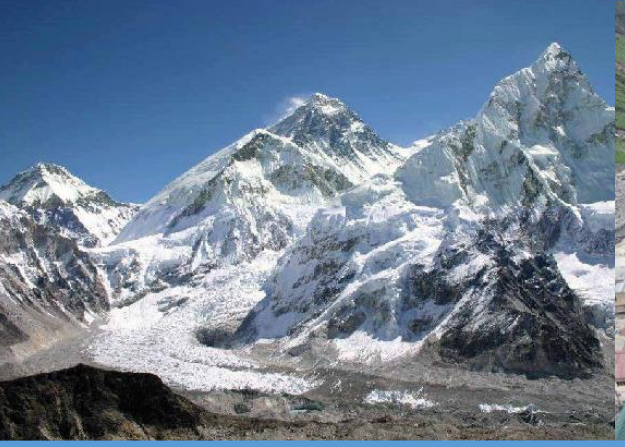
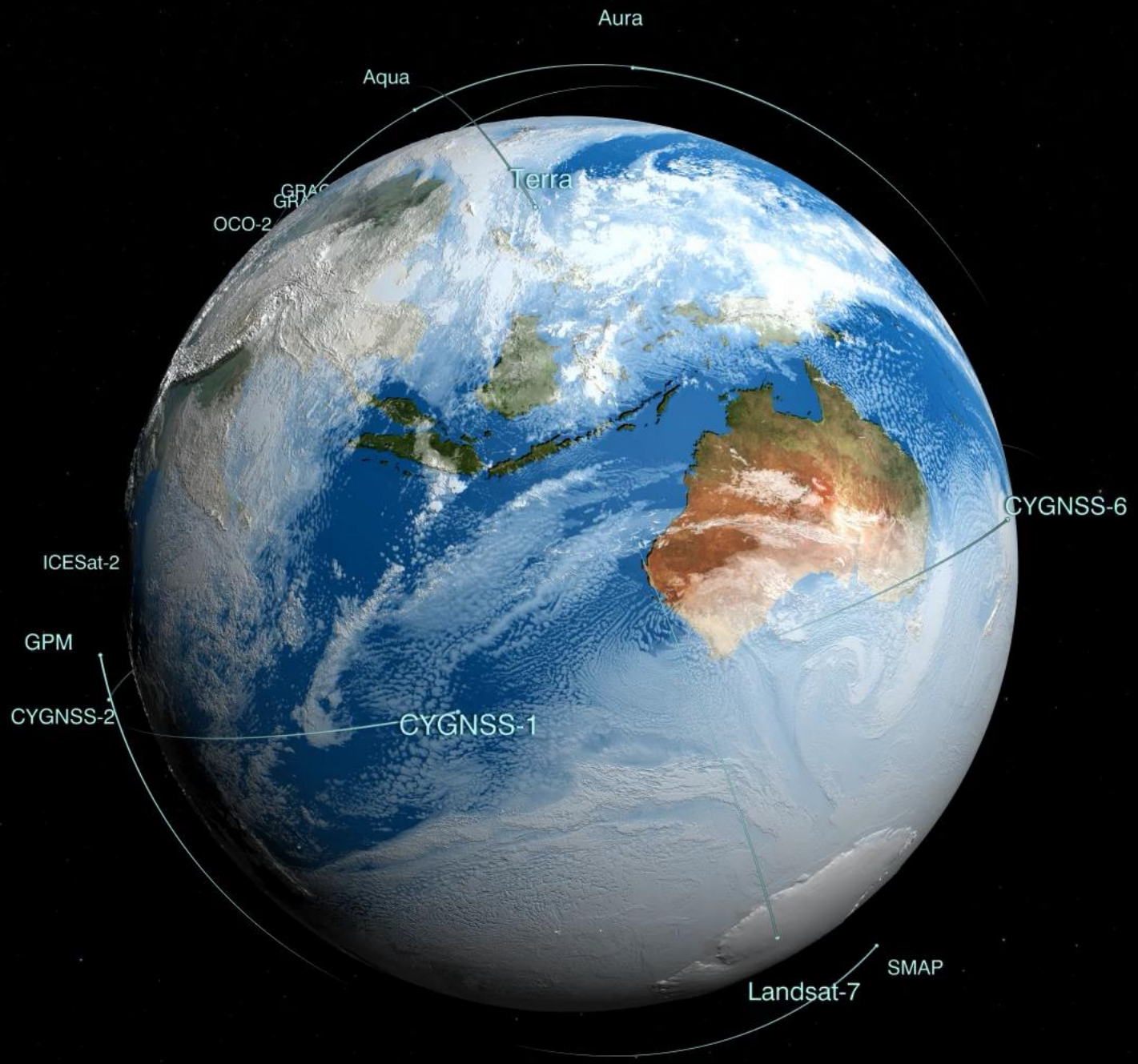



Earth Observation-based landslide mapping, nowcasting and forecasting

Dalia Kirschbaum [1] , Pukar Amatya [1,2] Thomas Stanley [1,2], Sana Khan [1,3], Robert Emberson[1,2] and Nishan Kumar Biswas[1,2]

[1] Hydrological Sciences Laboratory, NASA Goddard Space Flight Center
[2] Universities Space Research Association
[3] Earth System Science Interdisciplinary Center


Aura
Aqua
Terra
OCO-2
CYGNSS-6
ICESat-2
GPM
CYGNSS-2
CYGNSS-1
SMAP
Landsat-7

Landslide Mapping & Modeling: A multi-scale approach using remote sensing data

Local landslide mapping, slope-stability modeling

Regional landslide modeling & mapping

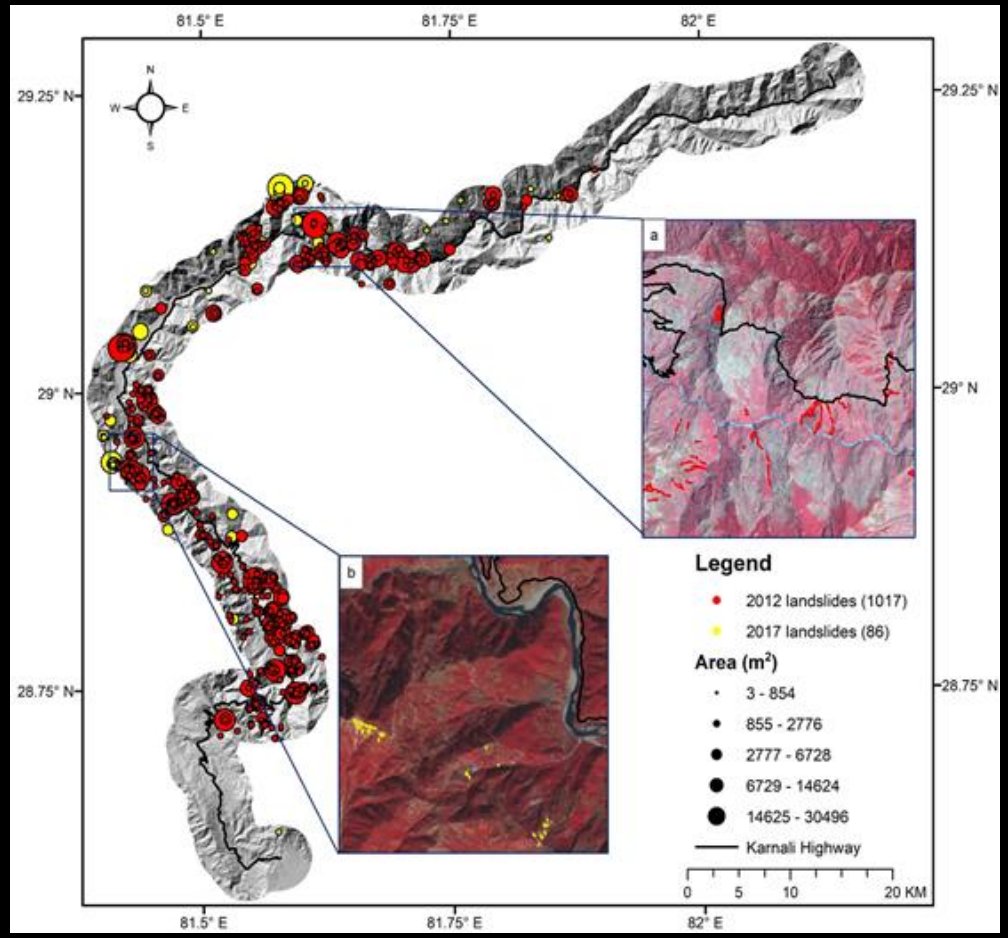
Global rainfall-triggered landslide hazard characterization (LHASA)

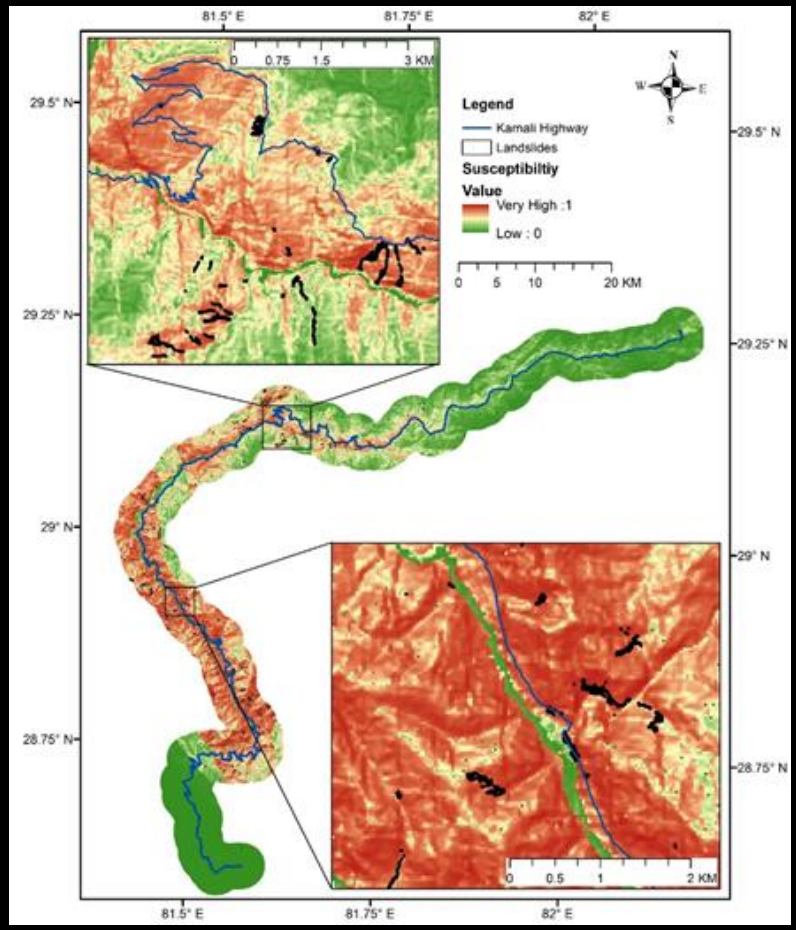
Local

Regional

Global

Landslide and susceptibility mapping along the Karnali highway





Amatya et al. (2019)

Semi-Automatic Landslide Detection (SALaD) system

Python packages:

GDAL

Orfeotoolbox (OTB)

