Monitoring Vegetation Phenology Using Daily Nadir BRDF-Adjusted VIs from VIIRS

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Phenology monitoring approaches

- **PhenoCam Network**

  - gcc(green chromatic coordinate)(gcc = G/[R + G + B])
  - http://phenocam.sr.unh.edu/webcam/
- **Remote sensing**
  - Vegetation Index(VI)
  - MODIS, AVHRR
  - VIIRS
- **Others**
  - Project Budburst

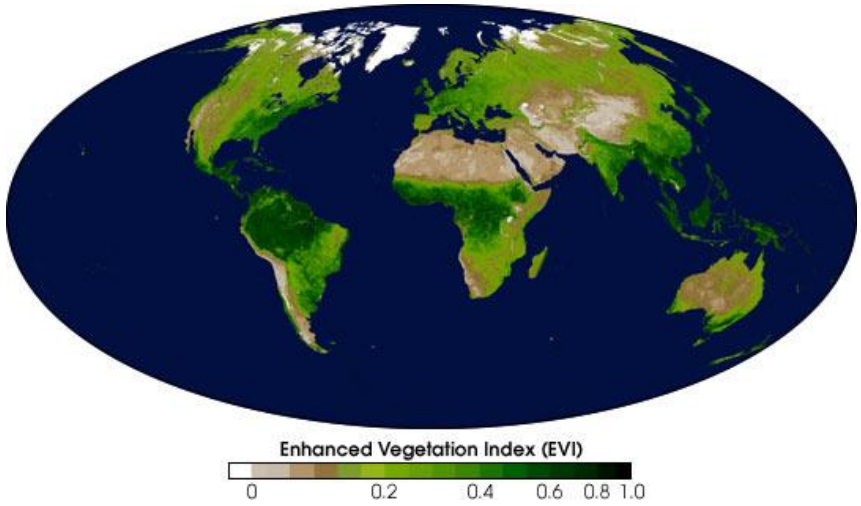


Image courtesy MODIS Land Group/Vegetation Indices, Alfredo Huete, Principal Investigator, and Kamel Didan, University of Arizona.

VIIRS info

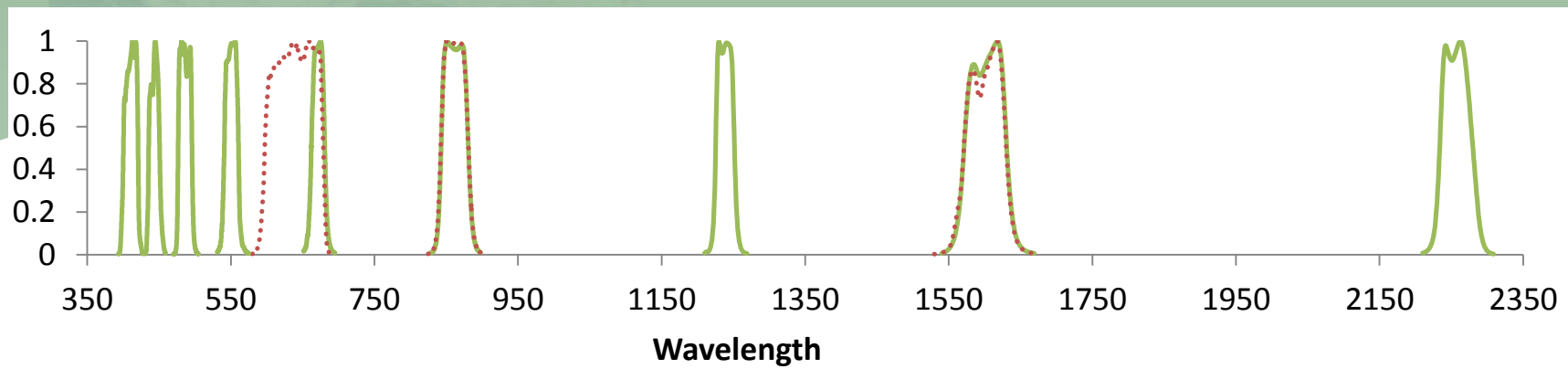
- Launched on October 28, 2011
- Data available: 019 2012
- Aiming to provide continues data record of MODIS(2000-now)
- 9 bands at 1km--EVI/NDVI
- 3 bands at 500m--NDVI

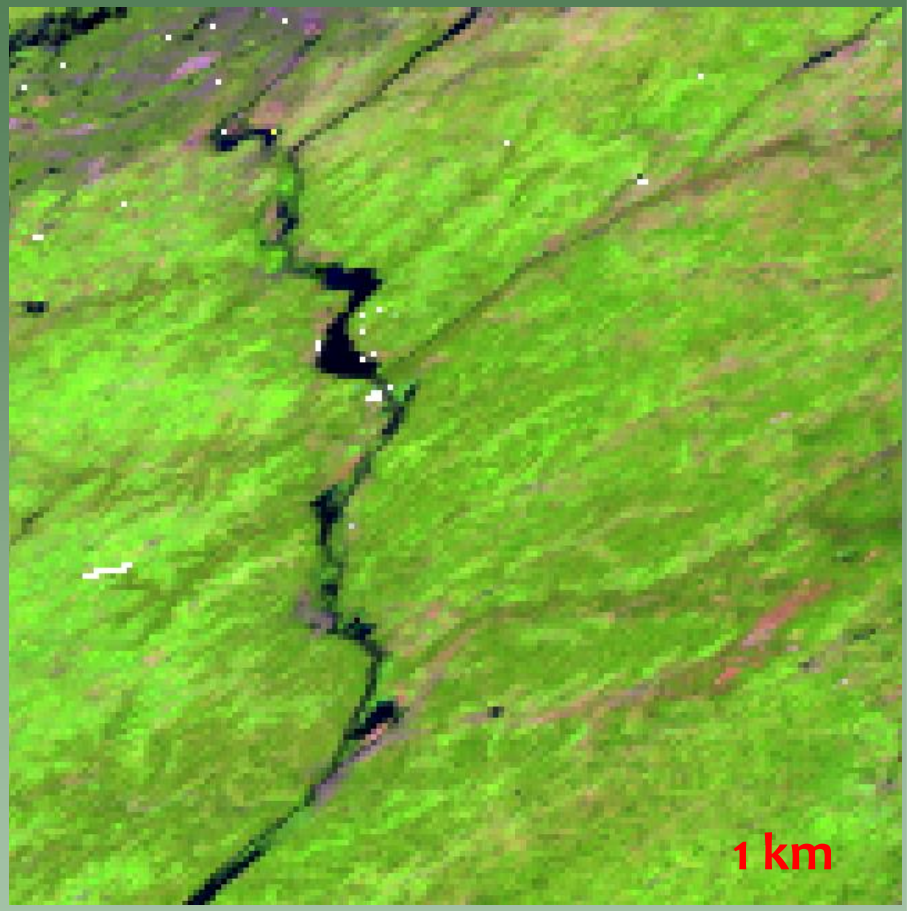
EVI : Enhanced Vegetation Index
NDVI : Normalized Difference Vegetation Index

$$NDVI = \frac{\rho_{NIR} - \rho_R}{\rho_{NIR} + \rho_R}$$

$$EVI = 2.5 * \frac{\rho_{NIR} - \rho_R}{\rho_{NIR} + 6 * \rho_R - 7.5 * \rho_B + 1}$$

