Camera/In Situ Networks - Summaries and Data Availability

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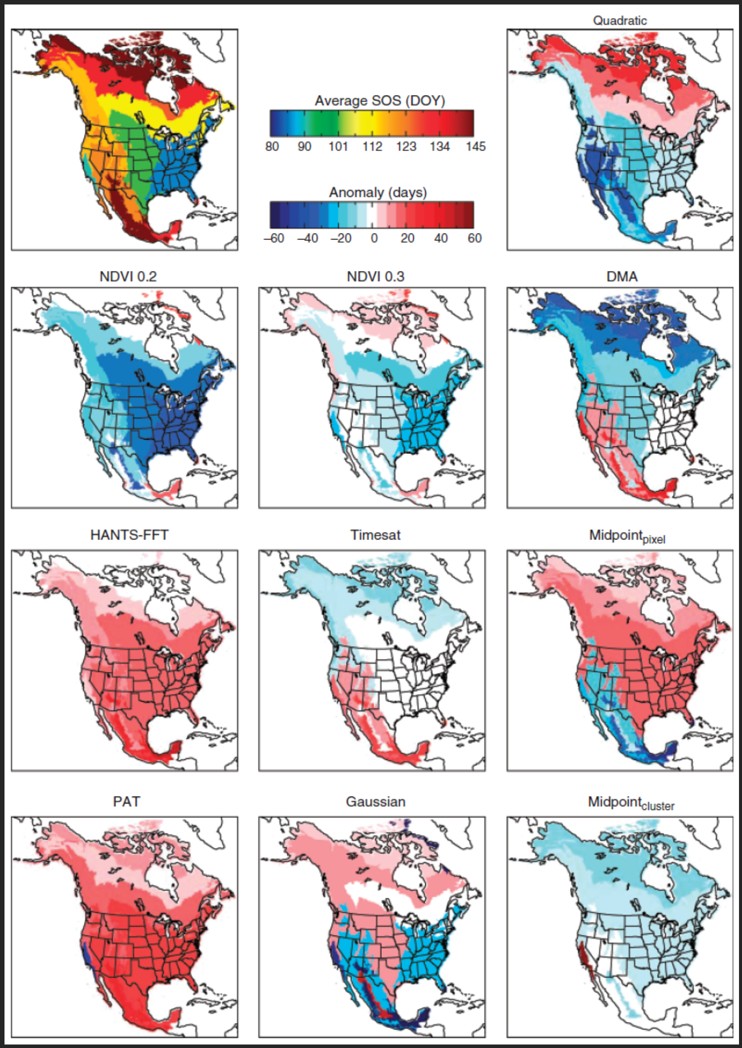
The challenge

- Remote sensing plays major role in providing evidence for phenological changes (Myneni et al. 1997)
- Considerable variability in estimates 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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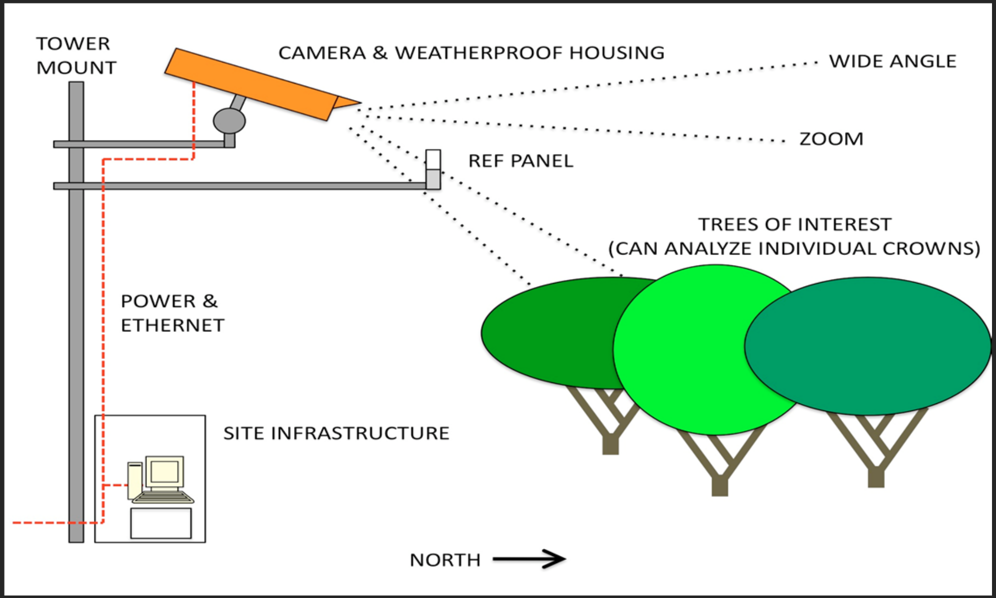
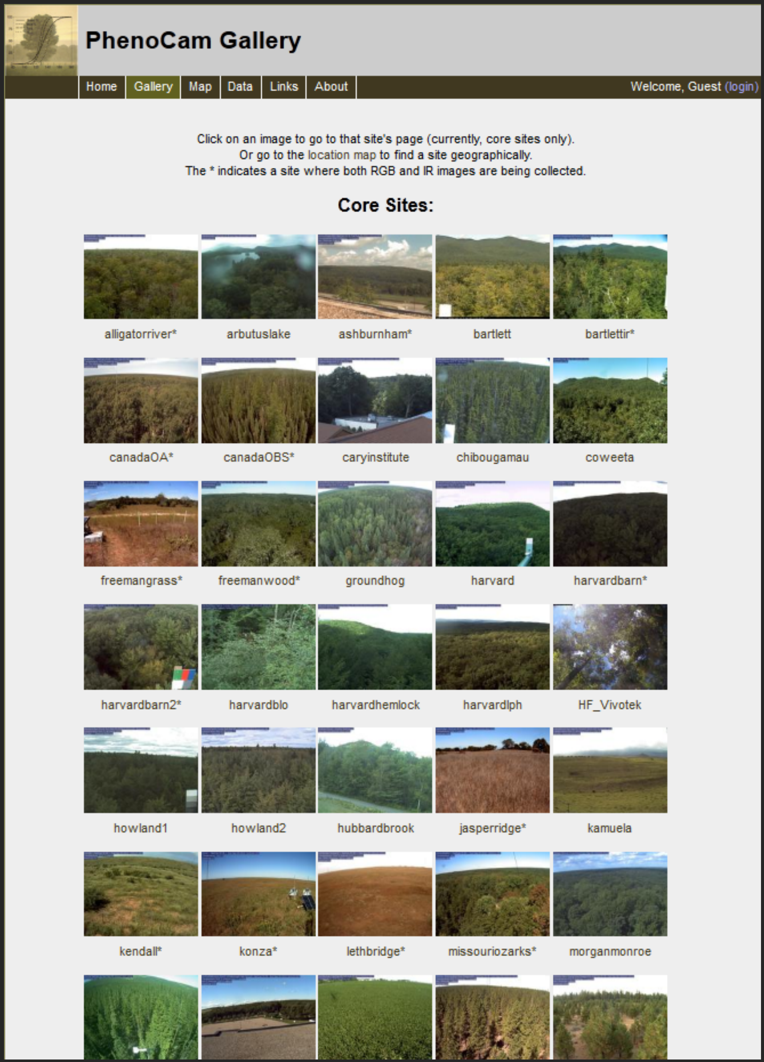
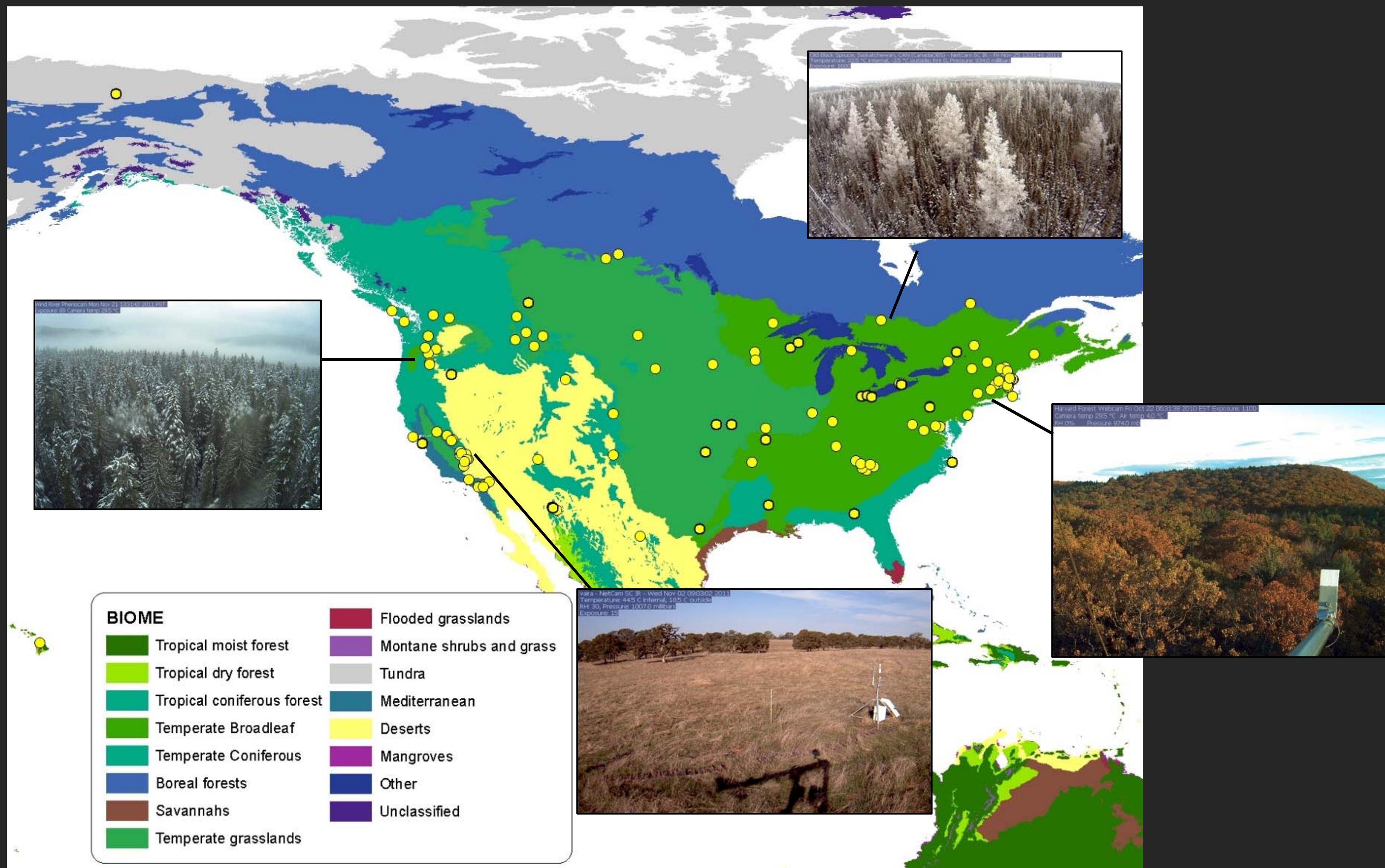
Phenocam

