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Reducing risks together

MYRIAD-EU project: multi-risk challenge

Judith Claassen & Philip Ward (IVM VU Amsterdam)
With inputs from the the MYRIAD-EU TEAM

The MYRIAD-EU project has received funding from the European Union's Horizon 2020 research and innovation programme call H2020-LC-CLA-2018-2019-2020 under grant agreement number 101003276

Introductions

menti.com
3124 4309

https://www.menti.com/alcmho4bfy2e

Learning objectives

After this lesson, you should be able to:

- define what is meant by multi-hazard and multi-risk
- describe the complexities of multi-hazard and multi-risk
- describe several state of the art methods and approaches for understanding multi-hazard and multi-risk
- describe how multi-hazard and multi-risk information can be used in disaster risk management

What is multi-hazard?

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How do we define Multi-hazards?

Multi-hazard means (1) the selection of multiple major hazards that the country faces, and (2) the specific contexts where hazardous events may occur simultaneously, cascadingly or cumulatively over time, and taking into account the potential interrelated effects.

UNDRR
UN Office for Disaster Risk Reduction

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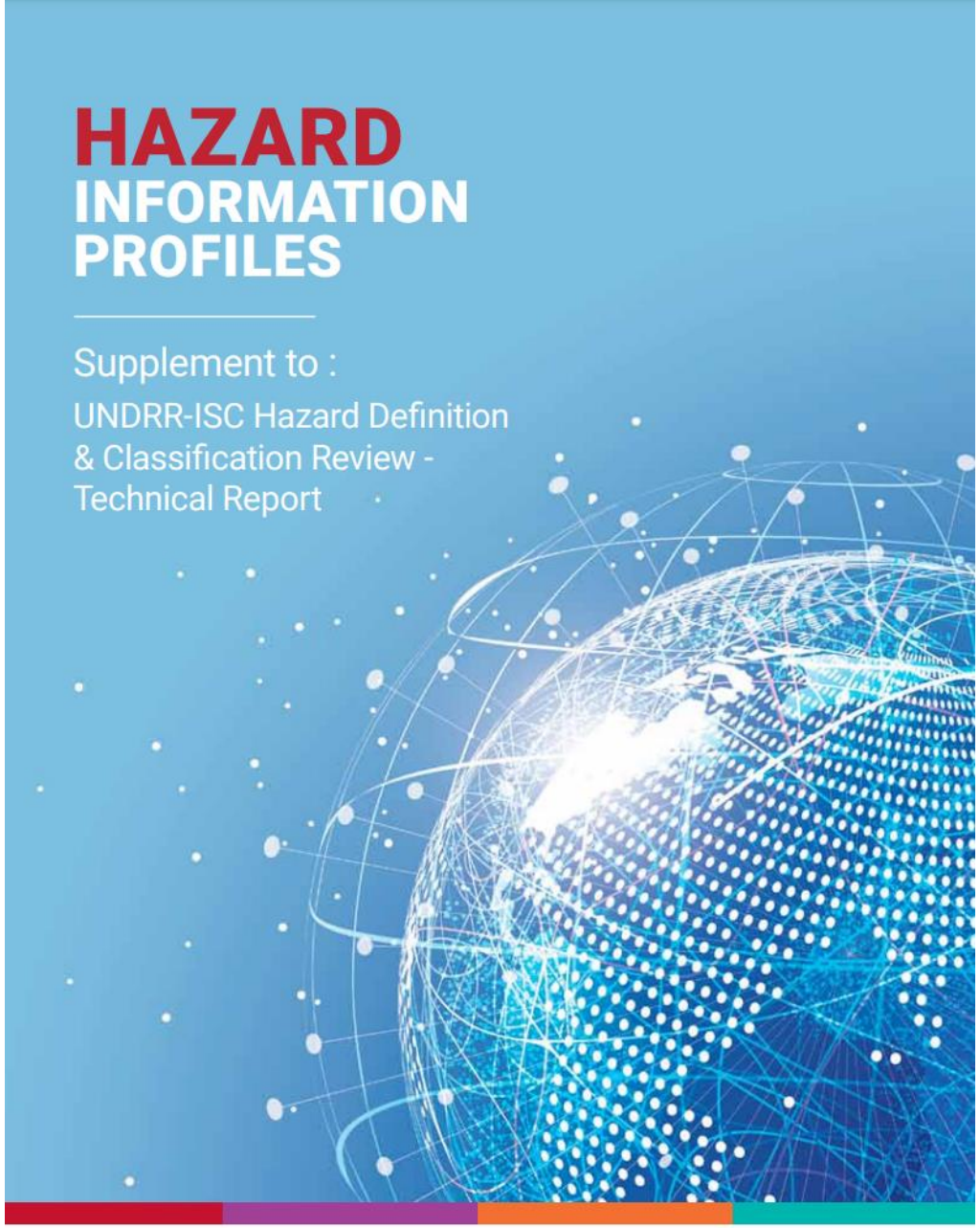
UNDRR
UN Office for Disaster Risk Reduction



302 hazard information profiles (HIPs)

Meteorological and Hydrological

Geohazards

Biological

Environmental

Chemical

Technological

Societal

Extraterrestrial

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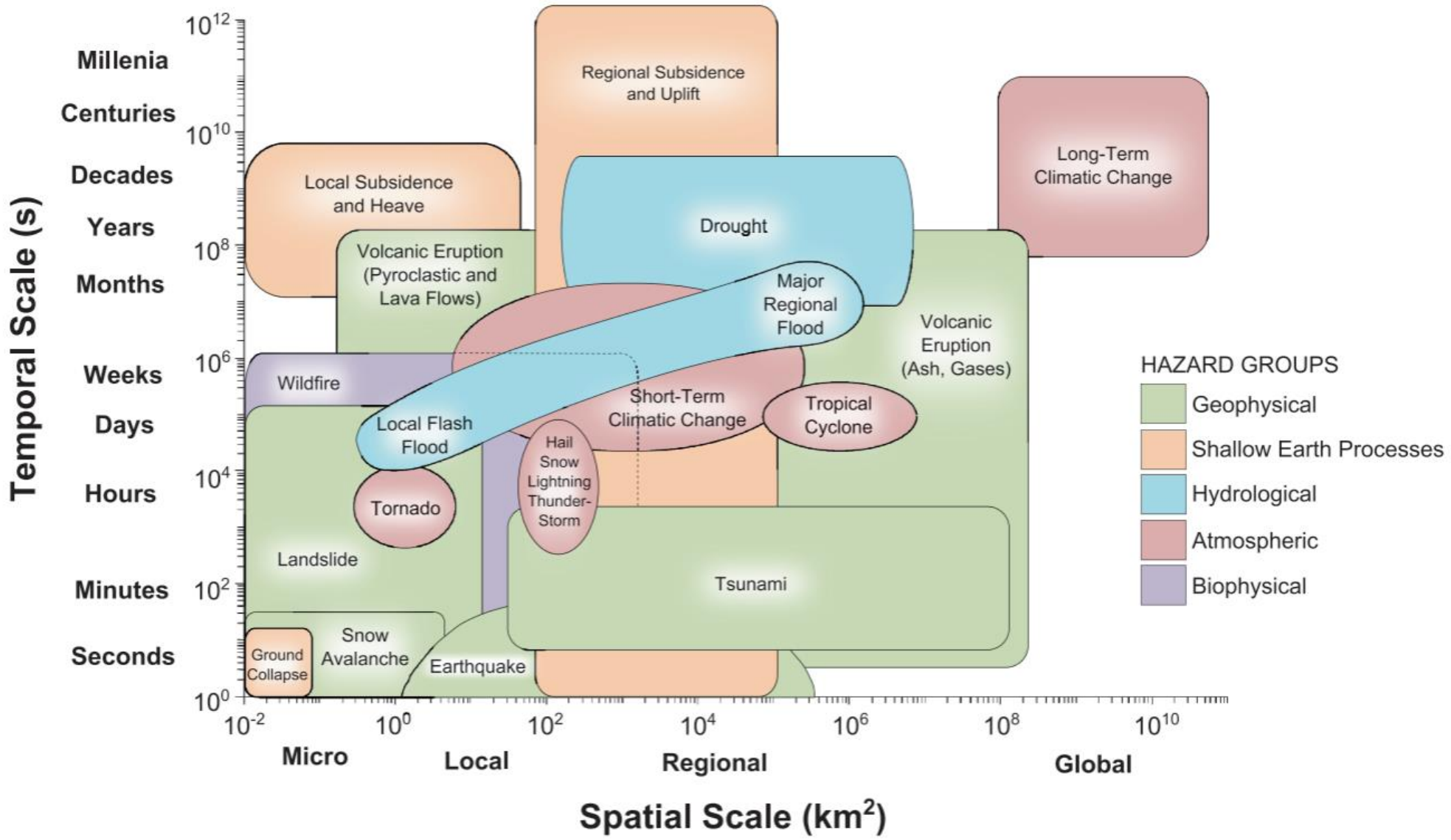

(Gill and Malamud, 2014)

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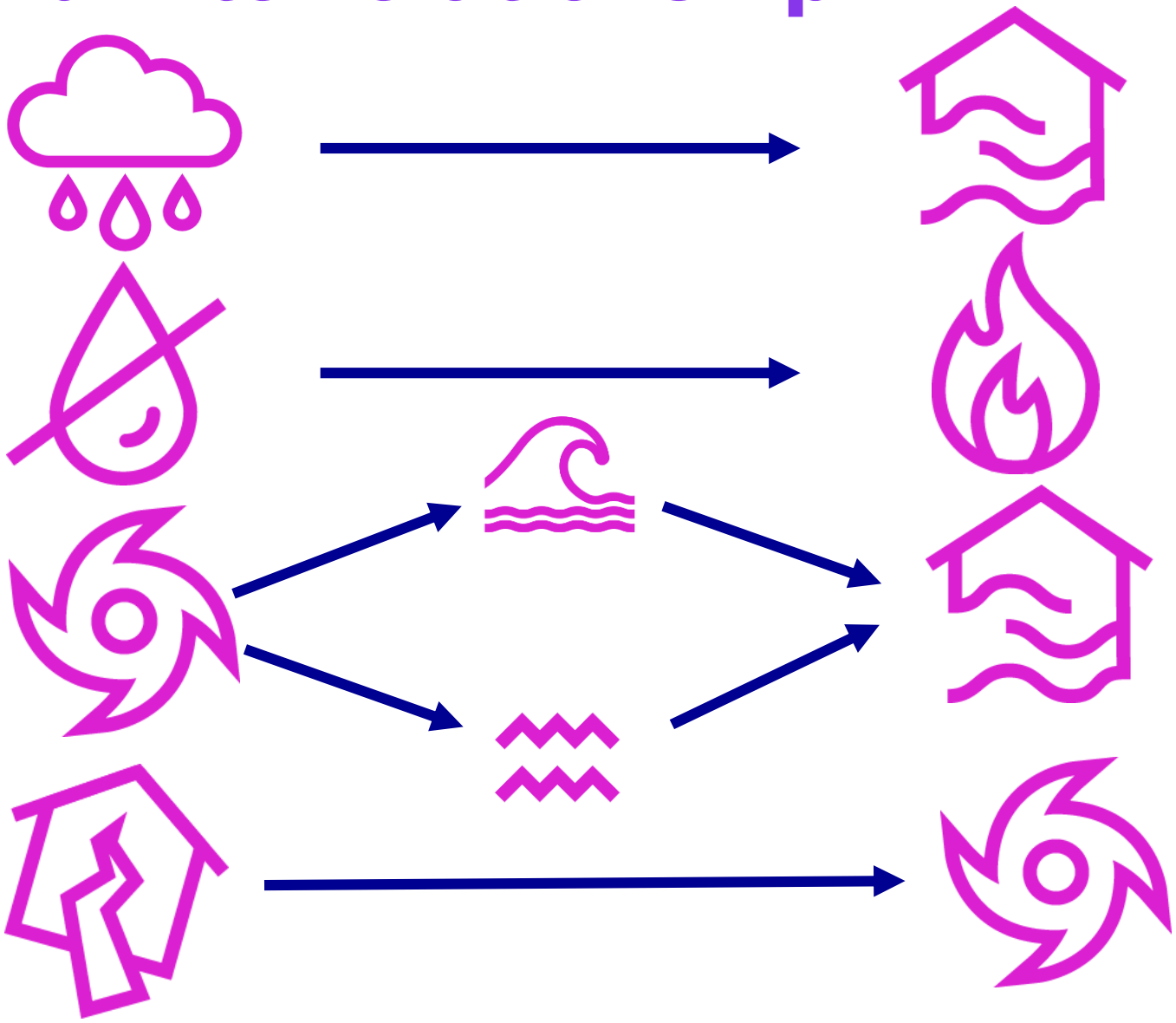
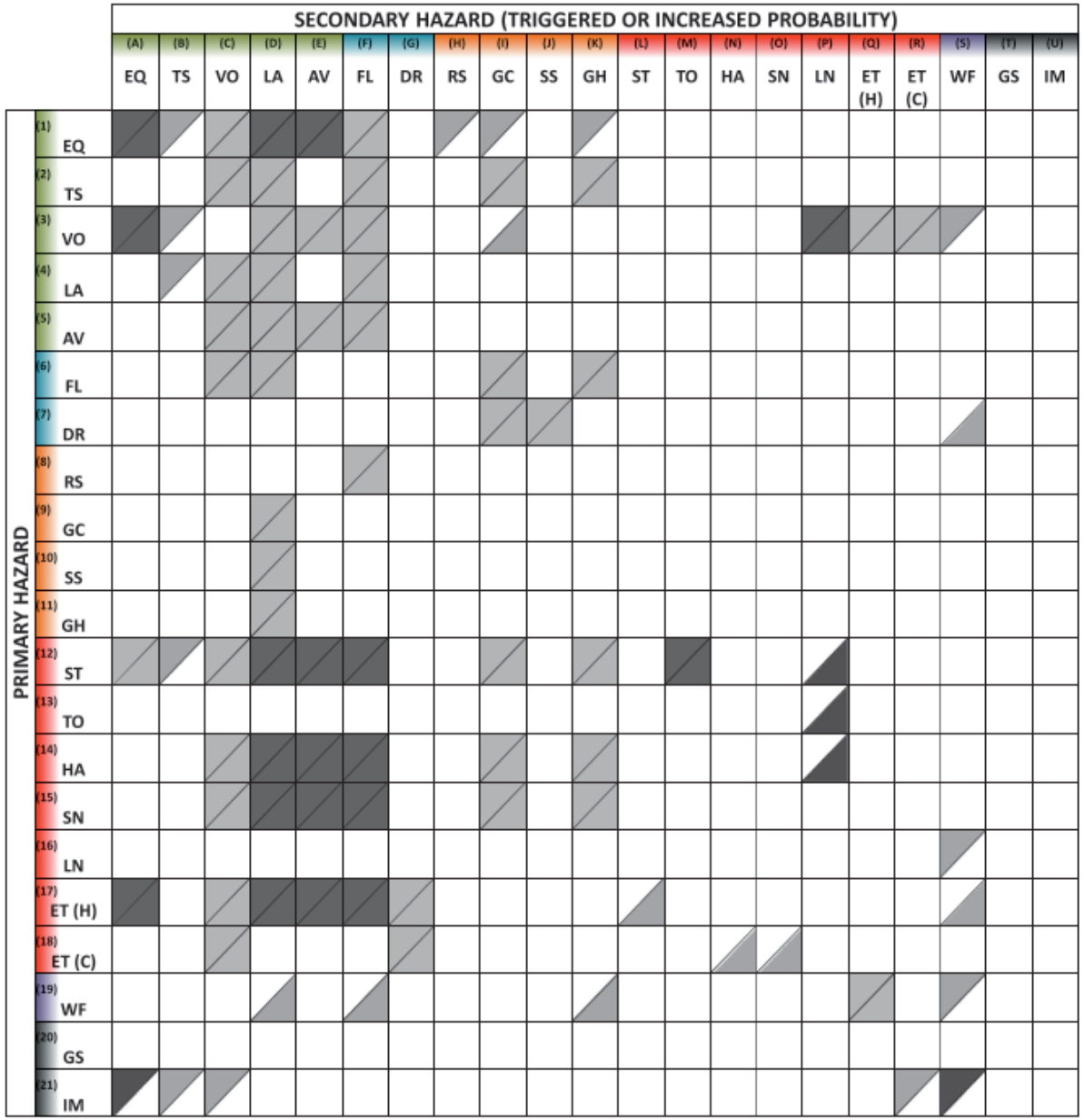
Multi-Hazard Interrelationship

