Google Developer Experts

Cloud computing with Google Earth Engine

Emma Izquierdo-Verdiguier
GDE Earth Engine

BOKU Institute of Geomatics

Eric Smit

Álvaro Moreno-Martinez
GDE Earth Engine

Universitat de València

Earth Observation

Source: Global Earth Monitor

Source: ESA

Google Earth Engine

What is GEE?

- Platform for large-scale analysis of Earth data, including satellite imagery and census data.
- Two main components:
  - Scientific data collection
  - Massive computational power to process that data
- The EE API allows users to specify the operations they want Earth Engine to execute

Experts

The Earth Engine Data Catalog

Landsat & Sentinel
10-30m, weekly

MODIS
250m daily

Vector Data
WDPA, TIGER, WHC

Terrain & Land Cover

Weather & Climate
NOAA NCEP, OMI, ...

900+ public datasets

70+ petabytes of data

100+ datasets added yearly

~2 PB of new data every month

Source: Google Inc.

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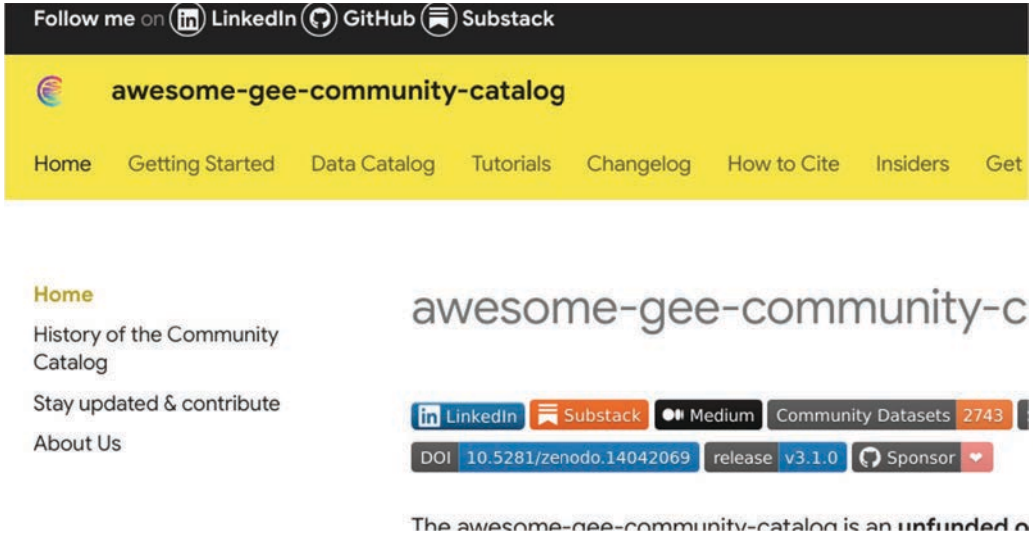
The awesome-gee Data Catalog

Just in case you want more data.....



Awesome GEE Community Catalog

https://gee-community-catalog.org/

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Google Scholar trends

Total References and Mentions

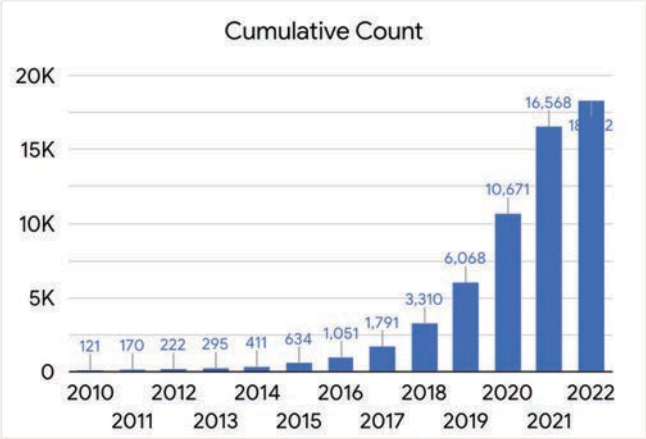
18,332

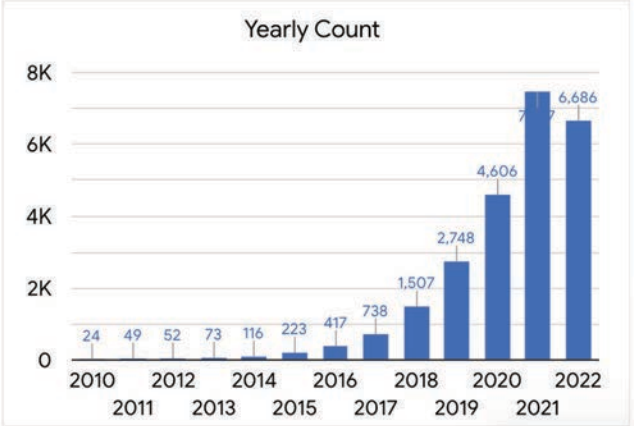
References and Mentions this Year

4,606

Count of estimated scholar search results for text: "google earth engine".

Search results exclude patents and citations.

