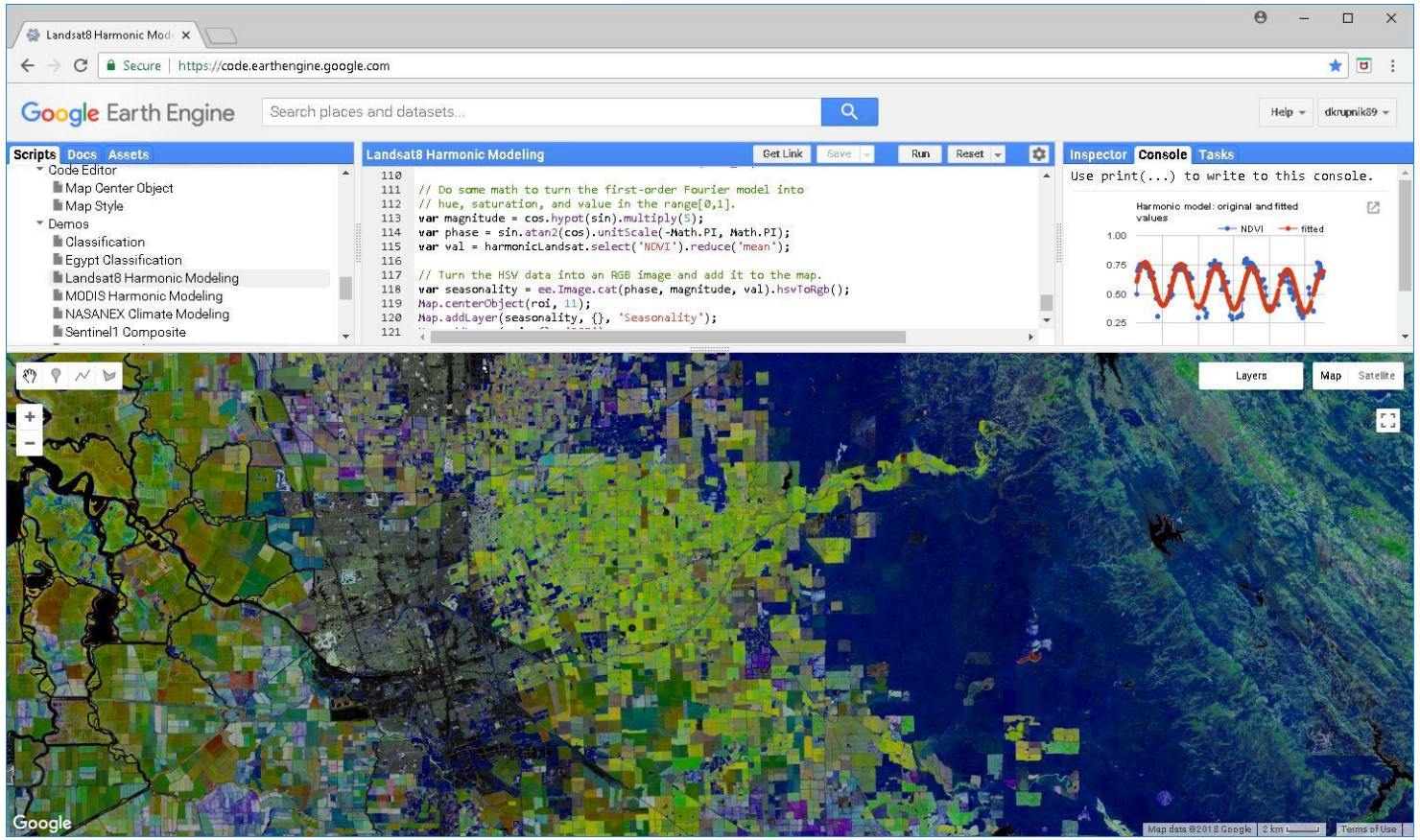
Google Earth Engine

FELIPE CAMACHO

JUNE 1, 2023



serc.carleton.edu

Overview

1. **Introduction**
   a. Big Data in Remote Sensing
   b. What is Google Earth Engine (GEE)?
   c. Why is it Important?

2. **GEE Key Components**
   a. Data Catalogue
   b. Computation
   c. Browser-Based IDE

3. **GEE Concepts and Workflow**
   a. Main Concepts
   b. Common Workflow
   c. Additional Characteristics

4. **Study Case and Demo**
5. **References**

1.a) Big Data in Remote Sensing

- Big Data refers to a tremendous and complicated dataset that is difficult to store, manage, and process using traditional processing tools. (Liu, el al. 2015)

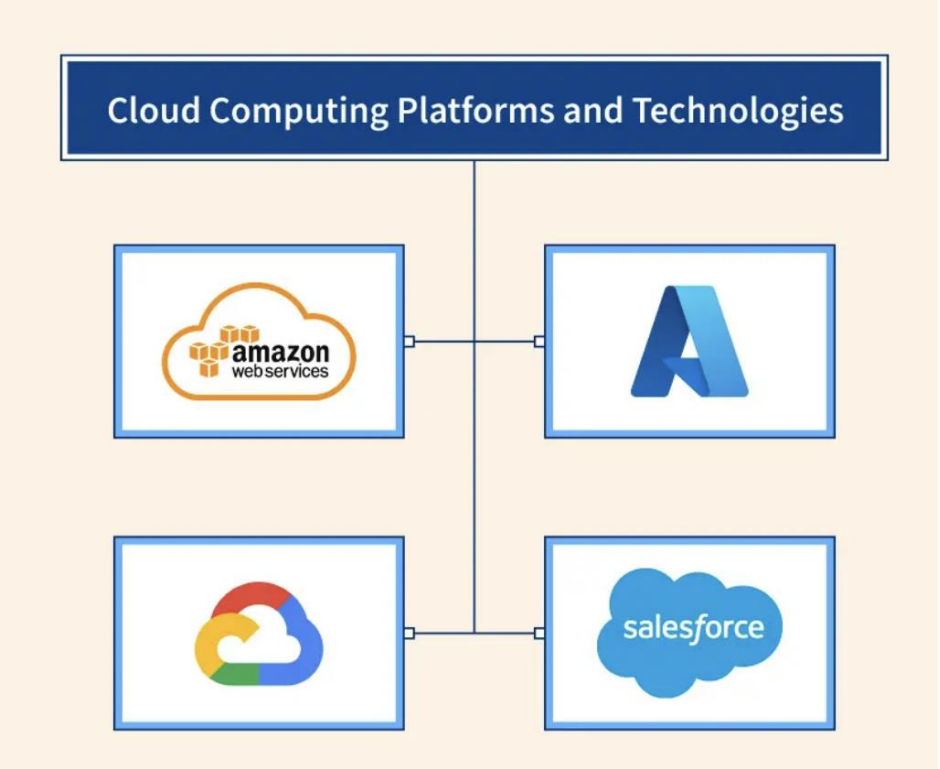
- Big Data is characaterized by four dimesions know as the 4Vs (Sugumaran, et al. 2015).

Ahamed, T. (2022). Big Data Scheme from Remote Sensing Applications

1.a) Big Data in Remote Sensing

- These characteristics raise several challenges, including the acquisition, storage, searching, sharing, transferring, analysis, and visualization of big data (Liu, el al. 2015)

- To address the existing challenges in geo-big data analysis, cloud platforms were implemented.

