Coding in Earth Engine

An Introduction using JavaScript in the Code Editor

David Gibson / 2019-09-16

Agenda

- Demo
- Earth Engine Subsystems
- Coding Concepts
- Coding Hands-On
- Next Steps

Data >> Bandwidth

PNAS

Next-generation Digital Earth

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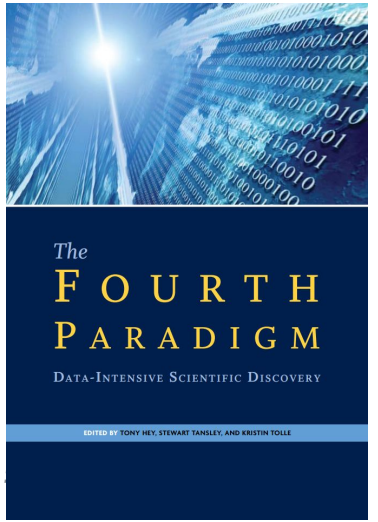
"*The supply of geographic information from satellite-based and ground-based sensors has expanded rapidly, encouraging belief in a new, fourth, or "big data," paradigm of science that emphasizes* **international collaboration, data-intensive analysis, huge computing resources, and high-end visualization.**"

-Goodchild et al. (2012)

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

-Jim Gray (1944-2007)



Earth Engine Subsystems

Data

An exhaustive catalog of remote sensing datasets, including multispectral, radar, aerial, climate, land cover, and vector.

Computation

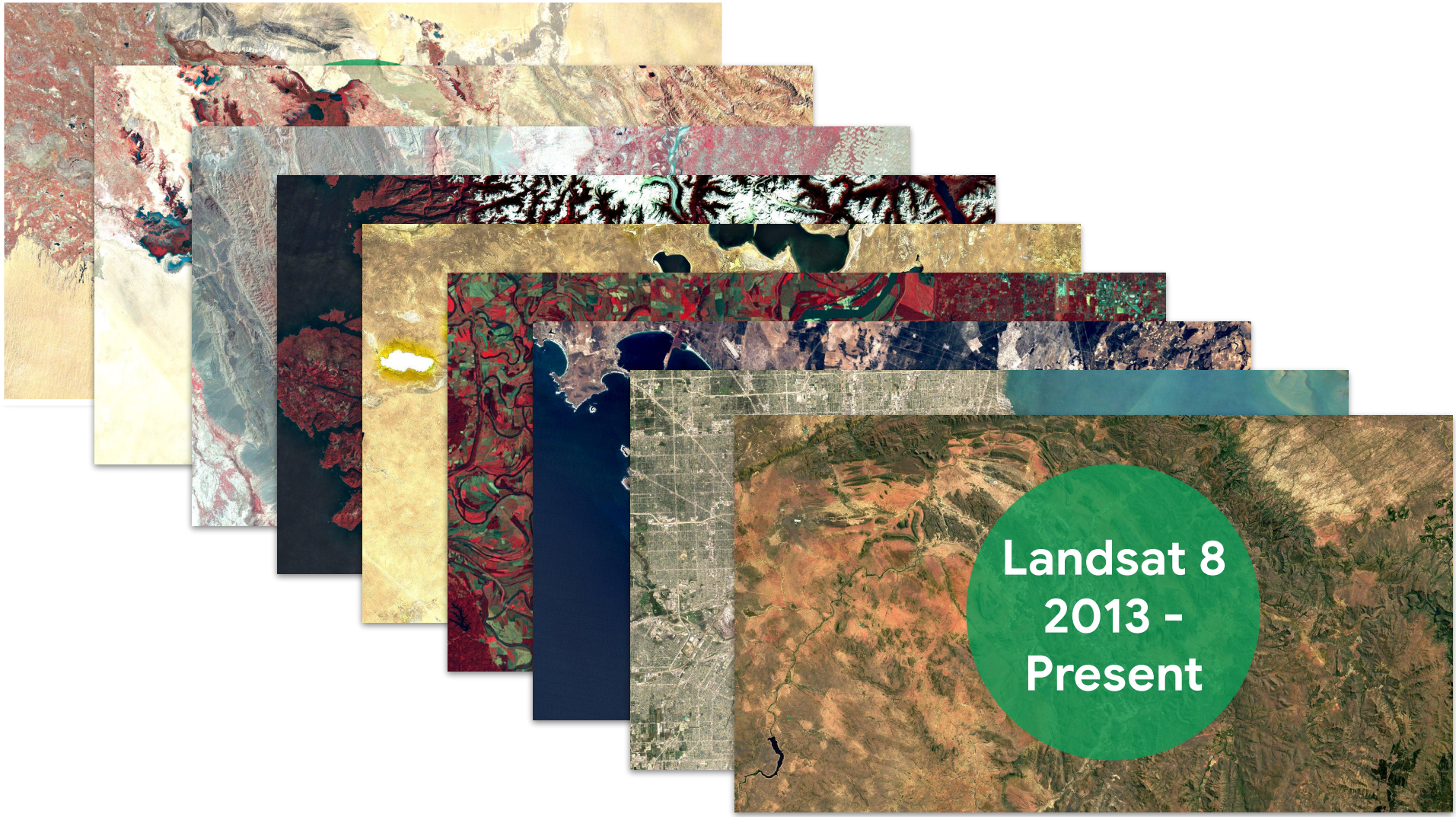
Colocated data storage and computation

API

Rich JavaScript API, and support for Python, hosted on GitHub.

Web IDE

No software to download or keep up to date. All you need is a modest internet connection.

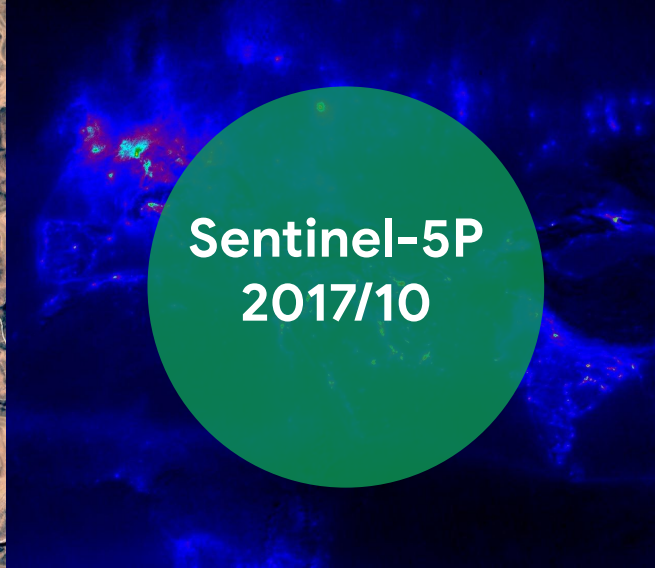

Landsat 8
2013 -
Present

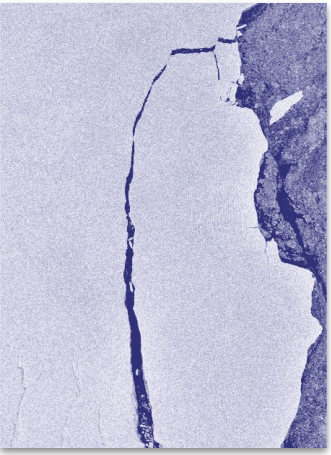
Landsat

Satellite	Date Range	Instruments	Resolution (m/px)
Landsat 1	1972 - 1978	MSS	60
Landsat 2	1975 - 1982	MSS	60
Landsat 3	1978 - 1983	MSS	60
Landsat 4	1982 - 1993	MSS/TM	60 / 30
Landsat 5	1984 - 2012	MSS/TM	30
Landsat 7	1999 - present	ETM+	30 / 15 (pan)
Landsat 8	2013 - present	OLI/TIRS	30 / 15 (pan)

