Satellite image processing in Google Earth Engine cloud platform

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Topics of the presentation

- Introducing Google Earth Engine platform
- Case study of GEE / forest plantation mapping in Tanzania

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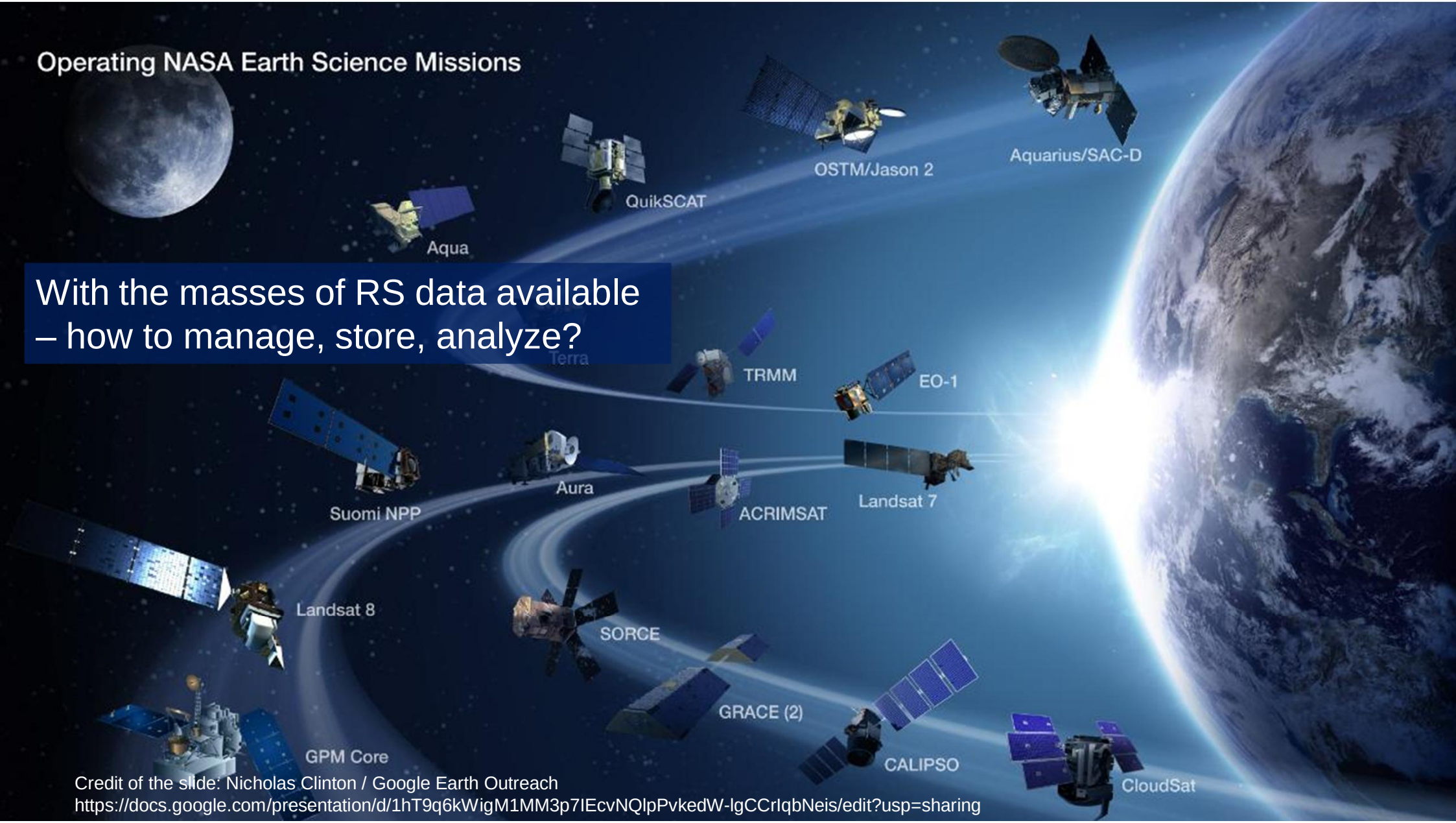

Credit of the slide: Nicholas Clinton / Google Earth Outreach
https://docs.google.com/presentation/d/1hT9q6kWigM1MM3p7IEcvNQlpPvkedW-lgCCrIqbNeis/edit?usp=sharing

Goodchild et al. (2012):

PNAS

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.**"

Credit of the slide: Nicholas Clinton / Google Earth Outreach
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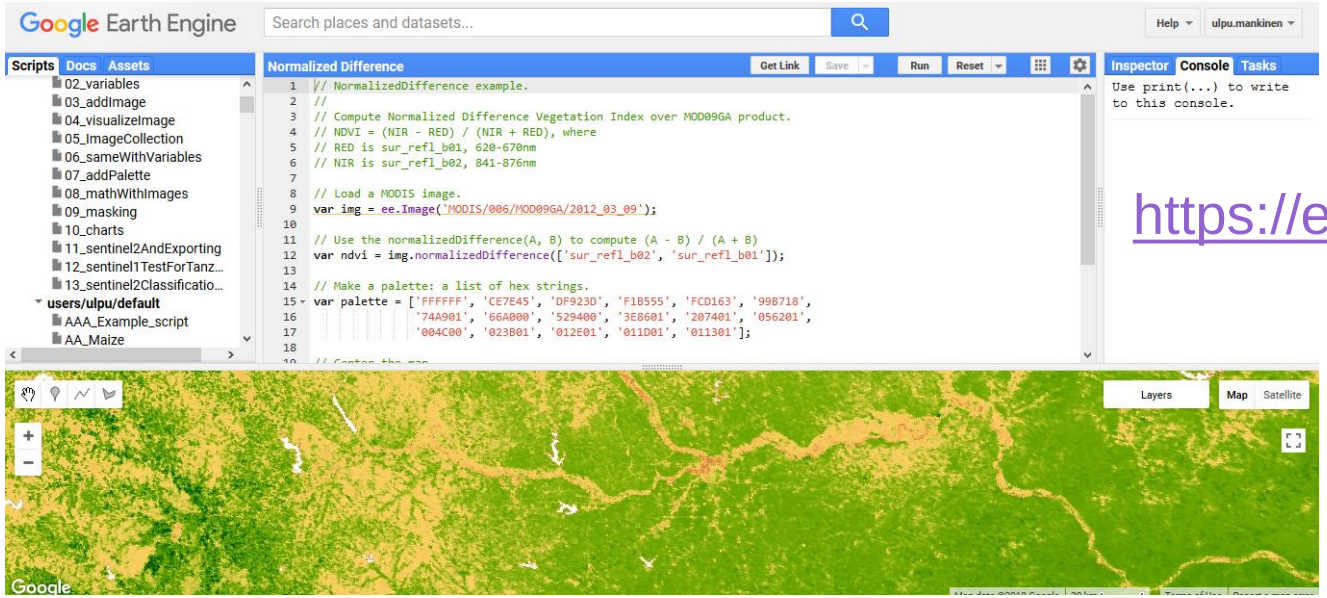
Google Earth Engine (GEE)

- A planetary-scale platform for Earth science that allows users to run geospatial analysis on data which is readily in Google's infrastructure



