# What’s the Consequence?
# Using field and laboratory approaches to assess Volcanic Impacts to Society

**1st IAVCEI/GVM workshop: From volcanic hazard to risk assessment**

**Geneva, 27-28 June 2018**

Thomas Wilson, Susanna Jenkins, Johnny Wardman, George Williams, Daniel Blake, Peter Baxter, Carol Stewart, Natalia Deligne, Graham Leonard, Gustavo Villarosa, Russell Blong, Ben Kennedy, Christina Magill, Kristi Wallace, Shane Cronin

# Overview

1. Introduction
2. Field observations
3. Empirical laboratory experiments
4. Summary + suggested future directions

# Framework

Hazard

Exposed elements

Vulnerability

Impact/Risk

# The issues...

- PROBLEM 1: Insufficient knowledge of impacts...
  - ...of volcanic hazard impact and appropriate mitigation strategies within responding organisations
  - NEED: specialised, sector-specific impact, preparedness and post-event response/recovery information for volcanic hazard preparedness
- PROBLEM 2: Insufficient access to required information
  - Which further exacerbates uncertainty for preparedness, response and mitigation decision-making
- PROBLEM 3: Few agencies or groups have the required integrated capability to provide this applied knowledge
- PROBLEM 4: Volcano disasters occur in complex multi-jurisdictional settings which required well-established pre-existing networks between information providers and responders

*Paton et al. 1998. Organisational Response to a Volcanic Eruption.* Disaster Prevention & Management 7 (1): 5-13

# 2. Field Observations of Impacts

- Field based observations have identified a rich catalogue of potential volcanic impacts which society may experience.
- Used to inform quantitative risk models and other disaster risk management resources
    - powerful case-study narratives

- Seminal work by the likes of Russell Blong, Peter Baxter, Robin Spence, and others through the 1980’s and 1990’s
    - Expanded breadth and depth of knowledge
    - Drove quantification…where appropriate


1980 Mt St Helens eruption

# Field: empirical data collection
## The Merapi 2010 eruption

- Provides detailed catalogue of event and impacts; local scientists often have limited resources at times of crisis
- Empirical impact data help to reduce uncertainty in establishing relationships between the hazard process and impact/consequences
- Merapi 2010 large explosive eruption was unique opportunity to study explosive eruption impacts on a densely populated area

Courtesy of Susanna Jenkins

***Damage to the village of Balerante, 5km from Merapi volcano during the October-November 2010 eruption***

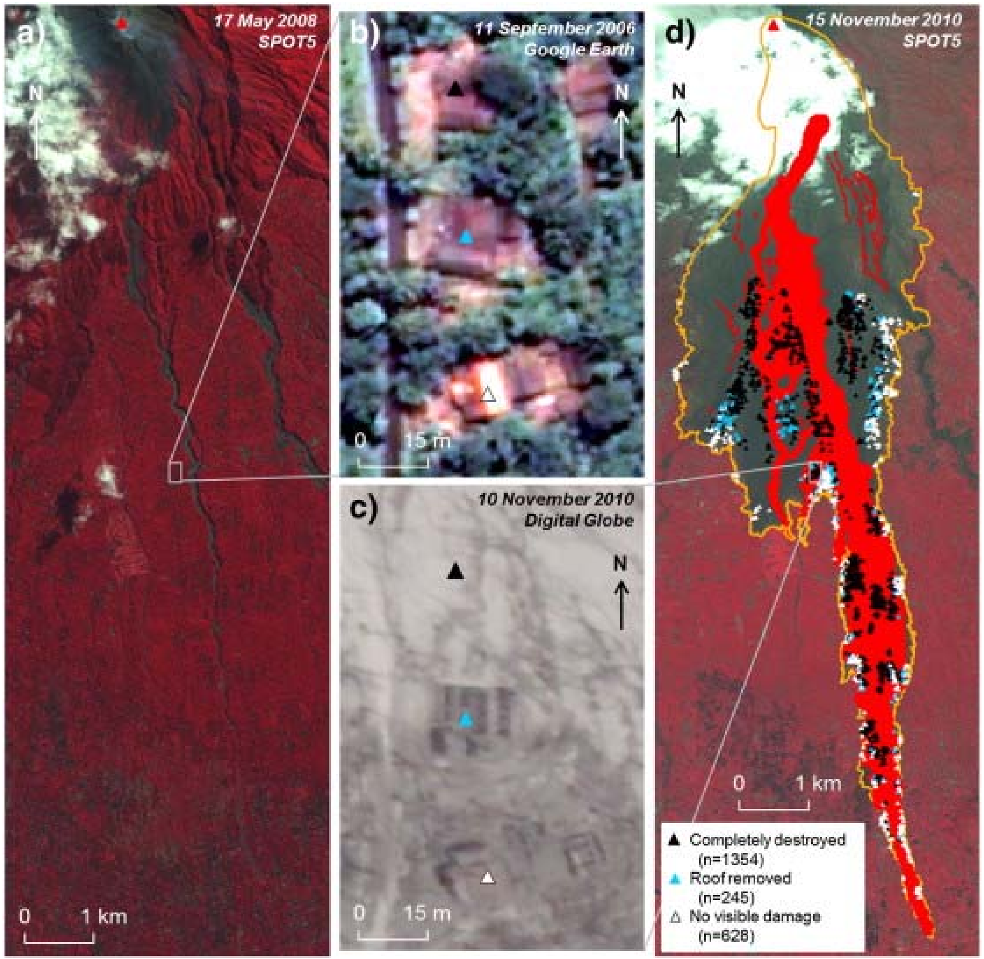
***[Photo: courtesy of Balerante village chief]***

# COLLECTING EMPIRICAL IMPACT DATA:
## The Merapi 2010 eruption, Indonesia

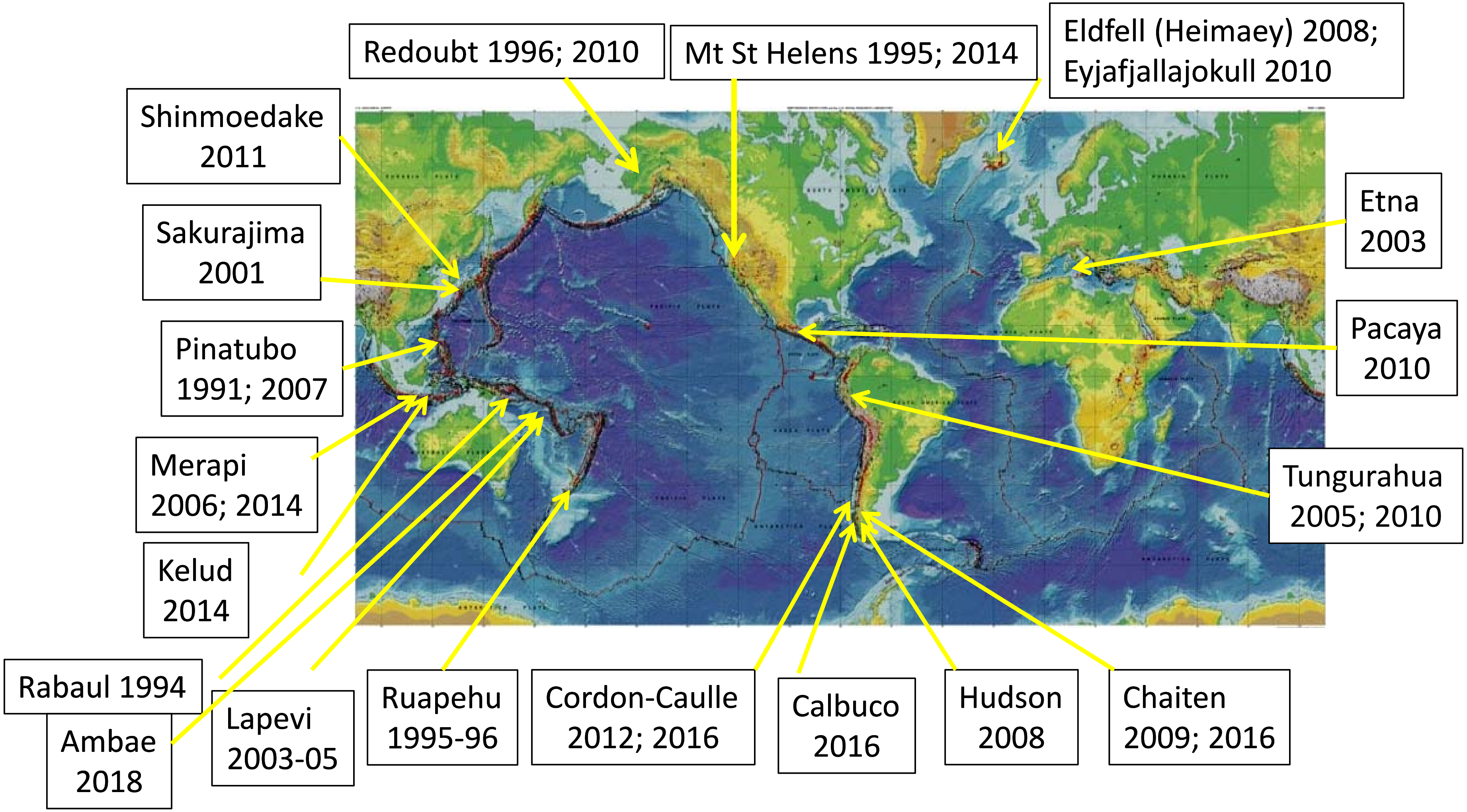
- Empirical data can be used to derive the physical processes involved
- Multi-disciplinary assessment preferable, e.g. Geology, Engineering, Medical, Social sciences
- Combine multiple data sources: Remote; Field; Desk (e.g. GIS); Laboratory
- Longitudinal study important for recovery
- Collaboration and support of local scientists and population essential
    - capacity development
    - sustainable data collection, crisis response support, field support