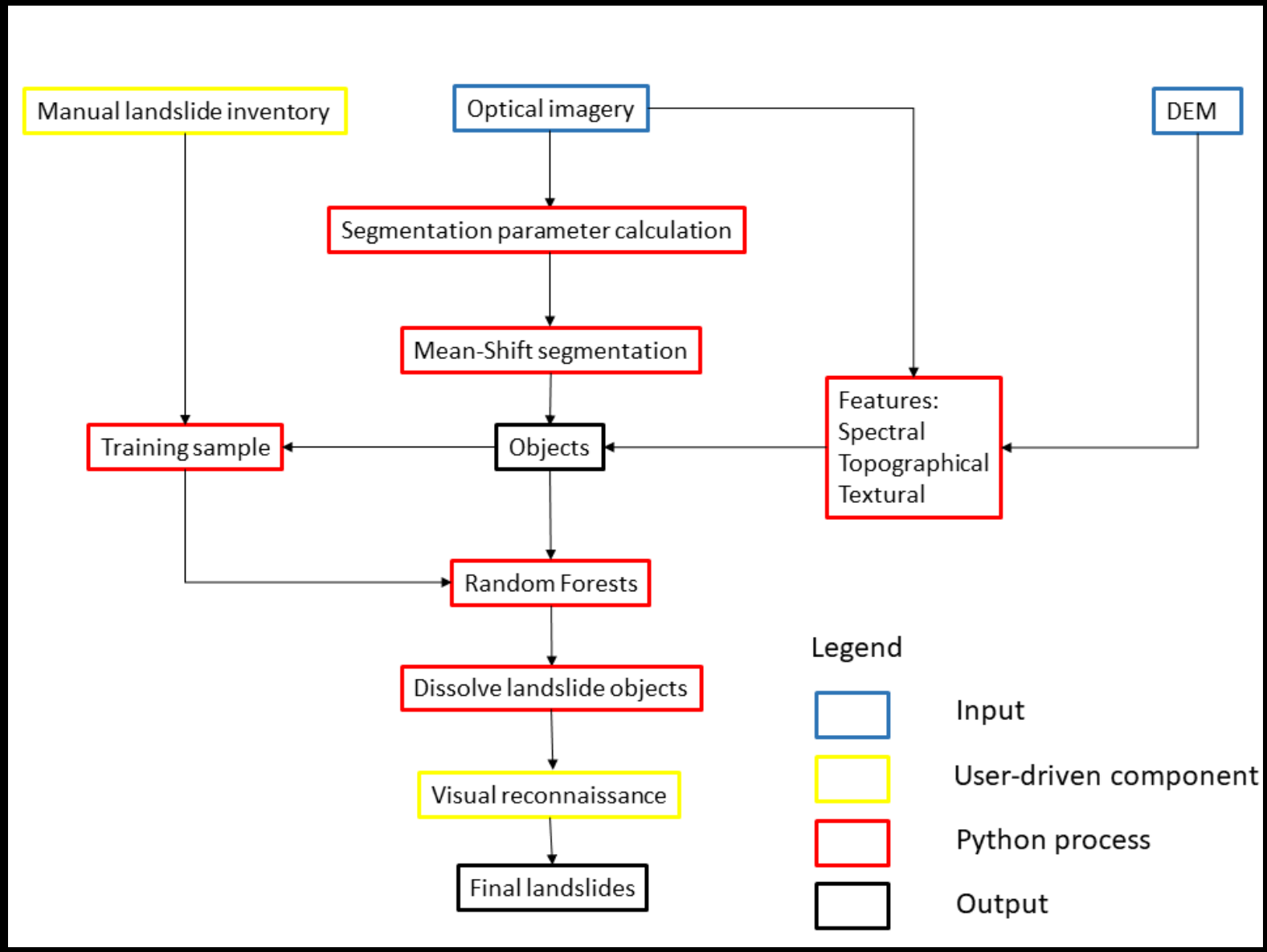
Raster stats

Scikit-Learn

Geopandas

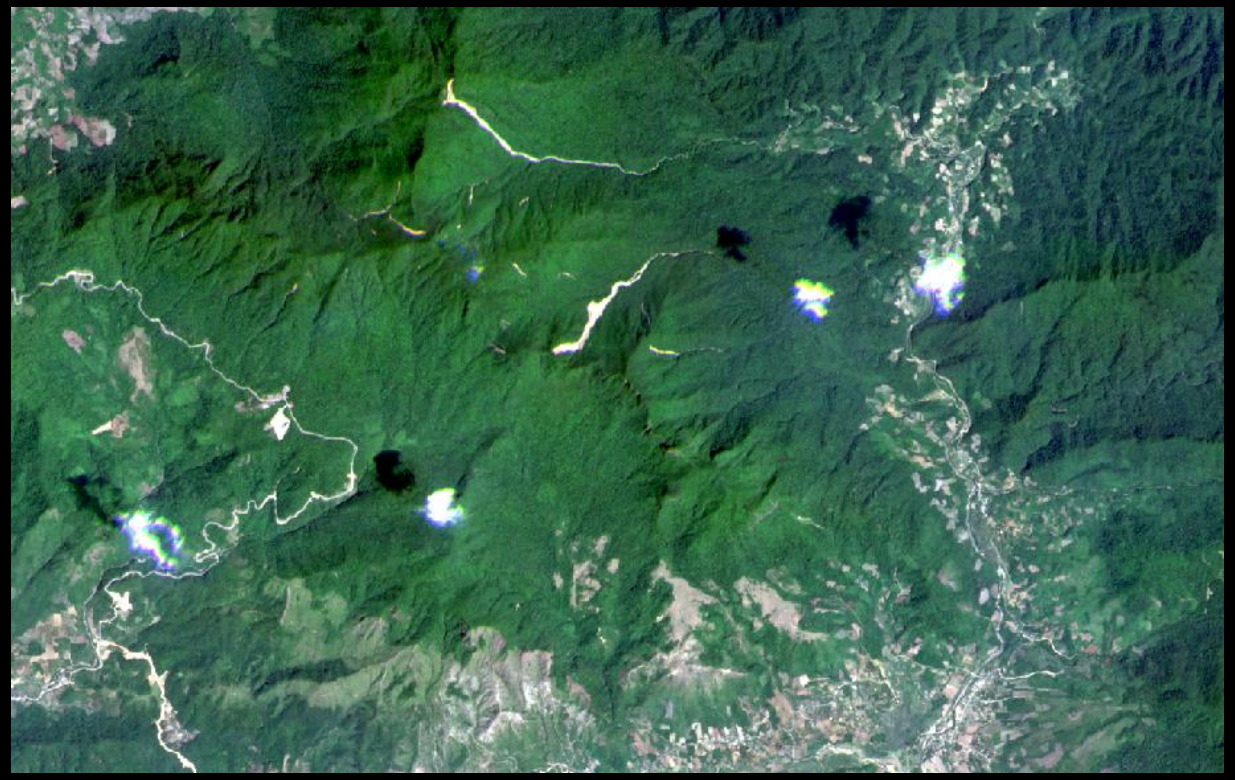
Operating System: Linux or Windows

Currently configured in NCCS ADAPT Linux platform

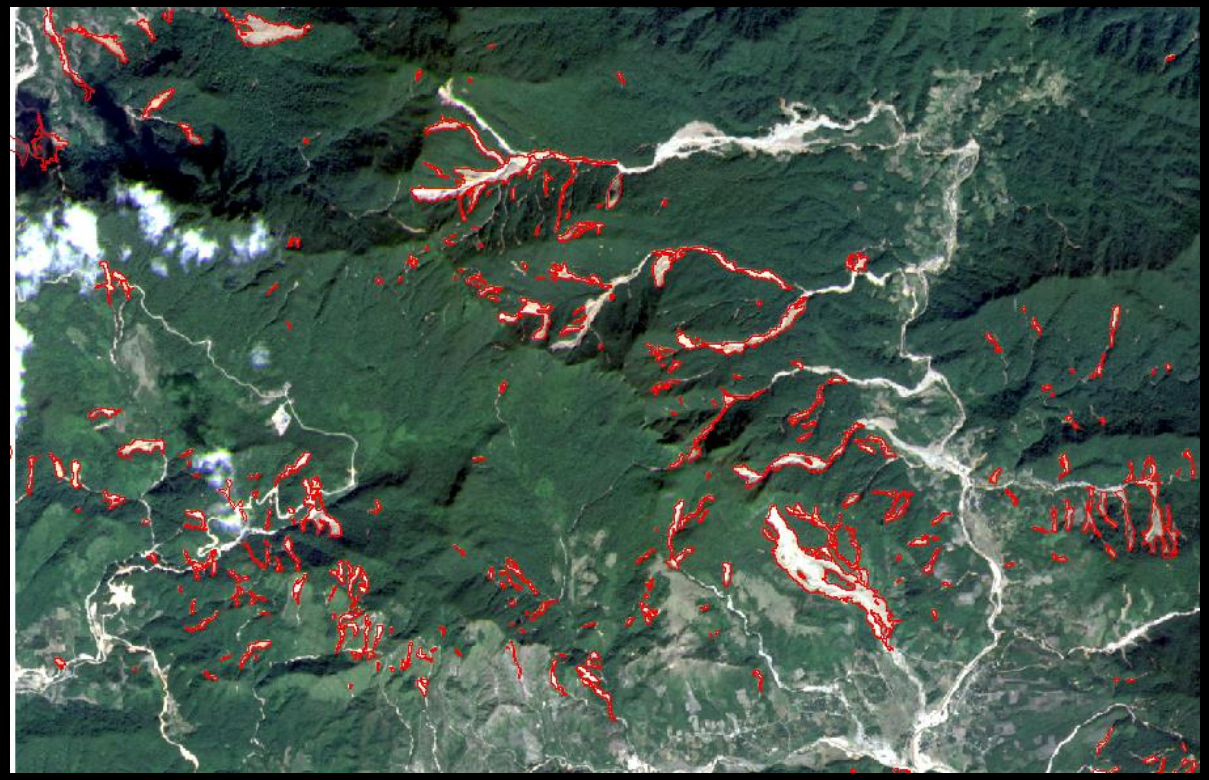


Amatya et al. (2021)

