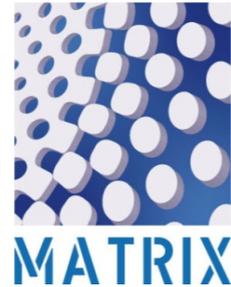


MATRIX – new methods and tools for multiple risks

1. Introduction

The importance of multiple risks has been a scientific focus for several years. However, the phrase “multiple-risk” includes different concepts. On the one hand, it relates to natural risks or other events which may occur in parallel without any causal relations. For example, an earthquake and a flood may occur at the same time independently, which may in combination result in higher damages than the two individual events separated in time. On the other hand, one event can initiate a series of negative events which are related in space and time. In this case, one speaks about a chain of natural events or cascading effects and events. One remarkable recent example is the strong earthquake in Japan in March 2011, which generated a tsunami. This earthquake and tsunami destroyed wide areas in east Japan and caused the nuclear crisis in the atomic reactors in Fukushima. Another example is the flooding in Pakistan in 2010, which caused crop failures in the Punjab which in turn caused a food crisis. Moreover, multi-risk is not bounded to a certain region. The flooding of the nuclear power plant Blayais during the winter storm Lothar in the Aquitania region in France showed clearly that Europe could also be affected by multi-risk events. Nor is the concept of multi-risk limited to natural events as a trigger, since anthropogenic triggers like industrial accidents may also occur, with negative impacts upon the environment to be followed by health risks for the population being possible (EC 2010 1626 final, p. 23).



A first and important step in treating cascading multi-risks correctly is their assessment. Until now, projects which focused on the assessment of multi-risks did not necessarily take into account cascading events. Projects like *Cities* in Australia (Granger, 1999) investigated the risks of a series of urban areas threatened by a number of natural hazards. Dependent upon the location, earthquakes, flooding, tsunamis, and storms were taken into account. However, cascading effects, as well as the impact of one event on the vulnerability of the region to further events, were not taken into account. Similarly, the project “Deutsches Forschungsnetz Natur Katastrophen” (DFNK) treated single hazards separately and possible interactions between the different risks were not investigated (Grünthal et al., 2006).

The multi-risk concept, in which cascading events and effects are taken into account, as well as a possible time dependent vulnerability, is a relatively new field which takes into account cascading and simultaneous events. It offers the possibility to assess risks more precisely, as possible interactions between different natural risks and anthropogenic structures are taken into account. The aim of MATRIX is therefore to investigate the potential of this concept and to develop methodologies for assessing multi-risks.

2. MATRIX

MATRIX stands for “New Multi-Hazard and Multi-Risk Assessment Methods for Europe”, and it represents an international collaborative project coordinated by the Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences. Financial support for MATRIX comes from the Seventh Framework Programme (FP7), Environment theme, with a total budget of 4.3 Mio. EUR and a contribution from European Commission is 3.3 Mio. EUR. The project started in October 2010 and will last 3 years.

As the name suggests, MATRIX is dealing with multiple natural hazards and risks. This refers to events that occur close in time as well as those triggered by other natural events (so-called domino or cascade events). Within the framework of MATRIX, not only are interactions between natural risks considered, but also their impact upon the environment. For example, after an event, the vulnerability of a region may have increased substantially, which increases the risk to future events. In addition, a

chain of events may result in unexpected scenarios and damages which will not have occurred with a single event.

In this respect, the MATRIX project is distinguished from other projects that also deal with multi-risks. Within the framework of MATRIX, interactions in time and space and their impact upon vulnerabilities and risks are explicitly part of the research. In addition, the research groups put a special focus the evaluation and integration of uncertainties in multi-risk estimation.

The main aim of MATRIX is therefore the development of new methodologies and tools for quantifying hazards and risks which allow for the analysis of multiple natural hazards and to compare different hazards. Additional areas of focus are:

- Cascading hazards and time-dependent vulnerability.
- The development of information technology for multi-risk scenarios.
- The possibility of determining direct and indirect damages.
- The distribution of the results and interactions with national platforms for disaster prevention.

