

Atmos. Chem. Phys. Discuss., referee comment RC1
<https://doi.org/10.5194/acp-2021-354-RC1>, 2021
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Comment on acp-2021-354

Anonymous Referee #1

Referee comment on "Traces of urban forest in temperature and CO₂ signals in monsoon East Asia" by Keunmin Lee et al., Atmos. Chem. Phys. Discuss.,
<https://doi.org/10.5194/acp-2021-354-RC1>, 2021

Review of ACP-2021-354

This paper presents energy and CO₂ exchange at a complex urban forest site in Seoul, Korea. Sub-daily, seasonal and interannual differences in the observed fluxes are analysed and related to climate conditions (e.g. the effect of the monsoon, drought) and characteristics of the site (e.g. land cover, the proportion of road in the source area). Urban-rural differences in CO₂ exchange and the role of the urban forest in reducing the urban heat island are discussed. The observed net CO₂ flux is analysed in terms of its anthropogenic and biotic components, although the method of partitioning is not described in this paper.

Overall, this is an interesting and useful study. There have been relatively few studies of CO₂ exchange made in urban forests (with most similar studies focusing either on non-urban forests or on more built-up urban neighbourhoods). The detailed analysis at this complex site takes into consideration numerous potential factors which could affect the measurements. The comparison with a more built-up urban site nearby is very interesting and demonstrates the impact of surface characteristics on energy partitioning. Assessing two main roles of urban vegetation (i.e. helping to offset CO₂ emissions and cool the urban environment) as well as the effect of land management and weather conditions is also relevant for urban planning and broadens our knowledge of interactions in urban climates.

Generally the paper is in good shape (clearly written, well-structured, suitable figures). My main concern is that there is not enough information given about the partitioning method used. Although the method (and some of the analysis) is described in a MethodsX article that is often referenced here, to make this a standalone publication more of the important information needs to be readily available to readers of this paper. This also makes the review challenging, since it is difficult to assess the suitability of the approaches and validity of the findings without really knowing how the data have been treated. I have several other queries and suggestions about various aspects - please see below for detailed comments.

Major issues

Methods described elsewhere

L210-1 As the partitioning of F_c is central to some of the results, more information is needed here for this paper to be a standalone publication. A paragraph should be added which summarises the approach used and highlights any important caveats. This will help the reader to understand roughly what has been done to the data (they can still read the MethodsX article for the details) so that they can interpret the results of this study.

There should also be a paragraph which gives an overview of how the gap-filling of F_c was done. This is not an easy task in urban areas with many different controls and a heterogeneous source area. Sufficient information needs to be given here in order for the reader to understand what the annual sums given in Section 3.6 mean.

Measurement height needs further consideration

L123-136 The site characteristics described here are difficult to follow. Different distances from the tower are used and several values are given for the roughness length and displacement height without any clear justification for the values chosen. In L195-198 the measurement height is justified based on a relation including displacement height, but it is not clear what displacement height was used to decide this and for some of the values given in Section 2.2.1 this relation is not satisfied. By other commonly used relations (e.g. a measurement height of at least twice the mean obstacle height), the tower would be too low. Careful explanation is needed here so the reader can clearly follow the justification. Since the measurement height is fairly low, the authors may consider adding additional information to convince the reader. For example, did spectra or turbulence characteristics (e.g. the drag coefficient) suggest the measurements were sufficiently high, or problematic for certain wind sectors? If there is a strong possibility the measurements were made lower than typically recommended, is it possible to say whether this would affect the findings of the paper?

Minor issues

L26 It's not clear here whether the urban population will increase by 68% by 2050 or whether the urban population will reach 68% by 2050

L33-4 Delete 'as opposed to gray spaces' as it is not needed and does not really fit here

(gray spaces are also exposed to the range of conditions mentioned)

L37 Some examples of harmful effects would be helpful

L46-7 May be helpful to explicitly mention air-conditioning here if that is what is implied

L51-2 (and other places) What is meant by direct heat fluxes? Surface heat fluxes?
Turbulent heat fluxes? Sensible heat flux?

