Biogeosciences
Discussions

Interactive comment on "The asynchronous response of carbon gain and water loss generate spatio-temporal pattern of WUE along elevation gradient in southwest China" *by* Xiangyang Sun et al.

Anonymous Referee #4

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General comments: This paper is chock full of information (14 figures!) that describes multiple aspects of the relationships between plant, or ecosystem, C(O2) gain and plant, or ecosystem, water use by Abies fabri trees/forests arrayed along an elevational gradient (2800-3700 m) located at the transition between the eastern Chinese subtropics and the Tibetan Plateau in a rather small latitudinal and longitudinal range (<1°). The authors suggest that understanding how Abies tree and forest WUEs (C gain per unit water used—expressed in multiple ways throughout the manuscript) respond to environmental factors will enable a number of benefits when estimating/predicting, e.g., "... the potential responses of trees to climate change." (lines 57-58); "... indi-

cator of the coupled relationships between the carbon cycle and water cycle..."; or to address the problem derived from past inconsistent definitions (calculations) of WUE that prevent comparison of WUE values and findings from different locations/studies (line 88).

The feeling I got was that the ms. was trying to address too many questions (not stated, but implies), and that the Introduction did not effectively lay out a compelling argument, or series of logical statements, that culminated in a "Thus, the objectives of our study were: (1) ...; (2) ...; (3) ...; and (4) ..." The aims of the study are too diffuse (to analyze the temporal and elevational [sic] patter of the ecosystem WUE ... to demonstrate why these anticipated changes occurred). What sort of benefit does high WUE impart to trees/forests? Is high WUE "better" than low WUE in terms of survival of a tree or forest? What is the "... obvious practical importance" of knowing about elevational patterns "in WUE in subalpine forests in southwestern China [that] is still not characterized"? Statements that accurately account for which aspects of the hydrologic cycle have and have not been characterized could be compelling incorporated in the line of argumentation that identified the problem that exists and needs solving, and that propels the reader toward the statement of objectives. However, the feeling I came away with was that the pure absence of measurement of a process something had not been b propelled the study because something had not been measured (characterized). For example, lines 75-82 include several true statements, but they do not seem to be part of a clear logical chain of argumentation that demonstrates a need for your study. The end effect of simply presenting a list of true statements in the Introduction, followed by some general relatively nonspecific objectives, is that results become disconnected from a purpose/objective for a measurement (e.g., Fig. 12: What hypothesis/questions/objective do the plots of SLA on delta 13C address, or Leaf[N] on delta 13C address?).

Perhaps a larger concern for me was the difficulty I had in deciphering how empirical data (measurements) were used in combination (or separately from?) with the model,

and how accurate all of the values were for variables not measured at the sites other than at the 3000 m site. I think it would be very important to show the actual 30 min values for NEE and ET that were measured at the 3000 m site using eddy covariance and actually show the WUE of NEE/ET calculated using empirical data. Also, since GPP is a calculated value, it would be extremely valuable to know how this was calculated. Presumably, this was done by using the relationship between nighttime NEE and air T and applying this estimate to calculate daytime ecosystem respiration (R-eco), but whatever was done should be shown (i.e., show Nighttime NEE on air T scatter plot for 30 min values for various times of the year). It is not clear why data are presented as monthly values in the figures. Since environmental conditions appear to be used in calculations of GPP, NPP, and ET for the nine non-measured sites at the other elevations, it seem quite risky (unreliable) to me to simply use a constant temperature lapse rate, especially since these are known not to hold at times scales that are <1 year; certainly not at a 30 min time scale. These uncertainties, and the apparent assumption of no prediction errors of values generated by the model made it very difficult for me to know the reliability of the values presented in the figures, and thus the relationships shown with fitted curves.

Overall, I think the underlying basis for the paper, although not clearly or compellingly argued in the introduction, has merit. So the potential for a meaningful scientific contribution is there. However, given the questions and uncertainties I have described above and below, I would withhold final assessment of the ms. until these issues are adequately addresses. I would not be able to effectively interpret the Results and Discussion until these conceptual (Introduction) and methodological questions are clarified. The ms. in its present state still needs some work.

