Finding the Slippery Slope: Detecting Landslides from Space

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Why Landslides?

1. **They are important geomorphologically**

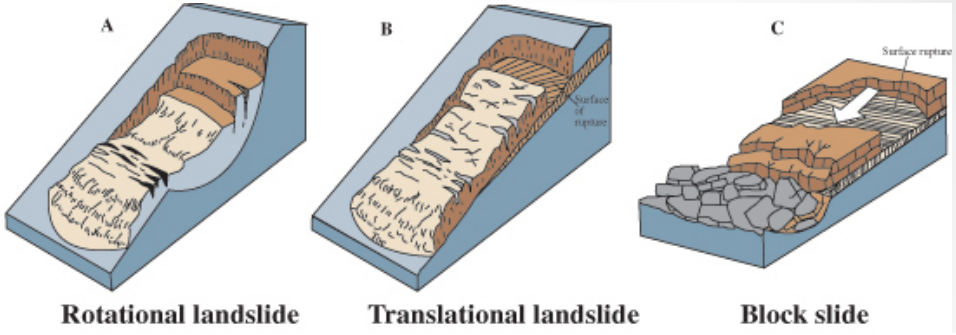
   Movement of a mass of rock, debris, earth, or soil down a hill

2. **They are pervasive**

   Triggered in nearly every country in the world and state in the U.S.

3. **They impact people**

   Landslides have killed over 26,000 people worldwide since 2007 (~3,700/year) and impacted millions

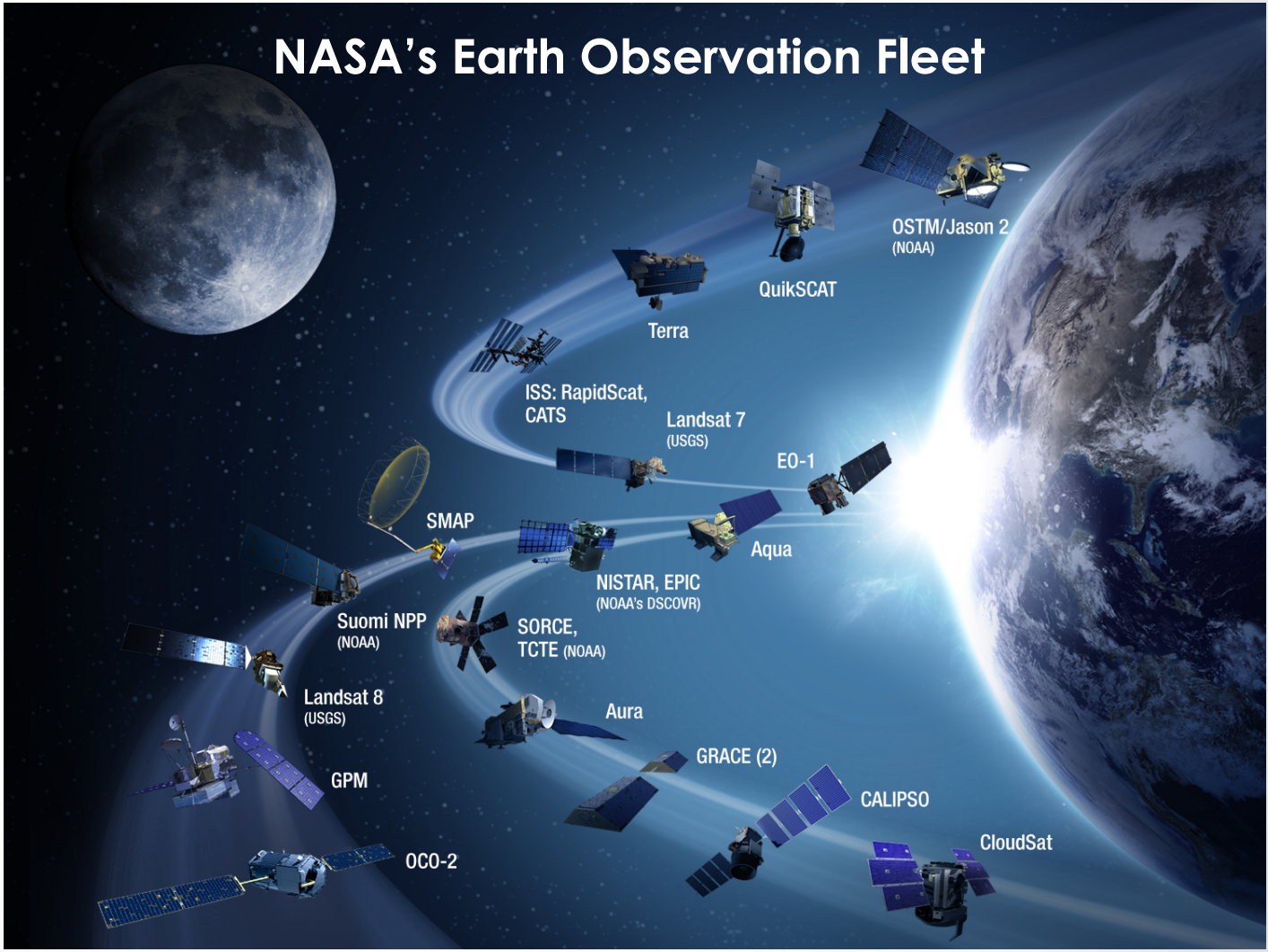


Why from Space?

NASA's BIG QUESTION:

How is the global earth system changing and how will it change in the future?

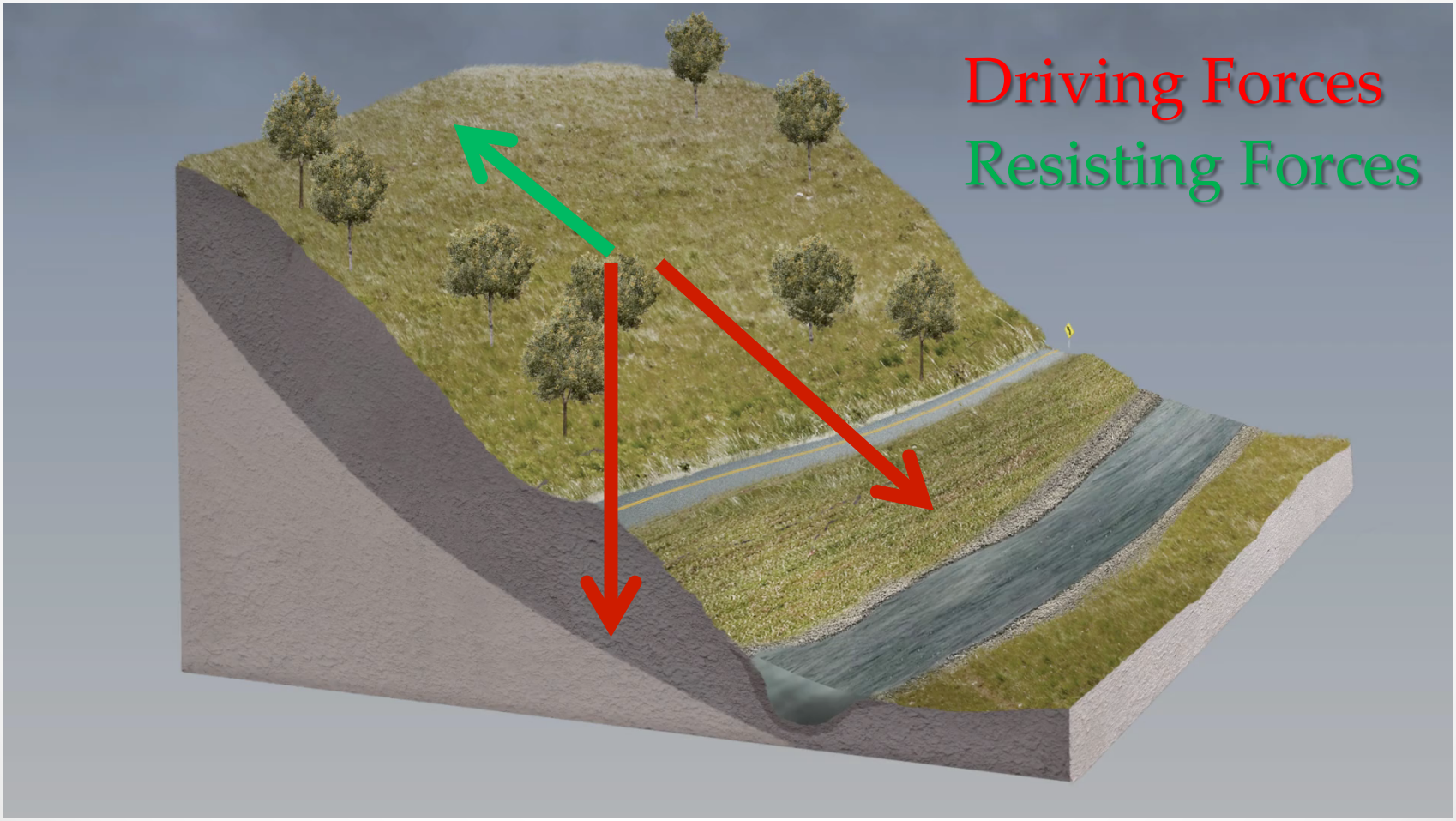
Remote Sensing enables us to study our environment across the globe



The rundown…

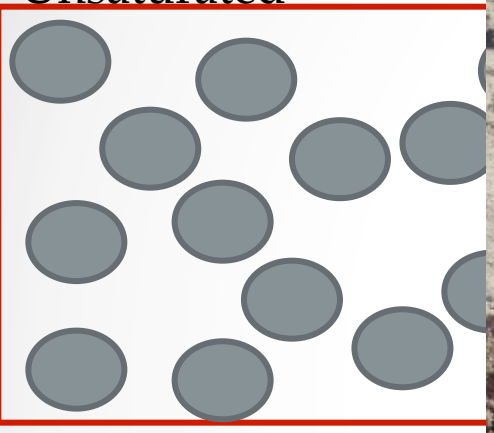
1. Landslides 101
2. Where and when they occur
3. Observation with remote sensing
4. Modeling Efforts
5. Where can you get more information?

