EGU General Assembly 2022

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Application of Remote Sensing Big Data in Landslide Identification

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Introduction

Landslide: general and frequent natural disaster

↓

Landslide identification: helpful in disaster mitigation and reduction

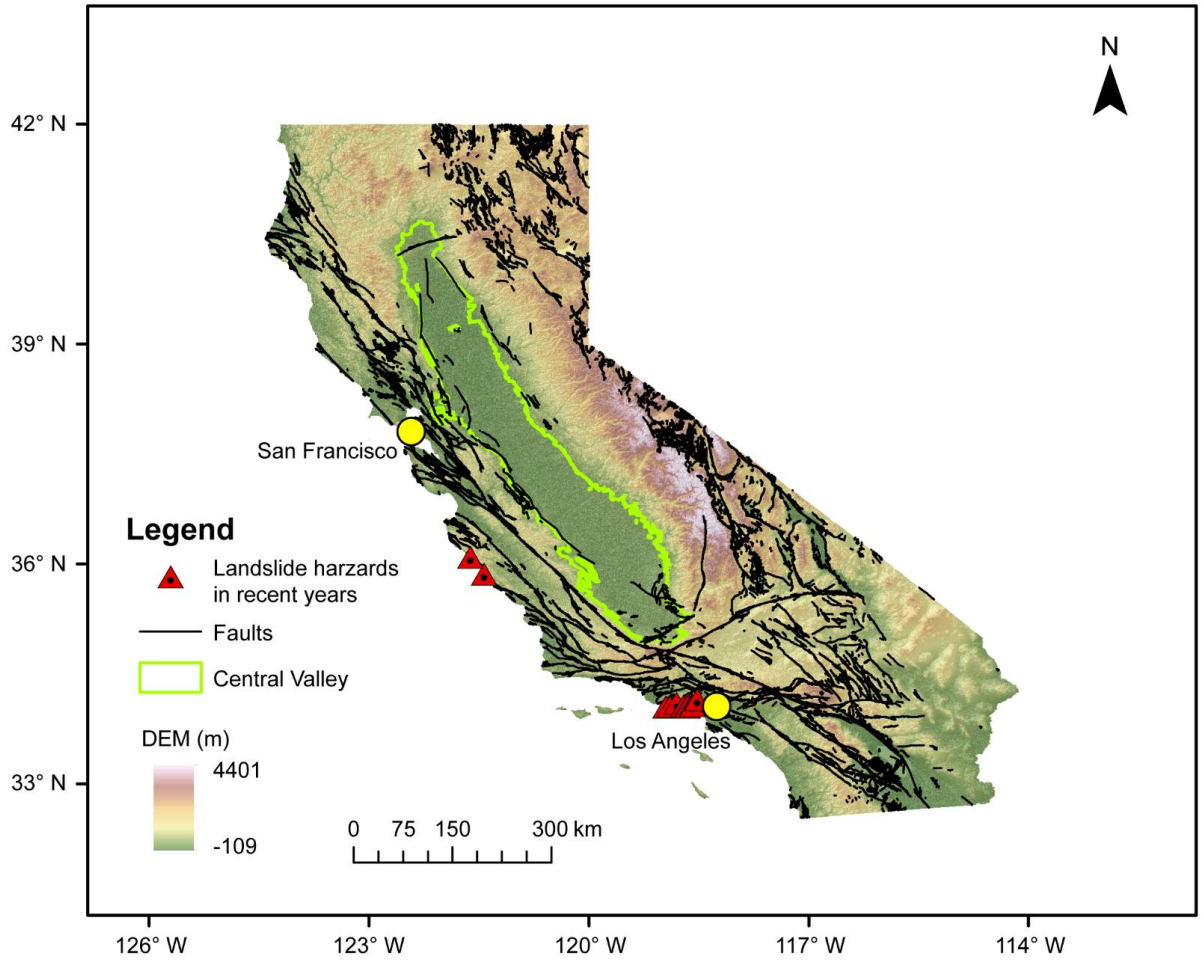
Motivation:
1. Refine landslide inventory
2. Predict landslide

Remote sensing data & products:
extract environmental features related to landslide mechanism (terrain, hydrological process, tectonic activities…)

→ **Machine Learning**

Introduction

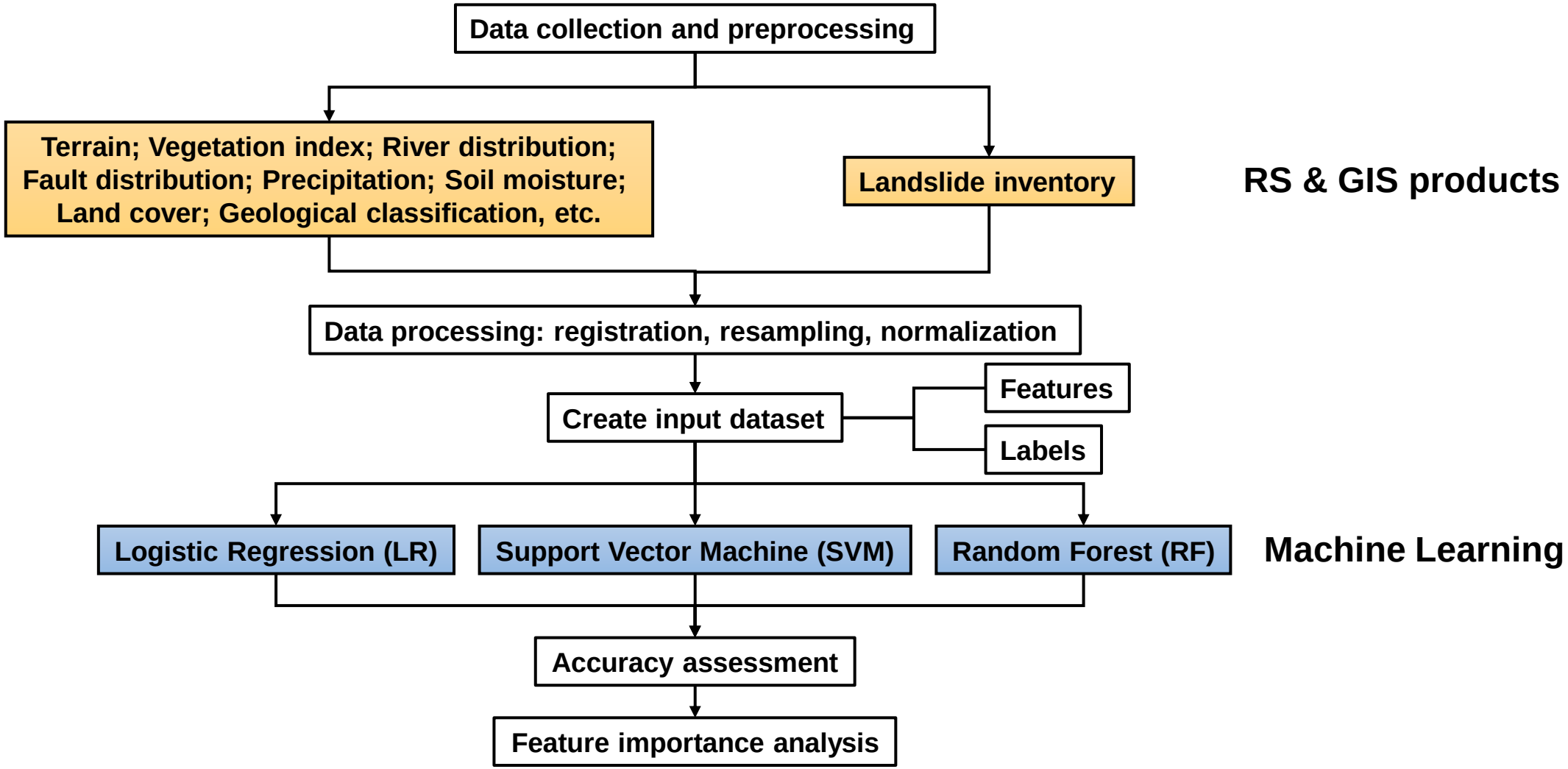
Study area: California, U.S.



