Anonymous Referee #2

Received and published: 5 March 2019

I apologize for the delay in getting my review in. Overall I think this study is interesting and the paper is mostly well written. It is unfortunate that it is just 2 seasonal sampling events. It is unclear if the sampling occurred over more than one day each season? Please clarify. The authors do a good job of limiting their results to what they can say with the data at hand (assuming that they sampled more than one day per season). I do think that some things need to be clarified. Below I provide comments and suggestions of issues that need to be clarified.

We thank referee #2 for their constructive feedback and suggestions. We have attended to all of these in details below in blue font.

Lines 35 and 36- negative relationships between Fe, and SO4, and CH4? Or Fe and CH4, and SO4 and CH4? The wording is unclear.

Amended as follows (Lines 35-38):

"*For example, distinct negative relationships between CH_4 fluxes and both Fe(III) and SO_4^{2-} were observed. Where sediment Fe(III) and SO_4^{2-} were depleted distinct positive trends occurred between CH_4 emissions and Fe(II) / acid volatile sulphur (AVS).*

Line 46- what do you mean by early system recovery periods? Recovery from what? Was this wetland recovering from something? This was a remediated wetland?

We meant recovery from anthropogenic drainage. To clarify this for the reader, the abstract now reads as follows (lines 45-47):

"*…We suggest that wetland remediation strategies should consider geochemical profiles to help to mitigate excessive and unwanted methane emissions, especially during early system remediation periods.*"

Line 59- how are drivers and effects of seasonal weather oscillations different?

We have added (lines 64-70):

"Resolving the drivers, pathways and effects of seasonal weather oscillations on wetland CH_4 sink or source behaviours is important to enable more accurate climate model projections and to reduce uncertainties in the global wetland CH_4 budget (Saunois et al., 2016; Kirschke et al., 2013). Weather oscillations affect the total wetland areal extent and inundation periods, with wet conditions facilitating anaerobic conditions favouring methanogenesis, while the opposite is seen during dry periods which potentially mitigates CH_4 emissions (Whiting and Chanton, 2001;Wang et al., 1996)."

Line 62- See problems with Mitsch et al 2013 calculations from Bridgham et al 2014 and Neubauer 2014 papers. I see you cite those papers.

We agree and have acknowledged Bridgham et al., (2014)'s response paper as follows (lines 70-75):

"Mitsch et al. (2013) estimated that the average ratio of freshwater wetland CO_2 sequestration to CH_4 emissions was 25.5:1, though was later refuted by Bridgham et al. (2014). As CH_4 is 34 times more potent than carbon dioxide (CO_2) over a 100 year time scale (Stocker et al., 2013), this suggests that many freshwater wetlands may have a net positive radiative forcing effect on climate (Petrescu et al., 2015;Hernes et al., 2018)."

Line 68- "lack of spatially resolved wetland CH4 emission data"? There are many studies that have measured this. Some of which you already cited.

Agree, by 'spatial' we meant latitudinal as discussed with figure 9. This now reads (lines 77-82):

"The lack of latitudinally-resolved wetland CH_4 emission data, as well as the limited number of studies constraining the multiple wetland CH_4 flux pathways (i.e. ebullition, diffusion and plant-mediated) coupled with ongoing anthropogenic conversion of wetland systems (Saunois et al., 2016;Neubauer and Megonigal, 2015;Bartlett and Harriss, 1993) further contribute to the uncertainties around CH_4 regional to global scale budgets."

Line 84- Is Lal 2008 an appropriate citation for this sentence?

Removed.

Line 92-how was that 1.2 Pg C estimated?

We have now provided an explanation as follows (lines 99-104):

"Within Australia, it has been estimated that more than 50% of natural wetlands have been lost to land use change, drainage and degradation since European settlement (Finlayson and Rea, 1999;ANCA, 1995). By comparing and reviewing pristine Australian wetland carbon stocks to drained sites, and GHG dynamics, Page and Dalal (2011) estimated that through biomass loss, enhanced soil respiration, N_2O production and a reduction in CH_4 emissions, that Australian wetland loss equated to ~1.2 Pg CO_2 equivalents emitted to the atmosphere."

