



# Introduction to Google Earth Engine

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# What is Earth Engine

## A computation Platform

Tools for analyzing and visualizing  
geospatial data at scale

## A Data Catalog

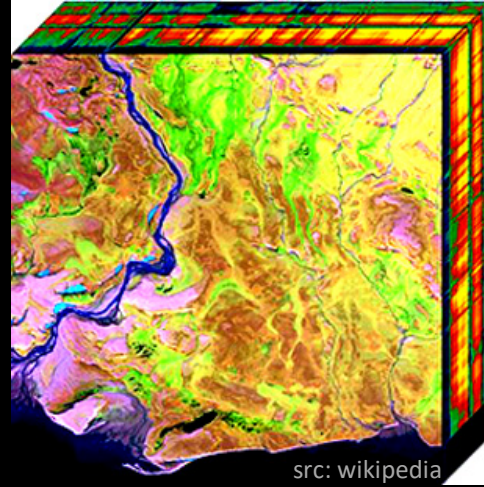
50PB archive of satellite imagery and  
other geospatial datasets



# What makes GEE powerful

## Co-located

- Big Data
- Massive Computation
- Scientific Algorithms

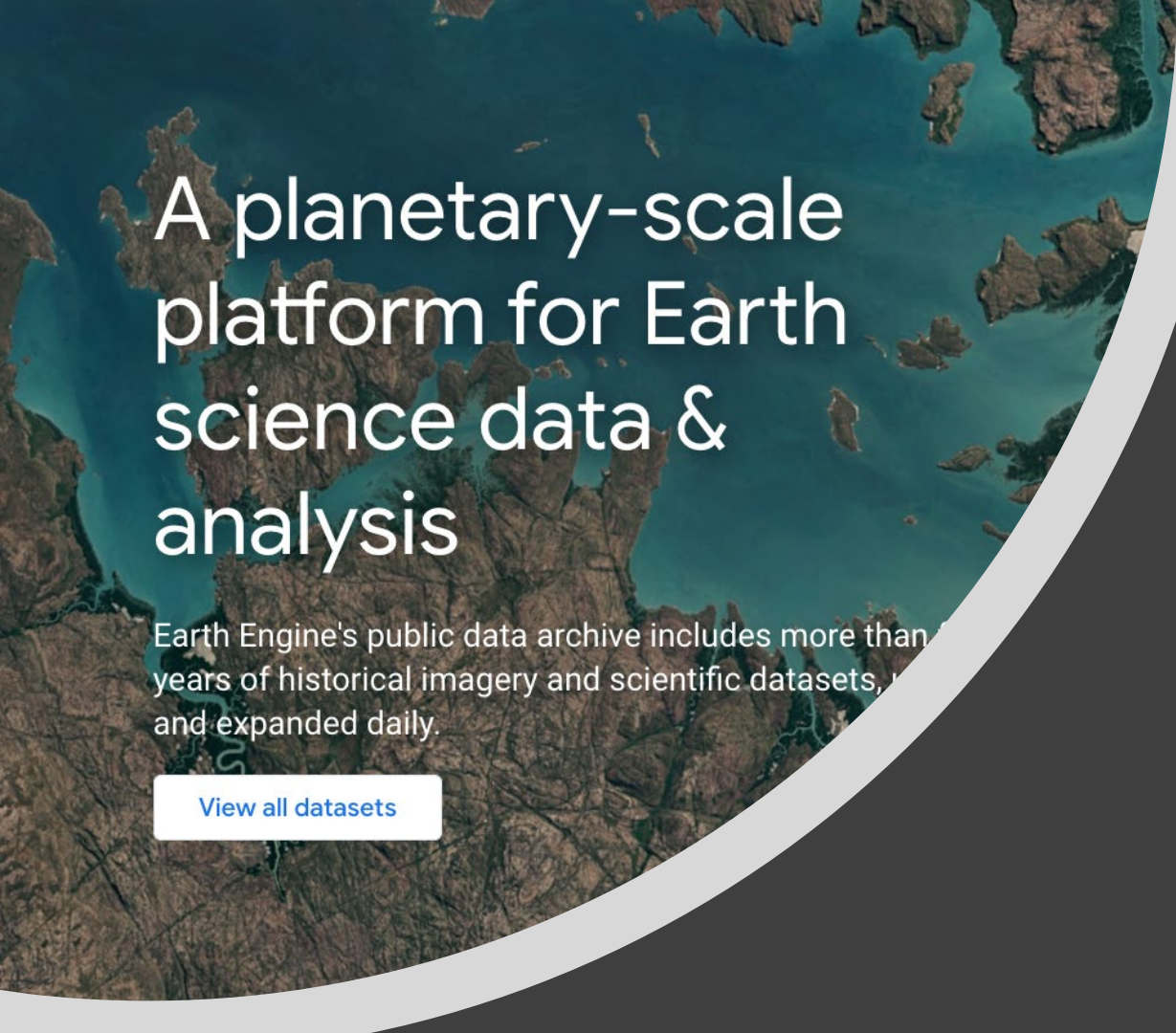


|                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                              |                                                                                                                                                                                                  |                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <h3>Datasets</h3> <p>Petabyte-scale catalog of public and free-to-use geospatial datasets.</p> <p><a href="#">Explore the Data Catalog</a></p> |  <h3>Compute</h3> <p>Leverage Google's cloud platform for planetary-scale analysis of Earth science data.</p> <p><a href="#">Read the publication</a></p> |  <h3>APIs</h3> <p>Full-featured JavaScript, Python and REST APIs.</p> <p><a href="#">Developer guides</a></p> |  <h3>Apps</h3> <p>Dynamic, publicly accessible user interfaces for Earth Engine analyses.</p> <p><a href="#">Apps gallery</a></p> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Gorelick et al. <https://doi.org/10.1016/j.rse.2017.06.031>



# Data Catalog



# A planetary-scale platform for Earth science data & analysis

Earth Engine's public data archive includes more than 40 years of historical imagery and scientific datasets, and expanded daily.

