

# Scenarios in volcanology

Causes and implications of deterministic and probabilistic choices

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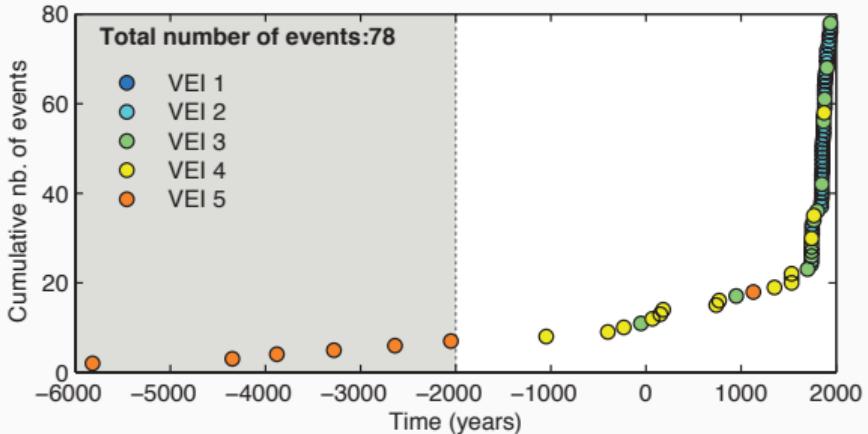
## Volcanoes

- Multiple, nested hazards
- Lower frequency
  - Geologically-biased records
  - Historically-biased records
- No F–M relationship
- No general useful measurable quantity

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### Geological bias: Cotopaxi



Blaauw and Bonadonna (2011); Hall and Mothes (2008); Siebert et al. (2011)

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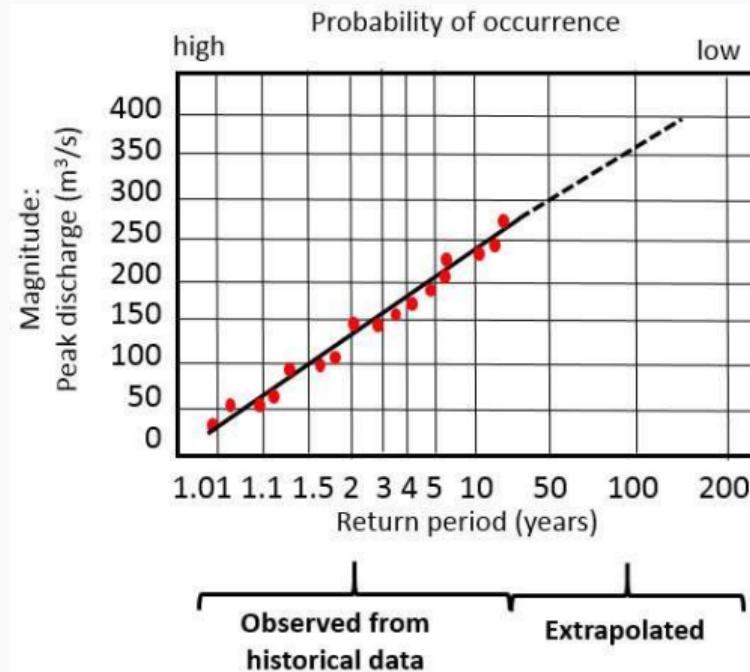
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Historical bias: Kīlauea



