Geospatial Revolution in times of urgency for Climate Change

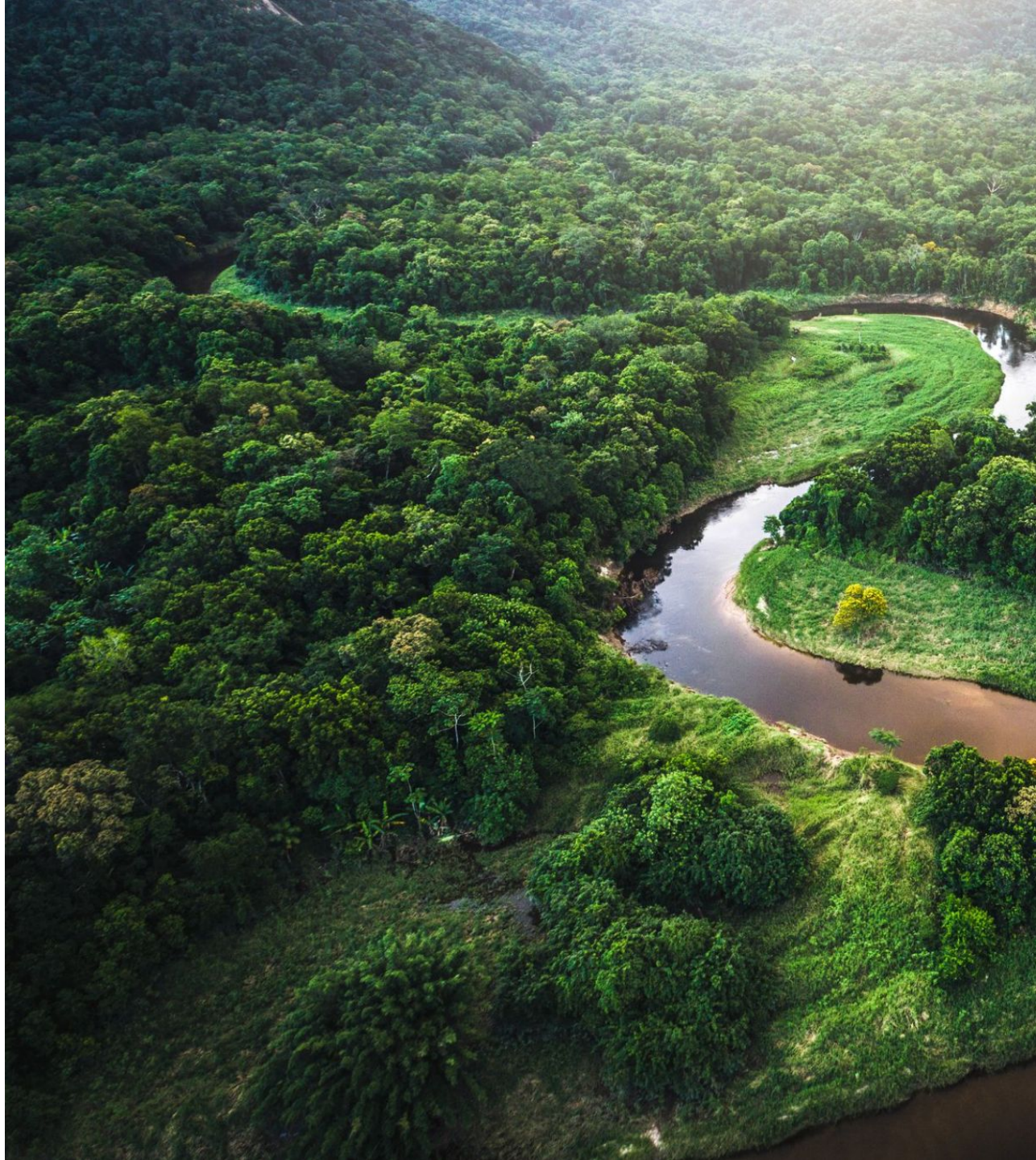
Rebecca Moore, Director, Google Earth, Earth Engine & Outreach
Google
AmazonTEK2023
Nov 15, 2023


Mato Grosso, Brazil

We are hitting planetary tipping points

In 2021

For the first time in history, the Amazon rainforest emitted more carbon than it removed



Source: Nature (2021)


OSTM/Jason 2
(NOAA)
Aquarius
QuikSCAT
TRMM
Terra
ISS-RapidScat,
CATS
EO-1
Landsat 7
(USGS)
SMAP
Aqua
Suomi NPP
(NOAA)
Landsat 8
(USGS)
SORCE,
TCTE (NOAA)
Aura
GPM
GRACE (2)
CALIPSO
CloudSat
OCO-2

Source: NASA

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

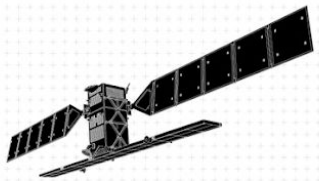
Marine Environmental Monitoring. Observations and forecasts on the state of the physical oceans and regional seas

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

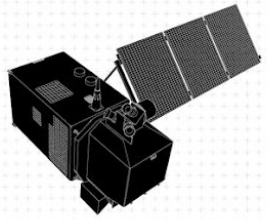
SENTINEL-1

- **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



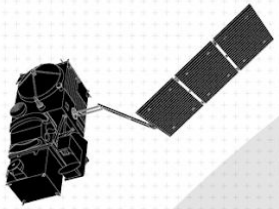
SENTINEL-2

- **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

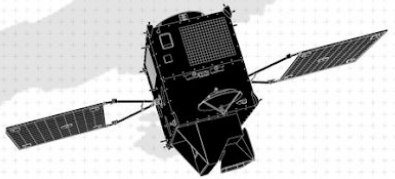


SENTINEL-5P

- **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

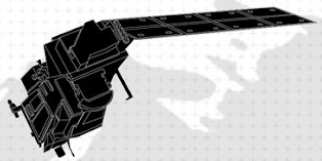
SENTINEL-4

- **Provides hourly updates on air quality with data on atmospheric aerosol and traces 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

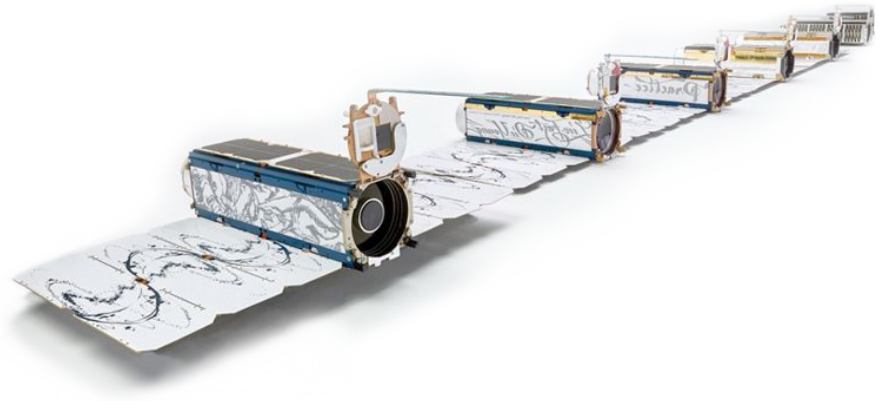
2014 — 2020

Earth Observation Data Archives

Revolution begins: Explosion of Earth Observation “Big Data”

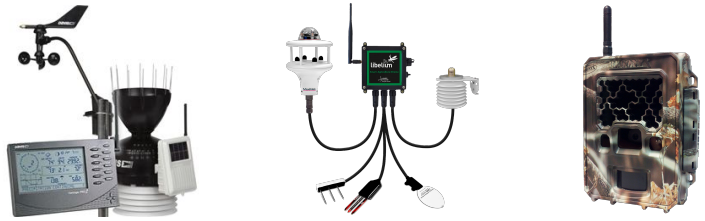
Big commercial & government satellites

Constellations of small sats



Drones & aerial reconnaissance

Mobile & in-situ sensor networks



But researchers and practitioners are not software engineers!
How can they access and process all this data?

Earth Engine Mission

Build the leading geospatial analysis platform to advance planetary sustainability and resilience to climate change

Meet Earth Engine

Data Catalog

The world's largest archive of open Earth data at your fingertips.

+

Computation Platform

A powerful tool to analyze and visualize Earth data at scale.

+

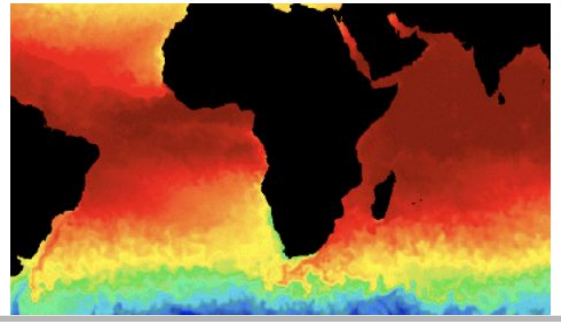
Collaborative Ecosystem

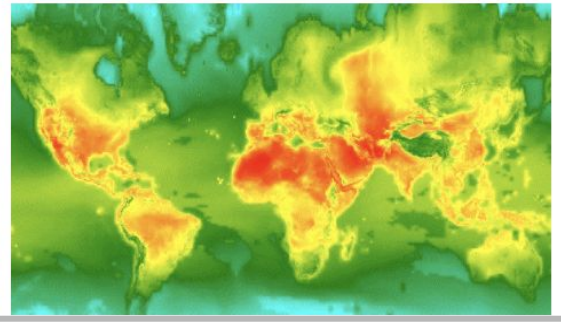
100,000+ monthly-active users (and growing).

