Assessment of Coarse and Medium Resolution Land Surface Phenology Products Using Multiple Sources of Independent Data

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Land Surface Phenology Products

- **Collection 6 MODIS Land Cover Dynamics (MCD12Q2) Product**
  - 500 m spatial resolution
  - 2001 - Present

- **Landsat Phenology Algorithm**
  - Entire Landsat Archive
  - 30 m spatial resolution
  - 1984 – Present

- **Multisource Land Surface Phenology (MS-LSP)**
  - Harmonized Landsat Sentinel (HLS) data
    - 3-5 day revisit
  - 30 m spatial resolution
  - 2015 - Present

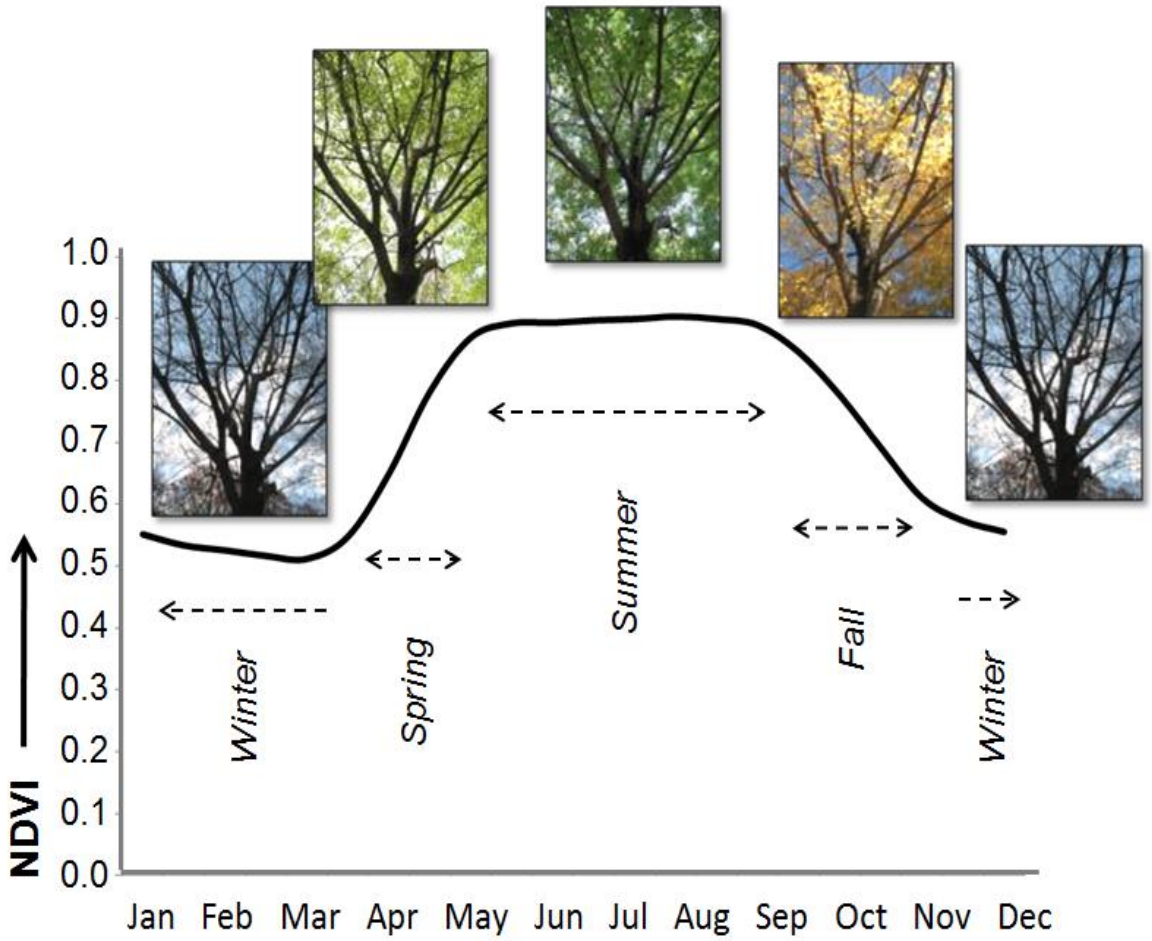


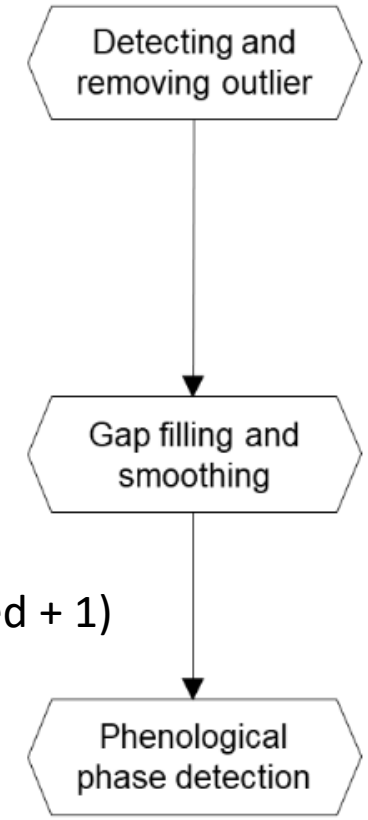
image credit: Bill Hargrove (ForWarn)

