

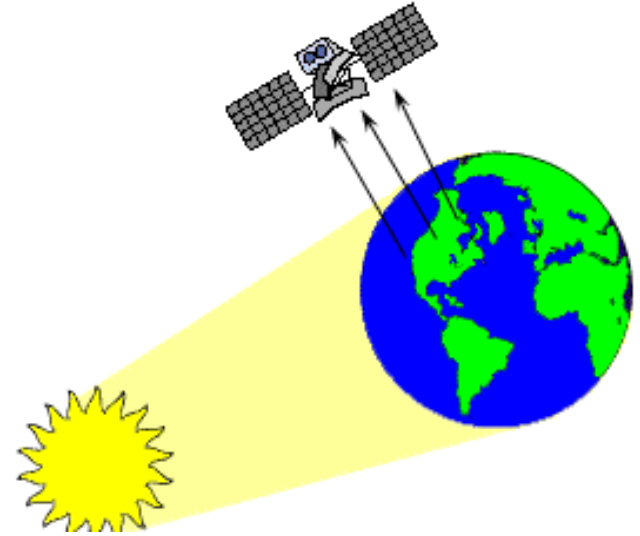
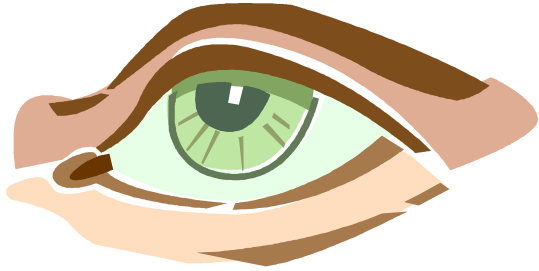
Introduction to Remote Sensing

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University of California San Francisco

alemayehu.midekisa@ucsf.edu

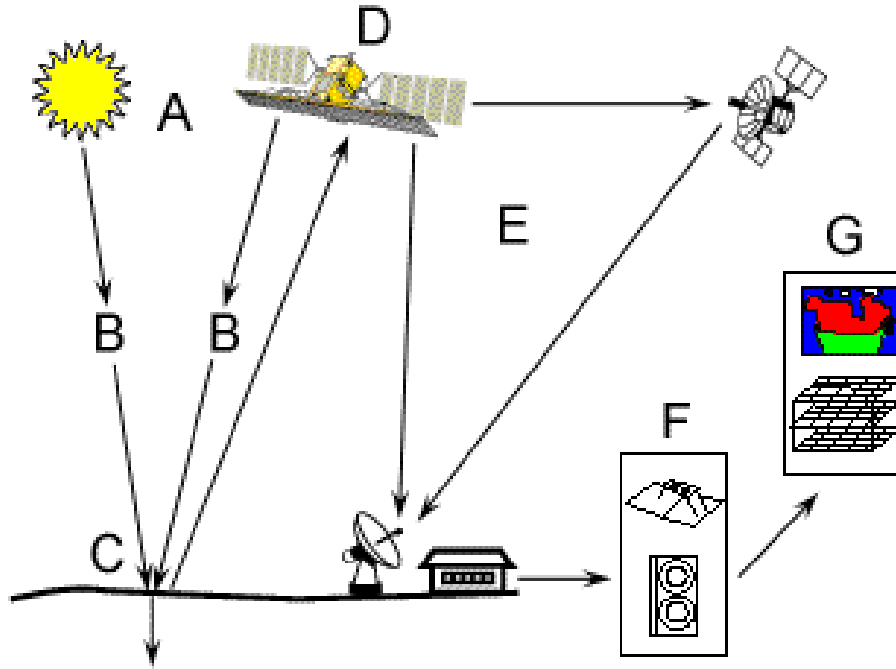
Background to Remote Sensing



Remote sensing is a method of obtaining information about the properties of an object without coming into physical contact with it.



Remote Sensing Process Components



(A) Energy Source or Illumination

(B) Radiation and the Atmosphere

(C) Interaction with the Target

(D) Recording of Energy by the Sensor

(E) Transmission, Reception, and Processing

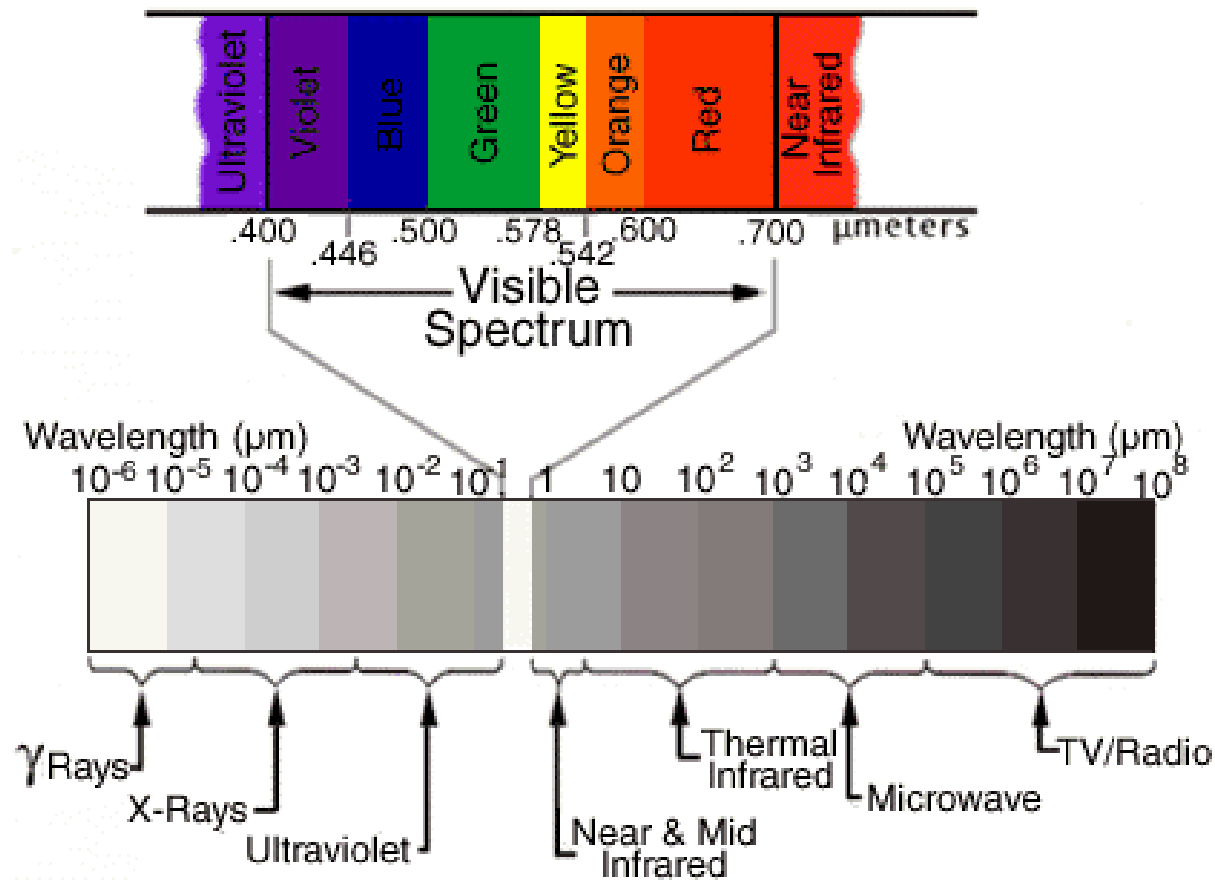
(F) Interpretation and Analysis

(G) Application

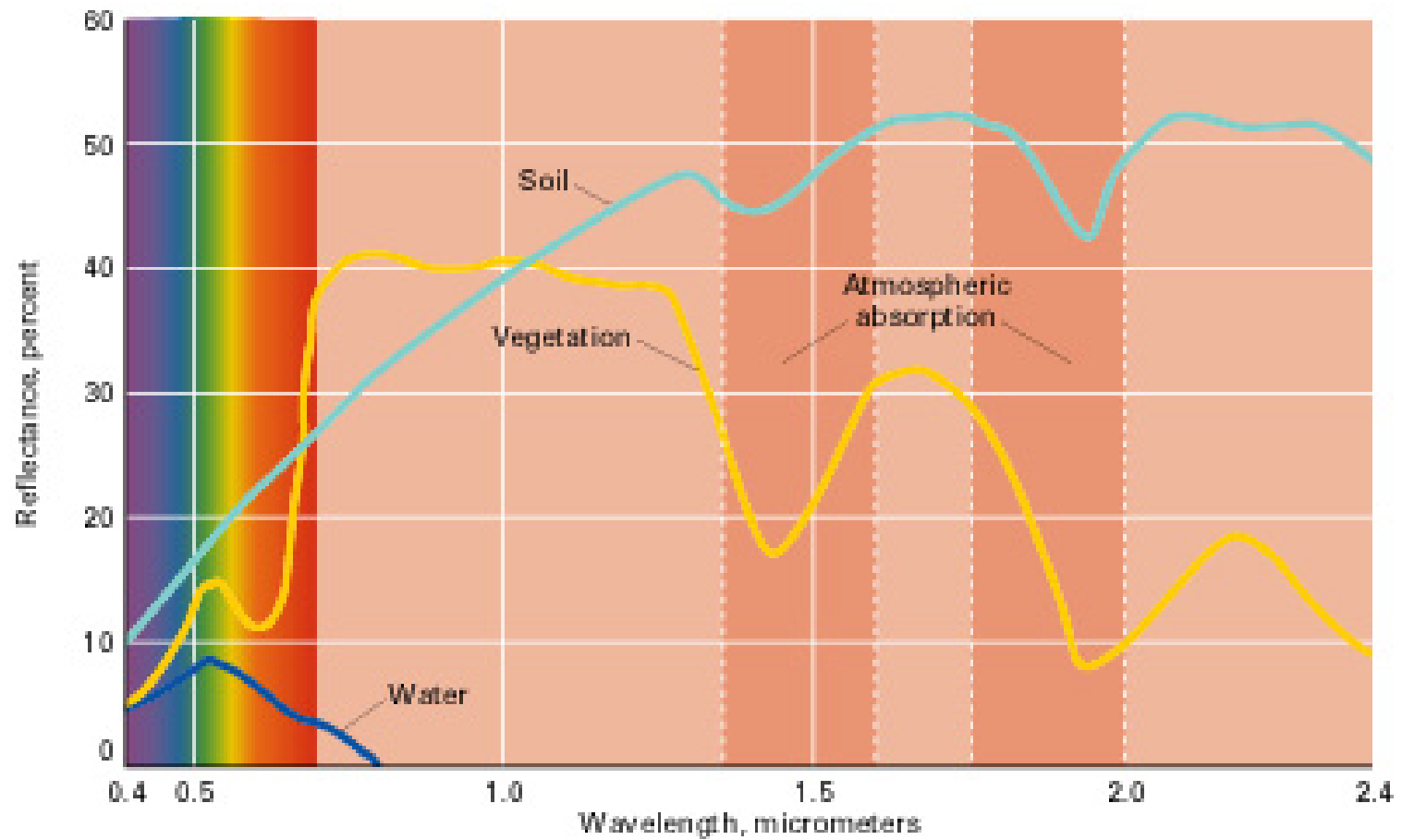
Source: Canadian Centre for Remote Sensing
<http://www.nrcan.gc.ca/>



Electromagnetic Spectrum



Signature Spectra



Resolution

- **There are four types of resolution in remote sensing:**
 - Spatial Resolution
 - Temporal resolution
 - Radiometric resolution
 - Spectral resolution



Spatial Resolution

- **Spatial resolution** is the smallest area on Earth that a satellite can observe.
- Spatial resolution depends on the type of instrument.
- In **low or coarse spatial resolution** images only large features such as cities, forests, and lakes are visible.
 - E.g. 10 kilometer
- In **high or fine spatial resolution** images small objects such as buildings, roads, and trees can be detected.
 - E.g. 10 meter





**Landsat:
30 meters**



**Digital Globe:
< 10 meters**



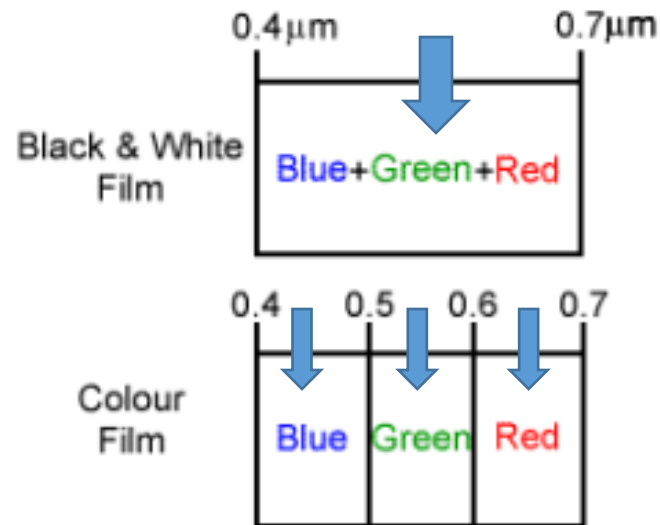
Temporal Resolution

- Temporal resolution is how frequently a satellite observes the same area on Earth.
- The revisit period of a satellite sensor.
- High temporal resolution:
 - E.g. 3 hours (every 3 hours)
- Low temporal resolution:
 - E.g. 16 day (only one observation per 16 days)



Spectral Resolution

- **Spectral resolution** is the ability of a sensor to define fine wavelength intervals.
- The finer the spectral resolution, the narrower the wavelength range for a particular channel or band.
- **Low spectral resolution:**
 - **Black and white film** records wavelengths extending over much of the visible portion of the electromagnetic spectrum.
- **High spectral resolution:**
 - **Color film** has higher spectral resolution and it is sensitive to the blue, green, and red wavelengths.



Source: Canadian Centre for Remote Sensing
<http://www.nrcan.gc.ca/>



Radiometric Resolution

- The radiometric resolution of an imaging system describes its ability to discriminate very slight differences in energy.
- The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy.
- Examples:
 - 8 bit = $2^8 = 256 = (0-255)$
 - 12 bit = $2^{12} = 4096 = (0-4095)$

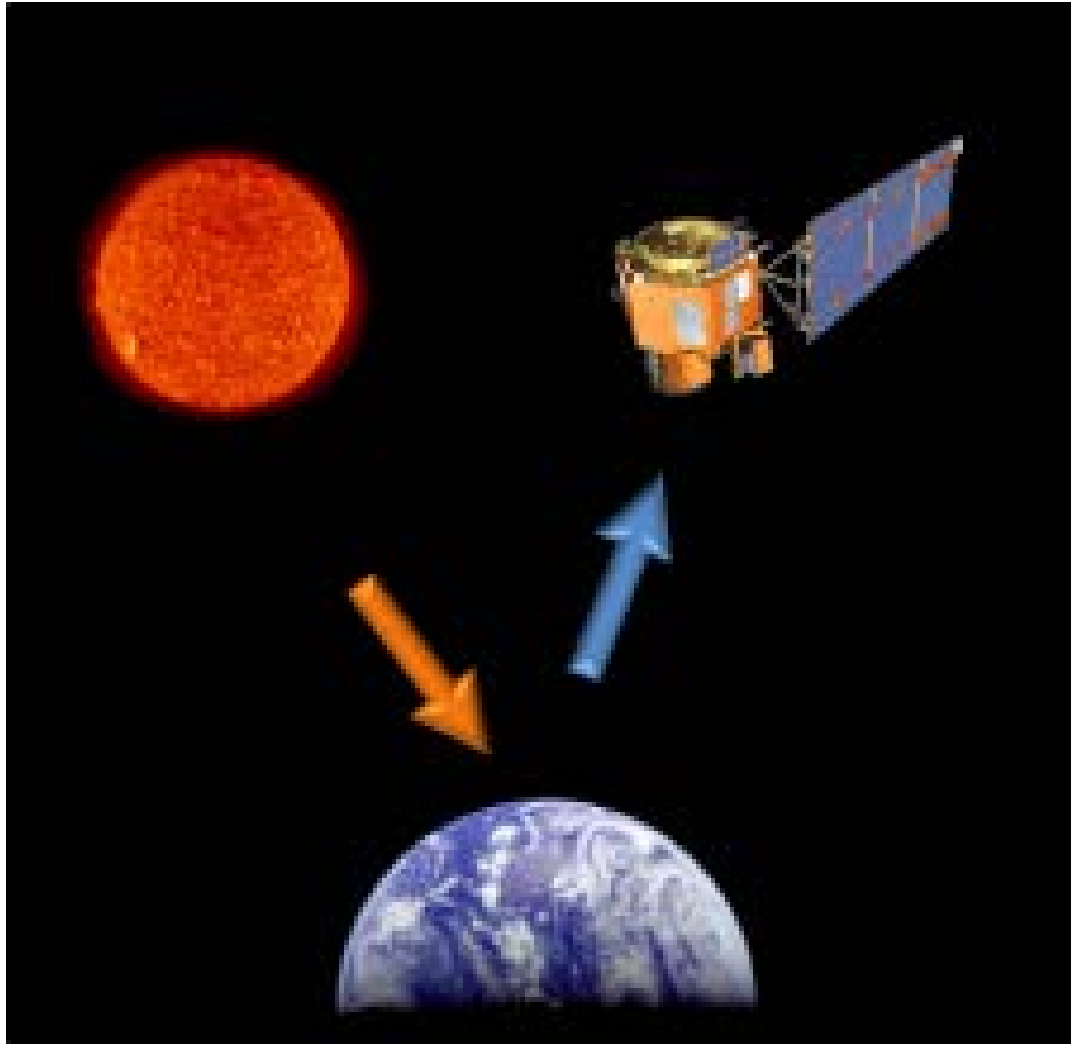


Passive and Active Sensors

- **Passive sensors:**
 - Remote sensing systems that measure energy that is naturally available.
 - They can only be used to detect energy when the naturally occurring energy is available.
 - For all reflected energy, this takes place during the day time.
 - There is **no reflected energy available from the sun at night.**



