Remote Sensing 1: GEOG 4/585

Lecture 7.2.

Introduction to Google Earth Engine (GEE)

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jryan4@uoregon.edu
Office hours: Monday 15:00-17:00
in 165 Condon Hall

Required reading:
Earth Engine 101 - Introduction to the API

Google Earth Engine

What is Google Earth Engine?

Nick Clinton, nclinton@google.com
Earth Engine Developer Relations

https://goo.gl/n5Gh5Q

Background

Goodchild et al. (2012):

Next-generation Digital Earth

Michael F. Goodchild[a,1], Huadong Guo[b], Alessandro Annoni[c], Ling Bian[d], Kees de Bie[e], Frederick Campbell[f], Max Craglia[c], Manfred Ehlers[g], John van Genderen[e], Davina Jackson[h], Anthony J. Lewis[i], Martino Pesaresi[c], Gábor Remetey-Fülöpp[j], Richard Simpson[k], Andrew Skidmore[f], Changlin Wang[b], and Peter Woodgate[l]

[a]Department of Geography, University of California, Santa Barbara, CA 93106; [b]Center for Earth Observation and Digital Earth, Chinese Academy of Sciences, Beijing 100094, China; [c]Joint Research Centre of the European Commission, 21027 Ispra, Italy; [d]Department of Geography, University at Buffalo, State University of New York, Buffalo, NY 14261; [e]Faculty of Geo-Information Science and Earth Observation, University of Twente, 7500 AE, Enschede, The Netherlands; [f]Fred Campbell Consulting, Ottawa, ON, Canada K2H 5G8; [g]Institute for Geoinformatics and Remote Sensing, University of Osnabrück, 49076 Osnabrück, Germany; [h]D_City Network, Newtown 2042, Australia; [i]Department of Geography and Anthropology, Louisiana State University, Baton Rouge, LA 70803; [j]Hungarian Association for Geo-Information, H-1122, Budapest, Hungary; [k]Nextspace, Auckland 1542, New Zealand; and [l]Cooperative Research Center for Spatial Information, Carlton South 3053, Australia

"The supply of geographic information from satellite-based and ground-based sensors has expanded rapidly, encouraging belief in a new, fourth, or "big data," paradigm of science that emphasizes **international collaboration, data-intensive analysis, huge computing resources, and high-end visualization.**"


OSTM/Jason 2
(NOAA)
Aquarius
QuikSCAT
TRMM
Terra
ISS-RapidScat,
CATS
EO-1
Landsat 7
(USGS)
SMAP
Aqua
Suomi NPP
(NOAA)
Landsat 8
(USGS)
SORCE,
TCTE (NOAA)
Aura
GPM
GRACE (2)
CALIPSO
CloudSat
OCO-2
Source: NASA

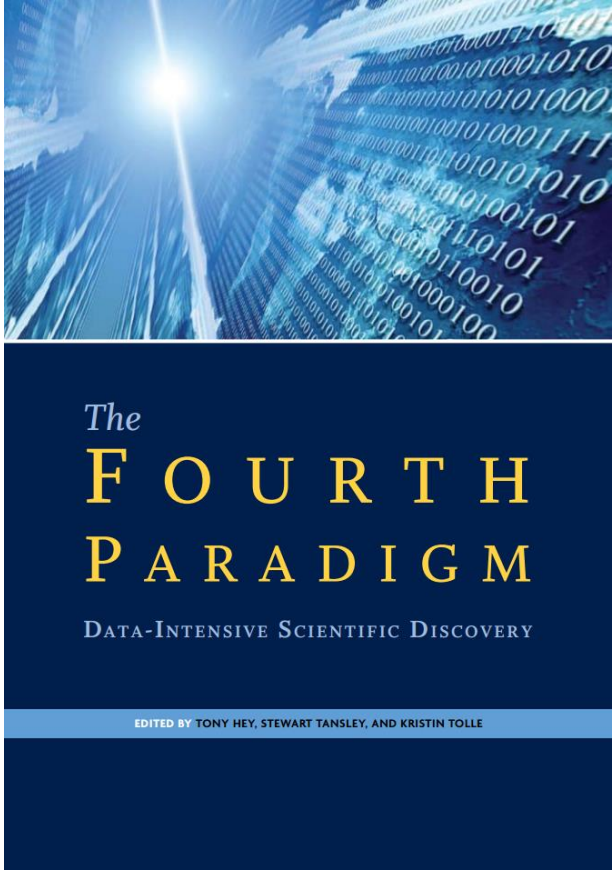
Google Mission Statement

"To organize the world's information and make it universally accessible and useful."

https://www.google.com/about/company/

"Often it turns out to be more efficient to move the questions than to move the data."

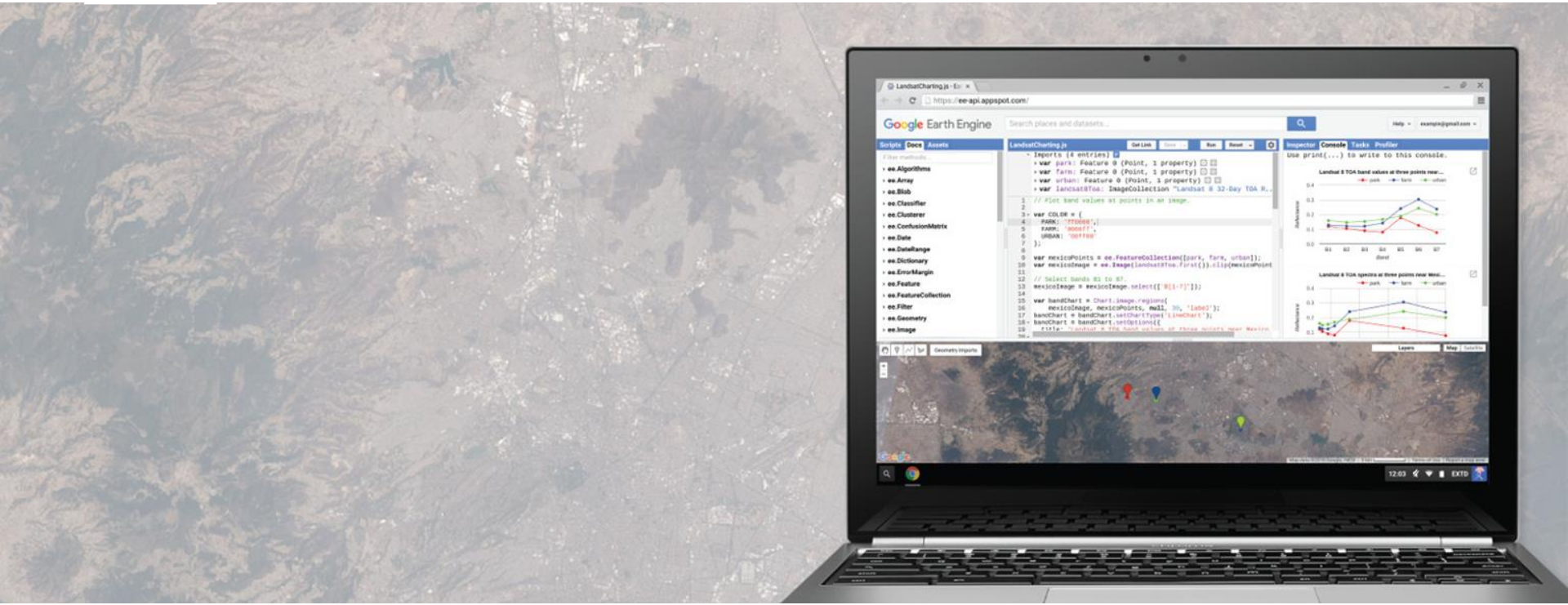
-Jim Gray (1944-2007)



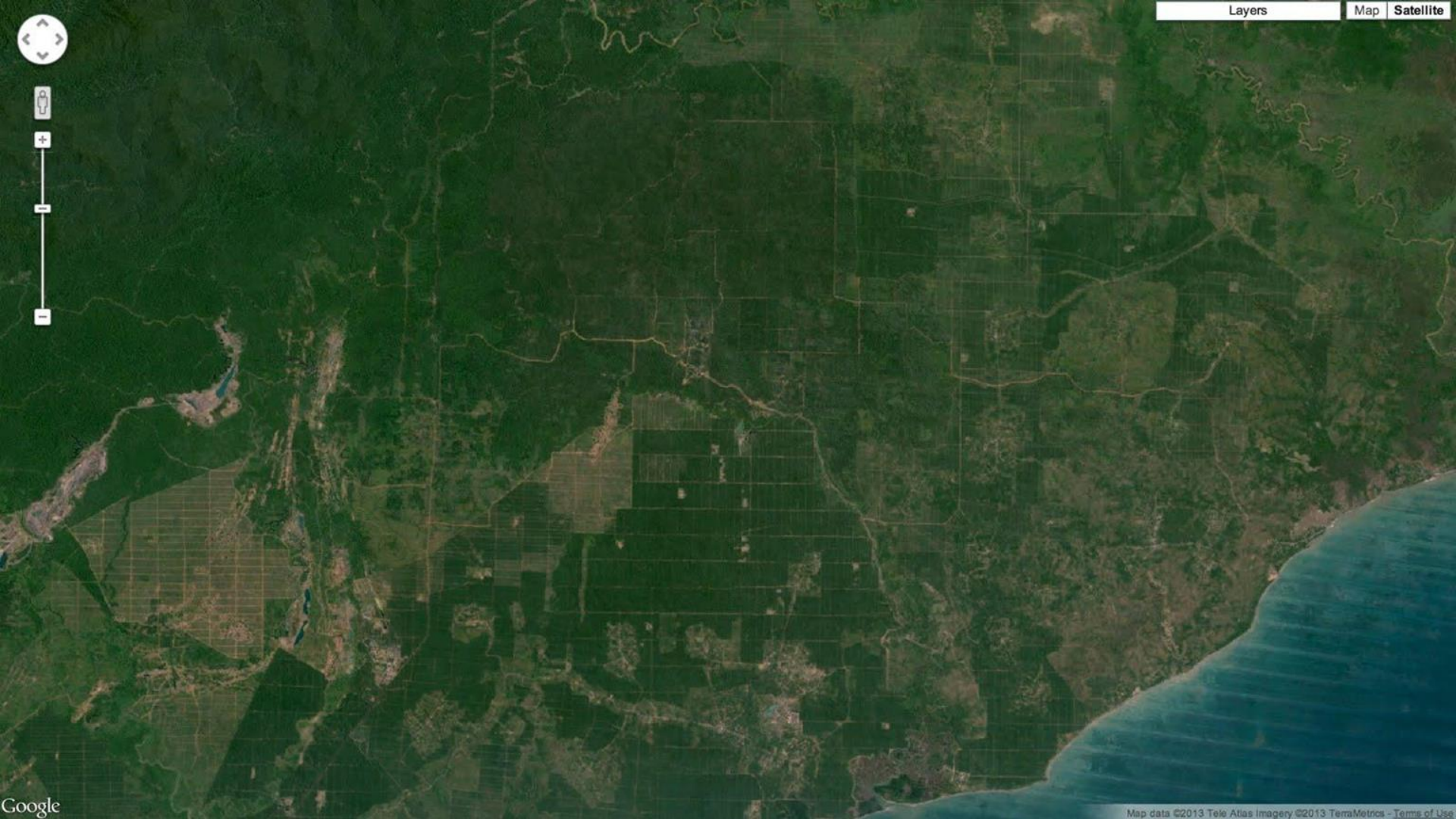
> 50 Petabytes of Earth observation data (imagery, weather, etc.)

Google computational infrastructure

Powerful JavaScript* API



* python too!

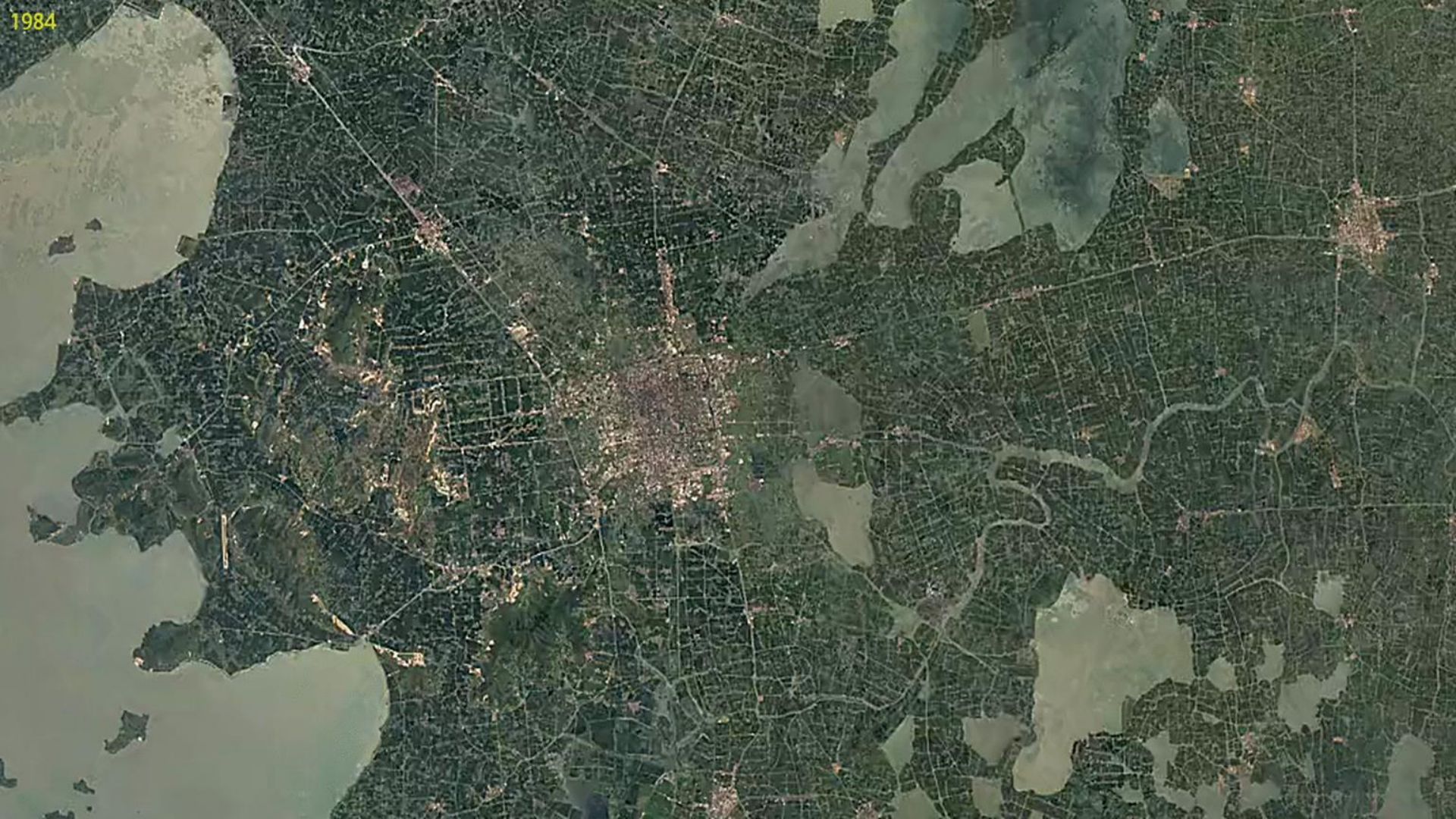

Layers
Map
Satellite
Google
Map data ©2013 Tele Atlas Imagery ©2013 TerraMetrics - Terms of Use