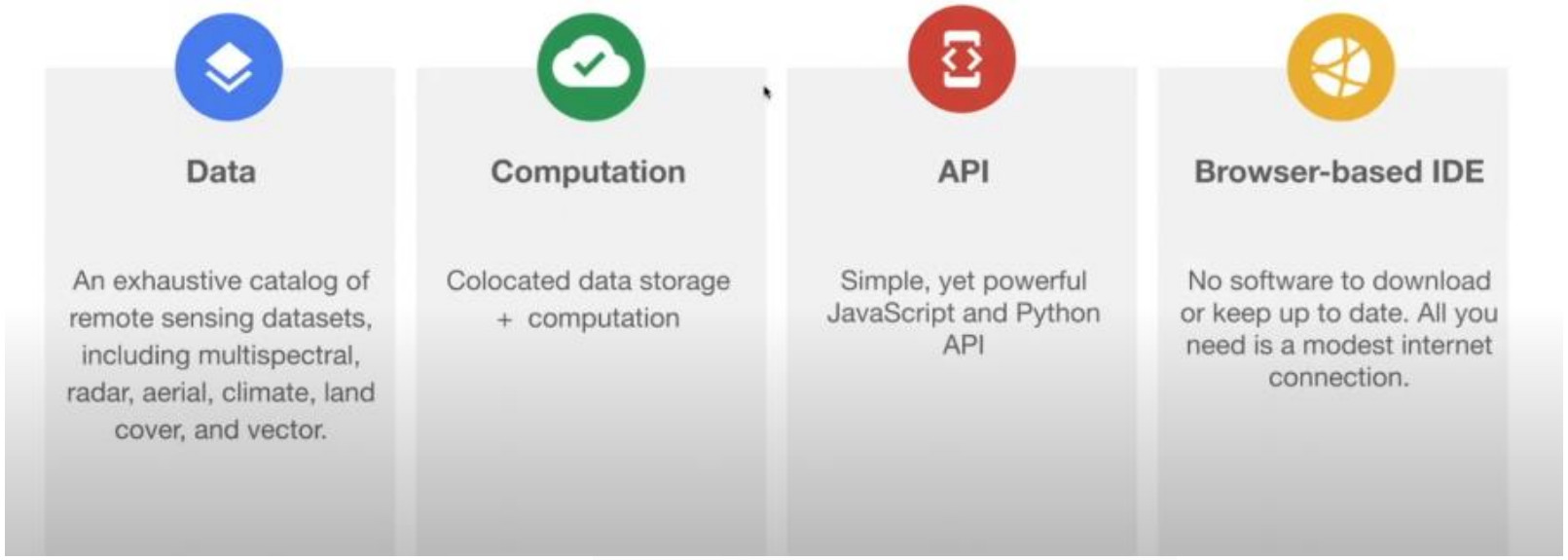


https://www.scaler.com/topics/cloud-computing-platforms/

1.b) Google Earth Engine (GEE)

- GEE is a **cloud computing platform with a multi-petabyte catalog of satellite imagery and geospatial datasets** (Gorelick et al., 2017).

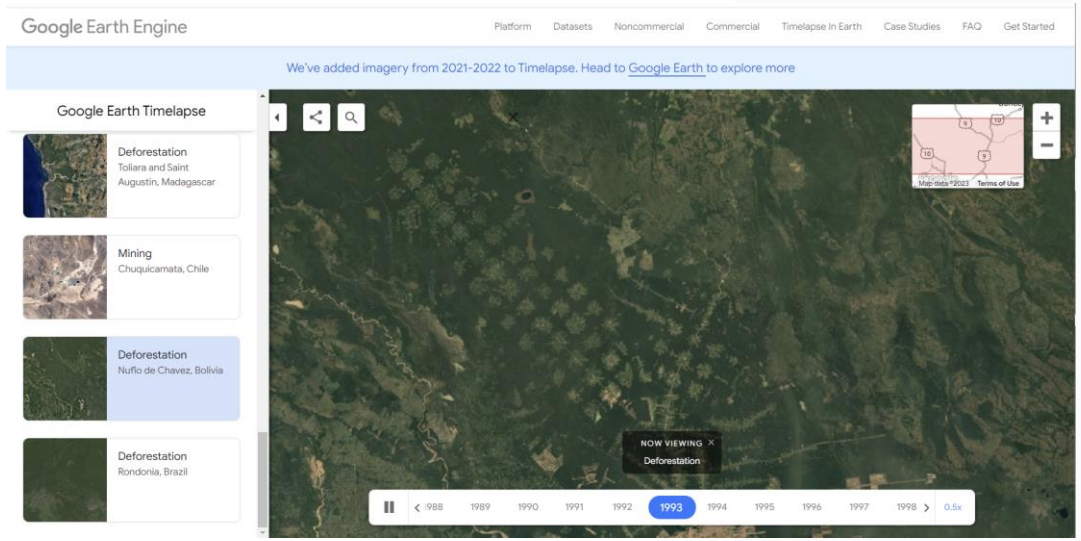
- GEE is a cloud-based platform that **enables large-scale processing of satellite imagery to detect changes, map trends, and quantify differences on the Earth's surface**. (Gandhi, 2021)



Gandhi, 2021. End-to-End Google Earth Engine Course

1.c) Why is it Important?

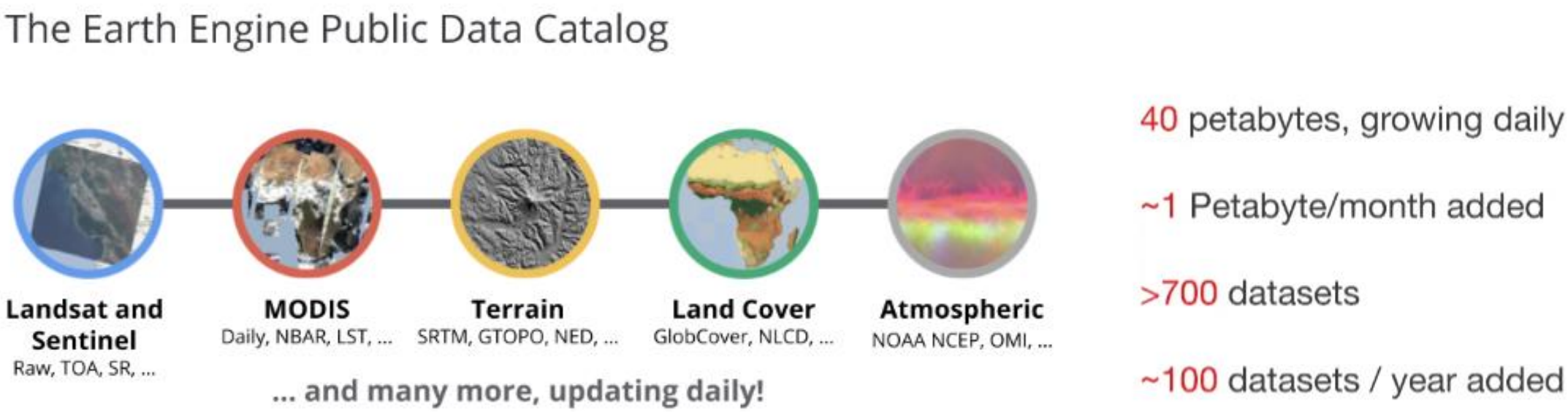
- *"Google Earth Engine has made it possible for the first time in history to rapidly and accurately process vast amounts of satellite imagery, identifying where and when tree cover change has occurred at high resolution."* Dr. Andrew Steer, President and CEO of the World Resources Institute.



Google Earth Timelapse

Hansen, et al. (2013). Forest Loss in Riau, Indonesia.

