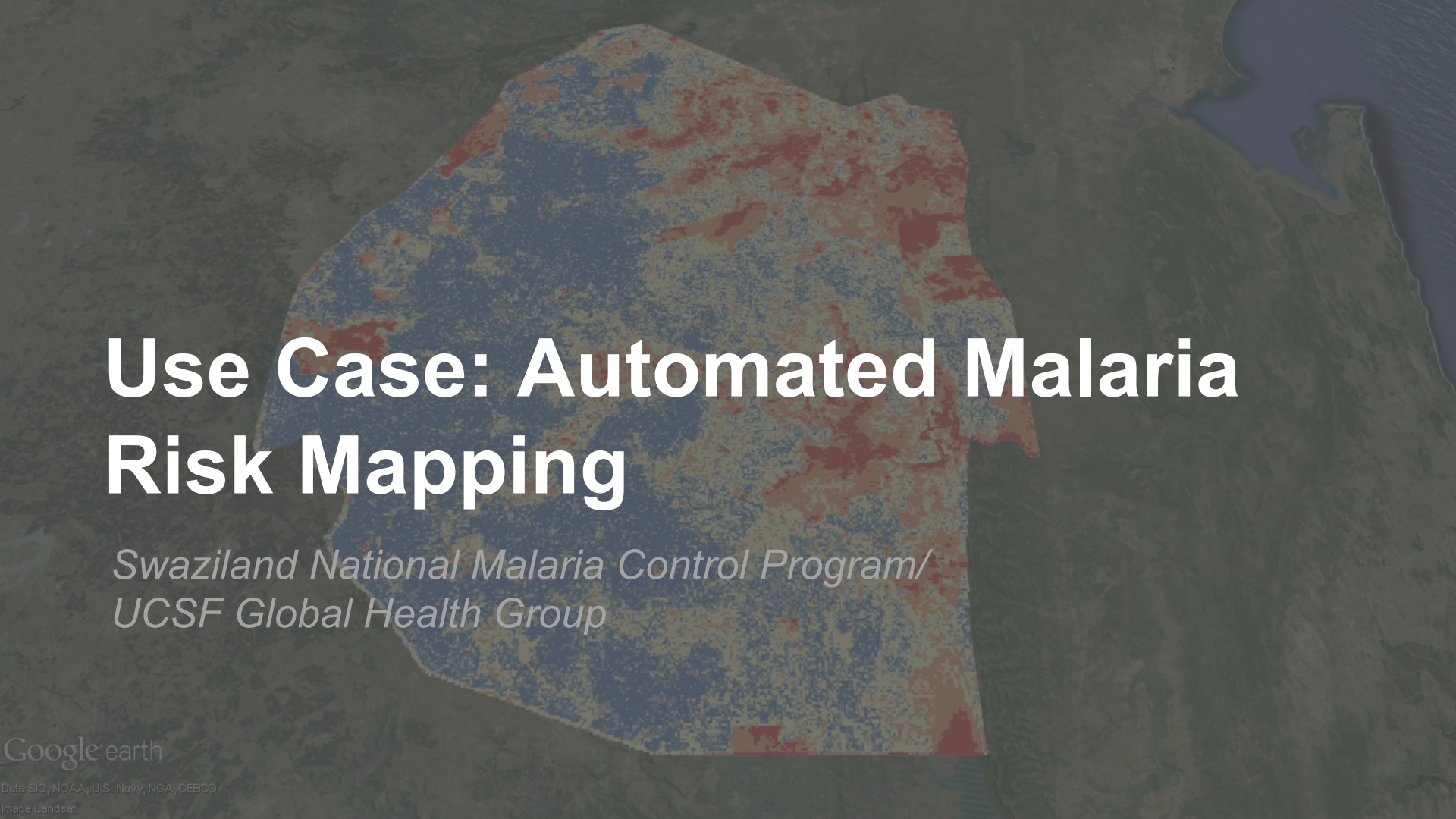
Google
Earth Engine
Health Applications of Google's Cloud Platform for Big Earth Data