TIMELAPSE

Watch the world change over the course of nearly three decades of satellite photography

Pictured: The megacity of Dubai grows in the desert, from 1984 to today


1984


1984


1984
https://earthengine.google.com/timelapse/

33 years

Of satellite data

Over 5,000,000

Landsat and Sentinel scenes analyzed

3 Quadrillion Pixels

3,000,000,000,000,000

Data Catalog

The Earth Engine Data Catalog

Landsat & Sentinel 1, 2
10-30m, weekly

MODIS
250m daily

Vector Data
WDPA, Tiger

Terrain & Land Cover

Weather & Climate
NOAA NCEP, OMI, ...

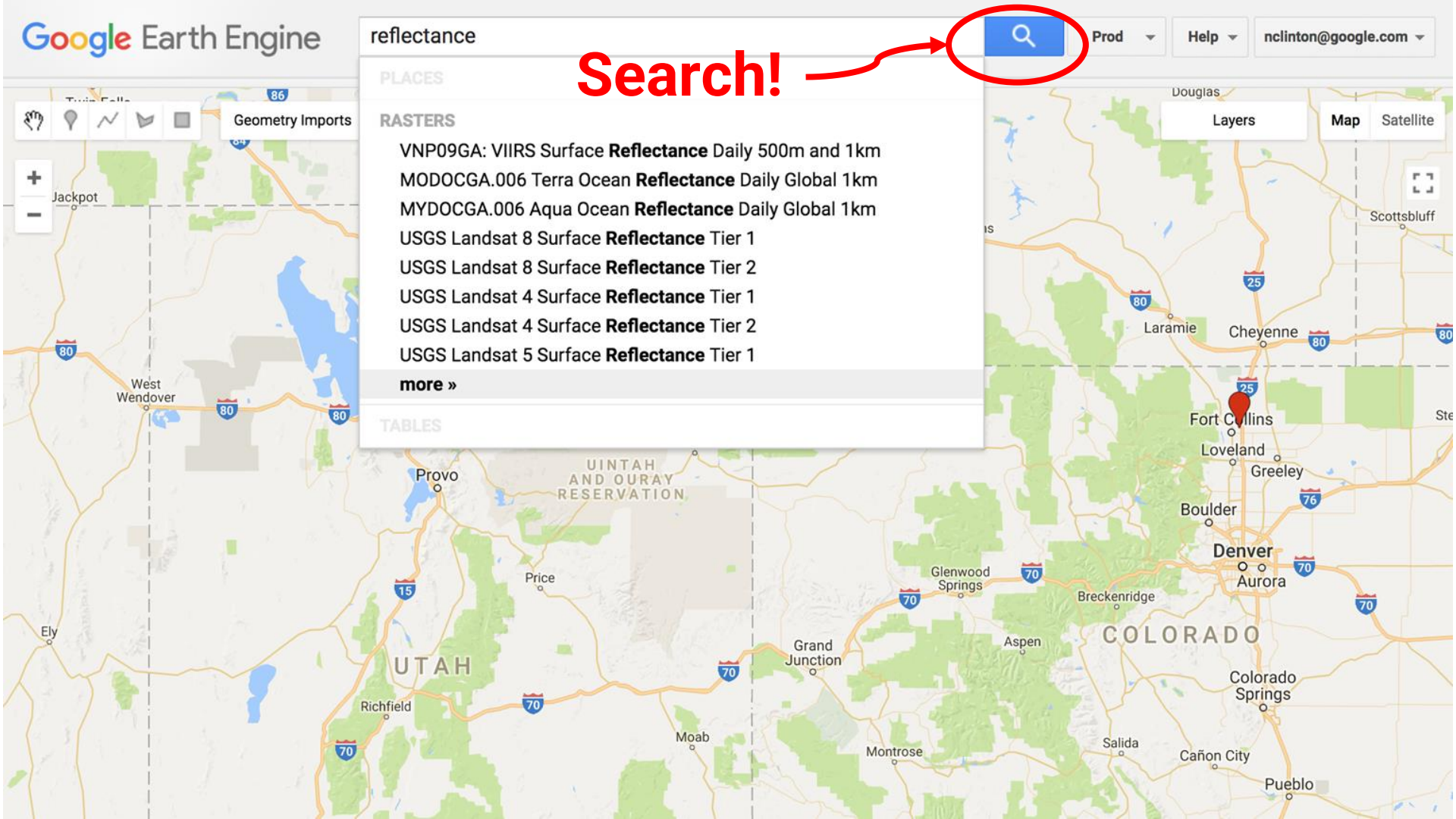
... and upload your own vectors and rasters

