

# Earthquake triggered landslide reactivations: Kaikoura, NZ



Geospatial Data Analysis with Python, Final Presentation  
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# The hazard isn't over just because the shaking is over

- > Reactivated landslides are a serious hazard
- > After the 2008 Wenchuan Earthquake, post landslide debris flows caused serious destruction



Post Earthquake debris flow, 2008 Wenchuan Earthquake  
-Photo- David Wald, USGS

# **But what happened after the initial landslides... A case study using the 2016 Kaikoura Earthquake**

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## **Goals:**

### **1: Track Reactivations, Where do landslides fail again?**

- > Asses which landslides were reactivated though land surface level changes from multiple post-event Lidar acquisitions.

### **2: Does vegetation control reactivations?**

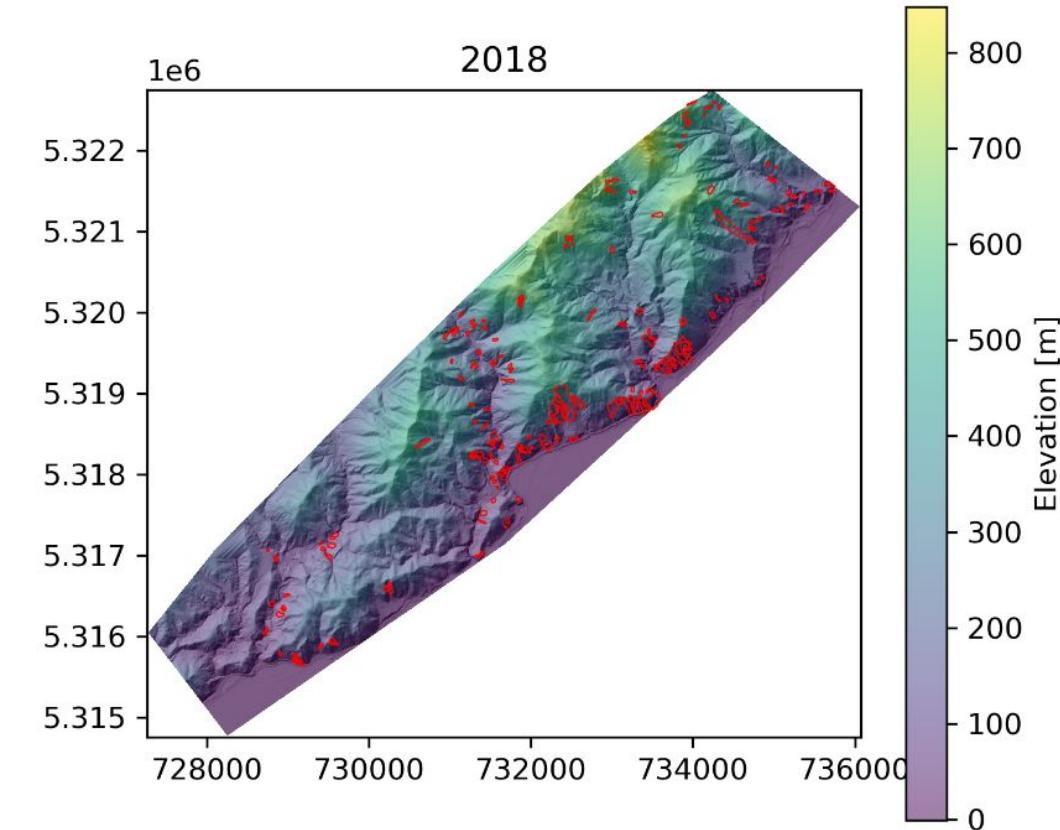
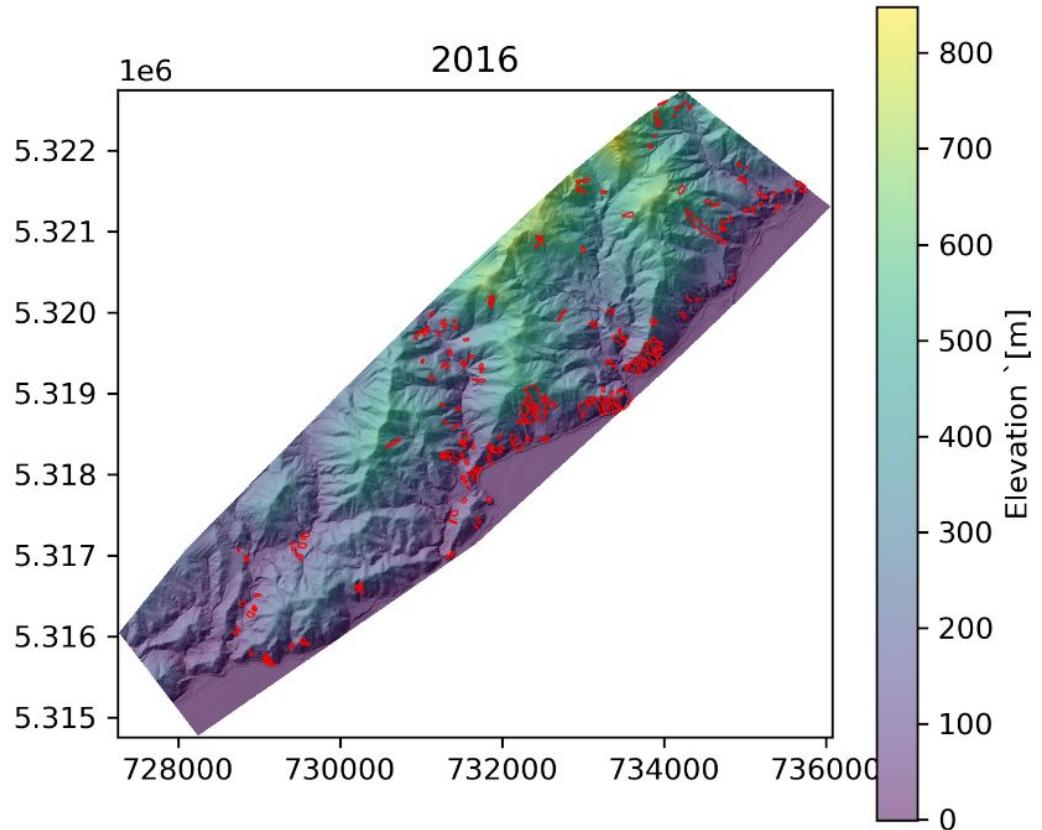
- > Use NDVI analysis in concert with our landslide dataset

### **3: Does morphology control reactivations?**

- > Use digital elevation model morphometric analysis in concert with our landslide dataset

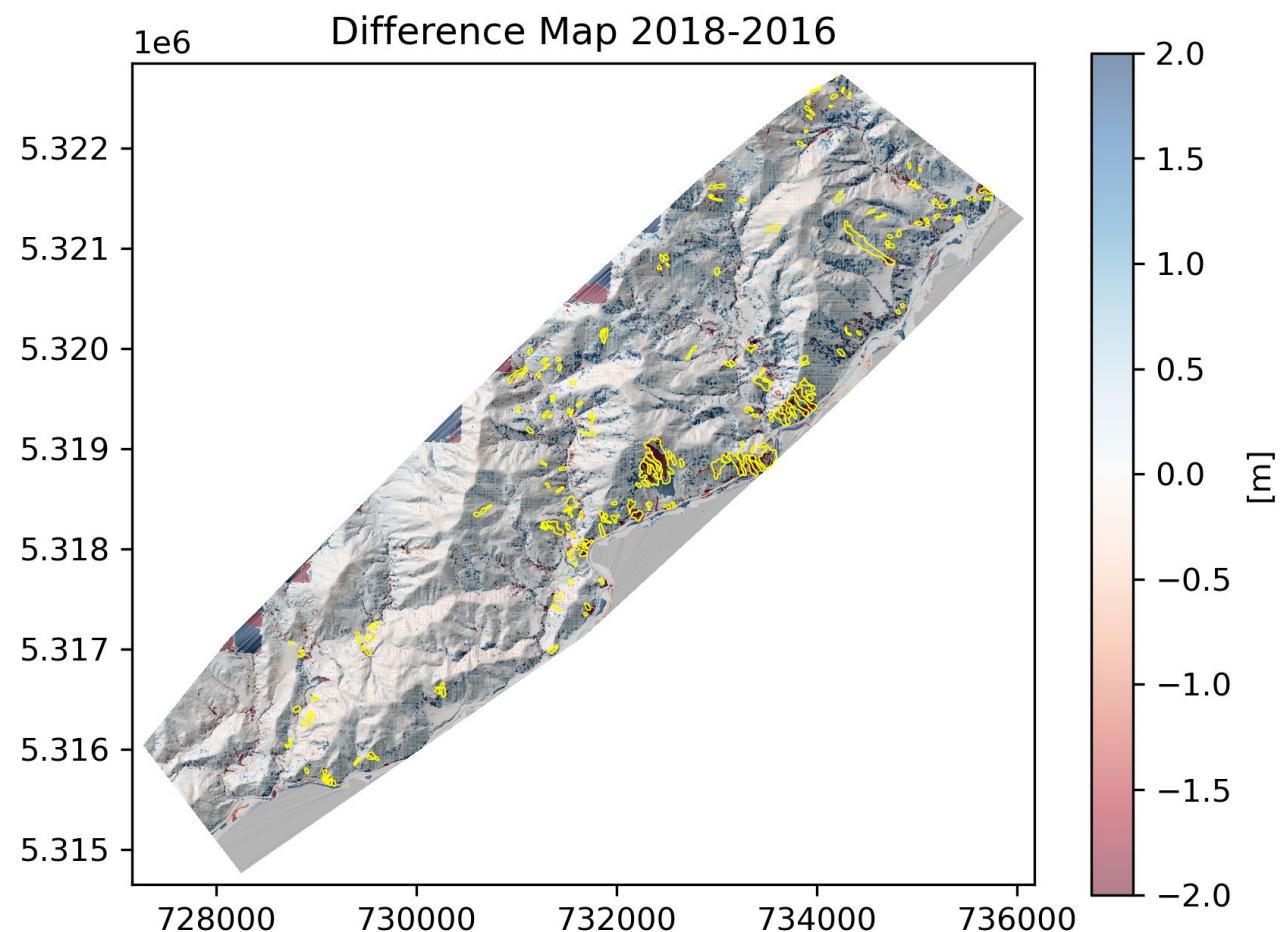
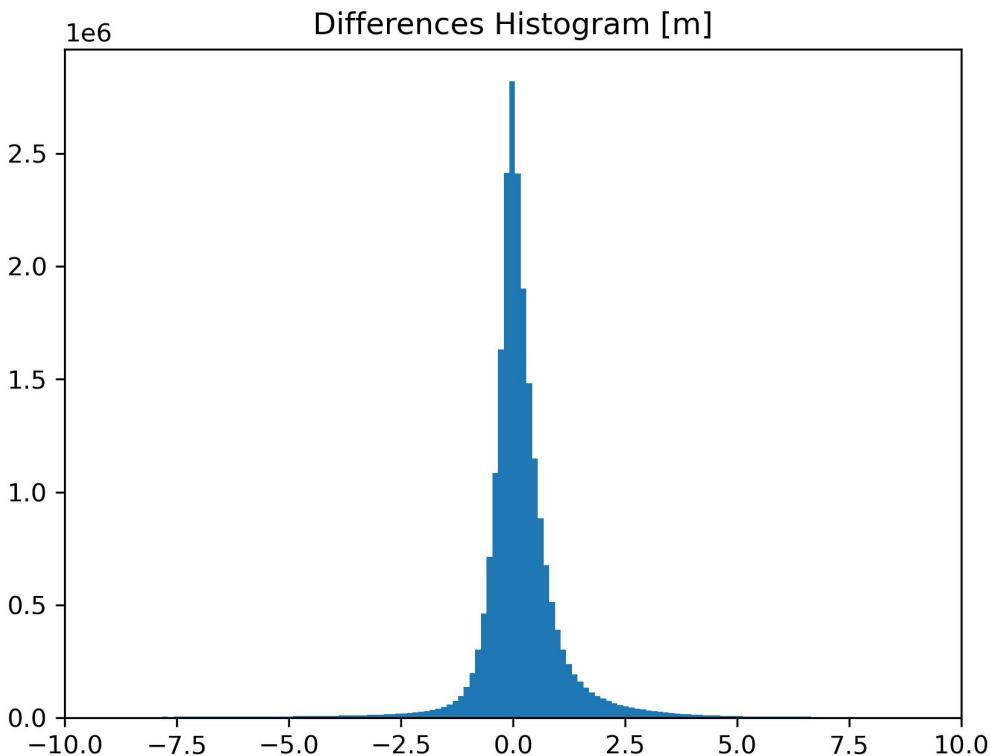
# Raw Data: DEMs + Landslide Inventory