Agenda

- Example Use Case
- Earth Engine
  - –Data
  - –Analysis
- Applications



Use Case: Automated Malaria Risk Mapping

Swaziland National Malaria Control Program/
UCSF Global Health Group

Swaziland

Swaziland

Photos · Search nearby

Namibia

Botswana

Gobabis

Swakopmund

Windhoek

Walvis Bay

Rehoboth

Namib-Naukluft National Park

Solitaire

Mariental

Central Kalahari Game Reserve

Gaborone

Polokwane

Kruger National Park

Hazyview

Maputo

St Lucia

Richards Bay

Mthatha

East London

Grahamstown

Oudtshoorn

Cape Town

Port Elizabeth

Knysna

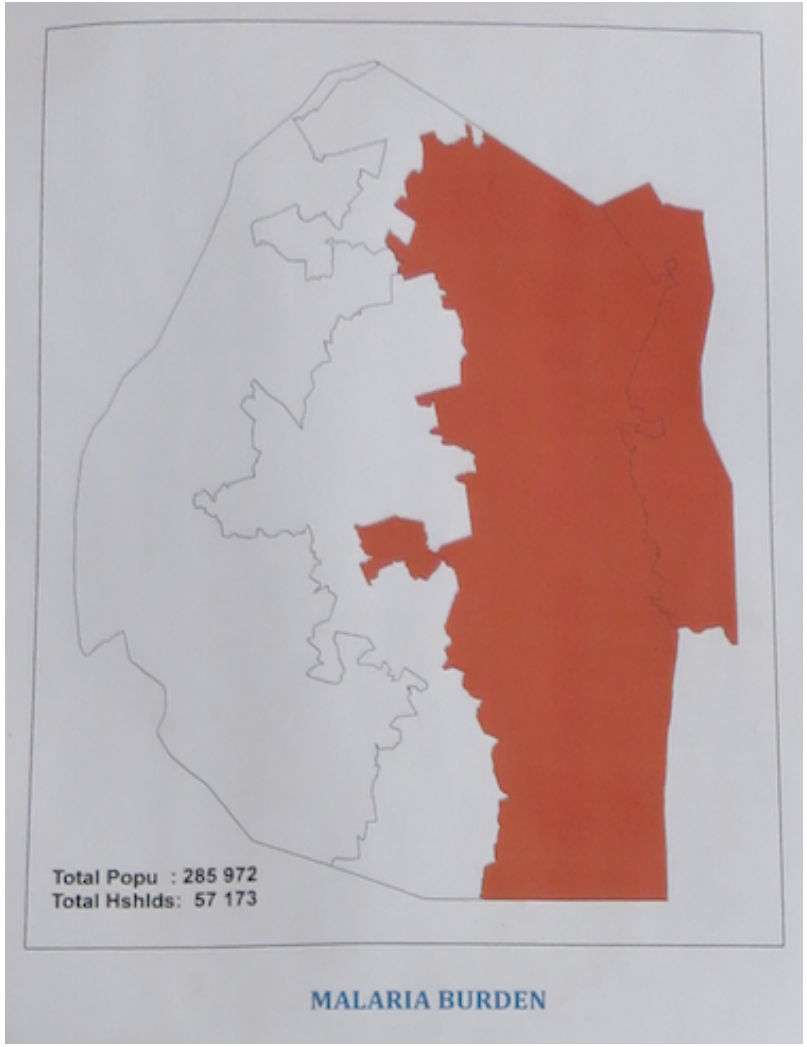
Plettenberg Bay

Hermanus

Langebaan

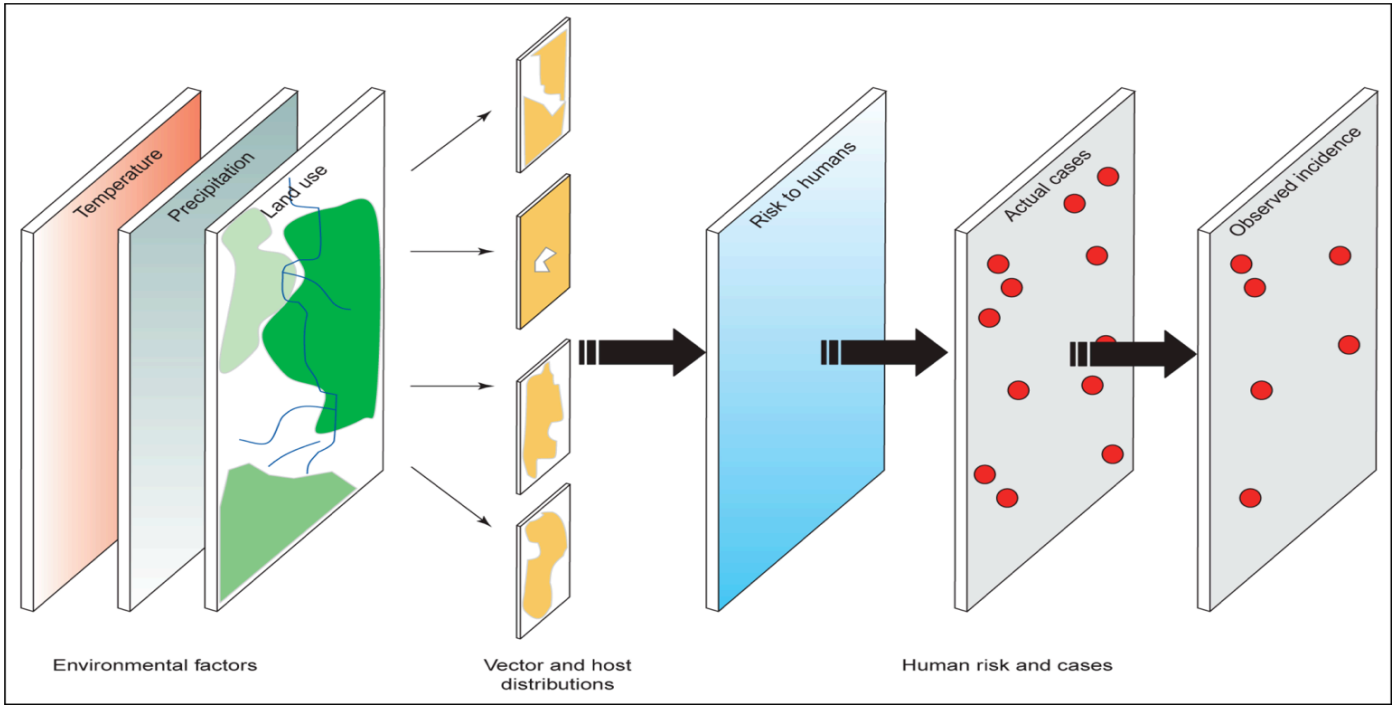
Earth

Google

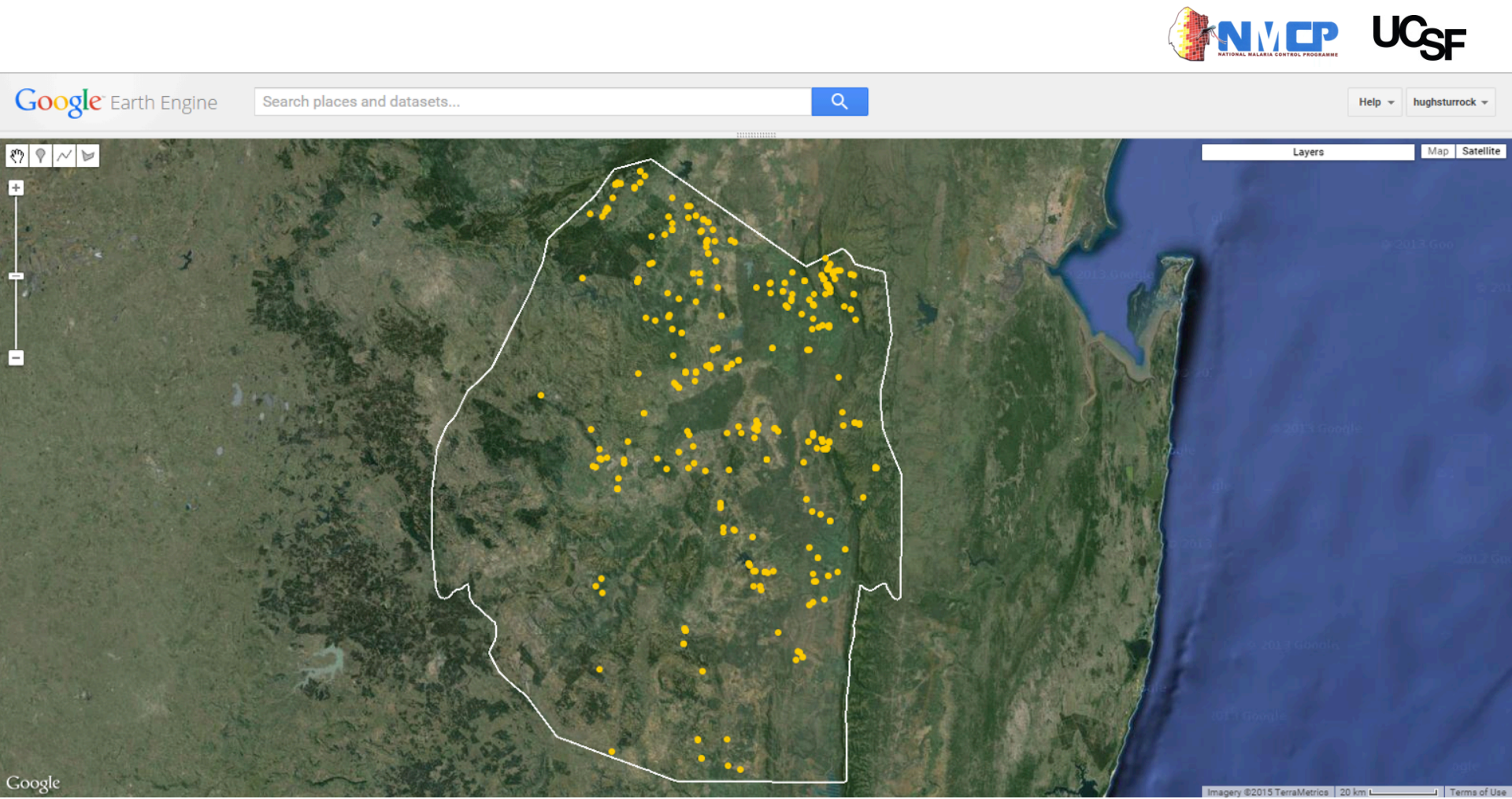


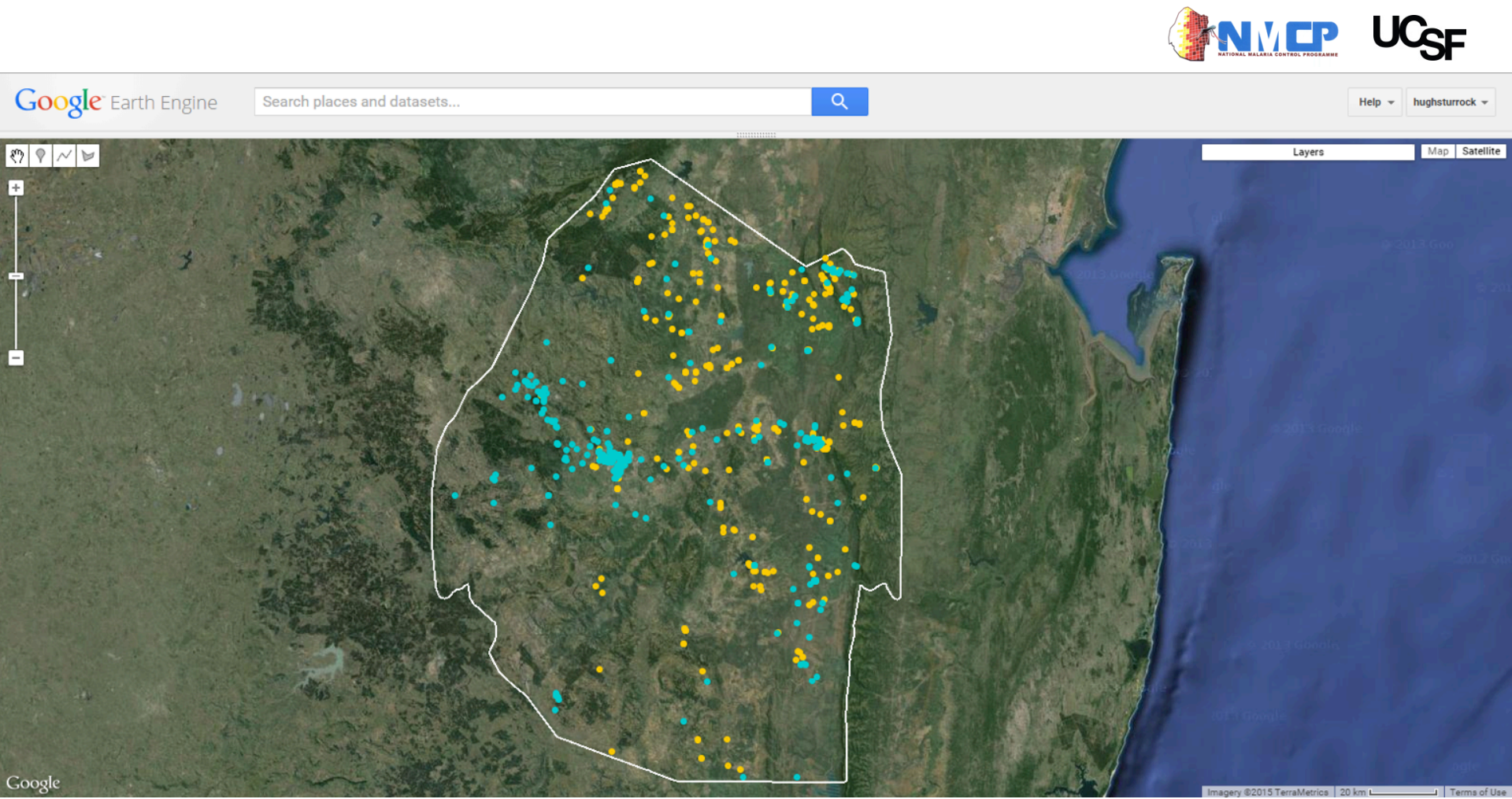
MALARIA BURDEN

Disease Risk Mapping



Ostfeld et al 2005, TRENDS in Ecology and Evolution Vol.20 No.6


NMCP
NATIONAL MALARIA CONTROL PROGRAMME
UCSF
Google Earth Engine
Search places and datasets...
Help
hughsturrock
Layers
Map
Satellite
Google
Imagery ©2015 TerraMetrics
20 km
Terms of Use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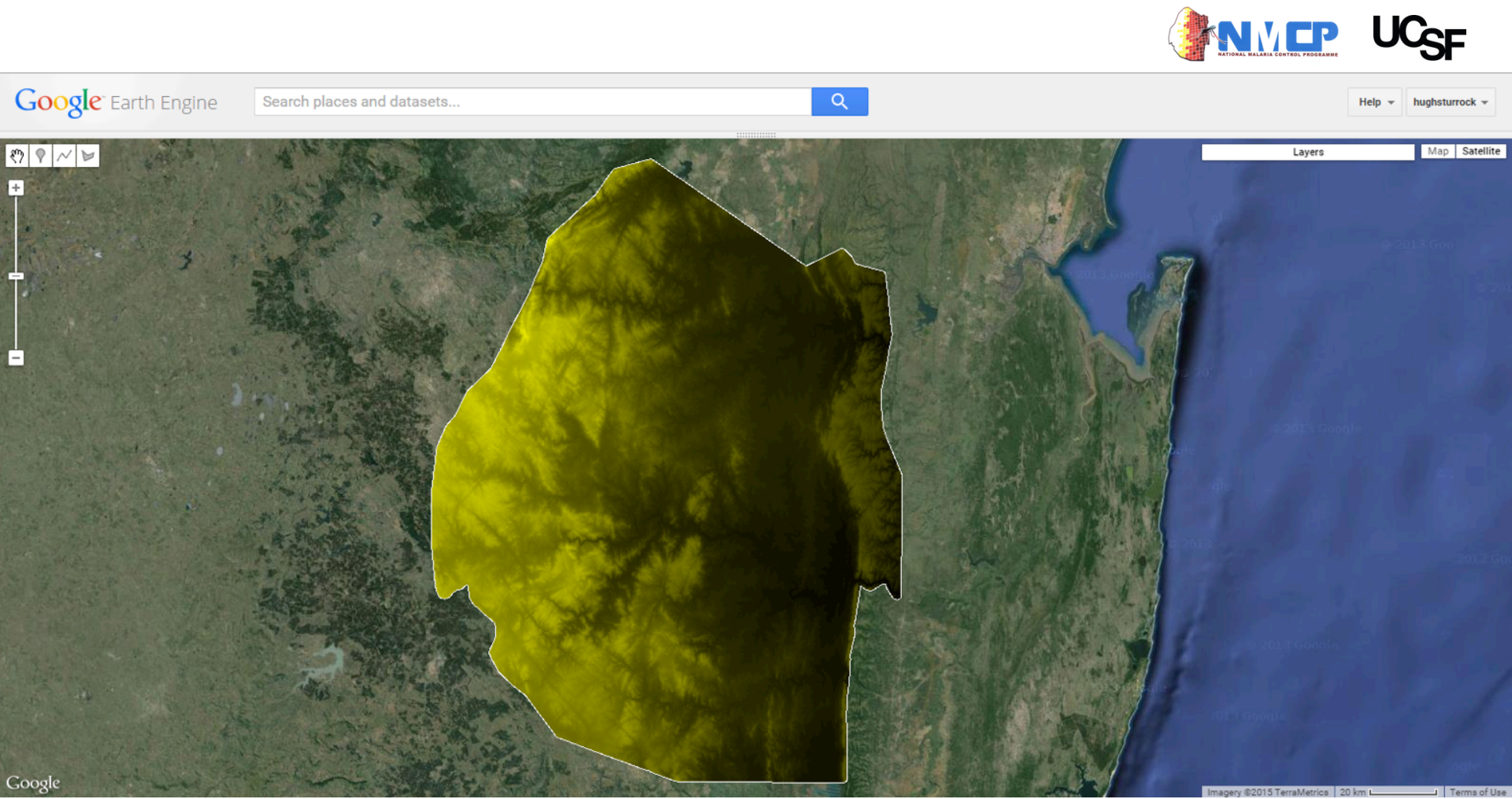
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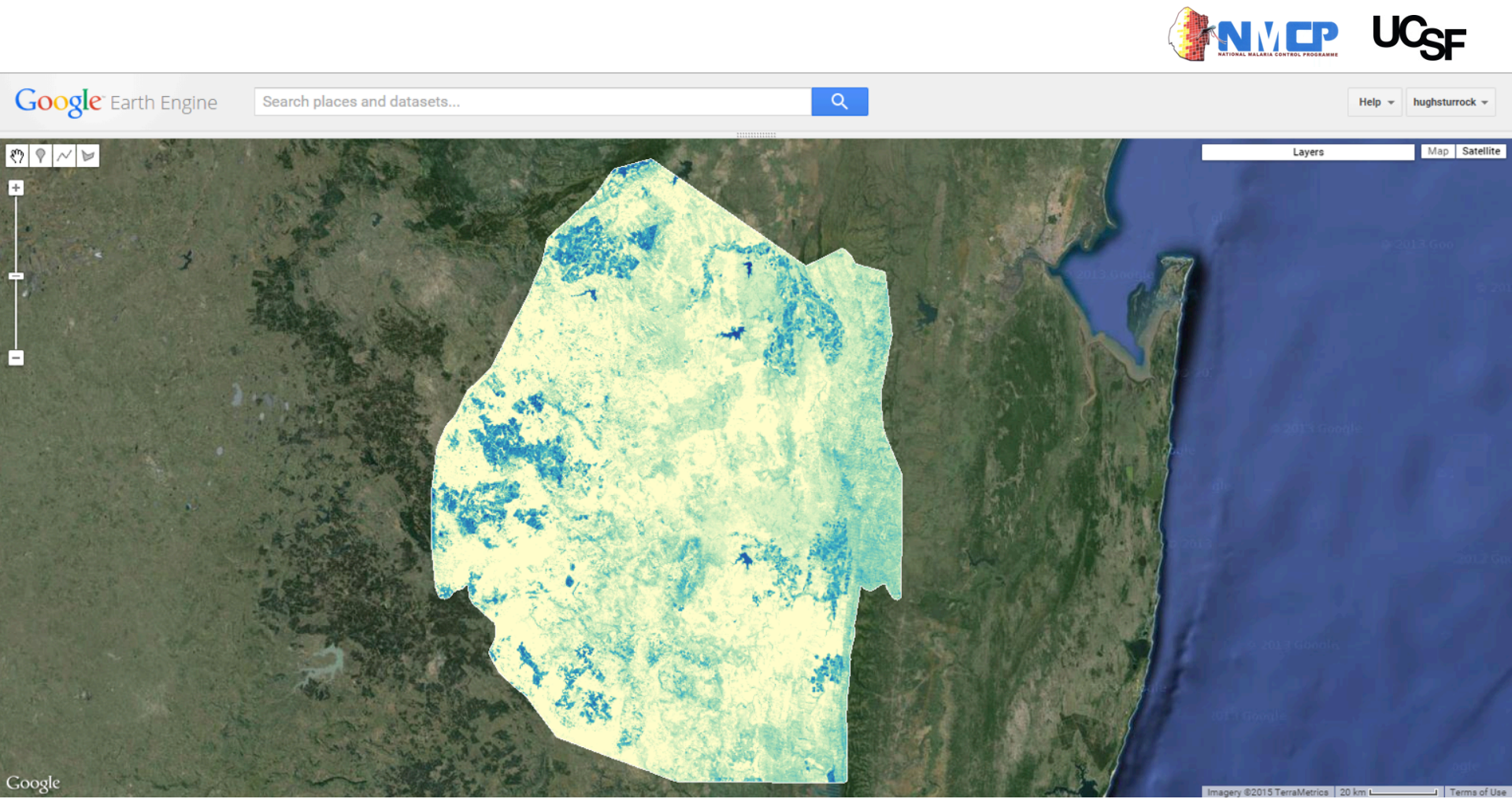
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Satellite
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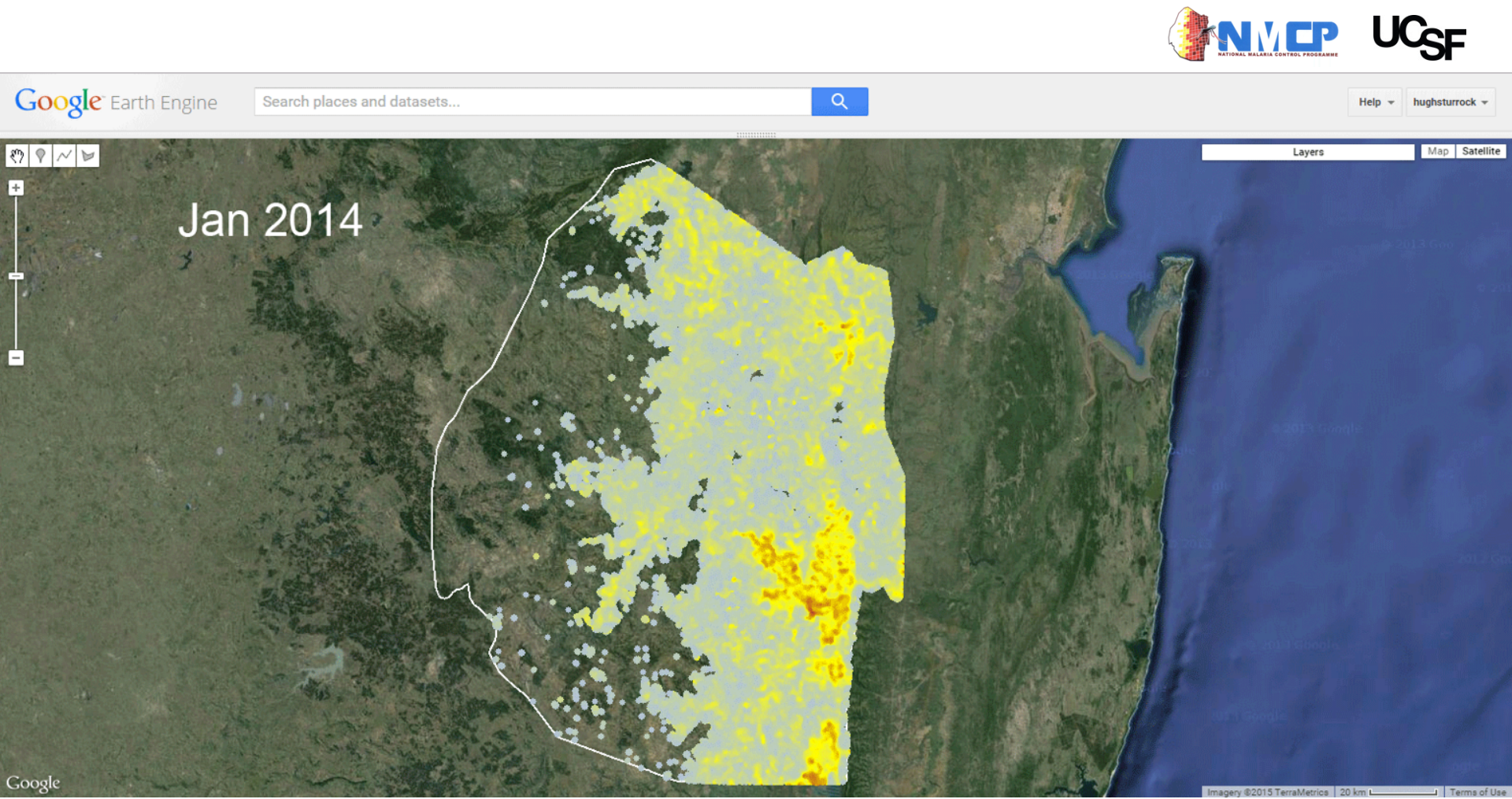
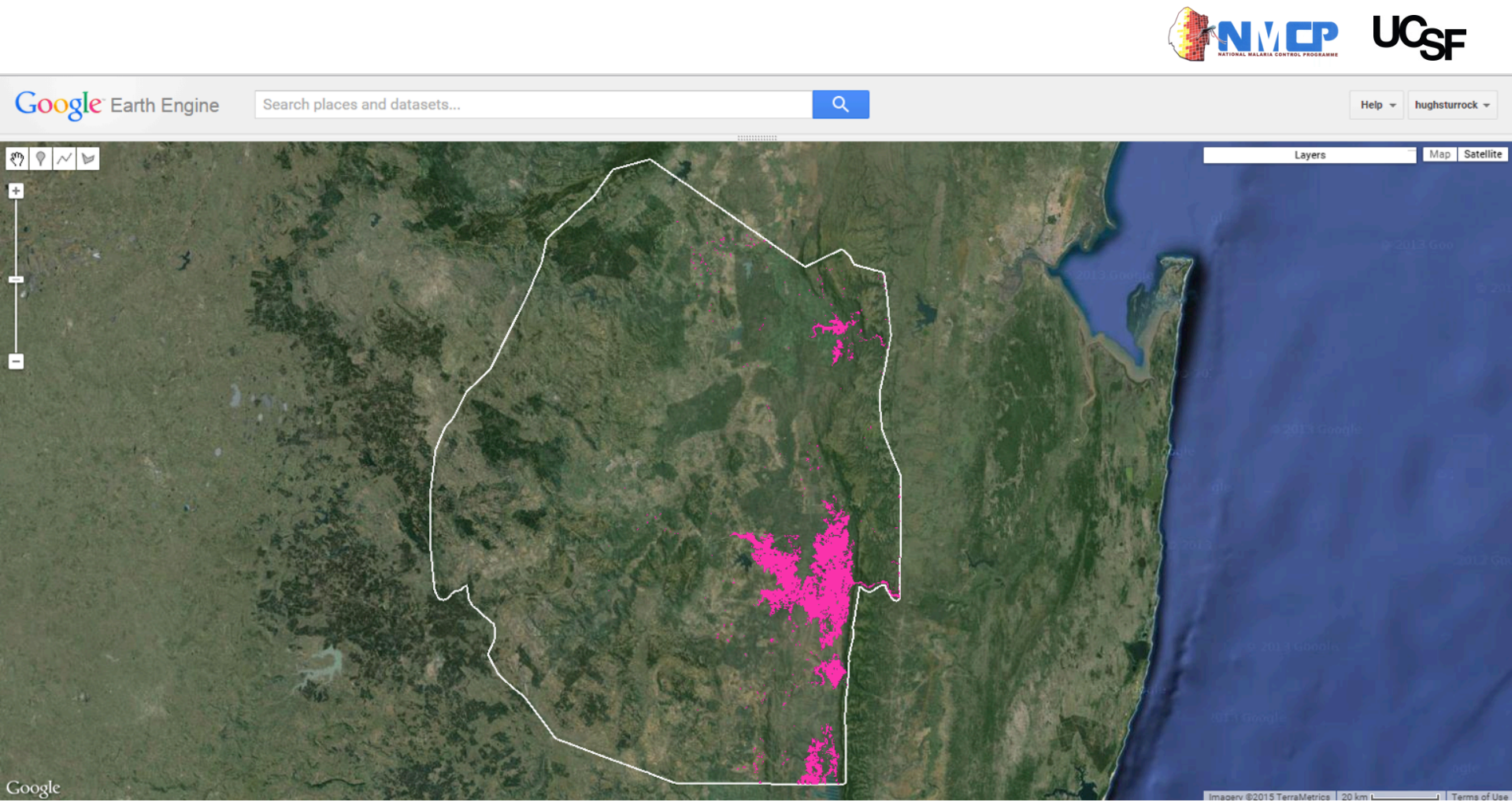

Google Earth Engine
Search places and datasets...
Help
hughsturrock
Jan 2014
Layers
Map
Satellite
Google
Imagery ©2015 TerraMetrics
20 km
Terms of Use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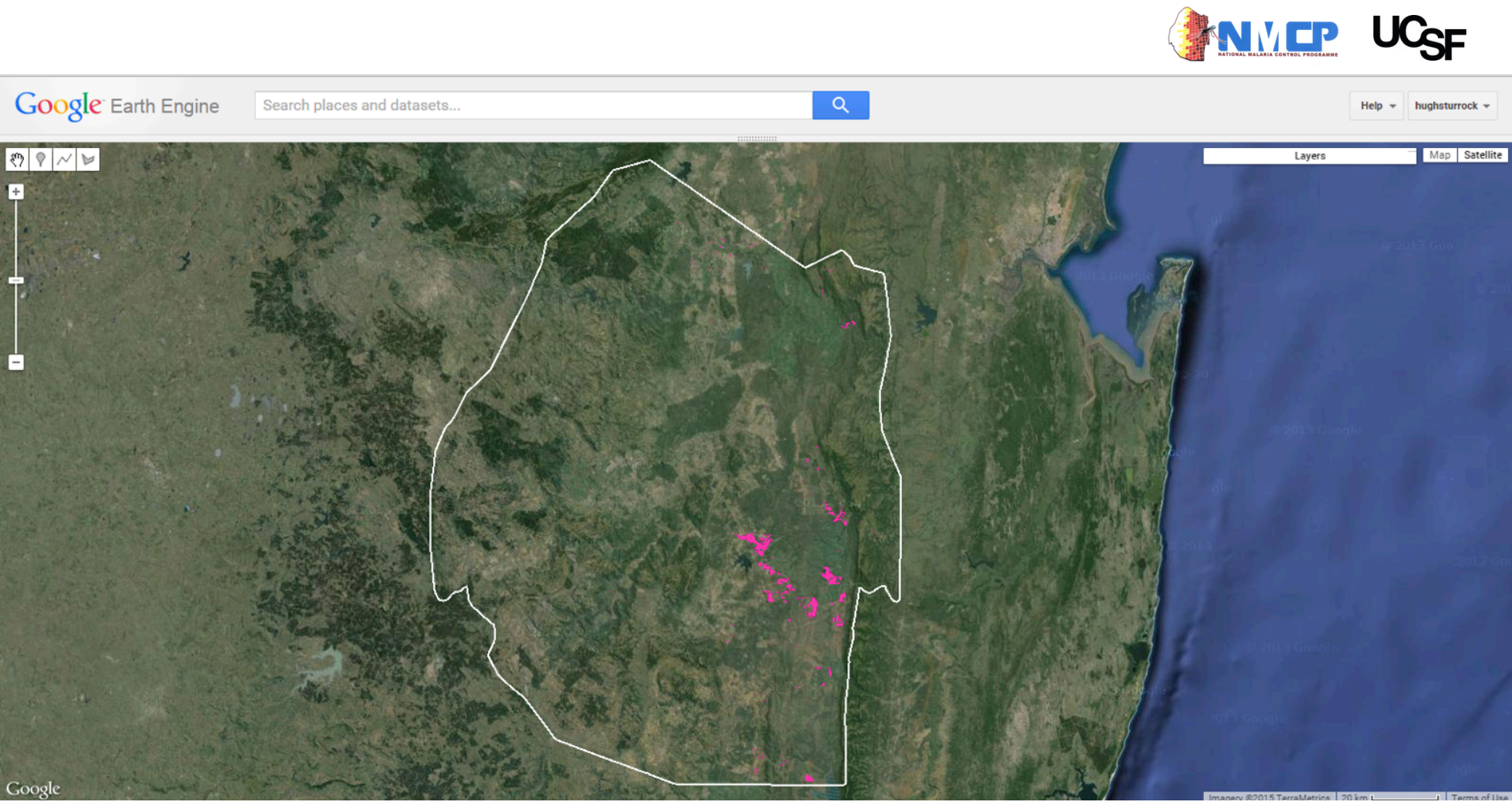
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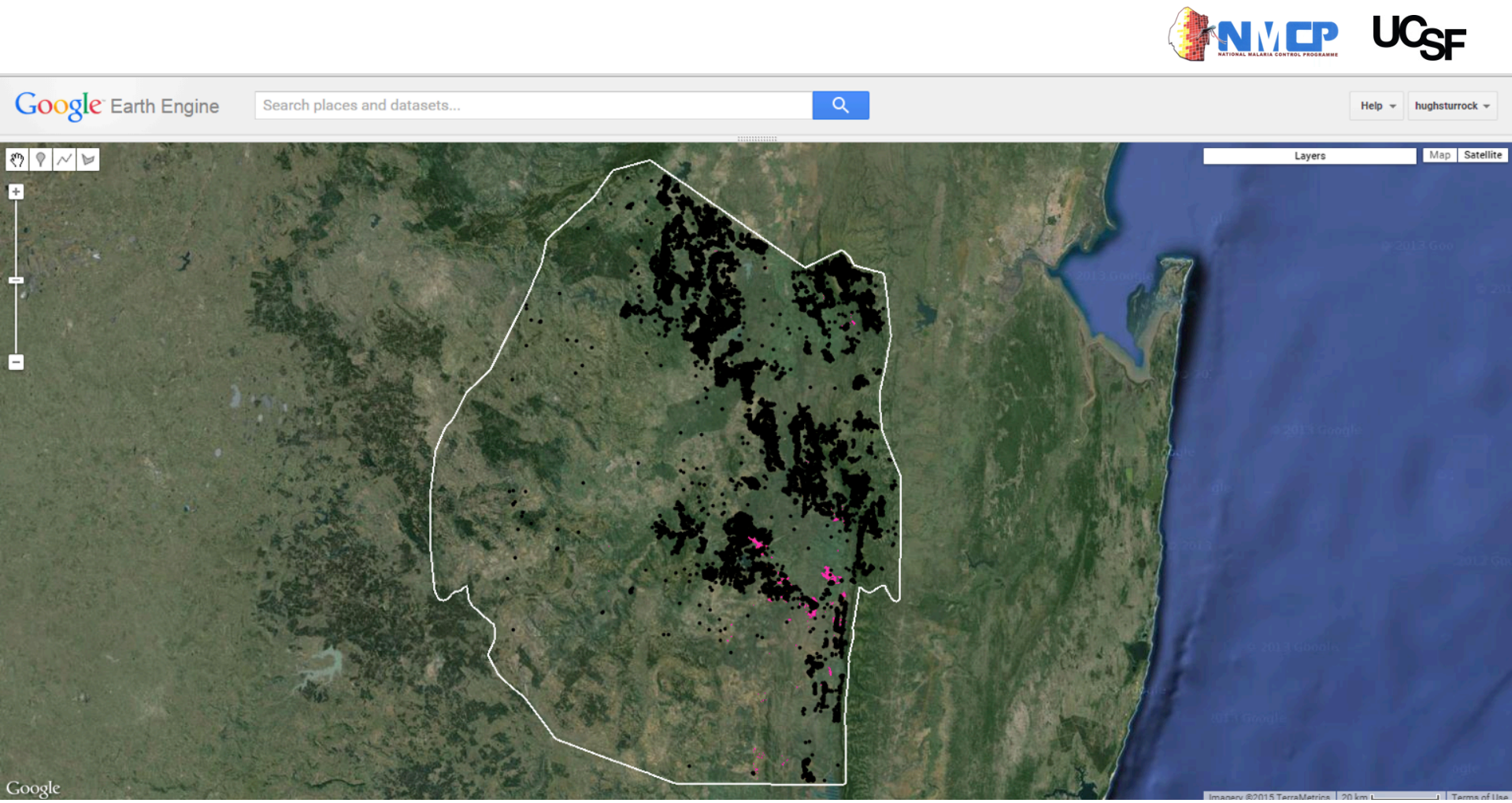
Layers
Map
Satellite
Google


