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Biogeosciences Discussions

Interactive comment on "Surface energy exchanges above two grassland ecosystems on the Qinghai-Tibetan Plateau" *by* S. Liu et al.

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Reply to general comments

Thank you very much for reviewing our manuscript and providing valuable suggestions. In our manuscript, we focus on the comparison of radiation balance and energy partitioning between two ecosystems based on 4-5 years continuous measurements on the Qinghai-Tibetan Plateau. We suggest that annual precipitation and air temperature in May are the main factors controlling interannual variability of energy exchange at alpine shrub (AS) and alpine meadow (AM), respectively. Bowen ratio is a widely used parameter in explaining the energy partitioning, especially at interannual scale. The main objective of analysis of relationship between Bowen ratio and SWC, VPD, and net radiation is to discern the direct and indirect effects of atmospheric conditions

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Interactive Discussion

Discussion Paper

and soil moisture on surface energy partitioning. In addition, the manuscript will be proofread carefully in the final revised version.

Reply to specific comments

Q: Report longitude, latitude, and altitude for each site. (P9164 L11)

A: The longitude, latitude, and altitude for each site are reported in Table 1.

Q: Also consider energy balance. PM equation assumes energy balance is closed, thus energy imbalance can cause unrealistic surface conductance estimates. (P9166 L16)

A: Wilson et al (2002) suggested that the imbalance was prevalent in all vegetation types in FLUXNET. The energy balance ratio (EBR) ranged between 0.83 and 0.91 for grassland sites of ChinaFLUX including AM and AS (Yu et al., 2006), suggesting that the estimation of surface conductance is reasonable in our study. We agree with you that there are some errors because that energy imbalance can cause unrealistic surface conductance estimates, but the reason of energy imbalance and its effect on estimation of surface conductance need to be further studied.

Q: Define the uncertainty. It is applied throughout the manuscript. (P9167 L7)

A: "507$\pm$33mm and 418$\pm$130mm" mean "the mean value $\pm$ standard deviation".

Q: As authors reported, annual rainfall was lower for AS than AM. Thus I suspect the lower SWC at AS in not only due to soil water holding capacity but also due to smaller rainfall. (P9167 L8)

A: We suggest that lower soil water holding capacity is the main factor leading big difference in SWC due to the scattered stones in the surface soil profile at AS compared with AM although smaller rainfall is also one of factors resulting in lower SWC.

Q: It is unclear why the ratio of net longwave radiation to net shortwave radiation is used. Explain why this quantity is related with energy partitioning. (P9168 L11)

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A: We just use the quantity of the ratio of net long-wave radiation to net shortwave radiation to provide a better understanding of the difference in radiation balance between the two sites.

Q: The expression on the linear model ([albedo=-0.003*SWC+0.208$\pm$0.002]) is weird. Why $\pm$appears in the intercept? Also, the authors suggested that albedo was influenced by SWC and vegetation activity. Then the linear model must include both variables. The variance of albedo was explained only 50% when using SWC only. (P9168 L24)

A: The vegetation cover was very low due to the degradation resulted from overgrazing activities in the past decades at AS sites, therefore the variable of vegetation cover such as LAI was neglected in the linear model. The linear model was modified: albedo=-0.003*SWC+0.208

Q: This section focuses on the interannual variation of Bowen ratio. However, the authors used May ET in this sentence. How higher ET in May 2006 is related with annual scale bowen ratio? (P9169 L20-22)

A: The higher ET in May 2007 leads to higher total LE, which resulting in lower Bowen ratio at annual scale.

Q: I do not follow this logic. The large variation of Bowen ratio and precipitation does not necessarily indicate annual Bowen ratio is controlled by precipitation. (P9169 L23-24)

A: We suggest that the variation of available water resulting from precipitation is the main factor controlling the energy partitioning at annual scale.

Q: Higher sensible heat flux does not necessarily indicate the increase of air temperature. There are a range of feedback mechanisms (e.g. PBL feedback). Remove this sentence. (P9170 L15)

A: We agree to remove this sentence. The increase in Bowen ratio indicates that a higher fraction of available energy (Rn−G) is partitioned into H.

Q: This paragraph is mixed with different arguments that are not related each other. The authors argued that grazing effects must be considered (for what?). How grazing effects modulate energy partitioning? Table 1 shows that there is grazing in the only winter. However, grass is not active in this season. Then why grazing effects must be considered? (P9170 L15-26)

A: Overgrazing can decrease the LAI and SWC in surface soil layers, which affect the energy partitioning. Although there is grazing in the winter at two sites now, actually it has degraded due to overgrazing in the past decade at AS which should be considered as historical disturbance in the research.

Q: I do not think gs is the indicator of vegetation growth status. (P9171 L14)

A: We suggest that NDVI is the indicator of vegetation growth status, not gs in the manuscript.

Q: The authors did not explain Fig 7 adequately. Given NDVI (or gs), why Bowen ratio at the AM site is higher than the AS site? (P9171 L15-19)

A: In Fig 7, given NDVI, Bowen ratio at AM is higher than that at AS, which is caused by the difference in phenology of the vegetation. For example, the NDVI value in spring or autumn at AM was approximately equal to that in summer at AS.

Q: The Fig 8 shows that SWC controlled Bowen ratio where SWC only ranged 5-10% at the AS site. Thus I do not think SWC was the main factor that regulated Bowen ratio as the authors argued. What factors explain the variation of Bowen ratio when SWC is larger than 10% at the AS site? (P9171 L27-P9172 L12)

A: In our manuscript, it is obvious that SWC is an important factor affecting the energy partitioning at AS. In addition, NDVI and gs explain the variation of Bowen ratio when SWC is not limiting factor.