- NGS - Linz - OpenTopography
- Deal with storage - 2Tb of data (HUB - Repo limitations)
- Clipped an area of interest
- In red, the landslide inventory (right after the earthquake)



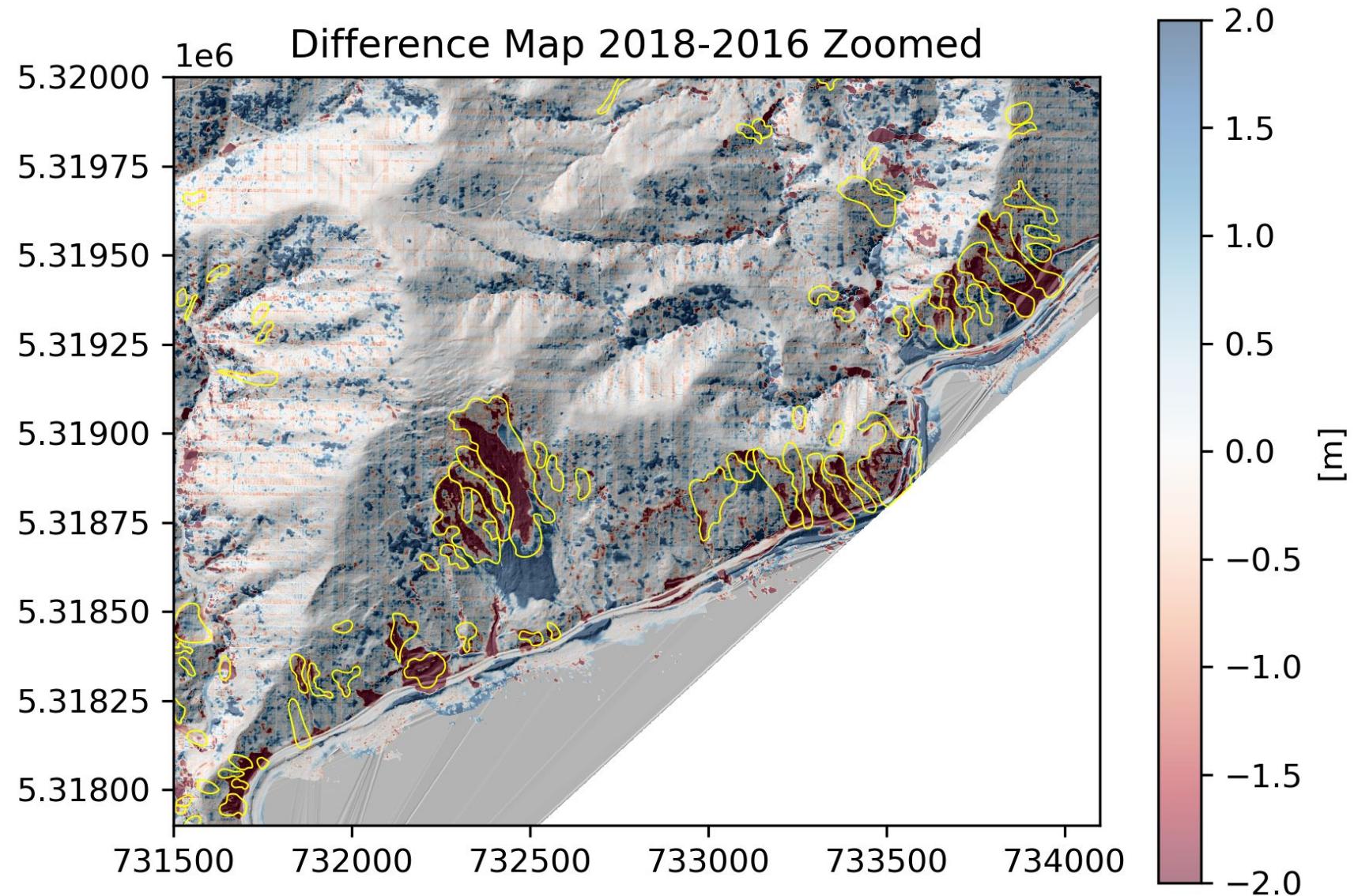
# DEM differencing!

- One issue we encountered was that raster did not have the same shape to do the differencing.
- Clipped the raster to a the same shape.
- Sanity check (distribution has its peak in zero) - DEMs have the same elevation datum.



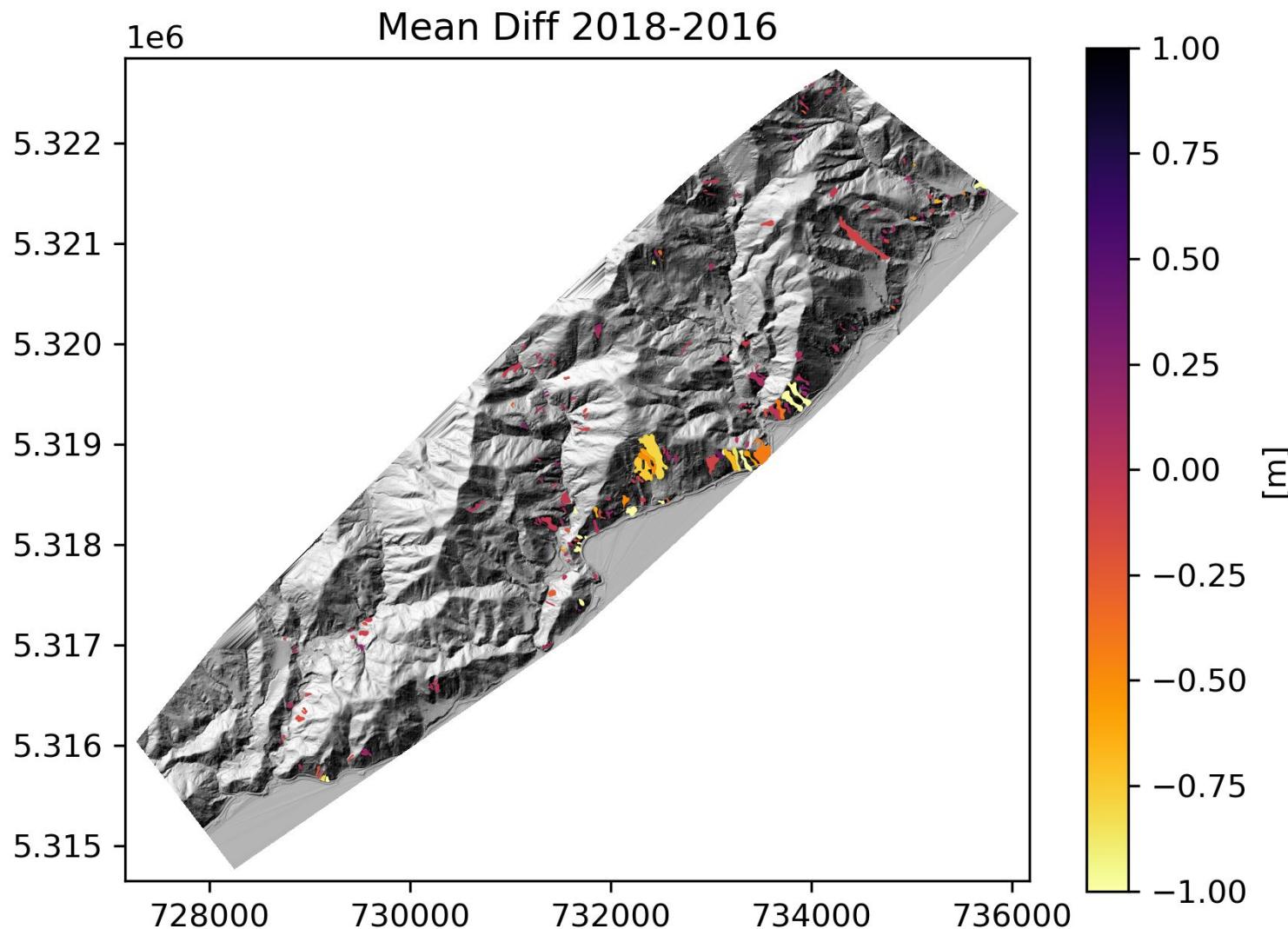
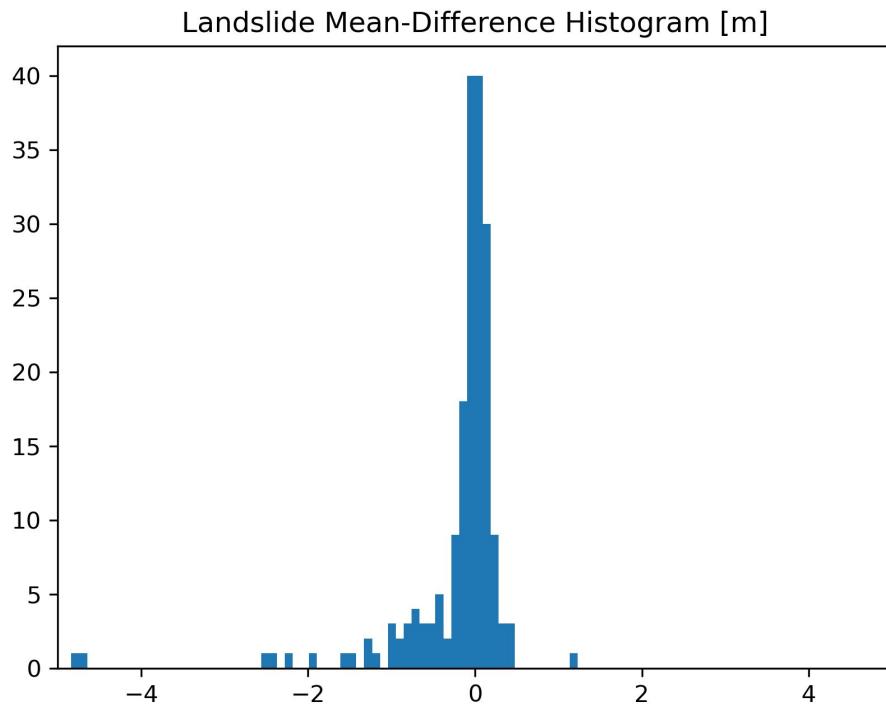
# Zoomed DEM differencing!