Google Earth Engine
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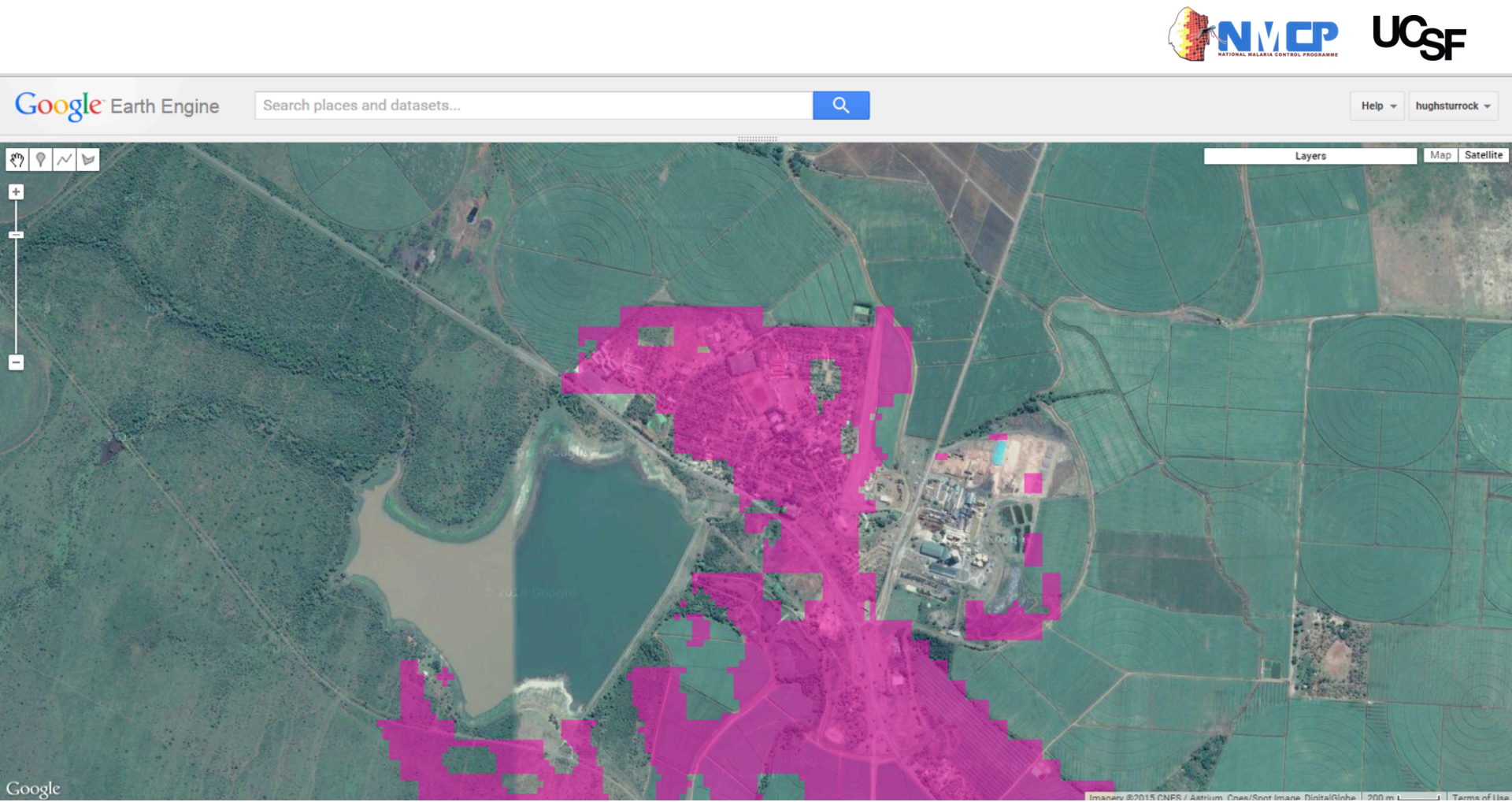
Google Earth Engine
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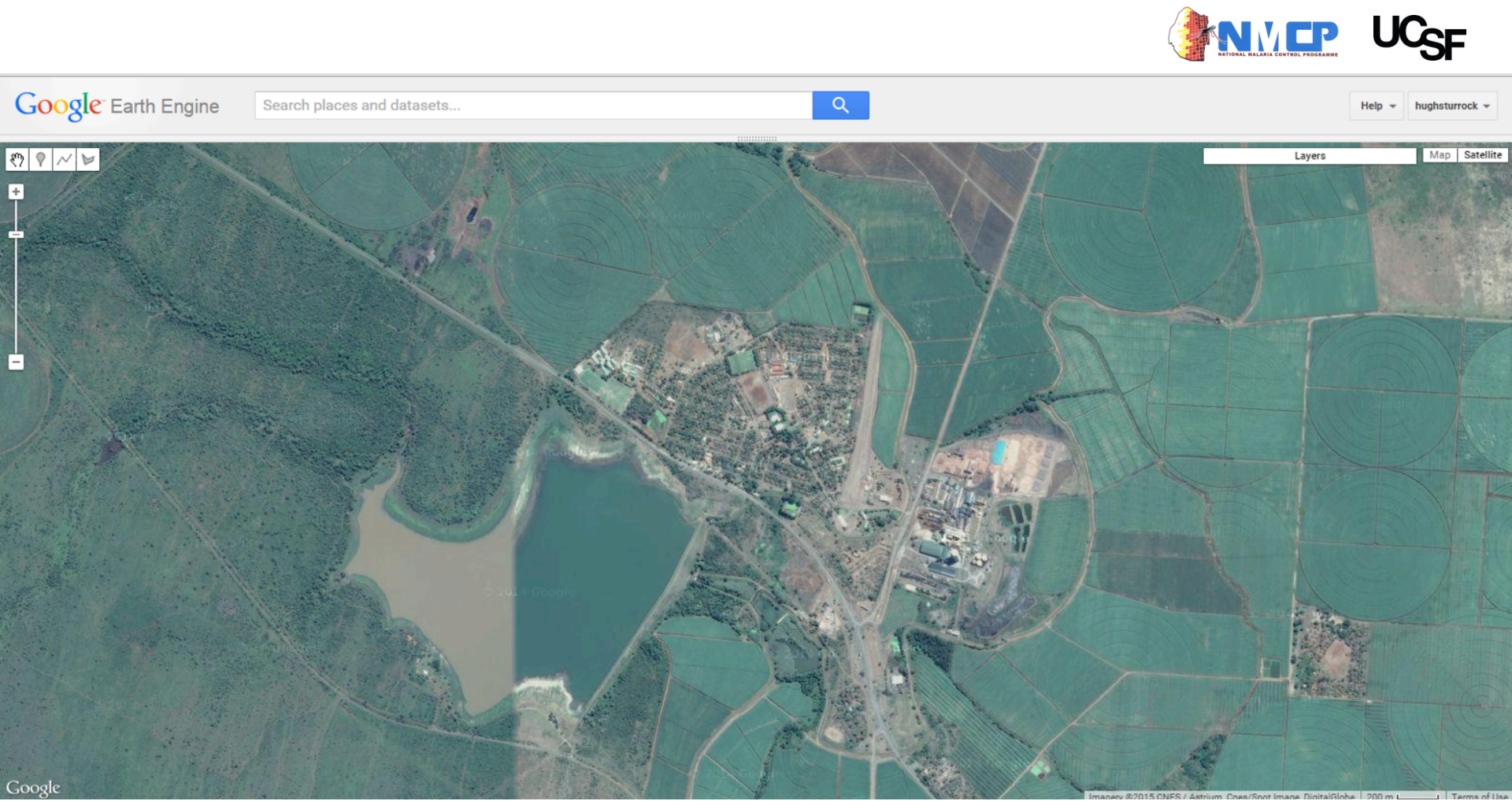
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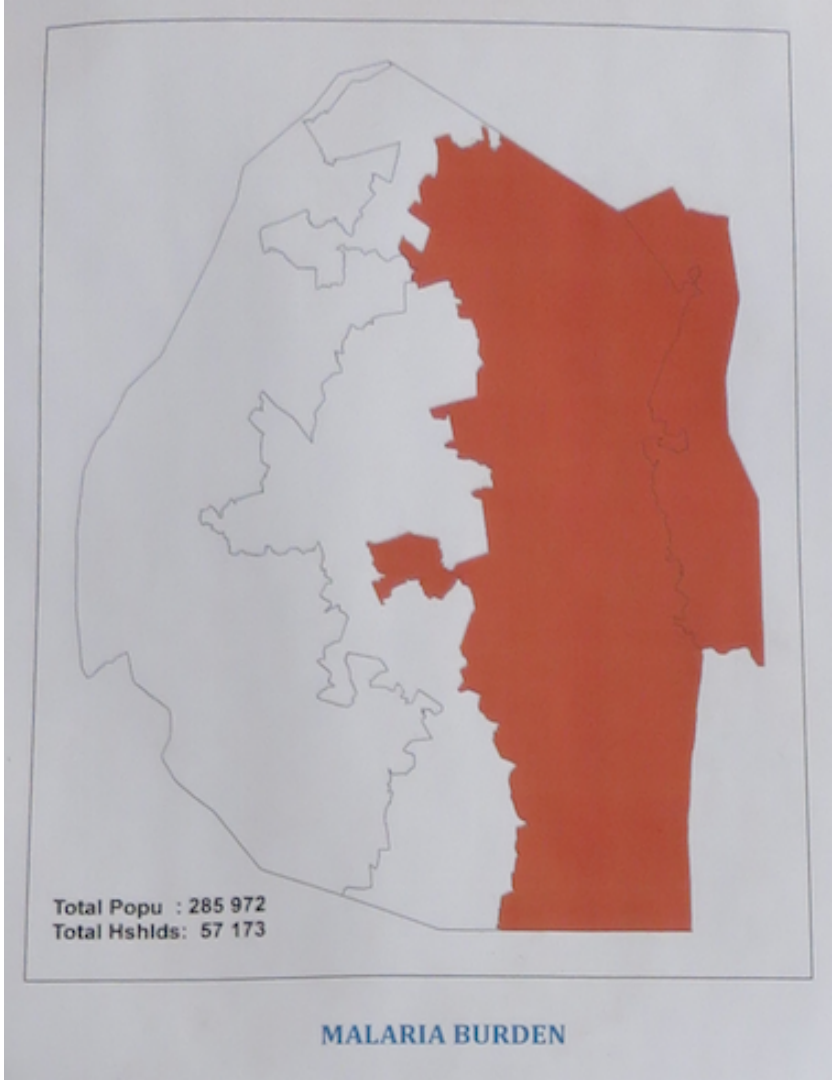
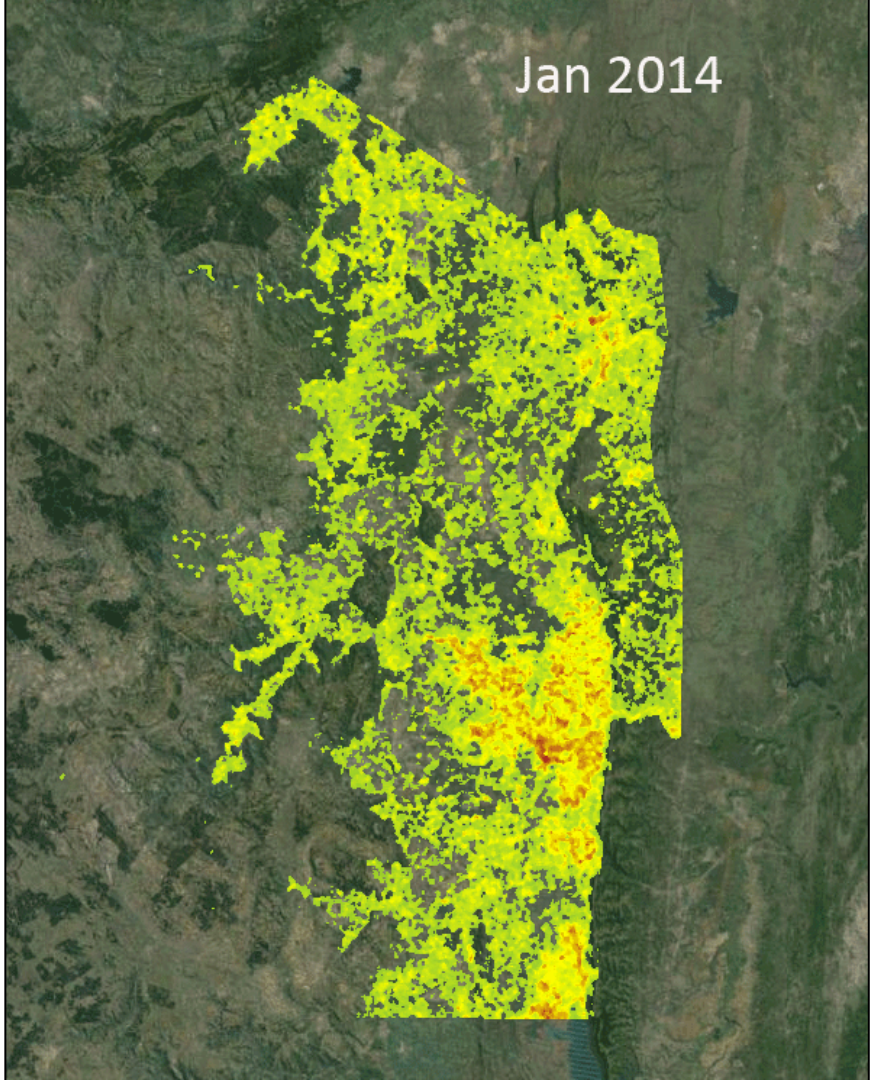

Total Popu : 285 972
Total Hshlds: 57 173
MALARIA BURDEN

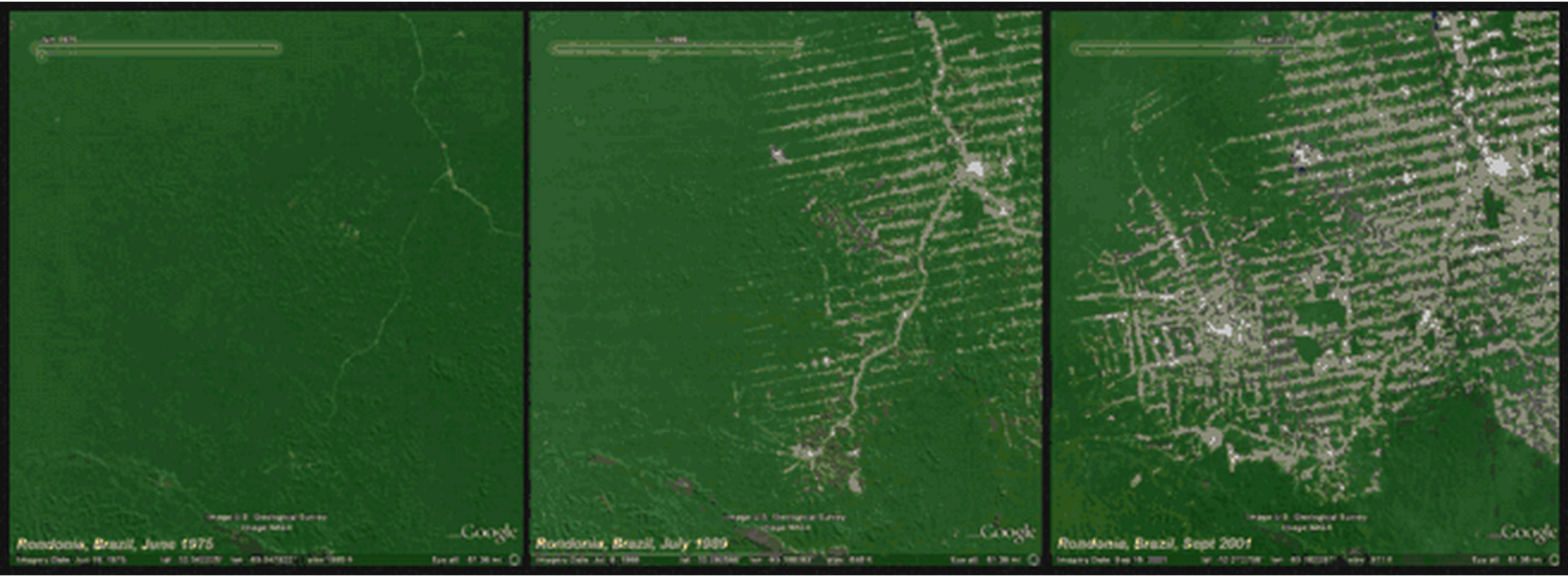

Jan 2014

What is Earth Engine?

