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Interactive comment on "Net global warming potential and greenhouse gas intensity in rice agriculture driven by high yields and nitrogen use efficiency: a 5 year field study" *by* X. Zhang et al.

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Dear Reviewer#1, Thank you very much for your critical comments and great support! Please see the attached point-by-point answers and the manuscript with tracking system for your further evaluation. Sincerely yours, Zhengqin (on behalf of all authors) Referee #1 GENERAL COMMENTS The authors present an interesting and complete assessment on Global Warming Potential (GWP) and greenhouse gas intensity (GHGI) during three years in a rice-wheat rotation. The number of crop seasons, as well as the complete overview the sustainability of the agro-ecosystem (soil GHG emissions, SOC, CO2 equivalents from inputs and operations, and crop yields) are, from my point

of view, the main strengths of the this study, which fits well into the scope of the journal. Conversely, the manuscript requires additional details and explanation before it can be considered for publication. Moreover, I do not understand why the authors did not set some variables (e.g. Zn fertilization -which has been reported to influence crop yields and GHG emissions- plant density, water management. . .). That would have simplified the discussion and maybe would have allowed obtaining some conclusions about management techniques (and not only about the overall scenarios) and the possibilities of combining scenarios. The authors should also improve the Materials and Methods section, explaining much better the GWP calculations and other issues of major interest. The conclusions are adequately presented: since each scenario is a combination of several management techniques, the authors cannot recommend any single practice, only the full scenario. Conversely, ALL the management factors that could have influence the measured variables (yields, GHG fluxes, GWP) should be briefly discussed. A: Thank you very much for your great support and critical comments. Those comments are all valuable and very helpful for revising and improving our paper, as well as further important guidance for our researches. We have made corrections which we hope to meet with approval. Please see the following point-by-point answers. 1. Yes, all of these variables such as Zn fertilization, plant density, and water management affect crop yields and GHG emissions. We are sorry that we did not set them as separate variables and just integrated them to realize our goal for better yield and NUE. According to your comments, we added some information for better understanding in discussion, such as on Page 10, Lines 262-265 and 270-275 for yield, Page 12, Lines 306-308 for GHG emissions. 2. It is really true that we update all possible components for calculating GWP as both of you Referee suggested. So, we put them in a better way on Page 6, Lines 149-173. 3. In conclusion, the ISSM scenarios could be adopted for both food security and environmental protection. We discussed scenarios in detail emphasizing the main components. Revised accordingly Page 14, Lines 385-388 and Page 16, Lines 430-432.

SPECIFIC COMMENTS Abstract, lines 19-23. It seems that treatments only differ in N

rate, and that is not true. Please indicate briefly other parameters that were different between treatments. A: Thank you for your comment. Revised accordingly Page 2, Lines 18-20. Lines 82-84. Include, if available, the information on clay, silt and sand contents and soil texture. A: Thank you for your comment. Revised accordingly Page 4, Lines 90-91. Lines 84-86. Please indicate the annual precipitation and mean temperature in each campaign. Were "normal years" with regard to these parameters, compared to the average values (15.5°C and 1038 mm)? In any case, I think that this information fits better in the results section. A: Yes, thank you. Revised accordingly Page 4, Lines 88-89. Lines 88-98. What was the N source applied? What were the dates (or phenological stages) of N application in rice -4 split applications in some treatments-? What about the wheat? When was the N applied? A: Urea was used as N fertilizer and 20 kg N ha-1 in the form of rapeseed cake fertilizer was applied as N fertilizer for N3 and N4 treatments in this study. Revised accordingly Page 5, Lines 112-119. Please indicate that Zn and Na2SiO3 fertilization, plant density and the use of an organic amendment were also management techniques for improving rice yield and NUE. A: Thank you very much for your comment! According to your comments, we added some information for better understanding in discussion. Did you consider the N supplied through rapeseed cake manure for NUE calculations (you should!)? In any case, please indicate in this section the composition of this residue, at least the C and N contents and C:N ratio. A: We are sorry for the inconvenience. We recalculated the NUE according to your comment.. Revised accordingly Page 5, Line 102, Page 8, Lines 196-199 and Fig. 1. Lines 99-104. What amount of irrigation water was applied during the rice growing season in each campaign? Was it different between scenarios (as could be deduced from line 329)? A: The amount of irrigation water applied during the rice growing season in each campaign was as shown in Table 4. It was different between ISSM scenarios and FP and NN. Please describe briefly the residue management at the end of rice and wheat growing season. A: The rice and wheat straws were removed out of the field for all the treatments in this study. Revised accordingly Page 5, Lines 119-120. Line 116. To my knowledge, it is not possible to measure N2O

