Welp et al. "Increasing summer net CO_2 uptake in high northern ecosystems inferred from atmospheric inversions and remote sensing", ACP

This study takes an important step beyond the well-documented increase in atmospheric CO2 seasonal amplitude at Arctic monitoring sites and asks whether this amplitude increase actually reflects a net gain in CO2 uptake in boreal and Arctic regions. The methodology involves exploring trends in NEE fluxes inferred from 2 different inversion systems over the common period 1986-2006 (and also 1985-2012 for one of the inversions). In general, the study is well presented and documented and I support publication with minor revision. Some of my more important (although still relatively minor) concerns are that the results differ substantially between the two inversions in many aspects, leading to doubts about the robustness of either. Also, the Arctic zone >60N is the region with the most unequivocal increase in CO2 amplitude, yet the inversions estimate significant trends in net CO2 uptake mainly in the boreal zone (50-60N), not the Arctic zone. The CO2 amplitude increase at Barrow, AK (71N) in particular has been the subject of much attention, yet it doesn't seem to be associated with an actual increase in CO2 uptake in the surrounding region. A particularly interesting result is that the inversions suggest that increased CO2 respiration and release in fall may largely balance increased CO2 uptake in summer (although they don't agree where the increased fall respiration is occurring). I am curious about the heavy focus on mid-summer (July) at the expense of late spring/early summer, when the CO2 cycle (e.g., at Barrow) indicates an earlier onset of photosynthesis. Could this be when some of the net gain in CO2 uptake is occurring?

Re: the 2 time periods chosen: 1986-2006 and 1985-2012. I suggest making the second period 1986-2012, to remove ambiguity about why the results differ between the 2 periods. With the 1985 start year, we don't know whether the changes in the trends are due to the influence of starting in 1985 vs. 1986 or due to more recent changes from 2006-2012. The latter possibility seems more relevant to global change, therefore I suggest eliminating this ambiguity by starting both periods in 1986. Trend calculations of this sort can be sensitive to the starting year, especially when operating on the margins of statistical significance, as is the case here. On a related note, is the legend in Fig 3b (86-12) a typo?

Some specific comments

Abstract, there are a couple of grammatical errors or typos that interfere with smooth reading:

AbL17-18 "Here we examine CO_2 fluxes from northern boreal and tundra from 1986 to 2012 ..."

AbL29-31 sentence beginning with "Meanwhile …

P2L35 (1997)?

P3L20-26 Please define what exactly is meant by "browning" and "greening," e.g., does this refer to changes in seasonality of NDVI, or does it refer to an annual mean index?

The Introduction in general is quite good and informative, but is marred by the paragraph on L8-17. I have several suggestions for improving it:

P4 L8-17 The emphasis on aboveground vs. belowground in the first sentence seems incongruous because it is not mentioned earlier as a strength of inversions. Perhaps start this paragraph with a more general statement about the strengths of forest inventories.

P4 L13 For clarity, should "several studies" be "several process-based model studies"?

P4 L11-17 Can we believe these results? What are the weaknesses of process-based model studies? (Referring back to earlier statement that, "Each of these methods has its strengths and weaknesses.")

P4L18 "…50N, using the atmospheric inversion method."

P4L35 What is "It" ?

P5L7 What period?

P5L9 Temporal coverage of what? Years, months, weeks? What is the time resolution?

P5L21 What is LPJ?

P5L30 What are the units of NDVI? Are they mass units, e.g., kg/m2 or flux units, e.g., in kg/m2/s?

P6L10- Perhaps I am missing something, but I don't see the 2 different analysis methods for trends and significance reported in Table 2 described anywhere in this section. There is only a brief mention of them in the Table 2 caption, which is not very informative.

P6L15 In Figure 1 the boreal forest stippling extends well north of 60 degrees. Does this mean that the so-called Arctic zone consists largely of boreal forest? This is somewhat confusing and perhaps should be noted here. Other parts of the text seem to suggest the Arctic zone is mainly tundra, but later p.12 mentions that tundra covers only 25% of the Arctic zone.

Figure 3c,d. Should the Y-axis units be gC/m2/day *per year*?

P7L33. Probably should note that $P < 0.1$ is significant at only 10% level, which is a weak standard. In general $p < 0.05$ is the standard level required for

significance.

P9L13. How were these 40-50 and 55-65N bands chosen? Figure 7 seems to suggest net release and net uptake for 40-55N and 55-75N, respectively. Also, please check P13L10 for consistency.

P9L25 In order to …

P10L27 "We found significantly strong positive correlations between July CO_2 flux and April through August temperatures of the same year…" The next sentence is confusing because it suggests lower CO2 uptake (more release) in warm years, in contrast to the quoted sentence – please clarify that "positive correlation" means the July flux is weaker not stronger.

P12L17-20 "Increased summer CO_2 uptake cannot be explained by earlier spring leaf-out, but rather points to changes in mid-summer photosynthetic and respiration fluxes themselves." Where is this sentence supported in the Results?

P12L31-33 "This difference could reflect the importance of structural ecosystem changes due to warming on the long time scale increasing photosynthesis (Graven et al., 2013), but on the short time scale, respiration is the dominant control." This seems like a core conundrum of this study (together with the fact that no apparent increase in net CO2 uptake is occurring in the band where the CO2 amplitude is increasing). Both of these points might be worth discussing more.