

Second review by referee #1

General comments

Literature review should go partly from Discussion to Introduction.

The N₂O flux data is still a little bit misplaced in the manuscript. In the results some N₂O flux patterns are described, but only after reading the discussion it becomes clear to the reader WHY the authors want to study N₂O fluxes in combination with CO fluxes, and suddenly in the Conclusions, it becomes one of the main findings. I agree with the authors that some process understanding and previous studies should be known by the readers, but since the link between CO and N₂O is not so well known, I would add a few lines in the Introduction as well. So, part of what is written in Discussion should also/only appear in the Introduction.

The same remark counts for the NEE/CO₂ literature review. In the last sentence of the Introduction, the authors state that they will focus on CO₂, and don't mention NEE. It should be clear to the reader earlier why this is of interest. So, part of the NEE-CO relationship literature review should appear earlier in the manuscript.

Concerning the NEE-CO discussion, it would be good if the authors are a little more careful with their conclusions. They state that a negative correlation between FCO and NEE indicates biological CO formation (page 14, line 21-22). Here no reference is given, is this a conclusion of the authors themselves? While I agree that the negative correlation CAN be an indicator for the biological CO formation, it can also be caused by other indirect effects (some environmental factors are closely related to NEE, and could also be a driving factor for FCO). It would be good if the authors give a reference here, or shortly elaborate why they are sure about this statement.

Footprint analyses

Footprint analyses are now well explained, just a minor comment. In the introduction it is made clear that CO fluxes are pretty dependent on environmental factors such as ground water. Considering this, are there any elevation changes in your footprint? Wet or dry spots? Or does this not play any role? A sentence can be added to clarify this for the reader.

Figure 2, 3 and 4.

The figure which was added to the Authors response (so not in manuscript) is very useful. Is it possible to plot the soil temperature inside the manuscript as well? I see that the authors decided to write 'not shown' but I think there is no need for a new figure, it could be easily added to Figure 3. This would help for the statement that thermal degradation probably doesn't place a role in the early morning hours (page 14, line 10-15). A small remark on this point. It seems unlikely that thermal degradation is ever fully absent. However, considering the previous studies who found exponential curves with temperature, and that the field site is located in a cold climate, the fluxes are probably very small. Therefore, I would rephrase your sentence like 'we expect it to be negligible'.

Figure 2: It would be good to draw a black line on the 0-line, to clearly divide uptake and emission periods. Also, in this figure, could you indicate the moment of sunset and sunrise?

Figure 3: As said, the addition of soil temperature here would be very nice and insightful.

Figure 4: Maybe also here indicate the moment of sunrise and sunset.

Tables 1 and 2 (and explanation in text)

Table 1 and 2, and the explanation in the text, need quite some improvement. In the current form, it takes a lot of effort from the reader to interpret each column, and especially the values in Table 2 are quite a puzzle without a good explanation. This could be easily improved by adding a few lines either in the text, or besides the column.

Table 1

Table 1, please check the description and maybe clarify methods. As I understand, first 'mean' column takes average of FCO when $h_{sun} > 0$, second 'mean' column takes average of FCO when $h < 0$. But the last 'mean' column is not explained. The reader probably assumes it is the mean over all FCO data, but it is better to clarify this.

Table 2

Table 2: I think the use of FCO is confusing here. In Table 1, FCO is meant for the actual measured flux (right?). In Table 2, you state 'gross FCO', but I think you actually mean 'estimated production during daytime', right? In the text, it is more clear because you define it as emissions (page 9, line 24). However, using 'gross FCO' is confusing, since F stands for flux, and flux is usually the net result of uptake and emission. So, if the authors indeed mean production, please rename this term and call it 'gross CO production during the day' or something similar. Gross FCO will confuse the readers.

The first columns of Table 2 'Gross FCO' are explained in the Table-text in the last sentence (Gross CO fluxes refer to the difference between.... presented in Table 1). Please add such a sentence for all 3 'mean' values (for 'gross FCO-day', for 'uptake FCO_{day}(Q10,1.8)', for 'gross FCO_{day}(Q10, 1.8)'), and elaborate. For example:

Gross CO fluxes (gross FCO_{day}) refer to the difference between daytime fluxes (FCO_{day}) and nighttime fluxes (FCO_{night}) presented in Table 1. With other words, this is the estimated net production of CO with an assumed constant CO uptake, based on measured uptake rates at night.