Landslides mapped using SALaD and Planet Imagery

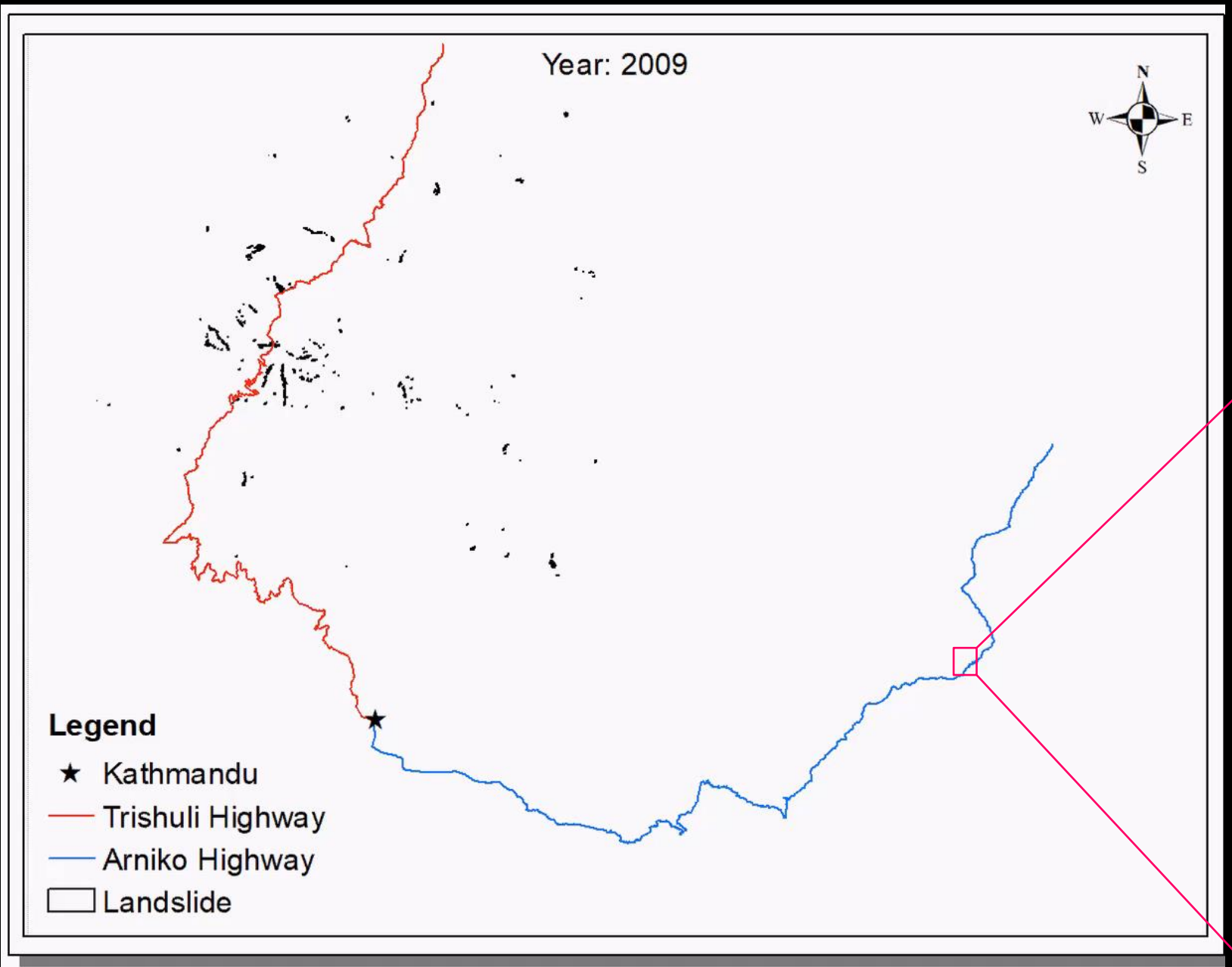


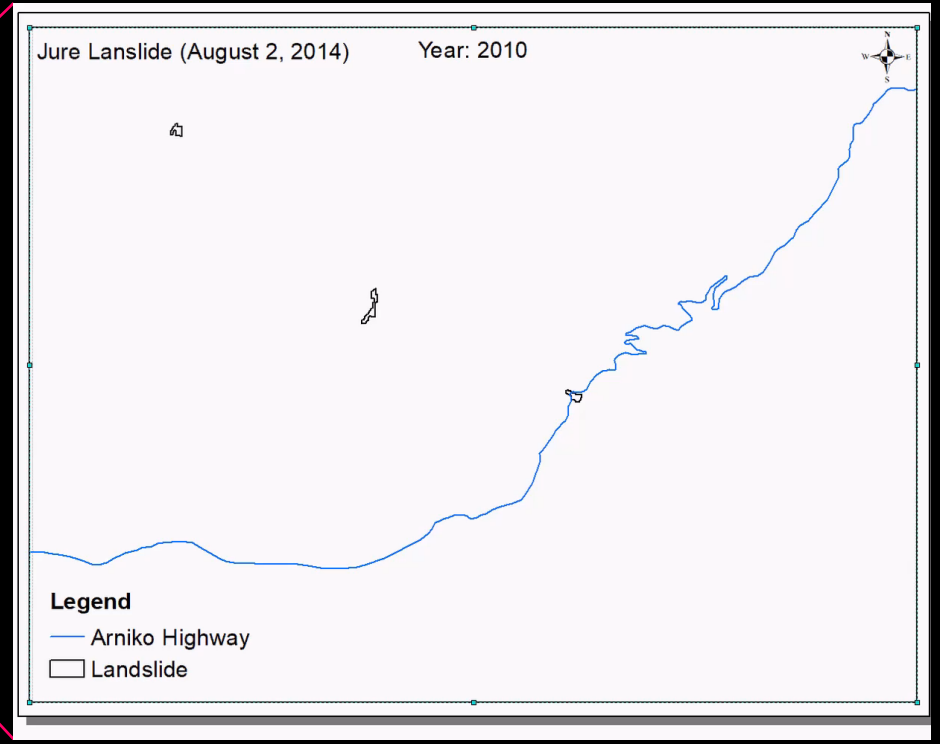
Pre



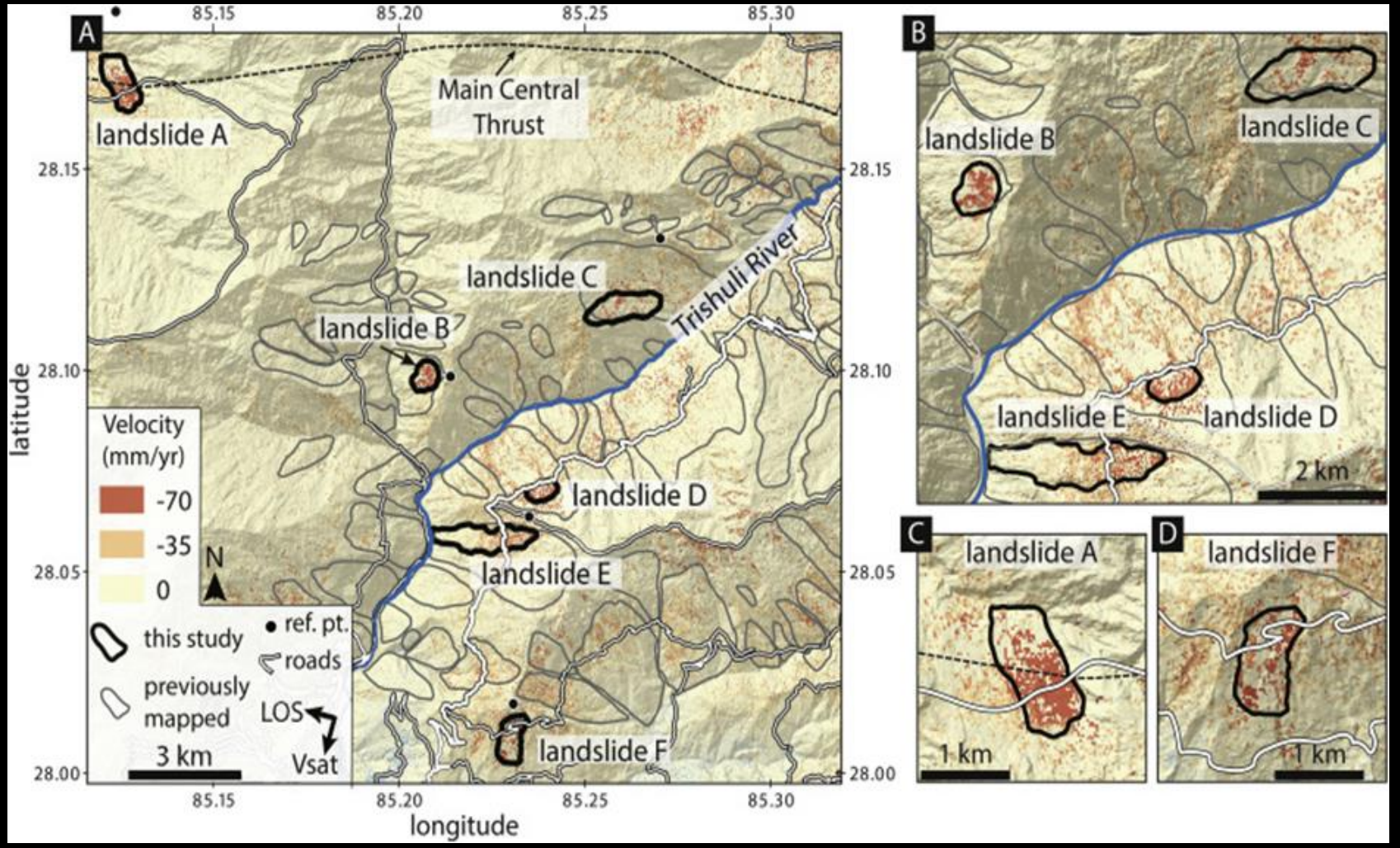
Post

Landslides along Arniko and Pasang Lhamu highway (2009 – 2018)





Trishuli Basin Sentinel-1 Slow -moving landslides

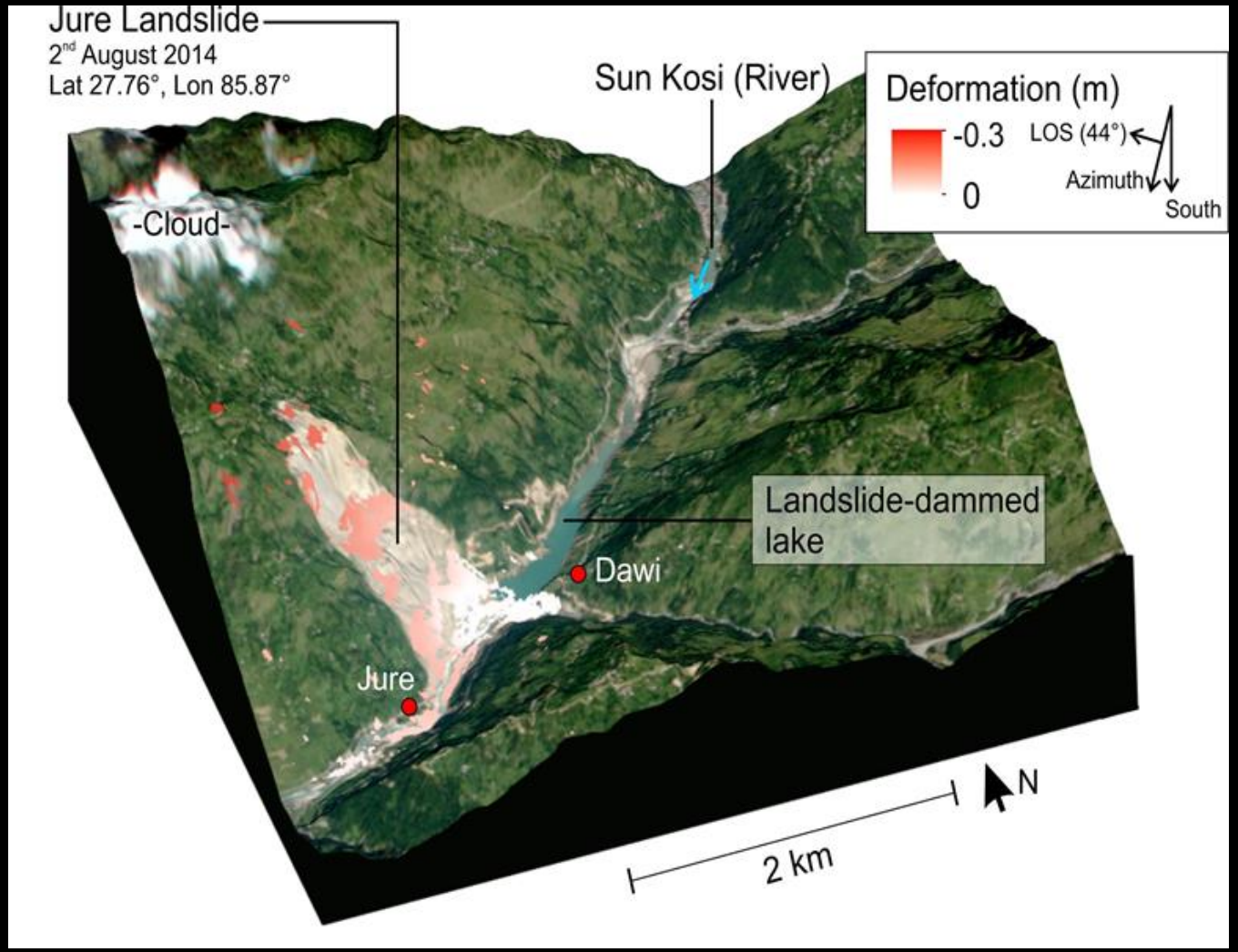


A novel method is developed to detect landslides in mountainous terrain. InSAR time-series is used to identify and monitor slow-moving landslides

