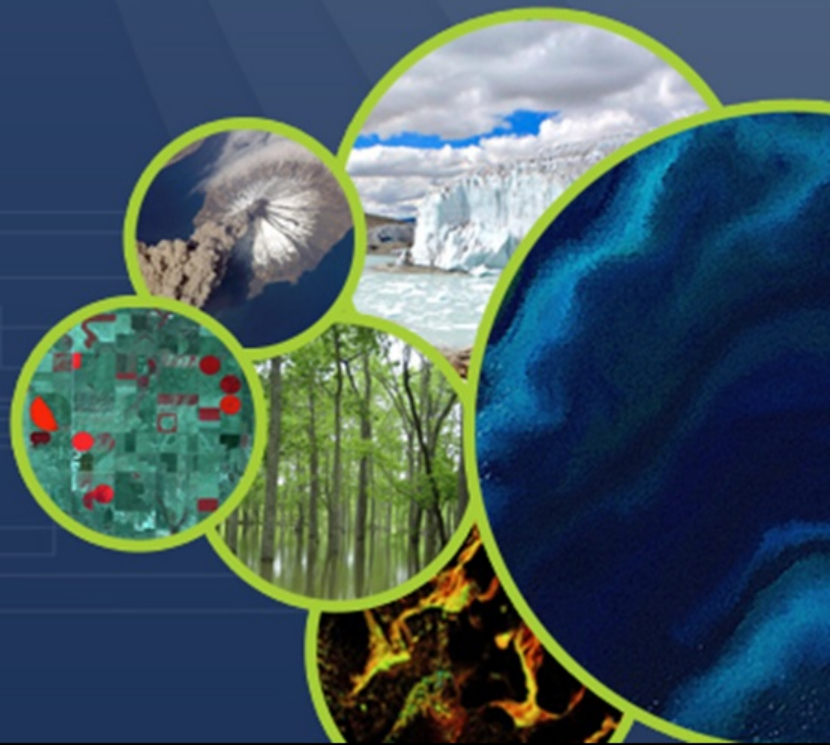
Committee on Earth Observation Satellites

CEOS Landslide Pilot Working Group: An Overview

September 4th, 2017



Co-leads of landslide pilot

Dr. Dalia Kirschbaum, NASA Goddard Space Flight Center, Maryland, USA

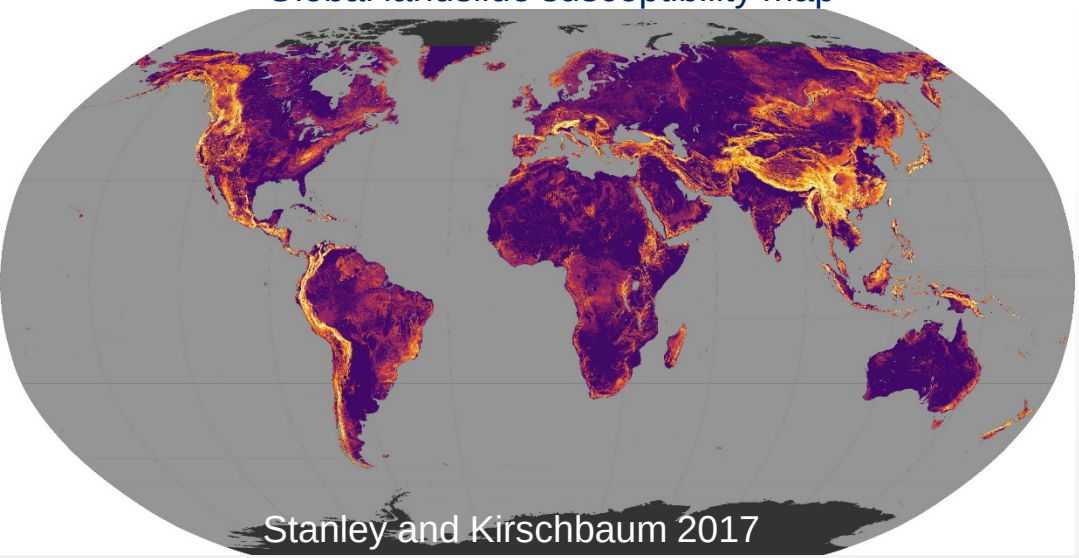
Dr. Jonathan Godt, Landslide Hazards Coordinator, U.S. Geological Survey, Colorado, USA

Dr. Jean-Philippe Malet, School and Observatory of Earth Sciences, University of Strasbourg, France

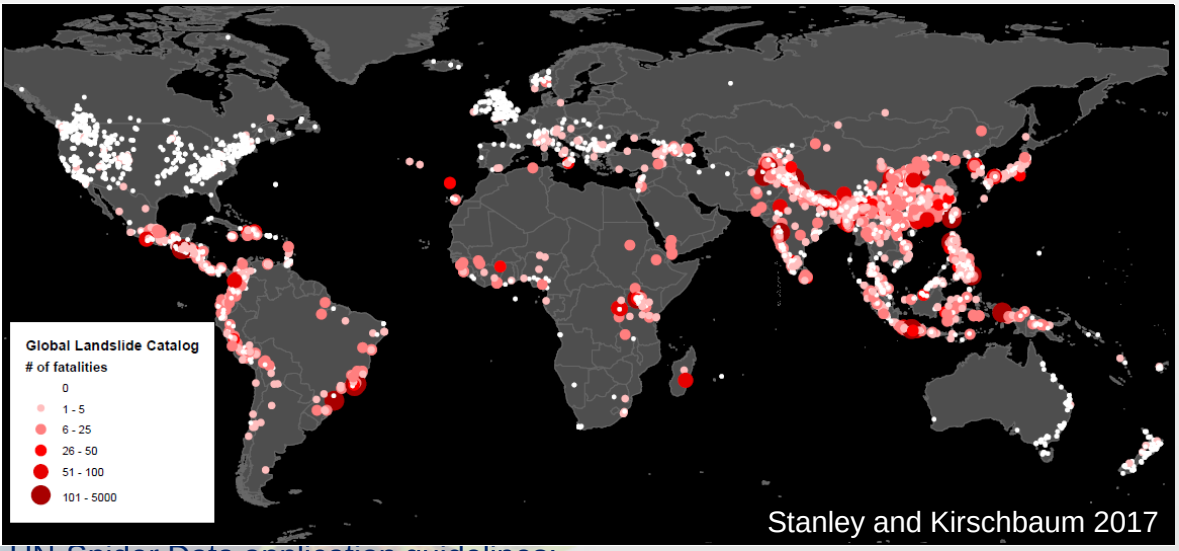
Dr. Sigrid Roessner, GFZ German Research Centre for Geosciences, Germany

Landslides – global phenomenon

Global landslide susceptibility map



The Sierra Leone landslide triggered by heavy rainfall, with the main event appe aring to be a large landslide in the Rege nt area, on the margins of the city of Fre etown on August 14th, >500 fatalities esti mated



David Petley estimates that landslides between 2002-2012 ca. 90,000 fatalities (http://blogs.agu.org)

UN-Spider Data application guidelines:
http://www.un-spider.org/links-and-resources/data-sources/daotm-landslides

Landslides in multi-hazard environments

Earthquakes **Major triggers** **Hydrometeorologic extremes (e.g. typhoon)**

New Zealand: 2016 (7.8Mw) ca. 6,000 landslides
Nepal: 2015 (7.8Mw) ca. 20,000 landslides

