Workshop

FROM VOLCANIC HAZARD TO RISK ASSESSMENT

Geneve, 27-28 June 2018

A scenario-based approach to the multi-temporal and multi-scale consequences of volcanic eruptions

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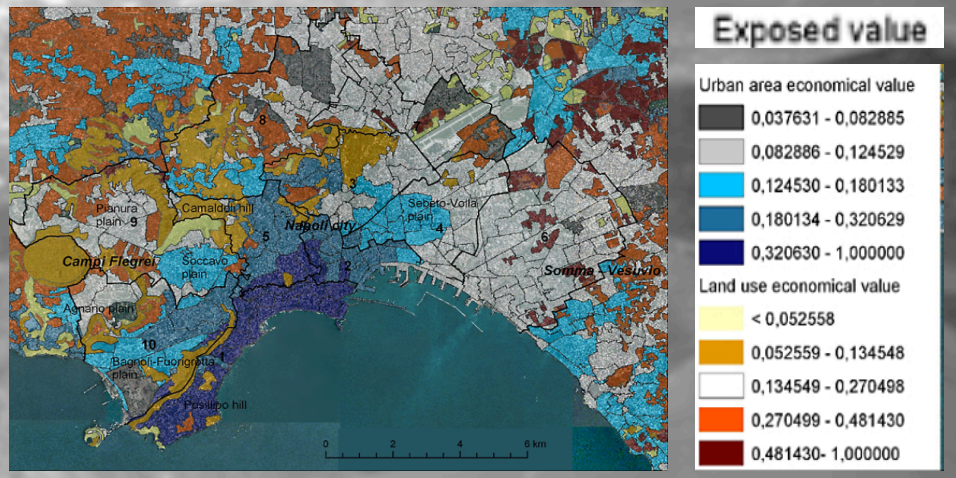
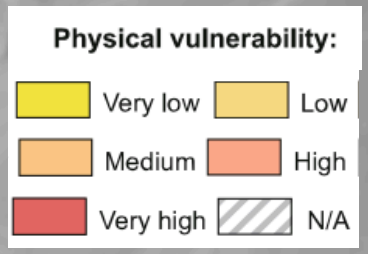
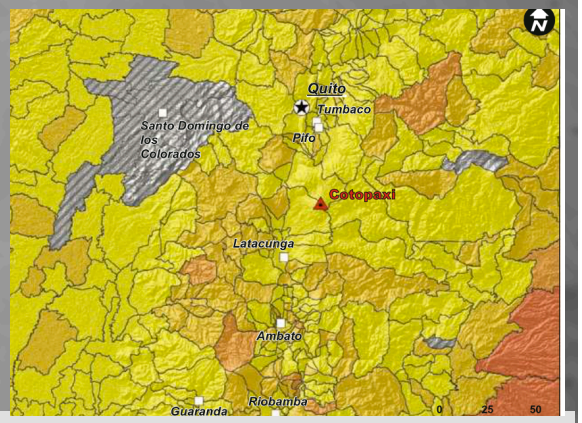
Volcanic risk assessment has been mostly focused so far on hazards, **exposure** and (sometimes) on **physical vulnerability** of exposed elements (buildings, critical infrastructures, etc.).



ALBERICO et al., 2011





BIASS et al., 2012

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Risk assessment is generally represented through **maps**, limited to the **scale** of the hazardous phenomena, providing a **static** (and often qualitative) representation of the expected damage levels.

These maps, despite being useful to both civil protection and land use planning purposes, often neglect the **complex chains of primary and secondary events** that follow a hazardous event and that take on particular relevance in case of volcanic events.

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Despite being the notion of ***risk as a combination of hazard and vulnerability*** largely shared in the scientific community, the word '**combination**' does not fully integrate **interactions** among both hazard factors and exposed elements and systems.

Risk results from a complex set of hazard(s) and vulnerability(ies), which interact each other and change along time: therefore, in case these dynamics are neglected, important aspects of disasters will be missed out.

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Volcanic eruptions are characterized as a set of different hazards, which arise **in different temporal spans.**

These phenomena induce primary and secondary impacts, **affecting different areas** whose scale (from a local up to a global one) largely depend on the **functional and economic role of hit area** within the wider territorial context.

