



What is Google Earth Engine?

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

<https://goo.gl/n5Gh5Q>

Background

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. Lewisⁱ, Martino Pesaresi^j, Gábor Remetey-Fülöpp^k, Richard Simpson^k, Andrew Skidmore^f, Changlin Wang^b, and Peter Woodgate^l

^aDepartment of Geography, University of California, Santa Barbara, CA 93106; ^bCenter for Earth Observation and Digital Earth, Chinese Academy of Sciences, Beijing 100094, China; ^cJoint Research Centre of the European Commission, 21027 Ispra, Italy; ^dDepartment of Geography, University at Buffalo, State University of New York, Buffalo, NY 14261; ^eFaculty of Geo-Information Science and Earth Observation, University of Twente, 7500 AE, Enschede, The Netherlands; ^fFred Campbell Consulting, Ottawa, ON, Canada K2H 5G8;

^gInstitute for Geoinformatics and Remote Sensing, University of Osnabrück, 49076 Osnabrück, Germany; ^hD_City Network, Newtown 2042, Australia; ⁱDepartment of Geography and Anthropology, Louisiana State University, Baton Rouge, LA 70803; ^jHungarian Association for Geo-Information, H-1122, Budapest, Hungary; ^kNextspace, Auckland 1542, New Zealand; and ^lCooperative Research Center for Spatial Information, Carlton South 3053, Australia

Goodchild et al. (2012):

"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.**"



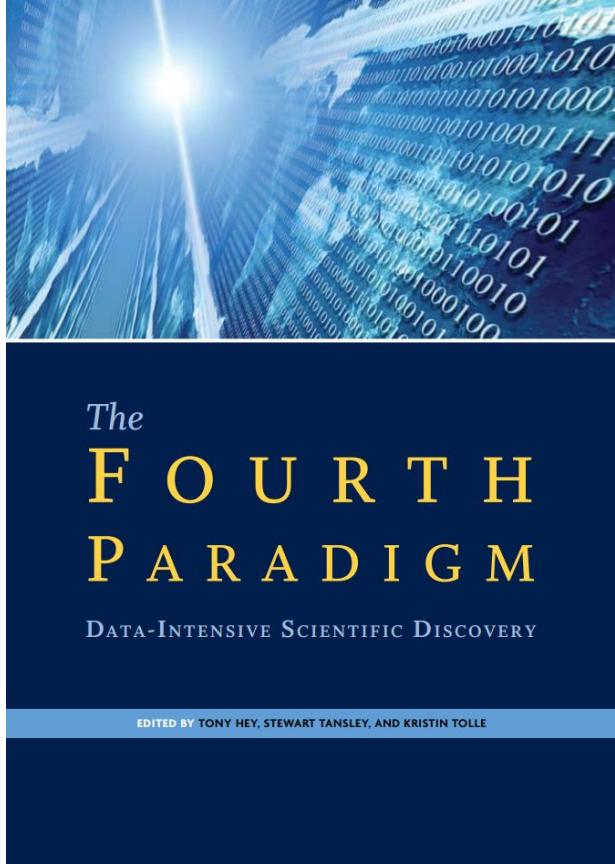
Source: NASA

Google Mission Statement

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

*“Often it turns out to be more efficient
to move the questions than to move
the data.”*

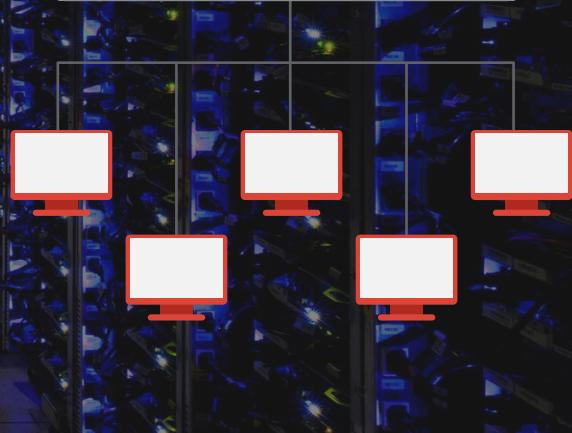
-Jim Gray (1944-2007)



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



Google computational infrastructure



Powerful JavaScript* API



* python too!

Layers

Map | Satellite

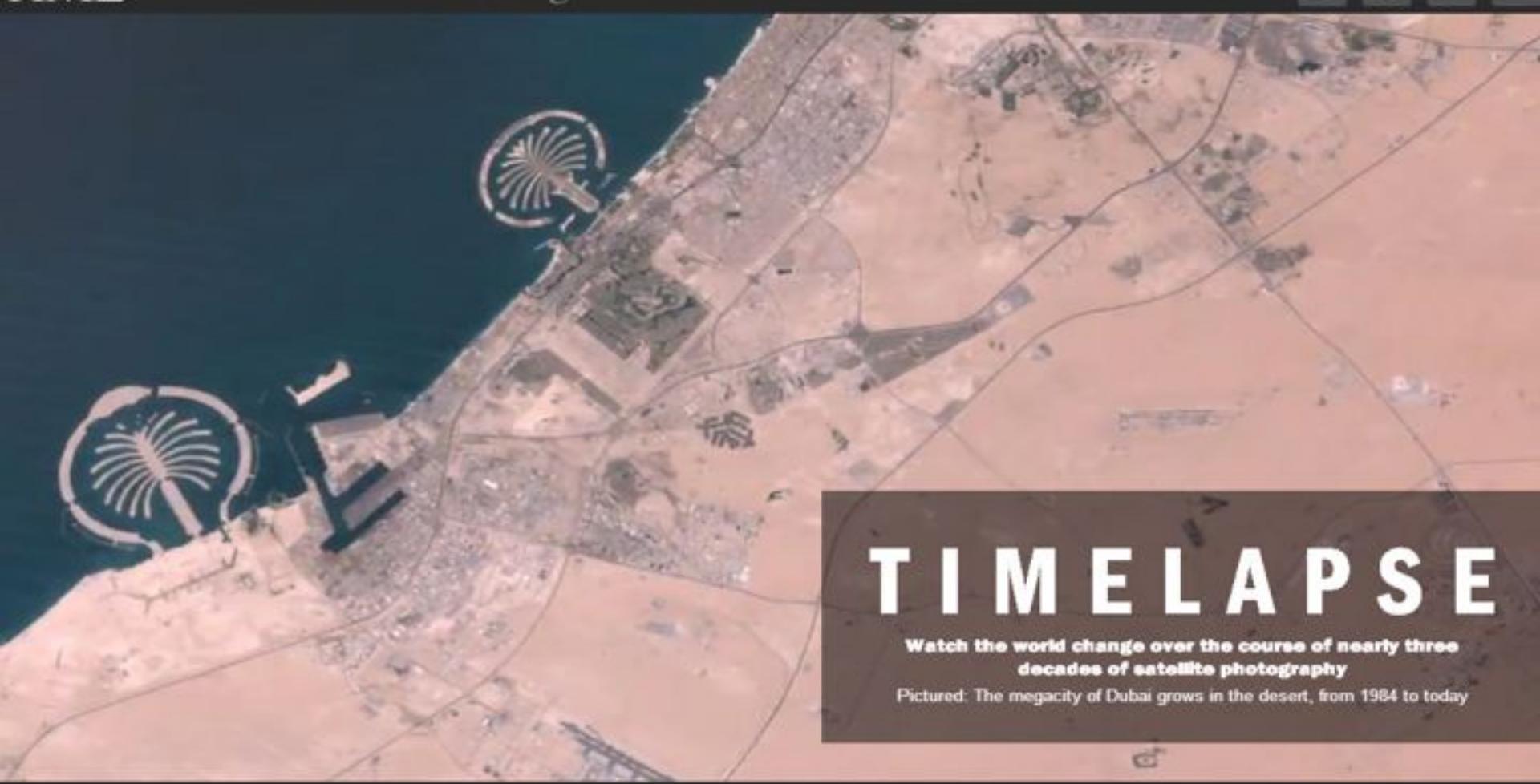


Google



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





TIMELAPSE

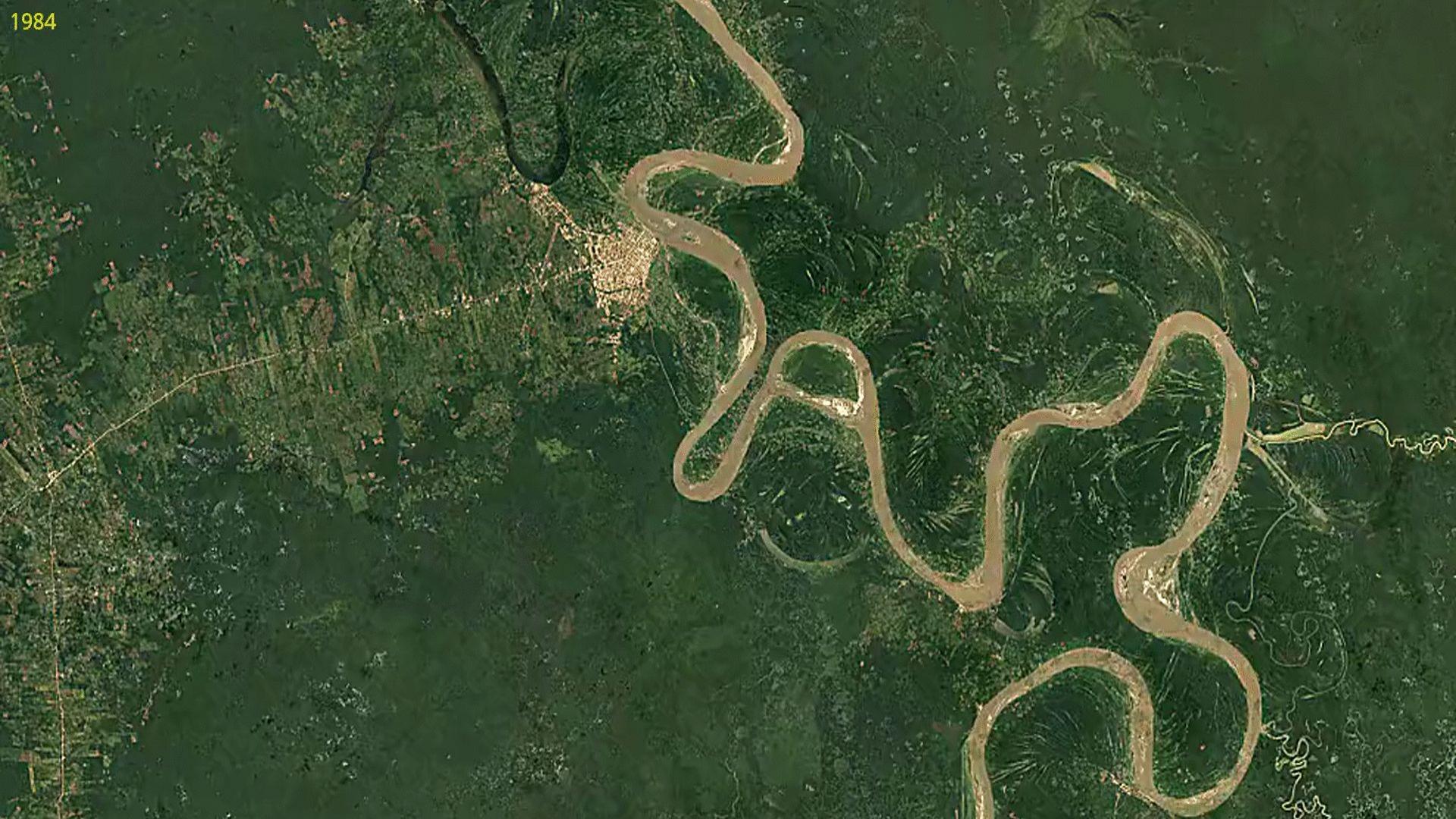
Watch the world change over the course of nearly three decades of satellite photography

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

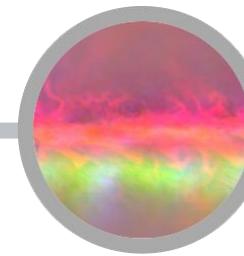
Over 5,000,000
Landsat and Sentinel scenes analyzed

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

> 4000 new images every day

> 5 million images

> 7 petabytes of data

reflectance



Prod

Help

nclinton@google.com

Search!



