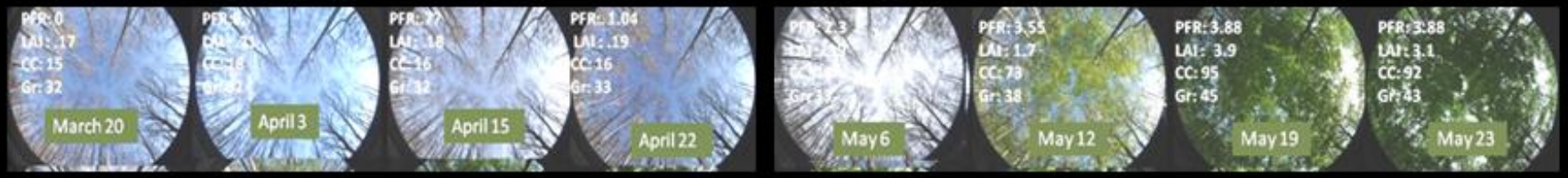
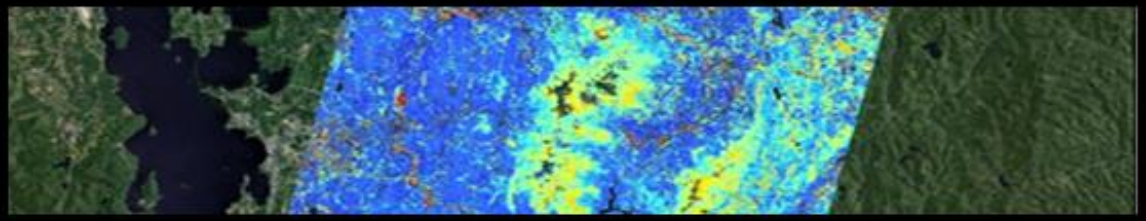
SWAC
"Fostering climate knowledge and geospatial skills for all"

The University of Vermont

VERMONT

NSF

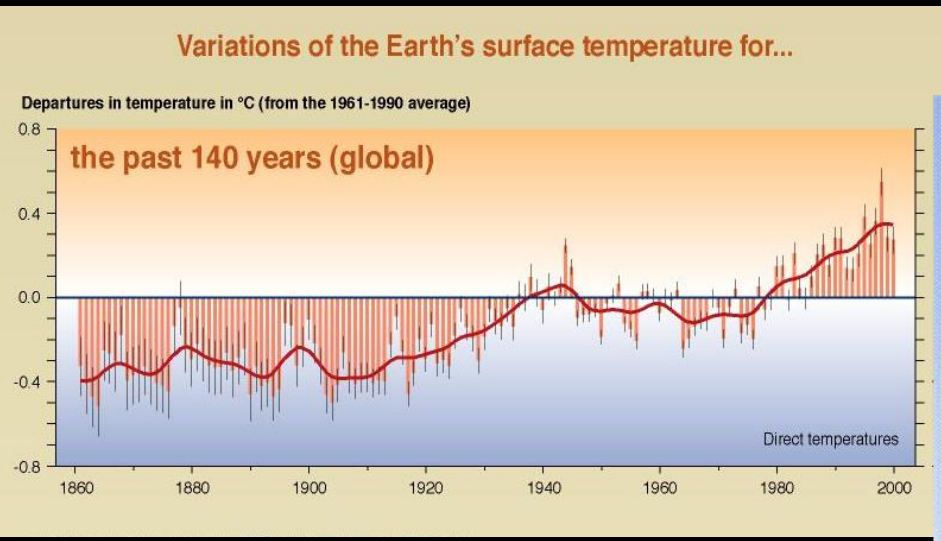




Vegetation Phenology

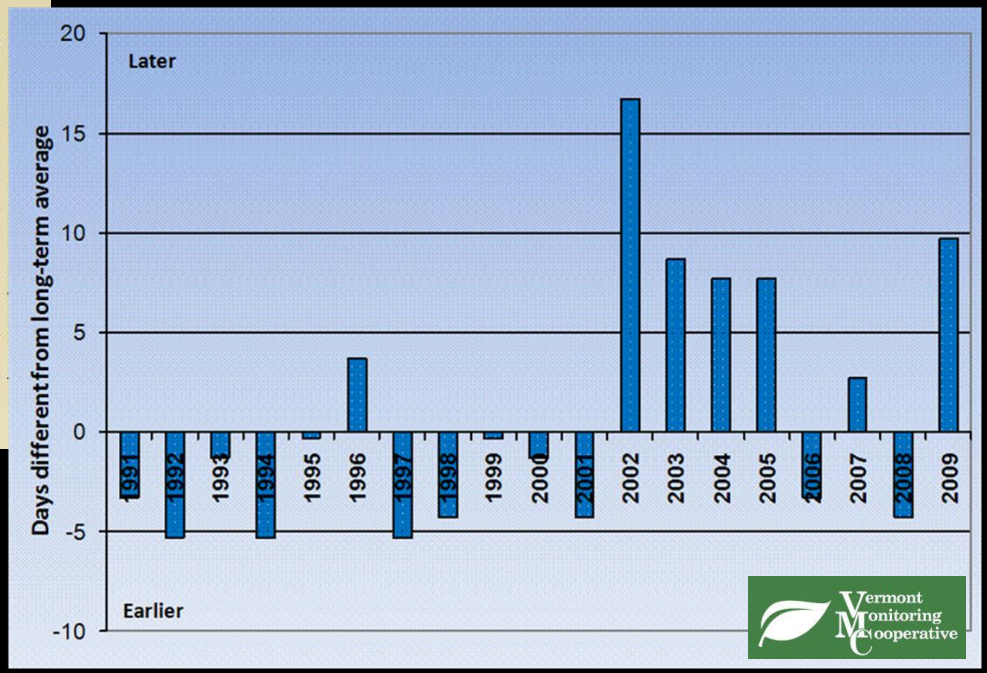
Quantifying climate impacts on ecosystems: Field and Satellite Assessments

Plants can tell us a story about climate.

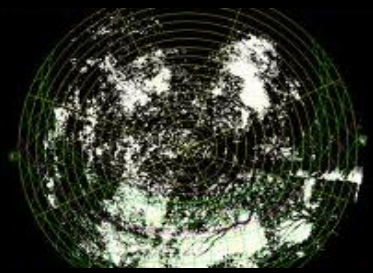


(Ollinger, S.V. "Potential effects of climate change and rising CO2 on ecosystem process in northeastern U.S. forests)

Timing of sugar maple leaf drop



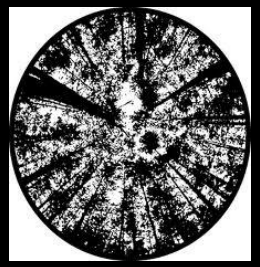




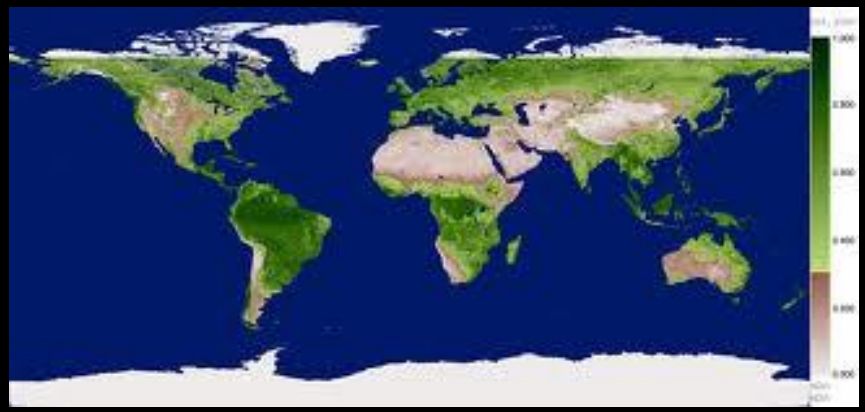

Phenology (the timing of leaf out and leaf off) is a common metric of climate impacts.

This is typically quantified in two ways:

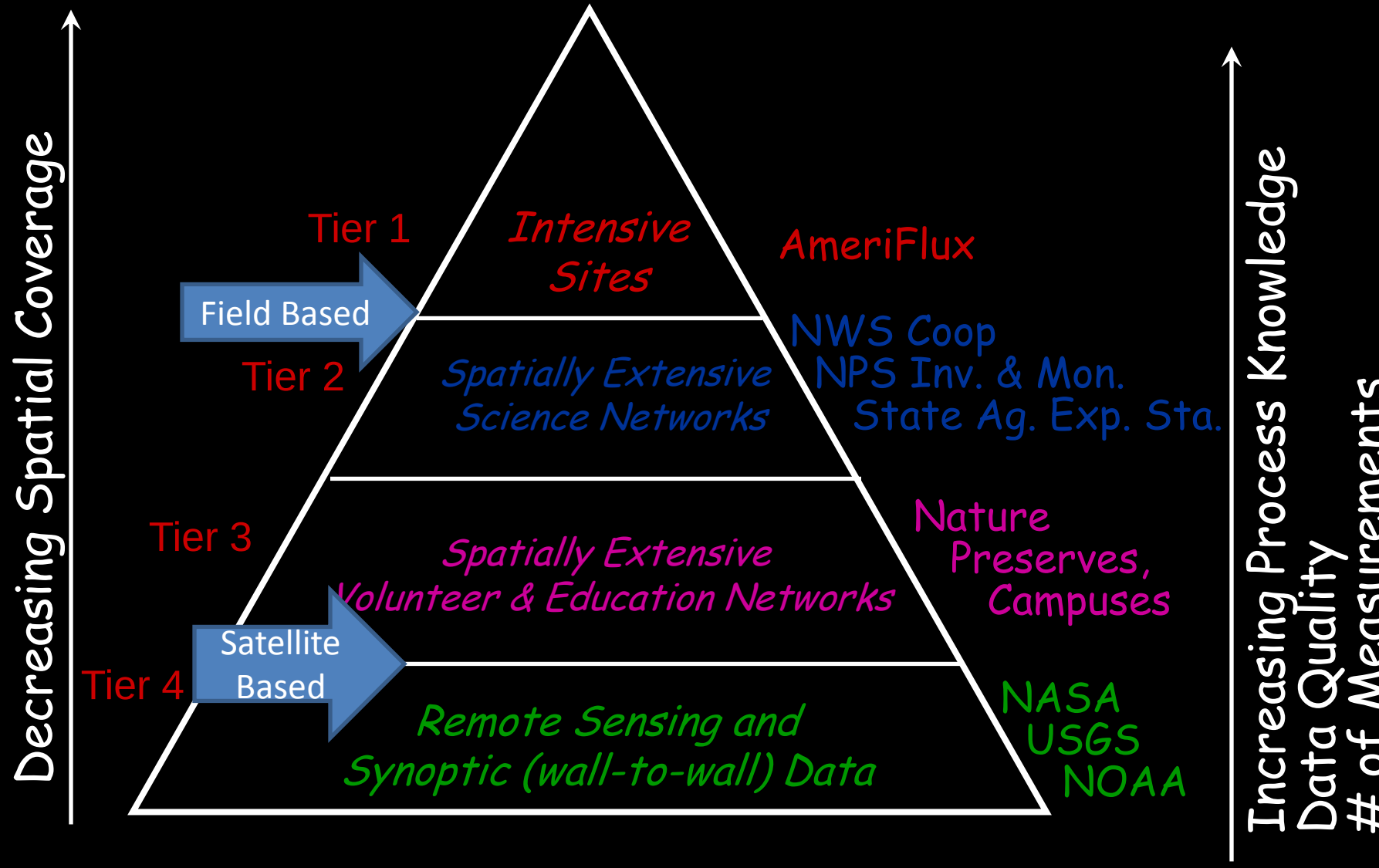
Field assessments



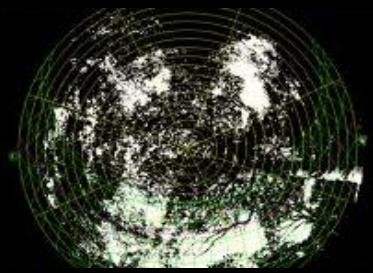
Satellite Observations



Really a combination of field and satellite observations are best



George R. Kish U.S. Geological Survey


The goal of this module is to introduce students to these concepts by linking ground and satellite measurements at their own intensive research site.

Getting Started

1. Establish a site

You should have a location nearby that students can visit frequently during times of rapid change.

(ideally this would be weekly in early spring and then 3-5 day returns as buds burst and expand)

- Look for a dense forest canopy
- Mark plot center for accurate returns
- Determine geographic coordinates for plot center

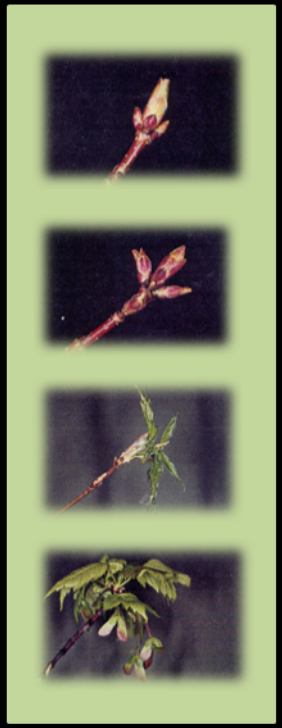
Collecting Data- Field Metrics

There are many different ways to quantify phenology.

We suggest including both visual assessments and digital measurements

Field Phenology Ranks

For each tree on the "plot" determine the dominant bud stage. This means that a value of 1,2,3 or 4 will be recorded for each tree. Average all of these values to come up with one summary field phenology rank for the plot.



Leaf Development Stage Rating	Bud/Leaf Characteristics
1	Bud is swollen
2	Green tip of leaf showing
3	Leaf emergence
4	Leaves fully expanded

Collecting Data- Field Metrics

There are many different ways to quantify phenology.

We suggest including both visual assessments and digital measurements

Digital Canopy Metrics

At the center of each plot take a digital photograph looking strait up at the canopy.

Automatic settings should ensure consistent lighting over time.

Be sure to always orient the camera strait up, with the top facing the same direction and with no obstructions in the field of view.

Collecting Data – Field Metrics

There are many different ways to quantify phenology.

We suggest including both visual assessments and digital measurements

Digital Canopy Metrics

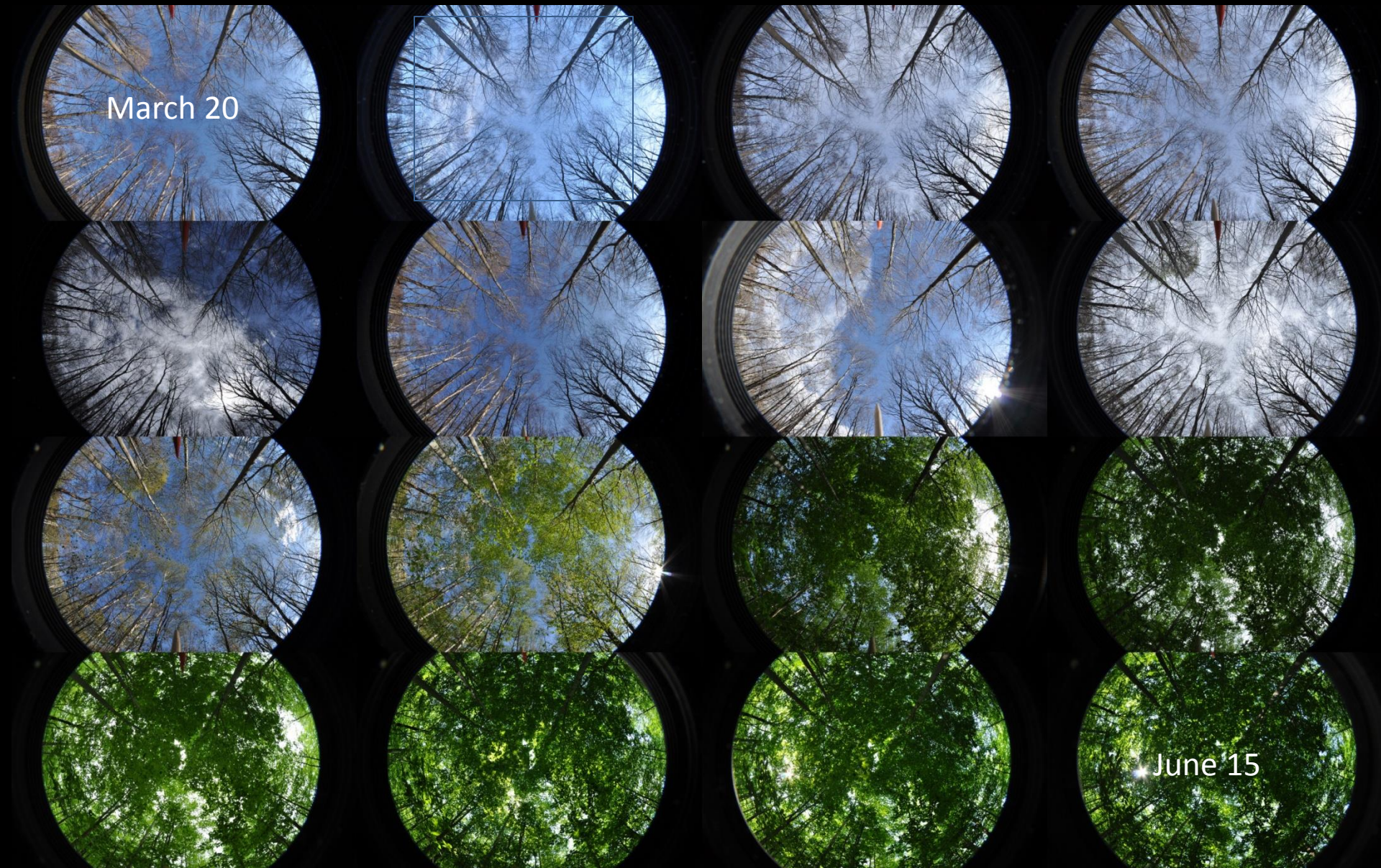
These digital metrics help us to "see" the canopy as a satellite might see it.

While most scientists use a hemispherical camera, any digital camera will work.

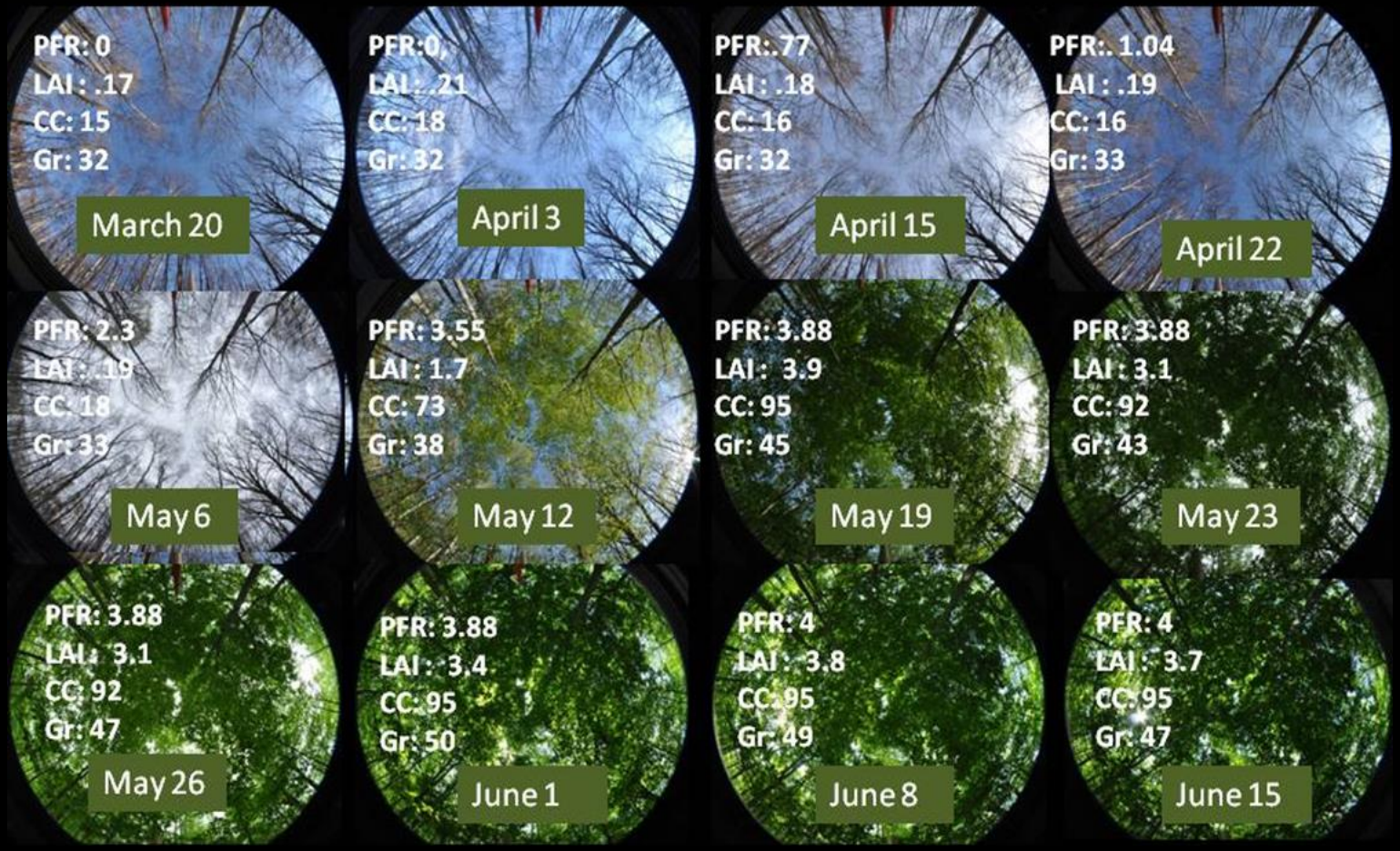
From these images we can use specialized software to calculate lots of different canopy characteristics:

"greeness", canopy closure, gap fraction, leaf area index, etc.

