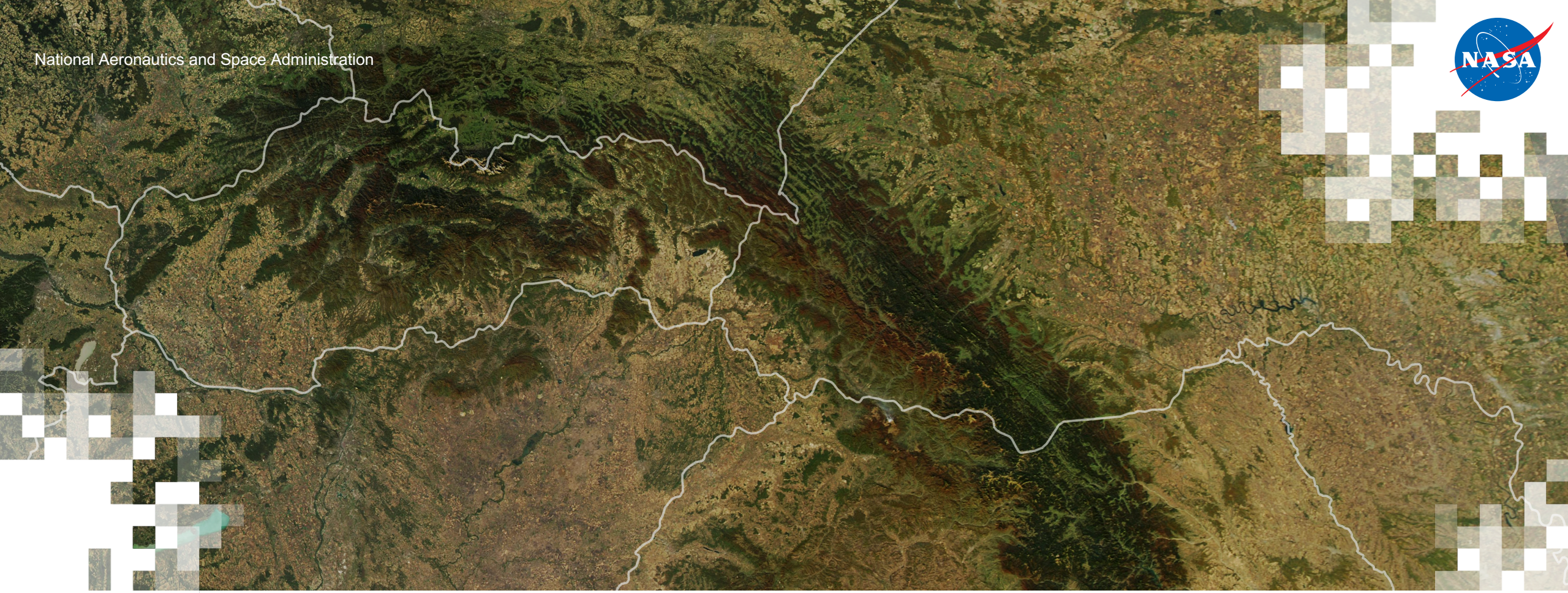


Tracking Vegetation Phenology with Remote Sensing

Amber McCullum and Juan Torres-Pérez

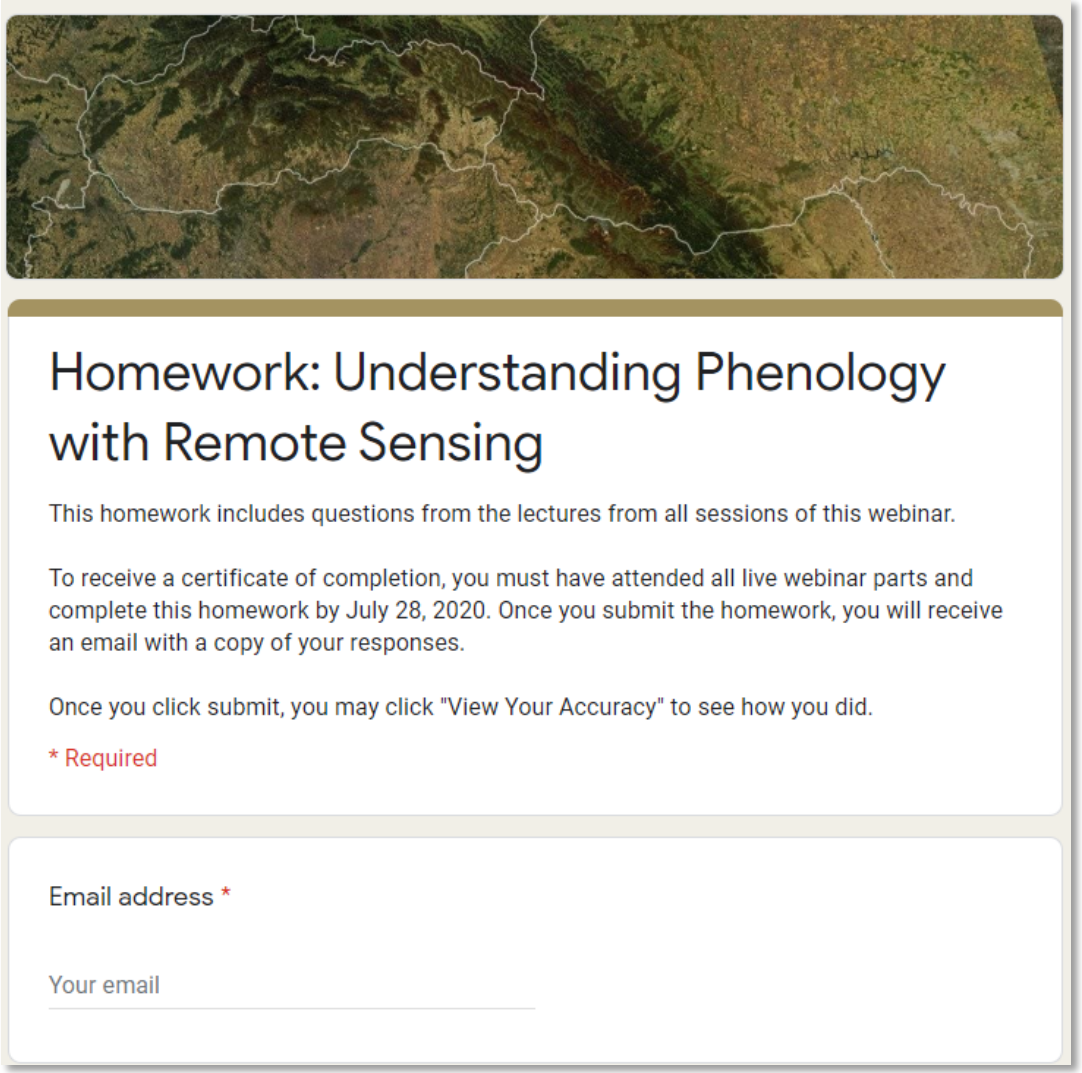
June 30 – July 14, 2020

Course Structure and Materials

- Three, 1-hour sessions on **June 30, July 7, and July 14**
- Recordings, slides, and homework assignments can be found after each session at:
  - https://arset.gsfc.nasa.gov/land/webinars/phenology
- Prerequisites:
  - Fundamentals of Remote Sensing
- Q&A: Following each lecture and/or by email at:
  - amberjean.mccullum@nasa.gov
  - juan.l.torresperez@nasa.gov

Homework and Certificates

- **Homework:**
  - One homework assignment
  - Answers must be submitted via Google Forms
- **Certificate of Completion:**
  - Attend all three live webinars
  - Complete the homework assignment by **Thursday, July 28th** (access from ARSET website)
  - You will receive certificates approximately two months after completion of the course from: marines.martins@ssaihq.com



Course Outline

Part 1:Overview of Phenology and Remote Sensing

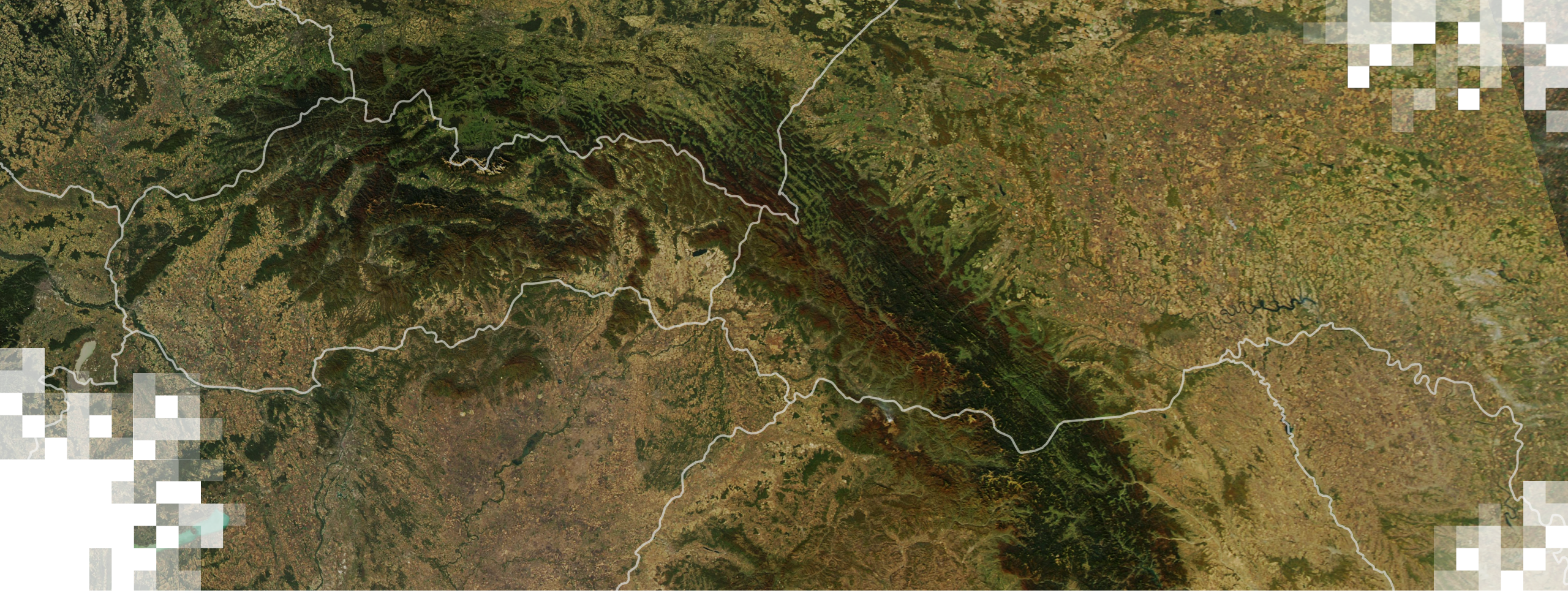
Part 2: Scales of Phenology and National Networks

Part 3: Examples of Multi-Scalar Analyses

Learning Objectives

By the end of this presentation, you will be able to:

- Identify how remote sensing can be used to study phenology
- Recall the satellites and sensors that can be used to estimate land surface parameters
- Identify various NASA products for phenology
- Access remote sensing data via portals and webtools



Phenology Overview

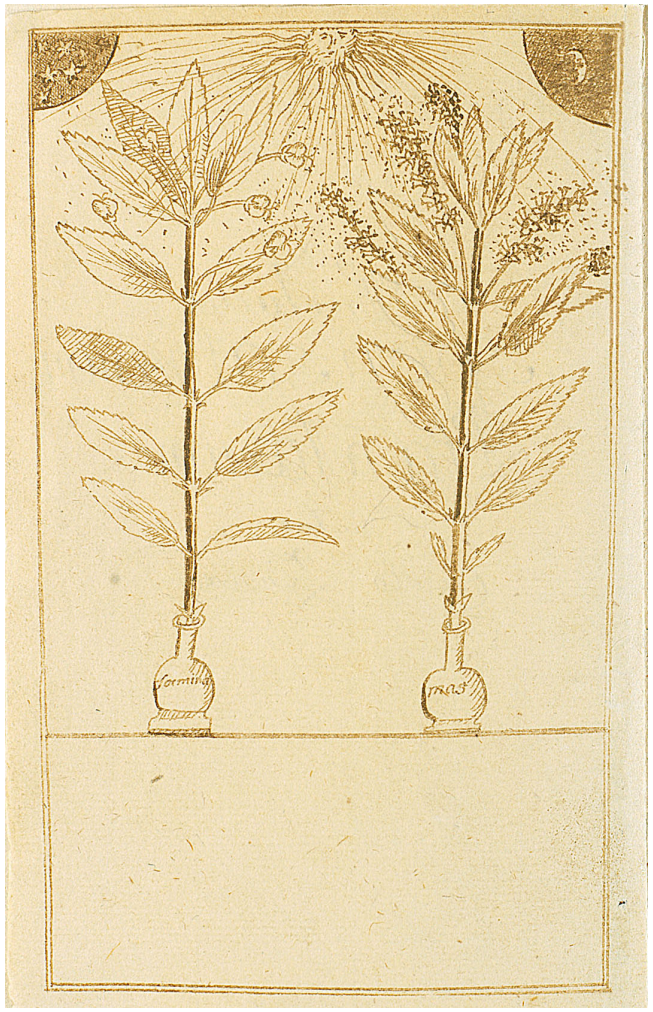
Phenology

- The study of plant and animal life cycles in relation to the seasons.
  - The science of appearance
- Timing of specific biological events
  - Sensitive to environmental conditions
- Seasonal changes include variations in day length, temperature, and precipitation.
  - How do plants and animals respond?

Seasonal cycle of a tree, Image Credit: USGS/NPN)

Phenology: A Brief History

- One of the oldest branches of environmental science
- Originates from the Greek word *phaino* - to show and bring to light
- Many cultural references to seasonal changes
- Swedish botanist, Carolus Linnaeus, systematically recorded the flowering times of plants and the associated climate conditions.
- British landowner, Robert Marsham, kept phenological records on his estate.
  - Flowering, bud burst, emergence of insects



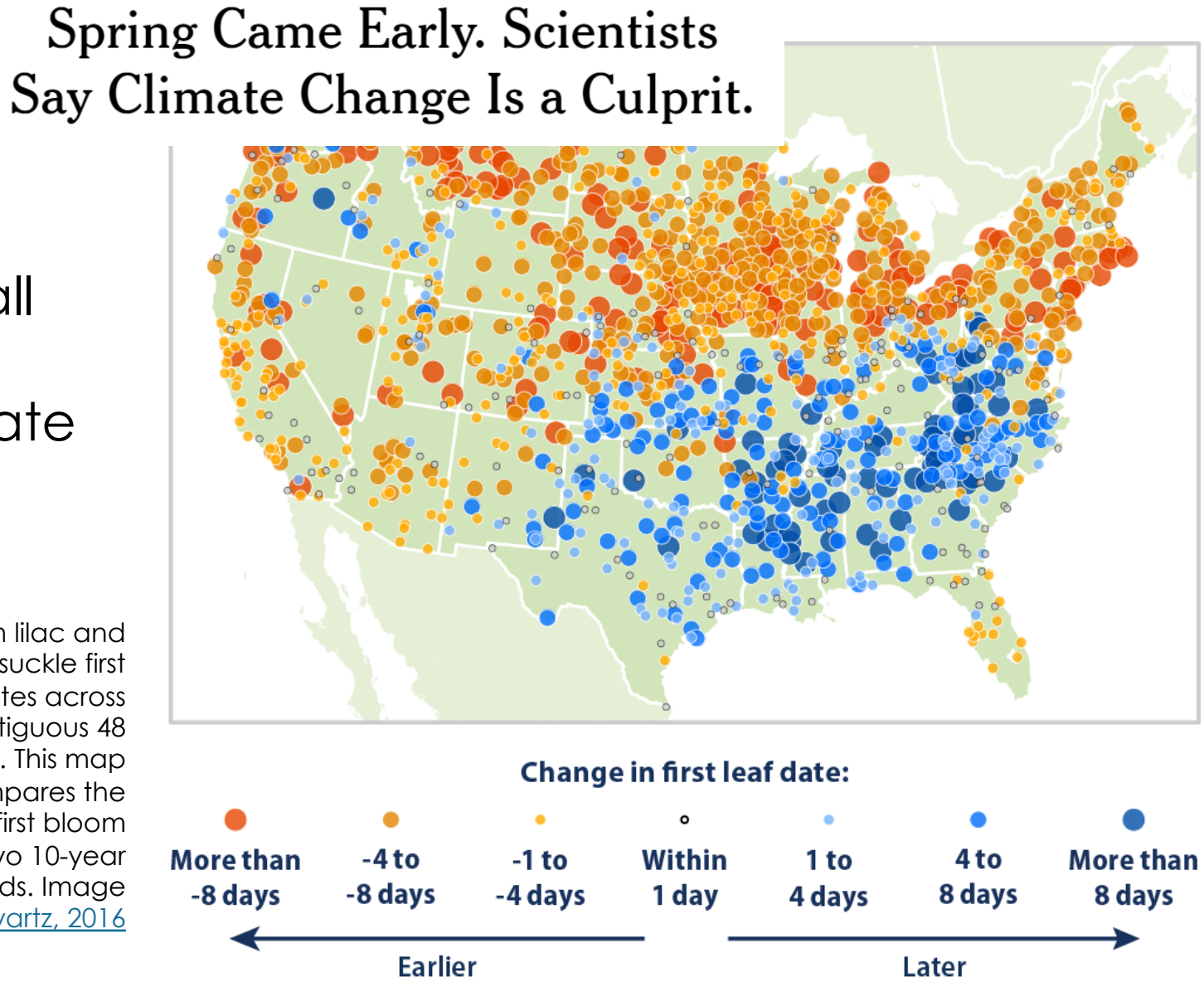
Thesis of Linnaeus, Pollination depicted in *Praeludia Sponsaliorum Plantarum* (1729). Image Credit: Digital Commons

Phenology: Ecological Importance

- Phenological events change from year to year.
- Timing of events (phenophase) such as flowering, leafing, migration, and insect emergence can impact how plants and animals are able to thrive in their environment.
- Influences abundance and distribution of organisms, ecosystems services, and global cycles of water and carbon.

Phenology: Ecological Importance

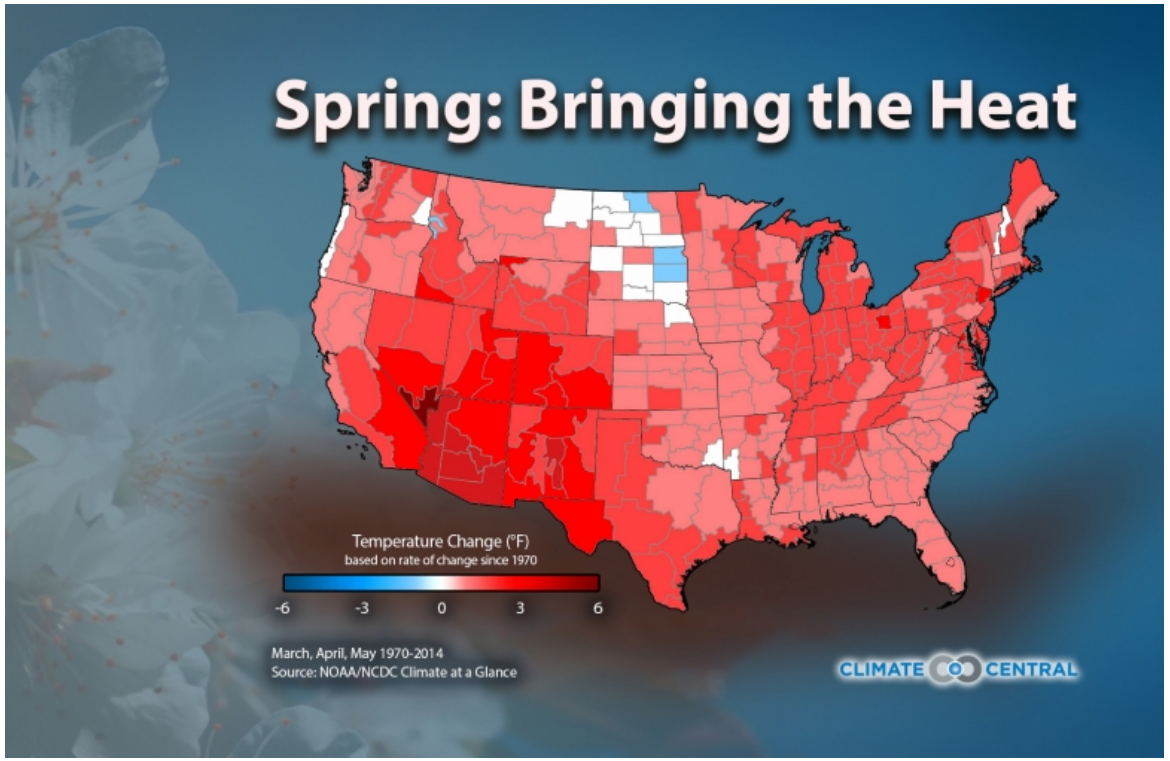
- These processes are sensitive to climate change.
  - Earlier spring, later fall
  - Not all species changing at same rate or direction



