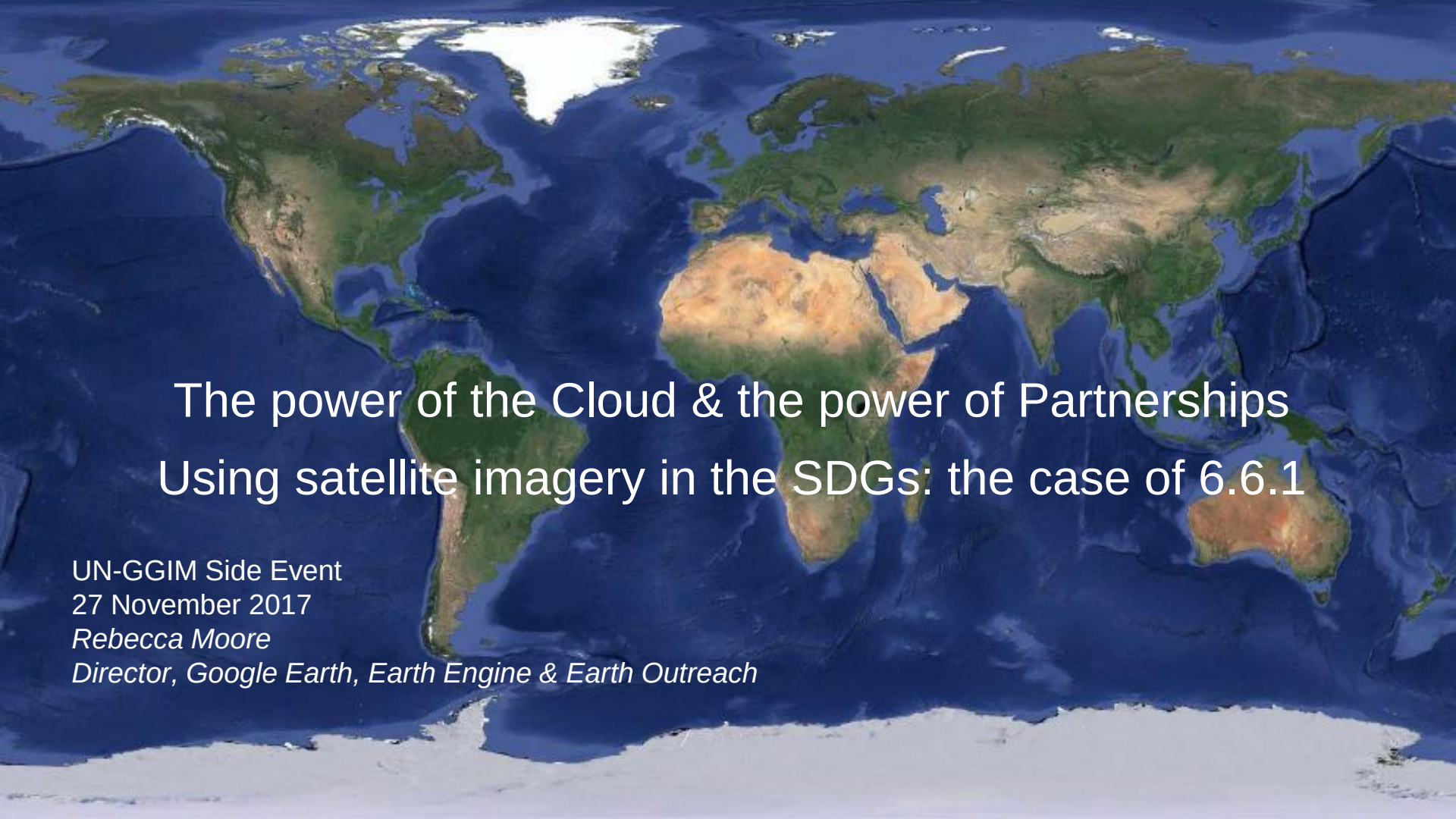


The power of the Cloud & the power of Partnerships

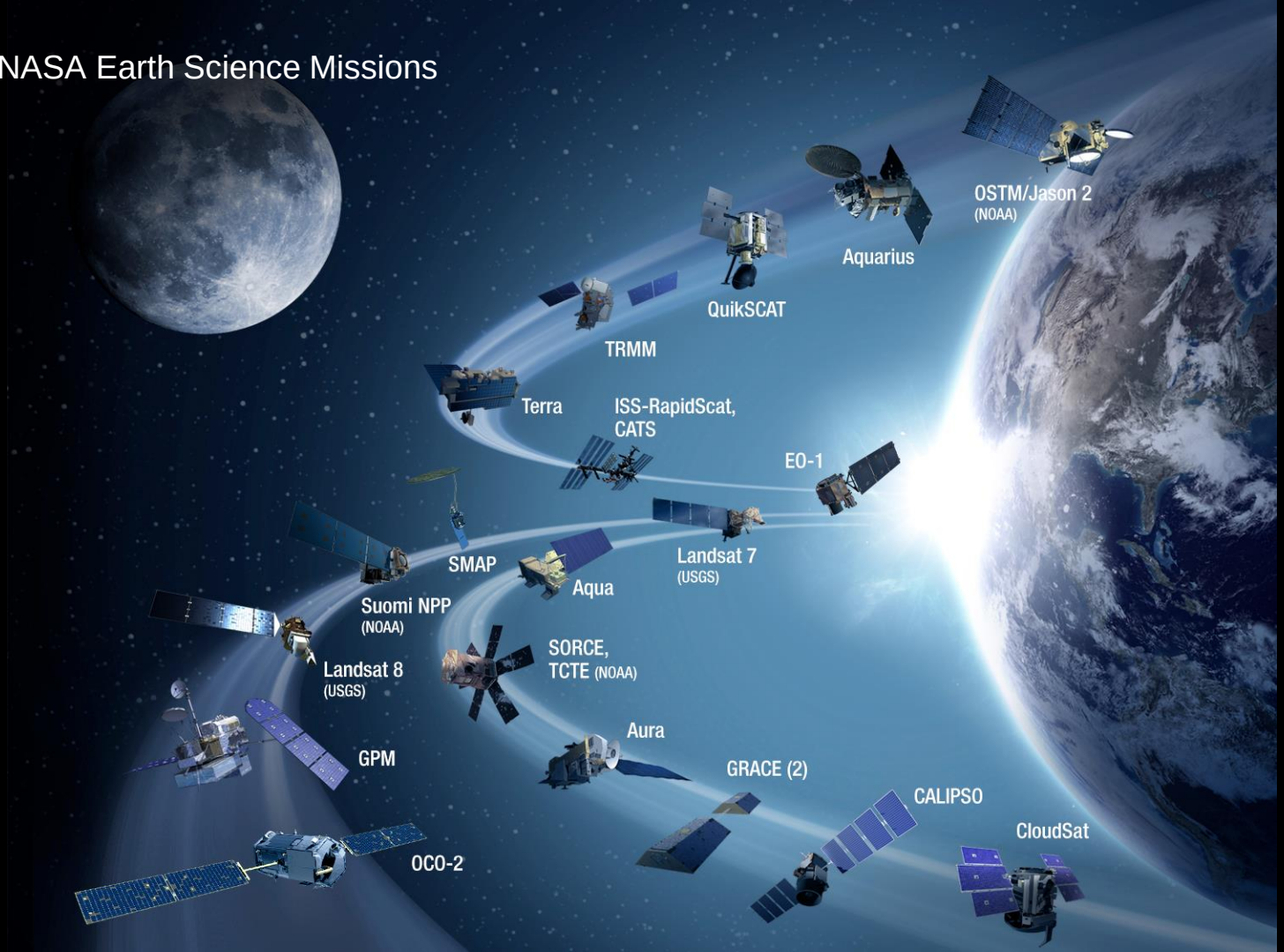
Using satellite imagery in the SDGs: the case of 6.6.1

UN-GGIM Side Event
27 November 2017

Rebecca Moore
Director, Google Earth, Earth Engine & Earth Outreach


Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat
Image IBCAO
Google earth

Operating NASA Earth Science Missions



COPERNICUS AND ITS SENTINELS

European Earth Observation Programme Copernicus: observing our planet for a safer world

Known as **GMES** until 2012 - Global Monitoring for Environment and Security

30 Public and Private missions are also contributing data

16 years of development and testing

Sentinel-Missions at the heart of the space component

Civil Security. Allowing early warning and crisis prevention in conflict and disaster areas

Emergency Management. Accurate and timely data for emergency plans and rescue for disaster management

Land Surface Monitoring. Geographical information on land cover, related variables and urban development

Marine Environmental Monitoring. Observations and forecasts on the state of the physical oceans and regional seas

Climate Change Monitoring. Helps to understand the reason for climate change, rising sea levels and melting ice caps

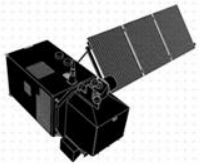
Earth Atmosphere Monitoring. Daily information on the global atmospheric composition and when Sentinel-4 is in service this will be hourly

SENTINEL-1

- **All-weather, day-and-night radar imaging satellite for land and ocean services**
- Able to "see" through clouds and rain
- Data delivery within 1 hour of acquisition
- Airbus Defence and Space developed C-band radar instrument

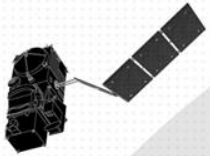
SENTINEL-2

- **Medium Res Multispectral optical satellite for observation of land, vegetation and water**
- 13 spectral bands with 10, 20 or 60 m resolution and 290 km swath width
- Global coverage of the Earth's land surface every 5 days
- Airbus Defence and Space prime contractor for satellites and instruments



SENTINEL-3

- **Measures sea-surface topography with a resolution of 300 m, sea and land surface temperature and colour with a resolution of 1 km**
- Measures water vapour, cloud water content and thermal radiation emitted by the Earth
- Determines global sea surface temperatures with an accuracy greater than 0.3 K
- Airbus Defence and Space supplies Microwave Radiometer



SENTINEL-5P

- **Global observation of key atmospheric constituents, including ozone, nitrogen dioxide, sulphur dioxide and other environmental pollutants**
- Improves climate models and weather forecasts
- Provides data continuously during five-year gap between the retirement of Envisat and the launch of Sentinel-5
- Airbus Defence and Space prime contractor for satellite and TROPOMI instrument