http://phenocam.sr.unh.edu/webcam/





Phenocam network



Objectives

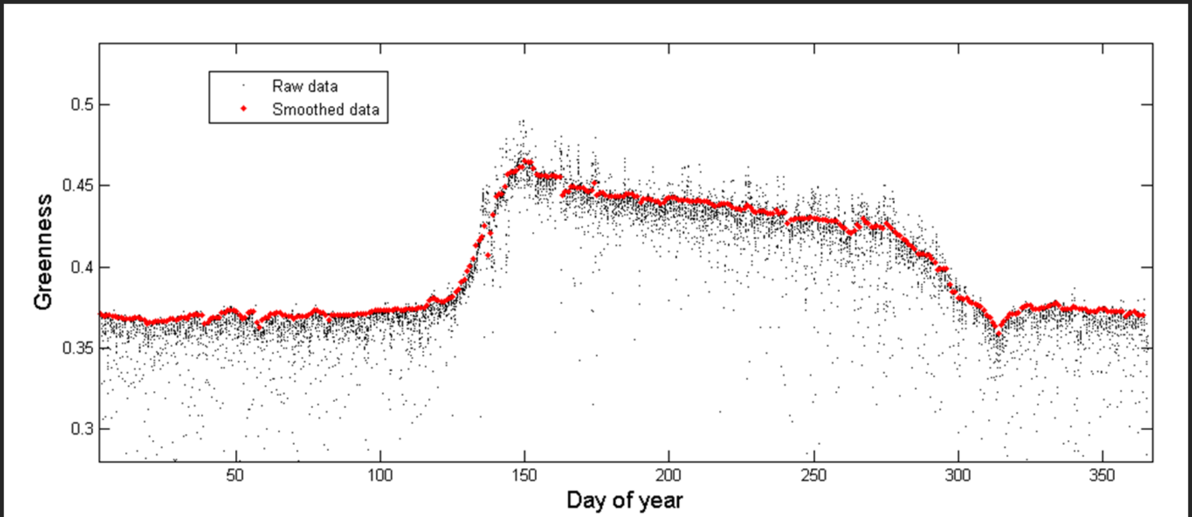
- Use cameras to scale stand-level heterogeneity to satellite view
- Establish relationships between phenology and ecosystem functions using eddy covariance measurements of carbon and water fluxes made at core sites.
- Assess nature and magnitude of climate change impacts on phenology and ecosystem function,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

Methods

– Calculate % greenness – green chromatic coordinate (GCC)

$$GCC = \frac{DN_{Green}}{DN_{Red} + DN_{Green} + DN_{Blue}}$$

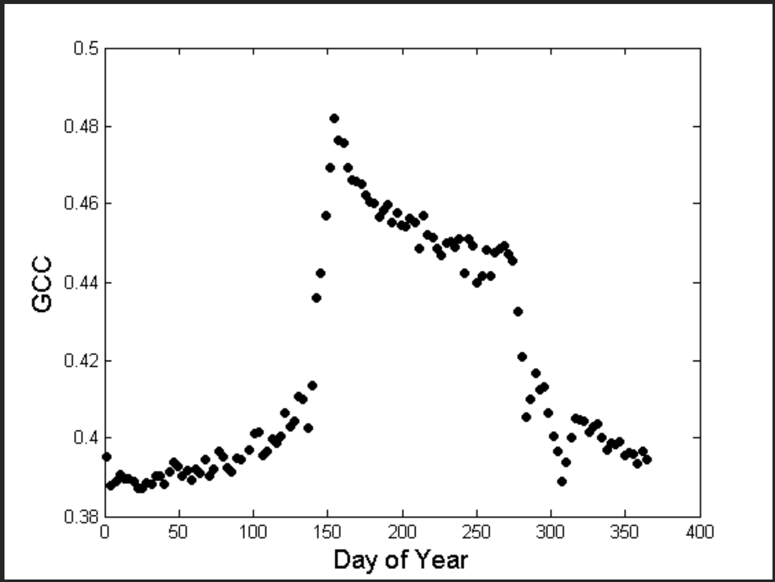
– 90% filtering, 3-day moving window (Sonnentag et al. 2012)

