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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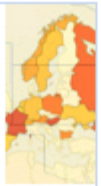
google.org

- Home
- About Us
- Products
  - Google Flu Trends
  - Google PowerMeter
  - Earth Engine
  - RE<C
  - Collaboration Projects
- Advocacy
- Blog
- Philanthropy @ Google

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.
Learn more

Google PowerMeter

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

Philanthropy @ Google

Check out all of Google.com's philanthropic activities.
Learn more

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

www.google.org

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

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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

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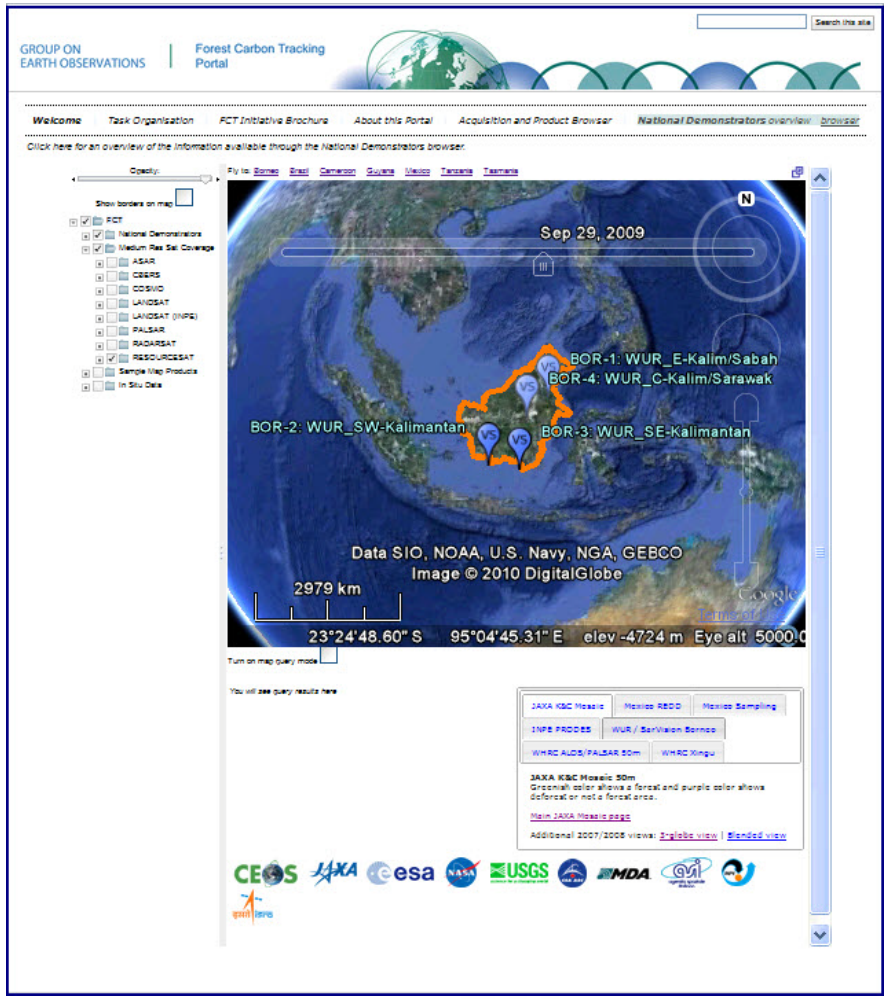
GEO-FCT

