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Interactive comment on "Interpreting canopy development and physiology using the EUROPhen camera network at flux sites" *by* L. Wingate et al.

Anonymous Referee #3

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This study presents a synthesis of phenology research based on color indices derived from digital repeat photography using a newly established European phenology network. By applying a change point detection method, start and end dates of the growing season as well as management effects on phenology are quantified and compared among different ecosystem types. In addition, a mechanistic model is used to describe changes in leaf chemical properties. The paper concludes with a section highlighting current challenges and gaps in phenology research based on digital repeat photography. This study provides very interesting information on underlying causes for phenology pattern both in time and among different ecosystem types. Understanding phenology and its link to the ecosystem carbon cycle is crucial and the study therefore provides valuable data needed for improving process-based models of ecosystem C cycling. The applied methods and interpretation of results are sound. Unfortunately,

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however, in my view the current manuscript does not provide a coherent content structure. Individual sections with different study goals are merged together and thereby distracting from each other and weaken the overall quality of this study. I therefore suggest that the authors should carefully examine and re-evaluate their main objectives and adjust the focus the study. My detailed comments follow below:

Major comments:

1) My main concern is that this study includes two themes which are not joined together well and in fact each of these two could be the basis for a separate manuscript:

i) The first theme is based on the objective to present 'the first synthesis from a growing observational network of digital cameras installed on towers across Europe'. This objective is exiting and raises the expectations that this work will focus on introducing a new research network to the research community. Moreover, the wealth of data existing within this network could allow a broad synthesis that could result in novel and more general knowledge of phenology patterns emerging across the different biomes. Instead, only a fraction of the network sites is included in the current analysis and the presented information is often too site-specific. For instance, the effect of acorn production on phenology or details on exact camera positioning observed at a specific site (page 7997, line 1-10) could be discussed in a site specific paper, however, it does not add general knowledge on phenology patterns across European ecosystems. Thus, instead of presenting a broad network analysis of phenology patterns, this section is primarily a compilation of site specific findings. In addition, by adding the second theme on mechanistic modelling, the authors, i.e. the network participants, miss out on the opportunity of presenting their European Phenology Network based on digital repeat photography in a dedicated publication.

ii) The second theme builds on the use of the mechanistic PROSAIL model to explore how seasonal changes in canopy color relate to changes in leaf area, leaf chlorophyll and carotenoid concentrations. This work is very interesting and provides novel in-

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formation on the underlying causes for color changes as detected with digital repeat photography. It is crucial to understand the individual effects of leaf area and chemistry on canopy color to be able to create links between changes in canopy color and the ecosystem carbon cycle. However, since this detailed work is of very different nature than that of theme i), its value gets obscured by presenting this work as an add-on to the first section. Thus, I think that the current manuscript could be considerably strengthened by focusing on only one of these two themes and I recommend that the authors should therefore carefully re-assess the structure of the manuscript.

2) The break point analysis provides interesting insights into the timing of important phenological events. However it is not clear why the maximum amount of breakpoints was set to 5 for both managed and unmanaged ecosystems (Page 7988, line 2-4). In my opinion it would be more logic to allow more breakpoints in managed systems than in natural ecosystems. The choice of the number 5 is also not well justified. Moreover, while breakpoints 1 and 5 are relevant to quantify the start and end of the vegetation period, it is often not clear to which event the additional breakpoints in between relate to (see Fig 5 and 6), specifically in the natural systems. Thus, while the change point analysis is presented as tool to objectively quantify phenological events, in the end it is still a subjective choice of which breakpoints are used in the results interpretation.

3) Both abstract and conclusions highlight the need for understanding and quantifying changes in the growing season length, start and end. However, the study itself provides little quantitative information on growing season length effects on the ecosystem C cycle. Moreover, the uncertainty of estimating start and end dates of the growing season based on change point detection compared to visual expert judgement was estimated between 9-16 days. Given that the dates for growing season length, start and end are likely to shift by a smaller number of days only over coming decades, the question arises how well this technique will be able to detect subtle shifts and to provide knowledge on its implications for the ecosystem C cycle.

Minor /detailed comments:

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Page 7983, line 16 and at other places: avoid the term ‘dramatic’

Page 7985, line 7-8. It might be merely a matter of wording, however, the current formulation of the first objective ’i) how well can digital images be automatically processed to reveal the key phenological events. . .’ is weak. It is known that images can be easily processed automatically with standard software routines. I believe the actual relevant question in this objective could be ‘how well do color indices derived from digital image analysis describe phenological patterns. . .’

Page 7985, line 26: Having only 1 image per day is not enough to derive robust color indices since the effects of illumination for this specific image might introduce considerable noise. Moreover, the method by Sonnentag et al 2012 used in in this study (method section Page 7987, line 14-15) was developed for image archives with more than 1 image per day.