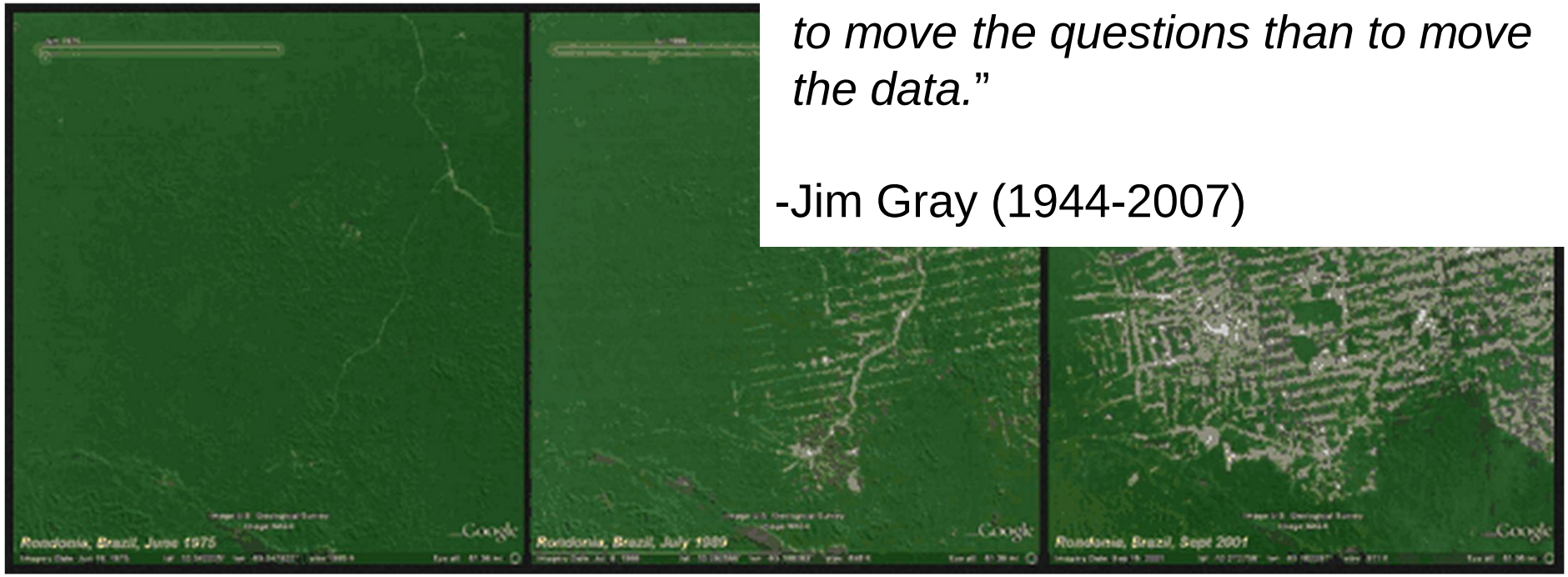
https://earthengine.google.com/

Google Earth Engine

What started with Google Earth was taken further..

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

-Jim Gray (1944-2007)



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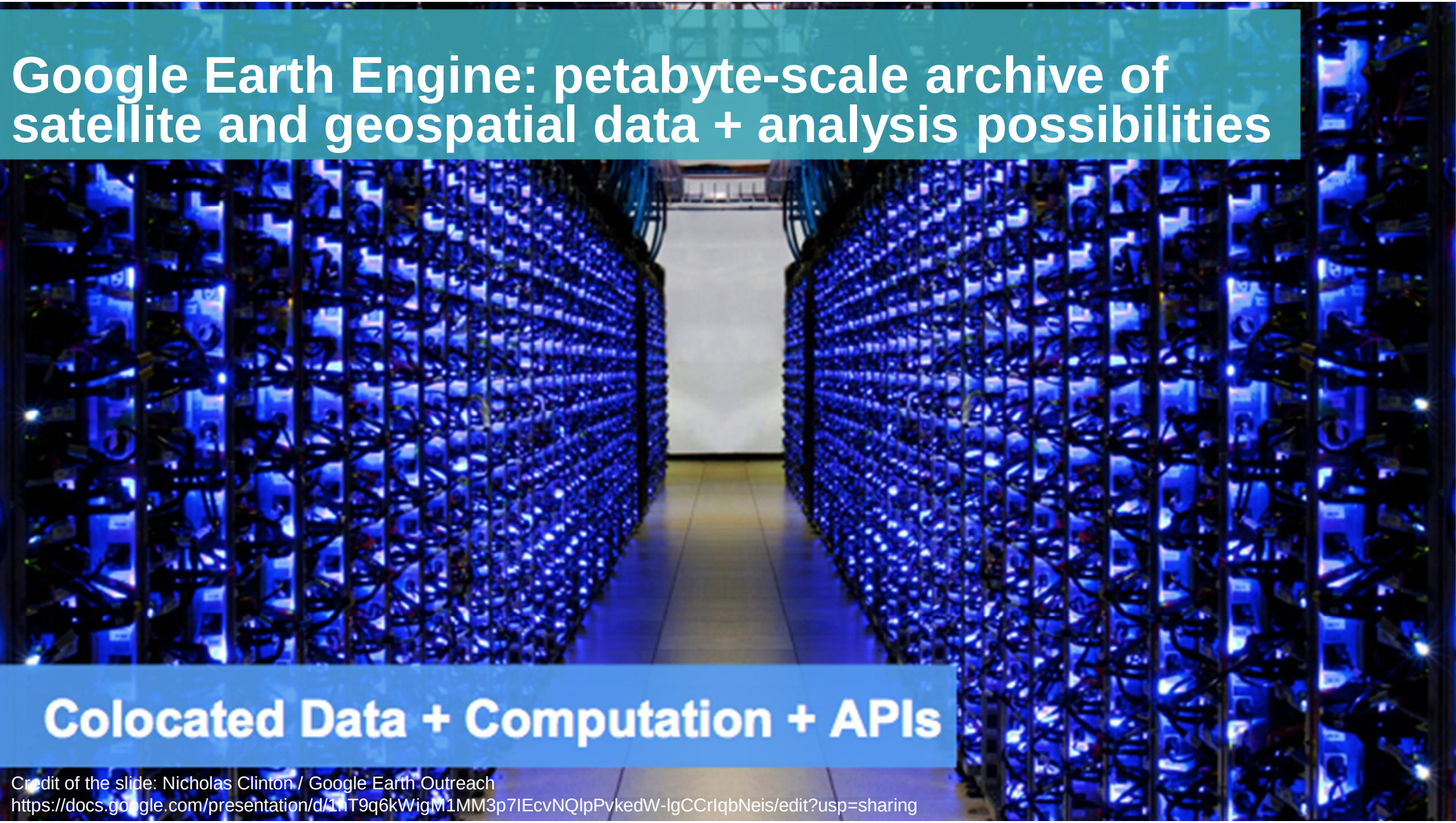
Google Earth Engine: petabyte-scale archive of satellite and geospatial data + analysis possibilities



Credit of the slide: Nicholas Clinton / Google Earth Outreach
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The Earth Engine Public Data Catalog

https://developers.google.com/earth-engine/datasets/

Landsat and Sentinel
Raw, TOA, SR, ...

MODIS
Daily, NBAR, LST, ...

Terrain
SRTM, GTOPO, NED, ...

Land Cover
GlobCover, NLCD, ...

Atmospheric
NOAA NCEP, OMI, ...

... and many more, updating daily!

