COLLECTING EMPIRICAL IMPACT DATA:
The Merapi 2010 eruption

Susanna Jenkins
Susanna.Jenkins@Bristol.ac.uk

With thanks to JC. Komorowski, P. Baxter, R. Spence, F. Lavigne, Surono, A. Picquout , E. Mei, N.Cholik, Sardjito Hospital, Universitas Gadjah Mada, Village chiefs and local population affected by the Merapi 2010 eruption

UNIVERSITY OF CAMBRIDGE

CAMBRIDGE ARCHITECTURAL RESEARCH LIMITED

MIA VITA

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

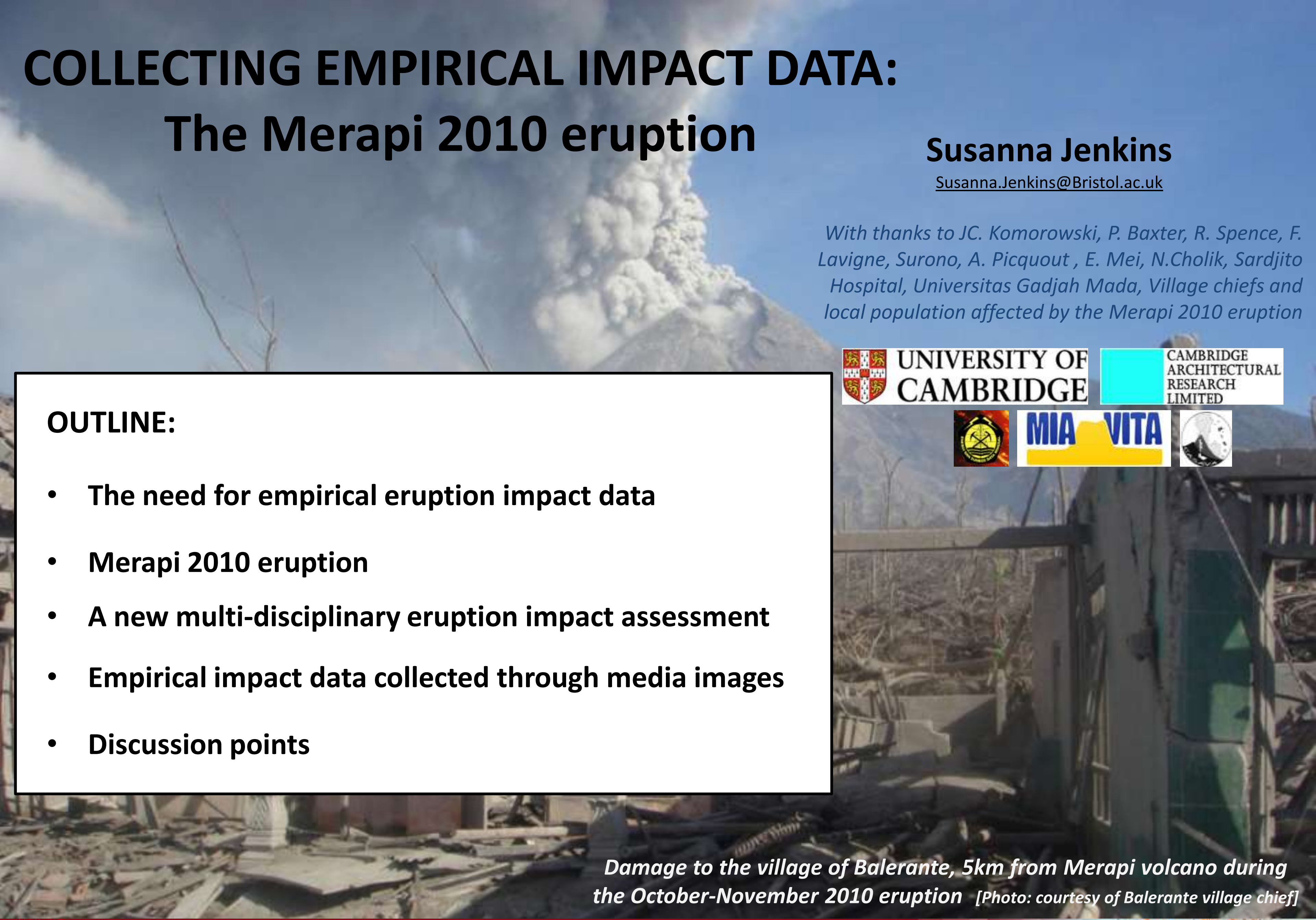
Susanna Jenkins
Susanna.Jenkins@Bristol.ac.uk

With thanks to JC. Komorowski, P. Baxter, R. Spence, F. Lavigne, Surono, A. Picquout , E. Mei, N.Cholik, Sardjito Hospital, Universitas Gadjah Mada, Village chiefs and local population affected by the Merapi 2010 eruption

UNIVERSITY OF CAMBRIDGE
CAMBRIDGE ARCHITECTURAL RESEARCH LIMITED
MIA VITA

OUTLINE:

- **The need for empirical eruption impact data**
- **Merapi 2010 eruption**
- **A new multi-disciplinary eruption impact assessment**
- **Empirical impact data collected through media images**
- **Discussion points**



***Damage to the village of Balerante, 5km from Merapi volcano during the October-November 2010 eruption** [Photo: courtesy of Balerante village chief]*

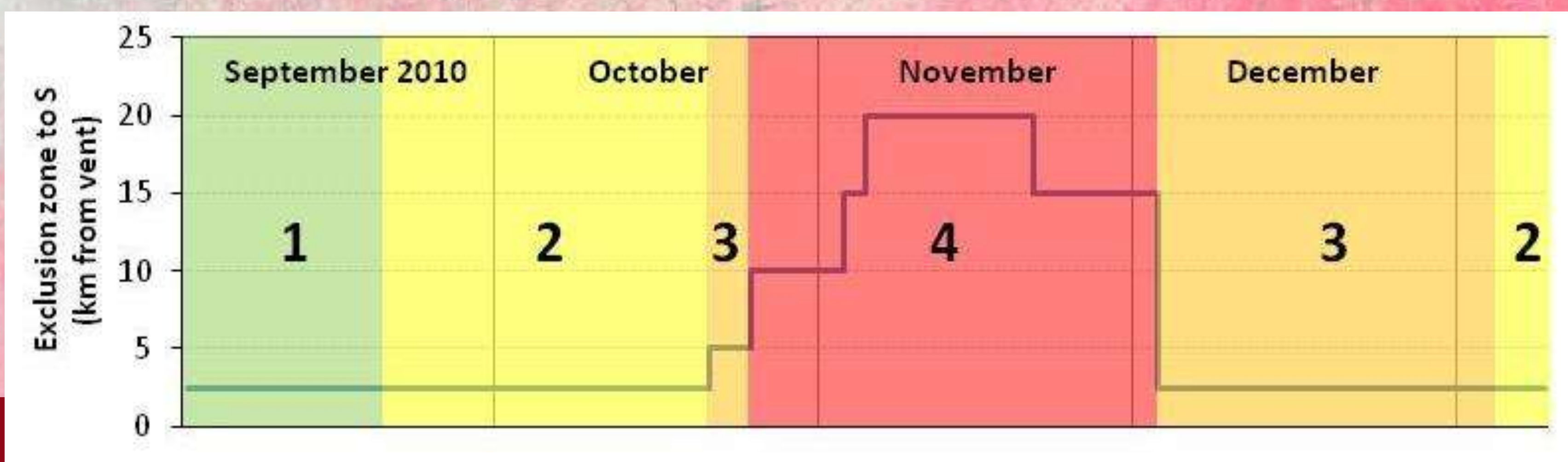
Empirical eruption impact data

- Rarity of large explosive eruptions in populated areas means that forecasting future impacts (damage, casualties) is characterised by significant uncertainty
- Provides detailed catalogue of event and impacts; local scientists often have limited resources at times of crisis
- Data can be used to derive the physical processes involved
- Empirical impact data help to reduce uncertainty in establishing relationships between the process and impact
- Implications for other at-risk volcanic areas
- Merapi 2010 large explosive eruption was unique opportunity to study explosive eruption impacts on a densely populated area, i.e. 'forensic volcanology'

SPOT5 image, 15th November 2010, IPGP

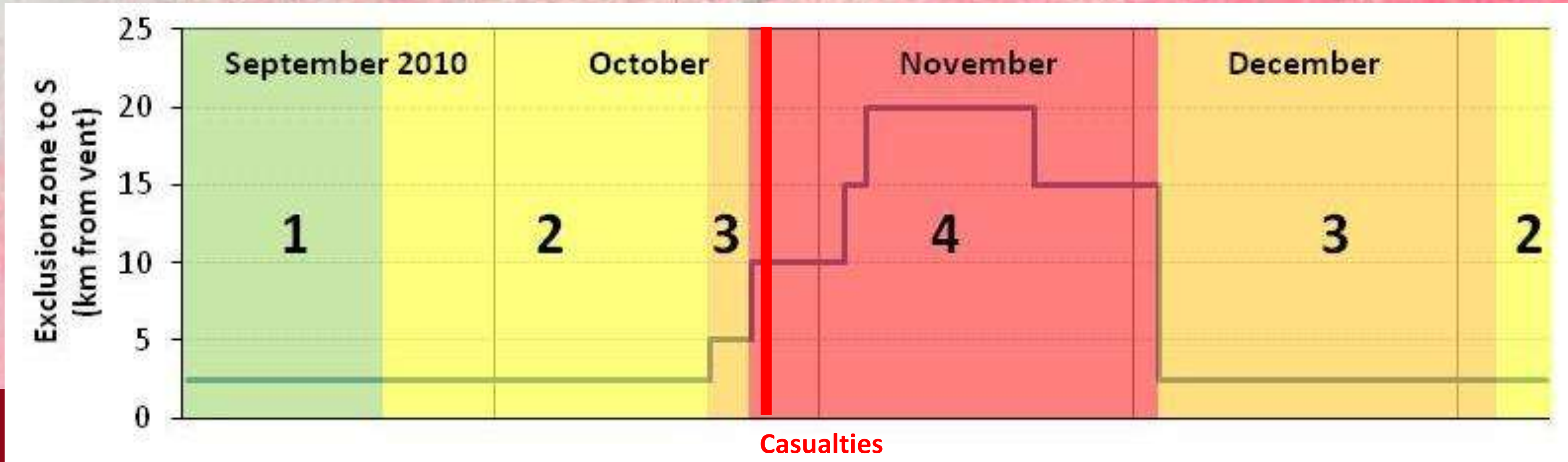
Merapi 2010 eruption

- Rapidly escalating crisis: First eruption 26 Oct 2010; Final (paroxysmal) eruption 5 Nov 2010
- Exclusion zones progressively increased 2.5km -> 20km; Some shelters relocated with expanding exclusion zone
- Over 400 official deaths; ~200 from contact with Pyroclastic Density Currents (PDCs)
- PDCs caused casualties up to 15.5km (17.6km) from source
- >1 million people displaced
- Total damage and losses exceeds 4 trillion rupiahs (£286M)
- Future lahar hazard severe because of deposits
- Last eruption of this size was 1872: change in style?



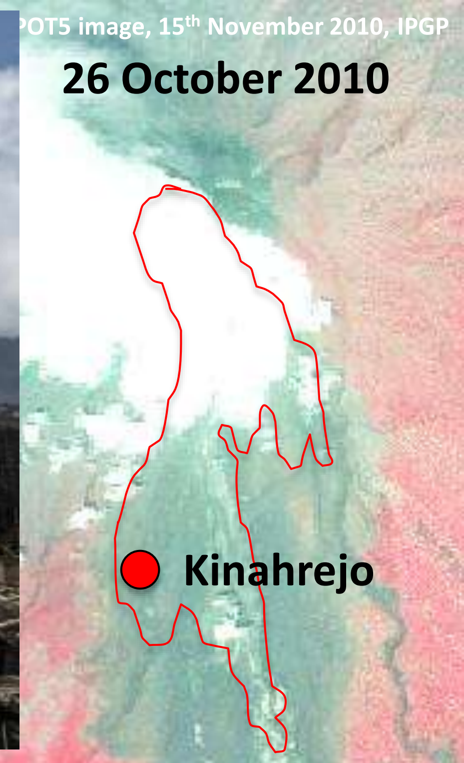
Merapi 2010 eruption

- Rapidly escalating crisis: First eruption 26 Oct 2010; Final (paroxysmal) eruption 5 Nov 2010
- Exclusion zones progressively increased 2.5km -> 20km; Some shelters relocated with expanding exclusion zone
- Over 400 official deaths; ~200 from contact with Pyroclastic Density Currents (PDCs)
- PDCs caused casualties up to 15.5km (17.6km) from source
- >1 million people displaced
- Total damage and losses exceeds 4 trillion rupiahs (£286M)
- Future lahar hazard severe because of deposits
- Last eruption of this size was 1872: change in style?



Merapi

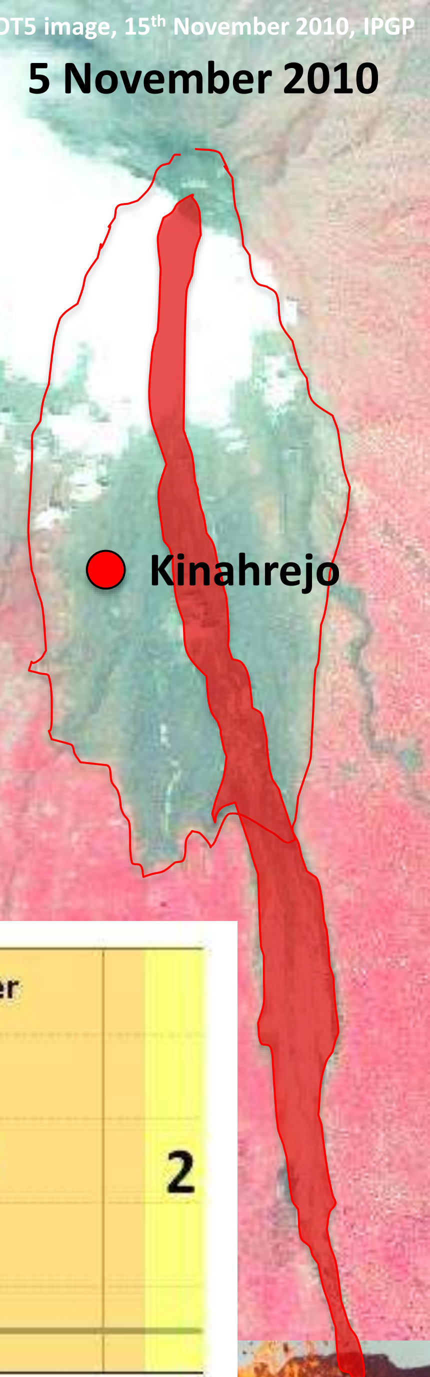
- Rapidly esca
  Final (paroxy
- Exclusion zo
  Some shelte
- Over 400 off
  Pyroclastic D
- PDCs caused
- >1 million pe
- Total damage and losses exceeds 4 trillion rupiahs (£280M)
- t
- s



All images: Boston.com; 27 October 2010

Merapi 2010 eruption

- Rapidly escalating crisis: First eruption 26 Oct 2010; Final (paroxysmal) eruption 5 Nov 2010
- Exclusion zones progressively increased 2.5km -> 20km; Some shelters relocated with expanding exclusion zone
- Over 400 official deaths; ~200 from contact with Pyroclastic Density Currents (PDCs)
- PDCs caused casualties up to 15.5km (17.6km) from source
- >1 million people displaced
- Total damage and losses exceeds 4 trillion rupiahs (£286M)
- Future lahar hazard severe because of deposits
- Last eruption of this size was 1872: change in style?



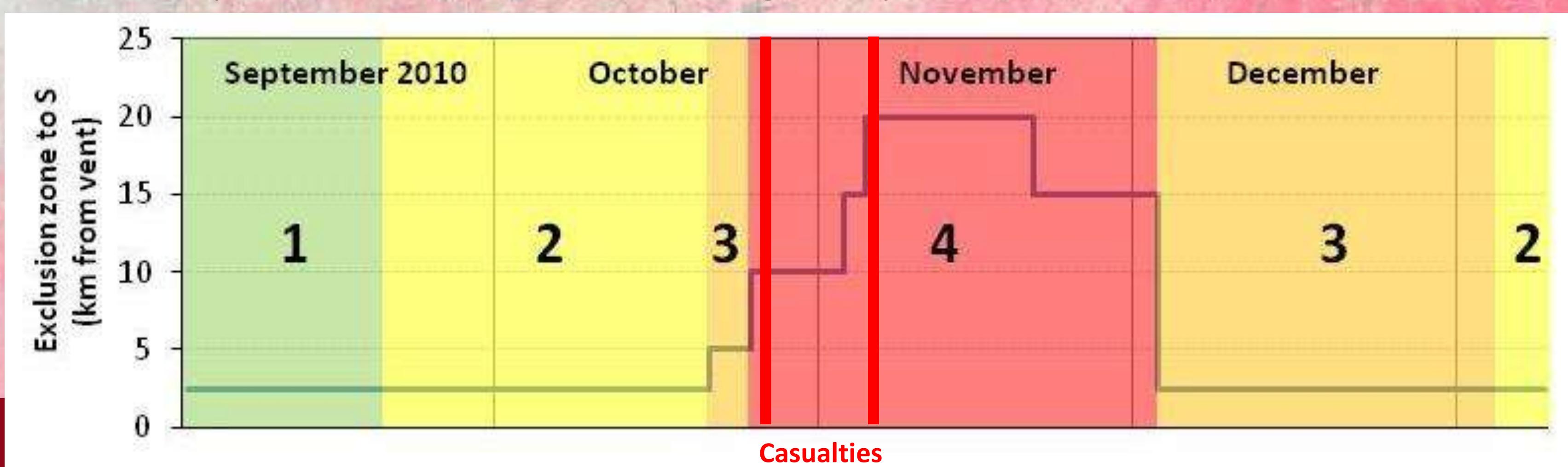
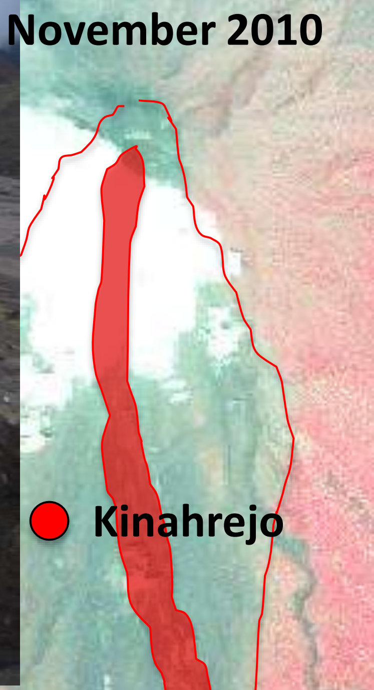


Image: S.Jenkins; 4 July 2011

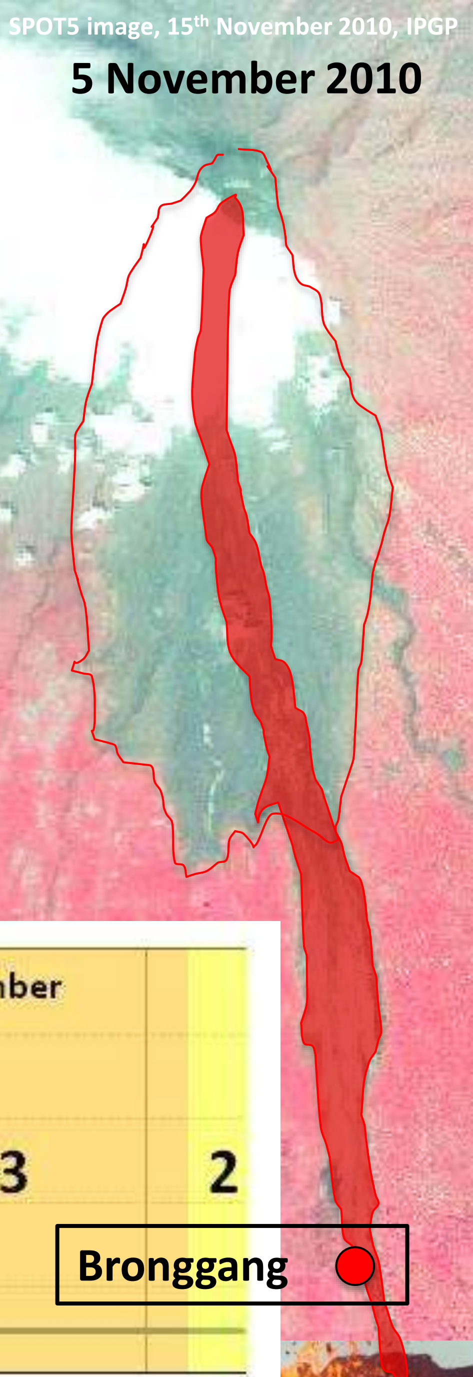


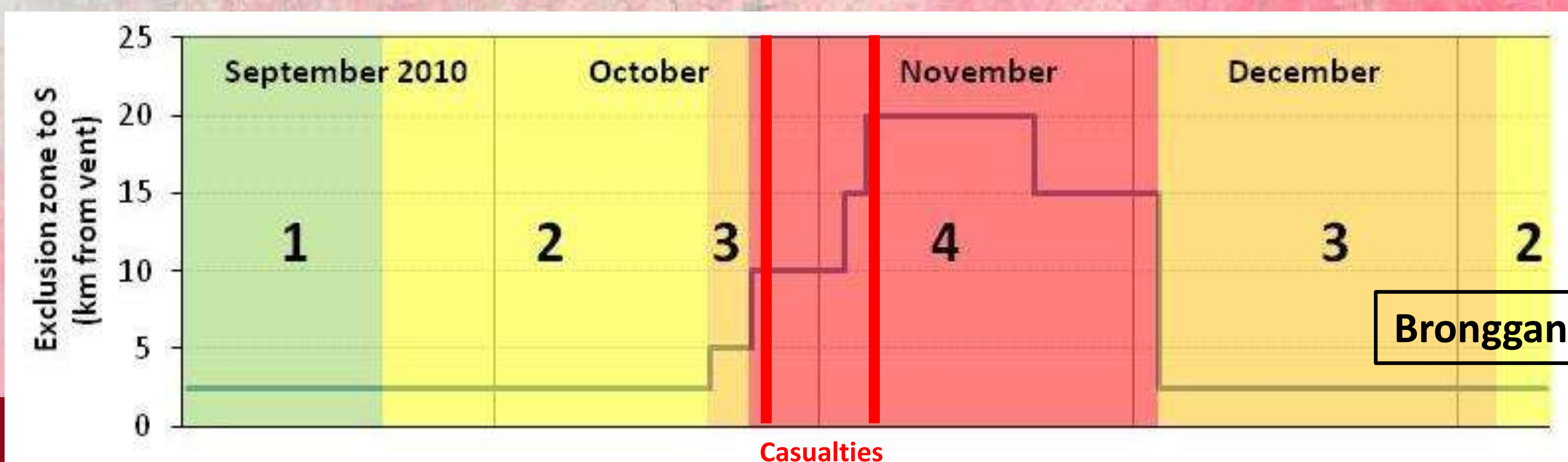
- PDC's caused casualties up to 15.5km from source

All images but above: S.Jenkins; 6 December 2010

Merapi 2010 eruption

- Rapidly escalating crisis: First eruption 26 Oct 2010; Final (paroxysmal) eruption 5 Nov 2010
- Exclusion zones progressively increased 2.5km -> 20km; Some shelters relocated with expanding exclusion zone
- Over 400 official deaths; ~200 from contact with Pyroclastic Density Currents (PDCs)
- PDCs caused casualties up to 15.5km (17.6km) from source
- >1 million people displaced
- Total damage and losses exceeds 4 trillion rupiahs (£286M)
- Future lahar hazard severe because of deposits
- Last eruption of this size was 1872: change in style?





Merapi 2010 eruption

5 November 2010

Image: S.Jenkins; 4 December 2010

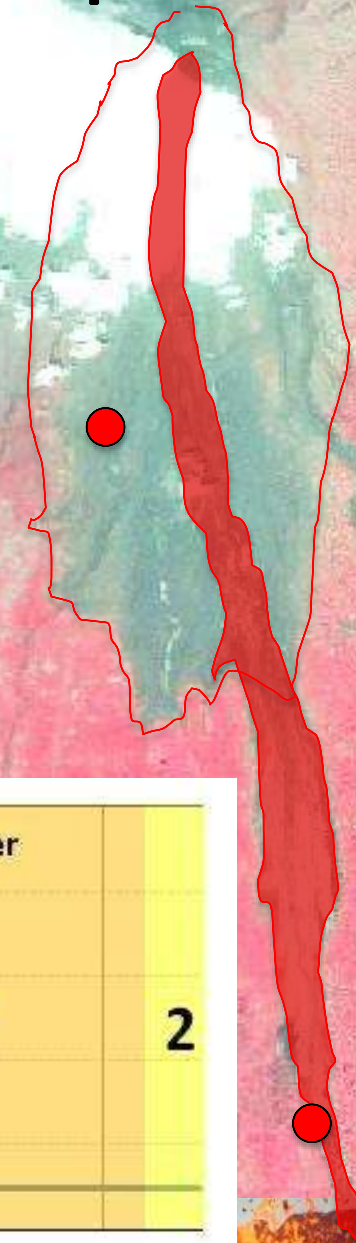
Image: S.Jenkins; 2 December 2010

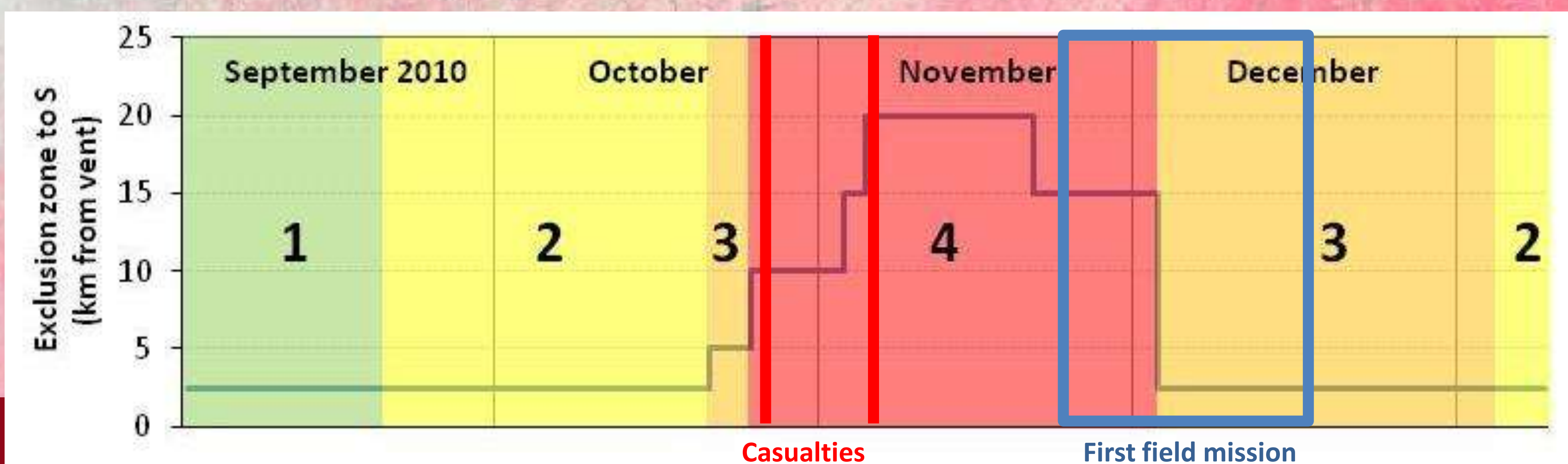
Image: www.boston.com; 5 November 2010

SPOT5 image, 15th November 2010, IPGP

Merapi 2010 eruption: Collecting empirical impact data

- **Rapidly escalating and declining crisis:** Enter safely; Pristine impact environment
- **Multi-disciplinary assessment:** Geology, Damage, Casualties
- **Multiple data sources:** Remote; Field; Desk (e.g. GIS)/Laboratory
- **Remote assessment:** Map impact across large areas; Focus on areas of highest impact; Assess damage throughout eruption; Impact environment at time of impact
- **Longitudinal study:** Field missions 3 weeks, 8 months and 1 year after eruption (and continuing)
- <u>**Collaboration and support of local scientists and population**</u>
- ***Jenkins et al. (in review). A new multi-disciplinary impact assessment. JVGR***



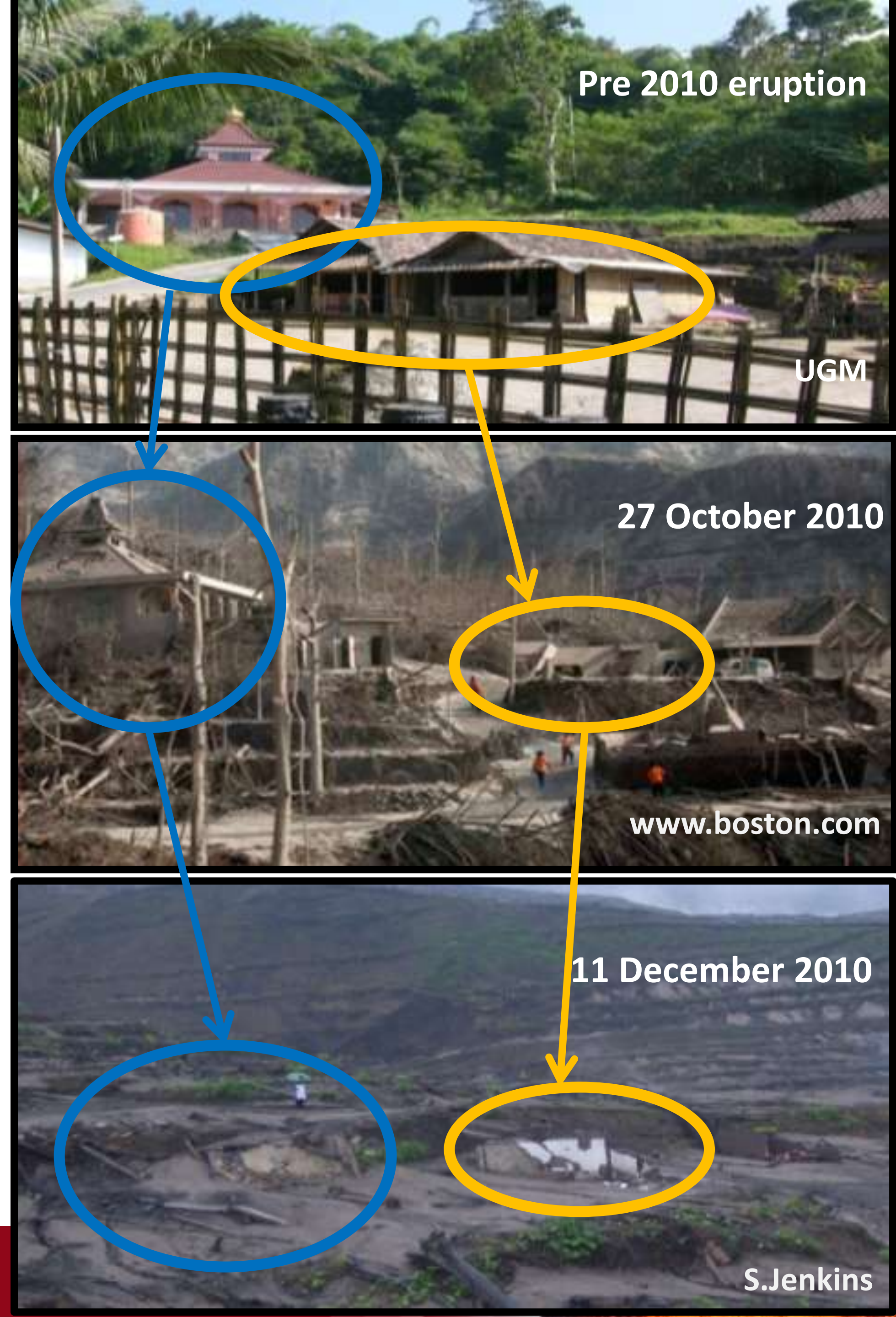


Remote assessment: media images

Remote sensing data also include professional and social media images and footage freely available on the internet throughout the eruption.

These allowed us to:

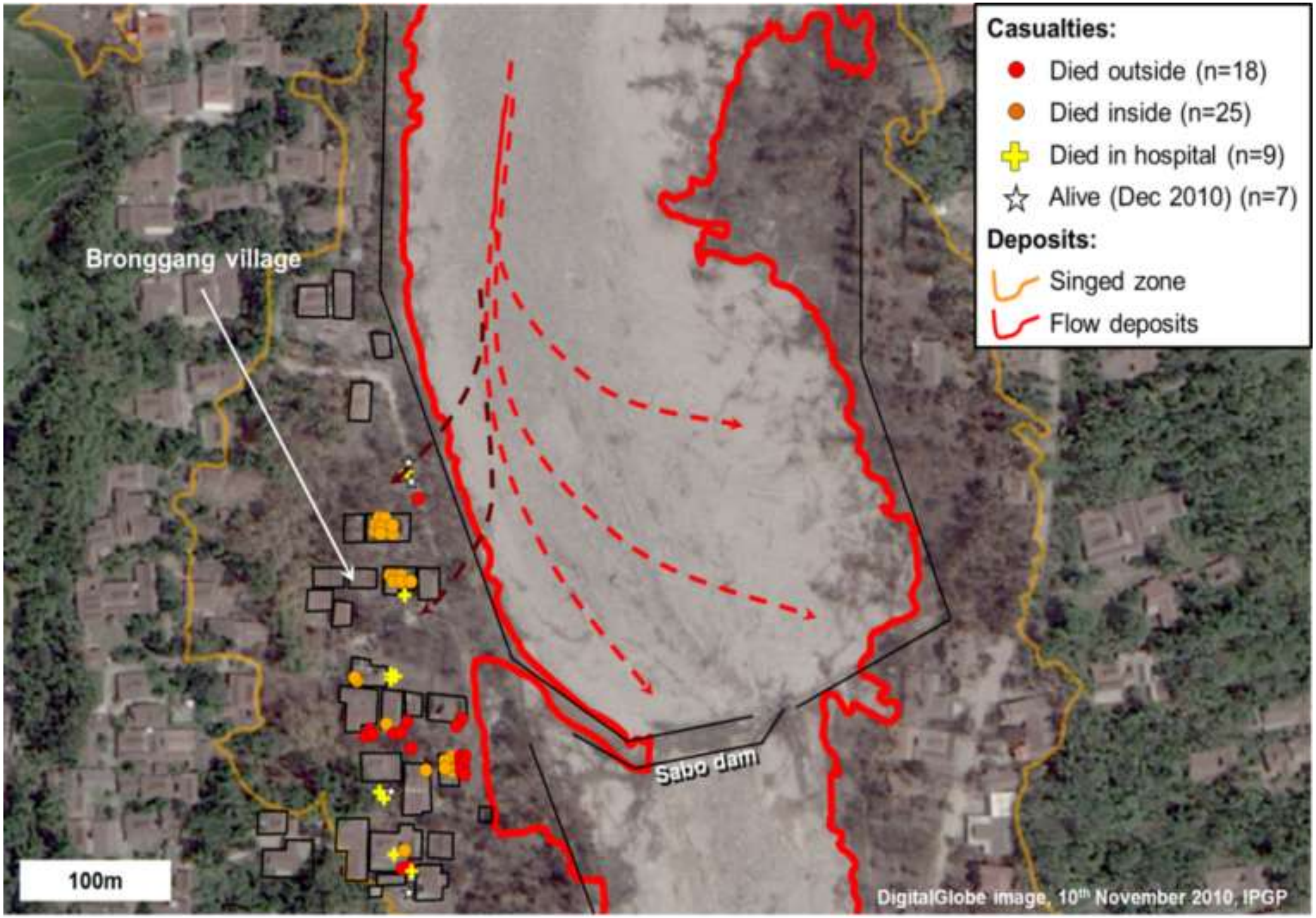
- Constrain rescue and fatality times
- Learn more about damage and casualties around the time of impact, e.g. ash adherence to casualties, ongoing fires, hot ash deposits
- See impact in areas subsequently destroyed
- Identify if impact environments were pristine at the time of our visit



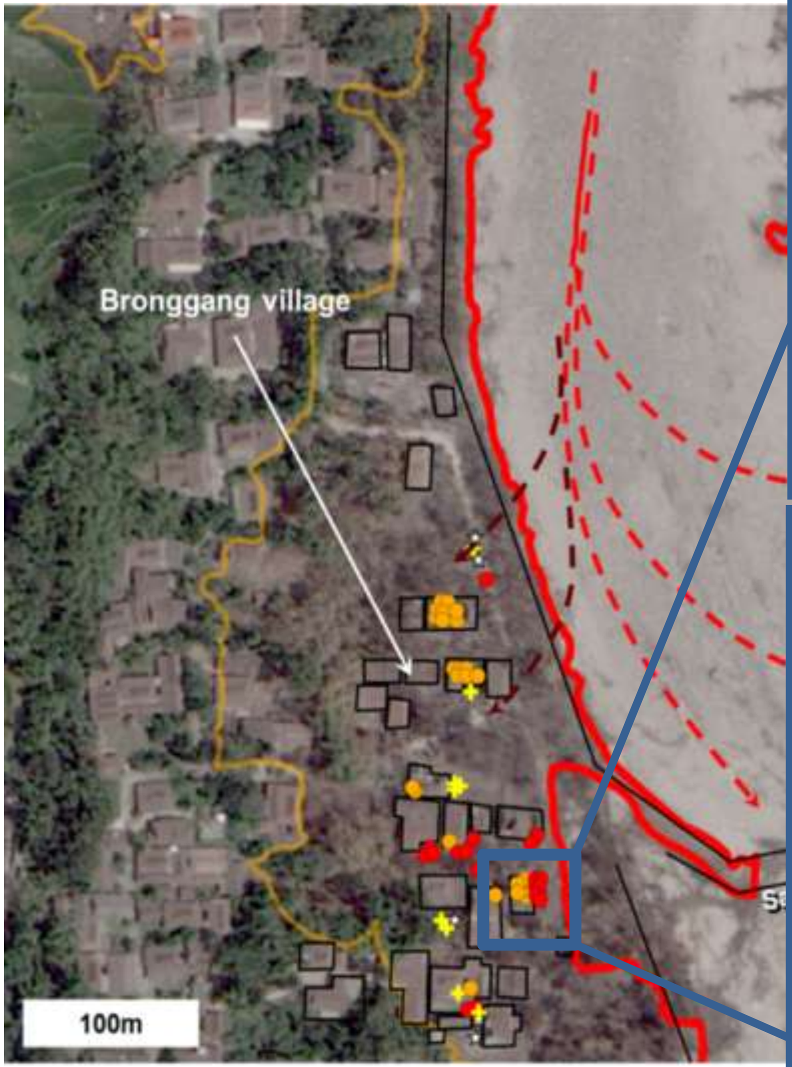
Remote assessment: media images

JCK interpretation: 1 November 2010 10:15 local
PDC view due East
Very nice example of the liftoff plume (Mandrews and Manga, Geology, 2011) due to flow block and diversion by Kendill 200 m high ridge forming the south part of the Gendol funnel.

Remote assessment: media images

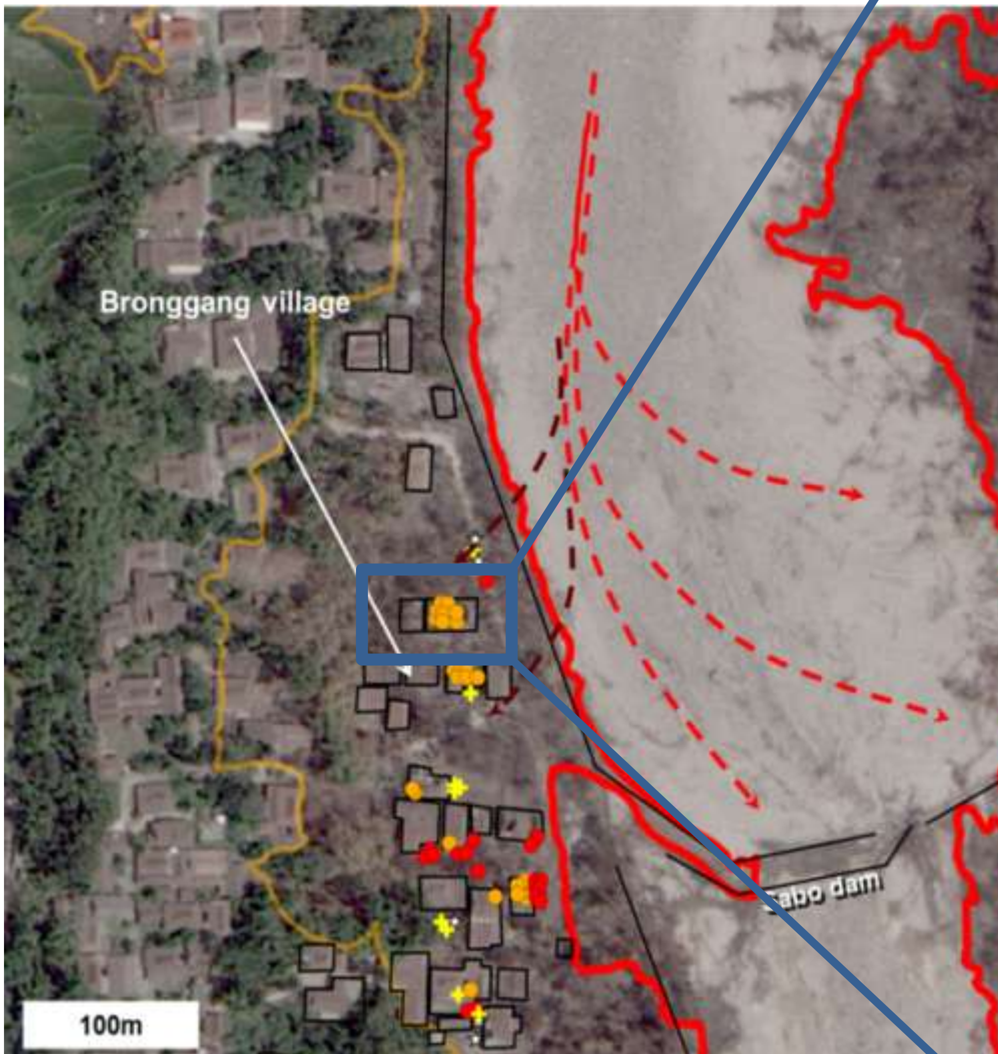


Remote assessment: media images



Remote assessment: media images

Remote assessment: media images




www.boston.com – 5 November 2010


www.boston.com – 5 November 2010

Remote assessment: media images

Remote assessment: media images

01 November 2010

Google Translator: « Circulating on the internet and Blackberry Messenger a picture showing the final seconds of hot clouds wedhus trash will swallow a car reportedly driven by volunteers.

In the photo, it appears a cloud of hot clouds billowed swallow all those in front. Blue vehicle carrying the relawanpun become victims. Reportedly, four volunteers died from crashing in the event that the hot cloud. [mah] »

Inilah Foto Wedhus Gembel Akan Telan Mobil Relawan

Posted in Amazing World on 02/11/2010 by juliussumant

Inilah.com | Senin, 1 Nopember 2010

Beredar di internet dan Blackberry Messenger sebuah foto yang menunjukkan detik-detik akhir awan panas wedhus gembel akan menelan sebuah mobil yang kabarnya dikendarai oleh para relawan.

Dalam foto itu, tampak kepulan awan panas bergulung-gulung menelan semua yang berada didepannya. Kendaraan berwarna biru yang ditumpangi para relawanpun menjadi korbannya. Dikabarkan, empat relawan tewas akibat terhempas awan panas dalam peristiwa itu. [mah]

http://nasional.inilah.com/read/detail/934792/inilah-foto-wedhus-gembel-akan-telan-mobil-relawan

Discussion points

- Ethical/Moral difficulties in obtaining critical empirical data, should there be restrictions on taking, distributing and/or using graphic images?

S.Jenkins – 6 Nov 2010

[redacted]

Discussion points

- Ethical/Moral difficulties in obtaining critical empirical data, should there be restrictions on taking, distributing and/or using graphic images?

S.Jenkins – 6 Nov 2010

www.letelegramme.com – 5 Nov 2010

Discussion points

- Ethical/Moral difficulties in obtaining critical empirical data, should there be restrictions on taking, distributing and/or using graphic images?
- What role does social media have in communication, (self) evacuation and rumour spreading?
- Was it a well managed crisis? Or were they just lucky?
- Pros/Cons of evidence-based, e.g. SHV, versus solo expert, e.g. Merapi, crises management
- How did so many people successfully evacuate so quickly? Lessons for other densely populated volcanoes, e.g. Vesuvius
- Management approach to next eruption – precautionary? Logistically possible given the number of people and financial implications?
- How to incorporate a wide range of potential surge and flow behaviour in s/t and l/t planning

