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Analysis of temporal and spatial overlapping of hazards interactions at different scales

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Main goal of this talk

Present a **framework** to investigate

- **hazard interactions**
- the resulting **damage interactions**

in a given region

Overview

- 1 Hazard interactions: a
- 2 Causal dependencies a

Spatial and temporal c

Overview

- 1 **Hazard interactions:** a brief overview
- 2 **Causal dependencies** among hazards
- 3 **Spatial and temporal overlapping** of hazards and how they result in different **damage interaction mechanisms**
- 4 How to **model** damage **interactions?**
- 5 **TOOL : QGIS plugin** (prototype)
- 6 Main **reflections** on multi-hazard damage assessment

1

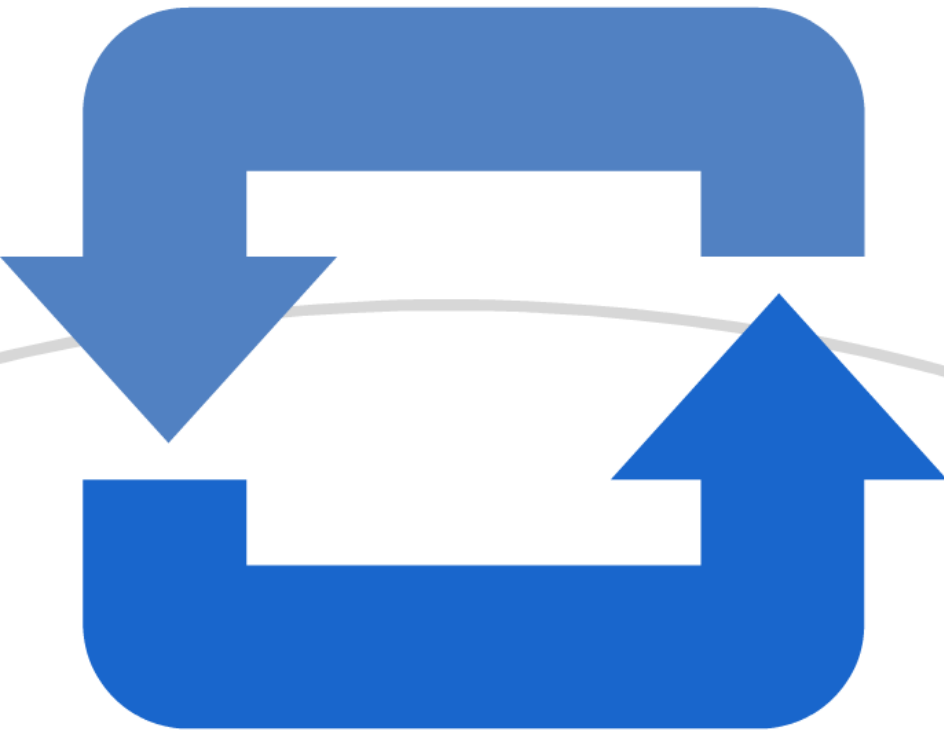
Hazards Superimposition VS Hazard Interactions