Over time you can quantify changes in canopy characteristics, compare rates of change and timing of changes.

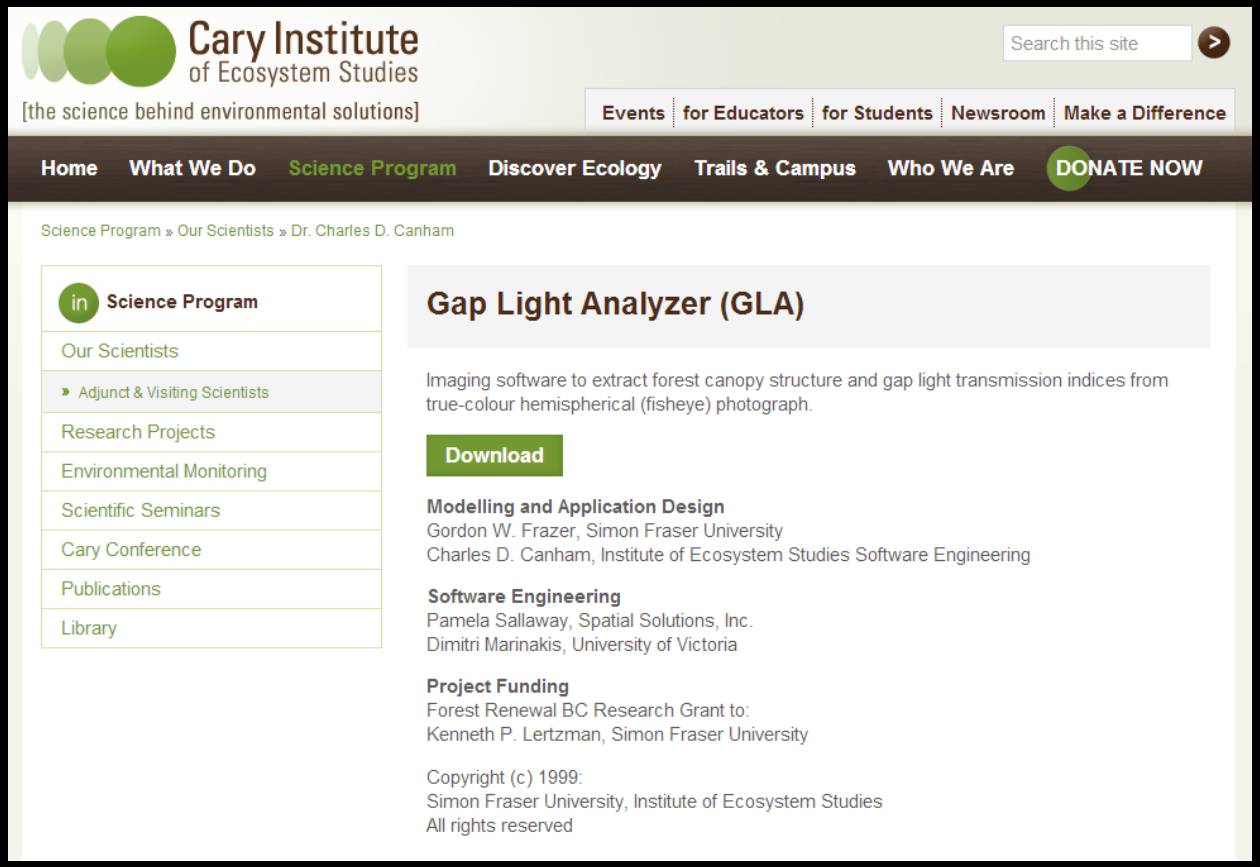


Specialized software can quickly calculate a suite of different canopy metrics we can use.



Gap Light Analyzer (GLA)

- http://www.caryinstitute.org/science-program/our-scientists/dr-charles-d-canham/gap-light-analyzer-gla

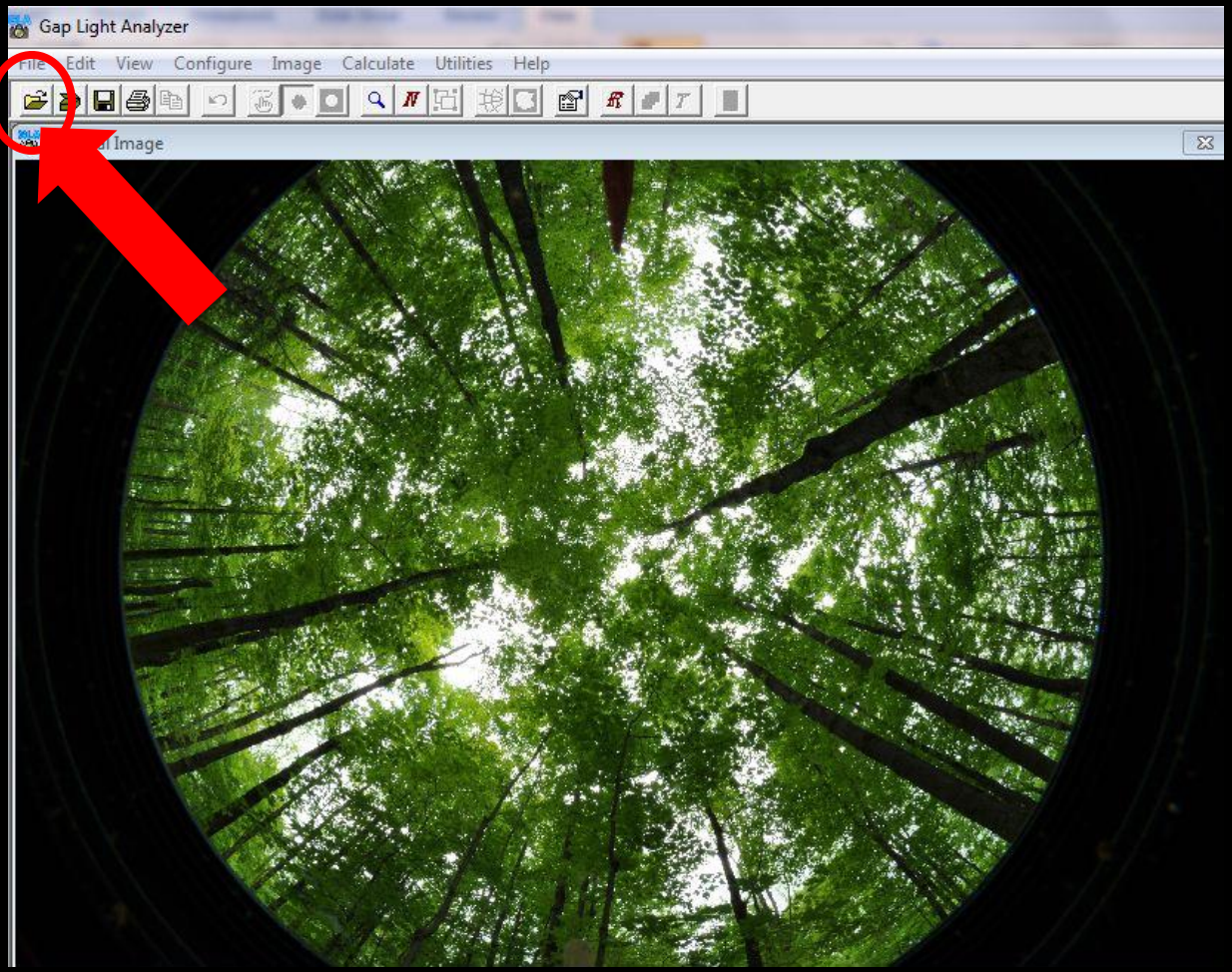


Download
Unzip
Double click “setup.exe to install

Here is the catch:

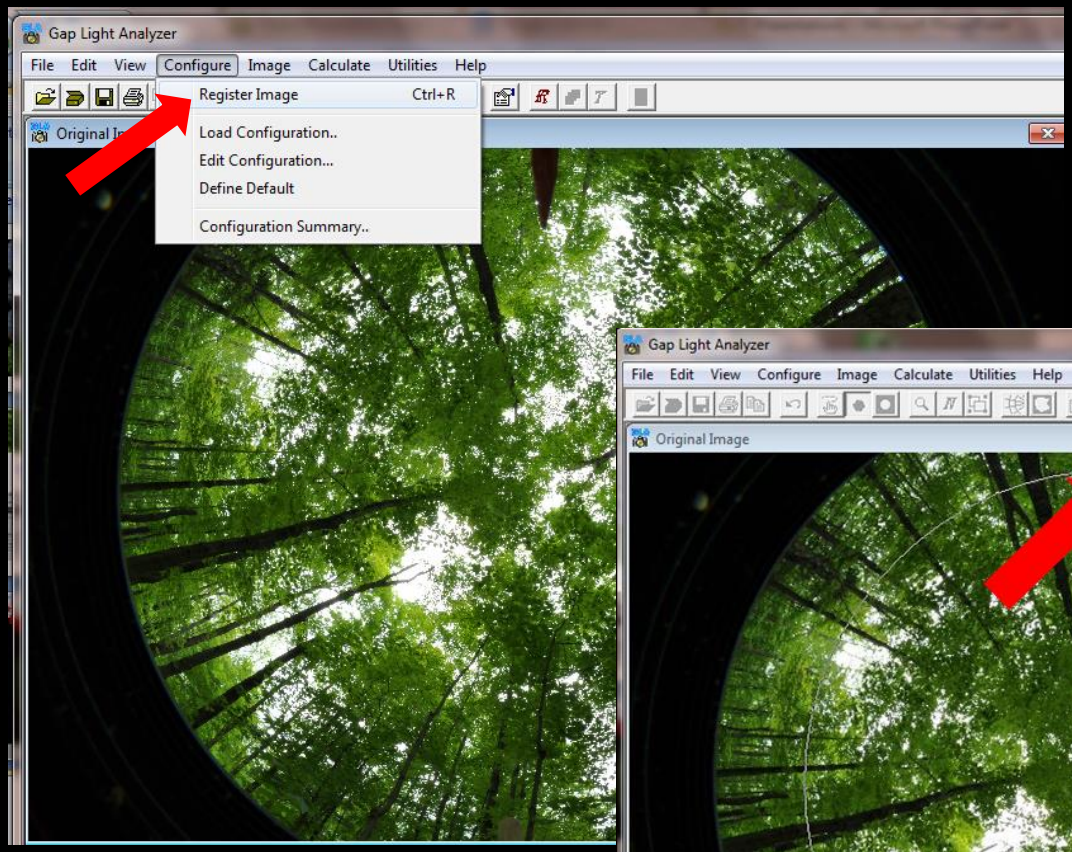
It only runs on 32-bit versions of windows (so use an older machine if possible)