- Zoomed into a more interesting area
- Note areas of loss of elevation, and gained elevation.



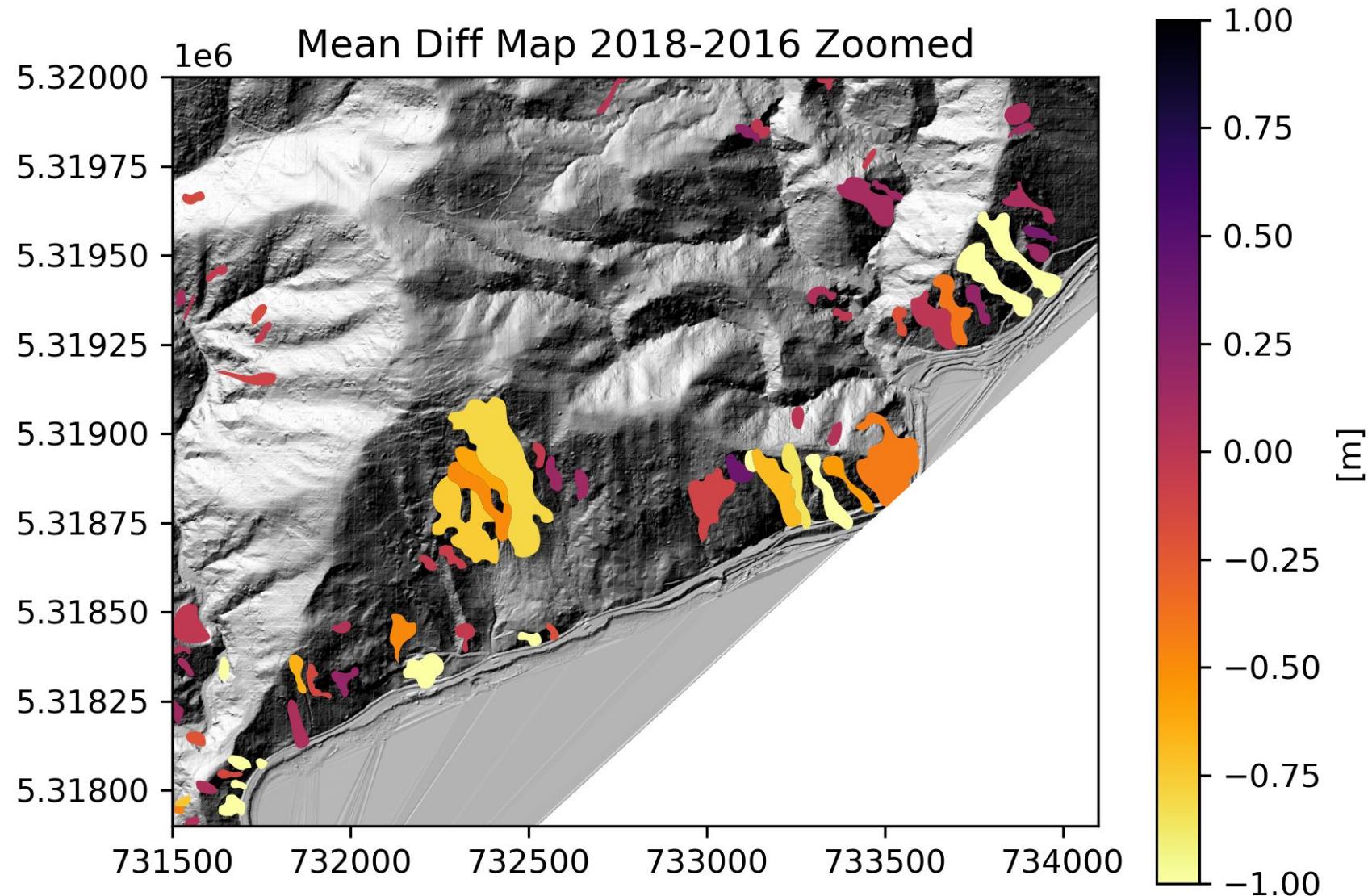
# Difference Raster Sampling by Landslide

- Then we sampled the difference map with the landslide inventory using the mean value



# Zoomed Difference Raster Sampling by Landslide

- 55% of landslides have negative mean difference (note that some of these are not indeed reactivations - some removals had to be done for reads to be reactivated in some cases)



# NDVI Data Download

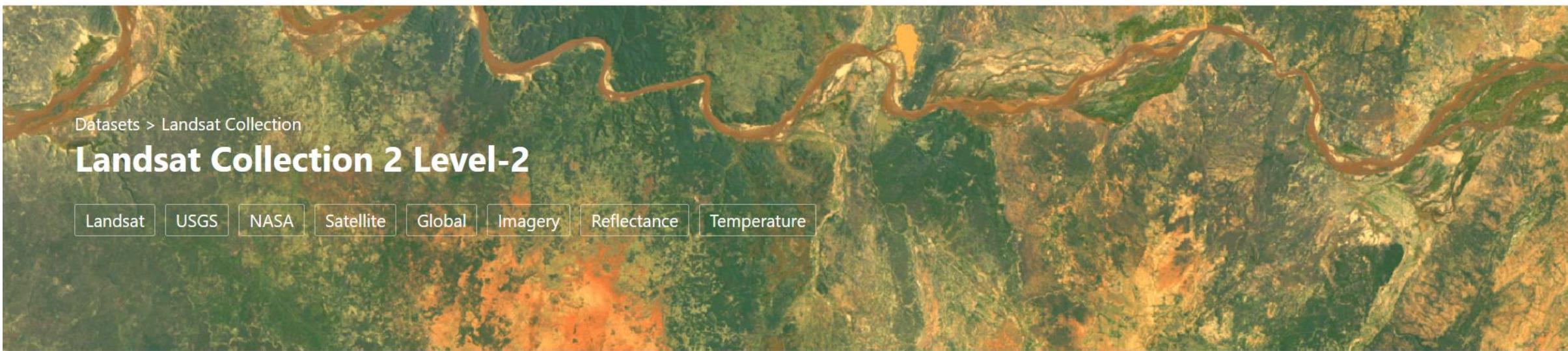
- Data Source: Microsoft Planetary computer
- Original approach: rio.open
  - Lots of errors, inconsistent 404s

```
if not os.path.exists(out_fn) or overwrite:  
    with rio.open(f'{image_url_b4}?{token}') as r_src:  
        with rio.open(f'{image_url_b5}?{token}') as nir_src:
```

- New approach: odc.stac
  - Better results!

```
bands_of_interest = ["nir08", "red", "green", "blue", "qa_pixel", "lwir11"]  
data = odc.stac.stac_load(  
    ..., [selected_item], bands=bands_of_interest, #bbox=bbox_of_interest  
).isel(time=0)  
data
```

✓ 3m 8.1s



Datasets > Landsat Collection

## Landsat Collection 2 Level-2

Landsat USGS NASA Satellite Global Imagery Reflectance Temperature

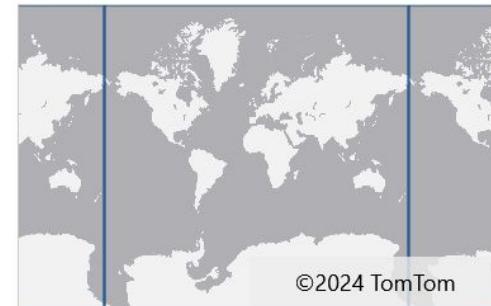
[Overview](#) [Example Notebook](#)

### Overview

Landsat Collection 2 Level-2 [Science Products](#), consisting of atmospherically corrected [surface reflectance](#) and [surface temperature](#) image data. Collection 2 Level-2 Science Products are available from August 22, 1982 to present.

This dataset represents the global archive of Level-2 data from [Landsat Collection 2](#) acquired by the [Thematic Mapper](#) onboard Landsat 4 and 5, the [Enhanced Thematic Mapper](#) onboard Landsat 7, and the [Operational Land Imager](#) and [Thermal Infrared Sensor](#) onboard Landsat 8 and 9. Images are stored in [cloud-optimized GeoTIFF](#) format.