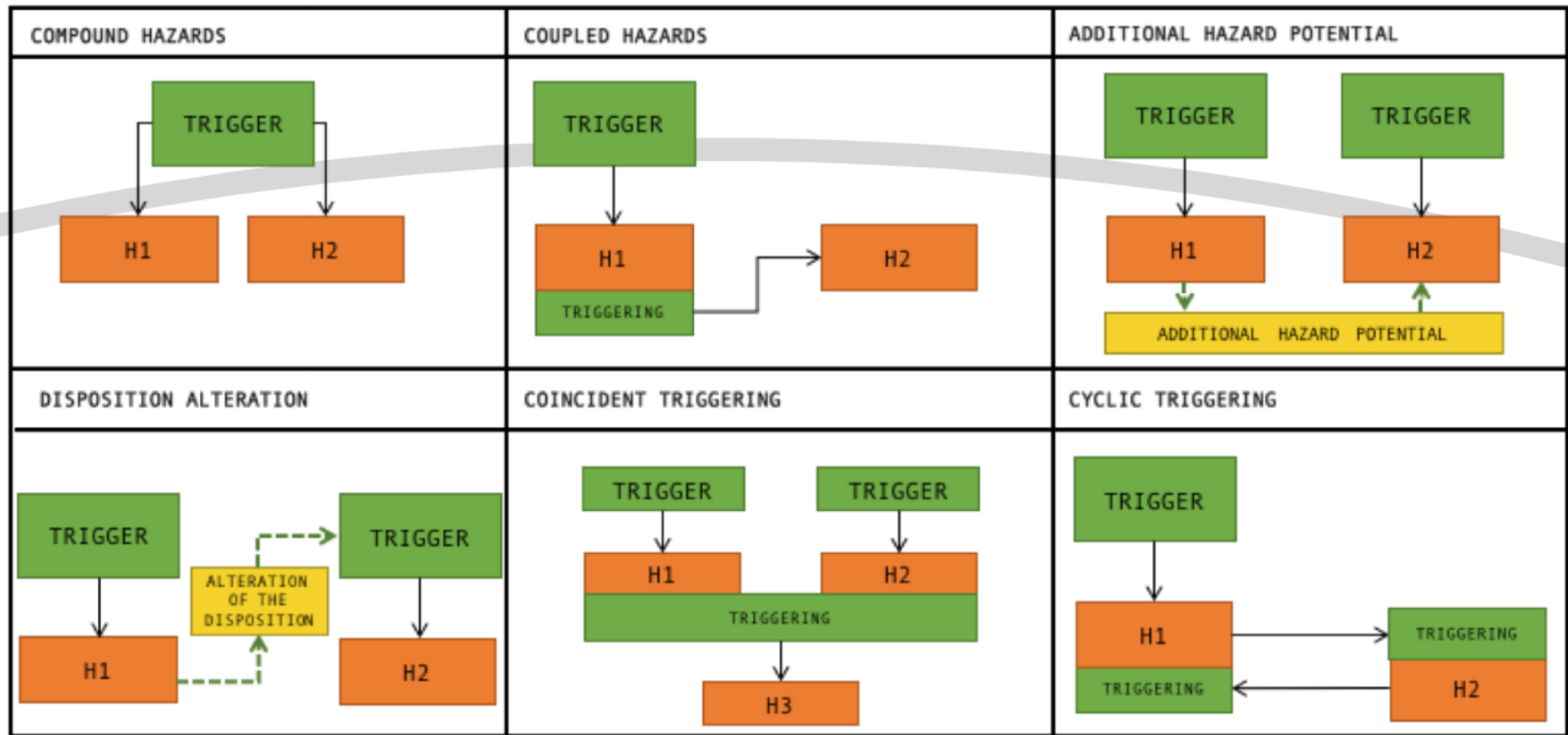
2

**Causal dependence
of one hazard with
respect to another**

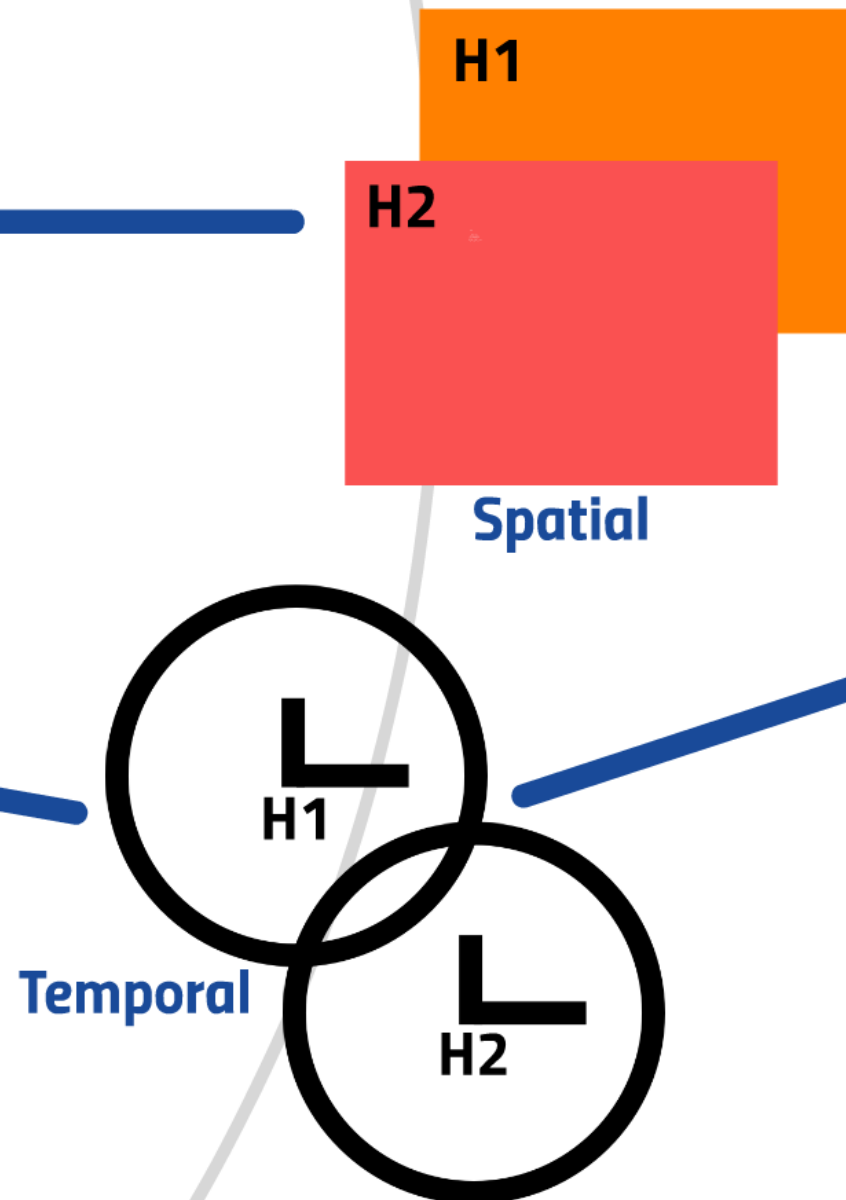


2

Basic mechanisms of interaction amongst hazards



3.1 Spatial and temporal overlapping of hazards



3

Influence of spatial and temporal hazard overlap on damage

2



		Hazard Spatial Overlap	
		YES	NO
Hazard Temporal Overlap	YES	A Spatial – Temporal overlap damage	B Temporal (but not Spatial) overlap damage
	NO ($\Delta T_{H1-H2} < T_{H1}^{REC}$)	C Spatial overlap damage (with residual and subsequent damage)	D No spatial or temporal overlap damage
	NO ($\Delta T_{H1-H2} > T_{H1}^{REC}$)	D No spatial or temporal overlap damage	D No spatial or temporal overlap damage

ΔT_{H1-H2} = time window between the two hazards H1 and H2

T_{H1}^{REC} = time required by the system to completely recover from damage caused by H1

A

SPATIAL - TEMPORAL OVERLAP DAMAGE:

combination of
simultaneous
damages from
different hazards in
the same place



Example



Windstorm and flooding

B

- **TEMPORAL (but not Spatial) OVERLAP DAMAGE:**

temporal overlapping of damages from different hazards in different places



Example



Image captured by Aqua satellite on Feb. 17, 2015.
Credit: Jeff Schmaltz, MODIS Rapid Response Team.