- San Andreas Fault System
- Frequent landslide hazards
- Refine landslide inventory


2017.5 Mud Creek landslide in Big Sur (USGS)

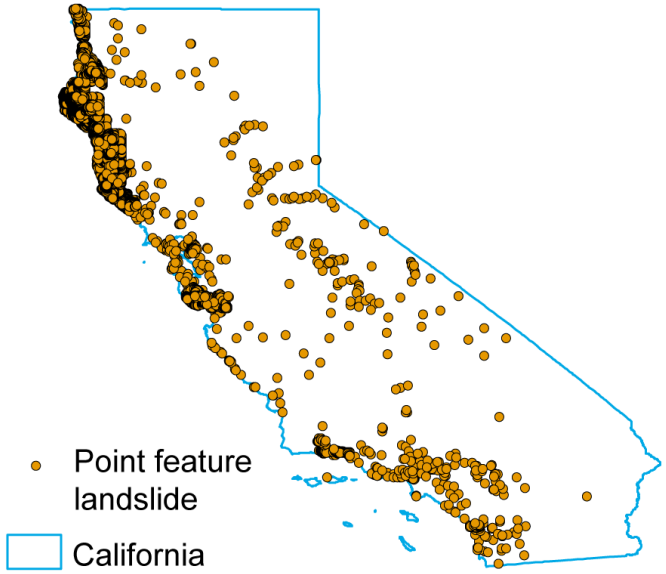
Workflow

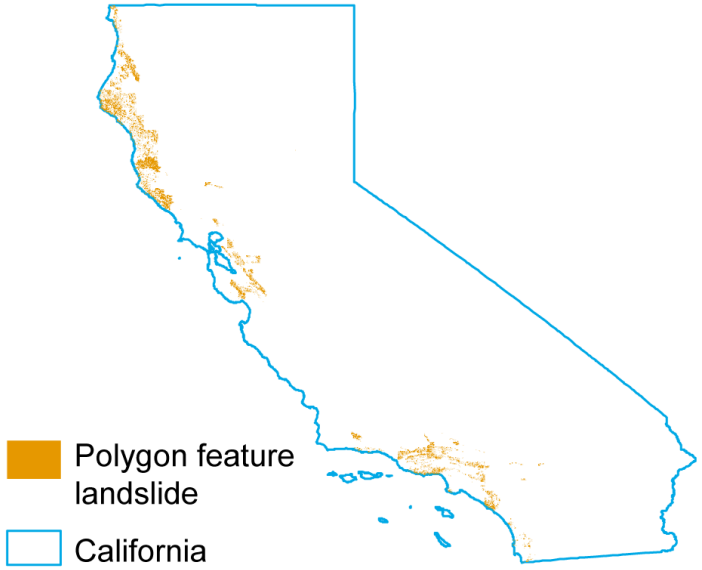

Data collection and preprocessing
Terrain; Vegetation index; River distribution; Fault distribution; Precipitation; Soil moisture; Land cover; Geological classification, etc.
Landslide inventory
RS & GIS products
Data processing: registration, resampling, normalization
Create input dataset
Features
Labels
Logistic Regression (LR)
Support Vector Machine (SVM)
Random Forest (RF)
Machine Learning
Accuracy assessment
Feature importance analysis

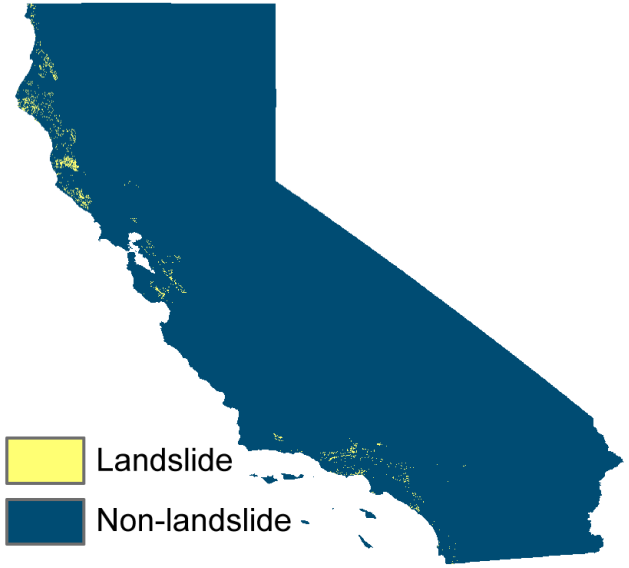
Data

Landslide inventory

86k landslide records in C.A.





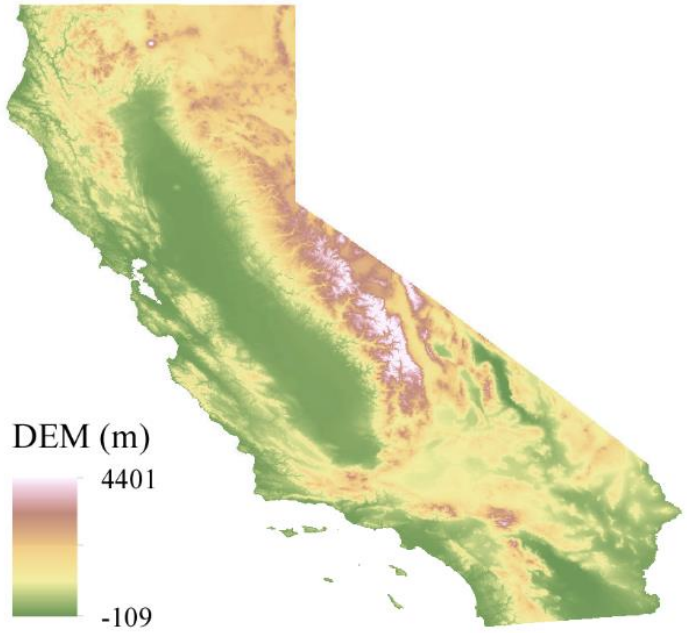


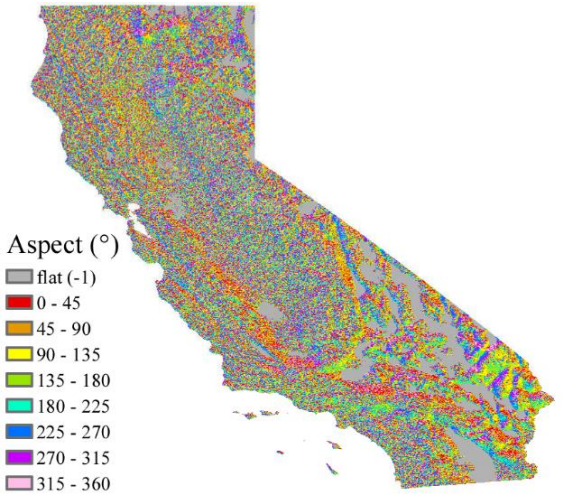
Source: USGS Landslide Inventories across the United States
https://www.sciencebase.gov/catalog/item/5c7065b4e4b0fe48cb43fbd7

