmann, Maren Glattfelder, Susanna Mohr, Michael Kunz

The year of 2018 was characterized by an exceptionally hot and dry summer in many parts of Europe. Intense heat and drought occurred even in England and Scandinavia. The 4-month period from April to July 2018 was the warmest in Germany since regular weather recordings began in 1881. Rain sums were exceptional low almost everywhere in Germany since February 2018. Saxony-Anhalt, for example, received only half of the usual amount of rain between February and July 2018 (Fig. 2). The dry weather conditions across central and northern Europe were the result of large and persistent high pressure systems, impressively visible in a huge positive geopotential anomaly centred over southern Scandinavia in the period from April to July 2018.
As a result, large parts of Germany suffered from an exceptional drought during spring and summer, which affected both the topsoil (down to a depth of 25 cm) and the total soil (~ 180 cm on average). The total soil was already under drought in some parts of Germany at the beginning of the year (Fig. 3). Due to the persistent precipitation deficit and the unusually high temperatures and associated high evaporation rates already in April and May, the drought could develop in both the topsoil and the total soil. In August, almost 90 % of the German territory was under drought (note that the drought persisted until 2020; see drought monitor at *Helmholtz-Zentrum für Umweltforschung, UFZ*). This extent is much larger compared to the last extreme heat wave in 2003, where 74 % of the territory was under drought. At the time of the FDA report, a similarly extensive drought has not occurred in Germany since 1976.
The consequences were partly dramatic: Agriculture suffered enormous crop losses, the forests also struggled against high temperatures and low precipitation, and many trees fell victim to heat and drought stress. Devastating forest fires occurred in southern Europe and Scandinavia. In addition, almost all rivers had extremely low water levels, some of them extremely low. All mode of transport (road, waterway, rail and air) were significantly impacted and restricted and had to fight with failures and damage to infrastructure.

Fig. 1: Riverbed at the Elbe in on 8 July 2018 (Image credit: Marco Kaschuba).

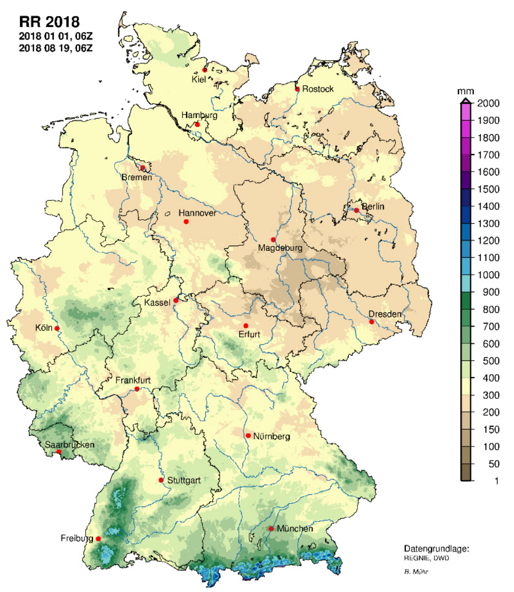


Fig. 2: Rain sums in Germany from 1 January to 18 August 2018 (Data: REGNIE, DWD).

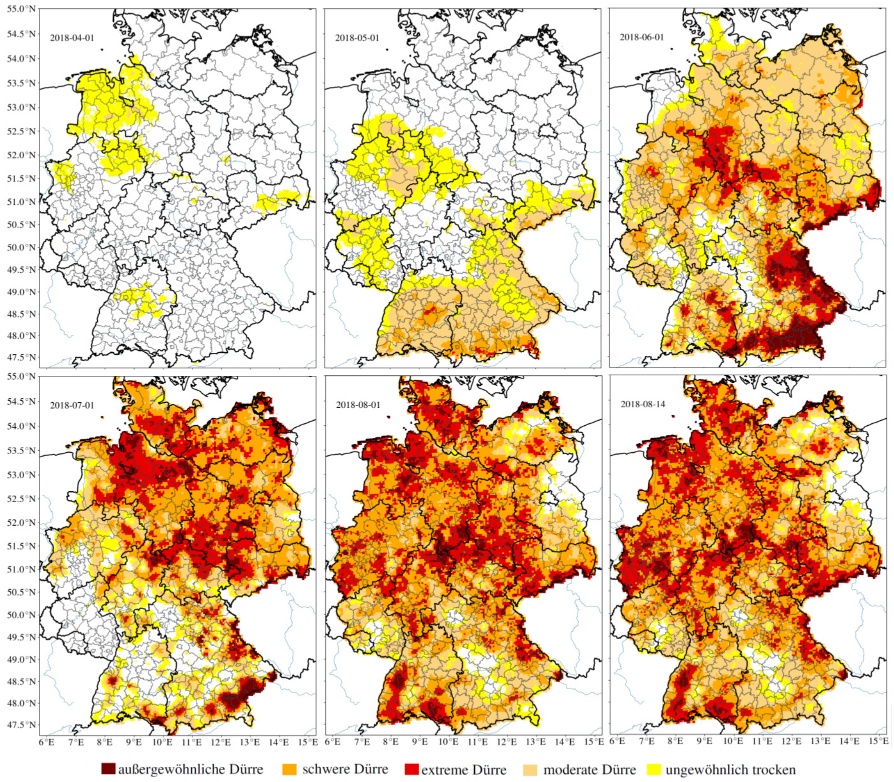


Fig. 3: Course of the dryness of the topsoil down to a depth of 25 cm (date indicated in the subfigures). The drought is shown in 4 classes (exceptional is the driest class), "unusually dry" means an early warning stage and is not counted as drought (Data source: Dürremonitor Deutschland, UFZ).

Further reading

KIT-Presseinformation 102/2018: Dürre betrifft rund 90 Prozent der Fläche Deutschlands, https://bit.ly/2Bv3Zkw.

UFZ Drought Monitor Germany: https://www.ufz.de/duerremonitor.

Dürre & Hitzewelle, Deutschland (August 2018)

Das Jahr 2018 zeichnete sich in vielen Teilen Europas durch einen außergewöhnlich heißen und trockenen Sommer aus. In Deutschland waren bereits die Frühjahrsmonate außerordentlich niederschlagsarm, so dass die Folgen der Trockenheit im Laufe des Sommers umso deutlicher sichtbar wurden. Anfang August befanden sich nahezu 90 % der Landesfläche Deutschlands unter Dürrestatus. Die Landwirtschaft hatte enorme Ernteausfälle zu beklagen, und auch die Wälder litten an Hitze- und Trockenstresses. Der Zeitraum April bis Juli 2018 war in Deutschland der wärmste seit Beginn der regelmäßigen Wetteraufzeichnungen. Nahezu überall herrschte in Deutschland seit Februar 2018 große Trockenheit vor; Sachsen-Anhalt empfing von Februar bis Juli 2018 nur rund die Hälfte der sonst üblichen Regenmengen.

Super typhoon Mangkhut, Philippines (2018)

Bernhard Mühr, James Daniell, Johanna Stötzer, Christian Latt, Maren Glattfelder, Fabian Siegmann, Susanna Mohr, Michael Kunz

Overview

In mid-September, the world's strongest tropical system in 2018 so far hit the northern main island of the Philippines, Luzon, and southern China. Super Typhoon Mangkhut fell ashore on Luzon on 14 September 2018 causing landslides and flooding and claimed many lives. Mangkhut was the first typhoon of the highest category since typhoon Megi in 2010 that struck the Philippines. The typhoon raged for nearly 10 days through the tropical western Pacific Ocean, its track had a length of 6600 km. At peak intensity, Mangkhut had sustained winds of 287 km/h, with observed peak gusts up to 352 km/h.

As was the case in the Philippines, extensive evacuation measures were also underway in southern China, where Mangkhut made landfall two days later as Cat. 1 or 2 typhoon in Guangdong province. The storm centre barely missed Hong Kong and Macau, but the storm surge created new record water levels, caused uncountable fallen trees and major property damage. And for the first time ever, Macau, the Asian gambling capital, closed its casinos because of Mangkhut.

