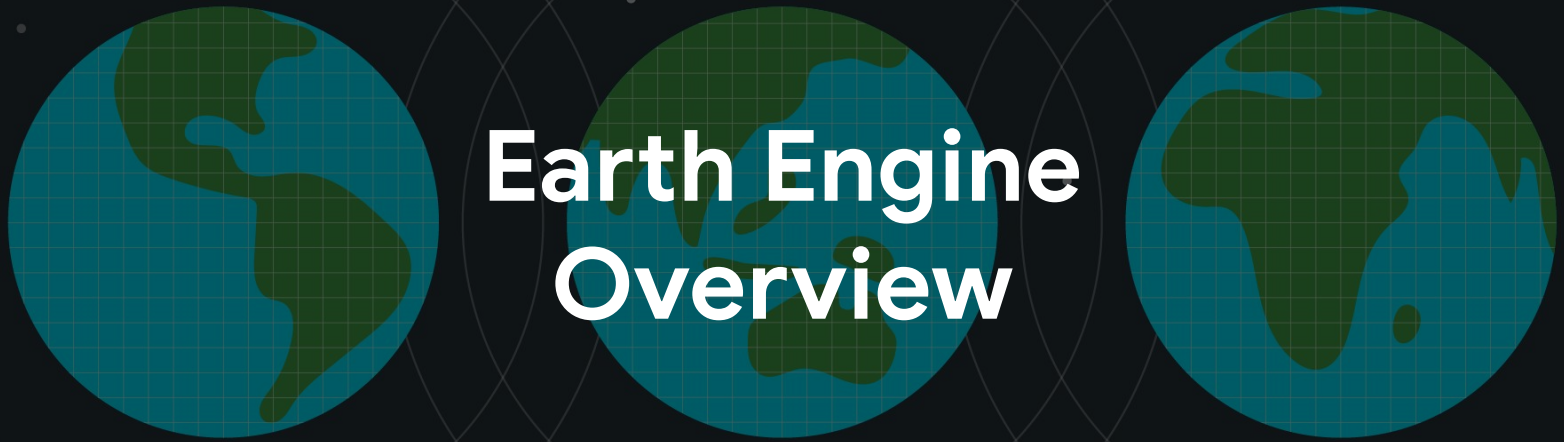
Google

#GeoForGood19

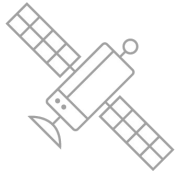


Earth Engine Overview

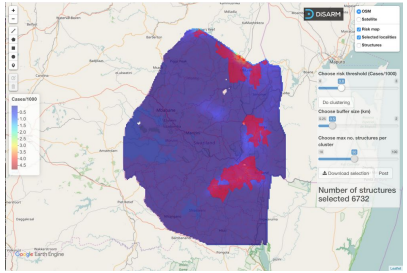
Michael DeWitt
Sr. Software Engineer,
Google Earth Engine

#GeoForGood19

At a high level...

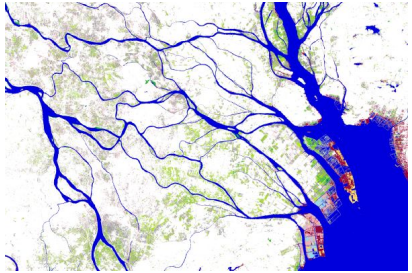


- Why build Earth Engine?
- What have we made?
- How do people use it?
- A brief peek under the hood
- Where is it going?



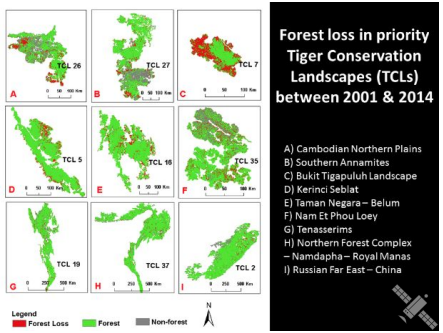
Infectious disease

In order to make progress on global problems, researchers and decisionmakers need to be able to ask questions of increasingly large and complex geospatial datasets.

