A Global Landslide Hazard Assessment Model for Situational Awareness

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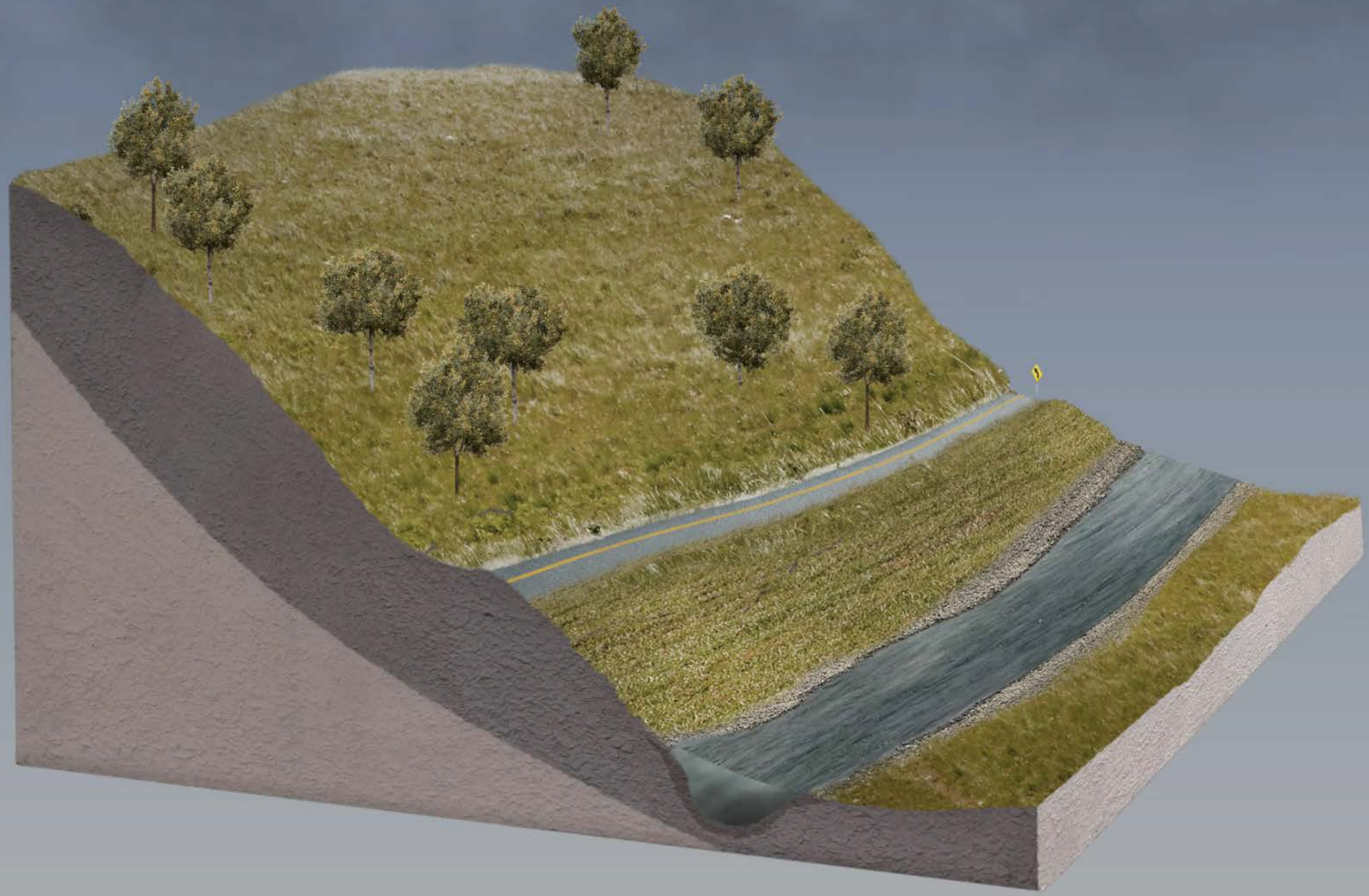
Landslides 101



We can estimate the processes that create potential for landslides and observe their impact remotely

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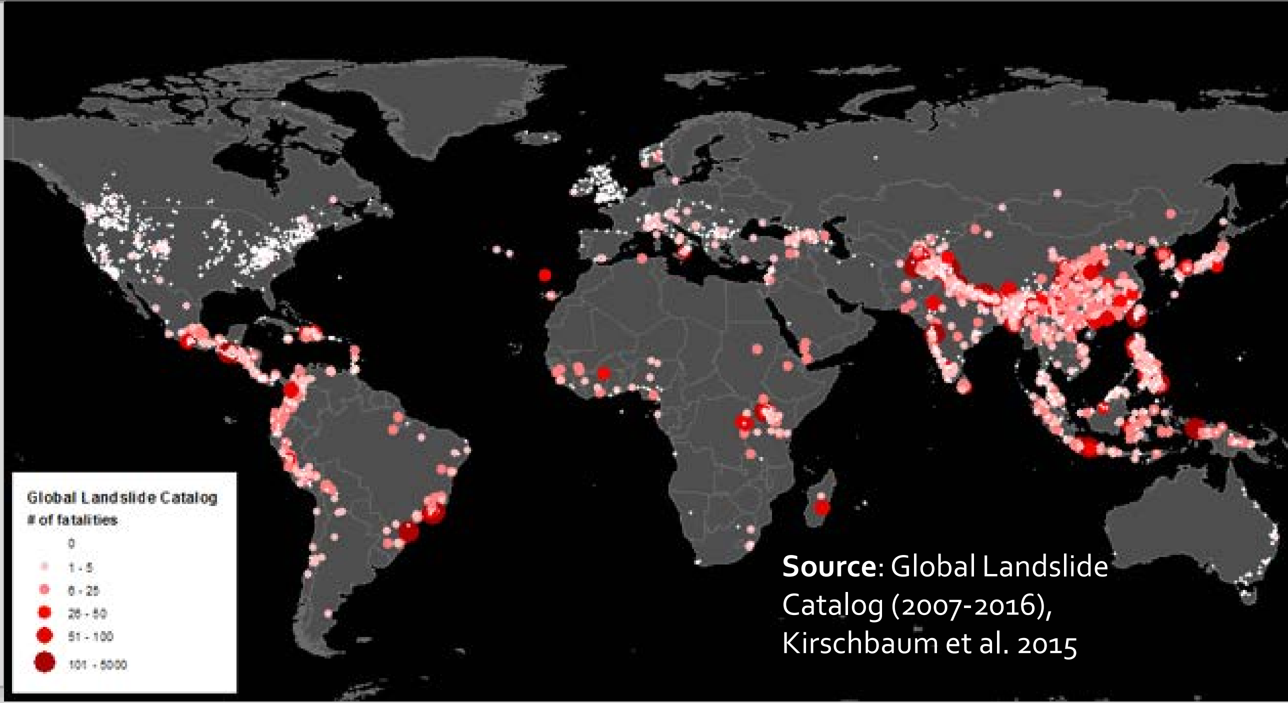
Motivation and Challenges

1. Rainfall-triggered landslides **impact nearly every country in the world,** but we lack sufficient global information to provide situational awareness
2. This type of information could help to **guide local, national and international awareness** of this hazard, and improve potential response and planning

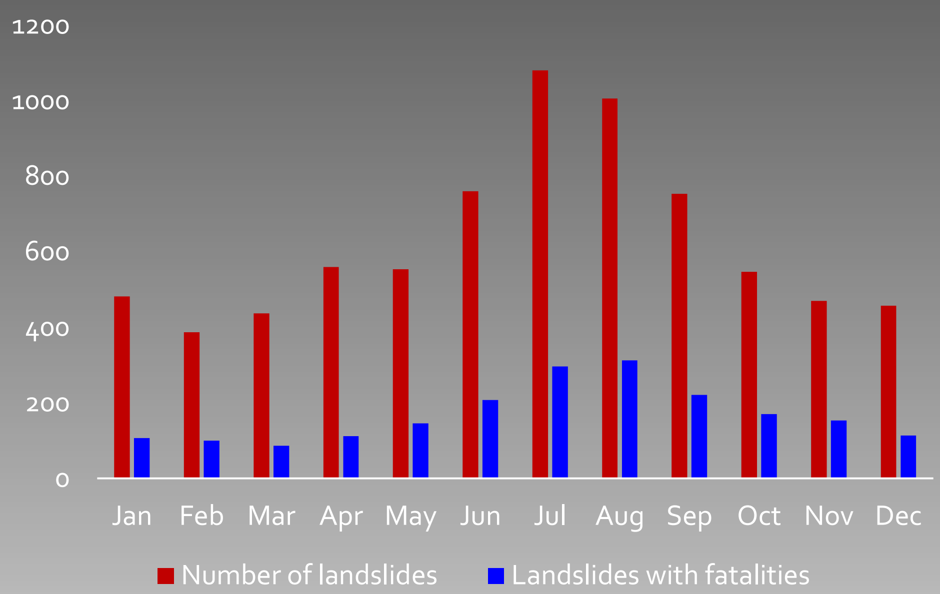
-8,000+ rainfall-triggered landslide reports
-Compiled from media sources, online databases, etc.
-http://ojo-streamer.herokuapp.com/