SENTINEL-4

- **Provides hourly updates on air quality with data on atmospheric aerosol and trace gas concentrations**
- Spatial sampling is 8 km and spectral resolution between 0.12 nm and 0.5 nm
- Airbus Defence and Space prime contractor for spectrometer
- Carried aboard EUMETSAT's Meteosat Third Generation (MTG) satellites

SENTINEL-5

- **Measures air quality and solar radiation, monitors stratospheric ozone and the climate**
- Global coverage of Earth's atmosphere with an unprecedented spatial resolution
- Airbus Defence and Space prime contractor for instrument
- Carried aboard EUMETSAT's MetOp Second Generation satellites

SENTINEL-6

- **Observes changes in sea surface height with an accuracy of a few centimeters**
- Global mapping of the sea surface topography every 10 days
- Enables precise observation of ocean currents and ocean heat storage; vital for predicting rises in sea levels
- Airbus Defence and Space prime contractor for satellite

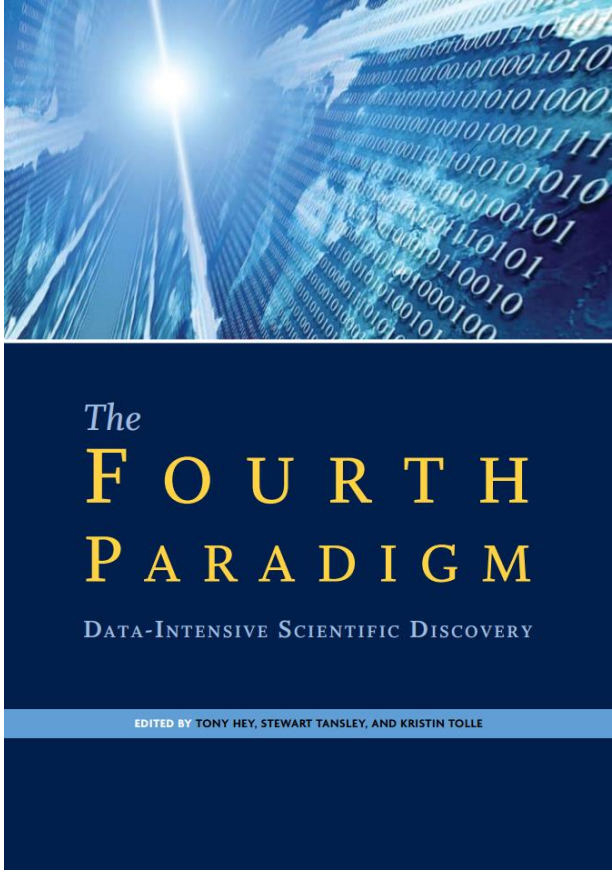
2014 — 2020

6 Million Landsat images *(1972-2017)*
2 Petabytes stored on tapes at USGS

Earth Observation Data Archives

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

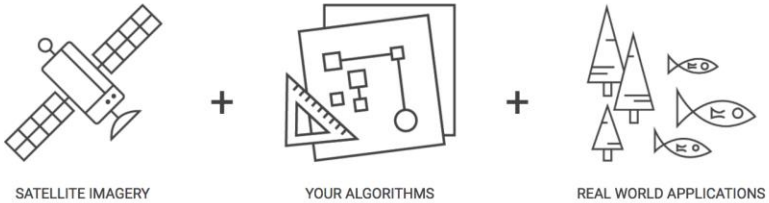
-Jim Gray (1944-2007)

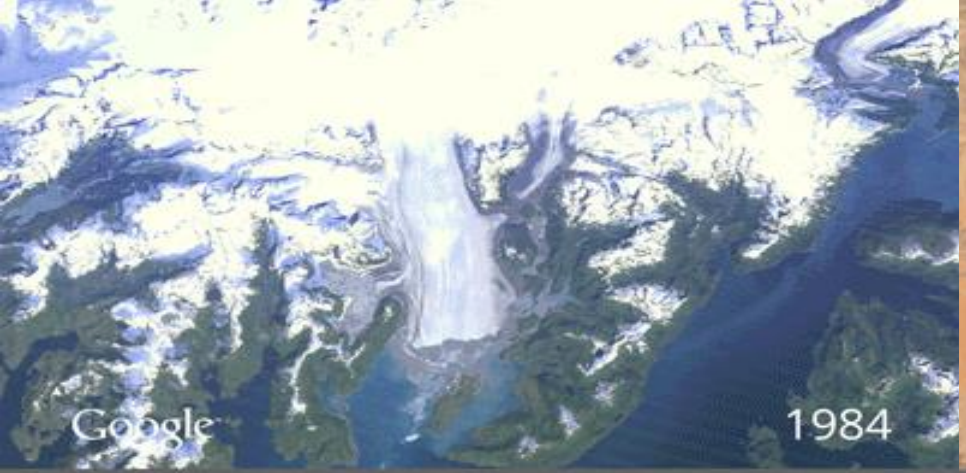


Google Cloud: Data Storage co-located with Processing

Meet Earth Engine

Google Earth Engine combines a multi-petabyte catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities and makes it available for scientists, researchers, and developers to detect changes, map trends, and quantify differences on the Earth's surface.





Columbia Glacier Retreat, 1984-2011

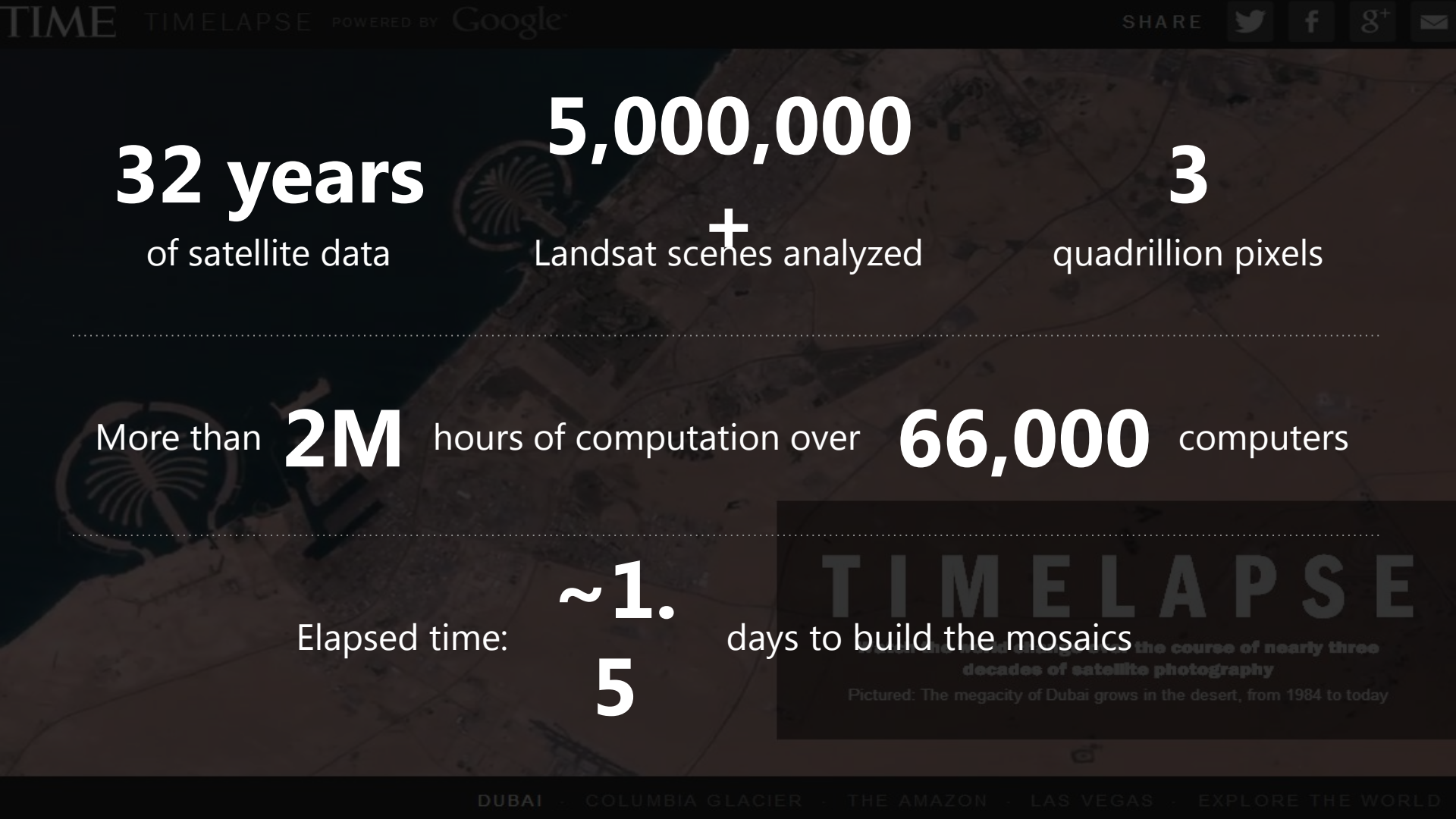
Saudi Arabia Irrigation, 1984-2012

Dubai Coastal Expansion, 1984-2012

Brazilian Amazon Deforestation, 1984-2012


Google
MIRUIXIANG TIBET
1984


1984
earthengine.google.com/timelapse


TIME TIMELAPSE POWERED BY Google
SHARE
32 years
of satellite data
5,000,000
+
Landsat scenes analyzed
3
quadrillion pixels
More than 2M hours of computation over 66,000 computers
Elapsed time: ~1.5 days to build the mosaics
TIMELAPSE
the course of nearly three
decades of satellite photography
Pictured: The megacity of Dubai grows in the desert, from 1984 to today
DUBAI · COLUMBIA GLACIER · THE AMAZON · LAS VEGAS · EXPLORE THE WORLD

The Earth Engine Public Data Catalog

Our (long-term) mission: Organize **all the world's Earth science data** and make it universally accessible and useful, with computation on top.