Passive sensors



<http://www.nasa.gov/>

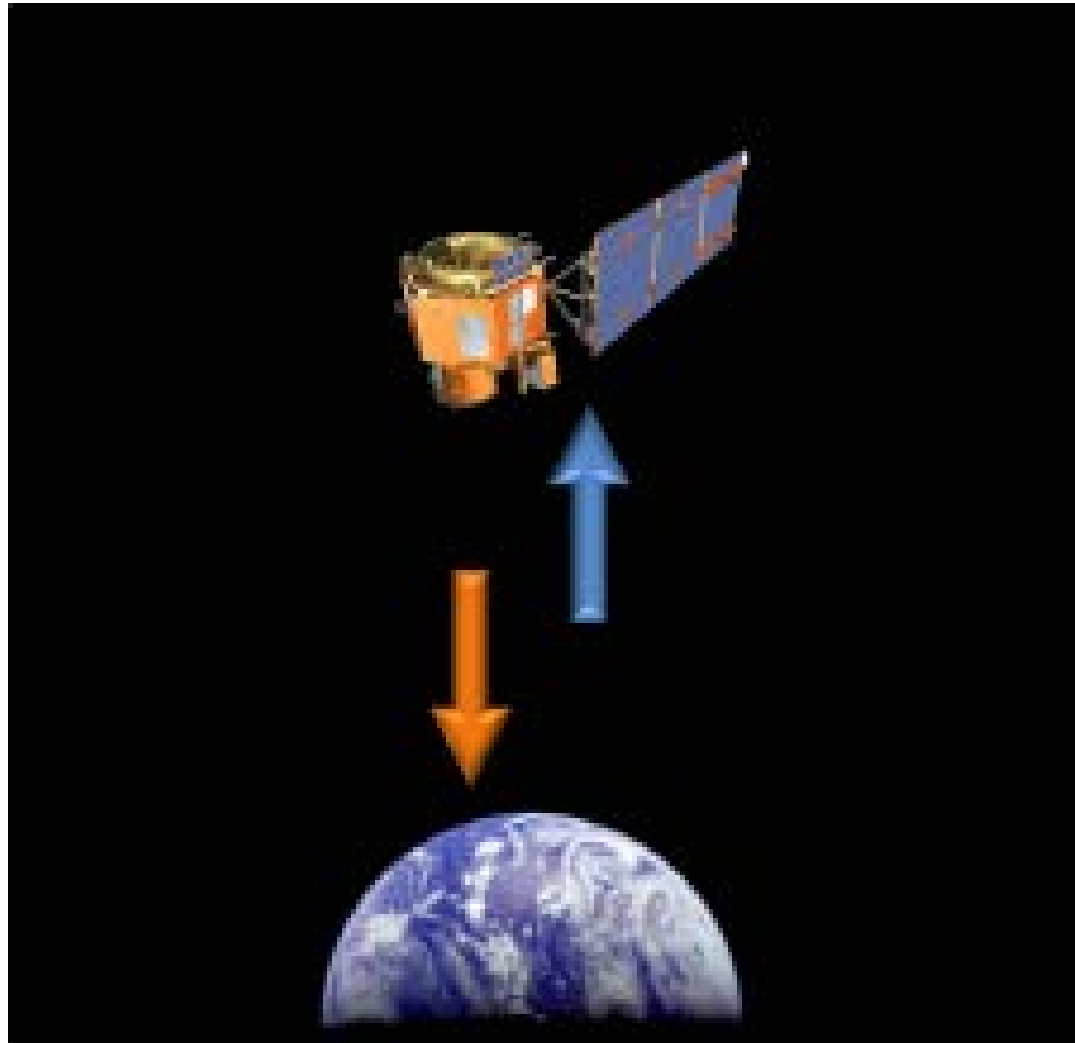


Active sensors

- **An active sensor** provide their own energy source for illumination.
- The **sensor emits radiation** which is directed toward the target to be investigated.
- The radiation reflected from that target is detected and measured by the sensor.
- Active sensors can obtain measurements **anytime, regardless of the time of day or season.**



Active sensor

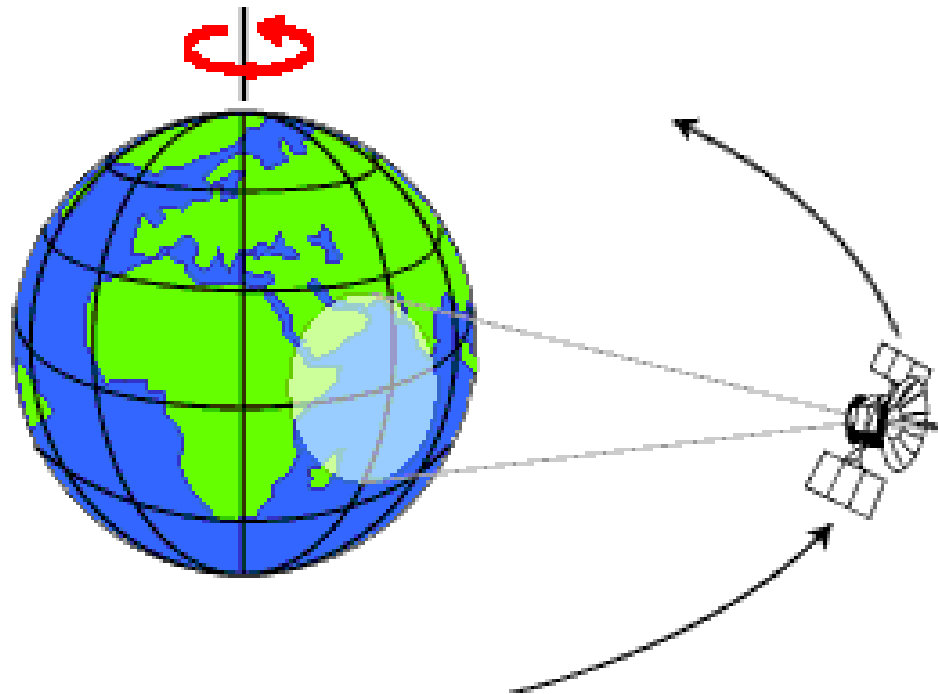


<http://www.nasa.gov/>



Geostationary orbits

- Satellites at very high altitudes (~36,000km), which view the same portion of the Earth's surface at all times have **geostationary orbits**.
- They revolve at speeds which match the rotation of the Earth so they seem stationary, relative to the Earth's surface.
- E.g. Geostationary Operational Environmental Satellites (GOES)

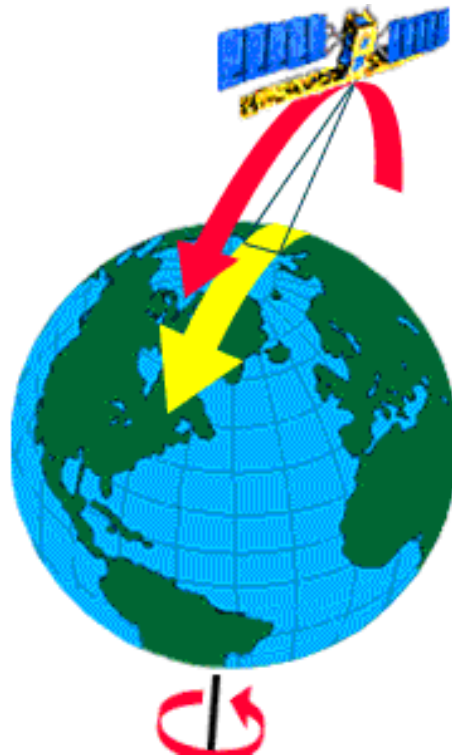


Source: Canadian Centre for Remote Sensing
<http://www.nrcan.gc.ca/>



Sun-synchronous

- **Sun-synchronous satellites** pass over the same part of the Earth at roughly the same local time each day.
- This will allow them to cover most of the Earth's surface over a certain period of time.
- They cover each area of the world at a constant local time of day called **local sun time**.
 - E.g. Landsat, MODIS



NASA Earth Observation Satellites



ASTER

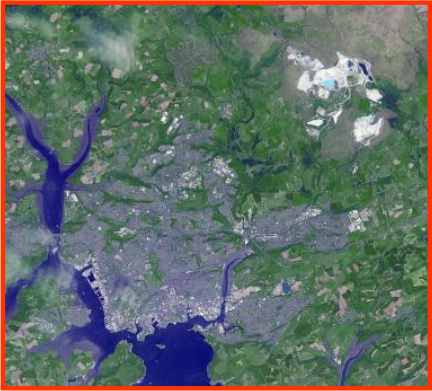
Navigation: JPL HOME | EARTH | SOLAR SYSTEM | STARS & GALAXIES | TECHNOLOGY

ASTER
Advanced Spaceborne Thermal Emission and Reflection Radiometer

SEARCH ASTER: GO

HOME
MISSION
GALLERY
DATA
ABOUT US
PRESENTATIONS & DOCUMENTS
LINKS
LATEST NEWS

LATEST FEATURED IMAGE FROM ASTER:



[Drakelands Mine, England](#)

The Drakelands Mine (previously known as the Hemerdon Mine) is a historic tungsten and tin mine located northeast of Plymouth, England. Tin and tungsten deposits were discovered in 1867, and the mine operated until 1944. [Read More](#). Updated on 8/21/2015

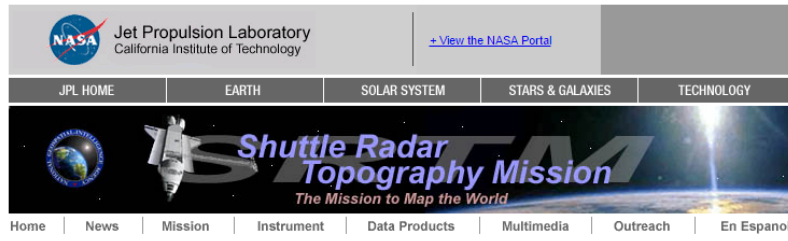
The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is an imaging instrument onboard Terra, the flagship satellite of NASA's Earth Observing System (EOS) launched in December 1999. ASTER is a cooperative effort between NASA, Japan's Ministry of Economy, Trade and Industry (METI), and Japan Space Systems (J-spacesystems). ASTER data is used to create detailed maps of land surface temperature, reflectance, and elevation. The coordinated system of EOS satellites, including Terra, is a major component of NASA's Science Mission Directorate and the [Earth Science Division](#). The goal of NASA Earth Science is to develop a scientific understanding of the Earth as an integrated system, its response to change, and to better predict variability and trends in climate, weather, and natural hazards.

ASTER Data Archive
GET DATA
[Request an Acquisition](#)
Acquisition Calendar
ASTER Global DEM
TerraLook
ASTER Volcano Archive

- ASTER provides high-resolution images of the planet in bands ranging from visible to the thermal infrared.
 - Bands 1-4 (VNIR: visible near infrared) 15 meter
 - Bands 5-10 (SWIR: Shortwave infrared) 30 meter
 - Bands 11-15 (TIR: Thermal Infrared) 90 meter
- ASTER data are used to create detailed maps of land surface temperature, reflectance, and elevation.
- ASTER Global Digital Elevation Model(GDEM) covers the planet from 83 degrees North to 83 degrees South at 30 meter resolution.
- ASTER GDEM version 1 was released in 2009 and version 2 in 2011.



SRTM



Gallery of Images
- Image Policy

Public Data Distribution

Video Multimedia

Project Status
Photojournal Search
SRTM Related
- NASA
- German Aerospace Ctr
- Italian Space Agency

Data Users Forum

Site Index
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U.S. Releases Enhanced Shuttle Land Elevation Data



On September 23, 2014, the White House announced that the highest-resolution topographic data generated from NASA's Shuttle Radar Topography Mission (SRTM) in 2000 will be released globally over the next year. The announcement was made at the United Nations Heads of State Climate Summit in New York. Since then the schedule has been accelerated, and all global SRTM data, except for the Middle East region, has been released.

See the full [JPL Release 2014-321](#).

Previously, SRTM data for regions outside the United States were sampled for public release at 3 arc-seconds, which is 1/1200th of a degree of latitude and longitude, or about 90 meters (295 feet). The new data are being released

with a 1 arc-second, or about 30 meters (98 feet), sampling that reveals the full resolution of the original measurements. Data for most of Africa and its surrounding areas were released with the September 2014 announcement. The next release, in November 2014 included all of South America and North America, most of Europe, and islands in the eastern Pacific Ocean. The most recent release, in January 2015 includes most of continental Asia (now including India), the East Indies, Australia, New Zealand, and islands of the western Pacific.

See an [index map](#) of the newly available full-resolution data. (SRTM did not produce data for the northernmost latitudes or Antarctica.)

The new data are available for download from the [USGS EROS Data Center](#) - see [Public Data Distribution](#) for details.

See the Africa image above and its caption at the [PIA04965](#). A fly around video of the Crater Highlands of Tanzania, using SRTM elevation data and Landsat images is available at http://www.jpl.nasa.gov/video/details.php?id=1335_id=1335.

These additional fly around videos further illustrate SRTM elevation data:

India and the Himalaya Mountains, with Landsat satellite images draped over SRTM elevation data. View the [full size movie here](#).
[A smaller version can be viewed here](#).

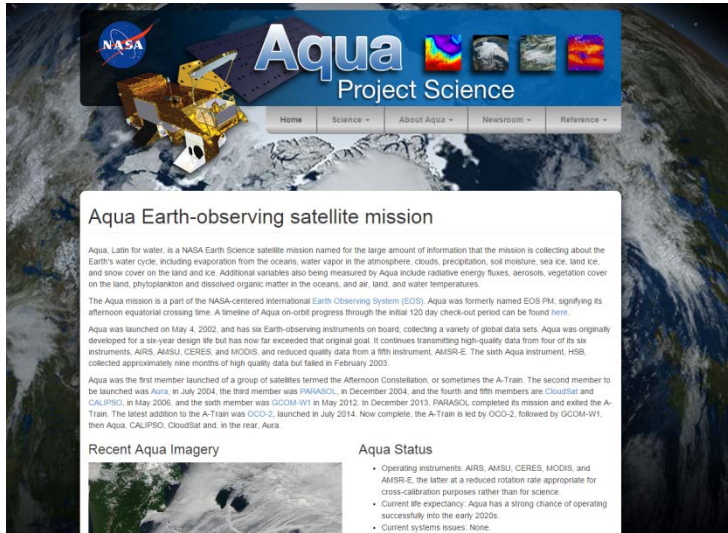
Indonesia, with many volcanoes, starting at Bali, flying westward over Java, and ending at Krakatoa (Pulau Krakatau). This fly around uses only SRTM data, shaded and with colored height. [View the movie here](#).



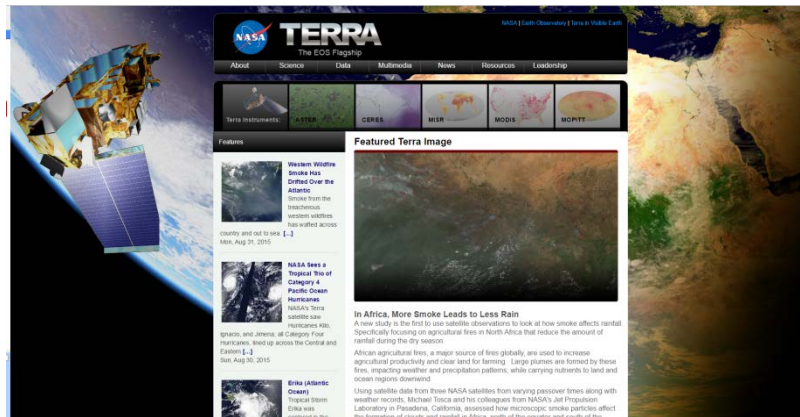
- The Shuttle Radar Topography Mission (SRTM) is an international research effort that obtained digital elevation model on a near-global scale from 56° S to 60° N.
- SRTM flew on board during the 11 day mission in February 2000.
- The resolution of the raw data is 30 meter for the US territory and 90 meter globally.