Snowstorm and wildfires

C

SPATIAL OVERLAP DAMAGE

(with residual and
subsequent
damage):

a second damage is
overlapping an
existing residual
damage in the same
place



Example



Levee damage
due to
earthquake

Levee
collapse
during
a flood



D



NO SPATIAL OR TEMPORAL OVERLAP DAMAGE:

- Independent single hazard damages
- No damage interactions

3.2 hazard overlap on damage



		Hazard Spatial Overlap	
		YES	NO
Hazard Temporal Overlap	YES	A Spatial – Temporal overlap damage	B Temporal (but not Spatial) overlap damage
	NO ($\Delta T_{H1-H2} < T_{H1}^{REC}$)	C Spatial overlap damage (with residual and subsequent damage)	D No spatial or temporal overlap damage
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ΔT_{H1-H2} = time window between the two hazards H1 and H2

T_{H1}^{REC} = time required by the system to completely recover from damage caused by H1

**Spatial
scale**

3 **3**

REGIONAL/NATIONAL

Temporal
(but not
Spatial)
overlap
damage

LOCAL

Spatial –
Temporal
overlap
damage

Spatial
overlap
damage
(with residual
and subsequent
damage)

Independent
single
hazards
damages

FROM HOURS TO DAYS

FROM DAYS TO MONTHS

FROM MONTHS TO YEARS

Time



4

3

How to model damage interactions?

	$wd \leq 0.3m$	$0.3 < wd < 0.6 m$	$wd \geq 0.6m$
Asphalt road	Very Low	Low	Low
Gravel/cobble stone road	Very Low	Medium	Medium
Unpaved road	Very Low	Medium	High

Damage from Hazard 1

	$v < 3(m/s)$	$3 \leq v < 7(m/s)$	$v > 7(m/s)$
Asphalt road	Very Low	Low	Low
Gravel/cobble stone road	Very Low	Medium	Medium
Unpaved road	Very Low	Medium	High

Damage from Hazard 2

What about
the combined
damage?





4

2

Significant aspects to consider in order to properly model damage interactions:

- Hazards **sequence**
- **Time window** between hazards
- **Recovery** process dynamic between hazards (if possible)
- **Damage targets** (structure/content/both)
- Kind of **physical interaction** between hazards and targets



