

Scenarios in volcanology

Causes and implications of deterministic and probabilistic choices

Sébastien Biass¹ (sbiasse@ntu.edu.sg), Susanna Jenkins¹, Costanza Bonadonna²

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¹ Earth Observatory of Singapore

² Université de Genève

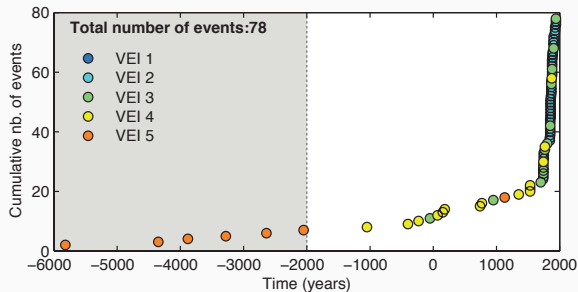
Volcanoes

- 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



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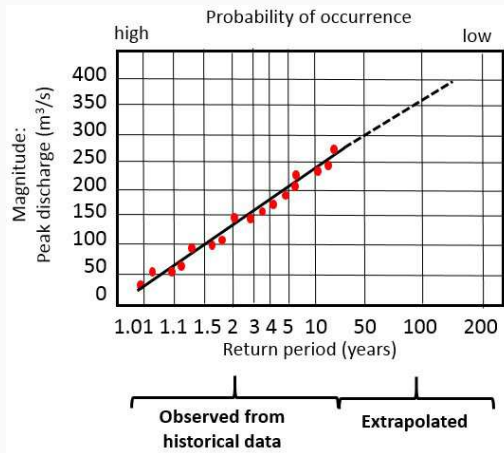
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Historical bias: Kīlauea



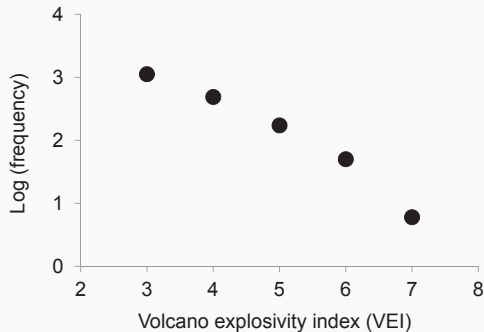
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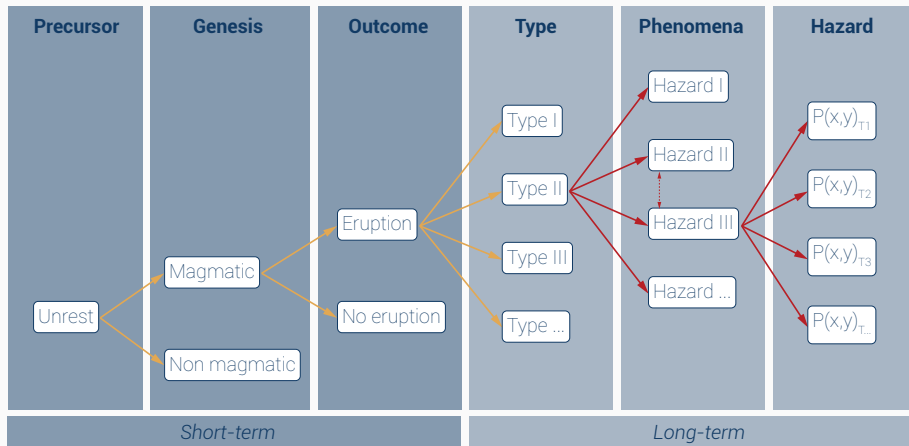
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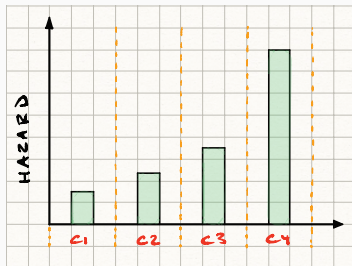
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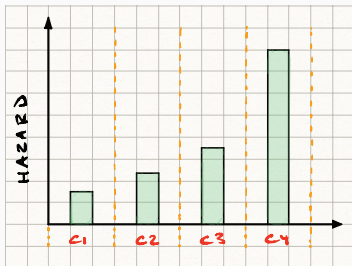