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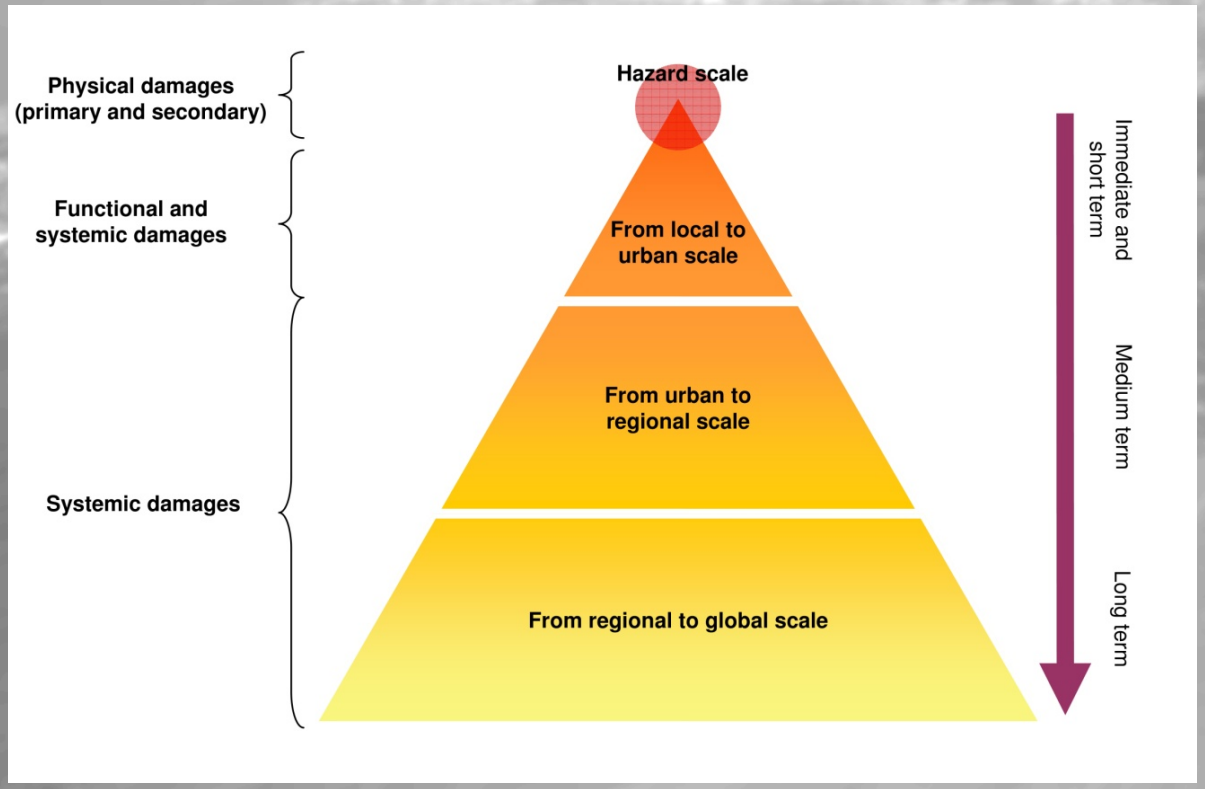

Hence, “the narrower the time-space focus, the greater the likelihood that losses will be underestimated” (Cochrane, 2004)

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A **scenario-based approach**, by embracing a systemic perspective and focusing, above all, on **interactions** among both hazard factors and exposed elements and systems, might allow us to better understand, describe and communicate the dynamic evolution of one or more hazardous events and the consequent potential chains of impacts, failures and damages.

Hence, it may allow us to evaluate some aspects of disasters that have been often neglected by scholars.

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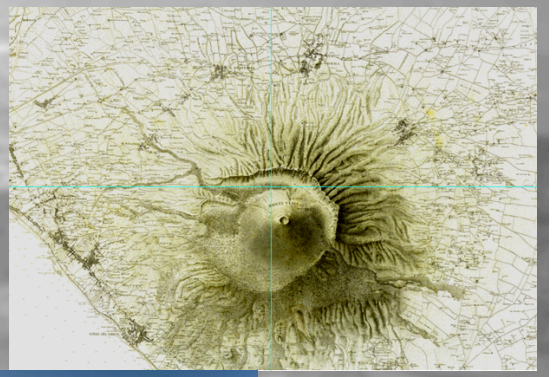
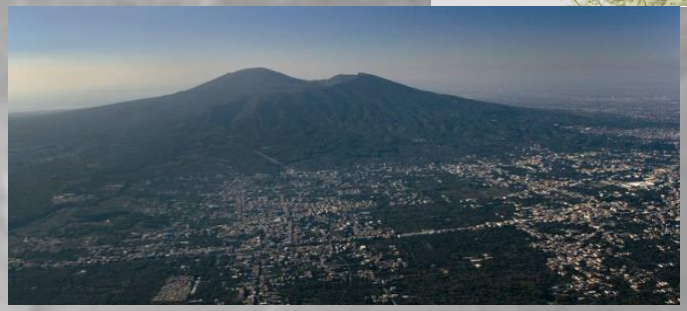


To better clarify the potential of a scenario-based approach, we will briefly present a case study developed in the frame of the EU project SCENARIO and focused on the Vesuvius' area.