> 200 public datasets

> 5 million images

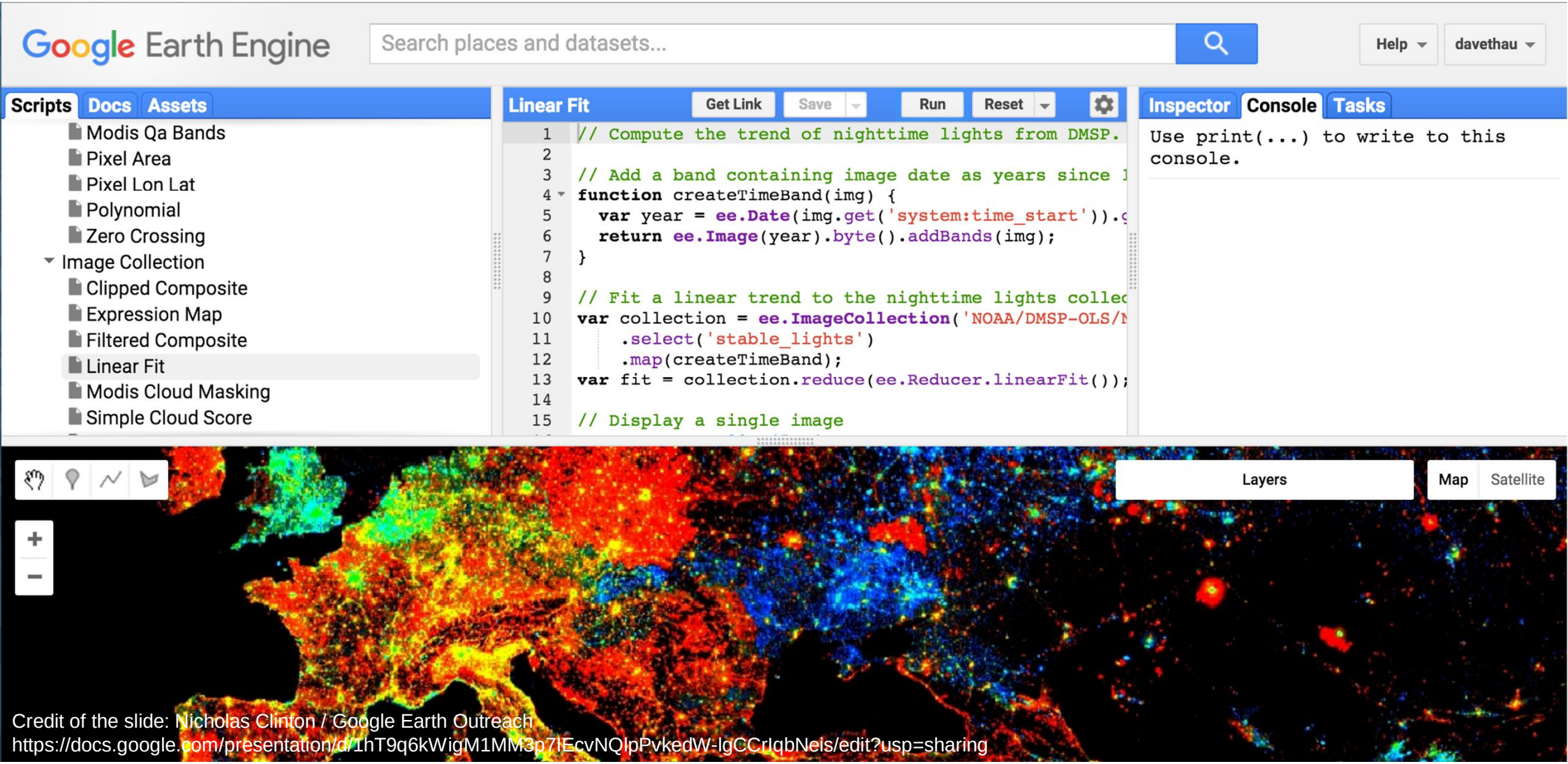
> 4000 new images every day

> 5 petabytes of data

Credit of the slide: Nicholas Clinton / Google Earth Outreach
https://docs.google.com/presentation/d/1hT9q6kWigM1MM3p7IEcvNQlpPvkedW-lgCCrIqbNeis/edit?usp=sharing

Online IDE (JavaScript)

https://code.earthengine.google.com/



Credit of the slide: Nicholas Clinton / Google Earth Outreach
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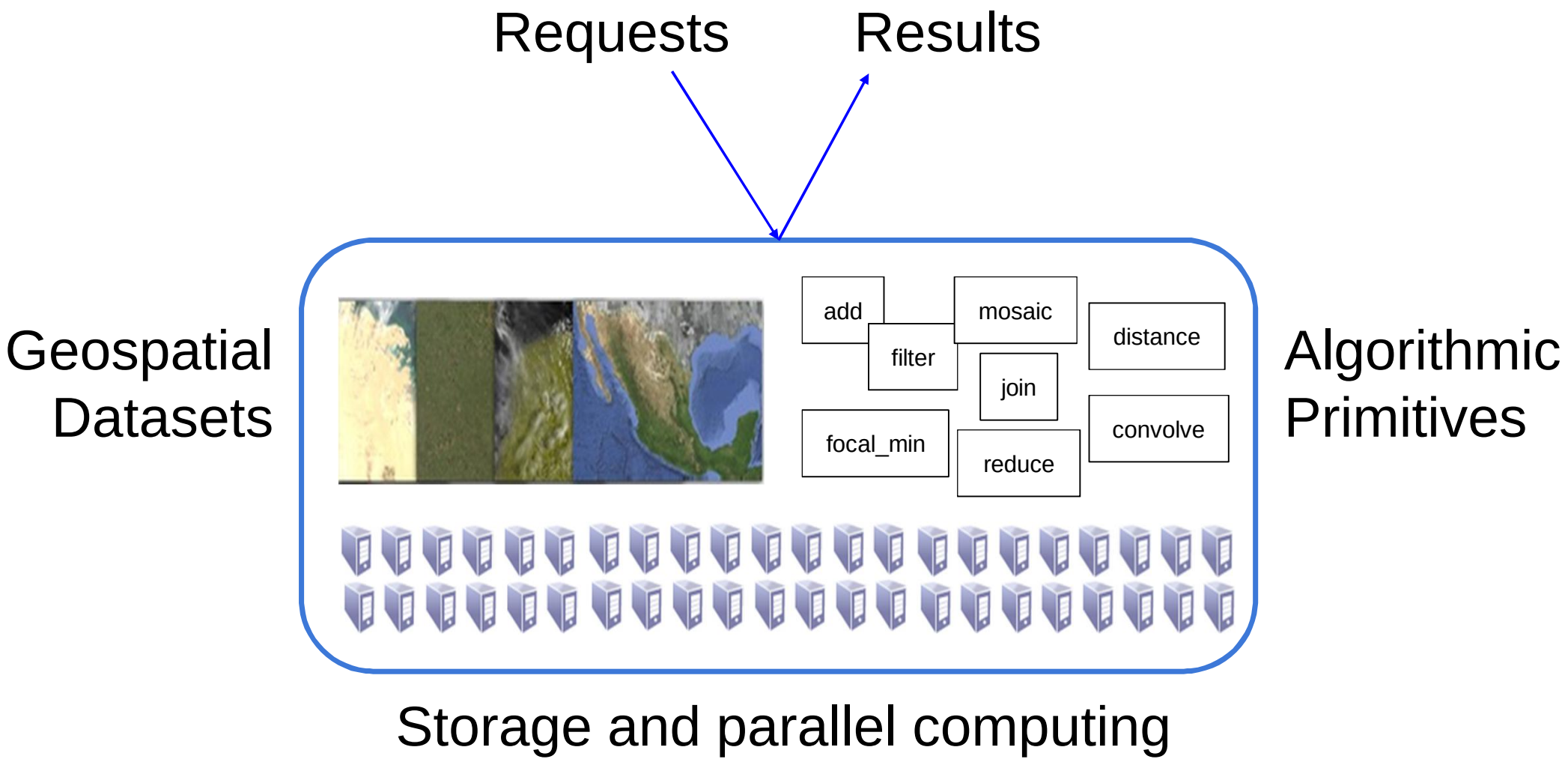

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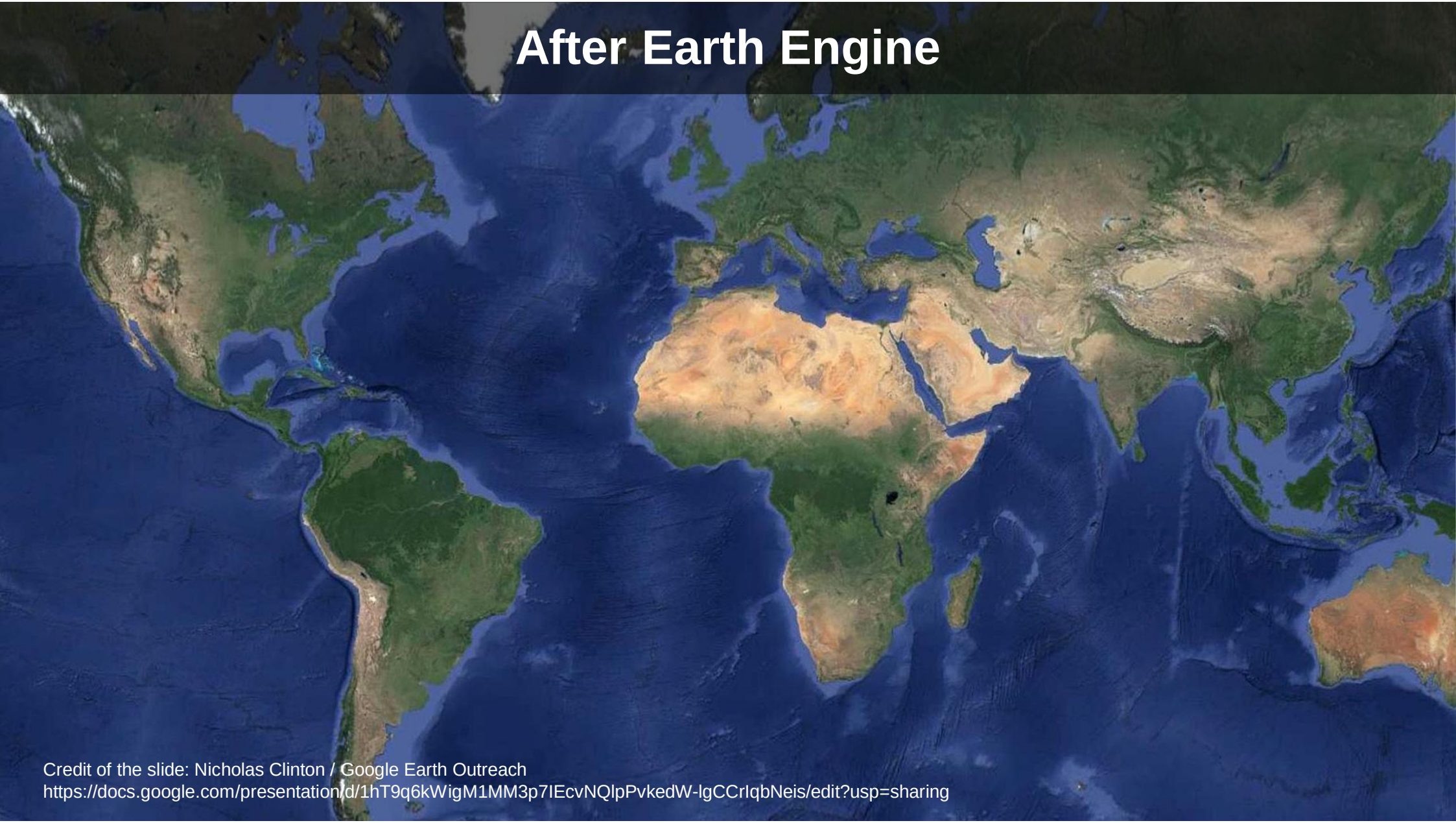
After Earth Engine



