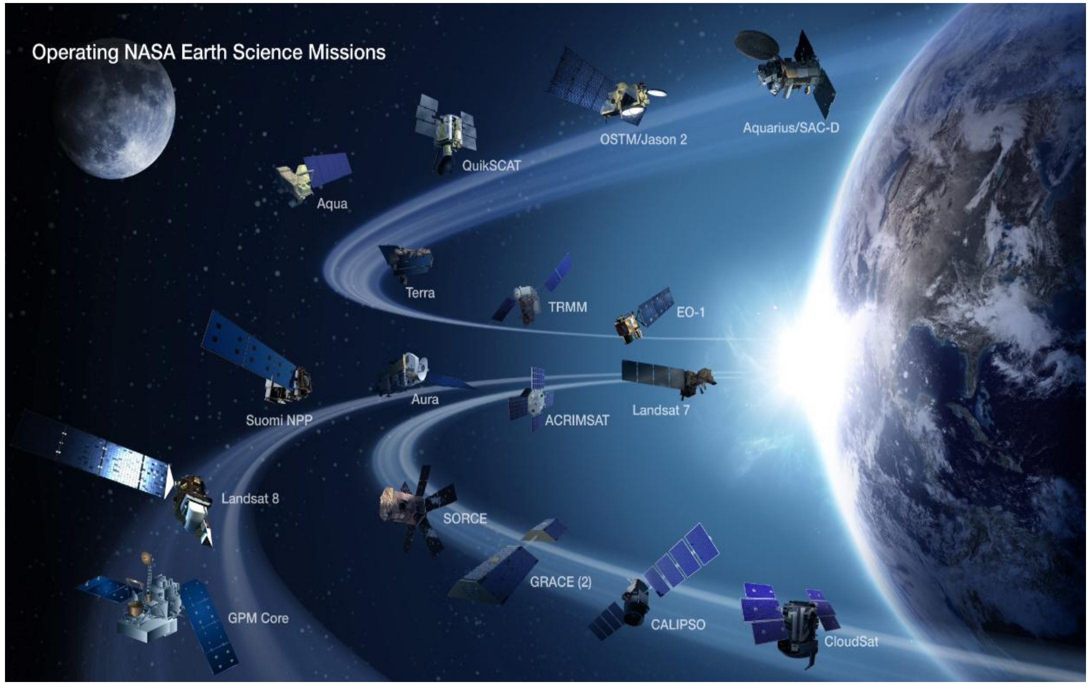
Spatial Data Analysis and Modeling for Agricultural Development, with R - Workshop

Advances in Remote Sensing

FEED THE FUTURE
The U.S. Government's Global Hunger and Food Security Initiative

FEED THE FUTURE INNOVATION LAB
Collaborative Research on Sustainable Intensification

Remote Sensing Instrument/platform



Data Processing

4 Million Landsat images *(1972-2016)*
More than a petabyte stored on tapes at USGS and growing daily

Cost of Remote sensing instruments

No matter how much you screw up, you will never have to tell your boss: "mmm... I think I may have toppled that 290 million dollar NOAA-N prime satellite right onto the lab floor

NASA launches $855 million Landsat mission

And the data is free!!!