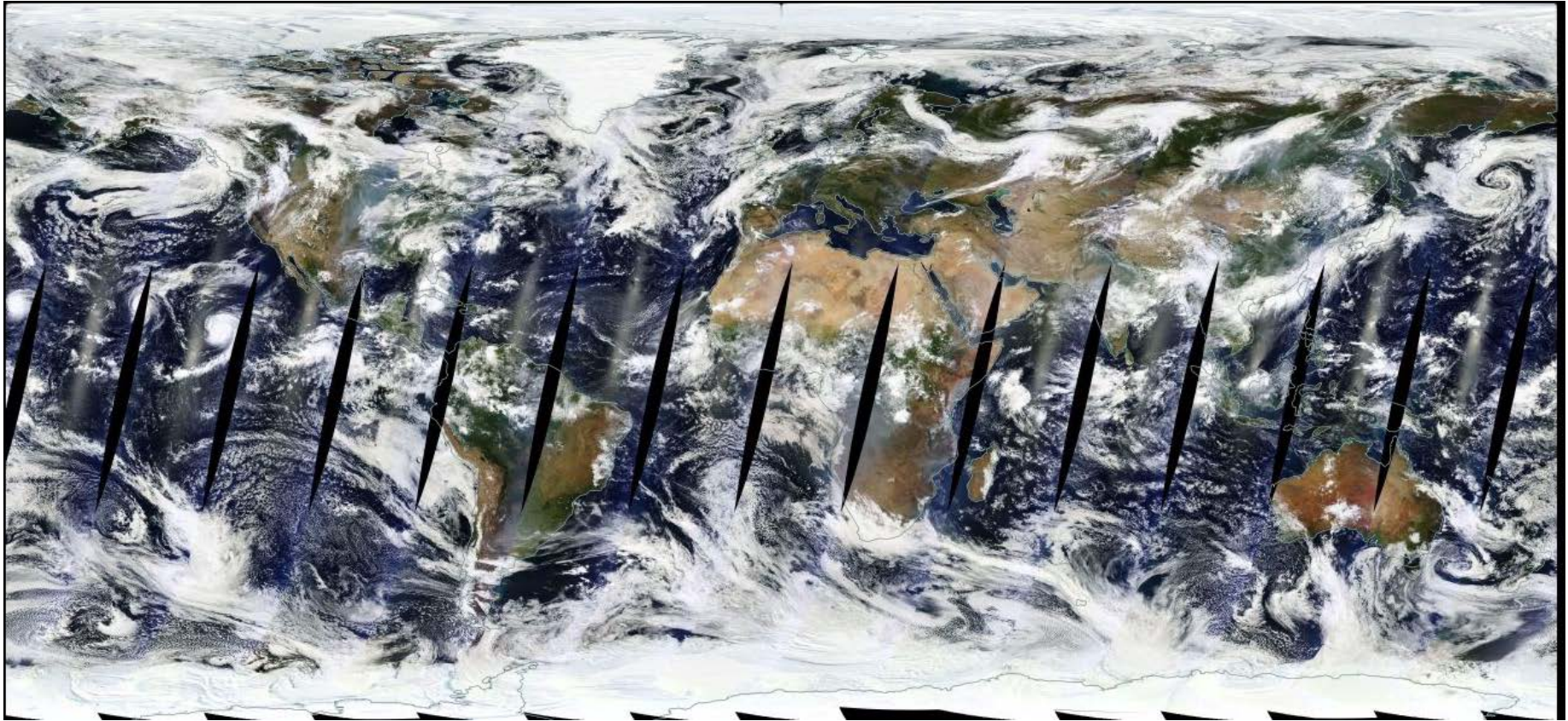
MODIS



- Moderate Resolution Imaging Spectroradiometer (MODIS)
- Two satellites onboard: Terra and Aqua (10:30 am and 1:30 pm equator overpass).
- Terra MODIS and Aqua MODIS are viewing the entire Earth's surface every 1 to 2 days.
- MODIS instrument provides data in 36 spectral bands
- Spatial resolution of 250, 500 and 1000 meters



MODIS (Terra Satellite)



<https://earthdata.nasa.gov/labs/worldview/>



Satellite Derived Indices

- **Vegetation Indices:**

- Normalized difference vegetation index (NDVI)
- Enhanced vegetation index (EVI)

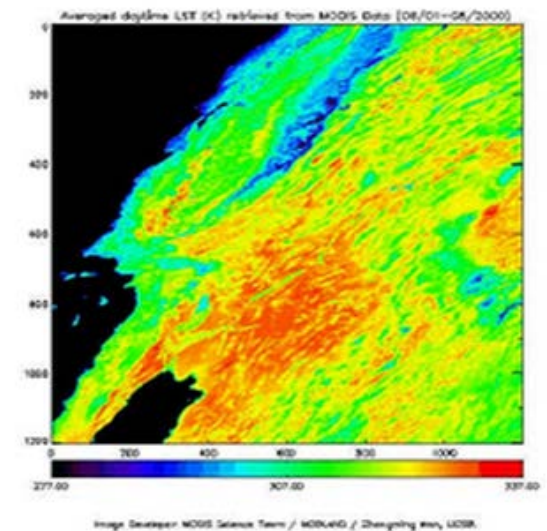


- **Moisture indices:**

- Normalized difference water index (NDWI)
- Evapotranspiration (ET)

- **Temperature:**

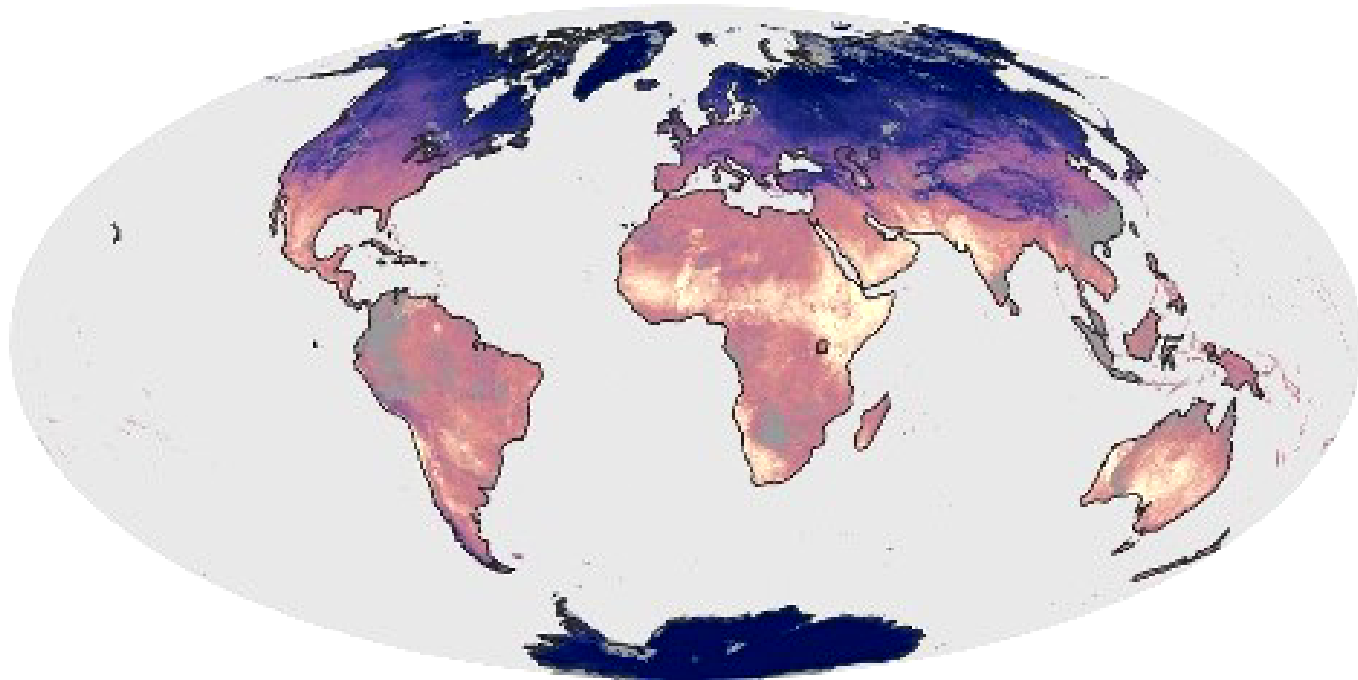
- Land surface temperature (LST)



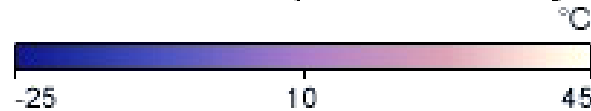
Source: <http://modis-land.gsfc.nasa.gov/>



Land Surface Temperature(MODIS)



Land Surface Temperature (daytime)

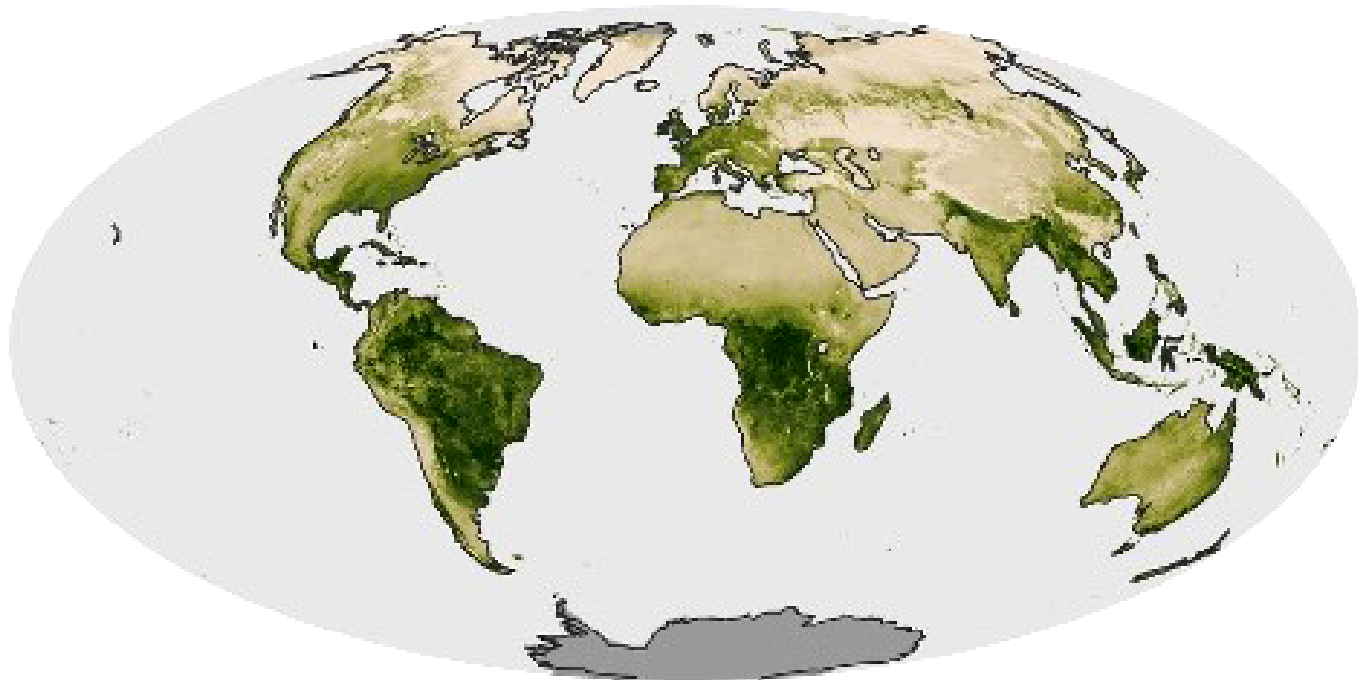


February 2000

www.earthobservatory.nasa.gov



Vegetation Index (MODIS)



Vegetation Index (NDVI)

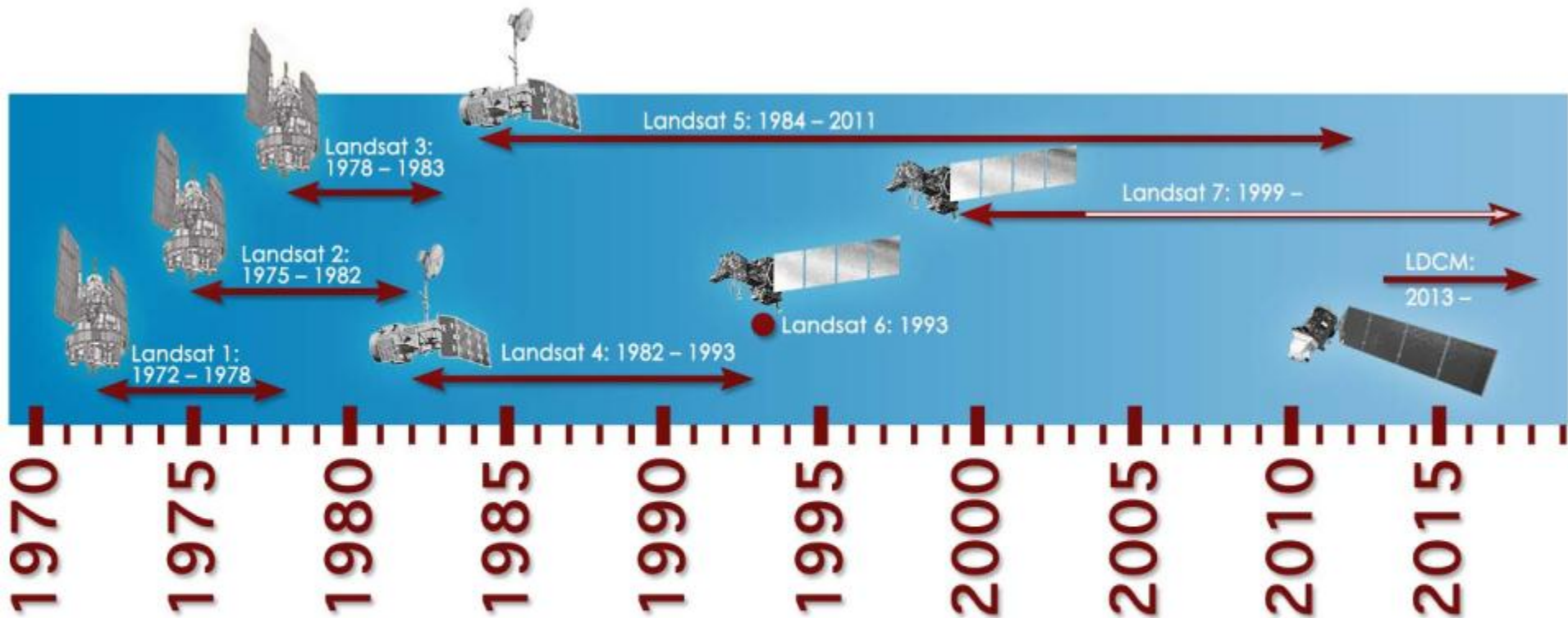


February 2000

www.earthobservatory.nasa.gov



LANDSAT



<http://landsat.usgs.gov>

Four decades of monitoring the Earth!



Landsat

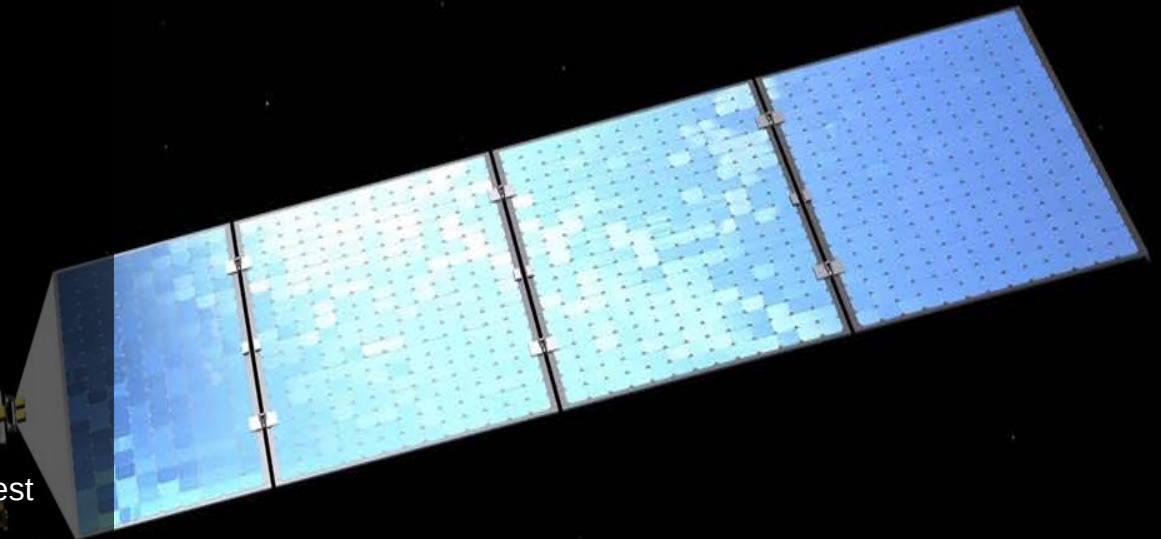
Sensors: 1, 2, 3, 4, 5, 7, 8

Date Range: 1972 to present

Landsat 8, launched in 2013, is the newest sensor in the program, capturing between 550–750 new images every day.