Storm track

Mangkhut first appeared on 7 September 2018 as a tropical depression about 100 kilometres north of Rongelap Atoll (Marshall Islands). On 9 September, 00 UTC, Mangkhut passed the criteria to a category 1 typhoon, located with its centre 1100 km east of Guam.

Two day later, extremely favourable environmental conditions led to an explosive development and within a mere 30 hours, the category 1 typhoon become a category 4 super-typhoon approx. 1500 km east of the Philippines. On 11 September 12 UTC, the typhoon was in the highest category 5 and kept it until landfall. The development peak was reached in the evening of 13 September for 6 to 12 hours reaching gusts of 352 km/h across the waters of the Pacific Ocean. With average wind speed of 265 km/h, the centre of the typhoon crossed the coastline of Luzon near Baggao in the province of Cagayan on 14 September 2018 at 18 UTC (Fig. 1). Only about 8 hours later, Mangkhut travelled across entire Luzon while the mountainous island caused a significant weakening of the circulation due to friction. The eyewall collapsed and Mangkhut entered the South China Sea as a category 3 typhoon near Laoag City. While weakening slowly, Mangkhut moved to the northwest across the South China Sea. The final landfall was on 16 September 2018 at 09 UTC near Jiangmen City in the southern Chinese province of Guangdong. Mangkhut quickly lost its strength over land and was downgraded to a tropical storm on the afternoon of 16 September 2018.

Precipitation, wind, and storm surge

Mangkhut brought enormous rain along its track amounting several hundred mm. On the Philippines, the rains caused flooding and landslides that buried many people. In the northwest of Luzon, Baguio reported a rainfall of more than 660 mm. Hong Kong Observatory dropped to 167.5 mm in 24 hours.

Mangkhut's cloud bands covered a huge area when the typhoon came ashore, and destructive winds extended far from the centre. Hurricane force wind speeds occurred at a distance of 160 km from the centre, tropical storm force winds even at a distance of 500 kilometres. In Macao, which was missed by the eye of Mangkhut by only 65 kilometres, a storm surge of 1.9 meters occurred. In Quarry Bay, the storm surge had a level of 2.4 m; the previ-

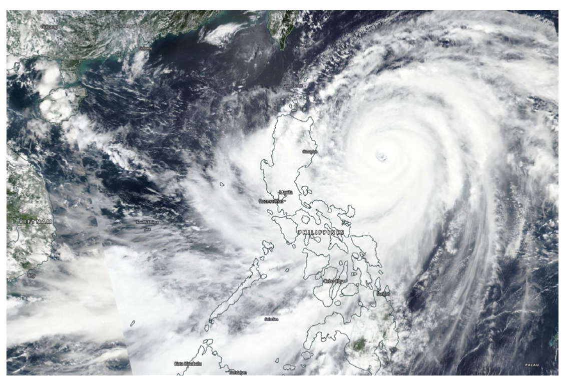


Fig. 1: Satellite image showing CAT-5 Super Typhoon Mangkhut on 14 September 2018 few hours before making landfall in Luzon, PH (Image credit: NASA Worldview).

ous record level was 1.77 m (typhoon Wanda 1962). And also in Tai Po Kau there was a new record with 3.38 m.

Impacts

Mangkhut affected millions of people, especially on Luzon (Philippines) and in the Chinese provinces of Guangdong and Guangxi. About 61 million people were exposed to Mangkhut of category 1 strength or higher.
The estuary of the Pearl River is one of the world's most important manufacturing hubs and the large metropolitan areas of Hong Kong, Shenzhen or Guangzhou are home to tens of millions of people. Hundreds of thousands of people had to move to safer ground. The news agency Xinhua, citing government reports, said that nearly 2.5 million people in the province had been affected in some way.
Despite extremely high estimates like $ 16 to 20 billion damage for the Philippines (Fig. 2) from private firms such as Enki Research with the current storm track, total losses across Philippines are likely less than $ 1 billion including private housing, given the fact that this typhoon had 20 times less damage than Typhoon

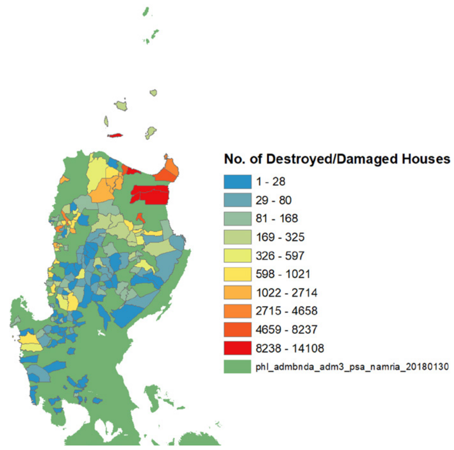


Fig. 2: Number of damaged and destroyed buildings on North Luzon island visualised from the NDRRMC reports showing that.

Yolanda which caused at most $ 9 billion. Similar high estimates were given for Hong Kong from Enki Research being likely around 20 to 30 times too high at $ 26 billion. $ 50 billion was estimated for China. A total loss estimate from Enki Research was at $ 120 billion for all Asian countries as published in Bloomberg and other news outlets.

Supertaifun Mangkhut, Philippinen (2018)

Mitte September traf der bis dato stärkste tropische Wirbelsturm im Jahr 2018, Super-Taifun Mangkhut, die nördliche Hauptinsel der Philippinen, Luzon und Südchina. Zahlreiche schwere Erdrutsche und Überschwemmungen forderten viele Menschenleben. Fast 10 Tage lang tobte der Taifun durch den tropischen Westpazifik, seine Bahn hatte eine Länge von 6600 km. Bei Spitzenintensität hatte Mangkhut anhaltende Winde von 287 km/h mit gemessenen Böen von bis zu 352 km/h. Auf den Philippinen und in Südchina fanden umfangreiche Evakuierungsmaßnahmen statt. Das Sturmzentrum verpasste Hongkong und Macau, aber die Sturmflut führte zu neuen Rekorden bei den Wasserständen. Und zum ersten Mal überhaupt schloss Macau, die asiatische Glücksspiel-Hauptstadt, ihre Casinos.

Tropical cyclone Idai, Southeast Africa (March 2019)

Bernhard Mühr, Susanna Mohr, James Daniell, Andreas Schaefer, Johannes Brand, Timea Barta, Anna Neuweiler, Michael Kunz

Overview

Over a period of 2 weeks, the long-living tropical system Idai hit large parts of South East Africa. Shortly after peak intensity, Idai fell ashore in Mozambique a few kilometres north of the city of Beira in the night from 14 to 15 March 2019. The slow propagation speed, a destructive storm surge, heavy winds and enormous precipitation led to extensive damage and flooding. And even the remnants of the weakening tropical system caused further floods and landslides far inland in the east of Zimbabwe. Around 3 million people were affected by Idai and its impacts. The storm claimed several hundred lives and left hundreds of thousands of people homeless and displaced across the region. CEDIM's damage estimation was

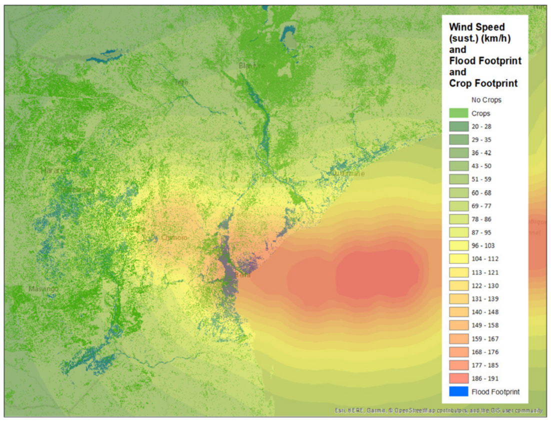


Fig. 1: Estimated flood footprint (from 4 March to 31 March), wind speed (from 13 to 20 March), and crop footpring.