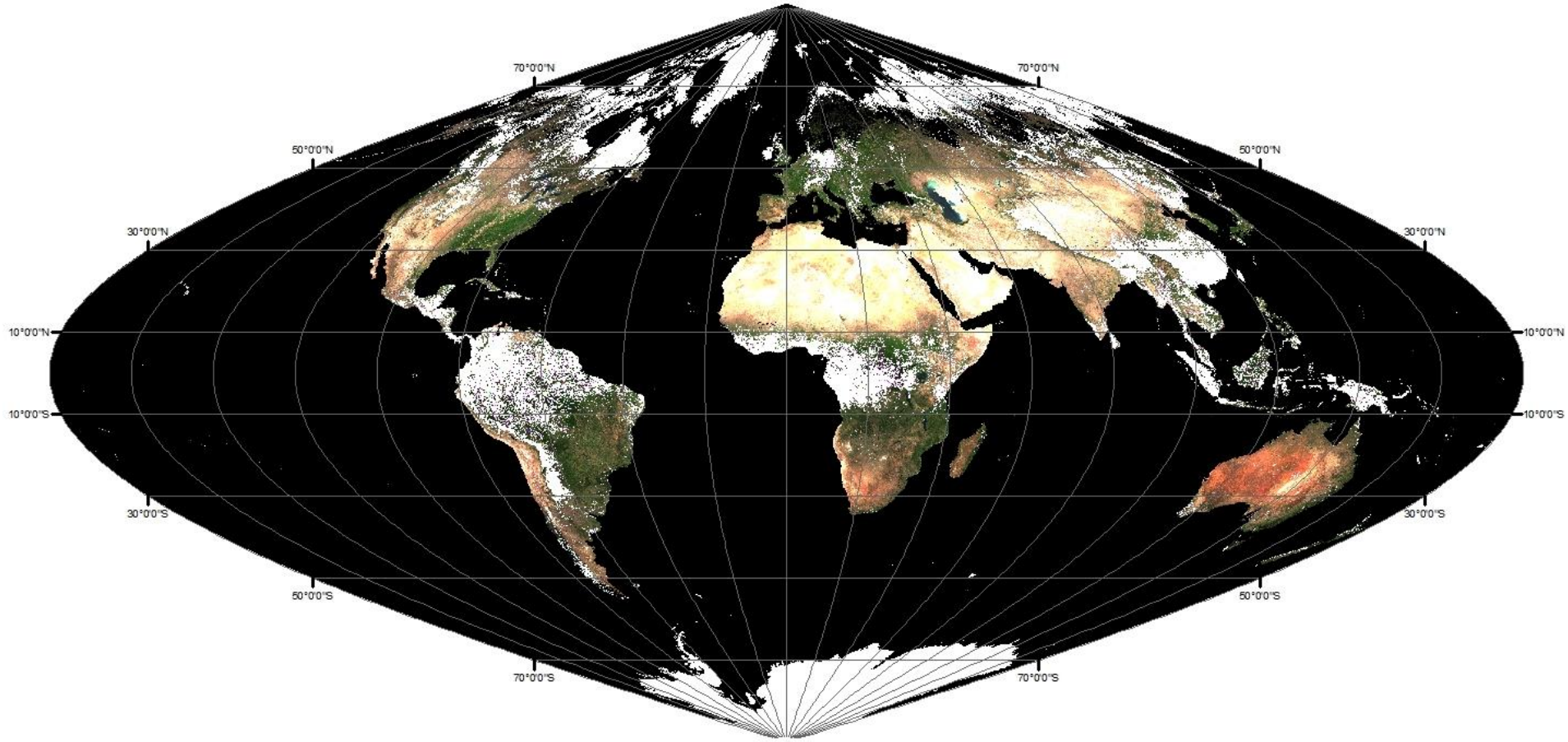
$$EVI2 = 2.5 * \frac{\rho_{NIR} - \rho_R}{\rho_{NIR} + 2.4 * \rho_R + 1}$$





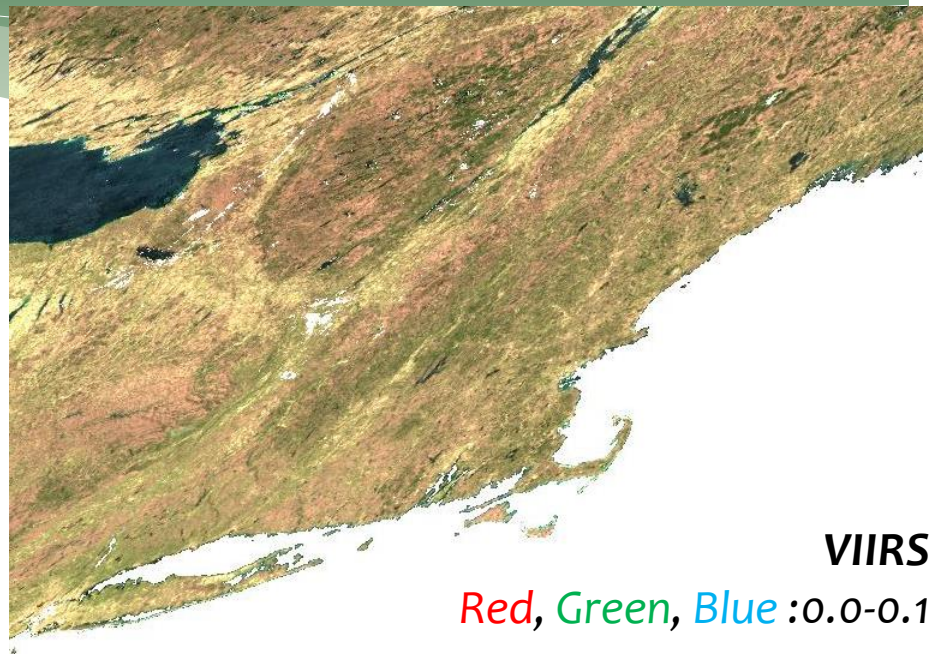
	R	G	B
500M	1.58-1.64	0.850-0.880	0.600-0.680
1KM	1.58-1.64	0.846-0.885	0.662-0.682
SCALE	0.03-0.36	0.05-0.45	0.00-0.20