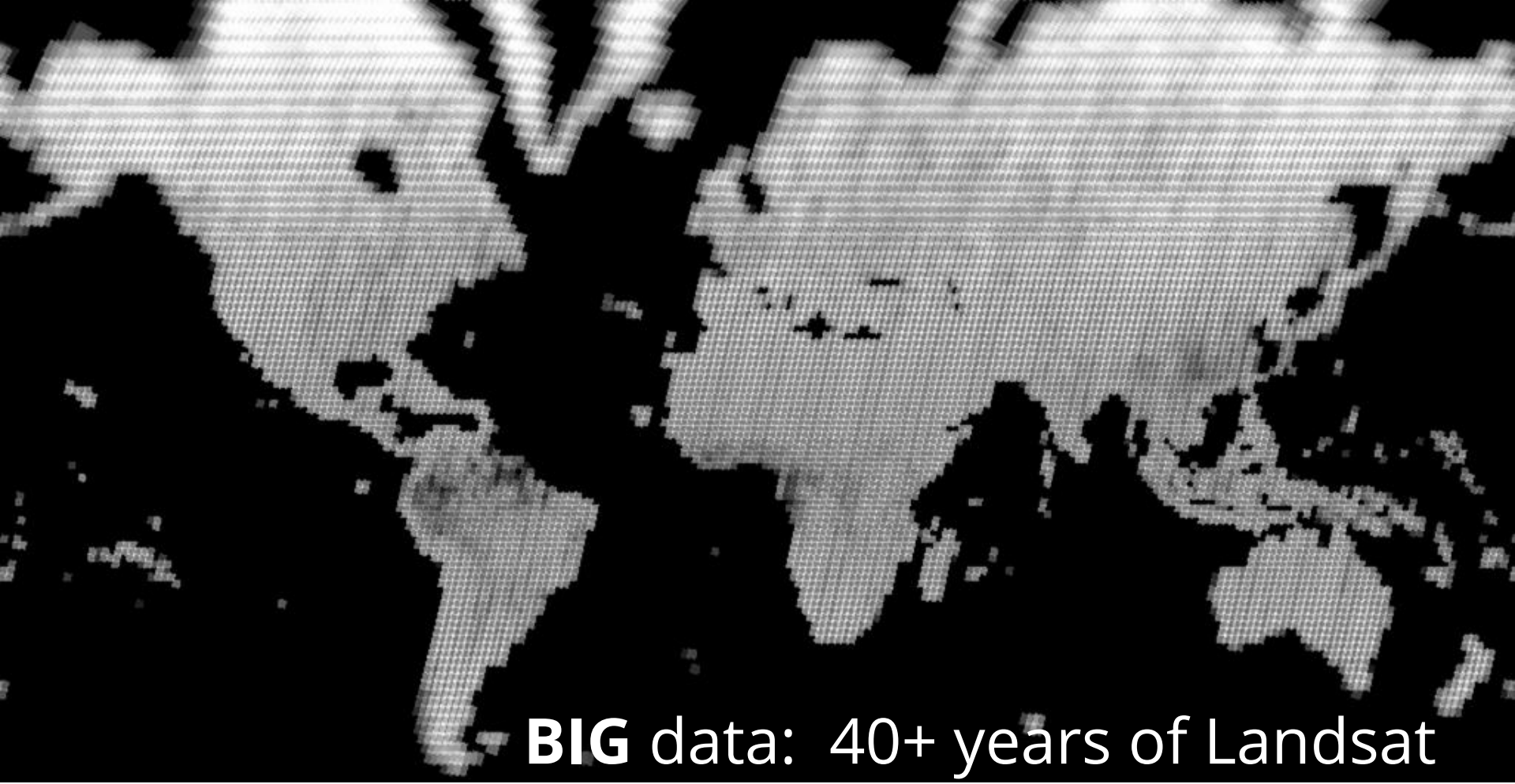
> 200 public datasets

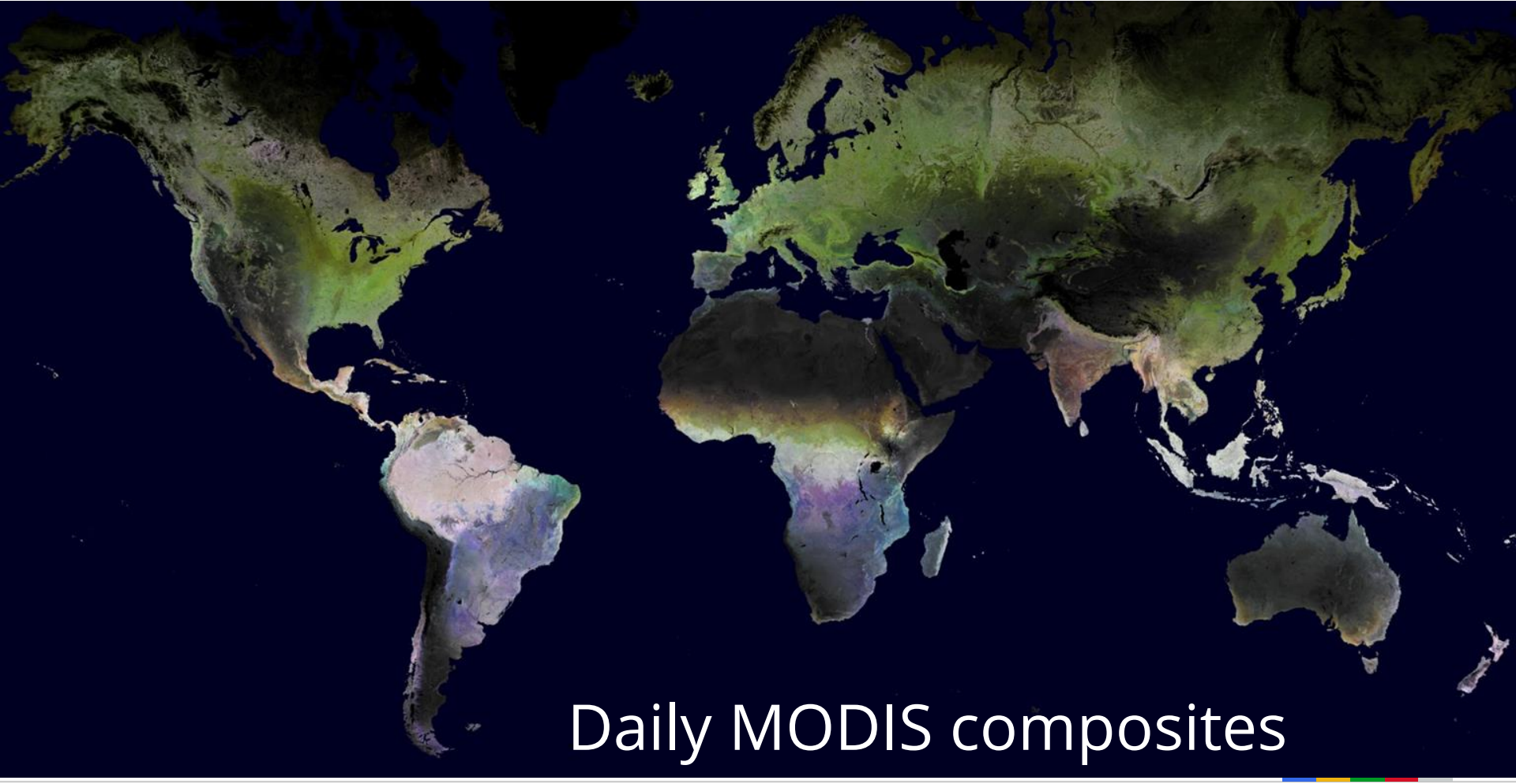
> 5 million images

> 4000 new images every day

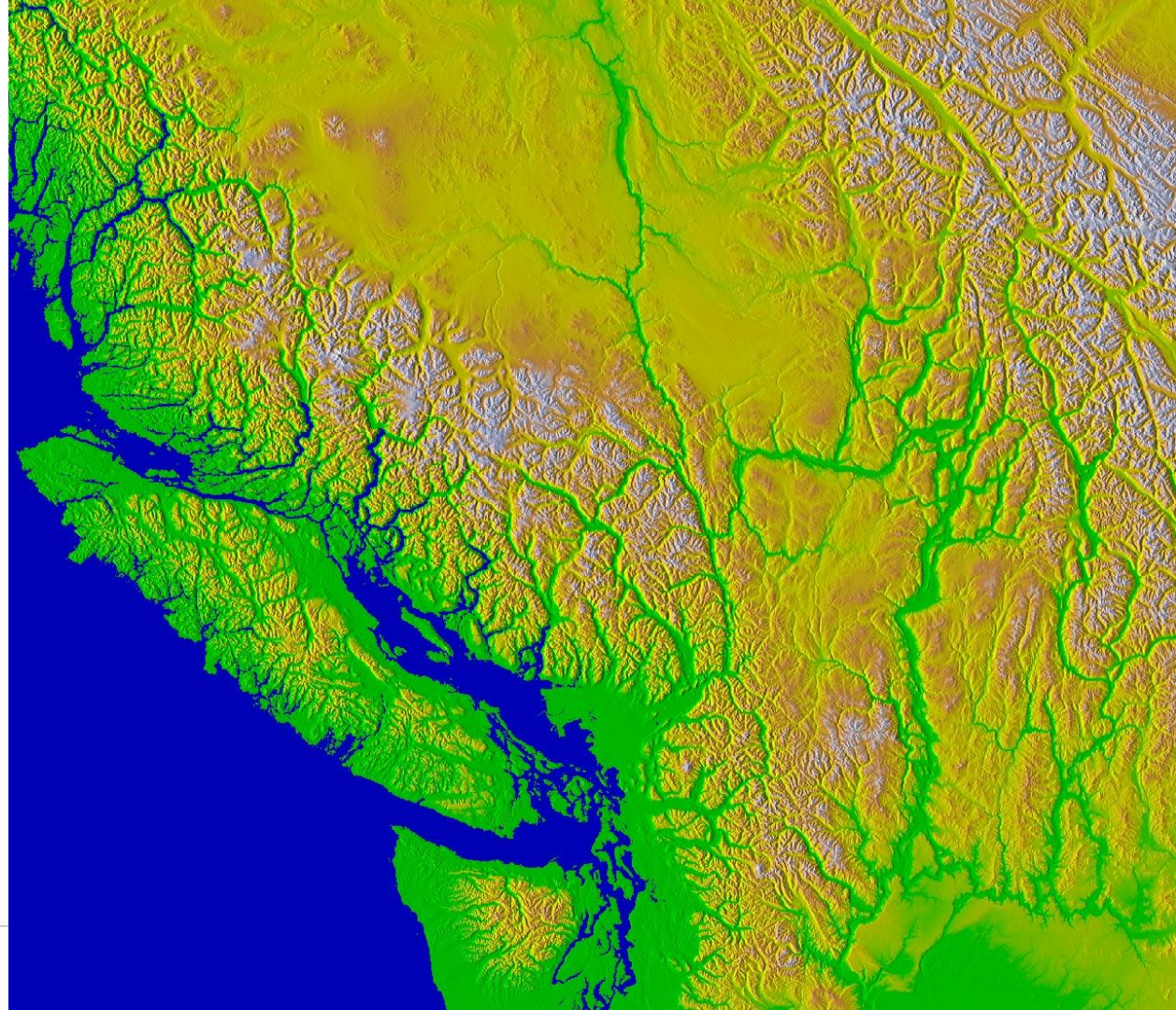
> 7 petabytes of data


Google Earth Engine
reflectance
Search!
Prod
Help
nclinton@google.com
PLACES
RASTERS
VNP09GA: VIIRS Surface Reflectance Daily 500m and 1km
MODOCGA.006 Terra Ocean Reflectance Daily Global 1km
MYDOCGA.006 Aqua Ocean Reflectance Daily Global 1km
USGS Landsat 8 Surface Reflectance Tier 1
USGS Landsat 8 Surface Reflectance Tier 2
USGS Landsat 4 Surface Reflectance Tier 1
USGS Landsat 4 Surface Reflectance Tier 2
USGS Landsat 5 Surface Reflectance Tier 1
more »
TABLES
Geometry Imports
Layers
Map
Satellite
Douglas
Jackpot
Scottsbluff
Laramie
Cheyenne
West Wendover
Fort Collins
Loveland
Greeley
Provo
UINTAH AND OURAY RESERVATION
Boulder
Denver
Aurora
Price
Glenwood Springs
Breckenridge
Ely
UTAH
Grand Junction
Aspen
COLORADO
Colorado Springs
Richfield
Moab
Montrose
Salida
Cañon City
Pueblo

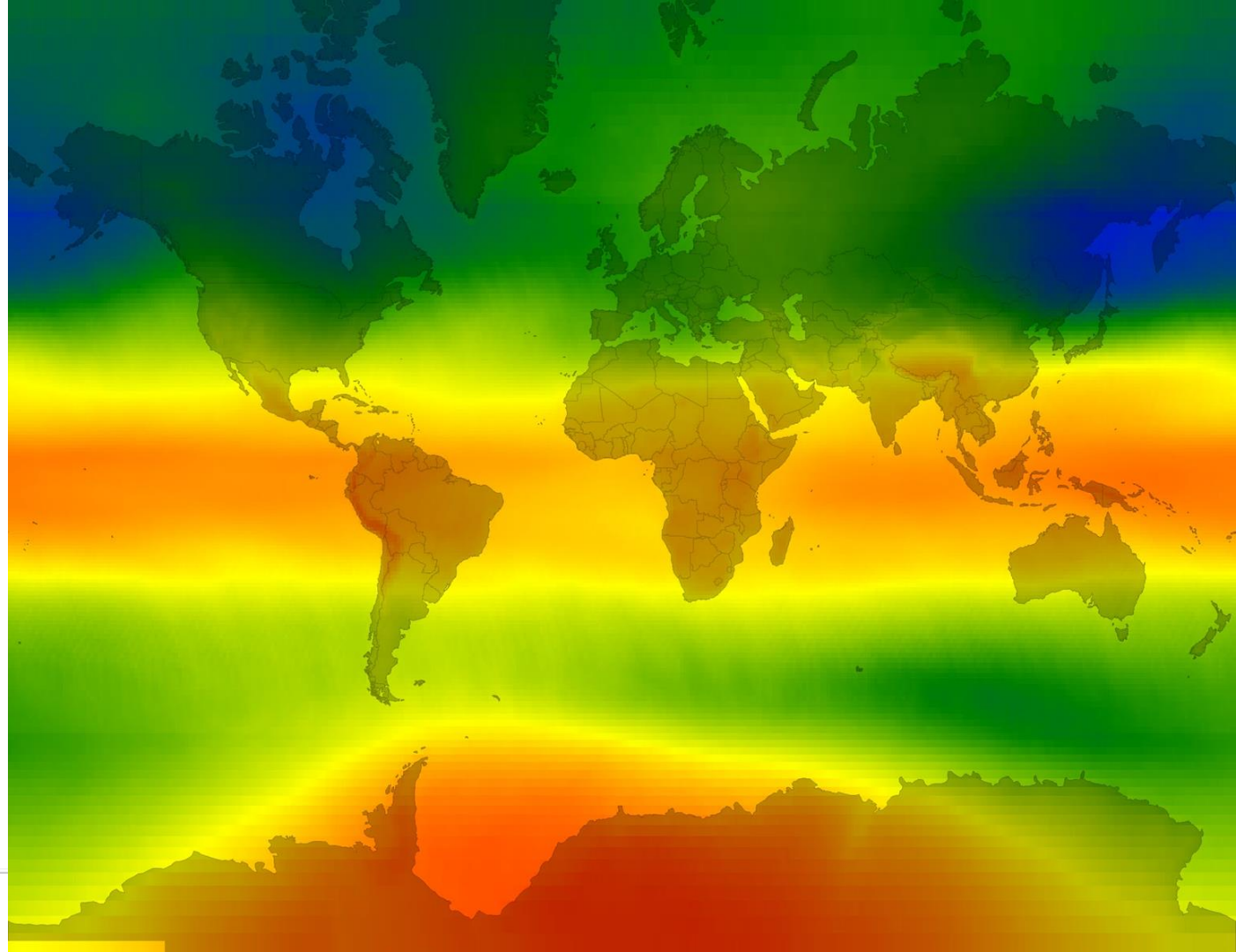

BIG data: 40+ years of Landsat


Daily MODIS composites

Terrain



Atmosphere



Google Earth Engine


Sentinel-1

API

Google Earth Engine

Data Types and Geospatial Processing Functions

- **Image** - band math, clip, convolution, neighborhood, selection ...
- **Image Collection** - map, aggregate, filter, mosaic, sort ...
- **Feature** - buffer, centroid, intersection, union, transform ...
- **Feature Collection** - aggregate, filter, flatten, merge, sort ...
- **Filter** - by bounds, within distance, date, day-of-year, metadata ...
- **Reducer** - mean, linearRegression, percentile, histogram ....
- **Join** - simple, inner, outer, inverted ...
- **Kernel** - square, circle, gaussian, sobel, kirsch ...
- **Machine Learning -** CART, random forests, bayes, SVM, kmeans, cobweb ...
- **Projection** - transform, translate, scale ...

over 1000 data types and operators, and growing!

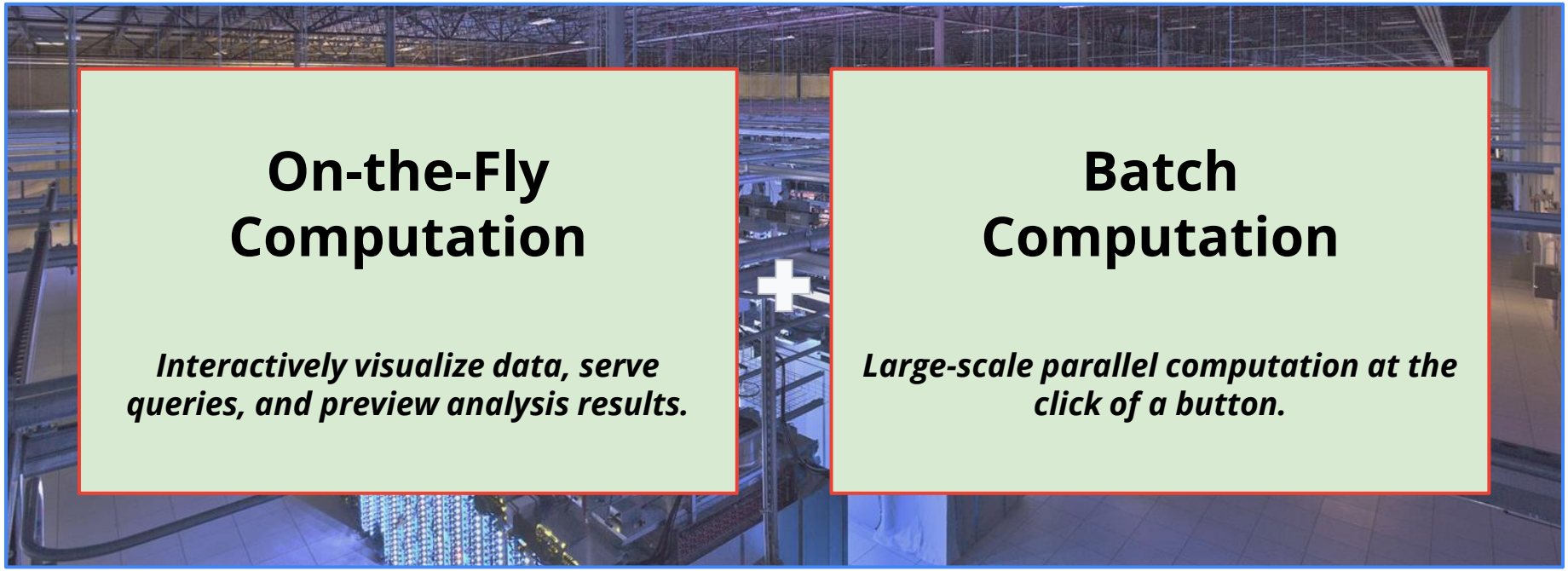
Global composites with a few lines of code

```
var composite = ee.Algorithms.Landsat.simpleComposite({
  collection: ee.ImageCollection('LANDSAT/LC08/C01/T1'),
  asFloat: true
});

Map.addLayer(composite,
             {bands: ['B4', 'B3', 'B2'], max: 0.3},
             'composite');
```

https://code.earthengine.google.com/05d2e23206b329dfe696e5ba8e232c3f

Computation Platform



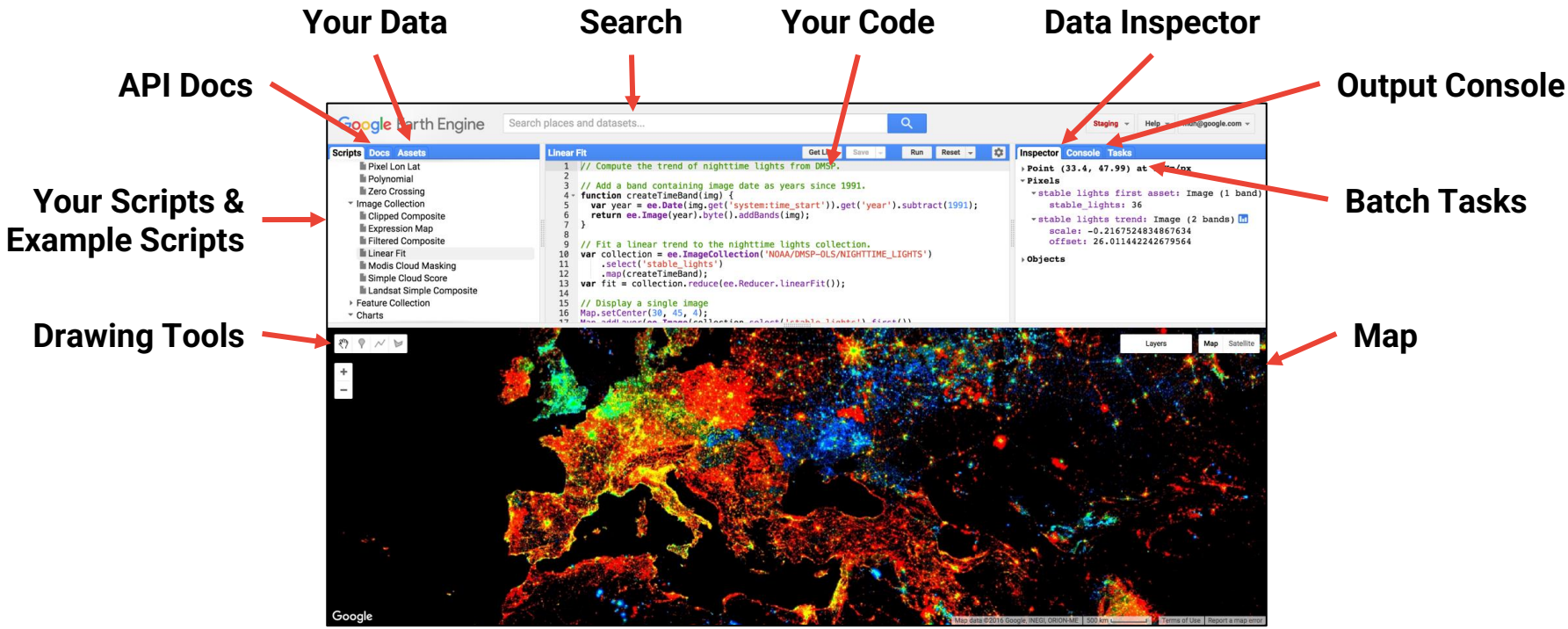
On-the-Fly Computation

Interactively visualize data, serve queries, and preview analysis results.

