

Forest Monitoring, Reporting and Verification: Update on Google Initiatives

Rebecca Moore, Google





Who are we?

google.org - Technology-Driven Philanthropy.

Goal: Use Google's strengths in information and technology to address global challenges.



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Technology-Driven Philanthropy

Google.org uses Google's strengths in information and technology to build products and advocate for policies that address global challenges.

Google Flu Trends

Google Flu Trends uses aggregated Google search data to estimate flu activity in near real-time in 20 countries.

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Google PowerMeter

Google PowerMeter is a home energy monitoring tool that gives you the information you need to use less electricity and save money.

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Helping Chile and Haiti

- Discover information, resources and ways you can help in [Chile](#) and [Haiti](#)
- Use [Chile Person Finder](#) and [Haiti Person Finder](#) to locate loved ones
- Download [mapping data](#) for relief groups use
- See the most recent satellite images of [Haiti](#)

Official Google.org Blog

[Response to China Earthquake](#)

Posted: April 15, 2010

[Powering consumers with information about their energy use](#)

Posted: April 5, 2010

[Liberia: A Country in Transition](#)

Posted: April 2, 2010

[Blog archive](#)

Why Forest Carbon Tracking?

Globally significant and time-sensitive

- Tropical Deforestation accounts for ~14-20% GHG
- REDD protocol under consideration for post-2012 Climate Treaty
- Google.org concerns: Climate change and global poverty alleviation

No existing technology platform

- To implement REDD/FCT operationally at global scale

Google-scale problem

- Requires petabytes of data
- Forest Carbon algorithms are computationally complex
- Image processing algorithms are often parallelizable
- Cloud-computing is a natural solution
- Google Earth already playing a role (visualization)

Many requests to Google

- Scientists, Developing world nations, Multi-lateral institutions, Donors, Policymakers



Current Initiatives

1. Group on Earth Observations [demonstration portal](#)
 - Contribution to GEO Forest Carbon Tracking Task
2. Web-integrated mobile devices
 - Android smartphones + [Open Data Kit](#)
 - In-situ forest carbon measurements and monitoring
3. [Google Earth Engine](#)
 - New technology platform
 - Improve access to earth observation data
 - Provide computational resources for processing at scale
 - Prototype demonstrated at COP15
 - Now designing & building production version



GEO-FCT Demonstration Portal

www.geo-fct.org/national-demonstrators/browser

GROUP ON EARTH OBSERVATIONS | Forest Carbon Tracking Portal

Welcome | Task Organization | FCT Initiative Brochure | About this Portal | Acquisition and Product Browser | National Demonstrators overview | [Browse](#)

Click here for an overview of the information available through the National Demonstrators browser.

Costly: Fly to: [Borneo](#) | [Borneo](#) | [Cambodia](#) | [Guinea](#) | [Mexico](#) | [Tanzania](#) | [Tanzania](#)

Show borders on map

- FCT
- National Demonstrators
- Medium Res Sat Coverage
- ASAR
- CBERS
- COSMO
- LANDSAT
- LANDSAT (NPP)
- PALRSAR
- RADARSAT
- RESOURCESAT
- Sensor Map Products
- In Situ Data

Sep 29, 2009

BOR-1: WUR_E-Kalim/Sabah
BOR-4: WUR_C-Kalim/Sarawak
BOR-2: WUR_SW-Kalimantan
BOR-3: WUR_SE-Kalimantan

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2010 DigitalGlobe

2979 km
23°24'48.60" S 95°04'45.31" E elev -4724 m Eye alt 5000.0

Turn on map query mode

You will see query results here

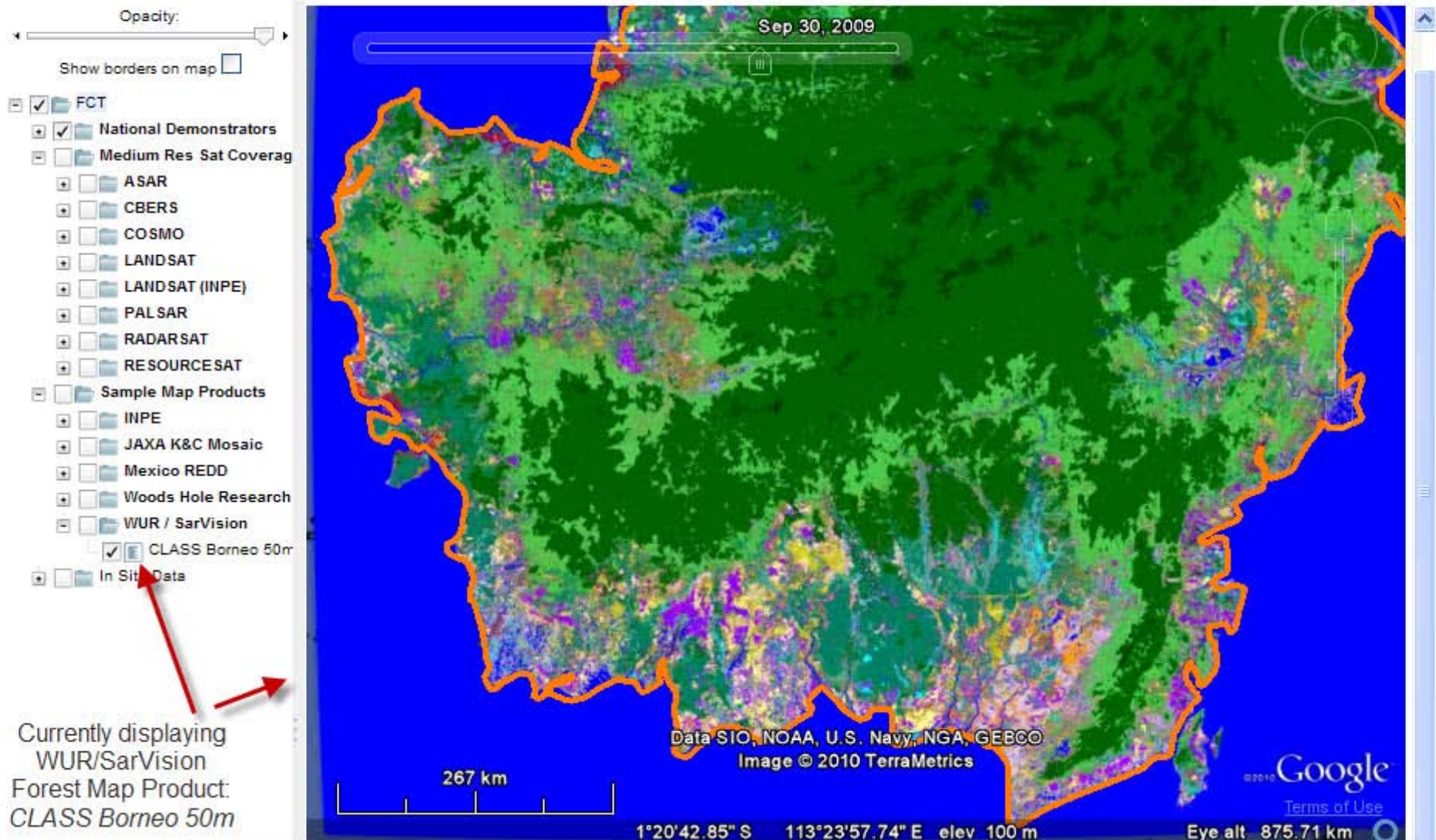
JAXA KBC Mosaic | Mosaic RBD | Mosaic Sampling
INPE PRODES | WUR / SerVision Borneo
WHRD ALOS/PALSAR 50m | WHRC Xingu