[View all datasets](#)

## Massive Data Catalog

- 35 petabytes total
- ~1 petabyte/month
- >700 datasets
- ~100 datasets / year

- 
- Landsat from 1972
  - Sentinel 1, 2, 3, 5P
  - Many more: topography, weather, population, etc

<https://developers.google.com/earth-engine/datasets>

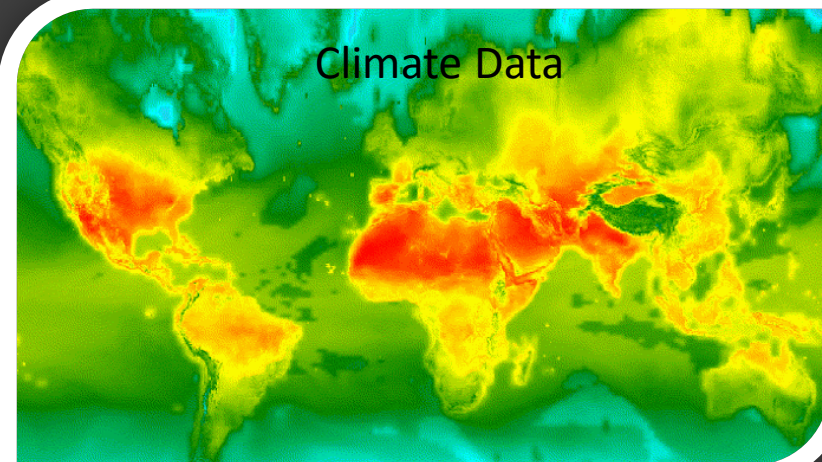


Landsat Derived Products, e.g.

- Burn Area Index
- Enhanced Vegetation Index
- NDVI
- ...



Climate Data



A few Examples

# Bring your own data

- Shapefiles
- CSV
- TFRecord
- GeoTiff

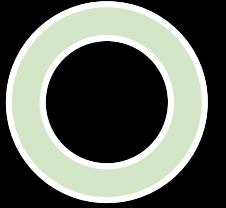
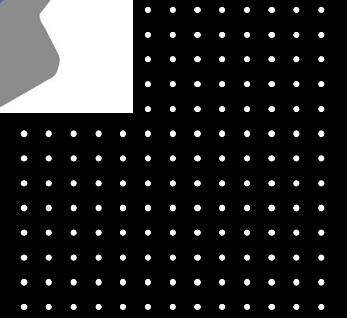
earthengine upload

Earth  
Engine  
Assets

[https://developers.google.com/earth-engine/guides/image\\_upload](https://developers.google.com/earth-engine/guides/image_upload)  
<https://developers.google.com/earth-engine/guides/importing>

Cloud Optimized GeoTIFF

Google  
Cloud  
Storage



# Example Applications



Image Credit: Noel Gorelick

Search Places

Map Satellite

PARAMETERS

LCMS DATA

- ☐ Gain Year
- ☒ Fast Loss Year
- ☐ Slow Loss Year
- ☐ Land Cover
- ☐ Land Use
- ☐ LCMS Change Time Lapse
- ☐ LCMS Land Cover Time Lapse
- ☐ LCMS Land Use Time Lapse

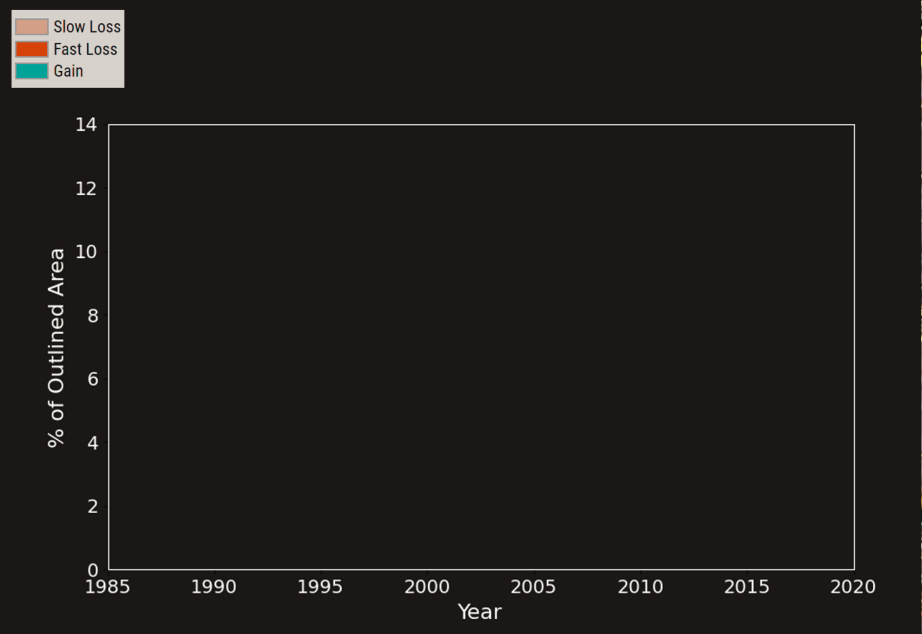
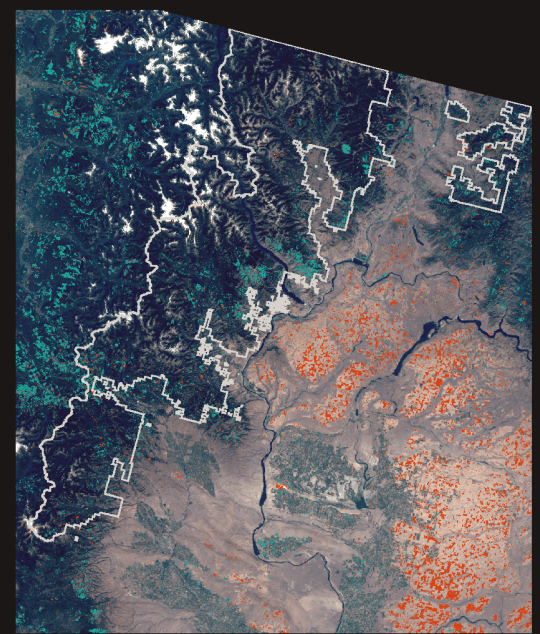
REFERENCE DATA