Q: Such an expression "slightly increased" does not make sense. If the authors want to show the positive slope, then report p-value on the linear regression. (P9172 L24)

A: The linear models are At AS: β=0.002Rn+1.267, n=264, adjusted R2 = 0.079, F =22.6, P<0.0001 (drought condition); β=0.00008Rn+0.269, n=1774, adjusted R2 = 0.014, F=24.6, P<0.0001 (Non-drought condition). At AM: β=0.0004Rn+0.807, n=1010, adjusted R2 = 0.016, F=16.08, P<0.001. Q: Soil heat flux must be considered here. Fig 5 shows that the proportion of soil heat flux in the surface energy budget is considerable. (P9173 L1-4)

A: We agree that soil heat flux is an important component of surface energy budget, but the Bowen ratio is the key point in our discussion here.

Q: It is really unclear whether there is stronger positive relation between Bowen ratio and Rnet under drought condition. Fig 9a shows the scatter plot at drought condition looks "clouds". Develop linear regression for both drought and non-drought condition, and then test whether their slopes are significantly different. (P9173 L4)

A: The slope of linear regression under drought conditions is significantly higher than that of non-drought conditions at AS. The linear models see the answer to the question of P9172 L24.

Q: Did Gu et al (2006) conduct field measurements at the current study sites? (P9173 L5-8)

A: The site was added in the manuscript. Gu et al. (2006) suggested that the difference in the Bowen ratio between drought and non-drought conditions increased with Rn and VPD because more available energy was partitioned into LE with the increase of Rn, and this trend was intensified at higher levels of VPD at the Missouri Ozark AmeriFlux site.

Q: I recommend moving this paragraph to the next section because the current section focuses on Rnet, not VPD. (P9173 L5-12)

A: The heading of this section is “effect of net radiation”, therefore we suggest the position of this paragraph is feasible because VPD has effect on the relationship between Rnet and Bowen ratio.

Q: Test the significance of slopes in the Fig 10 a and b. If VPD and Bowen ratio showed significantly positive relation at drought condition, explain the reason. (P9173 L16-17)

A: Under drought condition, β increase significantly with the increase of VPD. It is because VPD increases with the increase of air temperature leading large sensible flux, while latent flux is limited by SWC. The linear models at are β=0.873VPD+1.037, n=263, adjusted R2 = 0.209, F =69.2, P<0.0001 (drought condition); β= –0.079 VPD +0.345, n=1774, adjusted R2 = 0.028, F=50.8, P<0.0001 (Non-drought condition).

Q: Use statistics. In Fig 11 a and b, test whether the slope is significantly negative. The authors argued that the slope was “sharper” at (b). Prove this using statistics. In Fig 11, narrow the x-limit from 0-3 to 0-2. (P9173 L20-21)

A: Fig 11 was modified in the attach file. The linear models at are β= –0.451VPD+1.365, n=943, adjusted R2 = 0.081, F =82.9, P<0.001 (Rn>500 Wm-2); β= –0.16 VPD +0.861, n=690, adjusted R2 = 0.008, F=5.71, P<0.05 (Rn<250 Wm-2).

Q: Define the degree of “medium”. (P9173 L20-21)

A: The medium here is compared with Fig 11a and 11b.

Q: Fig 10 and 11 are not comparable because they used different criteria to separate their data. The comparison between 10a and 11 does not make sense. (P9173 L23-24)

A: Water is not limiting factor when Rnet is low, therefore we can make comparison between Fig 10a and 11 because Fig 10a is under non-drought condition at AS, which is similar to Fig 11 at AM.

Q: “nonlinear”. Fit the non-linear curve and report p-value. (P9173 L24)

A: β= 1.302 eˆ(–0.468 VPD), n=943, adjusted R2 = 0.10, F =99, P<0.0001 (Rn>500

Wm-2);

Q: Provide references on “Studies”. (P9173 L25)

A: The studies include Gu’s study published in J. Geophys. Res. in 2006.

Q: All discussion can stand after testing the significance of the slope at Fig 10 and 11 as I pointed above. (P9174 L1-9)

A: Actually, our discussions stand after the testing the significance of the slope.

Q: Scatterplot between gs (or ga) and decoupling factor must experience autocorrelation because decoupling factor is the function of gs and ga. All discussion in L18-26 does not make sense. (P9174 L18)

A: We agree with you that there is a self-correlation between ga, gs and omega. The ga and gs are influenced by wind regime and surface roughness, which will affect omega as shown in Eqn. (2). In this study, our focus was on the differences in the relationship between ga, gs and omega for the two contrasting ecosystems, and the influence of wind regime and surface properties on omega at these two systems.

Q: Add annual evaporation (mm yr-1), sensible heat flux (GJ m-2 yr-1), latent heat flux, ground heat flux and net radiation. The annual budget of water and energy will be greatly useful to other scientists. (Table 2)

A: It is a good suggestion though we have not decided to add the data such as annual evaporation, and these can or will be found in other published papers and some manuscripts presently.

Technical corrections: P9168 L20: Remove “same latitude”. Otherwise, one might interpret albedo is related with latitude. P9168 L7: generatively => generally P9169 L6: Gwas => G was A: Thank you very much for providing valuable corrections and the manuscript will be modified.

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Interactive Comment

Please also note the Supplement to this comment.

Interactive comment on Biogeosciences Discuss., 6, 9161, 2009.

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