Landsat 4, 1980's

Landsat 8, 2015~

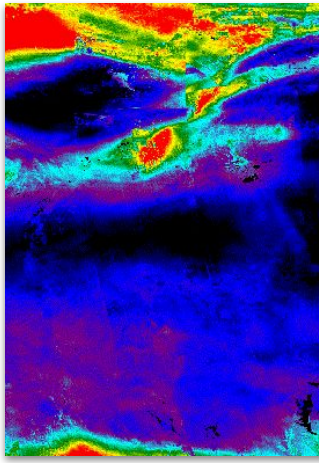


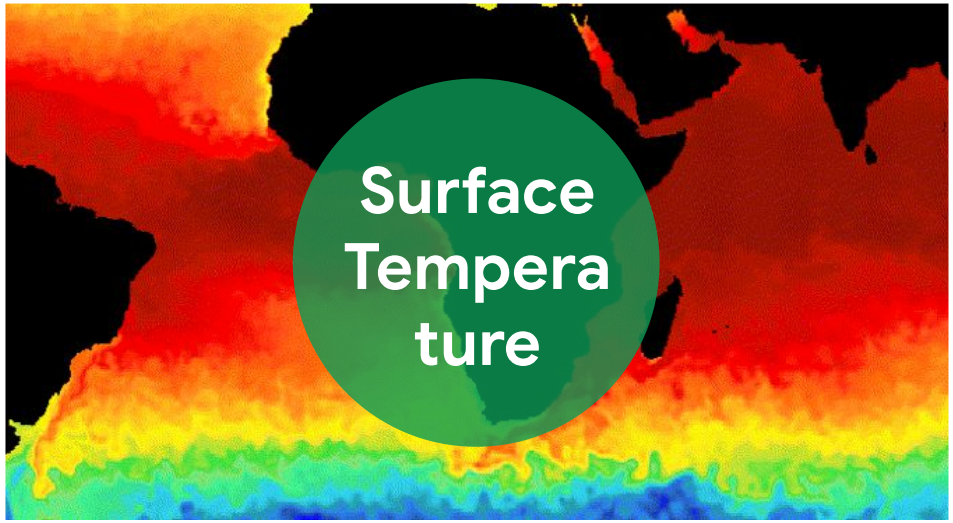


Snow and Ice
Oceans
Oil spills
Maritime activity
Deforestation
Natural disasters
Emergency response

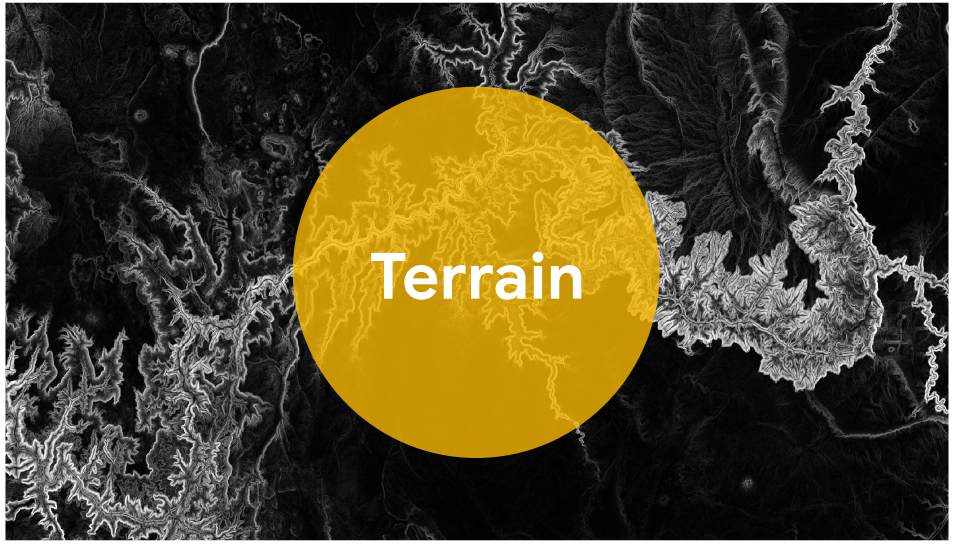
Urban expansion
Land use/change
Agriculture
Water monitoring
Disaster mapping
Infectious diseases

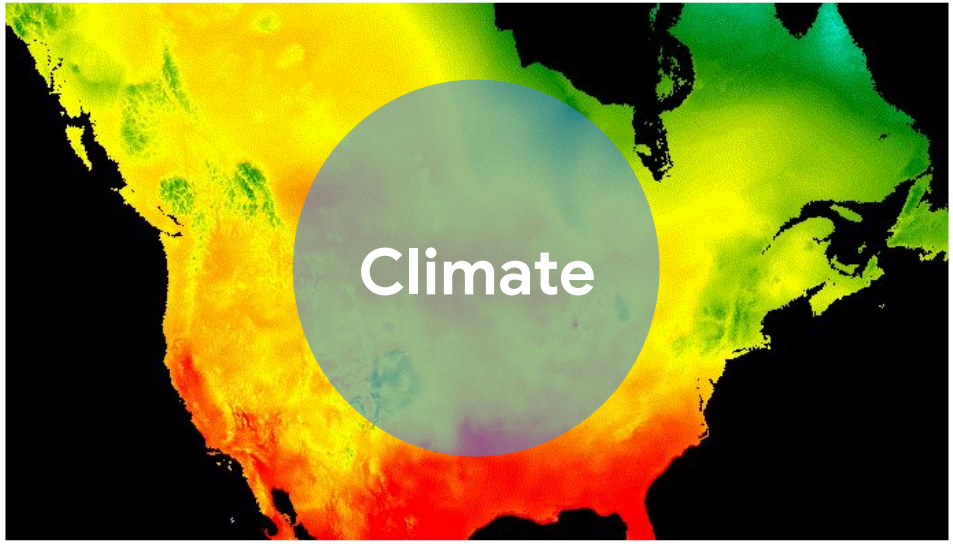
Near Real-Time
UV Aerosol Index, HCHO, NO2, O3, SO2




Surface
Tempera
ture


High-res
Imagery


Terrain


Climate

Data Catalog

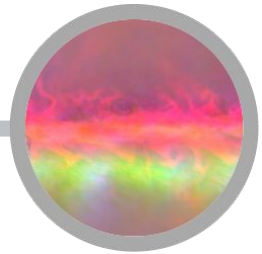
https://developers.google.com/earth-engine/datasets/

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

MODIS
250m daily

Vector Data
WDPA, Tiger

Terrain & Land Cover



Weather & Climate
NOAA NCEP, OMI, ...

