

Review of “Abrupt seasonal transitions in land carbon uptake in 2015” by Chao Yue et al.

Matthias Forkel, 2017-03-08

1. Does the paper address relevant scientific questions within the scope of ACP?

The article by C. Yue et al. addresses annual and seasonal variabilities in global land carbon uptake and the relations with climate and vegetation. This paper is within the scope of ACP.

2. Does the paper present novel concepts, ideas, tools, or data?

The paper is based on well established datasets and methods to generate such data (CO₂ measurements, NDVI data, atmospheric inversion). The title and the abstract of the paper mainly highlights one finding of the study about "abrupt seasonal transitions in land carbon uptake". This finding is not really new (except the focus on 2015) but the results of the study are a good opportunity to remind the land carbon cycle community about such mechanisms and to point to the year 2015 as a remarkable example of such seasonal transitions.

3. Are substantial conclusions reached?

The entire study is focussed on anomalies of the land carbon uptake in the year 2015 relative to the period 1981 to 2015. Consequently, the conclusions are very specific for climate/carbon cycle mechanism in this year. To make this paper more interesting for the land carbon cycle community and to reach more substantial and less specific conclusions, I would recommend to perform similar analyses also for other years and to finally draw conclusions about general mechanisms in comparison to specificities in single years. In this point, I completely agree with Anonymous Referee #1.

4. Are the scientific methods and assumptions valid and clearly outlined?

Overall, yes. For some datasets, I would expect scientific references additionally to the URLs from which the data was obtained (especially in Sections 2.2.2 and 2.2.3).

The only exception is the analysis of NDVI data (Section 2.2.1): For example, the authors calculated “seasonal mean standardized NDVI”. Although I have some experience with NDVI data (Forkel et al., 2013), I cannot imagine what this term means. How were NDVI values standardized? Why? Furthermore, mean NDVI values of winter seasons in northern regions are not very useful to draw conclusions about vegetation productivity or land carbon uptake. As NDVI is a land surface property it is not only affected by vegetation but outside the peak of the growing season strongly by changes in snow cover and soil reflectance. Consequently, a certain ranking in a season especially in northern regions might be due to the variability in snow cover but not in vegetation. The authors need to appropriate filter the NDVI time series to separate vegetation signals from other non-vegetation distortions (Hird and McDermid, 2009; Holben, 1986; Kandasamy et al., 2013). Furthermore, NDVI datasets from different sensors show large differences which are especially important for seasonal anomalies that are outside of the peak of the growing season (D’Odorico et al., 2014; Fensholt and Proud, 2012; Kern et al., 2016; Scheftic et al., 2014). Consequently, I'm wondering if the shown ranking of seasonal NDVI values (Fig. 1) is a robust result given the noise

of NDVI data and the differences between datasets. This rises the question if 2015 is indeed the greenest year.

5. Are the results sufficient to support the interpretations and conclusions?

Apart from the NDVI issues described above, the results are described in great detail and support the interpretation and conclusions.

6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?

The calculations are mostly well described. The calculation of seasonal NDVI ranks seems to be a new approach to analyse NDVI time series (at least no reference is provided). Therefore I would recommend that the authors present some more details on this approach (at least in the Supplement) and ideally could provide also the code.

7. Do the authors give proper credit to related work and clearly indicate their own new/original contribution?

Yes. The cited literature is relevant for this study. The own contributions of the authors are clear. However, I would recommend to provide a more detailed discussion on the link between vegetation greenness from satellites and carbon cycle or atmospheric CO₂ variability in order to improve the discussion section that is currently strongly focussed on the specificities of the year 2015. The results of this paper could be for example discussed with respect to the following relevant papers (Angert et al., 2005; Forkel et al., 2016; Gonsamo et al., 2017; Keenan et al., 2016; Myneni et al., 1997; Thomas et al., 2016).

8. Does the title clearly reflect the contents of the paper?

Yes. However, I recommend to extent the analysis to more years to draw less specific conclusions for a single years. This might imply to change the title accordingly.

9. Does the abstract provide a concise and complete summary?

Yes. The abstract is well written.

10. Is the overall presentation well structured and clear?

Yes.

11. Is the language fluent and precise?

Yes (as far as I can judge this). Some sentences are however too long and thus difficult to read, for example: lines 74-78, 90-93,

12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used?

Yes. Units and proper axis descriptions are missing in Fig. 4.

13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?

Lines 71-74 are repeating lines 58-61 and can be merged.

Lines 81-93: The affect of station network density on the inversion is well described for the CarboScope product. According to my understanding, the CAMS inversion should have the same problems. Please clarify how these issued are handled in the CAMS inversion.

Lines 131-139: Please make clear why the conversion from ppm to PgC was done and if there is any relevant uncertainty in this conversion factor.

Lines 163-164: What do you mean with “numerical instability”? Why could such an instability happen and why in 1993?

Line 296: I thought that the Jena inversion system uses flat land prior fluxes. Are results from the LPJ model really used?