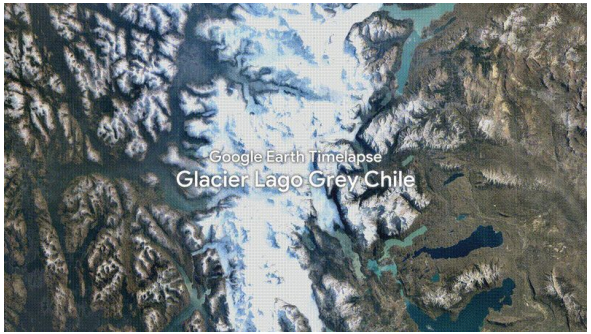


Access to water

Deforestation

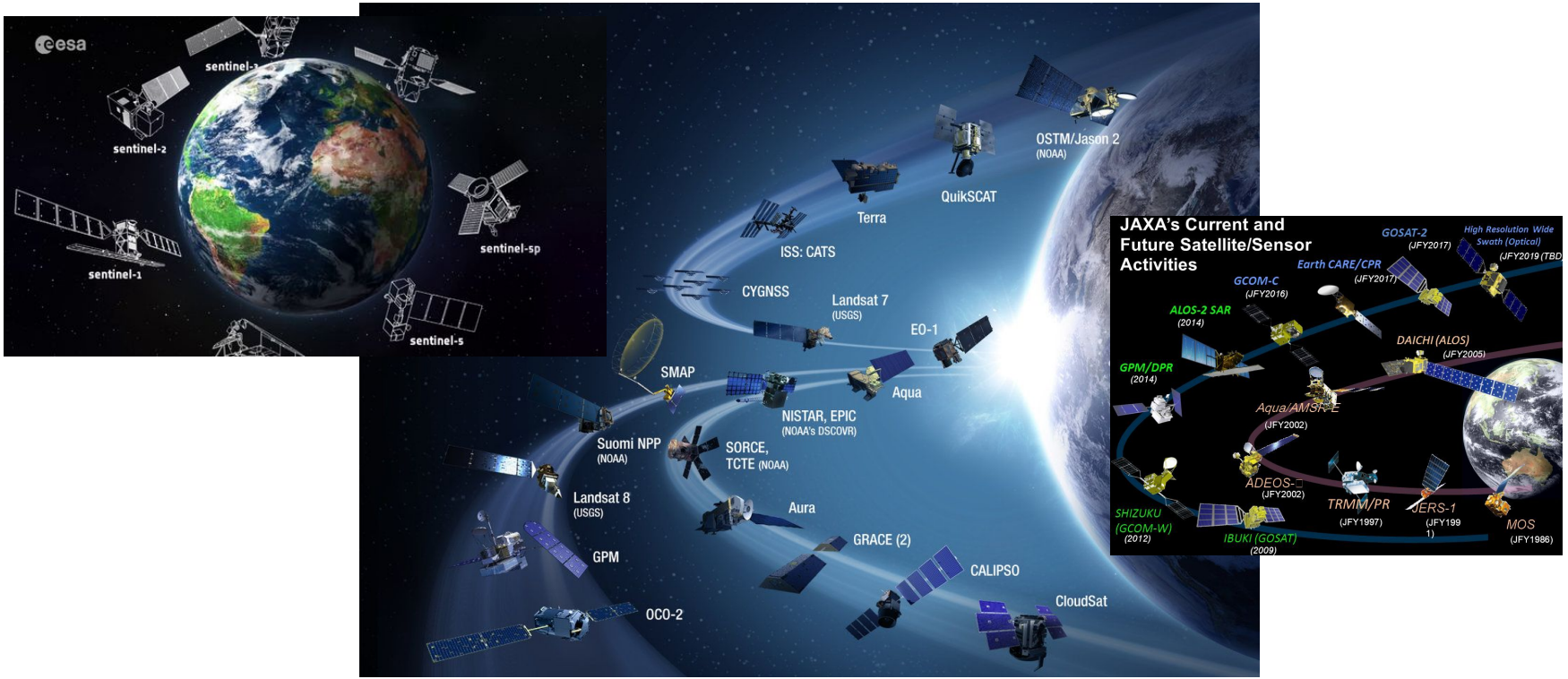


Threats to biodiversity

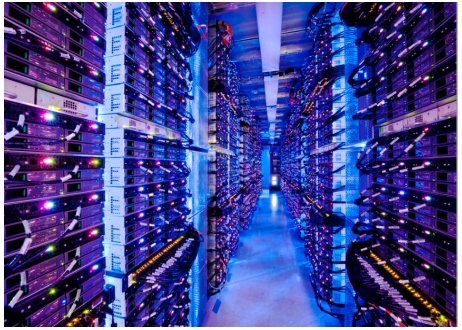


Climate change

There are a lot of data to manage.



Using these datasets requires lots of computational power.