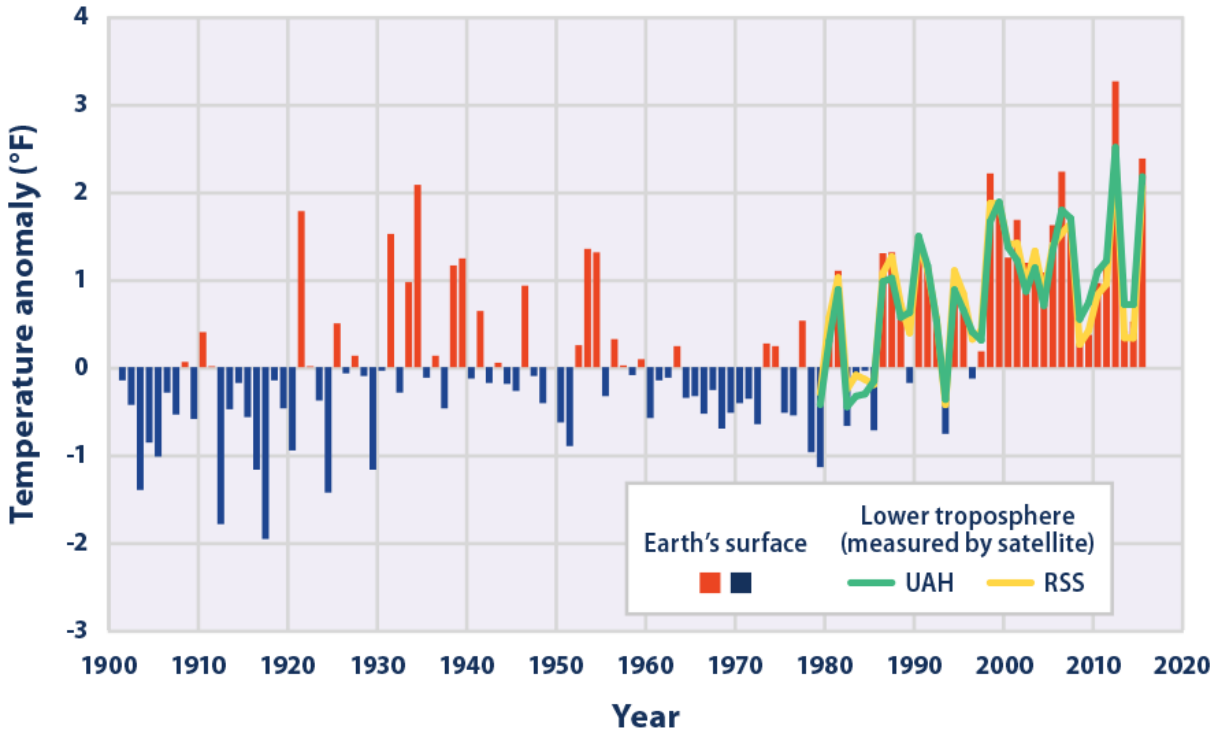
Trends in lilac and honeysuckle first bloom dates across the contiguous 48 states. This map compares the average first bloom date for two 10-year periods. Image Credit: Schwartz, 2016

Drivers of Phenology

Temperature



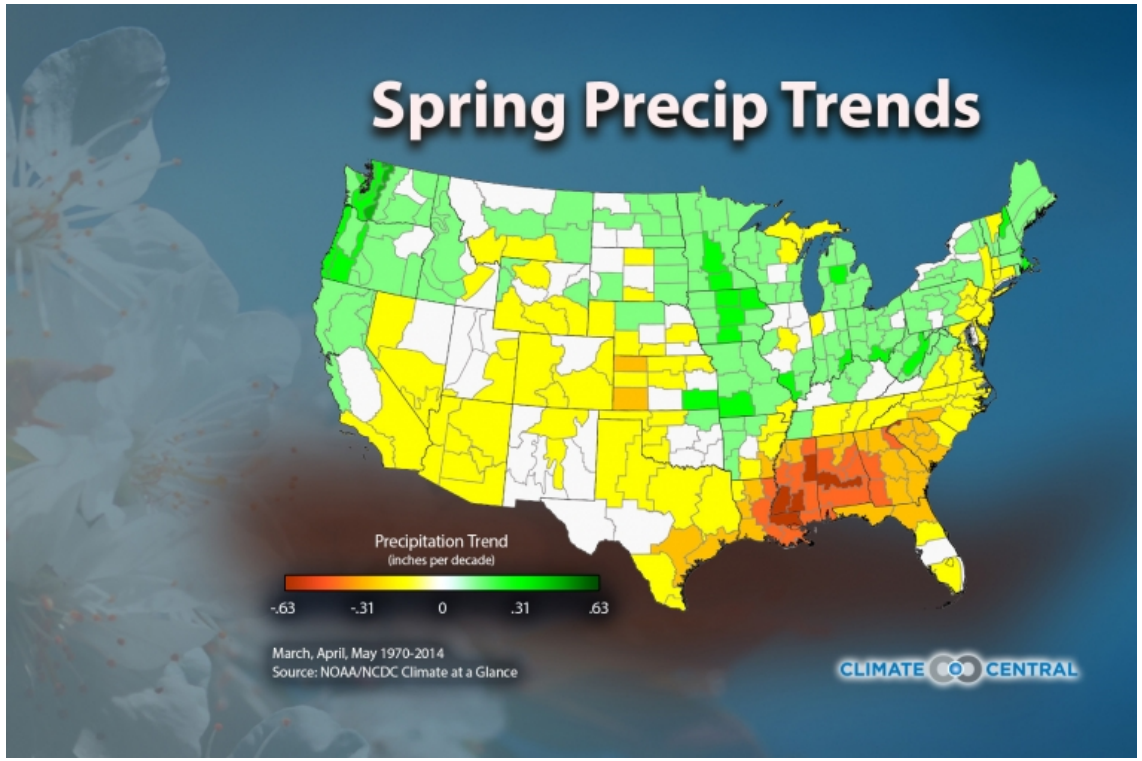
Spring temperature change from 1970-2014, based on rate of change from 1970. Image Credit: Climate Central.



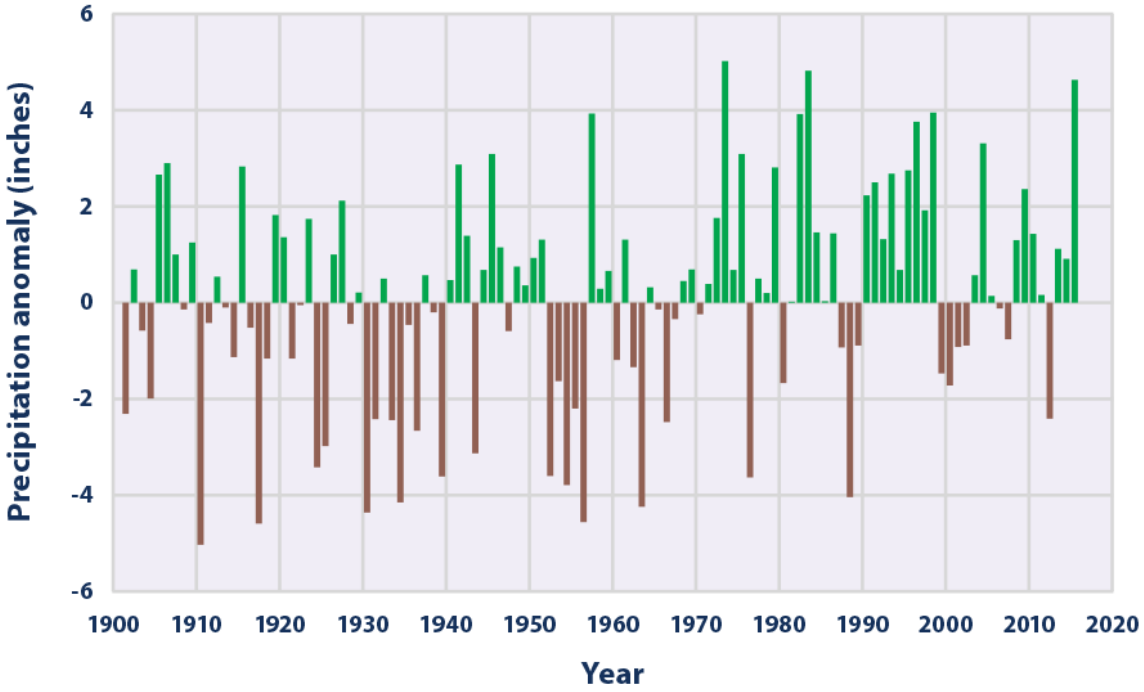
Annual average temperatures in the contiguous 48 states from 1901-2016. Image Credit: NOAA, 2016.

Drivers of Phenology

Water Availability



Precipitation trend in inches per decade from 1970-2014. Image Credit: Climate Central.



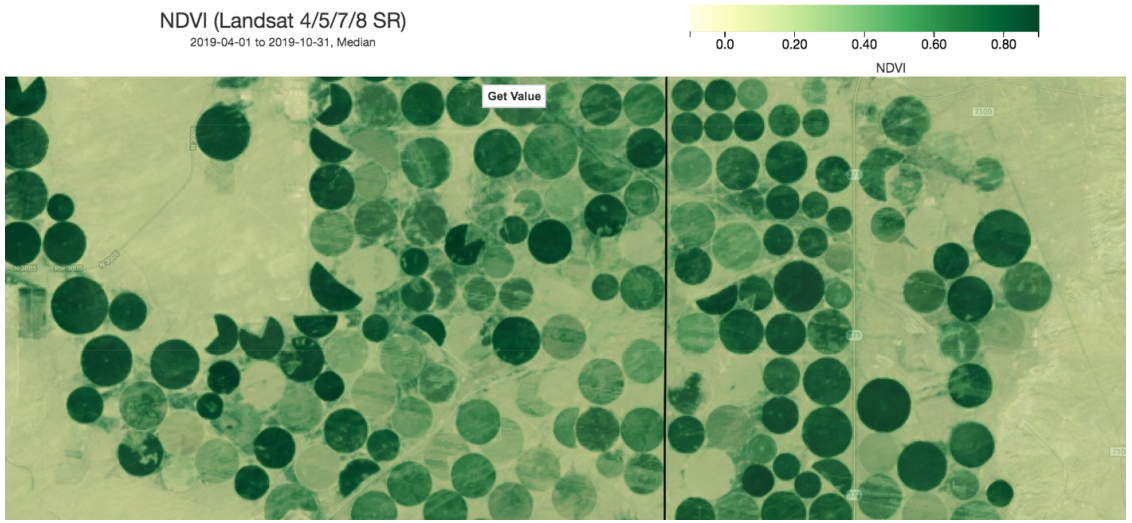
Total annual precipitation anomaly in the contiguous U.S. from 1901. Image Credit: NOAA, 2016.

Phenology: Applications

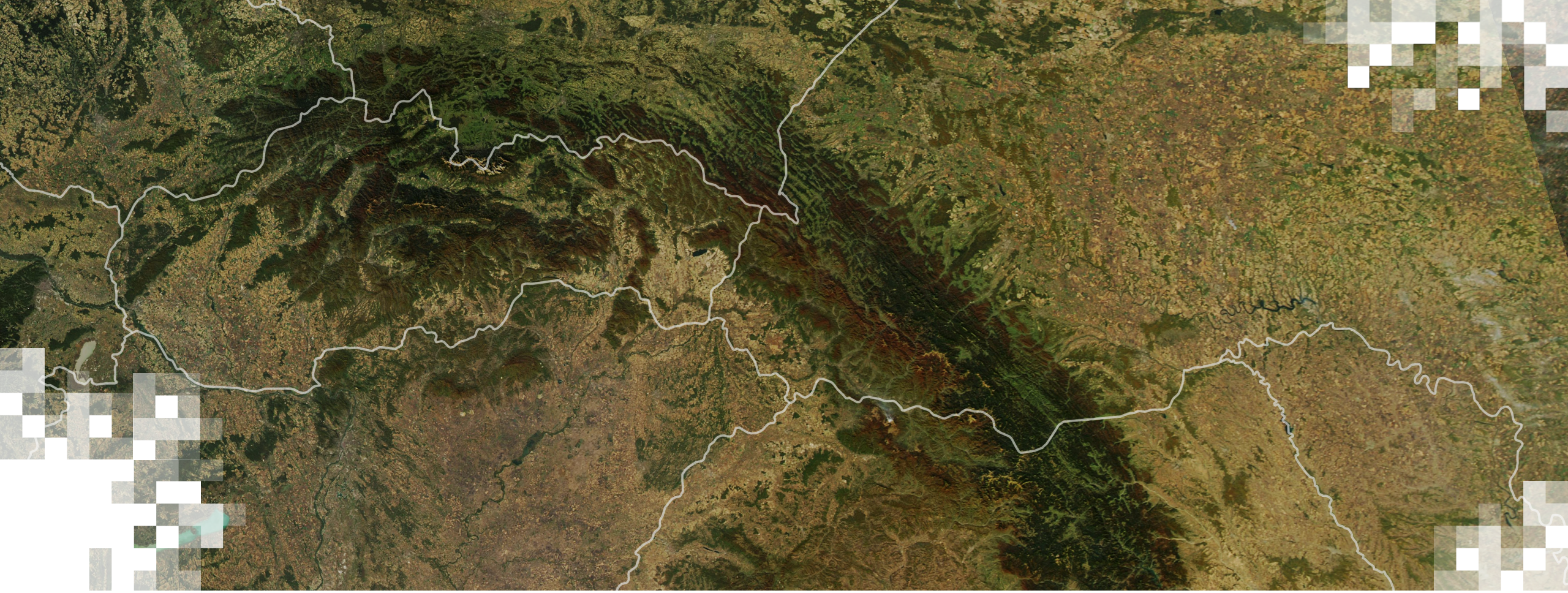
- Management of invasive species
- Predictions of human-health related events: allergies or mosquito-borne illness
- Crop management
- Understanding of carbon cycling
- Climate change vulnerability

Remote Sensing of Phenology

- Use of satellites and sensors to track seasonal patterns of variation in vegetated land surfaces
- **Land Surface Phenology (LSP)**
  - Regular monitoring of the entire global land surface
  - Gather information on entire ecosystems: broad scale trends
- Most useful when linked to ground observation networks
- Uses include:
  - Crop health assessments
  - Drought severity
  - Wildfire risks
  - Invasive species and pest tracking
  - Mapping infectious disease risk



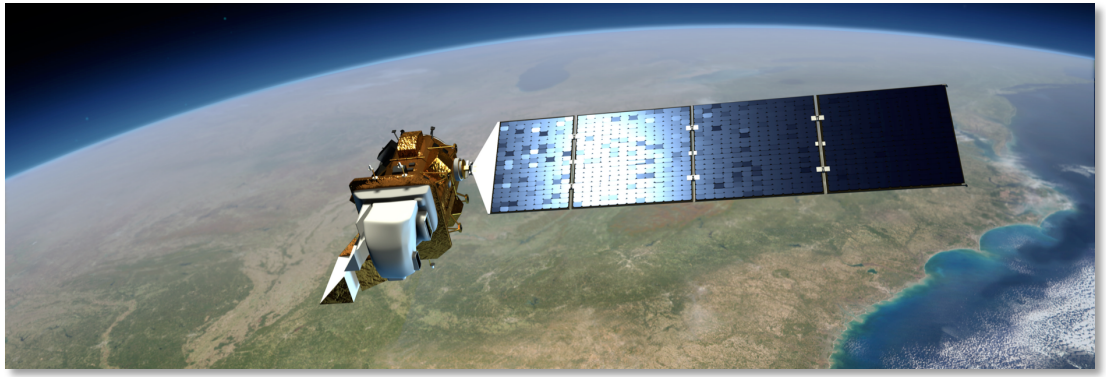
Center pivot irrigation with NDVI displayed. Image Credit: NASA/DRI DSET.

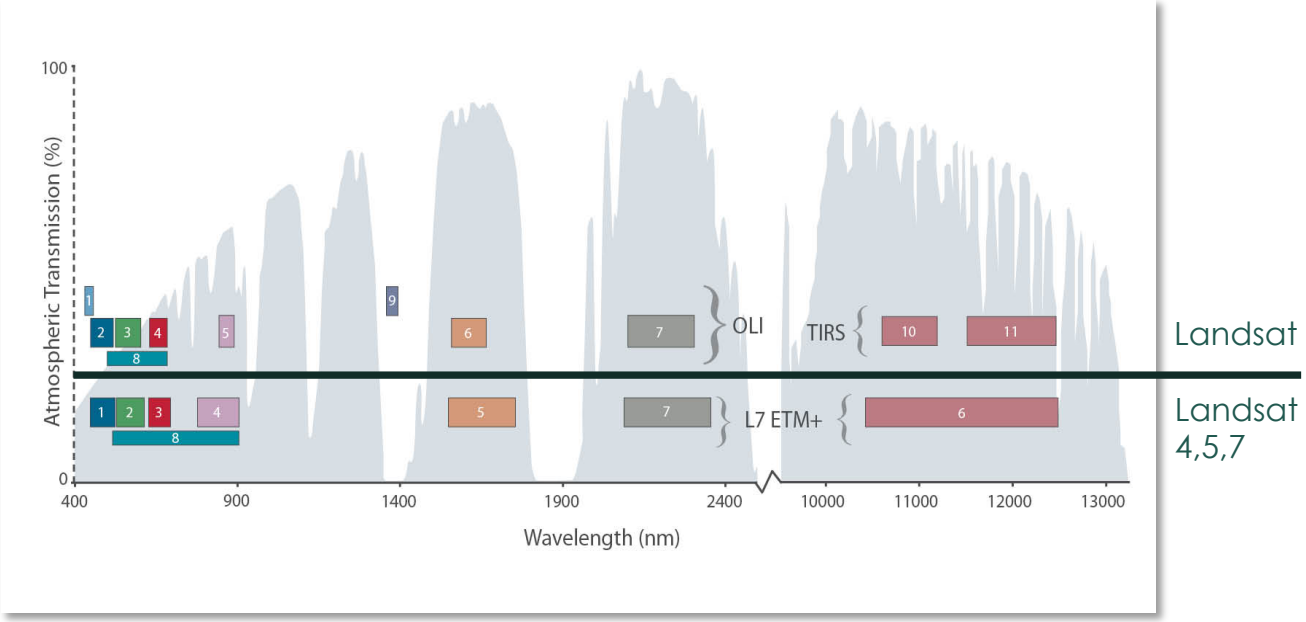


Satellites and Sensors for Phenology

Landsat

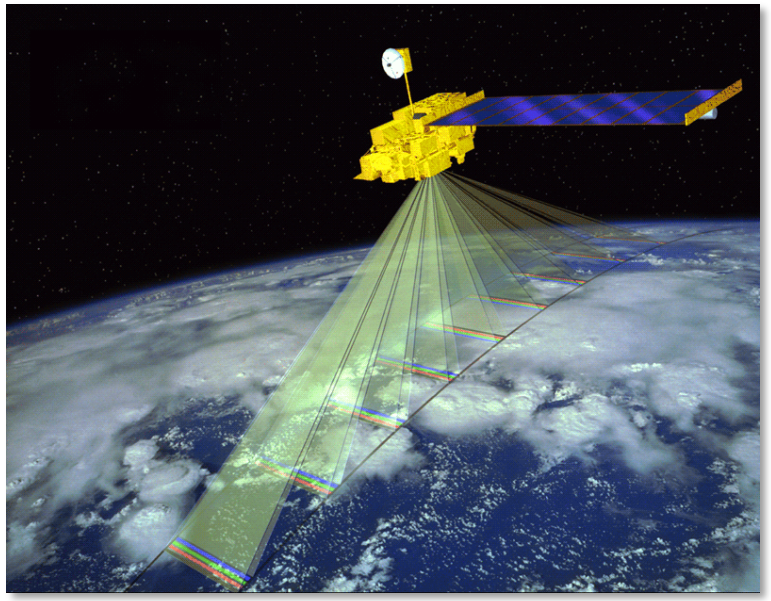
- First Landsat launched in 1972
- Landsat 8 launched in 2013
- NASA created and launched
  - USGS maintains data
- Passive Sensor - Obtains values of reflectance from Earth's surface
- 30-meter pixels, 15-meter panchromatic band
- Image of the entire Earth every 16 days

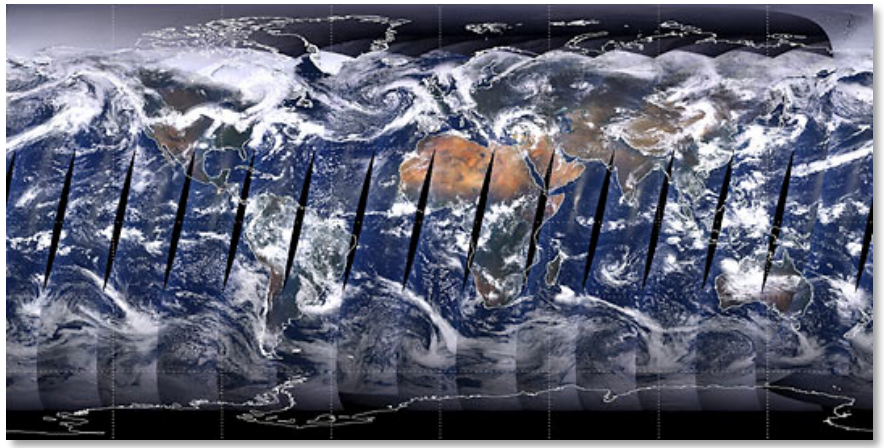




Moderate Resolution Imaging Spectroradiometer (MODIS)