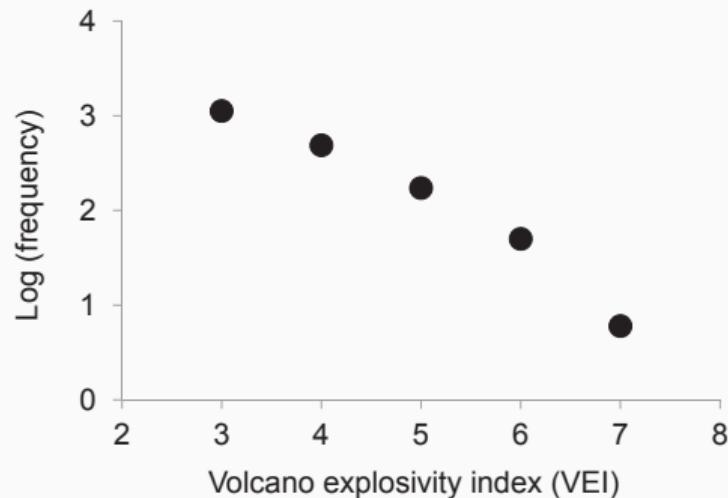
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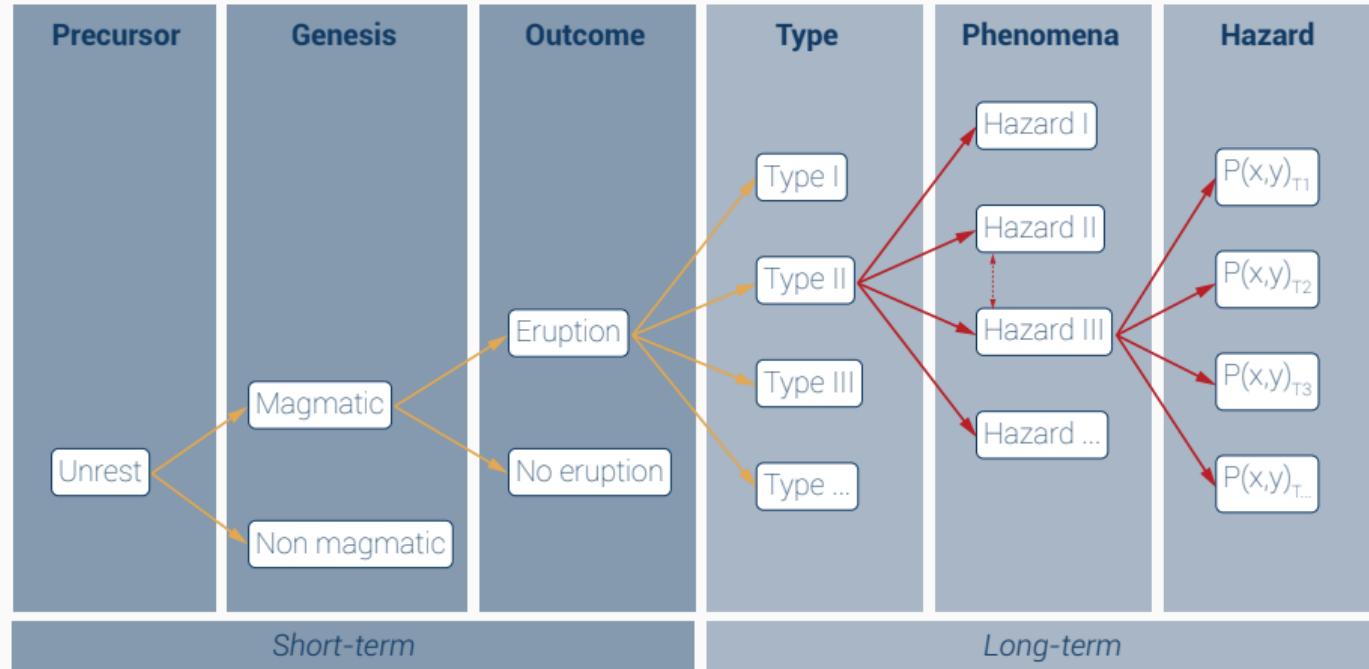


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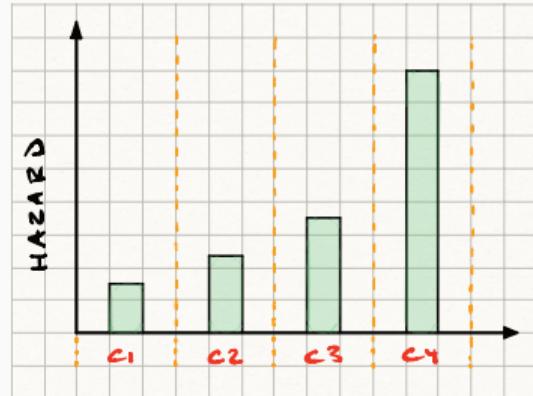


# Event trees



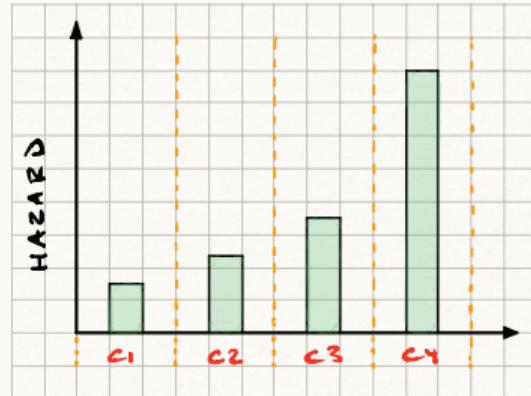
Modified after Newhall and Hoblitt (2002), Baxter et al. (2008), Marzocchi et al. (2010)