JAXA KBC Mosaic 50m
Greenish color allows a forest and purple color allows deforest or non forest area.
[Main JAXA Mosaic page](#)
Additional 2007/2008 views: [2 jobs view](#) | [Banded view](#)

CEOS | JAXA | esa | NASA | USGS | MDA |

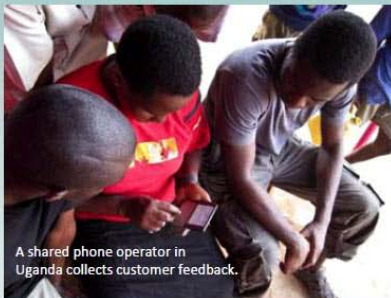
Google™

[Click here for an overview of the information available through the National Demonstrators browser.](#)



Currently displaying
WUR/SarVision
Forest Map Product:
CLASS Borneo 50m

Web-integrated mobile phones for field data collection



A shared phone operator in Uganda collects customer feedback.

Grameen AppLab in Uganda



An HIV counselor scans a patient's demographic information into ODK Collect.

HIV Counselors in Kenya



Surui tribe members in the Amazon monitor the forest with ODK tools.

Forest Monitoring in Brazil

Android/ Open Data Kit for in-situ data collection

In-country capacity-building (to date)

- Tanzania

- Trained >130 people from TZ Forestry and Beekeeping Division (FBD), JGI, local communities (*with UN-FAO*)
- Pilot data collection projects underway with NAFORMA (household surveys) and JGI (Masito Ugalla)

- Colombia

- Trained 75 people from IDEAM, Ministry of Environment, National Parks, NGOs, and local communities
- Potential pilot projects with local communities on Pacific coast, and for CLASlite field validation

- Brazil

- Introductory trainings: 30 people from Brazilian Forest Service, local NGOs and Amazon Surui indigenous tribe
- Pilot community-based carbon project underway with Surui

- Cambodia

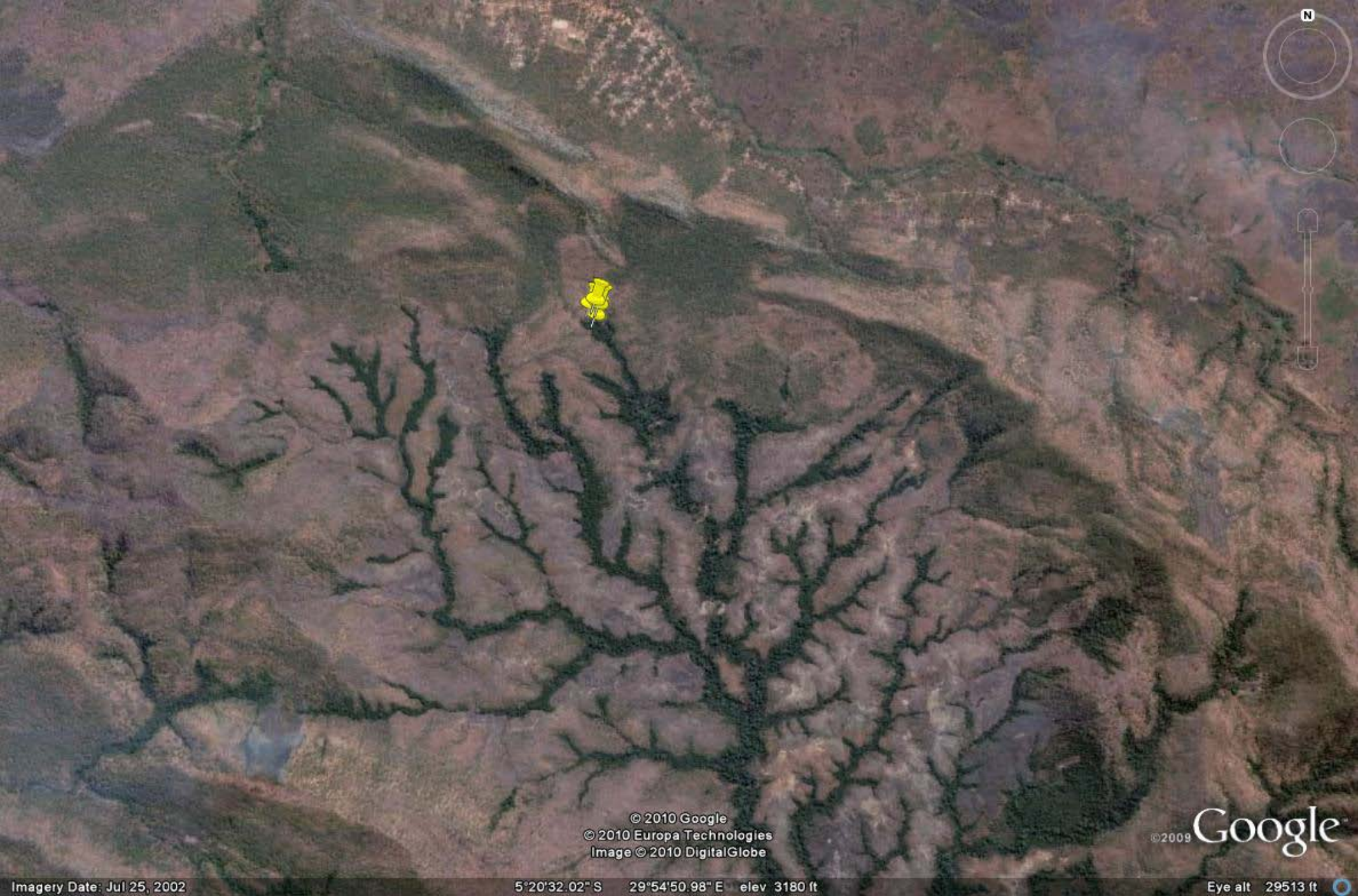
- Trained 15 people from Cambodian Forestry Administration
- Pilot project in development (currently refining data collection protocol)





Android phones+ *OpenDataKit* Training: Tanzania Village Forest Monitors, TZ Forestry and Beekeeping Division, Jane Goodall Institute, Nov 2009





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© 2010 Europa Technologies
Image © 2010 DigitalGlobe