L92 I did not find Appendix A

L100-1 What about contributions to respiration from visitors to the park?

L101-3 This sentence doesn't really fit here – merge with the Introduction, Section 3.4, or delete

L110-2 As these factors are central to the paper, consider adding some more examples here, such as transport options, fuel types, heating demand, weather conditions, etc

L111 The location of the tower does not affect the anthropogenic emissions, but rather the measured fluxes

L180 Are these really 'observatories', or would it be more accurate to say 'weather stations'?

L204-5 Please add a sentence to justify why negative CO₂ fluxes were discarded during nighttime

L214 (and elsewhere) the surface energy balance is often mentioned but only net radiation and the turbulent heat fluxes are analysed. At least the contributions of the storage heat flux (various components) and anthropogenic heat flux need to be considered for an energy balance study. If neither of these were estimated, the discussion should refer to the radiation and turbulent fluxes (and not the surface energy balance)

L218 Is 'sensible heat flux' intended rather than 'surface heat fluxes'?

L231 Should this be Fig 4 not Fig 6?

L230-5 Not clear here which are new findings from this analysis and which are being referred to in the Hong and Kim (2011) paper

L235-7 This discussion of QE fits better with the following evapotranspiration paragraph. Perhaps worth mentioning somewhere that QE and ET are equivalent – currently they are discussed almost as two separate variables

L238-51 Perhaps a sentence or two could be added to strengthen the discussion by considering sub-monthly variation with respect to the timing of the rainfall in July 2017. It would also be helpful to add some comparisons with other urban and forest sites in the literature and potential reasons for differences (e.g. as for the Fc discussion)

L245-6 The severity of the drought conditions should be made clearer in Section 2.2.2

L253-61 How were these warming rates calculated?

The authors could consider swapping the order of Section 3.3 and 3.2. To me, it would seem more natural the other way around.

L262-9 Is this temperature difference significant? Are the results robust (e.g. for the three sites that make up AVG independently)? How were the measurement and elevation heights accounted for? How was it ensured that the differences seen are not due to differences between instruments?

L277 'A possible reason for this' – this should be stated more strongly as the whole of the temperature part of the of the paper is based on the local characteristics being responsible for the near-surface conditions

L287-91 The thermal admittance discussion is not clear, please rephrase

Perhaps consider renaming 'AVG' to something more meaningful to readers, such as 'CBD' for Central 'Business District'

L309-10 It's not clear which results are shown here and which are from Lee et al. (2021). Try to make this clearer so that the reader knows what they can learn from this paper, and what additional information they need to look in the other paper for

L315 A couple of references showing this in natural ecosystems would be helpful here

L328-9 It is difficult to see this relation in Fig 9. Perhaps delete and rely on the reference to Lee et al. (2021)

Fig 3 first seems to be referenced in L335, after Figs 4-10. Given the importance of land cover around the tower in this section of the analysis, it would be helpful to add a subsection to 2.2 where the site characteristics are clearly described in preparation for these results. There is some information spread through Section 2.2.1 at the moment but this should be extended and more clearly described so the reader gets a good understanding of the site early on. The analysis in L346-355 may fit better at the start of Section 3.4 as it gives a general overview of the different processes in different parts of the source area.

L342 Should Fig 10b really be referenced here?

L344 Emissions from the park facility are mentioned here for the first time. It would be good to include this in the site description and to discuss the effect on the results. Are these emissions from a single nearby building responsible for a large proportion of the measured F_c , and if so, what implications would this have for the reliability of the measurements and the annual total CO₂ flux? Is it possible the Tair and QE measurements were also affected by these emissions?

L402-407 This paragraph is not very clear. Please rephrase

L415-516 The F_c results are set in context using other studies. It would be good to do the same for the UHI and energy balance results.

L463-5 Here the text suggests that the flux partitioning method was proposed in this paper which is not the case. There is no description of the method in this paper. Please amend. Similarly in L514-6 it should be made clear that the partitioning method is from

the Lee et al. (2021) paper and not developed in the current paper.