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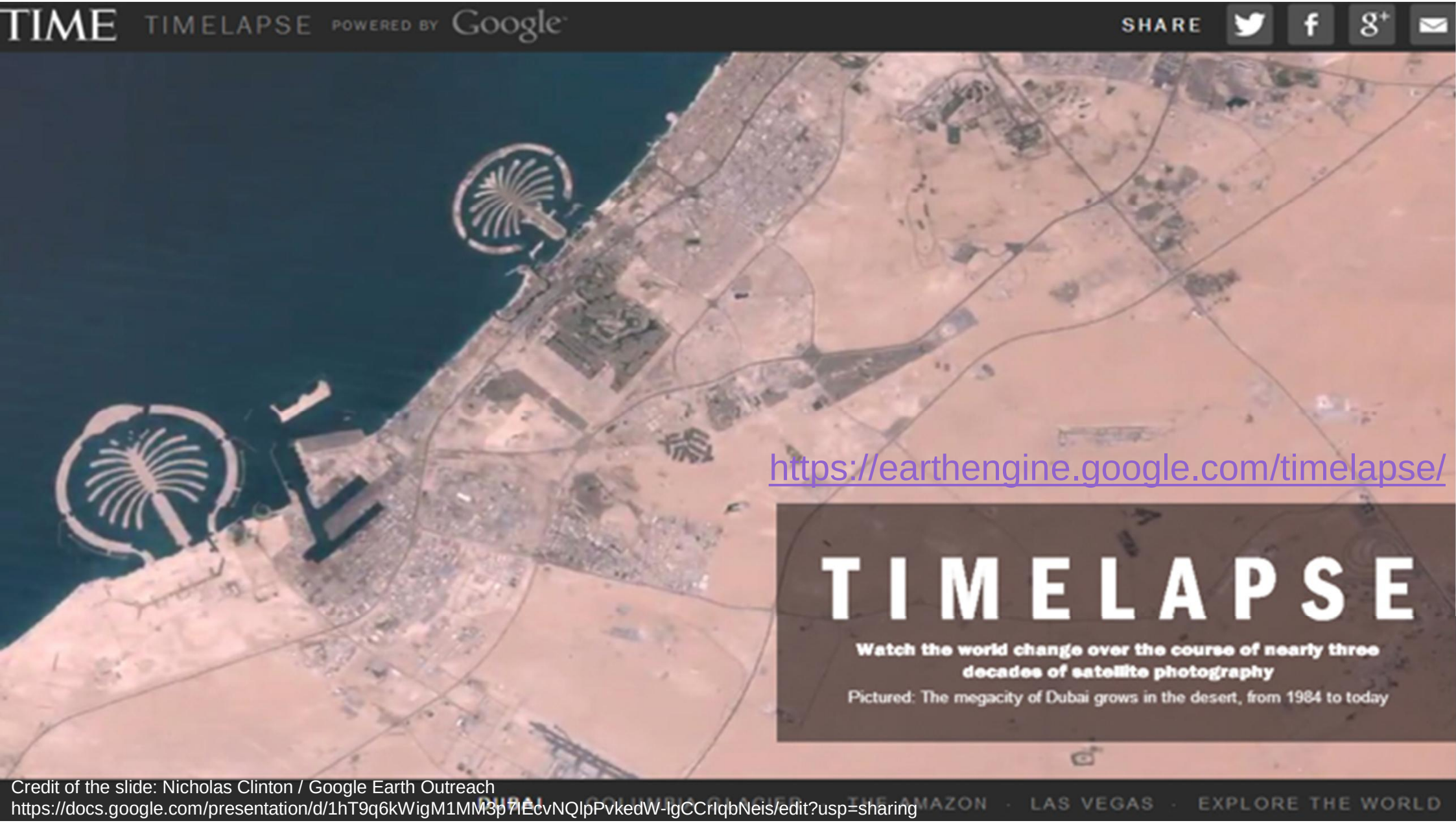

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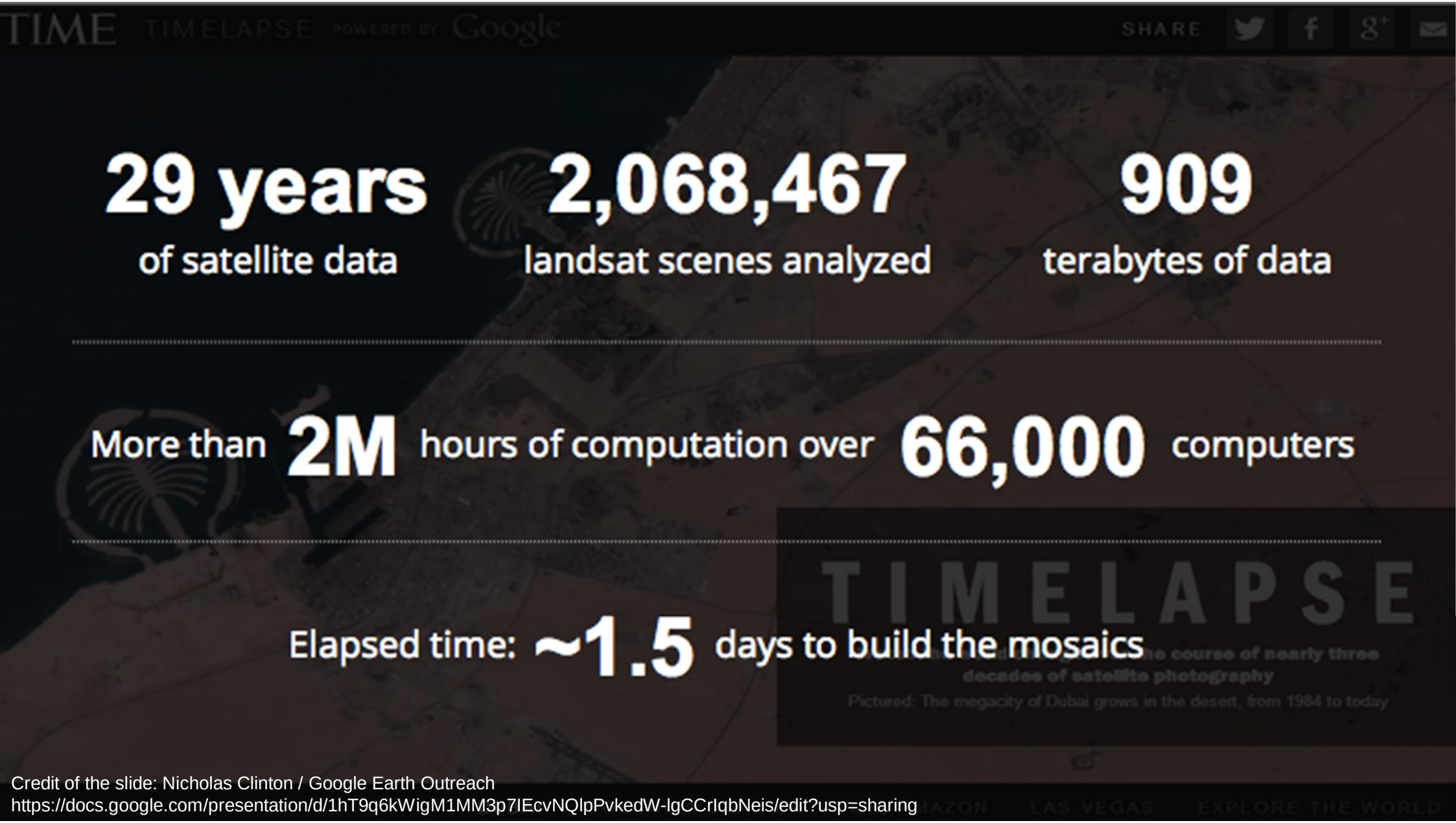

