Reducing rockslide risk in an increasingly crowded world

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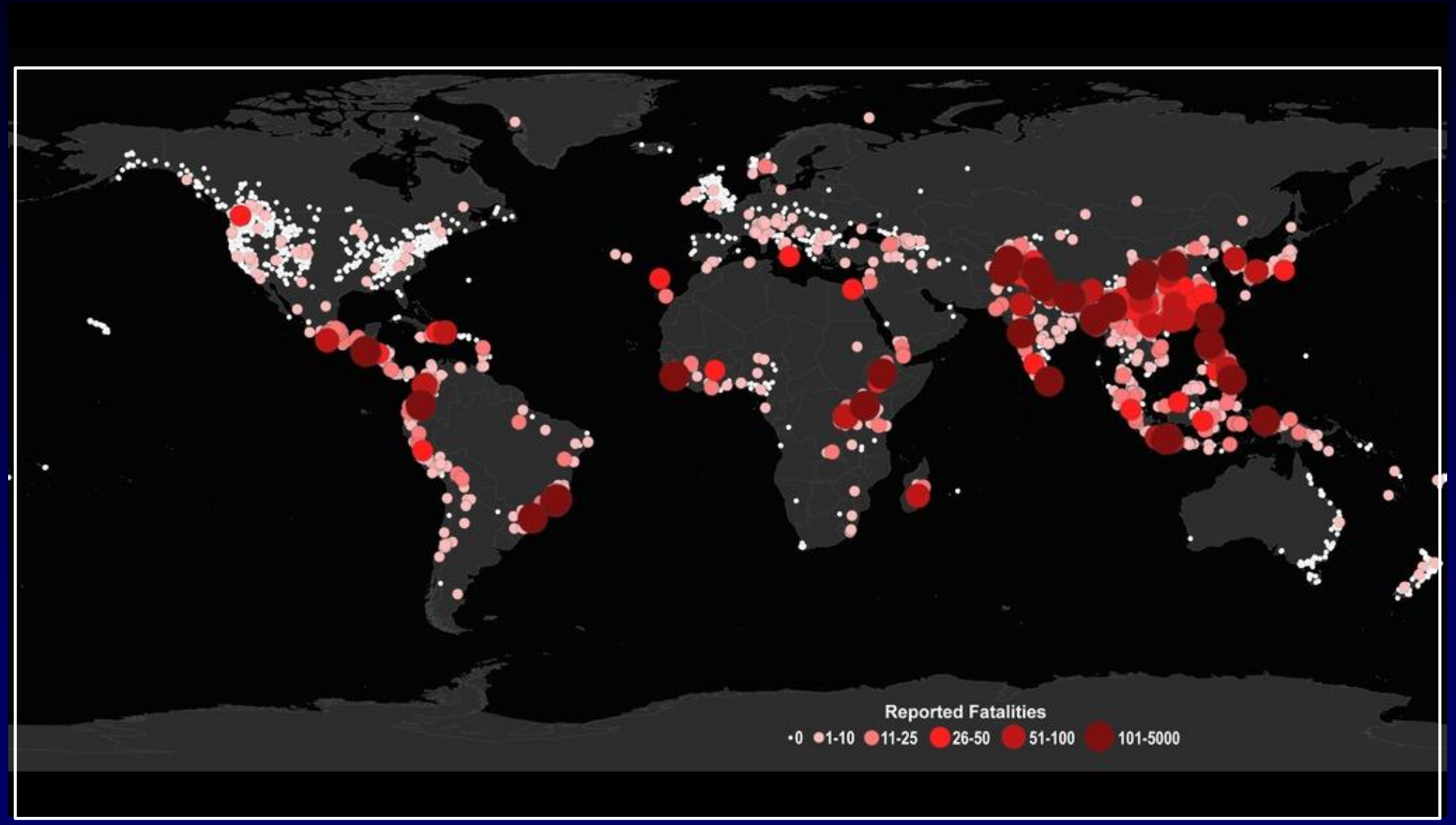
*In recent decades much progress has been made in understanding **why** and **how** rock slopes catastrophically fail*

In recent decades much progress has been made in understanding why and how rock slopes catastrophically fail

To date, however, earth scientists have been unable to use this knowledge to predict when and where rockslides and rock avalanches happen….Yet this is what is required to reduce the injury and infrastructure damage they cause

In support of this assertion, fatalities and economic losses from landslides have not decreased…



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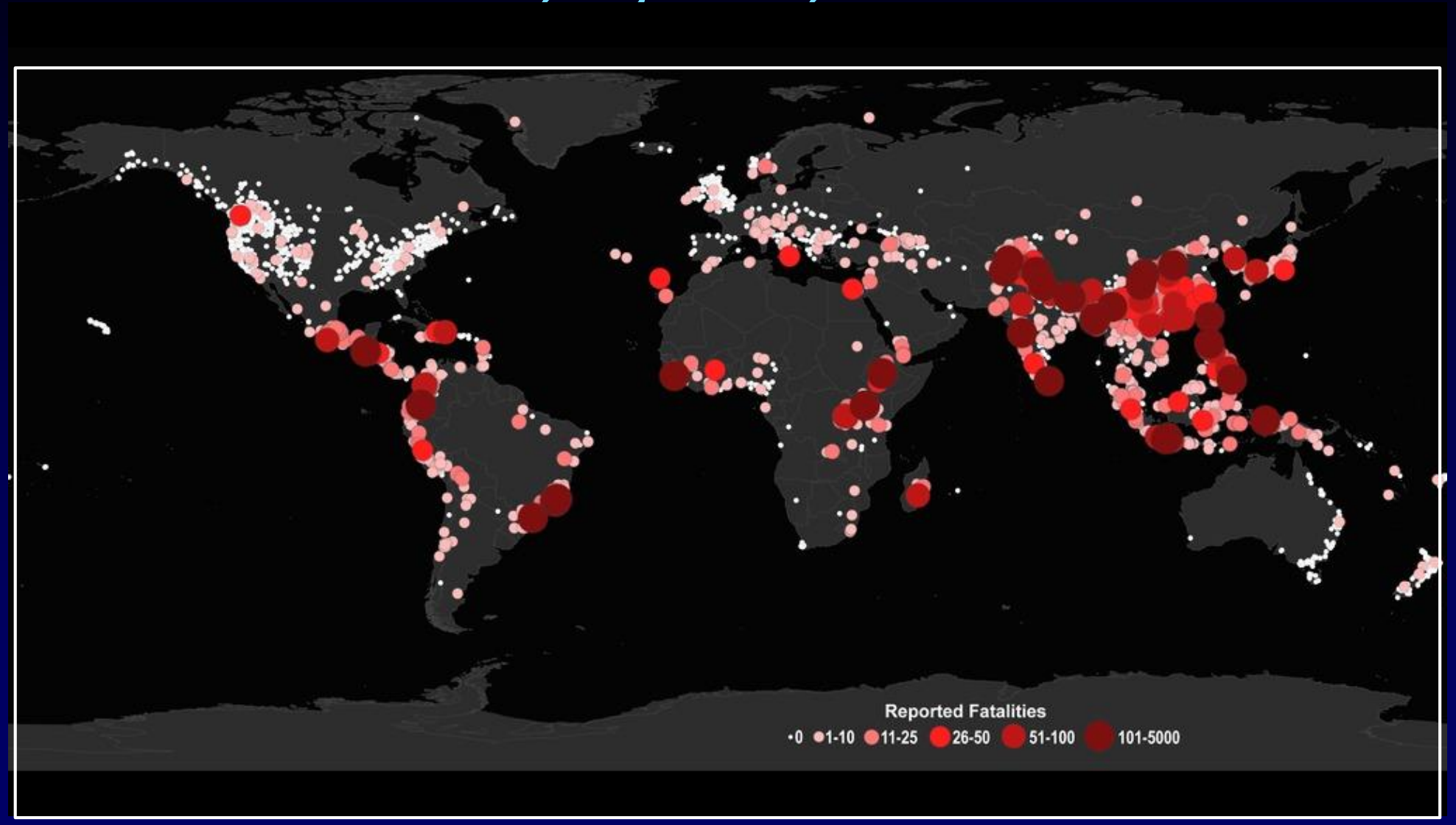
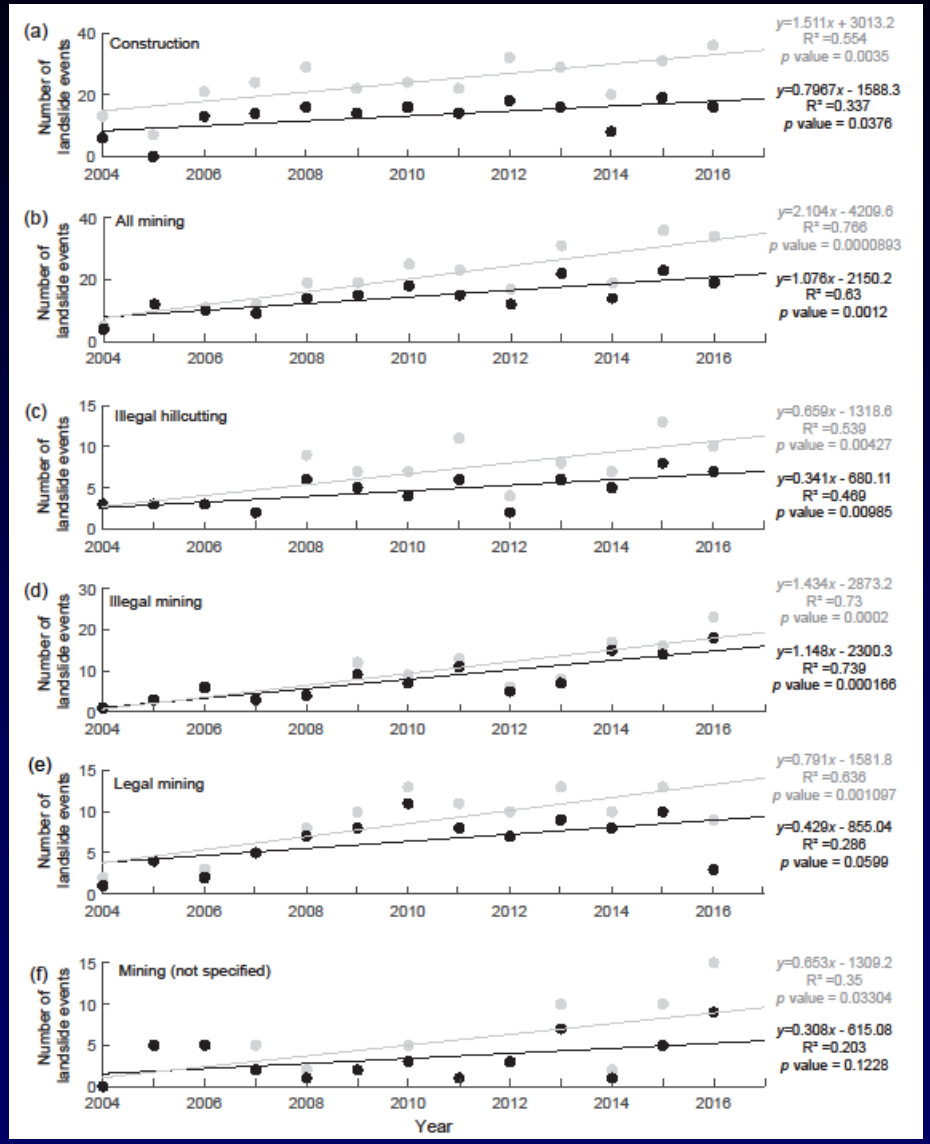


US Geological Survey

… and fatalities from human-caused landslides have increased



Froude and Petley 2018

I am not saying that the research/practitioner community is responsible for this situation ….

… An important driver is the relentless (and unsustainable) increase in human numbers, accompanied by an increase in mining, deforestation, and other human activities

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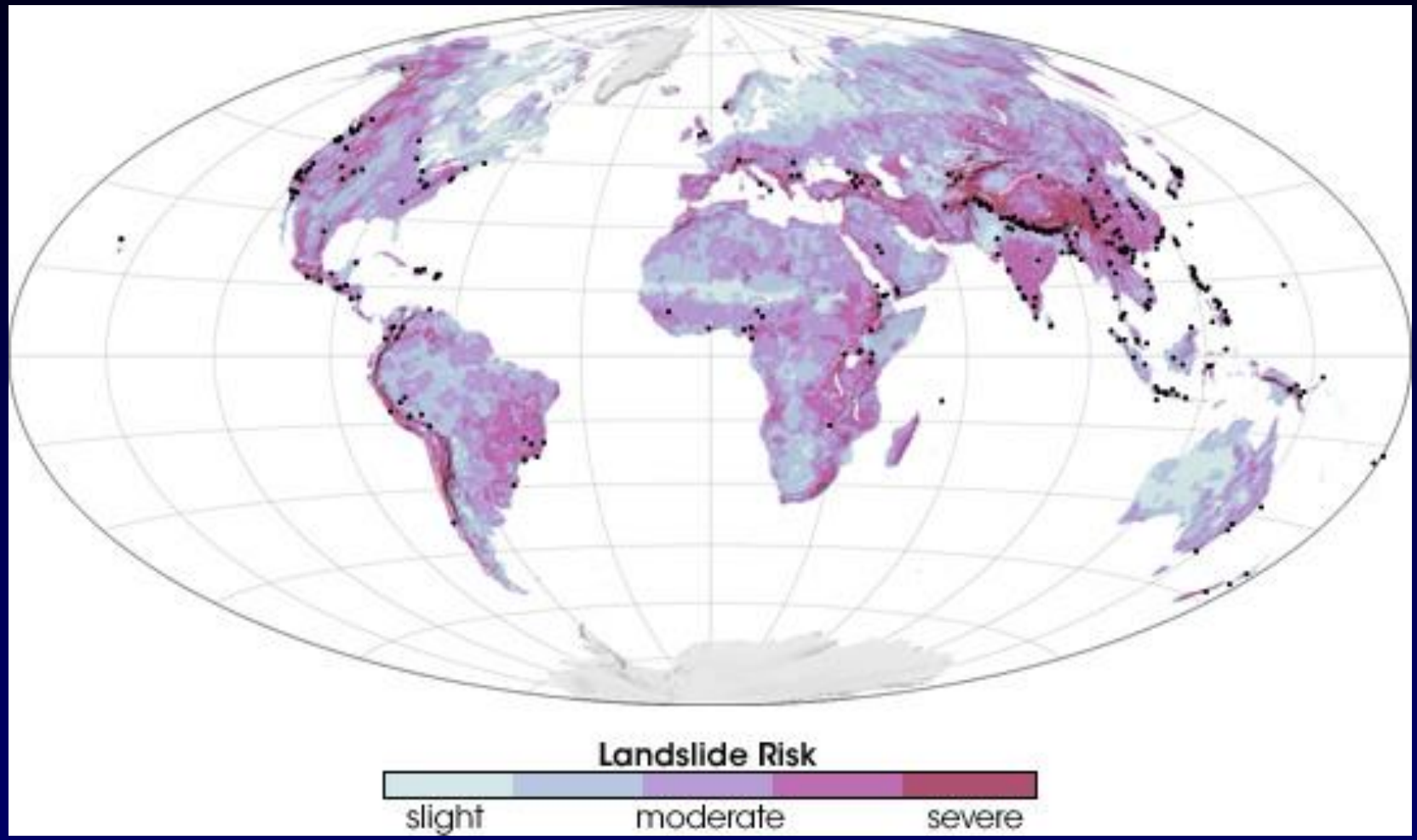
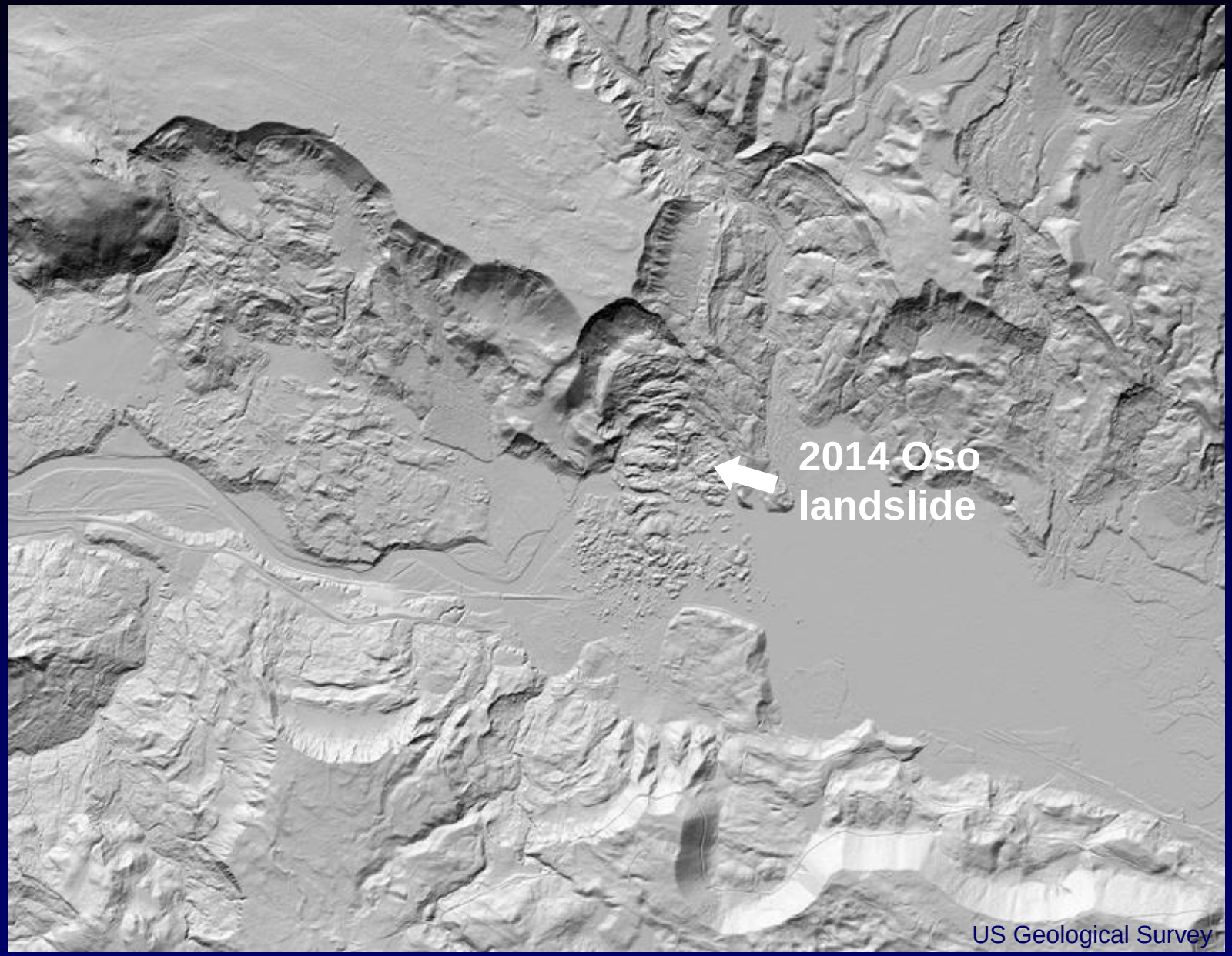


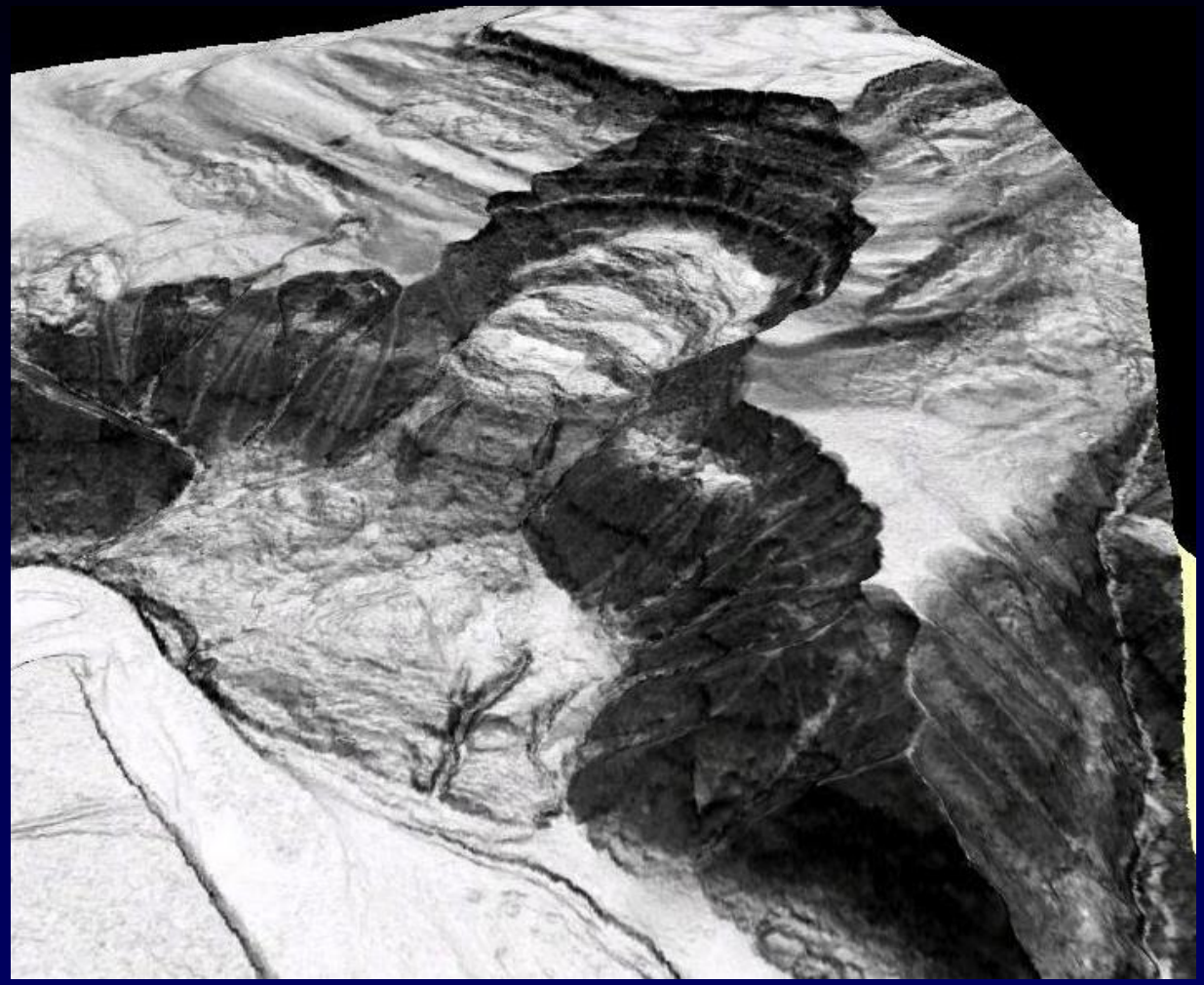
NASA

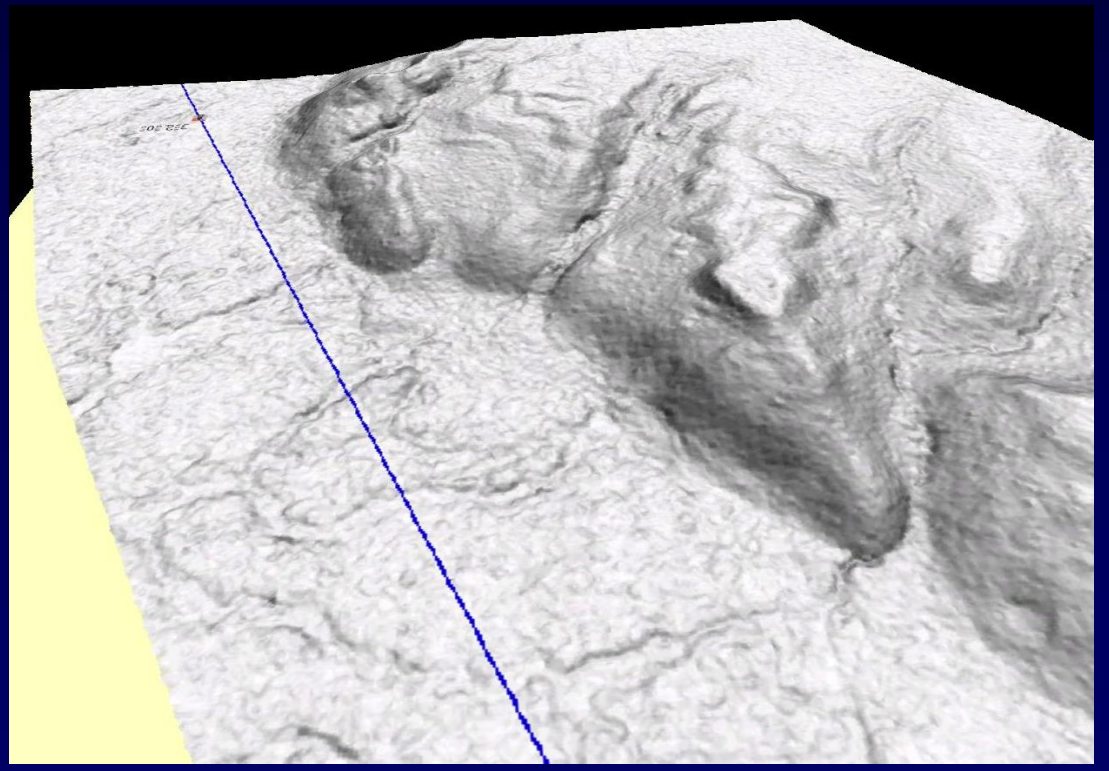
Yet one would think that we can do better because we are equipped with innovative tools and methods that allow us to better evaluate and monitor potentially dangerous slopes:

- **Remote sensing tools (lidar, InSAR, UAVs)**
- **Spatial data analytical tools (GIS)**
- **Digital elevation models and derived images**
- **3-D immersive tools (holography, HoloLens)**
- **Improved numerical modeling software**
- **Geophysical tools**

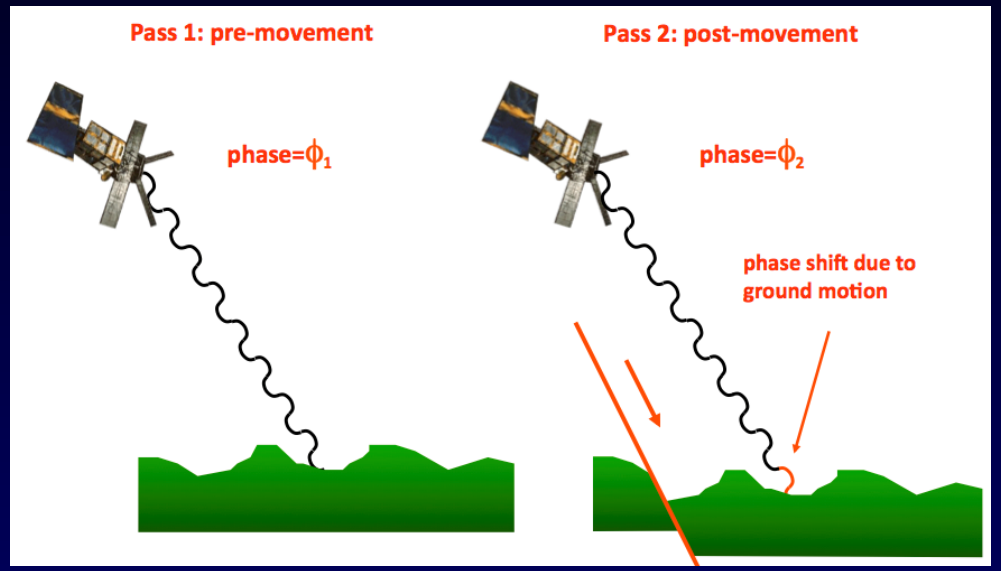
Lidar

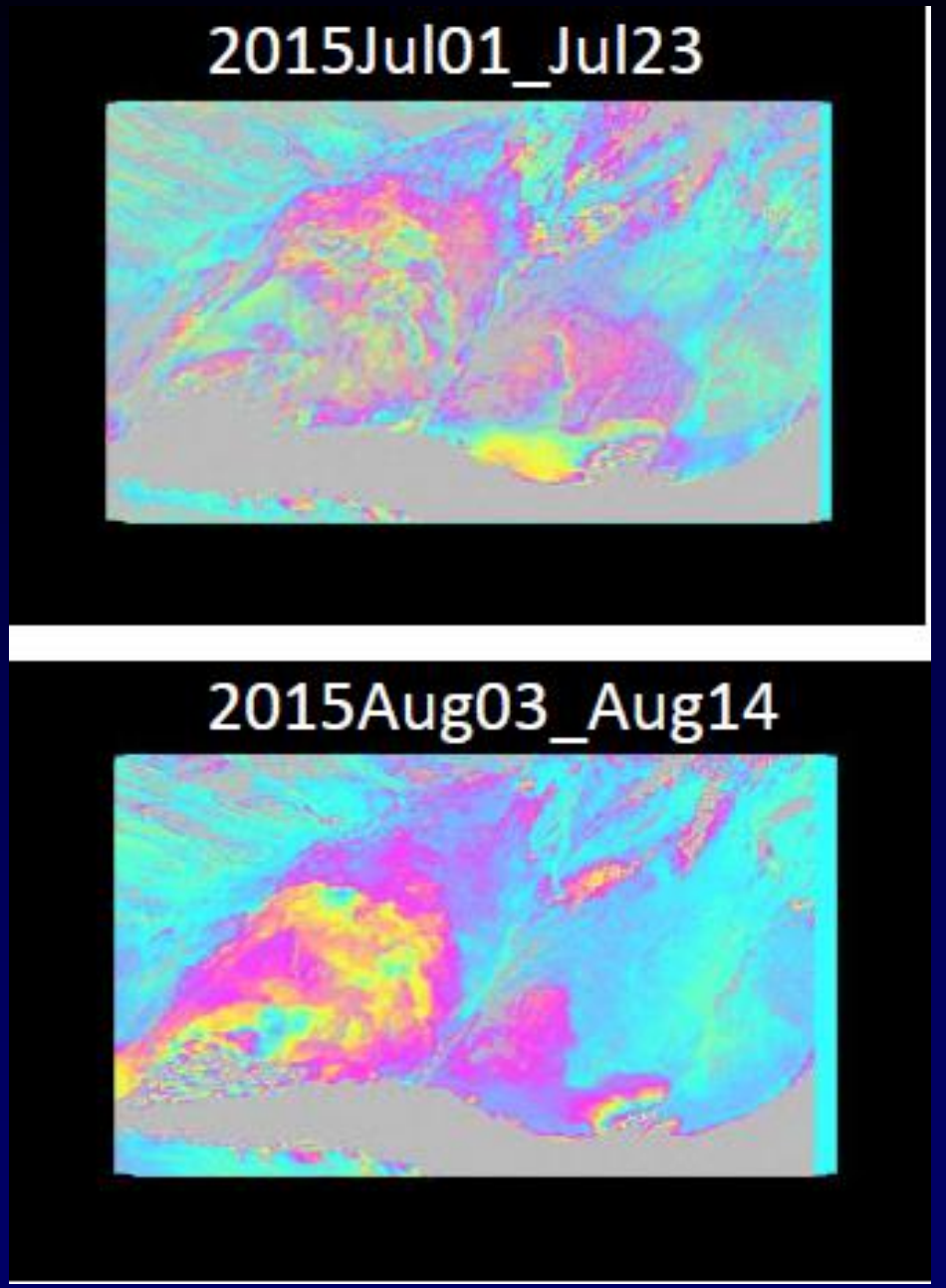






InSAR





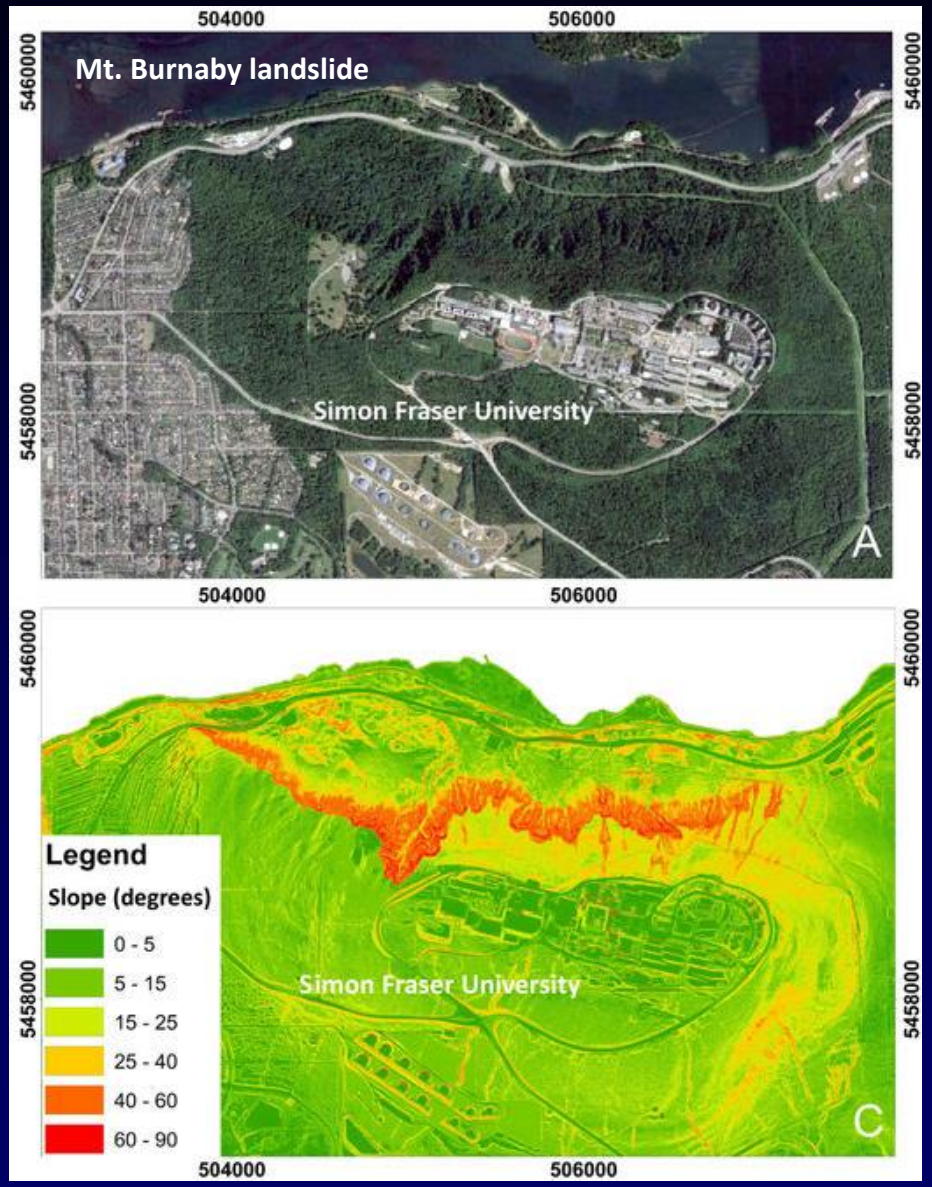
Line-of-sight displacements, Fels sackung, Alaska,

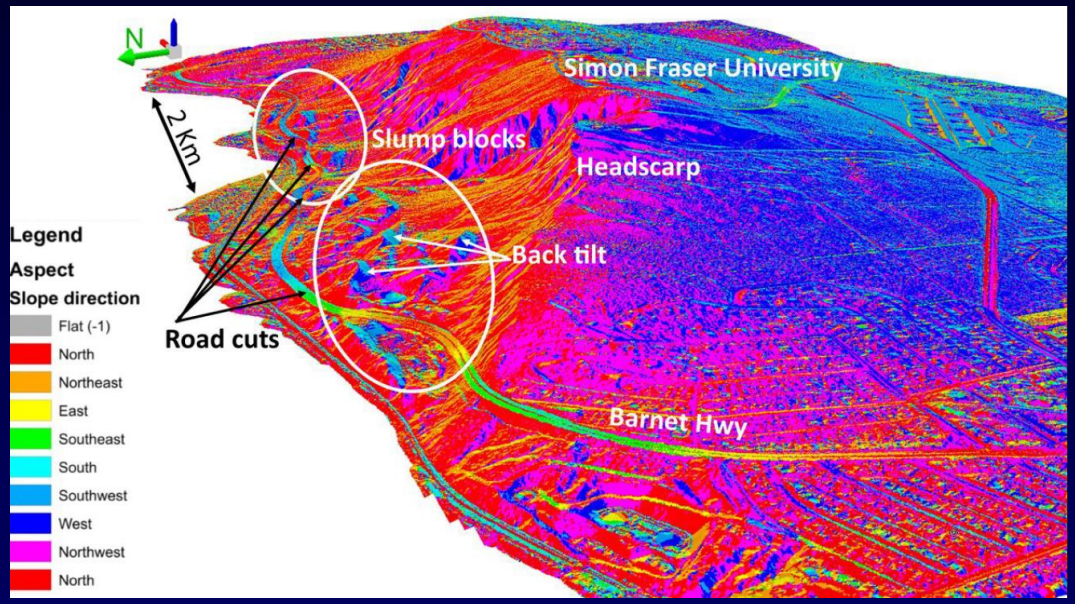
Bernhard Rabus

UAVs

UAV photo of gravel ‘megaripples’ on the floor of Alsek Valley, Yukon

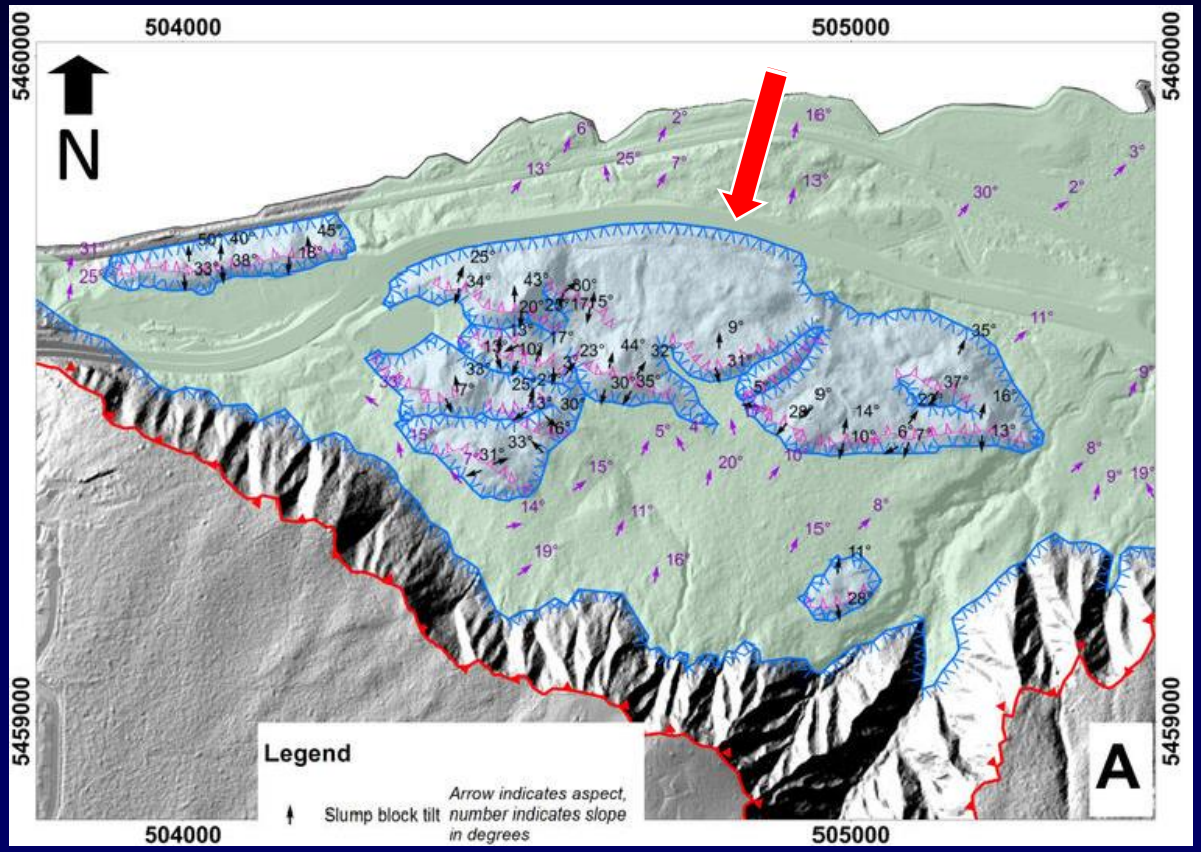
Orthophotos, DEMs, and derived thematic maps

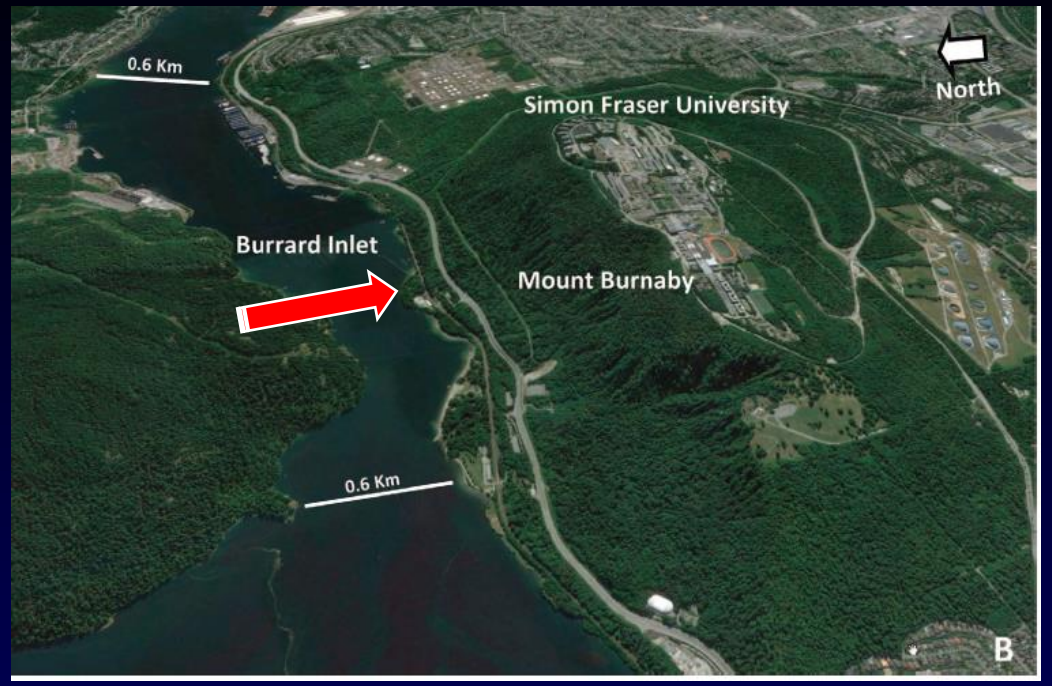




Francioni et al. 2017

Engineering geology maps

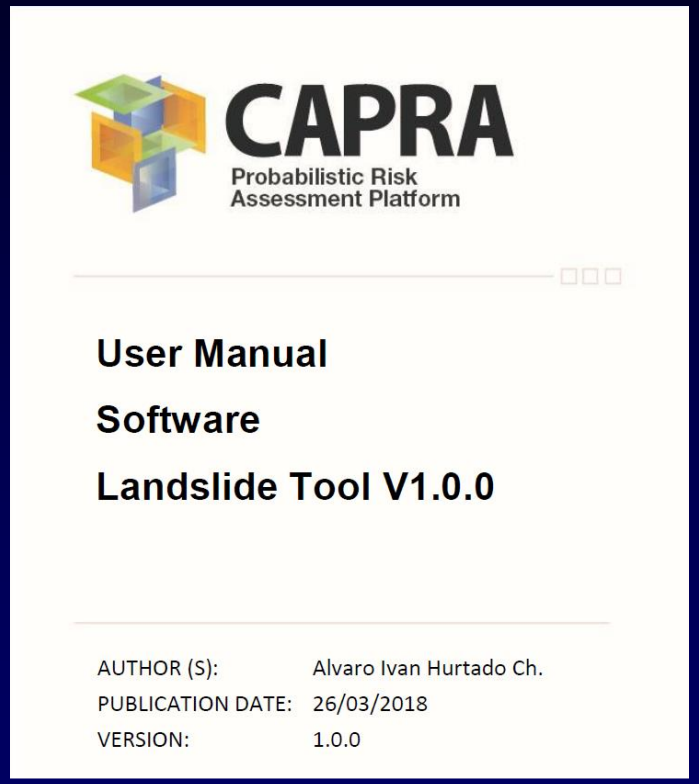




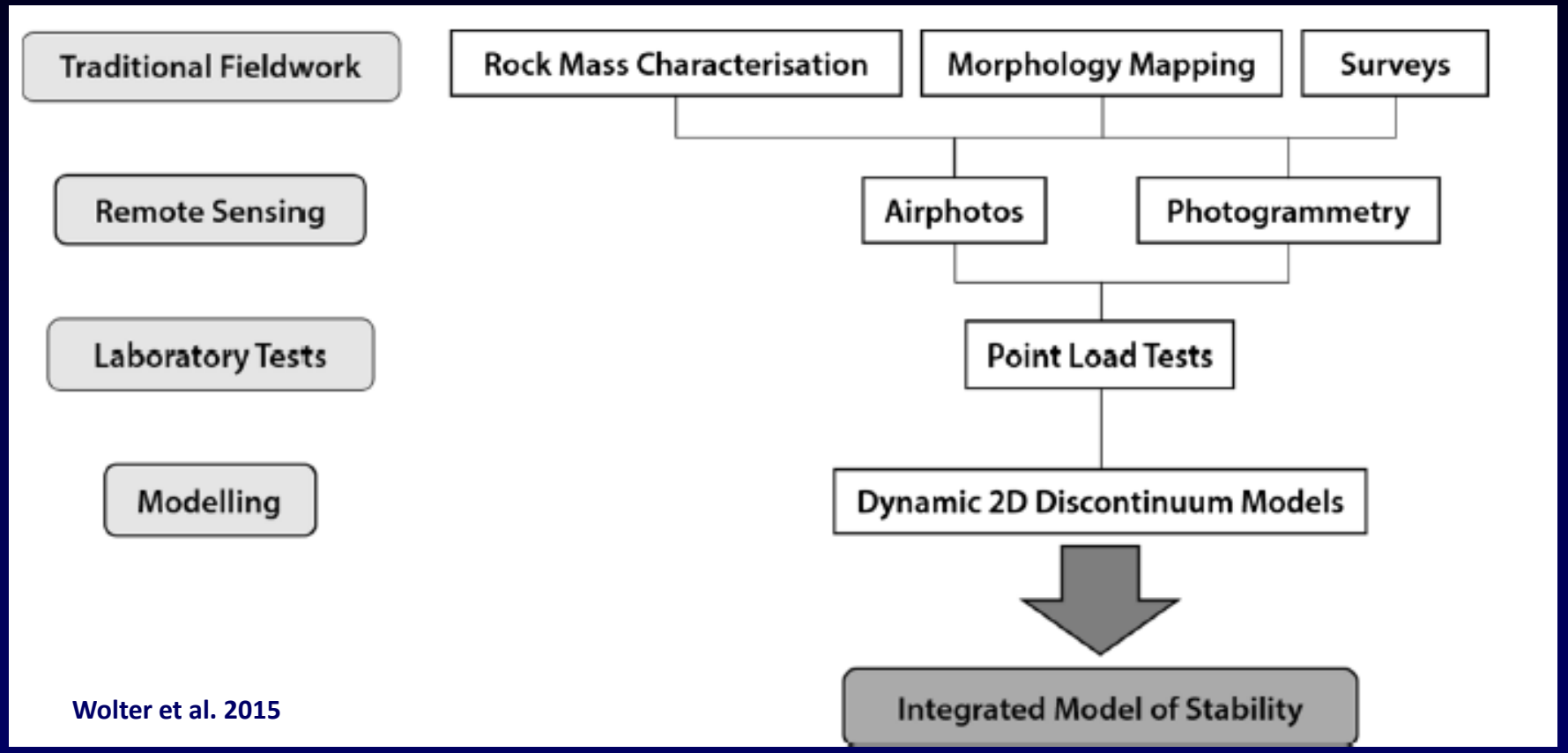
Francioni et al. 2017

Holography and HoloLens

Constant improvements in numerical modelling and machine-learning software



Use of multiple tools in investigations



Wolter et al. 2015

Yet in spite of the widespread use of these innovative tools and schema, I would argue that we have made little progress in predicting or even forecasting landslides….

Washinton State, 2014

El Salvador, 2007

Yet in spite of the widespread use of these innovative tools and schema, I would argue that we have made little progress in predicting or forecasting landslides….

….Nearly all landslide studies are retrospective in nature. Model-based predictions are not able to accurately predict when and where large landslides will happen

Washinton State, 2014

El Salvador, 2007

The greatest challenge to reducing landslide risk lies outside physical sciences, within the arena of societal decision-making

Questions we need to ask those of us who seek to reduce risk:

How can our improved scientific understanding of landslide hazards at local and regional levels be effectively incorporated into land-use decisions?

What procedures can we offer governments and the public to allow them to better understand landslide hazards and risk and to decide what level of that risk is acceptable?

To effectively reduce losses from landslides, we must develop tools and procedures that cost-effectively minimize losses due to landslides while …

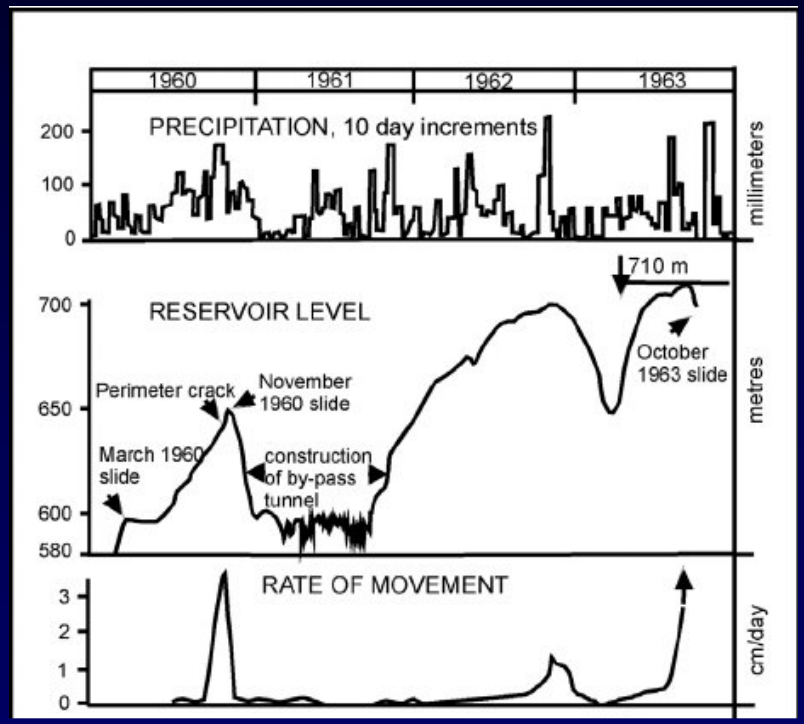
…working with all levels of government to adopt those tools and procedures

An example is how this might be done in the case of large rockslides is that they happen in areas of 'slope fatigue', where the slope is deforming slowly:

Fatigued slopes can be pinpointed with regional automated InSAR monitoring (Sentinel 1 has a 6-day revisit time), allowing detailed geotechnical study of sites of concern

Numerous studies have shown that catastrophic rock-slope failures are preceded by an acceleration of slow motion (e.g. Vaiont) that can be analyzed by the inverse velocity method. The acceleration can be detected with dynamic continuous InSAR monitoring

Such a program comes with a price tag and will require further development of InSAR algorithms. But is the price greater than the losses and injury that we continue to incur through unanticipated catastrophic rock slope failures.



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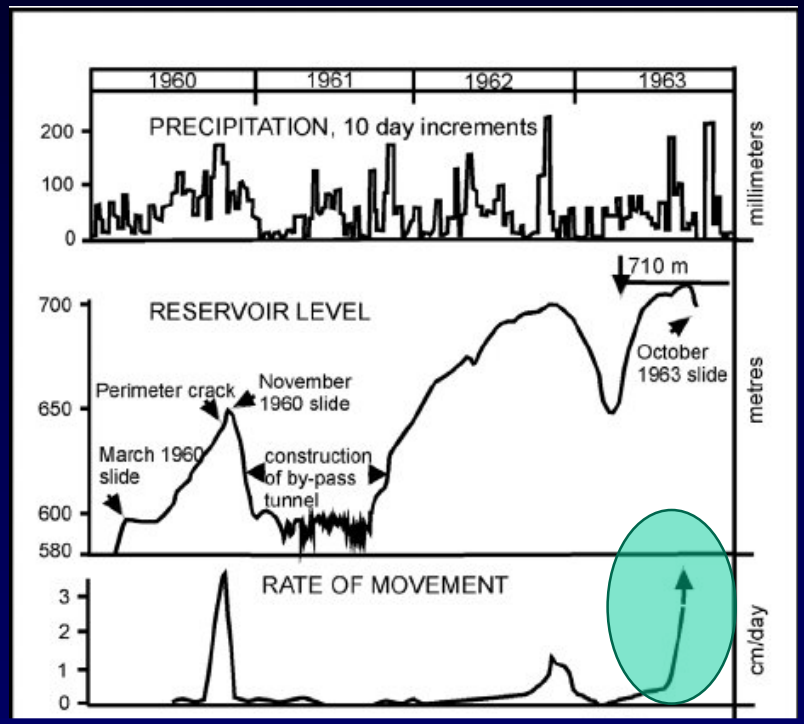

Thank you for your attention!