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with a flame ionization detector. Was not your GC equipped with an ECD detector? Please, clarify this crucial point. A: We are sorry for the inconvenience. All of the gas samples were analyzed using a modified gas chromatograph (Agilent 7890A, Shanghai, China) equipped with two detectors. N2O was detected by an electron capture detector (ECD). Argon-methane (5%) was used as the carrier gas at a flow rate of 40 ml min-1 for the N2O analysis. The temperatures of the column and the ECD were maintained at 40 °C and 300 °C, respectively. Revised accordingly Page 6, Lines 132-137. Line 125. Can you reference this equation? A: Yes. Revised accordingly Page 6, Line 142. Lines 131-149. This section needs to be significantly improved. I recommend the authors to summarize the information in a DETAILED Table, indicating for each variable that is included in GWP calculations: Amount/number of labors/inputs, unit cost (kg CO2 equivalents) and a reference. A: Thank you very much for your comment! Please see the Table 4 for the detailed information. The information on fertilizer rates is enough, but you should indicate the number of farm operations (labor passes, seeding, fertilizing, harvesting, irrigation –and amount of water applied-) in each treatment. Were the ZnSO4 and Na2SiO3 considered for the GWP? (They should!) A: Thank you for your comment. We added a new Table 4 for understanding the Eo and Ei components. The ZnSO4 and Na2SiO3 were also considered for the GWP. There must have other uncertainties in selecting parameters. This is only preliminary evaluation within our understanding. Thank you very much for your great support! What does the Ei involve? Only inputs application? Application + manufacture and transport? A: Ei involve application + manufacture and transport. What are the CO2 equivalents for N2O and CH4 emissions? Please, indicate (with a reference). A: Thank you for your comment. Revised accordingly Page 6, Line 152. Lines 151-157. Were the normal distribution and variance uniformity checked? Did you use any non-parametric test for non-normally distributed data? If affirmative, please indicate how. A: We have made the normal distribution and variance uniformity check. All data were conformed. Line 167-168. I don't know what you meant here. According to Table 2, significant increases were observed. . . If this statement is referred to average wheat-rice values, please add

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"data not shown" in brackets. A: Thank you for your comment. This statement was meant that significant increase was observed only in N4 scenario in wheat grain yields. NUE: See my comment on lines 88-98 for NUE calculations in N3 and N4 scenarios (with rapeseed cake manure). Correct NUE for these cultivation patterns if the N from rapeseed was not considered. A: We are sorry for the inconvenience. 20 kg N ha-1 in the form of rapeseed cake fertilizer was applied as basal fertilizer and should be included in the total N rate. Revised accordingly Page 8, Lines 196-199 and Fig. 1. Line 175-176. Please include this sentence "current ISSM strategy was only designed for rice production, not wheat production" in Materials and Methods. A: Thank you for your comment. Revised accordingly Page 5, Lines 100-101. Line 187-188. Avoid as possible the subjective statements (e.g. "due to the combined application of inorganic and organic fertilizers") in the results section. This sentence (from my point of view) fits better in the discussion. A: Thank you for your comment. Deleted accordingly Page 9, Line 215. Lines 189-196. The description of the N2O evolution should be improved. You should indicate how many peaks or increments (if any) were reported in each crop, and if they were reported after fertilization events. Comparing emissions (CH4 and N2O) between crops (wheat versus rice) would be interesting. A: Thank you for your comment. Revised accordingly Page 9, Lines 216-218. "Correlations between seasonal cumulative N2O emissions and fertilizer N application rates were also calculated": that should be indicated in Materials and Methods (Statistical Analysis section, in which you only explain that "linear relationships were determined"). About this regression, the N rate was not the only variable that could have influenced N2O emissions, since other variables were not fixed. Moreover, the N rate in N3 and N4 is not correct (you have not considered rapeseed manure). Therefore, I recommend removing this figure. A: Thank you for your comment. Deleted accordingly. "Relative to the FP plot, the N1 and N2 scenarios decreased the annual N2O emissions by an average of 41% and 22%, while the N4 scenario significantly increased it by 46% although there was no significant difference between N3 and FP plots ($P < 0.05$)". This sentence is so confusing for me. Is this statement referred to wheat? If affirmative,