©2009 Google

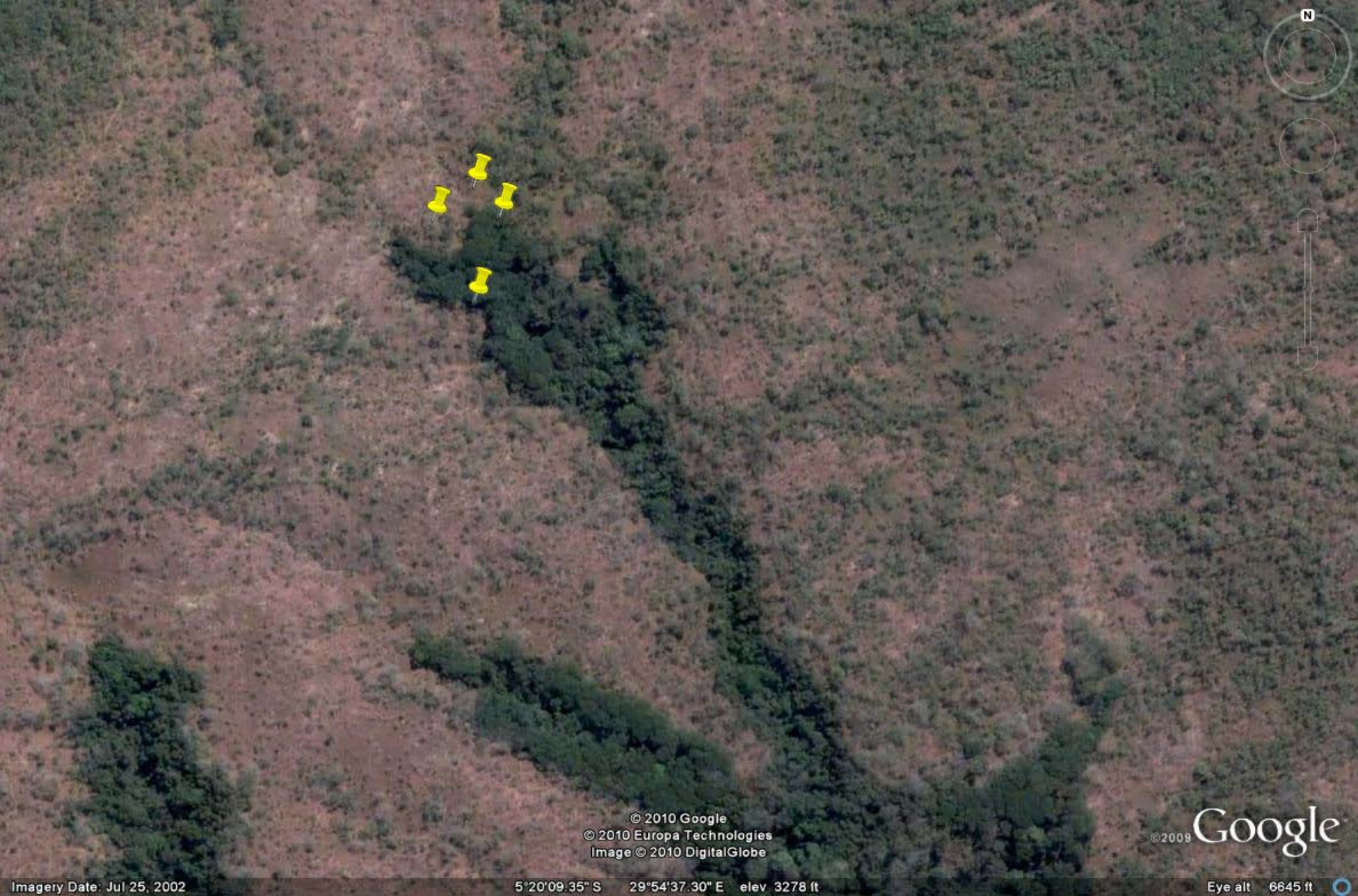
Imagery Date: Jul 25, 2002

5°20'32.02" S 29°54'50.98" E elev 3180 ft

Eye alt 29513 ft

Android/ODK data collection pilot project by JGI & villagers:
Masito-Ugalla ecosystem, Tanzania, December 2009





© 2010 Google
© 2010 Europa Technologies
Image © 2010 DigitalGlobe

©2009 Google

Imagery Date: Jul 25, 2002

5°20'09.35" S 29°54'37.30" E elev 3278 ft

Eye alt 6645 ft

Sample in-situ data collection points in riverine valley





Each point: GPS-tagged photo, tree info, plot info, more....



DeviceId	351676030232856
SubscriberId	640044100133890
PlotId	2.009120383401E12
DataCollectedBy	Tanu msekenyi
DataEnteredBy	Jovin Iwehabura
Date	Thu Dec 03 00:00:00 UTC 2009
UNCountryCode	834
GPSCoordinates-Latitude	-5.33410370349884
GPSCoordinates-Longitude	29.908953309059143
EstimatedDistanceToRoad	3.0
EstimatedDistanceToWater	3.5
EstimatedDistanceToSettlement	3.0
Vegetation	WOOD
Habitat	WOD
OtherHabitatDescription	null
HumanLandCoverUse	OTR
Topography	VAL
WaterRegime	INUNS
Soil	SSOIL
CanopyCover	2
DominanceCanopy	MI
CanopyHeight	2
DominanceUnderstory	MI
UnderstoryType	GRS
EvidenceOfLogging	N
EvidenceOfLoggingDescription	null
EvidenceOfFire	Y
EvidenceOfFireDescription	Area recently under fire. understory regeneration started
EvidenceOfGrazing	N
EvidenceOfGrazingDescription	null
GeneralDescriptionNotableFeatures	Scattered miombo trees dominated by brachystergia species
TallestTreeDBH1	118
TallestTreeH1	null
TallestTreeDBH2	220
TallestTreeH2	...

©2009 Google

Eye alt 4759 ft

5°20'04.75"S 29°54'35.13"E elev 8299ft

Imagery Date: Jul 25, 2002

...more data collected for each in-situ sample point





Colombia:
Android/ODK
May 2010



Google earth engine

a google.org project

Google™

Motivation



UNEP: "Atlas of our Changing Environment"



Forest MRV Challenges

Remote Sensing Data

- Data access, data storage – *terabytes or even petabytes*
- Onerous pre-processing requirements
 - Orthorectification, geo-registration, atmospheric correction, cloud removal, etc.
- Tracking ongoing data issues and updates
 - Landsat 7 SLC On/Off, new satellites, modified data policies, incompatible data formats
- Cost, availability & licensing

Data Processing Algorithms and Methodologies

- What is available / recommended and where to find it?
- Many countries lack required technology infrastructure and capacity
- Purchasing, installing, maintaining expensive hardware and software
- How to integrate in-situ data

UN-IPCC Guidance

- REDD MRV guidance to be open, transparent and verifiable

*Should every single country (and scientist)
have to solve these on their own?*



Forest MRV “Ecosystem”

1. National/Sub-national Governments & Local Project Teams

- Operational users: run MRV algorithms, on your own data or provided data
 - REDD implementation, natural resource mgmt, law-enforcement
- Seek sharing and collaboration with stakeholder communities & civil society

2. Scientists and Data Providers

- Scientists, university students, and others developing new algorithms
 - *Forest change detection, biomass estimation, carbon accounting*
- Space agencies, commercial RS data providers, NGO/IGO data sources

3. Stakeholders

- Civil society, NGO's, donors/investors, policymakers, media
- Primarily viewing and interpreting pre-generated results
 - Example: [Globo Amazonia](#), a Brazilian deforestation tracking website, publishes INPE DETER monthly results on Google map

Goal: design to satisfy these multiple user communities



What can we do?