Working Gap Light Analyzer

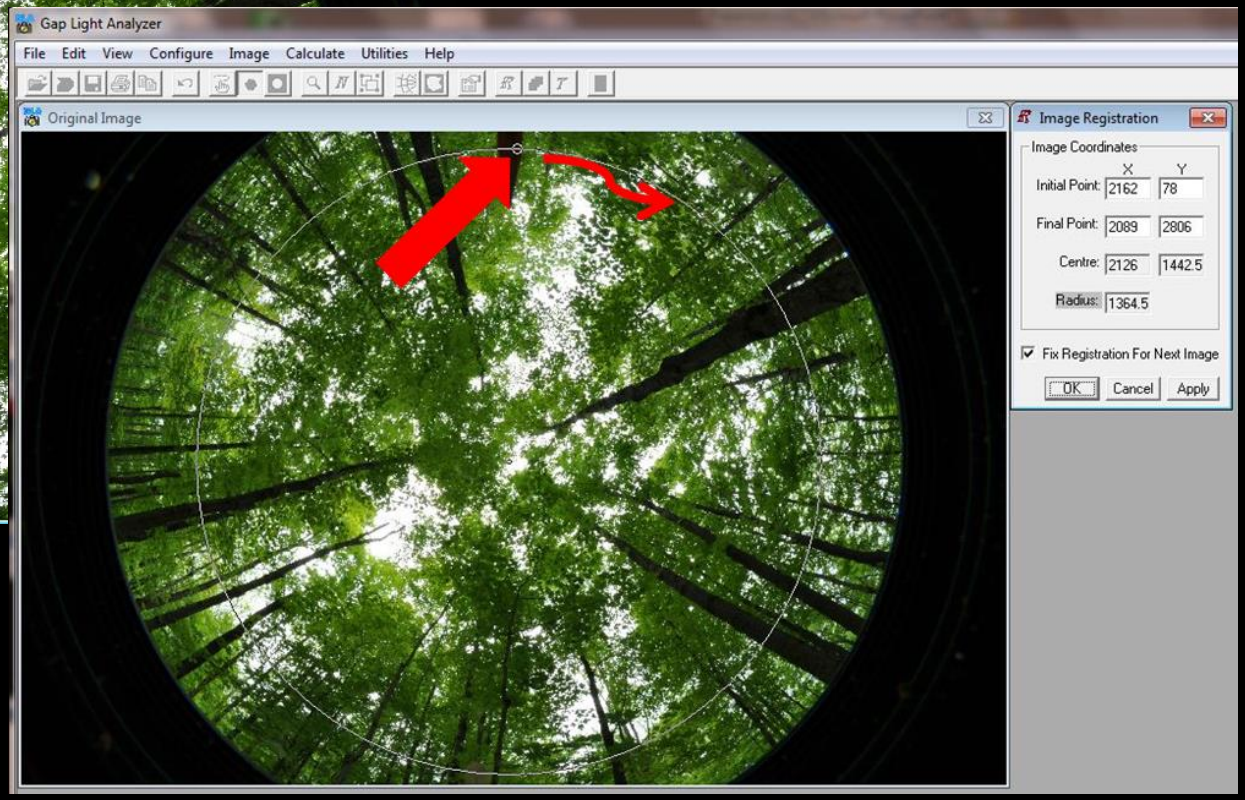


1. Open your digital image

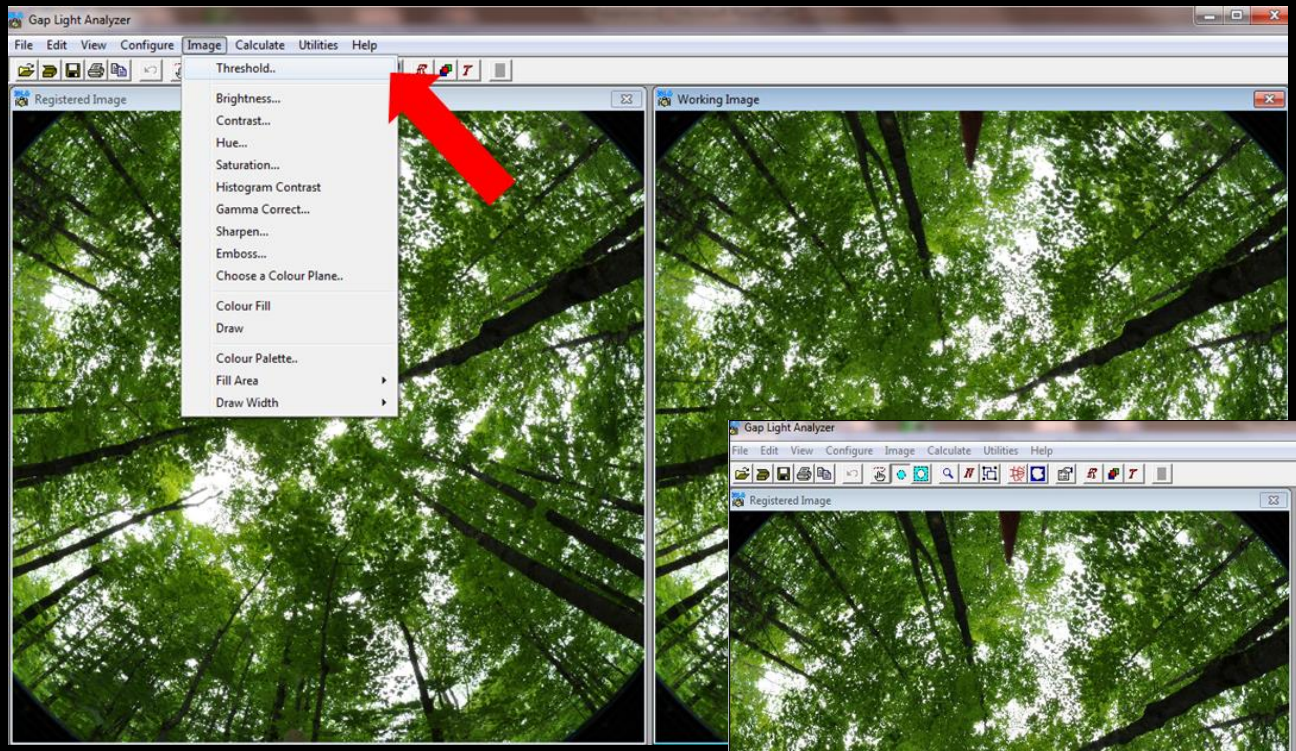
Working Gap Light Analyzer



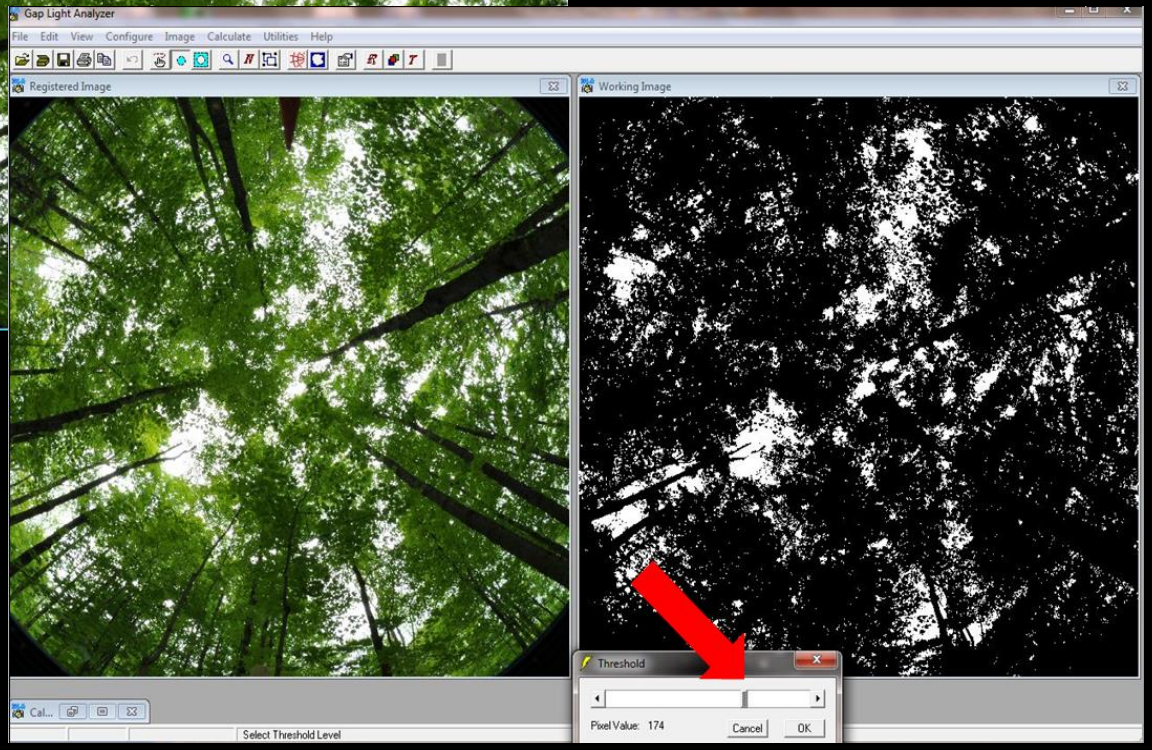
1. Open your digital image
2. Register your image