Source: Global Landslide Catalog (2007-2016), Kirschbaum et al. 2015

Motivation and Challenges

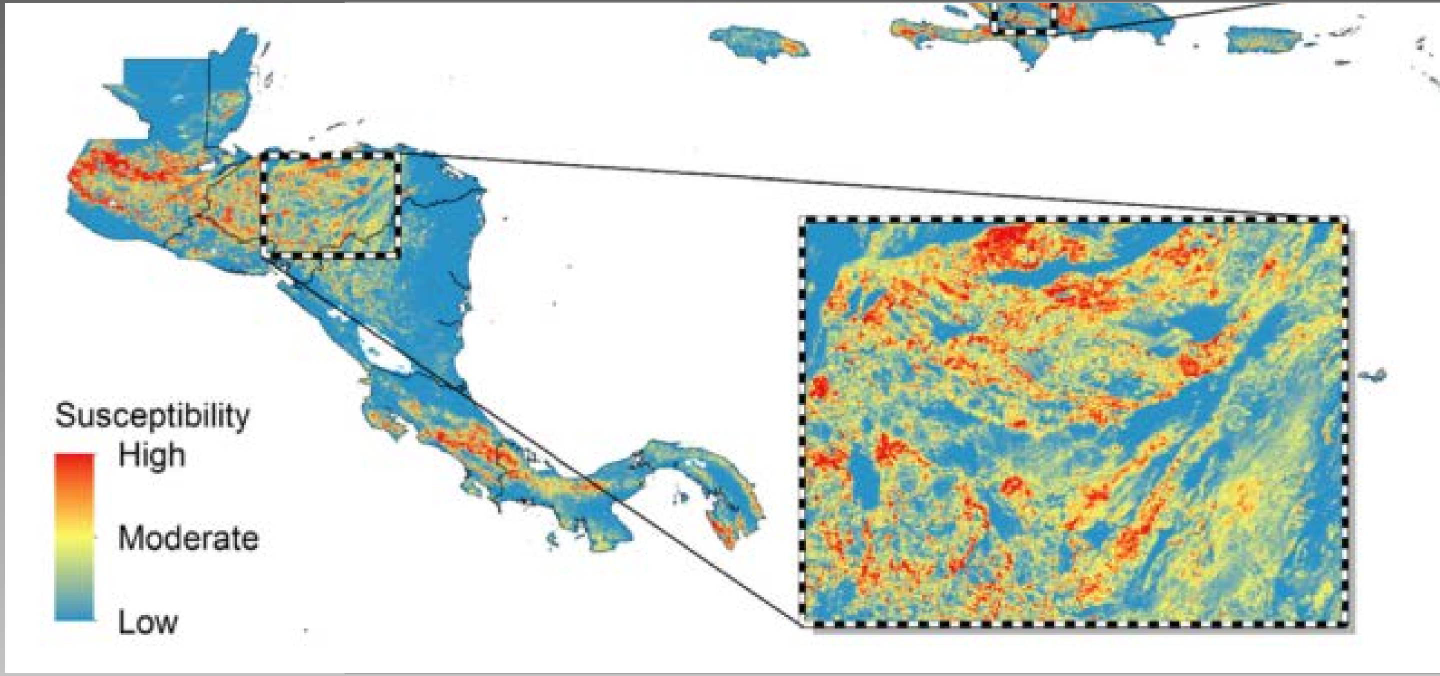
- Very little global landslide event information
- Coarse resolution or heterogeneous quality for in situ products for things like geology or soil types
- Limited characterization of rainfall triggering relationships outside of local to regional scales



*Excludes:
8/7/2010 - China, 1765 fatalities
5/2/2015 – Afghanistan, 2100 fatalities
6/16/2013 – India, 5000 fatalities

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 at a regional scale in near real-time
- **Approach**: Merge a regional landslide susceptibility map with satellite-based rainfall information to represent potential hazard every day



Regional susceptibility mapping approach, Kirschbaum et al. 2016, *Landslides*

Regional LHASA Model, Kirschbaum et al 2015, NHESS

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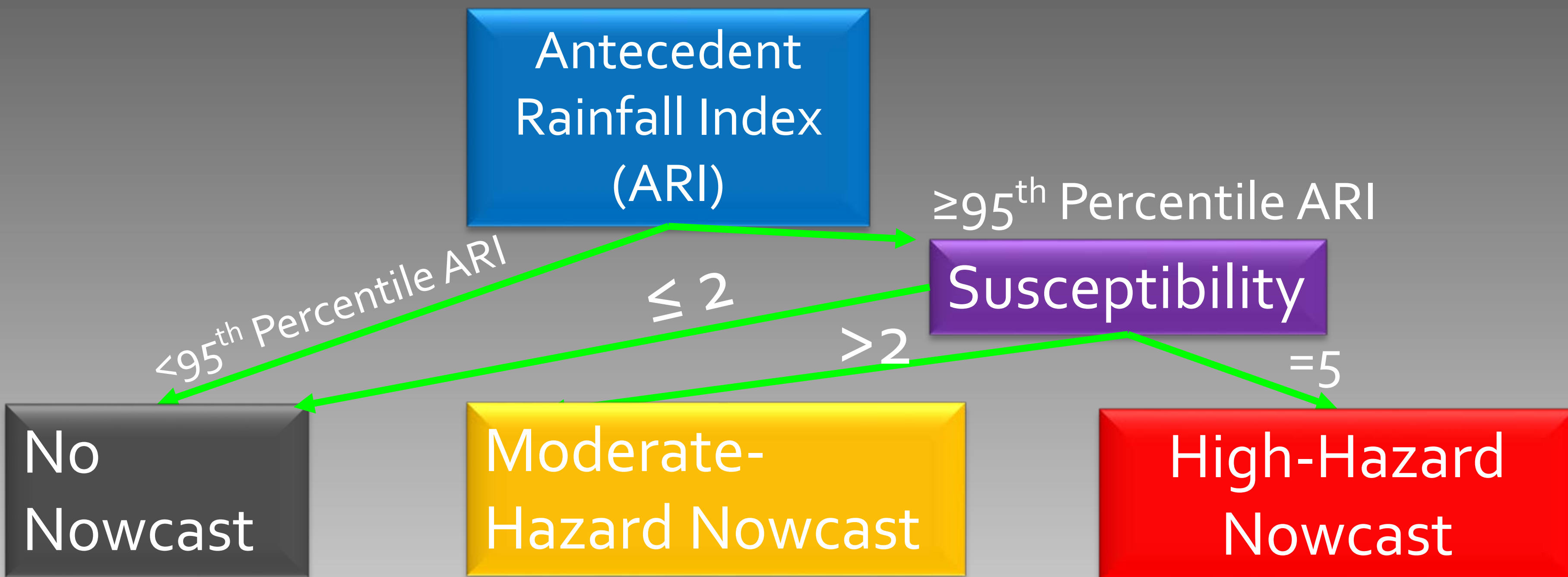
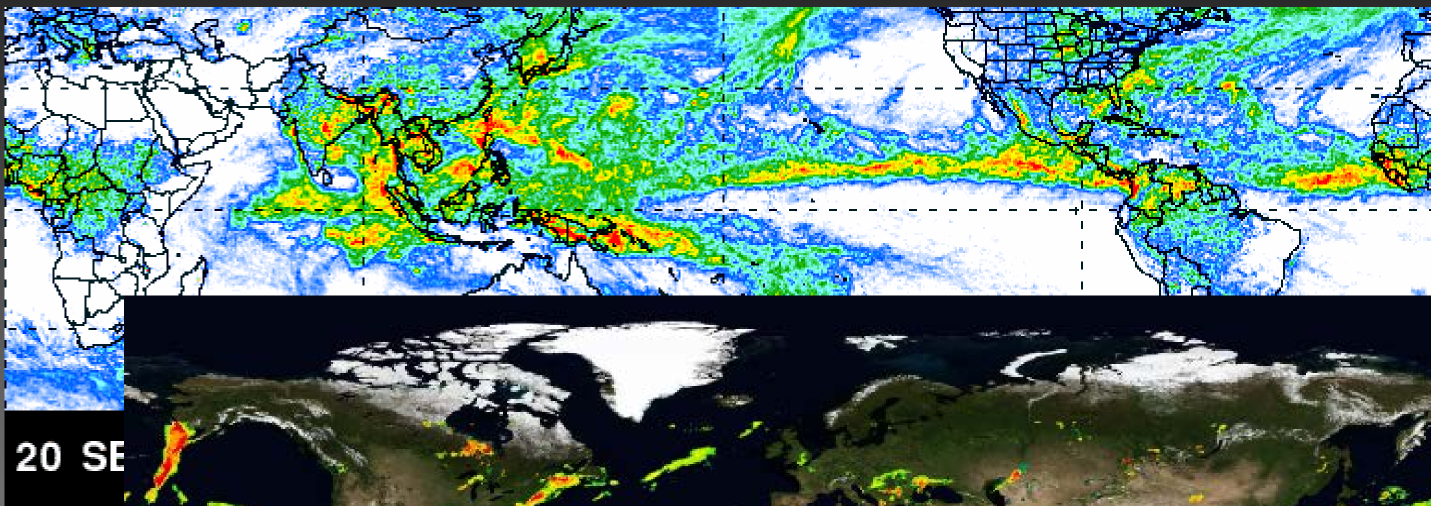
Global LHASA - Framework

