PARAMETRIC INSURANCE FOR VOLCANIC RISK

SAMBa ITT

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Willis Towers Watson

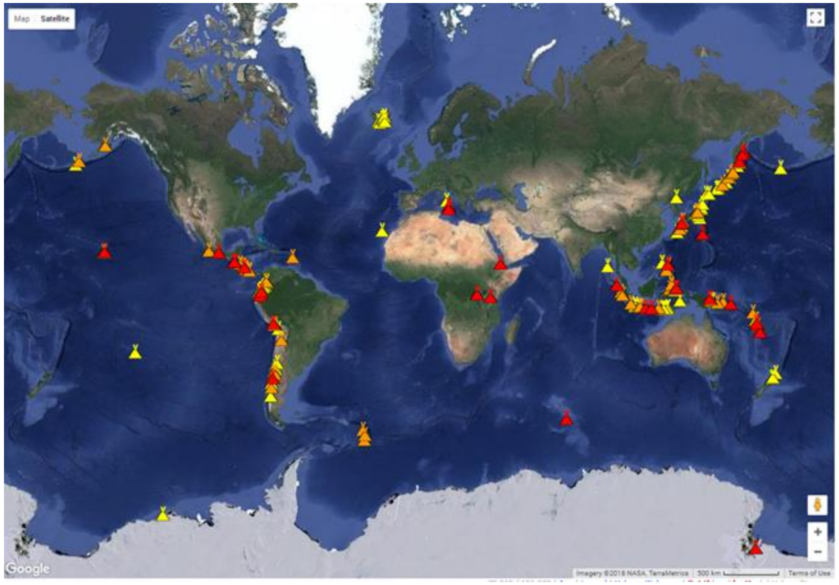
Feasibility Assessment of Parametric Insurance for Volcanic Unrest and Volcanic Eruption

VIP Consortium comprising:
Bristol University
GNS Science
Willis Towers Watson

with inputs from:
EOS-NTU
Univ. of Canterbury

and with support and funding from:
The World Bank

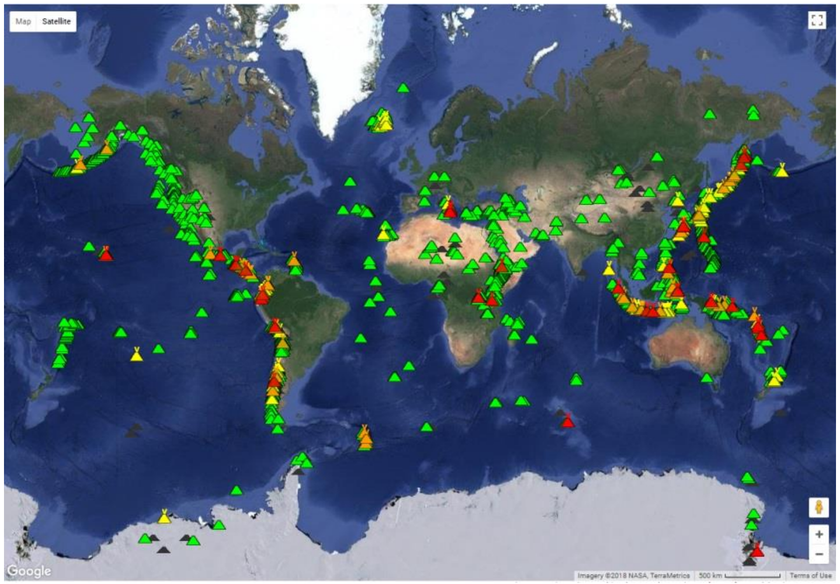
Current volcanic activity



- ✓ **159** volcanoes worldwide **:**
  - ✓ In eruption (red)
  - ✓ with signs of unrest (yellow)
  - ✓ with minor eruptive activity (orange).