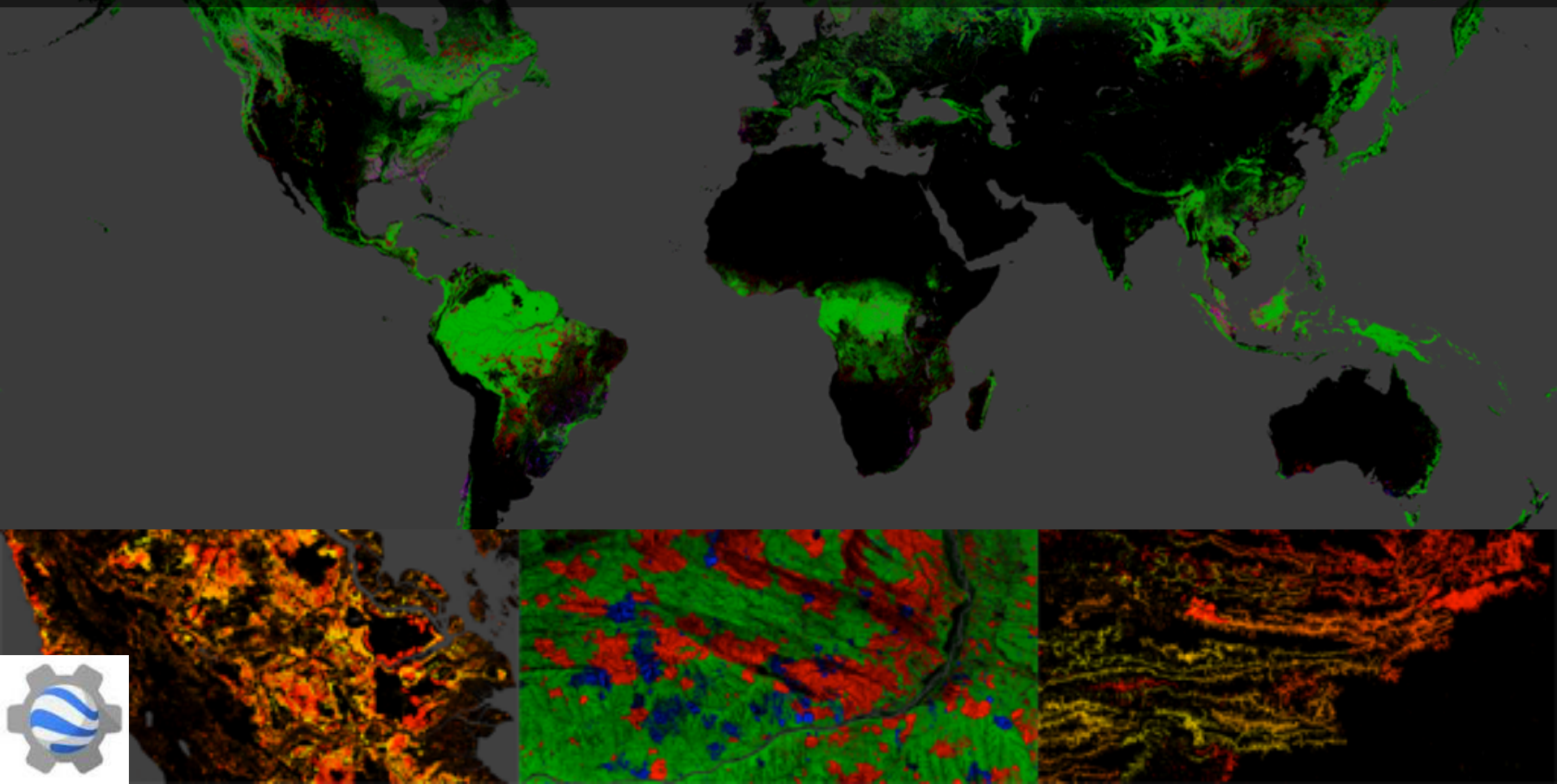
Earth Engine is Google's **cloud platform** for **petabyte-scale analysis** of **satellite imagery** and other **geospatial data**.

earthengine.google.com/signup

Google Earth Visualizations

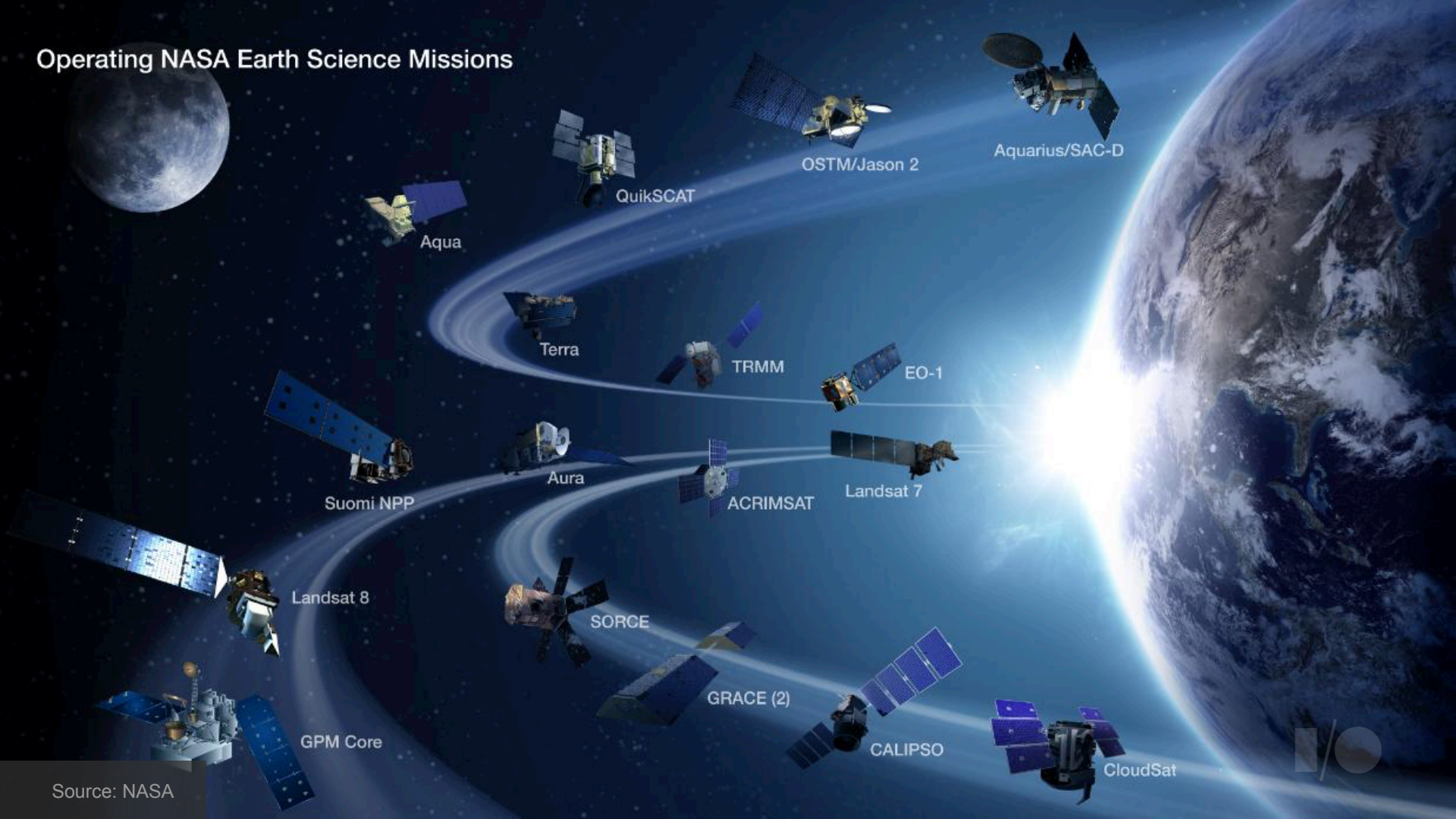


2013: Global Landsat Forest Extent and Change, 2000–2012



Data Library

Google Earth Outreach


Operating NASA Earth Science Missions
OSTM/Jason 2
Aquarius/SAC-D
QuikSCAT
Aqua
Terra
TRMM
EO-1
Suomi NPP
Aura
ACRIMSAT
Landsat 7
Landsat 8
SORCE
GRACE (2)
GPM Core
CALIPSO
CloudSat

Source: NASA

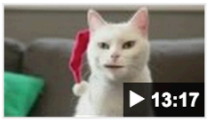
Colocated Data + Computation + APIs

Google cats

Web Images Videos News Shopping More Search tools

About 89,700,000 results (0.25 seconds)

Funny Cats Big Compilation 2015! [NEW] - YouTube

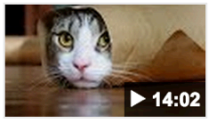


www.youtube.com/watch?v=eVo3LbVWjWc

Dec 2, 2014 - Uploaded by Funny Animals Channel

New Crazy compilation of 2014. ENJOY and SUBSCRIBE, Merry Christmas!

Funny Cats Compilation [Most See] Funny Cat Videos Ever ...



www.youtube.com/watch?v=tntOCGkgt98

Dec 30, 2013 - Uploaded by Forget Your Sadness

Get up to 40000 Instagram followers: http://imisland.us/instagram/ Funny **Cats** Compilation [Most See] Funny ...

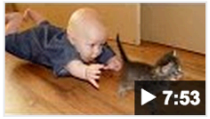
Funny Cats, Sweet Cat - CUTE Video! - YouTube

www.youtube.com/watch?v=V_53FZBTuxk

May 22, 2013 - Uploaded by Funny Animals Channel

Sweet Kitty A cute little Funny kittens plays in his own, beautiful pink world. Funny **cats**, funny **cat**, sweet **cat** ...

Funny cats and babies playing together - Cute cat & baby ...



www.youtube.com/watch?v=YDdueeBf7MY

Dec 3, 2014 - Uploaded by Tiger Productions

Cats can be very ignorant and mean but these **cats** are something special. Just look how all this kitties like ...

The Earth Engine Public Data Catalog

Landsat 4, 5, 7, 8
Raw, TOA, SR, ...

MODIS
Daily, LST, NDVI ...

Terrain
SRTM, GTOPO, NED, ...

Land Cover
GlobCover, NLCD, ...

Atmospheric
CHIRPS, NOAA, ...

… and population (world pop & GPWv4?)
... and many more, updating daily!

> 200 public datasets

> 4000 new images every day

> 5 million images

> 5 petabytes of data

Import your own raster & vector datasets

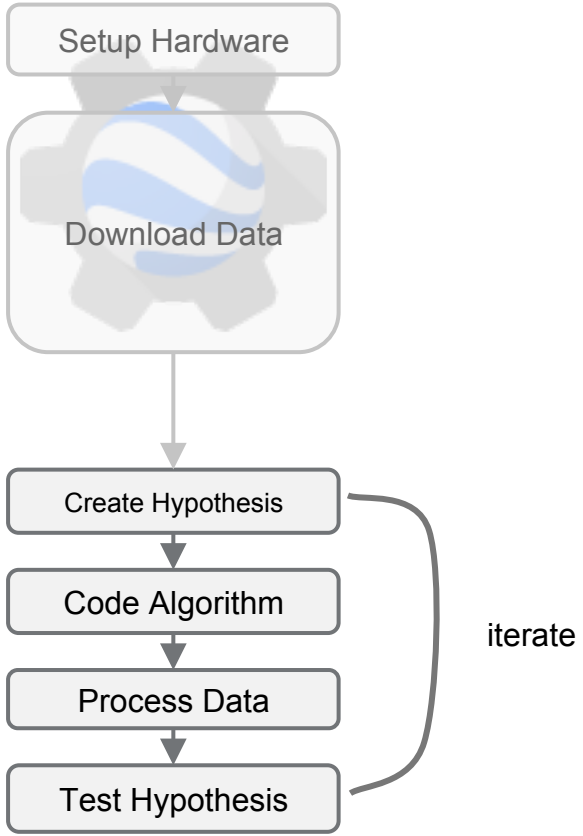
Analysis Platform

Google Earth Outreach

The Data Science Loop

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

Jim Gray
The Fourth Paradigm:
Data-Intensive Scientific Discovery



Google Earth Engine

Search places and datasets...

Help | matthancher

Scripts | Docs | Assets

Filter methods...

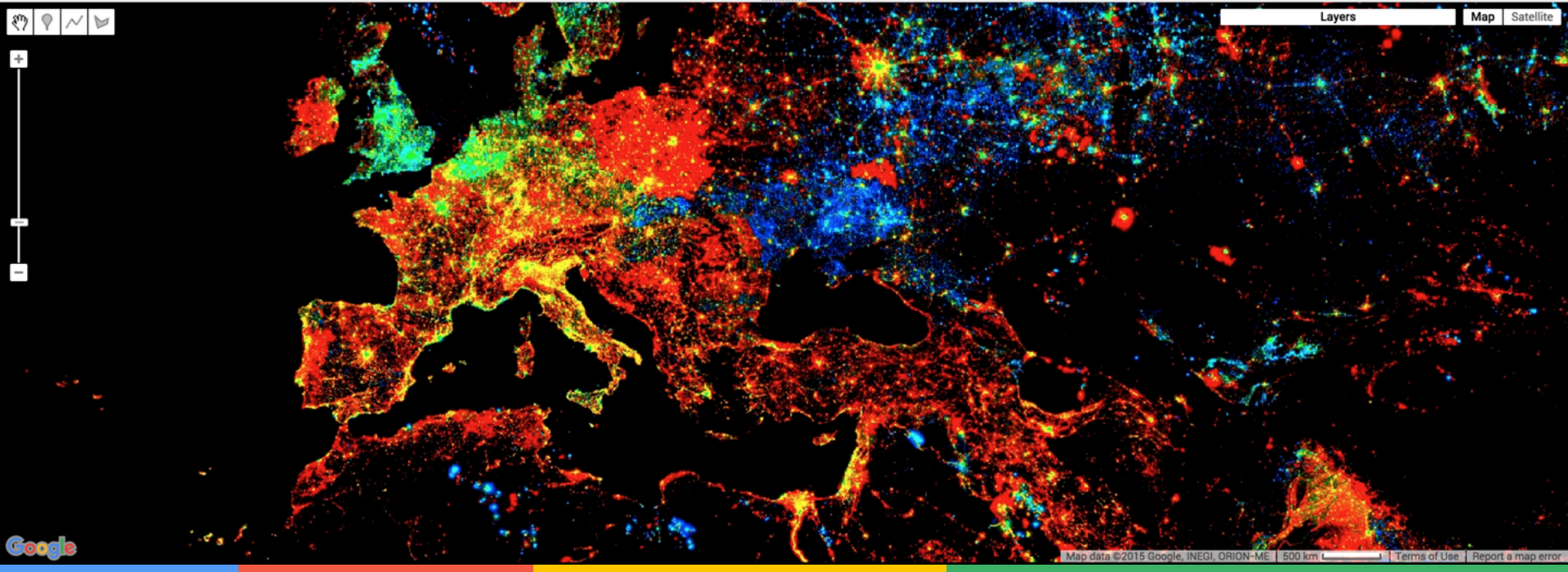
- ee.Algorithms
- ee.Array
- ee.Classifier
- ee.ConfusionMatrix
- ee.Date
- ee.DateRange
- ee.Dictionary

Linear Fit | Get Link | Save | Run | Reset

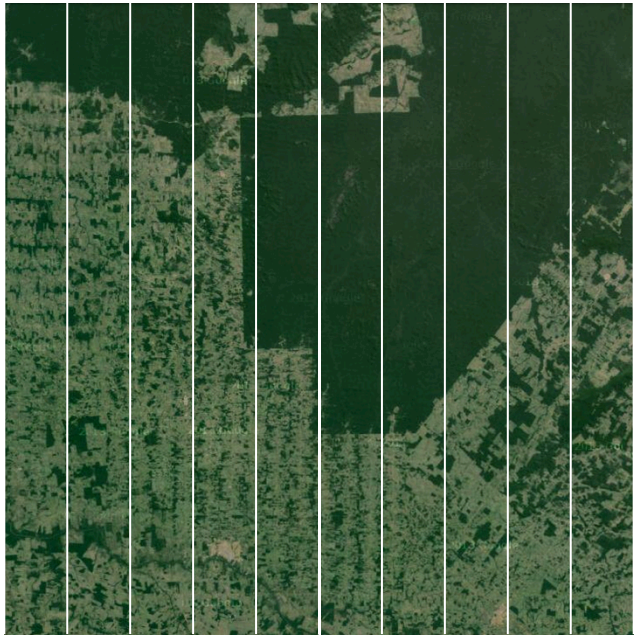
```
1  // Compute the trend of nighttime lights from DMSP.
2
3  // Add a band containing image date as years since 1991.
4  function createTimeBand(img) {
5    var year = ee.Date(img.get('system:time_start')).get('year').subtract(1991);
6    return ee.Image(year).byte().addBands(img);
7  }
8
9  // Fit a linear trend to the nighttime lights collection.
10 var collection = ee.ImageCollection('NOAA/DMSP-OLS/NIGHTTIME_LIGHTS')
11     .select('stable_lights')
12     .map(createTimeBand);
13 var fit = collection.reduce(ee.Reducer.linearFit());
```

Inspector | Console | Tasks

Use print(...) to write to this console.



Original Image



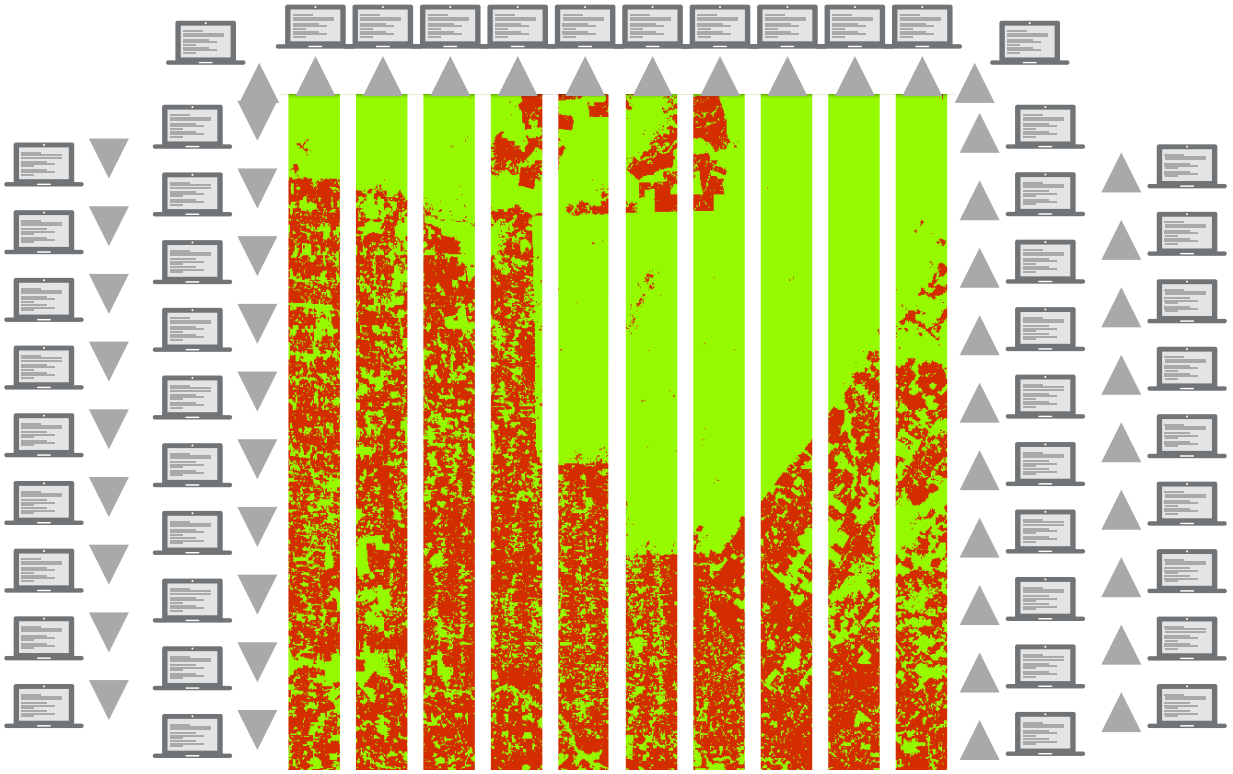
Original Image

is divided into 256px sub-units.

