

Response to reviewer's comments on "Carbon budget assessment of an irrigated wheat and maize rotation cropland with high groundwater table in the North China Plain" by Quan Zhang et al.

We appreciate the reviewer for the constructive comments, which will take seriously and use to improve the manuscript.

Anonymous Referee #1, comments received and published 05 Jan 2017

General comment:

The authors present a detailed carbon budget of an irrigated wheat and maize rotation cropland that is characterized by high groundwater table due to irrigation systems. They report that the studied cropland behaves as a weak carbon sink. The paper is of general high quality with original results and sound data analyses, and the results are well discussed with the existing literature.

Response:

We appreciate the reviewer's support for the quality of the manuscript and the constructive comments.

However, I have a few concerns which I list here-below:

- The largest concern I have is with respect to the possibility that methane (CH<sub>4</sub>) emissions could be large in this type of poorly-drained and often flooded ecosystem. I think the authors should be a lot more cautious throughout their analysis, discussion and conclusion when they conclude that this ecosystem behaves as a carbon sink (even if weak). This is only true with respect to CO<sub>2</sub> but I am afraid that potentially large CH<sub>4</sub> emissions could occur. Did you carry out CH<sub>4</sub> emissions at this site? Or could you provide any sort of estimation of these emissions? Anyway, I strongly recommend to the authors to be more cautious with their conclusion about the carbon sink behaviour of this agro-ecosystem.

Response:

We totally agree with the reviewer on that methane may be significant during the water logging condition. Because this is an upland cropland, methane issue has not been considered in previous efforts, therefore its measurement is not available at this experiment site. The reviewer is right that we should be cautious with the conclusion of 'carbon sink'. Considering CO<sub>2</sub> budget of this study remains a complete analysis, therefore we will change our topic from general carbon budget to CO<sub>2</sub> budget, which is more concise to this manuscript. We will change the title to "The budget of CO<sub>2</sub> in an irrigated wheat and maize rotation cropland over the North China Plain"

Following the reviewer's advice, we also realized methane release may be significant when soil is saturated, so we will definitely add methane measurement in future experiment for a complete carbon budget estimate.

- The paper should be entirely proof-read for English spelling and type-setting mistakes. I provide here below the specific mistakes I could already notice.

**Response:**

We will revise the whole manuscript carefully and ask an English native for further edits.

- The authors paid attention to the evaluation of uncertainties associated to their measurements, which is a good point. However, I think that the uncertainties associated with the carbon budget terms (NBP, NEE, GPP, TER, : : ) are missing and should be estimated and given along with the mean values. They could indeed help to seize the reliability of claiming that the ecosystem behaves as a carbon sink.

**Response:**

We will add uncertainty analysis for eddy covariance based NEE, GPP and TER. We will use the 'successive days approach' proposed by Hollinger and Richardson (2005) to quantify the uncertainty of eddy covariance based carbon flux.

- There are a few problems to fix in the figures (printed in black and white, some symbols or lines are not visible).

**Response:**

We appreciate the reviewer point out this problem, and we will redraw these figures to present them more clearly.

Specific comments

Abstract

L31-32: Is this written as a general characteristic for croplands? Or does this apply to this specific cropland? This is not quite clear.

Response:

This characteristic is very common from the literature we have collected, see Table 2 in the manuscript. We realized this conclusion may be not strong, because the carbon use efficiency is also subject to managements of irrigation, fertilization etc. Hence, we will only compare the carbon use efficiency in the discussion section, whereas no present in the abstract.

L32: CUE should be defined (ratio of NPP to GPP).

Response:

Will revise.

Materials and methods

L182-183: Is it really 200 wheat plants that are sampled at harvest? This sounds really a lot.

Response:

Correct, we collected 200 wheat plants at harvest to reduce the uncertainty associated with plant samplings. Such big samplings allow us the confidence in NPP estimate.

L202: can you check that reference temperature is well 0 °C? Isn't it 10 °C, as it is often the case in the literature?

Response:

We got the reviewer's point.

The reference temperature depends on the selected temperature response function,  $ER_{ref}$  here is the reference respiration at 0 °C because we use the function  $ER = ER_{ref} \exp(bT_s)$ .

But it should be reference respiration at 10 °C if the function writes as  $ER = ER_{ref} Q_{10}^{(T_s-10)/10}$ .