VIIRS NBAR 2013 DOY 201, July 20



Red, **Green**, **Blue** **:0.0-0.2**

Why NBAR

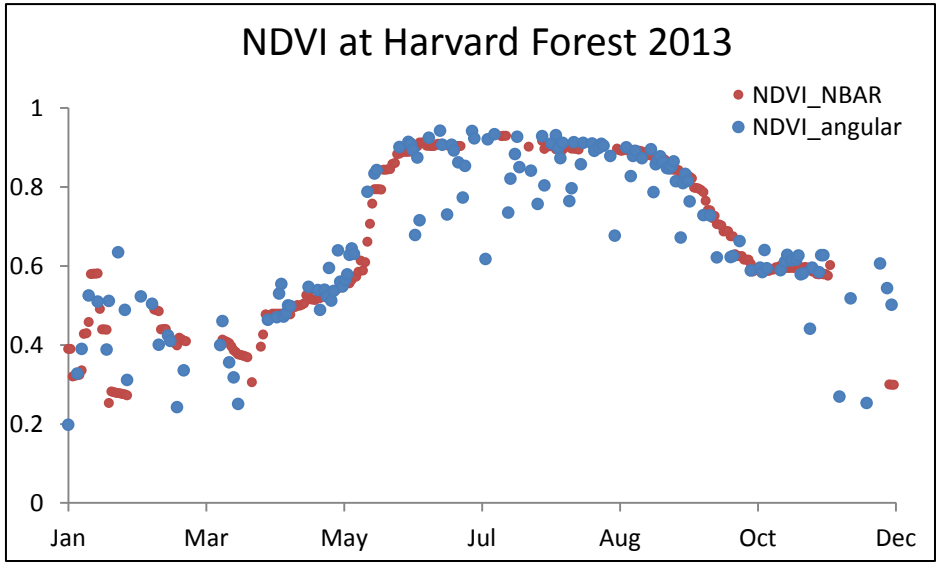


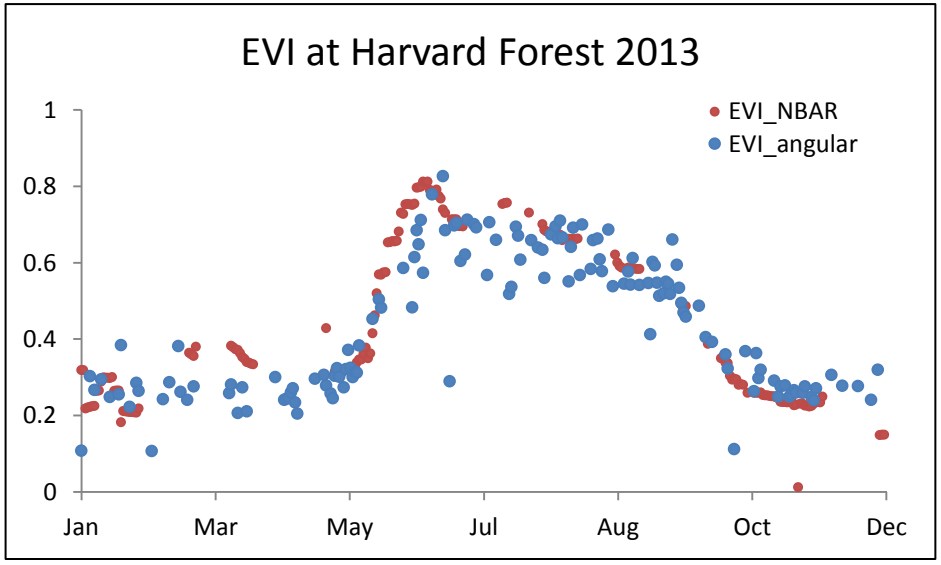
VIIRS

Red, Green, Blue :0.0-0.1

Surface reflectances from adjoining swaths

NBAR





How BRDF/Albedo and NBAR is calculated

Multidate, atmospherically-corrected surface reflectances

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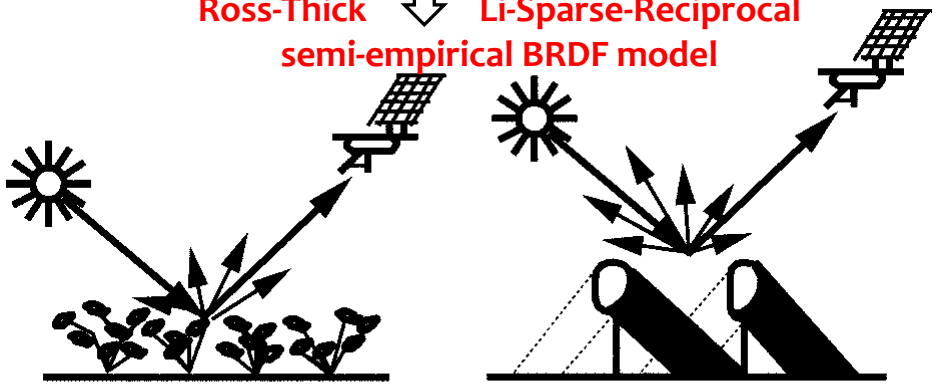
Quality Flag check

⇩

Ross-Thick ⇩ **Li-Sparse-Reciprocal**

semi-empirical BRDF model



Volume scattering BRDF: leaf/vegetation reflectance

Gap–driven BRDF (Forest): shadow–driven reflectance

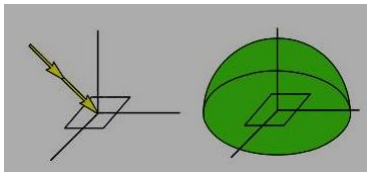
$$R(\theta, v, \phi, \lambda) = f_{iso}(\lambda) + f_{vol}(\lambda)K_{vol}(\theta, v, \phi) + f_{geo}(\lambda)(\lambda)K_{geo}(\theta, v, \phi)$$

⇩

BRDF Parameter
ISO VOL GEO

⇩

NBAR



BSA

WSA

(Schaepman-Strub 2006)