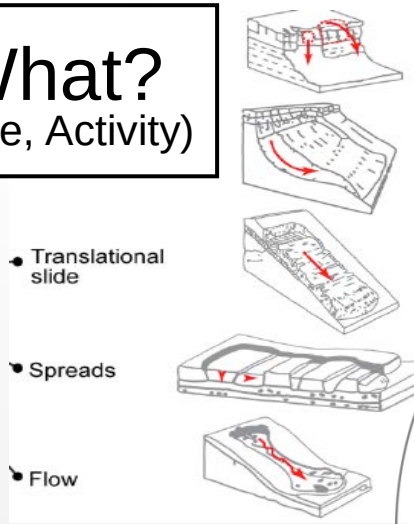
Nepal: Bhote Koshi (drone image month after EQ)

Taiwan: 2009 Typhoon Morakot: ca. 20,000 landslides

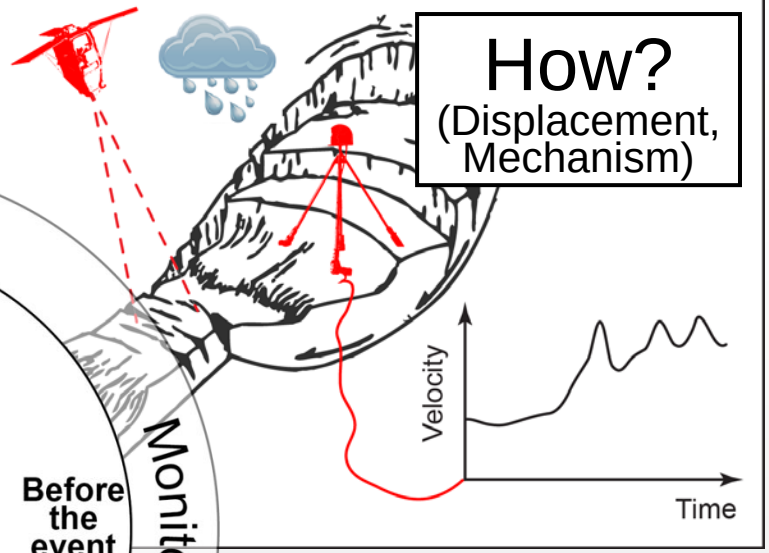
Taiwan: fotos before and after

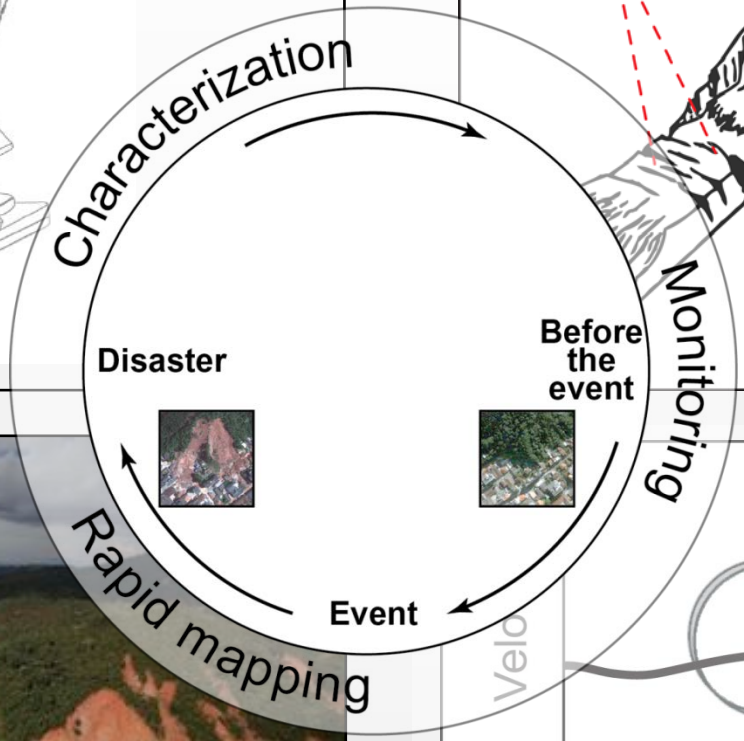
Landslide Remote Sensing

What?
(Type, Activity)

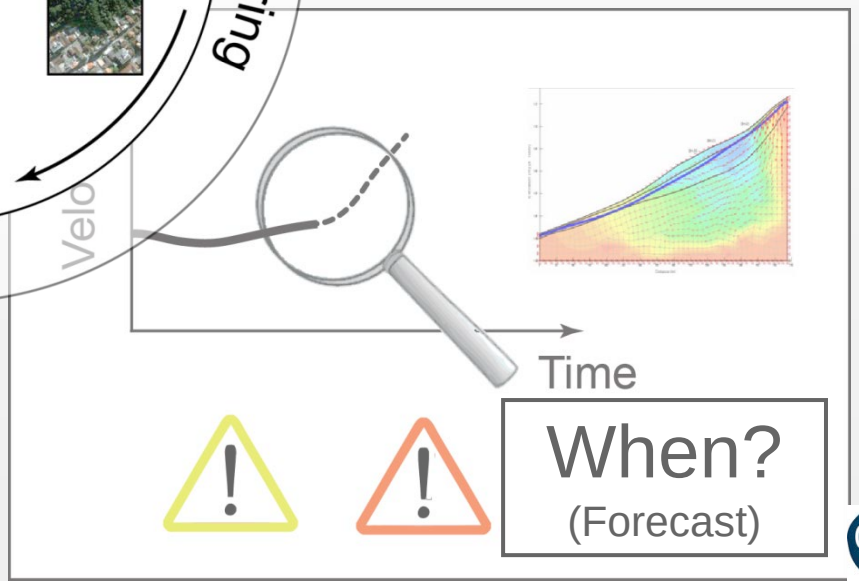


How?
(Displacement, Mechanism)





Where?
(Location)



When?
(Forecast)

Landslides Pilot: Main Goals

To demonstrate the **effective exploitation** of Earth observations (EO) data and technologies to **detect, map and monitor landslides and landslide prone hillsides**, in different physiographic and climatic regions.

To apply satellite EO across the **cycle of landslide disaster risk management**, including preparedness, situational awareness, response and recovery with a distinct multi-hazard focus on cascading impacts and risks.

Pilot Objectives

A. **Establish effective practices** for merging different Earth Observation data (e.g. optical and radar) to better monitor and map landslide activity over time and space.

B. Demonstrate how landslide products, models, and services can **support disaster risk management** for multi-hazard and cascading landslide events.

C. **Engage and partner with data brokers and end users** to understand requirements and user expectations and get feedback through the activities described in objectives 1-2.

Key Pilot Outputs & Deliverables

- Report on recommended practices for the combined exploitation of SAR and Optical imagery and technologies for landslide detection, mapping and monitoring". **(Objective A**)

- Report on effective methodologies and strategies for considering multi-hazard and cascading aspect of landslides through multi-temporal landslide mapping from multiple triggers (leveraging information/interactions with the volcano, flood and earthquake pilots) **(Objective A-C)**

- Landslide event inventory and activity (monitoring) maps produced using optical and SAR imagery and technologies, and their combination, for selected case studies / geographical areas. **(Objectives B-C)**

- Report on end user engagement strategies and characterize enablers, challenges, barriers to effective transfer of information, knowledge and technologies. **(Objective D)**