Earth Engine Data Catalog

HOME | VIEW ALL DATASETS | BROWSE BY TAGS

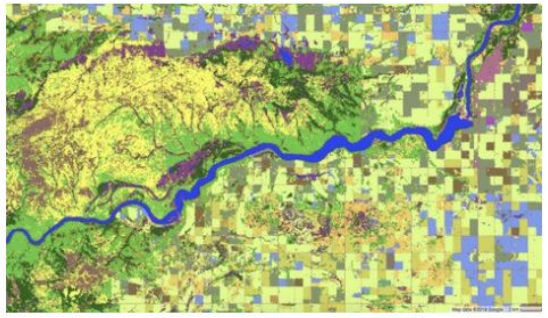
Climate and Weather





Imagery

Geophysical

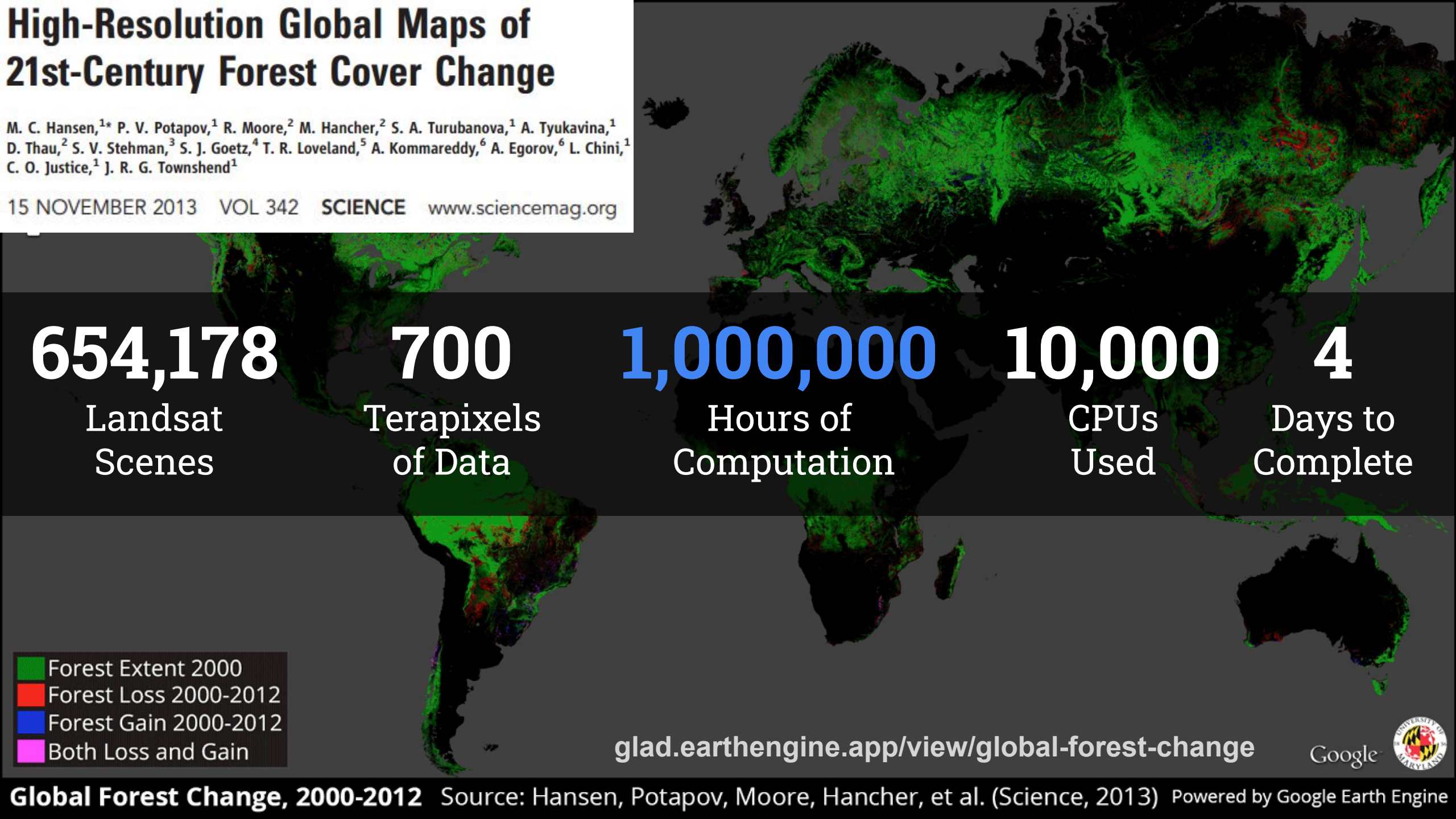


Google Data Center

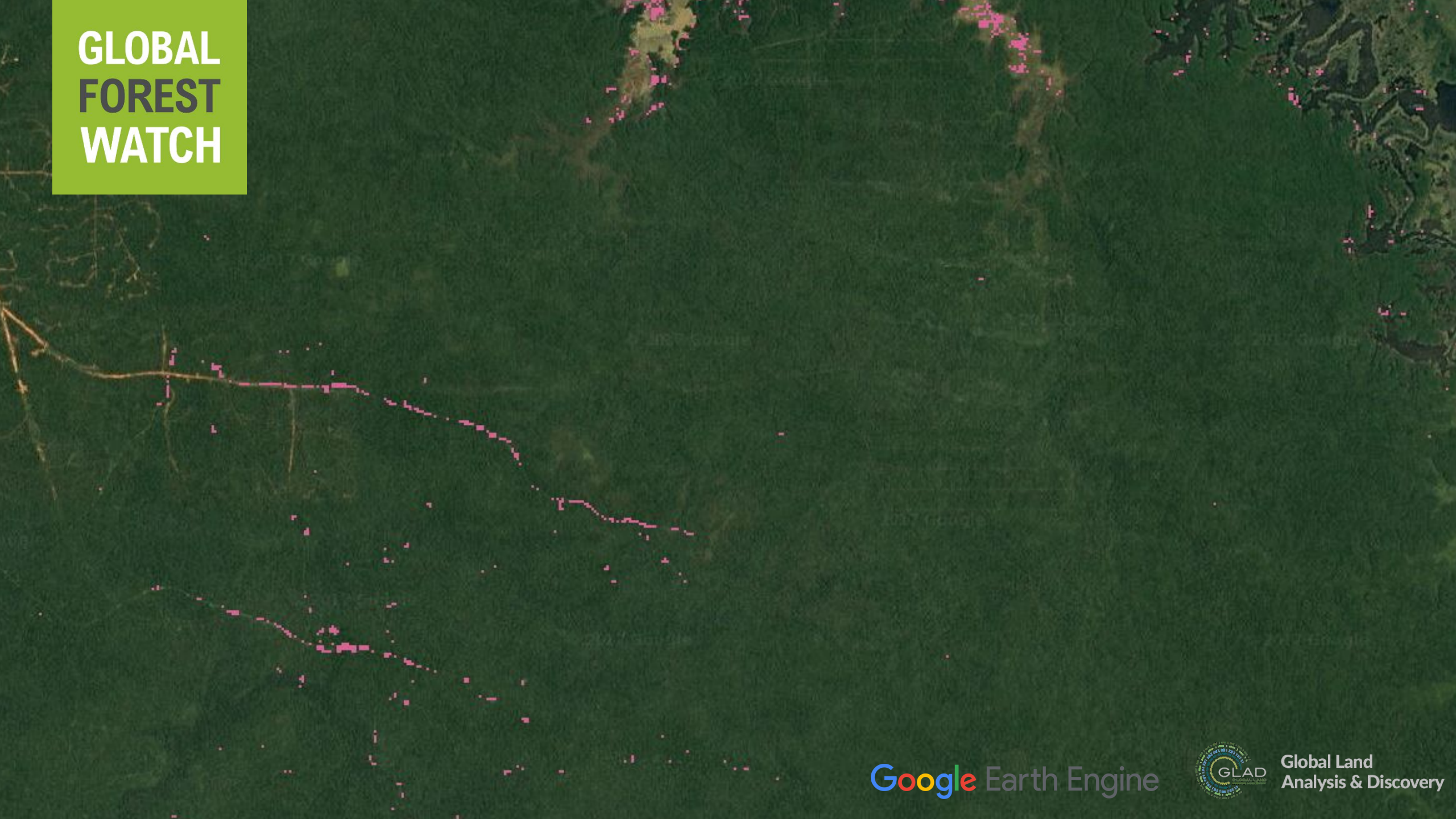
High-Resolution Global Maps of 21st-Century Forest Cover Change

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]

15 NOVEMBER 2013 VOL 342 SCIENCE www.sciencemag.org



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


GLOBAL
FOREST
WATCH
Google Earth Engine
GLAD
Global Land
Analysis & Discovery

Monitoring matters!

38 Indigenous territories in Peru saw a
51% reduction in deforestation

161 Mha of Congo Basin forests saw a
18% reduction in deforestation

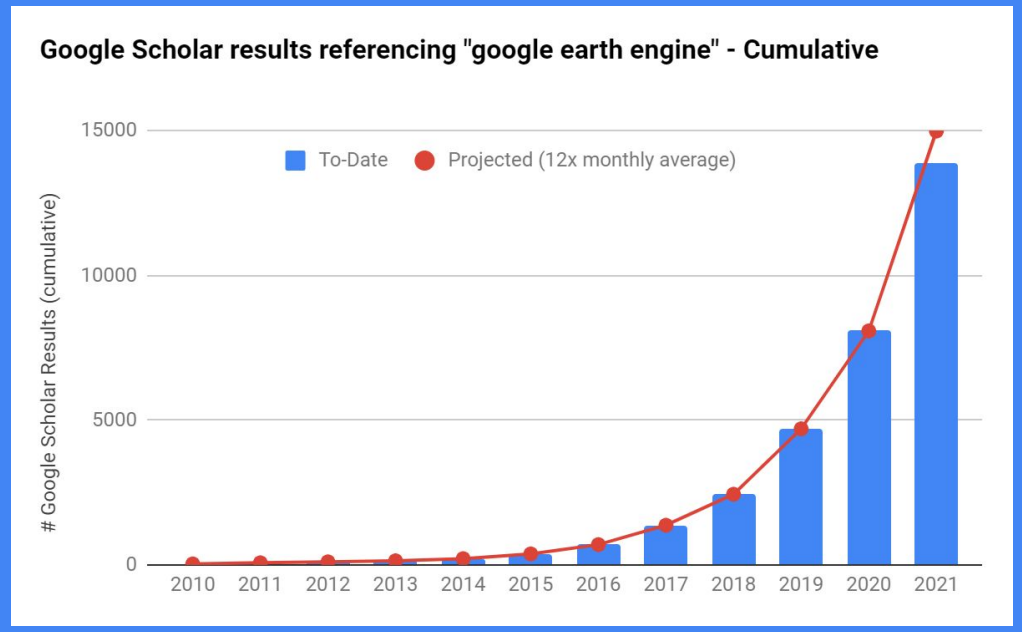
GLOBAL FOREST WATCH

500k+

Scientists around the world

20,000+

Scientific papers (*link*)



Remote Sensing of Environment
Volume 202, 1 December 2017, Pages 18-27

Google Earth Engine: Planetary-scale geospatial analysis for everyone

Science Home News Journals Topics Careers

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. ...

nature
International journal of science

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

Jean-François Pekel, Andrew Cottam, Noel Gorelick & Alan S. Belward

Science Home News Journals Topics Careers

Tracking the global footprint of fisheries

David A. Kroodsma[1,*], Juan Mayorga[2,3], Timothy Hochberg[1], Nathan A. Miller[4], Kristina Boerder[5], Francesco Ferretti[6], Alex ...

Science

RESTORATION ECOLOGY

The global tree restoration potential

Jean-Francois Bastin[1]*, Yelena Finegold[2], Claude Garcia[3,4], Danilo Mollicone[2], Marcelo Rezende[2], Devin Routh[1], Constantin M. Zohner[1], Thomas W. Crowther[1]

The restoration of trees remains among the most effective strategies for climate change mitigation. We mapped the global potential tree coverage to show that 4.4 billion hectares of canopy cover could exist under the current climate. Excluding existing trees and agricultural and urban areas, we found that there is room for an extra 0.9 billion hectares of canopy cover, which could store 205 gigatonnes of carbon in areas that would naturally support woodlands and forests. This highlights global tree restoration as our most effective climate change solution to date. However, climate change will alter this potential tree coverage. We estimate that if we cannot deviate from the current trajectory, the global potential canopy cover may shrink by ~223 million hectares by 2050, with the vast majority of losses occurring in the tropics. Our results highlight the opportunity of climate change mitigation through global tree restoration but also the urgent need for action.

Photosynthetic carbon capture by trees is likely to be among our most effective strategies to limit the rise of CO_2 concentrations across the globe (*1*–*3*). Consequently, a number of international initiatives [such as the Bonn Challenge, the related AFR100, and

measurements (data file S1) (*8*) of tree cover across all protected regions of the world (fig. S1) (*9*, *10*). Using global environmental layers (table S1) (*11*), we examined how climate, edaphic, and topographic variables drive the variation in natural tree cover across the globe. The focus on

mental conditions, with minimal human activity (Fig. 2A). This work is directly underpinned by our systematic dataset of direct tree cover measurements (entirely independent of climate and modeled remote sensing estimates) (*13*) across the globe (fig. S1) (*10*).

Across the world's protected areas (fig. S2), tree cover ranged between peaks of 0% in dry desert and 100% in dense equatorial forest, with fewer values falling between these two extremes (figs. S2 and S3). We paired these tree cover measurements with 10 global layers of soil and climate data (table S1) (*11*). Our resulting random forest model had high predictive power [coefficient of determination (R^2) = 0.86; intercept = −2.05% tree cover; slope = 1.06] (Fig. 1); rigorous *k*-fold cross-validation (fig. S4A) (*11*) revealed that our model could explain ~71% of the variation in tree cover without bias (R^2 = 0.71; intercept = 0.34% tree cover; slope = 0.99) (fig. S3, B and C). Our *k*-fold cross-validation approach also allows us to generate a spatially explicit understanding of model uncertainty (figs. S5 and S6) (*11*). Across all pixels, the mean standard deviation around the modeled estimate is ~9% in tree cover (28% of the mean tree cover) (figs. S5 and S6) (*11*). As

RESTOR BETA

Search place, organization, site

Draw an area

Upload area file

EN

Create Account/Sign in

CARBON

This shows an estimate of how much organic carbon currently exists in the soil of this area and how much could exist if the soil is restored

Current organic carbon in soil

Show on map

578 tonnes

Potential organic carbon in soil

Show on map

613 tonnes

This shows the rate at which carbon is accumulating as biomass in live plants

Net Primary Productivity

DATA LAYERS

RECENT SATELLITE IMAGERY

View satellite time series

Restor.eco

Roads

Google

v0.2.30 Send feedback -0.787, 37.158 20M

Keyboard shortcuts Map data ©2021 Imagery ©2021 CNES / Airbus, Maxar Technologies Terms of Use

MAPBIOMAS
[BRASIL]

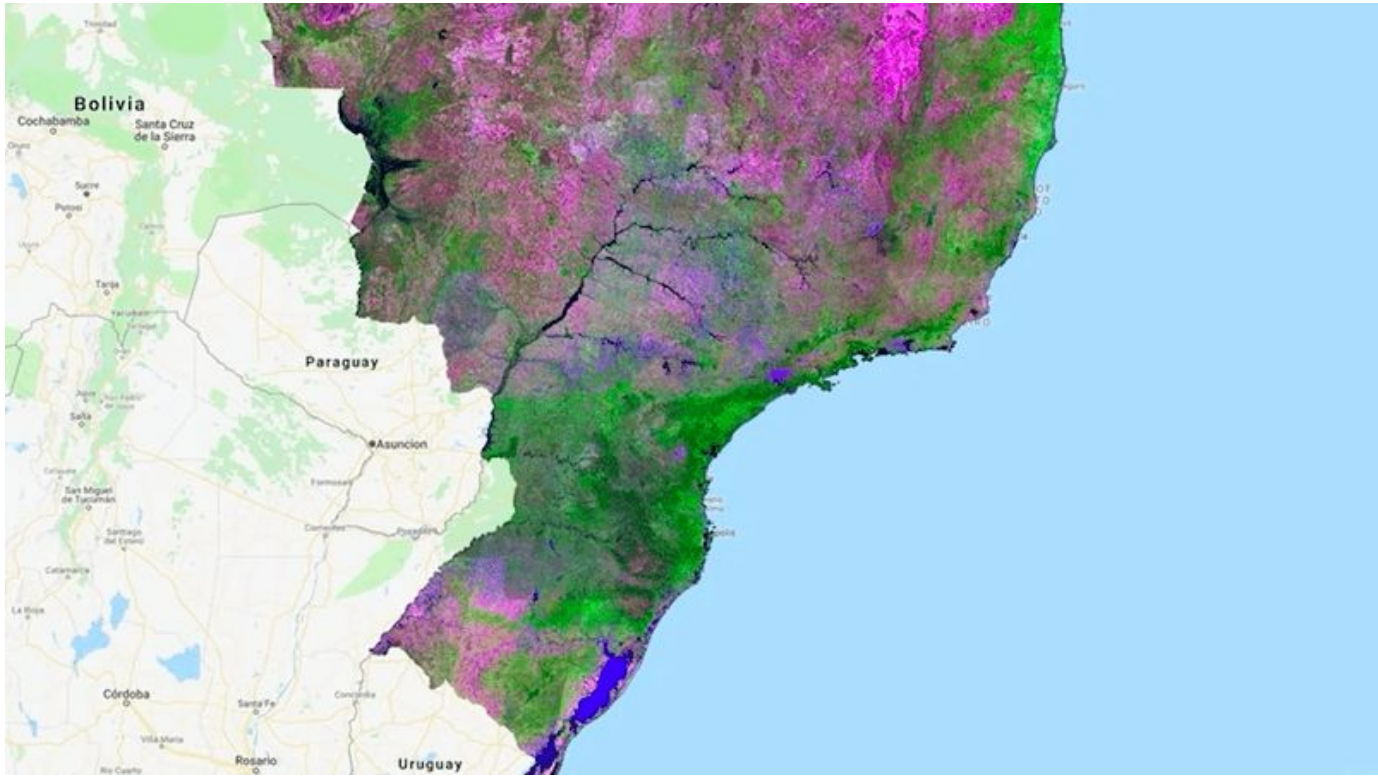
ALERTS

280 million
deforestation alerts

190 million
in the Amazon biome

3 million
hectares of validated deforestation

1,000+
Property loans stopped for detected violations



Imagery: Landsat (30m), Planet (3m)