Page 7986, line 2. Define ‘LT’. Using images between 11am and 1pm would provide 3 images, assuming hourly resolution. This is a limited number of images and their daily RGB means are likely sensitive to illumination changes. This uncertainty should be addressed.

Page 7986, line 4-5: Describe in more detail what the ‘fixed’ and ‘manual’ white balance settings are. Usually the fixed ‘daylight’ setting is recommended since it results in a color temperature of around 5200K. At this setting, the RGB digital numbers are the most neutral across all wavelengths. For lower and higher color temperature settings, especially the red and blue digital numbers deviate substantially for shorter and longer wavelengths. Consequently, this would hamper the comparison of the red and blue fraction among cameras with different white balance settings. This is also an important consideration with regards to the discussion on Page 8004, line 5-26.

Page 7986, line 11. Why should soil not be included in the ROI? This could provide valuable information on the fraction on ground covered by plants (e.g. in croplands).

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Page 7986, line 12-17. The term 'Automated segmentation methods' is not fully clear in this context. Does segmentation refer to defining a region of interest? Moreover, since this method was not used after all, I think there is no need to include a paragraph on it.

Page 7987, line 14. What is the amount of images (in %) that has been removed as outliers?

Page 7989, line 10-17. Since this study is about the phenology of European ecosystems, it is not clear why this analysis was done also for the Nikon camera since this model is used only at two sites within the European network.

Page 7993, line 4-5. Bp 2 and bp 4 occur on day 110 and 310, respectively, and cannot be assigned to a range of 10-20 days. Furthermore, there is actually no clear change visible in the gcc pattern shown in Fig 5 around the bp2 (day 110) and no clear change in GPP at bp4 (day 310). In my opinion, the timing of these breakpoints and their importance for linking GPP and gcc patterns has been over-interpreted in this specific analysis.

Page 7993, line 19-21: The sites selected from the network are mostly located within central Europe, thus it is not surprising that the differences are limited. The example of the alpine site Torgnon however indicates that including sites with more contrasting climate (i.e. maritime and Nordic sites) in the analysis would likely result in much greater differences among the patterns. Moreover, the breakpoint analysis does not capture well the onset of the greening up at the Klingenberg, Grillenburg and Neustift sites.

Page 7994, line 17-22. I don't see an issue with allowing breakpoint 1 to represent snowmelt and only breakpoint 2 describing leaf out, as long as this pattern is realistic for the specific ecosystem.

Page 7995, line 22. This statement is not well supported since the current study does

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not show any field data on how well the greenness color and leaf area correlate.

Page 7999, line 20-26 and Page 8000, line 20. Based on Fig 11, the slope of the Chl concentration rise is greater than that of Car concentrations at any time during the green-up phase, especially right around the time of the 'greenness hump'. It is therefore not clear why at some point the synchronous increase in Chl and Car should switch from an increase to a decline of the greenness fraction. Moreover, the model outputs are currently not validated with measured concentrations of Chl and Car. This is a limitation to take into account when interpreting the model outputs.

Page 8001, line 6 and Page 7996, line 6. What mechanism is changing the blue fraction? Is it possible that the blue fraction merely changes passively due to changes in the green and red signals? In that case the importance of humps and other patterns in the blue fraction would be limited.

Page 8002, line 25ff: I appreciate the discussion on current challenges; however, I suggest presenting only those solutions that offer a realistic option. For instance, suggesting the use of a color checker to quantify drifts is meaningless if within the same section it is acknowledged that the color checker itself might drift over time.

Language: Page 7988, line 16; Page 7992, line 7-9; Page 7995, line 10-14; and at several other places: Avoid subjective terms like 'few', steep' , 'slow', 'gentle' , 'rapid' or 'fairly similar', 'slightly shorter' etc and instead provide some quantitative information such as numbers and dates, e.g. 'within 5 days' , 'From April 1 to 5', etc.

Page 7995, line 1, Page 8004, line 27 to pg 8005, line 57 and at other places: the discussion is based on initial and 'preliminary' results at too many places. Preliminary result may be shown but in a limited quantity within a scientific publication. However, I suspect that this might be a language issue and that the authors actually refer to robust findings and analyses in these cases which however require further research. I suggest to avoid the term 'preliminary' where possible and/or to exclude results that provide no solid evidence.

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Avoid weak phrases such as ‘we tried to’, it seems that’, ‘it appears that’ or ‘tended to’ etc which occur frequently throughout the manuscript. It leaves the reader wondering about the robustness of the results and implications of such weak statements.

Table 1 & Figure 1: It seems odd that peatland sites are presented here while no dedicated section was included describing phenology patterns for this ecosystem type in the first section of the manuscript. I suggest including also a section on peatlands if the goal is to present a network synthesis (theme 1) or to otherwise remove these (and other) sites not used in the current analysis from the Table and Figure.

Interactive comment on Biogeosciences Discuss., 12, 7979, 2015.