Introduction to Google Earth Engine

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Housekeeping

- Instructor: Warren Scott
  - Contractor, USDA Forest Service, Geospatial Technology and Applications Center (GTAC)
- Microsoft Teams Meeting
  - Please remember to mute yourselves until the presentation is complete

Agenda for Today:

- **10:00 – 11:15:** Earth Engine Overview
- **11:15 – 11:45:** Demo of the Code Editor

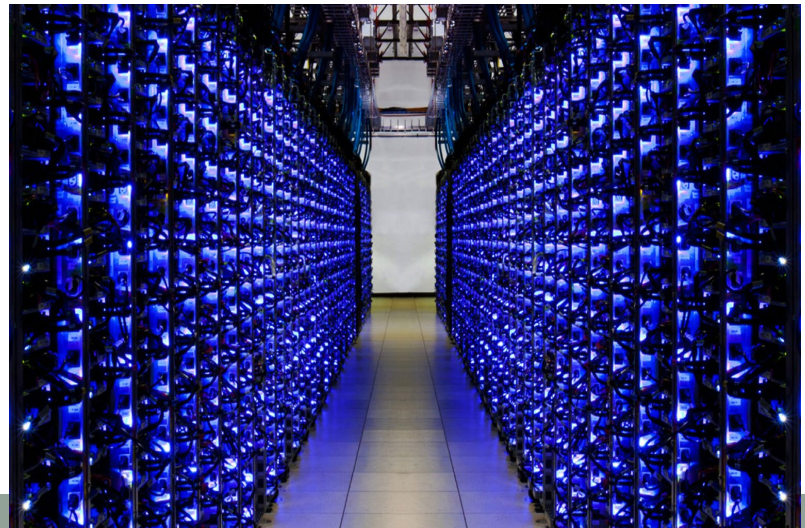
Earth Engine Overview

- What is Google Earth Engine?
- Example Applications
- Two Platforms:
  - Code Editor
  - Explorer
- Demo

What is Earth Engine?

1. A cloud-based geospatial processing platform for executing large-scale environmental data analysis.
2. Remote Sensing Archive:
   - Petabytes of data in one location

Photo courtesy of Google Earth Outreach



What it's not …

Why is it such a powerful image analysis software?

1. Public data catalog: vast amounts of publicly available data (you don't need to store data)
2. Processing power (computation engine):
    1. Distributed computation power
    2. Cloud processing (Google's computer clusters)
    3. Comprehensive toolset to analyze data: scientific algorithms ready for use & the building blocks to create your own
3. Interactive development platforms:
    1. Explorer
    2. Code Editor
4. Save and share work routines

1. Earth Engine Public Data Catalog

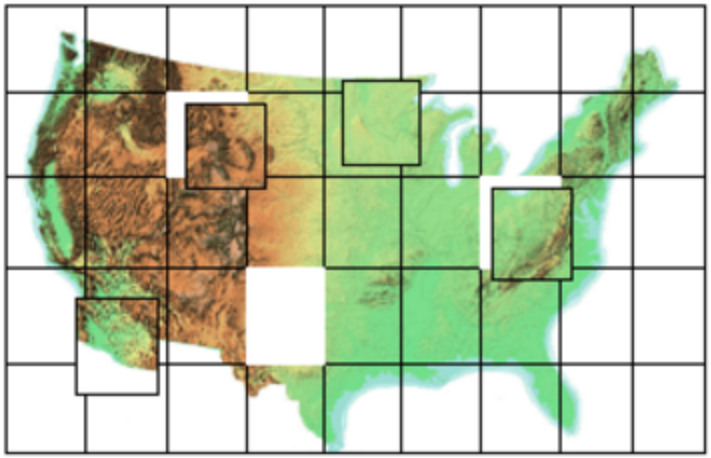
- Imagery
- Geophysical
- Climate & Weather
- Demographic
- Vector Data

Image: Dave Thau

2. Computation Engine

"The computation engine is a just in time distributed computation model, a cloud-based processing infrastructure that automatically parallelizes analyses on many CPUs across many computers in Google's data centers."

