Reply to Referee#2

1. The research is a unique effort to integrate multi-scale agricultural and ecophysiological measurements that readers would find interesting. Significant grammatical errors exist – if they were corrected then the paper would be much easier to digest and would more effectively convey its message.

Reply: Grammatical errors in text body were corrected. Please kindly check the updated version.

2. P2, L19: ": : : resolved using complex Bayesian melding". It was assumed that "melding" should be modeling; this reference doesn't provide evidence for why Bayesian hierarchical modeling would provide an adequate solution to solving the gaps in research.

Reply: That reference provides a possible technical routine to cover remote sensing hierarchical network. The previous sentence that discusses Bayesian melding was removed.

3. Hypothesis 1: Reads as if was formulated after the research was completed, and should be composed in present tense. It would also be beneficial to explicitly separate the second part of this hypothesis into a new hypothesis (LAI and canopy leaf physiology as the primary(?) driver of spatial variation in GPP).

Reply: Yes, it is well formulated after the field research completion in 2013 but a general framework associated with up-scaling estimation of crop photosynthetic productivity was planned in 2012 before commenced field experiments. That is why measurements at multi-spatial and temporal scales were deployed. Darwin never knew what is species change and evolution before doing lots of species investigation. We think it's not the matter when the hypothesis is proposed before or after research completion, the valuable properties of them rely on which kind of scientific question could be potentially related and resolved.

The two hypotheses were re-organized in the improved MS.

4. How many replications were used for each treatment? Were the treatments randomly assigned to plots? This is never addressed.

Reply: At least three replications were collected for each data sets used for statistic analysis. Please kindly check the description in Materials and Methods chapter. Healthy plants were randomly selected for gas exchange measurements. Please refer to pervious publications that described the same field experiments as in this MS (Lindner et al., 2016; Xue et al., 2017).

5. Top of page 5: It may be helpful to briefly mention why the measurement DOYs of the portable gas exchange and chlorophyll fluorescence systems did not match up and were not consistent across nutrient groups.

Reply: Measurements of diurnal courses of leaf gas exchange across PD nutrient treatments and RF rice over the growing seasons were intensively conducted. It is impossible to arrange such measurements for three nutrient groups on the same day because we only have one GFS photosynthesis system. Please refer to pervious publications that described the same field experiments as in this MS (Xue et al., 2016a, b, c).

6. P4, L20-24. Need citations for these methods to estimate Reco and GPP. For equations 2 – 8, citations and/or greater justification for using the equations is warranted.

Reply: Citations for these methods to estimate Reco and GPP were supplemented in P4 L20-24 (Xue et al., 2016a; Lindner et al., 2016). For equations 2 – 8, citations that show key parameters were already cited in P7 L25. Please kindly check them.

7. P7, L19, Eq 2: Need justification for LUE be a linear function of LAI (equation 2). The same holds for equation 3.

Reply: The findings here in terms of LUE_{cint}-LAI and GPPmax-LAI were consistent with previous reports (Lindner et al., 2015; 2016). The relevant citations were added in P7 L19.

8. P7, L19, Eq 5: Based on this formulation, it appears as though LAI appears twice in the numerator – in the GPP and LUE terms from eq.2 and eq. 3. This should be justified.

It would be helpful to have an explanation for why GPP is multiplied in the numerator and added in the denominator.

Reply: GPPmax and LUEcint are maximum gross primary productivity at relatively infinite high PAR and light use efficiency based on incident PAR, respectively, two key parameters comprising a classic photosynthesis light response model (Eq.1 in Owen et al., 2007, and Eq.2 in Lindner et al., 2015), see below,

$GPP = \frac{\alpha \times \beta \times PAR}{\alpha \times PAR + \beta}$, where α here is LUEcint, and β is GPPmax.

Use LAI may bring some biased estimations of α and β. Those two parameters tend to parallel change over growing seasons, which correlate to LAI, consistent with our previous reports.

9. P8, lower half: Justify the use of a non-directional exponential semi-variogram. It would also be helpful to know the number of observations that are used to derive the semi-variogram (number of pixels?). Was the semi-variogram applied to account for spatial autocorrelation of all the response variables or only some of them? This is detailed to some degree in the results but should be explicitly stated here.

Reply: All data sets/pixels (around 41536 pixels for high group, 124236 pixels for normal group, 39928 pixels for low group, and 6860 pixels for rainfed rice) in each nutrient and water treatment were processed in the calculation of semi-variogram, which run in an IDL/ENVI

integrated environment and looked for an overall pattern between proximity and the similarity of pixel values (P8 L19-20).

10. P9, L12. The difference between the PD high and normal groups may have been statistically significant, but was it practically significant (what was the magnitude?) Unclear whether difference between low group and mid/high PD groups is important.

Reply: Statistic analysis in leaf and canopy photosynthetic traits as well as biomass production between PD normal and high groups showed that there was no statistically significant difference. But it may not persist when take variations within fields into account. Variations in photosynthetic productivity in PD high nutrient field may make eigenvalue distinctly greater as compared to PD normal field at specific growth stage. This may also occur when compare within-field functional traits between PD low and normal, RF rice. We highlighted those in Results part.