MAPBIOMAS
[INDONESIA]

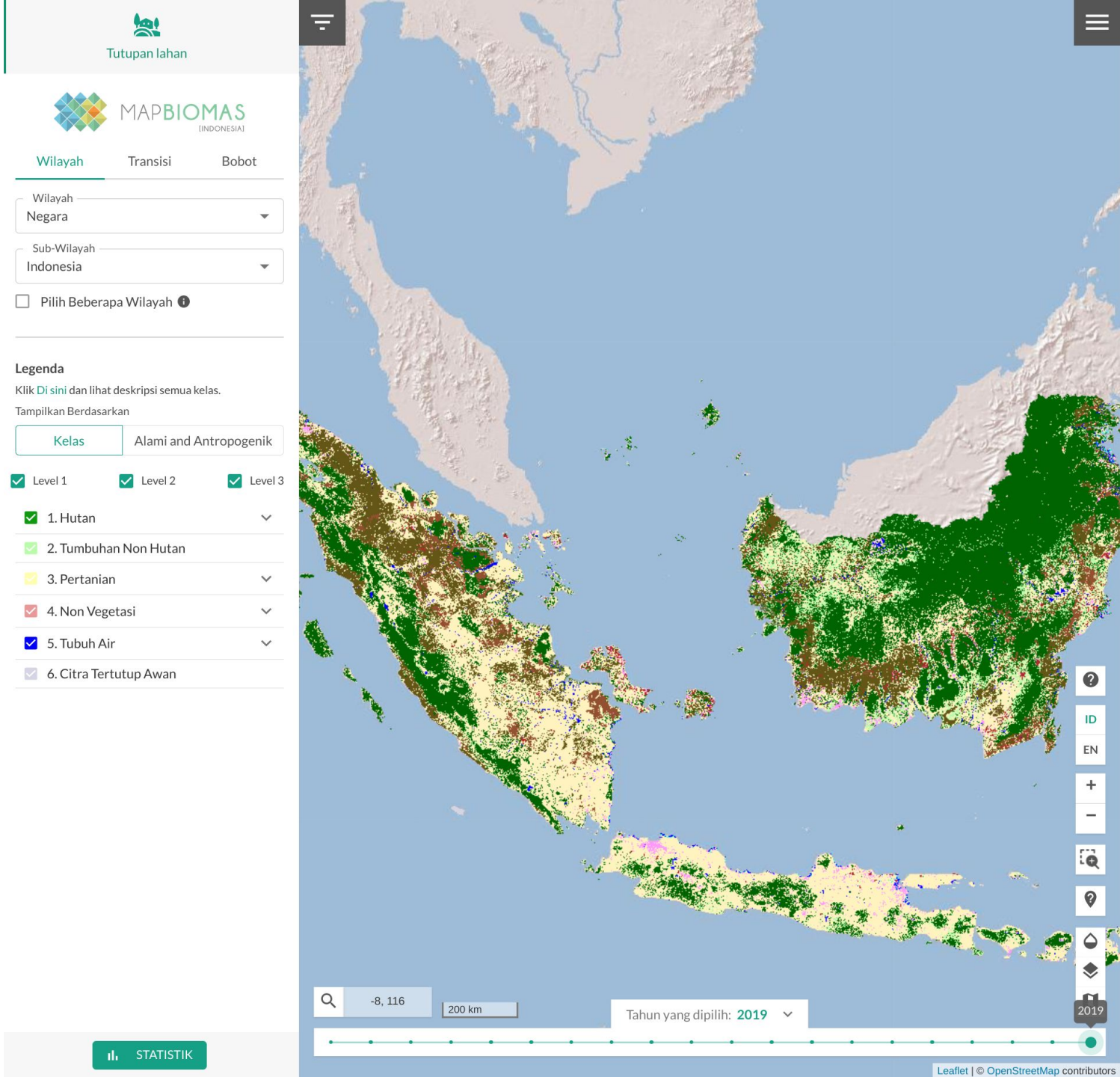
Expanding MapBiomas to Indonesia

Success story - scaling MapBiomas land cover detection and alerting tools regionally in South - South collaboration

MapBiomas Indonesia consists of ten Indonesian civil society organizations (CSO's) which are coordinated by Auriga Nusantara and integrated into the MapBiomas Global Network.

How Google Earth Engine supports impact

"Google Earth Engine (GEE) …is a key tool in the MapBiomas process."



OPENET

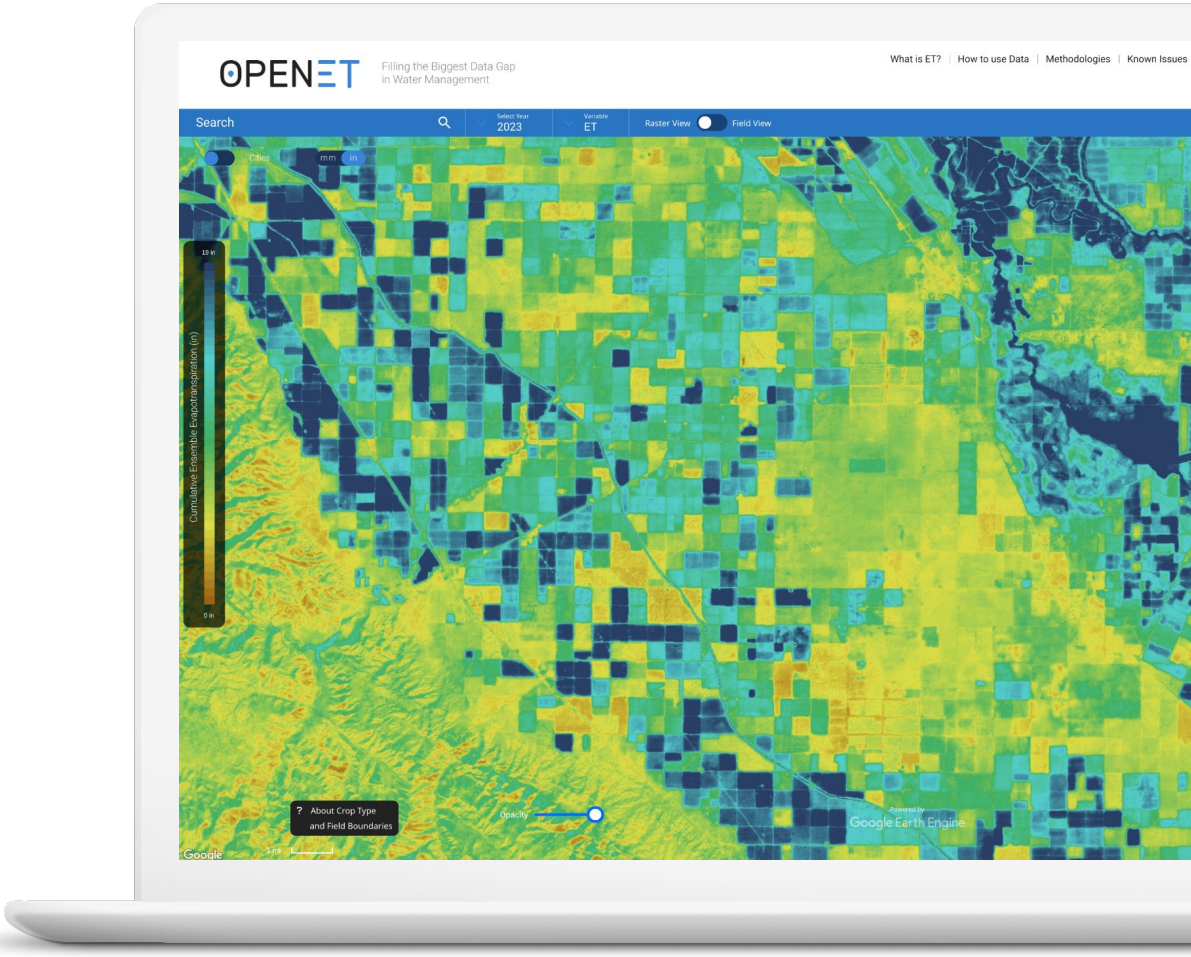
Accessible satellite-based evapotranspiration (ET) data for improved water management

Success story - fostering novel solutions that help decision making

Local communities and water agencies across the west are taking up and using historical and near real-time data from OpenET.

How Google Earth Engine supports impact

“Not only does Earth Engine enable OpenET to produce high resolution ET data at scale and make it readily available to anyone who needs it; it also makes it possible for the scientific community to easily compare approaches and standardize inputs, leading to important advances in the science that serve to continually improve the data over time.”



#GeoForGood23

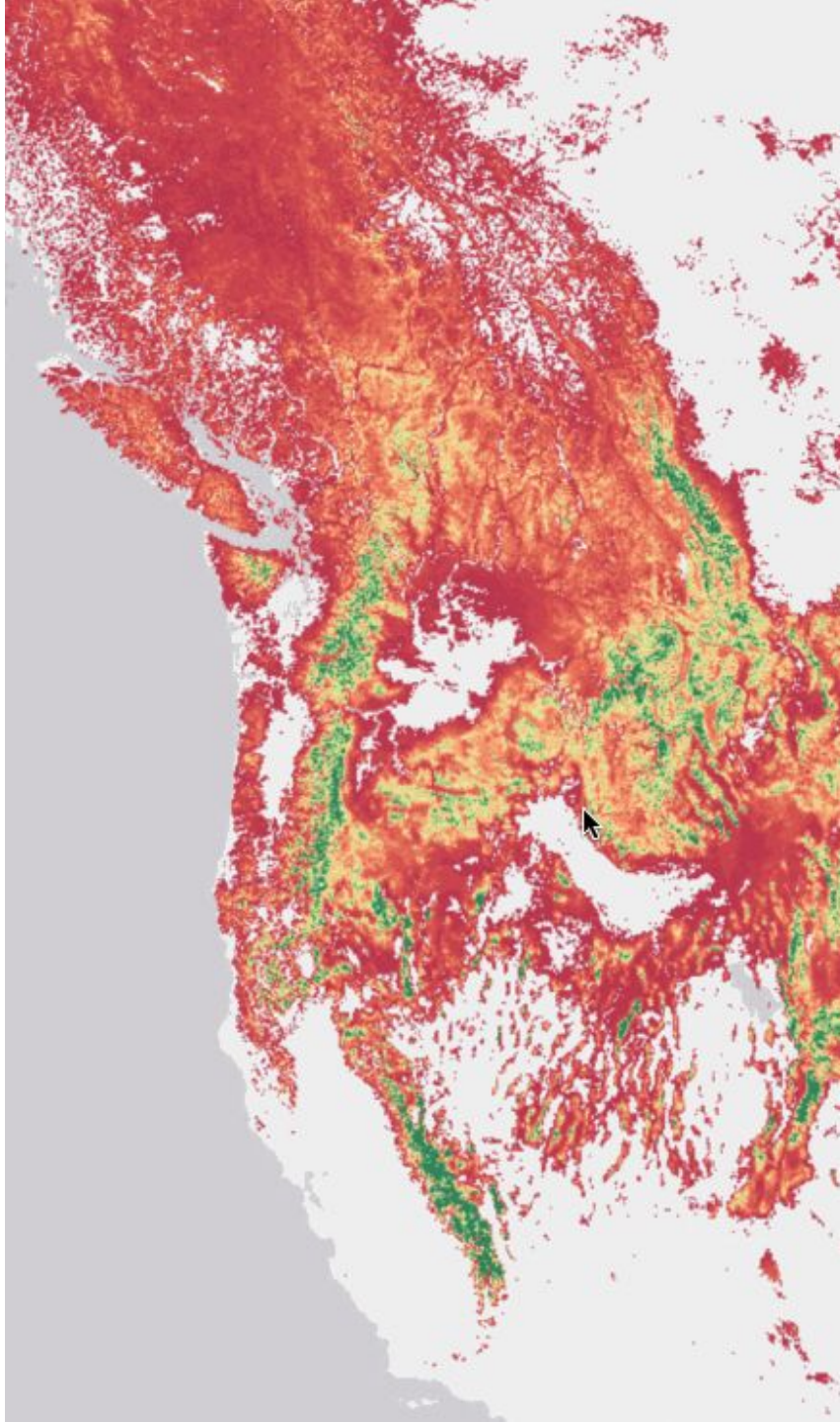
MOL
MAP OF LIFE

Indicators to identify and protect sufficient habitat to safeguard global biodiversity

Success story - Indicators adopted in UN Global Biodiversity Framework
Species Habitat Index (SHI), Species Protection Index (SPI) and Species Information Index (SII) all adopted as complementary indicators in UN Convention on Biological Diversity - Global Biodiversity Framework.