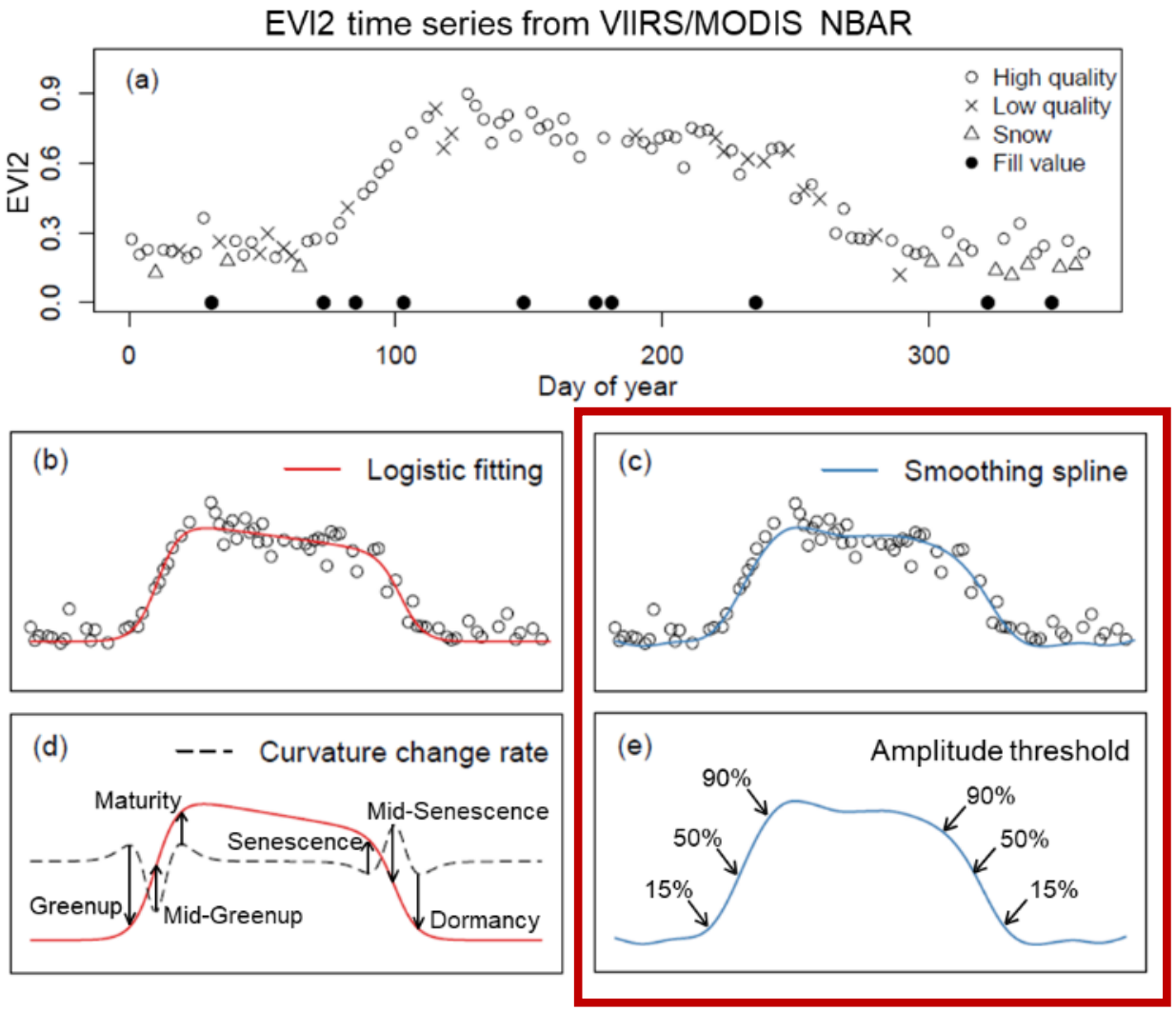
Collection 6 MODIS Land Cover Dynamics

MODIS algorithm now using splines instead of logistic fits

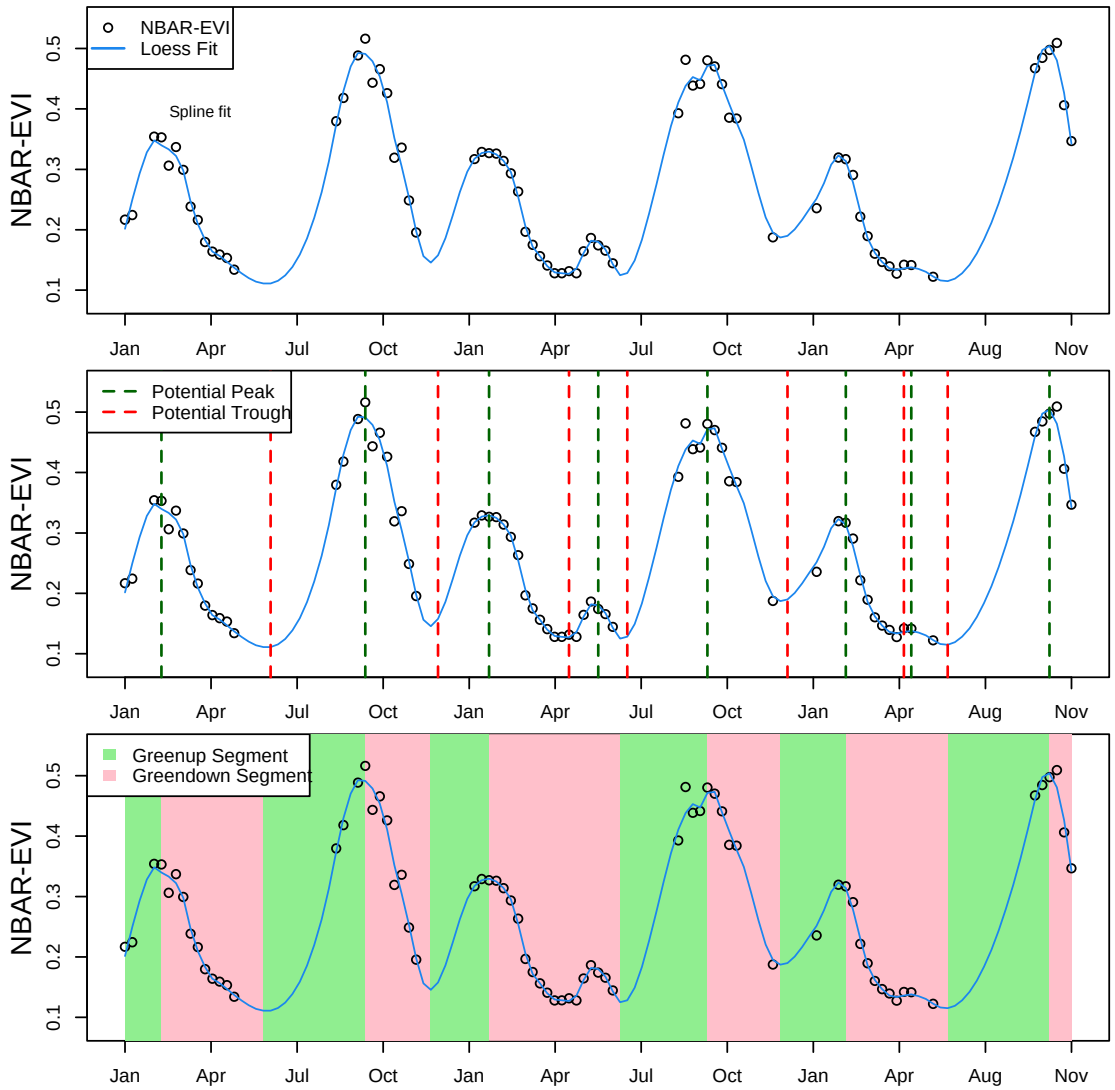
- Allows for more flexibility on curve shape

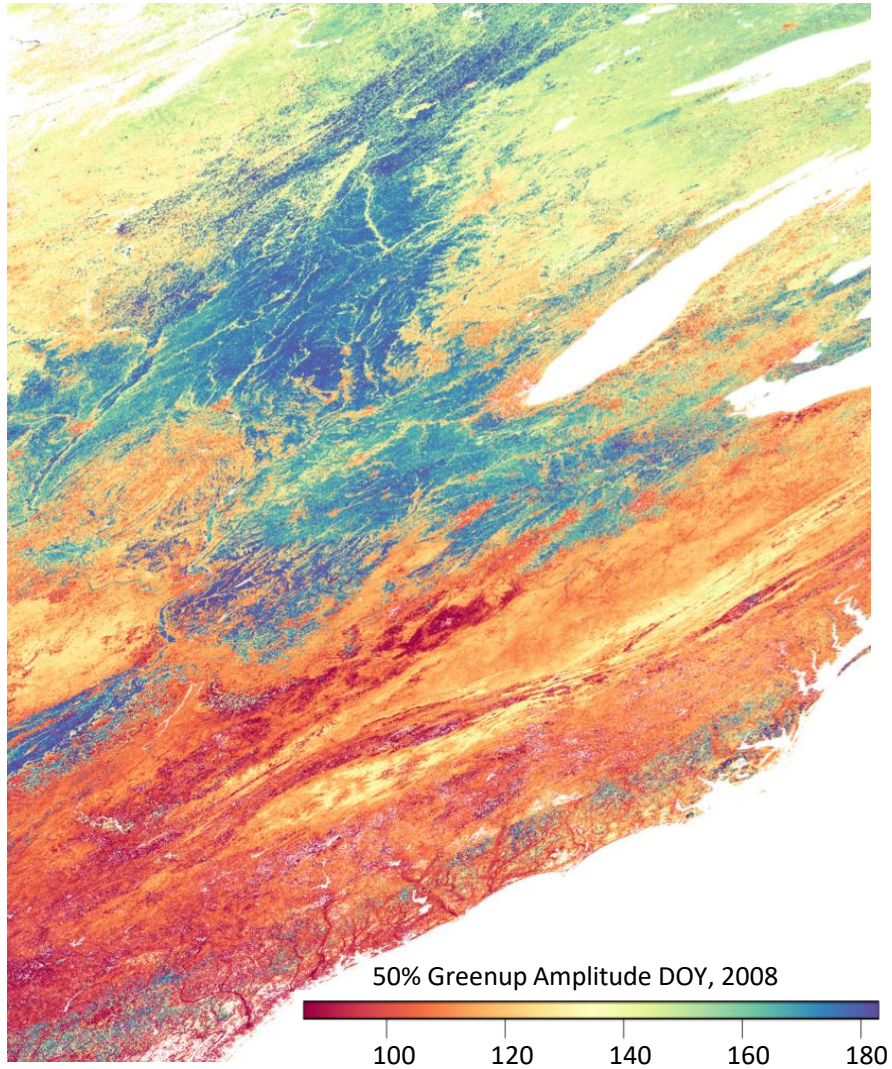
EVI2 = 2.5*(nir - red) / (nir + 2.4*red + 1)



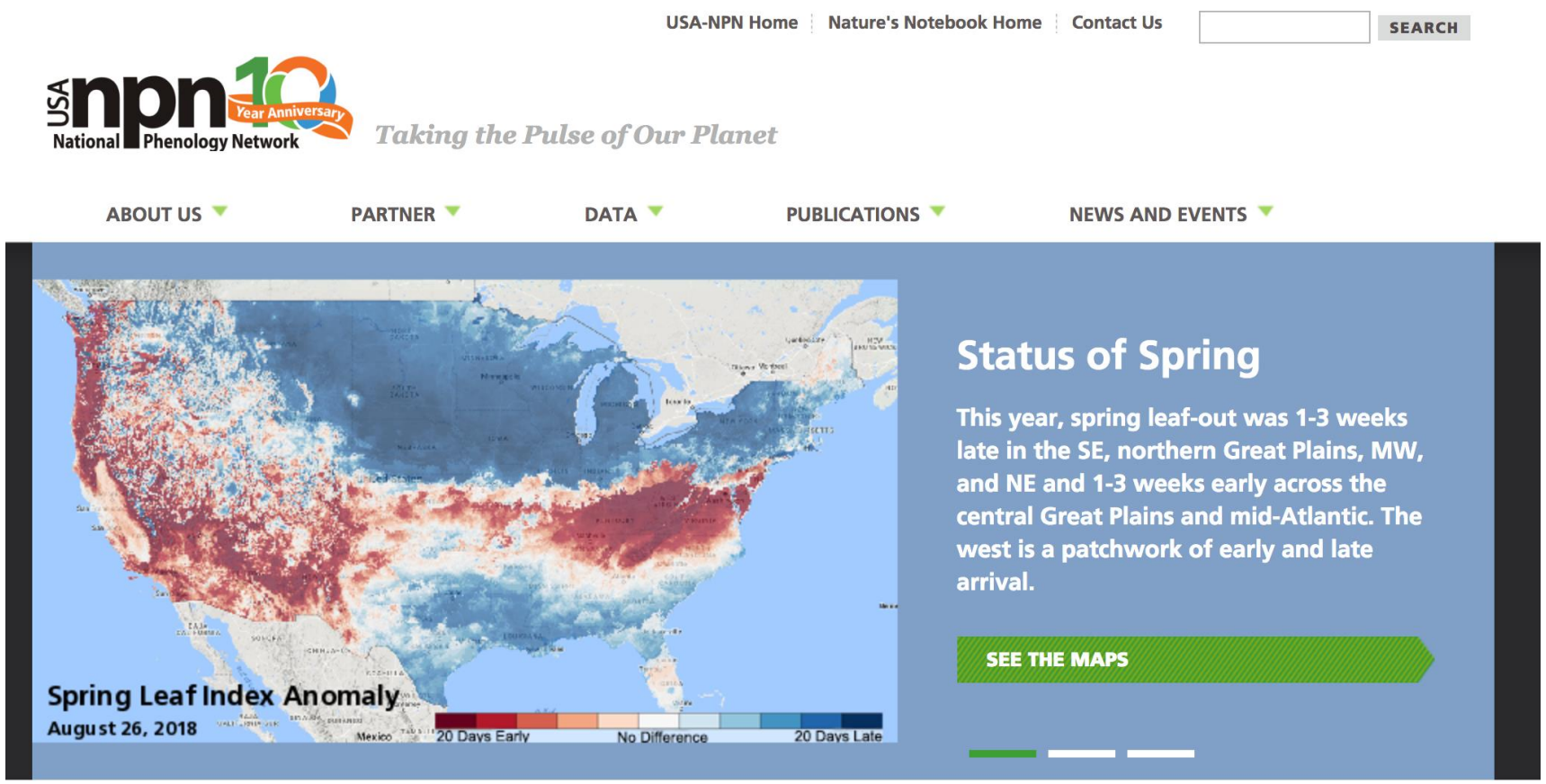


Collection 6 MODIS Land Cover Dynamics





Collection 6 MODIS Land Cover Dynamics



Talk on Friday at 2:40 PM:

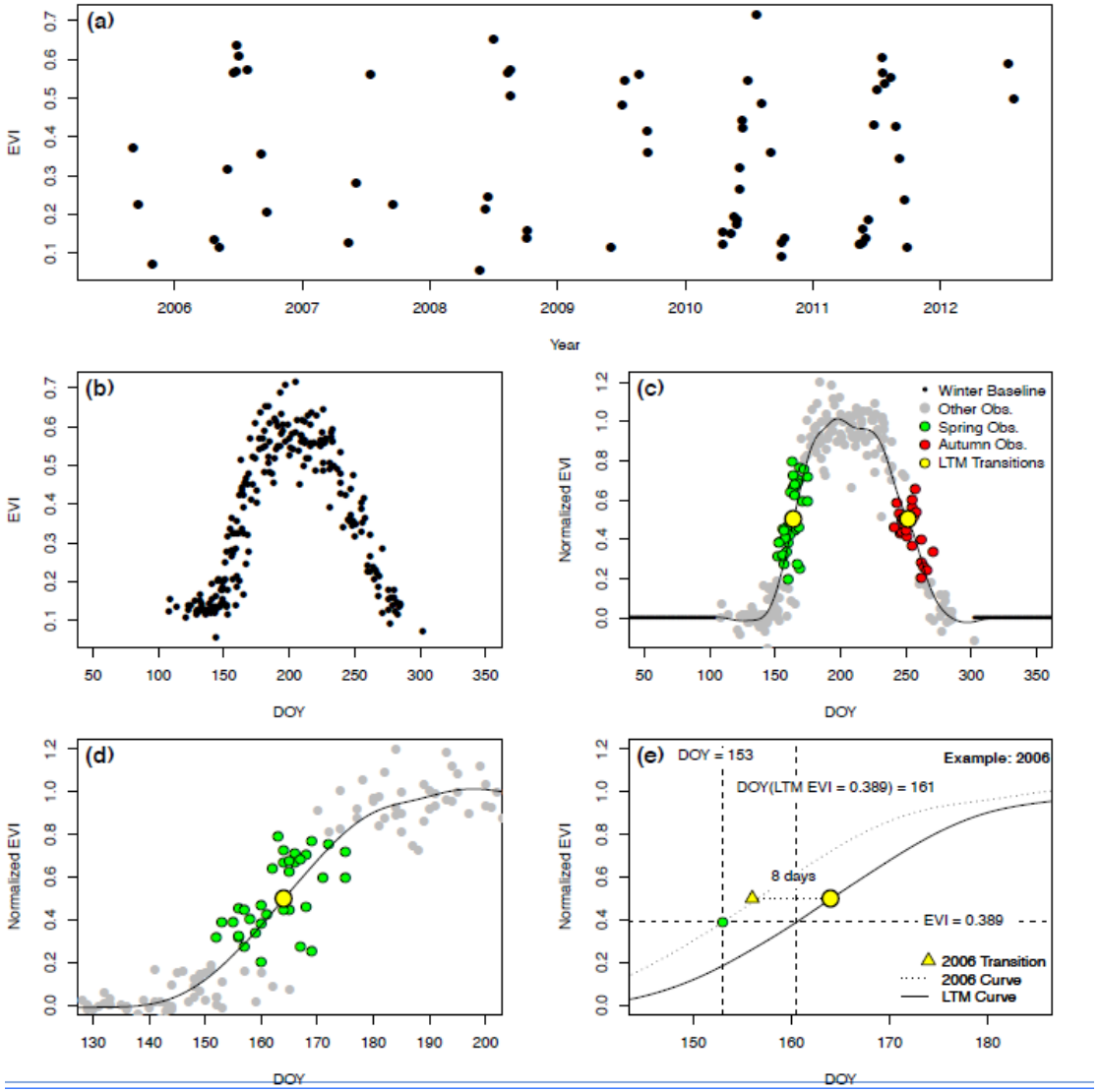
Josh M Gray et al. - B53C-05: USA-NPN Observations Reveal the Ecological Relevance of Remotely Sensed Phenology
Walter E Washington Convention Center - 147B

Landsat Phenology Algorithm

- Moving to finer spatial resolution
  - 500m to 30 m

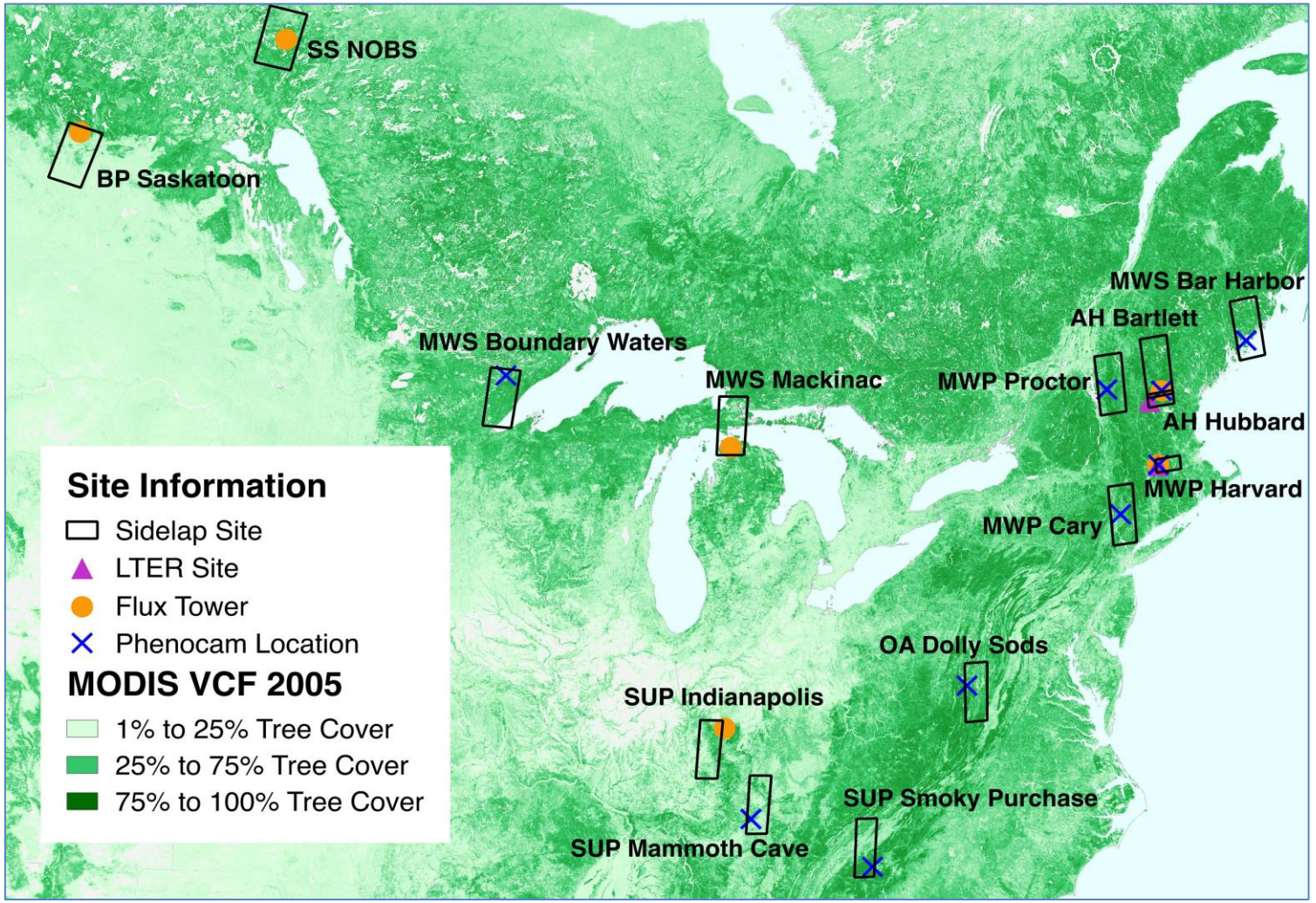
- Until recently, temporal frequency too low to fit curves annually at Landsat resolution

- Instead, looks for deviations from average phenology



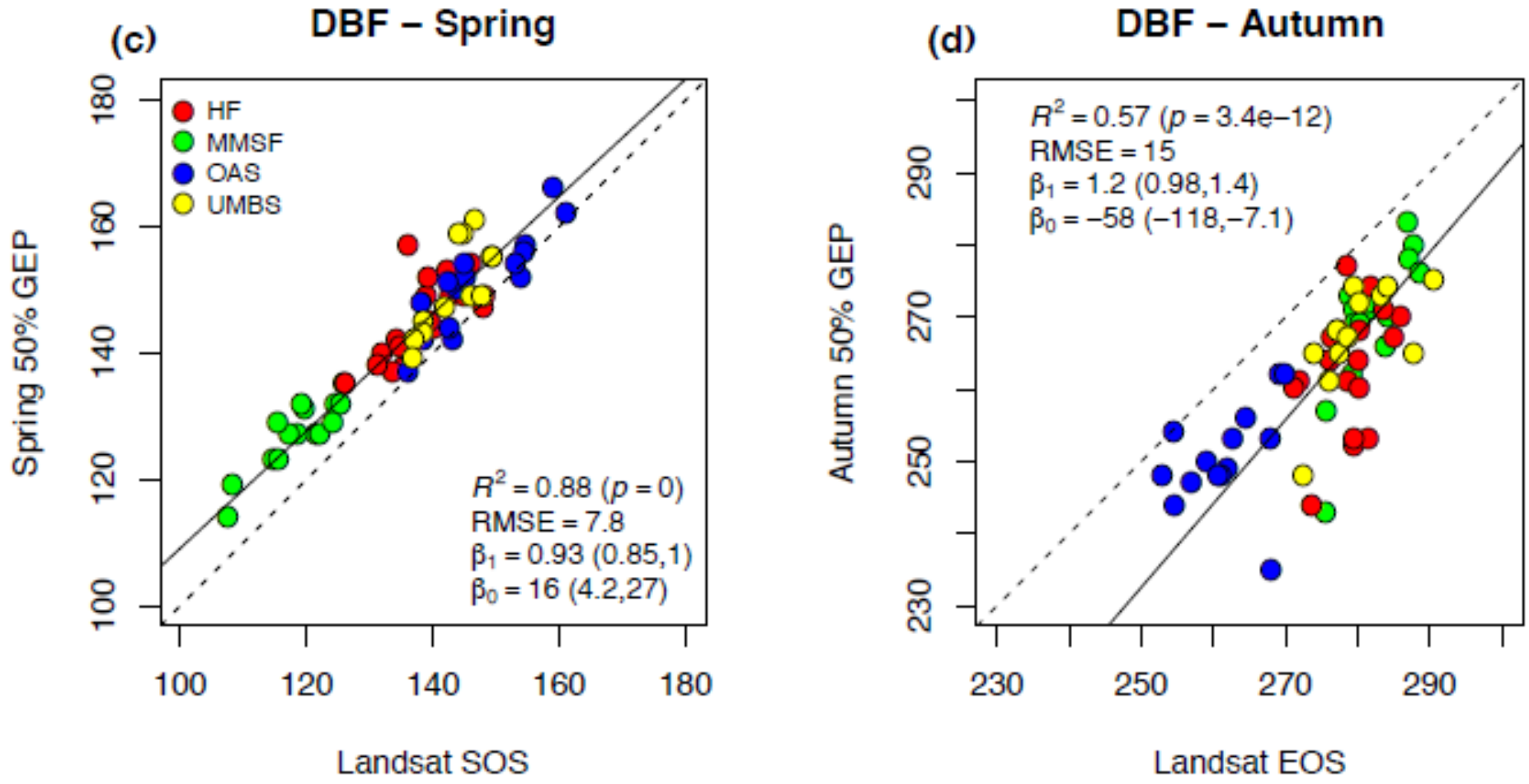
Landsat Phenology Algorithm

- Assessing start of season and end of season from Landsat
  - 14 Sites, Mix of data sources
    - Flux towers
    - Phenocams
    - Long Term Ecological Research (LTER) sites