Deterministic



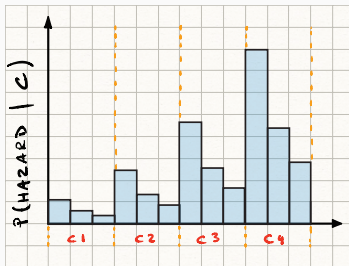
- $P_{\text{eruption}} = 1$
- Fixed ESP
- Single outcome

Deterministic



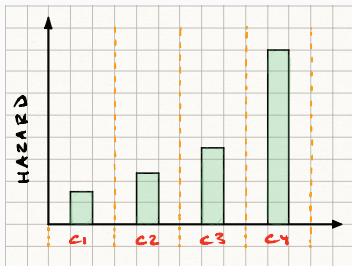
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Scenario-based



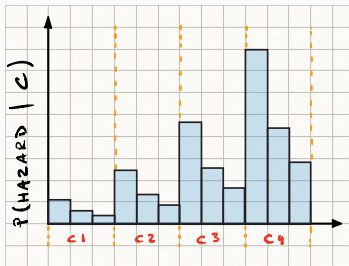
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- Distributions of ESP
- Probabilistic scenario

Deterministic



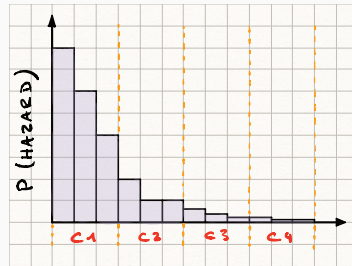
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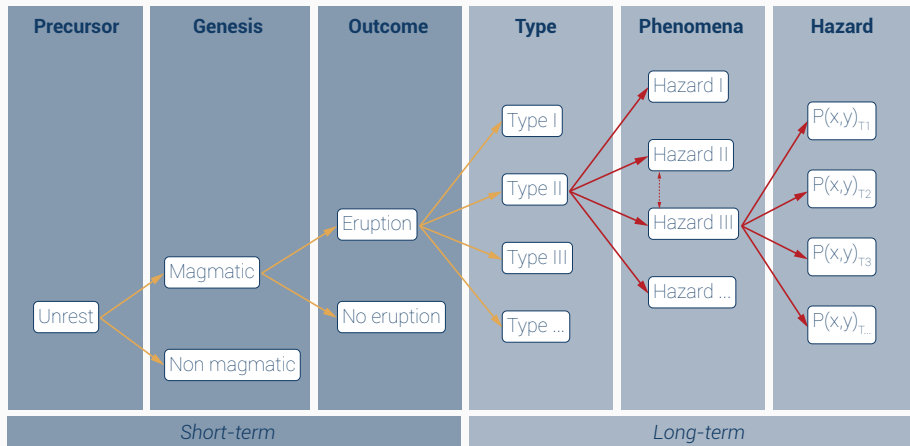