Line 112- why do you expect the fluxes going to differ across the wetland communities?

We have added (lines 122-128):

"…We hypothesize that wetland CH_4 emissions will differ significantly between the campaigns and between the four wetland communities due to differences in soil chemistry, hydrology and plant physiology. We account for three atmospheric flux pathways for methane; ebullition, diffusion and plant-mediated fluxes, over diurnal cycles and within different hydrological conditions. CH_4 fluxes were also assessed in relation to the underlying soil properties, including sulphate, reactive iron III and iron II, acid volatile sulphur, chloride and organic carbon."

Line 162-163- Why were those fluxes reported elsewhere? Is that paper available?

This is a companion study that is now published. This passage is now updated as (lines 181-183):

"…Examples of these, in addition to the ebullition and diffusive CH_4 flux methods and measurements from the permanent wetland have previously been reported elsewhere (Jeffrey et al., 2019)."

Line 164- how many chambers did you have in each vegetation type? How many days did you measure fluxes? Was it only one day each season?

We sampled in triplicate within each vegetation type (three sites), so n=9 in total. We measured at least a complete diel cycle each season. Each campaign covered five days with ebullition deployments, diel diffusion rates and redox etc. To more clearly clarify this in the manuscript we have added the following lines 186-191:

"Simultaneous time series chamber experiments were conducted over a minimum of 24 hours to measure diel CH_4 fluxes during each season from the three different wetland vegetation ecotypes. These ecotypes were Juncus kraussii, Phragmites australis and Juncus kraussii amongst Casuarina sp. forest (Fig. 1). In each ecotype, three acrylic bases (65 x 65 x 30 cm) were installed four months before the first time series experiment, to minimise disturbance to the sediment profile and vegetative rhizosphere.

And as per referee #1 suggestions we have also included more details about the number of chamber measurements taken during each campaign as follows at lines 204-212:

"Vegetation incubation times ranged from 6 to 15 minutes depending on the flux rate and were taken from triplicate chambers to account for heterogeneity within each ecotype. During the first time-series (C1), an average of 16.7 ± 2.9 daytime flux measurements (i.e. after sunrise) and 7.3 ± 1.6 night time (i.e. after sunset) were recorded within each habitat. During the second campaign (C2) an average of 27.7 ± 2.9 (day time) and 10.3 ± 1.5 (night time) flux measurements were recorded within each habitat. In addition, CH_4 fluxes from the adjacent exposed soils or shallow overlying water at each site were also measured at ~4 hourly intervals to determine the influence and role of plant-mediated CH_4 fluxes compared to non-vegetated CH_4 fluxes."

And diffusive chamber measurements (lines 175-177):

"…A total of 39 CH_4 floating chamber incubations averaging ~8 minutes in duration were recorded over the two campaigns, with 19 during C1 (nine at night) and 30 during C2 (12 at night)."

Lines 279-281- This sentence is more Discussion.

We agree and have moved to discussion as follows at line 375-379:

"Sediment profiles provide insights to the historical geochemical changes that have occurred across the CASS landscapes of the four Cattai Wetland sites (Fig. 5). We base our results and discussion on the upper rhizosphere depth zone (20 cm) as this featured the highest organic carbon concentrations is therefore assumed to be an active area of carbon metabolism, and CH_4 production and consumption (Nedwell and Watson, 1995)…."

Line 302- Structuring the Discussion in the same order as the Results makes it easier for the reader. I suggest you Discuss your results in the same order they were presented in the Results section.

We agree and have aligned our results to be the same order as our discussion.

Line 326-CASS wetland restoration the same as remediation?

Now amended to 'remediation' to be consistent.

Lines 345 and 346- It gets hard to keep track of C1, C2, Veg A, Veg B. Could there be more straightforward ways of talking about these?