Today:

> 200 public datasets

> 11 million images

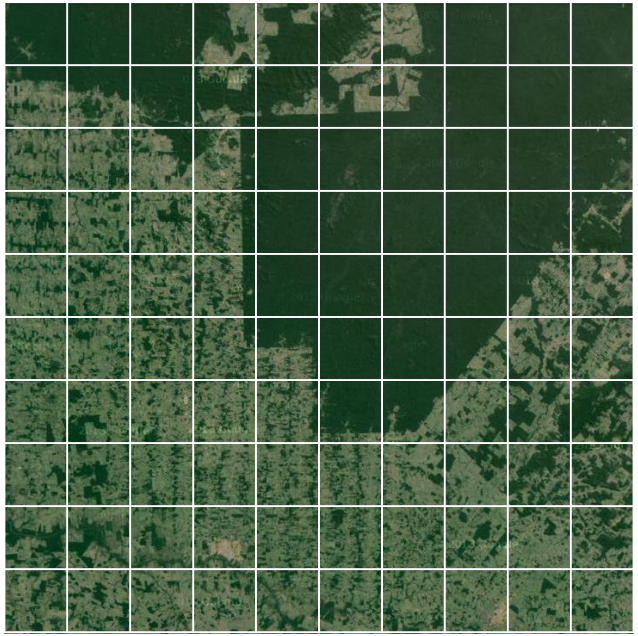
> 6000 new images every day

> 8 petabytes of data

Massive scale of Cloud-computation

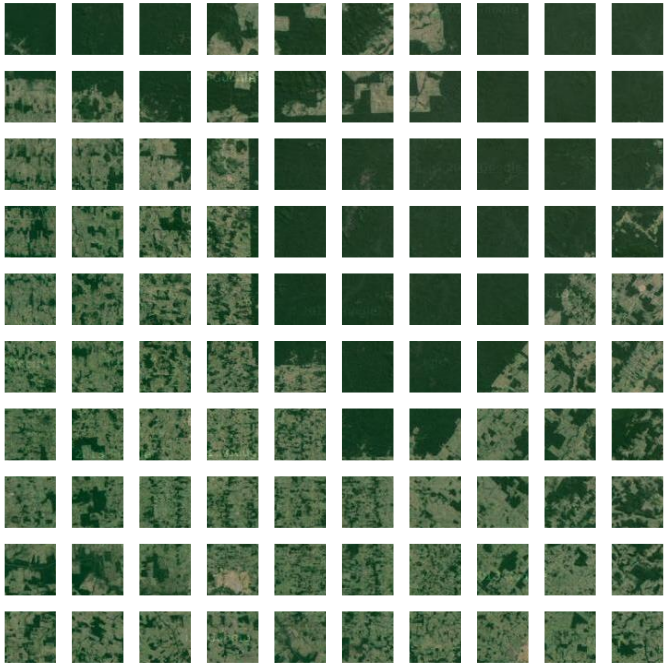
Parallel-processing on thousands of CPUs

Original Image

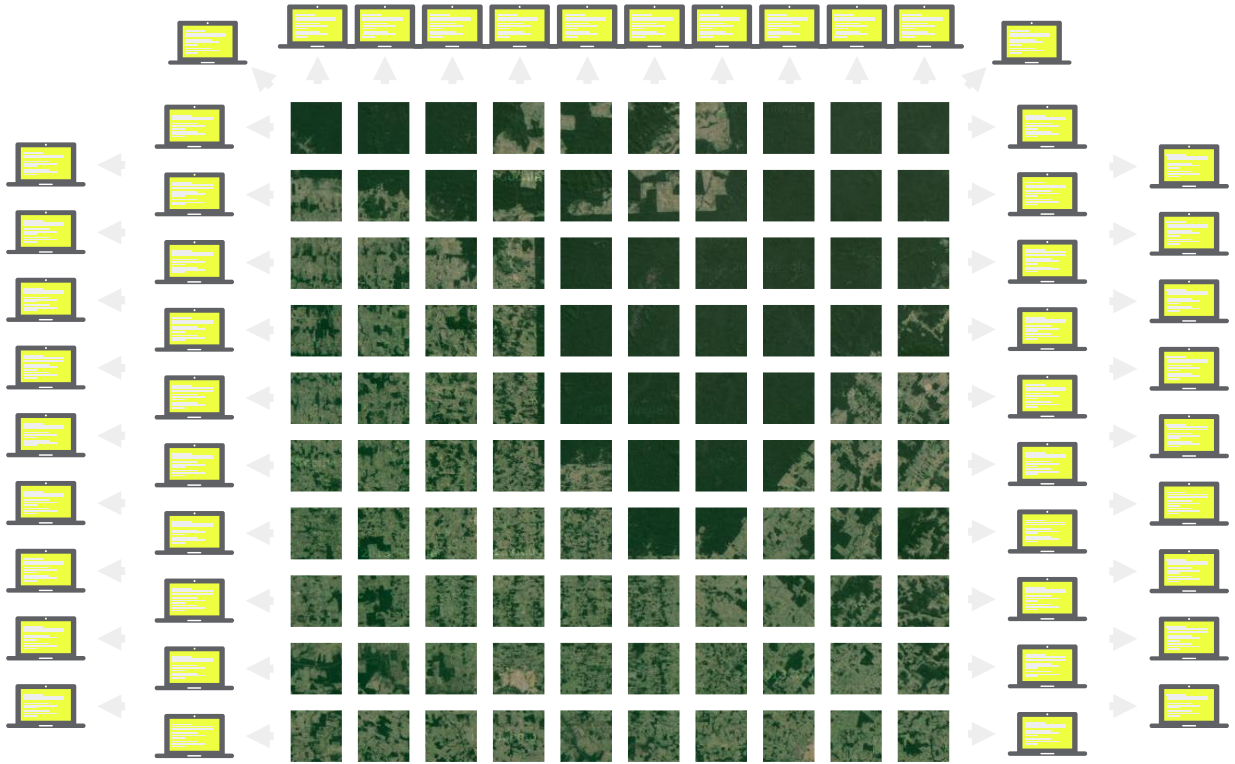


Original Image

is divided into 256px sub-units.

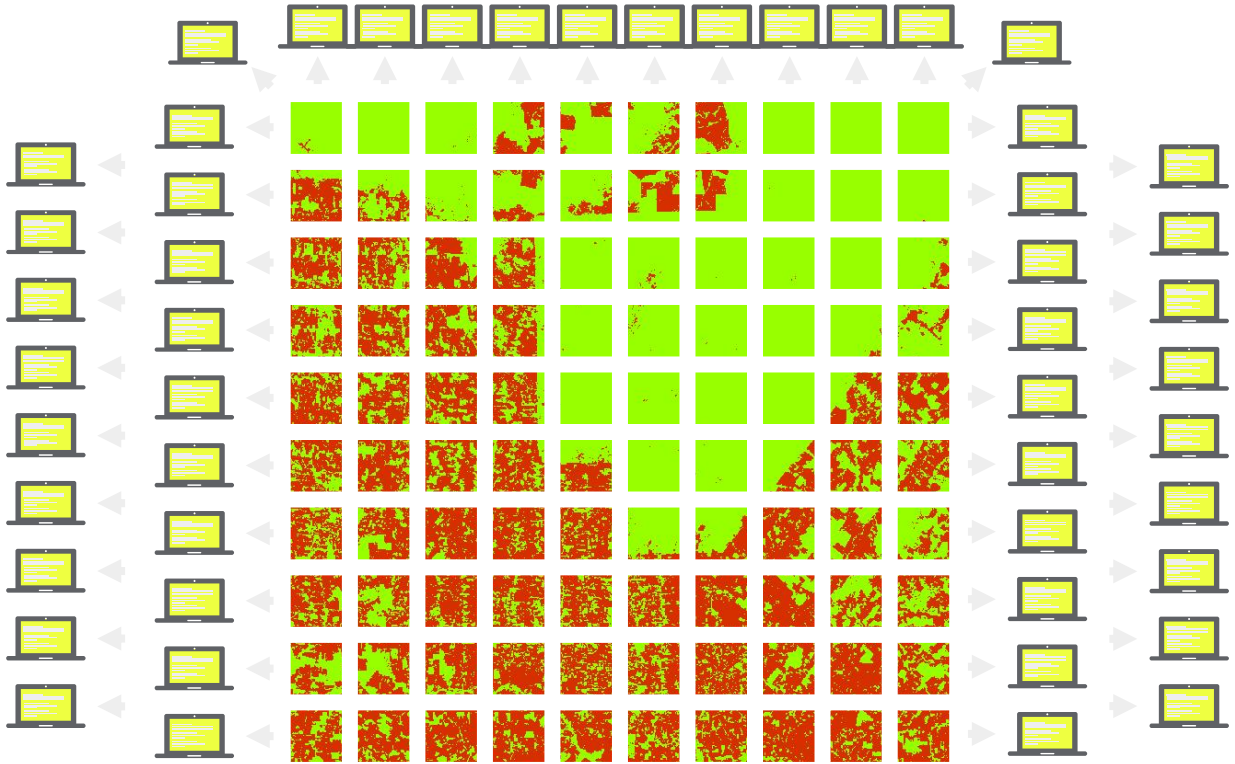


Sub-units are distributed

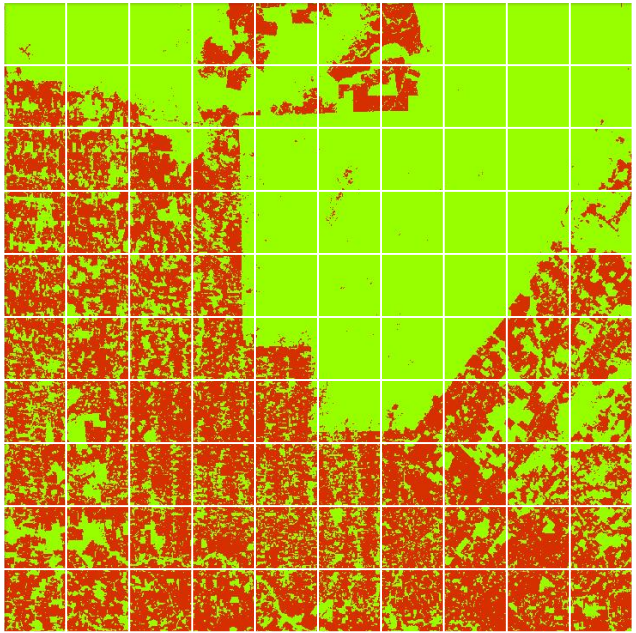


Sub-units are distributed

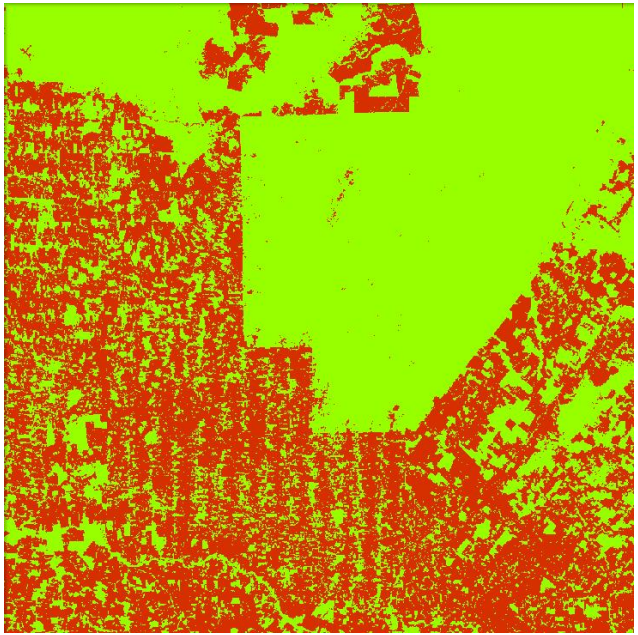
to separate machines where they can be processed in parallel.



