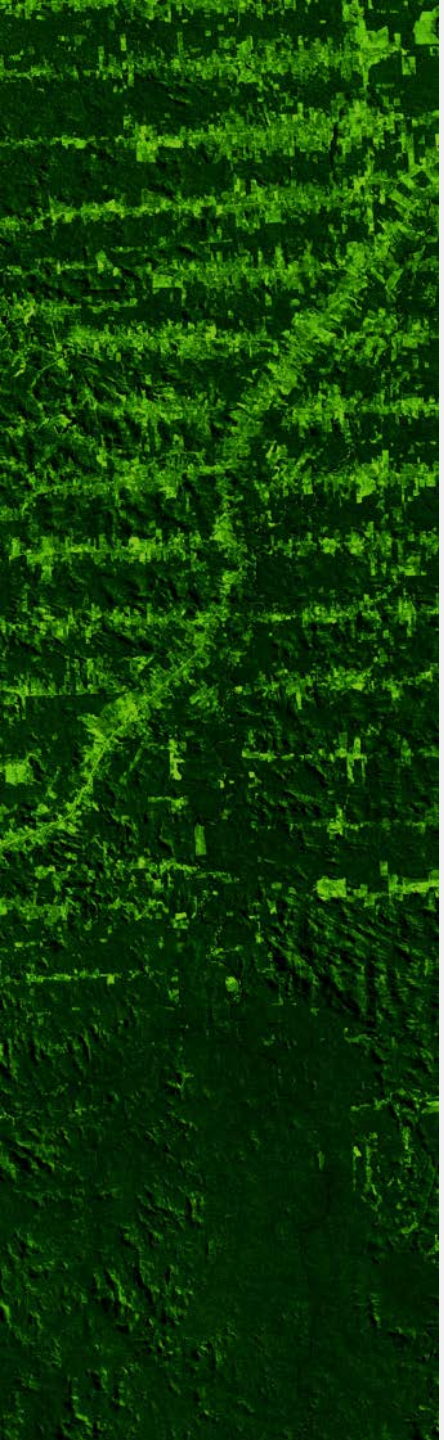


National Aeronautics and Space Administration

ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

@NASAARSET

Remote Sensing of Land Indicators of Sustainable Development Goal (SDG) 15

Instructors: Amber McCullum and Cindy Schmidt

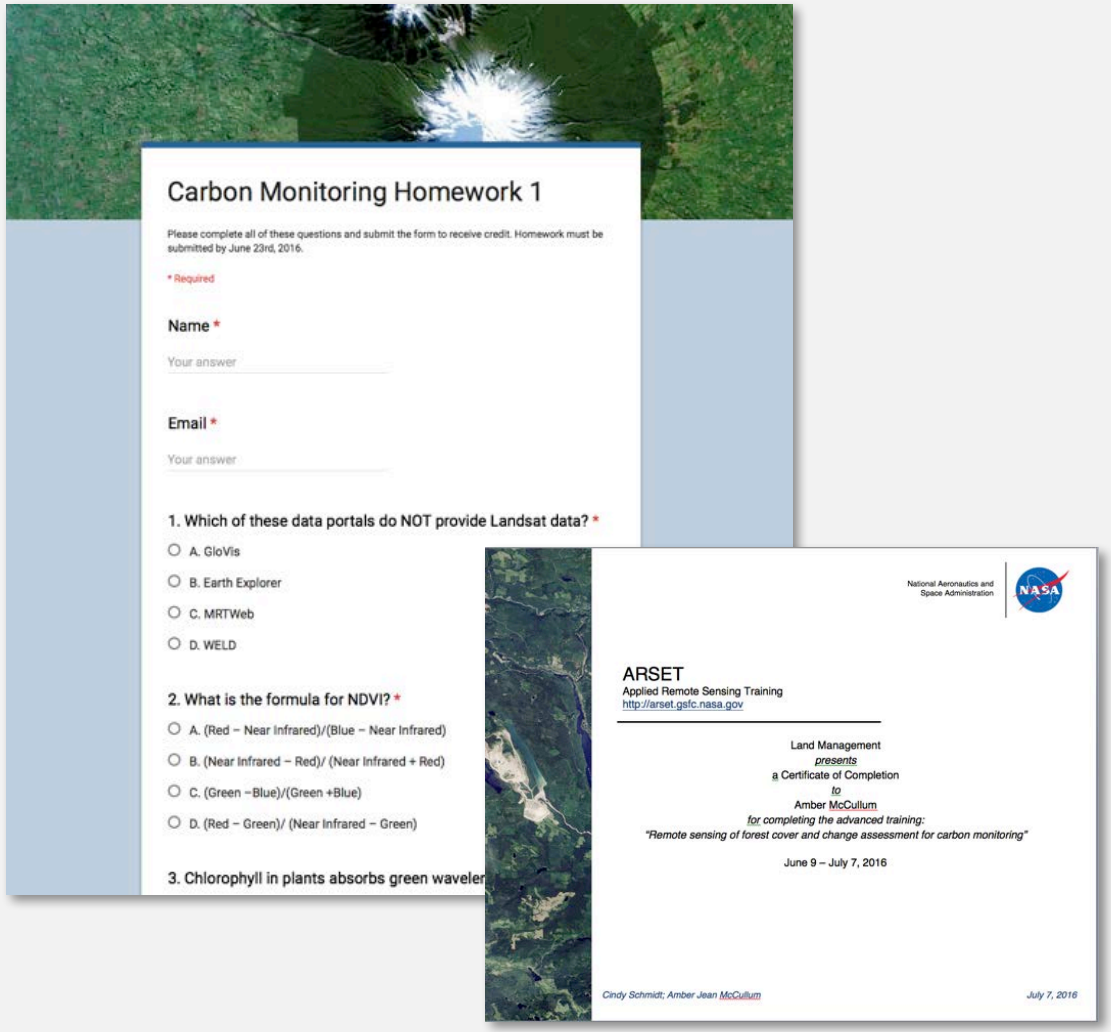
Session 1: June 20th, 2017

Course Structure

- Three sessions: Tuesday, June 20; Wednesday, June 21; Thursday, June 22
  - Each session will be given twice:
    - Session A: 1:00 – 200 p.m. EDT (UTC-4)
    - Session B: 10:00 – 11:00 p.m. EDT (UTC-4)
  - Please only sign up for and attend the same session each week
- Webinar recordings, PowerPoint presentations, and the homework assignment can be found after each session at:
  - http://arset.gsfc.nasa.gov/land/webinars/sdg15
  - Q&A: Following each lecture and/or by email
    - cynthia.l.schmidt@nasa.gov, or
    - amberjean.mccullum@nasa.gov

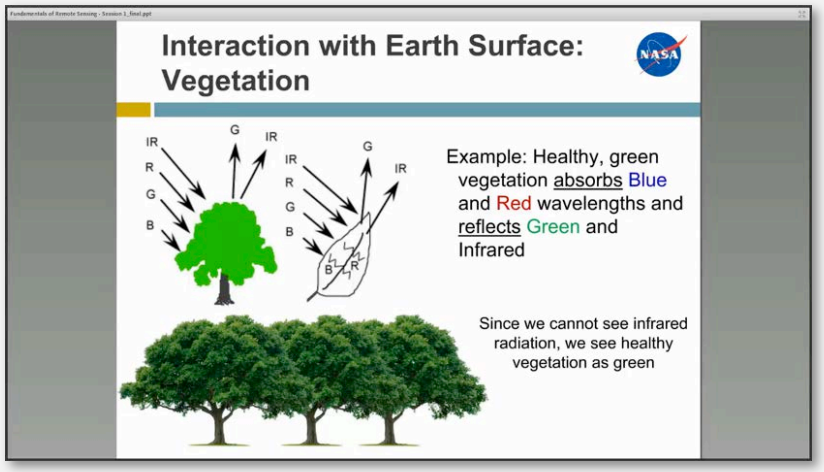
Homework and Certificates

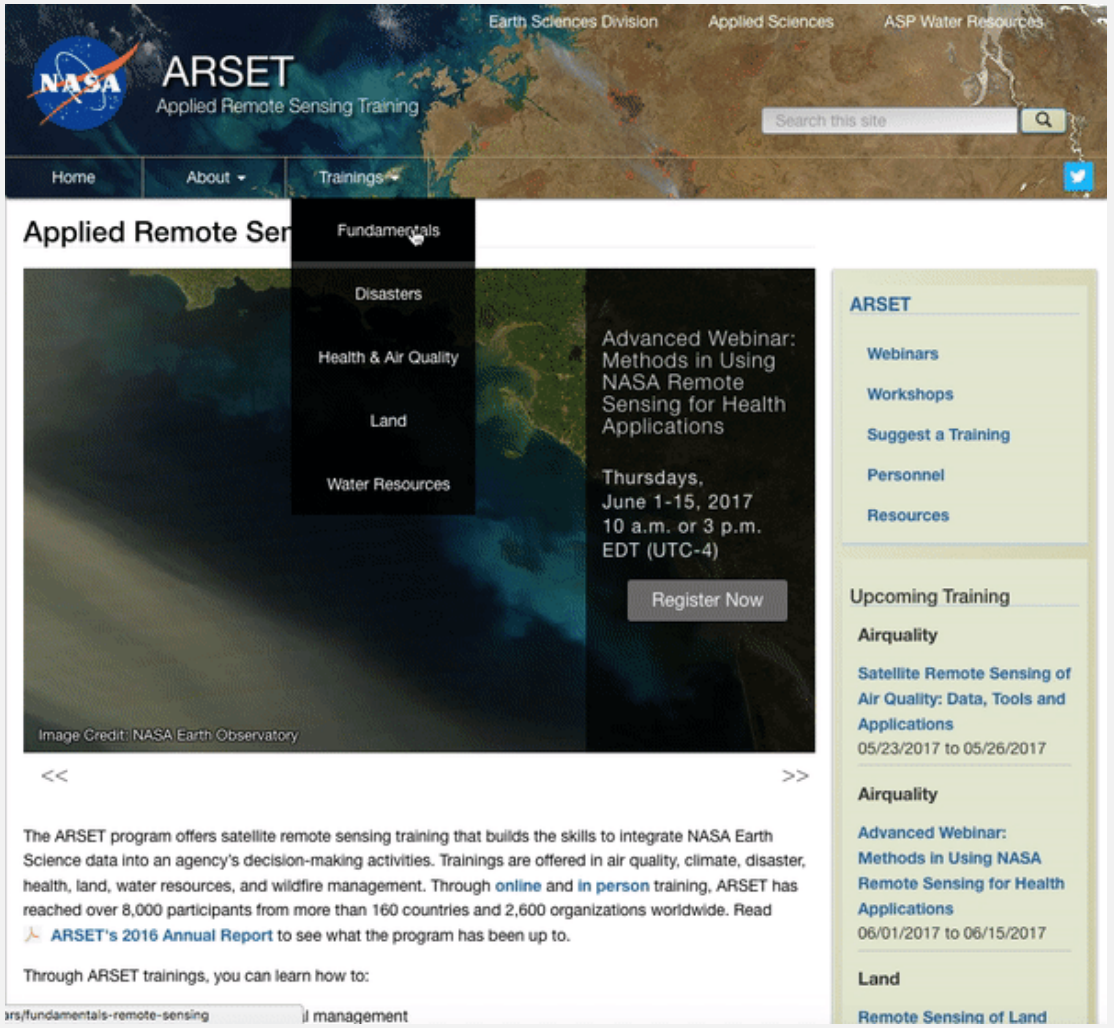
- Homework
  - Answers must be submitted via Google Form
- Certificate of Completion:
  - Attend all 3 webinars
  - Complete the homework assignment by the deadline (access from ARSET website)
    - HW Deadline: July 6th
  - You will receive certificates approx. two months after the completion of the course from: marines.martins@ssaihq.com



Prerequisite

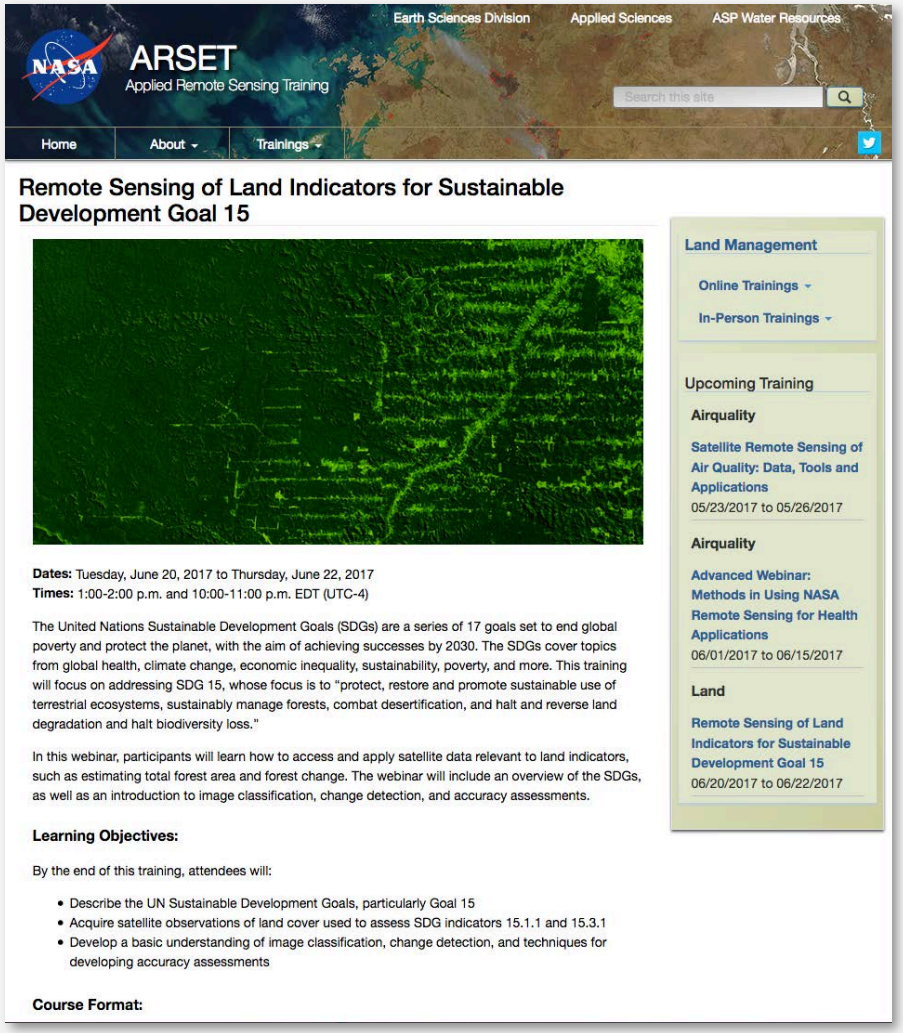
- Fundamentals of Remote Sensing
  - Sessions 1 and 2A (Land)
  - On demand webinar, available anytime
  - http://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing

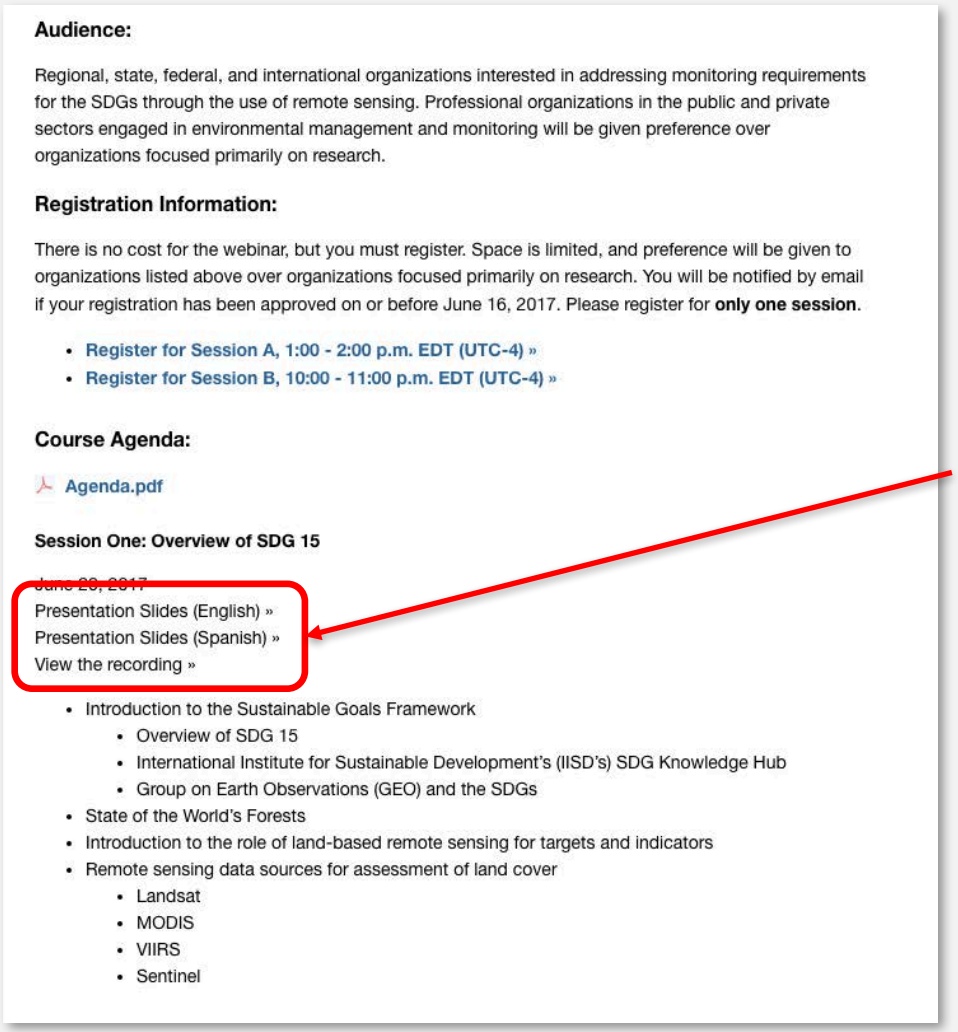




Accessing Course Materials

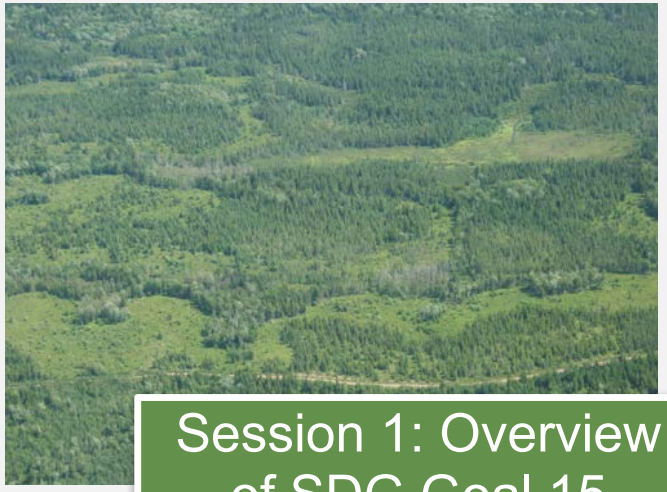
http://arset.gsfc.nasa.gov/land/webinars/sdg15/





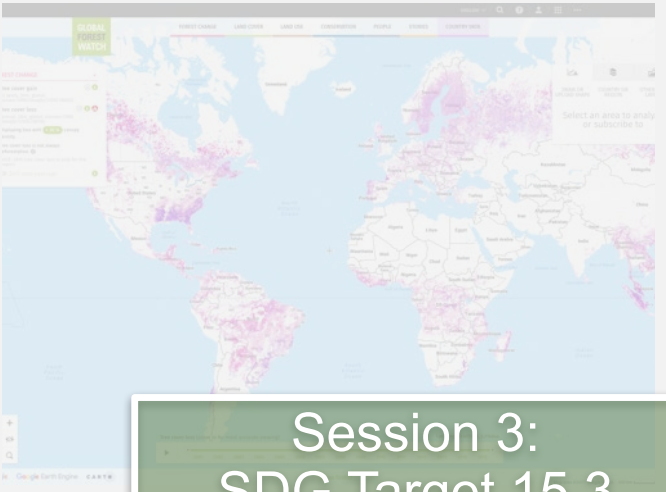
Course materials are provided here and will be active after each week

Course Outline



Session 1: Overview of SDG Goal 15

Session 2: SDG Target 15.1

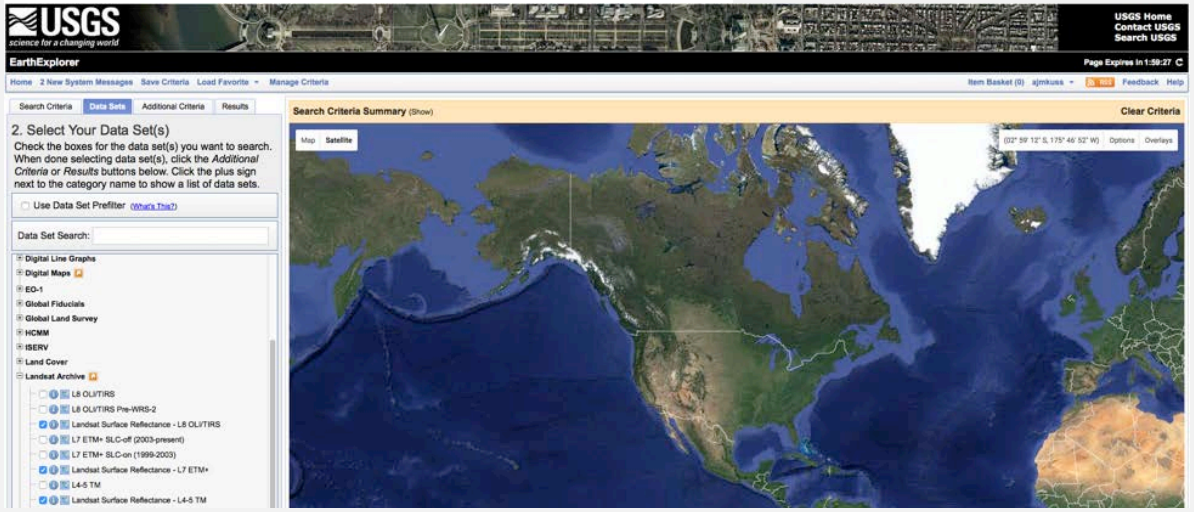


Session 3: SDG Target 15.3

Session 1 Agenda

- About ARSET
- Introduction to the Sustainable Goals Framework
- Related Forest Conservation Efforts
- State of the World's Forests
- The Role of Remote Sensing for SDG 15
- Remote Sensing Data Sources for Land Cover

(Left) Sustainable Development Goals Credit: United Nations. (Below) USGS EarthExplorer



About ARSET

NASA's Applied Remote Sensing Training Program (ARSET)

http://arset.gsfc.nasa.gov/

- Empowering the global community through remote sensing training
- Part of NASA's Applied Sciences Capacity Building Program
- Goal: increase the use of Earth Science in decision-making through training for:
  - policy makers
  - environmental managers
  - other professionals in the public and private sector
- Trainings offered focusing on applications in:

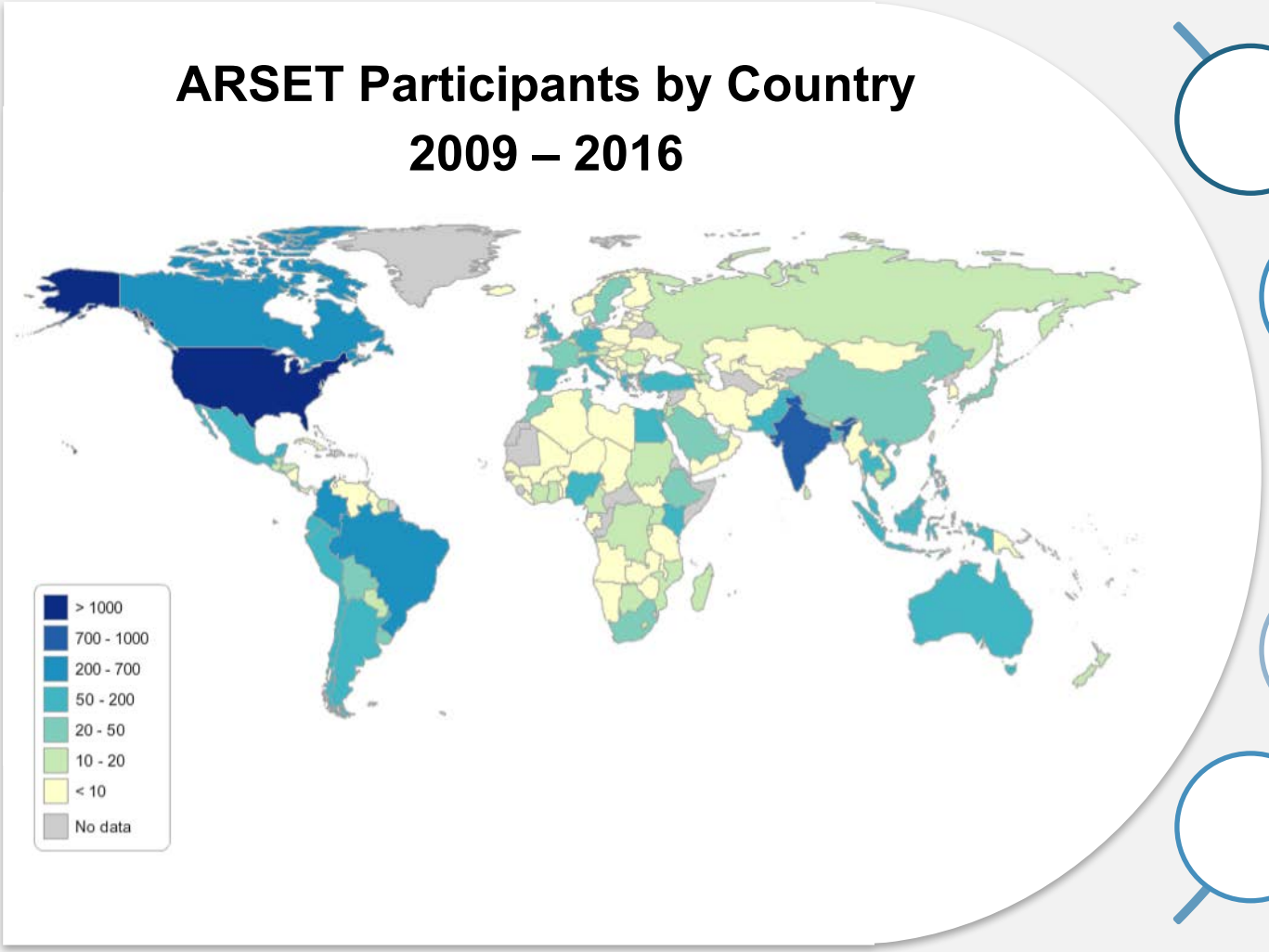
Disasters

Land

Health & Air Quality

Water Resources

ARSET's Global Footprint



- 85 ARSET Trainings
- 9,000+ participants reached
- 2,600+ organizations reached
- 150+ countries reached
- 55 U.S. States, Territories, and D.C. reached

ARSET Training Levels

Fundamentals

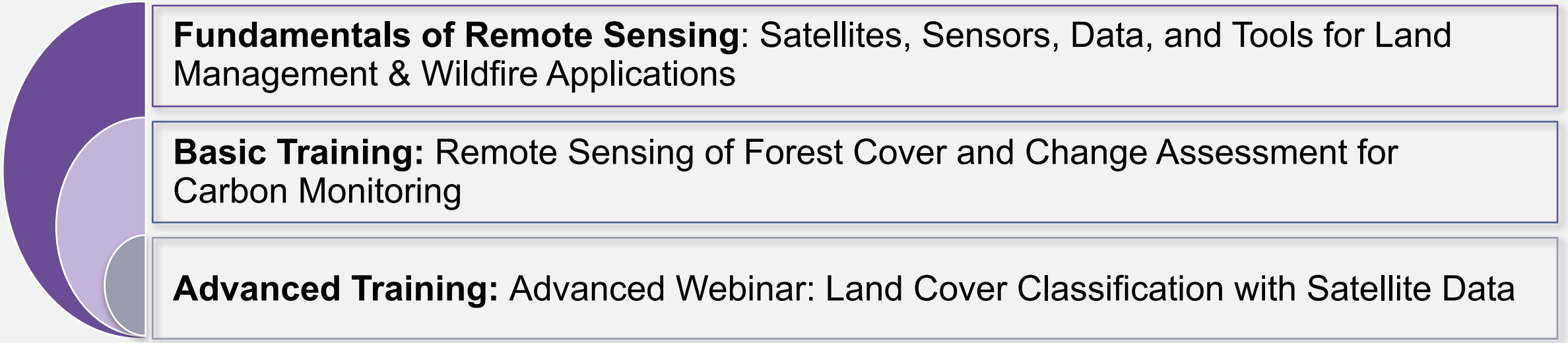
- Online only
- Assumes no prior knowledge of remote sensing

Basic Training

- Online and in-person
- Requires fundamentals training or equivalent knowledge
- Specific applications