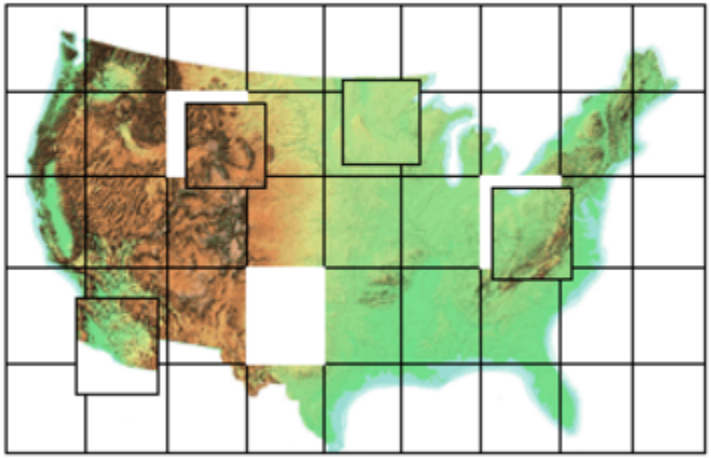
Divides data in independent grids



Storage Clusters (petabytes of data)
Computing clusters (1,000's of CPUs

2. Computation Engine

Divides data in independent grids



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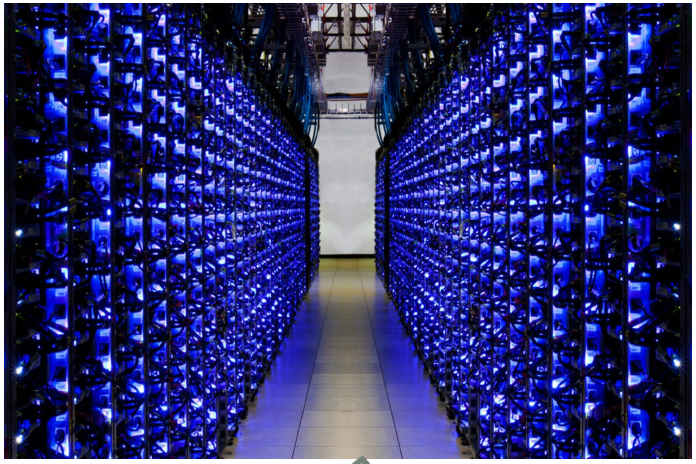


Merges all grid calculations

2. Computation Engine

- Unprecedented speed: reduce processing times by orders of magnitude by using the distributed, cloud-based computing power
- Ease of use and lower costs: online platform with easy access to data, scientific algorithms, computational power.

Example Application

Resource Need:

- Map all change between 2000 – 2010 over a specific forest
  - Extent of change
  - Year of occurrence

- How would you accomplish this task?

Traditional Method

- Select Area of Interest
- Find WRS path/row(s) – assume an area of 4 scenes

Data Prep:

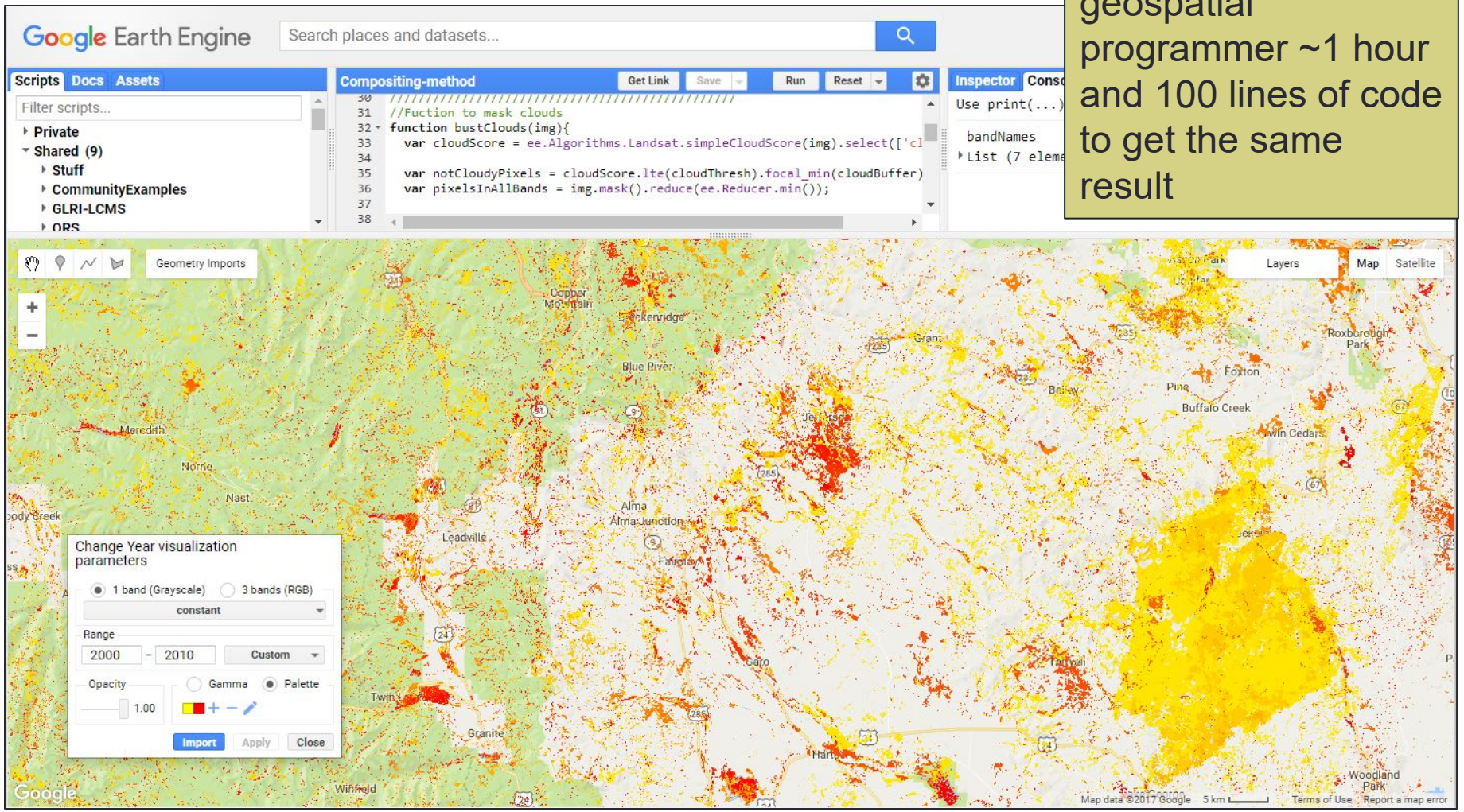
- Download and store all Landsat during growing season (1 GB / zipped scene)
- Extract and layer stack all Landsat (1.75 GB / scene)
- ~48 scenes per year * 11 years = ~528 scenes, or 924 GB
- Apply atmospheric correction (924 more GB)
- Normalize scenes
- Apply FMASK or similar to remove clouds and shadows
- Create composite and mosaic by year
- Generate vegetation index per year (NDVI and/or NBR)

Analysis:

- Build spatial model in ERDAS to compare year pairs
- Generate change layer
- Classify pixels > certain value as “change”
- Build spatial model to apply year attribute to each pixel
- Repeat for each year pair