2.a) GEE Key Components – Data Catalogue



40 petabytes, growing daily

~1 Petabyte/month added

>700 datasets

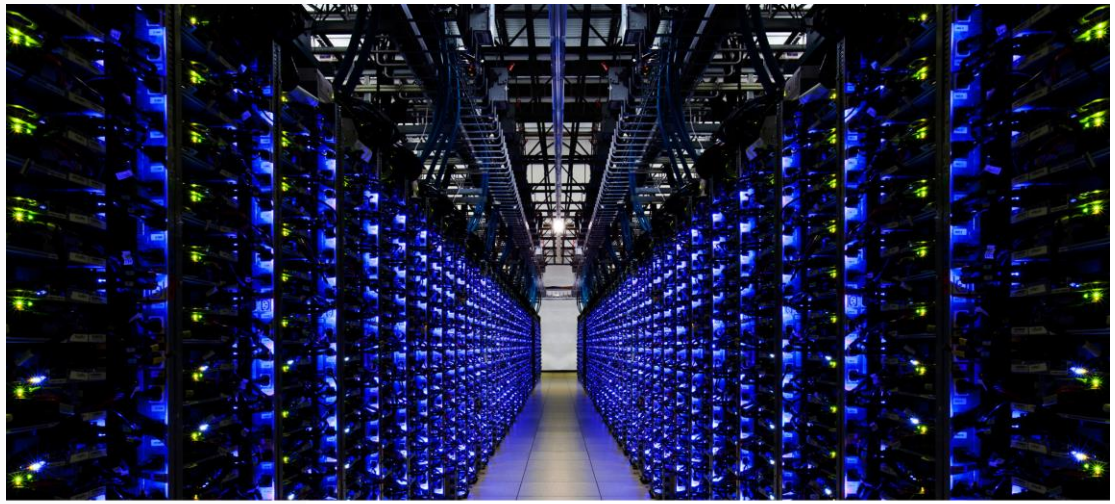
~100 datasets / year added

Earth Engine Data Catalogue

2.b) GEE Key Components - Computation

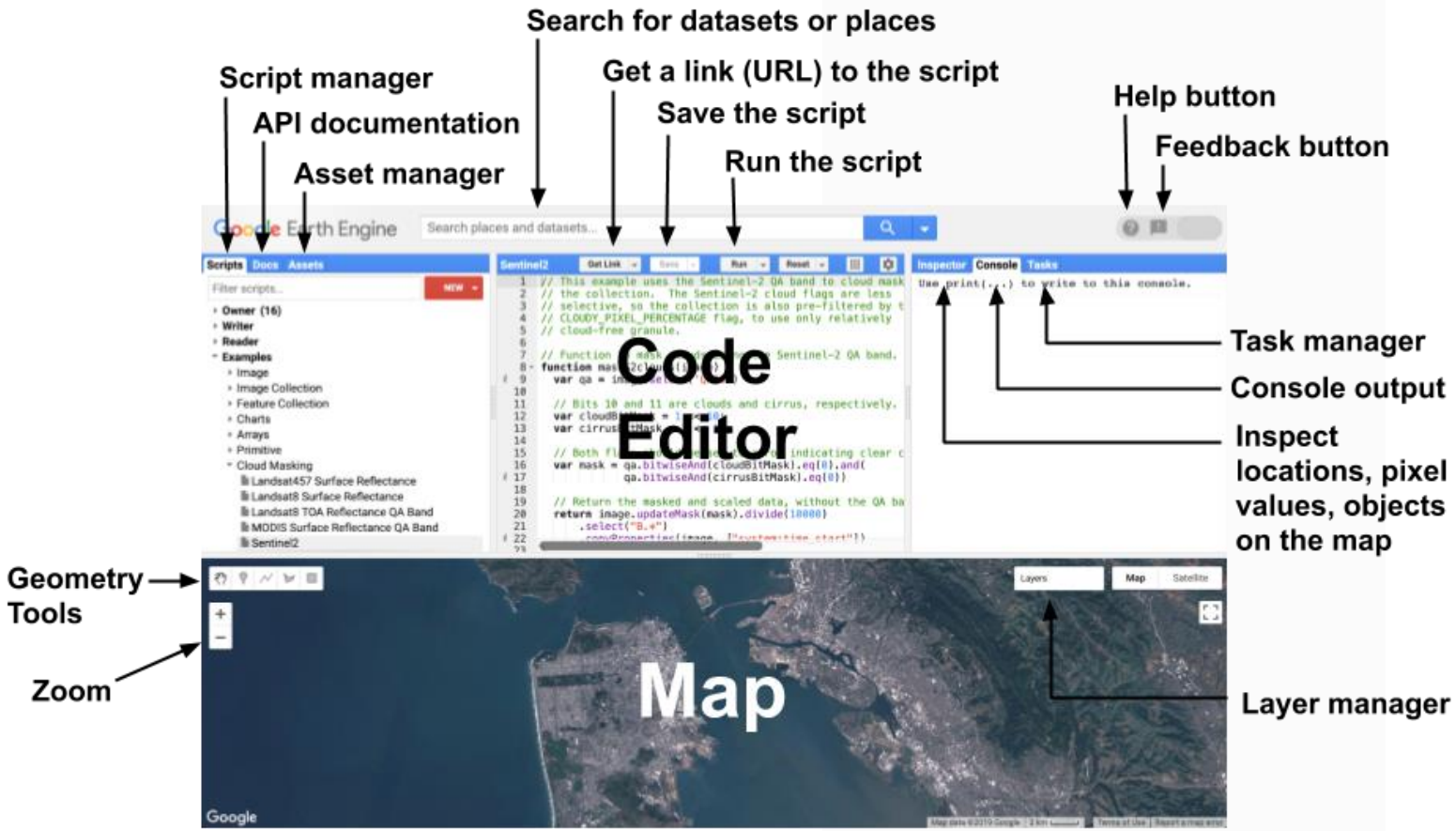
- Large pool of servers, co-located with data.
- Allows for cloud-based distributed computing.
- 300 Million CPU hours/year

Gandhi, 2021



Gorelick, 2020. Earth Engine 101.

2.c) GEE Key Components – Browser-Based IDE



Earth Engine Code Editor

- ✓ JavaScript Code Editor
- ✓ Map Display
- ✓ Console Output
- ✓ Geometry Drawing Tools

3.a) GEE Concepts and Workflow – Main Concepts

Feature

- Line / Point / Polygon
- List of Properties

TNC Ecoregions

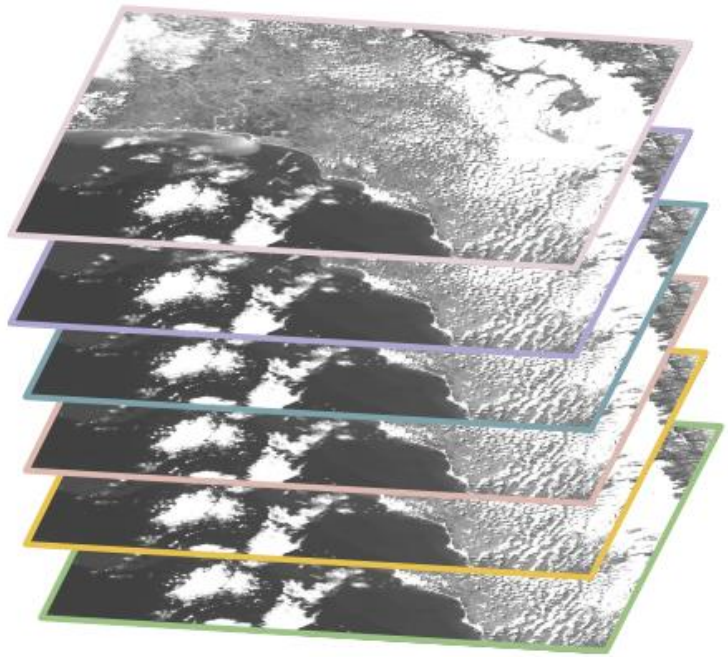
Gorelick, 2020. Earth Engine 101.

3.a) GEE Concepts and Workflow – Main Concepts

Feature

Image

- Stack of Georeferenced bands
- Each band has its own:
  - Mask, Projection, Resolution
- A list of properties, including:
  - Date, Bounding-box



Gorelick, 2020. Earth Engine 101.

3.a) GEE Concepts and Workflow – Main Concepts

Feature

Image

Collection

- Bag of Elements
  - Table of Features
  - Directory of Images
- Filter, Sort, Join, Map, Reduce

Gorelick, 2020. Earth Engine 101.

3.a) GEE Concepts and Workflow – Main Concepts

- Band math
- Clip
- Projections
- Statistics
- Filter
- Mosaic
- Composite bands
- Convolution
- Kernel
- Aggregate

https://gisgeography.com/google-earth-engine/

3.a) GEE Concepts and Workflow – Main Concepts

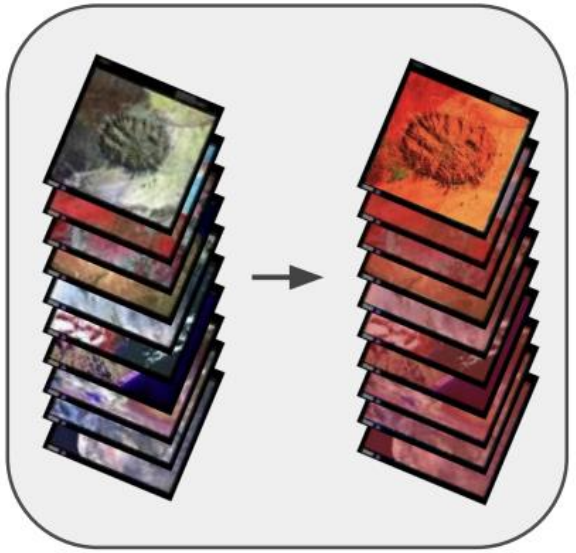
Map

Apply a function to each element of a collection

A "For Each" operation

Examples

- Compute area of each feature
- Cloud cover of each image
- Mosaic for each month



Gorelick, 2020. Earth Engine 101.