MATRIX deals with natural hazards that are relevant to Europe. These are earthquakes, volcanic eruptions, tsunamis, forest fires, landslides, storms, and flooding. Technological disasters caused by natural hazards, while acknowledged as being important, are not included in the research project. The MATRIX consortium (<http://matrix.gpi.kit.edu/Consortium.php>) is made up of well-known international scientific institutions and the German Committee for Disaster Reduction (DKKV), which provides the interface between MATRIX and the National Platforms for DRR and civil protection authorities.

Cologne, Naples, and Guadeloupe – case studies in MATRIX

Within MATRIX, the concept of multi-risk is studied in conjunction with several concrete case studies. In total, 3 case studies with different natural hazards and possible combinations of events are investigated. The case study Cologne deals with earthquakes, flooding and winter storms. The focus of the investigations is on the flood risk and its impact on the city and the surroundings in the event where an earthquake has a negative impact upon the dike system that protects this area against high water along the Rhine River. The Guadeloupe case study investigates volcanic eruptions, earthquakes, tropical cyclones, flooding, landslides, tsunamis and their impact upon the functionality of different critical infrastructure. In Naples, the hazards of interest include the combined impact of volcanic eruptions and earthquakes, with such issues as the effect these have on the structural vulnerability of lifelines (e.g., volcanic ash loading on pipes) being a prime topic.



Mt. Vesuvius – Picturesque landmark and potential source for cascading effects

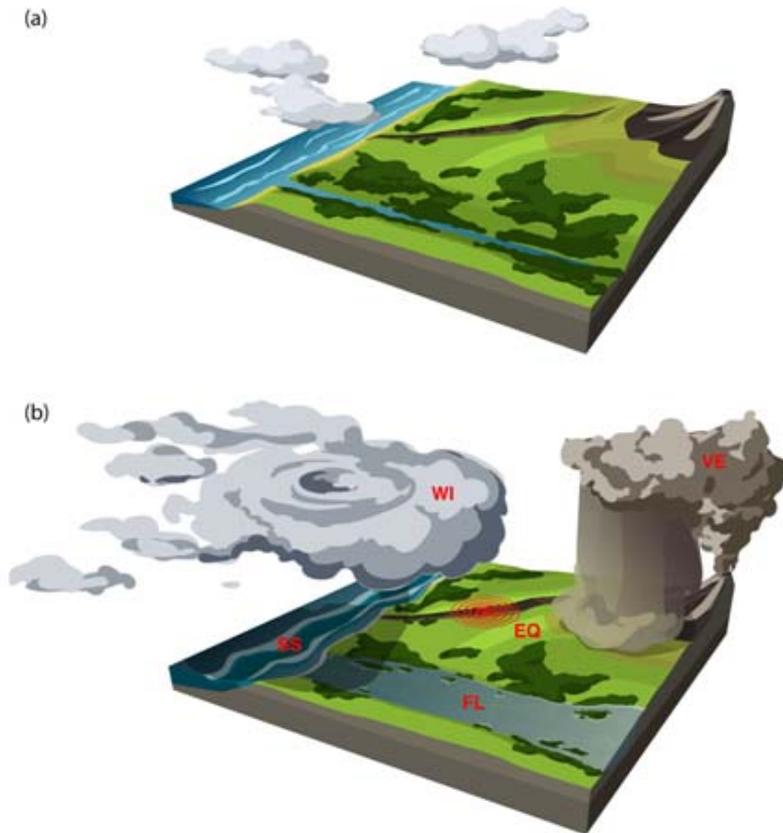
(photo: Roger Mrzyglocki, DKKV)



A street view in Cologne taken with an omni-directional camera system. These photos, in combination with the products of remote sensing and engineering expert knowledge, provide a rapid assessment of the vulnerability of a building stock (photo by Marc Wieland, GFZ).

MATRIX-CITY and Decision Support Systems

MATRIX-CITY (MATRIX-Common IT sYstem) is the general purpose MATRIX IT system. It is a simulation platform for quantifying the interactions of natural hazards, exposures, vulnerabilities, and risks. Because the availability of data plays a central role, MATRIX-CITY incorporates a data bank system containing data and definitions which are based on the concepts of a Virtual City / Virtual Region. Based on these concepts, general roles for multiple hazards and risks can be defined which can be applied to real cases. For example, in this way the consequences of multiple hazards and risks can be studied. MATRIX-CITY is based on the latest software technology with a flexible architecture that allows for an integration of additionally identified hazards and models at a later stage (Mignan, 2012).