Goodchild et al. (2012):

PNAS

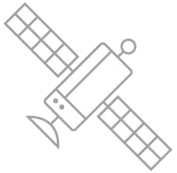
Next-generation Digital Earth

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.**"

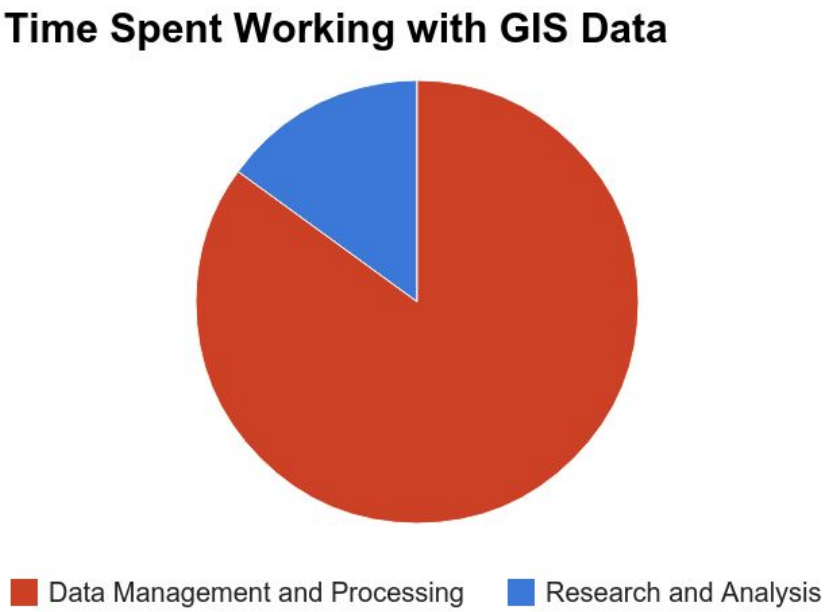
Why is Earth Engine?

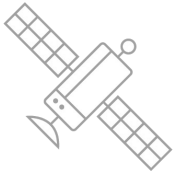


There are many domains where theory has outpaced the practical scale of applications; in essence, progress is limited by access to scalable IT.

State of the Art

Researchers spend a majority of their their time doing "**IT work**."



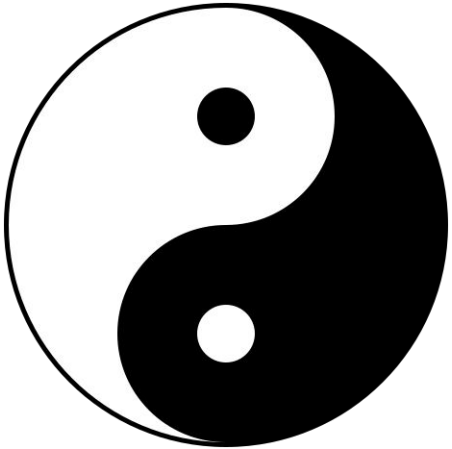


A Better Way

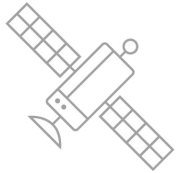
"Often it turns out to be more efficient to move the questions than to move the data."

- Jim Gray

Ideally, the data and the computational infrastructure would be colocated, and there would be an easy way to use them to derive knowledge.



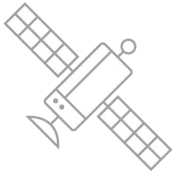
Why is Google?



Our mission is to organize the world's information and make it universally accessible and useful.

https://about.google/intl/en/

Why is Earth Engine?



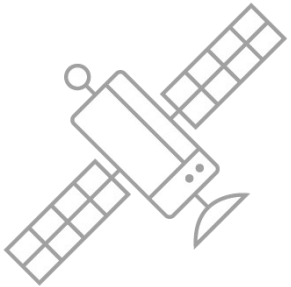
geospatial

Our mission is to organize the world's information and make it universally accessible and useful.

https://about.google/intl/en/

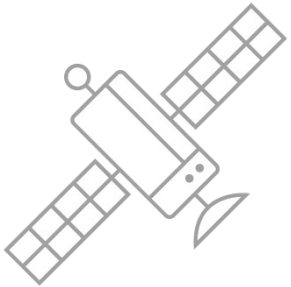
What are our goals?

- Build the world’s most advanced platform for geospatial data analysis.
- Seamlessly integrate it into Google's products and services.
- Use it to make substantive progress on global challenges.



Earth Engine in Three Sentences

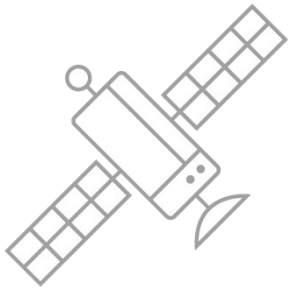
Earth Engine is Google's platform for doing scientific analysis of large-scale Earth data, including satellite imagery, census data, etc. It's composed of two big components: a **collection of scientific data**, and the **computational power** to effectively work with data at that scale.



