Biogeosciences

Discussions

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Interactive
comment

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.

Anonymous Referee #1

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Summary and Recommendation

This paper "Assessing the dynamics of vegetation productivity in circumpolar regions with different satellite indicators of greenness and photosynthesis" by Sophia Walther and co-authors provides an empirical analysis of the timing of peak vegetation productivity across pan-Arctic tundra as observed from satellite observed greenness and photosynthesis. The authors recognize and attempt to account for the many issues in observing this remote environment from space, combining multiple complimentary vegetation indicators/proxies and applying careful quality control. Analysis of environmental variables including temperature, soil moisture, and open water fraction provides

key mechanistic context. The introduction of background material is thorough and well written, and sets the stage well.

Their results indicate a pattern of differential phasing of annual peaks of vegetation proxies, starting with APAR, GPP, SIF, and Vis/VOD. This pattern is clear in the spatial and temporal mean, and although subject to significant uncertainty (which is quantified in figures but not in the main text), verifies some a priori expectations, such as a delay in SIF/GPP onset relative to APAR consistent with early season NPQ, but with an interesting surprise in the ordering of GPP before SIF, which may or may not be realistic and warrants further investigation. The use of VOD is novel, but the analysis is brief and doesn't add much to our phenological understanding of tundra ecosystems. More analysis and discussion is strongly encouraged; in particular, the authors missed an opportunity to discuss the potential use of VOD in this and/or future studies to explain seasonal to interannual changes in greenness (from EVI and NDVI) as a function of vegetation water content. I also wonder why the authors didn't assess satellite-based findings against ample flux tower data available across the pan-Arctic over the lengthy study period (2007-2016), for example by comparing FLUXCOM GPP and satellite SIF to tower GPP to confirm or falsify the differential phasing between APAR, GPP, and SIF.

Overall, I recommend this important study be accepted after the points discussed above and in major/minor comments below are addressed.

Major Comments

P7, L30-31: In the early growing season prior to soil thaw, AM SIF is delayed relative to PM SIF, leading to biases in SIF recovery as observed from predominantly morning overpasses. Comparisons to tower data support this (Parazoo et al. 2018). Although unlikely to affect peak SIF timing following thaw, I recommend filtering SIF into AM and PM values to test seasonal cycle phasing as a function of time of day.

Parazoo, N. C., Arneth, A., Pugh, T. A., Smith, B., Steiner, N., Luus, K., ... & Röden-beck, C. (2018). Spring photosynthetic onset and net CO 2 uptake in Alaska triggered

by landscape thawing. Global change biology.

P8, L4-5: Peak SIF timing differences between NASA and GFZ datasets could be related to different cloud screening criteria (clf = 0.3 for NASA and 0.5 for GFZ). Please test GFZ seasonality for clf = 0.3.

P8, L34: It's not clear if readers should treat FLUXCOM GPP differently from SIF in the interpretation of peak photosynthetic activity. Do the authors intend here to have multiple measures of photosynthesis, or is the purpose for SIF to provide a dynamical interpretation of vegetation proxies?

P10, L9: GLEAM SM looks very different from AMSR-E/2 (blue line in Fig. 2 & 3). The blue line isn't mentioned in the captions or in environmental analysis at the end of Section 2.8 (P10, L1-12) so it's difficult to tell if the differences a plotting error or if they are physical. Please explain. In general, AMSR-E/2 is only referred to one time in the results and discussion, and thus the authors might consider dropping this dataset.

P12, L5-7: I'm not clear what is being done here and why. It appears that for each satellite proxy, the timing of its annual maximum is correlated with the timing of 4 environmental variables for each year (2007-2016?), and the variable with the highest correlation is selected and color coded spatially. Is this correct? Is screening for statistical significance applied? It seems the point here is more to determine if there is a good predictor for peak vegetation activity, rather than prove that environmental-vegetation dynamics hold across years. Please clarify and explain.

P12, L7-10: As a follow up, the above relationships are difficult to pick out in figure 7, although I admit they do appear to emerge as a squint my eyes. Perhaps this can be better quantified in a histogram (or table) of fractional areal coverage for each variable (e.g., what percent of land is NDVI.Rg best correlated to (a) fraction of open water, (b) soil moisture, etc.)

P12, Section 3.4: There is no mention of VOD. It is highly variable between years and

across land covers. Please discuss. Also, what's going on in 2016 in 't2m'? Soil moisture, fraction open water, and VOD are also anomalous in 2016. Are these correlated? Please discuss

P12, L 26: I wouldn't classify these relationships as clear, due mainly to excessive variability in mean date and lag time. Certainly, this study has illuminated some interesting and potentially important emergent properties which warrant further investigation.

P12, L28: Please report uncertainties on these numbers, as these patterns are not statistically significant

P12, L32: VOD analysis needs more elaboration throughout the MS. In general, the study finds similar behavior to EVI and NDVI. Perhaps this means VOD doesn't tell us anything we don't already know from EVI and NDVI? Or rather, this suggests that seasonal and interannual changes in greenness are driven by vegetation water content, and potentially could help explain longer term change associated with greening and browning (drying vs wetting of vegetation). Please discuss.

P13, L20-22: This is the first mention of (prognostic) models, and it is rather brief and confusing. Are the authors saying that Earth system models have is wrong, due to reversed seasonal dependencies on LAI, light, and temperature? This is important insight and worth more discussion.

P13, L24-34:

a. Mean time lag is 6 to 11 days depending on SIF product.

b. It would be helpful if the authors could plot a seasonal time series of APAR, GPP, and SIF with arrows indicating how changing light absorption affects the timing of peak GPP (lower light & temp) and SIF (higher light & temp), assuming the differential phasing is physical.

c. The explanation of the difference between APAR and SIF is explained, but it's not clear from the discussion why instant SIF and SIF.cos(SZA) peak after GPP. The para-

graph discusses the theory that light saturating conditions leads to correlation of fluorescence and photosynthesis, suggesting the peaks are synchronized, not offset. Parazoo et al. (2018) show synchrony of SIF, SIF driven GPP, and tower GPP in summer, but an offset in spring, suggesting an error in GPP data. However it's possible the SIF delay reflects conditions of diverging SIF and GPP under increased heat and water stress later in summer, with time of day again playing an important role in observed phasing. Thus, it is worth discussing all of the range of outcomes that the SIF delay is (a) physical, (b) related to error in model GPP as discussed later (P15, L22-34), and (c) negligible due to high uncertainty and variability in all datasets.

Minor Comments

P9, L27-29: 2009 typo? Somewhere in this line the authors appear to extrapolate from 2012 to 2009, but it's not specifically mentioned

P12, L11: "less frequently" is vague. Please quantify.

P12, L20: "shrubs and trees" -> more precisely, "mixed shrub-tree land covers"

P16, L4: "second third of July" is awkward. Might rephrase as "one week later"

P16, L12: might check out parallel study by Parazoo et al (2018)

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