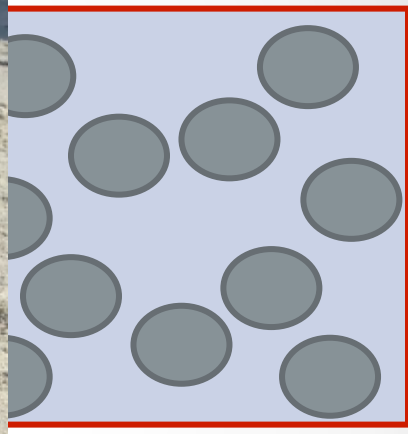
Landslides 101



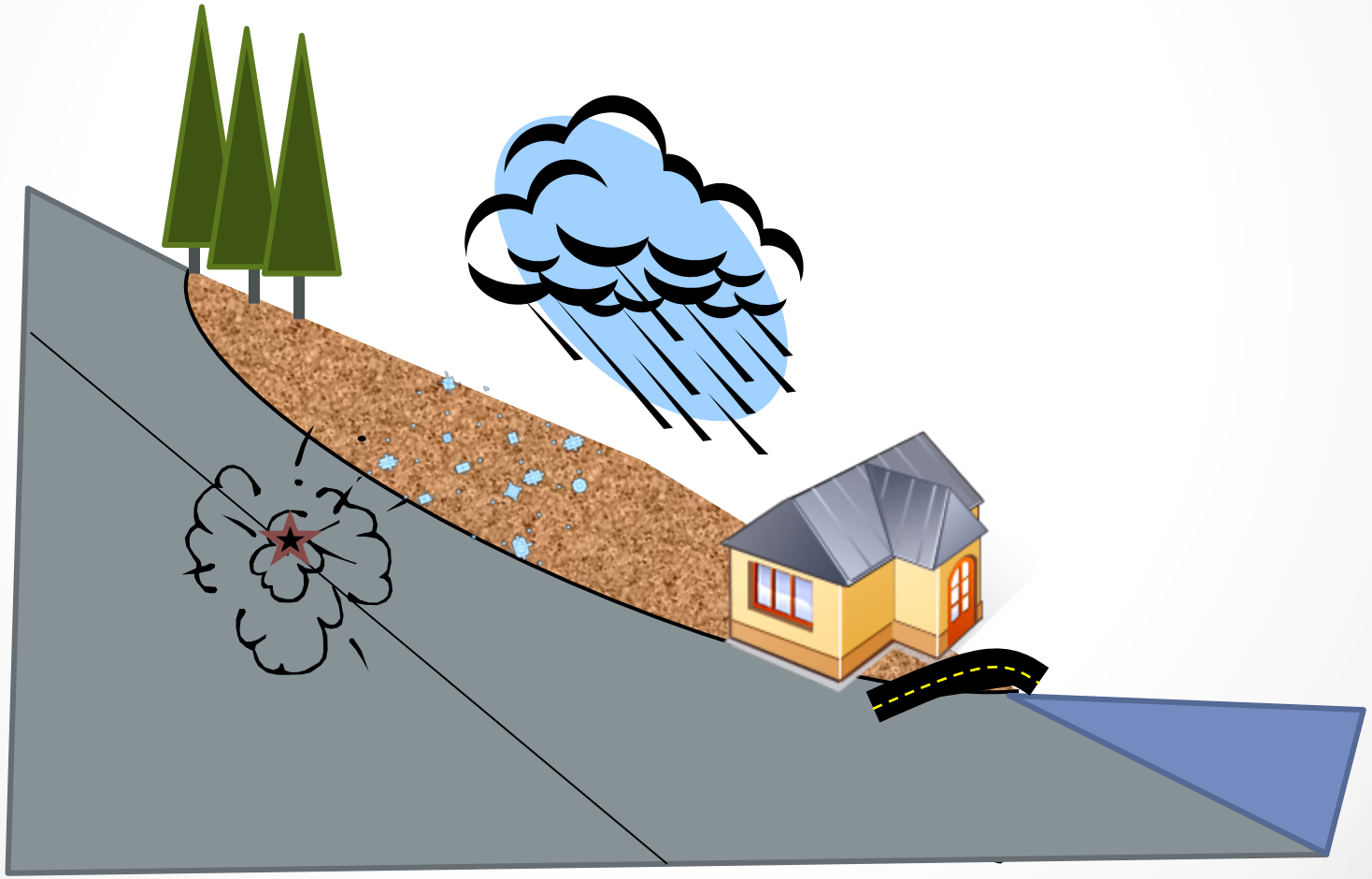
To build a sandcastle…

Unsaturated

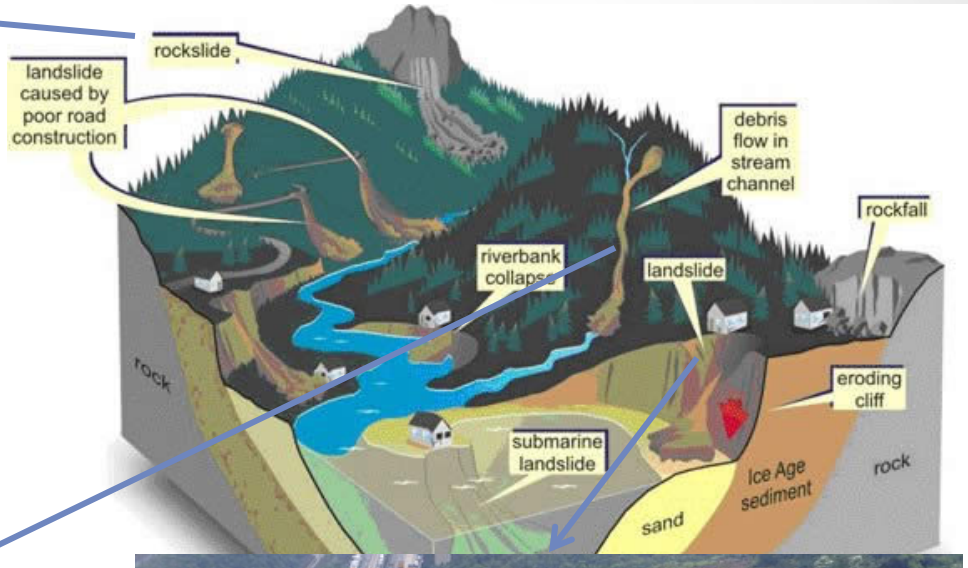




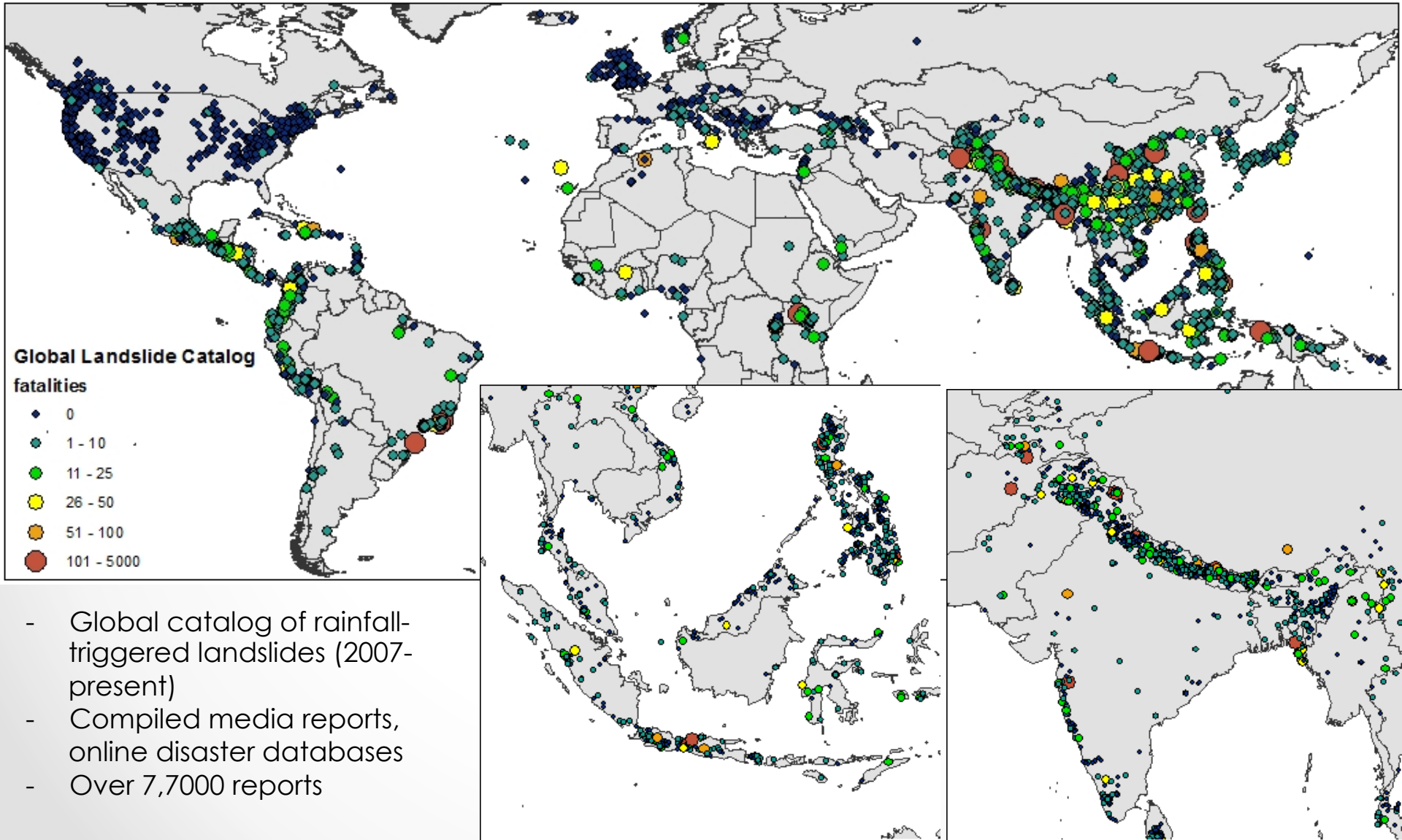
Landscape catalyst



A landslide by any other name…

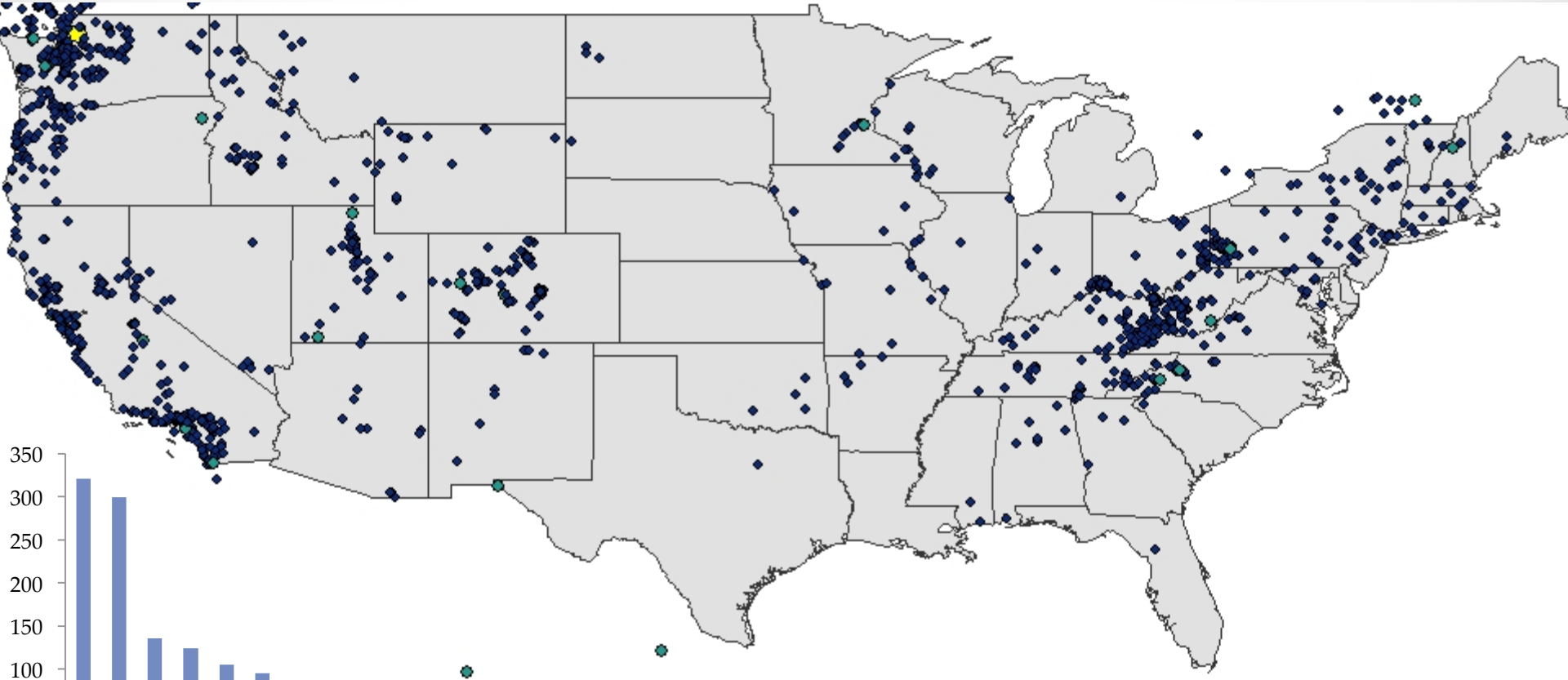


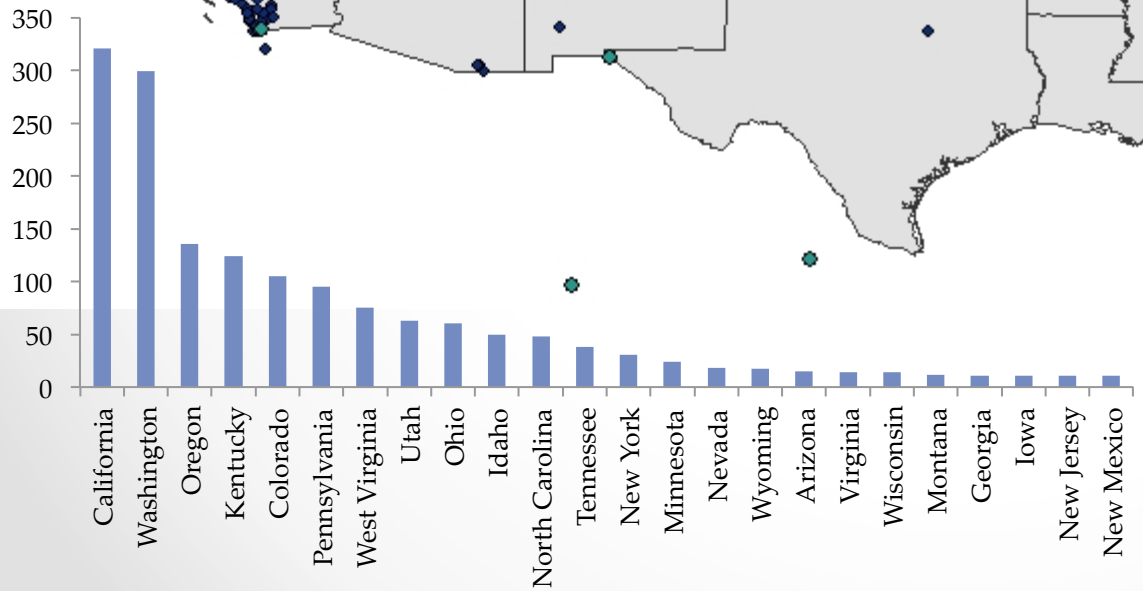
Where are they?