Specific comments: Introduction: 1. In this section, I suggest citing of literature only if it contributes directly to building the line of argumentation that propels the justification toward the objectives. For example, in line 53, extend the sentence after "(Alice et al. 2011)" by adding something like "because it tells us …... [about which the ecosys-

tem WUE community cares]". Also, avoid sentences that start with "Bert et al. (1997) found …" 2. Line 57-58: Why not make this the central focus of the paper? 3. Line 63: Unclear: "has a positive effect on …". Is a positive effect increasing the negative $\partial 13C$ value to be a smaller negative value? Change to "Increases delta 13C" or whatever direction you mean. 4. Throughout the ms., use "elevation" rather than "altitude". Altitude refers to position above Earth's surface in the air, such as when flying in an airplane. Elevation refers to height above sea level. 5. Lines 68-69: Why bring up plant functional types (PFTs) when the rest of the paper, and indeed the study sites, have nothing to do with PFTs? This was confusing and led to belief that PFTs would be a topic in the paper. 6. Line 73-74: This is a lonely sentence that does not compel your line of argumentation forward. Change to "Evapotranspiration can account for …" 7. Lines 80-82: Am again confused by reference to "different forest types", when your paper focuses on stands of Abies fabri. This statement apparently also justifies the study, whereas I thought the main reason for conducting the study was quantify how elevational shifts in tree WUE/forest WUE influenced the ability of trees to survive environmental changes (lines 57-58). 8. Lines 89-98: Please connect these individual statements of fact into a logical argument. 9. Line 96: What is meant by "water resources"? Do you mean "water resource use"? 10. Line 98: Insert "the" after "obvious". What questions are being referred to with "these questions"? No questions have been articulated. 11. Line 101: Your line of argumentation should enable you to write: "Thus [or: "consequently"], the objectives of our study were to: (1) …; (2) …; (3) …: and (4) …". Better to use "The objectives" than "The aim", I believe. 12. Lines 102-103: What does "… using a different definition" mean? 13. Lines 103-104: Please make a stronger case for why having this knowledge is essential. Clearly state what big problem your study was designed to solve/address and why this is important. 14. Lines 109-110: Perhaps another word should be used for "summit", maybe "highest points in the Hengduan Mountains". Summit indicates "the top" so there would be no elevational gradient present. 15. Lines 111-115: Why is only one elevation (3000 m) described here? It seems like such conditions should be described for all 10 sites. Did

you measure the air temperature lapse rate (i.e., record air T at each 100 m where you collected tree foliage)? Line 113, round 79.7% to "~80%". Is the 0.6°C/100 m of elevation change the annual lapse rate? This certainly varies at different times of the year and day. What sort of precipitation lapse rate was present along the elevational gradient used in the study? A table containing all of this vital information for each site would be very useful. 16. Line 116: Mentioning this large elevational range and diverse vegetation confused me, when just few lines below, I read the that actual range used in the study was 2800-3700 m and only one species was considered. I would delete the 1100-7556 m information. 17. Lines 125-126: Not knowing the AVIM2, I do not know how and how accurately it predicts/calculates GPP, NPP and ET, but this information would be essential to present to to allow the reader to assess the accuracy of the simulated values for the 10 sites. 18. Lines 131-140: Where any locally measured values for any of these variables at the sites used to verify model accuracy? 19. Lines 139-141: Because the entire paper relies upon knowing the accuracy of this/these models, more detail on accuracy must be provided in this paper (more information than provided in lines 273-275). 20. Line 147: The Farquhar et al. (1980) I believe is a leaf biochemical model. GPP is a land-area-based measure of total canopy gross photosynthesis. I recognize that it is often used for ecosystem-level/canopy calculations, but its accuracy for this purpose is questionable (e.g., canopies experience different PFD levels depending on depth within the canopy). 21. Lines 125-191: All of the variables estimated in this section have errors associated with them, however, I saw no mention of how these compounding errors (uncertainties) were dealt with when deriving the points in the graphs in each of the figures. 22. Line 158: Insert "plant" after "total". Line 159: What allocation rules were followed? 23. Lines 170-191: Were any local empirical data used to parameterize any of these variables? 24. Lines 193197: How often during the growing season (or from May to October 2012) was foliage collected? Were samples from each collection pooledâĂŤby tree, by site? 25. Lines 195-197: This section is not clear to me. How many trees were selected for foliage sampling at each site within the 50 x 100 m areaâĂŤ4-5 or 20-30? For what purpose were the 20-