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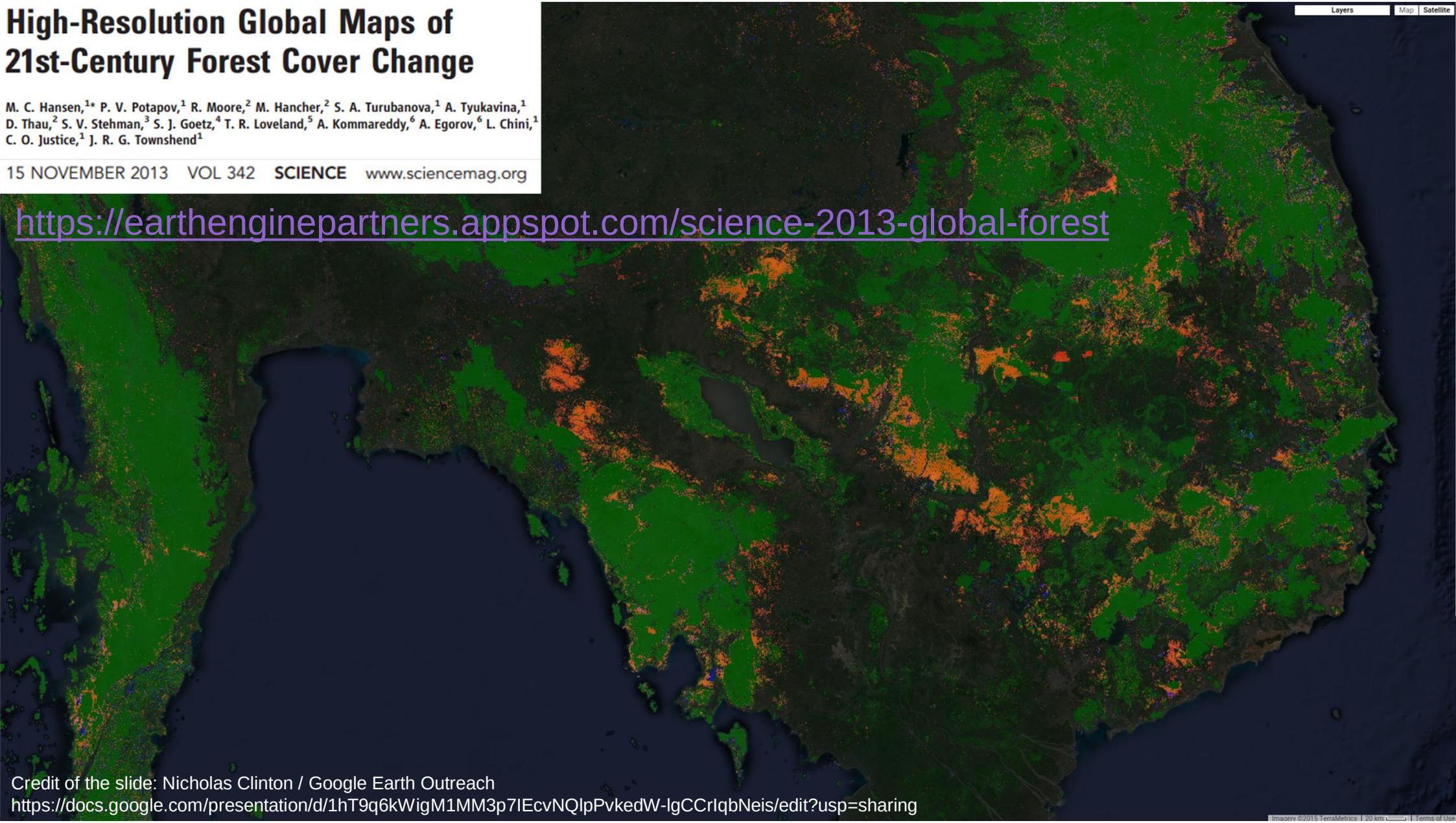
High-Resolution Global Maps of 21st-Century Forest Cover Change

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

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



Credit of the slide: Nicholas Clinton / Google Earth Outreach
https://docs.google.com/presentation/d/1hT9q6kWigM1MM3p7IEcvNQlpPvkedW-lgCCrIqbNeis/edit?usp=sharing