> 500+ public datasets

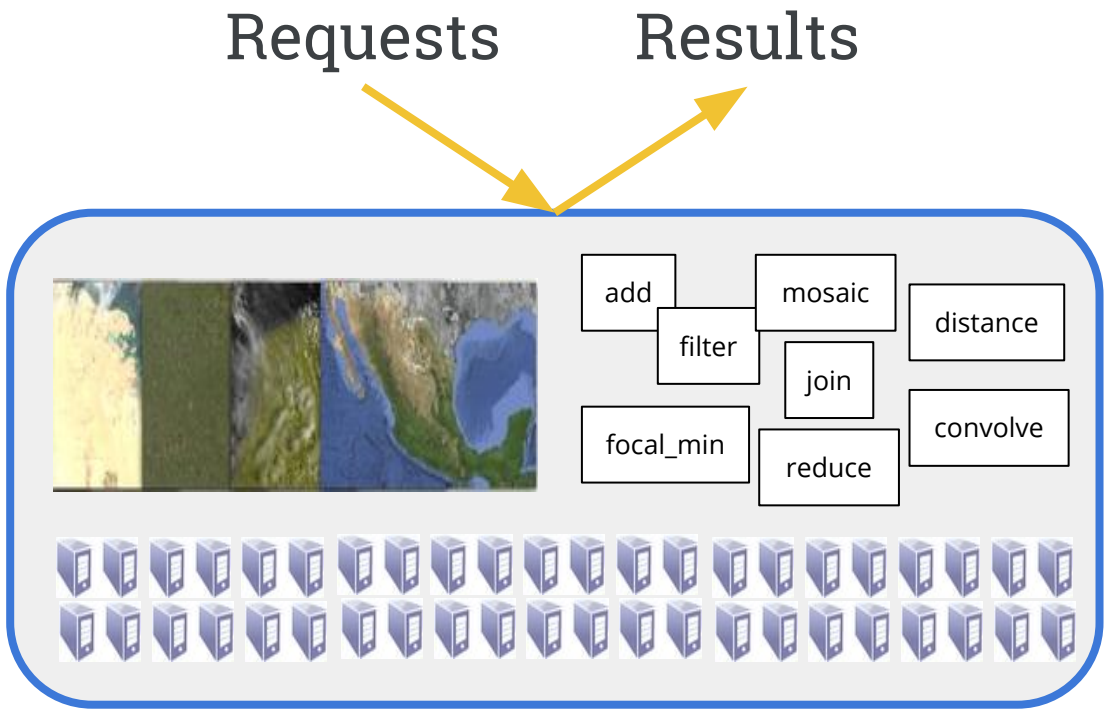
> 10s of millions of images

> 25+ petabytes of data

> 1000s of new images every day

... and upload your own vectors and rasters

Computation



API: Requests and Results

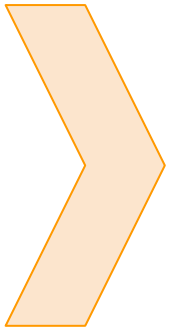
Requests

Compute Value

Generate Map

Fetch Map Tile

Perform Import/Export



Results

Numbers, Tables, other Data Structures

Map ID

Image

"OK"

"Error: ..."

