Deltares

Google Earth Outreach

Getting the most out of Google Earth Engine

Gennadii Donchyts, Deltares

FOSS4G NL

@gena_d

Introduction

What is Google Earth Engine?

Examples

Publications, apps, tools, libraries

Technical Concepts

Features, Images, Reducers, Filters, DAGs

Do's and Don'ts

Lessons learned

Introduction

Goodchild et al. (2012):

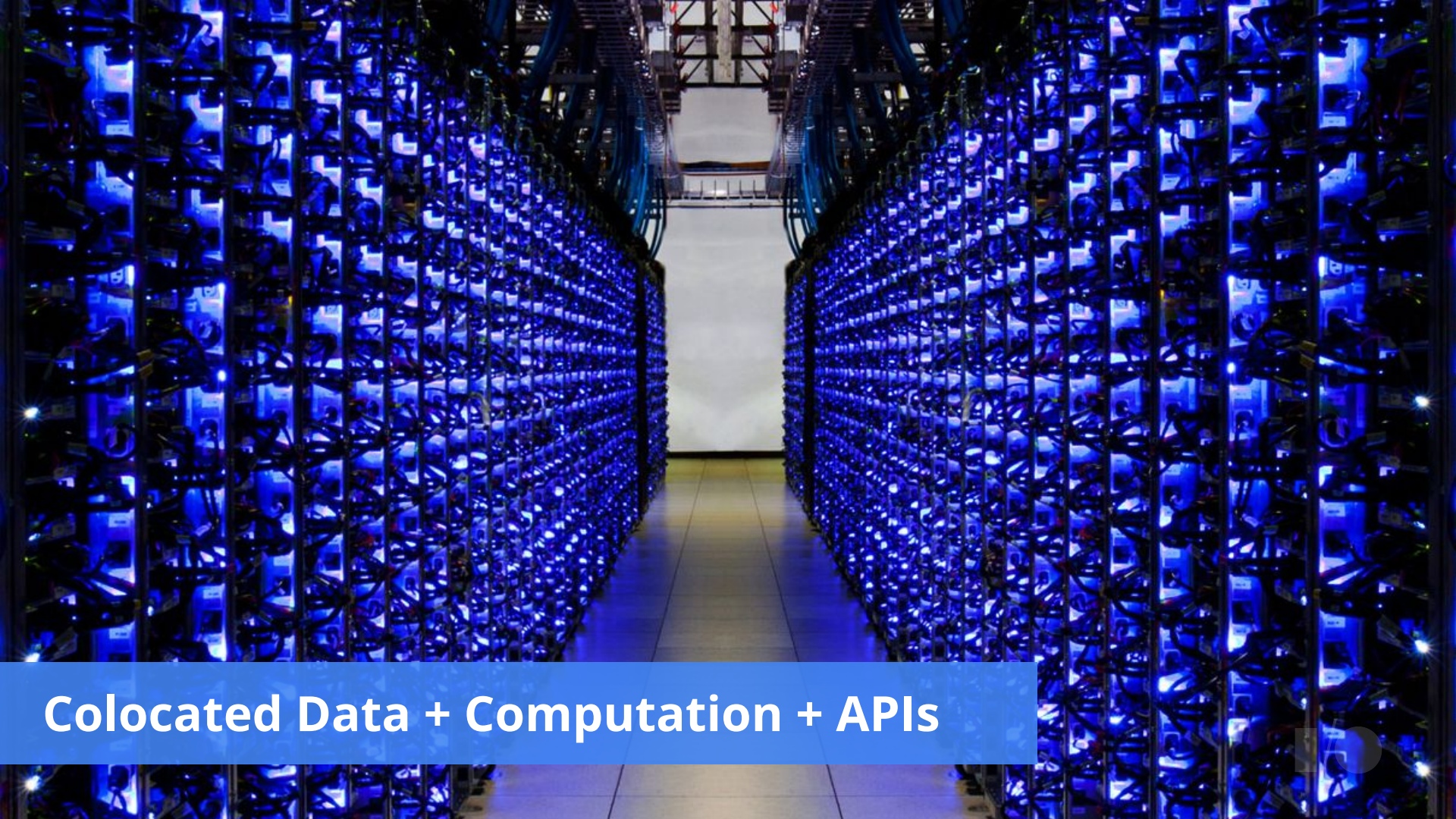
PNAS

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.**"



Colocated Data + Computation + APIs


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

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, ...

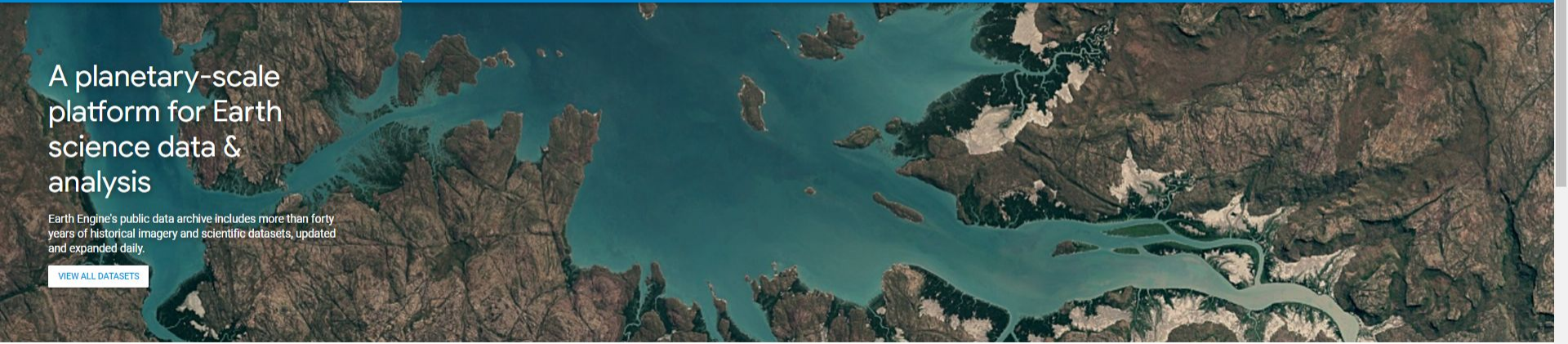
... and upload your own vectors and rasters

> 200 public datasets

> 5 million images

> 4000 new images every day

> 7 petabytes of data

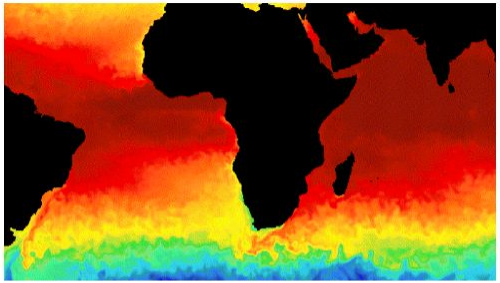


A planetary-scale platform for Earth science data & analysis

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

VIEW ALL DATASETS

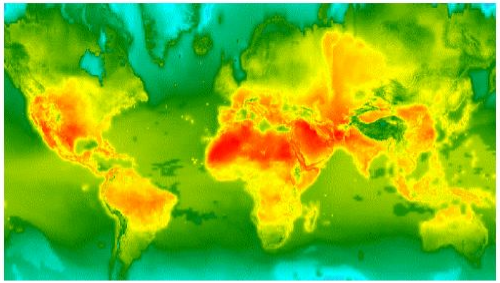
Climate and Weather



Surface Temperature

Thermal satellite sensors can provide surface temperature and emissivity information. The Earth Engine data catalog includes both land and sea surface temperature products derived from several spacecraft sensors, including MODIS, ASTER, and AVHRR, in addition to raw Landsat thermal data.

EXPLORE TEMPERATURE DATA



Climate

Climate models generate both long-term climate predictions and historical interpolations of surface variables. The Earth Engine catalog includes historical reanalysis data from NCEP/NCAR, gridded meteorological datasets like NLDAS-2, and GridMET, and climate model outputs like the University of Idaho MACAv2-METDATA and the NASA Earth Exchange's Downscaled Climate Projections.

EXPLORE CLIMATE DATA

Earth Engine Data Catalog

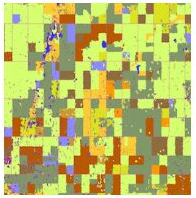
☆☆☆☆☆

Earth Engine's public data catalog includes a variety of standard Earth science raster datasets. You can import these datasets into your script environment with a single click. You can also upload your own raster data or vector data for private use or sharing in your scripts.

Looking for another dataset not in Earth Engine yet? Let us know by suggesting a dataset.

Filter list of datasets

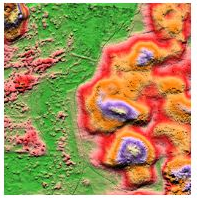
Canada AAFC Annual Crop Inventory



Starting in 2009, the Earth Observation Team of the Science and Technology Branch (STB) at Agriculture and Agri-Food Canada (AAFC) began the process of generating annual crop type digital maps. Focusing on the Prairie Provinces in 2009 and 2010, a Decision Tree (DT) based methodology ...

crop landcover canada aafc

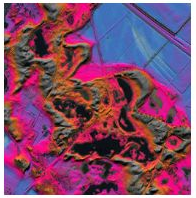
AHN Netherlands 0.5m DEM, Interpolated



The AHN DEM is a 0.5m DEM covering the Netherlands. It was generated from LIDAR data taken in the spring between 2007 and 2012. It contains ground level samples with all other items above ground (such as buildings, bridges, trees etc.) removed. This version is ...

lidar elevation netherlands dem geophysical ahn

AHN Netherlands 0.5m DEM, Non-Interpolated



The AHN DEM is a 0.5m DEM covering the Netherlands. It was generated from LIDAR data taken in the spring between 2007 and 2012. It contains ground level samples with all other items above ground (such as buildings, bridges, trees etc.) removed. This version is ...

lidar elevation netherlands dem geophysical ahn

AHN Netherlands 0.5m DEM, Raw Samples

The AHN DEM is a 0.5m DEM covering the Netherlands. It was generated from LIDAR data taken in the spring between 2007 and 2012. This version contains both ground level samples and items above ground level (such as buildings, bridges, trees etc). The point cloud ...

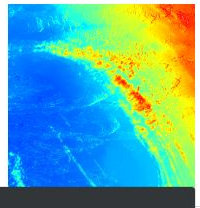
lidar elevation netherlands dem geophysical ahn

ASTER L1T Radiance

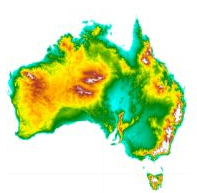
The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is a multispectral imager that was launched on board NASA's Terra spacecraft in December, 1999. ASTER can collect data in 14 spectral bands from the visible to the thermal infrared. Each scene covers an area of ...

vnir tir swir nir radiance thermal

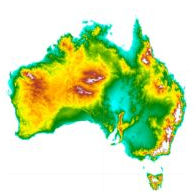
Australian 5M DEM



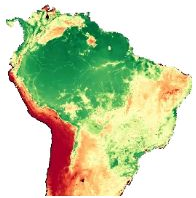
DEM-H: Australian SRTM Hydrologically Enforced Digital Elevation Model