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

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

doi:10.1038/nature20584

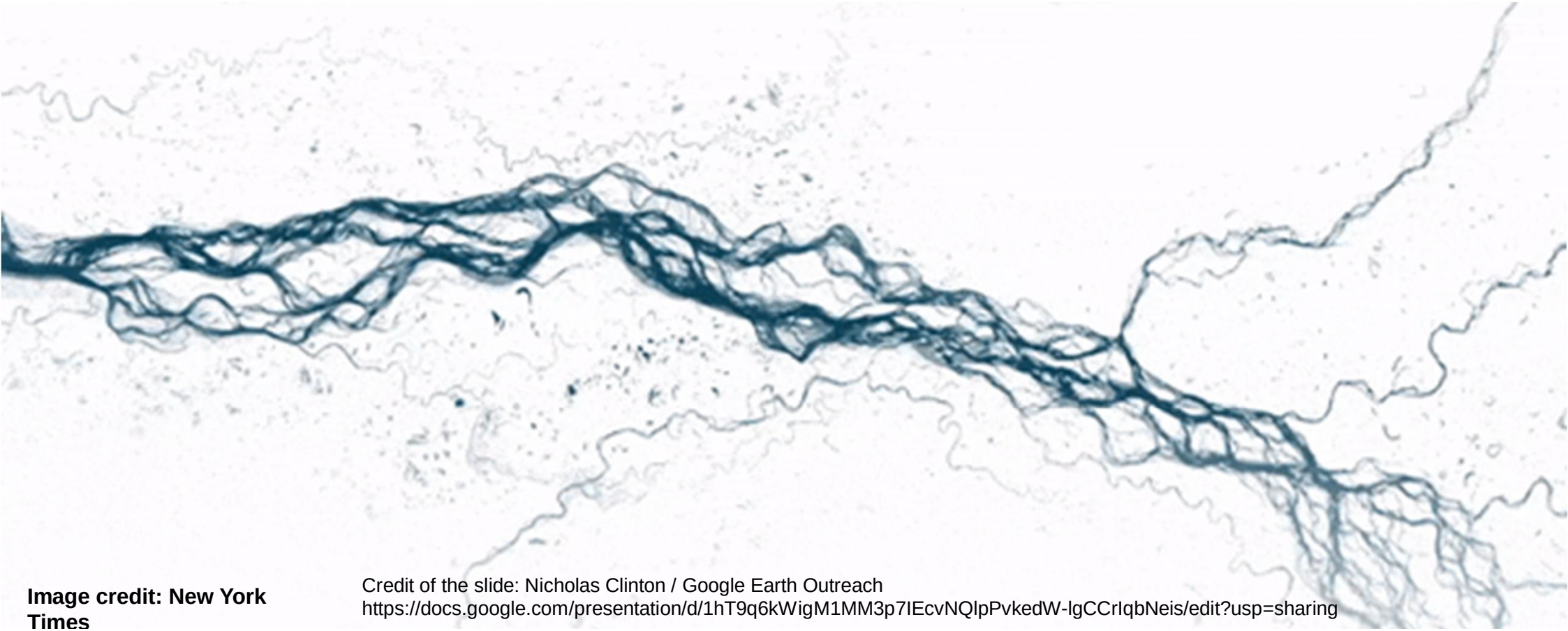


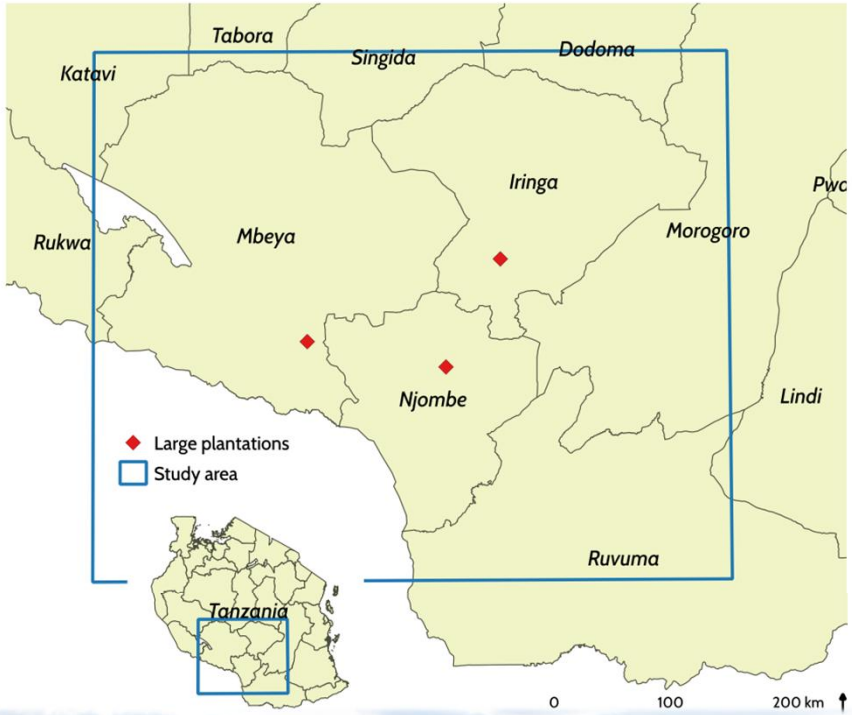
Image credit: New York Times

Credit of the slide: Nicholas Clinton / Google Earth Outreach
https://docs.google.com/presentation/d/1hT9q6kWigM1MM3p7IEcvNQlpPvkedW-lgCCrIqbNeis/edit?usp=sharing

FAO/University of Turku case study with GEE:

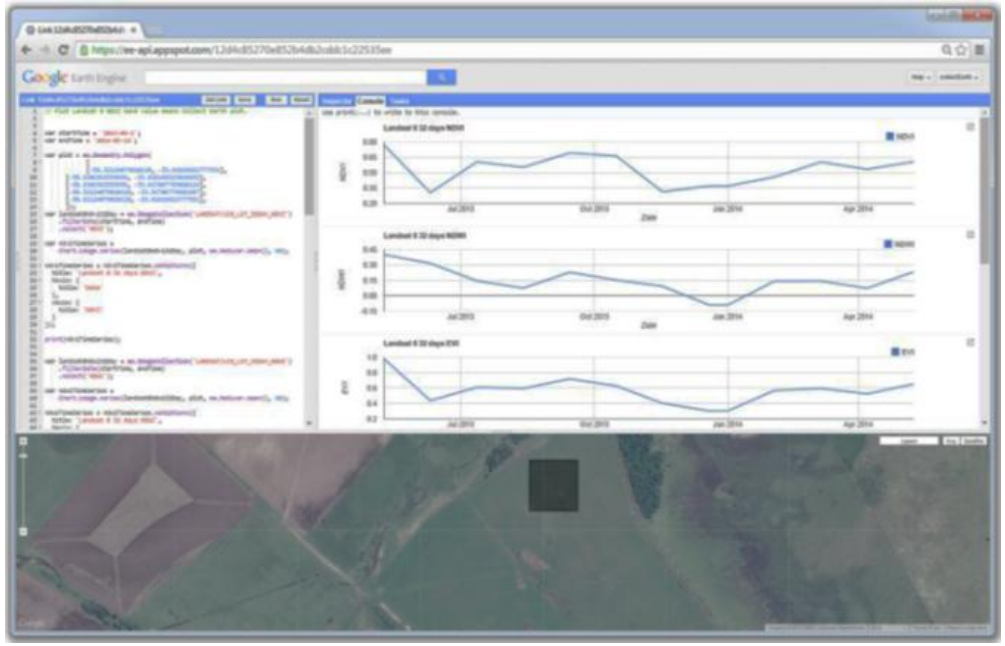
Mapping forest plantations in Southern Tanzania using Google Earth Engine

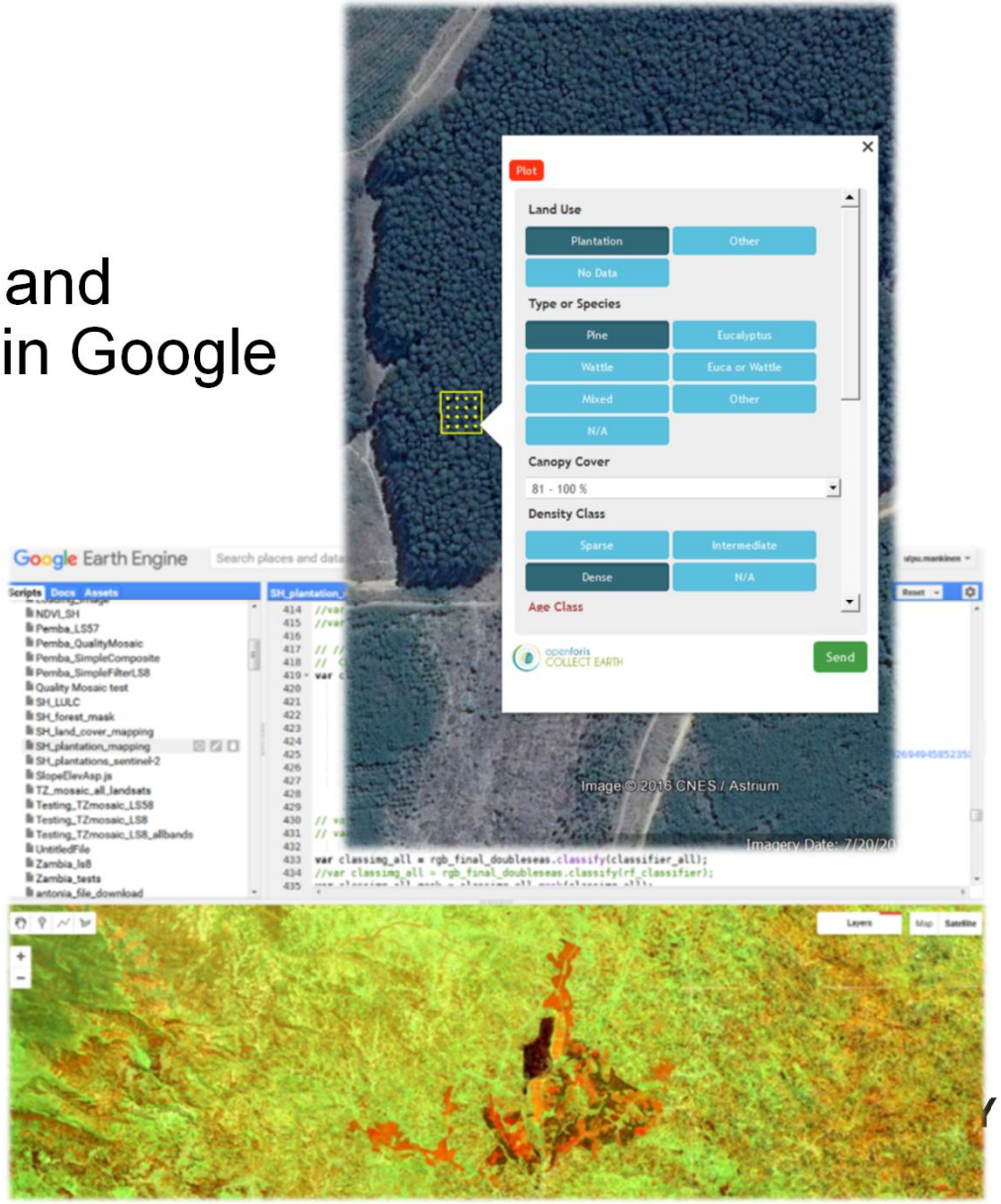
- Most important wood production area in Tanzania; extremely cloudy
- Study area approx. 200,000km2
- Existing forest plantation baseline has not been known outside the large industrial-scale plantations
  - Potential of the smallholder owned plantations?