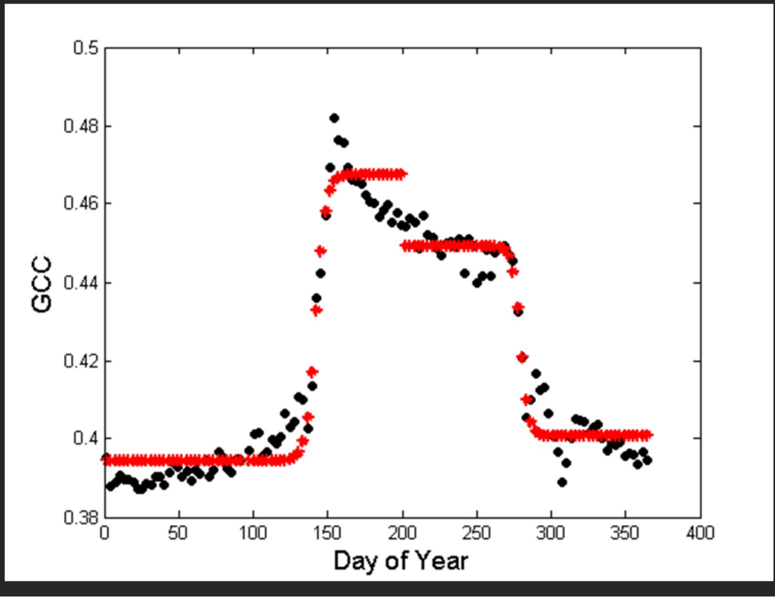


Methods

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

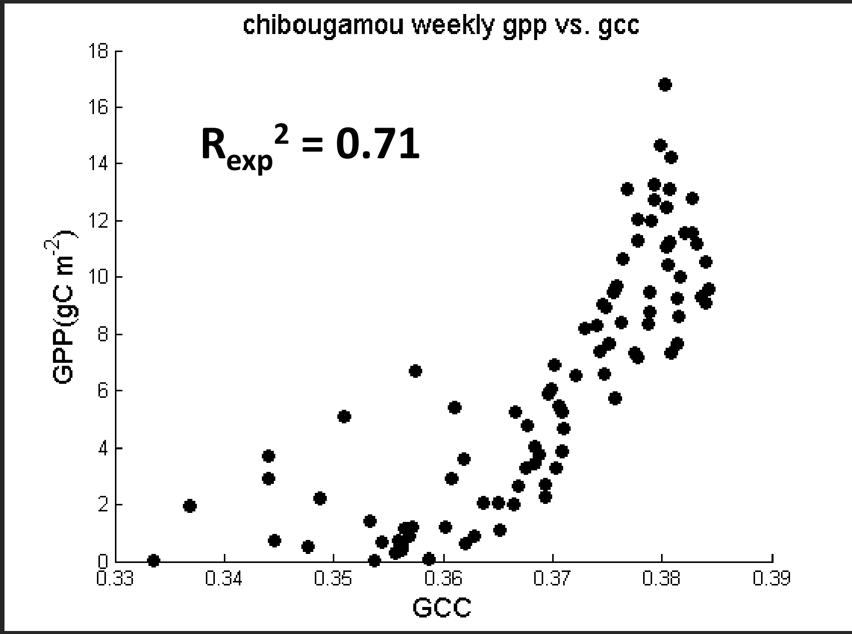
$$GCC(t) = a_s + \frac{b_s}{1+e^{(c_s - d_s t)}}$$