3.a) GEE Concepts and Workflow – Main Concepts

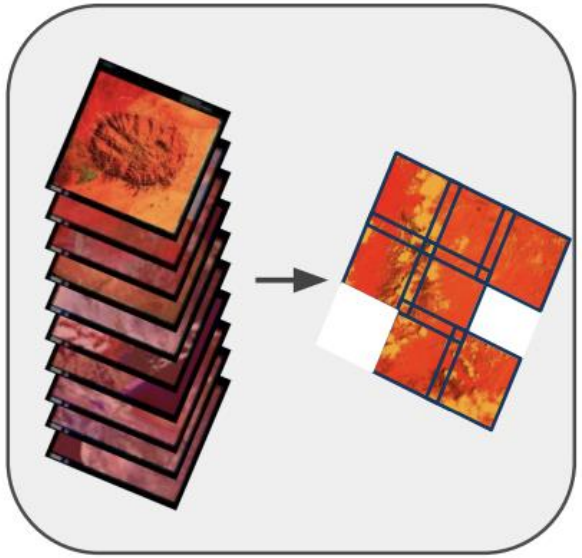
Reduce

Apply a function to everything in a collection

"Aggregation"

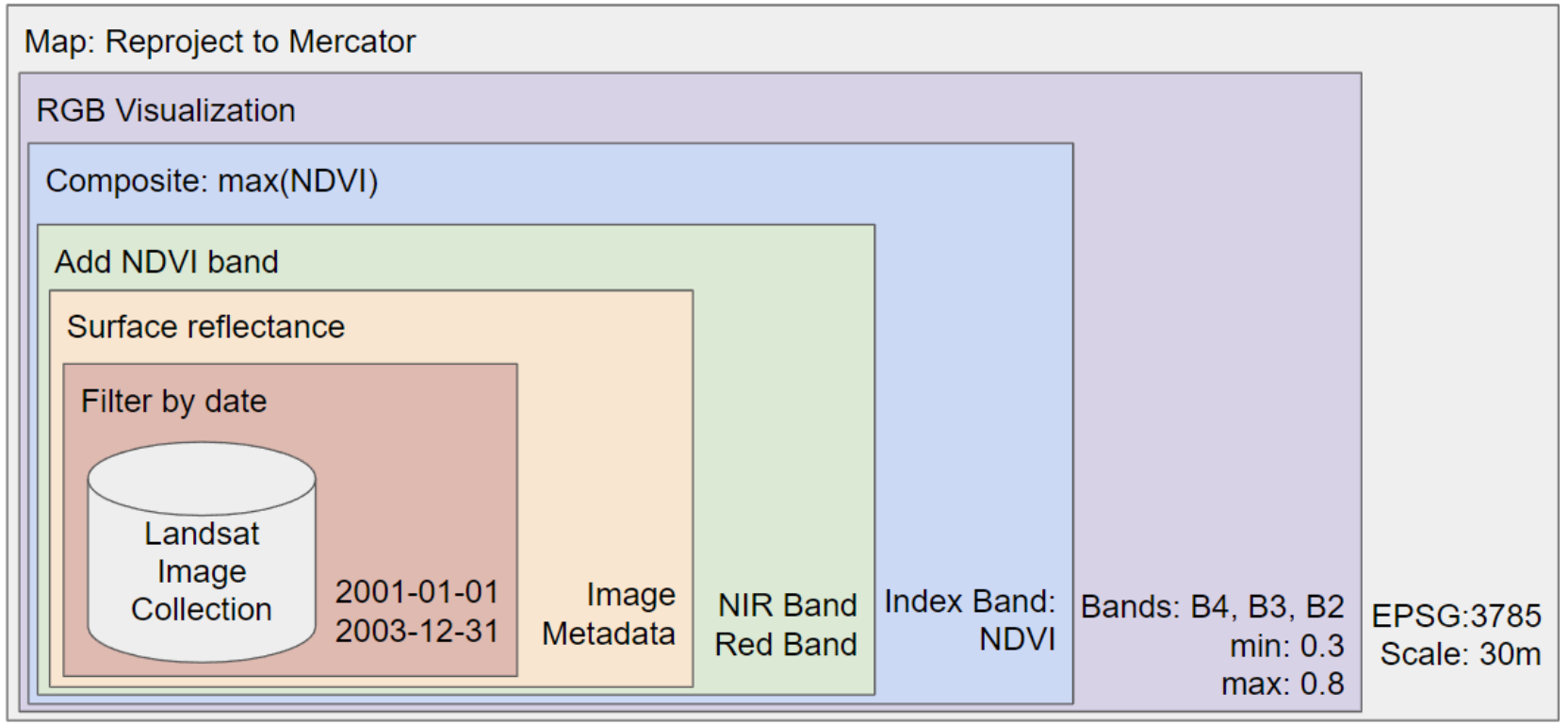
Examples

- Summed area over all features
- Median-pixel composite
- Train a classifier



Gorelick, 2020. Earth Engine 101.

3.b) GEE Concepts and Workflow – Common Workflow



Gorelick, 2020. Earth Engine 101.

3.c) GEE Concepts and Workflow - Additional Characteristics

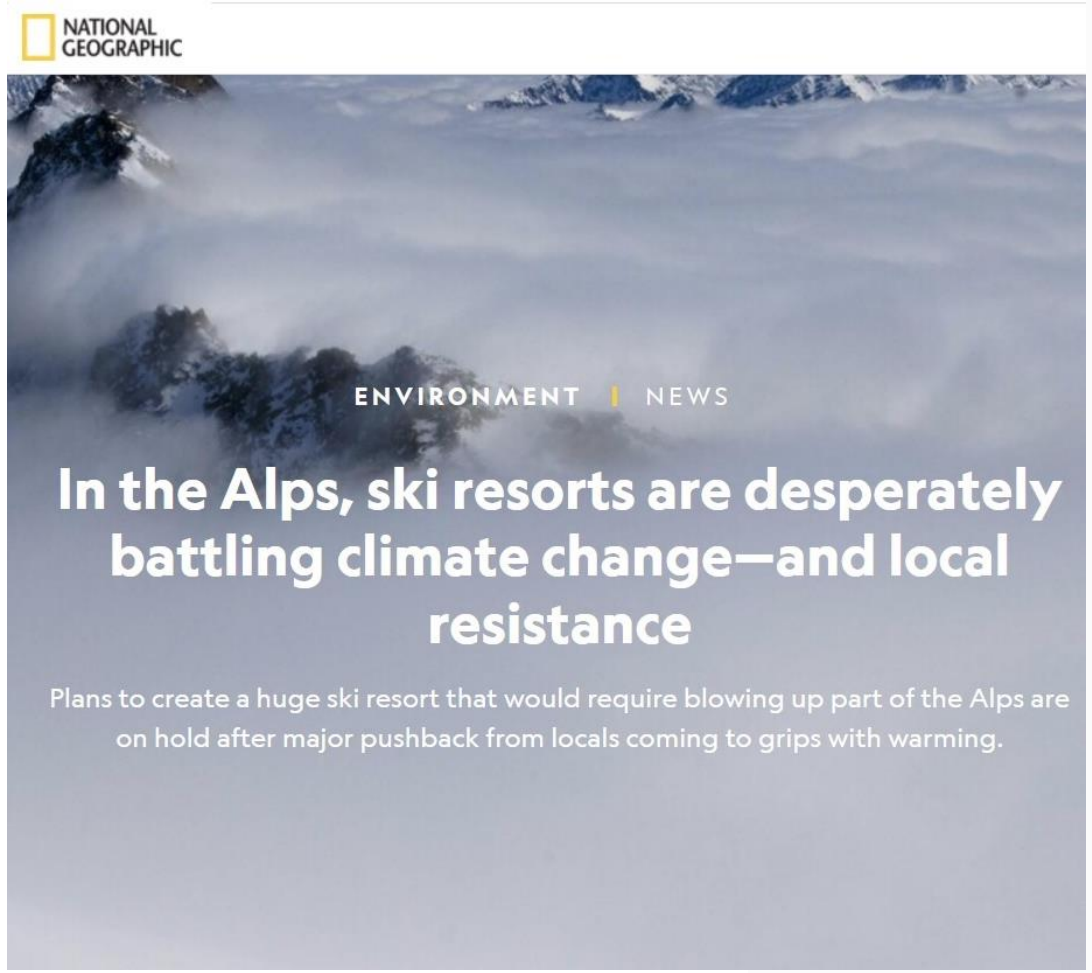
- ✓ Upload your own raster and vector data.
- ✓ Free for non-commercial use
- ✓ Flexible access through APIs.
- ✓ Version Control