TOOLS

DOWNLOAD DATA

SUPPORT

### LCMS Change, Okanogan-Wenatchee NF: 1985

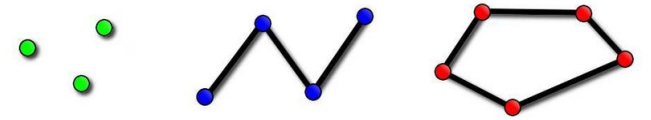


API

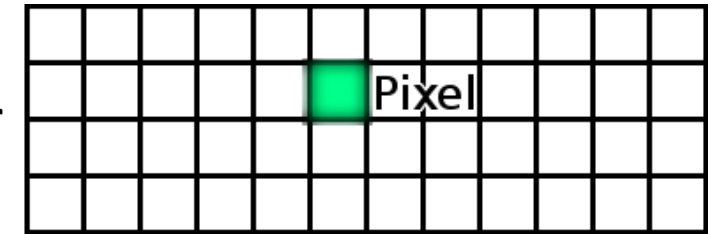
# Powerful API

- Analysis in Python and JavaScript
  - Same interface
  - Across platform
- **Geometry & Feature:** buffer, centroid, intersection, union, transform ...
- **FeatureCollection:** aggregate, filter, flatten, merge, sort ...

Vector



Raster



Tabular



---

# Powerful API (cont.)

---

**Image:** band math, clip, convolution, neighborhood ...

**Image Collection:** map, aggregate, filter, mosaic, sort ...

**Filter:** by bounds, within distance, date, day-of-year ...

**Reducer:** mean, linearRegression, percentile, histogram ....

**Join:** simple, inner, outer, inverted ...

**Kernel:** square, circle, gaussian, sobel, kirsch ...

**Classifier:** decision tree, GBT, randomForest ...

**Cluster:** kMeans, xMean, Cobweb ...

**Matrix computation:** determinant, decomposition ...

# Processing Concept: Map

Apply an operation to every element of a collection (FeatureCollection or ImageCollection)

For example:

- Compute NDVI for all images in 2018
- Derive area of each feature in a FeatureCollection
- Create monthly max and min temperature

```
// Load a Landsat 8 collection for a single path-row.
var collection = ee.ImageCollection("LANDSAT/LC08/C01/T1_SR")
  .filter(ee.Filter.eq('WRS_PATH', 45))
  .filter(ee.Filter.eq('WRS_ROW', 30))
  .filterDate('2020-01-01', '2020-12-31')

// This function add NDVI each image
var ndviFunction = function(image) {
  //calculate NDVI
  var ndvi = image.normalizedDifference(['B5', 'B4'])
  return ndvi
}

var ndvi = collection.map(ndviFunction)
```

- [https://developers.google.com/earth-engine/guides/ic\\_mapping](https://developers.google.com/earth-engine/guides/ic_mapping)
- [https://developers.google.com/earth-engine/guides/feature\\_collection\\_mapping](https://developers.google.com/earth-engine/guides/feature_collection_mapping)

# Processing Concept: Reduce

Aggregate over a collection or  
over a spatial context to derive  
summary values.