Bekaert et al. (2020)

Monitoring Jure landslide using CSK data post 2015 EQ, Nepal

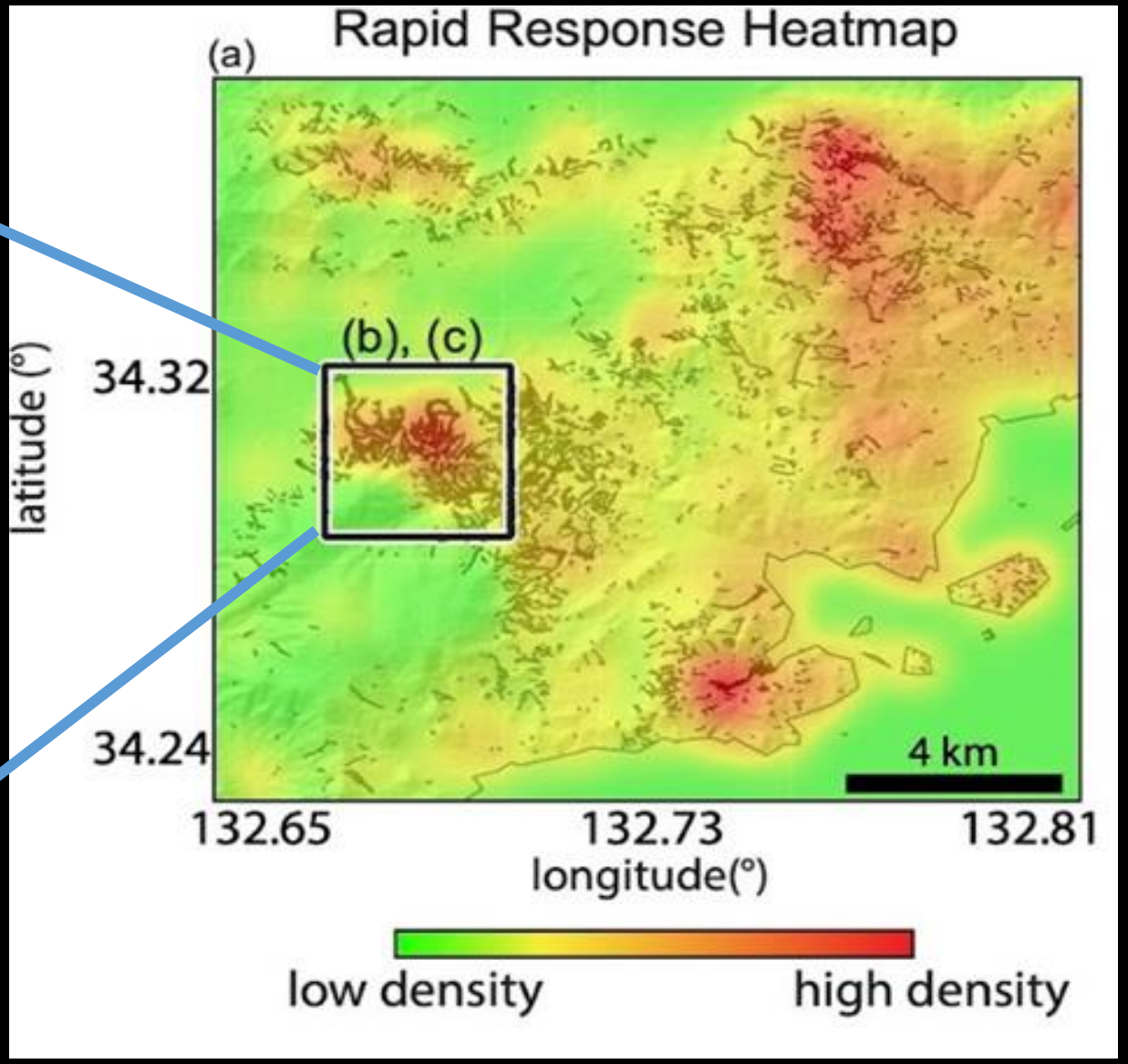
On the outcrop of the Jure Landslide scarp, surface deformation of about 0.3 m in line-of-sight (LOS) direction, was measured by stacking three post-seismic InSAR pairs using SBAS analysis.



Kirschbaum et al. (2019)

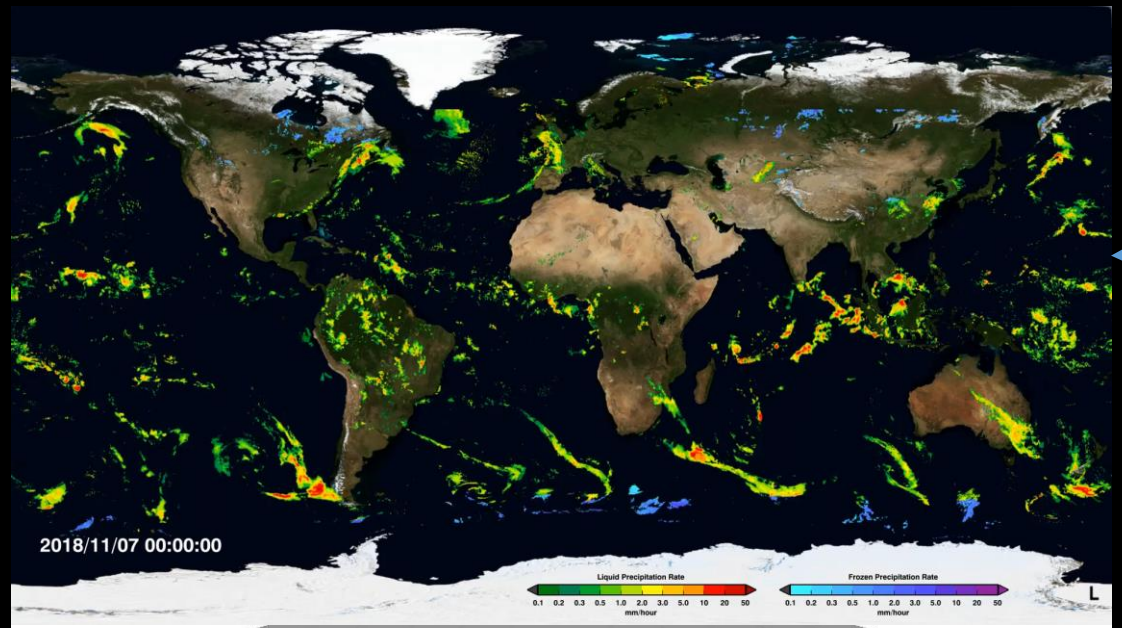
SAR amplitude-based change detection method in Google Earth Engine

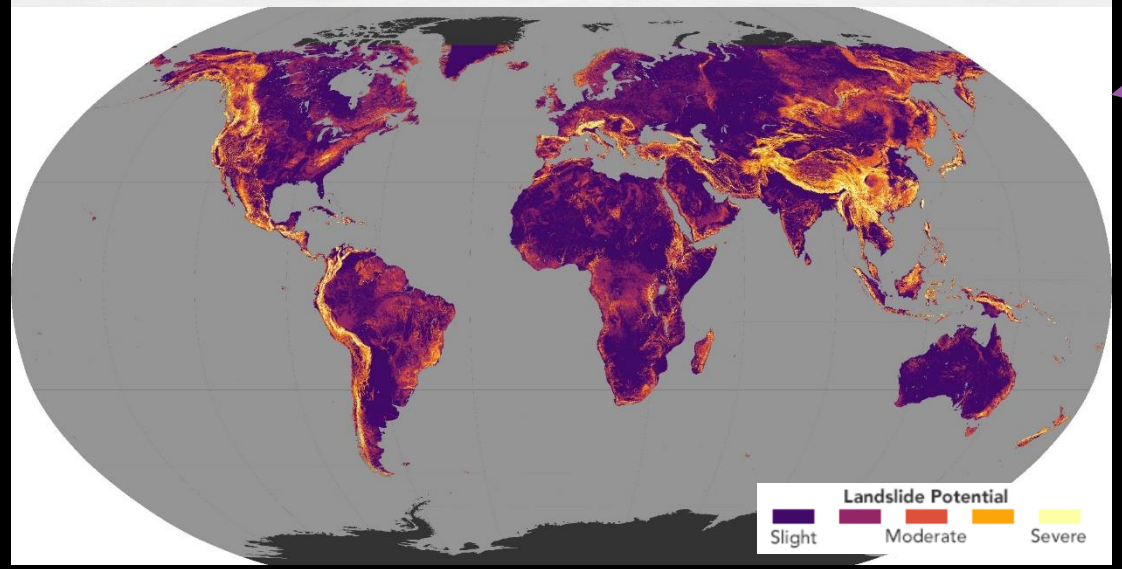
Hiroshima, Japan,
28 June - 8 July 2018

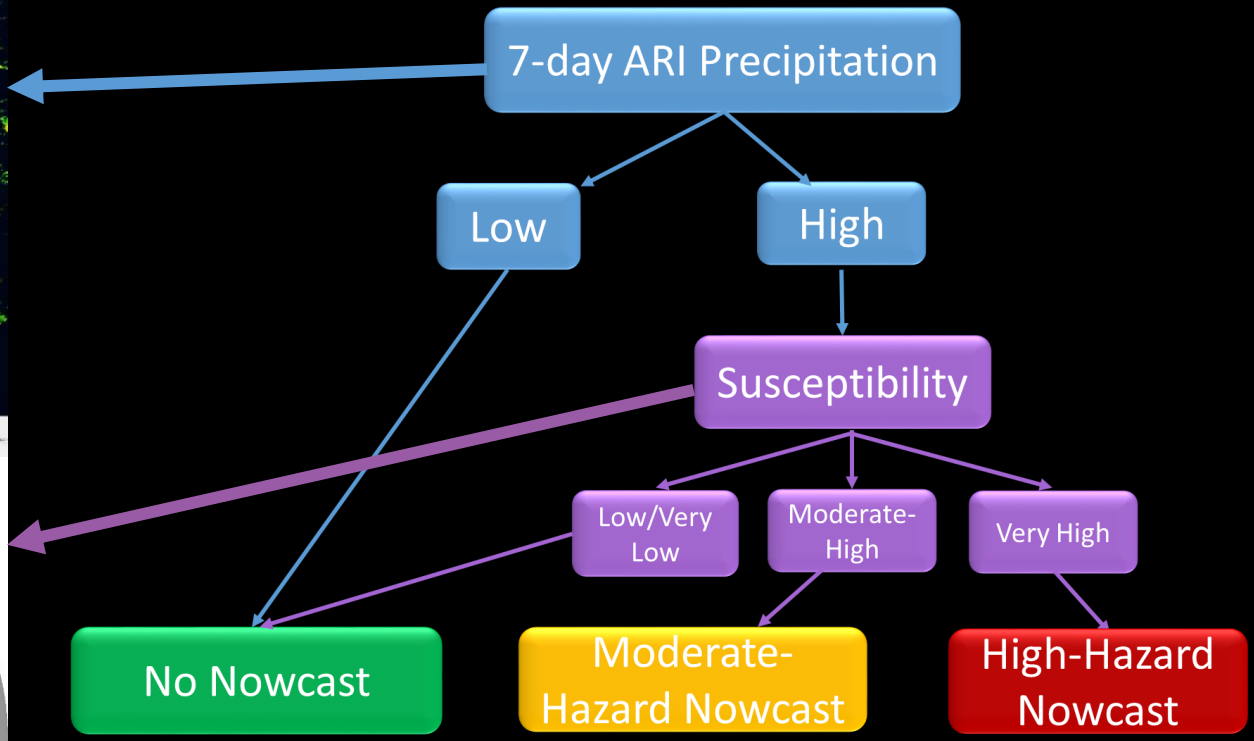


Alexander Handwerger (JPL) and Mong-Han Huang (Uni. Maryland)