Demonstration Portal

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



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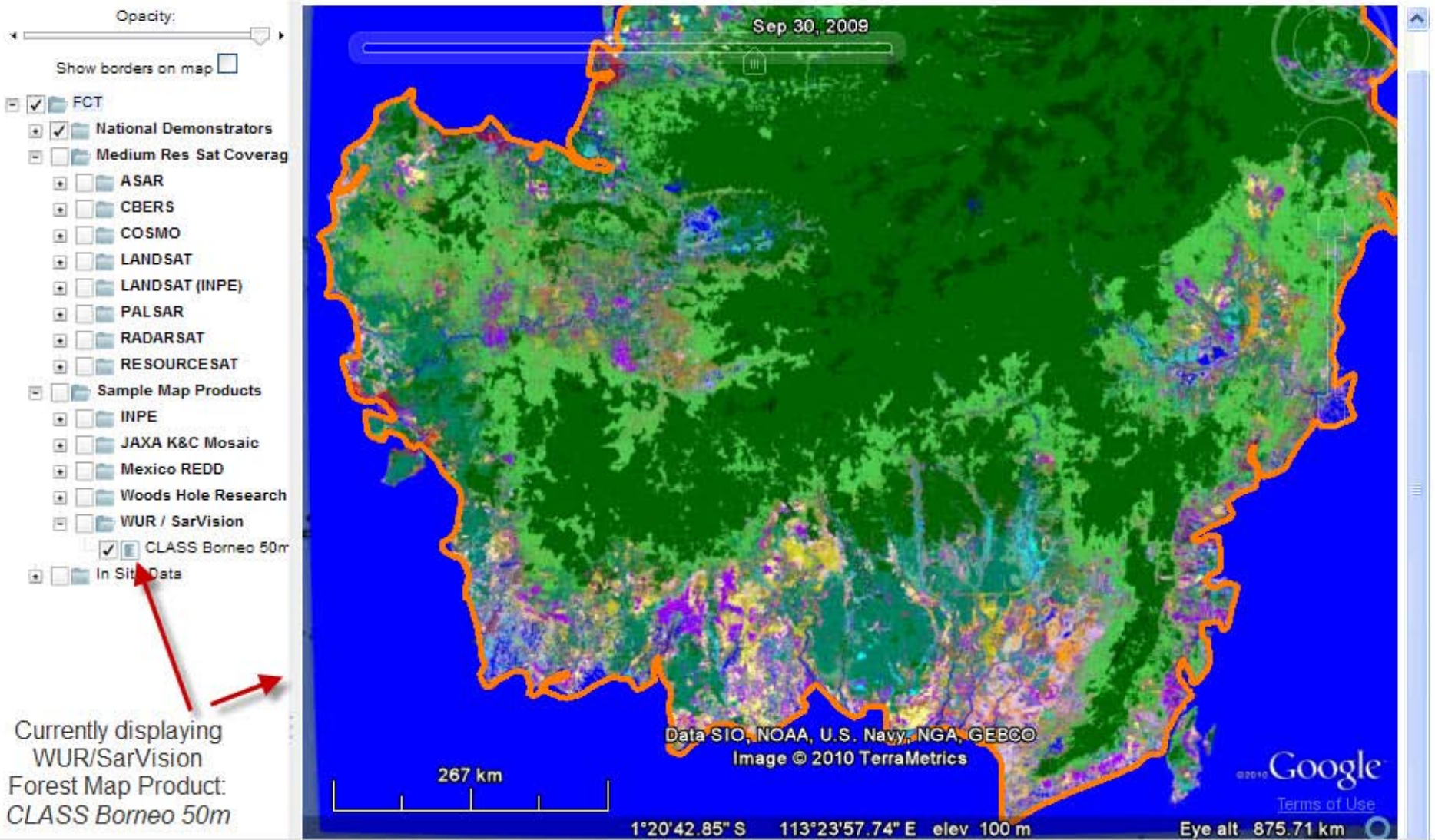
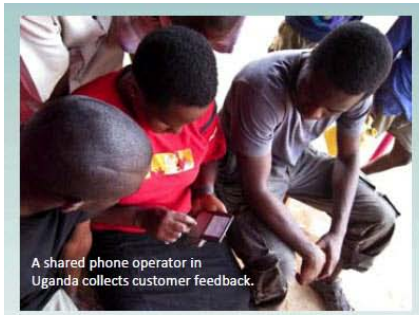
Click here for an overview of the information available through the National Demonstrators browser.



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

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Android/ Open Data Kit for in-situ data collection

In-country capacity-building *(to date)*

- **Tanzania**
  - o Trained >130 people from TZ Forestry and Beekeeping Division (FBD), JGI, local communities (*with UN-FAO)*
  - o Pilot data collection projects underway with NAFORMA (household surveys) and JGI (Masito Ugalla)
- **Colombia**
  - o Trained 75 people from IDEAM, Ministry of Environment, National Parks, NGOs, and local communities
  - o Potential pilot projects with local communities on Pacific coast, and for CLASlite field validation
- **Brazil**
  - o Introductory trainings: 30 people from Brazilian Forest Service, local NGOs and Amazon Surui indigenous tribe
  - o Pilot community-based carbon project underway with Surui
- **Cambodia**
  - o Trained 15 people from Cambodian Forestry Administration
  - o 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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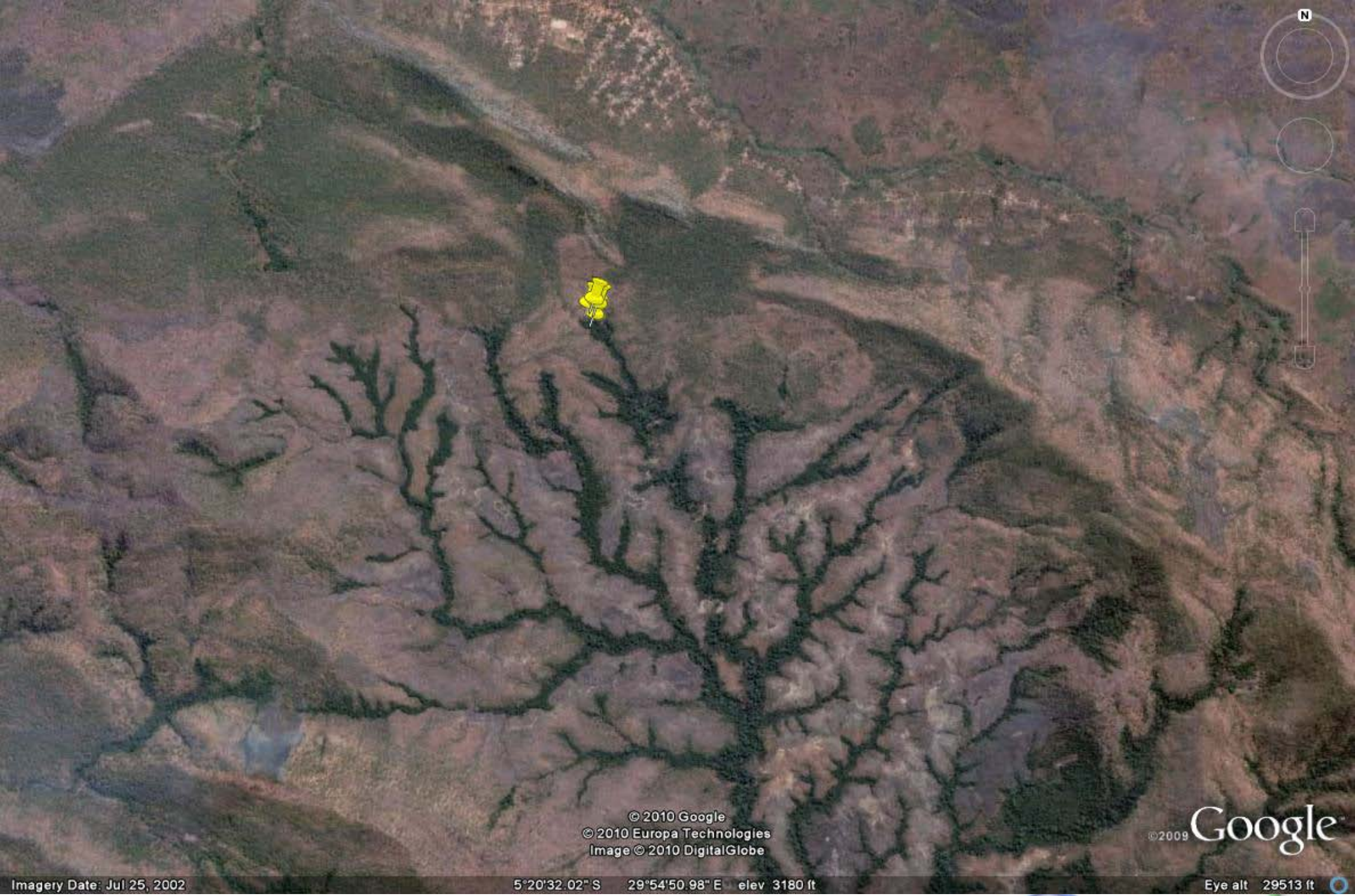