DEM-S: Australian Smoothed Digital Elevation Model

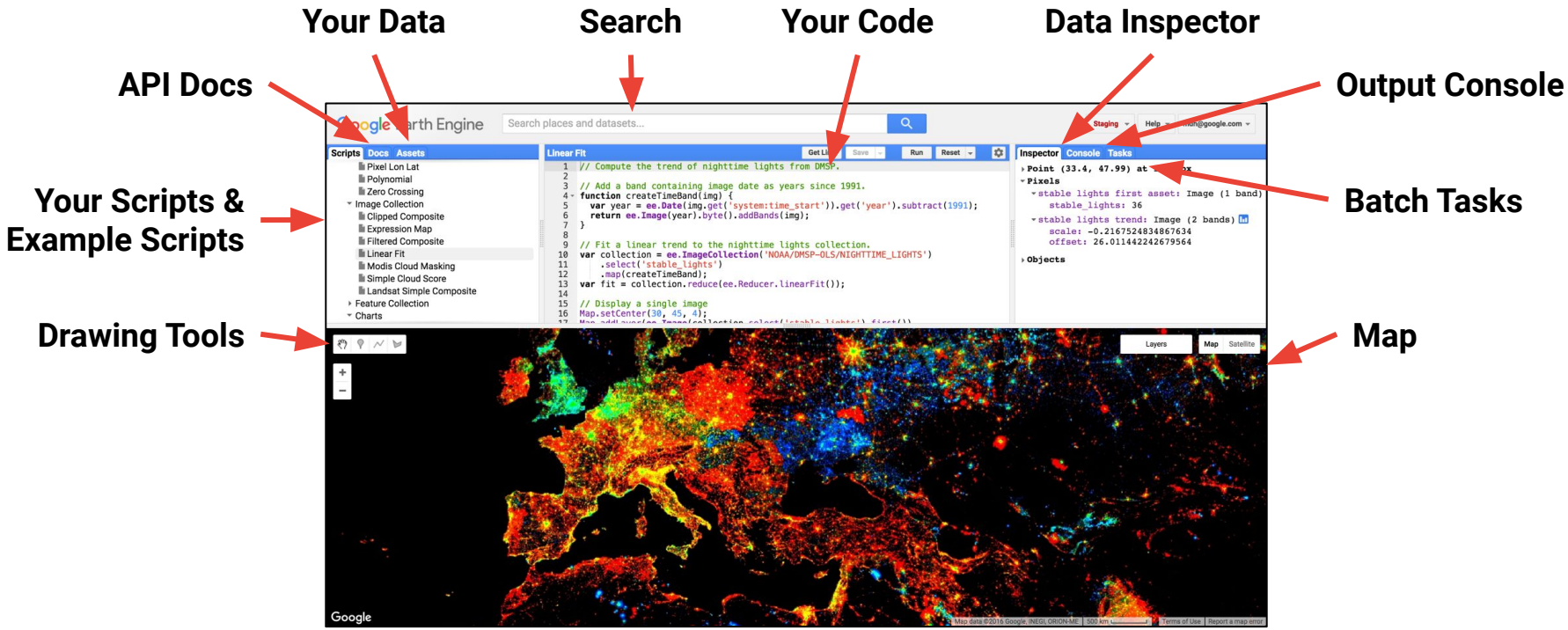


PML_V2: Coupled Evapotranspiration and Gross Primary Product

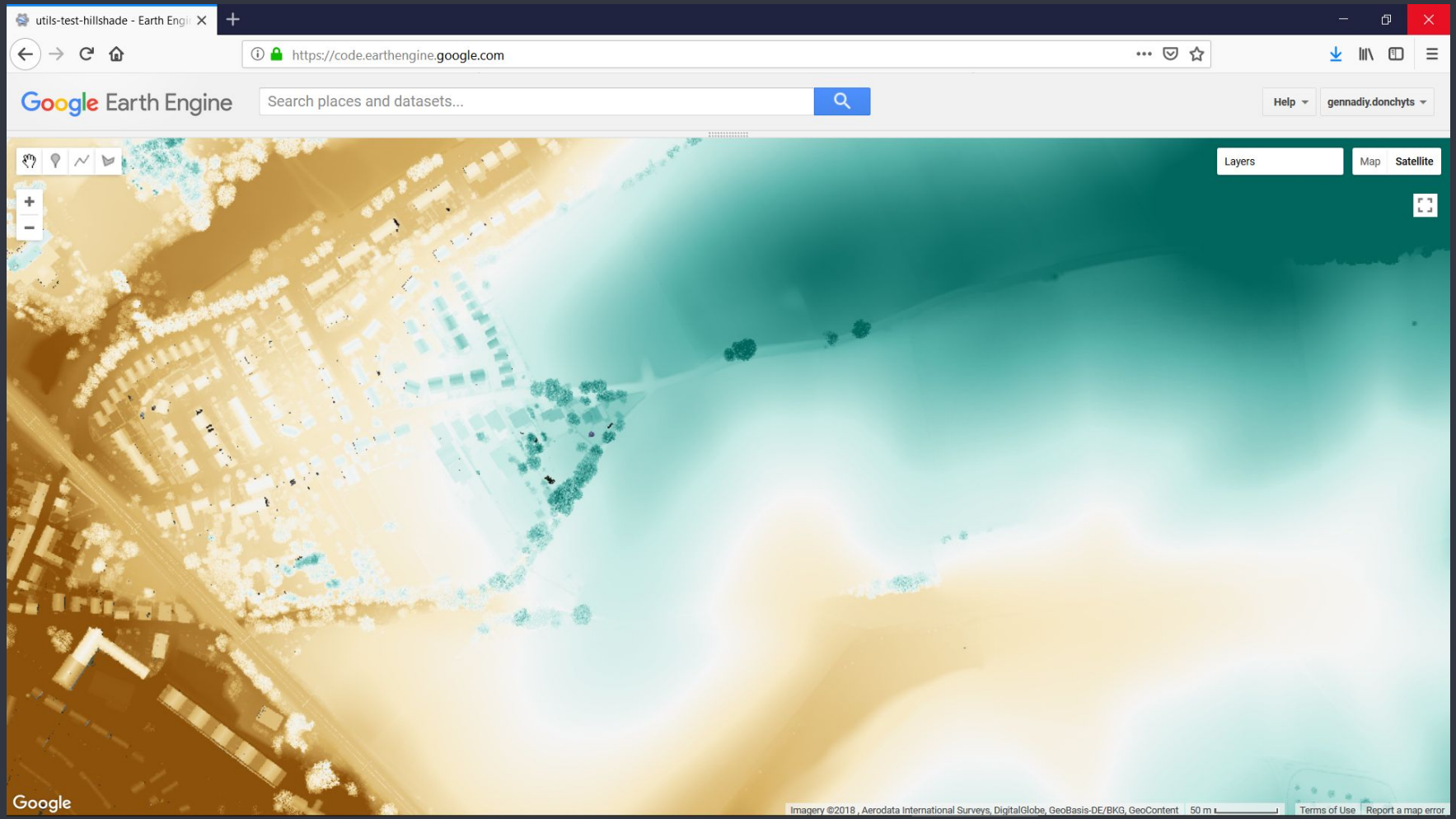


SRTM Digital Elevation Data Version 4

The Earth Engine Code Editor



code.earthengine.google.com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Layers
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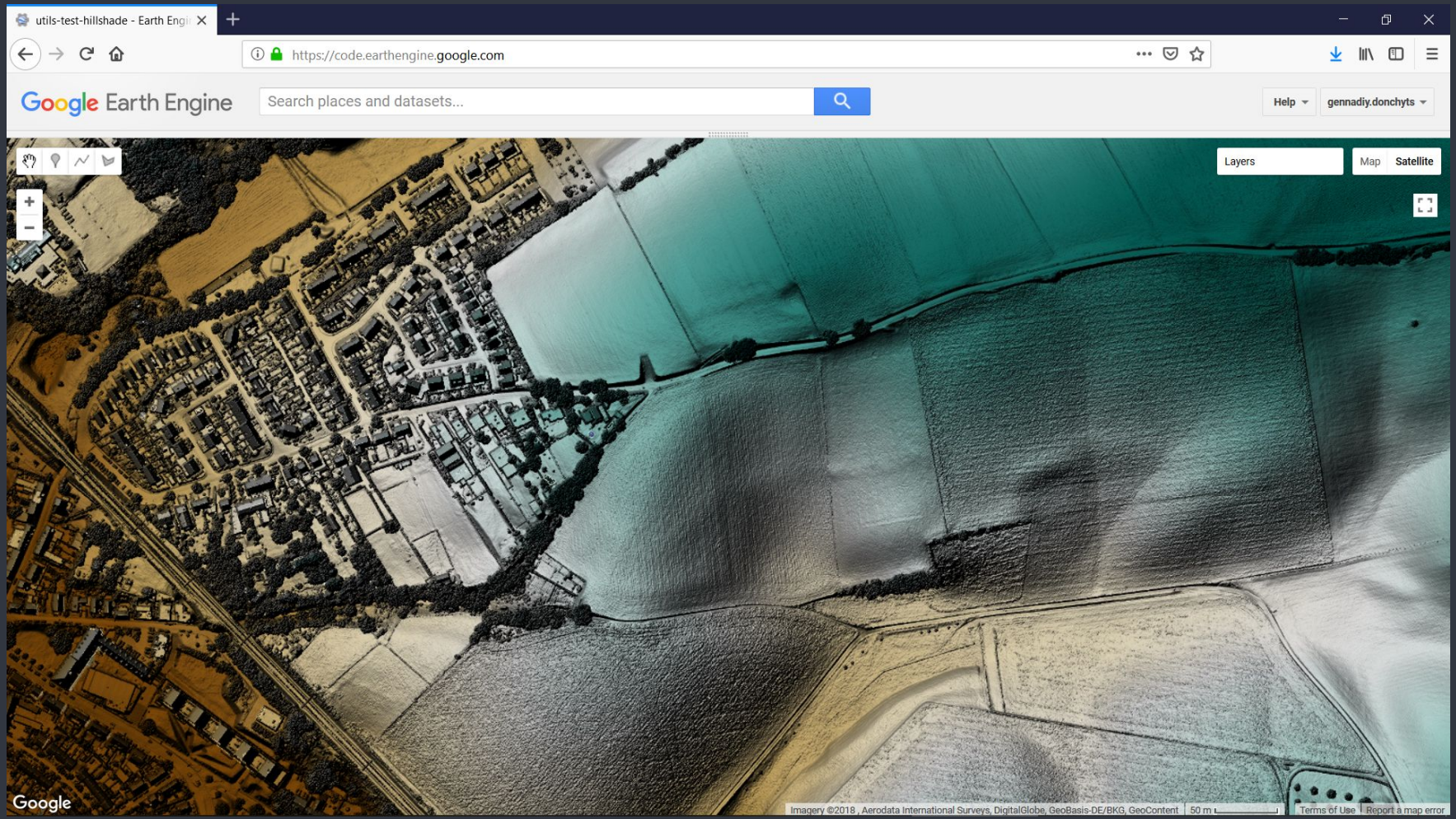
50 m
Terms of Use
Report a map error