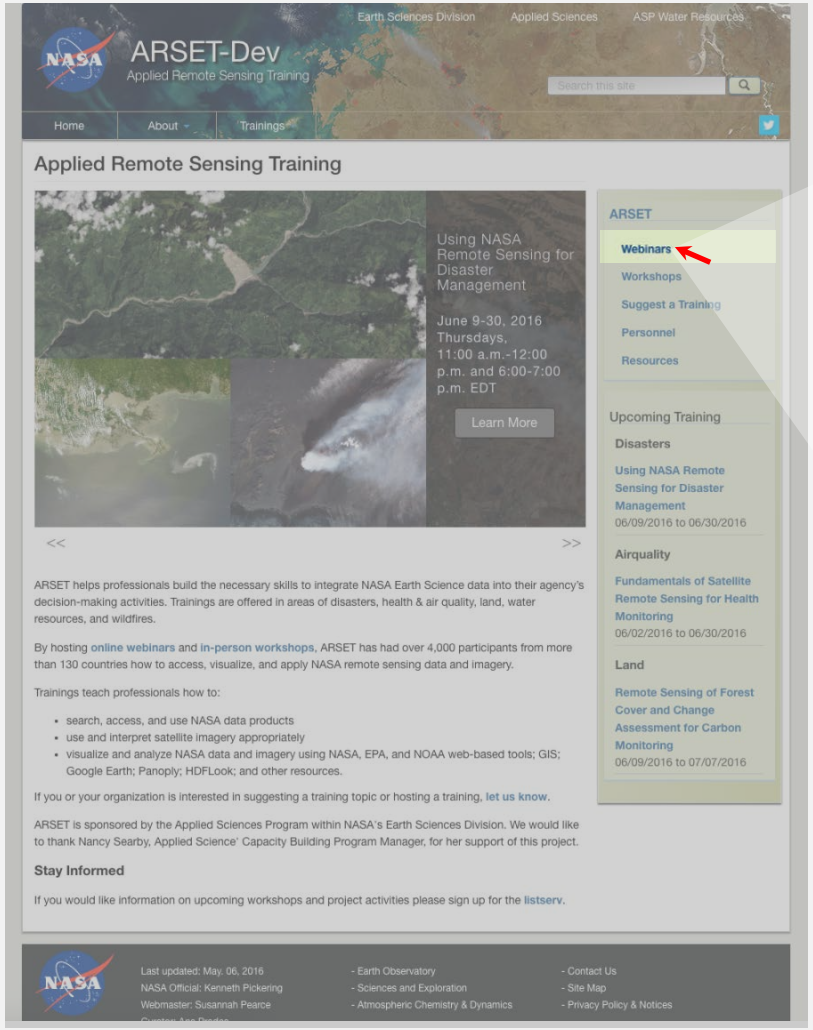
Advanced Training

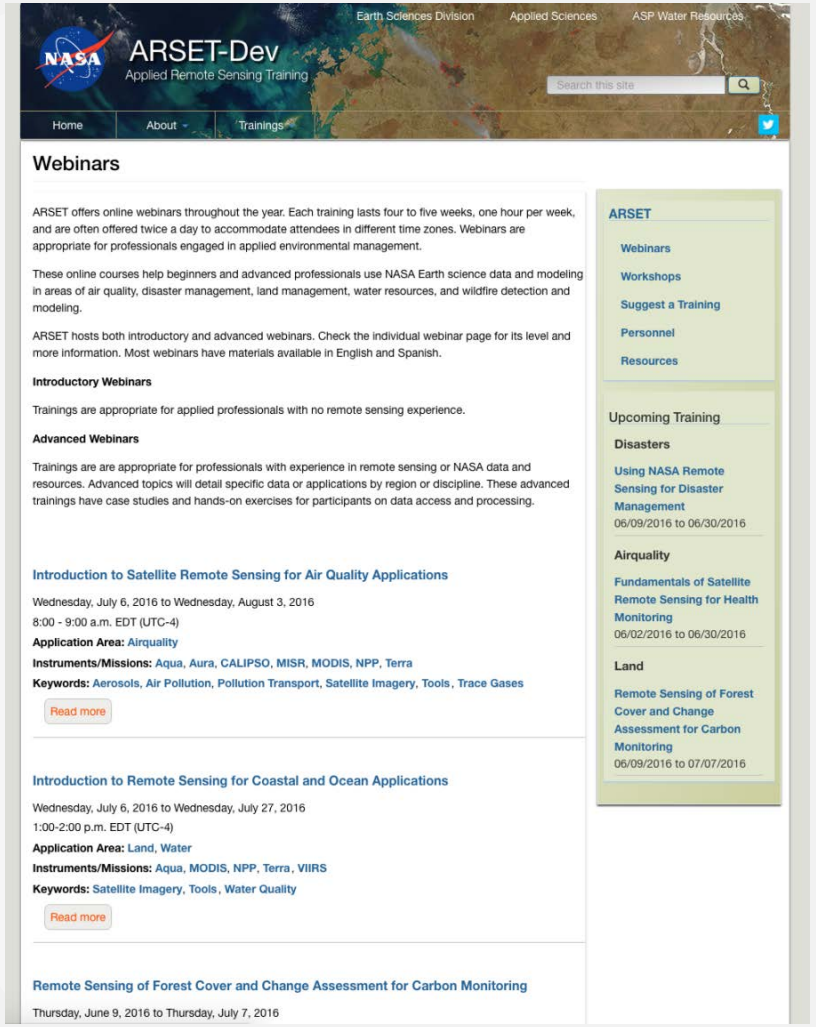
- Online and in-person
- Requires basic training or equivalent knowledge
- More in-depth or focused topics



ARSET Website: View Webinars

http://arset.gsfc.nasa.gov/webinars





Overview of SDGs

UN Sustainable Development Goals (SDGs)

Transforming Our World: The 2030 Agenda for Sustainable Development

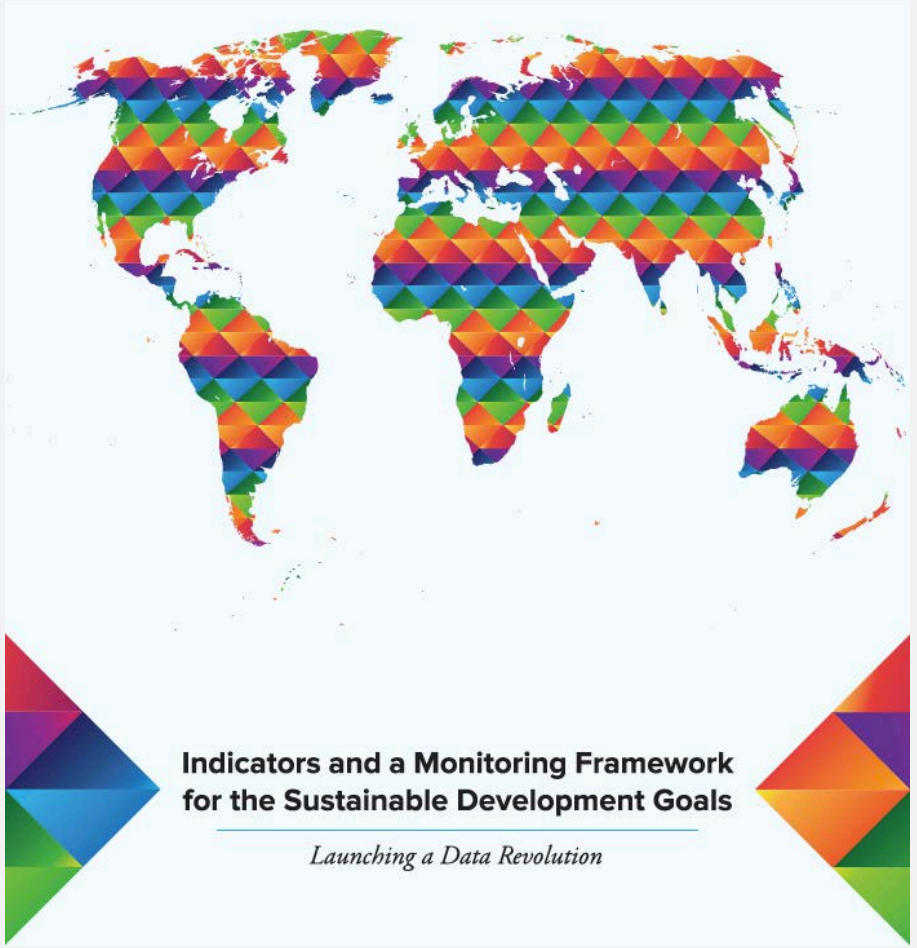
- A plan of action for people, planet and prosperity
- All countries and all stakeholders, acting in collaborative partnership, will implement this plan
- 17 SDGs and 169 targets under this agenda
- Balance the three dimensions of sustainable development:

  – economic, social, and environmental
- In this webinar series, our focus will be Goal 15: Life on Land

Text adapted from "Transforming our world: the 2030 Agenda for Sustainable Development"

SDG Indicators

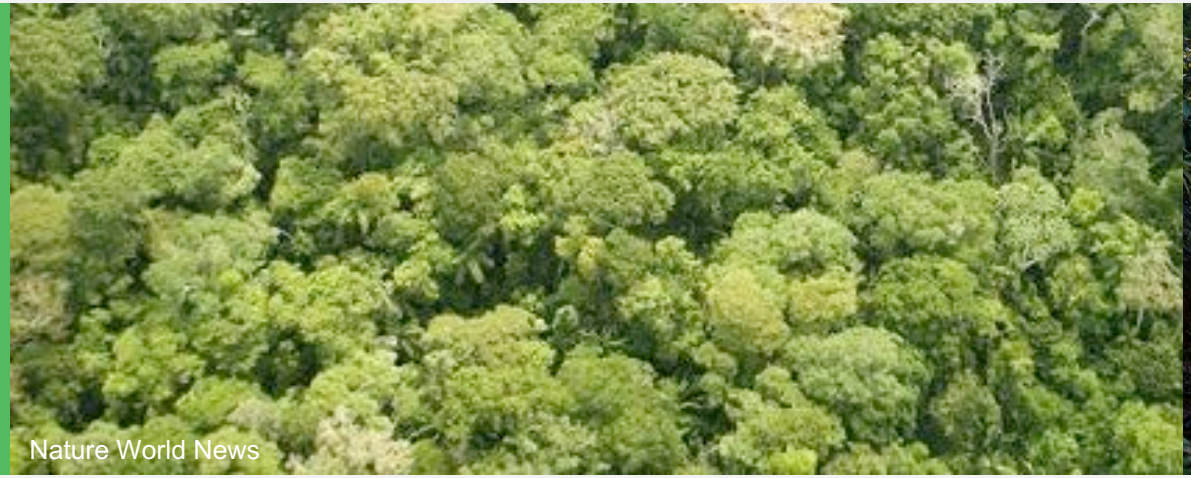
- Used to monitor progress towards SDGs at local, regional, and global levels
- Turns SDGs and targets into a management tool:
  - develop implementation strategies
  - measure progress (report card)
- 100 Global Monitoring Indicators
  - includes suggestions for complementary national indicators (CNIs)
- Each country chooses the number and range of CNIs to collect and analyze data



http://unsdsn.org/resources/publications/indicators/

SDG: Target 15.1

- By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
  – Indicator: 15.1.1: Forest area as a proportion of total land area


Nature World News


Center for International Forestry Research

SDG: Target 15.3

- By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
  - Indicator: 15.3.1: Proportion of land that is degraded over total land area
    - Subindicators: Land Cover and Land Cover Change, Land Productivity, Carbon Stocks

Agency Coordination

Statistics Division

United Nations
Convention to Combat
Desertification

SUSTAINABLE DEVELOPMENT
SOLUTIONS NETWORK
A GLOBAL INITIATIVE FOR THE UNITED NATIONS

GLOBAL PARTNERSHIP
FOR SUSTAINABLE DEVELOPMENT DATA

IISD
International Institute for
Sustainable Development

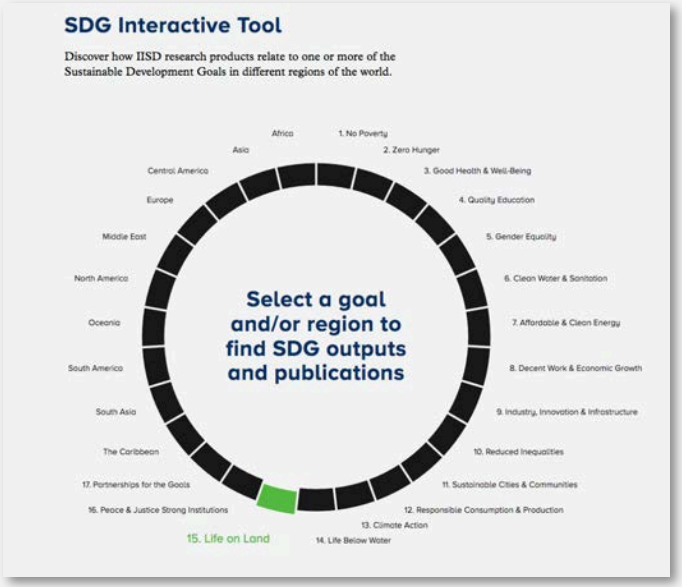
Food and Agriculture Organization
of the United Nations

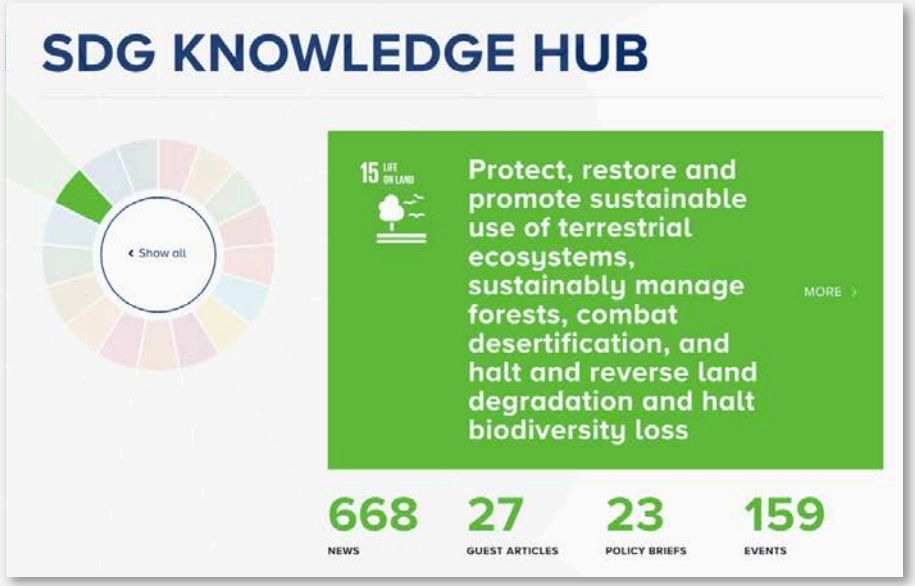
GEO
GROUP ON
EARTH OBSERVATIONS

IISD Knowledge Hub

http://sdg.iisd.org/

- Provides tools and resources about the SDGs
- Collects news, events, policy briefs for specific goals
- Also provides information on events, actors, and regions