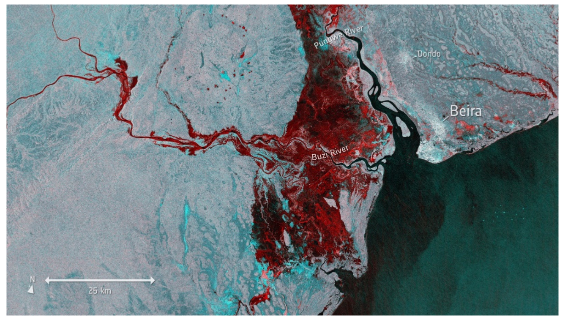


Fig. 2: Image of satellite Copernicus Sentinel-1 showing the flooded areas, depicted in red, in the aftermath of tropical cyclone IDAI in Mozambique (Image credit: ESA; CC BY-SA IGO 3.0).

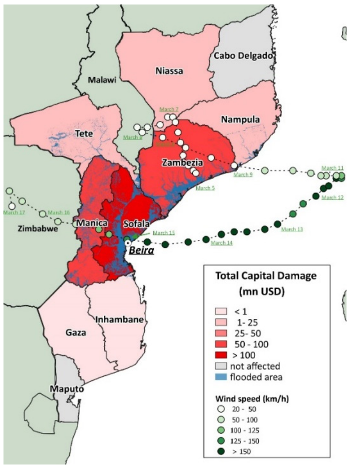
used by the World Bank within their program GRADE (Global Rapid post-disaster Damage Estimation).

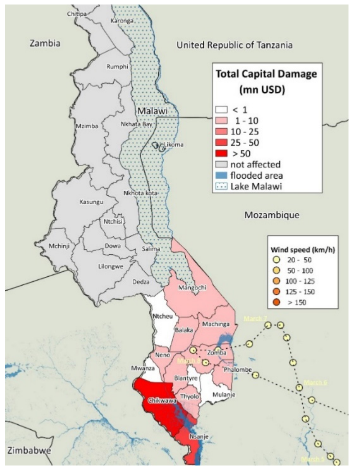
Meteorological information

Idai' development begun on 3 March 2019 as a tropical disturbance just off Mozambique's coast over the warm waters of the Mozambique Channel. The following days, Idai as a tropical depression made a loop crossing the far south eastern tip of Malawi and finally turned into an easterly to south-easterly direction. While looping inland, heavy rain occurred already across parts of Mozambique and southern Malawi resulting in devastating flooding.
The Mozambique Channel with very warm surface water and the absence of strong winds in the upper troposphere created favourable conditions for a rapid development. On 11 March between 03 and 06 UTC, Idai become a Cat. 3 tropical cyclone. Maximum wave heights were 8 meters. Until the next day, Idai weakened into a Cat. 2 storm, but developed a well-defined eye. On 14 March, 00 UTC, Idai reached the maximum intensity with 10-minute sustained winds of 195 km/h and gusts of 280 km/h. Landfall was on 14 March 2019, 23:30 UTC, few kilometres north of the city of Beira in Mozambique, with sustained winds of 177 km/h making Idai an upper Cat. 2 tropical cyclone (Fig. 1). While travelling slowly overland into a westerly direction, it took 2-3 more days for Idai to dissolve. During that time, the remnants of the cyclone caused heavy rain, riverine and flash flooding all affecting eastern Zimbabwe.
IDAI dropped enormous amounts of rain along its path. Due to its large spatial extent and the low propagation speed during landfall, the tropical cyclone was responsible for rain accumulations in excess of 500 mm in many regions of central Mozambique; in the Sofala province even more than 600 mm have been calculated estimated from the Integrated Multi-Satellite Retrievals (IMERG). Intense rainfall also occurred in the eastern parts of Zimbabwe, where the dissipating cyclone brought rain amounts well above 200 mm. The time Idai made landfall on 14 March 2019 coincided with high tide. Both the storm surge and the high tide led to a worst-case scenario with the storm pushing a wall of water inland. The storm surge was estimated as high as 6 meters in some places and caused large flooding in low lying areas along the Pungwe river. The storm surge and subsequent excessive amounts of rain led to an inland lake (Fig. 1 and 2). Entire communities and villages disappeared under water. Based on Sentinel-1 data from 19 March 2019, water covered an area of 2,165 km². In some places the water surface was as wide as 45 km.

Damage and consequences

A total of nearly 3 Million people have been affected by Idai. Even the precursors of Idai caused widespread flooding in southern Malawi and were responsible for at least 50 deaths. After landfall, the storm ravaged through the central parts of Mozambique, namely the provinces of Sofala, Zambezia, Manica and Inhambane. In the coastal town of Beira, which is the Mozambique's 4th largest city with a total population of 538,000 and equipped with an important harbour and an international airport, some of the area was destroyed and damaged.
The remnants of Idai affected at least half of the total population of eastern Zimbabwe's Chimanimani and Chipinge districts. At least





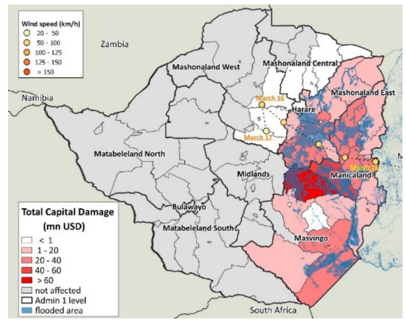


Fig. 3: Estimates of losses and footprints in Mozambique, Zimbabwe, and Malawi from the World Bank.

16,000 households need shelter assistance in Chimanimani, Mutare, Chipinge and Buhera, according to the government. Overall, there were

- Many roads destroyed, main access bridges washed away.
- The water and energy supply and telecommunication and other services interrupted.
- Significant damage to educational and health facilities.
- Hundreds of thousands of hectares of crops have been flooded, causing severe problems for the food supply for the months ahead, especially because the losses coincide with the annual harvest period (somewhere between 178,000 and 252,000 hectares in Mozambique;
- Increasing risk of water-born diseases (first cases of cholera have already been registered).

In terms of the total capital damage, Mozambique, Zimbabwe and Malawi have all seen significant damage. The distribution as expected is around the high wind speed areas in Mozambique, and for the other two countries is driven from the main flood inundation (Fig. 3). The agricultural losses are expected to cause huge issues in the three countries. Using local crop data from Geonode as well as the ESA 20 m land cover product for Africa, modelling was undertaken to examine the exposed crops (overlay in Fig. 1).

Tropischer Wirbelsturm Idai, Südost-Afrika (März 2019)

Während zwei Wochen im März 2019 erfasste das langlebige Tropensystem weite Teile Südostafrikas. Bereits die Vorläufer des tropischen Wirbelsturms führten in Malawi zu schweren Überschwemmungen. Einige Tage später durchlief das System aber über dem warmen Wasser des Mosambikkanals alle Entwicklungsstufen eines tropischen Wirbelsturms und wurde schließlich zu einem ausgewachsenen Zyklon der Kategorie 3. Kurz nach Erreichen der höchsten Intensität ging Idai in der Nacht vom 14. auf den 15. März in Mosambik einige Kilometer nördlich der Stadt Beira an Land. Seine langsame Verlagerungsgeschwindigkeit verbunden mit verheerende Sturmfluten, starken Winden und enormen Niederschlagssummen führten zu erheblichen Überschwemmungen in der Region. Insgesamt waren rund 3 Millionen Menschen von Idai und seinen Auswirkungen betroffen. Der Sturm forderte mehrere hundert Menschenleben und ließ Hunderttausende obdachlos und vertrieben in der Region zurück. Idai war für Mosambik der verheerendste und tödlichste tropische Wirbelsturm der Geschichte.