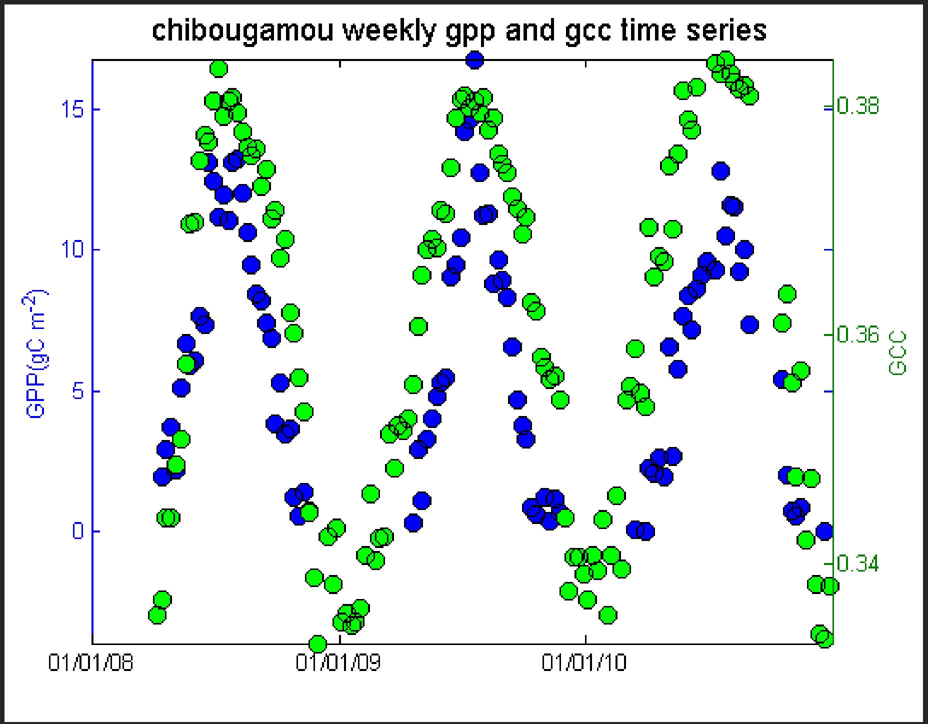




Validation Activities

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





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

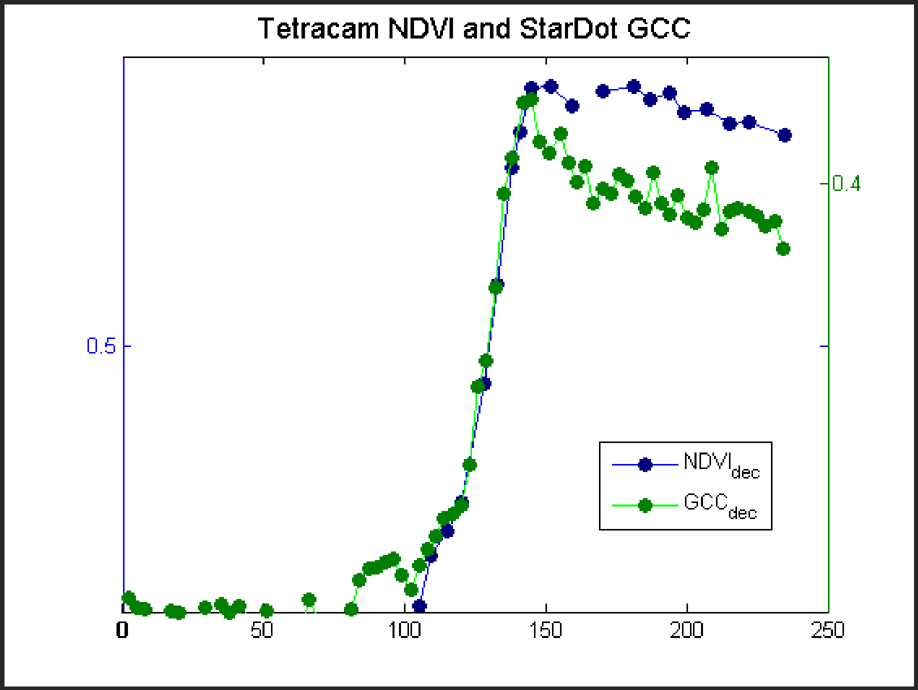
Images from StarDot; Harbortronics, Inc., Axis, Inc.; D-Link; Canon; and Moultrie

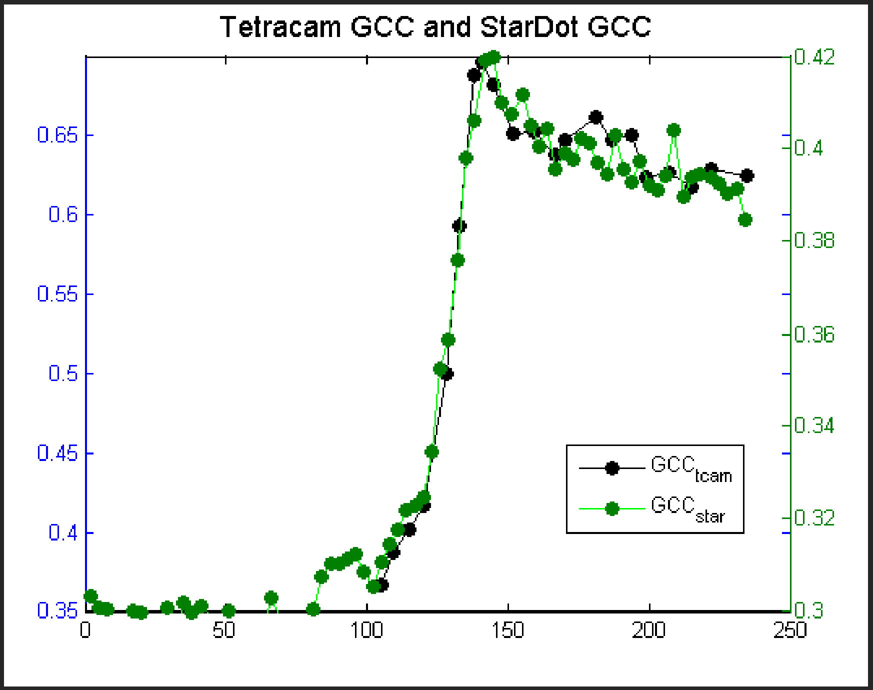
Tetracam® phenology monitoring

- 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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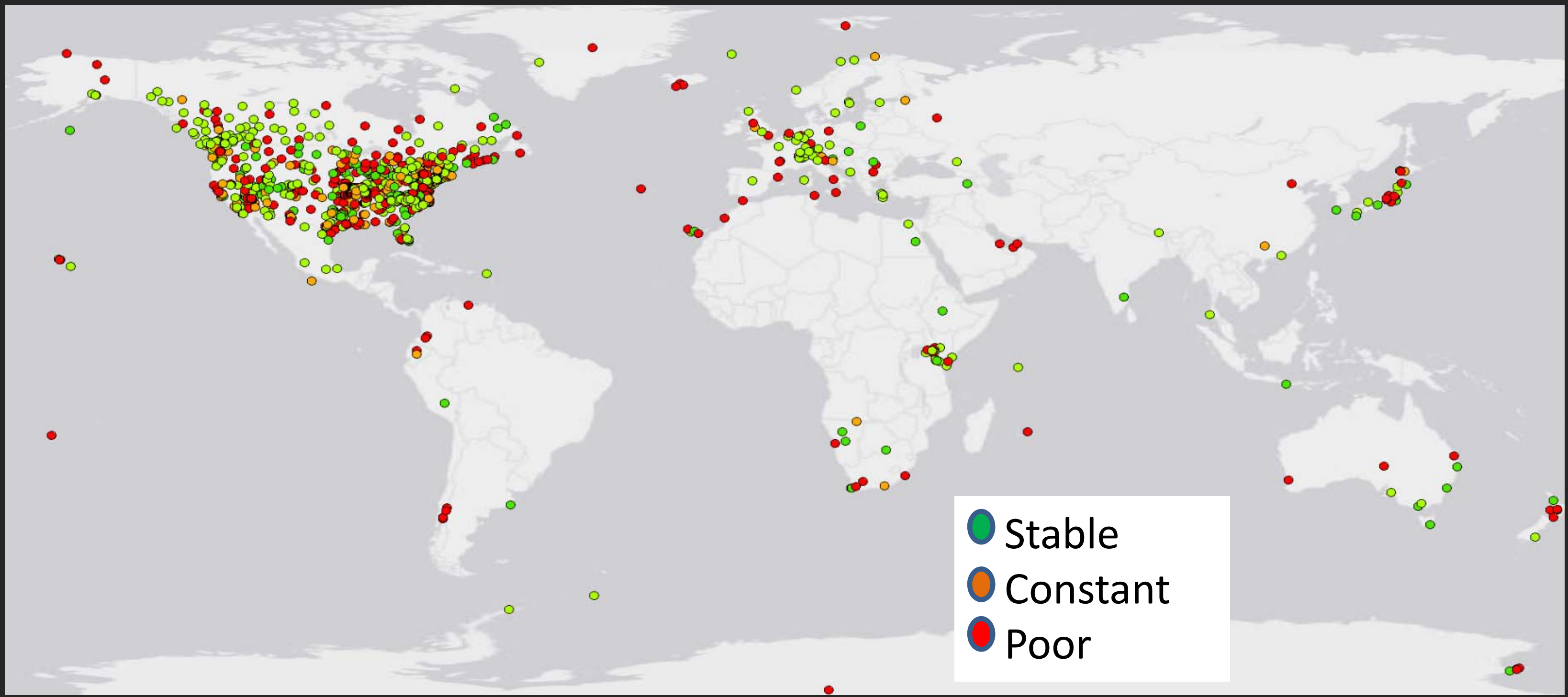
Archive of Many Outdoor Scenes (AMOS)

- 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/

A stable, continuous, long-term, and multi-ecosystem ground validation network for remote sensing.
Prototype started in 1999. Now 28 sites globally (mainly in Japan). Mostly at flux towers and ILTER sites.

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.