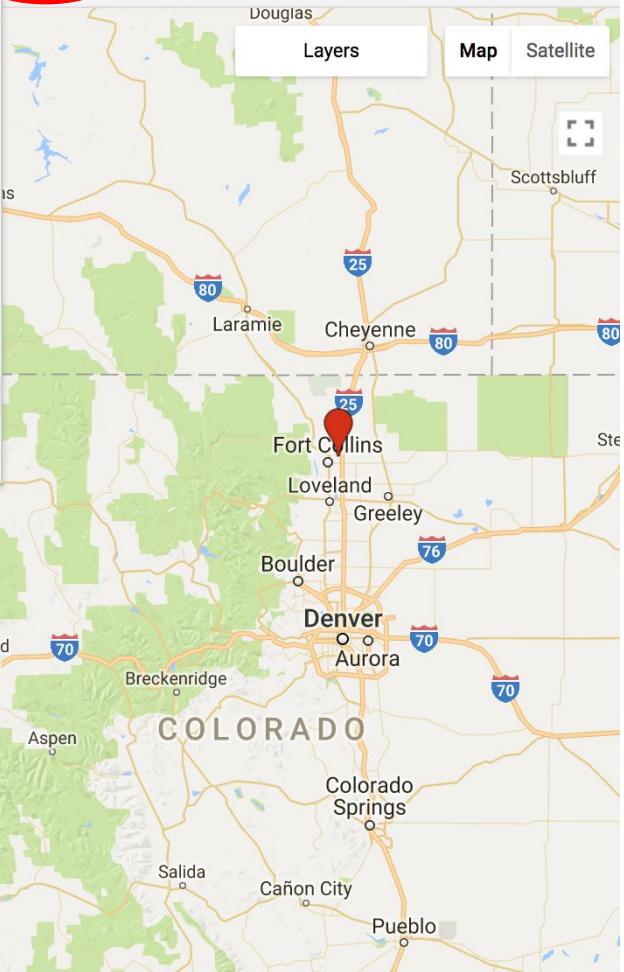
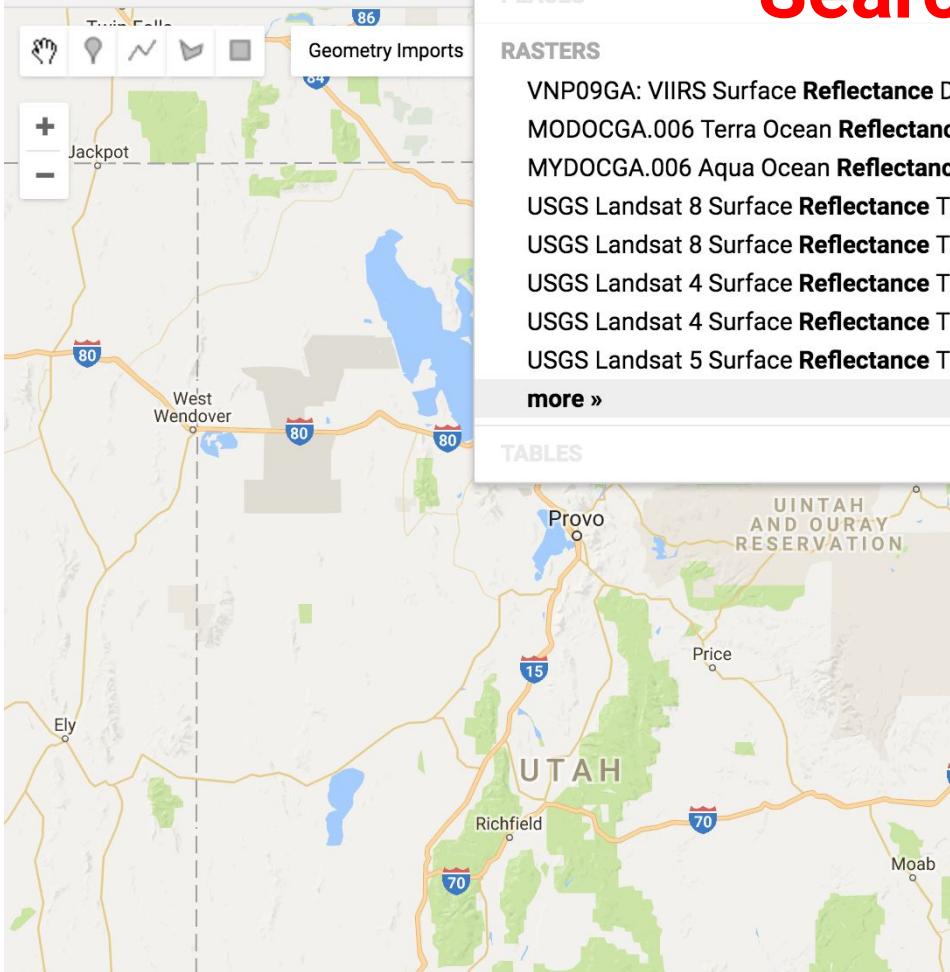
PLACES

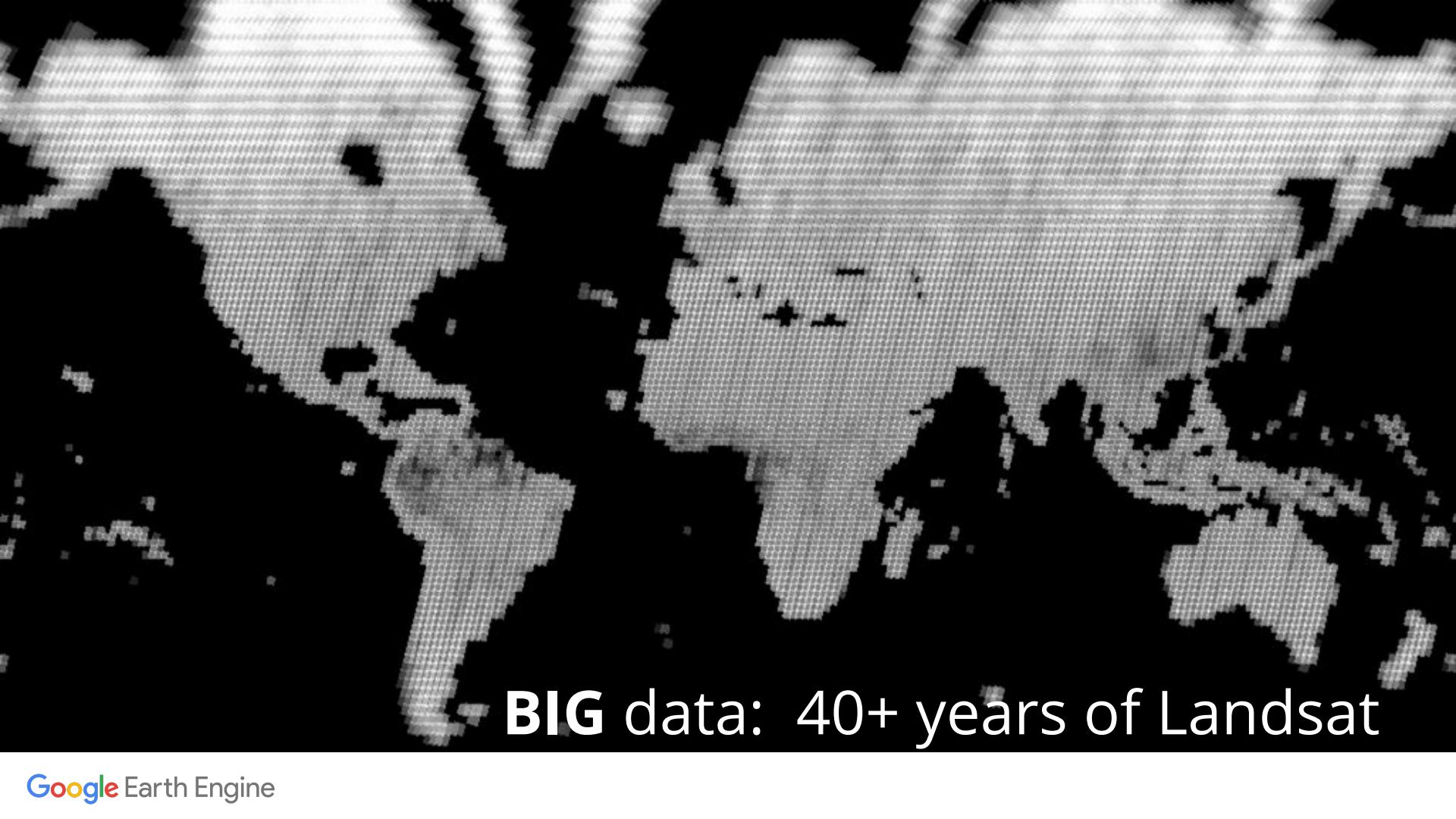
RASTERS

- VNP09GA: VIIRS Surface **Reflectance** Daily 500m and 1km
- MODOCGA.006 Terra Ocean **Reflectance** Daily Global 1km
- MYDOCAGA.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

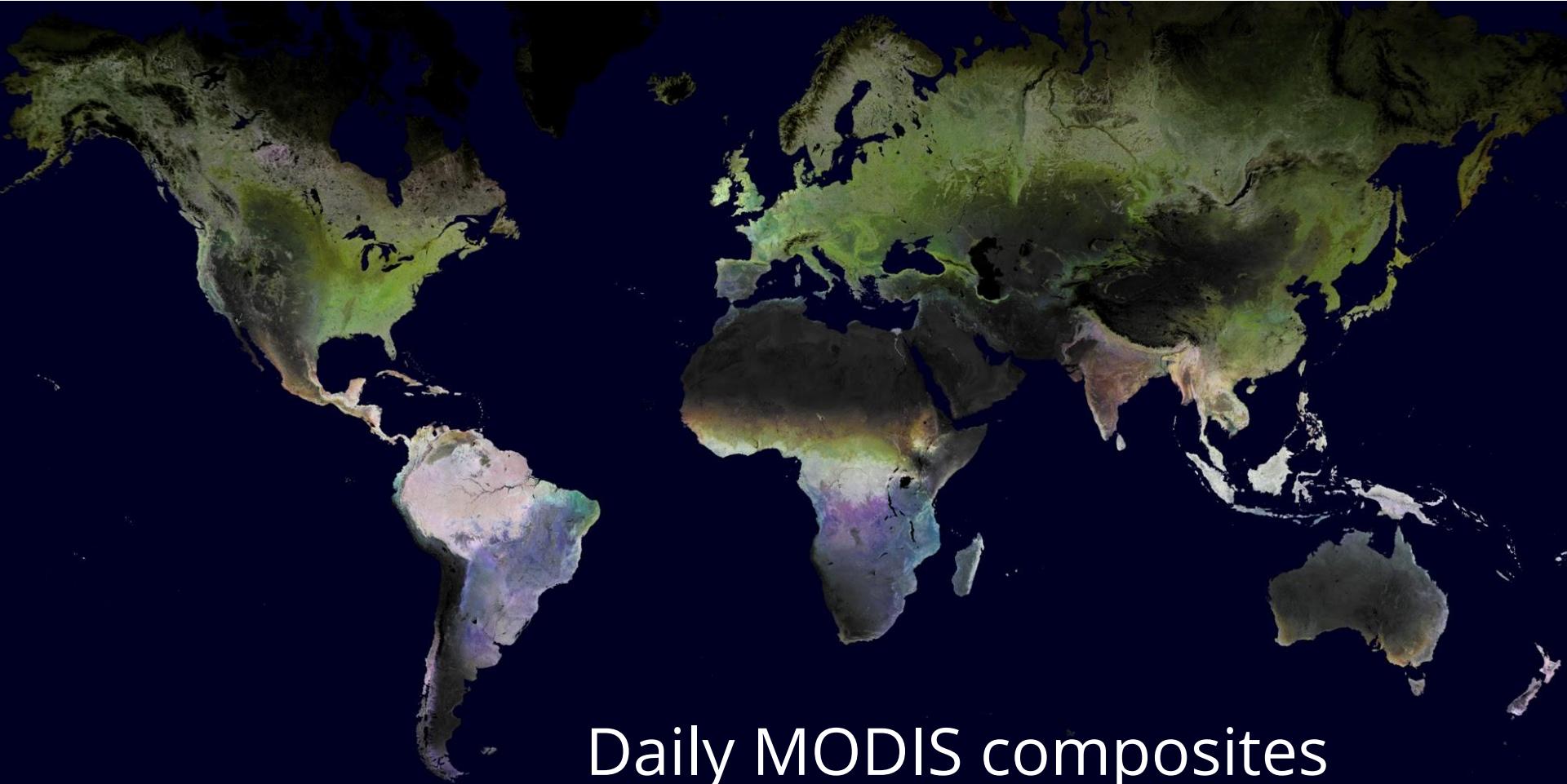
[more »](#)