Thousands can be processed simultaneously.



Result is reassembled



Result is reassembled

into a finished image.

Global Forests:
Map, Measure, Monitor

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Science 15 November 2013:
Vol. 342 no. 6160 pp. 850-853
DOI: 10.1126/science.1244693

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REPORT

High-Resolution Global Maps of 21st-Century Forest Cover Change

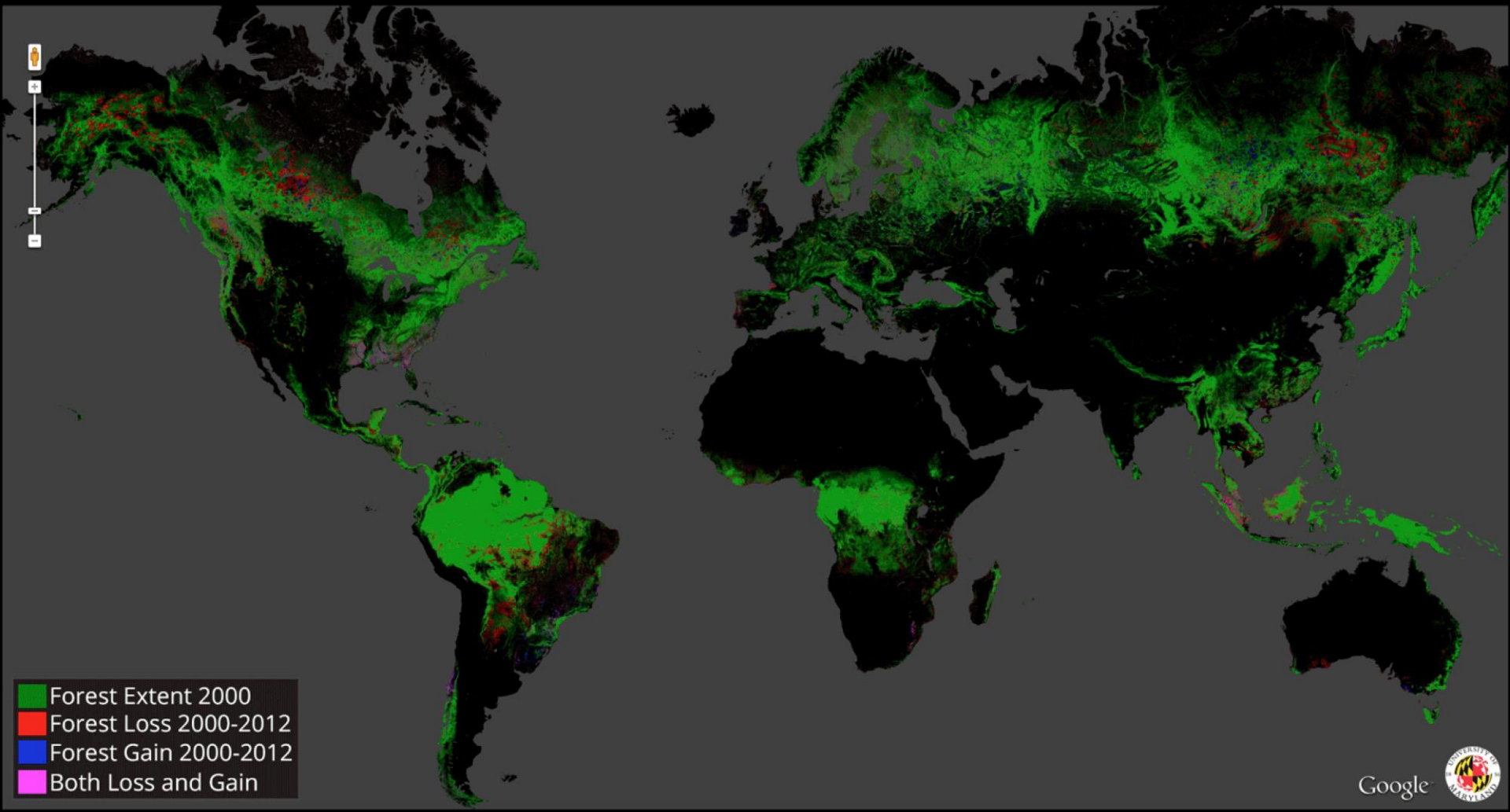
M. C. Hansen[1,*], P. V. Potapov[1], R. Moore[2], M. Hancher[2], S. A. Turubanova[1], A. Tyukavina[1], D. Thau[2], S. V. Stehman[3], S. J. Goetz[4], T. R. Loveland[5], A. Kommareddy[6], A. Egorov[6], L. Chini[1], C. O. Justice[1], J. R. G. Townshend[1]

± Author Affiliations

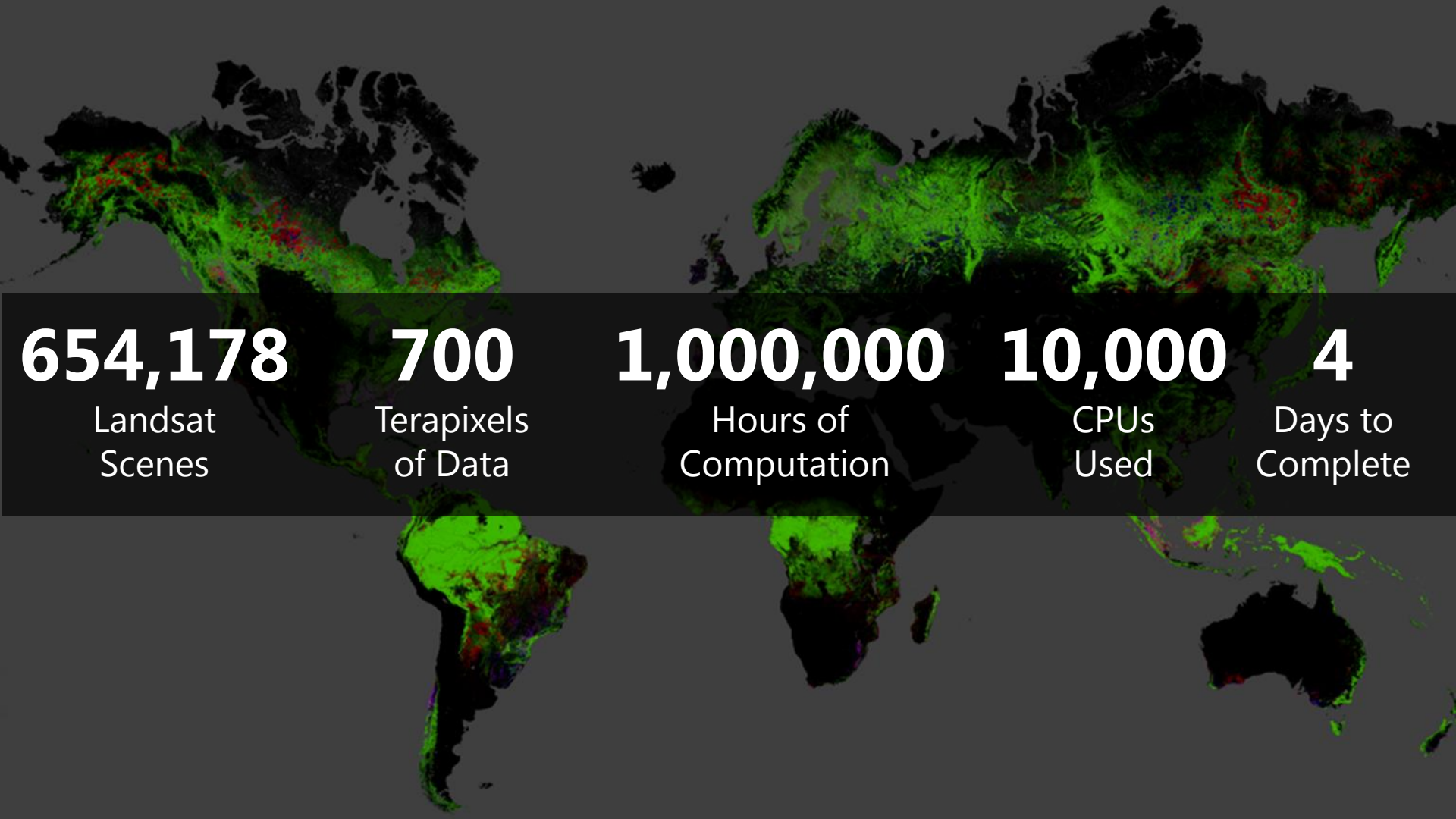
*Corresponding author. E-mail: mhansen@umd.edu

ABSTRACT | EDITOR'S SUMMARY

Quantification of global forest change has been lacking despite the recognized importance of forest ecosystem services. In this study, Earth observation satellite data were used to map global forest loss (2.3 million square kilometers) and gain (0.8 million square kilometers) from 2000 to 2012 at a spatial resolution of 30 meters. The tropics were the only climate domain to exhibit a trend, with forest loss increasing by 2101 square kilometers per year. Brazil's well-documented reduction in deforestation was offset by increasing forest loss in Indonesia, Malaysia, Paraguay, Bolivia, Zambia, Angola, and elsewhere. Intensive forestry practiced within subtropical forests resulted in the highest rates of forest change globally. Boreal forest loss due largely to fire and forestry was second to that in the tropics in absolute and proportional terms. These results depict a globally consistent and locally relevant record of forest change.



