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Interactive comment on "Assessing the dynamics of vegetation productivity in circumpolar regions with different satellite indicators of greenness and photosynthesis" *by* Sophia Walther et al.

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Summary: This paper analyzes the timing of peak vegetation productivity for high latitude treeless ecosystems based on spaceborne remote sensing observations. Satellite data utilized in the study includes: 1) MODIS-based GPP; 2) MODIS NDVI; 2) MODIS-based APAR; 3) GOME2 SIF; and 4) AMSR VOD. The authors find a consistent ordering of peaks: APAR < GPP < SIF < VIs / VOD. The authors conclude that the consistent differences between photosynthetic activity and greenness is an important consideration when using satellite observations as drivers in vegetation models. Overall, I find this to be a nice paper with some interesting/useful findings. I do how-

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ever have a number of recommended revisions before I can recommend this paper for publication. Most importantly, I highlight a number of ways to potentially improve the analysis and better demonstrate robustness of the findings.

Major Comments: 1. The introduction is very well written and does an excellent job of framing the research questions and establishing the importance of the work. 2. The processing of the various satellite observations is explained very well and done appropriately.

++Thank you. ###

3. The authors use a definition of the timing of peak vegetation productivity as "the timing of the annual maximum is defined as the average day of year (DOY) of all days at which the values exceed the 95th quantile of all valid values of the time series in a year in a given pixel." I question this method as these different data have inherently different levels of daily variability, which could result in spurious dates being included in the period exceeding the 95th quantile of all valid values. I recommend filtering (e.g., using a Savitzky-Golay filter) and then finding the peak of the time series. This would be a good check on the robustness of the main findings of the paper.

++We fully agree that different levels of data availability and variability renders the results sensitive to the method of peak identification and confirm that spurious effects of large values especially in the beginning and at the end of the growing season (looking at random pixel time series, not shown) affect the peak timing (examples e.g. in the manuscript in Figures A5 and A7 , or as also shown for SIF GFZ in the time series at site level in the plots for the EC site-level evaluation below) . These effects are stronger for some vegetation proxies than for others. We had also tested other methods for smoothing and the peak identification (including function fitting as in Gonsamo et al. 2013 Ecological Indicators), but did not find one method that could accommodate all problems and therefore decided to stay with the most straightforward method. Despite large spread and only a limited amount of years in the analysis we think that the order-

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ing of the groups of proxies in Fig.4 supports robustness on the large scale. In order to still test for robustness and obtain uncertainties we bootstrapped the time series (time series per proxy and year are resampled each 50 times consistently across proxies, i.e. the same DOYs are sampled for each proxy) and calculated the peak time for the bootstrap samples with the same method (average of all DOYs exceeding the 95th percentile). Preliminary results for selected proxies are shown below in fig.1: ###

4.Additionally, I find the examination of the peak of seasonal activity interesting, but feel it would be complemented by consideration of the start and end of season. Using the above-mentioned Savitzky-Golay filter (or something similar), start and end of season estimates could be easily derived. I recognize this is a lot of additional work and analysis, but I think it could really strengthen the findings of the paper. I put this forward as a recommendation that could strengthen the paper, but this additional analysis is not necessary needed to warrant publication as the current findings of the paper are still very interesting.

++Indeed, analysis of the complete growing season would make the study more complete. However, in tundra ecosystems the onset and end of the growing season are very fast transitions and considering the difficult observation conditions and high noise levels, accurate characterization of the sharp SOS and EOS will be more challenging. We therefore decided to focus here on the peak growing season. ###

5. I think the study would benefit from comparison at any eddy co- variance flux tower sites within the study area. EC flux tower-derived GPP data could be used more effectively than modeled GPP to establish which proxies are capturing peak photosynthesis and which are capturing other aspects of plant dynamics (e.g., changes in water content, changes in leaf area, etc.). In particular, this would be useful in establishing whether SIF observations are providing new information more directly associated with plant physiological function. For instance, the authors may find SIF bet- ter matches EC tower-based GPP compared to the modeled GPP used in the analysis. This would be very useful information for the modeling community.

