Vegetation Phenology from MODIS / AVHRR / PhenoCam: scaling and validation possibilities

Koen Hufkens[1], Mark A. Friedl[1], Andrew Richardson[2], Thomas Milliman[3], Mirco Migliavacca[4]

[1] Department of Geography and Environment, Boston University, 675 Commonwealth Avenue, Boston, MA 02215

[2] Department of Organismic & Evolutionary Biology, Harvard University, 22 Divinity Avenue, Cambridge, MA 02138

[3] Space Science Center, University of New Hampshire, Durham, NH 03824-3525

[4] Department of Environmental Sciences, University of Milano-Bicocca, 1 Piazza della Scienza, Milan, Italy

Introduction

Vegetation phenology derived from remote sensing is important for a variety of scientific applications. While many data sets related to plant phenology have been collected remote sensing provides the only way to observe and monitor vegetation phenology over large scales and at regular intervals. The MODIS Global Land Cover Dynamics Product (MCD12Q2) was developed to support scientific investigations that require regional to global scale information related to seasonal to internannual dynamics in vegetation phenology. In addition to satellite based remote sensing the PhenoCam [1] network was initiated in order to provide automated, near-surface remote sensing of canopy phenology using webcam data. In an effort to assess the influence of temporal and spatial scaling on the estimation of phenology parameters we compared growing season onset and dormancy dates for two remote sensing platforms (AVHRR / MODIS) and different data processing strategies (TIMESAT [2] / MCD12Q2 algortihm [3]).

Methods

- PhenoCam:

  The excess green index (VEG1, 2*Green – blue - red) was calculated for the PhenoCam webcam data. Regions of Interest (ROI) were selected within the webcam images based upon the distance to the sensor (foreground/background) and the vegetation type. A total of 25 ROIs were selected for the six PhenoCam sites. Finally, a gap filling routine assured a complete time series.

- MODIS data:

  Raw MODIS NBAR data was used to calculate the EVI without corrections for snow or other disturbances. The extracted smoothed MODIS MCD13Q1 data did not need preprocessing.

- AVHRR data did not need preprocessing.
- Phenological parameters were extracted from the different time-series using TIMESAT. TIMESAT was originally designed to extract seasonality information from noisy AVHRR NDVI time-series. However, the program has the capability to handle different types of remotely sensed time-series. TIMESAT was used as the in house algorithm does not yet scale to different time-series lengths.
- TIMESAT uses a double logistic least squares fit to estimate the onset and dormancy of the growing season. Both parameters are extracted for the four time series.
- For further comparison onset and dormancy dates from the MCD12Q2 product were extracted

Data Processing

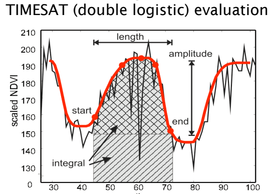
MODIS MCD13Q1 time-series

AVHRR NDVI time-series

PhenoCam VEG1 timeseries → data preprocessing: gap filling ...

MODIS raw NBAR time-series → EVI time-series calculation

TIMESAT (double logistic) evaluation



phenology data onset - dormancy

MODIS MCD12Q2 phenology data

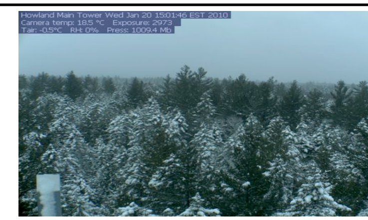
phenology comparison

AVHRR / MODIS / PhenoCam

(scatterplots, timeseries)

Input Data

- A preliminary set of 6 PhenoCam sites was selected based upon:
  - the total length of the time-series
  - the strength of the signal extracted from the webcam images
  - the completeness of the time-series (limited missing values)
- time-series for AVHRR GIMMS NDVI (1 pixel, ~8x8km, bi-monthly) and MODIS data (MCD43A4 and MCD13Q1, 3x3 pixels, ~1.5x1.5km, every 8 days) were gathered corresponding to the PhenoCam site locations
- Input data covered a wide range of spatial as well as temporal scales



Preliminary Results

Examining the results we can say that there was a:

- Weak to reasonable agreement between AVHRR and MODIS data. We see the expected earlier season onset (fig 2c) and delayed dormancy (not shown) due to the spatial scale difference and resulting smoothing of the time-series.
- Fair agreement between different remote sensing data sources and the PhenoCam data for the onset date of the growing season (fig 1; fig 2a,c,e).
- Weak to fair agreement between the satellite based remote sensing data and the PhenoCam data for the onset date of the growing season (fig 2a - f).
- Weak agreement between dormancy dates for all time-series (fig 2b,d,f).
- Overall later dormancy date for AVHRR data compared to MODIS and PhenoCam data (fig 2c – d).
- Clear stratification according to vegetation type with deciduous forest showing a stronger agreement between PhenoCam and satellite data on onset and dormancy dates than other vegetation types (fig 2a – f).
- Little or no stratification according to year or distance class (foreground or background ROIs, fig 1a – c).
- Figure 3 shows overlapping Phenocam, MODIS and AVHRR vegetation index time-series for the Bitteroot Valley site. Onset and dormancy dates are marked by vertical bars.

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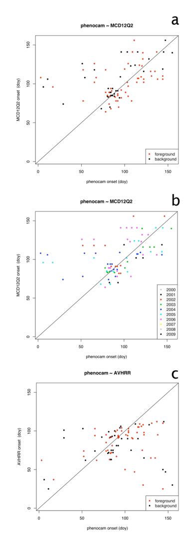

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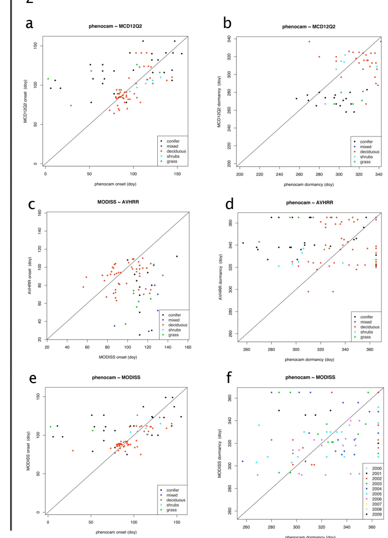

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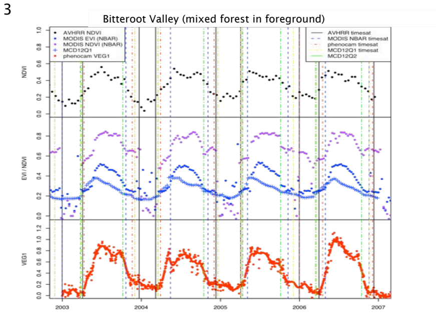

Discussion and Conclusion

The preliminary results are encouraging and suggest that PhenoCam and MODIS (and to a lesser degree AVHRR) data are comparable. This creates opportunities to use PhenoCam data as either an accurate phenology monitoring tool as well as an excellent source of validation data for MODIS phenology products. However, due to the lack of compatibility of the current MODIS phenology algorithm we used TIMESAT. It would be preferable to implement extend the current MCD12Q2 algorithm for comparison and validation. However, the enormous variability of the data quality impedes full automation and further preprocessing. Therefore, manual reviewing of the data is needed to assure proper validation and scaling across different products.

References

[1] http://klima.sr.unh.edu/

[2] Jonsson and Eklund TIMESAT - a program for analysing time-series of satellite sensor data. Computers and Geosciences (2004)

[3] Zhang et al. Monitoring vegetation phenology using MODIS. Remote Sensing of Environment (2003)