TABLES



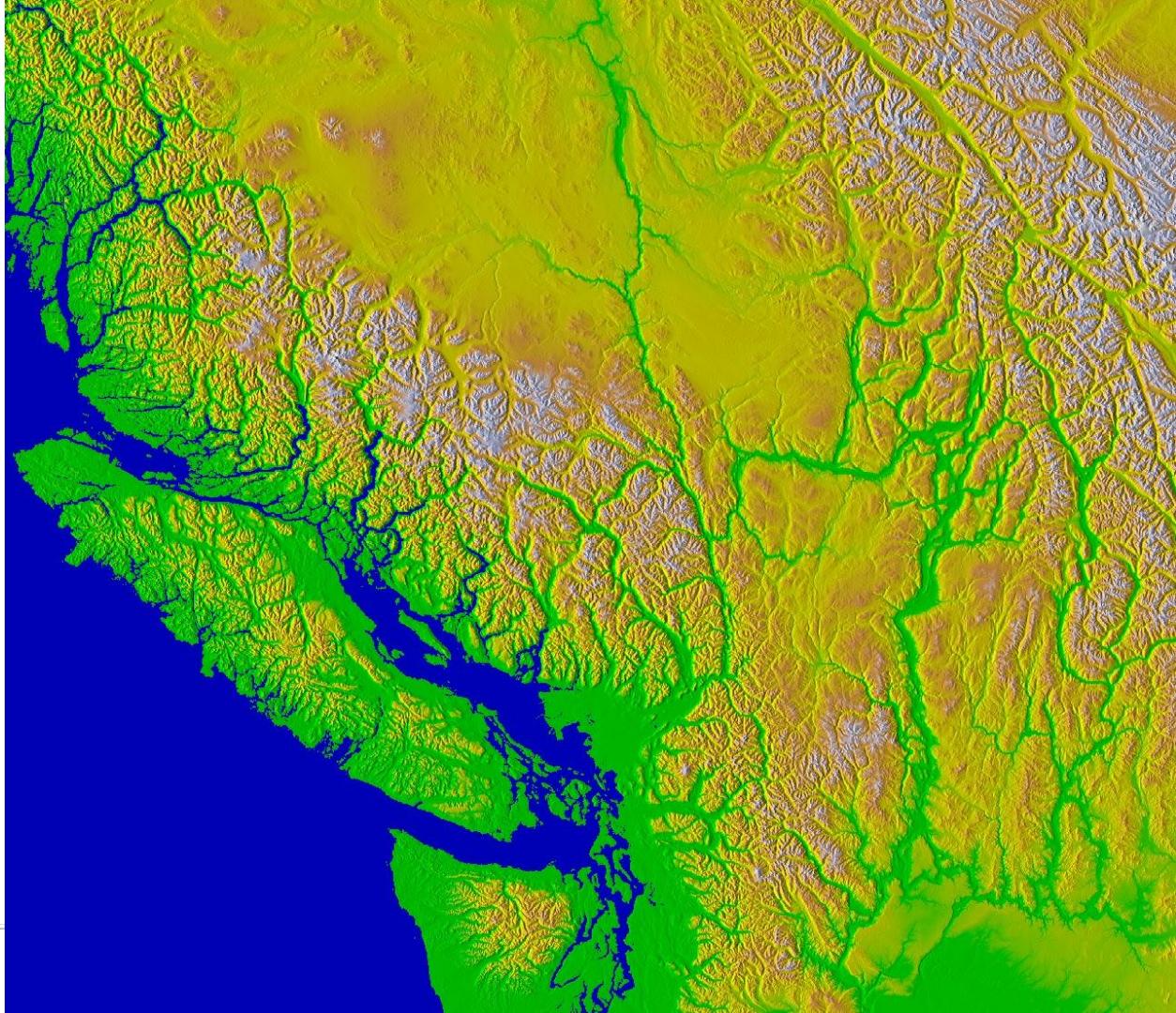


BIG data: 40+ years of Landsat

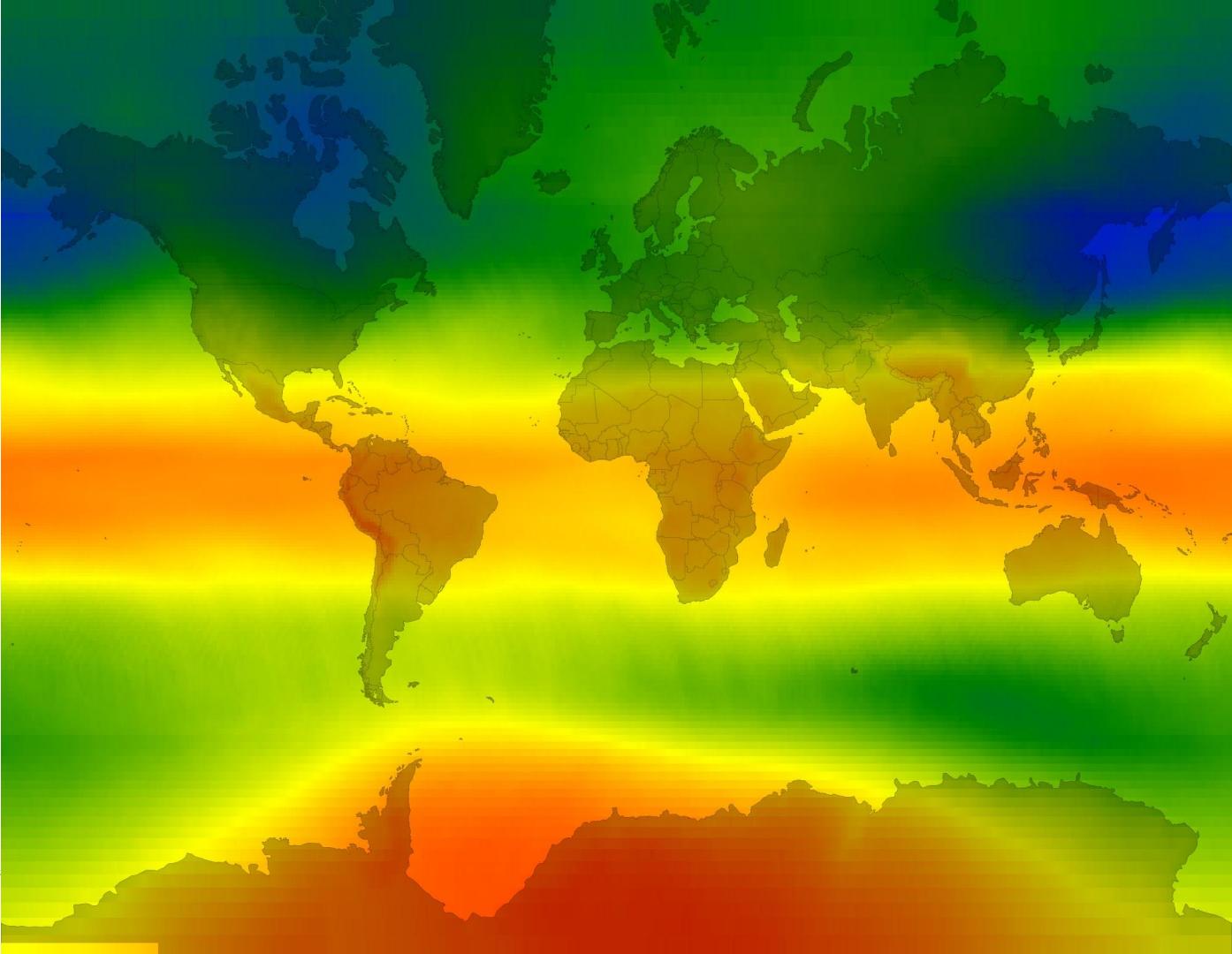


Daily MODIS composites

Terrain



Atmosphere



Sentinel-1



API

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');
```

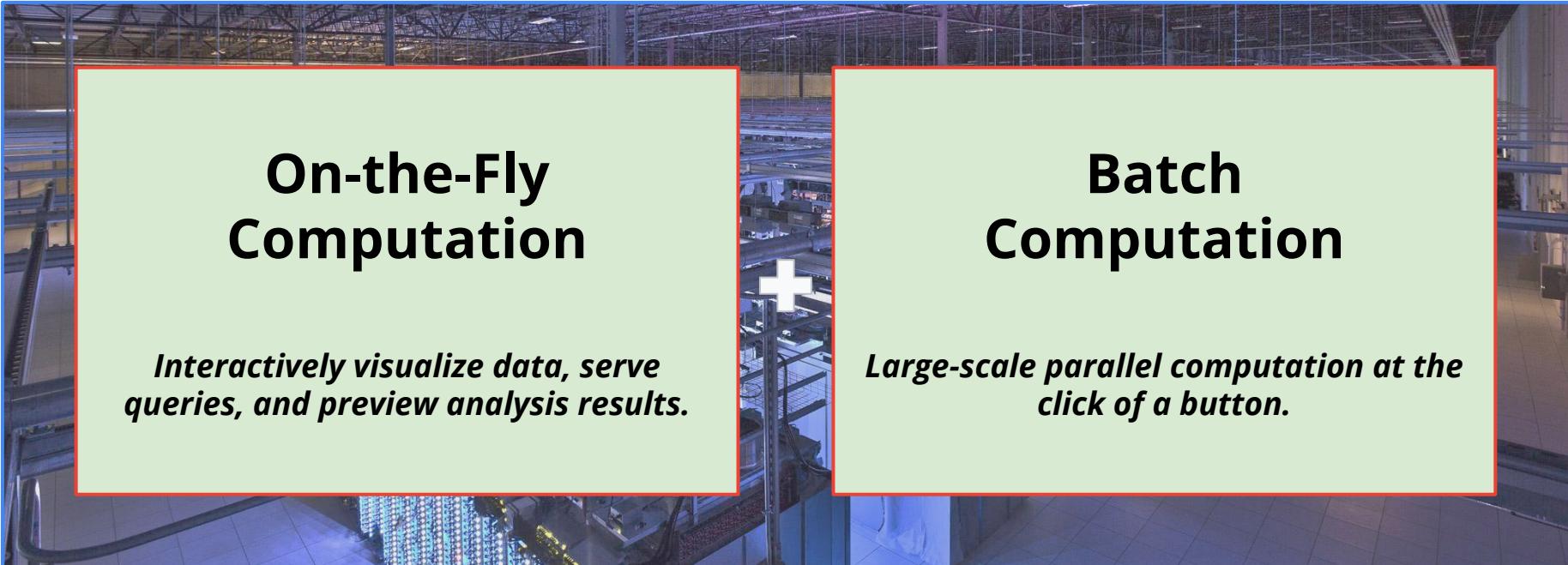
Computation Platform

On-the-Fly Computation

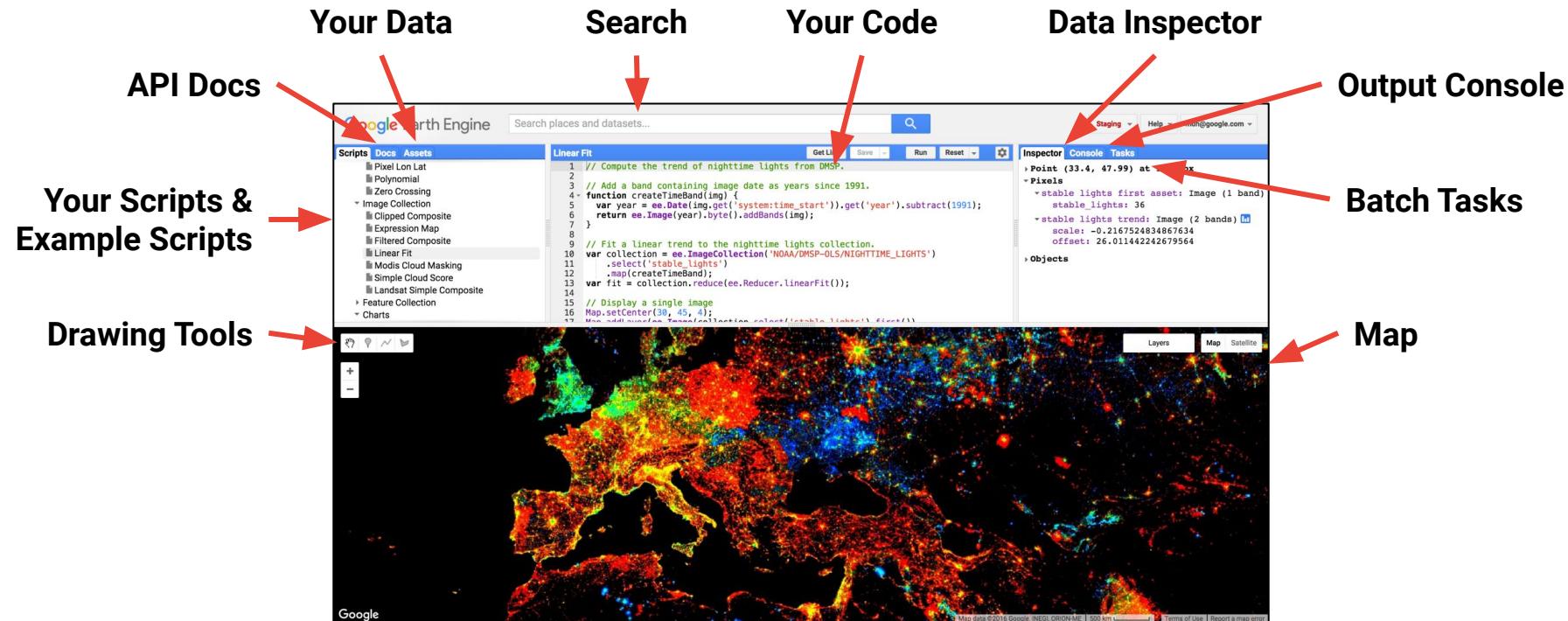
Interactively visualize data, serve queries, and preview analysis results.

Batch Computation

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



The Earth Engine Code Editor



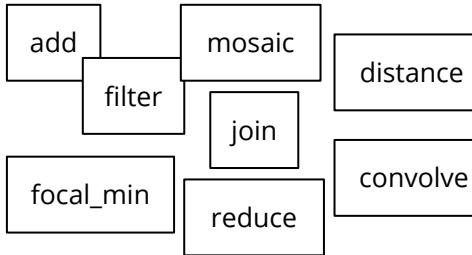
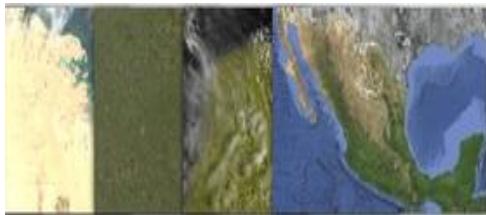
code.earthengine.google.com

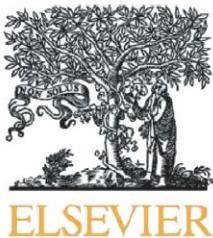
Geospatial
Datasets

Requests Results

Algorithmic
Primitives

Storage and Compute





Contents lists available at ScienceDirect

Remote Sensing of Environment

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

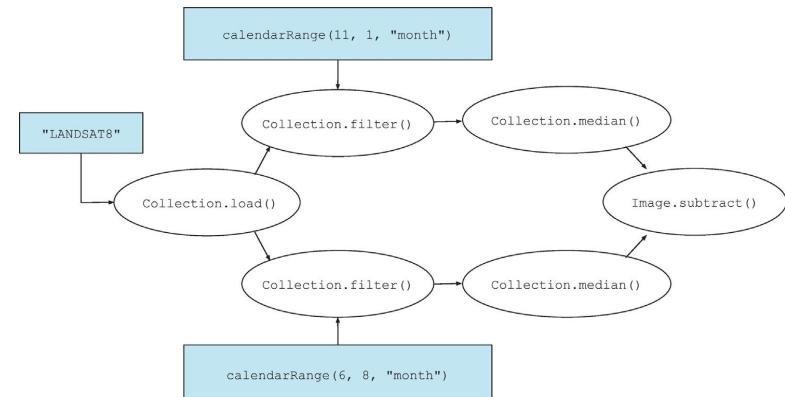


Google Earth Engine: Planetary-scale geospatial analysis for everyone