Courtesy of Susanna Jenkins

***Pyroclastic density current dynamic pressures mapped through assessment of damage to buildings, vegetation, infrastructure, etc.***
***[Jenkins et al., 2013]***



# Ash fall impact assessment recon trips: by volcano & year visited



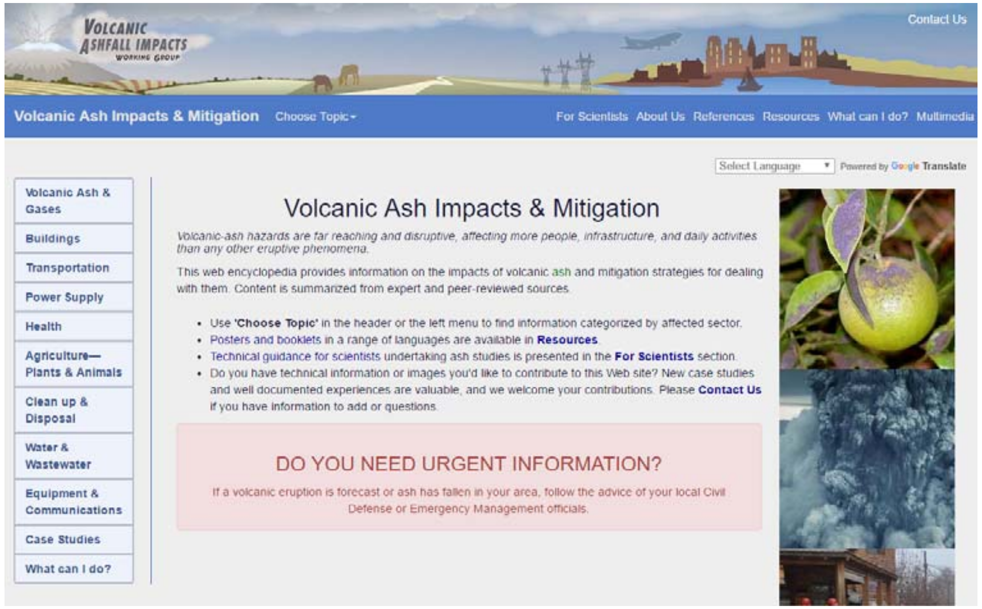
# Observations from areas following ash fall (typically >10 mm)

Volcanic ash falls are often regarded as exotic events (mysterious) which are rarely planned for

- ***Health*** *(most important!)*
  - *What does ash do to me….to my children?*
  - *What will ash do to water supplies?*
  - *What impact will it have on food?*
- ***Critical Infrastructure Services***
  - *Aviation, electricity, transportation and water supply disruptions are most common*
  - *Unexpected impacts.  Can they be mitigated?*
  - *Hard to clean up.*
  - *Where can I dump it?*
  - *More time & $$ than expected*
- ***Business Continuity***
- ***Farming***
  - *What will ash do to my animals and crops?*
  - *How can I remediate the damage?*
  - *How much Fluoride is in the ash?*

# Volcano Disaster Preparedness Resources

## Ash Impacts & Mitigation Online Encyclopedia



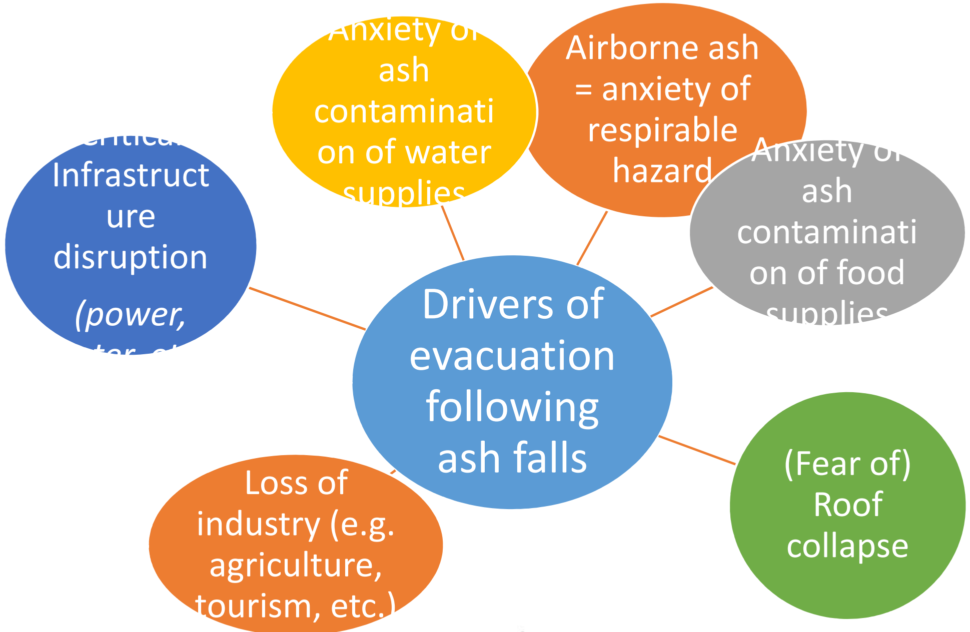

https://volcanoes.usgs.gov/volcanic_ash/

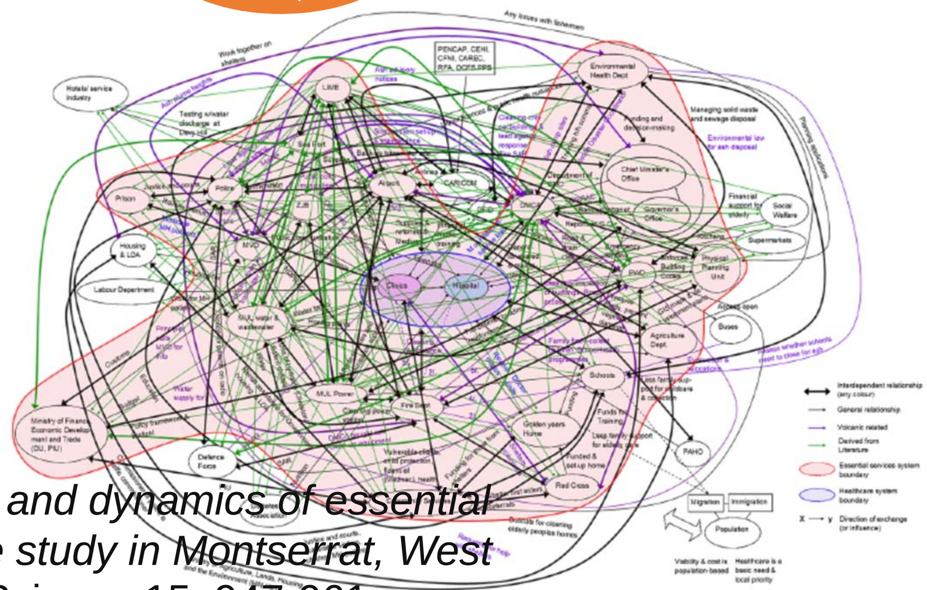
## VISG Ash Impacts Posters for Critical Infrastructure


http://www.gns.cri.nz/Home/Learning/Science-Topics/Volcanoes/Eruption-What-to-do/Ash-Impact-Posters

# Social + Economics Impacts

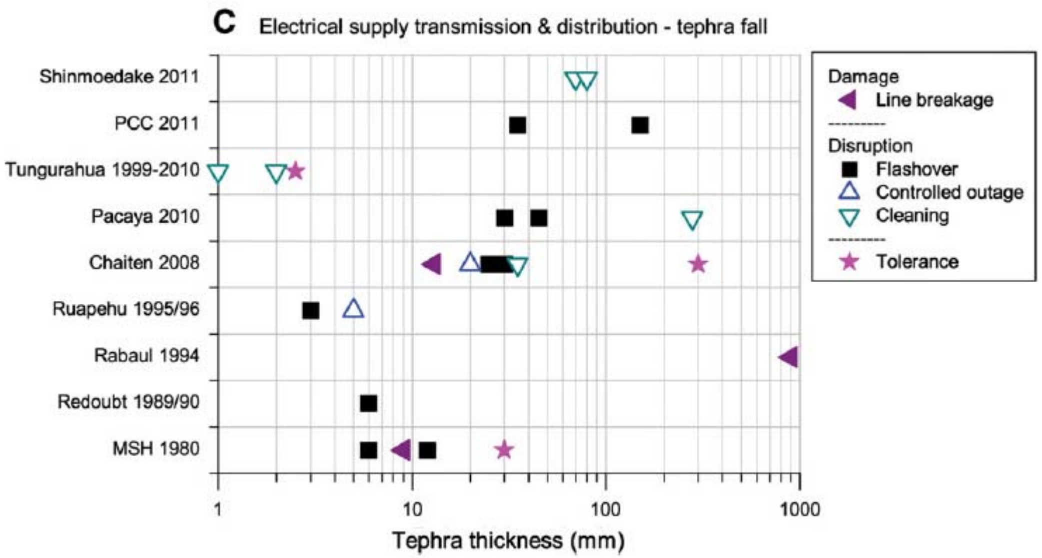
- Emergency management
- Evacuation dynamics and drivers
- Warnings (impact based)
- *Habitability?*
- *Well-being?*
- *Psychosocial effects?*
- *Institutional frameworks?*
- *Economic – direct, indirect, intangible?*
- *Supply chains?*
- *Etc…….*