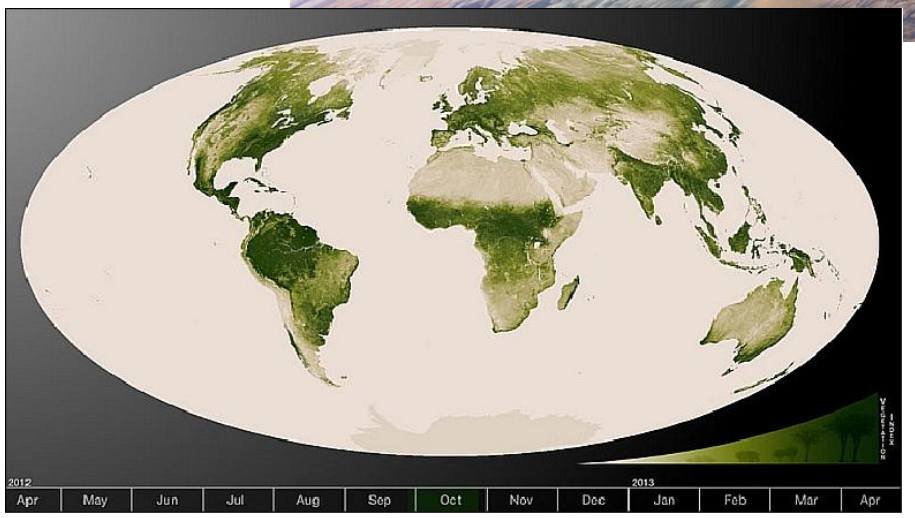
- Spatial Resolution:
  - 250 m, 500 m, 1 km
- Temporal Resolution:
  - Daily, 8-day, 16-day, monthly, quarterly, yearly
  - 2000–present
- Data Format:
  - Hierarchal data format – Earth Observing System Format (HDF–EO8)
- Spectral Coverage:
  - 36 bands (major bands include blue, green, red, IR, NIR,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





Visible Infrared Imaging Radiometer Suite (VIIRS)

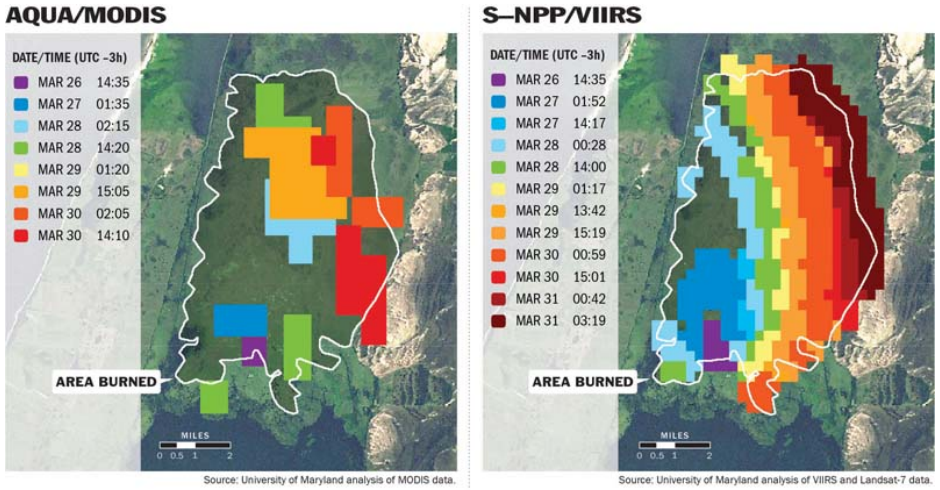
- A sensor onboard the Suomi National Polar-Orbiting Partnership (NPP)
- Data available globally from January 2012 to present
- Revisit Time: 1 day
- Spatial Resolution: 375m and 750m
- Similar to MODIS (with some differences)
- Visible, near-infrared channels (reflectance)
- Shortwave and longwave infrared (brightness temperature)
- Products:
  - Surface Reflectance
  - Vegetation Indices
  - Thermal Anomalies



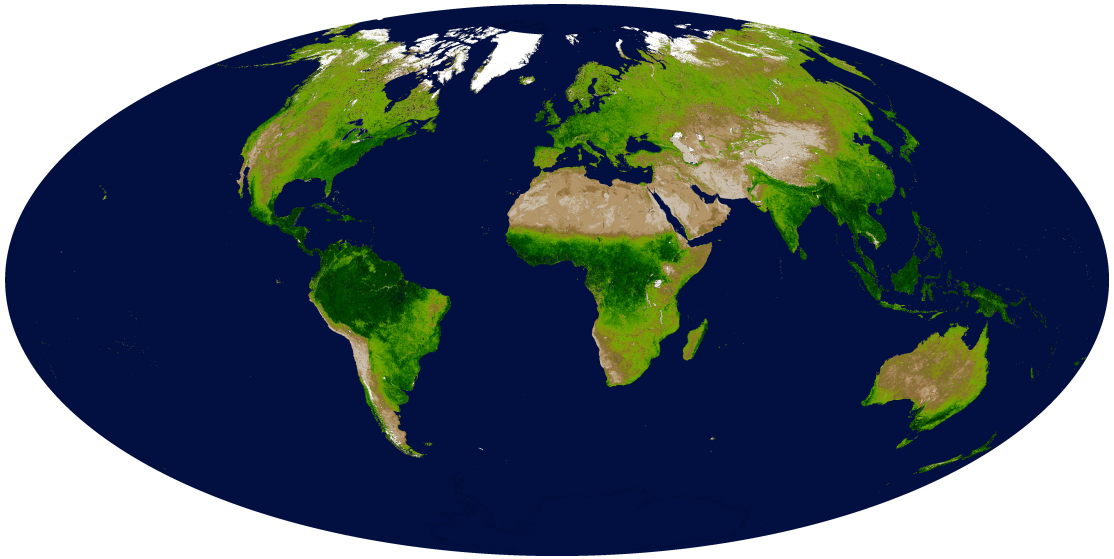
Suomi NPP Satellite (above); Global Vegetation Map (left). Image Credit: NASA/NOAA)

MODIS to VIIRS Transition

- Improved spatial resolution -
  - From 500 m and 1000 m to 375 m and 750 m
- Spectral coverage slightly smaller -
  - From 0.412 – 14 microns to .412 to 12 microns
- Fewer bands
  - From 36 to 22
- Higher orbit - Absolute full global coverage in one day
- Comparable radiometric and spectral quality -
  - 12-bit data
  - Similar on-board calibrators



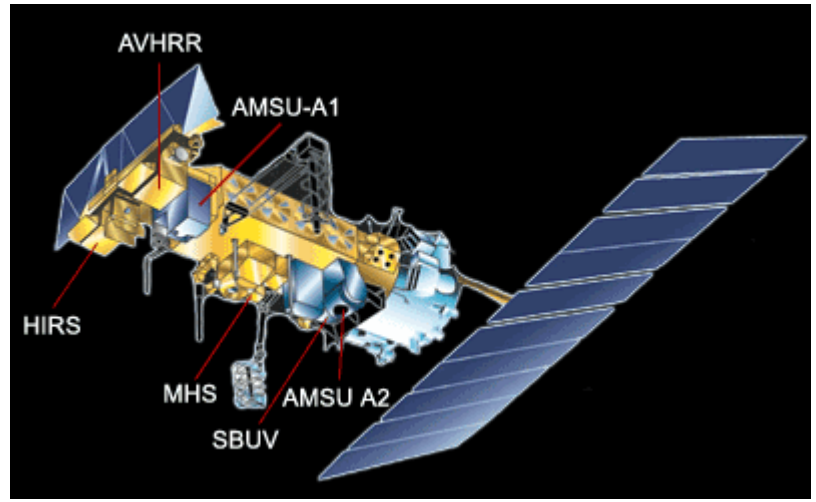
MODIS vs. VIIRS burned area from Brazil in 2013 (above), Image Credit: University of Maryland;



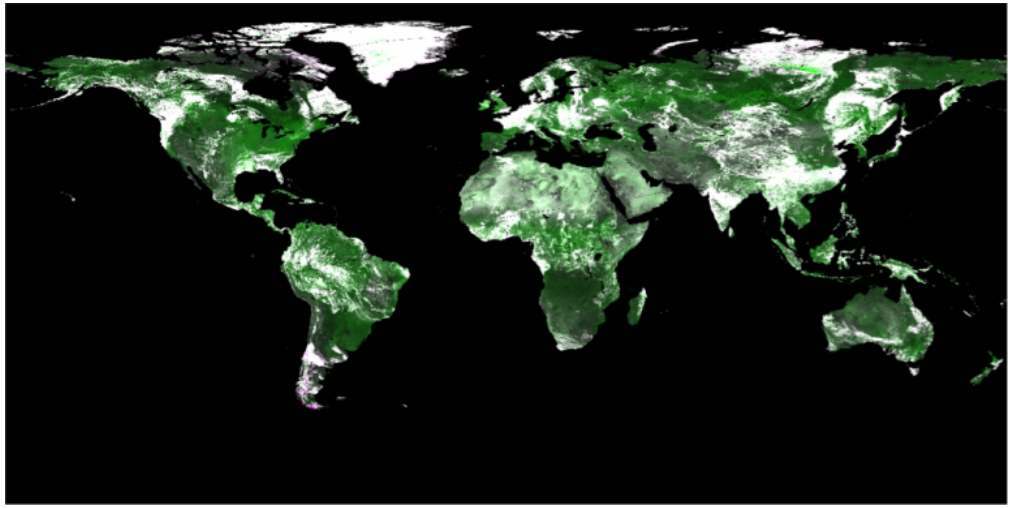
EVI from MODIS (left), Image Credit: NASA

Advanced Very High-Resolution Radiometer (AVHRR)

- Produced and operated by the National Oceanic and Atmospheric Administration (NOAA)
- Onboard many NOAA Polar Orbiting Environmental Satellites (POES)
  - Data available from 1978 to present
- Spatial Resolution: 1 km
- Temporal Resolution: Global coverage available twice daily (morning and afternoon)
- Spectral Resolution: 4-6 bands, multispectral, visible, near-infrared, and thermal bands
- Land cover and vegetation index products available



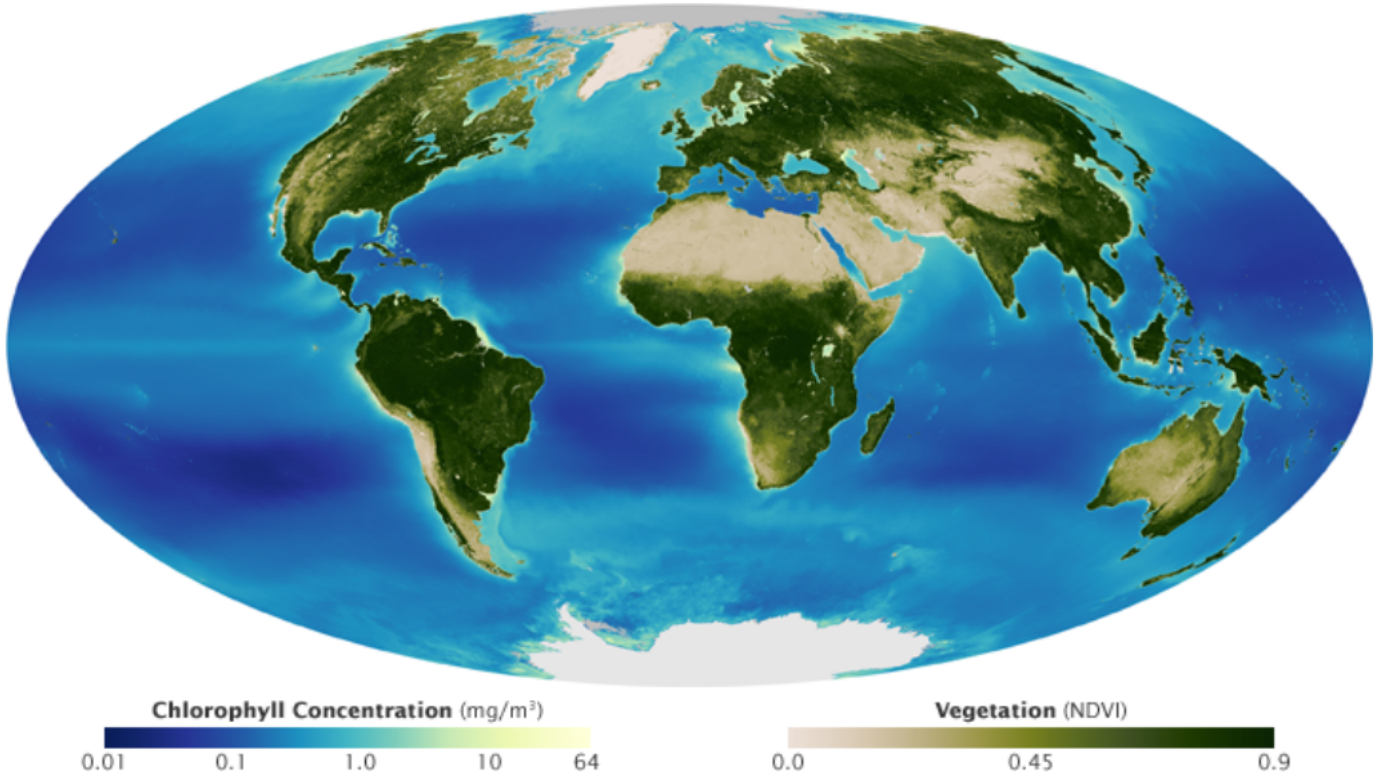
NOAA's N instrument, with the AVHRR sensor included. Image Credit: NOAA



Surface reflectance from AVHRR (global, 1km). Image Credit: NOAA

Sea-viewing Wide Field-of-view-Sensor (SeaWiFS)

- Designed to measure ocean chlorophyll, but can be used for land applications too
  - Built by private company: Orbital Sciences, onboard the OrbView-2 satellite
- Dates: 1998- 2010
- 8 bands
- Spatial Resolution: 4 km
- Global coverage every 16 days
- Applications:
  - Ocean Color
  - Vegetation Health (NDVI)

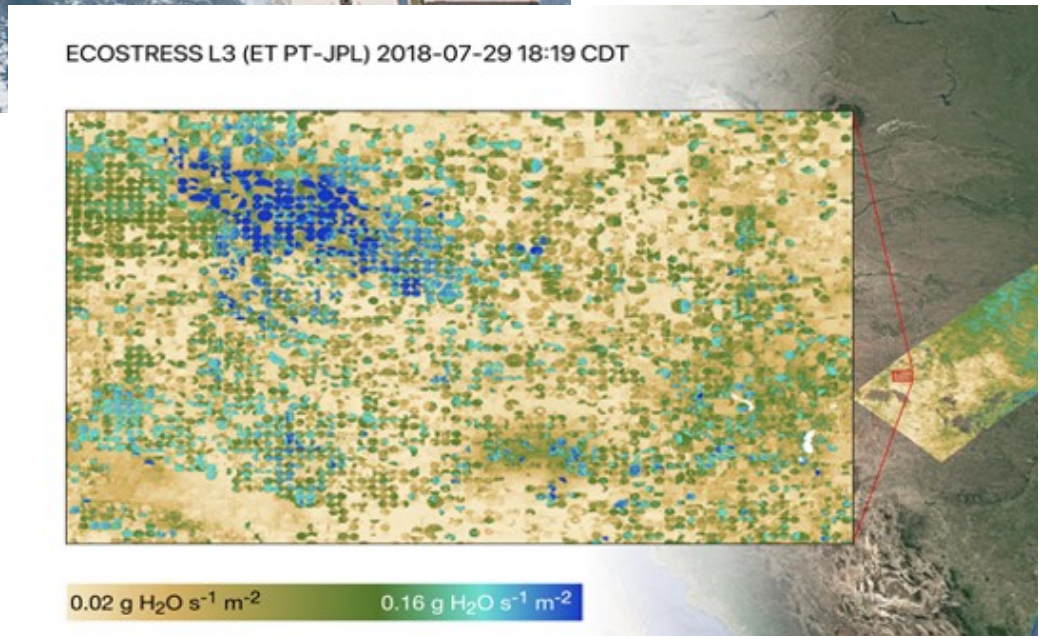


Ocean chlorophyll and NDVI from 1998-2010 via SeaWiFS. Image Credit: NASA

The ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS)

- Primarily used to measure Evapotranspiration (ET)
- Onboard the International Space Station (ISS)
- Data Coverage: 12 key climate zones and Fluxnet sites
- Spatial Resolution: 400 km
- Repeat Time: Hourly at those locations
- Data available on LP DAAC, Earthdata, AppEEARS, and USGS Earth Explorer

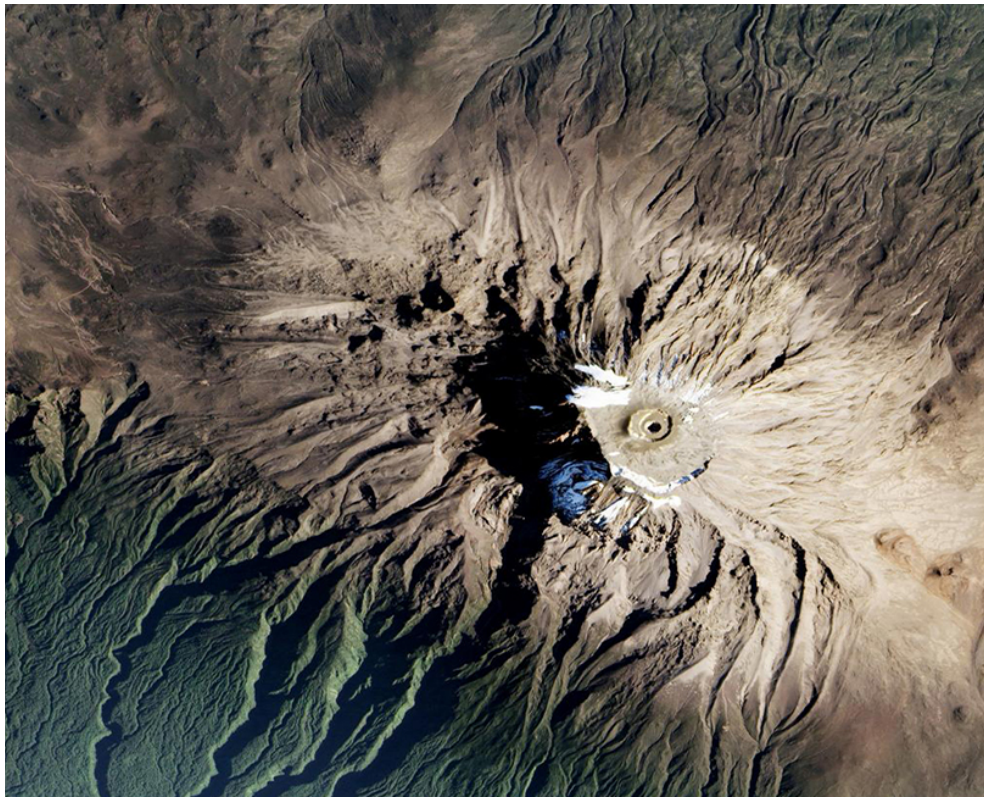
ECOSTRESS onboard the ISS (left) and ET from crop lands (below). Image Credits: NASA/Dr. Joshua Fisher



https://ecostress.jpl.nasa.gov/

Surface Biology and Geology (SBG) Mission

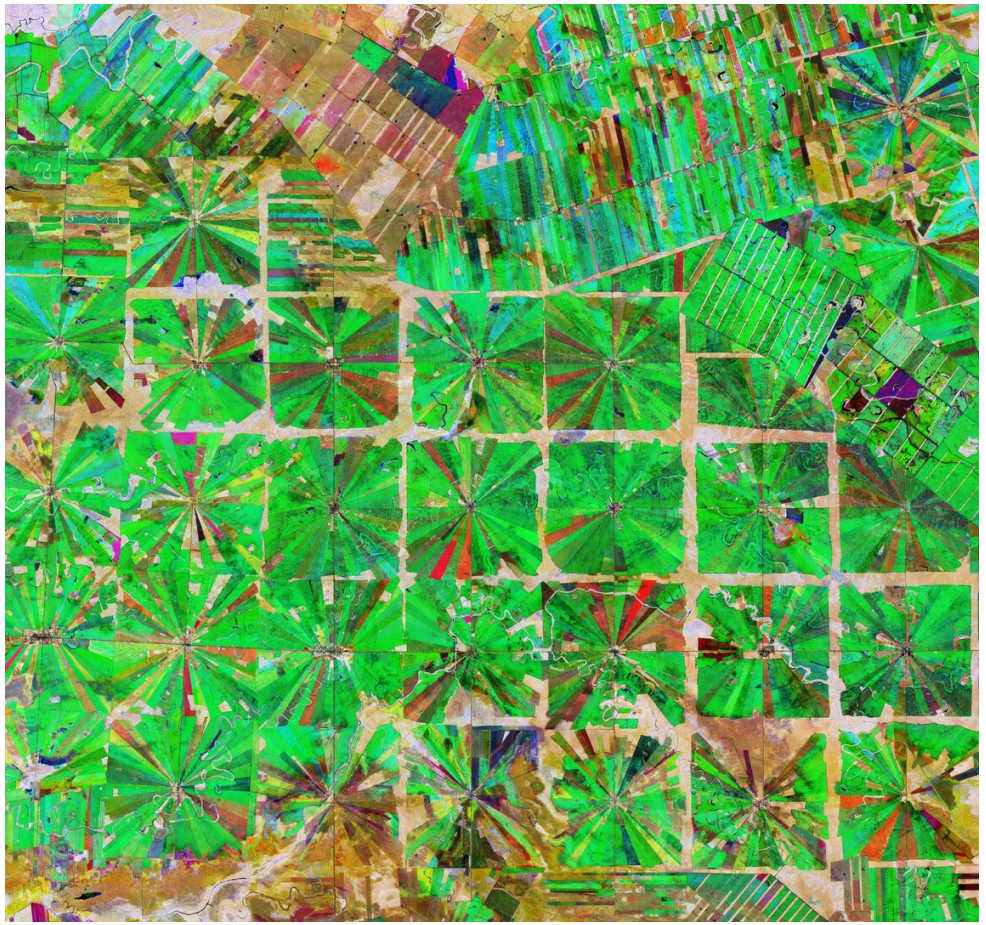
- New instrument in development: Guidance from the 2018 Decadal Survey
- Hyperspectral and thermal data under consideration
- Applications could include:
  - Water cycle and anthropogenic impacts
  - Biodiversity
  - Carbon fluxes
  - Land surface/atmosphere interactions
  - Volcanos
  - Landscape change
- The **Applications Working Group** is coordinating and integrating applications needs.
  - Email list for updates: sbg@jpl.nasa.gov
- For more info: https://sbg.jpl.nasa.gov/



