New Multi-Hazard and Multi-Risk Assessment Methods for Europe (MATRIX) project

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Multi-type interactions (1)

At the **hazard level**, multi-type interactions include:

- An initial event <u>triggering</u> (cascade, domino) other (possibly worse) events. e.g., earthquakes and tsunamis.

  2011 Tōhoku earthquake and tsunami (Wikipedia)

- <u>Simultaneous</u> or <u>near-simultaneous</u> unrelated events. e.g., an earthquake and major storms.

- An event may lead to the <u>increased likelihood</u> of another. e.g., heavy rains and landslides, drought and wildfires.

  2009 Victoria bushfire (Wikipedia)

Multi-type interactions (2)

Multi-type assessments also need to confront the dynamics of hazards.

Of these, climate change is perhaps the most obvious, especially extreme events.

e.g., the effect increased frequency and length of droughts have on hydro- (no water) and nuclear (cooling problems) power.

Multi-type interactions (3)

On the **vulnerability level**, multi-type interactions have an effect on the physical, social and economic sectors.

- Variety of exposed elements (e.g., population, buildings etc.). Each target has a different vulnerability to different hazards, hence requiring their own prevention and coping strategies.

- On the physical level, a given event increases the vulnerability of a system to future events.

  e.g., earthquakes weaken buildings, increasing their vulnerability to future earthquakes or other hazards (e.g., windstorms).
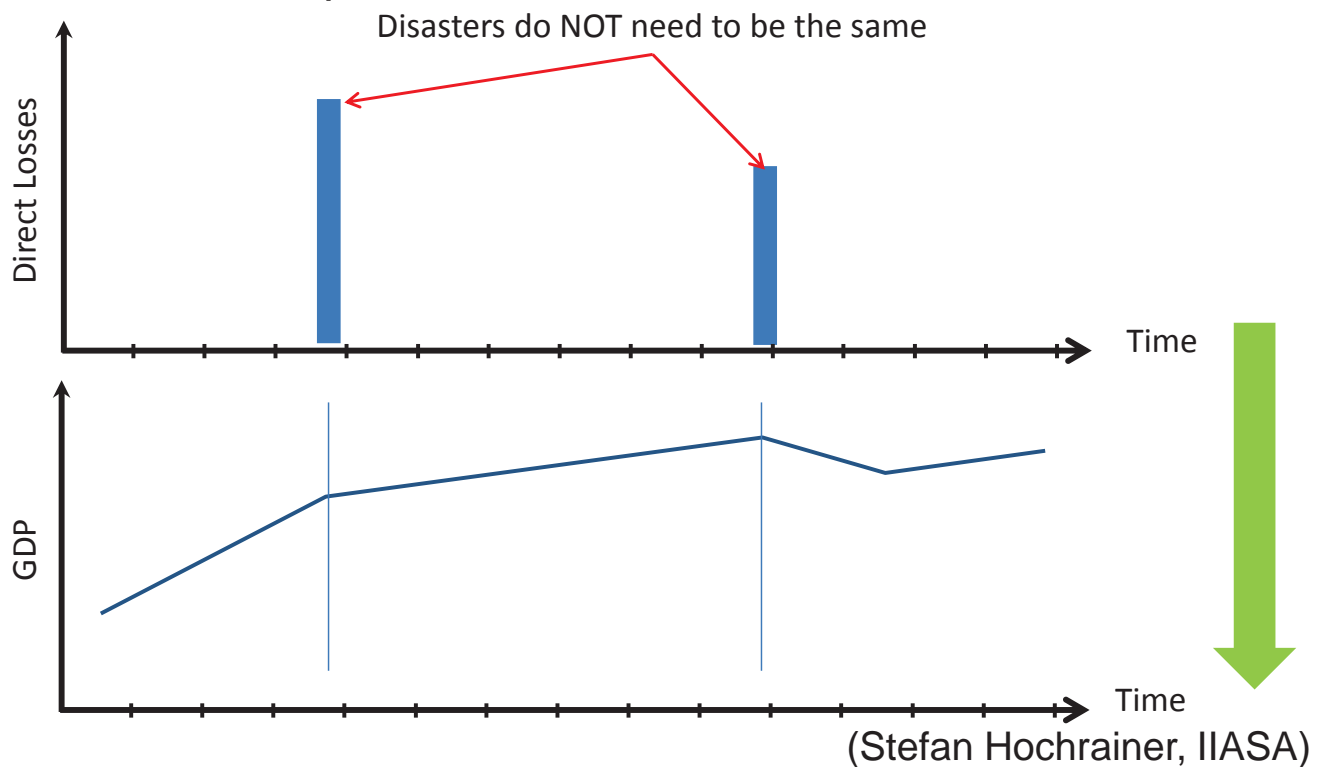

