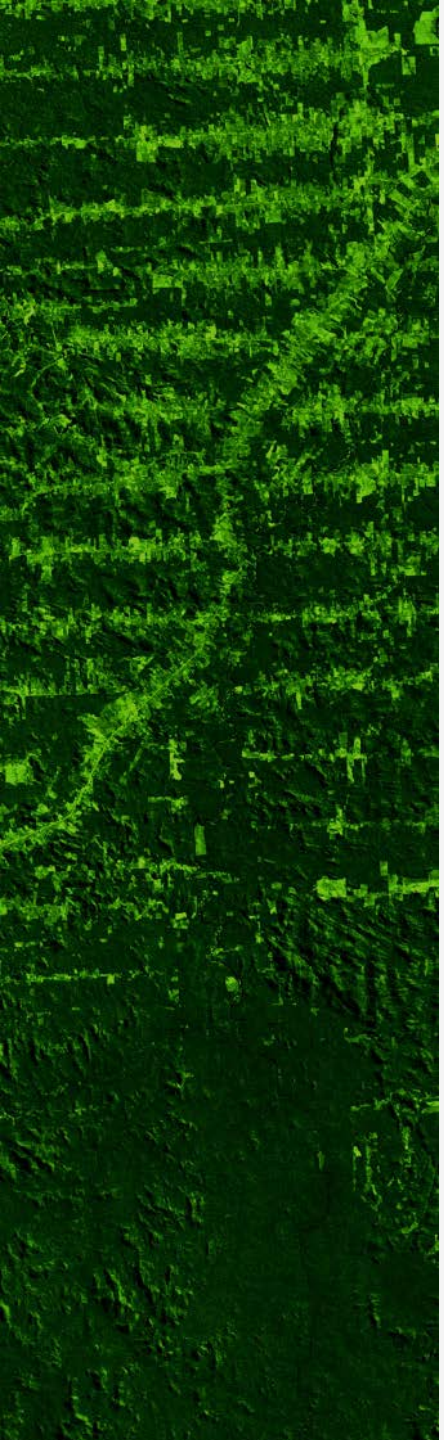


National Aeronautics and Space Administration

ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

@NASAARSET

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

Instructors: Cindy Schmidt and Amber McCullum

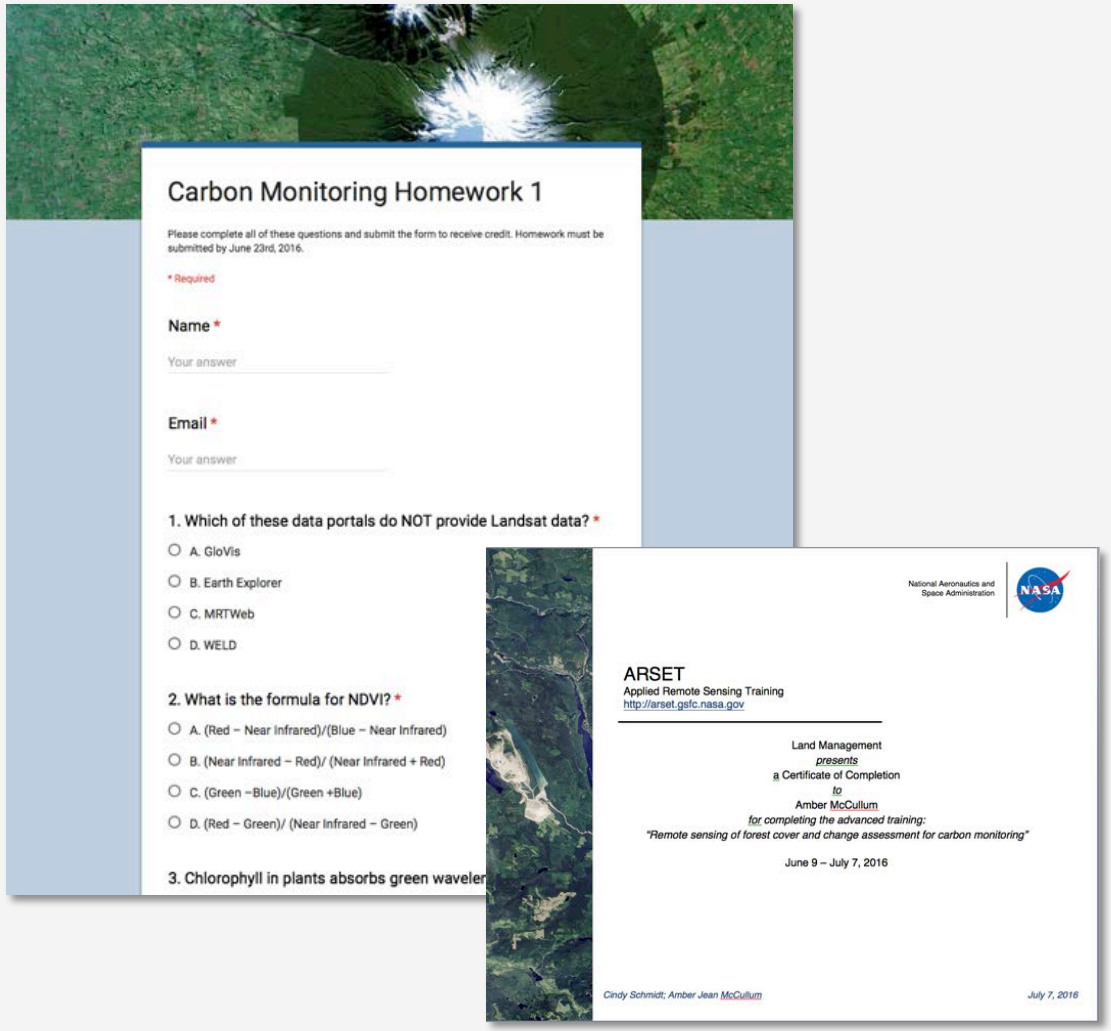
Session 3: June 22, 2017

Course Structure

- Three sessions: Tuesday, June 20; Wednesday, June 21; Thursday, June 22
  - Each session will be given twice:
    - Session A: 1:00 – 2:00 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

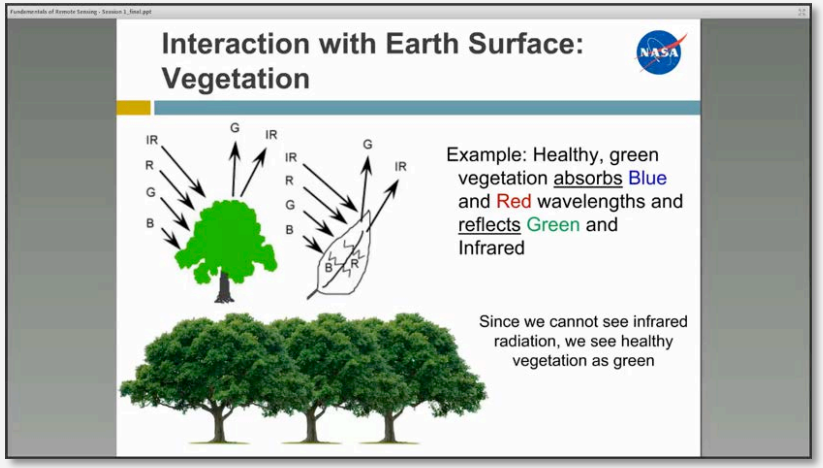
Homework and Certificates

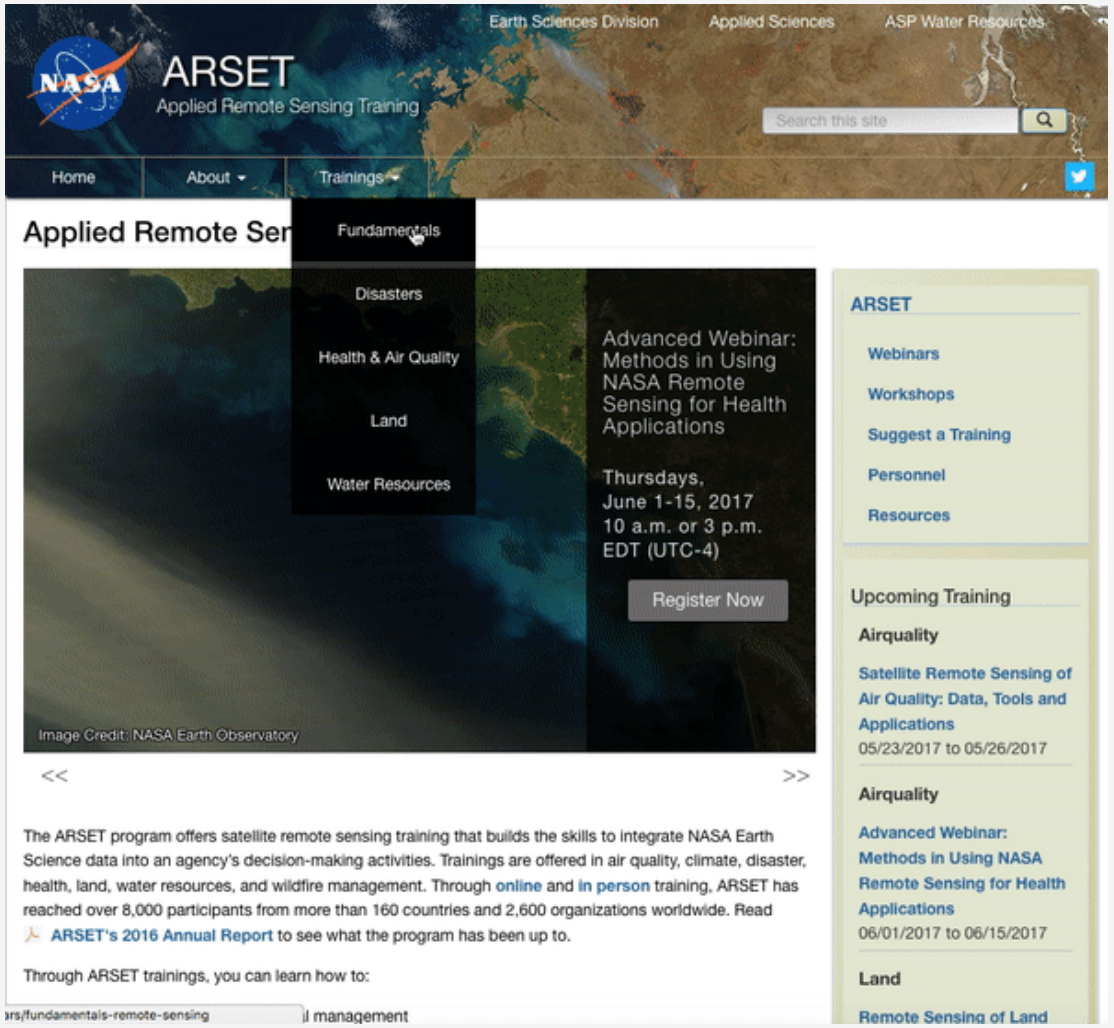
- Homework
  - Answers must be submitted via Google Form
- Certificate of Completion:
  - Attend all 3 webinars
  - Complete the homework assignment by the deadline (access from ARSET website)
    - HW Deadline: July 6th
  - You will receive certificates approx. two months after the completion of the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



