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***Interactive comment on* “Impact of cloudiness on net ecosystem exchange of carbon dioxide in different types of forest ecosystems in China” by M. Zhang et al.**

**M. Zhang et al.**

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Response to review comments of Referee 2 on manuscript

‘Impact of cloudiness on net ecosystem exchange of carbon dioxide of different types of forest ecosystems in China’ By Zhang et al.

We greatly appreciate your comments and suggestion on the manuscript. These comments are very helpful to improve our work. According to your comments, we had tried our best to revise and improve this manuscript. In the revised manuscript, the revision includes the following aspects:

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Comments about abstract:

Answer:

We already modified the abstract in terms of refining main results and discussion

Comment 1: 1st sentence: (1) Clouds affect not only ‘carbon uptake’ but also ‘carbon release’. (2) The term in bold and italics in “. . . the solar radiation on the ground. . .” was used throughout the manuscript. However, this is not an accurate description because the solar radiation on the ground does not affect canopy photosynthesis very much. Perhaps, the correct way to describe is “. . .the (quantity and quality of) solar radiation intercepted by forest canopy. . .”

Answer: We’ve modified the sentence as “Clouds can significantly affect carbon exchange process between forest ecosystems and the atmosphere by influencing the quantity and quality of solar radiation received on ecosystem surface, and other environmental factors” (Page 1, Line 22-24).

Comment 2: L.10-14: (1) Please, consider rewriting the current sentence (in passive form) into active form. (2) “. . .on cloudy skies. . .” → “. . .under cloudy skies (or conditions). . .”

Answer: We’ve modified the sentence according to referee’s comments. The modified sentence is “Compared with clear skies, the enhancement of light-saturated maximum photosynthetic rate ( $P_{ec,max}$ ) at CBS during mid-growing season (from June to August) was respectively by 34

Comment 3 L.20: Delete “rather” (because ‘rather than’ means ‘instead of’) L.24-25: Why is the phenomenon important only for temperate forests? A brief explanation would make the ending strong.

Answer: We modified the sentence from L.20 to L25 according to referee’s advices. The modified sentence is “The response of NEE to the changes in cloudiness in different types of forest ecosystem is important to evaluate regional carbon budget under

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climate change conditions.” (Page 2, Line 17-19).

Comments about Introduction:

Comment 1: P.8217, L.1-3: It would be better to cite some original papers.

Answer: We’ve modified the sentence. The two papers (Law et al., 2002; Baldocchi, 2008) cited in this sentence focused on the control of environmental factors on carbon exchange between different ecosystems and the atmosphere, which concluded that solar radiation, temperature and moisture were major environmental factors that control carbon dioxide exchange between terrestrial ecosystems and the atmosphere. Thus, we think we can cite the two papers in this sentence (Page 2, Line 22-24).

Comment 2: P.8217, L.6: If the authors want to emphasize the term “on the ground”, then consider adding “within-canopy” in front of “temperature”.

Answer: The papers which we cited in this sentence shown that not only the changes in cloudiness but also the changes in aerosol in the atmosphere can influence solar radiation received on Earth’s surface, balance of direct and diffuse components of the solar radiation received on Earth’s surface and regional climate (Gu et al., 2003; Niyogi et al., 2004; Min, 2005). We wrote the sentence in order to indicate that the changes in cloudiness and aerosol in the atmosphere can affect local environmental factors. We modified this sentence as “Changes in cloudiness and aerosol content in the atmosphere can directly influence solar radiation, direct and diffuse radiation received on the ground (Gu et al., 2003; Niyogi et al., 2004; Min, 2005), and correspondingly other environmental variables (temperature, vapor pressure deficit, etc) can be changed (Gu et al., 1999; Urban et al, 2007). ” (Page 2, Line 24-29).

Comment 3: P.8217, L.15: Need a reference for changes in aerosol content by air pollution.

Answer: We added two references (Niyogi et al., 2007; Farquhar and Roderick, 2008) in this sentence.