- Triggering
- Amplification
- Compound
- Consecutive





KEY		
HAZARD GROUP	HAZARD	CODE
GEOPHYSICAL	Earthquake	EQ
	Tsunami	TS
	Volcanic Eruption	VO
	Landslide	LA
	Snow Avalanche	AV
HYDROLOGICAL	Flood	FL
	Drought	DR
SHALLOW EARTH PROCESSES	Regional Subsidence	RS
	Ground Collapse	GC
	Soil (Local) Subsidence	SS
	Ground Heave	GH
ATMOSPHERIC	Storm	ST
	Tornado	TO
	Hailstorm	HA
	Snowstorm	SN
	Lightning	LN
	Extreme Temperature (Hot)	ET (H)
	Extreme Temperature (Cold)	ET (C)
BIOPHYSICAL	Wildfires	WF
SPACE	Geomagnetic Storm	GS
	Impact Events	IM

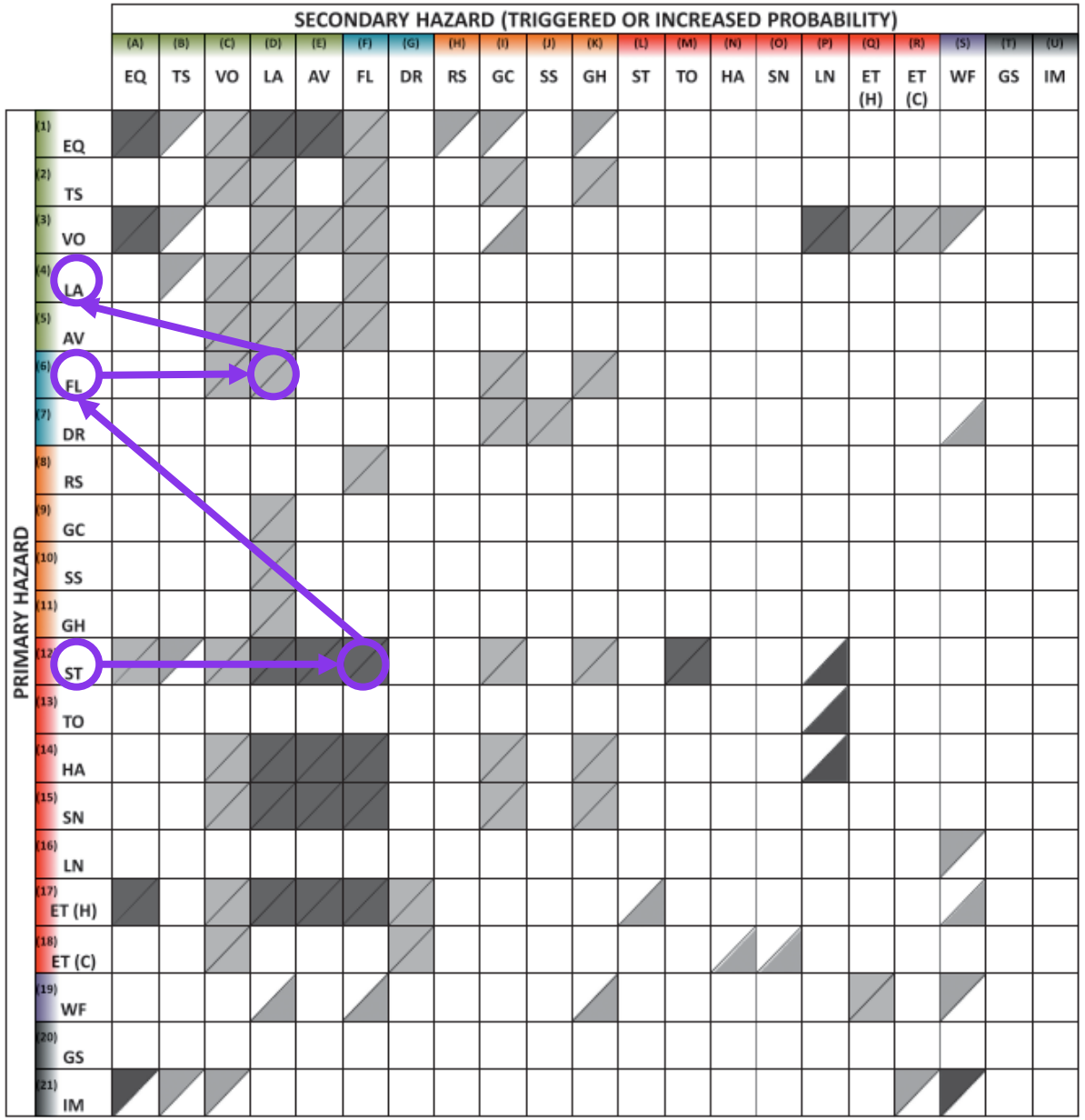
COLOUR CODE	NATURE OF SECONDARY HAZARD (FOLLOWING *ONE* OCCURRENCE OF PRIMARY HAZARD)
	Potential for a small number of hazard events (individual or a few occurrences)
	Potential for a large number of hazard events (multiple occurrences)

SYMBOL	EXPLANATION
	Hazard **Triggers** Secondary Hazard
	Hazard **Increases Probability** of Secondary Hazard
	Hazard Both **Triggers and Increases the Probability** of Secondary Hazard

In this matrix there are **231** possible pairs

Note: With the HIPs there are **45753** possible pairs

(Gill and Malamud, 2014)



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What is multi-risk?

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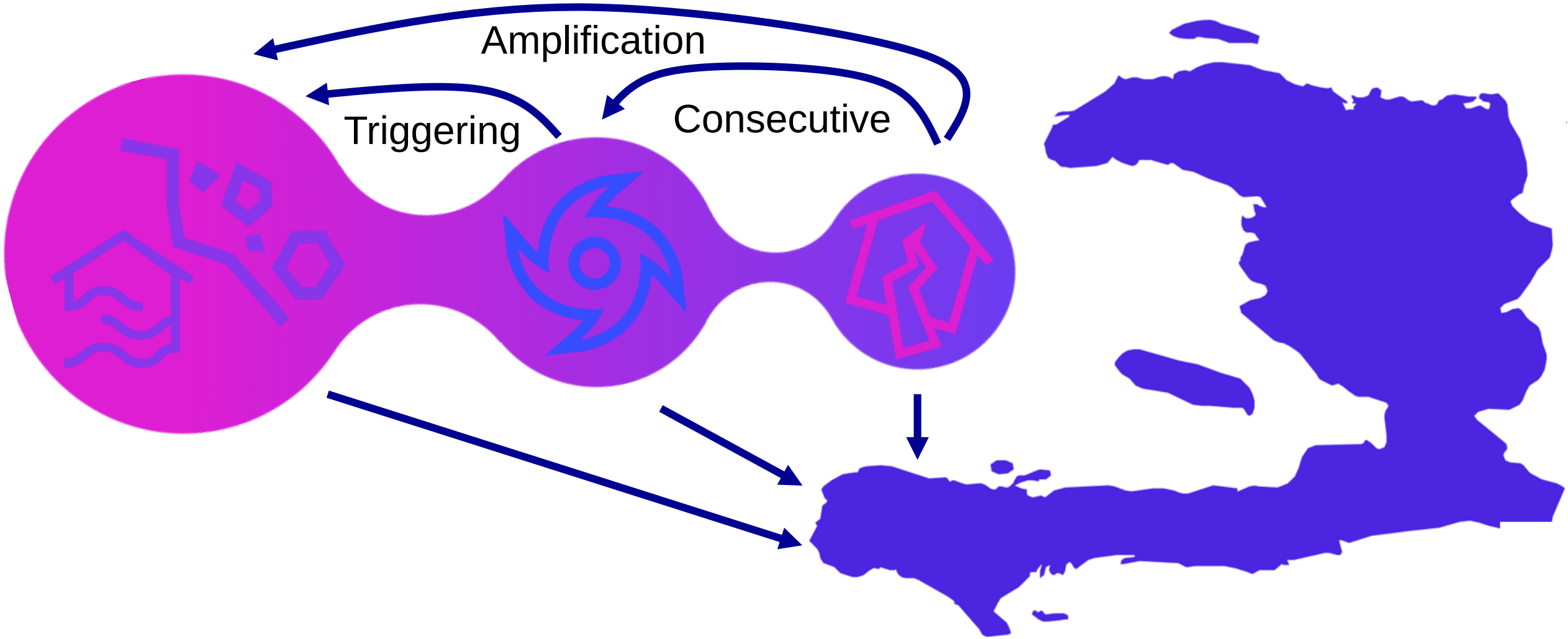
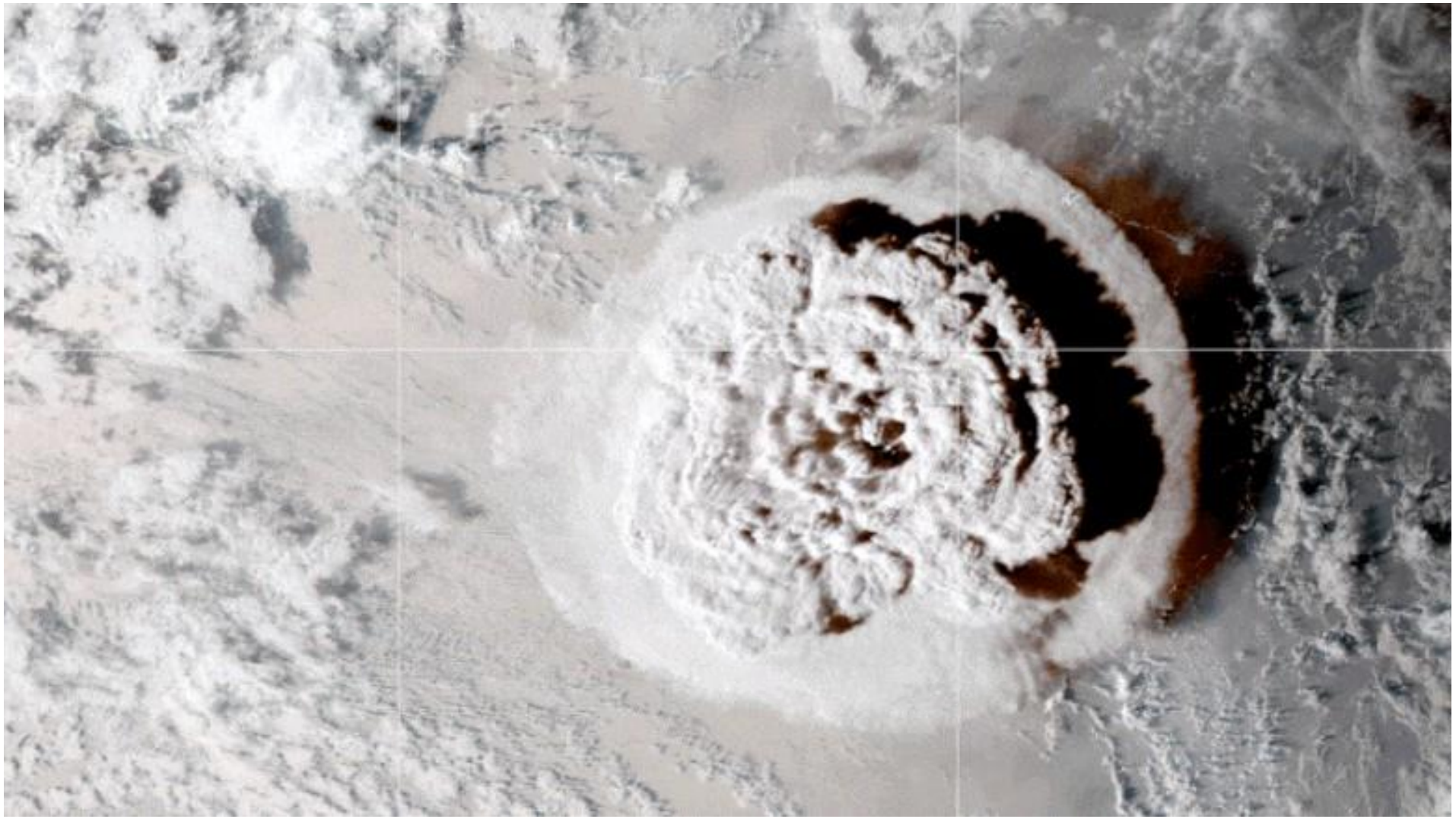
How do we define risk?

Term	Definition	Source
Multi-hazard	“The selection of multiple major hazards that the country faces, and the specific UNDRR (2017) contexts where hazardous events may occur simultaneously, cascadingly or cumulatively over time, and taking into account the potential interrelated effects	UNDRR (2017)
Multi-hazard risk	Risk generated from multiple hazards and the interrelationships between these hazards (**but not considering interrelationships on the vulnerability level**)	Zschau (2017)
Multi-risk	Risk generated from multiple hazards and the interrelationships between these hazards (**and considering interrelationships on the vulnerability level**)	Zschau (2017)
Multi-(hazard)-risk	Used to refer to the terms above collectively	Ward et al. (2022)

Haiti 2021



Hunga Tonga – Hunga Ha’apai eruption



Hunga Tonga eruption

Tsunami Santa Cruz, California

Foreign aid delivery

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Multiple hazards can have **interrelated effects** on risk

Triggering

Amplifying

How can risk be better managed by considering these interrelated effects?

Compound

Consecutive

MYRIAD-EU: Vision and aim

- **Vision:** to catalyse the paradigm shift required to move towards a multi-risk, multi-sector, systemic approach to risk assessment and management.

