Comparison of web-camera- and satellite-based observations on vegetation phenology in Finland

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Abstract

Satellite-derived vegetation index time series have been widely used for the monitoring of vegetation phenology. While satellite observations provide information on land surfaces phenology at large scale, near-surface observations with digital cameras allow both visual interpretation and automatic analysis at local scale at high temporal frequency. Low-cost networked digital cameras (webcams) can be used for the extraction of phenological events and may facilitate the interpretation and validation of satellite-based phenology products. Here, we compared image time series from web-cameras at four selected ecosystem research sites in Finland for the period 2014 to 2015 with satellite time series of vegetation indices and snow cover from the Moderate Resolution Imaging Spectroradiometer (MODIS). Time lapse images in forests were taken from above and below the tree canopy, thus allowing separate assessments of the related phenological features. Daily satellite time series of the Normalized Difference Vegetation Index, the Normalized Difference Water Index and the Fractional Snow Cover were extracted from MODIS pixels close to the ecosystem site and with the same vegetation type. In this poster we will show first results of web-camera- and satellite-based seasonal cycle and we will discuss the use of web-camera observations in the validation of satellite-observed phenology.
Keywords: Vegetation phenology, webcams, MODIS, vegetation indices, Fractional Snow Cover.

1 Introduction

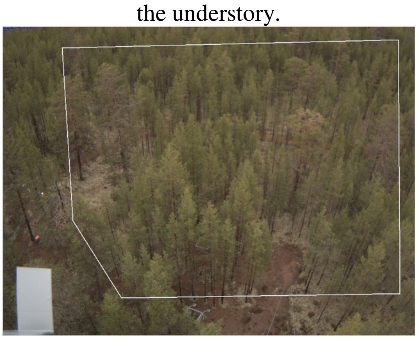
Vegetation phenology influences directly ecosystem processes related to carbon, water and nutrient cycling and serves as an indicator of long-term impacts of climate change on terrestrial ecosystems [1, 2]. Furthermore vegetation phenology has been proposed as an essential biodiversity variable (EBV) that could be used in the monitoring of biodiversity change [3].
Satellite observations provide information on vegetation phenology of the land surface at a large scale and phenological events, such as the start and end of season have been extracted from satellite observations for boreal regions [4-7]. The satellite-observed phenological events were linked to visual observations of phenological events of tree species or to the vegetation active period as inferred from CO_2 flux measurements [8]. Near-surface observations with networked digital cameras (webcams) may help in the interpretation and validation of satellite-based phenology products [9, 10] as they provide observations at high temporal resolution at an intermediate scale. Here, we compare daily satellite time series of vegetation indices and snow cover with web-camera observations that monitor selected ecosystem research sites in Finland.

2 Data and methods

Web-camera observations were obtained for the period 2014 to 2015 from four ecosystem sites (Tammela, Hyytiälä, Punkaharju and Sodankylä) located in spruce and pine forests. At each site, two to three cameras with different field of view monitored the landscape, canopy and the understory. Several regions of interest (ROIs) were selected from camera images: (i) covering a representative area to allow comparisons with satellite observations [10] and (ii) to separate the phenological cycle of tree canopy and understory (Figure 1). We used the software FMIPROT by the Finnish Meteorological Institute (FMI) for ROI definition and calculation of the relative colour signals: the green, red, blue chromatic coordinates (GCC, RCC, BCC) [11]. The 90th percentile value of the chromatic coordinates of an ROI during the hours around midday was used in the comparison with satellite products.

Figure 1: Selection of ROIs from webcam images for the Sodankylä site, covering (a) the landscape, (b) pine canopy (c) the understory.

(a)



(b)

(c)

Daily time series of the Normalized Difference Vegetation Index (NDVI), the Normalized Difference Water Index (NDWI) [12] and Fractional Snow Cover (FSC) [13] were calculated from MODIS Top-of-Atmosphere reflectance data. Clouds were masked using an operational algorithm by the Finnish Environment Institute. The satellite indices have a spatial resolution of 0.0025 (NDVI) and 0.005 degrees (NDWI and FSC). The fraction of land cover class was taken into account for the selection of MODIS pixels that correspond best to the observed vegetation type by the webcams.

3 Preliminary results

GCC time series from webcams showed a distinct phenological cycle in coniferous forest (Figure 2). The GCC of the canopy and at the landscape level increased before the snow-off date (FSC=0), whereas the understory GCC increased only after snow melt. The early spring rise of GCC in coniferous tree crowns was also observed by Richardson et al. [9] and has been attributed to biochemical changes in the existing foliage. The NDVI spring-rise began at about the same time as that of GCC and its increase before the snow-off date has been attributed to the changes in the surface reflectance due to the melting of snow [14]. The NDWI decreases during the snow melt and increases during the green-up of vegetation [6]. Its minimum coincides with the GCC rise in understory vegetation (lichen dominated patches) (Figure 4).

Figure 2: GCC time series for the three target ROIs shown in Figure 1. The blue vertical lines show the snow-off dates according to FSC satellite observations.