Sword-Daniels et al. 2015 *Interdependence and dynamics of essential services in an extensive risk context: a case study in Montserrat, West Indies.* Natural Hazards and Earth System Science 15: 947-961

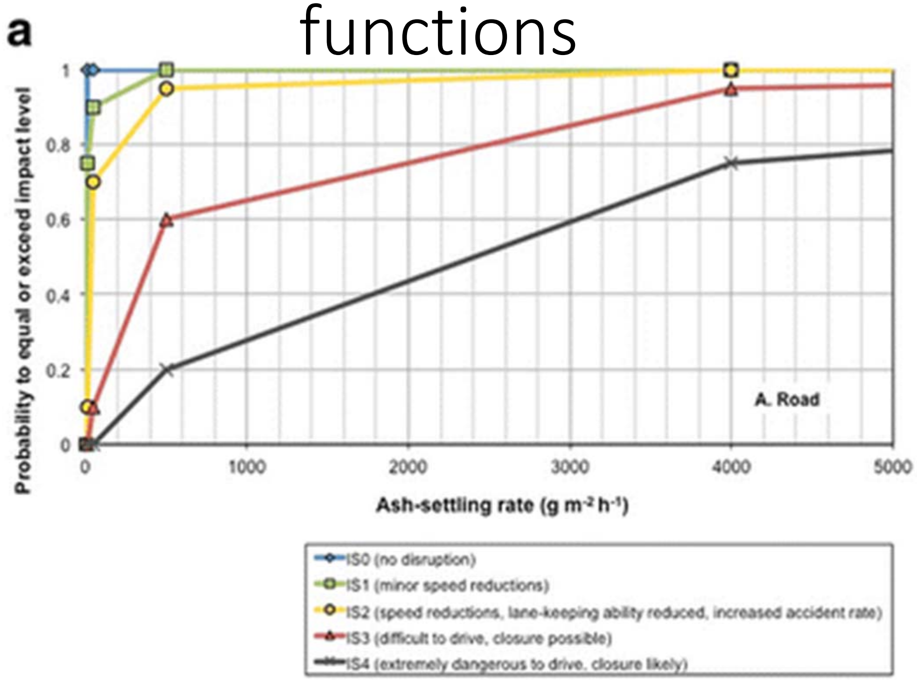
# Field studies informing vulnerability models




Thresholds

G. Wilson et al. 2014. Review of Volcanic Impacts to Critical Infrastructure, JVGR

Fragility functions




Blake et al 2017. *Improving volcanic ash fragility functions through laboratory studies: example of surface transportation networks.* Journal of Applied Volcanology

# Limitations of field based approaches

Limitations of field based data collection

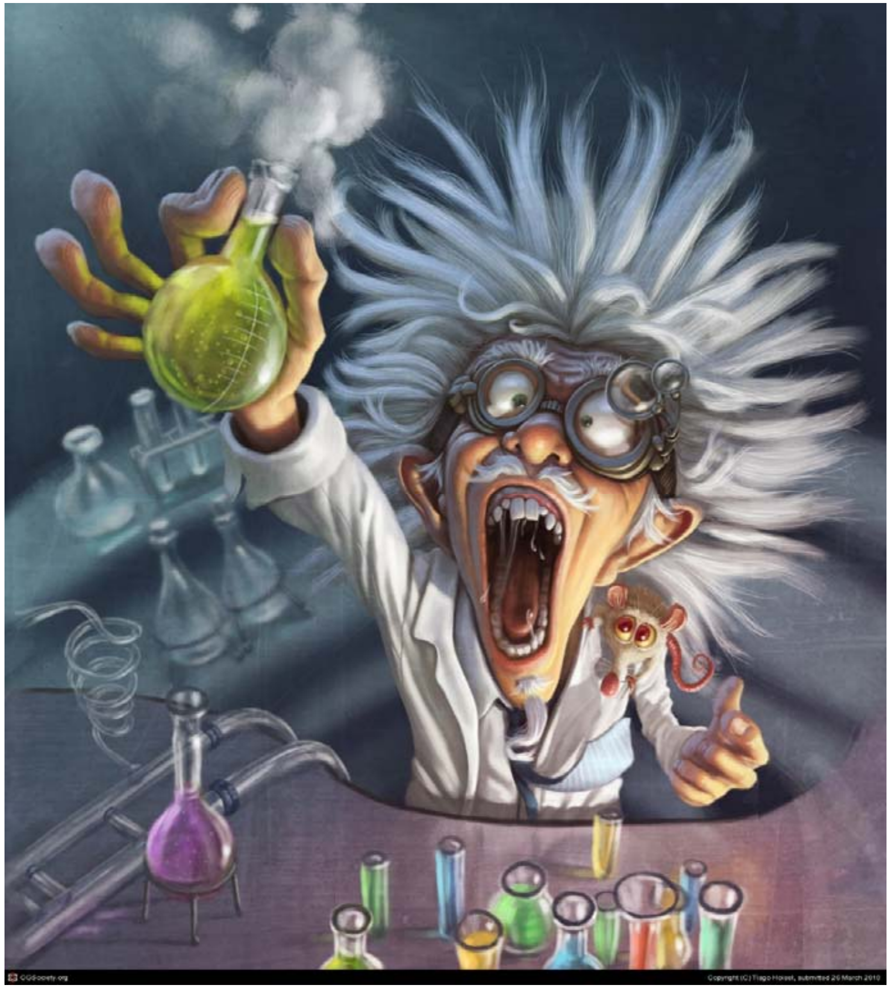
a) the broad range of potential volcanic hazards, hazard intensities, durations, and the complex interaction between these hazards
b) vast array of societal elements potentially exposed to volcanic hazards and their vulnerability (or resilience)
c) logistical, time, safety, ethical factors which may limit idealised data collection

Creates challenges for robust assessment of likely impacts and to inform potential mitigation measures.

# 2. Into the Lab!!

Empirical investigation of volcanic impacts in controlled laboratory settings are a promising area of research to assist addressing these challenges…

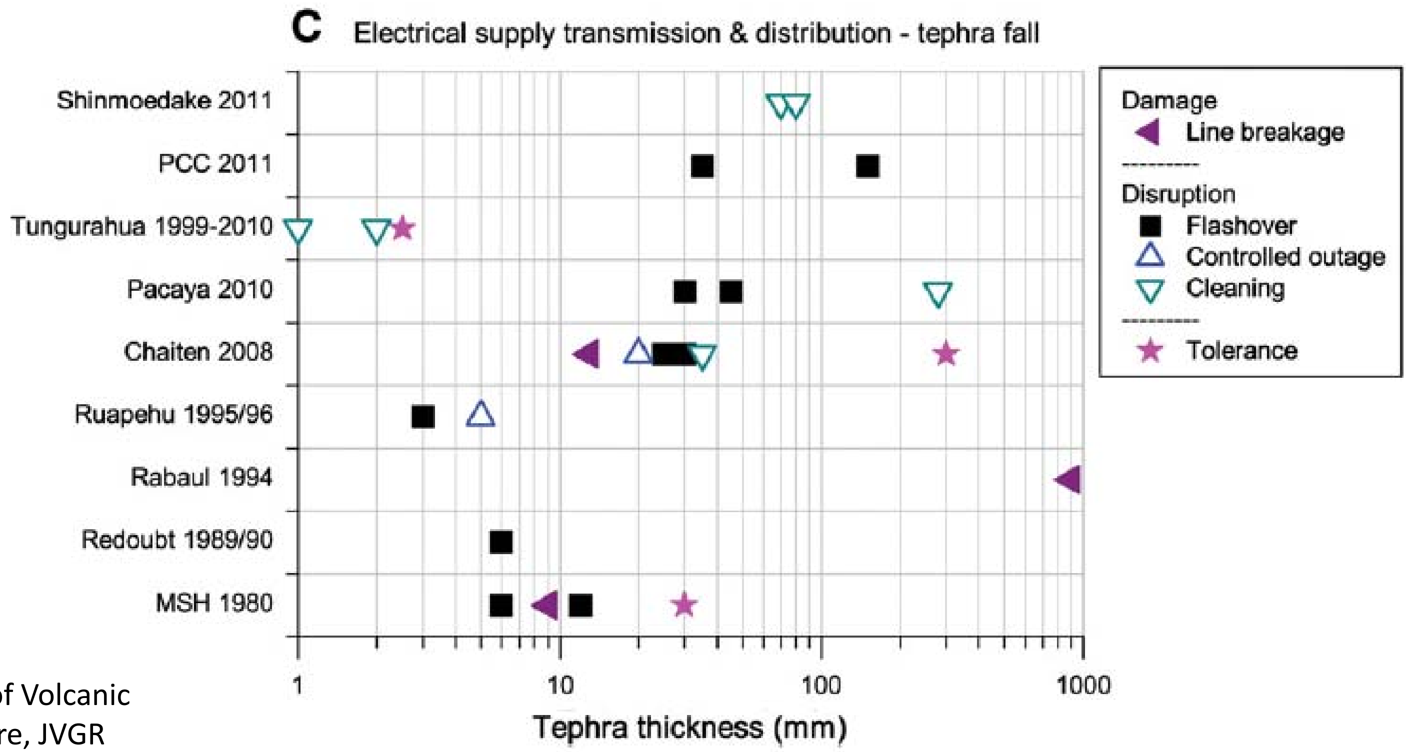
…particularly when informed by field observations and partnerships with practitioners



http://tiagohoisel.cgsociety.org/art/mad-photoshop-scientist-cartoon-866688

# Electrical networks vulnerability to ash

- Relate impact type to hazard intensity
  - How much ash fall?
- Identify performance threshold:
- Why? What factors are important?