Prerequisite

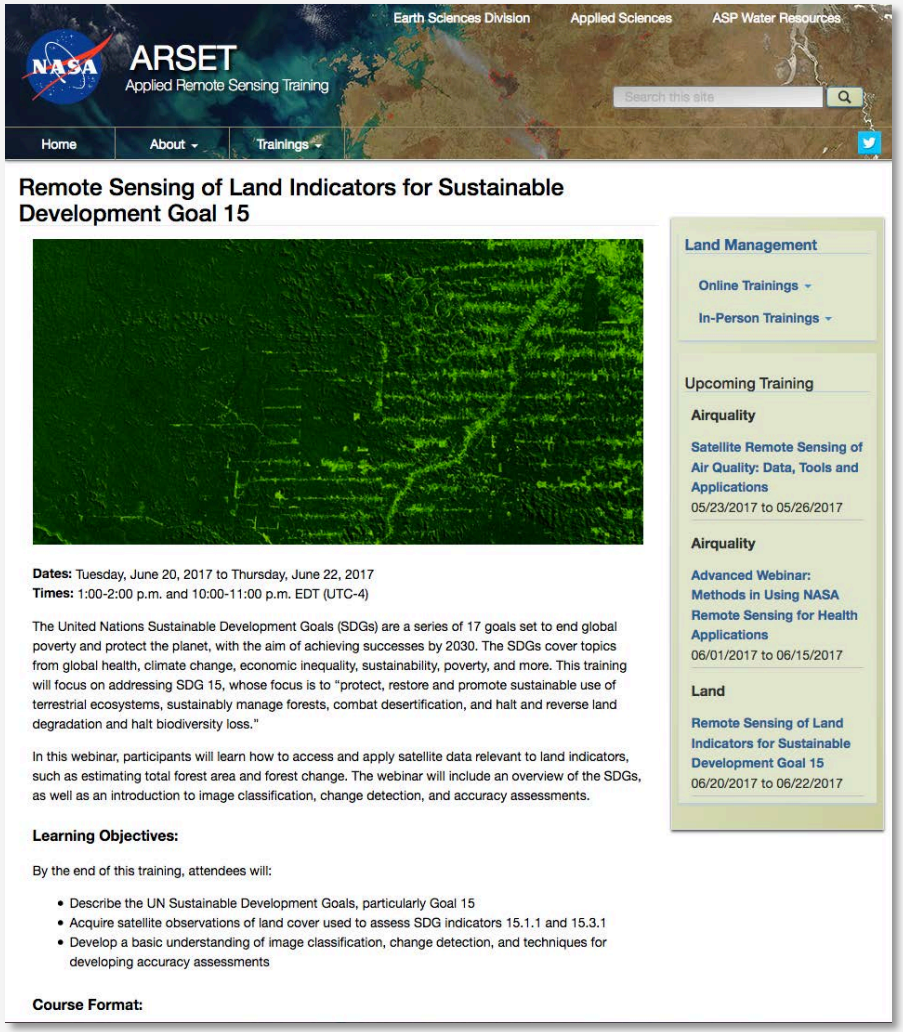
- Fundamentals of Remote Sensing
  - Sessions 1 and 2A (Land)
  - On demand webinar, available anytime
  - http://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing

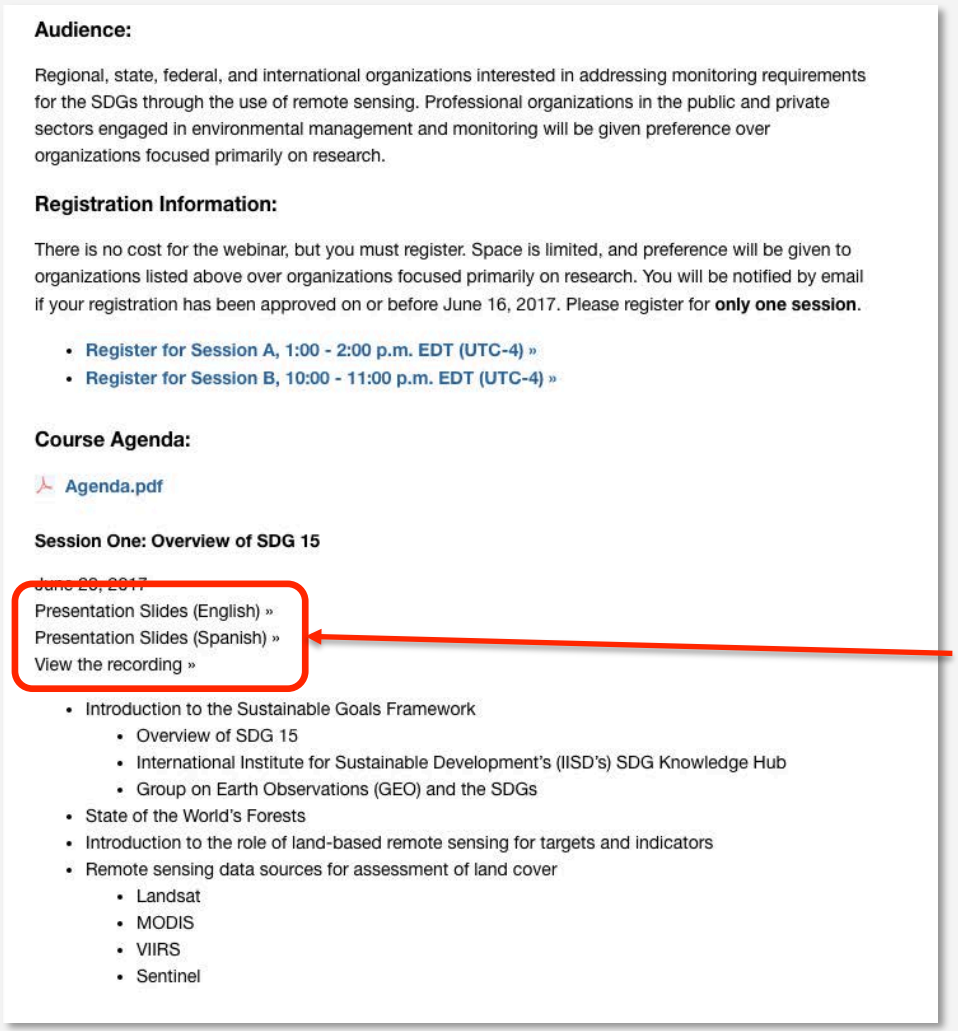




Accessing Course Materials

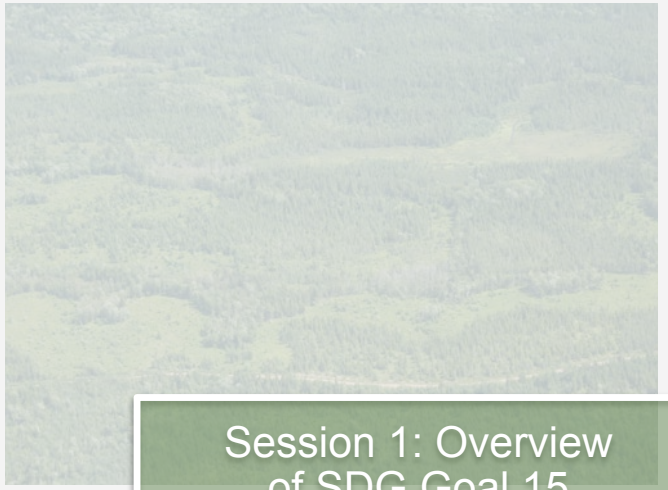
- http://arset.gsfc.nasa.gov/land/webinars/sdg15/



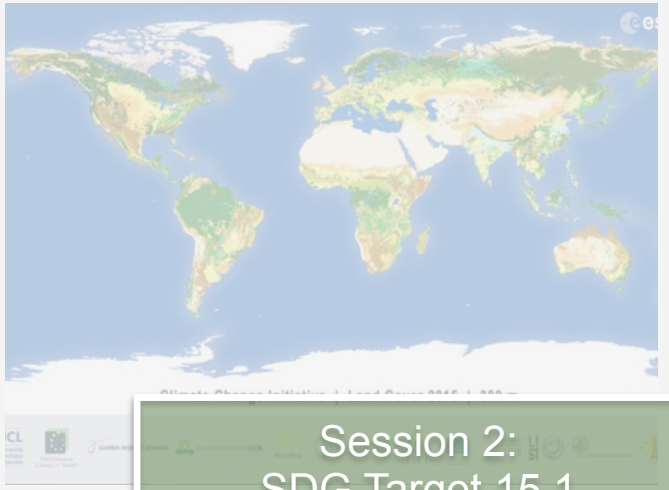


Course materials are provided here and will be active after each week

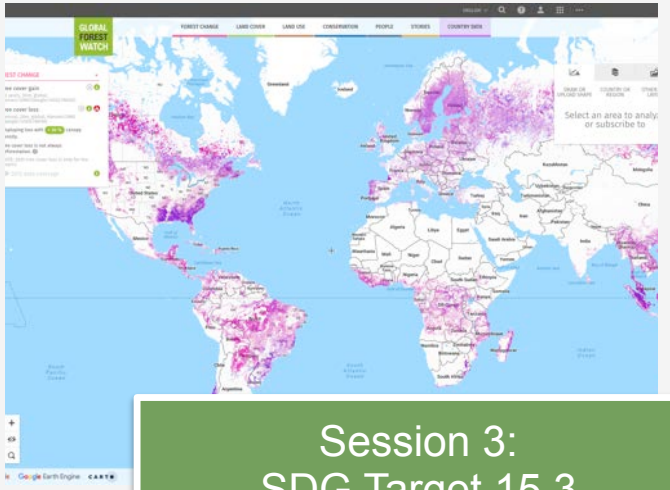
Course Outline



Session 1: Overview of SDG Goal 15



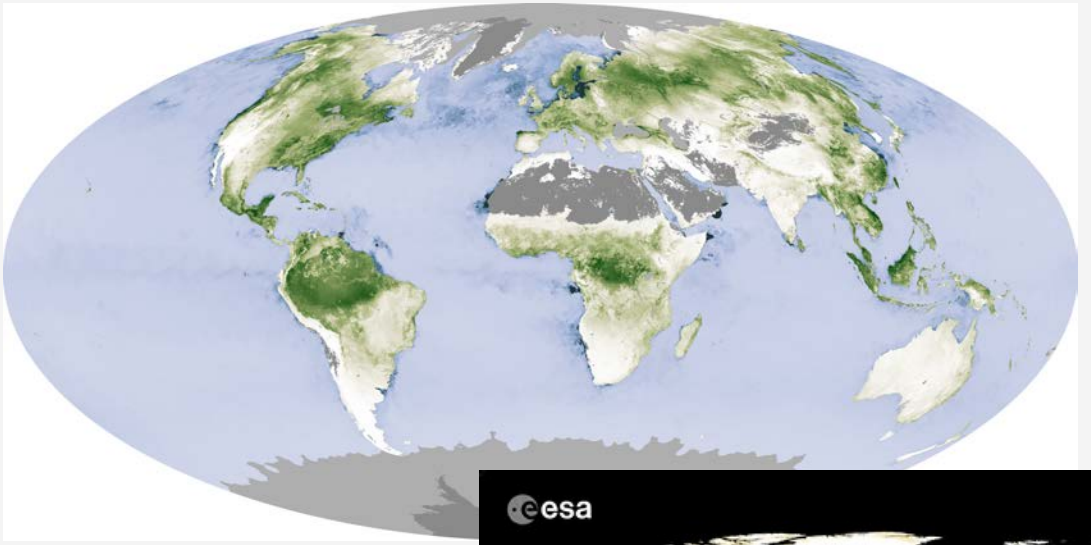
Session 2: SDG Target 15.1

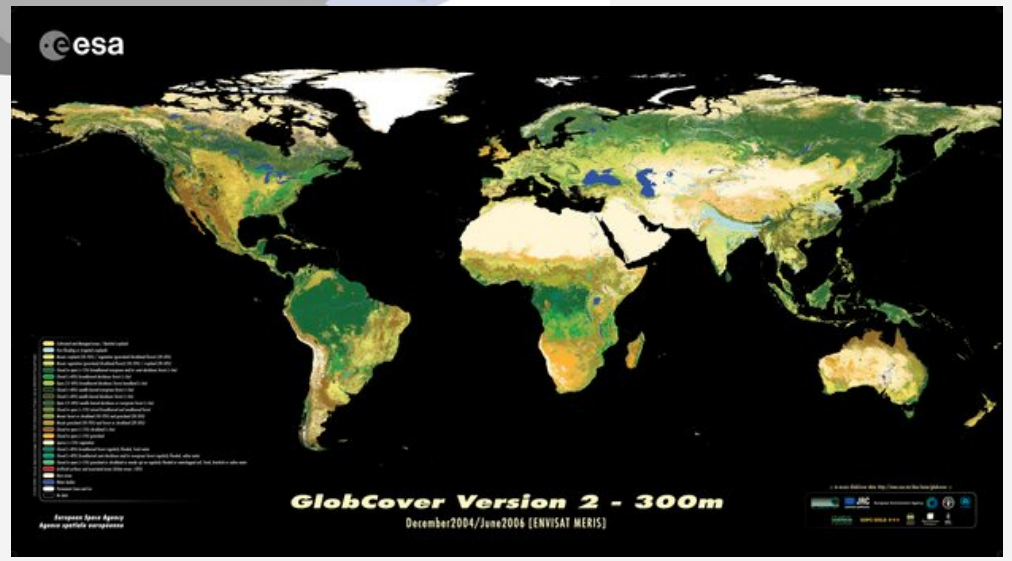


Session 3: SDG Target 15.3

Session 3 Agenda

- Overview of Target 15.3 and Indicator 15.3.1
- Vegetation definitions relevant to land productivity and health
- Global satellite-derived vegetation products
- Land cover change detection methods with satellite imagery





Net Primary Productivity (NPP) from MODIS in 2009 (Earth Observatory) (Top); Global land cover map, 2008 via ESA (right).