Batch Computation

Large-scale parallel computation at the click of a button.

The Earth Engine Code Editor

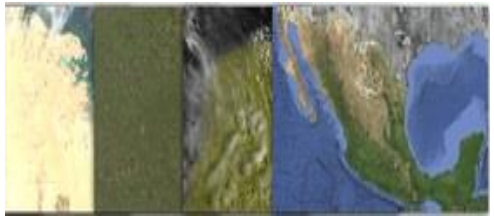


code.earthengine.google.com

Requests

Results

Geospatial Datasets



add

mosaic

distance

filter

join

focal_min

convolve

reduce

Algorithmic Primitives

Storage and Compute

Contents lists available at ScienceDirect

Remote Sensing of Environment

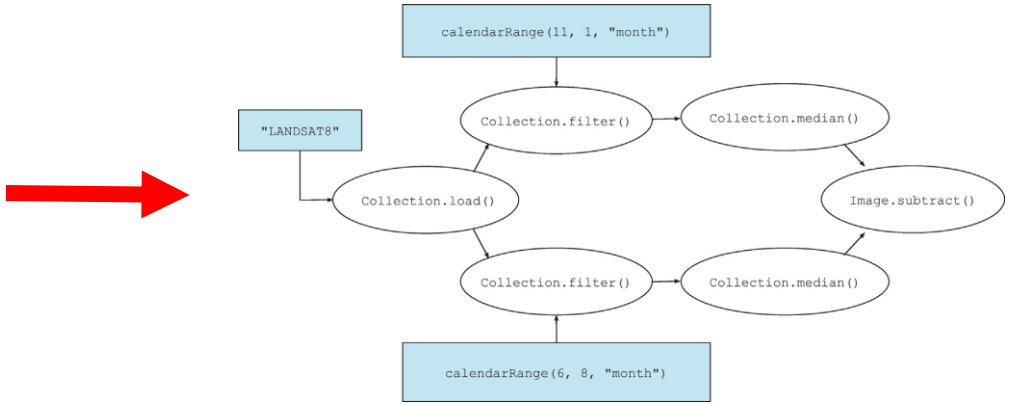
journal homepage: www.elsevier.com/locate/rse

Google Earth Engine: Planetary-scale geospatial analysis for everyone

Noel Gorelick [a,*], Matt Hancher [b], Mike Dixon [b], Simon Ilyushchenko [b], David Thau [b], Rebecca Moore [b]

https://www.sciencedirect.com/science/article/pii/S0034425717302900

```
collection = ee.ImageCollection("LANDSAT8")
winter = collection.filter(ee.Filter.calendarRange(11, 1, "month"))
summer = collection.filter(ee.Filter.calendarRange(6, 8, "month"))
diff = summer.median().subtract(winter.median())
```



Publications

High-resolution mapping of global surface water and its long-term changes

Jean-Francois Pekel[1], Andrew Cottam[1], Noel Gorelick[2] & Alan S. Belward[1]

doi:10.1038/nature20584

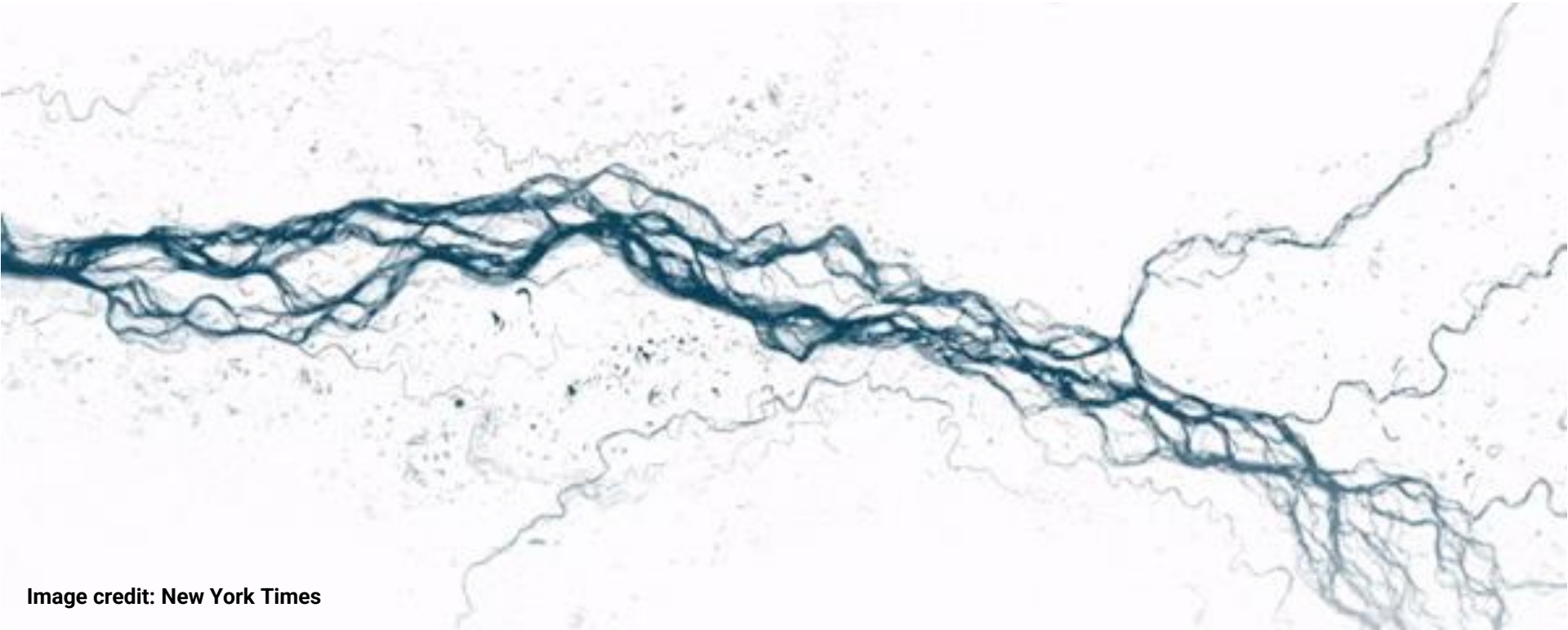
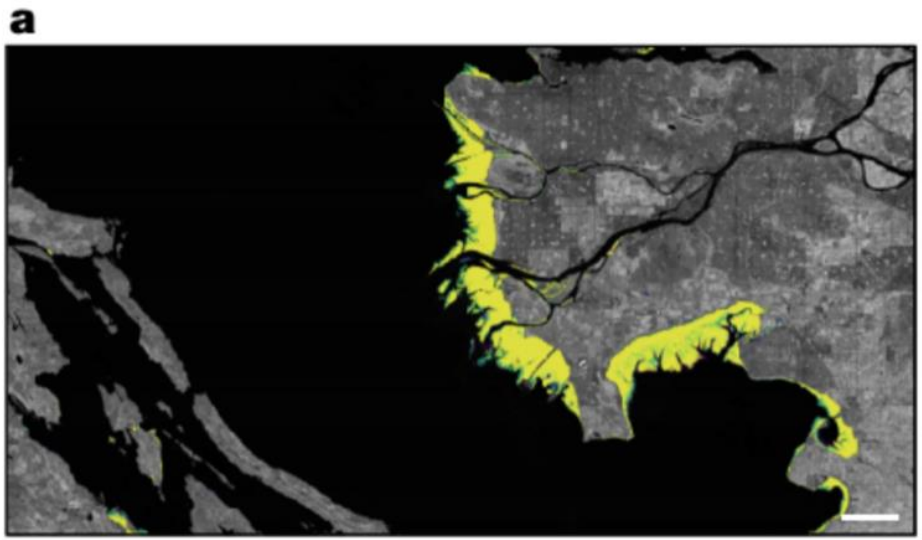


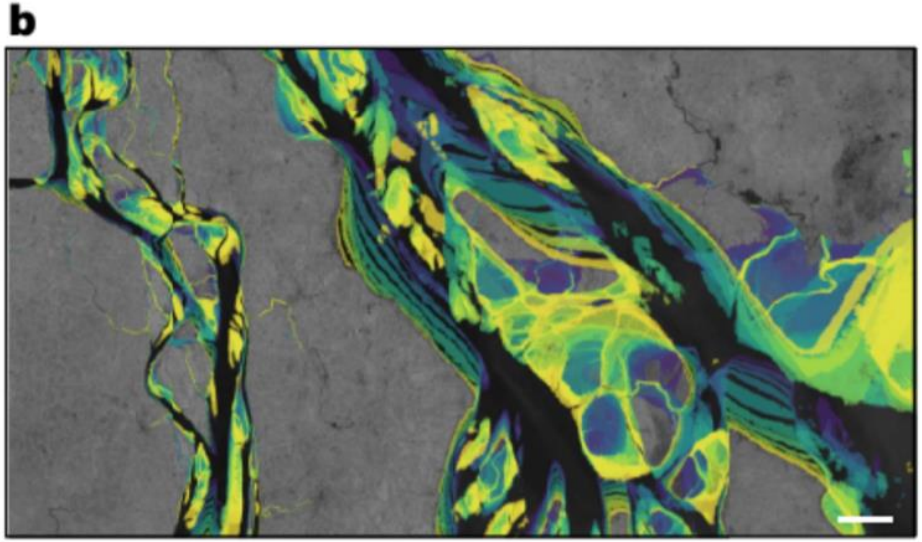
Image credit: New York Times

https://doi.org/10.1038/s41586-018-0805-8

The global distribution and trajectory of tidal flats

Nicholas J. Murray[1,2]*, Stuart R. Phinn[3], Michael DeWitt[4], Renata Ferrari[5], Renee Johnston[4], Mitchell B. Lyons[2], Nicholas Clinton[4], David Thau[4] & Richard A. Fuller[1]

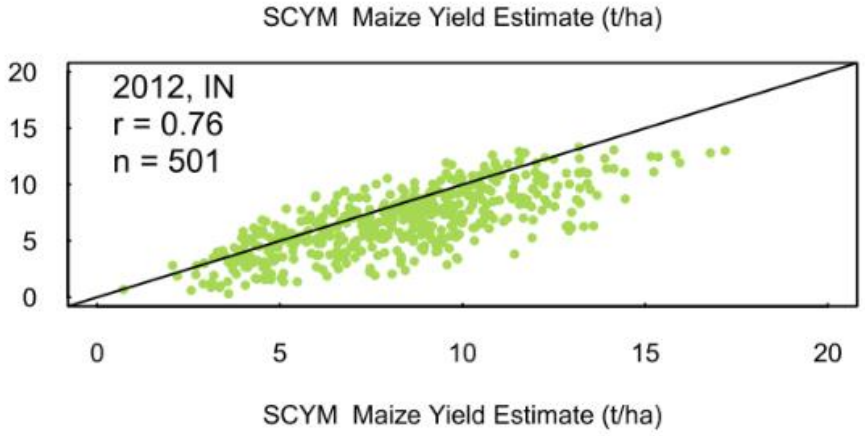


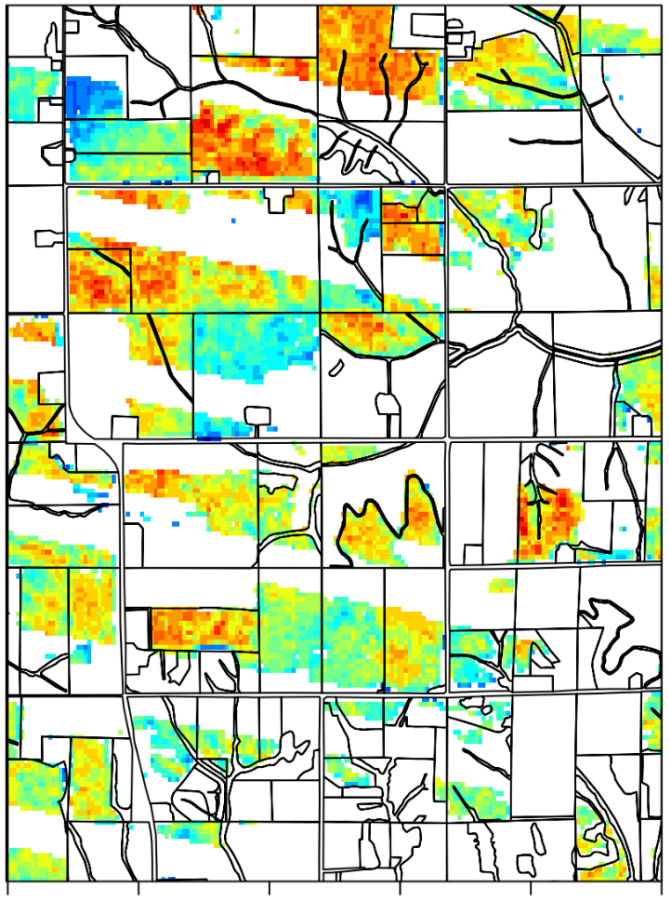


A scalable satellite-based crop yield mapper

David B. Lobell [a,*], David Thau [b], Christopher Seifert [a], Eric Engle [b], Bertis Little [c]