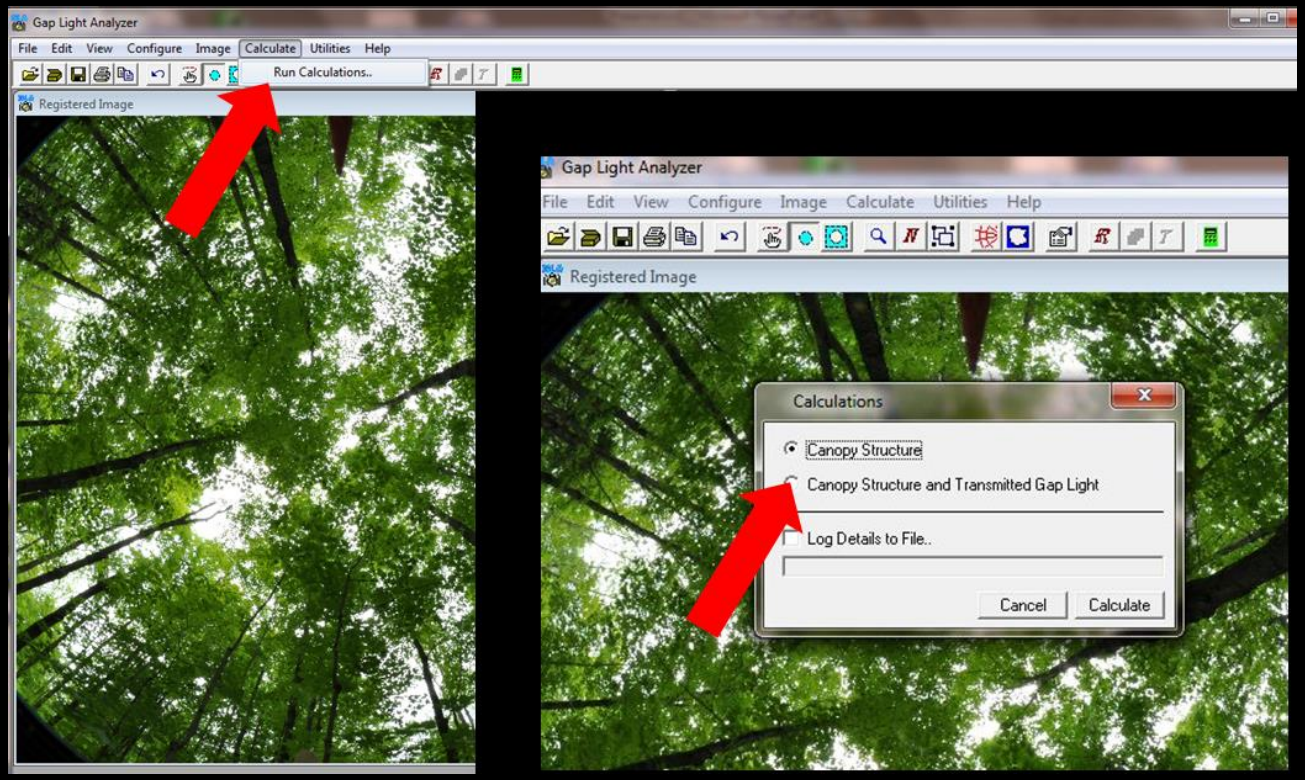
Working Gap Light Analyzer



1. Open your digital image
2. Register your image
3. Set the light/dark threshold

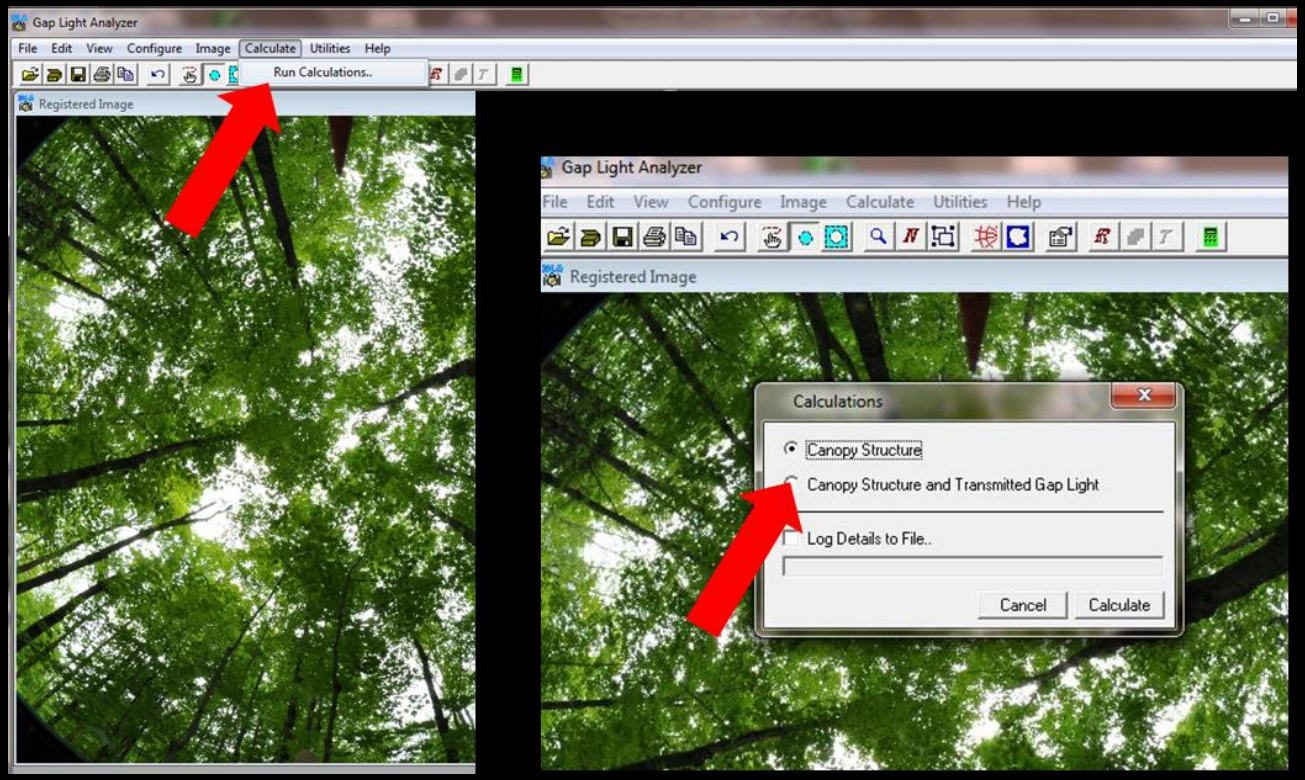


Working Gap Light Analyzer



1. Open your digital image
2. Register your image
3. Set the light/dark threshold
4. Run calculations

Working Gap Light Analyzer



1. Open your digital image
2. Register your image
3. Set the light/dark threshold
4. Run calculations

Collecting Data – Satellite Metrics

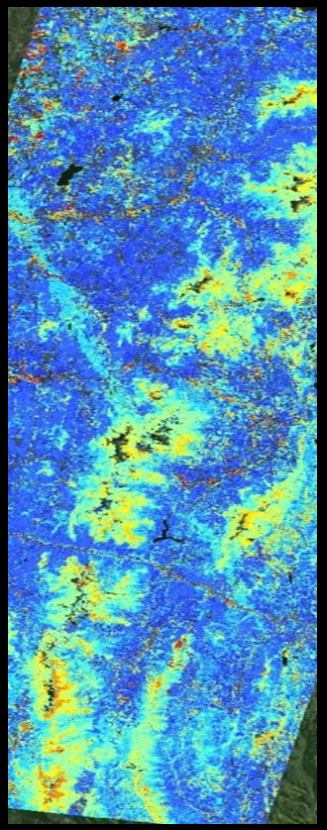
There are many different ways to quantify phenology.

We suggest including both visual assessments and digital measurements

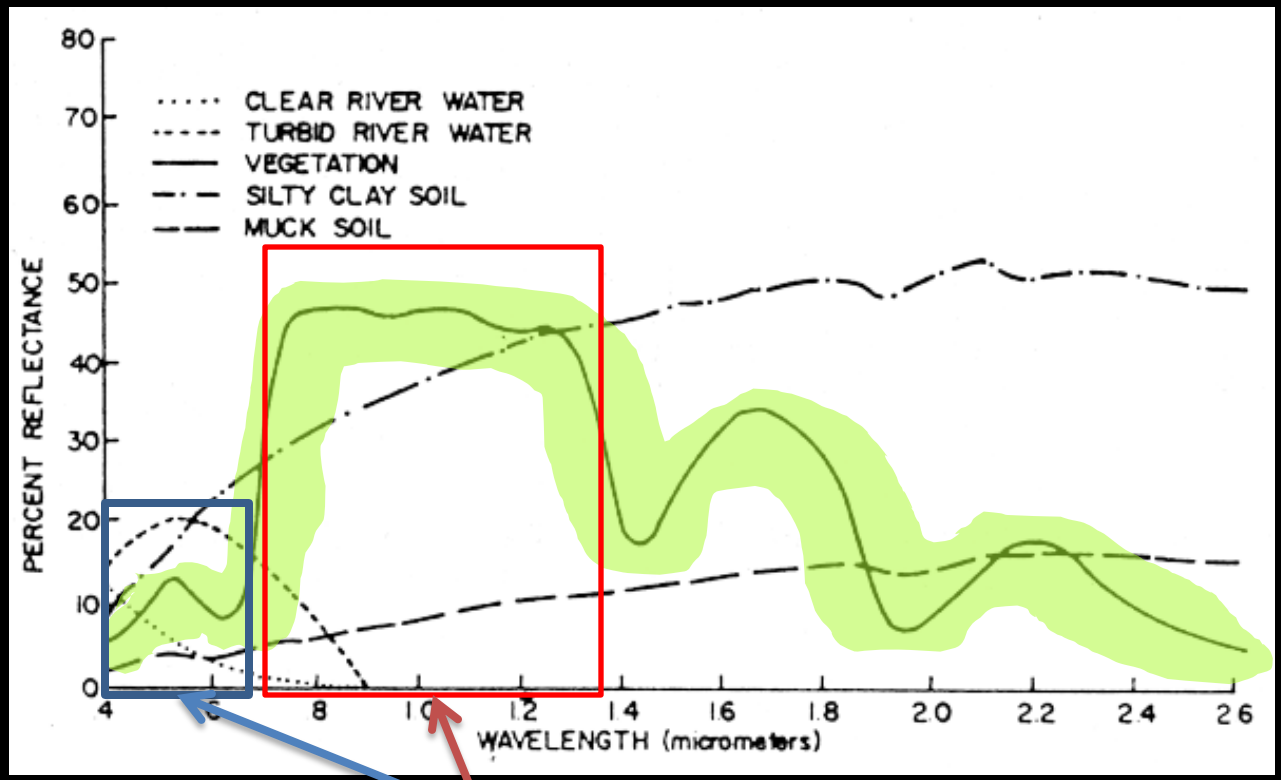
Satellite Assessments

Satellites cover a large geographic area, making them useful for regional, continental or global assessments.