- Build spatial model to stack all attributed change layers into a single raster image, with the most recently changed pixel on top
- Apply color ramp visually demonstrating change

In Earth Engine

It took an experienced geospatial programmer ~1 hour and 100 lines of code to get the same result

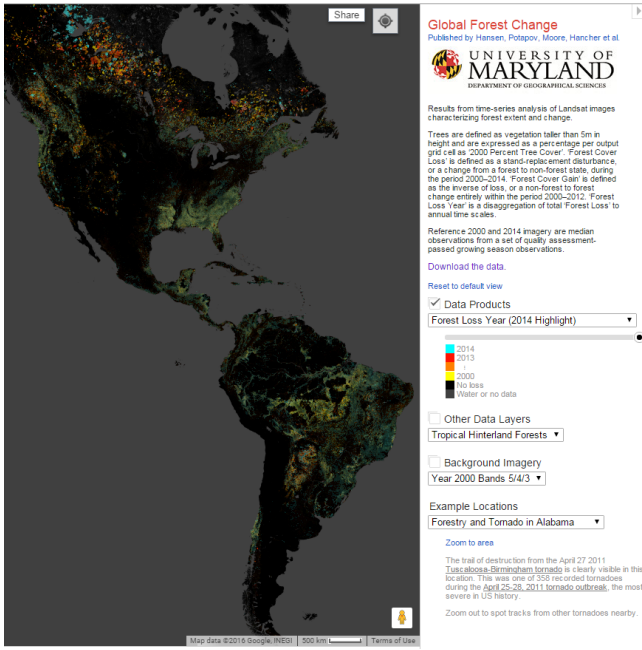


Example Application

- Classifying land cover conditions and change detection:
  - Video of deforestation in Brazil

    https://earthengine.google.com/timelapse/?location=rondonia
  - Global Forest Change Map, Hansen et al

    http://earthenginepartners.appspot.com/science-2013-global-forest



Earth Engine Costs

- It's free

An excerpt from their website:

"Why is Google working on Earth Engine?