Mount Kilimanjaro Image Credit: JPL SBG

ESA Satellites and Sensors for Phenology

- **Sentinel-2**
  - Launched in 2015
  - 13 spectral bands
  - Spatial Resolution:
    - Red, Green, Blue (RGB) at 10 meters
    - Near-infrared and Shortwave infrared at 20 and 60 meters
  - Revisit Time: ~5 days
  - Often combined with Landsat for continuity
    - Harmonized Sentinel-2 and Landsat surface reflectance products available
- **SPOT (multiple satellites)**
  - National Centre for Space Studies (*CNES*), French government space agency
  - Spot 6 (2012), 7 (2014)
  - 4 multispectral bands
  - 6-meter spatial resolution
  - Revisit Time: ~2-3 days

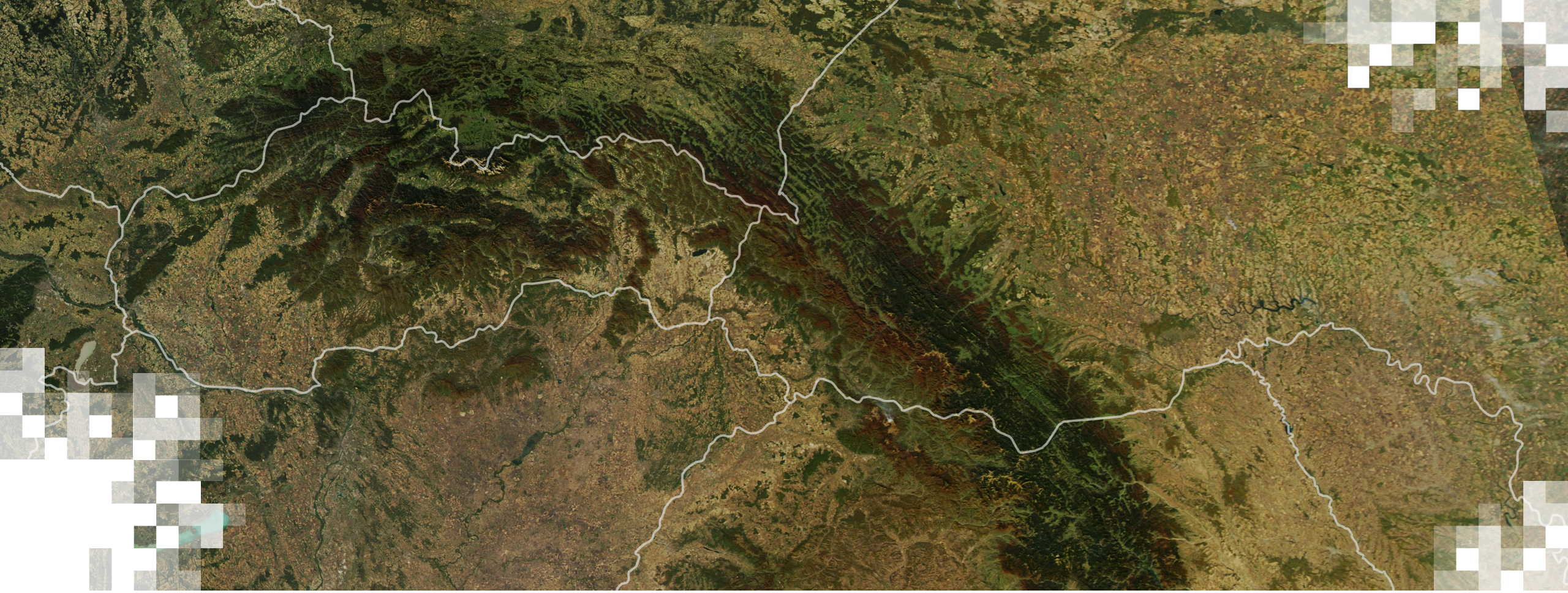


Composite Sentinel-2 image of forests converted to farmland in Brazil, 2019. Image Credit: ESA

ESA Satellites and Sensors for Phenology

- **Medium Resolution Imaging Spectrometer (MERIS)**
  - ESA sensor onboard the Envisat satellite
    - Launched in 2002, ended in 2012
    - 15 bands (visible and near infrared)
    - Reduced Resolution Data: 1.2 km available globally
    - Full Resolution Data: 300 m spatial resolution acquired regionally
    - 16-bit radiometric resolution
    - Global coverage every 3 days
  - Land cover mapping, vegetation health, drought applications
  - MERIS Global Vegetation Index (MGVI), which corresponds to the Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)

FPAR over Europe from 2006. Image Credit: ESA



Land Surface Parameters

Vegetation Indices and Biophysical parameters

Vegetation/Greenness Indices

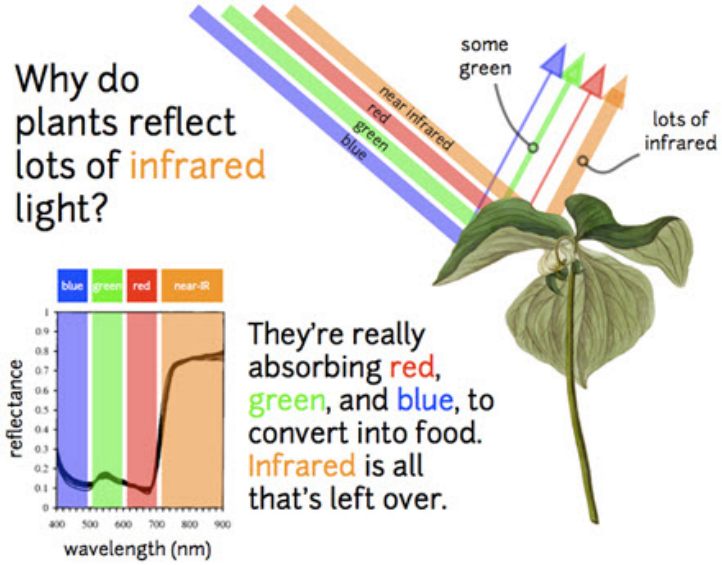
- NDVI - Normalized Difference Vegetation Index
- EVI - Enhanced Vegetation Index
- SAVI - Soil-Adjusted Vegetation Index
- MSAVI - Modified Soil-Adjusted Vegetation Index
- SATVI - Soil-Adjusted Total Vegetation Index
- Normalized Burn Ratio (NBR)

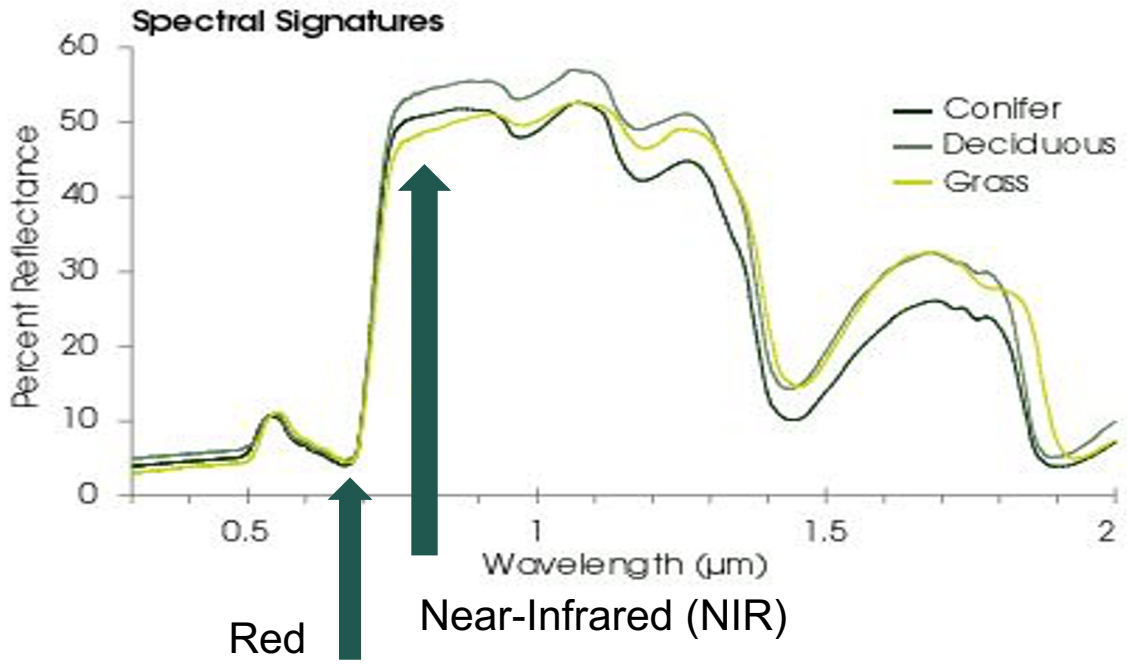
Biophysical Parameter Estimates

- fPAR - Fraction of Photosynthetically Active Radiation
- Fractional Cover
- GPP and NPP - Gross and Net Primary Productivity or Biomass
- LAI - Leaf Area Index

Normalized Difference Vegetation Index (NDVI)

- Based on the relationship between red and near-infrared wavelengths
- Chlorophyll strongly absorbs visible (red)
- Plant structure strongly reflects near-infrared





NDVI: Review

- NDVI Formula:

$$\frac{\text{Near-Infrared} - \text{Red}}{\text{Near-Infrared} + \text{Red}}$$

- Values range from -1.0 to 1.0
  - Negative values to 0 mean no green leaves.
  - Values close to 1 indicate the highest possible density of green leaves.

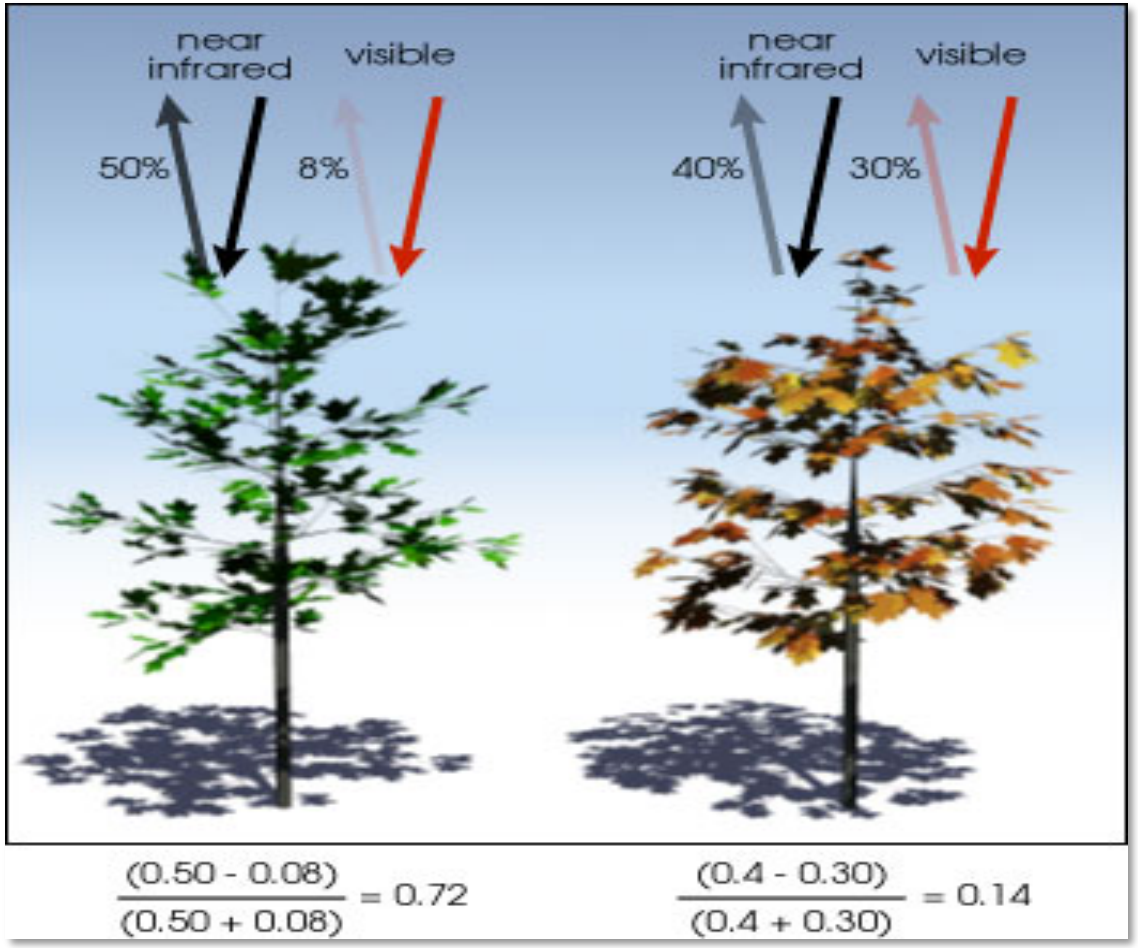
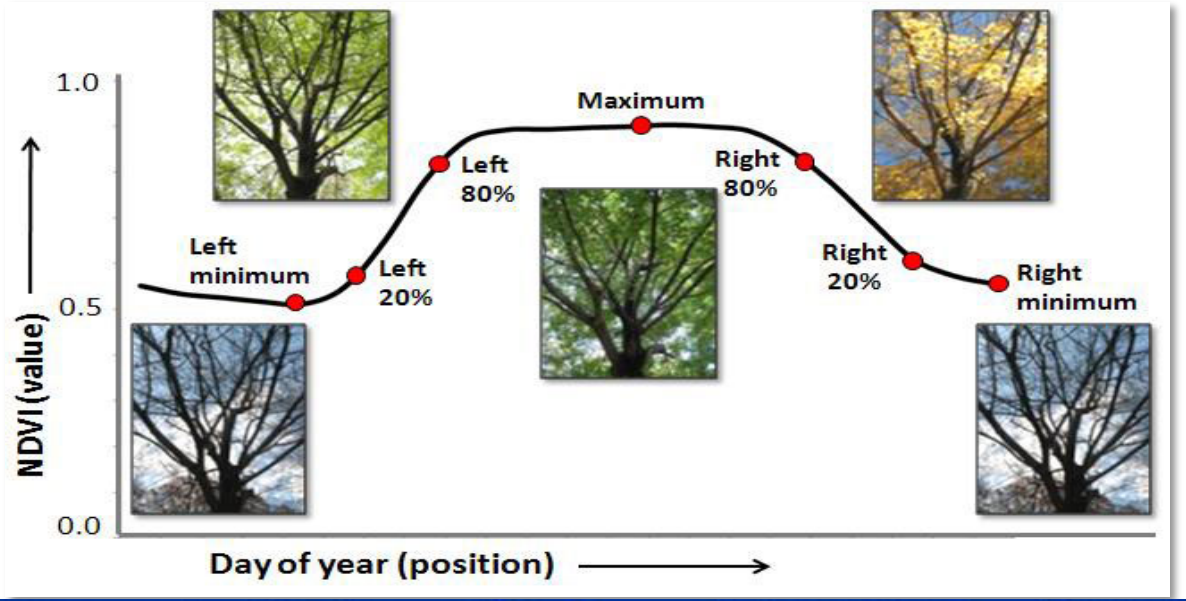


Image Credit: Robert Simmon

NDVI and Seasonality

- Remote sensing is used to track the seasonal changes in vegetation.
- Monthly NDVI images from MODIS or Landsat can be used to monitor phenology.



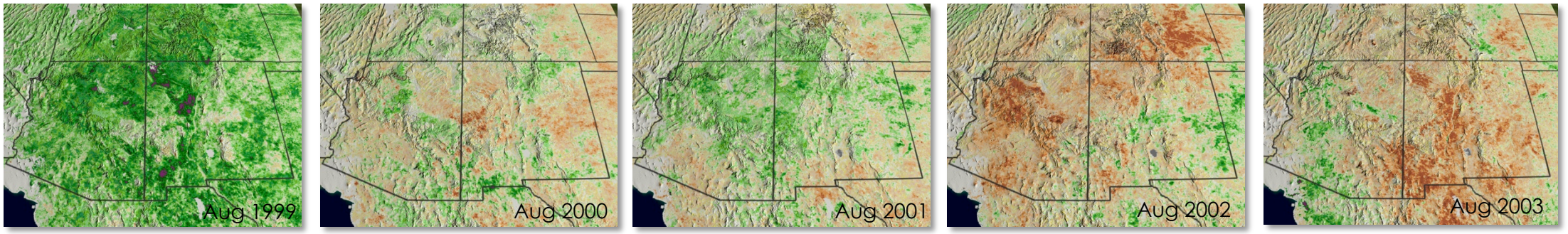
North America NDVI Images in Winter and Summer

Credit: spacegrant.montana.edu

NDVI: Anomalies

- Departure of NDVI from the long-term average, normalized by long-term variability
- Generated by subtracting the long-term mean from the current value for that month of the year for each grid cell
- Indicates if vegetation greenness at a particular location is typical for that period or if the vegetation is more or less green

NDVI Anomalies in the Southwestern United States



Enhanced Vegetation Index (EVI)

$$EVI = G * \left(\frac{(NIR - R)}{(NIR + C1 * R - C2 * B + L)} \right)$$

Constants

$G = 2.5$

$C1 = 6$

$C2 = 7.5$

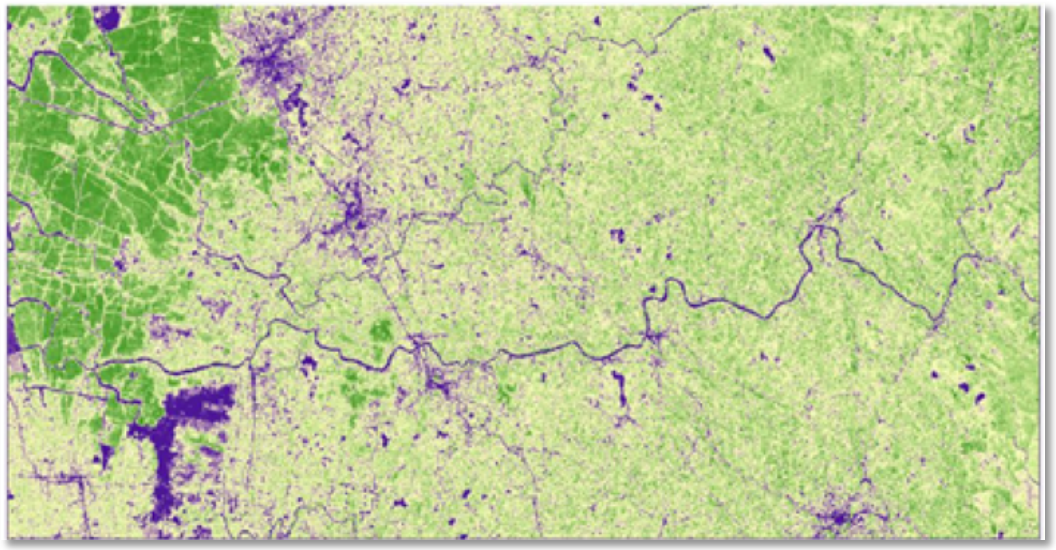
$L = 1$

- Does not saturate over high biomass regions
- L= Adjustment for canopy background
- C= Atmospheric adjustment
- Use of the blue band

Soil Adjusted Vegetation Index (SAVI)