Google's Mission

Organize the world's information and make it universally accessible and useful.

Help governments, scientists, local project teams:

- Better manage and scale their data and processing
- Discover and leverage each others algorithms and results
- Develop and share best practices locally, regionally, globally
- Increase transparency, reproducibility and collaboration
- *Essential to respect national sovereignty and avoid "re-inventing the wheel"!*

Help data providers

- Reach a broader audience of users and applications

Can we help countries monitor and manage their resources?

Can we spur scientific progress?



Early Vision *(at CD-REDD meeting, Brazil, Feb-09)*

1. Point your web browser to the Google forest monitoring portal, and log in.
2. **"What do you want to do?"**
 - Forest Cover analysis (*land cover classification - forest, cropland, savannah...*)
 - Forest Change detection (*e.g. look for deforestation or reforestation*)
 - Burnt area detection
 - Carbon Emissions Calculation
 - ...
3. **"Where do you want to do it?"**
 - Select by administrative region (global, country, state/province, biome...)
 - Or draw free-form area.
4. We display: **Here are the Remote Sensing datasets for your area:**
 - LANDSAT (with dates)
 - CBERS
 - SPOT
 - ALOS
 - ESA
 -
5. **"Please select the remote sensing data you want to use"**
6. We display: **Here are the software tools available for your selected task, area and remote sensing dataset:"**
 - PRODES
 - DETER
 - TREES
 - ALU
 - FAO FRA
 - ...
7. **"Please select the tool you want to use"**
8. We display: **"OK, thank you. We will email you when your results are ready".**



The Story So Far

Two Generations of Prototype

Gestalt

Hello, mdh. [Sign out.](#)

1. Choose your source data.
Pick a country...
 Show query polygon. Show result polygons.
[Draw your own region.](#) [Show advanced options.](#)

2. Select an algorithm.
CLASlite

3. Submit your query.
Submit Query

"True Color" (RGB) Preview
 "False Color" (432) Preview
 Vegetation Index (NDVI)
 CLASlite

powered by Google

COP15 Demo: CLASlite

rmoore@google.com | [CLASlite](#) | [Sign out](#)

Select a Time Range:
Start Date: Sunday, Januar End Date: Tuesday, Decer

1. Select a Region
2. Preview your Data
3. Display Forest Cover
4. Display Deforestation over Time

Shows deforestation and forest degradation events over time. Wide-area Images show preview data; for more accurate results, zoom in.

Recent
Oldest

Enable Spatial Filtering

CARNegie INSTITUTION FOR SCIENCE CLASlite: The Carnegie Landsat Analysis System Lite Carnegie Institution for Science

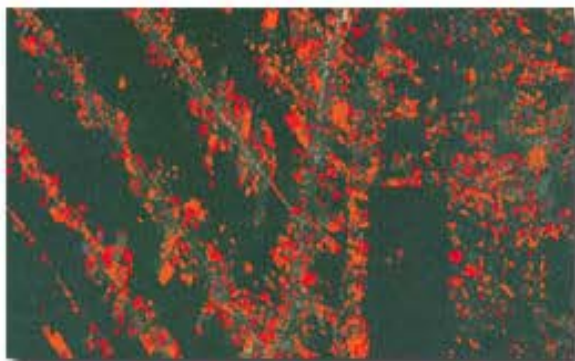
powered by Google

Imagery ©2009 TerraMetrics. Map data ©2009 MapData.com, Google, etc.



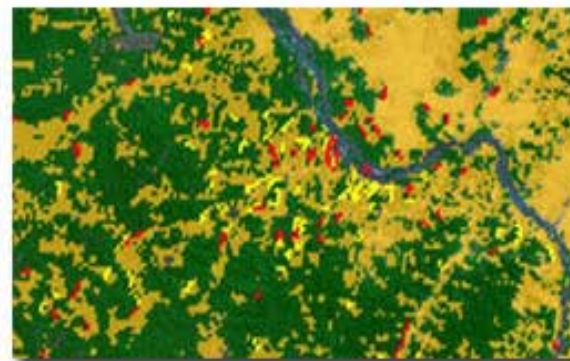
COP15 Demos

Carnegie Landsat Analysis
System Lite (CLASlite)



CARNEGIE
INSTITUTION FOR
SCIENCE

Imazon Sistema de Alerta de
Desmatamento (SAD)



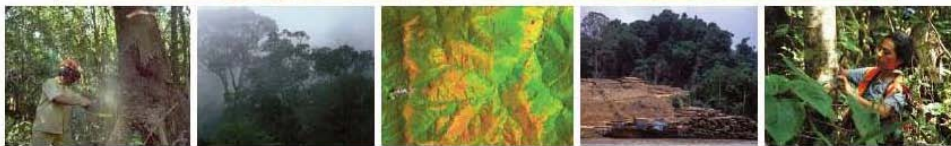
IMAZON
INSTITUTO DO HOMEM E
MEIO AMBIENTE DA AMAZÔNIA

[View on YouTube](#)

Science/Institutional partners *(to date)*

- Greg Asner, Carnegie Institution: *CLASLite*
- Carlos Souza, IMAZON: *NDFI, SAD, Pan-Amaonia Collaborative Monitoring Network*
- Dirk Hoekman, SarVision: *LULUC using ALOS PALSAR*
- Josef Kellndorfer, WHRC: *ALOS PALSAR Pan-tropical Mosaic*
- Ron Eastman, Clark Labs: *REDD+ Scenario Builder*
- Eric Vermote: *LEDAPS – Landsat Atmospheric Correction*
- Matt Hansen: *Landsat/MODIS-based forest change assessment*
- Gordon and Betty Moore Foundation
- GOFC-GOLD, GEO-FCT, UN-REDD *(informal collaboration)*

Potential: *GEO-FCT* & *GOFC-GOLD*



Reducing Greenhouse Gas Emissions from Deforestation and Degradation in Developing Countries: A Sourcebook of Methods and Procedures for Monitoring, Measuring and Reporting

GOFC-GOLD +++

- All contributors to GOFC-GOLD Sourcebook
- All referenced algorithms
- All referenced data sources
- GEO-FCT algorithms and data sources