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Comment 4: P.8218, L.15, 17, 19: “on the ground”→“by forest canopy”

Answer: We already modified the words according to referee’s advice. We changed “solar radiation received on the ground” to “Solar radiation received by ecosystem”. (Page 4, Line 6, 8, 10)

Comment 5: P.8218, L.23-29: The authors’ deduction may be misleading. In my opinion, it was the environmental conditions that were different and not the ecosystems’ responses. In other words, the response mechanism was consistent between the two forests but the different environmental conditions resulted in different results.

Answer: The different types of forest ecosystem grow in different climate zone. The vegetation adapt to the climate, which they lived in. Therefore, the responses of carbon exchange to environmental factors are not exactly the same. In order that we can indicate our viewpoint clearly, we modified the sentence as “Climate characteristics were different, and environmental controls on carbon exchange were different in the two types of forest ecosystem at CBS and DHS. Thus, changes in NEE with cloudiness may be different in the two forest ecosystems.” (Page 4, Line 15-17).

Comment 6: P.8219, L18-20: The study objective sounds okay. Without employing the modeling approach, however, it would be very difficult to separate the effect of cloudiness from those of other environmental factors that are concurrently changing. What do we expect to learn from the findings such as “different effects under different conditions in different forests at different locations”? L.23: “. . . to carbon budget . . .”→ “. . . on carbon budget . . .”

Answer: We modified the whole paragraph and added the hypothesis (Page 5, Line 10-15) in order that we can indicate our hypothesis clearly, according to referee’s advice.

Comments about Methods:

Comment 1: P.8221, L.14-16: “Based on the clear sky conditions, . . . analyzed . . . PAR under clear and cloudy sky, . . .” Probably the authors meant, “Based on the clearness

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index,..." Otherwise, what is the meaning of this sentence?

Answer: We modified the sentence as "We analyzed the responses of NEE to PAR under clear and cloudy skies, and examined the relationship between kt and NEE." (Page 7, Line 1-2).

Comment 2: P.8221, L.15: PAR has been defined already. No need to spell it out again.

Answer: We already deleted the repeat spell.

Comment 3: P.8221, L.23: "data was ..." → "data were..." L.24: "... the storage 25 below EC height ..." Delete "25".

Answer: We already modified these mistakes according to referee's advices (Page 7, Line 10, Line 11).

Comment 4: P.8222, L.19-22: Please, rewrite this part in a simple sentence with no additional explanation. Otherwise, divide this long sentence into two (and be careful with punctuation, also).

Answer: We already simplified the sentence as "For a given solar elevation angle, the value of kt closes to zero indicates the increase in cloud thickness, and the value of kt closes to 1 indicates the sky is clearer (Gu et al., 1999)." (Page 8, Line 6-8).

Comment 5: P.8222, L.20, 21: "... closing to ..." → "...close to ..."

Answer: We already corrected the mistake (Page 8, Line 7, Line 8).

Comment 6: P.8223, L.1: New paragraph usually would not start with "Because." Instead, consider "The rainy season in CBS and DHS was from June to August, and thus days with no clouds were rare during this period."

Answer: We already modified the sentences as "The rainy season in CBS and DHS was from June to August, and thus days with no clouds for the whole daytime were rare during this period." (Page 8, Line 10-11).

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Comment 7: P8223, L.8: “showed” → “shows”

Answer: We already changed “showed” to “shows”.

Comment 8: P8223, L.15-17: Changes in quality and quantity of solar radiation with changes in elevation angle is a known fact. Hence, use the ‘simple present tense’ throughout the sentence.

Answer: We already simplified the sentence as “For a given solar elevation angle, diffuse components of the solar radiation received by ecosystem could increase with cloudiness (Gu et al., 2002; Urban et al., 2007).”(Page 9, Line 3-4).

Comment 9: P.8224, L.11: No need to redefine PAR.

Answer: We already deleted the redefine PAR.

Comment 10: P. 8225, L.12-13: This sentence is not needed.