## Deterministic

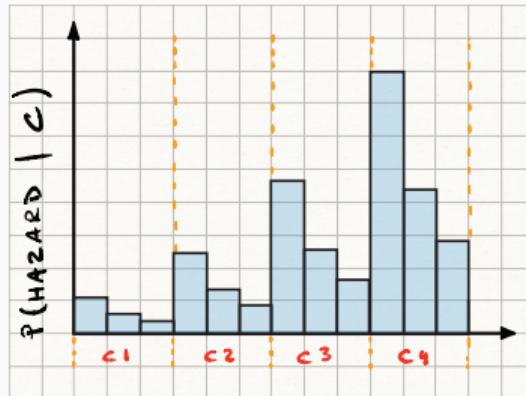


- $P_{eruption} = 1$
- Fixed ESP
- Single outcome

## Deterministic



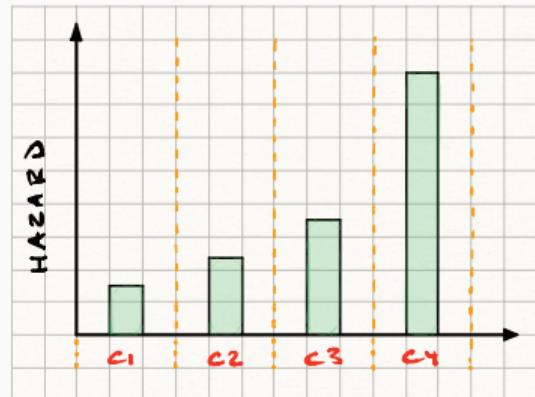
## Scenario-based



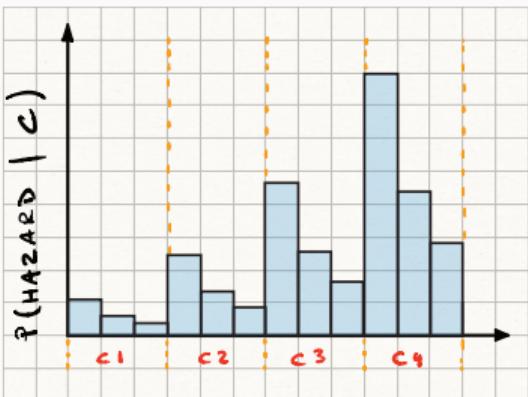
- $P_{\text{eruption}} = 1$
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- $P_{\text{eruption}} = 1$
- Distributions of ESP
- Probabilistic scenario