- Minimizes the influence of soil brightness
- Useful in areas with greater soil cover
  - Contains a soil brightness correction factor (L)
    - 0.5 typically used
    - Lower for areas with greater canopy cover
    - Higher for areas with less canopy cover

$$SAVI = \left(\frac{(NIR - R)}{(NIR + R + L)} \right) \times (1 + L)$$

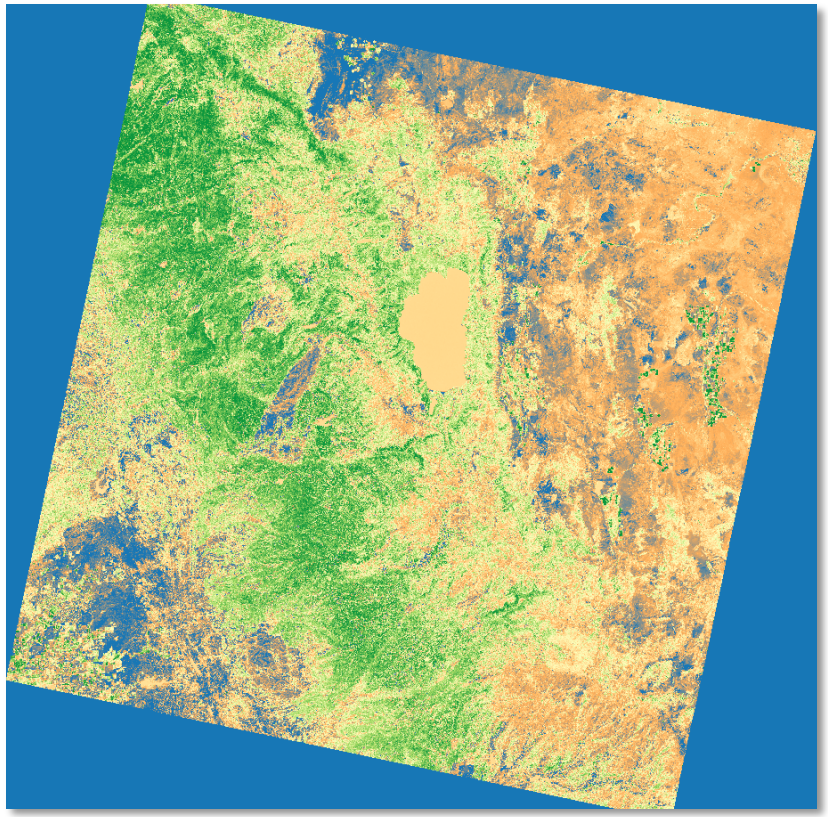


SAVI: Image Credit: Grind GIS

Normalized Difference Moisture Index (NDMI)

- Measure of vegetation moisture
- Frequently used in drought monitoring
  - Detects more subtle changes in vegetation moisture
- Used in wildfire hazard potential

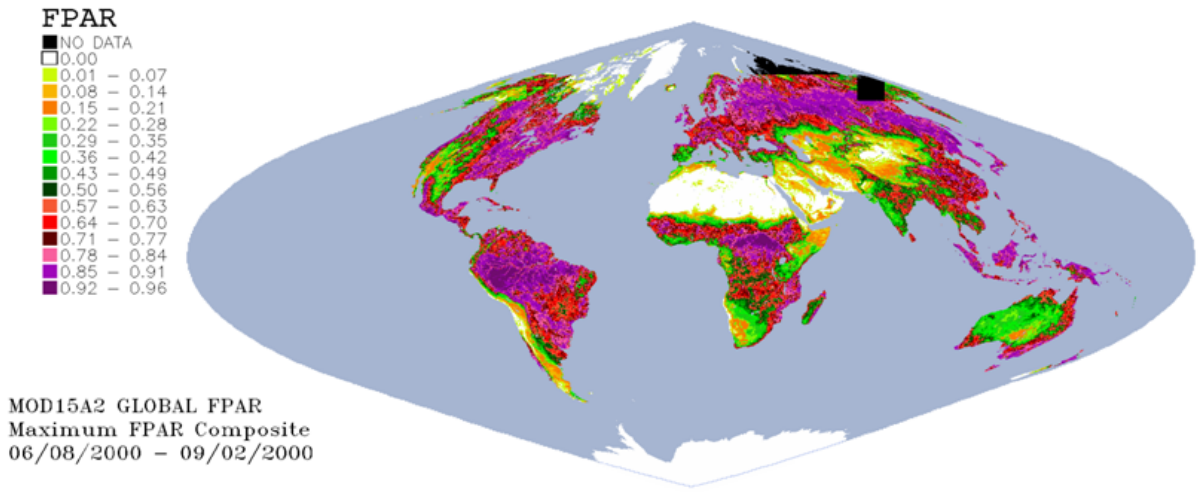
$$NDMI = \frac{(NIR - SWIR)}{NIR + SWIR}$$



Example of NDMI using the California Landsat

Fraction of Photosynthetically Active Radiation (fPAR)

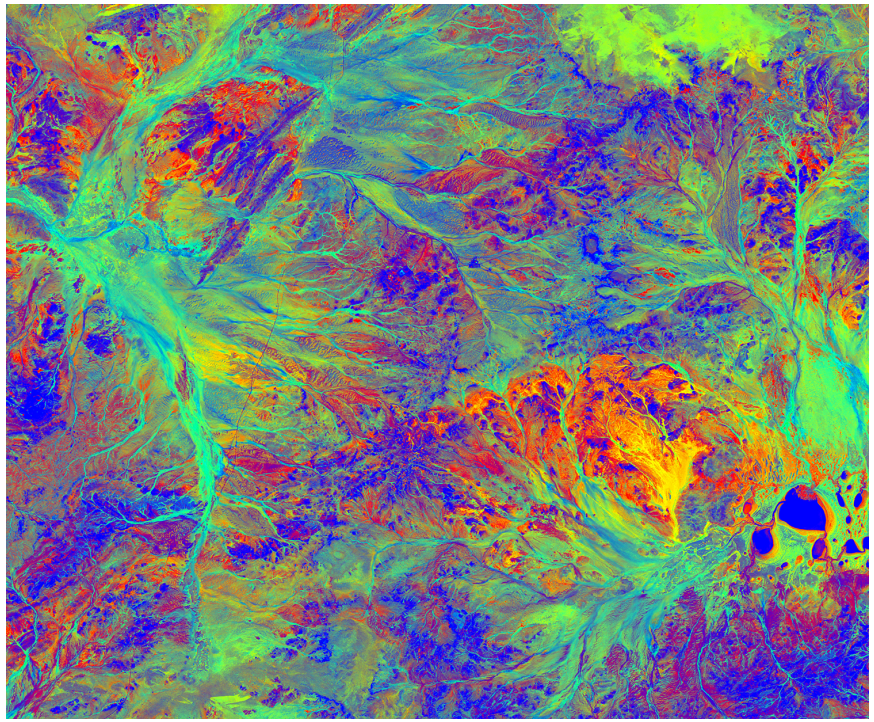
- Photosynthetically active radiation (PAR) is the spectral range from 400-700nm that is used by plants in photosynthesis.
  - The fraction of PAR (fPAR) signifies the portion of PAR used by plants.
- In remote sensing, FPAR is the fraction of incident photosynthetically active radiation (400-700 nm) absorbed by the green elements of a vegetation canopy.
- Precipitation and temperature are drivers of fPAR.
- fPAR is important for biomass production estimates.



Global fPAR from MODIS in 2000. Image Credit: Running, S.W. and NTSG. 2002

Fractional Cover (FC)

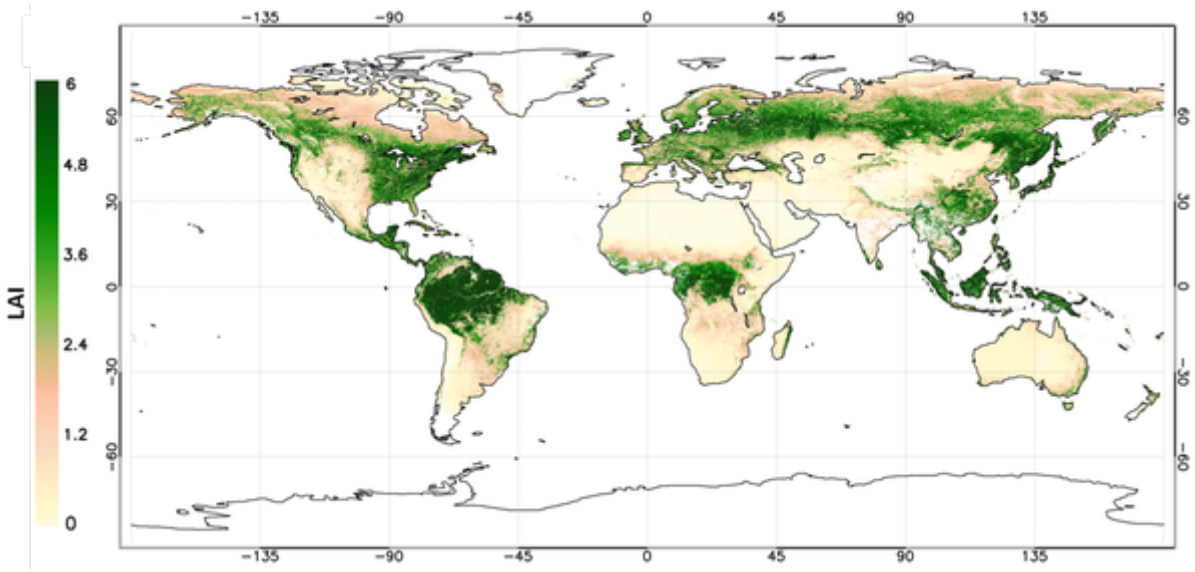
- Estimation of the proportion of an area that is covered by each member of a pre-defined set of vegetation or land cover types
- Requires conducting a land cover classification
- Limitations for FC estimates in remote sensing
  - Spatial Resolution (one value per pixel or need for spectral unmixing techniques)
  - Errors in classification will propagate into FC estimates.
  - Requires hyperspectral data for vegetation species distinctions



Fractional Cover (FC) from Australia: Green (leaves, grass, and growing crops), brown (branches, dry grass or hay, and dead leaf litter), and bare ground (soil or rock). Image Credit: Digital Earth Australia

Leaf Area Index (LAI)

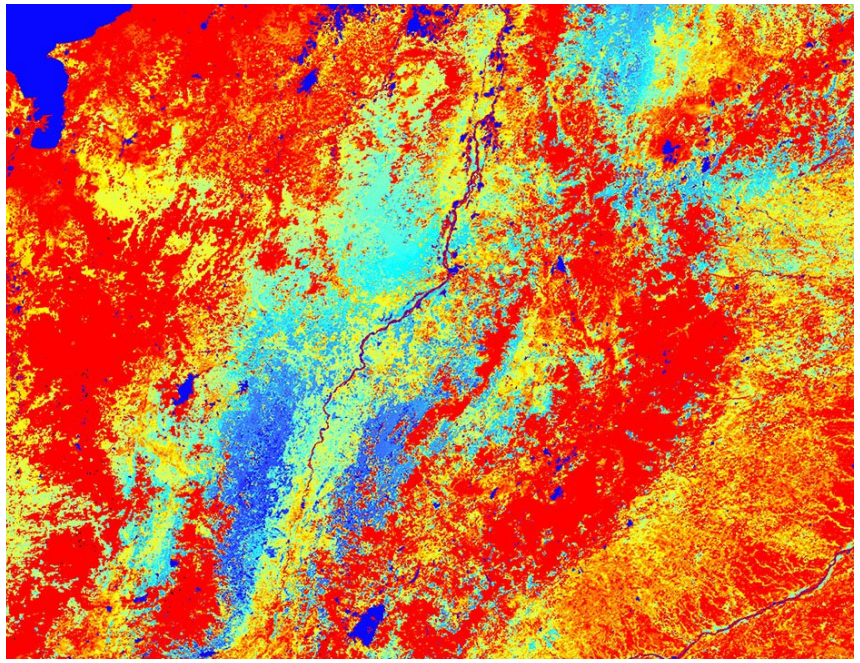
- Ratio of leaf area to per-unit ground surface area
  - Related to photosynthesis, evapotranspiration, rainfall interception, and carbon flux
- Can be calculated based on a regression and spatial relationship between NDVI, EVI, and other vegetation indices
  - Landsat, MODIS, etc.
- Vegetation indices and LAI relationships will not always be linear due to saturation and the complicated structure of the forest canopy.
  - Regression relationships best applied regionally
    - Time and site specific



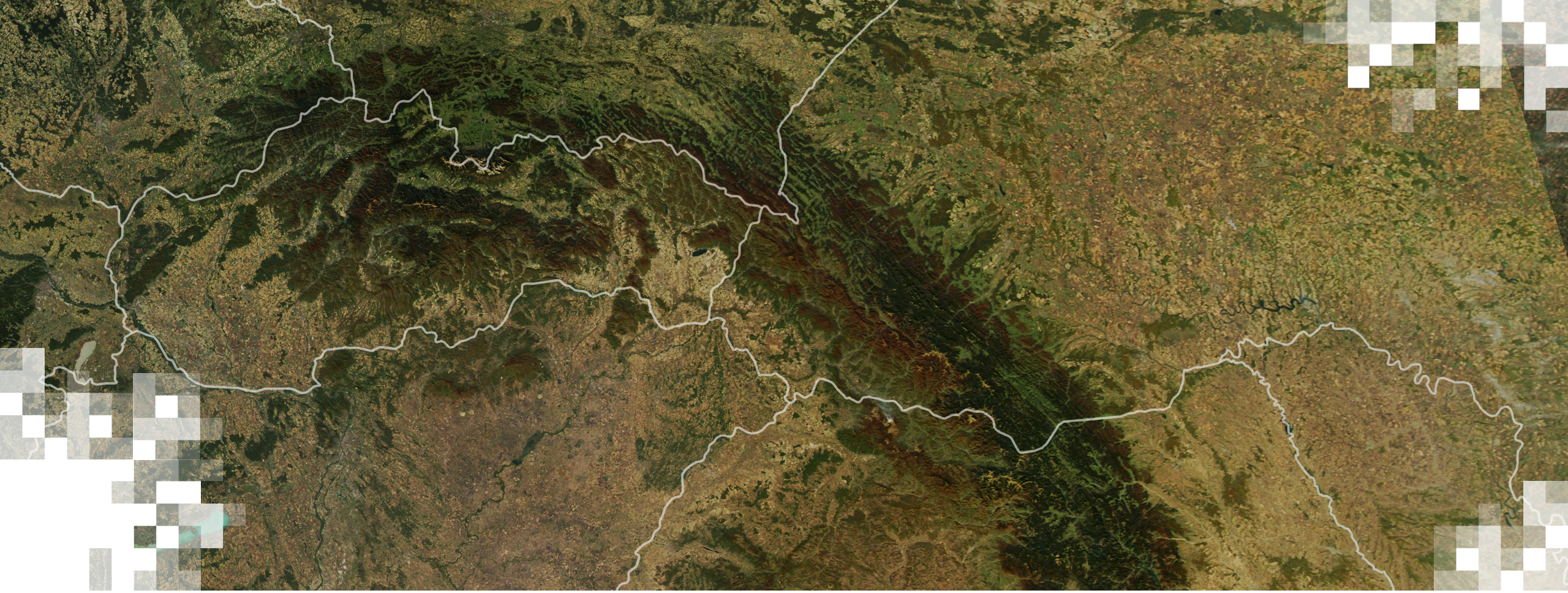
Global LAI from 2017. Image Credit: ESA

Gross and Net Primary Productivity (GPP and NPP)

- **GPP**: The overall rate of biomass production by producers.
- **NPP**: Net carbon fixed by vegetation through photosynthesis.
  - GPP – Respiration
  - The carbon required for maintenance of the structure of an ecosystem
- Can be calculated as a product of fPAR and light use (or radiation) efficiency
  - Linear Modeling: Correlate field measurements of fractional cover with NDVI
  - Physical Models: Incorporate parameters related to photosynthesis, evapotranspiration, stress, and decay of plant material
- Also commonly used to monitor ocean chlorophyll



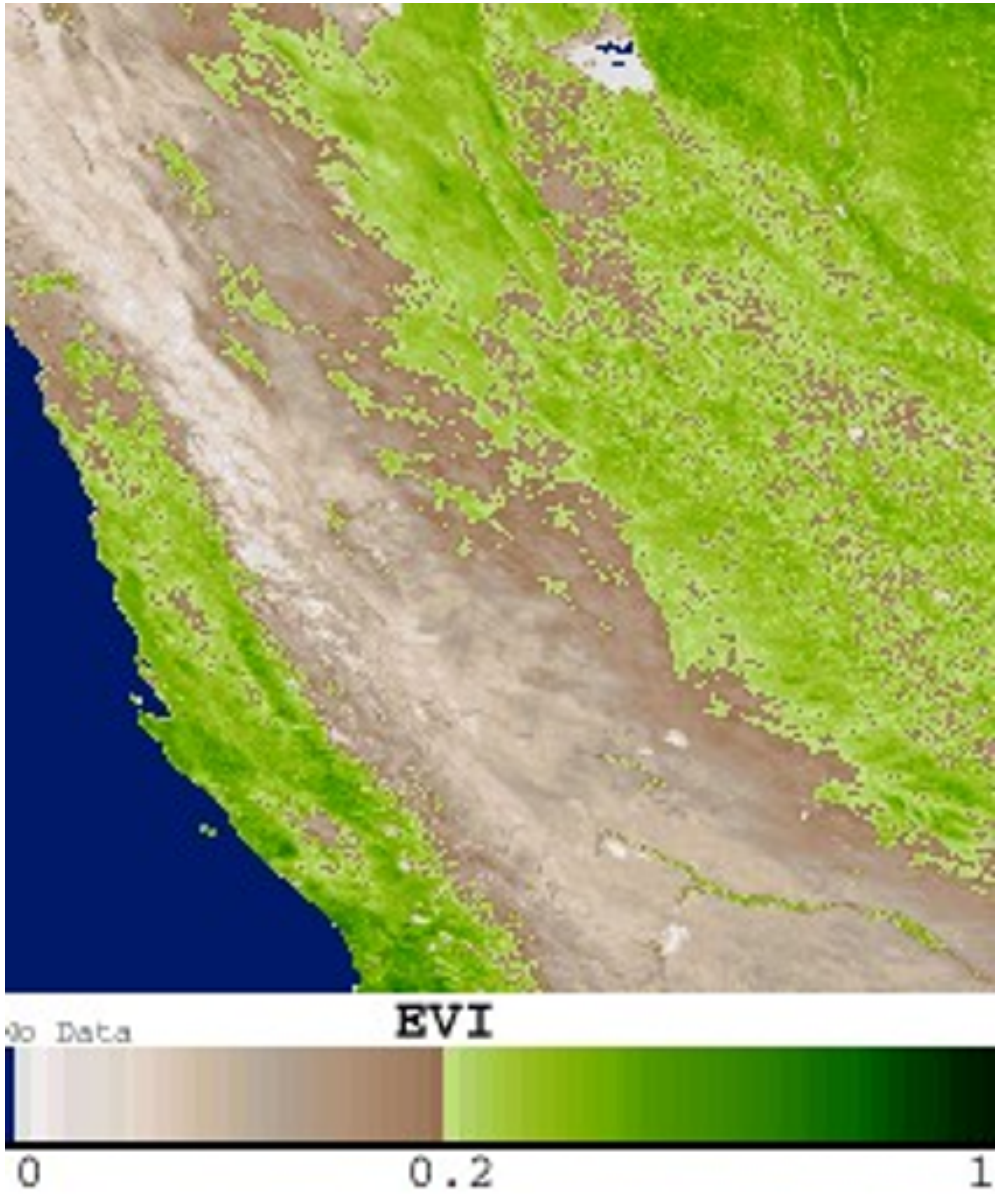
Gross Primary Productivity (GPP) from the MYD17A2H product over central South America on August 29 - September 5, 2018. Image Credit: USGS/NASA



Phenology Data Products

MODIS NDVI and EVI Products

- 16-day composites
- 250 m, 500 m, and 1 km resolutions
- Retrieved from daily, atmosphere-corrected, bidirectional surface reflectance
- Collection Names: MOD13 (Terra) and MYD13 (Aqua)
  - Multiple subsets based on spatial resolution
- Product available via the Land Processes Distributed Active Archive Center (LP DAAC) tools:
  - AppEEARS
  - Data Pool
  - Earthdata search
  - OPeNDAP

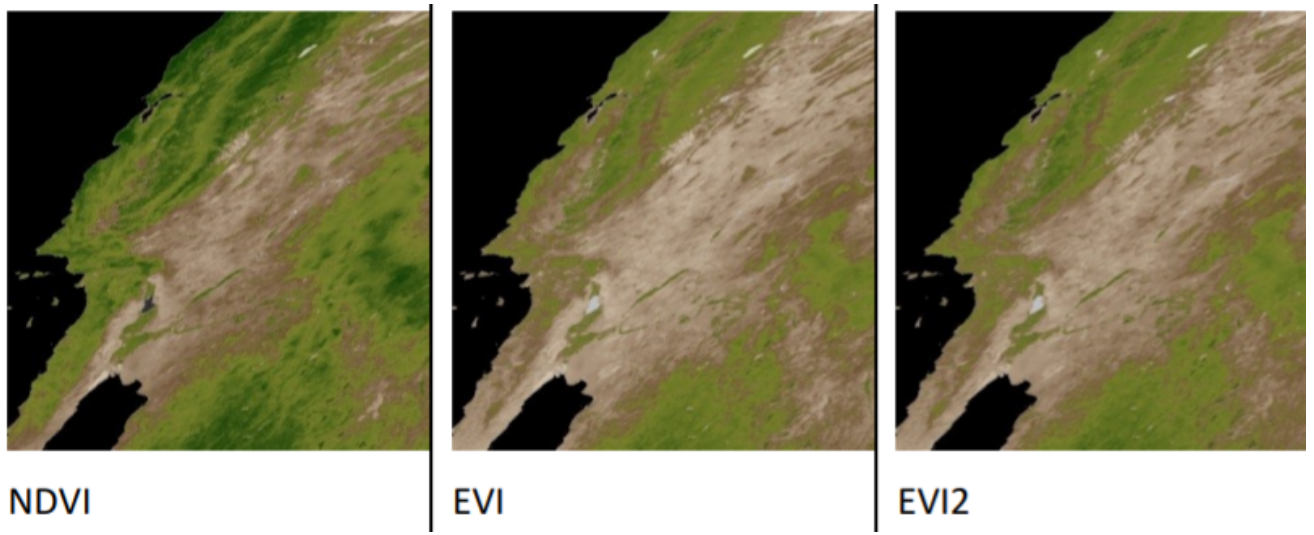


MODIS EVI from April 2020 of the western coast of Africa. Image Credit: USGS/NASA