Reduce Bands

Reduce Neighborhood

Reduce ImageCollection

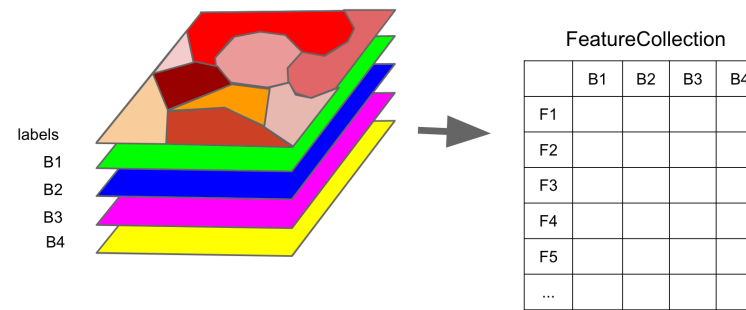
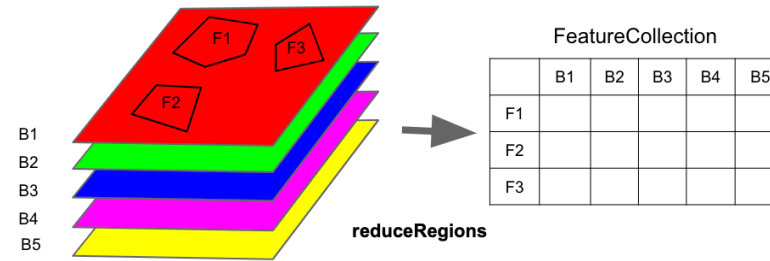
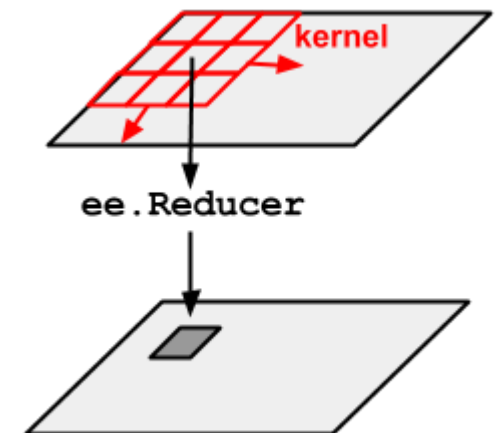
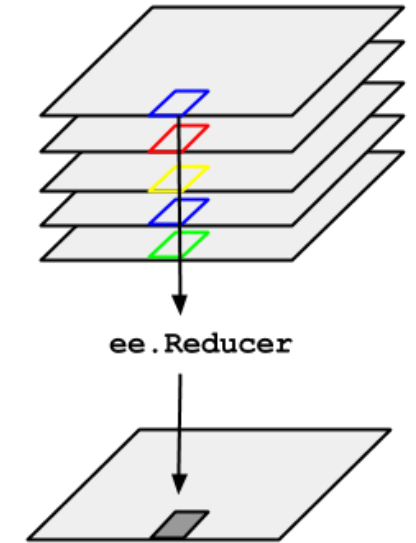
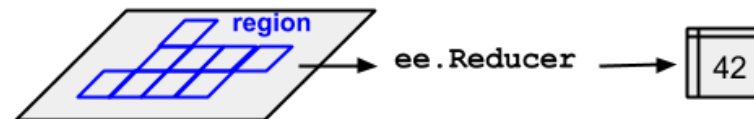


Image: Nick Clinton

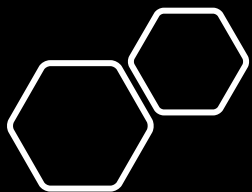


# Reducers

- ee.Array.reduce
- ee.List.reduce
- ee.FeatureCollection
  - reduceColumns
  - reduceToImage
- ee.Image
  - reduce
  - reduceConnectedComponents
  - reduceNeighborhood
  - reduceRegion
  - reduceRegions
  - reduceToVector
- ee.ImageCollection
  - reduce

48 reducers

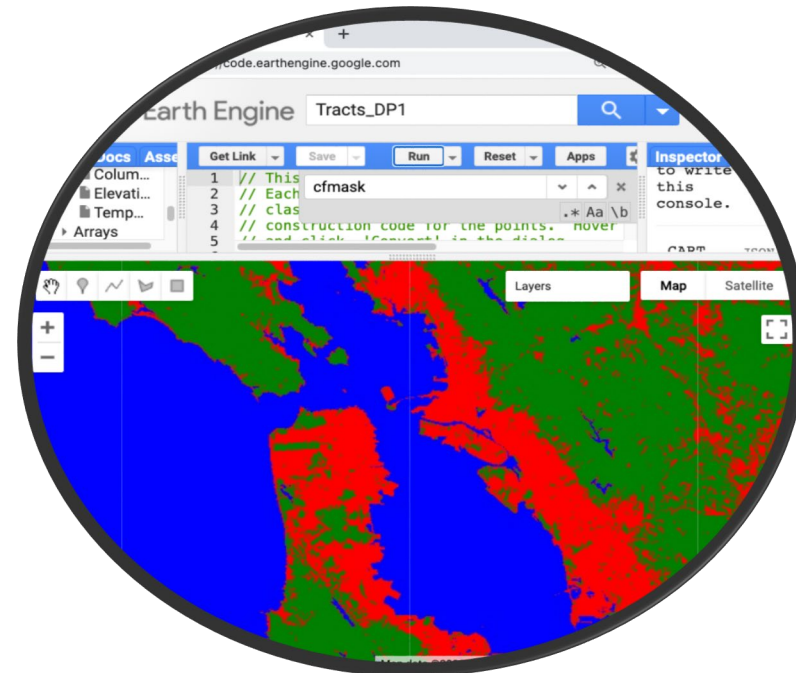
ee.Reducer.allNonZero()  
ee.Reducer.and()  
ee.Reducer.anyNonZero()  
ee.Reducer.autoHistogram(*maxBuckets*, *minBucketWidth*, *maxRaw*, ...)  
ee.Reducer.bitwiseAnd()  
ee.Reducer.bitwiseOr()  
ee.Reducer.centeredCovariance()  
ee.Reducer.count()  
ee.Reducer.countDistinct()  
ee.Reducer.countDistinctNonNull()  
ee.Reducer.countEvery()  
ee.Reducer.countRuns()  
ee.Reducer.covariance()  
ee.Reducer.first()  
ee.Reducer.firstNonNull()  
ee.Reducer.fixed2DHistogram(*xMin*, *xMax*, *xSteps*, *yMin*, *yMax*, *ySte...*)  
ee.Reducer.fixedHistogram(*min*, *max*, *steps*, *cumulative*)  
ee.Reducer.frequencyHistogram()  
ee.Reducer.geometricMedian(*numX*, *eta*, *initialStepSize*)  
ee.Reducer.histogram(*maxBuckets*, *minBucketWidth*, *maxRaw*)  
ee.Reducer.mean(*minPercentile*, *maxPercentile*, *maxP*)