The **Earth Engine API** is the interface through which scientists and researchers express the operations they'd like Earth Engine to perform.

Earth Engine in Three Sentences

Earth Engine is Google's platform for doing scientific analysis of large-scale Earth data, including satellite imagery, census data, etc. It's composed of two big components: a **collection of scientific data** (more than 25PB!), and the **computational power** to make sense of data at that scale.



The **Earth Engine API** is the interface through which scientists and researchers express the operations they'd like Earth Engine to perform.

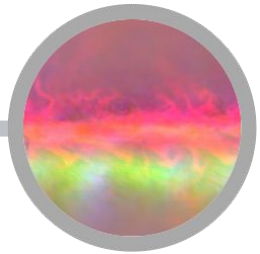
The Earth Engine Data Catalog

Landsat & Sentinel
10-30m, weekly

MODIS
250m daily

Vector Data
WDPA, TIGER, WHC

Terrain & Land Cover



Weather & Climate
NOAA NCEP, OMI, ...

... and upload your own vectors and rasters

600+ public datasets

29+ petabytes of data

100+ datasets added yearly

1+ PB of new data every month

API Client Libraries

API bindings for:

- JavaScript
- Python

Open-sourced on GitHub, PyPI, npm (and a growing list of others).

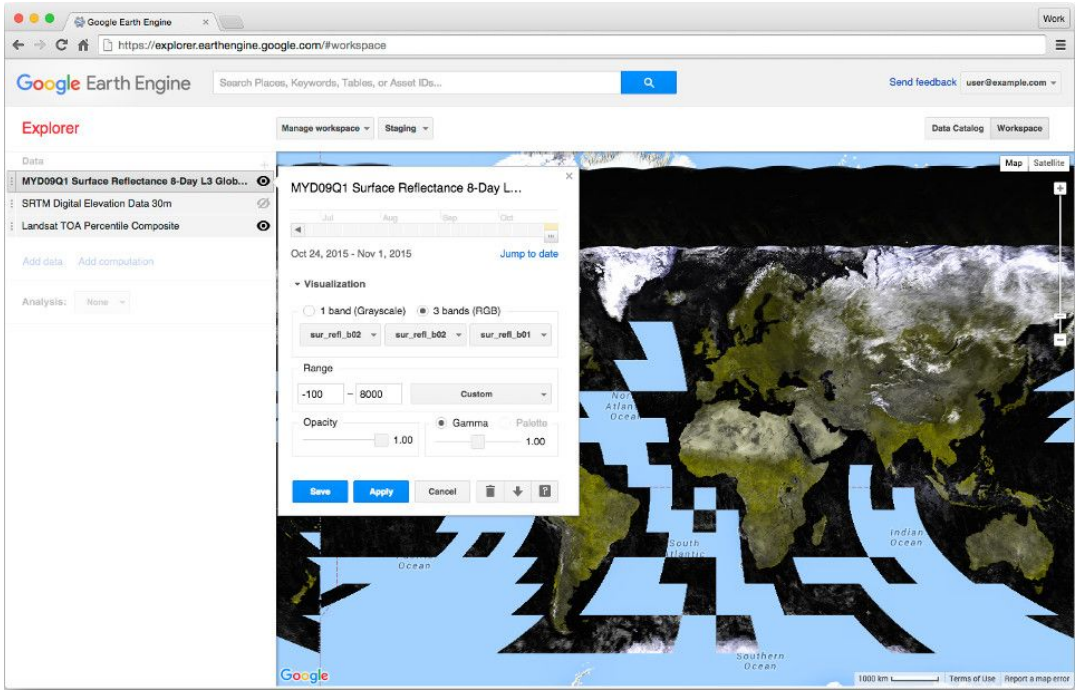
GitHub

github.com/google/earthengine-api

Earth Engine Explorer

A simple interface for performing visualization and classification tasks.