Android/ODK data collection pilot project by JGI & villagers:
Masito-Ugalla ecosystem, Tanzania, December 2009

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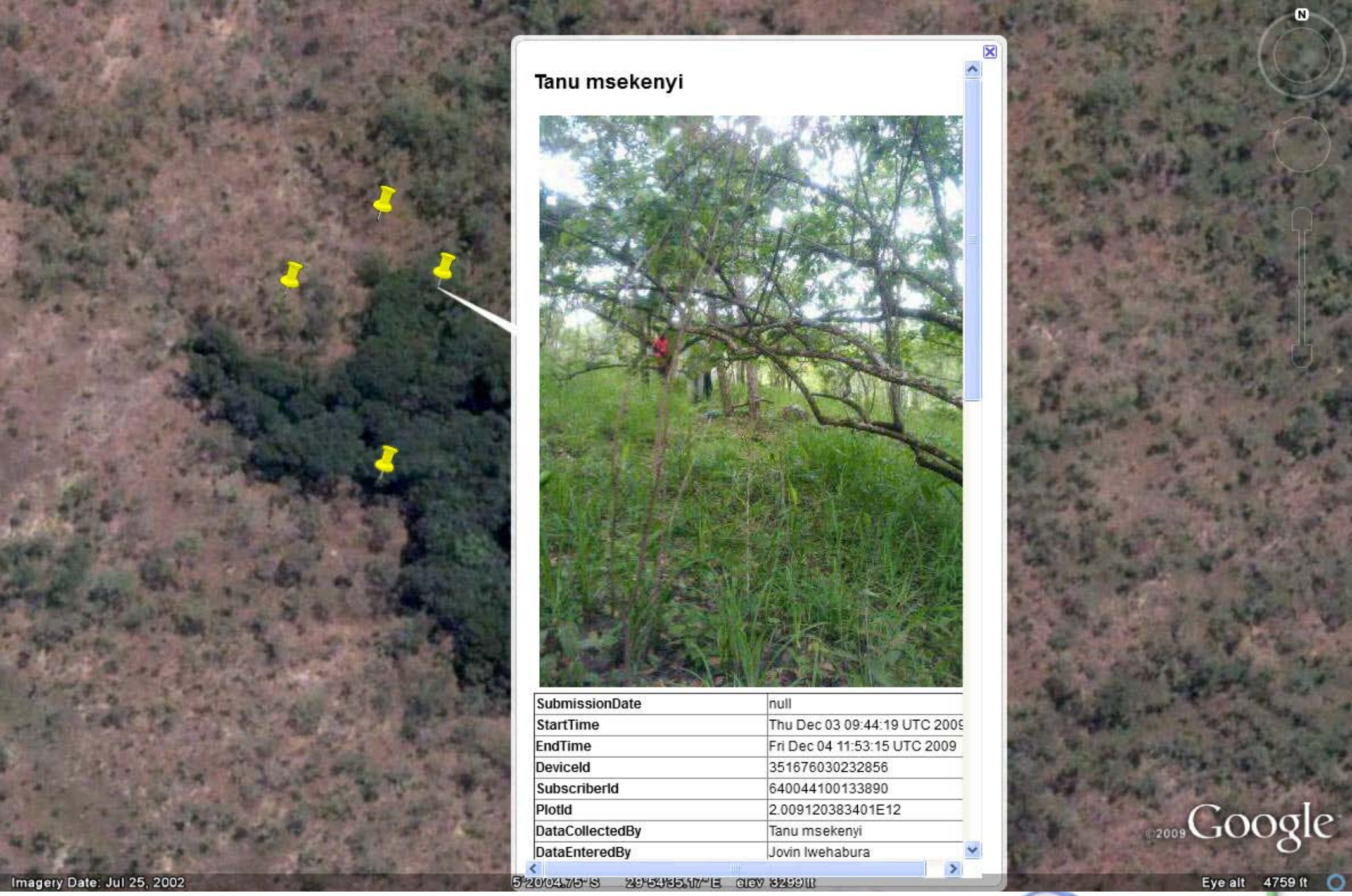
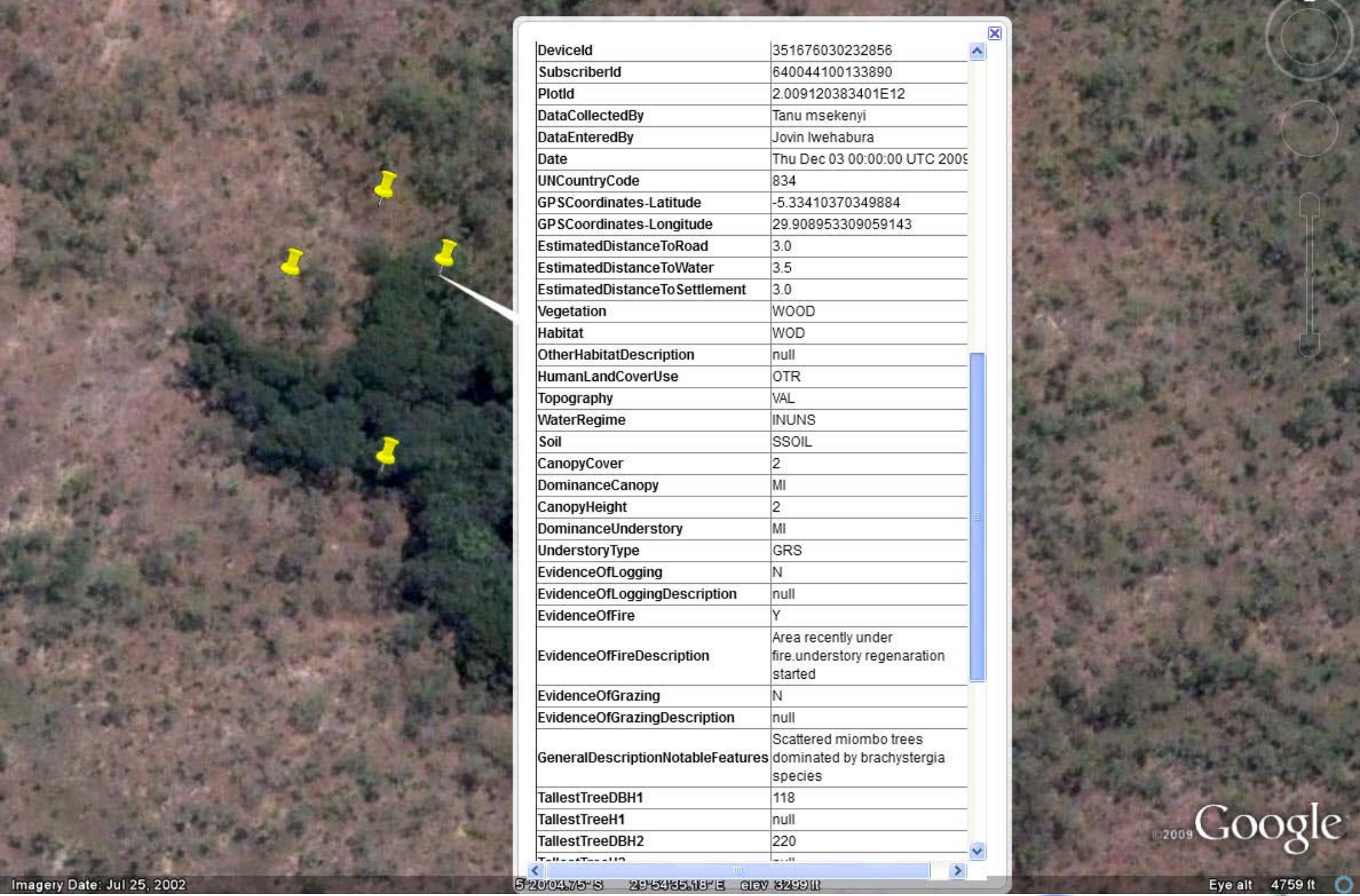
Sample in-situ data collection points in riverine valley



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



…more data collected for each in-situ sample point

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Colombia:
Android/ODK
May 2010

Google earth engine

a google.org project