# GEE Processing Mode

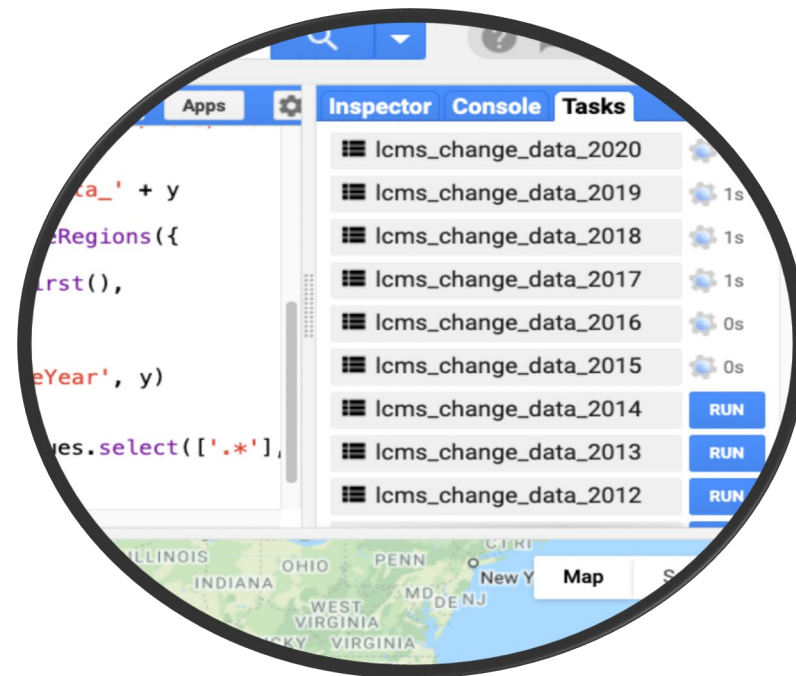
## Interactive Processing

Visualize data on the fly,  
preview analysis results,  
query google data catalog



## Batch Processing

Large scale, complex  
computation; multi-batching  
tasks with a few button  
clicks



# Accessing Google Earth Engine



Earth Engine Explorer

<https://explorer.earthengine.google.com/#workspace>

Not actively developed, use the following methods



Code Editor

<https://code.earthengine.google.com>



Google Colab

Not covered here

<https://colab.research.google.com/notebooks/intro.ipynb>



REST API

Not covered here

<https://developers.google.com/earth-engine/reference>



Customized Applications

Google Earth Engine search data catalog

Scripts Docs Assets

Filter NEW ↕

Owner (9)  
Writer (3)  
Reader (39)  
Archive (3)  
Examples

**code repository**

Seasonal Temperat... Get Link Save Run Reset Apps

```
1 // Plot average seasonal temperatures in US States.
2
3 // Import US state boundaries.
4 var states = ee.FeatureCollection('TIGER/2018/States');
5
6 // Import temperature normals and convert month features to band
7 var normClim = ee.ImageCollection('OREGONSTATE/PRISM/Norm81m')
8   .select(['tmean'])
9   .toBands();
10
11 Map.addLayer(normClim, {bands: '07_tmean', min: 10, max: 30, pal
12
13 // Calculate mean monthly temperature per state.
14 states = normClim.reduceRegions({
15   collection: states,
16   reducer: ee.Reducer.mean(),
17   scale: 5e4})
18   .filter(ee.Filter.notNull(['01_tmean']));
19
20 // Calculate Jan to Jul temperature difference per state and set
21 states = states.map(function(state) {
22
```

**code editor**

Inspector Console Tasks

Use print(...) to write to this console.

Average Temperatures in U.S. States

| Month   | Temperature (Celsius) |
|---------|-----------------------|
| January | ~10                   |
| April   | ~15                   |
| July    | ~25                   |
| October | ~20                   |