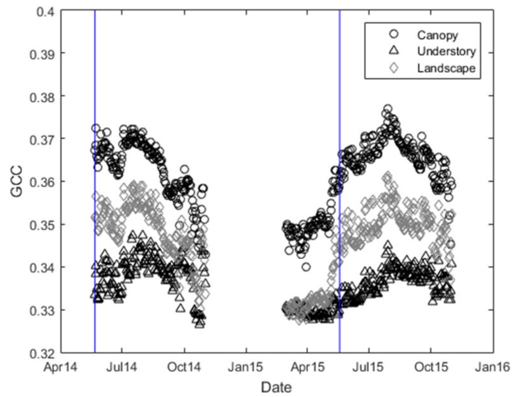


Figure 3: (a) Webcam time series compared to satellite time series of (a) NDVI and (b) NDWI at Sodankylä for the landscape ROI (Figure 1 a). The blue vertical lines show the snow-off dates according to FSC satellite observations.

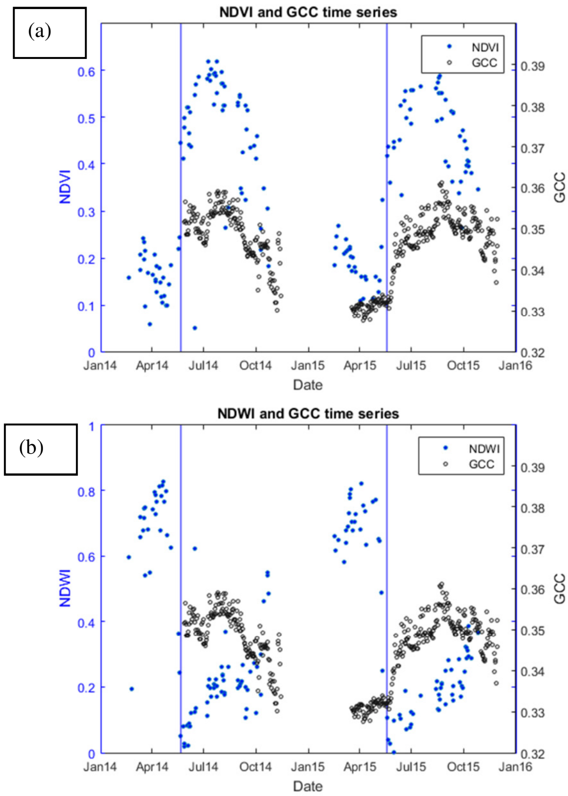
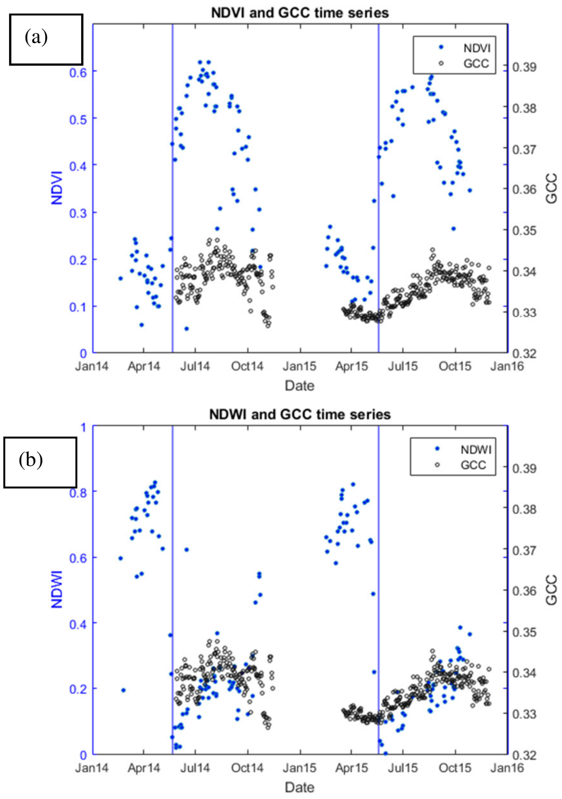


Figure 4: Webcam time series and satellite time series of (a) NDVI, (b) NDWI at Sodankylä for the understory ROI (Figure 1 c). The blue vertical lines show the snow-off dates according to FSC satellite observations.



4 Conclusions and outlook

We presented first results from comparison of webcam- and satellite time series for coniferous boreal forest in Finland. Previous studies that linked remote sensing and webcam observations on vegetation phenology focussed on deciduous broadleaf forest [10, 15]. Furthermore, the set-up of the webcam network in Finland allows the monitoring of understory in addition to forest canopy. This is important for the interpretation of satellite-observed phenology that provides an integrated view of the landscape. In further work, we will analyse the phenological events from webcams and high-resolution photographs visually and additional ancillary measurements are being carried out at the ecosystems sites to investigate the relation of GCC with pigment changes in coniferous forest. For the upscaling of the phenological events from webcams to the medium resolution satellite observation of MODIS and Sentinel-3 we plan to include high resolution satellite observations from Landsat-8 and Sentinel-2.

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