Biogeosciences Discuss., 12, C4269–C4280, 2015
www.biogeosciences-discuss.net/12/C4269/2015/

Biogeosciences Discussions
Open Access

BGD
12, C4269–C4280, 2015

Interactive Comment

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

L. Wingate et al.

lisa.wingate@bordeaux.inra.fr

Received and published: 13 August 2015

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. . .. 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.

Response: The referee points out that this paper presents two important and related themes. Originally back in 2011 we wrote a previous manuscript presenting the network and focusing on the phenology patterns and their automatic detection, with the idea of having a separate paper for the PROSAIL modelling. However, reviewers requested that the interpretation of the datasets with our model was necessary. We took this onboard especially because the network is immature and has only been running for at most several years and not decades. Thus we believe it would be premature to conclude any broad or large-scale results on phenological patterns or inter-annual variability across the network. For example, Arguez & Vose, 2011 (Bull. Am. Met. Soc.) argued that at least 30 years of met data would be necessary to construct a WMO climate normal. We would imagine this would also be applicable to phenology given the strong link to climate and currently this data does not exist. Thus as the referee points out besides presenting the network the main focus of our paper is about developing the tools that will be necessary to analyse these growing datasets. We believe there is a natural progression and link in the manuscript between the results of breakpoint analysis and the need to understand better where possible what mechanism(s) underlie certain breakpoints and seasonal trends. We believe the addition of the PROSAIL modelling explains these breakpoints and patterns in deciduous broadleaf forests and grasslands well. We believe the comments incorporated from the three referees comments have really improved the manuscript and we have made an effort to make the link stronger in the objectives, the transitions text and in the discussion.

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.

Response: This was also raised by Referee 1 and we completely agree that in managed ecosystems or in other applications such as studies of flowering phenology running the algorithm to obtain more breakpoints would be important. For example some sites like Fruebuel in good years can have up to 7 mowing events and thus at least 8 possible changes would need to be identified.

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

Response: We have substituted the use of ‘dramatic’ to ‘large’

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. . .’

Response: We completely agree with the referee that objective 1 could be better formulated. Following the referees suggestion we have amended objective 1 to read. ‘how well do colour indices derived from digital image analysis describe key phenological events such as. . ..’

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.

Response: We agree to some extent with the referee about this comment. It is definitely true that several images per day are preferred for the reconstruction of seasonal variability over only one image. This is mainly to overcome noise that can be introduced in colour signals through changes in sky conditions. However, of the digital image archives available to date from this network, not all sites have collected more than one image per day in the past years. Thus we are currently addressing this problem at the moment and a protocol has been written recently (as part of the ICOS infrastructure) to ensure each site in the network will collect several images during daylight hours in the future. You will also see from our analysis that at sites where multiple images per day were available we incorporated them.

Nonetheless, the sites where only one image per day are available for the seasonal analysis still appear to provide strong indications of changes in the different colour signals over the growing season. In addition the seasonal patterns in the deciduous sites where only one photo per day is available still present seasonal features consistent with those sites where many images are available. One example is reported in Fig 2a, where the differences between the original (raw) and reconstructed green fraction (applying the Sonnentag filter) show a good agreement, also during the spring and autumn transition phases, where the application of the method to archives with 1 image per day could be more problematic. To demonstrate this we performed an analysis using an example dataset with 8+ images per day. We then randomly removed daily images to have only 1, 2, 3 or 4 images per day and then applied our filtering procedure. The random removal was boot-strapped 100 times (to sample different images for a single day) and then a min-max envelope was computed as shown in the plot below for the Italian site Torgnon. As expected the more images per day reduce the thickness of the envelope. However, the overall shape of the seasonal curve is exactly the same, in terms of phenological events, and also in terms of the minimum and maximum green fraction values. Thus although the filtering algorithm of Sonnentag et al., 2012 was developed for datasets with several images per day, because it is based on a 3-day moving window it is robust enough to be used on datasets with less than one image per day. Thus we believe that even a dataset of one image per day can be analysed robustly with Phenopix.

In addition, it is also worth noting that sites with only one photo per day seem to provide reasonable agreement with the start and end of the CO2 uptake period (Figs. 5, 7, 8 and 12) and visual observations (Fig. 3). So we believe that it is still possible to identify the principal changes in canopy features over the season in deciduous and grassland/cropland sites even when very few photos are taken each day. We would consider data gaps of several days or changes in the camera ROI far more problematic.