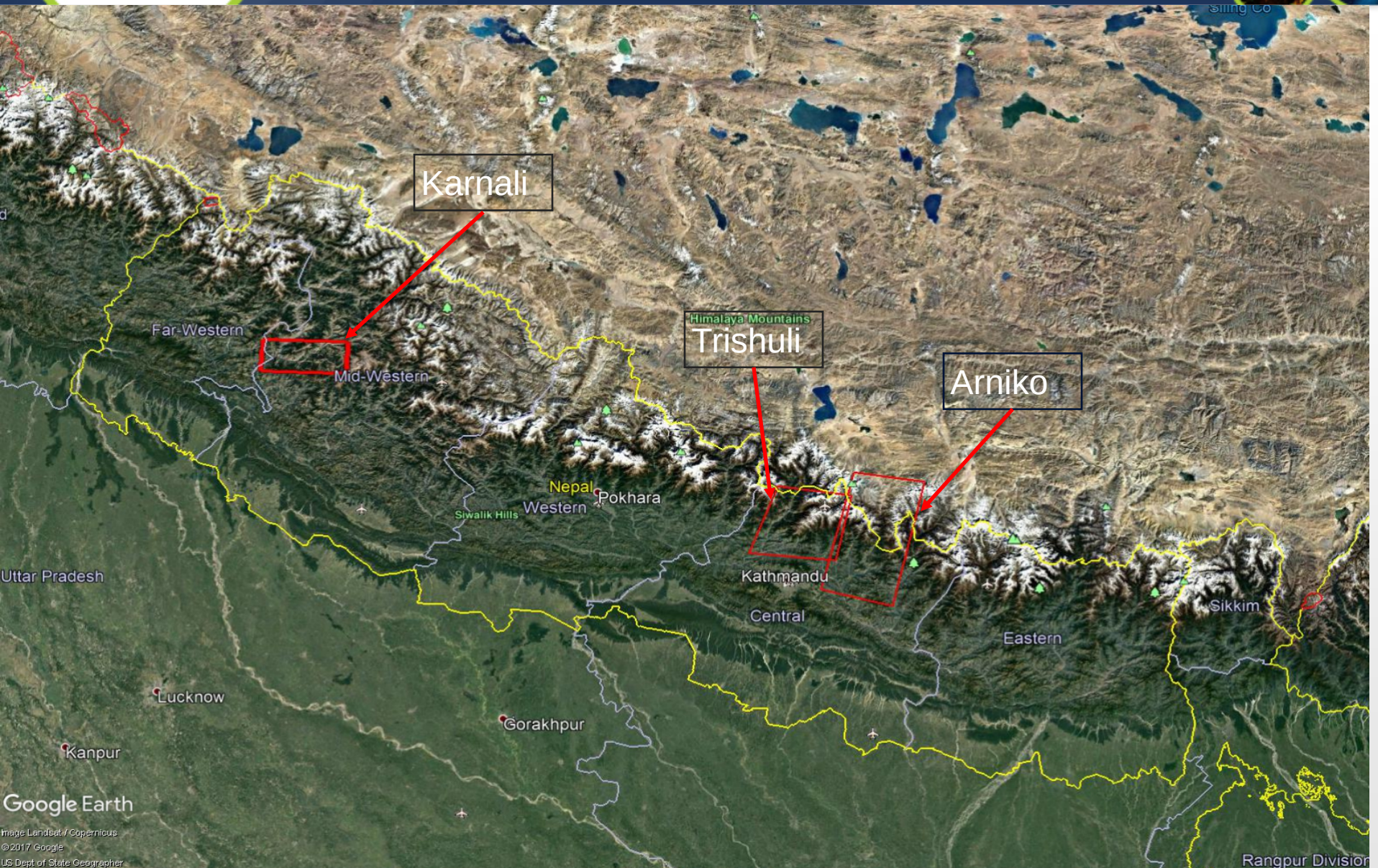
Proposed key user communities

- **Users**: national, regional and local governments, civil protection agencies, meteorological and geological services, land use planning decision makers, disaster risk reduction specialists with NGOs and international organisations, industry (including e.g., insurance, transport, forestry sectors).
- **Practitioners**: landslide modelers, scientists and engineers in hydrology, water and environment ministries, meteorological and geological services, satellite data providers, volcano observatories, and value added service companies.
- **Institutional bodies responsible for communication of risk** (gap between technical level and shared information with communities): research institutions with operational responsibilities.
- **General public**: landslide event information for some of the case studies will be made available to the general public for increased awareness of these hazards and remote sensing capabilities, although the main focus of the pilot is on specialized users.

Proposed regional study leads

Region	Regional Point of Contact
Nepal	Nick Rosser, Sigrid Roessner, Dalia Kirschbaum
Pacific Northwest, US	Jonathan Godt, Dalia Kirschbaum
Southeast Alaska	*Marten Geertsema*
Peru	*Jeff Kargel*
Caribbean (Cuba/Lesser Antilles)	*Enrique Castellanos, Jean-Philippe Malet*
China	*Zeng-Guang Zhou (TBD)*
Indonesia	*TBD*

Nepal tasking areas



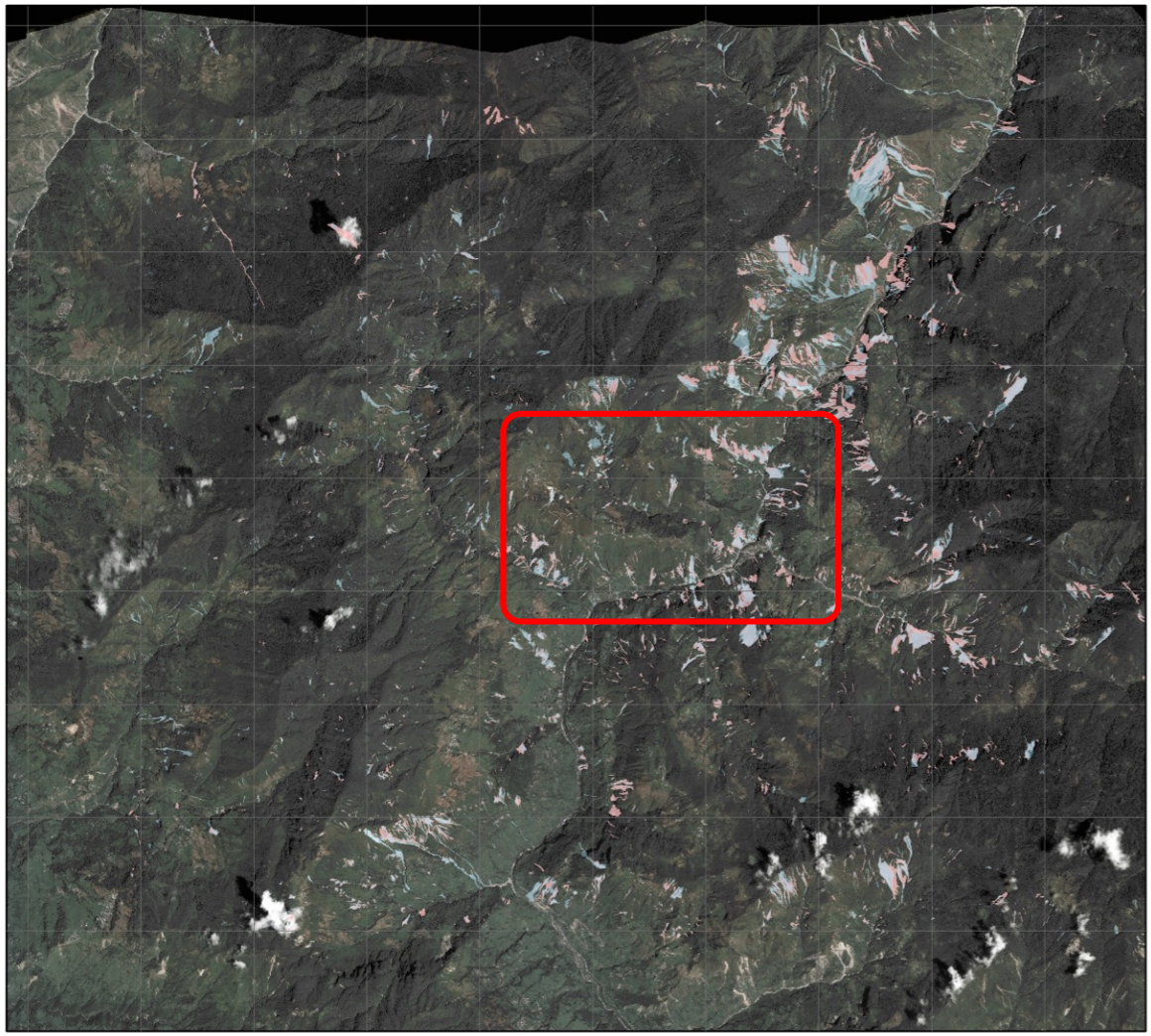
Pre- & post-monsoon landslide mapping, 2015