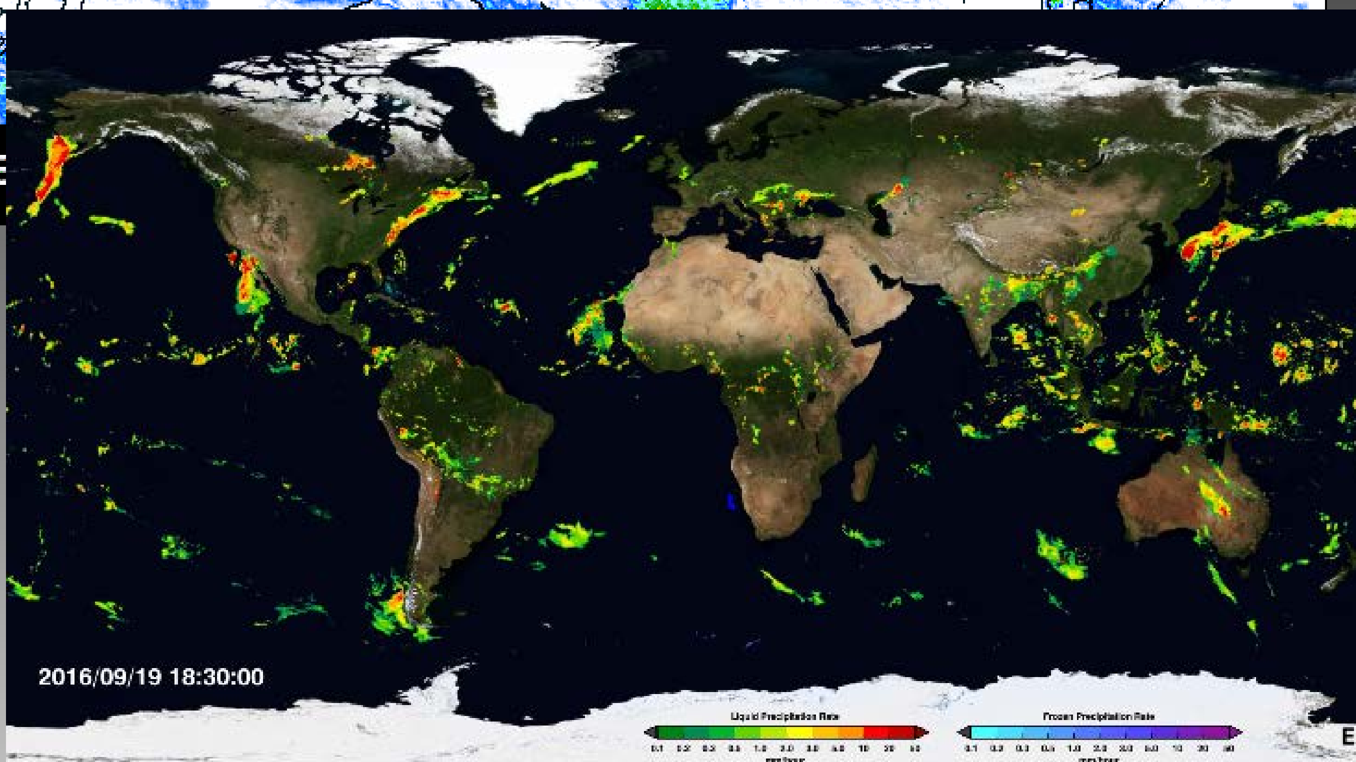
1. Calculate 7-day Antecedent Rainfall Index (ARI) using near real-time IMERG precipitation data
2. Compare ARI to thresholds (derived from TMPA)
3. Identify susceptible areas
4. Create near real-time nowcasts (moderate, high)



Satellite Precipitation



TMPA
0.25 Degrees
2001-present



IMERG
0.1 Degrees
2014-present

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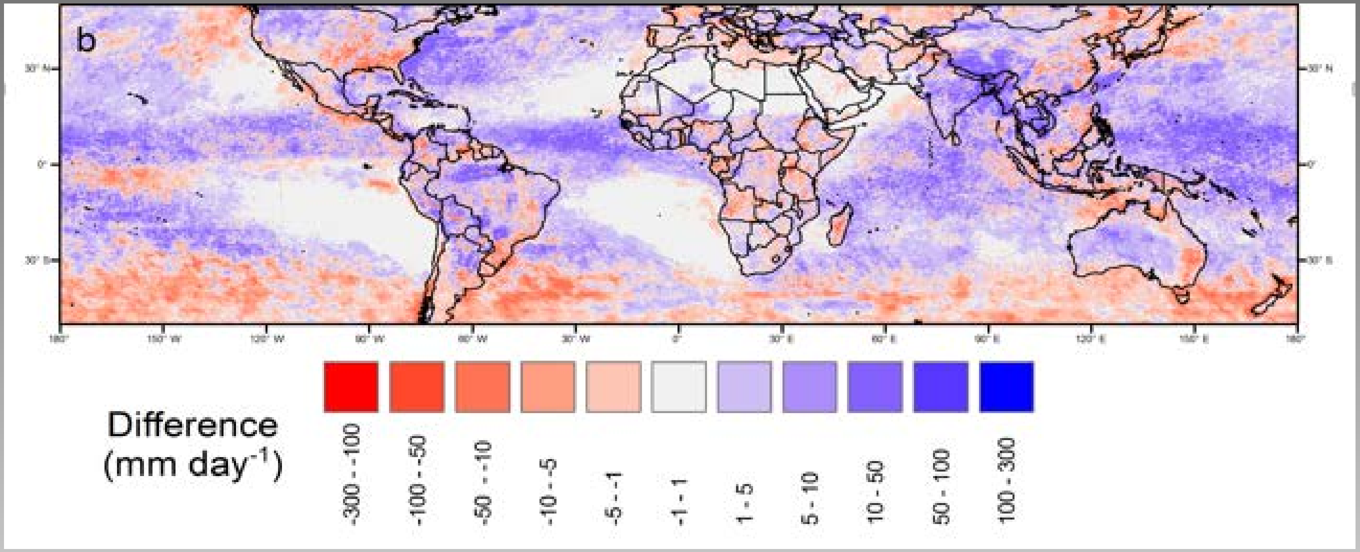
Step 1: ARI Calculation

