Changes in phenology and the influence on the carbon sequestration in a Danish beech forest over 20 years

Pilegaard, Kim; Ibrom, Andreas

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DTU Environment
Department of Environmental Engineering

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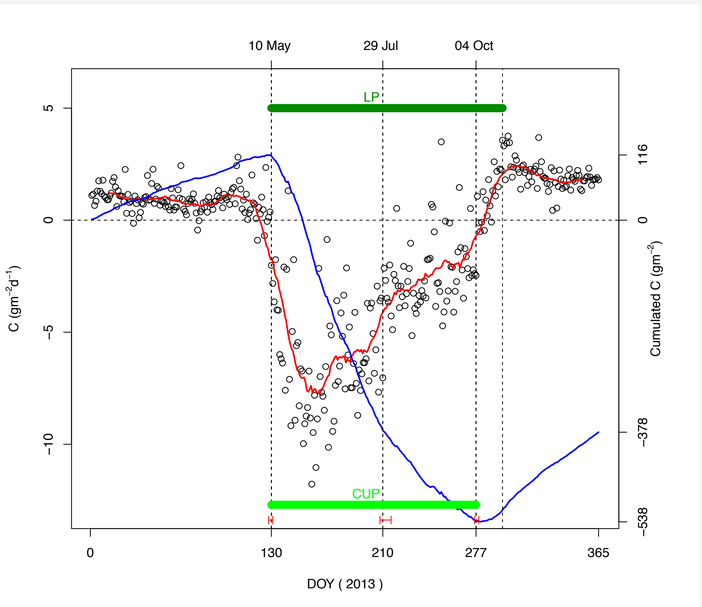
1 Introduction

Observations of carbon sequestration in a Danish beech forest over the last 20 years have shown a steady increase in NEE. Earlier studies (Pilegaard et al. 2011) have shown, that about half of the increase can be attributed to an increase in the growing season length. The growing season has been determined as the carbon uptake period (**CUP**); i.e. the period with net uptake, determined from flux data. Additionally, we have determined the period with leaves (**LP**) from the attenuation of light below the canopy. In this analysis we add information from a phenology camera with data from the last 6 years using the R package Phenopix (Filippa et al. 2016). The new data is compared with CUP and LP to give more detailed information on the phenology. The information is used to examine the evolution of net ecosystem exchange (**NEE**) over the 20 year period.

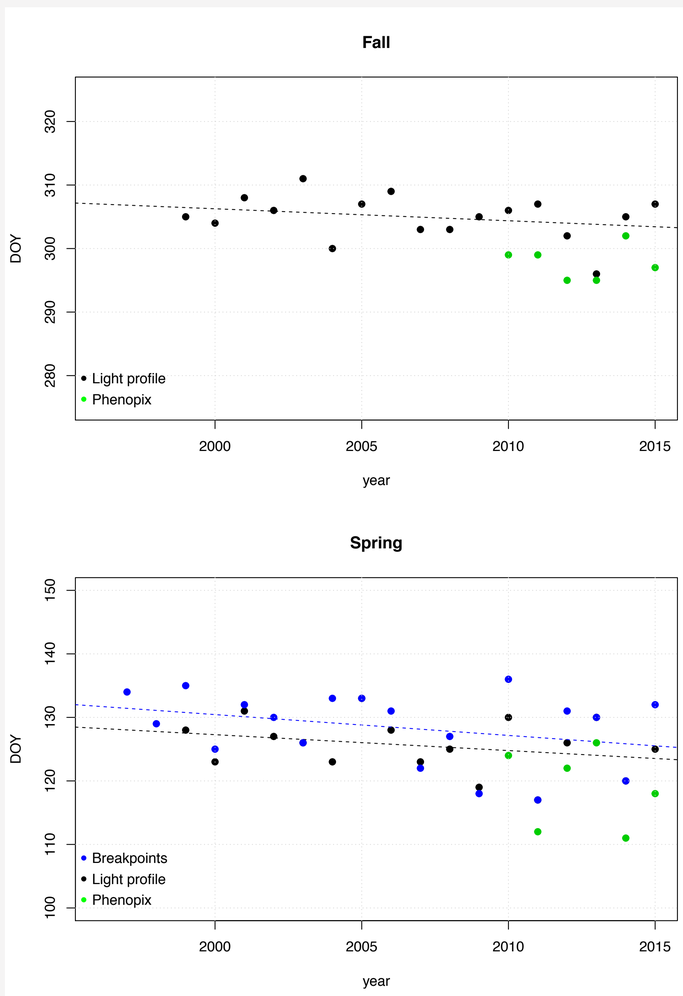
2 Phenology analyis

We used 3 methods to extract phenology information:

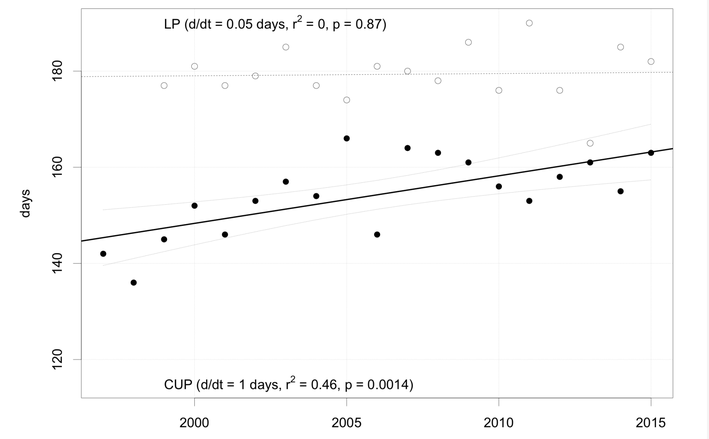
1. Determining the carbon uptake period (**CUP**) as the period with a net uptake of carbon by the forest using breakpoint analysis.
2. Determining the leaf period (**LP**) by finding abrupt changes in the ratio of PAR above and below the canopy.
3. Determining the start of season (**sos**) and end of season (**eos**) by means of image based analysis of pictures of the forest canopy taken with a PhenoCam.



3 Comparison of indices of phenology

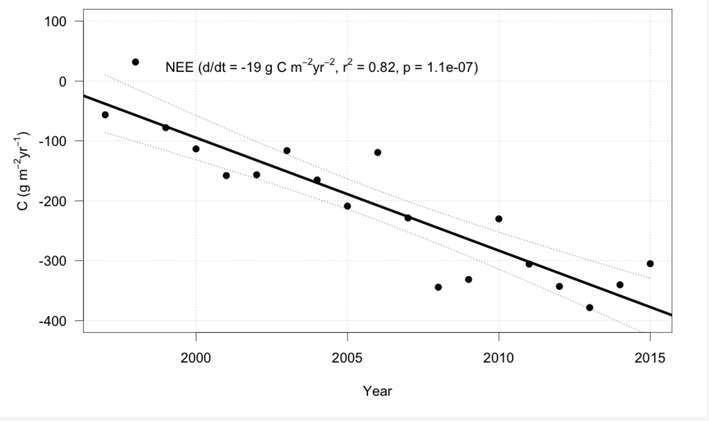


There seems to be a good correlation between the indices identified by the different methods. However, the end of CUP, as identified from the flux data, does not have a corresponding index in the image based analysis. The start of season (**sos**) indicated by the image analysis ocurs on average 6 days earlier than the start of **LP** as identified by the light attenuation. This is probably due to a green understory before leaf flush. The end of season (**eos**) occurs on average 6 days earlier than the end of **LP**, probably due to the complete loss of chlorofyll before the leaves are shed. The trends in both start and end of the growing season are not significant. The trend of **LP** is also not significant, but there is a significant increasing trend in **CUP** with an increase of 1 day yr^{-1}.



4 Carbon sequestration and phenology

The uptake of carbon by the forest has increased significantly over the period with an increase of 19 g C m^2 yr^{-1}. There is a significant correlation between annual **NEE** and **CUP**, although the increase in **CUP** only explains about half of the increase in **NEE**.



5 References

Filippa, G. et al.. 2016: Phenopix: A R package for image-based vegetation phenology. *Agricultural and Forest Meteorology*, 220:141-150.

Pilegaard, K. et al., 2011. Increasing net CO_2 uptake by a Danish beech forest during the period from 1996 to 2009. *Agricultural and Forest Meteorology*, 151: 934–946.

6 Authors

Kim Pilegaard, E-mail: kipi@env.dtu.dk
Andreas Ibrom, E-mail: anib@env.dtu.dk

DTU Environment
Department of Environmental Engineering
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Department of Environmental Engineering
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