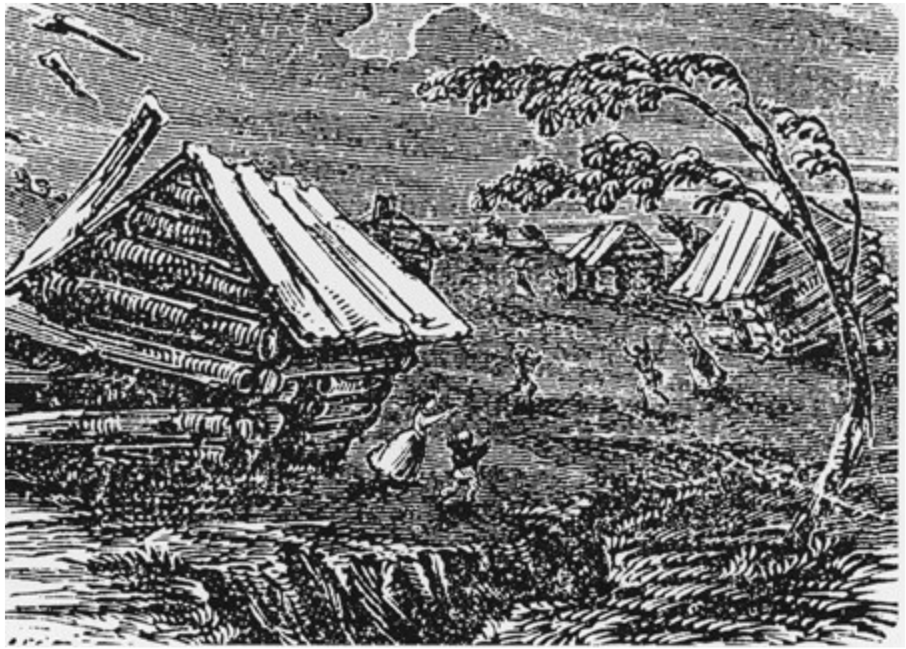
Cascade effects triggered by natural disasters

Fabio.Castelli@unifi.it



The 1811-12 New-Madrid earthquakes and the failure of Mississipi banks
(Devens, woodcut, 1877)

The most recent: the eruption of the volcano Eyjafjallajökull , the Tōhoku earthquake of 2011, Hurricane Sandy

Multi-hazard vs. Cascade Effects

Multi-hazard events are commonly perceived as 'very-low' probability threats

Cascade Effects (even when triggered by a single hazard) are 'huge-consequence' when Critical Infrastructures are disrupted

Exposure to Cascade Effects is then a likely disruption of Resilience

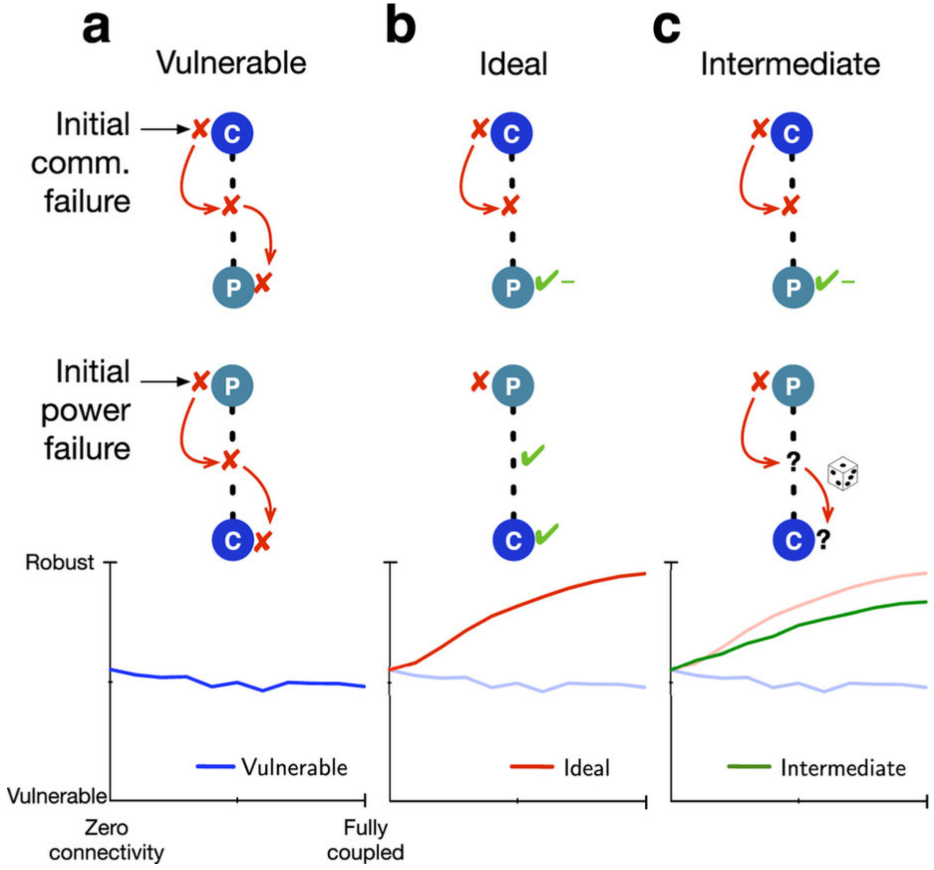
By definition, **Critical Infrastructure** may amplify both Asset and Vulnerability risk factors

Risk from Cascade Effects is expected to grow with:

- increased dependency on critical infrastructure (i.e. increase of criticality)
- increased (or unexpected) vulnerability of critical infrastructure

Risk from Cascade Effects cannot predicted with the traditional 'decomposition'* approach

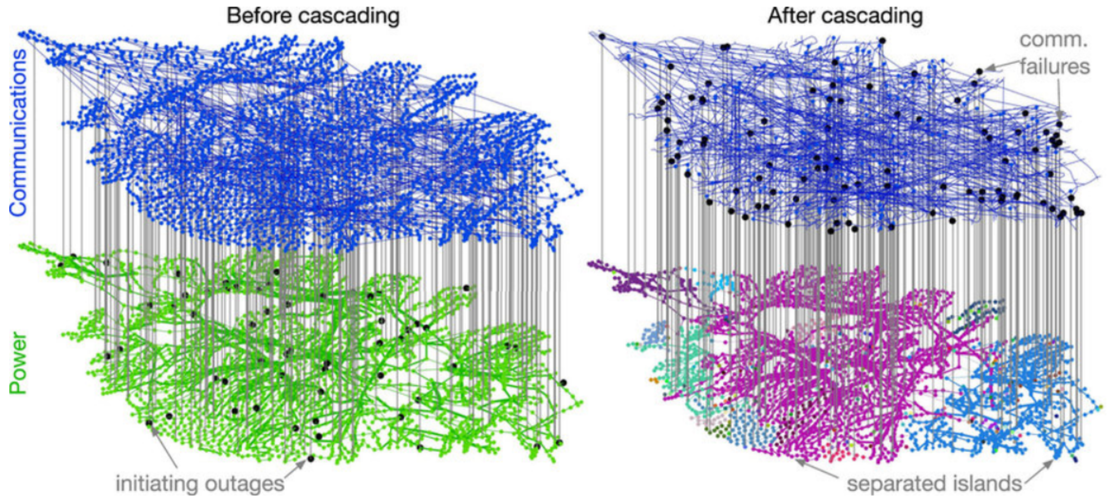
*(Hazard-Exposure-Vulnerability multiplication through simple maps overlay)



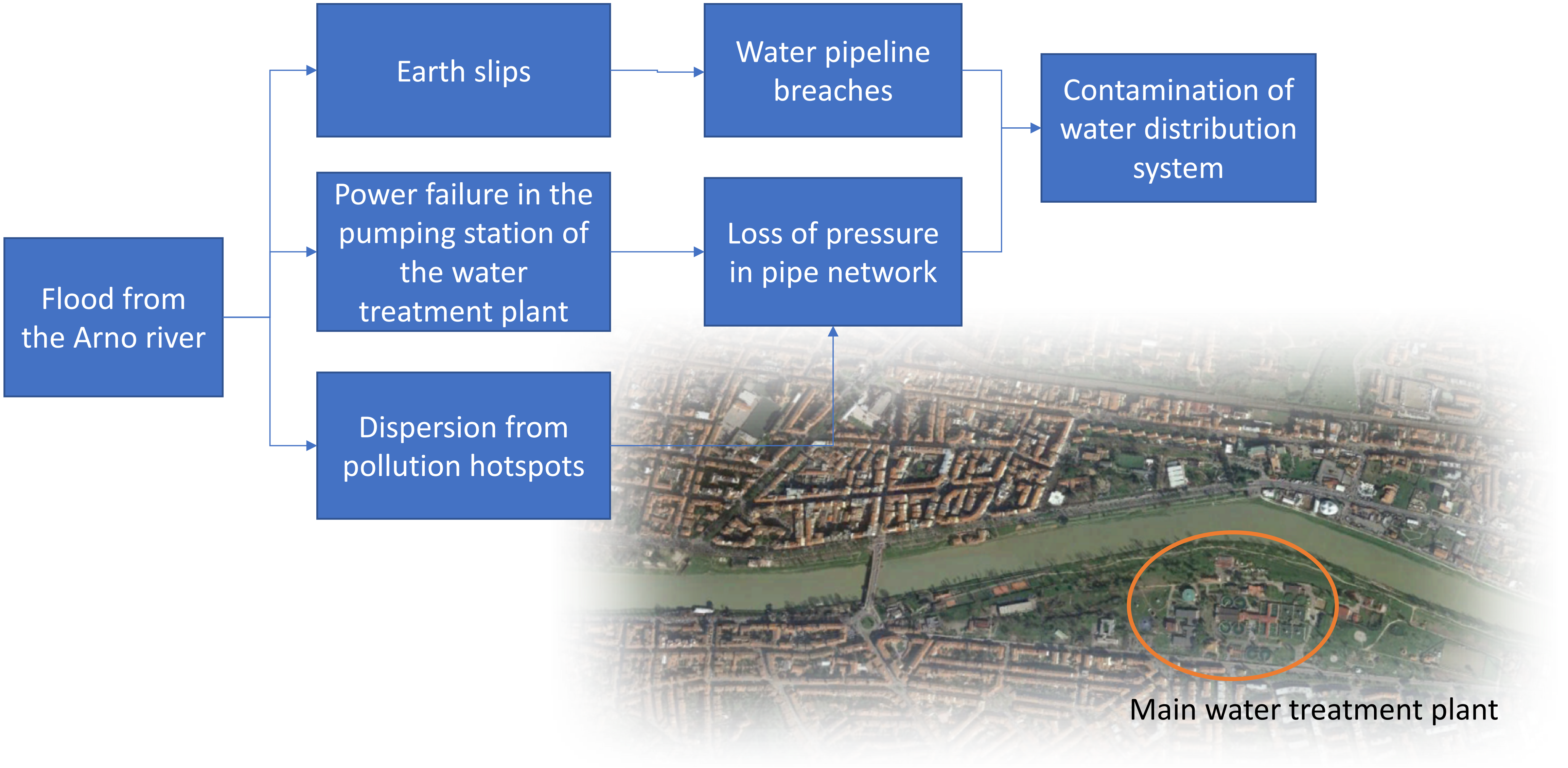
Korkali et al., 2017, Nature

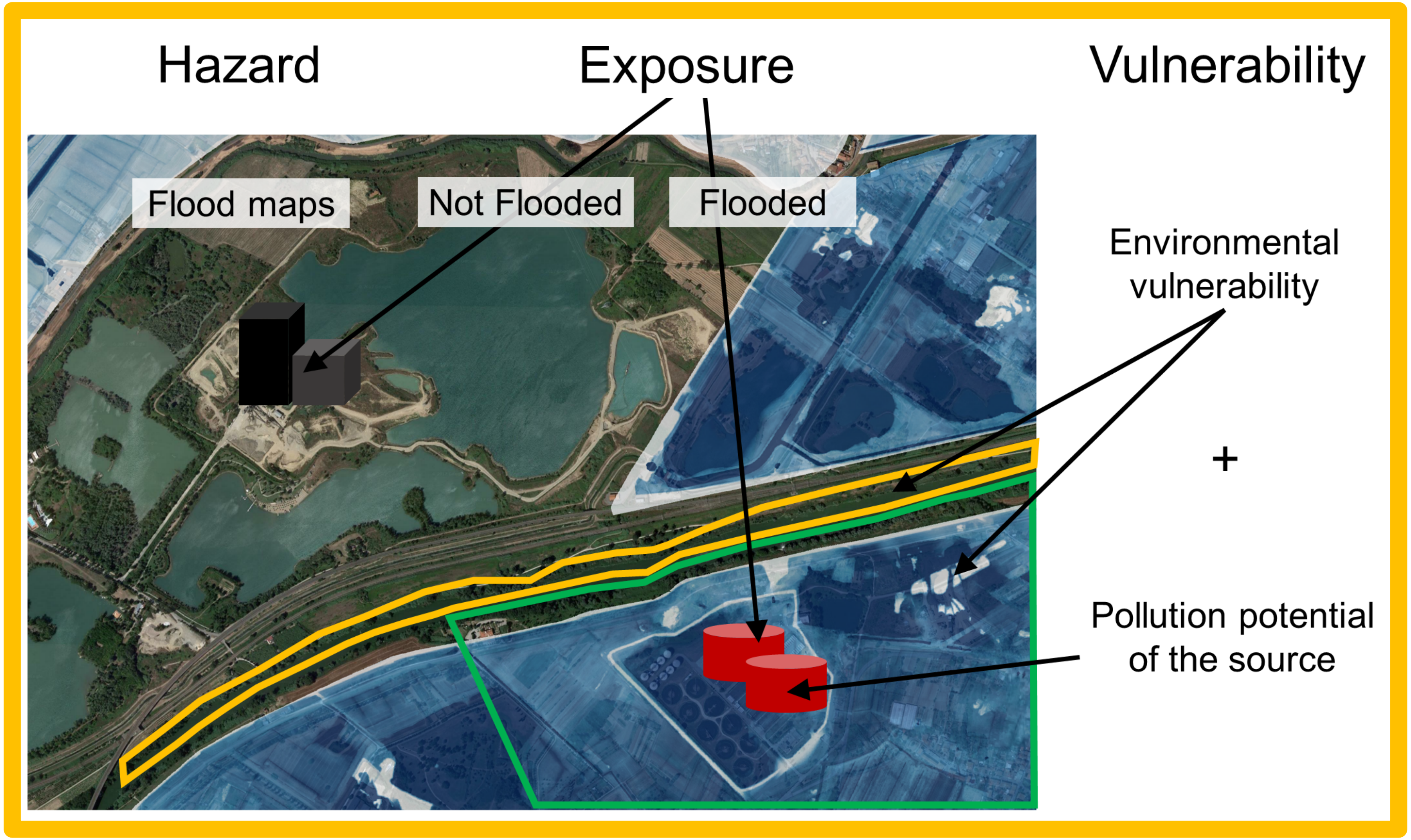
Shift of paradigm in risk prediction/assessment:

From scenarios based on hazard
(and what it may affect)
to scenarios based on failure
escalation from critical nodes
(and what are they vulnerable to)



Example of cascade (City of Firenze): flood hazard and urban water supply



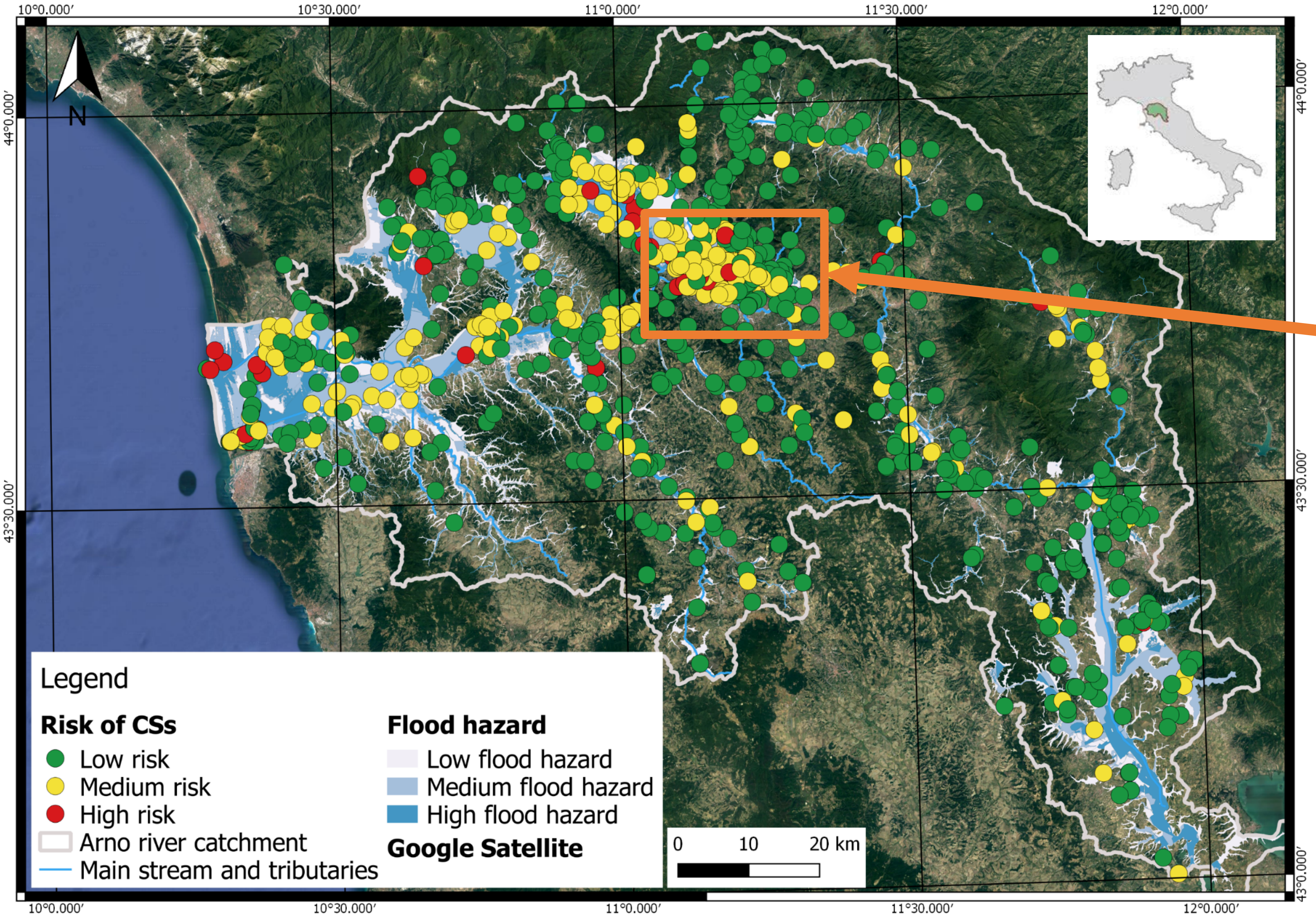


The potential spread of pollutants due to **floods** is an aspect that has been rarely examined with a risk-based approach. The aim is to estimate potential pollution risks related to flood events affecting **environmental pollution hotspots (EPHs).**

Risk is defined as the combination of:

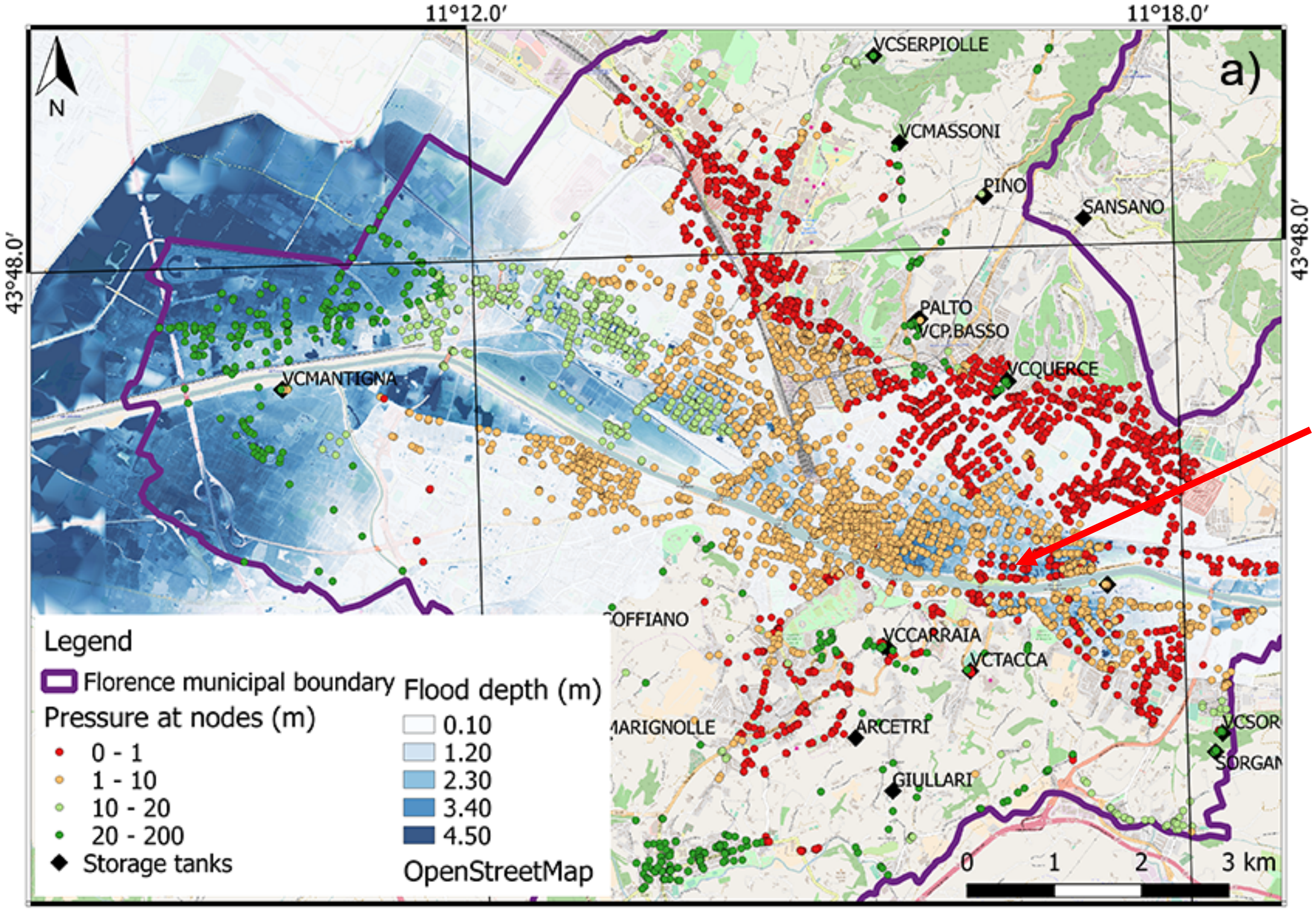
1. **Flood hazard**
2. **Exposure of EPHs**
3. **Pollution potential + environmental susceptibility**

Example: Contaminated sites (CSs) at risk



Firenze urban district

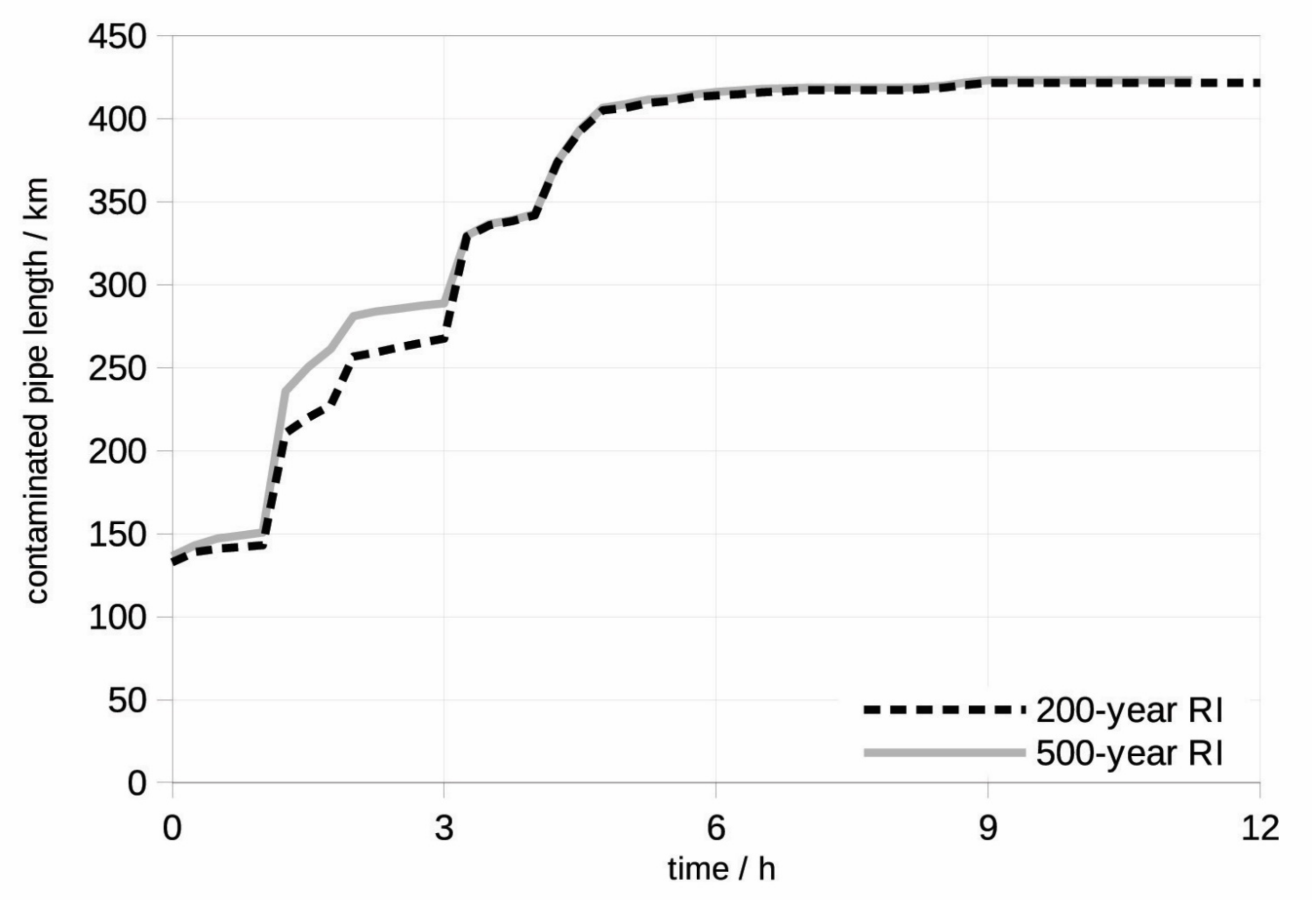
Arrighi, Masi, Iannelli: Flood risk assessment of Environmental Pollution Hotspots

