

# Vegetation Phenology

*Quantifying climate impacts on ecosystems:  
Field and Satellite Assessments*



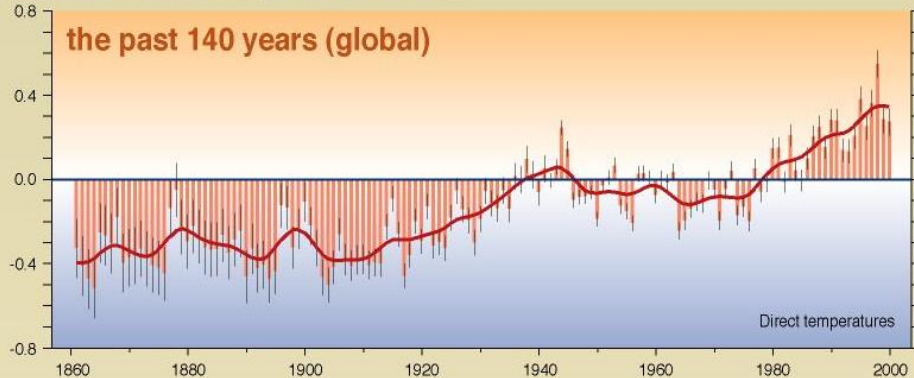


# Plants can tell us a story about climate.

## Variations of the Earth's surface temperature for...

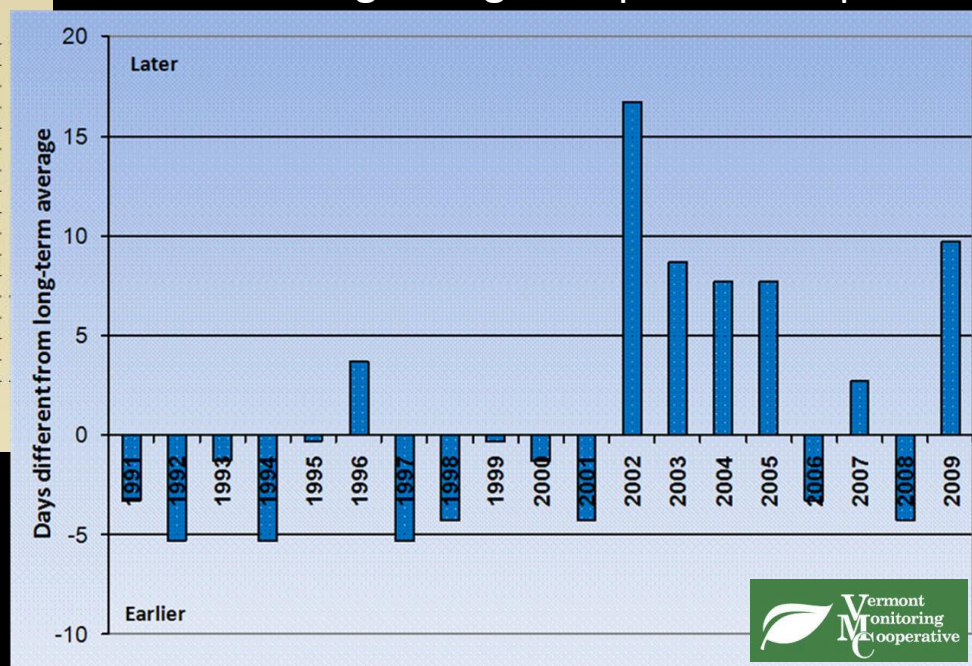
Departures in temperature in °C (from the 1961-1990 average)

the past 140 years (global)

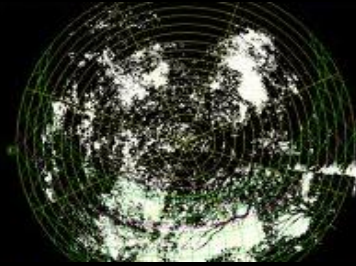


(Ollinger, S.V. "Potential effects of climate change and rising CO<sub>2</sub> on ecosystem process in northeastern U.S. forests")

## Timing of sugar maple leaf drop







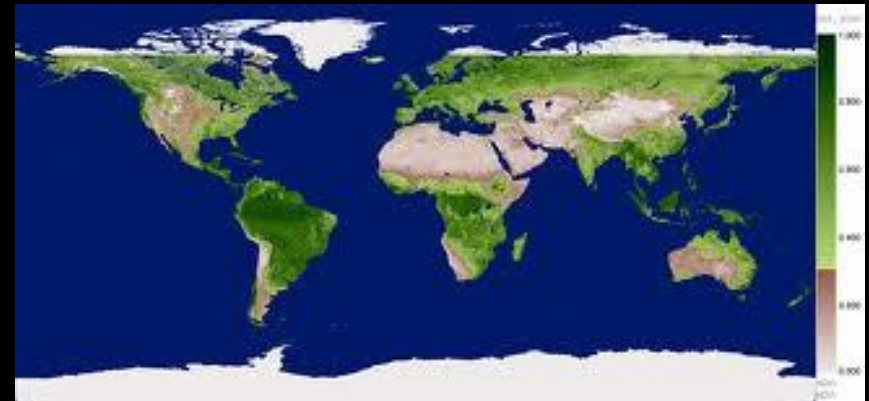
Phenology (the timing of leaf out and leaf off) is a common metric of climate impacts.

This is typically quantified in two ways:

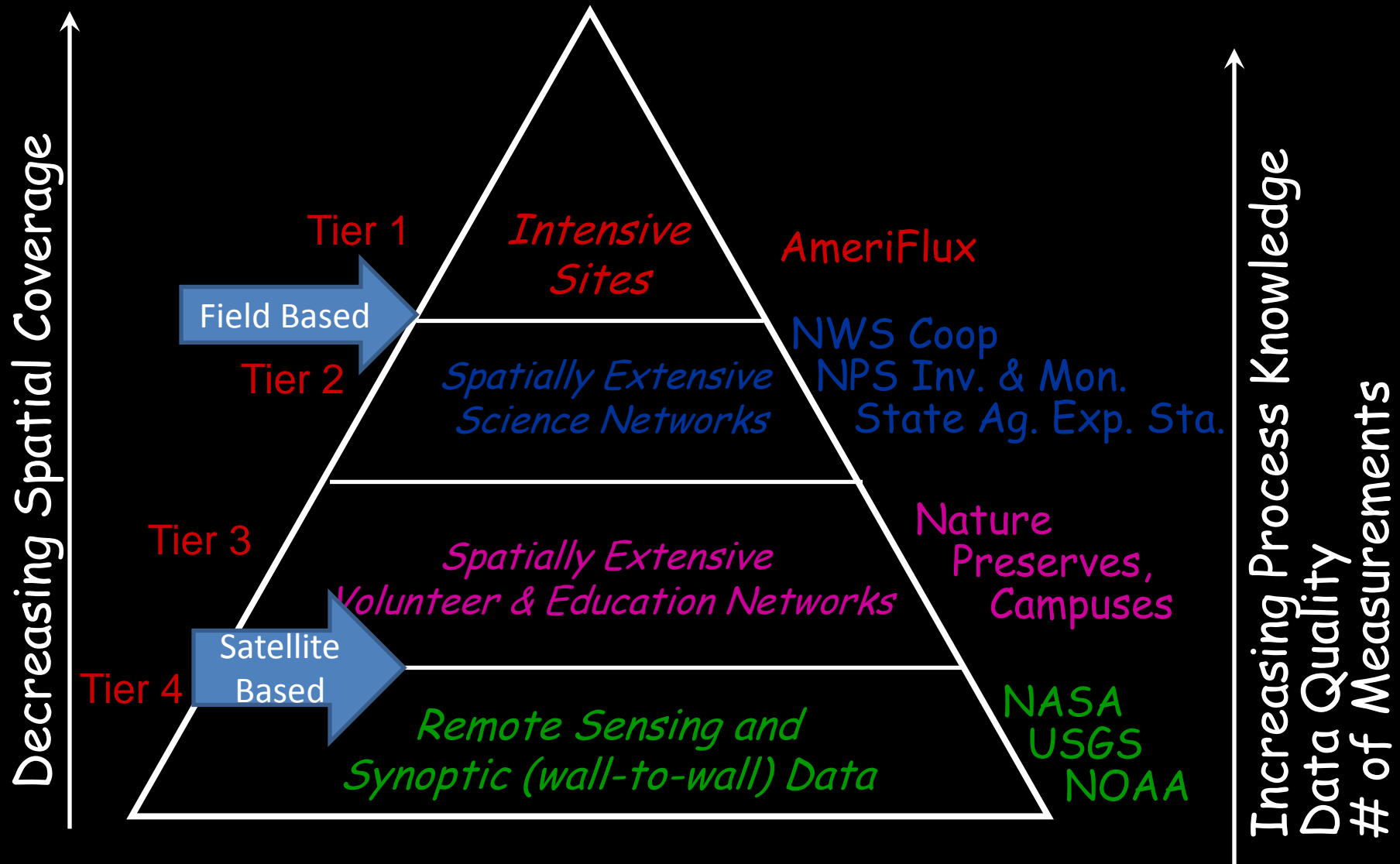
Field assessments

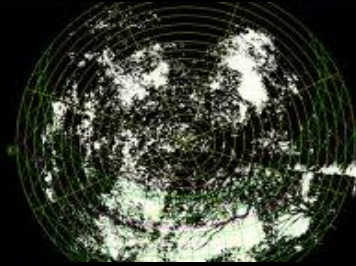


Satellite Observations



# Really a combination of field and satellite observations are best





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

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## 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

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## 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.