Mapping methodology

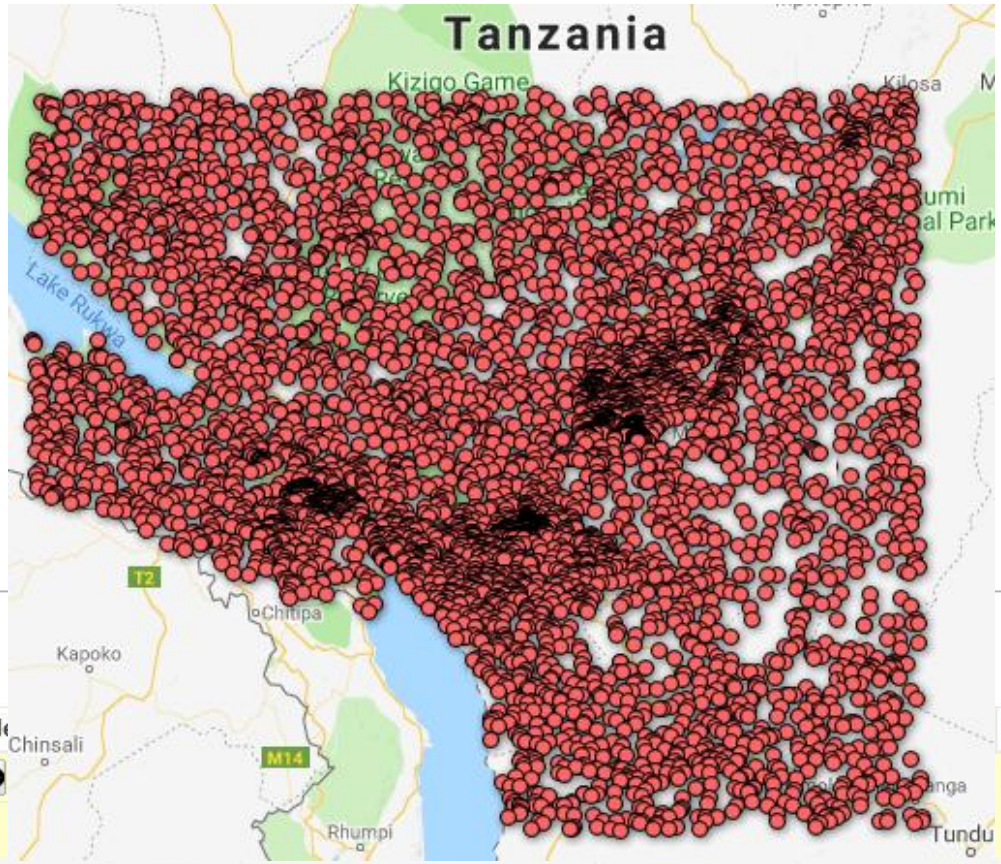
- Reference data collection from high and medium resolution satellite imagery in Google Earth, Bing Maps and Earth Engine
  - Participation of 20 Tanzanian experts





Mapping methodology

- Reference data taken into GEE as a fusion table
  - Possibility to upload shp added since



File Edit Tools Help | Rows 1 | Cards 1 | Map of geometry

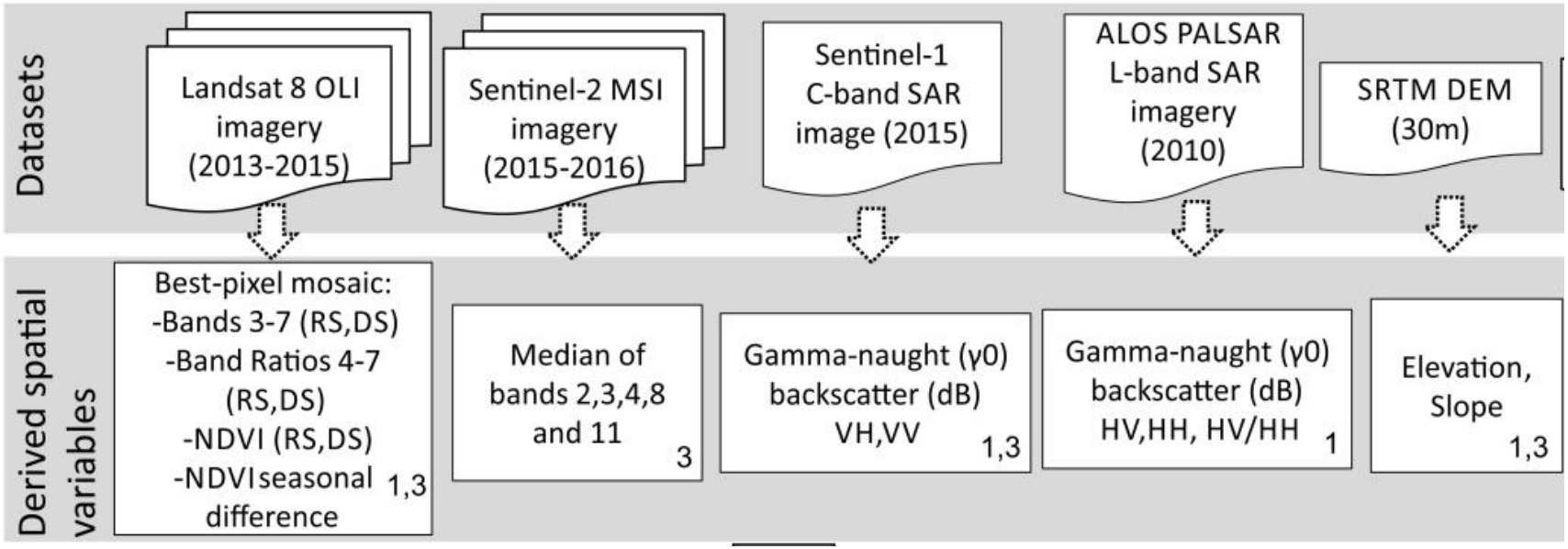
Filter | No filters applied

1-100 of 6866

id	location_x	location_y	land_use	land_use_type	accuracy	location_srs	ele						
1	35.7485079192657	-8.08642824189543	plantation	wattle	true	EPSG:4326							
2	36.2826381896034	-9.14462112083547	other	bushland	true	EPSG:4326	713	0.13104...	0.300...	open_bushland	not_available		
3	33.725180007788	-9.02761856543711	other	forest	true	EPSG:4326	2467	0.06657...	4.374...	montane_forest	not_available	81_100	
5	34.7795635011952	-10.2942392523658	other	bushland	true	EPSG:4326	877	0.05567...	2.330...	dense_bushland	dry_bushland		
7	35.3939629665148	-8.60096738668217	other	grassland	true	EPSG:4326	1777	0.02297...	2.633...	not_available	not_available		
8	36.3264461231359	-7.11149764656447	other	bushland	true	EPSG:4326	1072	0.28044...	3.696...	open_bushland	dry_bushland		
11	34.6541258778505	-7.7414067529533	other	woodland	true	EPSG:4326	965	0.02201...	1.277...	closed_woodland	deciduous_woo...		

Mapping methodology

- Collected data used as training data in classification of satellite imagery (natural forest / planted forest / other land cover)
  - Different classifiers and input combinations tested with validation data



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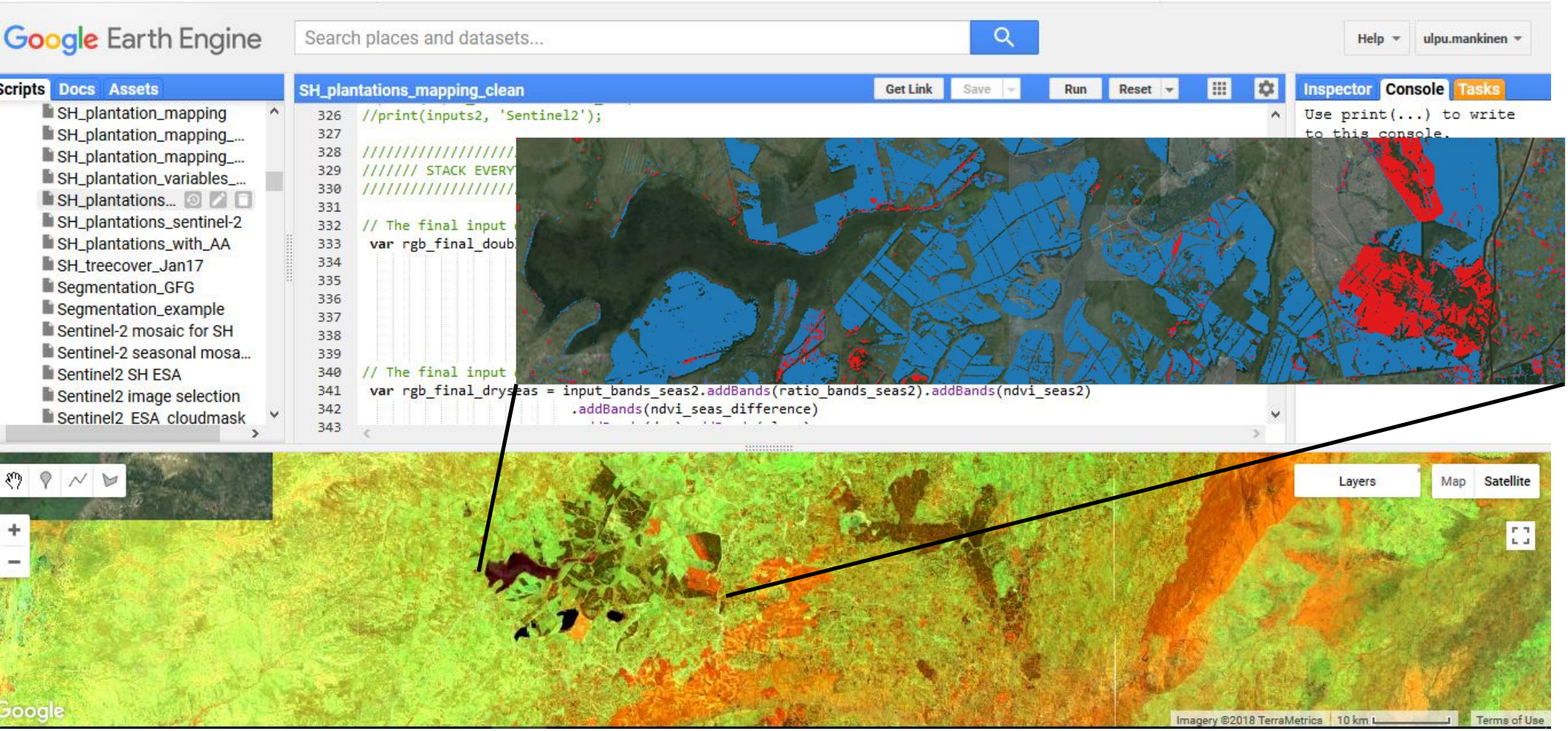