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++We used a subset of EC-sites from the FLUXNET 2015 data set for an additional comparison to satellite SIF, temperature (site-level, filled with down-scaled and regressed ERA-Interim) and FLUXCOM GPP (please note that FLUXCOM has been trained on the earlier LaThuile dataset). In addition, we were provided with EC data from the Cherski site in Russia by the PI (Mathias Göckede). As you say, site-level comparisons might be useful in order to get indications of whether SIF or model GPP are actually closer to site level GPP and whether there is indeed a relationship to temperature or not. We have summarized the time series as differences of the peak timing of the individual proxies to the annual temperature maximum per site and across sites in the plots below (Fig.2&3). We include them together as additional figures in the SI and discuss them. The results remain non conclusive. Model GPP and SIF have similar time lags to the temperature peak per site, but there is no consistent ordering of one before other for all sites. Importantly, site-GPP has overall similar time lags to temperature and also does not show consistency regarding the sign of the lags, not even between partitionings. So neither site-GPP, nor model GPP nor SIF shows consistent temporal behaviour with respect to temperature at site-level. Summarizing over all sites the time difference to temperature is actually largest for the tower GPP (indicated as squares excluding the sites No-Adv, DK-ZaH, DK-ZaF where SIF shows only noise and either only one year of good NEE is available or the partitionings show very different behaviour, the mean across sites and years including all sites is shown as diamonds). Such comparisons are hampered by a number of issues: 1) scale-mismatch and spatial representativeness, 2) temporal overlap of site-data with satellite data, 3) data quality of NEE and temperature at site-level, 4) quality of partitioning at site-level (partly strongly different behaviour between partitioning methods, though they mostly converge versus the peak growing season). Please find attached plots for two of the 12 sites (Fig. 4&5) containing all the time series and quality information. These site-level time series illustrate these issues very well and clearly suggest that EC cannot always be used as the 'truth' in evaluating satellite observations. These results strongly underline the observational problems in tundra outlined in the introduction of the manuscript

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and call for more in-situ measurements that are well characterized and understood in order to interpret the signals seen from the satellite. ###

6. Page 16, line 15: “Furthermore, the fact that the SIF maximum is reached in close temporal agreement with air temperature indicates a benefit for photosynthesis from highest temperatures.” Without comparing to actual GPP observations (e.g., from EC flux towers), I do not think this is a valid conclusion. There is nothing in this analysis to conclusively show SIF is actually tracking GPP since it is only compared to modeled GPP.

+++Yes, this cannot conclusively be shown, especially considering the above results at site-level. Still, both model GPP and SIF peak in closest temporal agreement with temperature compared to APAR-proxies and greenness at the satellite scale. We therefore underlined the hypothetical nature of this sentence by changing it to: “Furthermore, the fact that the SIF maximum is reached in close temporal agreement with air temperature might indicate a benefit for photosynthesis from highest temperatures.” ###

Minor Comments: Page 7, line 15: time should be corrected to “1:30 AM”. Page 8, Line 14: grammar error: “and it using such scaling factor may further amplify noise.” ++Both have been corrected in the manuscript, thanks for this. Interactive comment on Biogeosciences Discuss., https://doi.org/10.5194/bg-2018-196, 2018.

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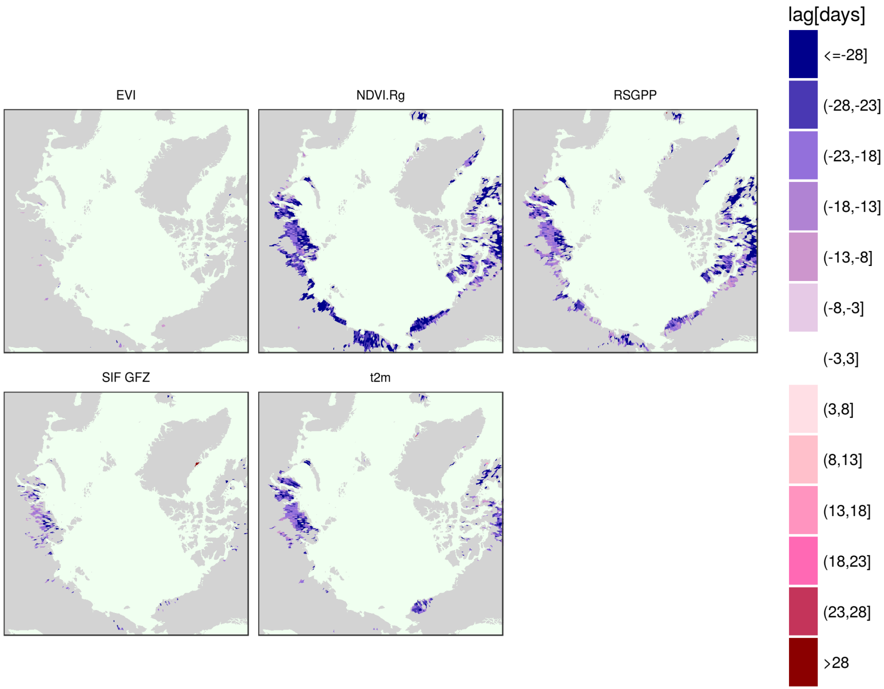

Fig. 1. Lag between the peak timing of the different proxies and the peak doy of NDVI based on 50 resampled time series per proxies, pixel, year. Shown are only the significant (95%) differences.