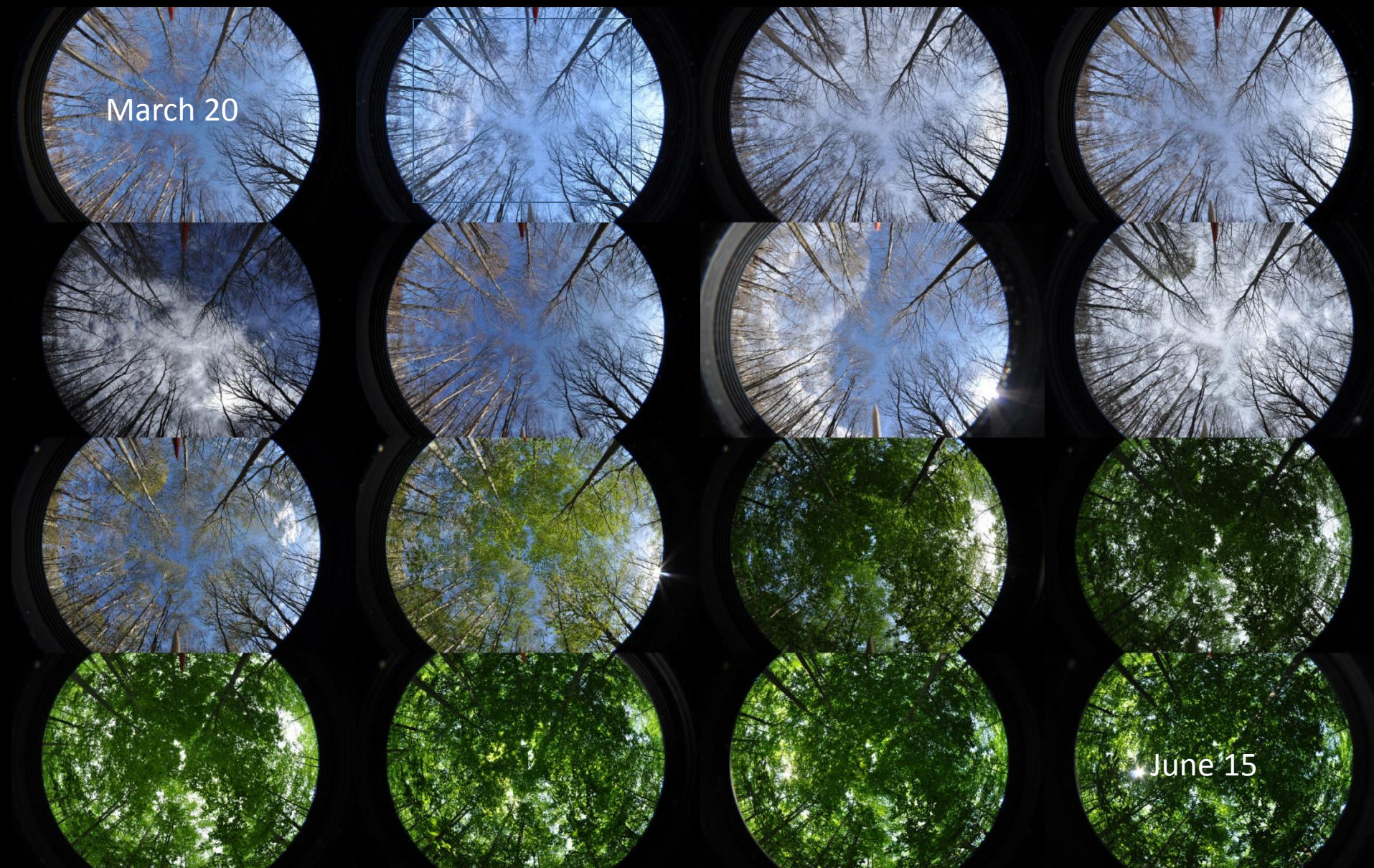
From these images we can use specialized software to calculate lots of different canopy characteristics:

“greenness”, canopy closure, gap fraction, leaf area index, etc.



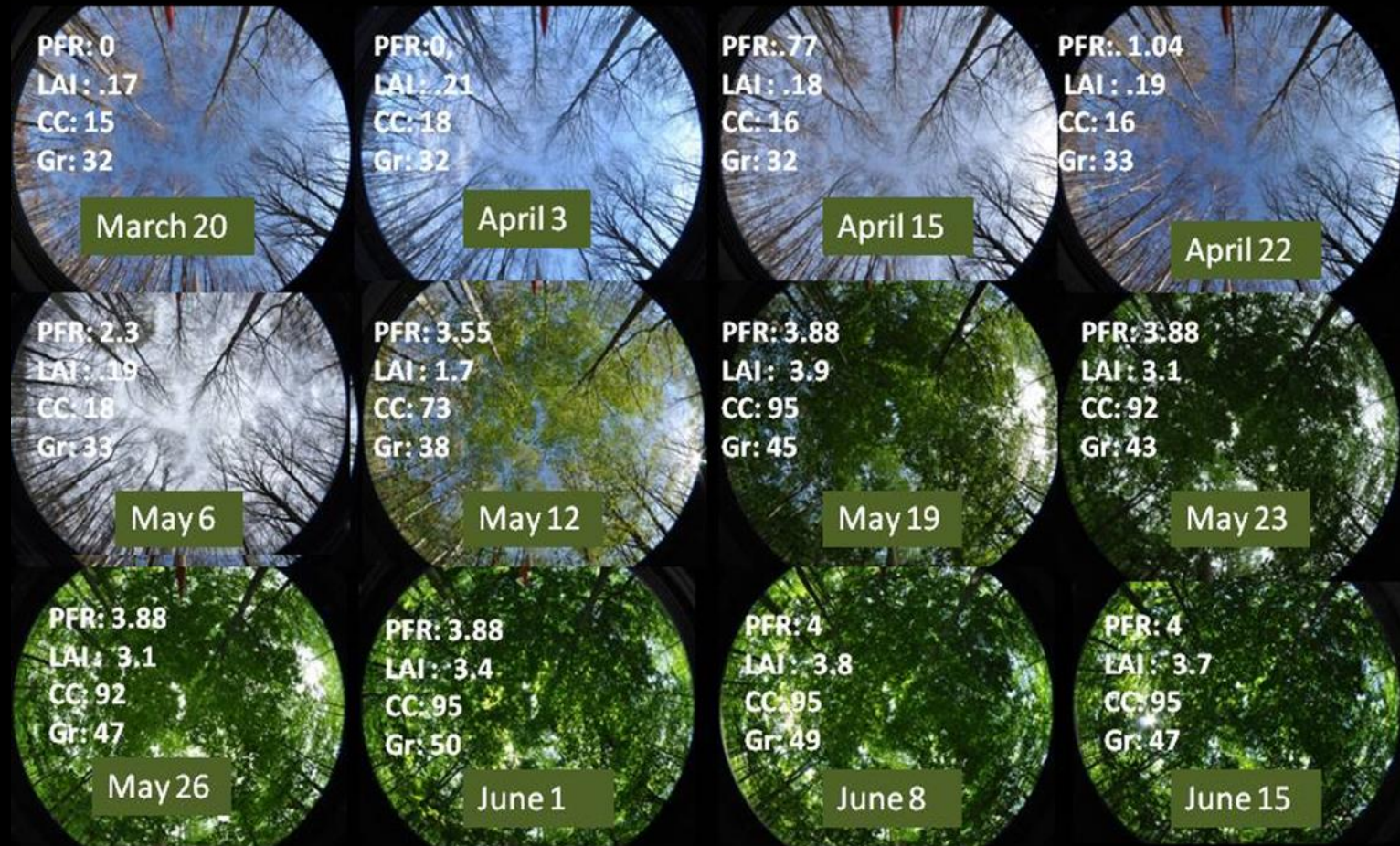


Over time you can quantify changes in canopy characteristics,  
compare rates of change and timing of changes.



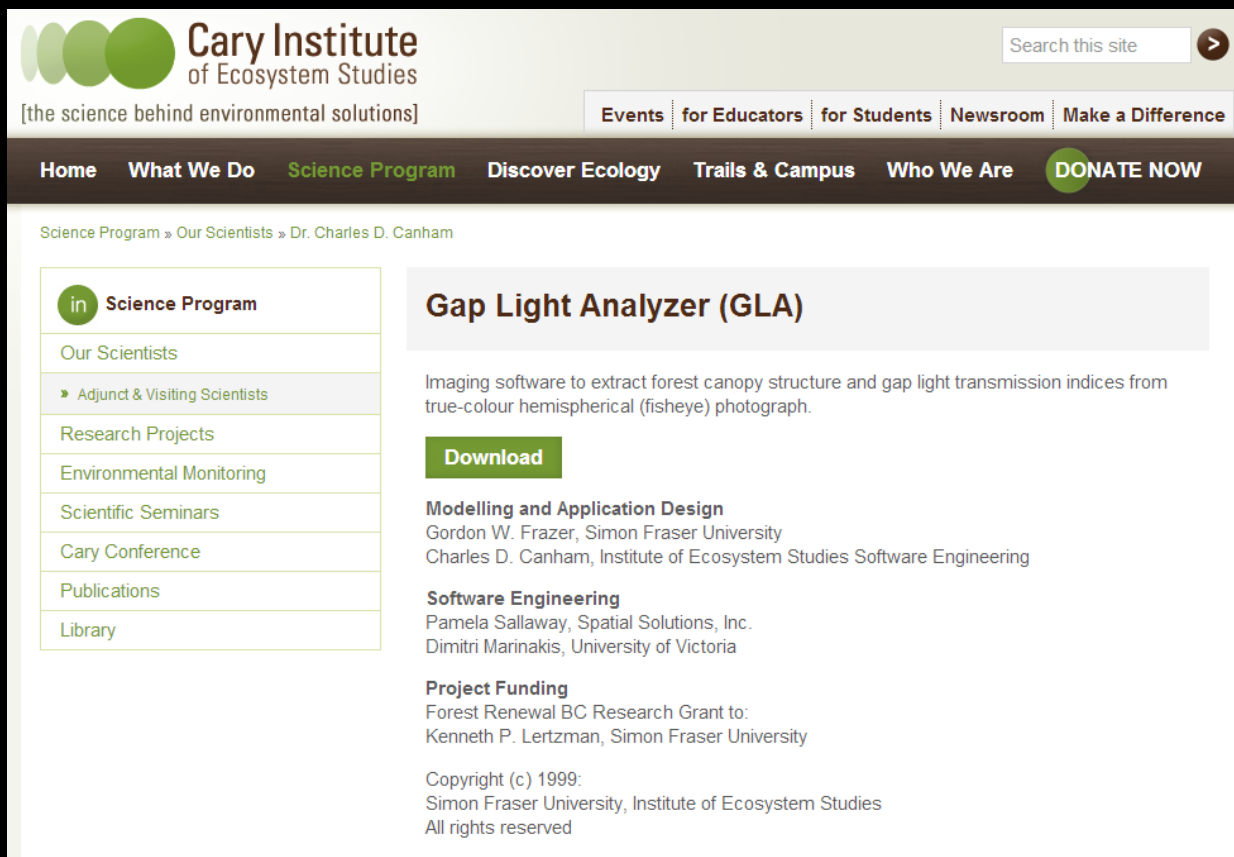


Specialized software can quickly calculate a suite of different canopy metrics we can use.