Stürme Sabine & Victoria, Deutschland (Februar 2020)

Bernhard Mühr, Susanna Mohr, Michael Kunz

Innerhalb von nur 10 Tagen ereigneten sich in einer bestens ausgeprägten Frontalzone auf dem Nordatlantik mehrere extreme Tiefdruckentwicklungen (Abb. 1). Der Kerndruck dieser Orkantiefs wies zum Teil Werte in Rekordnähe auf, auch die Druckfalltendenzen erreichten extreme Werte. In eine Kaltfront, die Deutschland am 10. Februar von Nordwesten nach Südosten überquerte, waren etliche Gewitter eingebettet (Abb. 2), die sich selbst noch im äußersten Süden am Bodensee oder in Oberbayern entluden. Aber auch in der nachströmenden hochreichend labil geschichteten Meereskaltluft entwickelten sich immer wieder Gewitter. Im Bereich der Gewitter waren teilweise die Windgeschwindigkeiten am höchsten. Die höchsten Windgeschwindigkeiten wurden auf den Berggipfeln der Mittelgebirge und über den Alpen beobachtet (Abb. 3). Mit 176.8 km/h verzeichnete der Feldberg (Schwarzwald) die stärkste Windböe. Vereinzelt registrierten aber auch Station im Flachland bzw. Binnenland Windböen in Orkanstärke (ab 119 km/h); das waren neben Wernigerode am Rande des Harzes (127 km/h) noch sechs weitere Stationen in Baden-Württemberg und in Bayern. Mit 154 km/h wurde in Fürstenzell bei Passau eine der höchsten jemals im Binnenland gemessenen Windgeschwindigkeiten beobachtet. Die Sturmfelder erfassten nicht nur den gesamten Nordwesten Europas, auch in Mitteleuropa kam es sturmbedingt zu größeren Problemen, wie beispielsweise bei der Deutschen Bahn, die den Fernverkehr zeitweise bundesweit einstellte. Sturmschäden konnten von Island bis zu den Alpen verzeichnet werden. Auf den Britischen Inseln gingen die Tiefs zudem mit größeren Niederschlagsmengen einher, die vor allem in Wales Überschwemmungen auslösten. Nach Mitteleuropa gelangten extrem milde Luftmassen, die selbst in der Nacht Temperaturen um 20 °C möglich machten und an zahlreichen Stationen in Deutschland zu neuen Dekaden- und Monatsrekorden für den Monat Februar führten.

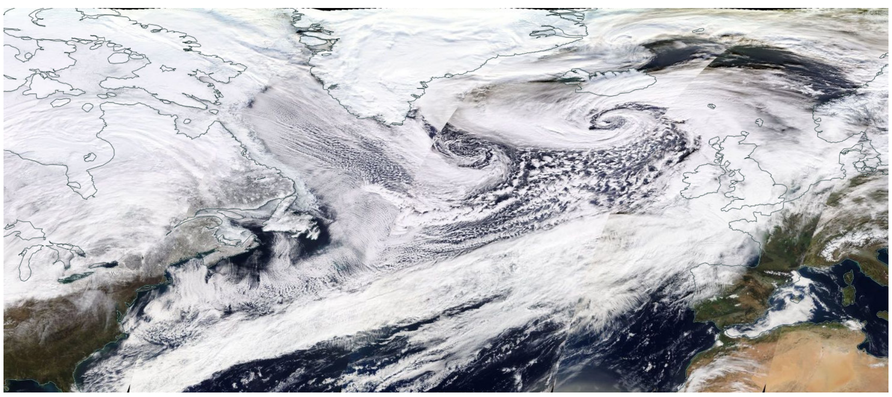


Abb. 1: Satellitenbild, 15. Februar 2020 (Quelle: https://worldview.earthdata.nasa.gov).

Storms Sabine & Victoria, Germany (February 2020)

Within just 10 days, several extreme low-pressure systems occurred in a very well-defined frontal zone on the North Atlantic. The core pressure of these storms sometimes reached record levels and the pressure drop also reached record values. The storm fields not only covered the complete northwest of Europe, but also caused major problems in central Europe, as for example at the Deutsche Bahn, which temporarily suspended long-distance traffic nationwide. Storm damage was recorded from Iceland to the Alps. Over the British Isles, the depressions were also accompanied by higher precipitation amounts, which triggered flooding, especially in Wales. Extremely warm air masses reached Central Europe, allowing temperatures of around 20 °C during the night, which led to new decade and monthly records for the month of February at numerous stations in Germany.

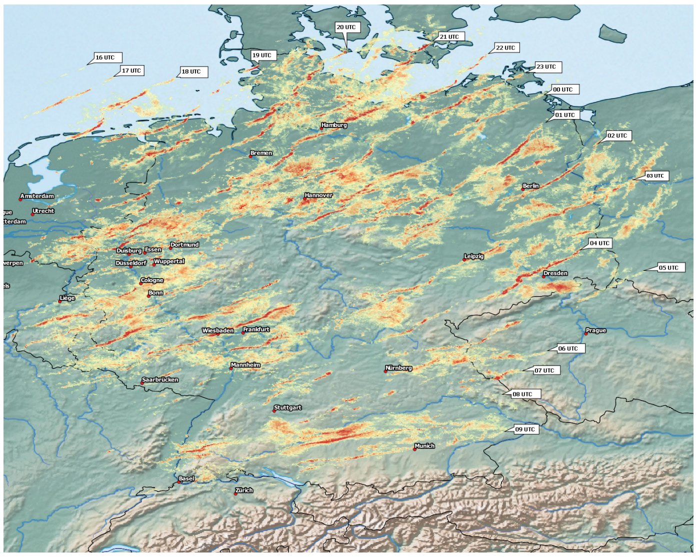


Abb. 2: Überlagerung von Radarbildern (Niederschlag) in stündlichem Abstand, 09.02.2020, 16 UTC, bis 10.02.2020, 09 UTC, mit Südostwärtsverlagerung der Kaltfront von „Sabine“ (Daten: DWD). Aus der Darstellung ergibt sich ein chronologischer Überblick über die Verlagerung der Kaltfront von Tief „Sabine“, ihrer Position und die Verlagerungsgeschwindigkeit.

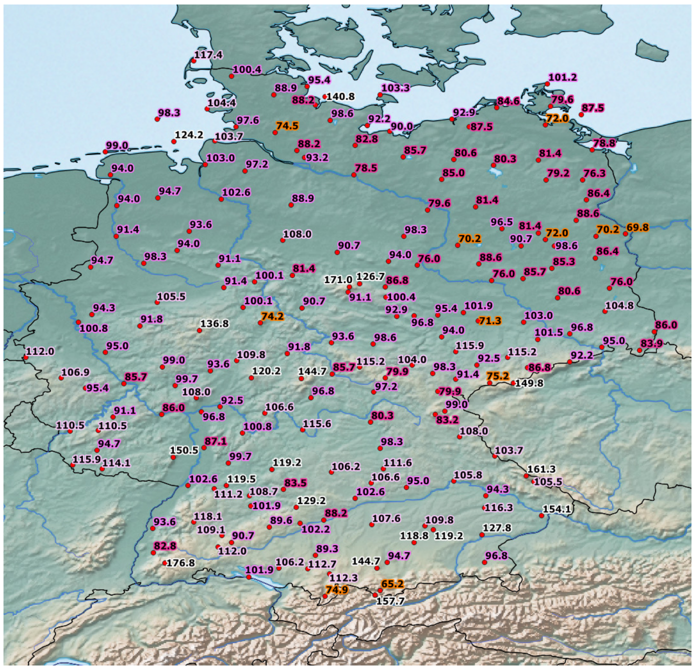


Abb. 3: Gemessene Spitzenböen an den Stationen des Deutschen Wetterdienstes am 9. und 10. Februar 2020. Farbliche Einteilung gemäß der Beaufort-Skala (von Bft 8 in orange bis Bft 12 in weiß; Daten: DWD).