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 Pekel¹, Andrew Cottam¹, Noel Gorelick² & Alan S. Belward¹

doi:10.1038/nature20584

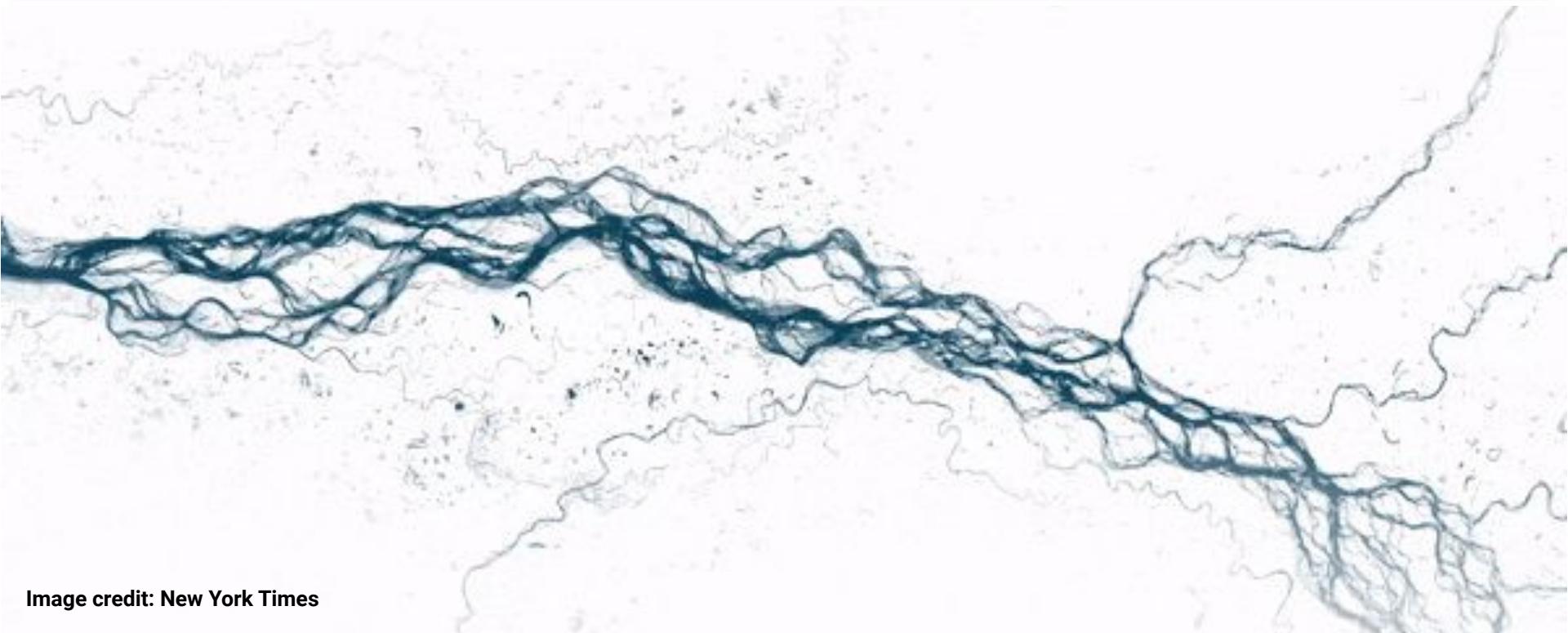
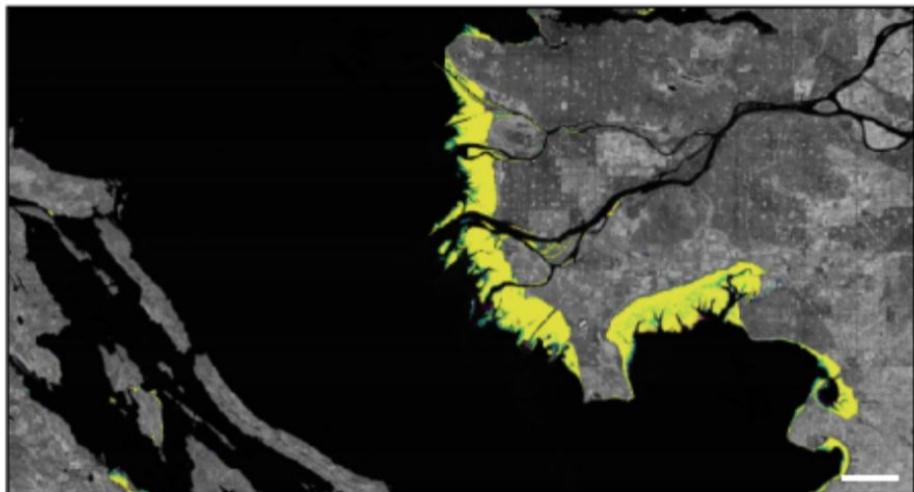


Image credit: New York Times

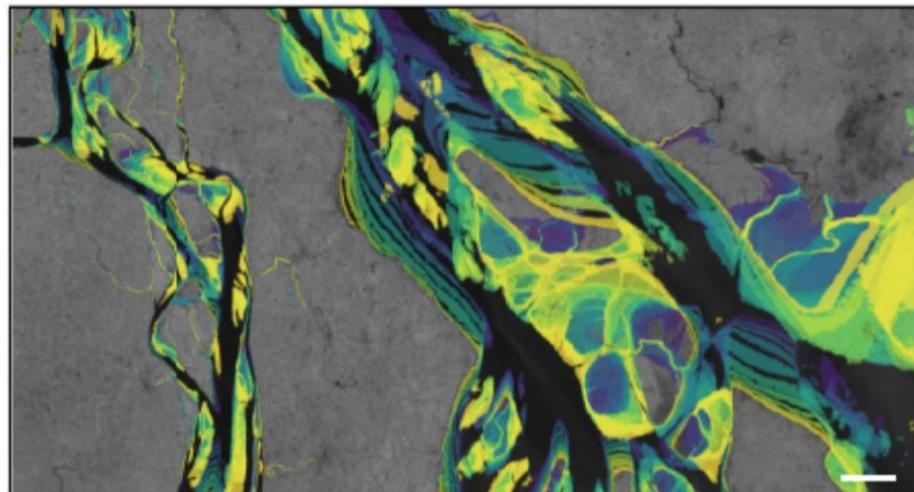
The global distribution and trajectory of tidal flats

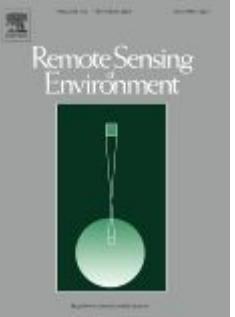
Nicholas J. Murray^{1,2*}, Stuart R. Phinn³, Michael DeWitt⁴, Renata Ferrari⁵, Renee Johnston⁴, Mitchell B. Lyons², Nicholas Clinton⁴, David Thau⁴ & Richard A. Fuller¹

a



b

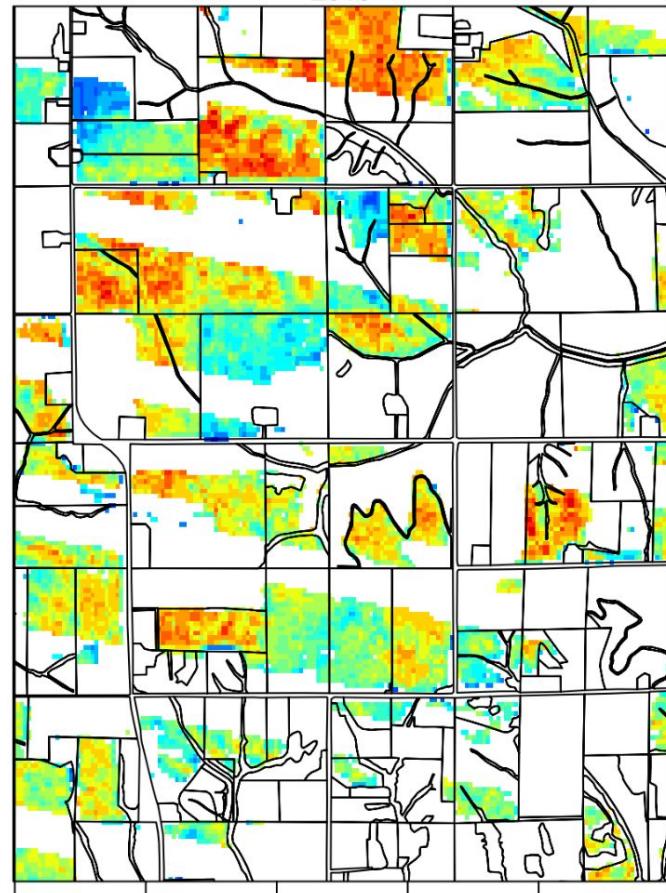
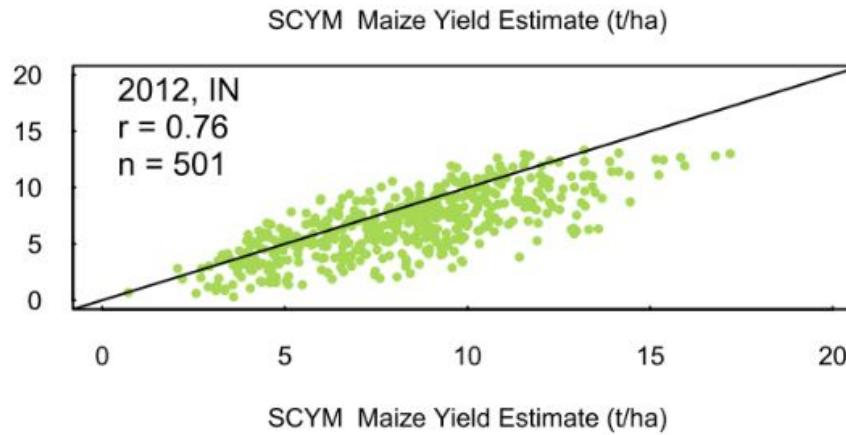


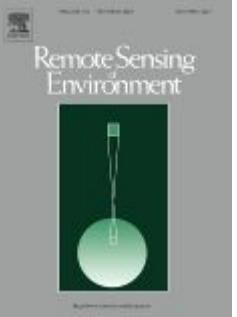


A scalable satellite-based crop yield mapper

David B. Lobell ^{a,*}, David Thau ^b, Christopher Seifert ^a, Eric Engle ^b, Bertis Little ^c

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

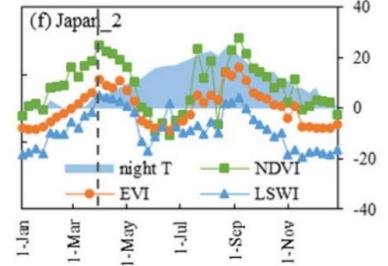
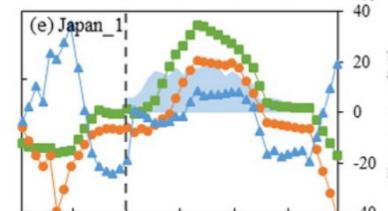
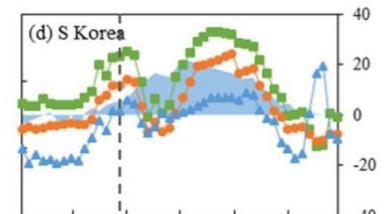
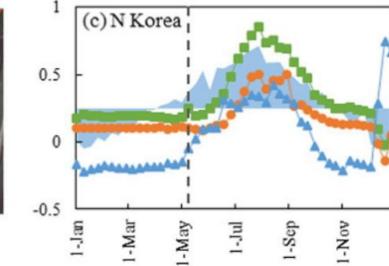
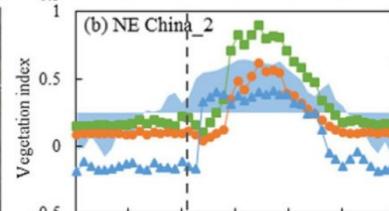