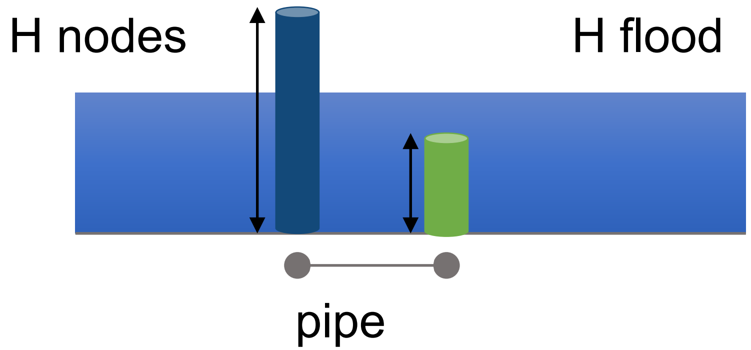


Arrighi, Tarani, Vicario and Castelli: Flood Impacts on a Water Distribution Network

Pressure distribution in the water supply network in case of power failure at main pumping station (likely in case of flooding)

0-pressure nodes in flooded areas, potential contaminant intrusion





Contamination risk

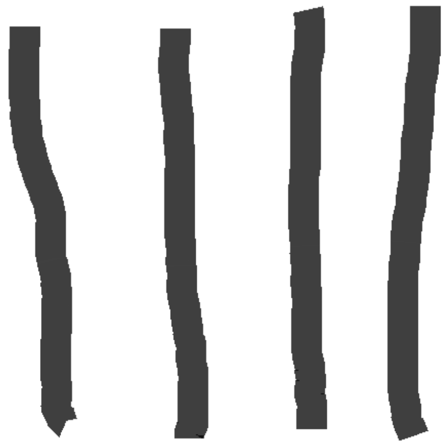
- A pipe is considered to be contaminated if <u>at any point in time the head inside the pipe is lower than the flood water</u> head outside or below zero)

BELMONT FORUM

Scoping meeting CRA

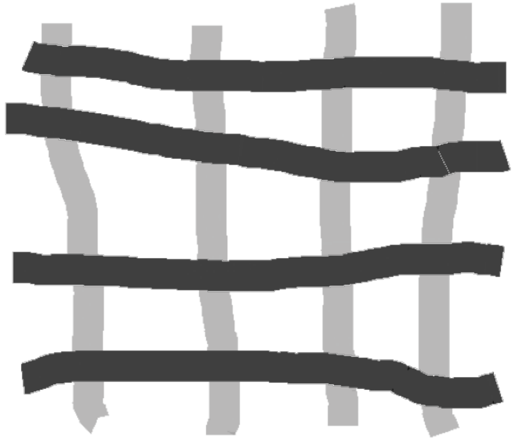
'Disaster Risk, Reduction and Resilience – DR^3'

Assessing the Current Landscape 1:
scientific advances in the identification and assessment of disaster risk

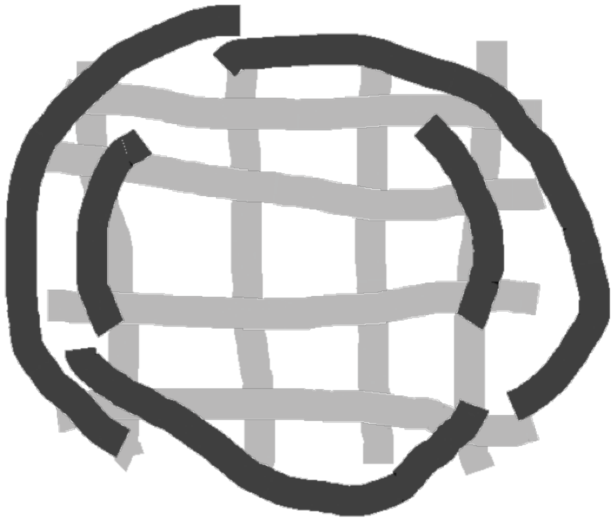


Verticals:

- Advancements in prediction capabilities
  - *Bayesian approaches based on precursors (e.g. earthquake, floods)*
- Climate change and extreme events
  - *… the very extreme ones*



Horizontals:
- Big Data Analytics
- Multi-hazard
  - *Simultaneous and cascading*
- Cascade effects
  - *NaTech, Critical Infrastructures*



Spinning:

- Reconciling uncertain prediction with utilitarian decision
  - *Dressing probabilistic forecast with real-time impact scenarios*
- Resilience through education
  - *Augmented reality, rare events and familiar environment*
- Measuring science impact through Sendai indicators

Belmont Forum | Scoping workshop on Disaster Risk, Reduction and Resilience | Florence | 5 June 2017

Fausto Guzzetti
Istituto di Ricerca per la Protezione Idrogeologica
Consiglio Nazionale delle Ricerche

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PREDICTION

"Prediction is very difficult, especially about the future"

Niels **Bohr**
Physicist and 1922 Nobel laureate

Which hazard?

sinkhole hail lightning subsidence

hurricane

meteorite impact avalanche tsunamis lahar

flood erosion earthquake snow

drought

liquefaction forest fire landslide rainfall

frost flash flood

glacial lake outburst flood

volcanic eruption freak wave

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- **Keywords**
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Words

Disaster, Risk, Resilience.

Hazard, Vulnerability.

Prediction.

PREDICTION

Prediction [noun]

/prɪˈdɪkʃ(ə)n/

A **thing predicted**; a **forecast**.

The **action of predicting** something.

https://en.oxforddictionaries.com/definition/**prediction**

TO PREDICT

Predict [verb]

/prɪˈdɪkt/

Say or **estimate** that a specified thing will happen in the **future**, or will be a consequence of something.

from the Latin verb **praedicere**,
prae- [**beforehand**] + dicere [**say**]

https://en.oxforddictionaries.com/definition/**predict**

Forecast

Forecast [noun]

/ˈfɔːkɑːst/

A **calculation** or **estimate** of **future events**, especially coming weather or a financial trend.

https://en.oxforddictionaries.com/definition/**forecast**

TO FORECAST

Forecast [verb]

/ˈfɔːkɑːst/

Predict or **estimate** a future event or trend.

https://en.oxforddictionaries.com/definition/**forecast**

PREDICT VS. FORECAST

In some **discipline**, a difference exists between **prediction** [to predict] and **forecast** [to forecast].

LINGUISTICS

In some **language** [e.g., **Italian**], a single word exists for **prediction** and **forecast**.

Language **determines** or **influences** our thoughts and decisions.

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ANTICIPATION OF FUTURE EVENTS

"The most direct … problem which our conscious knowledge of nature should enable us to solve is the **anticipation of future events**, so that we may **arrange our present affairs in accordance with such anticipation**."

Heinrich Rudolf **Hertz**, Physicist

ANTICIPATION OF FUTURE EVENTS

“As the basis for the solution of this problem we always **make use** of our **knowledge of events which have already occurred**, obtained by chance observation of by pre-arranged experiment.”

Heinrich Rudolf **Hertz**, Physicist

Uniformitarianism

Geological phenomena that operate today have operated, with the same intensity, in the past.

The **present** is the key to the **past**.

The **past** is the key to the **future**.

James **Hutton**, Geologist

PREDICTING PHENOMENA

Phenomena characterized by **high predictability**, and **low randomness**.

Phenomena characterized by **low predictability**, and **high randomness**.

Nassim Nicholas **Taleb** (2004)

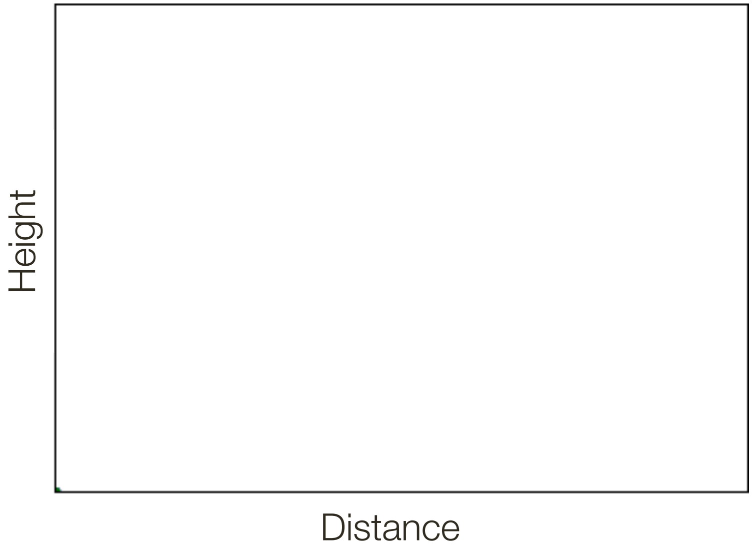
PREDICTING (NATURAL) PHENOMENA

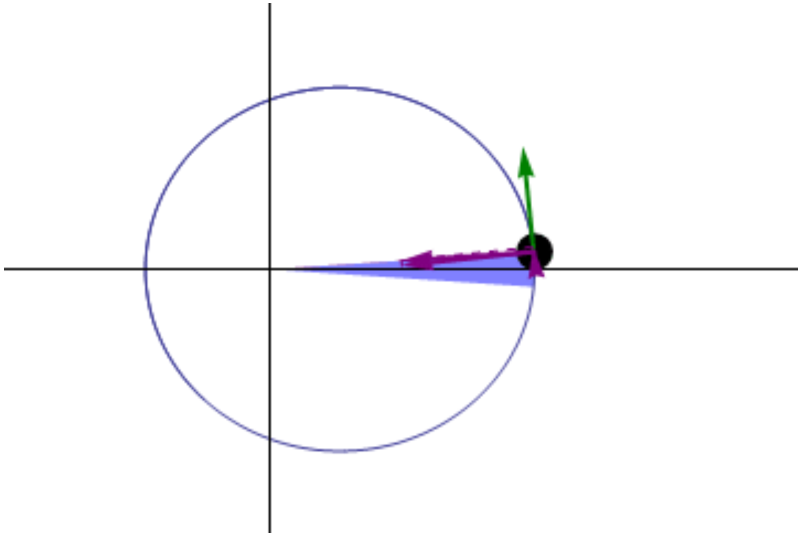
Prediction of **low randomness** (natural) **phenomena** can be based on the **analysis** of **past events**.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

T, period
L, length
g, gravitational acceleration

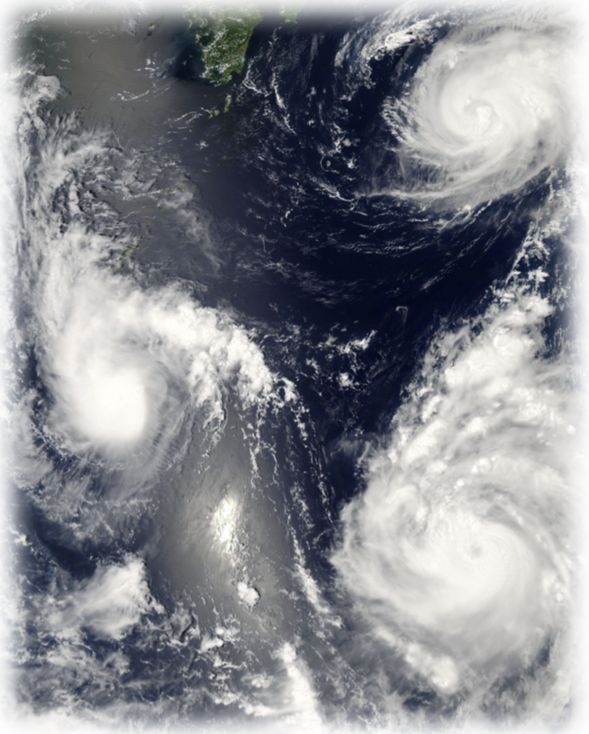
PREDICTING (NATURAL) PHENOMENA





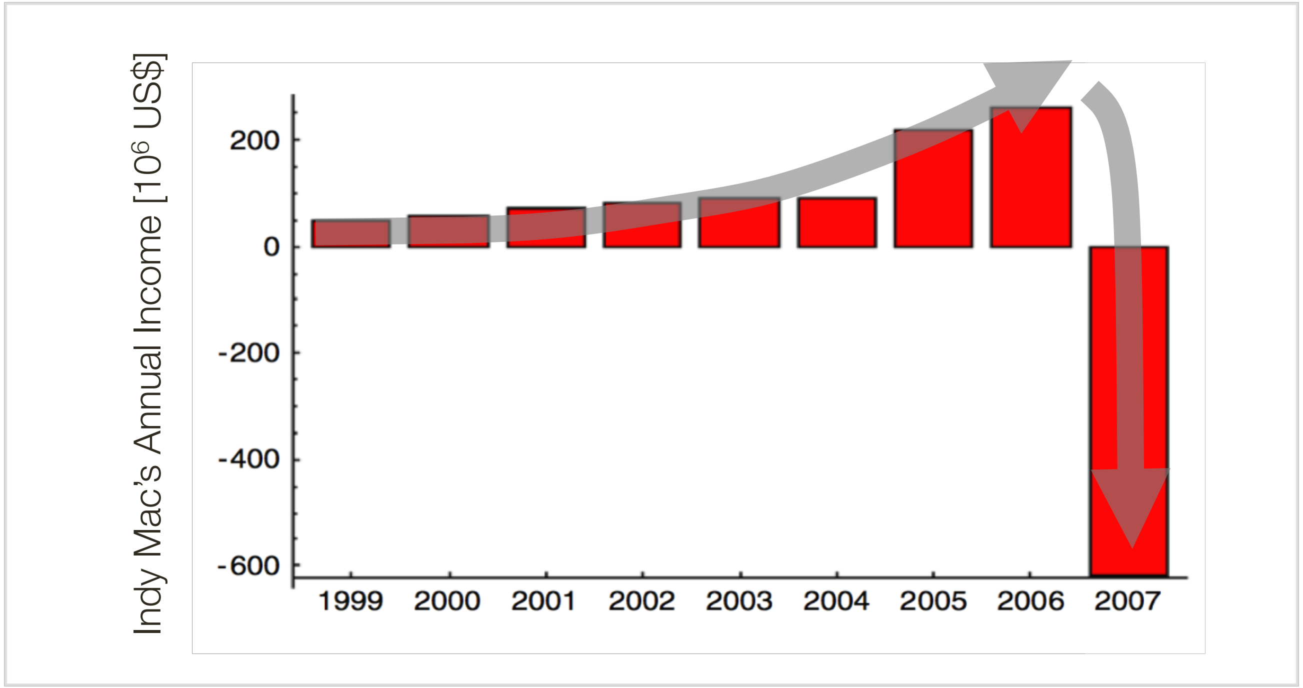
PREDICTING (NATURAL) PHENOMENA

For phenomena characterized by **high randomness**, **prediction** can be **misled** by the analysis of **past events**.



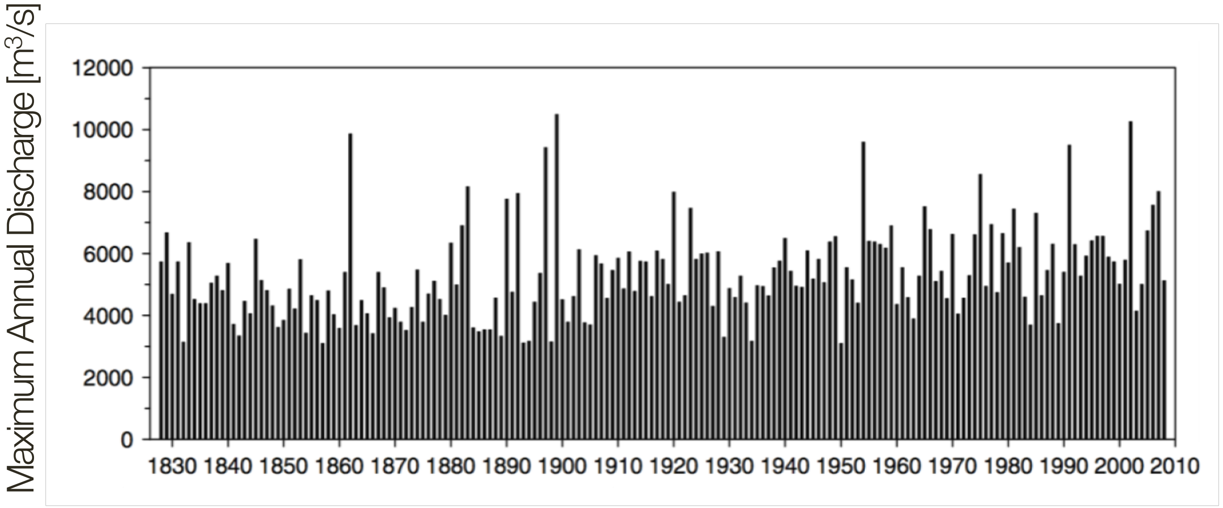
By: Jeff **Schmaltz**, NASA

PREDICTING (ECONOMIC) PHENOMENA



Nassim Nicholas **Taleb** (2004)

PREDICTING (NATURAL) PHENOMENA



Danube River, Vienna, 1828 – 2008

Günter **Blöschl** & Alberto **Montanari** (2010)

PAST AS KEY TO FUTURE?

Present-day measures and observations [...] may **add uncertainty** in the **prediction** of future trends.

Earth-Science Reviews 142 (2015) 38–46

Contents lists available at ScienceDirect

Earth-Science Reviews

journal homepage: www.elsevier.com/locate/earscirev

Is the present the key to the future?

Stefano Furlani [a,*], Andrea Ninfo [b]

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ARTICLE INFO

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Epistemology
Climate change
Forecasting
Predictions
Uncertainty

ABSTRACT

The empirical and conceptual relationships between Earth surface processes and global changes are very complex. The concept that "the present is the key of the future" implies that we know enough the present to be able to extend our knowledge forward to focus on the future. Field and remote observations on the present-day Earth surface processes represent the methodological instruments for the forecasting. At the end of the 1980s, the scientific community predicted a significant increase of global warming followed by changes in the trends of related surface processes. Some processes, such as the Arctic and Antarctic snow melting are now accelerating and even irreversible; thus these trends show that we are now in an 'out of scale' discontinuity moment. Present-day measures and observations could be scarcely significant and may add uncertainty in the prediction of future trends. The 'out-of-scale' trend raises a fundamental question regarding the present, since it may provide a new angle of thought for contemporary theoretical approaches. The need for reducing the uncertainty in the trends of future processes requires a deep rethinking of the current paradigms in order to consider also the 'out of scale' trends.

Contents

1. Introduction

The relationship between Earth's surface processes and global changes resulting from climatic fluctuations, tectonics and human impact's represents one of the most interesting aims of earth scientists (Rice and Macklin, 2008; Commitee on Challenges and Opportunities in Earth Surface Processes, 2010). Human-driven changes, in particular, are increasing the overall impact on the Earth System, which currently seems operating in a no-analogue state. This means that it is moving outside the range of 'natural variability' and works in different modes from previous geologic time periods (Kerr, 2013). 'Natural variability' refers to data recorded at least in the recent and better known geological past (Slaymaker, 2009). The proxy records vary from a few decades for instrumental observations up to several hundreds of thousands of years for some proxies, such as the amount of CO_2 in the atmosphere

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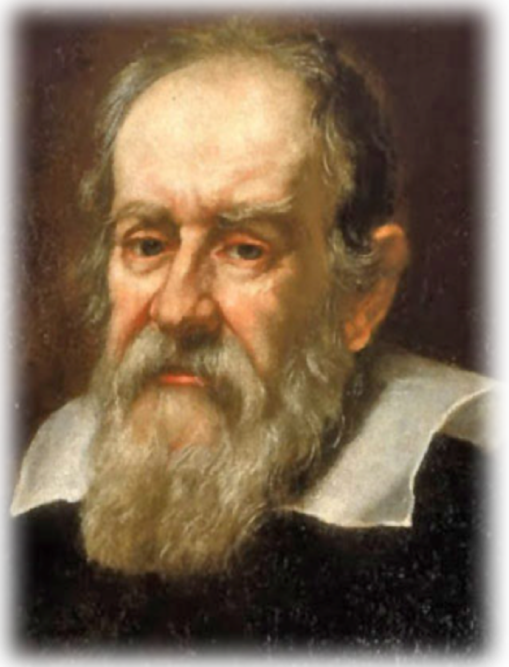
0012-8252/© 2014 Elsevier B.V. All rights reserved.

Stefano **Furlani** & Andrea **Ninfo** (2015)

NOTHING NEW

"It is easier to study the motion of infinitely distant celestial bodies than that of a stream flowing at our feet."



Galileo **Galilei**, Scientist

PREDICTING WHAT?

Where or **when** it may occur.

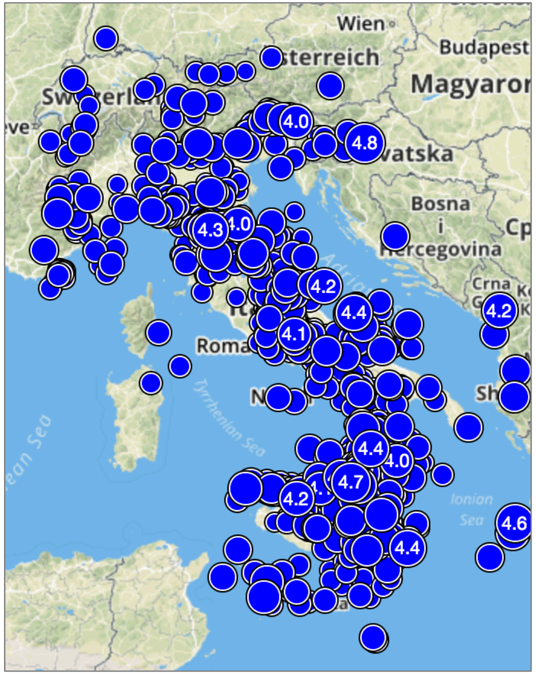
Where or **when** it will occur.

How **intense** or **destructive** it can, or will be.

PREDICTING WHAT?

Tomorrow there will be an earthquake ✓

Tomorrow there will be an earthquake in Italy ✓



1969 earthquakes in 2015 in Italy

By: National Earthquake Centre, **INGV**

PREDICTION VS. USEFUL PREDICTION

Within the next **7 days** [**when**] there will be an earthquake of **magnitude 6** or larger [**how large**], at a depth of 10 km, in **XYZ** [**where**].

This is a **useful prediction**, which we are not able to do today (unfortunately).

USEFUL TO WHOM?

Something useful to a **scientists** may not be useful to a **decision maker** or a **citizen**, and vice versa.

WHITE & BLACK SWANS?

Fausto **Guzzetti** (2007)

Nassim Nicholas **Taleb** (2004)

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Risk equation

$$R = H \times V \times E$$

$$H = M \times T \times S$$

$$\mathbf{R = M \times T \times S \times V \times E}$$

RISK EQUATION

$$\mathbf{R} = \mathbf{M} \times \mathbf{T} \times \mathbf{S} \times \mathbf{V} \times \mathbf{E}$$

$$P(\mathbf{r}) = P(\mathbf{m}) \times P(\mathbf{t}) \times P(\mathbf{s}) \times P(\mathbf{v}) \times P(\mathbf{e})$$

Is this probabilistic framework **too complex**?

Is there an **alternative framework**?

HAZARDS ARE NOT EQUAL

RISK [R]	WHERE [S]	WHEN [T]	MAGNITUDE [M]	VULNERABILITY [V]	EXPOSURE [E]
Earthquake	😀😀	😀	😀	😀😀	😀
Volcano	😀😀😀	😀😀	😀	😀😀	😀
Flood	😀😀😀	😀😀😀	😀😀	😀😀	😀😀
Landslide	😀😀	😀😀	😀	😀	😀
Tsunamis	😀😀	😀😀	😀😀	😀	😀
Drought	😀😀	😀	😀	😀😀	😀
Forest fire	😀😀	😀😀	😀	😀😀	😀

😀 poor 😀😀 sufficient 😀😀😀 good

VULNERABILITY & EXPOSURE

Not known sufficiently, for most hazards.

Change in time and space.

A QUESTION OF SCALE

Our ability to predict a hazard depends on the **scale** of the prediction.

MODEL VALIDATION & UNCERTAINTY

Very **advanced** in some communities, **poorly performed** in other communities.

Model validation is often **too optimistic**.

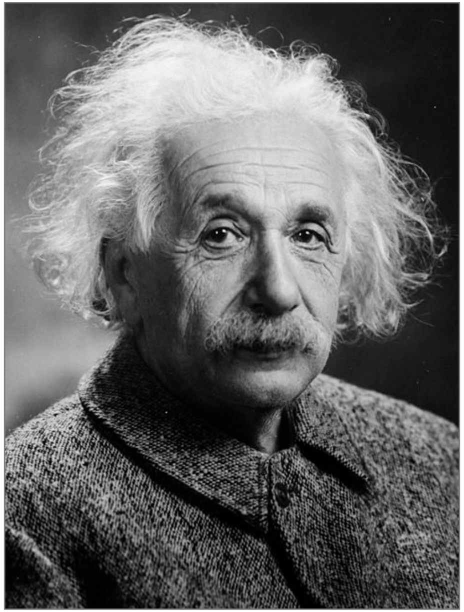
Model validation & uncertainty

Standards do not exist for all hazards / communities.

Numerical **models** are often **not open**.

Data not available for **independent** validation.

SCIENTISTS OR FORTUNE TELLERS?



Albert **Einstein**
Physicist and Nobel laureate, 1922

Tiresia
Greek fortune teller

Multiple hazards vs. hazard chains

Multiple hazards: two of more hazards in the same area, at the same time or at different times.

Hazard chain: A first hazard triggers a second hazard, that triggers a third hazard … in the same general area.

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ARE WE ON THE RIGHT TRACK?

Good ability to predict some hazard; **insufficient** ability to predict other hazards.

Better at predicting **where** than **when** or **how large** a hazard is expected.

Poor ability to predict complex (multiple, chained) events.

ARE WE ON THE RIGHT TRACK?

Is the **framework** used to ascertain the risk posed by a natural hazard **adequate** for risk reduction and to improve resilience?

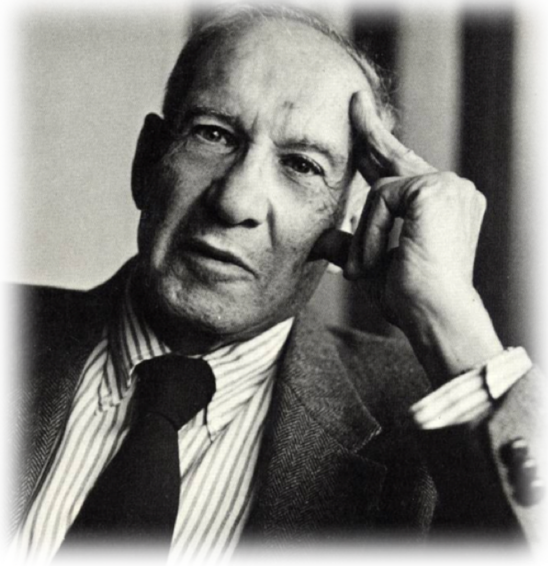
ARE WE ON THE RIGHT TRACK?

Improve risk **communication** to rise awareness.

Informed communities are **safer** and more **resilient** communities.

ON PREDICTION

"Trying to predict the future is like trying to drive down a country road at night with no lights while looking out the back window"



Peter F. **Drucker**
Economist and writer

THANK YOU!