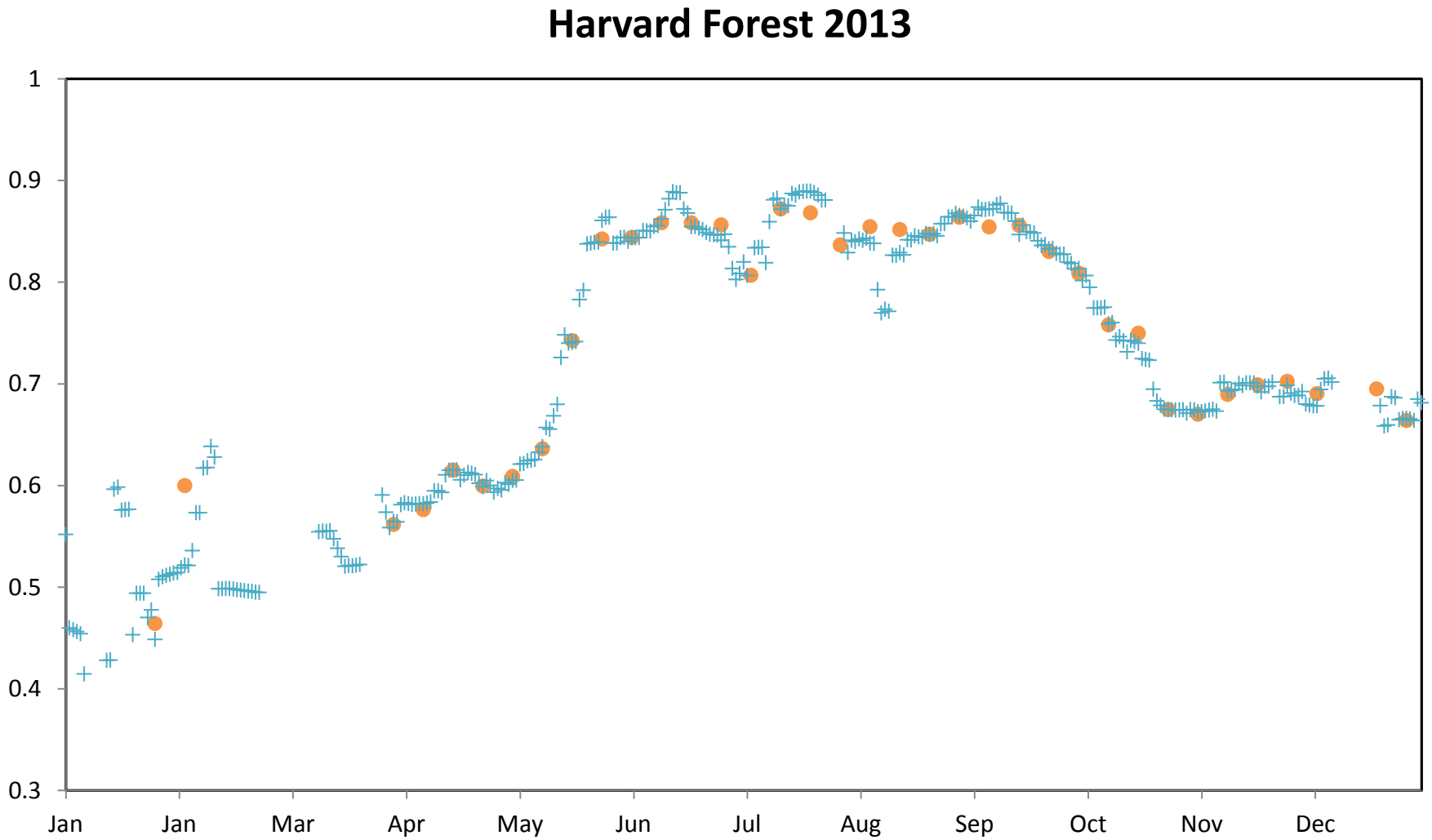
Version 6 updates

* The date of interest is focused on the center of retrieval period.
* The backup database is based on the most recent high quality
* Use snow fraction data
* Implement new N2B computations
  * For VIIRS
* Retrievals daily instead of every 8 days
  * Big improvement for phenology research

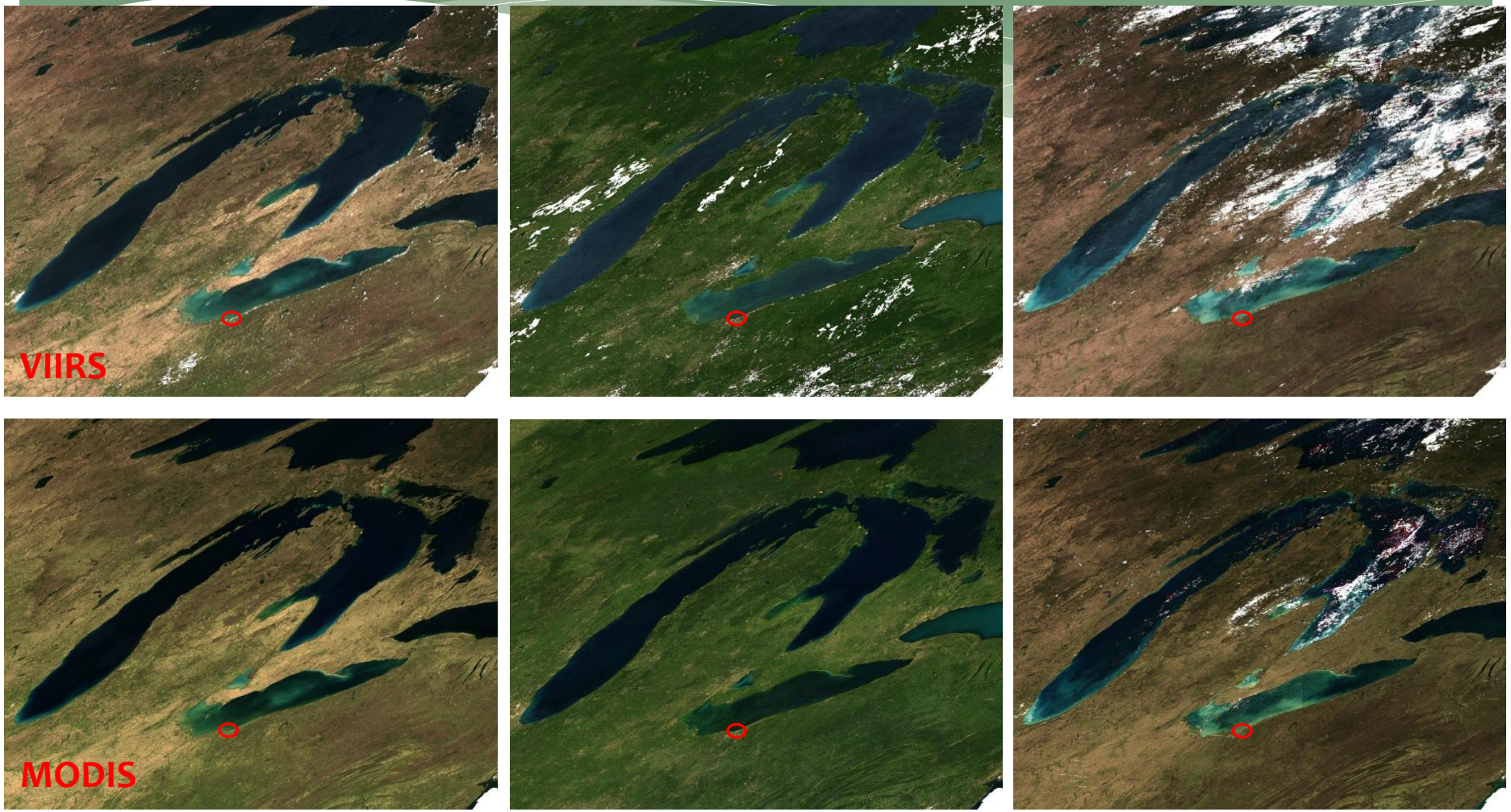
BRDF : Bidirectional Reflectance Distribution Function