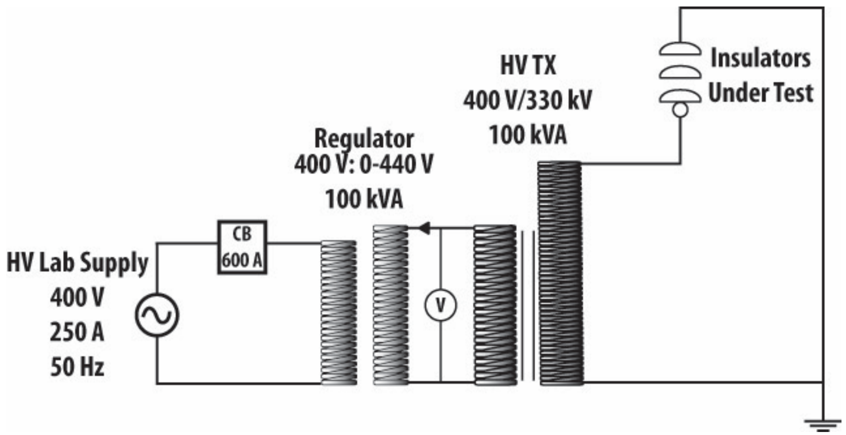

G. Wilson et al. 2014. Review of Volcanic Impacts to Critical Infrastructure, JVGR

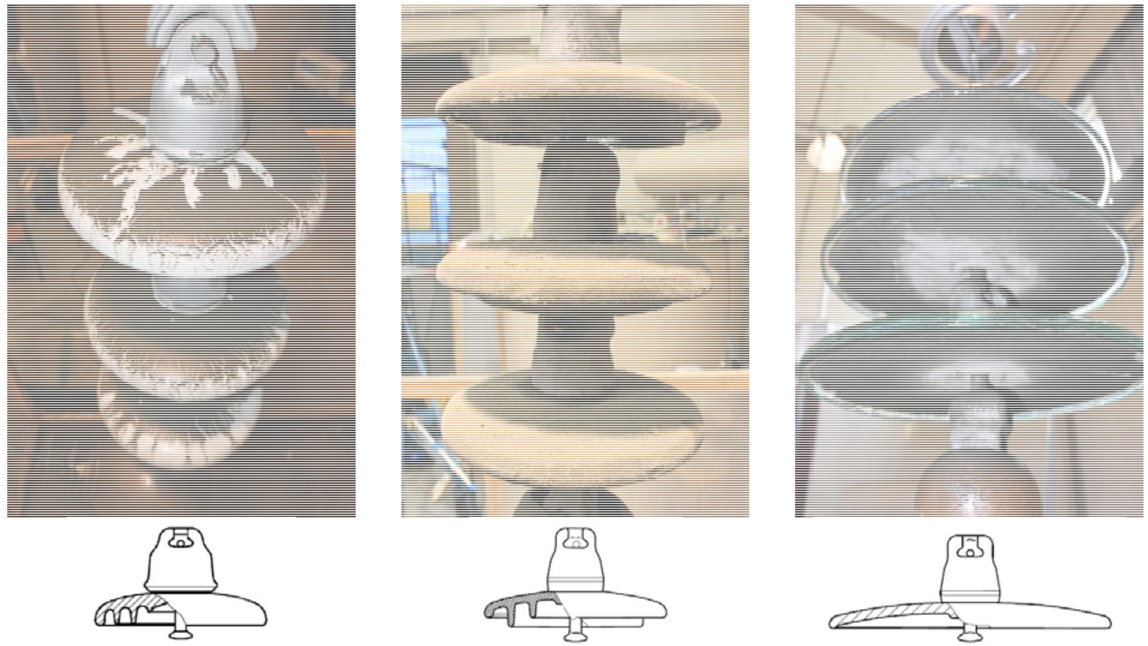




# Volcanic Ash Contamination on Flashovers to High-Voltage Insulators – lab study

1. Determine minimum flashover voltage ($V_{min}$)
    - 5 different insulators
    - 9 contamination scenarios
2. Identify critical ash thickness, coverage, ambient conditions and grain size
3. Measure partial discharge activity leading up to flashover



Courtesy of John Wardman

Wardman, J.B., Hardie, S.R., Wilson, T.M., Bodger, P.S., (2014) Influence of Volcanic Ash Contamination on the Flashover Voltage of HVAC Outdoor Suspension Insulators. *IEEE Transactions on Dielectrics and Electrical Insulation.*



Composite polymer best suited for ashy environments

Grain size has negligible influence on flashover voltage

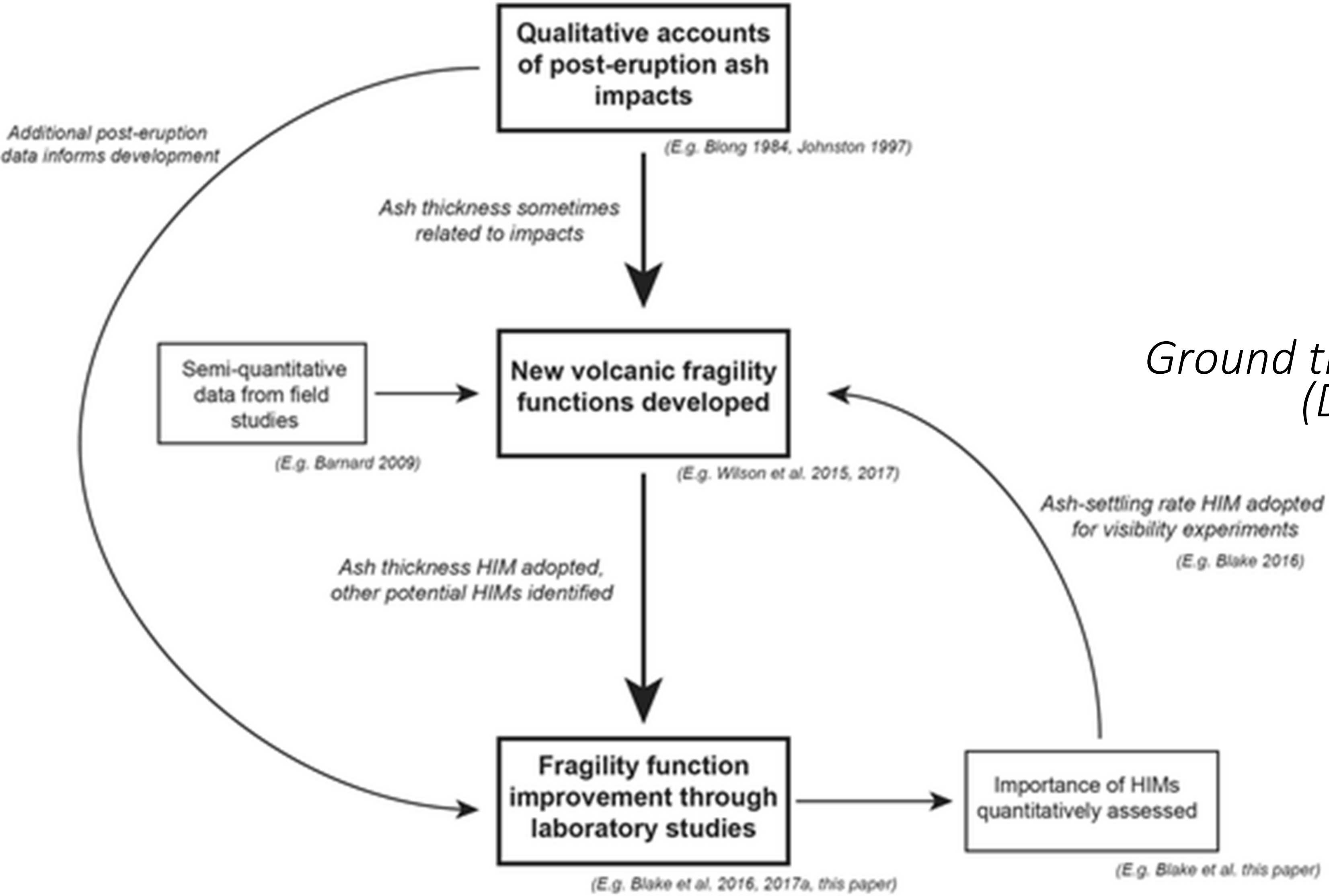
Creepage (surface area) coverage a primary control

Thick deposits of volcanic ash (3 mm) can accumulate on top of weathersheds without compromising insulator performance