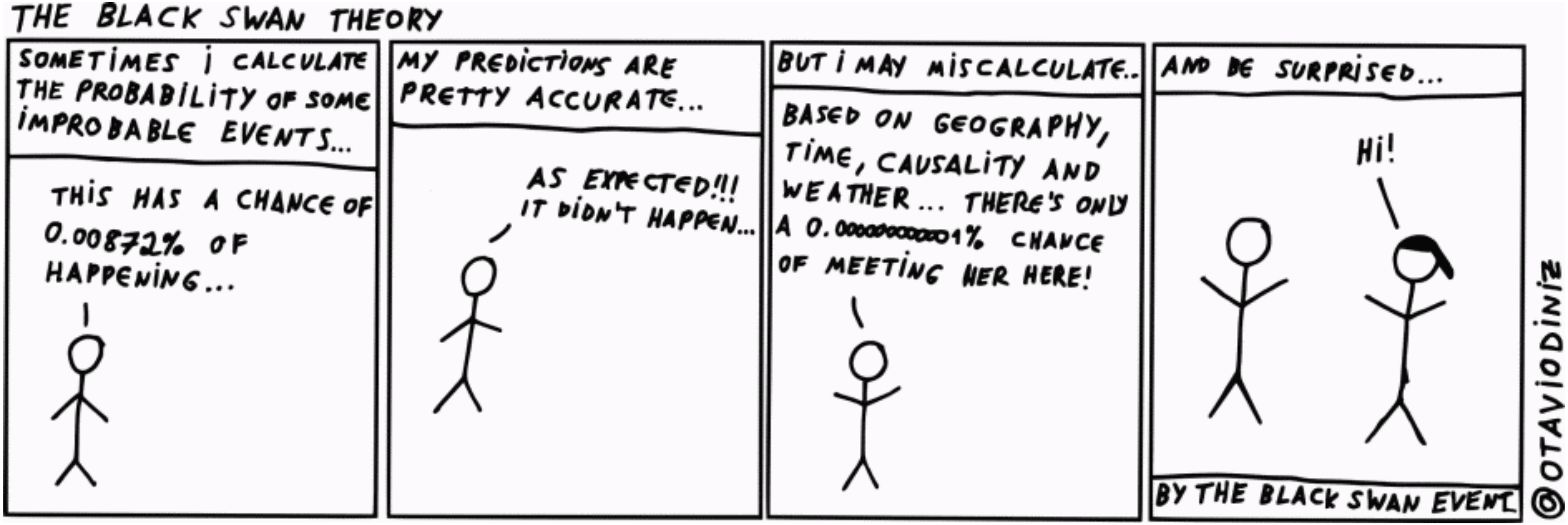
Fausto.Guzzetti@irpi.cnr.it

WORDS ARE IMPORTANT

"The pen is mightier than the sword."

Edward **Bulwer-Lytton**
English author, novelist, poet

Black swan theory



RISK EQUATION

$$\mathbf{R} = \mathbf{M} \times \mathbf{T} \times \mathbf{S} \times \mathbf{V} \times \mathbf{E}$$

Is this probabilistic framework **too complex**?

Is there an **alternative framework**?

Scoping meeting CRA

'Disaster Risk Reduction and Resilience – DR3.'

Florence 5-6-7 June 2017

E-INFRASTRUCTURE AND DATA MANAGEMENT CRA:

CALL FOR DEMONSTRATORS

Stefano Nativi

(CNR-IIA)

stefano.nativi@cnr.it

CALL ON

DEMONSTRATORS FOR ACCELERATING TRANS-NATIONAL DATA USE AND LEVERAGING BELMONT DATA PRINCIPLES IN THE CONTEXT OF INTERDISCIPLINARY GLOBAL CHANGE RESEARCH CHALLENGES.

stefano.nativi@cnr.it

OBJECTIVES

- ADDRESS WELL-IDENTIFIED, RESEARCH-DRIVEN **TECHNOLOGICAL AND ORGANISATIONAL BARRIERS**
- DELIVER AND DEMONSTRATE EXTENDED AND INCLUSIVE **FUNCTIONALITY FOR ACCELERATING THE *FULL-PATH* OF DATA USE,** FROM CAPTURE AND MANAGEMENT TO ANALYSIS, MODELING, AND PUBLICATION
- FACILITATE THE PROCESS OF OBTAINING **RESULTS FROM RESEARCH-DERIVED DATA** THAT BROADLY IMPACT RESEARCH PRACTICES AND SUPPORT DECISION- AND POLICY- MAKING

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TOPICS

- **MANAGEMENT AND STEWARDSHIP** OF MULTI-TYPE, MULTI-SCALE, AND **MULTI-DISCIPLINARY DATA**
- **FEDERATION OF DISTRIBUTED TRANS-NATIONAL DATA SOURCES** AND INTERDISCIPLINARY DATA-INTENSIVE ANALYSIS PLATFORMS IN SUPPORT OF END-TO-END ANALYSIS AND DECISION MAKING (I.E., THE SO-CALLED `GLUEWARE' COMPONENT)
- OPTIMISING STRATEGIES FOR **DATA MOVEMENT** IN END-TO-END ANALYSIS, TAKING INTO CONSIDERATION **`GREEN' APPROACHES** (E.G., MINIMISING ENERGY FOOTPRINT)
- **DATA AND MODEL INTER-COMPARISON** AND PREDICTION (DMIP) AND VALIDATION PROTOCOLS
- BRIDGING RESEARCH- AND **POLICY-DRIVEN NEEDS**
- **PERVASIVE PROVENANCE SYSTEM** IN SUPPORT OF OPEN SCIENCE DATA CREDENTIALS
- FINDABLE AND SHARABLE SOFTWARE COMPONENTS, STATISTICAL ANALYSIS AND **VISUALISATION TOOLS AND LIBRARIES**, EVENTUALLY PROVIDED AS A SERVICE TO A BROAD COMMUNITY

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MORE INFORMATION AND USEFUL LINKS

- SECRETARIAT@BFE-INF.ORG
- HTTP://WWW.BFE-INF.ORG/

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Scoping meeting CRA

'Disaster Risk Reduction and Resilience – DR3.'

Florence 5-6-7 June 2017

DATA ACCESS AND ANALYSIS

Stefano Nativi

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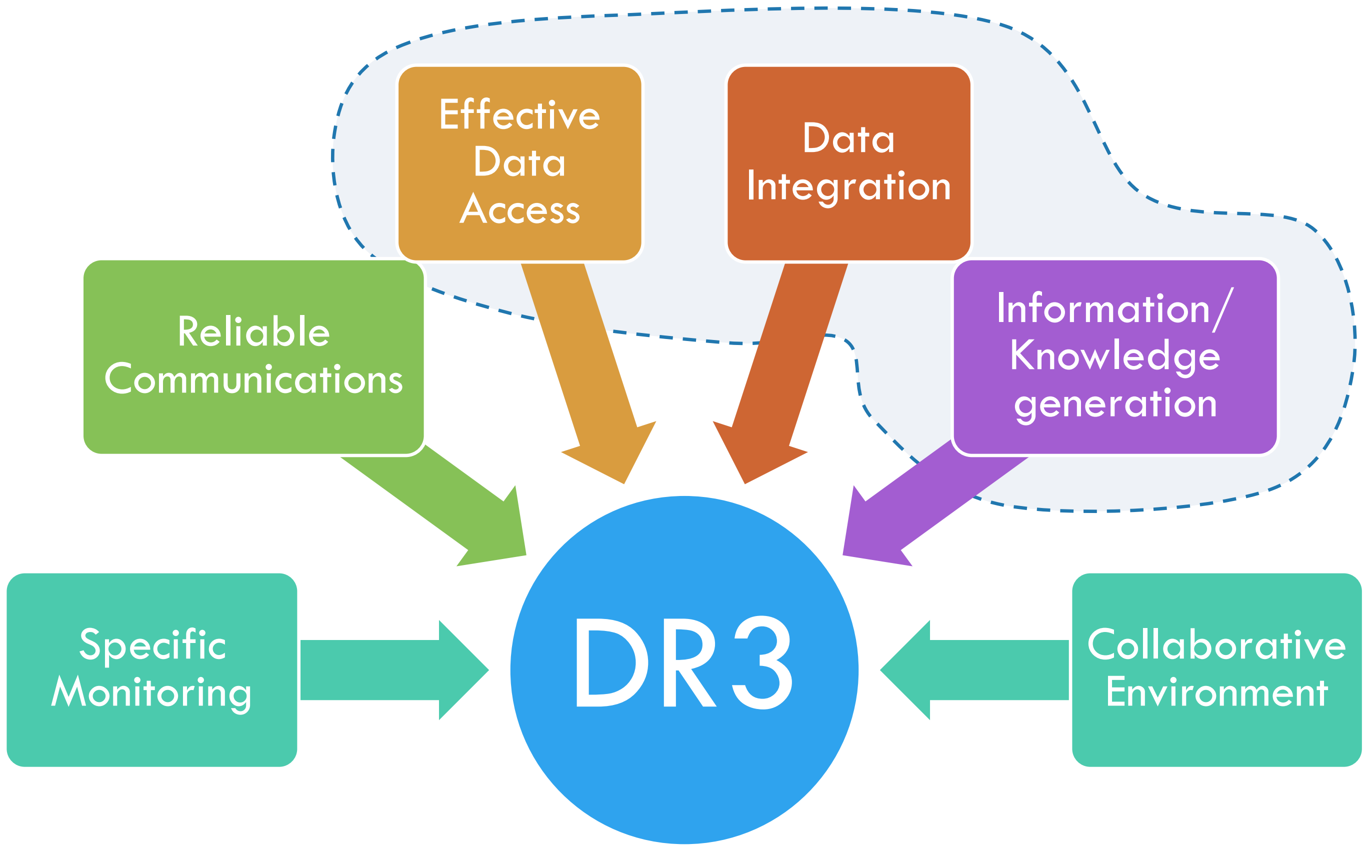
DR3 COMPLEXITY



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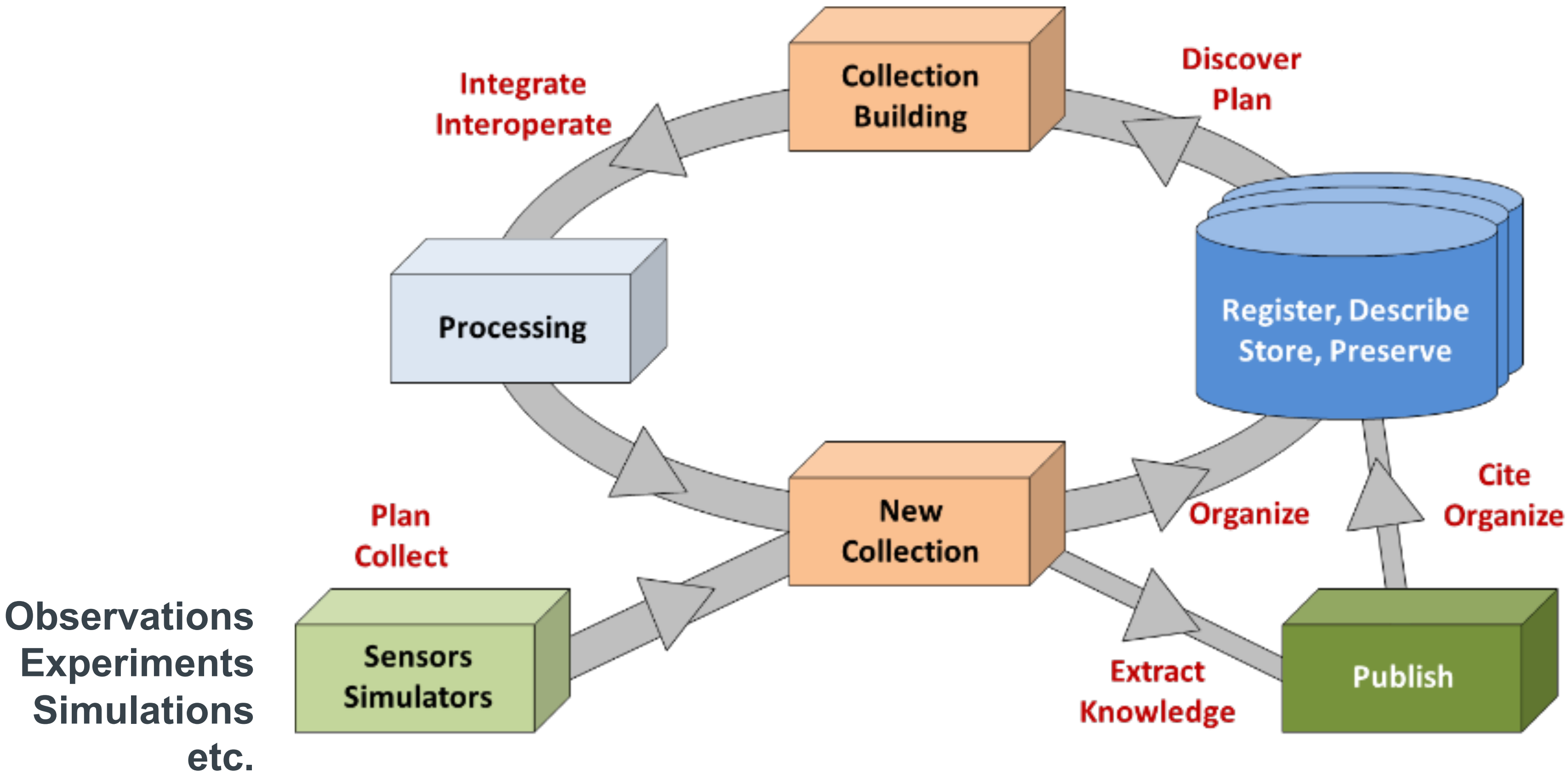
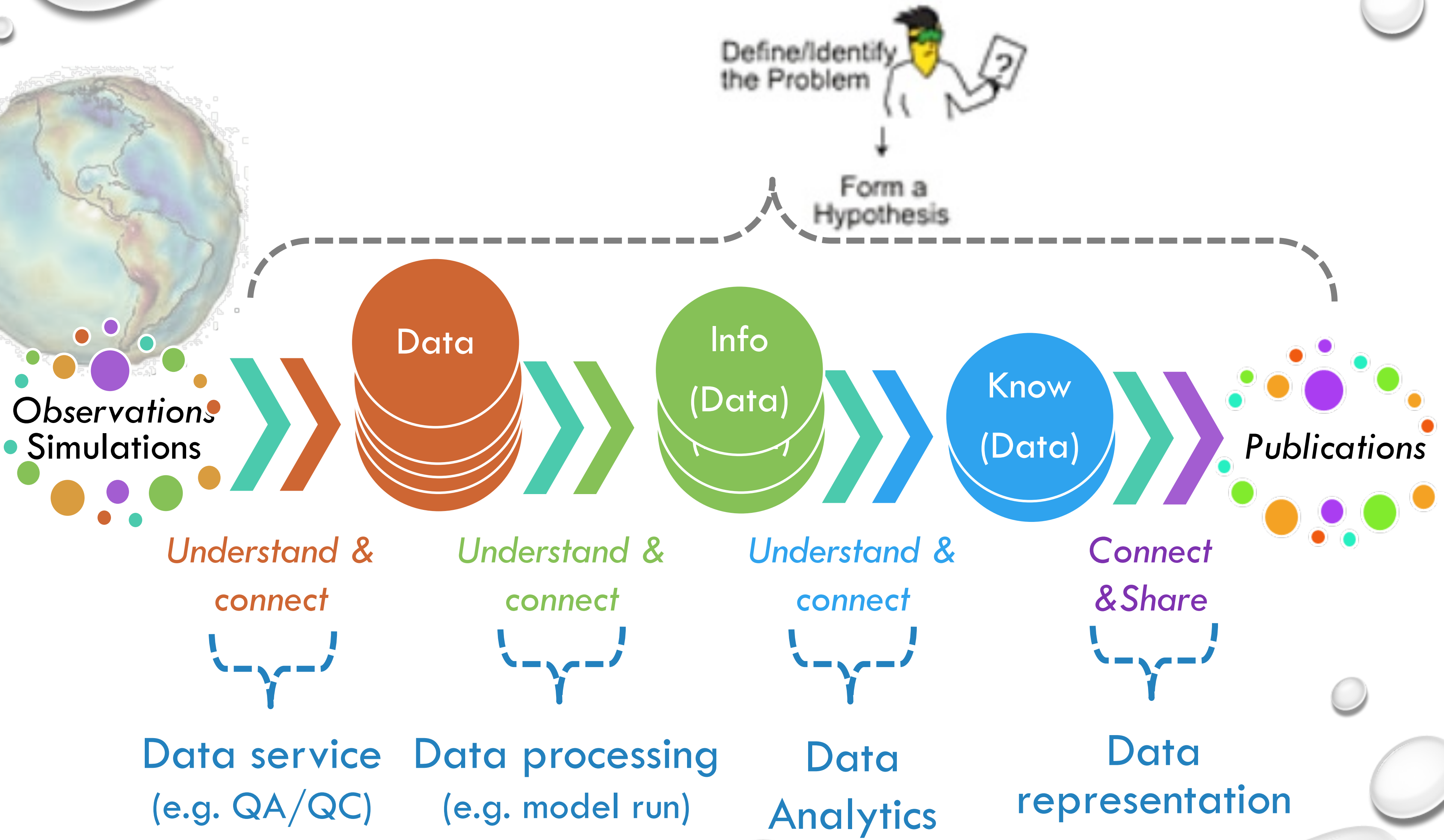
Data Fabric

[Credits: RDA DFIG]



DATA DRIVEN (EARTH) SCIENCE



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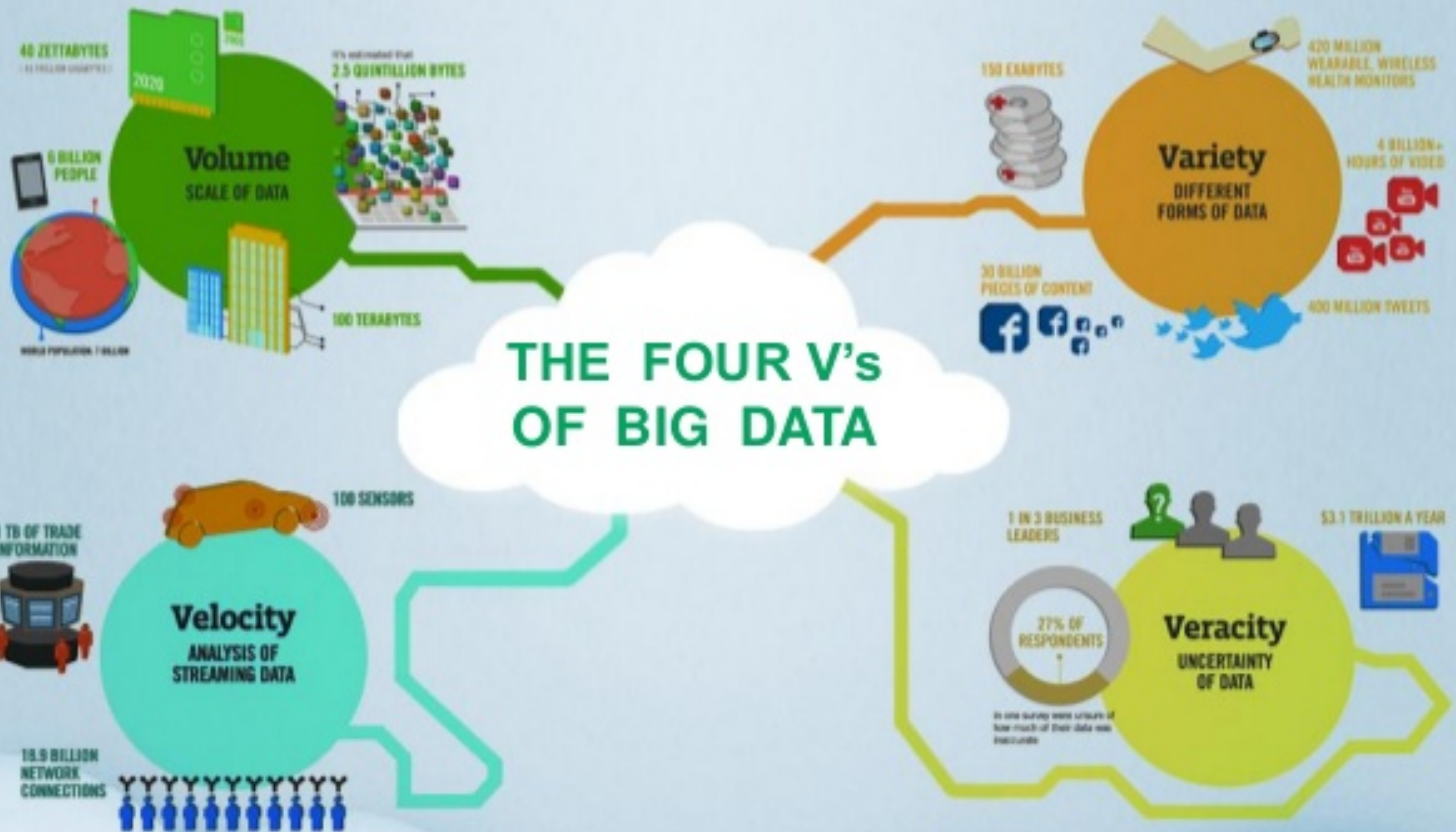
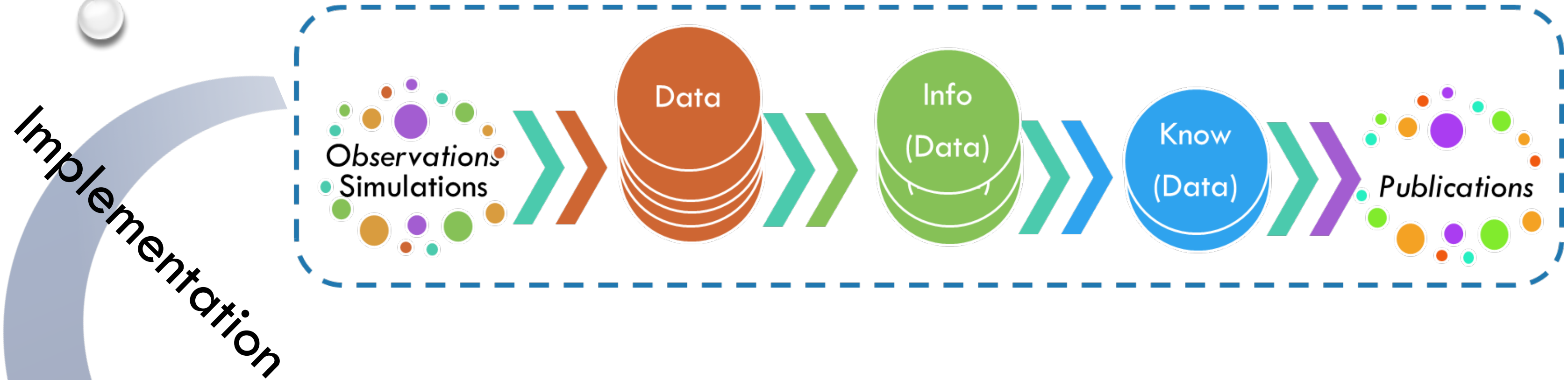
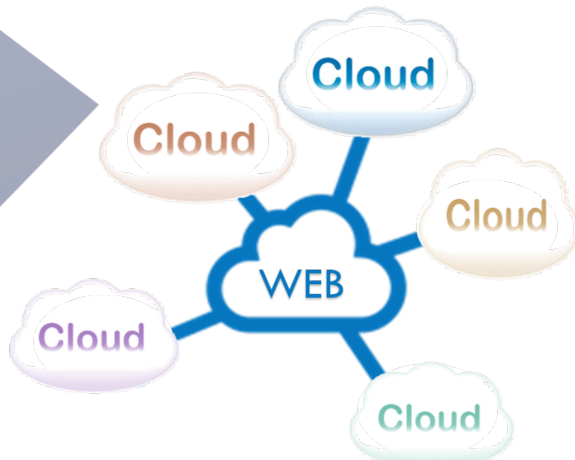
Big Data Challenges



Source: IBM

WEB-BASED CLOUD HYBRID ENVIRONMENT





- Model-as-a-Service ?
- Sensor-as-a-Service ?
- Workflow management ?
- Best interoperability architecture ?
- Infrastructure Flexibility level ?