We seek collaboration here



Earth Engine: Proposed Data Services

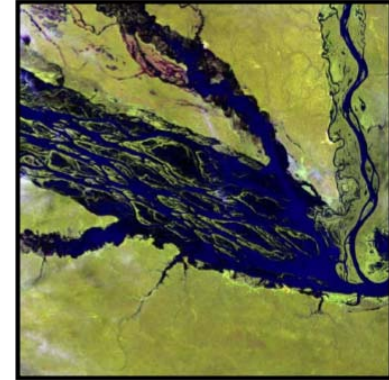
- *“Free, frequent and useful data”*
 - Continuous acquisition and hosting of free and useful data
 - Landsat, MODIS, terrain data, ECV vector data and more
- Hosting commercial data under appropriate access policy
- Hosting in-situ data and other contributed datasets (soils etc)
- Pre-processing of the data to specified standards and quality
 - Immediately useful for forest monitoring applications
- Types of data products
 - Source datasets for online computation and/or download (*Landsat...*)
 - Pre-processed intermediate datasets (*atmospherically-corrected, mosaics...*)
 - Final map products generated by partners (*time-series, biomass, carbon...*)
 - *Data products can be processed/viewed online and/or downloaded to desktop*



Example: Landsat

Landsat archive hosted at USGS:

- Currently 2,000,000 scenes in the archive (L5/L7)
 - 90% on tape – not online
- 1,200,000 scenes at <50% clouds
- 350,000 scenes in the pan-tropics



Earth Engine Goal:

- Host online **all Landsat scenes <50% clouds**
- More than one petabyte of data (one billion megabytes)
- Stay current with ongoing Landsat data acquisition
- Make available for processing online (and download)

Status:

- Collaborating closely with USGS EROS Data Center
- Target: all pan-tropical data online in Earth Engine this year
- Rest of world in 2011

Landsat acquisition status

Max cc:

0-25% 25-50% 50-75% 75-100%



Region	ALL_LANDSAT				LANDSAT5				LANDSAT7			
	% Google	% FTP	% Tape	# Total	% Google	% FTP	% Tape	# Total	% Google	% FTP	% Tape	# Total
World	22.5	1.2	76.3	1921473	20.1	0.0	79.9	809010	26.1	1.0	72.9	1034569
Region	ALL_LANDSAT				LANDSAT5				LANDSAT7			
	% Google	% FTP	% Tape	# Total	% Google	% FTP	% Tape	# Total	% Google	% FTP	% Tape	# Total
Indonesia	40.8	0.7	58.5	30463	12.8	0.1	87.1	8218	53.1	0.3	46.6	21431
Papua New Guinea	13.0	0.6	86.4	7355	10.1	0.0	89.8	2886	15.7	0.3	84.1	4237
Region	ALL_LANDSAT				LANDSAT5				LANDSAT7			
	% Google	% FTP	% Tape	# Total	% Google	% FTP	% Tape	# Total	% Google	% FTP	% Tape	# Total
Latin America	33.5	3.8	62.6	235430	27.0	1.6	71.4	89383	40.5	4.4	55.1	135194
Bolivia	40.8	1.1	58.1	14095	43.8	0.0	56.2	5044	40.6	0.5	58.9	8720
Brazil	47.1	9.7	43.2	72880	43.6	5.3	51.2	17358	50.3	10.3	39.4	53310
Colombia	31.6	1.3	67.0	17395	17.9	0.2	81.8	6056	47.0	0.1	52.9	9408
Ecuador	31.7	1.7	66.6	5314	34.2	0.1	65.7	1889	33.7	0.4	66.0	3076
Guyana	53.9	3.2	42.9	4266	48.9	0.0	51.1	1046	59.1	0.9	40.0	3026
Mexico	27.2	1.2	71.6	66694	22.7	0.9	76.4	43481	40.2	1.1	58.6	20559
Peru	41.7	1.6	56.6	17469	44.3	0.0	55.6	6396	43.5	0.2	56.3	10244
Region	ALL_LANDSAT				LANDSAT5				LANDSAT7			
	% Google	% FTP	% Tape	# Total	% Google	% FTP	% Tape	# Total	% Google	% FTP	% Tape	# Total
Sub-Saharan Africa	30.6	1.1	68.2	145138	26.2	0.3	73.5	34288	33.6	0.6	65.8	105480
Cameroon	62.8	4.8	32.4	4779	63.2	0.2	36.6	604	67.1	3.4	29.4	3900
DR Congo	54.1	1.5	44.3	16649	39.7	0.4	59.9	3809	60.7	0.6	38.7	12361
Kenya	37.6	0.9	61.5	5643	38.4	0.3	61.3	1328	40.0	0.4	59.5	4023

Landsat Acquisition Dashboard

(Google internal)

May-2010 download status
(updated daily)

We are downloading daily all L1T processed Landsat scenes that USGS publishes to their public FTP site.

This includes newly-acquired scenes as well as archive data based upon user requests.

USGS uses excess capacity (beyond other user requests) to systematically pull archive data off tape, process it and publish to their public FTP site, from which we download it.



A decorative header at the top of the slide features four overlapping spheres. From left to right, they are light green, light blue, light red, and light yellow. The spheres are partially cut off by the top edge of the slide.

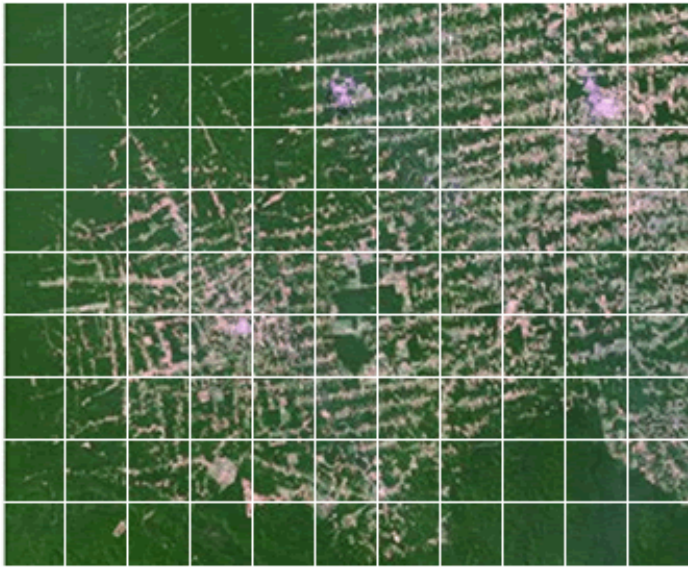
Parallel Processing “in the cloud”

(a brief illustration)