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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?

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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

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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?

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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

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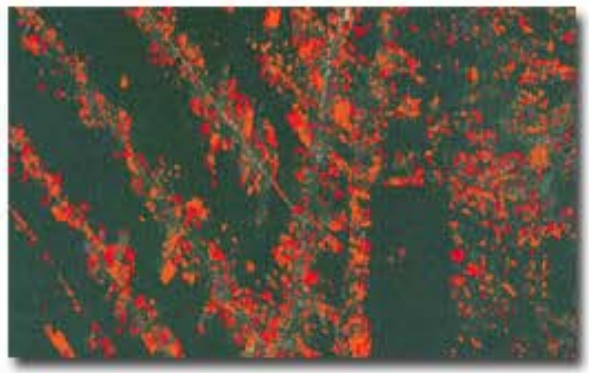
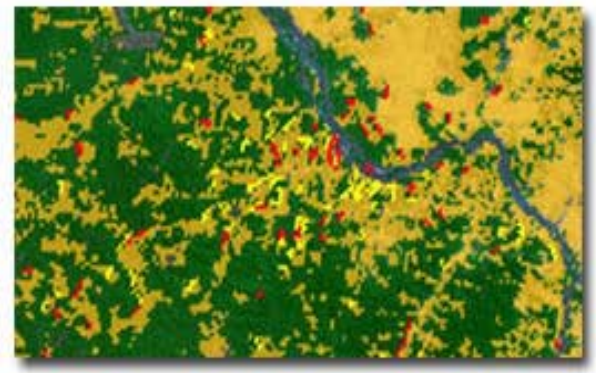
COP15 Demos