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PVHA

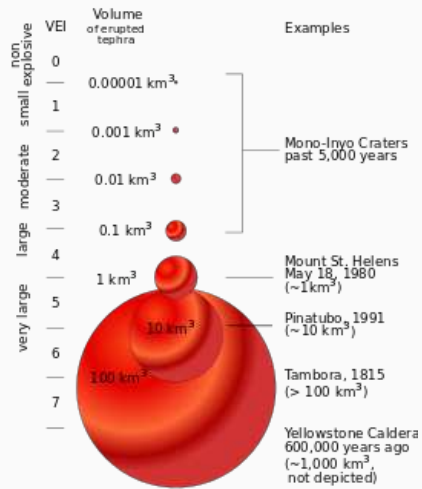


- Aggregate all scenarios
- Continuous outcome
- $P(t \leq T)$



Definition

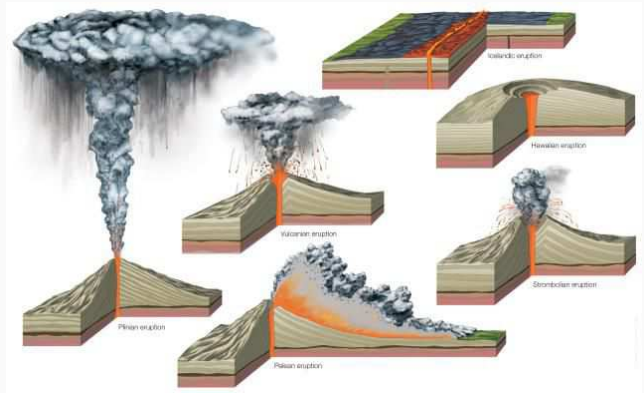
- Magnitude (VEI) (snapshot)
- Intensity
- Style
- Return period
- “Qualitative”



Newhall and Self (1982)

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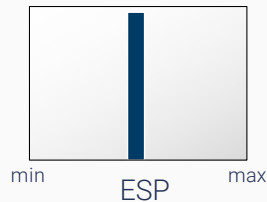
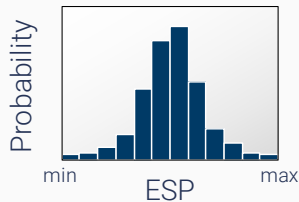
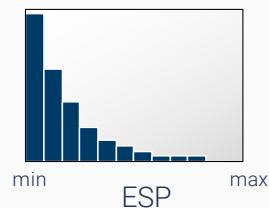
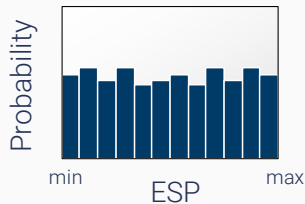


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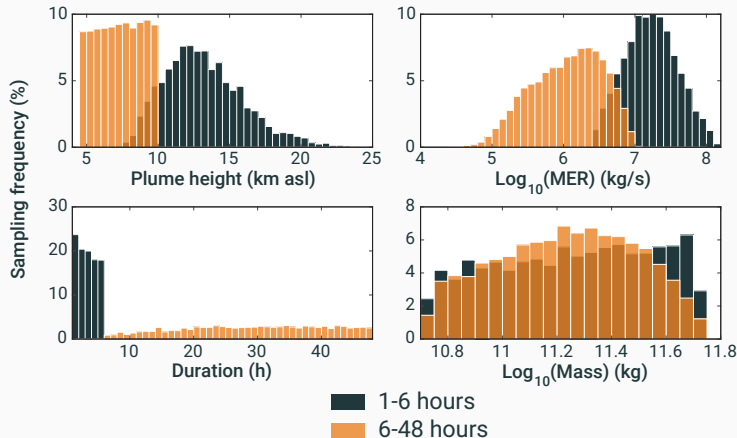
Quantification

- 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

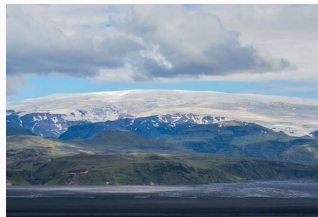


Iceland: Variable aleatory and epistemic uncertainties



Hekla

- Eruptions: 18
- Repose: 10-102 years



Katla

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



Eyja

- Eruptions: 1612, 1821-23, 2010

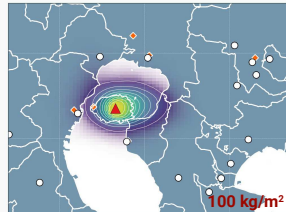
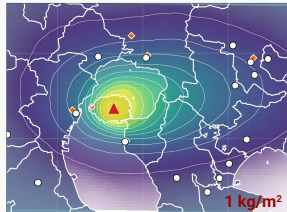


Askja

- Eruptions: 1875
- Multiphase

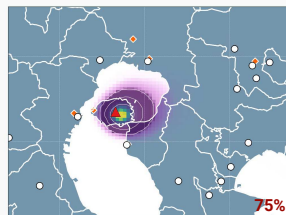
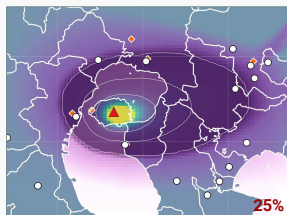
Scenario-based: Sakurajima