Revisit: 16 days

30/15m per pixel

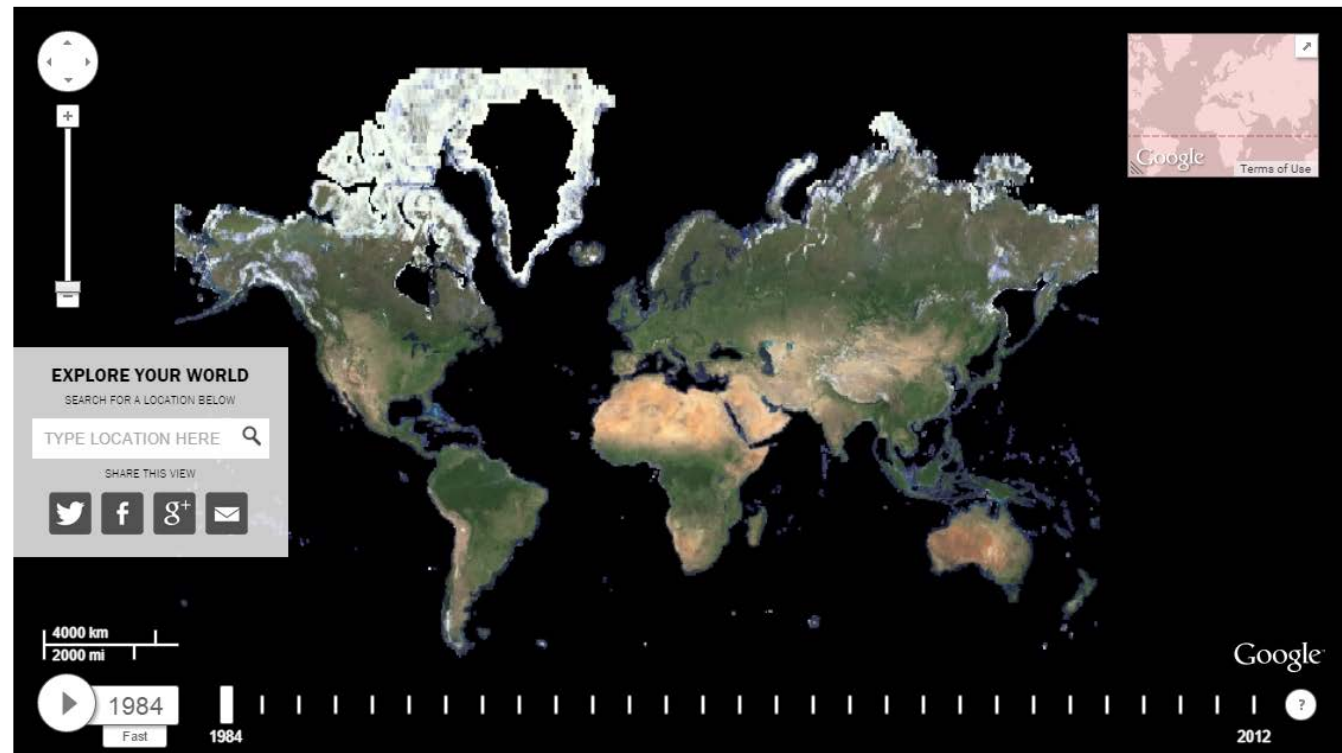


*Image: NASA/Goddard Space Flight Center
Conceptual Image Lab*



Timelapse

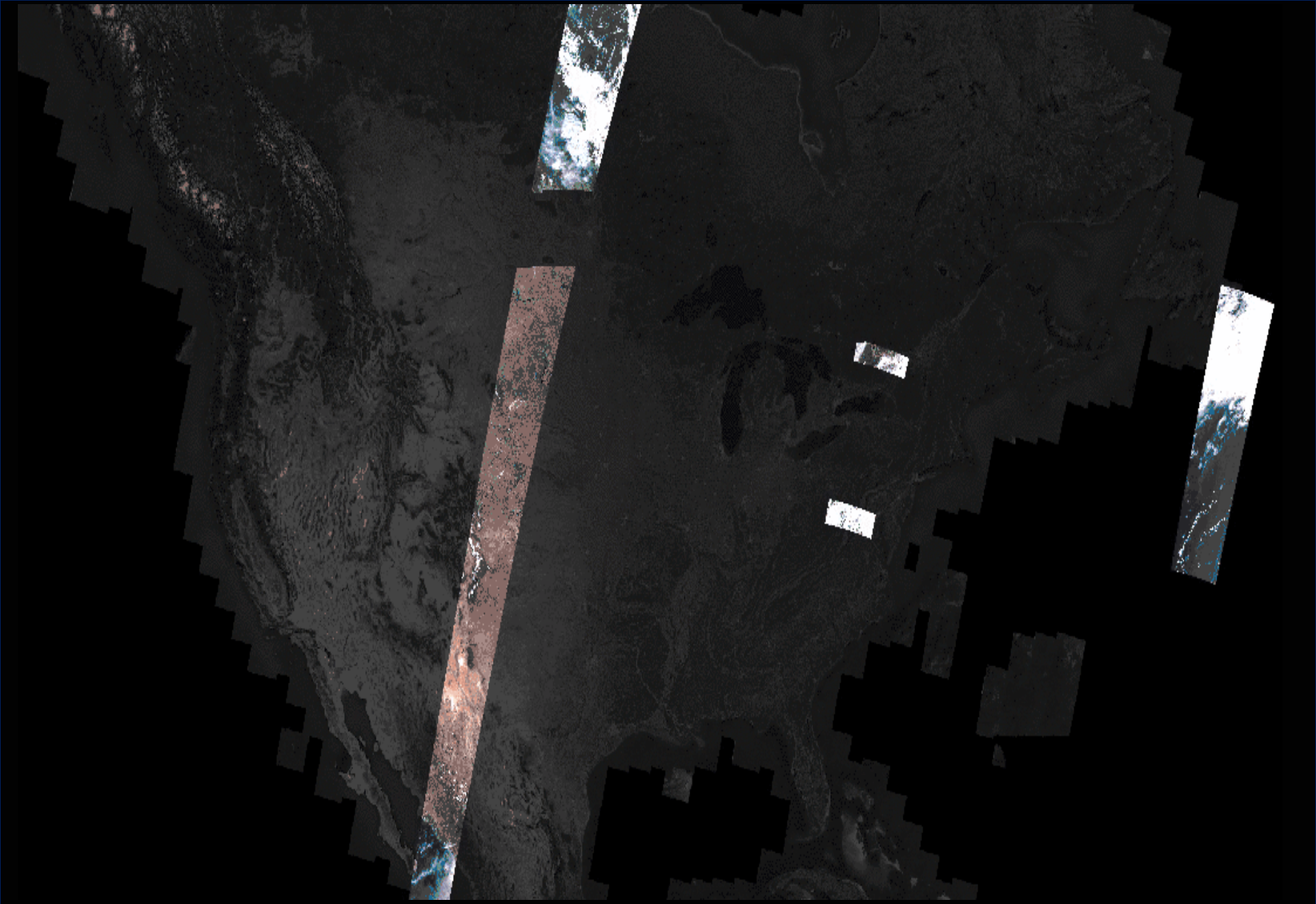
- Timelapse is powered by Google.
- It uses global scale historical archives of Landsat satellite imagery from 1984-2012 to monitor change on the planet.



Sentinel 2A

- Part of The European Space Agency's Copernicus Program
- First satellite in orbit since 6/2015
- Second (expected) launch: 4/2017
- **Revisit (at equator): 5 days***
- 10m per pixel

Photo: ESA/ATG medialab



Sentinel 1

- Part of The European Space Agency's Copernicus Program
- Uses radar to image the Earth in all weather conditions, even at night.
- The satellites capture C-band synthetic aperture radar (SAR) image data at 30- to 120-meter resolution in several polarization modes.

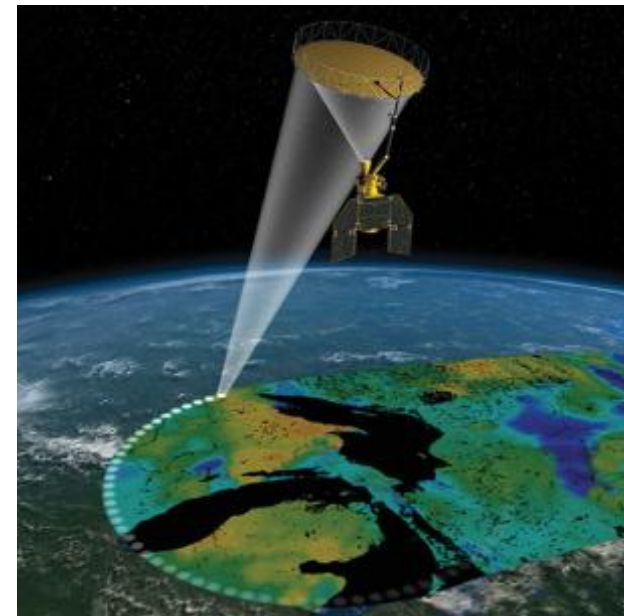


Photo: ESA–Pierre Carril

SMAP

(Soil Moisture Active Passive)

- SMAP provides a capability for global mapping of soil moisture with enhanced accuracy and temporal resolution.
- The mission acquires these measurements for at least three years with global coverage.
- 1-47 km spatial resolution
- Providing global coverage:
 - Within 3 days at the equator and
 - 2 days at boreal latitudes (>45 degrees N).
- **Potential application areas:**
 - **Weather Forecasting**
 - **Drought**
 - **Flood and Landslide**
 - **Agricultural Productivity**
 - **Human Health**



SMAP

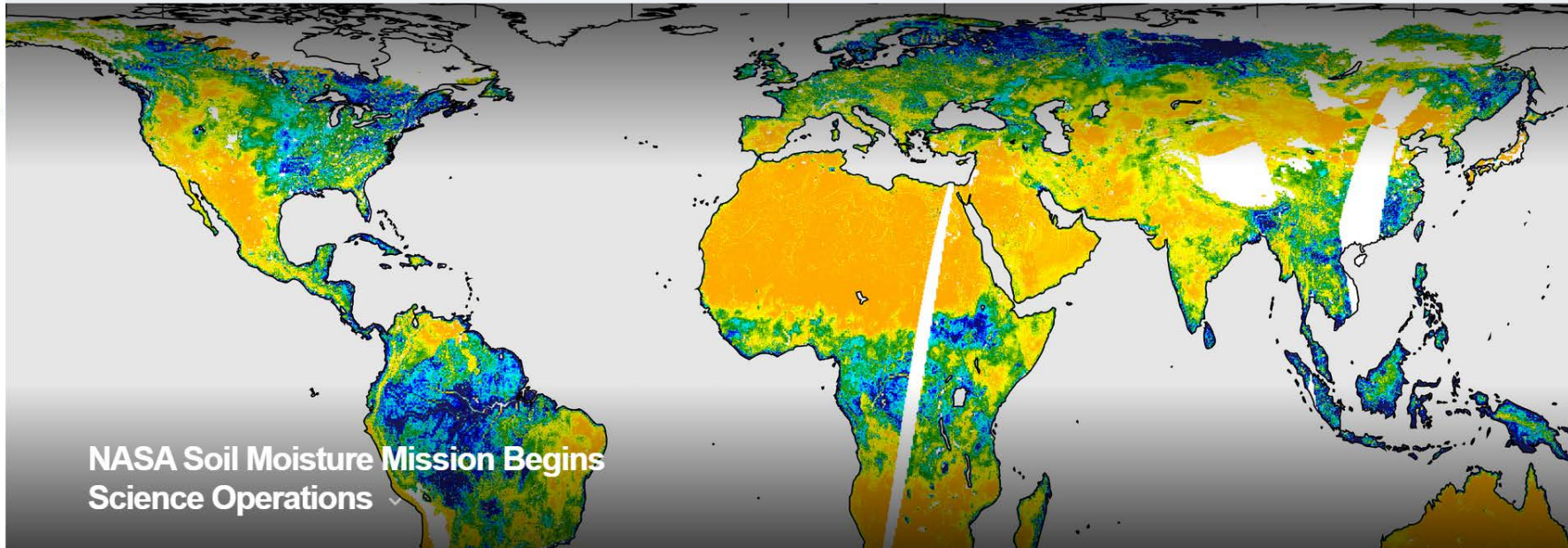


Jet Propulsion Laboratory
California Institute of Technology

SMAP SOIL MOISTURE
ACTIVE PASSIVE



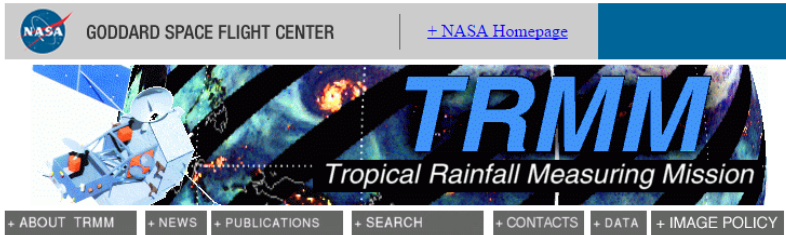
[Mission](#) [Observatory](#) [Science](#) [Data](#) [Multimedia](#) [Education](#) [News & Events](#)



**NASA Soil Moisture Mission Begins
Science Operations**



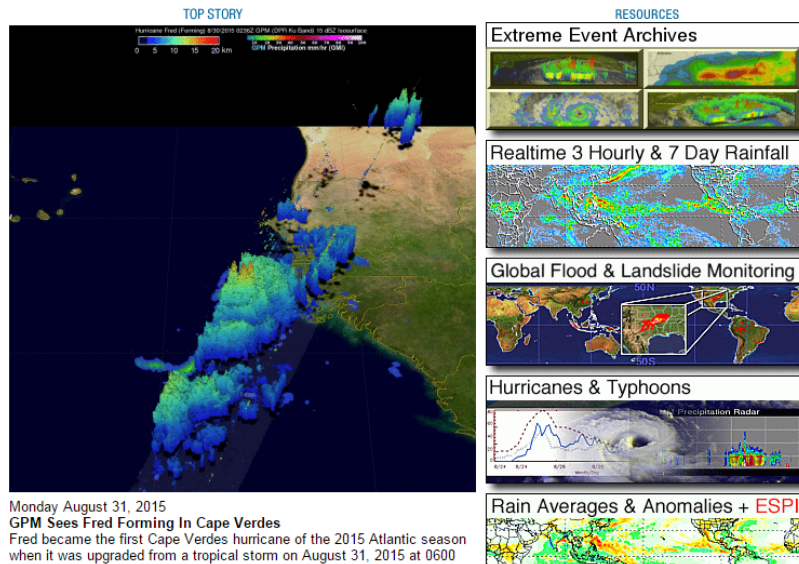
TRMM



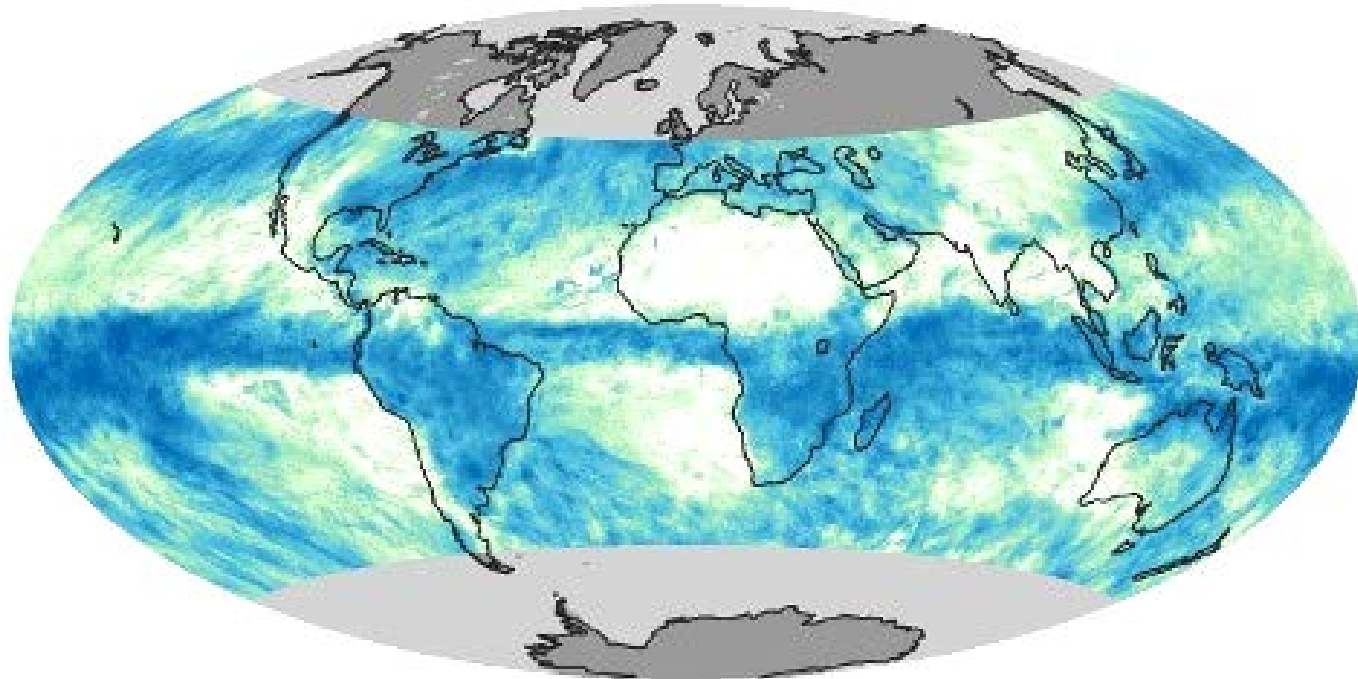
- Tropical Rainfall Measuring Mission
- TRMM is a joint mission between NASA and JAXA since 1997.
- Daily temporal resolution (~3 hourly)
- Spatial coverage extends from 50 degrees south to 50 degree north latitude.
- Spatial resolution of 25km
- Three instruments:
 - TRMM Microwave Imager (TMI)
 - Precipitation Radar (PR)
 - Visible and Infrared Scanner (VIRS)

The Tropical Rainfall Measuring Mission (TRMM), a joint mission between NASA and the Japan Aerospace Exploration Agency (JAXA) to study rainfall for weather and climate research, officially came to an end on April 15, 2015 (see <http://pmm.nasa.gov/trmm/mission-end>). Launched in November 1997, with a design lifetime of 3 years, TRMM produced over 17 years of valuable scientific data. TRMM carried 5 instruments: a 3-sensor rainfall suite (PR, TMI, VIRS) and 2 related instruments (LIS and CERES). TRMM delivered a unique 17-year dataset of global tropical rainfall and lightning. The TRMM dataset became the space standard for measuring precipitation, and led to research that improved our understanding of tropical cyclone structure and evolution, convective system properties, lightning-storm relationships, climate and weather modeling, and human impacts on rainfall. The data also supported operational applications such as flood and drought monitoring and weather forecasting.