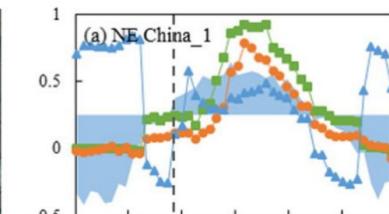




Mapping paddy rice planting area in northeastern Asia with Landsat 8 images, phenology-based algorithm and Google Earth Engine

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>



Ecosystem services lost to oil and gas in North America

Net primary production reduced in crop and rangelands

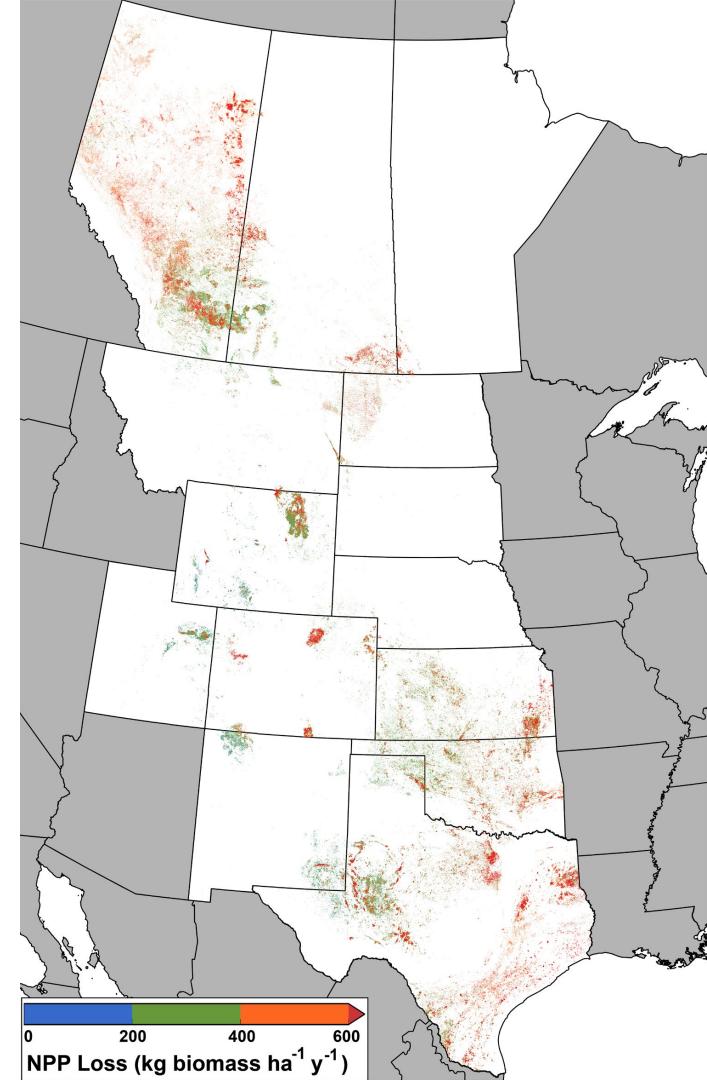
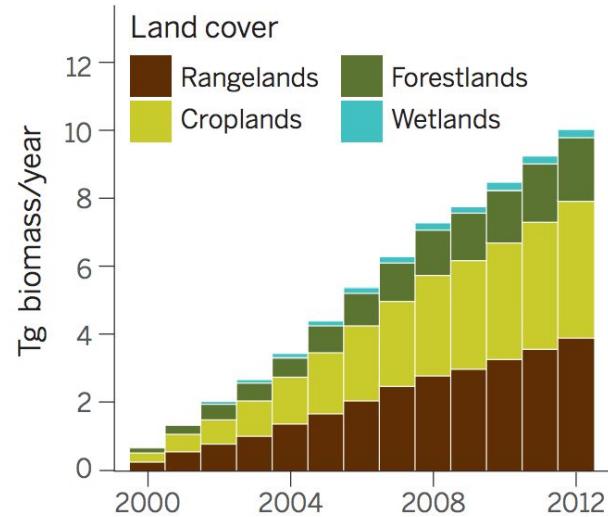
By Brady W. Allred,^{1*} W. Kolby Smith,^{1,2}

Dirac Twidwell,³ Julia H. Haggerty,⁴

Steven W. Running,¹ David E. Naugle,¹

Samuel D. Fuhlendorf⁵

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



Applications



Map Layer Options

Time Series Options



GET MAP LAYER

Product ?

Type:

Climate

Dataset:

UI METDATA/gridMET

Variable:

ET₀ (ASCE Grass Reference Evapotranspiration)

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

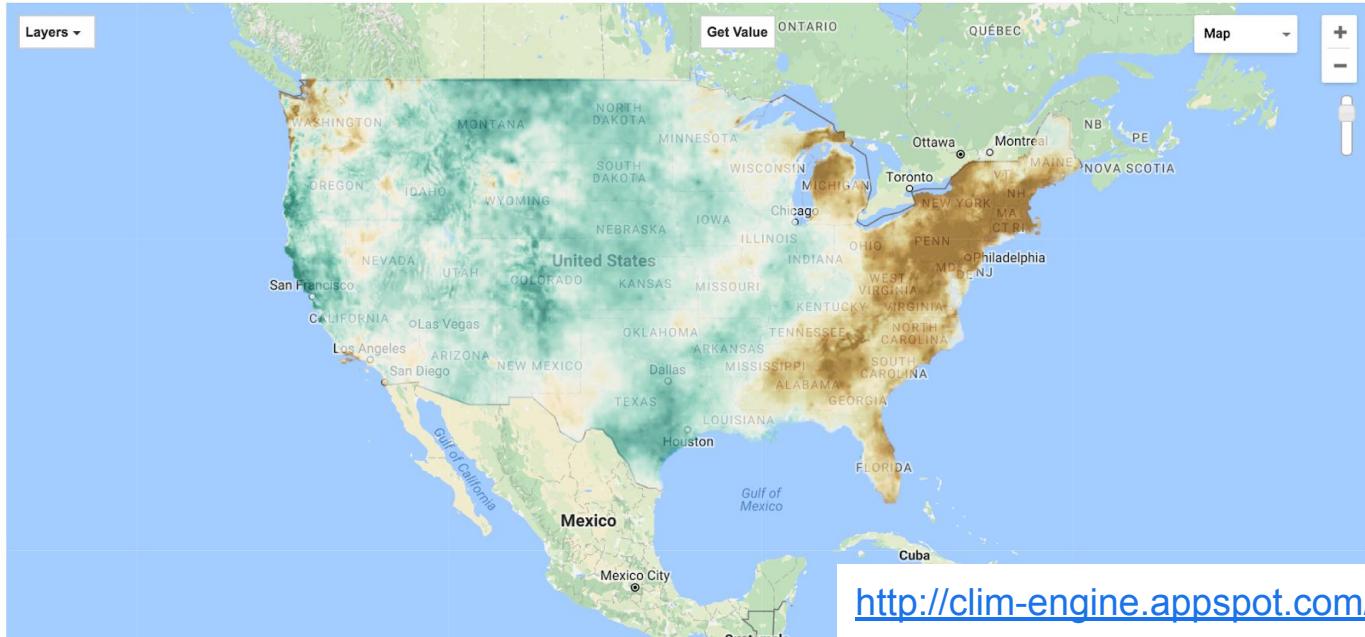
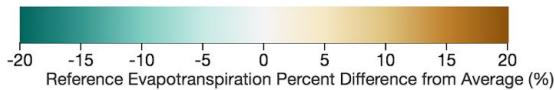
Get Link Reset Forms

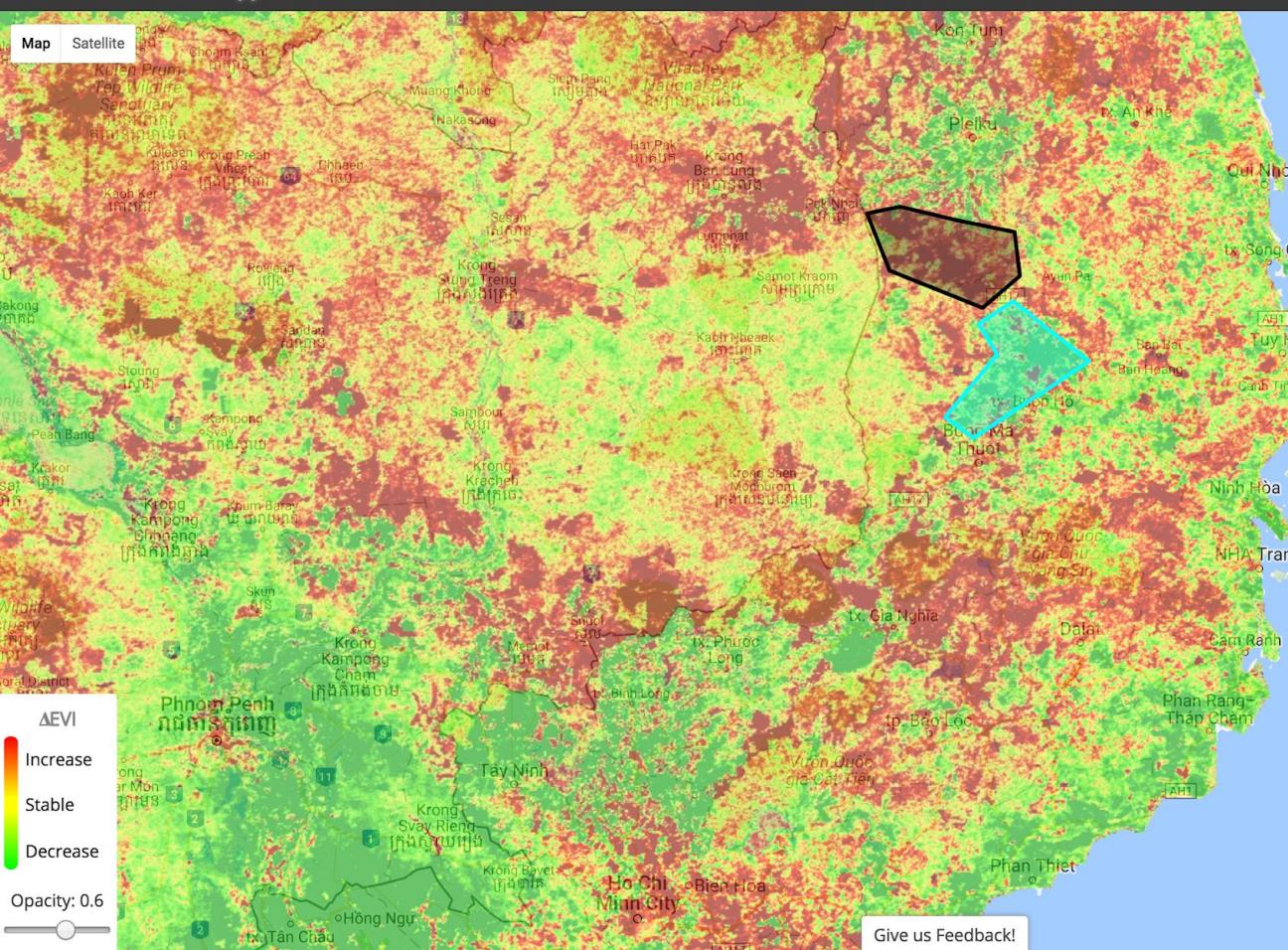
Mean Reference Evapotranspiration Percent