Google's mission is to organize the world's information and make it universally accessible and useful. In line with this mission, Earth Engine organizes geospatial information and makes it available for analysis. More generally, Google strives to make the world a better place through the use of technology. Earth Engine's technical infrastructure powers humanitarian, scientific, and environmental initiatives which Google is proud to support."

When to use Earth Engine

EE Benefits:

Good for projects that requires:

- Data coverage for a large region
- Extensive data library
- High speed, intensive processing capacity
- Advanced raster processing tools

EE Limitations:

- Better suited to image analyses than vector-based analyses
- Analysis based on pixel spatial relations are harder to complete (because of the processing on multiple CPU's). Image segmentation and hydrologic modeling options are limited

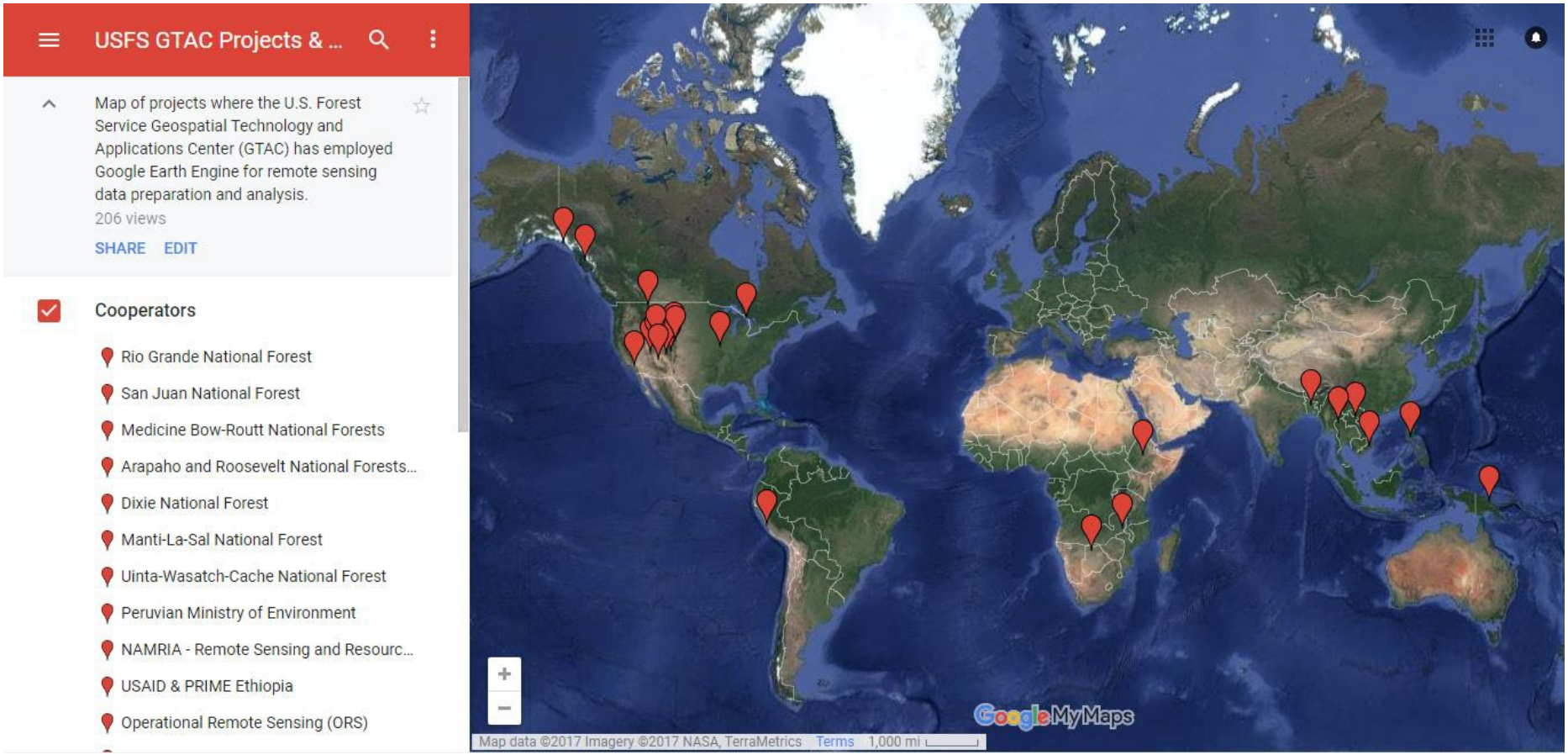
How GTAC uses Earth Engine

- Streamline & Share GIS/RS workflows
- Develop novel methods and algorithms
- Bridge gap between literature & application
- Create applications to deliver data & analysis capabilities to non Earth Engine users

Examples: GTAC use of Earth Engine

- Robust cloud-shadow masking
  - *Who*: USFS Northern Research Station for EPA Great Lakes Restoration Initiative (GLRI)
  - *Target*: Robust cloud shadow removal
  - *Where*: Great Lakes Basins - now being utilized in nearly all EE-based projects
  - *When*: 1984-2014
- Automated retrospective annual forest disturbance detection
  - *Who*: USFS Forest Health Technology Enterprise Team (FHTET) Operational Remote Sensing
  - *Target*: Both perennial and ephemeral forest disturbance events
  - *Where*: Continental US
  - *When*: Currently a pilot project intended to be implemented annually
- Automated deforestation and degradation detection
  - *Who*: Lowering Emissions in Asian Forests (LEAF) / UN REDD+
  - *Target*: Perennial forest disturbance events with effects that persist > 2 years
  - *Where*: Madang, Papua New Guinea; Houaphan, Laos; Measa Kongma, Thailand; Lamdong, Vietnam
  - *When*: 2000-2014

Where We Use Earth Engine



USFS EE Use Considerations

1. Google Earth Engine is a free platform that anybody can set up an account with. If you plan on using it for operational purposes, please email jesstclark@fs.fed.us and/or dvanderzanden@fs.fed.us
2. Google offers 256 gigabytes of extra storage space per user, plus 10 terabytes of shared storage space in addition to the data catalogs already considerable size.
3. Make sure you consider the sensitivity and privacy of any data you upload. Sensitive data (e.g. FIA plots) should be kept within the USFS, and not exposed to GEE.