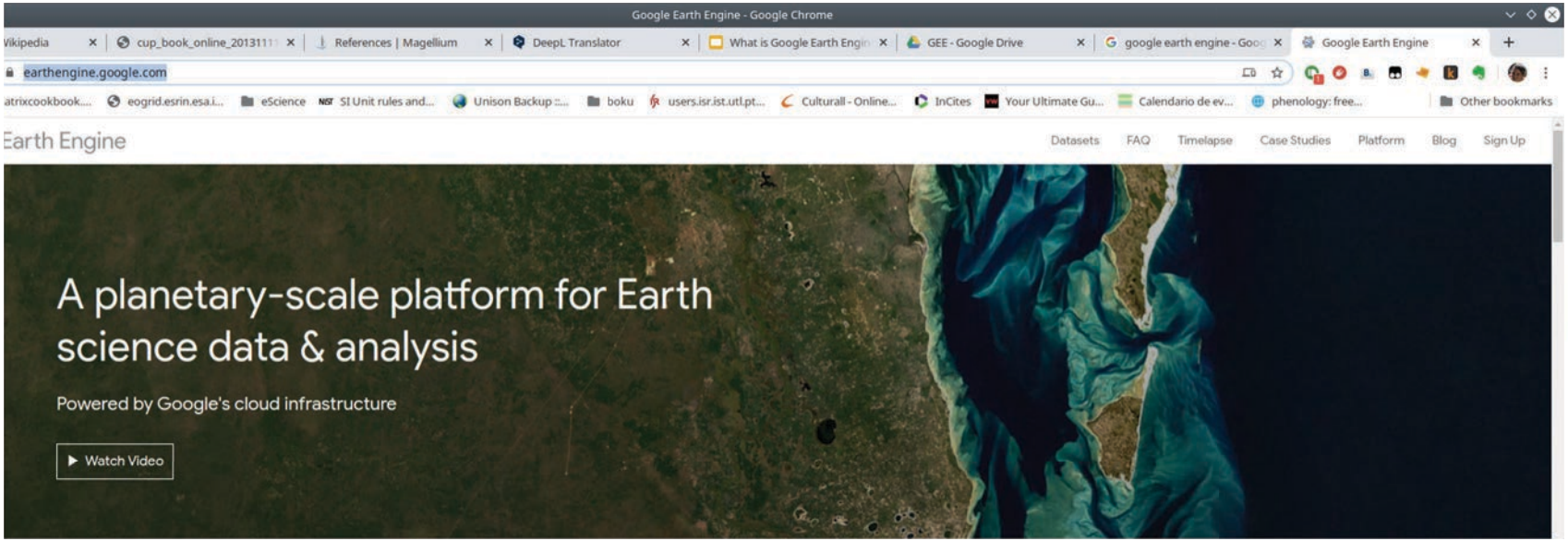




Source: Google Inc.

How to interact with GEE?

- Sign up in: [Google Earth Engine]



How to interact with GEE?

- Web development
- Limited processing

- Desktop development
- Faster processing

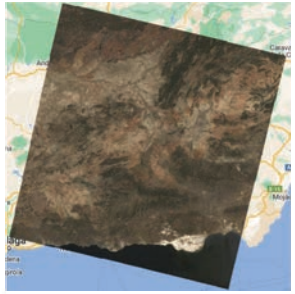
Experts

Core Concepts

GEE objects

ee.Image

```
Layer 2: Image (19 bands)
  SR_B1: 11993
  SR_B2: 13045
  SR_B3: 15728
  SR_B4: 18195
  SR_B5: 23308
  SR_B6: 24573
  SR_B7: 21072
  SR_QA_AEROSOL: 96
  ST_B10: 51319
  ST_ATRAN: 8507
  ST_CDIST: 2525
  ST_DRAD: 634
  ST_EMIS: 9740
  ST_EMSD: 70
  ST_QA: 160
  ST_TRAD: 12459
  ST_URAD: 1233
  QA_PIXEL: 21824
  QA_RADSAT: 0
```

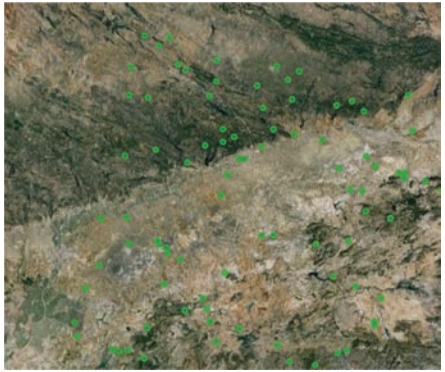


ee.ImageCollection

ee.Feature

```
Layer 1: Feature 0000000000000000030 (Point, 3 properties)
  type: Feature
  id: 0000000000000000030
  geometry: Point (-4.09, 37.21)
    type: Point
    coordinates: [-4.091601540343391,37.21329454958586]
      0: -4.091601540343391
      1: 37.21329454958586
  properties: Object (3 properties)
    EVI: 0.23289210804753152
    latitude: 37.21329454958586
    longitude: -4.091601540343391
```