Short Reports

Hurricane Florence, USA (2018)

Florence was the first major hurricane in 2018 of Category 3, with the highest average wind speeds of 225 km/h, gusts reaching 269 km/h and the lowest air pressure in the centre of 939 hPa. Florence was an unusually long-lasting storm crossing over the North Atlantic from 18 August 2018 to 14 September, when it made landfall near Wrightsville Beach in North Carolina. Thus, the hurricane moved over a distance of more than 6,500 kilometres in 16 days. As Florence approached the coastline, it became almost stationary, which caused rainfall totals of historic dimensions across Carolinas and thus catastrophic flooding. Both North and South Carolina registered new record rainfall totals caused by a hurricane or tropical storm. The exceptionally wet summer before with already saturated soils worsened the flood situation. Several communities, such as the city of Wilmington, were temporarily cut off from the outside world. Storm surges, prolonged river flooding and other storm-related consequences caused more than 40 fatalities.

Volcano-Tsunami Anak Krakatoa, Indonesia (2018)

The Volcano Anak Krakatoa is the successor of the great volcano Krakatoa, which last erupted in 1883. Anak Krakatoa is known for its significant growth during the last decades. On 22 December 2018, after a probable eruption, parts of its southwestern flank slid into the ocean, including an unknown underwater volume. This landslide triggered a tsunami, which hit almost all coasts in the Sunda Strait within 30 to 50 min. As the local time was early evening, the tsunami waves reached the coasts without large visual clues such as receding water leaving the people unprepared. In the province of Indonesia *Lampung*, the tsunami wave coincided with a high tide leading to an amplification. The wave pattern led to very local major inundations of up to 6 m and 1 to 3 m in a wider area. Quickly after the flank collapse, the volcano continued with major eruptive activity for several weeks including several more powerful explosions, which resulted in a significant mass loss and reduced its height by about 220 m.

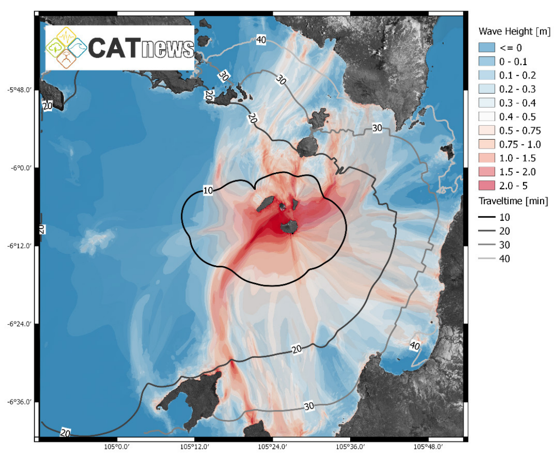


Fig. 1: Combined travel time and modelled wave height map of the 2018 Sunda Strait Tsunami using the model of Schaefer and Wenzel (2017; Source: CATnews).

Heavy rainfall, Germany (2019)

Heavy rainfall in May 2019 lasting over two days and reaching more than 200 mm totals at some stations in the centre and south of Germany caused moderate widespread flooding at several creeks and smaller rivers in Hesse, Baden-Württemberg and Bavaria with return periods between 2 and 10 years. In East Hesse, two water levels of Fulda tributaries even reached new historic records. The heavy precipitation was caused by a low-pressure system with its centre over eastern Central Europe; on the one hand, it transported moist and warm air masses in a wide arc from the north to Germany, and on the other hand

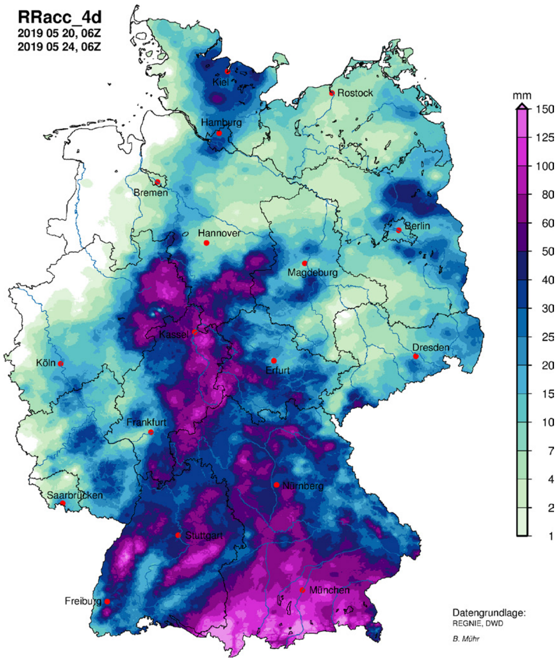


Fig. 2: 96-hour precipitation totals from 20 (06 UTC) to 24 May 2019 (06 UTC) based on the DWD's REGNIE data set (Source: Wettergefahren-Frühwarnung).

the strong incoming water vapour flux additionally produced significant amounts of orographic precipitation over the low mountain ranges and near the Alps. The large rain deficit lasting since the heat wave and drought in 2018 could be reduced, but not eliminated; also because the precipitation totals were lowest in the lowlands where the strongest drought prevailed.

Severe thunderstorms with large hail, Germany (2019)

Between 10 and 12 June 2019, a series of severe convective storms affected large parts of Germany, particularly the southern and eastern parts of the country. Hail with diameters of up to 6 cm, wind gusts reaching gale, and occasionally even hurricane strength, as well as heavy rain with daily totals up to 100 mm entailed considerable damage to buildings, vehicles, infrastructure, and agriculture. Munich Re reported a total (insured) loss of almost EUR 1.0 billion (~ EUR 0.75 billion) caused by a single supercell (rotating, most devastating storm type) that hit an area with one of the highest asset concentrations in Germany, the surroundings of Munich. Although inferior in losses compared to the famous Munich hailstorm on 12 July 1984 or the hailstorms on 27/28 July 2013 (depression Andreas), this event ranks at least about 8th or 9th on the list of the costliest hail-related loss events of the past 40 years in Europe. Atmospheric blocking (persistent large-scale high pressure system) in combination with a moist and unstably stratified air mass provided an excellent setting for the development of severe, hail-producing thunderstorms across the country. The vertical wind shear, which is necessary for the formation of supercells, was also present. Several weather stations registered new records of maximum wind gust speed and accumulated precipitation, and even two tornadoes were reported.

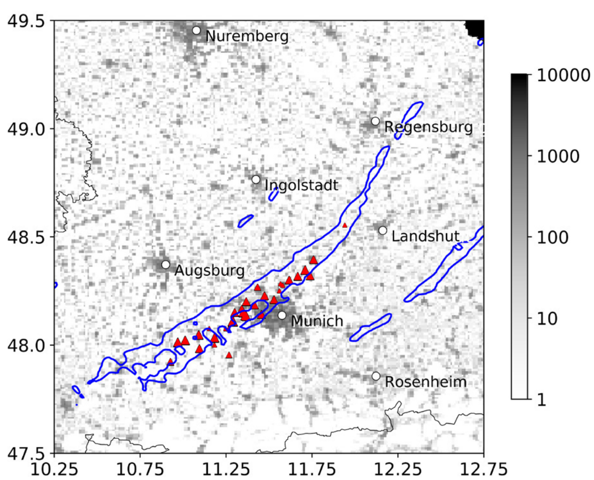


Fig. 3: Smoothed radar-derived storm-affected area (based on a reflectivity threshold of 55 dBZ; blue) and asset maps of capital stock (in million EUR per km²) for the Munich Region on 10 June 2019, including hail reports (red triangles; size scaled by reported diameter) from the European Severe Weather Database (Wilhelm et al., 2020).