You sacrifice spatial detail and accuracy, but gain a larger perspective



How do you see phenology from space?



- Chlorophyll, strongly absorbs visible light for photosynthesis.
- Leaf cell structure reflects near-infrared light.
- NDVI exploits these characteristics of vegetation reflectance to quantify how much, how dense and how productive vegetation is.

$$NDVI = \frac{(NIR - VIS)}{(NIR + VIS)}$$

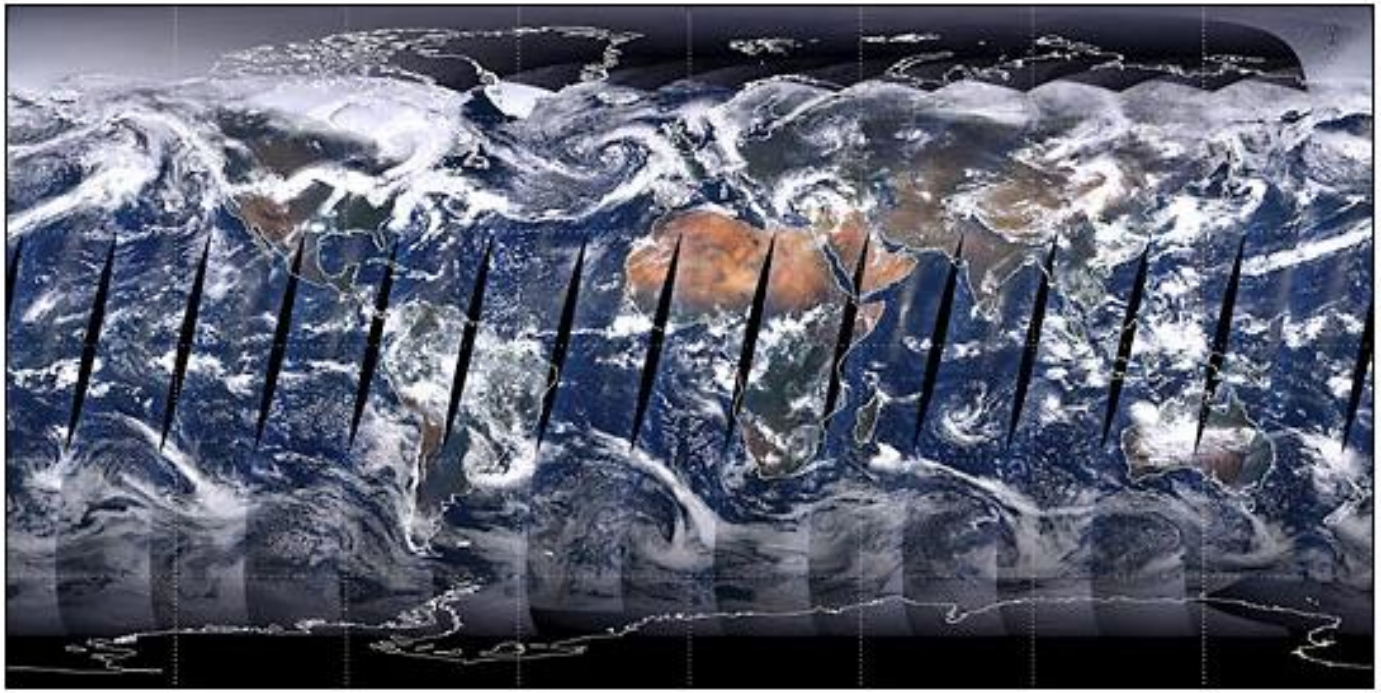
http://www.fao.org/docrep/003/T0446E/T0446E04.htm

Normalized Difference Vegetation Index NDVI

- Negative values of NDVI correspond to water.
- Values close to zero correspond to barren areas of rock, sand, or snow.
- low, positive values represent shrub and grassland
- high values indicate temperate and tropical rainforests.

Global Agricultural Monitoring Project Test Interactive Products

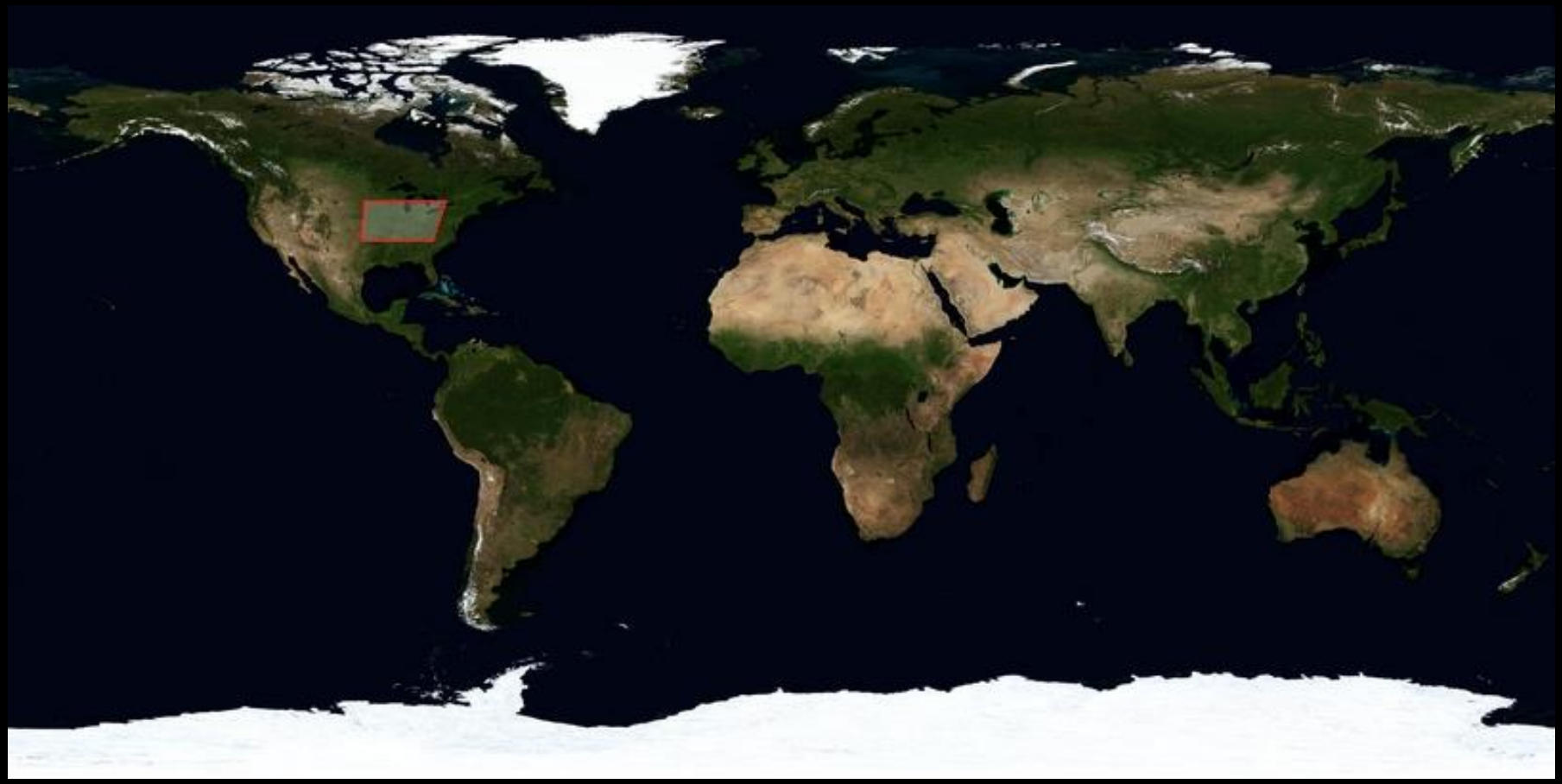
MODIS Overview



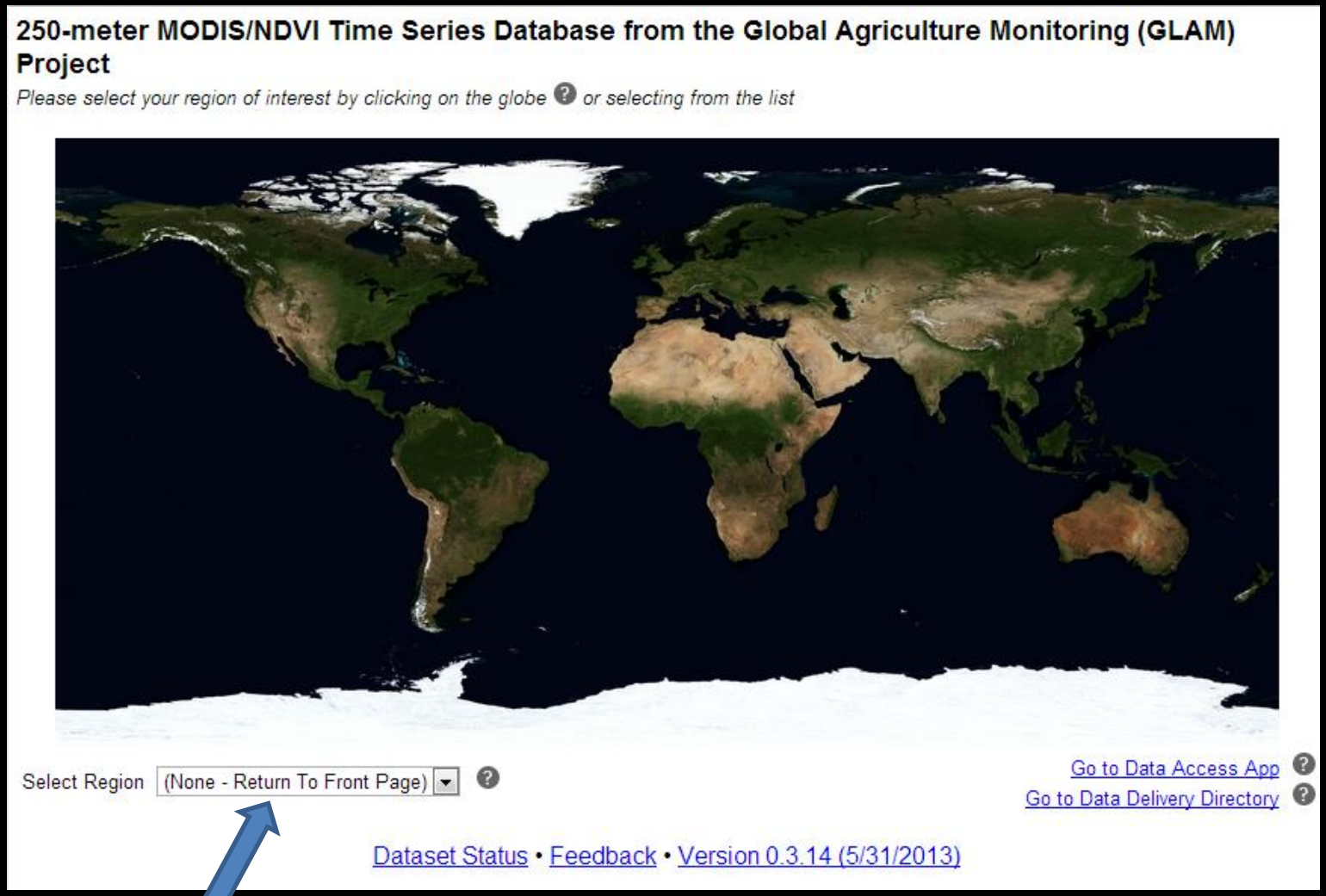
The Moderate Resolution Imaging Spectroradiometer (MODIS) instrument is operating on both the Terra and Aqua spacecraft. It has a viewing swath width of 2,330 km and views the entire surface of the Earth every one to two days. Its detectors measure 36 spectral bands and it acquires data at three spatial resolutions: 250-m, 500-m, and 1,000-m.