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-Amazonia 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)*

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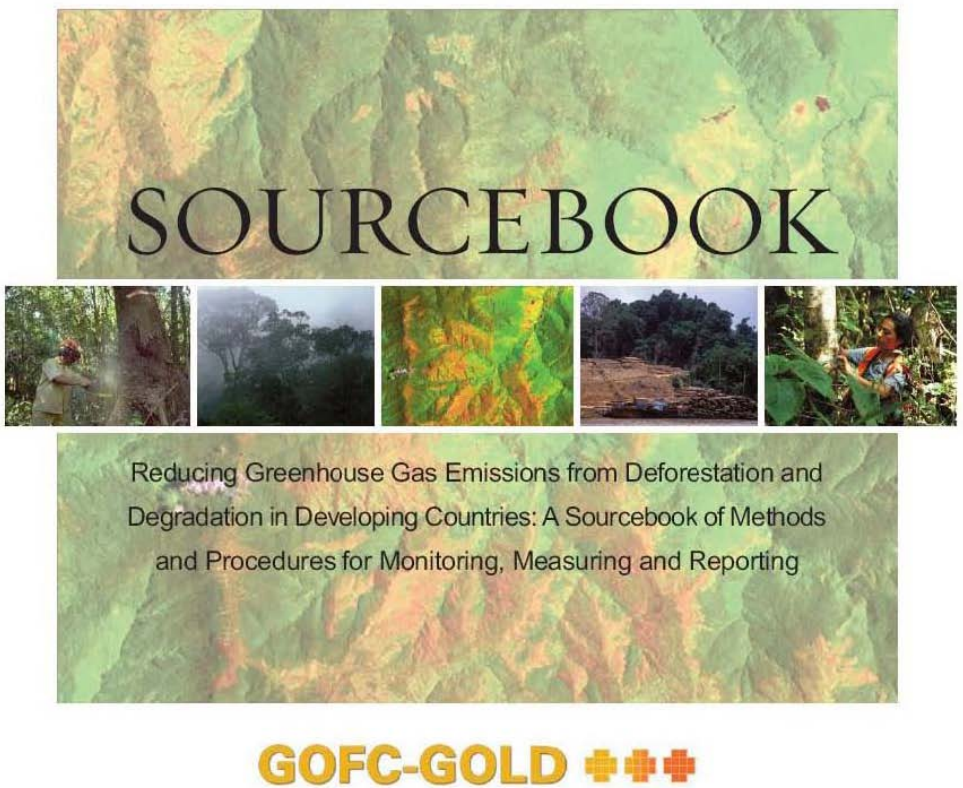
Potential: *GEO-FCT & GOFC-GOLD*



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

We seek collaboration here

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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*

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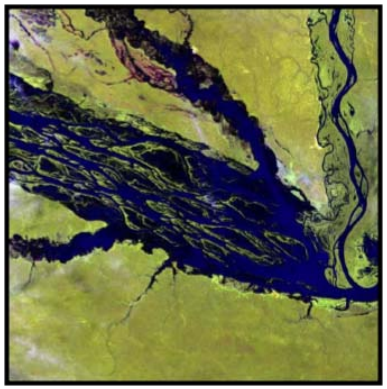
Example: Landsat



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

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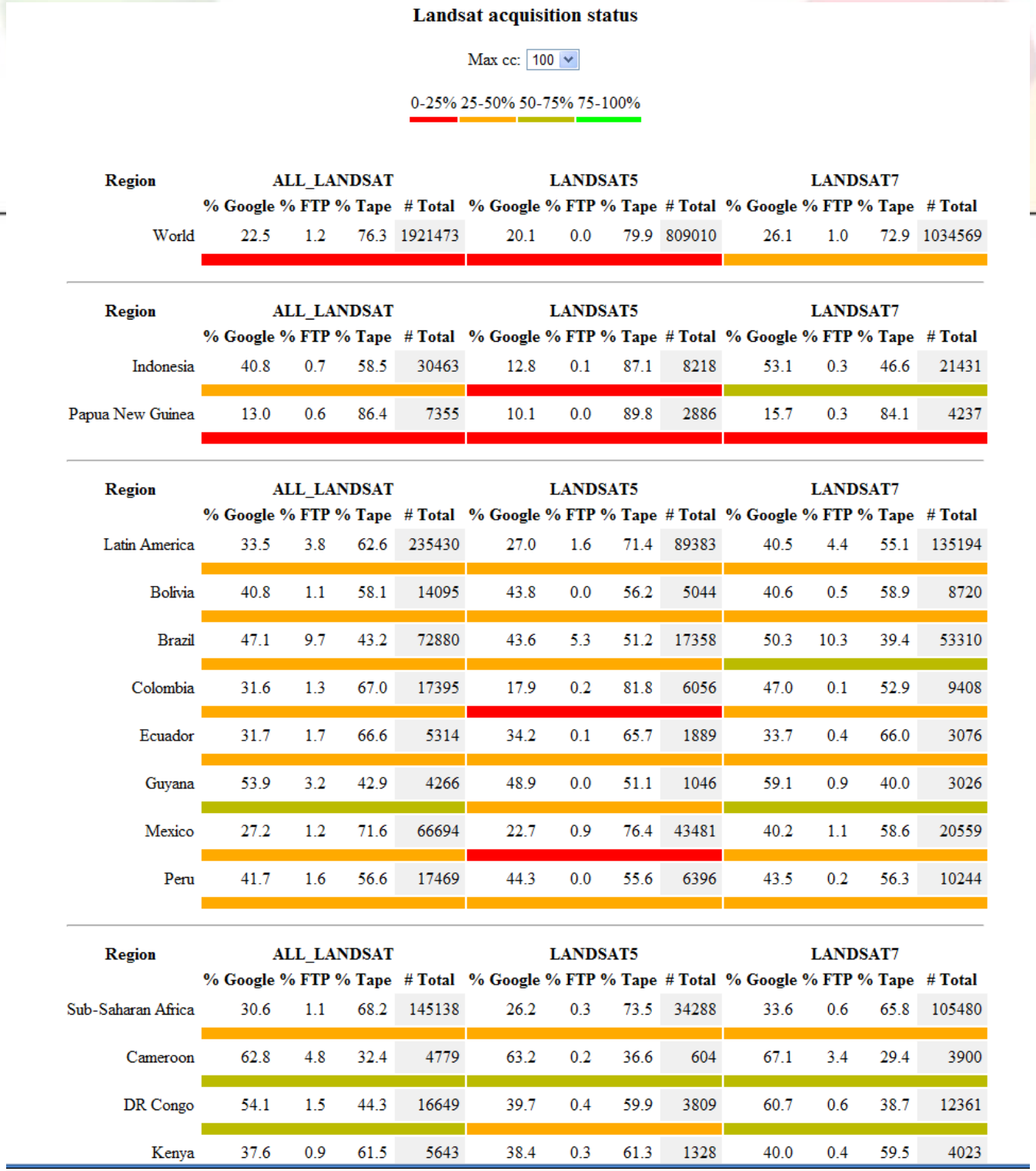
Landsat Acquisition Dashboad