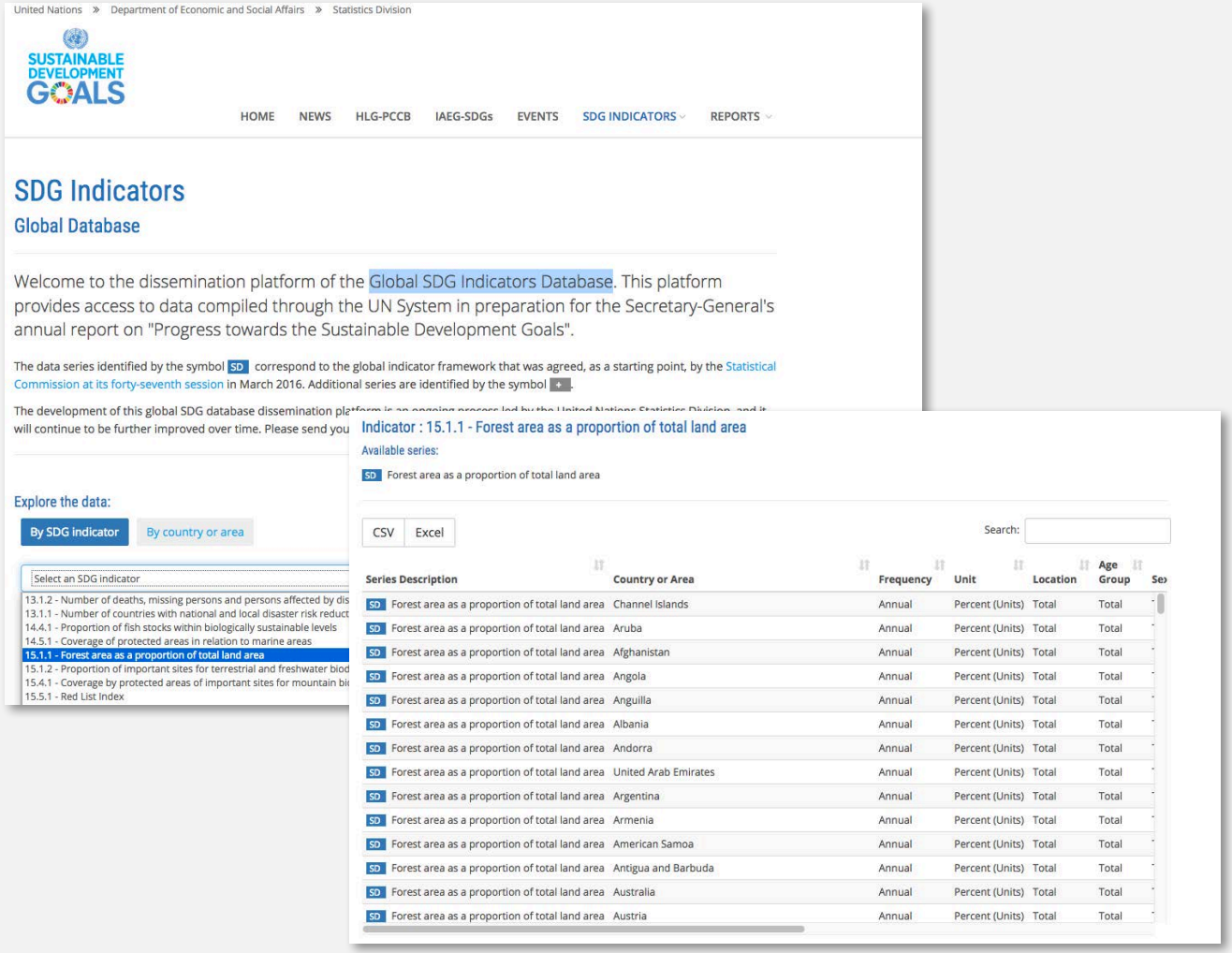




United Nations: Statistics for SDGs

https://unstats.un.org/sdgs/indicators/database/

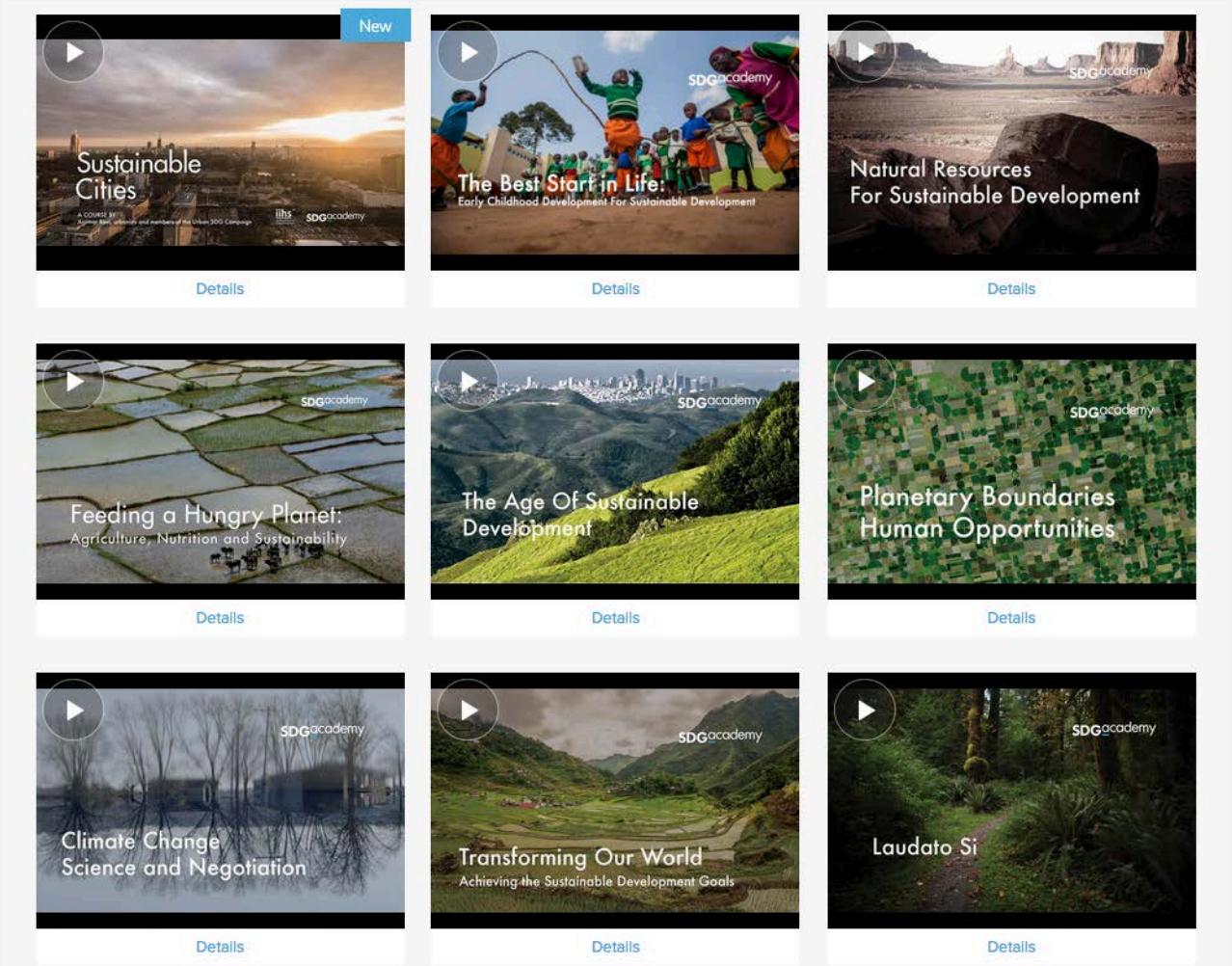
- Access SDG data for specific countries
- Obtain metadata and methodology for calculating indicators
- Groups information based on regions



Sustainable Development Solutions Network (SDSN)

http://courses.sdgacademy.org/

- Analytical and technical recommendations for SDGs
- SDG Academy
  – Free online courses about SDGs



Group on Earth Observations (GEO)

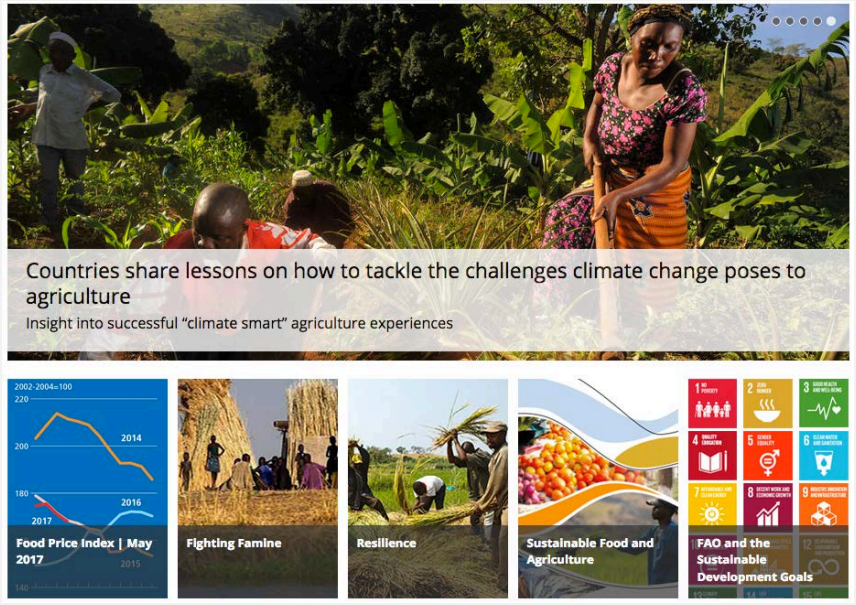
http://www.earthobservations.org/geo_sdgs.php

Initiative to support efforts to integrate Earth observations and geospatial information into national development and monitoring frameworks for the SDGs

Food and Agriculture Organization (FAO)

http://www.fao.org/sustainable-development-goals/en/

- FAO's priorities for the SDGs are:
  - End poverty, hunger and malnutrition
  - Enable sustainable development in agriculture, fisheries and forestry
  - Combat and adapt to climate change



Related Forest Conservation Efforts

The New York Declaration on Forests

http://forestdeclaration.org/

- Many world leaders endorsed a timeline to cut natural forest loss in half by 2020 and to strive to end it by 2030
- Ten main goals
- Concrete actions and plans
  - Includes
    - commodity traders
    - indigenous peoples
    - commitments from country governments multilateral programs
    - new procurement policies for use of forests

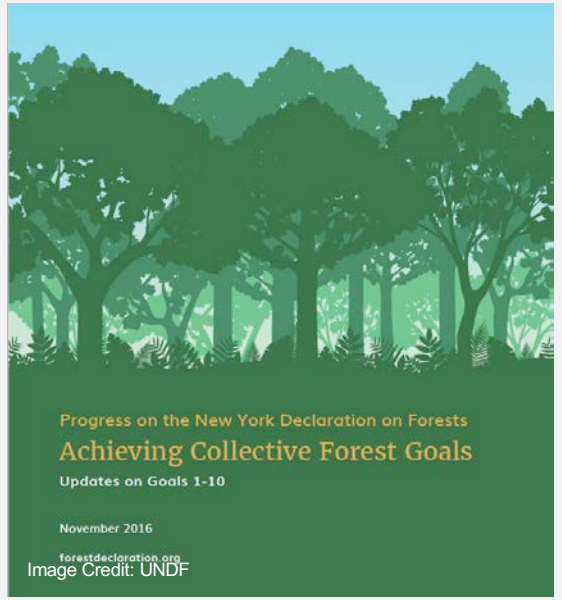


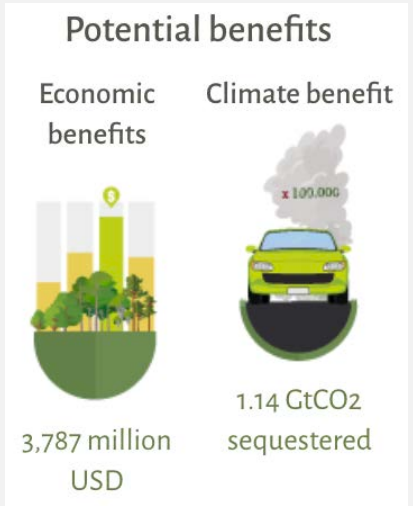
Image Credit: UNDF

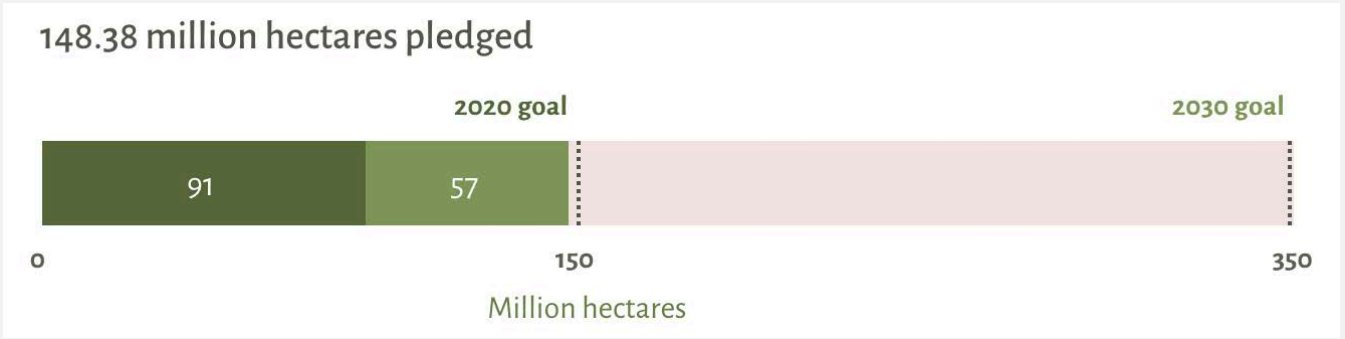
The Bonn Challenge

http://www.bonnchallenge.org/

- Global effort to restore 150 million hectares of the world's deforested and degraded land by 2020 and 350 million hectares by 2030
- Uses the Forest Landscape Restoration Approach (FLR)
- Vehicle for assisting in implementation of existing international commitments like REDD+

Image Credits: The Bonn Challenge





The United Nations REDD Program

http://www.un-redd.org/

- Reducing Emissions from Deforestation and Forest Degradation (REDD+)
- Climate change mitigation solution
- Incentivizes developing countries to keep forests by offering results-based payments for actions to reduce or remove forest carbon emissions
- Includes:
  - Reducing emissions from deforestation
  - Reducing emissions from forest degradation

  } REDD

  - Conservation of forest carbon stocks
  - Sustainable management of forests
  - Enhancement of forest carbon stocks

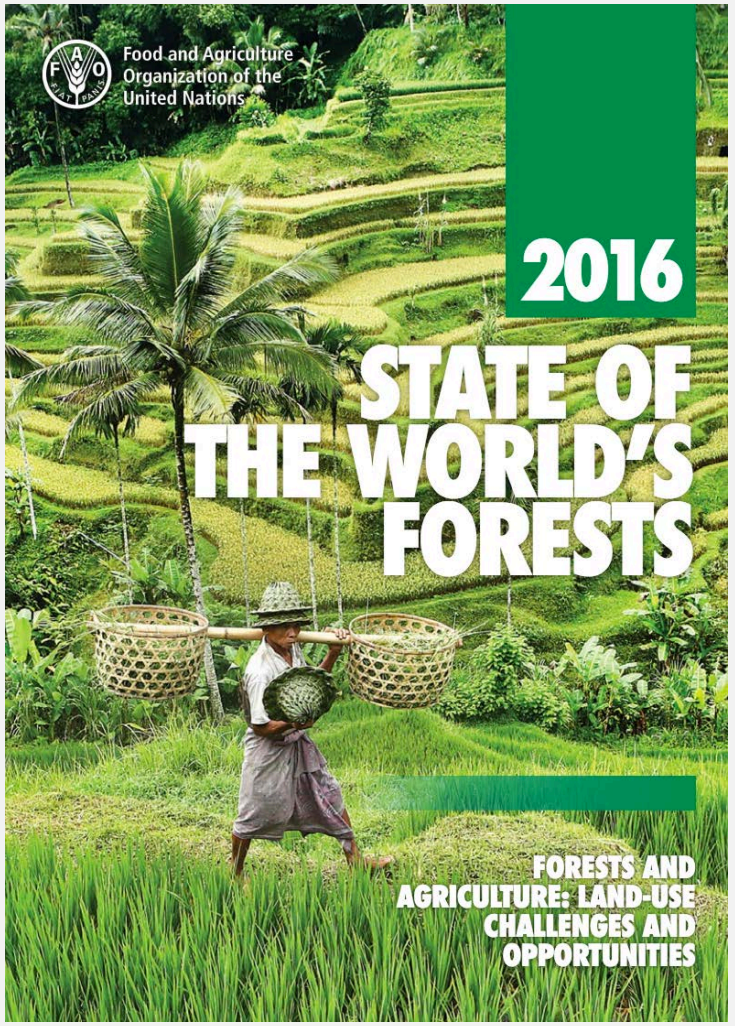
  } +

State of the World’s Forests

FAO 2016 Report

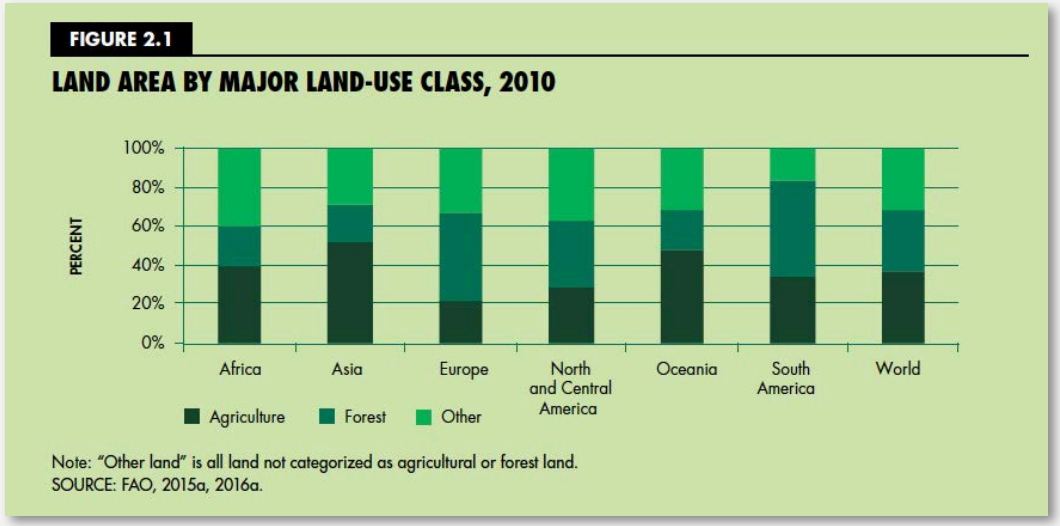
http://www.fao.org/publications/sofo/2016/en/