- Global catalog of rainfall-triggered landslides (2007-present)
- Compiled media reports, online disaster databases
- Over 7,7000 reports

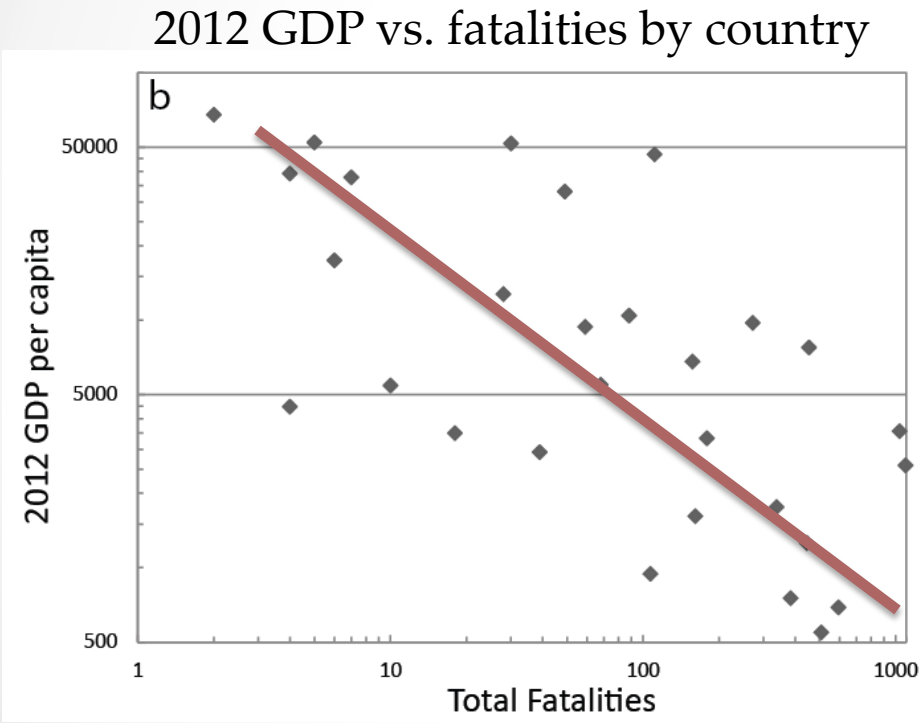
In our backyard

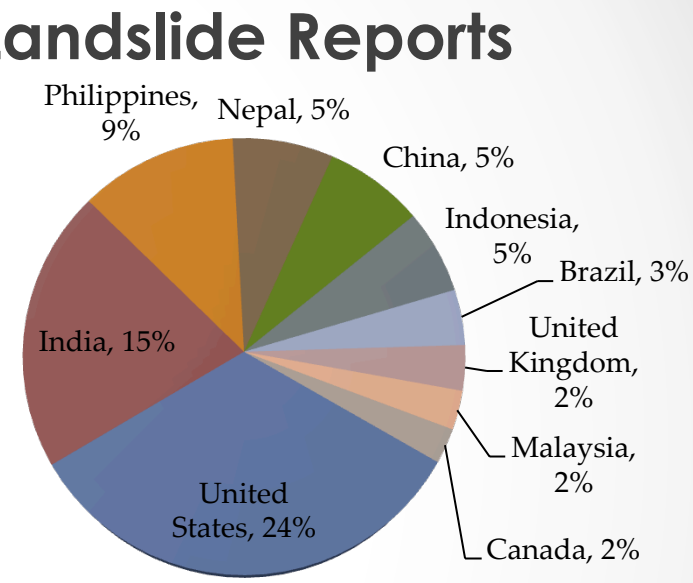


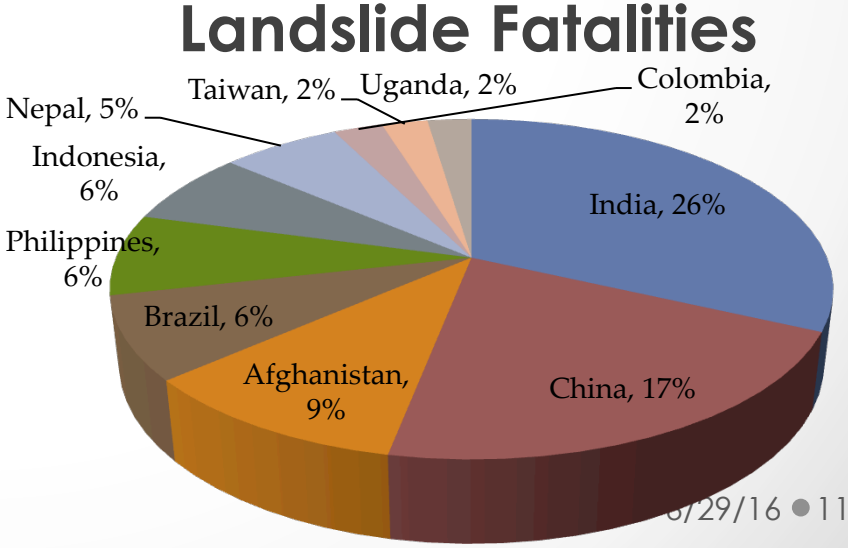


- 44 states with reported rainfall-triggered landslides
- California and Washington have 36% of the total reports

Where are they?



