Disclaimer: This review was written by MSc student Maaike de Boer as part of her course work on "scientific reviewing", under supervision of dr Arnold Moene from Wageningen University. The comments were submitted because they can contribute to the scientific process, and because they contain helpful questions and suggestions for the authors. Although the structure of this review follows the formal conventions, it is thus not a solicited peer-review from the editor of ACPD.

In the paper *Towards a global understanding of vegetation-climate dynamics at multiple time scales*, Linscheid et al. describe a novel approach to study the dynamics between vegetation and climate at multiple time scales. Due to long-term Earth observations (EOs), ecosystem analyses are possible at time scales of over thirty years. In this study, global NDVI is correlated with two climate variables, air temperature (T_{air}) and precipitation (Prec), and studied at short-term, seasonal, and long-term time scales. The different time scales were determined using Fast Fourier Transformation (FFT), and linear correlation methods were used for the correlation. Bivariate colour maps were used to present the correlations. The effect of land use change was also taken into account, to see its effects. The authors did a comparison between the techniques Fourier Transform and Empirical Mode Decomposition, to see whether the latter more data-adaptive technique leads to different insights.

The paper was written clearly and is well-structured, and the figures were clear and supportive of the paper. Using bivariate colour maps to present the correlations is an excellent choice for the variables considered in this research (Teuling et al., 2011). Similar research has been done before, but only for specific regions (Martinéz and Gilabert, 2009; Canisius et al., 2007; Hawinkel et al., 2015) or not taking co-interpretation with climate variables into account (Pan et al., 2018), which is why the findings in this paper are novel and valuable. The paper fits the scope of the journal *Biogeosciences* very well, but some revision needs to be done before the paper is ready for publication. The paper overall is good, but revisions could be made on several topics.

I recommend the authors to revise some parts of the paper. Specifically, in sections 2.1, 2.2, 2.3, 2.4 and 2.5 I have some major revisions. I also have some further minor and very minor revisions. I will go into further details on those revisions below.

Major comments:

- In section 2.5 the method for the correlations between variables at each time scale is discussed. Correlation of the time-scale specific sub-signals of NDVI, T_{air} and Prec was done using Pearson's correlation coefficient, Spearman correlation, and partial correlation. All three of those methods assume linear correlation. However, the authors do not specify anywhere in the paper why, or even if, linear correlation can be assumed for the data they are analysing. This assumption should be elaborated on, because if linear correlation could not be assumed, these correlation analyses would not be a possible method. The choice of linear correlation affects results section 3.4 and Figures 3 and 4, thus revision is needed. My proposed revision entails the authors explaining which assumptions are made to allow for linear correlation. It is also advisable to discuss the consequence of assuming linear correlation in the discussion, to evaluate its effect on the results of the study.
- In section 2.1 the data that is used for the study is elaborated on. A global gridded dataset of NDVI at 0.5° spatial resolution is used. T_{air} and Prec data is obtained at 0.083° spatial resolution. To match the NDVI data, the data for T_{air} and Prec were aggregated to 0.5° spatial resolution. For T_{air} this was done by averaging, and for Prec this was done by summation. However, detail on extreme values for both T_{air} and Prec is lost by this aggregation. For T_{air}, local extreme values will be lost due to averaging over a larger area, while for Prec local extreme values will be smoothened out due to summation over a larger area. Upscaling of the T_{air} and Prec data is part of the pre-processing of

the data, thus it has effects on all results and conclusions. A revision is recommended to include a quantification of the sensitivity of the resulting classification in regimes to the spatial averaging. Furthermore, NDVI data is available at 0.05° spatial resolution (National Center for Atmospheric Research Staff), so the upscaling of the T_{air} and Prec data to 0.5° is not necessary. There could be many reasons for not choosing the higher resolution 0.05° data, for instance due to the 0.5° data being more manageable. However, there is no discussion on these possible reasons. Revision is therefore advised to include a discussion about the choice for 0.5° rather than 0.05° spatial resolution data.