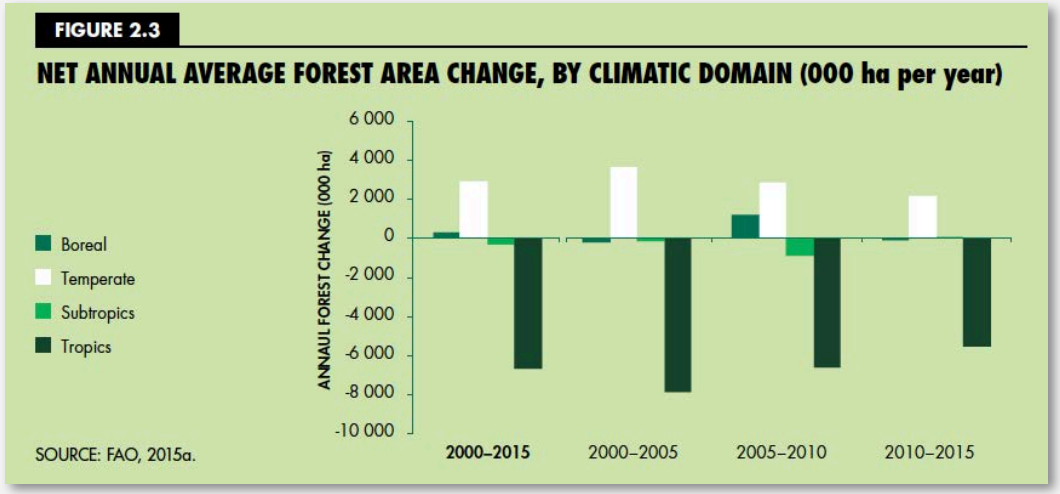
- Explores the relationship between forests, agriculture, and sustainable development
- Agriculture: major driver of deforestation globally
- Case studies of countries that have reconciled increased agricultural productivity and halting deforestation
- Focus on integrated land use planning



Trends in Land Use Change

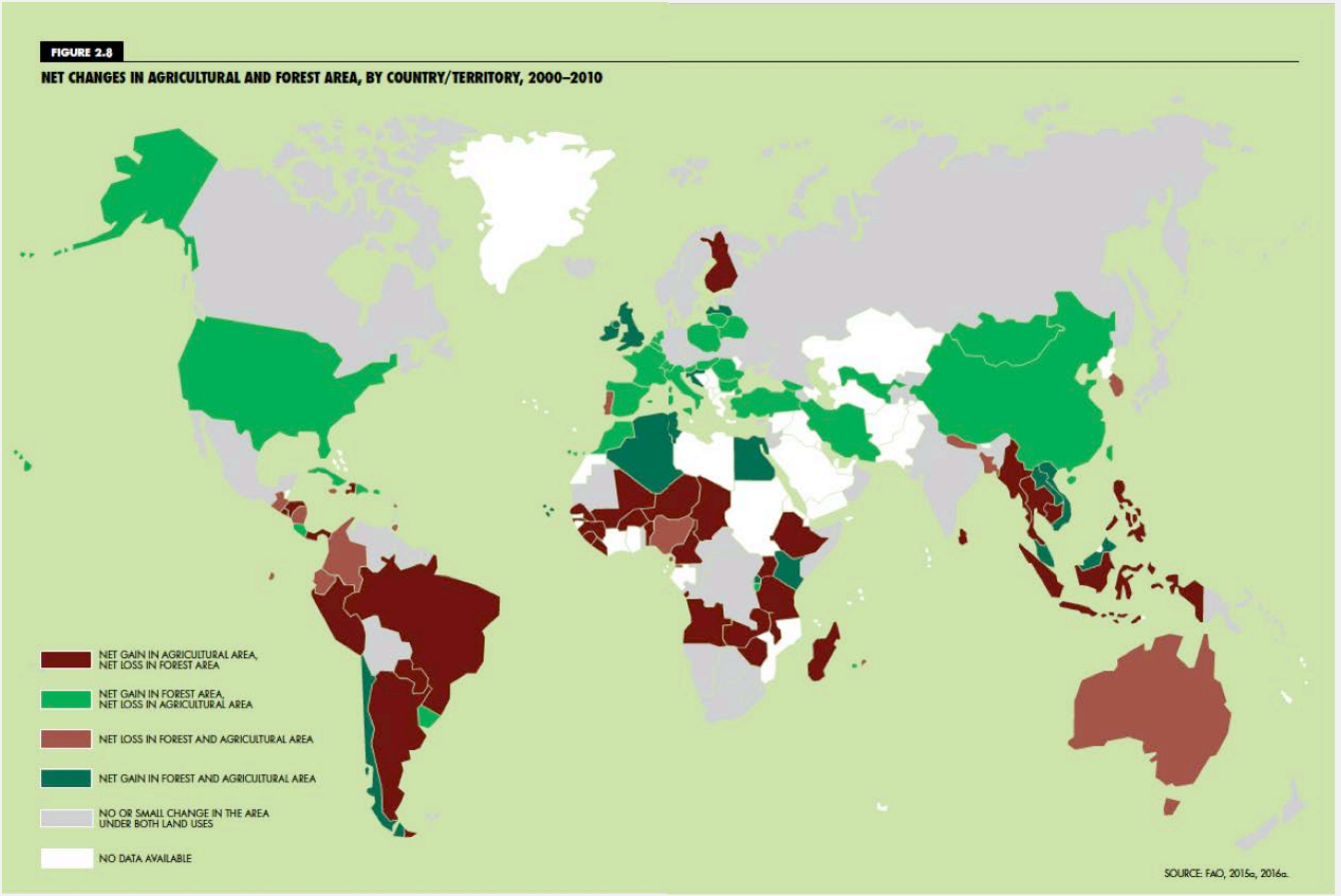
- Forests account for large portion of total land area in Europe, North America, Central America, and South America
- Global forest area fell by 3.1% from 1990-2015
- Net forest loss of 7 million hectares per year in tropical countries in 2000-2010





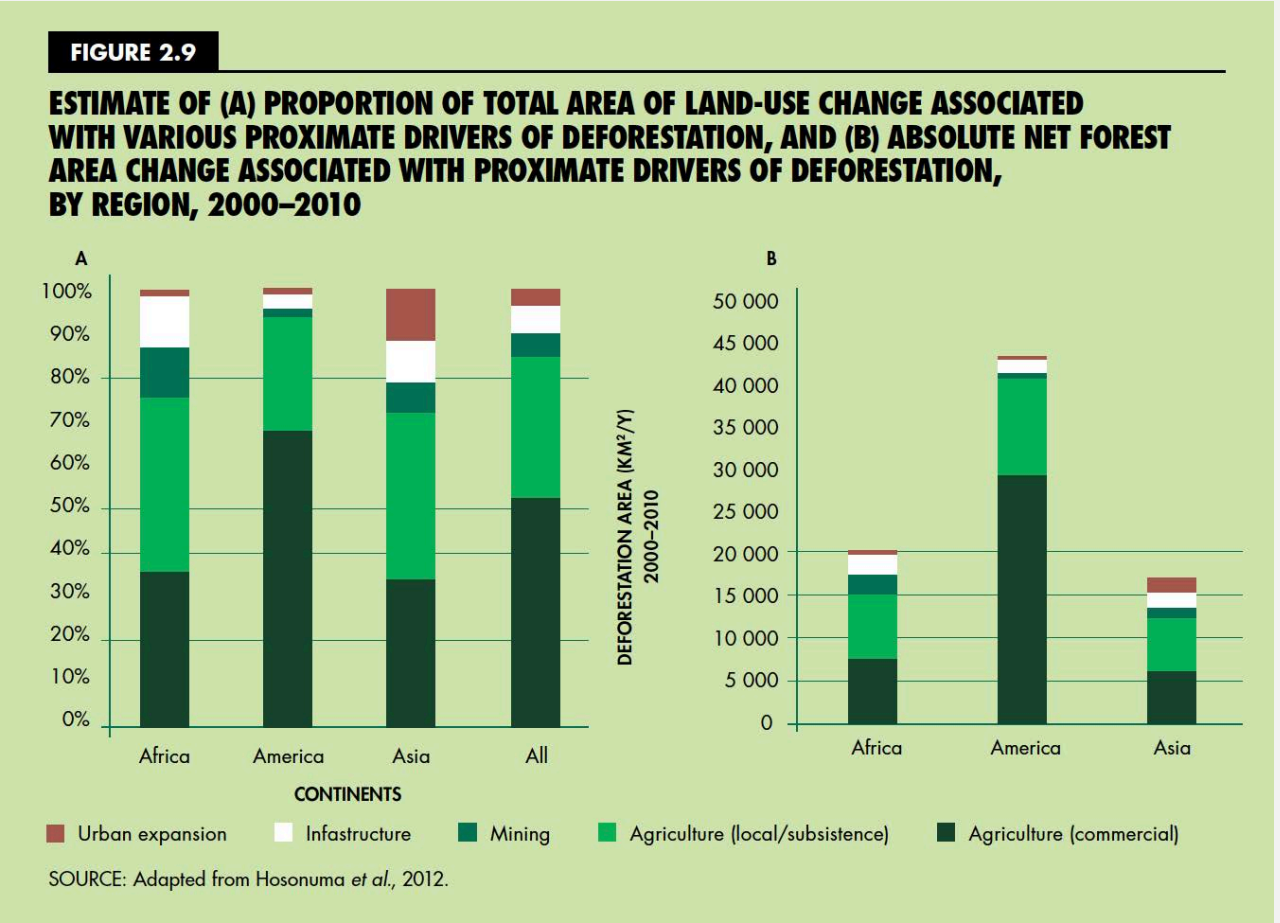
Trends in Land Use Change

- Strong correlation between agricultural expansion and deforestation in South America, sub-Saharan Africa, and South and Southeast Asia.
- Largest annual net loss of forest area occurred in low-income countries



Drivers of Land Use Change

- Commercial and subsistence agriculture accounts for 73% of deforestation in tropics and subtropics
- Other factors affecting forest conversion:
  - Population
  - Changing food consumption patterns
  - Technological advancements
  - Policy interventions



Management of Land Use Change

- International policies and frameworks to address deforestation
  - SDGs
  - Paris Agreement on Climate Change
- Legal frameworks for managing land use change are usually complex and vary among countries
- Difficult to ensure legal compliance
- Land use planning, investments, adequate monitoring of land use change, and coordinated efforts are key in addressing forest loss

Image Credit: Dalmann UK

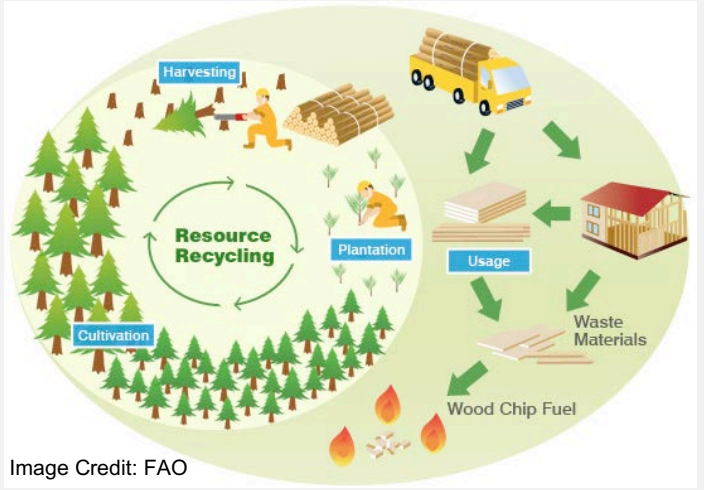


Image Credit: FAO

Remote Sensing for SDGs

Multi-data Framework

- SDGs recognize need for reporting based on multiple data types
  - "*…to explot the contribution to be made by a wide range of data, including Earth Observation and geospatial information, while ensuring national ownership in supporting and tracking progress.*"
- Earth observation data are often continuous in their spatial and temporal resolutions
  - Essential in capturing changes and progress related to SDGs over time

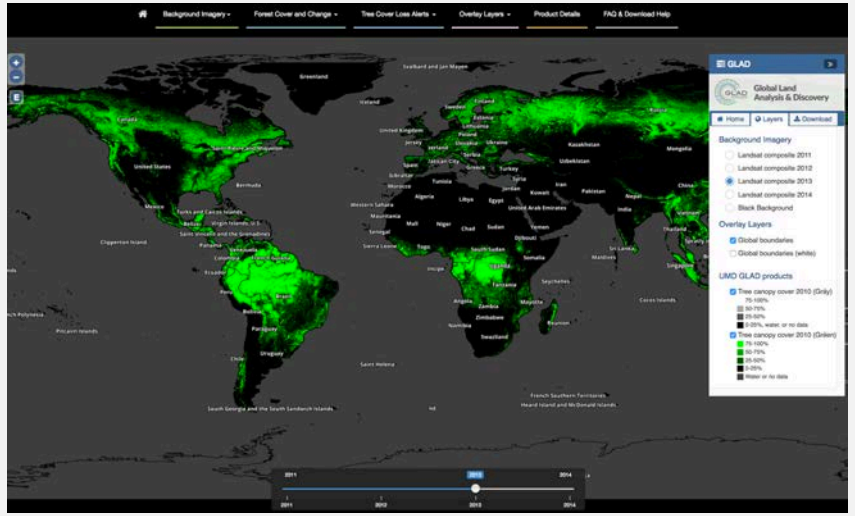
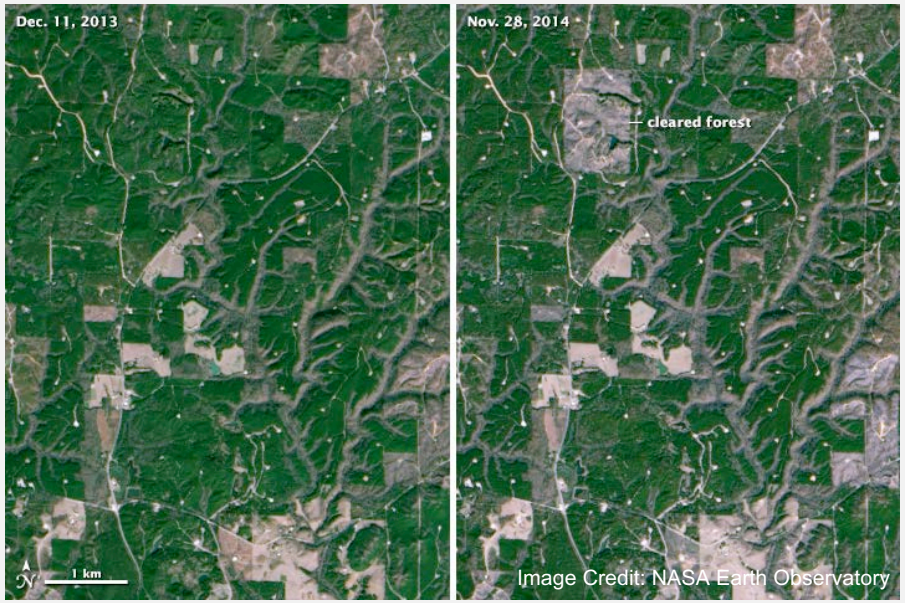
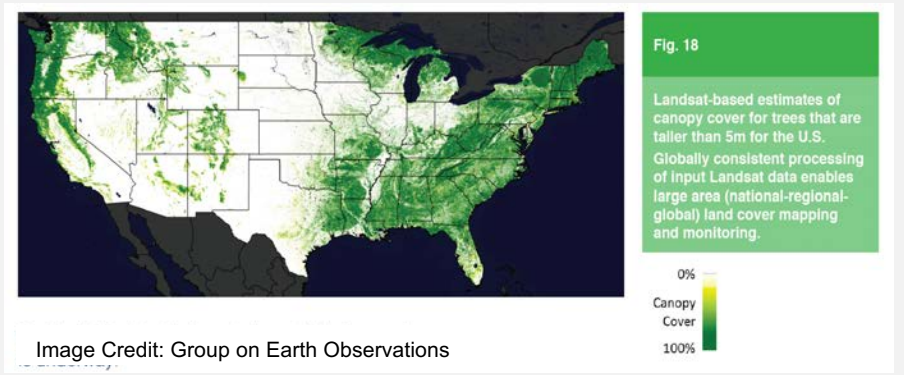


Image Credit: National Park Service (left), Global Land Analysis and Discovery (bottom)

Characteristics of Earth Observations

- Available for large regions
  - Only source of global information for some parameters
- Long time series and data continuity
  - Track progress
  - Establish baseline and trends
- Consistency and comparability
  - Among multiple countries
- Diversity of measurements
  - Many different physical parameters
- Complementarity with traditional statistical methods
  - Cross-check with in-situ data
- Mostly free and open access





Remote Sensing Data Sources

Considerations

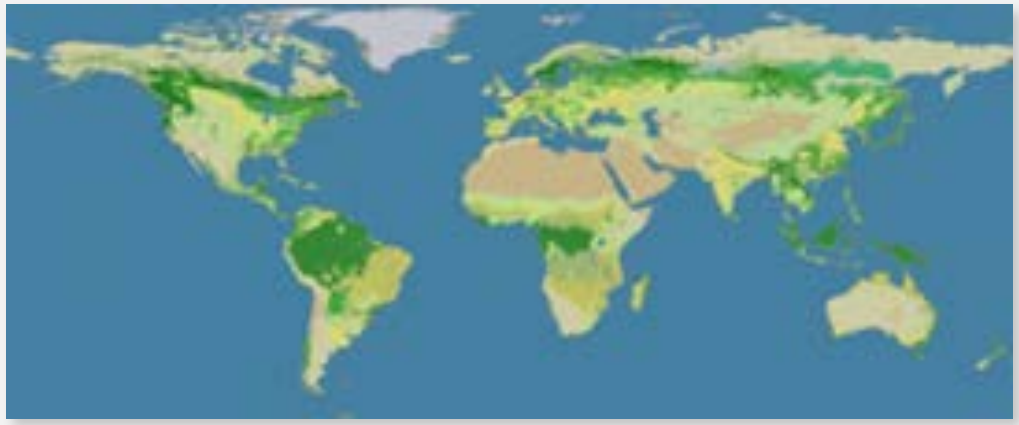
- What geographical, phenological, and atmospheric (especially persistent cloud cover) conditions exist?
- What is the spatial resolution of the data and how appropriate is it, relative to the scale of the land-cover changes to monitor?
- What is the temporal resolution in terms of potential frequency of acquisition of non-cloudy observations compared to the desired frequency of monitoring?
- What are the spectral regions, and bands within them, and how do these relate to the potential for distinguishing the land-cover types of interest, and changes among them?
- What is the longevity of the image archive length – does this meet the historical mapping needs?
- What are the cost implications of these data in terms of purchase and analysis?
- What are the future satellite development and launch commitments?