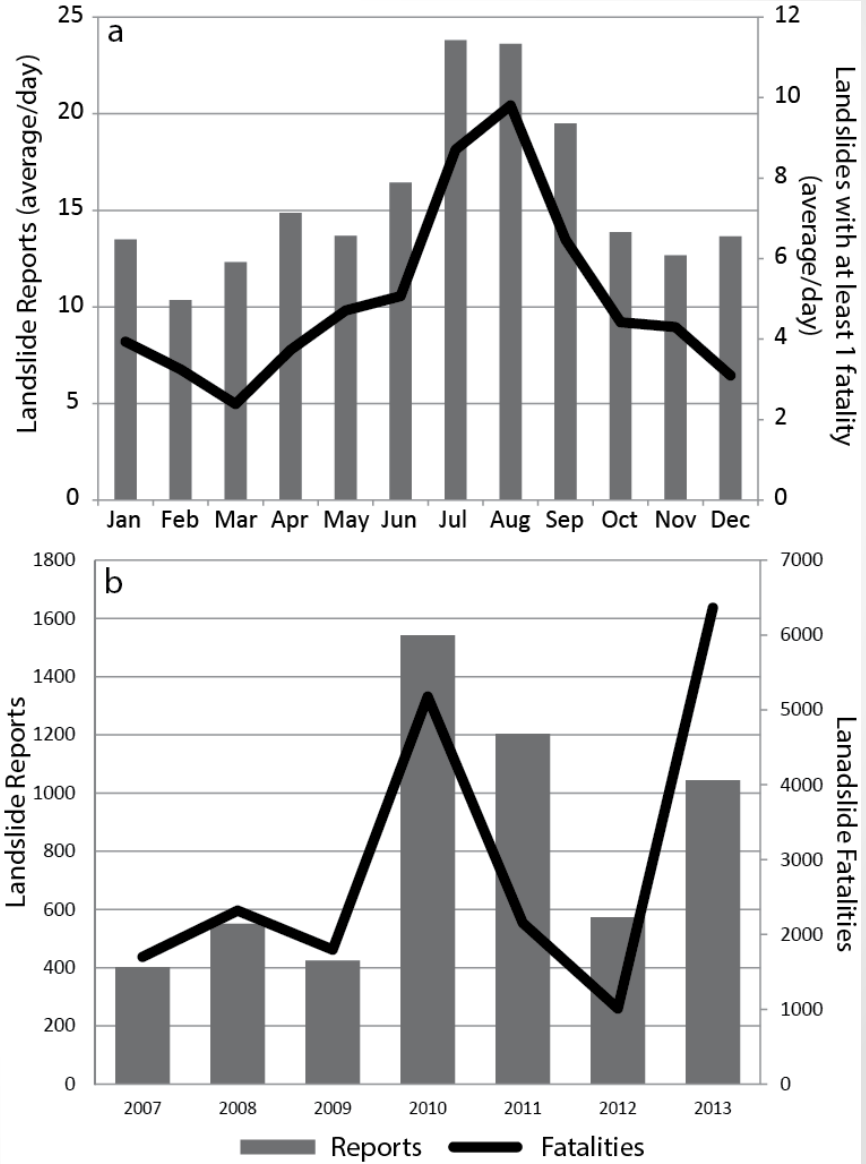




Kirschbaum et al. (2015)

When are they?

- And the "winner" is … rainfall, in a landslide
- Over 98% percent of landslides are triggered by landslides (Petley et al. 2003)
- Landslide reports and fatalities peak in Northern Hemisphere Summer



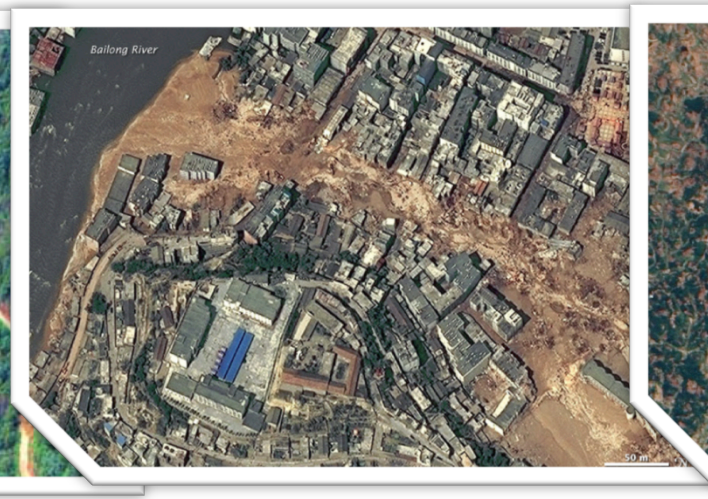
3. Observations of Landslides

- Airborne or ground based imagery can get detailed views of events, but have cost and time restrictions
- Satellite detection can get at the "where" of the event but often not the "when" and is also impacted by clouds and revisit times

Airborne

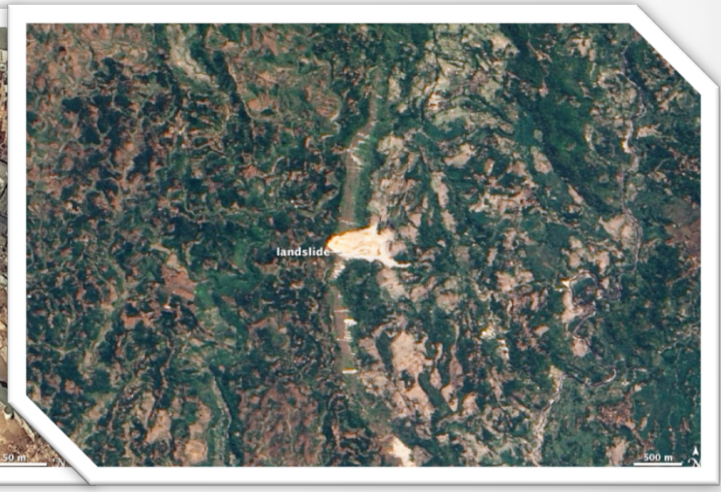
Aerial photos of landslides in Yunnan Province, China
http://english.sina.com/china/p/2008/1108/197201.html

Satellite: Commercial



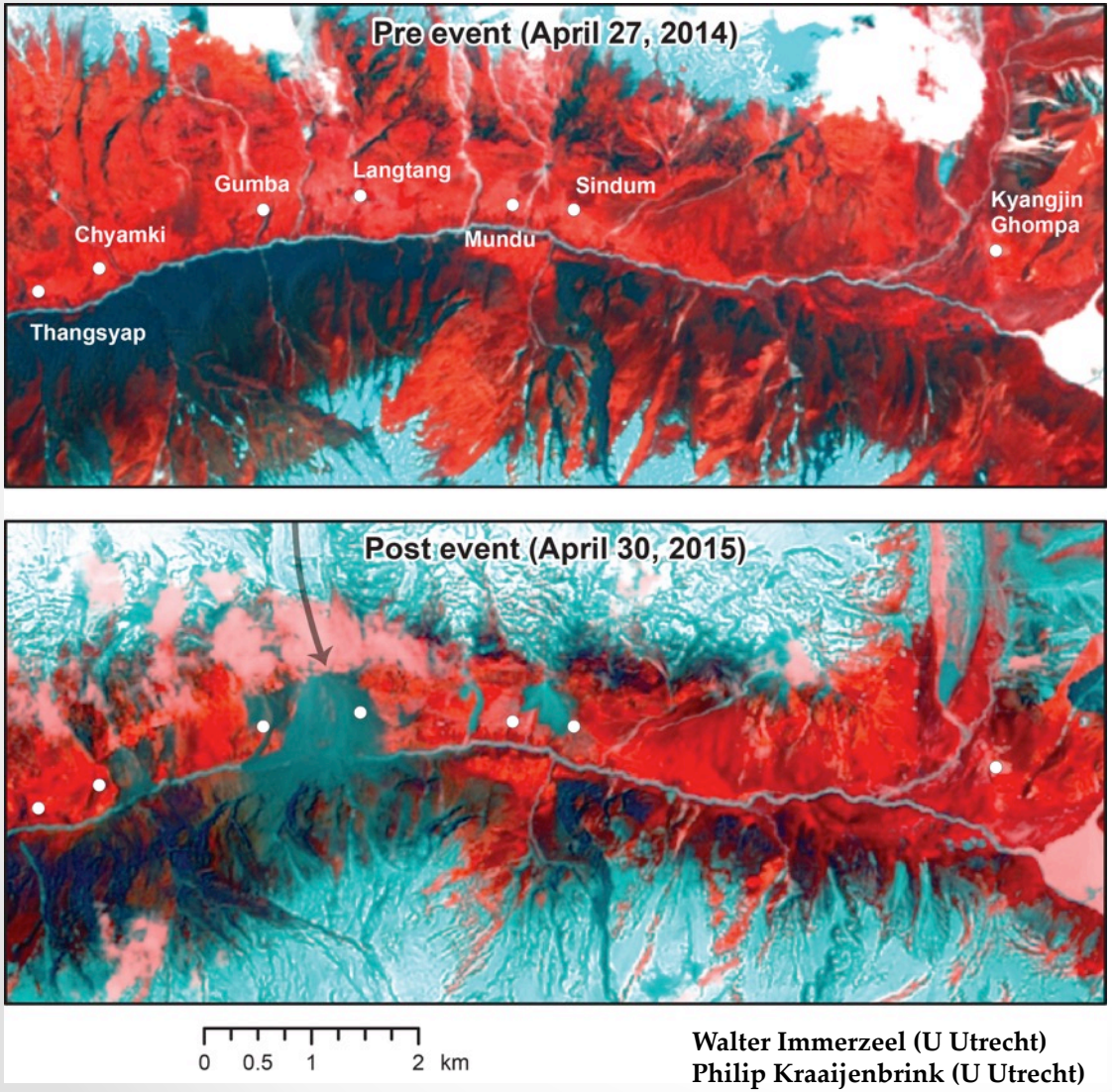
DigitalGlobe WorldView-2 satellite view of Zhouqu landslide in China (0.5 m resolution)

Satellite: NASA



EO-1 ALI Satellite image of Cikangkareng , Indonesia (10 meter resolution)