Difference from Average

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

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

Historical Period: 1981 - 2010





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

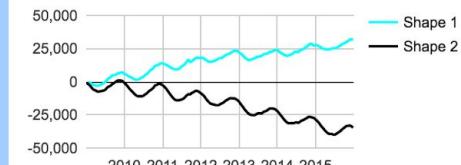
Draw Polygon

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

Biophysical Health

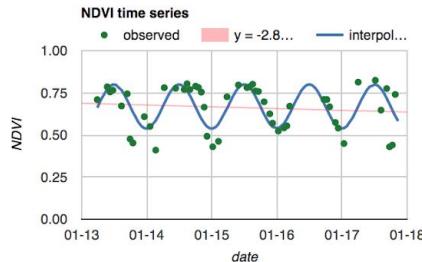
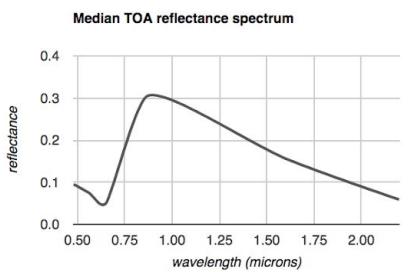




Pixel Dashboard

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

lon: -90.18 lat: 29.88



Training Concepts

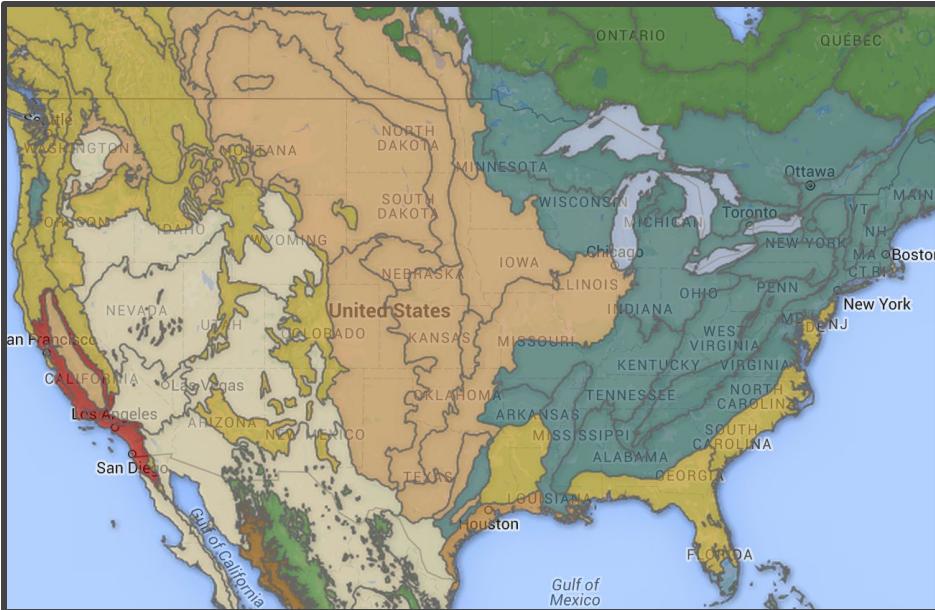


Data Models

Feature

Line / Point / Polygon

List of Properties



TNC Ecoregions

Data Models

Feature

Image

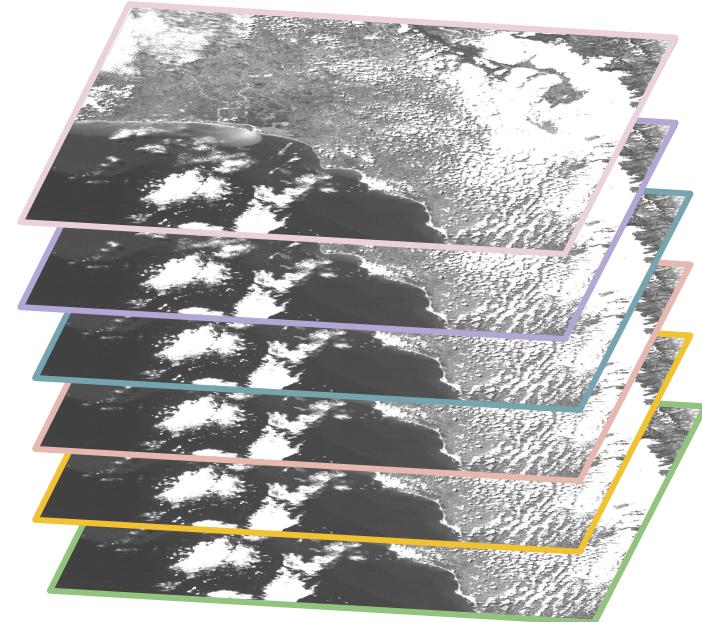
Stack of Georeferenced bands

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

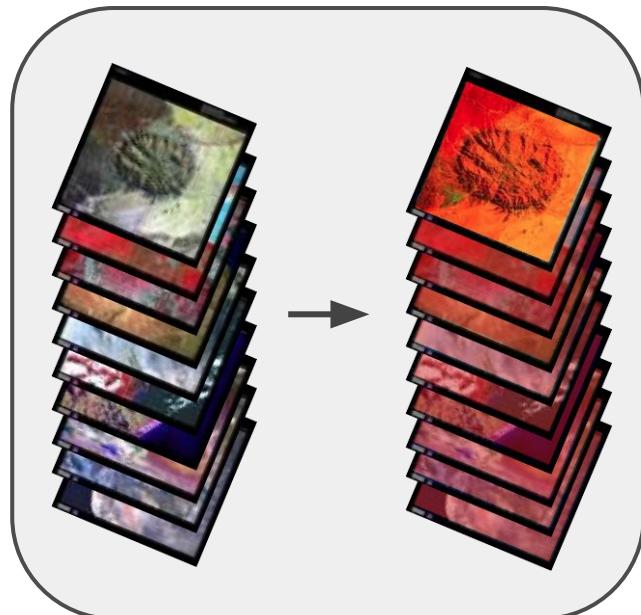
A "map" (for-each) operation

Examples

Compute area of each feature

Cloud cover of each image

Mosaic for each month



Reduce

Aggregate everything in a collection