**output window**

Layers Map Satellite

**map display**

Google

Map data ©2021 Google, INEGI 200 km Terms of Use

# Quick Tour of Code Editor

# Spatial Data in GEE

```
var point = ee.Geometry.Point([-116.82109375, 39.72805832737948]);

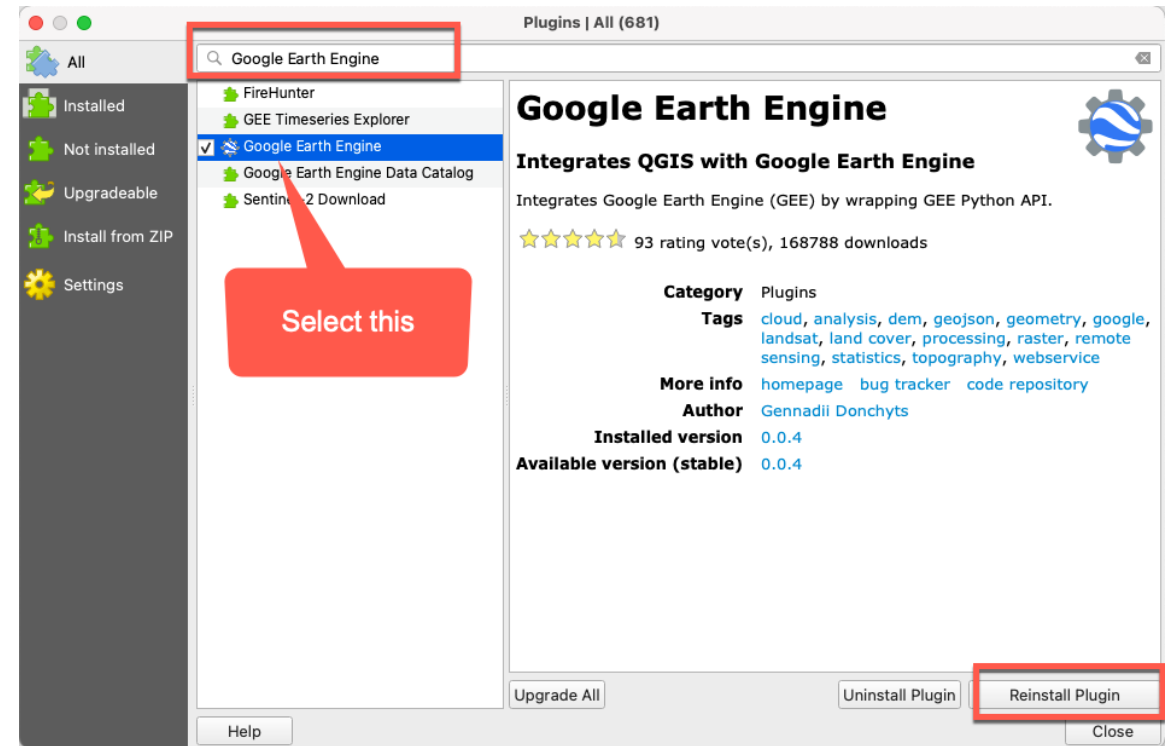
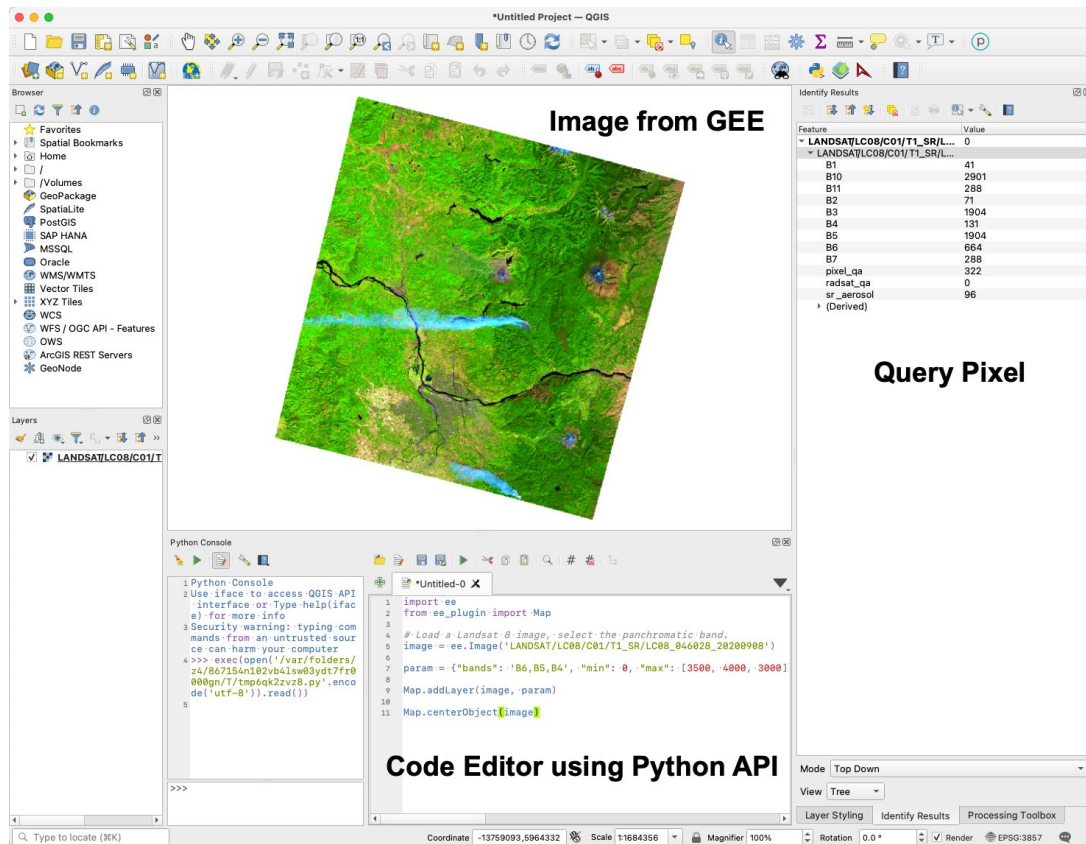
var line = ee.Geometry.LineString(
  [[[-112.77, 38.22],
    [-105.04, 38.15],
    [-106.53, 39.86]]]);

var polygon = ee.Geometry.Polygon(
  [[[-121.59479598829125, 43.22494422606919],
    [-122.18805770704125, 42.28924862371672],
    [-120.14460067579125, 42.85558325847169],
    [-120.49616317579125, 43.63980400099928]]]]);
```

```
//Single Image
var nlcd2016 = ee.Image('USGS/NLCD/NLCD2016')

//Image Collection
var nlcd = ee.ImageCollection('USGS/NLCD')
```