Langtang Valley



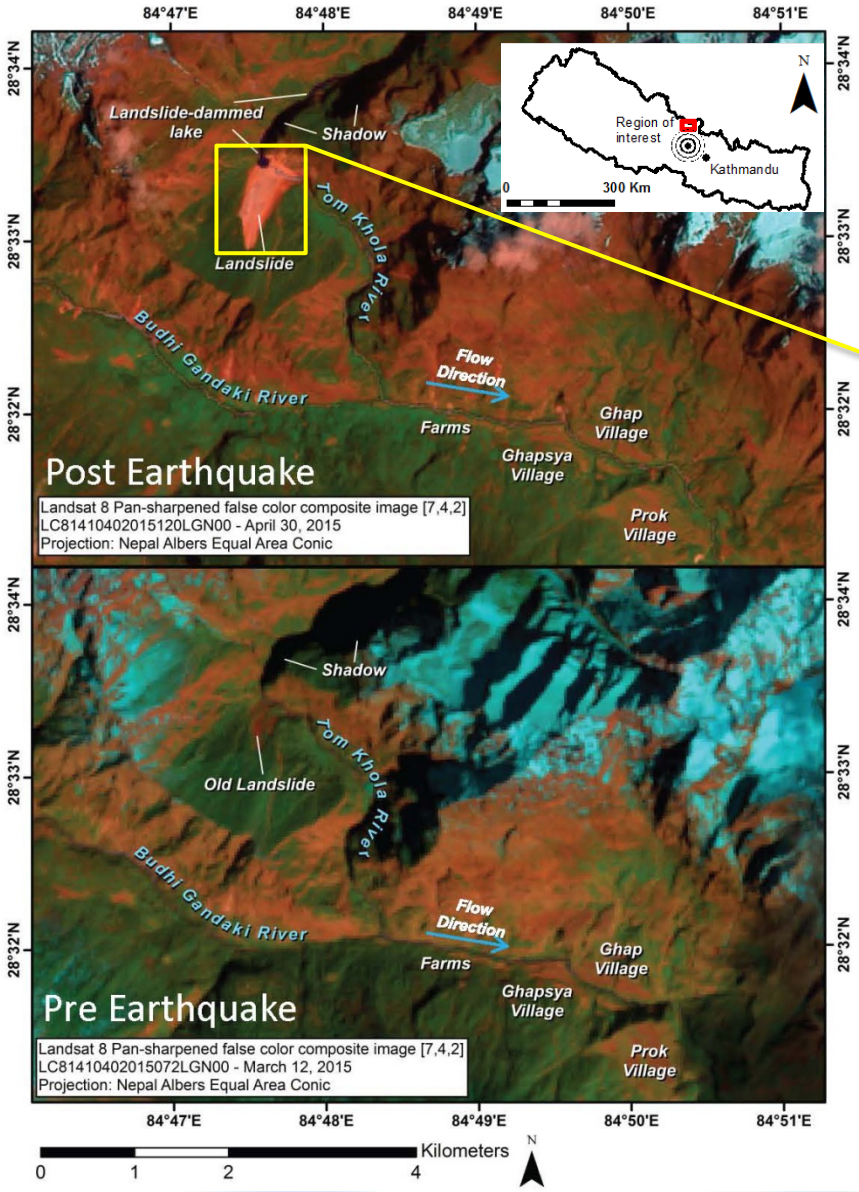
- Langtang Valley was **severely affected** by the main earthquake and aftershocks.
- Several villages destroyed or damaged, **more than 200 people killed**, dozens missing.
- Information relayed to authorities resulted in relief helicopter missions to area
- Recurrent landsliding resulted in **complete evacuation** and **public closure** of the valley.

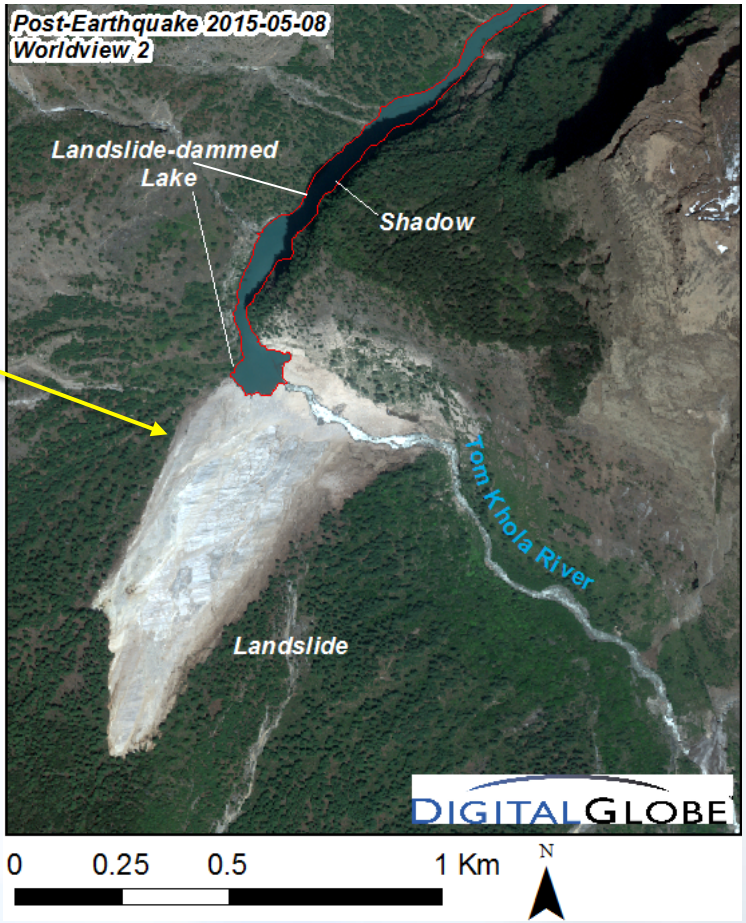
Walter Immerzeel (U Utrecht)
Philip Kraaijenbrink (U Utrecht)
Thomas Painter (NASA JPL)

Route of one of the Langtang Valley's major avalanches/landslides

Photos by Volunteer David Breashears.
Mosaic by Dan Shugar.

Ghap landslide-dammed lake, Manaslu



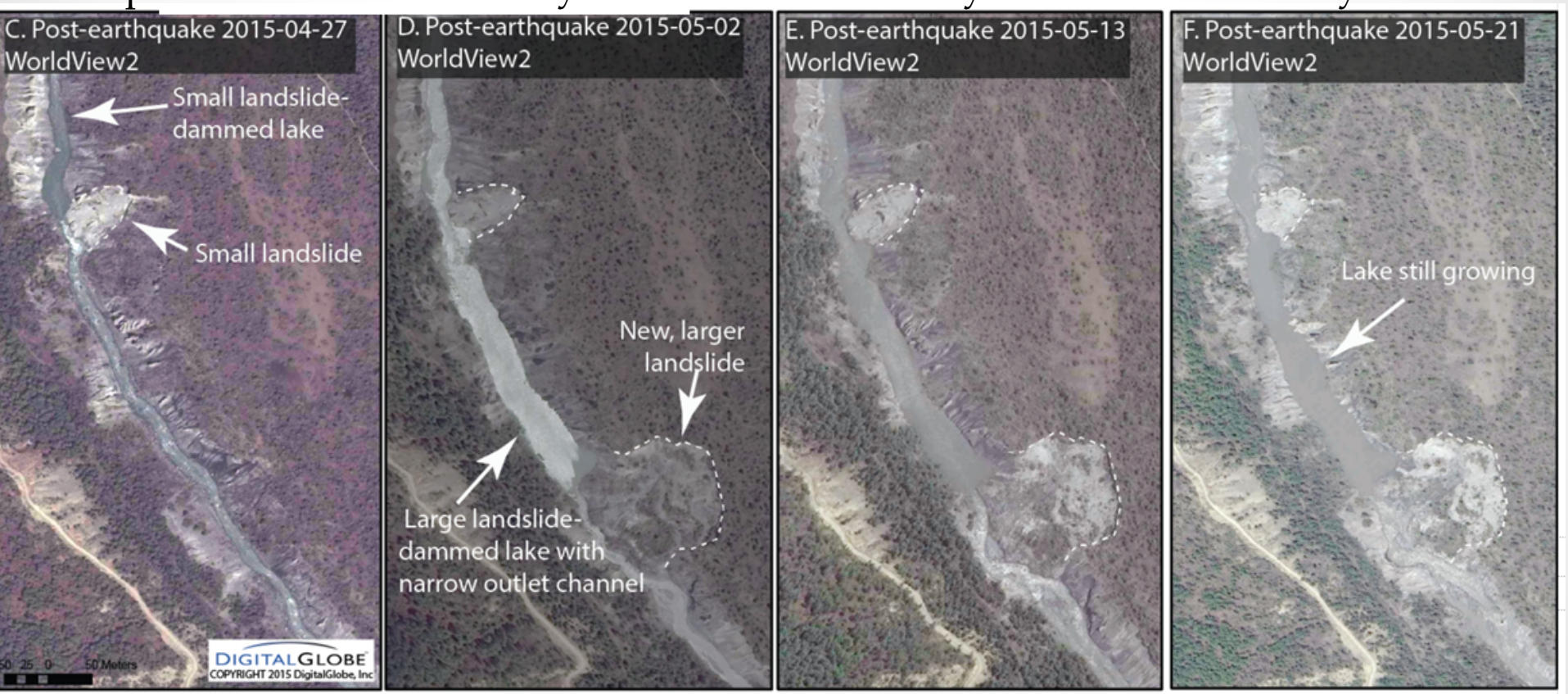


UNIVERSITY of DAYTON

- ~450 m wide landslide at its base at river level and originated from a point ~1 km up slope.
- ~150 m wide and 1.4 km long dammed lake
- Lake still exists and rose slightly as of May 17 Landsat coverage

Evolution of Lower Pisang lake

April 27th | May 5th | May 13th | May 21st

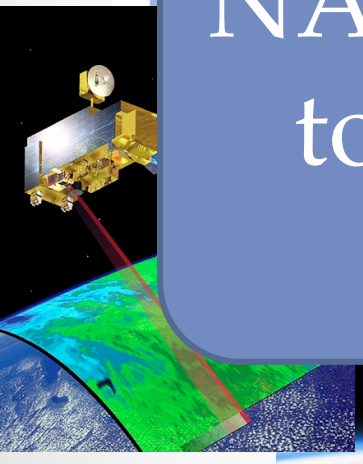


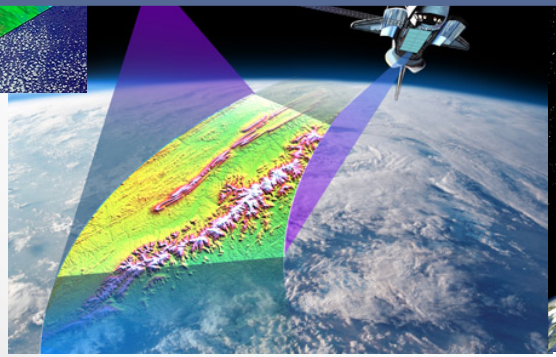
Dan Shugar (U Victoria and U Washington Tacoma)
Walter Immerzeel (U Utrecht)
Niko Wanders (U Utrecht)