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WEB 2.0 PATTERNS

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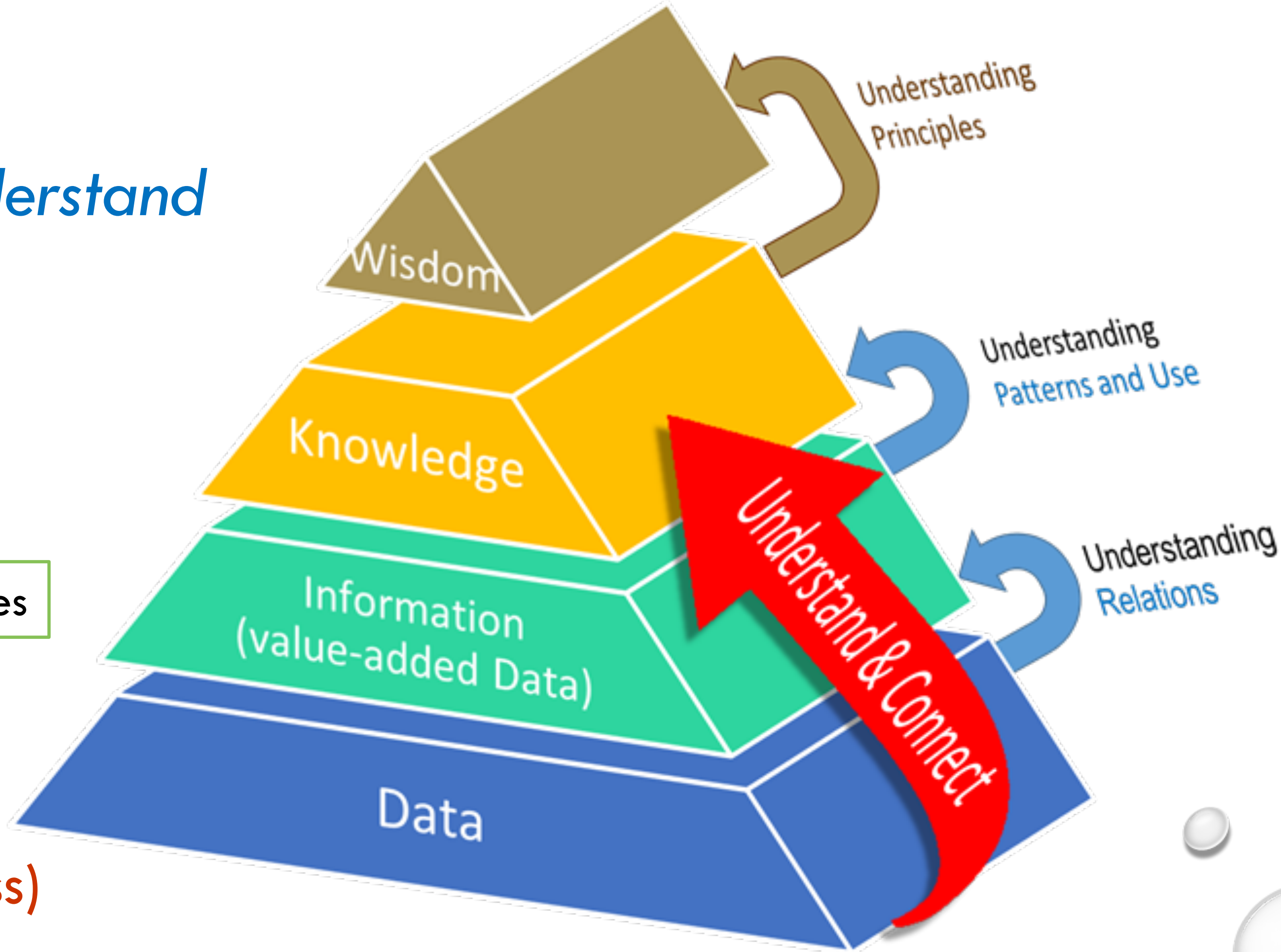
FROM DATA TO INFORMATION/KNOWLEDGE

Connect and Understand

- Principles
- Patterns
- Best Practices
- Relations



(phenomena/process)
Granularity level

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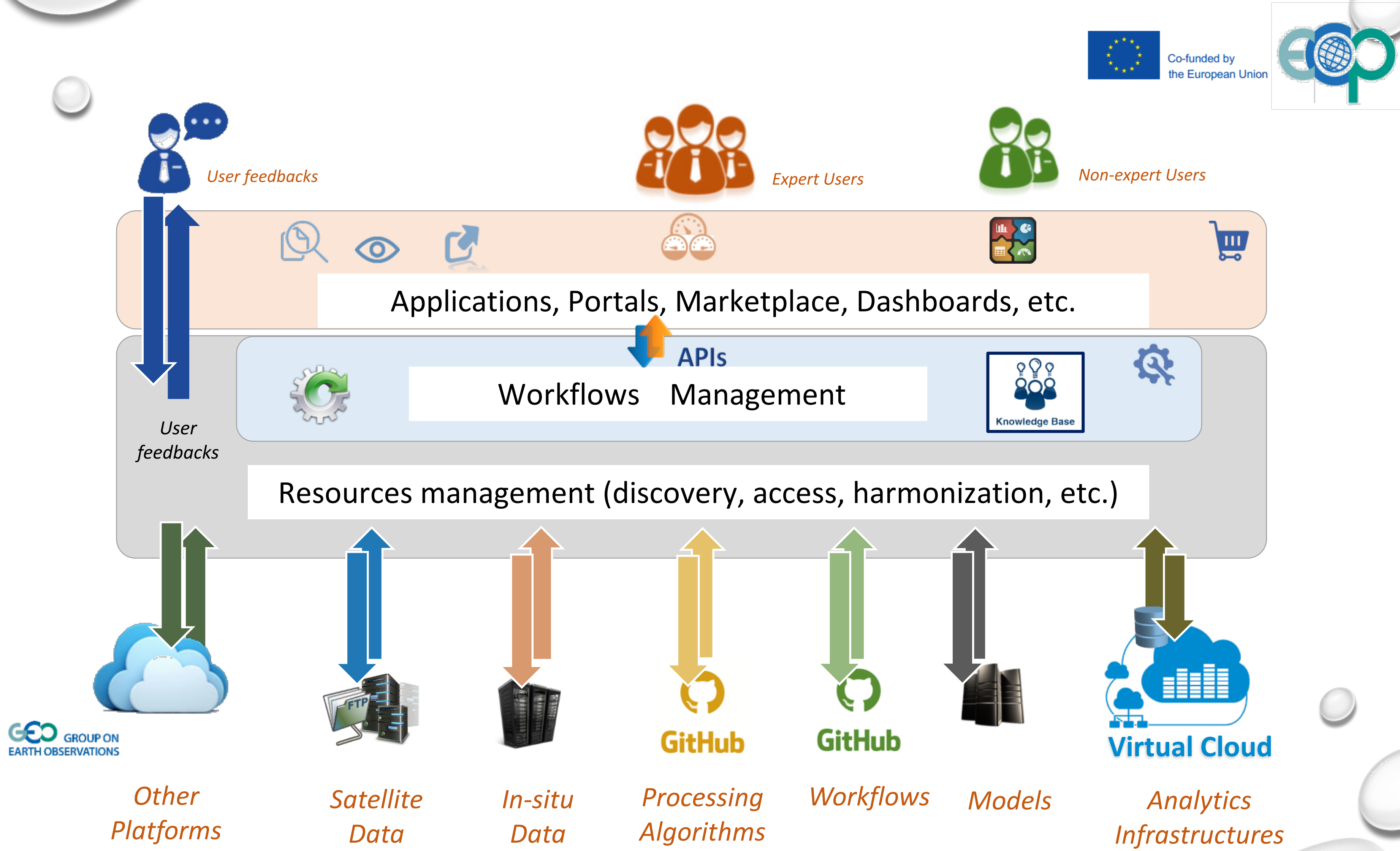
VIRTUAL LABORATORY PLATFORMS



stefano.nativi@cnr.it

Automated Data Processing
(Model-as-a-Service)

The GEO Model Web initiative

Integrated Modeling analysis

Problem statement → Conceptual Integrated Modeling Design → Integrated Modeling Execution → Analysis of the Result

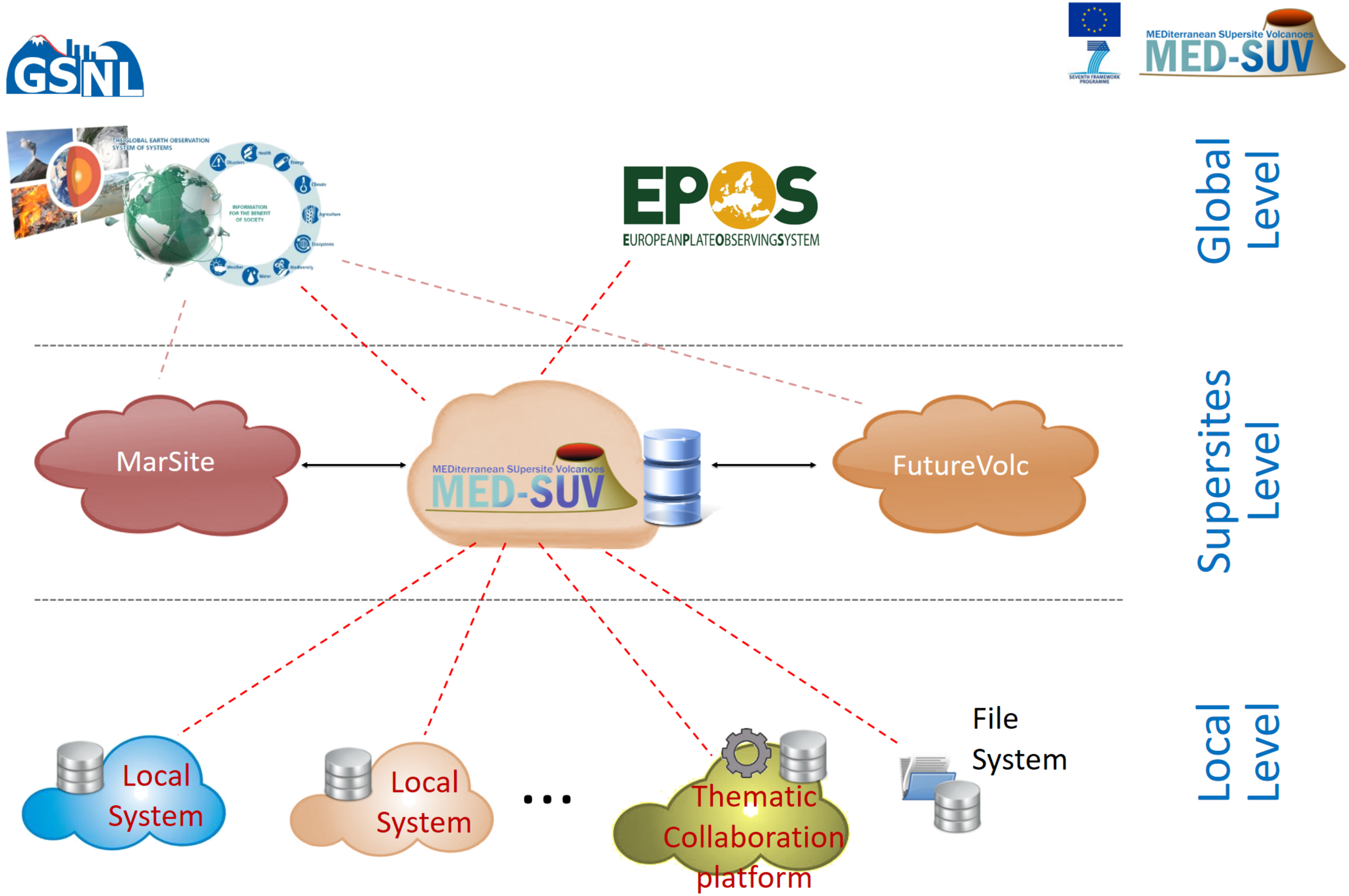
Scientist

IT Professional

Business Process design

Workflow execution

REGIONAL & GLOBAL SYSTEM-OF-SYSTEMS



THANK YOU !

STEFANO.NATIVI@CNR.IT

Scattered thoughts on

Disaster Risk, Reduction and Resilience

Antonello Provenzale, CNR IGG

Need for data:

What data, what metadata,

how to store, retrieve and distribute them

What do we do with the data:

Data analysis methods

Estimates of uncertainty

Conceptual frameworks

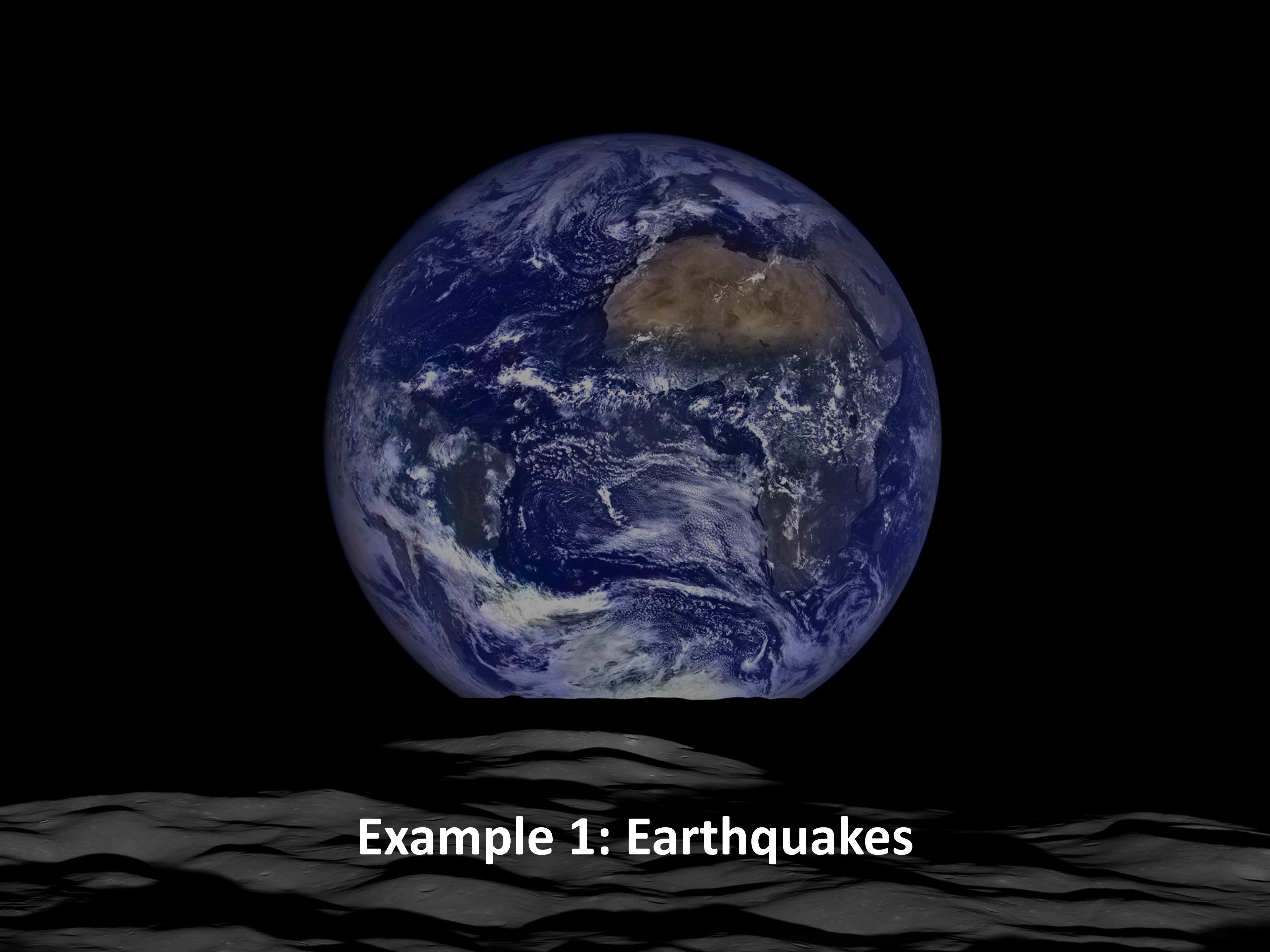
Data analysis methods and prediction

Statistical analysis (correlations)

Empirical models of correlation links

Statistics of extreme events (fat tails and power laws)

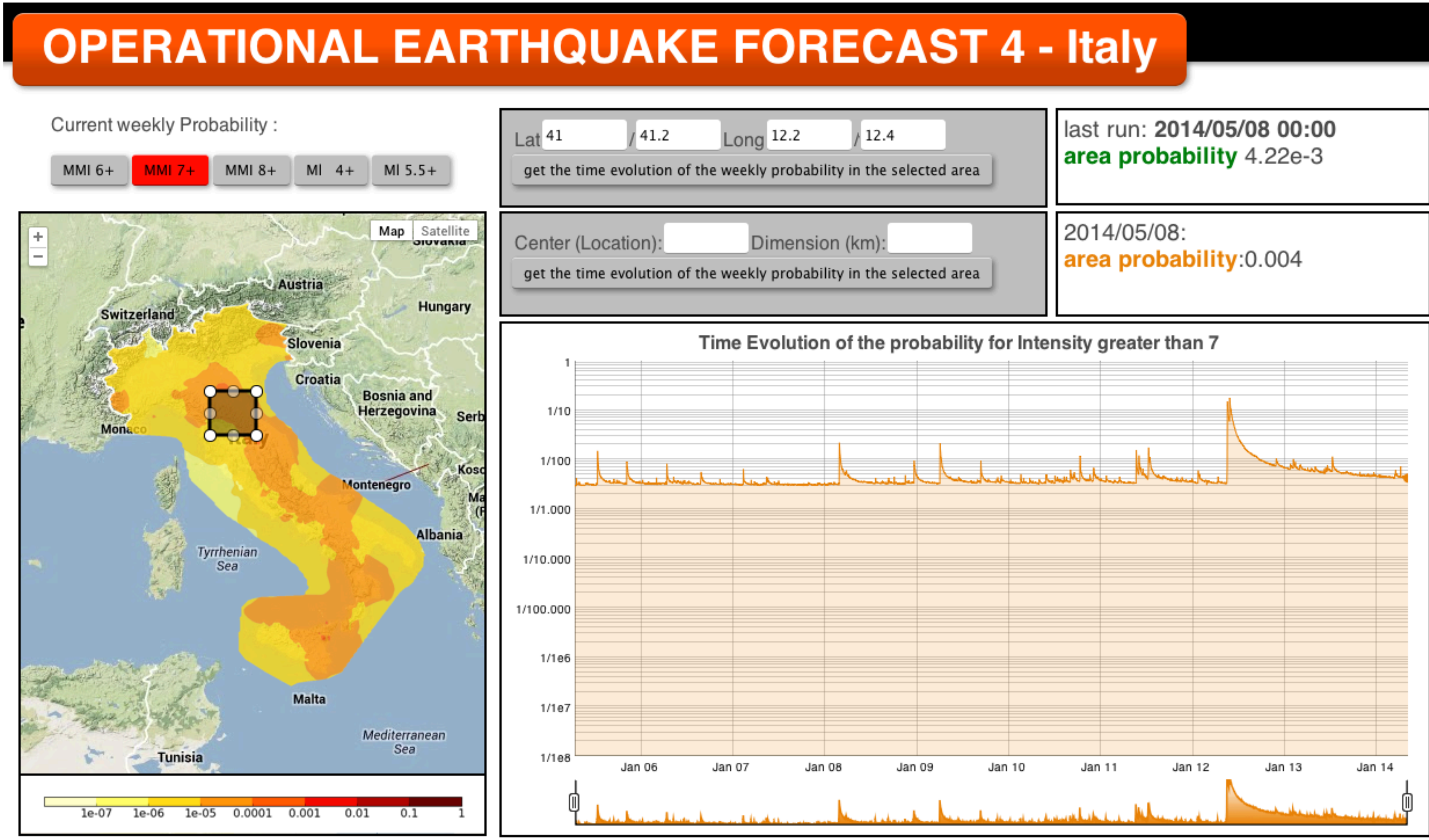
Dynamical system approaches
and physically-based models


Example 1: Earthquakes

Advances in seismic hazards: Operational Earthquake Forecasting (OEF) (Warner Marzocchi, INGV)

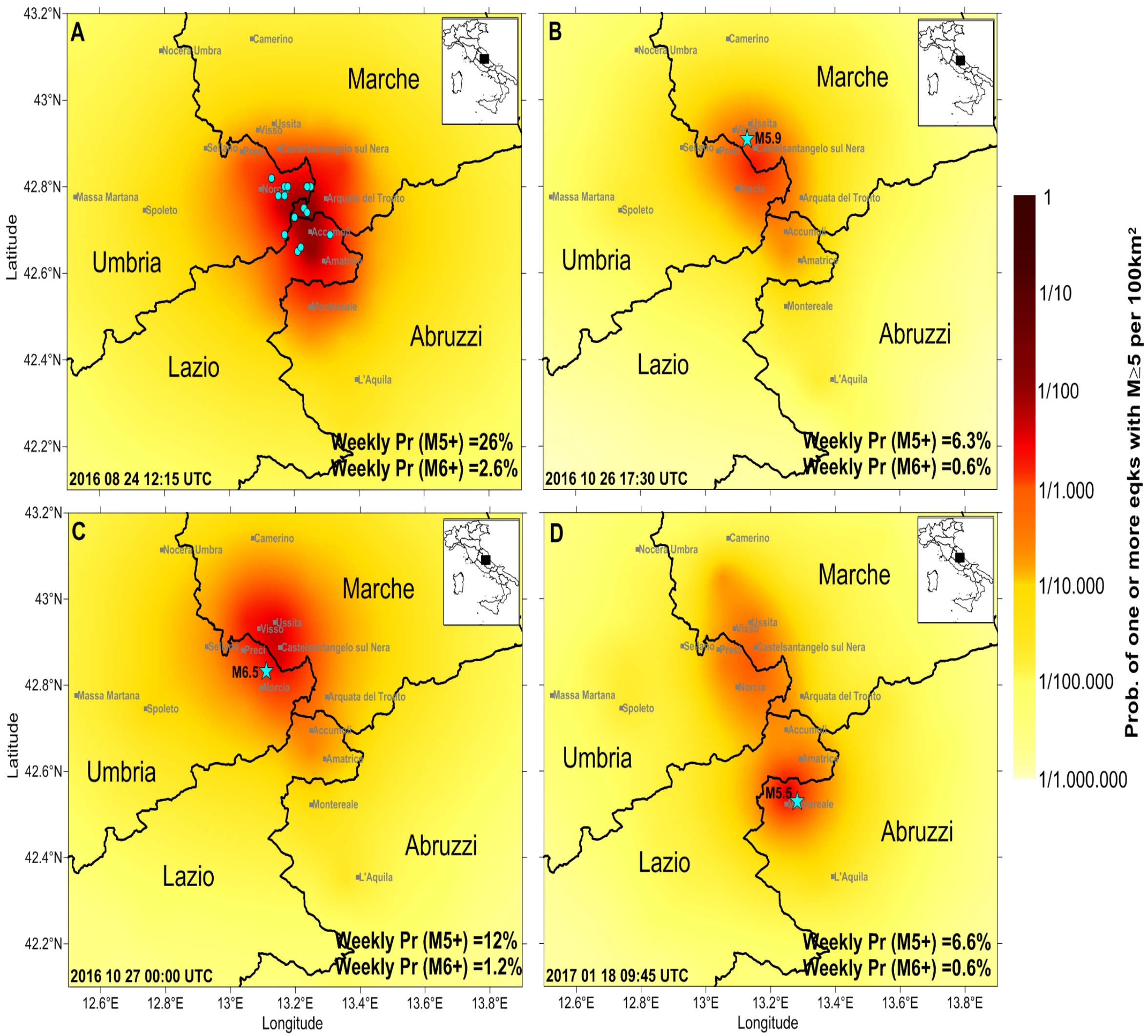
- Seismic (and risk) hazard **varies with time** (in particular in the short-term)
- During a seismic sequence (e.g., Kumamoto, 2016; Amatrice-Norcia, 2017) the weekly probability of a destructive earthquake can **increase 100-1000 times** with respect to the reference level, but this **probability barely reaches a few percent.** (NOTE: "small" probabilities may lead to unacceptable risk)
- Some models based on **earthquake clustering** provide **accurate estimations of such probabilities.** Despite the usual belief, such models are verified empirically **much better** than long-term hazard models for the building code.
- OEF models are useful to track the evolution of a seismic sequence (before Tohoku 2011; Christchurch 2010-2011; Kumamoto 2016; Amatrice-Norcia, 2016)

OEF in Italy (pilot phase): *probabilistic model based on ensemble*



Evolution of the **weekly probability** with time for the selected area: updated every **day** or after a M3.5+

Weekly Forecasts for the Amatrice-Norcia sequence (in light blue the earthquake that occurred during the forecasts)



A- just after Amatrice earthquake on August 24 (light blue dots the largest aftershcoks observed)

B- before the M5.9 (light blue star) on Oct. 26

C- before the M6.5 (light blue star) on October 27.

D- before the M5.5 (light blue star) on Jan. 18.

Basic (and common) question:

Is the OEF (weekly) probability of large earthquakes too small?

OPERATIONAL EARTHQUAKE FORECAST 4 - Italy

Current weekly Probability :

MMI 6+ | MMI 7+ | MMI 8+ | MI 4+ | MI 5.5+

Lat / Long /

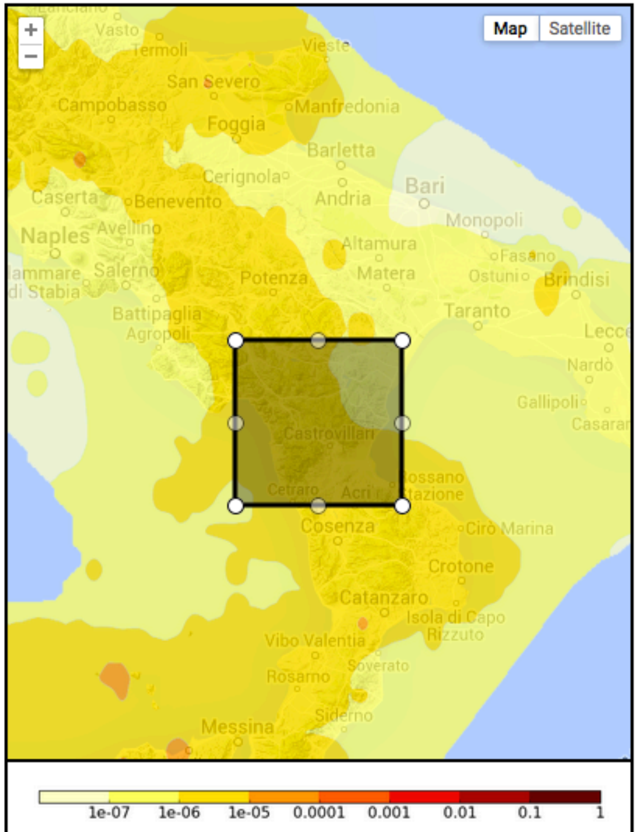
get the time evolution of the weekly probability in the selected area