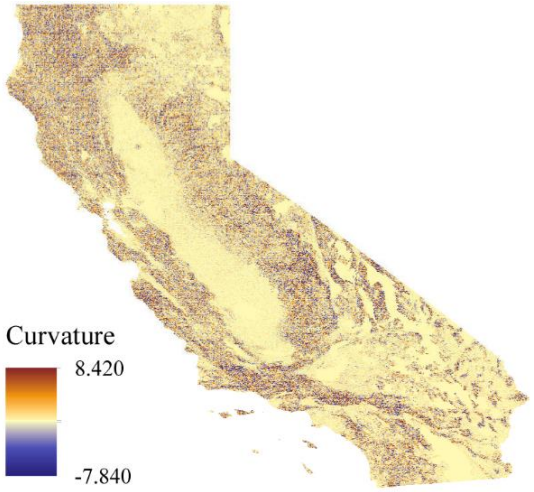
Data

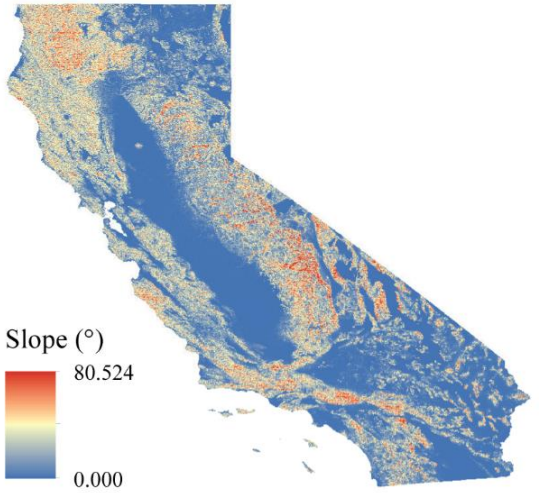
Terrain

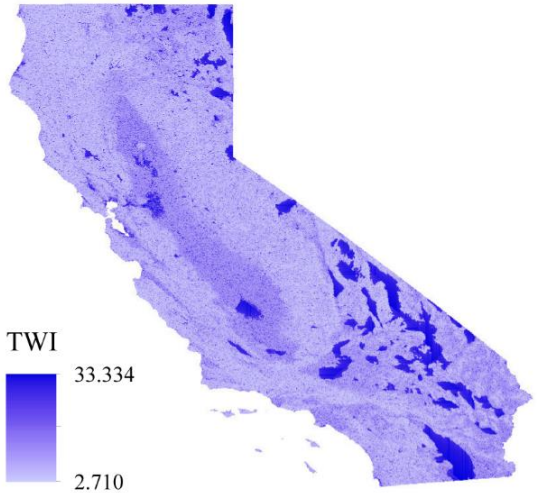
73 scenes of SRTM







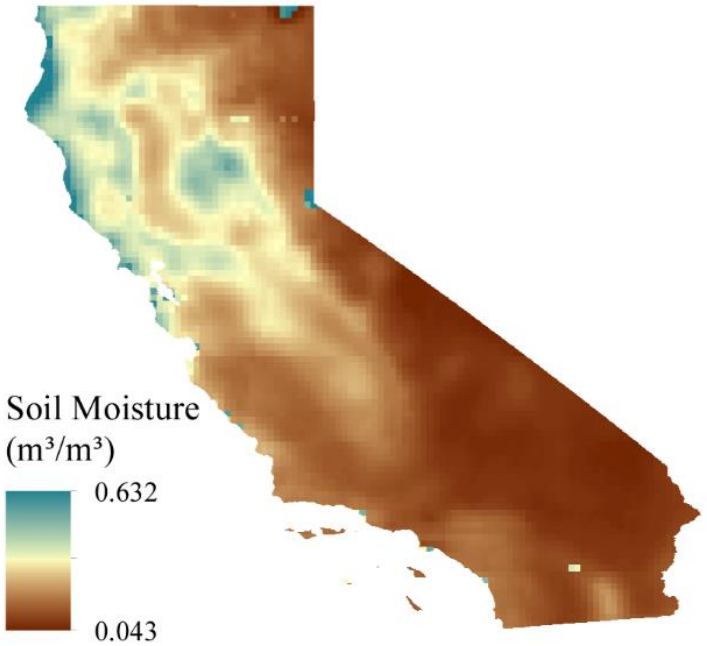




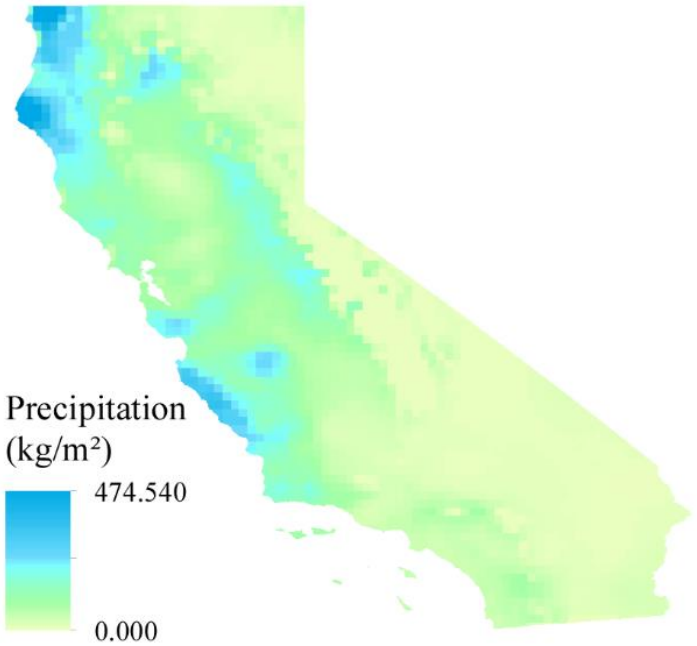
Source: SRTM 1 arc-second DEM
https://earthexplorer.usgs.gov/

Data

Soil Moisture & Precipitation



(a) 2020.12-2021.1 average soil moisture



(b) 2021.1 accumulated precipitation

Source:
(a) SMAP Enhanced L3 Radiometer Global Daily 9 km EASE-Grid Soil Moisture (Version 4), https://www.search.earthdata.nasa.gov
(b) NLDAS Noah Land Surface Model L4 Monthly 0.125 x 0.125 degree V002 (NLDAS_NOAH0125_M)
https://disc.gsfc.nasa.gov/datasets/NLDAS_NOAH0125_M_002/summary?keywords=NLDAS