Uptake CO fluxes (uptake FCO_{day}(Q10, 1.8)) refers to the estimated CO uptake taking place during the day, based on measured CO uptake values at night. The value is extrapolated from averaged measured night time CO uptake (Table 1), and extrapolated with a Q10 of 1.8 to day time temperatures (Whalen and Rheebug).

Estimated CO production/emission fluxes (gross F_{CO}_{day}) values are based on column 1 from Table 1, minus column 6 from Table 2. Etc.

You could also refer to page 9, line 24 here, where you describe the 2 'ways' of estimation. You could clearly state you refer to the first 'way' here. So link the text (at page 9, line 24) better with your values in Table 2.

Again, even if the information is probably findable in the text, it should be more clear since in this

form, it takes too much effort of the reader to interpret this table.

Specific comments

P1, line 15: 'However'.. I have the feeling this sentence does not contradict the previous one, so better not use 'however'. Maybe choose another word. 'In general, soils are considered as.....'

P1, line 16, micrometeorological eddy--> the micrometeorological eddy

P1, line 18: as well as relevant--> as well as to relevant

P1, line 20-21, you mention that mid-April to mid June the field is a net source, the rest of the measurement period (July-Nov) was a net sink, but you exclude the end of June in this sentence. This is not the maintenance period, right? I would rephrase.

P1, line 22: and an emission--> and a net CO emissions

P2, Line 17: reference to Funk 1994 is not in bibliography. Please check all your references once more

P2, Line 17: Emissions of CO from water logged soils have often been attributed to anaerobic production of CH₄.

The paper of Funk only says that the occurrence of CO fluxes correspond with the occurrence of CH₄ fluxes. This paper mostly underlines the UTILIZATION of CO for producing CH₄. Furthermore, the paper of Varella doesnt measure or mention any CH₄. Please remove or correct this statement, and refer to the correct papers.

P2, Line 18: 'such as thermal or UV- or visible light'
change to
'such as thermal, UV- or visible light'

P2-3, Line 26- Line 1:In the current form, the sentence is incorrect gramatically. Either divide into two sentences (split before 'while' and check commas), or rephrase.

P3, line 1-3: What is described here is also sometimes refered to as indirect photodegradation. Can you merge this with page 2, line 23?

P3, line 9: 'are needed for CO is formation'--> remove 'is'

P3, line 15: remove extra bracket

P 3, line 17, add white space before 'with a tendency'

P3, line 16-20: Here the statement is made that higher CO uptake is reported from natural and dry soils, followed by many references. Do these references all support this statement, or you state this

fact yourself after reading these articles? Or do these articles only support the first part of the sentence (the reported -2 to $2 \text{ nmol m}^{-2} \text{ s}^{-1}$)? Please clarify

P3, line 19-22. Same statement here. Now it seems that all these papers support this statement. I assume that you observed this gradient yourself after reading these papers? Maybe clarify this.

P3, line 25: 'and in North'--> change to 'and in the North'

P3, line 28: 'using micrometeorological'--> change to 'using the micrometeorological'

P4, line 1, 'as well as relevant' change to 'as well as with relevant'

P4, line 6, sentence has unlogical order. Change to something like:
The measurements were conducted on a mineral agricultural field located in Eastern Finland (63..., 27...), cultivated with a perennial reed canary grass (RCG, Ph.....)

P4, line 10, sentence has unlogical order. Change to something like:
In 2011 in the beginning of the growing season (23 May), the crop was fertilized with an N-P-K-S fertilizer.....

P4, line 11: Be consistent with dates. Sometimes you write 23 May, other places 28 OF april. Furthermore, in line 12, you add the day number (day 118). That is quite useful, since you continue using that the rest of the manuscript. Maybe also do that for page 4, line 11.

P4, line 20-22, 'within the ploughing layer from the surface to about 30 cm'--> does this count for as well the soil pH as the soil organic matter? Unclear from this sentence. Also the last part of the sentence seems to lack a verb. Please check.

P5, line 7: reduces footprint extent--> reduces the footprint extent

P5, line 9. Why is referred to figure 1 c. Do you mean 1d?