Pre- & post- monsoon

- WorldView & Quickbird
  - May 2014 & 24th May 2015
- Pléiades image
  - 9th September 2015
- Significant registration errors in steep topography

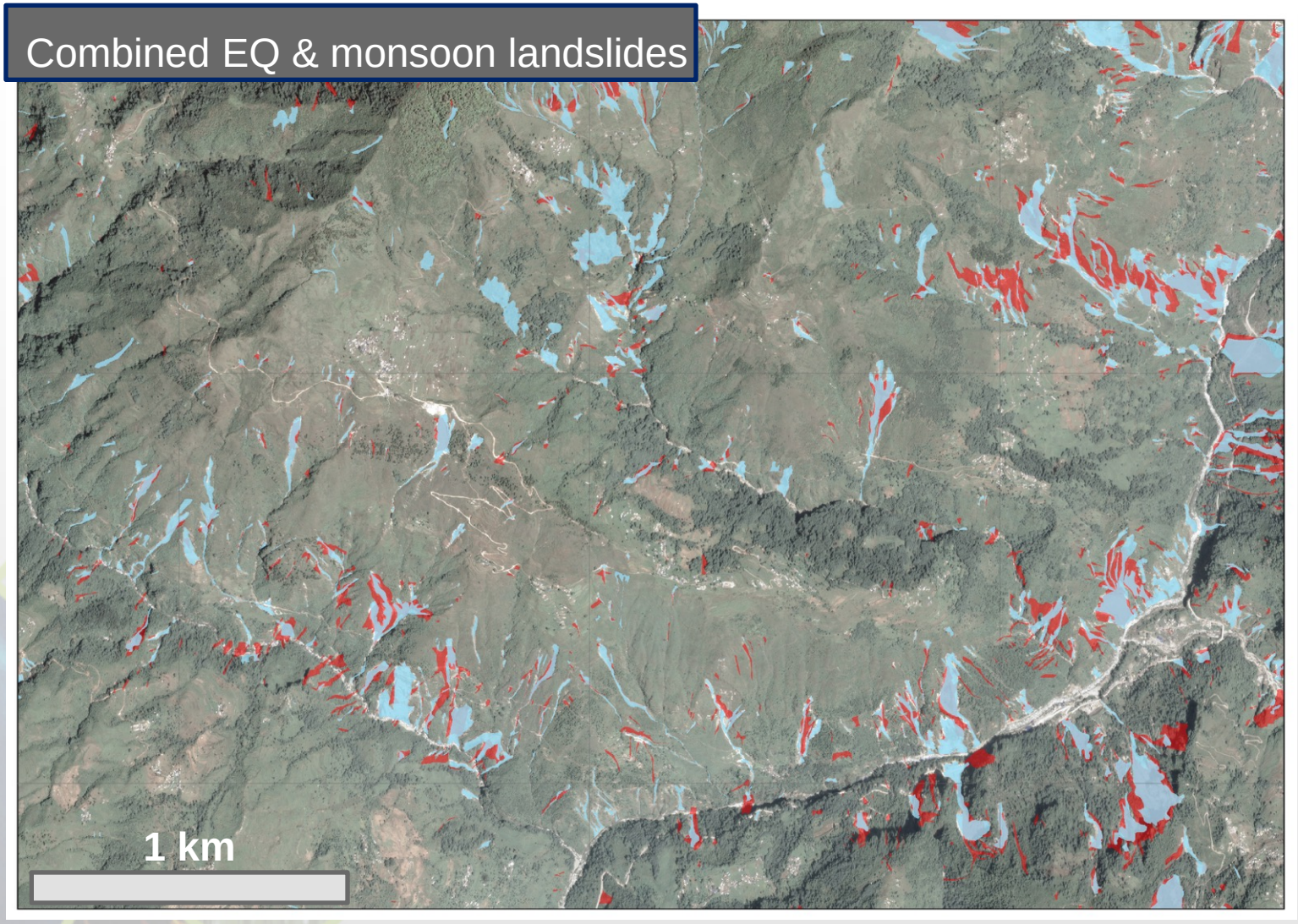
Results:

- 389 pre-EQ landslides (*c*. 1.3 / km^2)
- 2,626 post-EQ landslides (*c*. 9 / km^2)
- 2,550 post-monsoon landslides