4.3

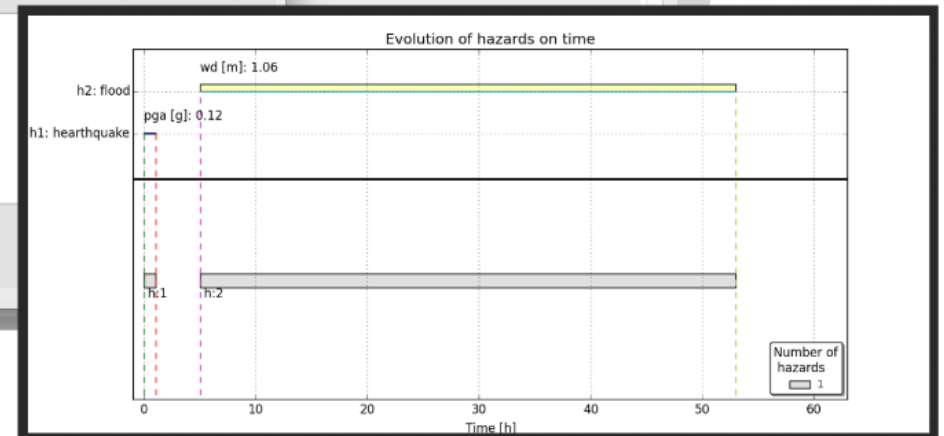
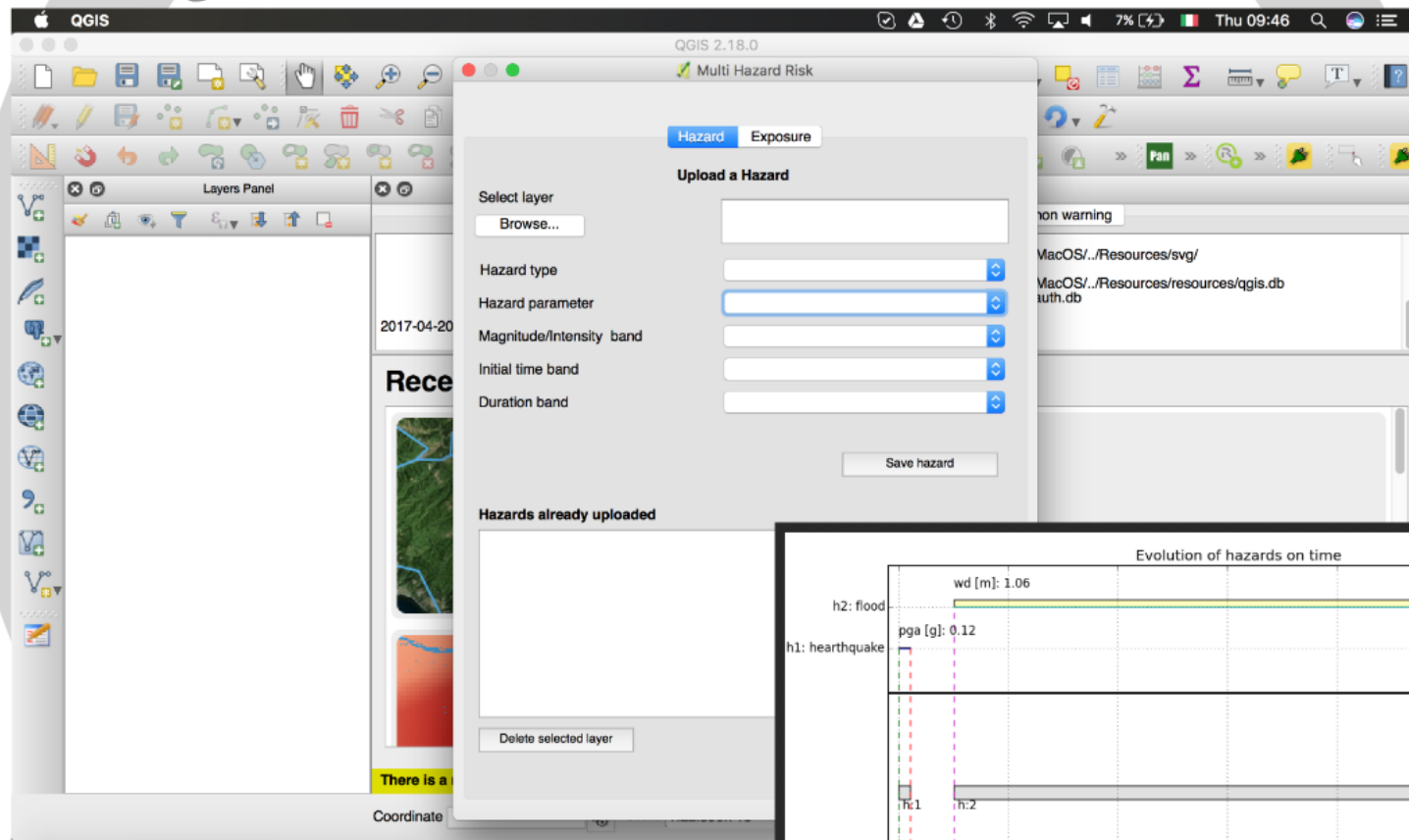


Use of the parameters to determine a **SET OF RULES** to **combine qualitatively damages from different hazards**



5

TOOL : QGIS plugin (prototype)



6

Main reflections on multi-hazard damage assessment

- Hard to find a general approach
- Qualitative or semi-quantitative approaches can be a starting point
- Spatial and temporal overlapping of hazards play a main role
- Change in exposure and vulnerability





THANK YOU
Questions?