ee.FeatureCollection



Feature Index	EVI (Float)	latitude (Float)	longitude (Float)	system:index (String)
0	0.23289210804753152	37.213294549558586	-4.091601540343391	
1	0.31745419937 78155	37.563098521222	-3.8638786158190923	
2	0.24068105732218195	36.9993158489 0859	-4.8391795197 87657	
3	0.21133466988 28024	37.3264822753 8492	-5.7395609290 60653	
4	0.13285587934 773682	38.1664968975 6508	-4.4966519019 52883	
5	0.24740481727 090008	37.9746167528 77154	-4.8685544295 78365	
6	0.54358349272 80193	37.7493192796 19975	-3.6399286154 880954	
7	0.01080862184 4571814	36.4746098914 5438	-3.9681730203 053687	
8	0.20130698684 116946	37.9557521319 1064	-3.4615232000 619582	
9	0.21938520042 804519	36.6400795667 8919	-4.8143860179 45958	

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What can GEE do?

Source: Google Inc.

Functions

Actions you can apply to objects

Core Functions

- Map
- Reduce
- Filter
- Export

Machine Learning

- Classifier.decisionTree
- Clusterer.wekaKMeans
- Model.predictImage
- Classifier.train
- Clusterer.train

Image Transformations

- Image.add
- Image.normalizedDifference
- Image.convolve
- Image.sample
- Image.clip

Feature Transformations

- Feature.area
- Feature.centroid
- Feature.union

... and many more

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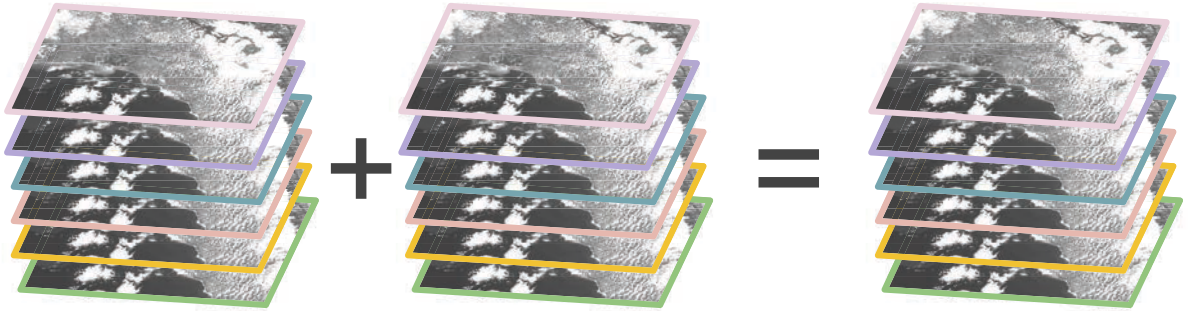
Functions: Band Math

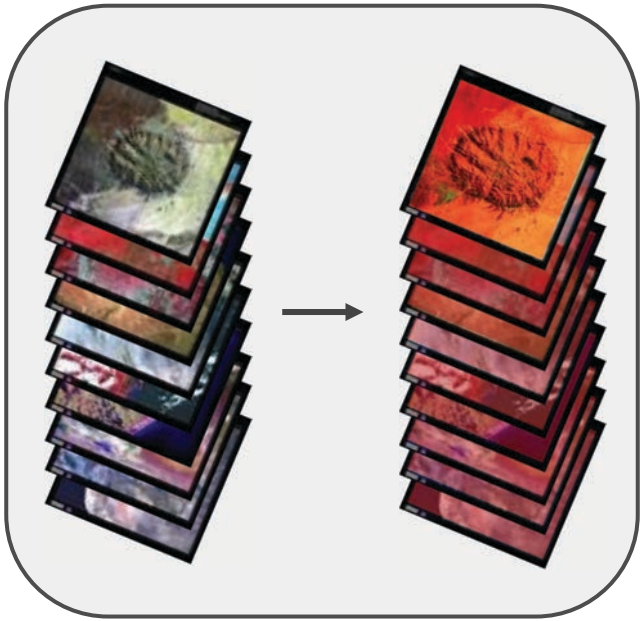
Apply to two image objects



Functions: Map

Apply to a collection object

- Apply a function to each element of a collection
- A “for-each operation”
- N -> N