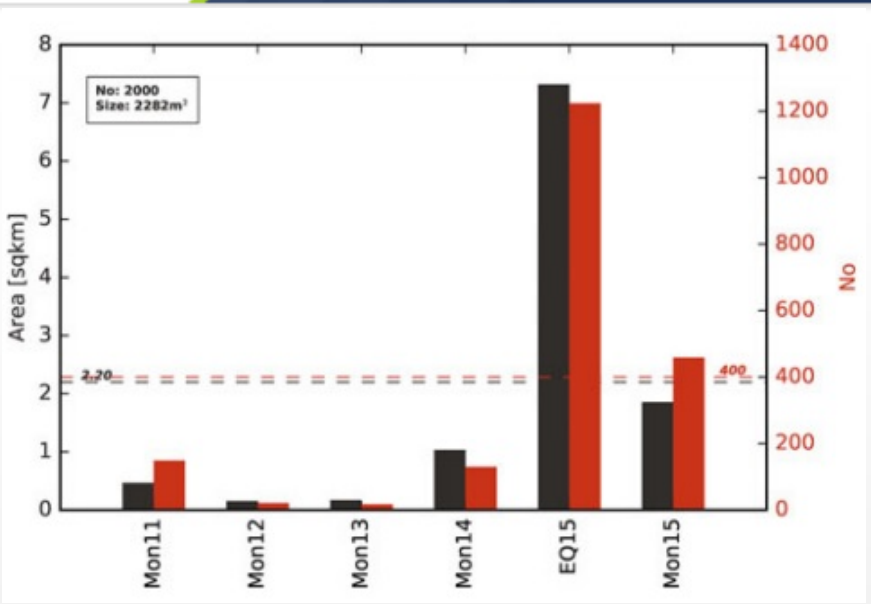
Slides from N. Rosser/Durham

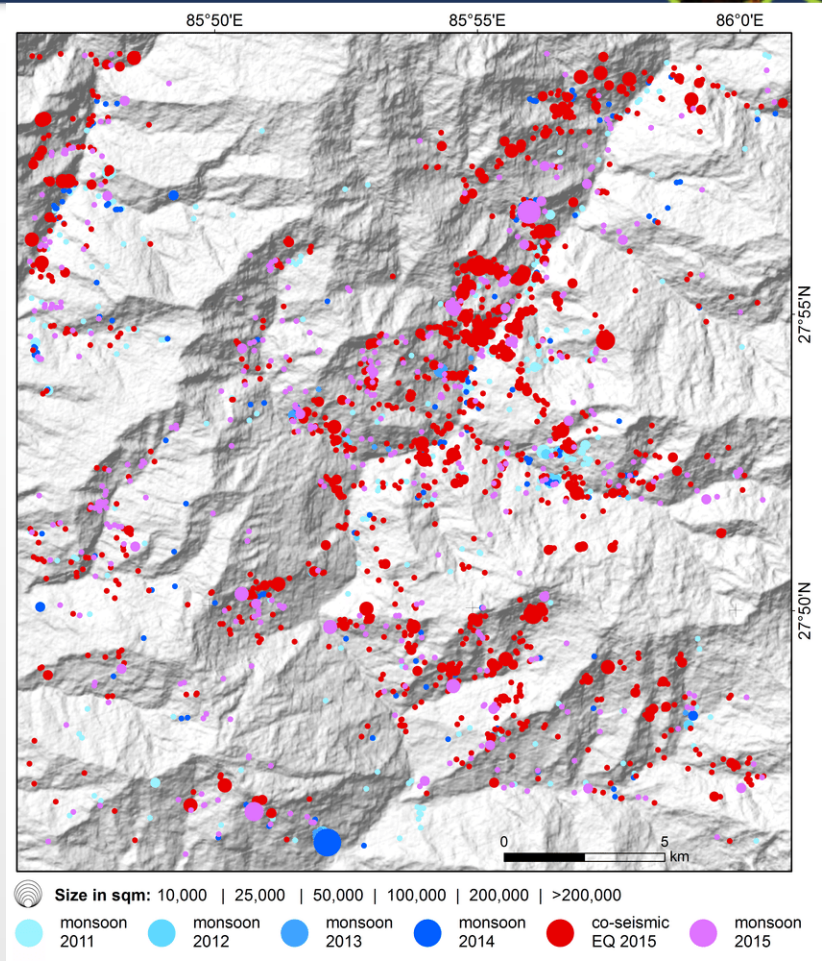
Pre- & post-monsoon landslide mapping, 2015



Slides from N. Rosser/Durham

Multi-temporal monsoonal landslide along Pasang Lhamu Highway, Nepal

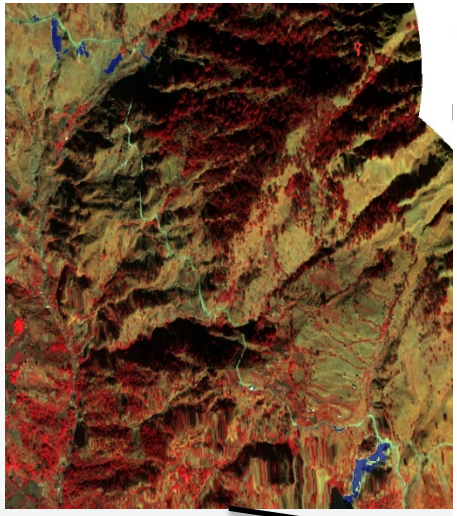


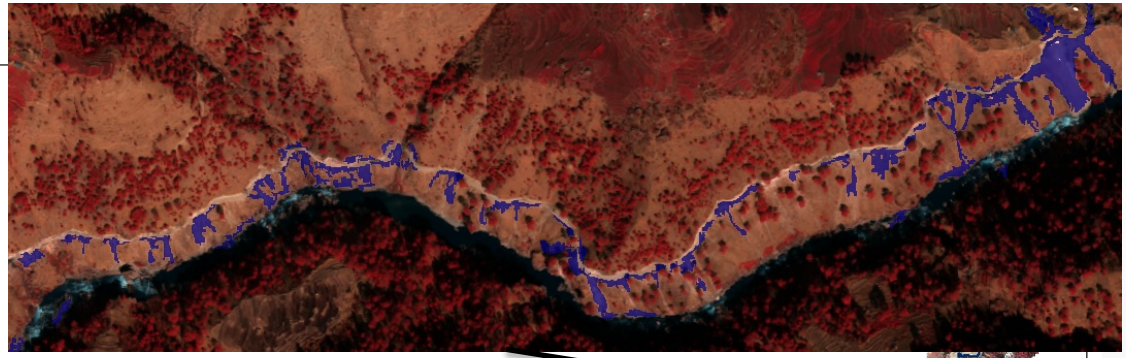


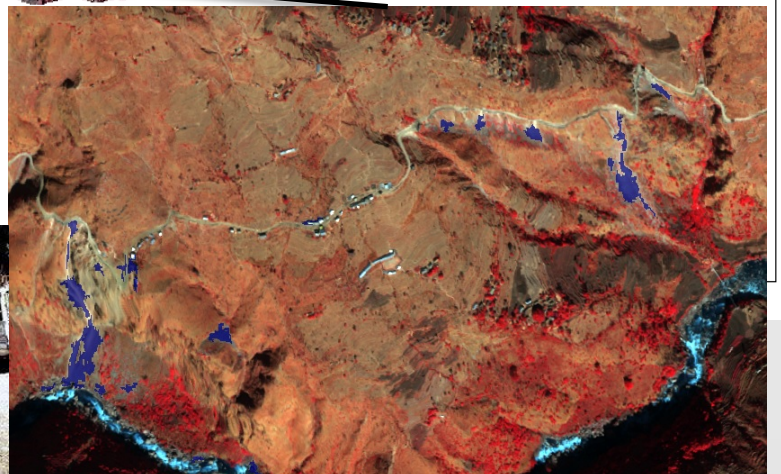
- Multi temporal monsoonal landslide inventory (2011 – 2015) derived from a time series of 13 Rapideye Level 3A data.
- 2000 landslides with sizes ranging from 200 m^2 to 0.76 km^2 affecting a total area of 10.9 km^2.
- 1224 landslides triggered by 2015 Gorkha earthquake.

Behling and Roessner (2017)

Object oriented analysis based landslide mapping (Karnali Highway, Nepal)