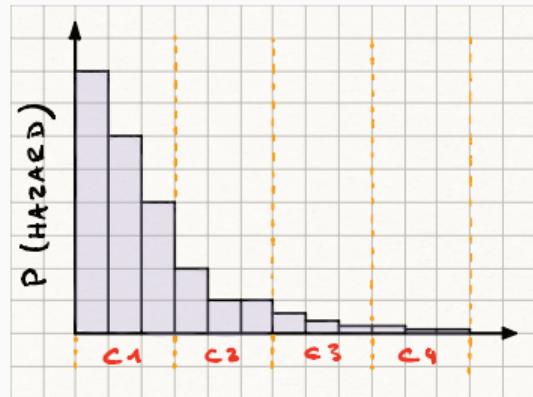
## Deterministic



## Scenario-based



## PVHA

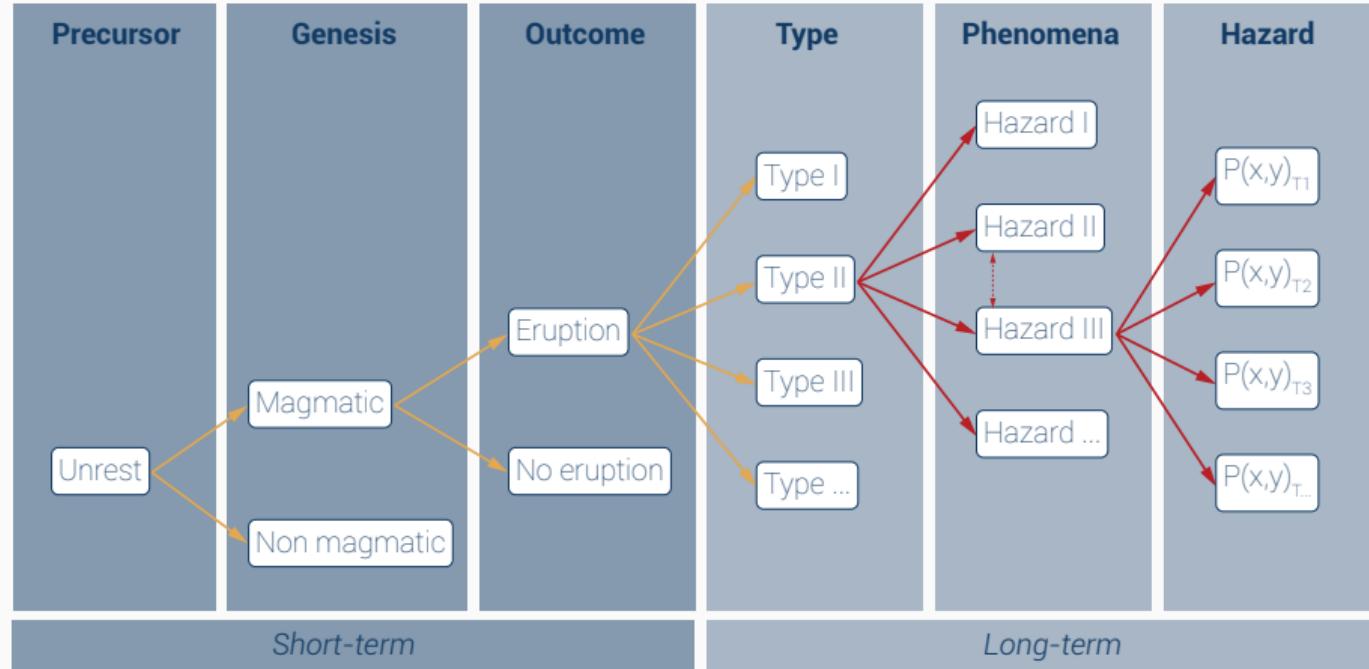


- $P_{\text{eruption}} = 1$
- Fixed ESP
- Single outcome

- $P_{\text{eruption}} = 1$
- Distributions of ESP
- Probabilistic scenario

- Aggregate all scenarios
- Continuous outcome
- $P(t \leq T)$

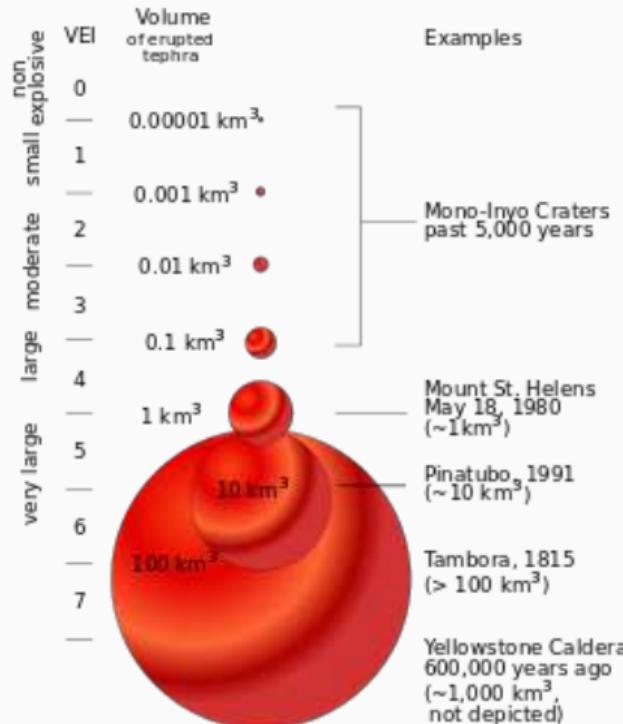
# Event trees



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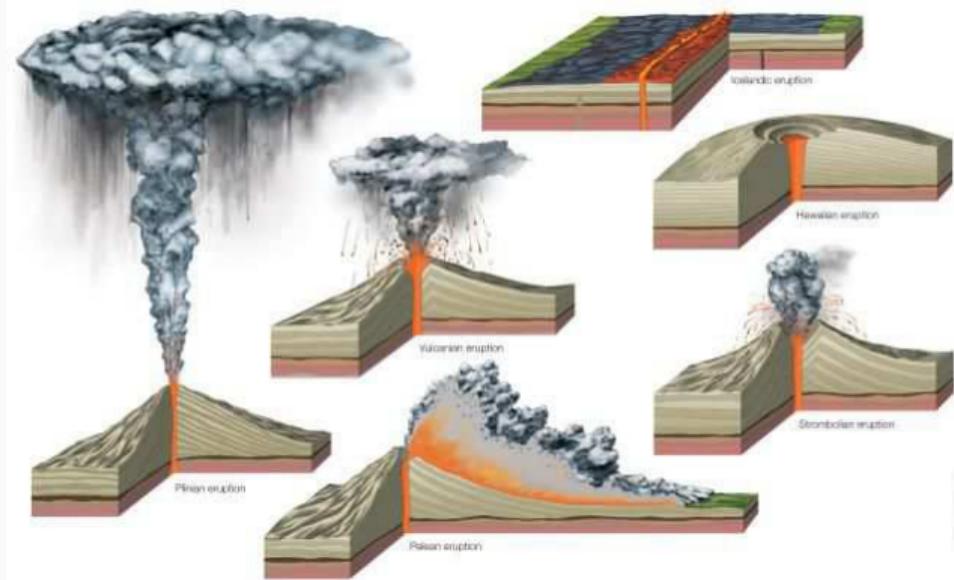
## Definition

- Magnitude (VEI) (snapshot)
- Intensity
- Style
- Return period
- “Qualitative”



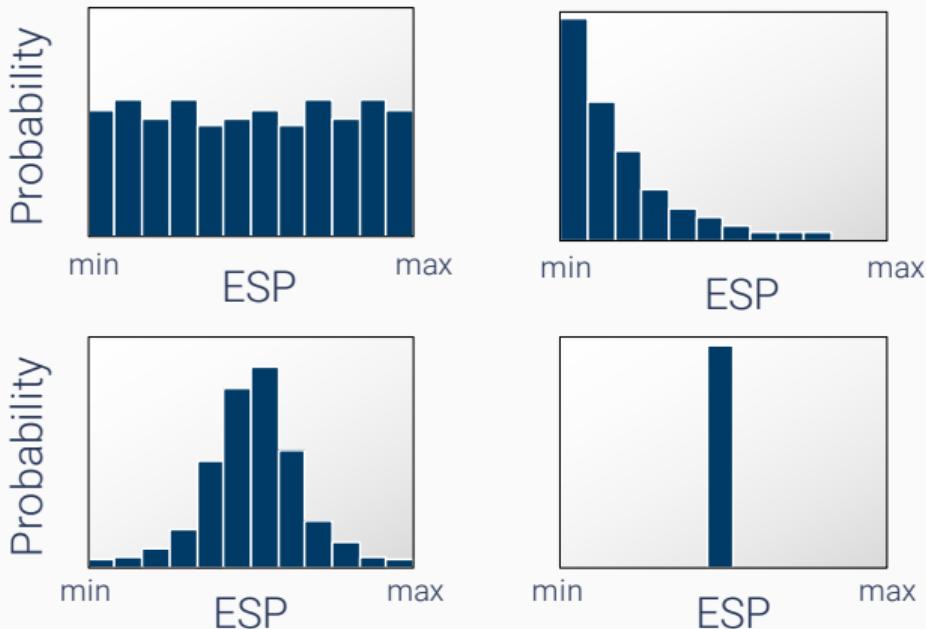
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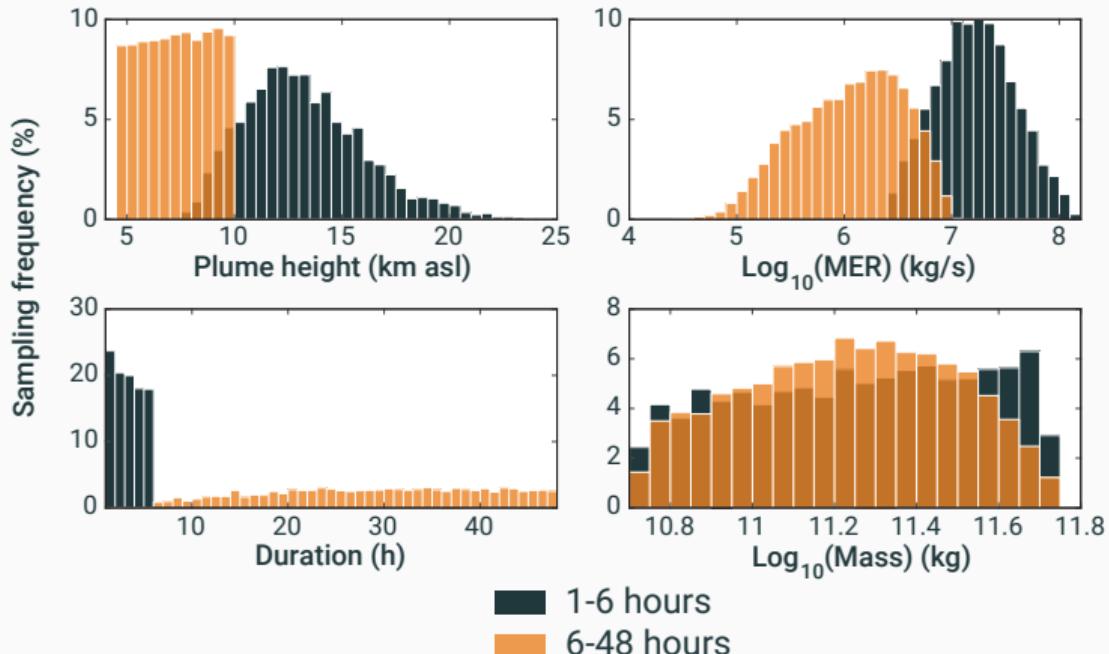