http://www.sciencedirect.com/science/article/pii/S0034425715001637

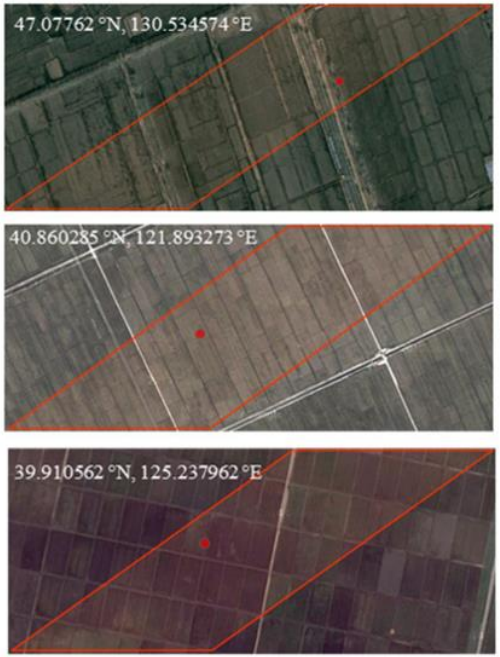




Mapping paddy rice planting area in northeastern Asia with Landsat 8 images, phenology-based algorithm and Google Earth Engine

Jinwei Dong [a,b,*], Xiangming Xiao [a,b,c,*], Michael A. Menarguez [a,b], Geli Zhang [a,b], Yuanwei Qin [a,b], David Thau [d], Chandrashekhar Biradar [e], Berrien Moore III [f]

http://www.sciencedirect.com/science/article/pii/S003442571630044X



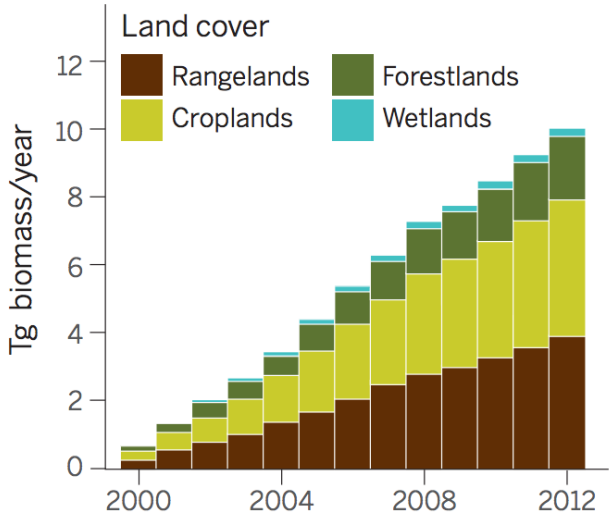
SUSTAINABILITY

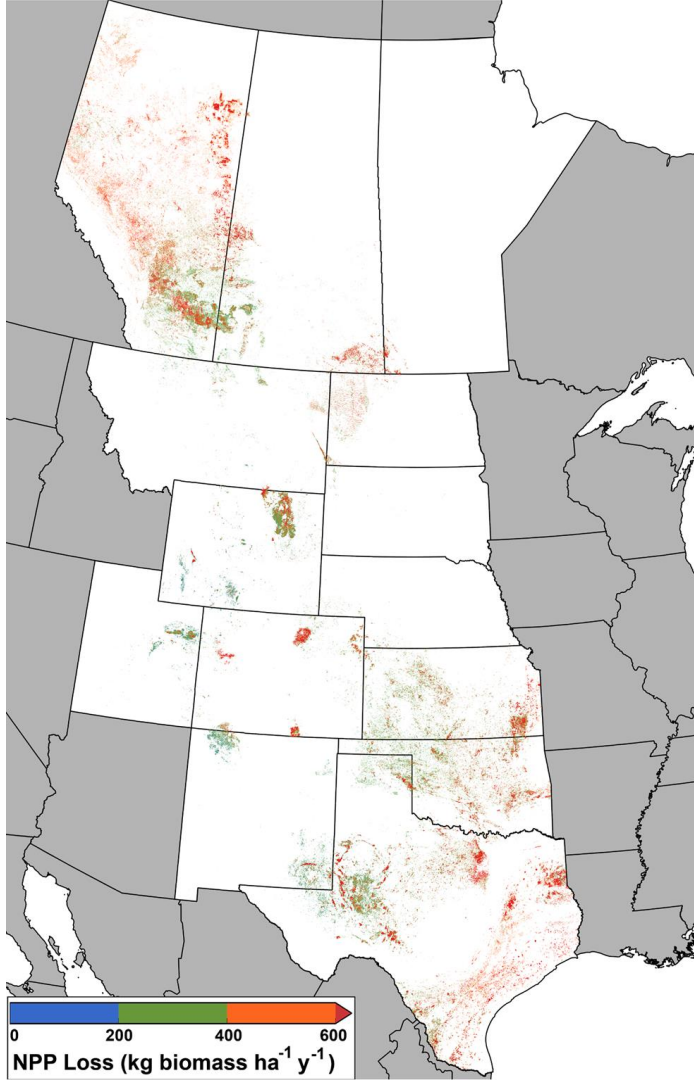
Ecosystem services lost to oil and gas in North America

Net primary production reduced in crop and rangelands

By **Brady W. Allred,[1]* W. Kolby Smith,[1,2] Dirac Twidwell,[3] Julia H. Haggerty,[4] Steven W. Running,[1] David E. Naugle,[1] Samuel D. Fuhlendorf[5]**

24 APRIL 2015 • VOL 348 ISSUE 6233 **SCIENCE** sciencemag.org





Applications

Climate Engine Beta

Guided Tours | Video Tutorials | Examples | Manual | Contact

ClimateEngine | Data | Metrics | References | Sponsors

Map Layer Options | Time Series Options | INFO

GET MAP LAYER

Product

Type: Climate

Dataset: UI METDATA/gridMET

Variable: ETo (ASCE Grass Reference Evapotranspirati

Processing

Calculation: Percent Difference From Average Conditions

Statistic: Mean

Time Period

(Data:1979-01-01 to 2016-09-25)

Last Year

Start Date: 2015-09-26

End Date: 2016-09-25

Year Range for Historical Avg/Distribution: 1981 - 2010

TOGGLE MENU | Map | Animations

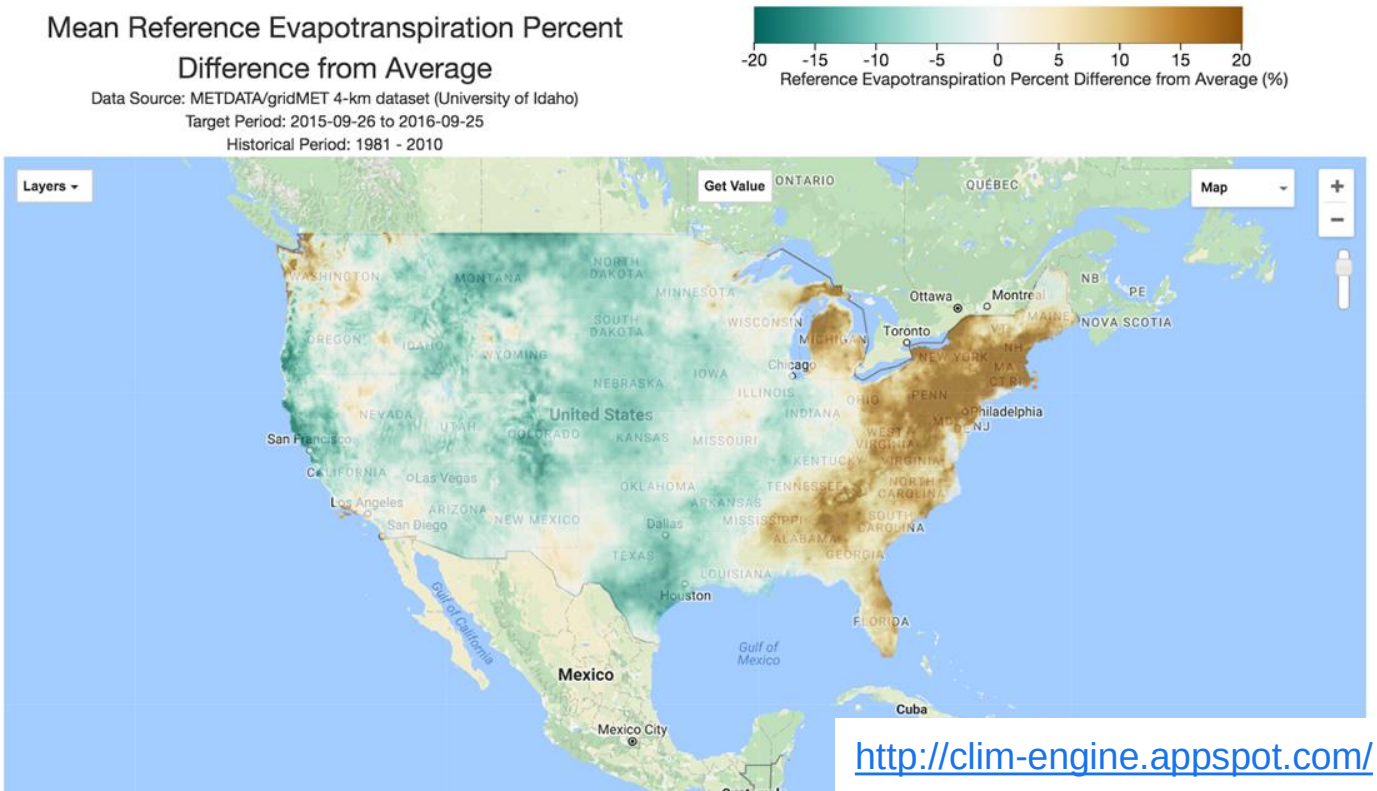
Colormap Options | Apply Mask | Download | Get Link | Reset Forms

Mean Reference Evapotranspiration Percent Difference from Average

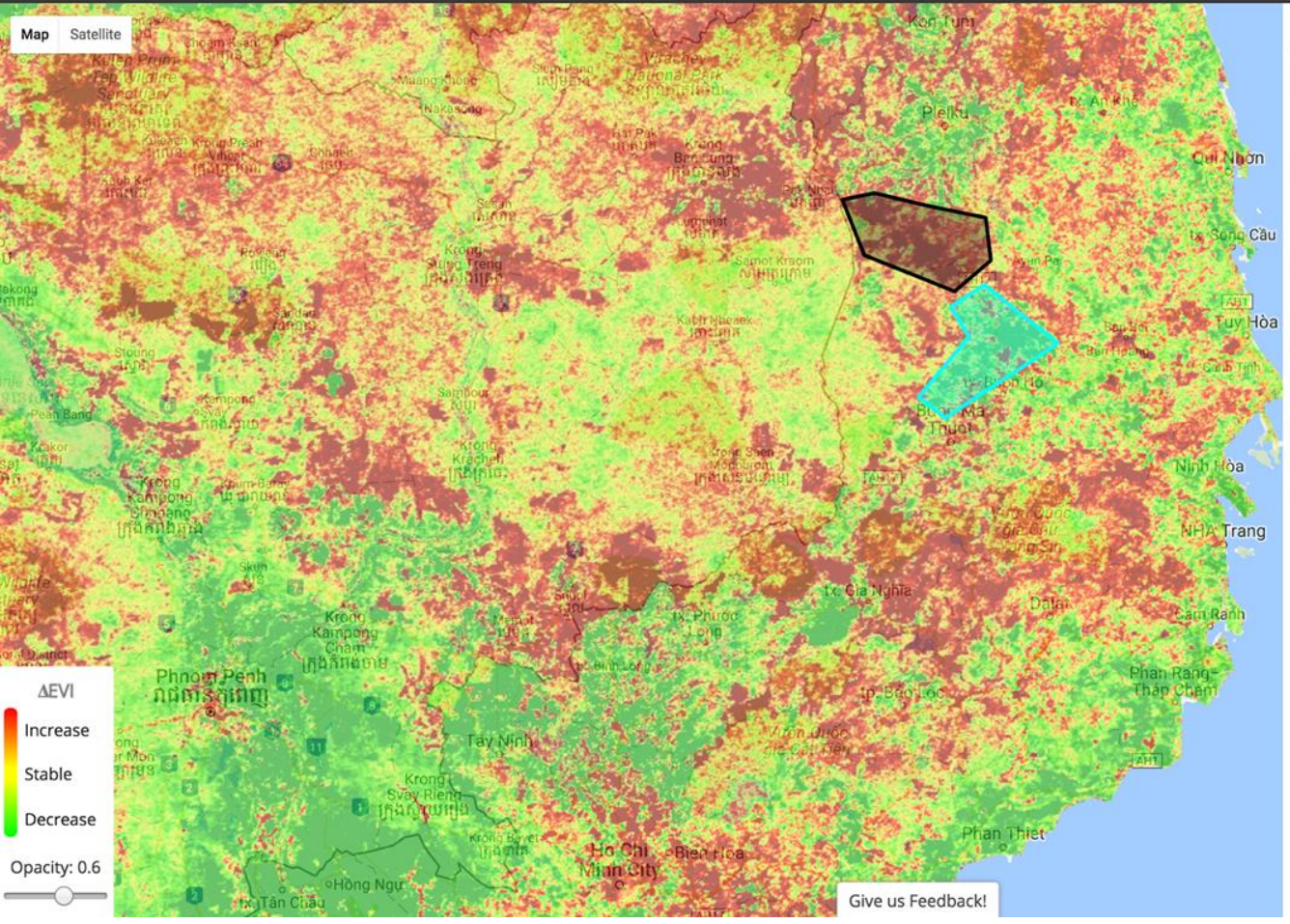
Data Source: METDATA/gridMET 4-km dataset (University of Idaho)