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please indicate and check the percentages of abatement/enhancement (looking at Table 2, average 2011-2013, I think there are some mistakes). You should describe also the results for the rice (in spite of the lack of significant differences between fertilized treatments). If these percentages are based on information of Table 2, please refer to this Table. A: Sorry for the inconvenience. This statement referred to the annual N2O emission rates including the results for both rice and wheat. Revised accordingly Page 9, Lines 222-323. “With respect to the N application effect, the annual cumulative N2O emissions in all four ISSM scenarios were significantly higher than in NN ($P < 0.05$)”. In what crop? In wheat? Please indicate, because this is not observed for rice (Table 2, Average 2011-2013 fluxes). A: Sorry for the inconvenience. The annual cumulative N2O emissions indicate the average rates in rice-wheat rotations of 2011–2014. Line 202-203. “Although N fertilizer increased annual CH4 and N2O emissions, they also increased SOC sequestration in this cropping system”. Please change “N fertilizer” by “fertilized treatments”. The idea that N fertilization can increase SOC sequestration is speculative, particularly in the Results section. A: Thank you for your comment. Revised accordingly Page 9, Lines 233. Lines 206-207: “CO2 equivalents from machinery used for Ei (2449–4192 CO2-eq ha−1 yr−1) were higher than Eo (1285–1697 CO2-eq ha−1 yr−1) of the fertilized plots”. The word “machinery” is confusing form me since you explain (in lines 123-133) that the Ei component accounted the CO2 emissions from agrochemical inputs. A: Sorry for the inconvenience. Revised accordingly Page 9, Lines 238. Lines 211-212: “Consequently, the lowest NGWP was achieved under the N1 scenario for the ISSM.” The NGWP in N1, N2 and FP was statistically similar. Please remove or correct this sentence. A: Thank you for your comment. Deleted accordingly Page 9, Lines 243. General comments on Discussion section: the Discussion should be significantly improved. First of all, the document (and particularly this section) should be reviewed by a native speaker. As explained above, each scenario is a combination of several management techniques, and even though authors cannot recommend any single practice (only the full scenario), ALL the management factors that could have influence the measured variables (yields, GHG fluxes, GWP) should