Web IDE: the Code Editor

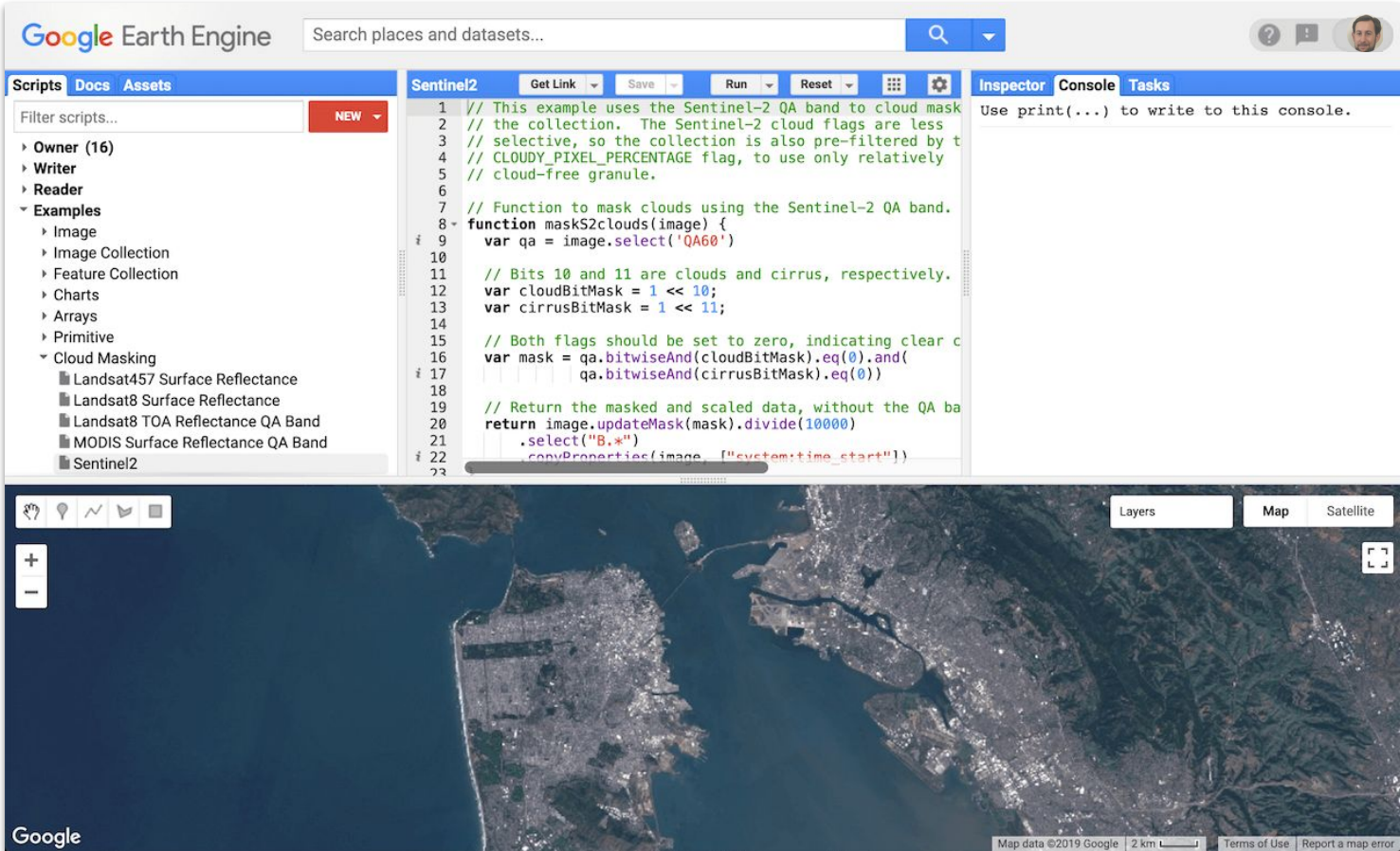
Workspace

for

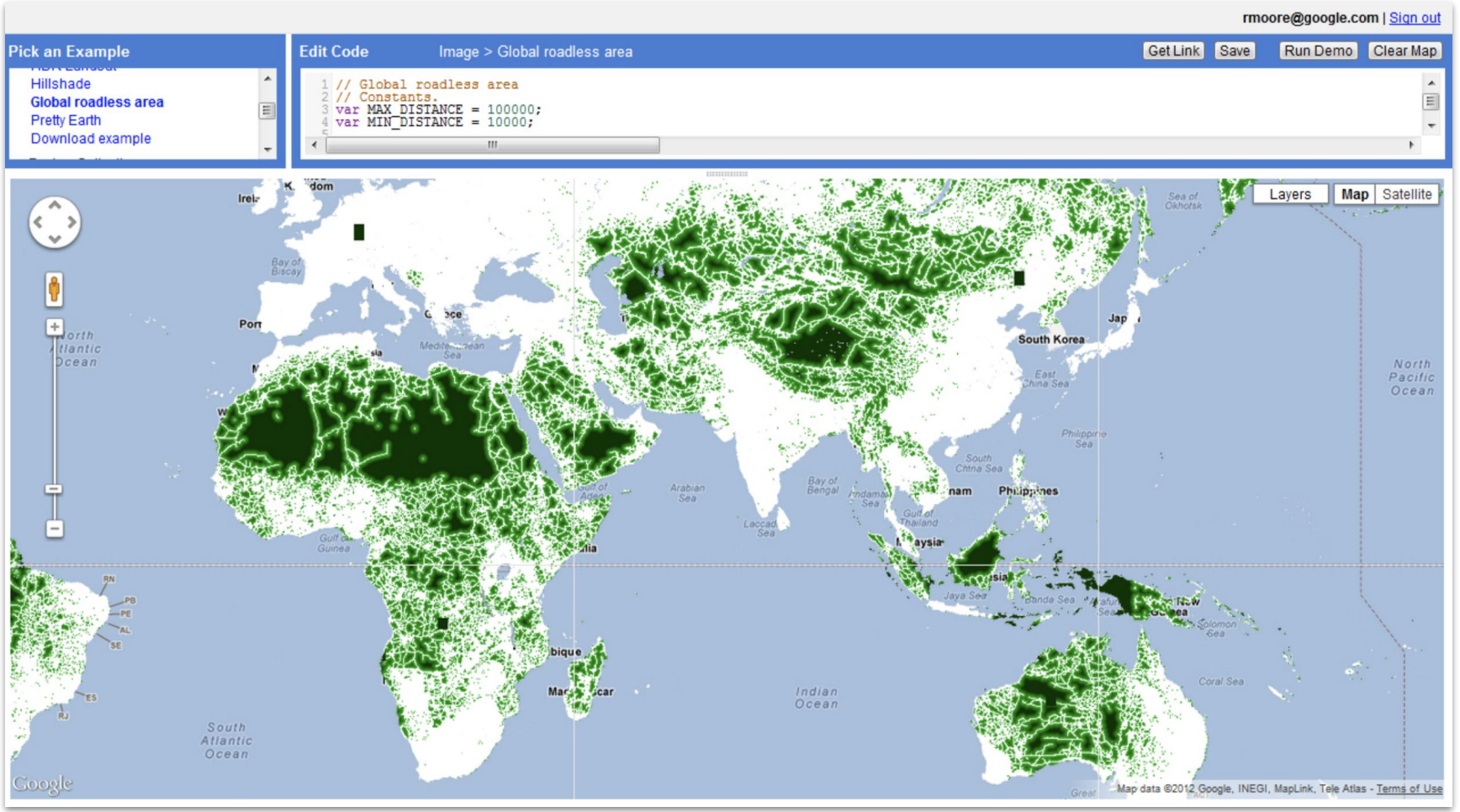
Investigation

and

Collaboration



… in 2012


rmoore@google.com | Sign out
Pick an Example
Hillshade
Global roadless area
Pretty Earth
Download example
Edit Code
Image > Global roadless area
Get Link
Save
Run Demo
Clear Map
// Global roadless area
// Constants.
var MAX_DISTANCE = 100000;
var MIN_DISTANCE = 10000;
Layers
Map
Satellite
South Korea
North Pacific Ocean
Indian Ocean
South Atlantic Ocean
Google
Map data ©2012 Google, INEGI, MapLink, Tele Atlas - Terms of Use

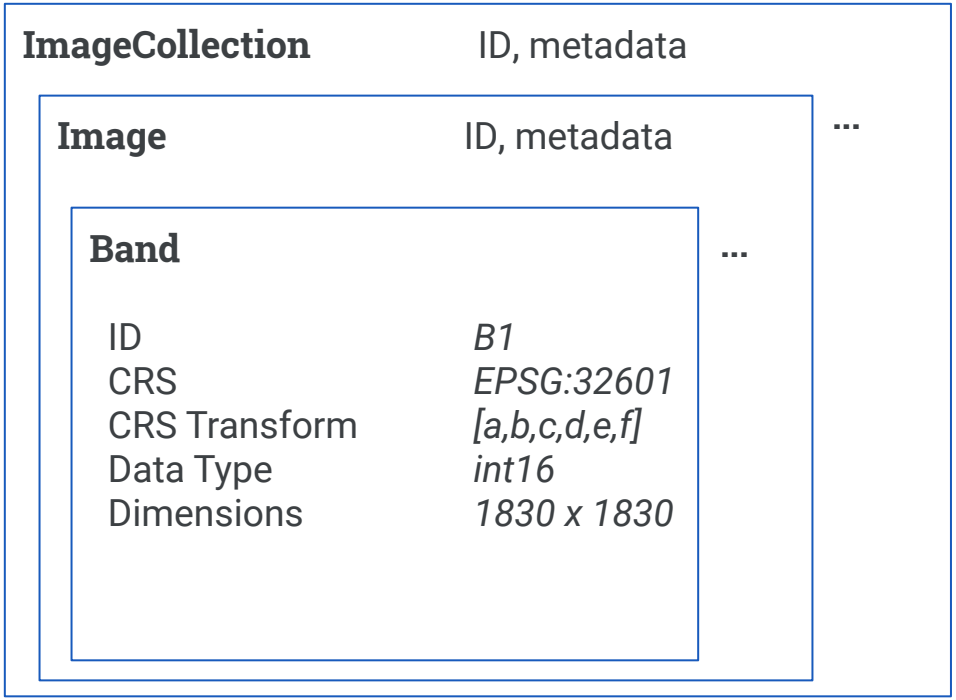
Coding Concepts: Images

Image bands may have different transforms, data types, and pixel counts.