Target Period: 2015-09-26 to 2016-09-25

Historical Period: 1981 - 2010



http://clim-engine.appspot.com/



Eco Dash Controls

Step 1: Select a time period to use as the baseline EVI

2002 - 2008

Step 2: Select a time period to measure ΔEVI

2009 - 2015

Step 3: Update the map with the cumulative ΔEVI

Update Map

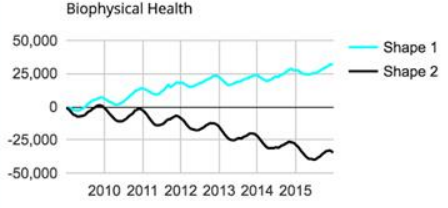
Step 4: Choose a polygon selection method

○ Province ○ Country ◉ Draw Polygon

Step 5: Click a polygon on the map or draw your own

Draw Polygon Selection: *Shape 1, Shape 2*

Step 6: Review the historical ΔEVI in the selection



POWERED BY
Earth Engine

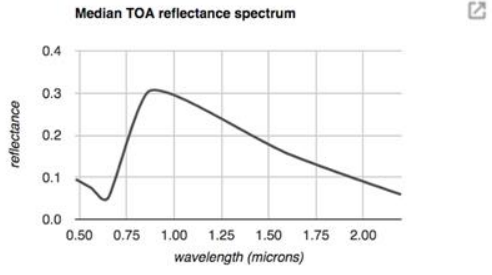
Search places

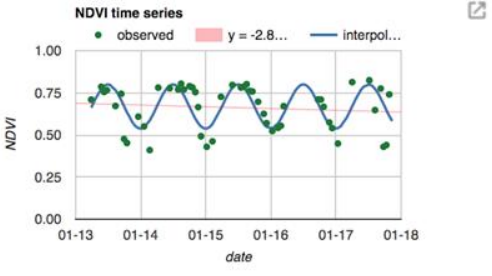
Layers | Map | Satellite

Pixel Dashboard

Click a point on the map to get: Landsat 8 median TOA spectrum, Landsat 8 TOA time series.

lon: -90.18 lat: 29.88





Google

Map data ©2017 Google, INEGI | 5 km | Terms of Use | Report a map error

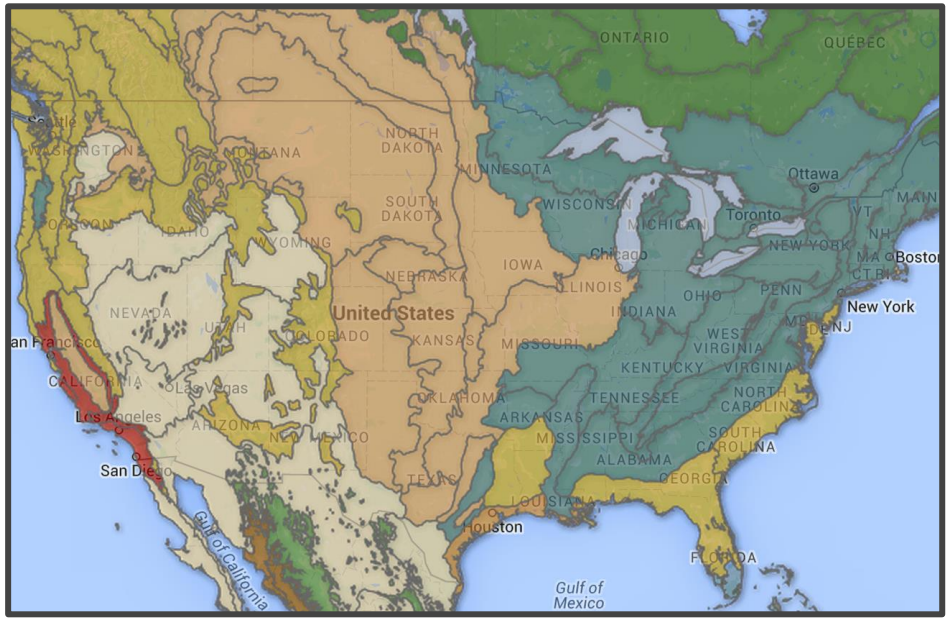
Training Concepts

Data Models

Feature

Line / Point / Polygon

List of Properties



TNC Ecoregions

Data Models

Feature

Image

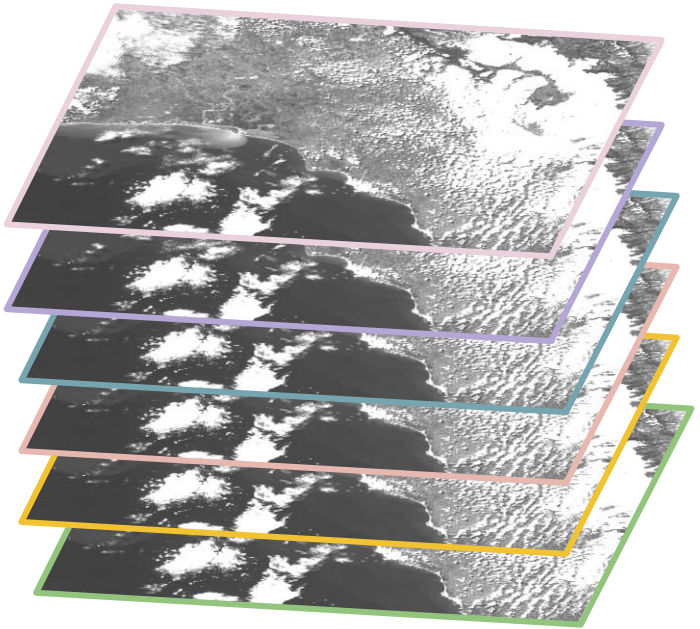
Stack of Georeferenced bands

Each band has its own:

Mask, Projection, Resolution

A list of properties, including:

Date, Bounding-box



Data Models

Feature

Image

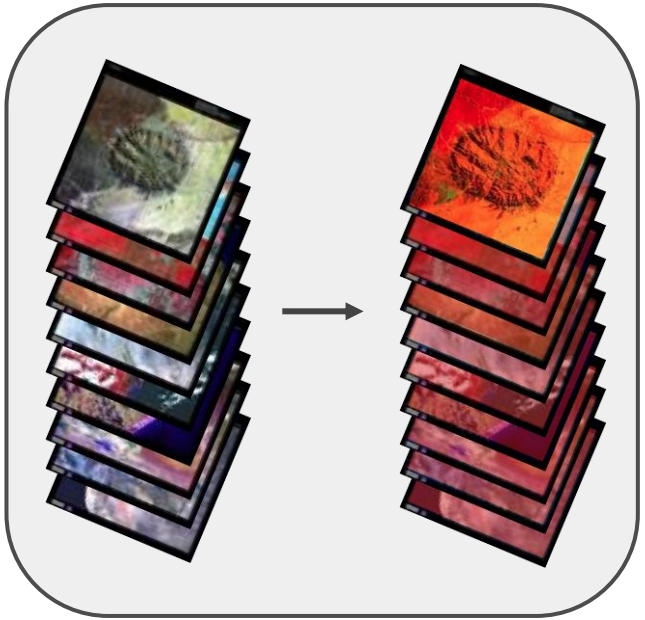
Collection

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

Map

Apply a function to each element of a collection

A "map" (for-each) operation



Examples

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

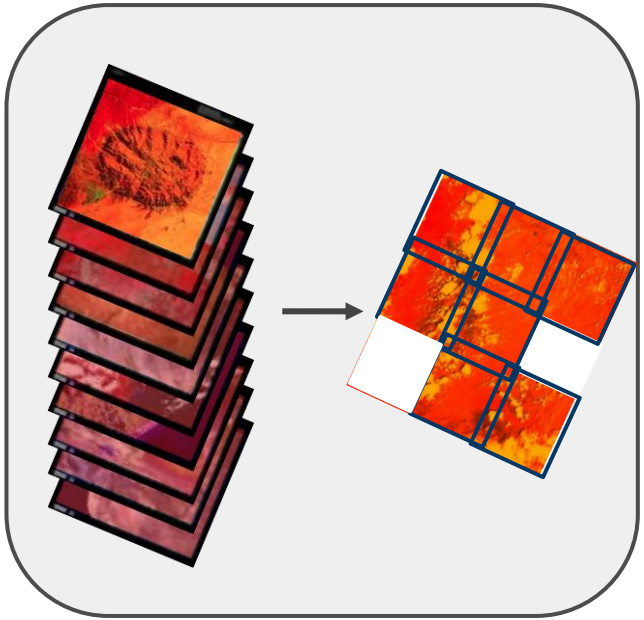
Reduce

Aggregate everything in a collection

"Reduction"