- Vector Data
  - ee.Geometry or ee.Feature
  - ee.FeatureCollection (multiple features)
- Raster Data
  - ee.Image, represents a single image, usually with multiple band bands
  - ee.ImageCollection, a set of images usually with the same data structure



# QGIS with Plugin

APP

# Earth Engine App

- Coder interface from Code Editor
- Publish directly from Code Editor
- Share work as web application

## Publish New App

**Owner**

users/username

**App Name** ?

Burning Bright

Your App ID will be burning-bright [Edit](#)

URL: <https://username.users.earthengine.app/view/burning-bright>

**Google Cloud Project** ?

ee-username [CHANGE](#)

**Access Restriction** ?

☐ Restrict access to this app

**Public Gallery**

☒ Feature this app in your [Public Apps Gallery](#)

☐ Reset Thumbnail

Description (Optional)



This app was created by me using Google Earth Engine. It maps changes on the Earth's surface at a global scale.

**Source Code** ?

☒ Current contents of editor

☐ Repository script path

When the app is published, **it's public and anyone can view it**. The published source code will be publicly readable. All assets must also be shared publicly or with the app to display properly. See <https://developers.google.com/earth-engine/apps> for more information about publishing apps.

CANCEL

PUBLISH

## The Living Map of MSO Forest Habitat

[README](#)

Select layer to view with the "Layers" dropdown on the map

Select polygon collection:

EMU

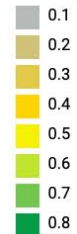
Select Unit:

Upper Gila Mountains

Select View Year:

2020

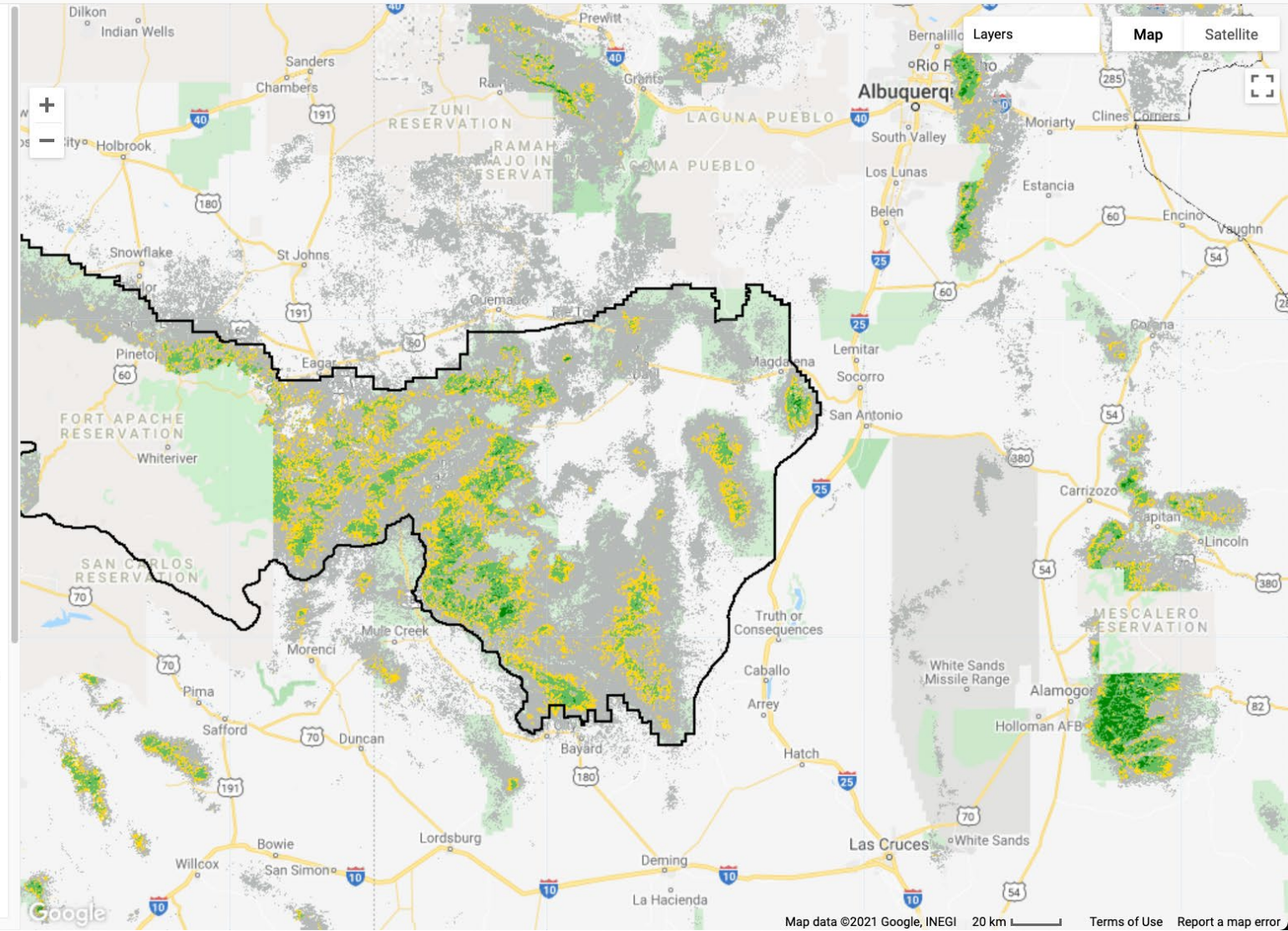
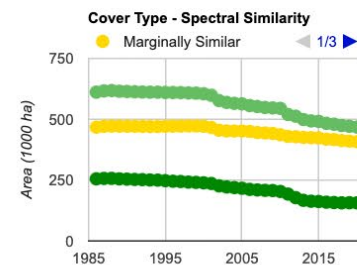
### Habitat probability