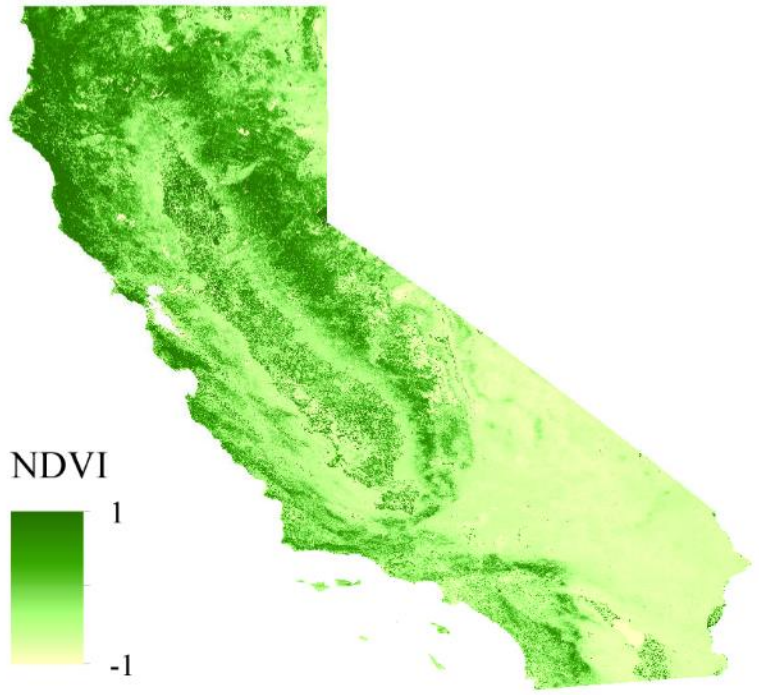
Data

Vegetation index (NDVI)

NDVI: normalized differential vegetation index

31 scenes of Landsat 8 OLI optical images

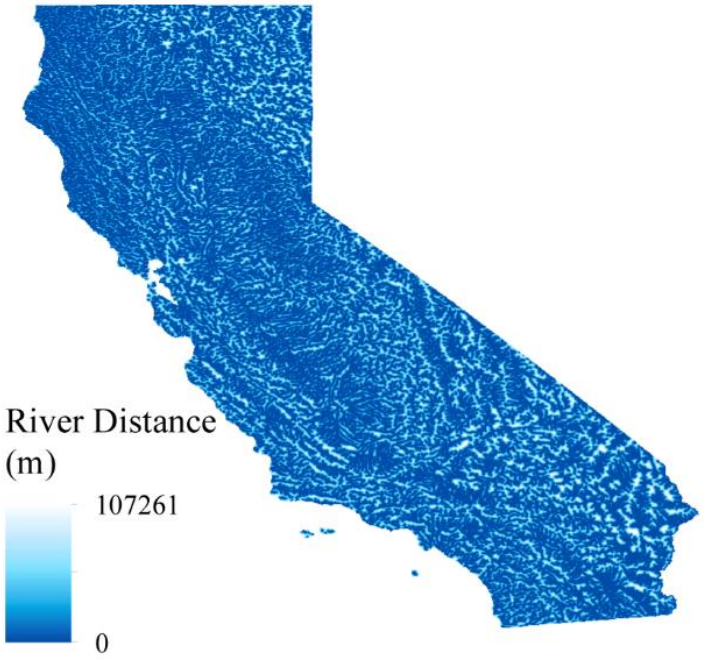
$$NDVI = \frac{NIR - Red}{NIR + Red}$$



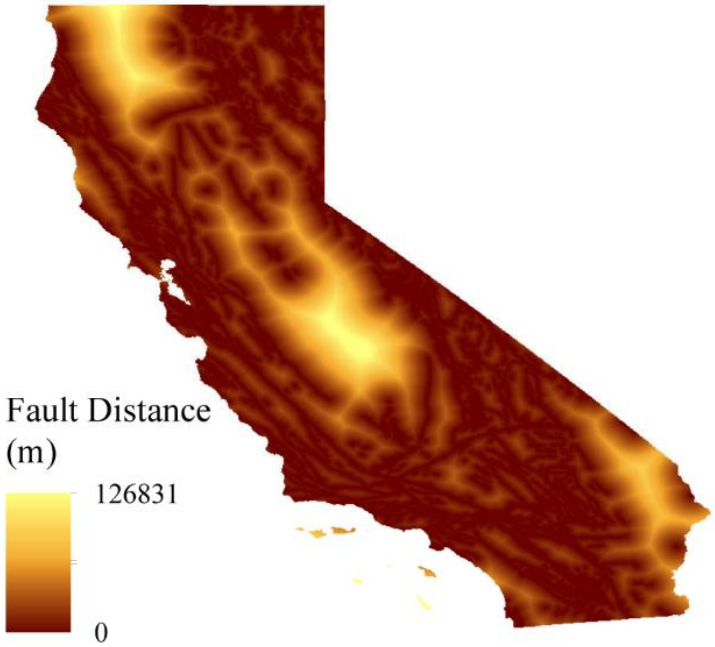
Source: Landsat 8 OLI Collection2 Level2
https://earthexplorer.usgs.gov/

Data

Distance map



(a) Distance to the nearest river

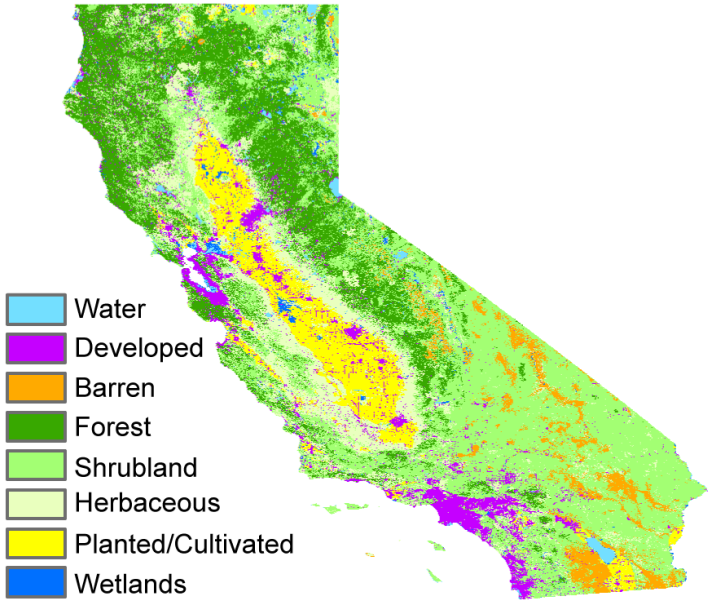


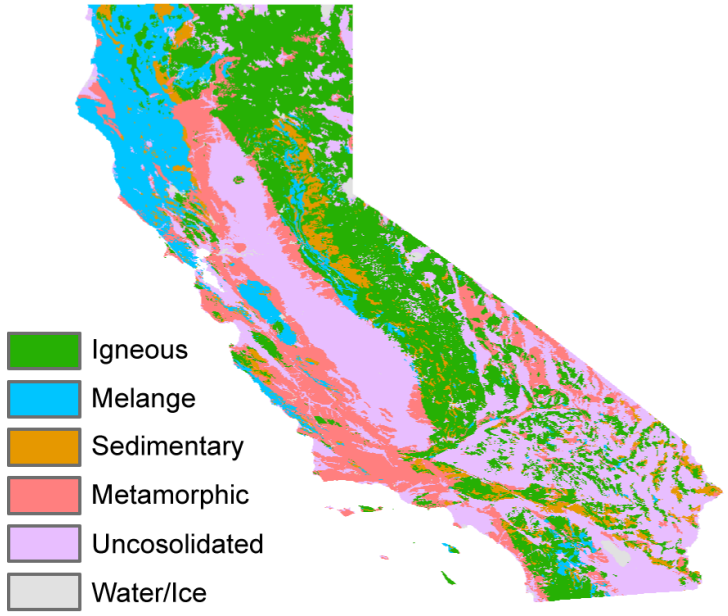
(b) Distance to the nearest fault

Source:
(a) HydroRIVERS Version 1.0, https://www.hydrosheds.org/products/hydrorivers
(b) Quaternary Fault and Fold Database of the United States, https://www.usgs.gov/programs/earthquake-hazards/faults