Examples

- Area of each feature
- Cloud cover of each image
- Composite for each month

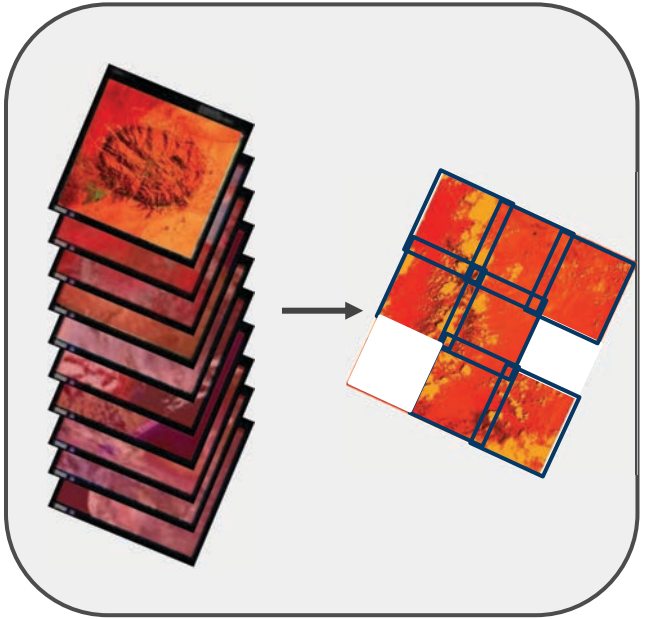
Functions: Reduce

Apply to a collection object

- Aggregate everything in a collection
- N -> 1 (or N -> M for some Reducers)

Examples

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



Reducers in Earth Engine

8 ways to reduce

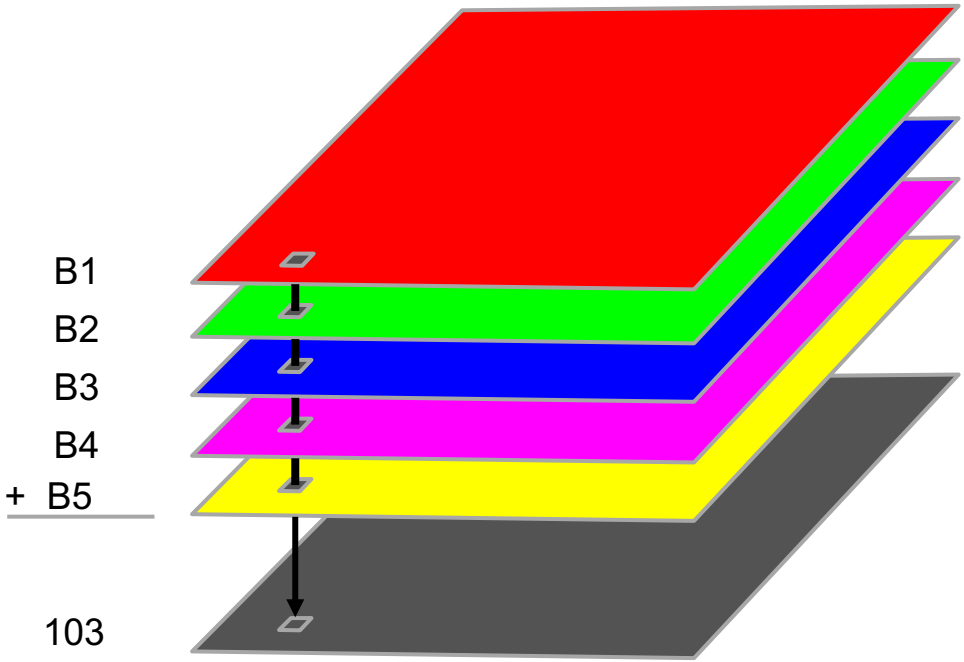
Image.reduce
Image.reduceNeighborhood
Image.reduceRegion
Image.reduceRegions
Image.reduceToVectors
ImageCollection.reduce
FeatureCollection.reduceColumns
FeatureCollection.reduceToImage

40+ reducers

Reducer.allNonZero
Reducer.and
Reducer.anyNonZero
Reducer.count
Reducer.countEvery
Reducer.histogram
Reducer.intervalMean
Reducer.linearFit
Reducer.linearRegression
Reducer.max
Reducer.mean
Reducer.median
Reducer.min
Reducer.minMax
Reducer.mode
Reducer.or
Reducer.percentile
Reducer.product
Reducer.sampleStdDev
Reducer.sampleVariance
Reducer.stdDev
Reducer.sum
Reducer.toCollection
Reducer.toList
Reducer.variance