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be discussed: A: Thank you for your comment. Revised accordingly throughout the discussion. We also asked AJE for re-editing the texts. Thank you for your patience. We added references (Kabata-Pendias and Mukherjee, 2007 ; Hossain et al., 2008) in the text. âĂć Fertilization: Not only different N rates were tried, but also different P, K, silicon and Zn. This fact may have directly affected crop yields, and also N2O emissions indirectly (i.e. the more a crop grows, the more N is uptaken and the less N is likely to be lost as N2O). Particularly, Zn has been reported to influence CH4 and N2O emissions (Glass and Orphan, 2012) and yields in some crops, e.g. rice (Hossain et al., 2008). The effects of silicon in rice physiology have also been described (Kabata-Pendias and Mukherjee, 2007). Hossain, M. A., Jahiruddin, M., Islam, M. R., & Mian, M. H. (2008). The requirement of zinc for improvement of crop yield and mineral nutrition in the maize–mungbean–rice system. Plant and soil, 306(1-2), 13-22. Glass, J. B., & Orphan, V. J. (2012). Trace metal requirements for microbial enzymes involved in the production and consumption of methane and nitrous oxide. Frontiers in microbiology, 3. Kabata-Pendias, A., & Mukherjee, A. B. (2007). Trace elements from soil to human. Springer Science & Business Media. âĂć The rapeseed cake manure is also an important variable. This organic amendment can substantially modify CH4 and N2O fluxes thorough the release of C and N. You should indicate the composition of this residue (C and N contents) and discuss better its influence on GHG emissions (Thangarajan et al., 2013) and C sequestration. Moreover, the residues from Brassicaceae have been reported to inhibit nitrification, thus affecting N2O losses (Subbarao et al., 2015). A: Thank you for your comment. Revised accordingly throughout the discussion. We added reference (Thangarajan et al., 2013) in the text. Thangarajan, R., Bolan, N. S., Tian, G., Naidu, R., & Kunhikrishnan, A. (2013). Role of organic amendment application on greenhouse gas emission from soil. Science of the Total Environment, 465, 72-96. Subbarao, G. V., Yoshihashi, T., Worthington, M., Nakahara, K., Ando, Y., Sahrawat, K. L., ... & Braun, H. J. (2015). Suppression of soil nitrification by plants. Plant Science, 233, 155-164.

âĂć Plant density, split N application ratio and water regime were not the same in all

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treatments (I do not know why). Could these changes have modified GHG emissions and crop yields? For instance, in lines 230-234, you consider that the changes in rice yields in N1 and N2 treatments as opposed to FP are due to changes in N fertilization rate. But the crop density and split ratio were different, and that could have also affected yields. In the reference that you provide (Peng et al., 2006) only the N rate is changed between treatments. A: Thank you for your comment. Revised accordingly Page 10, Lines 262-265. As indicated above, the N supplied thorough the manure should be taken into account for NUE calculations. Therefore, the NUE should be recalculated and re-discussed. A: Thank you for your comment. Revised accordingly Page 8, Lines 196-199 and Fig. 1. Lines 239-240: "Possible explanations can be that organic fertilizer supplemented with adequate nutrients in combination with improved rice yield and efficient control of pests and diseases". As indicated above, many factors could have contributed to this higher yields and must be discussed (i.e. why the organic amendment increase yields? Maybe due to the higher supply of nutrients that you have not considered)... But what about the efficient control of pest and diseases? Were not efficiently controlled in the rest of treatments? This point needs to be clarified. A: Thank you for your comment. Revised accordingly throughout the discussion. Lines 248-252. Please split and/or rewrite this sentence for better understanding and be careful with the variables that were not measured (e.g. leaching and volatilization). A: Thank you for your comment. Revised accordingly Page 11, Lines 282-285. Line 277: add a reference for this statement. A: Thank you for your comment. Revised accordingly Page 12, Lines 318. Lines 278-279. Likely, the flooded conditions during rice season led to the reduction of N2O to N2 (complete denitrification). A: Thank you for your comment. Lines 280-282: add a reference for this statement. A: Thank you for your comment. Revised accordingly Page 12, Lines 324. Lines 286-287: as explained above, I recommend removing this correlation analysis. A: Thank you for your comment. Deleted accordingly Page 12, Lines 328. Lines 325-327: why the fertilized treatments could have increased SOC sequestration? That should be briefly discussed (maybe that could be related to residue management, which you should also explain).