Those photosynthetic traits on which biomass production tightly depends could be quantified by at-surface traditional physiological measurements, and are directly relevant for hierarchical remote sensing network.

11. Fig 2: Recommend breaking sub-figures a and b into two figures, one for PD, one for rainfed. It would also be helpful to have error bars on sub-figures c and d.

Reply: Error bars on sub-figures c and d has been provided. We suggest to group those four subplots in one figure as we have now.

12. P10, L7. The distinction in LAI-LUE slopes should likely be tested with an interaction parameter and F-test rather than comparing R-squared and p-values.

Reply: Comparing two regression line was done in R, showing significant difference at 0.01 level in slope of regression line (P10, L4).

13. P10, L18. Pink pixels in PD rice are not evident.

Reply: There is indeed pink colors, a product of blue and red, shown in Fig. 5c. Please zoom in Fig. 5c in a relative advanced computer system 64-bit with high screen resolution (for example 1920 * 1080). An aesthetical Fig. 5c was reproduced, see below,

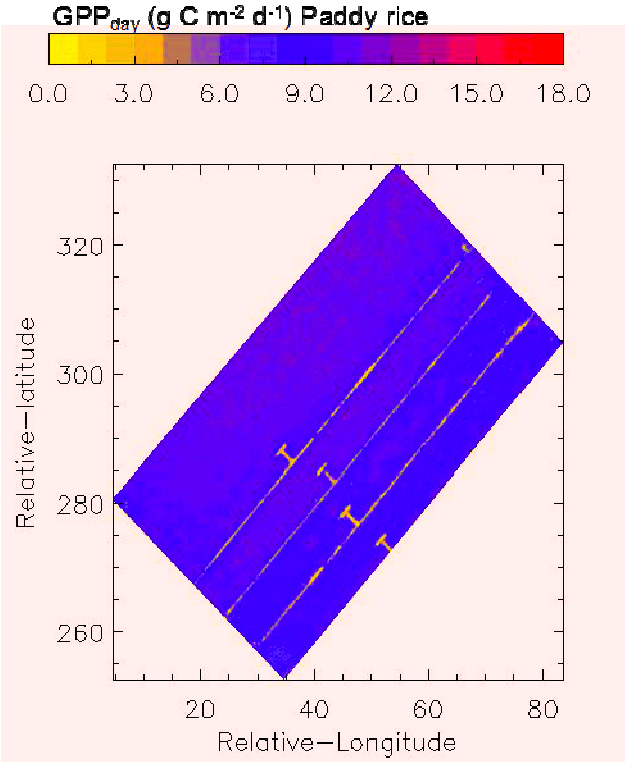

Fig.5c Field map of GPP_{day} in paddy rice.

14. P12, L22. Was the paired t-test using observations across the range of DOY? This seems apparent in the subsequent text but should be stated up-front.

Reply: This is stated up-front (P12, L20).

15. What was the background macro- and micro-nutrient concentrations in each treatment excluding N?

Reply: Description of study site including soil information was stated in Materials and Methods (P3, L20-21). Other nutrient elements that may bring large effects on plant growth and development were discussed in P16, L14.

Reference:

Owen, K.E., Tenhunen, J., et al. Linking flux network measurements to continental scale simulations: Ecosystem carbon dioxide exchange capacity under non-water-stressed conditions. Global Change Biology, 13, 734-760.

Lindner, S., Otieno, D., Lee, B., Xue, W., Arnhold, S., Kwon, H., Huwe, B. and Tenhunen, J.: Carbon dioxide exchange and its regulation in the main agro-ecosystems of Haean catchment in South Korea, Agr. Ecosyst. Environ., 199, 132-145, 2015.

Lindner, S., Xue, W., Nay-Htoon, B., Choi, J., Ege, Y., Lichtenwald, N., Fischer, F., Ko, J., Tenhunen, J. and Otieno, D.: Canopy scale CO_2 exchange and productivity of

transplanted paddy and direct seeded rainfed rice production systems in S. Korea, Agr. Forest Meteorol., 228, 229-238, 2016.

Xue, W., Lindner, S., Dubbert, M., Otieno, D., Ko, J., Muraoka, H., Werner, C. and Tenhunen, J.: Supplement understanding of the relative importance of biophysical factors in determination of photosynthetic capacity and photosynthetic productivity in rice ecosystems, Agr. Forest Meteorol., 232, 550-565, 2017.

Xue, W., Lindner, S., Nay-Htoon, B., Dubbert, M., Otieno, D., Ko, J., Muraoka, H., Werner, C., Tenhunen, J. and Harley, P.: Nutritional and developmental influences on components of rice crop light use efficiency, Agr. Forest Meteorol., 223, 1-16, 2016a.

Xue, W., Nay-Htoon, B., Lindner, S., Dubbert, M., Otieno, D., Ko, J., Werner, C. and Tenhunen, J.: Soil water availability and capacity of nitrogen accumulation influence variations of intrinsic water use efficiency in rice, J. Plant Physiol., 193, 26-36, 2016b.

Xue, W., Otieno, D., Ko, J., Werner, C. and Tenhunen, J.: Conditional variations in temperature response of photosynthesis, mesophyll and stomatal control of water use in rice and winter wheat, Field Crop. Res., 199, 77-88, 2016c.