- Weighted average of the most recent 7 days of rainfall, including the current date if possible.
- $ARI = \frac{\sum_{t=0}^{6} p_t w_t}{\sum_{t=0}^{6} w_t}$, where t = the number of days before the present, p_t = the precipitation at time t, and $w_t = (t+1)^{-2}$

95th Percentile



TMPA-RT – IMERG from March 2015 - 2016 for daily rainfall

RED – IMERG is higher

BLUE – TMPA is higher

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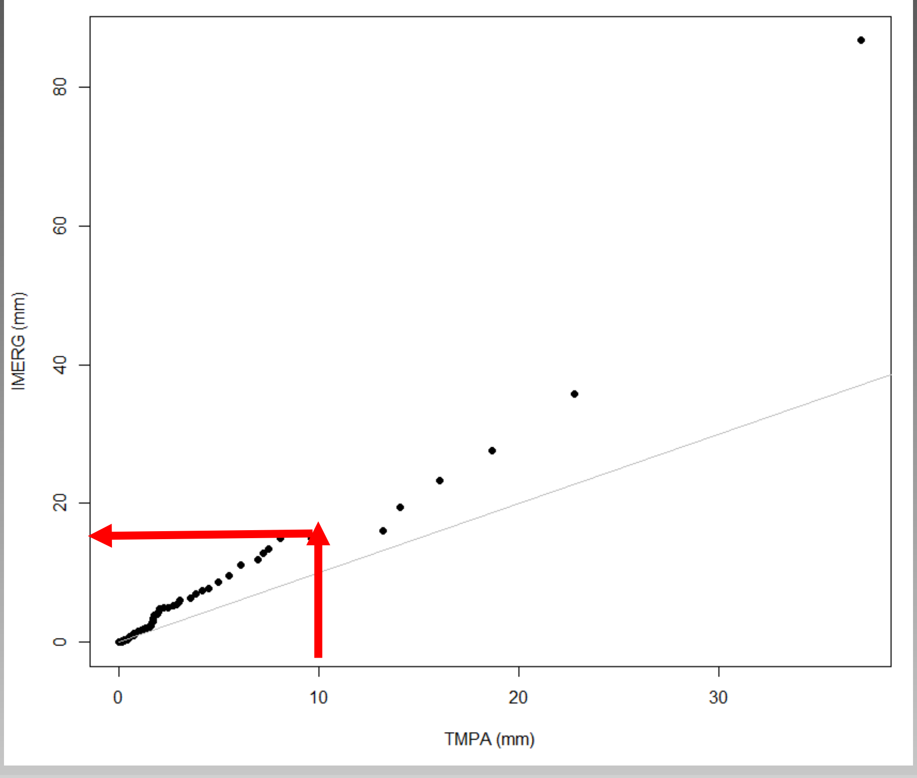
Step 2: Compare ARI to thresholds

- 7-day ARIs were calculated for IMERG and compared historically with TMPA for 2001-2014
- ARI values at each pixel were re-mapped based on the differences between IMERG and TMPA

Stanley et al., *accepted*

Quantile-quantile plot example for one pixel, where the value from one product is used to look up the value of the second product at the same quantile.



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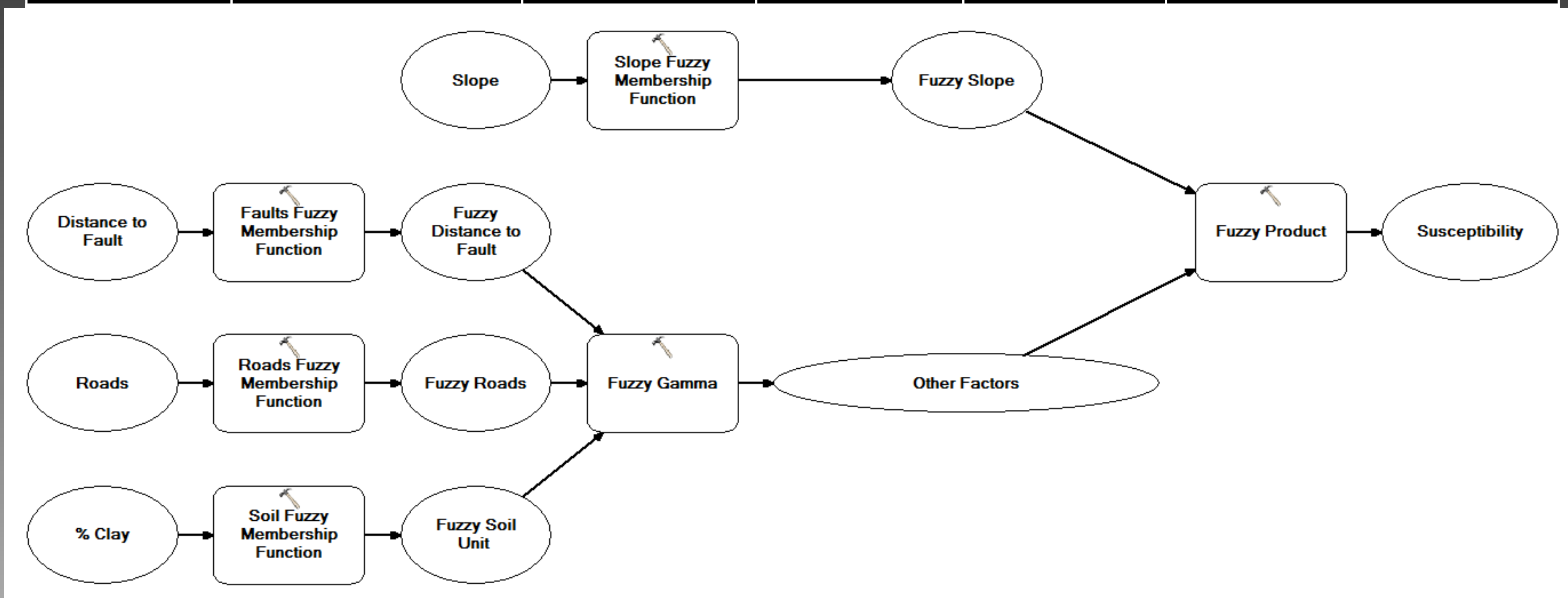
Step 3: Identify susceptible areas

Data Type	Data Set	Resolution/ Accuracy	Explanatory Variable	Extent	Source and Details