Baptist Church after the 2010 Canterbury earthquake, later destroyed in an aftershock (Wikipedia)

Multi-type interactions (4)

- On the <u>social-economic</u> level, a population may have the resources to cope with 1 disaster, but not more.

Disasters do NOT need to be the same

(Stefan Hochrainer, IIASA)

Multi-type interactions (5)

On the **<u>exposure level</u>**, interactions include changes in the extent and nature of human populations.

e.g., expansion of mega-cities, rural depopulation.

Istanbul (Wikipedia)

Abandoned rural building, Russia (Wikipedia)

These may also act back onto the hazard and vulnerability levels.

Multi-type interactions (6)

A multi-hazard and risk perspective needs to also
consider how mitigating one risk may affect others.

e.g., In Kobe, Japan, older buildings with
heavy roofs were fine for annual typhoons
BUT not so for much rarer earthquakes.

Destroyed houses, Kobe, Japan, 1995 (Wikipedia)

e.g., In drought affected areas of Iran, government assistance
tended to benefit the richer farmers.
This lead to them modernizing their farms, reducing their need
to employ poorer farmers who were denied this source of
income, hence further exasperating their troubles.

Some problems with multi-type frameworks

- <u>Comparability of hazardous events</u> with each other.
  Different return periods, effects, measures of intensity, extent.

- Comparison of the vulnerability of exposed elements, different
  <u>measures of vulnerability</u>.

- Different <u>metrics for different end-users</u>, different hazards.

- <u>Weighting</u> the relevance of hazards or exposed elements.
  Conflicting views between decision makers/stakeholders.

- Accounting for <u>difficulties</u> in collecting data, information, and
  knowledge in a <u>coherent and easily accessible</u> way.
  Includes <u>harmonizing</u> data from single-risk assessments.

The "New Multi-Hazard and Multi-Risk Assessment Methods for Europe" project

MATRIX was a FP7 Collaborative project under the Environment theme "New Methodologies for multi-hazard and multi-risk assessment".

Coordinated by Prof. Dr. Jochen Zschau of GFZ.
- 12 partners
- 10 countries (including Canada)
- 10 research institutions
- 1 end-user (DKKV, Germany)
- 1 industry (Aspinall, UK)

MATRIX ran from the 1st October 2010 to 31st December 2013

Core objective of MATRIX

"to develop methods and tools to tackle multiple natural hazards in a common framework "

Develop new methodologies for multi-type hazard and risk assessment	Compare new multi-type methods with state-of-the-art probabilistic single-risk analysis.
Establish an IT framework for test case analysis within a multi-risk environment	Disseminate the results to multiple communities

Hazards of interest

The "usual suspects" for Europe.