- **Aim:** by the end of MYRIAD-EU policy-makers, decision-makers, and practitioners will be able to develop forward-looking disaster risk management pathways that assess trade-offs and synergies across sectors, hazards, and scales

Definitions and concepts

Handbook

D1.2
Handbook of Multi-hazard, Multi-Risk Definitions and Concepts

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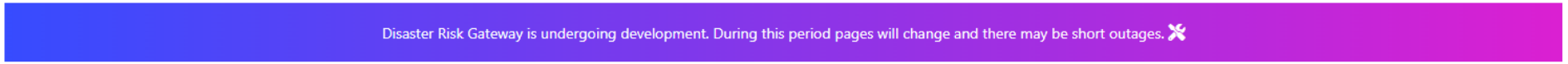
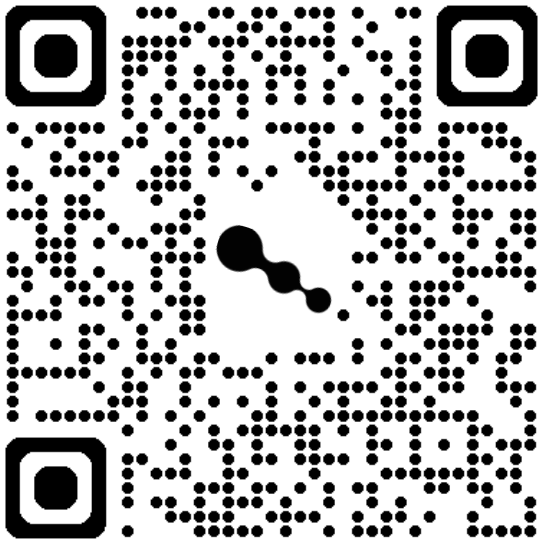
WP1 Disaster Risk Gateway





Welcome to Disaster Risk Gateway; an open access, editable wiki for discovery and sharing of approaches for understanding, analysing, and managing multi-hazard and multi-hazard risks. This growing catalogue of platforms, frameworks, methods, models, tools, and resources has been created as part of the MYRIAD-EU project.

Disaster Risk Gateway has been developed for multi-hazard and risk researchers, academics, practitioners, policy makers, educators, and students. If you would like to become a contributor to the wiki, visit the Contribute page to learn how.


About


Catalogue


Definitions


Contribute

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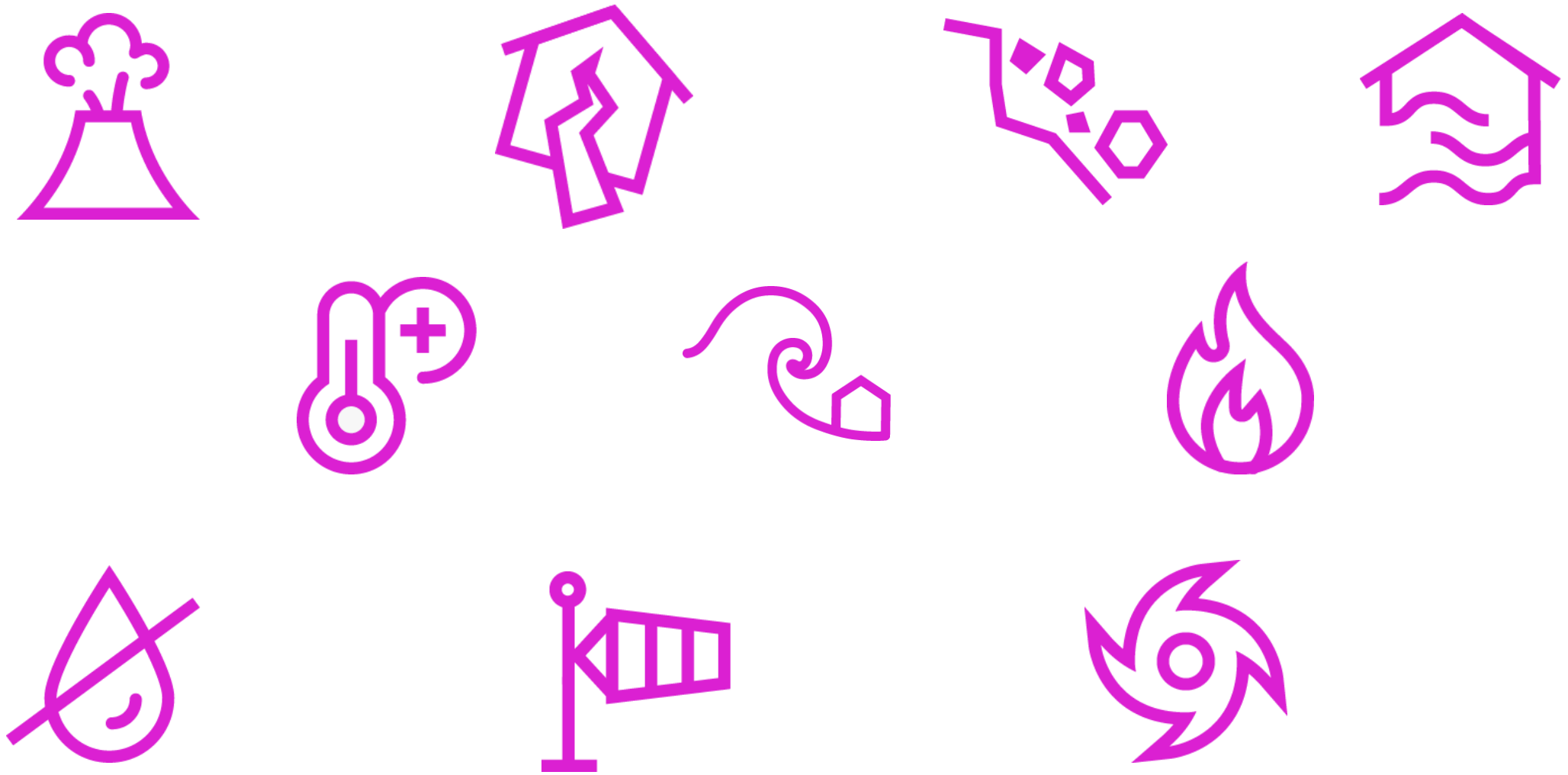
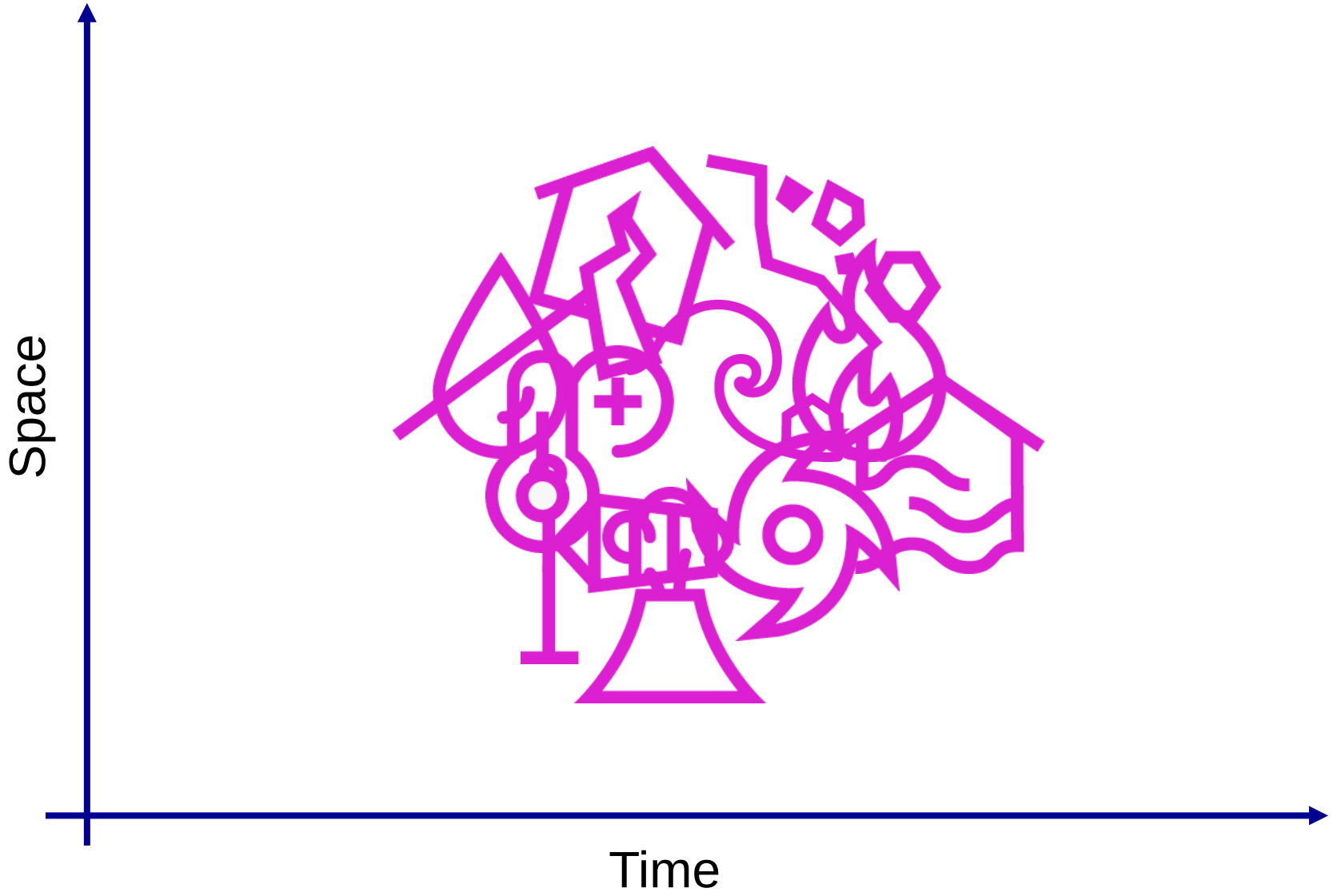
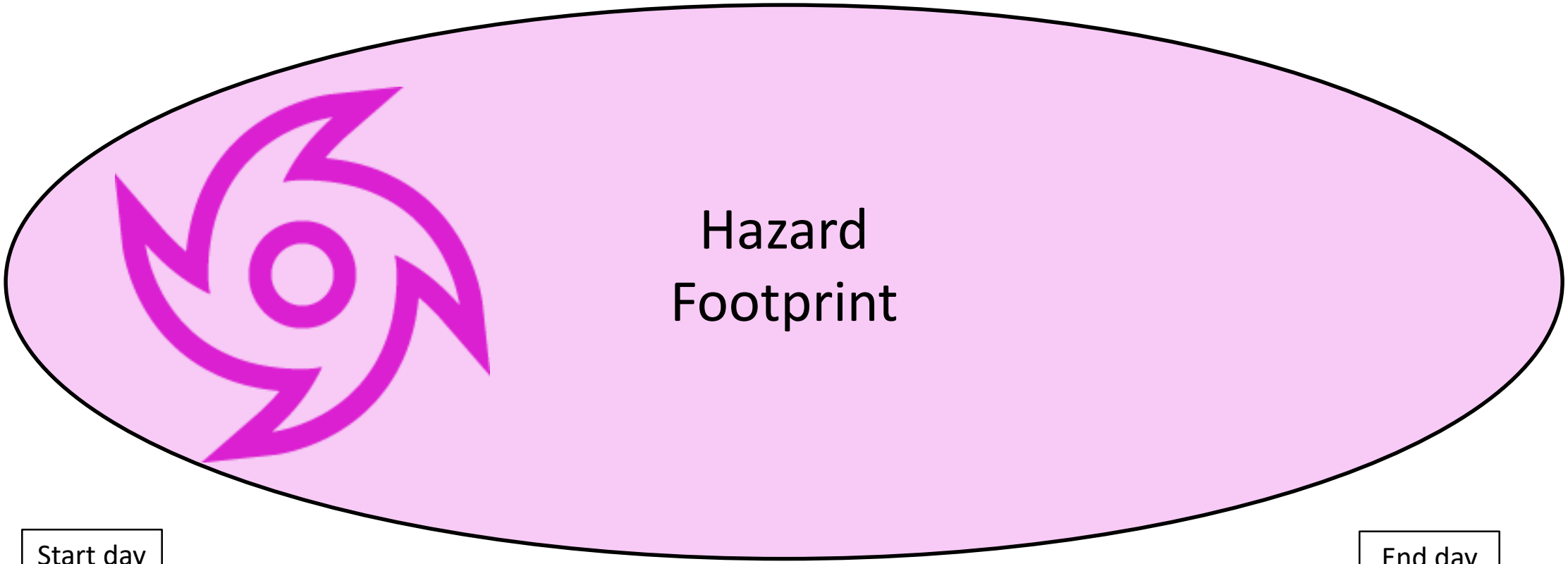
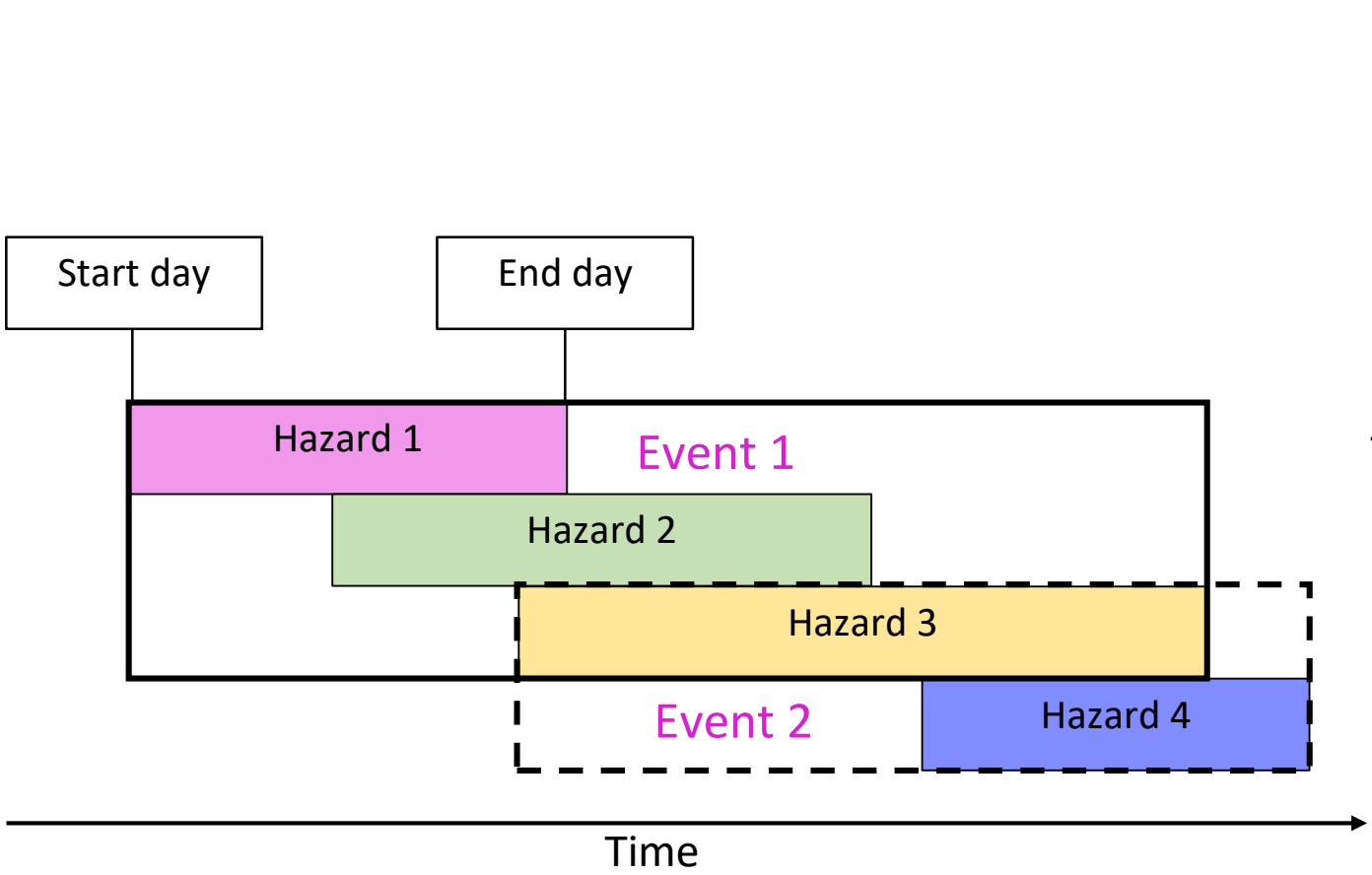
Multi-hazard event sets