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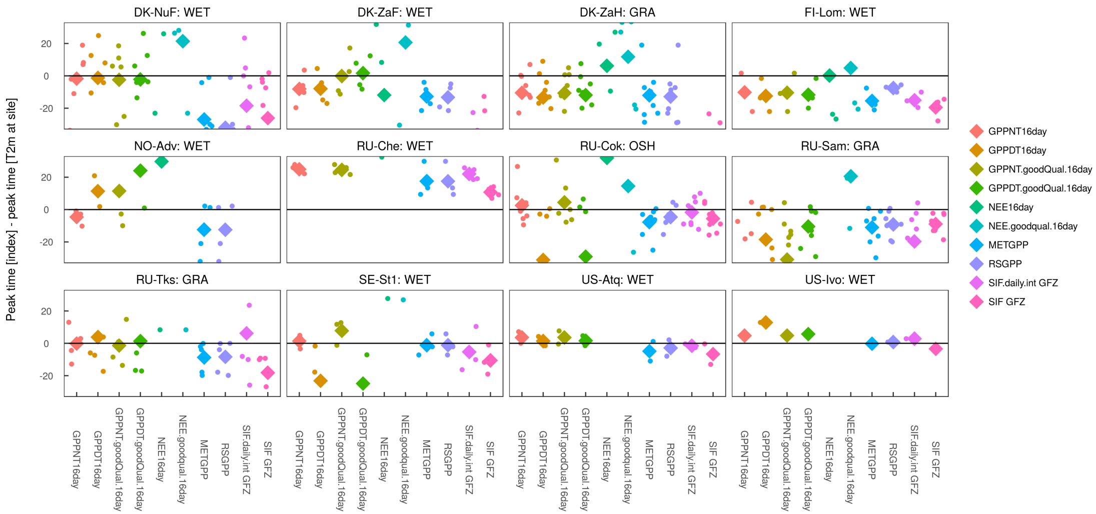

Fig. 2. Difference in peak timing of the different indicators to site-level temperature over years at selected FLUXNET sites. Diamonds represent the average peak lag across all years per site and variable.

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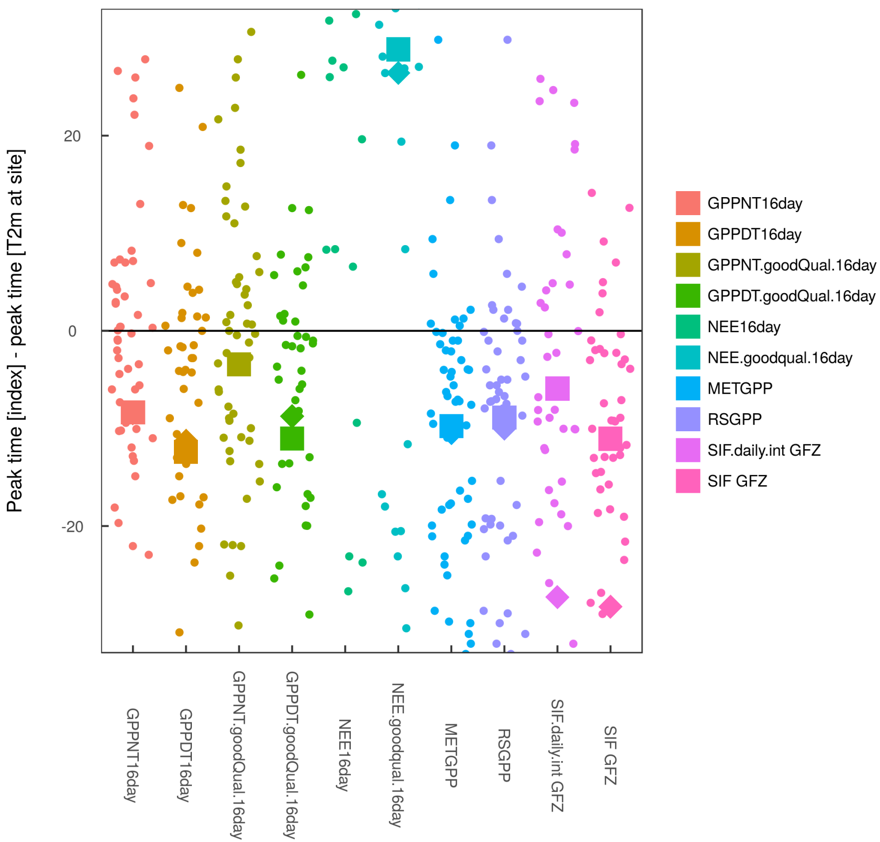

