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Biogeosciences
Discussions

Interactive comment on "Modelling anomalies in the spring and autumn land surface phenology of the European forest" *by* V. F. Rodriguez-Galiano et al.

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The study contributed by Rodriguez-Galiano et al uses machine learning approach to model anomalies of spring and autumn phenology of the European forest, and ranking the relative importance of the pre-selected climate factors. This is sort of a new approach, comparing to the most commonly used Growing Degree Days approach, so it is useful and may be of interest to some people. However, I have been feeling many key information are missing, which weaken the quality of the manuscript. I would recommend a substantial revision before the official publication. The most unclear part

is on the methods. (1) I know the study region is the European Forest; but could the authors provide a map showing the study domain?

A map showing the study domain and the extent of forest cover during the study period has been provided.

Figure 1. Spatial distribution of Globcover broadleaved deciduous forest and needleleaved evergreen forest in 2005 (a) and 2009 (b).

-See Figure 1 in compressed file-

(2) MTCI data covers 2002-2012; daily temperature and precipitation data covers 2002-2011; but I don't find any information of the temporal coverage of the SIS data. Could you clarify it? So is the study period 2002-2011?

Yes it is the same study period for SIS, DAL, and temperature and precipitation. This has been clarified further in the revised text. It should be noted that that periods of MERIS MTCI and the climatic variables are different. Land surface phenology was extracted for each year from 2003 to 2011 using composites from 2002 to 2012 (composites from the previous and the subsequent year are needed to estimate LSP parameters as the phenology extraction algorithm needs 18 months of data to fit a seasonal cycle; see next comment). Most LSP extraction methods require composites of data contiguous to the year for which the estimate is needed. For instance, for the estimation of OG or EOS for 2003, the method will consider the whole of 2003 and the last and first months of 2002 and 2004, respectively. Thus, given that we are estimating 2003 and 2011, some data of 2002 will be included in the estimation of the phenology parameters for 2003 and a part of 2012 in the estimation of 2011. Weather predictors are computed using 30 and 90 days backward moving functions, so the computation period is shifted in relation to LSP. This is why the climatic dataset starts in 2002, even when 2003 is the first year for the LSP estimate.

(3) How were the MTCI Phenology dates were derived? And what's the accuracy of it?

I know the authors have mentioned something in the paragraph of 20, but a few more details should be added.

More details regarding LSP parameter estimation and accuracy assessment are provided and the text has been modified as below: “The time-series of MERIS MTCI data was used to estimate both the onset of greenness (OG) and end of senescence (EOS) from 2003 to 2011. Data for every estimation year considered 1.5 years of data (from October in the previous year to July in the next year) because the annual pattern of vegetation growth in some parts of Europe spans across calendar years and, hence, insufficient information about LSP is captured using a single year of data. The yearly values of OG and EOS were estimated for each image pixel of the study area using the methodology described in Dash et al. (2010). This methodology consists of two major procedures: data smoothing and LSP estimation (Figure 2a). Smoothed MTCI time-series data were obtained using a discrete Fourier transform because of its advantage of requiring fewer user-defined parameters compared to other methods (Atkinson et al., 2012). The peak in the annual profile was defined as a point on the phenological curve where the first derivative changes sign from positive to negative. Next, the derived data were searched backward and forward departing from the maximum annual peak to estimate the OG and EOS, respectively. OG was defined as a valley at the beginning of the growing season point (a change in derivative value from positive to negative) and EOS was defined as a valley point occurring at the decaying end of a phenology cycle (a change in derivative value from negative to positive). These satellite-derived LSP estimates were compared to ground observations of the thousands of deciduous tree phenology records of the Pan European Phenology network (PEP725) (Rodriguez-Galiano et al., 2015a). This comparison resulted in a large spatio-temporal correlation of the phenology estimates with the spring phenophase (OG vs leaf undolding; pseudo-R2=0.70) and autumn phenophase (EOS vs autumnal colouring; pseudo-R2=0.71).”

(4) The section 2.3 is very hard to follow. For example, how should I understand "The

different climatic measures were computed based on the 30 and 90 days previous to the Julian date"? I suggest you first present what climate predictors are used, then you can introduce how the climate predictors are calculated for spring and autumn phenology respectively. The climatic measurements are computed starting from the Julian date of a given LSP relative timing value in OG or EOS, and considering the previous 30 or 90 days to this date for computing the climatic function (i.e. moving average, growing degree days, identification of the first freeze within this period…). This section of the manuscript has been rewritten and a list of the variables used for spring and autumn modelling is given in a new table (Table 1):