[TRMM Reentry Assessment \(pdf file\)](#)
[\(6/3/2015\) Frequently Asked Questions about TRMM Spacecraft Re-Entry.](#)



Precipitation (TRMM)



Total Rainfall

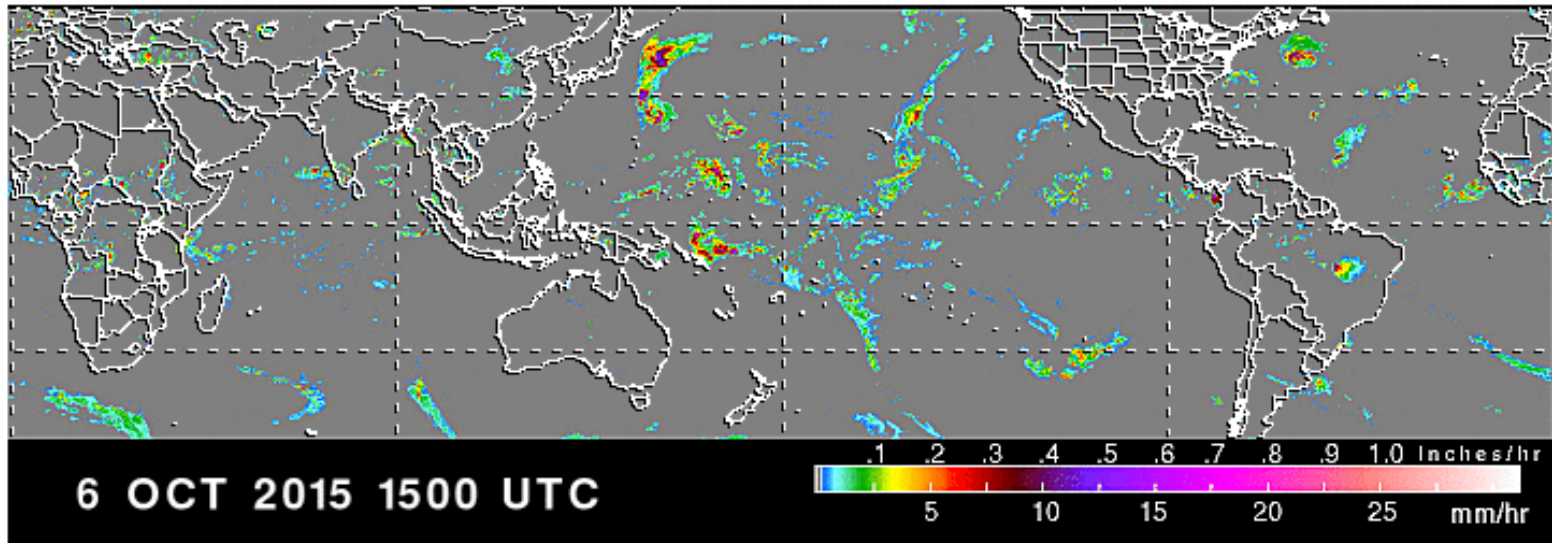


January 1998

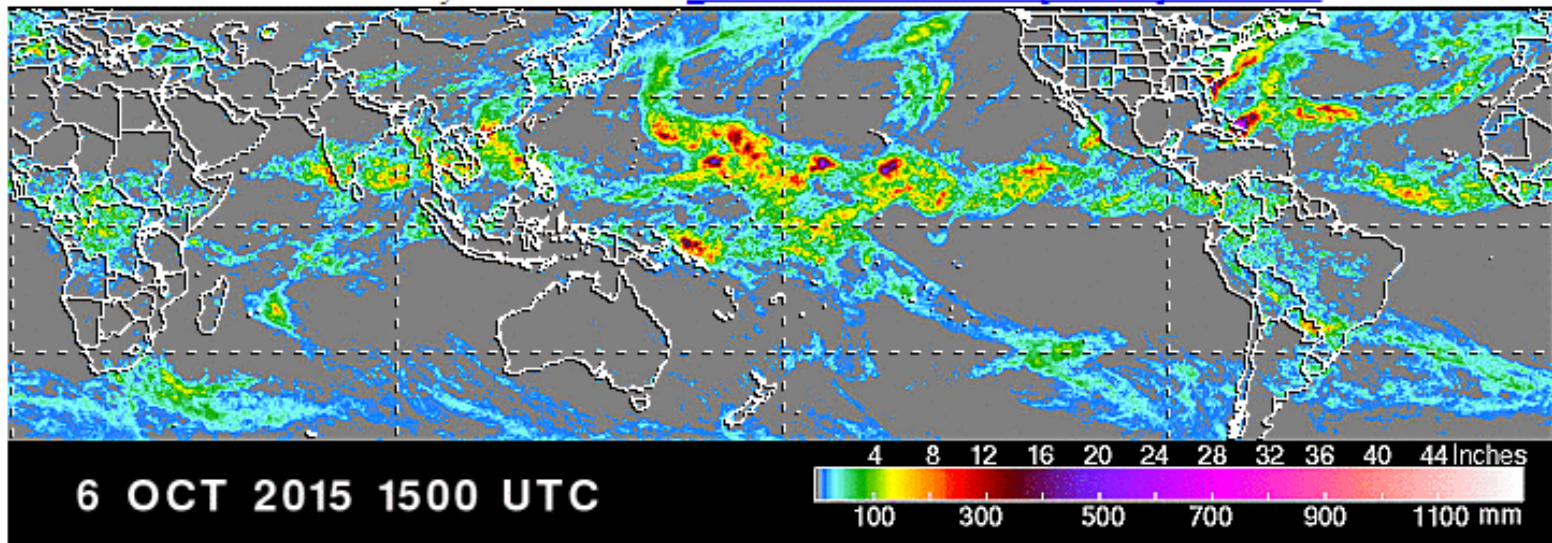
www.earthobservatory.nasa.gov



Global Rainfall



Latest 3 Hourly Global Rainfall [Click to See a Medium \[1.7 MB\] Animation](#)

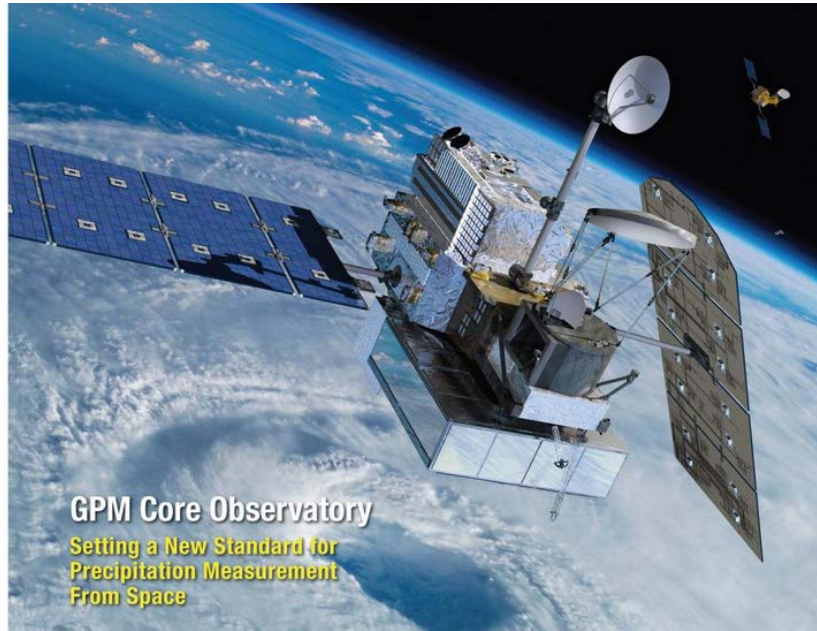


Latest Week of Global Rainfall Accumulation [Click to See a Medium \[1.7 MB\] Animation](#)

<http://trmm.gsfc.nasa.gov/>



GPM



- The GPM Core Observatory is a consortium of GPM partners in the United States, Japan, France, India, and Europe.
- The GPM observes precipitation over the entire globe every 2-3 hours.
- Spatial resolution of 25km
- The Core satellite will measure rain and snow using two science instruments:
 - The GPM Microwave Imager (GMI) and
 - The Dual-frequency Precipitation Radar (DPR).
- GPM covers the Earth from 65°S to 65°N - from about the Antarctic Circle to the Arctic Circle.

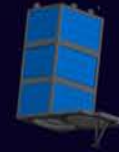
http://www.nasa.gov/mission_pages/GPM



GPM Advancement of TRMM

- GPM launched February 27, 2014.
- The design of the GPM is an advancement of TRMM.
- The GPM instruments extend the capabilities of the TRMM sensors to detect falling snow, measure light rain.
- This is significant because light rain and falling snow account for a significant fraction of precipitation occurrence in middle and high latitudes.





Terra Bella

SkySat public imagery

SKYSAT/GEN-A/PUBLIC/ORTHO

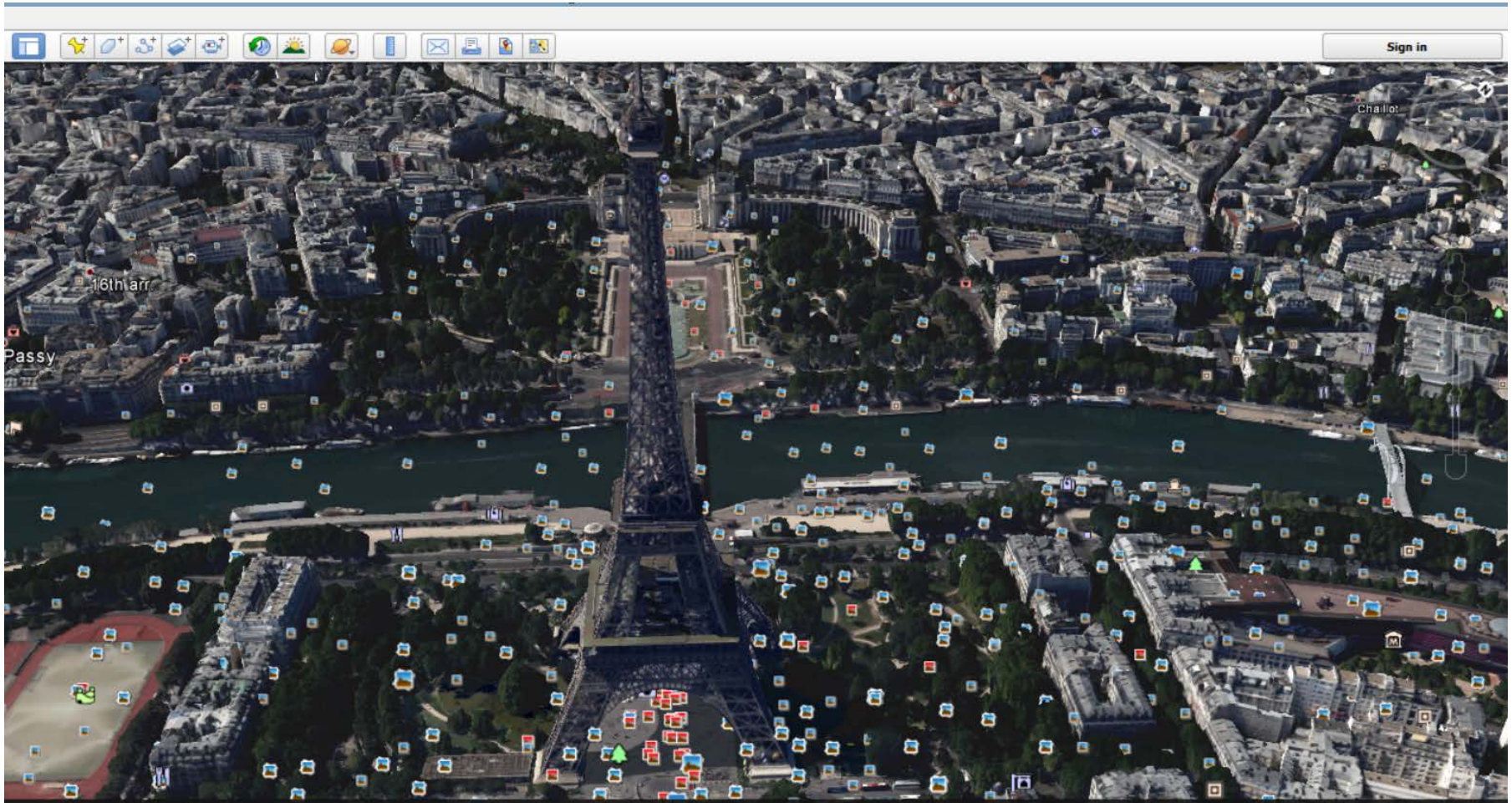
- /RGB
 - Three pansharpened, 8-bit bands: Red, Green, Blue
 - Resolution: ~0.8 m per pixel (closer to 1 m off-nadir)
- /MULTISPECTRAL
 - Five 16-bit bands:
 - Blue (450-515 nm)
 - Green (515-595 nm)
 - Red (605-695 nm)
 - Near-Infrared (740-900 nm)
 - Panchromatic (450-900 nm)
- **Resolution:**
 - B, G, R and Near-IR: ~2m per pixel,
 - Pan: ~0.8 m per pixel (closer to 1 m off-nadir)
- **Data type:** 16-bit, shifted up from original 12-bit