### Spatial Extent



[Launch in Explorer](#)

### Azure data region

westeurope

### Temporal Extent

08/22/1982 – Present

CSD

### STAC Collection

<https://planetarycomputer.microsoft.com/api/stac/v1/collections/landsat-c2-l2>

### Providers

[NASA](#) (producer, licensor)

[USGS](#) (producer, processor, licensor)

[Microsoft](#) (host)

# Challenges: I bricked my Jupyterhub!

REMINDER: Winter quarter 2024 JupyterHubs are scheduled to be deleted on or after June 7, 2024. Please download any files you would like to keep before then.

Your server is starting up.

You will be redirected automatically when it's ready for you.

Spawn failed: Server at http://10.2.198.103:8888/2024-winter-cee-467-a/user/aviola2/ didn't respond in 30 seconds

Event log

Server requested

2024-03-08T19:10:19Z [Normal] Successfully assigned rttl-2024-winter-cee-467-a/jupyter-aviola2 to gke-uwit-mci-0012-clu-node-pool-bravo-0a177270-6lss

2024-03-08T19:10:27Z [Normal] AttachVolume.Attach succeeded for volume "pvc-b4c5249a-b875-4ba6-b980-80f1060c8c80"

2024-03-08T19:10:31Z [Normal] Container image "quay.io/jupyterhub/k8s-network-tools:3.2.1" already present on machine

2024-03-08T19:10:31Z [Normal] Created container block-cloud-metadata

2024-03-08T19:10:31Z [Normal] Started container block-cloud-metadata

2024-03-08T19:10:32Z [Normal] Pulling image "uwgda/uwgda-image-2024:latest"

2024-03-08T19:10:33Z [Normal] Successfully pulled image "uwgda/uwgda-image-2024:latest" in 383.143905ms (383.202205ms including waiting)

2024-03-08T19:10:33Z [Normal] Created container notebook

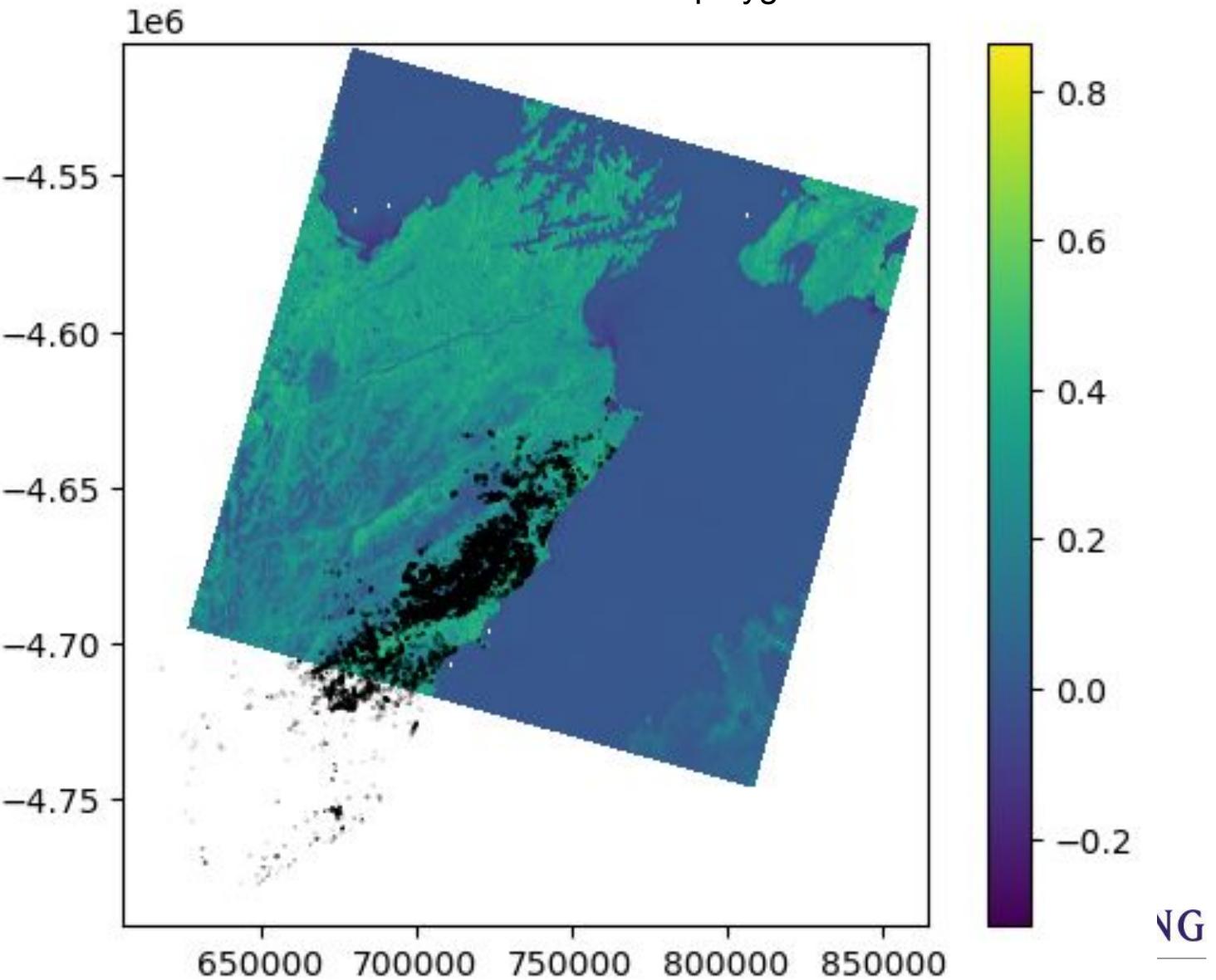
2024-03-08T19:10:33Z [Normal] Started container notebook

2024-03-08T19:10:34Z [Normal] Successfully pulled image "uwgda/uwgda-image-2024:latest" in 148.752948ms (148.776688ms including waiting)

Spawn failed: Server at http://10.2.198.103:8888/2024-winter-cee-467-a/user/aviola2/ didn't respond in 30 seconds