Data

Land cover & geological map



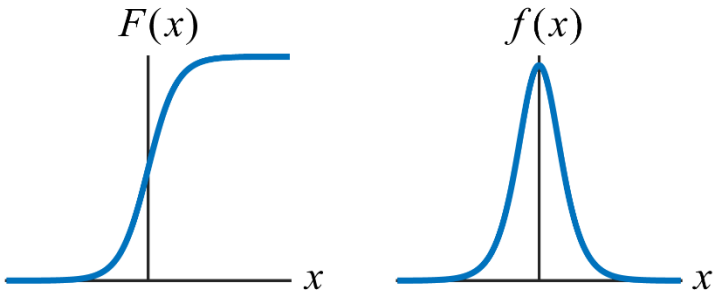


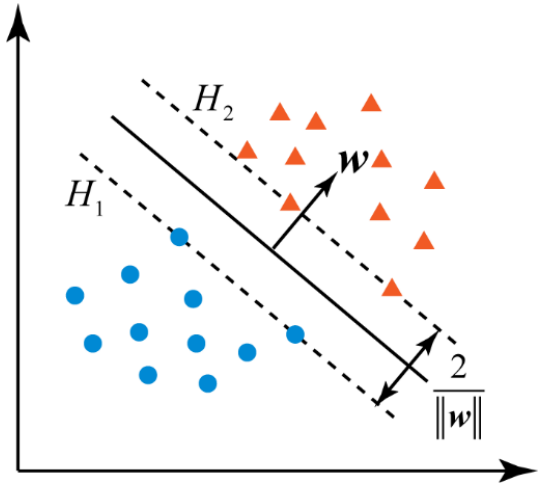
Source:
(a) NLCD 2019 Land Cover (CONUS), https://www.mrlc.gov/data/nlcd-2019-land-cover-conus
(b) The State Geologic Map Compilation (SGMC) Geodatabase of the Conterminous United States, https://www.sciencebase.gov/catalog/item/5888bf4fe4b05ccb964bab9d

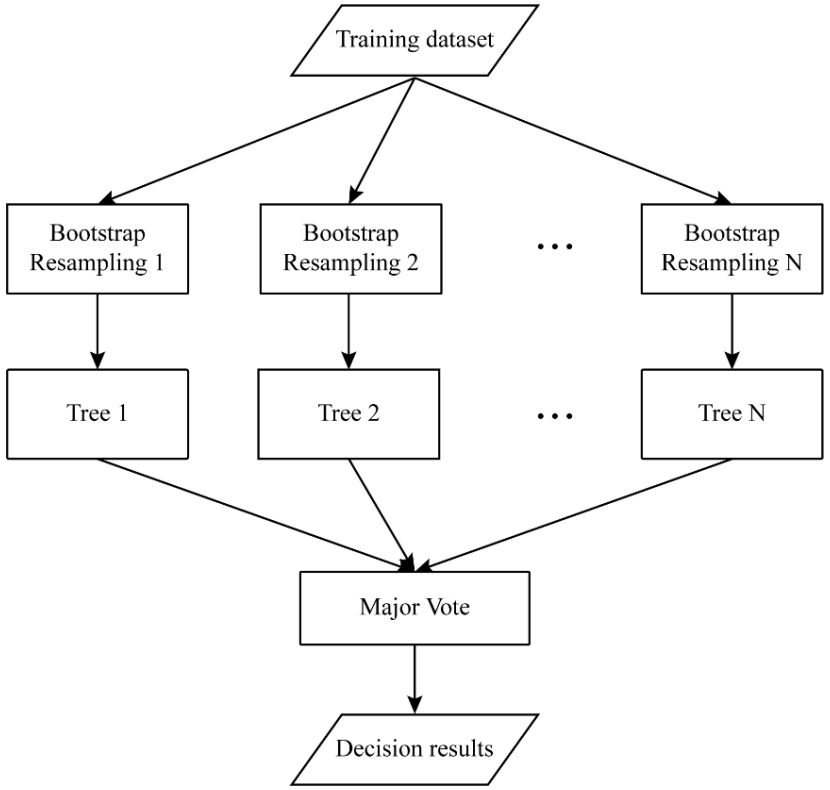
Method

Machine Learning algorithms

- ✓ Logistic Regression (LR)
- ✓ Support Vector Machine (SVM)
- ✓ Random Forest (RF)