Cost of Purchasing data

Mono High & Medium-Resolution Satellite Imagery Price List

Satellite(s)	Product + Resolution	Archive - > 90 days	Archive - ≤ 90 days	Standard Tasking*	Priority Tasking*	Rush Tasking
WorldView-3	30-cm Natural Color 30-cm 4-band PS 30-cm Pan + 1.2-m MS	$22.50/km² 25 km² Pan = $19	$32.50/km² 25 km² Pan = $29	$32.50/km² 100 km² Pan = $29	$54.50/km² 100 km² Pan = $51	N/A
WorldView-3	30-cm Pan + 1.2-m 8-band MS	$24/km² 25 km²	$34/km² 25 km²	$34/km² 100 km²	$56/km² 100 km²	N/A
WorldView-3	7.5-m 8-band SWIR only	$24/km² 25 km²	$34/km² 25 km²	$34/km² 100 km²	$56/km² 100 km²	N/A
GeoEye-1 *WorldView-2* *WorldView-3*	40-cm Natural Color 40-cm 4-band PS 40-cm Pan + 1.6-m MS	$19.50/km² 25 km² Pan = $16	$29.50/km² 25 km² Pan = $26	$29.50/km² 100 km² Pan = $26	$51.50/km² 100 km² Pan = $48	$93.50/km² 100 km² Pan = $90 GeoEye-1 only
WorldView-2 *WorldView-3*	40-cm Pan + 1.6-m 8-band MS	$21/km² 25 km²	$31/km² 25 km²	$31/km² 100 km²	$53/km² 100 km²	N/A

Stereo High & Medium-Resolution Satellite Imagery Price List

Satellite(s)	Product + Resolution	Archive - > 90 days	Archive - ≤ 90 days	Standard Tasking*	Priority Tasking*	Rush Tasking
WorldView-3	30-cm Natural Color 30-cm 4-band PS 30-cm Pan + 1.2-m MS	$45/km² 100 km² Pan = $38	$65/km² 100 km² Pan = $58	$65/km² 100 km² Pan = $58	$109/km² 100 km² Pan = $102	N/A
WorldView-3	30-cm Pan + 1.2-m 8-band MS	$48/km² 100 km²	$68/km² 100 km²	$68/km² 100 km²	$112/km² 100 km²	N/A
GeoEye-1 *WorldView-2* *WorldView-3*	40-cm Natural Color 40-cm 4-band PS 40-cm Pan + 1.6-m MS	$39/km² 100 km² Pan = $32	$59/km² 100 km² Pan = $52	$59/km² 100 km² Pan = $52	$103/km² 100 km² Pan = $96	N/A
WorldView-2 *WorldView-3*	40-cm Pan + 1.6-m 8-band MS	$42/km² 100 km²	$62/km² 100 km²	$62/km² 100 km²	$106/km² 100 km²	N/A

If the data is not free!!!

Cost effective alternatives: UAV

Rotary wing

[*]