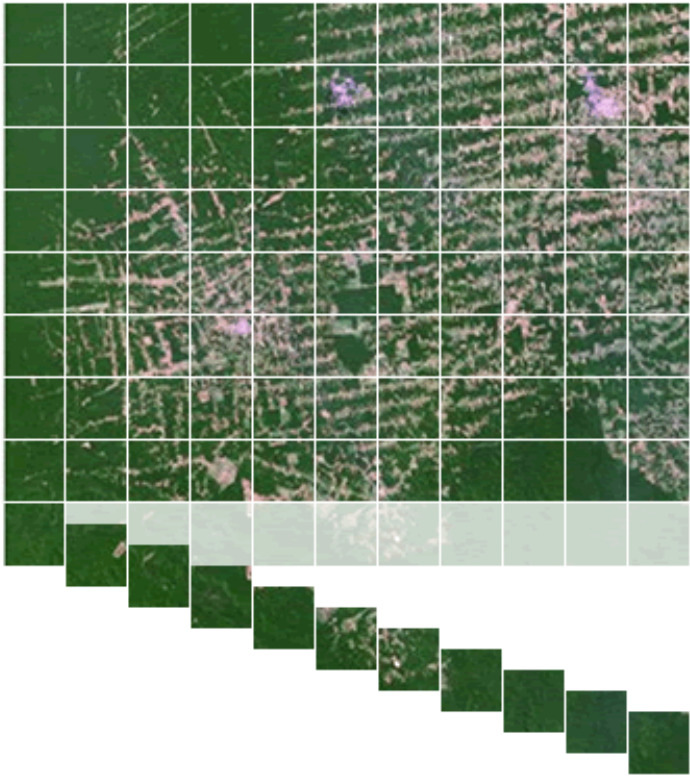


Original image

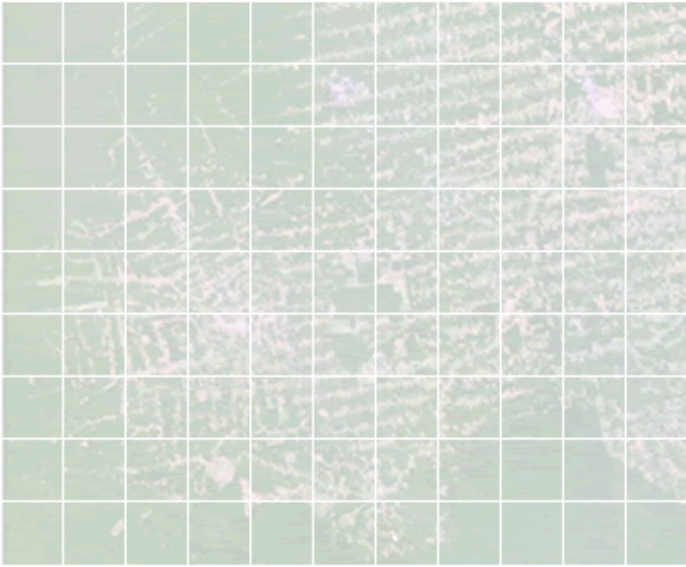


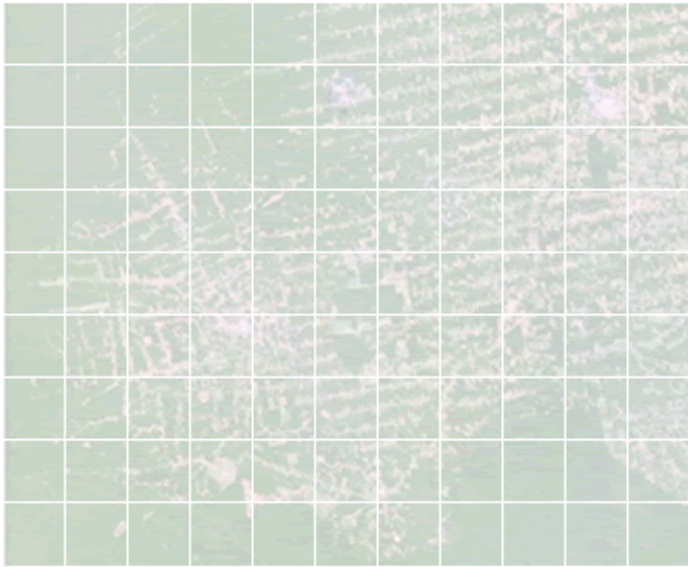
Original image
... is divided into 256px sub-units.

Sub-units are distributed

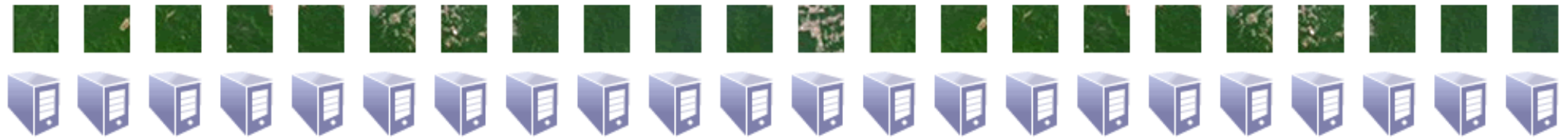


Sub-units are distributed
... to separate machines.

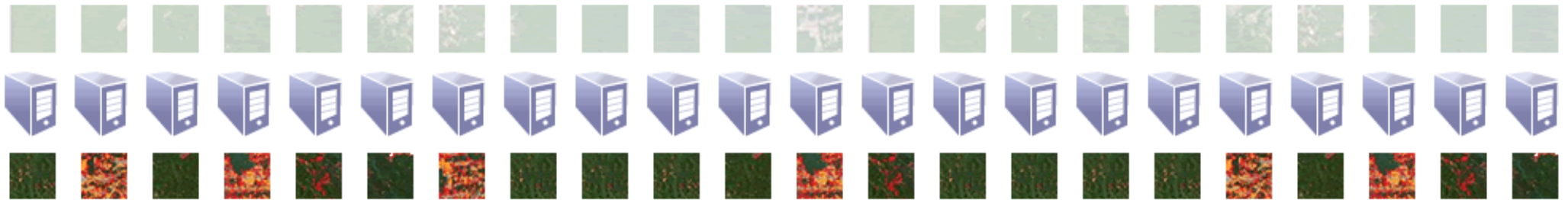
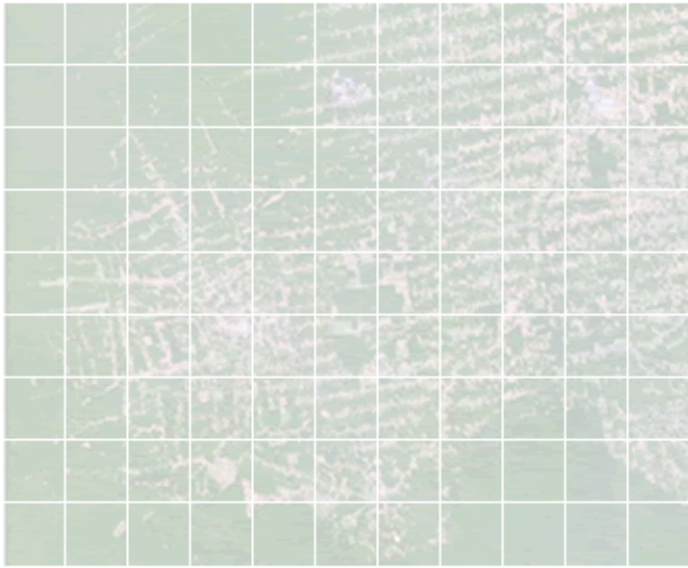