## Quantification

- Eruption source parameters
- Central value
- Distribution

## Subplinian eruptions at Sakurajima volcano (Japan)

- Duration of **1–6 h** and **6–48 h**
- Scaling of MER to produce tephra mass in given duration



## Iceland: Variable aleatory and epistemic uncertainties



Hekla

- Eruptions: 18
- Repose: 10-102 years



Katla

- Eruptions: 18 (tephra)
- Repose: 47 (mean)



Eyja

- Eruptions: 1612, 1821-23, 2010

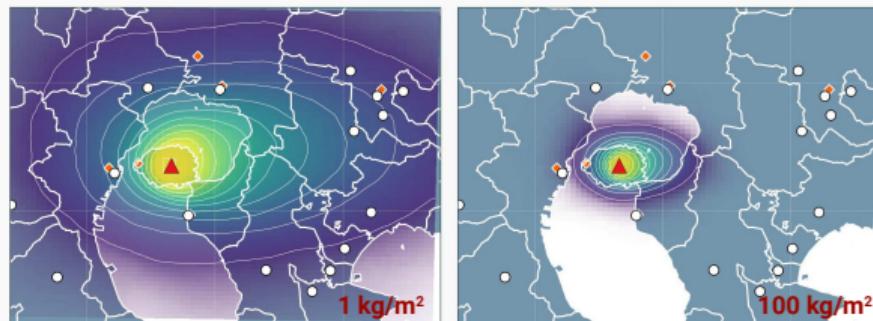


Askja

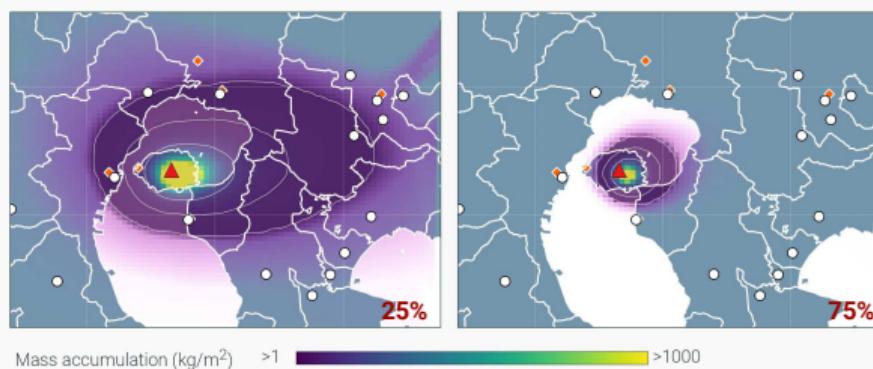
- Eruptions: 1875
- Multiphase

## Scenario-based: Sakurajima

Probability to exceed  
tephra accumulation:

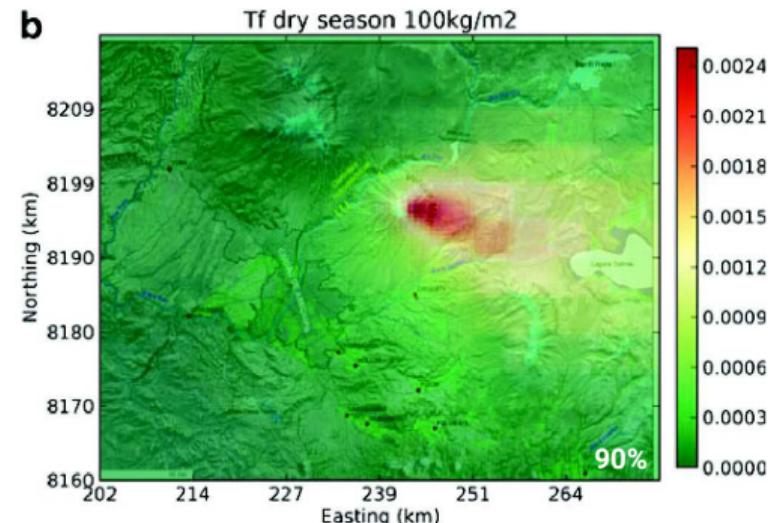
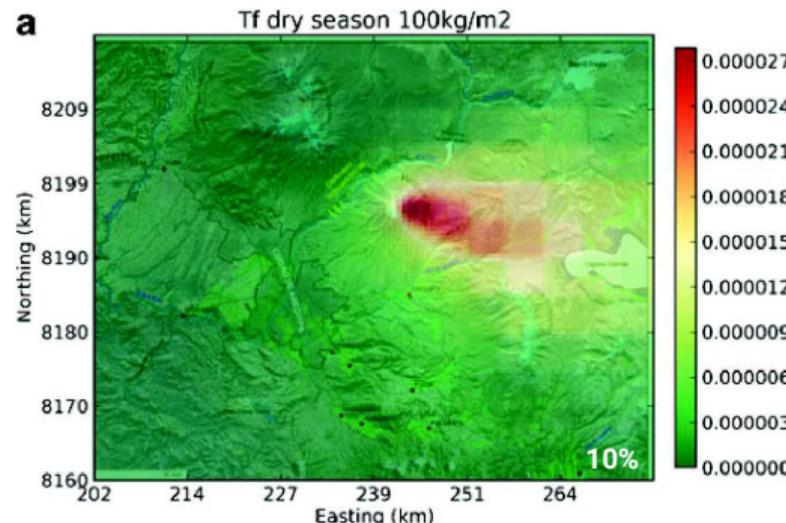


Intensity for a given  
percentile:

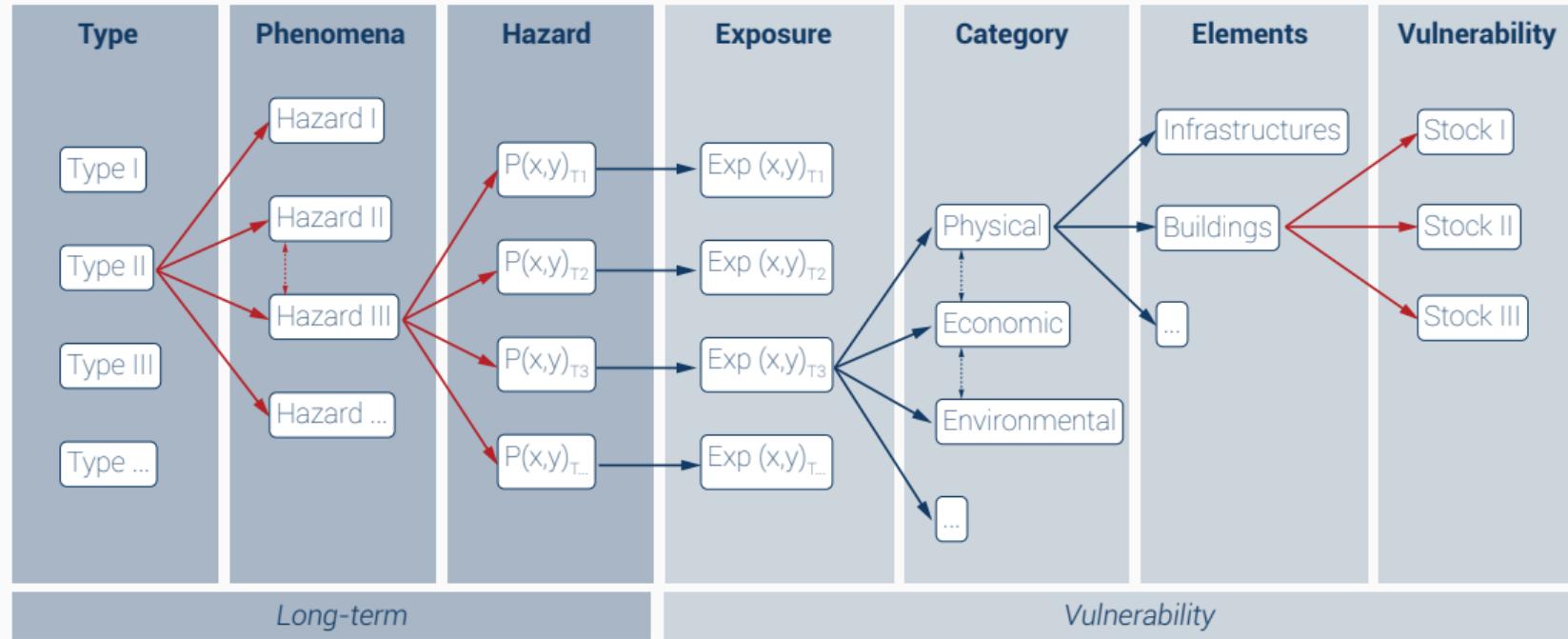


## PVHA: Misti

Probability to exceed a tephra accumulation of  $100 \text{ kg/m}^2$

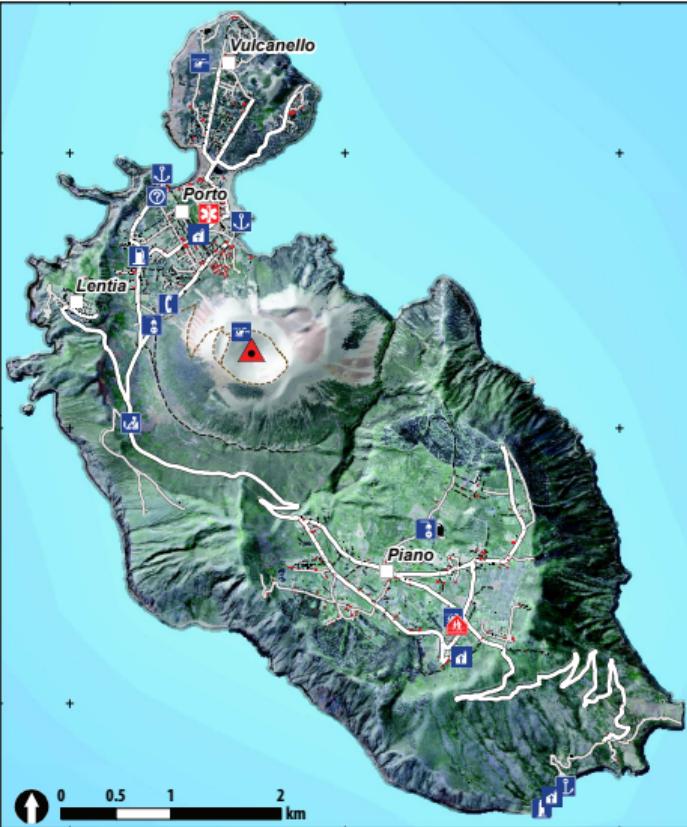


# Event trees: Vulnerability?



# Physical vulnerability

## La Fossa, Vulcano Island (Italy)



## La Fossa, Vulcano Island (Italy)

- 70% single-storey
- 73% flat roofs
- 54% regular morphology
- Homogeneous over island
- Clay bricks and concrete
- 1970's to 1980's



*Pictures by C. Frischknecht, CERG-C/UniGE Team, Biass et al. (2016)*

## Composite fragility curves

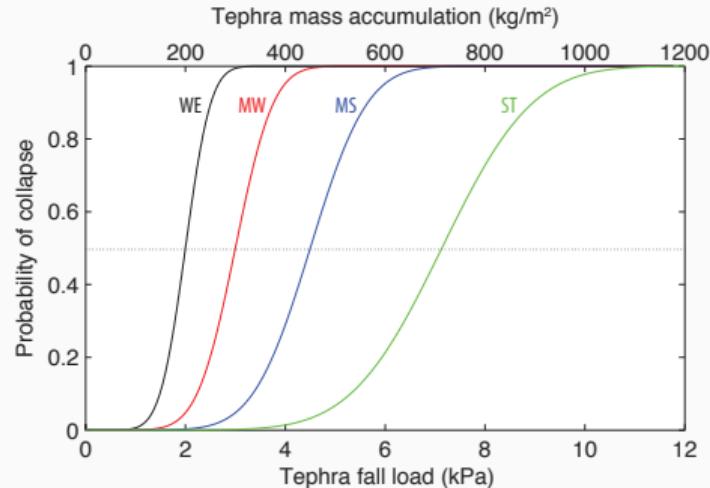
$$P(\text{collapse}|I) = \Phi(I, Q_{\text{mean}}, Q_{\text{std}})$$

$\Phi$  CDF of Normal distribution

$I$  Load of a given intensity (kPa)

$Q_{\text{mean}}$  Mean collapse load (kPa)

$Q_{\text{std}}$  Standard deviation



Roof class	Description	$Q_{\text{mean}}$	$Q_{\text{std}}$
Weak (WE)	Tiled roof, poor condition	2	0.4
Medium weak (MW)	Tiled roof, average or good	3	0.6
Medium strong (MS)	Flat RC roof	4.5	0.9
Strong (WE)	Flat RC roof < 20 years	7	1.4