Answer: We deleted this sentence.

Comment 11: P. 8225, L.17:“Statistical . . .”→ “Statistically . . .”

Answer: We already corrected the mistake.

Comments about Results:

Comment 1: P. 8225, L.20-21: Again, the paragraph does not start with “Since,” so please rewrite it. This statement is only partially correct because the authors showed the results from other years in many figures. On the other hand, if the statement is indeed true, then this is an important result. In other words, the consistency and repeatability of the results for four years in two ecosystems should be highlighted.

Answer: As referee’s comments, the sentences (P. 8225, L. 20-21) can not generalized all results indeed in this study. Therefore, we put the paragraph (P. 8225, L. 20-21) in proper section of the paper. We showed the results from other years in many figures, such as Fig. 4, because the responses of NEE to PAR at CBS and DHS were differ-

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ent under cloudy skies and clear skies, and the difference varied from 2003 to 2006. However, Changes tendency of NEE with the clearness index were similar for the four years in the two forest ecosystems, thus we put the paragraph (P. 8225, L. 20-21) in section “3.3” paragraph 1 (Page 12, Line 10-11).

Comment 2: P.8226, L.5-10: The description in these three sentences are very subjective and not convincing. The similarity in the patterns of Ta and P at DHS is as good as that at CBS. By the way, what is the point of saying about the agreement between the patterns of Ta and P?

Answer: The seasonal pattern of Ta was in good agreement with P at CBS due to the in-phase of Ta and P, which attained highest in July at CBS (Figs. 2b and 2c). Ta and P were higher in DHS from June to August. However, when Ta reached the maximum in July, precipitation was relatively lower (Figs. 2e and 2f), which was different with that at CBS. We already modified the description about the seasonal variations of Ta and P (Page 11, Line 4-9).

Comment 3: P.8226, L.20: The sentence should be deleted. L.21: “. . . PAR of clear . . .”→ “. . .PAR under clear . . .” L.22-24: Either delete this sentence or move it to “Discussion.”

Answer: We already deleted the sentence (P.8226, L.20). We changed “. . . PAR of clear . . .” to “. . .PAR under clear . . .” (P.8226, L.21). We already deleted the sentence (P.8226, L.22-24).

Comment 4: P.8226, L.25-27: (1) Response of NEE to cloudiness can be different depending on the individual response of GPP and RE to cloudiness. Unless the authors examine these components, the analysis with NEE is less meaningful. (2) The authors stressed that the difference was not consistent between the two forests. I am afraid that the opposite is true. Such different responses in fact show the very consistency of the two ecosystems in terms of their responses to environmental changes including cloudiness.

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Answer: Not only responses of NEE to PAR under cloudy skies and clear skies, but also response of NEE to kt can indicate straightly the different effects of changes in cloudiness on NEE in the two forest ecosystems. In discussion, we analyzed responses of GEP and Re to environmental factors in order to explain the differences in response of NEE to cloudiness at CBS and DHS. We already modified the sentences (Page 11, Line 21-22) in order that we can describe the results correctly according to referee's advices.

Comment 5: P.8226, L.27: "... than that clear ..."→"... than that under clear ..."

Answer: We already corrected the mistake.

Comment 6: P.8227, L.2: No need re-define Pec,max. Delete "the light saturated maximum photosynthetic rate"

Answer: We already deleted "the light saturated maximum photosynthetic rate".

Comment 7: P.8227, L.2-4: Earlier, the authors pointed out that only 2005 results were presented because the results from 2003 to 2006 were similar. The results shown here, however, demonstrate relatively large variations from year to year. L.5-9: This also demonstrates differences in the results from different years. L.8-9: The authors' statement mentioned here (i.e., clear conditions were more favorable to increase the net carbon uptake at DHS) is not acceptable. Based on the results presented in Table 2, (1) the results from individual years are inconsistent to support the authors' argument and (2) the results for and Pec,max are inconsistent to support the authors' argument. For example, except for 2003, (Pec,max) decreased (increased) from cloudy to clear conditions in 2004, 2005 and 2006. The reverse was the case in 2003. (In fact, such an inconsistency was also noted at CBS between and Pec,max and between different years.)