HSSR

ADFC

SP

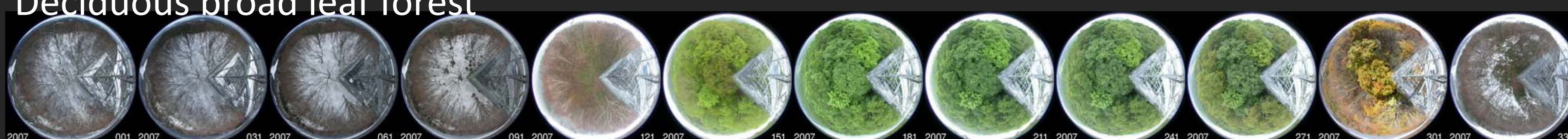
Phenology observation with ADFC

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

Evergreen conifer

Deciduous conifer (larch)

Deciduous broad leaf forest

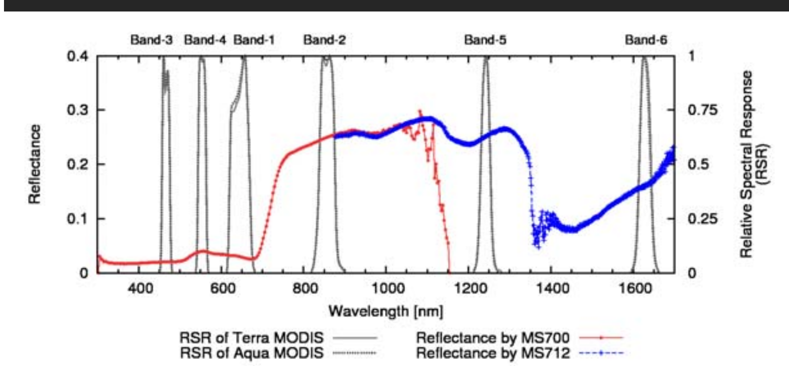


Rice paddy field

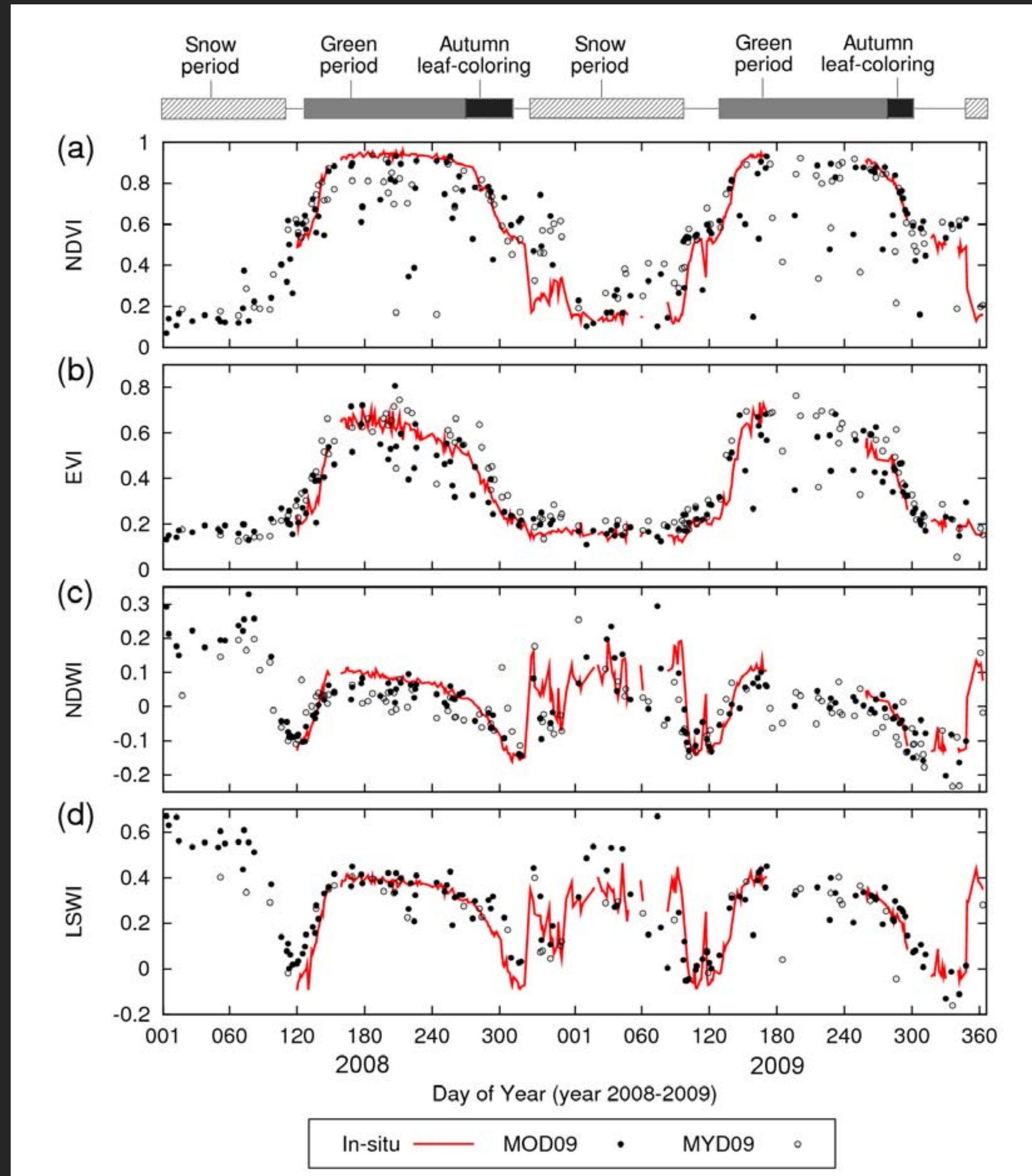
What is the best index for:
- phenology detection?
- GPP estimation?

... NDVI? EVI? PRI? LSWI?