→ Earthquakes

→ Landslides

→ Volcanic eruptions

Tsunamis

→ Wildfires

→ Winter storms
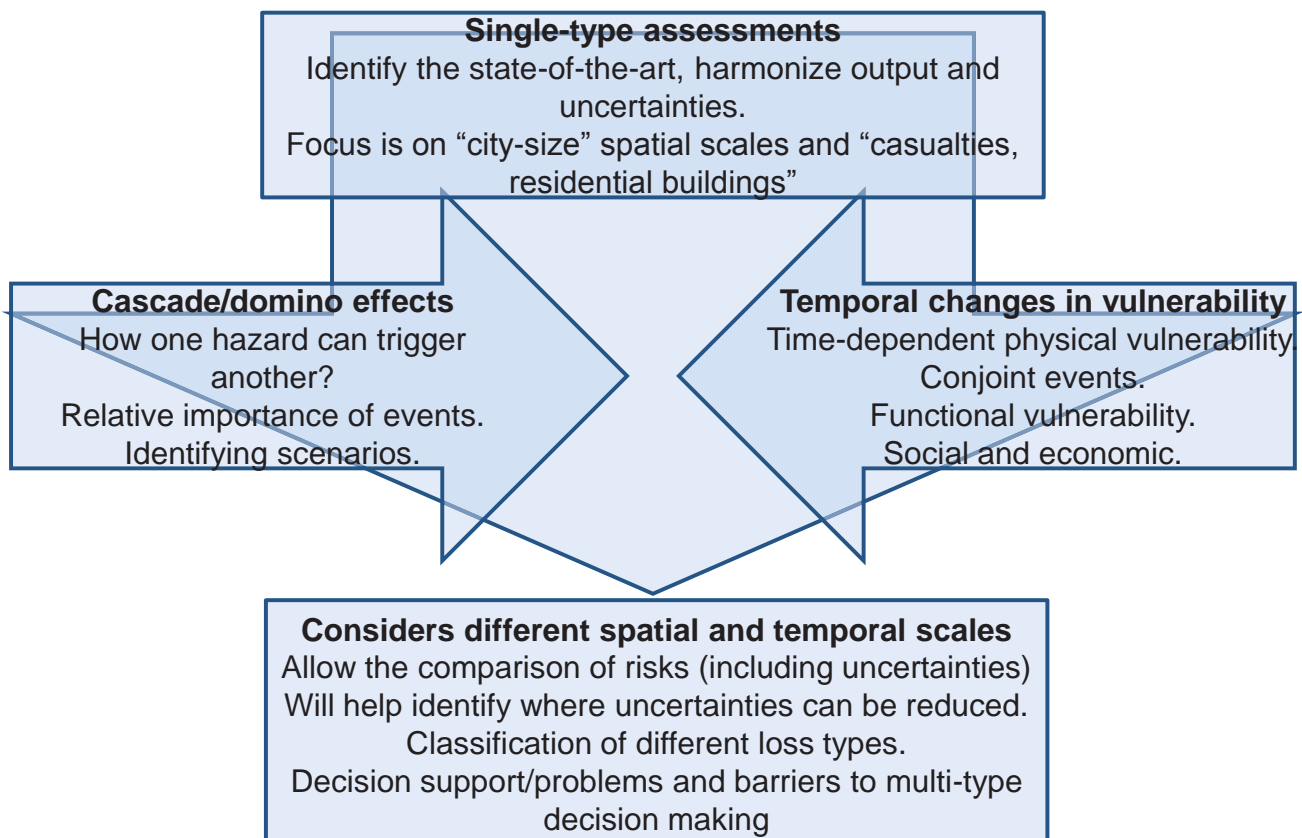
Cold and heat waves

→ Fluvial and coastal flooding

General work scheme

Single-type assessments
Identify the state-of-the-art, harmonize output and uncertainties.
Focus is on "city-size" spatial scales and "casualties, residential buildings"

Cascade/domino effects
How one hazard can trigger another?
Relative importance of events.
Identifying scenarios.

Temporal changes in vulnerability
Time-dependent physical vulnerability
Conjoint events.
Functional vulnerability.
Social and economic.