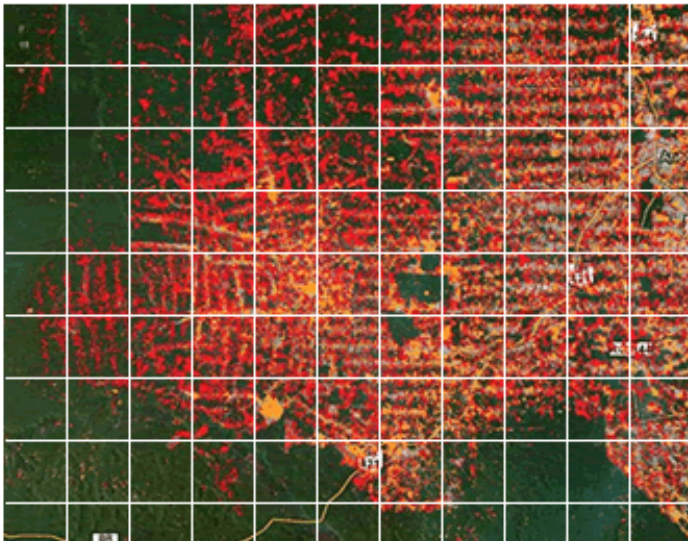
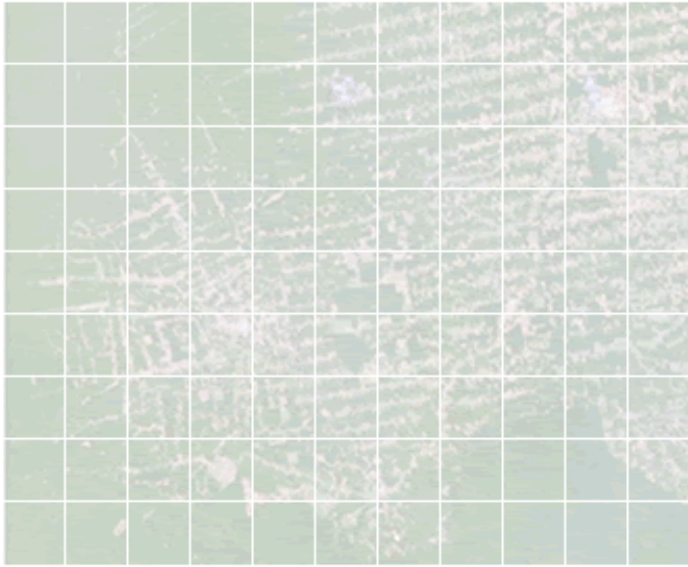
Sub-units are distributed
... to separate machines
... where they can be processed
in parallel.