Schematic view of the Virtual Region where earthquakes (EQ), volcanic eruptions (VE), flooding (FL), storms (WI), and subsidence (SS) can occur at the same time (either by chance or based on interacting processes like EQ/EQ or WI/SS coupling). A VirtualCity (not shown in the picture) can be placed everywhere within the Virtual Region (source Mignan, 2012).

In order to include expert knowledge in the decision-making processes, MATRIX is developing a decision support system. This system supports the development of scenarios and is being used in the generation of the risk matrix. Within the framework of a participation process, where decision makers from different technical and administrative areas are involved, the weighting of the damage categories (e.g., human, economy, ecology, and infrastructure) are transparently defined and the risk ranking is obtained by a consensus result.

Interaction with National Disaster Preparedness Platforms

In order to enhance the awareness of multiple-risks of civil protections and national platforms for disaster reduction on a European level, as well as to learn about the needs and expectations from risk research, selected national platforms were involved in the project from its very beginning. The national platforms and civil protection authorities in question are from Austria, the Czech Republic, Croatia, France, Germany (represented by the BBK), Italy, Norway Poland, Sweden, England, and UN-ISDR Europe, all of which are participating in this process and work on a voluntarily basis. The special perspectives and feedback provided by these cooperation partners enter not only into the development of the MATRIX IT system itself, but also presents an important factor in the further

development of MATRIX and the best directions for future research, while at the same time provide a key element to the applied methodologies' development.

MATRIX-Stakeholder Workshop 2012

On July 5/6 2012, the MATRIX Stakeholder Workshop was organised in Bonn/Germany in cooperation with the German Committee for Disaster Reduction (DKKV) together with representatives of the national platforms and UN-ISDR. In advance to the workshop, a detailed questionnaire was sent to the cooperation partners to identify the most up-to-date status of hazard and risk assessment in Europe. With this questionnaire, information related to the needs in multi-risk methodologies and tools could be gained, and the ability for the integration of the methods developed in MATRIX in current practice could be assessed. The results also provided a first impression of the state of the general knowledge of multi-risk within this community.

The aim of the workshop was to obtain an overview of the different branches and necessary components existing within the multi-risk context, and to clarify the needs of the end-users concerning the information technology.

The participants came to the conclusion that the areas for the application of hazard assessment and risk estimation are very different. While hazard maps can be used within the framework of planning and prevention, most risk maps can mainly be used for awareness and preparedness, although general standards are missing for risk estimation. Cascading phenomena are an important field of investigation according to the workshop, which could be better accessed within the context of scenarios rather than in probabilistic analyses. Some of the representatives were also interested in information about determining probabilities of cascading and simultaneous events. All participants showed a strong interest in the IT tools being developed in MATRIX, they encouraged the further development and expressed their interest in further interactions.

MATRIX is following this interest and is preparing a second "MATRIX – Stakeholder Workshop" which is being planned for the end of June 2013 in Bonn. Important elements of the workshop will be presentations, discussions and working groups considering multiple events which have taken place in the past. The aim of the workshop will be to identify, through a dialogue with the representatives of civil protection, the national platforms for disaster reduction, operators of critical infrastructure, and the insurance industry, past and future needs of multi-risk assessment and to develop recommendations for further research. Through the identification of knowledge gaps and positive examples, important hints for the further development of methodologies in risk estimation will be extracted.

3. Summary

MATRIX represents a multifaceted project that combines, in a unique way, theoretical knowledge from the latest multi-risk research with applied science within the framework of case studies. At the same time, MATRIX receives important input through its member's interactions with experts from the national platforms and civil protection authorities for the further development of methodologies and tools. The integration of national platforms into this process represents an important step towards the linking of science and practice in disaster prevention and mitigation, and could be used as a model for future research projects. The benefit of this cooperation is the development of useful products which contribute to the development of realistic multi-risk scenarios. The next planned workshop in June 2013 will identify further important directions for multi-risk research and will contribute to the fine-tuning of the MATRIX methodologies and tools.

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