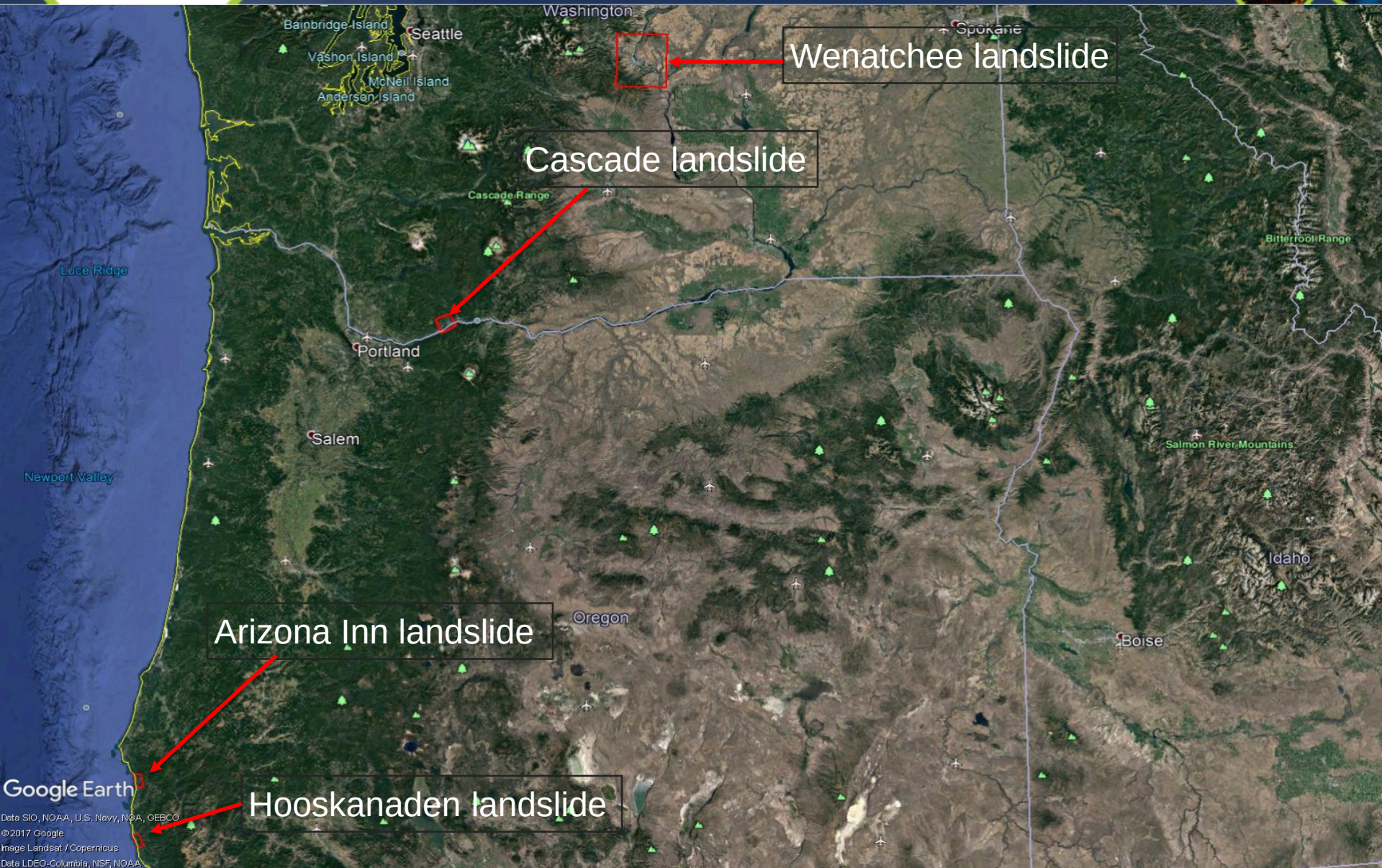


- Three stretch along the 60 km highway identified to be highly affected by landslides.
- Data obtained from Dit igal Globe

(NASA/USRA)

@KarnaliKo

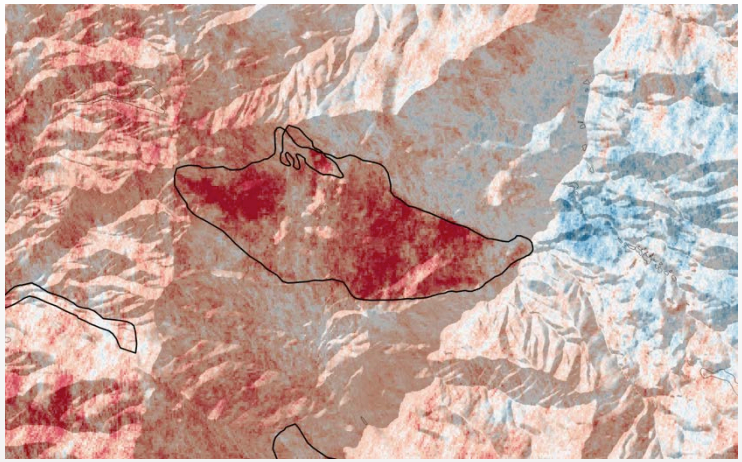
PNW tasking areas

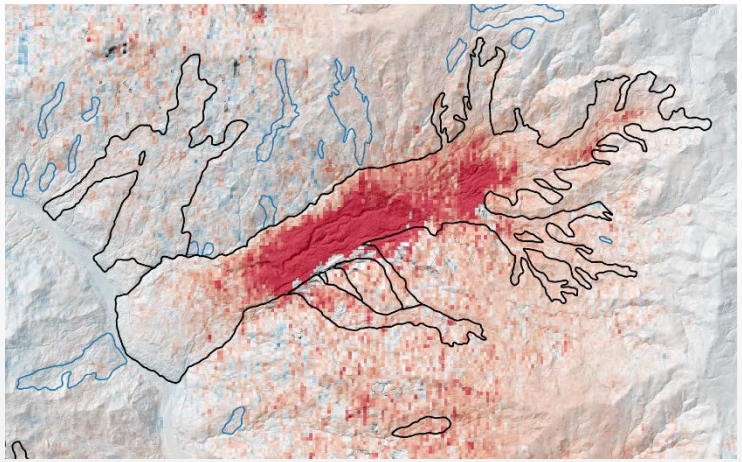


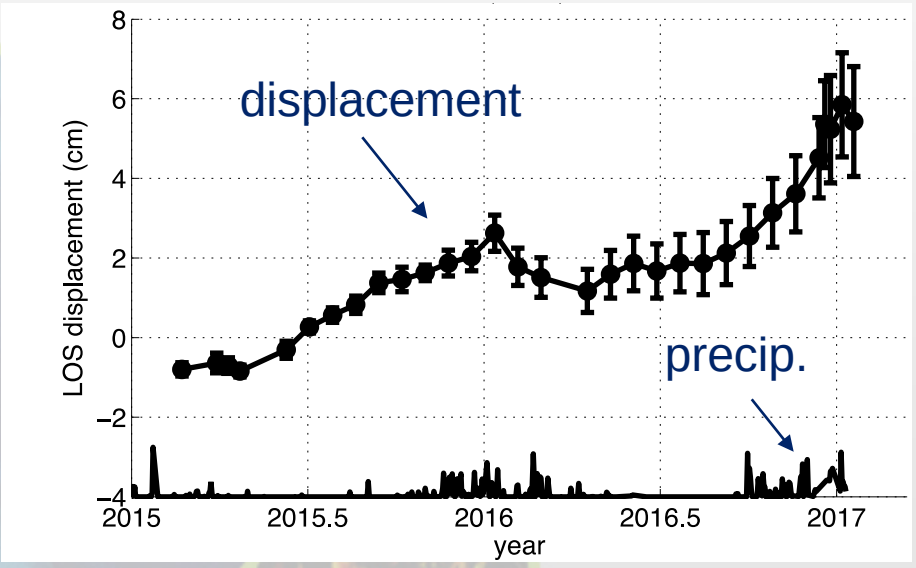
Landslide Monitoring
North California / Eel River