These two functions are equivalent *per se*, and are linked by  $Q_{10} = \exp(10b)$ . And the reference respiration should also be 10 °C when using the temperature response curve by Reichstein et al. (2005), i.e.,  $ER = ER_{ref} \exp[E_0(1/(T_{ref} - T_0) - 1/(T - T_0))]$ .

## Results

L338-342: I think here the uncertainties related to the budget terms, and particularly NBP should be added, and particularly because the NBP values you give for wheat, maize and full crop rotation are averages.

### Response:

We will add uncertainty for the CO<sub>2</sub> budget components, and also evaluate the uncertainty of NBP estimate.

## Discussion

L357-359 (and in the conclusion): I think here should appear some comments on the possibility that this ecosystem releases CH<sub>4</sub> during those periods. Unless you can provide some measurements showing that no methane emissions are observed at this site? At least more caution should be placed in this section.

### Response:

We realized that CH<sub>4</sub> flux may be significant at our site during the water logging period, but we do not have such measurement, so we will focus our topic on CO<sub>2</sub> budget. A thorough estimate of CO<sub>2</sub> budget remains a necessary work for carbon cycle in cropland of this kind, but we will incorporate CH<sub>4</sub> in future work.

L389-390: I think this sentence is not correct: to me, GPP is the largest term and therefore it outweighs ER. Can you check this?

### Response:

The reviewer is right, GPP is usually the largest flux term.

Here we wanted to express that both GPP and ER decrease in water logging conditions, but the reduction of ER (i.e.,  $\Delta ER = ER(\text{no water logging}) - ER(\text{water logging})$ ) is higher than that of GPP ( $\Delta GPP = GPP(\text{no water logging}) - GPP(\text{water logging})$ ), so the net ecosystem carbon sink (i.e.,  $GPP - ER$ ) is higher in water logging conditions than under regular field conditions, if explaining it from a mathematical perspective,

we have  $\Delta ER > \Delta GPP$ , i.e.,

$ER(\text{no water logging}) - ER(\text{water logging}) > GPP(\text{no water logging}) - GPP(\text{water logging})$

then we get,

$GPP(\text{water logging}) - ER(\text{water logging}) > GPP(\text{no water logging}) - ER(\text{no water logging})$ ,

which indicates that net carbon sink is higher in water logging conditions.

We will revise this part to explain it more clearly.

L471: As stated above, and unless it is certain that this site cannot be a source of CH<sub>4</sub>, I really think that some words should be added to say that this site could potentially be a net source of carbon if CH<sub>4</sub> emissions are taken into account.

Response:

We agree with the reviewer, because of lacking CH<sub>4</sub> measurement, we will focus this study on CO<sub>2</sub> and will modify our conclusion on CO<sub>2</sub> alone. However, we will incorporate the reviewer's comments by discussing a little about the possible emission of CH<sub>4</sub> as an outlook for future study.

Tables and figures

Fig. 8: As the NBP terms that appear on the figure are averages between two methods and do not correspond to the difference between NEE and ER, you should recall in the legend more clearly what is exactly this value of NBP.

Response:

We appreciate the review's advice, we will make it clearer by adding texts explicitly explaining that NBP is the average of two independent methods (i.e., eddy covariance-based and crop sampling-based).

Technical corrections

L68 : please remove the comma (,) after AND.

Response:

Will revise.

L96-98 : This sentence should be rewritten. Is one verb missing ?

Response:

The sentence was not clear, we will revise it into “The North China Plain is one of the most important food production regions in China, it guarantees the national food security by providing more than 50 % wheat and 33 % maize to the whole nation (Kendy et al., 2003).

L100 : please write leading TO dramatic: : :

Response:

Will revise.

L147-150 : This paragraph should be reformulated and the capital letters after the sign ; should be removed.

Response:

Will reformulate this paragraph, and use lower case word after sign ‘;’.

L178 : DISTRIBUTED rather than DISTRIBUTING

Response:

Will revise.

L196-200 : this sentence is too long and not very clear. This should be reformulated.

Response:

We will revise this part to describe the details of NEE partitioning method, we used the method proposed by Reichstein et al. (2005) and we will describe the details.

L270 : One S should be added to SHOW.

Response:

Will revise.

L283 : I think the correct term is -1500 kPa, and not -1500 MPa.