Kirschbaum et al. 2016 (methodology)
Stanley and Kirschbaum, ***in review***

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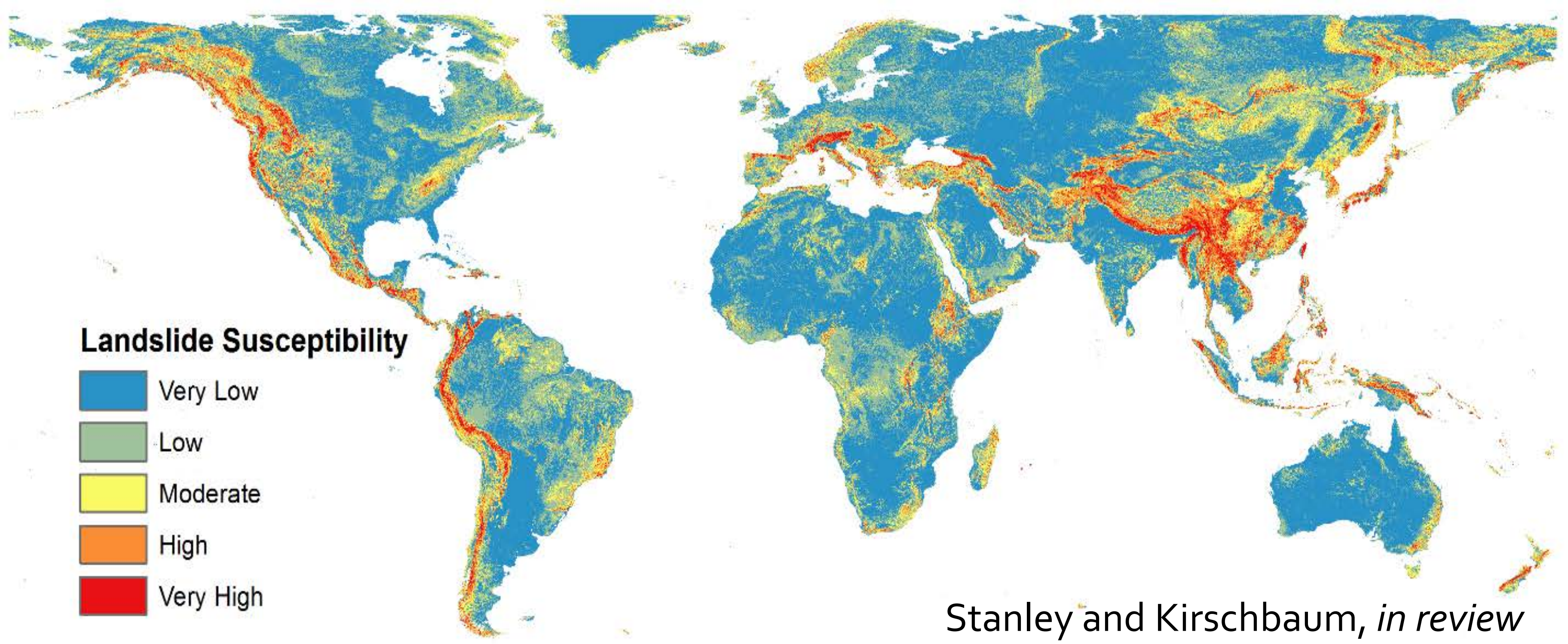
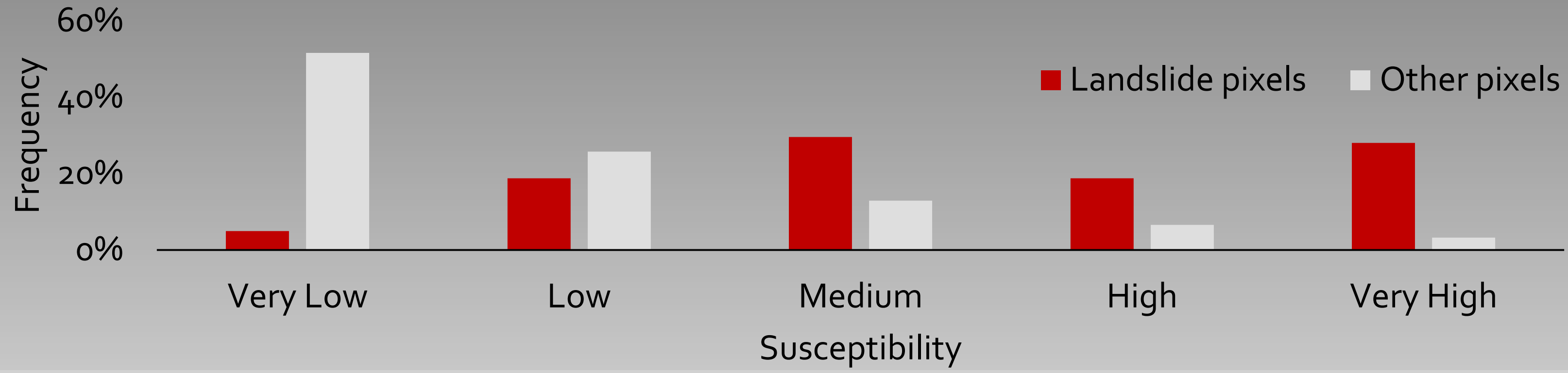
Global landslide susceptibility



Stanley and Kirschbaum, *in review*



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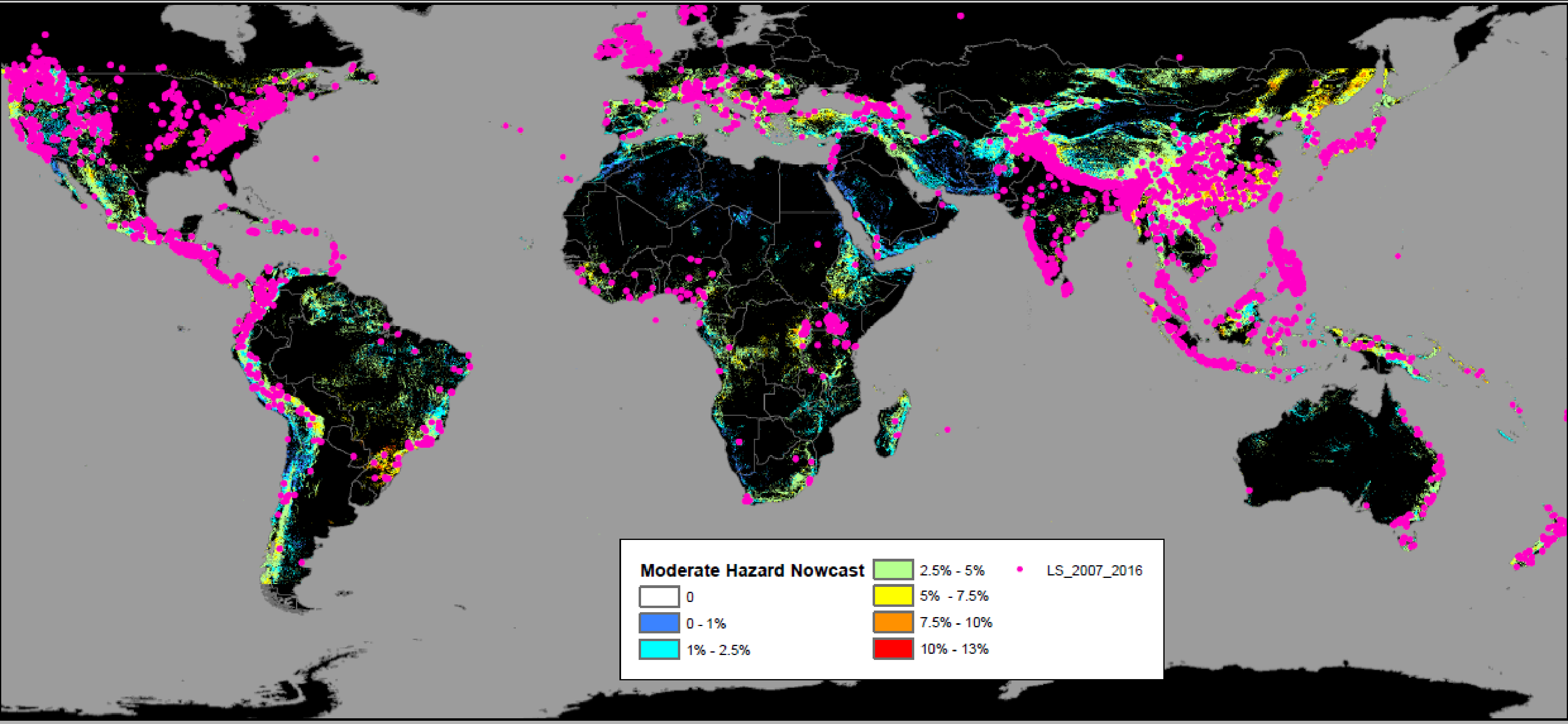
Average Annual Nowcast Rate (using TMPA thresholds) – 2001-2014



Model Validation

- For the time span where the GLC is reporting, our TPR averages ~32% for IMERG data at 1 day, this increases to >50% when considering a 7 day window (±3 days)
- There are several areas where the FPR rate is higher, likely due to overestimation of susceptibility or precipitation

Threshold Values & Range	Forcing Precipitation	1-day TPR	3-day TPR	7-day TPR	FPR	Landslide reports
TMPA 2001-2014	TMPA 2007-2014	26%	36%	47%	1%	3,984
TMPA 2001-2014	TMPA 2015-2016	31%	47%	57% *	1%	289
Adapted TMPA 2001-2014+	IMERG 2015-2016	34%	48%	58% *	1%	289