Easier to pilot, agile maneuvering
Vertical take-off and landing

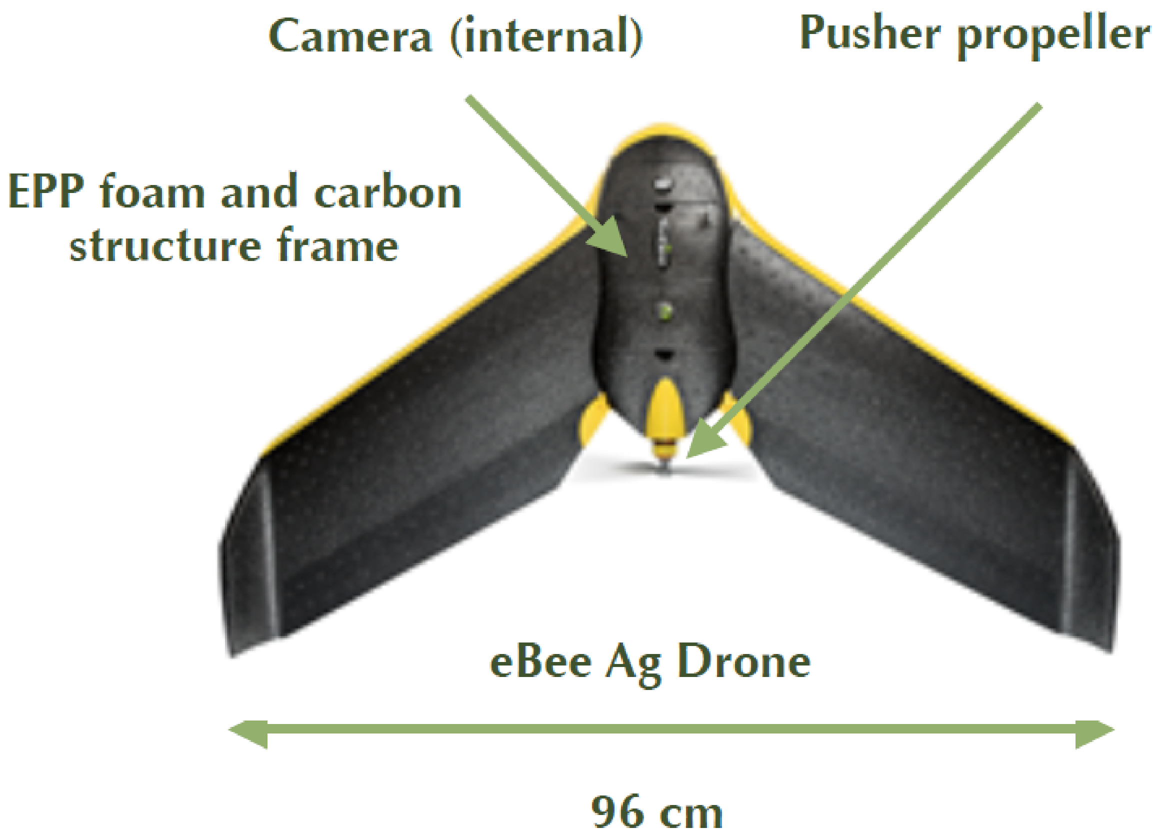
Fixed wing

[o]

More efficient aerodynamics
longer flights, higher speed
Large space for take-off and landing

[*] "Parrot AR.Drone 2.0", N. Halftermeyer – Wikimedia Commons
[o] "InView Unmanned Aircraft" by Fasicle, http://www.barnardmicrosystems.com/ - Wikimedia Commons

$12500 + $4000 for camera



eBee Ag Hardware	
Weight (including supplied camera)	Approximately 1.56 lbs
Wingspan	96 cm
Material	EPP foam, carbon structure and composite parts
Propulsion	Electric pusher propeller, 160 W brushless DC motor
Battery	11.1 V, 2150 mAh
Camera (supplied)	12 Mp (megapixel) S110 NIR (near-infrared)
Carry case dimensions	55 x 45 x 25 cm

What can you get from UAV data?

plants

- Vegetation indices
- Plant growth, counting, diseases identification
- Impact of chemical or biological treatments

soil

- Temperature and moisture
- Water issues and irrigation systems
- Ground erosion and modifications, topography

- Plant stress assessment.
- Yield monitoring.
- Chlorophyll indication.
- Senescence analysis.
- Drought assessment.
- Biomass indication.
- Leaf area indexing.
- Nitrogen recommendation.
- Phenology.
- Growth monitoring.
- Crop discrimination.
- Leaf area indexing.
- Tree classification.
- Plant counting.

Optimization of the treatments
only where and when necessary … fertilizers cut down till to 20 – 40 %

Reduction and prevention of waste
water consumption … in some cases till to almost 90 %

Reduction of labor and material costs

Reduction of pollution
Small UAVs are electrical machines.

Reduction of the risks
Automatic and continuous analysis of the processes and field status.
Prevention.

Can this be replacement for satellite remote sensing data?

High resolution commercial data for local applications: YES!!!

Large area monitoring: NO; but those data are free!

Challenges???