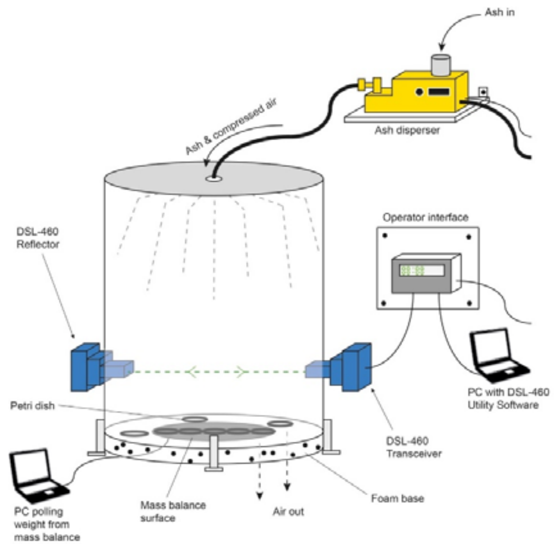
**Courtesy of**

**John Wardman (BIOS)**

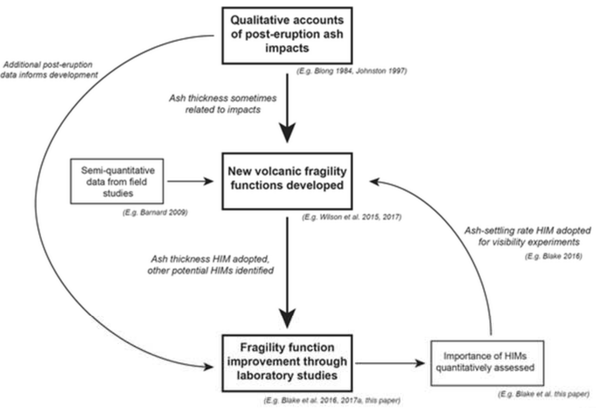
# Laboratory experiments informing vulnerability models




*Ground transport application (Daniel Blake)*



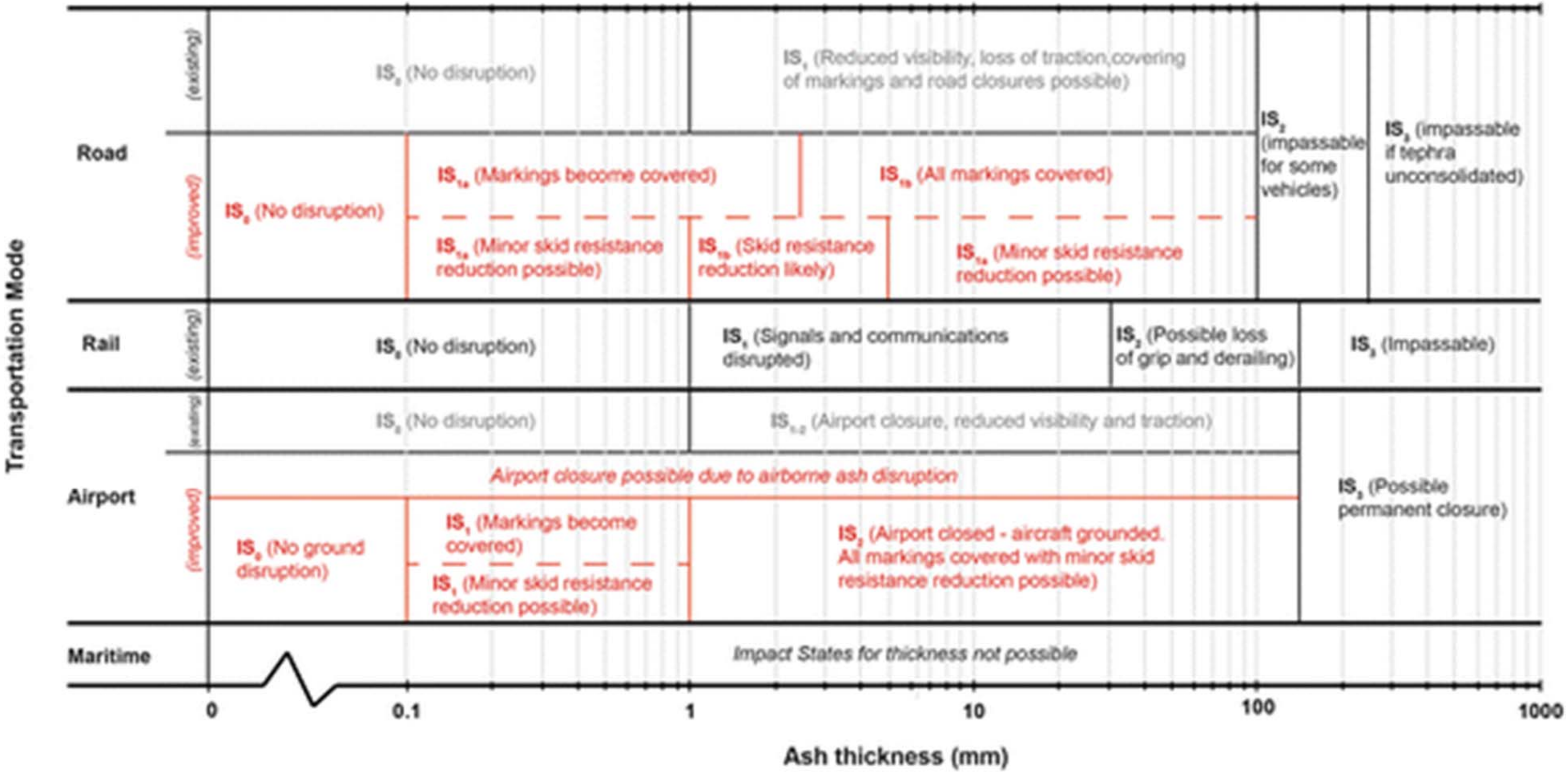
# Lab updating empirical vulnerability models



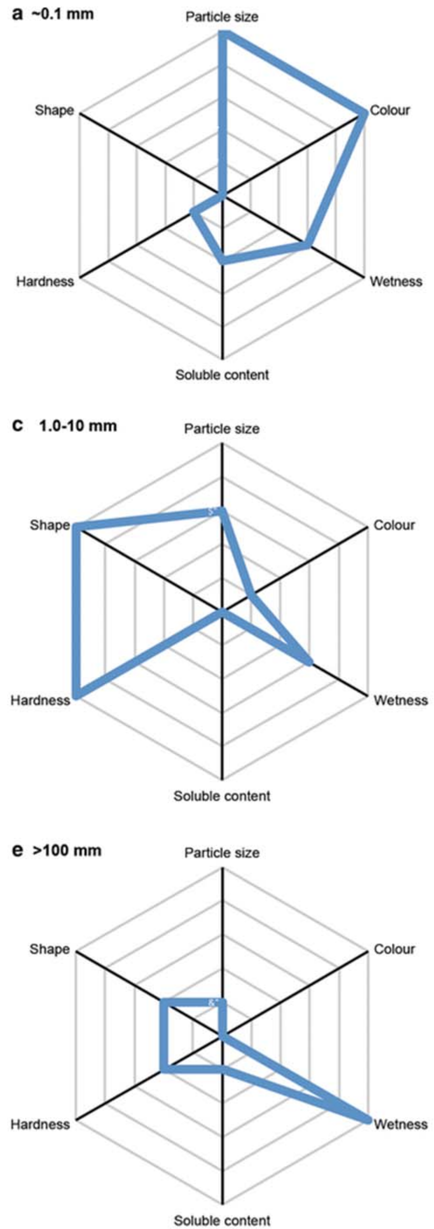
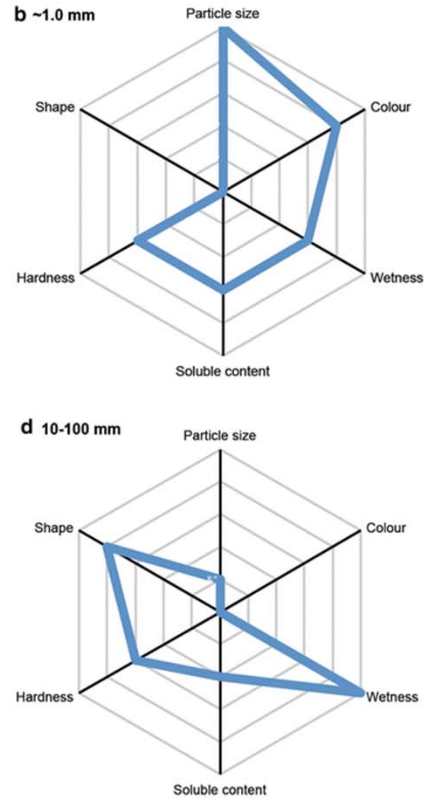

Impact states for expected ground-related disruption to transportation as a function of ash thickness.