Target 15.3

SDG: Target 15.3

- 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

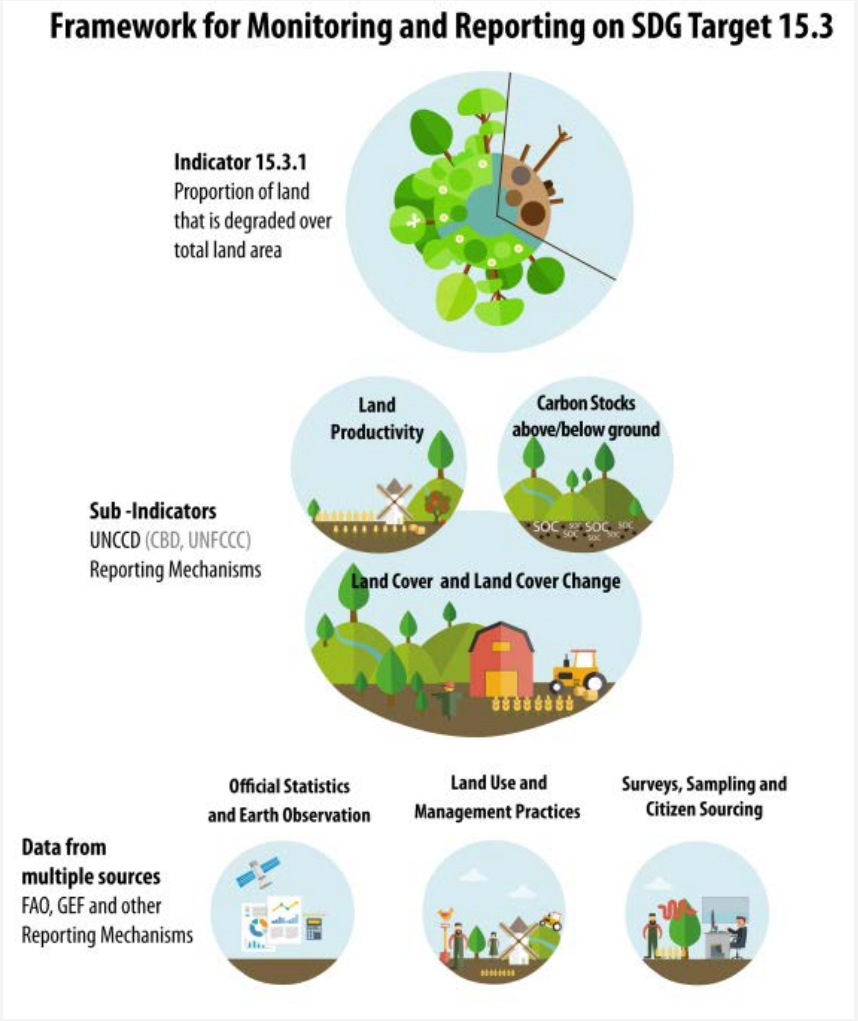
"Land degradation is the reduction or loss of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes arising from human activities."

Elaboration of an international convention to combat desertification in countries experiencing serious drought and/or desertification, particularly in Africa (1994, September 12). http://www.unccd.int/Lists/SiteDocumentLibrary/conventionText/conv-eng.pdf

Indicator 15.3.1

Sub-indicators

- Land cover and land cover change
- Land productivity
- Carbon stocks above and below ground
- A combination of satellite Earth observations and site-based data will be needed to
  - set baselines to determine the initial status of the sub-indicators
  - detect change in each of the sub-indicators
  - derive the indicator by determining what areas of change are considered land degradation



Framework and Guiding Principles for a Land Degradation Indicator, United Nations Convention to Combat Desertification

United Nations Convention to Combat Desertification

http://www2.unccd.int/

- Focus on Target 15.3 in effort for land degradation neutrality
  - http://www2.unccd.int/land-degradation-neutrality
- Links environment and development to sustainable land management
- Specifically addresses arid, semi-arid, and dryland ecosystems
- Works to:
  - improve living conditions in drylands
  - maintain and restore land & soil productivity
  - mitigate drought
  - combat desertification and land degradation

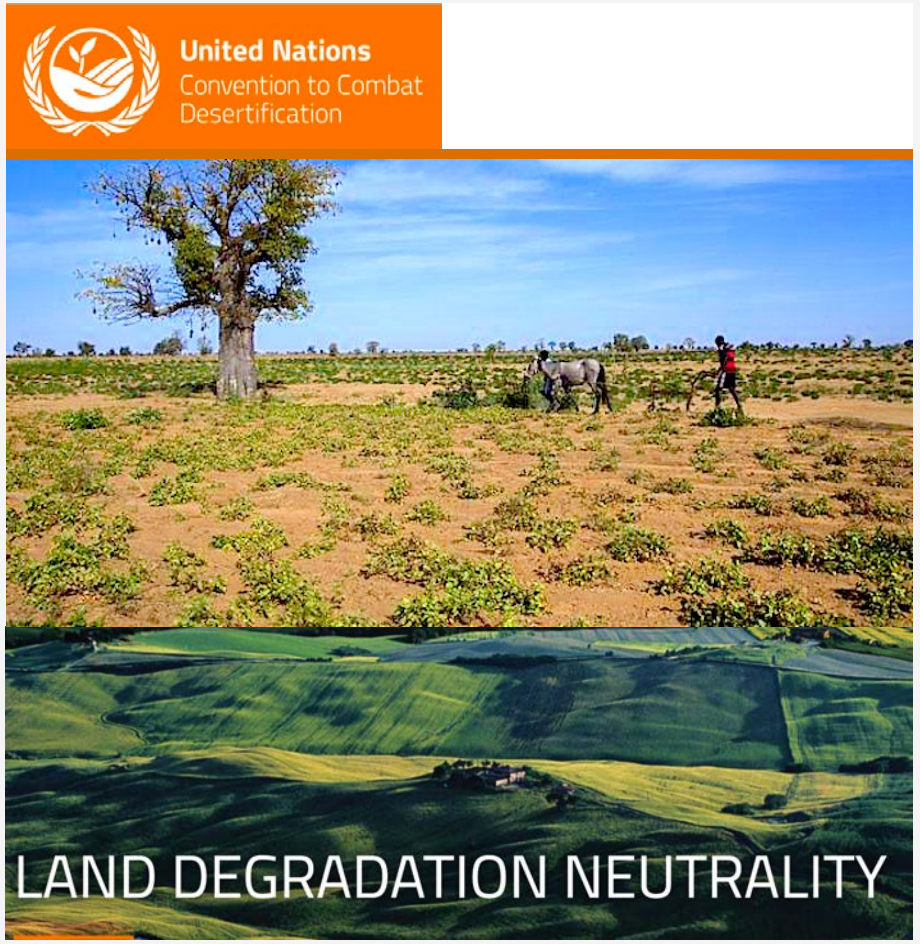
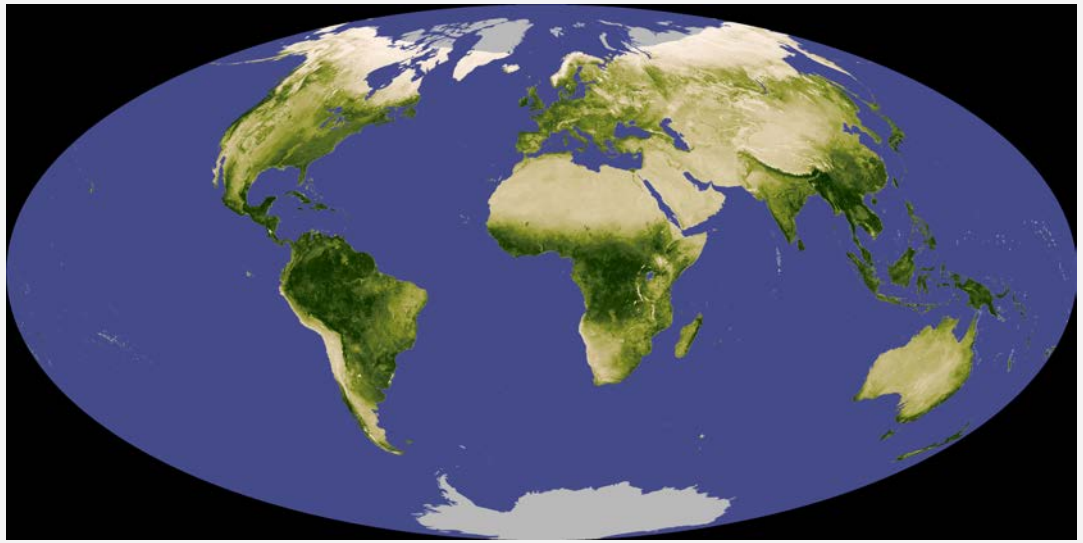


Image Credit: (Top) BBC (Bottom) UN Convention to Combat Desertification

Vegetation Definitions

Land Productivity

- For plants, productivity, or primary production is the production of chemical energy in organic compounds by living organisms, usually through photosynthesis
- Reflects the net effects of changes in ecosystem functioning on plant and biomass growth
- Can be monitored by Earth Observation proxies of above-ground net primary productivity (NPP) such as:
  - Spectral Indices (e.g. NDVI)
  - Biophysical retrievals (e.g. fraction of absorbed photosynthetically active radiation, fAPAR)



MODIS NDVI

Vegetation Definitions: Carbon Pools and Fluxes

- **Gross Primary Productivity (GPP)**: total of all carbon fixed through photosynthesis
- **Autotrophic Respiration (Ra)**: the carbon that a plant uses and loses in the process of constructing and maintaining its biomass (above & below ground)
- **Heterotrophic Respiration (Rh)**: carbon that is released to the atmosphere by consumers or decomposers that are breaking down organic matter (OM)
- **Net Primary Productivity (NPP)**: the amount of carbon uptake after subtracting plant respiration from GPP