Big Data

in Remote Sensing

Storage estimates:

Typical laptop data storage: 500 GB and memory 4 GB

Landsat data for Tanzania at 30 m with 8 bands around 20 GB;
Sentinel data at 10 m >> 100 GB (with compression)

Alternatives:
Workstation: cost of running; data archive;

Goodchild et al. (2012):

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

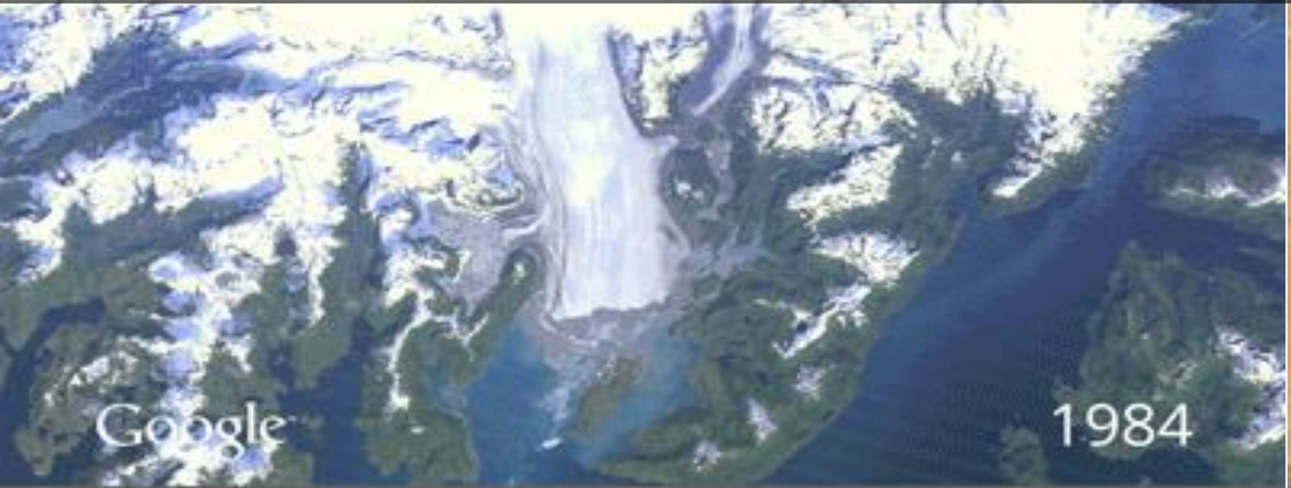
"The supply of geographic information from satellite-based and ground-based sensors has expanded rapidly, encouraging belief in a new, fourth, or "big data," paradigm of science that emphasizes **international collaboration, data-intensive analysis, huge computing resources, and high-end visualization.**"