- ✓ Internet Connectivity
- ✓ Complexity (Steep learning curve)

4. Study Case

TIME-SERIES ANALYSIS OF SNOW COVER AND LAND SURFACE TEMPERATURE IN AUSTRIA SKIING AREAS WITH GEE

Context



National Geographic (December 2020)

- Skiing industry represent 3% of Austrian Gross Domestic Product.
- Snow cover decrease increase erosion and rock fall, lost of habitat, drought and floods.

Context

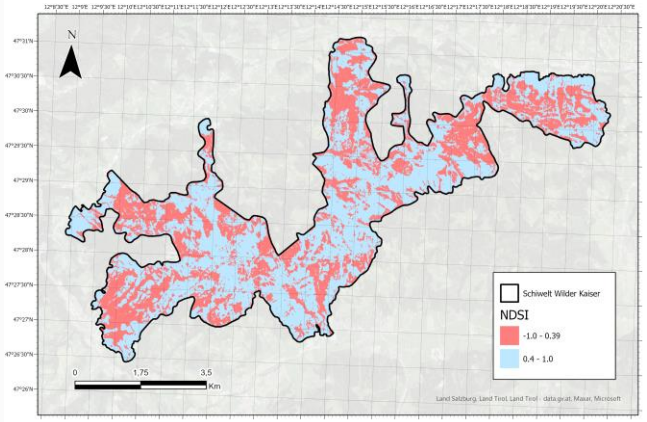
- The Alpine climate has changed radically over the past century, with temperatures rising by 2°C: twice the global average.

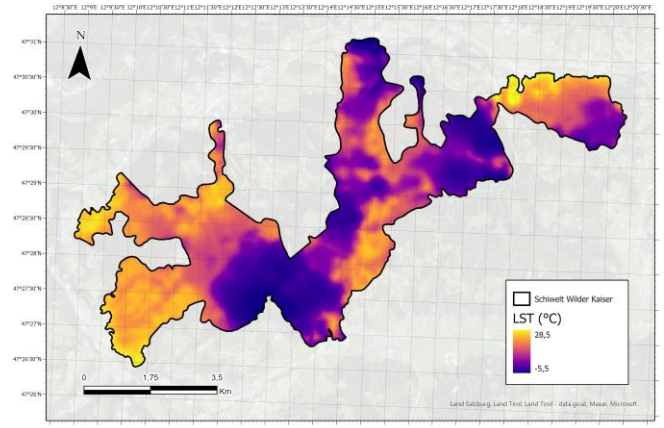
- As the climate has warmed, the altitude at which temperatures are generally cold enough for snow to stick has risen by over 1,300 feet (396 m) over the last century (Knutti, 2022)

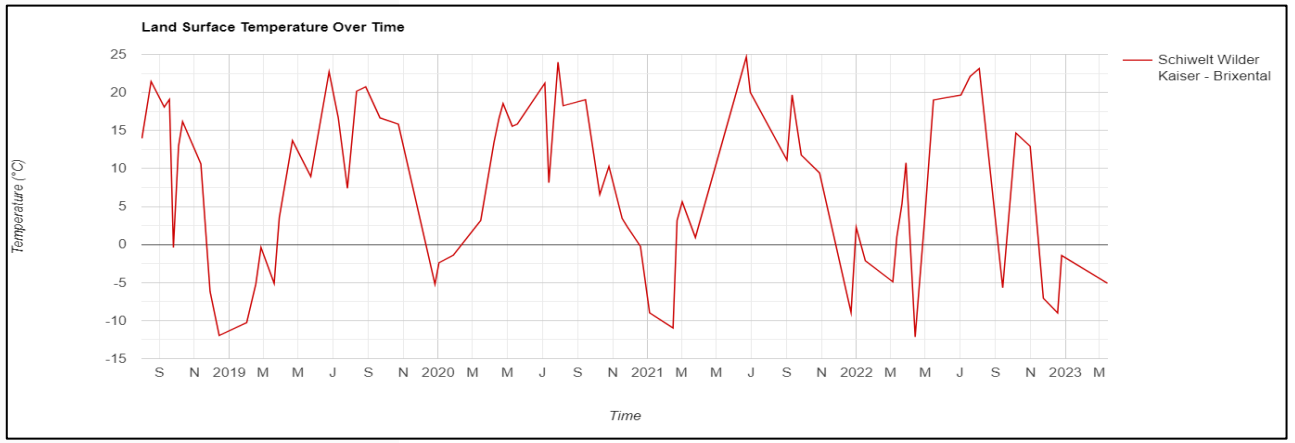
National Geographic Magazine (March 2022)

Objectives

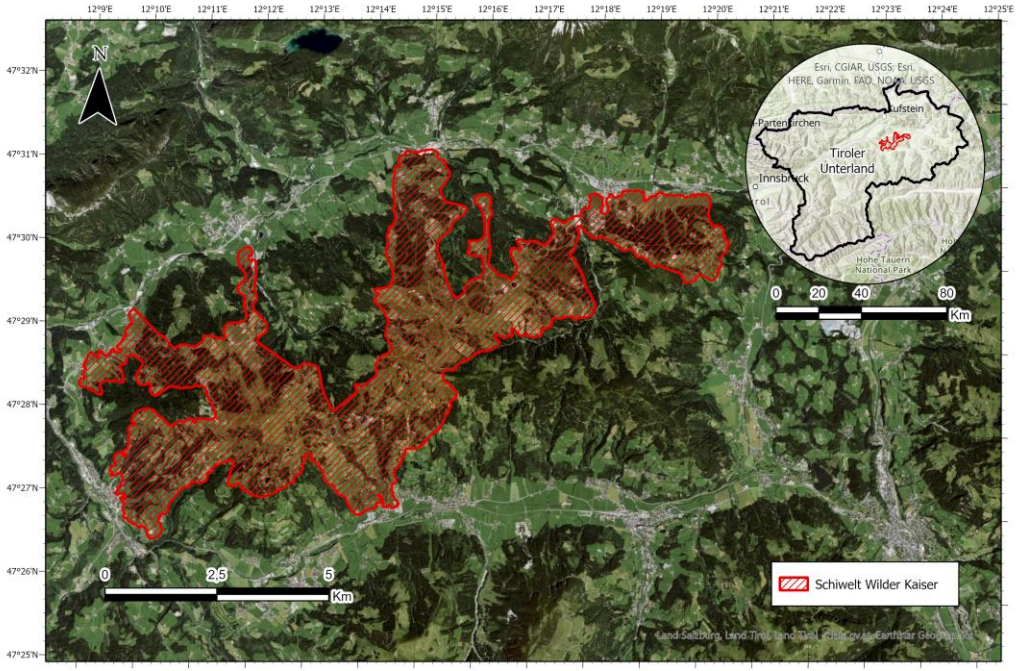
- Identify temporal variations of snow cover in Austrian Alps between 2018 and 2023, using Sentinel 2 Imagery.
- Identify temperature tendencies in Austrian Alps between 2018 and 2023, using Landsat 8 Imagery.
- Generate time series charts.



