Dear Dr. Ibrom,

Please find enclosed the revised version of the manuscript: "Modelling interannual variation in the spring and autumn land surface phenology of the European forest" [MS No.: bg-2015-342].

The authors would like to thank the reviewer for the detailed comments and for taking the time to carefully read our revision and our reply to the referees. A detailed response to reviewer comments is given below:

Comment 1:

The authors have made some successful revision on the original form, which is great. However, I am still not very convinced on how a model can predict leaf phenology in two distinct phenological PFTs: deciduous broadleaved forest and evergreen needle leaved forest. Only climate predictors (temperature, solar radiation etc) were used in this model, can I interpret it as PFT doesn't make any difference? Say if I have two sites with different PFTs, and they have the same/similar climate, does the model predict the same OG and EOS at the two sites? Maybe I am wrong, but I hope the authors could provide more comprehensive explanations on their random forest method to help the reader better interpret the results.

Reply 1:

We would like to clarify that we are modelling interannual variation (i.e., changes, differences or deviations from one year to the next compared to the norm) in spring and autumn land surface phenology and we are not predicting the absolute dates of leaf phenology. We agree that it is likely that the absolute value of SOS or EOS will vary by PFT as the referee suggests, but this is not what we are predicting. It is not clear that the deviations (i.e., slightly earlier or slightly later phenology relative to the norm) will vary by PFT, and any such variations are likely to be subsumed by other greater sources of variation within the pixel (see below). This focus on deviations is clearly expressed in the title and throughout the manuscript. We are, thus, modelling relative temporal measurements associated to the same location (pixel) to explore the potential overall drivers of changes in LSP across Europe. This means advances or delays in the LSP when considering the temporal average for that particular pixel (*z*-score).

Land surface phenology (LSP) can be defined as the seasonal pattern of variation in vegetated land surfaces observed from remote sensing (Henebry and Beurs, 2013). In contrast to conventional phenology data, which typically include the timing of specific phenophases for individual plants, metrics of LSP represent the timing of reflectance changes that are driven by the aggregate activity of vegetation within the areal unit measured by satellite sensors (1 km in our case) (Huete et al., 2014). Therefore, these satellite-derived LSP metrics are associated to the phenology of the landscape, and do not provide exclusive information about the phenology of specific PFTs. However, despite the generalized nature of satellite sensor-derived measurements, they have proven useful for studying changes in LSP associated with weather and climate changes (Cook et al., 2005; De Beurs and Henebry, 2008; Post and Stenseth, 1999); and long-term trends in phenology and its key driving variables (Ivits et al., 012; Maignan et al., 2008a; Maignan et al., 2008b; Stöckli et al., 2011; Stöckli et al., 2008; Zhou et al., 2001). All these studies are focused on modelling of LSP changes or trends considering LSP as a whole and do not distinguish between PFTs.

We have applied our modelling approach to Globcover forest categories only such as to reduce the influence of non-climatic controls in the modelling of LSP changes. On the other hand, we believe that our approach -a relative measure of changes and its aggregation using the median of a larger population (50<N<625)- is probably far more robust than considering the absolute LSP values for different PFTs. There are numerous sources of uncertainties associated to the latter approach: i) mixed pixels between PFTs (the classical point vs. pixel problem); ii) the accuracy and the representation of the Globcover land cover maps. The following sentences are included in section 3.2 in this regard:

"To match the spatial resolution of the weather predictors, the LSP z-score values for each year were resampled to a spatial resolution of 0.25°×0.25° by calculating the median of all the LSP z-score values within this area after excluding the areas with fewer than 50 LSP estimates and the non-forest pixels according to the Globcover2005 and Globcover2009 land cover maps (http://due.esrin.esa.int/globcover/) (Figure 1). Only LSP estimates of Globcover forest categories with complete temporal coverage (2003–2011) were included in the analysis to reduce the likelihood of natural and human disturbances (Potter et al., 2003) and to minimize the effects of human management (i.e. irrigation in croplands). Globcover was selected for its greater consistency with the MERIS MTCI time-series and its high geolocational accuracy (<150 m) (Bicheron et al., 2011).."

Comment 2:

Figure 1 is not cited in the text.
Reply 2: Figure 1 is cited in the text now.

Comment 3:

L129-130: what is the difference between DAL and SIS? It seems they are both solar radiation.
Reply 3:

SIS and DAL are different and not discriminatory measurements of radiation as they account for different wavelength regions. Daylight (DAL) and shortwave radiation (SIS) measurements account for global surface irradiance (direct and diffuse). The solar surface irradiance consists of a diffuse fraction and a direct fraction. The diffuse fraction of the surface irradiance is defined as the solar radiation that has undergone scattering in the atmosphere. The direct irradiance is the solar flux reaching a horizontal unit of the Earth's surface from the direction of the Sun without being scattered. Both quantities are expressed in $W\ m^{-2}$. However, DAL is the solar surface irradiance in the visible wavelength region (photosynthetically active radiation; PAR), and SIS corresponds to the surface shortwave radiation (the surface radiation in the wavelength region between 200 nm and 4000 nm).

Mercado et al. (2009) in a recent paper published in *Nature* found a major impact on global carbon sink due to changes in the diffuse fraction in the shortwave and PAR radiation (http://www.lmd.jussieu.fr/~obolmd/PDF/2009_Mercado_et_al_Nature.pdf). Therefore, we believe that both measurements are important and might be explanatory of changes in vegetation phenology.

Comment 4:

L137-138: acronyms here are very confusing. For example, what is CDR? I would suggest the author combine the two paragraphs in the Data section together and don't use acronyms in the introduction of data;

Reply 4:

CDR means “Climate Data Record”. This is the internal notation used by Climate Monitoring Satellite Application Facilities.

It is true that the number of acronyms might be overwhelming and they are not necessary in some cases. We have rewritten the manuscript to remove all the unnecessary acronyms.

The paragraph has been rewritten as follows:

‘Three sources of data were used for this research: i) Satellite sensor derived temporal composites of MERIS Terrestrial Chlorophyll Index (MTCI), ii) temperature and precipitation data from the European Climate Assessment and Data project (http: //www.ecad.eu) and iii) surface radiation daylight (DAL; w/m2) data and surface incoming shortwave (SIS; w/m2) radiation data from the Climate Monitoring Satellite Application Facilities (http://www.cmsaf.eu). We used weekly composites of MTCI data at 1 km spatial resolution from 2002 to 2012. This dataset was supplied by the European Space Agency and processed by Airbus Defence and Space. Daily temperature (mean, minimum and maximum) and daily precipitation data were derived from the European Climate Assessment & Dataset time-series (version 10.0) with spatial resolution of 0.25° ×0.25°, covering the period from 2002 to 2011 (Haylock et al., 2008). Both radiation datasets, DAL (Müller and Trentmann, 2013) and SIS (Posselt et al., 2012; Posselt et al., 2011) were derived from Meteosat satellite sensors at a spatial resolution of 0.05° x 0.05° covering the same period as the temperature and precipitation datasets.’

Comment 5:

L155: "a change in derivative value from positive to negative" sounds a peak rather than a valley, please clarify it?

Reply 5:

Both of them are valleys, as a change from positive to negative is a valley when the derived data are searched backwards.

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