L471-3 Consider mentioning irrigation here

L483-4 It is not clear if the 'rule of thumb' is for this study or more generally. Probably replace 'rule of thumb' by 'For this study'

Table 1 It would help the reader to write the descriptions of the LCZs here instead of subscripts with the codes which most readers would have to look up elsewhere. 'Flux' is too general in the 'used variables' column. Please be specific (or this column could probably be deleted). What to the heights represent – measurement height above ground, elevation?

Table 2 As mentioned above details are needed about the gap filling procedure. Do these totals correspond to the source area (i.e. dependent on the wind direction distribution) or neighbourhood averaged values? Were the energy fluxes here gap-filled analogously to the CO₂ fluxes or were totally different methods used? Similarly for Fig 13, do these bars correspond to the source area composition (i.e. are they affected by wind direction) or has the wind direction dependency been accounted for by the gap-filling procedure.

Figure 3 How was the dominant wind direction decided? Is this the modal value? Change 'ratio' to 'proportion'. Currently Fig 3 is not used very much in the text – as suggested above developing this part to give a clearer idea of source area characteristics and variability would be helpful for the reader. As an example, the proportion of road in the footprint could be added.

Fig 4 Consider adding a row with incoming shortwave measurements as you have the data.

Fig 8 It would be interesting to explore the scatter in this graph and indicate which points correspond to which month in which year. What does the dashed line represent? Is a simple linear regression of y against x appropriate when both x and y have appreciable uncertainties? Why are there no error bars shown in the x-direction?

Fig 9 The caption is difficult to follow and should be rephrased. The gap due to power failure should be mentioned in the Methods section.

Fig 10 Why was this monthly separation chosen between panels (a), (b) and (c)? It might

help to indicate the road sector on this plot.

Fig 11 It would be useful to add why EB does not feature in the equation in L834

Fig 12 It is not clear what the reference means here. What do the dashed lines represent?

Very minor/language issues

Generally the standard of English is very good, though there are a few places where more natural phrasing could be used. I have made some suggestions here:

L9 'two years of surface fluxes'

L18 'than for typical'

L21 'if the goal is lower CO2 emissions...' or 'when aiming to reduce CO2 emissions...'

L24 'Cities comprise' or 'Cities make up'

L31 'urban forests'

L35 'during urban redevelopment'

L36-7 'and overcome their maintenance costs'

L39 'have been addressed'

L43 'for longer than'

L44 'contribute to reducing'

L53 'have reported on the surface'

L55-6 'Forests can even produce a warming trend as a result of their low albedo'

L73-4 'It is challenging to partition F_c into individual sources and sinks in urban areas because'

L78 'carbon cycles'

L81-2 Not clear, could delete the text 'where a hot... ..warming trends'

L83 'based on partitioning of FC data measured by eddy covariance'

L128 'south and west sectors (120-330°)'

L129 'and roads lie outside of the park'

L137 'The roads'

L166 'for comparative analysis because the sites are'

L207 Delete 'after the processes'

L208 'Here we partition the measured F_c into'

L209-10 'This study applied a statistical'

L250 'is unknown' or 'has not been quantified' would be clearer than 'is inexplicit'

L267 'when photosynthesis is highest. Our results'

L271 'also produces'

L309 Define EVI

L310-1 Move 'accordingly' to the start of this sentence

L312-3 'absorbs more CO₂ than is emitted by local sources and F_c is negative only during the summer daytime. Because of...'

L320 'Greater reduction'

L332 'The seasonal F_c variation also depends on...'

L335 Delete 'particularly'

L348 'further indicate the'

L359 'contrast to F_c in high-rise high population residential areas... that does not respond to PAR'

L318 'from a suburban area with about'

L425 Delete 'cumulative sum of the'

L456-7 'method in order to examine the role'

L462 Suggest deleting 'and was redeveloped from a racetrack and factory in the mid-2000s' as this is not really relevant for the conclusions

L479 'a typical diurnal'

L418 'and the time of the minimum is delayed'

L500 Delete 'Eventually'

L508 'forests have important impacts on air...'

L810 Move 'in summer' after 'AVG and SD'