Source: www.volcanodiscovery.com, Smithsonian Institution

Worldwide (known) active volcanoes



- More than 1,500 (known) active volcanoes
- ~ 575 “historically” active terrestrial volcanoes (Indonesia 75, USA 65, Japan 58, Russia 52, Chile 42)
- ~ 200 of these have some sort of geophysical monitoring or observation system
- ~ 12 eruptions annually with VEI of 2+

Source: www.volcanodiscovery.com, WOVO, Smithsonian Institution

Introduction to Parametric Insurance

Complexity

Indemnity

- Scheme pays on actual, assessed loss
- Higher cost of loss adjustment and, in some situations, higher cost due to risk assessment uncertainty
- Loss adjustment also results in payment delays
- Close correlation with experienced loss (though contract conditions may inhibit expected recovery amount)

Parametric

- An event occurs, payment is made
- Simple, easy to understand, flexible
- Uses objective and independent data – removes uncertainty and subjectivity in claims adjustment
- Potential for basis risk: less intense events may trigger a large pay-out, while an intense event may only trigger a small – or no – pay-out

Basis Risk

Parametric Solutions

Parametric risk transfer requires a number of critical components:

- A clear, robust definition of the policy trigger
- An independent, recognised and trusted source of the measurement of the policy trigger
- An agreed basis of settlement should the trigger event occur

Policy triggers	Measurement of policy trigger	Basis of settlement
▪ Natural catastrophes such as earthquake, windstorm or volcanic eruptions ▪ Adverse weather such as snow, freeze or drought ▪ Man-made perils such as terrorism ▪ Life perils such as pandemic or increased mortality	▪ Intensity and location of a windstorm as measured by the NHC ▪ The annual rainfall at an agreed location as measured by a WMO Met Office ▪ Confirmation of the outbreak of a covered disease by the WHO ▪ The imposition of travel restrictions by the CAA or a specified government.	▪ A fixed payment should the trigger event occur ▪ An agreed scale of payment according to the severity of the trigger event ▪ An agreed scale of payment based upon the impact of the event on a secondary index such as passenger numbers or flight cancellations ▪ A traditional business interruption calculation

Parametric Triggers for Volcanic Unrest and Eruption

Solution for volcanic unrest

- Not intended to influence decision-makers or the criteria to evacuate
- Potentially provides rapid access to finance (external or internal) to cover additional costs associated with escalating unrest, including preparedness activities and evacuation

Solution for volcanic eruption

- Potentially provides rapid liquidity to national and / or regional government after an eruption - for medical supplies, food and clean water, for example
- Could also be used to compensate individuals for livelihoods which have been interrupted or assets that have been damaged or destroyed

Encourages robust *ex ante* risk awareness

- Parametric insurance solutions can provide risk management benefits
  - A quantitative understanding of volcanic risk has to be built
  - Highlights the financial consequences of volcanic activity to local, regional and national economies, and encourages active consideration of financial risk and its mitigation

Parametric insurance for volcanic unrest

Forecast based finance for preparedness and evacuation

Immediately Implementable Unrest Product Trigger Design

Multiple Triggers and a Progressive Pay-out Mechanism

Product offers national coverage (single aggregate policy for all volcanoes) and utilises the official Volcano Alert Level (VAL) and an Official Evacuation Call as dual indices

Payout triggered by VAL

- Sub-trigger (small fraction of limit to be triggered) at the move from a background VAL to the next higher VAL to support additional costs related to increasing unrest, including but not limited to enhanced volcano monitoring and community preparedness / awareness-building
- Inherent connection between upward change in VAL and increased burden on the coverage buyer- the very action of increasing the VAL will, in most cases, cause certain actions to be taken, with those actions designed to better-protect the at-risk population and each (or most) bearing a cost to the sovereign

Payout triggered by Evacuation Call

- Main trigger to support additional costs related to increasing unrest, including but not limited to evacuation costs and, potentially, benefits for evacuated individuals
- Inherent connection between Official Evacuation Call and increased burden on the coverage buyer

Evacuation Database

The Global Volcanism Program of the Smithsonian Institution record evacuations as events in VOTW. Their dataset was used to generate an evacuation database, comprising the following data:

- **Volcano Number: A unique identifier for the volcano**
- **Volcano Name: The volcano name**
- **Volcano Type: The primary volcano type**
- **Activity ID: A unique number for the related eruption**
- **Event ID: A unique number for the evacuation event**
- **Start date: The start date of the eruption**
- **End date: The end date of the eruption**
- **Event date: The date of the evacuation**
- **Evacuation count: The number of people evacuated**
- **Evacuation cause: The hazard or event leading to evacuation**
- **Evacuation remarks: A narrative on the eruption and evacuation event**

The Challenge

Probability of Evacuation

Using Indonesia as a case study country, how can we constrain the probability estimation of evacuations at the national level?

