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)*
MODIS algorithm now using splines instead of logistic fits

- Allows for more flexibility on curve shape

\[
\text{EVI2} = 2.5 \times \frac{\text{nir} - \text{red}}{\text{nir} + 2.4 \times \text{red} + 1}
\]
Collection 6 MODIS Land Cover Dynamics

- NBAR-EVI
- Loess Fit
- Spline fit
- Potential Peak
- Potential Trough
- Greenup Segment
- Greendown Segment

50% Greenup Amplitude DOY, 2008

Collection 6 MODIS Land Cover Dynamics

Douglas Bolton - Vegetation Index Focus Area Workshop - December 12, 2018
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
• 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
Compare against flux data:

Landsat Phenology Algorithm

![DBF - Spring](image)

- $R^2 = 0.88 \ (p = 0)$
- RMSE = 7.8
- $\beta_1 = 0.93 \ (0.85, 1.1)$
- $\beta_0 = 16 \ (4.2, 27)$

![DBF - Autumn](image)

- $R^2 = 0.57 \ (p = 3.4 \times 10^{-12})$
- RMSE = 15
- $\beta_1 = 1.2 \ (0.98, 1.4)$
- $\beta_0 = -58 \ (-118, -7.1)$
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

![Graphs showing phenology comparisons](image)
Harmonized Landsat Sentinel-2 (HLS)

**Sentinel-2A, 2B**
- 10, 20 m spatial res.
- 10-day revisit
- Oct. 2015 - present

**HLS**
- 30 m spatial res.
- 3- to 5-day revisit
- Oct 2015 – present
- BRDF Normalized
- Cloud/Shadow Mask

**Landsat 8**
- 30 m spatial res.
- 16-day revisit
- May 2013 - present
Multisource Land Surface Phenology (MS-LSP)

Greenup
- 15% - 50% - 90%

Greendown
- 90% - 50% - 15%

EVI2

Month

Douglas Bolton - Vegetation Index Focus Area Workshop - December 12, 2018
Multisource Land Surface Phenology (MS-LSP)

Distributed via LP-DAAC

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

Illumination vs Band 4 reflectance

Tan et al. 2013 – Rotational Correction

Jan 25, 2017 image
Topographic correction of imagery

Illumination vs Band 4 reflectance

Tan et al. 2013 – Rotational Correction

Jan 25, 2017 image
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
Date of 50% EVI2 increase

Bakersfield, CA
Multisource Land Surface Phenology (MS-LSP)

Date of 50% EVI2 increase

Bakersfield, CA

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!

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