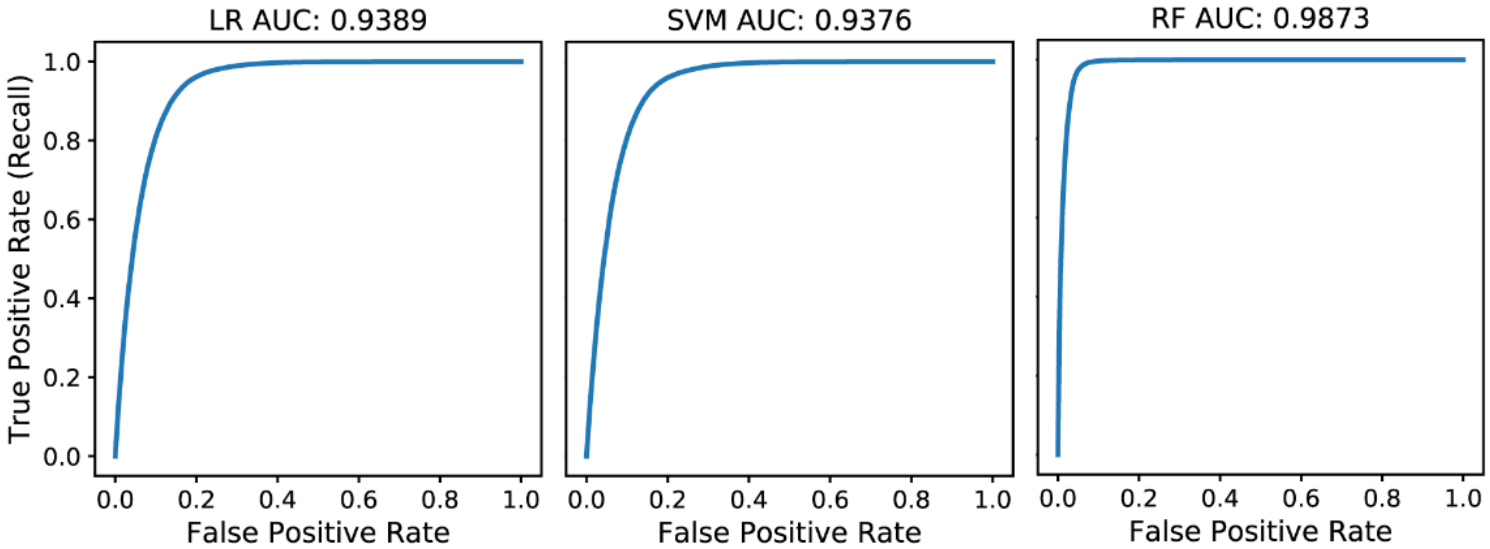




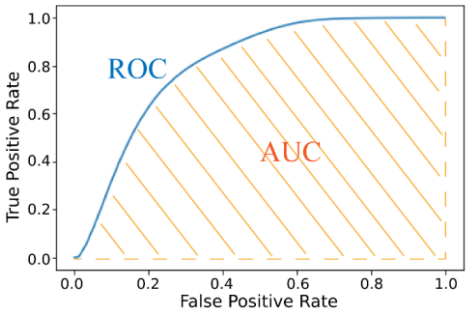
Discussion

Accuracy assessment

Models	Accuracy	Precision	Recall	F_1 score	FPR	AUC
LR	0.8840	0.8555	0.9242	0.8885	0.1561	0.9389
SVM	0.8840	0.8450	0.9405	0.8902	0.1725	0.9376
RF	0.9616	0.9389	0.9876	0.9626	0.0643	0.9873