The outlined scenario provided a qualitative description of a potential volcanic event and its consequences, highlighting how different damages may occur, in different temporal phases, involving different areas.

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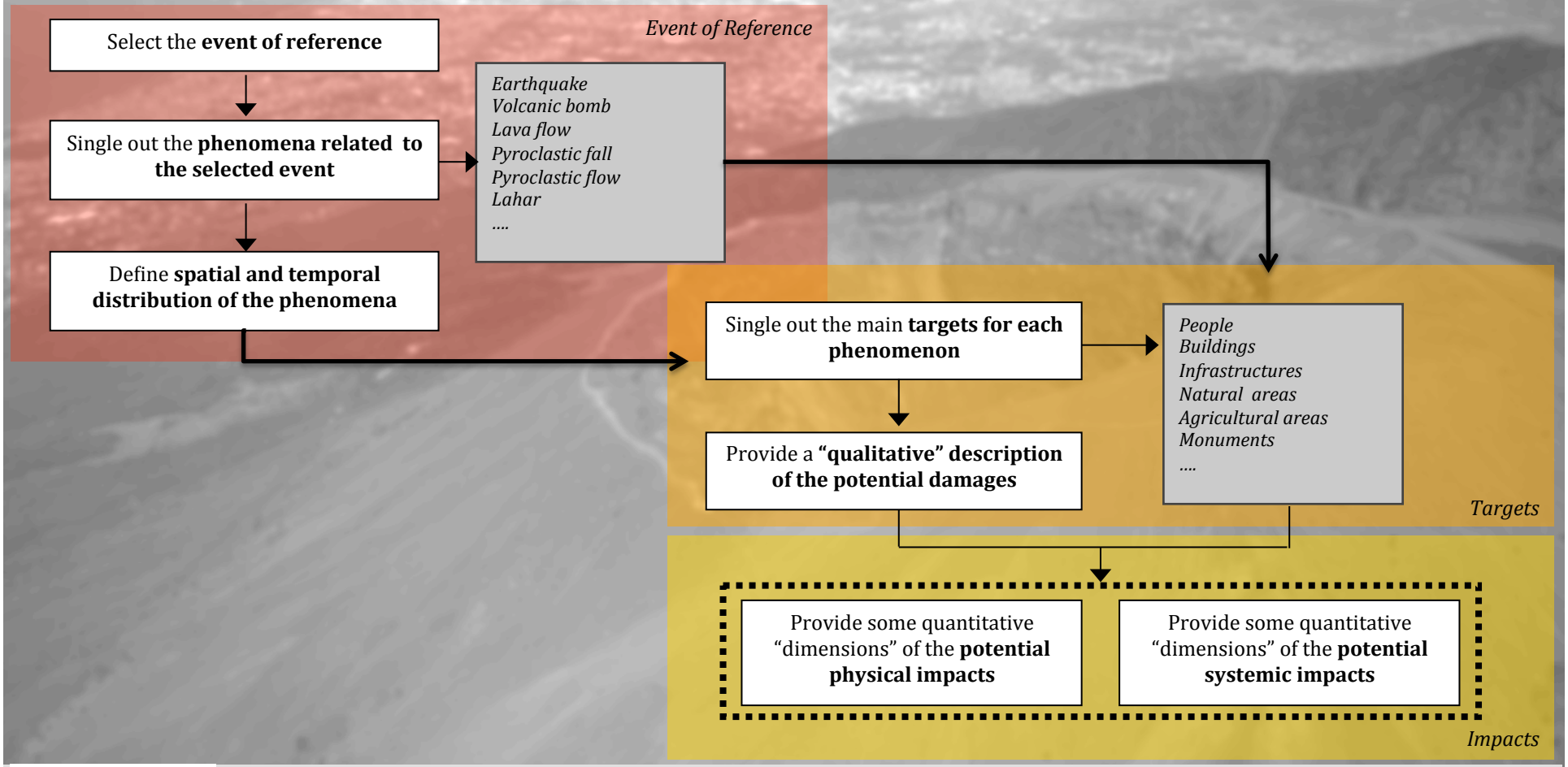

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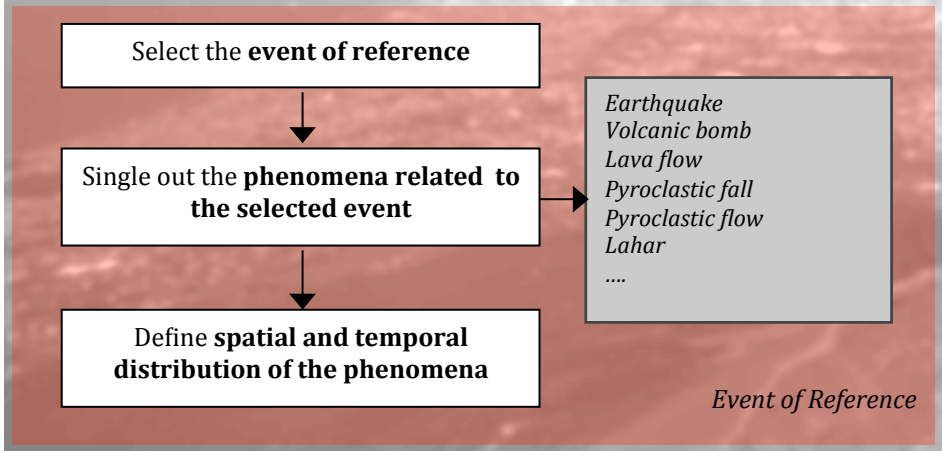

