Authors response to comments from Reviewer 2

This paper adds data on emissions from peat-lands, contributing with 9 sites with thorough measurement program on which models are made for EF construction. The methods and data processing used are excellence. This study will be of large use for compilation of National Inventory reports, and hopefully making the large emissions from drained peat more visible. Thus laying the ground for emission reductions, by rewetting drained peat areas.

However I find it important to discuss more deep the influence of WT on the flux. A reader can get the faulty impression that mainly the temperature is the controlling factor, however the prerequisite is that the site is drained. This study also point to the need for additional measurements, on sites with more variable fertility and drain levels. Also there is a need to measure N2O, which this study did not include.

I find the paper overall interesting and easy to read, why I suggest a minor revision making the text and discussion more clear and fix some small errors.

Response: We thank Reviewer 2 for the positive review of the manuscript and for the helpful comments and suggestions.

Specific

Abstract

Line 6, Difficult sentence to read.
Response: Could the reviewer be more specific as to the difficulty with the sentence?

2.3 Environmental monitoring

Line 8-9, Explain what PP System and CPY-4 chamber means.
Response: PP System is the manufacturer of the CPY-4 chamber. The chamber is described in the text. We have now provided the manufacturers details to accompany it.

Soil temperature was recorded at 10 minutes interval, except DP3, where it was hourly intervals. Not clear. How much data gaps?
Response: Agreed, this is unclear. While weather stations were indeed established at all sites (exception IP5), their data was not used in the calculation of the annual CO2-C balance at the IP sites. We have replaced the original text with
"Soil loggers (µ logger, Zeta-tec, UK, Hobo External Data Loggers, Onset Computer Corporation, MA, USA or Comark N2012 Diligence Loggers, Norwich, UK) were established in all the IP sites and recorded soil temperatures at hourly intervals. Weather stations were installed at all the DP sites and recorded photosynthetic photon flux density

(PPFD; µmol m^{-2} s^{-1}) and soil temperatures at 10 minute intervals. At DP3, soil moisture content (%) was also recorded (at 10 min intervals) by the weather station at that site."

2.5.1 Field measurements

22. clear acrylic chamber, measuring Reco, must include also photosynthesis and thus NEE? Why not tell?
Response: Peat extraction had recently ceased at the site (IP6) and as the soil was totally devoid of vegetation, photosynthesis was not likely to occur. As such, NEE = Reco

2.5.2 Flux calculations

For how long time was the chamber closed?
Response: This varied between 60-180 secs. The information was given on P7500, L1 but was missing the units (i.e. seconds). This has been amended.

2.5.4 Annual CO2-C balance

21. Each 12 month period. How many years? One year each site?
Response: The information is already provided in Table 1 and in Figure 4.

2.6 Peat fire emissions

Loose Irish moss peat. How decomposed?
Response: The peat moss is Sphagnum peat ranging between H2-H3 on the von post decomposition scale.

What influence could drying of the peat before combustion have on the result? In nature, peat fires continue, still it is not fully dry. Burning of peat in nature is not only in the surface, but deep down. How could this influence gases produced?
Response: We found that in our setup it was not possible to ignite peat that had not been dried beforehand. This would also be the case in natural/managed peatlands, where surface vegetation fires will only spread into the peat when the peat is dry (i.e. during periods of drought) or is dried by the smouldering front moving through the peat. We follow the methodology of other peat fire studies (Christian et al., 2003; Yokelson et al., 1997; Stockwell et al., 2014) who all dry their peat samples before ignition.

The main difference between our lab-dried samples and drying in natural/managed peatlands is that the peat would be dry at the surface of open peatlands, but would retain moisture deeper down, whereas our lab samples are dry throughout. In open

peatland fires, the combustion of dry peat at the surface may spread into deeper moister layers, but only after these have been dried by the heat produced from the combustion of the surface layer. This is likely to affect the rate of spread into the deeper, moister, peat as energy is used to dry these layers before combustion can commence (Rein et al., 2009). Rein et al. (2009) find that the main resultant effect of increasing peat moisture content on combustion emissions is an increase in the Modified Combustion Efficiency (MCE) with slightly higher (a few percent) CO_2 emissions per unit mass of peat burned, whilst CO and CH_4 emissions remain unaffected.

3.2.1 Modelling

8. T is the temperature at which respiration reaches zero,… Should it not be T0?
Response: Yes, the text should be *"T_0 is the (minimum) temperature at which respiration reaches zero and is set here at 227.13 K, T is the soil temperature at 5 cm depth"*. This has now been amended.