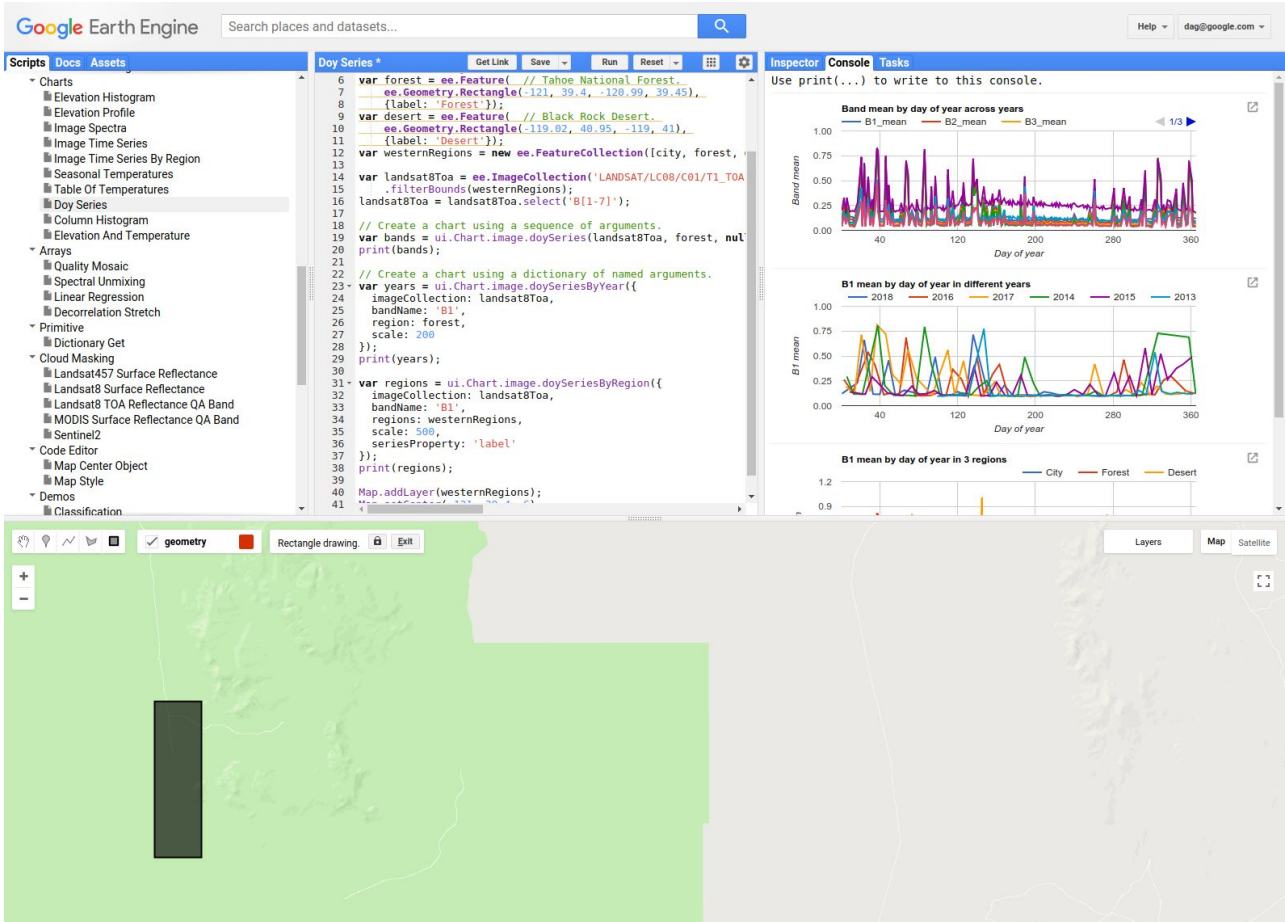
The Explorer drives a substantial portion of Earth Engine traffic.



The Code Editor

A web-based environment for:

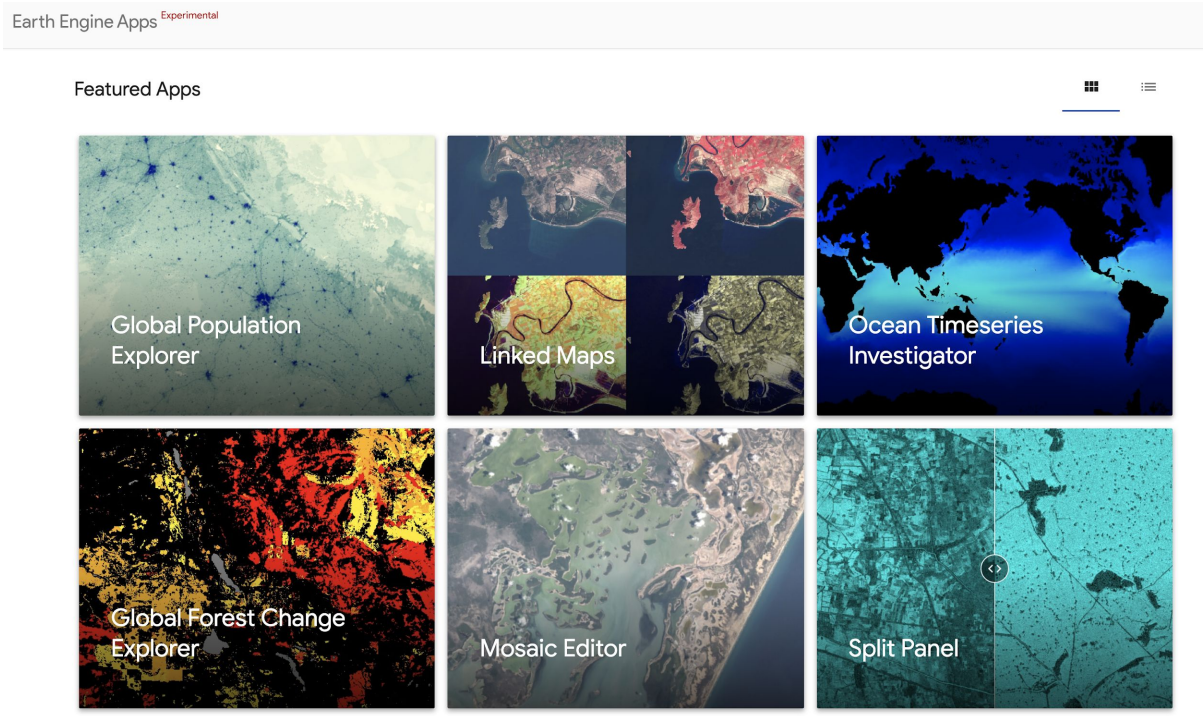
- performing analyses
- investigating datasets
- managing scripts, data
- building interactive tools



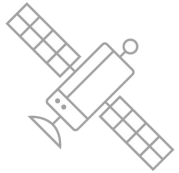
code.earthengine.google.com

Earth Engine Apps

EE Apps are "Code Editor" windows without the code. They enable EE users to create tools for *their* users.



Publications and Applications



Planetary-scale geospatial analysis for everyone (Gorelick, 2017)

Forest (Hansen, 2013)

Surface water (JRC, 2016)

Tidal flats (Murray, 2019)

More here.