# NDVI

12/16/2016 NDVI and landslide polygons

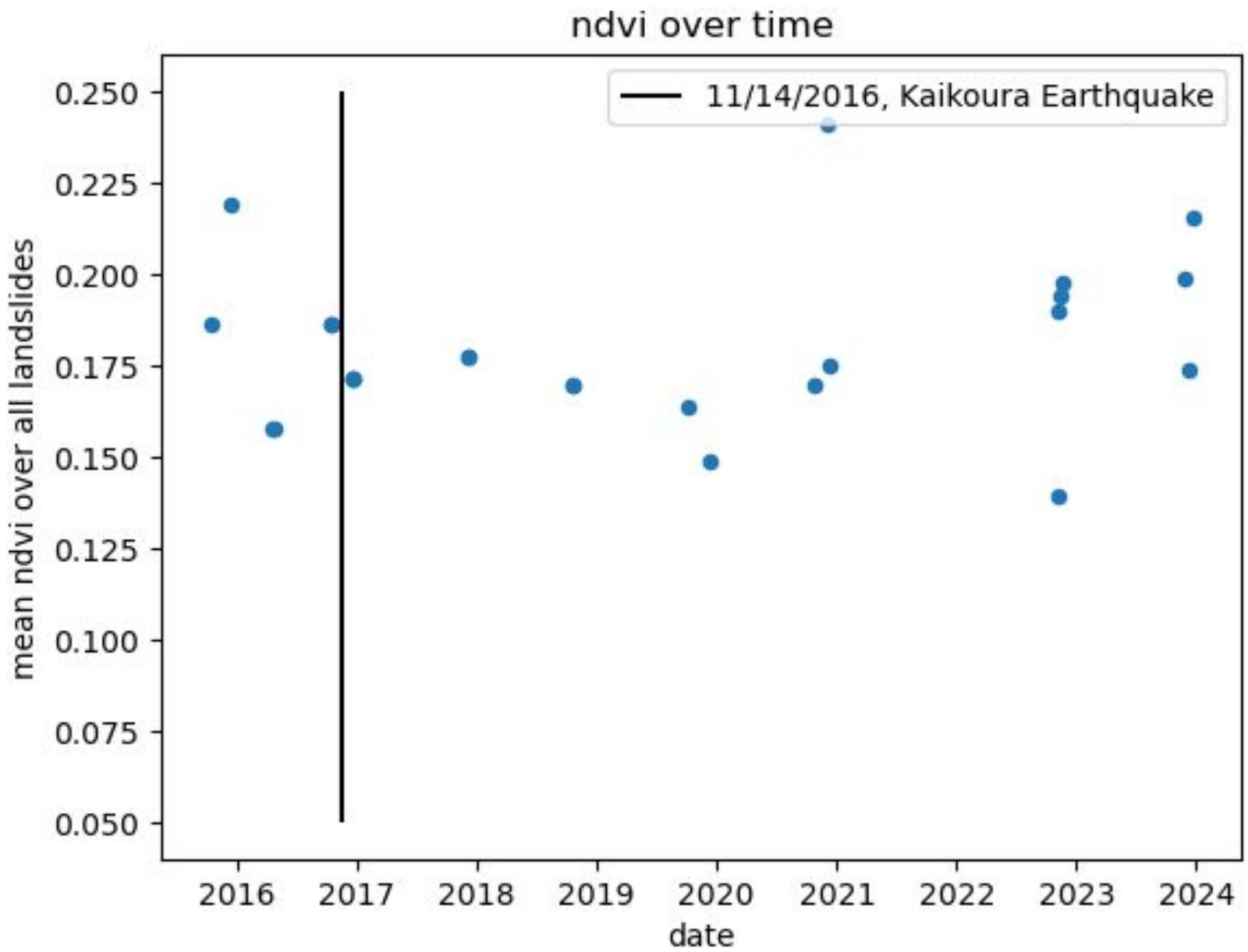


# NDVI

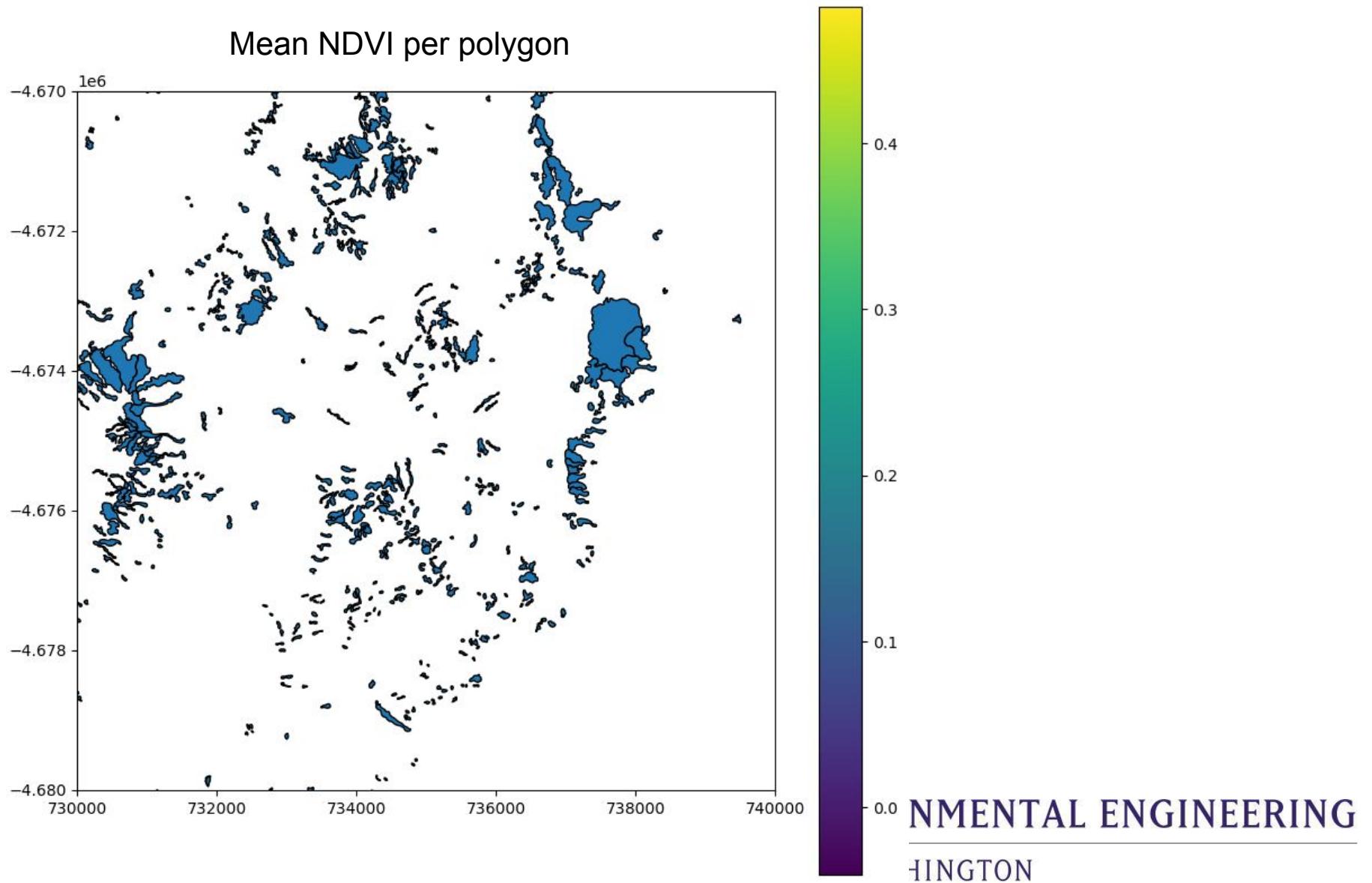
Tracking ndvi over time over all landslides.

Data from landsat collection 2 imagery taken in October, November, or December with cloud cover <10%

No clear change in NDVI after earthquake

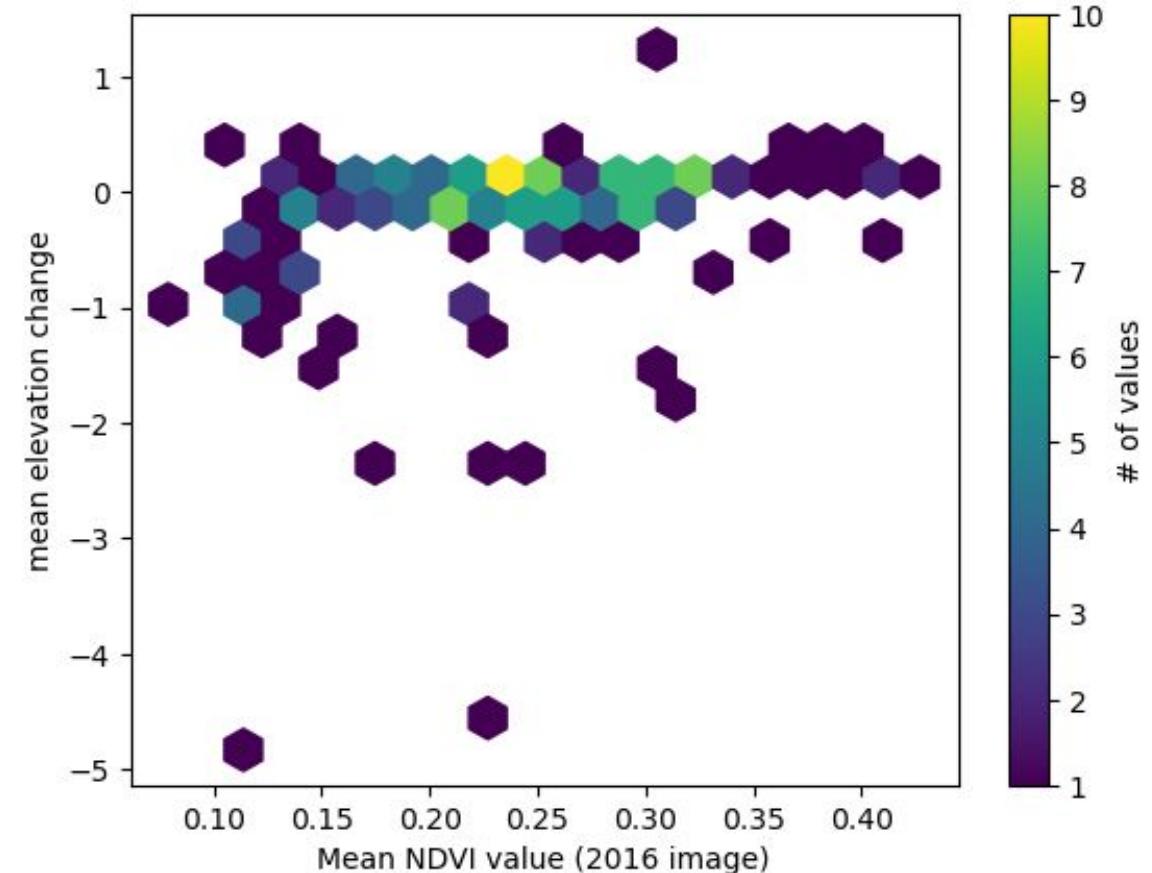
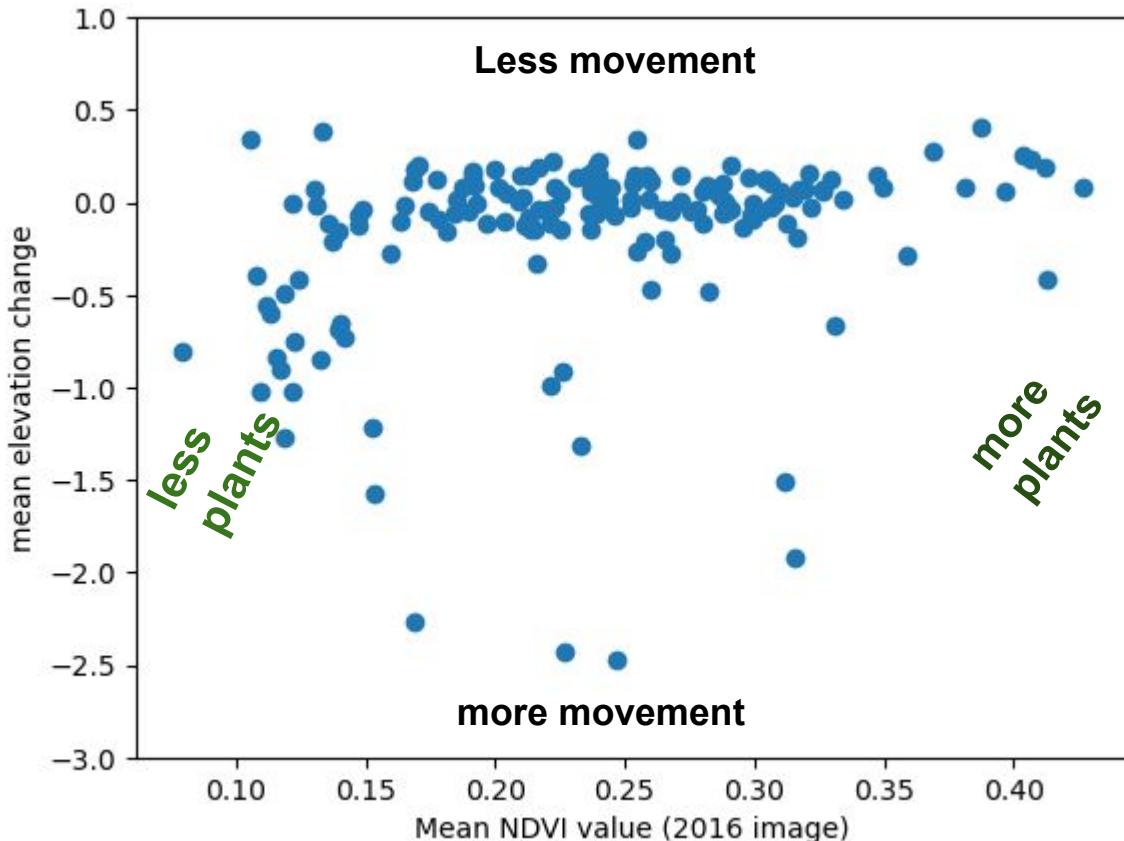


# NDVI



# Does NDVI correlate with reactivation

We might see more movement in less plant areas



The same data in two plots

# DEM analysis

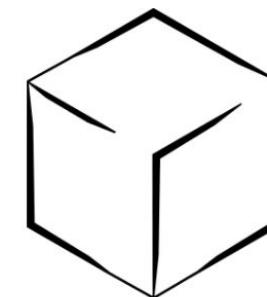
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I found a new (to me)  
landscape analysis toolset



The first paid Python  
package I've seen?  
Fortunately many of their  
tools are still free

Seats	Price	Select
1	\$360.00	<input checked="" type="radio"/>
2	\$414.00	<input type="radio"/>
3	\$468.00	<input type="radio"/>
5	\$576.00	<input type="radio"/>
10	\$846.00	<input type="radio"/>
25	\$1,656.00	<input type="radio"/>
50	\$3,006.00	<input type="radio"/>