* Only 275 landslides were used for this assessment

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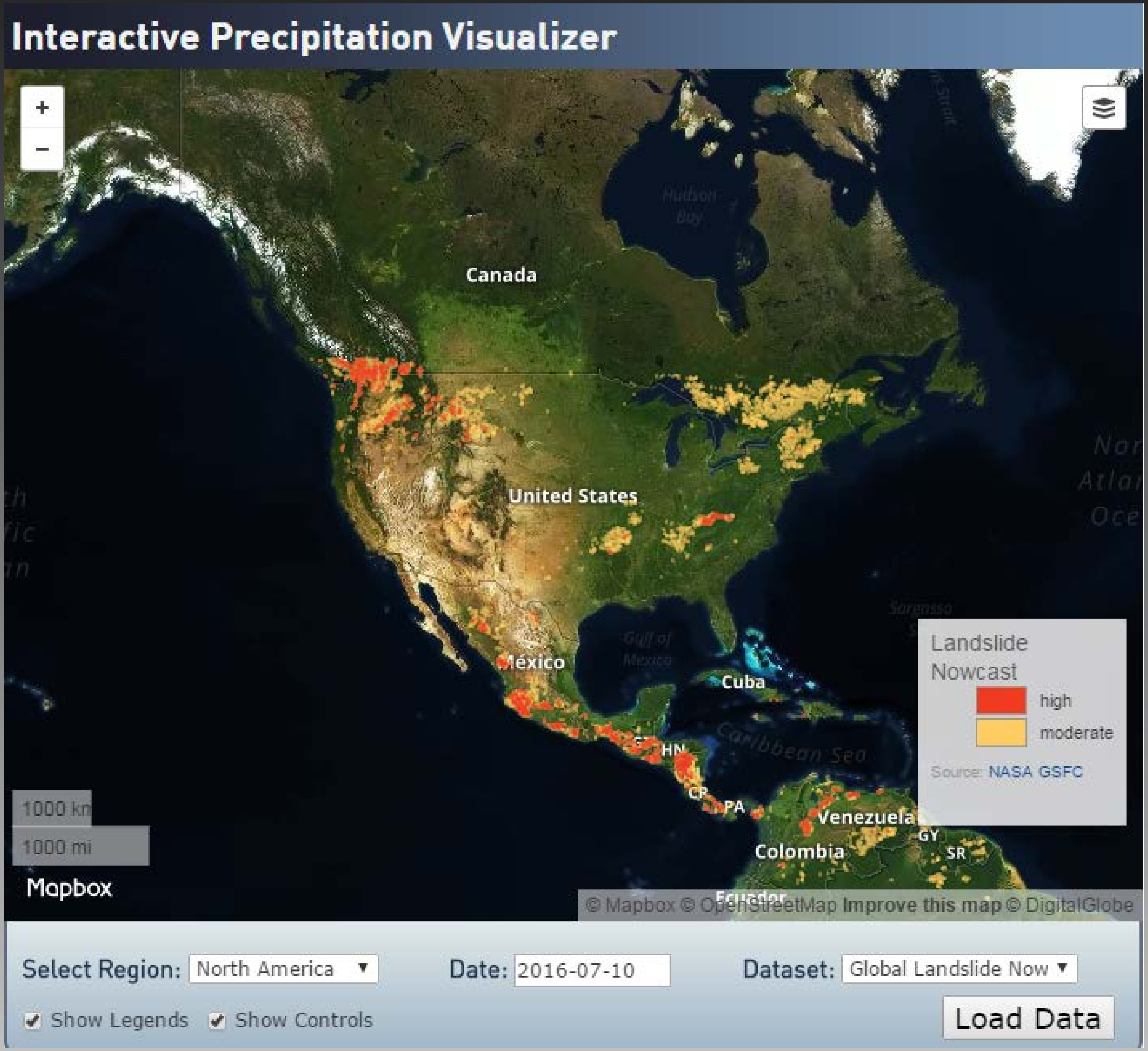
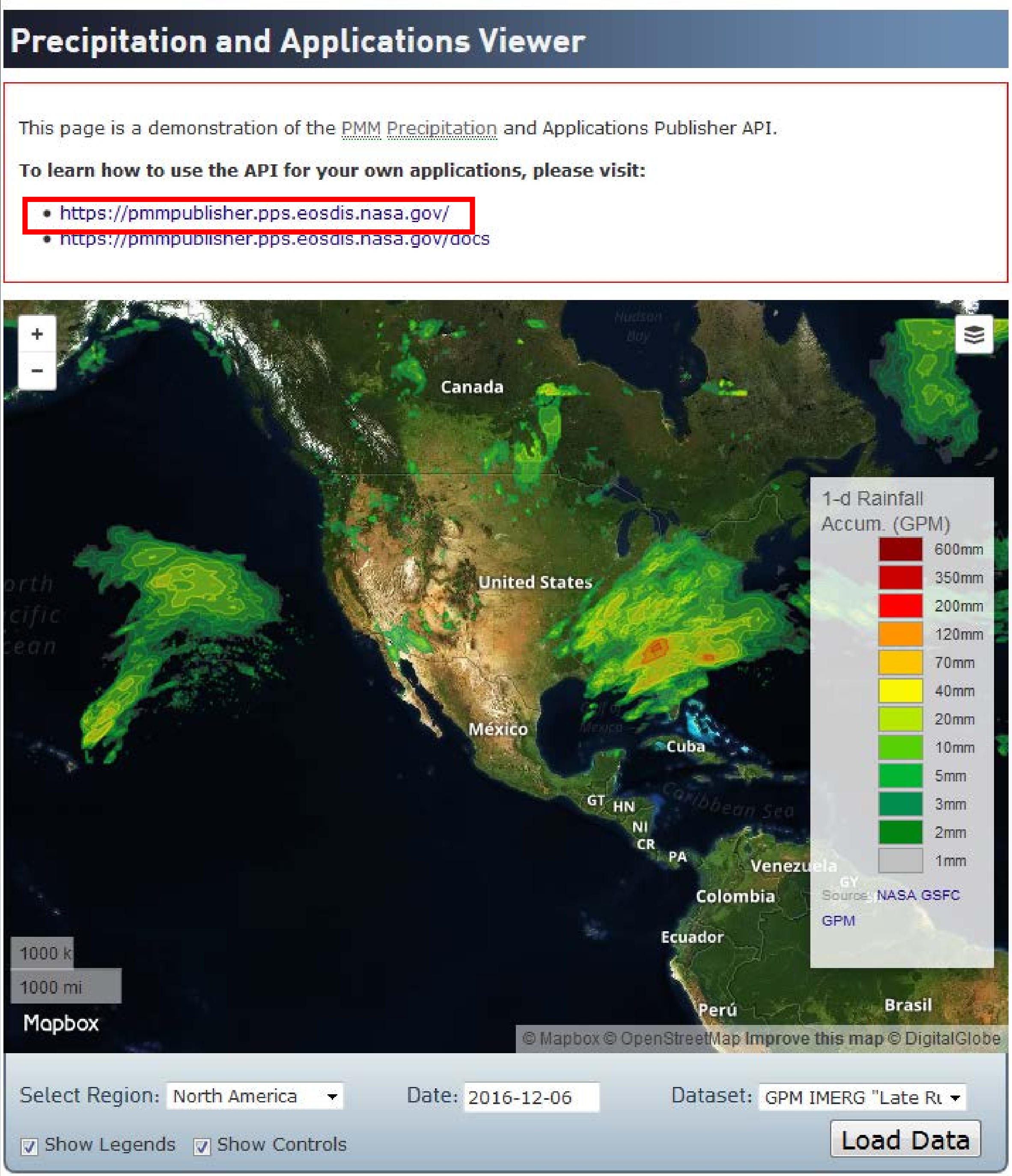
New system



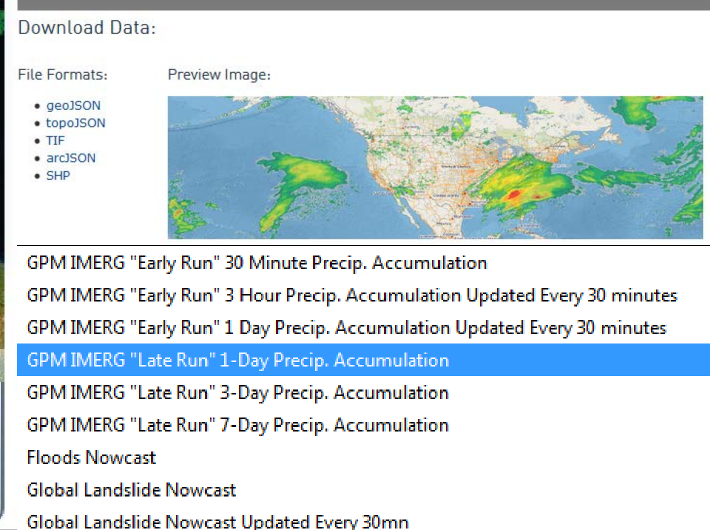
- New interactive viewer that exports landslide nowcasts, flood nowcast, and IMERG precipitation
- **Available datasets:**
  - IMERG 30mn, 3hr, 1day, 7day
  - Flood Nowcast (GFMS, U of MD)
  - Global Landslide Nowcast Model (NASA GSFC)
- Export file formats: geoJSON, topoJSON, arcJSON, TIF, SHP
- Publisher / consumer architecture – use the API to automate data collection or write your own consumer UI.