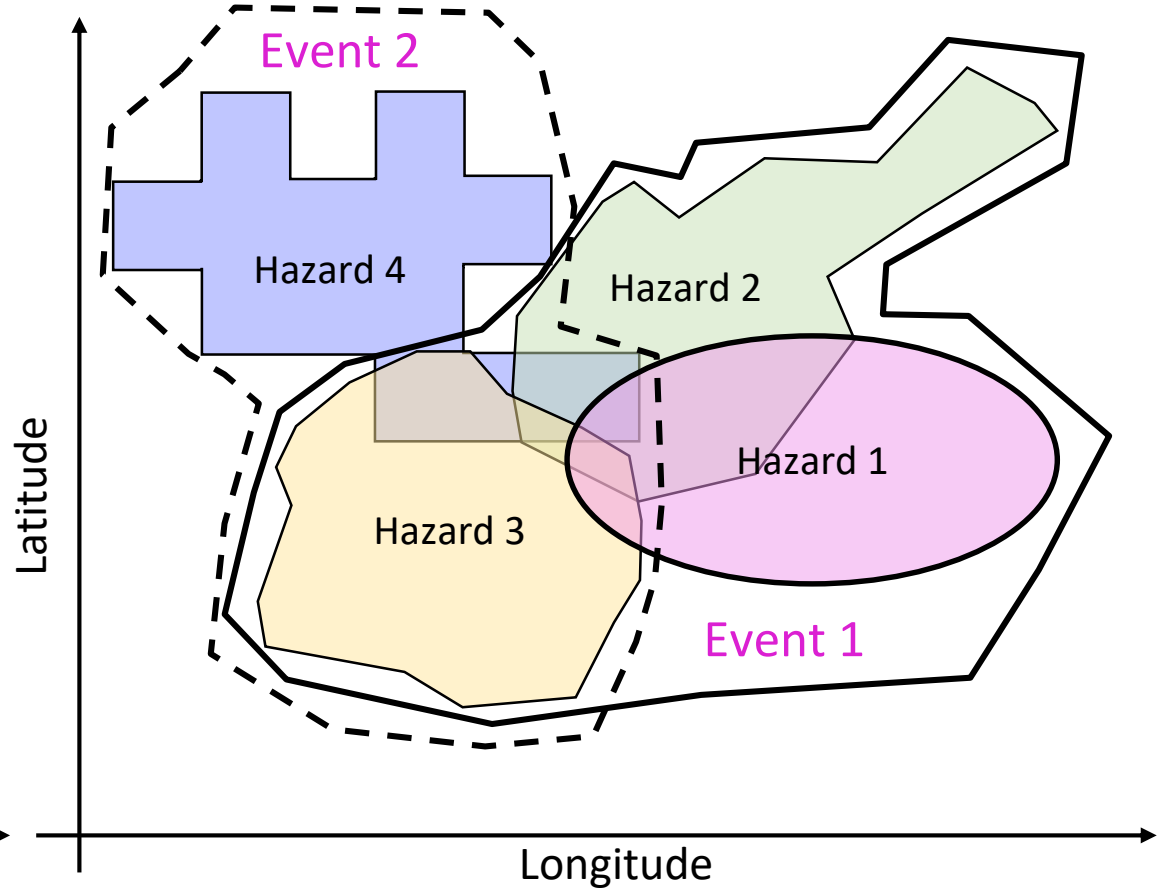



Space
Time

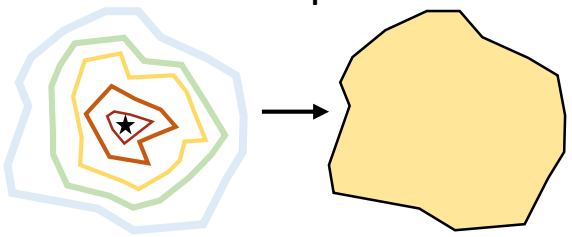

Hazard
Footprint
Start day
End day
Duration

MYRIAD-HESA: MYRIAD – Hazard Event Sets Algorithm





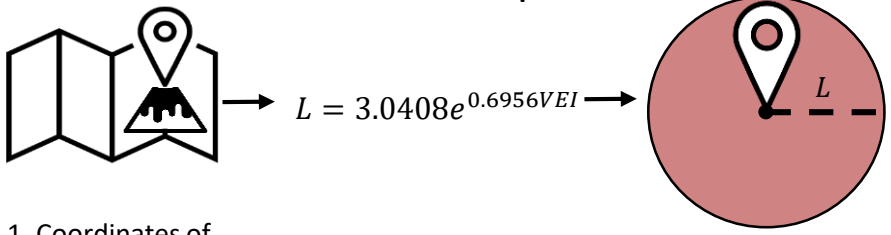
Earthquake



1. Define the outer bound where the MMI is at least five

2. **Final polygon**

Volcanic Eruption

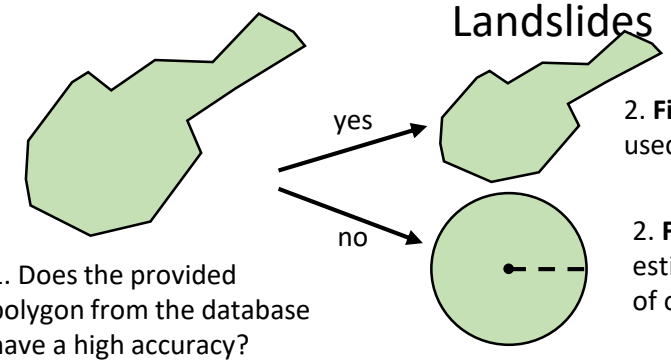


1. Coordinates of volcanic eruption and VEI

2. Calculate radius of influence

3. **Final polygon**

Landslides

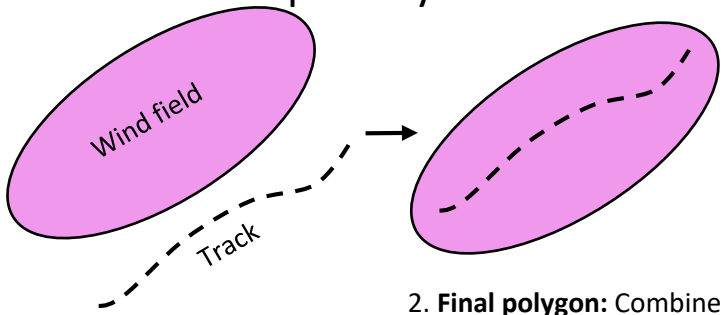


1. Does the provided polygon from the database have a high accuracy?

2. **Final polygon**: polygon is used as provided

2. **Final polygon**: polygon is estimated based on coordinates of occurrence and fixed radius

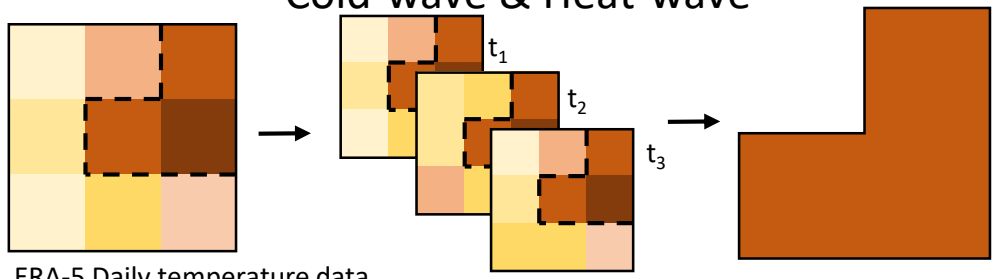
Tropical Cyclone



1. Wind field from WRN-TC and track from IBTrACS

2. **Final polygon:** Combine track and wind field based on tropical cyclone name and year

Cold-wave & Heat-wave

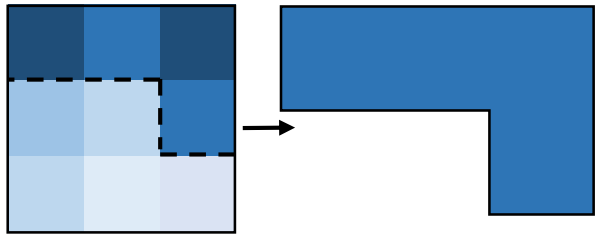


1. ERA-5 Daily temperature data, calculate the daily extremes (< 5 percentile for cold wave, > 95 percentile for heat-wave).

2. See where temperatures are extreme for at least three consecutive days

3. **Final polygon**

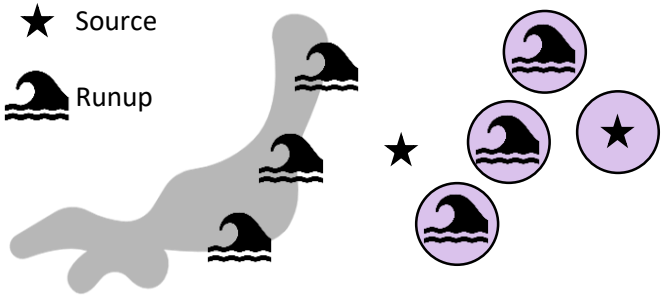
Extreme Wind



1. ERA-5 Maximum daily wind gust data, calculate the daily extremes (> 99 percentile). Max wind of polygon above 15 ms-1

2. **Final polygon**

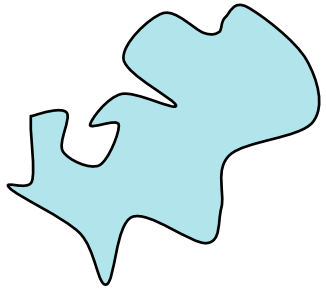
Tsunami



1. Source and runup data Global Historic Tsunami database

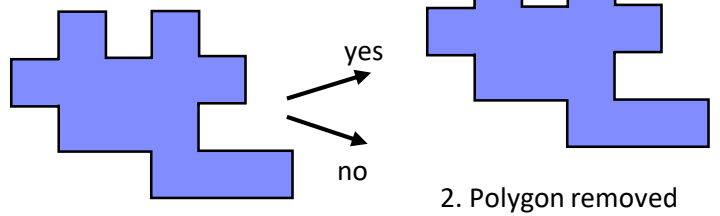
2. **Final polygon**

Flood



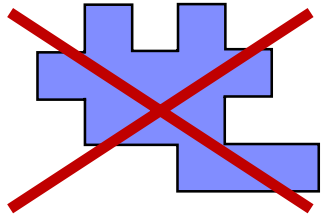
1. **Final polygon:** taken directly from The Global Flood Database

Wildfire



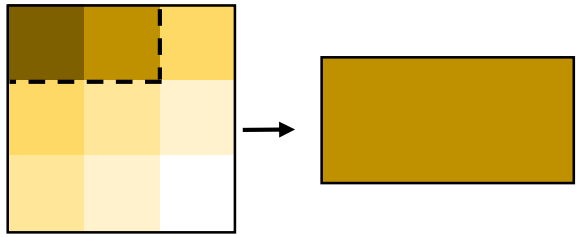
2. **Final polygon**

2. Polygon removed from dataset



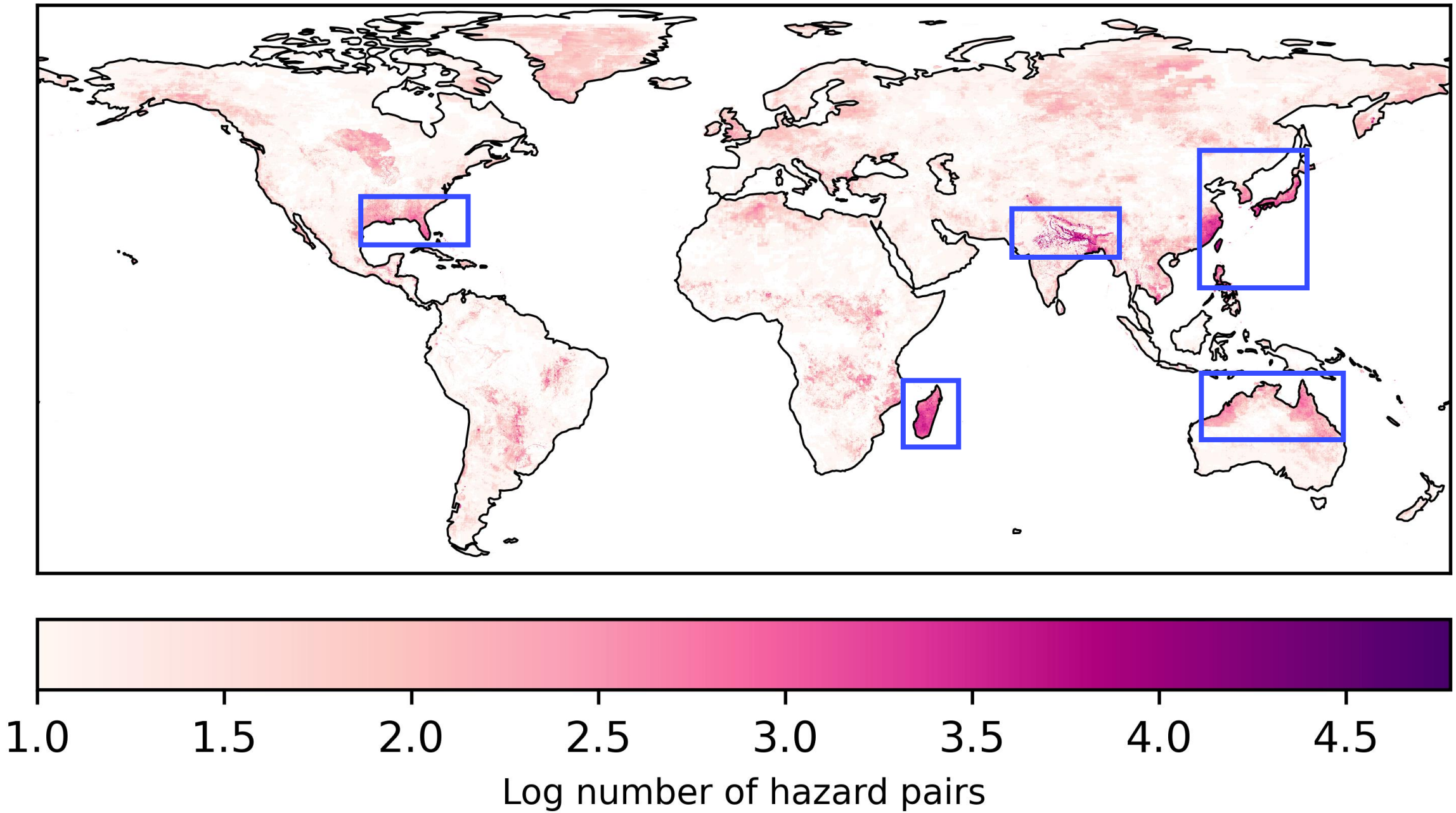
1. Polygon from the global wildfire dataset. Is the area of the polygon above 5 km^2 and the duration of the wildfire at least 3 days?