## Composite fragility curves

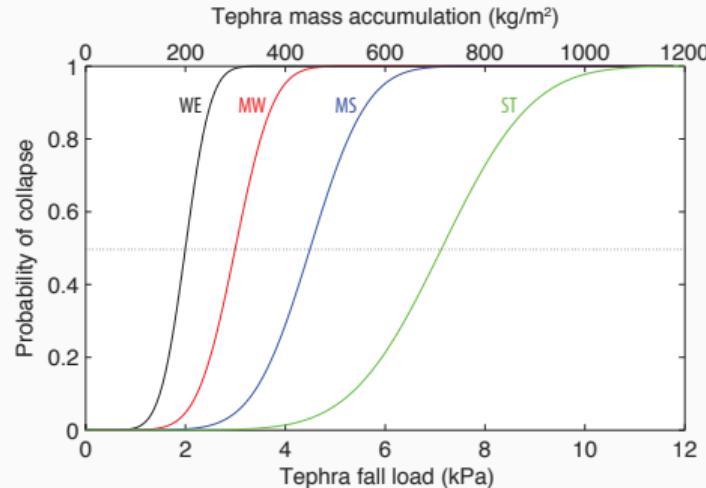
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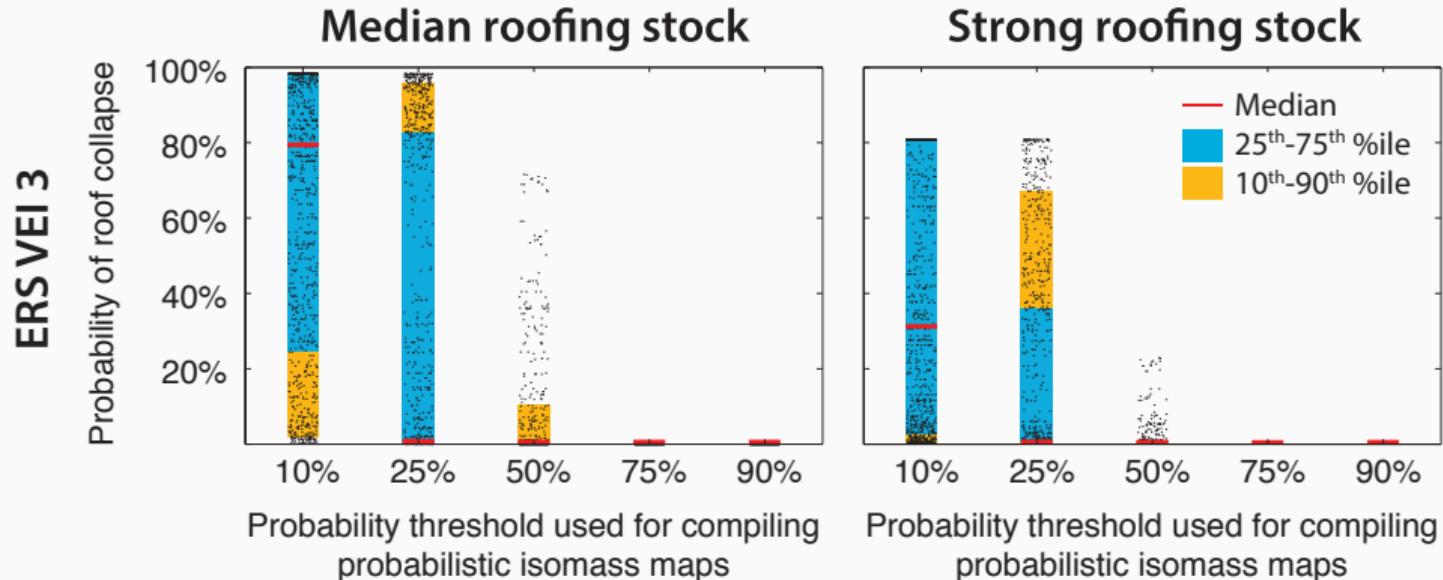
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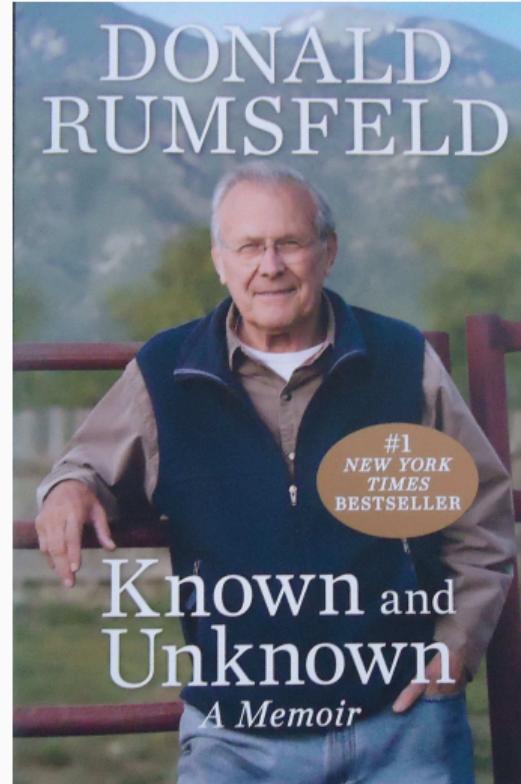
Roof class	Description	Weak	Median	Strong
		10%	50%	90%
Weak (WE)	Tiled roof, poor condition	85.7%	34.3%	2.7%
Medium weak (MW)	Tiled roof, average or good	13.5%	44.1%	18.9%
Medium strong (MS)	Flat RC roof	0.7%	18.9%	44.1%
Strong (WE)	Flat RC roof < 20 years	<0.1%	2.7%	34.3%

Spence et al. (2005)  
Jenkins et al. (2014)



*"There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we now know we don't know. But there are also unknown unknowns. These are things we do not know we don't know."*

- Epistemic
- Aleatory
- Ontological



Rumsfeld (2002)

- Aggregating scenarios/hazards: it's all about context! (Tom!)
- Scenarios tell a story (Natalia!)
- Quantification provides feeling of knowledge (Susanna!) ...
- ...contradicted by uncertainty bounds?
- Purpose of hazard/impact/risk assessments varies with stakeholders
  - What are they?
  - What are the acceptable uncertainties?

# Questions?

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