# Gap Light Analyzer (GLA)

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



The screenshot shows the Cary Institute of Ecosystem Studies website. The header includes the Cary Institute logo, a search bar, and navigation links: Events, for Educators, for Students, Newsroom, and Make a Difference. The main navigation bar includes Home, What We Do, Science Program (highlighted), Discover Ecology, Trails & Campus, Who We Are, and a DONATE NOW button. The breadcrumb trail reads: Science Program » Our Scientists » Dr. Charles D. Canham. The left sidebar contains a 'Science Program' menu with links to Our Scientists, Adjunct & Visiting Scientists, Research Projects, Environmental Monitoring, Scientific Seminars, Cary Conference, Publications, and Library. The main content area is titled 'Gap Light Analyzer (GLA)' and describes it as imaging software to extract forest canopy structure and gap light transmission indices from true-colour hemispherical (fisheye) photographs. A green 'Download' button is present. Below this, there are sections for 'Modelling and Application Design' (listing Gordon W. Frazer and Charles D. Canham), 'Software Engineering' (listing Pamela Sallaway and Dimitri Marinakis), and 'Project Funding' (listing Forest Renewal BC Research Grant to Kenneth P. Lertzman). The footer contains copyright information: Copyright (c) 1999: Simon Fraser University, Institute of Ecosystem Studies. All rights reserved.

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## Gap Light Analyzer (GLA)

Imaging software to extract forest canopy structure and gap light transmission indices from true-colour hemispherical (fisheye) photograph.

**Download**

**Modelling and Application Design**  
Gordon W. Frazer, Simon Fraser University  
Charles D. Canham, Institute of Ecosystem Studies Software Engineering

**Software Engineering**  
Pamela Sallaway, Spatial Solutions, Inc.  
Dimitri Marinakis, University of Victoria

**Project Funding**  
Forest Renewal BC Research Grant to:  
Kenneth P. Lertzman, Simon Fraser University

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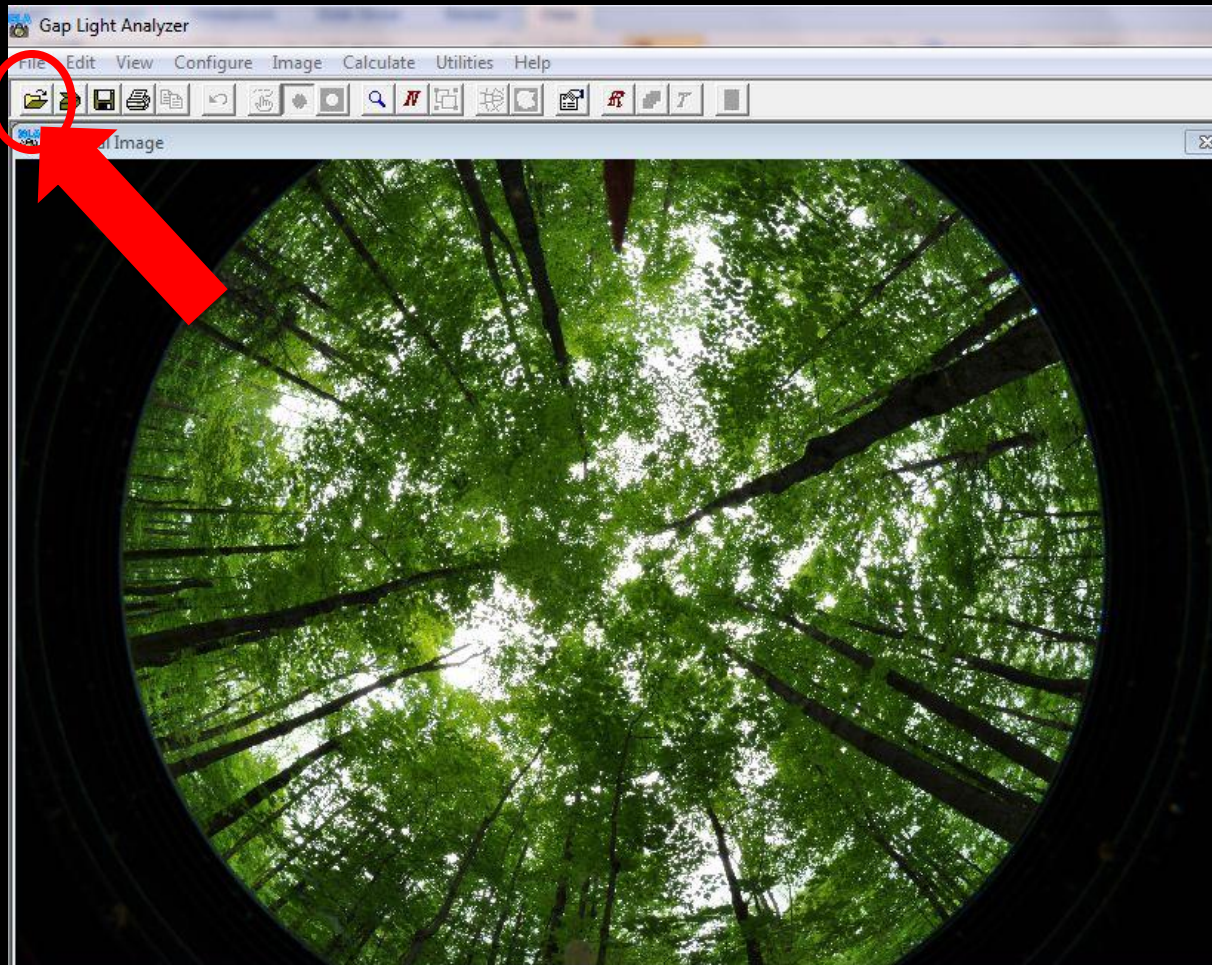
Download  
Unzip  
Double click "setup.exe  
to install

Here is the catch:

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

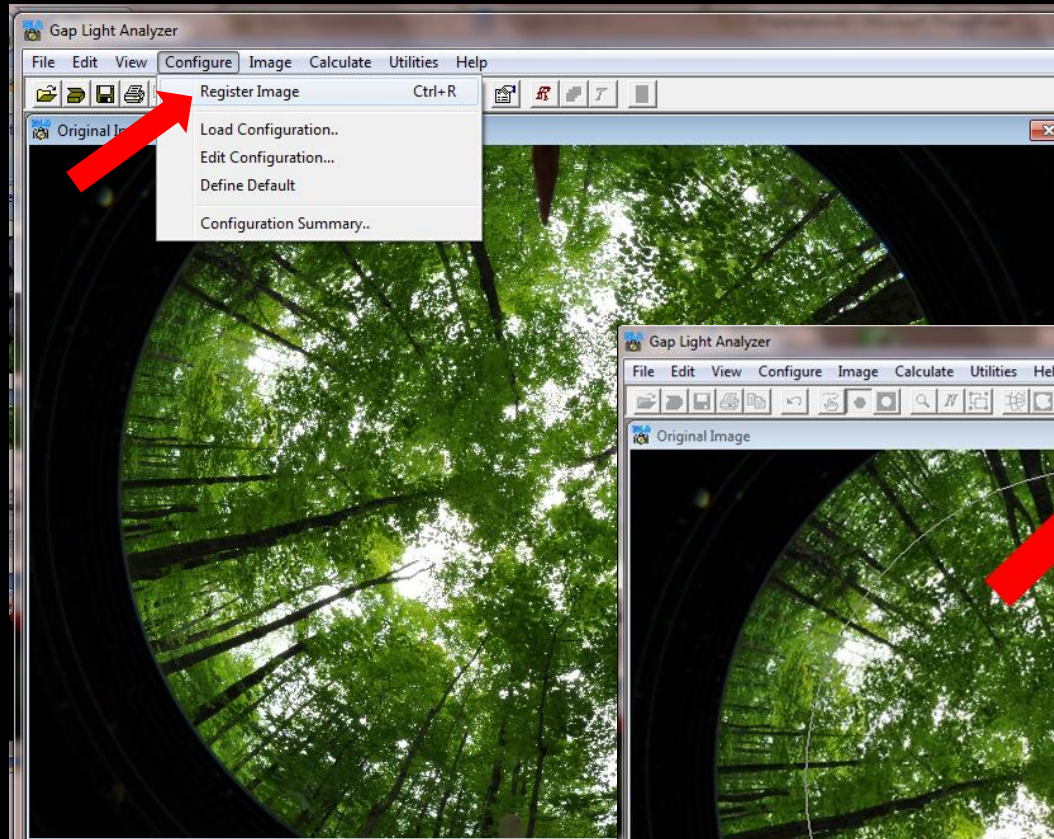


# Working Gap Light Analyzer

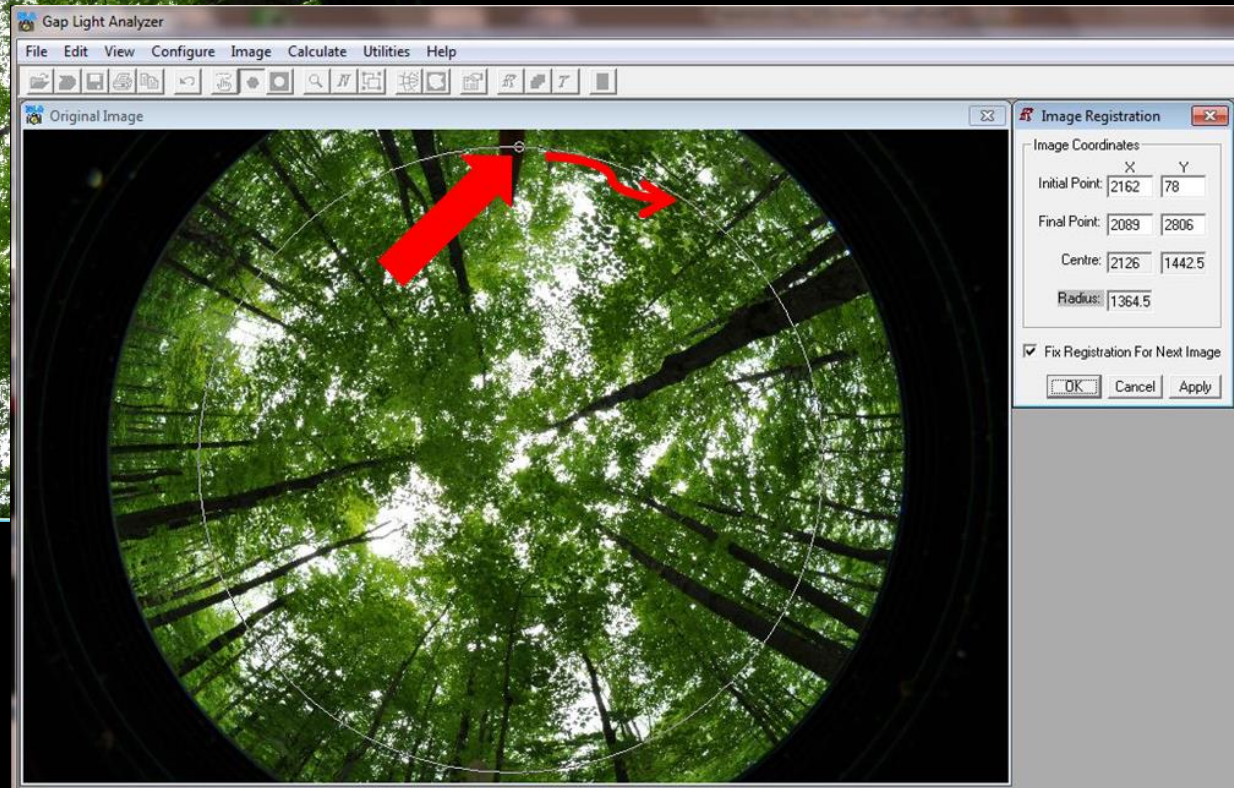


1. Open your digital image

# Working Gap Light Analyzer

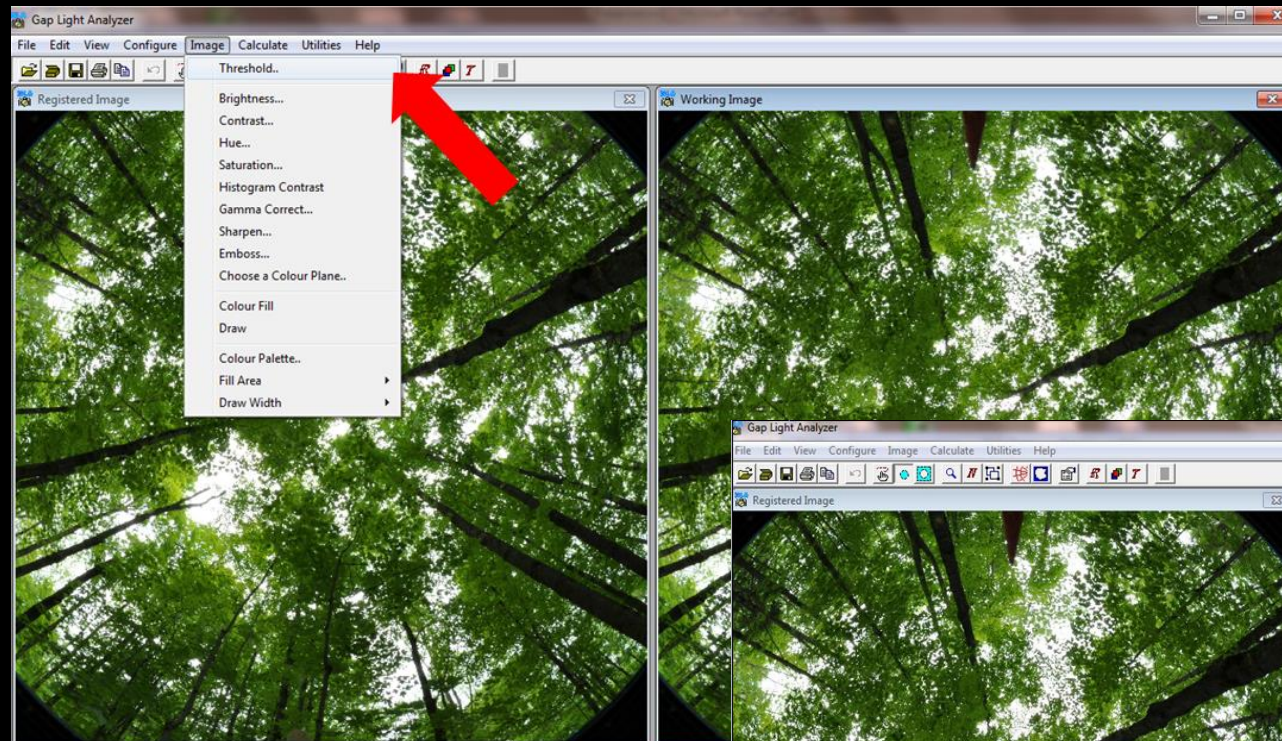


1. Open your digital image
2. Register your image

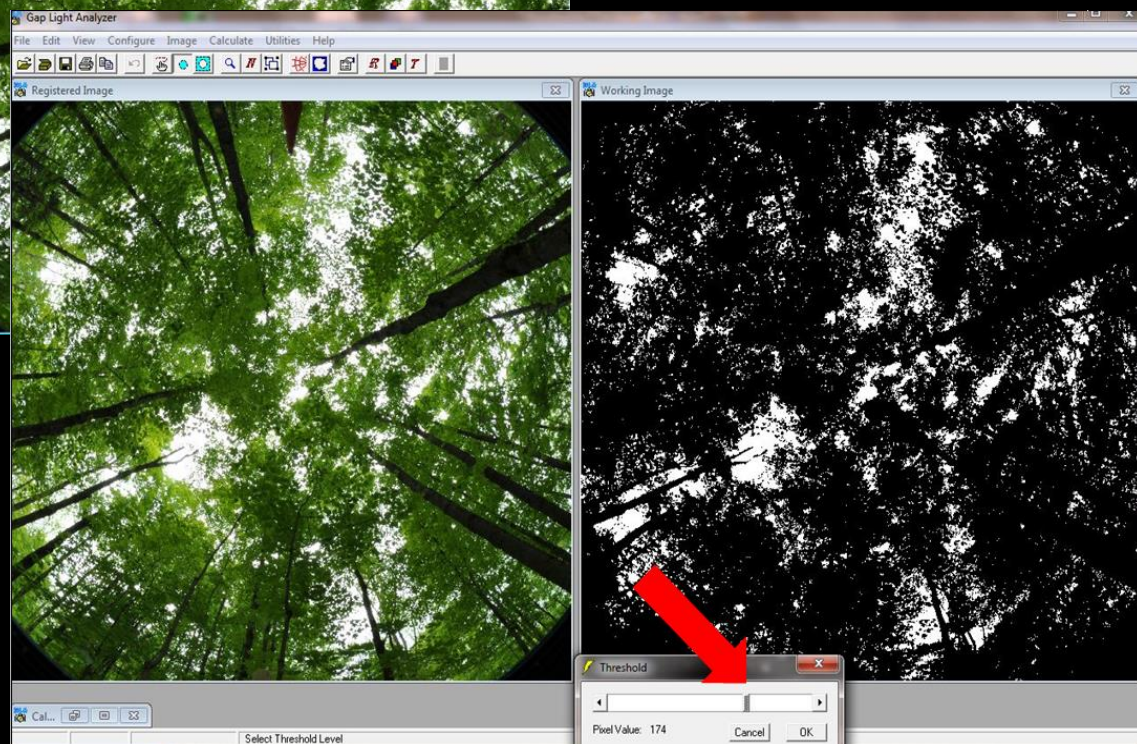




# Working Gap Light Analyzer



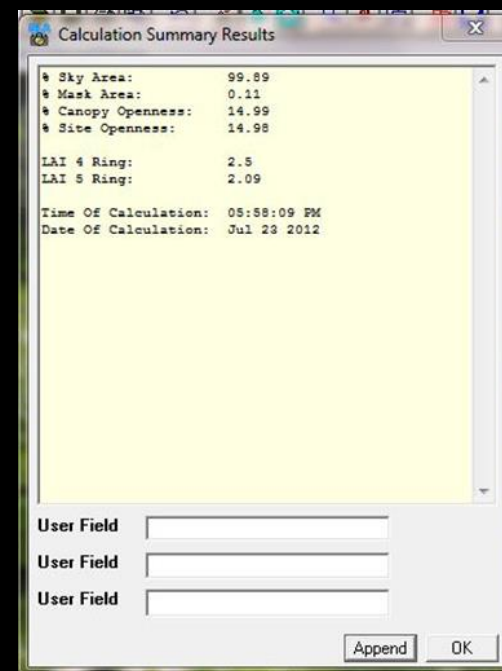
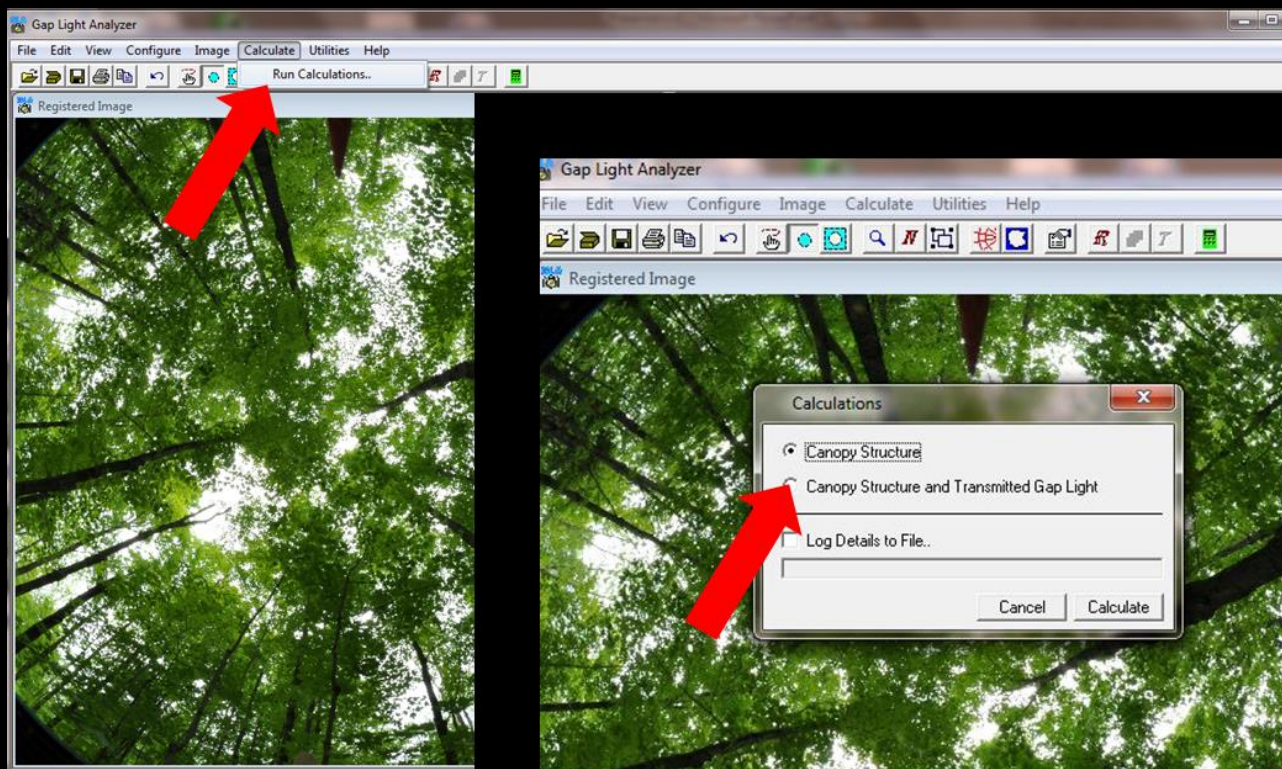
1. Open your digital image
2. Register your image
3. Set the light/dark threshold