Probability to exceed
tephra accumulation:



Exceedance probability (%): >10 >90

Intensity for a given
percentile:

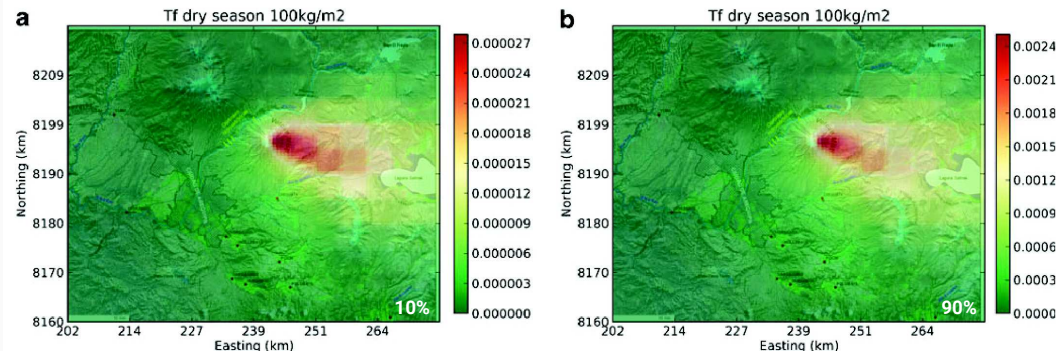


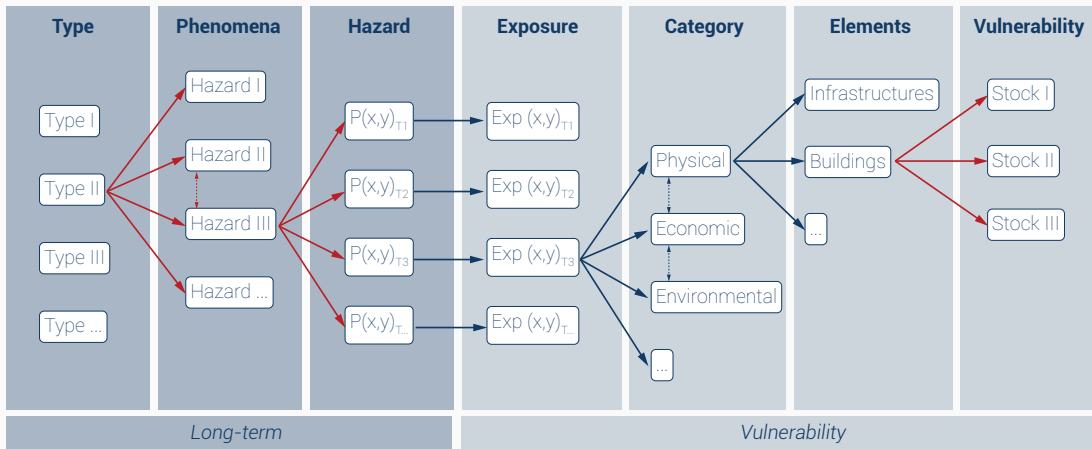
Mass accumulation (kg/m²) >1 >1000

Biass et al. (2017)

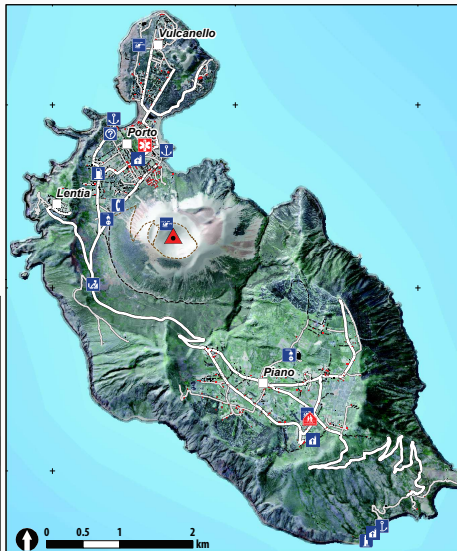
PVHA: Misti

Probability to exceed a tephra accumulation of 100 kg/m^2





La Fossa, Vulcano Island (Italy)