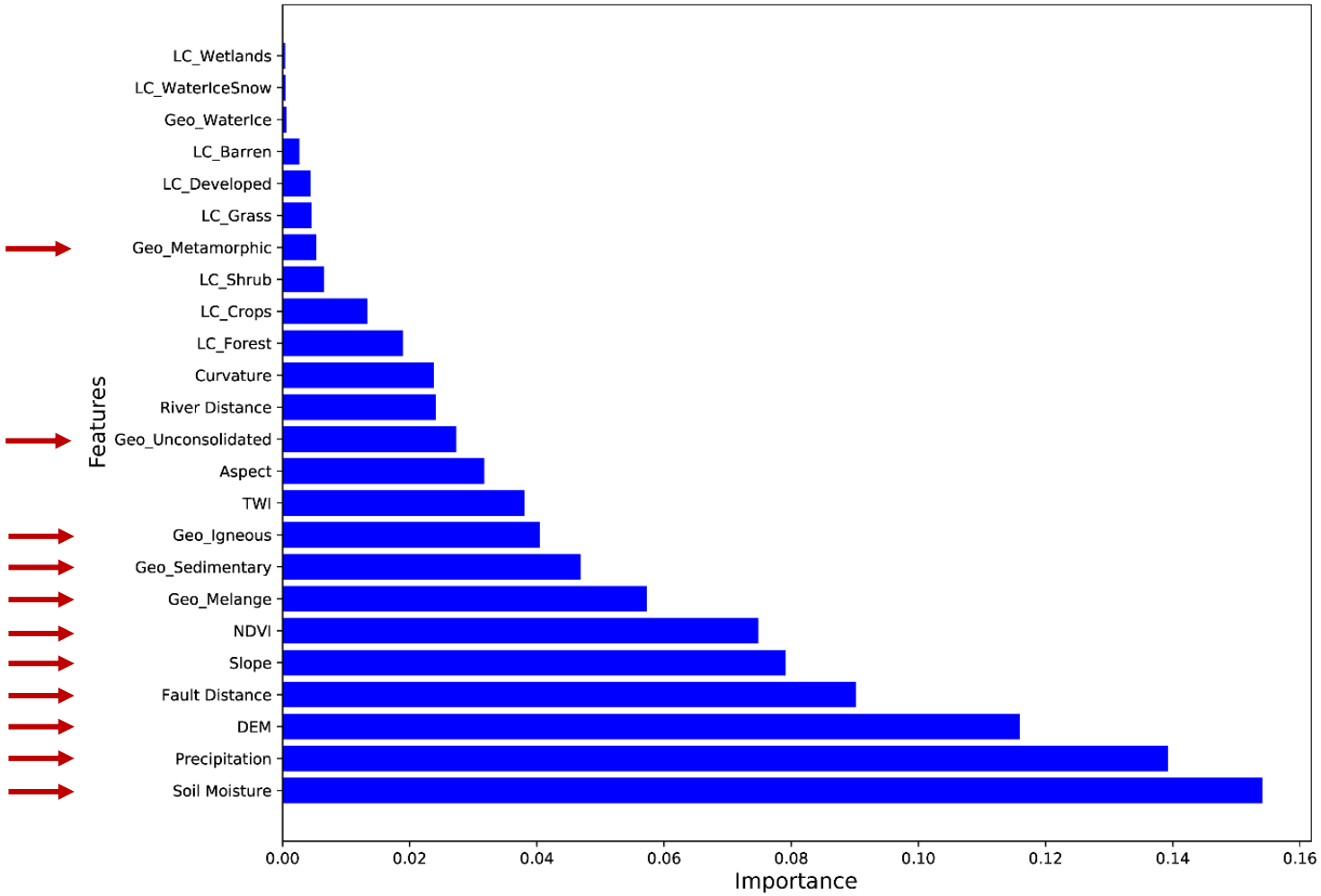


(a) LR (b) SVM (c) RF



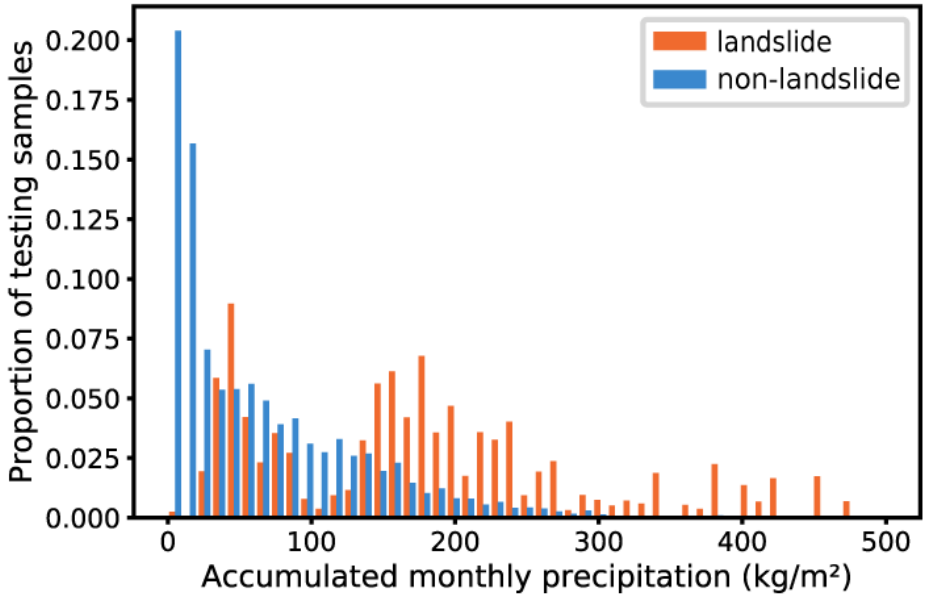
Discussion

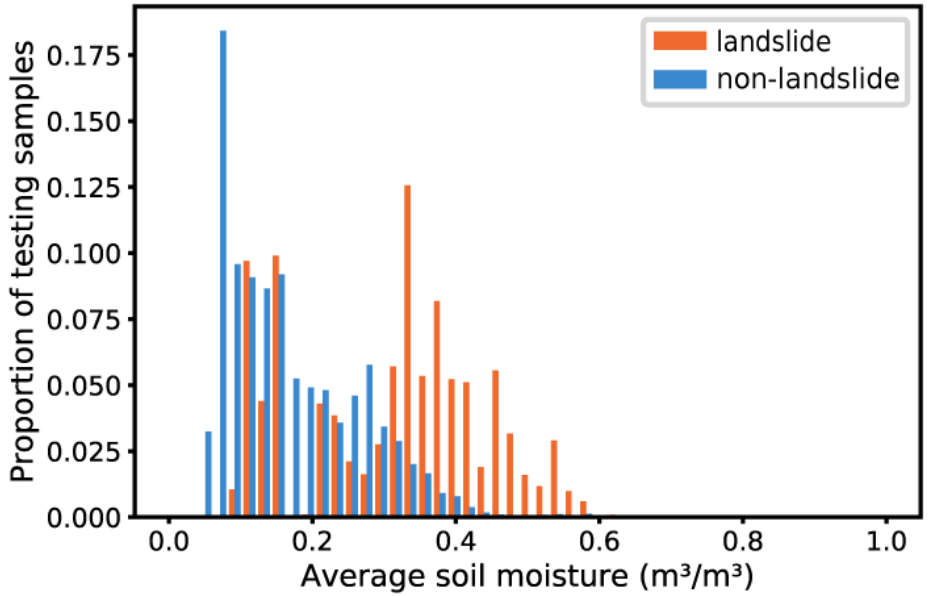
Feature importance



Discussion

Precipitation & Soil moisture

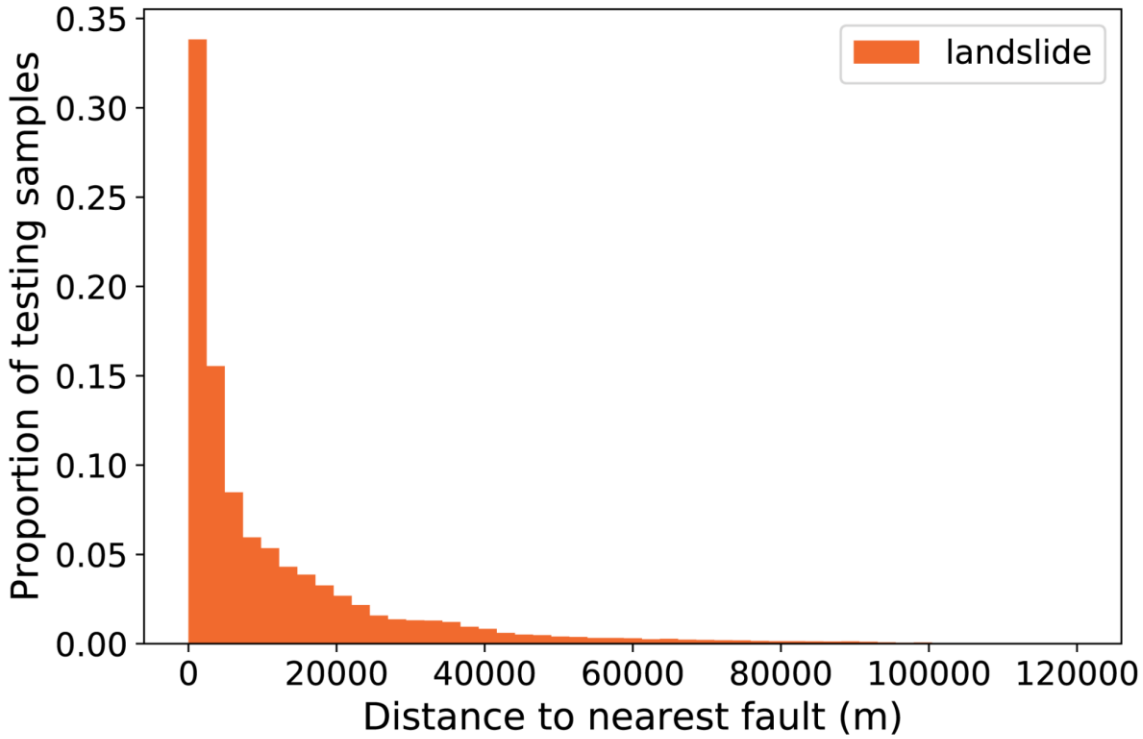




✓ Landslides mostly occur in areas with higher precipitation and soil moisture

Discussion

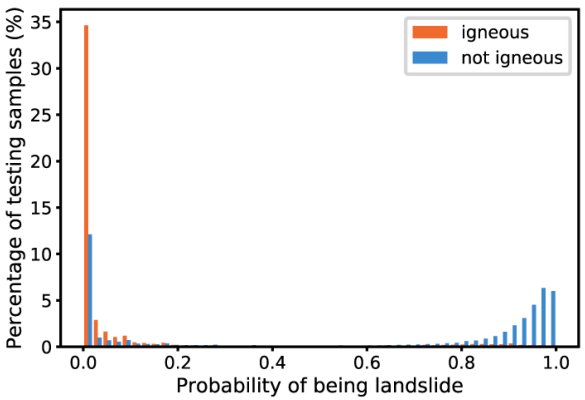
Distance to the nearest fault



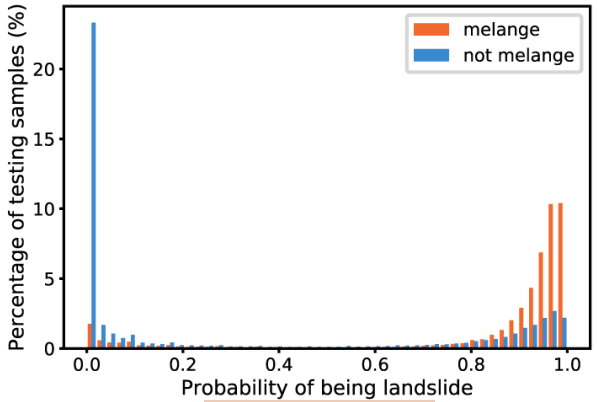
✓ ~ 50% of the landslides are located within 4.8 km from faults