NBAR : Nadir BRDF Adjusted Reflectance

Daily Retrieval vs. retrieval every 8 days



Images of VIIRS and MODIS, Cleveland, Ohio

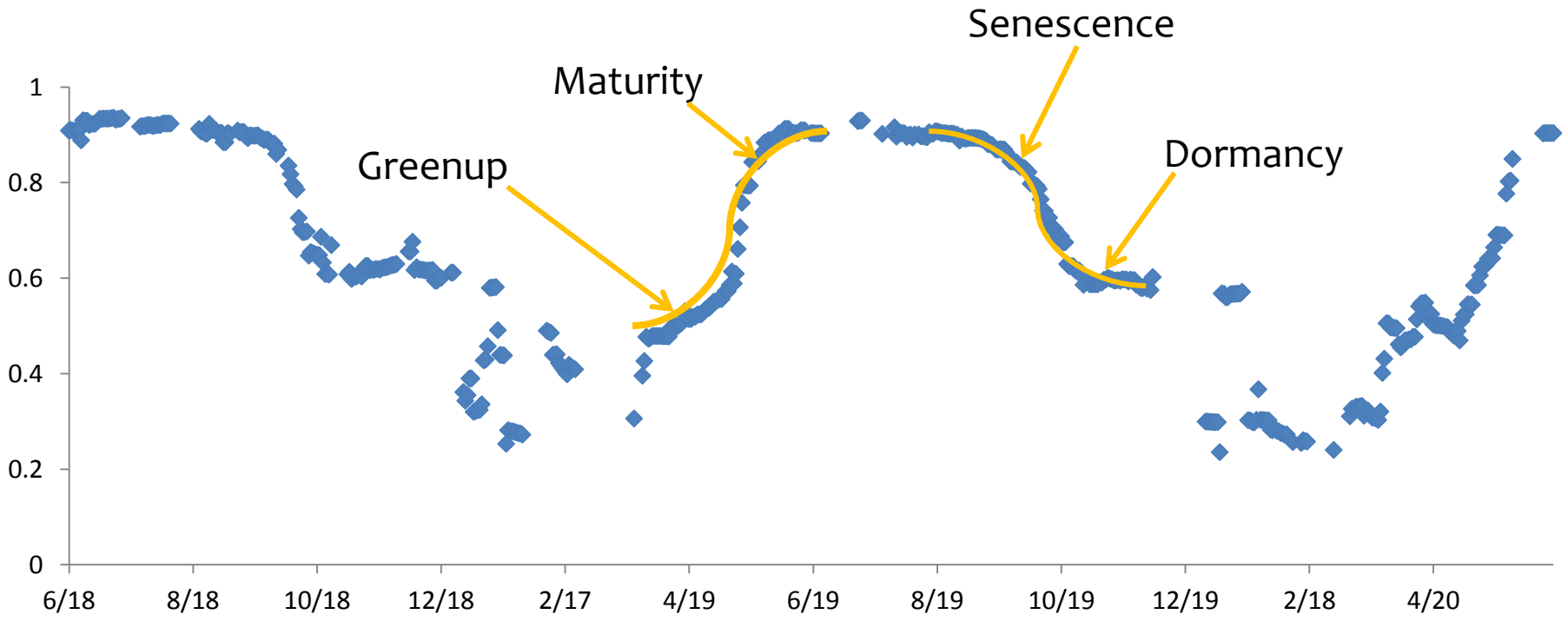


Year 2012 April 14(DOY 105) August 26(DOY 239) November 14(DOY 319)

NBAR: Red, Green, Blue :0.0-0.2

	R	G	B
VIIRS	0.662-0.682	0.545-0.565	0.478-0.488
MODIS	0.620-0.670	0.545-0.565	0.459-0.479

Phenology process



Piecewise Logistic Functions

Zhang, X., Friedl, M. A., Schaaf, C. B., Strahler, A. H., Hodges, J. C. F., Gao, F., … Huete, A. (2003). Monitoring vegetation phenology using MODIS, *84*, 471–475.