Fig. 3. Difference in peak timing of the different indicators to site-level temperature over years and at selected FLUXNET sites. Diamonds represent the average peak lag across all years and sites, while squa

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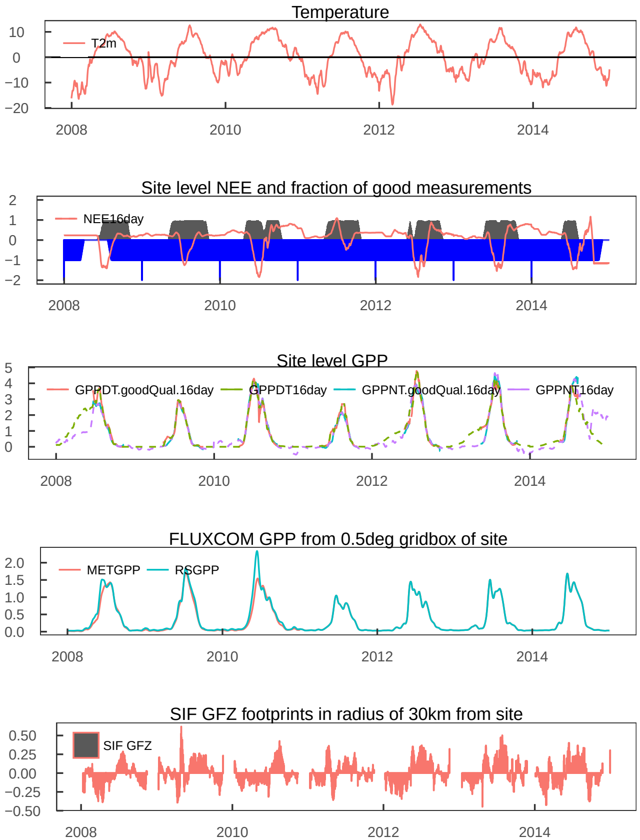

Fig. 4. DK-NuF: Gray bars: fractions of good measured and gap-filled NEE data, blue bars: the same for temperature data

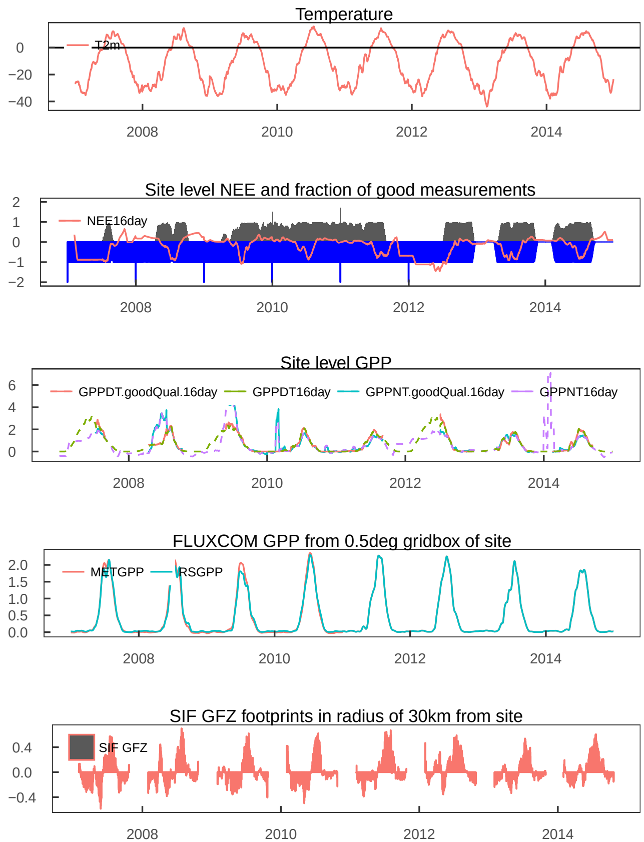

Fig. 5. RU-Sam: Gray bars: fractions of good measured and gap-filled NEE data, blue bars: the same for temperature data

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