Discussion

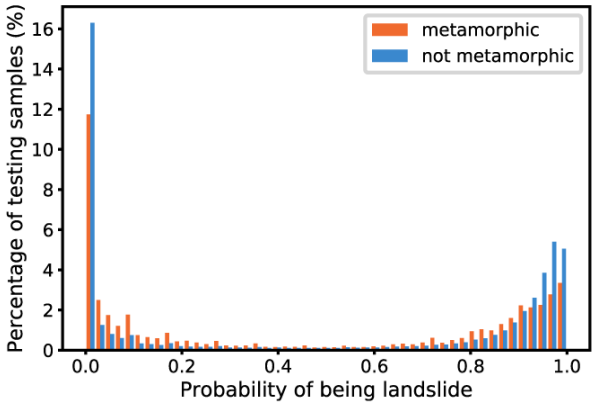
Geological units



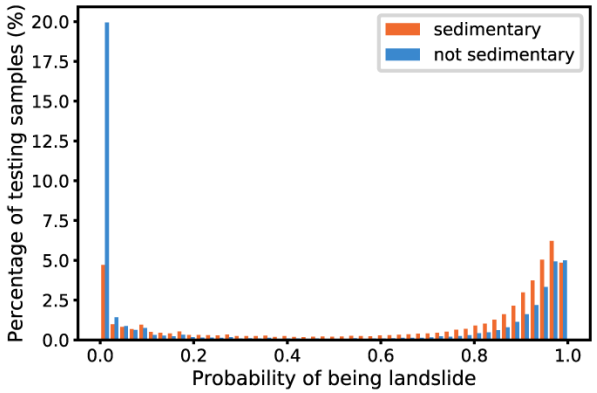
(a) igneous



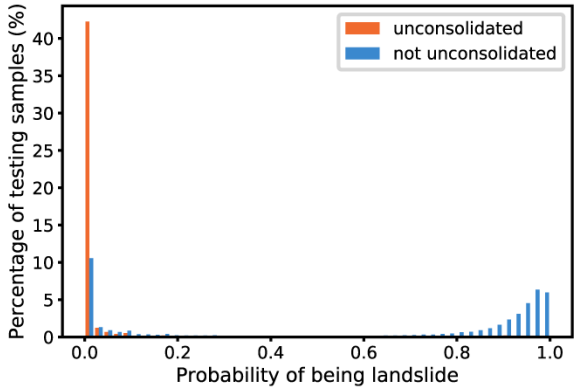
(b) mélange



(c) metamorphic



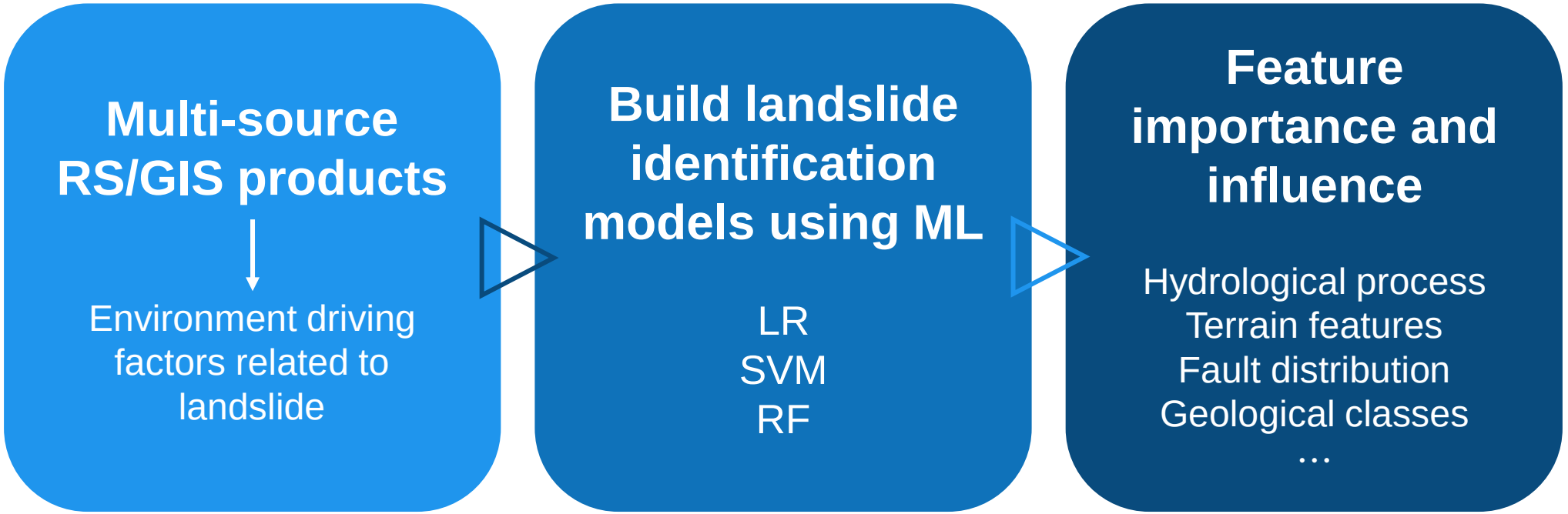
(d) sedimentary



(e) unconsolidated

- ✓ Higher landslide probabilities in mélange and sedimentary area
- ✓ Low landslide probabilities in igneous and unconsolidated area

Conclusion



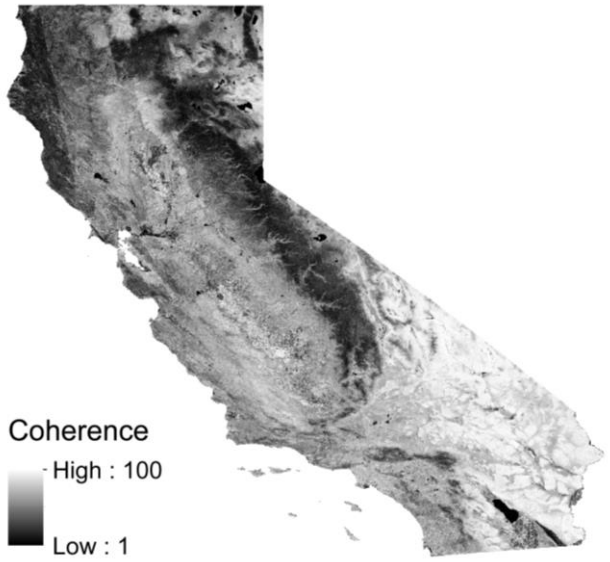
Besides precipitation and topography,
the distance to fault and the geological units (mélange)
also play important roles in landslide occurrence in CA.

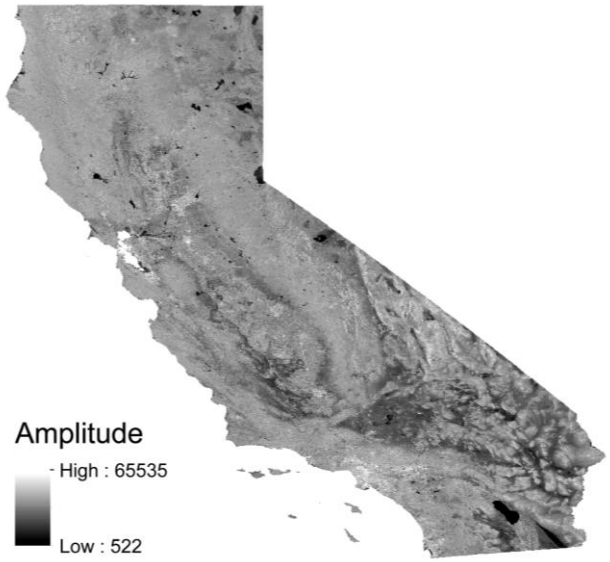
Conclusion

Future work

1. Add new features:
   - SAR data and products
   - Seismic peak ground acceleration (PGA)

2. Time-dependent modeling





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