The Emergency National Plan of the Vesuvius adopts an approach based on the probability of occurrence of different eruptive scenarios.

	Stromboliane violente	Sub-Pliniane I	Pliniane
	(VEI=3)	(VEI=4)	(VEI=5)
Vesuvio: tempo di riposo tra 60 e 200 anni	72%	27%	1%
Vesuvio: tempo di riposo maggiore di 60 anni	65%	24%	11%

Although the most likely one is a VEI 3, the Emergency Plan adopts a sub-Plinian event (VEI 4) (comparable to the 1631 eruption, the most violent one in recent times that produced more than 4.000 victims in 48 hours) as event of reference.

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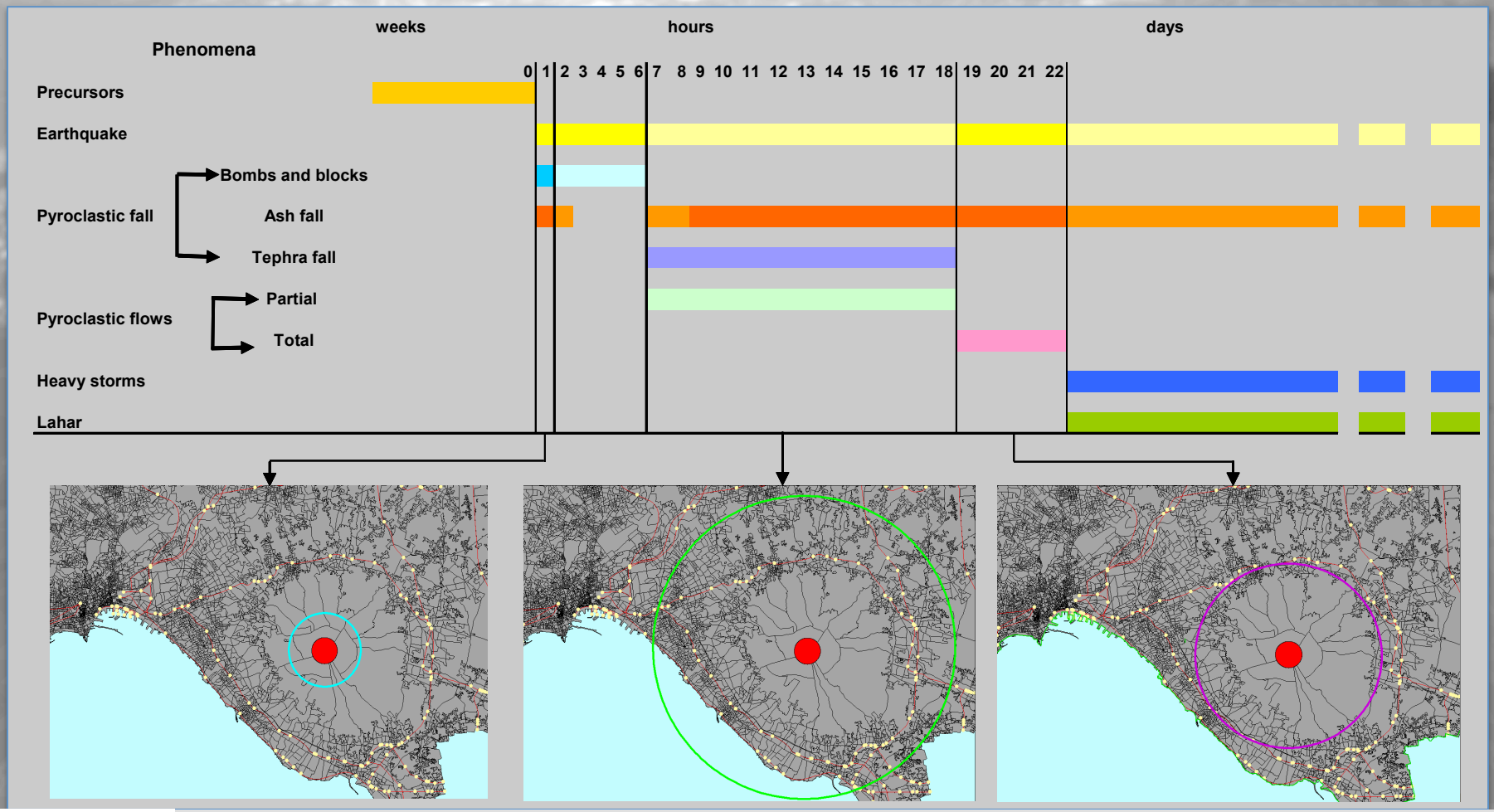