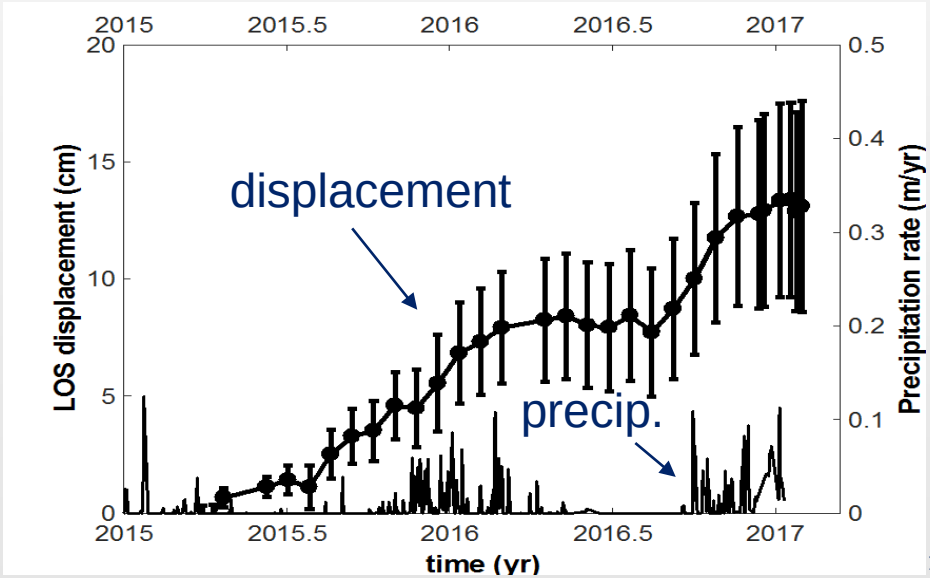
InSAR time series Offset Tracking

A. Handwerger, M.-H. Huang, E.J. Fielding





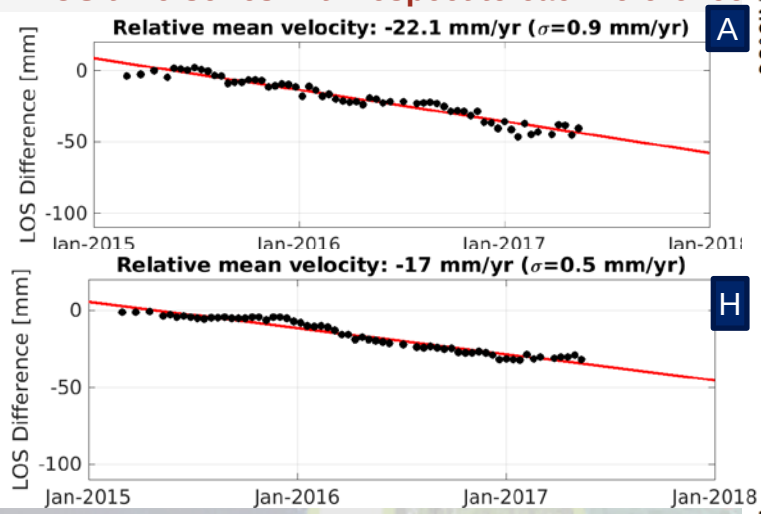


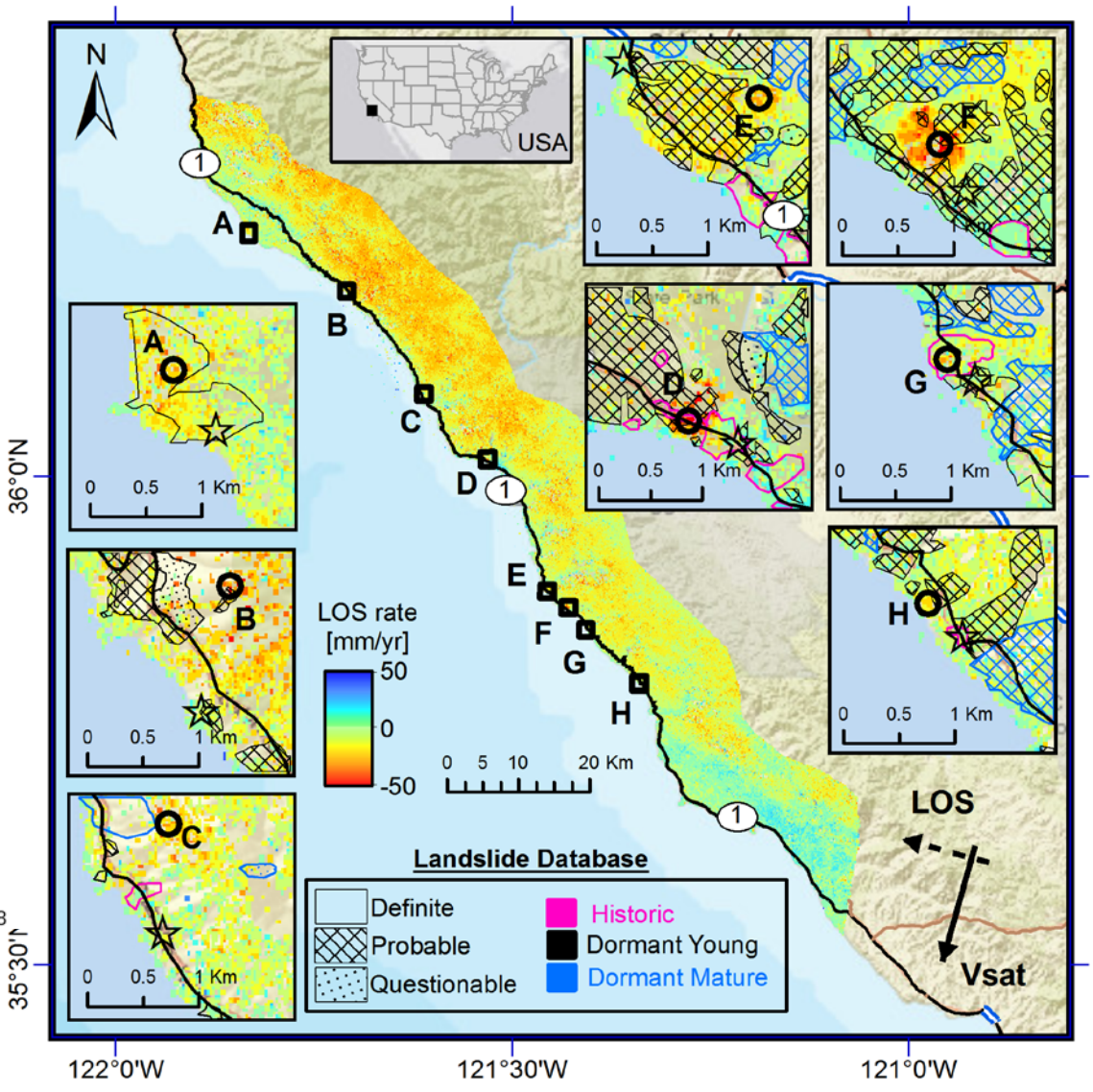


Time-series InSAR research Demonstration of landslide mapping using Sentinel-1 (PNW, USA)

Map shows average line-of-sight surface displacement rates between Oct 2014-May 2017 using Sentinel 1 SAR data and processed using JPL's ISCE processor and StaMPS time-series package.