Google Earth Engine

earthengine.google.com

Global Landsat Timelapse Animations

earthengine.google.com



Columbia Glacier Retreat, 1984-2011

Saudi Arabia Irrigation, 1984-2012

Las Vegas Urban Growth, 1986-2012

Brazilian Amazon Deforestation, 1984-2012

29 years

of satellite data

2,068,467

landsat
scenes analyzed

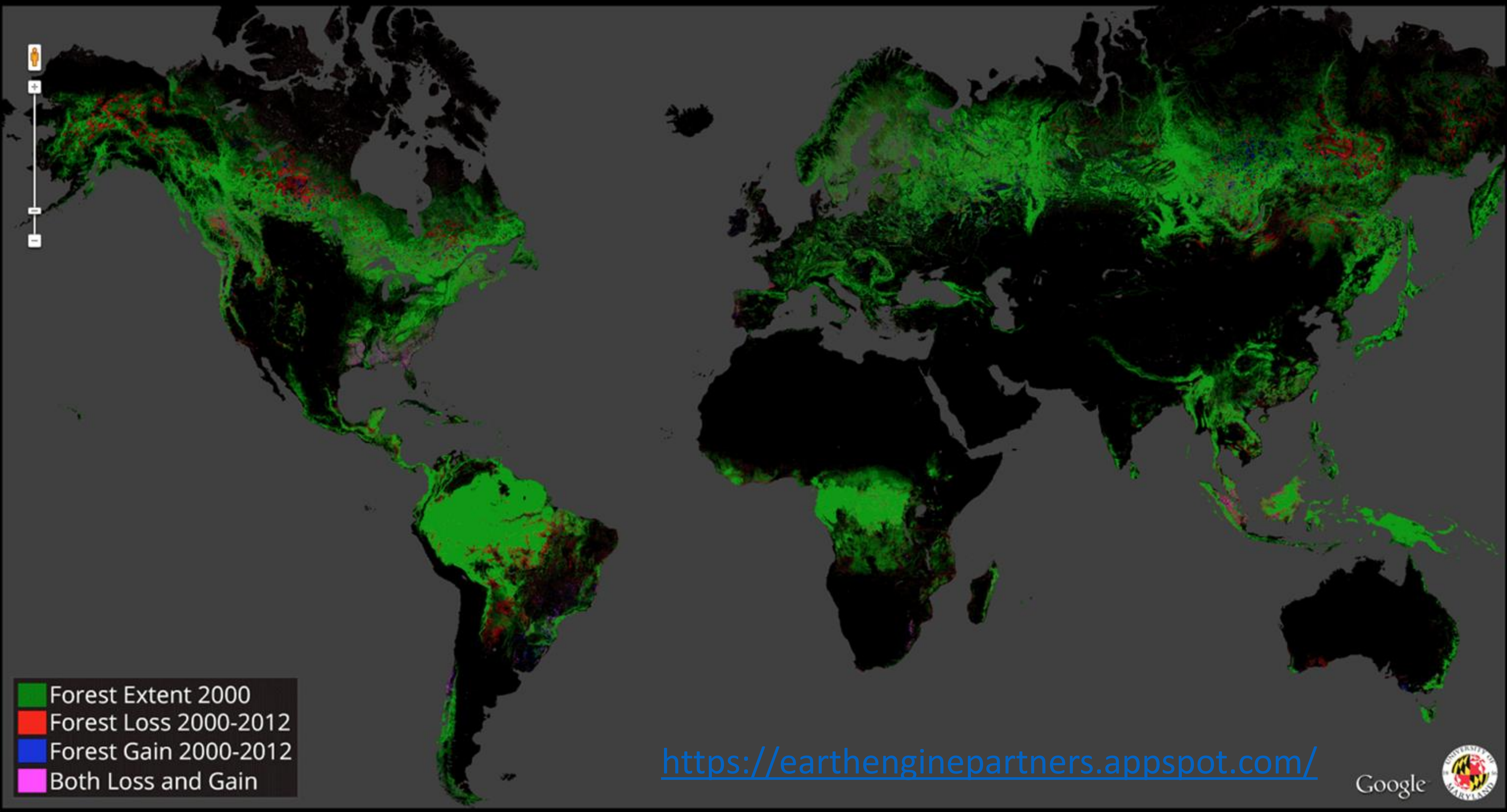
909

terabytes
of data

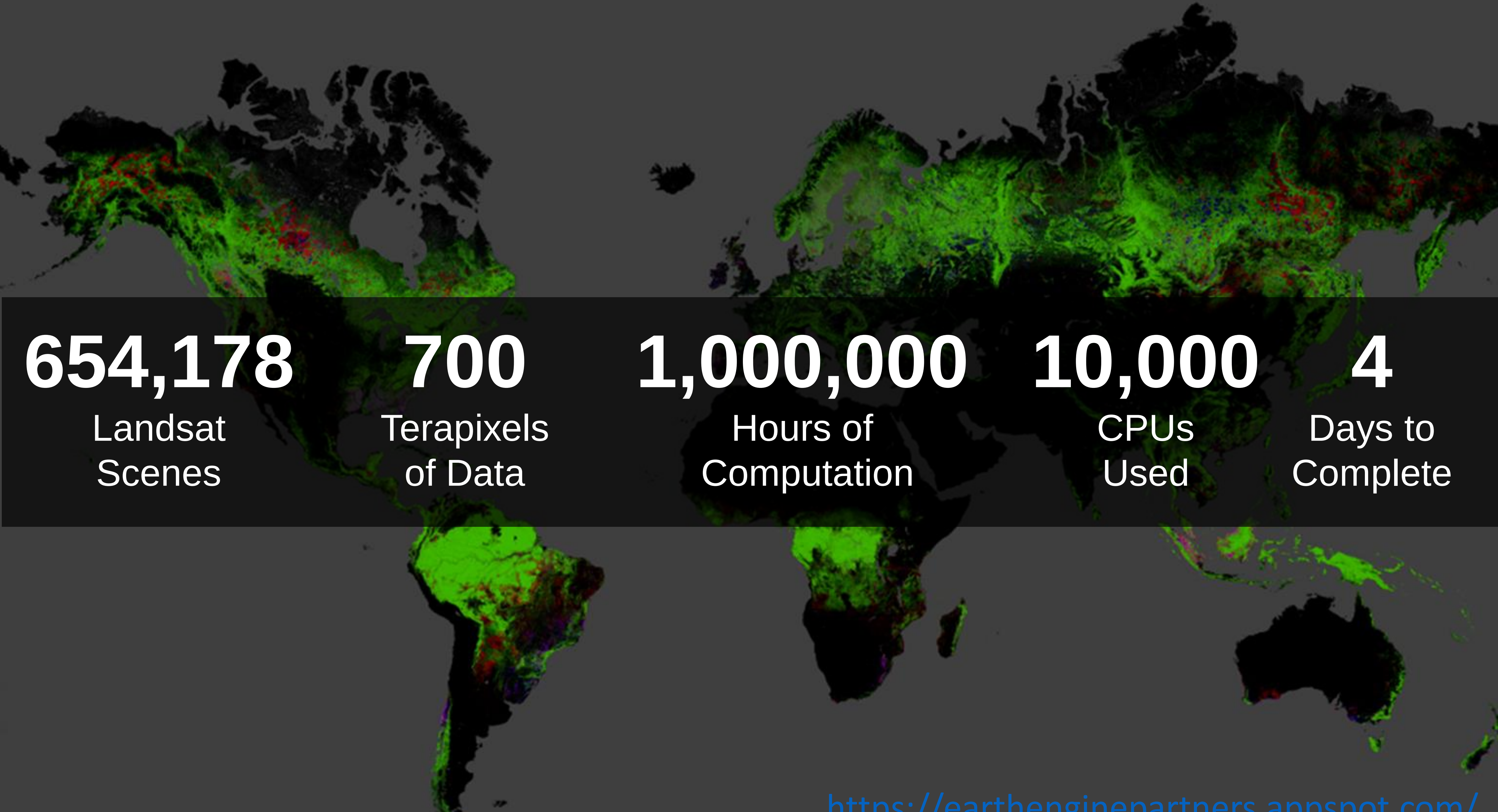
More than **2M** hours of computation over **66,000** computers

Elapsed Time: ~**1.5** days to build Timelapse

earthengine.google.com



Global Forest Change, 2000-2012 Source: Hansen, Potapov, Moore, Hancher, et al. (Science, 2013) Powered by Google Earth Engine



654,178
Landsat Scenes

700
Terapixels of Data

1,000,000
Hours of Computation

10,000
CPUs Used

4
Days to Complete

https://earthenginepartners.appspot.com/

The Earth Engine Data Catalog

Landsat & Sentinel
10-30m, 14-day

MODIS
250m daily

Terra Bella
<1m daily–weekly

Terrain & Land Cover

Weather & Climate
NOAA NCEP, OMI, ...

... and many more, updating daily!