Drought

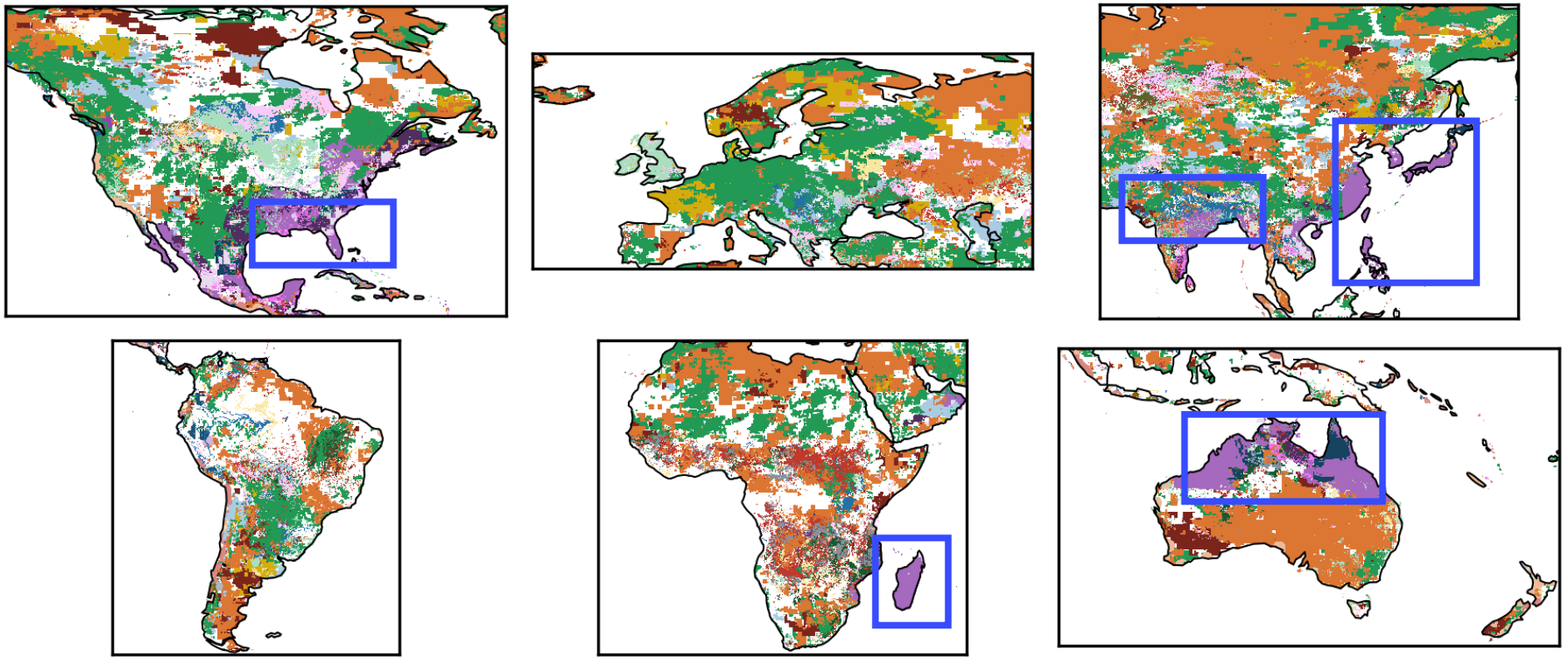


1. GDO SPI-3 (3-month Standardized Precipitation Index) monthly data below 1.3

2. **Final polygon**


1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
Log number of hazard pairs

Most Frequent Hazard Pair Between 2004 and 2017



20 Most Frequent

dr & hw	ew & cw	fl & hw	ew & wf	dr & ts
hw & ew	dr & ew	fl & fl	tc & hw	eq & ts
tc & ew	hw & wf	fl & dr	dr & tc	tc & tc
dr & cw	fl & ew	dr & wf	fl & tc	fl & cw

cw: coldwave

dr: drought

eq: earthquake

ew: extreme wind

fl: flood

hw: heatwave

ls: landslide

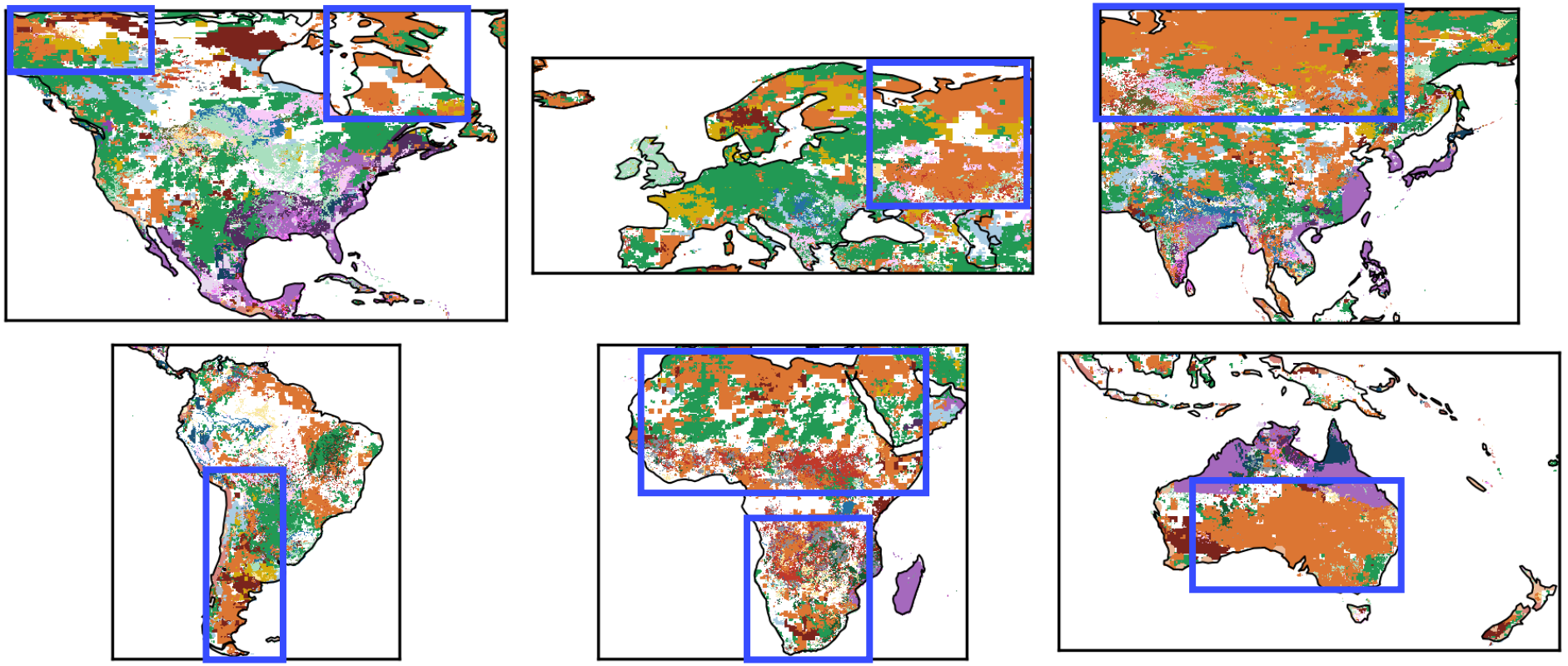
tc: tropical cyclone

ts: tsunami

vo: volcanic eruption

wf: wildfire

Most Frequent Hazard Pair Between 2004 and 2017



20 Most Frequent

dr & hw	ew & cw	fl & hw	ew & wf	dr & ts
hw & ew	dr & ew	fl & fl	tc & hw	eq & ts
tc & ew	hw & wf	fl & dr	dr & tc	tc & tc
dr & cw	fl & ew	dr & wf	fl & tc	fl & cw

cw: coldwave

dr: drought

eq: earthquake

ew: extreme wind

fl: flood

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ls: landslide

tc: tropical cyclone

ts: tsunami

vo: volcanic eruption

wf: wildfire

MYRIAD-HESA: global multi-hazard dataset

www.nature.com/scientificreports

scientific reports

Check for updates

OPEN

A new method to compile global multi-hazard event sets

Judith N. Claassen[1]✉, Philip J. Ward[1,2], James Daniell[3,4], Elco E. Koks[1], Timothy Tiggeloven[1] & Marleen C. de Ruiter[1]

Impact

From Case Studies to Global Data (EM-DAT)

How are multi-hazard impacts different from single-hazard impacts?

Dr. Wiebke Jäger

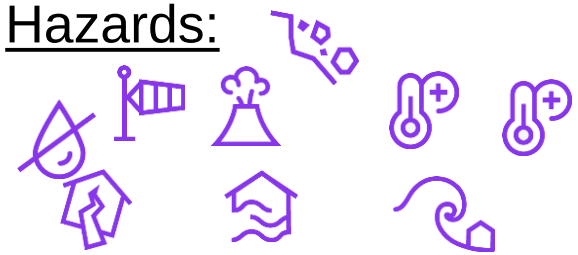
Input data

EM-DAT[1]: Socio-economic impact data

GDIS[2]: Spatial footprints on admin-level

Period: 2010 – 2018

Hazards:

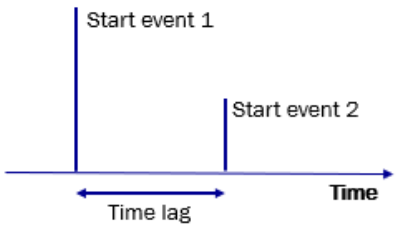


Single & Multi-Hazard Identification

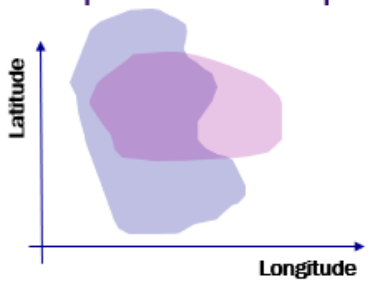
Adapted MYRIAD-HESA algorithm[3]:

1 . EM-DAT multi-hazard information

2. Time lag

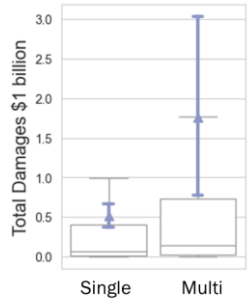


3. Spatial overlap

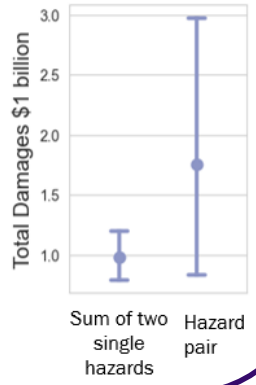


Statistical Analysis of Impacts

Single hazard vs. hazard pair impacts



Sum of two single hazard vs. hazard pair impacts



1: Guha-Sapir et al. (2014), 2: Rosvold & Buhaug (2021); 3: Claassen et al. (2023)

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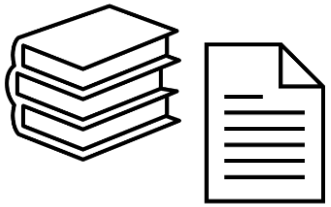
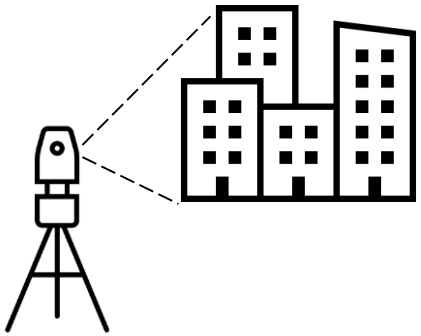
Vulnerability

VulneraCity: urban vulnerability dynamics



3000+ articles reviewed*

6 natural hazards**



Focus on empirical drivers

Tristian Stolte, MSc.
tristian.stolte@vu.nl

VulneraCity - The urban vulnerability drivers database

Stolte, Tristian; Koks, Elco; de Moel, Hans; Reimann, Lena; van Vliet, Jasper; de Ruiter, Marleen; Ward, Philip

Paper

*Based on a systematic literature review of peer-reviewed scientific articles
**Pluvial flooding, waterborne diseases, earthquakes, drought, heatwaves, coastal flooding

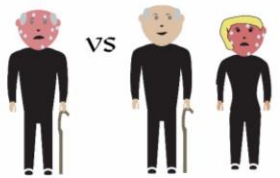
VulneraCity: urban vulnerability dynamics

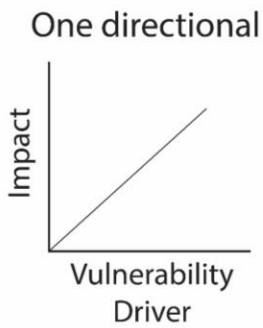
	Hazard	Vulnerability_dimension	Vulnerability_sub_dimension	Vulnerability_class	Vulnerability_drivers	Acquisition_method	Source(s)
16	Coastal_flooding	Physical	Critical_Infrastructure	Hazard_Protection	Hardenend infrastructure	Empirical	https://doi.org/10.1016/j.jort.2020.100346
17	Coastal_flooding	Physical	Critical_Infrastructure	Hazard_Protection	Watertight utility conduits	Empirical	Wilson, M. T. (2020). Assessing voluntary resilience standards
18	Coastal_flooding	Physical	Critical_Infrastructure	Hazard_Protection	Mobile gates at coastal inlets	Adopted	Strozzi, T., Teatini, P., & Tosi, L. (2009). TerraSAR-X reveals the ir
19	Coastal_flooding	Physical	Critical_Infrastructure	Medical_Capacity/Equipment	Hospitals in flood prone areas	Empirical	Allen, T. R., Crawford, T., Montz, B., Whitehead, J., Lovelace, S.,
20	Coastal_flooding	Physical	Critical_Infrastructure	Preparedness	Anticipating climate change in urban systems	Theoretical	Allen, T. R., Crawford, T., Montz, B., Whitehead, J., Lovelace, S.,
21	Coastal_flooding	Physical	Critical_Infrastructure	Redundancy	Critical infrastructure density	Adopted	Karamouz, M., & Zahmatkesh, Z. (2017). Quantifying Resilience
22	Coastal_flooding	Physical	Critical_Infrastructure	Transport/Traffic	Designating roads that should not be flooded du	Empirical	Allen, T. R., Crawford, T., Montz, B., Whitehead, J., Lovelace, S.,
23	Coastal_flooding	Physical	Critical_Infrastructure	Transport/Traffic	Important traffic hubs in the flood zone	Modelled	Fang, Z., Wu, Y., Zhong, H., Liang, J., & Song, X. (2021). Revealing
24	Coastal_flooding	Physical	Critical_Infrastructure	Transport/Traffic	Elevated walkways	Adopted	Ferrarin, C., Valentini, A., Vodopivec, M., Klaric, D., Massaro, G.,
25	Coastal_flooding	Physical	Critical_Infrastructure	Transport/Traffic	Elevated metro entrance	Theoretical	Zhang, Y., Ayyub, B. M., Zhang, D., Huang, H., & Saadat, Y. (2019).
26	Coastal_flooding	Physical	Critical_Infrastructure	Transport/Traffic	Public transport systems that connect compacted	Theoretical	Duy, P. N., Chapman, L., Tight, M., Linh, P. N., & Thuong, L. V. (201
27	Coastal_flooding	Physical	Critical_Infrastructure	Transport/Traffic	Emergency exits that lead to evacuation routes	Theoretical	Duy, P. N., Chapman, L., Tight, M., Linh, P. N., & Thuong, L. V. (2018
28	Coastal_flooding	Physical	Critical_Infrastructure	Transport/Traffic	Port dependency	Empirical	Becker, A. H., Matson, P., Fischer, M., & Mastrandrea, M. D. (201
29	Coastal_flooding	Physical	Critical_Infrastructure	Transport/Traffic	Elevated roads	Empirical	Lasage, R., Veldkamp, T. I. E., de Moel, H., Van, T. C., Phi, H. L., V
30	Coastal_flooding	Physical	Critical_Infrastructure	Transport/Traffic	Elevated ports	Adopted	Becker, A. H., Matson, P., Fischer, M., & Mastrandrea, M. D. (201
31	Coastal_flooding	Physical	Critical_Infrastructure	Transport/Traffic	Road condition	Modelled	Buchori, I., Pramitasari, A., Pangi, P., Sugiri, A., Maryono, M., Bas