As per previous suggestions we have renamed our three vegetation sites with more intuitive titles: 'Juncus', 'Phragmites' and 'Juncus/Forest' but will keep C1 and C2 to represent the two campaigns.

Line 352-354- This is more of a results sentence and I am not sure I understand what you are saying. Please clarify.

We agree and have removed as this sentence was redundant and have now combined with the previous paragraph as (lines 422-428):

"...Further, as iron reduction yields more free energy than SO_4^{2-} reduction (Burdige, 2012), then Fe reduction at the Juncus site may outcompete CH_4 production ahead of SO_4^{2-} reduction at Phragmites, which may help explain some of the differences in CH_4 production between the two sites. The positive significant trends between Fe(II), AVS and the $Cl:SO_4^{2-}$ ratios with CH_4 flux rates (r_s=0.88, $p<0.01$) further support our hypothesis that reducing conditions and a smaller pool of sediment Fe(III) and SO_4^{2-} facilitate higher CH_4 production rates (Fig. 7)…."

Line 409 and 410- this Veg A and B is getting tiring. Why not just talk about the species?

As mentioned above, we have amended throughout the manuscript and adjusted all figures. This are now introduced first by scientific name and then shortened as follows at lines 156-159:

"The seasonal wetland to the south is dominated by the sedge; Juncus kraussii ('Juncus' from herein) and features scattered stands of Phragmites australis ('Phragmites' from herein) with areas of slightly higher elevation dominated by Juncus kraussii below Casuarina sp. ('Juncus/ Forest' from herein) (Fig. 1)."

Line 433- it is hard for readers to access submitted papers. Please do not cite papers that are not already published in some form.

These are now published and the reference list has been updated.

Line 467- Again see Bridgham et al. 2014 about the problems with Mitsch et al use of radiative forcing vs balance.

As these numbers have been refuted, we have removed Mitch and provided a more suitable reference to this uncertainty at lines 565-569:

"Although remediating degraded wetlands through re-flooding is a common technique to improve biodiversity, increase C sequestration and improve downstream water quality issues (Johnston et al., 2014;Johnston et al., 2004), our results propose a nuanced dilemma for land use managers, as wetland remediation can potentially have net positive radiative forcing effects on the Earth's climate due to high rates of CH_4 production (Petrescu et al., 2015)."

Line 452, comma between budget and however.

Amended.

Figure 6- those are really low r2 values! Are these significant relationships? If they are not significant, it is better not to report the value. And r2 of 0.0005 is better to just say there was no relationship.

Amended.