Available data for Indonesia, over 52 years:

Total # of evacuations	69
Total people evacuated	1,323,805
Evacuations per year	1.33
People evacuated per evacuation	19,186
People evacuated per year	25,458

We have data on historical evacuation event rates, which can provide a constraint on probability estimation of evacuations at the national level. However, is it possible to constrain the probability estimation of evacuations at an individual volcano level, or perhaps 'volcano type' level?

Parametric Insurance for Volcanic Eruption

Finance for immediate post-event liquidity / emergency response

A Footprint-Based Trigger

Payout triggered by the occurrence of an eruption

The Challenge: What is the probability of an eruption?

- The traditional catastrophe modelling used to understand the probability of a loss is much more complicated for volcanos than, for example, windstorm

Catastrophe Modelling

Cat models are used to quantify loss frequency / severity, and manage exposures

For low-frequency perils such as natural hazards and terrorism, standard actuarial techniques based on past events are inappropriate due to lack of historical data

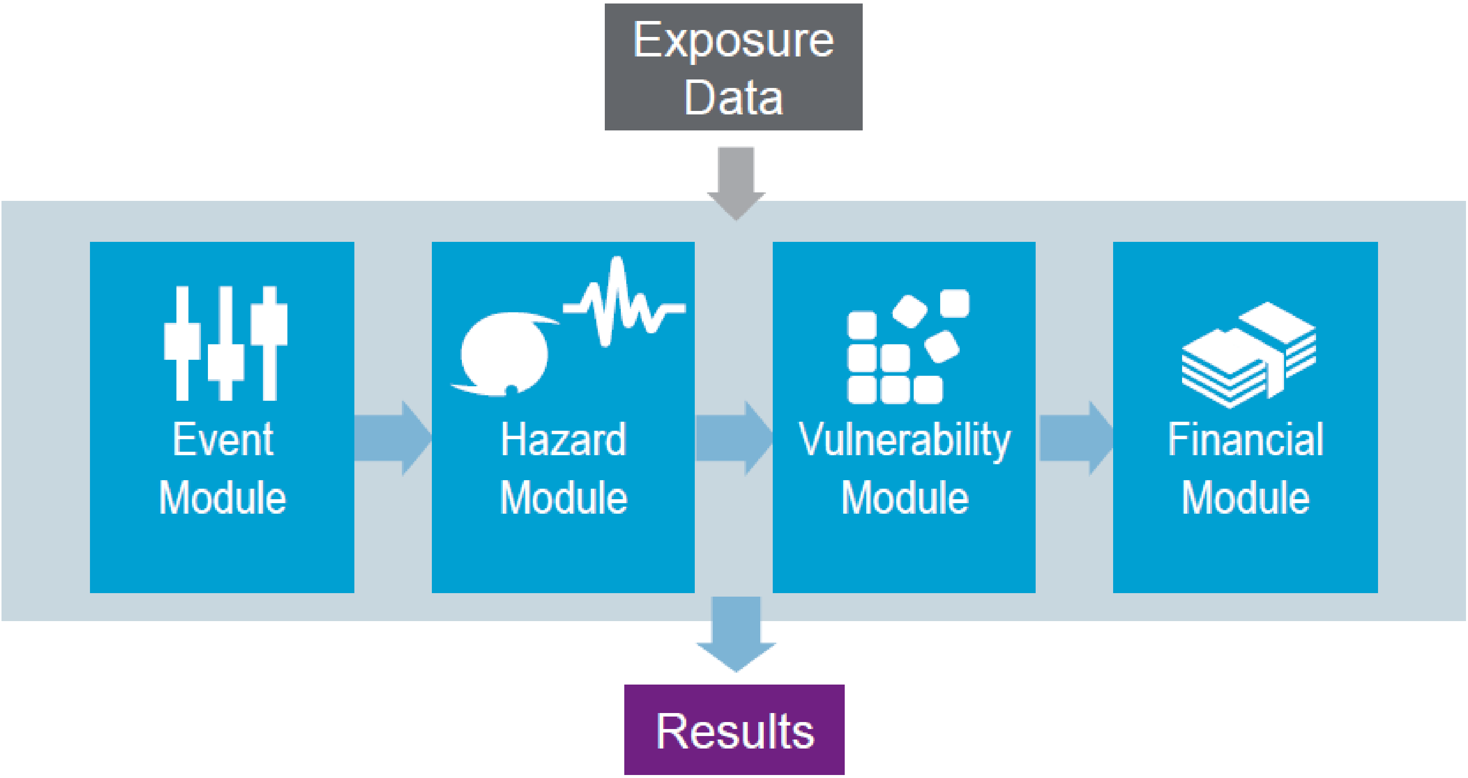
New methods based upon what could happen, not what has happened, had to be developed