How Google Earth Engine supports impact
"This is the power of the indicators: they simultaneously provide national metrics for tracking progress and provide locally specific, actionable information." Using EE & Cloud to generate Species Protection Index (SPI) for mapping 40,000 species

YALE
BGC
CENTER



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.

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

Related link

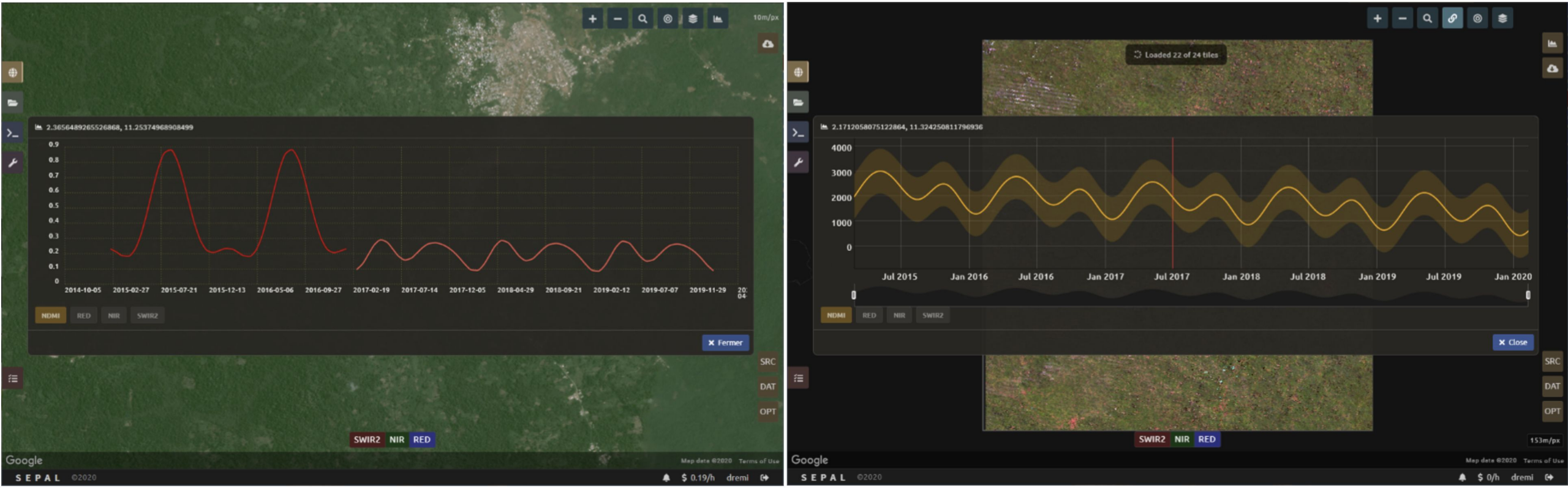
- FAO support to Forest monitoring and assessment

Ranchers in Azerbaijan compare a satellite map with the situation on the ground.

Cool tools

- FAO's Open Foris
- Google Earth Engine
- Collect Earth

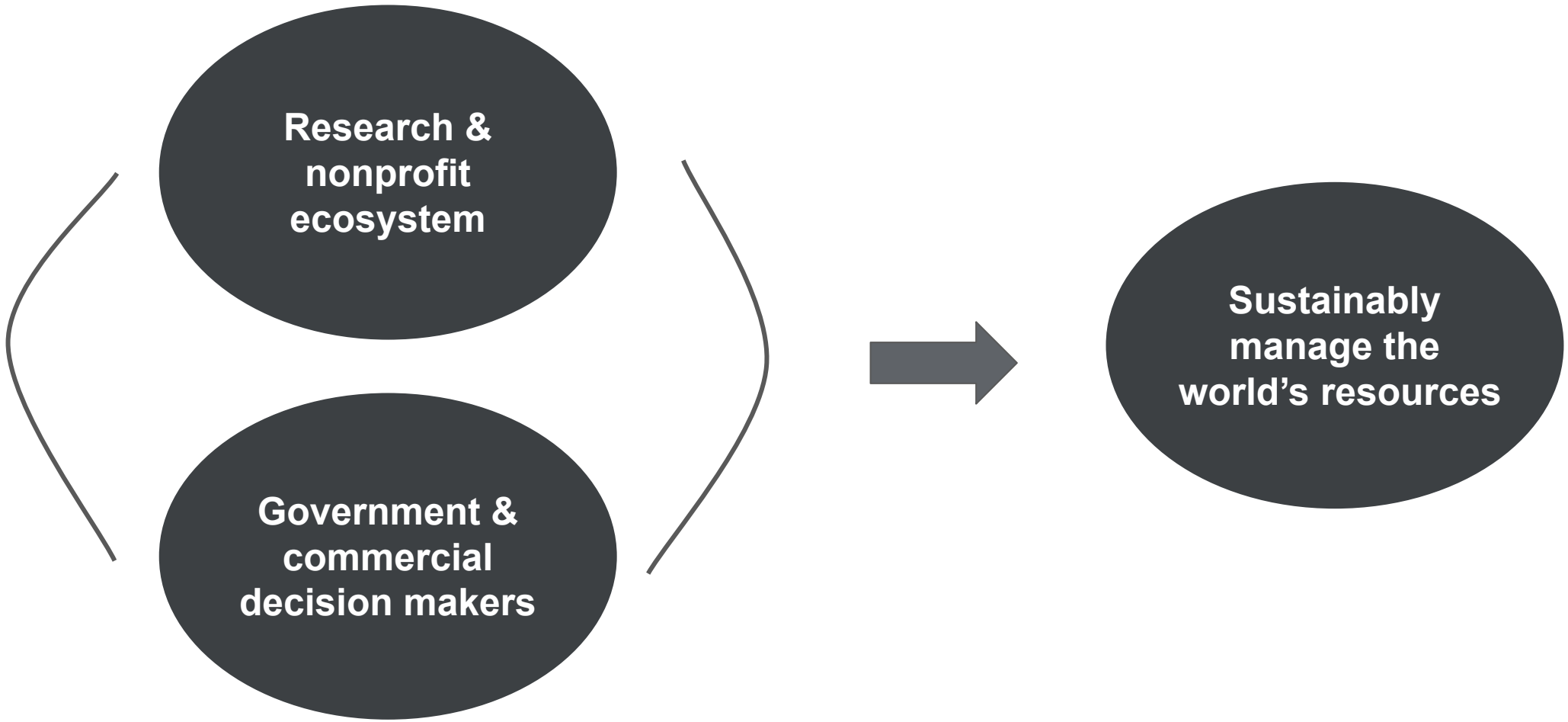
SEPAL



A temporal profile of a satellite pixel of deforestation (left) and degradation (right) in the Congo Basin

Source: UN FAO

Cycle of impact

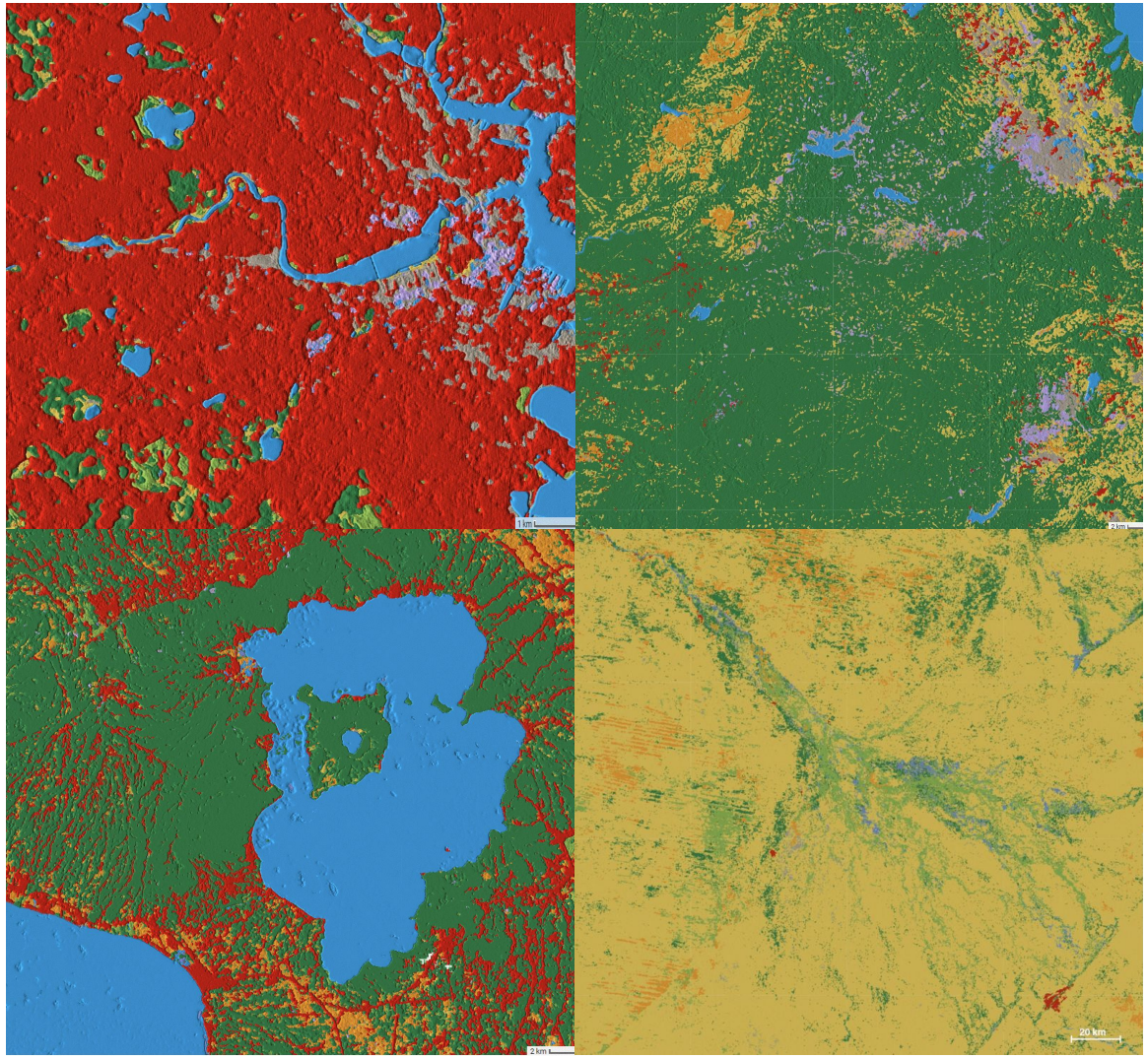


Sustainable sourcing with satellite-derived insights: Modeling palm oil sourcing factors