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



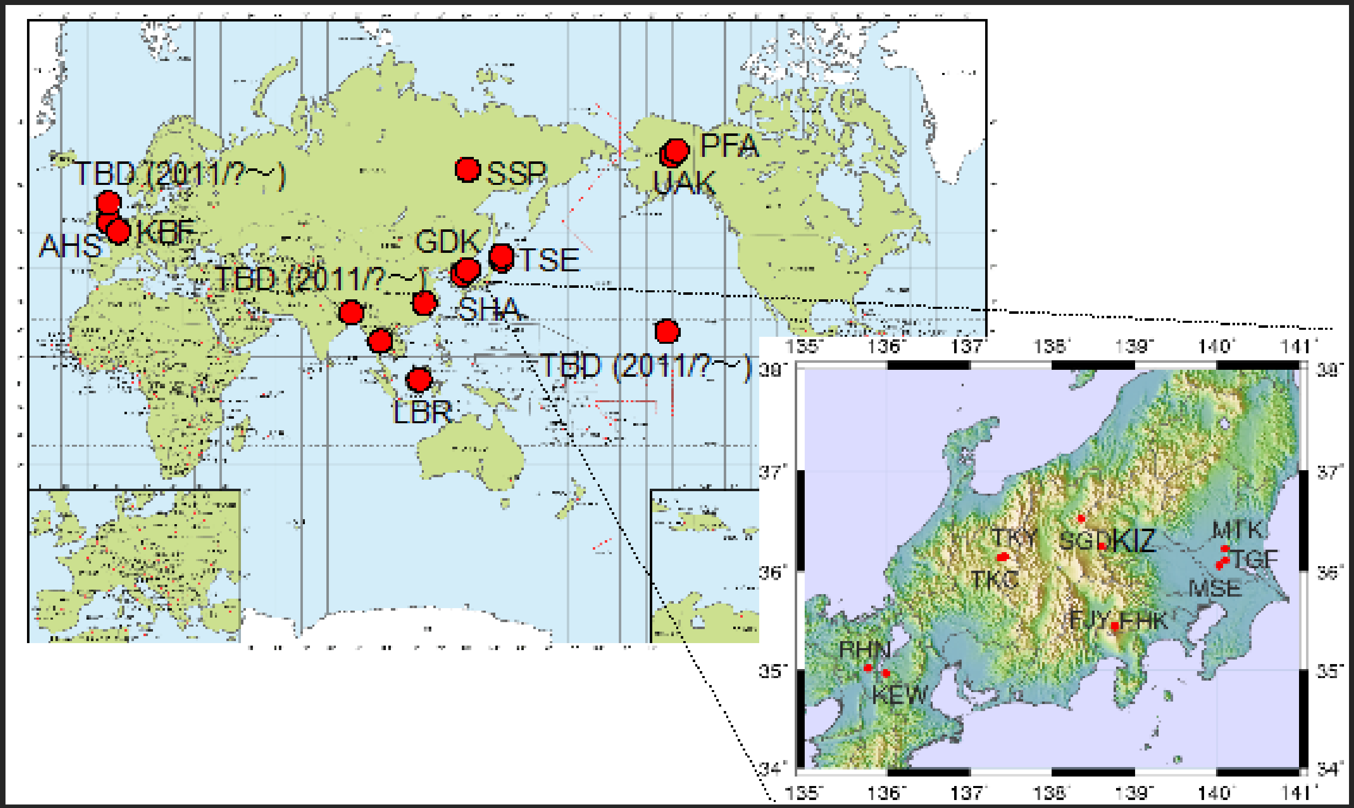
in situ spectral reflectance,
10 min interval, VNIR & MIR.



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

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

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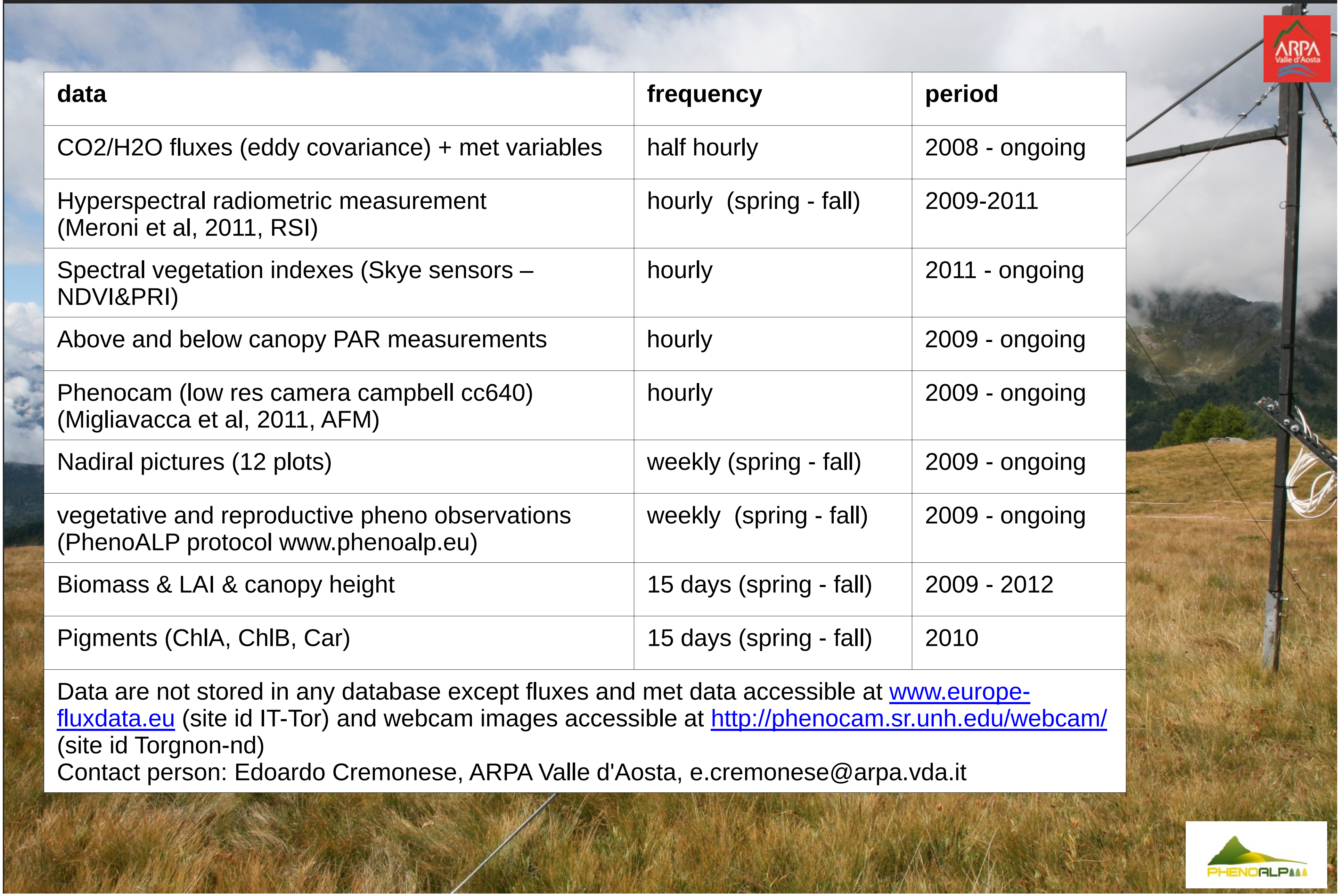

data	**frequency**	**period**
CO_2/H_2O fluxes (eddy covariance) + met variables	half hourly	2008 - ongoing
Hyperspectral radiometric measurement (Meroni et al, 2011, RSI)	hourly (spring - fall)	2009-2011
Spectral vegetation indexes (Skye sensors – NDVI&PRI)	hourly	2011 - ongoing
Above and below canopy PAR measurements	hourly	2009 - ongoing
Phenocam (low res camera campbell cc640) (Migliavacca et al, 2011, AFM)	hourly	2009 - ongoing
Nadiral pictures (12 plots)	weekly (spring - fall)	2009 - ongoing
vegetative and reproductive pheno observations (PhenoALP protocol www.phenoalp.eu)	weekly (spring - fall)	2009 - ongoing
Biomass & LAI & canopy height	15 days (spring - fall)	2009 - 2012
Pigments (ChlA, ChlB, Car)	15 days (spring - fall)	2010