The methodology to develop such models was outlined in the early 1980s

By the late 1980s we had the first windstorm and hurricane “stochastic” catastrophe models

By the end of the 20th century the majority of the world’s insured catastrophe exposed property had been modelled

Catastrophe Model Components



What is a Stochastic Catastrophe Model?

The earliest catastrophe models were scenario models

- If this event occurred (or reoccurred) what would the damage be?
- These models are also known as deterministic models

A stochastic model not only considers the past but what could happen

- Not only assessing event loss amounts but also their probabilities
- These models are also known as probabilistic models

They have their own jargon and terminology

- Exceedance Probability = Probability of suffering a loss over a given amount
- Return Period = How many years pass before a loss of a given amount or larger is expected to occur, the inverse of probability (eg 1% probability = 1 in 100 return period)
- OEP = Occurance Excedence Probability, concerns return periods of event losses
- AEP = Annual Excedence Probability, concerns return periods of total annual losses
- AAL = Annual Average Loss, also know as Expected Loss

Understanding Volcanic Hazard

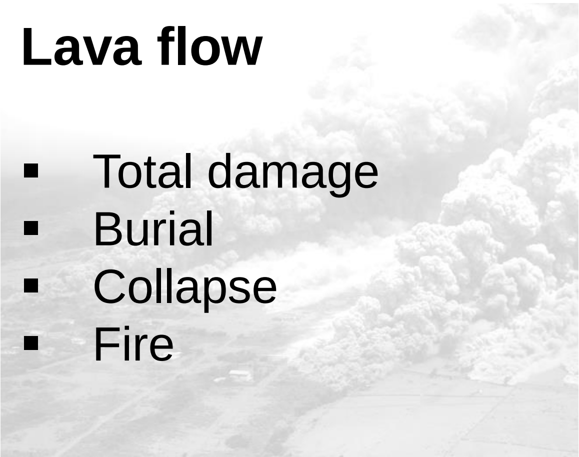
More than you would expect






Understanding Volcanic Hazard

Lava flow



Lava flow

- Total damage
- Burial
- Collapse
- Fire

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Understanding Volcanic Hazard

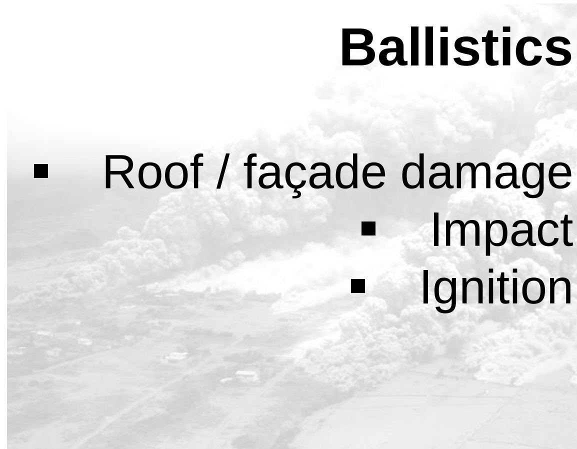
Pyroclastic flows and surges

Pyroclastic flow

- Building damage
- Pressure impact
- Ignition
- Burial

Understanding Volcanic Hazard

Volcanic ballistics



Ballistics

- Roof / façade damage
  - Impact
  - Ignition


Understanding Volcanic Hazard

Landslides, rockslides and collapses (which could trigger tsunamis)