VIIRS NDVI and EVI Products

- 16-day composites of NDVI, EVI, and EVI2
- 500 m, 1 km ,and 0.05-degree resolutions
- Algorithm selects the best available pixel in a 16-day window

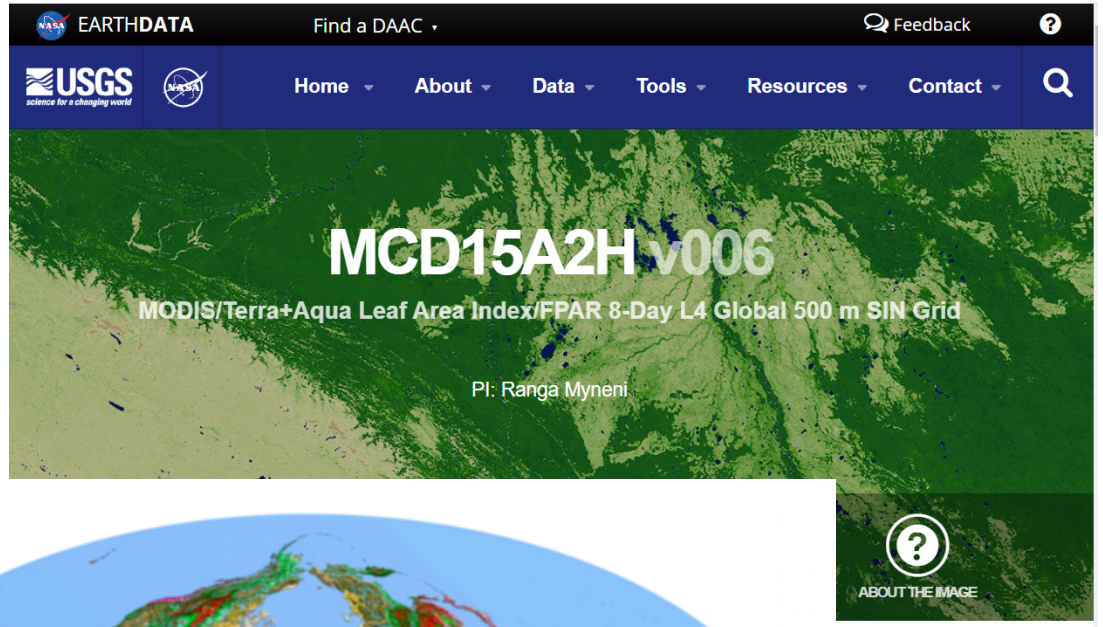
- Collection Name: VNP13
  - Multiple subsets based on spatial resolution
- Product available via the Land Processes Distributed Active Archive Center (LP DAAC) tools:
  - AppEEARS
  - Data Pool
  - Earthdata search
  - OPeNDAP

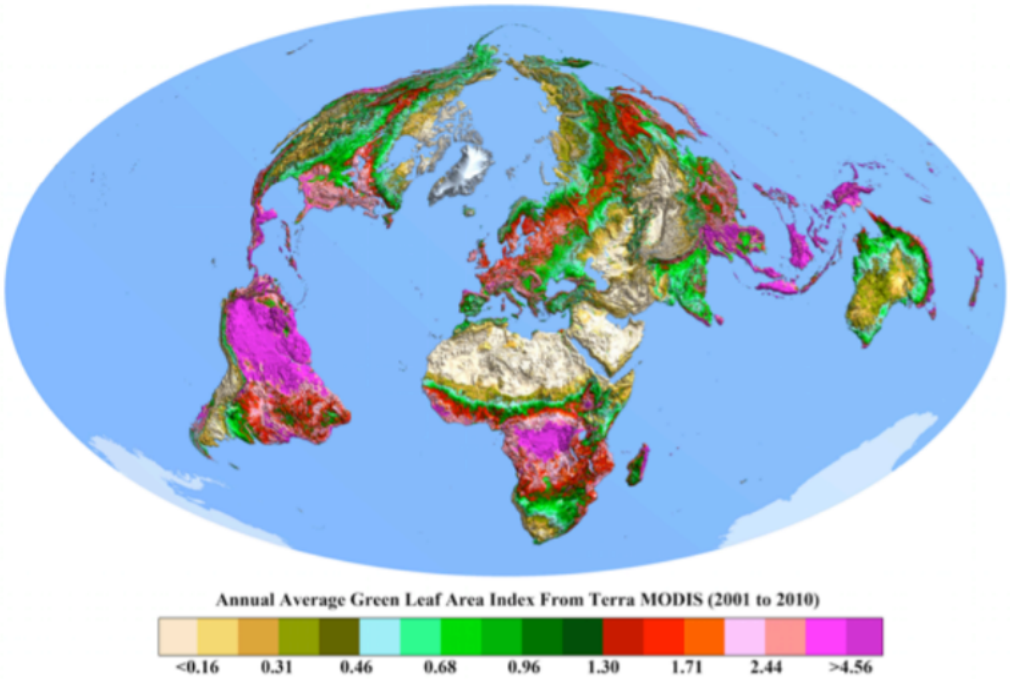


NDVI, EVI, and EVI2 from VIIRS over western North America Image Credit: USGS/NASA

MODIS LAI and fPAR Products

- 4-day and 8-day composites
- Spatial Resolution: 500 m
- Collection Names: MCD15A2H (8-day), MCD15A3H (4-day)
- The algorithm chooses the best pixel available from MODIS sensors located on NASA's Terra and Aqua satellites from within the 8-day period.
- Product available via the Land Processes Distributed Active Archive Center (LP DAAC) tools:
  - AppEEARS
  - Data Pool
  - Earthdata search
  - OPeNDAP

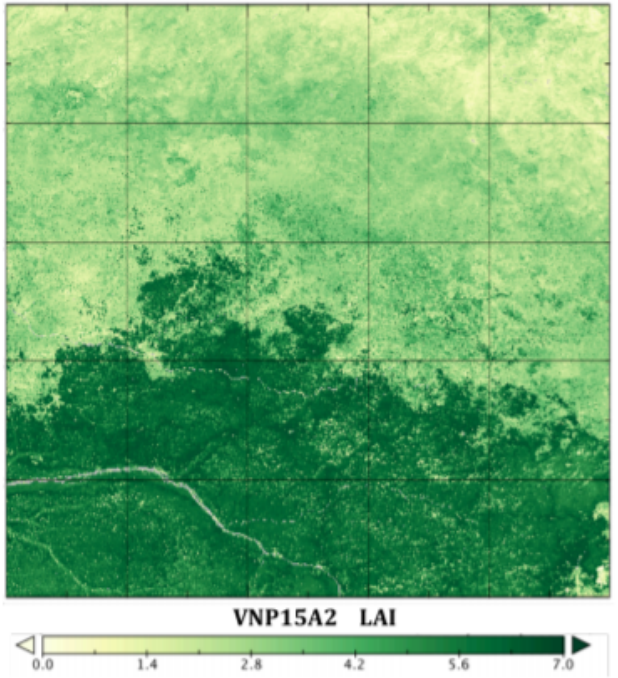


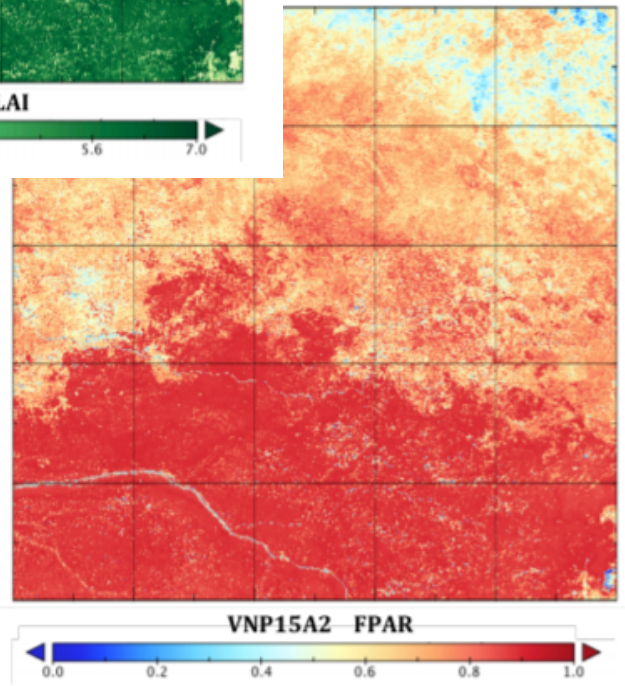


Product Documentation website (above); Global annual average LAI from 2001-2010. Image Credit: USGS/NASA

VIIRS LAI and fPAR Product

- 8-day composites
- 500 m spatial resolution
- Collection Name: VNP15
- The algorithm chooses the best pixel available from VIIRS from within the 8-day period.
- Product available via the Land Processes Distributed Active Archive Center (LP DAAC) tools:
  - AppEEARS
  - Data Pool
  - Earthdata search
  - OPeNDAP

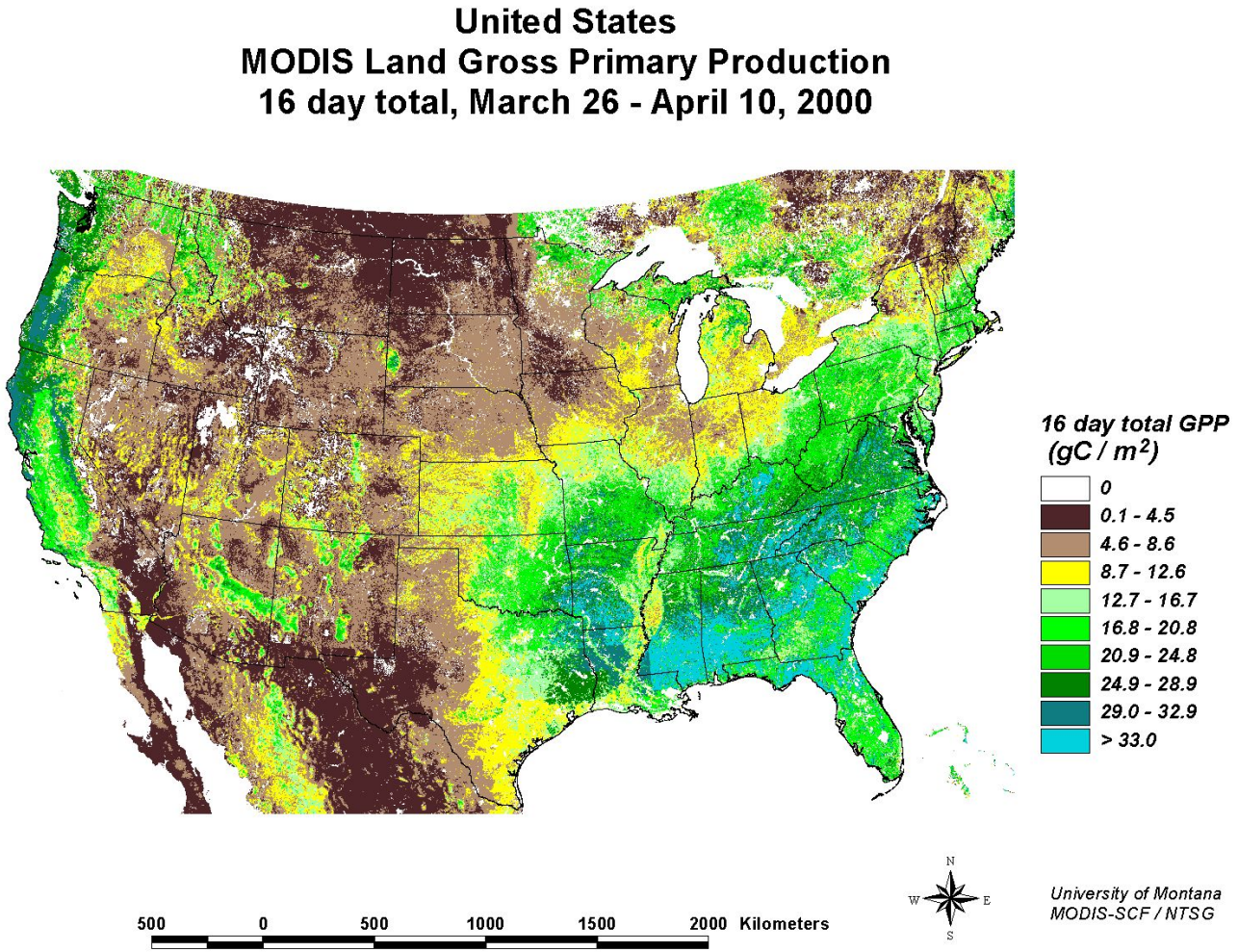




One-tile sample images of VIIRS V1 VNP15A2H product: LAI (left) and FPAR (below). The data shown here was obtained on July 2015 and is for a tile of H20V08 covering northern central Africa. Image Credit: USGS/NASA

MODIS GPP Product

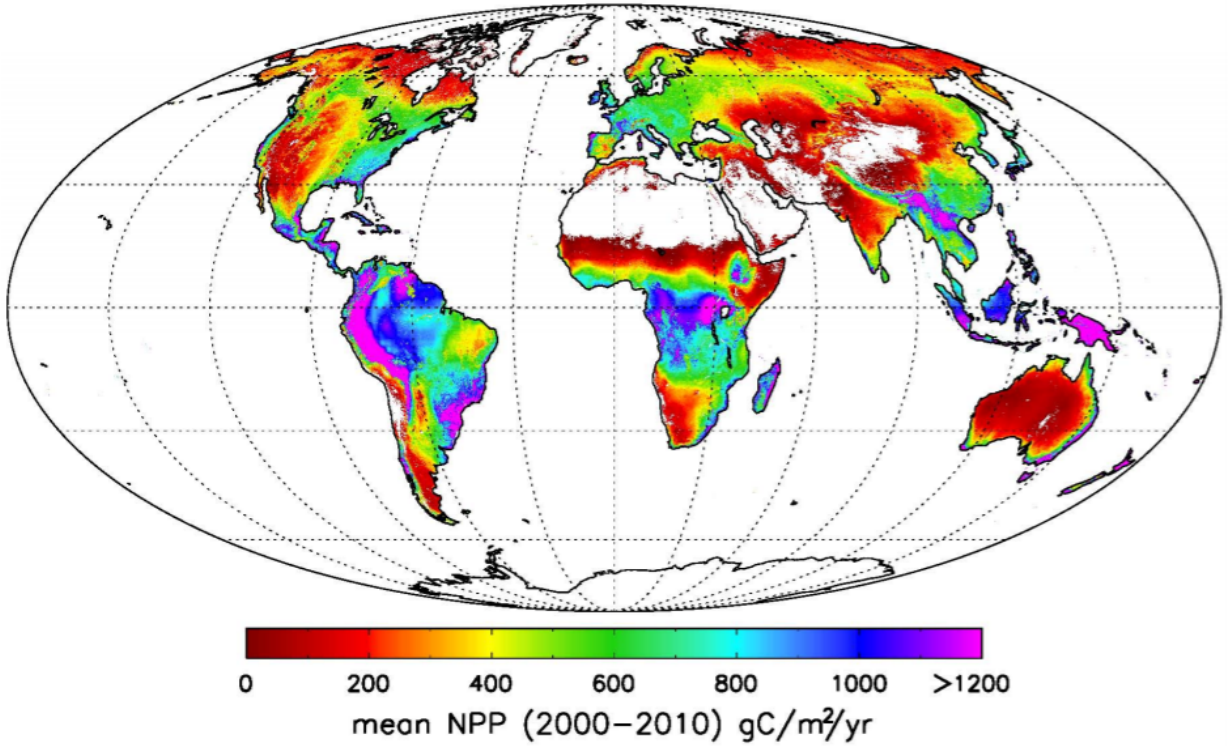
- 8-day composite
- Spatial Resolution: 500 m
- Collection Name: MCD17A2H
- The algorithm chooses the best pixel available from MODIS sensors located on NASA's Terra and Aqua satellites from within the 8-day period.
- Product available via the Land Processes Distributed Active Archive Center (LP DAAC) tools:
  - AppEEARS
  - Data Pool
  - Earthdata search
  - OPeNDAP



MODIS GPP from 2010. Image Credit: NASA

MODIS NPP Product

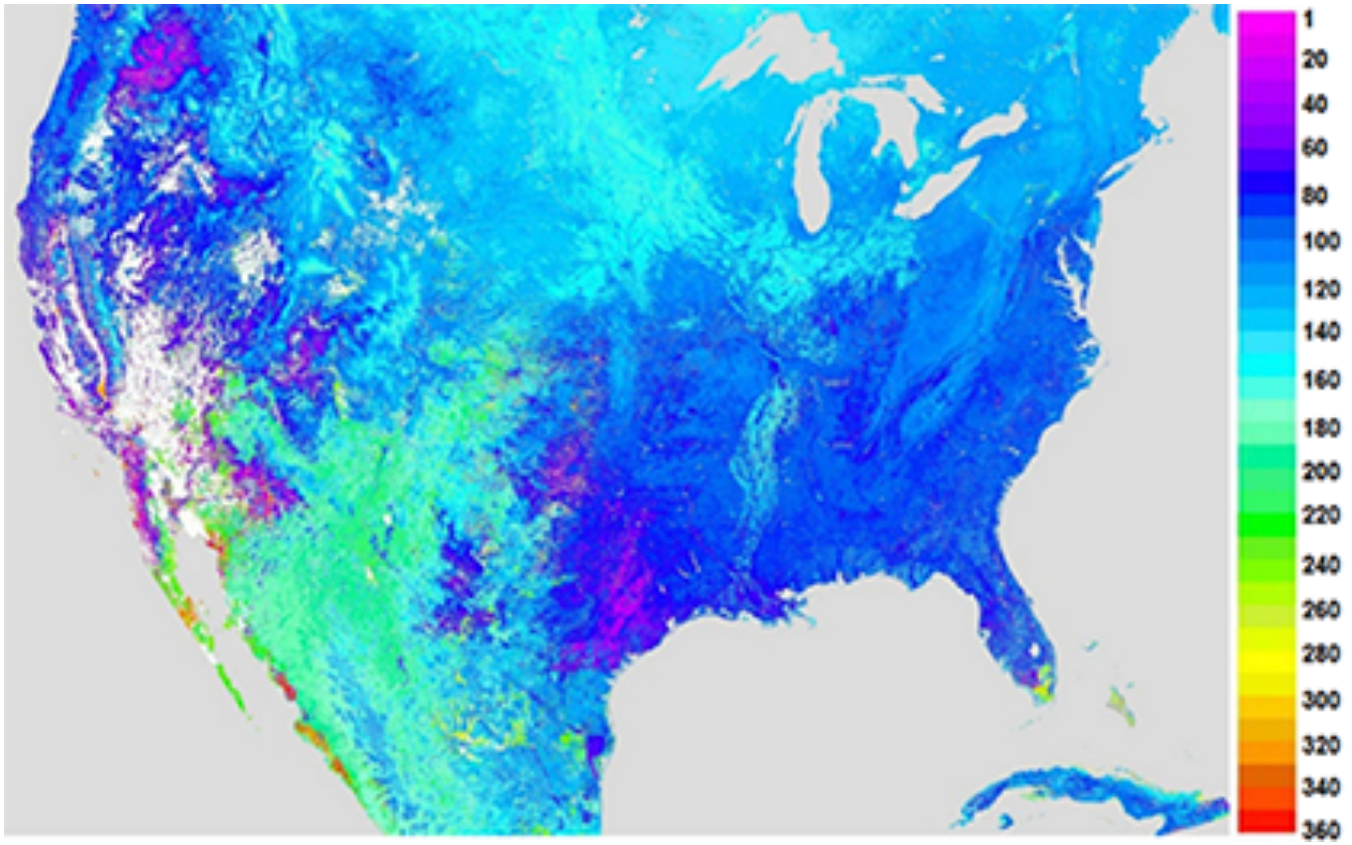
- Annual
- Spatial Resolution: 500 m
- Collection Name: MCD173HGF
  - New gap-filled version 6
- Derived from the sum of all 8-day Net Photosynthesis (PSN) product (MOD17A2H) from the given year. The PSN value is the difference of the Gross Primary Productivity (GPP) and the Maintenance Respiration (MR).
- Product available via the Land Processes Distributed Active Archive Center (LP DAAC) tools:
  - AppEEARS
  - Data Pool
  - Earthdata search
  - OPeNDAP