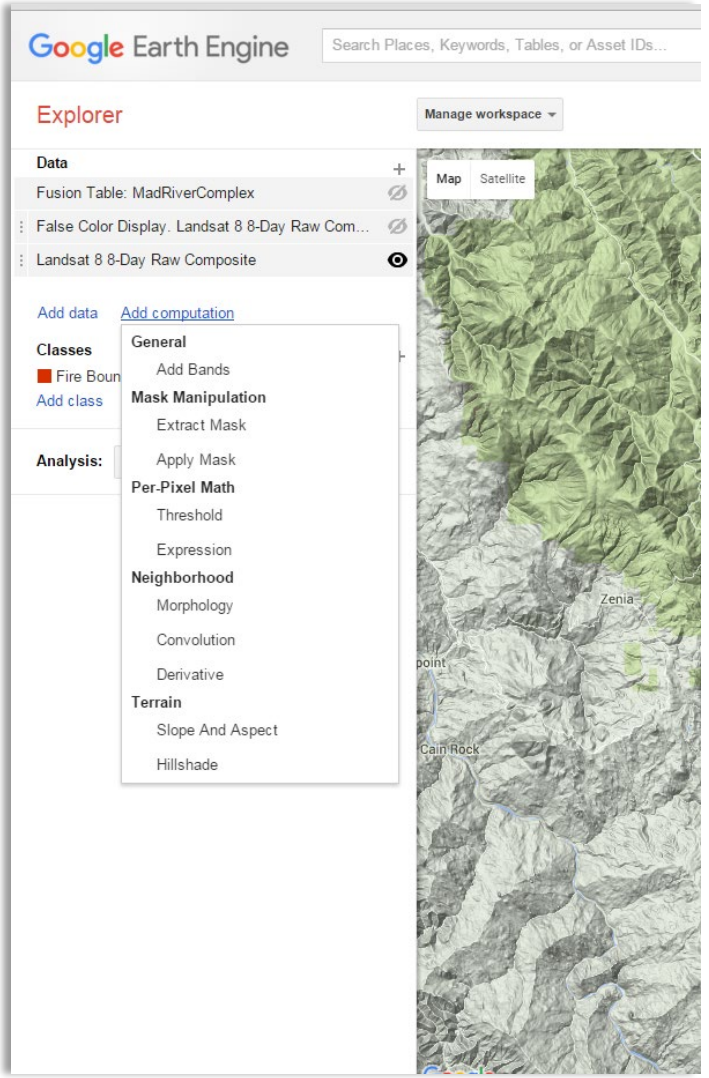
3. Two Platforms

- Graphical User Interface (Explorer)
  - https://explorer.earthengine.google.com/#workspace
  - User friendly way to begin exploring and analyzing data

- Application Program Interface (Code Editor)
  - https://code.earthengine.google.com/
  - Powerful geospatial tool to create complex custom analysis
  - Requires some programming knowledge
  - Supports both JavaScript and Python*

Explorer Platform

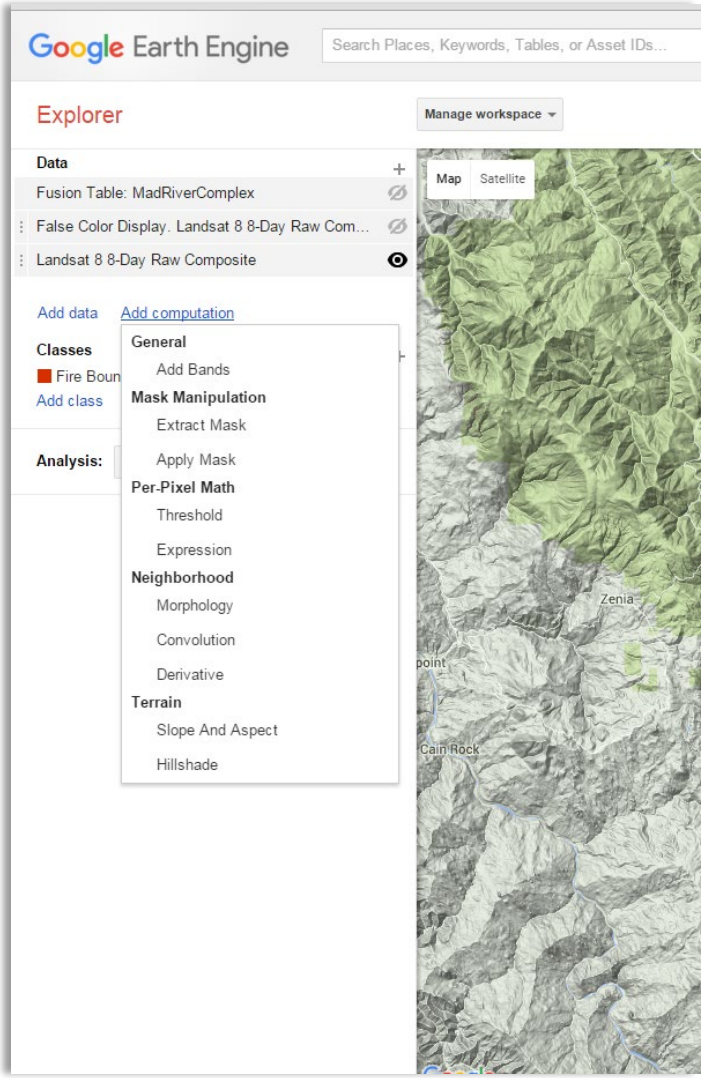
- A point and click platform:
  - Audience: non-programmers
- Basic analysis functionality
  - Per pixel math (~ESRI's raster calculator),
  - Neighborhood algorithms,
  - Terrain algorithms, etc
- Save and share workspace
- Explore and export data



Explorer Platform

Cons:

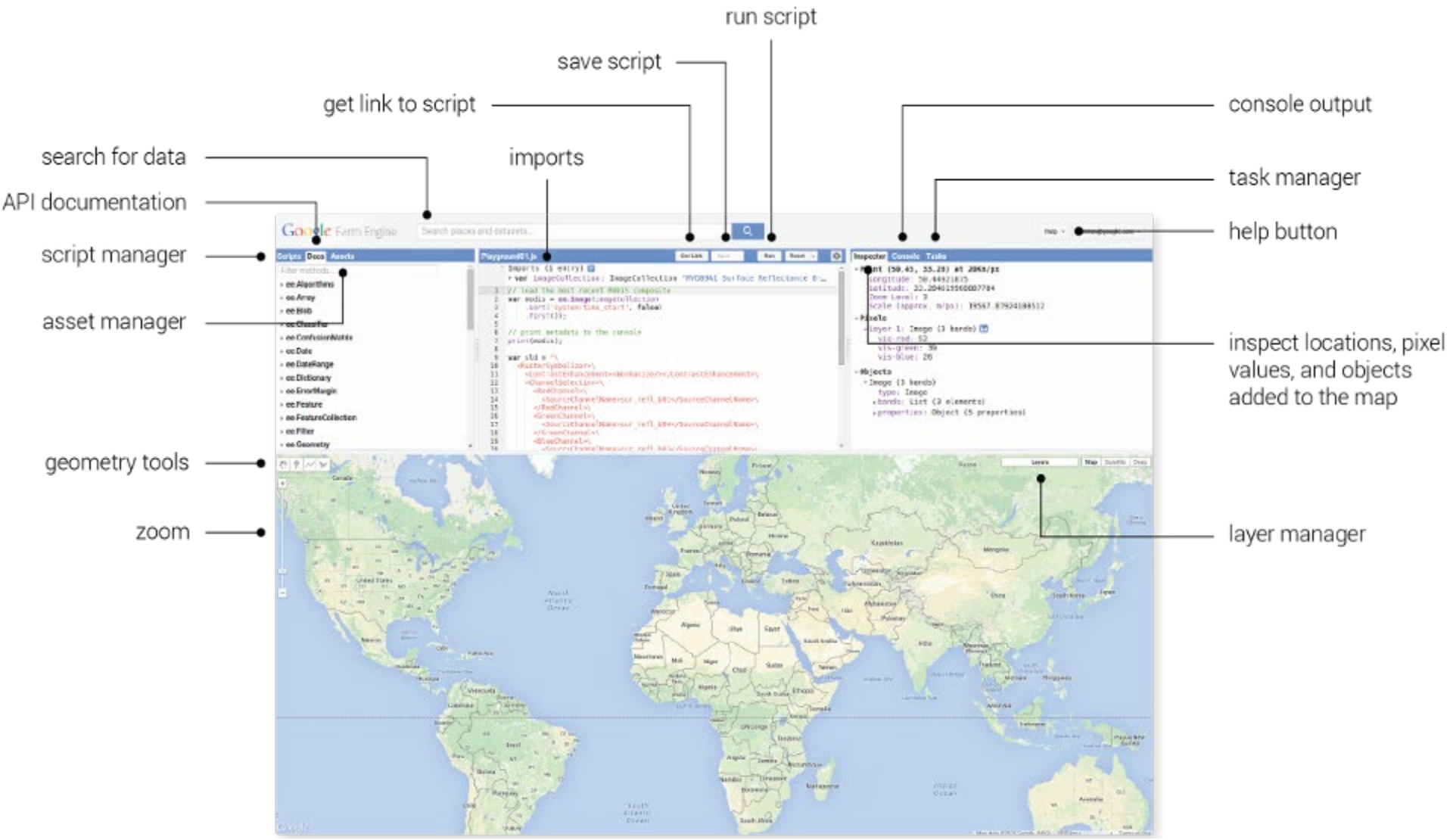
- Limited analysis power:
  - subset of tools
- Some collections cannot be accessed



Code Editor

- What is it?
  - Web based IDE for the Earth Engine API
  - Access many pre-made geospatial tools
    - JavaScript
    - Python

Code Editor Interface



Registration Process

- Sign up for an Evaluator account:
  - Register here: https://earthengine.google.com/signup/
  - It may take up to one week to be granted access
- If you don't have access to the developers forum, sign up here:
  - https://groups.google.com/forum/#!forum/google-earth-engine-developers.

Some Code Editor Benefits

- Allows user to create extremely complex workflows (batch tasks) using
  - any data in Earth Engine, and
  - its extremely high speed computation engine
- Workflows can be shared easily between users

Some Code Editor Cons

- Requires programming knowledge
- Need to be aware of unique GEE classes and methods

Common Classes

- Images
- Image Collections
- Feature Collections
- Geometries

Demonstration

- https://code.earthengine.google.com/46bf1bebe7f905c4cf840ecb457d3ad3
- https://explorer.earthengine.google.com/#workspace

Questions?