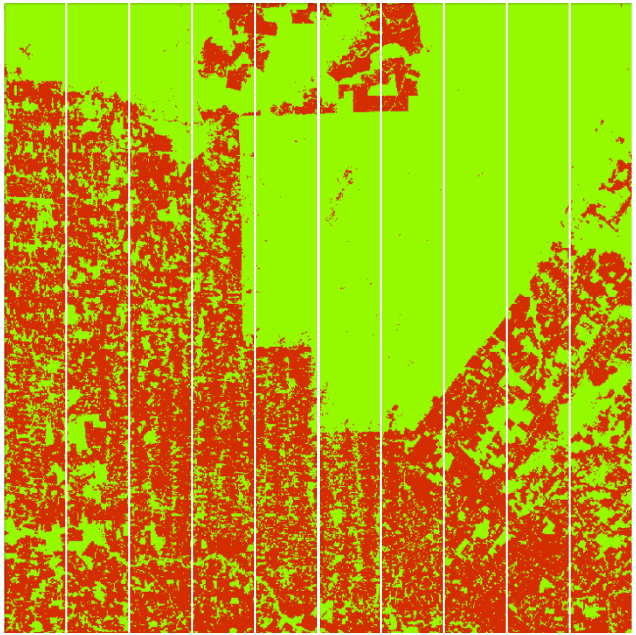
Sub-units are distributed

Sub-units are distributed

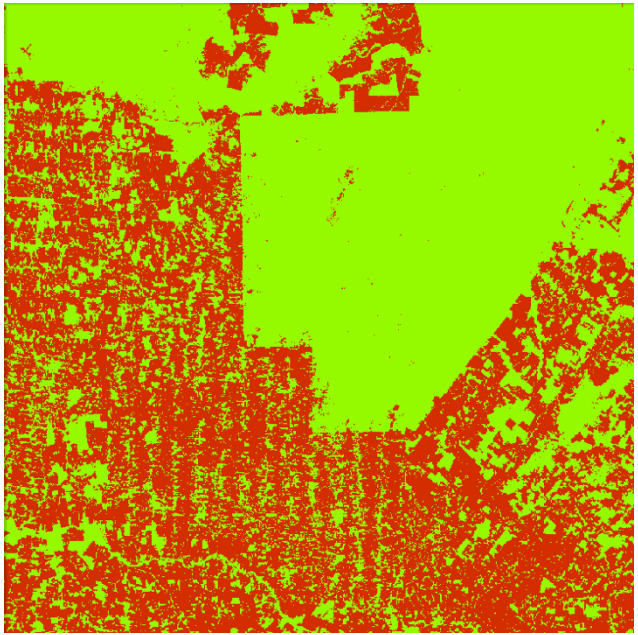
to separate machines where they can be processed in parallel.



Thousands can be processed simultaneously.



Result is reassembled



Result is reassembled

into a finished image.

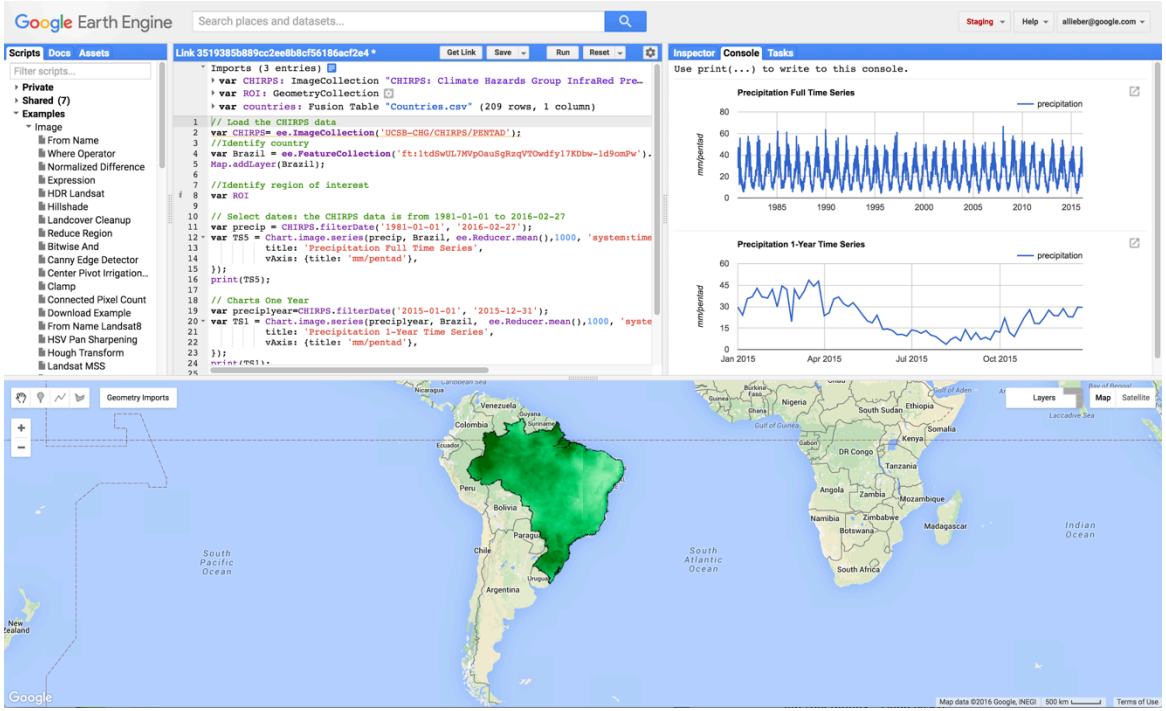
Data Types & Geospatial Processing Functions

- **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!

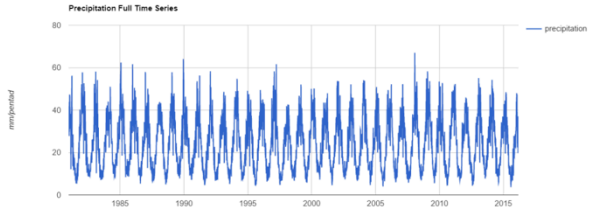
IRI Example: CHIRPS Tutorial

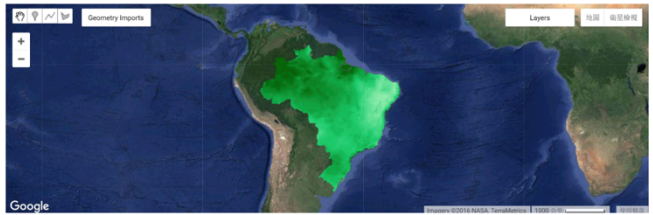
Climate Hazards Group InfraRed Precipitation with Station data



1.5 Case study – Brazil

Taking Brazil for example, this tool shows the potential to analyze precipitation in various time frames. The first chart and map shows the mean pentad precipitation amount averaging over the full time series.





International Research Institute for Climate and Society
Earth Institute | Columbia University

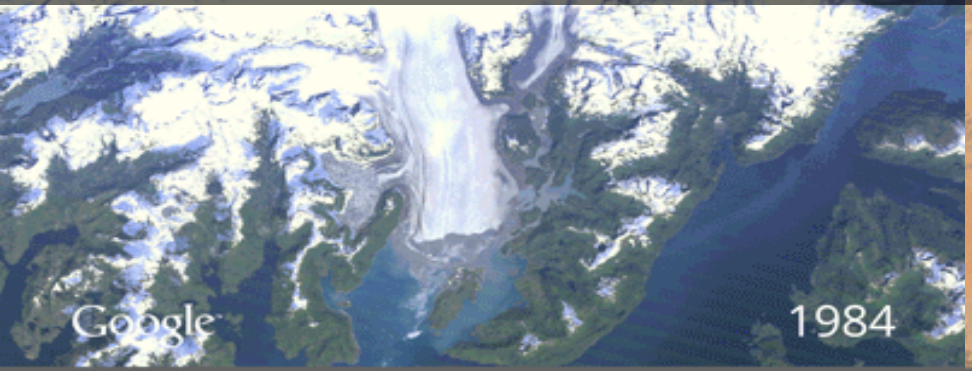
COLUMBIA UNIVERSITY | MAILMAN SCHOOL of PUBLIC HEALTH

Applications

Google Earth Outreach

earthengine.google.com/timelapse

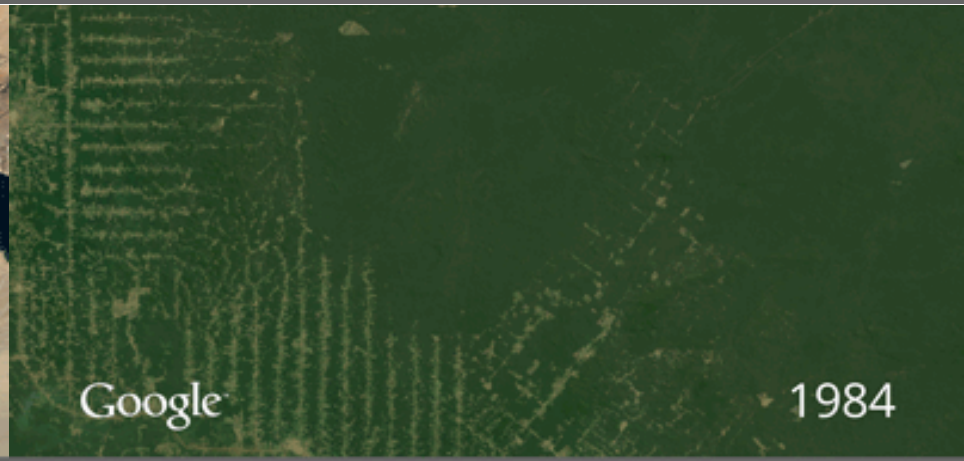
Global Landsat Timelapse Animations



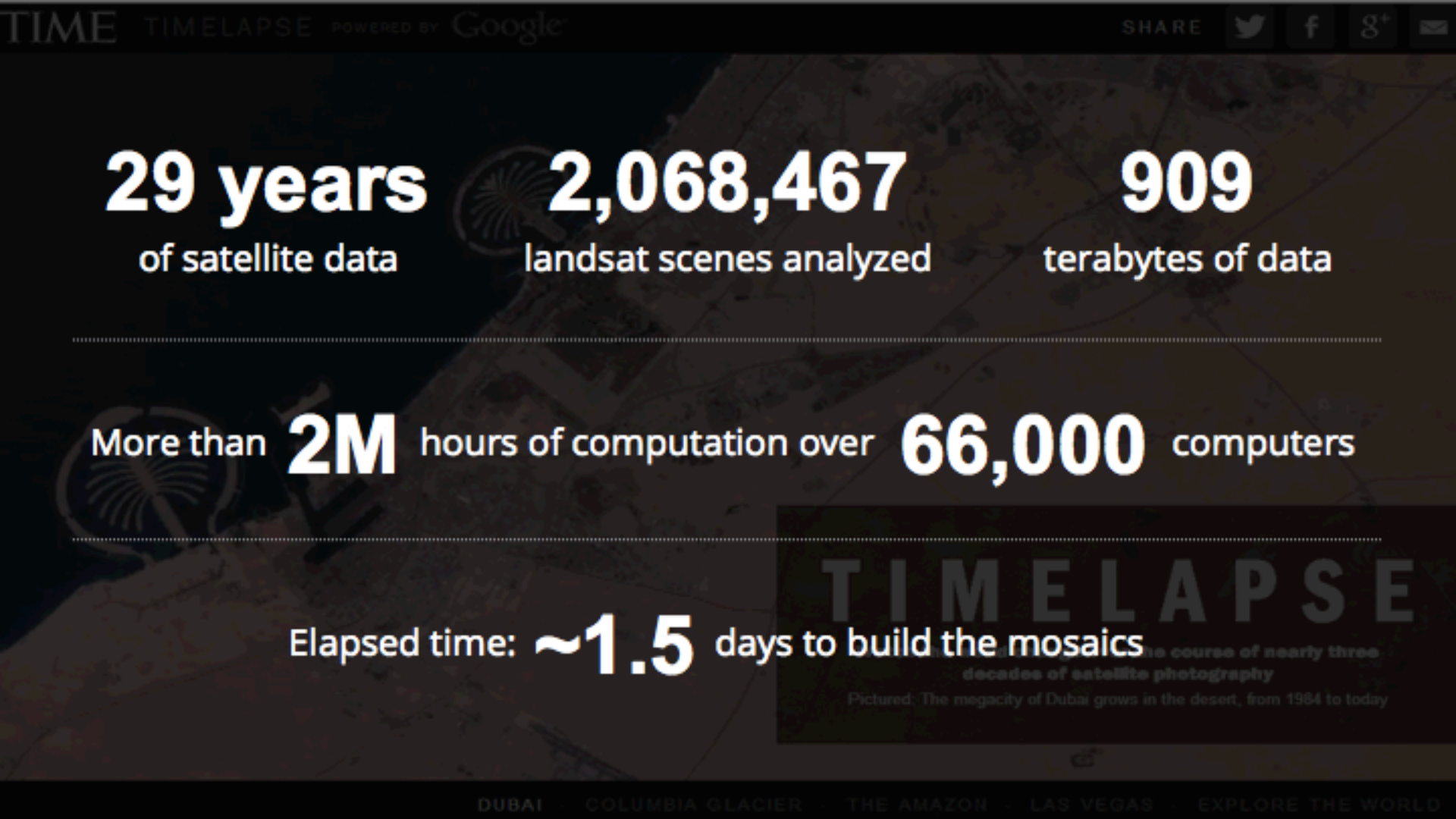
Columbia Glacier Retreat, 1984-2011

Saudi Arabia Irrigation, 1984-2012

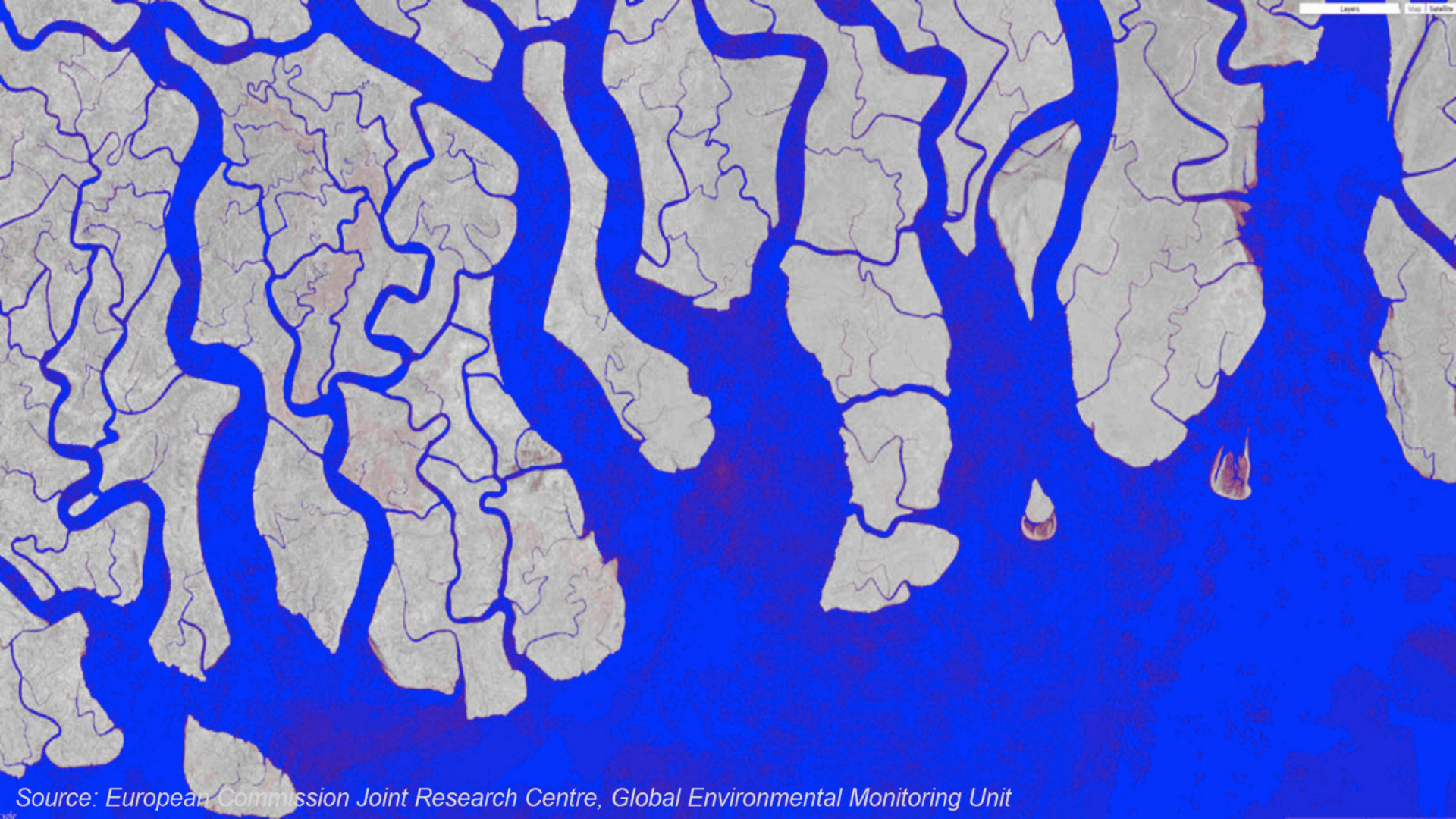
Las Vegas Urban Growth, 1986-2012



Brazilian Amazon Deforestation, 1984-2012


TIME TIMELAPSE POWERED BY Google
SHARE
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 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

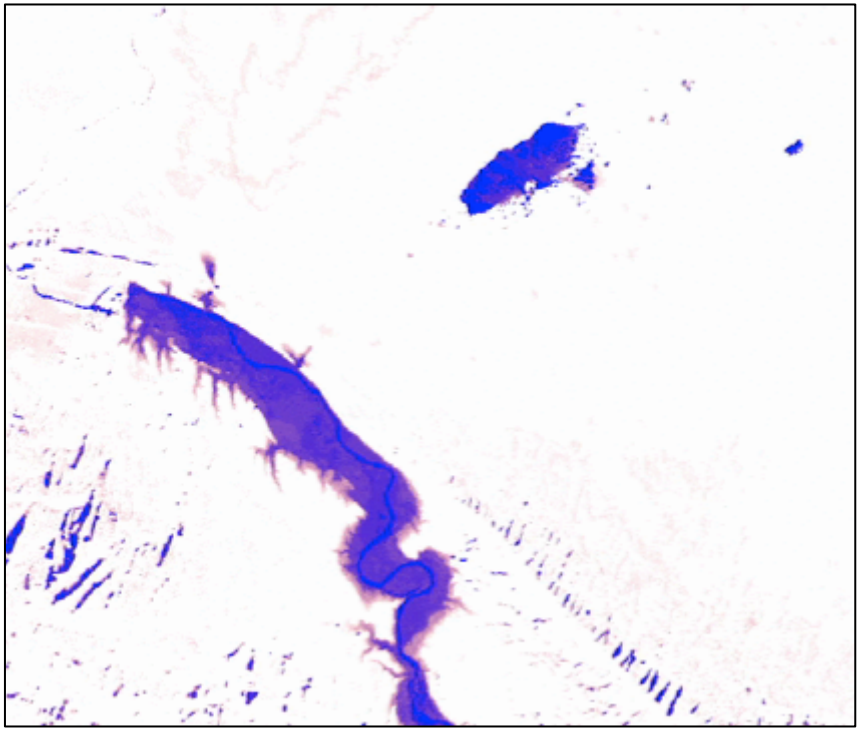
https://earthengine.google.com/timelapse/