Global average NPP from 2000-2010. Image Credit: USGS/NASA

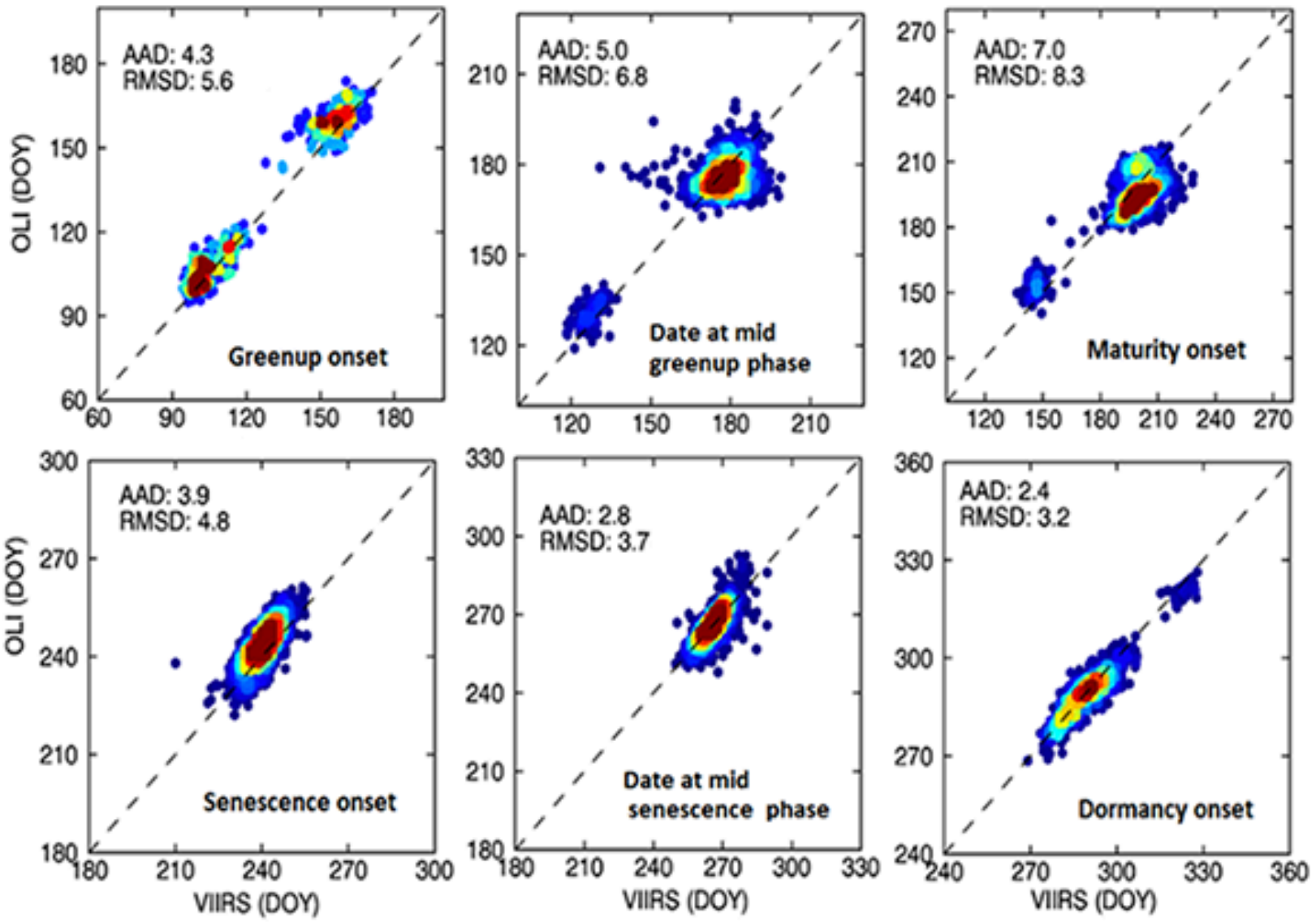
LSP from VIIRS

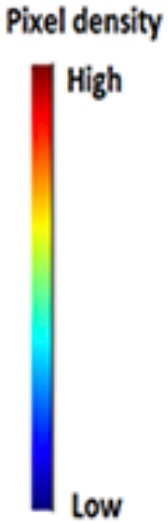
- 10-day repeat time
- Spatial Resolution: 500 m
- Collection Name: MCD17VNP22
- 12 phenological measurements
  – Dates and magnitudes
- Daily inputs such as BRDF (bidirectional reflectance distribution function)-Adjusted Reflectance (NBAR) data in combination with land surface temperature, snow cover, and land cover type at each pixel.
- Comparable to Landsat data and PhenoCam observations



VIIRS phenology product displaying greenup onset, DOY. Image Credit: NASA

LSP from VIIRS

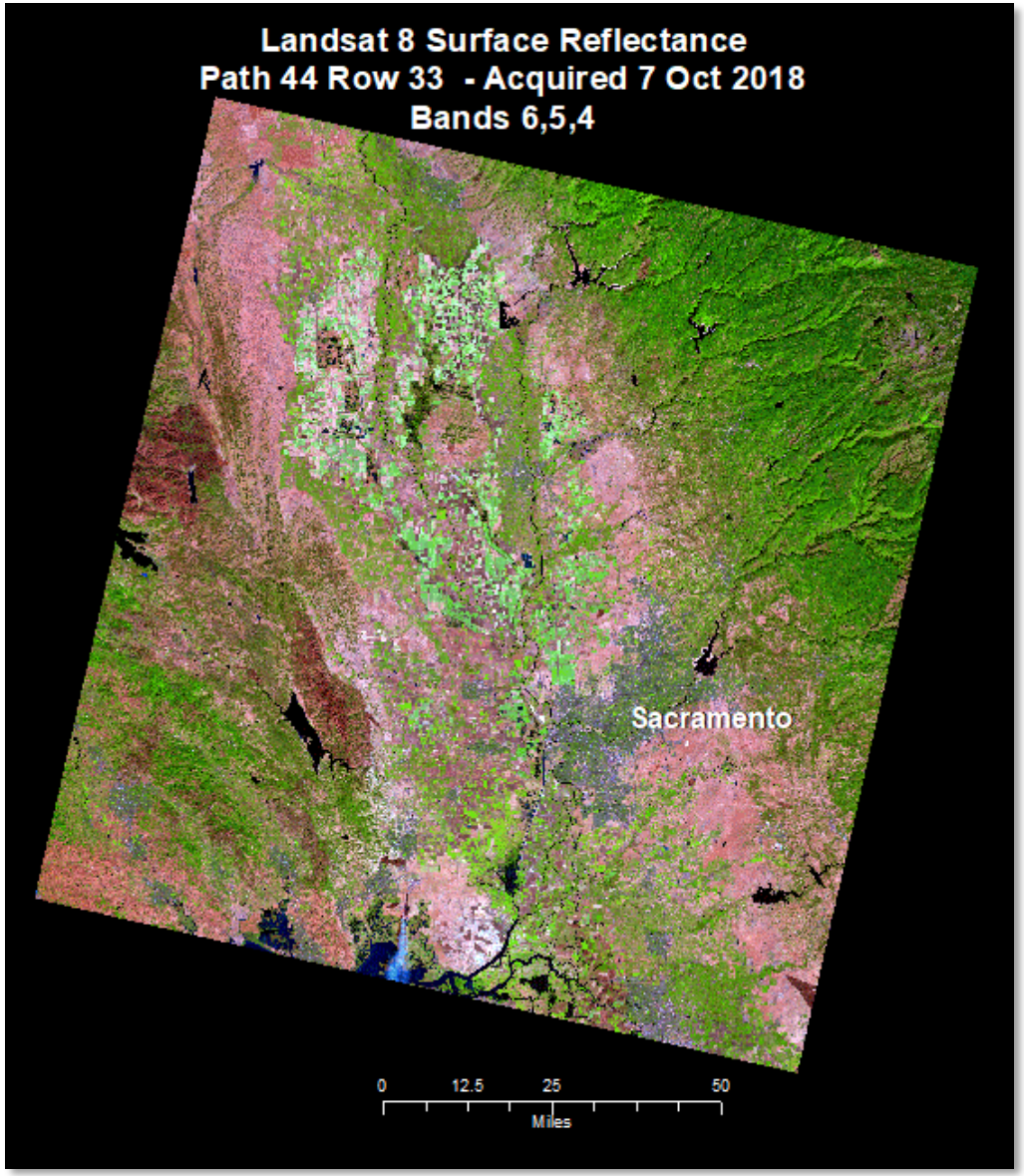




Evaluation of VIIRS GLSP (500m) using fused MODIS-Landsat OLI detections (30m) in 2013 in the central US. AAD is average absolute difference and RMSD is root mean square difference (both units are days). Image Credit: NASA

Landsat Products

- Temporal resolution: 16 days
- Spatial Resolution: 30 m
- Multiple products available: NDVI, EVI, SAVI, NDMI, NBR
- Available upon request from: USGS Earth Resources Observation and Science (EROS) Center Science Processing Architecture (ESPA) On Demand Interface



Animation of the multiple Landsat vegetation indices available. Image Credit: USGS/NASA

Making Earth System Data Records for Use in Research Environments (MEaSUREs) Program

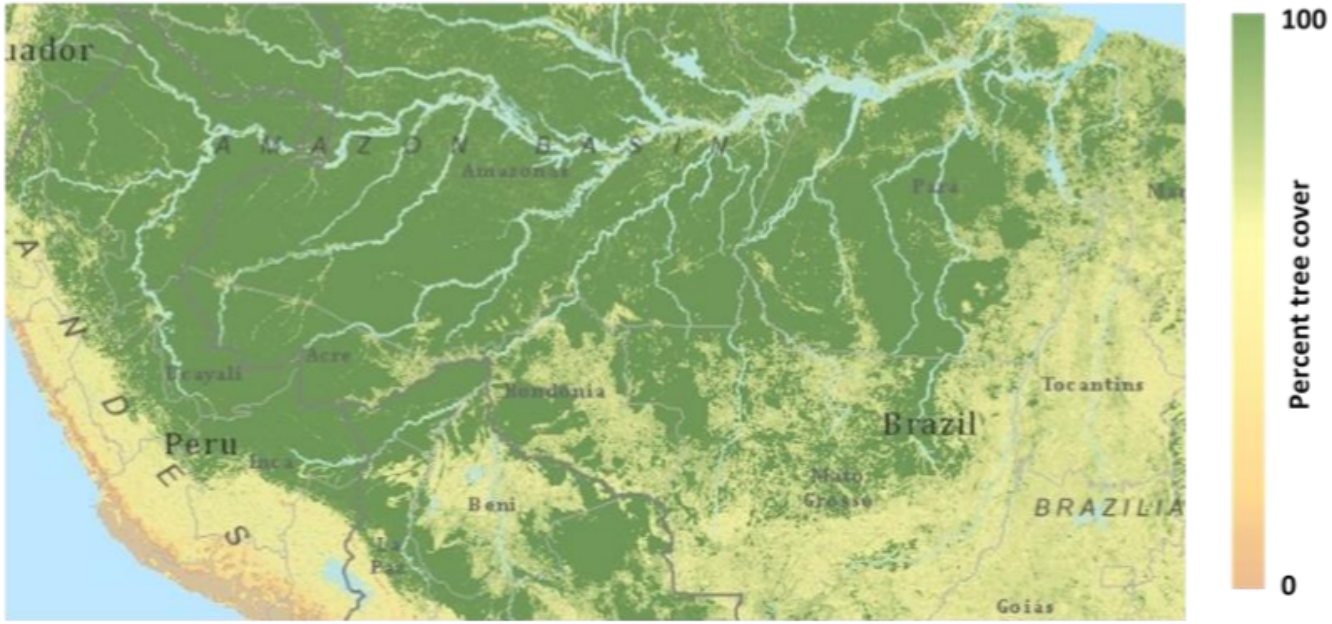
- The MEaSUREs projects are focused on product generation, availability, and utility of Earth System Data Records (ESDRs).
- MEaSUREs provides an opportunity for the research community to participate in the development and generation of data products, which complement and augment the Earth science already available to the research community.

Relevant Products:

- The Vegetation Continuous Fields (VCF)
  - AVHRR-derived
- The Vegetation Index and Phenology (VIP)
  - Multiple satellites

AVHRR Products

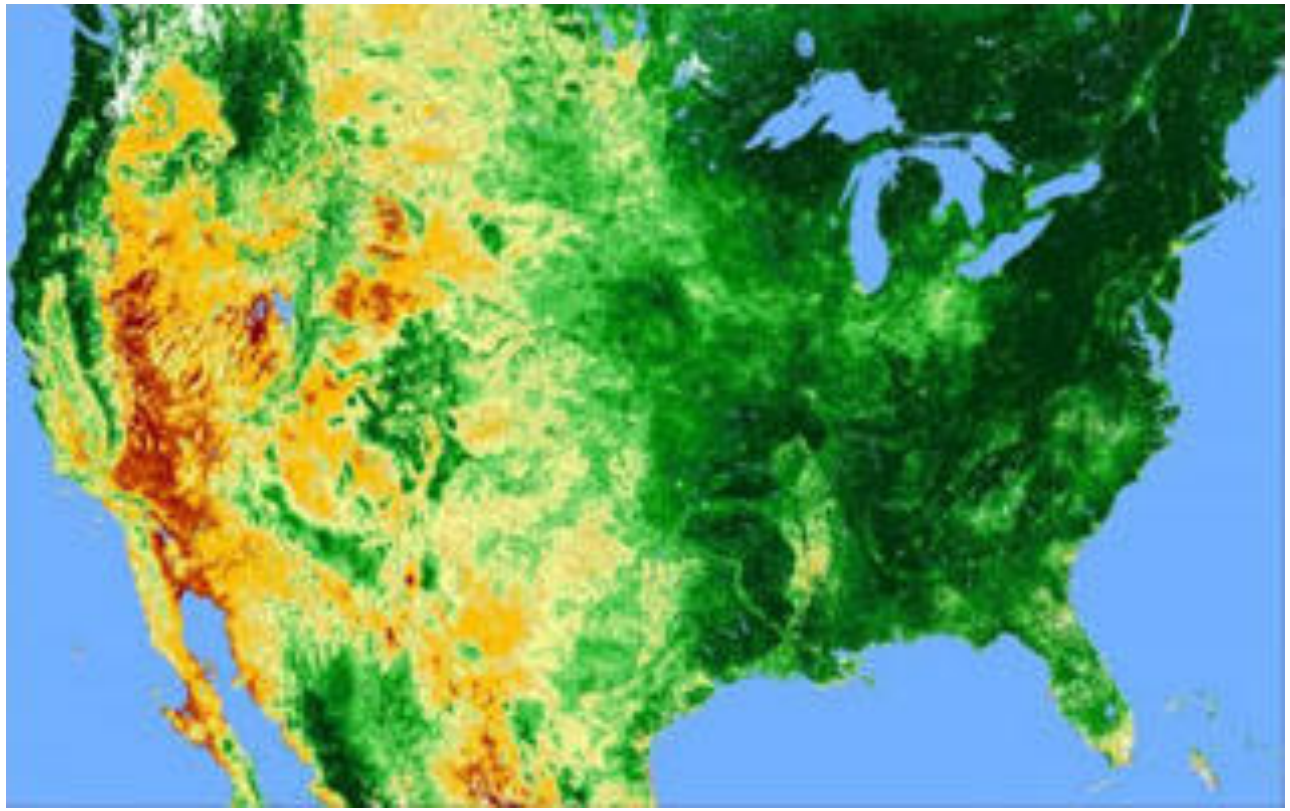
- Vegetation Continuous Fields (VCF)
  - Ratio of the area of the vertical projection of green vegetation above ground to the total area, capturing the horizontal distribution and density of vegetation on the Earth's surface
  - 0.05-degree resolution (5,600 m)
  - Annual from 1982-2016
  - Data Access:
    - Data Pool
    - Earthdata search
    - EarthExplorer
  - Making Earth System Records for Use in Research Environments (MEaSUREs) Program



VCF tree cover for the Amazon Basin from the MEaSUREs VCF ESDR project in 2010. Image Credit: NASA

Combined Satellite Products: NDVI and EVI

- The Vegetation Index and Phenology (VIP)
- Daily, weekly, monthly, yearly
- 0.05-degree resolution (5,600 m)
- NDVI, EVI, EVI2
- 34 years of a consistent, global record of vegetation indices and landscape phenology.
- Based on MODIS, AVHRR, and Satellite Pour l'Observation de la Terre (SPOT) data inputs
- Making Earth System Data Records for Use in Research Environments (MEaSUREs) Program



NDVI AVHRR composite for September 17-30, 2013. Image Credit: USGS/NASA

Additional Data Products

- Climate Data:
  - Temperature
    - MODIS Land Surface Temperature
    - VIIRS Land Surface Temperature
    - Landsat Land Surface Temperature
  - Precipitation
    - Global Precipitation Mission
    - Tropical Rainfall Measuring Mission
      - Integrated Multi-satellitE Retrievals for GPM (IMERG)
  - ARSET Webinars: Water Resources
    - https://arset.gsfc.nasa.gov/water

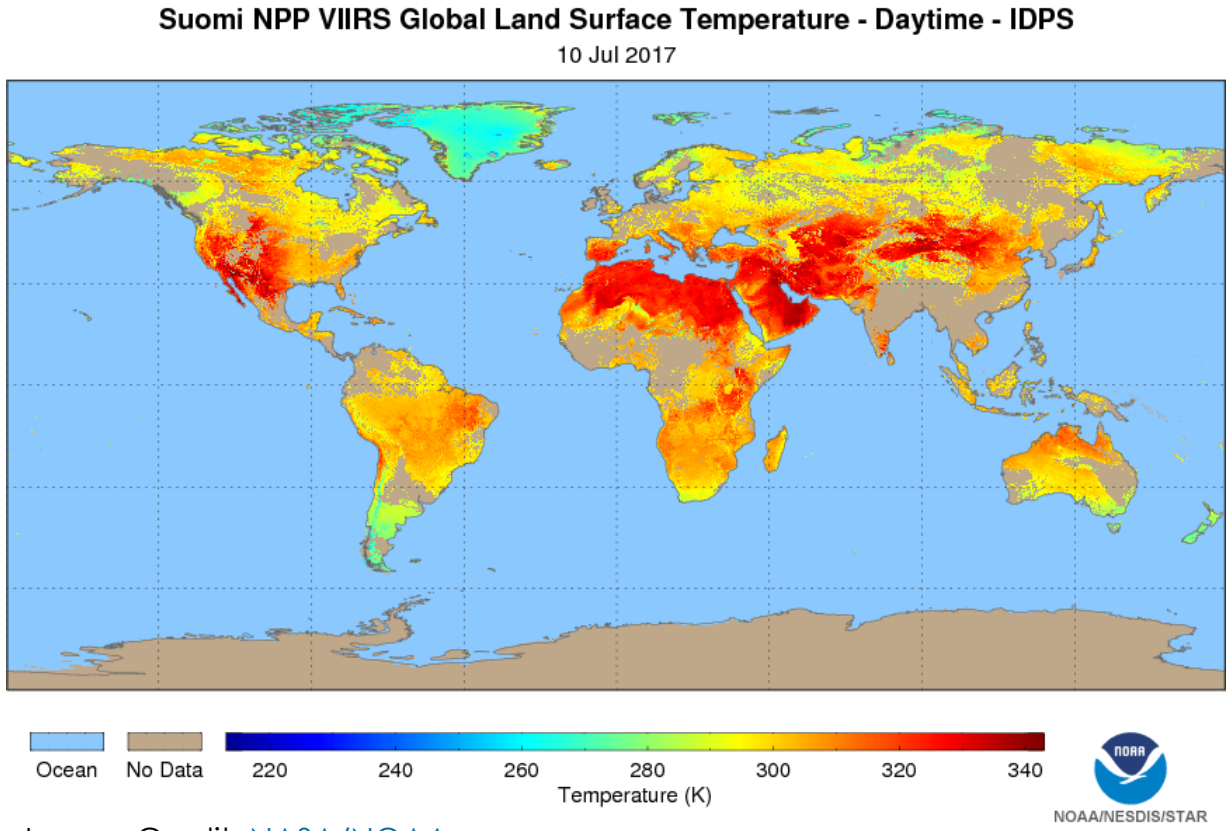
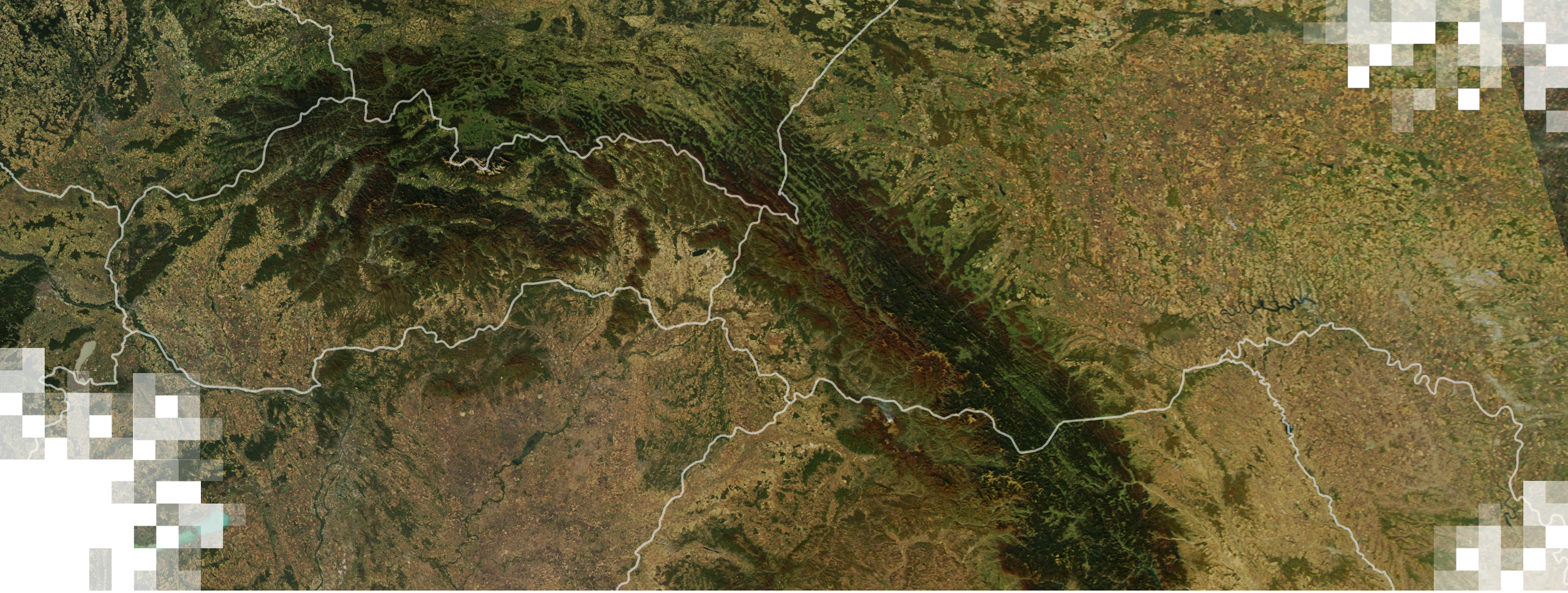