For equations 1-3 I have a reflection. For all these soils draining is the prerequisite for soil decomposing. Thus the water table depth >20cm is of need for these equations to be valid. This is why the effect of temperature becomes important, and only in some cases the WT becomes a limitation.
Response: Agreed.

3.4 Emission factors

For clearness I suggest here once again to tell the reader on which variable the EF's are based.
Response: We feel that this is not necessary, as the basis for the EFs has already been well described.

3.5 Peat fire emission factors

MCE have not been defined/explained.
Response: Combustion efficiency is a measure of the amount of fuel carbon released as CO_2, and may be approximated using the *Modified Combustion Efficiency* (MCE) formula, which requires only a measurement of CO and CO_2 rather than all the carbon containing gases (Yokelson *et al.*, 2008):

$$MCE = \frac{\Delta CO_2}{\Delta CO_2 + \Delta CO} \quad (1)$$

Where ΔCO_2 and ΔCO represent the elevated mixing ratios of these gases (the difference between mixing ratios measured in biomass burn emissions and those in the ambient air). MCE is often expressed as a percentage. Generally, an MCE lower than

0.9 (90%) is considered a low combustion efficiency burn (Lobert *et al.*, 1991; Yokelson *et al.*, 1996).

MCE typical of smouldering combustion… Reference needed.
Response: The following references will be cited, all of which publish MCE separately for flaming and smouldering combustion stages (where smouldering stage is typically below MCE of 0.9):
"(e.g. Yokelson et al. 1996; Bertschi et al. 2003)"

4.1 Effects of climate

P7509 L3. Table 2 should be Table 3, Please check the numbering of tables and figures!
Response: We would disagree. In this sentence we explicitly refer to the annual CO2-C emissions from Site IP6 and direct the reader to *Table 2. Emission factors (t CO2-Cha-1 yr-1) for sites IP1–6 and DP1–3. Uncertainties are 95% confidence intervals.*

L4-6. You say this confirms that soil temperature rather than water table is the main driver of emissions. I am not sure this could be said, since a prerequisite for all sites in this study is a WT level of >-20 cm. And for these types of systems, you show the temperature to be the most influential, which is OK if mentioning the prerequisites. This is confirmed by the wetter conditions and thus lower emission in the DP3 site.
Response: We discuss the effects of drainage at length in Section 4.2. However, we agree that drainage is a pre-requisite at these sites and have now included this proviso in the text as follow;
"Given that all the sites are drained to a similar depth (Fig. 1), the variation in emissions appeared to be controlled largely by differences in soil temperatures between the sites (Fig. 6)."

L19-. It is not clear how the LAI or PPFD could be drivers for peat decomposition. My suggestion is that the vegetation influences the water content of the soil, by transpiration, making it more aerobic, and thus higher soil CO2 flux. Thus the sunny days are more important than rainy. This also goes for LAI which also influence transpiration. Could this be discussed?
Response: We did not state that LAI or PPFD were drivers for peat decomposition rather that they were drivers of GPP. Vegetation could stimulate decomposition of the more recalcitrant peat through the addition of labile organic matter (root exudates, leaves etc.). Under higher PPFD and LAI more organic matter is produced by the vegetation and could therefore lead to higher levels of priming in the older peat.

Drainage plays a much greater role in determining the water table position (and therefore the zone for aerobic decomposition) than transpiration at these sites.

However, given the relatively shallow rooting depth of Calluna vulgaris (the dominant vegetation species at these sites) the effects of transpiration are likely to be confined to the upper 20 cm of the peat profile (Aerts and Heil, 1993), where it may reduce the moisture content in the peat under warm temperatures and at low vapour pressure deficits (open stomata). This is confirmed at DP3, where the addition of the moisture content variable improved the performance of the Reco model at that site. We have now added the following text;

"During the growing season, the transpiration process is also likely to play a role in determining the moisture content of the peat within the rooting zone (~20cm depth) at these vegetated sites. Moisture losses are likely to be accentuated on sunny days when air and soil temperatures are high, when LAI values are highest (mid-summer) and when vapour pressure deficit is not a limiting factor. As CO_2 emissions were closely correlated to soil temperature at 5 cm depth, reduced moisture content in this zone is likely to stimulate aerobic microbial activity."

4.3 Peat Characteristics

L10 Interesting that IP4, with C/N lower than 25 had highest emissions. IP2 had similar low C/N however not this high emission. You could have connected the C/N discussion to published similar studies.

Response: A relationship between C:N ratios and CO2 emissions was not evident at our sites. As such, we endeavoured to concentrate on a discussion of variables that did have a tangible impact on CO2 emissions at these sites.

4.4 Effects of peat extraction…

L11. It is odd, RH was only measured ad DP1, how could you say it is higher also for DP2 compared to….?