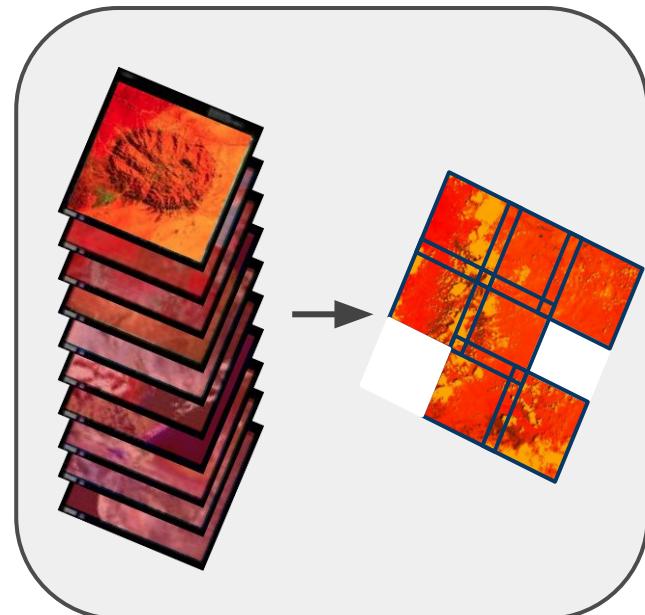
"Reduction"

Examples

Summed area over all features

Median-pixel composite

Train a classifier



Reducers in Earth Engine

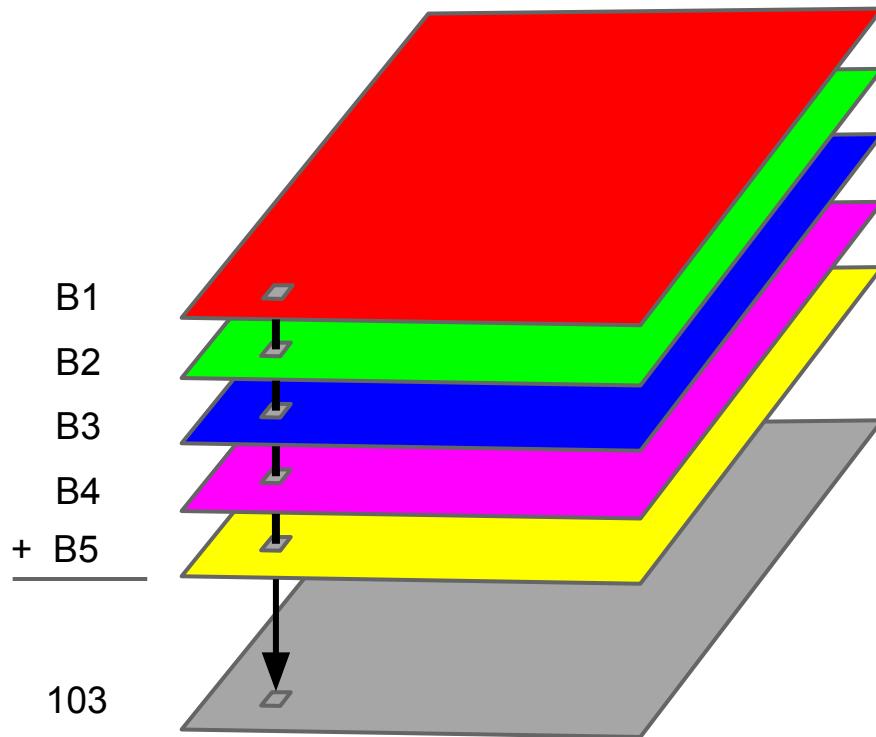
8 ways to reduce

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

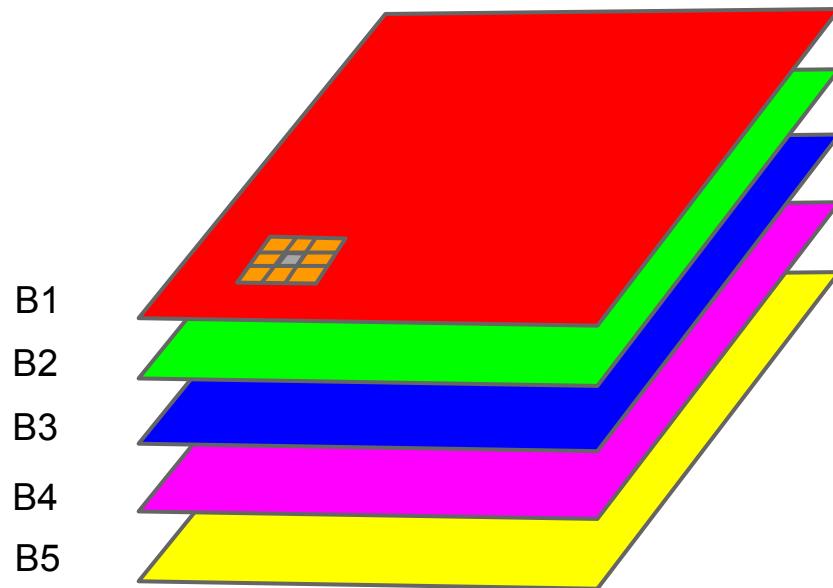
40+ reducers

- 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

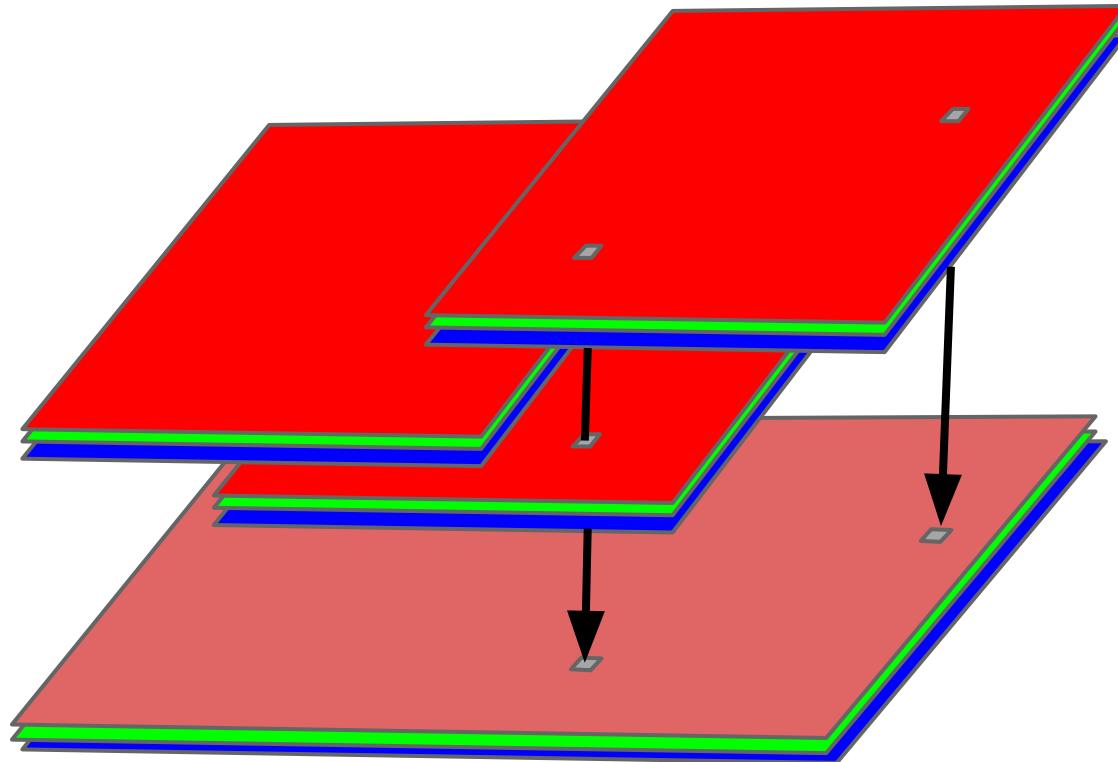
Reduce Bands



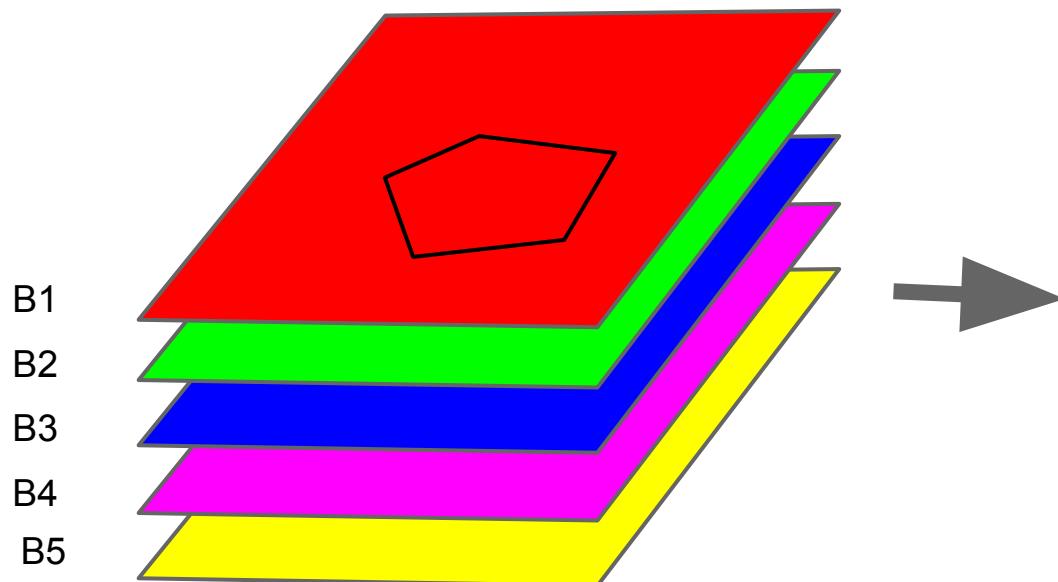
Reduce Neighborhood



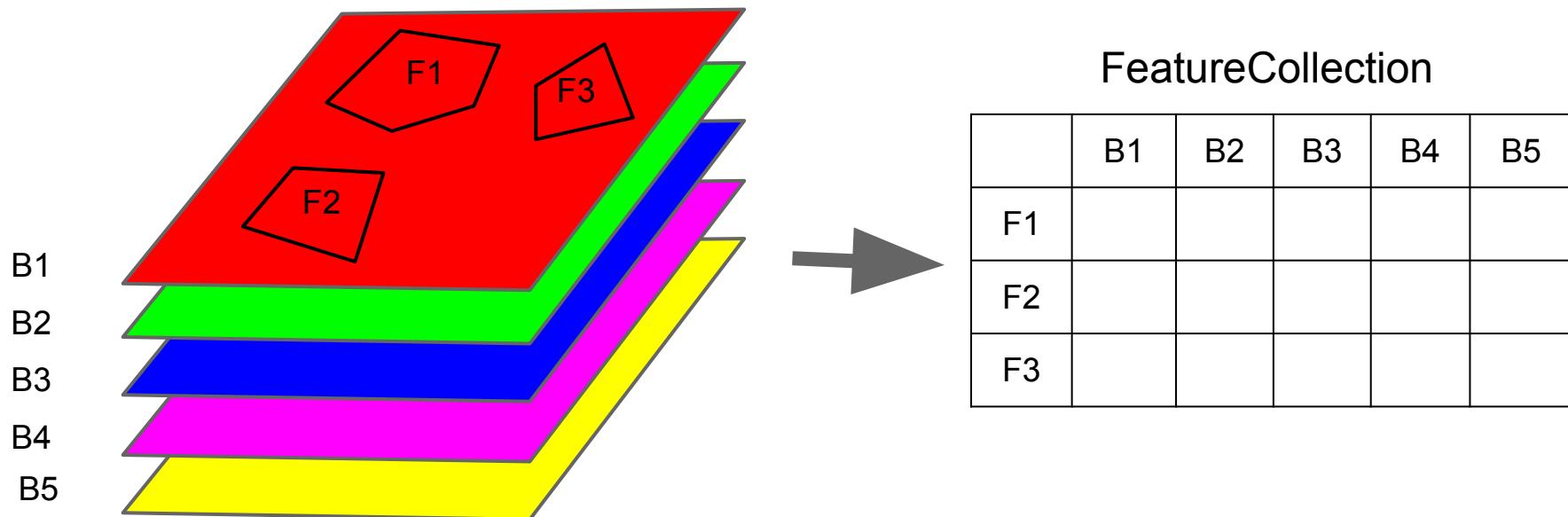
Reduce Image Collection



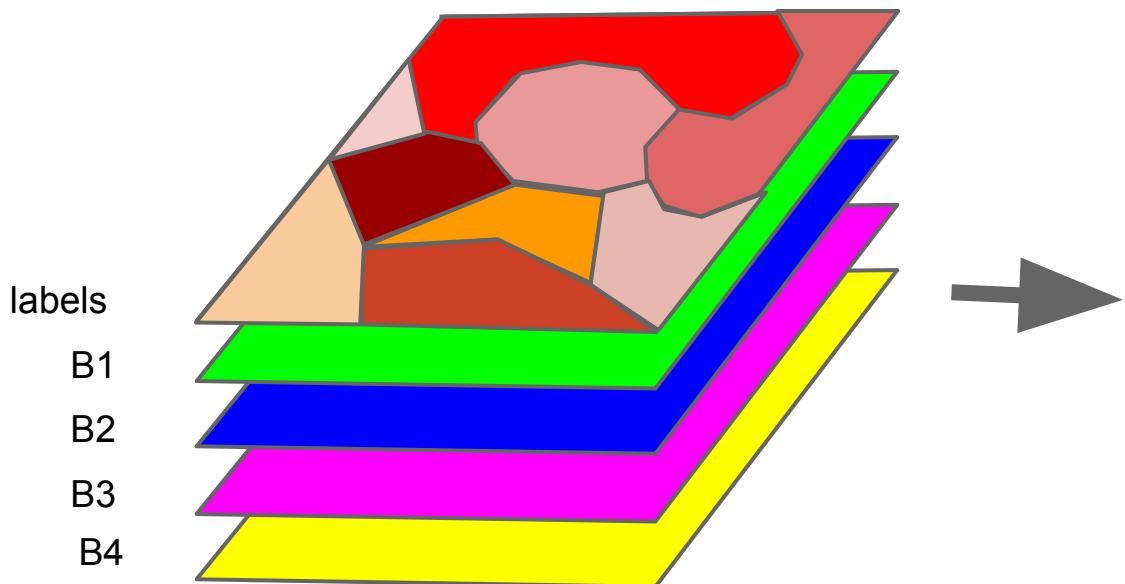
Reduce Region



Reduce Regions



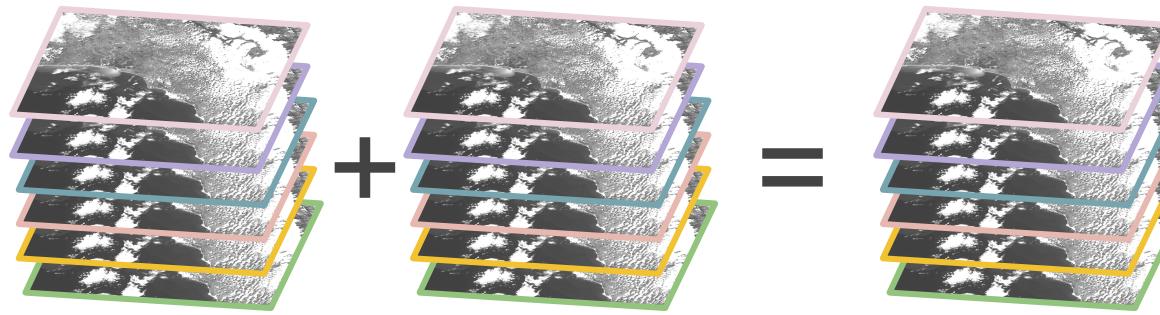
Reduce To Vectors



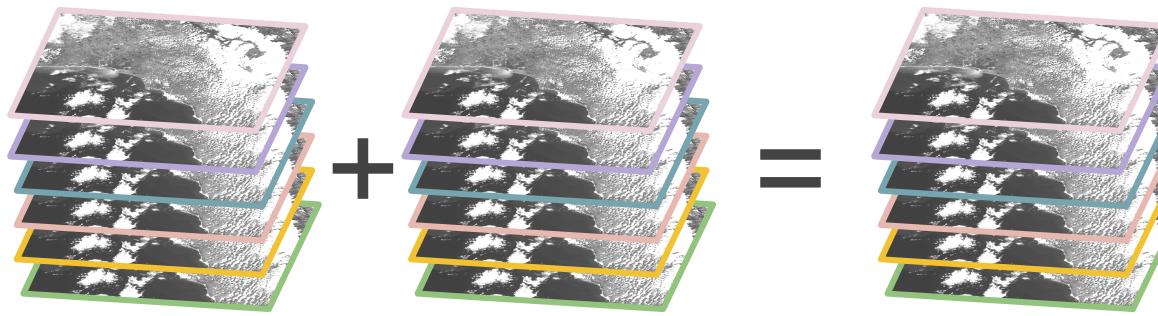
FeatureCollection

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

Band Math



Band Math



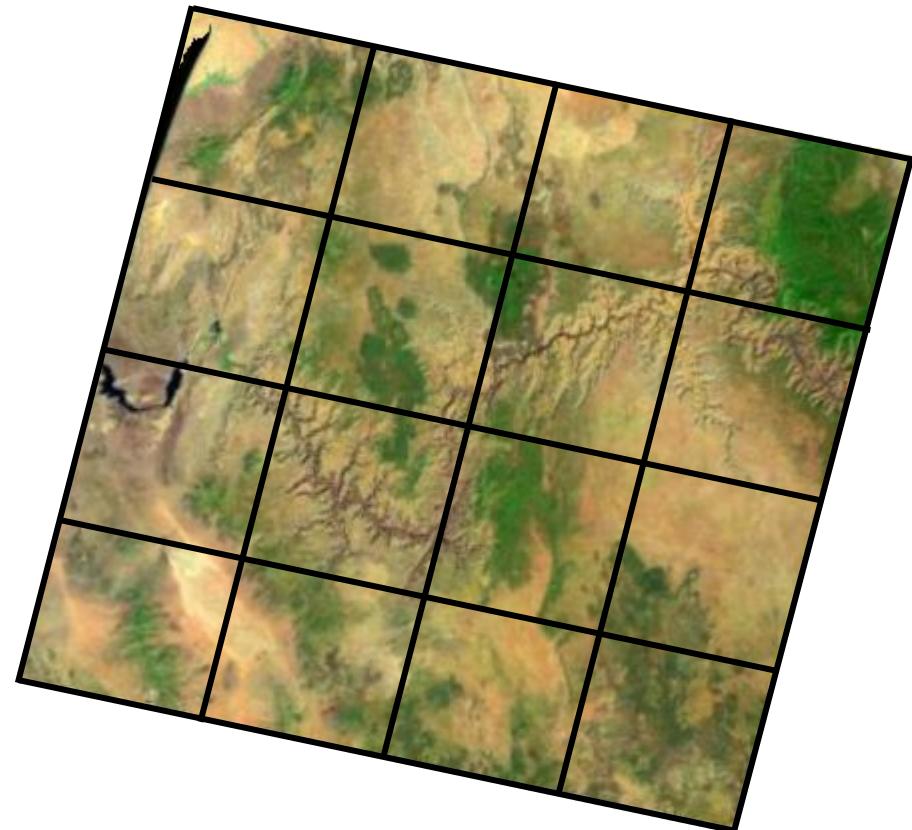
Tiling

Images are tiled during ingestion



Tiling

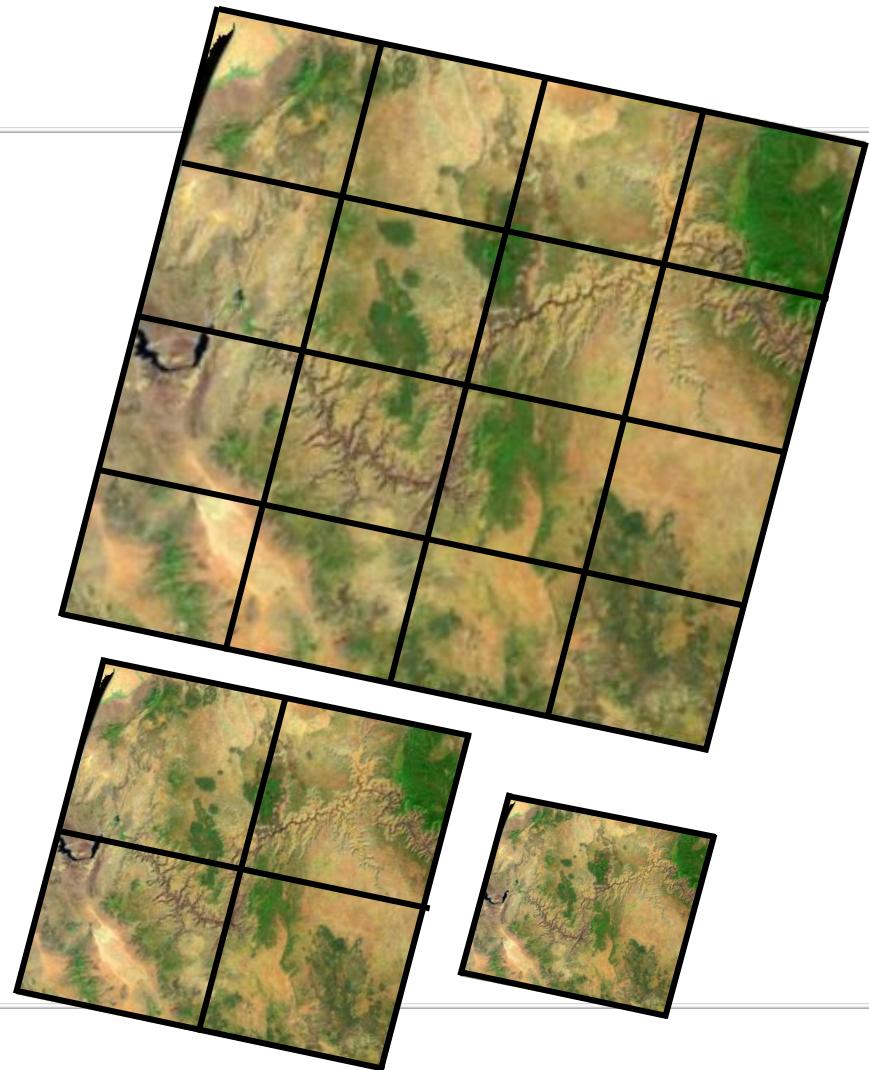
Images are tiled during ingestion



Tiling

Images are tiled during ingestion