Considers different spatial and temporal scales
Allow the comparison of risks (including uncertainties)
Will help identify where uncertainties can be reduced.
Classification of different loss types.
Decision support/problems and barriers to multi-type decision making

MATRIX Test Cases
The new methodologies will be evaluated at three test cases
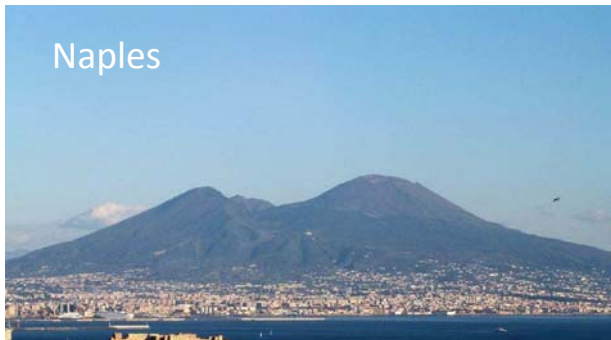
Naples
Wikipedia

Wikipedia
Cologne

French West Indies
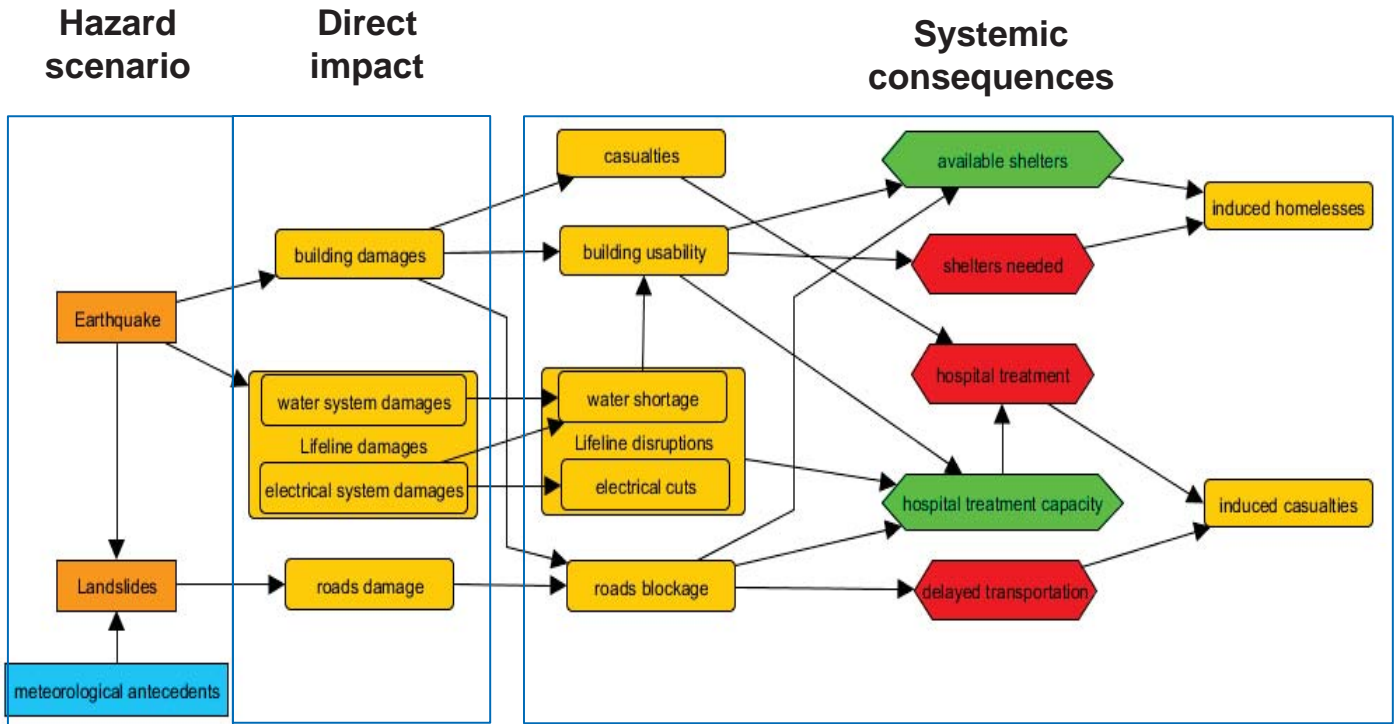@BRGM, Jean-Marc Montpellat