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The “acqua alta” in Venice, Italy (2019)

In November 2019, the lagoon city of Venice experienced the second largest flood since 1872. The world-famous St. Mark’s Square was more than one-meter-high under water, and also St. Mark’s Cathedral badly suffered from the flood. During the autumn and winter months, flood events frequently occur in the lagoon city; however, there has never been a series of four consecutive extreme flood events. Within 5 days, from 12 to 17 November 2019, the water level rose four times to more than 140 cm, a threshold marking an extreme flood. It was only the second time since recordings began in 1872 that the water level exceeded 180 cm. During the night of 12/13 November, the flood was at 187 cm, and 87 % of the historic city centre were inundated. The damage to residential and commercial buildings and cultural monuments amounts to several hundred million euros. An extreme flood in Venice results from the superposition of the normal (astronomical) tide or high tide and with a storm surge (wind, wave height, wave direction) triggered by meteorological influences. When an extensive and strong low-pressure system is established over the western Mediterranean and Northwest Africa, persistent strong easterly to southeasterly winds push large amounts of water into the Venice lagoon as it was the case during mid-November 2019. Unusual large air pressure anomalies over Europe resulted in several low pressure systems over the northern Adriatic Sea, which repeatedly led to strong winds from the southeastern to northeastern sector provoking the flooding of Venice.

Drought & fire, Australia (2019/2020)

In 2019, the Australian continent experienced its warmest and driest year since records began in 1910, with a national average temperature for the year of 21.8 °C, which is 1.5 °C above the long-term mean (reference period: 1961 – 1990), leading to an exceptional heat wave in December and January. The associated devastating bush fires and their smoke clouds caused extreme air pollution and dangerous concentrations of pollutants, especially in the states of Queensland, New South Wales, Australian Capital Territory and Victoria on the east coast, but also in South Australia, Western Australia, Tasmania and the Northern Territory. In total, the bush fires spread over an area of around 126,000 km², and in many places a state of emergency was declared. The persistent extreme high temperatures made it considerably difficult for the fire brigades to extinguish the fire.

Doganyol earthquake, Turkey (2020)

The earthquake in Doganyol (Turkey) on 24 January 2020 reaches intensity VIII on the Modified Mercalli intensity (MMI) scale. Very well-built structures were only slightly damaged. Older buildings, however, suffered much greater damage. There was also limited liquefaction. The damage seen corresponds to VIII intensity and perhaps very isolated sites VIII to IX on the MMI scale. The rapid damage estimate by CEDIM gives a total damage value of between USD 0.49 and 1.56 billion with replacement costs (USD 0.64 to 1.9 billion) in the order of 30 % of the provincial GDP. The exposed stock with some earthquake damage was calculated to be over USD 30 billion. It is expected that the indirect losses and the overall macroeconomic impact will increase this estimate.

III. Cooperations

In recent years, CEDIM researchers have collaborated with various national and international partners, such as universities, research institutions, insurance companies, or other enterprises. In the following, we briefly introduce the most important partnerships and cooperations that have continued or have been established over the last two years on risk-related topics.

Research Institutions

University of Adelaide

Currently, CEDIM/GPI works together with the University of Adelaide in the context of various analyses in the multi-risk domain for locations around Australia. Additionally, together the software tool UnHARMED (Unified Natural Hazard Risk Mitigation Exploratory Decision Support System) is developed. UNHaRMED is a spatial decision support system for planners and policy makers to assist in the reduction of risk from multiple natural hazards, transforming planning risk reduction in Australia. UNHaRMED aims to enable planners and policy makers to understand current and future risks, what is driving the emergence of new risks and develop risk reduction strategies for the changing threats of multiple natural hazards in a systematic, transparent and consistent manner.

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Institute for Environmental Studies (VU Amsterdam)

The collaboration between CEDIM and Institute for Environmental Studies (IVM) has increased considerably in the recent years with a combined EGU session on „Global and continental scale risk assessment for natural hazards: methods and practice“. In addition, a set of cross-cutting PhD theses and research projects are in hand at both KIT and IVM which have considerable co-supervision overlap as well. The complementary studies on flood, climate change and drought at Amsterdam overlap well with the earthquake and meteorological focal points in Karlsruhe. Current activities are dedicated to consecutive disasters.

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Swinburne University of Technology

CEDIM/GPI collaborates with the Swinburne University of Technology in Melbourne (Australia) in residual risk research. Various approaches have been implemented or proposed in the last decade for setting risk-based performance requirements for seismic design of building structures. However, there is insufficient consideration about the aggregated risk for society, which could be significant especially for a densely populated metropolitan city. A recently published study introduces a rational and universal approach for evaluating the adequacy of structural safety requirements by comparing societal risk functions based on probabilistic loss assessment with a proposed regulatory requirement that aims to limit the mortality rate to “as low as reasonably practicable”.

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Federal Authority

Bundesamt für Bevölkerungsschutz und Katastrophenhilfe (BBK)

In 2019 and 2020, James Daniell (GPI) supported the production of a risk scenario for Germany from The German Federal Office for Civil Protection and Disaster Assistance (*Bundesamt für Bevölkerungsschutz und Katastrophenhilfe*, BBK) as an expert in the panel working group of geoscientists, engineers from various disciplines, planning scientists, local and federal authorities and disaster management representatives having bi-monthly meetings in Bonn at the BBK. The analyses done by *Deutsche GeoForschungsZentrum* (GFZ) were carefully reviewd by German earthquake experts, and recommendations were made in a separate report that was recently published.

Further reading

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Economy and Industry

Stadtwerke Karlsruhe (SWK)

Stadtwerke Karlsruhe
Besser versorgt, weiter gedacht.

A cooperation between the Karlsruhe Stadtwerke-Netzservice (utility provider) and ITES was established in 2017. The main topic concerns the security of supply against the background of technological transformation and the associated changes in consumption. Based on the data provided, we are able to conduct studies on smart grid planning that focus on aspects of resilience and supply security. In addition to new scientific findings on the design of resilient distribution networks, we can also offer municipal utilities long-term decision support on these topics.

SV SparkassenVersicherung

In the framework of the project HARIS-SCM (Hagelrisiko und Schadenmodellierung; hail risk and damage modelling), CEDIM/IMK-TRO have developed a novel hail risk model for the SV SparkassenVersicherung insurance company. The model estimates the probable maximum loss of a 200-year event (PML200). This quantity is required by insurers according to the regulatory directive Solvency II. The HARIS-SV hail risk model is based on several thousands of footprints of past hailstorms in Germany estimated from radar reflectivity from the German Weather Service (DWD) radar network. The stochastic event set is created from polygons that are randomly constructed from the radar-derived event set. Besides the hail risk model, CEDIM has also developed risk models for earthquakes (EQRISK-SV) and floods (FLORIS-SV; see page 35). The cooperation between SV and CEDIM is unlimited.

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Willis Research Network (WRN)

Willis Research Network
WillisTowersWatson

CEDIM has been a member of the Willis Research Network (WRN) since 2009, a network of excellence funded by the global insurance broker Willis Towers Watson. WRN cooperates with CEDIM by funding a Willis fellow (full position) in the working group “Atmospheric Risks” (IMK-TRO), who is working on the topic of country- and continental-scale hail hazard and risk assessment. WRN provides an open forum for the advancement of the science of extreme events through close collaboration between highly-ranked universities, insurers, reinsurers, catastrophe modelling companies, government research institutions and non-governmental organizations. As the only German partner of the network, CEDIM researchers gather experience in the cooperation with the insurance industry and learn about their needs and research priorities. Within a flagship project, CEDIM has developed a unique method to identify and characterize hail events using a satellite-processing algorithm in cooperation with NASA (see page 49). The resultant Willis Re European Hail Model (WEHM), covering 34 European countries, is applied by several insurance companies to estimate hail risk for property, motor and agricultural portfolios. Building on WEHM’s success, the model was adapted to other hail-prone regions of the world, such as Australia. Current activities in the framework of the 4-year NASA programme Research Opportunities in Space and Earth Science (ROSES) focus on hail risk assessment in South Africa, a country highly exposed to hail risk. The next focus continent will be South America. Another topic is the ramification of climate change on the probability on severe convective storms.

Further reading

Willis Research Network Website: https://bit.ly/2BVFzBf.

The Willis Research Network Brochure 2020 – Science for Resilience: https://bit.ly/2ZTcqyx.