Existing impact states (shown in *black*) were derived from qualitative post-eruption impact assessments and limited semi-quantitative field studies

Impact states that were improved in this study are shown in *red*



# Relative importance of additional HIMs at key ash thickness intervals for Ground transport


| HIM | Characteristic responsible for greater disruption |
|---|---|
| Particle size | Finer ash (between 0.1 and 2.5 mm), Coarser ash (above 2.5 mm) |
| Colour | Lighter-coloured ash |
| Wetness | Wet ash (not enough water for remobilisation) |
| Soluble content | More solubles present |
| Hardness | Hard ash |
| Shape | Spherical ash / less irregularity |

# Agriculture

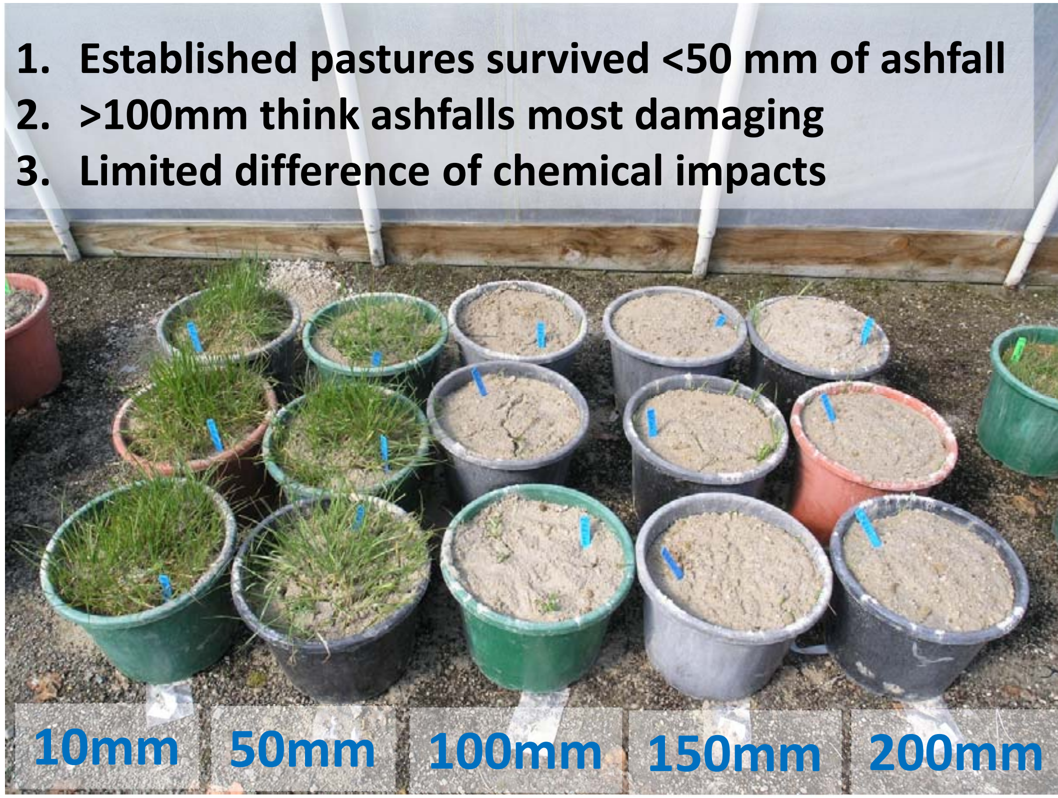
- What factors influence pasture damage?
  - Ash type?
  - Ash thickness/load?
  - Rainfall?

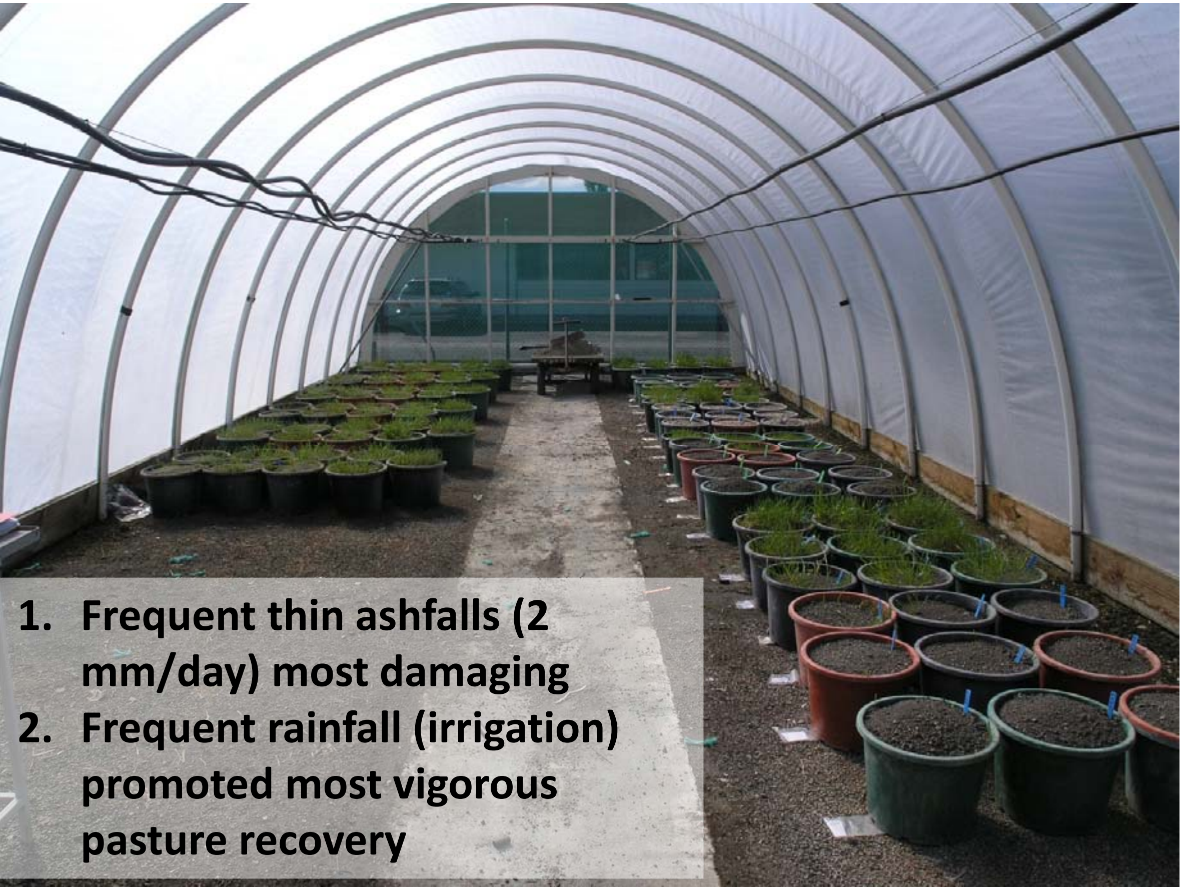
- What are the most effective rehabilitation strategies?
  - seed type
  - cultivation
  - fertilizer regime

**Thick tephra fall following the 1991 Hudson eruption, Rio Ibanez valley, Chile (1993, Steve Weaver)**

**~100 mm tephra deposit covering pasture in Amarillo valley, Chile following the 2008 Chaiten eruption (photo: 2009)**

# How do pastures and soils perform following ashfall?




- Ash thickness?
- Ash type?
- Frequency of ash falls?
- Frequency of rainfall?

# What tephra will kill what pastoral seed varieties?

## What are the most effective rehabilitation strategies following ash fall

- Which seed is best?
- Chemical treatments? (fertilisers)
- Physical treatments? (cultivation)

# Opportunities and challenges for laboratory studies

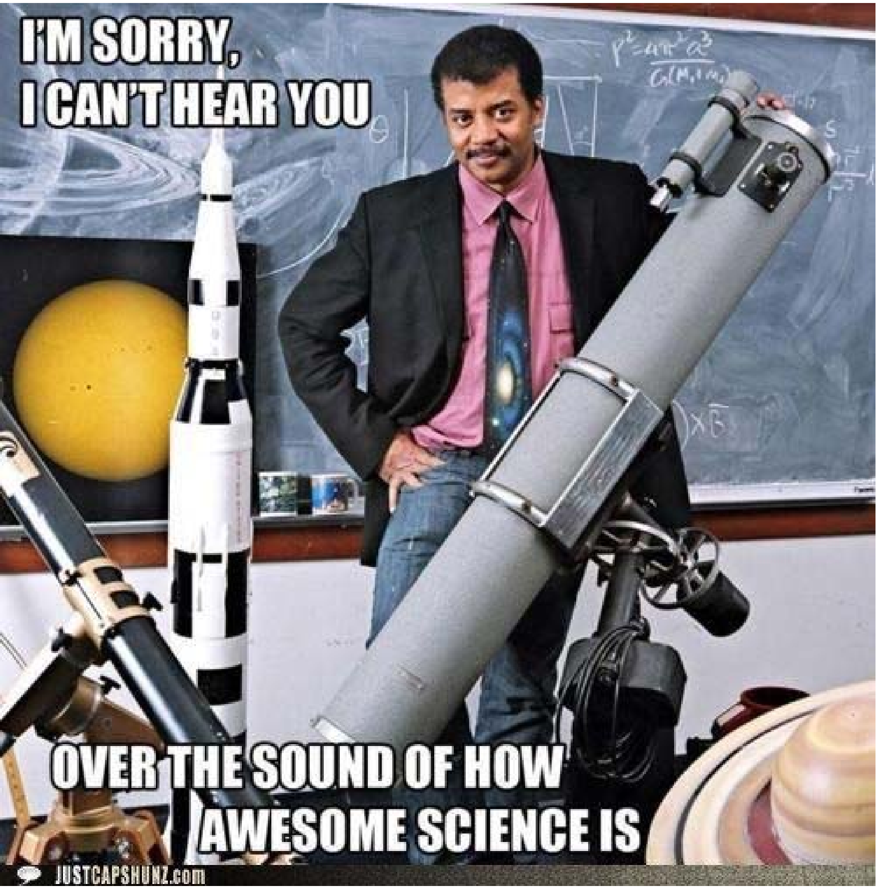
- Explore range of fragilities and mitigation measures exposed elements and hazard intensities in controlled settings

- Methodology development is essential + hard
  - Physical process modelling – scaling, etc.
  - Environment effects – e.g. rainfall, wind, etc.
  - What hazard intensity measure?
  - Construction of specialist facilities…$$$

- Applicability beyond narrow testing scope?