Source: Unilever, NGIS


Detecting Roads in the Amazon with GEE + AI
Source: Carlos Souza, Imazon

Dynamic World: Near Real Time land cover data



Dataset and AI Model

01 Global Land Cover Dataset

02 10m resolution based on ESA Sentinel-2

03 Near Real Time: 2-5 day globally for seasonal and recent events

04 Per-pixel probabilities across 9 classes

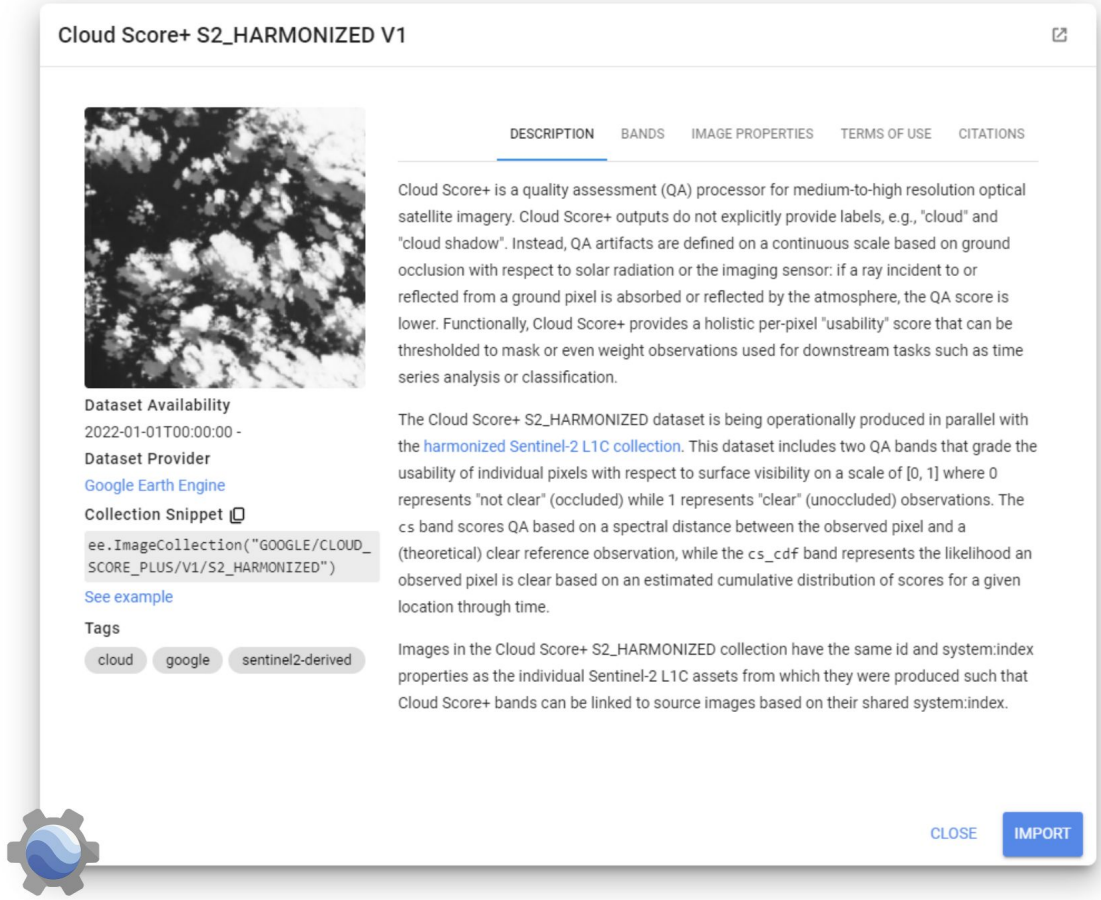
05 Free, Open License model & dataset

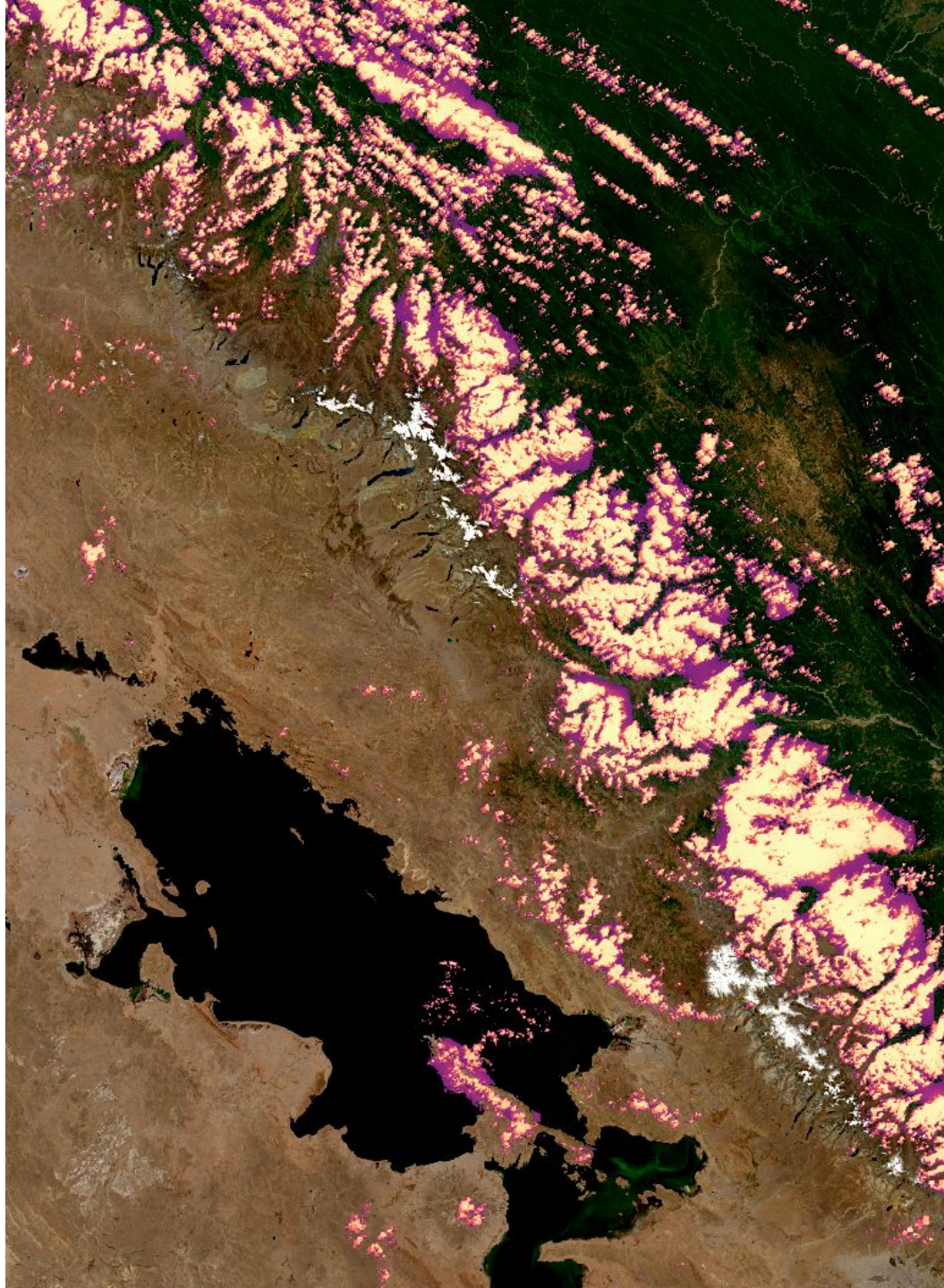
nature SCIENTIFIC DATA

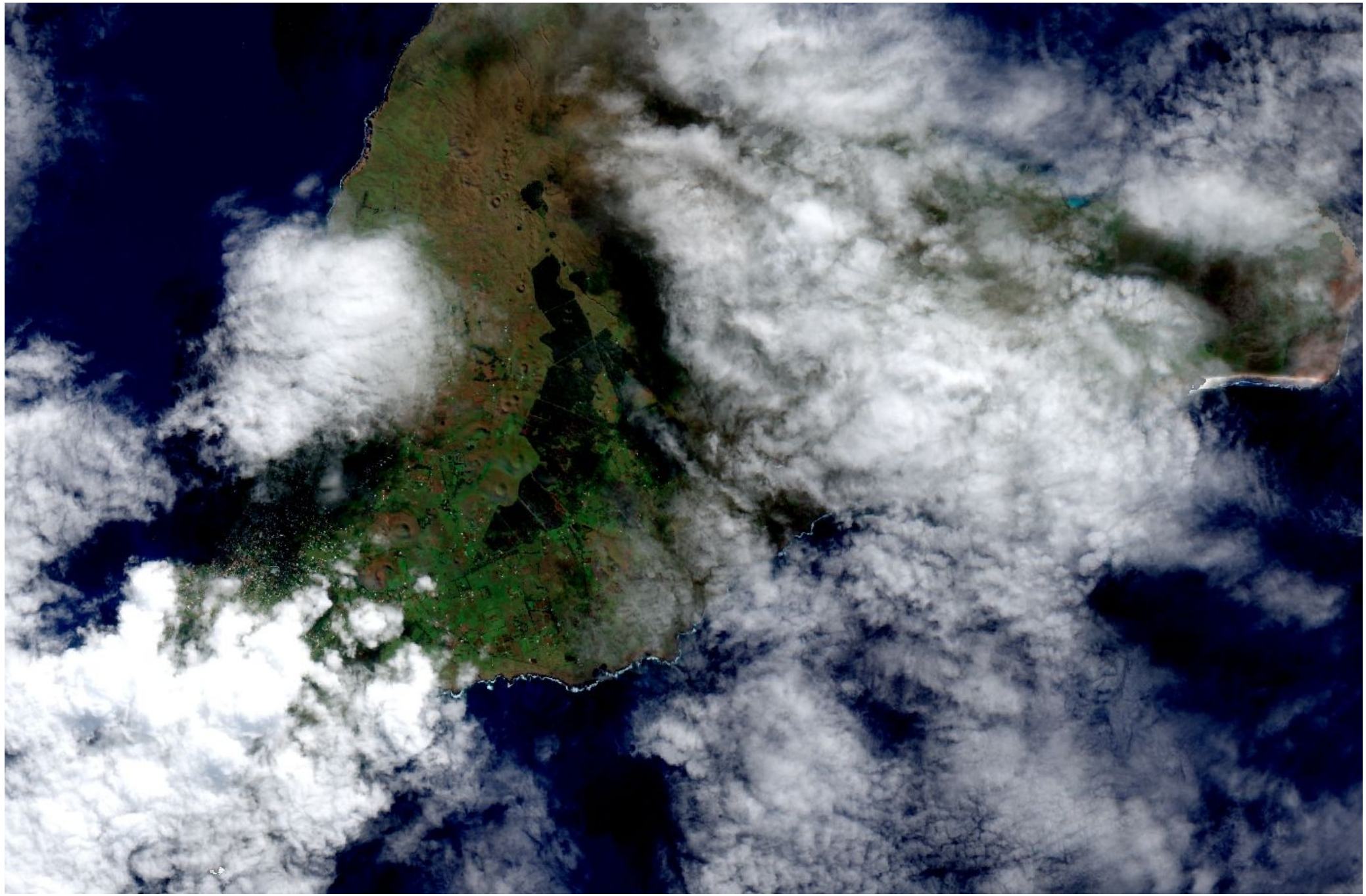
Announcing new GeoAI-powered EE Dataset

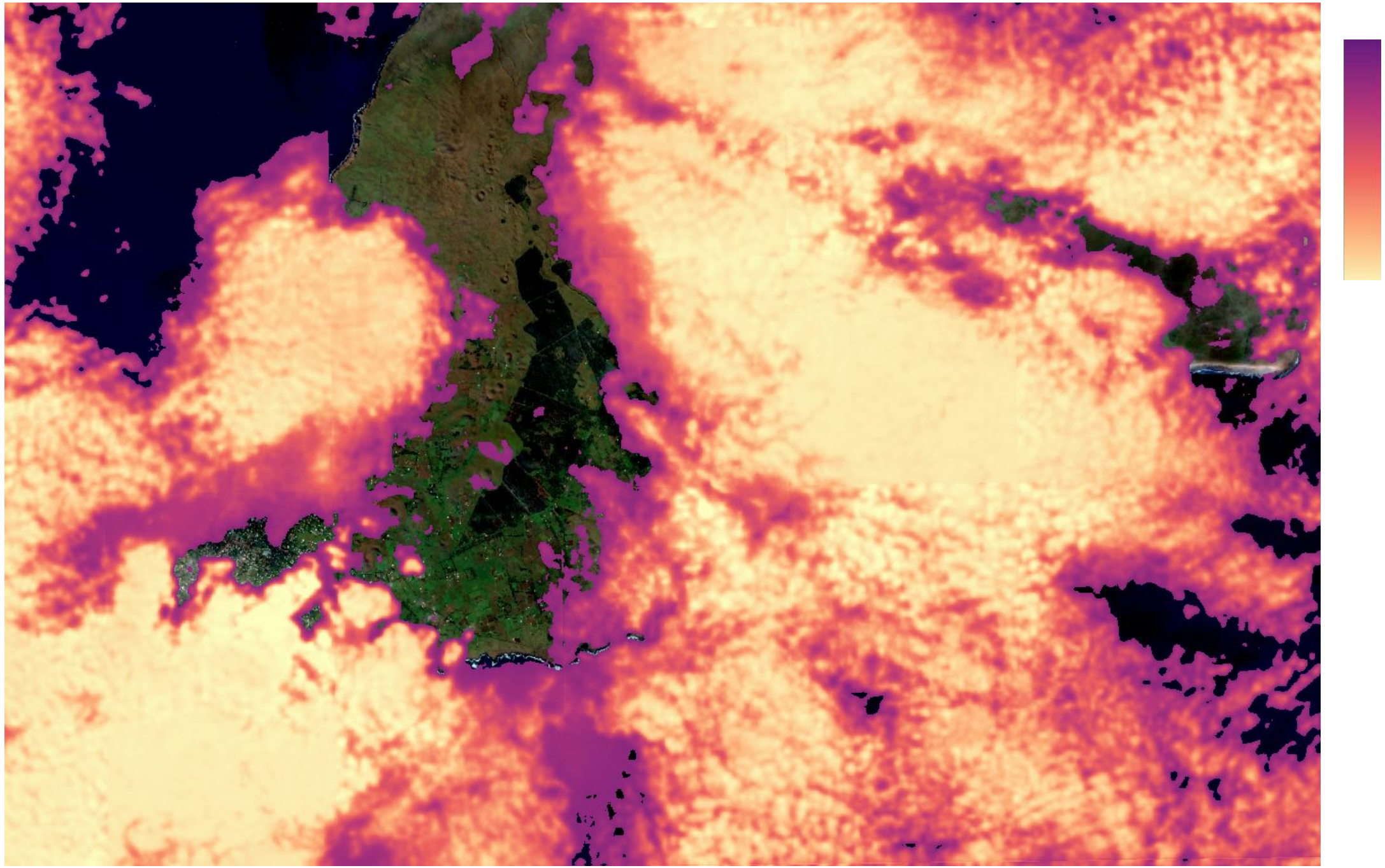
Earth Engine > Cloud Score+

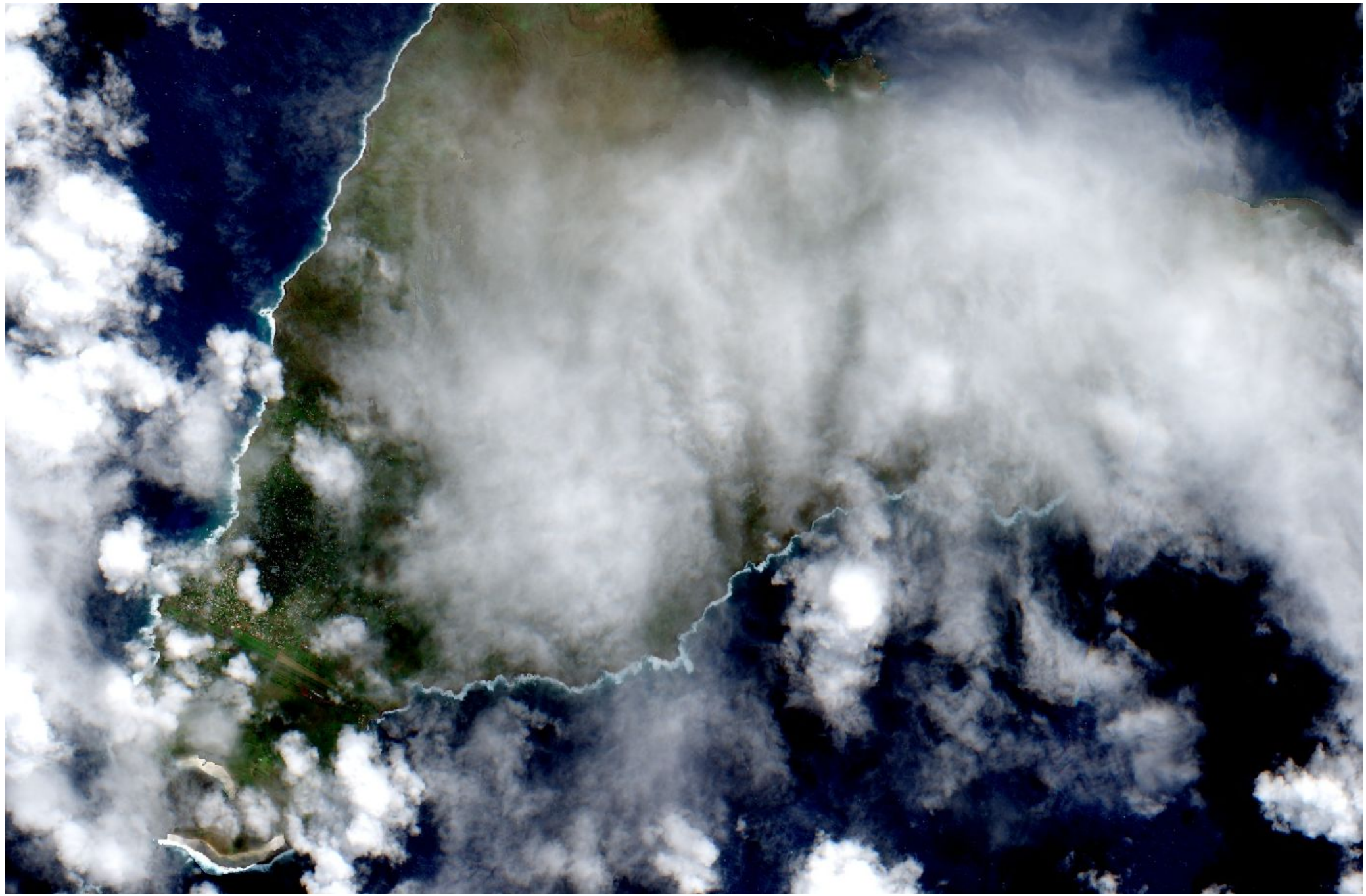
Comprehensive Sentinel-2 pixel quality assessment, supporting flexible generation of clear S2 composites worldwide

