Impacts of volcanic ash on surface transportation

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Kelud 2014 ash (Rudianto/Zuma Press/Corbis)

Worldwide context

GVM
GLOBAL VOLCANO MODEL

"800 million people in 86 countries live within 100 km of a volcano that could potentially erupt" (GVM 2014)

GAR
Global Assessment Report on Disaster Risk Reduction

"Volcanic eruptions are associated with increasingly large economic impacts" (GAR 2015)

Eyjafjallajokull eruption *(Reuters 2011)*

Importance of the research

- Functional surface transport networks critical for society
  - evacuation
  - emergency services
  - recovery
- Ash is a disruptive hazard & widely dispersed
- Small eruptions capable of widespread disruption for months

Accident in Yogyakarta, Indonesia due to volcanic ash (iStock)

Multi-vehicle accident during a dust storm in Oklahoma (Rolf Clements, 2012)

Impact data sources

- 'Real world' information
    - Post-eruption studies in different locations
    - Mt. St Helens (1980) onwards
    - *E.g. Kelud Volcano (2014)*

- Experimental data (VAT Lab)
    - controlled conditions
    - systematic and repetitive testing

- Expert judgment - consultation
    - address gaps in knowledge

The 2014 eruption of Kelud volcano, Indonesia: impacts on infrastructure, utilities, agriculture and health

D.M. Blake, G. Wilson, C. Stewart, H.M. Craig
J.L. Hayes, S.F. Jenkins, T.M. Wilson, C.J. Horwell
S. Andreastuti, R. Daniswara, D. Ferdiwijaya, G.S. Leonard
M. Hendrasto, S. Cronin

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Laboratory studies - why?

- Frequently occurring impacts:

1. **Skid resistance reduction**
2. **Road marking coverage**
3. **Visibility impairment**

- Quantitative empirical evidence can inform transport management strategies

- Various ash characteristics can be isolated and their effects investigated

Visibility – historical evidence (roads)

Volcano	Year	Ash Thickness (mm)	Visibility Observations		Mitigation Measures	R[illegible]
			Initial ashfall	Re-suspended ashfall		
Ruapehu	1945	" few mm"	✓	✓	✓	[illegible]
St Helens	1980	<50	✓	✓	[illegible]	[illegible]en and Wii[illegible] 1981, Warrick 1981, Blon[illegible] [illegible]ston 1997
Hudson	1991	200-300	✓	✓	[illegible]	Wil[illegible], Wilson 2009 [illegible] field notes)
Spurr	1992	3	✓	[illegible]	[illegible]	[illegible]ston 1997, Barnard 2009
Unzen	1992		✓	[illegible]	[illegible]	Yanagi et al. 1992, Barnard 2009
Ruapehu	1995-96	"thin"	✓	✓	✓	Johnston 1997, Barnard 2009
Etna	2002	<2	[illegible]	[illegible]		Barnard 2009
Chaitén	2008		[illegible]	[illegible]	✓	Wilson et al. 2012b, Wilson 2008 (unpublished field notes)
Pacaya	2011	20-30	✓		✓	Wardman et al. 2012
Cordón Caulle	2011	[illegible]	[illegible]	✓	✓	Wilson et al. 2013, Folch et al. 2014, Craig et al. 2016
Shinmoedake	20[illegible]	[illegible]	✓	✓	✓	Magill et al. 2013
San Cristóba[illegible]	[illegible]	[illegible]	✓		✓	GVP 2013
Kelu[illegible]	2014	[illegible]	✓	✓	✓	Blake et al. 2015
Calb[illegible]	2015	[illegible]0	✓			AccuWeather 2015