Landslide Hazard Assessment for Situational Awareness (LHASA Version 1.1)





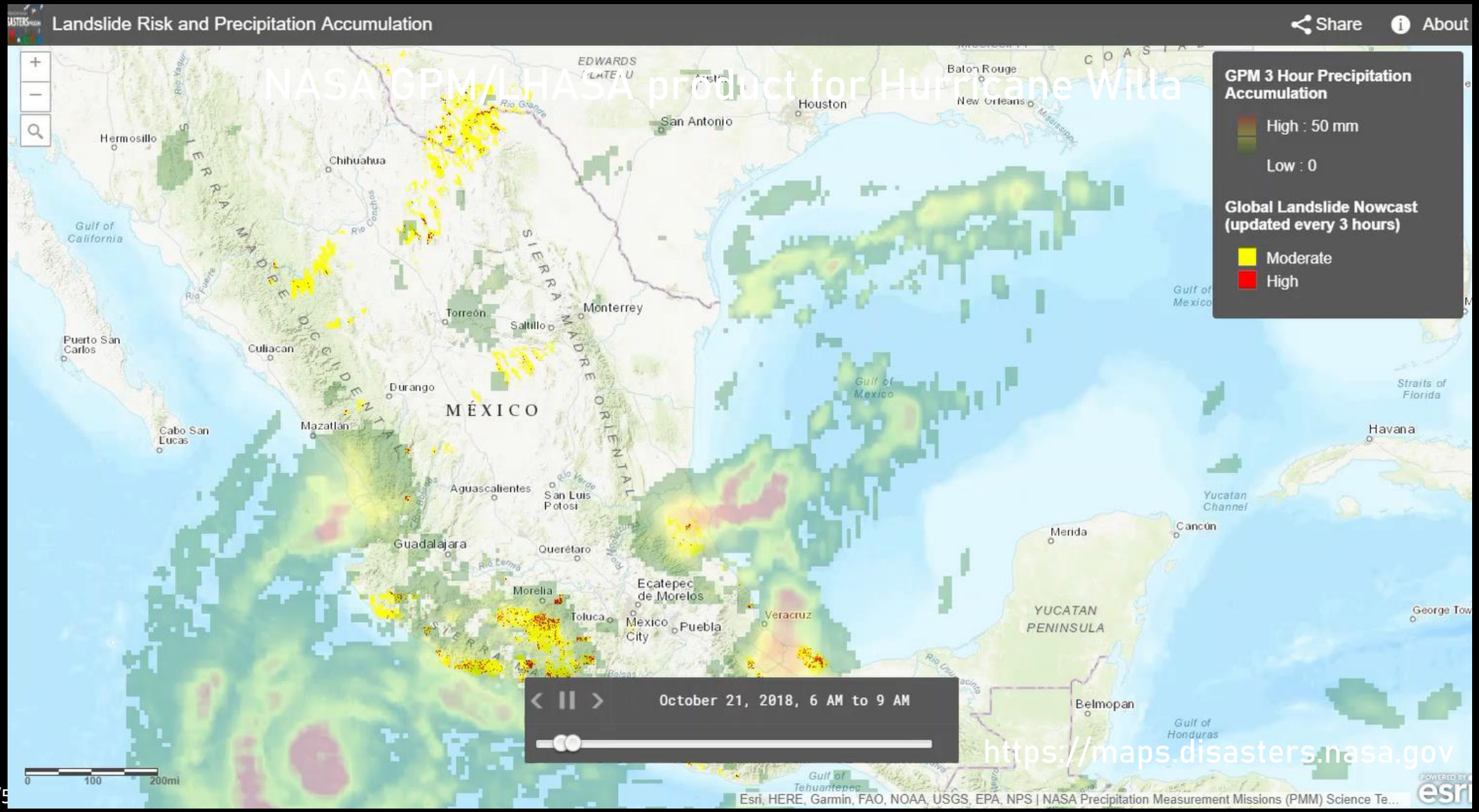


Kirschbaum and Stanley 2018

https://landslides.nasa.gov

Kirschbaum and Stanley (2018)

LHASA Output for Hurricane Willa, 2018



LHASA 2.0

Static Factors
DEM
Geology
Rock strength

Triggers
Satellite Rainfall
Rainfall Forecast
Soil Moisture
Snow Mass

Earthquake
PGA
(% shaking),
recent events

Post-fire Debris Flow Module

Landslide Nowcast & Forecasts:
Probability of
- Rainfall-triggered landslides
- Post-fire debris flows

Exposure Model
Population
Roads
Infrastructure

Methodology:
XGBoost machine-learning model trained with different types of landslide data

Stanley et al. (2021)