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

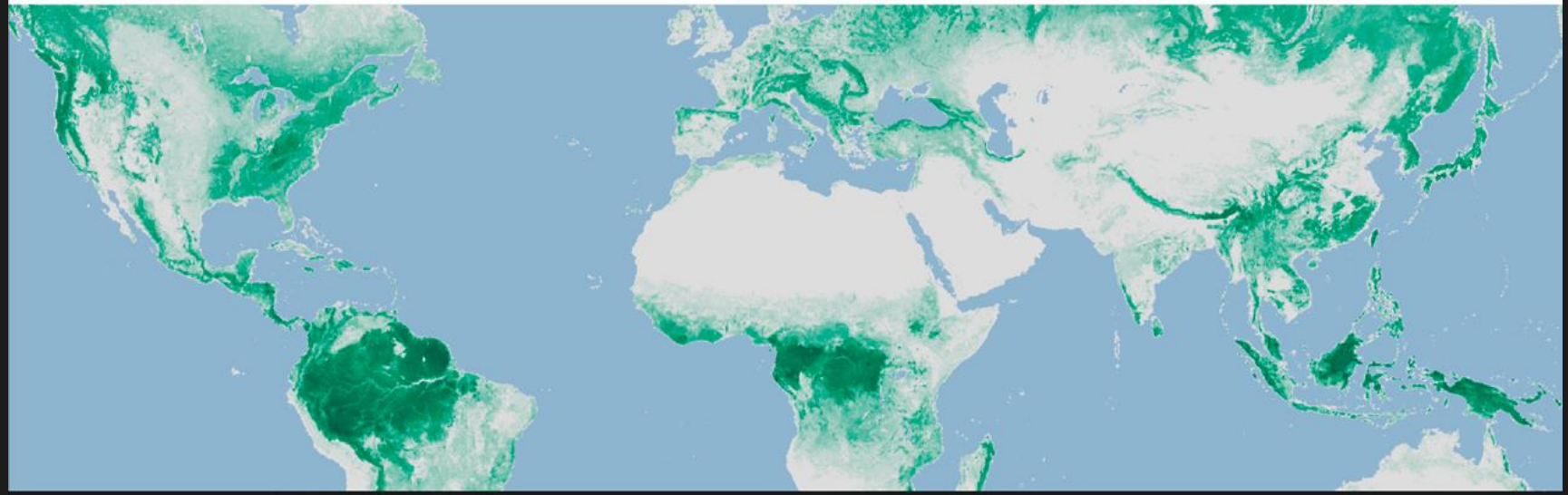
GLOBAL FOREST WATCH 2.0

HOME COUNTRIES STORIES MAP BLOG DATA ABOUT ENGLISH +

Find out what is happening in forests right now

44,479
ALERTS IN THE PAST YEAR

3
NEW FOREST STORIES



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Analysis tool

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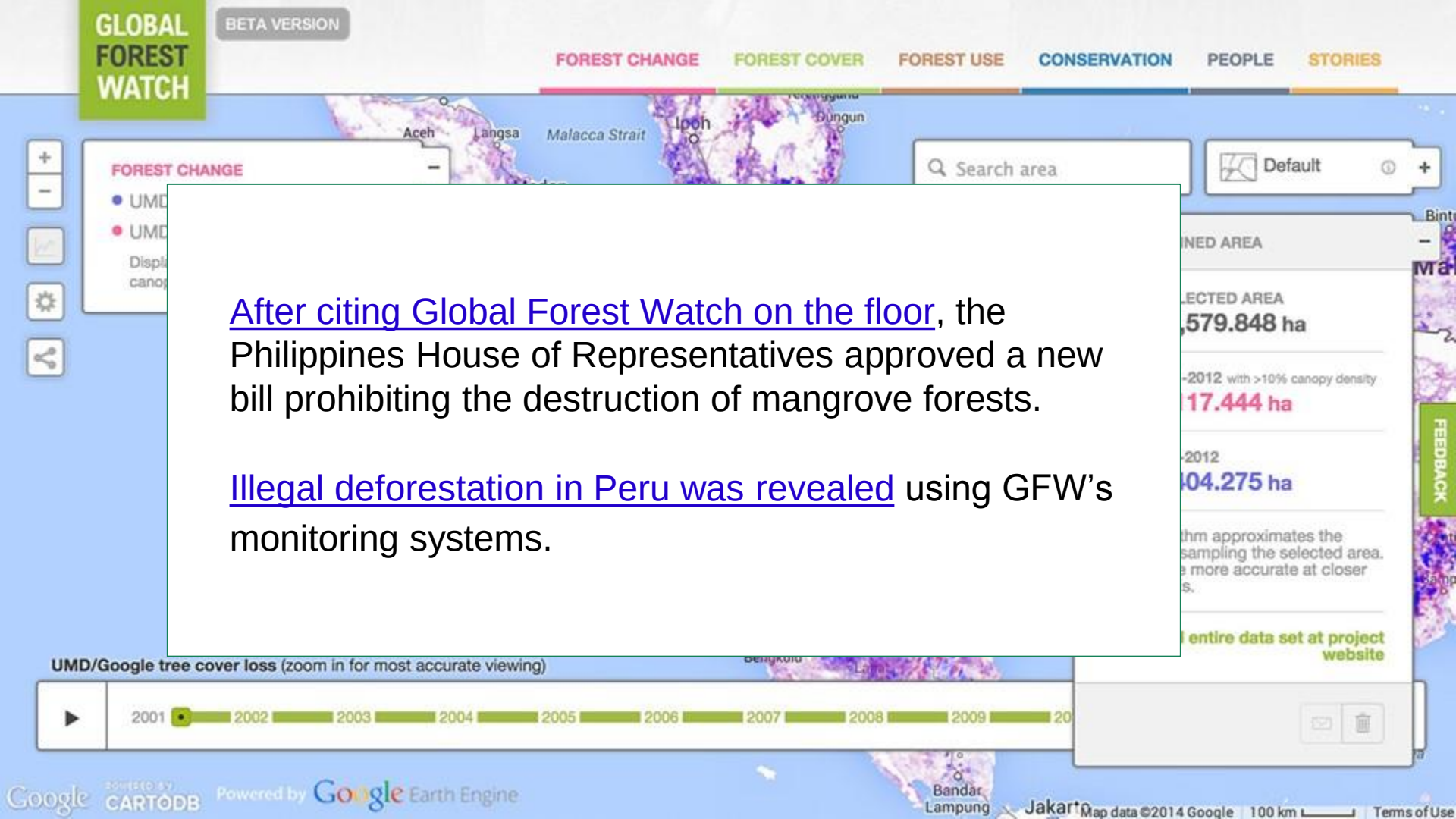


[After citing Global Forest Watch on the floor], the Philippines House of Representatives approved a new bill prohibiting the destruction of mangrove forests.

[Illegal deforestation in Peru was revealed] using GFW's monitoring systems.

CONSERVATION BIOLOGY

Tracking changes and preventing loss in critical tiger habitat

10.1126/sciadv.1501675

Anup R. Joshi,[1]* Eric Dinerstein,[2] Eric Wikramanayake,[2] Michael L. Anderson,[2] David Olson,[2] Benjamin S. Jones,[3] John Seidensticker,[2,4] Susan Lumpkin,[2] Matthew C. Hansen,[5] Nigel C. Sizer,[6] Crystal L. Davis,[6] Suzanne Palminteri,[2] Nathan R. Hahn[2]

Sci. Adv. 2016;2:e1501675 1 April 2016

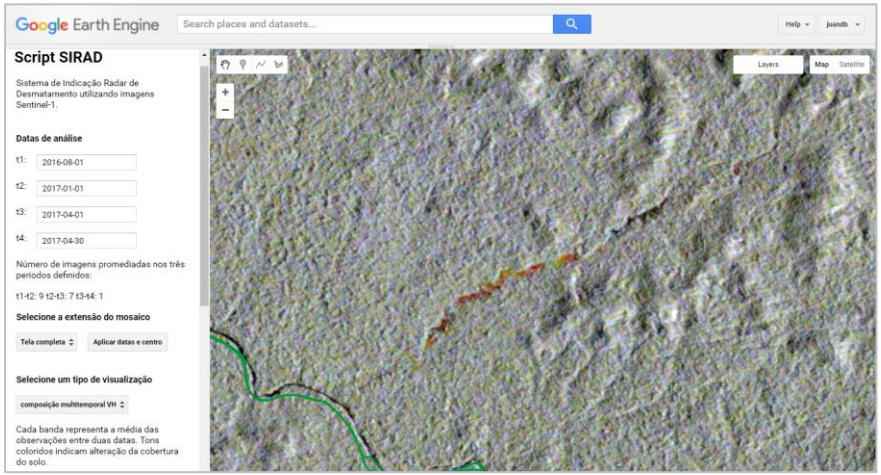
"*This study was made possible by free availability of satellite imagery, cloud computing services, and interactive web tools.* ***We were able to analyze 14 years of high-resolution global forest loss data across 76 landscapes that span 13 countries.***"

Photo: Dibyendu Ash, www.goingwild.com

http://advances.sciencemag.org/content/2/4/e1501675.full

Chasing deforestation through the clouds

Instituto Socioambiental



Lineal deforestation feature growing deep into a National Forest, identified by ISA in February using their SIRAD app on ESA Sentinel-1 radar data in Earth Engine.

Google and FAO partner to make remote sensing data more efficient and accessible

Partnership enhances ability to assess changing forest and to estimate greenhouse gas emissions

Forest researchers in Viet Nam use laser technologies to measure tree height and thickness.

1 December, Paris - Google Maps and FAO have agreed to work closely together to make geospatial tracking and mapping products more accessible, providing a high-technology assist to countries tackling climate change and much greater capacity to experts developing forest and land-use policies.

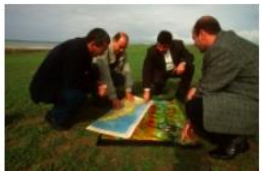
Digital technology tapping into satellite imagery is revolutionizing the way countries can assess, monitor and plan the use of their natural resources, including monitoring deforestation and desertification.

"For FAO, this is not just a partnership. This is a strategic alliance," said FAO Director-General José Graziano da Silva, noting it combines FAO's global effort to combat climate

FAO's José Graziano da Silva and Google's Rebecca Moore celebrate the partnership formalization at COP21 in Paris.