NOW AVAILABLE: https://pmm.nasa.gov/precip-apps

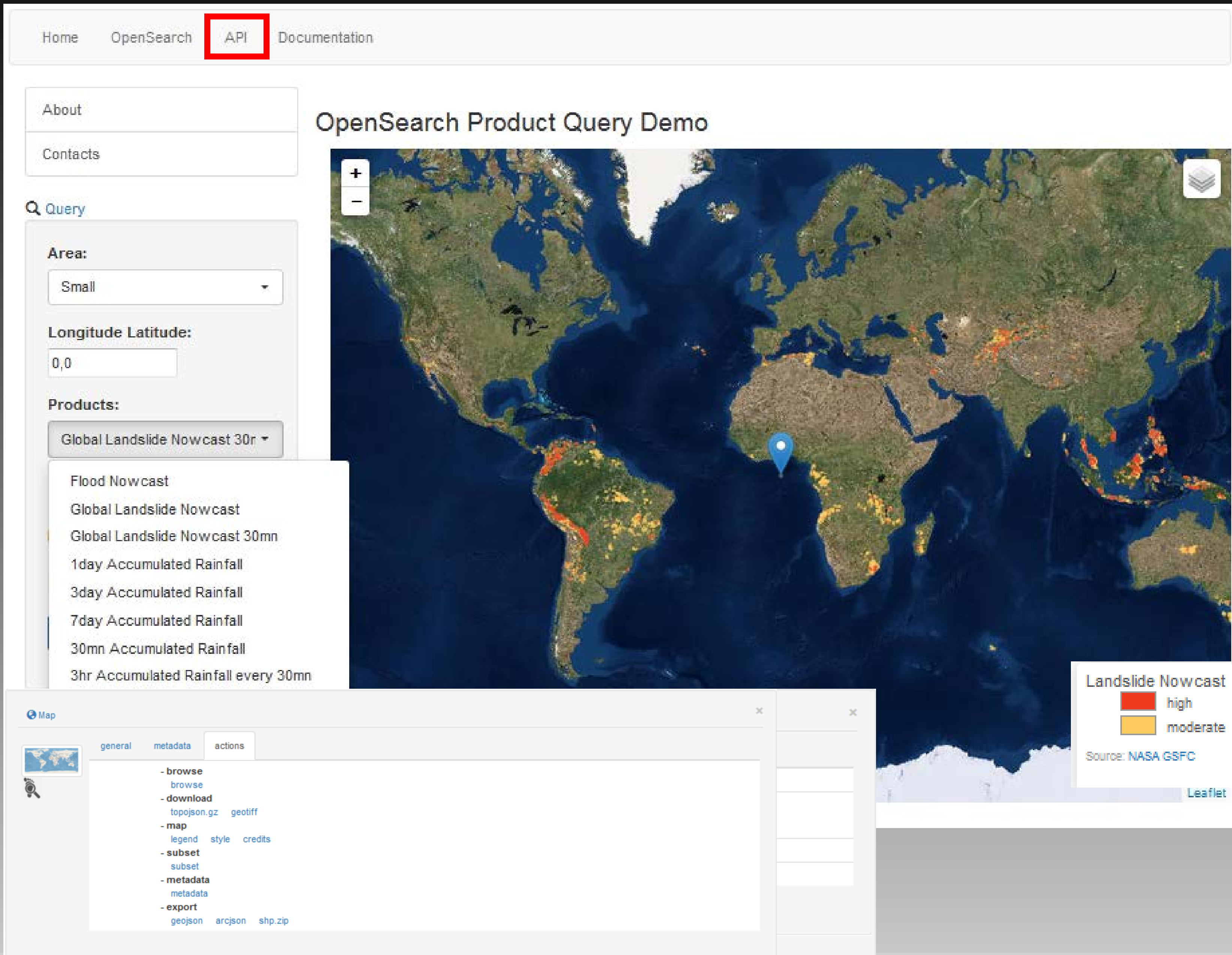


https://pmm.nasa.gov/precip-apps

- Consumer interface
- PMM API Publisher



https://pmmpublisher.pps.eosdis.nasa.gov/opensearch/



API Publisher

https://pmmpublisher.pps.eosdis.nasa.gov/swagger/index.html#!/opensearch/opensearch

https://pmmpublisher.pps.eosdis.nasa.gov/docs

PMM Publisher API

These are the PMM Publisher REST Application Programming Interface Defintions.

Find out more about the PMM Publisher

https://pmmpublisher.pps.eosdis.nasa.gov
Contact the developer
Apache 2.0

opensearch : OpenSearch

Show/Hide | List Operations | Expand Operations

GET /opensearch

Implementation Notes

Generic OpenSearch

Parameters

Parameter	Value	Des
q	precip_30mn (default)	Pro
lat	0	Lati
lon	0	Lon
limit	2	Lim
startTime	(required)	Sta
endTime	(required)	End

Response Messages

HTTP Status Code	Reason	Response Model
200	OK	

Try it out!

Example Request / Response

Below is a typical request with its associated response. Comments have been added to the JSON response file to indicate specific fields of interest.

Request URL

```
https://pmmpublisher.pps.eosdis.nasa.gov/opensearch?q=precip_1d&lat=38&lon=100&limit=1&startTime=2016-11-12&endTime=2016-11-12
```

Response Body


```
{
  "@context": "http://pmmpublisher.pps.eosdis.nasa.gov/vocab",
  "@language": "en",
  "@id": "urn:ojo:opensearch:q=precip_1d&lat=38&lon=100&limit=1&startTime=2016-11-12&endTime=2016-11-12",
  "displayName": "NASA GSFC Product Publisher",
  "@type": "as:Collection",
  "url": "http://pmmpublisher.pps.eosdis.nasa.gov/opensearch?q=precip_1d&lat=38&lon=100&limit=1&startTime=2016-11-12&endTime=2016-11-12",
  "mediaType": "application/activity+json",
  //total number of results returned from the query
  "totalItems": 1,
  //array of length = totalItems, each of which is one dataset that matches the request parameters
  "items": [
    {
      "@id": "gpm_1d_20161112",
      "@type": "geoss:precipitation",
      "displayName": "gpm_1d_20161112",
      //preview .png image of this dataset
      "image": [
        {
          //request this URL to access the preview image
          "url": "https://pmmpublisher.pps.eosdis.nasa.gov/products/s3/r09/gpm_1d/2016/317/gpm_1d.20161112_thn.png",
```

Pacific Disaster Center: Disaster Alert

http://disasteralert.pdc.org/disasteralert/

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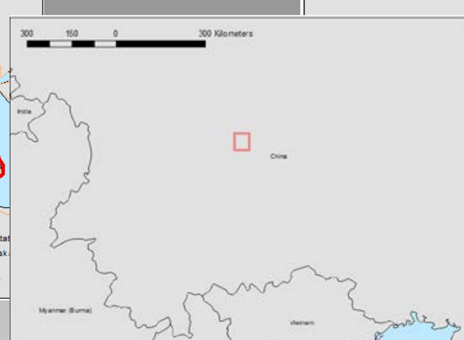
CEOS Landslide Pilot