LHASA 2.0 Nowcast dynamic variables

Antecedent conditions represent year-to-date

Soil Wetness = Full-profile Soil Moisture / Porosity

SMAP L4

Soil Temperature

SMAP L4

Antecedent Rainfall = $\sum_{t=-1}^{-2} rain$

IMERG Late NRT

Current Daily Rainfall Total

IMERG Early NRT

						t=-2	Yesterday	Today (t0)	Tomorrow

LHASA 2.0 Forecast dynamic variables

Antecedent conditions represent year-to-date

Soil Wetness = Full-profile Soil Moisture / Porosity GEOS-FP

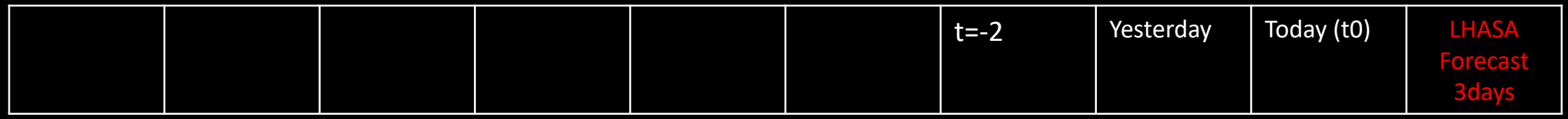
Snow Depth GEOS-FP

Antecedent Rainfall = $\sum_{t=-1}^{-2} rain$

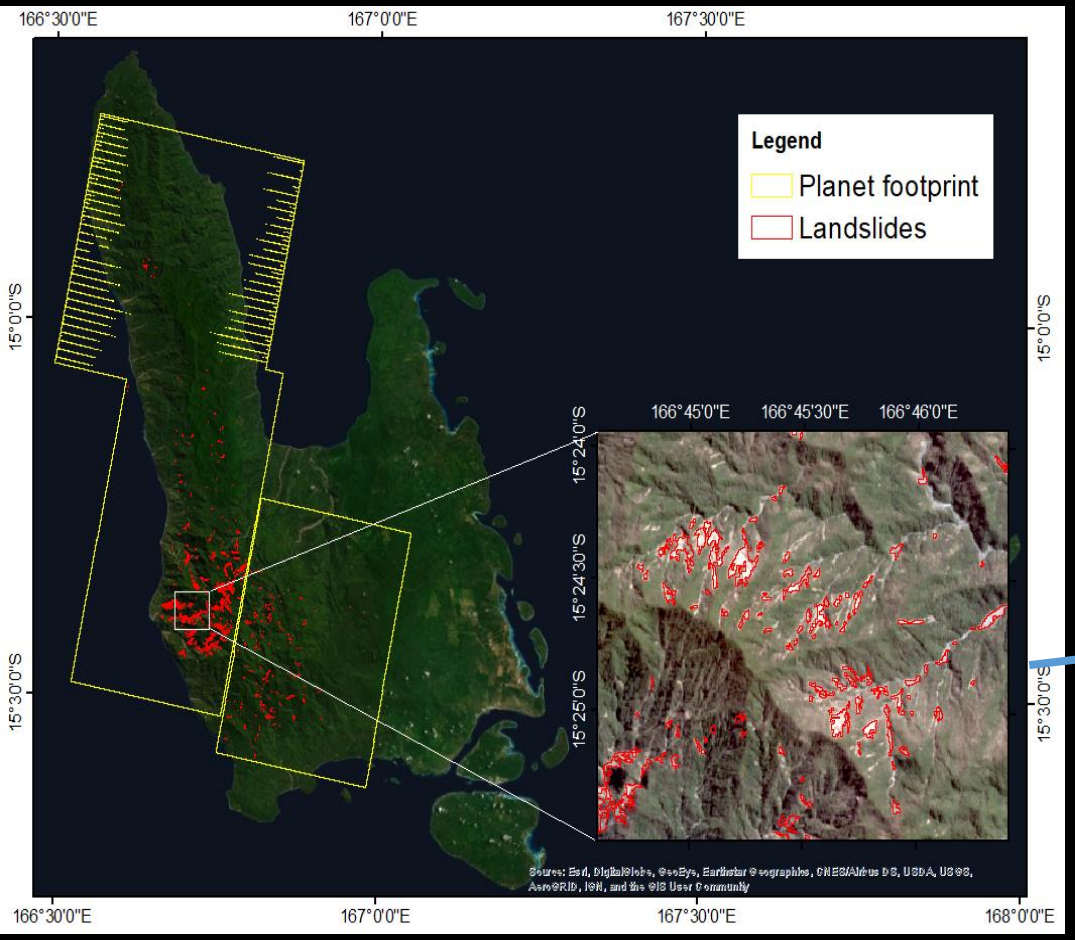
IMERG Late NRT

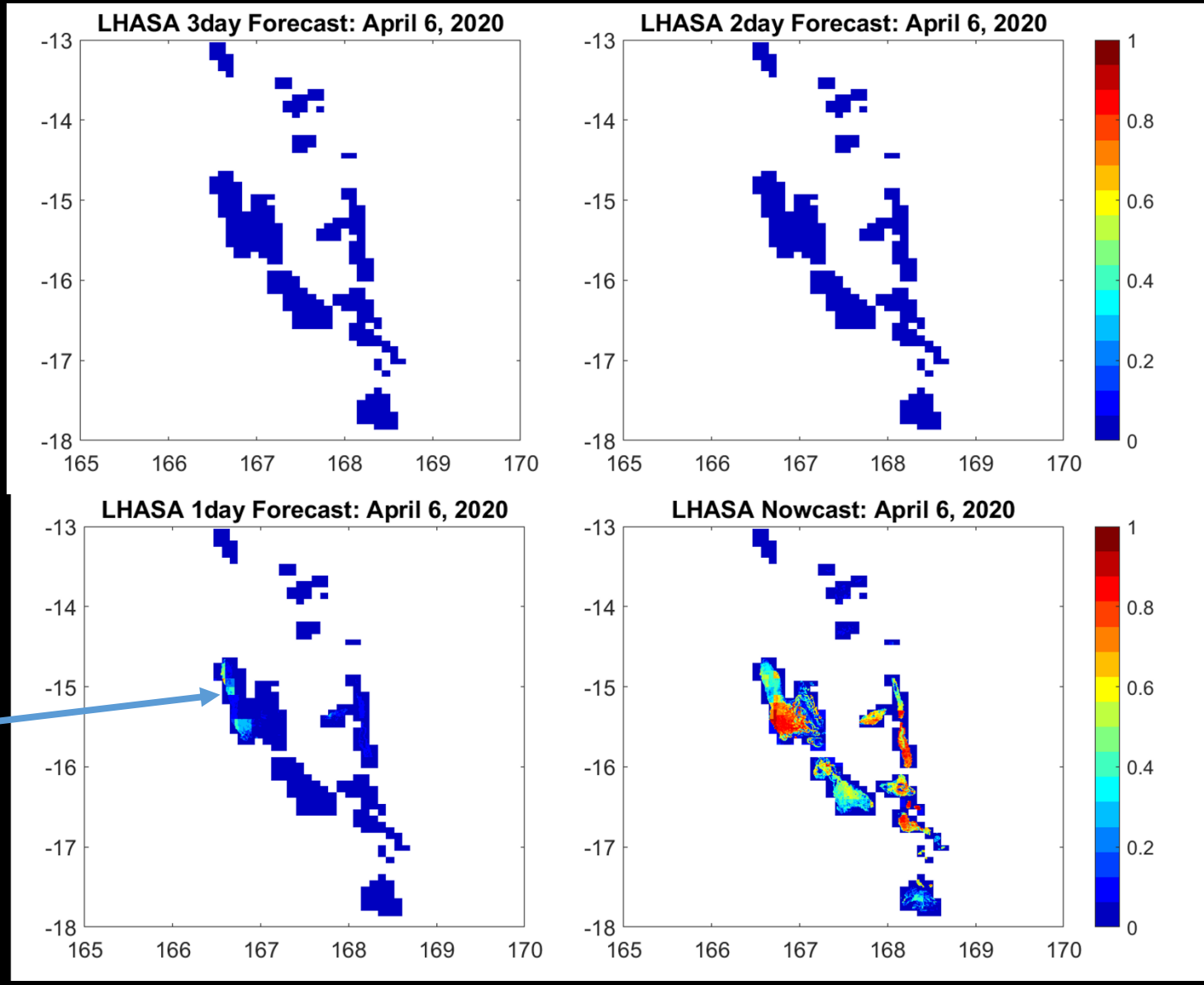
Forecasted Precipitation 1-3 days

GEOS FP



LHASA 2.0 and SALaD outputs

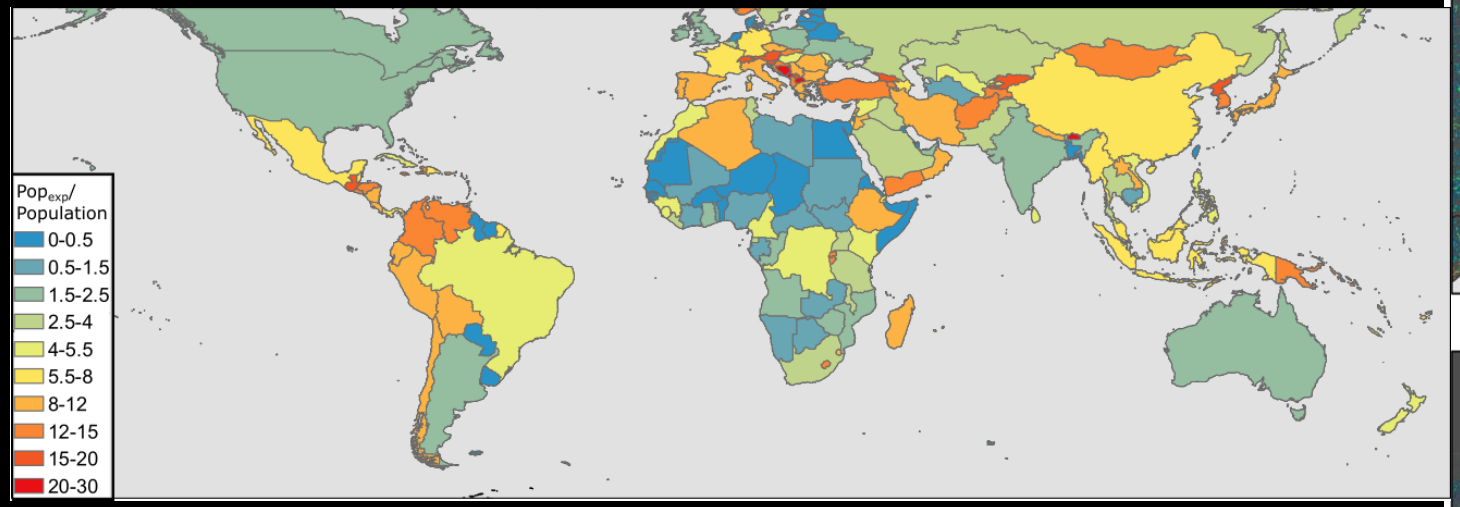




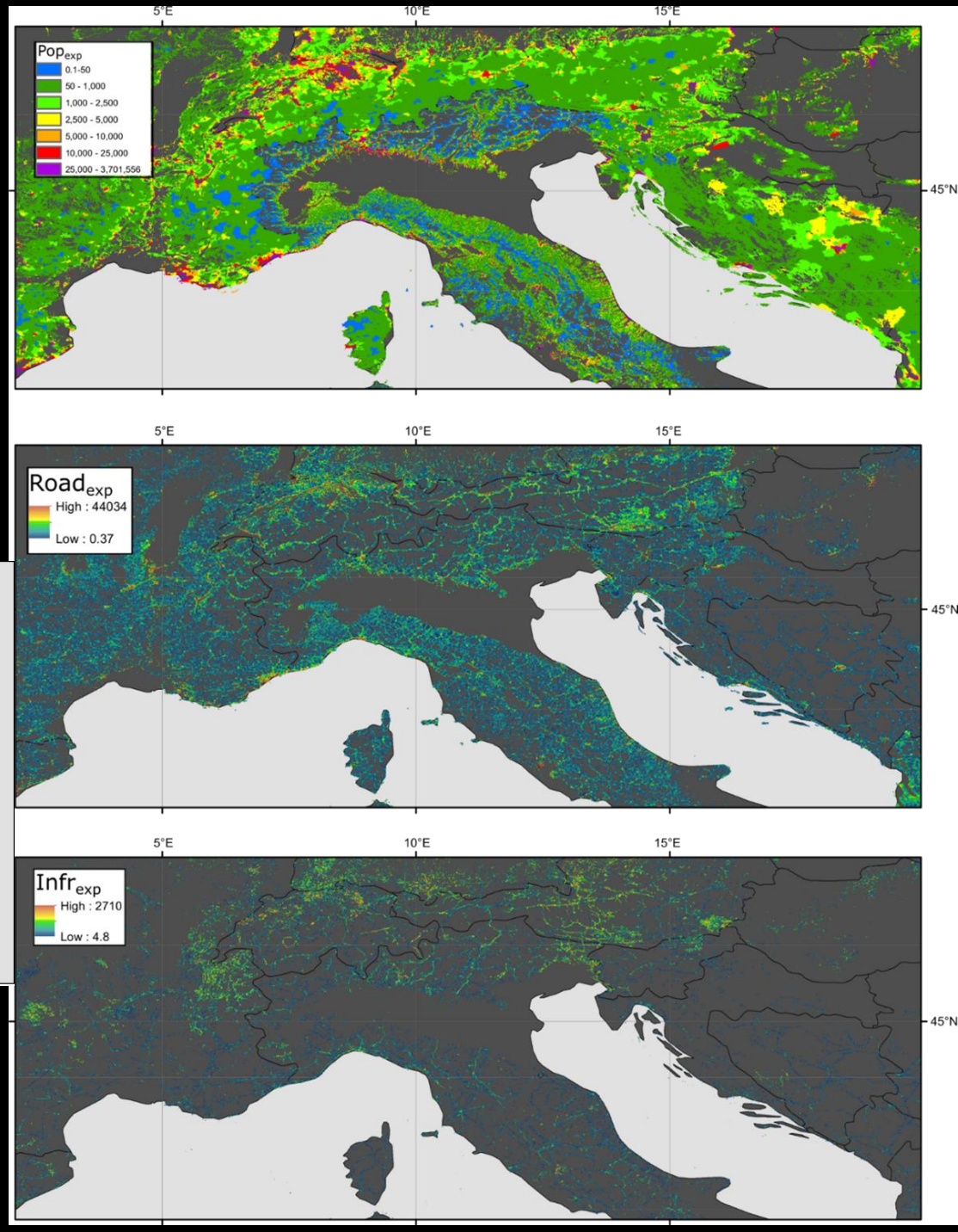
Cyclone Harold, Vanuatu (April 1-11, 2020)

Exposure Estimates

1 km resolution maps of exposure to landslides for population, roads, and critical infrastructure