Remote Sensing Data Sources

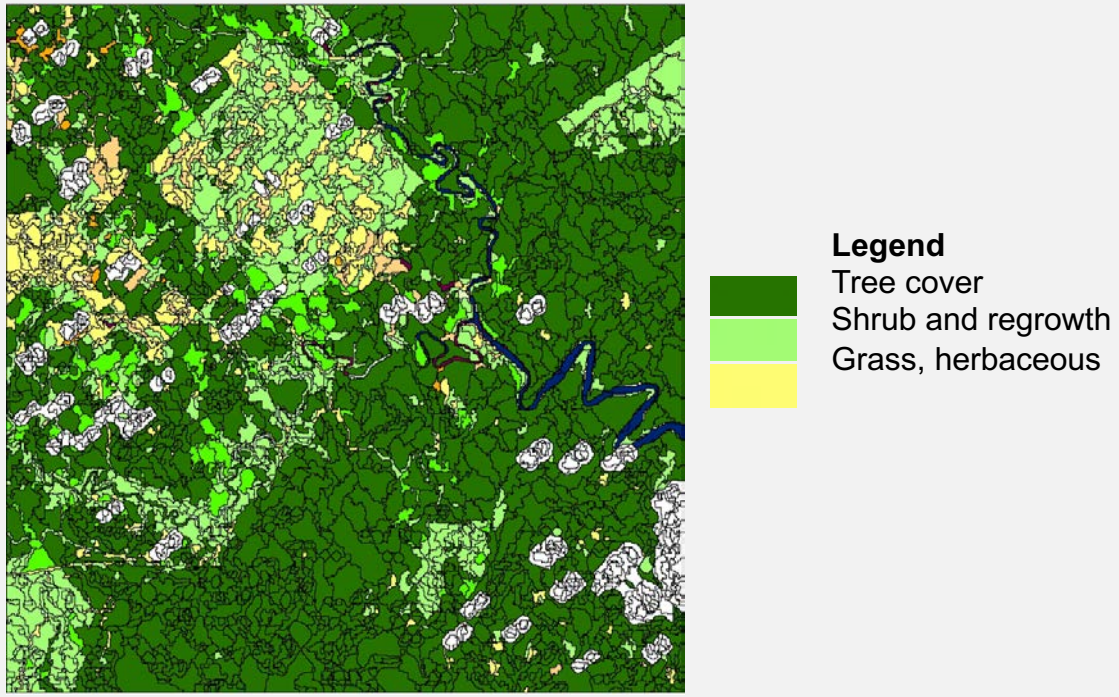
Overview

- Coarse spatial resolution (optical)
- Medium spatial resolution (optical)
- High spatial resolution (optical)
- Synthetic Aperture Radar
- LiDAR

MODIS Land Cover Map



Landsat Land Cover Map

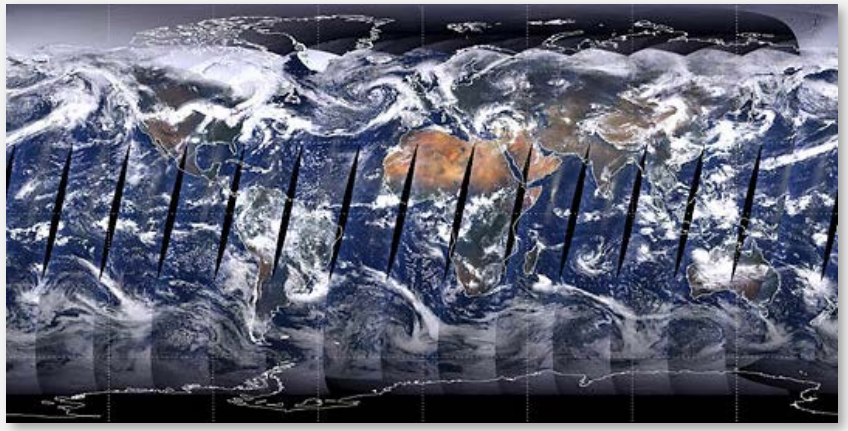


Sources: USGS 2015, GLS dataset; Bodart et al. 2011; and Raši et al. 2011.

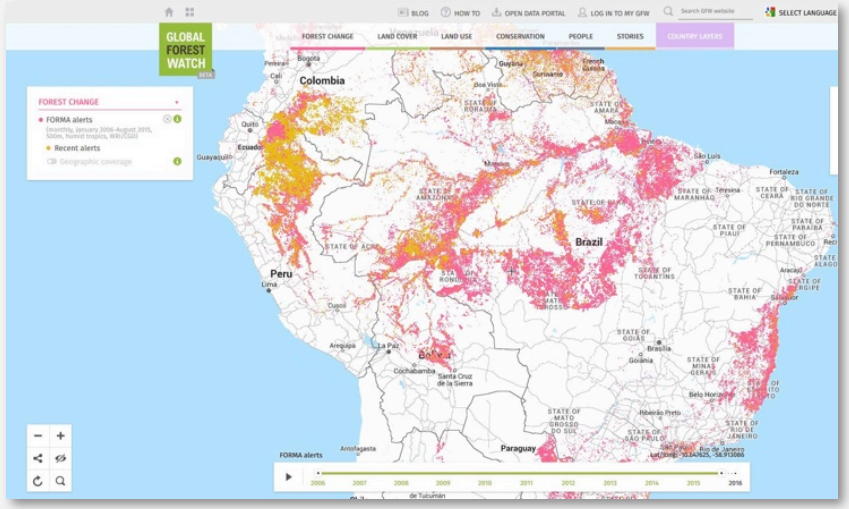
Remote Sensing Data Sources

Coarse Spatial Resolution (Optical)

- Greater than 250m
- Ex: MODIS, CBERS-2
- High temporal resolution useful for early warning and detection of forest clearing and degradation
- Example: FORMA
  - a monitoring system that issues monthly forest loss alerts for the humid tropics.
  - Generates alerts of likely forest clearing activity every 16 days at 500 m spatial resolution (Hammer et al. 2014)



NASA Worldview

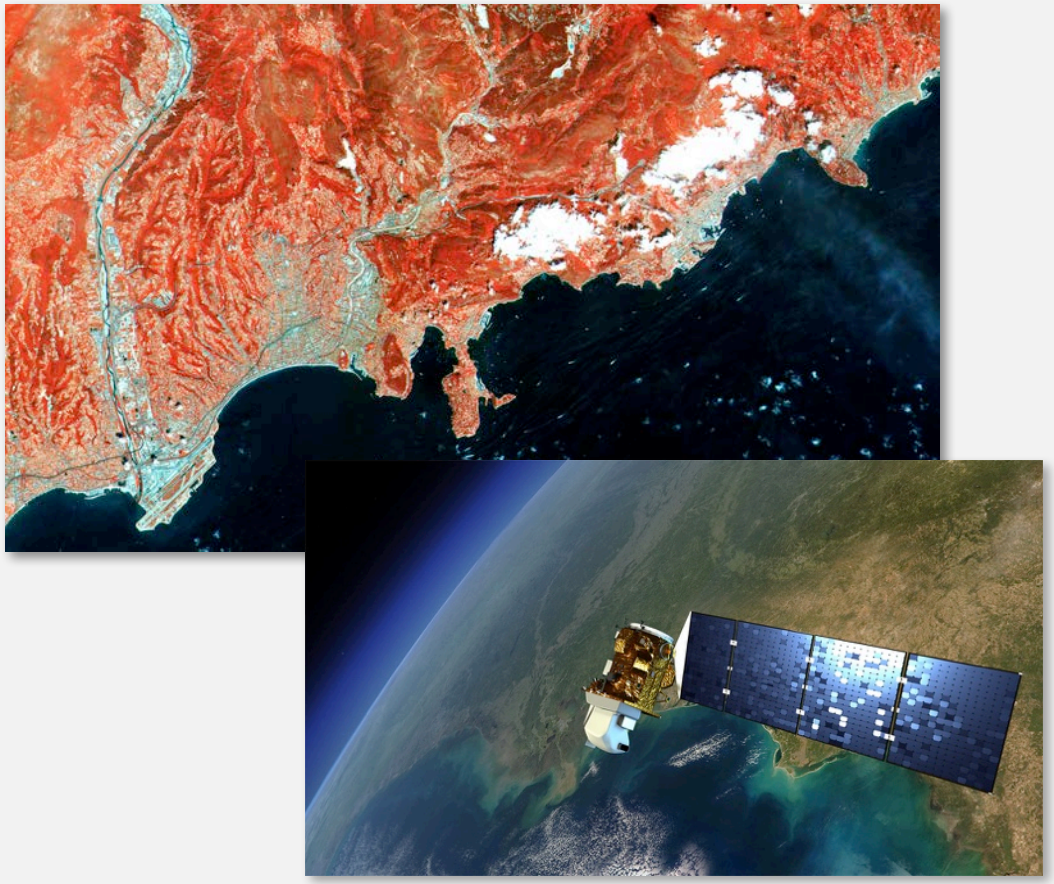


FORMA Alerts from Global Forest Watch

Remote Sensing Data Sources

Medium Spatial Resolution (Optical)

- 10 m – 80 m spatial resolution
- Most common: Landsat (30 m) and more recently, Sentinel 2
- Benefits:
  - Historical archive (early 1980s)
  - Easily accessible and freely available
  - Global coverage
- Limitations: Areas of persistent cloud cover
- Example: Global Forest Watch (Hansen et al. 2013)



Top: Image of the French Riviera, credit: Copernicus data (2015)/ESA. Bottom: Landsat

Remote Sensing Data Sources

High Spatial Resolution (Optical)

- Better than 10 m spatial resolution
- Examples: Worldview 2 and 3
- Primarily used for accuracy assessment or hot spot assessment
- Benefits
  - Forest activity data can be monitored more accurately and with greater differentiation
- Limitations
  - Higher acquisition and processing costs
  - Spatial and temporal coverage may not be adequate

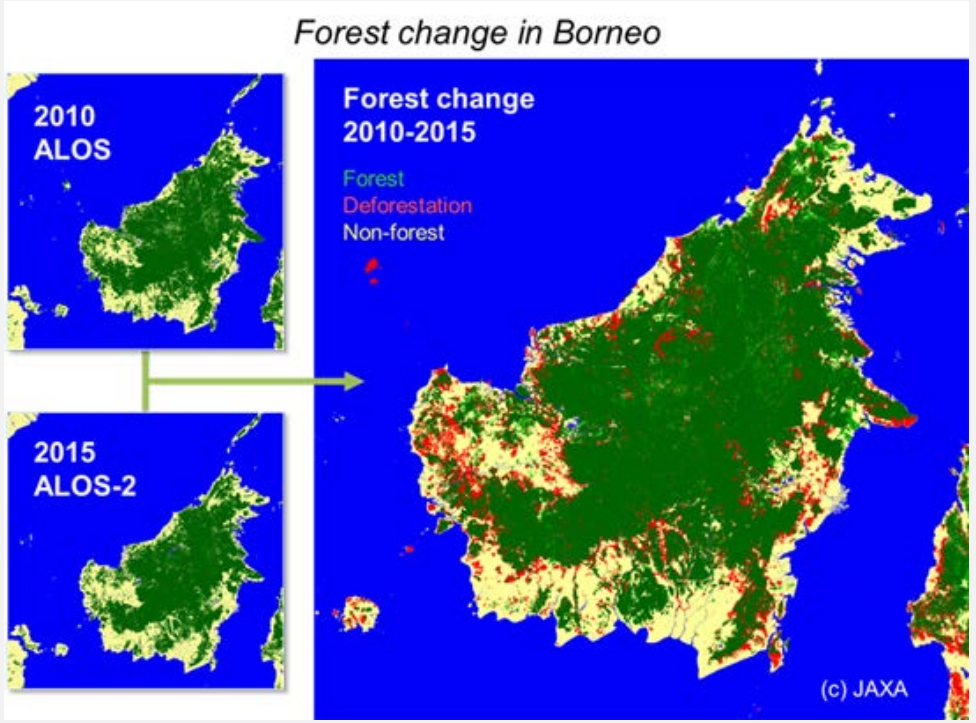

Image Credit: DigitalGlobe


Nilo Forest Reserve, Tanzania. Credit: Digital Globe and Norsk Regnesentral

Remote Sensing Data Sources

Synthetic Aperture Radar

- Two types:
  - shorter wavelengths (C- and X-band SAR)
  - longer wavelengths (L-band SAR)
- Can detect forest/non-forest and changes
- Benefits:
  - Useful in areas of persistent cloud cover
  - Can provide information on forest structure; complementary to optical data
- Limitations:
  - Difficult to process
  - Not currently used operationally

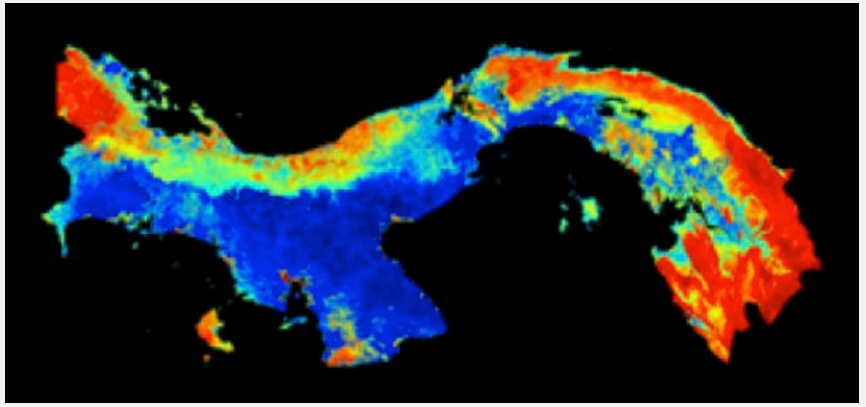


Forest change in Borneo (Masanobu et al. 2014)