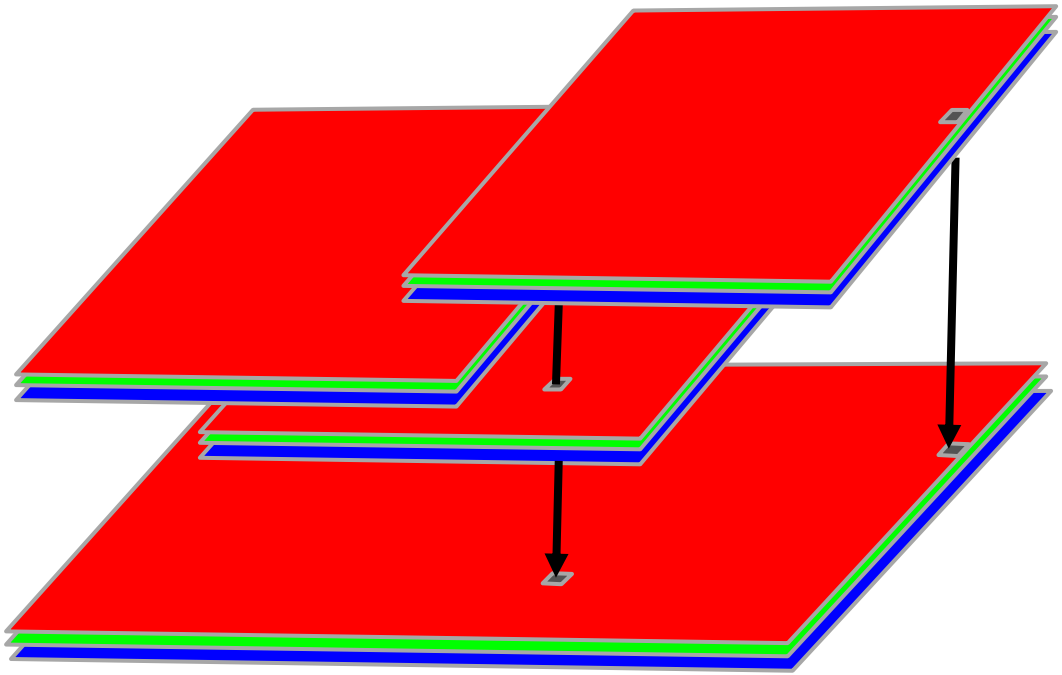
Reduce Bands

Image.reduce



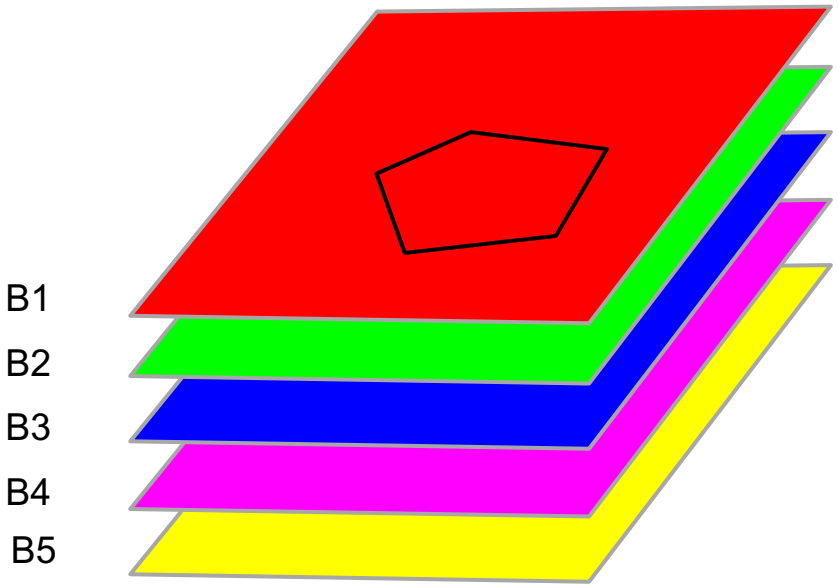
Reduce Image Collection

ImageCollection.reduce



Reduce Region

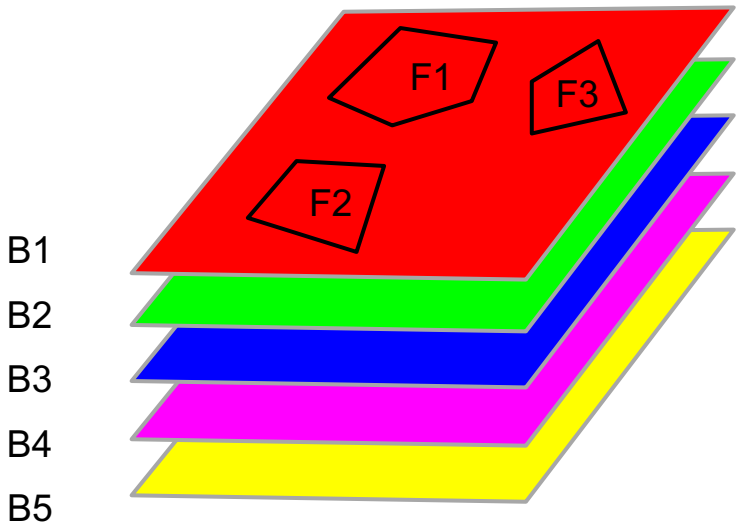
Image.reduceRegion



Dictionary
{
B1: 8.3,
B2: 14,
B3: 176,
B4: 1.6,
B5: 7
}

Reduce Regions

Image.reduceRegions



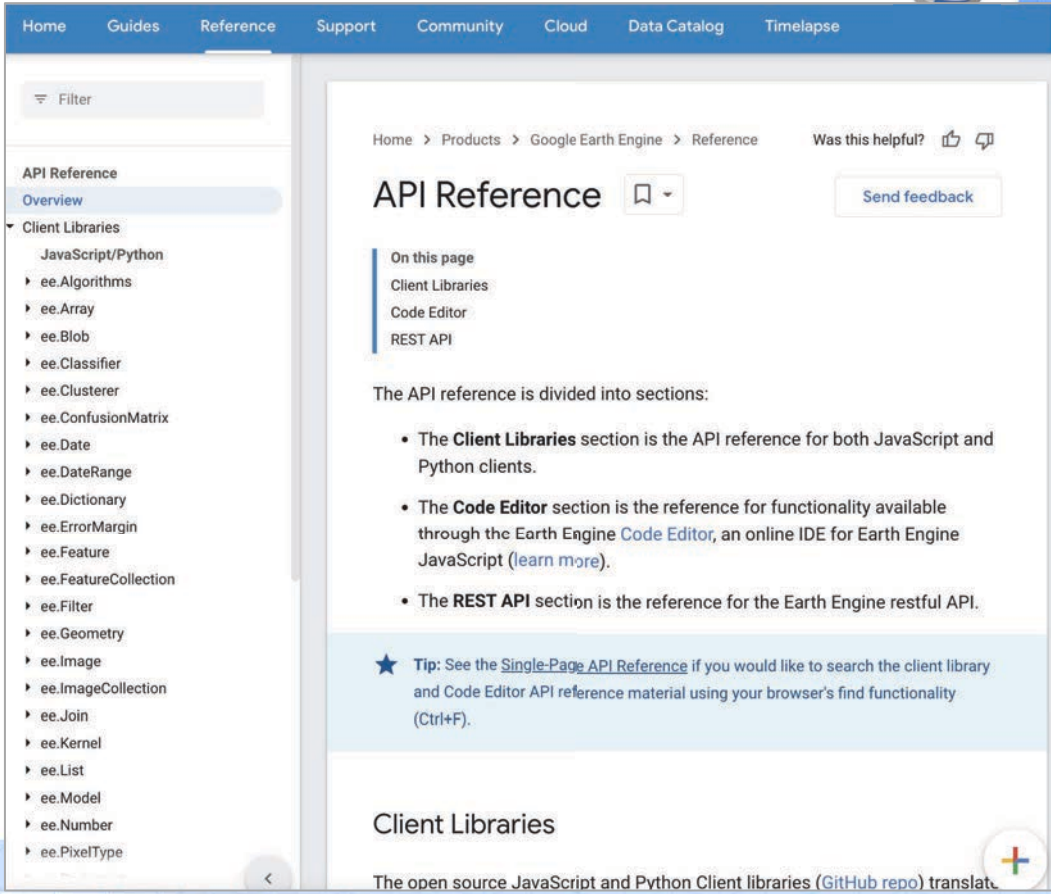