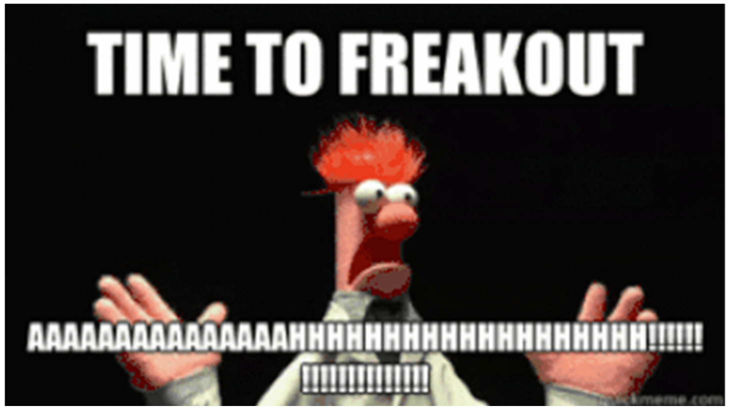
- Partnerships with stakeholders and other disciplines – co-creation opportunity


We generally know the problem…
…but sometimes struggle to **identify**, **evaluate** and **translate** useable solutions for decision makers



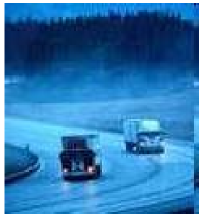
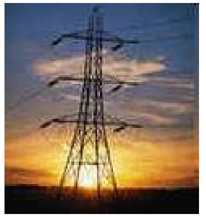
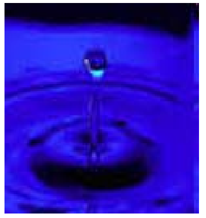


Sweet spot between apathy and fatalism
Relevant, Credible, Timely



# 4. Some suggested future directions



- **Further impact data collection necessary – community of practice required?**
  - Development of guidelines to aid consistent data collection and quality control
  - Big field campaign? Timeliness, expertise, resourcing, ethically appropriate?
  - Longitudinal studies – how does impact manifest through time? Recovery? Pre-event?
  - Dynamic hazard, exposure and vulnerability → risk and resilience
  - Social appetite for resilience…incentivise solutions
- **Working with Users…what do they want? What helps them?**
  - They often don't know until you build a partnership (co-production / co-design)
  - Evaluate effectiveness of 'decision support products', be flexible to their needs/priorities
  - Grounded in the social context
  - Critical evaluation of the volcano risk science activities – are we used, useful and useable?
- **Multi-hazard impact and interdependencies *(tricky but necessary)***
  - Cascading, compounding impacts
  - Infrastructure, social systems and beyond
  - Develop partnerships… Synergies, overlaps and compromises
- **Partnerships are key → process may be more important than the product**
  - Integration mechanisms + interdisciplinary
  - Encourage and incentivising other disciplines to engage in volcanic impact research
  - Communication…translation

Thank you for your attention

Any questions?

# 5. Conclusions

**Hazard** Natural phenomena | **Exposure** Population and assets | **Vulnerability** Structural and social

- Disaster risk: combined dynamics of hazard, exposure, and vulnerability

- **End of the beginning**: relatively good understanding of likely volcanic impacts, but often lack quantification
  - On-going need for all types of impact data collection…which is relevant for users
  - Consistent approaches…field and lab → community of practice
  - Multi-hazard? Compounding, cascading impacts?
  - Longitudinal studies

- **Impacts research is relevant to everyone**. This is an opportunity to engage with agencies, businesses and individual citizens to co-produce disaster risk management initiatives.
  - Process often more important than any product
  - Staff turn over and need continuous re-engagement (~2 year cycle)

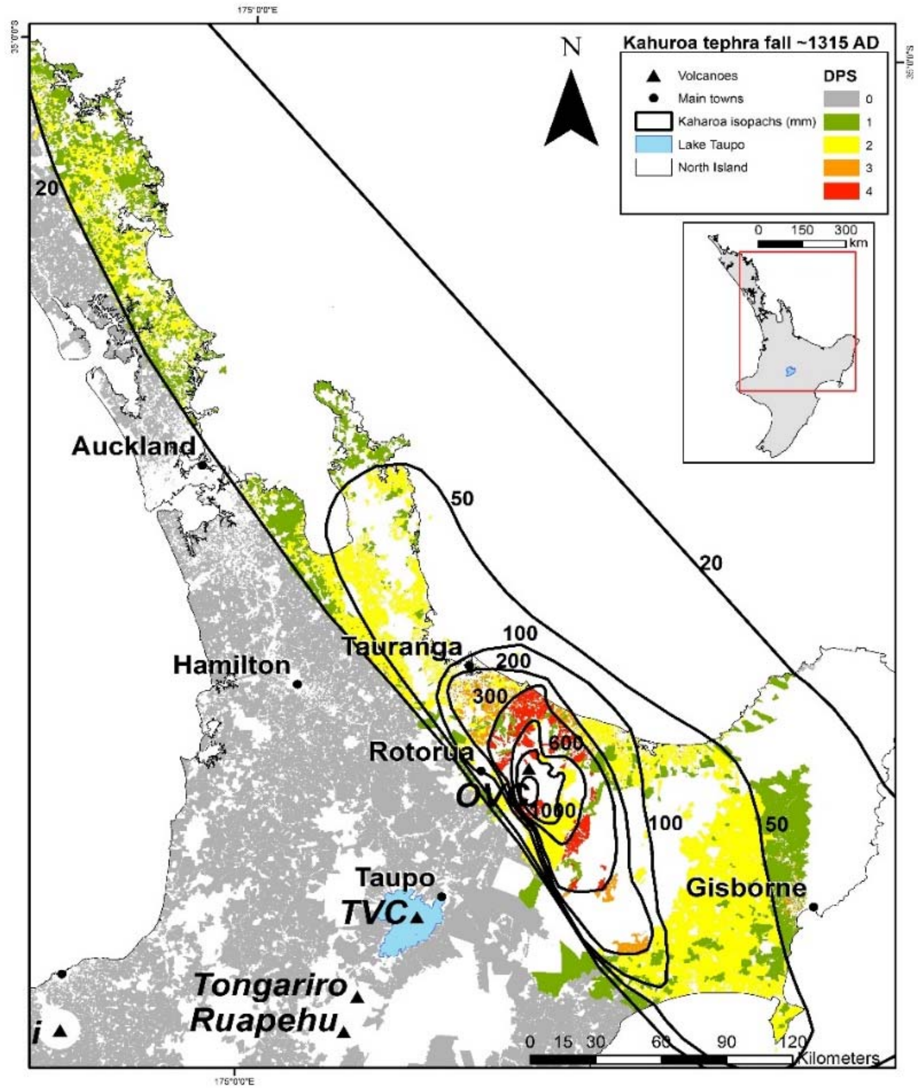
GFDRR 2016, The making of a riskier future: How our decisions are shaping future disaster risk. *Global Facility for Disaster Reduction and Recovery*

# 4. Applications of impacts research

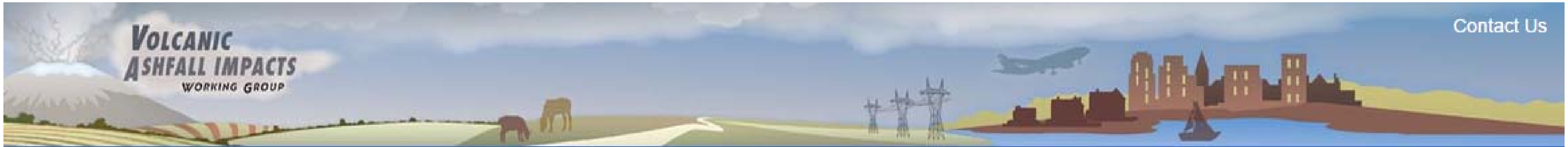
- Dialogue starter with the public and stakeholders
- Basis for mitigation

- Impact/Risk assessment modelling (why is it worthwhile doing)
  - Illustrates economic benefit
  - Couched in the right terms, leads to more sustainable and profitable development

- Community and organisation specific planning resources
  - Impacts and mitigation actions




Agricultural losses estimated for 1315 AD Kaharoa eruption scenario, New Zealand (Craig 2015)






- Volcanic Ash & Gases
- Buildings
- Transportation
- Power Supply
- Health
- Agriculture—Plants & Animals
- Clean up & Disposal
- Water & Wastewater
- Equipment & Communications
- Case Studies
- What can I do?

