The USA National Phenology Network Land Surface Phenology/Remote Sensing Phenology Program

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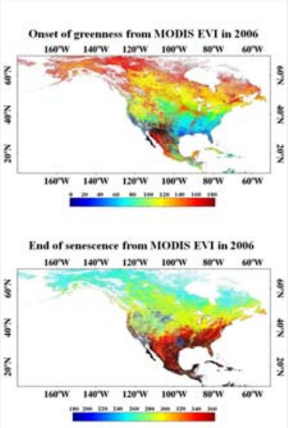
RESEARCH



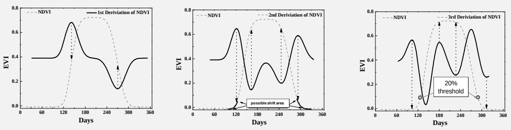
Improving Algorithms

USA-NPN, USGS, and NASA are collaborating to improve LSP phenology algorithms.

There are multiple variables related to constructing a LSP product, including
(but not limited to):

- the vegetation index to use
- threshold vs. curvature vs. parametric methods for determining key dates
- adjustments for snow cover
- missing data due to cloud cover, adverse atmospheric conditions, and sensor anomalies.

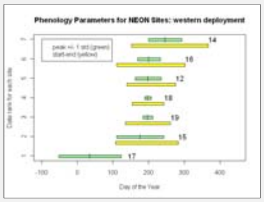
The figure above shows the day of the year for the start and end of the growing season. It is based on MODIS EVI data from 2006. The algorithm relies on the 3rd derivative curvature method (see below), as well as QA, snow cover, and temperature (below 0°C) screening. This product is labeled as the **North American Carbon Project Phenology** in the table to the lower right. A careful validation-based inter-comparison is needed to see how this product compares with others listed in the table.

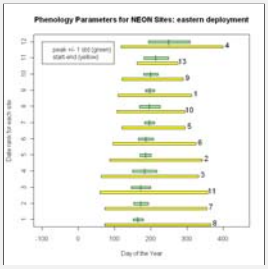


Applying Results

USA-NPN is coordinating with the National Ecological Observatory Network (NEON) to help with the deployment of their proposed Airborne Observation Platform. NEON is interested in estimating the timing of peak greenness, length of growing season, as well as within-site and year-to-year variability for each of NEON's 20 core sites. Using phenological variables from the 250m MODIS vegetation index, the graphics below demonstrate the objective and repeatable land surface phenology information that can help NEON with its deployment.

No	Domain	Site
1	North East	Harvard_Forest
2	Mid Atlantic	Mid_Atlantic
3	South East	Ordway_Swisher
4	Atlantic Neotropical	Gußnica Forest
5	Great Lakes	Great_Lakes
6	Prairie Peninsula	Konza
7	Appalachian	Walker_Branch
8	Ozarks	Talladega
9	Northern Plains	Woodworth
10	Central Plains	CPER
11	Southern Plains	LBJ
12	Northern Rockies	Yellowstone
13	Southern Rockies	Niwot
14	Desert SW	Santa_Rita
15	Great Basin	Onaqui_Benmore
16	Pacific NW	Wind_River
17	Pacific SW	San_Joaquin
18	Tundra	Toolik
19	Taiga	Caribou_Poker_Creek
20	Pacific Tropical	Laupahoehoe





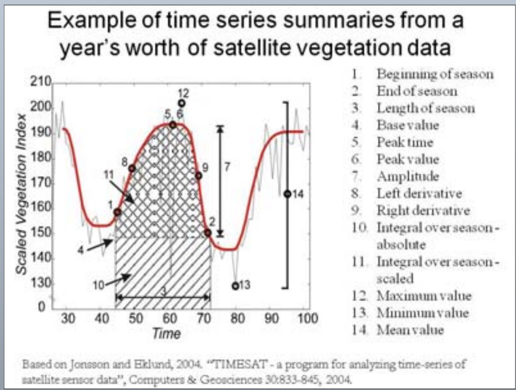
Definition

Land Surface Phenology: the seasonal pattern of variation in vegetated land surfaces observed from remote sensing.