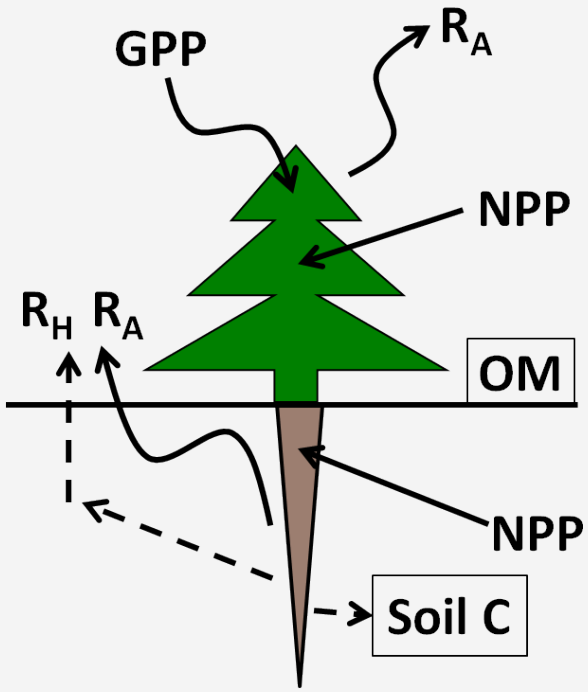
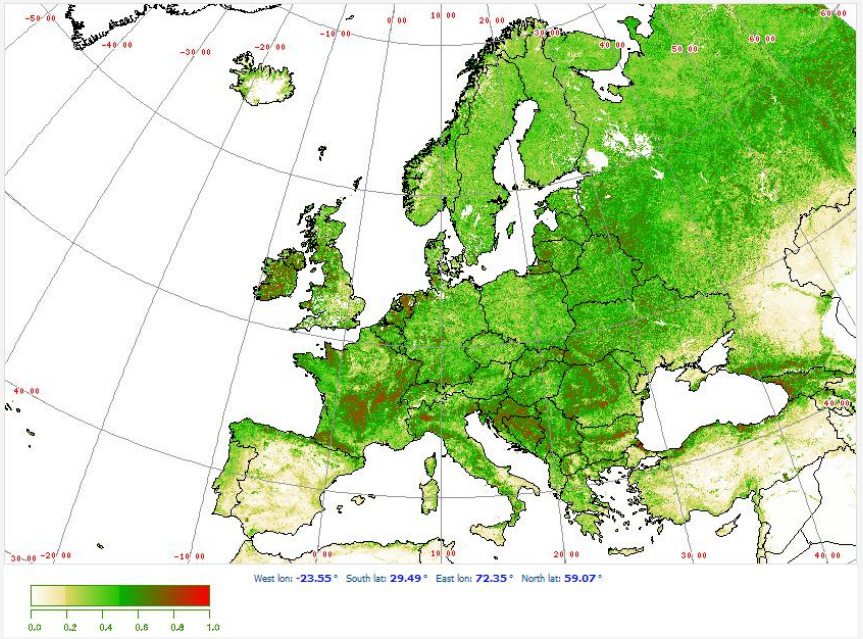


Image Credit: Silviculture and Applied Forest Ecology at Stephen F. Austin State University

More Definitions

- **Photosynthetically active radiation (PAR):** the spectral range from 400-700 nm that is used by plants in photosynthesis
- **Fraction of Absorbed Photosynthetically Active Radiation (fPAR or fAPAR):** the portion of PAR used by plants
  - Precipitation and temperature are two of the major determining factors
  - Important parameter in measuring biomass production
  - fPAR can be measured on the ground or inferred from satellite imagery

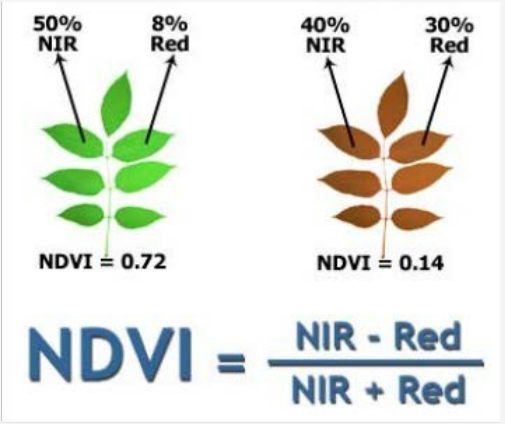


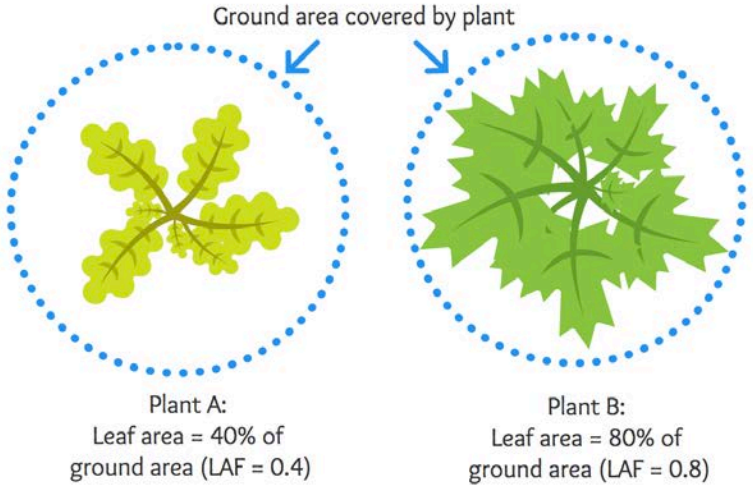
fAPAR in Europe, August 2011 from European Space Agency (ESA)

Vegetation Indices

- **Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI):** relationship between visible and near-infrared radiation to compare the photosynthetic capacity of vegetation per pixel
  - *These are not quantifiable measurements*
- **Leaf Area Index (LAI):** the leaf area per unit ground area
  - The one-sided green leaf area per unit ground area in broadleaf canopies and ½ the total needle surface area per unit ground area in coniferous canopies
- LAI is related to, but not directly proportional to, NDVI

NDVI equation and schematic (right); Leaf Area Index Depiction (bottom)

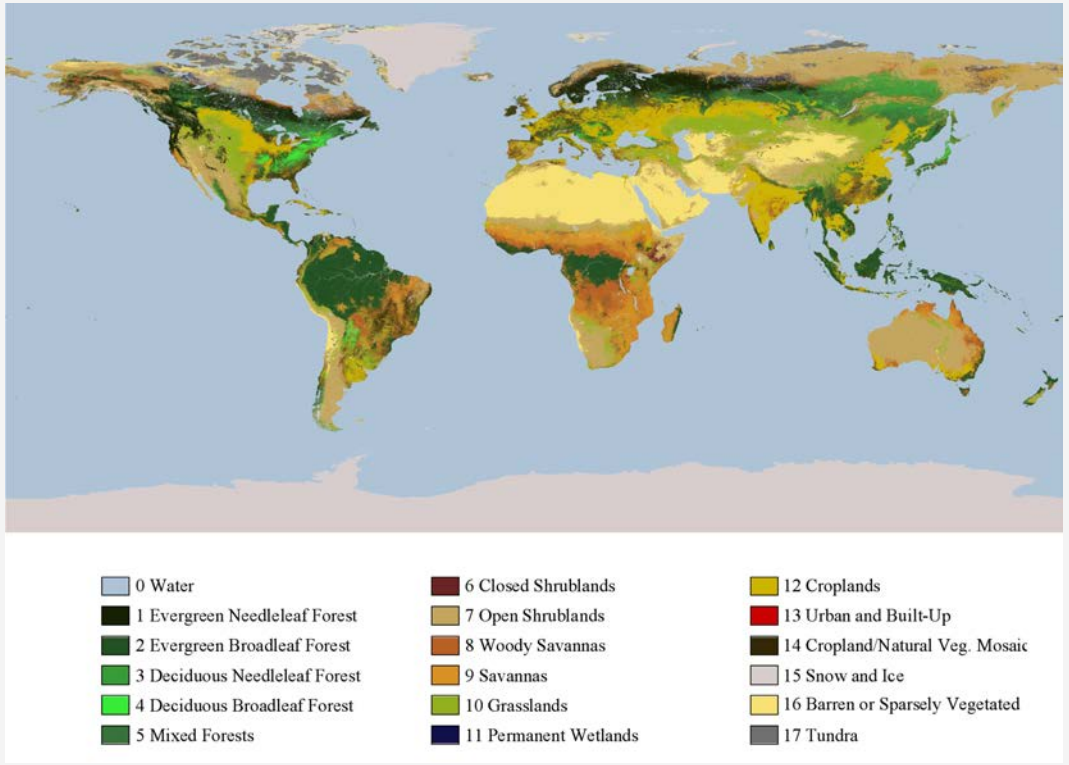




Vegetation Products

Global Land Cover Maps (from session 2)

- FAO Global Land Cover SHARE (GLC-SHARE)
  - http://www.fao.org/geonetwork/srv/en/main.home
- European Space Agency Climate Change Initiative Land Cover
  - http://maps.elie.ucl.ac.be/CCI/viewer/
- GlobeLand30 (China)
  - http://www.globallandcover.com/GLC30Download/index.aspx
- MODIS Land Cover
  - https://search.earthdata.nasa.gov



Global Productivity Data

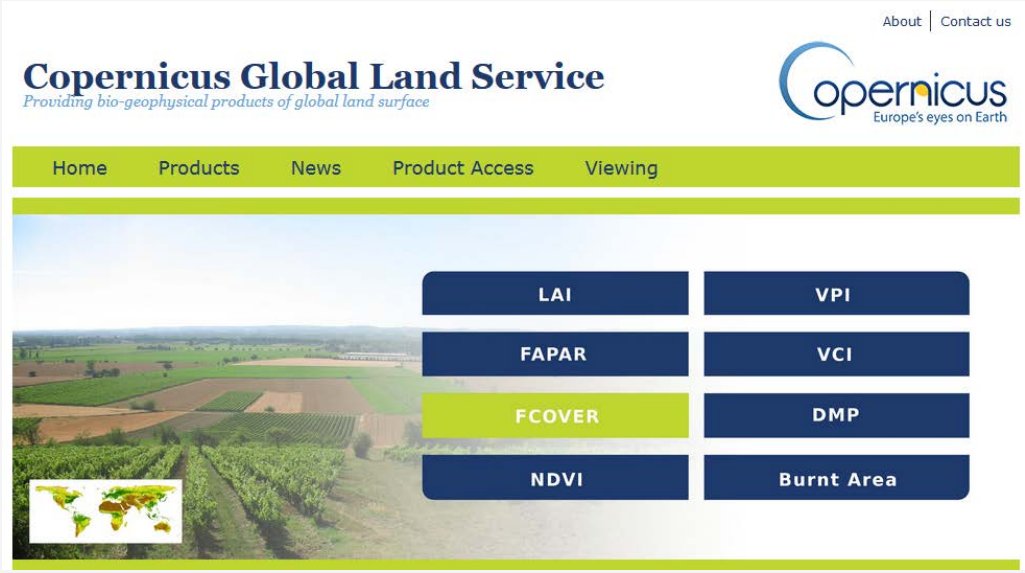
- Copernicus Global Land Service vegetation products
- MODIS vegetation products
- European Space Agency Vegetation Product (SPOT – Vito viewing portal)
  www.vito-eodata.be

ESA 10-dat vegetation product via SPOT

Copernicus Global Land Service

http://land.copernicus.eu/global/themes/Vegetation

- **LAI:** Leaf Area Index
- **FAPAR:** Fraction of Absorbed Photosynthetic Active Radiation
- **FCOVER:** Fraction of green vegetation cover
- **NDVI:** Normalized Difference Vegetation Index
- **VPI:** Vegetation Productivity Index
- **VCI:** Vegetation Condition Index
- **DMP:** Dry Matter Productivity



- Spatial Resolution: 300 m/ 1 km
- Temporal Coverage: ranges depending on the product
- Available through product portal