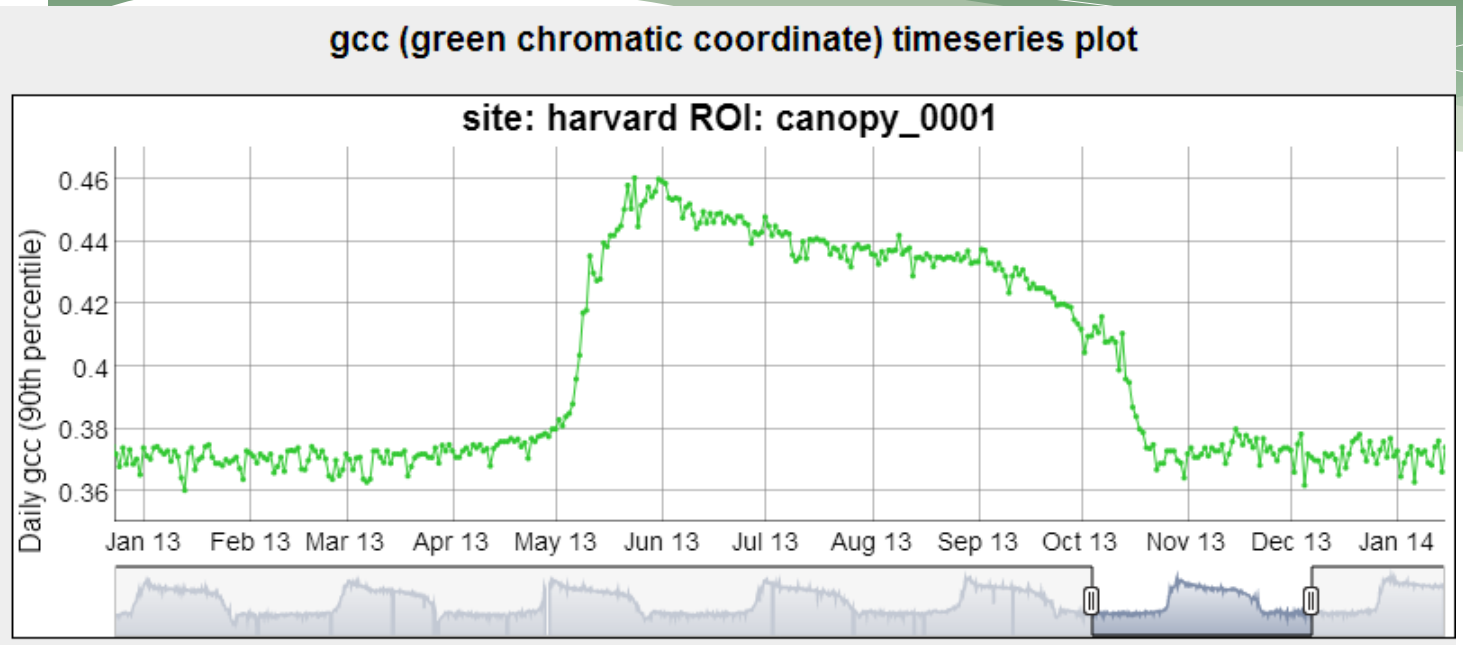
Results at Two PhenoCam sites

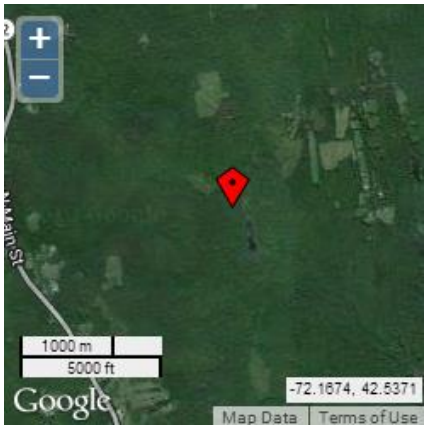
* Harvard forest
  * Location: Harvard Forest, Petersham, MA
  * Lat: 42.5378, Lon: -72.1715, Elev(m): 340
  * Land cover: Temperate deciduous forest
* Tonzi
  * Location: Amador County, California
  * Lat: 38.4309, Lon: -120.9659, Elev(m): 177
  * Land cover: Oak, Savanna, Woodland
* Comparison of VIs from VIIRS, MODIS with gcc from PhenoCam

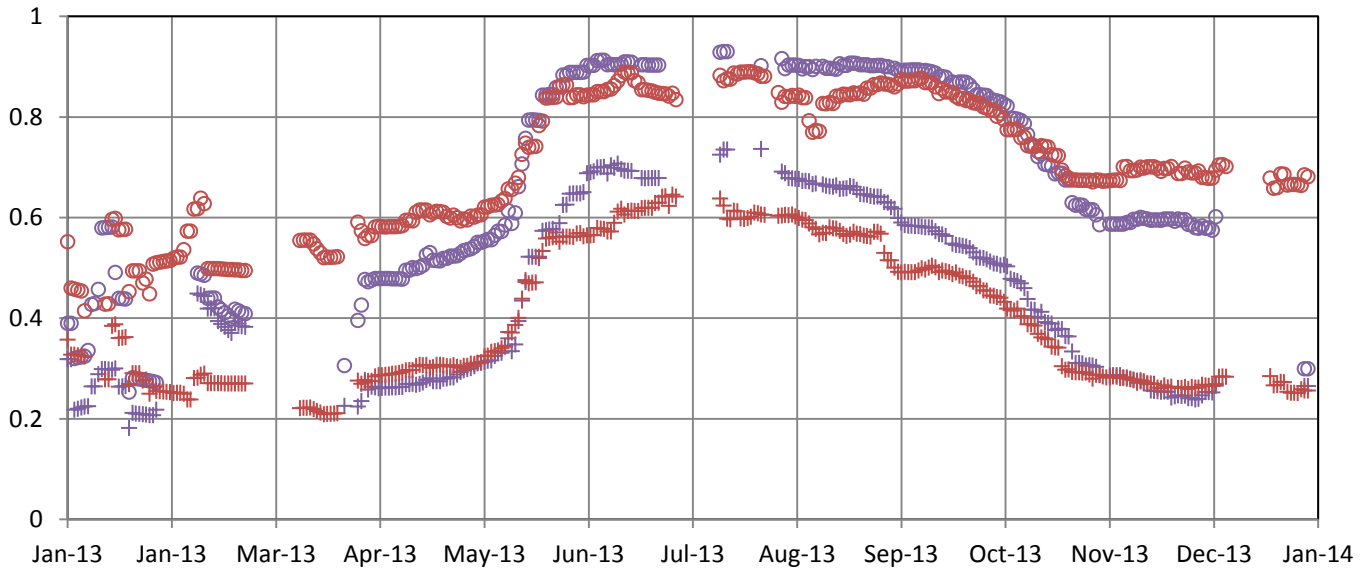
	B	R	NIR
MODIS	0.459-0.479	0.620-0.670	0.841-0.876
VIIRS	0.478-0.488	0.662-0.682	0.846-0.885