P5, line 17, please add day numbers after April to November 2011 (Like you did in line 18)

P 5, lines 20-21. This sentence seems to assume that the reader knows about the Rannik paper. Please rephrase, something like:
The AR-CW-QCL and LGR-CQ-QCL were the same as used in the study of Rannik (2015) wherein four laser based fast response gas analyzers to measure N₂O were compared (or something similar).

P 5, line 22, add day number

P6, line 21. 'Sa' is not defined in text.

P6, line 23-26. The despiking process is well described. However, which percentage of your data was replaced? Can you state this in the text?

P7, line 27, add coma after 'the fluxes', makes reading more smooth

P7, line 28. Groups of days well described. Just a suggestion, is it possible to add real dates between brackets? Easer for reader to interpret the groups.

P8, line 22: the term 'cumulative CO flux' is introduced as cum FCO. The text says it shows that the site is a net sink of CO. Where is that shown? I assume that cumulative stands for the total measurement period of 7 months? Is this the same term as 'net FCO' for days 110-325 in table 1? If so, you can refer to Table 1, and clarify that cumulative is the same as net FCO for the period 'all' in Table 1.

P9, line 9, The autumn was characterized by decreasing FCO..... Statement too vague. By 'the autumn' do you mean A+LA (so days 241 to 325)? And, which FCO is meant here? Net FCO during the day or night or net? Or estimated production in Table 2? Please clarify

Page 10, line 2, add white space

Page 11, lines 19: over the whole measurement period → over the whole 7 month measurement period.

Page 12, line 5-7. sentence unclear. Maybe: were rather low, crop was not yet → were rather low and the crops were not yet....

Page 12, line 10. Decreasing amount of--> decreasing amounts of

page 12, line 25: to calculate and annual--> to calculate an annual

Page 12, line 25: when stating the number -0.25, please refer to Table 1, so reader knows where the number comes from

Page 13, line 7-11. I would refer here to the same papers as in Table 5, to be consistent to the reader

Page 13, line 14. You introduce Mco here, and introduce the abbreviation. However, if you dont use this term anymore afterwards, I think there is no need to introduce an abbreviation.

Page 13, line 15: In line 12 you state that you expect CO emission also exists during the day. In line 15, you state 'if existing'. I would phrase your doubt less strong, more like

In our site the estimated/assumed daytime CO consumption is overruled by.....

Page 13, line 26: drives → drive

Page 14, line 29. You state that a supporting factor includes the high C to N ratio. However, since it is an important point, I would add the accompanying reference right after this point. Now it is at the

end of the sentence and unclear for the reader which reference belongs to which supporting factor. Or you could take this point out of this sentence and merge it with the next sentence, since you elaborate there anyway.

Page 14, line 15-16: Is thermal degradation not by definition temperature dependent? No need for reference here.

Page 14, line 21: Based on understanding of biological CO formation, a negative correlation between FCO and NEE....

This is nice information, but it would be good if the reader is aware of this assumed relationship before. Could this expected relationship be stated and explained in Introduction? This might help the reader understand the flow and content of the paper better. Also, as mentioned in general comments, please elaborate on this negative correlation, can this only mean biological formation, or can this correlation also be caused by something else.

Page 14, line 25-26: at the RCG crop--> at the RCG field site/arable land/....

Page 15, line 6-7: verb missing. Maybe: net CO emission also--> net CO emissions occurring also

Page 15, line 14: verb too much, remove 'remain'

Page 15, line 14-16: incorrect/unclear sentence. Rephrase to something like:

A study by K&C (2002) demonstrated the lack of understanding in sink-source dynamics of CO, and showed that plant roots are capable of producing CO, which rate/source can be as high as the current.....

Page 15, line 17. Also stated in general comments. This expected strong relationship should already be clear in Introduction.

Page 16, line 6: the smaller emissions of CO..... Do you refer to literature here or to your own data? Rephrase/clarify

Figures

Figure 1. If the manuscript is printed in black/white, the lines are hard to differentiate. Could the lines have different patterns?

Very minor comments, but why are there different types of blue used in figure 5, in comparison to previous figures?

Tables

Table 2, please add white space before (Q10, 1.8) (two times)

Table 5, The authors have explained why they keep the table in this form, and have elaborated in the text about which study measured at daytime, and which diurnal. This is fine, but it would help if the header and table would be more self-explanatory. Elaborate column 4 by for example: 'Data Period, measurement frequency, and moment of measurement'. In the current form the header 'diurnal cycle' doesn't really cover the content of the column