Copernicus Global Land Service

Providing bio-geophysical products of global land surface

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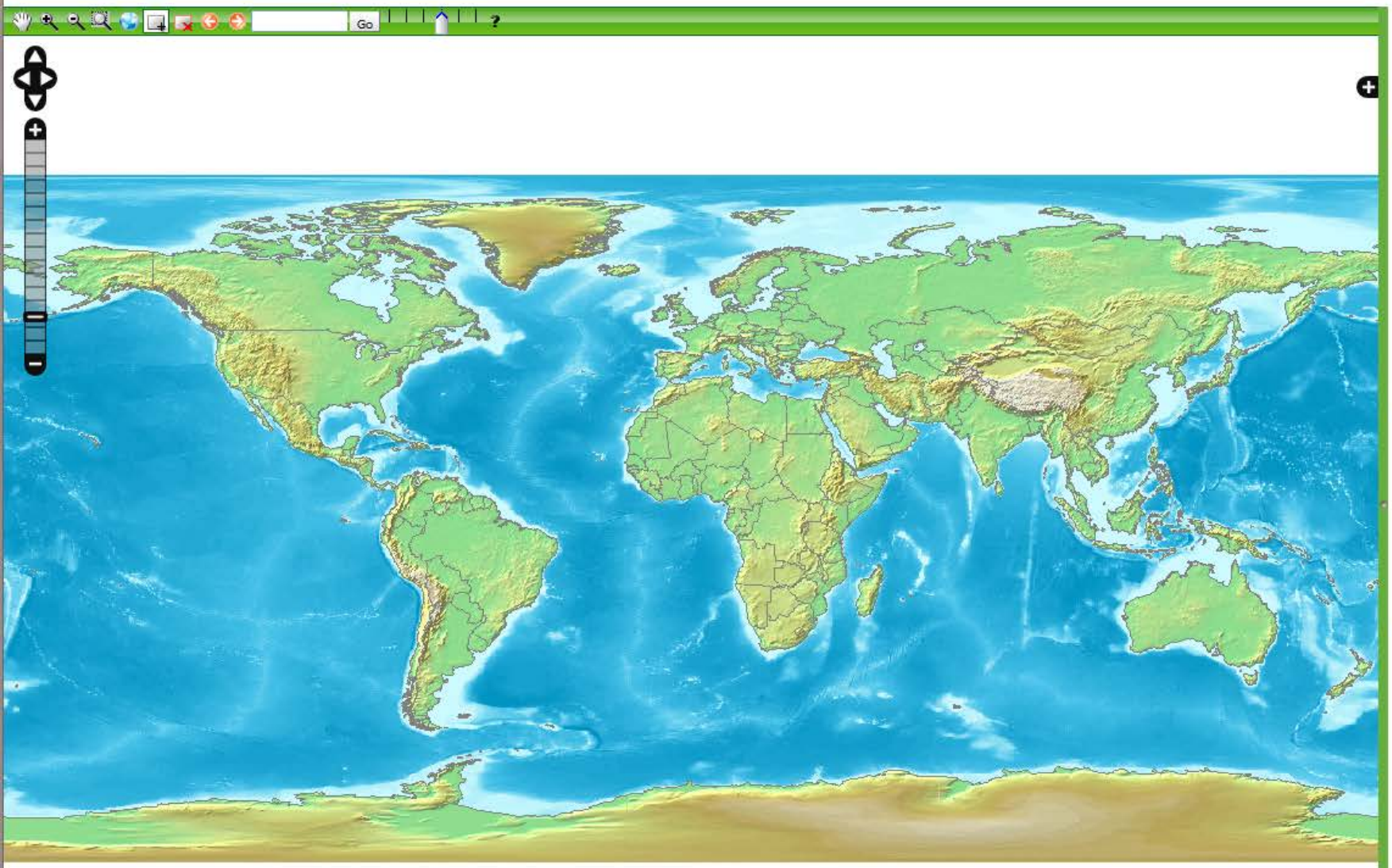


Catalogue search | Subscription

Vegetation Properties - FCOVER 1km V2

- Help
- Collection
  - LAI 300m V1 (118 products)
  - LAI 1km V2 (659 products)
  - LAI 1km V1 (4617 products)
  - FCOVER 300m V1 (118 products)
  - FCOVER 1km V2 (659 products)
  - FCOVER 1km V1 (4619 products)
  - FAPAR 300m V1 (118 products)
  - FAPAR 1km V2 (659 products)
  - FAPAR 1km V1 (4618 products)
- Basic
  - Date | Slot
  - Start date 01/01/1999
  - End date 02/05/2017
  - ROI
- Advanced

Search | Reset

Number of results per page 100

MODIS Vegetation Products

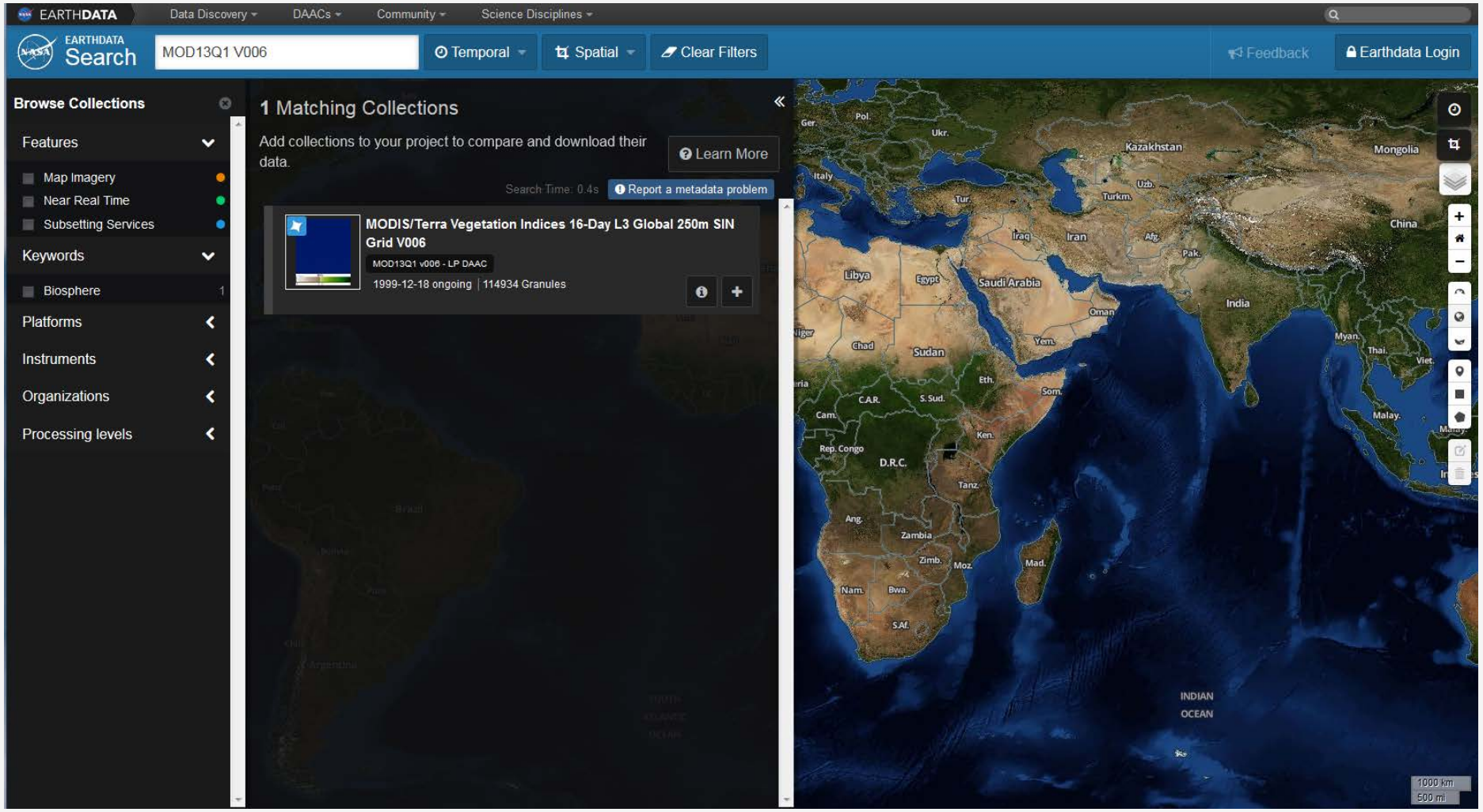
Product	Spatial	Temporal
FPAR*/ LAI**	500 m	8-day composite
NDVI/EVI	250, 500, 1000, 5600 m	monthly, 16-day composites
GPP	500 m	8-day composite
NPP	500 m	8-day composite

*FPAR (Fraction of Photosynthetically Active Radiation): The fraction of incident photosynthetically active radiation (400-700 nm) absorbed by the green elements of a vegetation canopy

**LAI (Leaf Area Index): The one-sided green leaf area per unit ground area in broadleaf canopies and half the total needle surface area per unit ground area in coniferous canopies

MODIS Vegetation Products

https://earthdata.nasa.gov



European Space Agency Vegetation Product

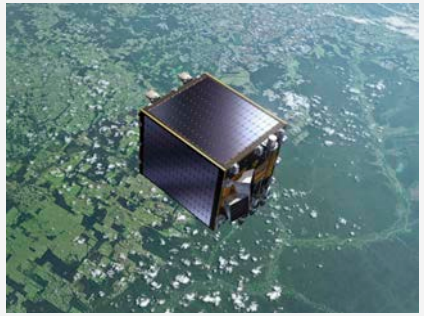
SPOT Vegetation Programme (1998-2014)

- Consists of two instruments:
  - VEG 1: aboard the SPOT 4 satellite, launched 1998
  - VEG 2: aboard the SPOT 5 satellite, launched in 2002
- Overall objective: To provide accurate measurements of the basic characteristics of vegetation canopies on an operational basis
- Two types of products:
  - VGT-DS: a daily synthesis product (between the two instruments) with ground reflectance and NDVI computed from those reflectance values
  - VGT-PS: a 10-day period synthesis of NDVI maximum values
  - Spatial resolution of 1.15 km
- Mission ended in 2013 but has been replaced by the PROBA-V mission

European Space Agency Vegetation Product

PROBA-V

- Preparation for the ESA Sentinel-3 satellite mission
- Spectral channels are similar to SPOT-VGT
- Platform is smaller than a cubic meter