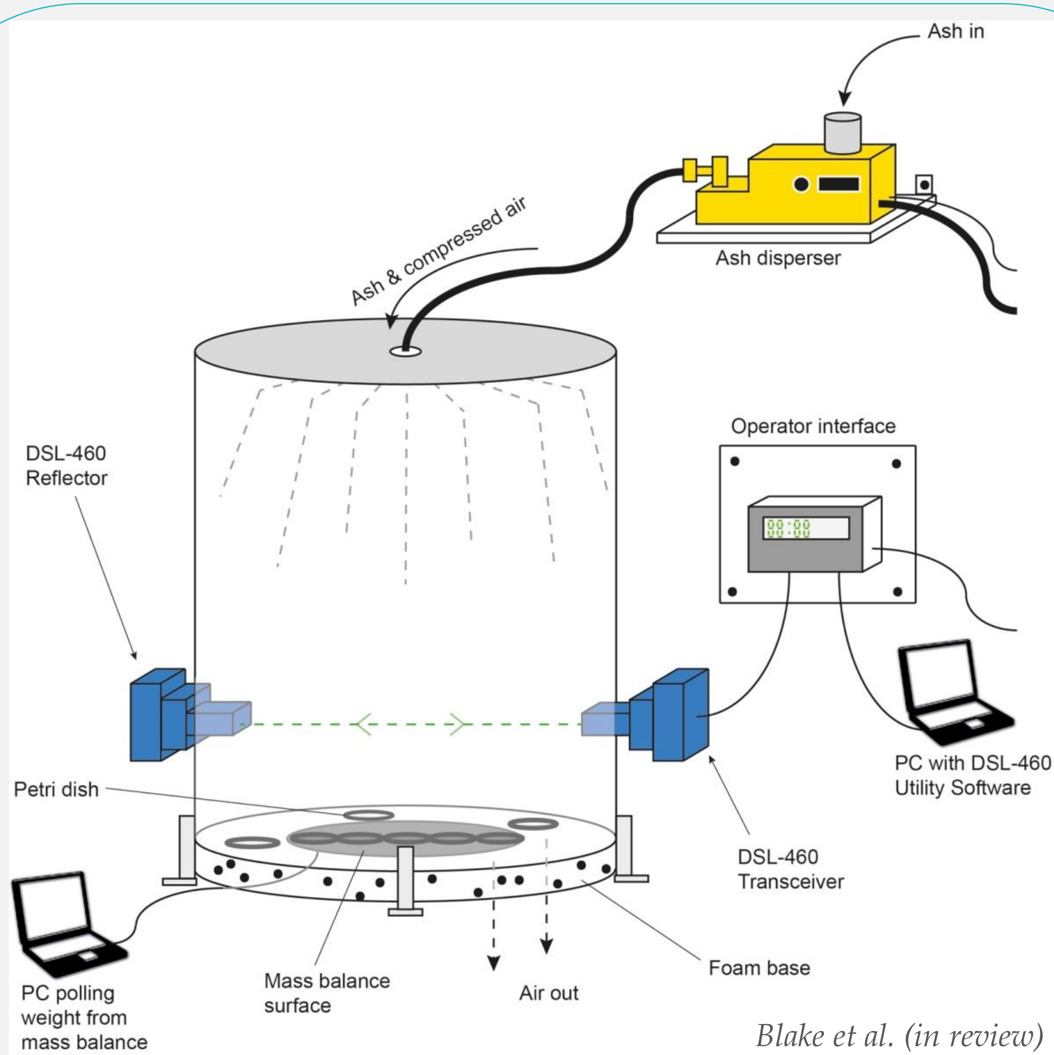
Illogical to associate an atmospheric-related impact to a ground-based measurement.

Opportunities with contemporary ash dispersion & fallout models.

Blake et al. (in review)

Visibility – experimental set-up

- Ash dispersed into container
- Ash falls through high intensity light beam
- Extinction coefficient (b_{ext}) recorded
- Visual range calculated:
  $VR = 3912 / (b_{ext} + 10)$



Blake et al. (in review)

Visibility – key findings for Auckland

- **2.5 to 100 m** visual range likely for Auckland
- Visual range low for **fine-grained ash**
- Visual range low for **light-coloured** and more **elongated** ash particles

Compared results of visual range in ash to other atmospheric hazard findings

Ash in Kagoshima, Japan (Kagoshima City Office, 2015)

Visibility - suggested mitigation options

(BESIDES CLEAN-UP)

- **Lowering of speed limits** *(to ~20 km/h may be necessary)*
- **Consider one-way systems**
- **Organised spacing of vehicles** *(>5 minutes desirable)*
- **Dampen surfaces**

Calbuco 2015 ash (AP/Federico Grosso)

Application - Māngere Bridge scenario

1. **Hazard maps** for evolving situation
   - informed by AVF & worldwide research

2. **Evacuation maps** based on hazard scenario and policy

3. **Damage** and **'Level-of-Service' maps**:

   Electricity, fuel, roads, rail, aviation, port, water supply, wastewater, stormwater, telecommunications, building damage