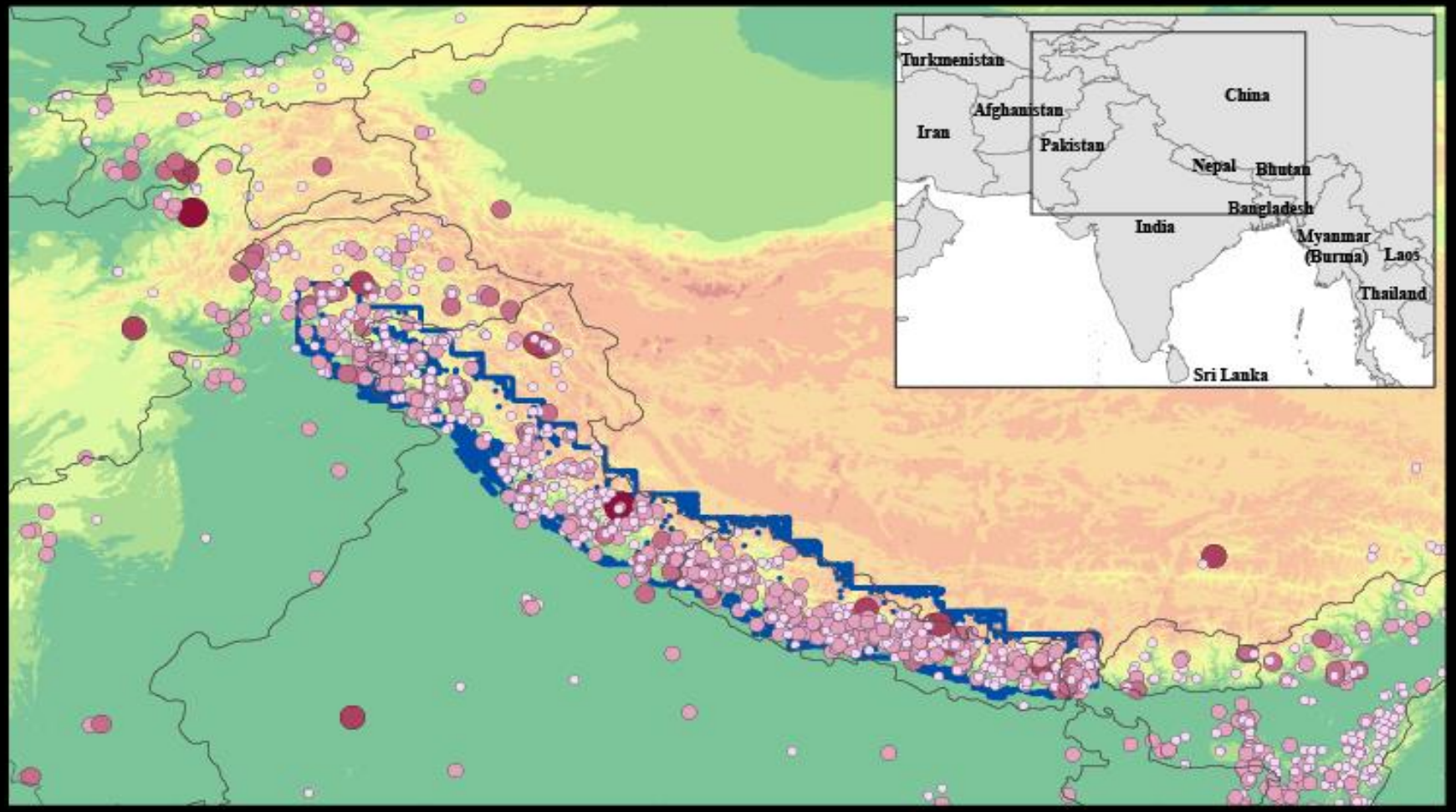


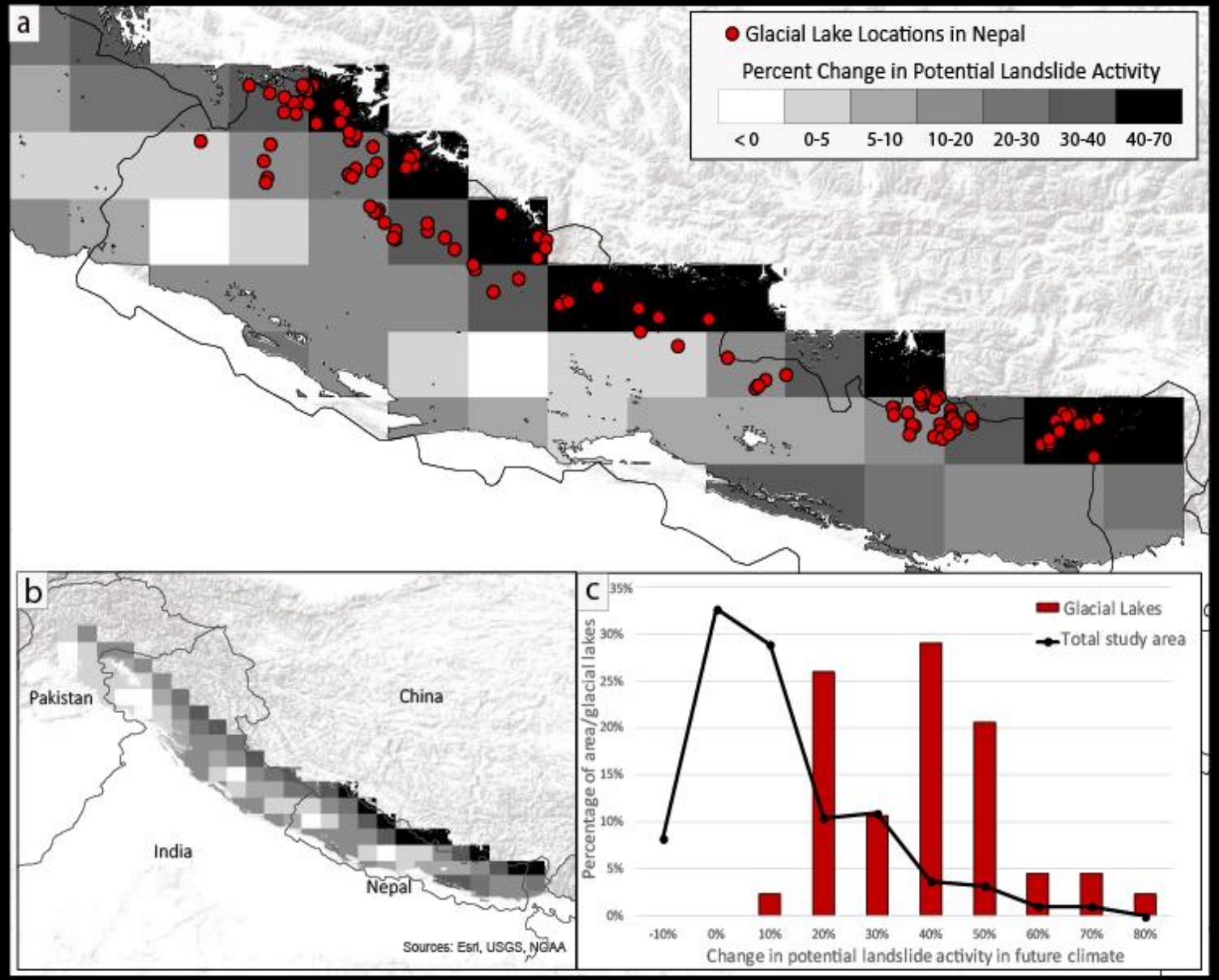
Population exposure normalized by total population



Emberson et al. *(2020)*

Landslide Mapping and Modeling over High Mountain Asia





Percent change in potential landslide activity at end of century

- Compared present (1961-2000) and future scenarios (2061-2100)
- Rate of increase in landslide activity at the end of the century is expected to be greatest over current glaciers and glacial lakes
- Demonstrates the feasibility of applying Global Climate Model outputs to model landslide impacts at timescales affected by climate change

Kirschbaum et al. 2020

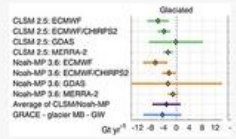
High Mountain Asia Science Team

HiMAT Home Data Meetings Teams Publications

Model Validation and Data Assimilation

Optimizing and standardizing model evaluation and assimilation techniques

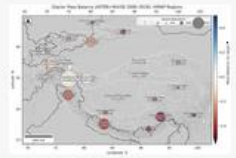
Last updated on Apr 6, 2021



Cryosphere

Changes in the High Mountain Asia Cryosphere in response to climate change

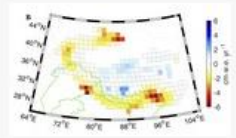
Last updated on Feb 25, 2021



Water Budget – Processes

Closing the water budget in High Mountain Asia

Last updated on Jan 19, 2021



What we do

... and how we do it

Some of the questions that guide our research:

1. What is driving changes in hydrology and cryosp
2. What range of possible impacts on local stakeho
3. ...

In our research, we use satellite data, model simulatio
hydrology and cryosphere of the High Mountain Asia r

ORIGINAL RESEARCH article

Front. Earth Sci., 04 September 2019 | https://doi.org/10.3389/feart.2019.00197

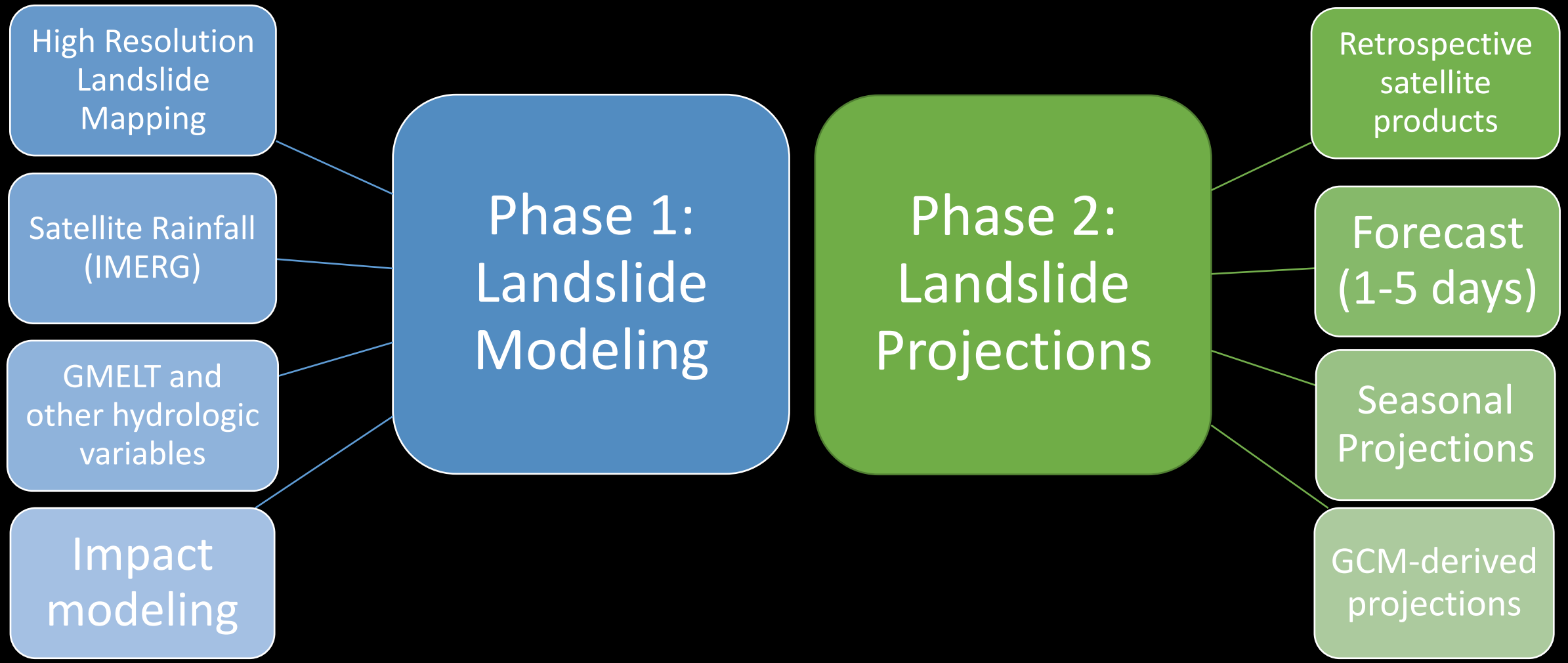
Check for updates

The State of Remote Sensing Capabilities of Cascading Hazards Over High Mountain Asia

Dalia Kirschbaum[1*], C. Scott Watson[2], David R. Rounce[3], Dan H. Shugar[4], Jeffrey S. Kargel[5], Umesh K. Haritashya[6], Pukar Amatya[1,7], David Shean[8], Eric R. Anderson[9] and Minjeong Jo[7,10]

https://www.himat.org/

High Mountain Asia Project Plans



Conclusions

- The proliferation of publicly available remote sensing and model data increase our ability to better characterize landslide hazard and exposure
- Regional efforts including NASA's High Mountain Asia Science Team and NASA Disasters Program are focused on developing new data and models that address changes in hydrology and the cryosphere, which could be a key set of variables to advance regional landslide hazard assessment
- Data and model discovery, access and stakeholder capacity to implement these capabilities remains a challenge and continued co-development, trainings and engagement may address this in part

References

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- Stanley TA, Kirschbaum DB, Benz G, Emberson RA, Amatya PM, Medwedeff W, Clark MK. (2021). Data-Driven Landslide Nowcasting at the Global Scale. Frontiers in Earth Science