Landsat Phenology Algorithm

Compare against flux data:

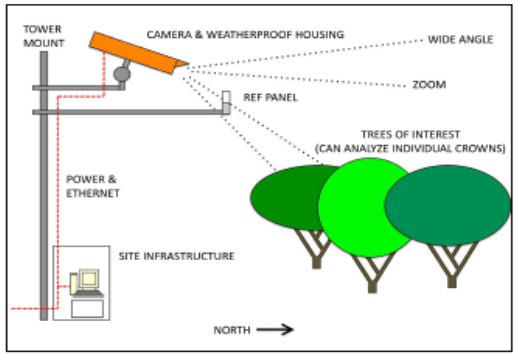


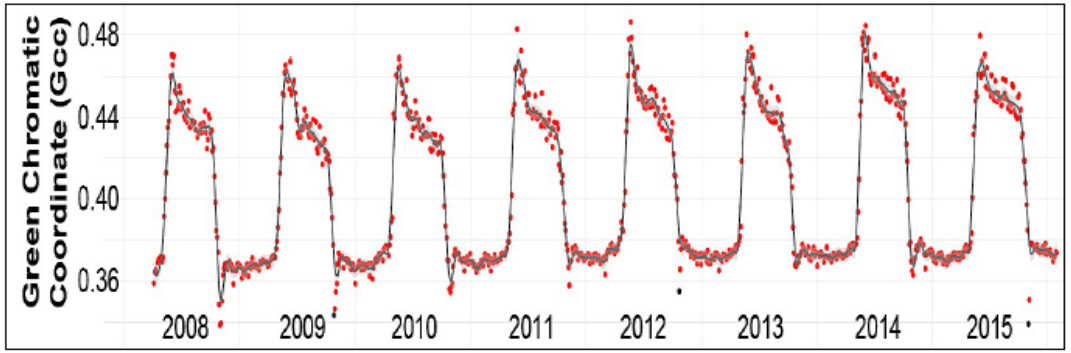
Landsat Phenology Algorithm

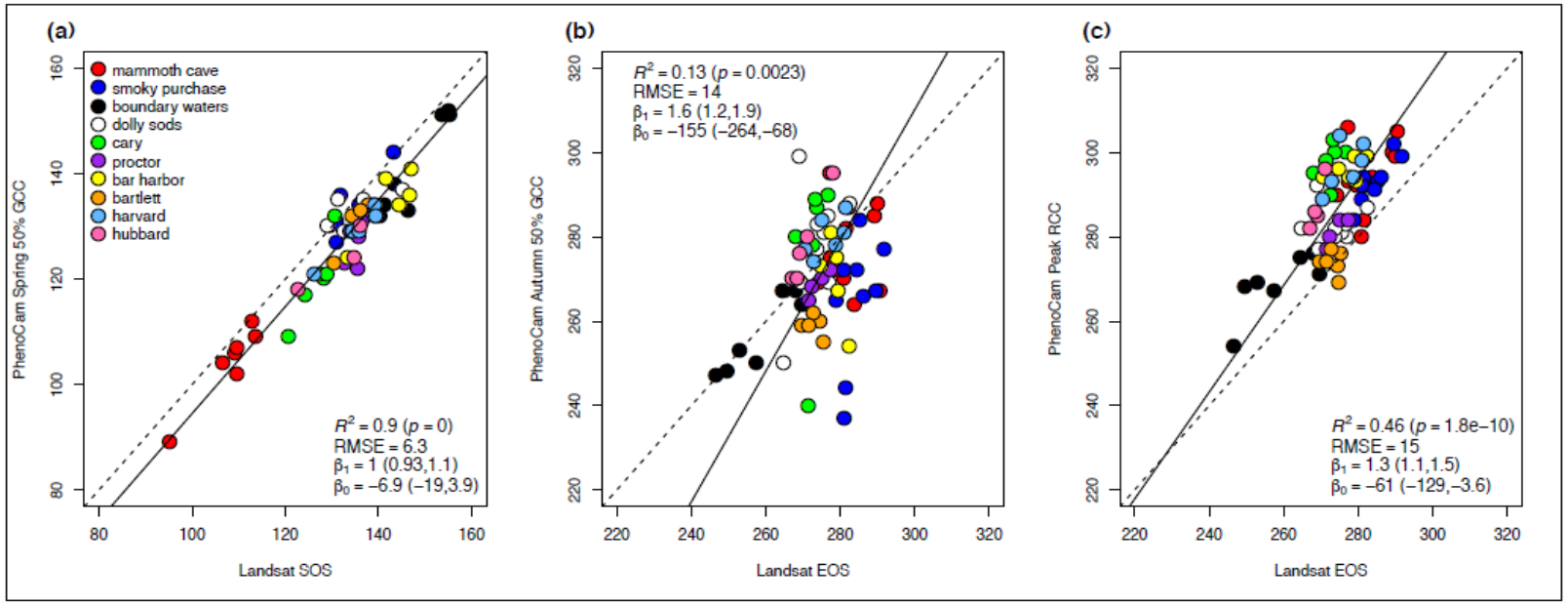
Compare against phenocams:

$$GCC = G / (R+G+B)$$

$$RCC = R / (R+G+B)$$



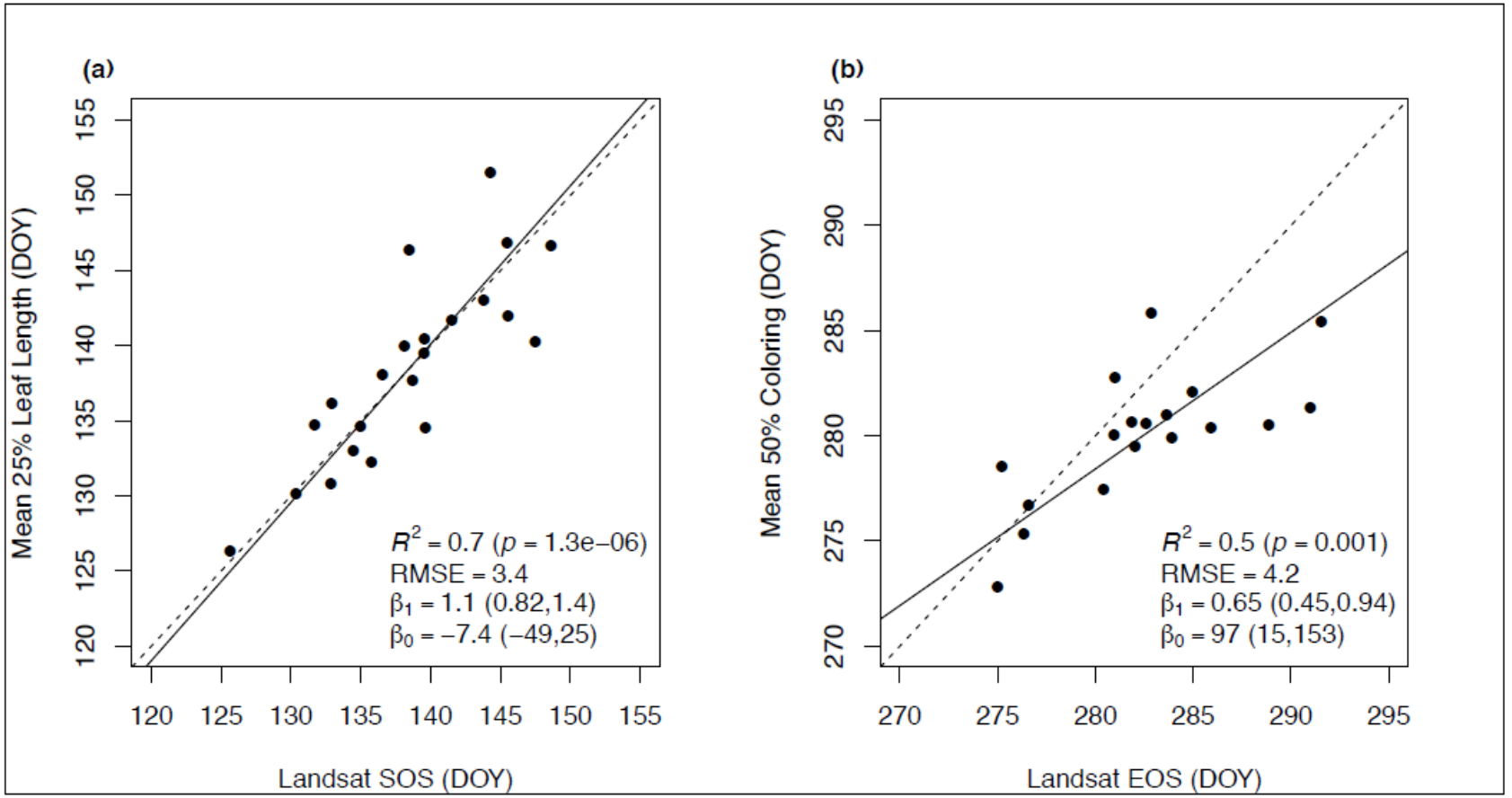




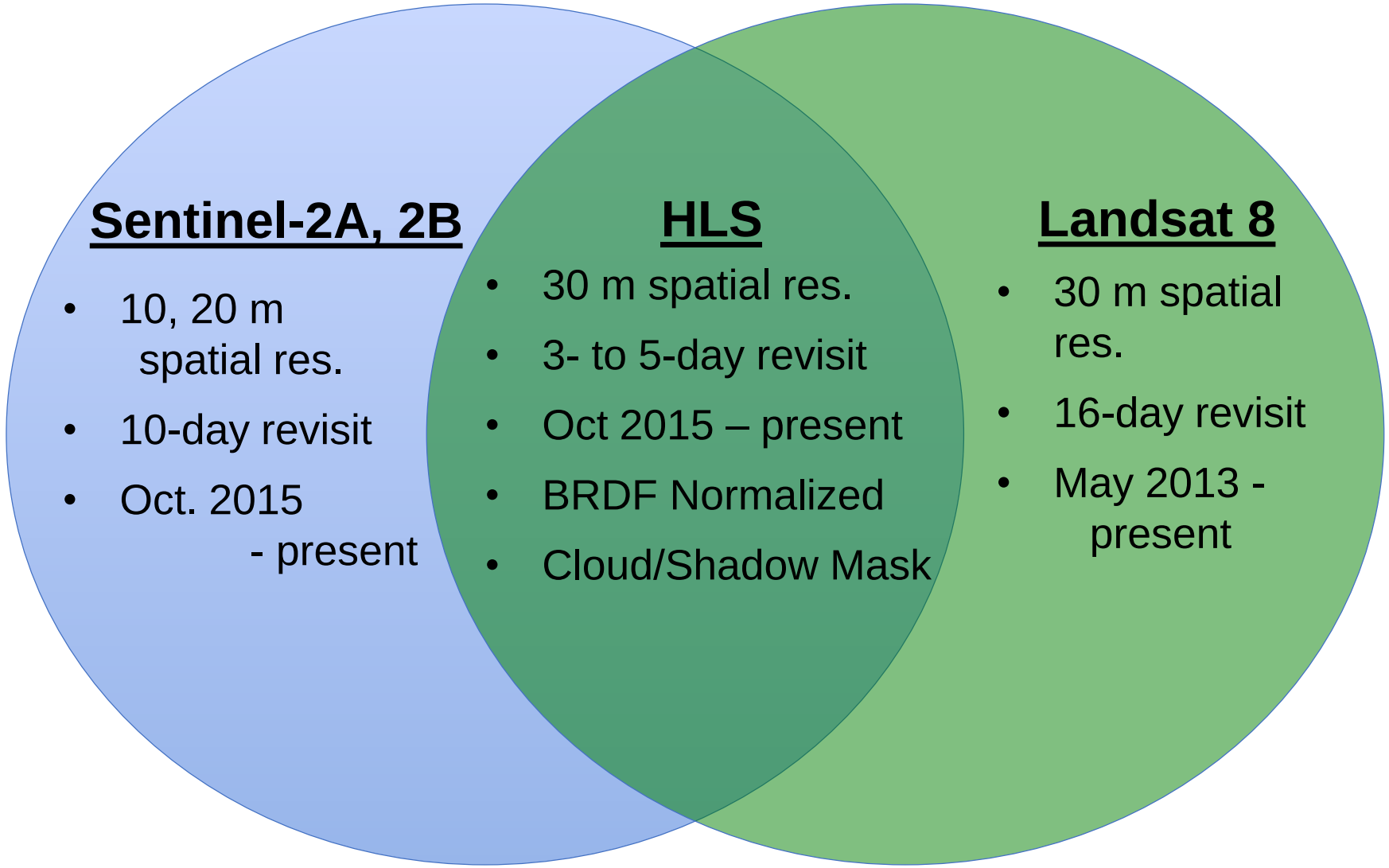
Landsat Phenology Algorithm

Compare against ground data:

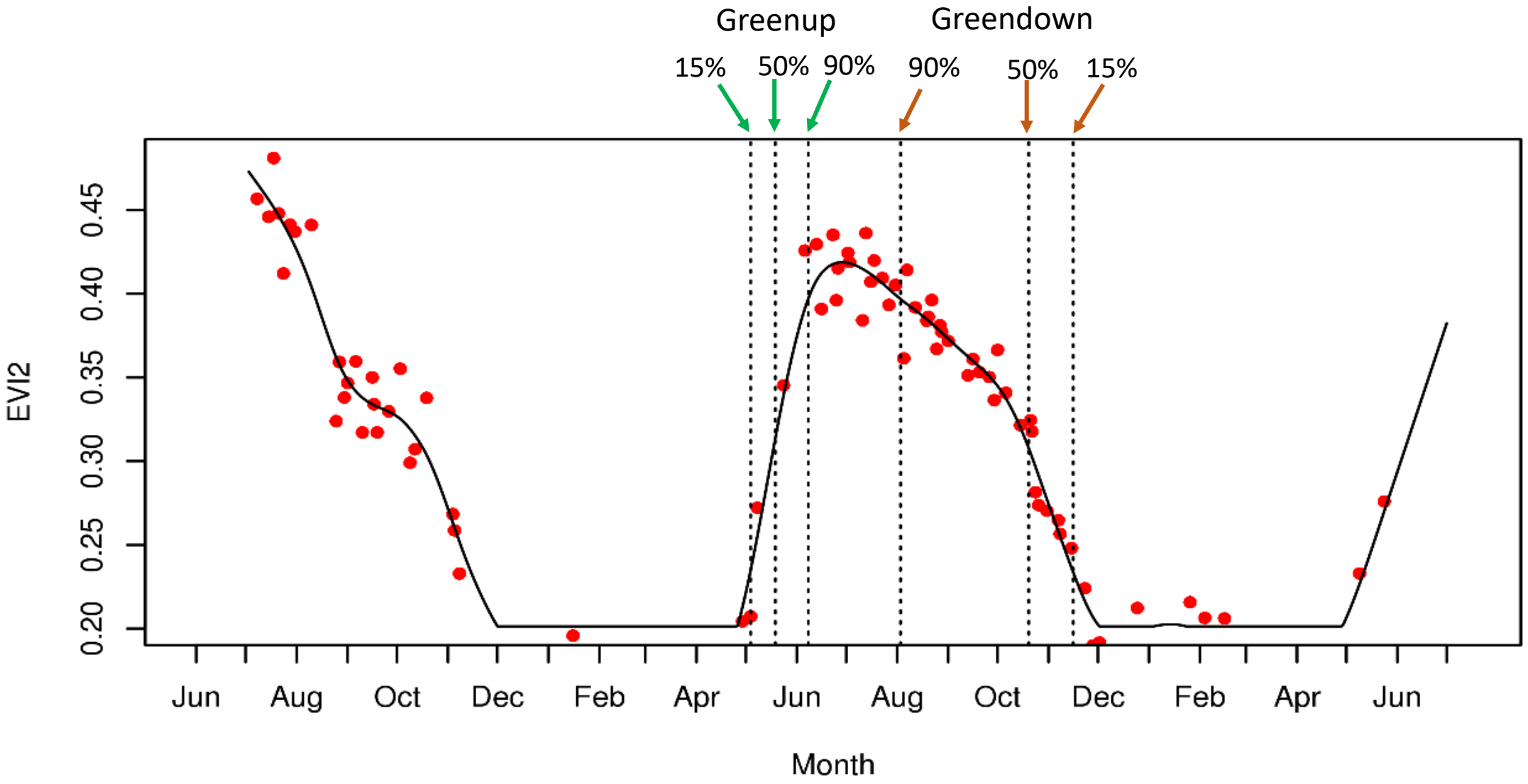
- Surveys of budburst, leaf coloring, and leaf fall



Harmonized Landsat Sentinel-2 (HLS)

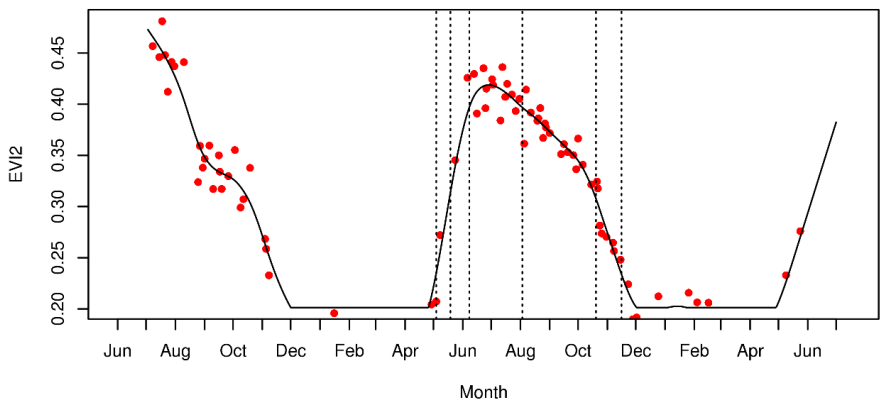


Multisource Land Surface Phenology (MS-LSP)



Multisource Land Surface Phenology (MS-LSP)

Distributed via LP-DAAC

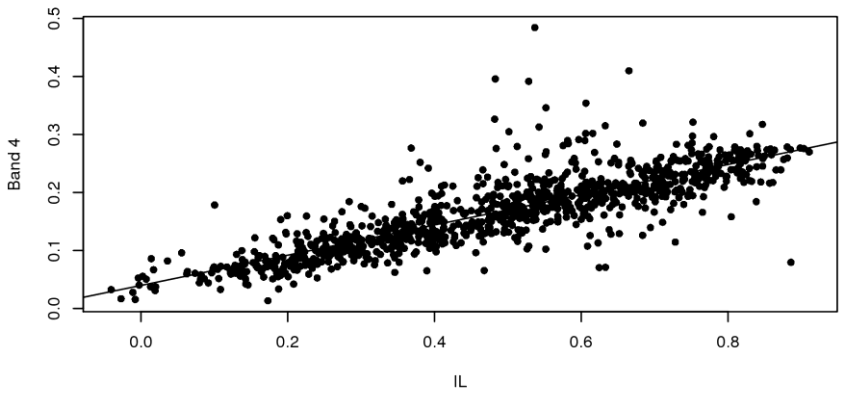


Science Data Set	SDS Description
Phenological Timing Metrics	
Onset Greenness Increase (OGI)	Date, number of days from Reference Date
50 Percent Greenness Increase (50PCGI)	Date, number of days from Reference Date
Onset Greenness Maximum (OGMx)	Date, number of days from Reference Date
Onset Greenness Decrease (OGD)	Date, number of days from Reference Date
50 Percent Greenness Decrease (50PCGD)	Date, number of days from Reference Date
Onset Greenness Minimum (OGMn)	Date, number of days from Reference Date
Integrated Greenness	Sum of daily EVI during growing season
HLS Reflectance Metrics	
HLS Reflectance on OGI Date	Bands 1-6 HLS surface reflectance on OGI date
HLS Reflectance on 50PCGI Date	Bands 1-6 HLS surface reflectance on 50PCGI date
HLS Reflectance on OGMx Date	Bands 1-6 HLS surface reflectance on OGMx date
HLS Reflectance on OGD Date	Bands 1-6 HLS surface reflectance on OGD date
HLS Reflectance on 50PCGD Date	Bands 1-6 HLS surface reflectance on 50PCGD date
HLS Reflectance on OGMn Date	Bands 1-6 HLS surface reflectance on OGMn date
LSP Mean and Anomaly Metrics	
Long Term Weekly Mean EVI	Average EVI across available years, at 7-day time steps; Available in 2019.
Weekly EVI Anomaly	In-season anomaly in EVI, relative to long-term mean, at 7-day time steps; Available in 2019.
Cumulative EVI Growing Season Anomaly	Sum of anomalies in daily interpolated EVI versus long-term mean at each pixel; Available in 2019.