Whitebox Geospatial Inc

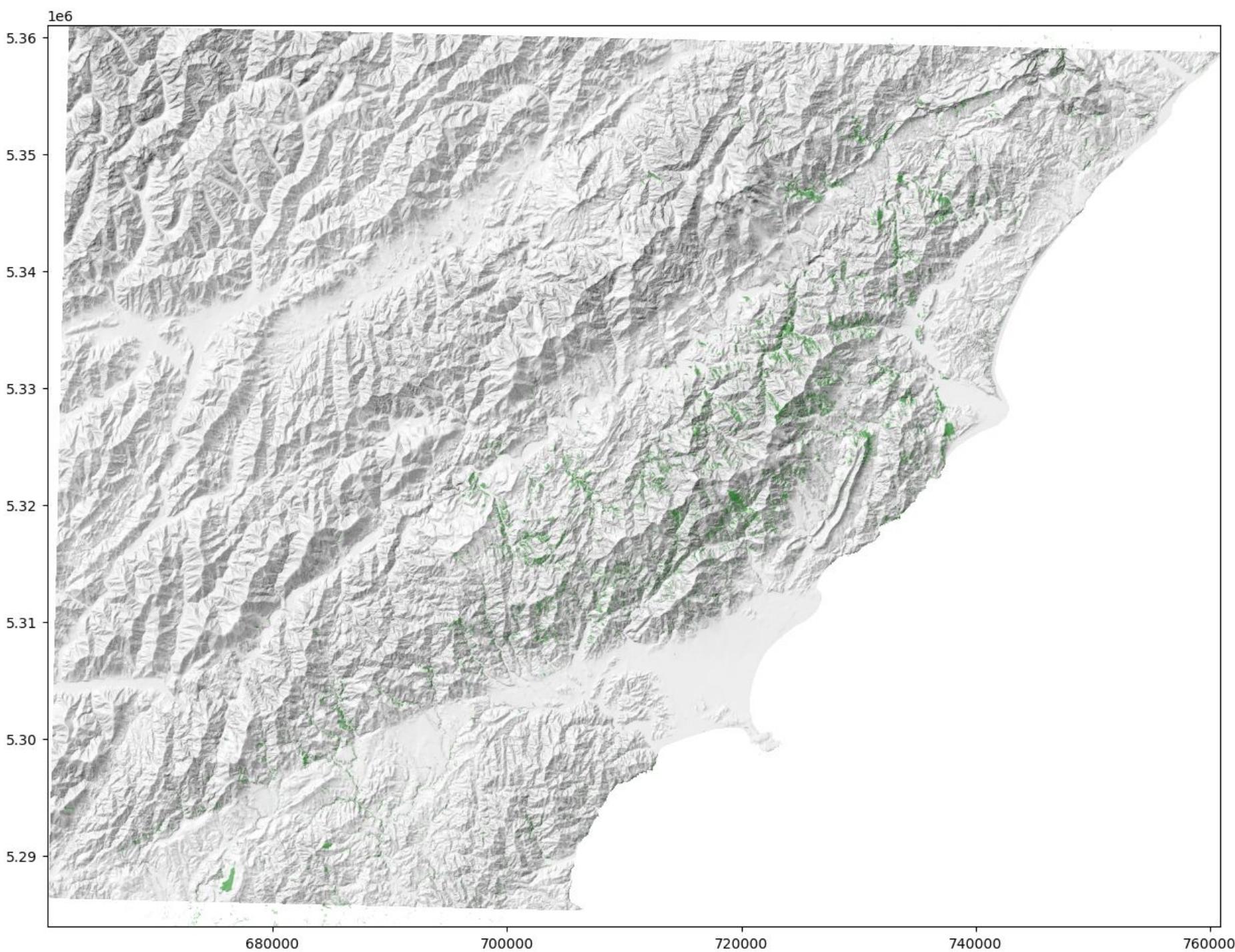
Innovative geospatial software built on open-source

# A pretty hillshade

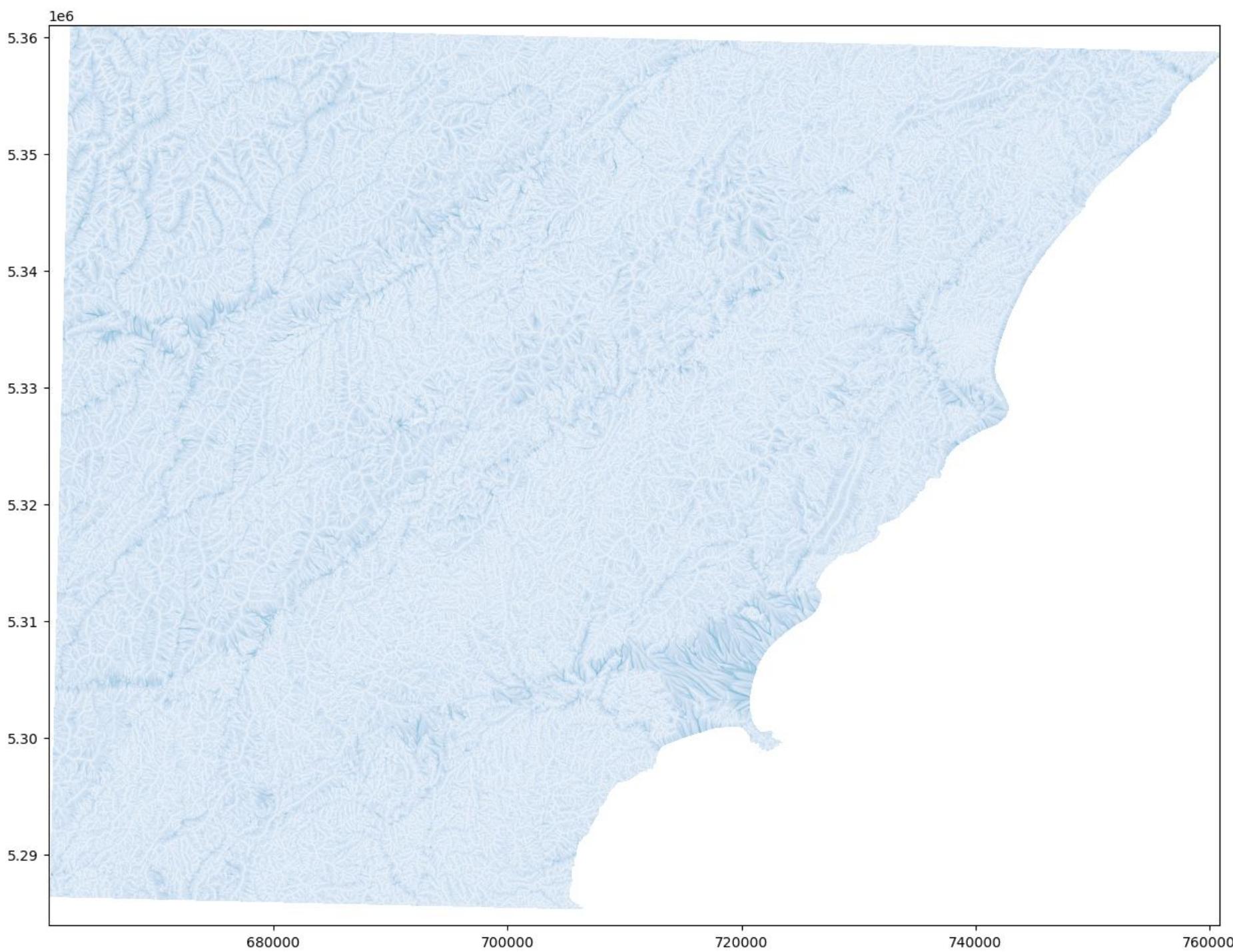
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Goals-

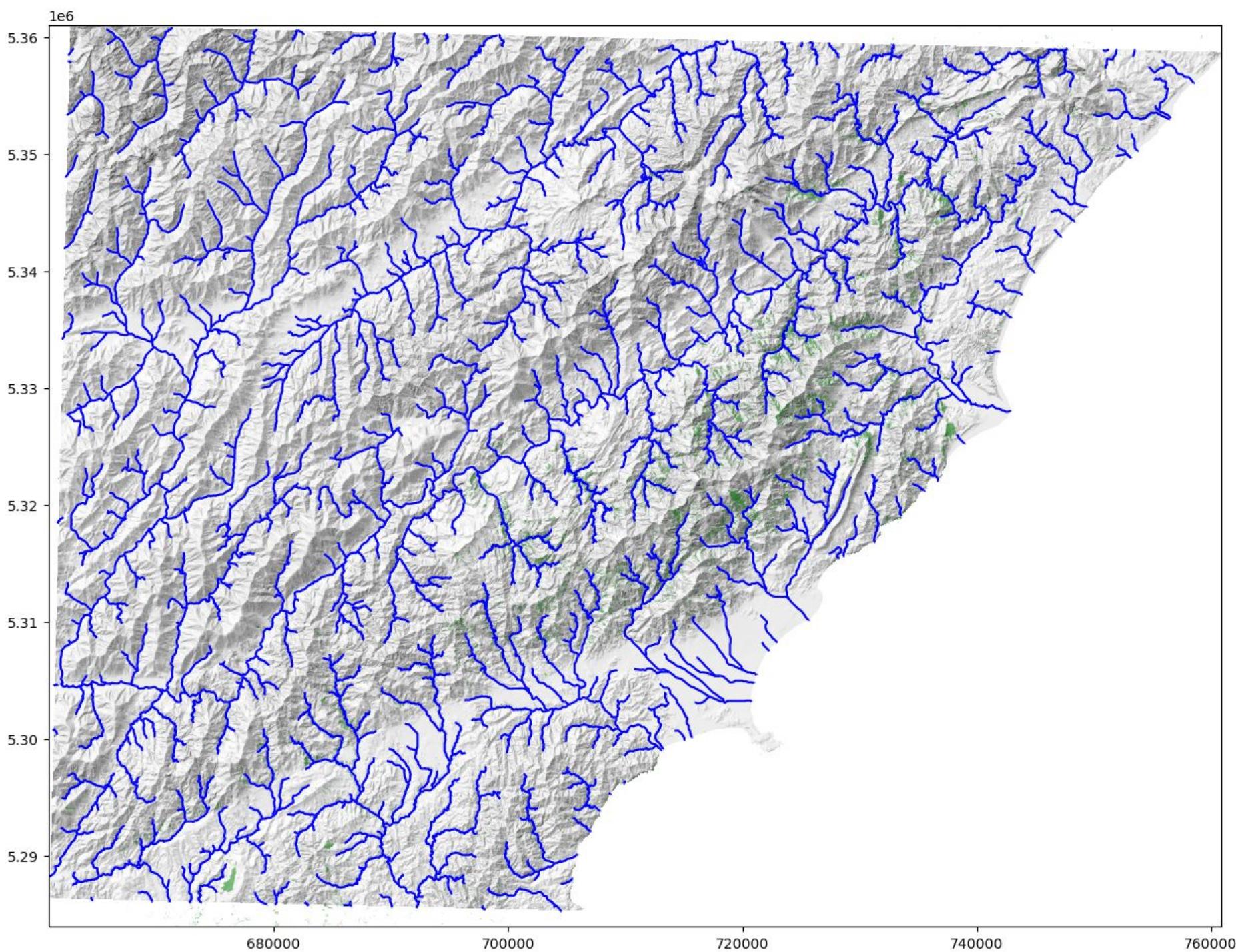
- Extract DEM info at the landslides
- assess hillslope position of the landslides