### Cover type spectral similarity



☒ View Chart



## RESEARCH ARTICLE

# COVID-19 lockdowns cause global air pollution declines

 Zander S. Venter,  Kristin Aunan,  Sourangsu Chowdhury, and  Jos Lelieveld  
[+ See all authors and affiliations](#)

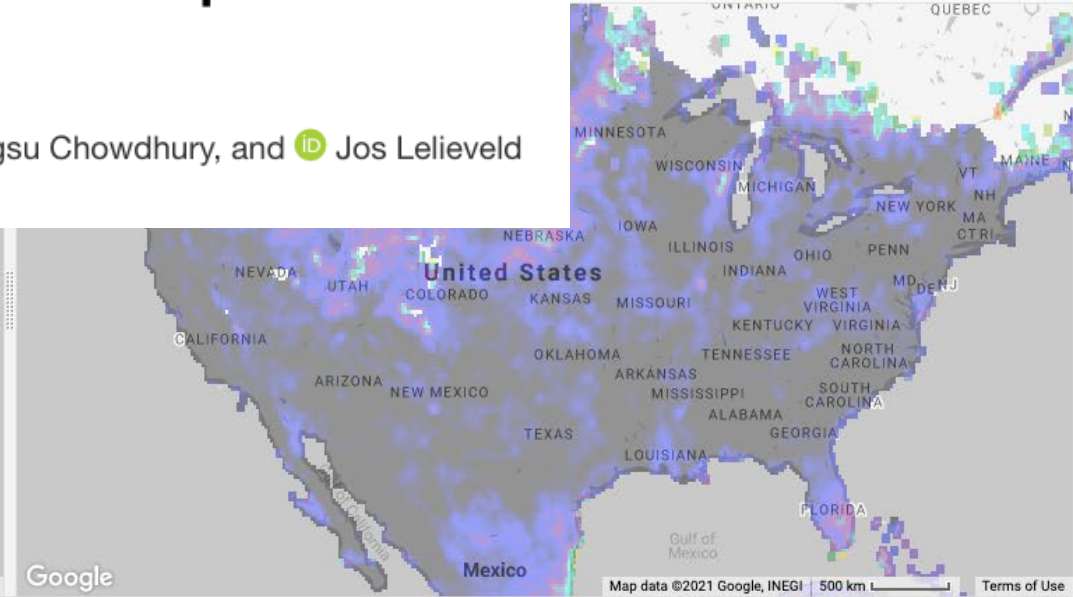
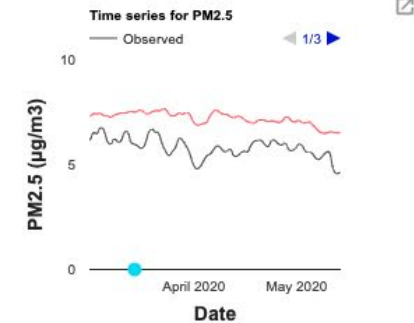
Earth Engine Apps Experimental

### Air pollution changes during COVID-19 lockdowns

Refer to scientific paper here: [PNAS](#)

1. Select country: **United States**

2. Select pollutant: **PM2.5**



<https://nina.earthengine.app/view/lockdown-pollution>

# Sign-up

<https://signup.earthengine.google.com>

# Super useful demonstration code repos

Nick Clinton has put together these very useful learning script

- Basics: JavaScript, data access, visualization, mapping, reducing, compositing
  - [https://code.earthengine.google.com/?accept\\_repo=users/nclinton/EE101](https://code.earthengine.google.com/?accept_repo=users/nclinton/EE101)
- Multi-spectral and multi-temporal classification, parameter tuning
  - [https://code.earthengine.google.com/?accept\\_repo=users/nclinton/EE102](https://code.earthengine.google.com/?accept_repo=users/nclinton/EE102)
- Classification, phenology modeling, terrain visualization, spectral unmixing
  - [https://code.earthengine.google.com/?accept\\_repo=users/nclinton/EE201](https://code.earthengine.google.com/?accept_repo=users/nclinton/EE201)
- Earth Engine best practices, client-server interaction, gotchas
  - [https://code.earthengine.google.com/?accept\\_repo=users/nclinton/EE202](https://code.earthengine.google.com/?accept_repo=users/nclinton/EE202)
- UI stuff for beginners
  - [https://code.earthengine.google.com/?accept\\_repo=users/nclinton/ui-api-101](https://code.earthengine.google.com/?accept_repo=users/nclinton/ui-api-101)
- NDVI inspector
- <https://code.earthengine.google.com/8bae27d7011e93b84db2013155f3bb23>

# Other Resources

- API Guide: <https://developers.google.com/earth-engine/guides>
- Community Guide: <https://developers.google.com/earth-engine/tutorials>
- GEE Blogs: <https://medium.com/google-earth/tagged/earth-engine>
- <https://gee-community.github.io/qgis-earthengine-plugin>
- GEE Map: <https://geemap.org>