FeatureCollection

	B1	B2	B3	B4	B5
F1					
F2					
F3					

API Reference

These are just a few of the major concepts at play in Earth Engine.

See the **API reference docs** for additional objects and over 1500 object methods.



Experts

Putting it together

Experts

Get an image

Pick your:

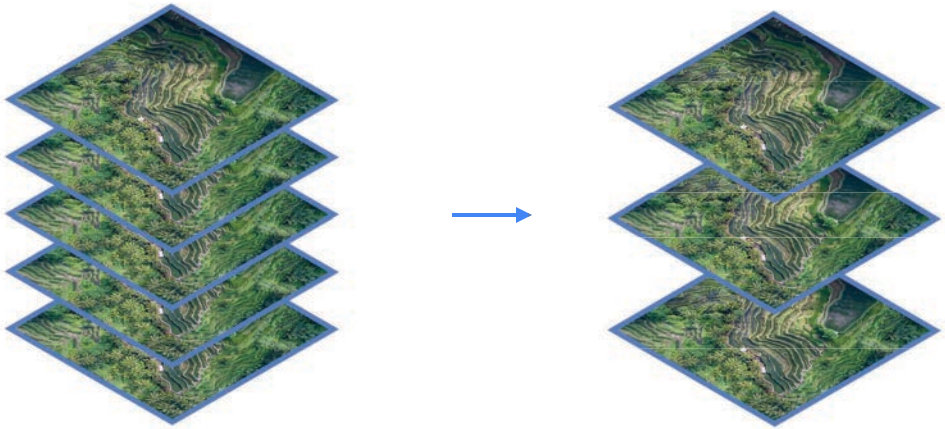
projection, resolution, bands, bounding-box, visualization

