Reply to Reviewer 2 Comments

Advanced interpretation of land surface carbon exchange in spatial and temporal aspects as well as in bio-geophysical processes is indispensable to improve the accuracy and reliability of climate change prediction. This study by Lee and colleagues focuses on carbon budget in catchment- and decade-scale which not only induce scientific interests but also give important insight in making climate change policies because both drivers of human activities on terrestrial carbon budget and impacts of climate change on human society are most significant in inhabitable catchments. Moreover, the temporal scale of decades is consistent to that of political targets against the climate change. Even with its ambitious objective to relate transpiration and carbon balance in the catchment scale, this paper has some fundamental issues and unclearness.

1. The authors estimated catchment evapotranspiration *ET* by subtracting river discharge *Q* from precipitation *P* first followed by partitioning *ET* into transpiration *T* and interception E_I , where *Q* is determined by a regression analysis to *P*. However this calculation sequence is wrong ordered. Interception by vegetation is actually the first process of precipitation partitioning occurs above ground before decomposition of *Q* and *T* in underground processes. Therefore, E_I should be subtracted from *P* to make net precipitation *P* vs. E_I prior, and consequently *Q* should be estimated by a regression to *P* vs. E_I. You may think this difference of sequence being trivial but you should be aware that a regression between *Q* and *P* already implies the dependence of E_I (as a constituent of *ET*) on precipitation amount or intensity that you predicted afterward.

Reply:

In most catchments, *P* and *Q* are derived from direct field measurements. On the other hand, E_I is estimated mostly by modeling efforts or up-scaling from field measurements with limited spatial coverage. The relationship between *P* and *Q* is primary and the use of '*P* minus E_I' instead of *P* will inevitably introduce uncertainties associated with the estimation of E_I. This is why the relationship between *P* and *Q* is commonly used to estimate *Q* for ungauged catchments or ungauged periods in hydrological communities (e.g., Boughton and Chiew, 2007). Moreover, it is commonly accepted in many studies that E_I depends on the amount and intensity of precipitation.

In our study, the estimation of E_I is independent from the determination of $ET(=P\text{-}Q)$ since E_I is calculated as a fraction of *P*. The only variables used to estimate E_I are monthly *P*, daily expected *P* and daily interception threshold. Therefore, the estimation of E_I can be performed either before or after the determination of *ET*.

Nevertheless, following the reviewer's suggestion, we derived *Q* using the relationship between Q and 'P minus E_I' in the Han River from 1966 to 1979 and compared the result with those originally presented in this report (based on P vs. Q relationship). The derived Q from two methods differed by 0 ~ 4 % with an average of 1.2±0.8 %. Due to the small difference between two practices and the reasons stated above, we followed the order originally suggested in this paper.

<Reference>

Boughton W. and Chiew F. (2007) Estimating runoff in ungauged catchments from rainfall, PET and the AWBM model. Environmental Modelling & Software, 22, 476-487.

2. Monthly precipitation interception was estimated by using Eq. (4) after Groen and Savenije (2006) which calculates the ratio of interception to gross precipitation employing two parameters D and β is well defined as "amount of rainfall on a rainy day (mm/d)" and was well determined from long term meteorological record by applying statistical analysis. In the other hand, both definition and determination method of D "the daily interception threshold (mm/d)" by "correlation between rainfall and throughfall+stemflow" are unclear and should be described in detail. Also observation method and results of interception reported by Kim et al. (2005) should be discussed because the article is not easily accessible. D seems to be rather a stochastic parameter than a deterministic one such as "canopy storage capacity" often used in physical canopy water balance models of precipitation interception. It is preferable to refer literatures discussing the parameters and accuracy of similar models if exist.

Reply:

The study of Kim et al. (2005) is on the field measurement of interception for selective vegetation types in Korea. They reported year long data of precipitation, throughfall and stemflow. The data were analyzed using precipitation (X-axis) vs. throughfall and precipitation(X-axis) vs. stemflow crossplots. For each plot, a best-fit line was determined by regression and its x-intercept was interpreted as the threshold of precipitation below which no throughfall or stemflow was generated (Bryant et al., 2005). The amount of precipitation thus determined was considered as "daily interception threshold" expressed as mm/d. Following the reviewer's comment, we added above explanation in the revised manuscript (from page 9 line 4 to line 11).

The "daily interception threshold" needs to be derived as a measurable quantity to be incorporated into interception estimates and may best be translated into 'the canopy storage capacity' (Croackford and Richardson, 2000). To avoid confusion, we have decided not to use the term 'canopy storage capacity' in the revised manuscript and added an explanation on how to derive this quantity from the field measurement (from page 9 line 4 to line 11, from page 20 line 9 to line 11).

<References>

Bryant M.L., