Applications of Sentinel-1 Amplitude ~~and Coherence~~ Time Series to Rapid Landslides Triggered During Long Rainfall Events

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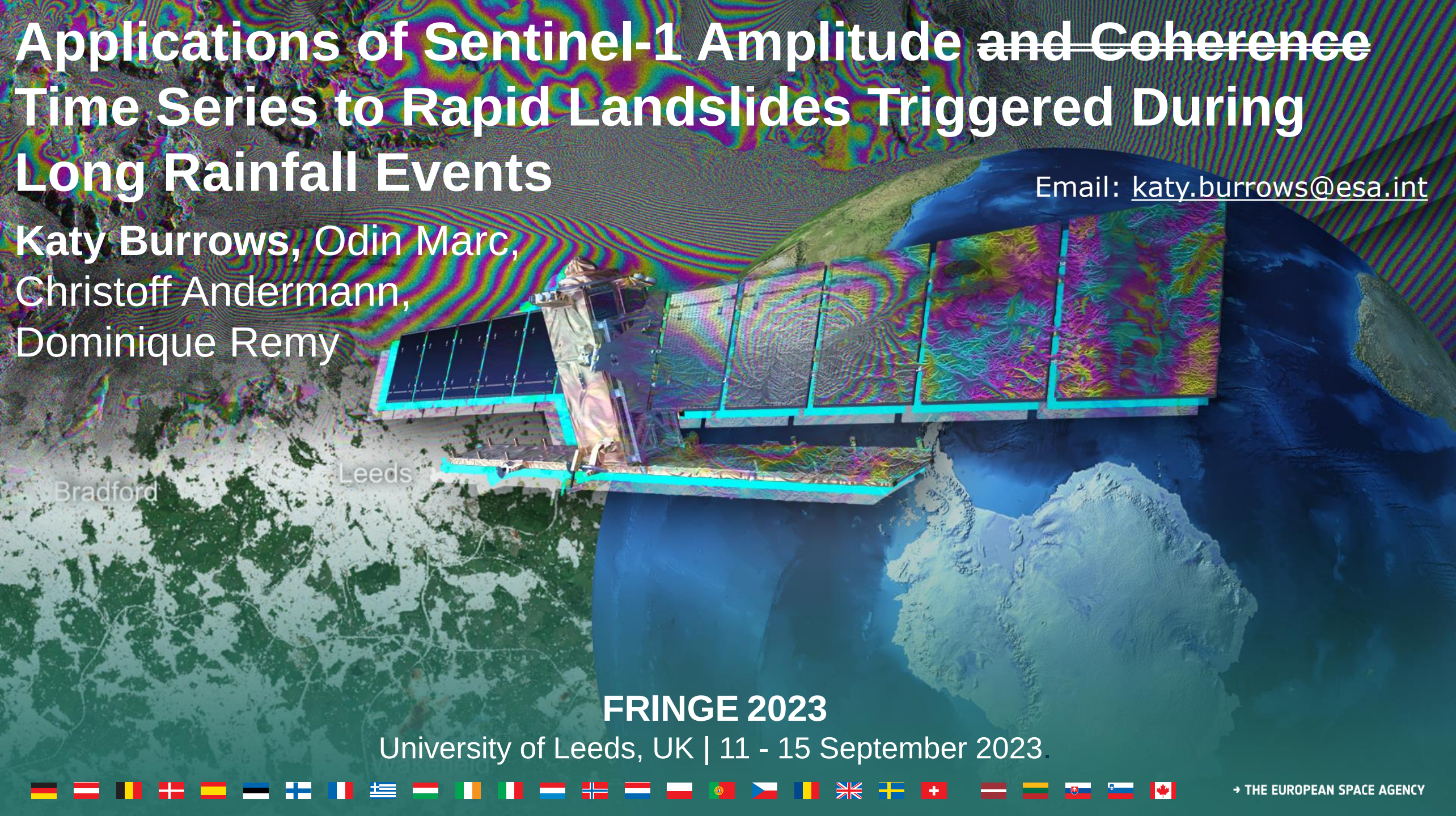
Katy Burrows, Odin Marc, Christoff Andermann, Dominique Remy



FRINGE 2023

University of Leeds, UK | 11 - 15 September 2023.

Introduction

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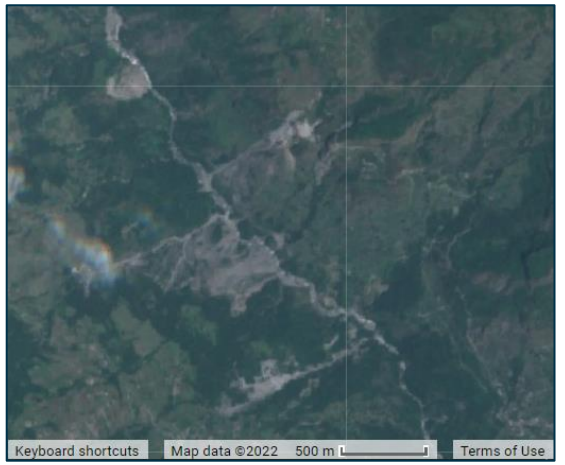
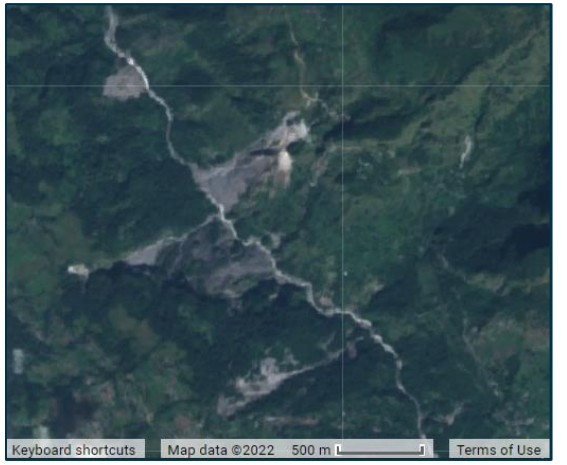


Pre-monsoon, 2017, Nepal
Sentinel-2



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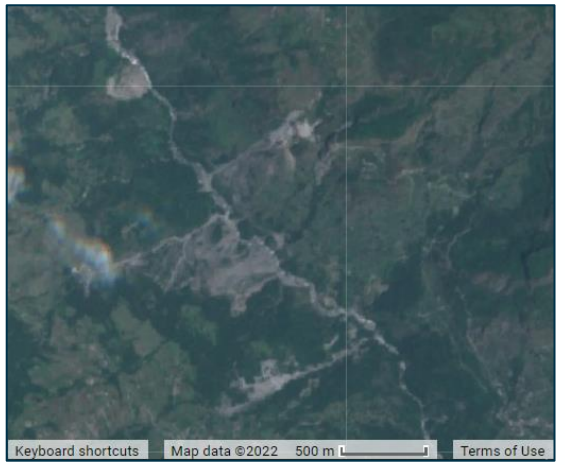

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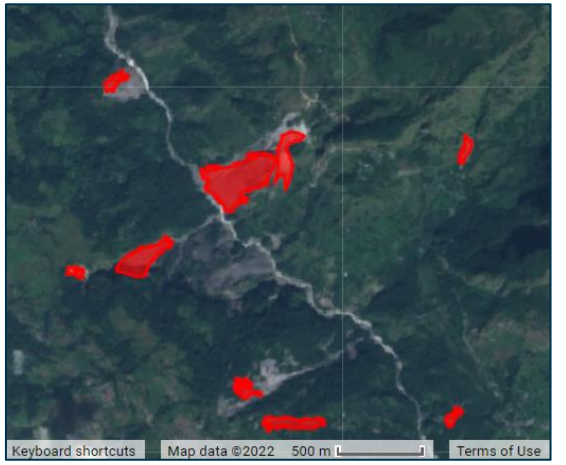

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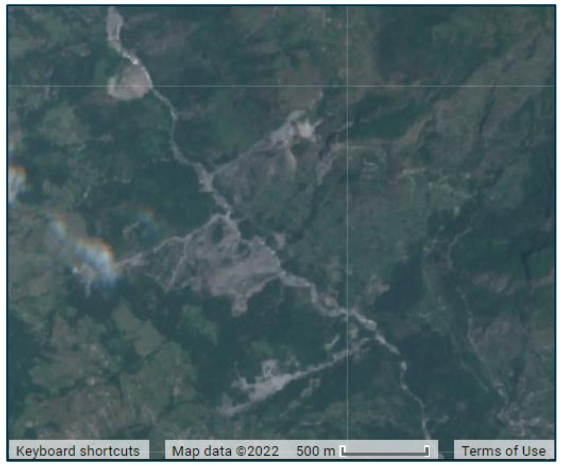

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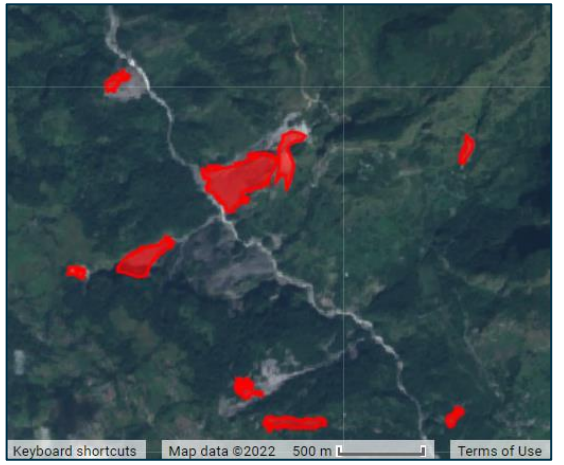

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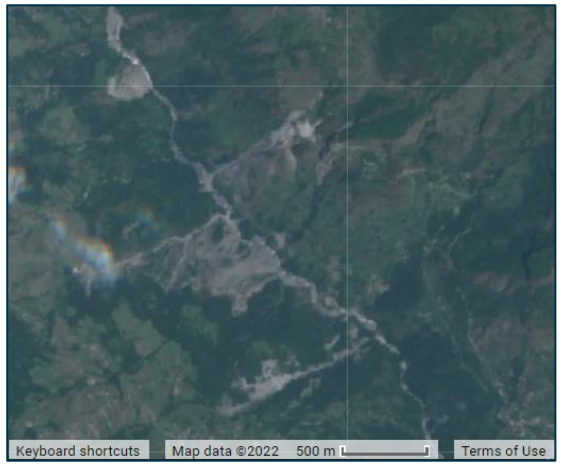

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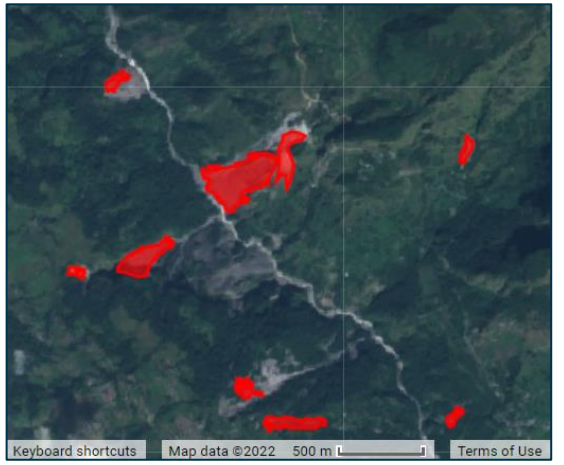


Post-monsoon, Nepal, 2017

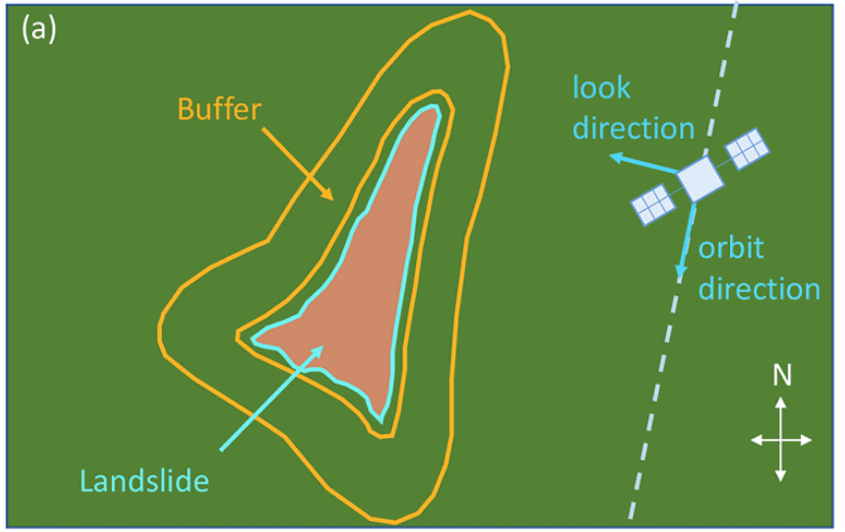
Solution: 1. Map landslide polygons with optical satellite imagery

2. Use Sentinel-1 to constrain their timings

Landslide timing from Sentinel-1 amplitude

4 methods used in combination

1. Difference between landslide amplitude and local background amplitude



Burrows et al. 2022, NHESS

Landslide timing from Sentinel-1 amplitude

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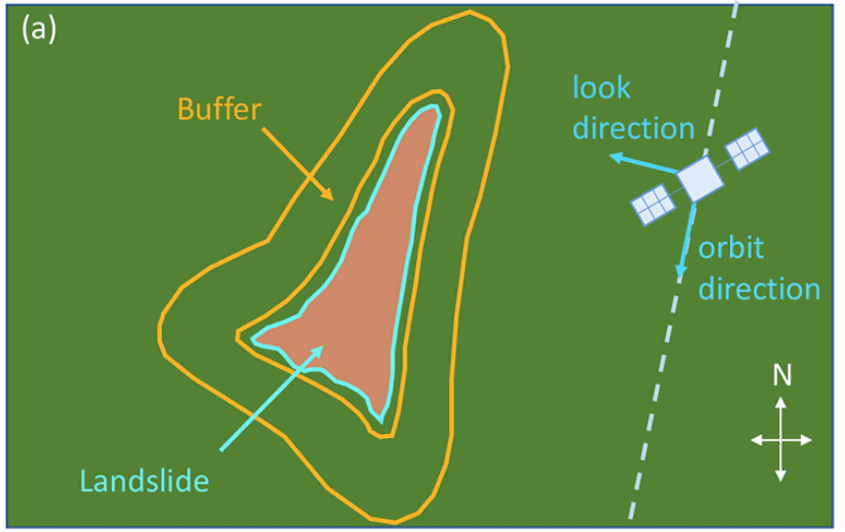

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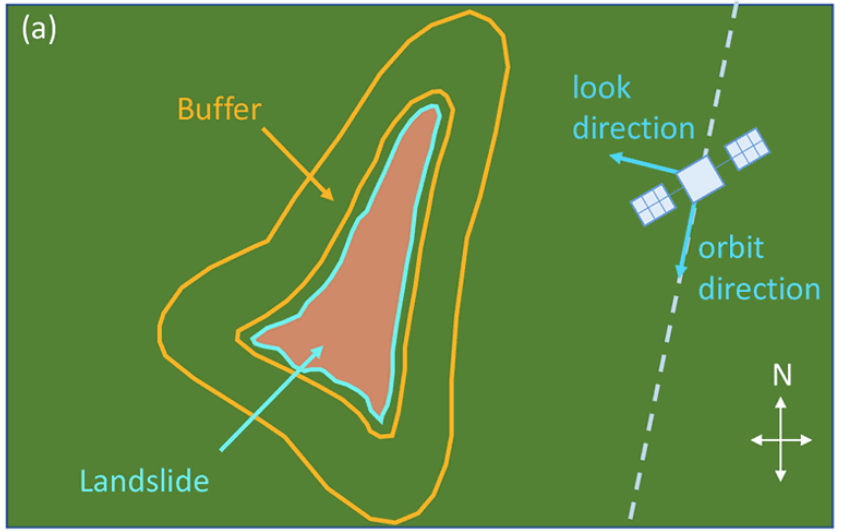
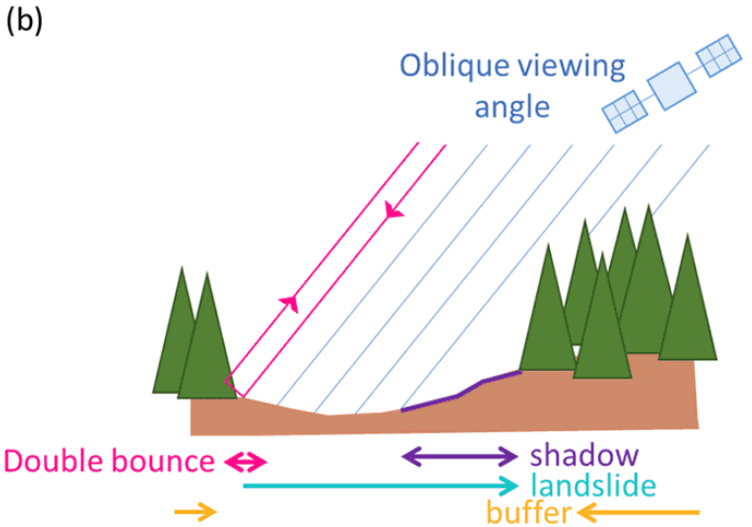
4. Dihedral scattering within landslide polygon





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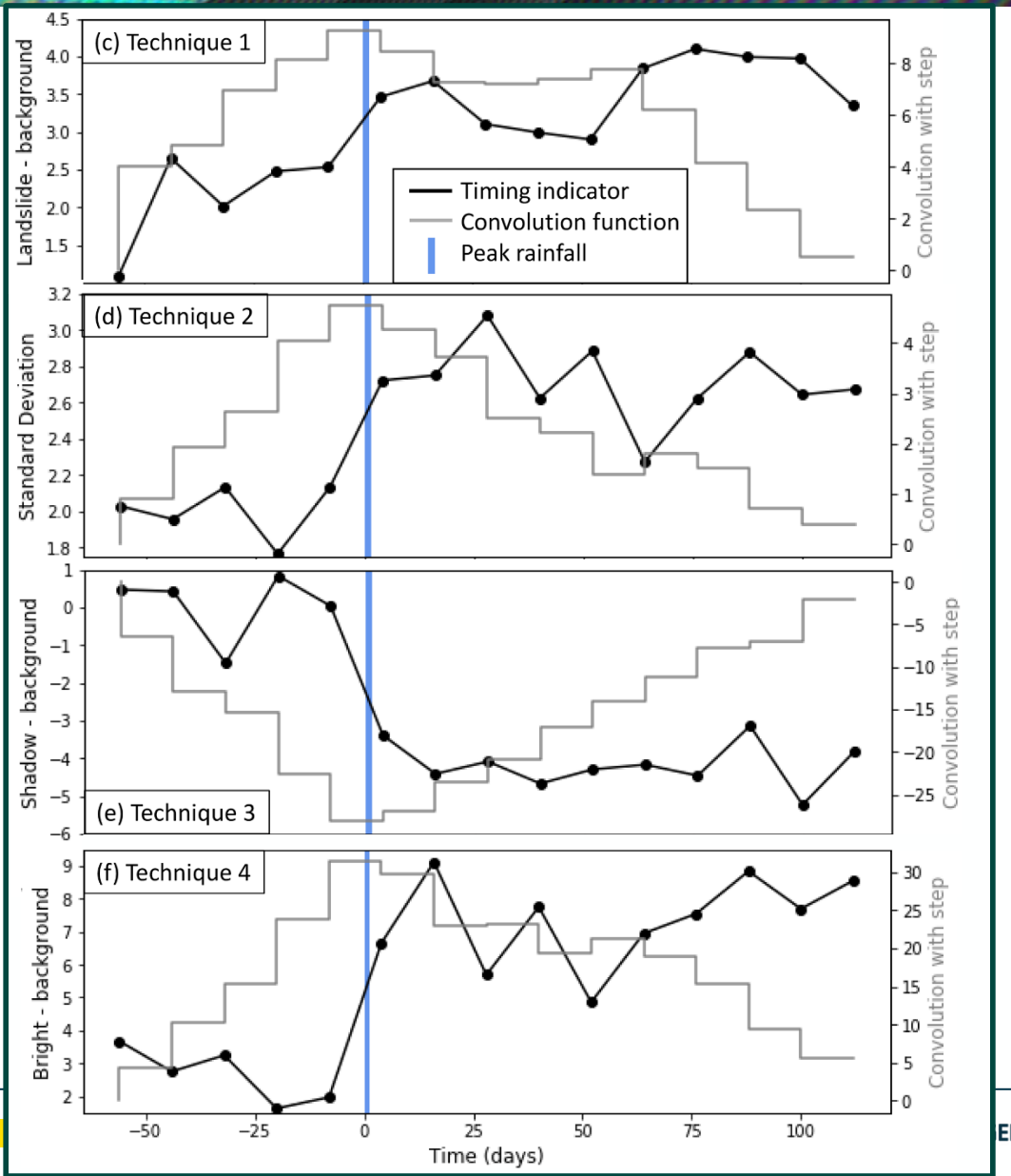

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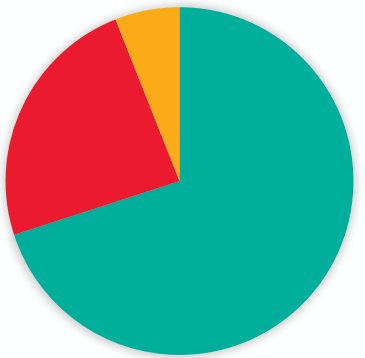
Testing on events with known timing:
If the same 12-day window is selected by at least 2 methods -> **80% accuracy**
30% of landslides in an inventory can be timed
Helpful when landslides are triggered by a sequence of storms or earthquakes!



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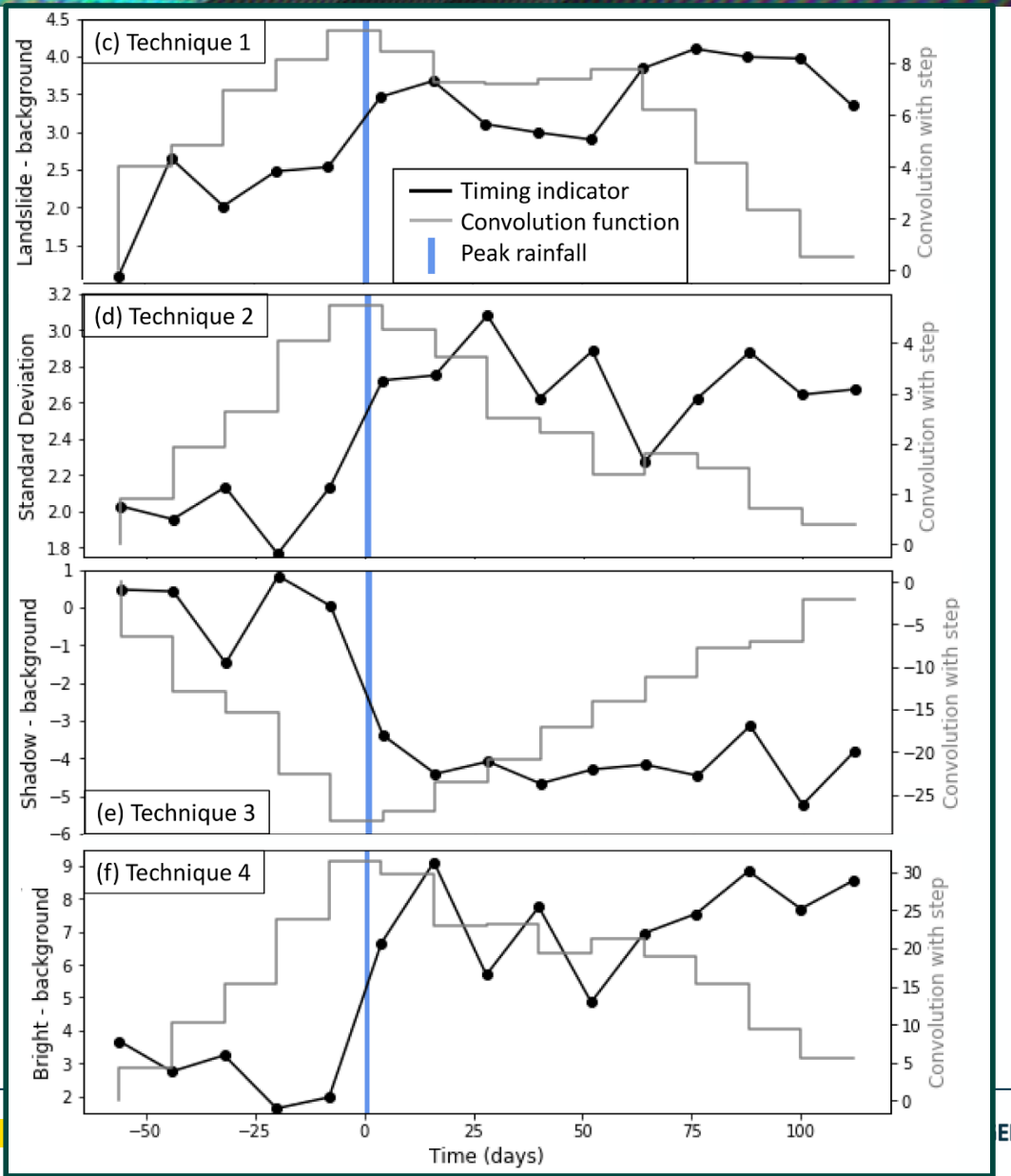
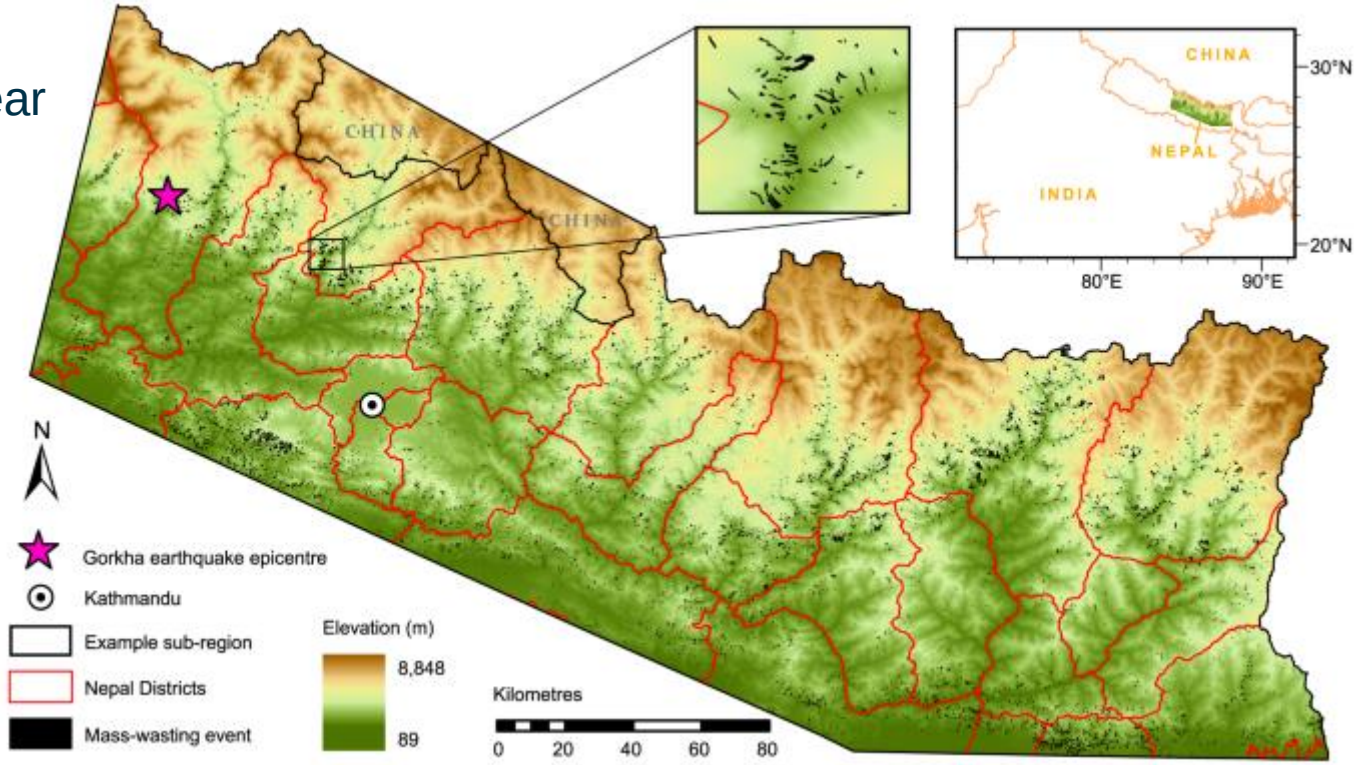


Case study: The Nepal Monsoon

Heavy rain triggers thousands of landslides every year between May and October



Jones et al. 2021

Case study: The Nepal Monsoon

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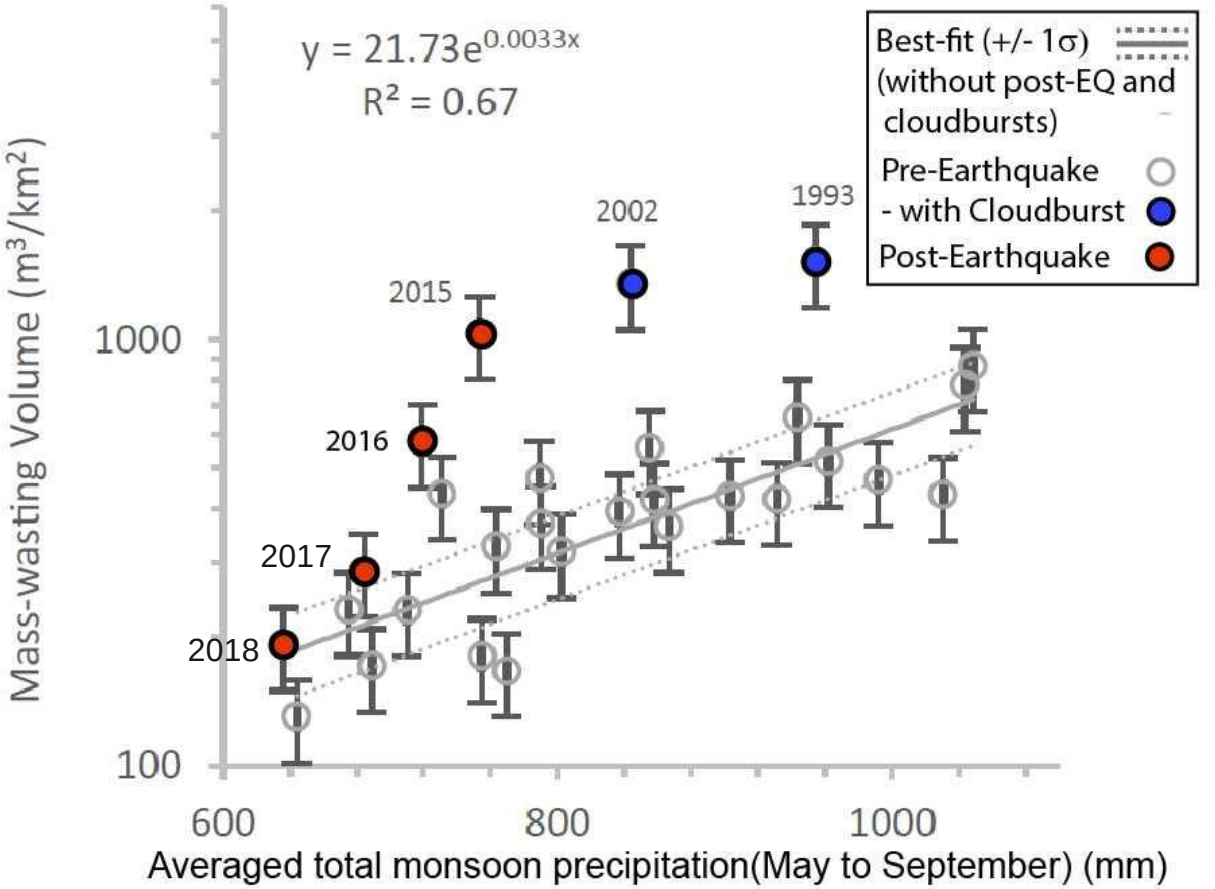
Three triggering factors

1. Progressive accumulation of soil water during monsoon
2. Short, intense storms
3. Earthquakes (M_w 7.8 25th April 2015)



Modified from Jones et al. 2021

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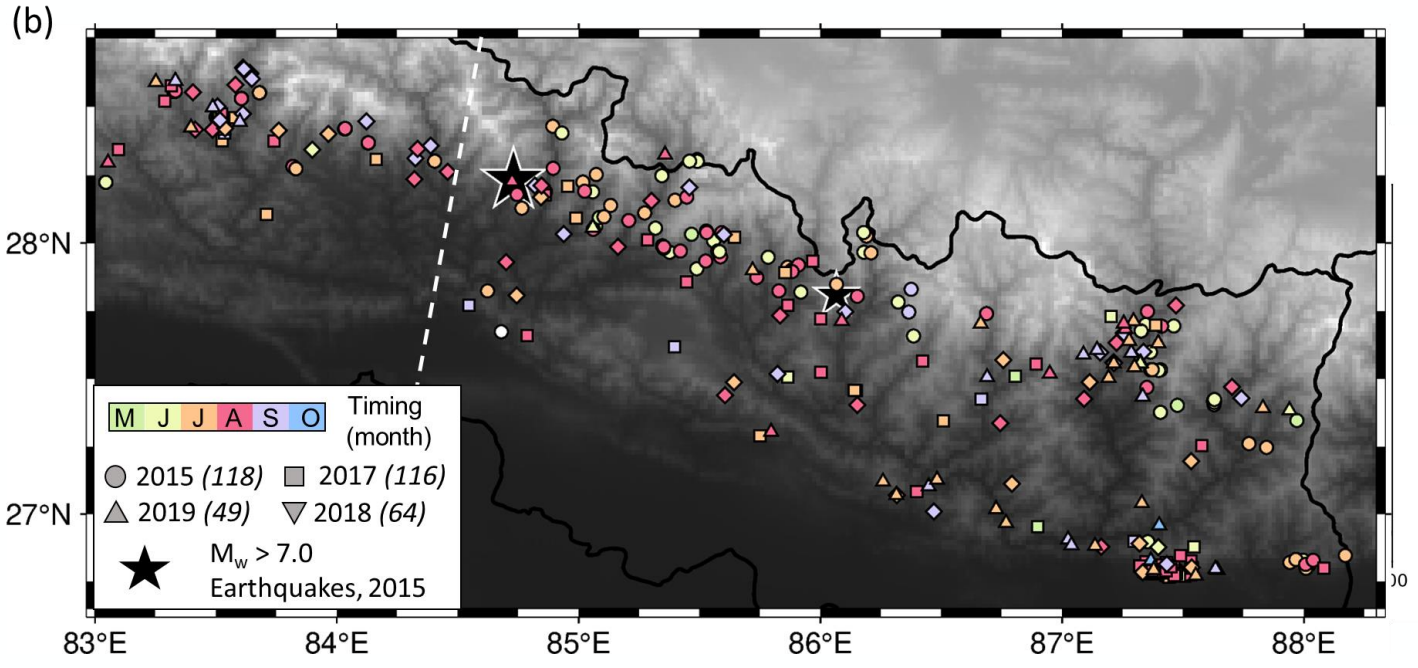
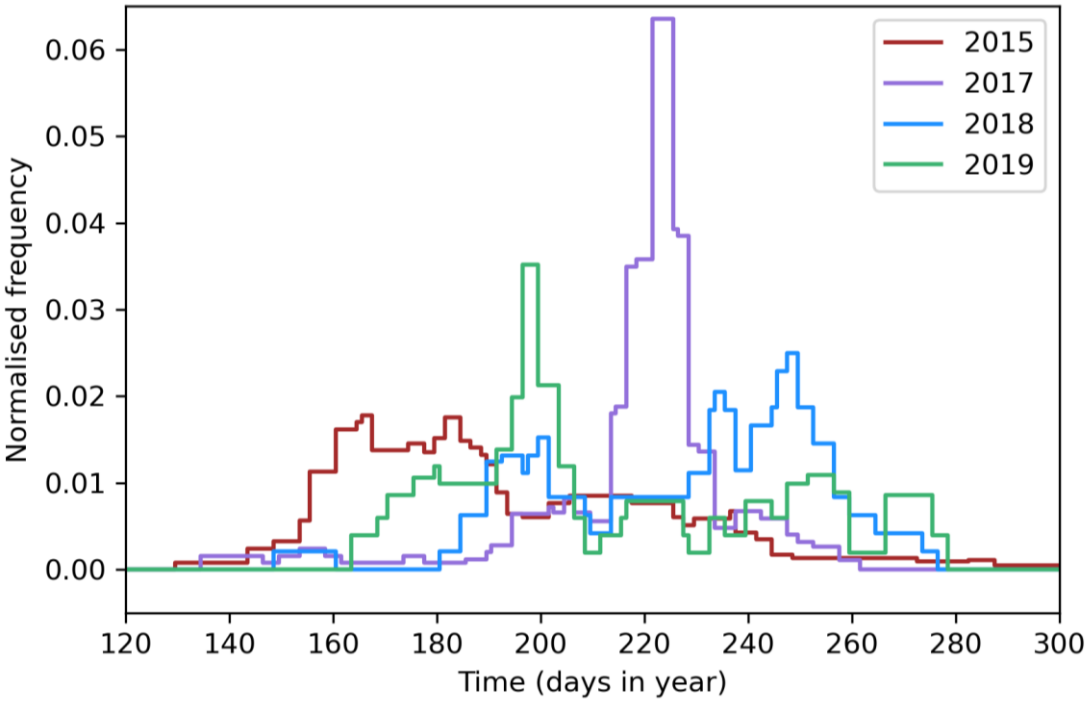
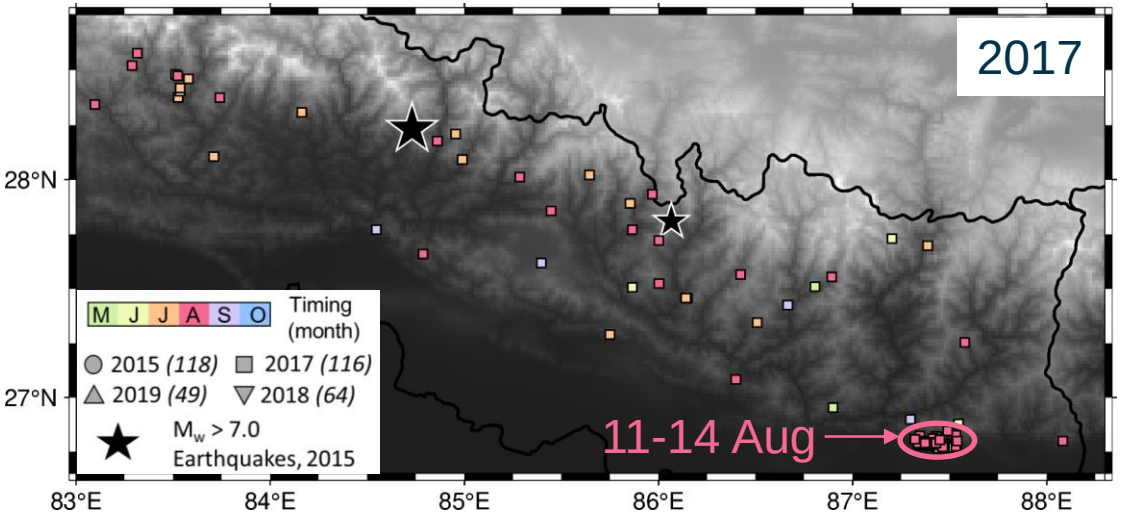


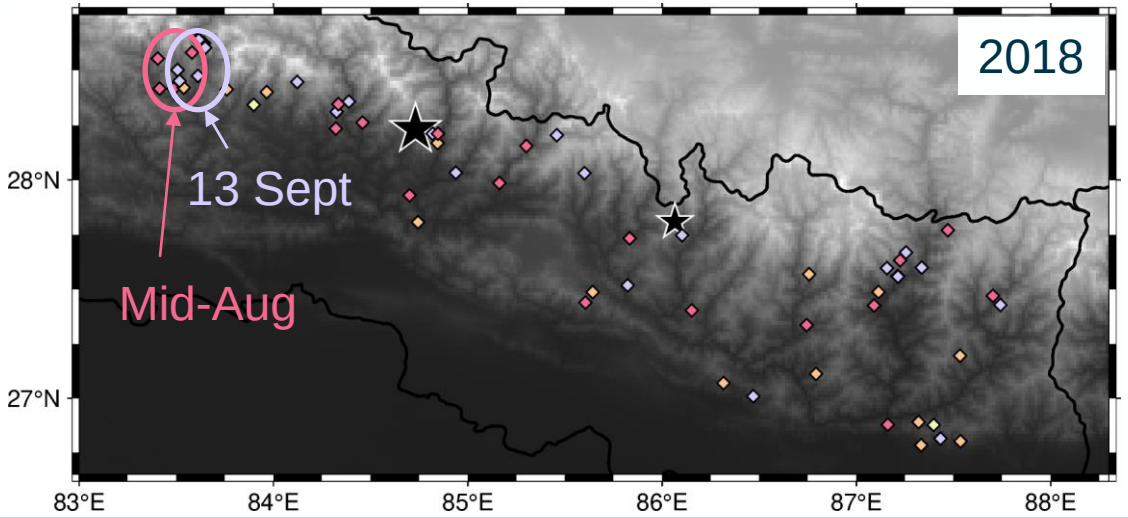


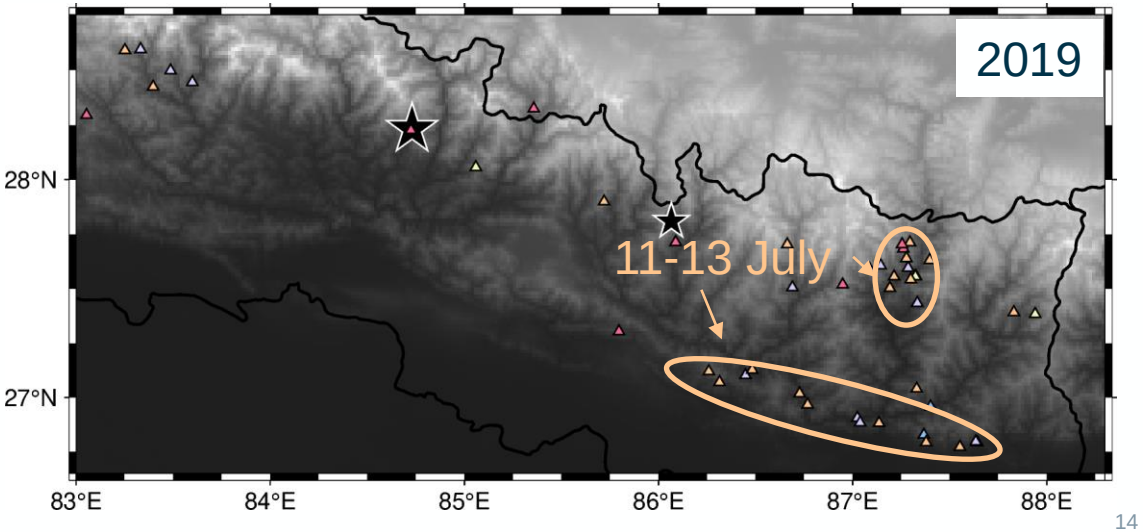
Burrows et al. 2023 GRL

Linking landslides to individual storms

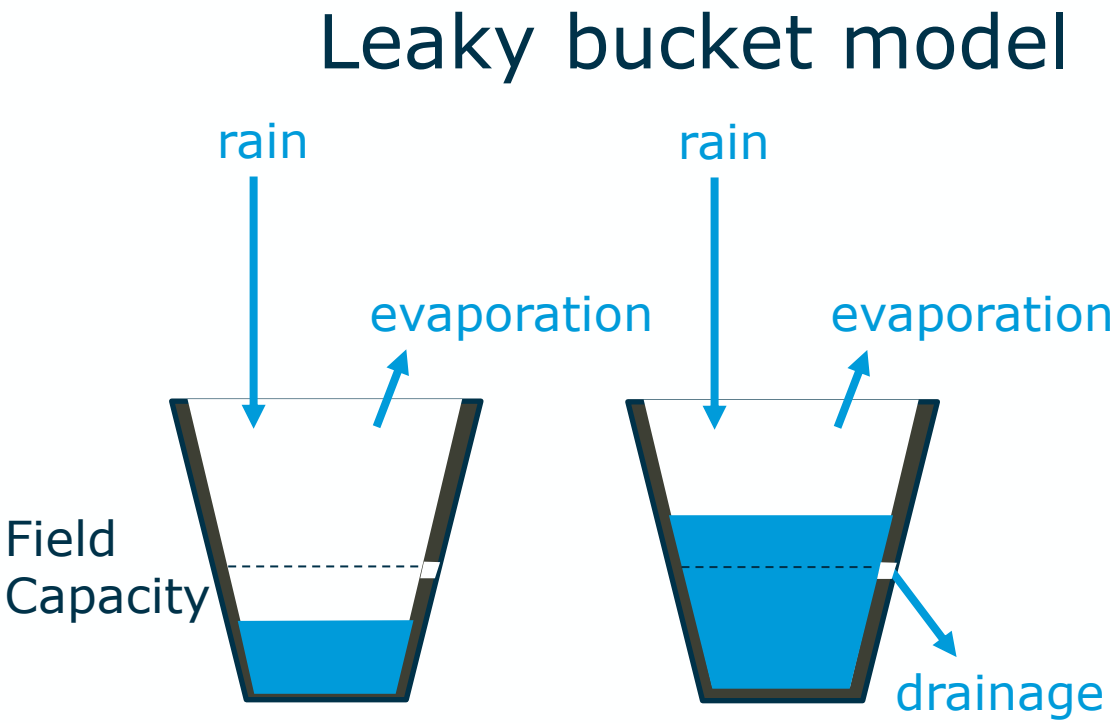
- Once assigned timings, spatio-temporal clusters of landslides can be linked to periods of intense, localised rainfall
- In 2017, 40% of the landslides in our study area were triggered by a 3 days of heavy rainfall in the Terai region
- A single spatial cluster in 2018 was separated into two spatio-temporal clusters