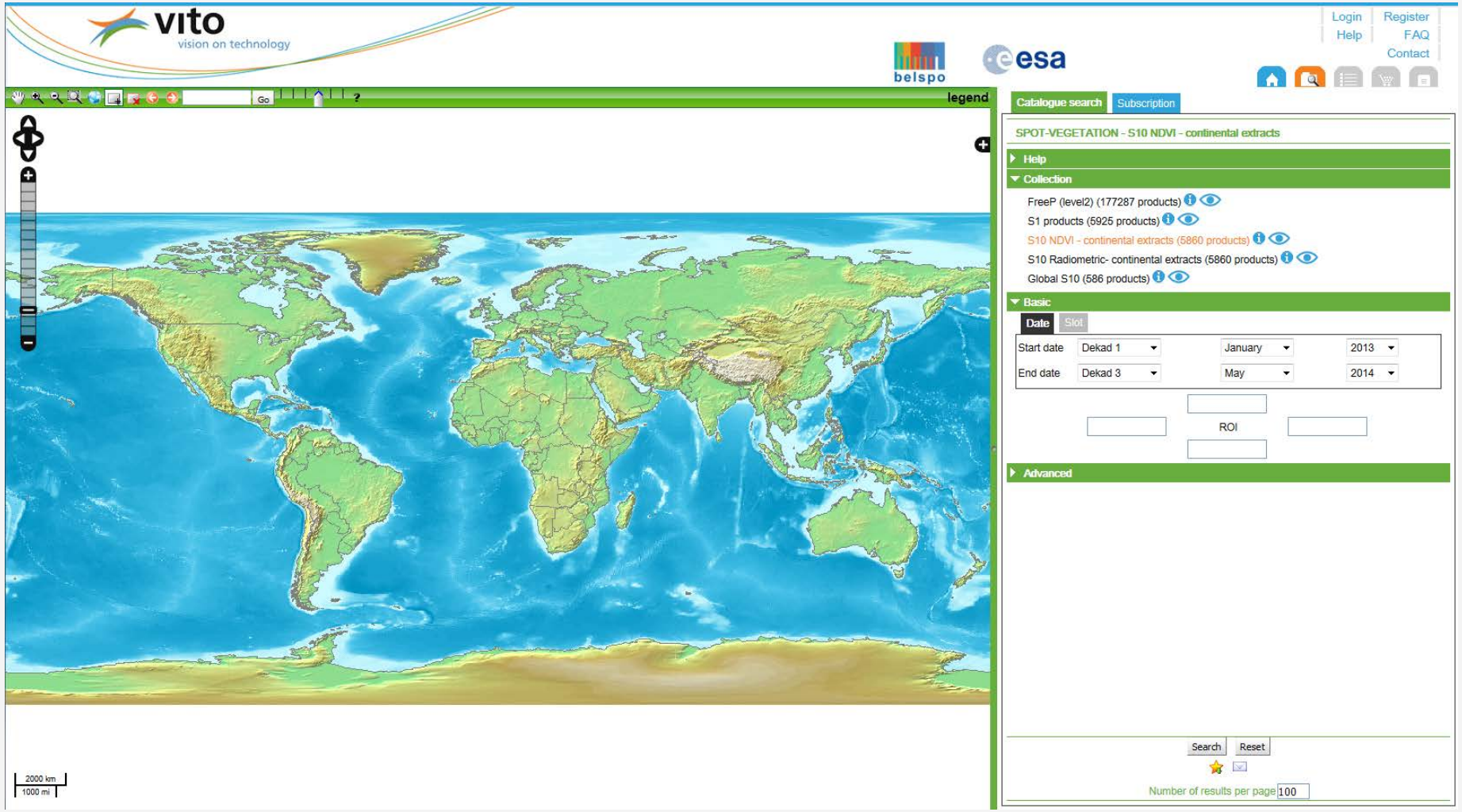
Product	Spatial Resolution	Temporal
Top of Atmosphere/ Top of Canopy	100 meter	Daily, 5-day composite
NDVI	100 meter	Daily, 5-day composite
Top of Atmosphere/Top of Canopy	300 meter	Daily, 10-day composite
NDVI	300 meter	10-day composite
Top of Atmosphere/Top of Canopy	1 kilometer	Daily, 10-day composite
NDVI	1 kilometer	10-day composite

ESA Product Distribution Portal

http://www.vito-eodata.be/

ESA Product Distribution Portal

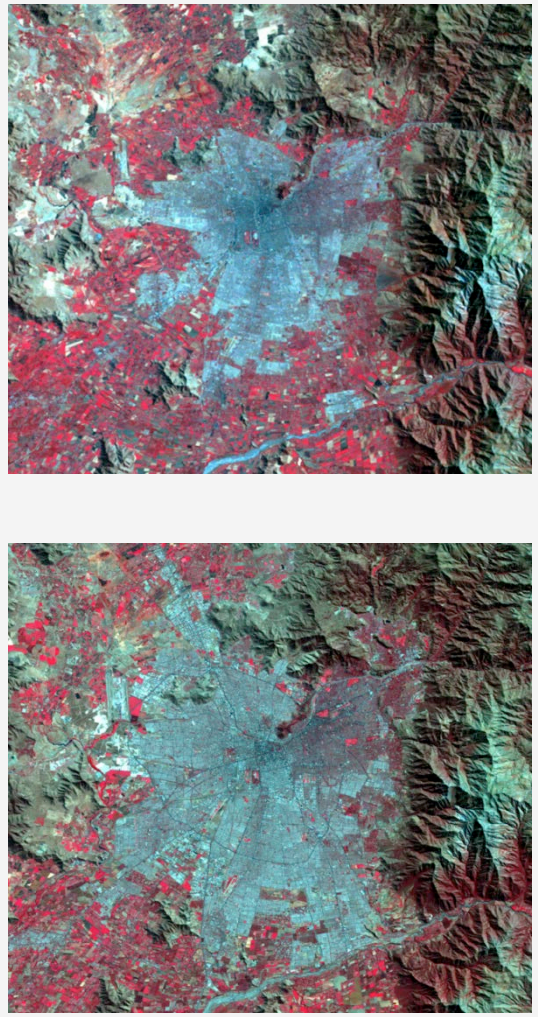
http://www.vito-eodata.be/



Land Cover Change from Satellite Imagery

Land Cover Change: What is it?

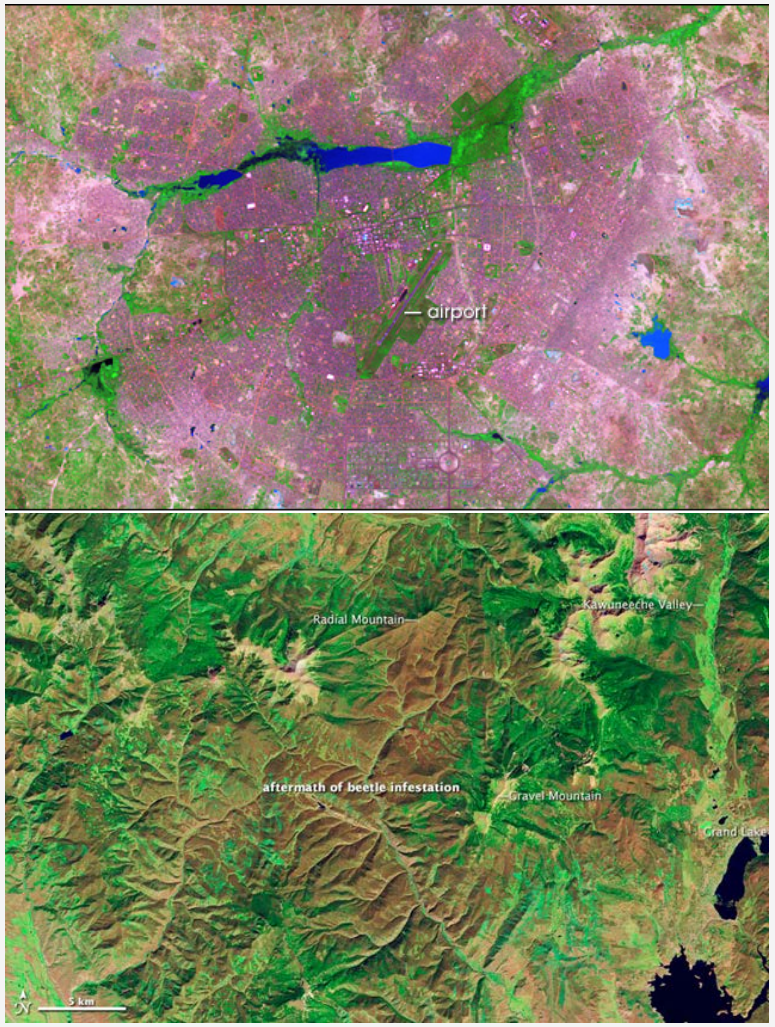
- The conversion of the landscape from one dominant feature type to another
- Examples:
  - Changes in tree cover due to wildfire or land clearing
  - Urbanization
- Information that can be derived from satellites:
  - Where and when has change taken place?
  - How much and what type of change has occurred?
  - What are the cycles and trends in the change?



Santiago, Chile urban growth from 1975 (top) to 2013 (bottom) from Landsat
Source: USGS

Broad Categories of Change

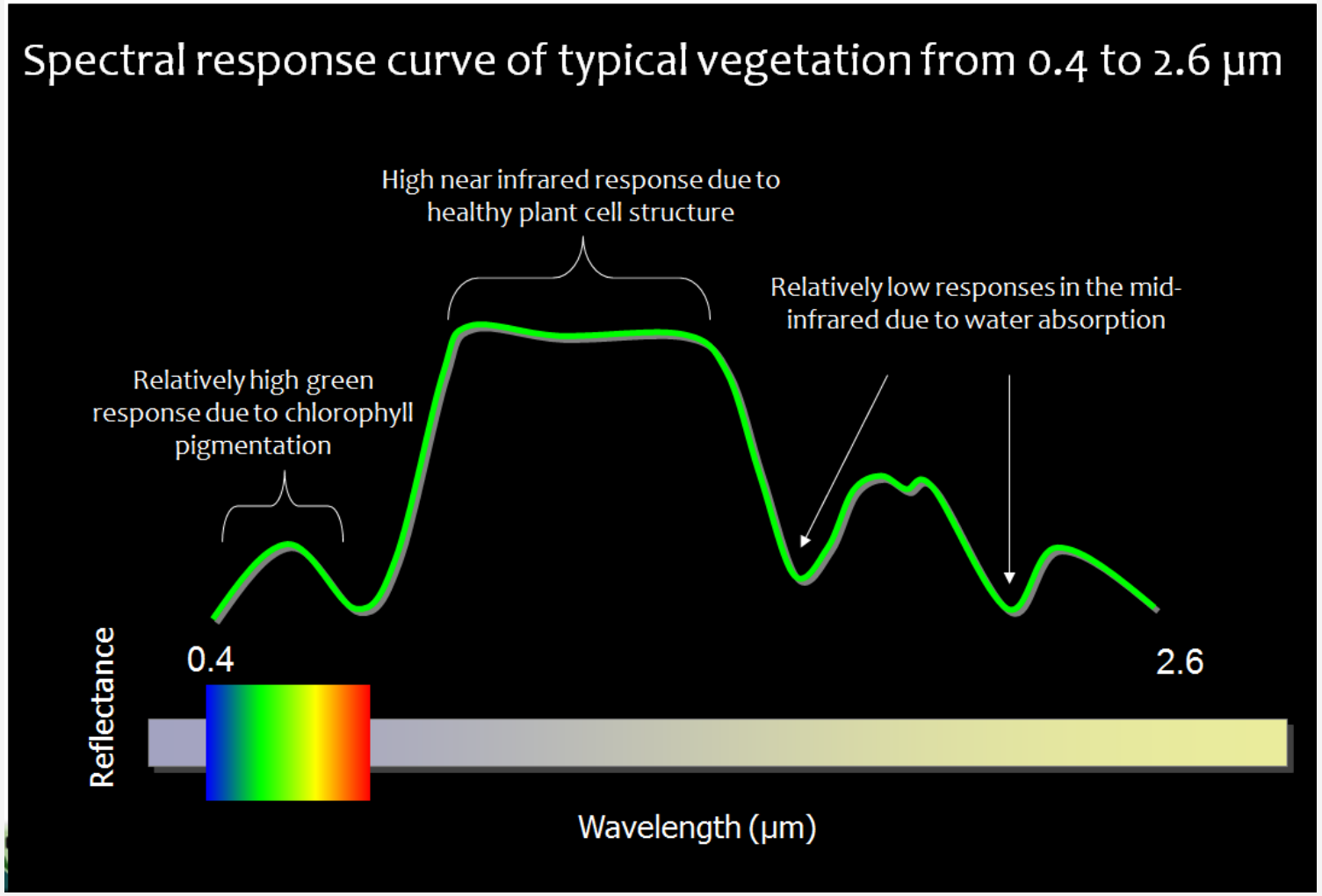
- Change in shape or size of patches of land cover types (urbanization)
- Slow changes in cover type or species composition (succession) vs. abrupt land cover transitions (wildfire, deforestation)
- Slow changes in condition of a single cover type (forest degradation due to insect or disease)
- Changes in timing of extent of seasonal processes (drought monitoring)



(Top) Urbanization in Burkina Faso, 2006
(Bottom) Bark Beetle Infestation: Colorado, 2011