Image Credit: NASA/NOAA

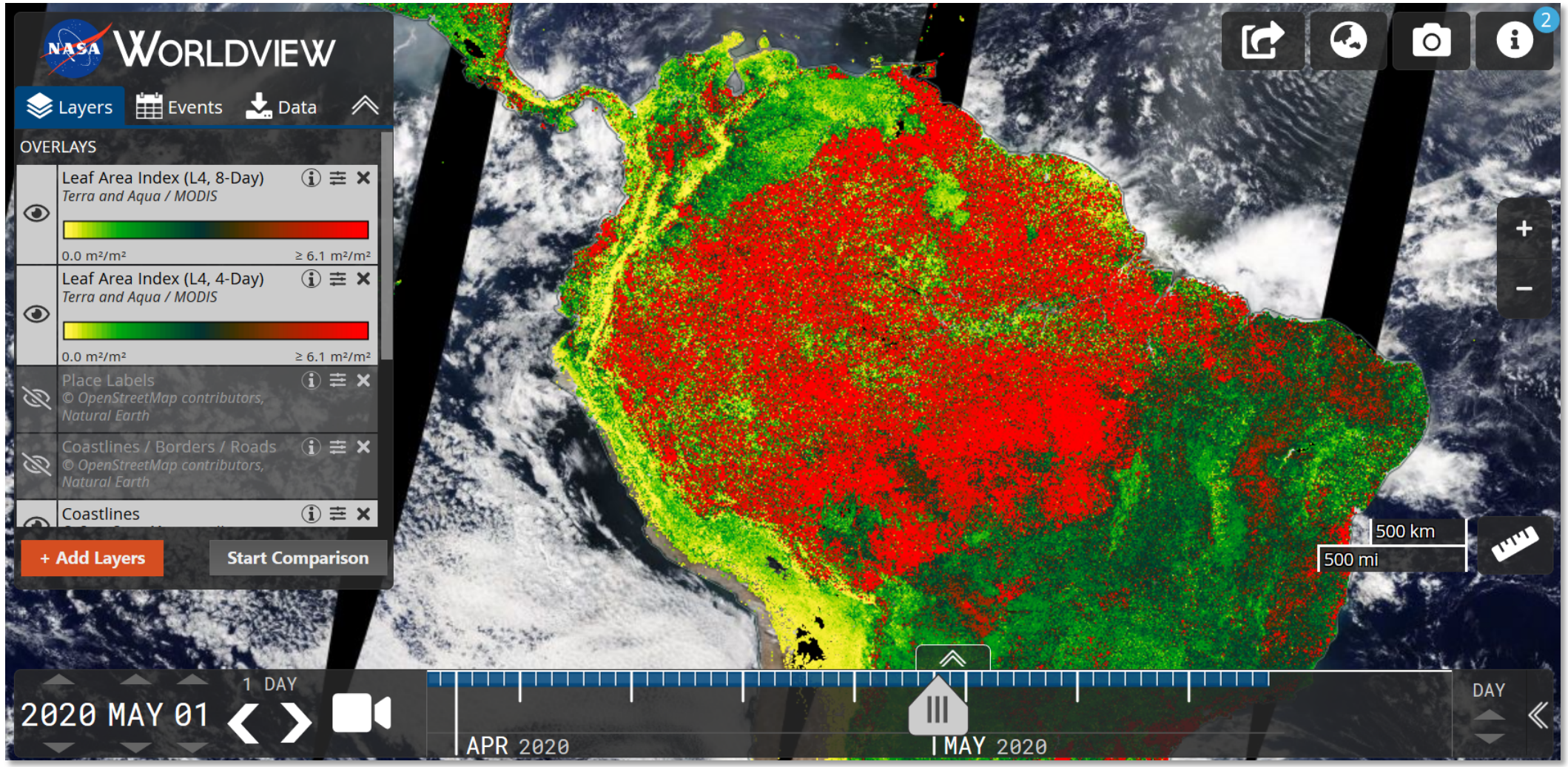
ESA Data Products

https://land.copernicus.eu/global/index.html



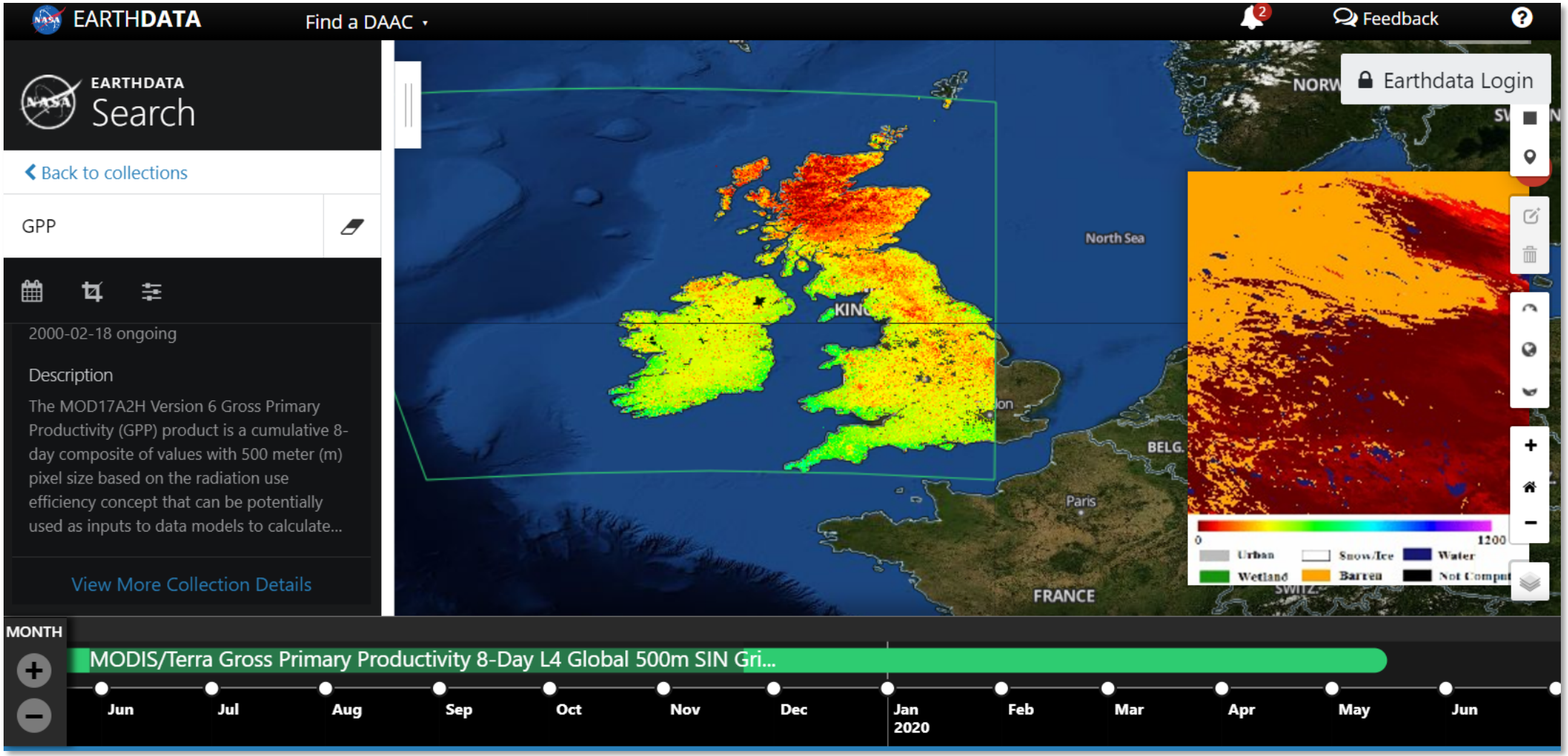
Accessing and Analyzing LSP Data

WorldView



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

Earthdata Search



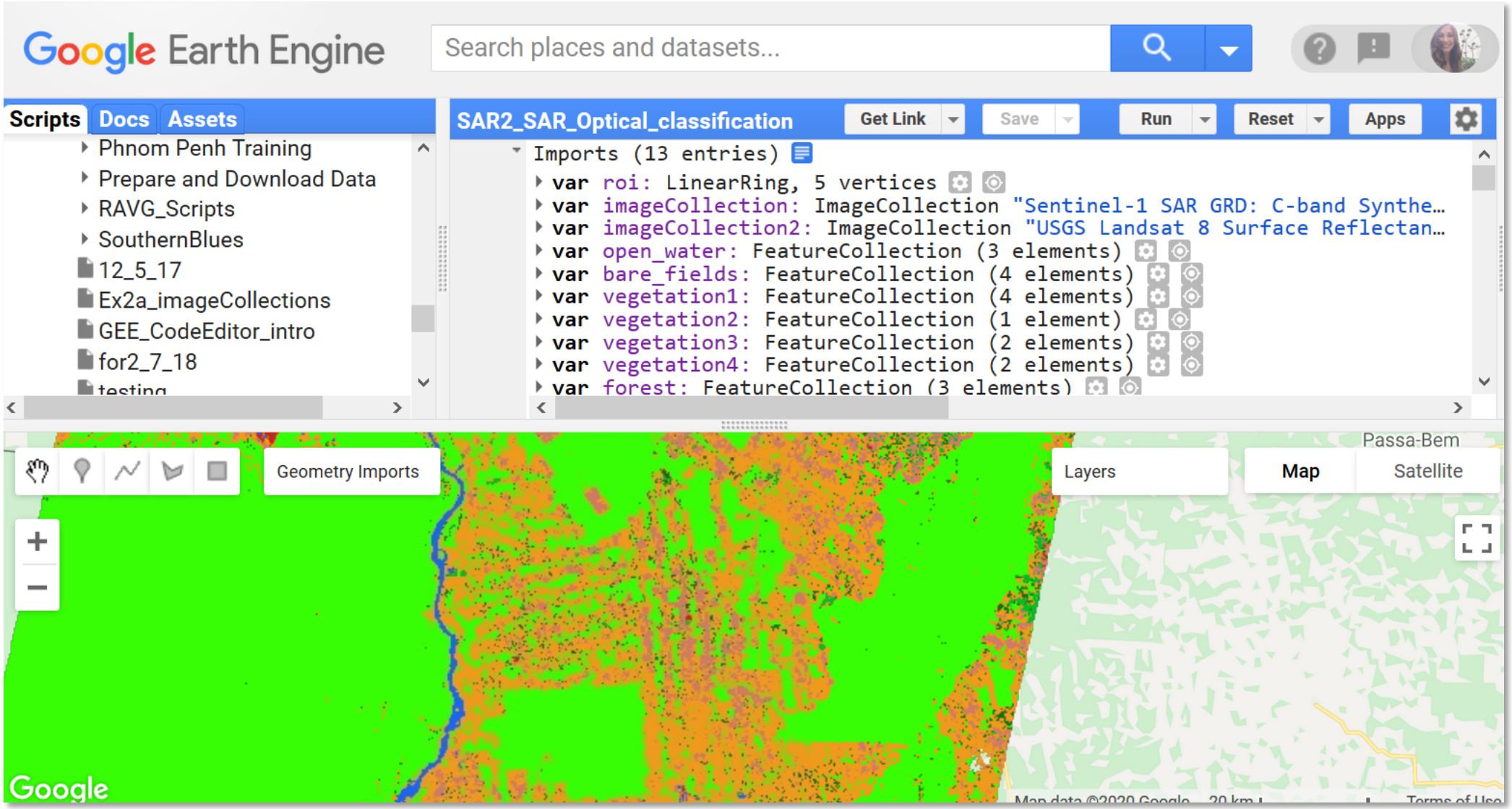
https://search.earthdata.nasa.gov/

Application for Extracting and Exploring Analysis Ready Samples (AppEEARS)

- Cloud-based computing using MODIS and VIIRS
- Time series analysis of user-specified points or areas
- Outputs include time series data in .csv format for easy analysis
- Example: Monitoring changing reservoir levels in Cape Town, South Africa

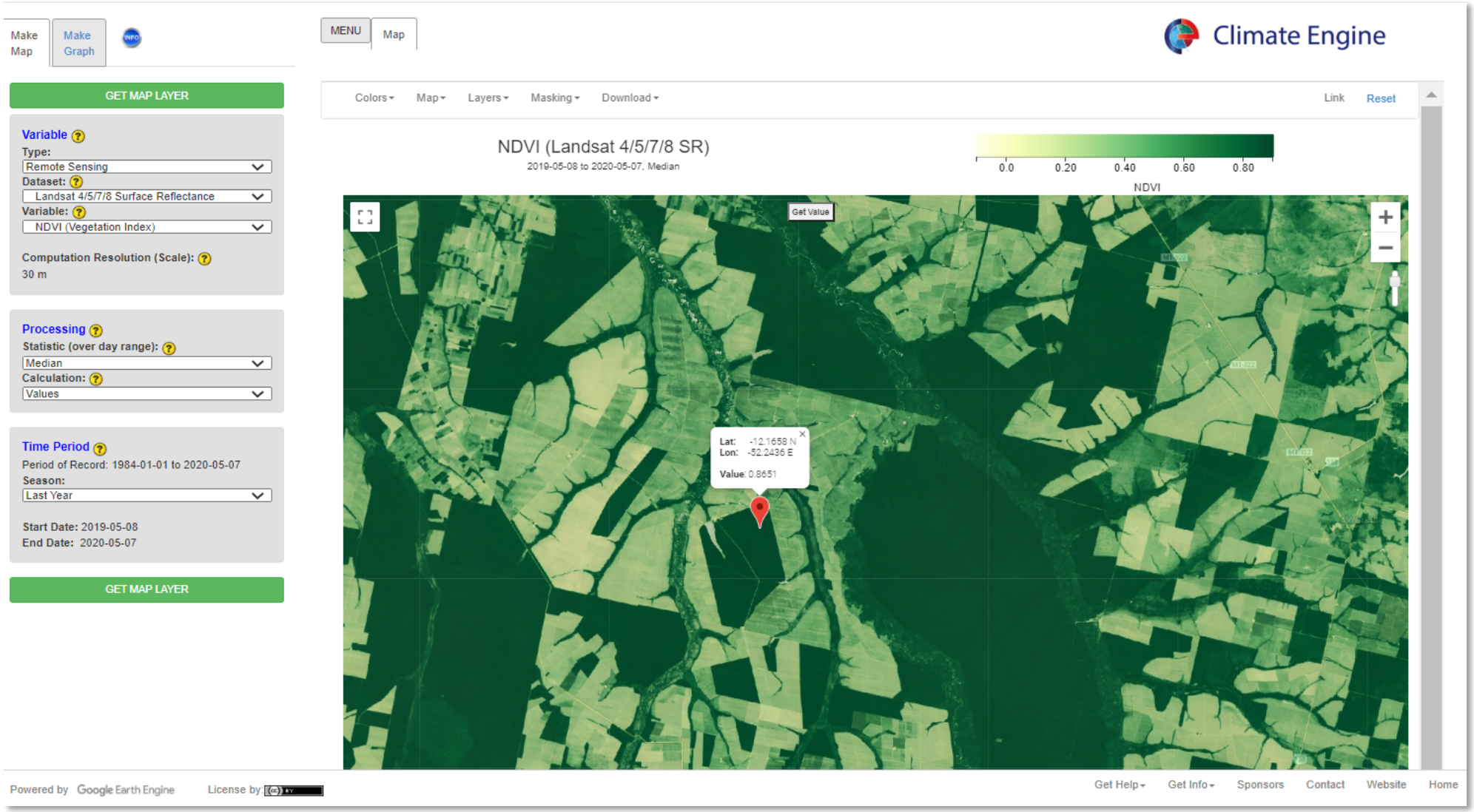
https://lpdaac.usgs.gov/tools/appeears/

Google Earth Engine



https://code.earthengine.google.com

Climate Engine



http://app.climateengine.org/

And Many Others…

- There are many other networks and data portals for airborne and near-surface remote sensing, ground-based data, and integrated data layers that combine these types of data.

- Stay tuned to hear more about
  - National Phenology Network (NPN)
  - National Ecological Observatory Network (NEON)
  - PhenoCam
  - And more…

Summary

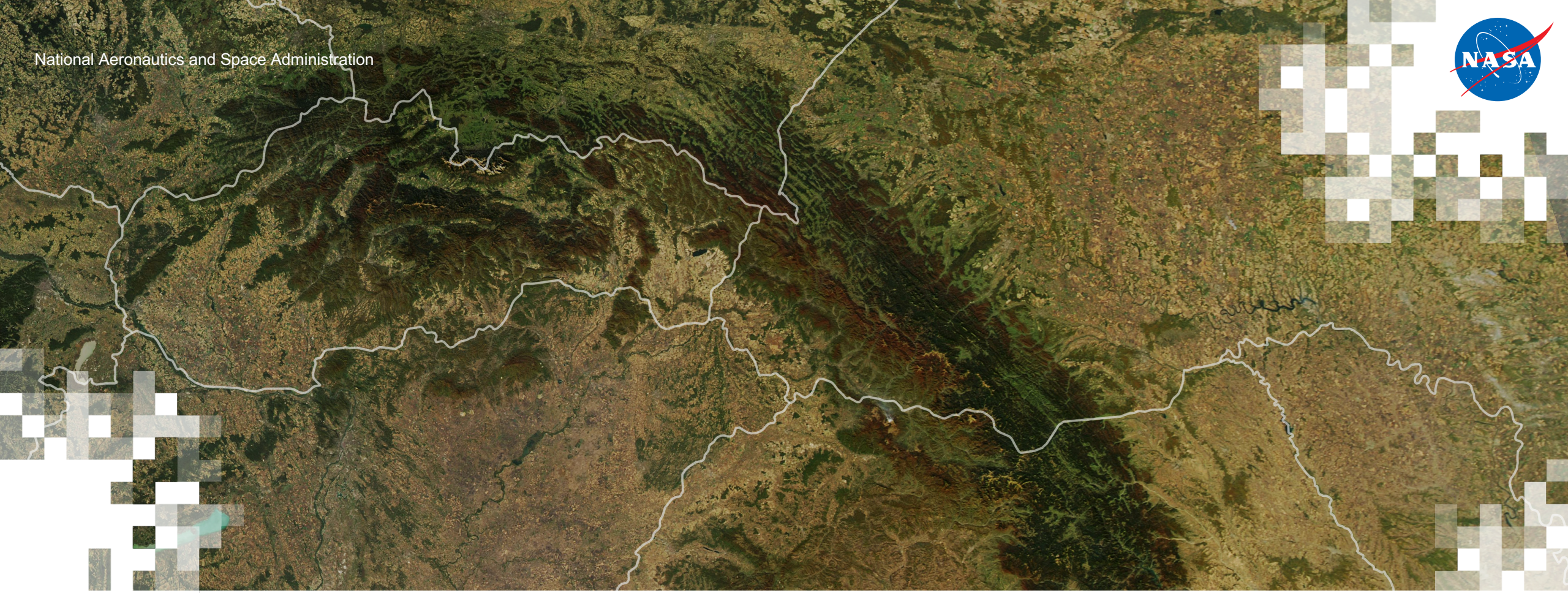
- Phenology: The study of plant and animal life cycles in relation to the seasons.
- Land Surface Phenology (LSP): Regular monitoring of the entire global land surface.
  - Gather information on entire ecosystems: broad-scale trends
- Many vegetation/greenness indices for LSP
  - NDVI, EVI, SAVI, NDMI, etc.
- Biophysical parameters
  - fPAR, LAI, NPP, etc.
- Data products and portals

Contacts

- ARSET Contacts
  - Amber McCullum: AmberJean.Mccullum@nasa.gov
  - Juan Torres-Perez: juan.l.torresperez@nasa.gov

- General ARSET Inquiries
  - Ana Prados: aprados@umbc.edu

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



Next Session: Scales of Phenology and National Networks

July 7th, 2020

Questions

- Please enter your questions into the Q&A box.
- We will post the questions and answers to the training website following the conclusion of the course.


APPLIED REMOTE SENSING TRAINING PROGRAM
TRAIN - EMPOWER - ADVANCE

Thank You!