# Working Gap Light Analyzer

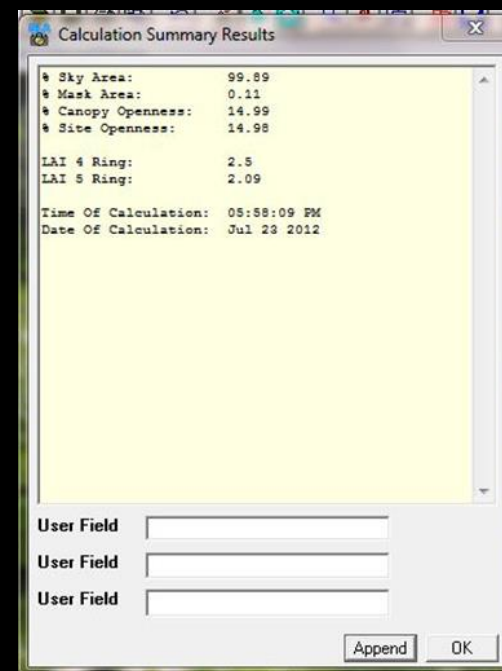
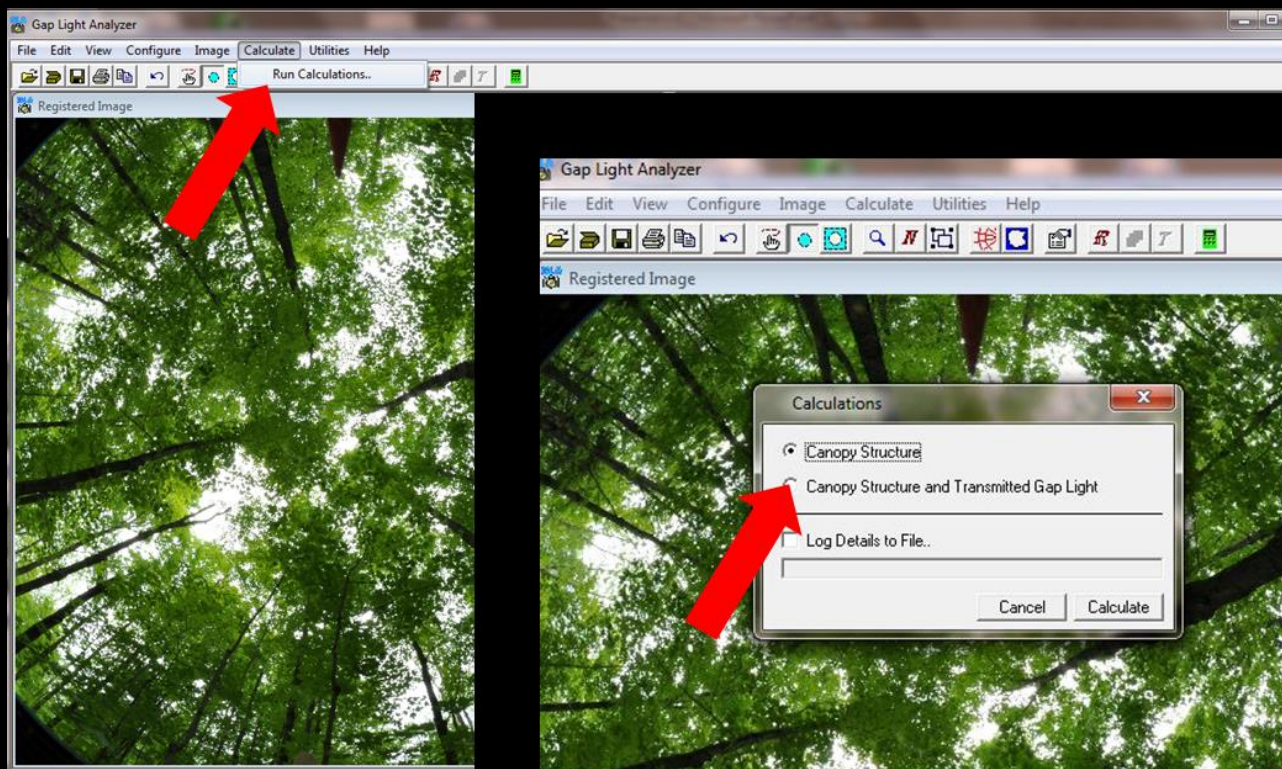
1. Open your digital image
2. Register your image
3. Set the light/dark threshold
4. Run calculations





# 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

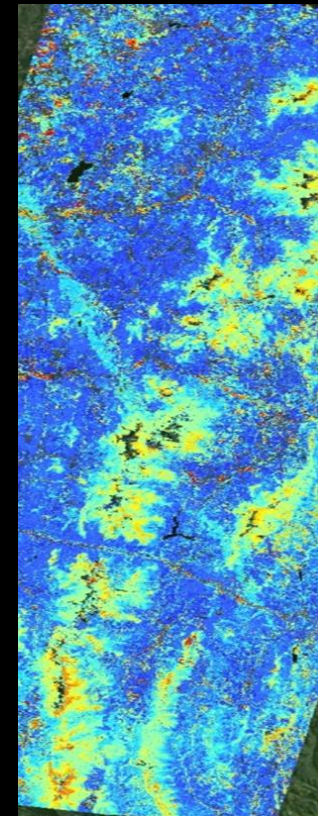
There are many different ways to quantify phenology.

We suggest including both visual assessments and digital measurements

## Satellite Assessments

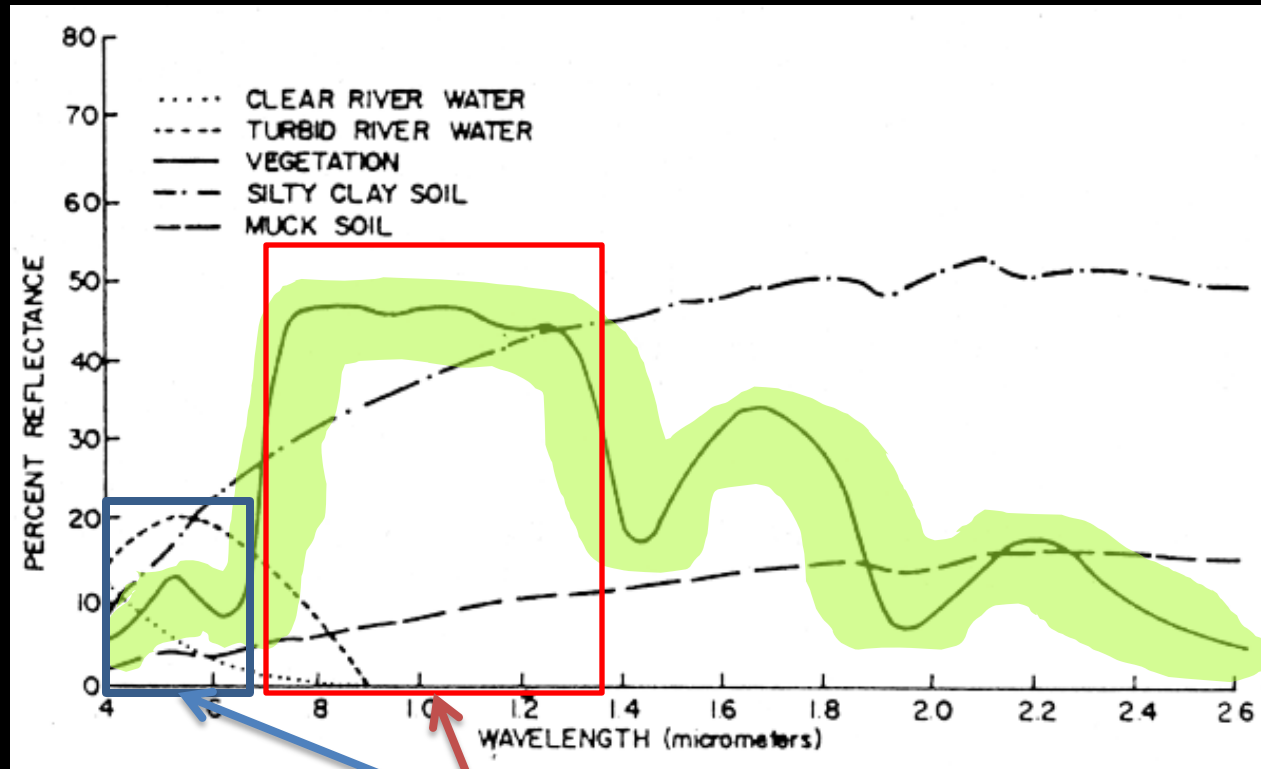
Satellites cover a large geographic area, making them useful for regional, continental or global assessments.