Critical facilities

- Church
- Gas station
- Harbour
- Heliport
- INGV
- Lighthouse
- Medical center
- Police station
- Power plant
- School
- Telecommunication

Transportation network

- Main road
- Secondary roads
- Paths
- Hiking paths

Buildings

- Surveyed
- Other

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



Composite fragility curves

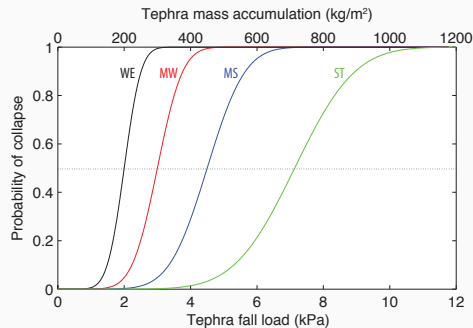
$$P(\text{collapse}|I) = \Phi(I, Q_{\text{mean}}, Q_{\text{std}})$$

Φ CDF of Normal distribution

I Load of a given intensity (kPa)

Q_{mean} Mean collapse load (kPa)

Q_{std} Standard deviation



Roof class	Description	Q_{mean}	Q_{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

Spence et al. (2005)

Jenkins et al. (2014)

Composite fragility curves

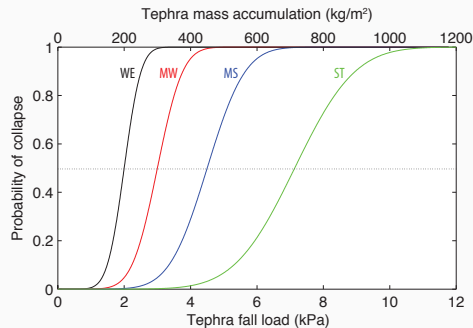
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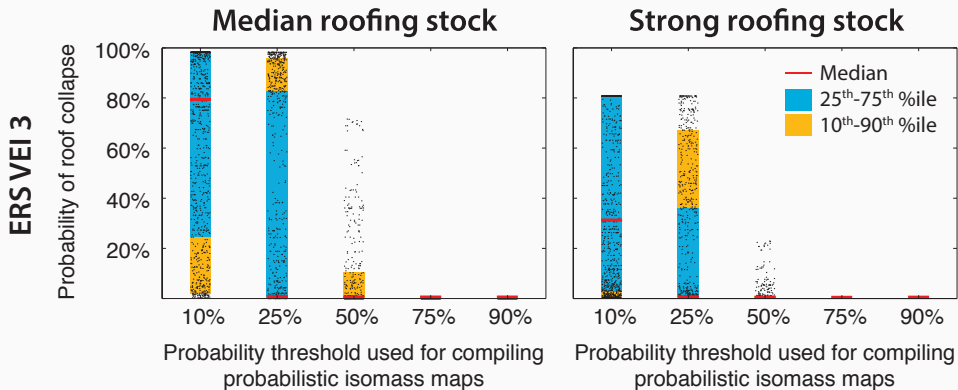
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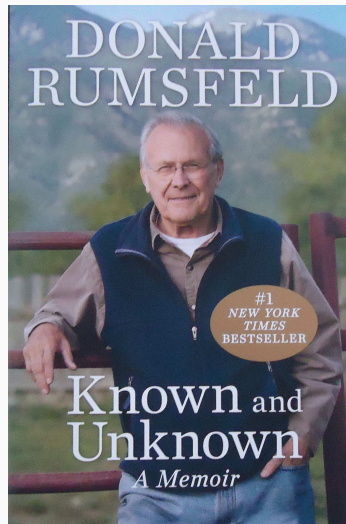
Roof class	Description	Weak	Median	Strong
		10%	50%	90%
Weak (WE)	Tiled roof, poor condition	85.7%	34.3%	2.7%
Medium weak (MW)	Tiled roof, average or good	13.5%	44.1%	18.9%
Medium strong (MS)	Flat RC roof	0.7%	18.9%	44.1%
Strong (WE)	Flat RC roof < 20 years	<0.1%	2.7%	34.3%

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



- 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?

 sbiasse@hawaii.edu

 e5k