Remote Sensing Data Sources

LiDAR

- Provides information on forest structure (e.g. tree height, canopy volume) and biomass
- Currently acquired using aircraft platform – no operational LiDAR satellites
- Benefits
  - Provides detailed information of forest structure
  - Verification of biomass estimates, reduces need for ground sampling
- Limitations
  - Expensive to acquire & process

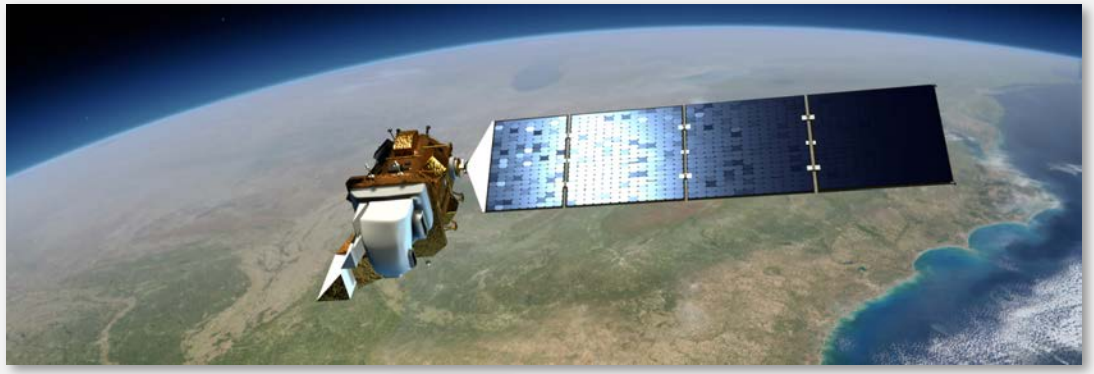


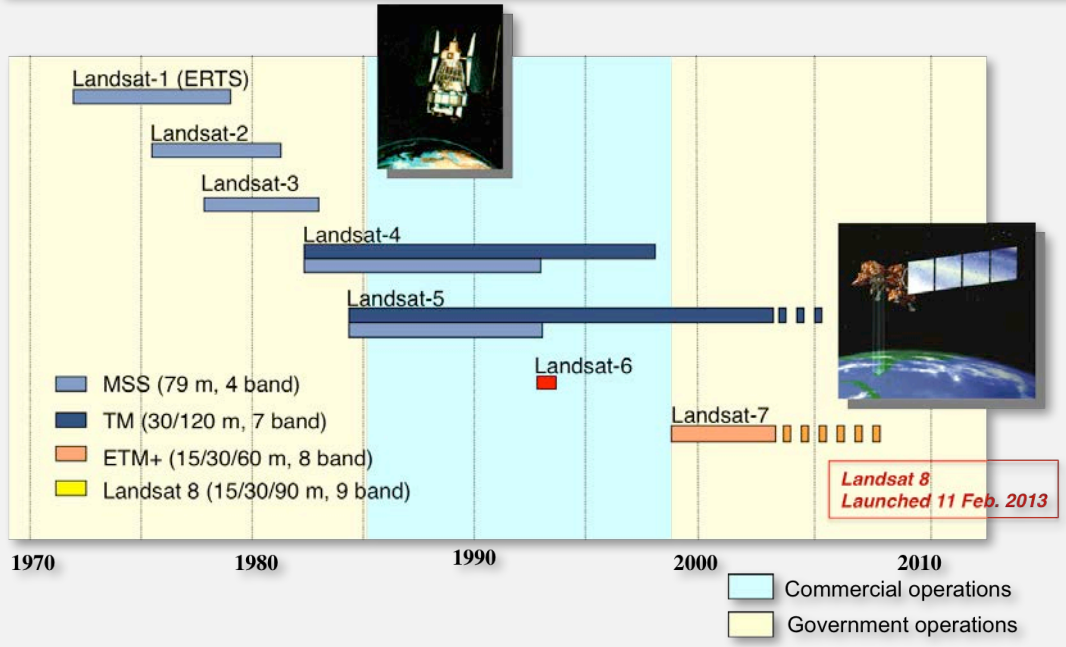
National carbon map of Panama by integrating field data with satellite imagery and LiDAR (Carnegie Institution, 2013). Credit: Carnegie Institution.

Remote Sensing Data Sources for Assessment of Land Cover

Landsat

- First Landsat launched in 1972
- Landsat 8 launched in 2013
- NASA created and launched
  – USGS maintains data
- Passive sensor: obtains values of reflectance from Earth's surface
- 30 meter pixels, 15 meter panchromatic band
- Entire image of the Earth every 16 days

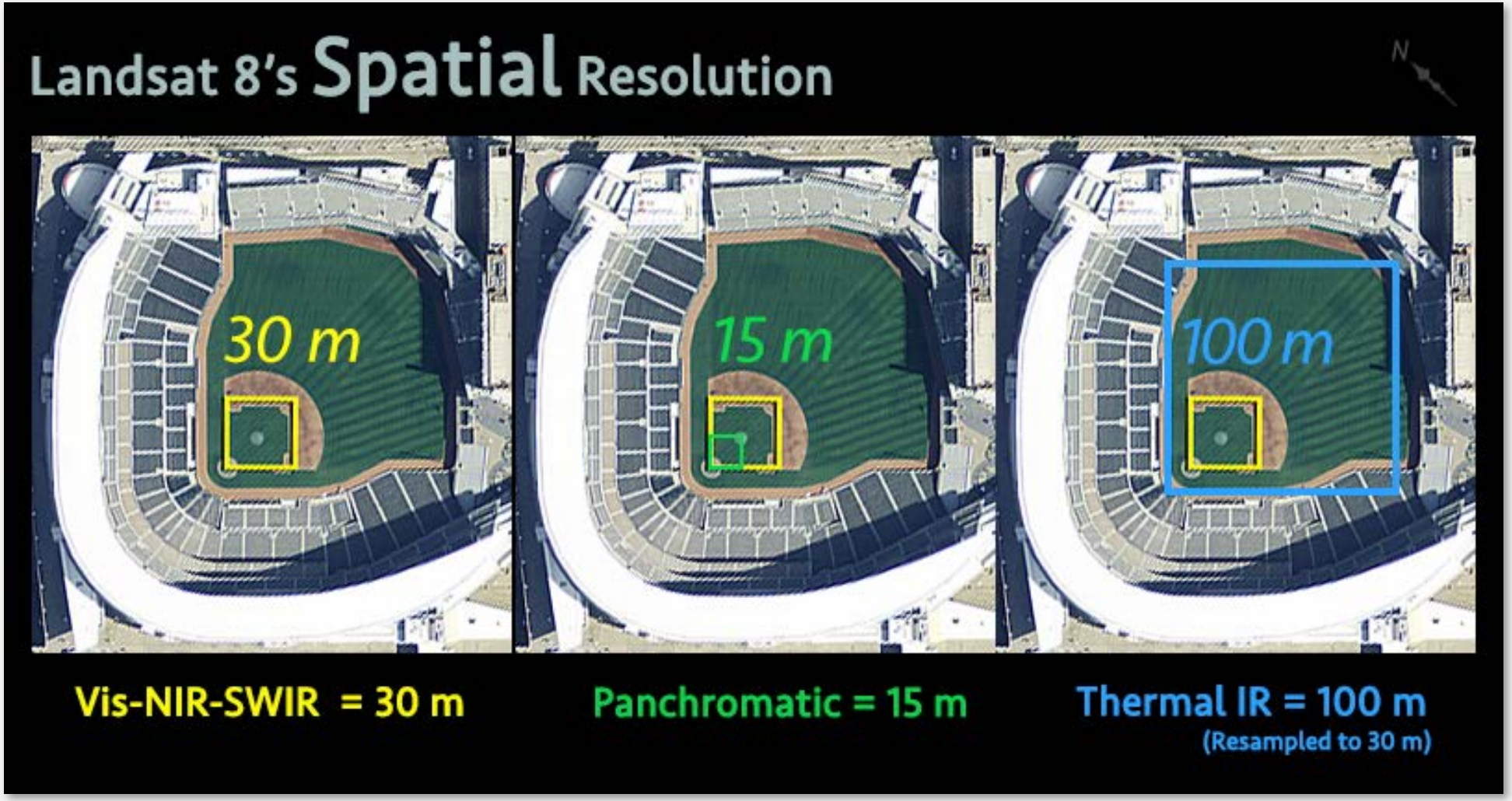




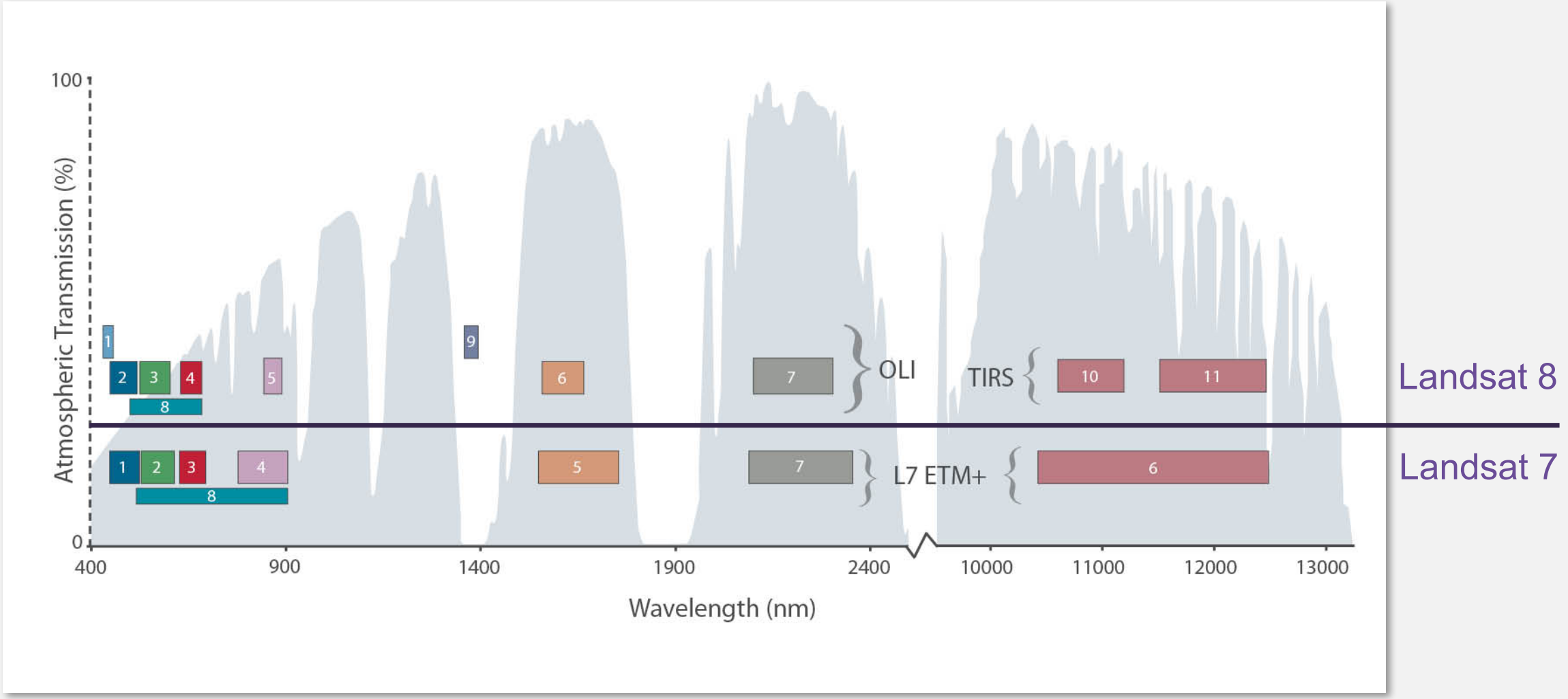
Landsat Bands

Landsat-7 ETM+ Bands (μm)			Landsat-8 OLI and *TIRS* Bands (μm)		
			30 m Coastal/Aerosol	0.435 - 0.451	Band 1
Band 1	30 m Blue	0.441 - 0.514	30 m Blue	0.452 - 0.512	Band 2
Band 2	30 m Green	0.519 - 0.601	30 m Green	0.533 - 0.590	Band 3
Band 3	30 m Red	0.631 - 0.692	30 m Red	0.636 - 0.673	Band 4
Band 4	30 m NIR	0.772 - 0.898	30 m NIR	0.851 - 0.879	Band 5
Band 5	30 m SWIR-1	1.547 - 1.749	30 m SWIR-1	1.566 - 1.651	Band 6
Band 6	60 m TIR	10.31 - 12.36	*100 m TIR-1*	*10.60 – 11.19*	Band 10
			100 m TIR-2	*11.50 – 12.51*	Band 11
Band 7	30 m SWIR-2	2.064 - 2.345	30 m SWIR-2	2.107 - 2.294	Band 7
Band 8	15 m Pan	0.515 - 0.896	15 m Pan	0.503 - 0.676	Band 8
			30 m Cirrus	1.363 - 1.384	Band 9

Landsat Spatial Resolution



Landsat Bands



Where to Obtain Landsat Images

LandsatLook Viewer: http://landsatlook.usgs.gov/

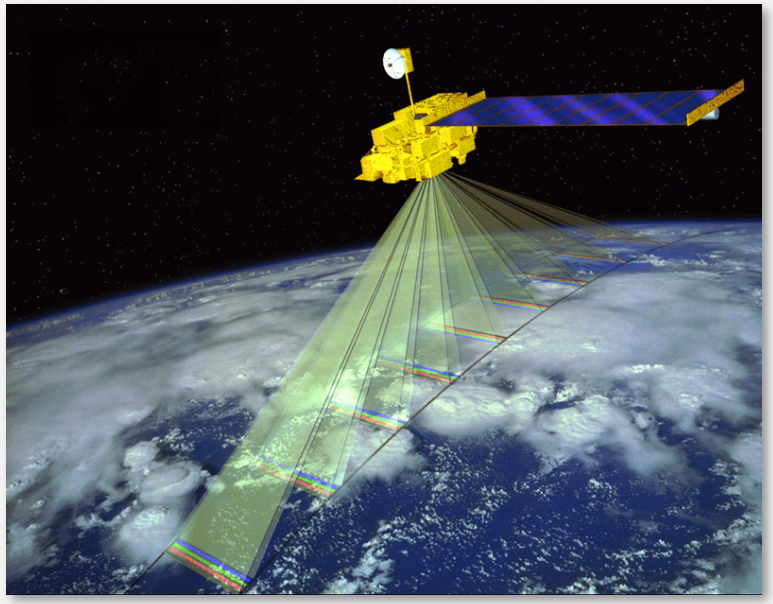
GloVis Next: http://glovis.usgs.gov/next/

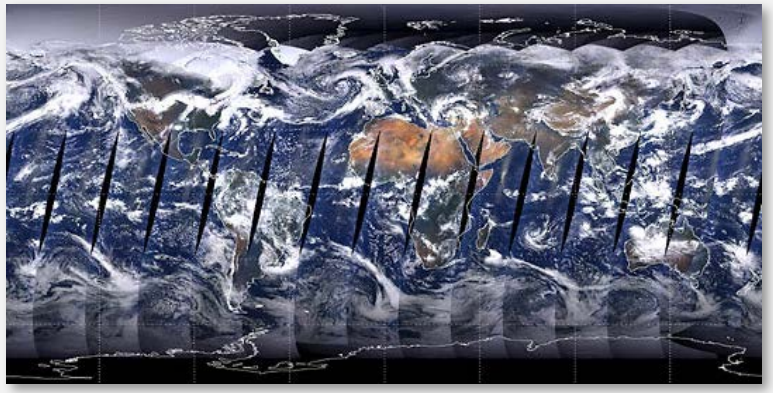
Global Land Cover Facility: http://glcf.umd.edu/data/landsat/