Related link

FAO support to Forest monitoring and assessment



The extent of forest in dryland biomes

Jean-François Bastin[1,2,*], Nora Berrahmouni[1], Alan Grainger[3], Danae Maniatis[4,5], Danilo Mollicone[1], Rebecca Moore[6], C...
+ See all authors and affiliations

Science 12 May 2017:
Vol. 356, Issue 6338, pp. 635-638
DOI: 10.1126/science.aam6527

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Mapping the world's dry forests

The extent of forest area in dryland habitats, which occupy more than 40% of Earth's land surface, is uncertain compared with that in other biomes. Bastin *et al.* provide a global estimate of forest extent in drylands, calculated from high-resolution satellite images covering more than 200,000 plots. Forests in drylands are much more extensive than previously reported and cover a total area similar to that of tropical rainforests or boreal forests. This increases estimates of global forest cover by at least 9%, a finding that will be important in estimating the terrestrial carbon sink.

Science, this issue p. 635

High–resolution mapping of global surface water and its long–term changes

Jean–Francois Pekel[1], Andrew Cottam[1], Noel Gorelick[2] & Alan S. Belward[1]

doi:10.1038/nature20584

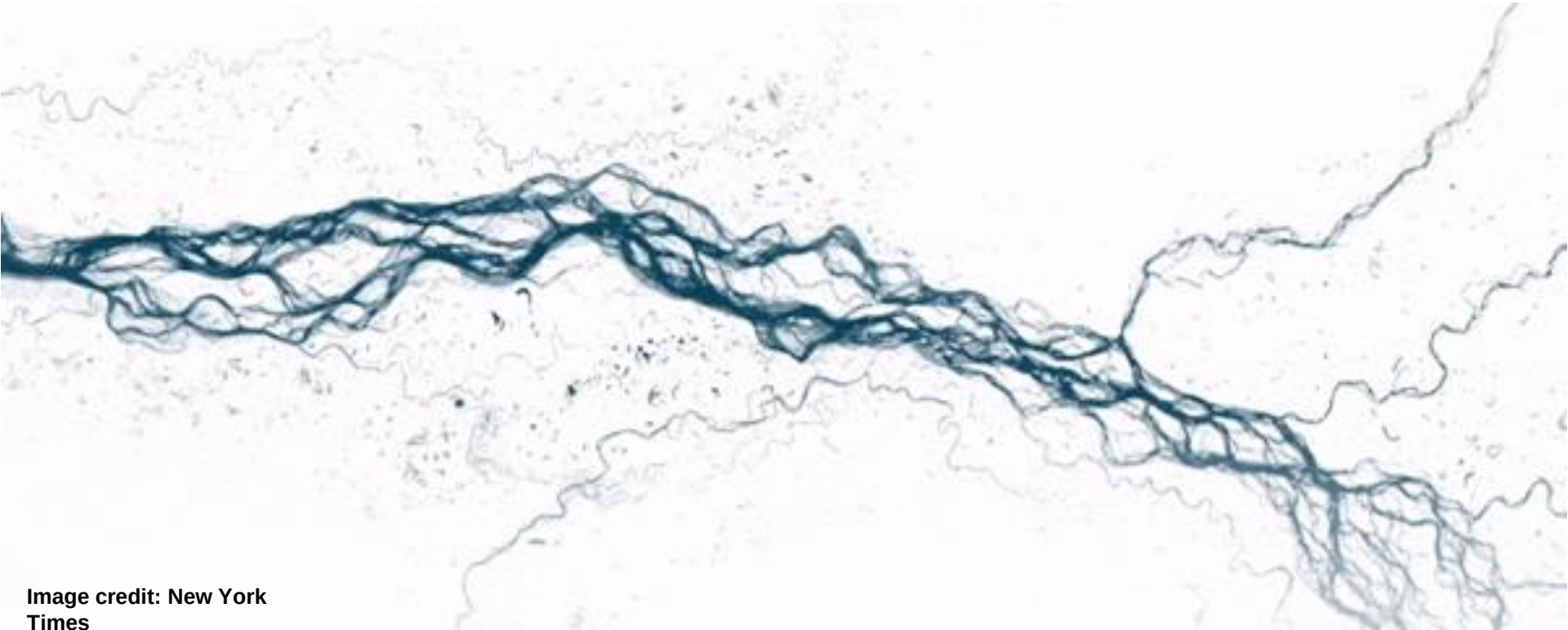
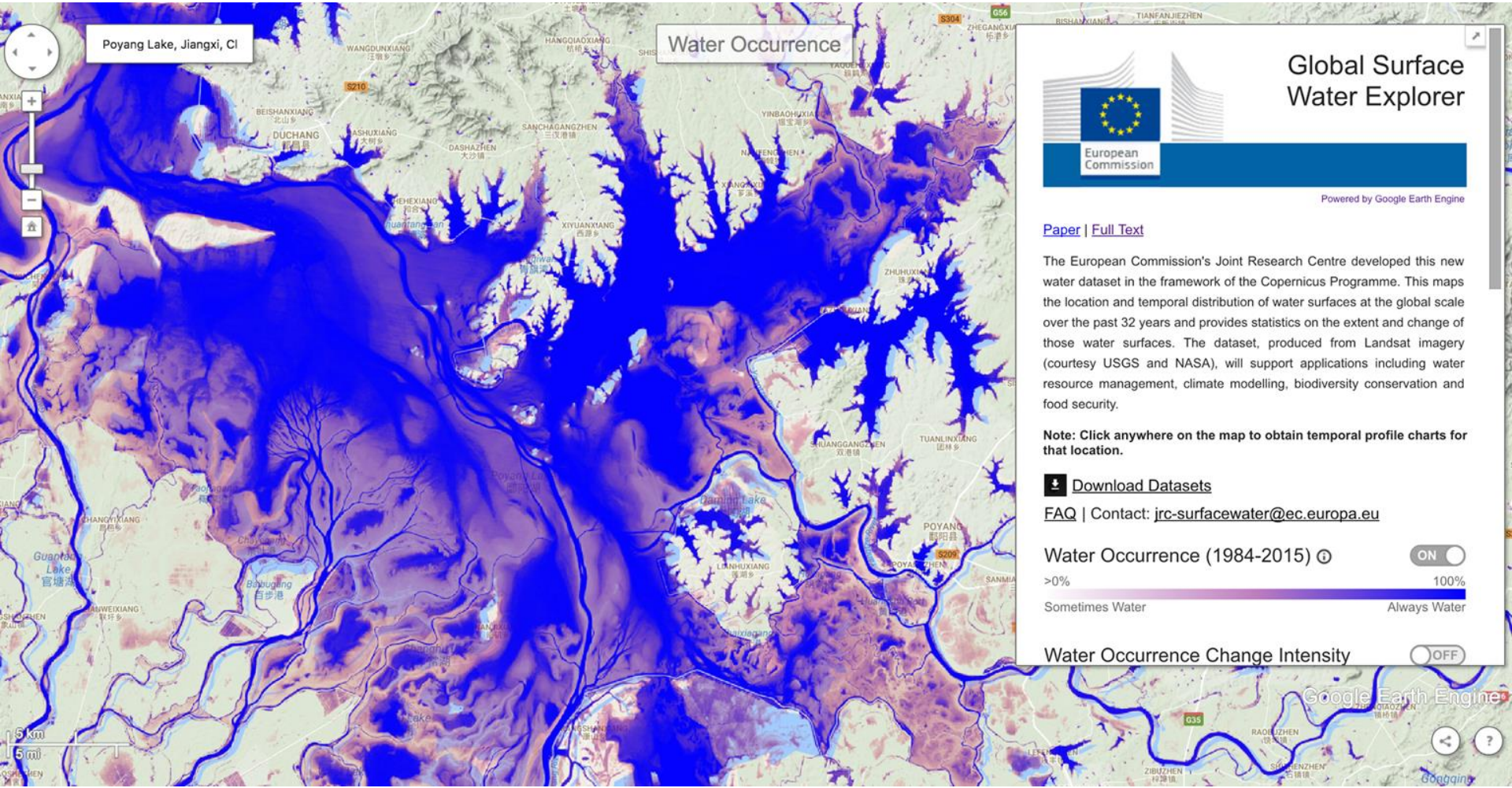
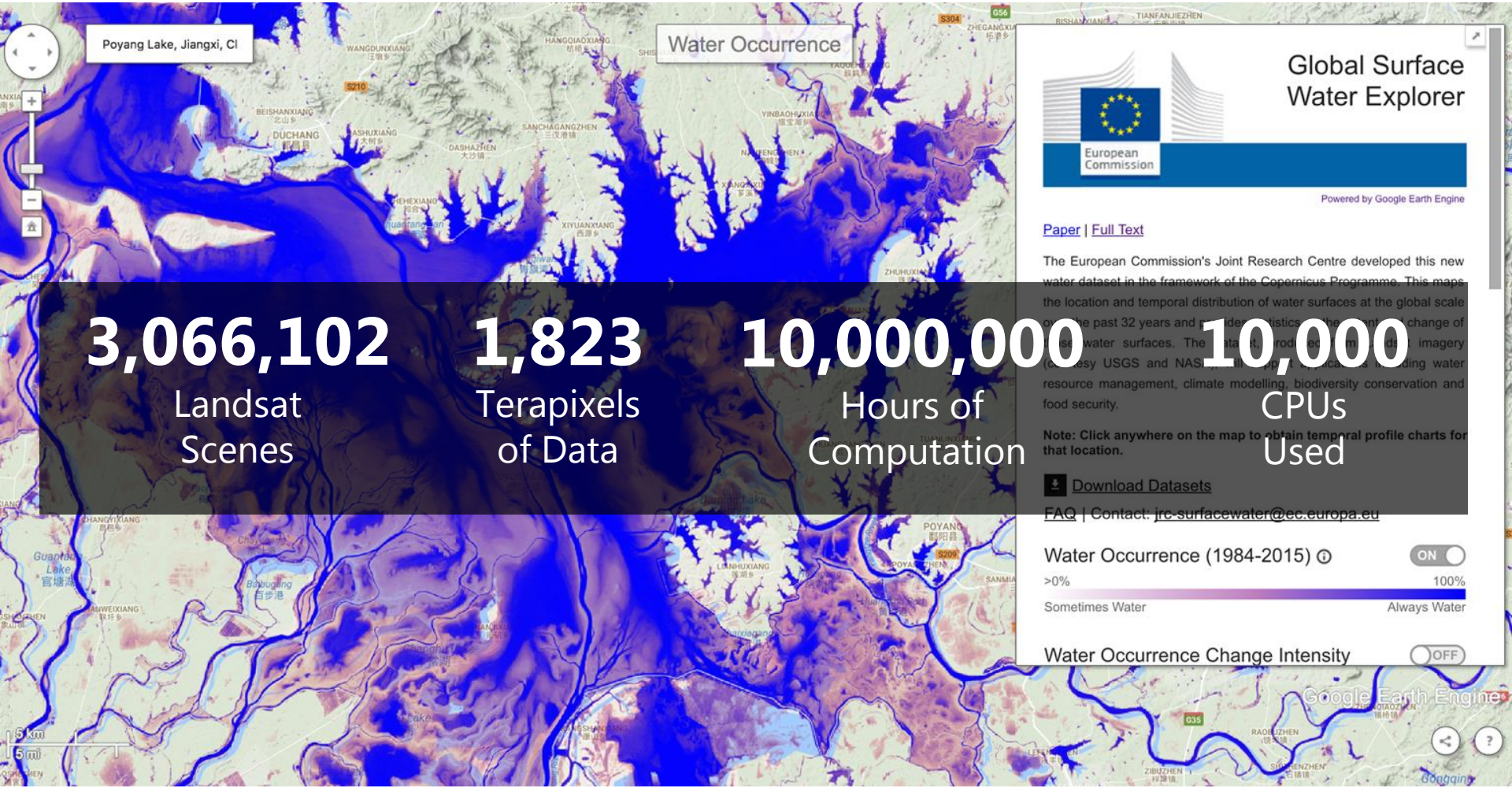