Answer: The description in the paragraph (P. 8225, L. 20-21) can not generalized indeed the section "3.2", we already put that paragraph (P. 8225, L. 20-21) in proper of

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the paper (Page 12, Line 10-11). We already modified this whole paragraph (Page 11, Line 21-30, Page 12, Line 1-4) in order to describe correctly the results.

Comment 8: P.8227, L.20: “It meant . . .” → “It means . . .”

Answer: We already corrected this mistake.

Comment 9: P.8227, L.21-23: Either delete “Although” or complete the sentence.

Answer: We deleted the “Although” in this sentence.

Comment 10: L.23-24: The statement is not correct. In Fig. 5, the NEE-kt relationships were not much different for different  $\beta$  intervals at DHS. L.24-28: Again, the statement is partial and biased. (Furthermore, the description is backward. “NEE increased” actually means NEE became more negative. Either say “the magnitude of NEE” or reverse the description.) The authors pointed that only at high  $\beta$ , the magnitude of NEE decreased at DHS. In Fig. 5, however, such a decrease was observed in all other intervals of  $\beta$  at DHS. L.29: The authors’ conclusion is not acceptable. The clearer sky conditions restrained net carbon uptake at DHS, also.

Answer: We already modified these sentences according referee’s suggestion. For different interval of solar elevation angle, the common characteristic of changes in NEE with kt was that NEE tended to maximum when the value of kt varied between 0.4 and 0.6 at DHS. However, when the value of kt exceeded 0.6, the reduction in NEE was less at DHS than at CBS. Therefore, we can conclude that the clear sky condition more restrained net carbon uptake at CBS than at DHS. The modified contents are in section “3.3” (Page. 12, Line. 18-24).

Comments about discussion:

Answer: We modified discussion according to modified results and referee’s comments. We summarized the characteristics of changes in NEE with cloudiness in the two forest ecosystems and compared the results with other researches in section “4.1”. We analyzed the changes in environmental factors with cloudiness to discuss the en-

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vironmental conditions under cloudy skies are beneficial to enhance the NEE in the two forest ecosystems in section “4.2”. We analyzed the changes in GEP and Re with environmental factors in the two forest ecosystems to discuss why the changes in NEE under clear skies were different in the two forest ecosystems in section “4.3”.

Comment 1: P.8228. L.14-15: As already pointed out, the statement is not true and thus should be deleted. Although the sensitivity was relatively lower, the general relationship between NEE and  $kt$  at DHS was similar to that at CBS. L.16-20: According to the above-mentioned points, this paragraph regarding the different responses of NEE is no longer needed. Besides, the paragraph is grammatically and logically erroneous, thus equivocal. This paragraph may be divided into two sentences and be rewritten as: “(1) Inconsistent responses of environmental factors to cloudiness resulted in different responses of NEE to cloudiness between the two ecosystems. (2) The control of environmental factors on carbon exchange processes are not different between the two ecosystems.” Then, these two statements may be summarized as, “The carbon exchange mechanisms in two ecosystems are the same but their environmental factors were different.” Is this the point of the authors’? In view of the above points, the subtitle of this section 4.1 needs modification.

Answer: We already modified whole section “4.1” (Page. 12-13, Line.1-16). We summarized the results which were that NEE of the two forest ecosystems at CBS and DHS reached maximum under cloudy skies, when the value of  $kt$  was between 0.4 and 0.6, however, when the value of  $kt$  exceeded 0.6, NEE of temperate forest at CBS more reduced with increasing  $kt$  than that at DHS, and we compared the results with other researches. Therefore, we deleted the sentences (P.8228, L.14-15) and the paragraph (P.8228, L.16-20).