Scenario for Guadeloupe

> An earthquake occurs
> Due to meteorological conditions, the earthquake causes landslides in mountainous areas, potentially affecting road network
> Focus on the RD23 due to its importance:
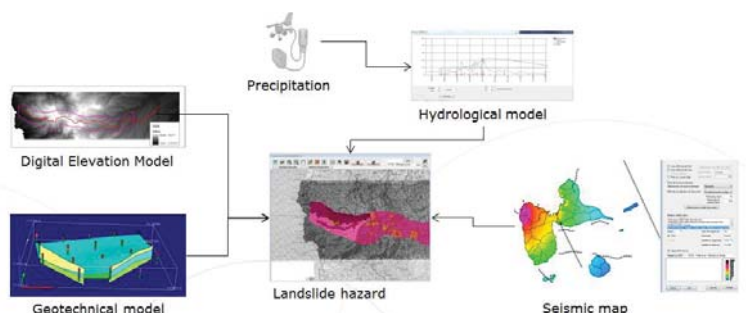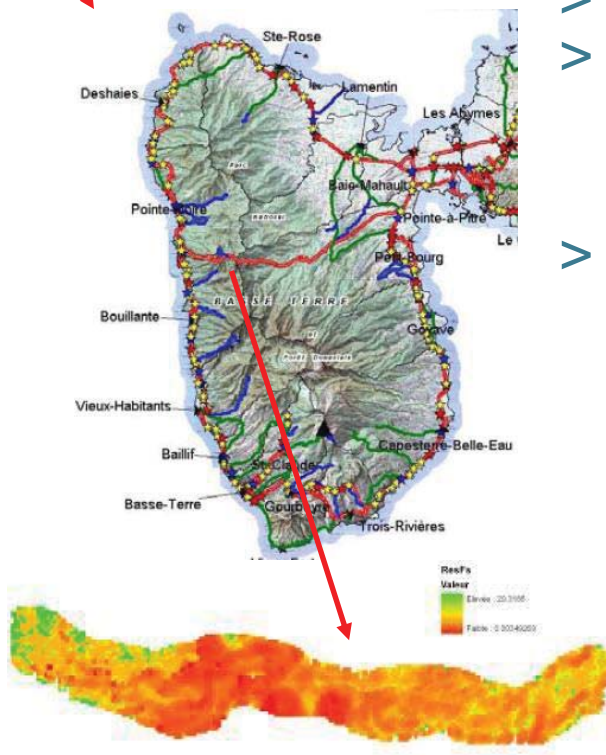
(Nicolas Desramaut, BRGM)

General Approach

(Daniel Monfort, BRGM)