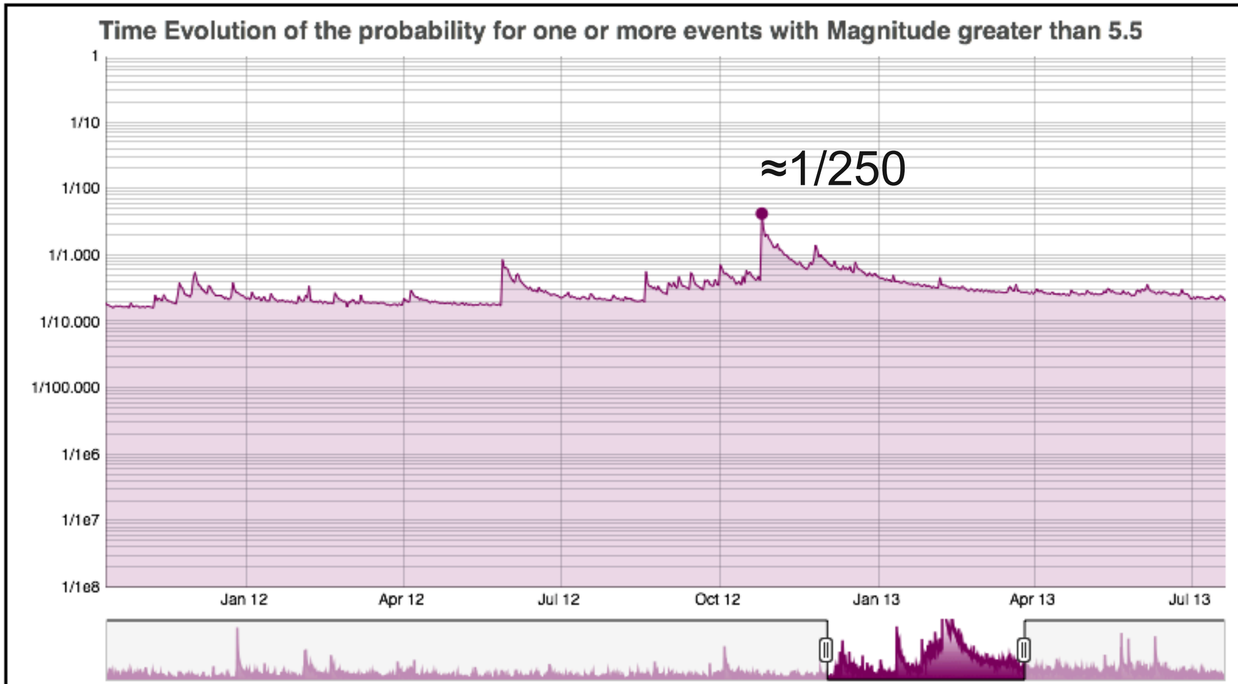
Center (Location): 39.85 16.05 Dimension (km): 50

get the time evolution of the weekly probability in the selected area

last run: **2015/05/12 02:30**
area probability 1.80e-4

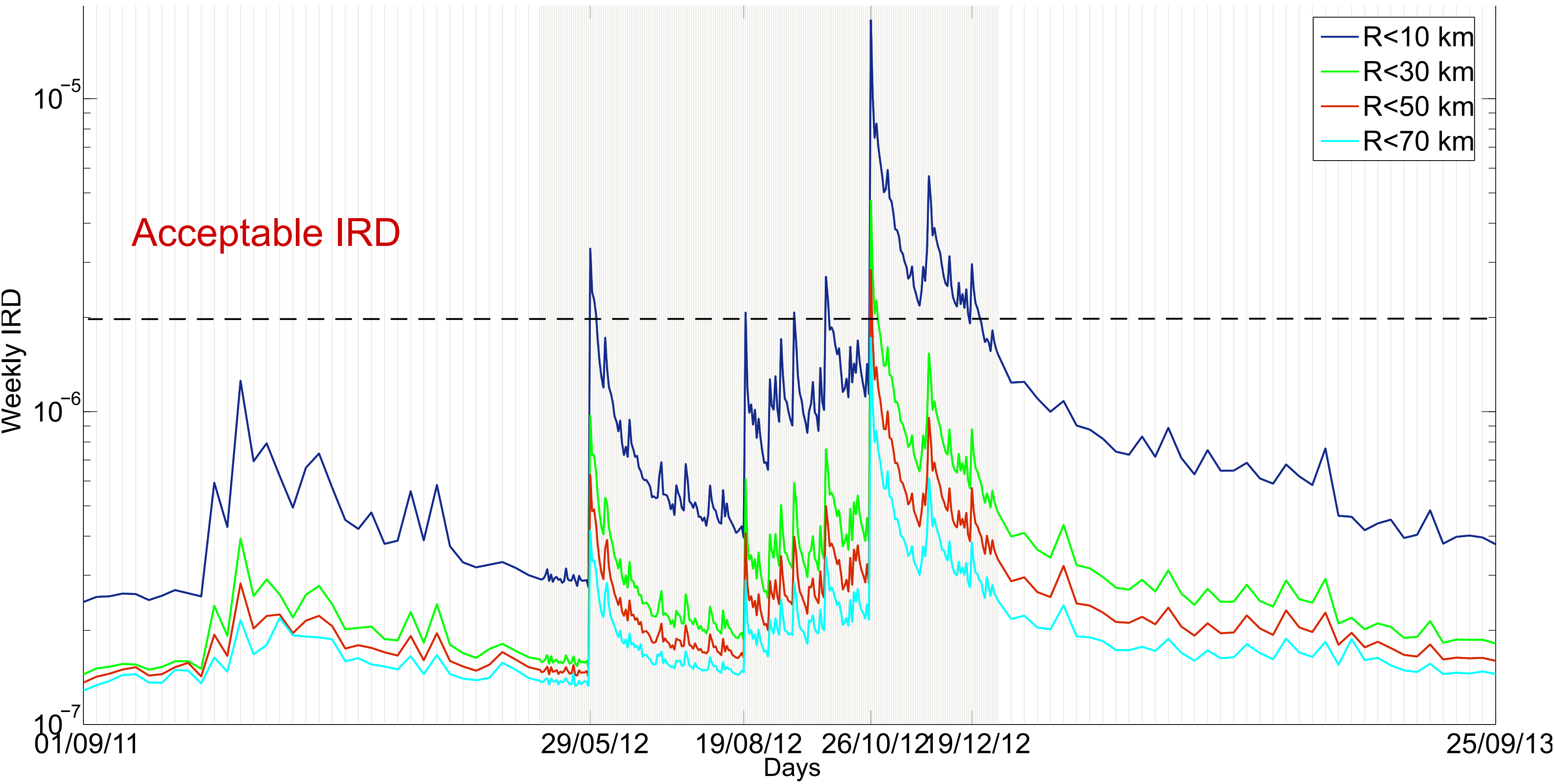
2012/10/26:
area probability:0.004





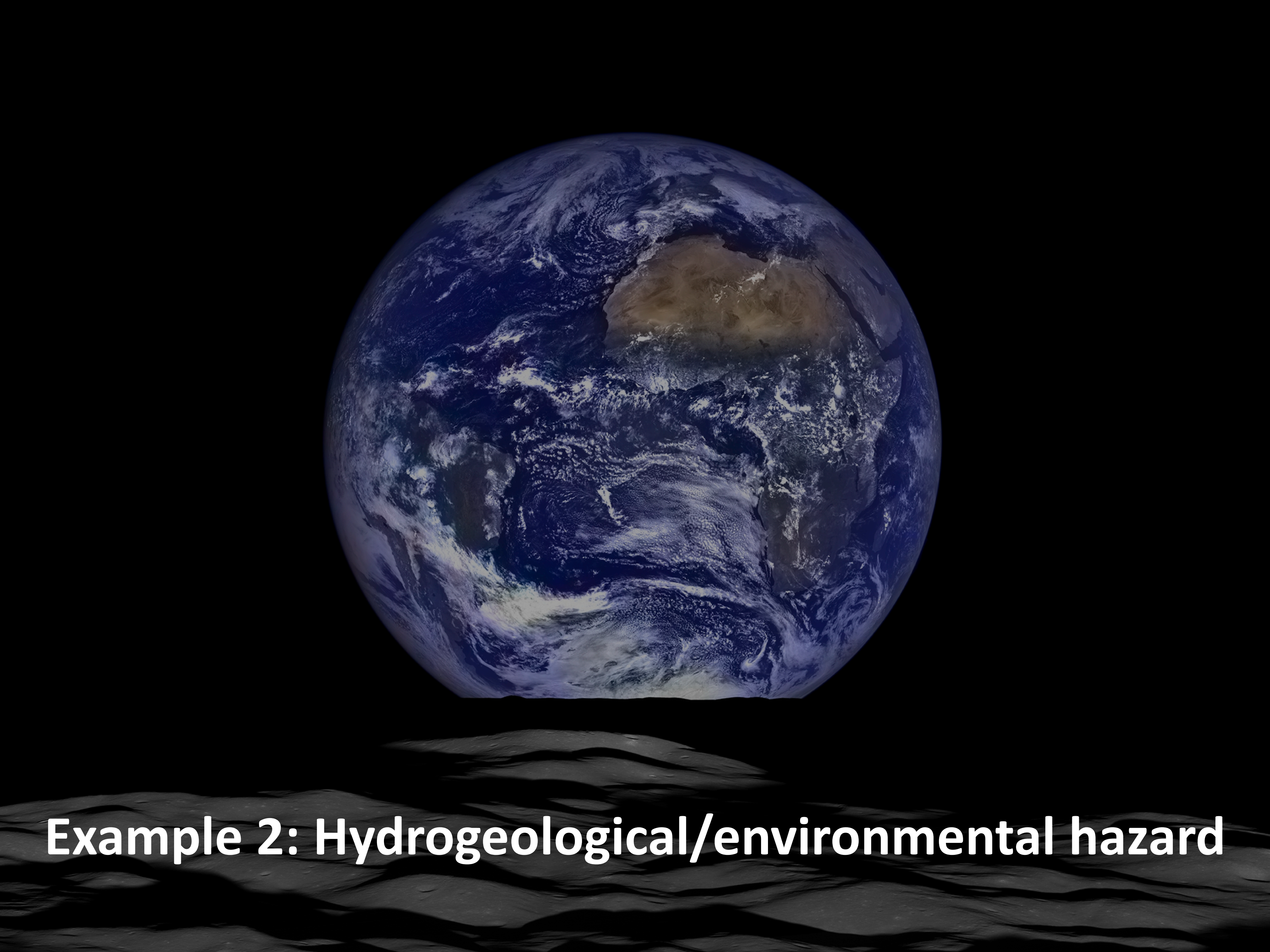
When is the probability of a large earthquake too small? (Marzocchi et al., SRL, 2015)

(a seismic sequence in Italy with largest earthquake M5: the weekly probability of a large earthquake is at most 1/250, but the individual risk of death is above the acceptable risk)



Discussion items

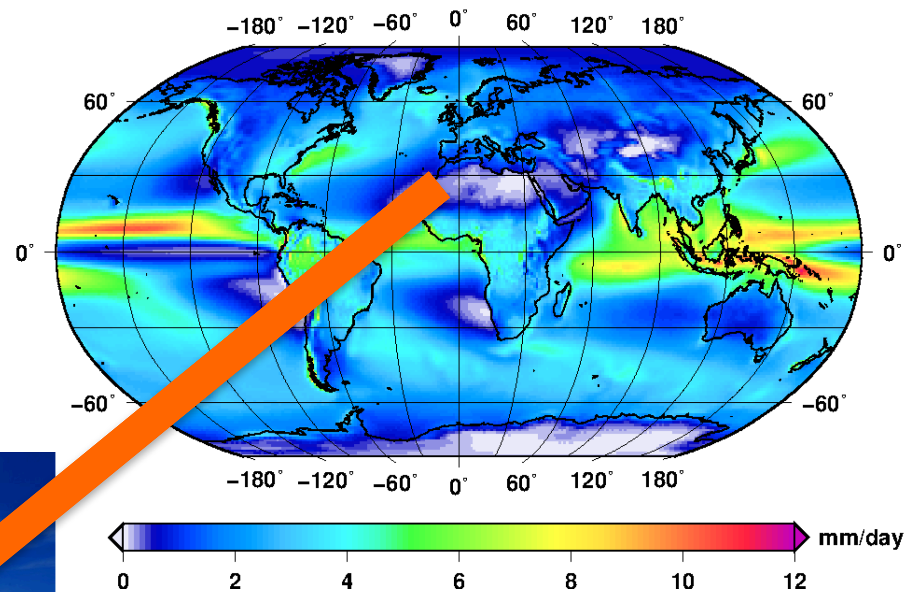
1. Risk reduction requires many different expertises, not only science.
2. Low-probability high-impact events are difficult to manage. Importance of communication (e.g., pandemic and terrorist risks)
3. Seismologists are not able to predict exactly earthquakes but this does not mean that they know nothing. They can make probabilistic forecasts
4. Communicating uncertainties and probabilities. Although it is a hard task, not communicating them is hard a viable option.
5. Decision-making must be based on probabilities (unavoidable uncertainties prevent to make deterministic predictions; at least in most of natural disasters)


Example 2: Hydrogeological/environmental hazard

To estimate future environmental risks, we need impact models

Global Climate Models: The most advanced tools that are currently available for simulating the global climate system and its response to anthropogenic and natural forcings.

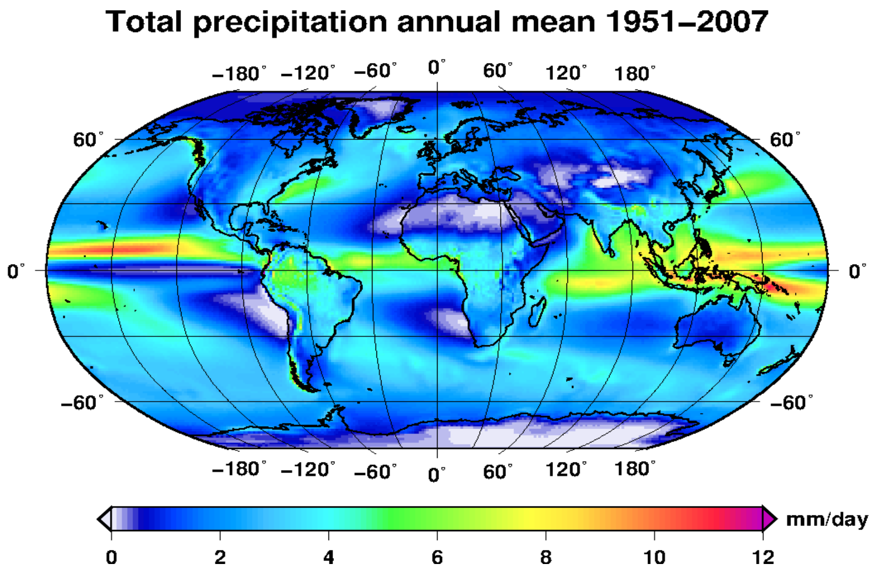
Total precipitation annual mean 1951–2007



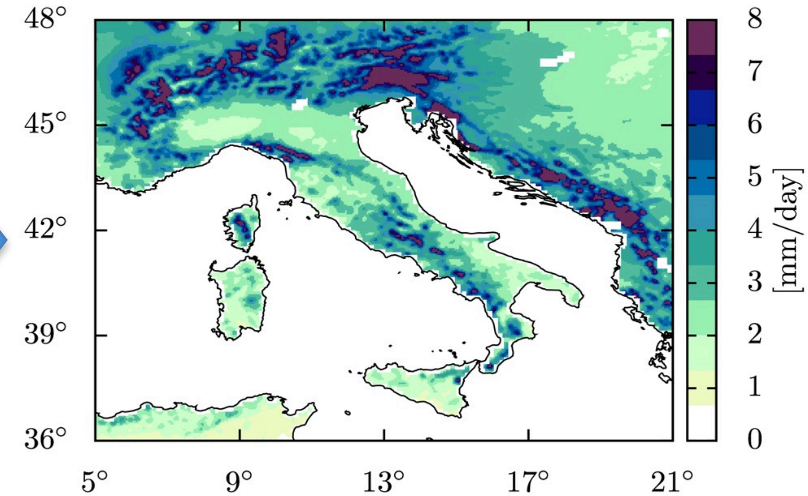
Impact models:
Basin response
Ecosystems
Glaciers and snow
Agriculture, Land surface

The downscaling-impact chain

Global climate model



Regional climate model



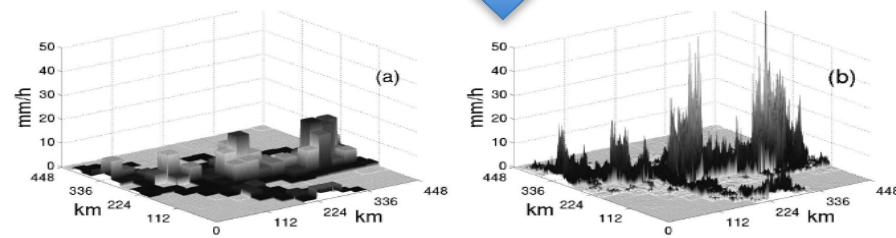
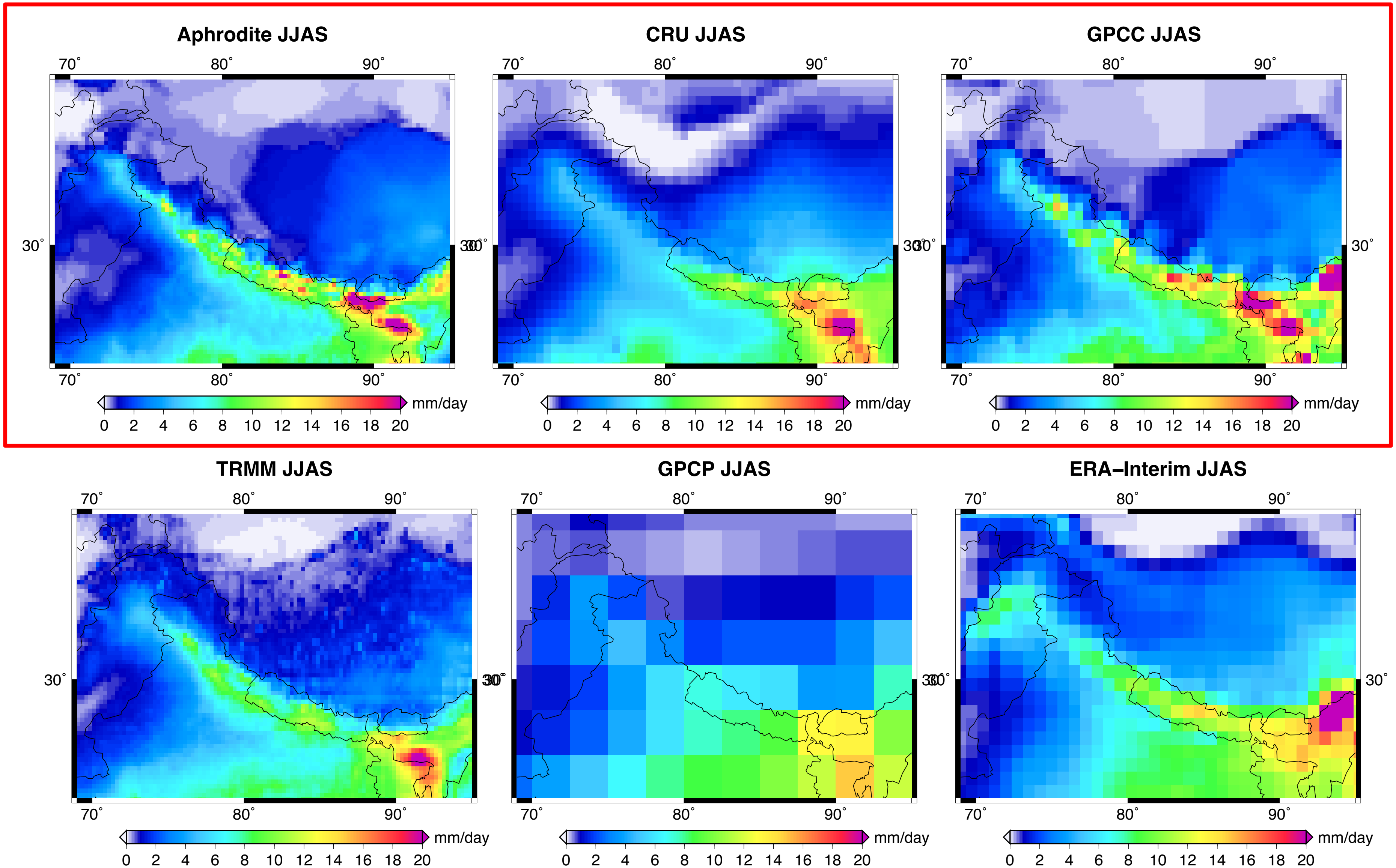


FIG. 10. (a) A snapshot of the forecasted rain field obtained from the LAM forecast and (b) one example of a downscaled field obtained by application of the RainFARM. The vertical scale indicates precipitation intensity (mm h^{-1}) and it is the same for the two fields.

Statistical/stochastic downscaling

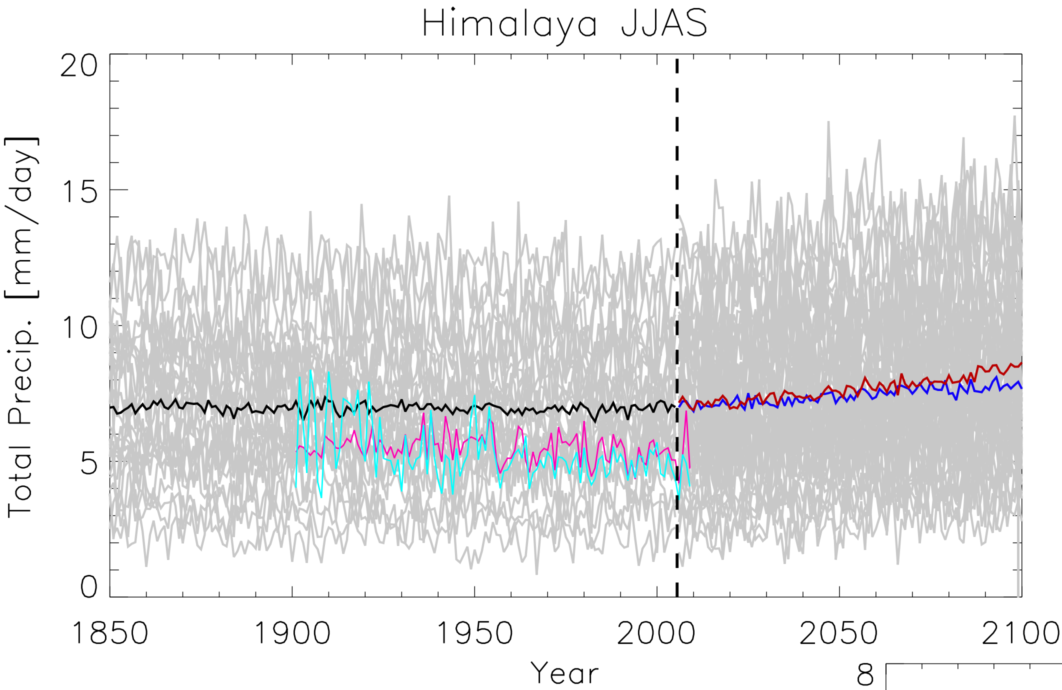
Impact on eco-hydrological processes

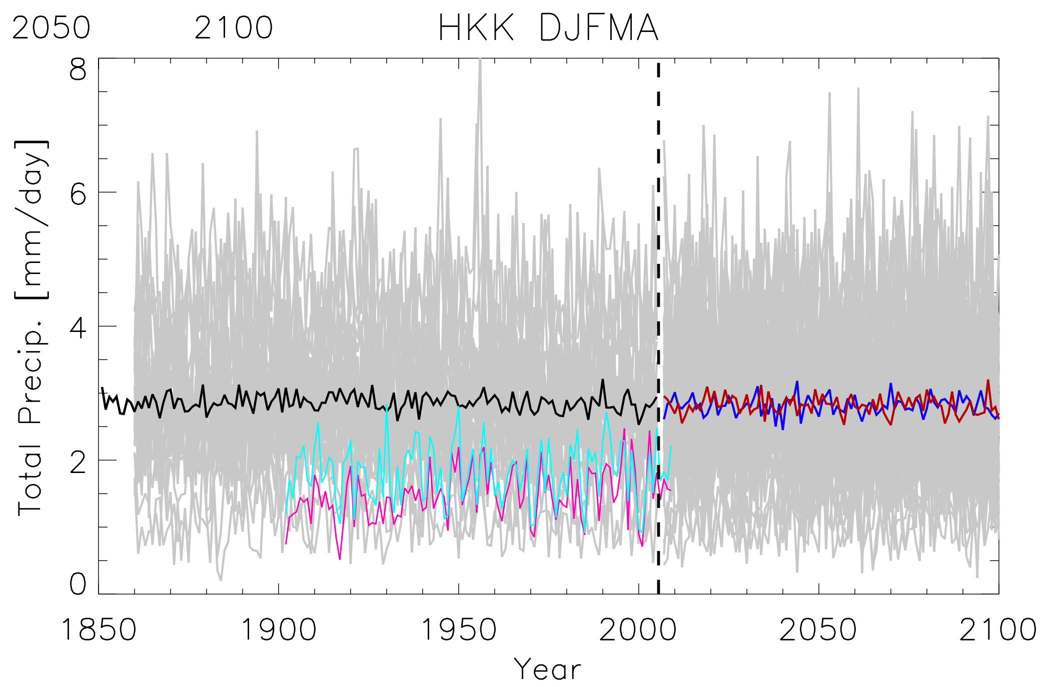
The chain of uncertainties: (1) data for model validation
Summer precipitation (JJAS), Multiannual average 1998-2007



Palazzi E., von Hardenberg J., Provenzale A.: Precipitation in the Hindu-Kush Karakoram Himalaya: Observations and future scenarios, JGR 2013

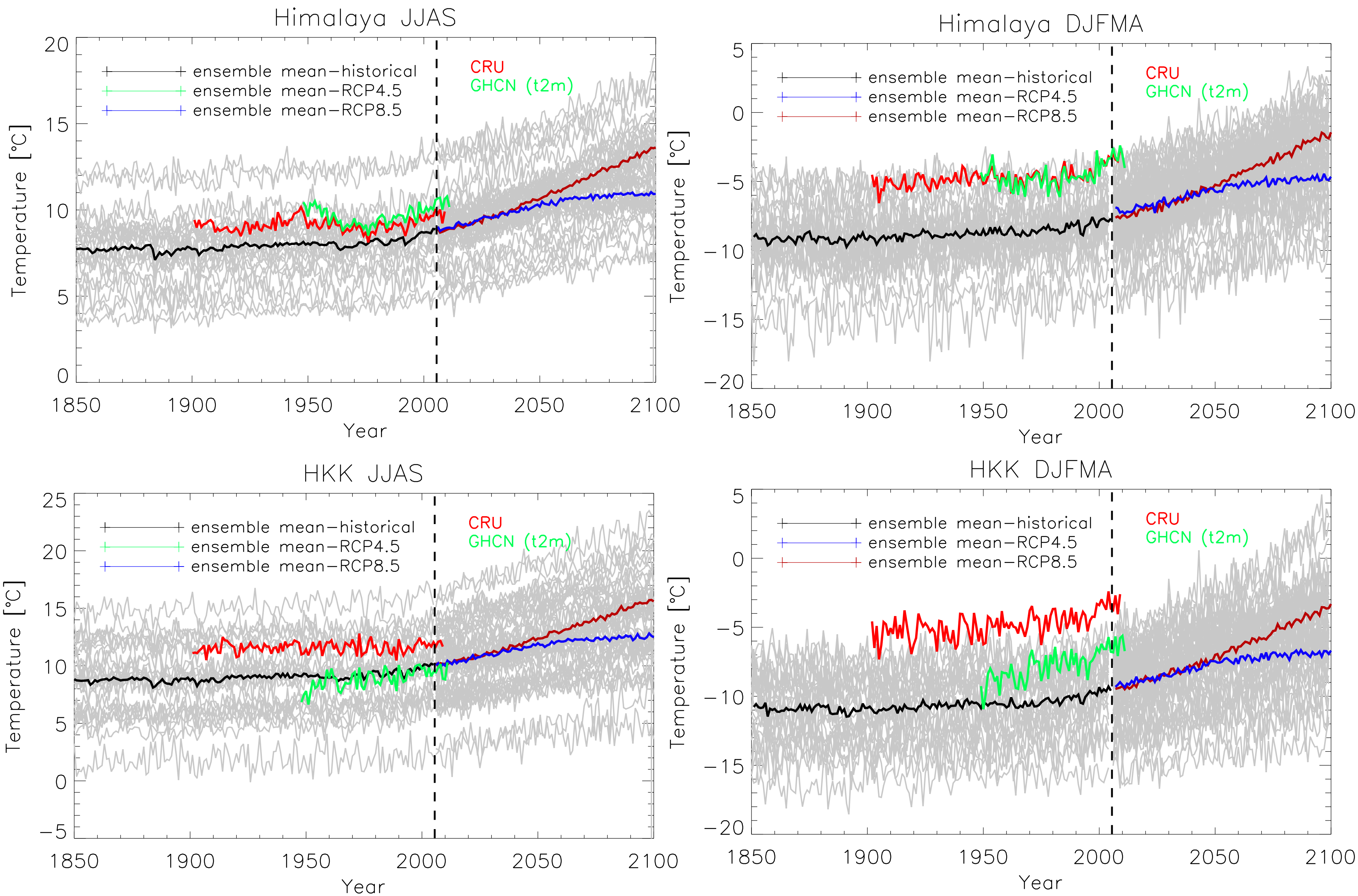
The chain of uncertainties: (2) spread between CMIP5 models