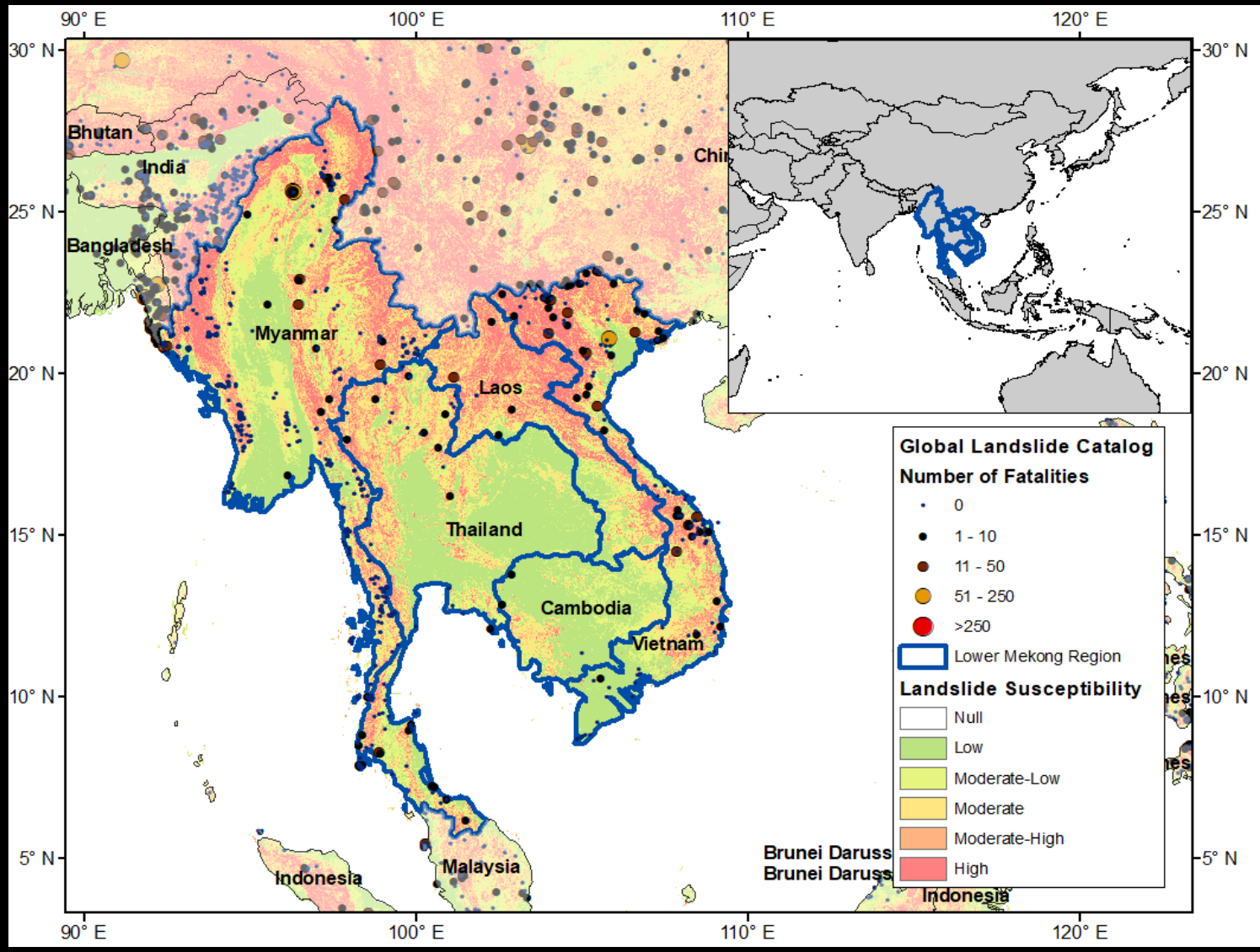
Contact:

Dalia Kirschbaum, dalia.kirschbaum@nasa.gov

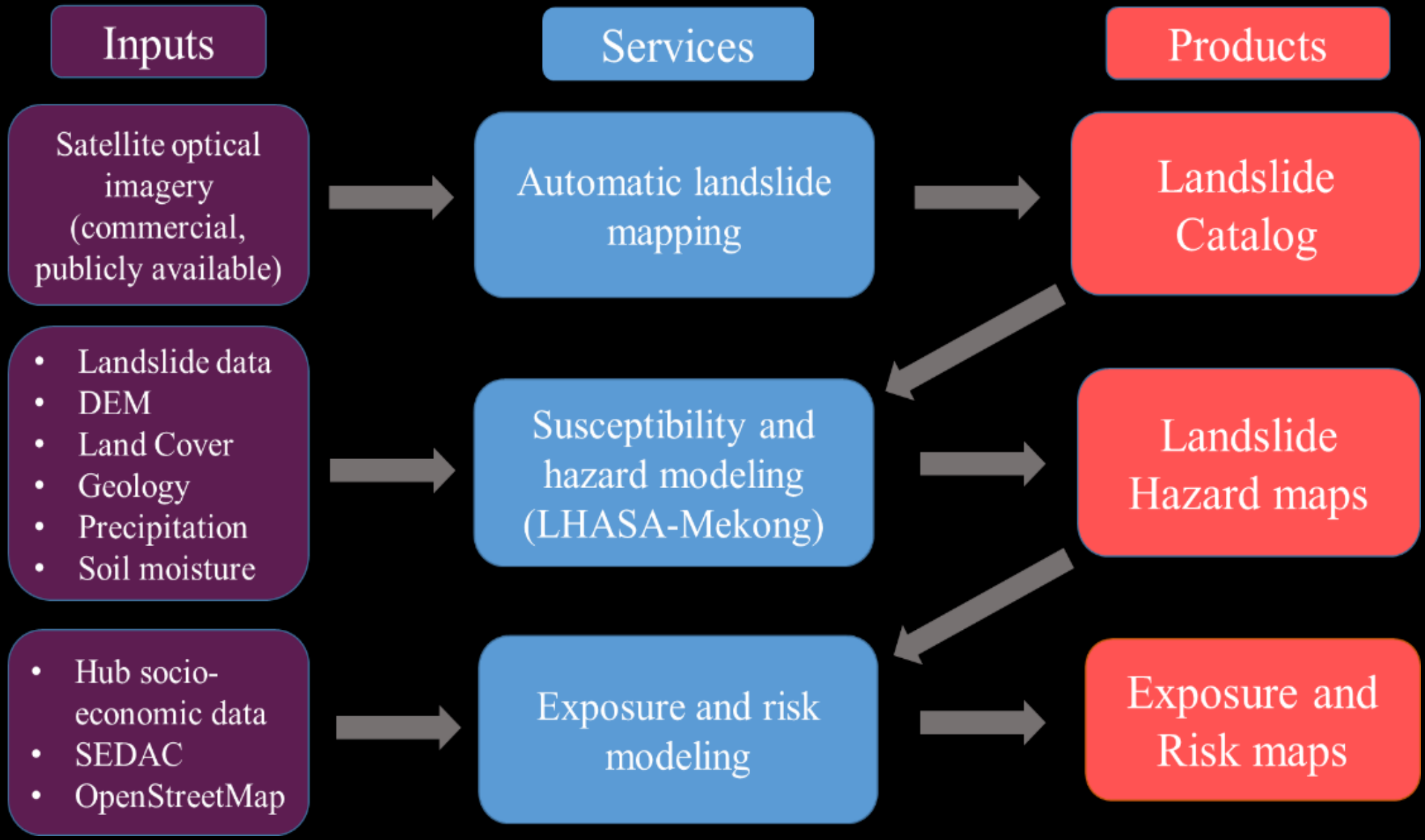
LHASA-Mekong

Goals of Project:

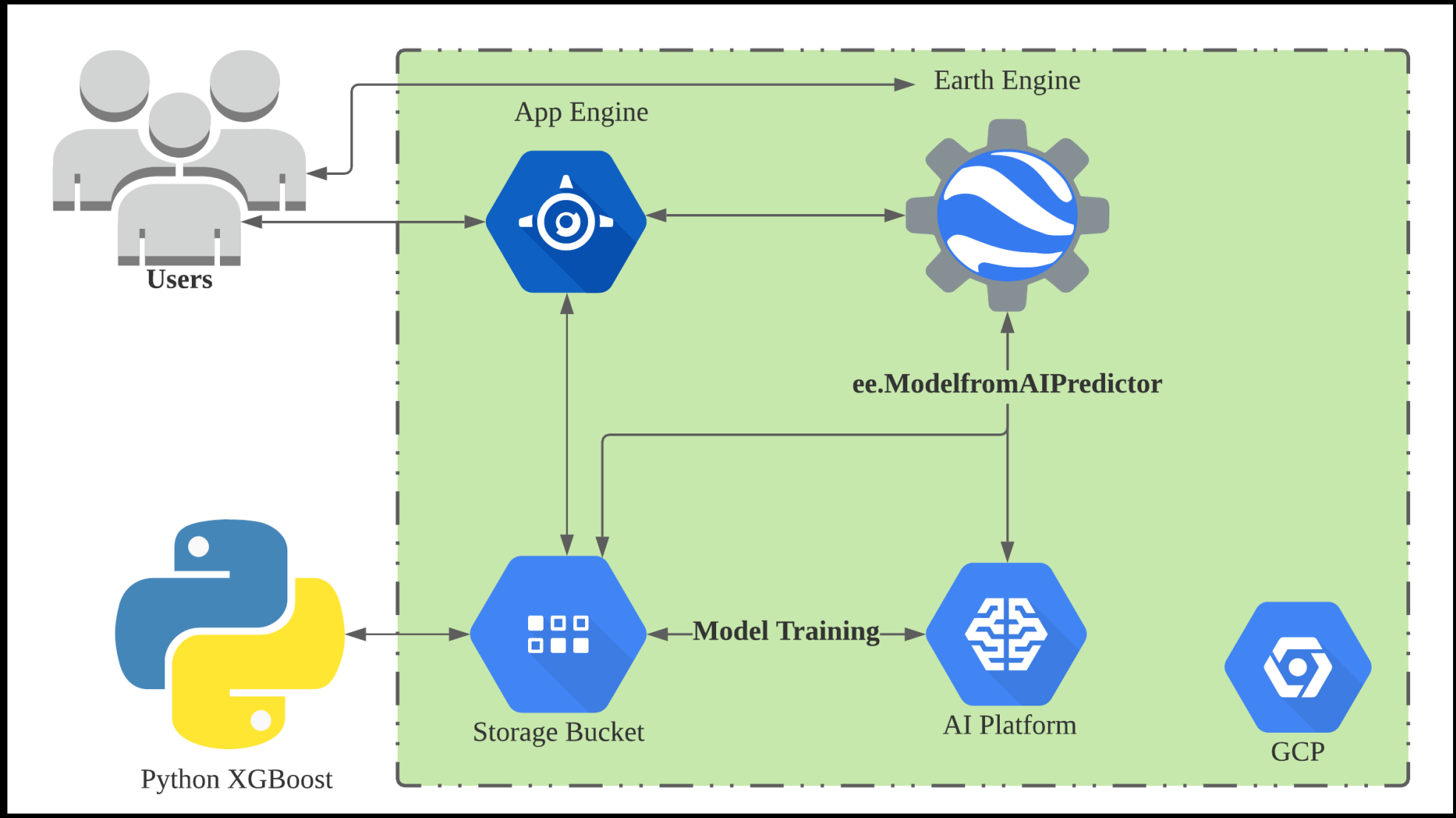
- Enable informed decision making on landslide hazard and risk leveraging EO data
- Build the capacity of regional and national agencies and other stakeholder groups to increase situational awareness, support preparedness activities
- Create a suite of products and services that will inform comprehensive landslide characterization and awareness



LHASA-Mekong structure



LHASA-Mekong in Google Earth Engine



Landslides in Huong Hua district, Vietnam (18 October, 2020)

19 OCTOBER 2020

Huong Phung: another deadly landslide in Vietnam

Posted by Dave Petley

3

Huong Phung: another deadly landslide in Vietnam

Early on Sunday 18 October 2020 a large landslide struck an army barracks in Huong Phung commune in Huong Hoa District of Quang Tri Province in Vietnam. This was the latest in a series of deadly landslides in Vietnam in recent weeks, triggered by heavy rainfall. It is the second event to kill a substantial number of soldiers.

LHASA 2.0 output