Source: European Commission Joint Research Centre, Global Environmental Monitoring Unit

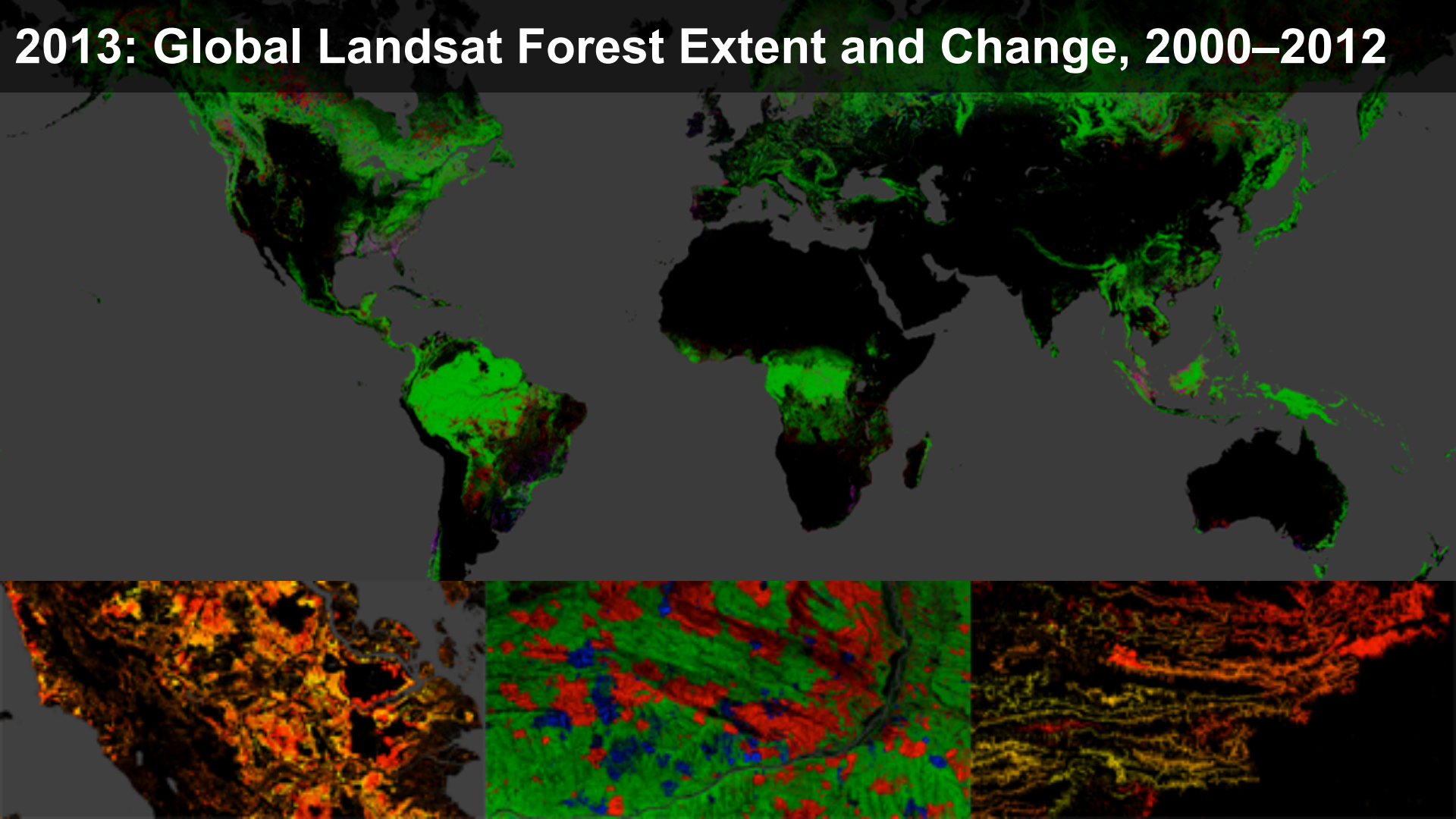
Global Surface Water

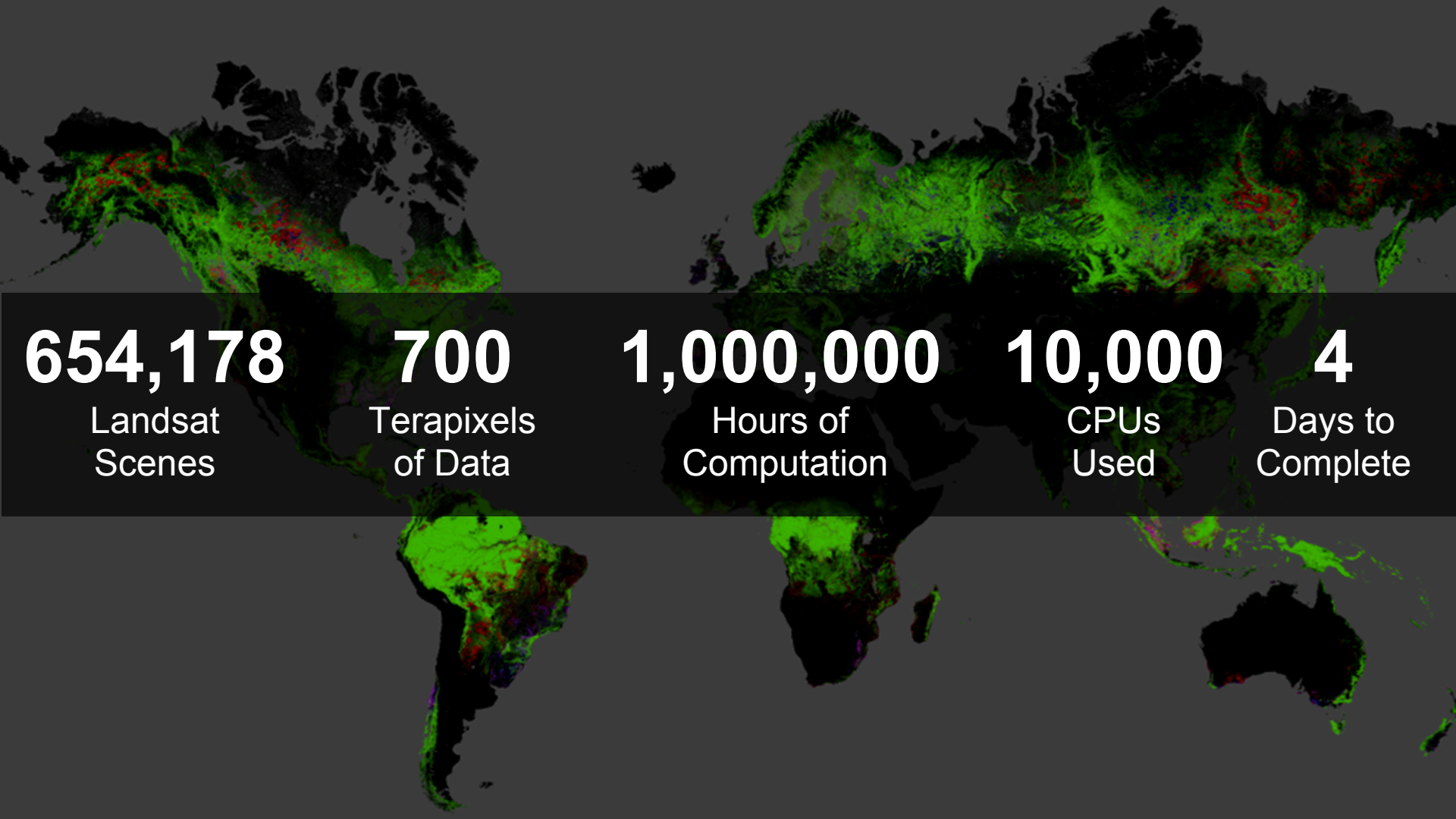
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
2000	0	0	0	1	1	1	1	0	0	0	0
2001	0	1	1	1	0	1	0	0	0	0	0
2002	0	0	1	0	0	1	0	1	0	0	0
2003	0	0	0	0	0	1	0	0	0	0	0
2004	0	0	0	0	0	0	1	1	0	0	0
2005	0	0	0	1	0	0	0	1	0	0	0
2006	0	0	0	1	1	0	0	1	0	0	0
2007	0	1	0	0	0	1	1	0	0	1	0
2008	0	1	1	0	0	1	0	0	0	0	0
2009	0	0	1	0	0	1	1	1	0	0	0
2010	0	0	1	1	0	1	0	0	0	0	0
2011	0	0	1	1	1	1	0	0	0	0	0
2012	0	1	0	0	1	0	1	0	0	0	0
2013	0	0	0	0	0	1	1	0	0	0	0
2014	0	0	0	0	1	0	0	1	0	0	0
2015	1	0	1	0	0	1	1	1	1	0	0



https://earthengine.google.com/timelapse/

2013: Global Landsat Forest Extent and Change, 2000–2012




654,178
Landsat Scenes
700
Terapixels of Data
1,000,000
Hours of Computation
10,000
CPUs Used
4
Days to Complete

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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

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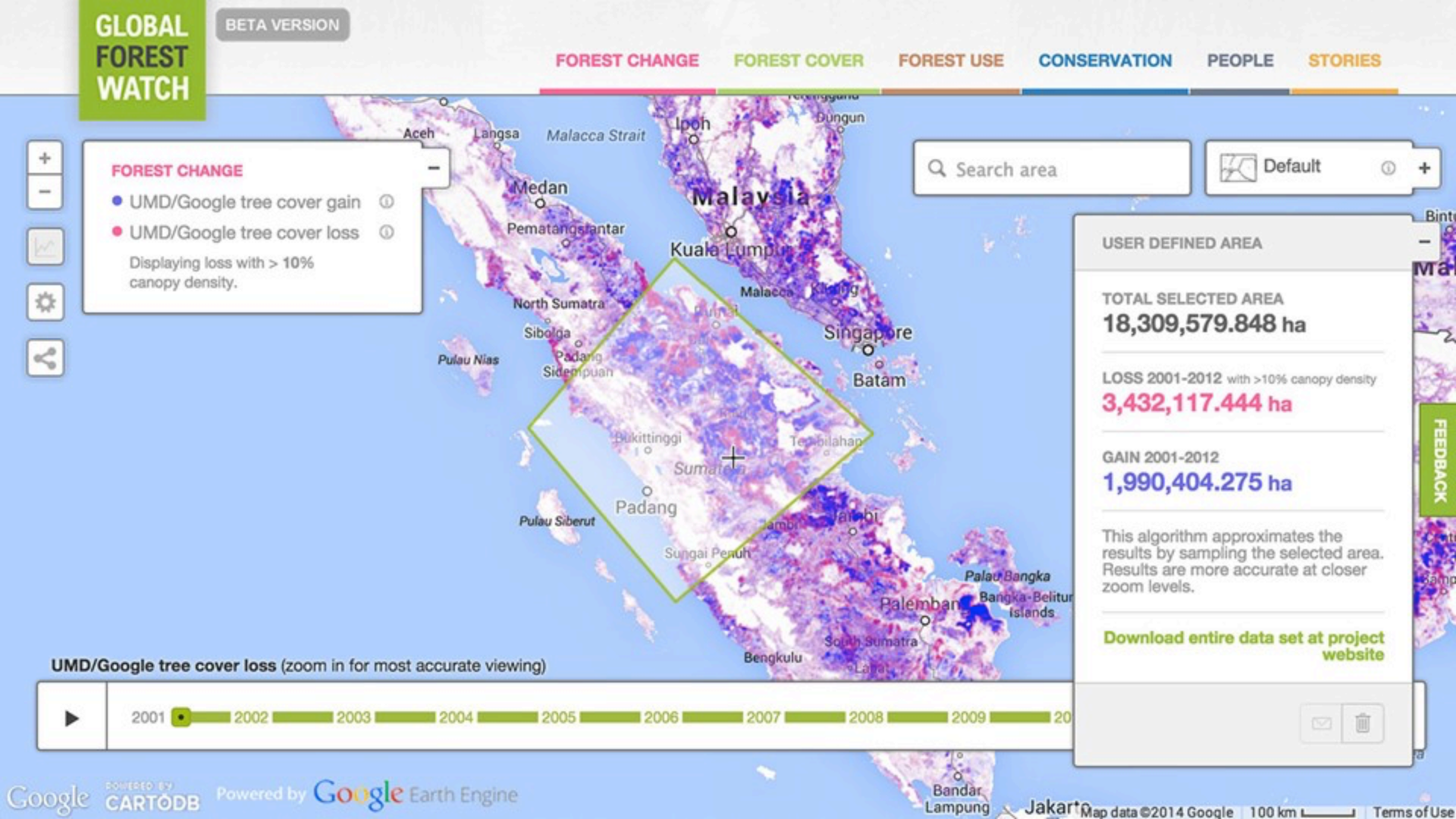
ABSTRACT | EDITOR'S SUMMARY

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 WATCH
BETA VERSION
FOREST CHANGE
FOREST COVER
FOREST USE
CONSERVATION
PEOPLE
STORIES
FOREST CHANGE
UMD/Google tree cover gain
UMD/Google tree cover loss
Displaying loss with > 10% canopy density.
Search area
Default
USER DEFINED AREA
TOTAL SELECTED AREA
18,309,579.848 ha
LOSS 2001-2012 with >10% canopy density
3,432,117.444 ha
GAIN 2001-2012
1,990,404.275 ha
This algorithm approximates the results by sampling the selected area. Results are more accurate at closer zoom levels.
Download entire data set at project website
FEEDBACK
UMD/Google tree cover loss (zoom in for most accurate viewing)
2001 2002 2003 2004 2005 2006 2007 2008 2009
Aceh
Langsa
Malacca Strait
Ipoh
Dungun
Medan
Malaysia
Pematangsiantar
Kuala Lumpur
Malacca
North Sumatra
Sibolga
Singapore
Batam
Pulau Nias
Padang Sidempuan
Bukittinggi
Padang
Pulau Siberut
Sungai Penuh
Palau Bangka
Bangka-Belitung Islands
Palembang
South Sumatra
Bengkulu
Bandar Lampung
Jakarta
Google
Powered by CARTODB
Powered by Google Earth Engine
Map data ©2014 Google
100 km
Terms of Use

Indonesia Govt UKP4 utilizing GFW in law enforcement

Convening 7 Head of Provincial Police Force (1/2)…evidence, evidence, evidence evidence

UKP4 dan 7 Kapolda Koordinasi Penanggulangan Kebakaran Hutan

Sabtu, 20 September 2014 10:46 WIB

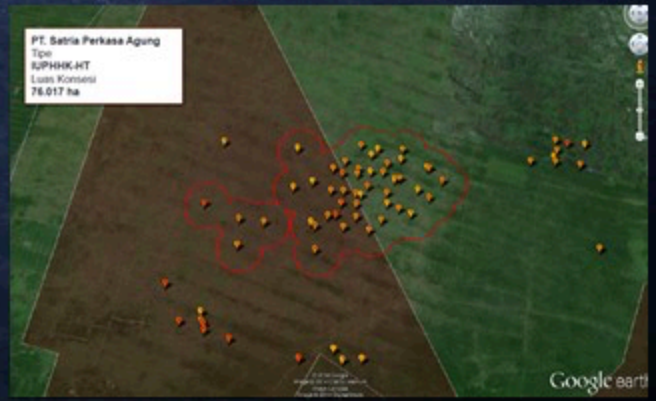
Virna P Setyorini

kebakaran hutan di Riau mengakibatkan kabut asap.

Jakarta (Antara Kalbar) - Unit Kerja Presiden Bidang Pengawasan dan Pengendalian Pembangunan bersama Badan Pengelola REDD+ koordinasi dengan tujuh kepala kepolisian daerah yang di wilayah hukumnya terjadi kebakaran hutan dan lahan.

"Kenapa tujuh Kapolda yang diundang? Karena di wilayah mereka sekarang terdapat titik api, yang jika koordinasi cepat dilakukan masalah lebih besar bisa ditanggulangi," kata Deputi VI Unit Kerja Presiden Bidang Pengawasan dan Pengendalian Pembangunan (UKP4) bidang Penegakan Hukum Mas Achmad Santosa kepada wartawan di Jakarta, Jumat (19/9).

Tujuh kepala kepolisian daerah itu adalah Kapolda Kalimantan Barat Brigjen Pol Arief Sulistyanto, Kapolda



Source: Pak Koni, Govt Indonesia

Map-of-Life, habitat suitability modeling

MOL MAP OF LIFE

Overview | Detailed Map | Habitat Distribution | Reserve Coverage

Snow leopard
Panthera uncia

Sources | Features

Point observations 5
Local inventories 6
Expert range maps 1

Point filters 1 of 5 selected
Uncertainty 5 selected
Years 1 selected

Update map

KAZAKHSTAN
MONGOLIA
ULAANBAATAR
ALMATY
BISHKEK
URUMQI
UZBEKISTAN
TASHKENT
KYRGYZSTAN
TURKMENISTAN
DUSHANBE
TAJIKISTAN
ASHGABAT
MASHHAD
AFGHANISTAN
KABUL
ISLAMABAD
IRAN
LAHORE
PAKISTAN
NEW DELHI
JAIPUR
KANPUR
LUCKNOW
NEPAL
KATHMANDU
BHUTAN
CHINA
BAOTOU
BEIJING
TIANJIN
DALIAN
SHENYANG
CHANGCHUN
NORTH KOREA
PYONGYANG
SEOUL
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BUSAN
HIROSHIMA
FUKUOKA SHI
TAIYUAN
JINAN
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NANJING
SHANGHAI
WUHAN
CHONGQING
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GUIYANG
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TAIPEI
TAIWAN
KAOHSIUNG
GUANGZHOU
HONG KONG
DUBAI
MUSCAT
OMAN
KARACHI
AHMEDABAD
SURAT
NAGPUR
INDIA
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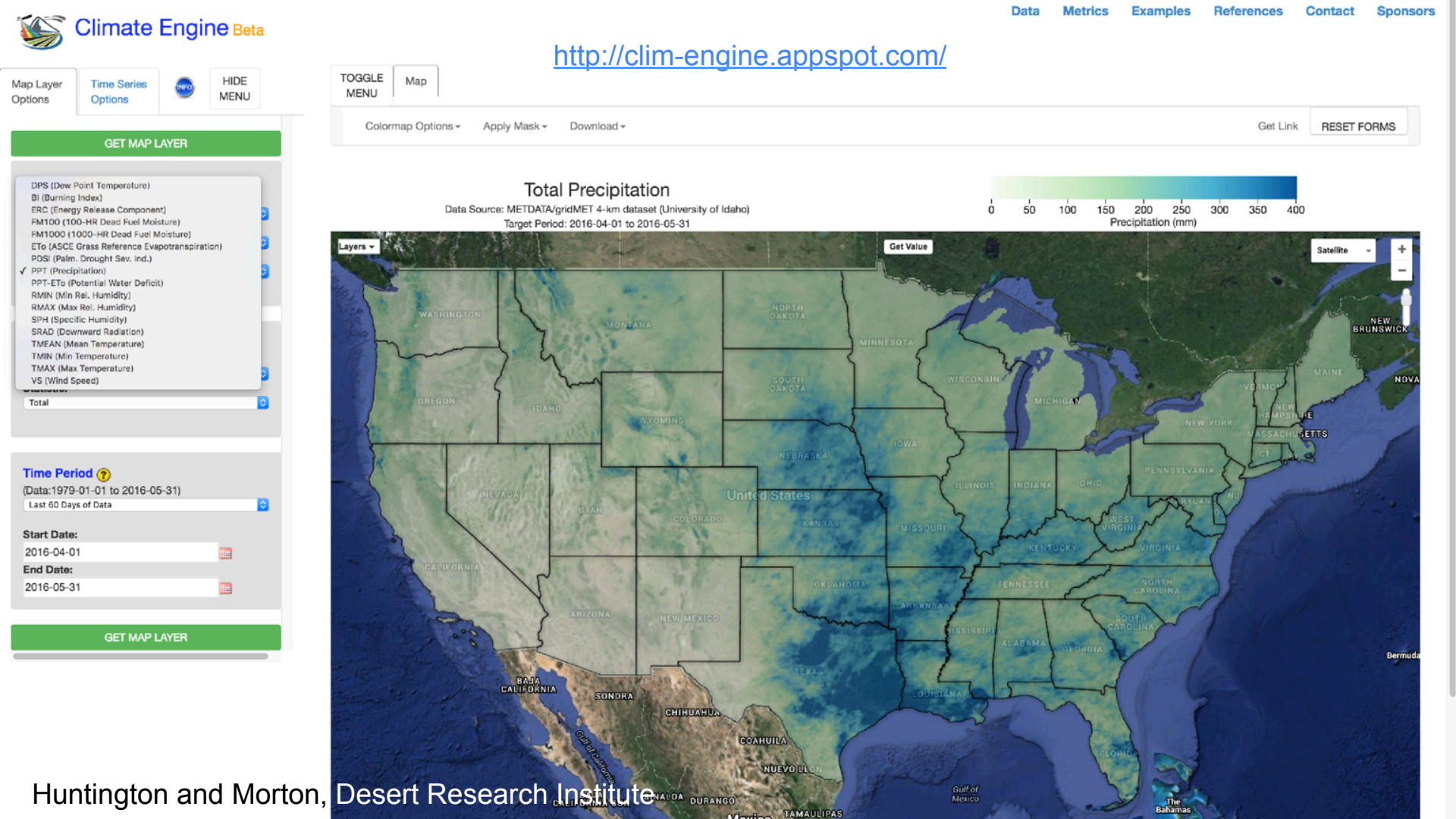
KOLKATA
CHITTAGONG
MYANMAR
HANOI
East China Sea
Luzon Strait