Effect on lifelines
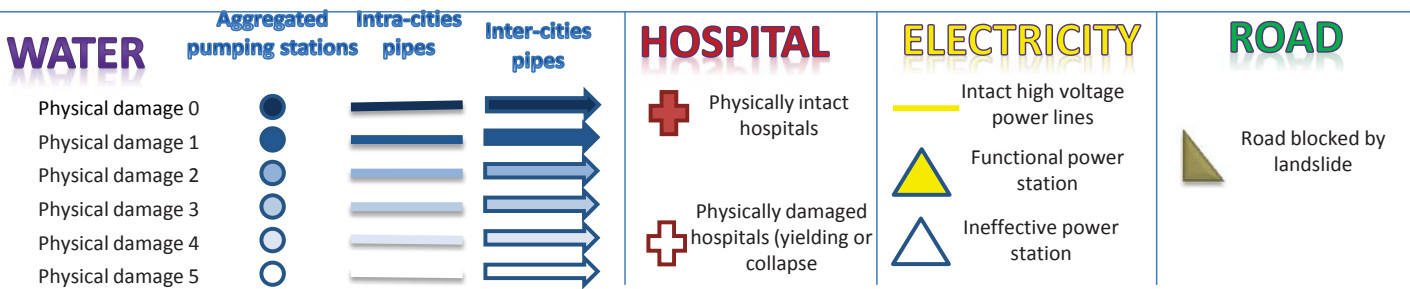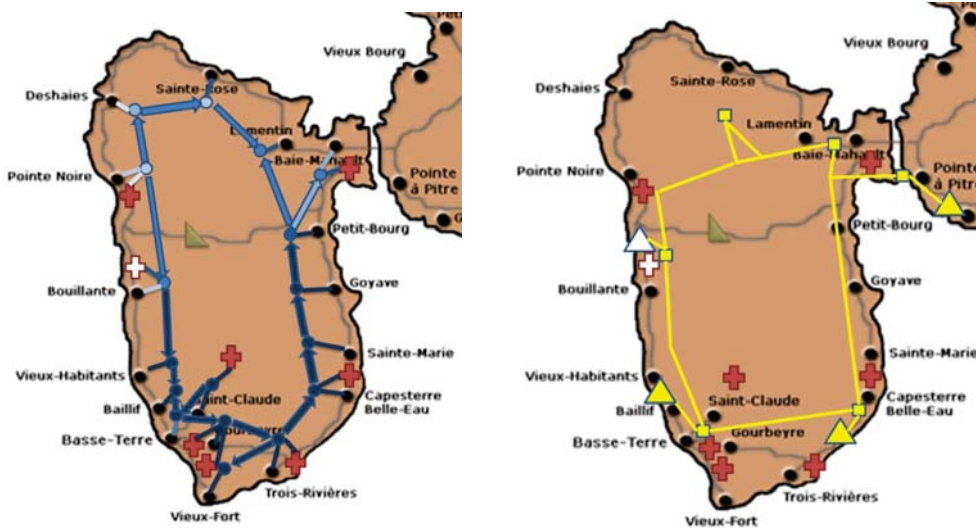
(Daniel Monfort, BRGM)