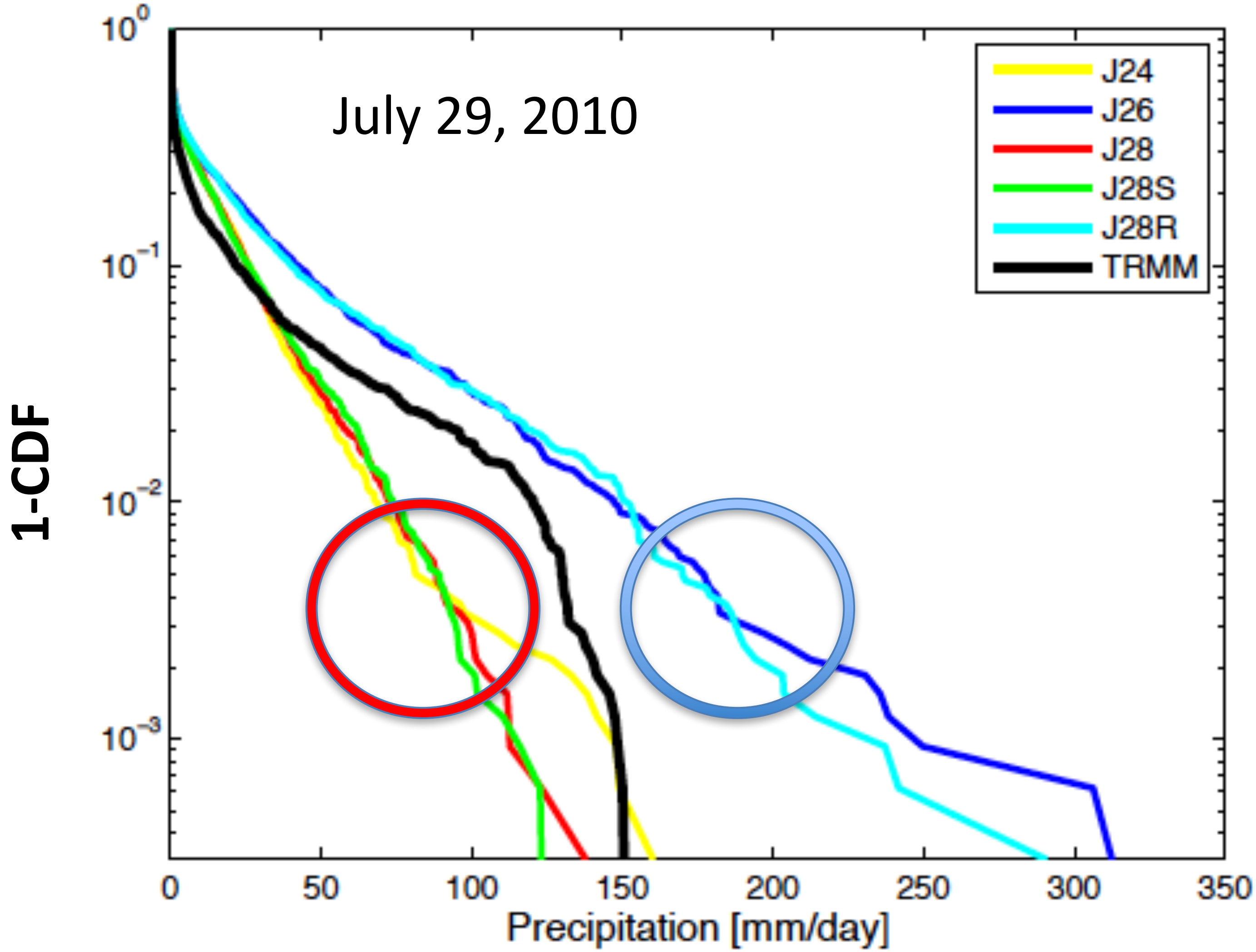


Palazzi E., von Hardenberg J.,
Terzago S., Provenzale A.:
Precipitation in the Karakoram-Himalaya:
A CMIP5 view, Climate Dynamics,
2014 (in press)

And the spread of CMIP5 temperatures

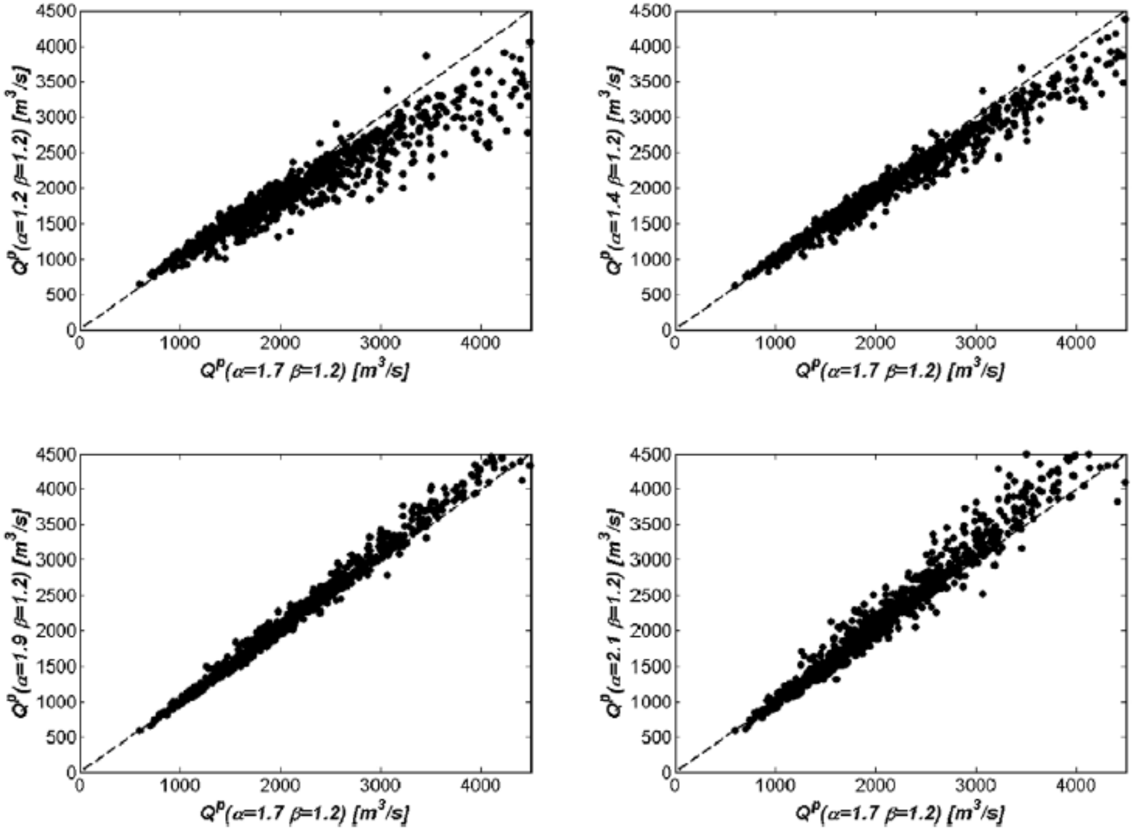


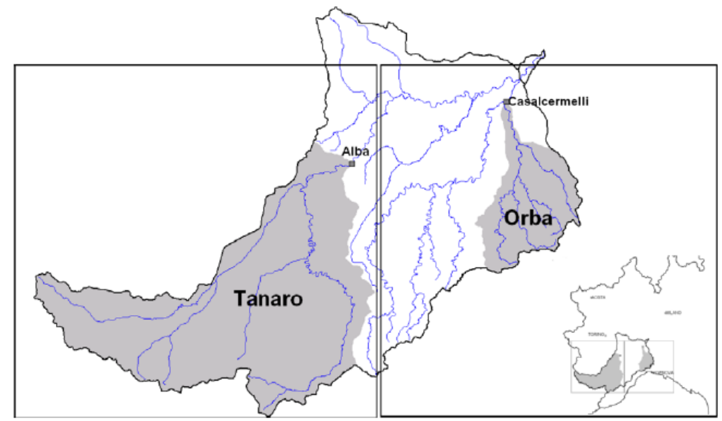
Precipitation statistics from WRF (Pakistan Flood 2010)

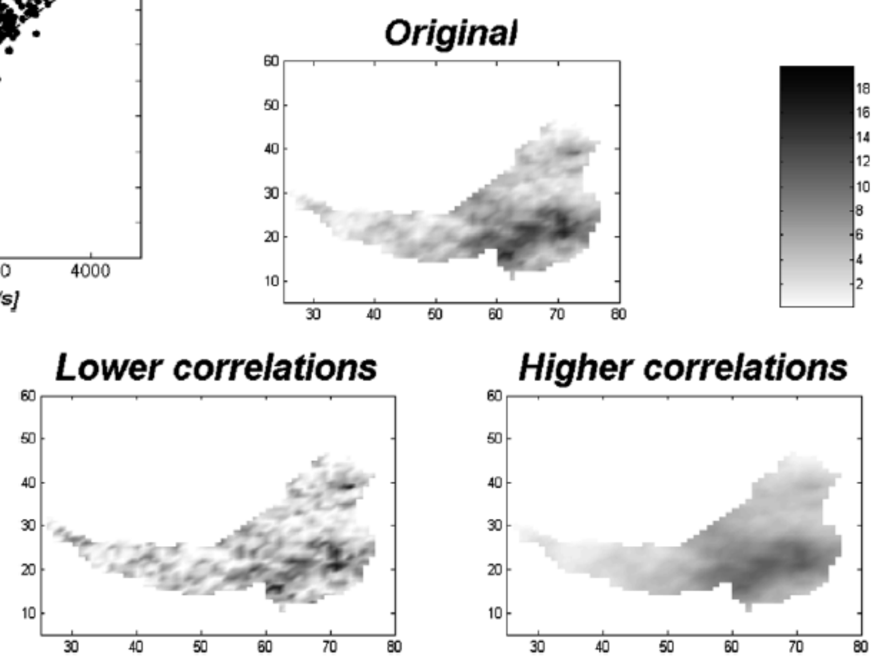


Francesca Viterbo et al., J. Hydrometeorology (2015)

The chain of uncertainties: (3) downscaling







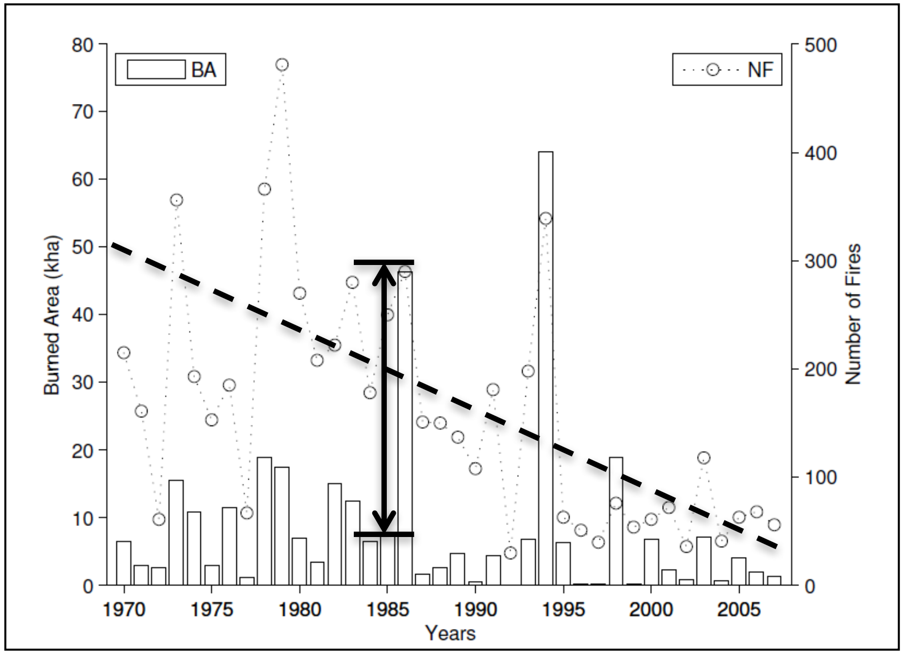
Gabellani, Boni, Ferraris,
von Hardenberg, Provenzale
Adv. Water Res. 2007

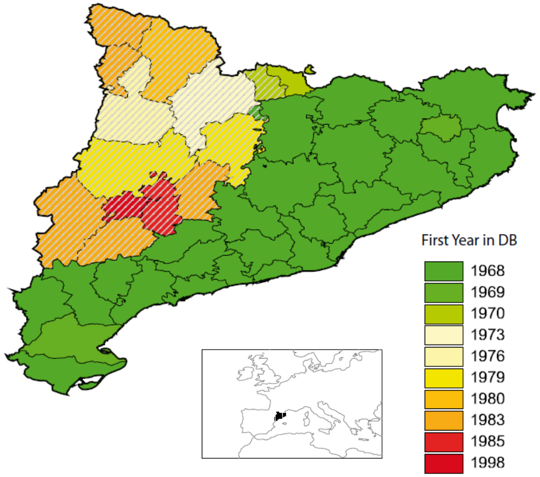
The chain of uncertainties: (4) local impact models
Climate change and forest fires

Long-term changes → human activities, climate trends.

The year-to-year changes in NF and BA are mainly related to **climate variability**.

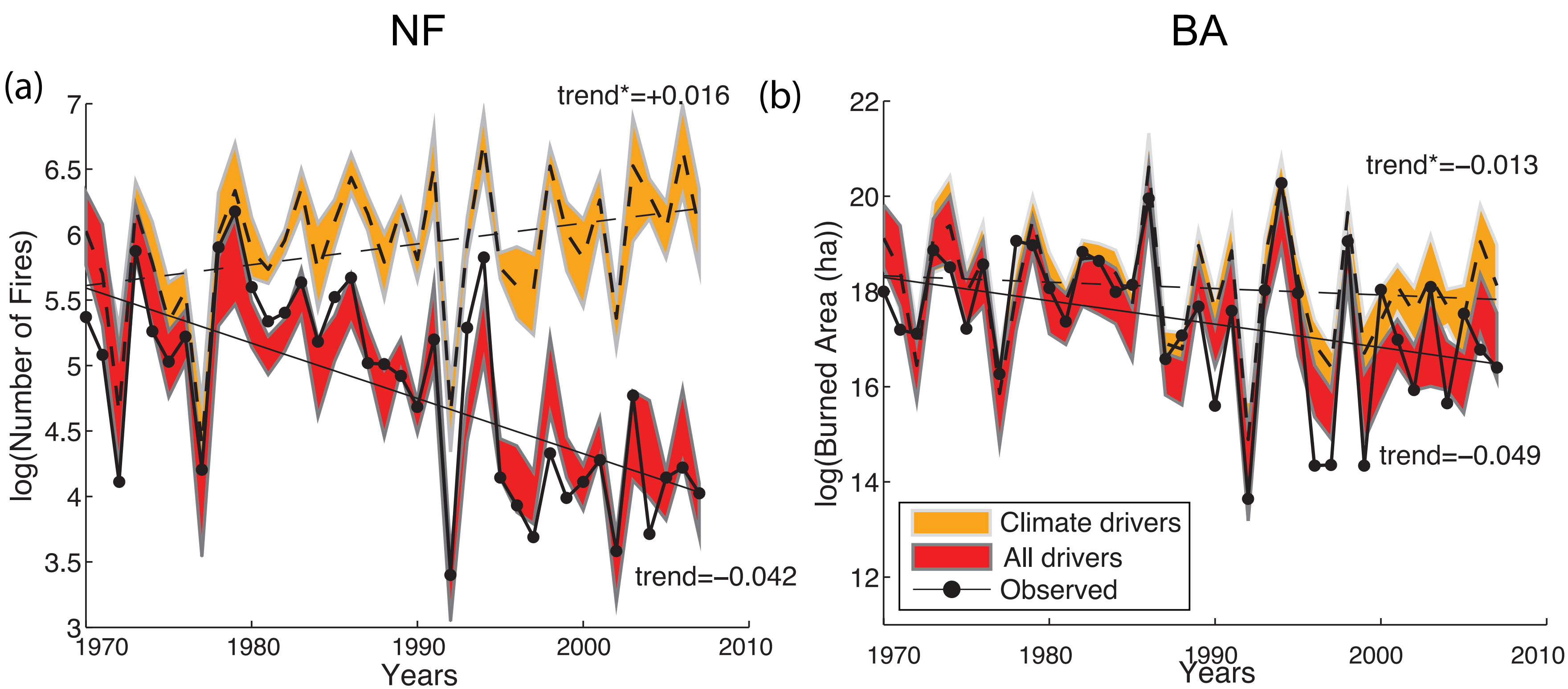
The climate acts mainly on two aspects: (i) **antecedent climate** → fuel to burn; (ii) **coincident climate** → fuel flammability.





Turco et al. Climatic Change 2013, 2014, NHESS 2013

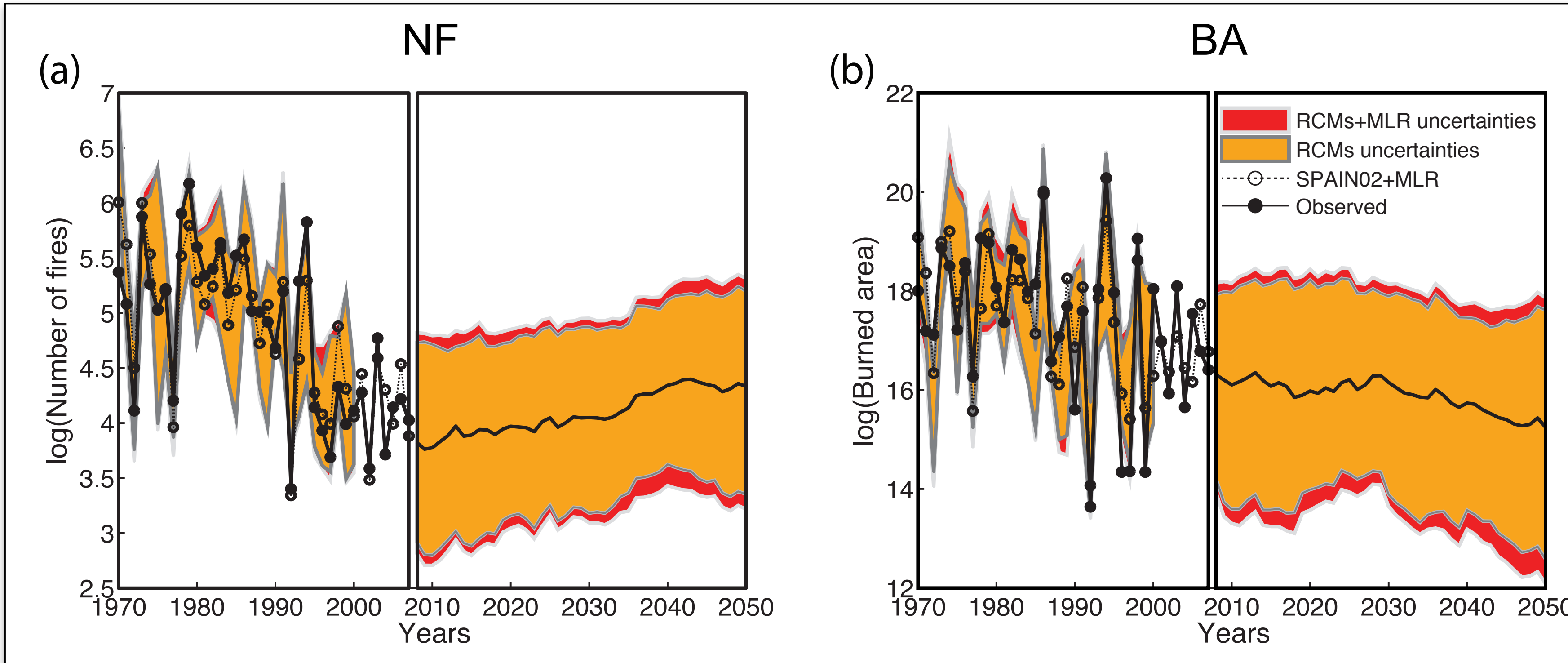
Fire response to climate trends



Uncertainty bands: includes 90% of the members of 1000 different bootstrap replicates

Climate drivers = both interannual variability and trend are driven by climate
All drivers= MLR considers the year-to-year climate variation + overall trend

Impact of future climate change on wildfires



- Future response depends on management strategies
- Uncertainty in RCM scenarios is larger than impact model uncertainties for forest fires

We need … a Solid Earth systems model: An approach to **structuring distributed knowledge** of the science of geology to provide an integrated view in the context of sciences of the solid Earth as a whole. A model of the systems of the solid Earth, organised within a framework that depicts and clarifies the principal relationships among the … multiple … findings of geology, providing a multidimensional map to locate and connect ideas, concepts, workflows of investigation and threads of reasoning.
From “Systems Geology”, TV Loudon, 2005.

We need new research,
not only application of existing results

Disaster Risk Reduction and Resilience: A Global Imperative for Earth System Sustainability

Belmont Forum Scoping Workshop on Disaster Risk, Reduction and Resilience

Hassan Virji

Academia dei Georgofili
Florence, Italy
June 5-7, 2017

Take home message

Disaster resilience is everyone's business and is a shared responsibility among citizens, the private sector, and government. Increasing resilience to disasters **requires bold decisions and actions** that may pit short-term interests against longer-term goals.

Disaster Resilience, US NAS, 2012, ISBN-13: 978-0-309-26150-0

Definition of Risk

World Economic Forum - Global Risks 2017

HIGH

Impact

A global risk is an uncertain event or condition that, if it occurs, can cause significant negative impact for several countries or industries within the <u>next 10</u> years.

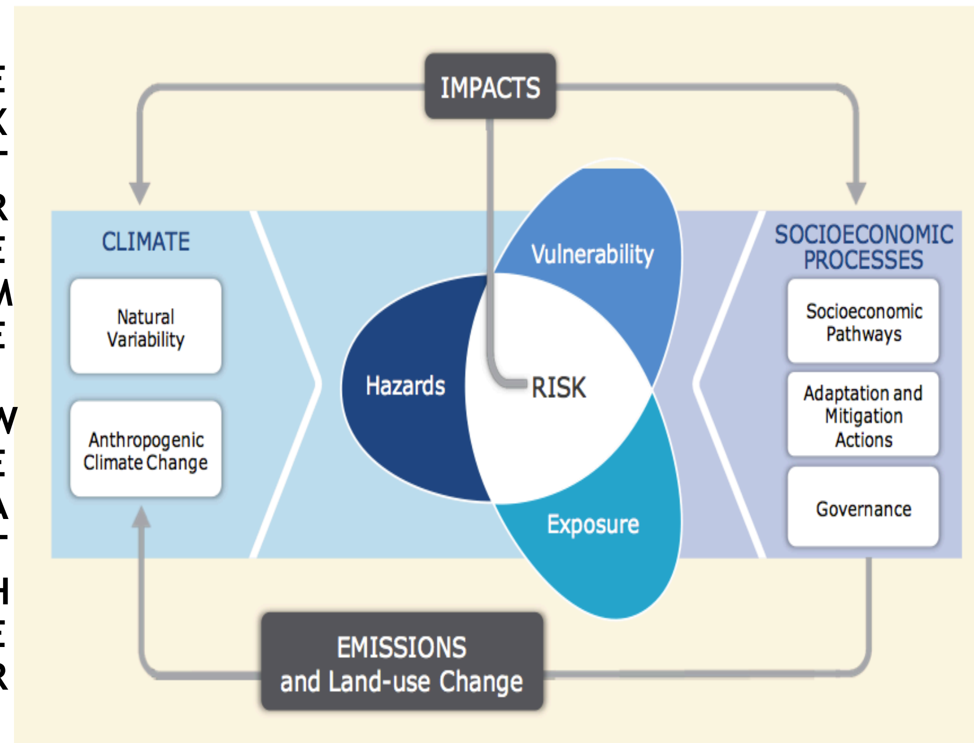
LOW → HIGH

Likelihood

IPCC

Climate, Risk and Human Development Framework

EXTREME WEATHER

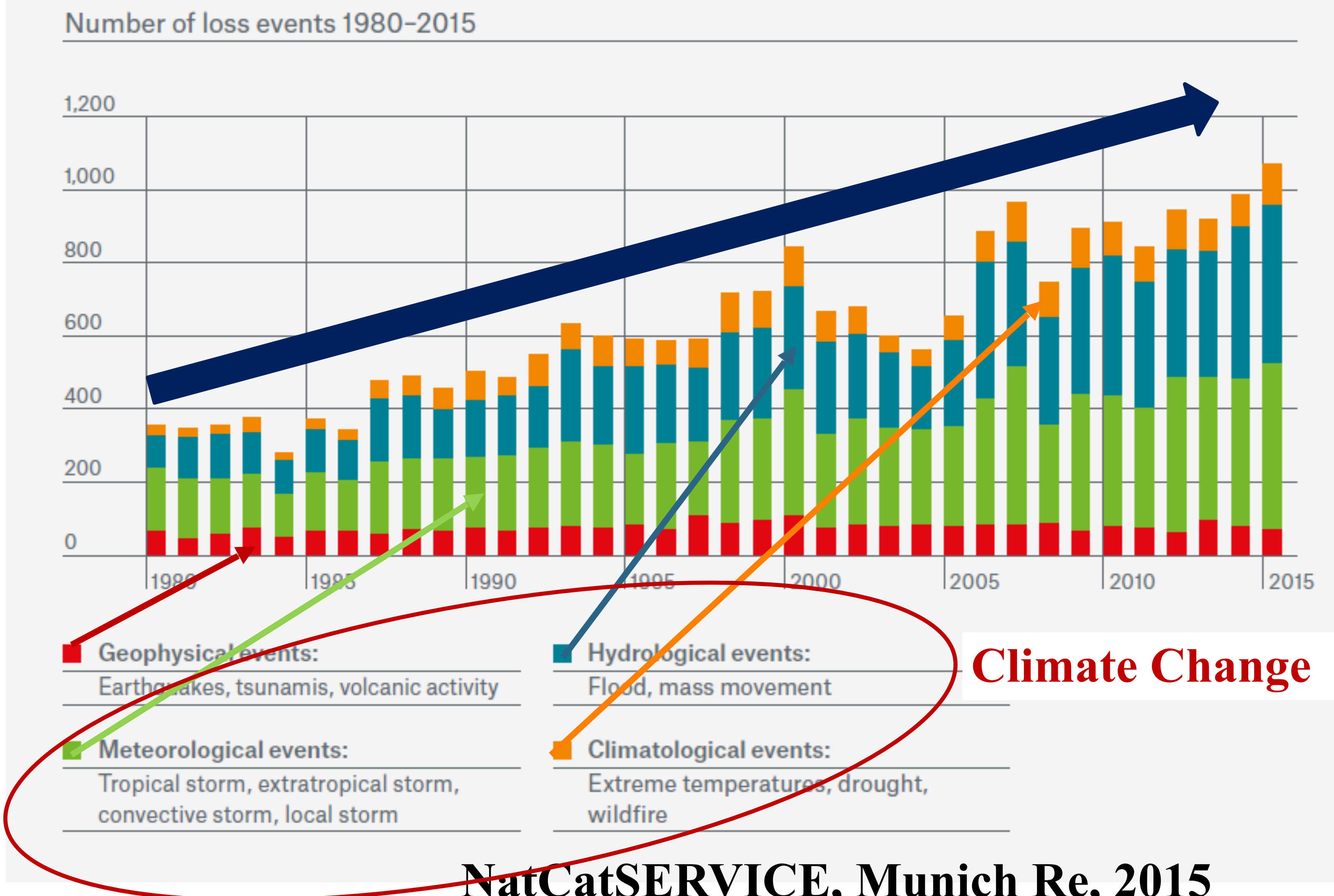


URBANIZATION

INCOME INEQUALITY

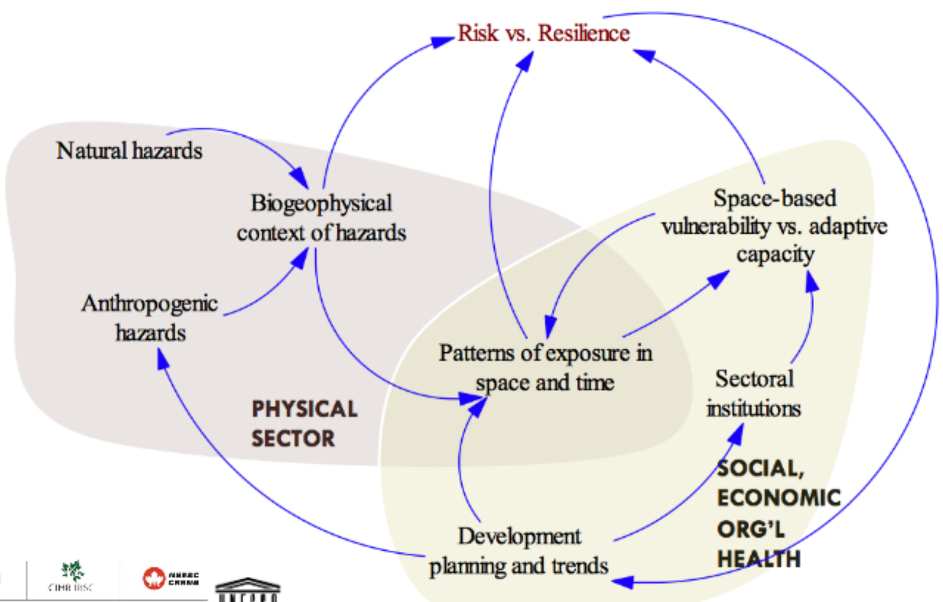
Extreme Weather Events

Number of "Natural" Catastrophes 1980-2015

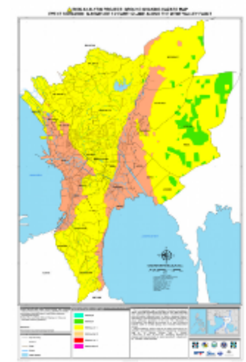


NatCatSERVICE, Munich Re, 2015

Risk is systemic, complex and dynamic



Gotangco and See,2015



Intensive Risk – High Severity, mid- to low-frequency events

Extensive Risk – Low-severity, high frequency and is linked local hazards

The SFDRR Context:

- During 2005 to 2015 [700,000 people lost their lives, 1.4 million injured, 23 million homeless, 1.5 billion affected. Economic loss: 1.3 trillion USD]
- More small scale disasters and slow onset disasters
- People centered preventive approach
- Engagement of stakeholders
- Need to link to SDGs, climate change framework
- Role of Science and Technology in EWS, preparedness, response, recovery, rehabilitation and reconstruction

Sendai Framework for Disaster Risk Reduction 2015-2030

UN World Conference on Disaster Risk Reduction
2015 Sendai Japan

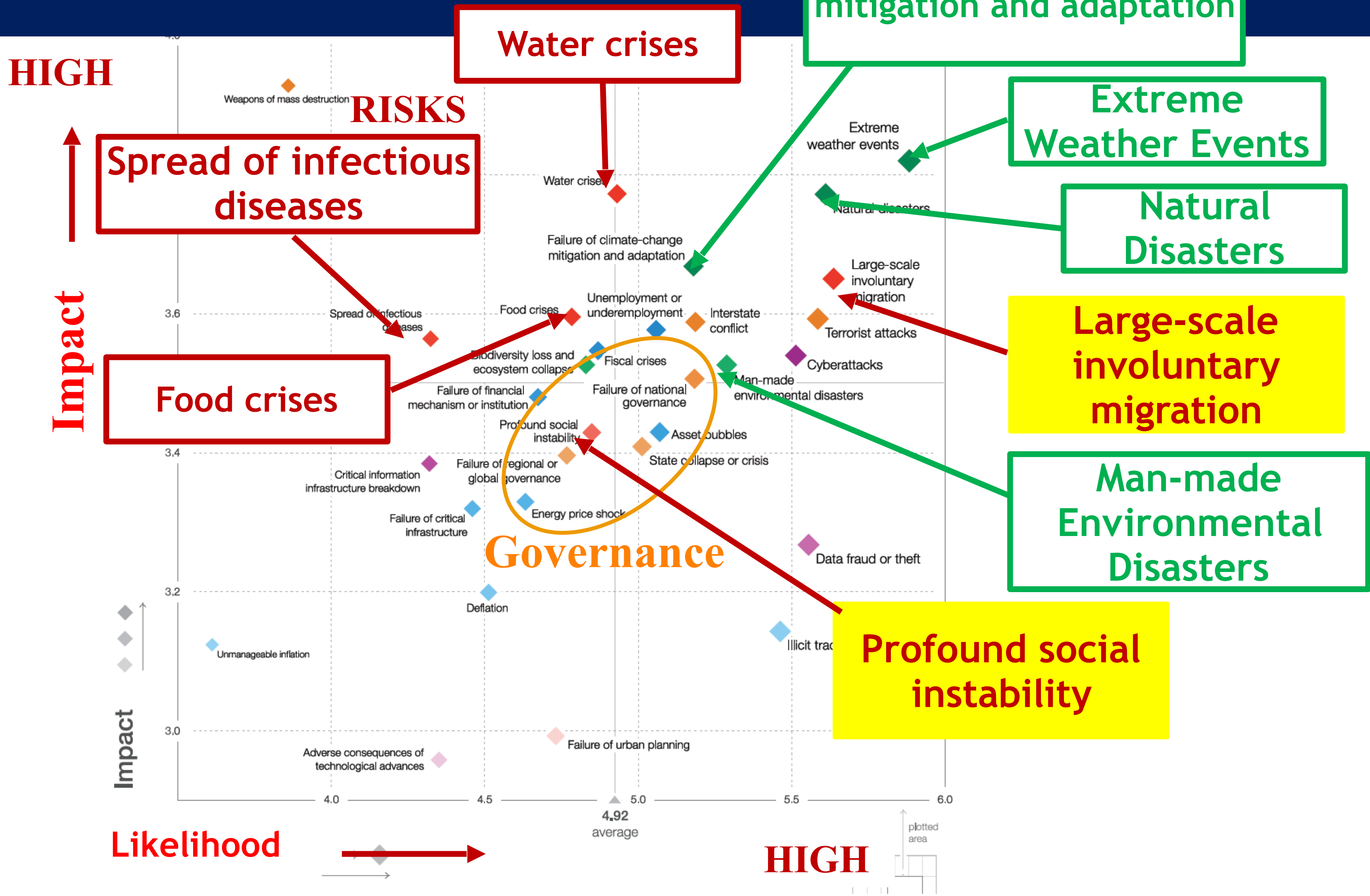
Lead - S&T Major Grp

The post-2015 development agenda, financing for development, climate change and disaster risk reduction …
Ensuring credible links, … between these processes will contribute to building resilience and achieving the global goal of eradicating poverty." …
action within and across sectors by States at local, national, regional and global levels

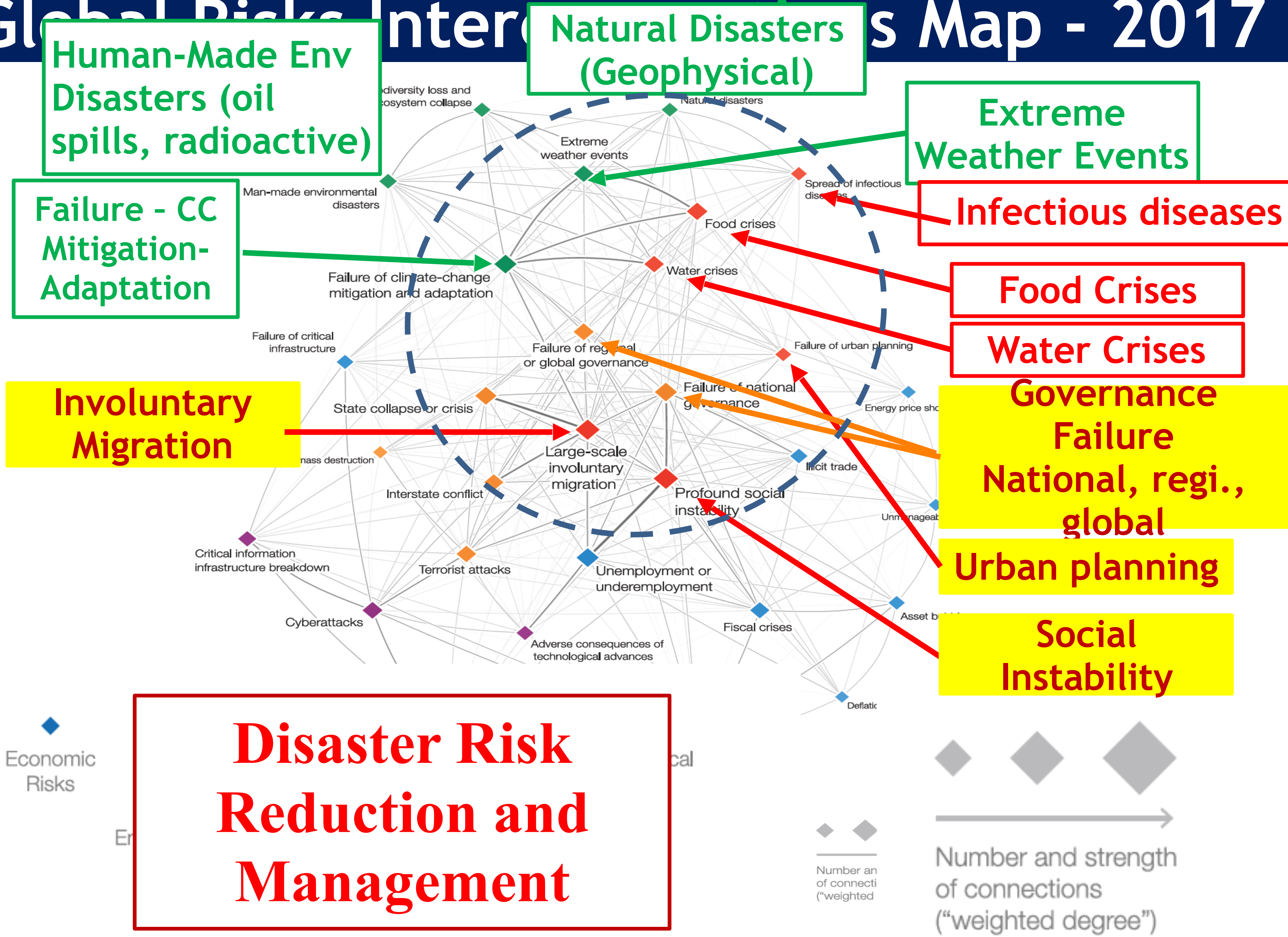
Four priority areas for Disaster Risk Reduction

1. **Understanding** disaster risk;
2. Strengthening **disaster risk governance** to manage disaster risk;
3. **Investing** in disaster risk reduction for resilience;
4. Enhancing disaster preparedness for effective response, and to "**Build Back Better**" in recovery, rehabilitation and reconstruction.

World Economic Forum - 2017

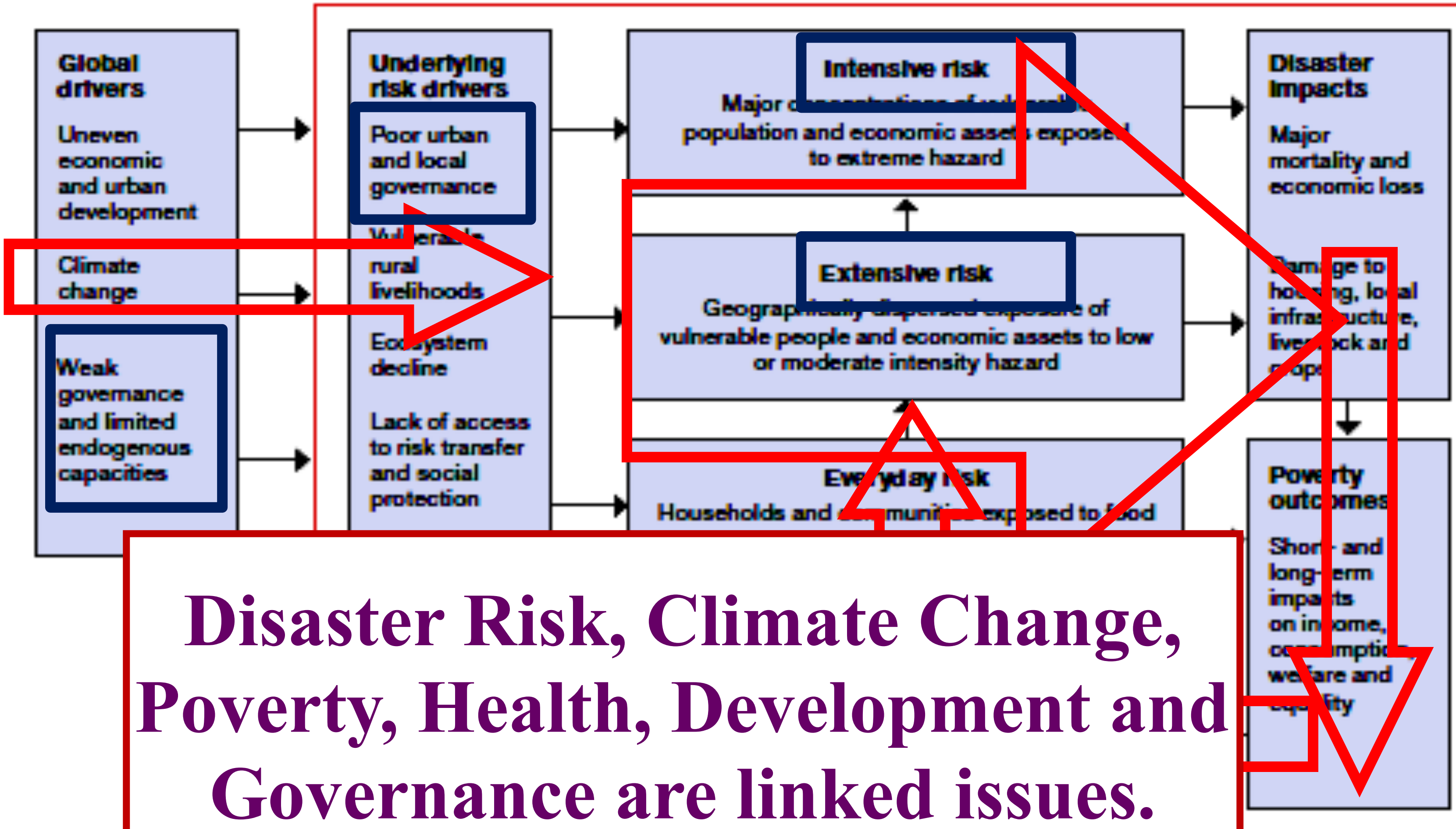


Global Risks Interconnections Map - 2017



Disaster Risk Reduction and Management

Development-Climate-Disaster Risk-Poverty Nexus



Disaster Risk, Climate Change, Poverty, Health, Development and Governance are linked issues.

Need for integrated "transdisciplinary" science

SFDRR Targets for Disaster Risk Reduction 2015-2030

1. **Disaster mortality: lower average global mortality per 100,000 in 2020–2030 compared with 2005–2015.**
2. **Affected populations: lower average number of people affected per 100,000 in 2020–2030 compared with 2005–2015.**
3. **Economic loss: reduce direct economic loss in relation to gross domestic product by 2030.**
4. **Critical infrastructure: substantially reduce damage and disruption of services by 2030.**
5. **Risk reduction strategies: substantially increase the number of countries with national and local strategies by 2020.**
6. **Implementation support to developing countries: substantially enhance support to complement national actions by 2030.**
7. **Multi-hazard warning systems and risk information: substantially increase their availability by 2030.**

How can we measure disaster loss reduction in the absence of reliable loss data on the economic and human impacts? Existing loss accounting systems vastly underestimate the true burden of disasters, both nationally and globally.

- **Sendai targets at risk – S. Cutter and M. Gall - Nature Climate Change, 2015**

SFDRR: Four Priority for Actions

1. Understanding disaster risk
2. Strengthening disaster risk governance
3. Investing in risk reduction
4. Enhancing disaster preparedness for collective response, and to “build back better” in recovery, rehabilitation and reconstruction

About Sustainable Develoment Goals (SDGs)

SUSTAINABLE DEVELOPMENT -

"Humanity has the ability to make development <u>sustainable</u> - to ensure that it meets the needs of the <u>present</u> without compromising the ability of <u>future</u> generations to meet their own needs"

Sustainable Development Goals

17 SDGs - with 169 targets

2015-30 Developmen

1. End poverty in all its forms everywhere
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3. Ensure healthy lives and promote well-being for all at all ages
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5. Achieve gender equality and empower all women a
6. Ensure availability and sustainable management o for all
7. Ensure access to affordable, reliable, sustainable and modern energy for all
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Interconnections

Sustainable Development Goals

9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10. Reduce inequality within and among countries
11. Make cities and human settlements inclusive, safe, resilient and sustainable
12. Ensure sustainable consumption and production patterns
13. Take urgent action to combat climate change and its impacts
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective accountable and inclusive institutions at all levels
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

Interconnections


IISD / SDG KNOWLEDGE HUB
A project by IISD

NEWS COMMENTARY EVENTS ACTORS REGIONS SDGS

ELENA KOSOLAPOVA
Thematic Expert for Climate Change and Biodiversity Policy (Russia/Netherlands)

30 May 2017

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Global Platform Commits to Fostering Linkages among DRR, Climate Action and SDGs

UN Photo/ Logan Abassi

STORY HIGHLIGHTS

- The Fifth Global Platform for Disaster Risk Reduction (DRR) issued the Cancún High-Level Communiqué, which commits to implement the Sendai Framework for DRR in coherence with the Sustainable Development Goals (SDGs), the Paris Agreement on climate change and the New Urban Agenda.
- The Global Platform for DRR met for the first time since the adoption of the Sendai Framework for DRR at the Third World Conference on DRR in March 2015, and focused on implementation.
- Another outcome of the meeting was the Chairs' Summary addressing the priority action areas that emerged from the meeting, which will be forwarded to the High-Level Political Forum (HLPF) of the ECOSOC, scheduled to meet in New York, US, from 10-19 July 2017.

26 May 2017: The Fifth Global Platform for Disaster Risk Reduction (DRR), which convened under the banner 'From Commitment to Action,' issued the Cancún High-Level Communiqué titled 'Ensuring the resilience of infrastructure and housing.'

The Global Platform for DRR, which took place from 24-26 May 2017 in Cancún, Mexico, was meeting for the first time since the adoption of the Sendai Framework for DRR at the Third World Conference on DRR in March 2015, and focused on implementation. The meeting included plenary sessions on: national and local DRR strategies; reducing vulnerability of countries in special situations; Sendai Framework monitoring; and coherence among the Sendai Framework, the Paris Agreement and the 2030 Agenda for Sustainable Development. Two special sessions held during the meeting addressed: availability of and access to multi-hazard early-warning systems and disaster risk information; and enhancing disaster preparedness for effective response and to "build back better" in recovery, rehabilitation and reconstruction.

UNISDR WORLD BANK GROUP

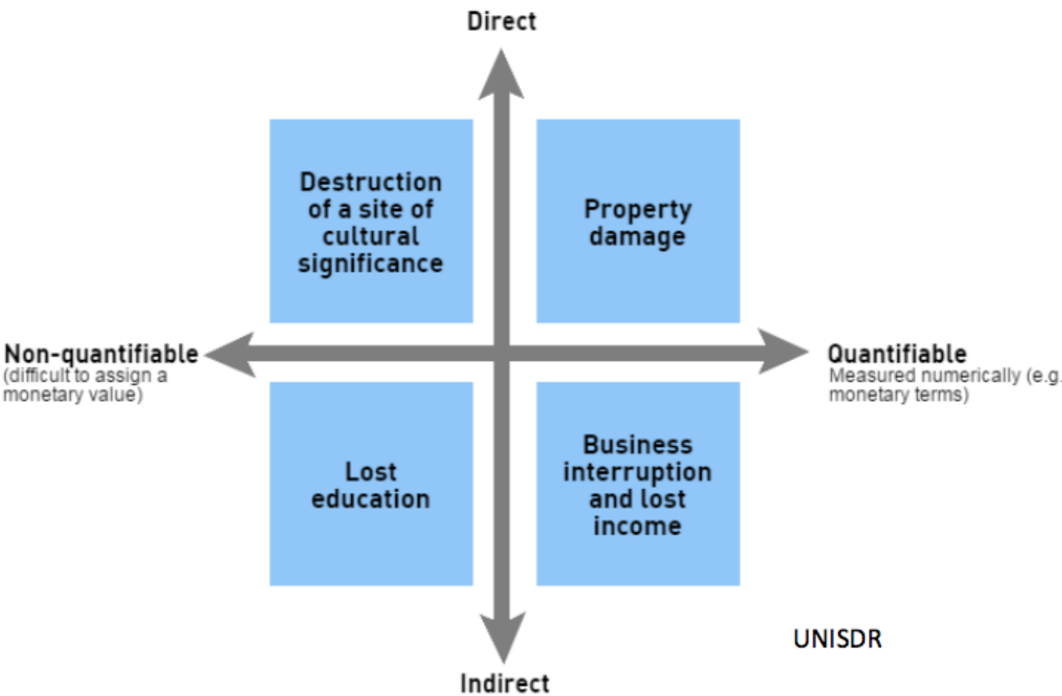
SDGS
1. NO POVERTY
3. GOOD HEALTH & WELL-BEING
5. GENDER EQUALITY
11. SUSTAINABLE CITIES & COMMUNITIES
13. CLIMATE ACTION
17. PARTNERSHIPS FOR THE GOALS

In the Cancún High-Level Communiqué, the leaders committed to implement the Sendai Framework for DRR in coherence with the Sustainable Development Goals (SDGs), the Paris Agreement on climate change and the New Urban Agenda; and promote people-centered, gender-sensitive, accessible and resilient urban development that supports all of society, including the vulnerable, the poor and the marginalized.

Definition of Resilience

Resilience - The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.

Resilience needs to address potential loss and damage + future risk

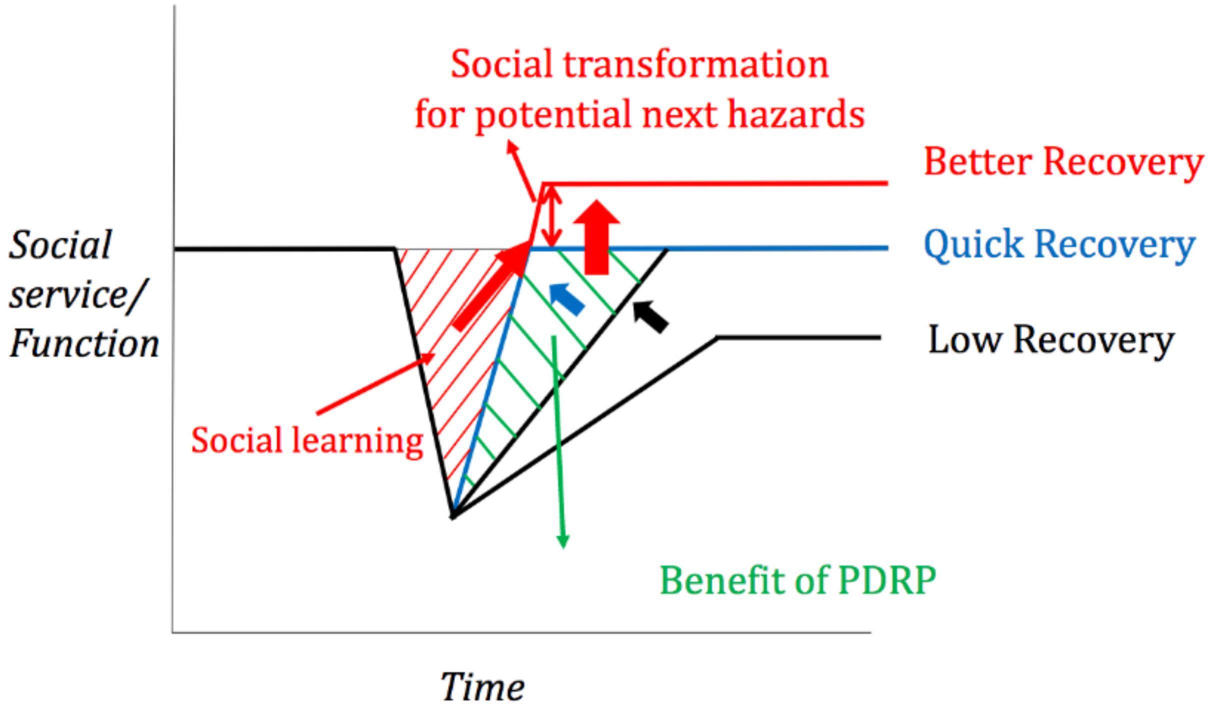


UNISDR

Pre-disaster Recovery Planning is strategic to resilient development

Pre Disaster Recovery Planning (PDRP) is any planned attempt to strengthen disaster recovery plans, initiatives, and outcomes before a disaster occurs. (IRP)

PDRP enables bouncing forward vs. bouncing back



Maki,Otsuyama,Yuda,Sasaoka,Santiago,Pribadi,2017

Risk Management, Resilience and Sustainable Development

- **Mitigating, preparing for and building resilience against global risks is a long and complex process and difficult in practice.**
- **Global risks transcend borders –capacity and authority to act?**
- **Effective communication to the public, government, business and civil society.**
- **Prediction - Keys: linking social, economic, technology, science and environmental issues and the future with the present**
- **Early warning system - timely and meaningful warning information - prepared and act appropriately and in sufficient time to reduce harm or loss. Preparedness - knowledge and capacities …**

Societies face increasing complexity and uncertainty in decision making to cope with extreme weather events. Therefore oversimplified risk approaches should evolve to much richer resilience strategies. Yet, resilience is often more a policy buzzword or topic for theoretical debate than an actual operational paradigm. It is often not clear for policy makers and practitioners how they can translate the main notions of resilience thinking into practical implementation.

‘Environmental Science & Policy’, April 2017, Institute of Water Policy of the National University of Singapore, the Faculty of Technology, Policy and Management of the Delft University of Technology and Deltares

Five practical principles to develop strategies that enhance resilience to disasters

- Importance of a **systems approach**:

Understanding of the entire system under risk of extreme weather events – including the physical, environmental, social and economic aspects and how they are connected – is required to define societal effective measures.

- Focus on **beyond-design events**:

Rare events with disastrous and lasting consequences may call for protection against higher costs than justified by a standard cost-benefit analysis. A resilience approach considers the entire possible spectrum of events as opposed to a risk approach which often focuses on design events. It stimulates thinking about the worst case, or even unimaginable scenarios.