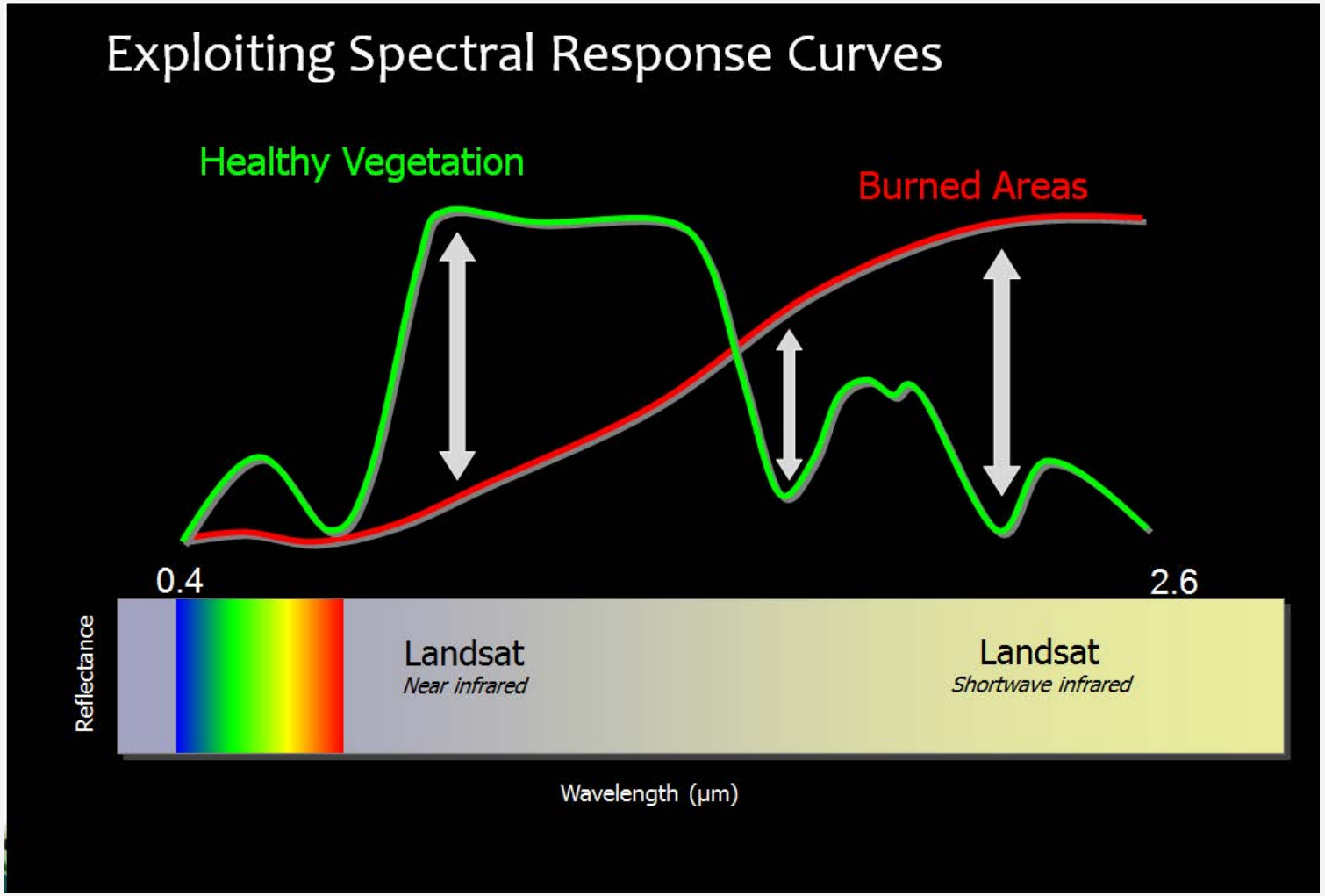
Land Cover Change Detection

- Typical spectral response of healthy, green vegetation
- Some reflectance in the green wavelengths, very high reflectance in the Near-Infrared wavelengths
- Absorption in the Shortwave-infrared wavelengths



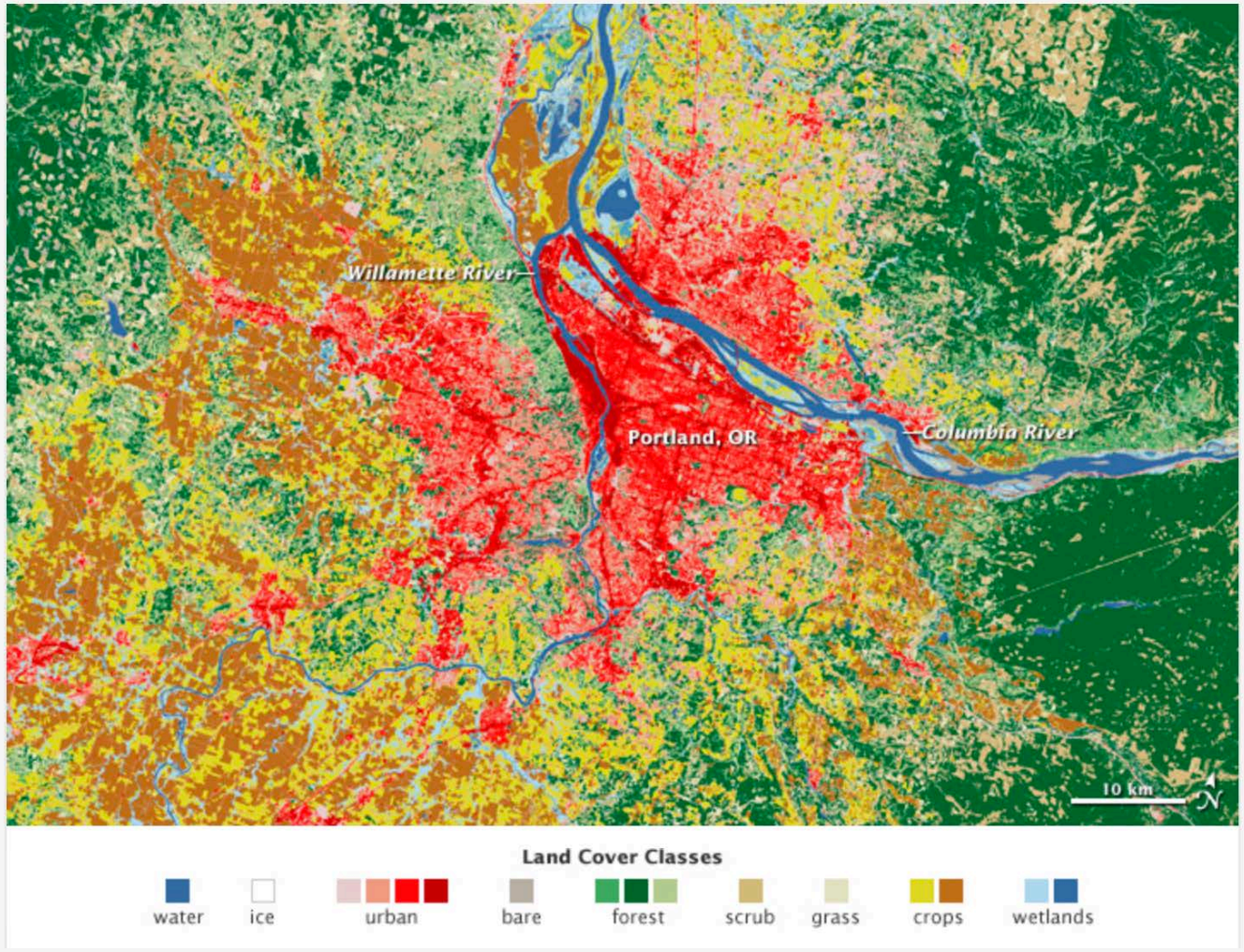
Land Cover Change Detection

- Changes on the landscape can be detected as changes in the spectral value of pixels
- Burned areas have low reflectance in the G and NIR but high in the SWIR



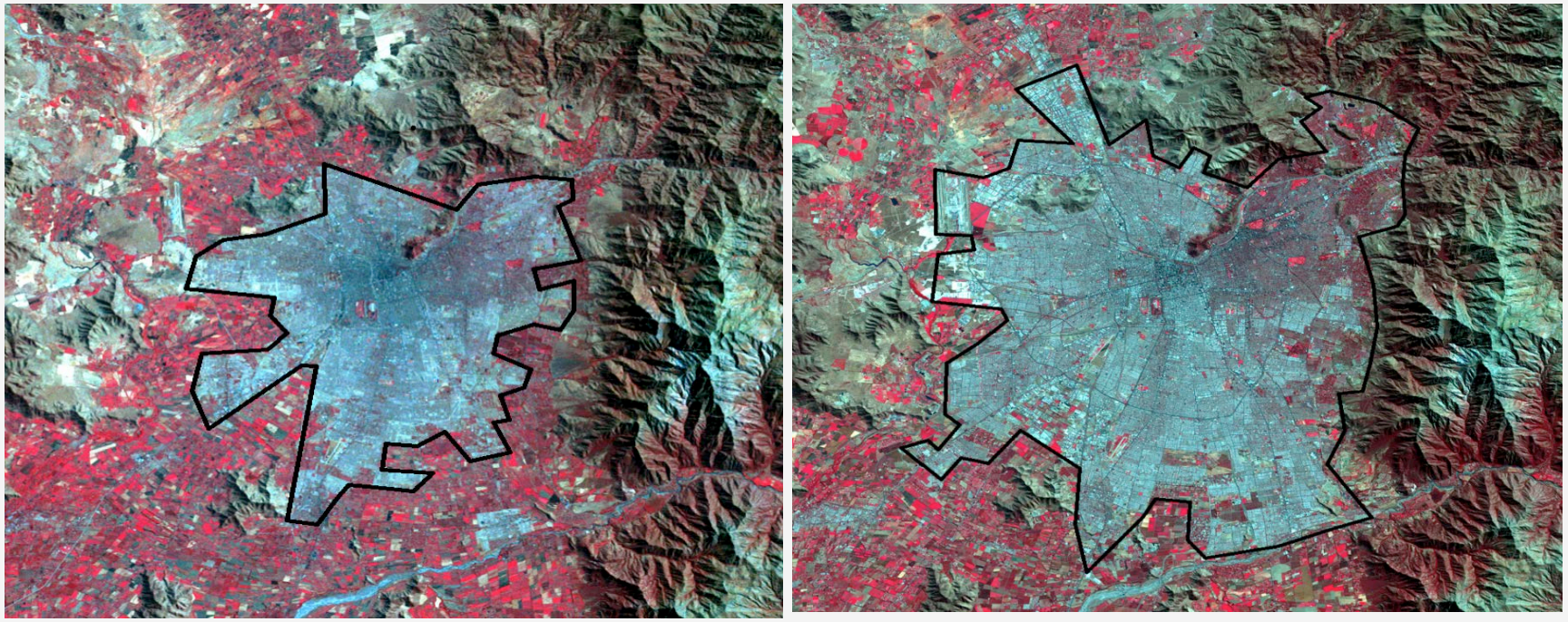
Change Detection Methods

- Visual Analysis
- Classification Approaches
- Image Differencing
- Temporal Trajectories



Change Detection: Visual Analysis

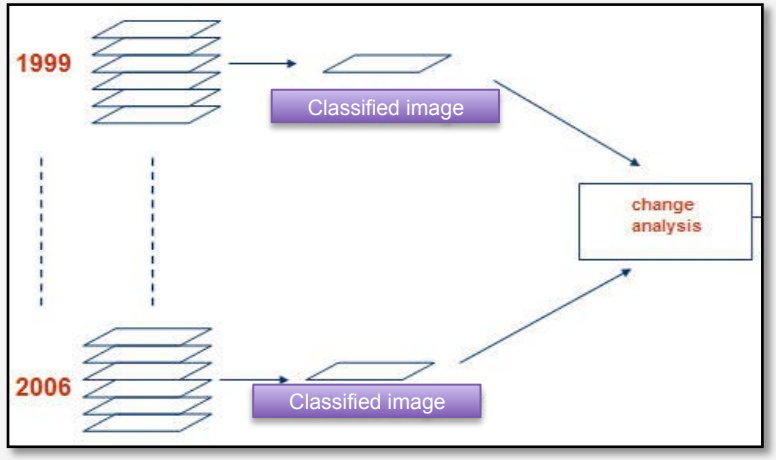
- Heads-up digitizing
- Good for large changes like shape or size of patches
- Not as good for subtle changes (land degradation)