Image operations usually work independently across bands.

Images have a *mask* band.

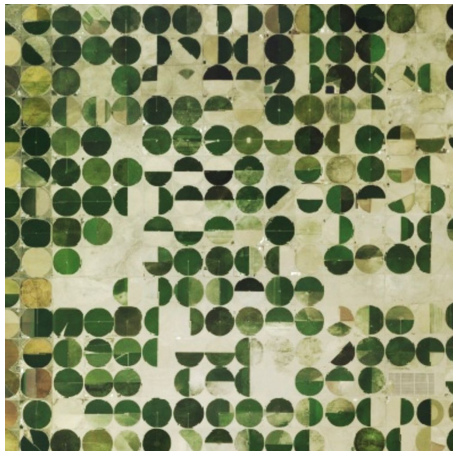
Computed output pixels will often correspond to multiple input pixels.



Coding Concepts: Filter, Map and Reduce

Pick your: projection, resolution, bands, bounding-box, visualization

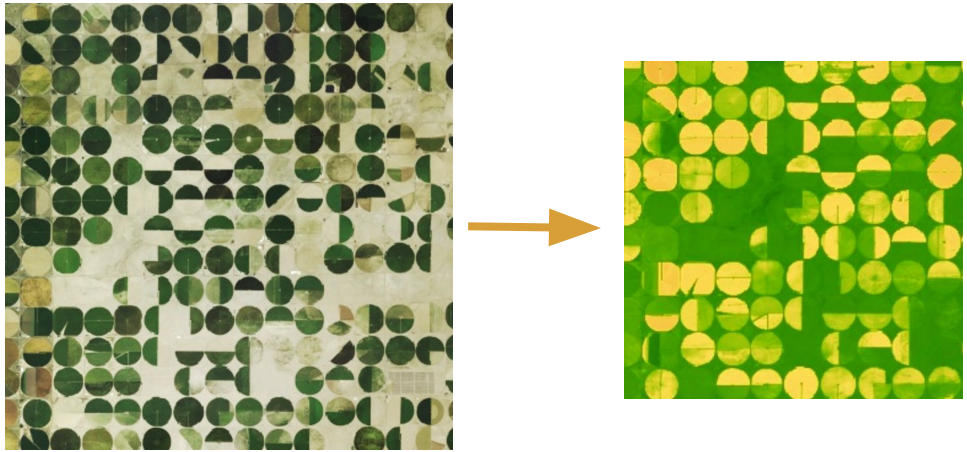
Get an image



Coding Concepts

Apply an algorithm to an image

Use library functions or script your own

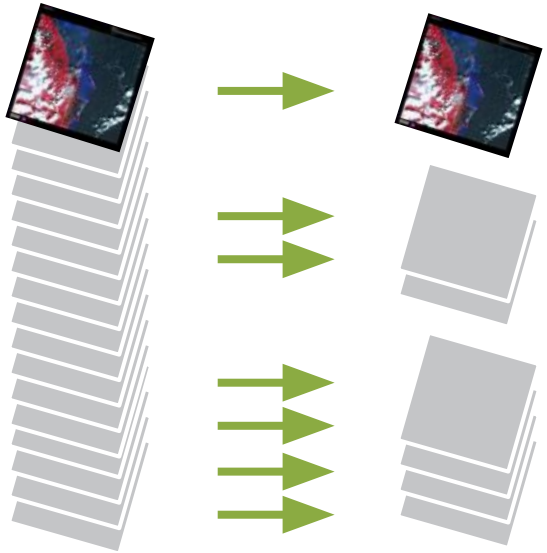


Coding Concepts

Apply an algorithm to an image

Filter a collection

Time, Space & Metadata Search



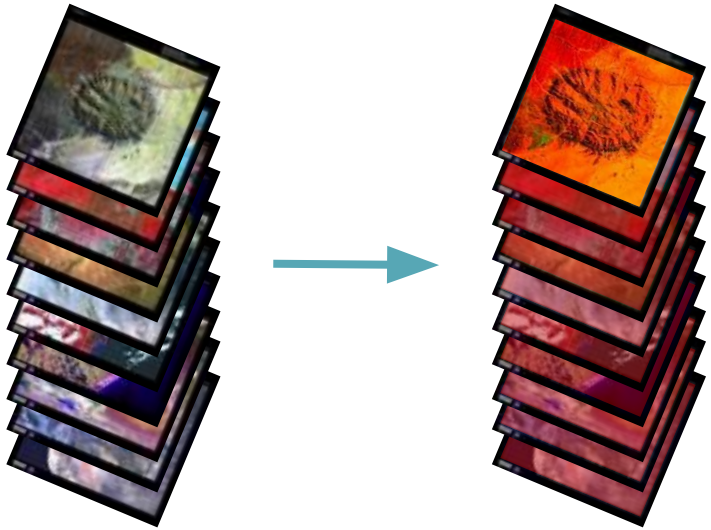
Coding Concepts

Apply an algorithm to an image

Filter a collection

Map an algorithm over a collection

$N \rightarrow N$



Coding Concepts

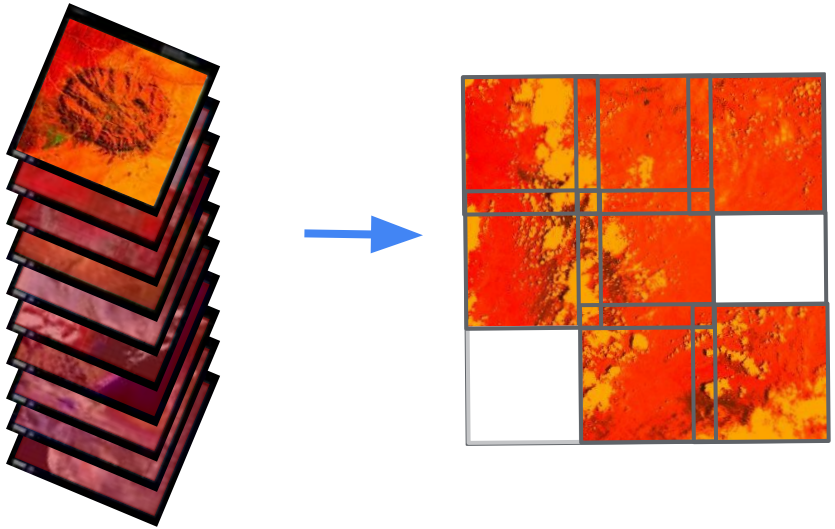
Apply an algorithm to an image

Filter a collection

Map an algorithm over a collection

Reduce a collection

N → 1 or N → M



Coding Concepts

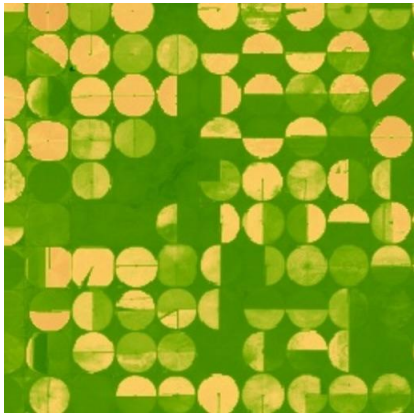
Apply an algorithm to an image