Response: We provide details at P7506, L15-18 as to how we obtained an estimate for RH at DP2 and DP3.

"Estimated emissions from heterotrophic respiration (RH) at DP1 were 344 g CO_2-Cm^{-2} yr^{-1}, which equates to 49% of Reco at that site. Applying this proportional value to the other DP sites, we estimate that RH emissions to be 337 and 213 g CO_2-Cm^{-2} yr^{-1} at DP2 and DP3 respectively."

4.5 Fire emission factors

L4. Here it is said: ' the importance of understanding the full suite of trace gas emissions from biomass burning, rather than focussing solely on CO2 and CH4 emissions." The question then is: Why did you not include N2O in the measurements? In the wetland supplement it is only 4 studies on which the Tier 1 EF is based, temperate extraction sites. Some discussion on why you did not include this in the measurements would be good.

Response: For the peat extraction areas, we focus solely on CO2 emissions in this discussion paper. CH4 and N2O have been quantified at some of the sites (but not all) and the data is currently being processed with a view to publication in the future.
In terms of the fire study, N_2O is a difficult gas to measure using our FTIR setup as it can only be determined from spectra with very large enhancements of trace gases. This is because the N_2O absorption occurs in a similar wavenumber region to both the CO_2 and CO absorption bands (Paton-Walsh et al., 2014). Paton-Walsh et al. (2014) could only determine N_2O from two of their five open fires, whilst Smith et al. (2014), who used a similar setup, failed to determine N_2O from any of their 21 fires studied. In our study of Irish sphagnum moss peat burns, we found that excess mole fractions of N_2O could not be correlated to either CO_2 or CO for the determination of emission ratios, precluding the calculation of emission factors. One explanation for this is that N_2O is predominantly a product of flaming combustion and is strongly correlated to CO_2 (Paton-Walsh et al., 2014). The lack of flaming combustion in our peat burns probably explains our inability to detect significant excess N_2O mole fractions.

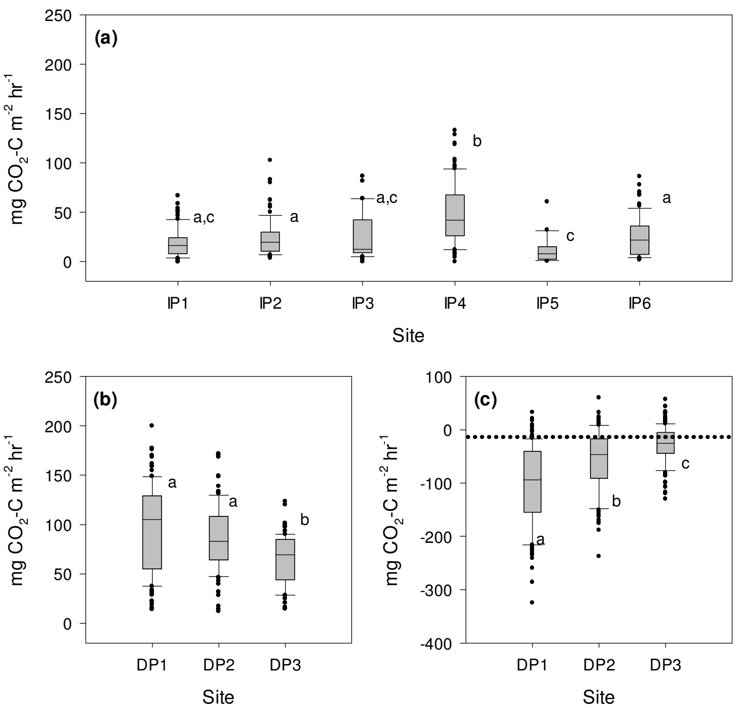
4.6 Implications…

L20. Why not say 1.7 t C?
Response: Given that we found no significant difference between the IP and DP sites, we then used the mean value (1.68 t CO2-C) from all the sites as a single EF. Two decimal points provide a higher level of precision – particularly important for inventory reporting.

P7515 L1. After '6' I lack the word 'times'.
Response: Amended.

Figures

Figure 3 and Figure 5 do not match. For Figure 3c the NEE show a net uptake of C but the Figure 5 shows NEE as loss. How come? Confusing.
Response: Indeed. The caption to Fig. 3 should have included the following text *"(c) net ecosystem exchange (NEE; mg CO_2-C m^{-2} hr^{-1}) when PPFD>1000 µmol m^{-2} s^{-1} at sites DP1-3".* This has now been added. The letters denoting differences between fluxes were also lost during the uploading process and are now presented below.



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