# Volcanic Ash Impacts & Mitigation

*Volcanic-ash hazards are far reaching and disruptive, affecting more people, infrastructure, and daily activities than any other eruptive phenomena.*

This web encyclopedia provides information on the impacts of volcanic ash and mitigation strategies for dealing with them. Content is summarized from expert and peer-reviewed sources.

- Use **'Choose Topic'** in the header or the left menu to find information categorized by affected sector.
- Posters and booklets in a range of languages are available in **Resources**.
- Technical guidance for scientists undertaking ash studies is presented in the **For Scientists** section.
- Do you have technical information or images you'd like to contribute to this Web site? New case studies and well documented experiences are valuable, and we welcome your contributions. Please **Contact Us** if you have information to add or questions.

## DO YOU NEED URGENT INFORMATION?

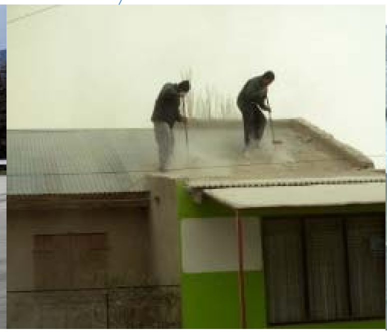
If a volcanic eruption is forecast or ash has fallen in your area, follow the advice of your local Civil Defense or Emergency Management officials.

## Tephra fall

Tolerance ? | Disruption ? | Damage

Zero — HAZARD INTENSITY — Maximum possible

Chile 2011



Chile 2011

Montserrat 1997

Philippines 1991

## Lava flow

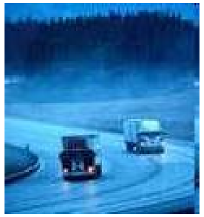
Damage

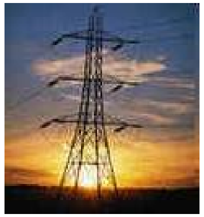
Zero — HAZARD INTENSITY — Maximum possible

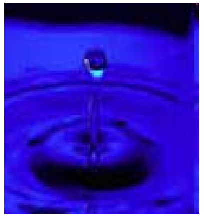
Hawaii

Italy 2001

G. Wilson et al. (2014)







## Problem 3:
Few agencies or groups have the required integrated capability to provide this applied knowledge…

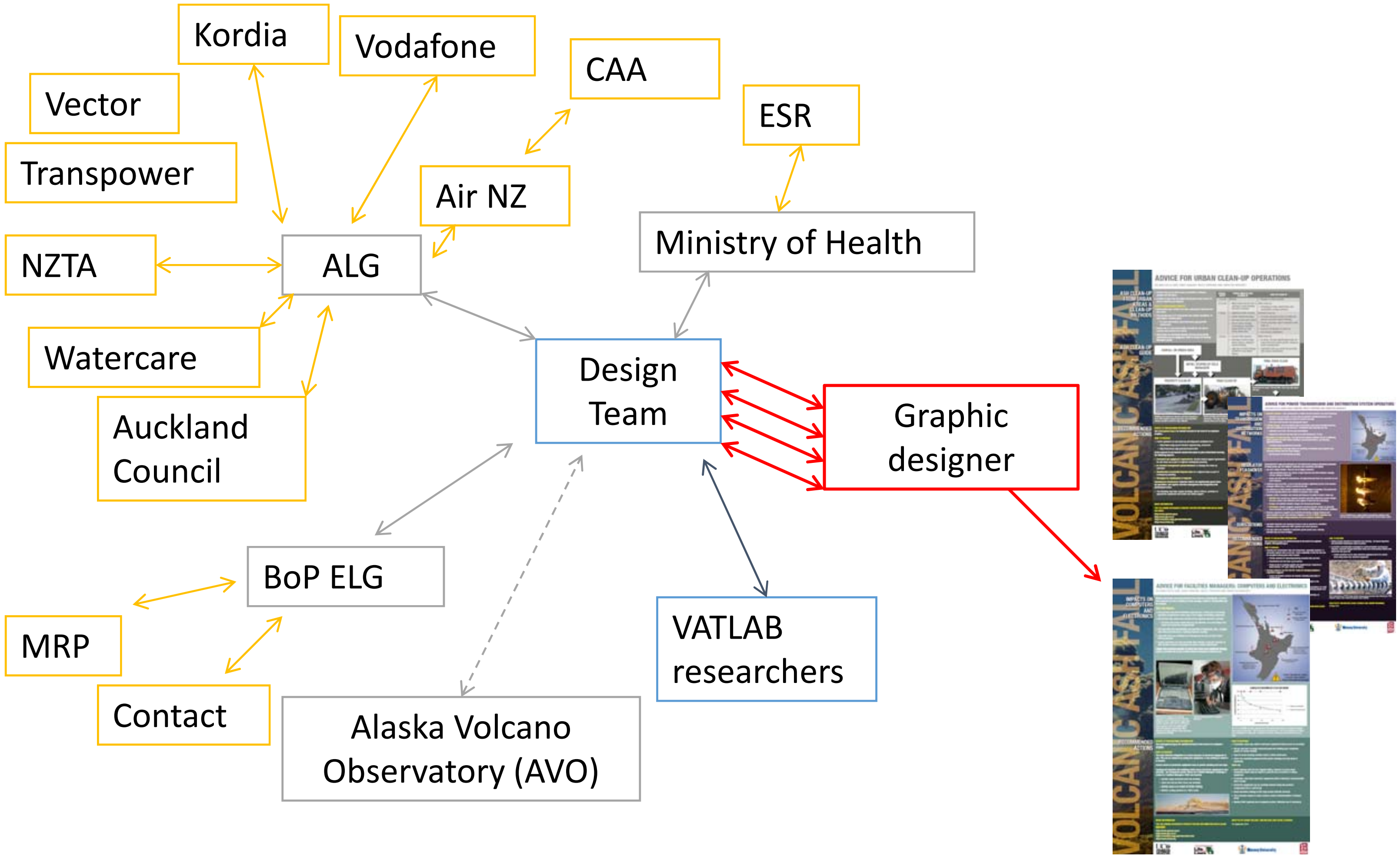
# Volcanic Impacts Study Group (VISG)

- Impacts of volcanic hazards on lifelines and mitigation measures
  - Facilitating uptake of knowledge
  - Supporting research
- Members:
  - Critical Infrastructure organisations
  - Emergency Management organisations
  - Science organisations
- National focal point for volcanic impacts research as it relates to infrastructure

# Sector specific ash impact and mitigation advice

- Electricity – distribution & transmission
- Electricity – generation
- Water supply
- Wastewater
- Airport
- Road Managers
- http://www.gns.cri.nz/Home/Learning/Science-Topics/Volcanoes/Eruption-What-to-do/Ash-Impact-Posters


# Development with users



*“Tomorrow’s risk is being built today.”*


1. **Global disaster risk is changing fast, due to combined dynamics of hazard, exposure, and vulnerability.**

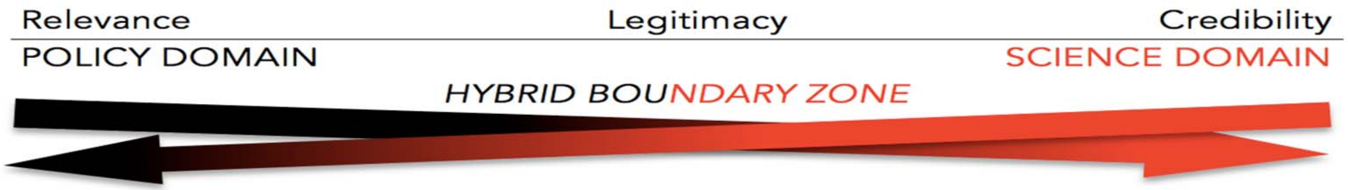
2. **The drivers of disaster risk are in the control of policy makers, society, and individuals**—but accurate assessment and continuous re-evaluation of risk are required to enable effective risk reduction and prevent drastic increases in future losses.

3. **Most disaster risk assessment today is static, focusing only on understanding current risks. A paradigm shift is needed toward dynamic risk assessments, which reveal the drivers of risk and the effectiveness of policies focused on reducing risk.**


GFDRR 2016, The making of a riskier future: How our decisions are shaping future disaster risk. *Global Facility for Disaster Reduction and Recovery*

Boundary management: **balancing** credibility, relevance and legitimacy

Cash et al. 2003 Knowledge Systems for Sustainable Development *PNAS* 100:14 8086-8091




RELEVANCE Requirement

Policy and practitioner activities/culture are driven by a rule **requiring (social/political) relevance**

LEGITIMACY Requirement

Collaborative activities/culture between/across knowledge domains are driven by a rule **requiring cross-boundary balance**

CREDIBILITY Requirement

Research activities/culture are driven by a rule **requiring scientific credibility**

| RELEVANCE requirement *drives demand for* | CREDIBILITY requirement *drives demand for* |
|---|---|
| Applied science | Basic science |
| Demand-driven (consultancy) | Supply-driven (autonomy) |
| Inter-disciplinarity | Disciplinarity |
| Real time | Long term |
| Timely process | Quality assessment |
| Simple information | Uncertain, complex information |

**Useful?**

**Useable?**

**Used?**

# Science-Policy Boundary

## Lessons available

e.g. Beaven et al. 2016

## Approaches available

Spectrum of tensions across the science/policy boundary (adapted from Parker & Crona 2012 and Sarkki et al. 2014). Courtesy of Sarah Beaven (UC)