“A suite of weather predictors were computed for each 0.25 $\times$0.25° grid cell associated with the occurrence of positive or negative relative timing values in LSP based on the ECA&D and CM SAF datasets (see Table 1). The predictors include temporal average values of temperature variables (Tmax, Tmin and Tavg), precipitation, DAL and SIS; temporal cumulated predictors such as growing degree days, chilling, precipitation, SIS and DAL; and the date of specific events such as the onset of greenness (legacy effect for autumn phenology modelling) the first freeze or the last freeze, as well as the difference between both dates (freeze period) for the modelling of autumn only. Growing degree days were computed using temperature thresholds of 0° and 5°. Chilling requirements were computed as the sum of negative temperatures (temperatures below 0°). Freeze was defined as dates with minimum temperatures lower than -2° (Schwartz et al., 2006). The different weather predictors were computed based on the 30 and 90 days previous to the day of the year (DOY) of the relative timing values in OG and EOS (Figure 2b) following Schwartz et al. (2006) and Menzel et al. (2006), who found that most phenophases of plant observations in Europe correlated significantly with weather predictors representing the month of onset and the two preceding months. The chilling requirements for spring modelling and freeze predictors were an exception, as the period for its computation starts 90 days prior to the OG. Relative differences between each predictor and its multi-year average for the same period were computed to capture the inter-annual variability in climate variables at the pixel level for every predictor and to facilitate the modelling of climate-driven variation in phenology (Table 1).”

-See Table 1 in the manuscript (compressed folder)-

Figure 1 is hard to read, too. I guess (not sure) it might be better to split Figure 1 into 2 sub-figures. One shows how the climate predictors are calculated and the second shows the big picture of the study. Also, the image quality of Figure 1 should be improved.

Figure 1 (Figure 2 now) has been modified to improve its interpretability and graphical quality.

-See Figure 2 (compressed file)

(5) Most of the first paragraph on the details of model application should be moved into Methods. Most of the technical details of this paragraph have been moved to methods. (6) R2 is not enough for validating your methods. RMSE, Bias should be included in the statistics. We agree with the referee that R2 is not enough. The relative errors of the different models are given in Figure 3 (Figure 2 in the previous version of the manuscript). However, it is also true that RMSE could be informative, especially in Figure 5 (Figure 4 in the previous submission), where R2 was given only. RMSE values for RF and multivariate linear regression have been included in the caption of the Figure.

Figure Caption: “...The explained variances (percentage R2) and RMSE values are 90% and 0.43 (spring Random Forest model), 68% and 0.92 (autumn Random Forest model), 39% and 1.04 (spring Linear model) and 25% 1.40 (autumn linear model).”

(7) Table 1 and 2 are hard to follow. The authors must provide the full names of the acronyms. The name of the weather predictors cannot be given in full due to a space limitation. However, a table containing all predictor names and acronyms have been included (Table 1).

(8) Lines 29-31: what are the simplified models? The simplified models are those obtained through the feature selection approach (see section 3.5 of the current submission).

(9) Line 34: is the "daily temperature" here the mean daily temperature in the preceding days (how many?)? This sentence has been rewritten as follows: “Our results suggest that temporal variation in the onset on greenness (LSP) of temperate forest species are driven mainly by the daily temperature of the 30 days prior to onset (but not necessarily the GDD), with the most important driver being the minimum temperature.”

(10) I think a comparison between the performances of the "traditional GDD approach" and the machine learning approach will be very useful in this paper.

GDD based approach is used in literature to predict spring phenology and in many cases a linear relationship was assumed between the GDD and the onset of spring phenophases (e.g. Yu et al 2015 in IJB). However, the focus was to identify the weather factors (predictors) that drives phenological changes and we consider GDD as one of the factors. LSP from satellite was derived at a fine spatial resolution and validated, these LSP were used to compute LSP relative timing values and a series of weather predictors using the DOY of the LSP relative timing value (z-score value) as the starting point are used to model the LSP temporal variation. Our approach is therefore an inverse approach because we LSP relative timing value and we explained it looking into the past weather. Therefore, this is not the case of direct approach to estimate the changes in phenology as a phenological GDD model could be. Nevertheless, we have applied an alternative approach regressing out our LSP relative timing values estimation with multiple single predictors (GDD included) which can inform about the variance explained by GDD predictors as proxies of temperature. This is therefore an alternative approach to that published by Cook et al, allowing to achieve the same objectives. Therefore, GDD linear models are implicit in our comparison. A direct approach to compare LSP temporal variation with that of a GDD phenological model would imply to apply a phenological GDD model in order to predict the DOY of phenology, then compute the relative timing of GDD onset and finally compare with LSP relative timing using a linear regression too (the same method for comparison that we have already applied). This is somehow similar to what we have done, as linear association are measured as well, but doing it in this way would imply to redesign the whole study.

(11) Figure 2: what is the x-axis? (number of climatic drivers? If yes, what are they?) The title of the x-axis has been included: “Number of weather predictors”, along with the following note in the caption: “See previous figure for the weather predictor variables in the models, as shown in the x-axis.”

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/12/C8723/2015/bgd-12-C8723-2015-supplement.zip

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Interactive comment on Biogeosciences Discuss., 12, 11833, 2015.