We also discuss in the manuscript that the green fraction variability is relatively small

BGD
12, C4269–C4280, 2015

within and between consequent measurement days in comparison to those of the red and blue signals over the growing season, as it is the green signal is least affected by diffuse sky conditions. We would also add that assimilating data on the fraction of diffuse radiation within and between days with PROSAIL can allow one to simulate the typical daily and seasonal variability in RGB signals. Thus in the future even these limited datasets may still provide useful information for time-series trend analyses.

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.

Response: Local time has been defined in the manuscript. We believe this comment has been addressed in the response to the previous comment.

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.

Response: The most important point about our statement in the Material and Methods is that to track seasonal changes in colour fractions the 'automatic' setting must be off, otherwise the camera will default to a 'grey world' algorithm, meaning the entire picture will be averaged and thus = grey. Red total = Green total = Blue total. The result of this problem is demonstrated nicely in the manuscript of Mizunuma et al., (2013). We also believe that in order to track seasonal changes in phenology, inter-camera differences do not seem to be a critical issue as demonstrated by Sonnentag et al., 2012. However, we agree that a network containing the exact same camera model would make future site inter-comparisons easier. We also agree with the referee that differences in how colour balance settings vary between cameras must be known or characterised if the link between colour signals and canopy pigment content are to be made. This is why so far we have only attempted the PROSAIL modelling for two camera models where we have the required information available to complete this step (Figs S1 and S2).

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).

Response: We agree with the referee that there is no reason why soil should not be included in the ROI especially if the objective of the study is to look at the fraction of ground covered by a canopy. However, this would require that the camera is mounted looking downward in a manner similar to those installed in the Japanese PEN network and used to generate Figs S8 (former S7) and S2. However, the majority of cameras in the European network are not suited to measure soil and are specifically mounted on towers to contain an ROI that can be easily related to the net ecosystem exchange also measured at the site and plant phenology.

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.

Response: On reflection we agree with this comment and we will remove this statement from the text.

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

Response: For the Migliavacca filtering there is a very small removal (<1%) for most sites. However, for some sites this can increase demonstrating the effectiveness of the

BGD

12, C4269–C4280, 2015

Interactive Comment

filtering procedure when necessary.

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.

Response: We agree this manuscript is focused on European ecosystems. However, although the wider implications of the present manuscript can be linked to phenology it more specifically aims to develop tools that can help us interpret RGB signals from digital cameras and make links to canopy development and physiology. In particular we explored the novel use of PROSAIL to simulate the signals obtained from digital cameras. In order to test this approach we felt that it was necessary to test the model at a site where more than one model of camera was installed. Over the years we have been very fortunate to have a successful collaboration with researchers from the PEN network and have both a Stardot and a PEN system (with a Nikon camera) installed and running at the same site. These systems are quite different in the way they are set-up, one looking across the canopy and another looking down (Mizunuma et al., 2013) as well as having slightly different RGB sensor characteristics (Figs S1 & S2). Thus they present a challenging test of the PROSAIL parameterisation and approach. The test shows that with information on the camera angle and sensor characteristics it is possible to model the RGB signals of different camera models with our seasonal inputs of pigment, LAIproxy and radiation. We hope it is now clearer the reasons behind our local choice but we also feel that by doing this we have demonstrated the modelling approach can work on the two camera systems that dominate the ‘global’ network of cameras at flux sites, making the result internationally important.

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

BGD

12, C4269–C4280, 2015

Interactive Comment

analysis.

Response: We thank the referee for pointing out this oversight and have corrected the day numbers accordingly. We also agree that the link between bp4 and the decrease in GPP is not as clear as in spring and have tamed down our interpretation in the text.

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.

Response: We agree that the recent addition of Nordic sites to the network will likely provide some very nice contrasts in the RGB signal when compared with the continental and Mediterranean sites in the future. We agree that the analysis for Klingenberg and Grillenburg is not great and is likely affected by the lack of temporal resolution (weekly) in the digital images.

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.

Response: We completely agree with the referee on this point and depending on the study having more breakpoints could be an advantage.

Page 7995, line 22. This statement is not well supported since the current study does not show any field data on how well the greenness color and leaf area correlate.

Response: We have modified this sentence.

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.

Response: The increasing pigment content of the leaves causes the decrease in the green fraction. Chlorophyll concentrations above 30 ug cm-2 and Car concentrations above 7 ug cm-2 cause a decline in the green fraction, this is demonstrated with the sensitivity analysis in Fig. 11. We also agree that measurements at the site would be great to confirm this model response, this is something we are currently working on. Preliminary results however indicate that the seasonal trends and values in pigment content we report for Oak are consistent with the present parameterisation and those found in a number of other published studies providing confidence in our interpretation.