Image credit: New York Times



Global-surface-water.appspot.com



3,066,102
Landsat Scenes

1,823
Terapixels of Data

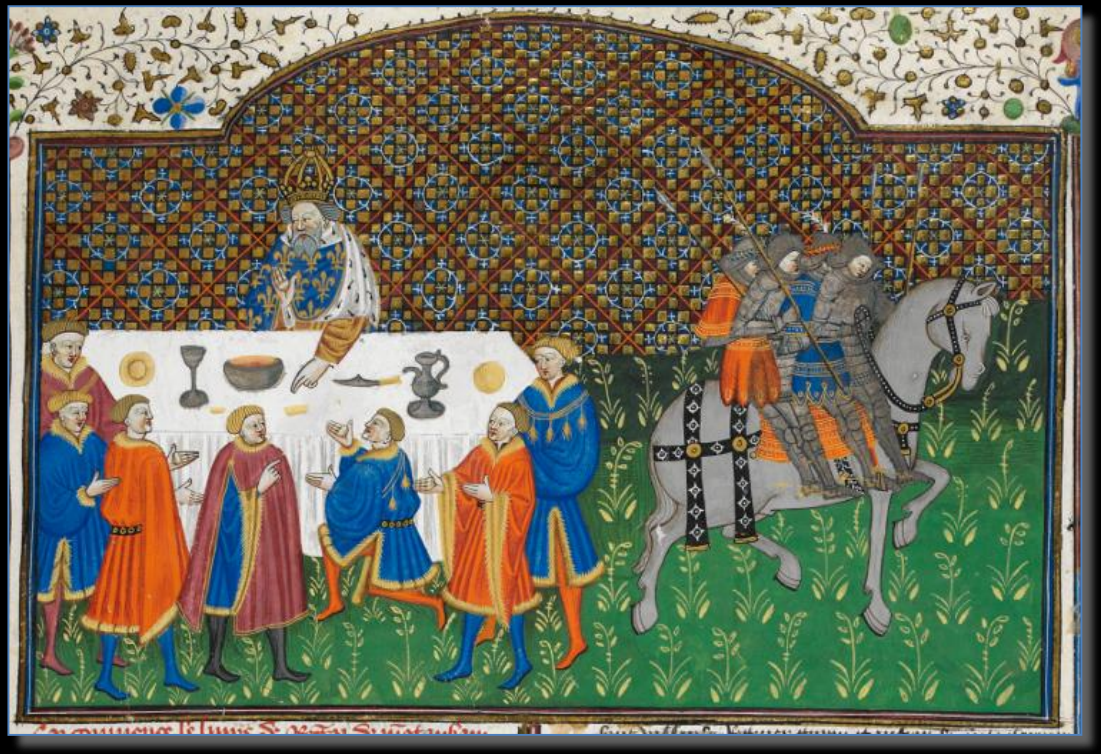
10,000,000
Hours of Computation

10,000
CPUs Used

Global-surface-water.appspot.com

Processing 3 million scenes on one computer would have taken 1,212 years

Processing 3 million scenes in Google's Earth Engine took 45 days



Start your computer running just after Charlemagne conquers Saxony in 804... leave it running 24 hours a day, 7 days a week and the water maps just might be ready today

Charlemagne at dinner; detail of a miniature from BL Royal MS 15 E vi, f. 155r (the "Talbot Shrewsbury Book"). Held and digitised by the British Library.

Bringing the Power of Google to Scientists in the Lower Mekong

Photo: Shutterstock/Denis Rozan

Introduction

Landscapes on Earth are changing at unprecedented levels. For scientists, practitioners and environmental decision makers, tracking these changes efficiently and accurately is critical to protecting lives and livelihoods. While there are

With GEE, people can get their questions answered virtually instantly. Work that usually takes months is now processed in seconds. Financial resources that would have been spent on large servers and high-computing processors are extraneous and can instead be reallocated for other

https://www.servirglobal.net/Global/Articles/Article/2527/bringing-the-power-of-google-to-scientists-in-the-lower-mekong

USAID FROM THE AMERICAN PEOPLE

NASA

adpc

SERVIR MEKONG

Home About

Map Satellite

EcoDash Controls

Step 1: Select a time period for the baseline EVI

2000 - 2010

Step 2: Select a time period to measure ΔEVI

2010 - 2015

Step 3: Update the map with the cumulative ΔEVI

Update Map

Step 4: Choose a polygon selection method

- Province
- Country
- Draw Polygon

ΔEVI

Increase

Stable

Decrease

Opacity: 1

Give us Feedback

Spatial Informatics Group

SEI STOCKHOLM ENVIRONMENT INSTITUTE

Deltares

Coastal Risk Vanuatu

Predicted Coastal Flooding Resulting from Climate Change

Background | Guide | Useful Links

Where do you want to look?

Coastal Risk Vanuatu 2100

Place Search

Predicted | Manual

Predicted Inundation Scenario

1.High

Current Day Highest Tide	2100 | + 0.74m Highest Tide

Aerial Photography

Cyclone Pam UAV Imagery

Cyclone Pam Crowd Sourced Photos

DEM

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Predicted

Manual

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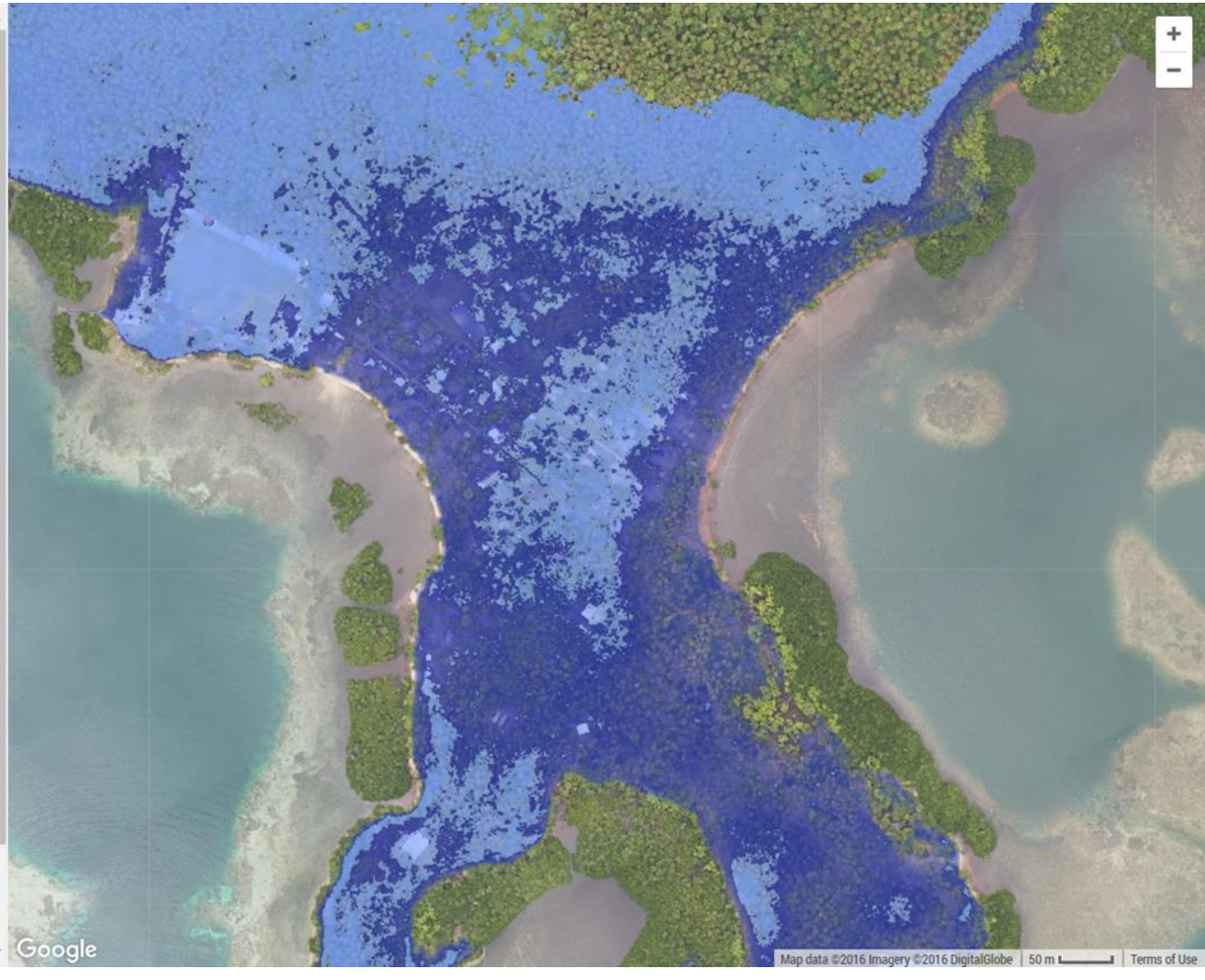