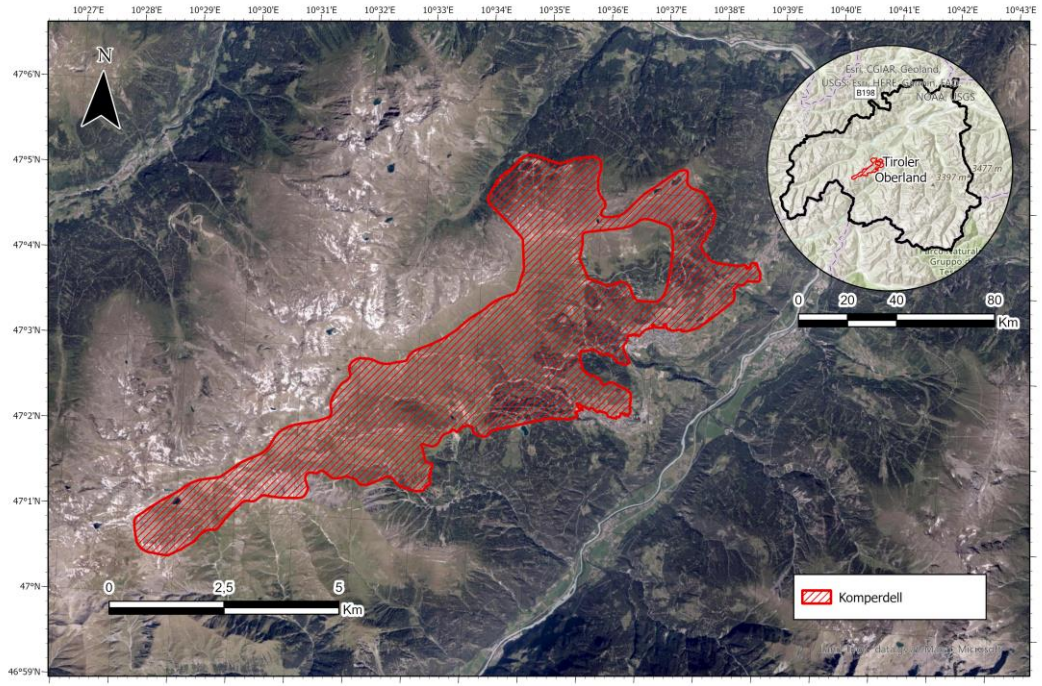




Study Areas



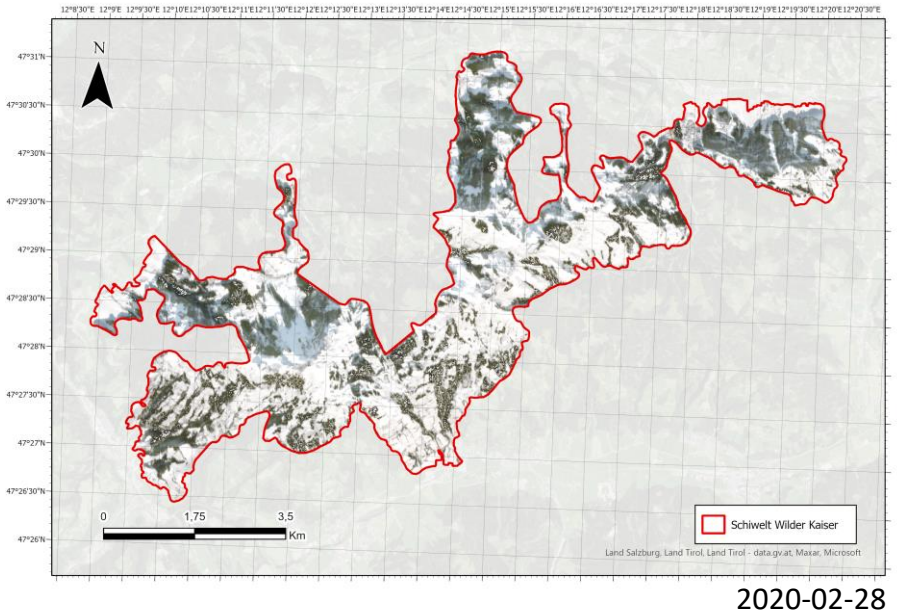
Name: Schiwelt Wilder Kaiser - Brixental
Location: Tiroler Unterland
Area: 37,14 Km^2
Mean Elevation: 1202,96 m



Name: Komperdell
Location: Tiroler Oberland
Area: 31,36 Km^2
Mean Elevation: 2788 m

Image Collections

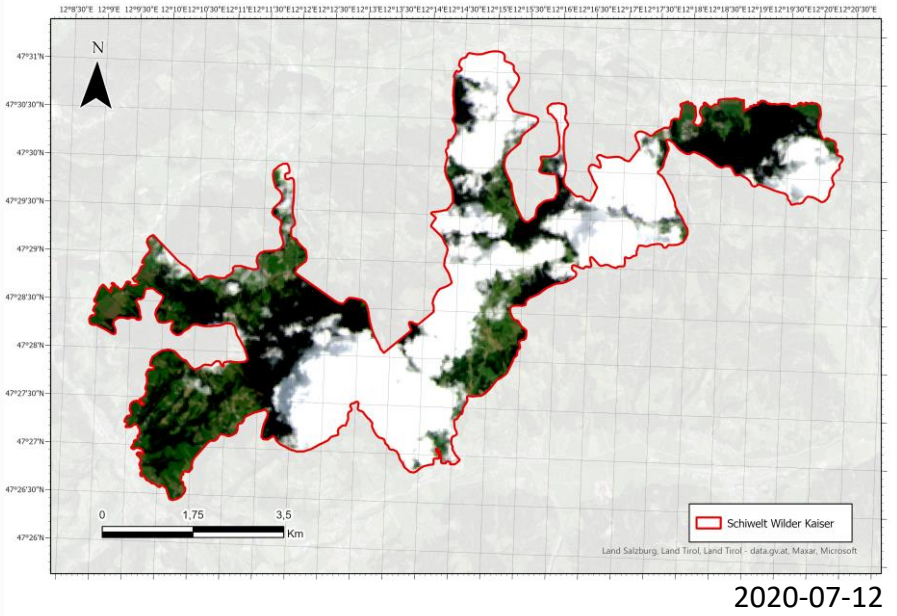
SENTINEL 2



2020-02-28

Collection: COPERNICUS/S2_SR_HARMONIZED
Dates: 2018/08/01 – 2023/05/30
Cloud Cover: Less than 10%
Bands: B2, B3, B4, B11