LOS time-series with respect to each reference

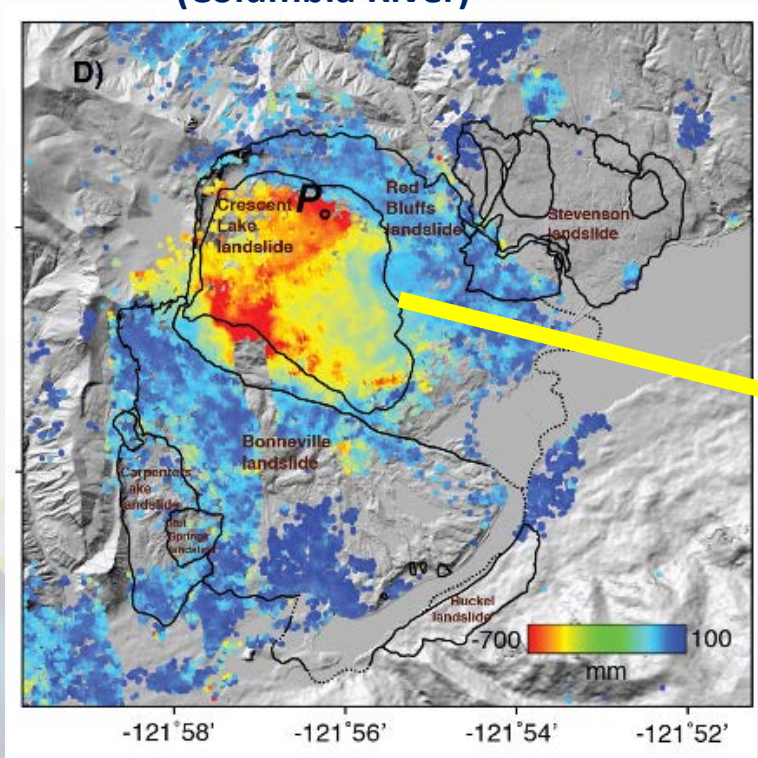


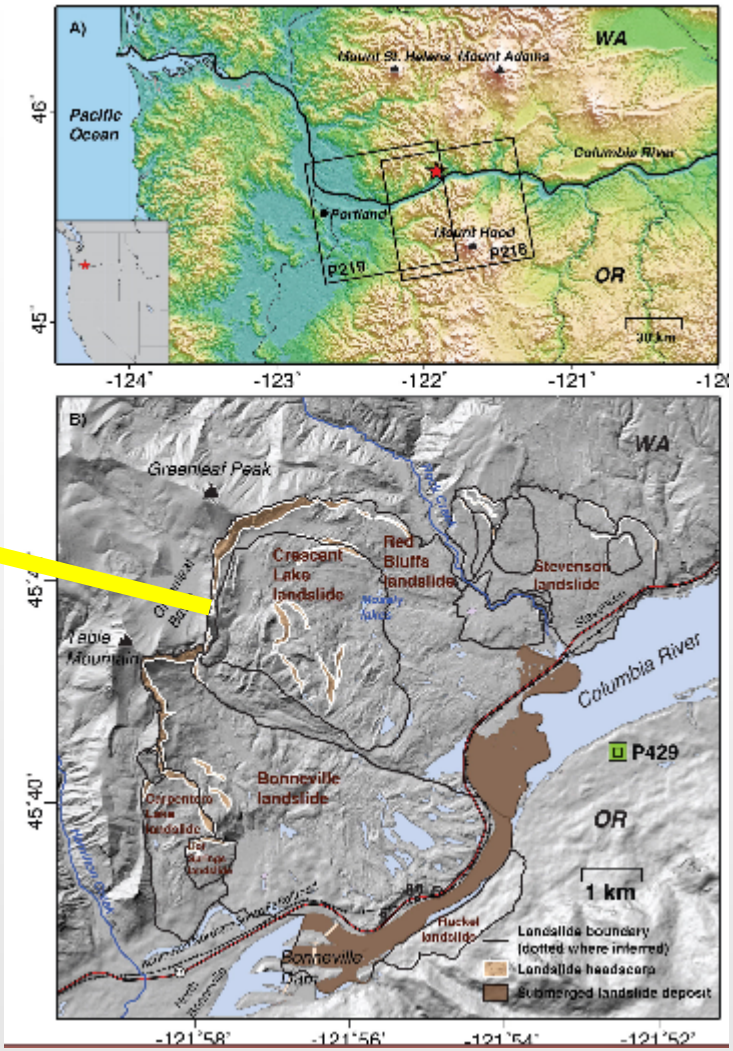


D. Bekaert, P. Agram, and H. Fattahi.
(Jet Propulsion Laboratory, California Institute of Technology)

Landslide Monitoring Washington / Columbia River

Previous demonstrations of InSAR movement analyses for Washington State Landslides (Columbia River)

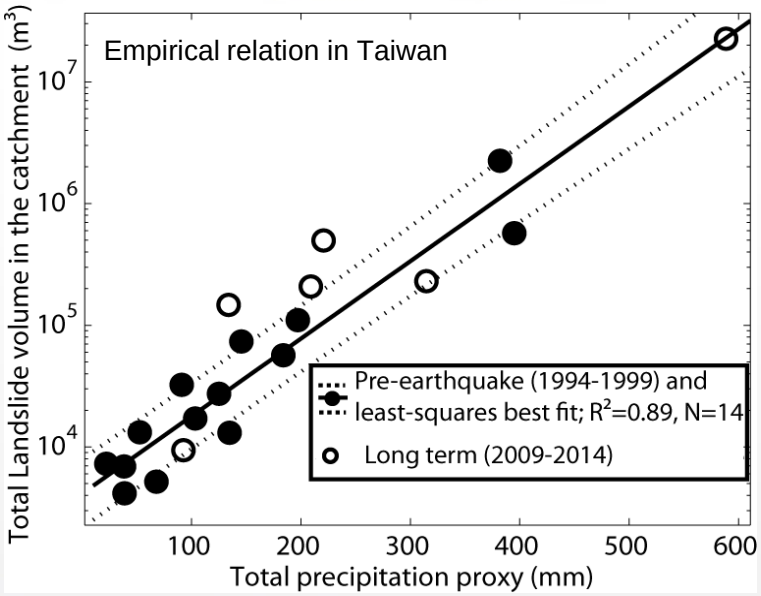




Movement (in mm) of the Crescent Lake Landslide from 2007 to 2011 using InSAR techniques

Source: https://www.smu.edu/-/media/Site/Dedman/Academics/Departments/EarthSciences/PDF/Lu/136_Hu_et_al_InSAR_Cacades_Landslide_Complex_RSE_2016.ashx?la=en

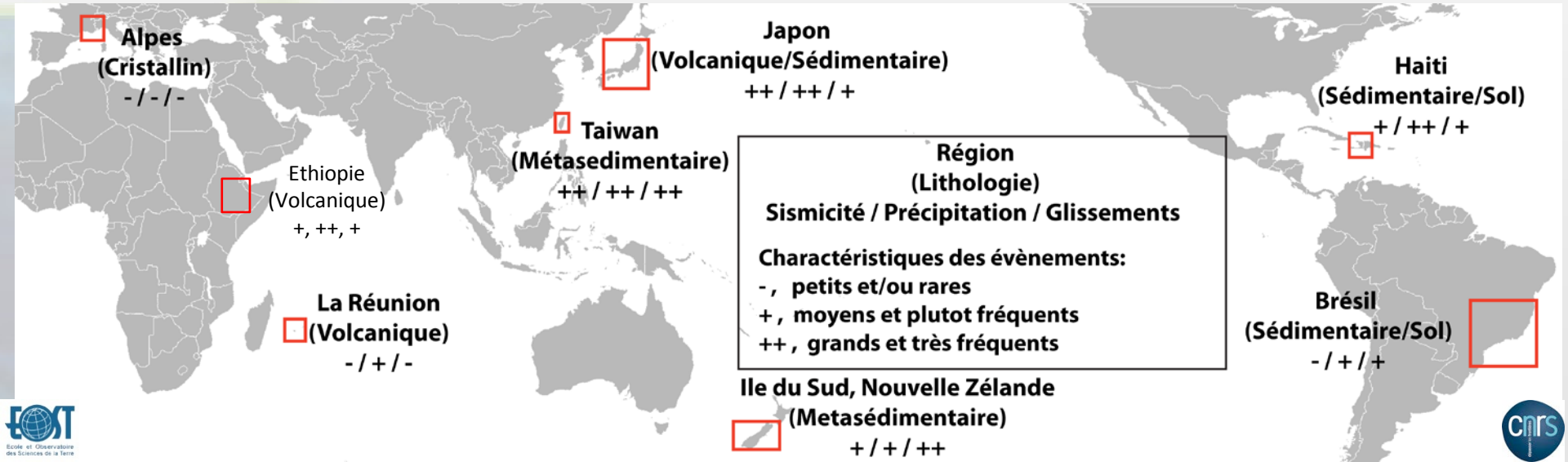
Generalizing the creation of EO-based inventories after major triggering events



Systematizing the creation of EO-based landslide inventory after major triggering events (ETQ > threshold M_L; rainfall event > XX mm) at the global scale
Document the triggering event (seismology, EO-based rainfall estimate using GPM)

→ Create scaling laws relating landslide intensity to the triggering events

→ CNES project: Post-doc project of Odin Marc at CNRS/EOST



Pilot Status

- Pilot started in Fall 2016, most licensing agreements have been signed and we hope to obtain data within the next month
- The first focus has been on primary study regions (Nepal and the Pacific Northwest, US) but we will move focus to other experimental regions early next year
- It is an open community and we welcome new members, ideas, and research opportunities!

Thank you for your attention

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Jean-Philippe Malet, jeanphilippe.malet@unistra.fr