Response:

The reviewer is right, the unit is messed up. We will revise this.

L294 : please remove the capital letter after the sign ;

Response:

Will revise.

L310 : please remove THE before HIGH TEMPERATURE

Response:

Will revise.

L363 : the word IN is missing before OUR STUDY

Response:

Will revise.

L363-365 : I do not understand this sentence, which should be re-written

Response:

We wanted to express that ecosystem respiration decline magnitude is higher in water logging condition than the regular field condition, so the carbon loss from field was suppressed in water logging conditions.

We will revise the sentence into some explanation like “While our study further implies that water logging condition suppresses Ecosystem Respiration more than Gross Primary Productivity, therefore reduces the net CO<sub>2</sub> release to the atmosphere”

L370 : I guess the term CLOSE should be added after PRETTY?

Response:

Correct, will revise.

L375 : one S should be added to EXHIBIT

Response:

Will revise.

L378-379 : please remove the capital letter after the sign ;

Response:

Will revise.

L382 : BE should probably be added between MAY and SUBJECT

Response:

Will revise.

L431 : BE should be added between ALSO and SUBJECT

Response:

Will revise.

L437 : -GROUND should be added after ABOVE

Response:

Will revise.

L437-440 : I do not understand this sentence. Please can you reformulate ?

‘ecosystem respiration is dominated by below- ground and above autotrophic respirations. As autotrophic respiration, especially above-ground autotrophic respiration in these studies release high proportions of assimilated carbon by photosynthesis, therefore, their crops have relatively lower carbon use efficiency as aforementioned.’

Response:

We will revise this to explain more clearly.

We wanted to explain the reason why previous studies report a lower carbon use efficiency (i.e.,  $CUE=NPP/GPP$ ). Because  $NPP=GPP-RA=GPP-(RAB+RAA)$ , then we get  $CUE=1-(RAB+RAA)/GPP$ . The previous studies have a high  $(RAB+RAA)/GPP$  ratio as an index of carbon release through autotrophic respiration, supporting the reason why they have lower carbon use efficiency. Here RA-autotrophic respiration; RAB- below-ground autotrophic respiration; RAA- above-ground autotrophic respiration.

Table 1: in the column titles, it should be written GREEN instead of GREE.

Response:

Will revise.

Fig. 3(c): this figure is not clear, and particularly the distinction between rainfall and irrigation.

Response:

We will redraw this figure to make it clearer.

Fig.4 (legend): one T is missing in the word HARVESING

Response:

Will revise.

Fig. 6: The distinction between GPP and NEE colors and line types is not possible. In addition, the acronyms HW, PM and HM should be explained in the legend.

Response:

We will redraw this figure to make it clearer.

We will also add explanation of HW, PM and HM in the figure caption. They are: HW- Harvest Wheat, PM-Plant Maize, HM-Harvest Maize

Fig. 5 (legend): OF is missing before THE FOUR SAMPLING POINTS. And STARDARD should be written STANDARD. You can also add (SEE LEGEND IN GRAPH) after DIFFERENT ORGANS.

Response:

Will revise.

## References used in this response

- Kendy, E., Gerard-Marchant, P., Walter, M. T., Zhang, Y. Q., Liu, C. M., and Steenhuis, T. S.: A soil-water-balance approach to quantify groundwater recharge from irrigated cropland in the North China Plain, *Hydrol. Process.*, 17, 2011-2031, doi: 10.1002/hyp.1240, 2003.
- Reichstein, M., Falge, E., Baldocchi, D., Papale, D., Aubinet, M., Berbigier, P., Bernhofer, C., Buchmann, N., Gilmanov, T., Granier, A., Grunwald, T., Havrankova, K., Ilvesniemi, H., Janous, D., Knohl, A., Laurila, T., Lohila, A., Loustau, D., Matteucci, G., Meyers, T., Miglietta, F., Ourcival, J. M., Pumpanen, J., Rambal, S., Rotenberg, E., Sanz, M., Tenhunen, J., Seufert, G., Vaccari, F., Vesala, T., Yakir, D., and Valentini, R.: On the separation of net ecosystem exchange into assimilation and ecosystem respiration: review and improved algorithm, *Global Change Biol.*, 11, 1424-1439, doi: 10.1111/j.1365-2486.2005.001002.x, 2005.