Code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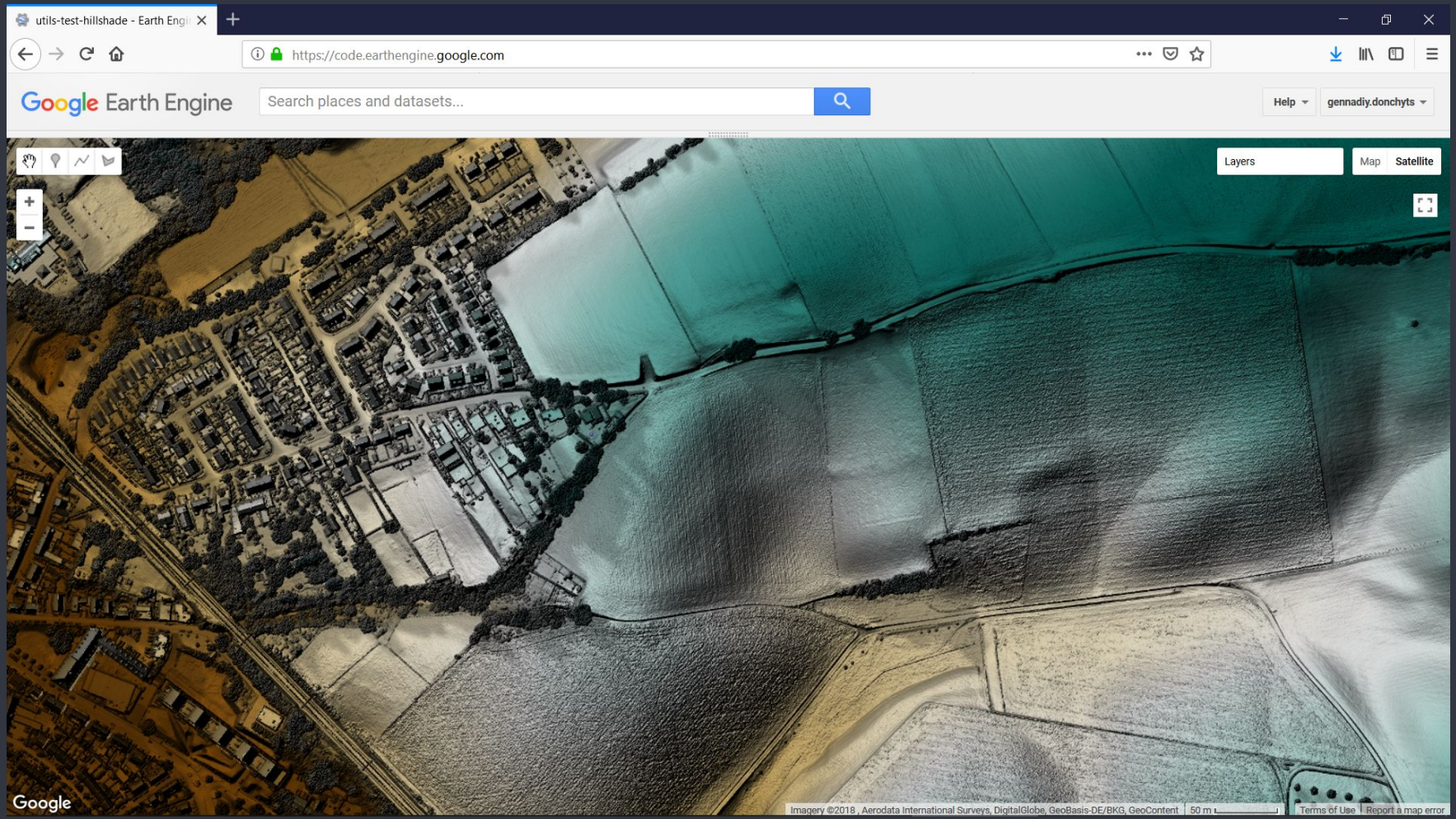
Code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Map
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50 m
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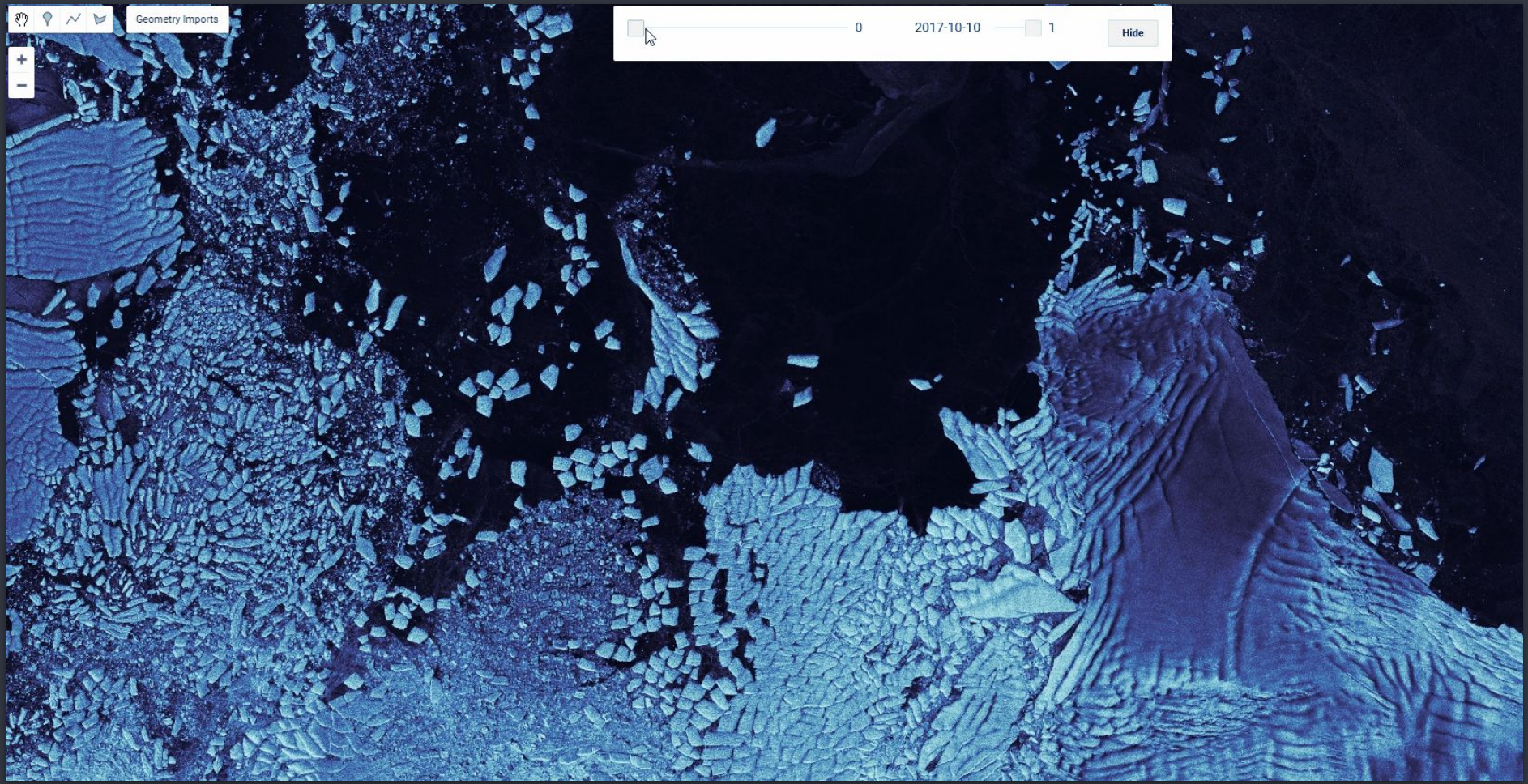
Report a map error