Filter a collection

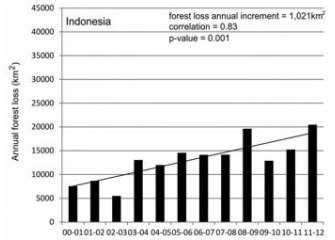
Map an algorithm over a collection

Reduce a collection

Compute aggregate statistics

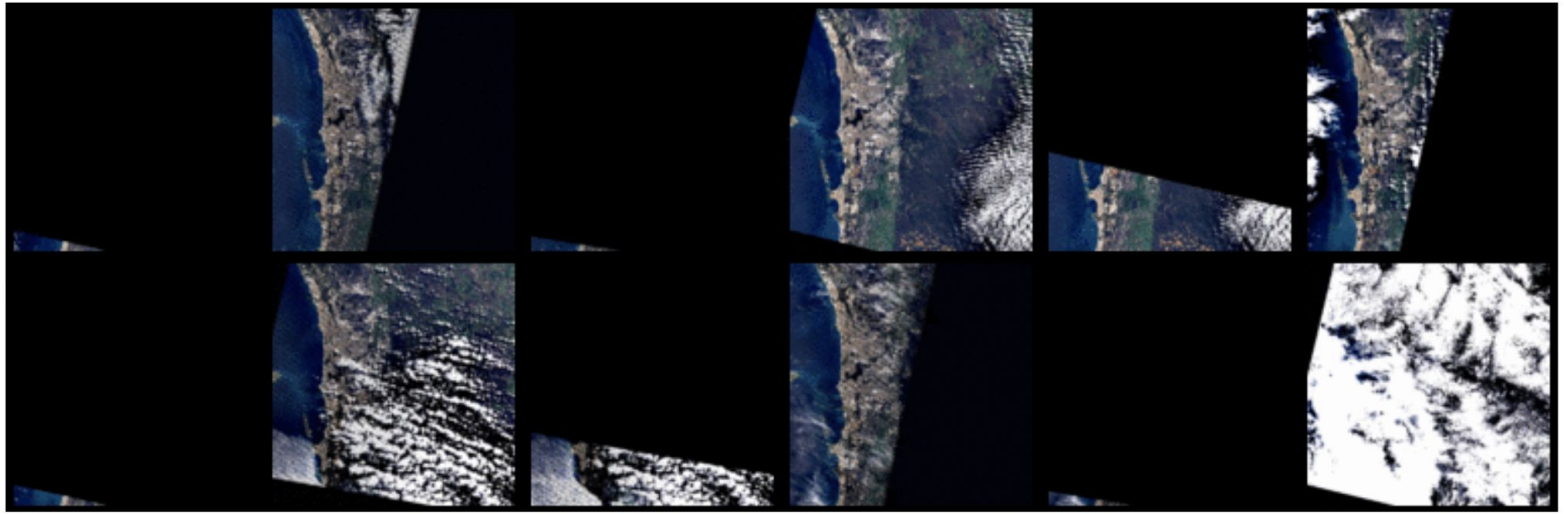


Gabon	1891	391	11898
Lithuania	1845	1226	40296
Cuba	1725	2271	68008
Mali	1694	0	1247103
Costa Rica	1653	382	11327
Czech Republic	1646	1331	46934
South Sudan	1635	38	460581
North Korea	1605	137	67695
Italy	1603	898	201331



Example: Filter, Map, and Reduce

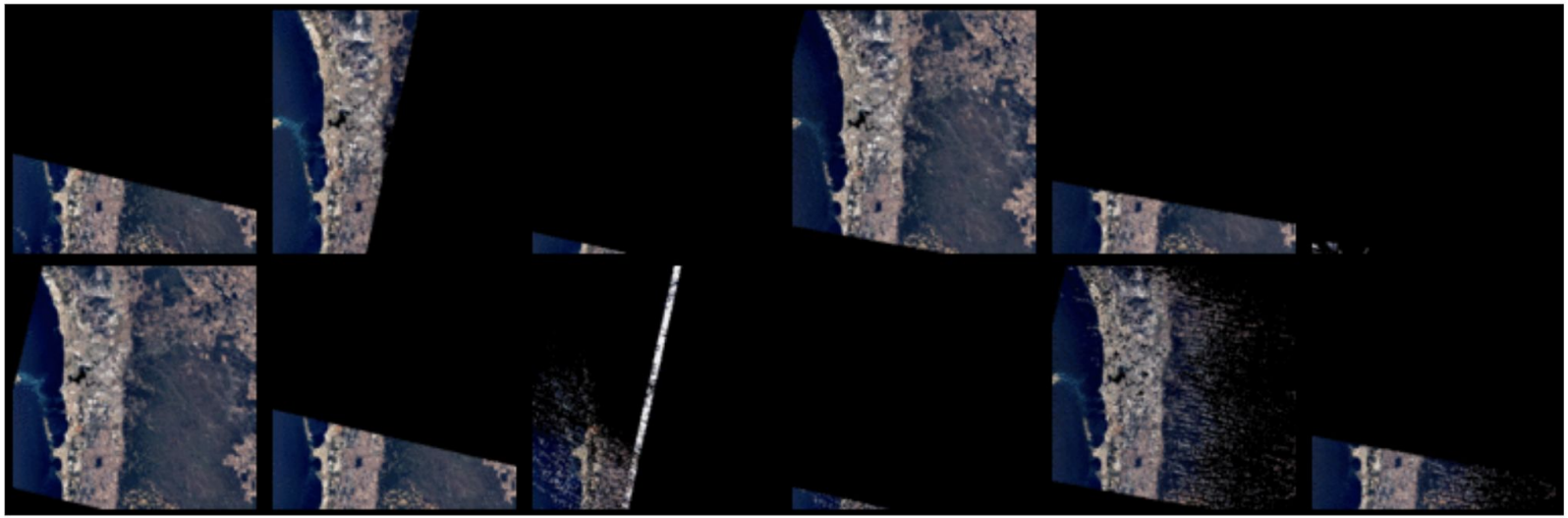
Core concept: Filter



Filter Condition:

"All L7 and L8 images acquired after 2013 that intersect polygon over Perth, Australia."

Core concept: Map



Map Operation: Band values for pixel at location → Cloud score at location

Earth Engine's built-in Landsat cloud score algorithm computes a cloud-likelihood score for each pixel, letting you identify the cloudy ones.

Core concept: Reduce

Reduce Operation: All pixel values & cloud scores → Consensus pixel value

Choose the best of the cloud-free pixels and make final mosaic.