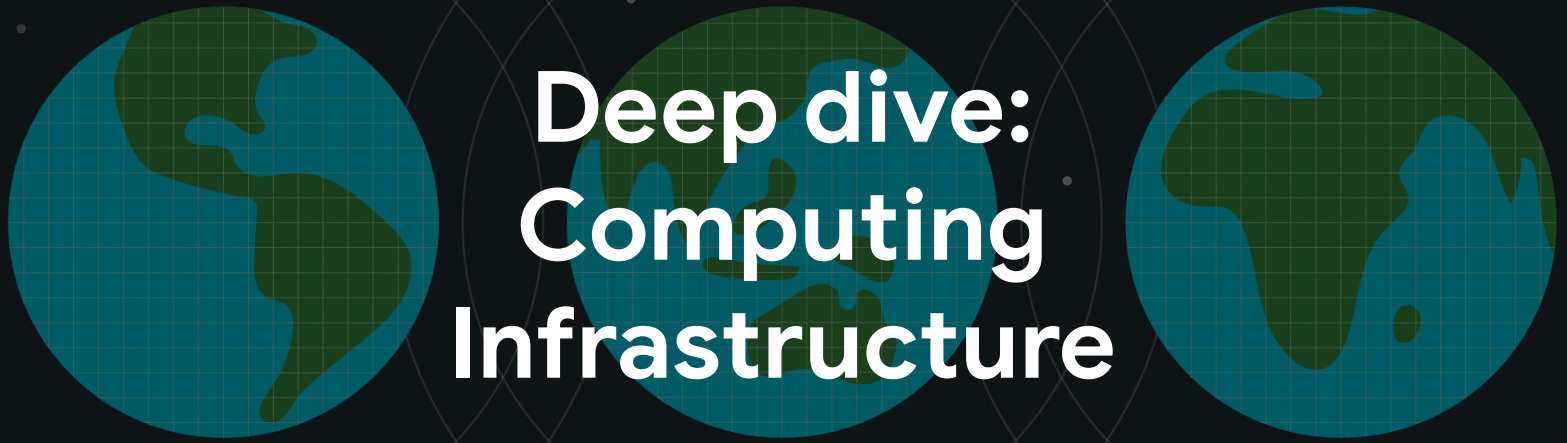
Timelapse

DiSARM

Global Forest Watch

Internal Google projects
- Google Earth
- Crisis Response

Live Demos



Deep dive: Computing Infrastructure

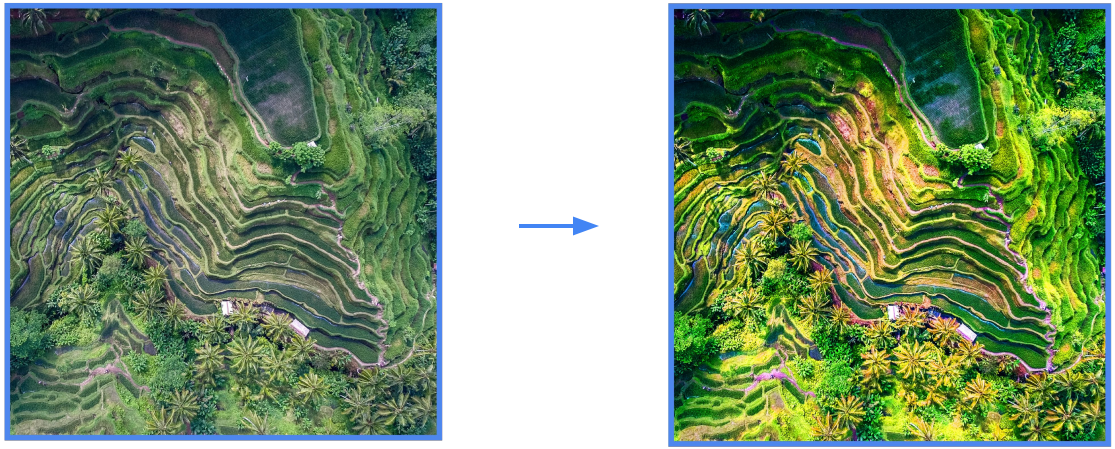
#GeoForGood19

Get an image

Pick your:

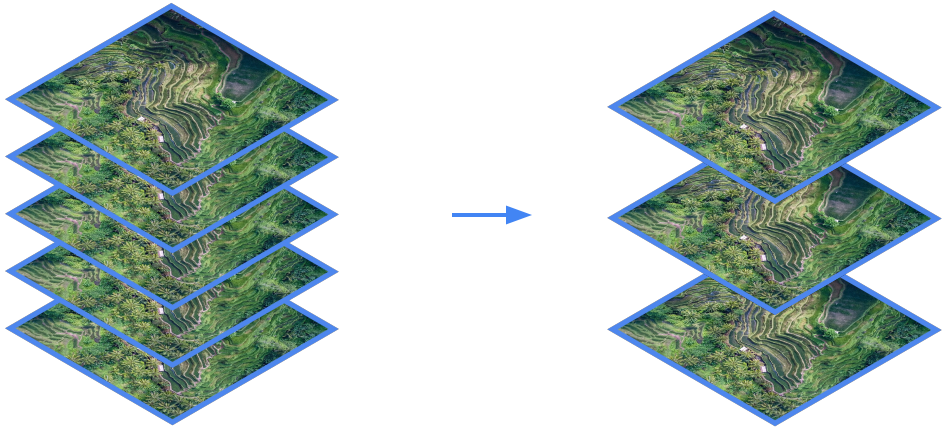
projection, resolution, bands, bounding-box, visualization

Apply an algorithm to an image



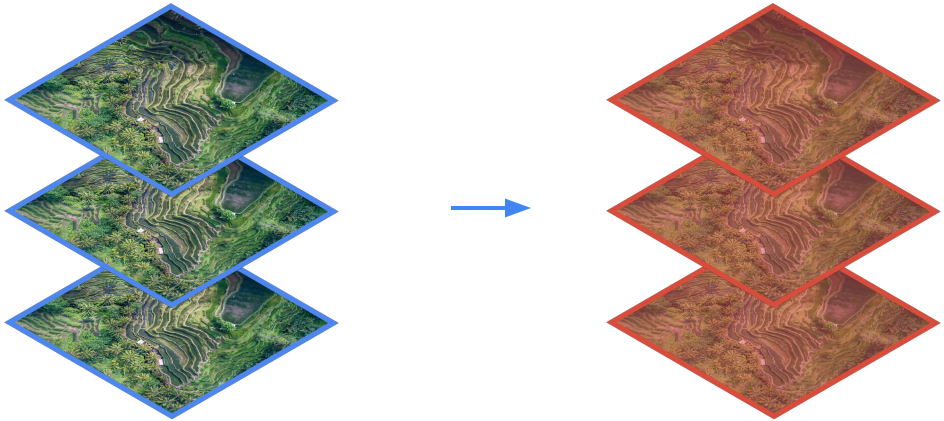
Use library functions or script your own