Examples

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



Reducers in Earth Engine

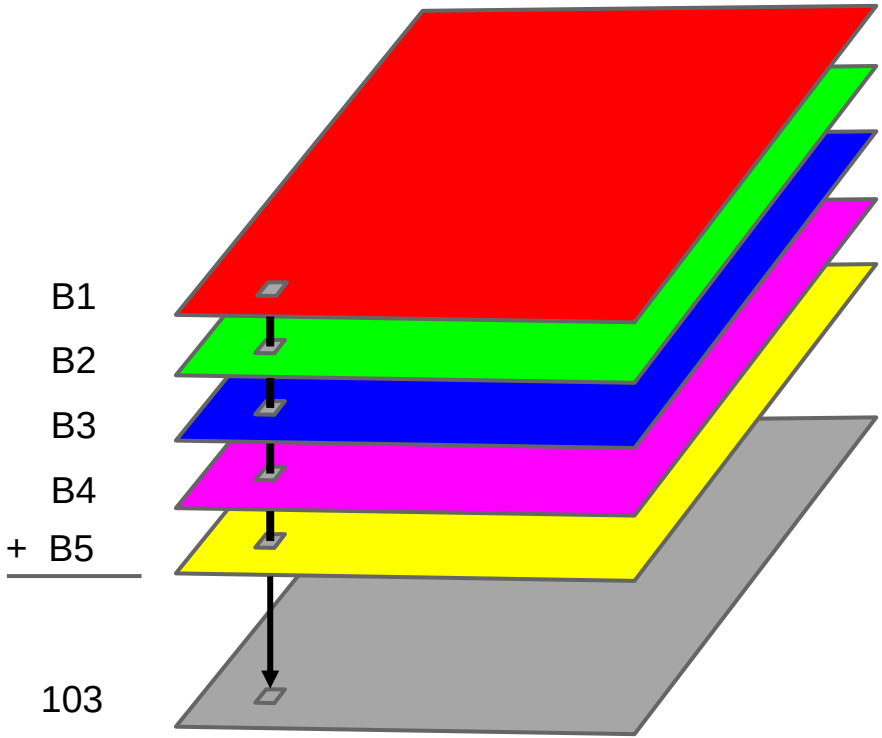
8 ways to reduce

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

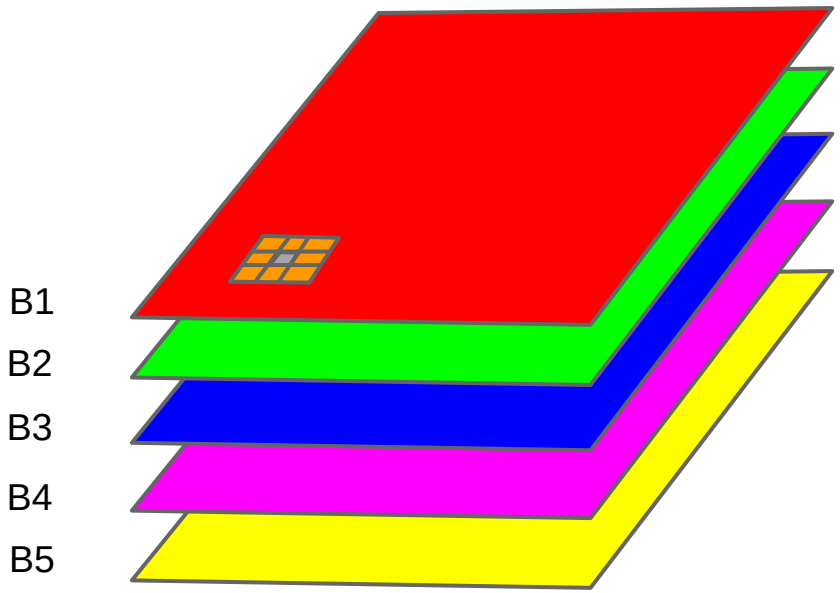
40+ reducers

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

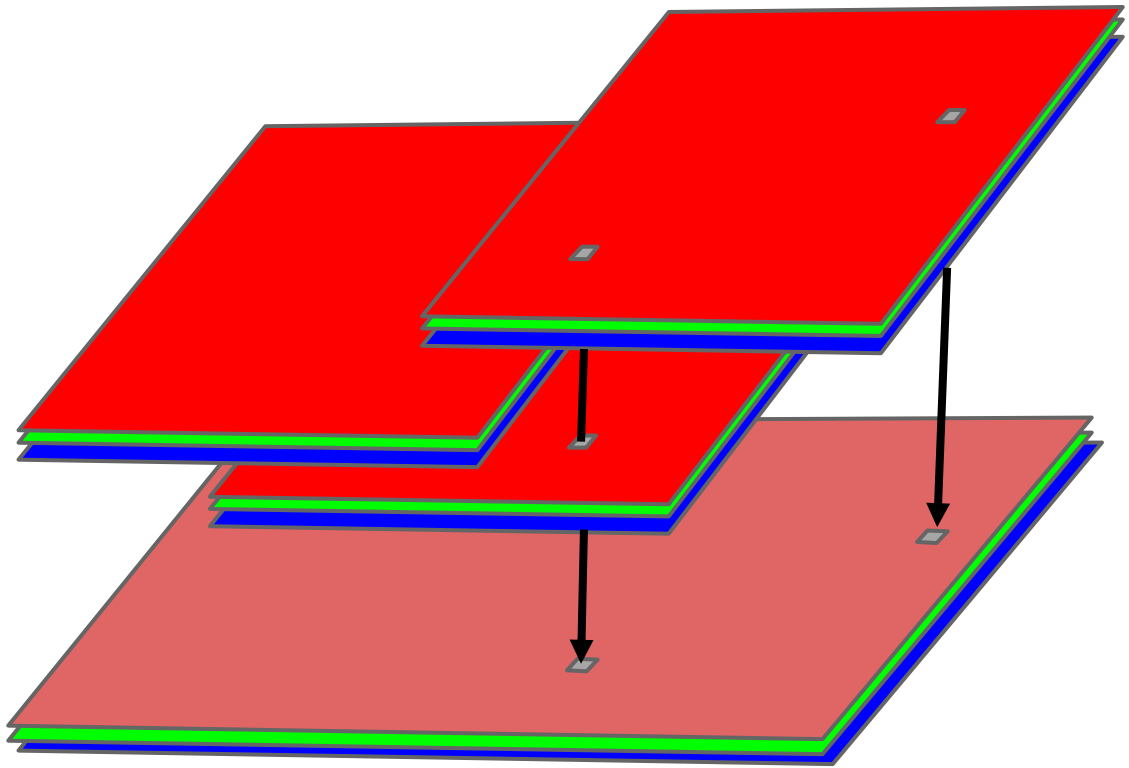
Reduce Bands



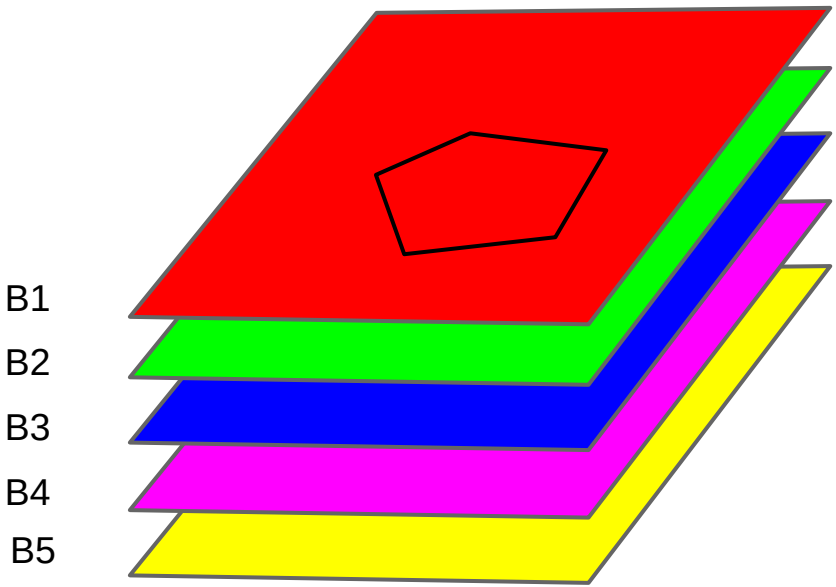
Reduce Neighborhood



Reduce Image Collection

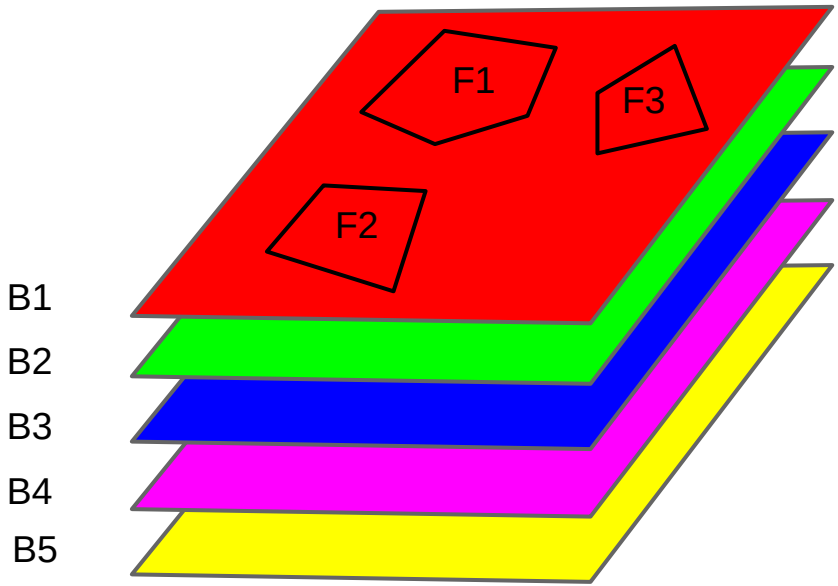


Reduce Region



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

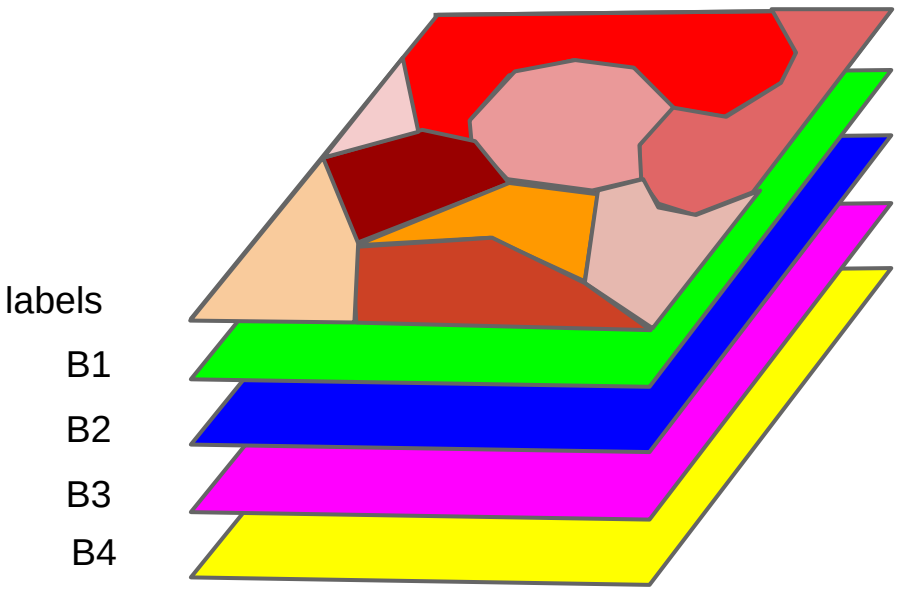
Reduce Regions



FeatureCollection

	B1	B2	B3	B4	B5
F1					
F2					
F3					

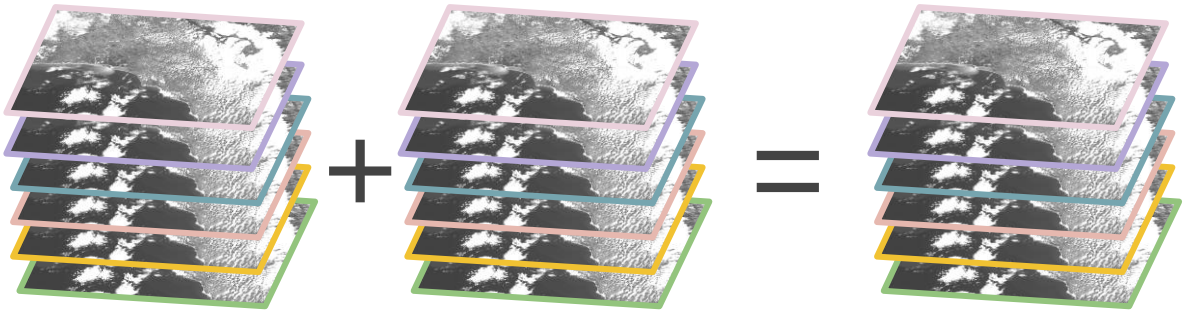
Reduce To Vectors



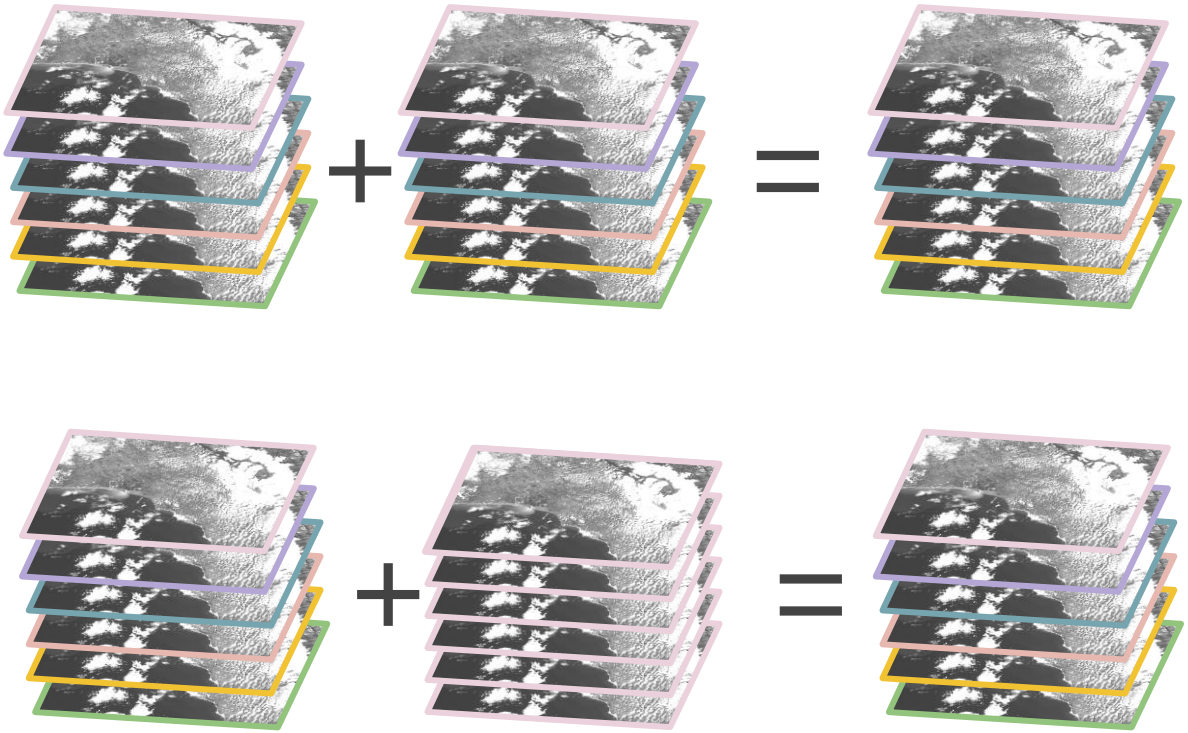
FeatureCollection

	B1	B2	B3	B4
F1				
F2				
F3				
F4				
F5				
...				