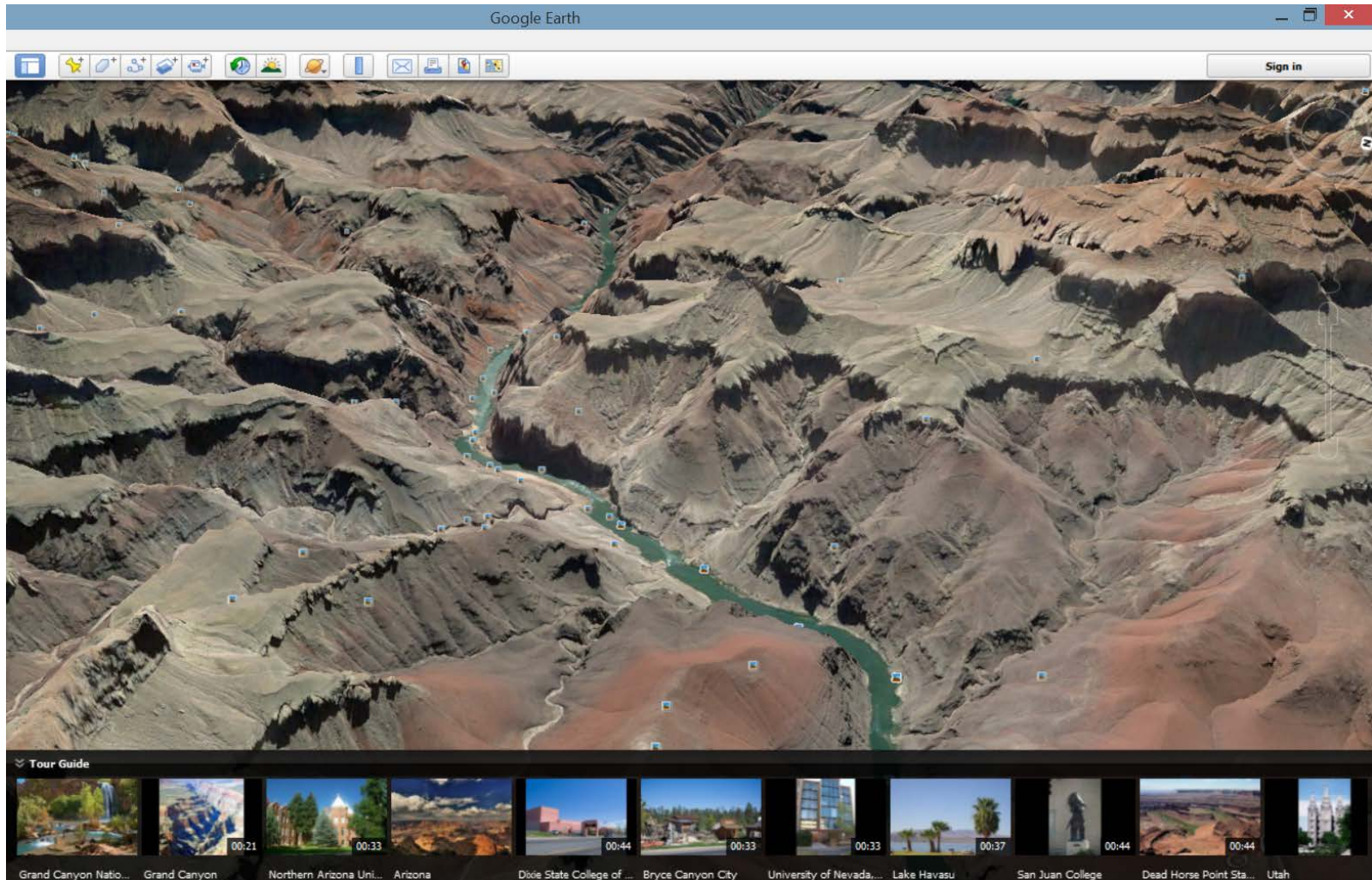
SkySat 1 and 2 Satellites



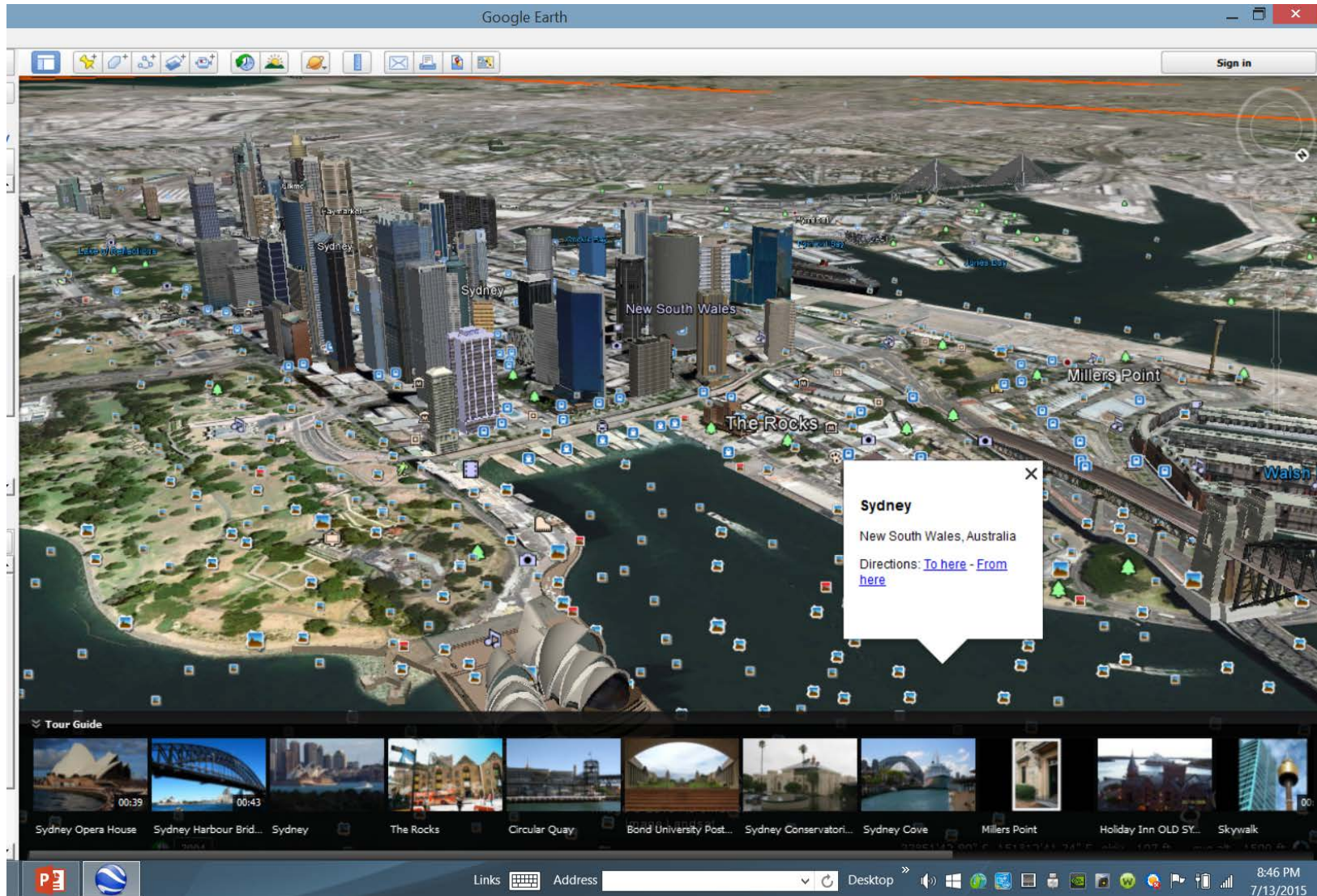
Google Earth: Paris



Google Earth: Grand canyon



Google Earth: Sydney



Remote Sensing Data Access

- **Google Earth Engine**
<https://earthengine.google.org>
- **Earthexplorer**
<http://earthexplorer.usgs.gov/>
- **The USGS Global Visualization Viewer (GloVis)**
<http://glovis.usgs.gov/>
- **LPDAAC**
(Land Processes Distributed Archive Data Center)
https://lpdaac.usgs.gov/data_access/data_pool
- **Earthdata**
<https://search.earthdata.nasa.gov/>
- **GDEx**
<http://gdex.cr.usgs.gov/gdex/>



A planetary-scale platform for Earth science data & analysis

Powered by Google's cloud infrastructure

▶ WATCH VIDEO

Meet Earth Engine

Google Earth Engine combines a multi-petabyte catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities and makes it available for scientists, researchers, and developers to detect changes, map trends, and quantify differences on the Earth's surface.



Google Earth Engine

<https://earthengine.google.org>

The screenshot displays the Google Earth Engine workspace. The top navigation bar includes the Google Earth Engine logo, a search bar, and links for 'Send feedback' and 'alenaychu79@gmail.com'. The main map area shows a world map with various countries labeled. The left sidebar contains the 'Earth Engine' logo, a search bar, and a 'Data' section with 'Add data' and 'Add computation' buttons. Below this is the 'Analysis' section with a 'None' dropdown. The 'Data Catalog' section lists 'Popular Tags' (daily, 8-day, 32-day) and 'Surface reflectance' data. The '8-day mosaics' section lists 'MYD09Q1 Surface Reflectance 8-Day L3 Global 250m' and 'Landsat 8 8-Day Raw Composite'. The bottom status bar shows the map data is from 2015, the scale is 1000 km, and there are 21+ downloads.

Google Earth Engine

Search Places, Keywords, Tables, or Asset IDs...

Earth Engine

Manage workspace

Data

Add data Add computation

Analysis: None

Home Data Catalog Workspace

Map Satellite

Popular Tags

daily 8-day 32-day

surface_reflectance radiance toa mc4394 usgs srtm

Contribute to Earth Engine

We are continually adding new datasets and updating existing datasets with new data as it becomes available.

Would you like to contribute data to the Earth Engine catalog? Contact our data team.

Surface reflectance

MYD09Q1 Surface Reflectance 8-Day L3 Global 250m - open in workspace

USGS LPDAAC - Every 8 days from 2002 to 2015

The MODIS Surface Reflectance products provide an estimate of the surface spectral reflectance as it would be measured at ground level in the absence of atmosphere.

MOD09A1 Surface Reflectance 8-Day Global 500m - open in workspace

USGS LPDAAC - Every 8 days from 2000 to 2015

The MODIS Surface Reflectance products provide an estimate of the surface spectral reflectance as it would be measured at ground level in the absence of atmosphere.

MOD09Q1 Surface Reflectance Daily L2 Global 250m - open in workspace

USGS LPDAAC - Every 8 days from 2000 to 2015

The MODIS Surface Reflectance products provide an estimate of the surface spectral reflectance as it would be measured at ground level in the absence of atmosphere.

More surface reflectance data

8-day mosaics

MYD09Q1 Surface Reflectance 8-Day L3 Global 250m - open in workspace

USGS LPDAAC - Every 8 days from 2002 to 2015

The MODIS Surface Reflectance products provide an estimate of the surface spectral reflectance as it would be measured at ground level in the absence of atmosphere.

Landsat 8 8-Day Raw Composite - open in workspace

USGS - Every 8 days from 2013 to 2015

These Landsat 8 composites are made from Level 1T orthorectified scenes, using the DN values, representing scaled, calibrated at-sensor radiance. These are...

MOD09Q1 Surface Reflectance 8-Day Global 250m - open in workspace

USGS LPDAAC - Every 8 days from 2000 to 2015

The MODIS Surface Reflectance products provide an estimate of the surface spectral reflectance as it would be measured at ground level in the absence of atmosphere.

More 8-day mosaics

Map data ©2015 Google, INEGI 1000 km Terms of Use

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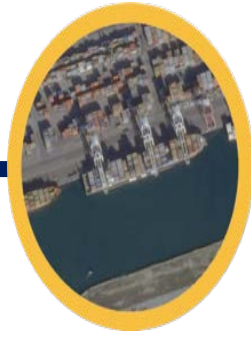
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Landsat & Sentinel
10-30m, 14-day



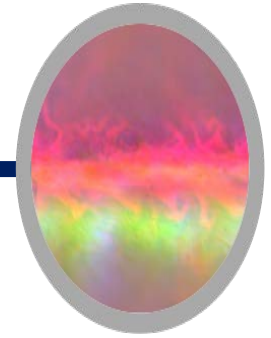
MODIS
250m daily



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Terrain &
Land Cover



Weather & Climate
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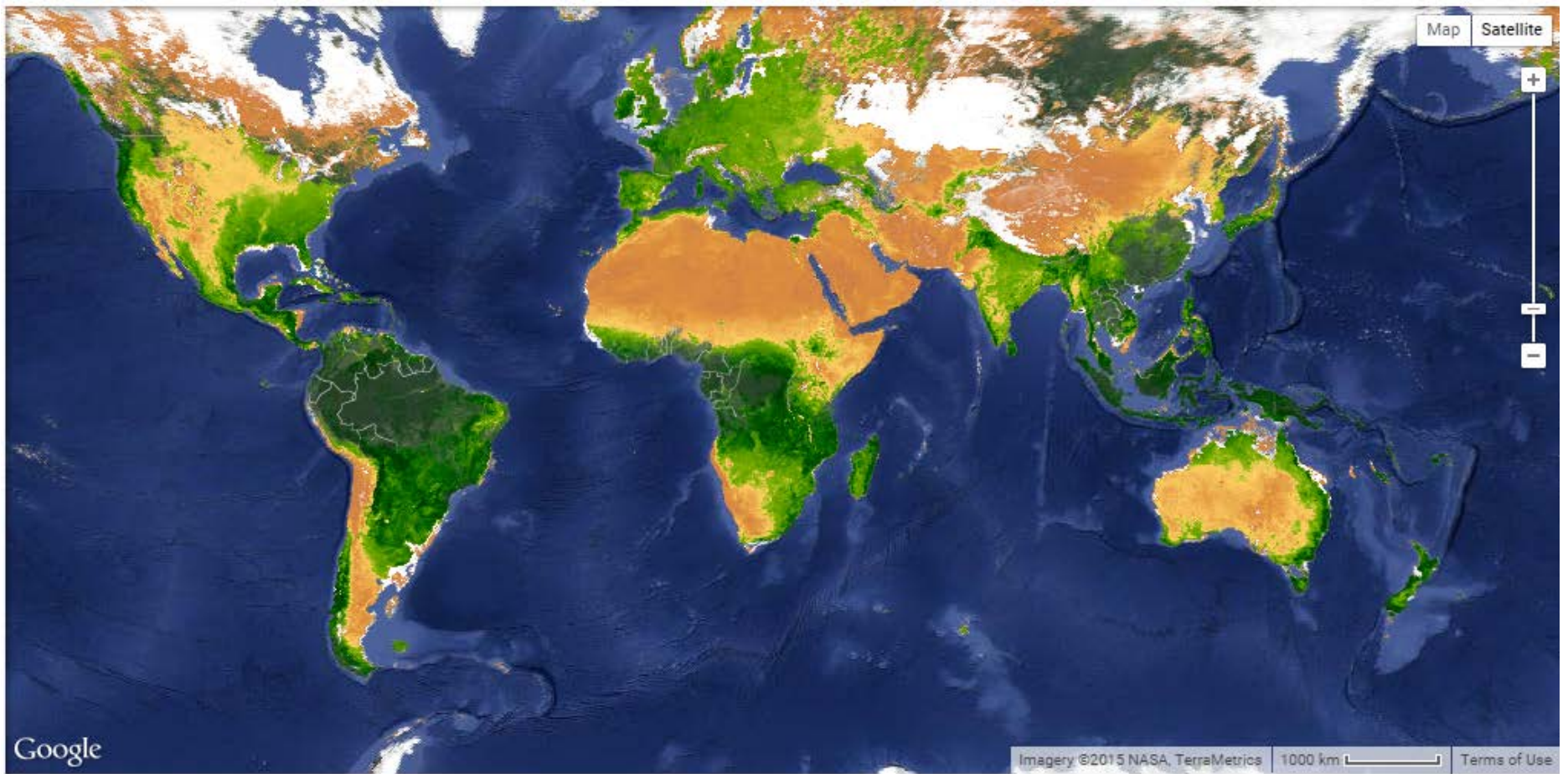
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> 4000 new images every day

> 5 million images

> 5 petabytes of data





MODIS Normalized Difference Vegetation Index (March 2015)



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(Land Processes Distributed Archive Data Center)

https://lpdaac.usgs.gov/data_access/data_pool

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Data Pool

The Data Pool is the publicly available portion of the LP DAAC online holdings. Data Pool provides a more direct way to access files by foregoing their retrieval from the nearline tape storage devices. All Data Pool holdings are available at no cost to the user.

Available datasets include:

- All MODIS data holdings
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- ASTER Level - 1A and Level - 1B Expedited data
- All WELD data holdings
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- All ASTER GED data holdings

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LP DAAC2Disk Download Manager