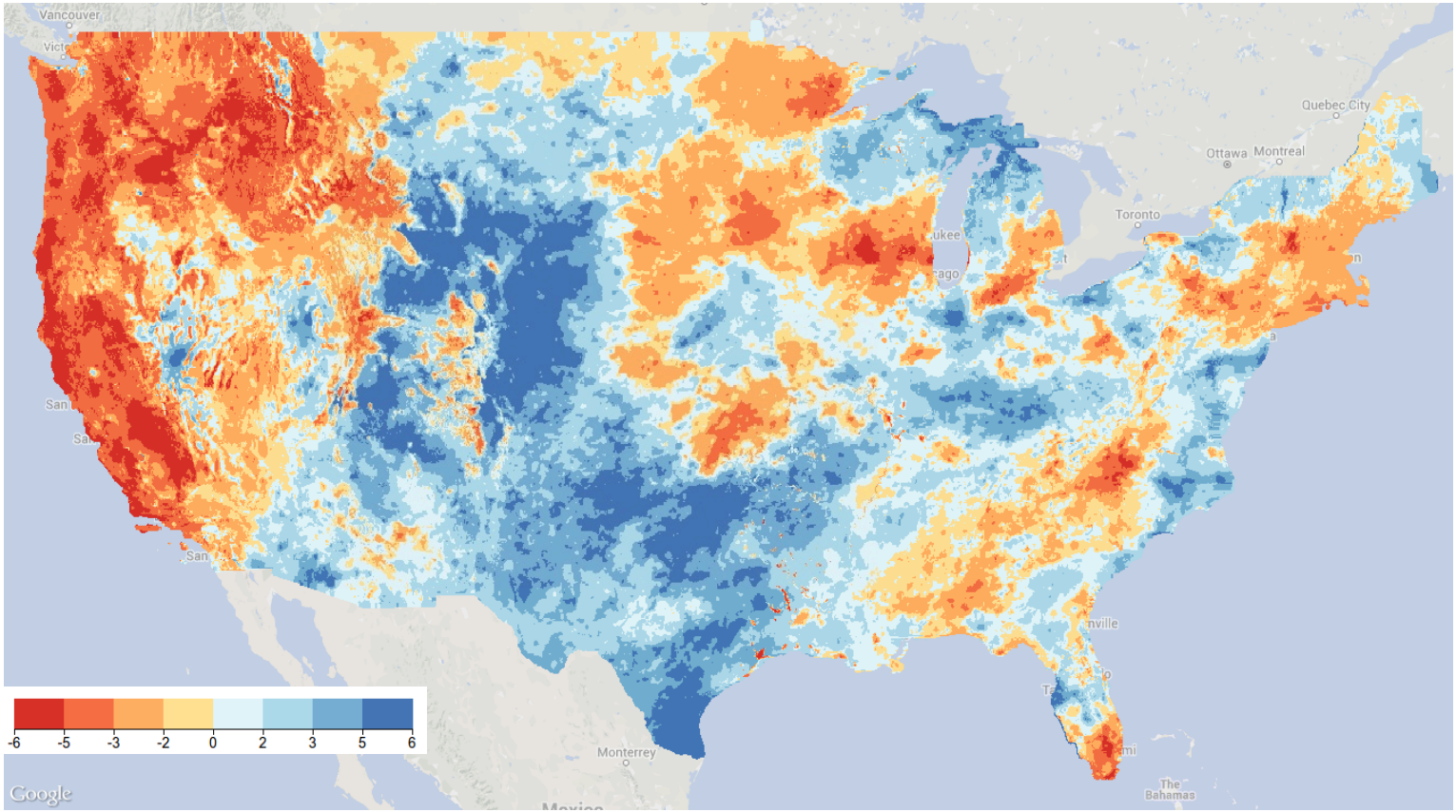
Google Earth Outreach

http://mol.org/



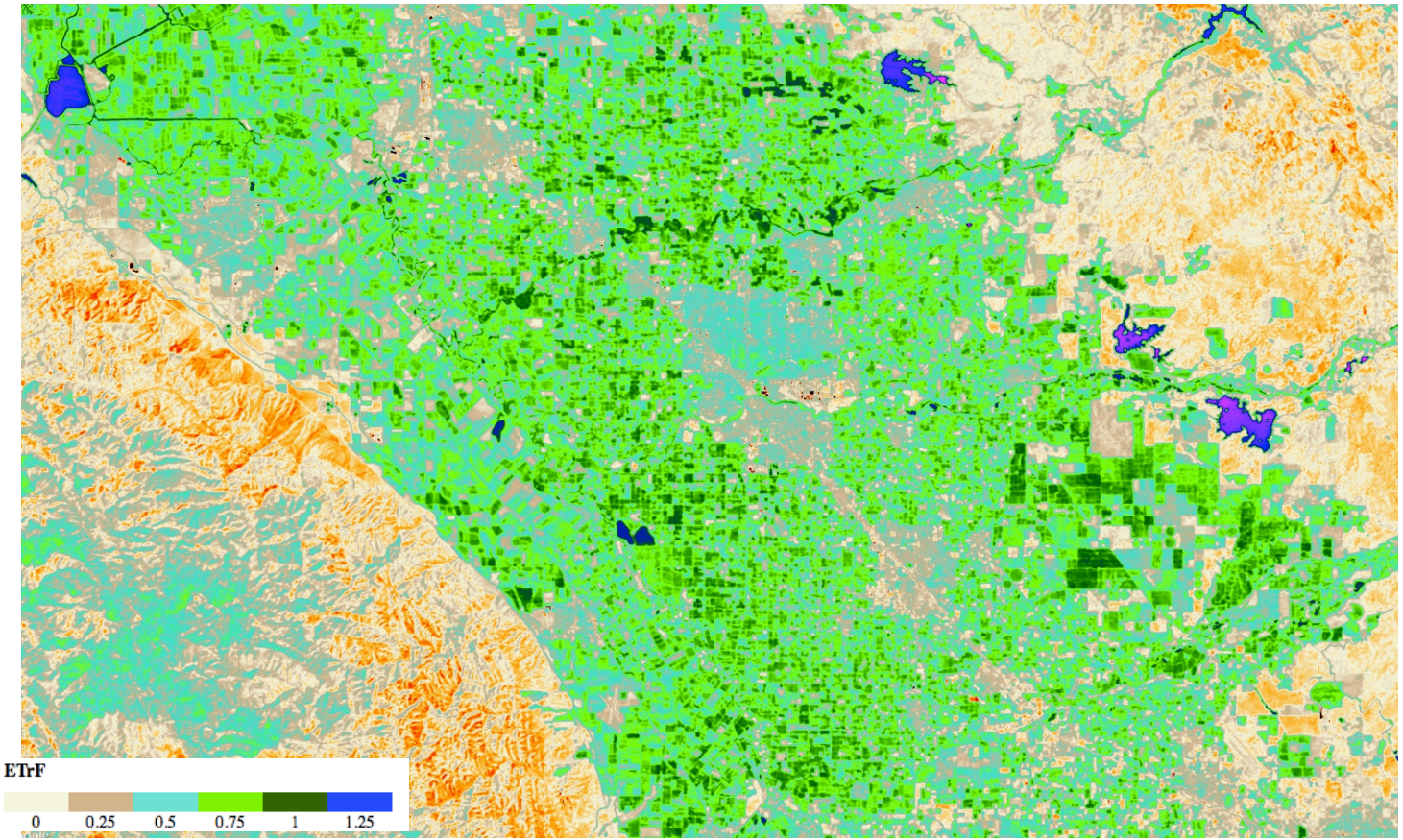
Huntington and Morton, Desert Research Institute

Palmer drought severity index, difference from median



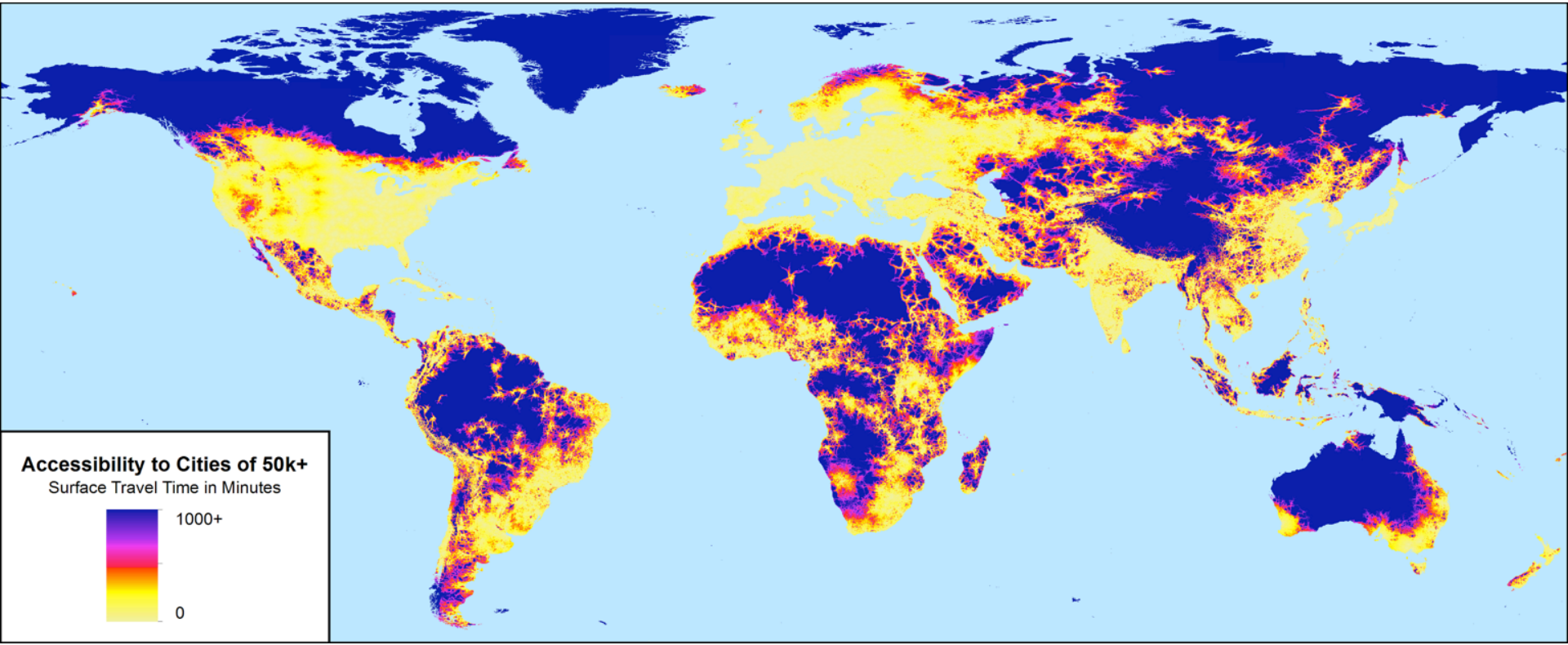
Huntington and Morton, Desert Research Institute

Simplified surface energy balance, reference evapotranspiration



European Commission | map malaria atlas project

UNIVERSITY OF OXFORD



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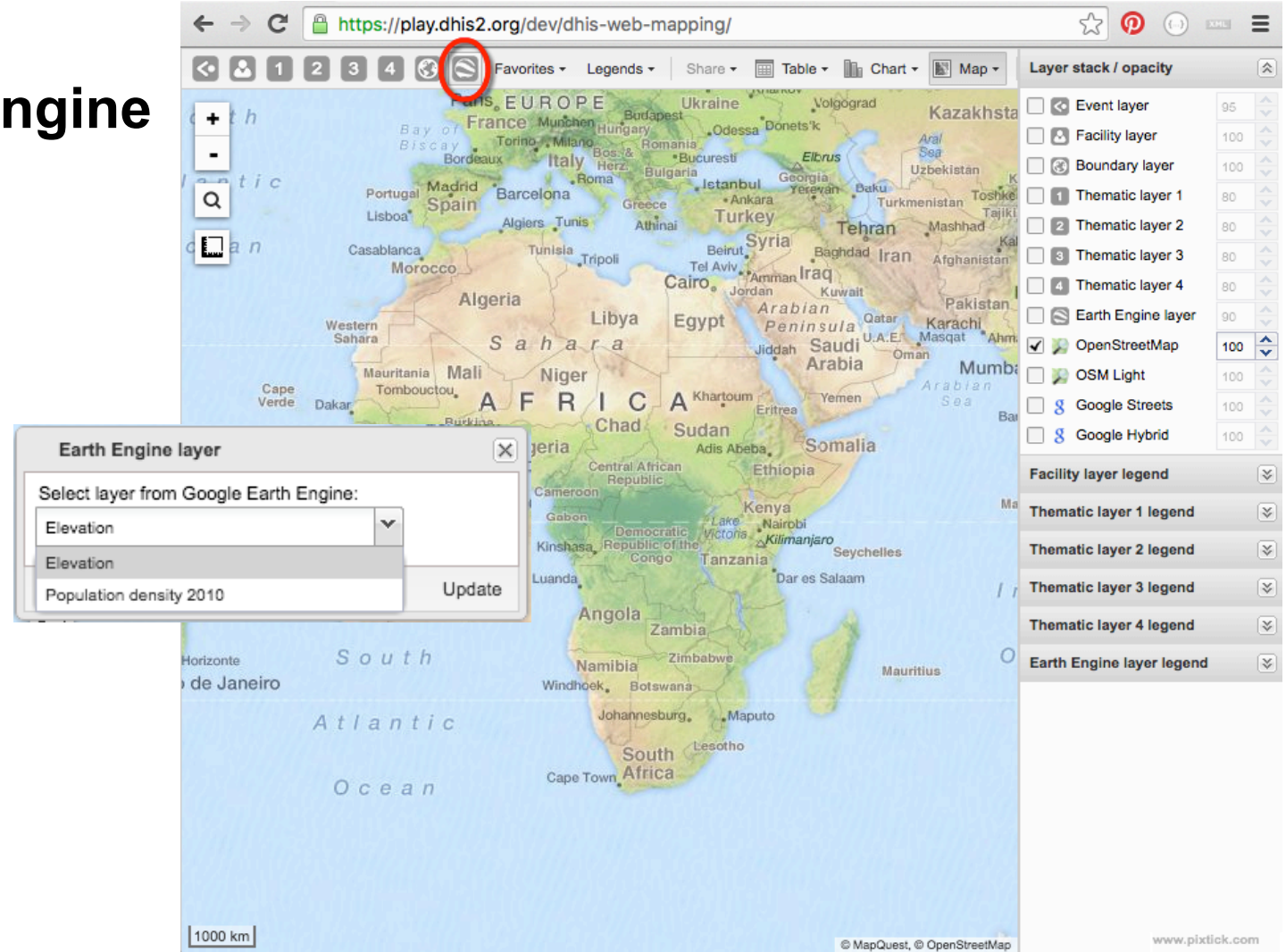