Code

Examples

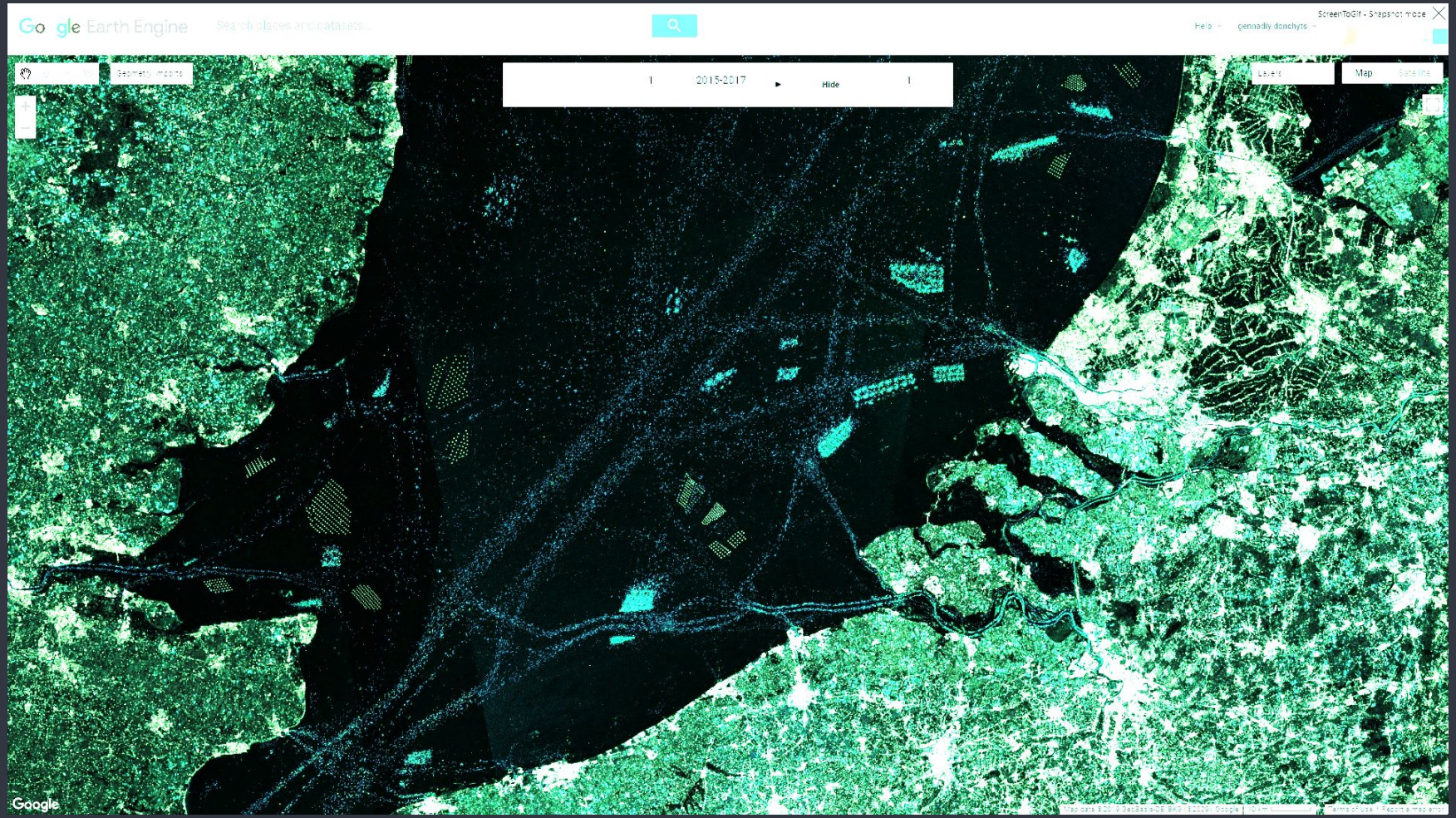

1984


1984

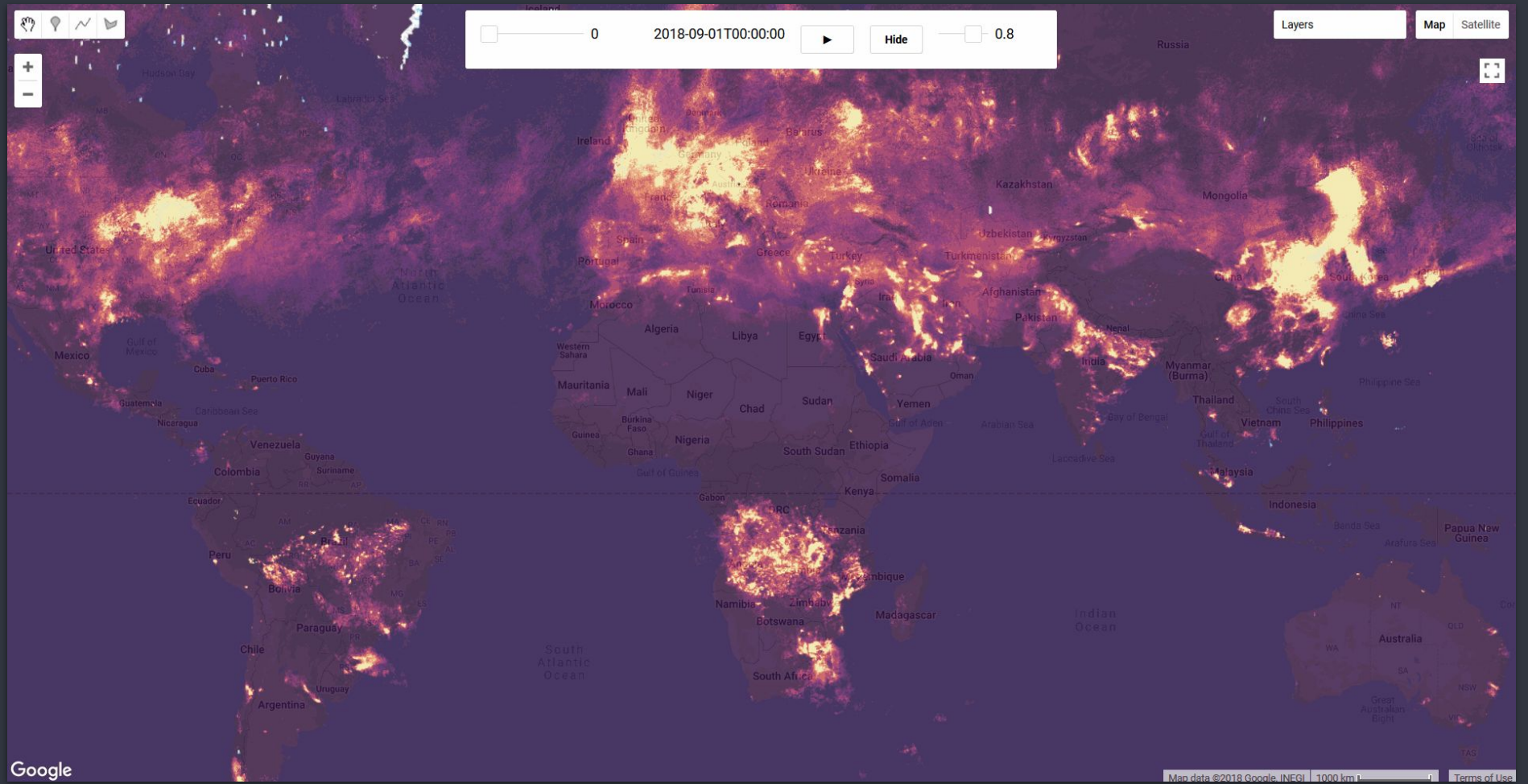


ESA Sentinel-1, ice advection

Code



ESA Sentinel-1, annual high percentile backscatter over, North Sea

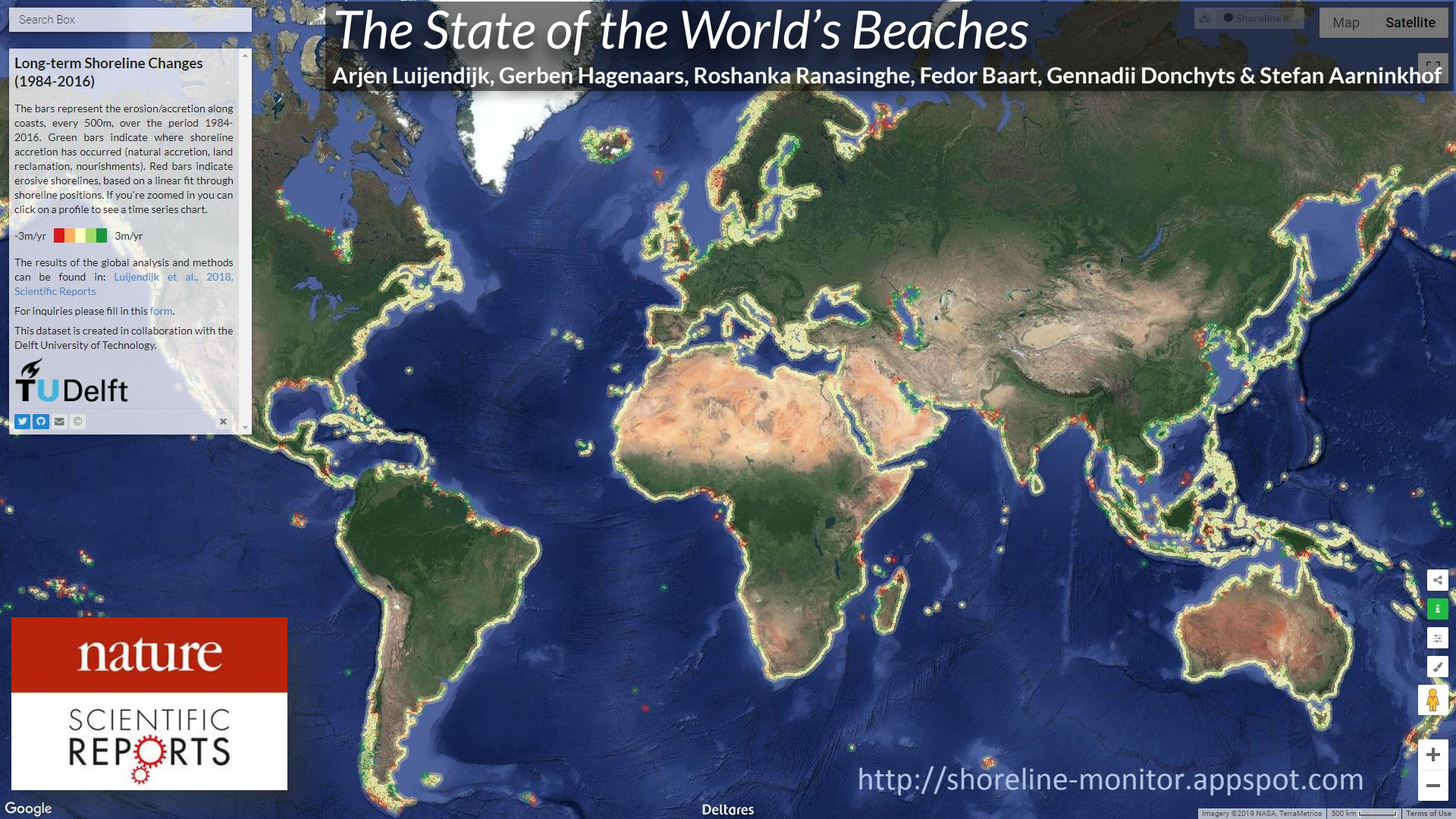


ESA Sentinel-5, NO2 concentration

See also: https://gena.users.earthengine.app/view/no2

Code


Search Box
Surface water changes (1985-2017)
Green and blue colors represent areas where surface water changes occured during the last 30 years. Green pixels show where surface water has been turned into land (accretion, land reclamation, droughts). Blue pixels show where land has been changed into surface water (erosion, reservoir construction).
The results of the analysis are published in:
Donchyts et.al, 2016, Nature Climate Change
Powered by
Google Earth Engine
Earth's surface water change over the past 30 years
Gennadii Donchyts, Fedor Baart, Hessel Winsemius, Noel Gorelick, Jaap Kwadijk & Nick van de Giesen
Map
Satellite
nature climate change
http://aqua-monitor.appspot.com
Google
Deltares
Imagery ©2018 NASA, TerraMetrics
500 km
Terms of Use


Search Box
Long-term Shoreline Changes (1984-2016)
The bars represent the erosion/accretion along coasts, every 500m, over the period 1984-2016. Green bars indicate where shoreline accretion has occurred (natural accretion, land reclamation, nourishments). Red bars indicate erosive shorelines, based on a linear fit through shoreline positions. If you're zoomed in you can click on a profile to see a time series chart.
-3m/yr
3m/yr
The results of the global analysis and methods can be found in: Luijendijk et al., 2018, Scientific Reports
For inquiries please fill in this form.
This dataset is created in collaboration with the Delft University of Technology.
TU Delft
The State of the World's Beaches
Arjen Luijendijk, Gerben Hagenaars, Roshanka Ranasinghe, Fedor Baart, Gennadii Donchyts & Stefan Aarninkhof
Shoreline
Map
Satellite
nature
SCIENTIFIC REPORTS
http://shoreline-monitor.appspot.com
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500 km
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waterbodies | Earth Engine Apps

Secure | gena.users.earthengine.app/view/waterbodies

Earth Engine Apps Experimental

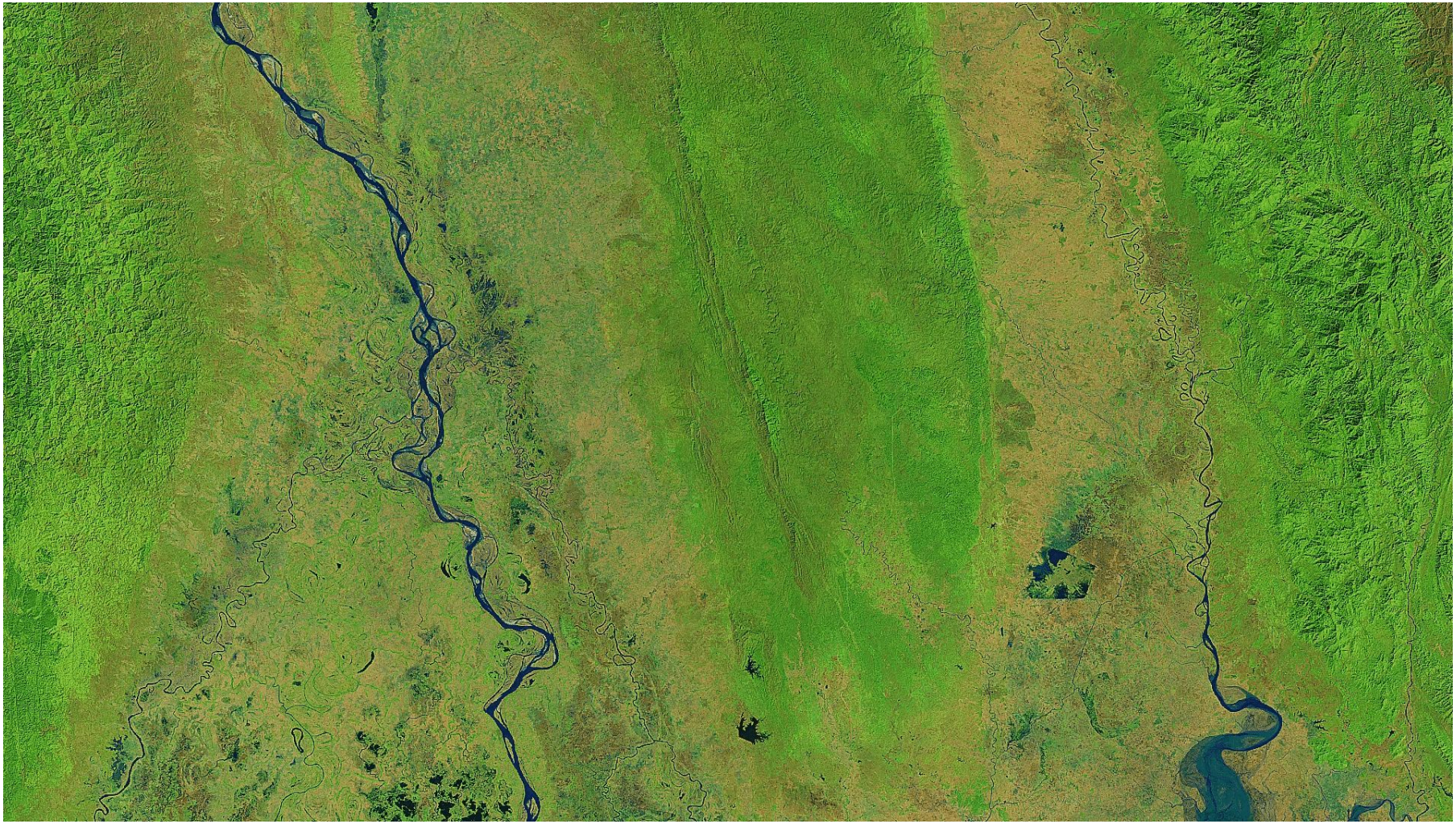
Search places

Monitoring Earth's Reservoirs

$N_{estimated} > 800\,000$

$N_{mapped} = 145\,000$

Google



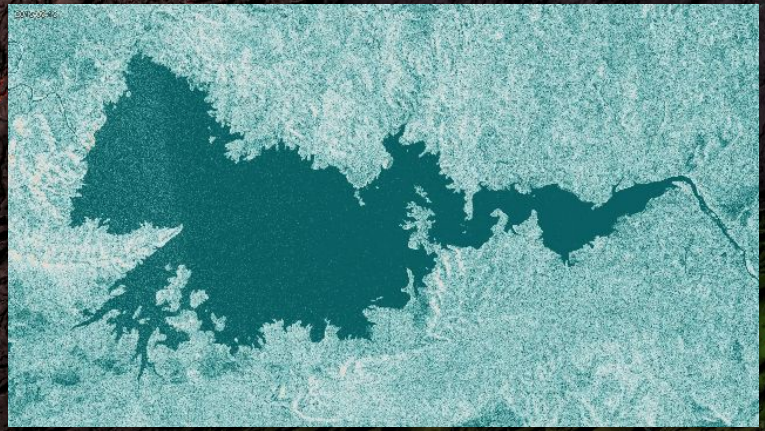
Earth Engine Apps Experimental

Search places

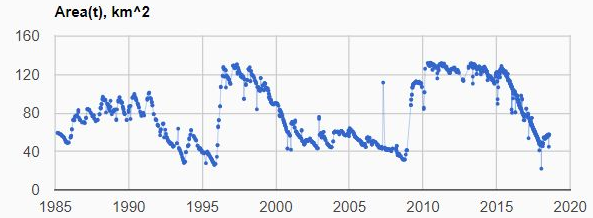
The Guardian International edition

'Day zero' water crises: Spain, Morocco, India and Iraq at risk as reservoirs shrink

A new early warning satellite system reveals countries where shrinking reservoirs could lead to the taps completely drying up Link



Al Massira Al Massira Dam MOROCCO, file: water_area_00076.geojson

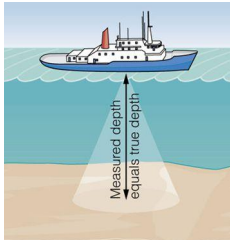


Google

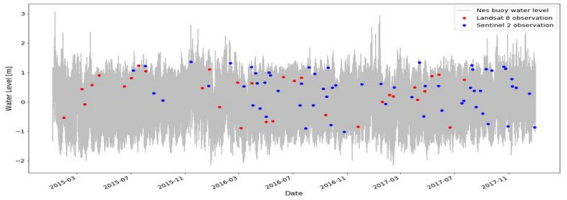
Map data ©2018 Google 20 km Terms of Use