Landslides

- Total damage
- Pressure impact
- Burial

Understanding Volcanic Hazard

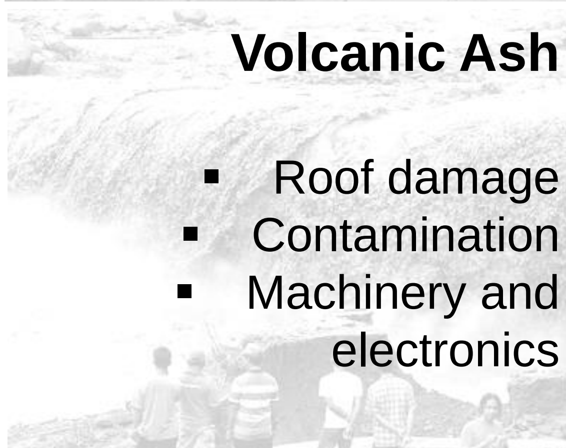
Lahars (mud flood)

Lahars (mud flow)

- Building damage
- Pressure impact
- Infiltration
- Burial

Understanding Volcanic Hazard

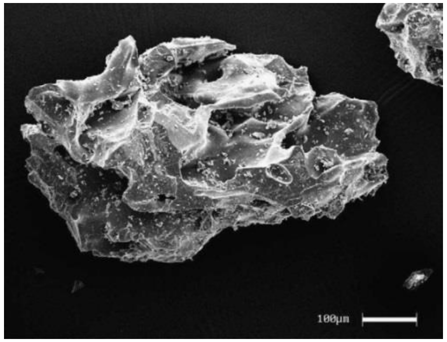
Volcanic Ash and Tephra



Volcanic Ash

- Roof damage
- Contamination
- Machinery and electronics

Volcanic Ash

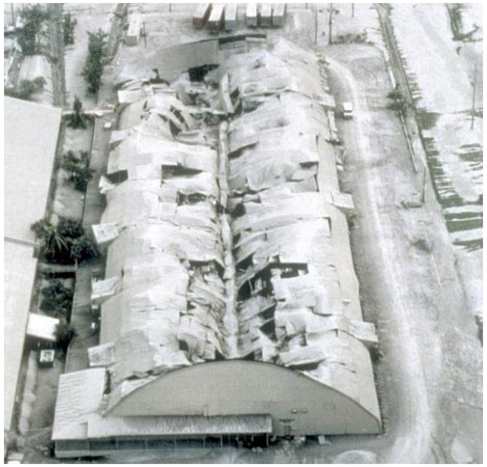


More ways of damage than you would expect

- Ash is heavy
- (5-20) x Snow
- 10cm ~ 200kg





Volcanic plumes and ash clouds

More than you would expect

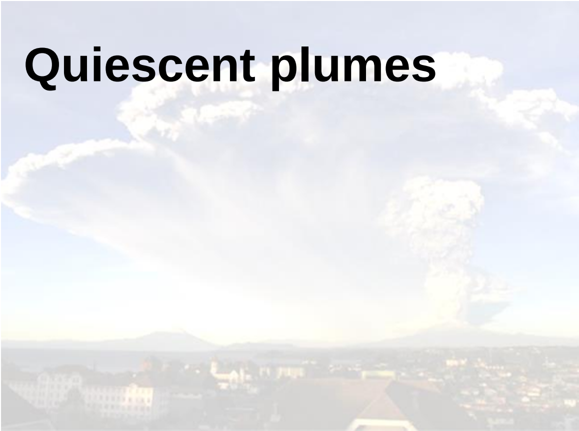




Volcanic plumes and ash clouds

More than you would expect

Quiescent plumes

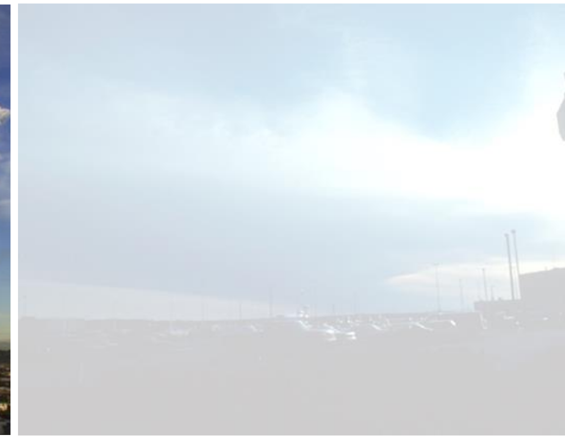


Volcanic plumes and ash clouds

More than you would expect

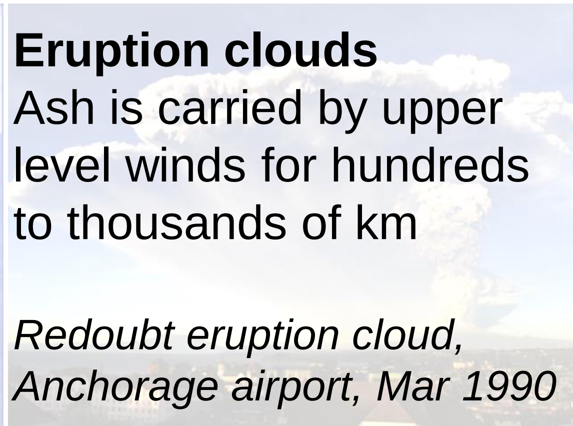
Eruption columns

Ash and gas that rise rapidly to altitudes above 100, 000 feet (>30 km)



Volcanic plumes and ash clouds

More than you would expect



Eruption clouds
Ash is carried by upper level winds for hundreds to thousands of km

Redoubt eruption cloud, Anchorage airport, Mar 1990

Volcanic plumes and ash clouds

More than you would expect

Eruption clouds

Difficult to distinguish from weather clouds

Rabaul, Sep 1994

Volcanic plumes and ash clouds

More than you would expect

Eruption clouds may enter the stratosphere and encircle the globe in days to weeks

Chile, Apr 2015

Volcanic plumes and ash clouds

More than you would expect

Eruption clouds

pose the greatest threat to aircraft

Eyjafjallajökull, Iceland 2010

Proxying Volcanic Eruption Impacts

VEI vs Hazard Footprint

Volcanic Explosivity Index (VEI)

- A relationship between VEI and fatalities (as a proxy for damage and loss) is established
- However, VEI does not include lava and lahar hazards, and eruptions with the same VEI can lead to very different levels of damage and loss
- Can a hybrid index proxy impact and loss?

Modelled Loss Approach

- A footprint-based approach to capture the spatial extent of volcanic hazards post-event