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.

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

# Normalized Difference Vegetation Index

## NDVI



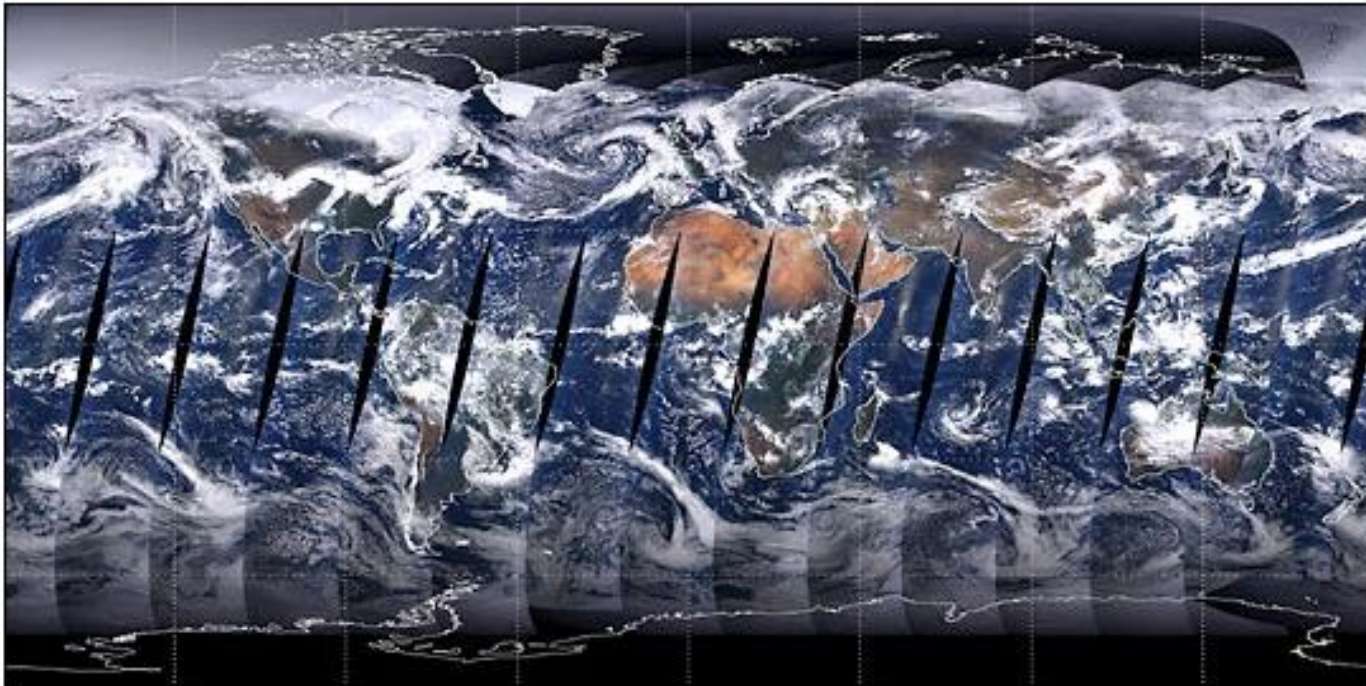
- Negative values of NDVI correspond to water.
- Values close to zero correspond to barren areas of rock, sand, or snow.
- low, positive values represent shrub and grassland
- high values indicate temperate and tropical rainforests.