Direct access to data directories for immediate HTTP retrieval is available

ASTER

MODIS AQUA

MODIS TERRA

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WELD

SRTM

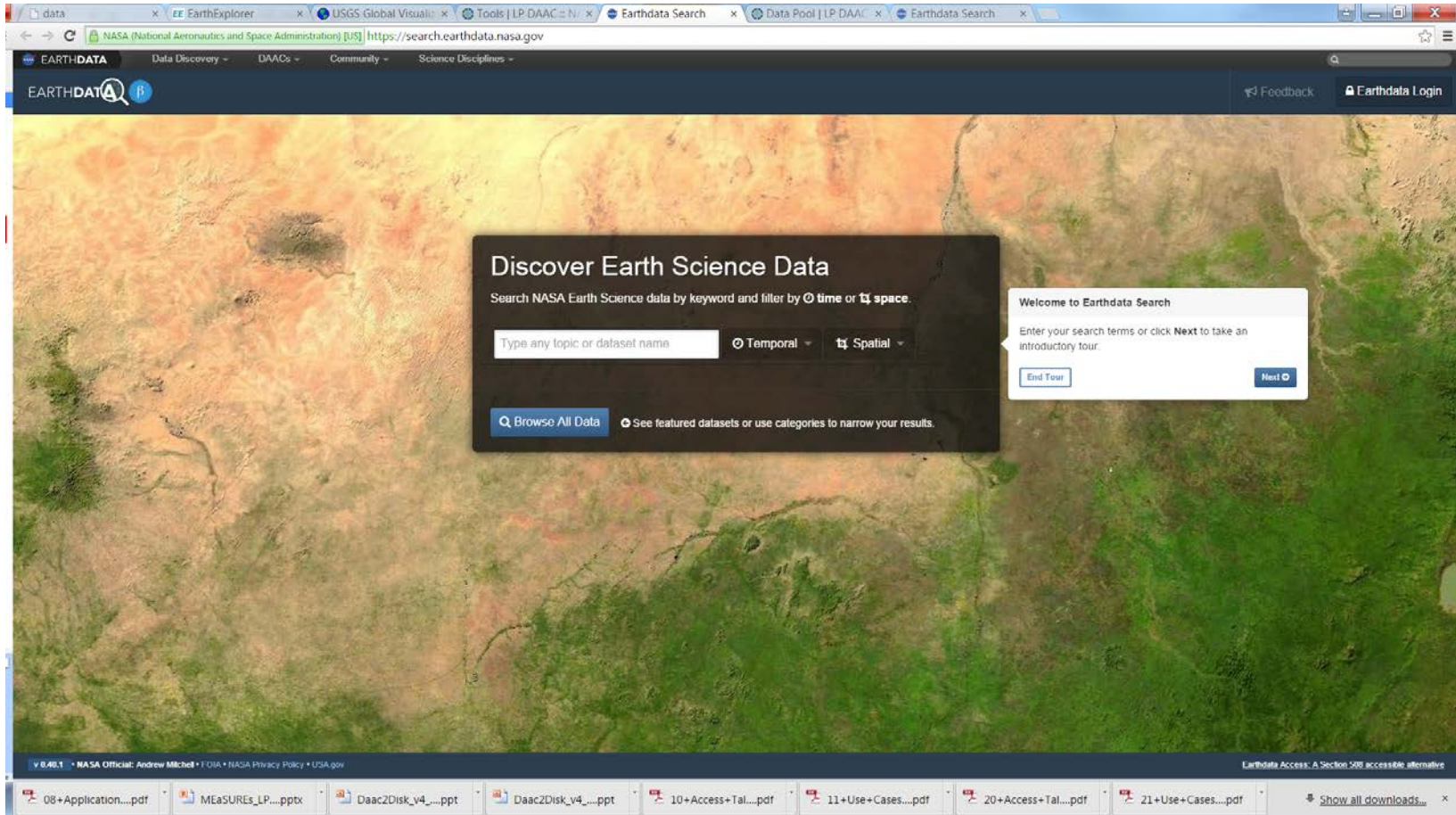
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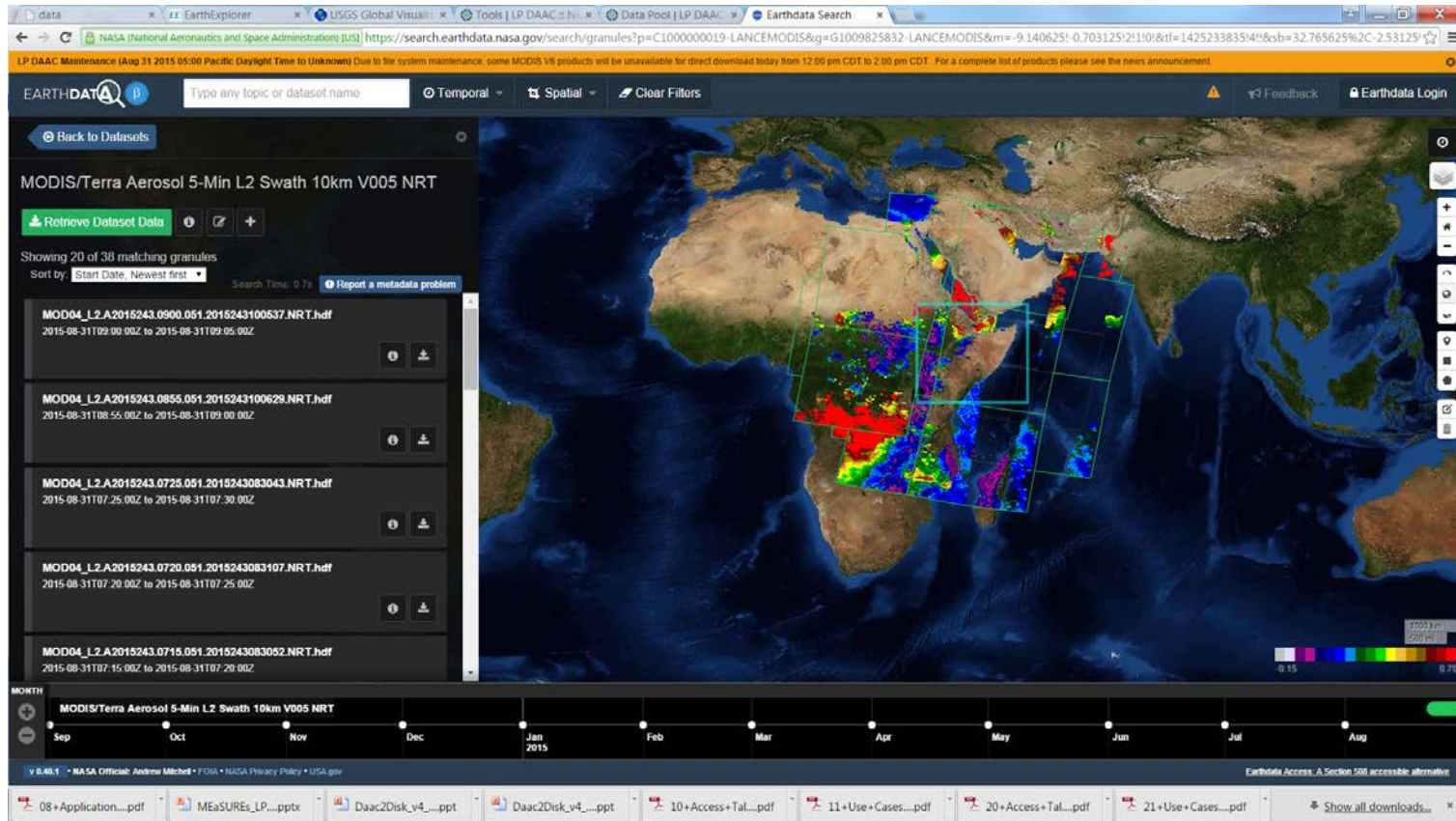


Earthdata offers discovering, searching, visualizing, and retrieving remote sensing.



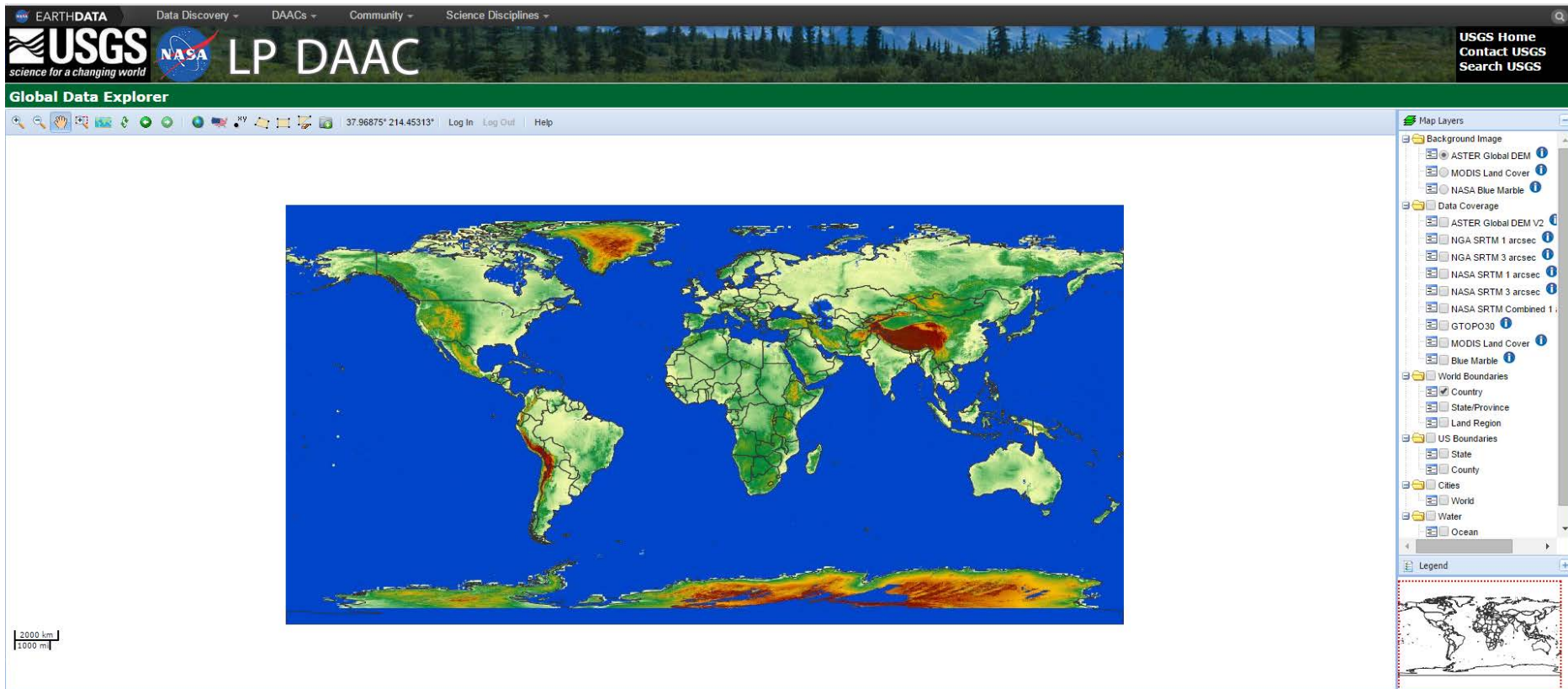
Earthdata

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GDEx

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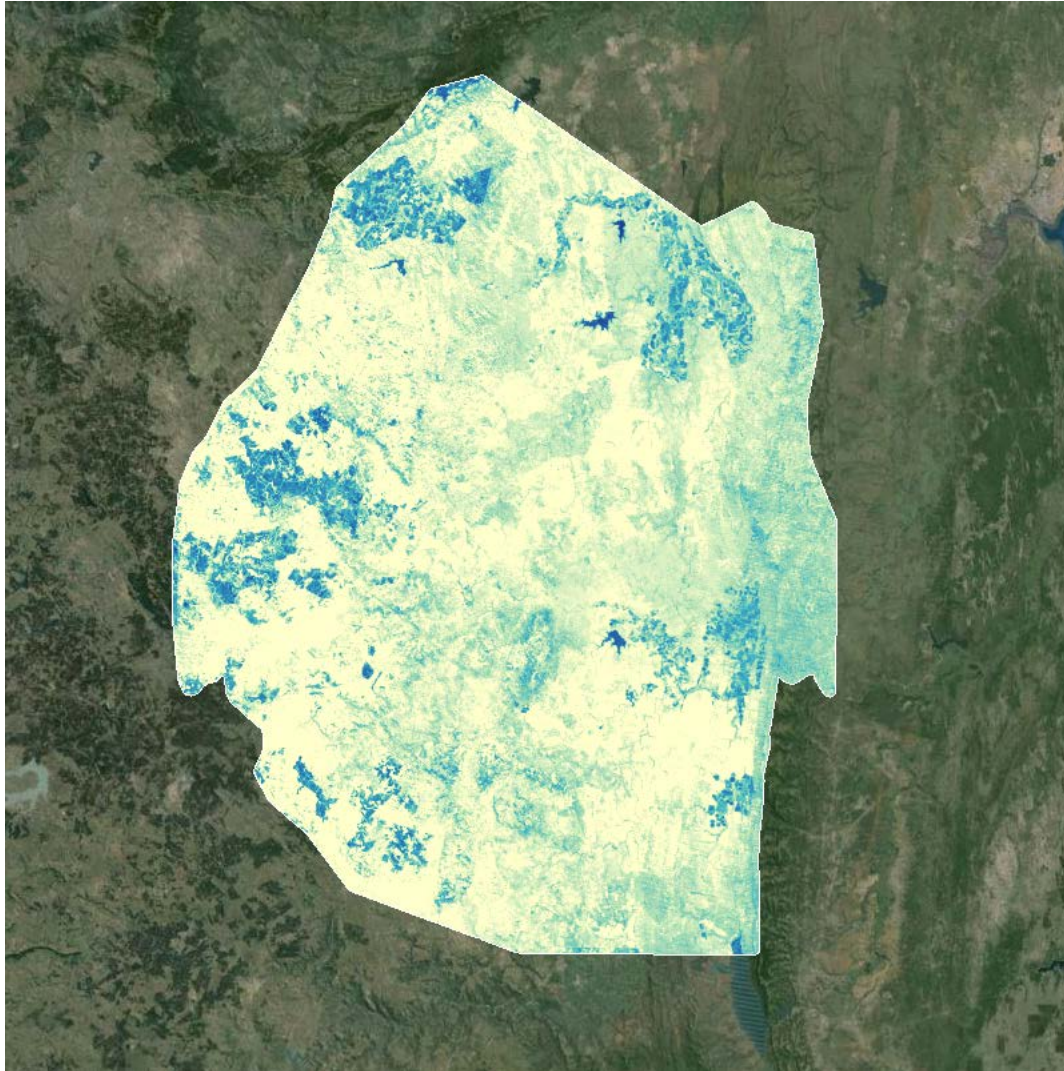
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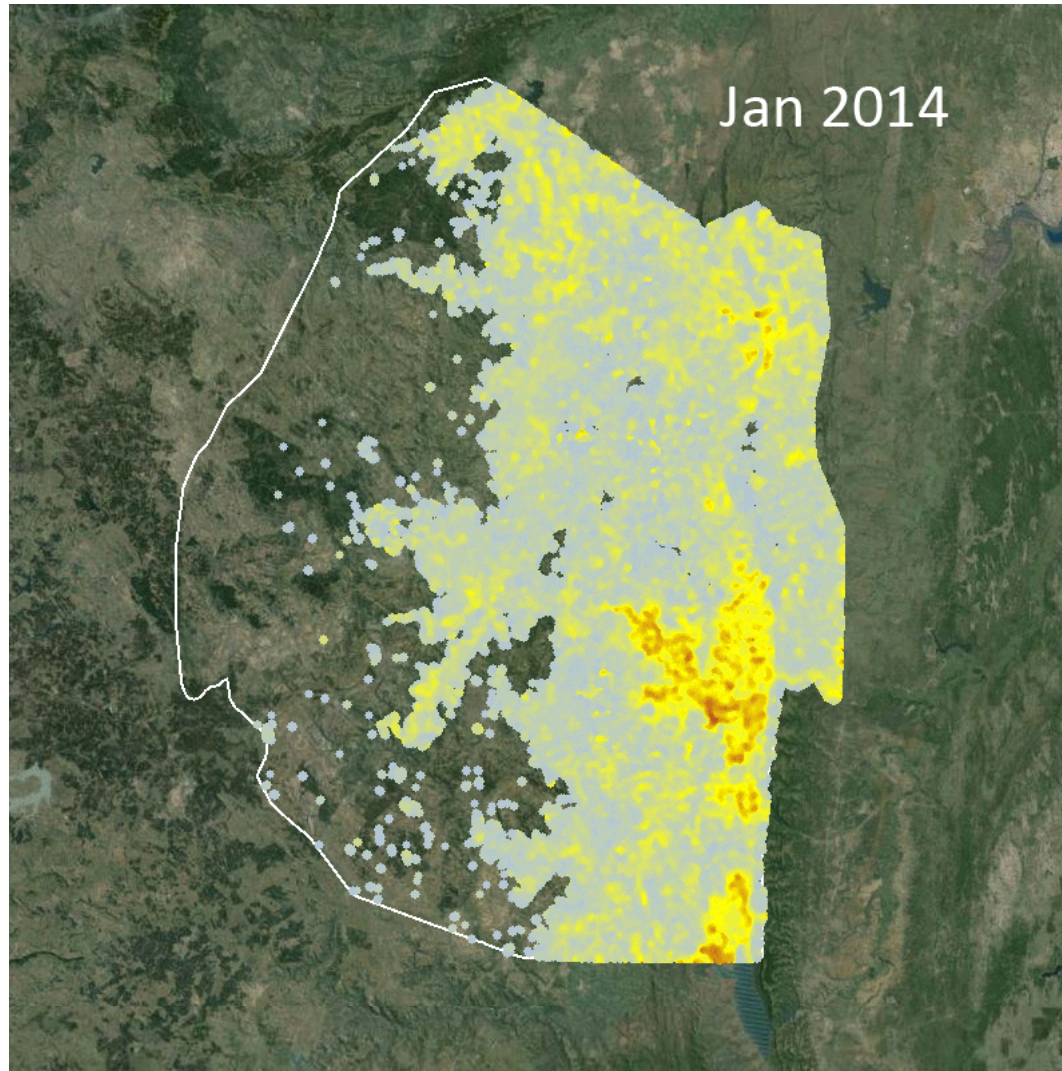
Remote Sensing Application in Public Health



A malaria risk forecasting platform lead by Dr. Hugh Sturrock at UCSF.



Real-Time Risk Forecast



Improve Targeting of Resources



Research Article

Multisensor earth observations to characterize wetlands and malaria epidemiology in Ethiopia

Alemayehu Midekisa¹, Gabriel Senay²
and Michael C Wimberly^{1,*}

DOI: 10.1002/2014WR015634

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Issue



Water Resources Research

Accepted Article (Accepted, unedited articles published online and citable. The final edited and typeset version of record will appear in future.)