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A: Revised accordingly Page 14, Lines 368-369. Line 343-344: I suggest adding a figure or table indicating the relative weight of each component in each crop. Were there any differences in Net GWP between years? A: Thank you for your comment. The SOCSR was calculated through the long-term experiment of annual average carbon sequestration rate, not on the crop seasonal scale. We added a new Table 4 for understanding the Eo and Ei components. The GWP between years was similar. Conclusions: you should indicate some results about wheat, not only about rice. A: Thank you for your comment. The results include rice-wheat rotation system, not only about rice. Lines 382-384: I guess that you are referring to one ISSM strategy in particular (N2), please indicate. Since you propose N2 as the most appropriate management strategy, I recommend describe briefly this scenario (10% reduction of N input, no rapeseed manure, no Zn or silicon addition, higher plant density. . .). A: Thank you for your comment. Revised accordingly Page 16, Lines 428-429. Table 2: please indicate with lowercase letters if there were significant differences between treatments in 2011, 2012 and 2013 (not only in the average). A: Thank you for your comment. Revised accordingly Table 2. Table 4: you must add the values for both wheat and rice in each component, and discuss in the text. Additionally, see my comment on lines 343-344. A: Thank you for your comment. We added a new Table 4 for understanding the Eo and Ei components. We use the replicates for understand the uncertainties. There must have other uncertainties in selecting parameters. This is only preliminary evaluation within our understanding. Thank you very much for your great support! Figure 2: You should delete figure 2a (this information is given on Table 2) and c (see the comment on lines 286-287). Add the standard errors (or deviations) to the columns in fig. 2b. A: Thank you for your sincere advice! Revised accordingly Figure 1. Figures 3 and 4. Indicate (e.g. with arrows) the times of N fertilization and the flooding cycles. A: Thank you for your comment. Revised accordingly Figures 2 and 3. TECHNICAL CORRECTIONS Abstract: A widespread criteria is that non-standard or uncommon abbreviations should be avoided in the abstract. Therefore, you should remove some abbreviations that you only use once, e.g. Ei, Eo and SOC. A: Thank you for your com-

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ment. Revised accordingly Page 2, Lines 22-23. Avoid abbreviations at the beginning of the sentence (e.g. K in line 102, CO2 in line 206, CH4 in line 263). A: Thank you for your comment. Revised accordingly. Line 214: The word "Conversely" does not make sense there. Please rewrite the whole sentence. A: Revised accordingly Page 10, Line 245-246. Line 224: at the beginning of the sentence, change "A" by "The". A: Revised accordingly Page 10, Line 255. Line 312: Although there were not significant differences... A: Revised accordingly Page 13, Line 352. Lines 314-316: In spite of producing. Change "considerable" by "similar". A: Revised accordingly Page 13, Line 355. Line 333: per unit OF grain produced. A: Revised accordingly Page 14, Line 375. Line 355: the word "technologies" is repeated twice. A: Revised accordingly Page 15, Line 399. Line 362: the word "increment" is repeated twice. A: Revised accordingly Page 15, Line 404. Caption Table 2: and yields during rice and wheat cropping seasons... A: Revised accordingly Table 2. Footnote Table 2: significant differenceS. A: Revised accordingly Table 2. Table 3: I guess that you have considered MEAN fluxes and yields during the three cropping seasons (please indicate in the caption). A: Yes, we considered mean fluxes and yields during the three cropping seasons. Revised accordingly Table 3. Caption Table 4: global warming potential (without "s") A: Revised accordingly Table 5. Be careful with the font and size in the figure captions. A: Yes, we greatly revised the whole manuscript according to your valuable comments. We also improved our Figures for clarity. Thank you very much for your great help!

Thank you once again for your critical comments and great support! Wish you a Happy New Year! Sincerely yours, Zhengqin (on behalf of all authors) ~~~~~~ Prof. Zhengqin Xiong, PhD College of Resources and Environmental Sciences Nanjing Agricultural University Weigang #1, Nanjing, 210095 PRC zqxiong@njau.edu.cn 86-13605188915 (cell) 86-25-84395148 (O) ORCID https://orcid.org/0000-0003-4743-7325 ~~~~~~

Please also note the supplement to this comment:

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http://www.biogeosciences-discuss.net/12/C9621/2016/bgd-12-C9621-2016-supplement.pdf

Interactive comment on Biogeosciences Discuss., 12, 18883, 2015.