Apply an algorithm to an image

Use library functions or script your own

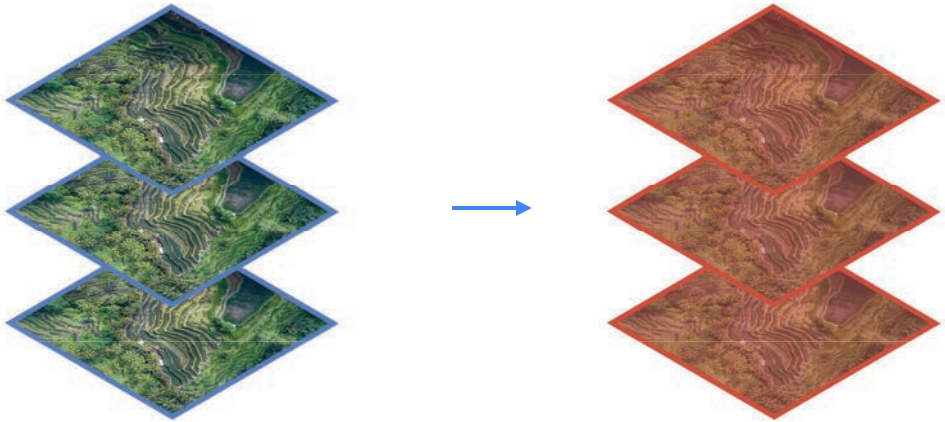
Experts

Filter a collection



Time, space & metadata search

Map an algorithm over a collection



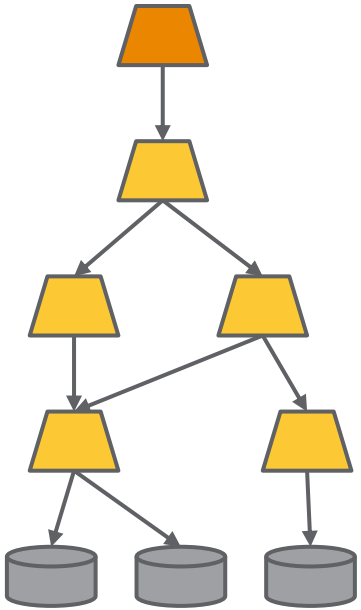
N → N

How GEE works: expressions and Lazy Evaluation

Earth Engine expressions define new objects in terms of existing objects, as a **directed acyclic graph (DAG)**.

When you write a script, that code determines the operations and their order in the expression graph.

The core types are **lazy** and **inherently parallel**.



Source: Google Inc.

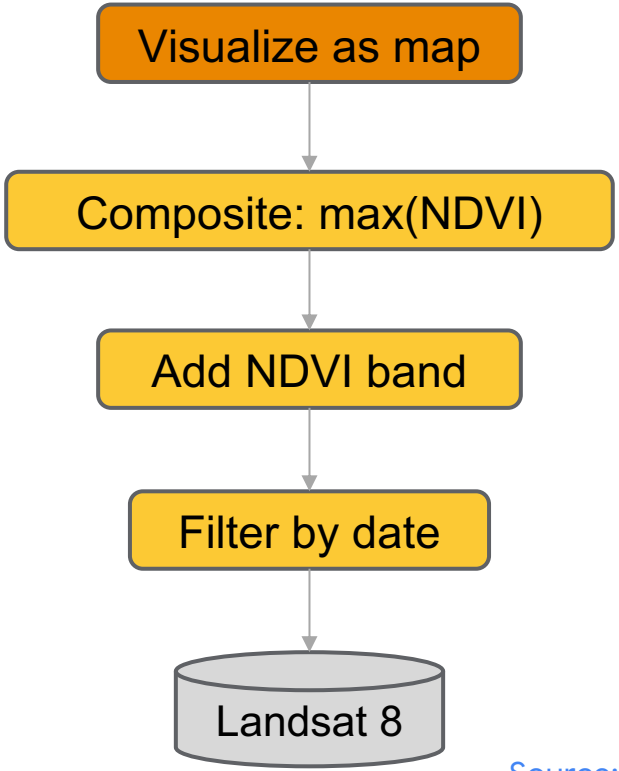
A Computation Example

How Earth Engine would do it

Goal: visualize a max NDVI composite of Landsat images in the year 2016

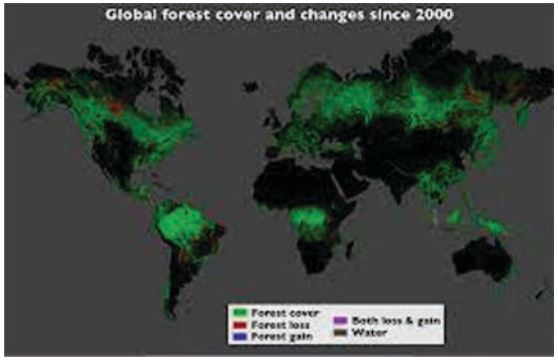
Earth Engine:

- Start with the artifact you want to materialize and work back
- Compute everything “on the fly”



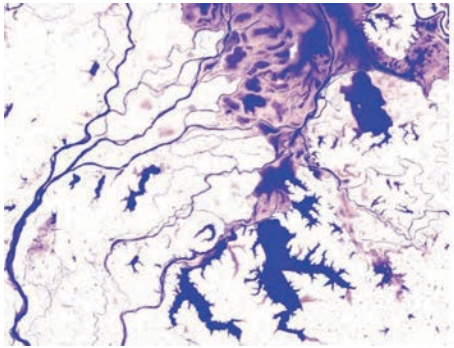
Source: Google Inc.