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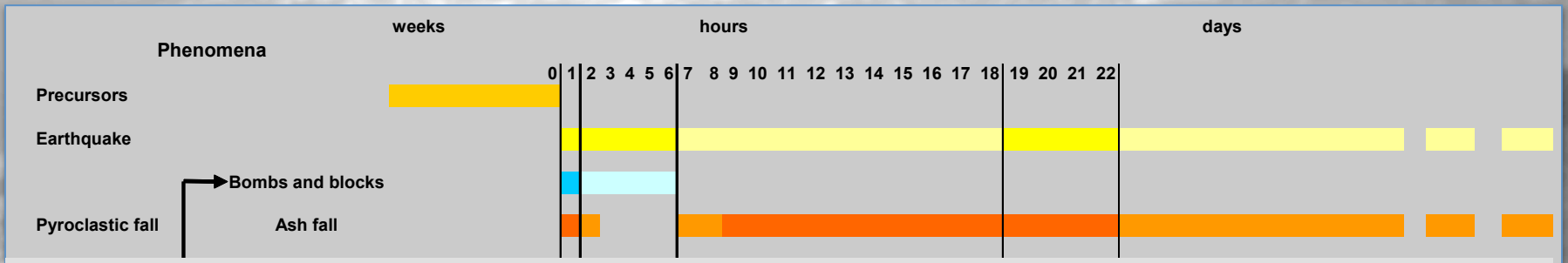
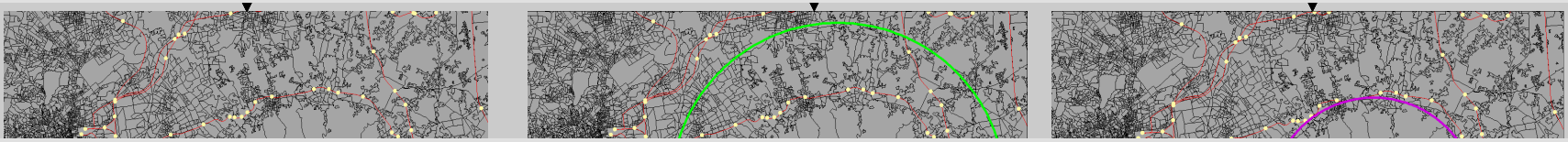
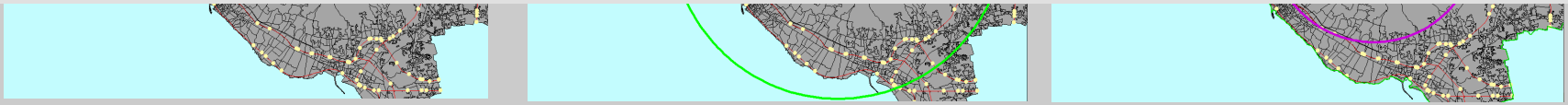


Based on the available descriptions and data related to past events, the reference event was articulated in different temporal phases, each of them characterized by different phenomena (*earthquakes, pyroclastic falls, pyroclastic flows, lahars*) affecting different areas.



Hence, according to the different temporal phases of the eruption, different areas will be involved or different phenomena will hit the same area.



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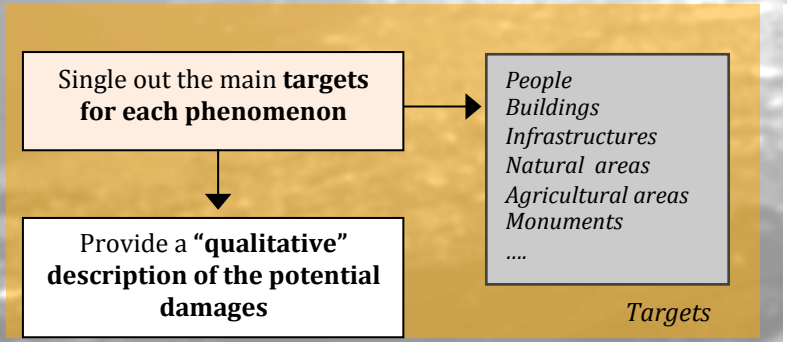

Based on the selected phenomena, the main targets have been singled out, taking into account that also targets will change over the different phases of the event