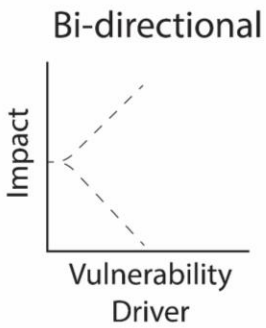
Snippet of VulneraCity

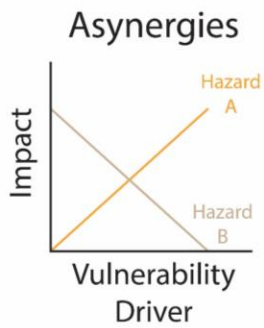
VulneraCity: urban vulnerability dynamics

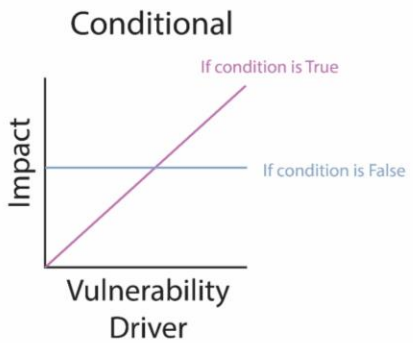
Beyond static vulnerability-impact relationships:
directional dynamics of vulnerability

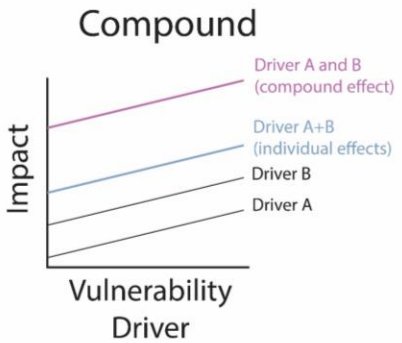


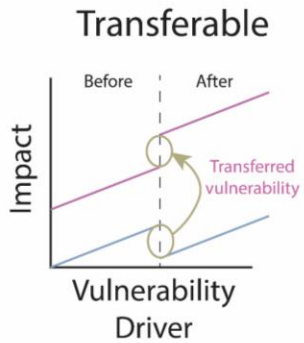


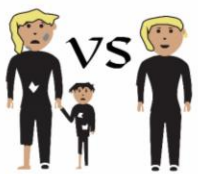






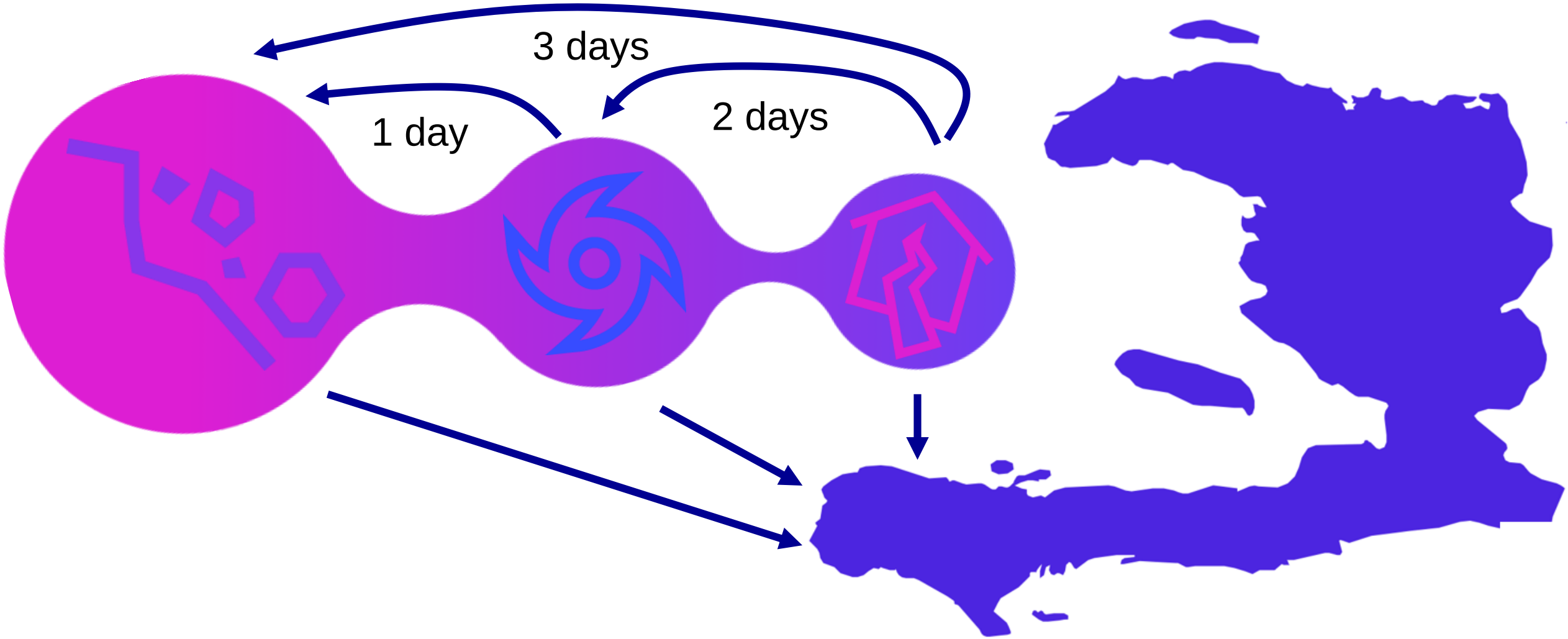




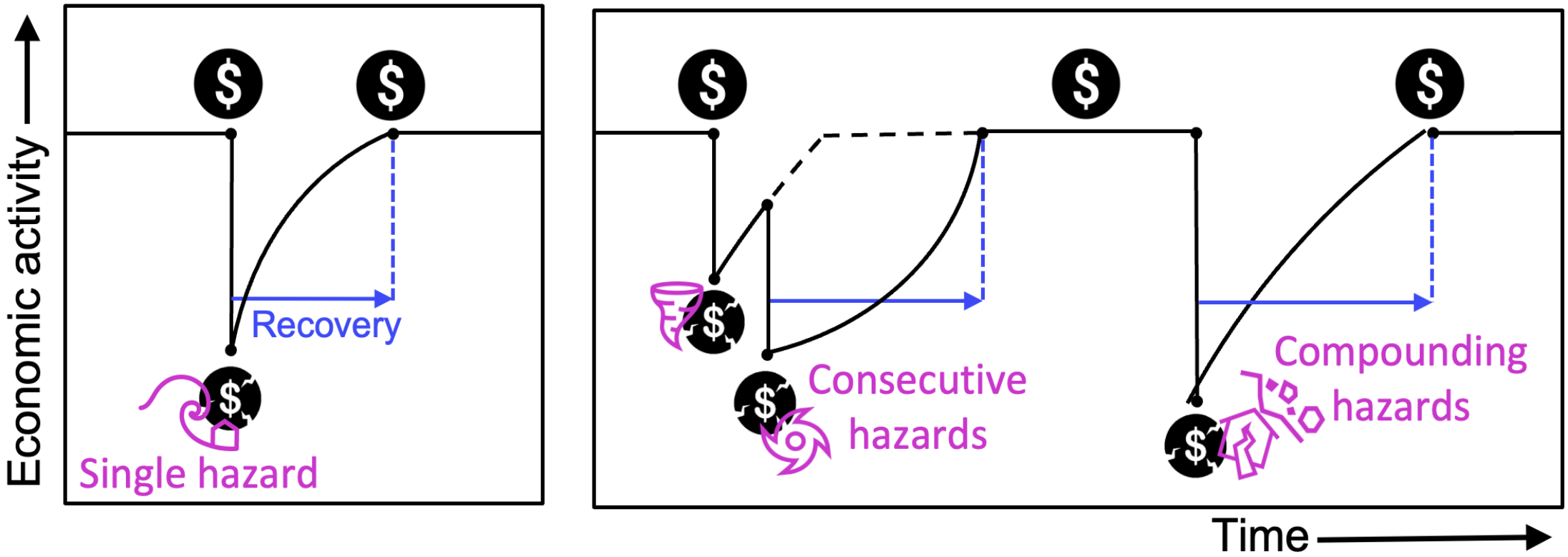


Recovery

Time-lag

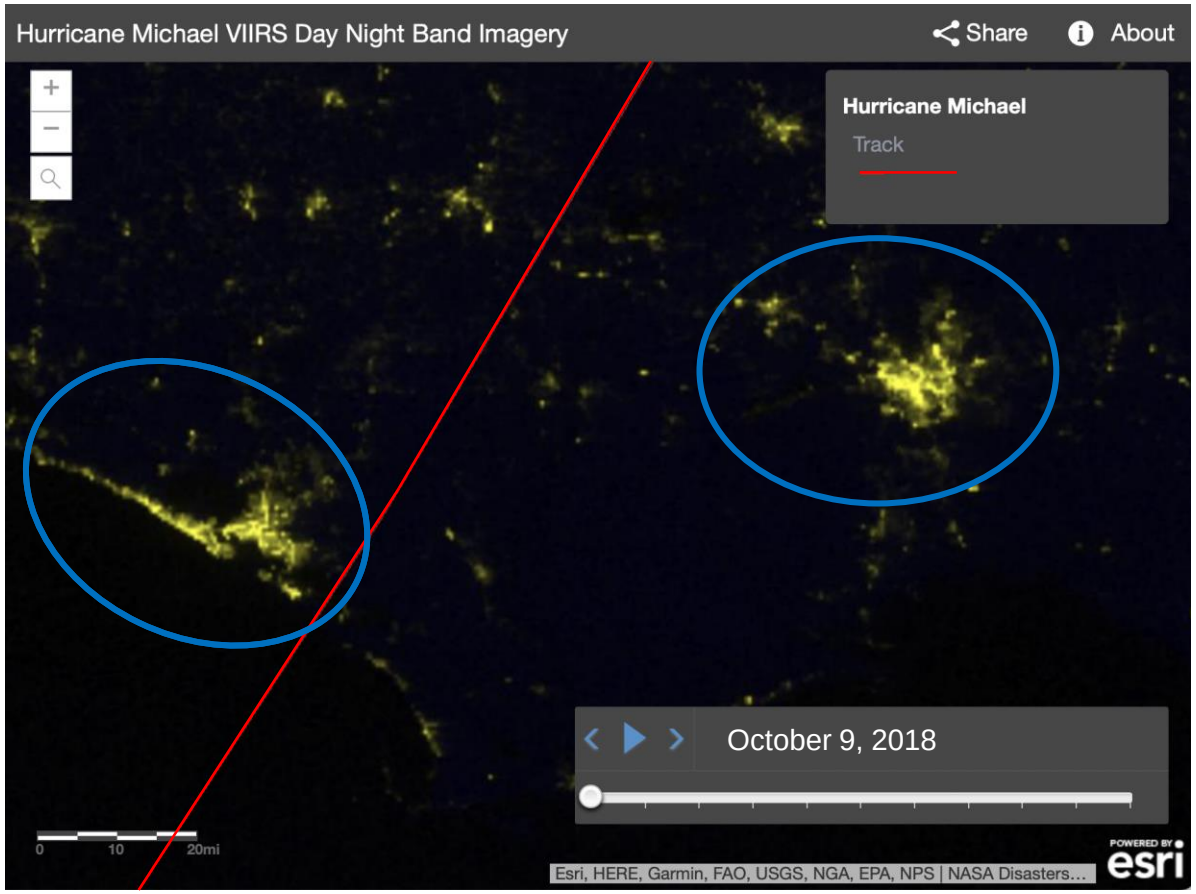


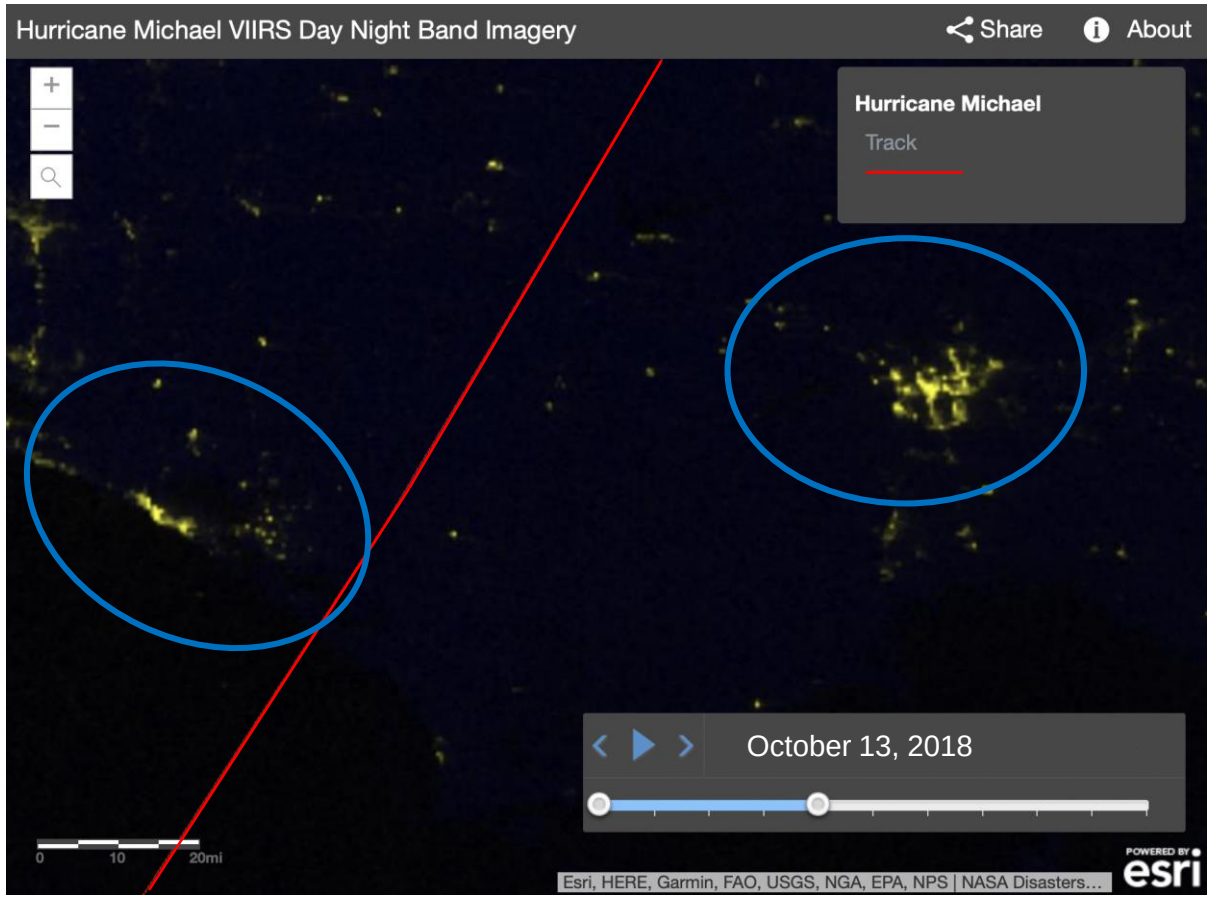
Recovery rates from nighttime light data