Global Agricultural Monitoring Project Test Interactive Products

http://pekko.geog.umd.edu/usda/test/



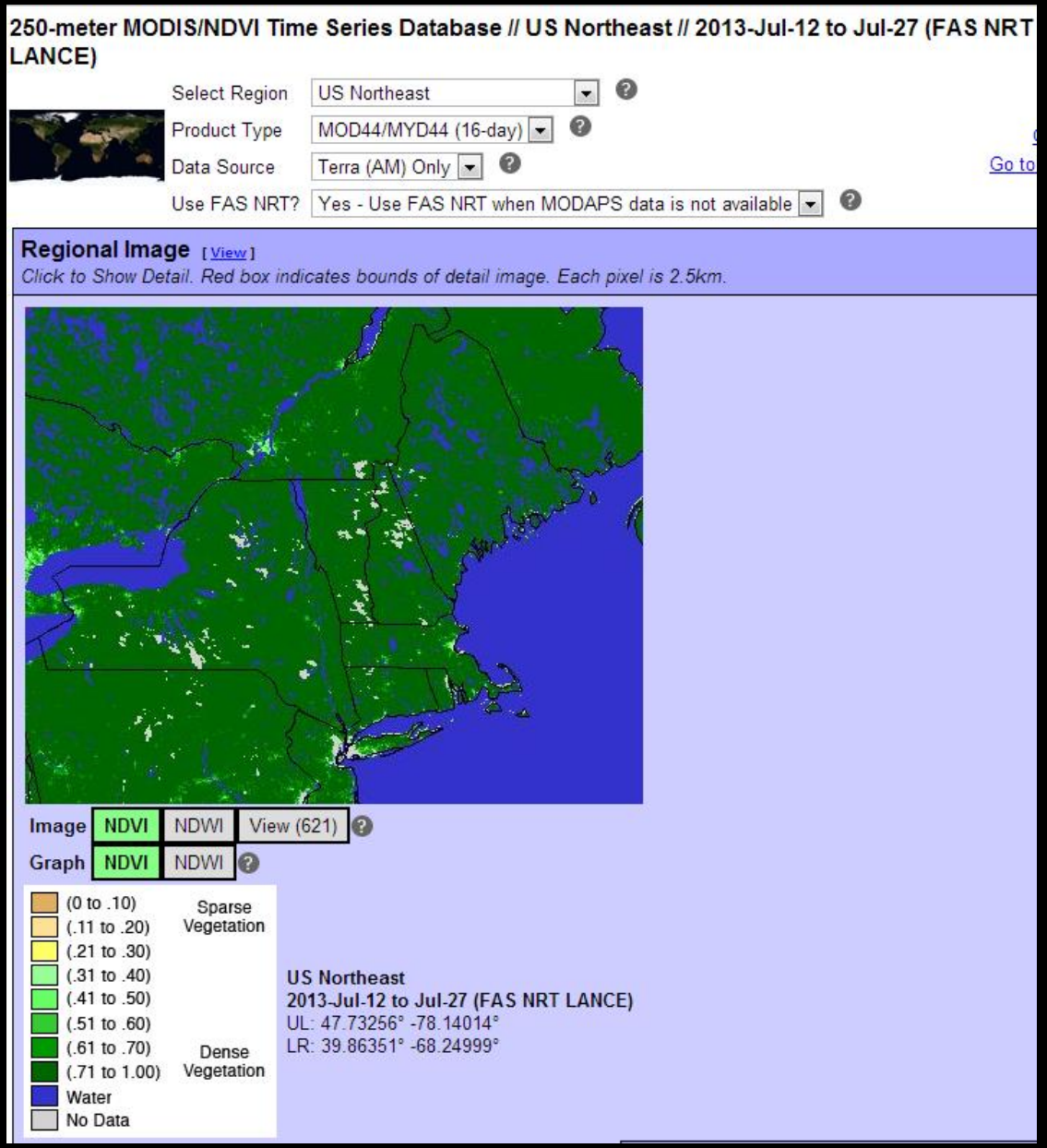
Getting NDVI Data for your location



Select US- Northeast from the drop down list to zoom to our region

Getting NDVI Data for your location

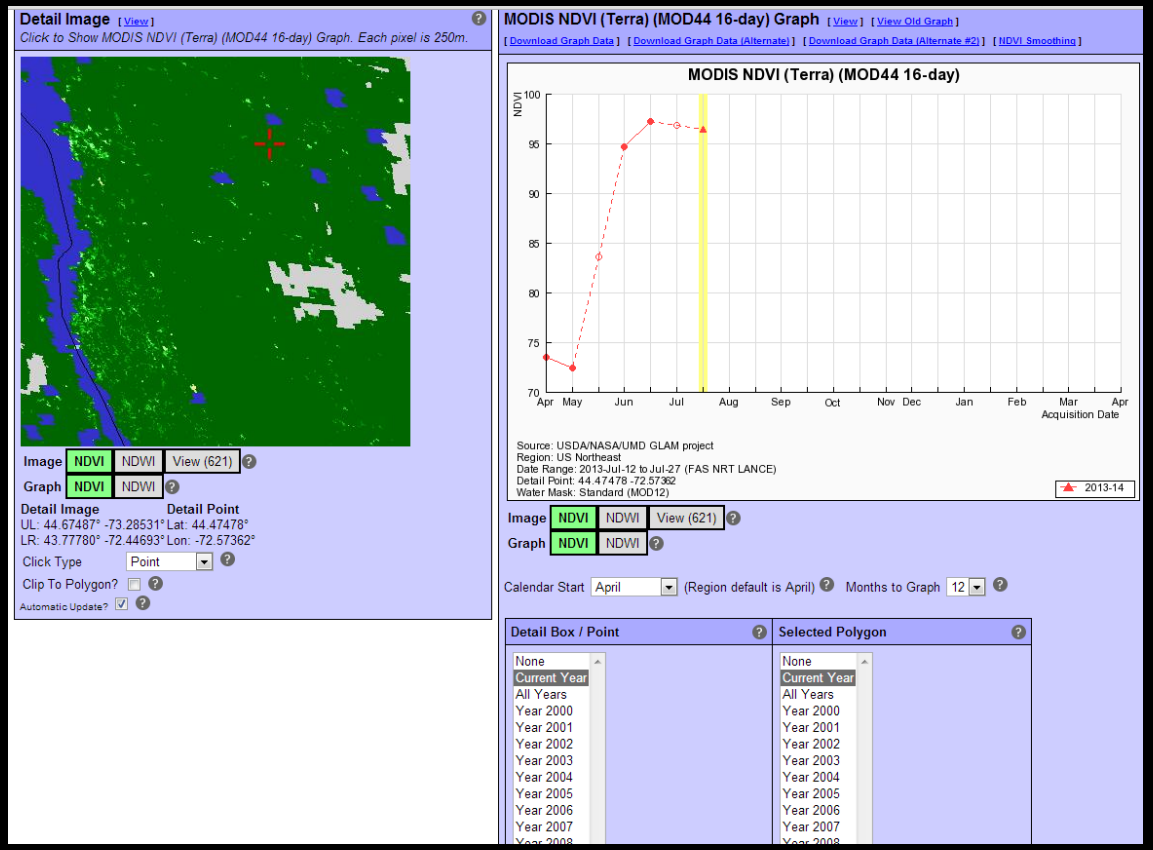
The full region is shown by default but you can click over an area of interest to see a zoomed image for more accurate data extraction.



Getting NDVI Data for your location

Once you zoom in you will see other options to select different time periods or graph values from a given point or polygon.

Click on a location in the map on the left, select a time period on the right, and your data will be graphed for you. Hover over a point and the data value will appear.