30 trees selected. From where on the trees was foliage collected (height, foliage age)? 26. Lines 210-211: Does this apply to conifers; to Abies? 27. Line 217: Do you mean "WUE of the Abies canopy"? 28. Line 222: Over what period? The growing season? Daytime only? 29. Lines 224-243: Because these EC data are the basis for so many calculations (e.g., at nine additional sites!), it is essential to plot all measured (valid) NEE and ET values for the 3000 m site for the entire period of record. These plots will illustrate when missing values occurred (35% of the time) and how reasonable missing data points were gap-filled. Was this just for the growing season, or year round? The other very large concern I have with the EC data is that the EC tower was likely located on a mountain slope where there was a high probability that the NEE and ET values were influenced by advective airflow common to mountain sides. This calls into question how the authors accounted for advective flow or even measured it 30. Line 242: "The closure of the energy balance was acceptable." is insufficient information. On what data were closure calculations based (e.g., average of 30 min data during a 24 h period); which season of the year? It seems that a slope of 0.71 suggest that 29% of the energy was unaccounted for, which would not be so acceptable to me. 31. Line 244: Change to "Calculation of WUE". Then in the text describe the differences between the first set of equations (14, 15) and the second set of equations (16, 17) 32. Lines 260-261: Not clear what "the difference" is between here; 14-16 or 15-17? Please clarify. How was "Measured WUE" (see Fig. 1a) actually measured, when GPP had to have been calculated from the relationship calculated between empirical measurements of nighttime R-eco and air T derived from eddy covariance (EC) data at the site at 3000 m. But at all other sites, it seems that the model would be needed to calculate GPP. So, I don't understand why, in Fig. 1a, the y-axis states "Measured", when this could only be true for the site at 3000 m. Perhaps I'm missing something here, but these terms are not clear to me. Again, in the current text, it is very difficult to know what was truly measured, what was calculated using measurements, what was modeled, and how measured and modeled data were used to estimate values plotted in the figures. 33. Line 265: Describes three stations/sites. Then in line 267, reference

is made to four sites. This needs to be clarified. Line 267-268: Surely these values varied in time. Do you mean that there were no differences among sites? 34. Lines 273-274: It would be very helpful to create a table that lists each of the variables and whether they were measured or modeled. Line 277: I'm not sure how one can say that measured and modeled values were "generally in agreement" when some of the measured values relied upon model output (e.g., GPP, ET). 35. Lines 302-304: Need to justify in the Methods section why WUE values were calculated at the monthly scale, rather than at the 30 min (daytime) or diel (24 h) time scale. This sentence should be moved to the Methods section. 36. Lines 304-308: It would be helpful in the interpretation of results to show data at higher frequency than annual and monthly (Fig. 4) 37. Lines 315-316: This is a statement for the Methods section. So if I understand this correctly, NEE (GPP calculated) and ET were measured at one site only (3000 m) during the May-October 2009 growing season, and this is represented by one point ($\pm$SE) in each of Fig. 1a and Fig. 1b. It would be helpful to label these points with their respective elevations. 38. Lines 318-319: This sentence is confusion. Which numbers are GPP and which NPP. There are four numbers and four years, but only half the numbers reported if there are four GPP and four NPP values. What are the uncertainties around these numbers: e.g., 5.8$\pm$0.1 g C m-2 d-1 or 5.8$\pm$4.5 g C m-2 d-1. Knowing this allows assessment of accuracy. 39. Line 324: 21134.7 kg C ha-1 a-1 (Really? The accuracy is as fine as 0.7 kg C ha-1 a-1?). Was this the average for the entire year—including from November through April; was EC tower at 3000 m deployed all year? 40. Line 663: Fig. 1: Legend says "annual water use efficiency" but measurements only from May through October. How were the values for the six month missing cold period calculated? 41. Line 670: Fig. 2: Shows 10 days during the growing season showing simulated and measured NEE. What was the agreement or disagreement in 30 min values, daytime values, nighttime values, and 24-h values (e.g., evaluate using scatter plots and simple linear regression). Please quantify "agreement". If I understand correctly, this 10-day comparison justifies modeling of NEE and GPP for all remaining days in the four-year period for the 3000 m site, as well as for the other nine sites?? 42.

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Line 687: Fig. 3: Please follow the same protocol as described in 41. This comparison is only two days. 43. Line 708: Fig. 4: I'm not sure why 1-month time resolution was chosen. These factors significantly impact GPP and ET at much shorter time scales (esp. diel), but maybe sufficient information can be extracted at the monthly scale. 44. Line 717: Fig. 5: For what elevation do these data apply? Was there no measure of uncertainty calculated for each point??? 45. Line 747: Fig. 7: What do the error bars here represent? Please specifiy? Why error bars presented here by not in Fig. 5? 46. Line 763: Fig. 8: Are these annual values (totals)? In what year? Insert "simulated" before "evapotranspiration". 47. Line 779: Fig. 9: What do the error bars here represent? Please specifiy? 48. Line 789: Fig. 11: Over what period are these points averaged (monthly, annually)? What do the error bars here represent? Please specifiy? 49. Line 797: Fig. 12: I am not sure why these data are presented at all. There was no question/hypothesis/objective articulated in the Introduction that would demand presentation of these data—as interesting as they may be. Inclusion of such a figure raises suspicions that the study was built around a bit of a fishing expedition to see what fish (data) were interested (interesting). Nothing wrong with that, except that the paper needs to be logically constructed in order for the reader to understand what was done and for what reason.