Sophie Buijs (IVM VU Amsterdam)

Recovery rates from nighttime light data

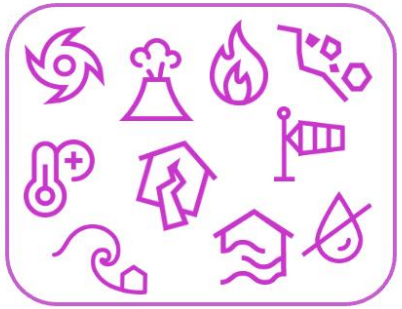




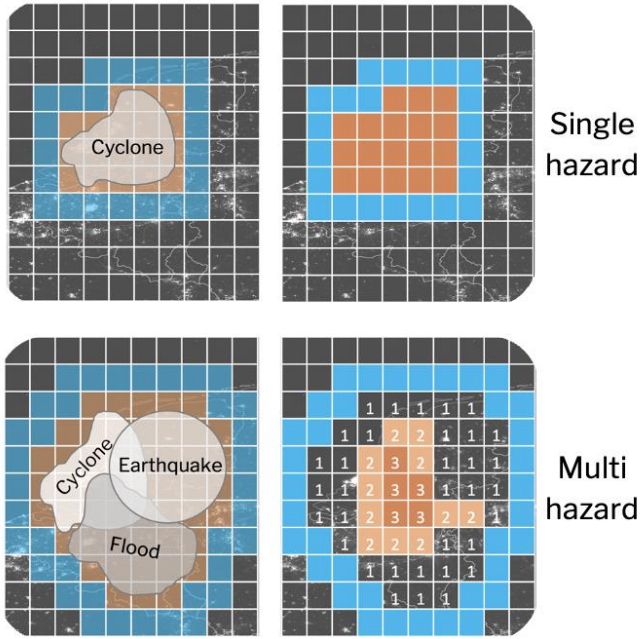
Recovery rates from nighttime light data

Nighttime light data
NASA's Black Marble corrected daily nighttime light composites (2012-present, 500m), are used as a proxy for economic activity.

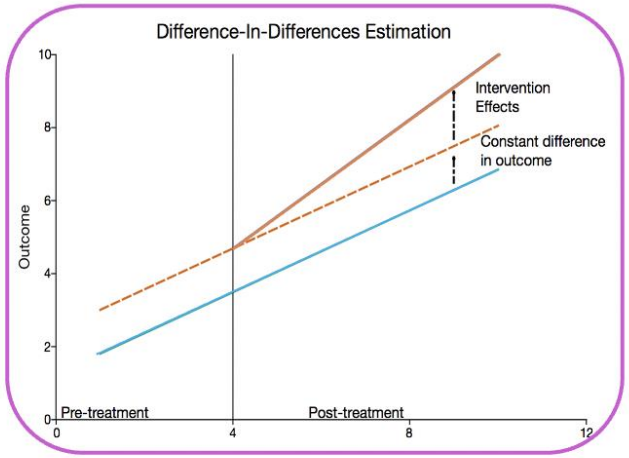
Hazard data
Single- and multi-hazard events of selected hazard types from MYRIAD-HESA are used.



Overlay
Using the hazard extent, the **affected** and **unaffected (control)** nighttime light cells are selected (simplified representation).



Statistical analysis
The affected and control regions are statistically analysed using a difference-in-difference analysis.



MYRIAD-EU: Vision and aim

- **Vision:** to catalyse the paradigm shift required to move towards a multi-risk, multi-sector, systemic approach to risk assessment and management.

- **Aim:** by the end of MYRIAD-EU policy-makers, decision-makers, and practitioners will be able to develop forward-looking disaster risk management pathways that assess trade-offs and synergies across sectors, hazards, and scales

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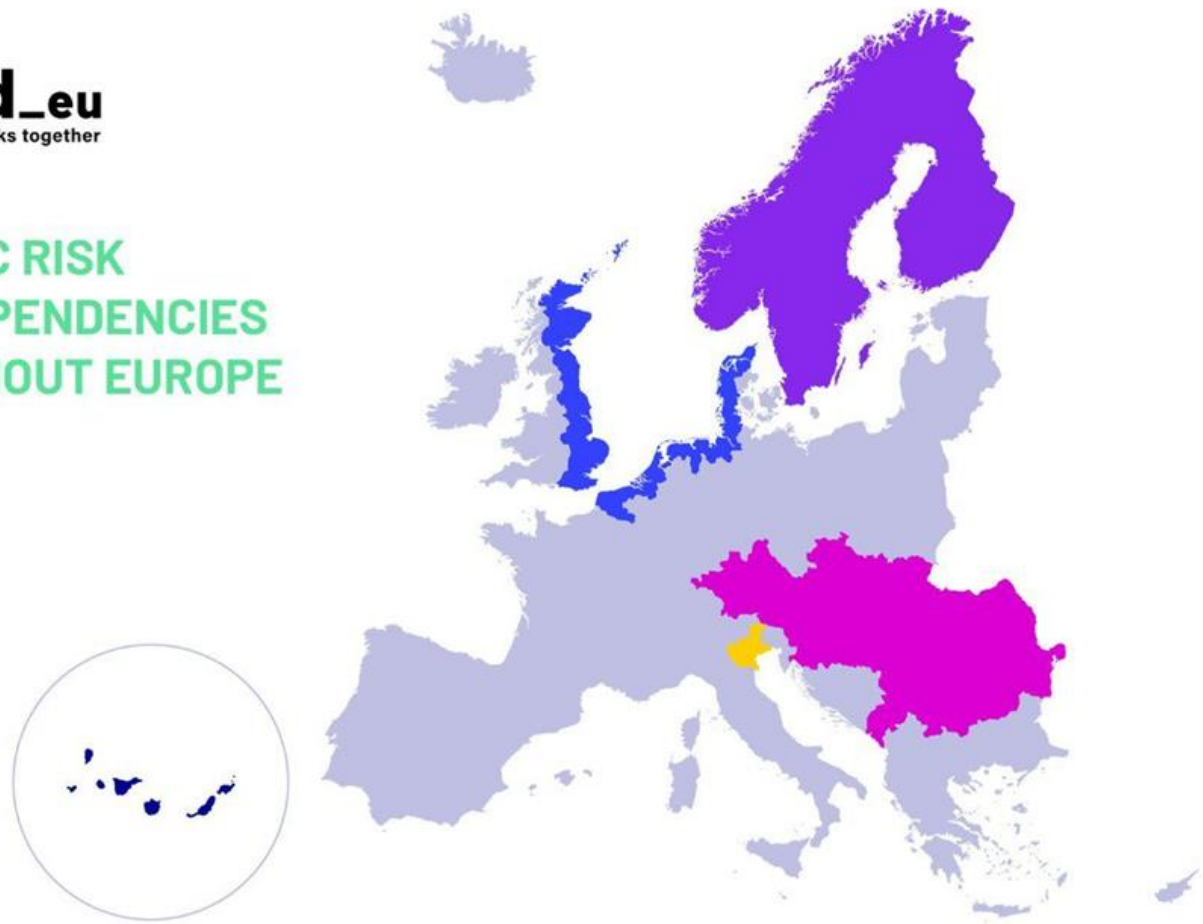
SYSTEMIC RISK INTERDEPENDENCIES THROUGHOUT EUROPE



NORTH SEA

CHALLENGE

How can spatial planning at the interface of the land and sea environments be optimised in the face of increasing and interrelated risk?

SECTOR
- ECOSYSTEMS & FORESTRY
- ENERGY
- INFRASTRUCTURE & TRANSPORT

HAZARDS
- Biological hazard
- Extreme wind
- Flood
- Heat
- Storm
- Thunder and hail

SCANDINAVIA

CHALLENGE

How can we maintain healthy ecosystems under climate-related risks while meeting increasing demands for energy, food, and other ecosystem services, and what is the role of nature-based solutions?

SECTOR
- ECOSYSTEMS & FORESTRY
- ENERGY
- FOOD & AGRICULTURE

HAZARDS
- Biological hazard
- Drought
- Fire
- Flood
- Heat
- Snow

CANARY ISLANDS

CHALLENGE

How can island regions with a strong dependence on tourism become more resilient to multi-hazard risk?

SECTOR
- ENERGY
- FOOD & AGRICULTURE
- TOURISM

HAZARDS
- Earthquake
- Flood
- Landslide
- Storm
- Tsunami
- Volcano

VENETO

CHALLENGE

How can diverse natural landscapes from the mountains to the sea achieve a forward-looking perspective conducive to multi-risk planning?

SECTOR
- ECOSYSTEMS & FORESTRY
- FINANCE
- TOURISM

HAZARDS
- Biological hazard
- Drought
- Fire
- Flood
- Landslide
- Snow

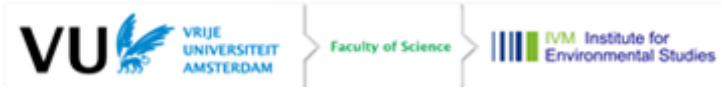
DANUBE

CHALLENGE

How can we increase resilience to multiple disasters that impact several interconnected countries with strong macro-economic relations?

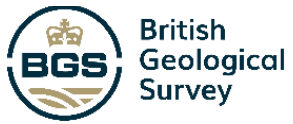
SECTOR
- FINANCE
- FOOD & AGRICULTURE
- INFRASTRUCTURE & TRANSPORT

HAZARDS
- Drought
- Earthquake
- Flood
- Heat
- Landslide
- Thunder and hail



risklayer
analysing and managing catastrophe risk

Arctik
Communication for sustainability



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Framework development

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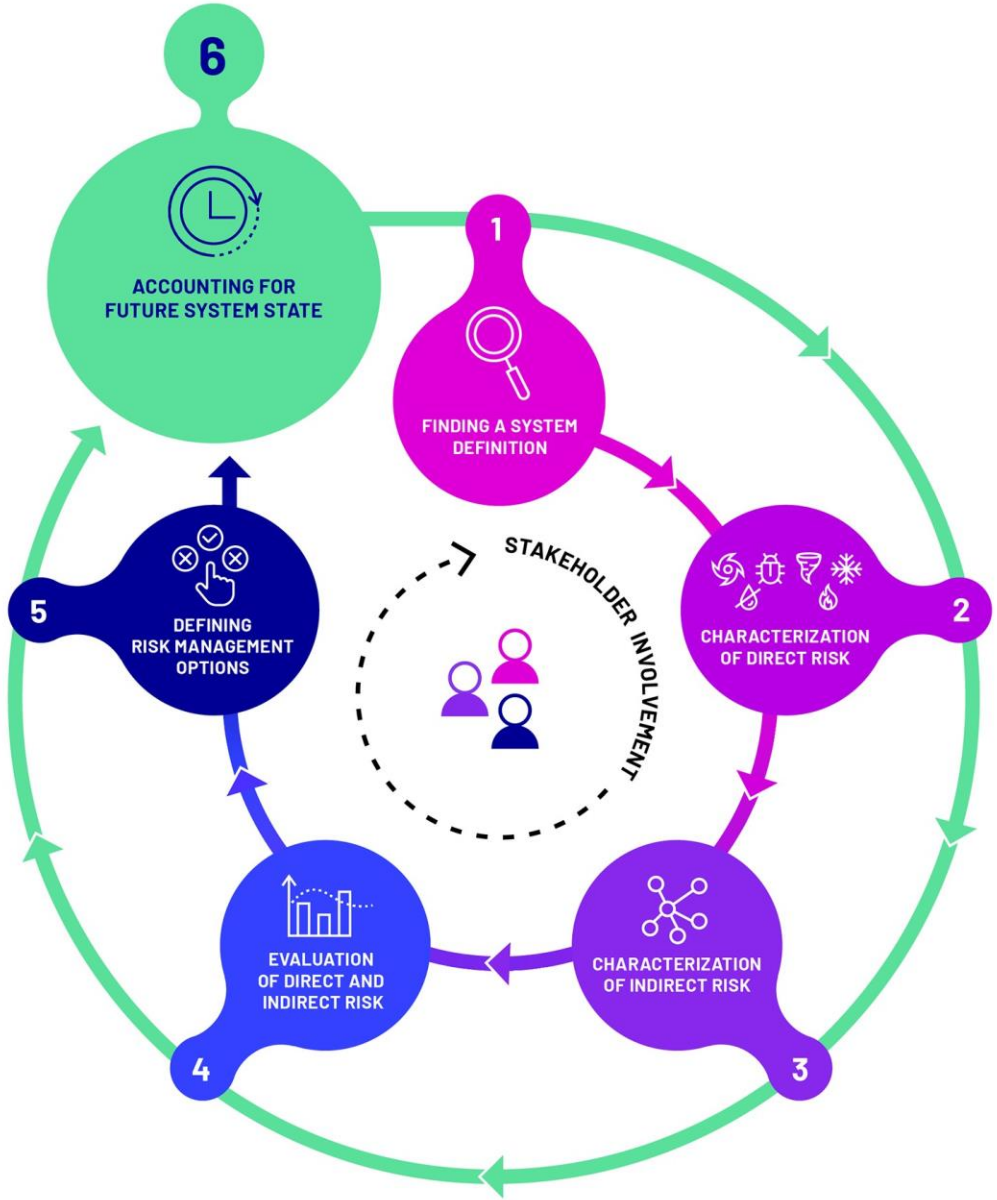
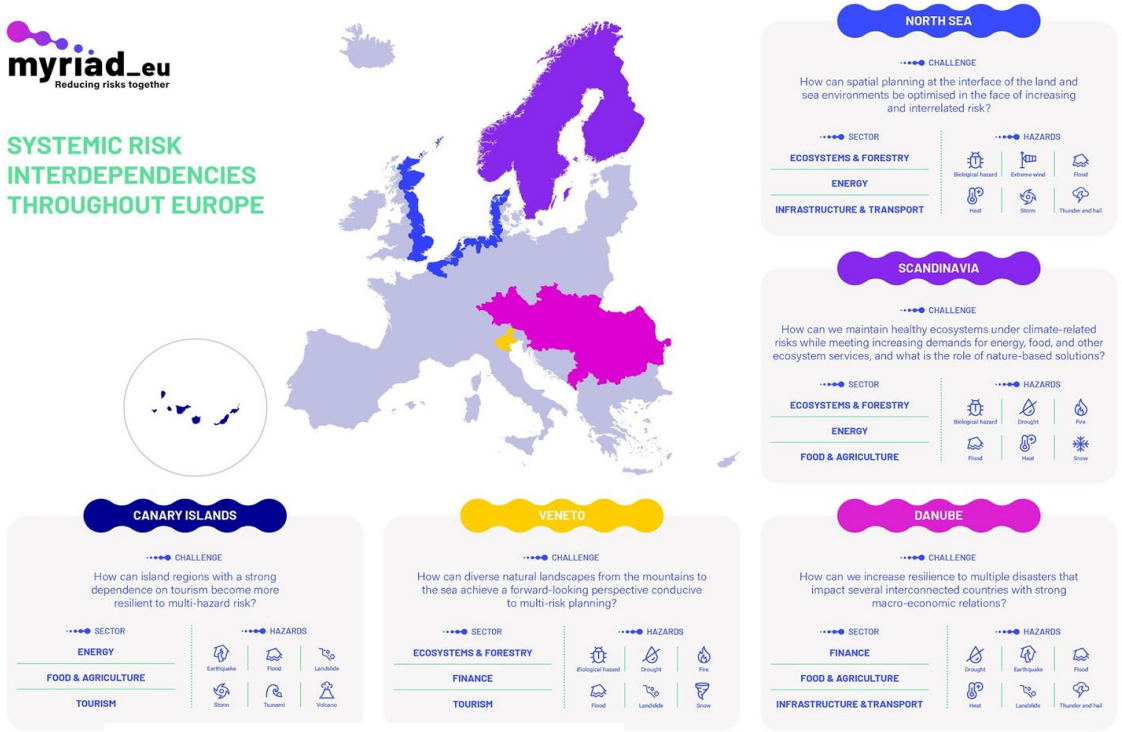
Perspective