Band Math



Band Math

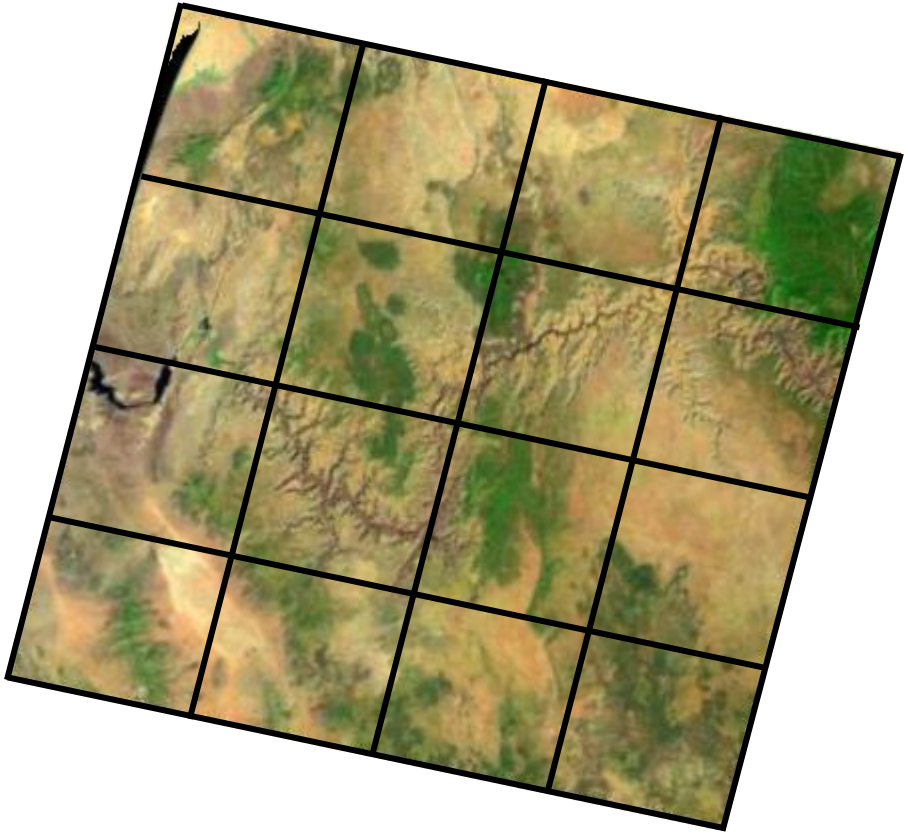


Tiling

Images are tiled during ingestion

Tiling

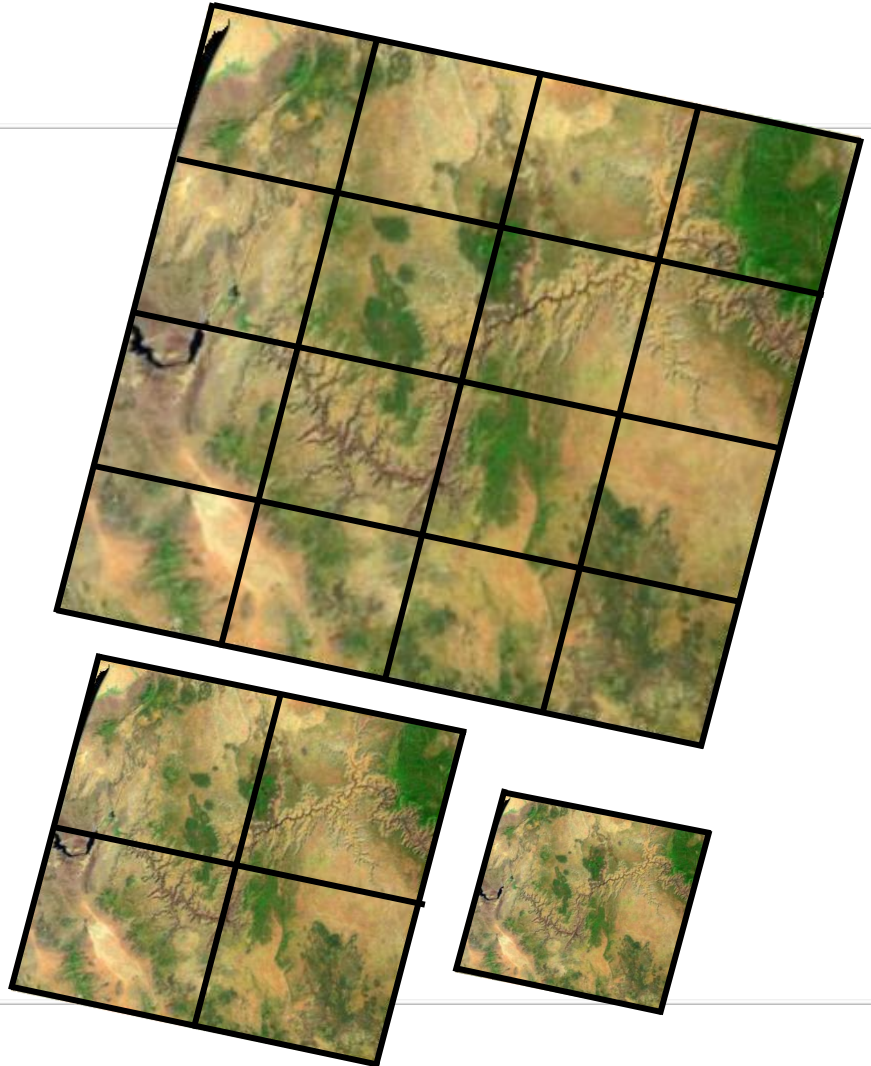
Images are tiled during ingestion



Tiling

Images are tiled during ingestion

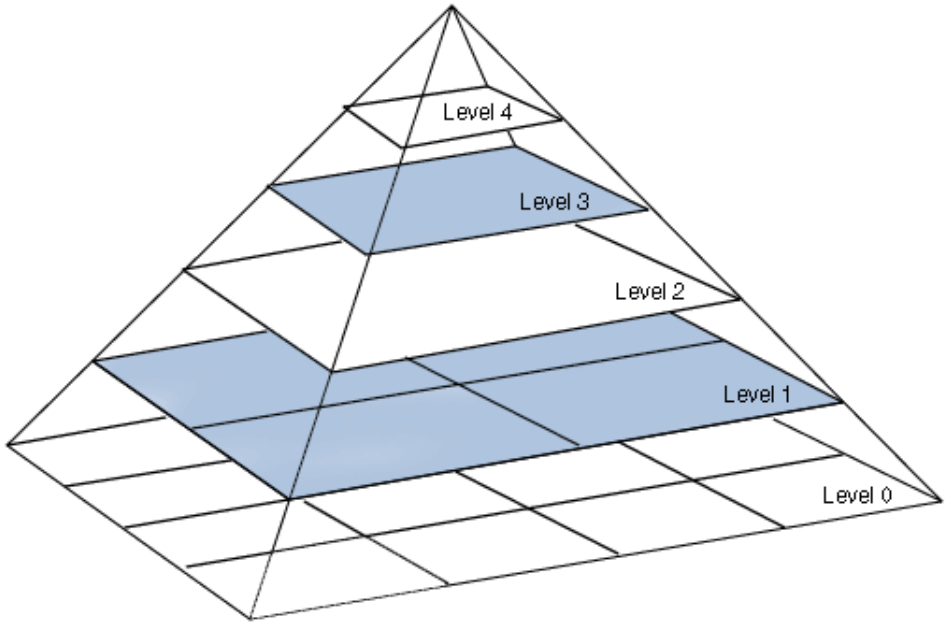
Downsampled by averaging



Tiling

Images are tiled during ingestion

Downsampled by averaging

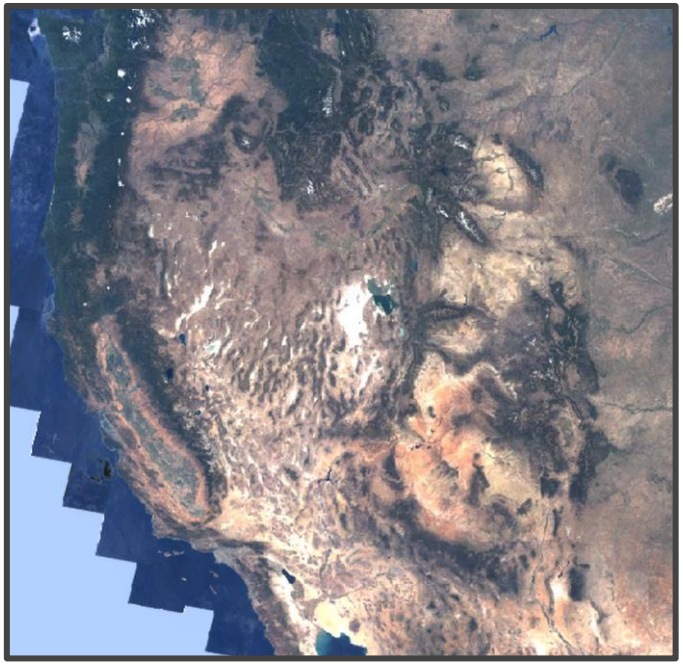


Tiling

Images are tiled during ingestion

Downsampled by averaging

During computation



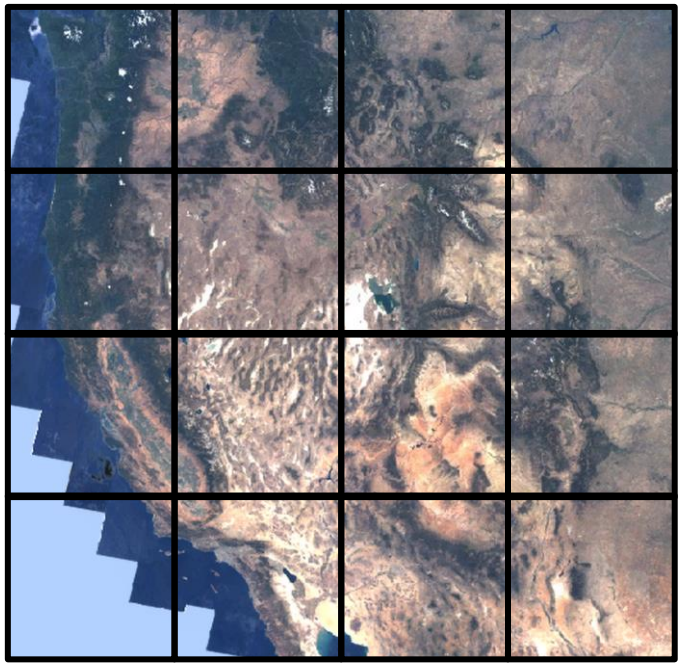
Tiling

Images are tiled during ingestion

Downsampled by averaging

During computation

Compute output tiles



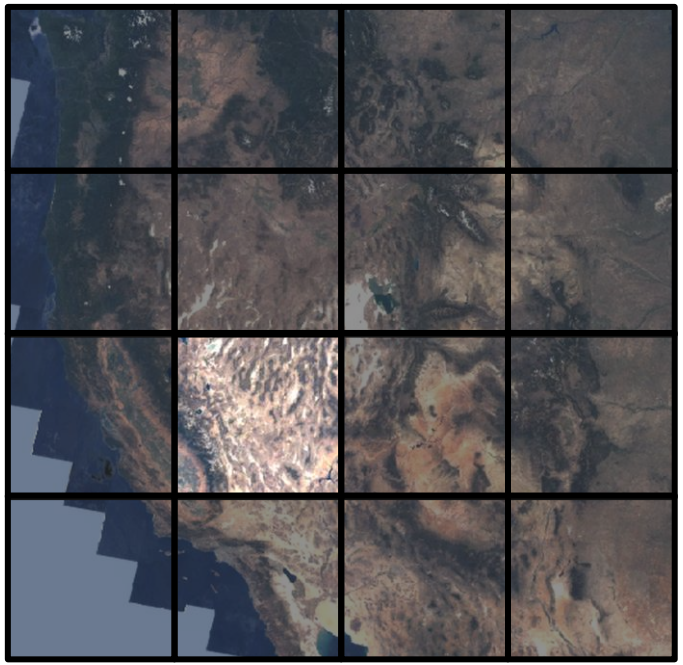
Tiling

Images are tiled during ingestion

Downsampled by averaging

During computation

Compute output tiles



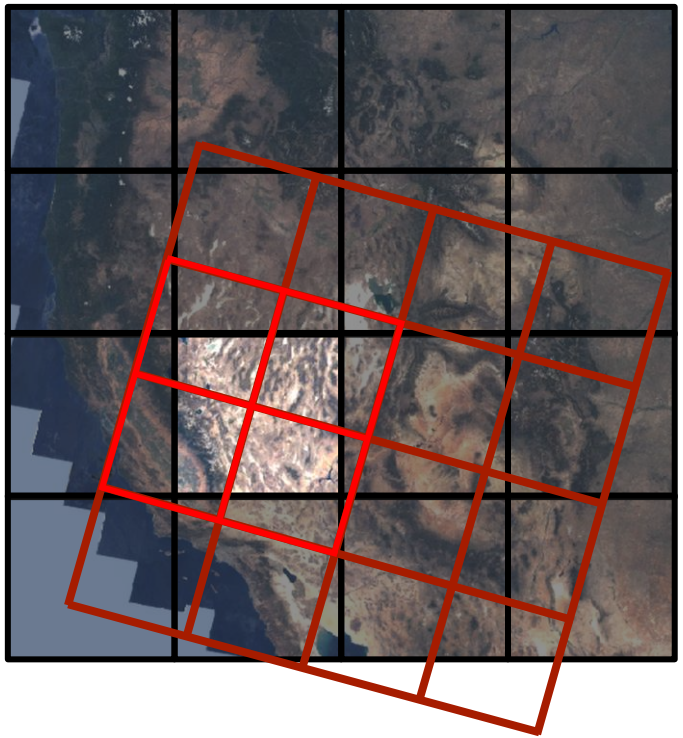
Tiling

Images are tiled during ingestion

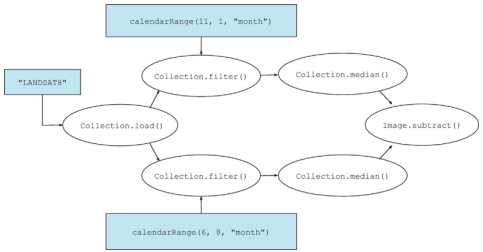
- Downsampled by averaging

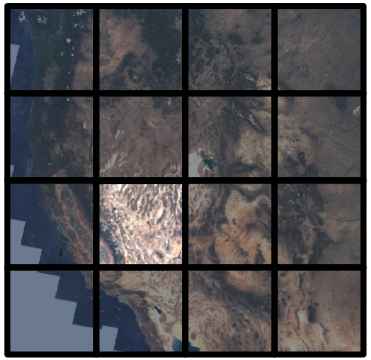
During computation

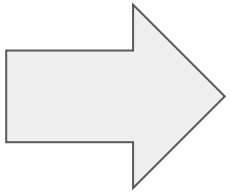
- Compute output tiles
- Find intersecting source tiles
- Reproject into the output projection

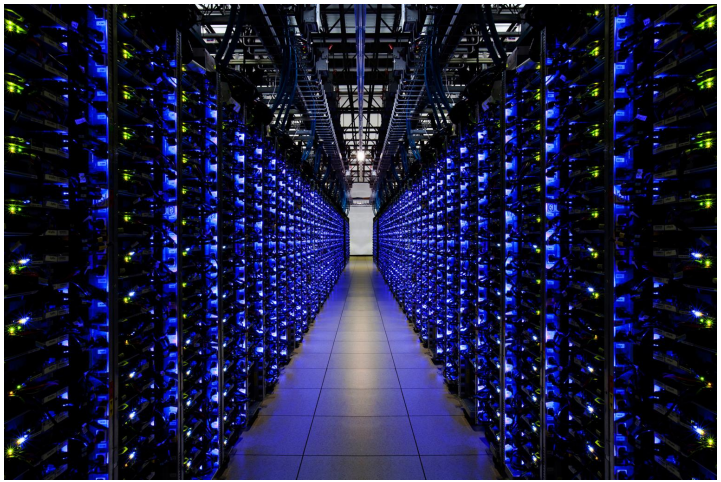


Running a Computation









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