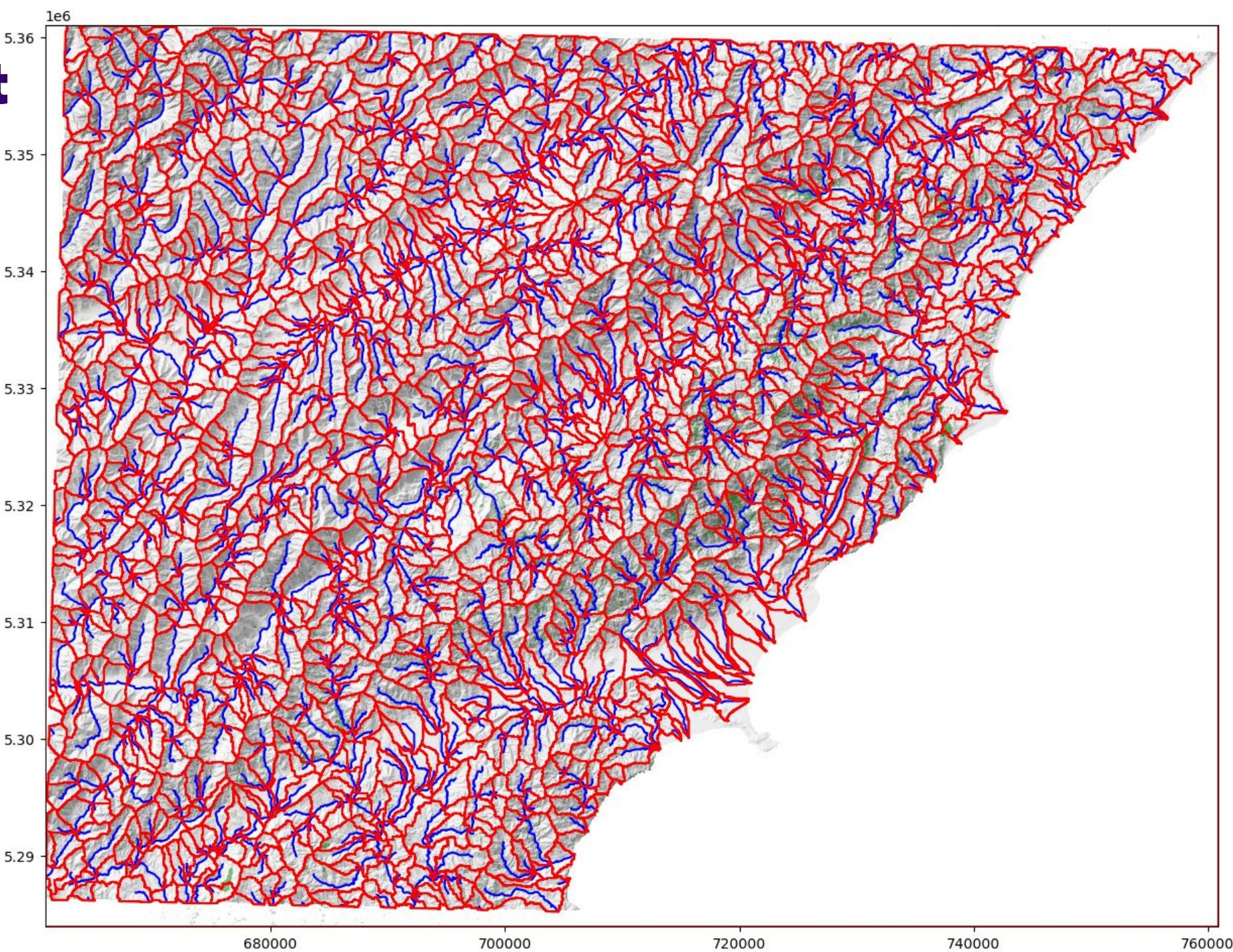
# flow accumulation



# Flow Routing

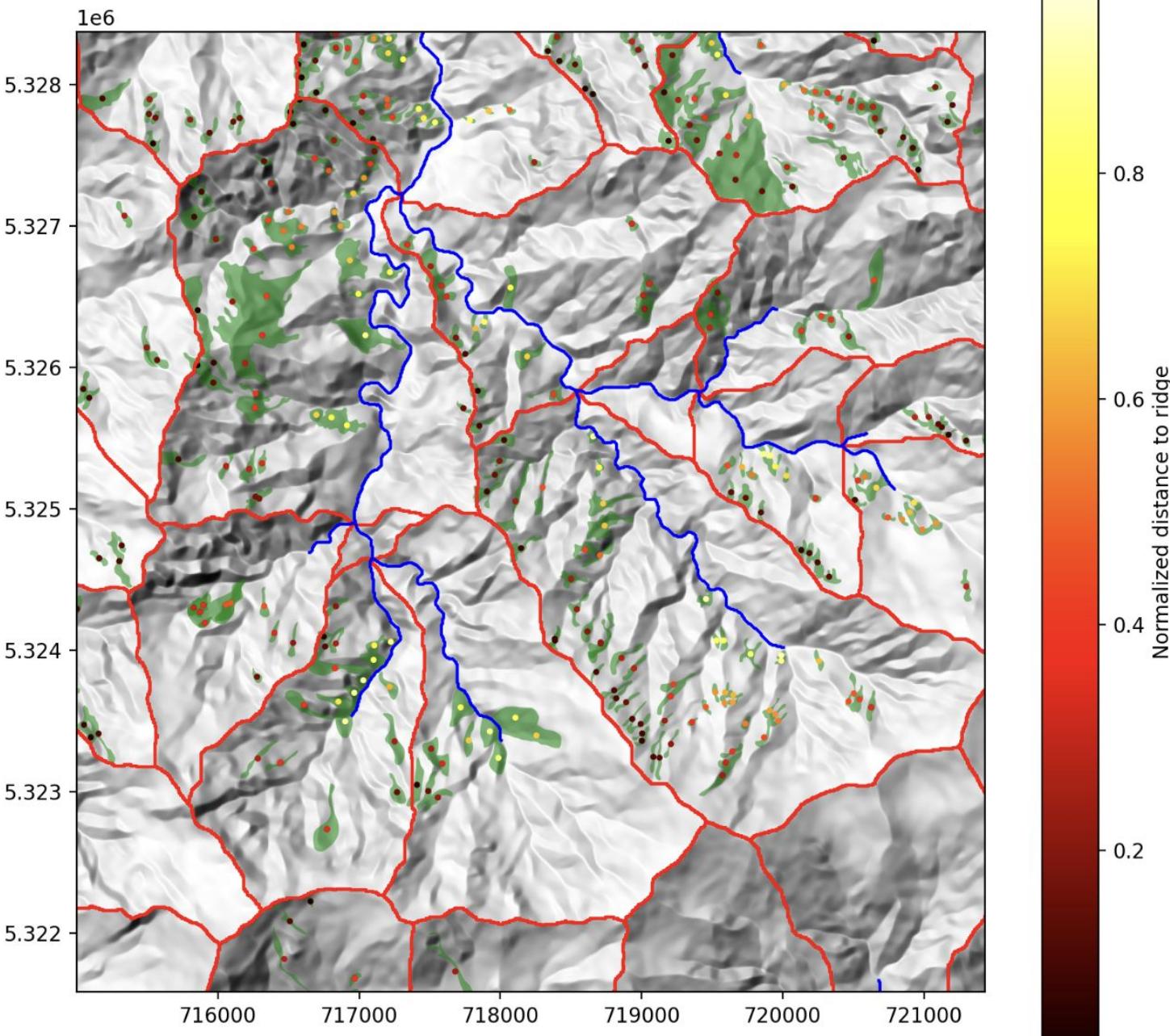
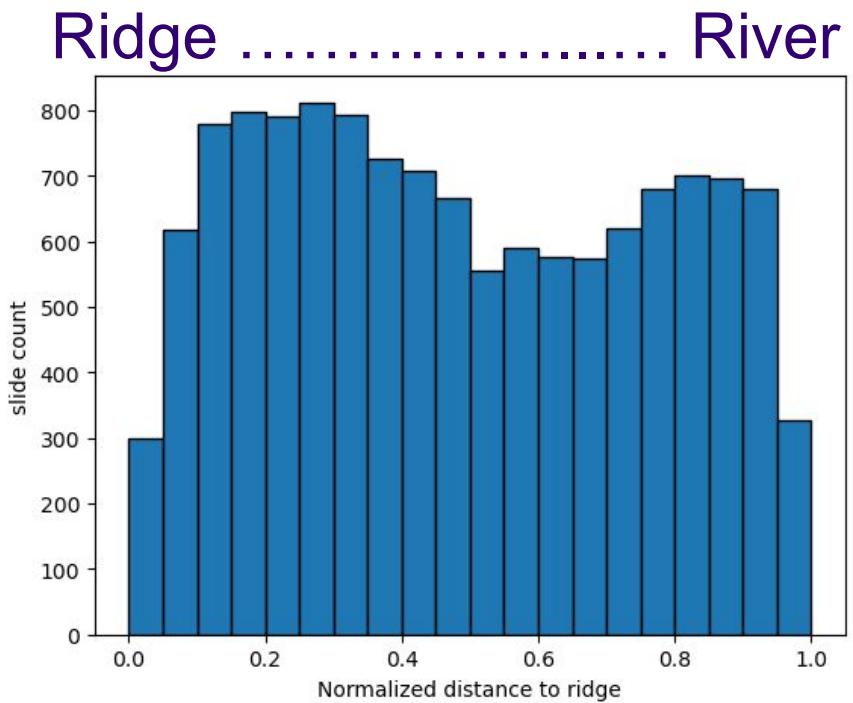