Richardson, Andrew D. *Phenocam*. http://phenocam.sr.unh.edu/webcam/

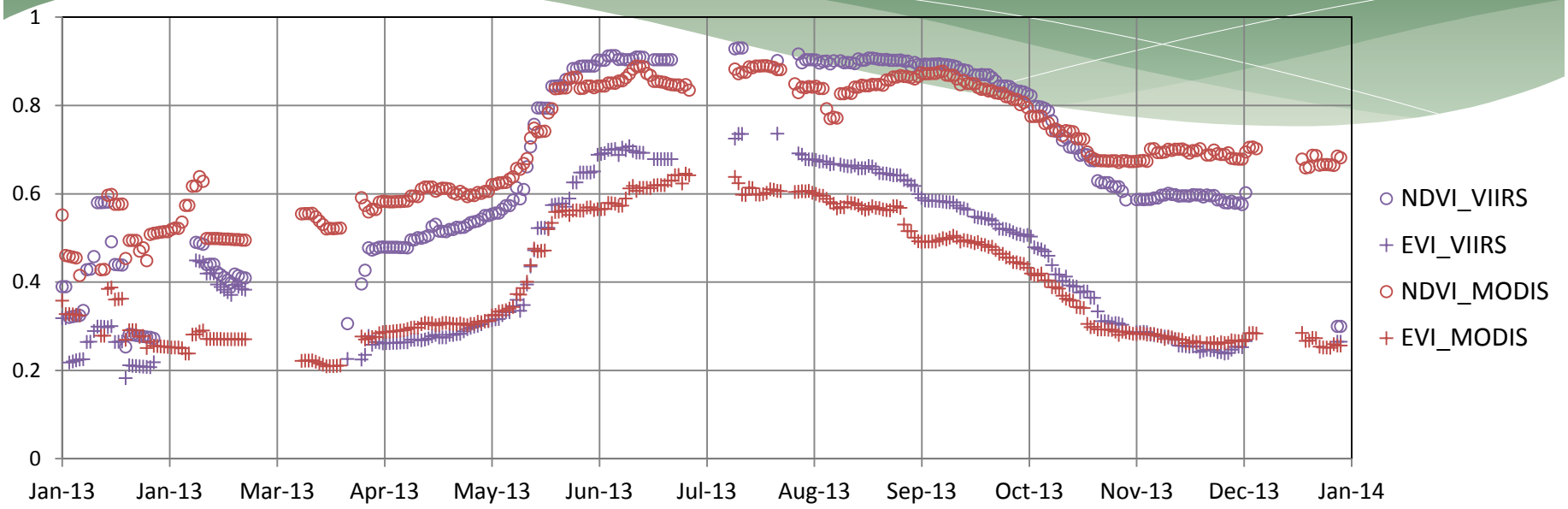
gcc and VIs at PhenoCam Network, Harvard Forest