Spatial element	*Targets*	*Exposure*
Areas	Population	Population density (number of residents/surface of the area in hectares)
	Buildings	Number of buildings
	Arable land and heterogeneous areas	Surface of arable land and heterogeneous areas (ha)
	Permanent crops	Surface of permanent crops (ha)
	Forest	Surface of forest (ha)
Lines	Road networks	Length and hierarchical level of the network
	Rail networks	Length and hierarchical level of the network
Points	Monuments	Number of archaeological sites
	Hazardous installations	Number of hazardous installations
	Infrastructures (Airports, Railway stations, etc.)	Number of infrastructures
	Emergency equipments (Hospitals, Fire brigades, etc.)	Number of emergency equipments

Exposed Targets

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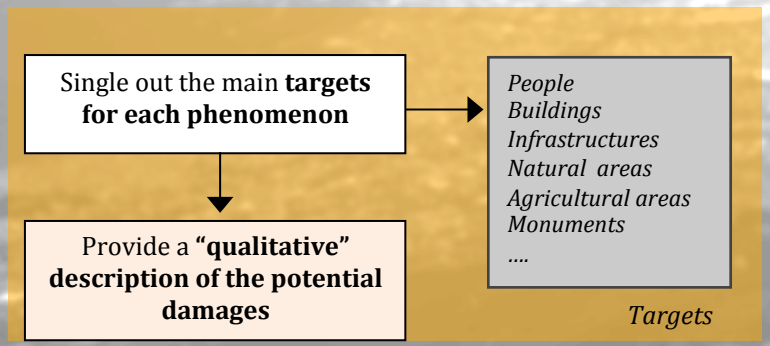

Phenomena / Targets	Pyroclastic fall		Pyroclastic flow		Earthquake		Lahar	
Population			●	●	◖		●	
Buildings	●	●	●	●	◖	○	●	
Arable/het. areas	●	●	●	●				◖
Permanent crops	●	●	●	●				◖
Forest	●	●	●	●				
Road/rail netw.		●	●	●				●
Other net. infras.			●		○			
Emerg. equipm.	●	●	●	●	◖	○	●	●
Infrastructures	●	●	●	●	○		●	●
Monuments	●	●	●	●	◖		●	
Commercial areas	●	●	●	●	○		●	◖
Industrial areas	●	●	●	●	○		●	◖
Hazard.install.	●	●	●	●	○		●	◖

In respect to each target, a qualitative description of type and intensity of the damage due to each phenomenon has been provided.

Physical damages: ● = high ◖ = medium ○ = low;

Systemic dam.: ● = high ◖ = medium ○ = low

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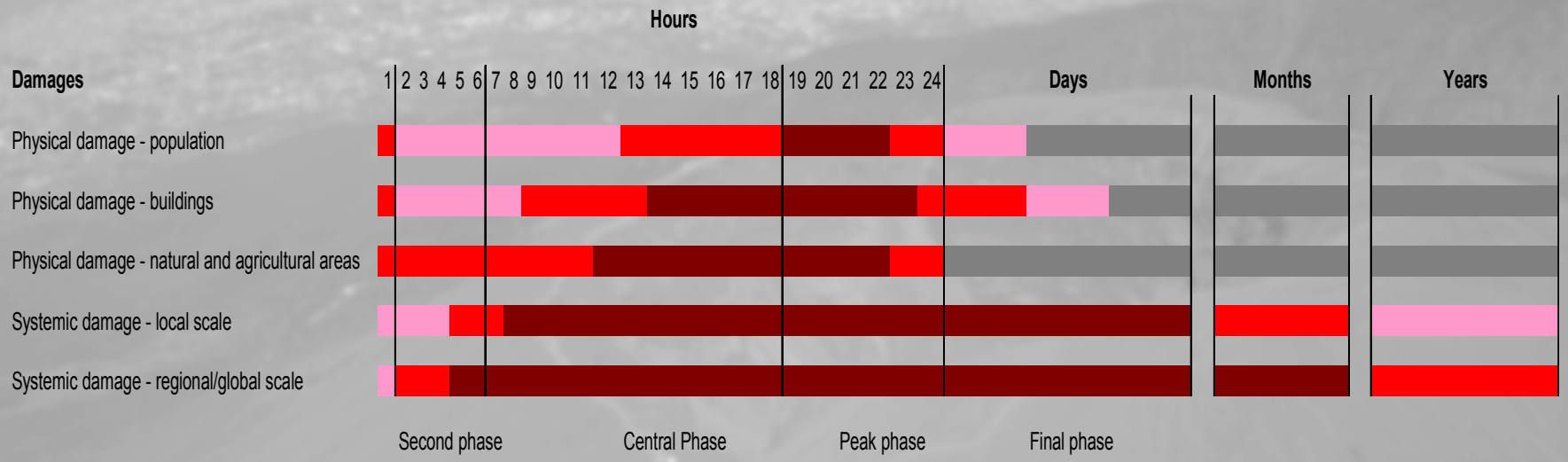