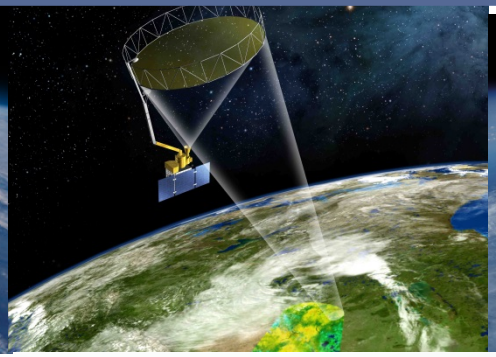
University of Victoria | UW TACOMA

4. Modeling Landslide Activity

NASA satellite data can be used to help anticipate, predict or observe landslides



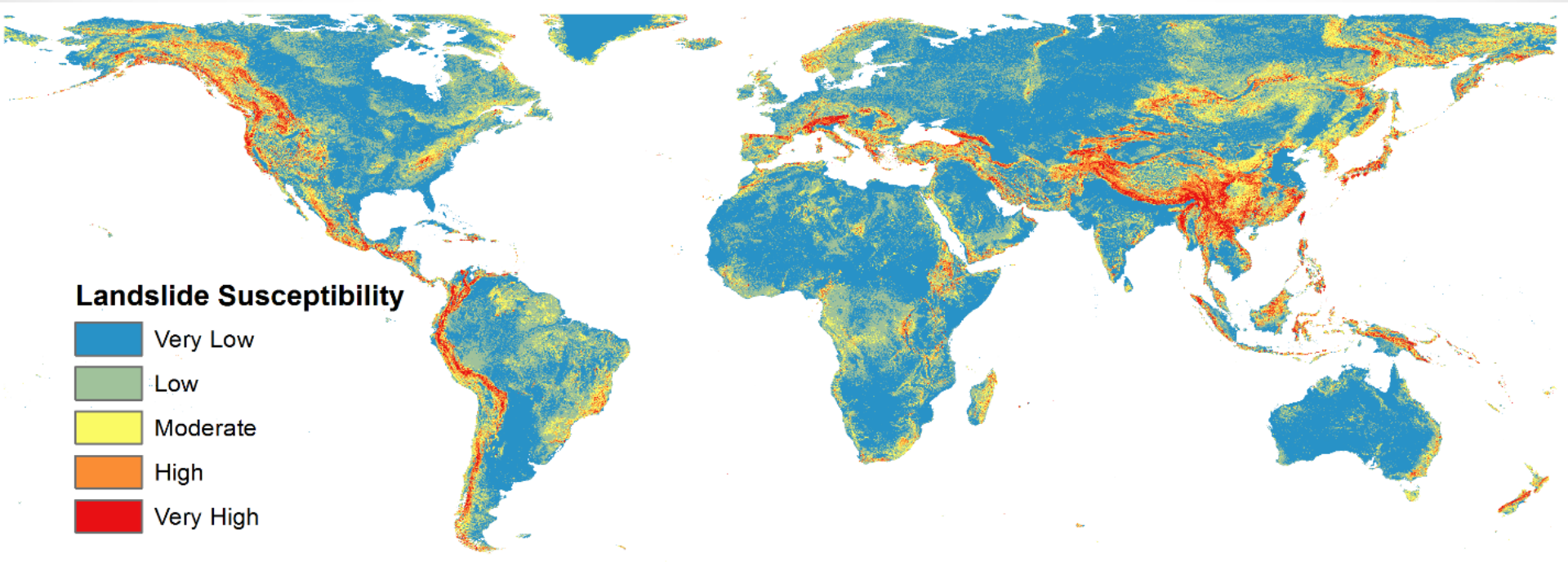




Relevant Datasets (and where to get them)

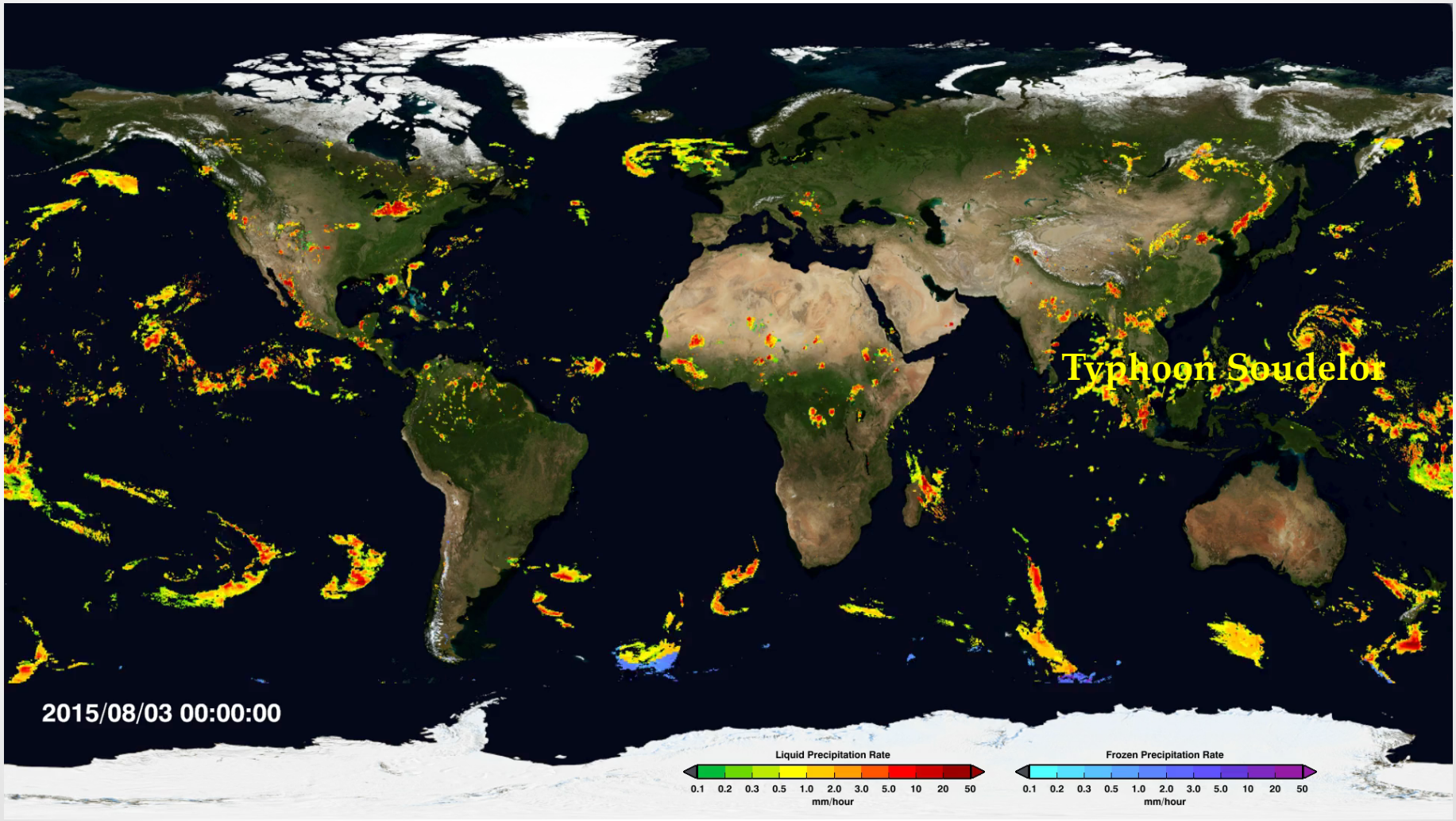
Data type	Data Set	Resolution/Map Scale	Source and website
Elevation	Digital Elevation Models	ASTER, near global, 30m	https://asterweb.jpl.nasa.gov/gdem.asp
	SRTM 30m	30m, near global	https://lta.cr.usgs.gov/SRTM1Arc
Forest Loss	Global Forest Change and Land Analysis	30 m	http://glad.umd.edu/dataset
Road Networks	Global Roads: gROADS	Variable	http://sedac.ciesin.columbia.edu/data/set/groads-global-roads-open-access-v1
Population	CIESIN Gridded Population of the World (V3)	30 arc-seconds, ~1 km	http://sedac.ciesin.columbia.edu/data/collection/gpw-v3
Precipitation	TRMM Multi-satellite Precipitation Analysis (TMPA)	0.25^0 x 0.25^0 3-hourly resolution, 12 hr latency	www.pmm.nasa.gov/data-access
	Integrated Multi-satellite Retrievals for GPM (IMERG)	0.1^0, 30-minute, 5 hour latency	www.pmm.nasa.gov/data-access
Modeled Precipitation	GEOS-5 model (NASA), 24, 48, 73 hour precip forecast (updated every 6 hours)	0.3125˚ longitude x 0.25-degree˚ latitude	ftp://ftp.nccs.nasa.gov/fp/forecast/; http://gmao.gsfc.nasa.gov
Soil Moisture	Soil Moisture Active/Passive (SMAP)	~36 km, 1-3 day latency Higher resolution products planned	https://nsidc.org/data/smap

Global Landslide Susceptibility



Paper in development, those interested in the data should contact dalia.b.kirschbaum@nasa.gov