(Google internal)



Landsat acquisition status

Max cc: 100

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
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
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
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

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.

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Parallel Processing
“in the cloud”

(a brief illustration)

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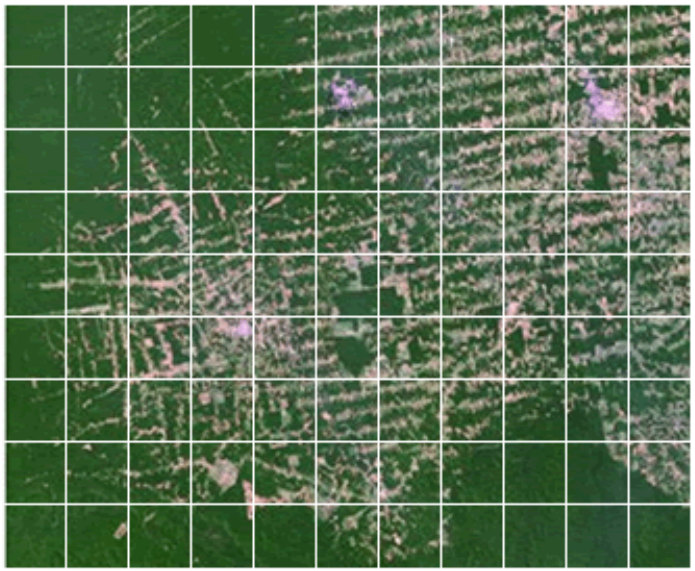
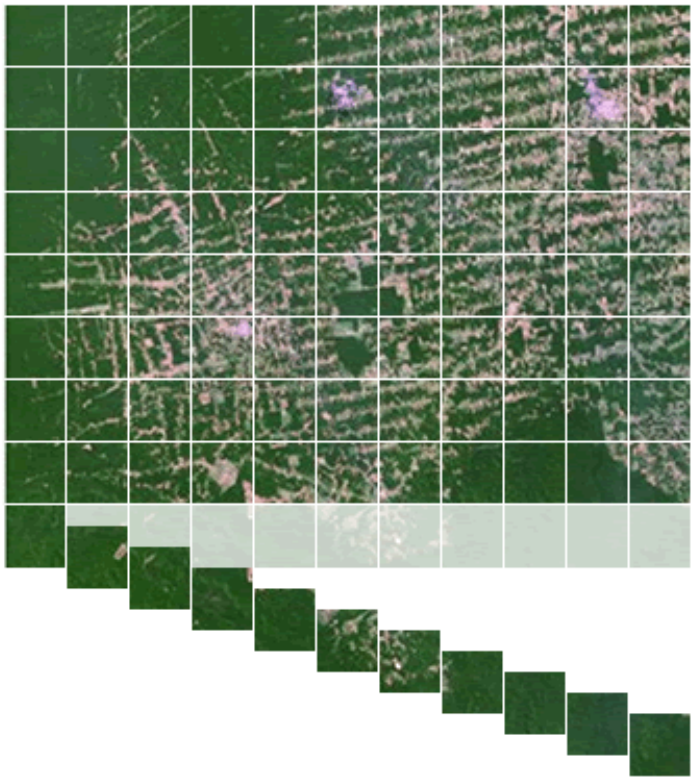
Original image