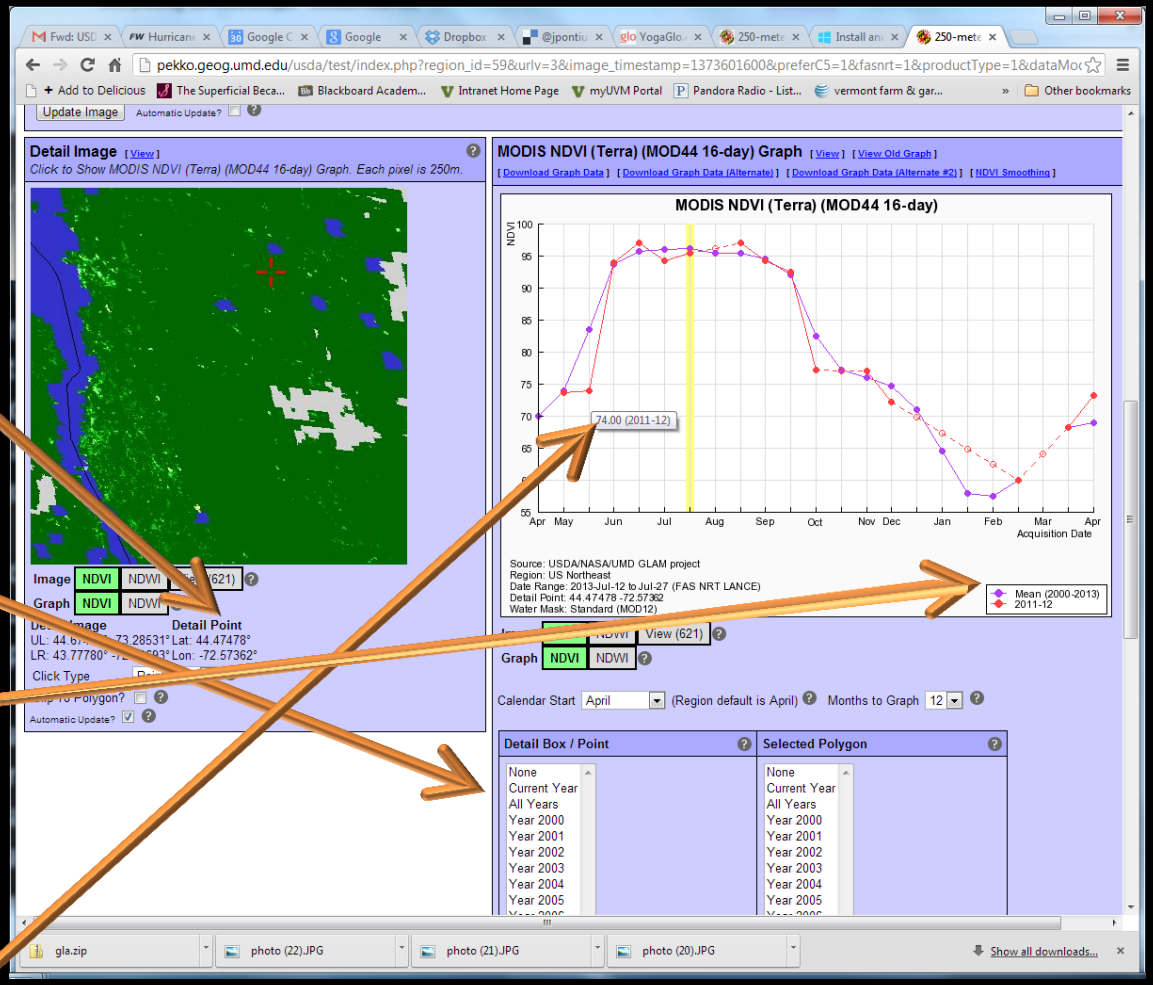
Getting NDVI Data for your location

You can move your point of interest around until you have a geolocation close to your field plot.

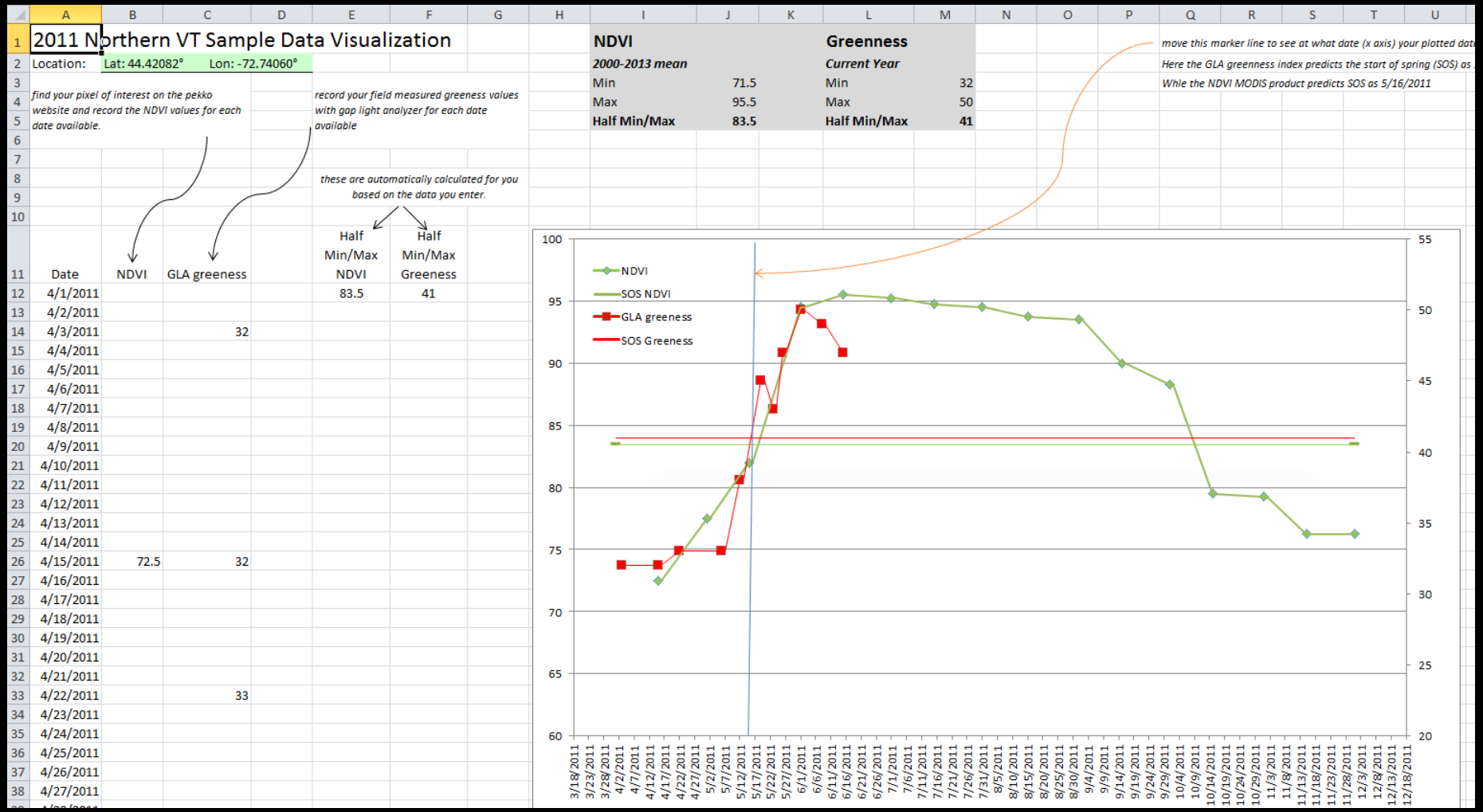
You can select any year to visualize from the lists here.

You can also overlay the mean values to see how anomalous a given year is.

Hover over a point and the data value will appear.



Visualizing your complete data set



The excel template provided allows you to quickly visualize your time series data, and identify a start of spring date based on both satellite and field measurements.

Potential explorations for this data set:

Aside from the basics (identify SOS date, quantify duration of greenup) other questions to be answered from this data set could include:

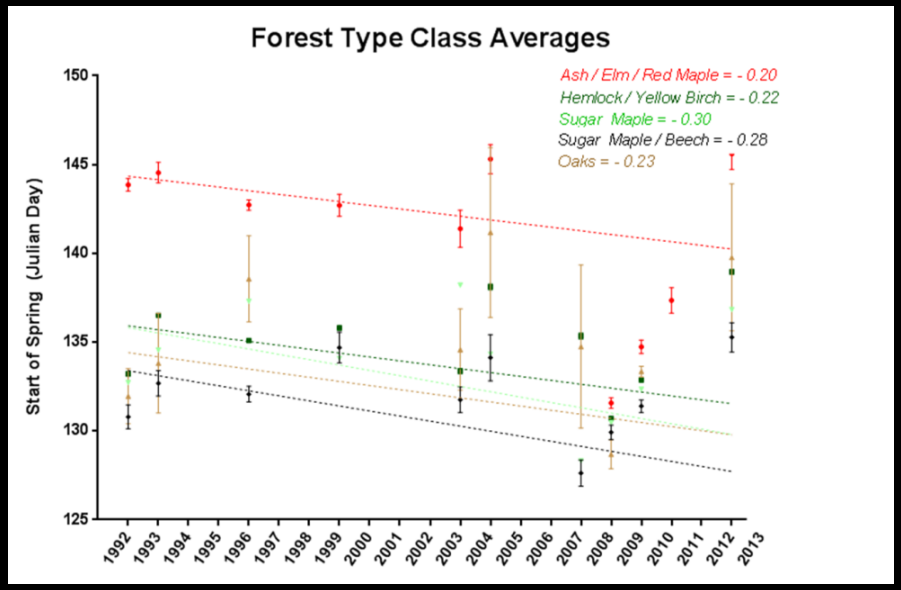
- How do our field metrics compare to the satellite metrics for our location?
    - What might account for differences between the measurements?
    - What are the strengths and weaknesses of both field and satellite metrics?

- How does phenology at our location differ from the average phenology response (compare to pekko mean data)?
    - Did spring start earlier or later than usual at our location?

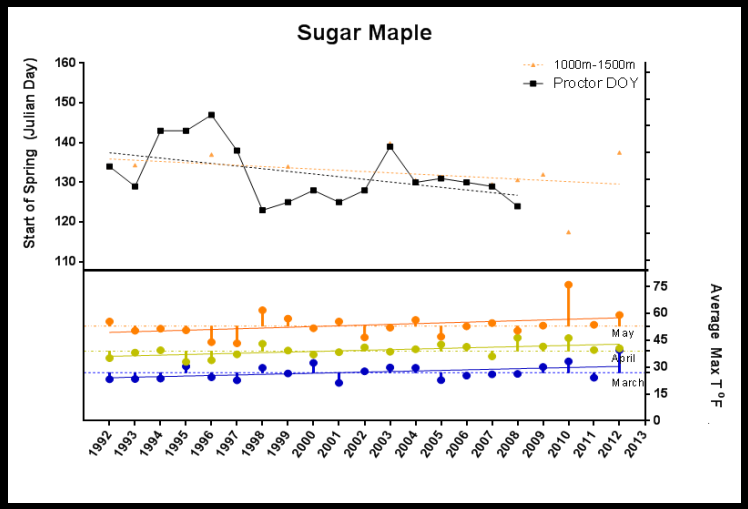
- How does phenology at our location compare to other nearby locations (examine NDVI for the date closest to determined SOS at nearby locations)?
    - Why might phenology timing differ across the landscape?
    - How does the general shape of the phenology curve differ across different eco-zones (tropical, tundra, southern temperate, etc)

More advanced inquiries:

- How is the SOS data changing over time (NDVI time series could be used until sufficient years of field measurements are obtained).
  - Is there a consistent trend in this change?
  - How much variability occurs from year to year that is not related to long-term trends?



- How does weather influence the rate of green up or SOS timing?
  - Is minimum, maximum or mean temperature more important in the timing of budburst?




Questions?