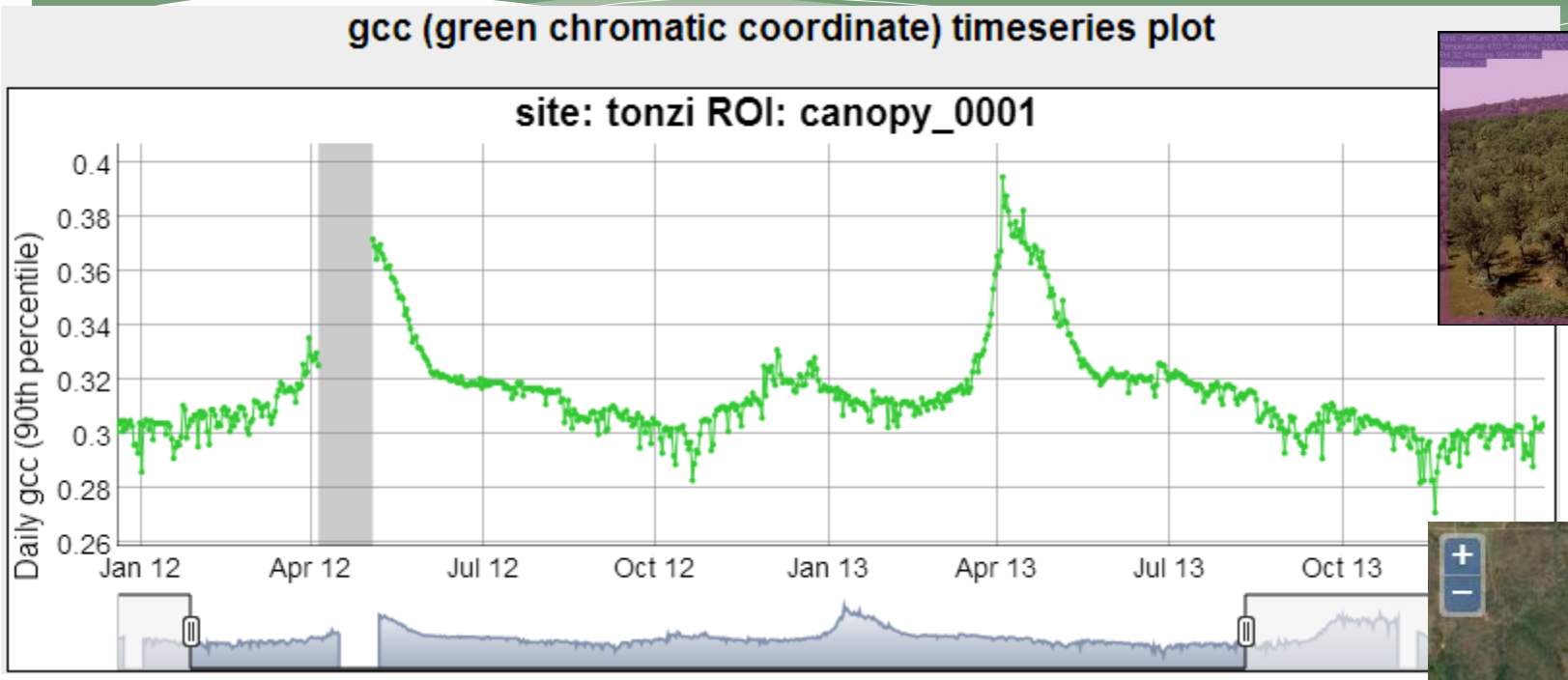


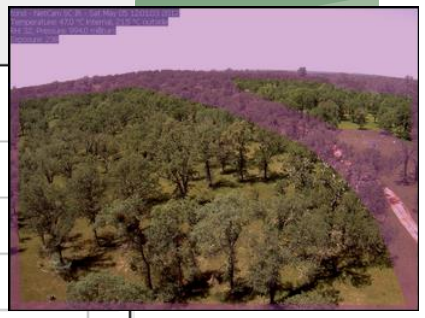
PhenoCam Network, Harvard Forest

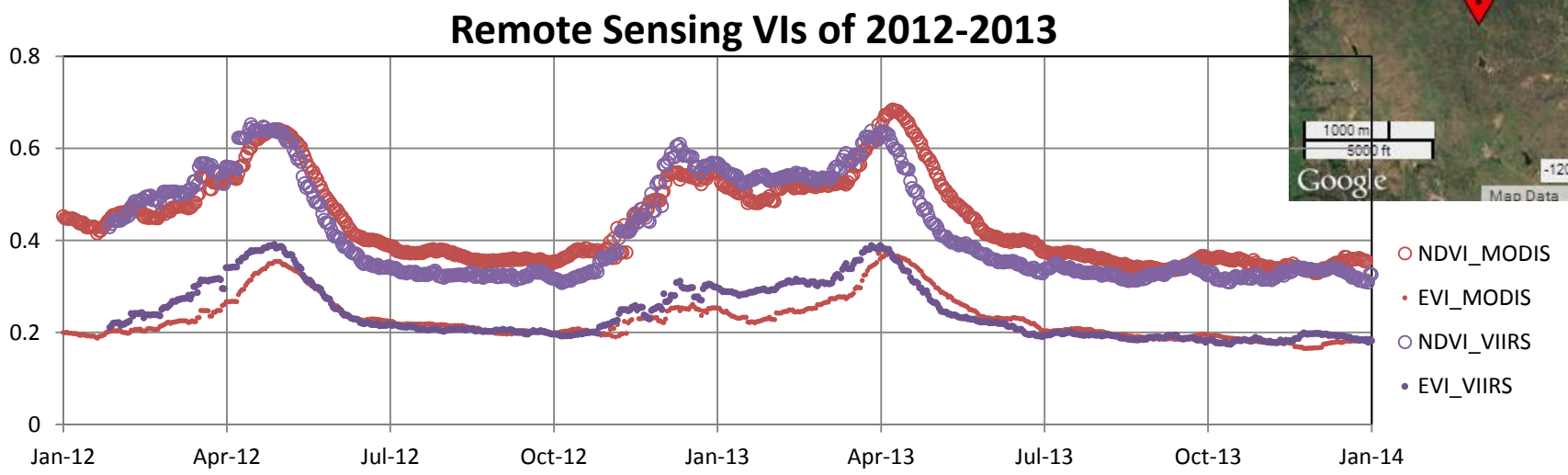


	Greenup	Maturity	Senescence	Dormancy
VIIRS EVI	DOY 109 Apr 19	DOY 178 Jun 27	DOY 206 Jul 25	DOY 307 Nov 3
MODIS EVI	DOY 116 Apr 26	DOY 165 Jun 14	DOY 220 Aug 8	DOY 303 Oct 30
VIIRS NDVI	DOY 129 May 9	DOY 148 May 28	DOY 250 Sep 7	DOY 301 Oct 28
MODIS NDVI	DOY 133 May 13	DOY 149 May 29	DOY 252 Sep 9	DOY 291 Oct 18

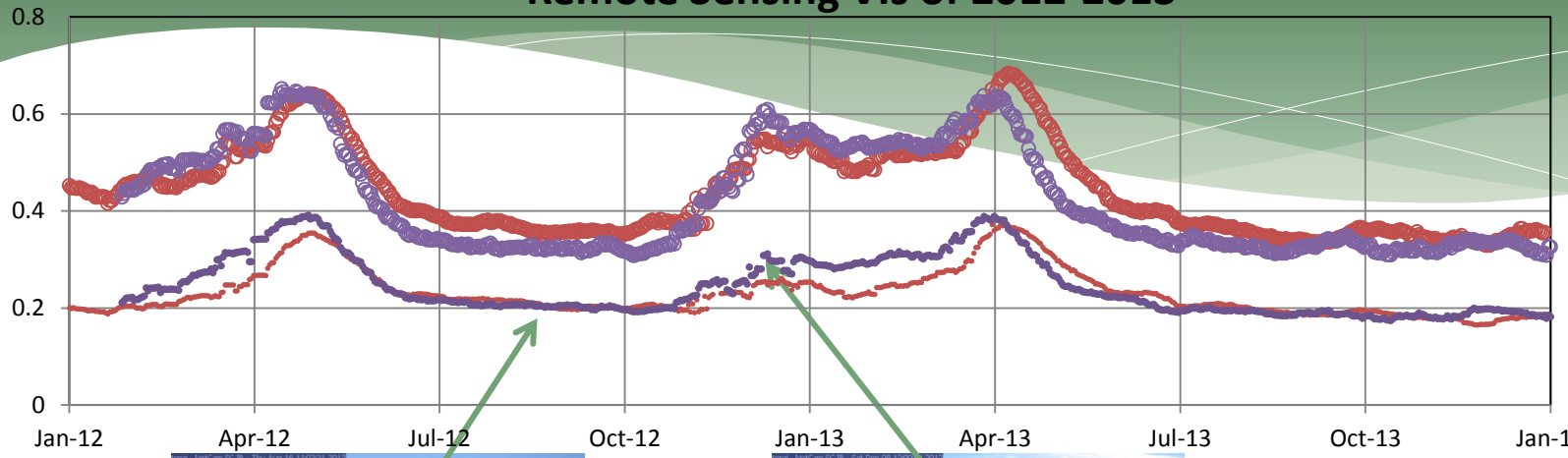
GCC and VIs at PhenoCam Network, Tonzi

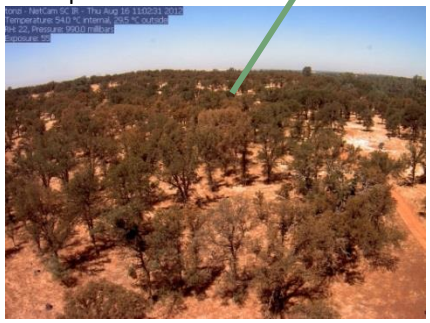






Remote Sensing VIs of 2012-2013





PhenoCam Network, Tonzi
Moisture limited

	Greenup	Maturity	Senescence	Dormancy
VIIRS EVI	2012 DOY 282 2012 Oct 09	DOY 81 Mar 21	DOY 100 Apr 10	DOY 163 Jun 12
MODIS EVI	2012 DOY 290 2012 Oct 15	DOY 89 Mar 29	DOY 106 Apr 16	DOY 187 Jul 06
VIIRS NDVI	2012 DOY 283 2012 Oct 09	DOY 88 Mar 28	DOY 107 Apr 17	DOY 156 Jun 07
MODIS NDVI	2012 DOY 278 2012 Oct 04	DOY 94 Apr 3	DOY 100 Apr 10	DOY 167 Jun 16

Conclusion

* VIIRS can continue the data record of MODIS for phenology monitoring;
* Daily full inversions guarantee more accurate phenology estimation;
* Coarse pixels are usually mixed pixels; Spatially averaged data misses some of the dramatic change as compared to PhenoCam;
* EVI detects greenup well while NDVI is better at detecting fall senescence.
  * EVI is more sensitive to GPP and chlorophyll-containing foliage then yellow or orange pigments.