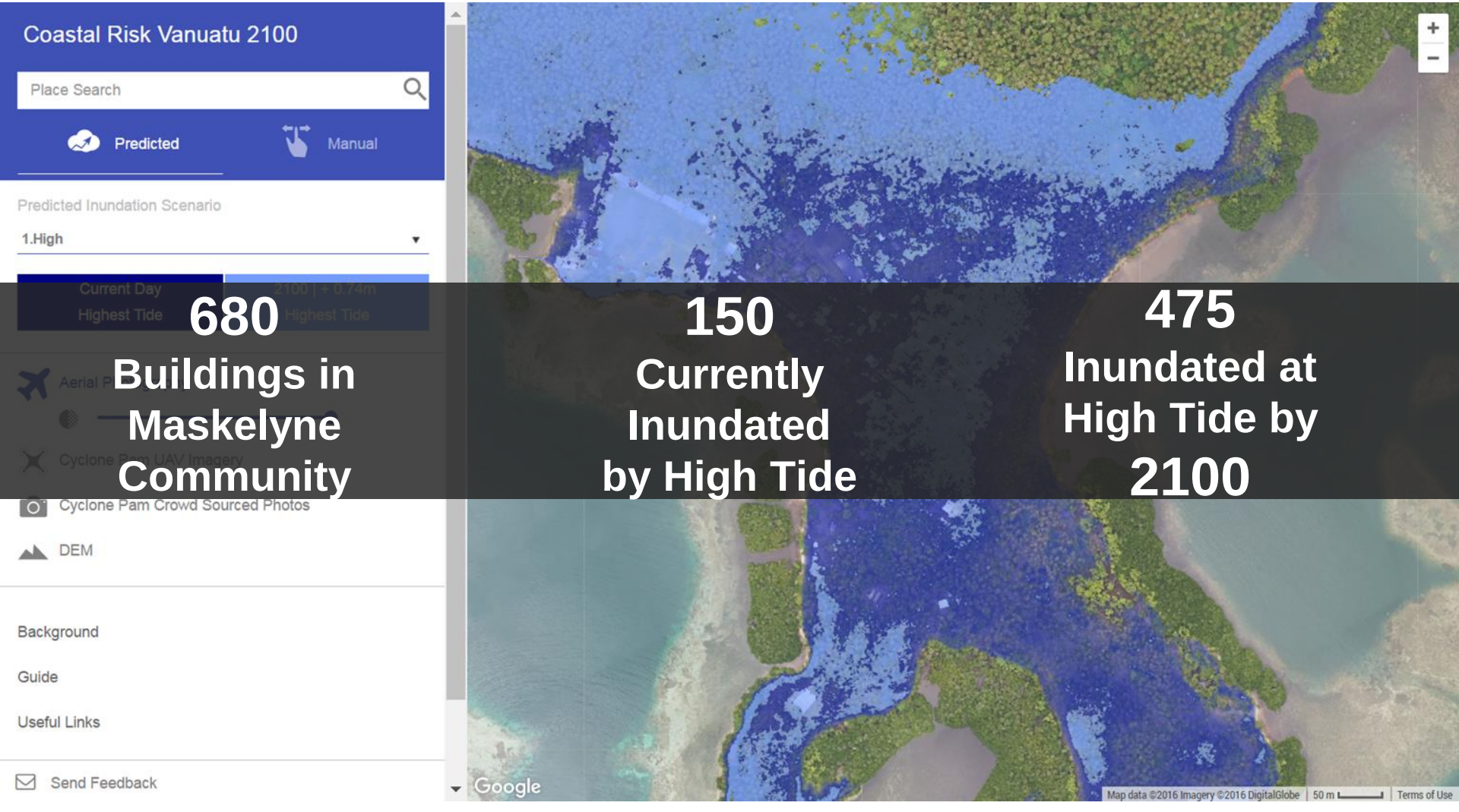
Coastal Risk Vanuatu 2100
Place Search
Predicted
Manual
Predicted Inundation Scenario
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Current Day
Highest Tide
2100 | + 0.74m
Highest Tide
Aerial P
Cyclone Pam UAV Imagery
Cyclone Pam Crowd Sourced Photos
DEM
Background
Guide
Useful Links
Send Feedback
680
Buildings in Maskelyne Community
150
Currently Inundated by High Tide
475
Inundated at High Tide by 2100
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Bodies

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Overview
Adaptation
Climate Finance
Mitigation
Technology

MAPPING EXPOSURE TO SEA LEVEL RISE | TONGA, SAMOA, VANUATU AND PAPUA NEW GUINEA

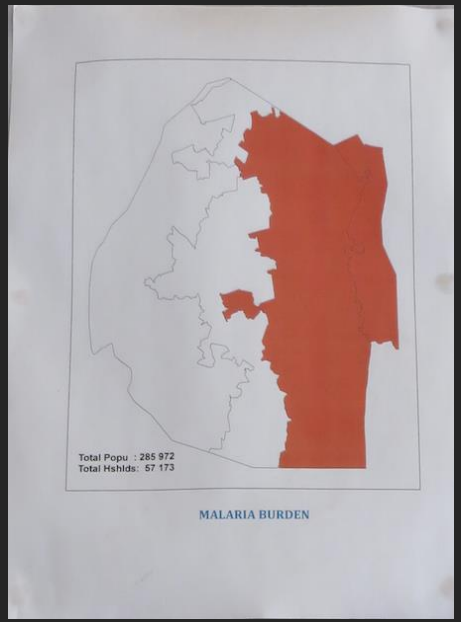
Innovative ICT solutions are helping Pacific Island countries prepare for and adapt to sea level rise brought about by climate change. This project provides the fundamental data, skills and tools at-risk communities need to make planning decisions. It trains government decision makers to use online tools and flood maps to understand and mitigate the risks of sea level rise. Using these maps, governments can better understand and communicate climate change risk to local communities and put adaptation plans in place.

DiSARM: Maps, Machine Learning & Malaria

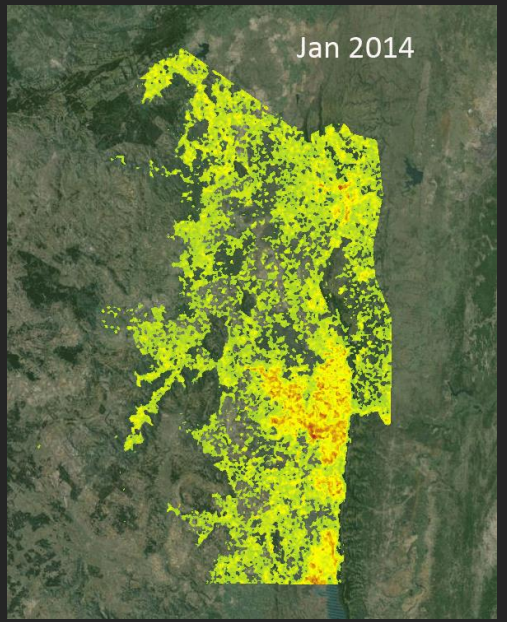
Problem: How to prioritize villages for intervention and resource deployment, e.g. bed nets?

UCSF and other orgs are using Earth Engine to generate automated high-resolution malaria risk maps in Zimbabwe and Swaziland.

DiSARM's mobile app can be used by the malaria programs and field teams to target interventions. The goal is to make their monitoring more efficient and effective, and to eliminate malaria in Swaziland in the next 3 years.



Current maps used by the ***National Malaria Control Program*** in Swaziland.



Monthly risk maps generated by the DiSARM platform, powered by Earth Engine. ***UCSF Global Health Group***

Learn more at disarm.io

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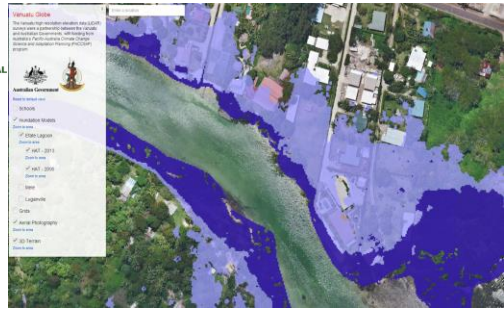
USGS
science for a changing world

NASA

CONAFOR
COMISIÓN NACIONAL FORESTAL



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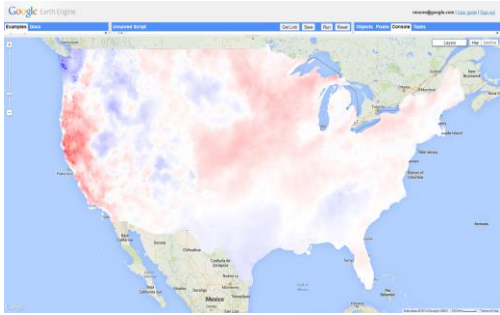

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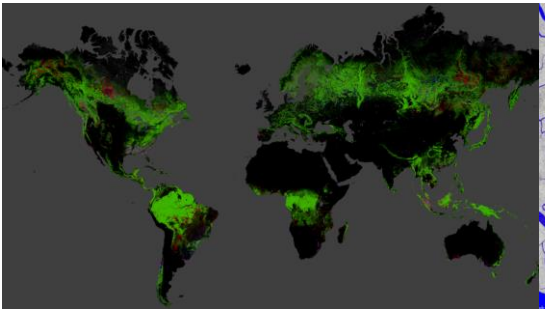

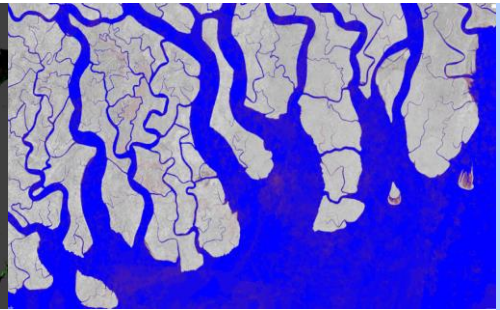

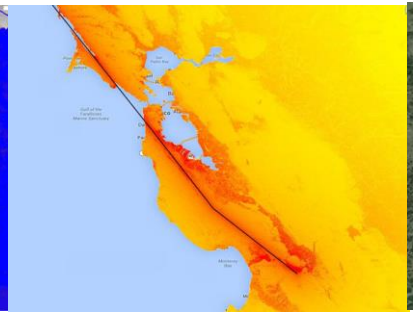

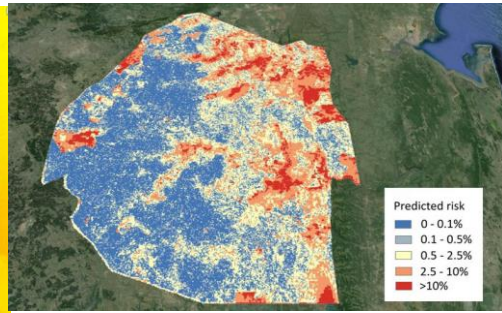

Thank you!

Rebecca Moore, Google

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