Programmes and Networks

World Bank & GRADE

In cooperation with the World Bank, forensic disaster analyses – in particular impact estimates – are carried out in near real-time. Since 2015, the World Bank has been implementing a rapid post-disaster methodology to create estimates culminating in the Global Rapid post-disaster Damage Estimation (GRADE) approach (2018). The GRADE can provide an initial rapid estimation of the physical post-disaster damage incurred by key sectors within two weeks of the disaster. The approach aims to create an independent, credible sectoral quantification of the spatial extent and severity of a disaster's physical impact, addressing specific damage information needs in the first few weeks after a major disaster, and complementing the more comprehensive post-disaster needs assessment (PDNA) process. A Memorandum of Understanding (MoU) is in preparation between World Bank and CEDIM in order to formalise the relationship to work on GRADEs and support various sectoral loss estimates. The GRADE process has many new research areas given the speed of analysis needed and uncertainty analysis as a function of time after the event onset as to when an estimate is stable. CEDIM will continue to work on approaches to analyse particular sectors such as energy and transport.

Further reading

The Global Rapid post-disaster Damage Estimation (GRADE) approach (2018): https://bit.ly/2DzbXdo.

Deutsches Komitee Katastrophenvorsorge (DKKV)

In 2019, CEDIM has become an Institutional member of German Committee for Disaster Reduction (Deutsches Komitee Katastrophenvorsorge e.V., DKKV). DKKV is a national platform for disaster prevention in Germany and an intermediary to international organisations and initiatives active in the field of disaster prevention. It supports interdisciplinary research approaches to disaster risk management in different specialist sectors as well as in politics and business and disseminates the knowledge of disaster preparedness at all levels of education. As a new member, CEDIM was presented in a 6-page article in the Jan. 2020 newsletter.

Further reading

DKKV Website: https://www.dkkv.org.

DKKV (2020): DKKV Newsletter 01/2020, Deutsches Komitee Katastrophenvorsorge (DKKV), Bonn, Germany, available on: https://www.dkkv.org/fileadmin/user_upload/Veroeffentlichungen/Newsletter/Newsletter_Januar_2020.pdf.

WMO's High Impact Weather Project (HIWeather)

In 2016, the World Meteorological Organization (WMO), part of the United Nations, launched a new 10-year World Weather Research Program on High Impact Weather events (HIWeather). The overall objective of HIWeather is to build resilience to a wide range of selected weather-related hazards through research and its application in key aspects of meteorology, hazard prediction, human impacts, warnings communication and evaluation. CEDIM is member of the Human Impacts, Vulnerability and Risk Task Team. CEDIM spokesman Michael Kunz was invited to the 1st HiWeather workshop in Bejing (China) in 2018.

Knowledge Action Network on Emergent Risks and Extreme Events (Risk KAN)

Since last year, CEDIM is a member of the Knowledge Action Network on Emergent Risks and Extreme Events (Risk KAN). Risk KAN is a joint initiative of Future Earth, the Integrated Research on Disaster Risk (IRDR) programme and the World Climate Research Programme (WCRP) of WMO. Risk KAN provides an open platform for scientific communities from across science disciplines and engineering working on extreme events, disaster risk reduction and governance to exchange information, knowledge and data and engage in collaborative research activities.

CEDIM Spin-Off Company Risklayer

Risklayer GmbH was founded in Karlsruhe in 2016 by active and former CEDIM researchers. The spectrum of tasks covers hazard and risk assessments for a variety of different natural disasters based on the company's own, worldwide largest socio-economic damage database CATDAT and self-developed software packages in the field of high performance computing and machine learning for risk analysis. Risklayer cooperates with various insurance companies in the field of probabilistic and stochastic risk models and provides rapid loss estimations in cooperation with global companies such as Facebook, Google, World Bank, Internal Displacement Monitoring Centre (IDMC) and Department for International Development (DFID). In doing so, profiles of the catastrophe dimensions, historical analyses and loss estimates are provided in near-real time after disasters. CEO James Daniell is also Deputy Spokesman of CEDIM.

Further reading

Risklayer Website: http://risklayer.com.

IV. Outreach

CATnews

The results generated in the Rapid Impact Modelling Framework (see page 18) are currently being distributed via the social media network CATnews on Twitter and Facebook. Within the last years, the public attention, both in- and outside social media, have increased significantly. During the first iterations, impact maps had only been seen by a few hundred interested people. However, today with about 7,000 followers and a reach of often more than 10,000 people, the maps provided by rapid impact modelling are well received. In some cases, the reach goes well beyond 100,000 individuals and is shared by regional news agencies including Qatar Day, Nevada Today, The Jakarta Post, India Times and our experts have been cited by the New York Times, the Wallstreet Journal or National Geographic.

Earth System Knowledge Platform (ESKP)

The Earth System Knowledge Platform (ESKP) is part of the of the portfolio process of the Helmholtz Association in the Research Field Earth and Environment. The website offers clear and understandable knowledge on various topics of natural hazards, climate change, pollutants and the effects of the energy system transformation on the environment by the participating Helmholtz centres (and other partners). On ESKP, CEDIM informs the public and various stakeholders about the most important results of its research and its FDA activities. In the last four years, CEDIM researcher disseminated 17 articles in topics of their research. With its expertise on hazards and risks, CEDIM is an important partner of ESKP. In 2017, ESKP has introduced a new format, the so-called topic specials (*Themenspeziale*). Different aspects of science are bundled and interlinked under one roof. CEDIM researcher contributed for example to the topic special “Metropolises under pressure – How cities become more sustainable”.

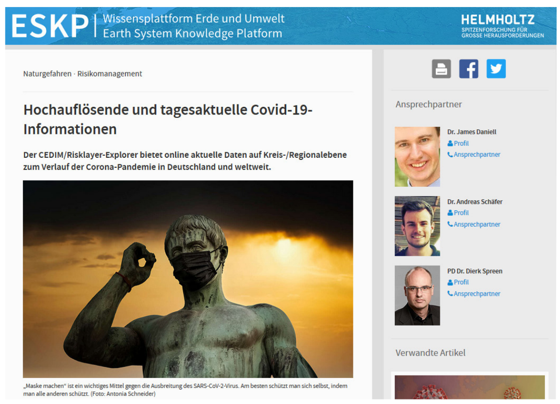


Fig. 1: Recent contribution on ESKP regarding our Covid-19 activities (courtesy Antonia Schneider, photographer of the original image on ESKP).

Further reading

ESKP Website: https://www.eskp.de.

ESKP Themenspeziale: https://themenspezial.eskp.de.

European Geosciences Union (EGU) General Assembly

CEDIM researchers have contributed to different formats of the annual General Assembly of the European Geosciences Union (EGU). From 2014 to 2018, the EGU featured a dedicated session to the core research fields of CEDIM called “Natural hazard event analyses for risk reduction and adaptation”, which was convened or co-convened by CEDIM researchers. In addition, the submissions from the 2017 session were published in a special issue “Natural hazard event analyses for risk reduction and adaptation“ of the open-access journal Natural Hazards and Earth System Sciences (NHESS). At the 2017 EGU General Assembly, James Daniell (GPI) was awarded the “Outstanding Early Career Scientist Award” from the Natural Hazards Division for his distinguished scientific achievements in the field of natural hazards (“Wine: the increasing risk of a highly vulnerable industry globally to natural disasters and climate change”). In 2018, Andreas Schäfer (GPI) presented the Tsunami Risk Index for holiday destinations around the world at the EGU press conference. He showed that about Euro 200 million losses for the tourism industry near beaches are to be expected each year. Based on the “TsuPy” simulation model, the team has examined more than 24,000 beaches and their economic relevance for more than 1,000 destinations worldwide to calculate the risk of each destination in terms of beach-related business shares (see also page 24).