Comment 2: P.8229, L.6: Delete the comma, “,”. L.3-10: This paragraph demonstrates the consistency in the responses of the two ecosystems. L.11: “. . . linearly with  $kt$  . . .” → “. . . linearly with decreasing  $kt$  . . .” L.12-15: The argument here is based on a weak and ambiguous analysis. The authors should clarify the details of the air temperature

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measurement used in Fig. 6 such as the measurement height. In Fig. 6 (and 7), explain why a different range of  $\beta$  was used for CBS and DHS for the analysis. Furthermore, a significance test is required for the difference between the  $r^2$  values from the two ecosystems to support the authors' argument. Figure caption should be corrected such as: Fig. 6. Changes of diffuse PAR (PAR<sub>diff</sub>) at (a) CBS, (b) DHS, and (c) air temperature ( $T_a$ ) with the clearness index ( $kt$ ) for selected intervals of solar elevation angles from June to August in 2005.

Answer: These comments focused on section “4.2”. We already modified the whole section (Page 13-14) according to referee's comments. We analyzed the changes in diffuse PAR,  $T_a$ , and VPD with  $kt$  in this section. We found that increase of diffuse PAR, decrease of VPD and  $T_a$  under cloudy skies were reasons that may cause photosynthesis increase and respiration decrease in the two forest ecosystem. As a result, NEE was enhanced in the two forest ecosystems under cloudy skies. We already modified the mistakes in P.8229, L.6 and in L.11. We added the details that shown the measurement height of air temperature in section “3.1” “ $T_a$ , near the height of EC system at the two site, 32m in CBS, 27m in DHS, see Table 1” (Page. 11, Line.2-3). The interval of change in solar elevation angles at the two sites are different due to CBS and DHS are located in different latitude, thus we chose the results of the higher interval of solar elevation angles of the two forest ecosystems to show. We added the detail to explain why a different range of  $\beta$  was used for CBS and DHS (Page. 14, Line. 13-16). We corrected the caption of Figure 6 “Fig. 6. Changes of diffuse PAR (PAR<sub>dif</sub>) at (a) CBS, (b) DHS, (c) air temperature ( $T_a$ ) and (d) vapor pressure deficit (VPD) with the clearness index ( $kt$ ) for selected intervals of solar elevation angles from June to August in 2005.”

Comment 3: L.18-22: This equivocal paragraph is contradictory to the authors' argument in the previous section. L. 24-27: Please, improve the sentence, which is grammatically wrong and has a typo. P.8230-8231: Most of these paragraphs are reiterations and thus should be reduced and combined with the Results section. L.15:

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“shade” → “shaded” L.20-21: The authors should highlight this point with more insightful analysis and discussion. For example, the LAI at CBS was higher than at DHS, which is further substantiated by 2.5 times higher biomass (i.e., much higher tree density) at CBS (Table 1). No wonder that more diffuse radiation was more beneficial at CBS due to denser canopy compared to DHS where more diffuse radiation was not appreciated much by its thinner canopy. Provide more detailed descriptions on clumping index, structure of the canopy, understory vegetation, for instance. L.22-26: The relationship between  $R_e$  and  $T_a$  should be analyzed based on Eq. (12) (not with a linear regression). The comparison should be based on a factor such as  $Q_{10}$ . P.8231, L.10-13: Again, this is a self-contradictory statement. L.13-16: It is not convincing and hard to justify.

Answer: These comments focused on section “4.3”. We already modified the whole sections (P. 14-16). We analyzed the changes in GEP with PAR, diffuse PAR and VPD, the changes in  $R_e$  with  $T_a$  in the two forest ecosystem in order to explain why the changes in NEE under clear skies were different in the two forest ecosystems. We found that increase of total PAR, decrease of diffuse PAR received by ecosystem, higher VPD under clear skies led to more decrease of GEP, and higher temperature under clear skies caused more increase of  $R_e$  for the temperate forests at CBS, comparing with DHS. As a result, the reduction of NEE was more at CBS than at DHS under clear skies. We already corrected the mistakes in words and grammar according to referee’s comments. We know it is not enough that we discussed the difference in responses of GEP to diffuse PAR in the two forest ecosystems only based on LAI. However, it is a pity that the clumping index was currently unavailable at the CBS and DHS sites. We accept your suggestion and will try to measure the clumping index of these sites in our future studies to promote the research about the effects of canopy architecture on photosynthesis in different parts of canopy. We already reanalyzed the relationship between  $T_a$  and  $R_e$  based on exponential function (Fig. 7d). Because soil respiration is major component of ecosystem respiration, we added some contents (Page 16, Line 10-15) about the effect of soil organic matter contents, temperature

