Development of land surface phenology monitoring with time series of remote sensing data

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  - land cover and use classification
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Background

• **Definition:** generally described as the art of observing life cycle phases or activities of plants and animals in their temporal occurrence throughout the year (Lieth, 1974).

• **Plant phenology:** annual calendars of leaf opening, flowering, fruiting, and leaf fall.

• **Importance:** global change has strong interactions with vegetation phenology (a bio-indicator for climate change; global change impacts on phenology; the integration of phenology in climate and vegetation models) (Menzel, 2002; Schwartz, 2003).
Background

◆ Phenology observation:
  – observational networks, historical records, controlled experiments;
  – intensive sites;
  – bioclimatic modeling;
  – space borne sensors and data assimilation;

◆ Different scales:
  – plot:<10km²
  – landscape:10-100km²
  – regional:100-10⁵km²
  – continental:>10⁵km²
  – global
Background

◆ **Land surface phenology**: the seasonal pattern of variation in vegetated land surfaces observed from remote sensing (Friedl, 2006; Henebry, 2005).

◆ **Advantage**: provides the potential to move from plant specific observations to complete, continuous expressions of phenological patterns on the landscape.
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Vegetation Spectra

Dominant factors controlling leaf reflectance

- Leaf pigments in the palisade mesophyll: chlorophyll a, b, β-carotene, etc.
- Scattering in the spongy mesophyll
- Leaf water content

Primary absorption bands

- Chlorophyll absorption bands
- Atmospheric water absorption bands

Reflectance (%)

Wavelength, μm

Visitable

Reflective infrared

Near-infrared

Middle-infrared
Remote sensing data

- **Vegetation Index**: dimensionless, radiometric measures usually involving a ratio and/or linear combination of the red and near-infrared (NIR) portions of the spectrum. They serve as indicators of relative growth and/or vigor of green vegetation, and are diagnostic of various biophysical vegetation parameters” (Huete, 1994).

- VIs used:
  - NDVI, EVI, LAI, MSAVI;
  - LSWI;
  - CI (Chlorophyll Index);
  - FPAR;
  - ……
Remote sensing data

Satellite sensors and data sets utilized for land surface phenology studies:

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Sensor</th>
<th>Operation</th>
<th>Resolution</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landsat</td>
<td>MSS</td>
<td>1973–1985</td>
<td>79 m</td>
<td>18 days</td>
</tr>
<tr>
<td>Landsat</td>
<td>TM</td>
<td>1984-present</td>
<td>30m</td>
<td>16 days</td>
</tr>
<tr>
<td>Landsat</td>
<td>ETM+</td>
<td>1999–present</td>
<td>30 m</td>
<td>16 days</td>
</tr>
<tr>
<td>NOAA</td>
<td>AVHRR</td>
<td>1982-present</td>
<td>8km</td>
<td>twice monthly</td>
</tr>
<tr>
<td>NOAA</td>
<td>AVHRR</td>
<td>1989-present</td>
<td>1km</td>
<td>biweekly</td>
</tr>
<tr>
<td>Terra</td>
<td>MODIS</td>
<td>2000-present</td>
<td>250 m, 500m, 1km</td>
<td>1-2 days</td>
</tr>
<tr>
<td>Aqua</td>
<td>MODIS</td>
<td>2002-present</td>
<td>250m, 500m, 1km</td>
<td>1-2 days</td>
</tr>
<tr>
<td>SPOT</td>
<td>Vegetation</td>
<td>1999-present</td>
<td>1km</td>
<td>1-2 days</td>
</tr>
<tr>
<td>Envisat</td>
<td>MERIS</td>
<td>2002-present</td>
<td>300m</td>
<td>1-3 days</td>
</tr>
<tr>
<td>Aqua</td>
<td>AMSR-E</td>
<td>2002-present</td>
<td>5km, 15km, 25km, 50km</td>
<td>1-2 days</td>
</tr>
</tbody>
</table>
Remote sensing data

- LSP Products:
  - MODIS: NASA (http://accweb.nascom.nasa.gov/data)
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**Aim:** use time series of vegetation indices to identify the timing of phenological transition dates such as the start and end of the growing season.
Methodologies

Different types of phenological metrics extraction methods:

- threshold-based techniques (Jonsson & Eklundh, 2002; White et al., 1997);
- methods based on moving average (Brown, 2002);
- techniques based on first derivatives (Xin et al. 2002; Viña et al. 2004; Zhang et al., 2003);
- techniques based on empirical equations (Koduk, 1996; Moulin, 1997);
- ….
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Applications: climate change

Phenology’s response to global warming

Relations between the year mean temperature and phenologies (Liu, 2010)
Applications: land cover and use

Assessment of Perennial Energy Crops

2007 crop map of the Tallgrass Prairie extracted from time series of MODIS imagery. (Wang, 2010)
Greenup onset date of winter wheat corresponds with cumulative temperature in the northern plain of China, 2003 (Lu, 2010).
Thanks!

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