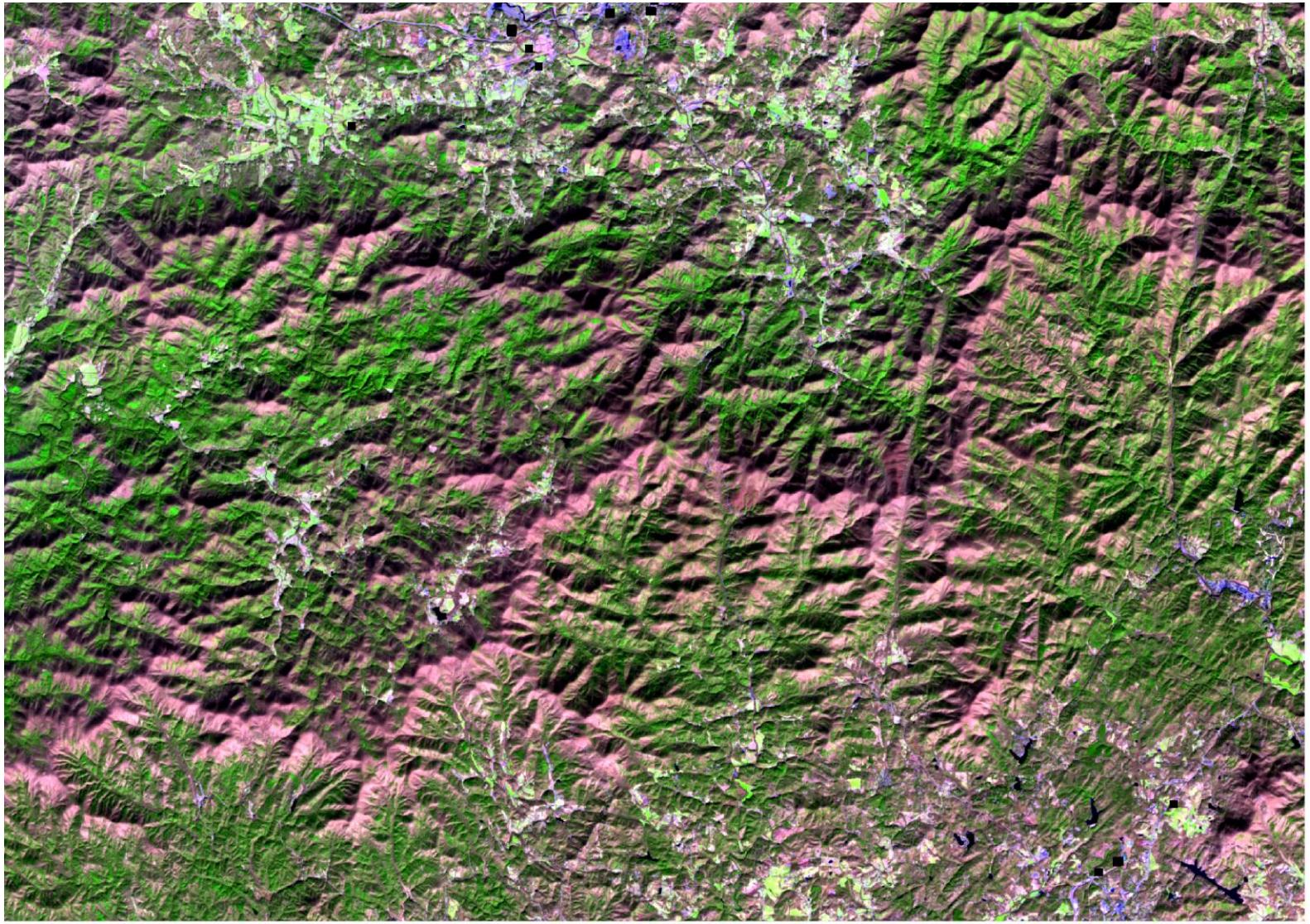
Topographic correction of imagery

Topographic correction of imagery

Illumination vs Band 4 reflectance



Tan et al. 2013 – Rotational Correction

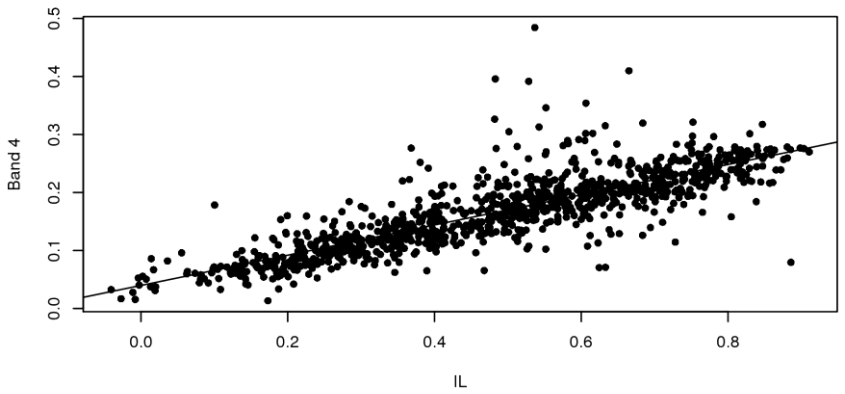


Jan 25, 2017 image

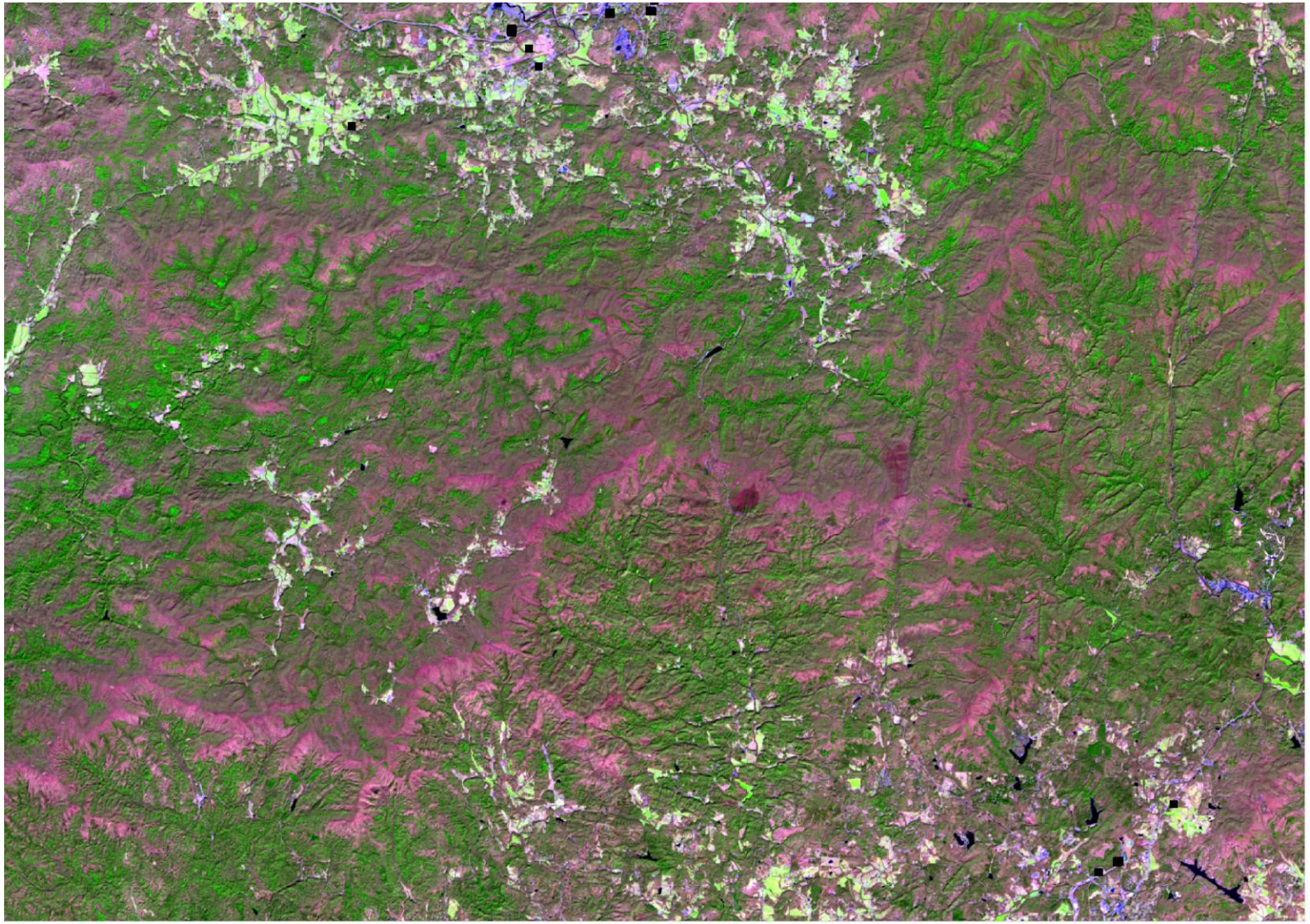
Topographic correction of imagery

Topographic correction of imagery

Illumination vs Band 4 reflectance



Tan et al. 2013 – Rotational Correction



Jan 25, 2017 image

Topographic correction of imagery

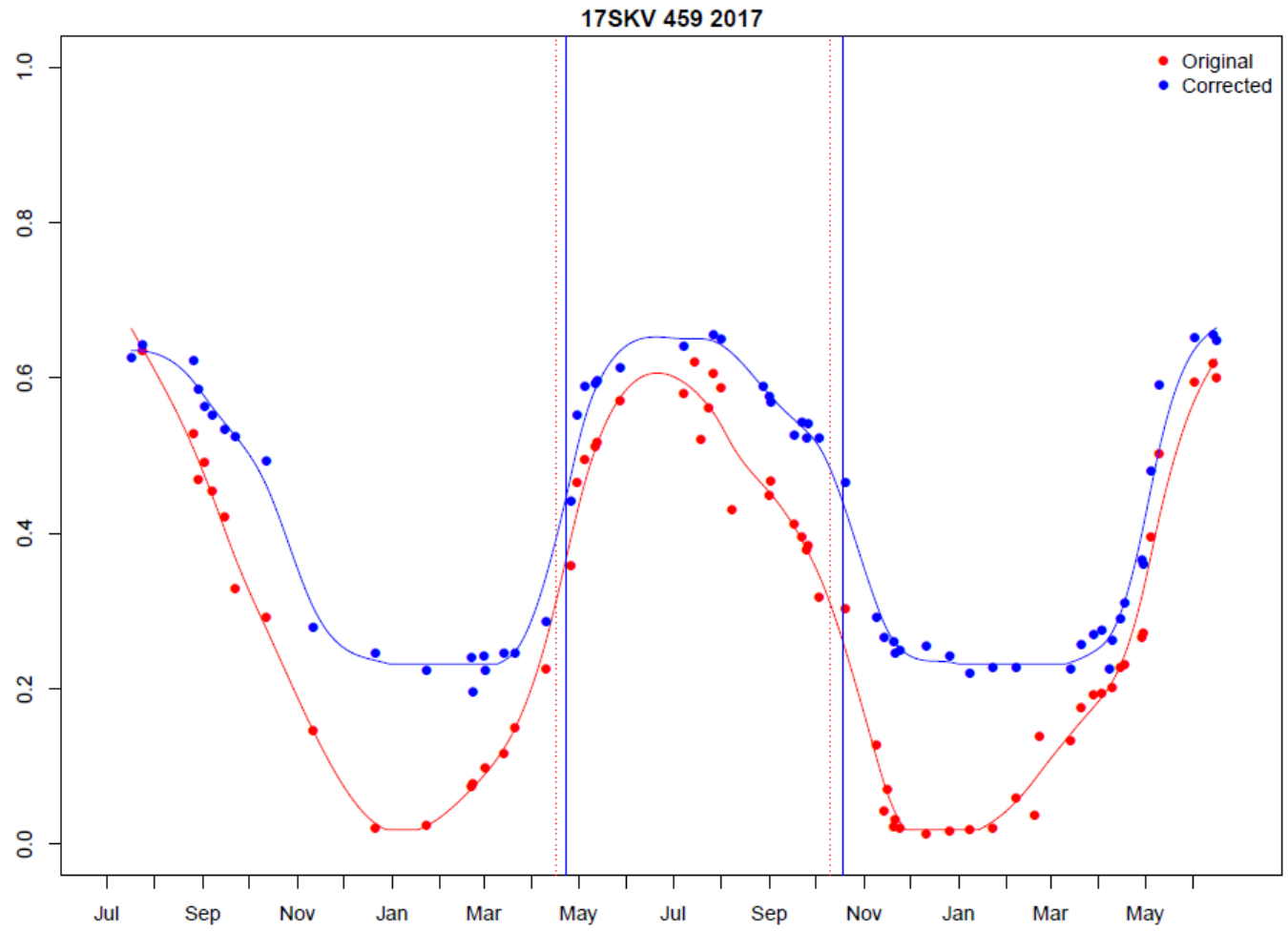