sensitivity (Q10) of soil respiration on soil respiration. These contents can help us to explain why responses of ecosystem respiration to temperature were different in the two forest ecosystems.

Comments about conclusion:

Comment: L.21-27: These conclusions are conditional depending on the canopy structure and plant density. P.8232, L.4: Delete “certainly”. Also, “could enhance” → “enhanced” L.5-6: After all these measurements and analyses, this is an inadequate and weak ending.

Answer: We already rewrite the conclusion (Page.16, Line. 24-30, Page. 17, Line.1-6) based on modified results, discussion and referee’s comments.

Please also note the supplement to this comment:

<http://www.biogeosciences-discuss.net/6/C3944/2010/bgd-6-C3944-2010-supplement.pdf>

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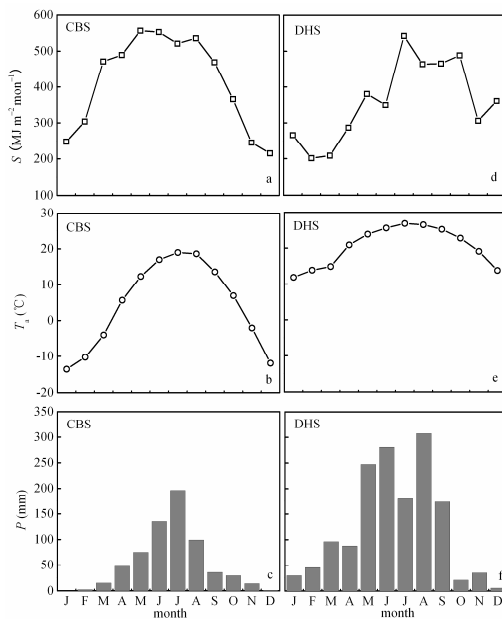


Fig. 2. The seasonal variation of global solar radiation ( $S$ ), air temperature ( $T_a$ ) and precipitation ( $P$ ) at CBS and DHS.

Fig. 1.

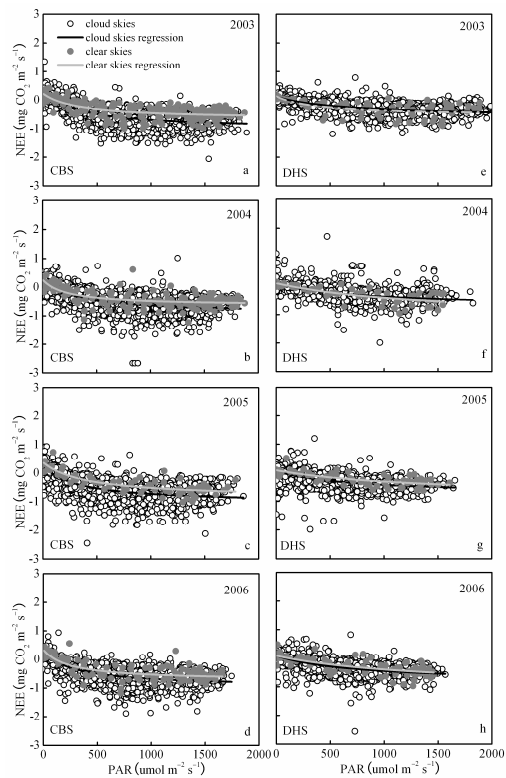


Fig. 4. Light response curves of the forests at (a–d) CBS and (e–h) DHS on clear skies and cloud skies from June to August in the years from 2003 to 2006.