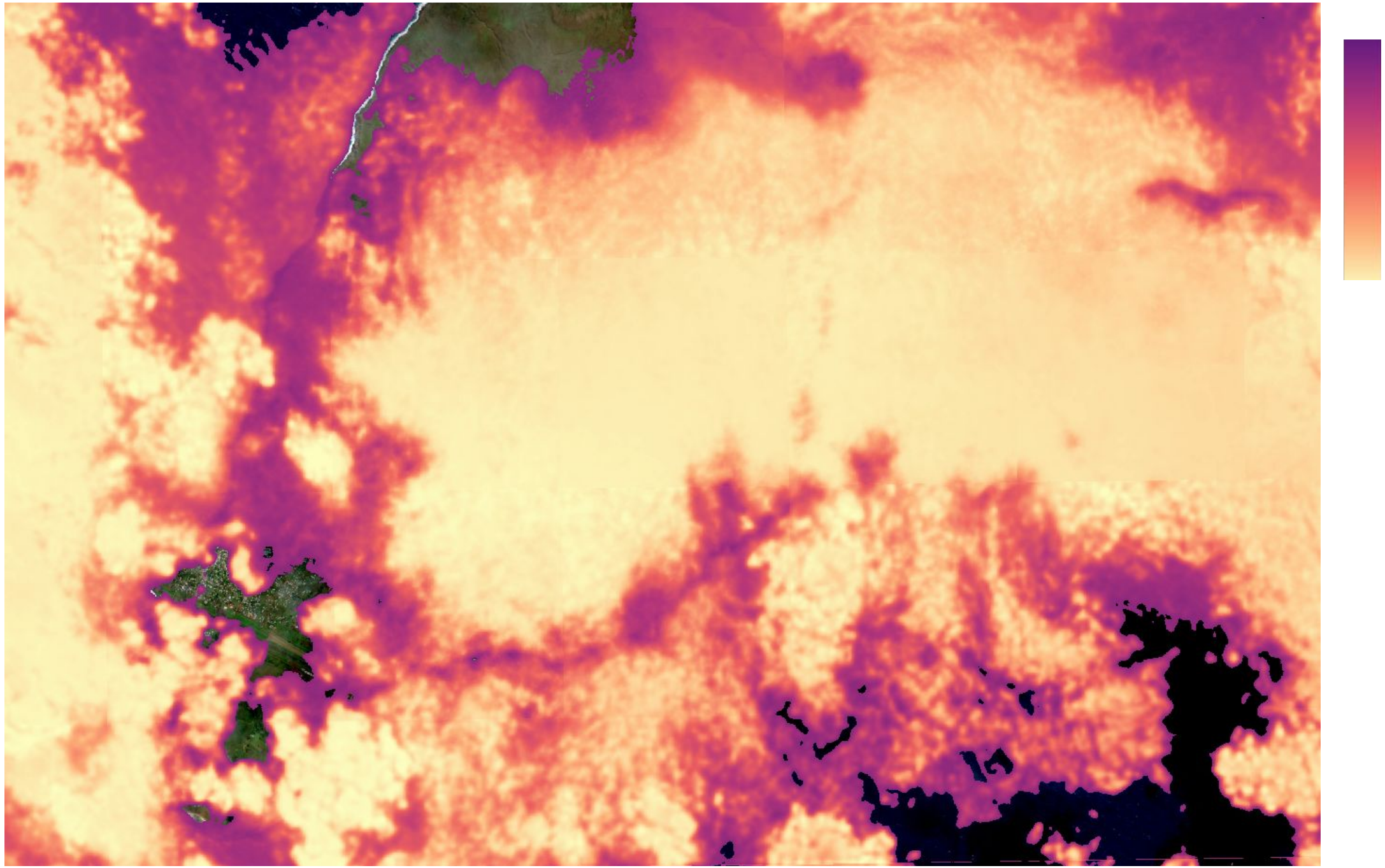


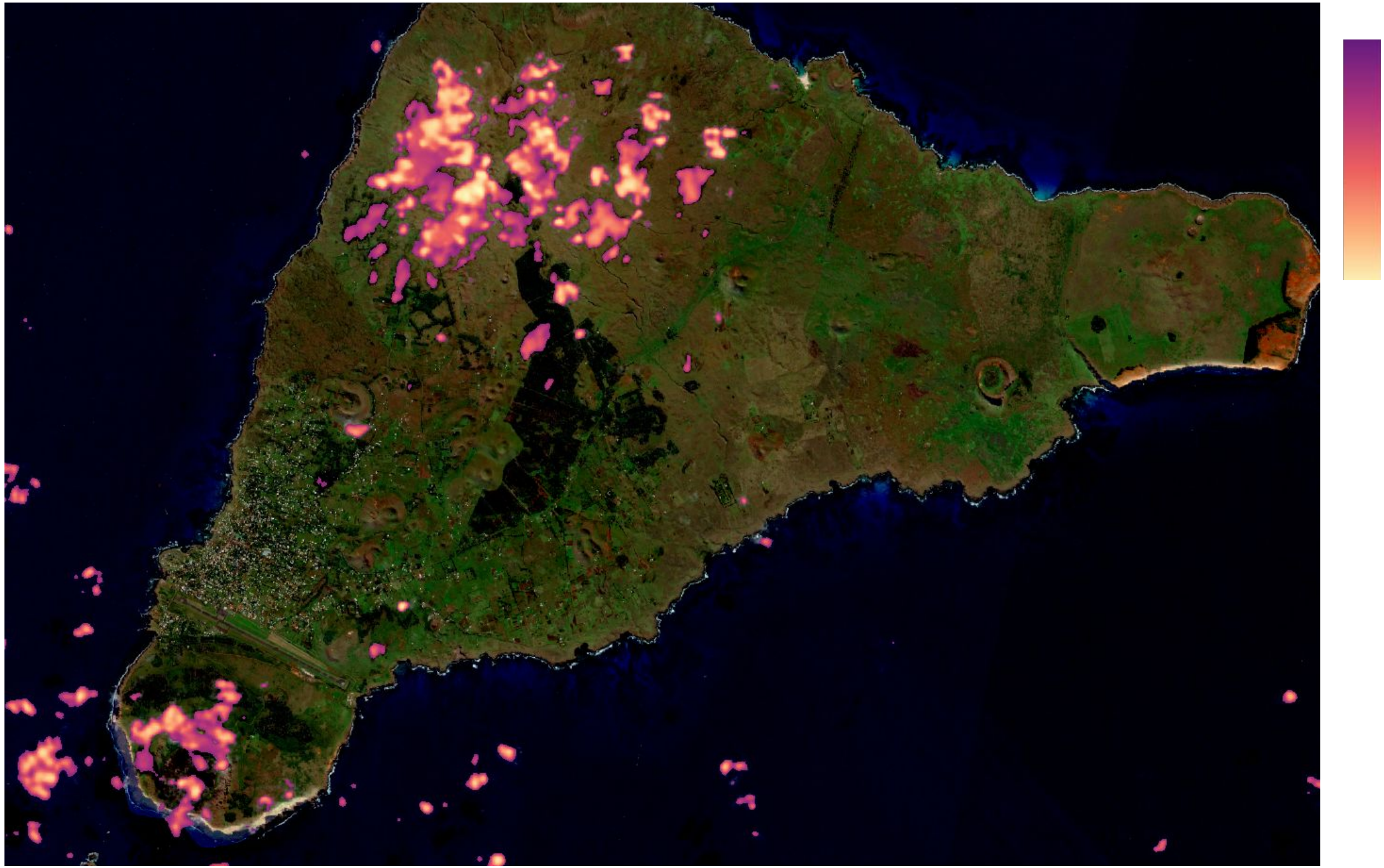


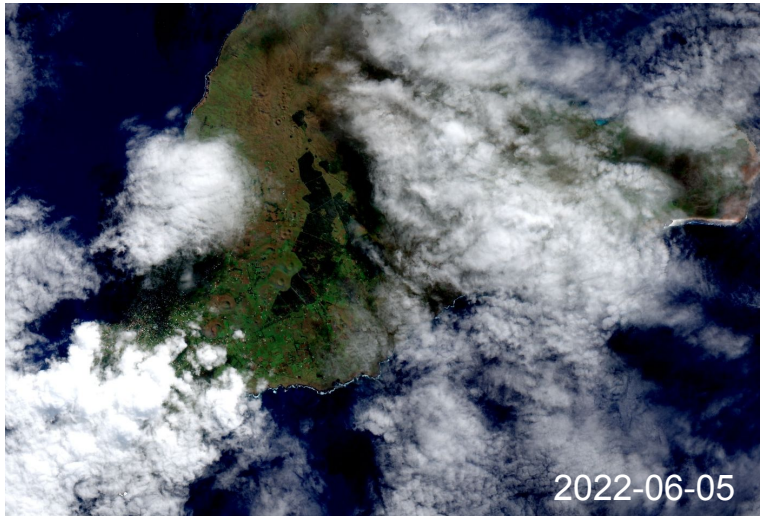








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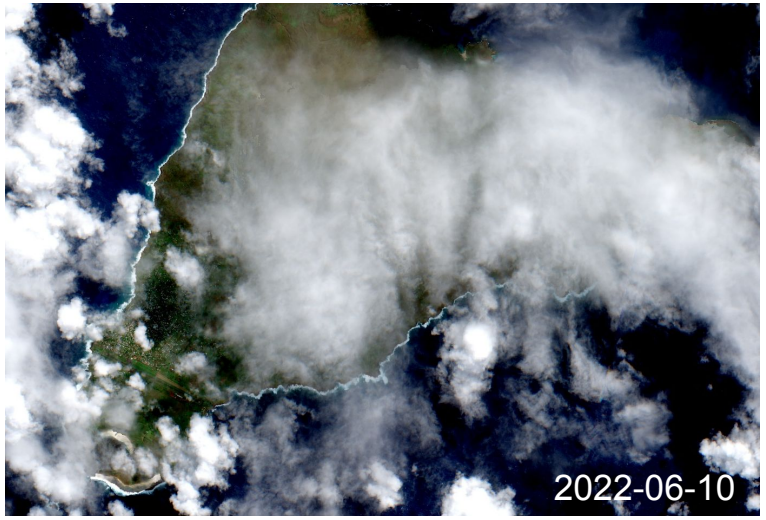
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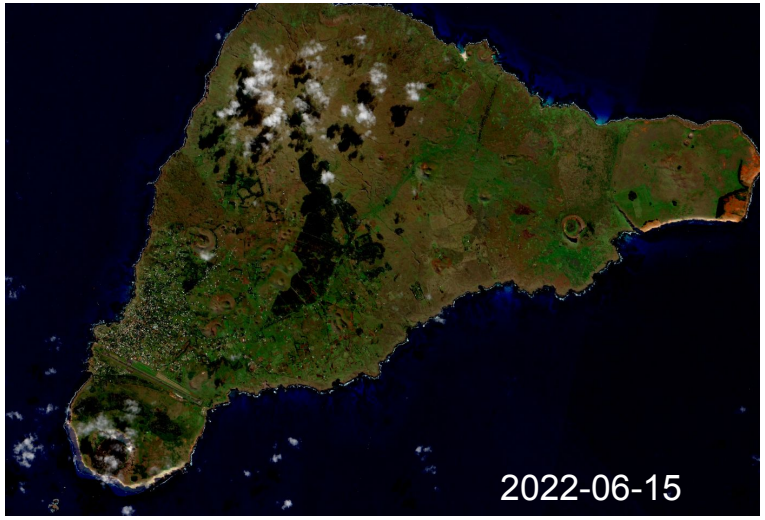
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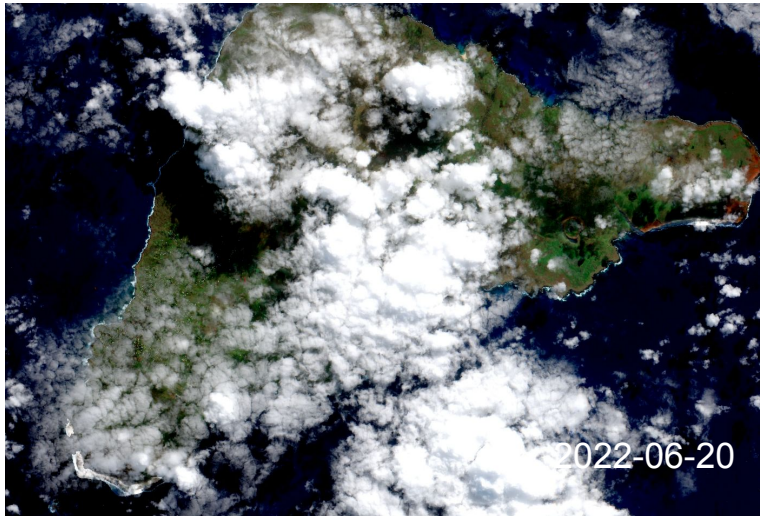
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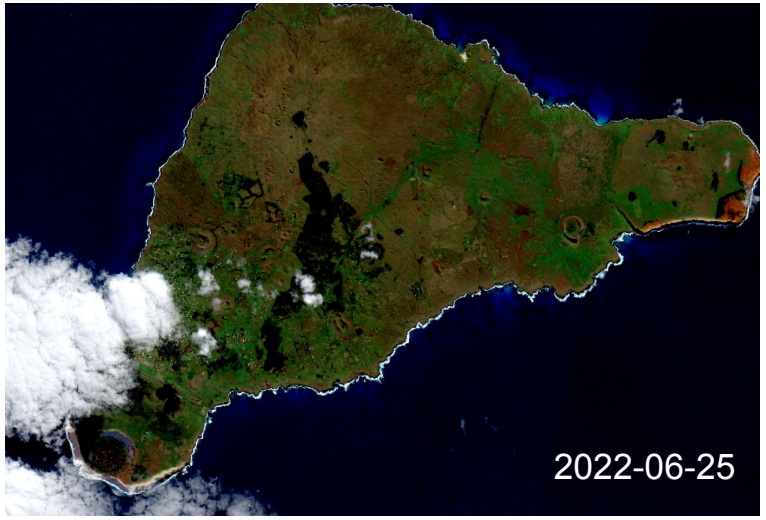
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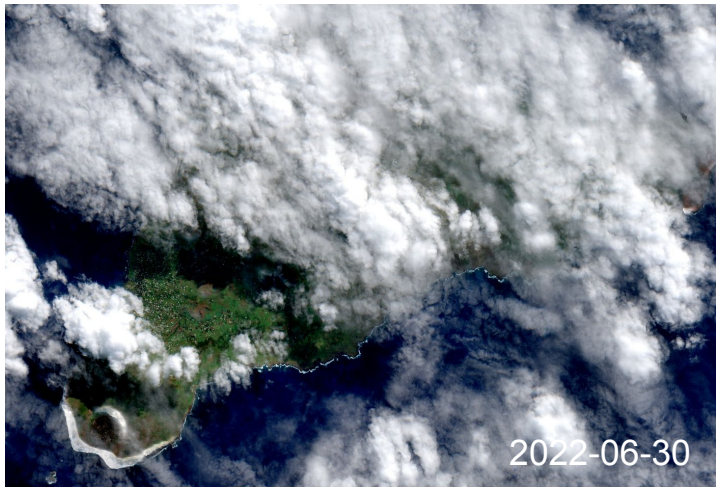