Data are not stored in any database except fluxes and met data accessible at www.europe-fluxdata.eu (site id IT-Tor) and webcam images accessible at 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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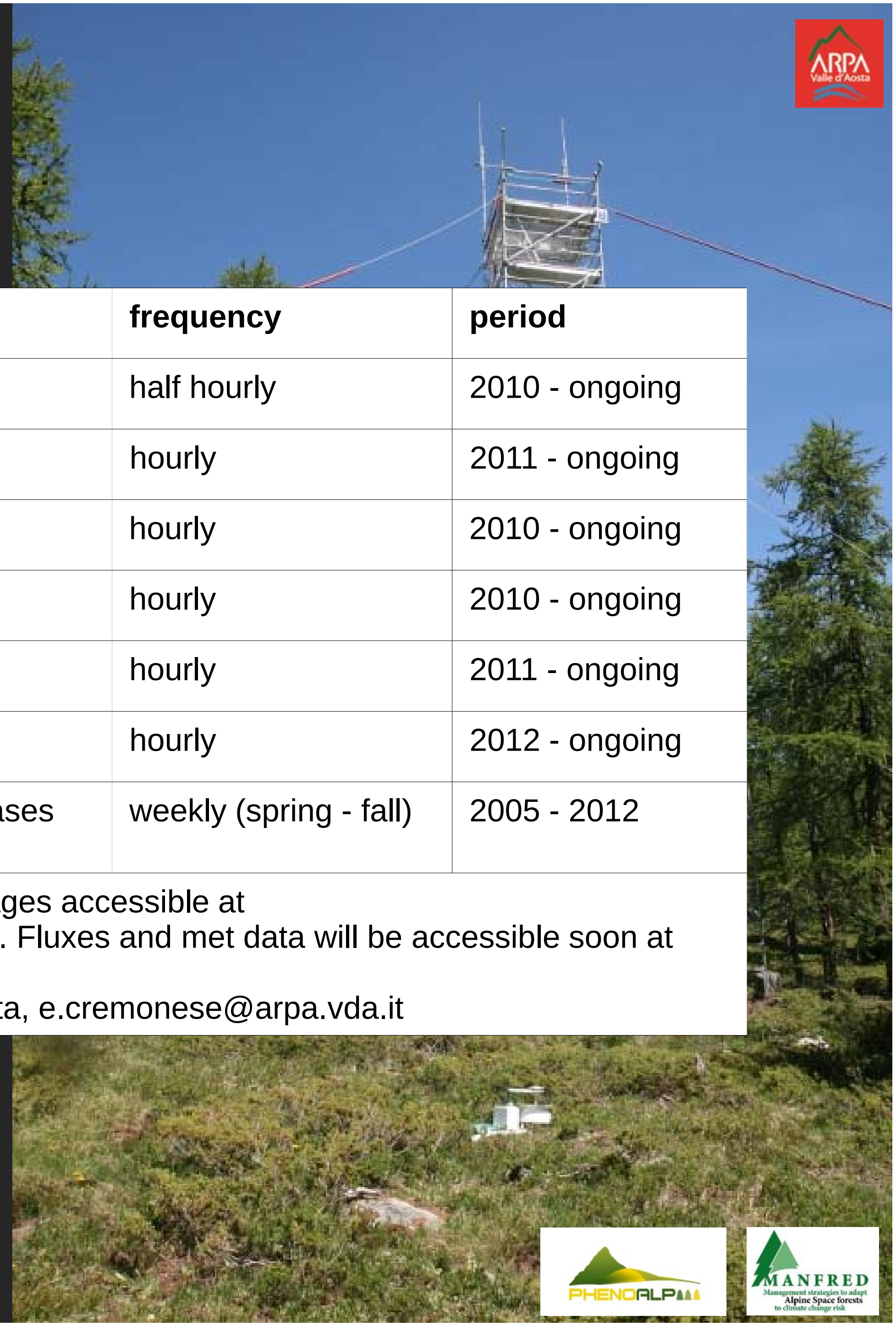

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Above and below canopy PAR measurements	hourly	2010 - ongoing
Phenocam (low res camera campbell cc640)	hourly	2010 - ongoing
Phenocam (high res camera nikon d5000)	hourly	2011 - ongoing
NIR Phenocam (TETRACAM)	hourly	2012 - ongoing
Larch phenological observations: spring and autumn phases on 60 trees (Migliavacca et al 2008, IJB)	weekly (spring - fall)	2005 - 2012

Data are not stored in any database except webcam images accessible at http://phenocam.sr.unh.edu/webcam/ (site id Torgnon-ld). Fluxes and met data will be accessible soon at www.europe-fluxdata.eu

Contact person: Edoardo Cremonese, ARPA Valle d'Aosta, e.cremonese@arpa.vda.it

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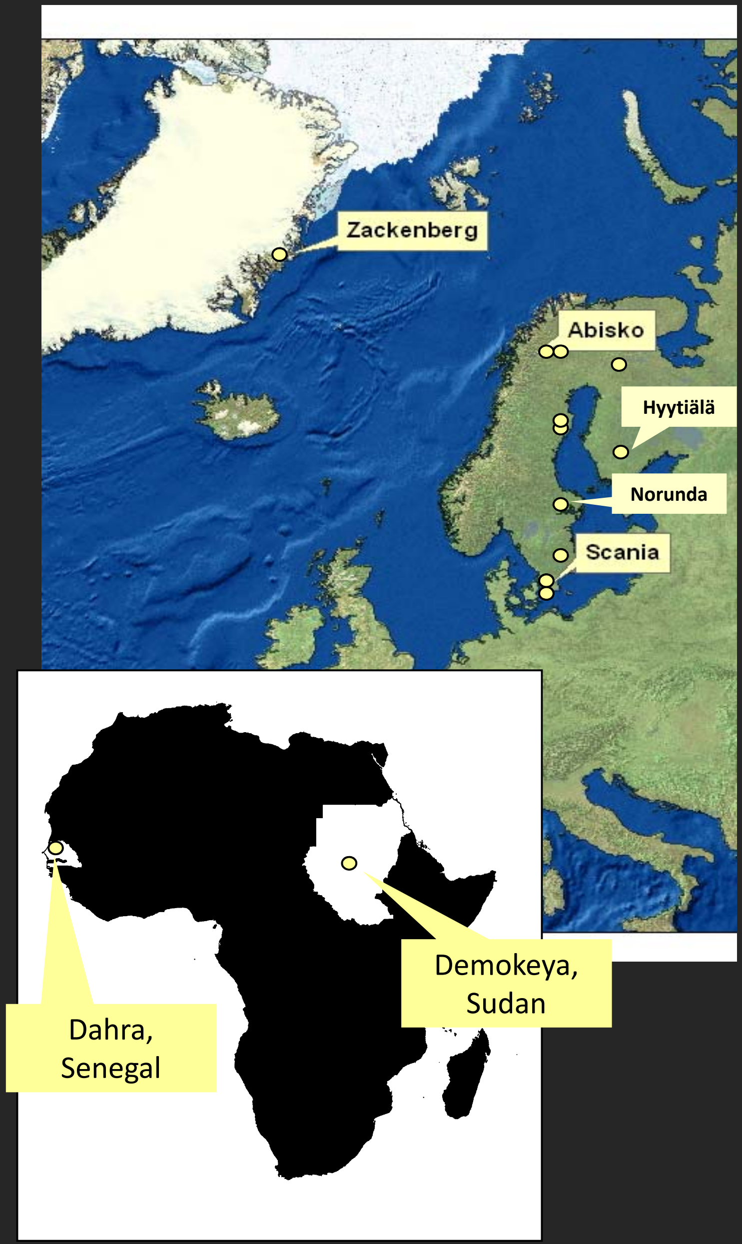
Lund university satellite phenology validation network