Then, physical and systemic damage have been articulated with respect to the considered temporal phases

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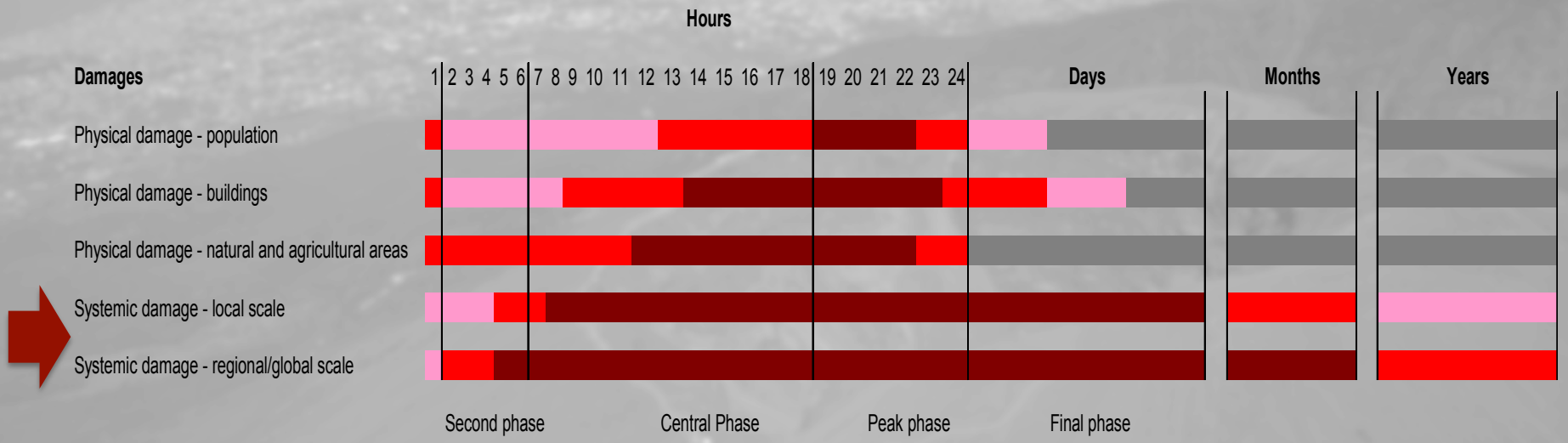

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In case of volcanic eruptions, **systemic damage** can arise not only as a consequence of physical damages (as in case of other natural hazards) but also **as a direct consequence of hazardous events** (e.g. ashes propagation).

Even though systemic damage is difficult to quantify, it may significantly contribute to multiply the negative effects in the area directly hit by the hazardous event and beyond.

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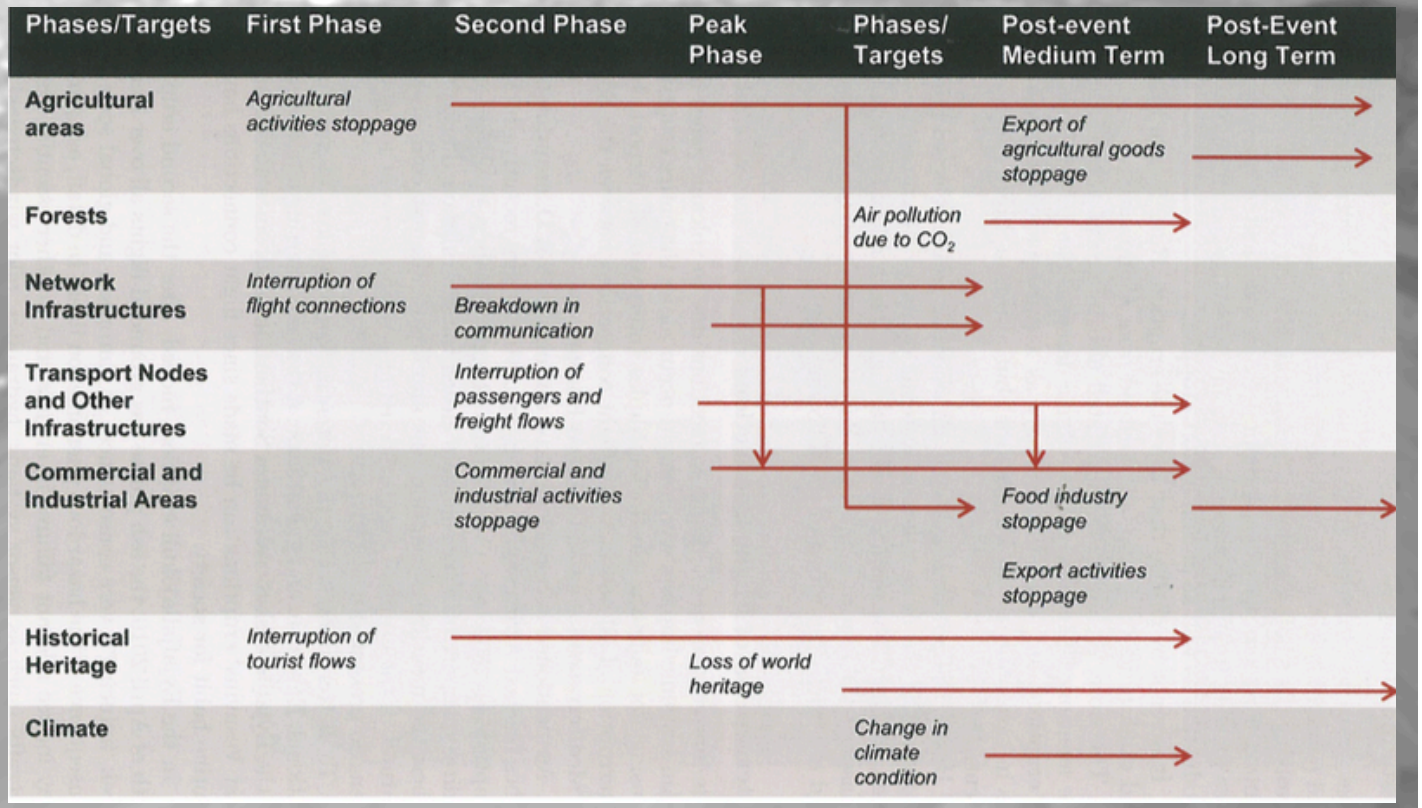
In the Vesuvius' case study, the main systemic impacts that may occur in the different temporal phases have been outlined