# Subcatchment delineation



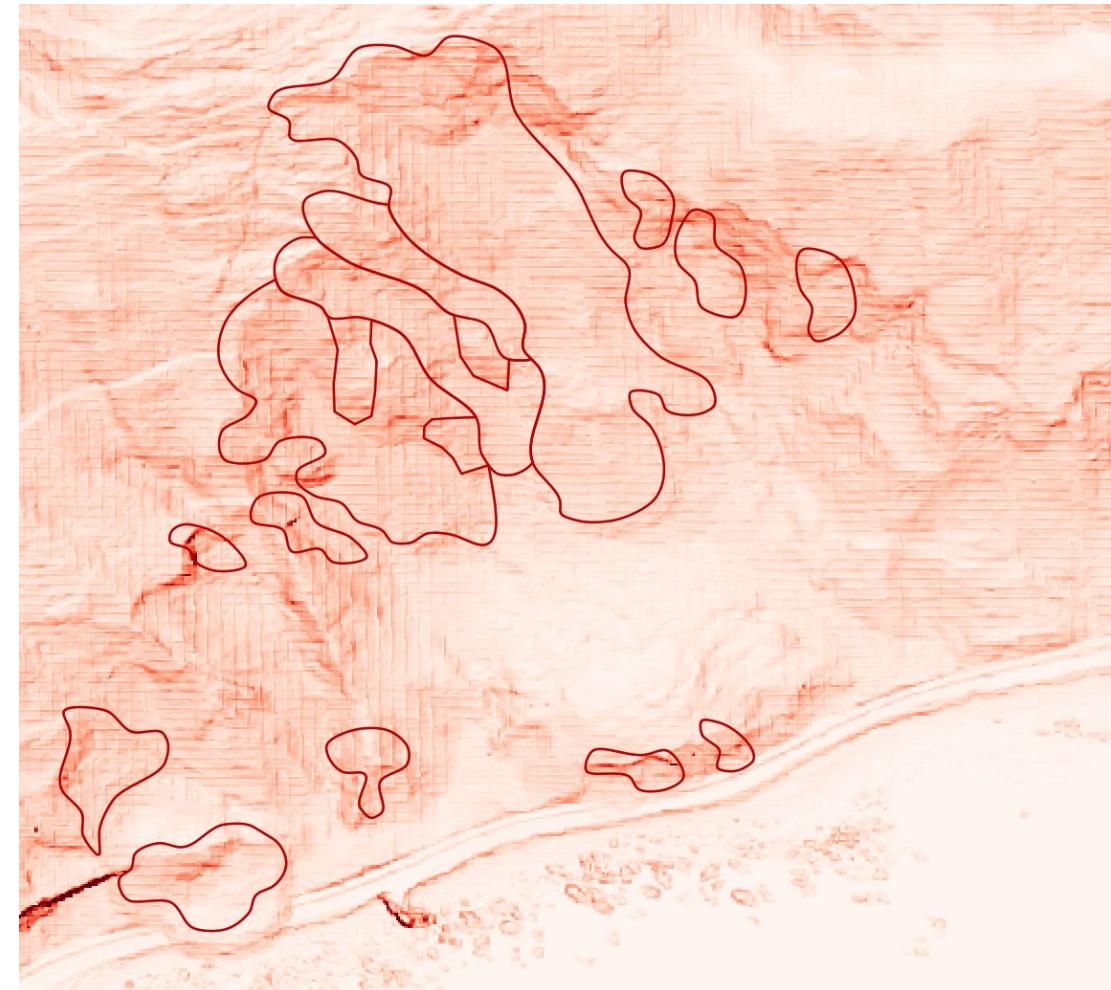
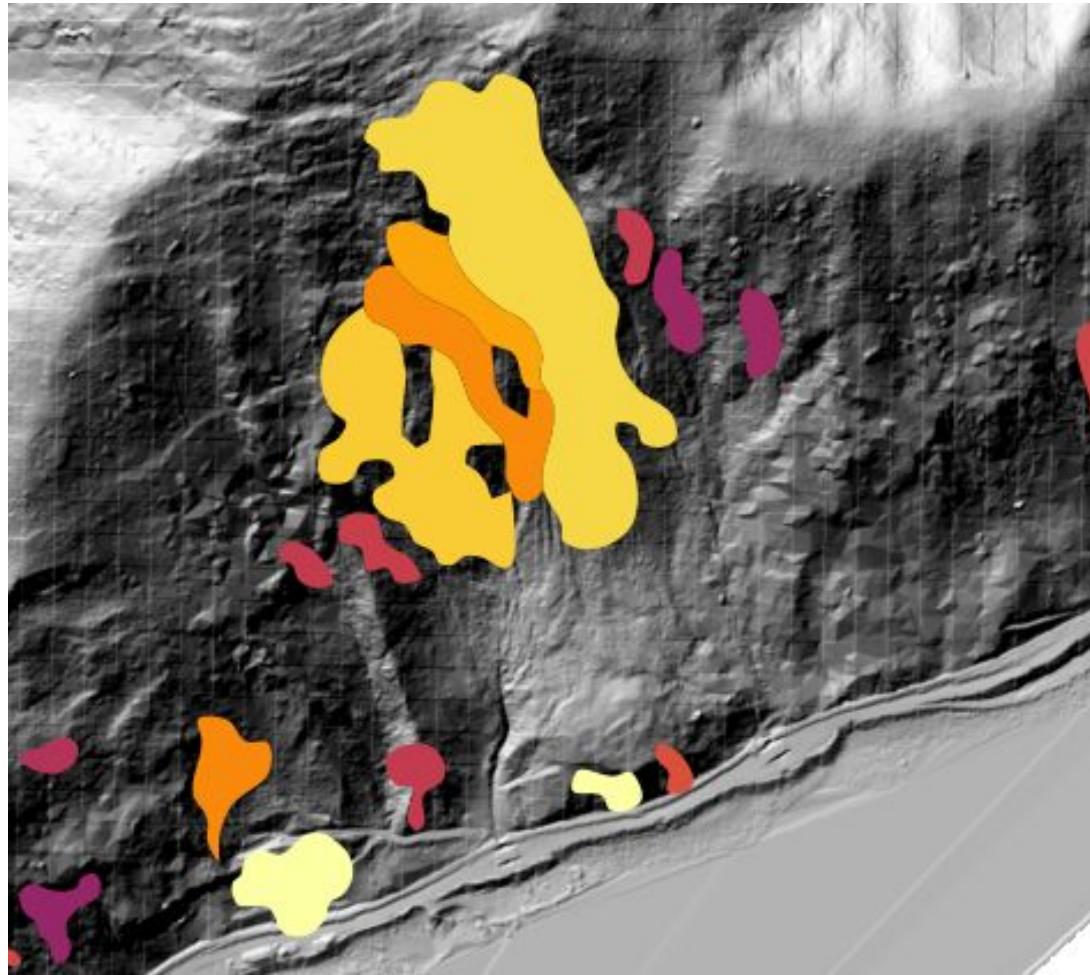
# Do landslides happen closer to ridges?

Maybe slightly, but the method is a little too imprecise at this point



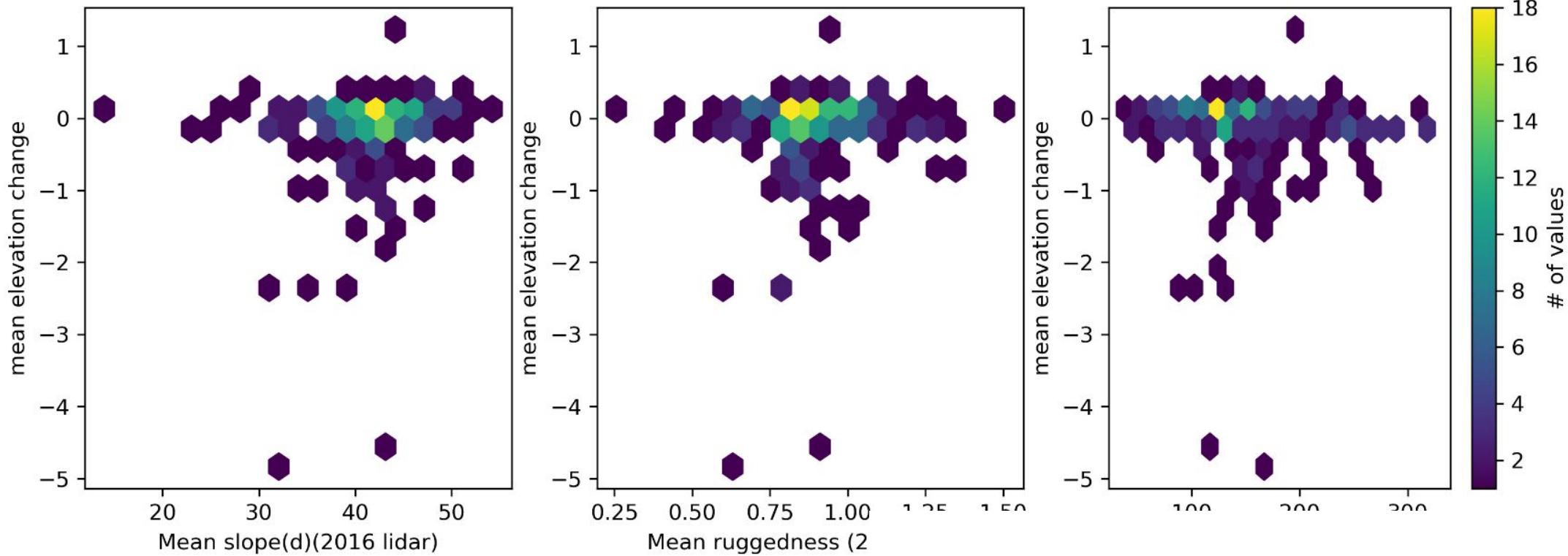
# Does morphology correlate with reactivation?

Deformation and surface roughness



# Are landslide reactiverations related to something measurable on the post-event DEM?

Maybe, but we havent' found it yet...



## Aside on future work

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- ❖ Track changes in surface elevation and NDVI over more timesteps.
- ❖ Correlate the reactivation - difference map with the multimodal failure (mode of failure).

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