Friedl, M., G. Henebry. B. Reed, A. Huete, M. White, J. Morisette, R. Nemani, X. Zhang, and R. Myneni. 2006. Land Surface Phenology.
A Community White Paper requested by NASA. Available online
http://landportal.gsfc.nasa.gov/Documents/ESDR/Phenology_Friedl_whitepaper.pdf

USA-NPN Land Surface Phenology: Background

A key initiative of the USA-NPN is to coordinate activities related to monitoring land surface phenology (LSP) across large areas, including, but not limited to, satellite-derived remote sensing phenology (RSP) products. Main objectives for this USA-NPN initiative are: 1) coordinating RSP activities across US federal agencies, other national programs, and academic scientists and 2) leading research on the utility and accuracy of RSP/LSP products.



Future Directions

At the Research Coordination Network/USA-NPN joint meeting in Milwaukee (Oct. '09) three collaborative products were identified by the LSP group as deliverable in the first half of 2010: (1) an "outreach" review article; (2) maps of peak VI timing corroborated with ground observations from key sites; and (3) alternative "pheno-regionalizations" of CONUS. A fourth product, a paper describing how to implement NPN plant protocols in a geospatial context to facilitate linkage with remote sensing observations, is targeted from the first quarter of 2011, nine months after the Dublin meeting

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http://www.usanpn.org/?q=content/national-coordinating-office

COORDINATION

USA-NPN is working to coordinate among the various LSP product producers and users
(see table below).

The USGS has established a Land Surface Phenology web site; which will be used for further coordination.

phenology.cr.usgs.gov

Also, USA-NPN is helping to initiate an international workshop on the validation and inter-comparison of regional and global LSP products. This meeting will take place 18 June 2010 at Trinity College, Dublin Ireland, as an extension of "Phenology 2010": *www.tcd.ie/Botany/phenology/2010/*