Earth Explorer: http://earthexplorer.usgs.gov/

MODIS

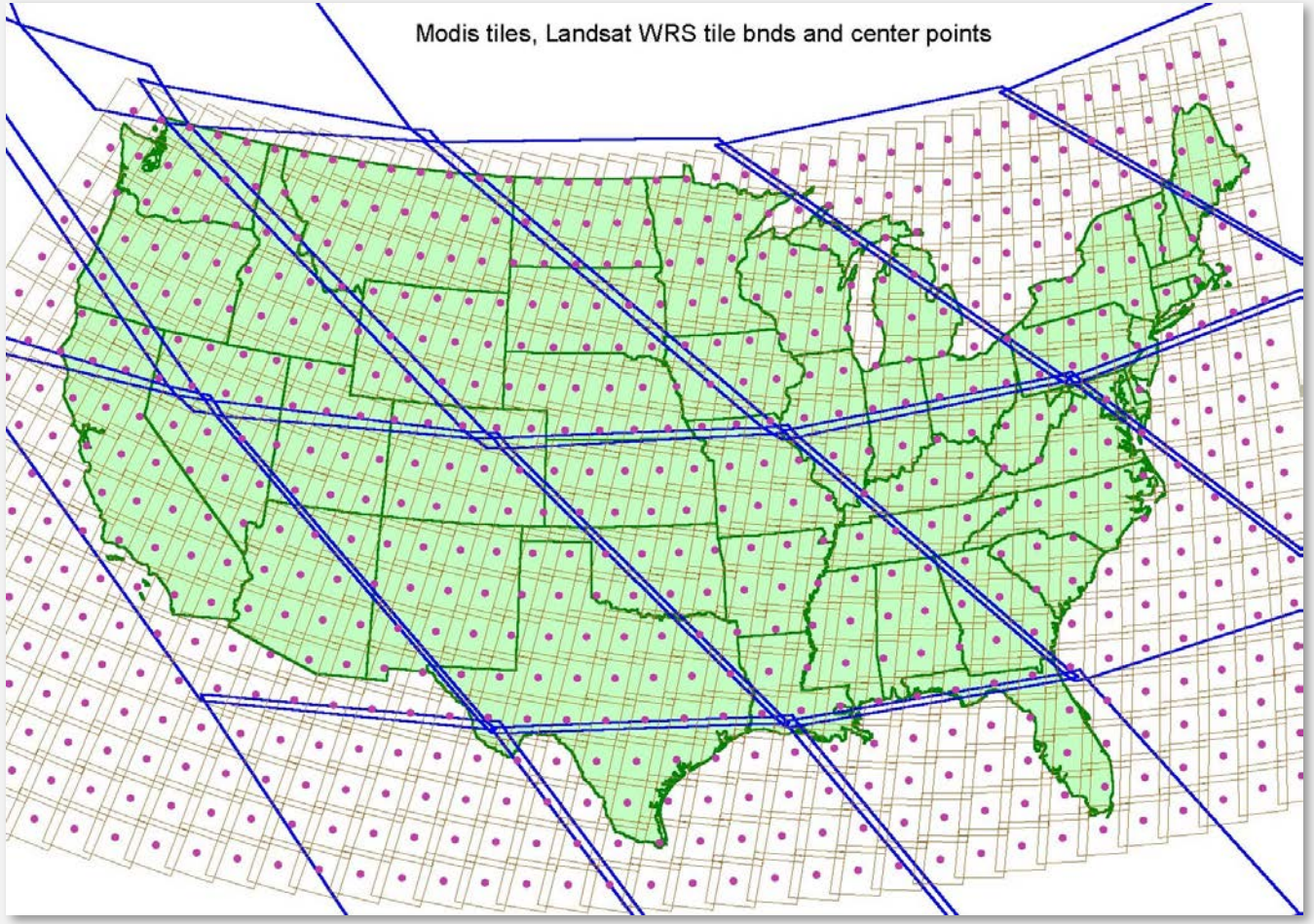
- Spatial Resolution
  - 250 m, 500 m, 1 km
- Temporal Resolution
  - Daily, 8 day, 16 day, monthly, quarterly, yearly
  - 2000–present
- Data Format
  - Hierarchal data format – Earth Observing System Format (HDF–EO8)
- Spectral Coverage
  - 36 bands (major bands include red, blue, IR, NIR, MIR)
    - Bands 1-2: 250 m
    - Bands 3-7: 500 m
    - Bands 8-36: 1000 m





MODIS vs. Landsat Images

- Large swaths!



Where to Obtain MODIS Products

Land Process Distributed Active Archive (LPDAAC): http://lpdaac.usgs.gov/

ECHO Reverb: http://reverb.echo.nasa.gov

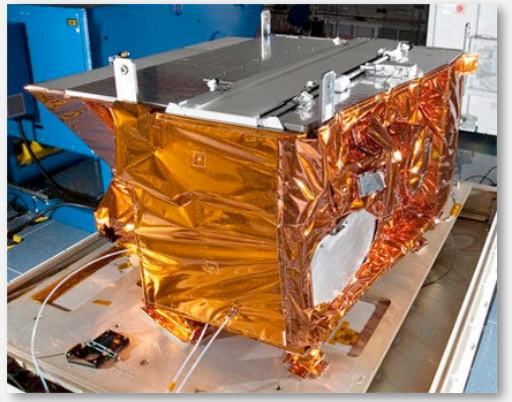
Worldview: https://earthdata.nasa.gov/labs/worldview

Earthdata Search: https://search.earthdata.nasa.gov/

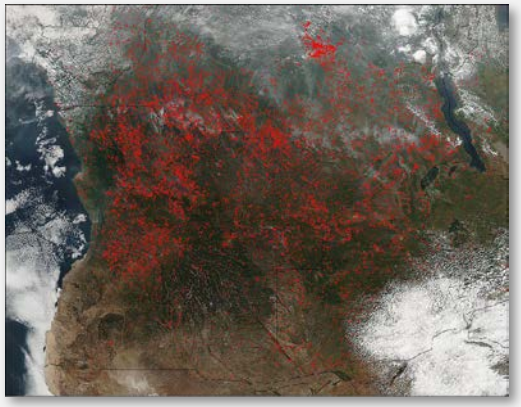
National Snow and Ice Data Center: http://nsidc.org/data/modis/data_summaries#snow

Suomi NPP: VIIRS

- Visible Infrared Imaging Radiometer Suite (VIIRS): instrument aboard Suomi National Polar-orbiting Partnership (NPP)
- Collects visible and infrared imagery and radiometric measurements
- Launched 2012
  - NOAA took control of operations in 2013
- Daily temporal resolution
  - Global coverage
- Spatial resolution
  - 5 high resolution bands: 375 m
  - 16 moderate resolution bands: 750 m
  - 1 day/night band: can observe fires at night



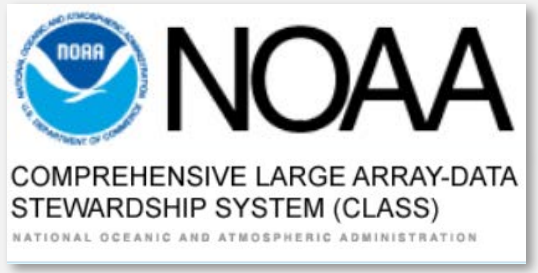
VIIRS sensor on Suomi-NPP



Fires in Central Africa acquired with VIIRS on Suomi-NPP on June 13, 2016 (Image credit: NASA, courtesy of Jeff Schmaltz)

Where to Obtain VIIRS Land Products

Worldview (Fires, Land Surface Temperature and Snow Cover):
http://earthdata.nasa.gov/labs/worldview



NOAA Comprehensive Large Array-Data Stewardship System (CLASS):
http://www.class.ngdc.noaa.gov/saa/products/welcome

Level-1 and Atmosphere Archive & Distribution System Website:
http://ladsweb.nascom.nasa.gov

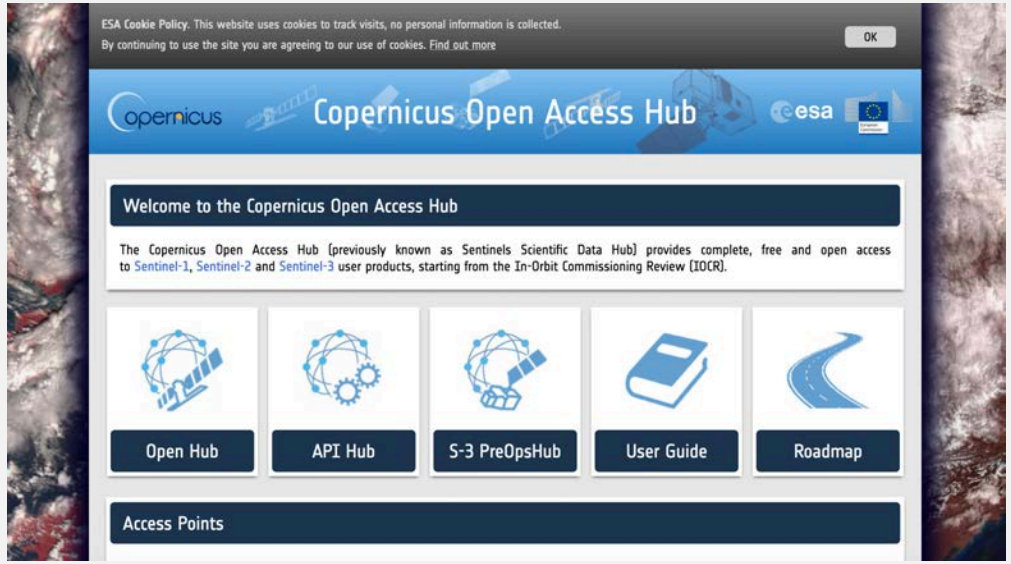
Sentinel-2

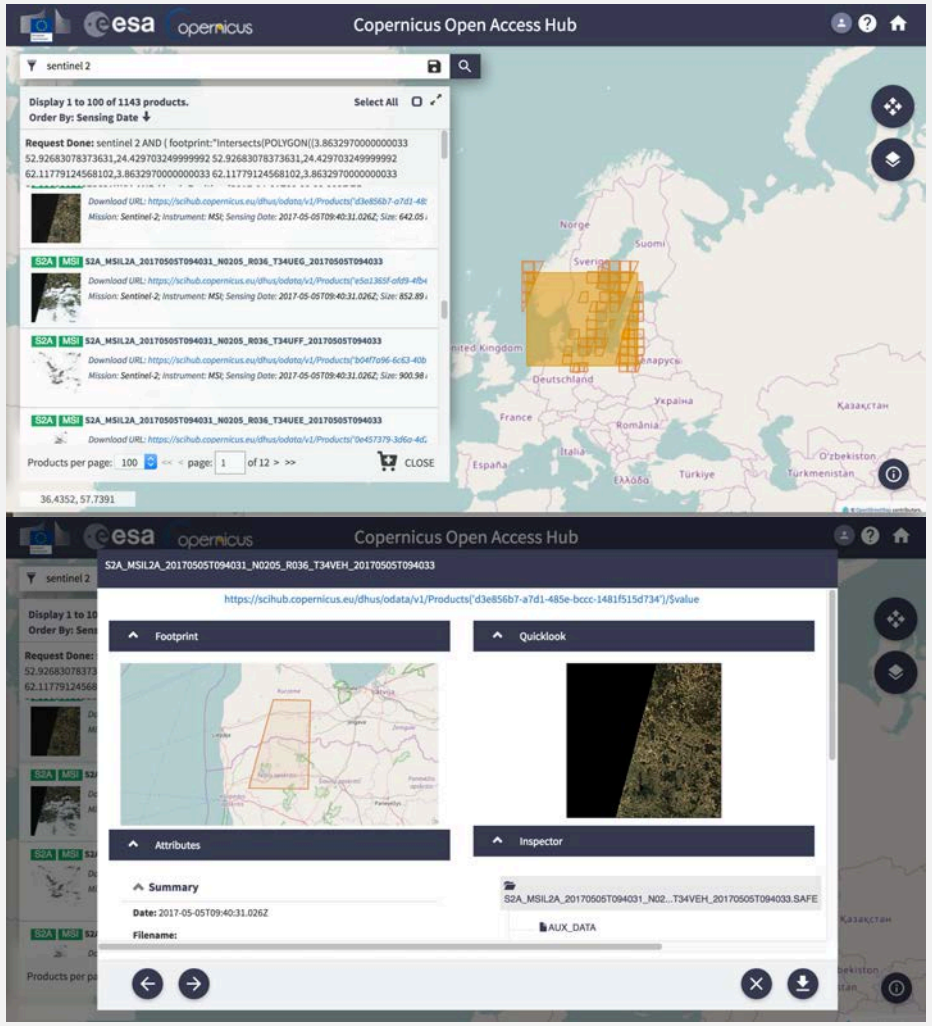
- Launched June 2015
  – Sentinel-2B in March 2017
- 2 Identical satellites
- 13 spectral bands
- Spatial Resolution: 20 m
- Temporal resolution: global coverage approximately every 5 days
- Applications:
  – Agriculture: yield prediction/plant growth
  – Forestry: land cover changes

Sentinel-2 satellite (top); Sentinel-2 image of central-eastern Brazil from August 2016 (bottom). Photo Credits: ESA

Accessing Sentinel-2

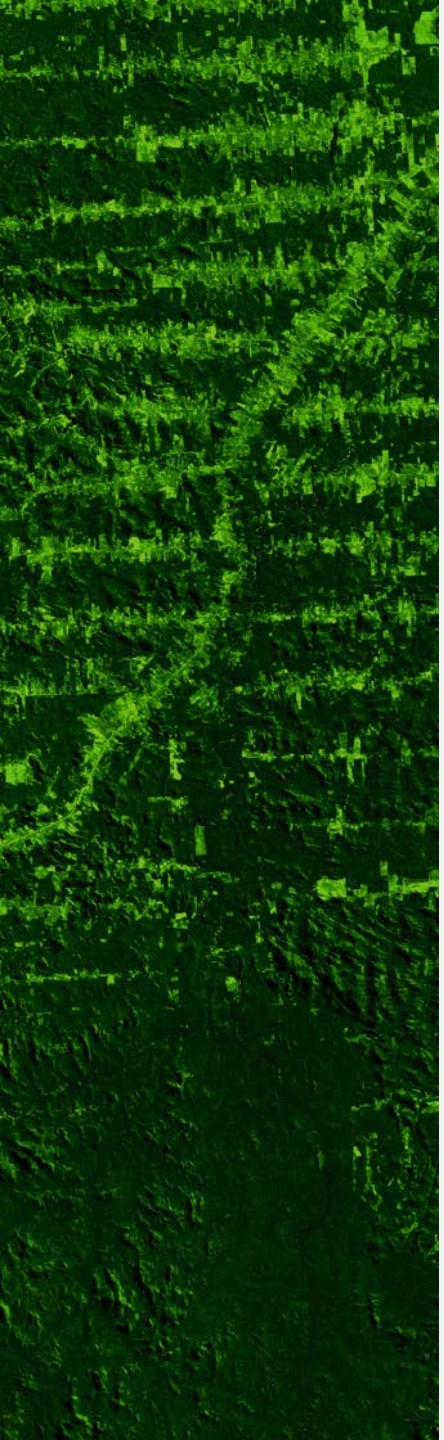
Copernicus Open Access Hub:
https://scihub.copernicus.eu/



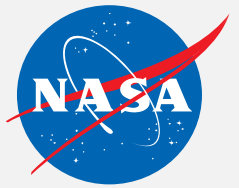


Contacts

- ARSET Land Management & Wildfire Contacts
  - Cynthia Schmidt: Cynthia.L.Schmidt@nasa.gov
  - Amber McCullum: AmberJean.Mccullum@nasa.gov
- General ARSET Inquiries
  - Ana Prados: aprados@umbc.edu
- ARSET Website:
  - http://arset.gsfc.nasa.gov



National Aeronautics and
Space Administration



ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

@NASAARSET

Thank You

Next Session (tomorrow):

SDG Target 15.1