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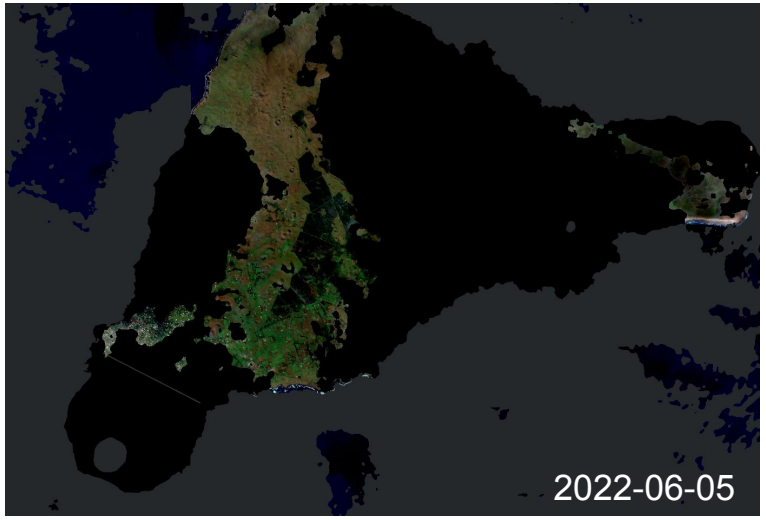
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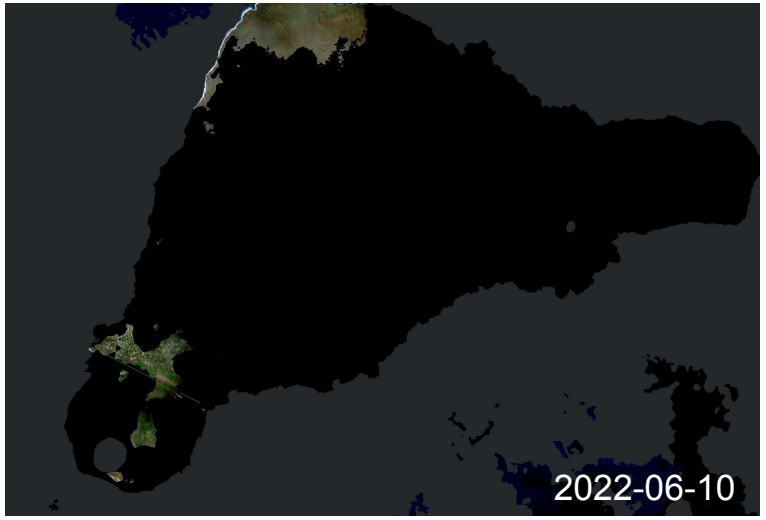
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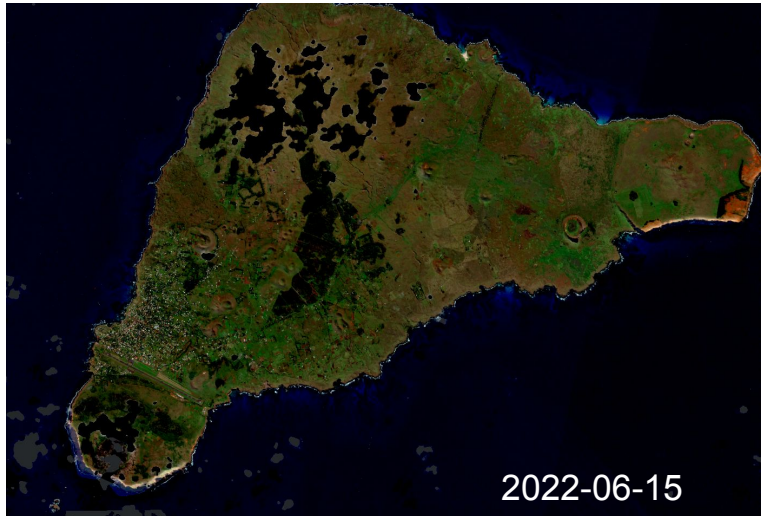
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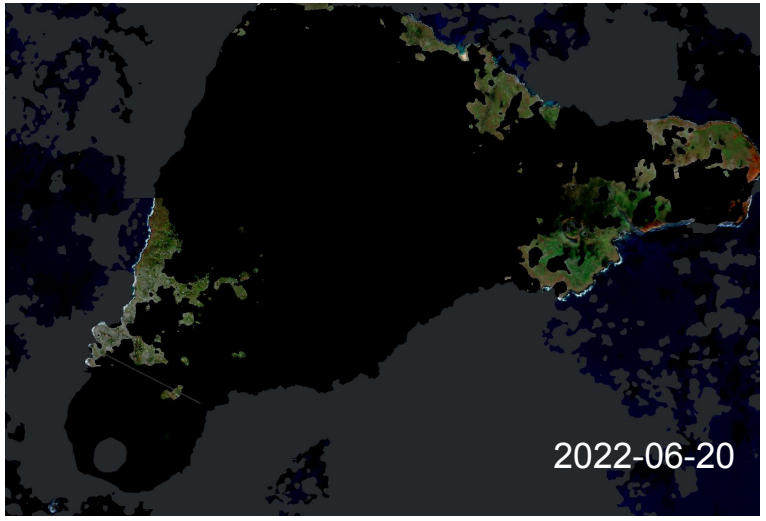
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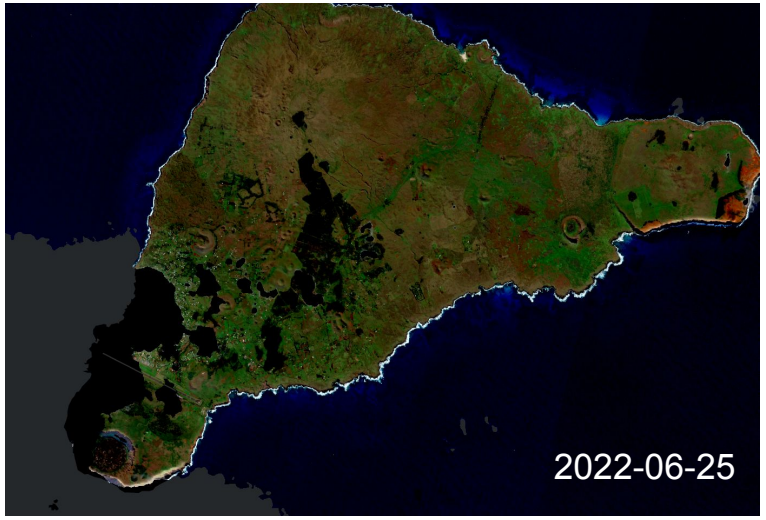
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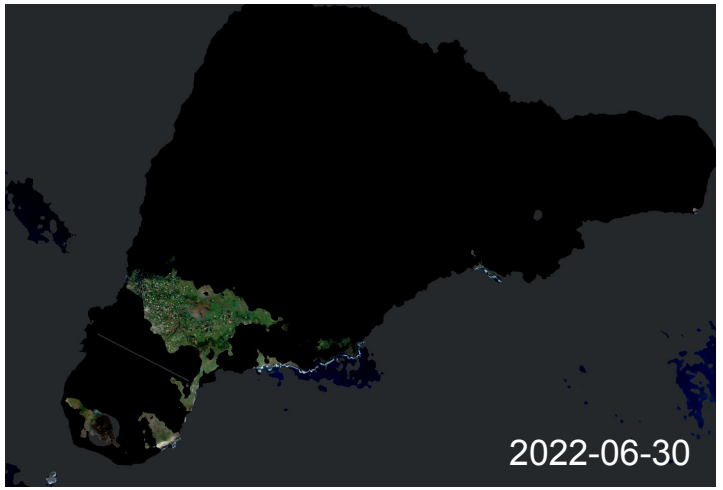
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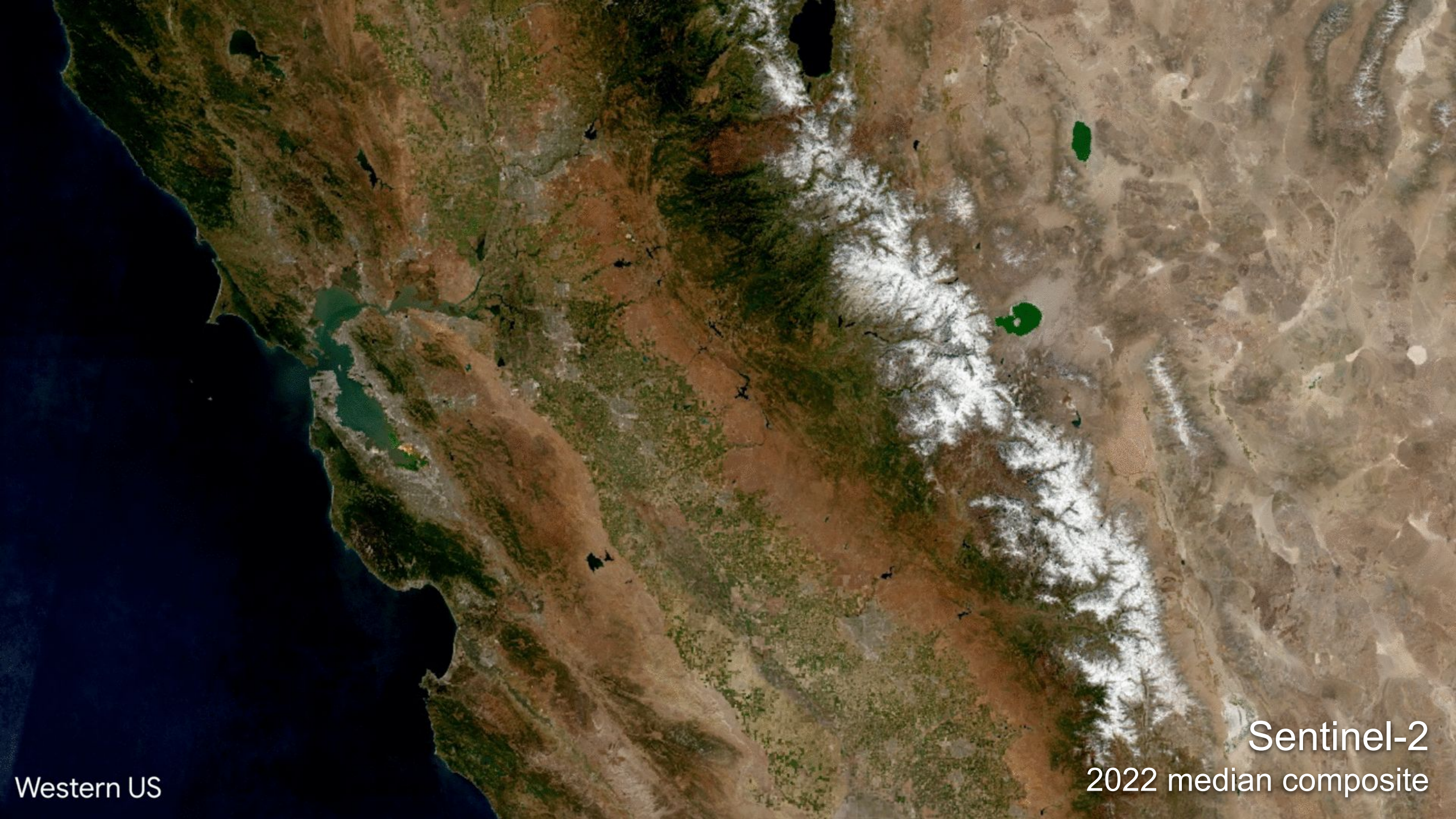
30-day median
composite
June 2022