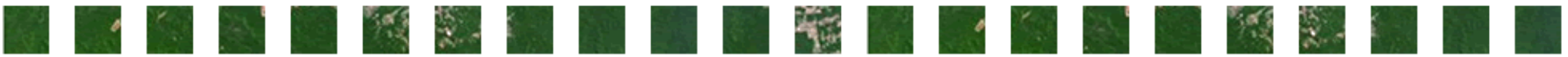


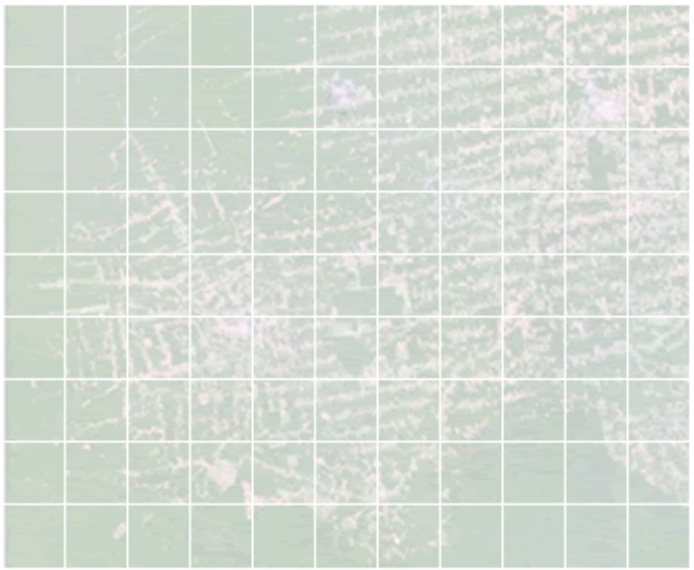
Original image
... is divided into 256px sub-units.



Sub-units are distributed

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

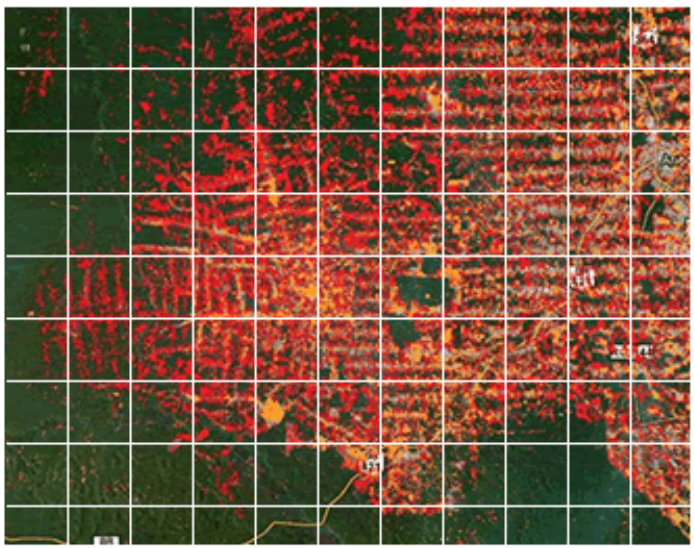




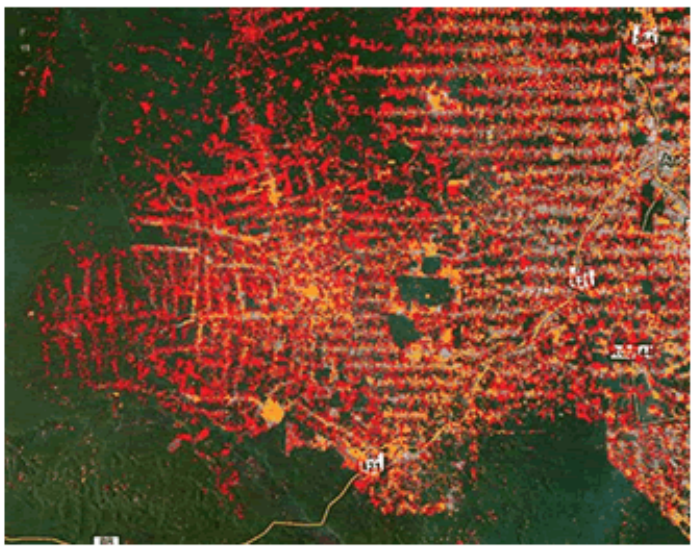
Sub-units are distributed
... to separate machines
... where they can be processed
in parallel.

Thousands can be processed simultaneously

Result is reassembled



Result is reassembled
... into a finished image



Example data processing service:

Removing clouds and gap-filling in Landsat 7 imagery

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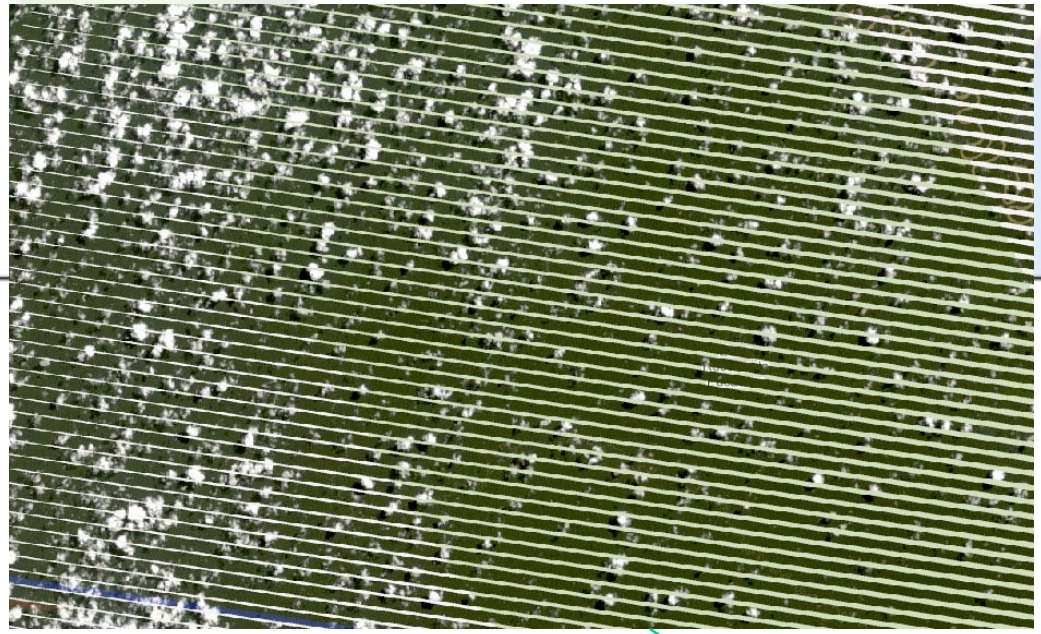
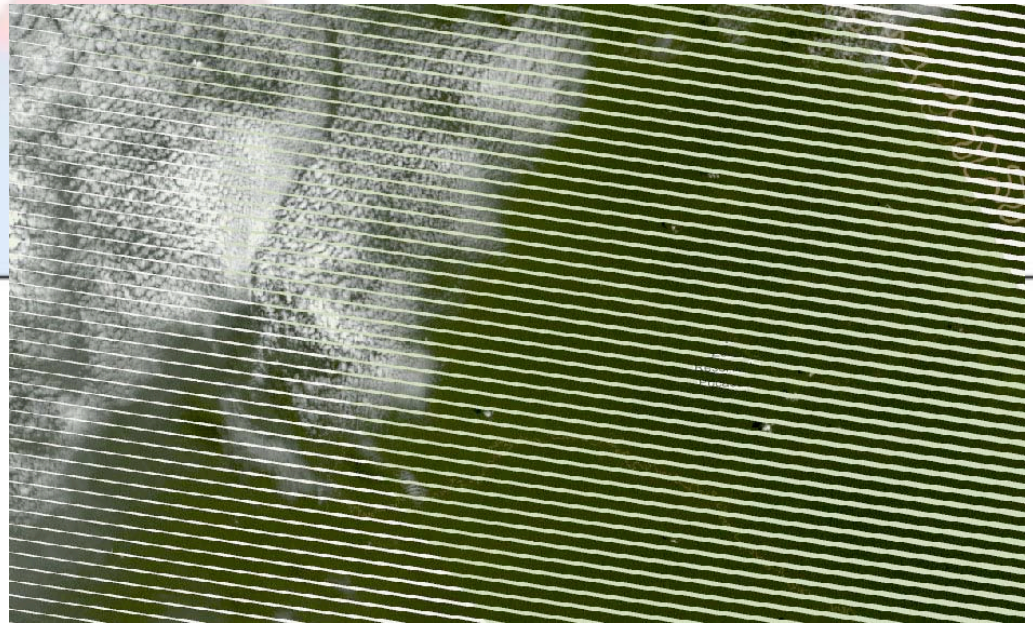
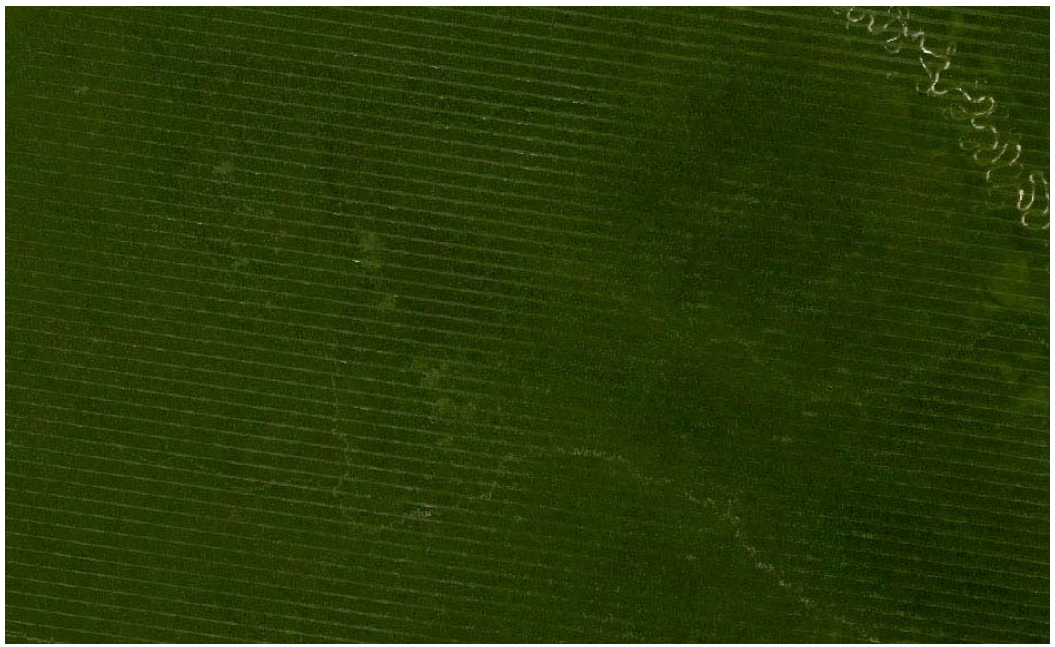




Landsat 7 images 2005



Zona Reservada Pucacuro in northern Perú

Greenest-pixel mosaic via NDVI

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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

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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
- IMAZON: 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)

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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*

Google

Thank you

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Google earth engine

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