Camera/In Situ Networks - Summaries and Data Availability

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The challenge

- Remote sensing plays a major role in providing evidence for phenological changes (Myneni et al. 1997)
- Considerable variability in estimates of phenophase transition dates using different remote sensing methods (White et al. 2009)
**In situ/camera phenological monitoring**

- Validate satellite remote sensing methods and products
- Provide ecophysiological context for phenological observations
- Landscape context for field observations
Networks

- Phenocam
- Archive of Many Outdoor Scenes
- Phenological Eyes Network
- PhenoAlp
- Lund Earth Observation Group
- Hubbard Brook Experimental Forest

Continental/Global
Regional
Local
Networks

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Phenocam

http://phenocam.sr.unh.edu/webcam/
Phenocam network
Objectives

• Use cameras to scale stand-level heterogeneity to satellite view
• Establish relationships between phenology and ecosystem functions using eddy covariance measurements of carbon and water fluxes made at core sites.
• Assess nature and magnitude of climate change impacts on phenology and ecosystem function, models will be run forward using IPCC climate projections to produce continental-scale forecasts.
Methods

– Calculate % greenness – green chromatic coordinate (GCC)

\[
GCC = \frac{DN_{Green}}{DN_{Red} + DN_{Green} + DN_{Blue}}
\]

– 90% filtering, 3-day moving window (Sonnentag et al. 2012)
Methods

- Use paired sigmoid-shaped logistic functions to extract phenophase transitions (Richardson et al. 2007)

\[
GCC(t) = a_s + \frac{b_s}{1 + e^{(c_s - d_s) t}}
\]
Validation Activities

- Comparison with carbon fluxes
- Chibougamou, QC, Canada – Boreal coniferous forest

$R^2_{exp} = 0.71$
Cameras

- StarDot NetCam SC IR
- IP addressable
- 1280 x 960 pixel resolution
- Linux operating system
- Images uploaded to PhenoCam server every 30 minutes
- Visual inspection of images, or quantitative analysis of red, green and blue channel brightness
Tetracam® phenology monitoring

- Tetracam® (Chatsworth, CA) 6-band VNIR camera
- Assess accuracy of visible-based indices
Tetracam Greenness + NDVI

- Preliminary results: high synchronicity between greenness-based indices and NDVI
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Archive of Many Outdoor Scenes (AMOS)

- Global collection 25,000 online webcams
- Administered by Washington Univ. (St. Louis)
- 700+ stable, vegetated cameras scenes (below)
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http://www.pheno-eye.org/


Main instruments:

- **HSSR** (Hemispherical spectral radiometers) --> vegetation spectrum. VIs & radiative transfer models.
- **ADFC** (Automatic digital fisheye cameras) --> phenology, snow cover, cloud cover, etc.
- **SP** (Sunphotometer) --> atmospheric correction for satellite images. Aerosols etc.
Phenology observation with ADFC

Prototype at EGAT flux tower, Thailand (1999-). Film camera.

- Evergreen conifer
- Deciduous conifer (larch)
- Deciduous broad leaf forest
- Rice paddy field
What is the best index for:
- phenology detection?
- GPP estimation?
... NDVI? EVI? PRI? LSWI?

Nagai et al., IJRS 2012
Nagai et al., AGFM 2011
Motohka et al., RemSens, 2011
etc.

Seasonal change of VIs in response to vegetation seasonality and snow cover.

in situ spectral reflectance, 10 min interval, VNIR & MIR.
Phenological Eyes Network

- 30 global sites, 9 countries, 3 continents
- Forest, grass, rice, urban environments
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Site: Torgnon – Tellinod (Italian Alps)
Alpine unmanaged grassland: 45°50'40'' N – 7°34'41'' E - 2160 m asl
<table>
<thead>
<tr>
<th>data</th>
<th>frequency</th>
<th>period</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2/H2O fluxes (eddy covariance) + met variables</td>
<td>half hourly</td>
<td>2008 - ongoing</td>
</tr>
<tr>
<td>Hyperspectral radiometric measurement (Meroni et al, 2011, RSI)</td>
<td>hourly (spring - fall)</td>
<td>2009-2011</td>
</tr>
<tr>
<td>Spectral vegetation indexes (Skye sensors – NDVI&amp;PRI)</td>
<td>hourly</td>
<td>2011 - ongoing</td>
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<tr>
<td>Above and below canopy PAR measurements</td>
<td>hourly</td>
<td>2009 - ongoing</td>
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<tr>
<td>Phenocam (low res camera campbell cc640) (Migliavacca et al, 2011, AFM)</td>
<td>hourly</td>
<td>2009 - ongoing</td>
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<tr>
<td>Nadiral pictures (12 plots)</td>
<td>weekly (spring - fall)</td>
<td>2009 - ongoing</td>
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<tr>
<td>vegetative and reproductive pheno observations (PhenoALP protocol <a href="http://www.phenoalp.eu">www.phenoalp.eu</a>)</td>
<td>weekly (spring - fall)</td>
<td>2009 - ongoing</td>
</tr>
<tr>
<td>Biomass &amp; LAI &amp; canopy height</td>
<td>15 days (spring - fall)</td>
<td>2009 - 2012</td>
</tr>
<tr>
<td>Pigments (ChlA, ChlB, Car)</td>
<td>15 days (spring - fall)</td>
<td>2010</td>
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Data are not stored in any database except fluxes and met data accessible at [www.europe-fluxdata.eu](http://www.europe-fluxdata.eu) (site id IT-Tor) and webcam images accessible at [http://phenocam.sr.unh.edu/webcam/](http://phenocam.sr.unh.edu/webcam/) (site id Torgnon-nd)