Using the Code Editor

bit.ly/ee2019ce

Setting Up: Home Folder, Default Repository.

Editing and Saving Scripts. Get Link.

Console and Inspector.

Online docs and Help.

Introduction to JavaScript

Definitions and rendering:

```
var variable = expression;
print(expression);
```

Data Structures:

```
List:        [expression, expression, ...]
Dictionary:  {key1: value1, key2: value2, ...}
```

Syntax highlighting and documentation.

https://code.earthengine.google.com/?scriptPath=users/dag/ee101:00+-+JavaScript

Introduction to JavaScript: Functions

Pieces of computation to execute "later".

REUSE At multiple points in the script

DEFER Until we know the object(s) of interest

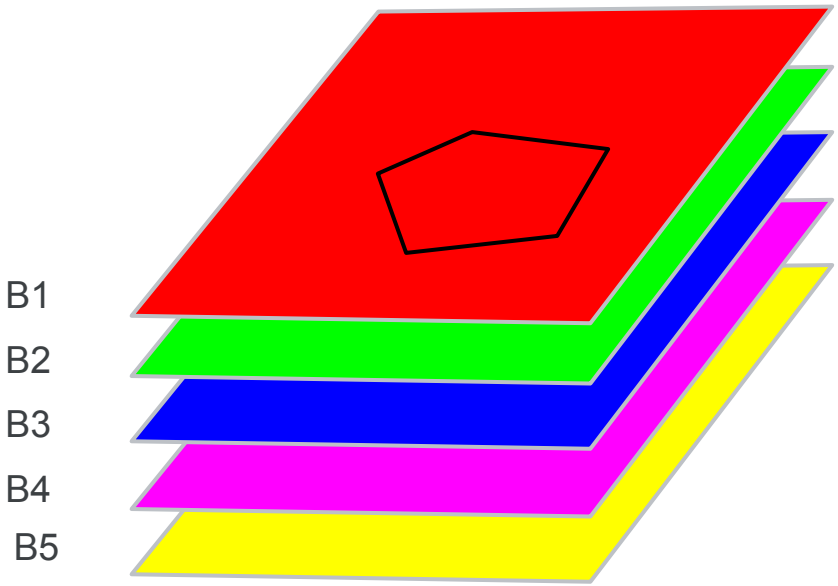
CALLBACK When something happens, eg click on map

```
function name(a, b) {
    // do stuff
    return expression;
}

// later ...

var result = name(x, y);
```

Examples:

- Predefined: Earth Engine Library
- Calculation: Normalised Difference
- Transform Image: Add Bands, Remove Clouds, Gather Statistics

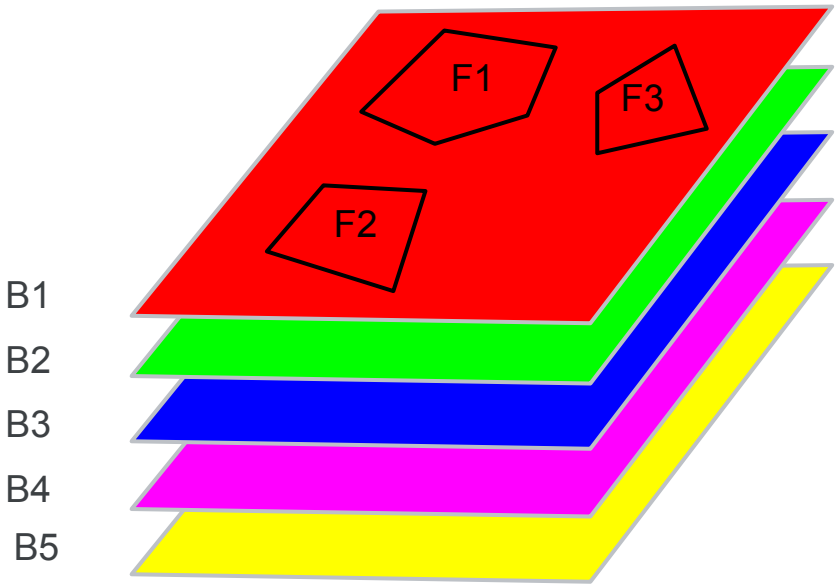
Reduce Region



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

https://code.earthengine.google.com/?scriptPath=users/dag/ee101:04+-+Apply+a+Spatial+Reducer