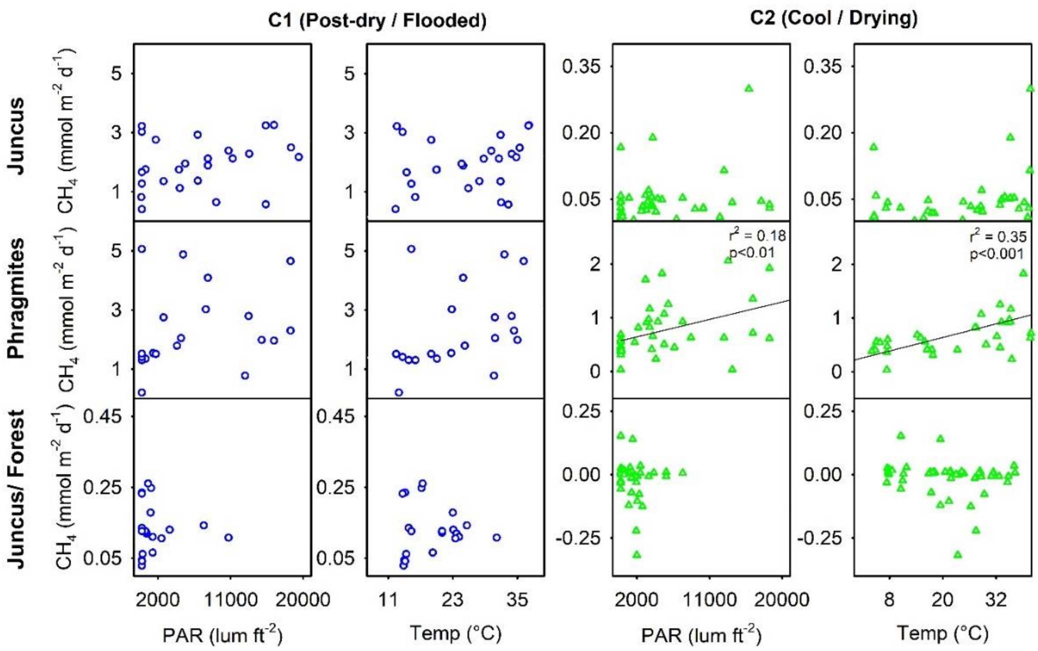

Figure 6. Correlations of CH_4 with temperature (ºC) and photo-synthetically active radiation (PAR) (lum ft^{-2}) for the three seasonal wetland vegetation sites of Cattai Wetland during two field campaigns.

Figure 8- I really like this figure. Is Fe(III) in Veg C above the axis break? It is a little hard to tell.

We have added a dashed line to show the axis break more clearly as follows:

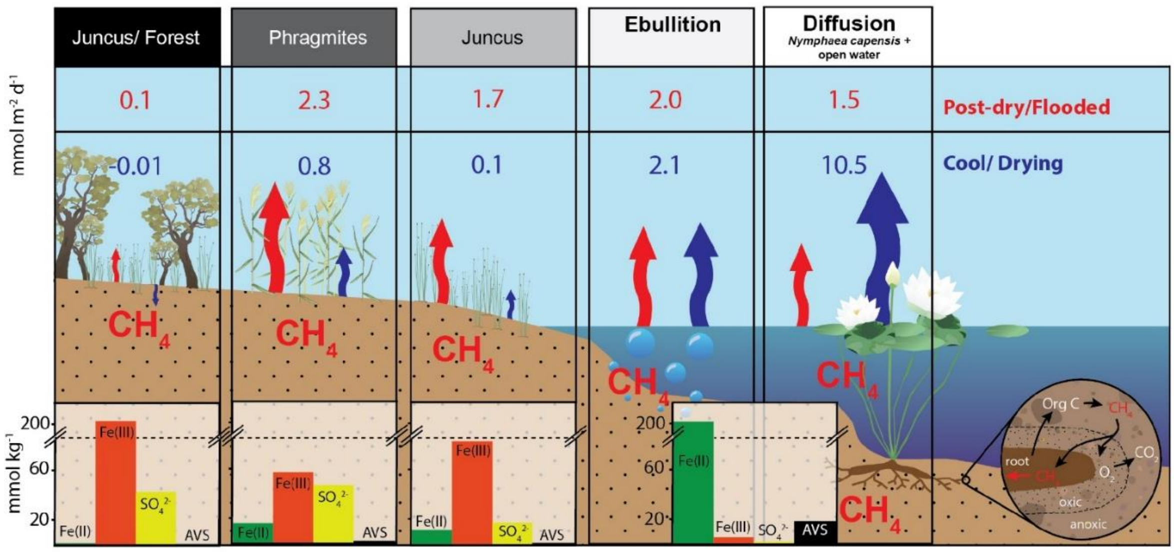

Figure 8. Conceptual model summarising the terrestrial and aquatic CH_4 fluxes (mmol m^{-2} d^{-1}) and sediment core profile parameters (mmol kg^{-1}) of the permanent and seasonal wetlands during C1 (post-dry/flooded conditions) and C2 (cool/drying conditions) of Cattai Wetland. Conceptual diagram expanded from Jeffrey et al. (2019) and rhizome process insert adapted from (Conrad, 1993). Note: Dashed line highlights y-axis break.

End of Referee #2 response file