"MATRIX-CITY" IT Platform

- Implement common data models, data exchange procedures (harmonization) and hazard and risk calculations.
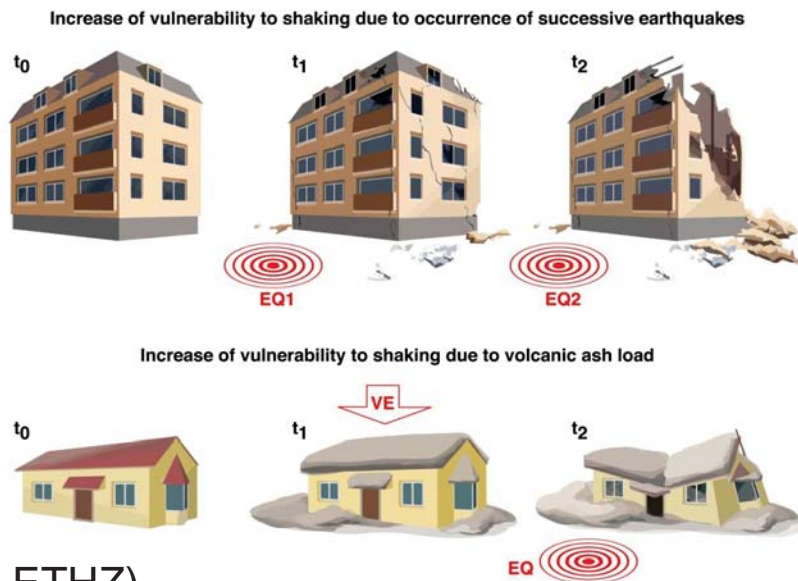- Modules act as black boxes.
- Visualization.
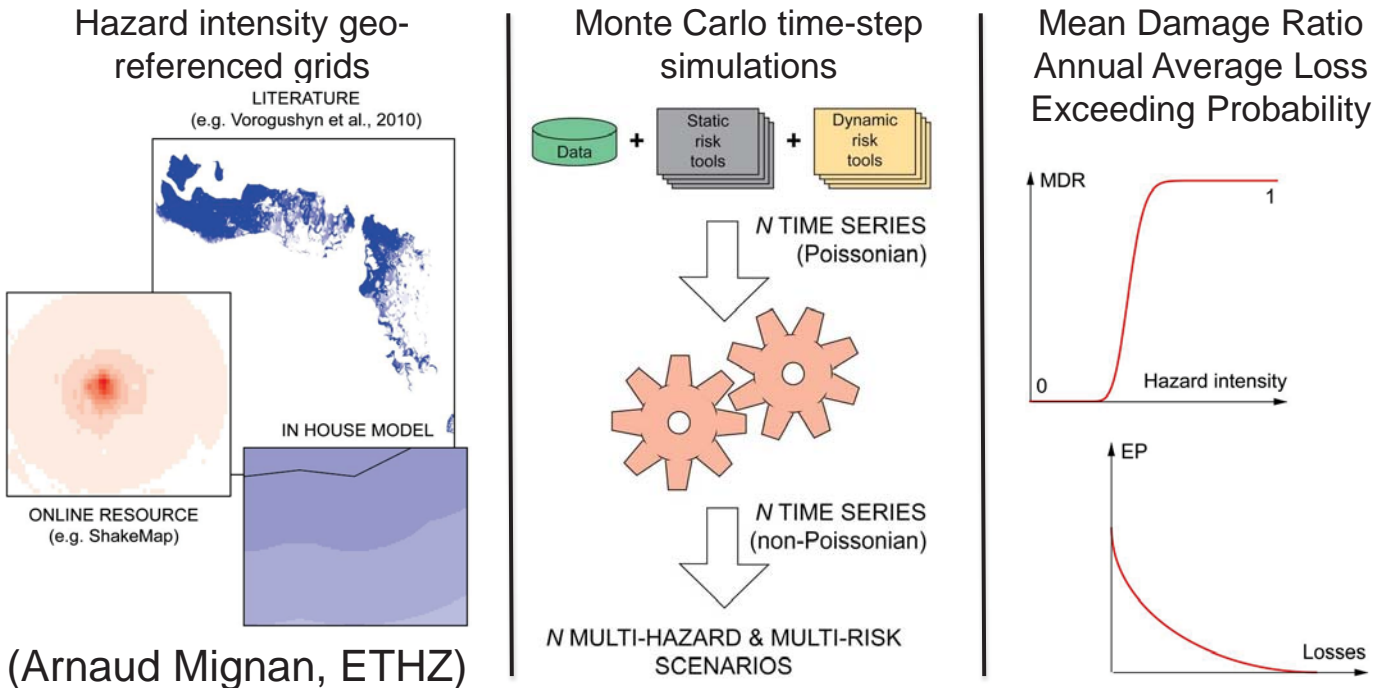
Hazard intensity geo-referenced grids

Monte Carlo time-step simulations

Mean Damage Ratio Annual Average Loss Exceeding Probability

LITERATURE (e.g. Vorogushyn et al., 2010)

ONLINE RESOURCE (e.g. ShakeMap)

IN HOUSE MODEL

Data + Static risk tools + Dynamic risk tools

N TIME SERIES (Poissonian)

N TIME SERIES (non-Poissonian)

N MULTI-HAZARD & MULTI-RISK SCENARIOS

(Arnaud Mignan, ETHZ)