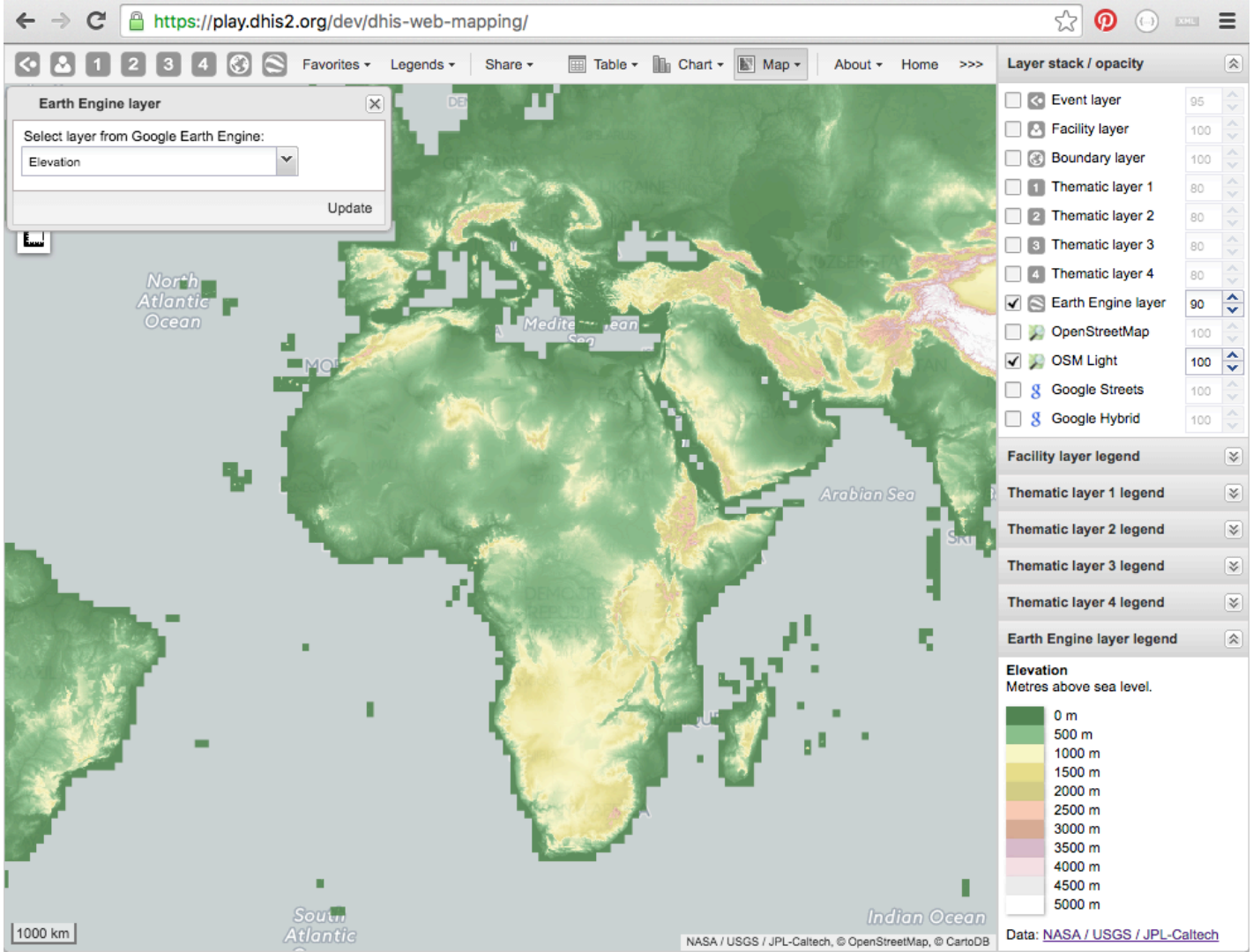
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Map
About
Home
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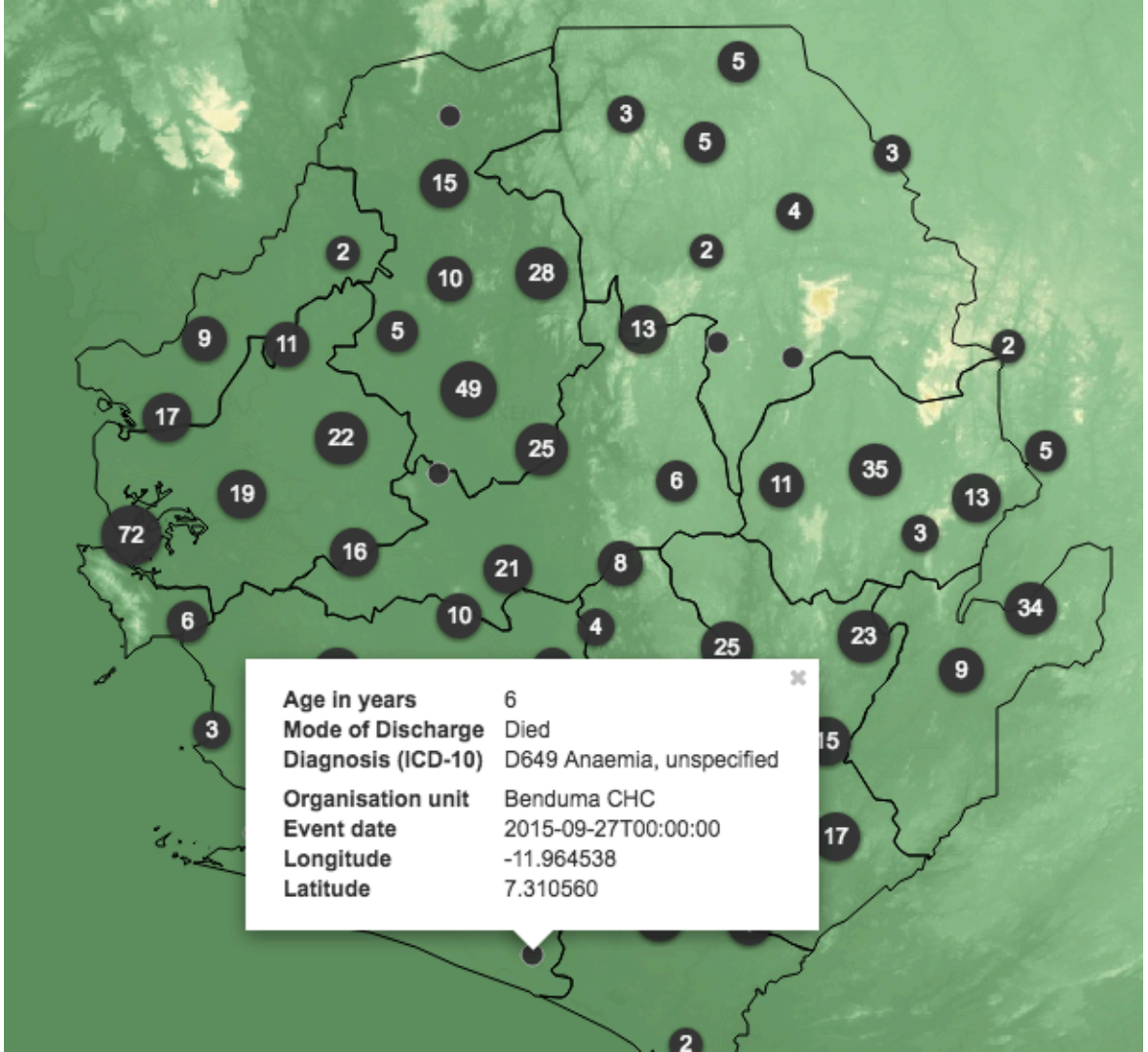
Earth Engine layer
Select layer from Google Earth Engine:
Elevation
Update
North Atlantic Ocean
Arabian Sea
Indian Ocean
South Atlantic
1000 km
NASA / USGS / JPL-Caltech, © OpenStreetMap, © CartoDB
Layer stack / opacity
Event layer
Facility layer
Boundary layer
Thematic layer 1
Thematic layer 2
Thematic layer 3
Thematic layer 4
Earth Engine layer
OpenStreetMap
OSM Light
Google Streets
Google Hybrid
Facility layer legend
Thematic layer 1 legend
Thematic layer 2 legend
Thematic layer 3 legend
Thematic layer 4 legend
Earth Engine layer legend
Elevation
Metres above sea level.
0 m
500 m
1000 m
1500 m
2000 m
2500 m
3000 m
3500 m
4000 m
4500 m
5000 m
Data: NASA / USGS / JPL-Caltech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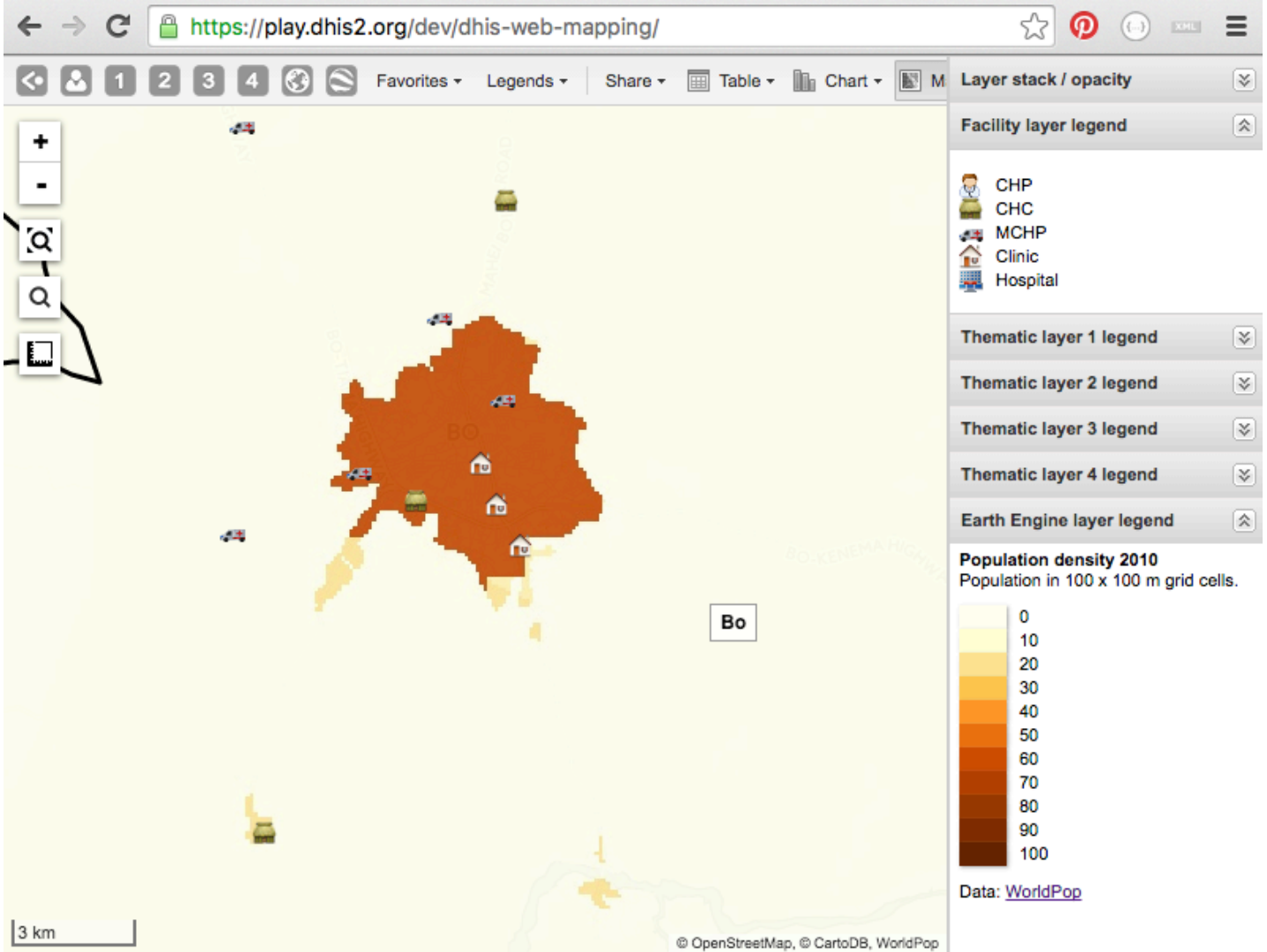
2
Age in years 6
Mode of Discharge Died
Diagnosis (ICD-10) D649 Anaemia, unspecified
Organisation unit Benduma CHC
Event date 2015-09-27T00:00:00
Longitude -11.964538
Latitude 7.310560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Layer stack / opacity
Facility layer legend
CHP
CHC
MCHP
Clinic
Hospital
Thematic layer 1 legend
Thematic layer 2 legend
Thematic layer 3 legend
Thematic layer 4 legend
Earth Engine layer legend
Population density 2010
Population in 100 x 100 m grid cells.
0
10
20
30
40
50
60
70
80
90
100
Data: WorldPop
Bo
3 km
© OpenStreetMap, © CartoDB, WorldPop

Takeaways

1. Cloud-based **data warehouse** for massive Earth Observation and derivative data
    a. Environment, Climate, Population, etc.
2. **Parallelized computation** platform for global-scale analysis
    a. Spatial statistics, raster math
3. Ability to **integrate** with existing tools and/or power new tools

Thank you!

Allie Lieber
Program Manager
Google Earth Outreach
allieber@google.com

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International Journal of Remote Sensing
Vol. 34, No. 7, 10 April 2013, 2607–2654

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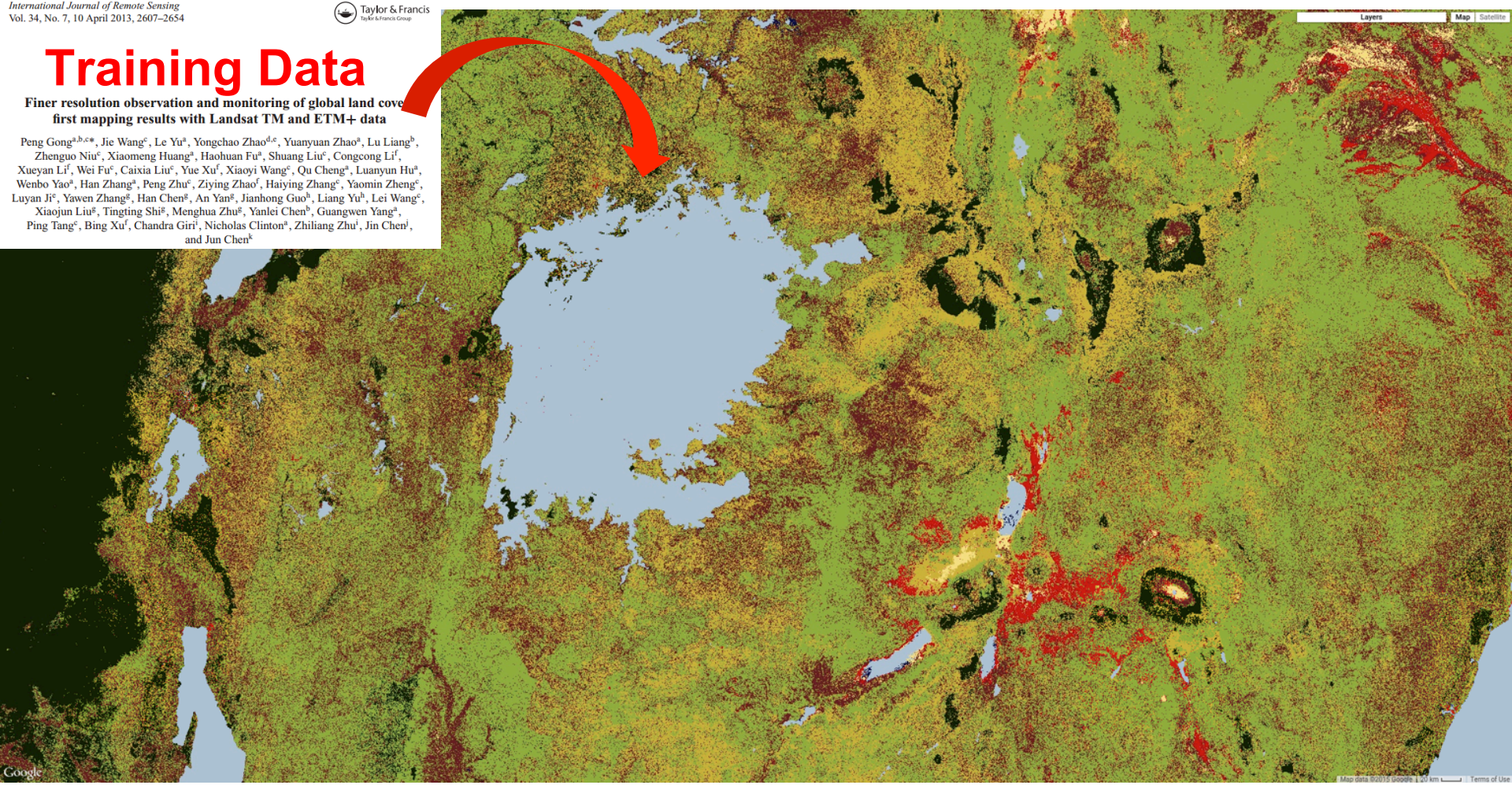
Training Data

**Finer resolution observation and monitoring of global land cove
first mapping results with Landsat TM and ETM+ data**

Peng Gong[a,b,c*], Jie Wang[c], Le Yu[a], Yongchao Zhao[d,c], Yuanyuan Zhao[a], Lu Liang[b], Zhenguo Niu[c], Xiaomeng Huang[a], Haohuan Fu[a], Shuang Liu[c], Congcong Li[f], Xueyan Li[f], Wei Fu[c], Caixia Liu[c], Yue Xu[f], Xiaoyi Wang[c], Qu Cheng[a], Luanyun Hu[a], Wenbo Yao[a], Han Zhang[a], Peng Zhu[c], Ziying Zhao[f], Haiying Zhang[c], Yaomin Zheng[c], Luyan Ji[c], Yawen Zhang[g], Han Chen[g], An Yan[g], Jianhong Guo[h], Liang Yu[h], Lei Wang[c], Xiaojun Liu[g], Tingting Shi[g], Menghua Zhu[g], Yanlei Chen[b], Guangwen Yang[a], Ping Tang[c], Bing Xu[f], Chandra Giri[i], Nicholas Clinton[a], Zhiliang Zhu[i], Jin Chen[j], and Jun Chen[k]



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River morphology

Bryk et al. UC Berkeley

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Satellite

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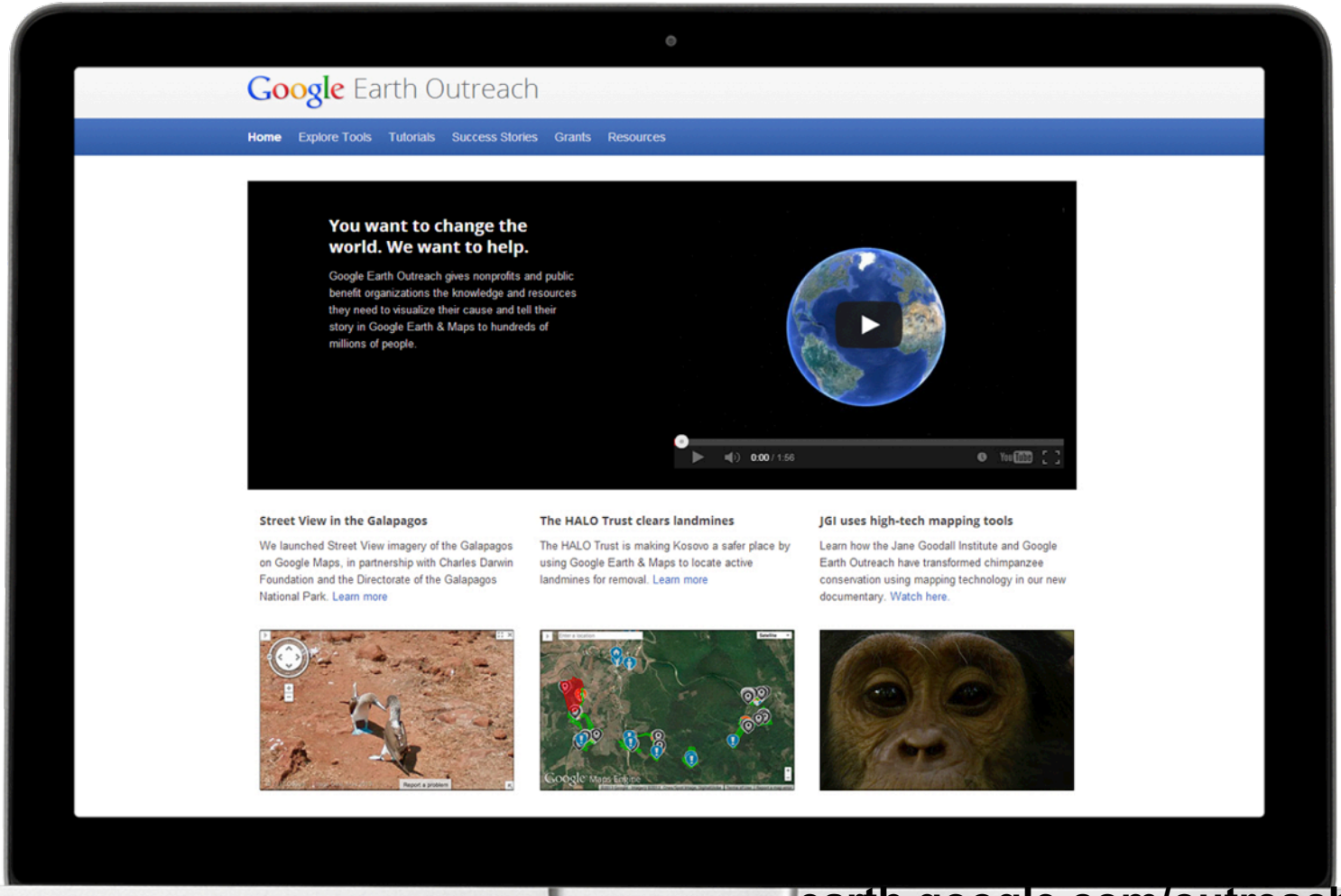

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