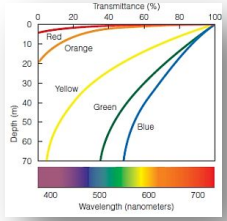
Satellite-derived Bathymetry (SDB)

Rijkswaterstaat
Ministerie van Verkeer en Waterstaat



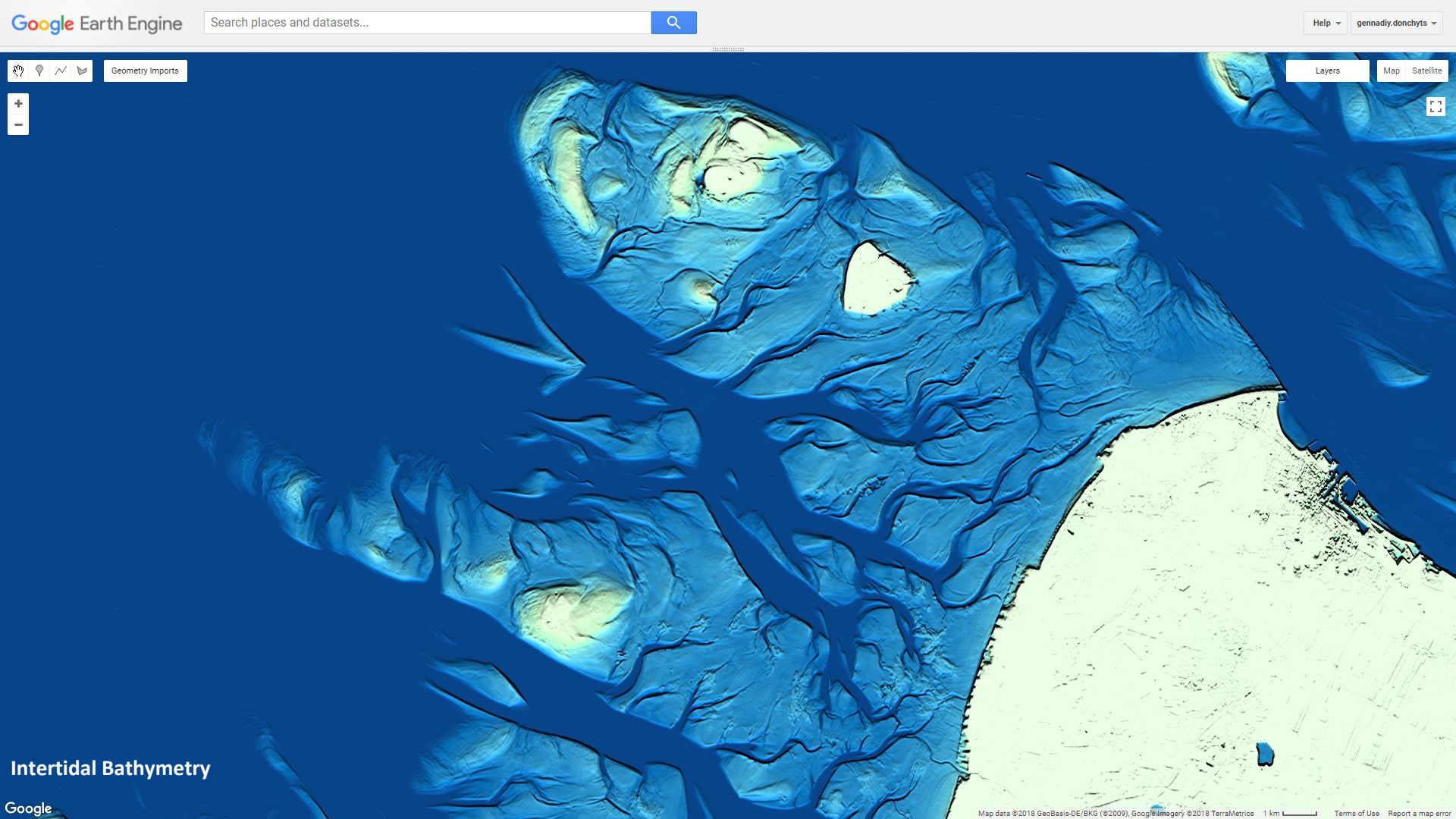
In-situ measurements





Derived from satellites


2017-01-03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Geometry Imports
Layers
Map
Satellite
Intertidal Bathymetry
Google
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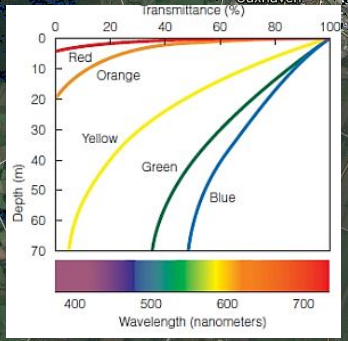
Geometry Imports

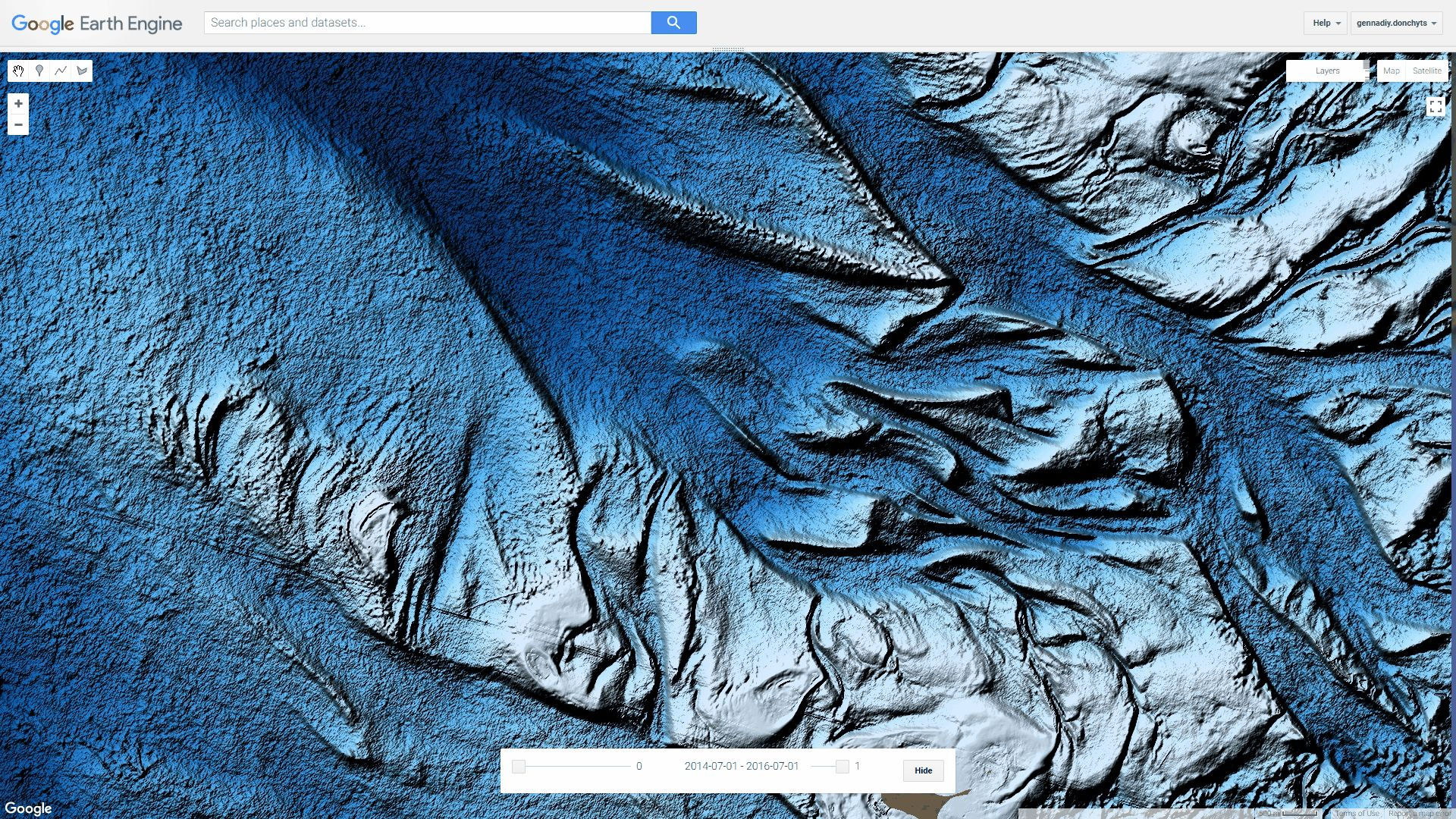
Layers
Map
Satellite

$$D = E[d] = \sum d \cdot w(f_{clouds}, x, y, t)$$

$$d = log(\rho - \rho_{deep})$$

Inverse-depth bathymetry

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Technical Concepts

Contents lists available at ScienceDirect

Remote Sensing of Environment

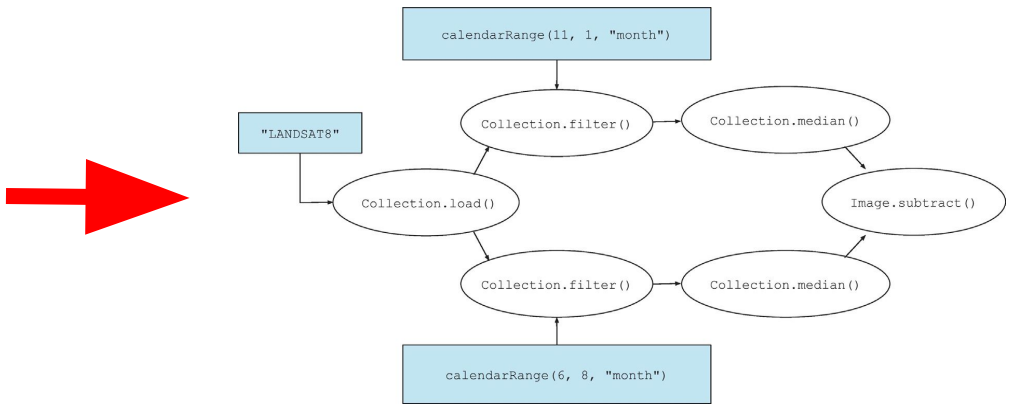
journal homepage: www.elsevier.com/locate/rse

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]

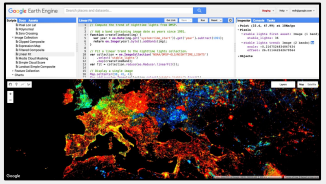
https://www.sciencedirect.com/science/article/pii/S0034425717302900

```
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())
```



open source

closed source



Earth Engine Code Editor

Third-party Web Apps

Client Libraries
(JavaScript / Python)

Web REST APIs

On-the-Fly Computation

Front Ends

Compute Masters

Compute Servers

Caches

Batch Computation

Data Stores

Fusion Tables

Tilestore Servers

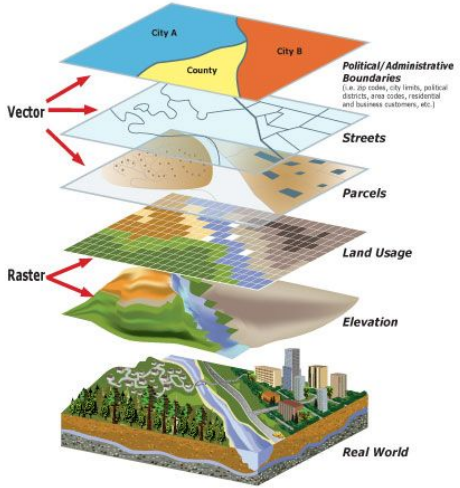
Asset Database

Storage

Compute

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 ...