Additional Information (Show All)

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Abstract

Supporting Information

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Keywords:

Malaria; Wetlands; Early Warning; Remote Sensing; Hydrology; Public Health

Abstract

Malaria is a major global public health problem, particularly in sub-Saharan Africa. The spatial heterogeneity of malaria can be affected by factors such as hydrological processes, physiography, and land cover patterns. Tropical wetlands, for example, are important hydrological features that can serve as mosquito breeding habitats. Mapping and monitoring of wetlands using satellite remote sensing can thus help to target interventions aimed at reducing malaria transmission. The objective of this study was to map wetlands and other major land cover types in the Amhara Region of Ethiopia and to analyze district-level associations of malaria and wetlands across the region. We evaluated three random forests classification models using remotely sensed topographic and spectral data based on Shuttle Radar Topographic Mission (SRTM) and Landsat TM/FTM+ imagery respectively. The model that integrated data from both sensors yielded more accurate land cover

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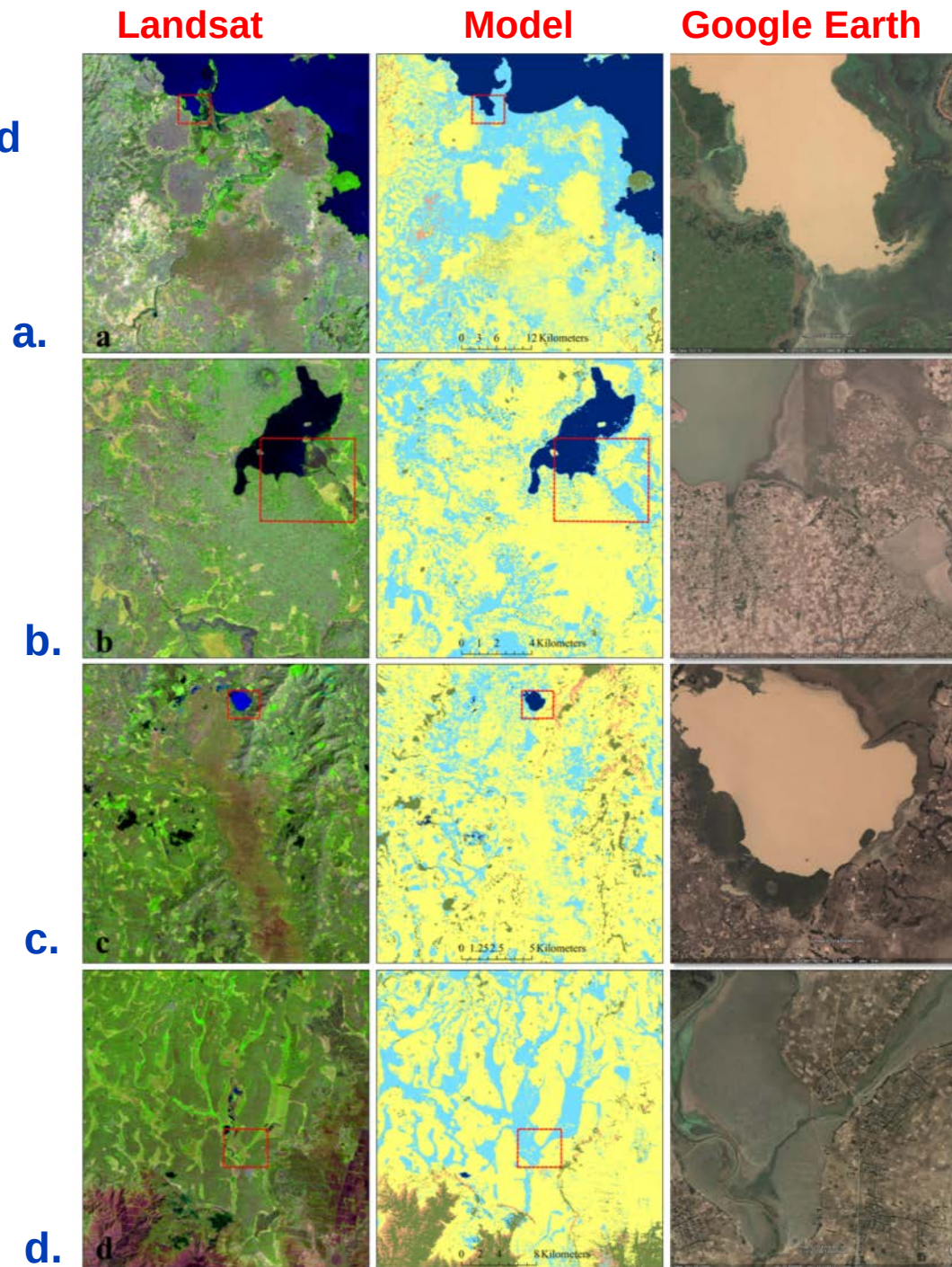
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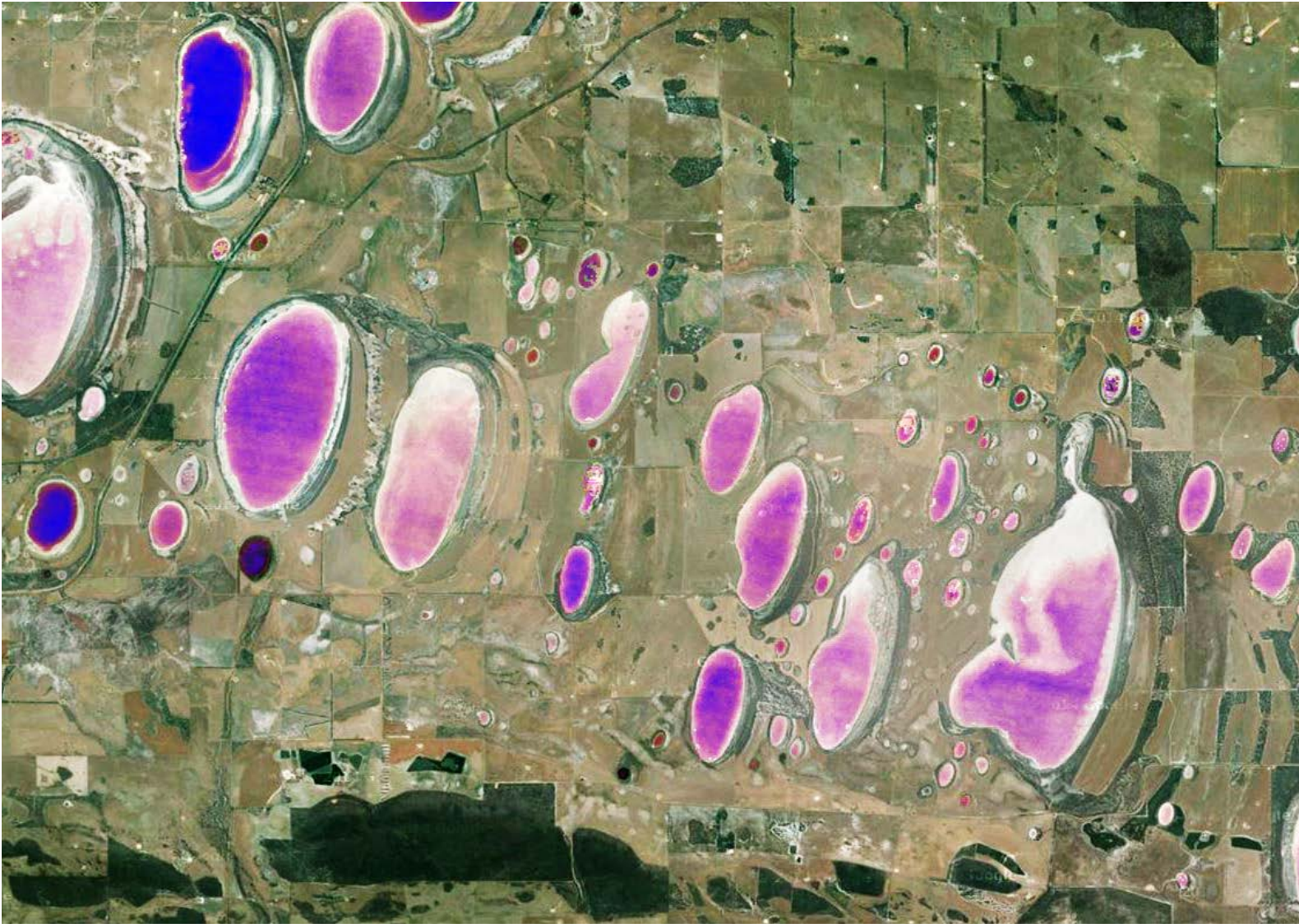
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Comparison of wetland classification with Landsat and Google Earth



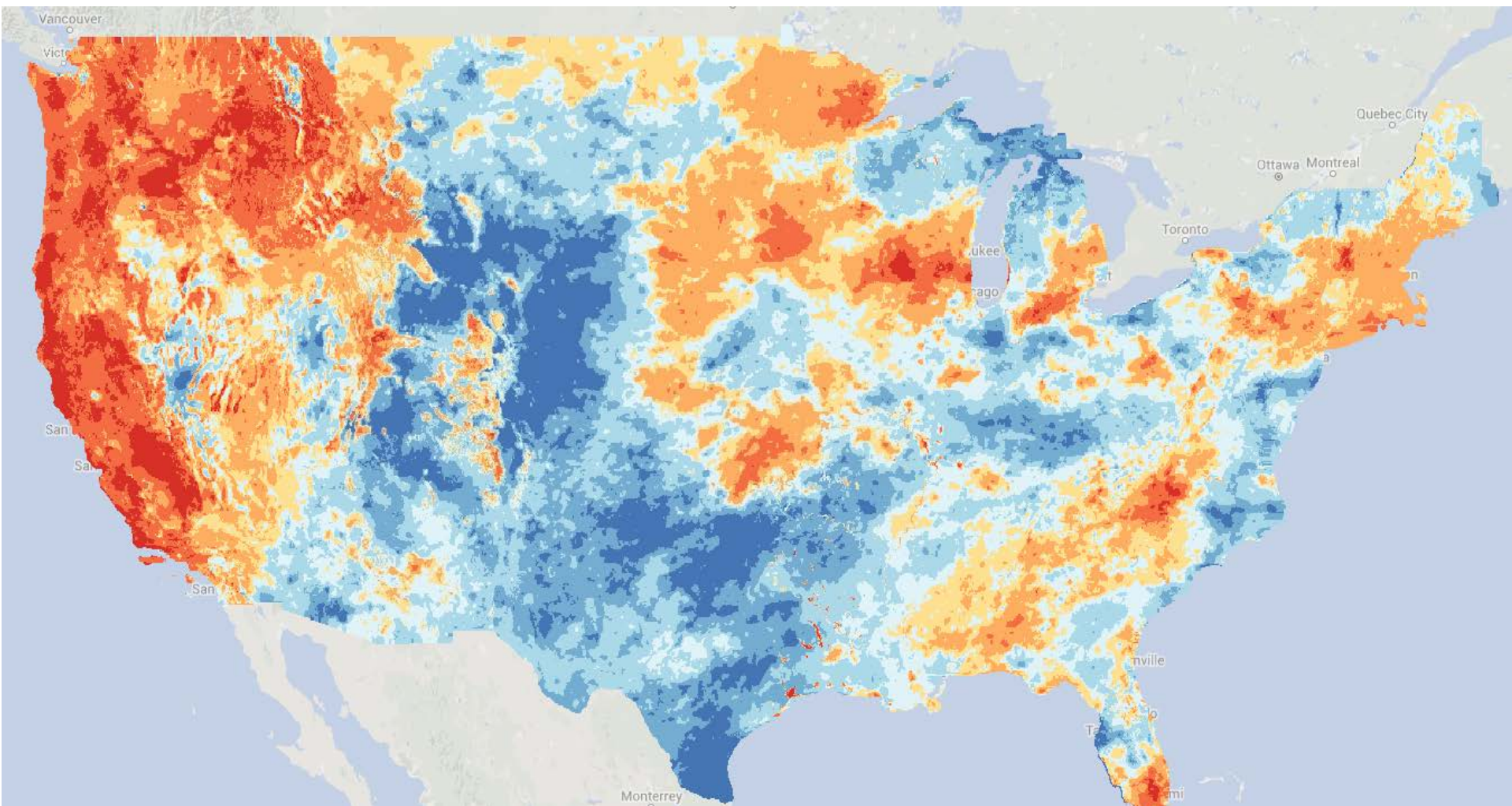
Water availability



European Commission Joint Research Centre:
Pekel, Cottam, Gorelick, Belward



Drought Severity



Desert Research Institute
Justin Huntington



COMMENTARY:

Earth's surface water change over the past 30 years

Gennadii Donchyts, Fedor Baart, Hessel Winsemius, Noel Gorelick, Jaap Kwadijk and Nick van de Giesen

Earth's surface gained 115,000 km² of water and 173,000 km² of land over the past 30 years, including 20,135 km² of water and 33,700 km² of land in coastal areas. Here, we analyse the gains and losses through the Deltares Aqua Monitor — an open tool that detects land and water changes around the globe.

NATURE CLIMATE CHANGE | VOL 6 | SEPTEMBER 2016 | www.nature.com/natureclimatechange

Application: <http://aqua-monitor.appspot.com/>



Xiamen, Fujian, China

Surface water changes (1985-2016)

Green and blue colors represent areas where surface water changes occurred during the last 30 years. Green pixels show where surface water has been turned into land (accretion, land reclamation, droughts). Blue pixels show where land has been changed into surface water (erosion, reservoir construction).

Note, it may take some time for results to appear, because the analysis is performed on-the-fly.

The results of the analysis are published in:

[Donchyts et.al, 2016, Nature Climate Change](#)

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REPORT

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

M. C. Hansen^{1,2,*}, P. V. Potapov¹, R. Moore², M. Hancher², S. A. Turubanova¹, A. Tyukavina¹, D. Thau², S. V. Stehman³, S. J. Goetz⁴, T. R. Loveland⁵, A. Kommareddy⁶, A. Egorov⁶, L. Chini¹, C. O. Justice¹, J. R. G. Townshend¹

[✚](#) Author Affiliations

[✉](#) *Corresponding author. E-mail: mhansen@umd.edu

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.



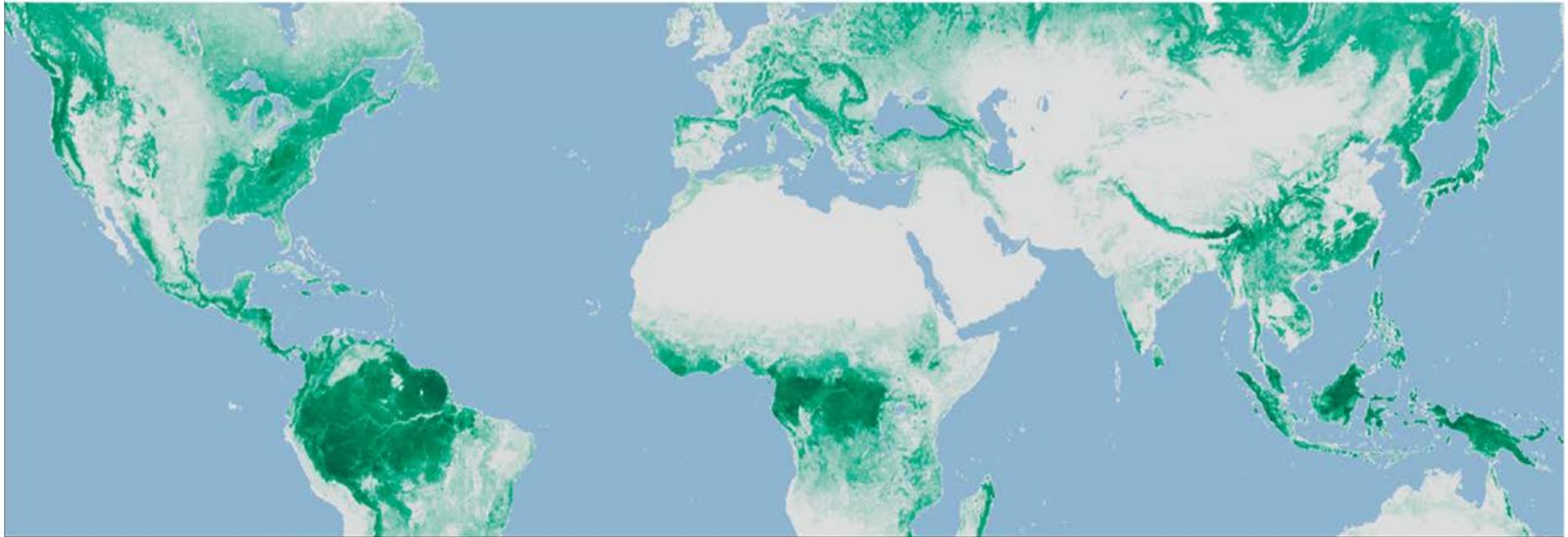
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44,479

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BETA

FOREST CHANGE

FOREST COVER

FOREST USE

CONSERVATION

PEOPLE

STORIES

COUNTRY LAYERS

FOREST CHANGE

- Tree cover gain
- Tree cover loss

Displaying loss with **> 30 %** canopy density.

Tree cover loss is not always deforestation. ?



DRAW SHAPE

COUNTRY OR REGION

OTHER DATA LAYERS

TOTAL SELECTED AREA

27,746,793 ha

LOSS 2001-2013 with >30% canopy density

3,754,595 ha

GAIN 2001-2012

2,016,743 ha

This algorithm approximates the results by sampling the selected area. Results are more accurate at closer zoom levels.



- +

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Tree cover loss (zoom in for most accurate viewing)



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Thank You!

Dr. Alemayehu Midekisa
alemayehu.midekisa@ucsf.edu