Figure 4: The figure could be much easier to read if you do some changes: #1 The red-green colour scale is not needed because the same information is already provided by the x-axis. Additionally, this colour scale might be not visible for colour-blind people. #2 The main purpose of this figure is to compare distributions of seasonal transitions from CAMS and Jena04. Overlaid histograms are not a good graphical choice. I would recommend to rather show distributions in terms of density lines, boxplots or violins which would make it easier to compare the distribution of CAMS and Jena04. The vertical lines for the year 2015 can be still added if you want to keep the focus on this year. #3 Please provide labels and units for the x-axis.

14. Are the number and quality of references appropriate?

Yes, but also refer to my answer to the question #7.

15. Is the amount and quality of supplementary material appropriate?

Yes, but an improved processing and uncertainty assessment of NDVI data might require more details in the supplementary material.

References

Angert, A., Biraud, S., Bonfils, C., Henning, C. C., Buermann, W., Pinzon, J., Tucker, C. J. and Fung, I.: Drier summers cancel out the CO₂ uptake enhancement induced by warmer springs, *Proc. Natl. Acad. Sci. U. S. A.*, 102(31), 10823–7, doi:10.1073/pnas.0501647102, 2005.

D’Odorico, P., Gonsamo, A., Pinty, B., Gobron, N., Coops, N., Mendez, E. and Schaepman, M. E.: Intercomparison of fraction of absorbed photosynthetically active radiation products derived from satellite data over Europe, *Remote Sens. Environ.*, 142, 141–154, doi:10.1016/j.rse.2013.12.005, 2014.

Fensholt, R. and Proud, S. R.: Evaluation of Earth Observation based global long term vegetation trends — Comparing GIMMS and MODIS global NDVI time series, *Remote Sens. Environ.*, 119, 131–147, doi:10.1016/j.rse.2011.12.015, 2012.

Forkel, M., Carvalhais, N., Verbesselt, J., Mahecha, M., Neigh, C. and Reichstein, M.: Trend Change Detection in NDVI Time Series: Effects of Inter-Annual Variability and Methodology, *Remote Sens.*, 5(5), 2113–2144, doi:10.3390/rs5052113, 2013.

- Forkel, M., Carvalhais, N., Rödenbeck, C., Keeling, R., Heimann, M., Thonicke, K., Zaehle, S. and Reichstein, M.: Enhanced seasonal CO₂ exchange caused by amplified plant productivity in northern ecosystems, *Science*, aac4971, doi:10.1126/science.aac4971, 2016.
- Gonsamo, A., D'Odorico, P., Chen, J. M., Wu, C. and Buchmann, N.: Changes in vegetation phenology are not reflected in atmospheric CO₂ and 13C/12C seasonality, *Glob. Change Biol.*, n/a-n/a, doi:10.1111/gcb.13646, 2017.
- Hird, J. N. and McDermid, G. J.: Noise reduction of NDVI time series: An empirical comparison of selected techniques, *Remote Sens. Environ.*, 113(1), 248–258, doi:10.1016/j.rse.2008.09.003, 2009.
- Holben, B. N.: Characteristics of maximum-value composite images from temporal AVHRR data, *Int. J. Remote Sens.*, 7(11), 1417–1434, 1986.
- Kandasamy, S., Baret, F., Verger, A., Neveux, P. and Weiss, M.: A comparison of methods for smoothing and gap filling time series of remote sensing observations – application to MODIS LAI products, *Biogeosciences*, 10(6), 4055–4071, doi:10.5194/bg-10-4055-2013, 2013.
- Keenan, T. F., Prentice, I. C., Canadell, J. G., Williams, C. A., Wang, H., Raupach, M. and Collatz, G. J.: Recent pause in the growth rate of atmospheric CO₂ due to enhanced terrestrial carbon uptake, *Nat. Commun.*, 7, 13428, doi:10.1038/ncomms13428, 2016.
- Kern, A., Marjanović, H. and Barcza, Z.: Evaluation of the Quality of NDVI3g Dataset against Collection 6 MODIS NDVI in Central Europe between 2000 and 2013, *Remote Sens.*, 8(11), 955, doi:10.3390/rs8110955, 2016.
- Myneni, R. B., Keeling, C. D., Tucker, C. J., Asrar, G. and Nemani, R. R.: Increased plant growth in the northern high latitudes from 1981 to 1991, *Nature*, 386(6626), 698–702, doi:10.1038/386698a0, 1997.
- Scheftic, W., Zeng, X., Broxton, P. and Brunke, M.: Intercomparison of Seven NDVI Products over the United States and Mexico, *Remote Sens.*, 6(2), 1057–1084, doi:10.3390/rs6021057, 2014.
- Thomas, R. T., Prentice, I. C., Graven, H., Ciais, P., Fisher, J. B., Hayes, D. J., Huang, M., Huntzinger, D. N., Ito, A., Jain, A., Mao, J., Michalak, A. M., Peng, S., Poulter, B., Ricciuto, D. M., Shi, X., Schwalm, C., Tian, H. and Zeng, N.: CO₂ and greening observations indicate increasing light-use efficiency in northern terrestrial ecosystems, *Geophys. Res. Lett.*, doi:10.1002/2016GL070710, 2016.