LANDSAT 8



2020-07-12

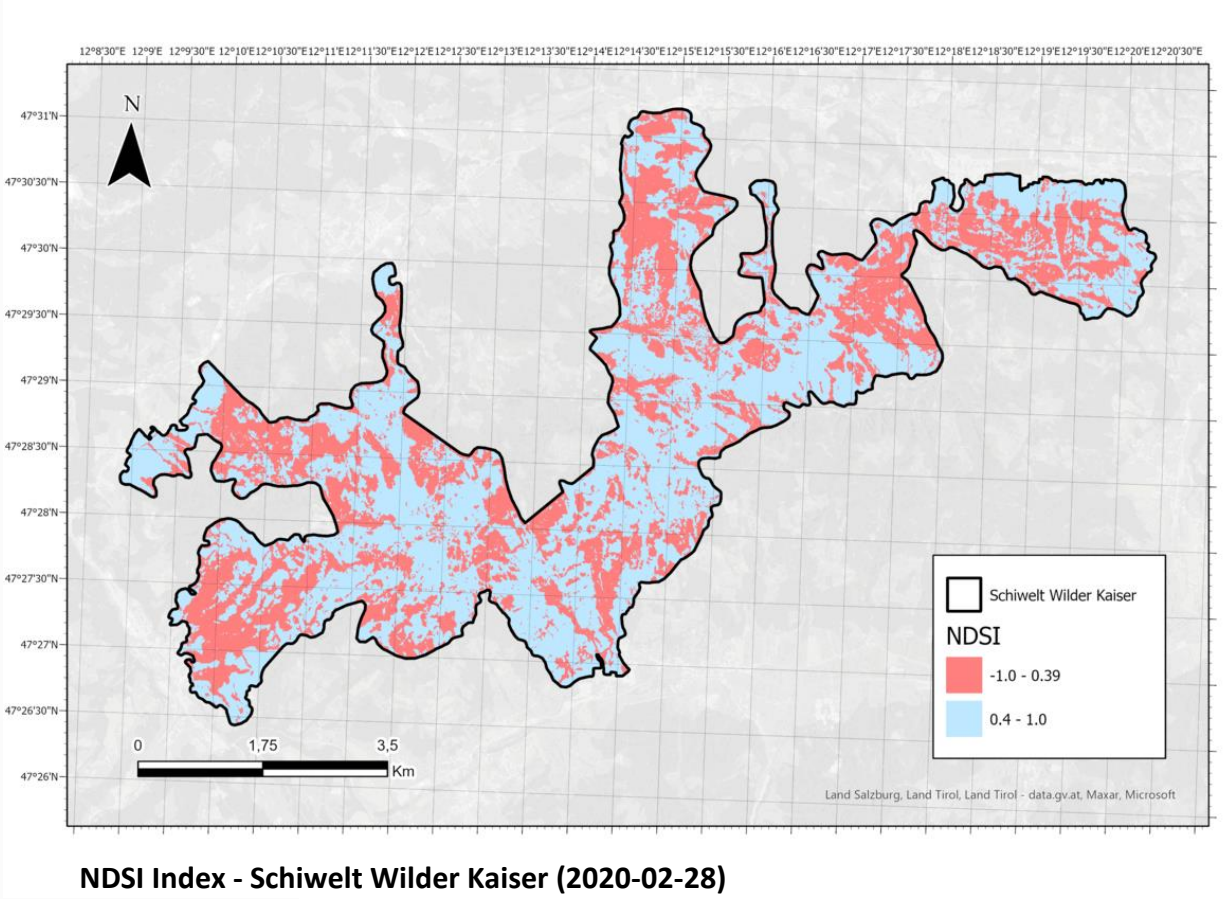
Collection: LANDSAT/LC08/C02/T1_TOA
Dates: 2018/08/01 – 2023/05/30
Cloud Cover: Less than 30%
Bands: B2, B3, B4, B10, QA_PIXEL

Methodologies

NDSI INDEX (Hall et al. (1995)).

The Normalized Difference Snow Index (NDSI) is a numerical indicator that shows snow cover over land areas using the green and short wave infrared (SWIR) spectral bands.

$$\mathbf{NDSI(Sentinel\ 2)} = \frac{B3\ - B11}{B3 + B11}$$



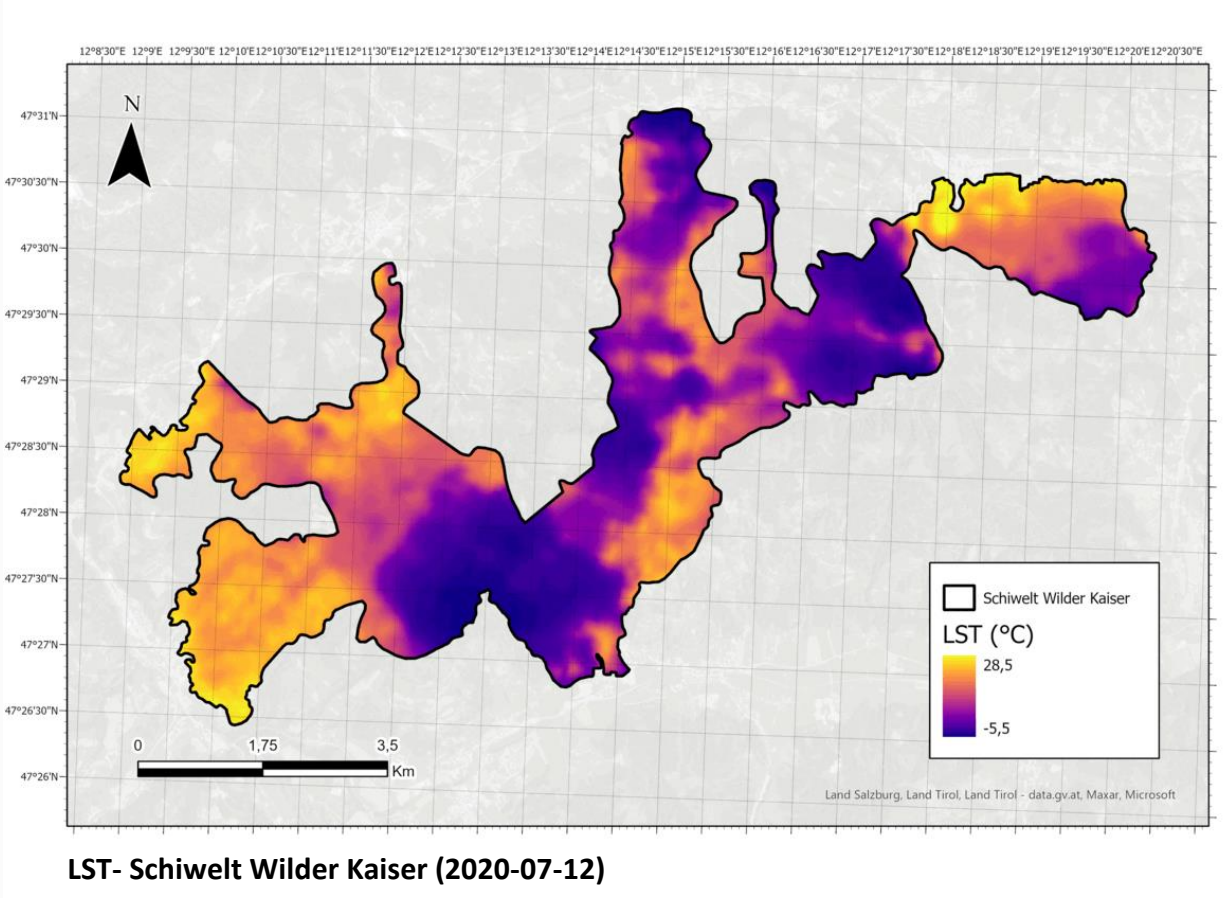
NDSI Index - Schiwelt Wilder Kaiser (2020-02-28)

Methodologies

Land Surface Temperature (LST)

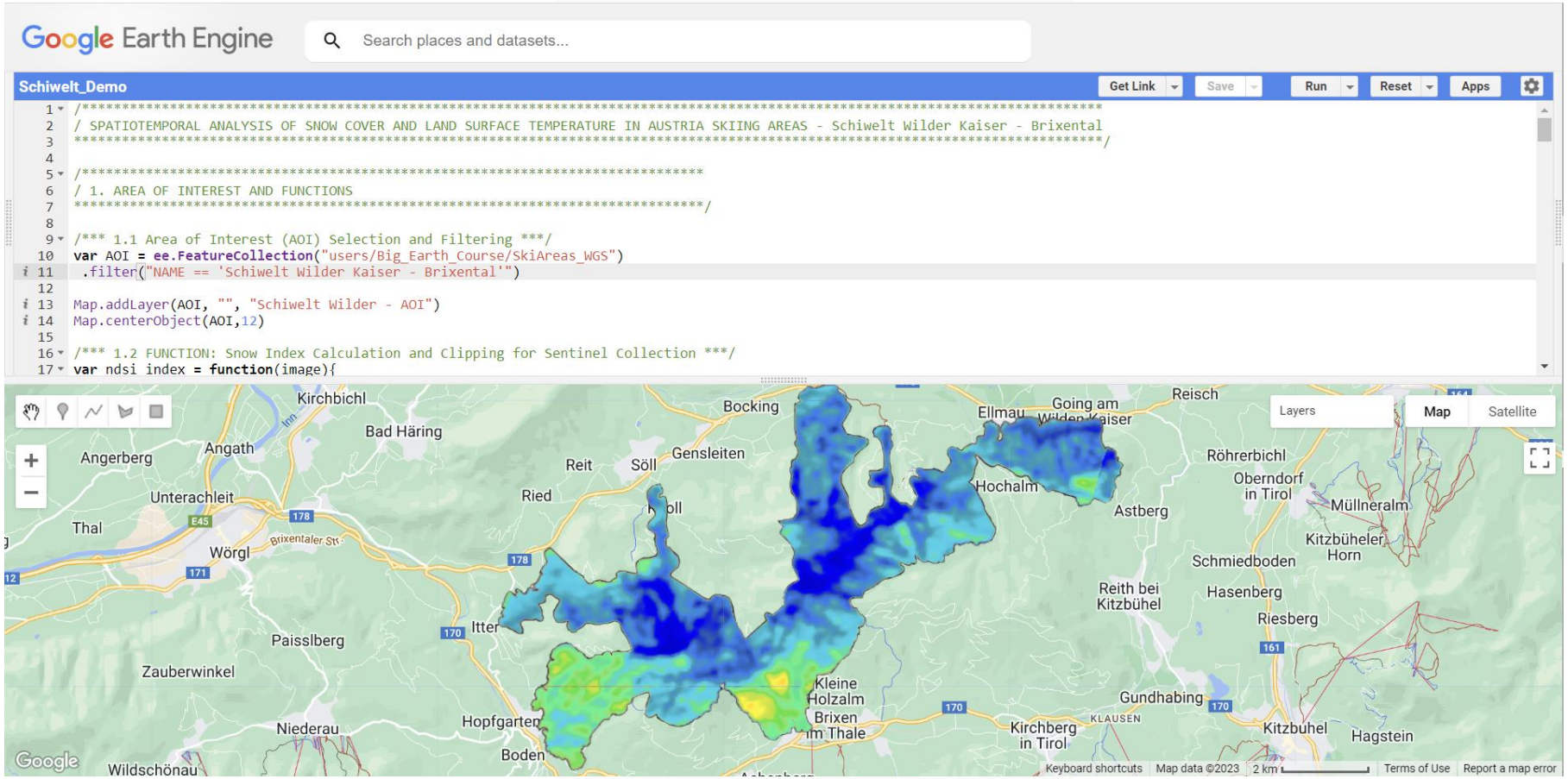
$$T_S = LST = \frac{T_B}{1 + \left(\lambda * \frac{T_B}{\rho}\right) ln\varepsilon}$$