https://github.com/utu-tanzania/sh-plantations

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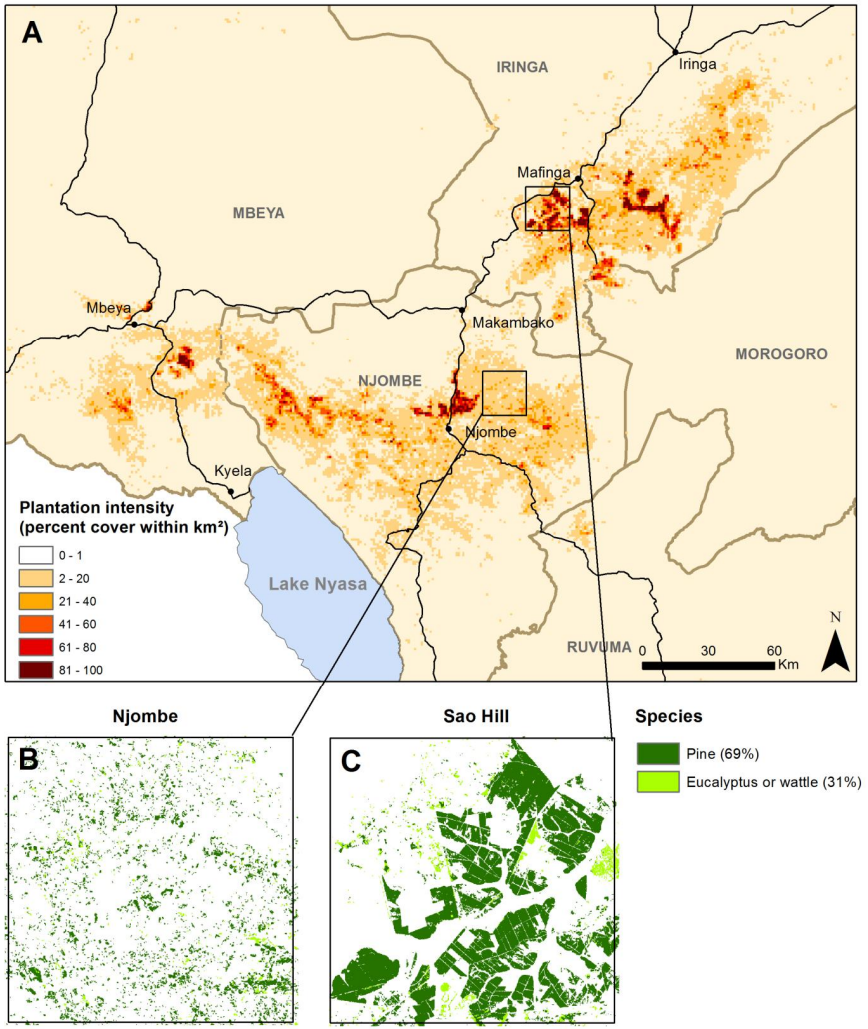
Some results

- Combining optical and radar satellite data and Random Forest classifier provided the best result
  - Data sets used: Landsat-8, Sentinel-1, Sentinel-2 and SRTM elevation & slope
- Overall accuracy 85±2%

	Forest plantation	Forest	Other	Total	Map area (ha)	Estimated area (ha)	User's accuracy	Producer's accuracy
Forest plantation	0.0075	0.0006	0.0008	0.0089	180011	239842 ± 87023	0.84 ± 0.07	0.96 ± 0.04
Forest	0.0044	0.3399	0.1100	0.4542	9200524	7132229 ± 425063	0.75 ± 0.04	0.95 ± 0.02
Other	0	0.0116	0.5252	0.5369	10874033	12882496 ± 420410	0.98 ± 0.01	0.76 ± 0.04
Total	0.0118	0.3521	0.6360	1	20254568			
Overall Accuracy	0.85 ± 0.02							



Source: Koskinen et al., in review at the ISPRS Journal of Photogrammetry and Remote Sensing

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On the experience of using GEE..

- Extremely powerful for large area satellite image processing
  - Access to a huge amount of data; currently one of the most significant **free** satellite image repositories in the world
- Computing in the cloud gives freedom
  - Creation of cloud-free composites for very cloudy regions, multi-temporal and multi-sensor analysis etc.
  - Repeatability and testing without limitations (almost!)
- Constantly updating (data and ready algorithms)
- JavaScript IDE
  - Control over the code; you know what happens behind the hood (ideally)
  - Not all algorithms/functionalities/processed data sets available; limitations for a beginner in coding
  - For example scrutinizing the results was difficult; leads to data transfer between different software
- Highly recommended especially if your study area is outside Finland

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Google is responding to the geospatial big data paradigm

Google Earth Outreach

Google's mission:

"To organize the world's information and make it universally accessible and useful."

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

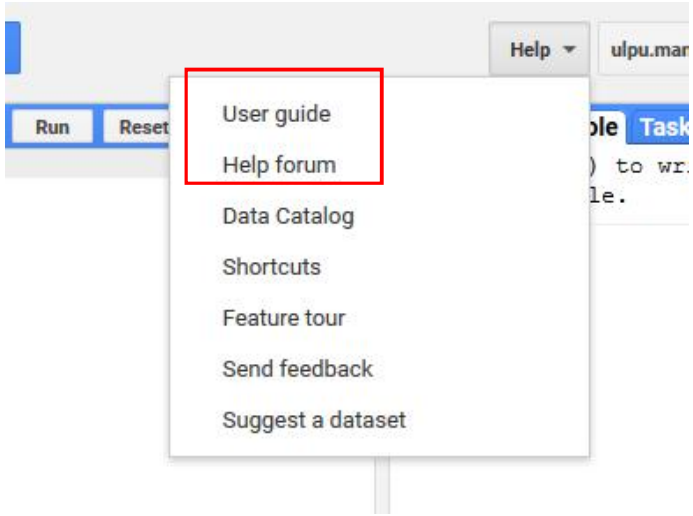
-Jim Gray (1944-2007)

https://earthengine.google.com/

To become a user

- earthengine.google.com/signup
  - The sign up means you request a **trusted tester access** to all the features of the API
  - Google account is needed, because then you can export data and outputs straight in to your Google Drive
- User guide and Help forum extremely useful, start with tutorials
- Basic GEE training at CSC later this year or next, stay tuned!

Google Earth Engine



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Contacts & links

- UTU Tanzania Team
  - Tanzania.utu.fi
  - Facebook: UTU Tanzania Team, @ututanzania
- Google Earth Engine
  - https://earthengine.google.com
  - https://code.earthengine.google.com/
- Forest plantation mapping results from the Southern Highlands, Tanzania
  - Participatory mapping of forest plantations with Open Foris and Google Earth Engine (Koskinen, J, Leinonen, U, Vollrath, A, Ortmann, A, Pekkarinen, A, & Käyhkö N, in review at the ISPRS Journal of Photogrammetry and Remote Sensing)
  - Data will become available at the time of publication at https://doi.pangaea.de/10.1594/PANGAEA.894892

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Thanks for your attention!

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