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.

Response: The blue fraction is responding directly to both changes in chlorophyll and carotenoid content thus we would not classify this as a passive response. For example in the Fig. 8 of Feret et al., the absorption for chlorophyll and carotenoids is not the same in all wavelengths and can account for most of the colour signal trends. However, in addition the spectral efficiency of the RGB colour sensors of the camera (Figs S1 & S2) is also sensitive to wavelength and thus also feeds into the RGB camera signal trends. Thus, to summarise the pigment content, the spectral efficiency of the camera sensors, the conversion to colour fractions and changes in sky conditions (particularly for Blue and Red) all contribute partially to the RGB signals observed by the camera. To understand these different components we have created a repository containing the documented code and data needed to generate

Fig. 12 (and also Figs. 11, 13, 14, S1, S2, S3, S7 and S8) on a Bitbucket account (https://bitbucket.org/jerome_ogee/webcam_network_paper). Should the paper be accepted for publication in Biogeosciences, this code will be open to public access. We will place the link information for this git repository in the methods section 2.3 of the paper and again in the legend of Fig. 12.

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.

Response: A colour checker could be used on a very limited (hrs) but regular basis (a few times a year), thus we do not rule out this method as a possibility, on the other hand we think it is important to point out that it would not be our recommendation to leave a colour checker in the field for long periods of time for calibration purposes.

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.

Response: We have searched the manuscript for 'subjective' terms and where appropriate and when it does not break the flow of the text we have made changes.

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.

BGD

12, C4269–C4280, 2015

Interactive Comment

Response: We agree with the referee on this issue and have corrected the language in 4 places to convey that the results are robust and further research is now required.

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.

Response: We agree with the referee on this issue also and have corrected the language in 4 places to make stronger 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.

Response: Peatland sites are an extremely recent and exciting addition to the network. However, incorporating further analysis on these new sites is currently beyond the scope of the present manuscript. Nonetheless, these sites will undoubtedly be analysed in future studies and thus we believe it is important to state in this paper that these sites are now contributing to the network or will be very shortly in 2015.

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

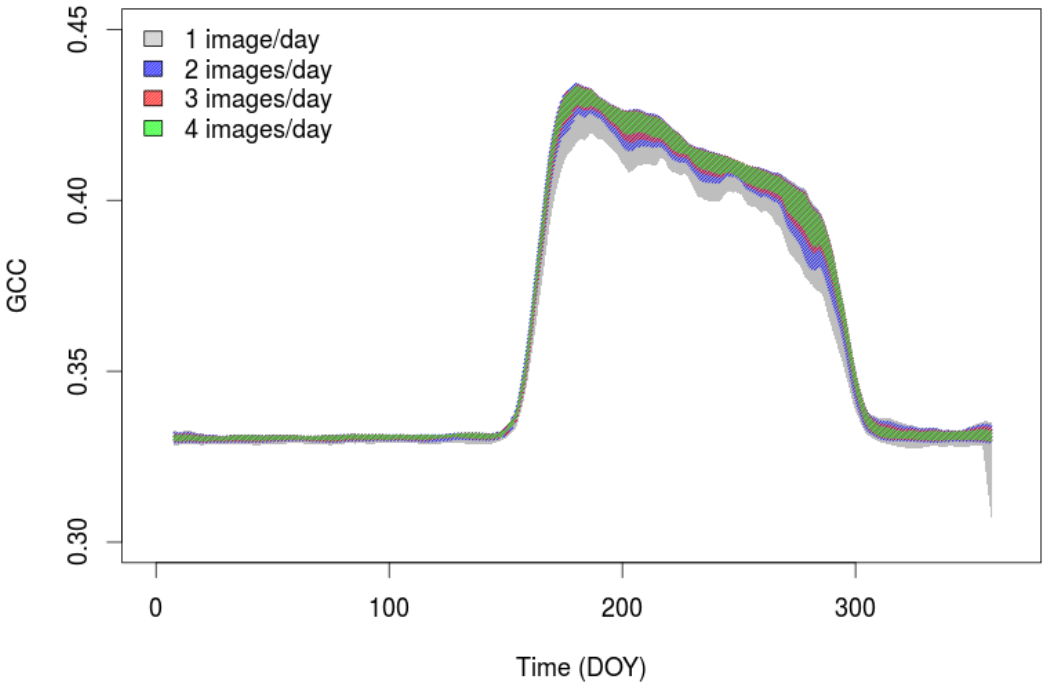

Fig. 1.

BGD

12, C4269–C4280, 2015

Interactive Comment