# Global Agricultural Monitoring Project

## Test Interactive Products

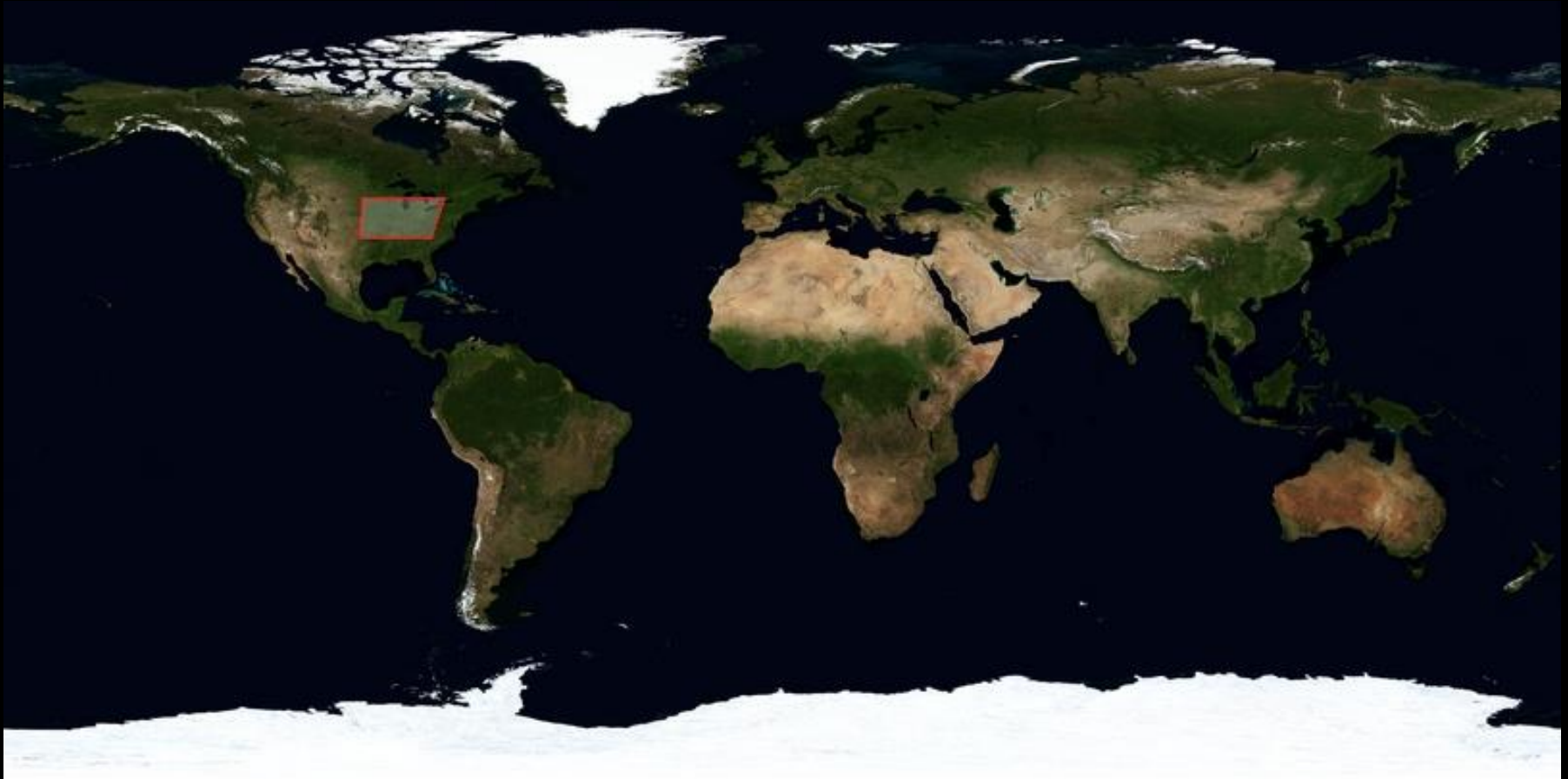
### MODIS Overview



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/>

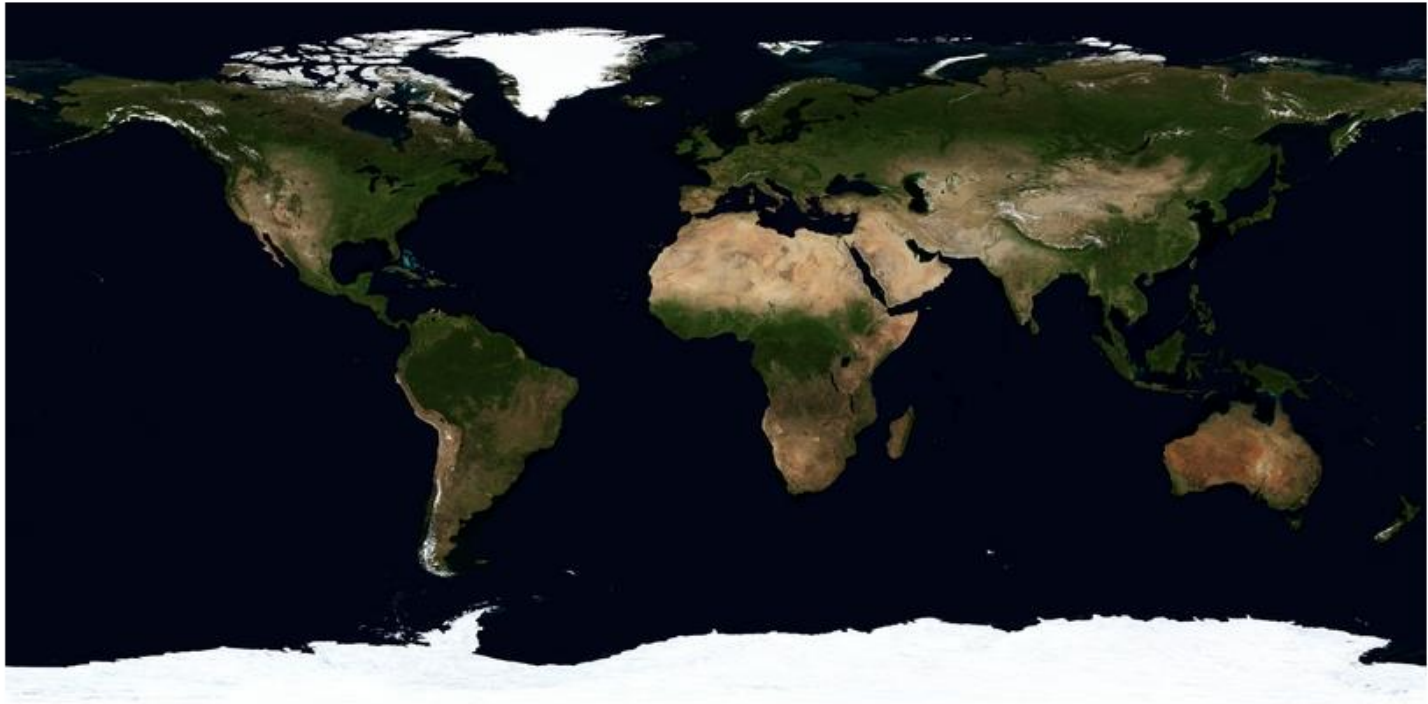




# Getting NDVI Data for your location

## 250-meter MODIS/NDVI Time Series Database from the Global Agriculture Monitoring (GLAM) Project

Please select your region of interest by clicking on the globe  or selecting from the list



Select Region  

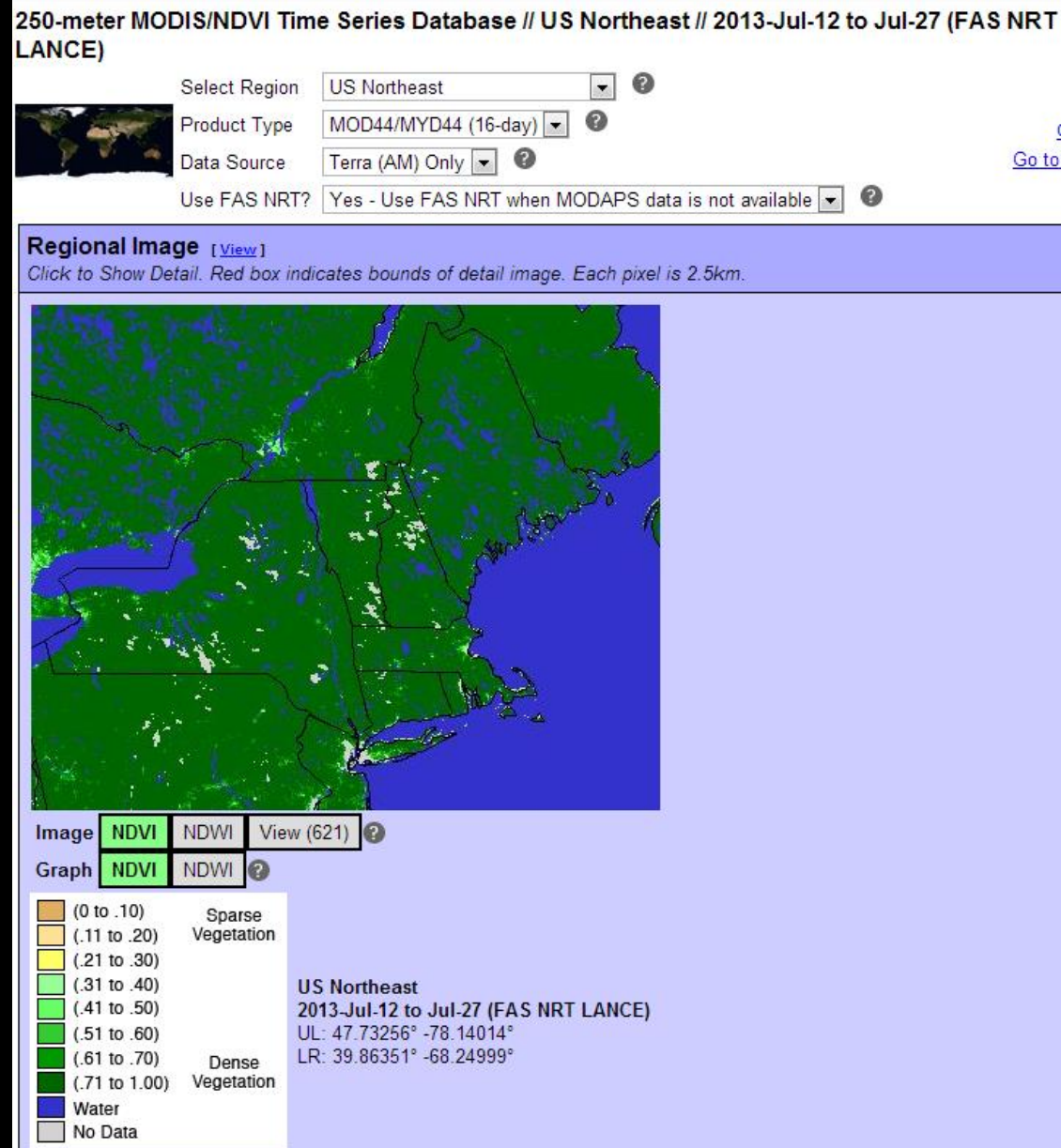
[Go to Data Access App](#)   
[Go to Data Delivery Directory](#) 

[Dataset Status](#) • [Feedback](#) • [Version 0.3.14 \(5/31/2013\)](#)

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.

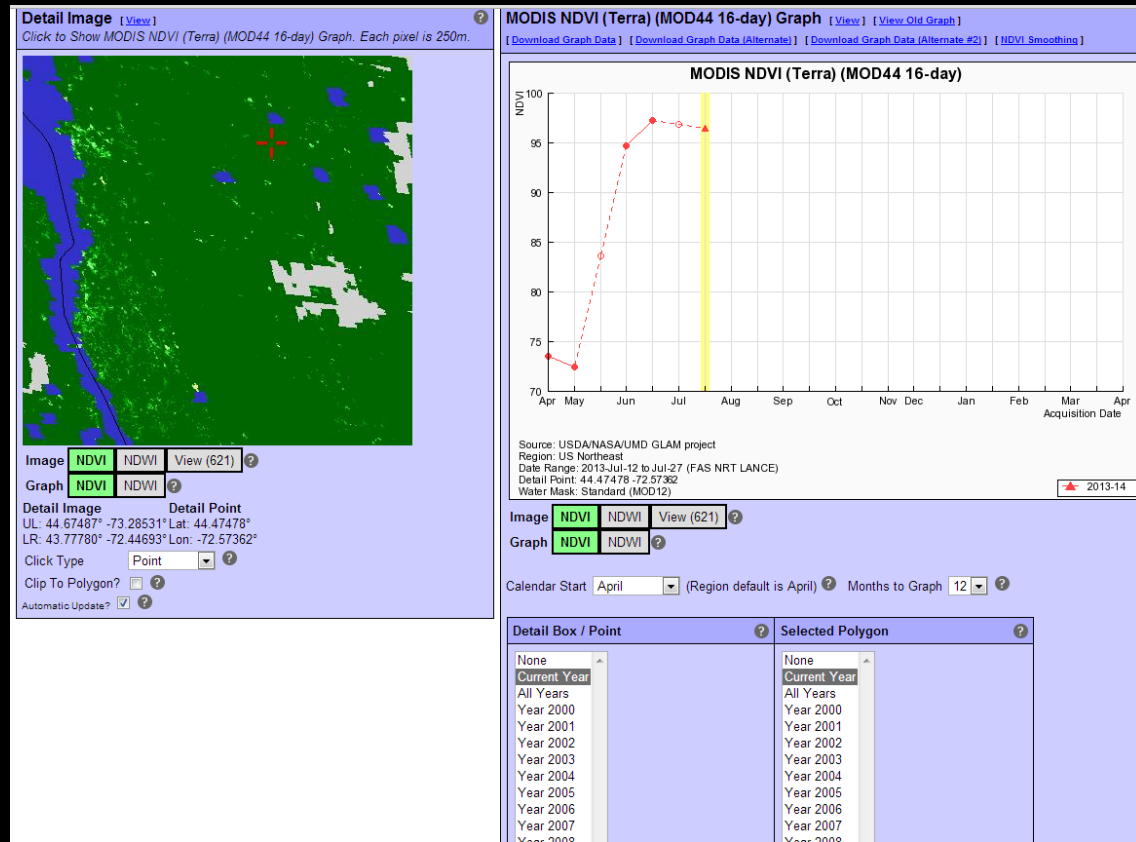




# Getting NDVI Data for your location

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.