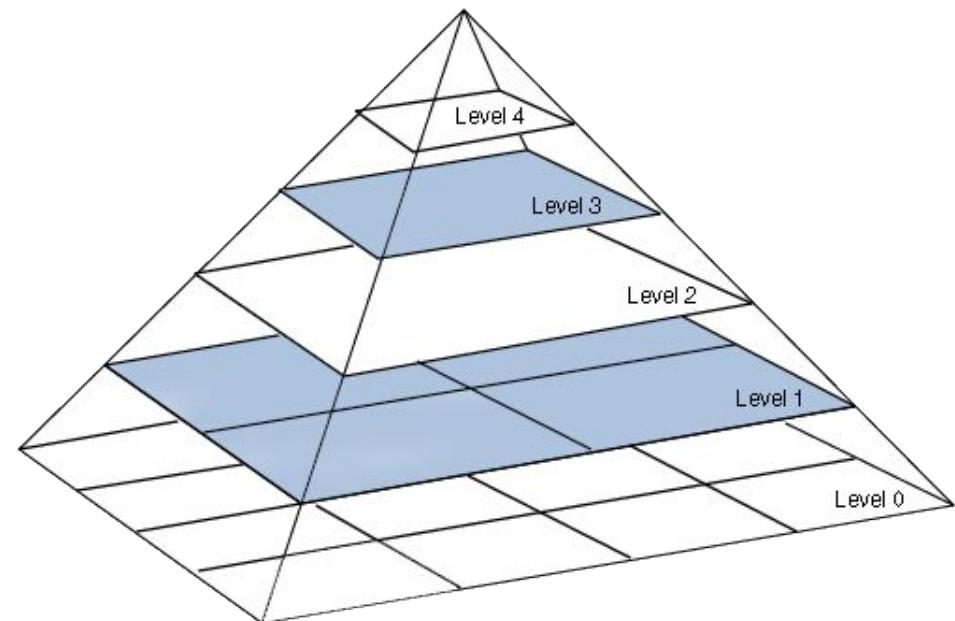
Downsampled by averaging



Tiling

Images are tiled during ingestion

Downsampled by averaging

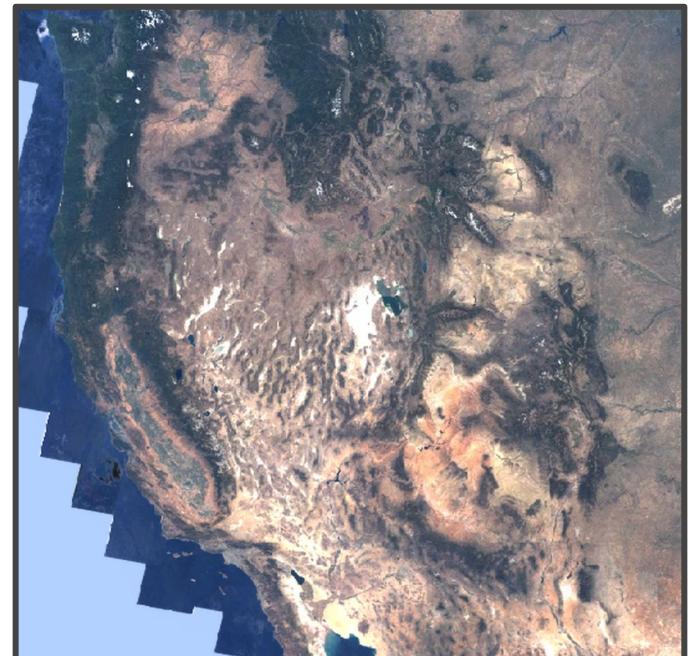


Tiling

Images are tiled during ingestion

Downsampled by averaging

During computation



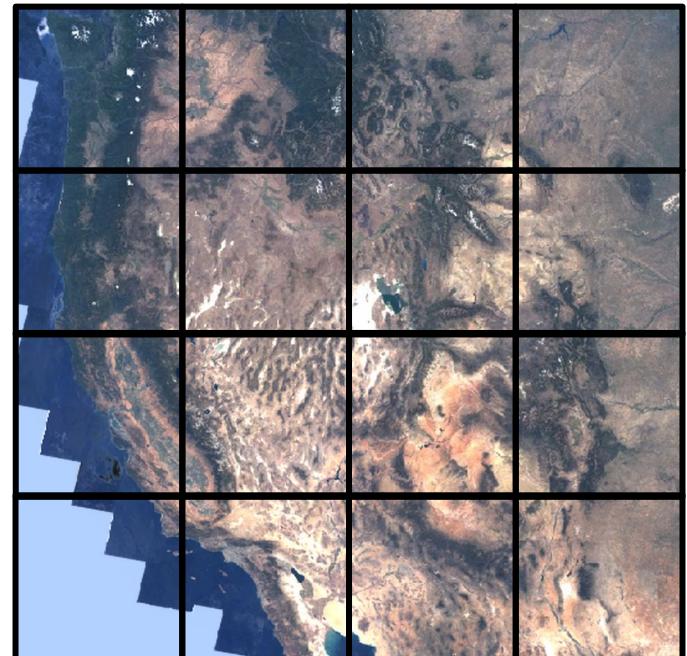
Tiling

Images are tiled during ingestion

Downsampled by averaging

During computation

Compute output tiles



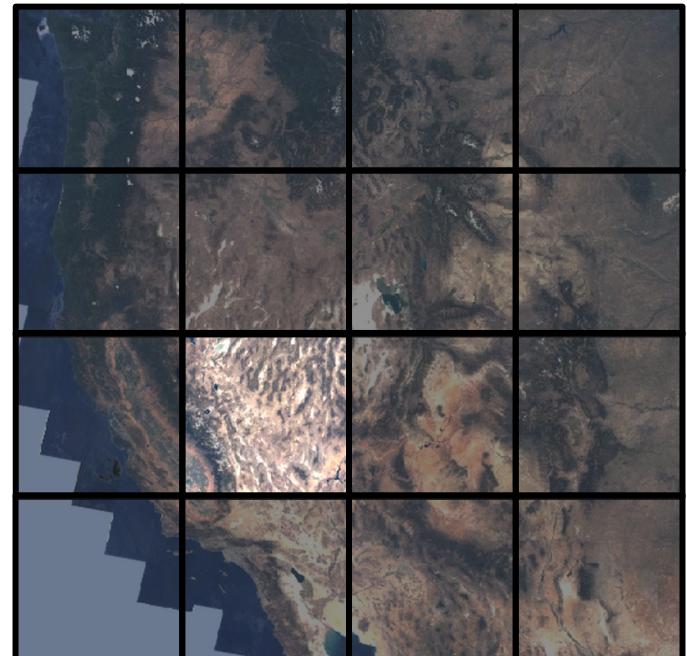
Tiling

Images are tiled during ingestion

Downsampled by averaging

During computation

Compute output tiles



Tiling

Images are tiled during ingestion

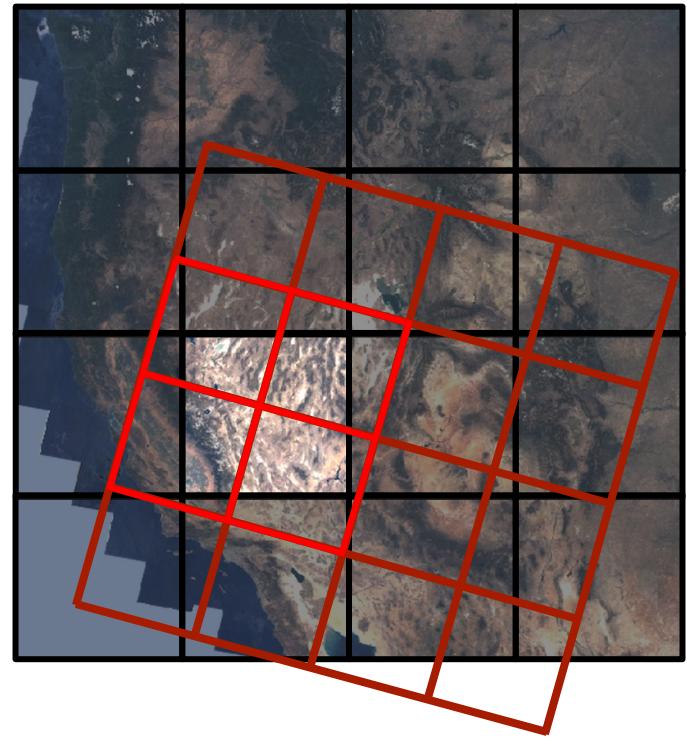
Downsampled by averaging

During computation

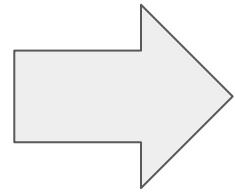
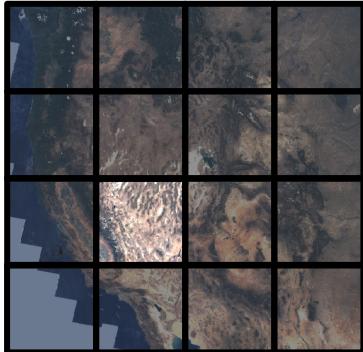
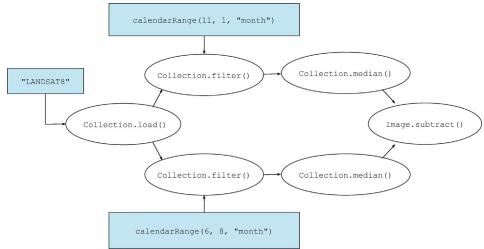
Compute output tiles

Find intersecting source tiles

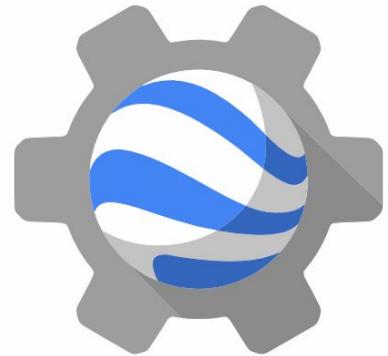
Reproject into the output projection



Running a Computation



Google Earth Engine



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