S.Jenkins – 6 Nov 2010

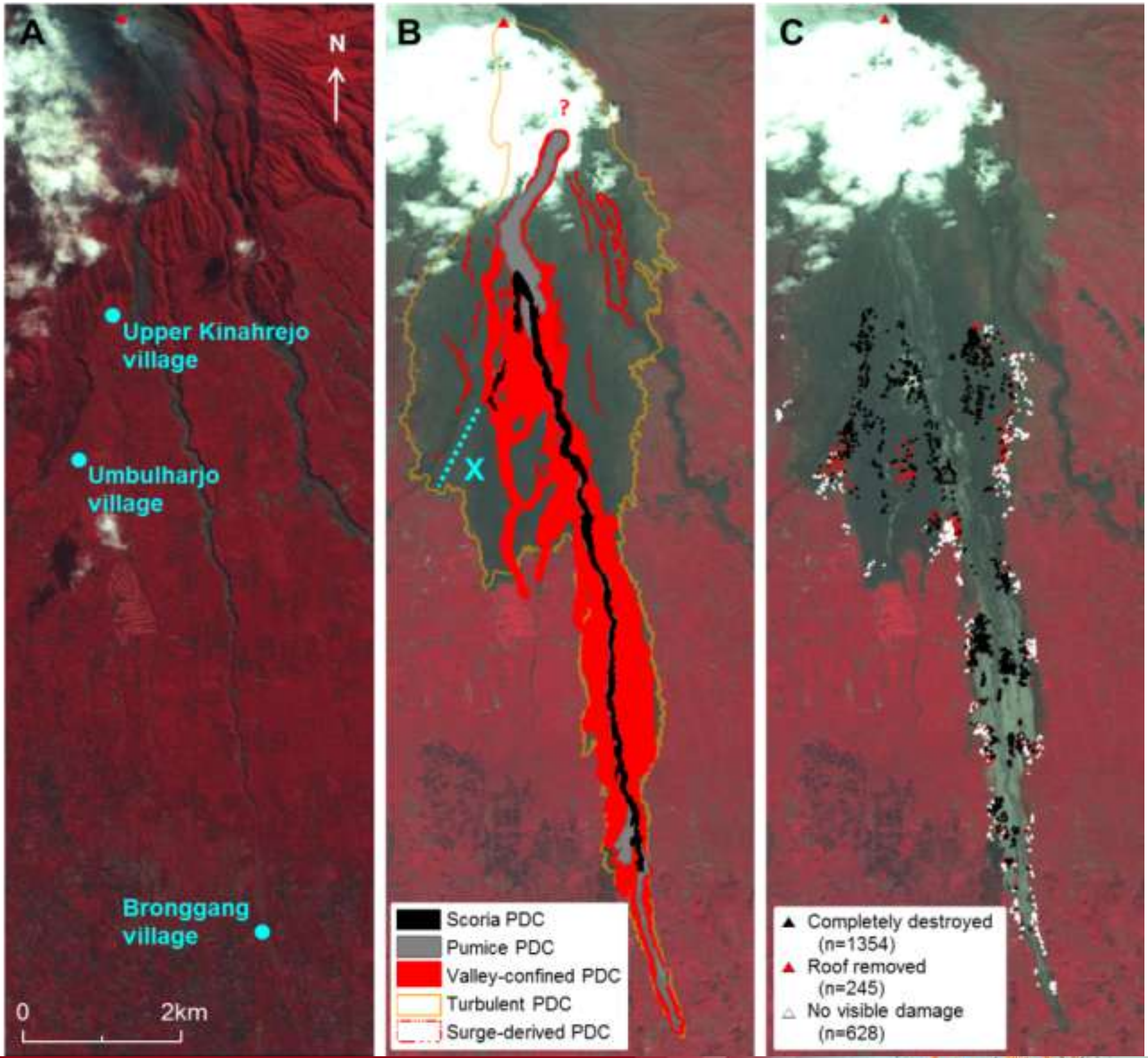
THANK-YOU

Susanna.Jenkins@bristol.ac.uk

Remote assessment: satellite and aerial images

Pre-, syn- and post-eruption images were invaluable, but:

- Expensive
- Limited by cloud
- Relatively infrequent
- Data processing intensive
- Available too late for real-time assessment in the Merapi eruption