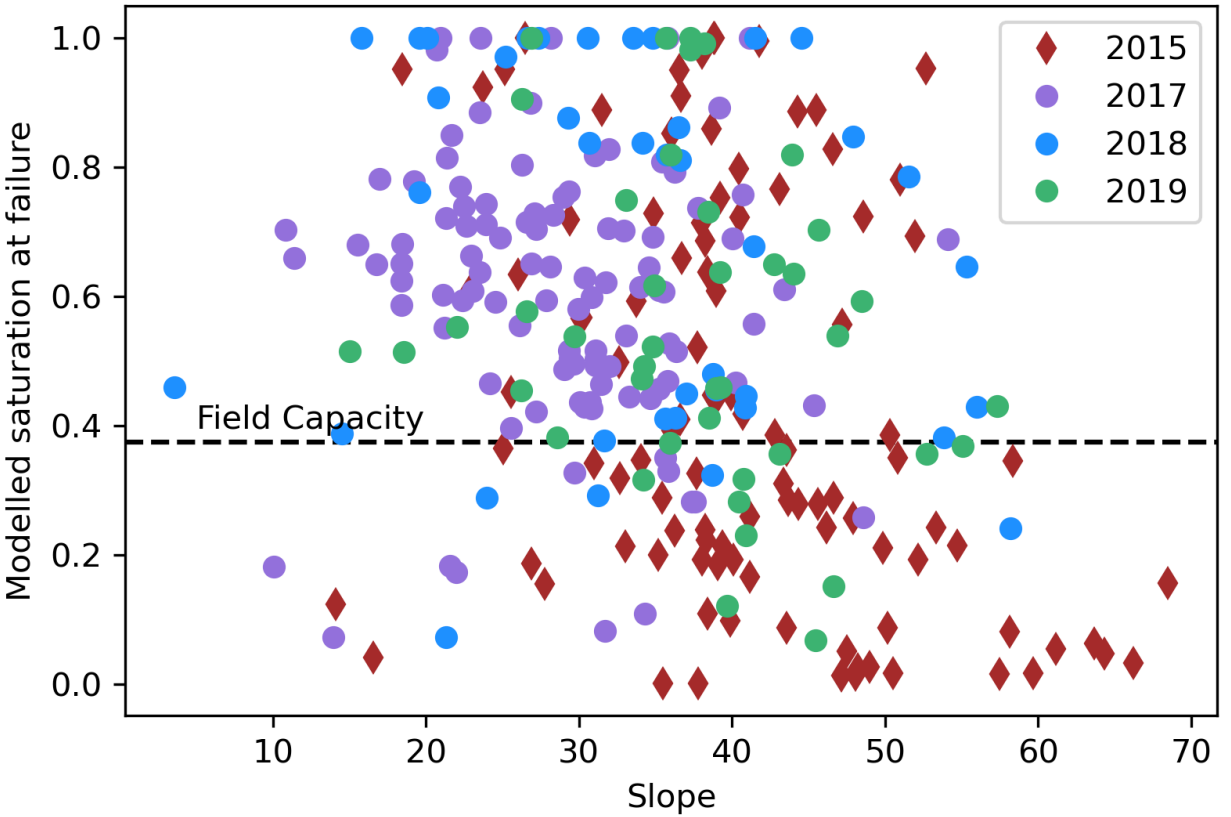






Modelling soil water content at failure with GPM

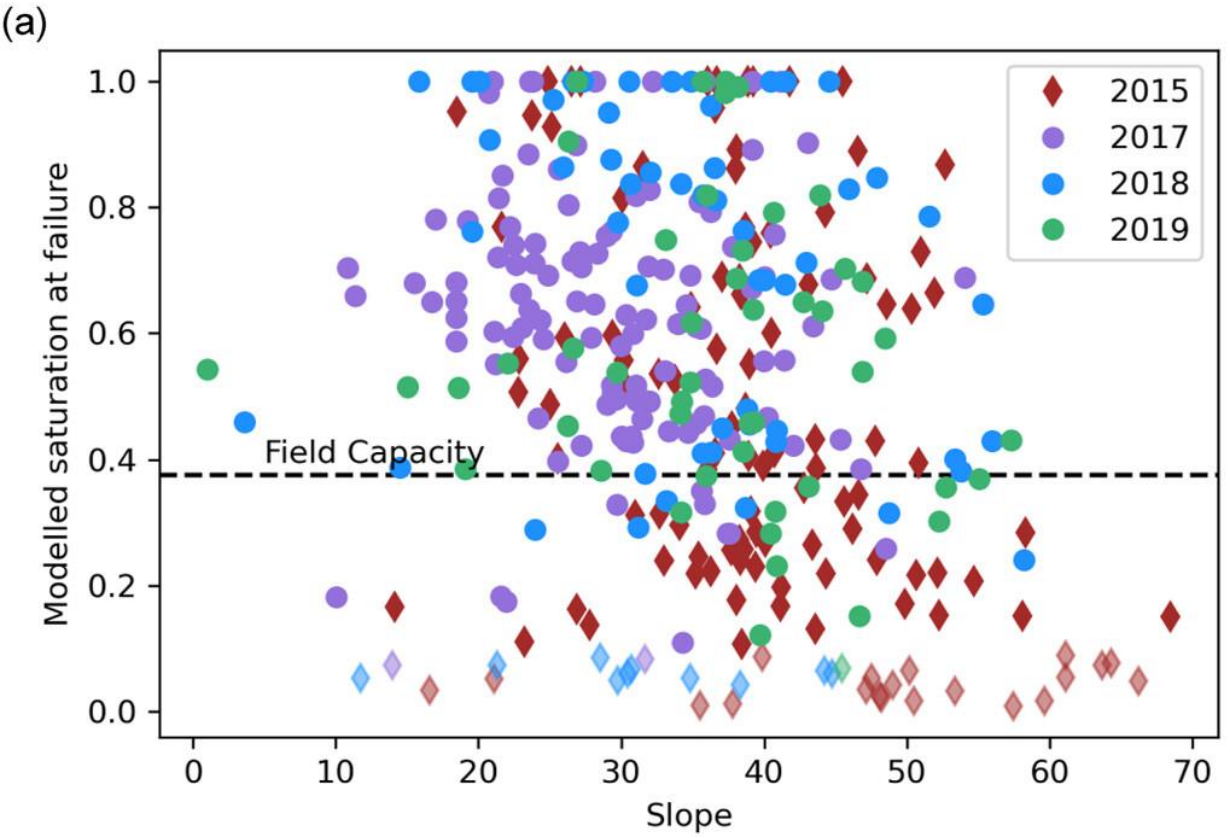




Burrows et al. 2023 GRL

Modelling hillslope weakening

Failure controlled by: **soil water content**, **slope steepness, internal friction** and **cohesion**



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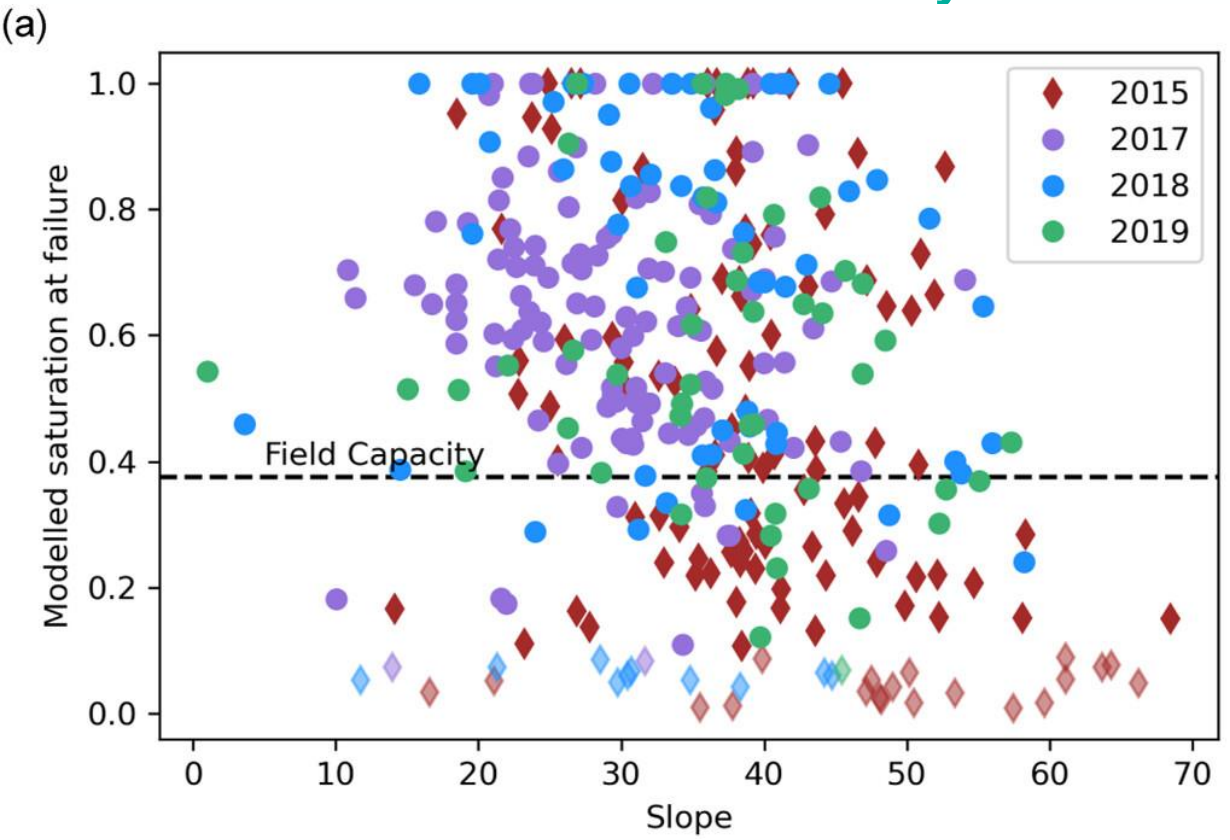
dryer **the same** **weaker**