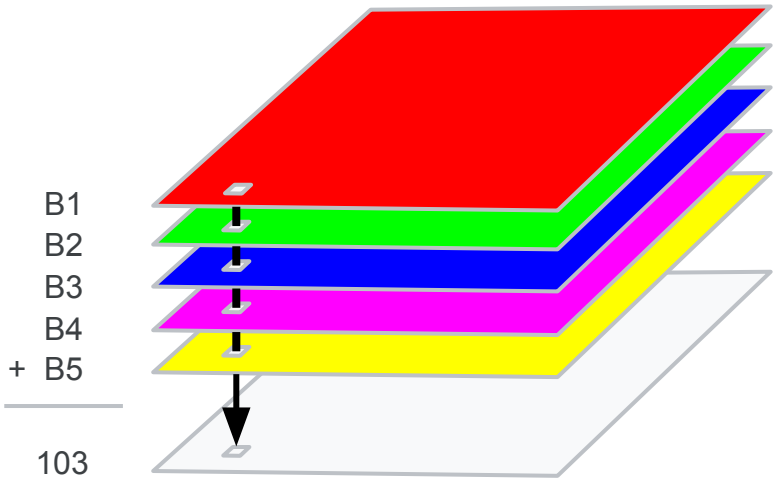
Reduce Regions



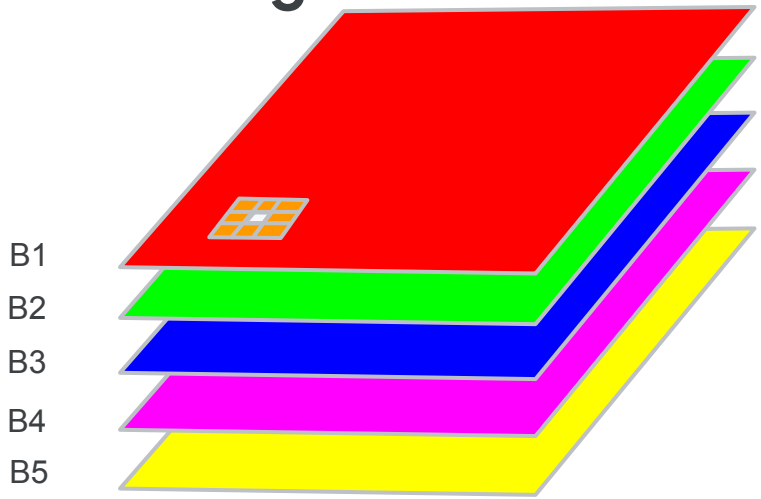
FeatureCollection

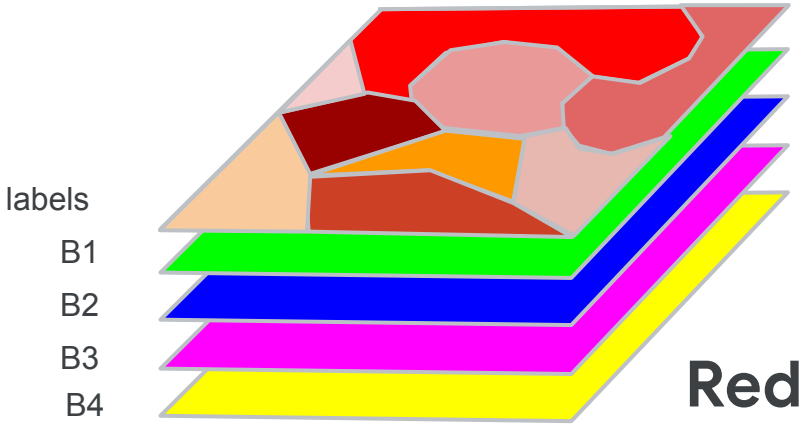
	B1	B2	B3	B4	B5
F1					
F2					
F3					

Reduce Bands



Reduce Neighborhood





Reduce To Vectors

FeatureCollection

	B1	B2	B3	B4
F1				
F2				
F3				
...				

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

Objects and Computations

```
// Construct an object
var eighties = ee.DateRange('1980-01-01', '1990-01-01');

// Objects contain predefined functions
print(eighties.intersection(ee.DateRange('1970'))
              .start());              // "chain" after intersection
```

Not: `intersection(eighties, ee.DateRange('1970'))`

All ee.* objects are *computations* which are sent to the server.

Functions for Filter, Map & Reduce

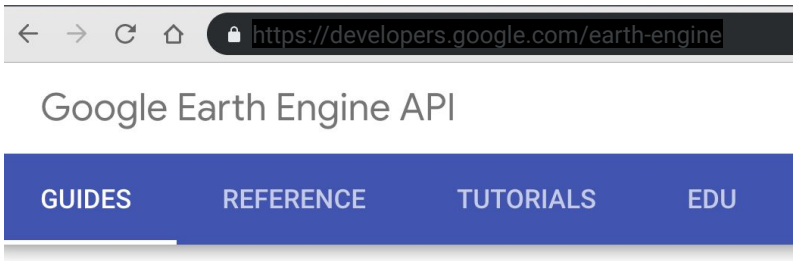
```
var filtered = L8.filterDate('2016-05-01', '2016-05-15')
                 .filterBounds(roi);    // Images -> fewer Images

function addNDVI(image) {
  var ndvi = image.normalizedDifference(['B8', 'B4']);  // NIR, Red
  return image.addBands(ndvi);
}
var with_ndvi = filtered.map(addNDVI);  // Images -> Images with NDVI

                                        // Images -> single Image
Map.addLayer(filtered.reduce(ee.Reducer.median()), rgb_vis, 'Median');
```

https://code.earthengine.google.com/?scriptPath=users/dag/ee101:demos/Greenest-Pixel+Composite

The 20 Most Useful Library Functions

Render	print, Map.addLayer
Constructors	ee.Array, ee.Dictionary, ee.Number, ee.String, ee.Date(Range)
ee.Image	addBands, select, reduceRegion(s), updateMask, add/max/sin/...
ee.Collection	filterDate, filterBounds, map, mosaic, first
ee.List	iterate, map

See the Docs tab, and Guides and Reference:



https://code.earthengine.google.com/?scriptPath=users/dag/ee101:08+-+Isolate+an+Image

Back to Greenest-Pixel Composite

A few more functions:

- `select` bands from image
- `qualityMosaic` choose pixels by quality score
- `updateMask` choose pixels to display

Recap:

- Functions and deferred execution
- Filter, Map, and Reduce
- Interactive Coding

Structure of a Script

Imports
Definitions: `var …, function …`
Rendering: `print, Map.addLayer, Export, ui.*`

Nothing happens without rendering!

New definitions allowed inside functions.

Caution: rendering inside functions.

Finding Problems

Check Intermediate Results
- print(), addLayer, Inspector
- Write tests for post-conditions

Delete Code
- Remove half the operations
- Find smallest failing example

Use Revision History

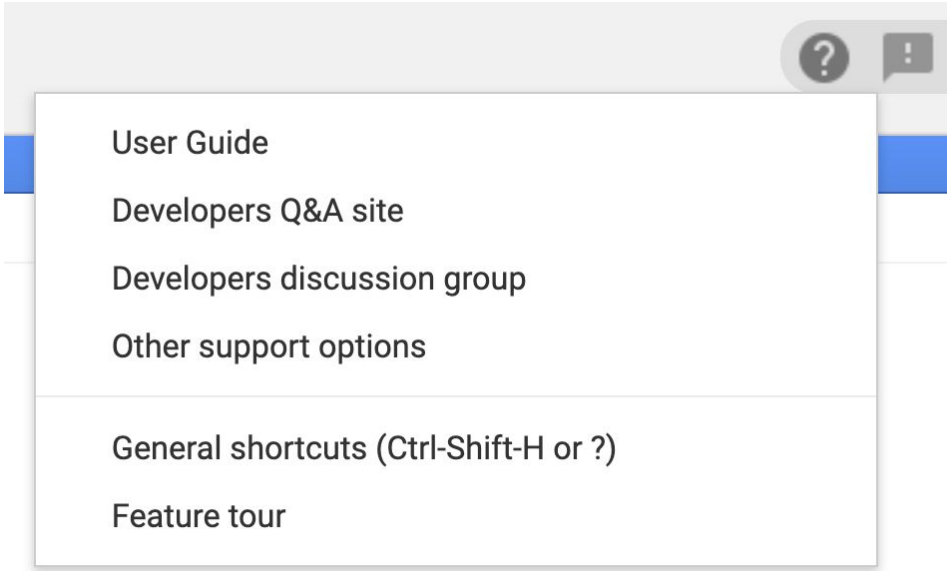
Finding Help

Primary Help Menu:

- User Guide
  - Tutorials
- GIS StackExchange
- Developer Forum

Learn (and steal) from other code:

- Examples
- Google Search



Where Next?

INTRODUCTORY 🌶

- Datasets Tour & Data Upload **Mon**
- Make your own Earth Engine App **Mon**, **Wed**
- Big Data Structures: Images and Features **Tue**
- Import/Export **Wed**, **Thu**
- Earth Engine Basics through Applied Examples (Night-time light, Agriculture) **Thu**
- Apps Showcase **Thu**

ANALYSIS 🌶🌶

- Reducers **Mon**, **Tue**
- Python API & Colab **Tue**, **Wed**
- Tables & Joins **Tue**, **Wed**
- Classification and Regression **Tue, Wed**
- Collections and map() **Tue**

VISUALIZATION 🌶🌶

- Animations in Earth Engine **Tue, Wed**
- User Interface Coding **Thu**
- User Interface and Apps **Wed**, **Thu**


GEO FOR GOOD
SUMMIT 2019