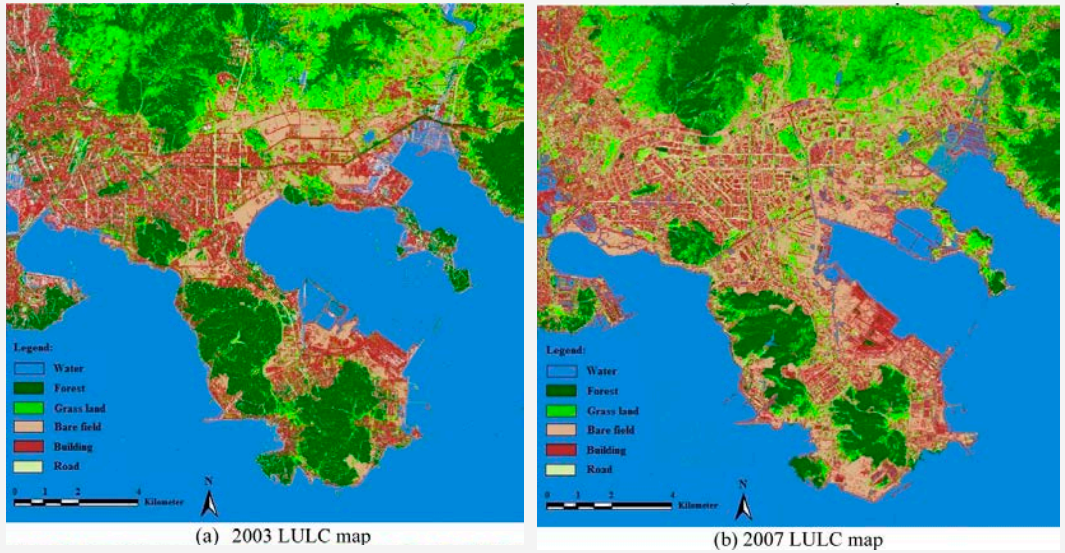
Santiago, Chile urban growth from 1975 to 2013 from Landsat
Source: earthshots.usgs.gov

Change Detection: Classification Approaches

- Need two dates of imagery
- Image classification
- Quantify land cover types in each image and compare (tabular), or
- Subtract one image from another to identify change



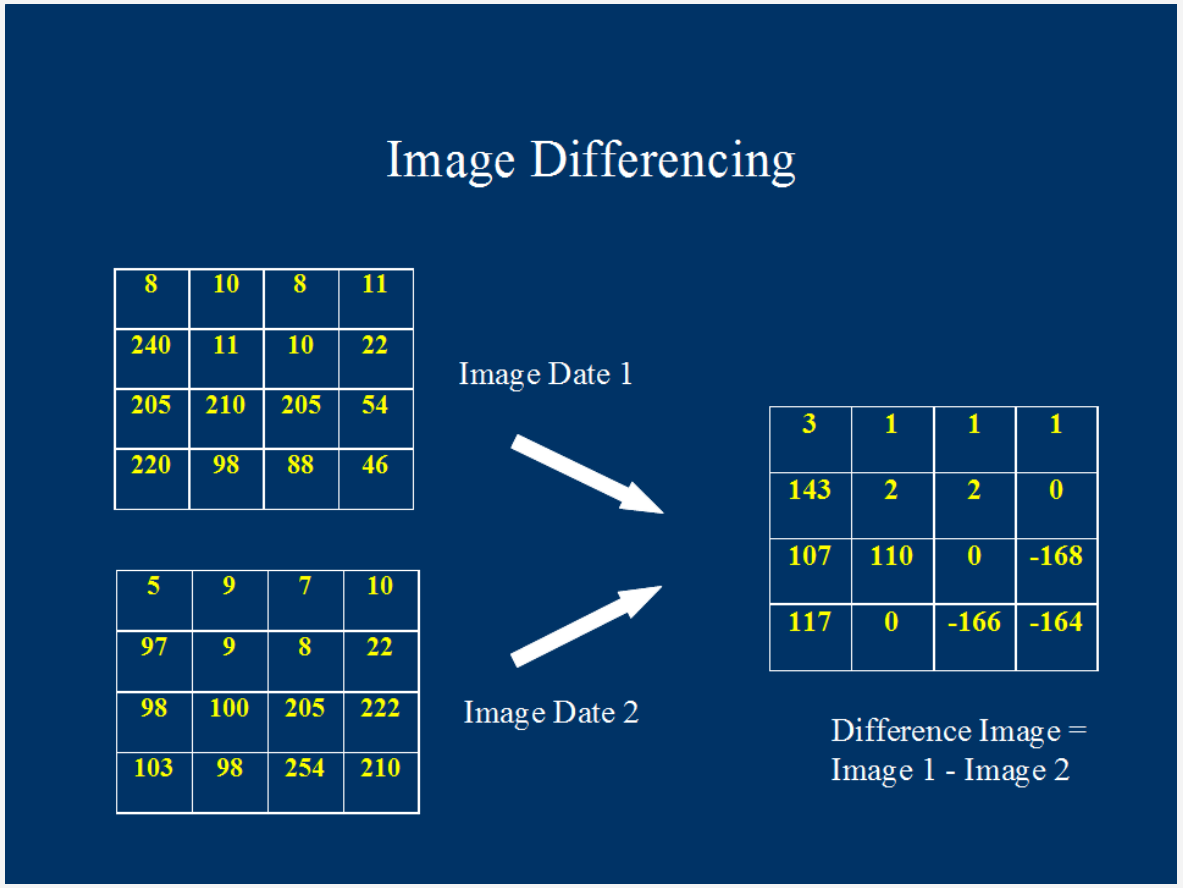
- Advantage: Easy to compute
- Disadvantage: Errors in classification will result in errors in detecting change



2003 and 2007 Land cover classifications of Dalian, China
Credit: Dr. Ni-Bin Chang, University of Central Florida

Change Detection: Image Differencing

- Subtract image date 1 from image date 2
- 0 means no change; positive or negative values indicate change
- Advantage: Can be used to detect subtle changes
- Disadvantage: Can be difficult to interpret



Change Detection: Temporal Trajectories

- Takes advantage of the entire satellite image archive (i.e. Landsat: 1985-current) by using an annual time series to examine changes/ trends
- Example: Landtrendr (Kennedy et al., 2010) products include:
  - Magnitude of change: 1-100% tree cover loss
  - Duration: 1-25 years
  - Year of onset of disturbance

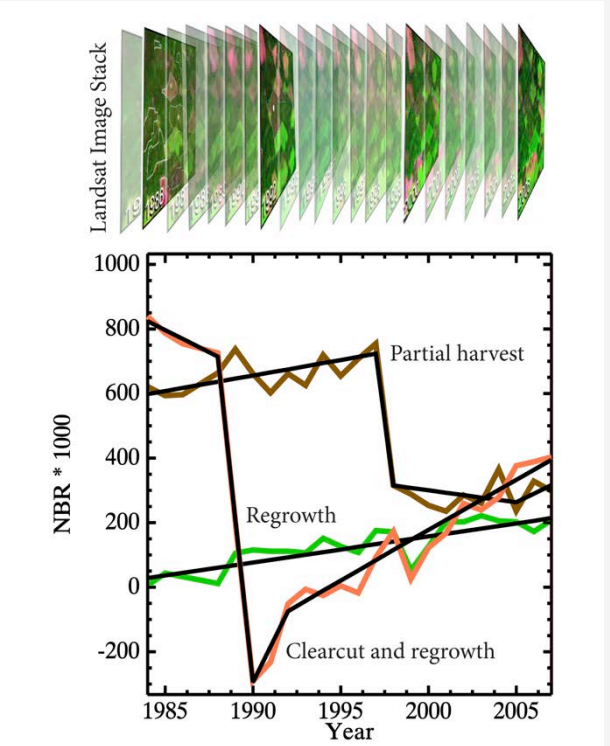
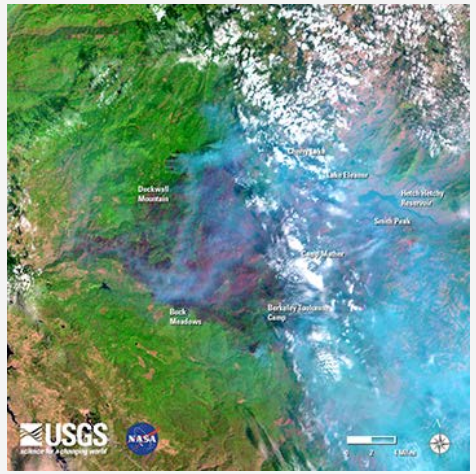


Figure 1. Temporal segmentation in the LandTrendr algorithm. a) A stack of yearly Landsat Thematic Mapper (TM) images is aligned, cleaned, and normalized. b) Statistical algorithms fit straightline representations (black lines) of cleaned pixel values (colored traces).

Change Detection: Important Considerations

- Need to minimize the amount of spectral change caused by:
  - Seasonal variation and phenology
  - Image mis-registration
  - Clouds and shadows
  - Radiometric inconsistences (atmospheric effects, etc.)
- Images must have atmospheric/radiometric correction.
- Images must be precisely registered to each other
- Choose images from approximately the same time of year



Summary

- Indicator 15.3.1: Proportion of land that is degraded over total land area
  - Land productivity and health can be measured using multiple parameters
    - For example: NPP, NDVI, fAPAR
  - There are various global products available for land productivity and health parameters
    - For Example: MODIS Vegetation Products, ESA Vegetation Products
  - Change detection can be assessed via remotely-sensed imagery
  - There are a variety of change detection methods

MODIS Land Cover and GFW Demo

Contacts

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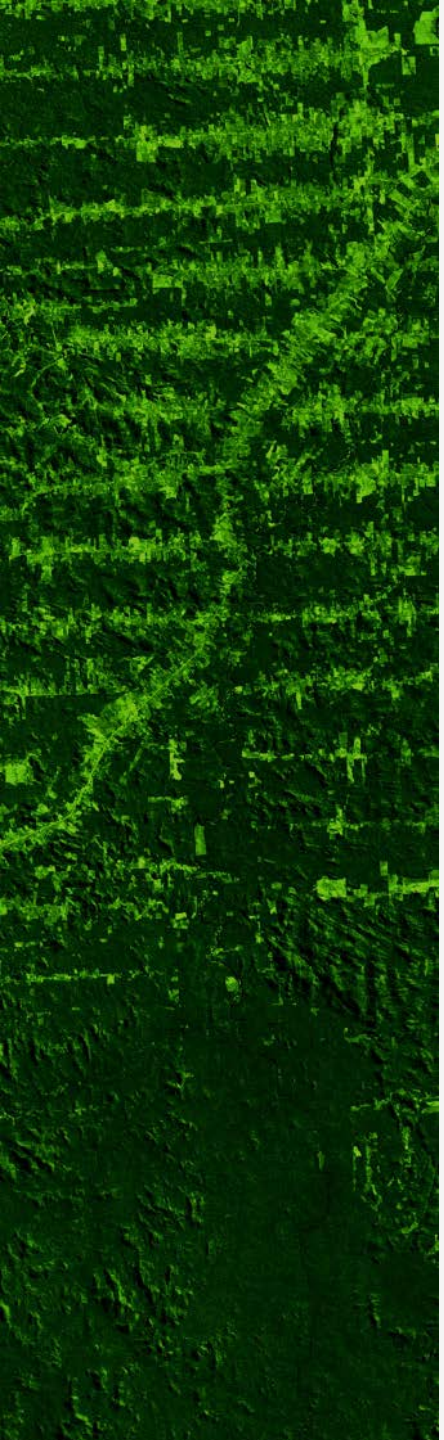
  - http://arset.gsfc.nasa.gov



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Thank You