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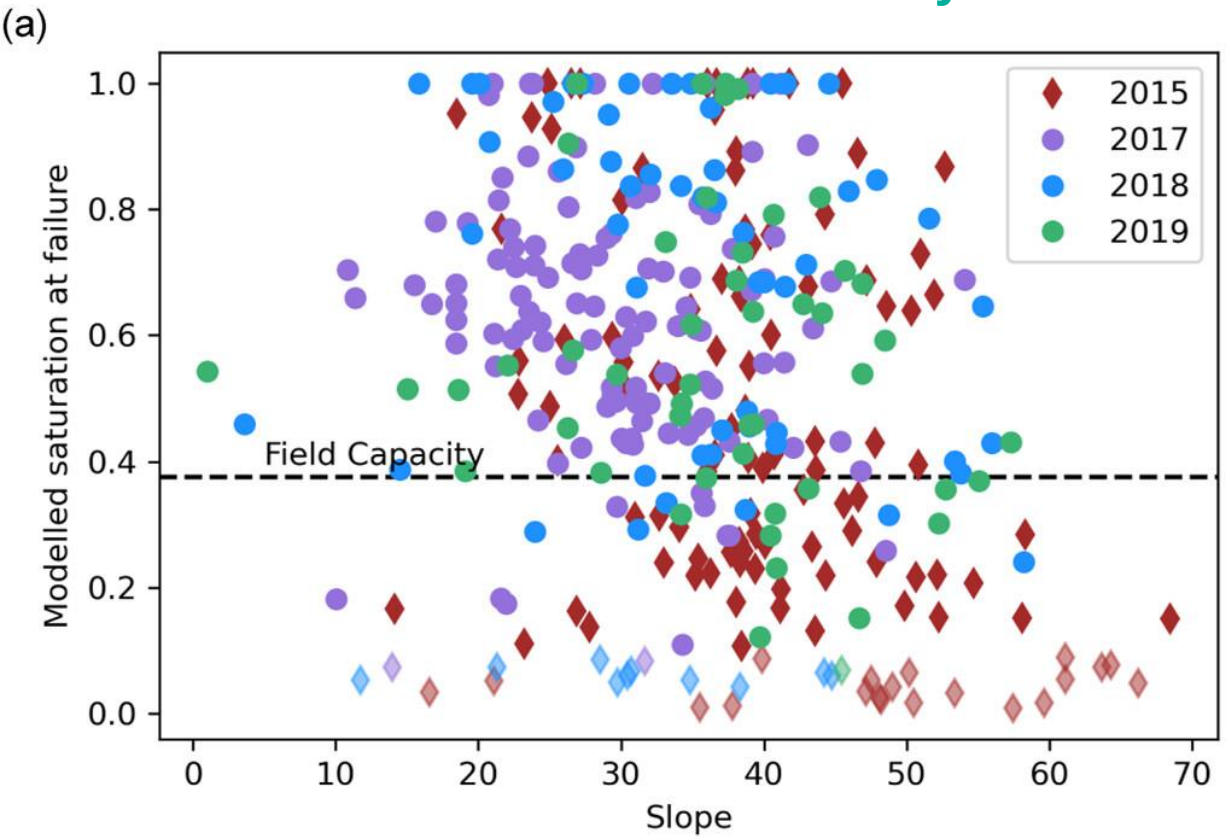

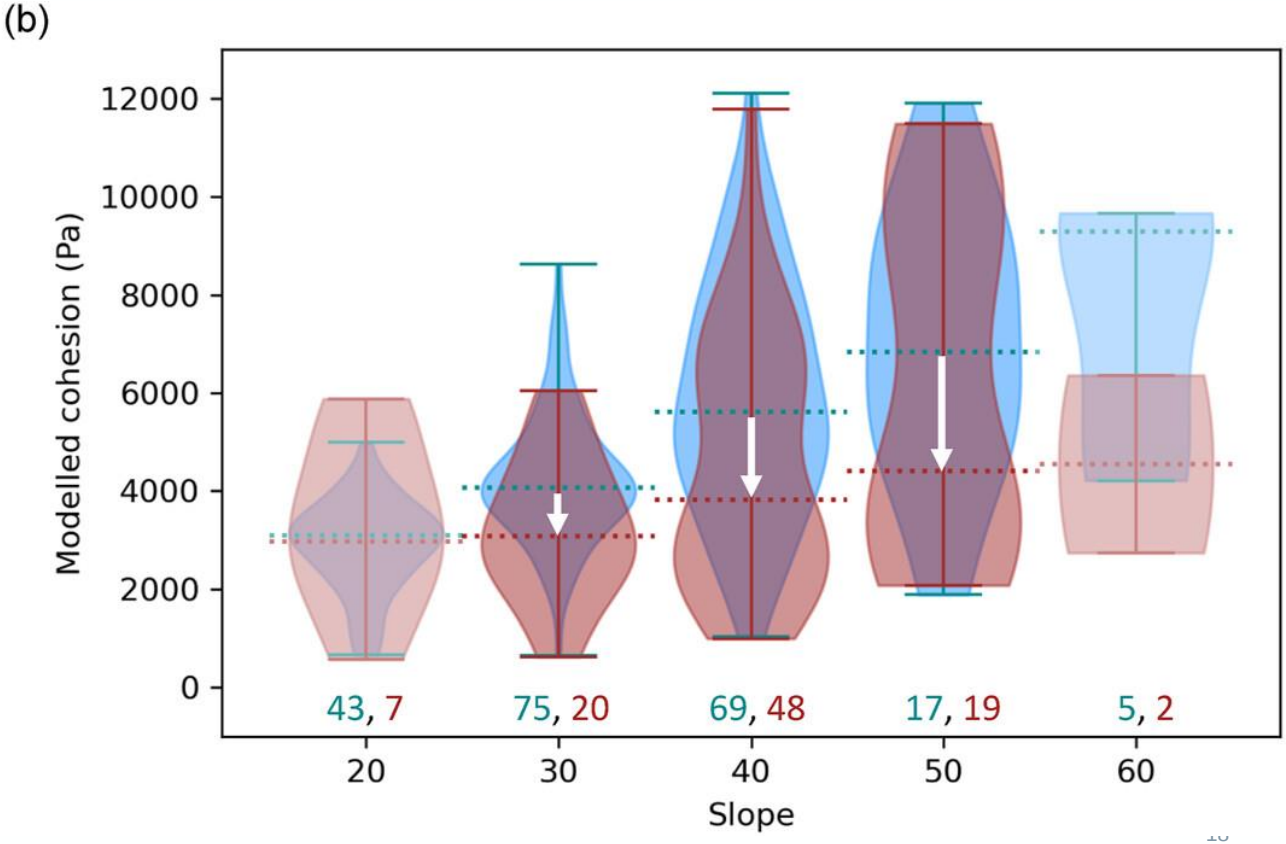

Conclusions

- Sentinel-1 amplitude can be used to assign 12-day time windows to 30% of landslides in an inventory with 80% accuracy
- With this information, we can **better assign landslides to individual storms or earthquakes**
- In Nepal, information on landslide timing during the monsoon allows us to begin to **untangle the combined effects of multiple triggers:** earthquakes, progressive increases in soil moisture, and individual storms
- In some years, intense, localised rainfall still accounts for a significant proportion of triggered landsliding (40% in 2017)
- Earlier and dryer landsliding following the 2015 earthquake indicates a transient loss of hillslope strength. **Sentinel-1-derived landslide timings offer a new way of exploring post-seismic hillslope weakening**

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A new way to study post-seismic hillslope weakening