Contact person: Edoardo Cremonese, ARPA Valle d'Aosta, e.cremonese@arpa.vda.it
Site: Torgnon – Tronchaney (Italian Alps)
Larch (Larix decidua) forest
45°49'23.38"N – 7°33'39.04"E – 2100 m asl
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<td>Phenocam (high res camera nikon d5000)</td>
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<td>NIR Phenocam (TETRACAM)</td>
<td>hourly</td>
<td>2012 - ongoing</td>
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<tr>
<td>Larch phenological observations: spring and autumn phases on 60 trees (Migliavacca et al 2008, IJB)</td>
<td>weekly (spring - fall)</td>
<td>2005 - 2012</td>
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Contact person: Edoardo Cremonese, ARPA Valle d'Aosta, e.cremonese@arpa.vda.it
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Optical network

- Aims at collecting seasonal data for satellite data and phenology validation
- Sensors for NDVI, PRI, transmitted and reflected PAR, cameras (some sites), etc.
- Located in the footprint areas of carbon flux towers (Fluxnet, Integrated Carbon Observation System [ICOS])
- Ca. three years of data
- Environments:
  - Arctic fen (Zackenberg, Greenland)
  - Sub-arctic birch forest (Abisko)
  - Sub-arctic melting permafrost mire (Stordalen)
  - Mixed coniferous forest (Norunda)
  - Clear-cut forest (Norunda)
  - Pine forest (Hyytiälä)
  - Temperate bog (Fäjemyr)
  - Dry grassland savanna (Demokeya)
  - Dry grassland savanna (Dahra)
Lund university satellite phenology validation network

Web: http://www.nateko.lu.se/vegetationphenology

Contact: Lars.Eklundh@nateko.lu.se

Optical mast next to flux-mast (right) at sub-arctic site

Example data (Stordalen peat bog, Abisko)

Multispectral and PAR sensors for incoming and reflected radiation
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Hubbard Brook Experimental Forest
New Hampshire, USA

Field Phenology Measurements

- Measurements by US Forest Service
- Weekly since 1989 (24 years)
- 3 co-dominant trees at 9 locations
- Sugar maple, American beech, yellow birch
- Individual trees are tagged
- Ranked on a scale of 0-4
- Data for both spring and fall

Data available on-line: http://hubbardbrook.org/data/dataset.php?id=51
**Webcams**

- StarDot camera
  - Three Megapixels (~100kb jpg image)
  - Interfaced with Campbell datalogger
  - Wireless communication
  - Powered by solar
- Three locations (one includes lake for ice in-out)
- Images taken hourly (8am-8pm)
- Part of PHENOCAM Network

**Interactive Websites**

- Phenology image and field data integration animation
  [http://studentclimatedata.unh.edu/animation/hbrookphenology_wNDVI.html](http://studentclimatedata.unh.edu/animation/hbrookphenology_wNDVI.html)
- MODIS NDVI integration animation
  [http://studentclimatedata.unh.edu/dygraph/hbr_phen.html](http://studentclimatedata.unh.edu/dygraph/hbr_phen.html)
- Mirror Lake Ice-out
Summary

• Numerous resources for land surface phenology validation
• Networks range from local to regional to global
• Rich sources for environmental and ecological data, including:
  – Hyperspectral measurements
  – Eddy covariance: carbon, water, energy fluxes
  – Leaf Area Index, biomass
  – Leaf chlorophyll, carotenoids
  – Near infrared photography
  – Hemispherical photography
• Testing grounds for novel monitoring techniques
Acknowledgments

- Phenocam and AMOS are supported by NSF and USGS
Network web pages/Contact

Michael Toomey: mtoomey@fas.harvard.edu

• Phenocam
  – http://phenocam.sr.unh.edu/webcam/

• AMOS
  – http://amos.cse.wustl.edu/

• Phenological Eyes Network
  – http://www.pheno-eye.org/

• PhenoAlp
  – www.europe-fluxdata.eu (fluxes); Phenocam for photos

• Lund Earth Observation Group
  – http://www.nateko.lu.se/vegetationphenology

• Hubbard Brook
  – http://hubbardbrook.org/data/dataset.php?id=51
References