"MATRIX-CITY" IT Platform

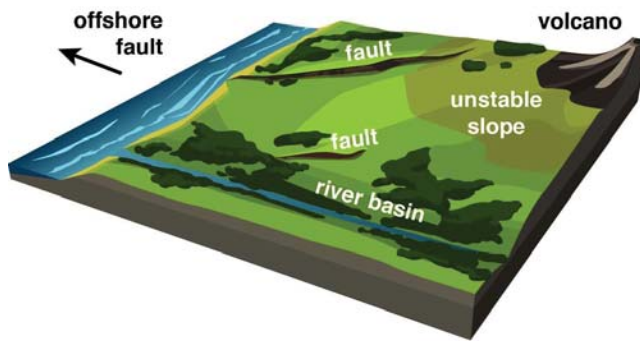MULTI-HAZARD + MULTI-RISK = DYNAMIC RISK FRAMEWORK

1. **Event interactions, cascade effects**
2. **Time-dependent exposure** (related to clustering of events)
3. **Time-dependent vulnerability** (related to clustering of events)

Increase of vulnerability to shaking due to occurrence of successive earthquakes

Increase of vulnerability to shaking due to volcanic ash load

(Arnaud Mignan, ETHZ)

"Virtual City"

*Concept of "**Virtual City**": From abstract concepts to a simplified reality*
- Playground for multi-risk testing
- Controlled environment
- Blueprint for site-specific analyses

Examples of perils considered
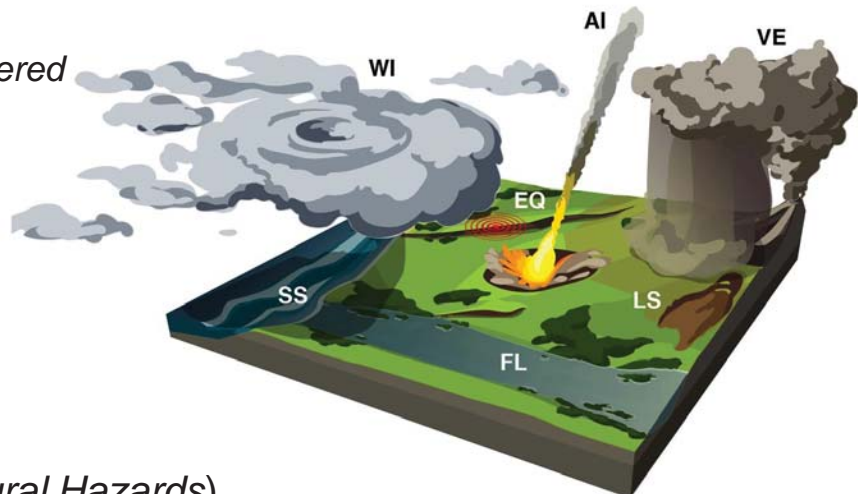AI: Asteroid impact
EQ: Earthquake
FL: Fluvial flood
LS: Landslide
SS: Sea submersion
VE: Volcanic eruption
WI: Wind

(Mignan et al., 2014, *Natural Hazards*)

Some "long way to go" statements

- <u>Terminology</u> is still something of an issue.
  e.g., do all experts use the "same language".

- <u>Question of uncertainties</u> are still unresolved.

  o How to deal with them technically/scientifically?

  o How to communicate them <u>not only to professionals</u> but to the <u>broader community</u>.

  o How could uncertainties influence decision making?

  o Is there willingness to spend money to reduce uncertainty? (<u>cost effectiveness</u> of acquiring additional information)

- Multi-hazard and risk assessment is very difficult BUT I believe we have <u>no choice, but to eventually adopt such a approach</u> to properly deal with the complexities of hazards and risks.
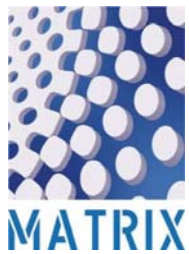
MATRIX was supported by the European Union's Seventh Framework Program (FP7).

MATRIX began on 1.10.2010, and ran until 31.12.2013.

MATRIX website

http://matrix.gpi.kit.edu/

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GFZ German Research Centre for Geosciences