Notable products



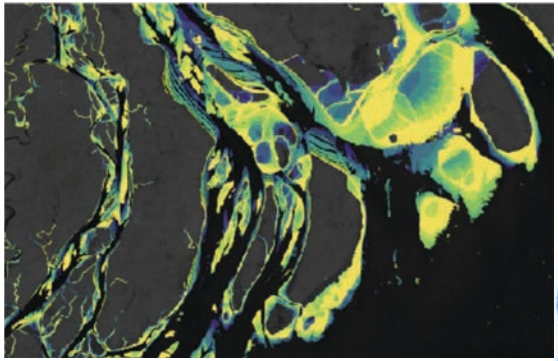
Tree Canopy Cover

Hansen, 2013



Surface Water

Pekel 2016



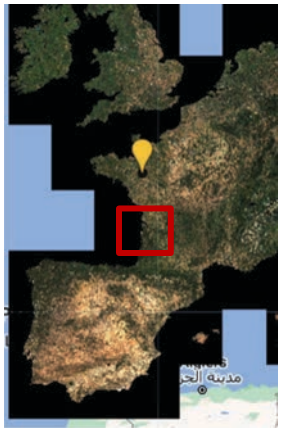
Intertidal Flats

Murray 2019

Source: Google Inc.

Experts

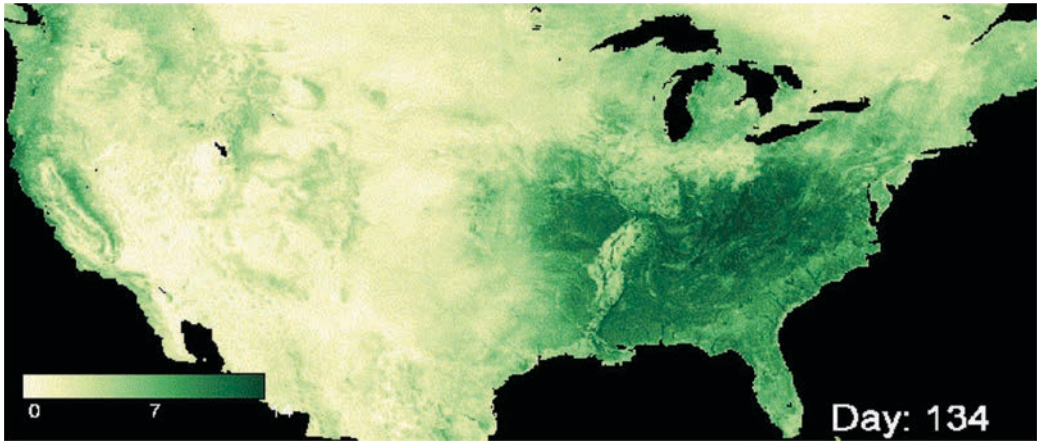
Our products



Data fusion of three sensors: MODIS + Landsat + Sentinel 2

Experts

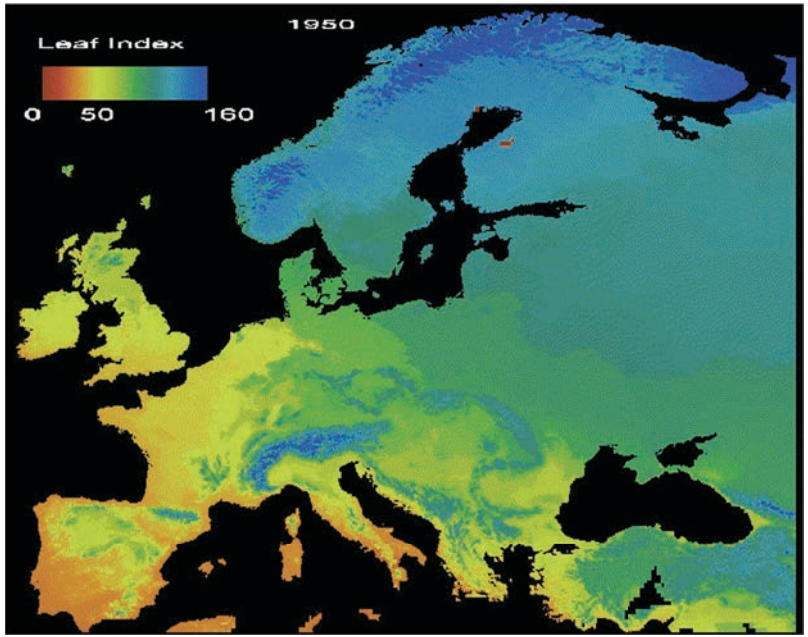
Our products



Ecosystem monitoring: Carbon uptake

Martinez-Ferrer, 2023

Our products

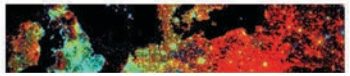


Spring onset

Izquierdo-Verdiguier, 2024

GEE key references

https://www.eefabook.org/introduction.html



Welcome to Cloud-Based
Remote Sensing with Google

- V. Solórzano, G A. Perilla, Cómo usar Google Earth Engine y no fallar en el intento, 2022, 202 pp. Open Access : https://www.researchgate.net/publication/365186199_Como_usar_Google_Earth_Engine_y_no_fallar_en_el_intento

- L Kumar, O. Mutanga, Google Earth Engine Applications, MDPI Basel, 2019, 408 pp. Open Access: https://www.mdpi.com/books/pdfview/book/1262

Experts

GEE examples

- Introduction to GEE in Python
- Biophysical parameter retrieval in Python
- Continuous change detection and classification, Python

GEE examples

Let's start!