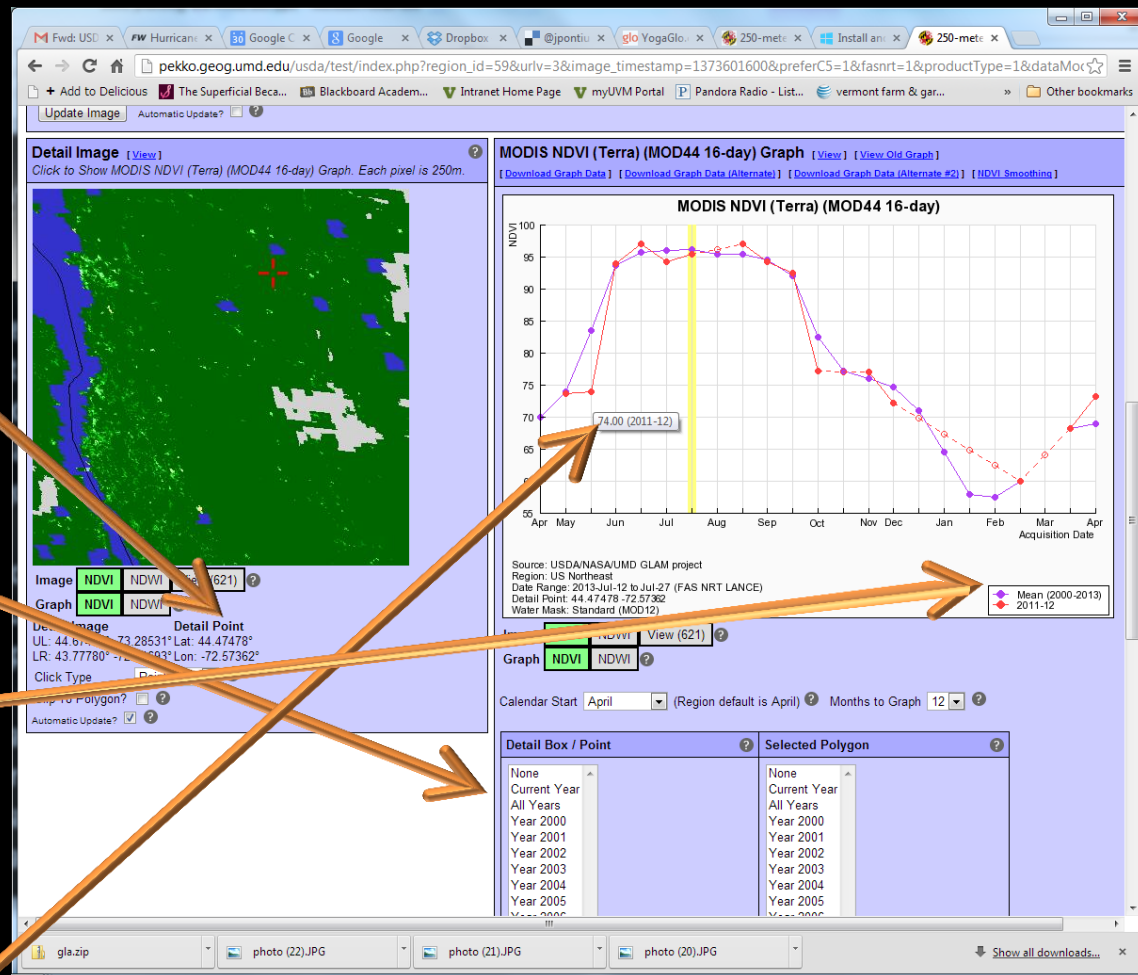
# Getting NDVI Data for your location

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.

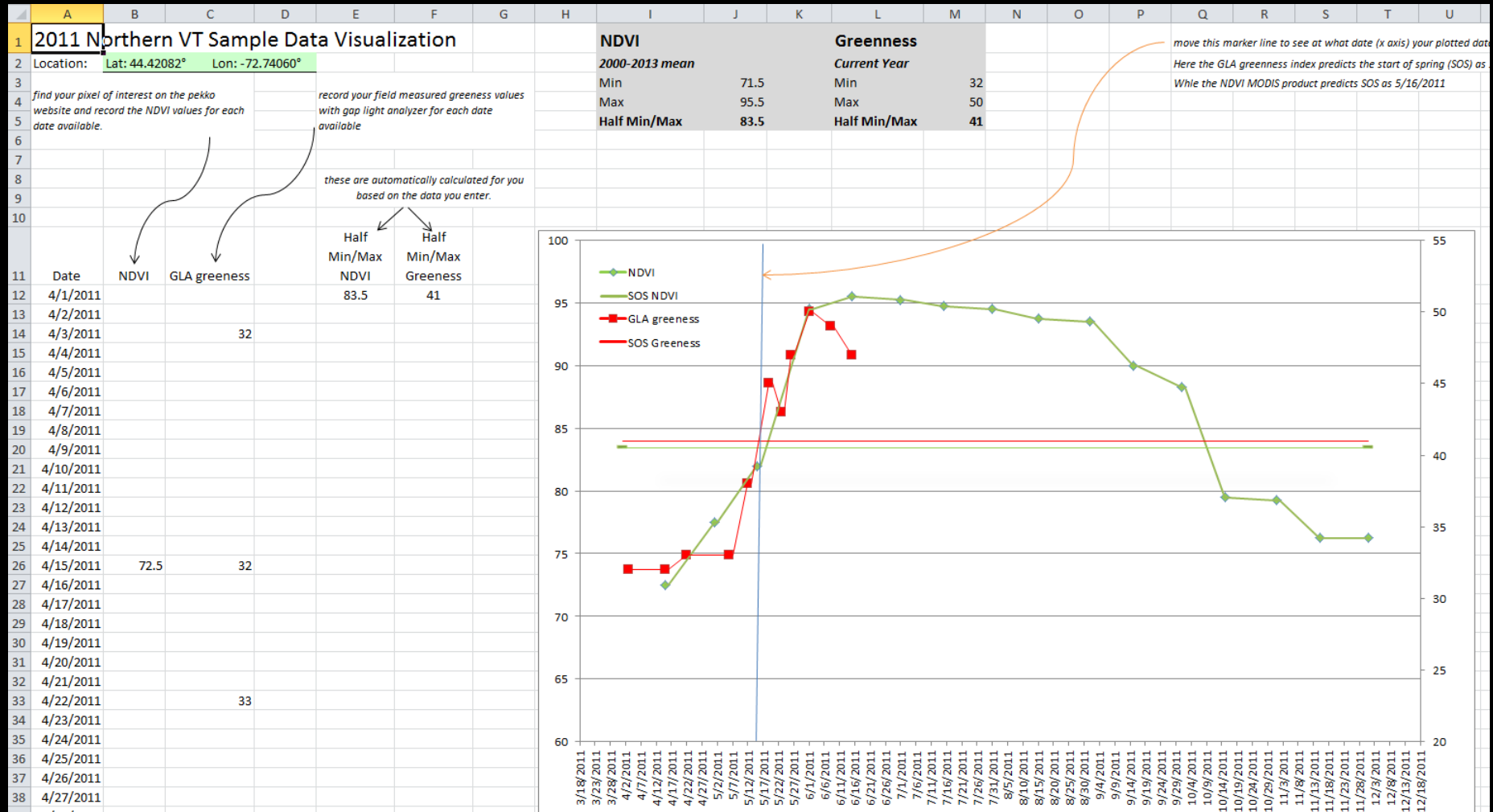
You can also overlay the mean values to see how anomalous a given year is.

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:

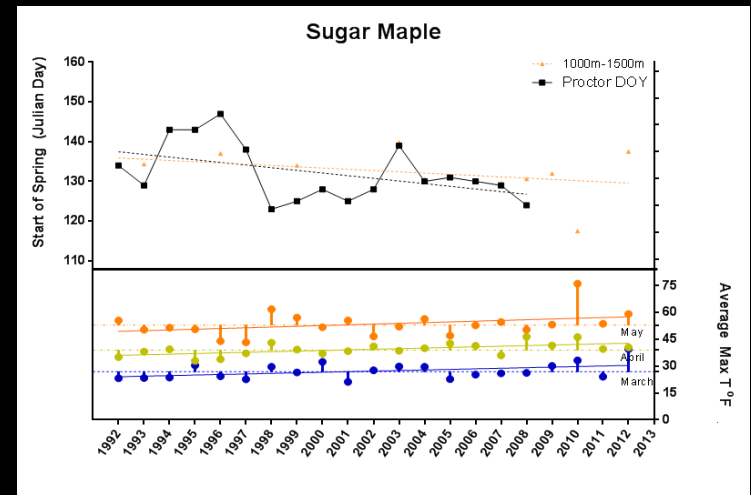
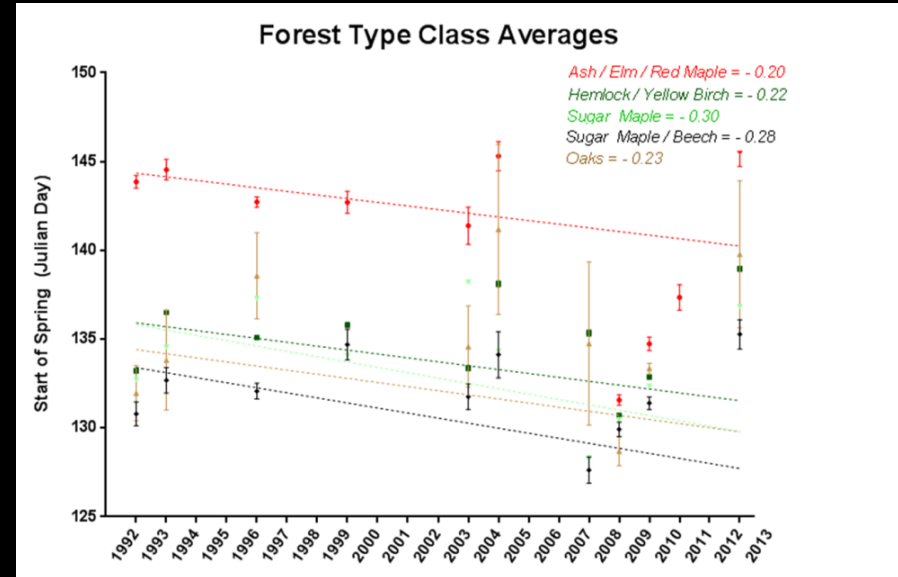
Aside from the basics (identify SOS date, quantify duration of greenup) other questions to be answered from this data set could include:

- 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?