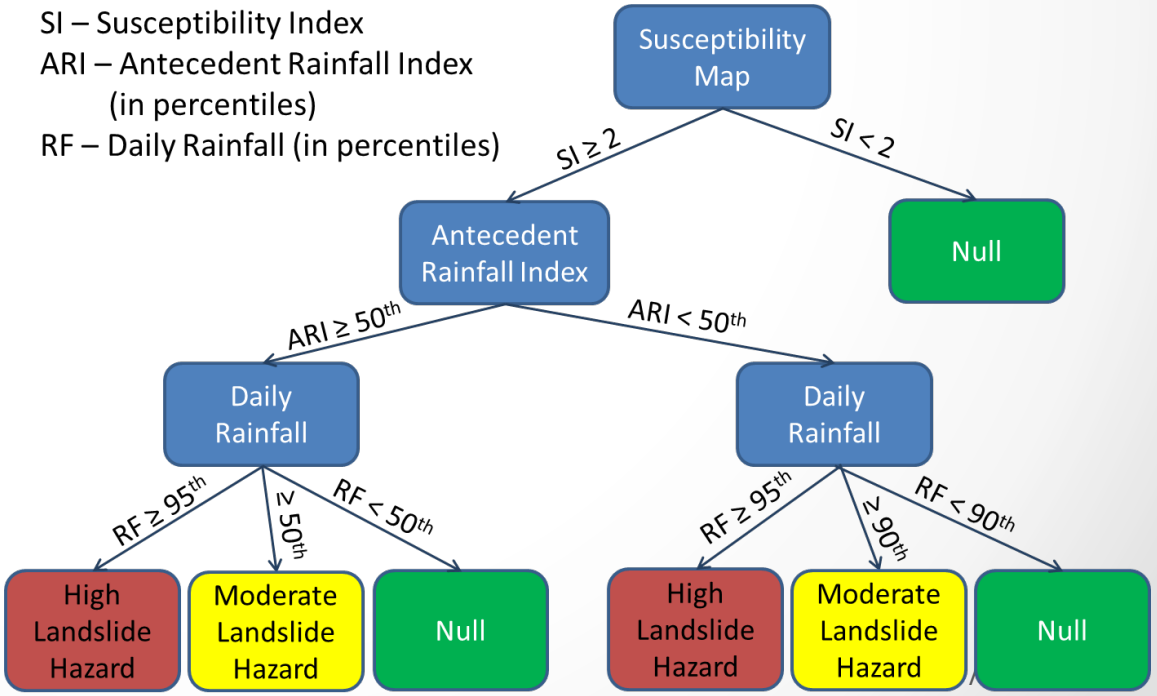
Global Picture of Rain and Snow



Landslide Hazard Assessment for Situational Awareness (LHASA)

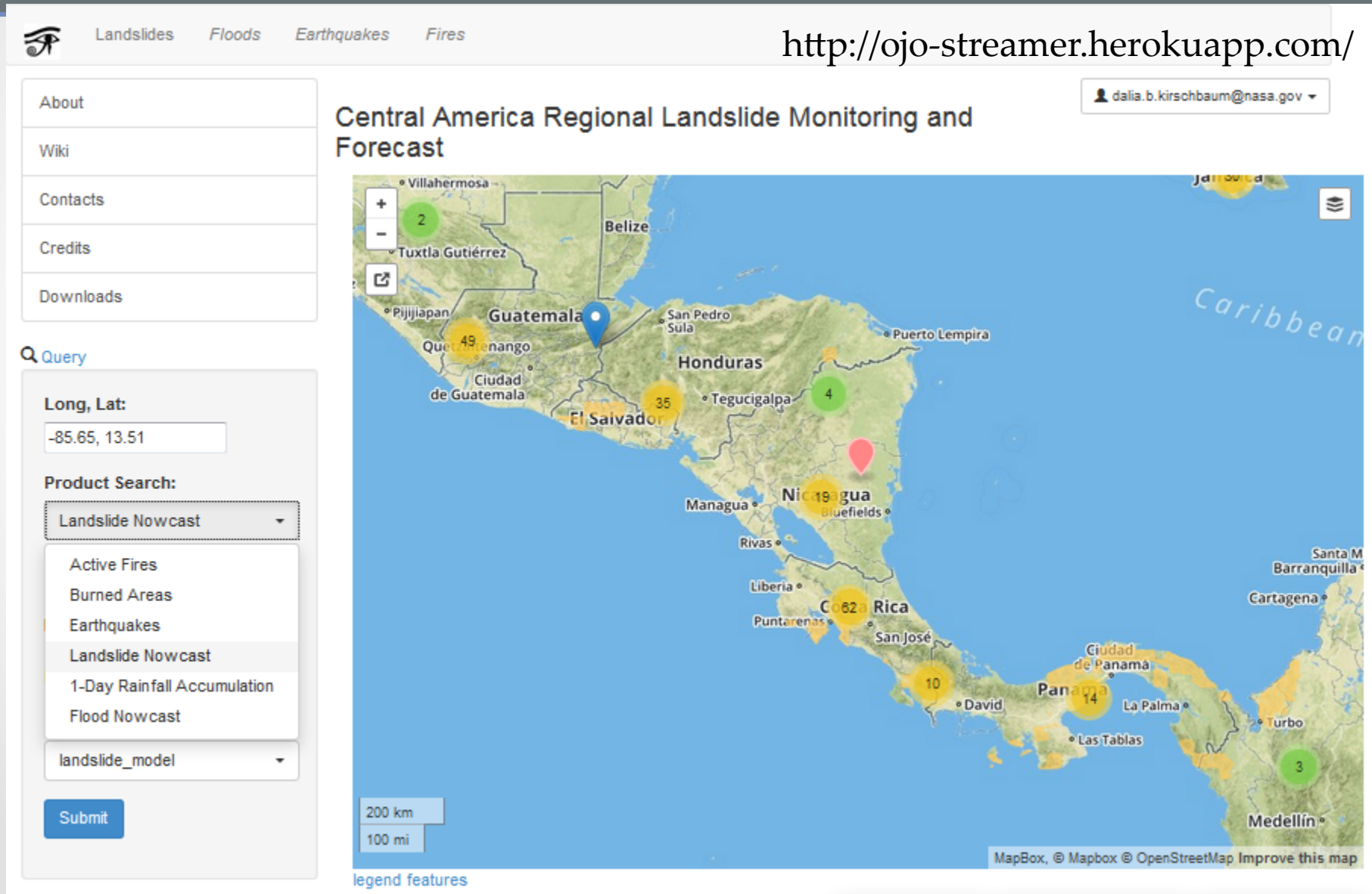
- **Goal:** Develop landslide model based primarily on remotely sensed data that can provide a relative awareness of potential landslide activity regionally in near real-time
- **Approach**: Merge landslide susceptibility map with satellite-based rainfall information to represent potential hazard every day

- Threshold approach for both rainfall and susceptibility
- Estimate landslide nowcasts daily for regional situational awareness
- Rapid visualization and export data as vectors