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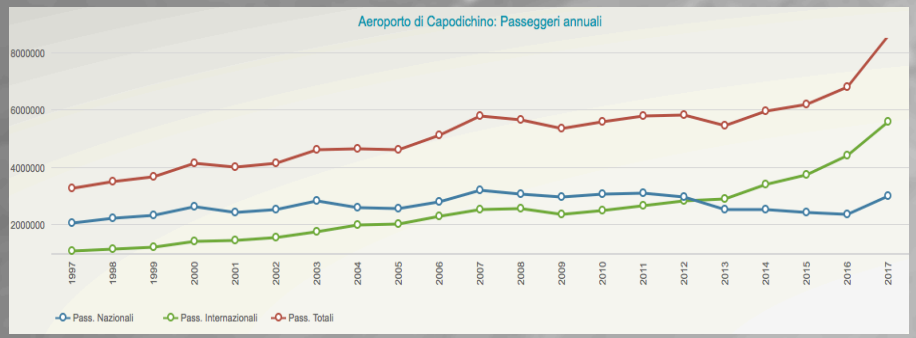
Although we did not provide a quantitative assessment of the expected damage, we provided some "quantitative dimensions" related to the functional/economic relevance of the hit sectors, in order to explore the main consequences of a local event on a wider scale.



Capodichino Airport: number of annual passengers

	% Red zone/ province	*Provincial values (euros)*	*Red zone values (euros)*
Jewellery, coral, cameo factories	79%	15.415.488	12.197.006
Food industries	19%	382.152.386	72.472.225
Textile and clothes	17%	330.920.733	56.096.250
Total		**4.228.948.260**	**140.765.480**

Estimated values of the yearly export billing for each sector of economic activity

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In the case of Vesuvius, systemic impacts could induce dramatic consequences to the regional economy and reverberate on a wider scale (at least national) due, for example, to the interruption of flight connections, to the business break down or to tourism disruption. Tourism represents nowadays one of the driving sectors of the Campania Region economy and it is particularly relevant in the Vesuvian area, where the UNESCO site, including Pompeii, Herculaneum and Oplonti archaeological areas, is located.

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The development of **comprehensive scenarios of hazards-impacts-damages,** capable to outline the complex chains of hazardous events, physical and systemic impacts and consequent damage at different geographical scales, could support both land use and emergency planning and, as in case of flight connections or business breakdown, they could support risk management strategies of European air traffic system or of the main economic activities.

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However, the development of comprehensive scenarios is still a difficult goal to achieve and presents us with many challenges, such us:

- the need for closer interactions among scholars from different disciplinary fields (volcanologists, structural engineers, planners, economists, etc.)
- the limited available knowledge related to systemic impacts in past events
- The need for effective methods to combine quantitative data and qualitative information/descriptions as well as for an effective quantification of the economic costs related to systemic impacts (business break down, tourism disruption, etc.) occurring in the different temporal spans and at different scales.

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Thanks for your attention!

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