Filter a collection



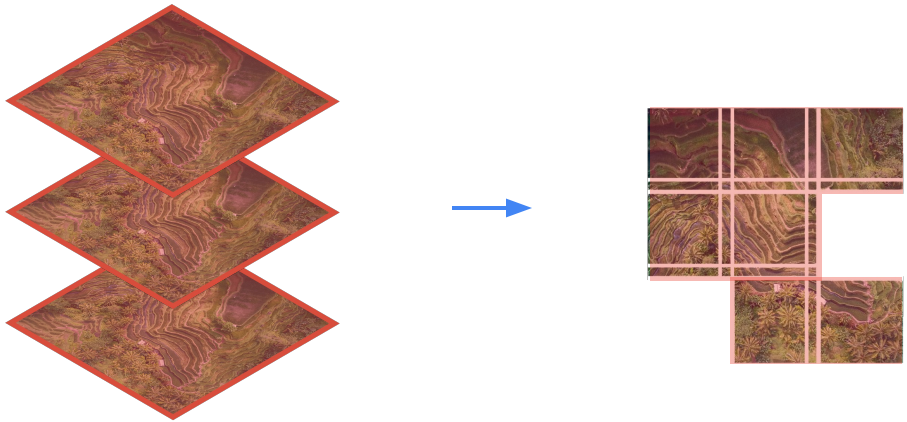
Time, space & metadata search

Map an algorithm over a collection



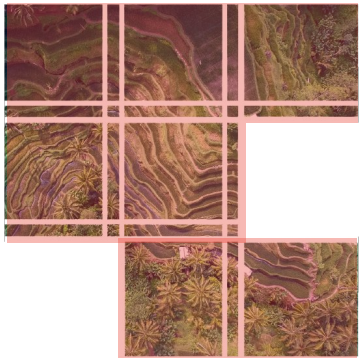
N → N

Reduce a collection

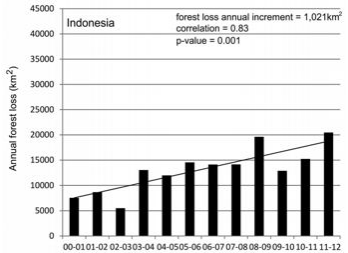


N → 1 or **N → M**

Compute aggregate statistics

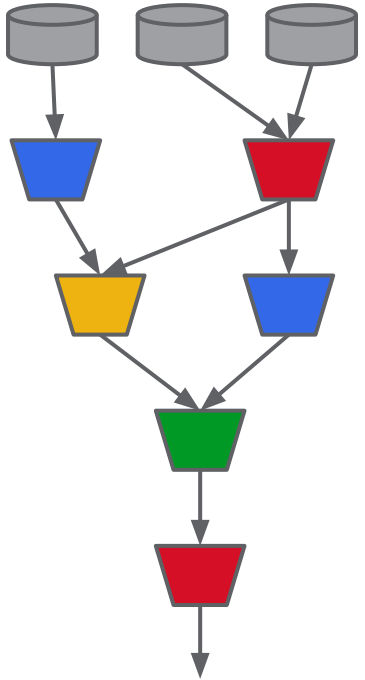


Gabon	1891	391	11898
Lithuania	1845	1226	40296
Cuba	1725	2271	68008
Mali	1694	0	1247103
Costa Rica	1653	382	11327
Czech Republic	1646	1331	46934
South Sudan	1635	38	460581
North Korea	1605	137	67695
Italy	1603	898	201331



Expressions and Lazy Evaluation

- Earth Engine expressions define new objects in terms of existing objects, as a **directed acyclic graph**.
- Users can define **custom functions** in terms of other functions.
- The core Image and Collection types are **lazy** and **inherently parallel**.
- Computations are specified by an expression + a selector (i.e. which part of the result is needed — for a raster, which pixels at what resolution)




Q&A

Current and future directions

Google Cloud tie-ins

TensorFlow integration

Data format support

Lower-latency data ingestion

Improved Code Editor interface

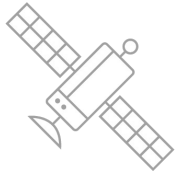
Earth Engine Apps

Programming language features

Further reading:

- earthengine.google.com
- Earth Engine 101
- Developers' site

Recap: At a high level...



- Why build Earth Engine?
  To ensure that global challenges aren't limited by IT.
- What have we made?
  A large-scale computing system with an app ecosystem on top.
- How do people use it?
  They publish scripts, apps, papers, datasets...
- A brief peek under the hood
  Everything is parallel.
- Where is it going?
  Up and to the right! 📈

Thanks!

#GeoForGood19

Google

#GeoForGood19