Western US
Sentinel-2
2022 median composite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Earth Engine Google Developer Experts


Aaron Zuspan


Abena Boatemaa Asare-Ansah


Africa Flores


Alvaro Moreno


Andréa Puzzi Nicolau


Biplov Bhandari


Craig Dsouza


Daniel Wiell


David Montero Loaiza


Eliana Lima de Fonseca


Emil Cherrington


Emma Izquierdo-Verdiguier


Eric Jensen


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Flávia De Souza Mendes


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Guneet Mutreja


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Keiko Nomura


Kyle Woodward


Liza Goldberg


Luiz Cortinhas


Maria Luize Pinheiro


Mathieu Gravey


Mirza Waleed


Modou Mbaye


Nathaniel Robinson


Olga Danylo


Qiusheng Wu


Sabrina Szeto


Samapriya Roy


Shengbiao Wu


Tim Mayer

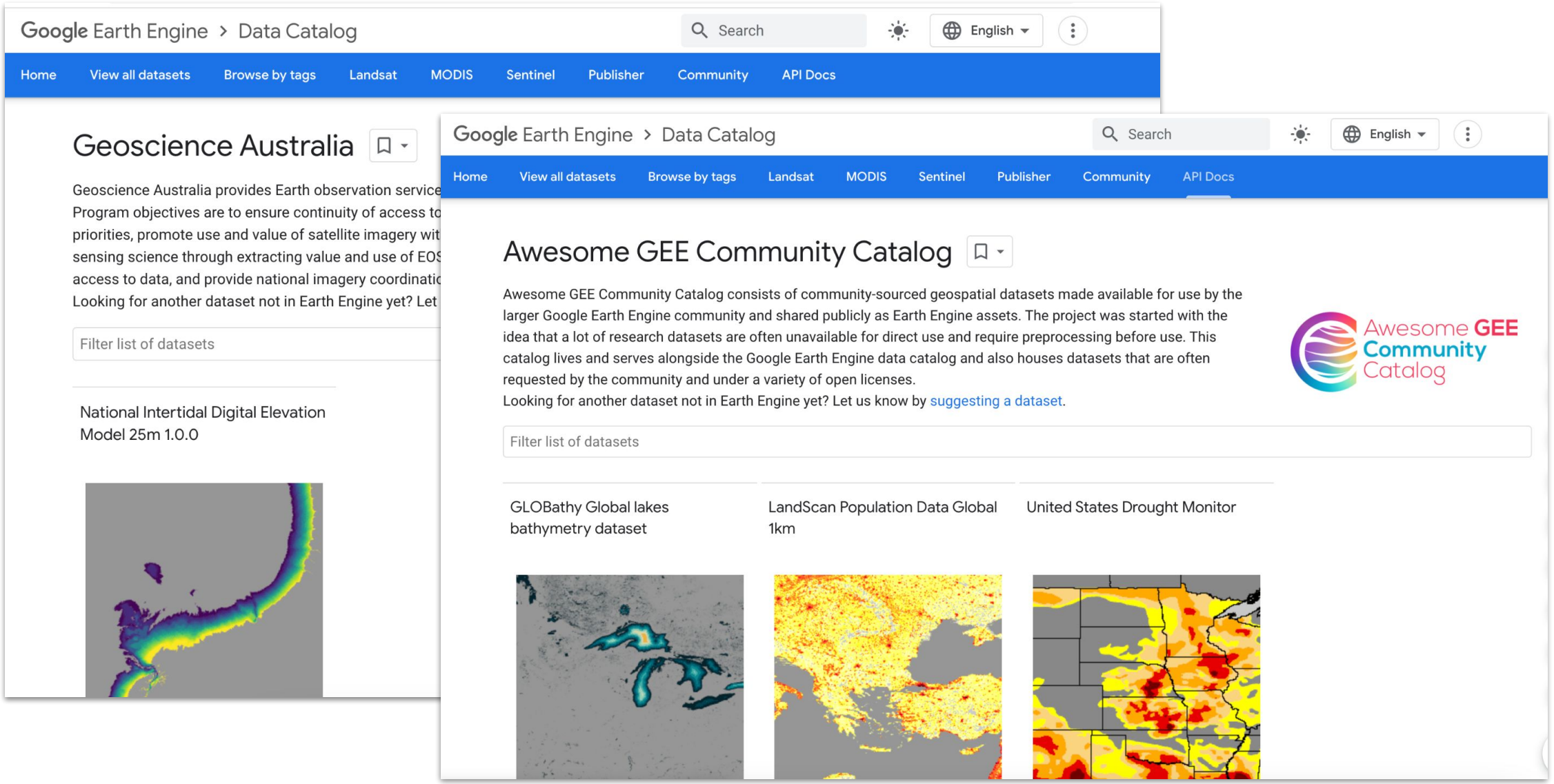

TC Chakraborty


Vivian Ribeiro

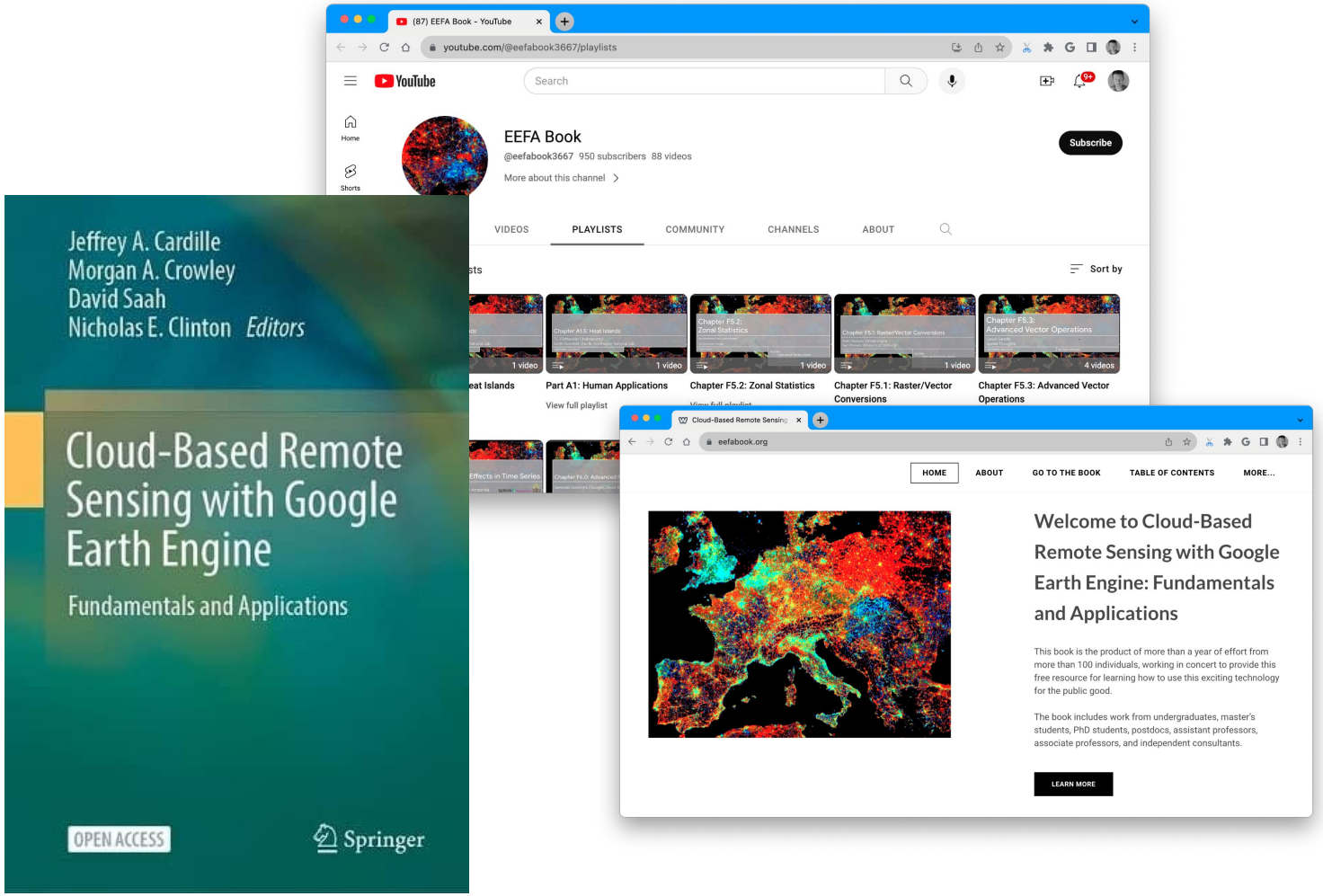

Zander Venter


Ziyu Lin

Preview: Publisher and Community Data Catalogs

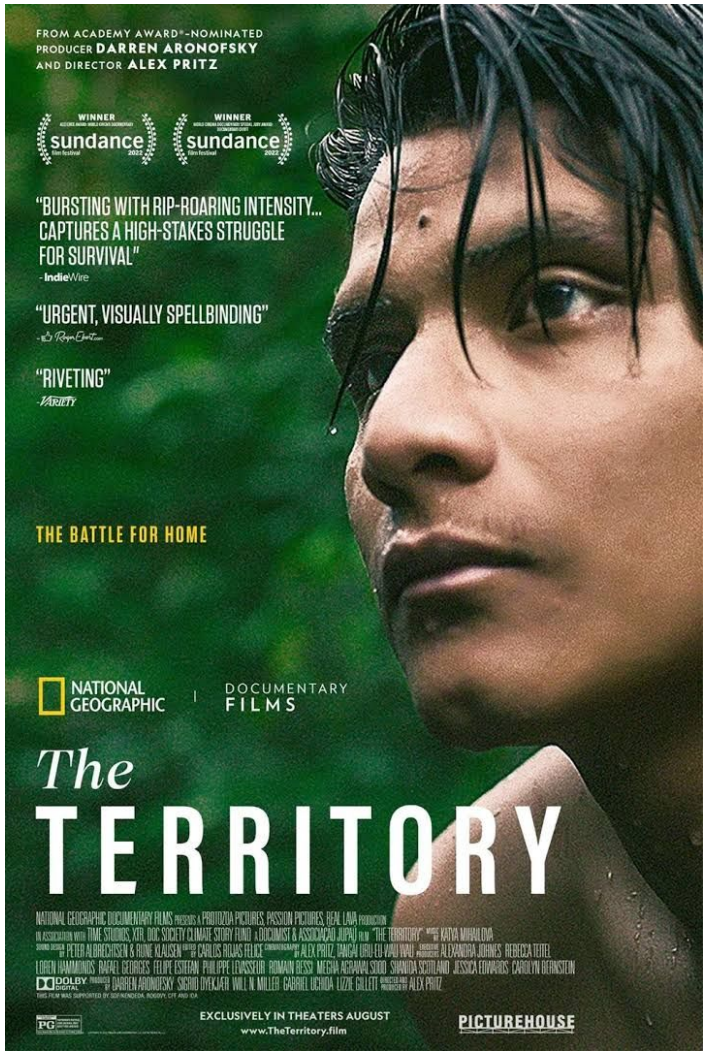


Learning Resources



http://eefa-book.org

The Indigenous **Uru-eu-wau-wau** people use Google Earth as a tool to defend their territory from illegal invasion



Thank you!

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