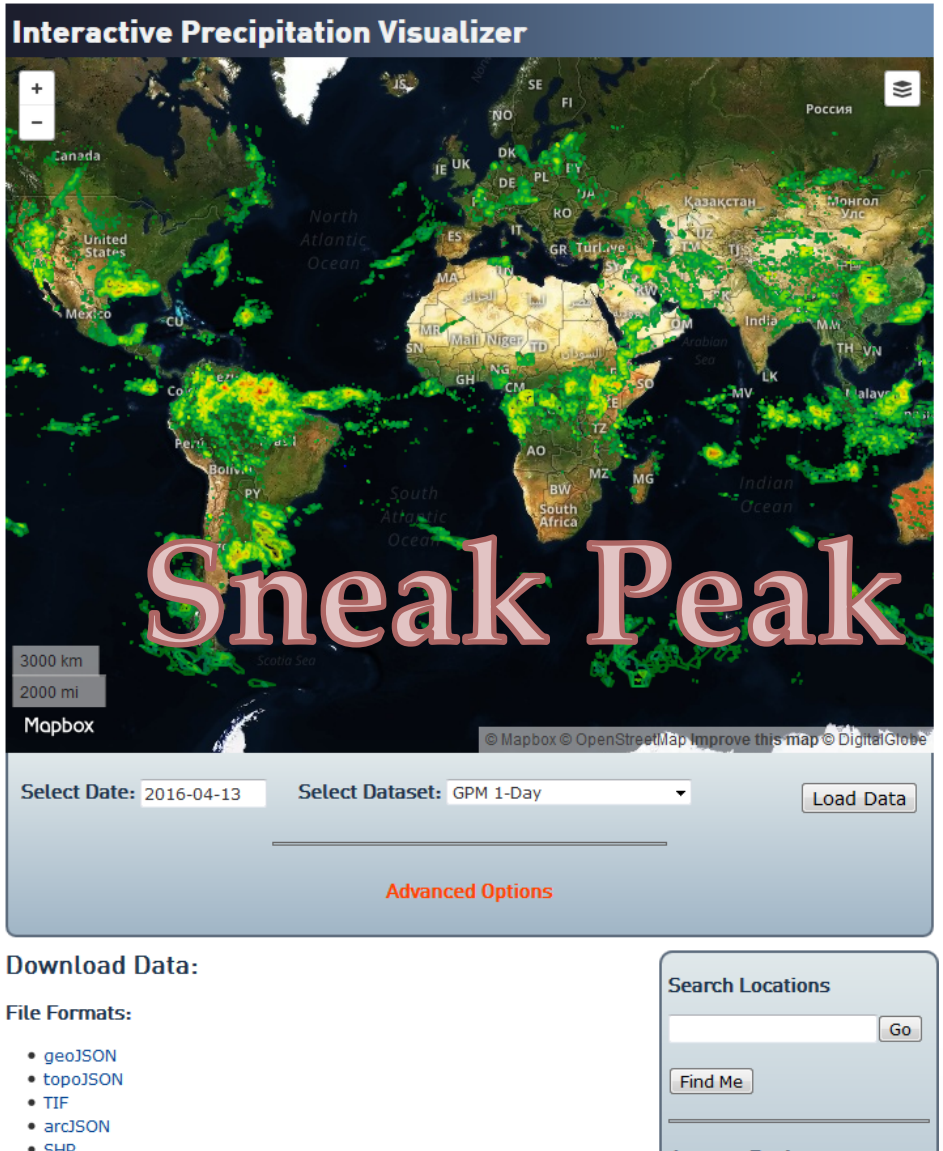


Global Landslide Data

http://ojo-streamer.herokuapp.com/

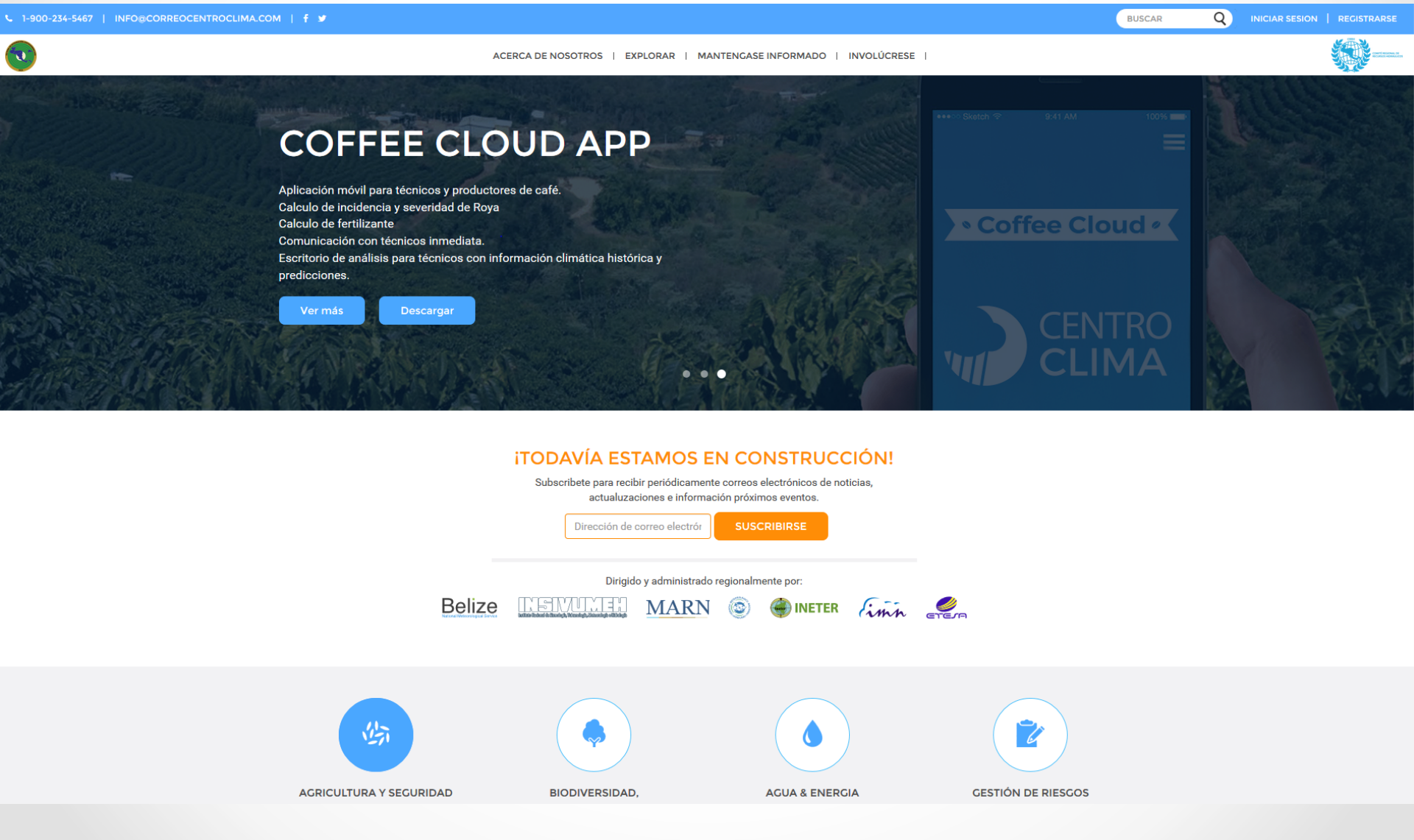


Global LHASA Development



- Working to build moderate and high hazard Global LHASA with IMERG data
- Data will be available as GeoTiffs, Raster and via API (IMERG, Landslide Nowcasts, Global Flood Monitoring System – U of Maryland) at www.pmm.nasa.gov
  - API access to IMERG data at 30 minute, 3 hours, 1 day and 7 days
  - Global Landslide Catalog: Moderate and High Landslide Hazard "Nowcast"

Centro Clima



More to do…

- **Remote sensing** already provides answer to questions about **landslide initiation, composition, hazard and risk**
- There are several different resources available
- **Landslide catalogs** remain one of the **biggest impediments** to more effective landslide modeling
- **Citizen scientists** can contribute to our global understanding and awareness of landslides through reporting events

Thank you!

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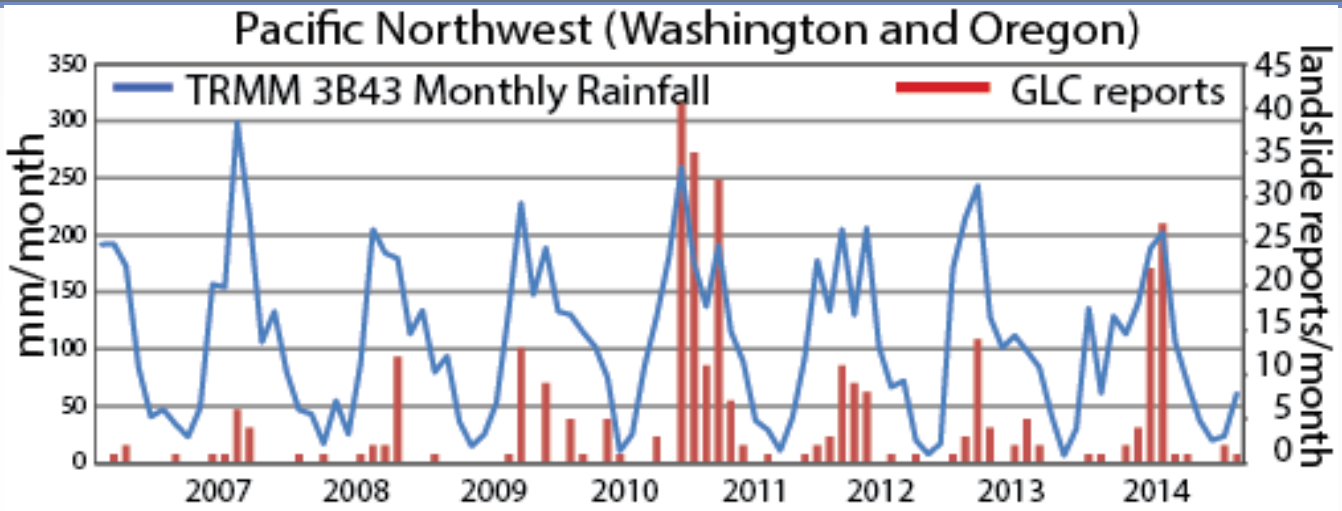
References

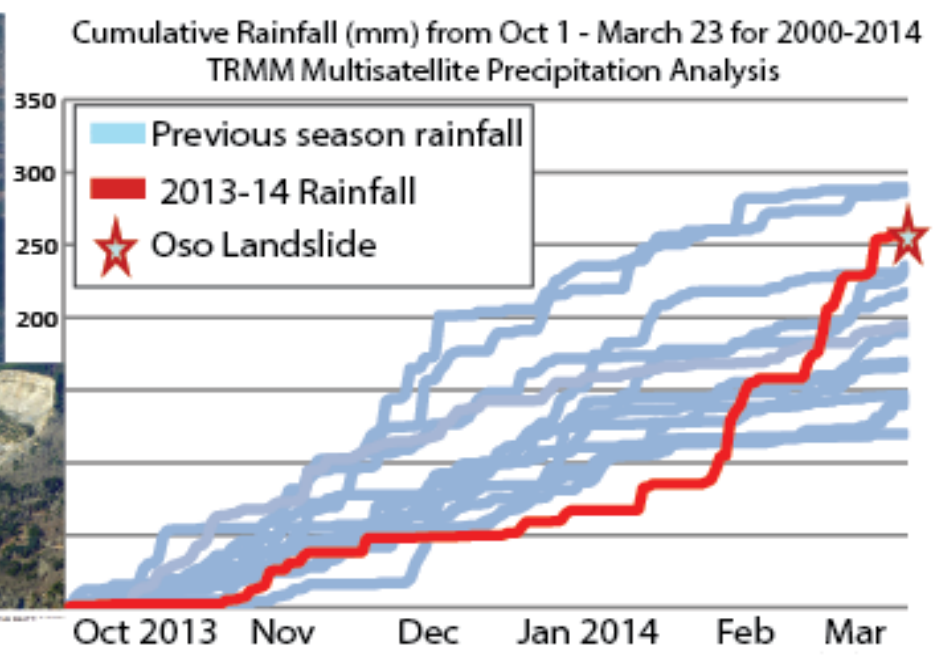
- Collins and Jibson, USGS Open-File Report 2015-1142, http://pubs.usgs.gov/of/2015/1142/ofr20151142.pdf
- Kirschbaum, D. B., Stanley, T. and Yatheendradas, S.: Modeling Landslide Susceptibility over Large Regions with Fuzzy Overlay, Landslides, doi:10.1007/s10346-015-0577-2, 2015.
- Kirschbaum, D. B., Stanley, T. and Zhou, Y.: Spatial and Temporal Analysis of a Global Landslide Catalog, Geomorphology, doi:10.1016/j.geomorph.2015.03.016, 2015.
- Kirschbaum, D. B., Adler, R., Hong, Y., Hill, S., & Lerner-Lam, A. (2010). A global landslide catalog for hazard applications: method, results, and limitations. *Natural Hazards*, *52*(3), 561–575. doi:10.1007/s11069-009-9401-4

Photo Credit: Ahmed, Bull Bay, Jamaica.

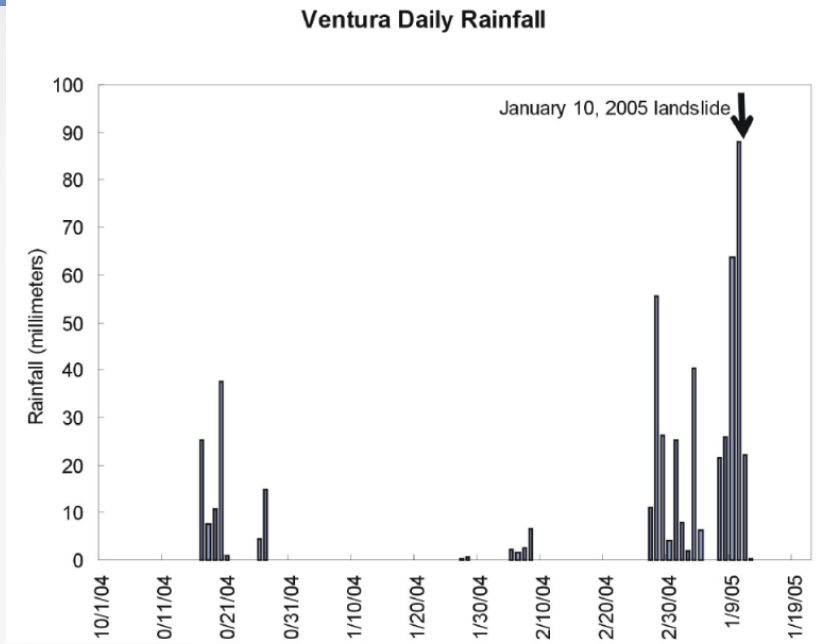
Extra Slides

Landslide Modeling





La Conchita: 2005



- Type: Shallow debris flow
- Occurred after 15-days of high-rainfall
- Destroyed 13 houses, severely damaged 23 others, and caused 10 fatalities.

La Conchita: 2005

Jibson (20