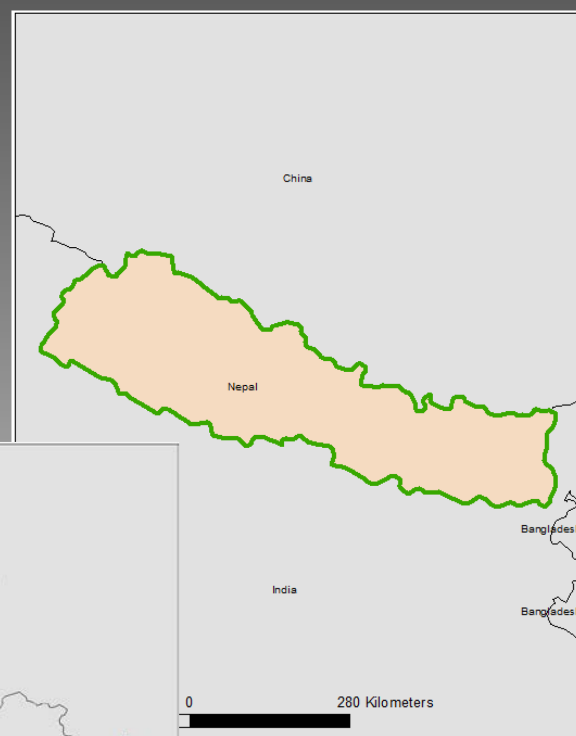
- Demonstrate the **effective exploitation** of Earth observations (EO) data and technologies to **detect, map and monitor landslides and landslide prone hillsides**, in different physiographic and climatic regions.
- To apply satellite EO across the **cycle of landslide disaster risk management**, including preparedness, situational awareness, response and recovery with a distinct multi-hazard focus on cascading impacts and risks.

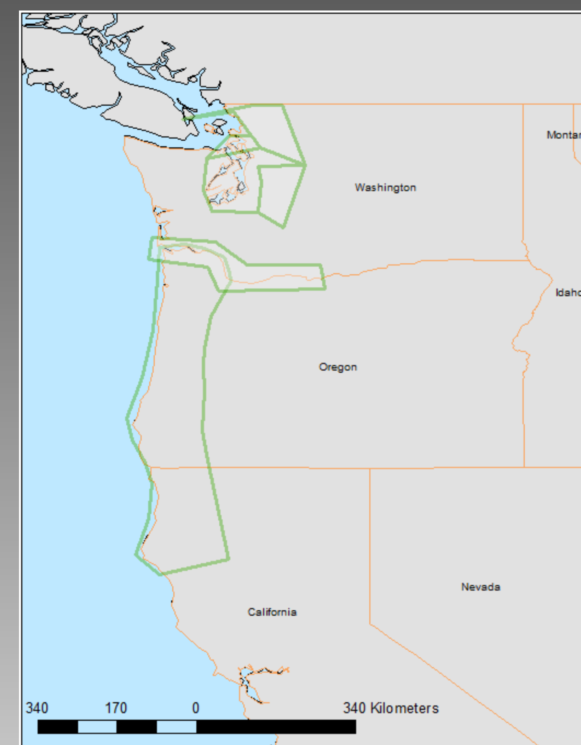
Study sites:

Main: Pacific Northwest, Nepal

Experimental: SE Alaska, China, Caribbean, & Peru



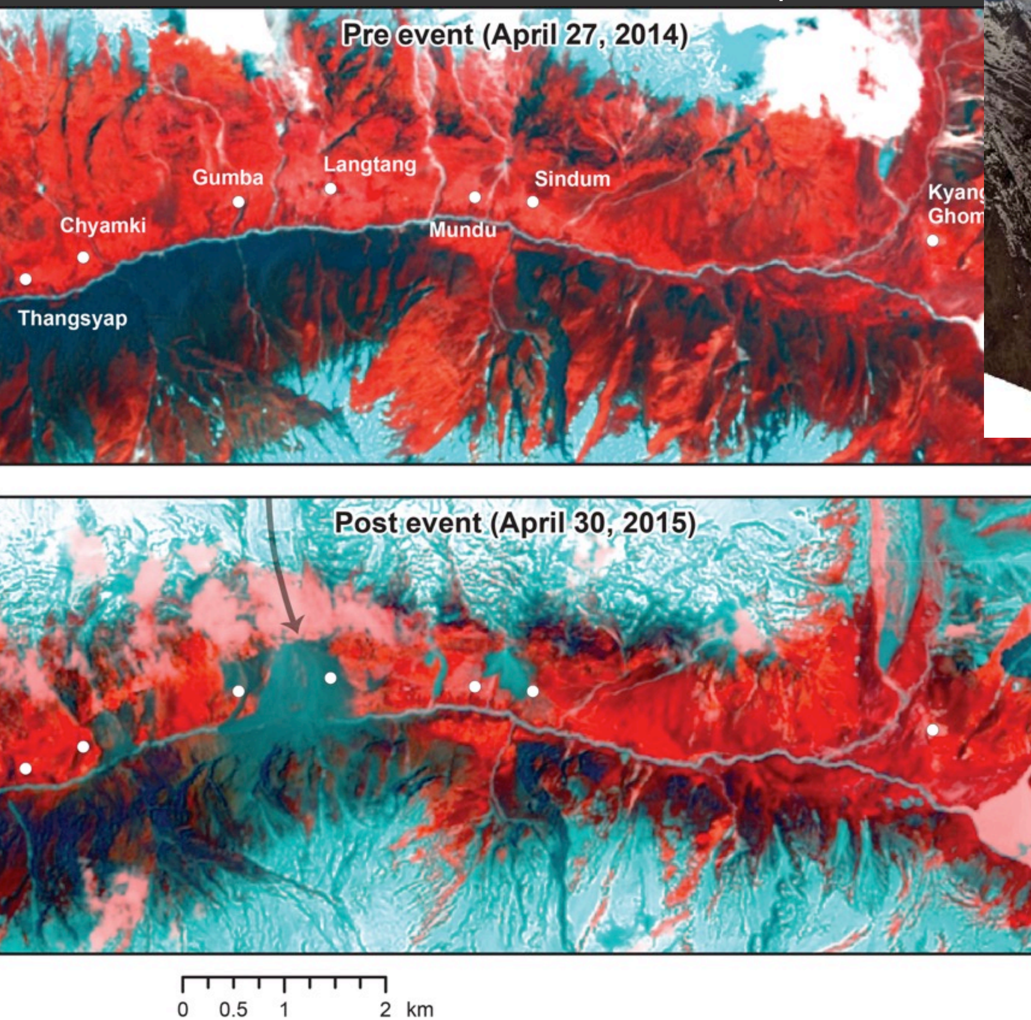




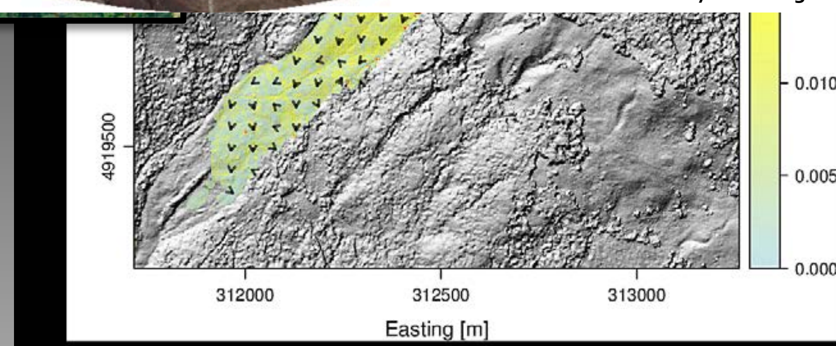
Observing from space

Motion field of the Debre-Sina landslide (Ethiopia) 2003–2016 from a combination of Landsat-7 and Sentinel-2 images

ASTER Pre- and Post-event Gorkha Earthquake



Photos by Volunteer David Breashears. Mosaic by Dan Shugar.



Motion field at La Valette landslide (SE Franch Alps) from a stack of 8 Pléiades images

(Stumpf & Malet, RSE, 2016 – in press)

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Thank you!

References:

- Kirschbaum, D., T. Stanley, and S. Yatheendradas, 2016: Modeling landslide susceptibility over large regions with fuzzy overlay. *Landslides*, **13**, 485–496, doi:10.1007/s10346-015-0577-2. http://dx.doi.org/10.1007/s10346-015-0577-2.
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- Stanley, T., and D. B. Kirschbaum, ***in review***. A heuristic approach to global landslide susceptibility mapping. *Nat. Hazards*.
- Stanley, T., D. B. Kirschbaum, G. J. Huffman, and R. F. Adler, 2016: Approximating long-term statistics early in the Global Precipitation Measurement era. *Earth Interact.*, **submitted**.