North facing deciduous forest pixel

More realistic EVI amplitude after correction

One week shift in 50% amplitude dates

Difficult to validate!

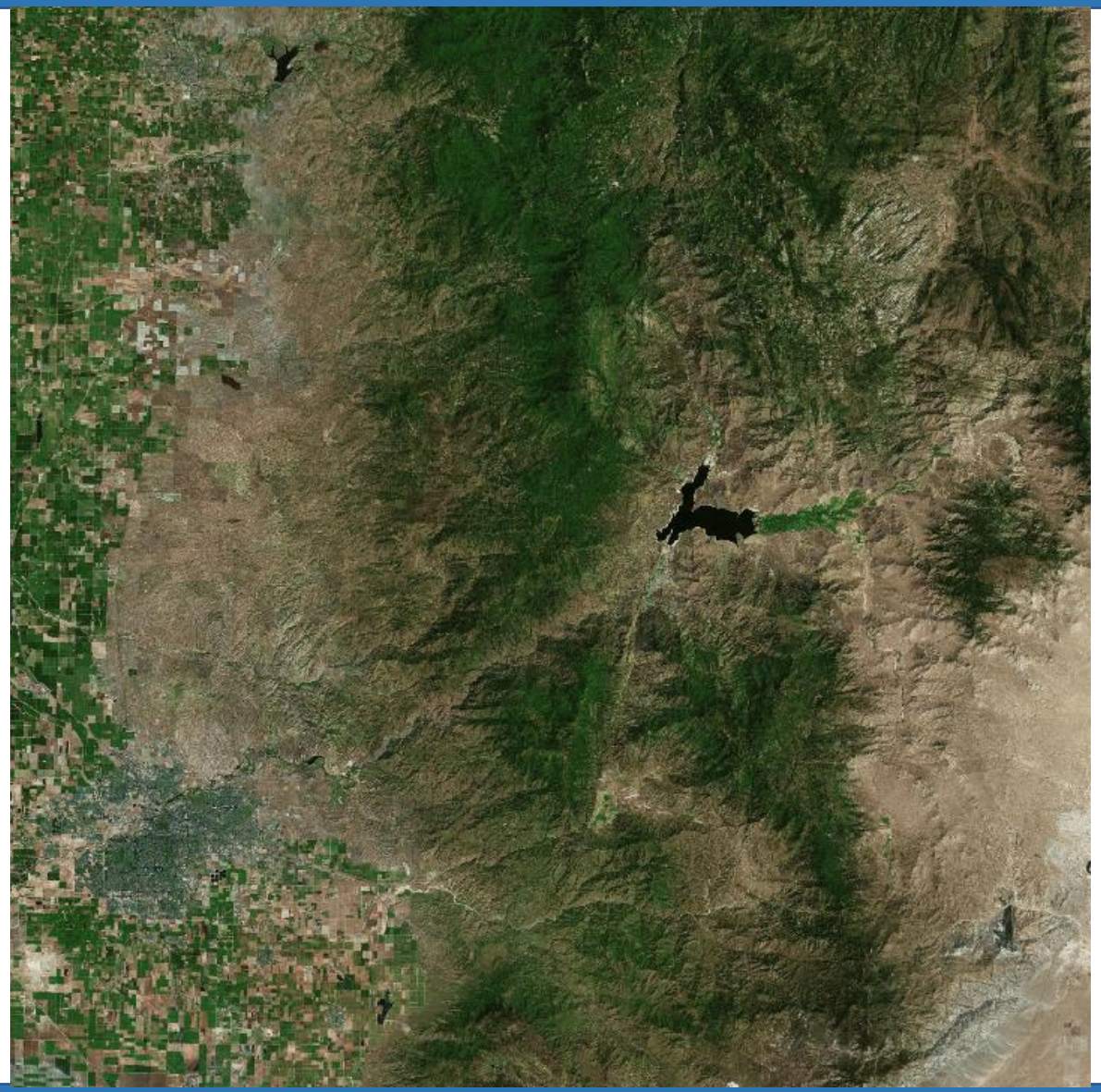
We don't have a sample of phenoCams on north and south facing slopes



Multisource Land Surface Phenology (MS-LSP)

Date of 50%
EVI2 increase

Bakersfield, CA



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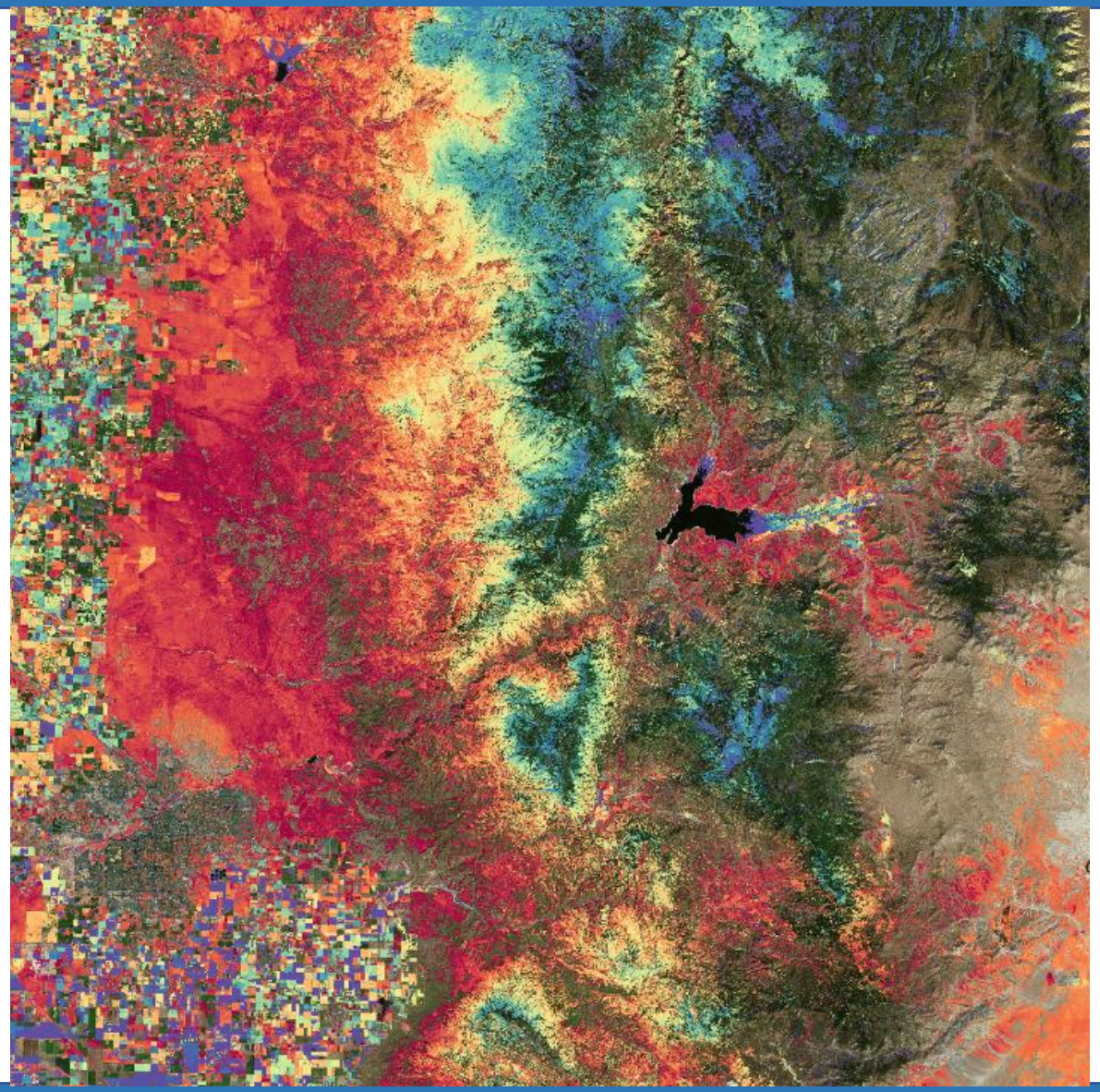
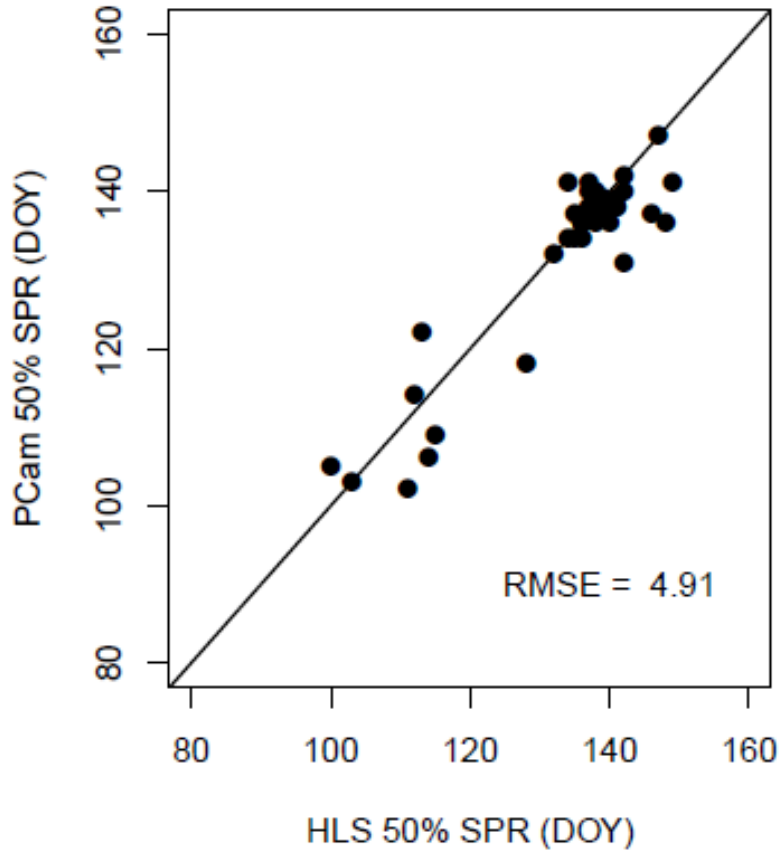
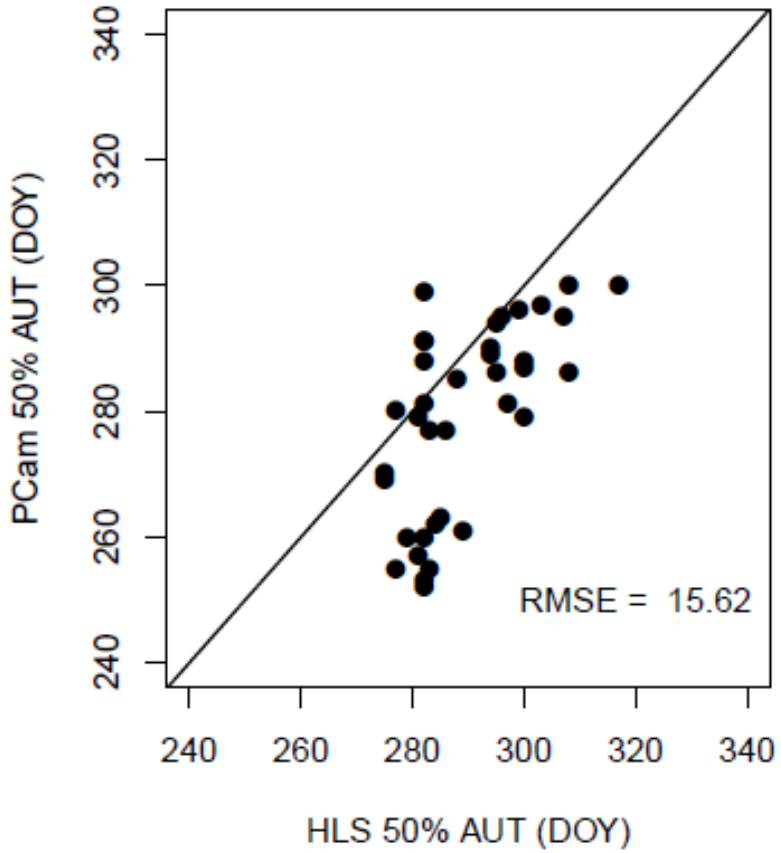