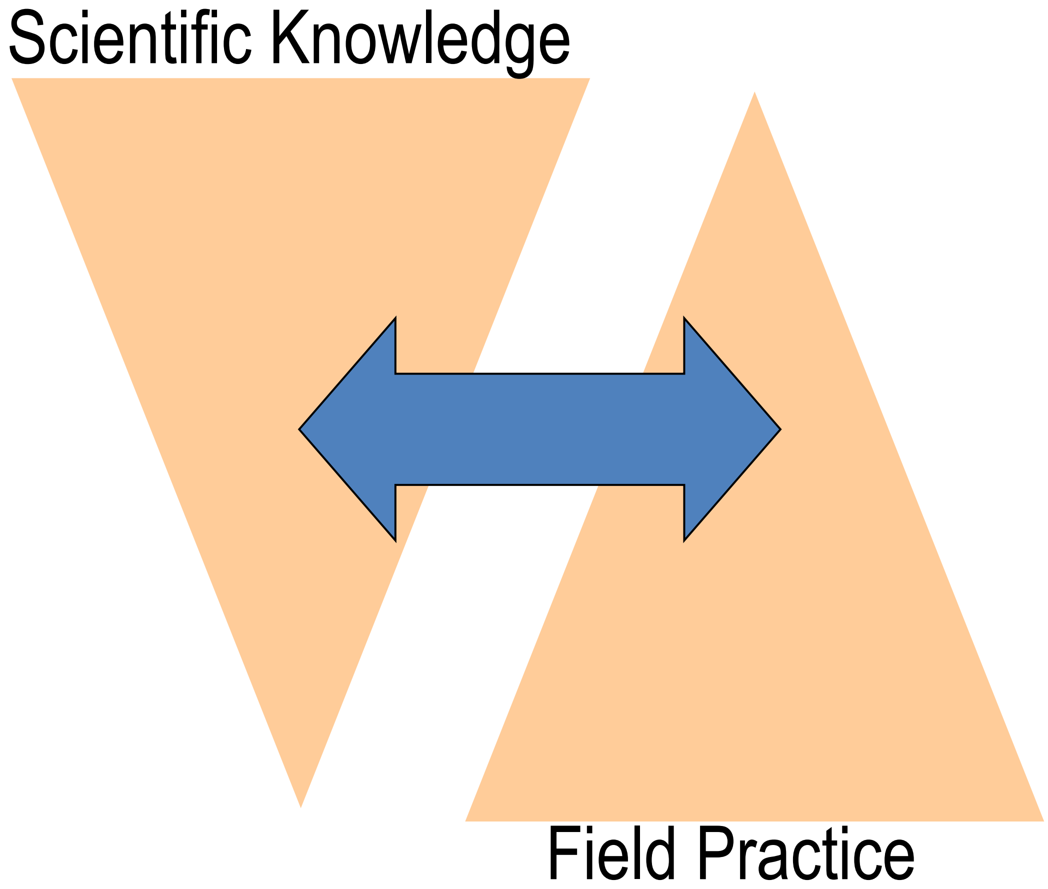
- Ensure **infrastructure robustness** to disasters: The consequences of failure are not catastrophic, but manageable e.g. because critical infrastructure remains in service. Making sure that a system remains functioning during extreme events acknowledges the fact that the possibility of failure cannot be eliminated altogether, and is typical for resilience thinking.

- Increase the **recovery capacity** of a society:

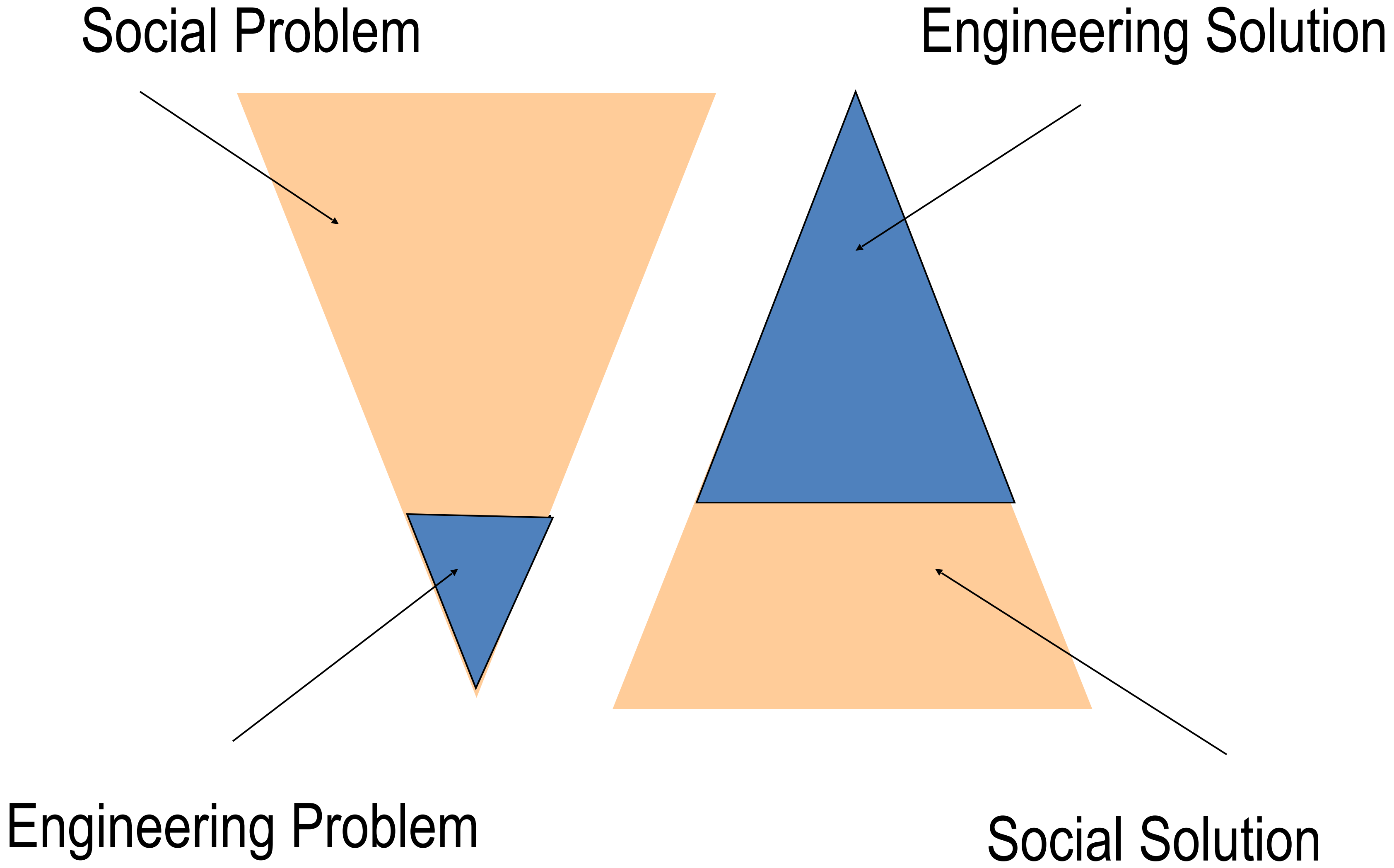
The long-term impact of an extreme event partly depends on the time it takes to recover. The capacity to recover depends on social capital (the individual ability of people to recover), institutional capital (the ability to organise repair and reconstruction), and economic capital (the ability to finance repair and reconstruction).

- Become **resilient into the future**: Flexibility, the ability to learn, the capacity to adapt and the willingness to transform if necessary are crucial to cope with gradual but uncertain changes. It is important to realize that the current resilience of a system may be exhausted due to gradual geo-physical developments such as climate change or subsidence, and socio-economic developments such as migration, conflicts, urbanization and economic growth.

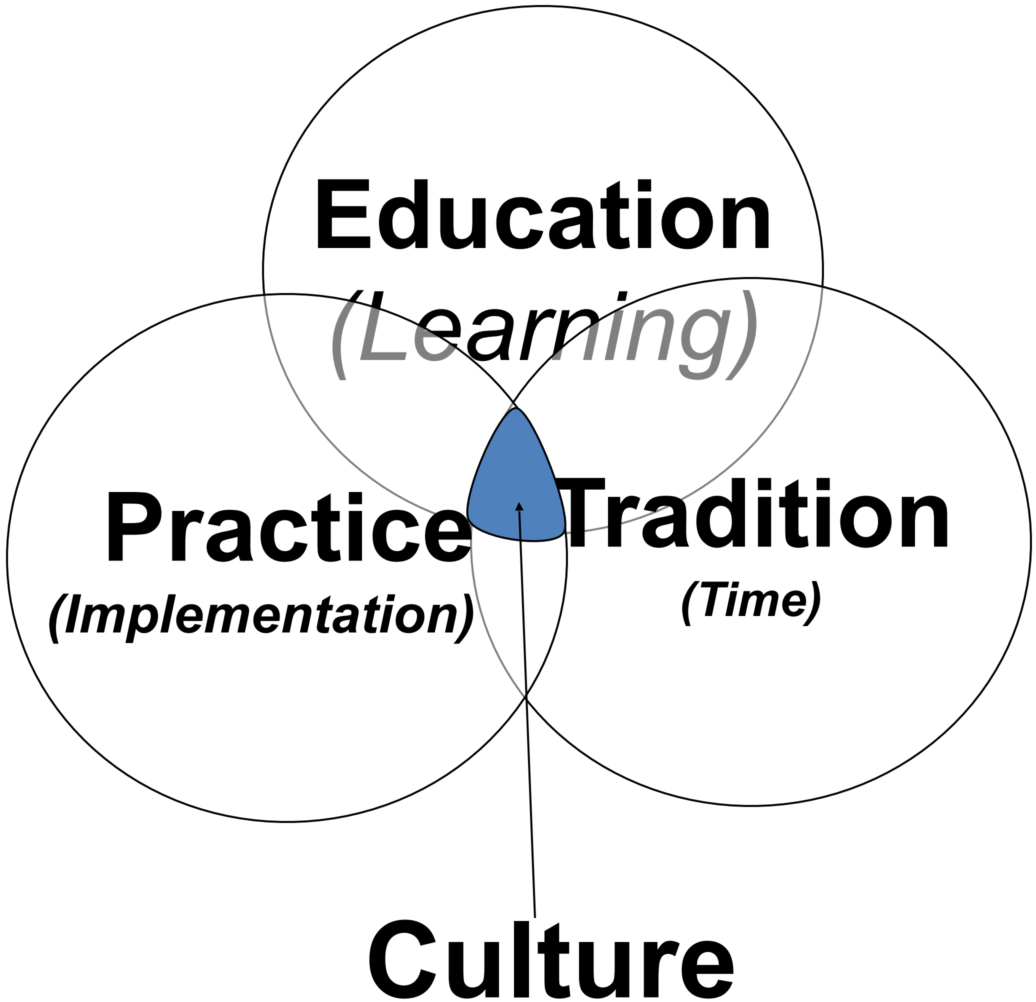
Knowledge & Practice



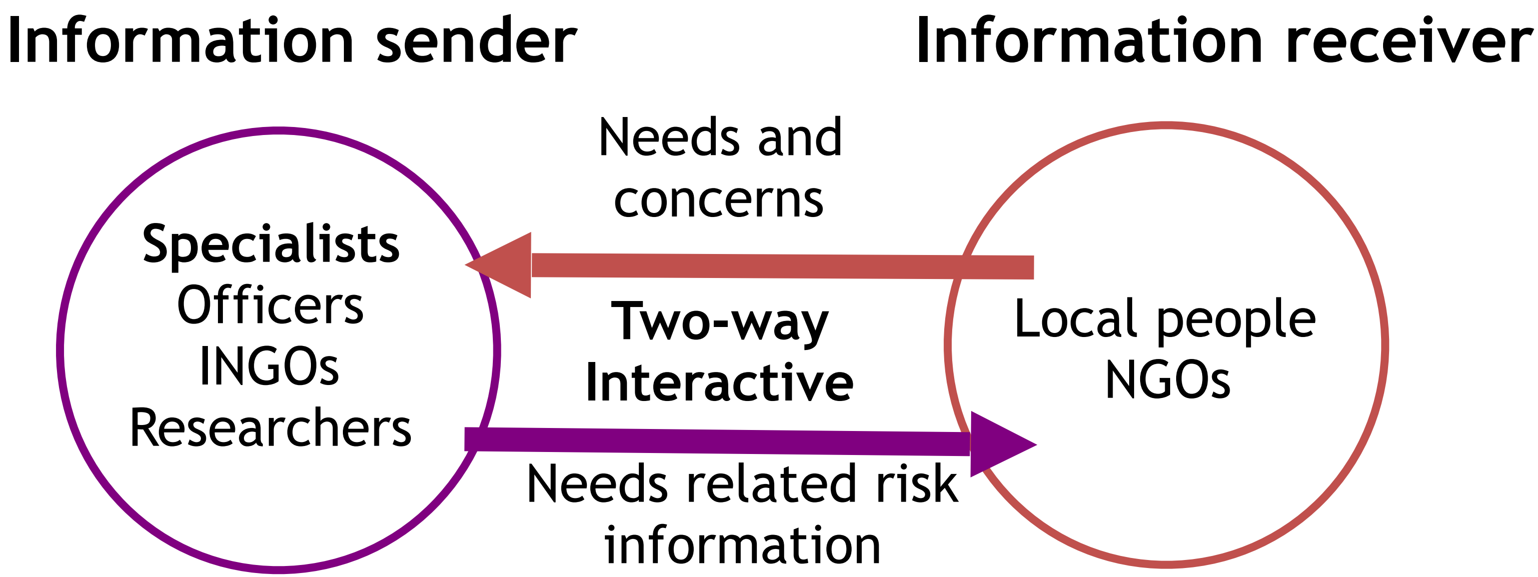
Problem versus Solution



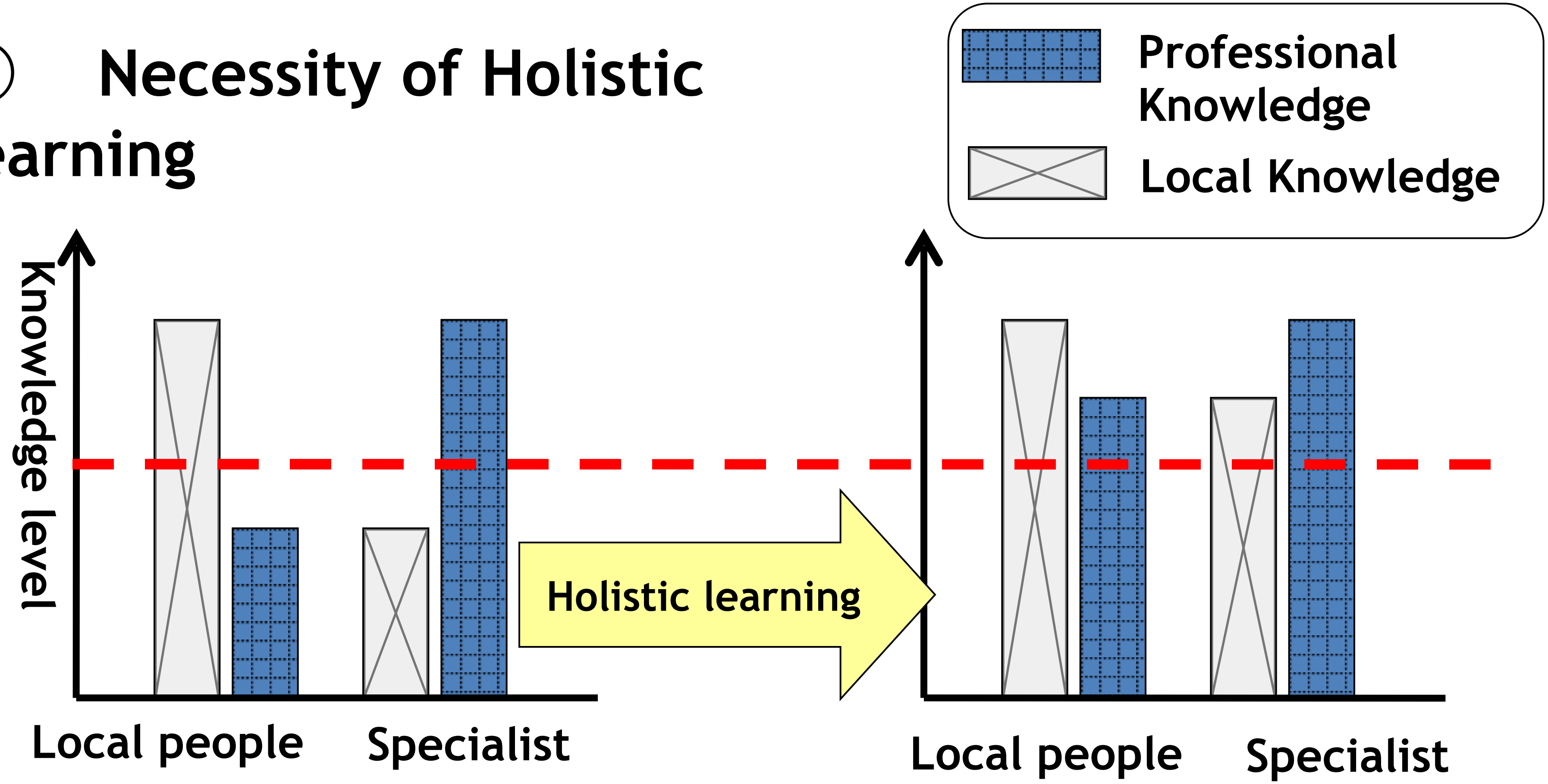
Culture of Preparedness for
Effective Env./ Disaster Management



Risk Communication Framework



① Necessity of Holistic learning



② Necessity of Facilitator

③ Trust with Communities

Policy Issues for Science and Society

Responsibilities of global science

To contribute to post-2015 frameworks, including the Sendai Framework, Agenda 2030, Paris Climate Agreement and the upcoming agenda.

SDG 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

Develop fully global science capacity

Science for the benefit of all societies and "leaving no scientists behind"

Science and Technology for Sustainable Development

Projecting science, technologies and societal change

Challenging science policy and practice

Time to create the 'conditions of possibility', to support science for a sustainable and just world

Integrated Actions on Disaster Risk Reduction

Capacity Enhancement

Regional Offices

Big Science Open Data

Intersecting Issues:

- cities, energy, economy resilience, people, health, … effective decision making

Intersecting Agendas

- Climate change
- Disaster Risk Reduction
- Sustainable Development

Sustainable Development Goals

Integrated Science to Policy

Integration of global-national-local research and programs

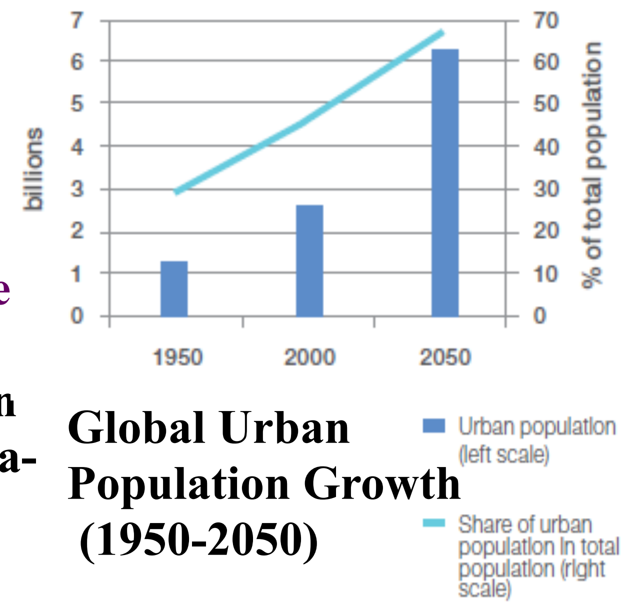
Integrated science

- Works across disciplines and fields - (inter-disciplinarity)
  - Supporting the joint, reciprocal framing, design, execution and application of research
- Works globally - (international collaboration)

  Including the agendas, perspectives, approaches, methods and models of scientists from all parts of the world
- Works with society – (trans-disciplinarity)
  - Engaging decision makers, policy shapers, practitioners, as well as actors from civil society and the private sector as partners in the co-design and co-production of solutions-oriented knowledge, policy and practice
- Science to Policy – via epistemic process – IPCC, IPBES, DRR science assessment, SDG science assessment – integrated assessment process

NEED FOR MAJOR FOCUS
Cities in hot spots of vulnerability

- **Migration from rural areas to cities – a factor - extreme weather, land degradation and desertification**
- **The rapid, inadequate and poorly planned expansion of cities (esp. in developing countries) can also leave urban populations highly exposed to the effects of climate change sea or natural waterways,**
- **15 of the world's 20 megacities – those with over 10 million inhabitants – are located in coastal zones threatened by sea-level rise and storm surges.**



Global Urban Population Growth (1950-2050)

Conclusion: The Importance of City Governance

For rapid urbanization to provide opportunities to all, carefully considered urban planning and good governance with effective regulatory frameworks are required. Inadequate planning and ineffective governance can bring significant economic, social and environmental costs, threatening the sustainability of urban development.

Urban Areas – Challenges for Disaster Risk Reduction, Climate Change and Sustainable Development

Failure of national governance

Failure of urban planning

uturearth

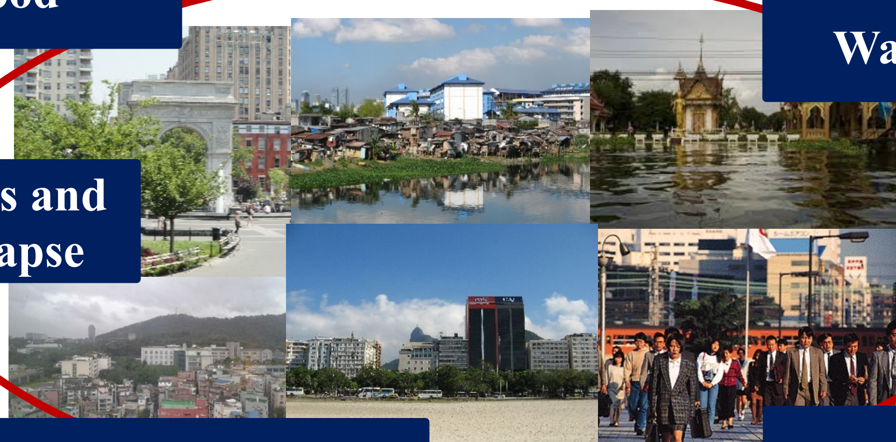
Migration

Natural Catastrophes

IRDR
Integrated Research on Disaster Risk

Food

Water crises



Biodiversity loss and ecosystem collapse

Extreme Weather Events

WCRP
World Climate Research Programme

Health

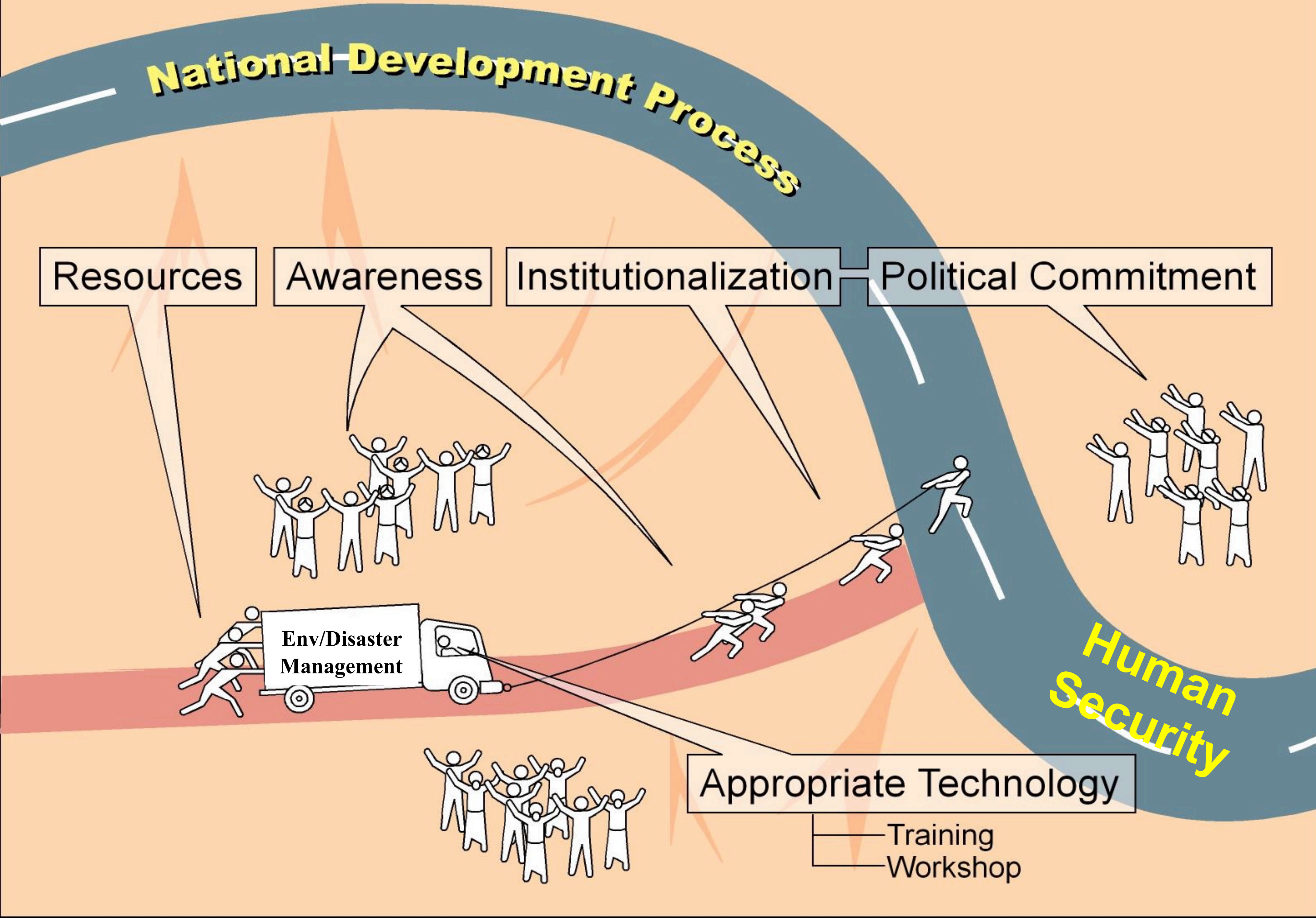
Capacity

URBAN HEALTH AND WELLBEING
A SYSTEMS APPROACH

START
global change SysTem for Analysis, Research and Training

We need to address issues of international and intergenerational equity and ethics – science for evidence-based policies for all.

Resilient Environment & Disaster Management: *Way Ahead*



Cape Town contends with worst drought in over a century

By Derek Van Dam, CNN Meteorologist

Updated 2:39 PM EDT, Wed May 31, 2017

Story highlights

…we have two choices:

- **We can maintain the status quo** and move along as we have for decades—addressing important, immediate issues such as the solvency of the National Flood Insurance Program, the most effective ways to discourage development in high-risk areas, and how to improve the speed and effectiveness disaster response.

Or,

- **We can embark on a new path**—one that also recognizes and rewards the values of resilience to the individual, household, community, and nation. Such a path requires a commitment to a new vision that includes shared responsibility for resilience and one that puts resilience in the forefront of many of our public policies that have both direct and indirect effects on enhancing resilience.

Disaster Resilience, US NAS, 2012, ISBN-13: 978-0-309-26150-0

Florence, Italy

Thank you for your attention