Optical network

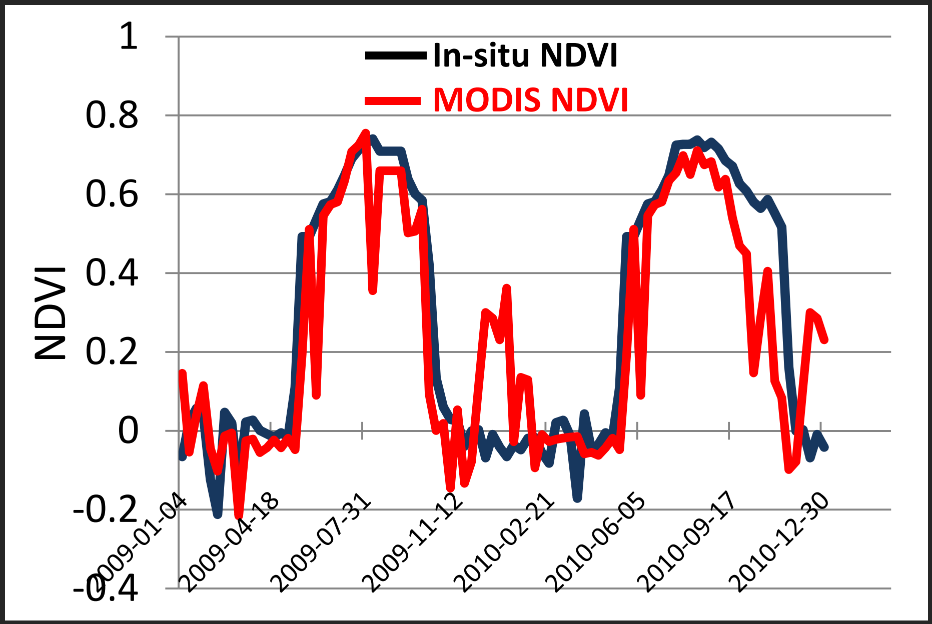
- Aims at collecting seasonal data for satellite data and phenology validation
- Sensors for NDVI, PRI, transmitted and reflected PAR, cameras (some sites), etc.
- Located in the footprint areas of carbon flux towers (Fluxnet, Integrated Carbon Observation System [ICOS])
- Ca. three years of data
- <u>Environments:</u>
  - 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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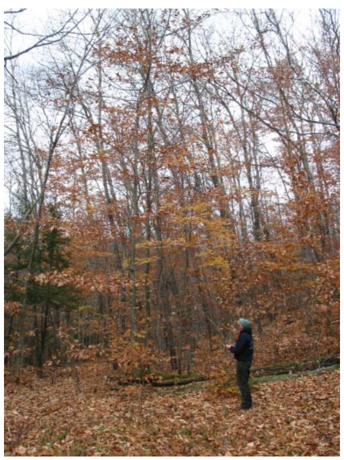
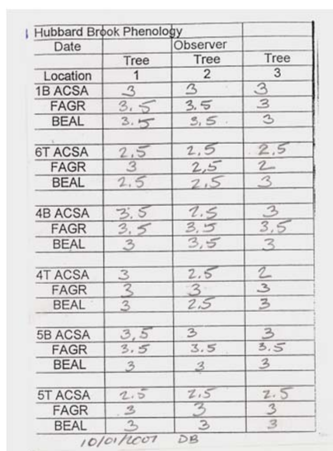
Hubbard Brook Experimental Forest
New Hampshire, USA

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

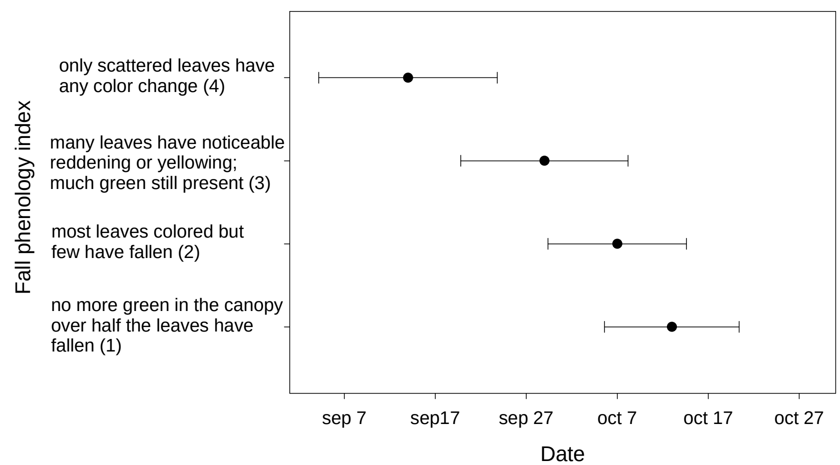




Hubbard Brook Phenology

Date		Observer	
	Tree	Tree	Tree
Location	1	2	3
1B ACSA	3	3	3
FAGR	3.5	3.5	3
BEAL	3.5	3.5	3
6T ACSA	2.5	2.5	2.5
FAGR	3	2.5	2
BEAL	2.5	2.5	3
4B ACSA	3.5	2.5	3
FAGR	3.5	3.5	3.5
BEAL	3	3.5	3
4T ACSA	3	2.5	2
FAGR	3	3	3
BEAL	3	2.5	3
5B ACSA	3.5	3	3
FAGR	3.5	3.5	3.5
BEAL	3	3	3
5T ACSA	2.5	2.5	2.5
FAGR	3	3	3
BEAL	3	3	3

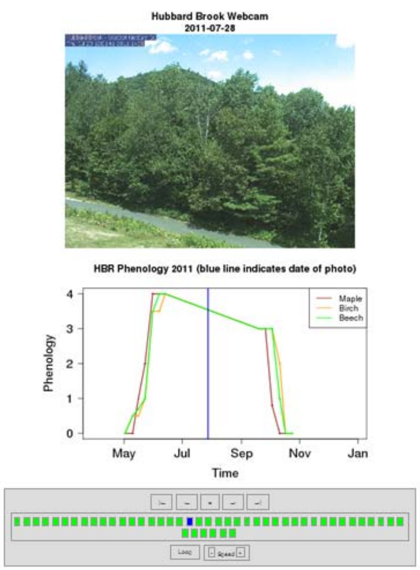
10/01/2007 DB



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

•MODIS NDVI integration animation
http://studentclimatedata.unh.edu/dygraph/hbr_phen.html

•Mirror Lake Ice-out
http://nesensornet.sr.unh.edu/animations/2012MirrorLakeIceOut/2012MirrorLakeIceOut.html

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

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- Richardson AD, Jenkins JP, Braswell BH, Hollinger DY, Ollinger SV, Smith ML (2007) Use of digital webcam images to track spring green-up in a deciduous broadleaf forest. Oecologia 152:323-334
- White et al. (2009). Intercomparison, interpretation and assessment of spring phenology in North America estimated from remote sensing for 1982-2006. Global Change Biology, 15, 2335 – 2359.