$\boldsymbol{T_B}$**:** Brightness Temperature
$\boldsymbol{\lambda}$**:** Band Wavelength (0.0000109 m)
$\boldsymbol{\rho}$**:** $\mathrm{h} * \frac{c}{\sigma}$ = 14380 m K
$\boldsymbol{\varepsilon}$**:** Surface Emissivity (0.9668)



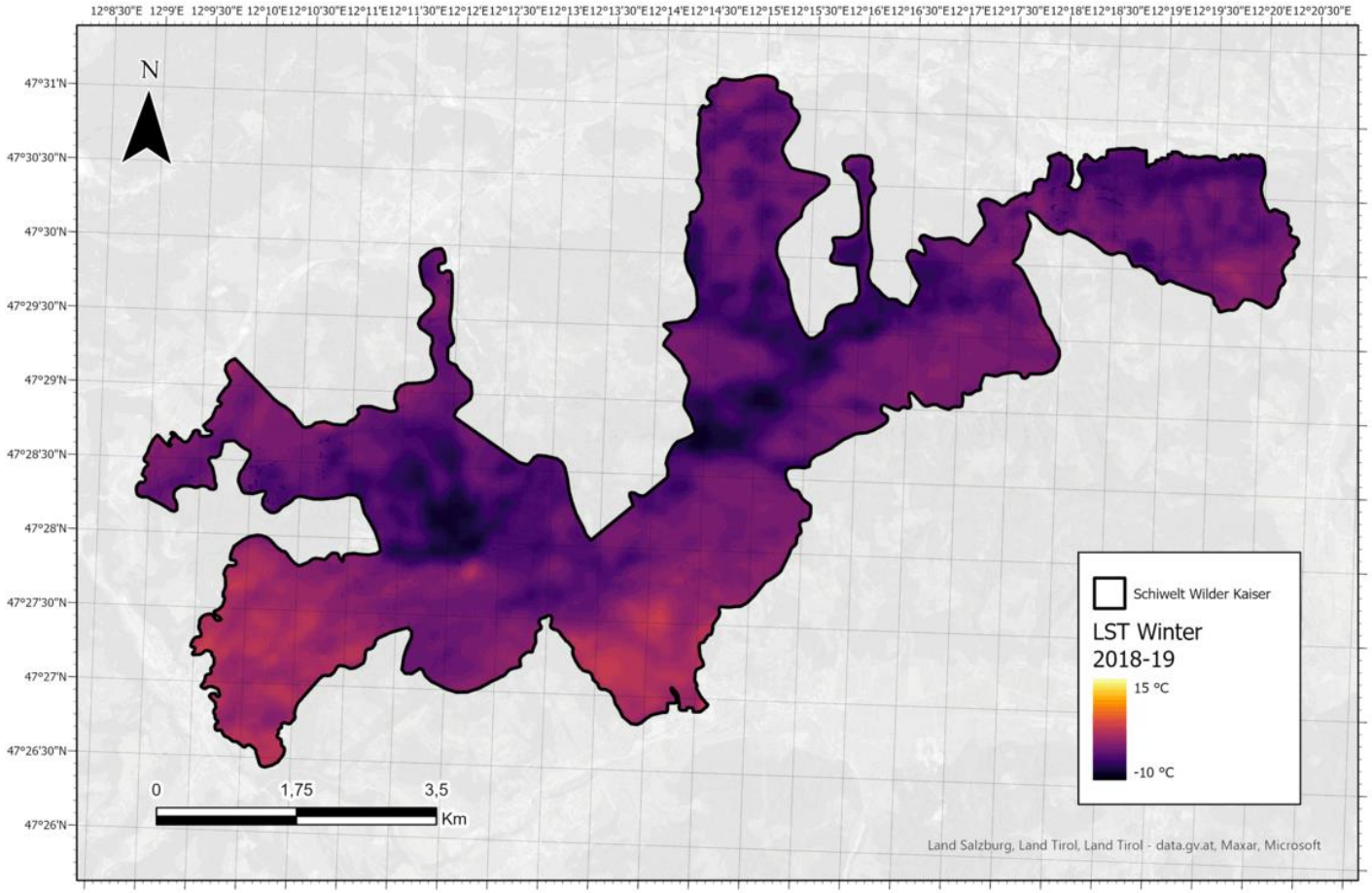
LST- Schiwelt Wilder Kaiser (2020-07-12)

DEMO



https://code.earthengine.google.com/603334c9ddb4565868440783da27290f

Additional Outputs



LST Winter Composite (2018-2022)- Schiwelt Wilder Kaiser.

5) References

- Ahamed, T. (2022). Big Data Scheme from Remote Sensing Applications: Concluding Notes for Agriculture and Forestry Applications. In *Remote Sensing Application: Regional Perspectives in Agriculture and Forestry* (pp. 351-361). Singapore: Springer Nature Singapore.

- Gandhi, Ujaval, 2021. *End-to-End Google Earth Engine* Course. Spatial Thoughts. https://courses.spatialthoughts.com/end-to-end-gee.html

- *Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. Remote sensing of Environment, 202, 18-27.*

- Hall, D. K., Riggs, G. A., & Salomonson, V. V. (1995). Development of methods for mapping global snow cover using moderate resolution imaging spectroradiometer data. *Remote sensing of Environment*, *54*(2), 127-140.

- Hruby, D. (2022, January 26). *In the Alps, ski resorts are desperately battling climate change-and local resistance*. Environment. https://www.nationalgeographic.com/environment/article/alps-ski-resorts-desperately-battling-climate-change-local-resistance?rnd=1684576540115&loggedin=true

- Hruby, D. (2022b, June 1). *The urgent efforts to save winter in the Alps*. Magazine. https://www.nationalgeographic.com/magazine/article/saving-winter-in-the-alps-feature

- Sugumaran, R., Hegeman, J. W., Sardeshmukh, V. B., & Armstrong, M. P. (2015). Processing remote-sensing data in cloud computing environments. In *Remotely Sensed Data Characterization, Classification, and Accuracies* (pp. 587-596). CRC Press.

- Tamiminia, H., Salehi, B., Mahdianpari, M., Quackenbush, L., Adeli, S., & Brisco, B. (2020). Google Earth Engine for geo-big data applications: A meta-analysis and systematic review. *ISPRS Journal of Photogrammetry and Remote Sensing*, *164*, 152-170.

Thank you

ANY QUESTIONS?