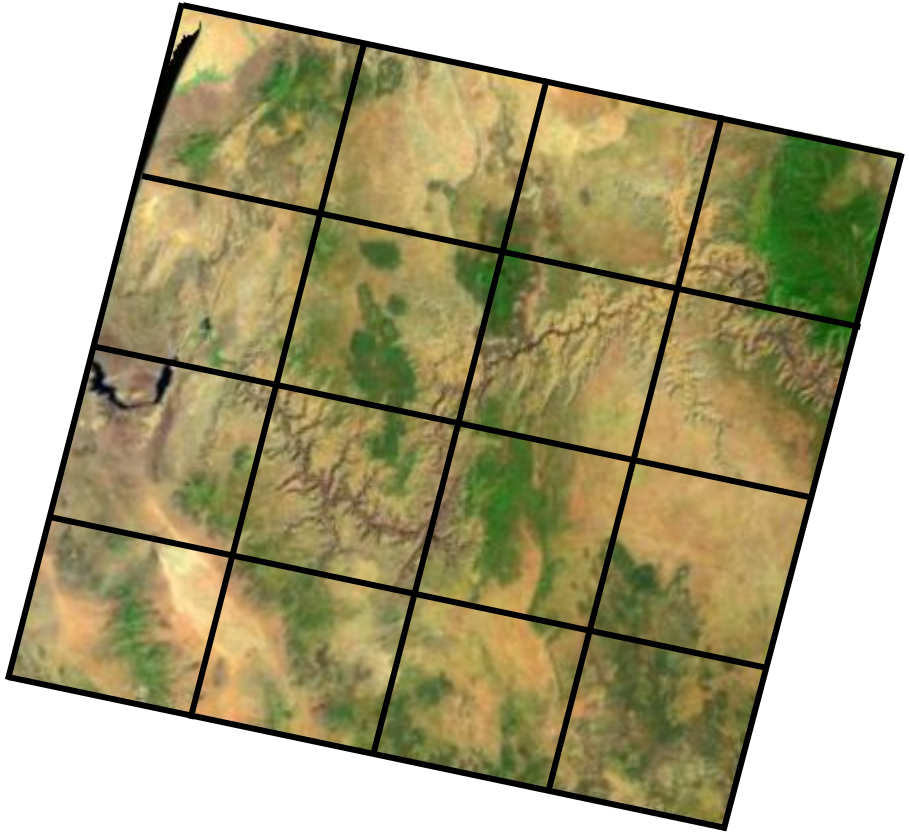
over 1000 data types and operators, and growing!