Further reading

Special issue “Natural hazard event analyses for risk reduction and adaptation” in the journal “Natural Hazards and Earth System Sciences (NHESS)” (Editors: K. Schröter, H. Kreibich, M. Kunz, and D. Molinari): https://nhess.copernicus.org/articles/special_issue220.html.

EGU Blog “Top ten tourist beaches threatened by tsunamis”: https://bit.ly/3ceSZUZ.

Media Presence (Television, Radio, Print)

CEDIM researchers are frequently sought-after experts for regional, national and international media such as TV, radio or print and online media. Several interviews on TV or radio and numerous citations in newspapers and news portals contributed to the large visibility of CEDIM’s work. Selected examples are:

- BCC interview about FDA activity on hurricane Harvey.
- BMBF Zahl der Woche „192 Milliarden US-Dollar Schaden haben Stürme 2017 angerichtet“.
- SmarterWorld „KIT-Simulationsmodell – Die Widerstandskraft smarter Grids stärken“.
- SWR „Hagel Ereignisse werden wohl häufiger auftreten”.
- SWR „KIT-Forscher: Wir brauchen in Zukunft bessere Konzepte für Pandemien“.
- Tagesspiegel „Risikoanalyst über Corona: Wir haben großes Glück, dass es so eine langsame Katastrophe ist”.
- ZDF „Wetterextreme in Deutschland: Dürre 2018 – Was sie bisher angerichtet hat“.

The Willis Research Network Spring Seminar Series

Within the framework of the “Effekte 2017” science festival, the KIT Campus North opened its doors for a “Public Open Day”. On Saturday, 24 June 2017, best weather attracted numerous visitors to the CEDIM booth, which was organized in cooperation with the KIT Climate and Environment Center and the South German Climate Office. Until the evening hours, CEDIM’s mode of operation and approach with regard to the rapid, interdisciplinary analysis of natural disasters were explained to numerous interested people. Several informative posters from the institutes involved in CEDIM as well as exciting experiments such as a tornado in a water glass or an earthquake table rounded off the event.

Science Slams & FameLab

CEDIM researcher Andreas Schäfer is active in the Science Slam (10 min presentation & Powerpoint) and FameLab (3 min & props, but without Powerpoint) community. Using these formats, scientists communicate their research topics to the audience in a short time in an entertaining and understandable way. Using that format, Andreas explained what disaster research is, how an earthquake sounds to a researcher or how to measure the size of tsunamis. In 2017, he was Champion West at the "Science Slam im Wissenschaftsjahr" and FameLab Germany finalist.

Further reading & viewing

Erdbeben – gestern, heute, morgen (Andreas Schäfer): https://www.br.de/fernsehen/ard-alpha/sendungen/campus/slam/campus-slam-schaefer-andreas100.html.

clicKIT "FameLab – Rampensau, aber wissenschaftlich": https://www.clickit-magazin.de/famelab-rampensau-aber-wissenschaftlich.

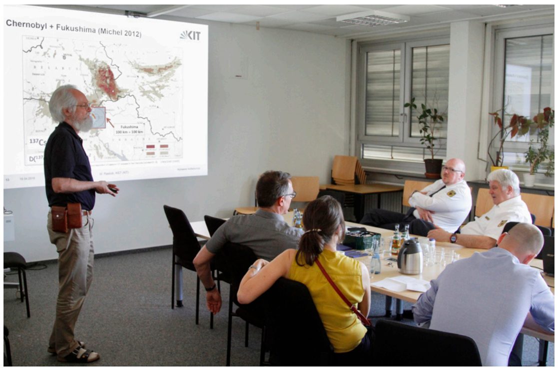
Science Slam: Andreas Schäfer | Die Frack'kalypse - Fake News in der Wissenschaft: https://www.youtube.com/watch?v=hawkLLYU6TQ.

Talking Disasters (Andreas Schäfer – Science Slam): https://www.youtube.com/watch?v=ArStP-cge-hc.

Talking Tsunami (Andreas Schäfer – Science Slam): https://www.youtube.com/watch?v=V3sw_WCDDl4.

Visits at CEDIM

Various organizations have been visiting CEDIM over the past years to learn more about our research. For example, a government delegation from the Zhejiang Province (China) visited us in 2017 to obtain information about research activities in hydraulic engineering and associated extreme events. In 2018, we hosted a delegation of the China Earthquake Administration (CEA), which were interested in the FDA activities and earthquake research at the Geophysical Institute (GPI). In the same year, the former president of the *Technisches Hilfswerk* (THW), Albrecht Broemme, and the head of the "Research and Innovation Management", Klaus-Dieter Büttgen, visited CEDIM to explore potential cooperation.



Visit of the former president of the Technisches Hilfswerk (THW), Albrecht Broemme, and the head of the "Research and Innovation Management", Klaus-Dieter Büttgen (Image credits: Susanna Mohr).

Visit of a government delegation from the Zhejiang Province (China) at the Institute for Water and River Basin Management (Image credit: Michael Kunz).

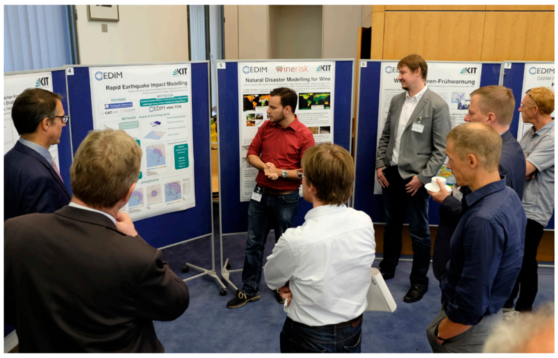
Visit of a delegation of the China Earthquake Administration (CEA) at the Geophysical Institute (Image credit: Michael Kunz).

Effekte 2017: KIT Open Day at Campus Nord

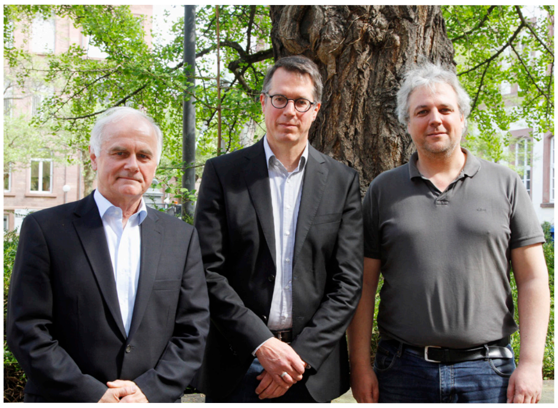
The Willis Research Network (WRN) held a 'Spring Seminar' series featuring a number of research projects and partners across several weeks in April and May 2018. Topics ranged from severe convective storms to corporate risk profiling. The first seminar was dedicated to Hail Hazard Modelling, where CEDIM spokesperson Michael Kunz and WRN Fellow Heinz Jürgen Punge presented their work on convective storm and hail modelling in Europe and Australia.

Impressions of the Science Festival "Effects 2017" (Open Day at Campus North; Image credits: Susanna Mohr & KIT/Anne Behrendt).

Further impressions of the last years



Strategic evaluation of CEDIM on 12 September 2017 (Image credits: Susanna Mohr).



CEDIM spokesmen from 2016 to 2019 (left): Franz Nestmann, Stefan Hinz and Michael Kunz & since Nov. 2019 (right): James Daniell, Stefan Hinz and Michael Kunz (including corona safety distance).

V. Publications 2017 – 2020

Articles in Journals and Books

Articles in Journals and Books 2017

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Ottenburger, S. S., Münzberg, T. (2017): An approach for analyzing the impacts of smart grid topologies on critical infrastructure resilience. Proceedings of the 14th International Conference on Information Systems for Crisis Response and Management (ISCRAM 2017), Albi, France.

Ottenburger, S. S., Bai, S. (2017): Simulation based strategic decision making in humanitarian supply chain management, Proceedings of the 4th International Conference on Information and Communication Technologies for Disaster Management (ICT-DM), doi:10.1109/ICT-DM.2017.8275683.

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