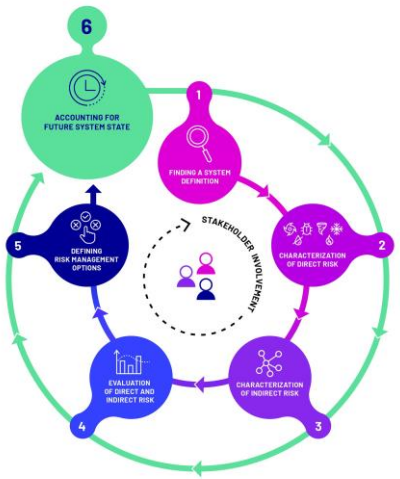
Toward a framework for systemic multi-hazard and multi-risk assessment and management

Stefan Hochrainer-Stigler,[1] Robert Šakić Trogrlić,[1,*] Karina Reiter,[1] Philip J. Ward,[2,5] Marleen C. de Ruiter,[2] Melanie J. Duncan,[3] Silvia Torresan,[4] Roxana Ciurean,[3] Jaroslav Mysiak,[4] Dana Stuparu,[5] and Stefania Gottardo[4]



Interim Pilot Results





- 2 Workshops
- 2 Focus Group meetings per pilot
- Continual testing of methods
- Iterative updating of framework

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Interim Pilot Results

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Challenges in assessing and managing multi-hazard risks: A European stakeholders perspective

Robert Šakić Trogrlić [a,*], Karina Reiter [a], Roxana L. Ciurean [b], Stefania Gottardo [c,d], Silvia Torresan [c,d], Anne Sophie Daloz [e], Lin Ma [e], Noemi Padrón Fumero [f], Sharon Tatman [g], Stefan Hochrainer-Stigler [a], Marleen C. de Ruiter [h], Julius Schlumberger [g,h], Remi Harris [c,d], Sara Garcia-Gonzalez [f], María García-Vaquero [f], Tamara Lucía Febles Arévalo [i,l], Raul Hernandez-Martin [f], Javier Mendoza-Jimenez [f], Davide Mauro Ferrario [c,d,j], David Geurts [g], Dana Stuparu [g], Timothy Tiggeloven [h], Melanie J. Duncan [k], Philip J. Ward [g,h]

[a] International Institute for Applied Systems Analysis (IIASA), 2361 Laxenburg, Austria
[b] British Geological Survey, Keyworth NG12 5GG, United Kingdom
[c] Fondazione CMCC - Centro Euro-Mediterraneo sui Cambiamenti Climatici, Lecce 73100, Italy
[d] Department of Environmental Sciences, Informatics and Statistics, Ca' Foscari University of Venice, Venice 30170, Italy
[e] CICERO Center for International Climate Research, Oslo 0318, Norway
[f] Faculty of Economy, Business and Tourism, University of La Laguna, 38071 La Laguna, Santa Cruz de Tenerife, Spain
[g] Deltares, Delft 2629 HV, the Netherlands
[h] Institute for Environmental Studies, Vrije Universiteit Amsterdam, Amsterdam 1081HV, the Netherlands
[i] School of Architecture, Universidad de Las Palmas de Gran Canaria, 35017 Las Palmas de Gran Canaria, Spain
[j] Istituto Universitario Studi Superiori di Pavia, Pavia 27100, Italy
[k] British Geological Survey, The Lyell Centre, Edinburgh EH14 4AP, United Kingdom
[l] Chair of Disaster Risk Reduction and Resilient Cities, Universidad de La Laguna, 38200 Santa Cruz de Tenerife, Spain

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Disaster risk reduction
Europe
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ABSTRACT

The latest evidence suggests that multi-hazards and their interrelationships (e.g., triggering, compound, and consecutive hazards) are becoming more frequent across Europe, underlying a need for resilience building by moving from single-hazard-focused to multi-hazard risk assessment and management. Although significant advancements were made in our understanding of these events, mainstream practice is still focused on risks due to single hazards (e.g., flooding, earthquakes, droughts), with a limited understanding of the stakeholder needs on the ground. To overcome this limitation, this paper sets out to understand the challenges for moving towards multi-hazard risk management through the perspective of European stakeholders. Based on five workshops across different European pilots (Danube Region, Veneto Region, Scandinavia, North Sea, and Canary Islands) and an expert workshop, we identify five prime challenges: i) governance, ii) knowledge of multi-hazards and multi-risks, iii) existing approaches to disaster risk management, iv) translation of science to policy and practice, and v) lack of data. These challenges are inherently linked and cannot be tackled in isolation with path dependency posing a significant hurdle in transitioning from single- to multi-hazard risk management. Going forward, we identify promising approaches for overcoming some of the challenges, including emerging approaches for multi-hazard characterisation, a common understanding of terminology, and a comprehensive framework for guiding multi-hazard risk assessment and management. We argue for a need to think beyond natural hazards and include other threats in creating a comprehensive overview of multi-hazard risks, as well as promoting thinking of multi-hazard risk reduction in the context of larger development goals.

5 core challenges for multi-hazard risk assessment and management in Europe:

- Governance of multi-hazard risk
- Knowledge of multi-hazard risk
- Existing approaches to DRM
- Translation of science to policy and practice
- Lack of data

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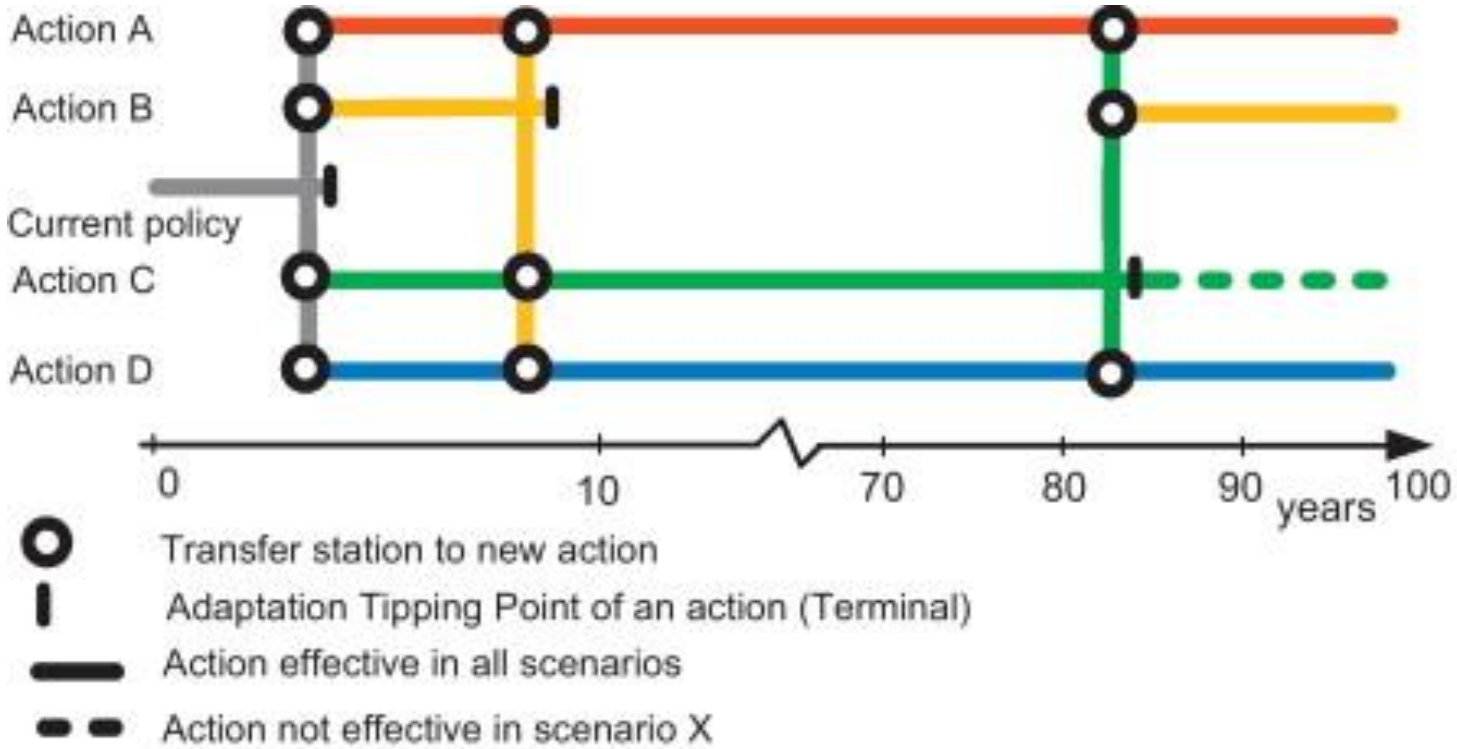
Developing forward-looking pathways



Adaptation Pathways Map

	Path actions	Relative Costs	Target effects	Side effects
1		+++	+	0
2		+++++	0	0
3		+++	0	0
4		+++	0	0
5		0	0	-
6		++++	0	-
7		+++	0	-
8		+	+	- - -
9		++	+	- - -

Scorecard pathways

DAPP-MR (DAPP-Multi-Risks)

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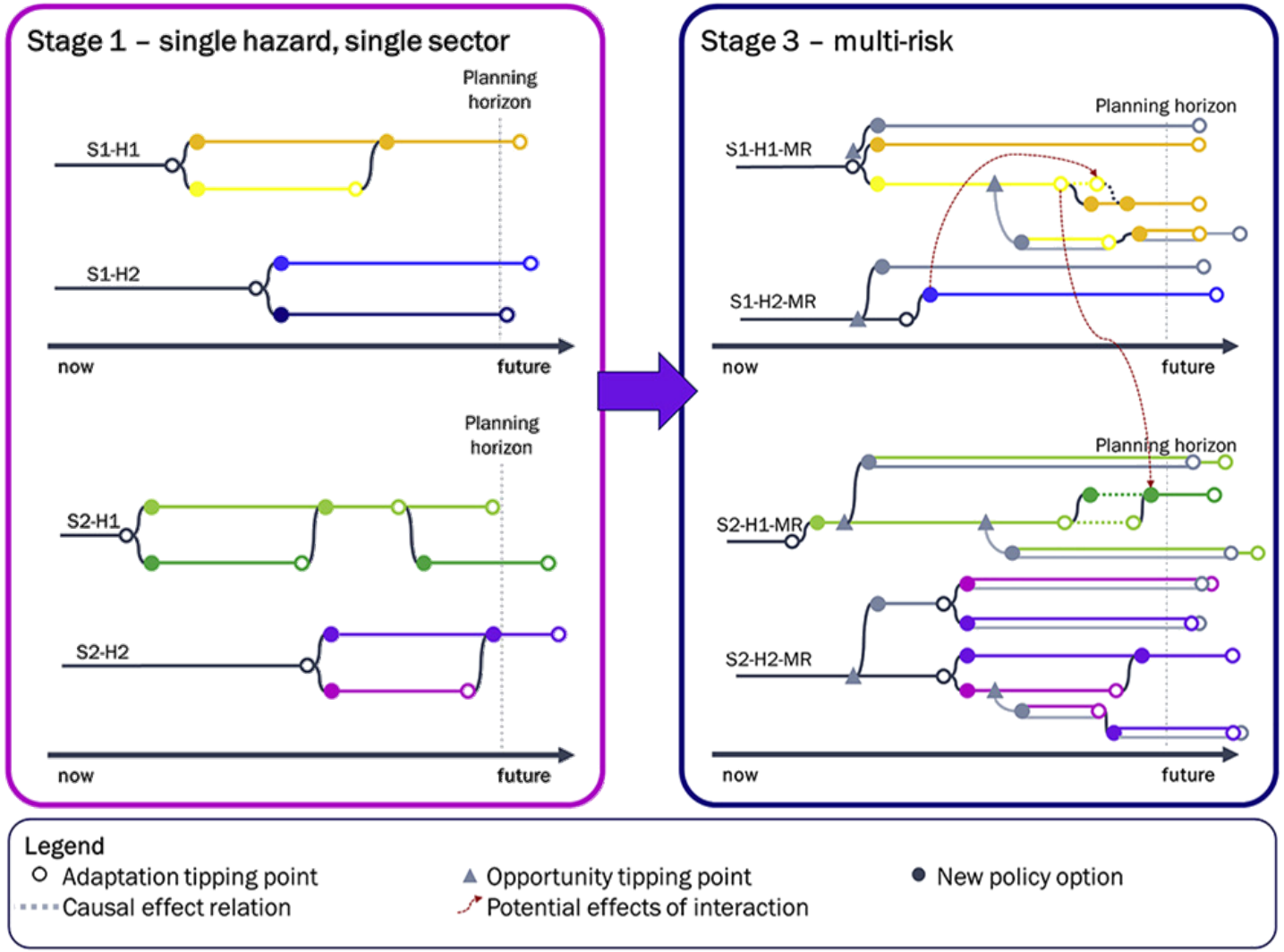
Volume 25, Issue 10, 21 October 2022, 105219

Article

Proposing DAPP-MR as a disaster risk management pathways framework for complex, dynamic multi-risk

Julius Schlumberger [1 2 3], Marjolijn Haasnoot [1], Jeroen Aerts [1 2], Marleen de Ruiter [2]



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