Day of year –
50% greenup

0
40
80
120
>160

Multisource Land Surface Phenology (MS-LSP)





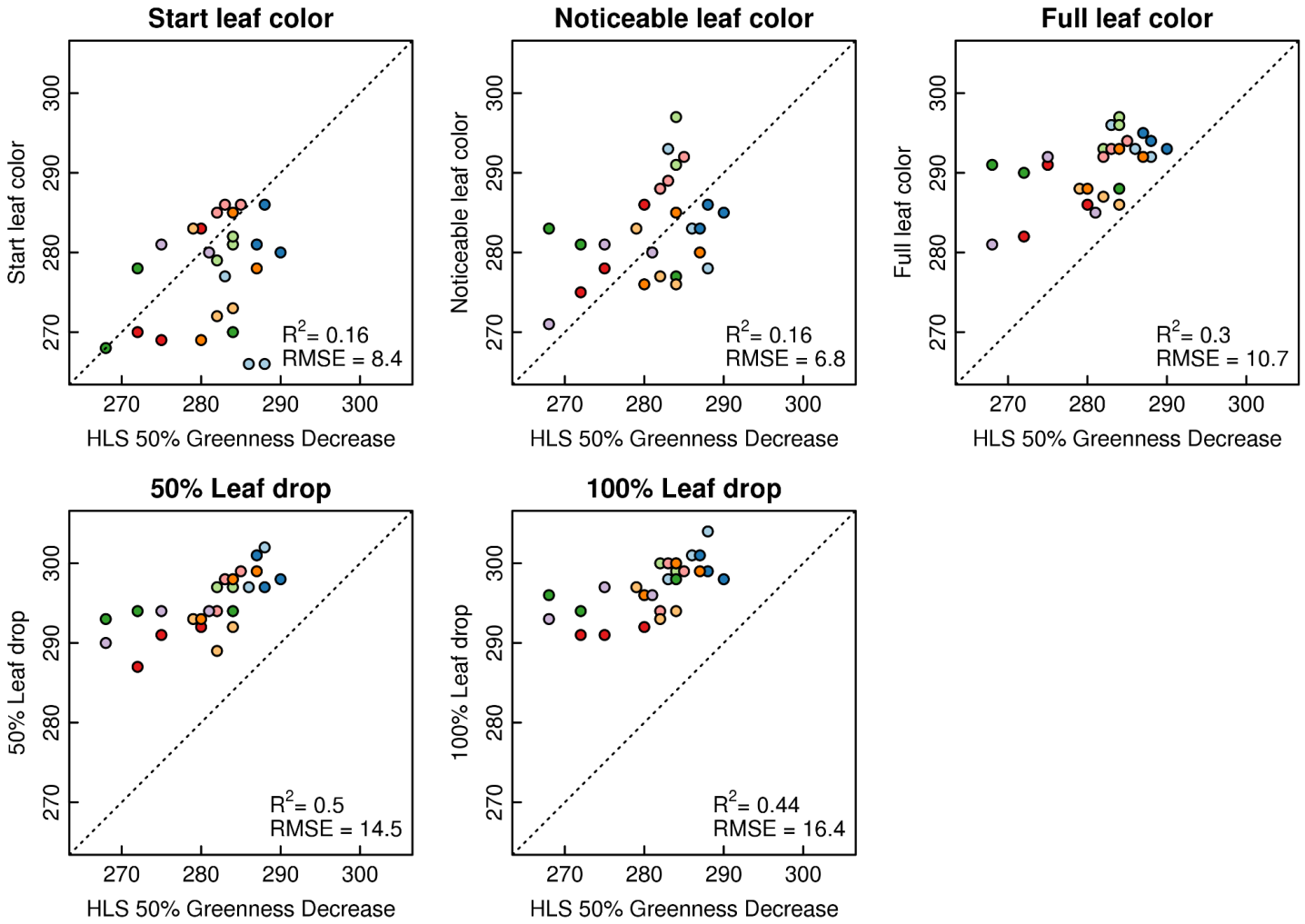
Multisource Land Surface Phenology (MS-LSP)

What does 50% decrease in HLS time-series correspond to?

8 sites at Hubbard Brook across 3 years (2015-2017)

Highest correlation is with 50% leaf drop

But lowest RMSE is with noticeable leaf color



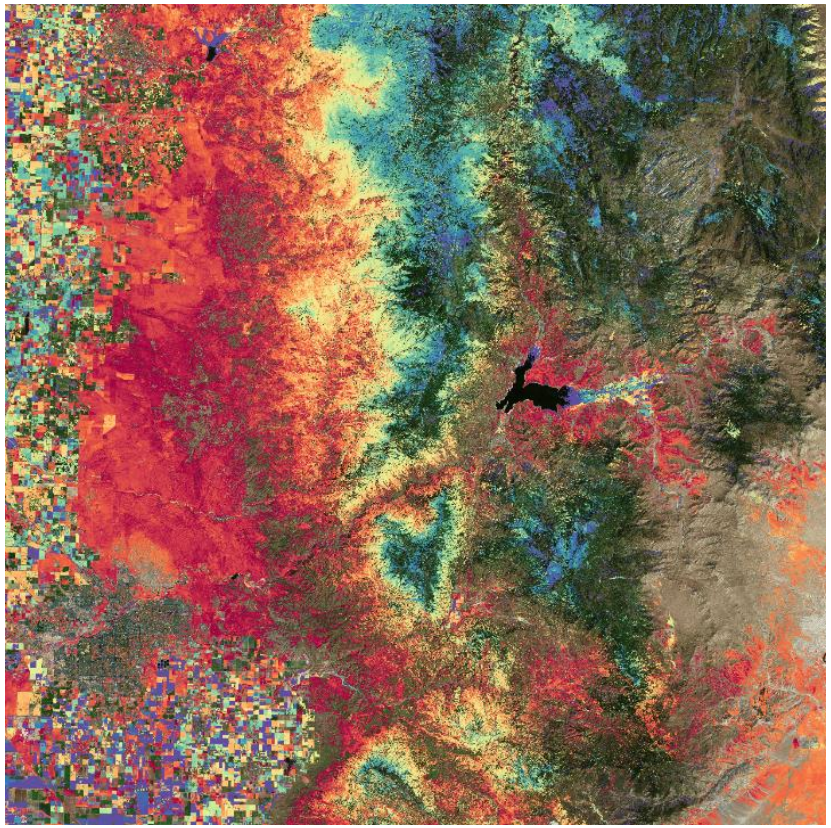
Conclusions

Multiple sources of validation:

- Flux towers
- Phenocams
- Ground Observations
- Citizen Science datasets (NPN)

Consistently better results in spring than fall

- Defined event in spring (Budburst)
- Fall is a gradual process of leaf coloring and leaf fall
  - What is it that we are measuring?



Thanks!

Email: dbolt@bu.edu
Group website: www.bu.edu/lcsc/