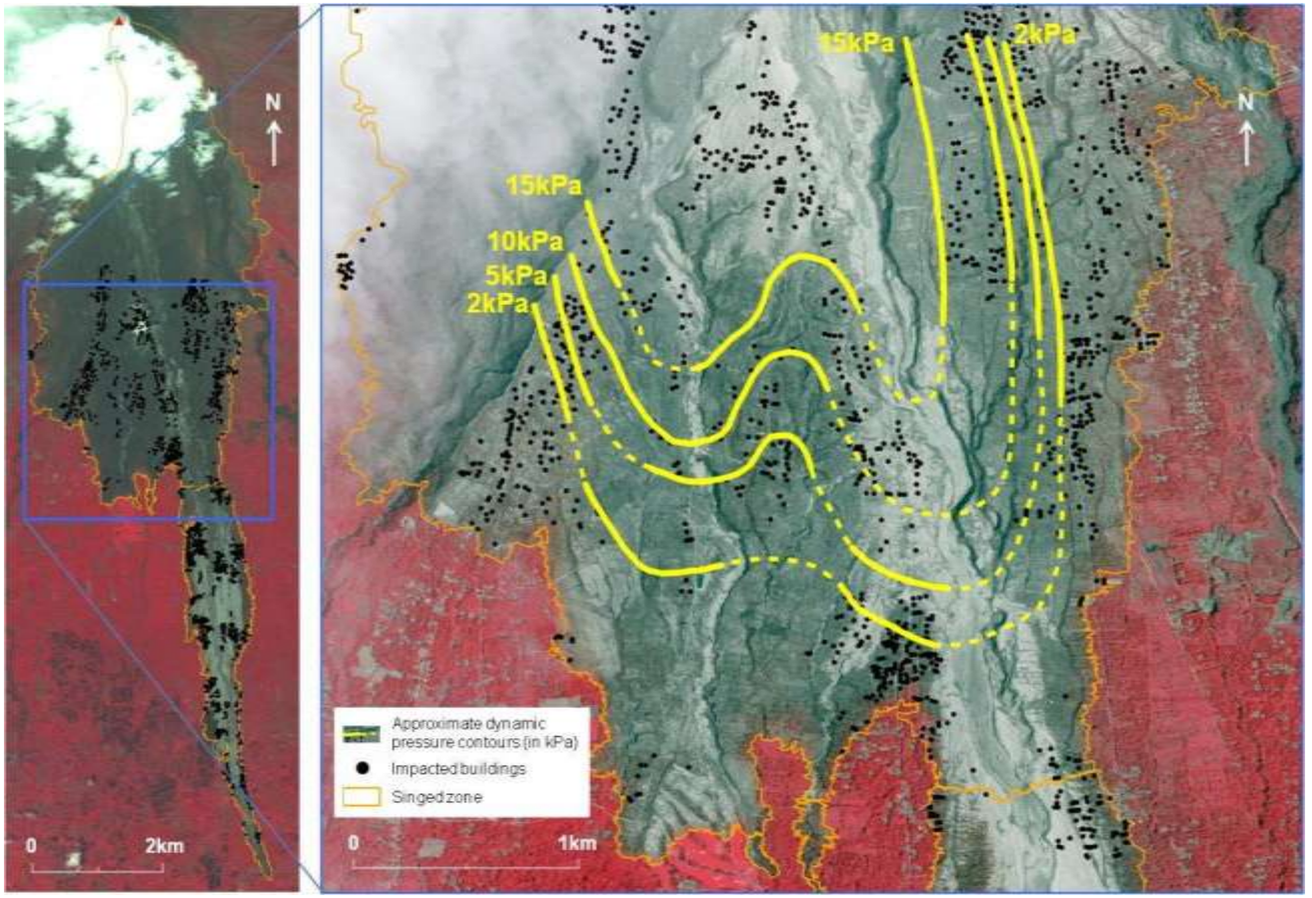


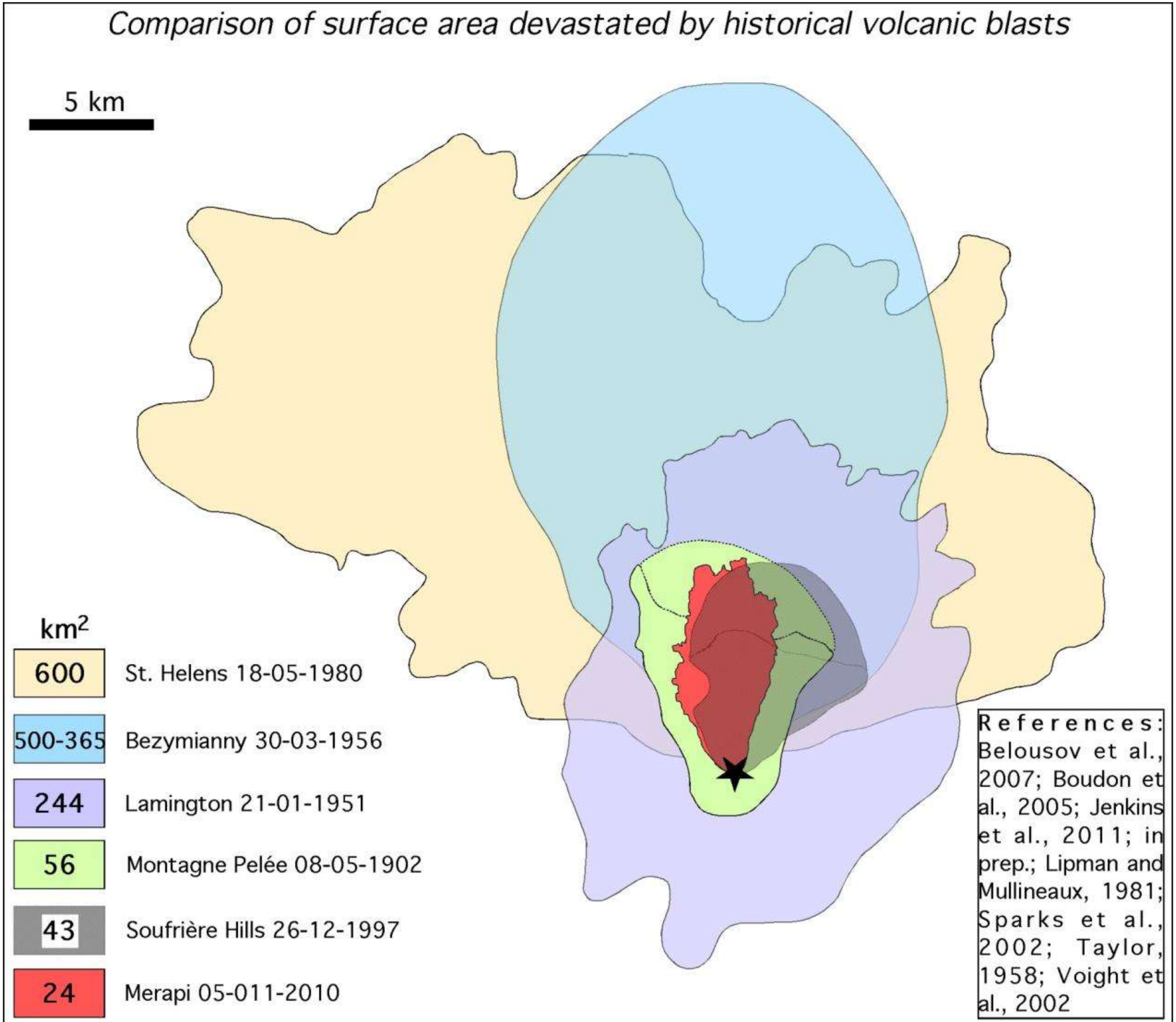
SPOT5 images: pre-eruption (2008) and post-eruption (15th November 2010). Purchased by IPGP

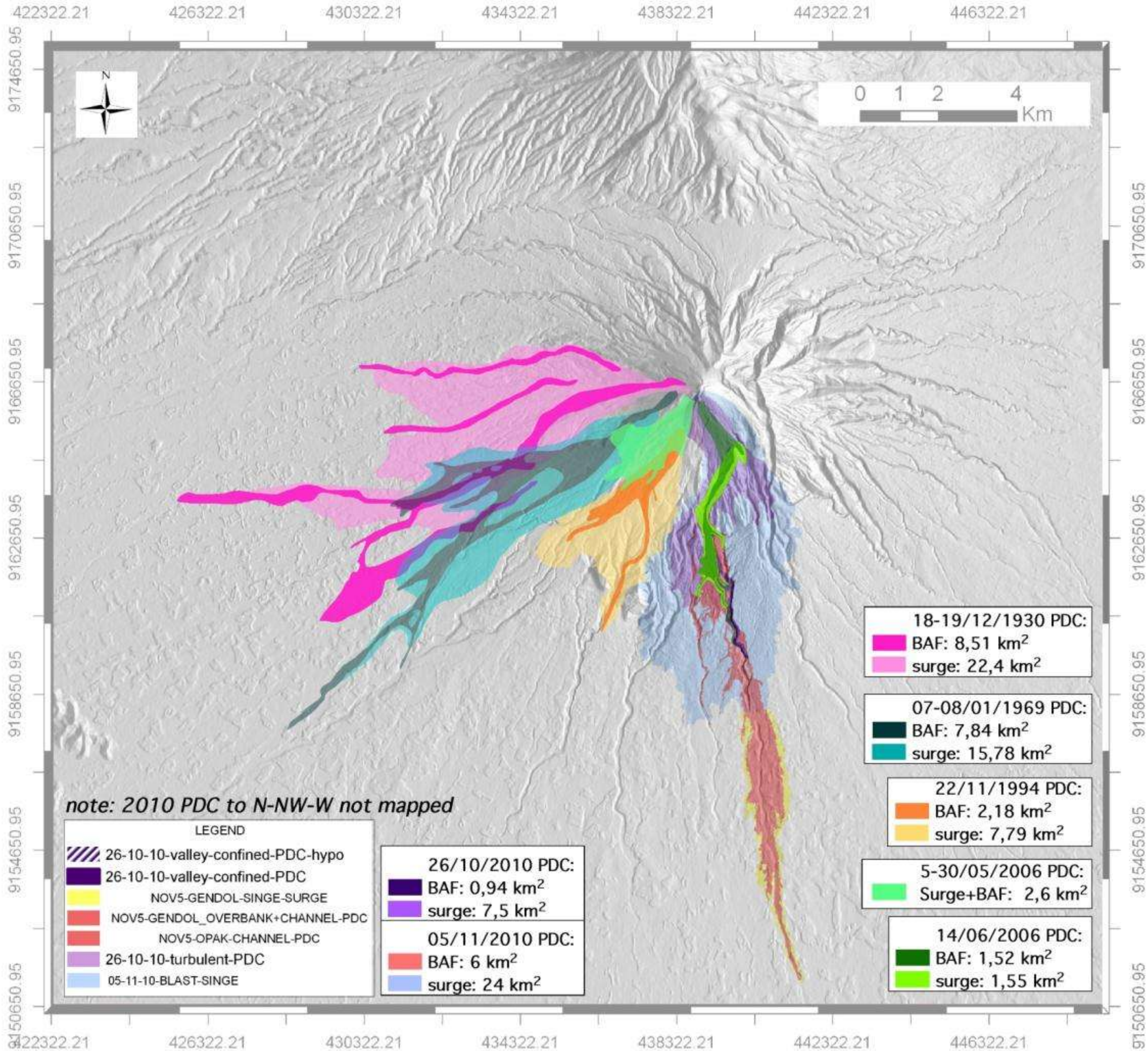
Deriving impact dynamics

Correlating geological data with damage and casualty data to reconstruct dynamics (e.g. temperature, dynamic pressure, density) of the range of pyroclastic density current behaviour exhibited through the 2010 eruption, through:

- Cataloguing nature and severity of charred, melted or softened building components/contents
- Limit state analyses for impacted objects
- Detailed GIS damage and deposits database
- Analyses of media images taken at the time of rescue
- Calculations, e.g. velocity from run-up, density from deposit thickness and 'high-tide' flow marks




Comparison of surface area devastated by historical volcanic blasts
5 km
km²
600
St. Helens 18-05-1980
500-365
Bezymianny 30-03-1956
244
Lamington 21-01-1951
56
Montagne Pelée 08-05-1902
43
Soufrière Hills 26-12-1997
24
Merapi 05-011-2010
References: Belousov et al., 2007; Boudon et al., 2005; Jenkins et al., 2011; in prep.; Lipman and Mullineaux, 1981; Sparks et al., 2002; Taylor, 1958; Voight et al., 2002



Distribution of major pyroclastic flow deposits from concentrated flows and dilute surges of recent eruptions at Merapi (data from Kelfoun et al., 2000; Abdurachman et al., 2000; Bourdier et al., 2001; CVGHM-BBPTK, Global Volcanism Program; Charbonnier et al., 2008; 2009; Jenkins et al., 2011; in prep). Shaded relief DEM: 1995-96, res. 15m, Gerstenecker, C., Läufer, G., Steineck, D., Tiede, C., Wrobel, B., 2005. Validation of digital elevation models around Merapi Volcano, Java, Indonesia. Nat. Hazards Earth Sys. 5, 863-876; courtesy of S. Charbonnier.