Tiling

Images are tiled during ingestion

Tiling

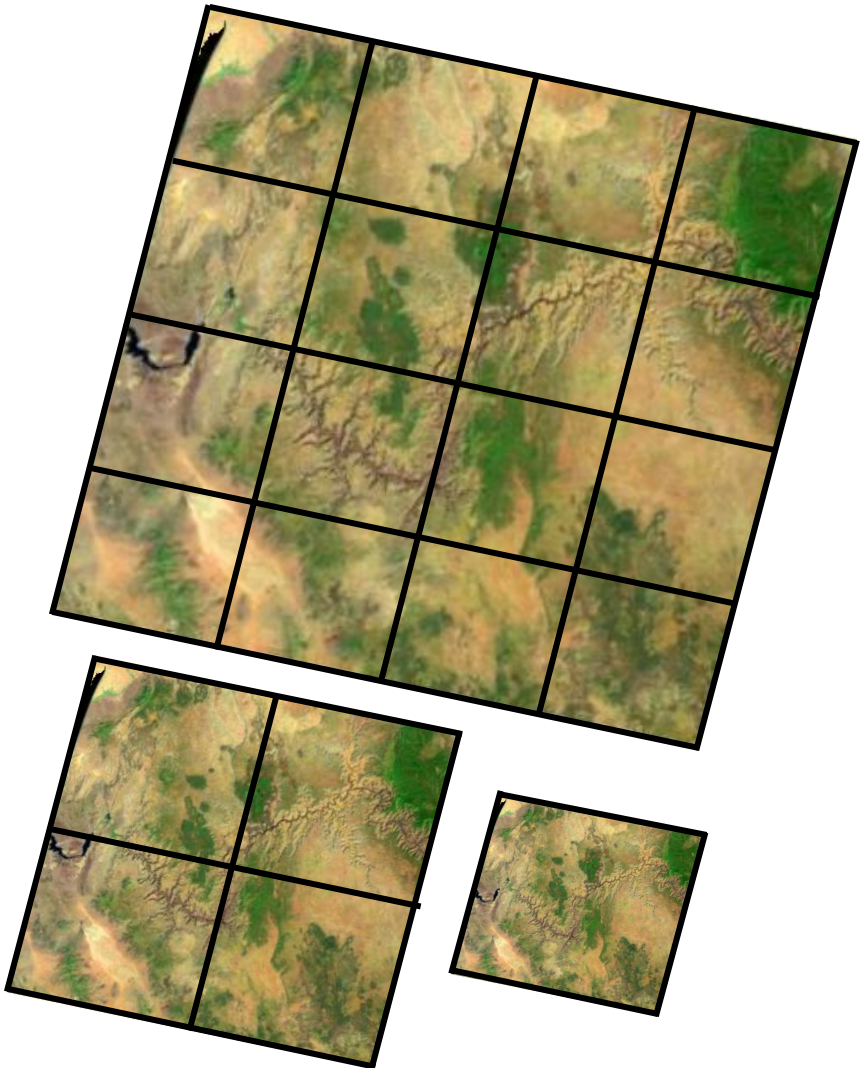
Images are tiled during ingestion



Tiling

Images are tiled during ingestion

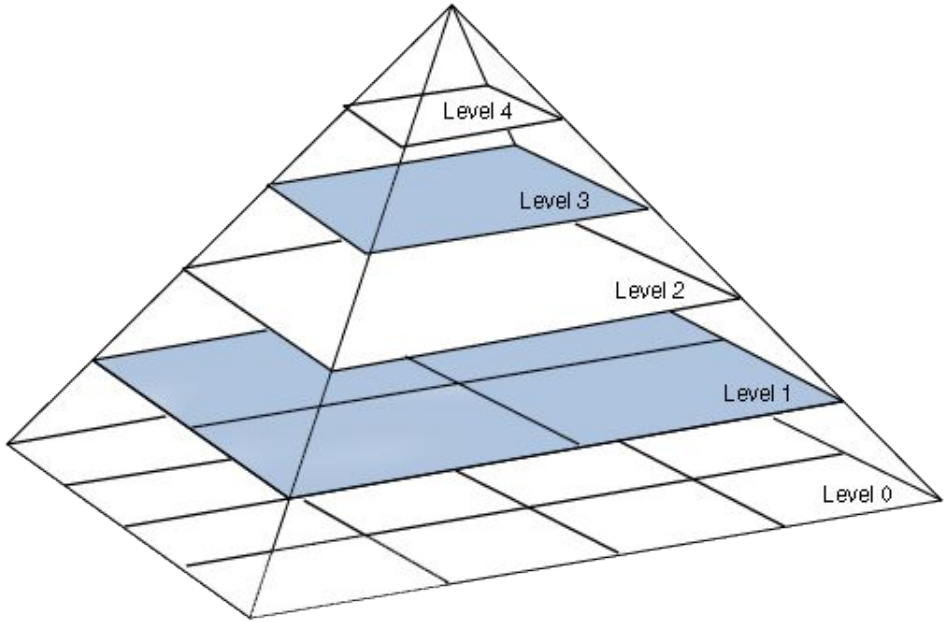
Downsampled by averaging



Tiling

Images are tiled during ingestion

Downsampled by averaging

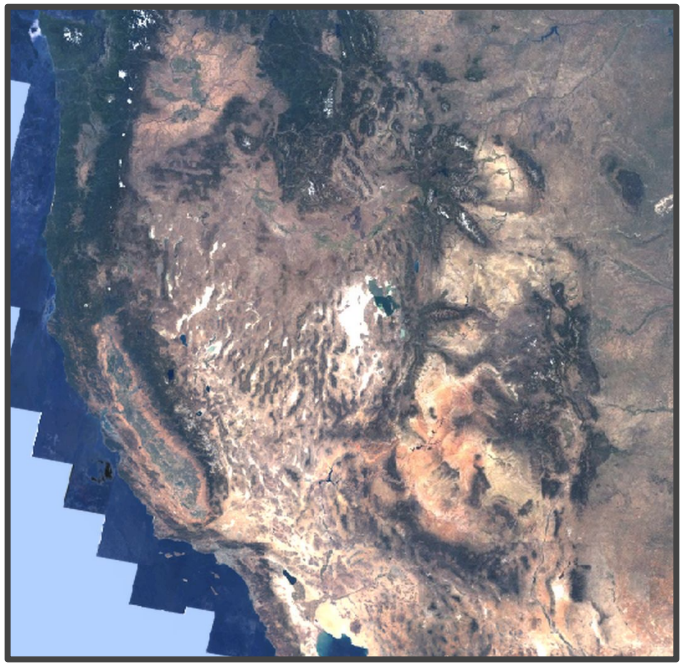


Tiling

Images are tiled during ingestion

Downsampled by averaging

During computation



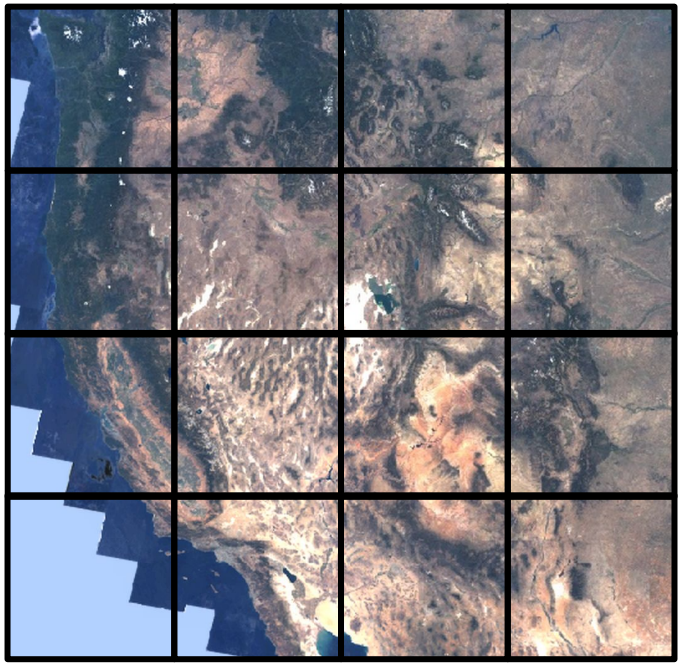
Tiling

Images are tiled during ingestion

- Downsampled by averaging

During computation

- Compute output tiles



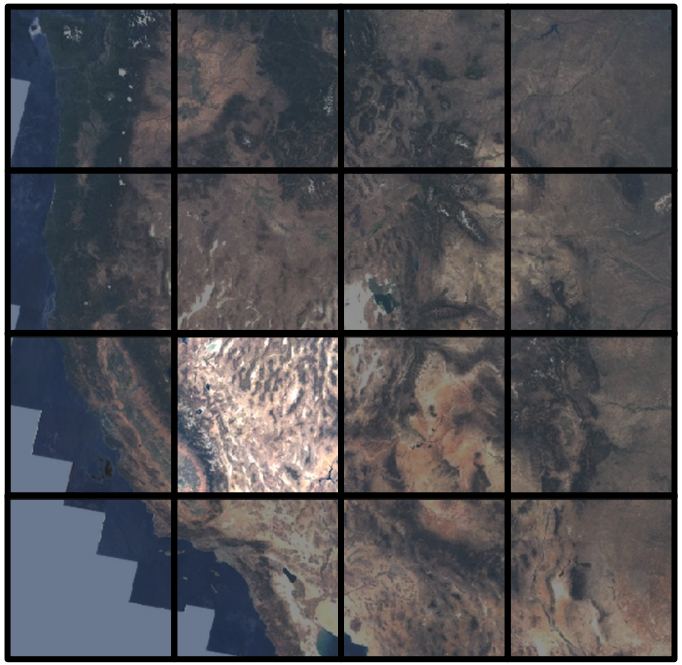
Tiling

Images are tiled during ingestion

- Downsampled by averaging

During computation

- Compute output tiles



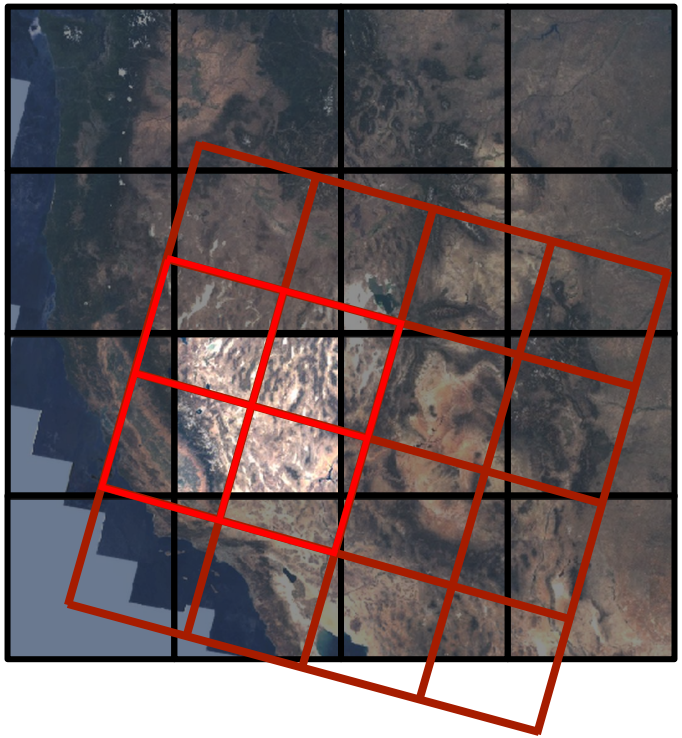
Tiling

Images are tiled during ingestion

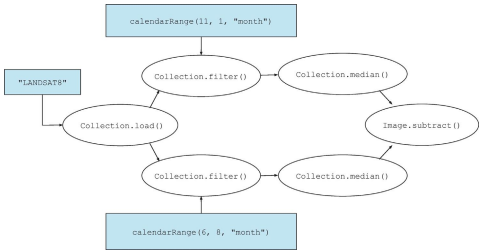
- Downsampled by averaging

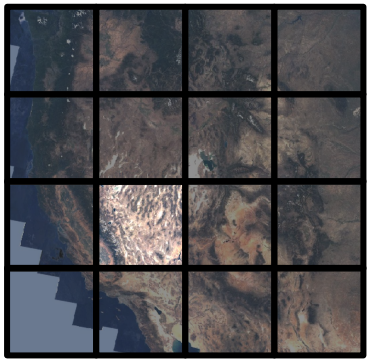
During computation

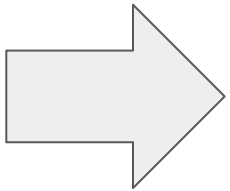
- Compute output tiles
- Find intersecting source tiles
- Reproject into the output projection

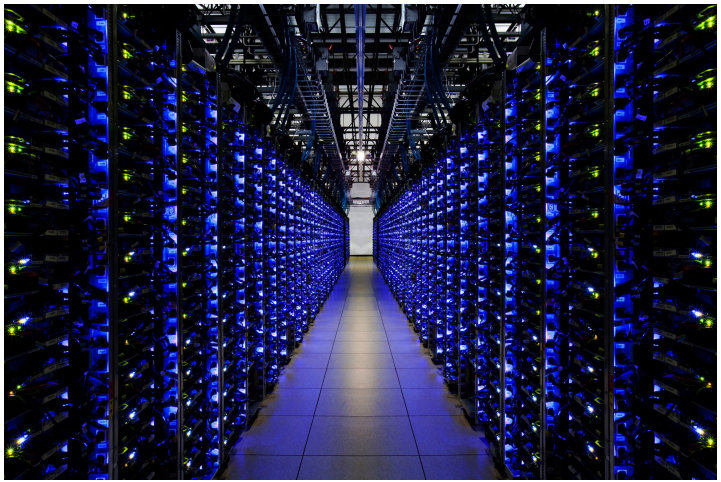


Running a Computation





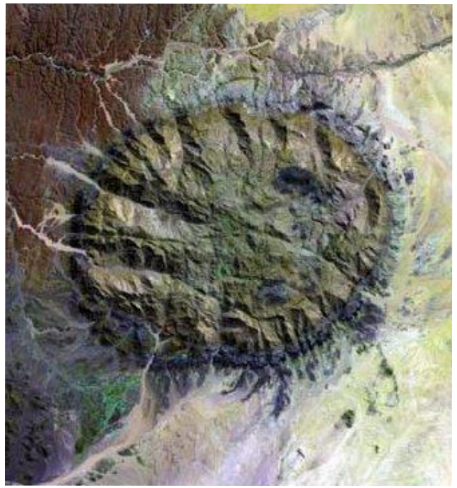




What can Earth Engine do?

Get an image

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



https://code.earthengine.google.com/3bad1c478bf03e734c17cd5e84cd35e5 - L8
https://code.earthengine.google.com/6cc52fed9c5c74833c00e921a0e1c71e - S2

What can Earth Engine do?

- Get an image
- Apply an algorithm to an image

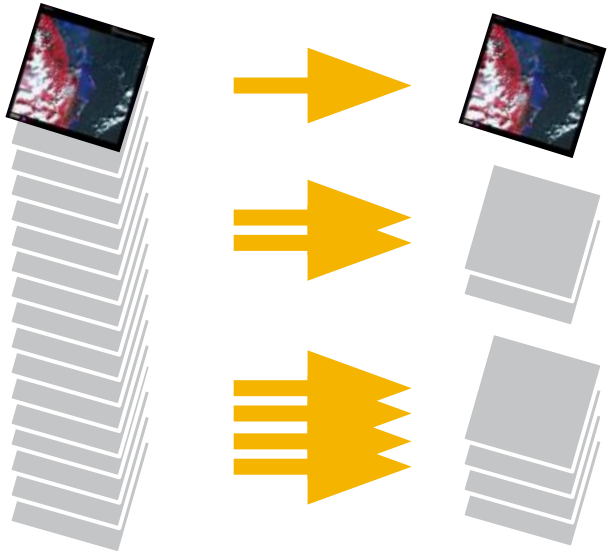
Use library functions or script your own

https://code.earthengine.google.com/3f5c46b69dd3c183aa83c32e2ffdbdfa - NDWI

What can Earth Engine do?

- Get an image
- Apply an algorithm to an image
- Filter a collection

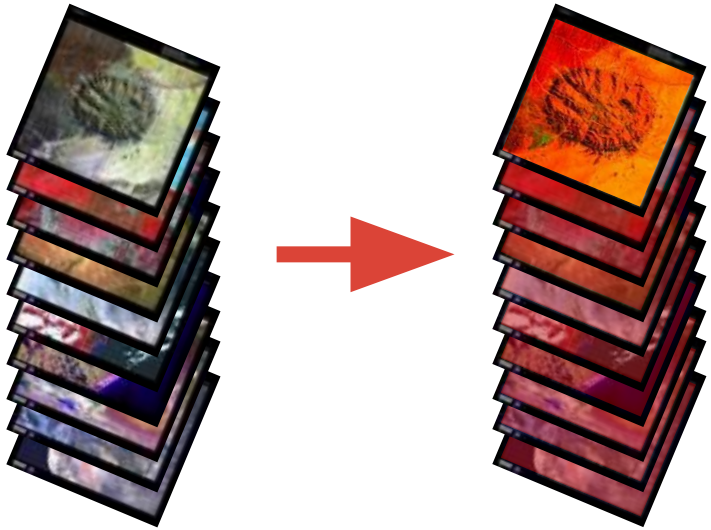
  Time, Space & Metadata Search



What can Earth Engine do?

- Get an image
- Apply an algorithm to an image
- Filter a collection
- Map an algorithm over a collection

$N \rightarrow N$

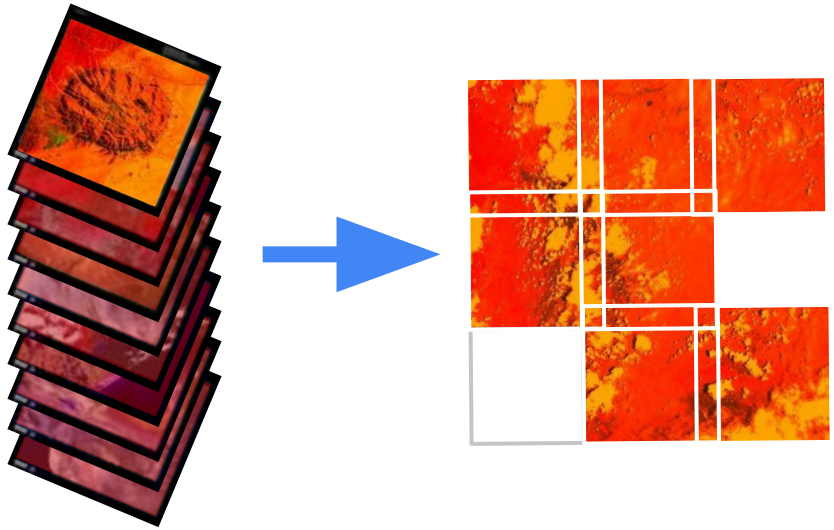


https://code.earthengine.google.com/4b79939690eb5430f162edae5d95b4bd

What can Earth Engine do?

- Get an image
- Apply an algorithm to an image
- Filter a collection
- Map an algorithm over a collection
- Reduce a collection

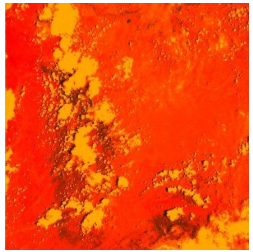
$N \rightarrow 1$ or $N \rightarrow M$

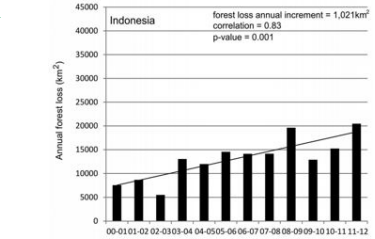


https://code.earthengine.google.com/894611dbb0f1f822c1db4158ebedaa33

What can Earth Engine do?