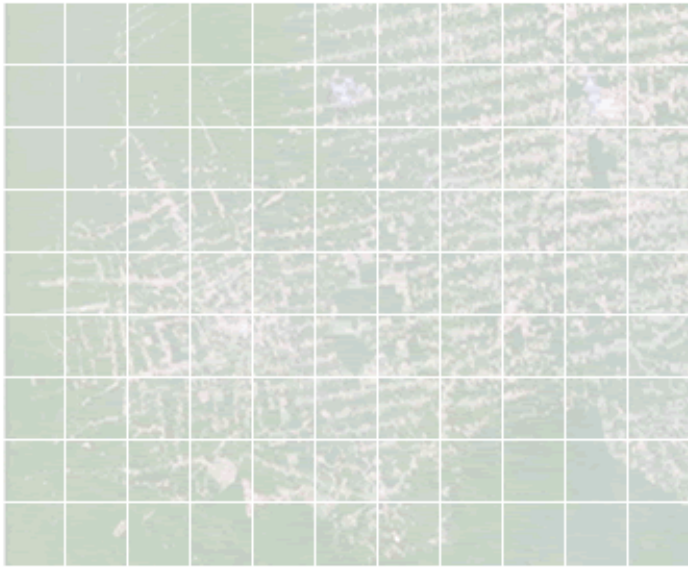


Thousands can be processed simultaneously

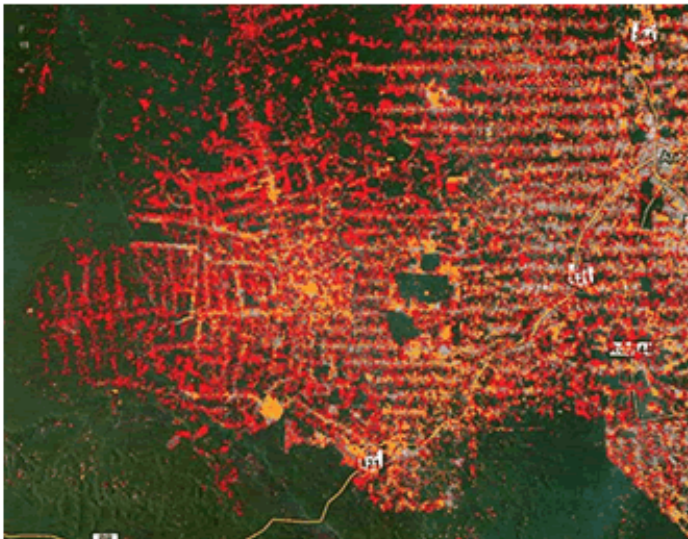


Result is reassembled





Result is reassembled
... into a finished image

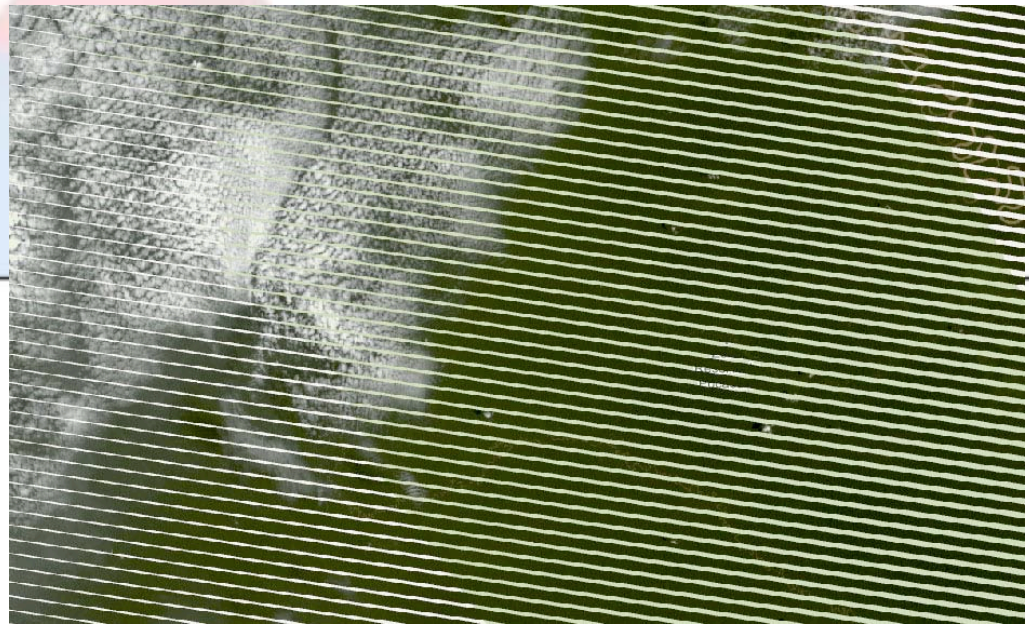
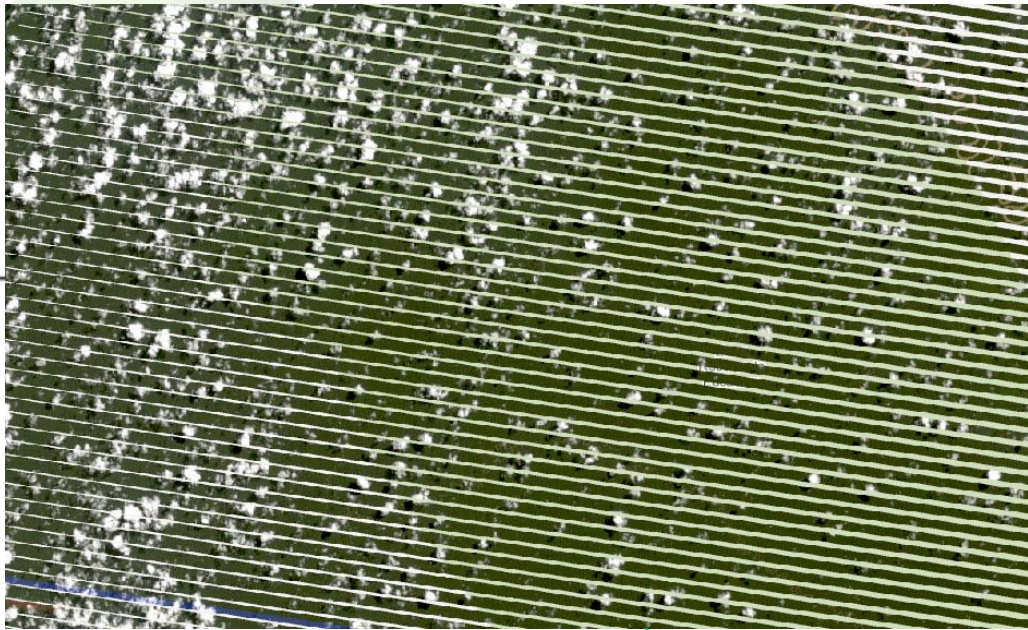


A decorative header at the top of the slide features a horizontal line. Above this line, there are four overlapping spheres: a green one on the far left, a blue one in the middle, a red one slightly behind the blue one, and a yellow one on the right.

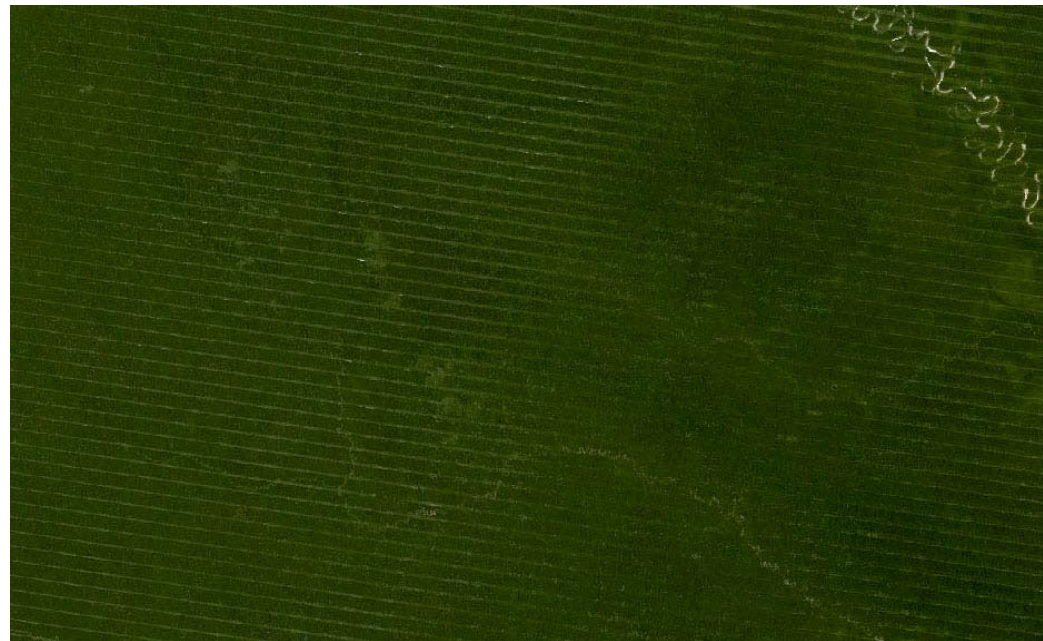
Example data processing service:

*Removing clouds and gap-filling in
Landsat 7 imagery*





Landsat 7 images 2005



Zona Reservada Pucacuro in northern Perú

*Greenest-pixel
mosaic via
NDVI*



Algorithms and Methodologies

- *Earth Engine API* for easily creating new forest MRV apps
 - Make remote sensing much easier than it is today!
- Product Development Processing Services
 - High-performance computational resources “in the cloud”
 - Countries can run their chosen algorithms on their own data
 - Keep their data and results private when desired; share results when ready
- Online environment and tools for accuracy assessment
 - Software tools for verification and validation
 - Access to very high res (VHR) imagery (DG, GeoEye, WV-II, IKONOS, SPOT)
 - In-situ data integration
- Publishing site for Forest MRV algorithms and methodologies
 - More discoverable by users, supportable, transparent
 - Allow scientists full control over where and how their methods can be applied

Earth Engine: v1.0 goals

Operational algorithms and data, in collaboration with partners

- USGS/NASA: Landsat and MODIS
- Carnegie: CLASlite: Carnegie Landsat Analysis System Lite
- AMAZON: SAD: Sistema de Alerta de Desmatamento
- LEDAPS team: Landsat Atmospheric Correction

Additional services (*from Google*)

- Ability to create spatial and temporal mosaics under user control
 - » Example: most-cloud-free Landsat mosaic for Ecuador in 1990
 - » For download to your desktop or further processing online
- Ability to upload, visualize, share in-situ data
- Basic methods for integrating reference data (in-situ, VHR) with remote sensing for calibration, verification, validation
- Others tbd (we welcome your input)



Final thoughts

- *Technology alone does not solve problems – people solve problems*
- *The operational development and application of ANY of these tools will require local knowledge and expertise*
- *Respecting national sovereignty and the expertise of scientists is essential for us*
- *Our goal is to put these tools in YOUR hands, to strengthen your ability to manage your own forests and lands*
- *We look forward to collaborating with you in addressing the global challenge of climate change and REDD*





Thank you

Contact:

Rebecca Moore, *rmoore@google.com*

Google earth engine
a google.org project

Google[™]