Fig. 2.

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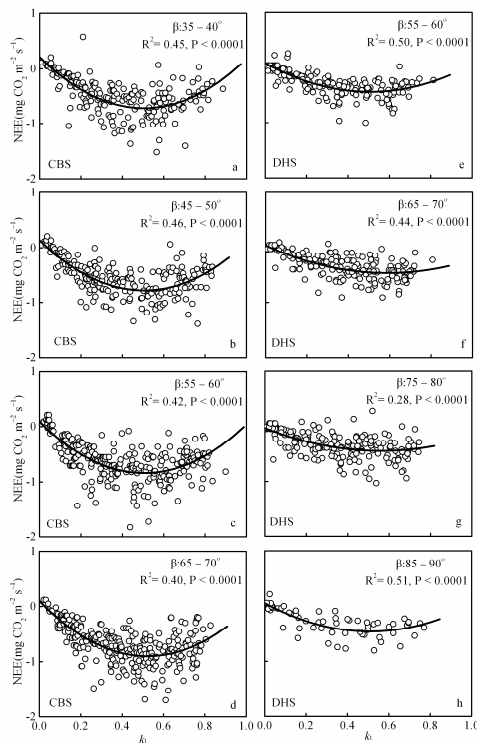


Fig. 5. Relationship between NEE and the clearness index ( $k_i$ ) at CBS and DHS for different intervals of solar elevation angles from June to August in 2005.

Fig. 3.



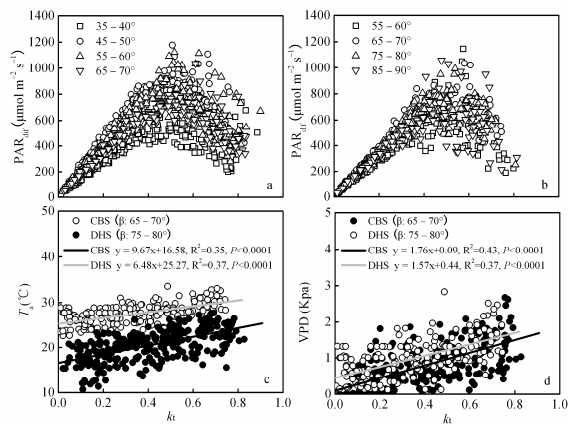


Fig. 6. Changes of diffuse PAR ( $\text{PAR}_{\text{dir}}$ ) at (a) CBS, (b) DHS, (c) air temperature ( $T_a$ ) and (d) vapor pressure deficit (VPD) with the clearness index ( $k_t$ ) for selected intervals of solar elevation angles from June to August in 2005.

Fig. 4.

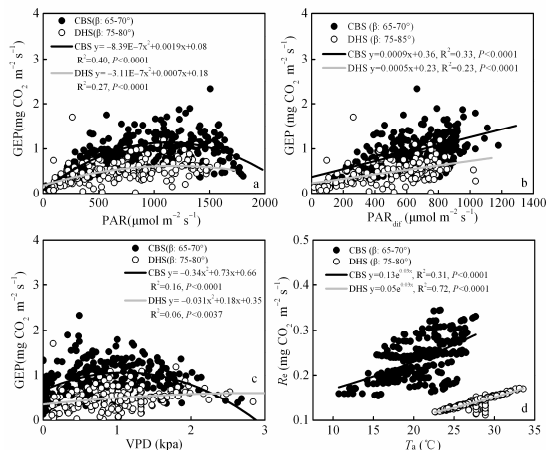


Fig. 7. Changes of GEP with (a) PAR, (b) diffuse PAR ( $PAR_{dir}$ ), (c) VPD and Changes of (d)  $R_e$  with air temperature ( $T_a$ ) for selected intervals of solar elevation angles at CBS and DHS from June to August in 2005.

Fig. 5.