- Get an image
- 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

https://code.earthengine.google.com/93d8cd51b08ac2bde42a2aae7010f41a

Reducers in Earth Engine

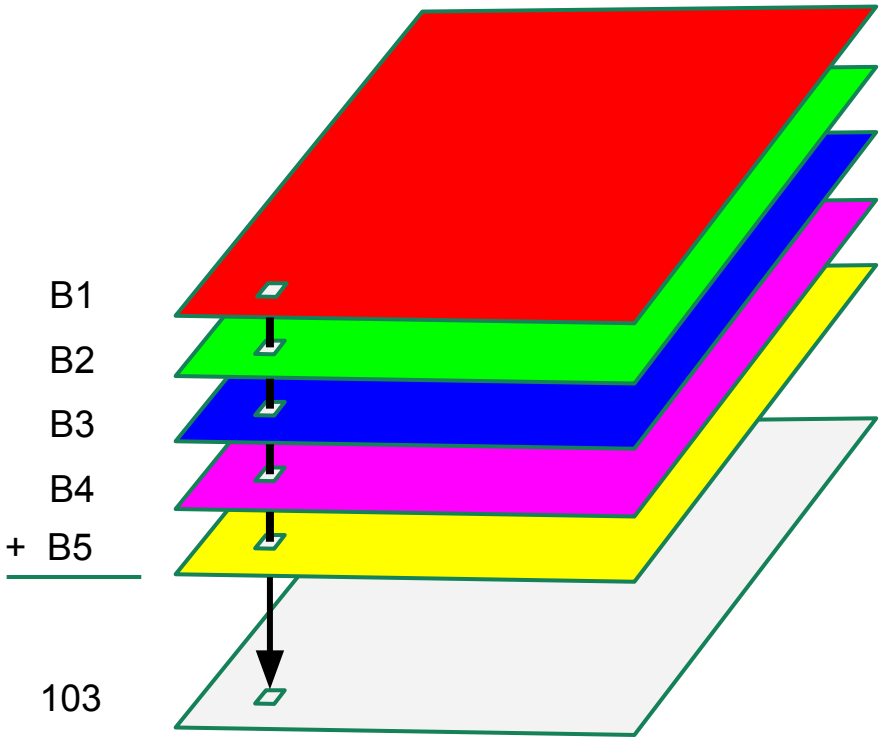
8 ways to reduce

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

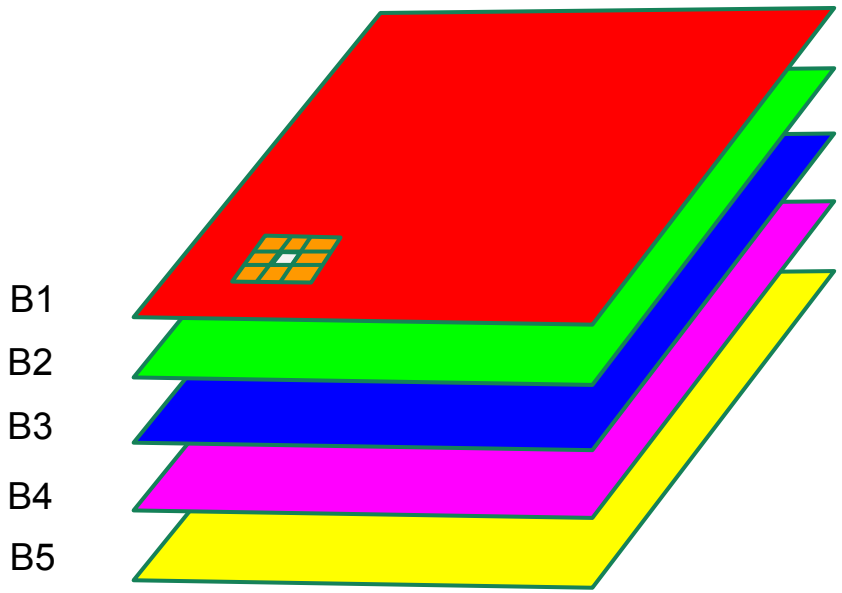
40+ reducers

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

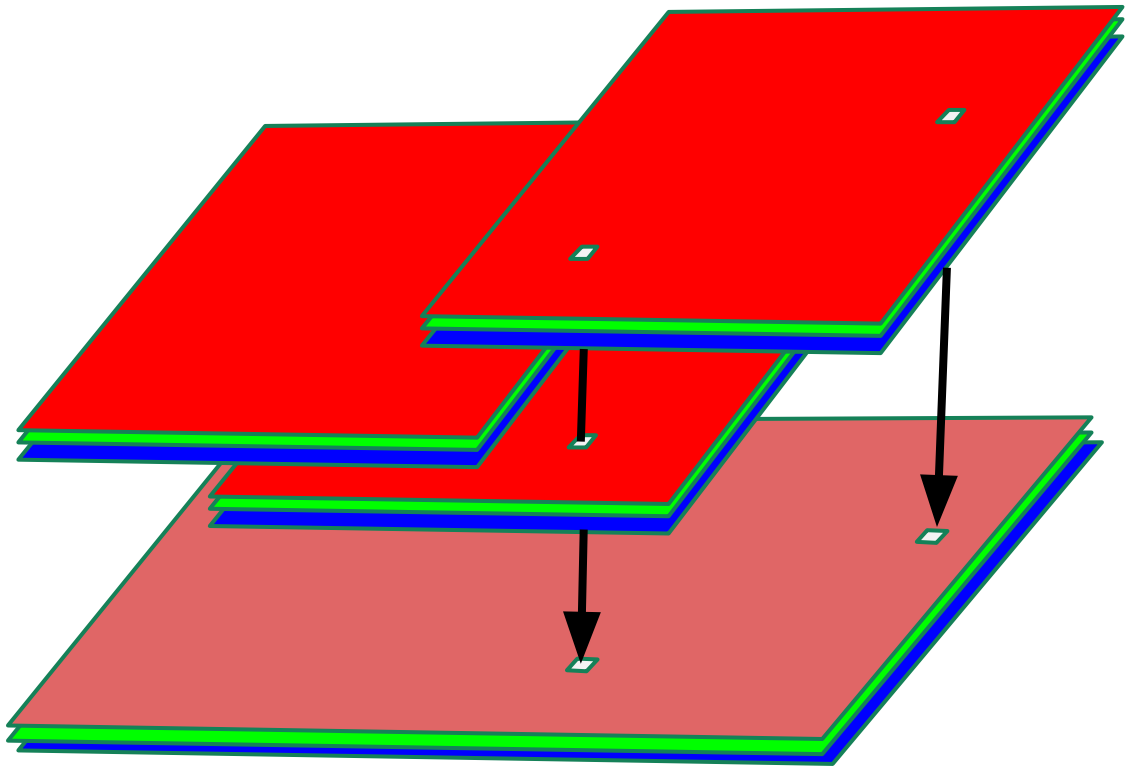
Reduce Bands



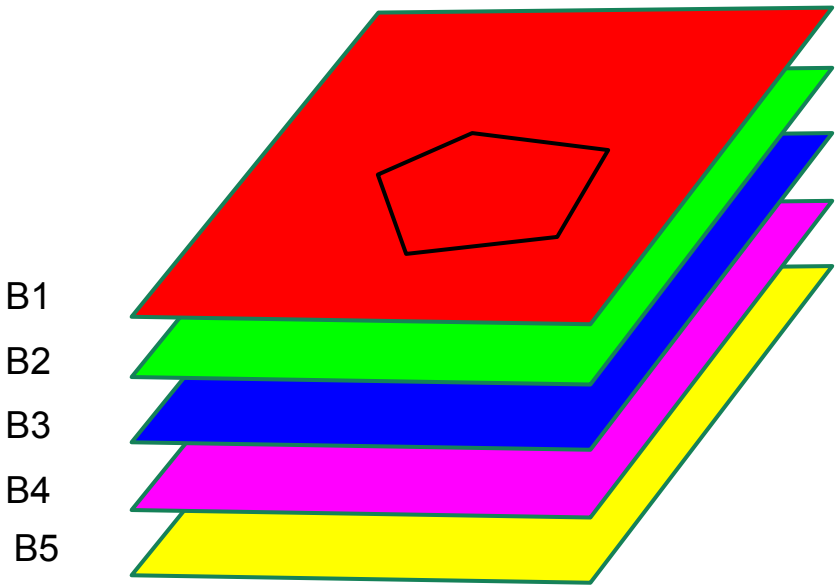
Reduce Neighborhood



Reduce Image Collection

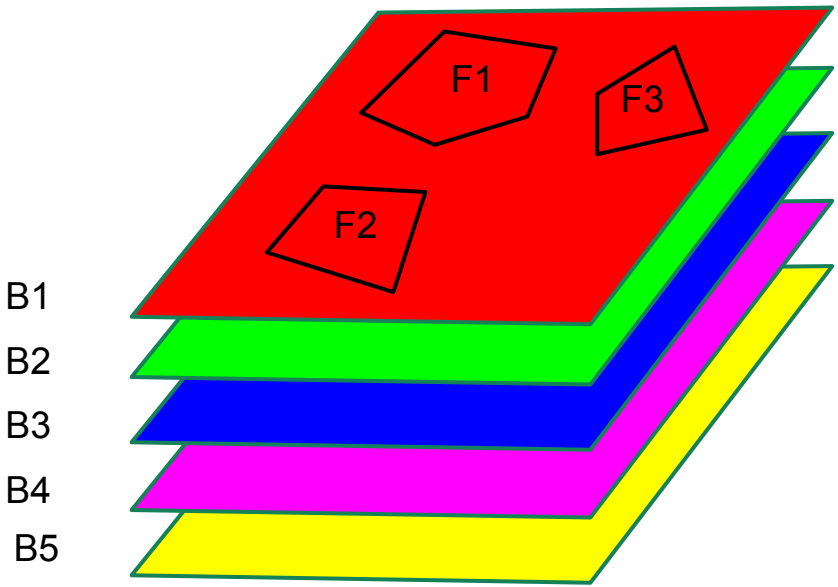


Reduce Region



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

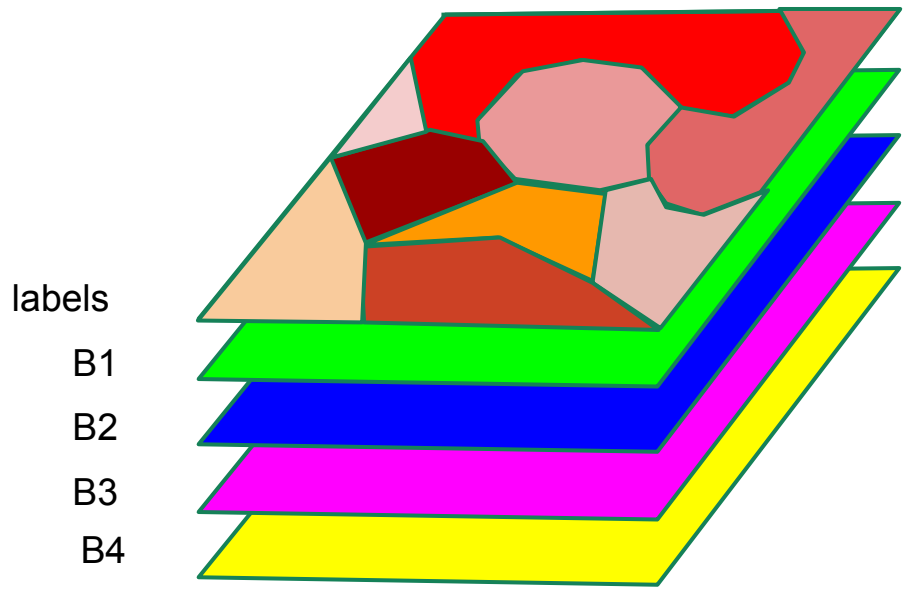
Reduce Regions



FeatureCollection

	B1	B2	B3	B4	B5
F1					
F2					
F3					

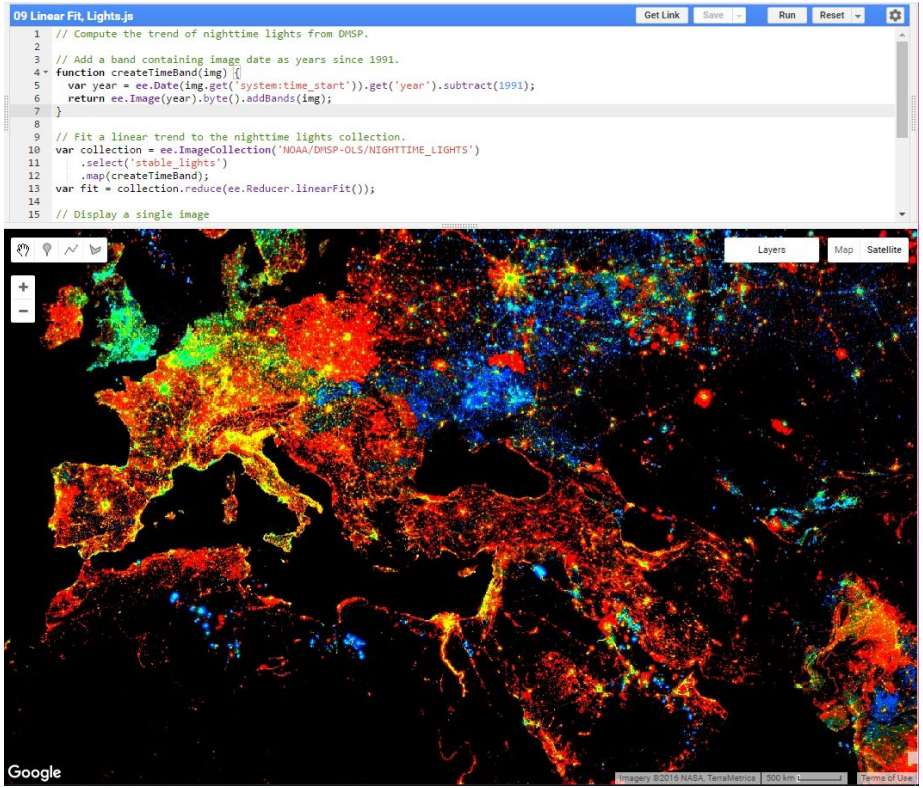
Reduce To Vectors



FeatureCollection

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

Linear Fit (lights)



$$p_t = \beta_0 + \beta_1 t + e_t$$

p_t = light at time t
t = time
e_t = random error

https://code.earthengine.google.com/5aa8ec2993d9052aafed234ee850c6e6

Do’s and Don’ts

- Processing Big Data (~PT)
- Time-dependent raster processing
- Collaborative
- Scales!
- Think functional
- Quick prototyping with Apps
- Huge data catalog (~50PB)
- Python API or ee-runner for batching

- Slow for small geoprocessing tasks (roundrip)
- Blackbox back-end
- Mainly Image and Feature
- Steep learning curve
- ES5
- Limited access to external resources from EE
- Only Shapefile ingestions
- Very limited Apps UI library

The End!