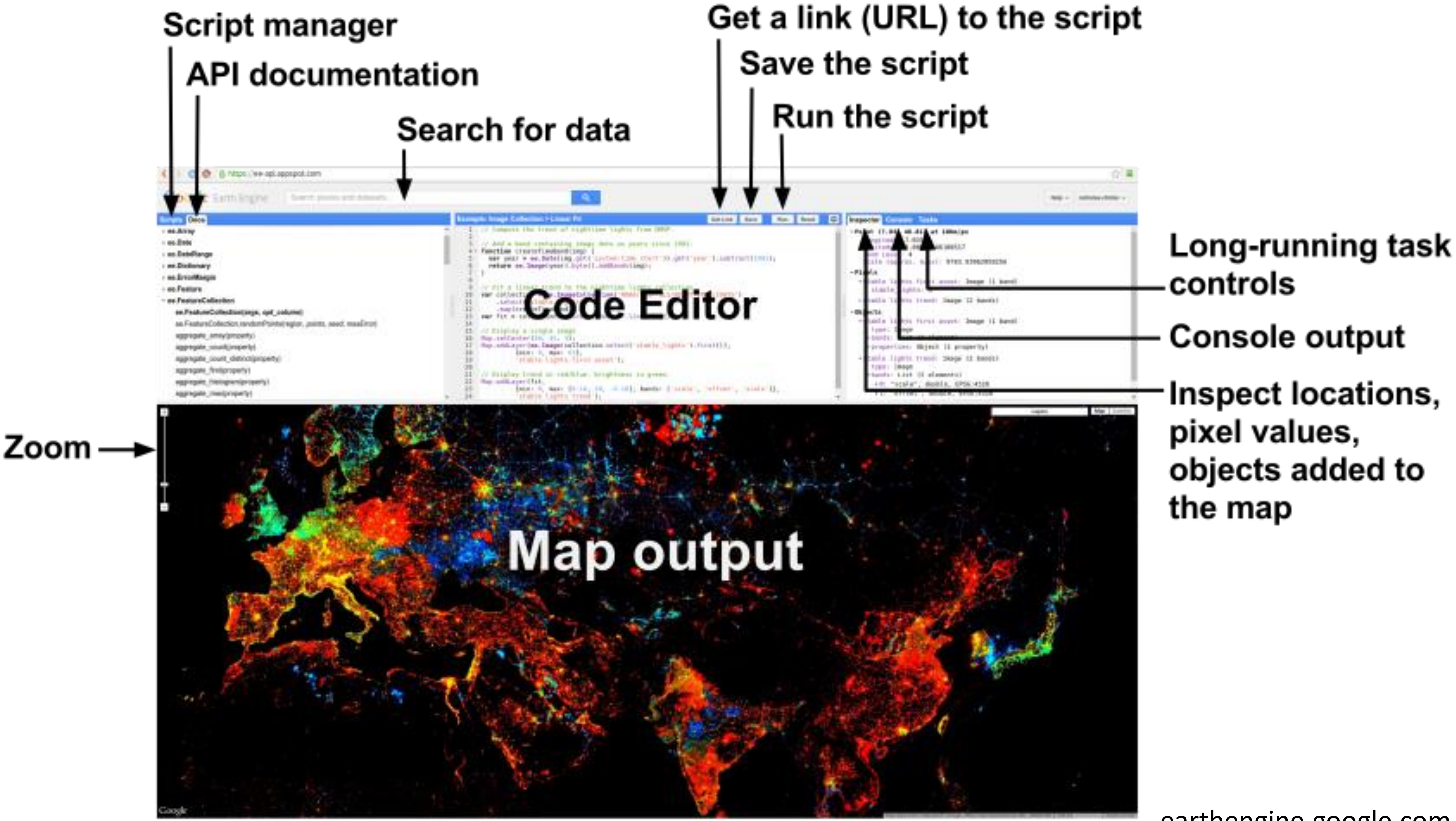
> 200 public datasets

> 5 million images

> 4000 new images every day

> 5 petabytes of data

earthengine.google.com



earthengine.google.com