Product Name	Satellite	Production Period	Geographic Extent	GIS / Metadata	Phenology Metrics & Methods	Contact / Key References
National Phenology Database NASA Stennis / US Forest Service	**MODIS** NDVI (from both MOD/MYD13, C5)	2003-2008	Conterminous USA (incl parts of Mexico and the Caribbean)	**Spatial Resolution:** 231m pixels **Temporal Resolution:** DOY when NDVI value obtained **Projection:** LAEA **Location:** TBD	• NDV I from MOD/MYD13 calculated separately and averaged together (16-day composites) • MATLAB (TSPT & PPET) to remove outliers and temporally smooth and interpolate using Savitzky-Golay filter. • Processing per pixel (no spatial fitting) 1. Leading minimum NDVI 2. 20% of maximum NDVI 3. 80% of maximum NDVI 4. Maximum NDVI 5. 80% of maximum NDVI in fall 6. 20% of maximum NDVI in fall 7. Trailing minimum NDVI Growing season length may be calculated using the above parameters	Bill Hargrove (hnw@geobabble.org) Hargrove et al. 2009. PE&RS 75 (10) 1150-1156 .
North American Carbon Project Phenology Product NASA GSFC	**MODIS** MOD09PHN: MOD09EVI, MOD09NDVI MOD15PHN: MCD15A2 LAI	2000-2008	North America, Central America and Northern South America.	**Spatial Resolution:** 250m, 500m for EVI/NDVI, and 1km for LAI **Temporal Resolution:** 8-day. DOY for each metric **Projection:** Can be defined during order process **Location:** http://accweb.nascom.nasa.gov/	• MOD09PHN is derived from spatially gap-filled and temporally smoothed (GFS) MOD09 estimated EVI and NDVI • MOD15PHN is derived from GFS MCD15 LAI (terra and aqua) at 1km resolution. Phenology metrics are derived from TIMESAT using the asymmetric Gaussian smoothing function: Layer 1: greenup Layer 2: browndown Layer 3: seasonlength Layer 4: baselevel Layer 5: peakdate Layer 6: maxpeakvalue Layer 7: amplitude Layer 8: greenuprate Layer 9: browndownrate Layer 10: largeintegral Layer 11: smallintegral Layer 12: AnnualMaximumValue Layer 13: AnnualMinimumValue Layer 14: AnnualMeanValue Layer 15: RMSE Layer 16: QualityFlag	Jeff Morisette (morisettej@usgs.gov) Methods to derive phenology metrics from TIMESAT are described in: Tan et al. (in prep) Temporal smoothing and spatial gap-filling using TIMESAT is outlined in: Gao et al. 2007. IEEE Geoscience and Remote Sensing Letters, 5(1)60-64
MODIS Land cover dynamics MOD12Q2 Boston University	**MODIS** EVI computed from the MODIS NBAR (MCD43B4) and MODIS LST (terra and aqua)	2001-2006	Global	**Spatial Resolution:** 500m **Temporal Resolution:** DOY for each metric **Projection:** Sinusoidal - but can be defined during order process **Location:** https://lpdaac.usgs.gov/	Pre-processing to fill data gaps using moving-window linear interpolation per pixel and snow, min temp information. Vegetation growth and senescence identified by periods of EVI increase and decrease (EVI change should be larger than 35% in annual range for that pixel, ratio of local minimum EVI to annual maximum should be ~0.7). Specific transition dates identified by sigmoidal functions and transitions are determined using curvature-change rate (CCR). Multiple growth cycles are determined. 1. Onset of greenness increase (greenup) 2. Onset of greenness maximum (maturity) 3. Onset of greenness decrease (senescence) 4. Onset of greenness minimum (dormancy) 5. Growing season minimum 6. Growing season maximum 7. Summation of EVI for growing season length	Mark Friedl (friedl@bu.edu) Zhang et al. 2003, Remote Sens. Environ., 84(3)833–845. Zhang, X., et al. 2006, Journal of Geophysical Research 111: G04017.
U.S. Remote Sensing Phenology USGS	**AVHRR** NDVI	1989 - 2008	Conterminous United States	**Spatial Resolution:** 1km (1989 – 2008) **Temporal Resolution:** DOY for each metric and associated NDVI value **Projection:** Lambert Azimuthal Equal Area **Location:** http://phenology.cr.usgs.gov/get_data.php	NDVI is smoothed using a weighed, least-squares linear regression approach. Utilize curve derivative method and employs a backward-looking or delayed moving average (DMA) 1. Start of season, DOY and NDVI value 2. End of season, DOY and NDVI value 3. Maximum NDVI value and DOY 4. Duration 5. Amplitude 6. Time integrated NDVI	Jesslyn Brown (jfbrown@usgs.gov) http://phenology.cr.usgs.gov/index.php, Reed, B. C., Brown, J.F., et al. 1994, Journal of Vegetation Science, 5: 703-714.
GEOLAND 2 / BIOPAR Phenology JRC, VITO, MEDIAS	**SPOT-VEGETATION** NDVI	1980 - 2009	Global	**Spatial Resolution:** 1km **Temporal Resolution:** DOY for each metric **Projection:** Geographic WGS-84 **Location:** http://www.vgt4africa.org	10-day NDVI composites are temporally filtered using an iterative polynomial algorithm. 1-1.5 years of time-series data are analyzed with curve fitting methods to determine phenological metrics Second seasons are not detected 1. Start of growing season 2. Maximum development 3. Half senescence 4. End of season 5. Length of season	Roselyne Lacaze (lacaze-roselyne@wanadoo.fr) Combal & Bartholome, User Manual http://www.vgt4africa.org
CSIR Phenology South Africa	**NOAA AVHRR** NDVI	1985-2000	South Africa	**Spatial Resolution:** 1km **Temporal Resolution:** 10 day max value composites **Location:** Contact K. Wessels	TIMESAT adaptive Savitzky-Golay filter using a local polynomial fit together with small moving windows in two fitting steps. Start and end of growing season defined using a 20% of the seasonal amplitude threshold. 1. Start of growing season 2. End of growing season 3. Length of growing season 4. Mid position of growth season 5. Maximum NDVI value 6. Small integral 7. Large integral 8. Amplitude	Konrad Wessels (KWessels@csir.co.za) Wessels, K., et al. 2009, Influence of composite period and date of observation on phenological metrics extracted from MODIS data – and- Remotely sensed phenology for mapping biomes and vegetation functional types. IGARSS, Cape Town, South Africa, IEEE.