- In section 2.2 the time periods that are used to reconstruct the different time scales are described, stating that similar frequency bins have been used in previous studies. The literature referenced however, by Mahecha et al., has no mention of these similar frequency bins. The article only states that the annual-seasonal was defined as periods in the interval 0.375-1.25 years. I could not obtain the other literature that was referenced for these similar frequency bins, a thesis by Fürst. Basing the time periods only on the annual-seasonal interval mentioned in the article by Mahecha et al. without further explanation is not valid. This section should be revised, and argumentation for the chosen time periods should be included, as well as a quantification on how the conclusions are influenced by these time period boundaries.
- The time series decomposition is done by Fast Fourier Transformation. However, Mahecha et al. (2010) state that classical Fourier decomposition is not the best method to segregate data into different temporal scales. Discrete Wavelet Transforms (DWT) or Empirical Mode Decomposition (EMD) are mentioned as better alternatives, because those methods do not assume a fixed superposition of weighted sines and cosines. The authors do a comparison of Fourier Transform with EMD in section 2.7 of the methods, and they discuss the difference in results between the two techniques in section 4.4, but it is recommended to include an explanation on the choice for FFT as method for the main research.
- In section 2.5, lines 124-125, it is stated that NDVI was lagged one time step (15 days) behind Prec in order to allow response time of vegetation to changes in water availability. However, Jamali et al. (2011) found a response time of 8-40 days of vegetation indices to rainfall changes for six sites in Africa. This response time is much longer than the 15 days assumed in this paper. The study by Jamali et al. was conducted in Africa, so perhaps in more moderate climates, the response time would be closer to 15 days. A revision is recommended to include a motivation for the 15 days response time chosen for this study, to discuss on what literature this choice was based and whether this is a valid choice for a global estimate.
- In section 2.4 the method for determining the variance per time scale and co-oscillation regime is discussed. It is explained that 64 possible combinations of oscillation regimes are possible, of which only 26 occurred. For simplicity, the analysis focussed only on the 11 most abundant oscillation regimes, which comprise 99.7% of pixels. The only argumentation given by the authors for choosing these 11 most abundant oscillations is for simplicity, which is not a concrete reason to make this choice. The choice to take only the 11 most abundant oscillation regimes into account affects results sections 3.2 and 3.3, as well as Figures 2 and 3. I therefore recommend the following revisions: the authors should elaborate on what they mean by simplicity. They should also specifically discuss why the eleven most abundant oscillation regimes are chosen, rather than a more logical and round number such as 10 or 15. The same goes for the percentage of pixels, why choose 99.7% rather than for example 99.5% or 99%?

Minor comments:

- No information is provided on data processing of NDVI to minimise effects by external factors. Some external factors that could have an effect are mentioned by Zeng et al. (2013): solar zenith

angle or volcanic stratospheric aerosol effects from major volcanic eruptions. Please include a discussion on possible effects by external factors.

- p5, lines 126-128: only the seasonal and longer-term oscillations are compared, and no motivation is provided for not including short-term oscillations in this comparison. Please elaborate on why short-term oscillations are not included in the comparison.
- p9, Fig 2a: it is not specified what the white colours on the map correspond with. It can be assumed that these correspond with NA, but this should be mentioned in the caption.
- p12, Fig. 3a: just as for Fig. 2a, no specification on what the white colours on the map correspond with. The caption mentions that NDVI<0.2 were excluded, but it is not mentioned that these are shown in white on the map.
- p13, Fig. 4: same as for Fig. 2a and Fig. 3a. The caption says that areas with correlations between -0.2 and 0.2 were not considered, but it is not mentioned that these are shown in white on the map.

Very minor comments:

- p4, line 110: change notation from "75'871'486 km^2" to "75,871,486 km^2".
- p7, Fig. 1: in the caption, change "seasonal(annual)" to "seasonal (annual)".
- p9, Fig. 2: in the caption, "DBF" is mentioned, but in the figure it is called "DBF_open". Please change one of the two, so they correspond with each other.
- p10, line 219: change "At" to "at", because after a colon.
- p10, line 228: change "While" to "while", because after a colon.
- p10, line 237: change "For" to "for", because after a colon.
- p10, line 239: change "northern" to "Northern".
- p11, line 269: change "Tair" to "T_{air}".
- p11, line 270: add a comma between "method" and "a".
- p12, Fig. 3: remove the second "." in the bold part of the caption.
- p13, Fig. 4: change "Tair" to "T_{air}" in the legend of the bottom map.
- p14, line 274: change "characterised" to "characterized" for consistency, because in the rest of the paper American spelling is used.
- p14, line 285: change "point" to "points", because it is a singular verb.
- p14, line 293: add a comma between "precipitation" and "are".
- p15, line 308: change notation from "3'939'362 km^2" to "3,939,362 km^2".
- p18, line 400: change "Tair" to "T_{air}".

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