   LoS important as consider **transportation users**

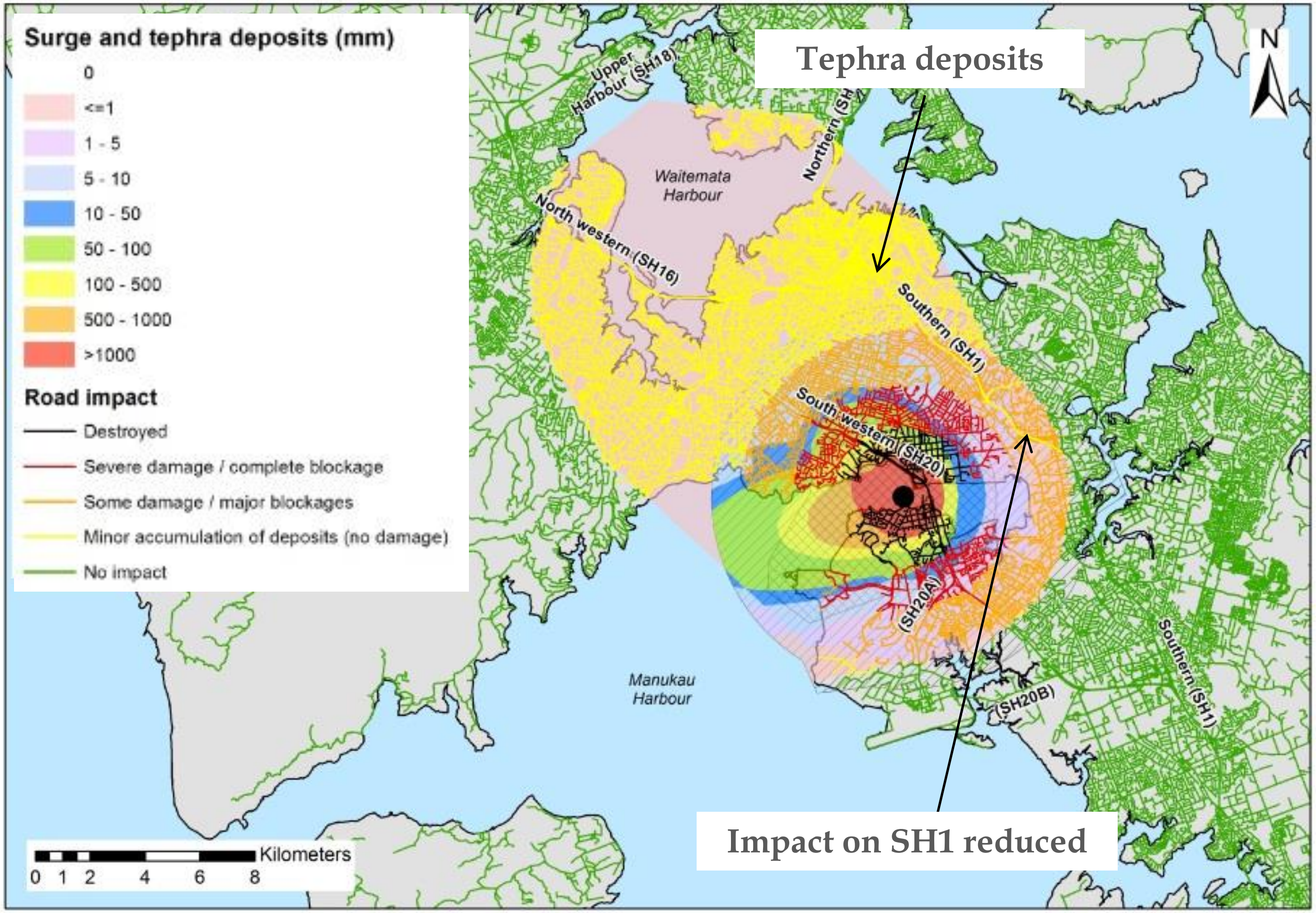
Eruption scenario in Auckland

Consultation with Infrastructure Providers & CDEM

Māngere Bridge scenario – physical damage

Damage example

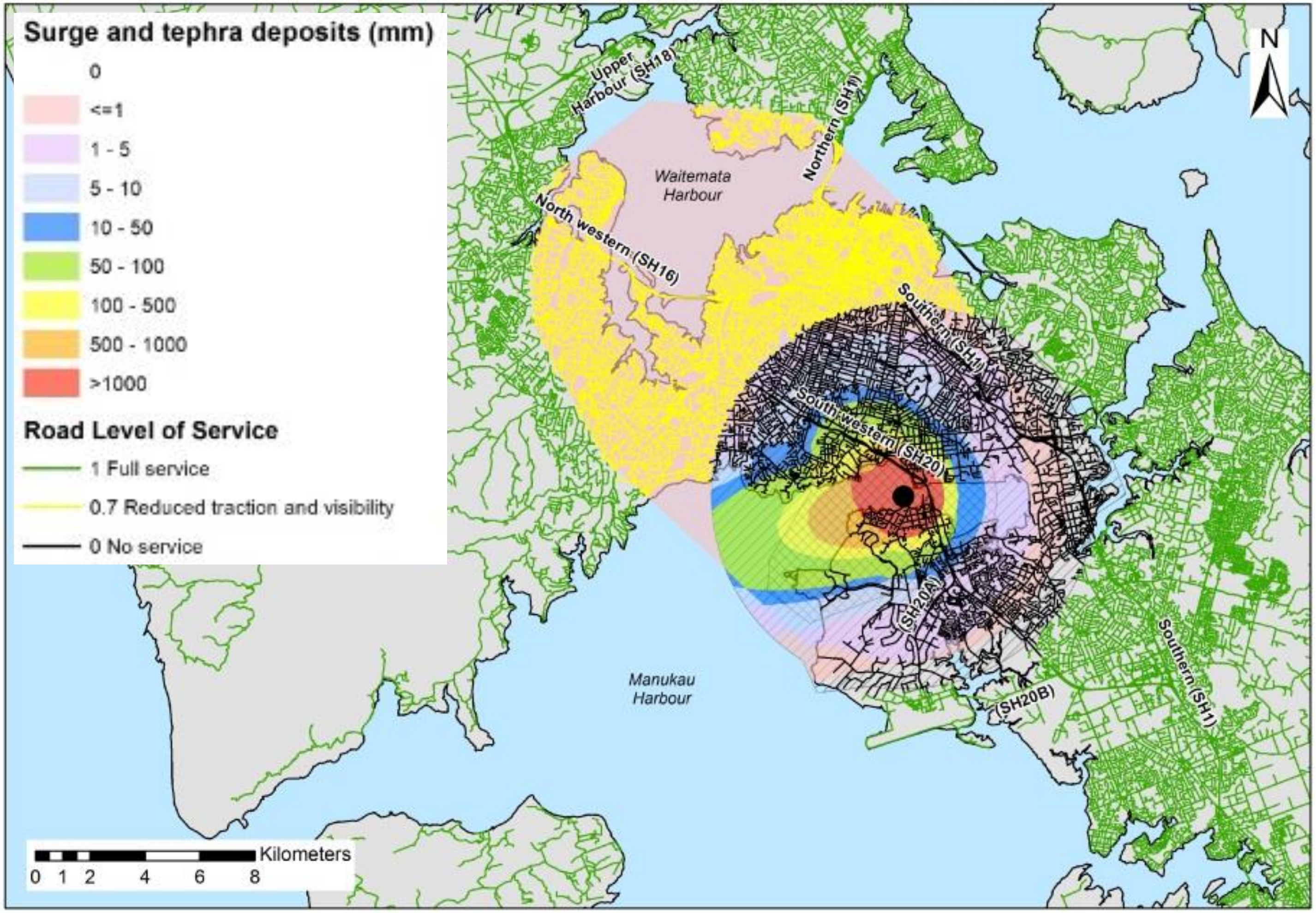
- Widespread tephra accumulation
- Some earlier impact on critical routes reduced



Māngere Bridge scenario – Level-of-Service

Level-of-Service example

- Tephra causes widespread LoS reduction
- Complete closure within evacuation zones



Conclusions

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- Identified key gaps in knowledge for surface transportation impacts
  - *laboratory experiments have helped fill these*
  - *also post-eruption impact assessment studies.*
- Different ash characteristics are important when considering impacts (not just ash thickness)
- Scenarios effective to demonstrate and explore transportation damage & Level-of-Service – Expert consultation critical.

Some further work…

- Discipline will benefit from further observations, field sampling and laboratory work
- People behaviour during volcanic activity including ash fall
- Interdependencies:
  - *how transportation impacts other critical infrastructure*
  - *how this other critical infrastructure impacts transportation.*

CoUGAR
Canterbury University Group for Ash Research.