- Hazard footprint then superimposed on ‘locked’ exposure and vulnerability modules to generate impact and, ultimately, financial loss
- Hazards can be modelled in advance to build a set of scenarios for a given volcano or volcanic type and, ultimately, a stochastic catalogue of hazard footprints, and both can be measured or mapped quickly after an event through either remote sensing (for flow footprints) or through modelling (for tephra footprint and thickness)

Modelling Volcanic Processes

Many perils, many models

Ash transportation

Numerical models - atmospheric winds usually change in space and time, which means we must solve the advection-diffusion-sedimentation equation numerically

- Simple models - Ashfall, Tephra2 (wind changes with height, uniform in space and time; gives tephra accumulation on the ground (tephra mass per unit area; open source, open access)
- Complex models - NAME, Fall3D, Ash3D, Puff (wind data from weather models, gives tephra in atmosphere and on ground

Probabilistic modelling at one volcano - Sample over distribution of eruption conditions, wind conditions, run tephra model for each input condition, and combine into probability map

Regional probabilistic modelling - Tephra from each volcano must be included, and each volcano has different recurrence interval, size, style

Surface mass flows

Energy cone model - For flow hazards (PDCs in particular) run-out distance might be all that is necessary (assume 100% loss)

- Run out distances in energy cones can be computed quickly – many iterations possible for uncertainty assessment or probabilistic models

Box models - Gravity current box models to build probabilistic hazard maps, sample uncertain conditions

- Combine with energy cone model to assess effect of topography

PDCs

Numerical models for dense PDCs - Titan2D (open source) or VolcFlow (not open source, semi-open access Matlab) - and 2 layer PDC models for flows and surges

Lahars

LaharFlow (open source) or LaharZ (use energy cone H/L = μ to define proximal hazard zone (μ = 0.1 – 0.3 for lahars)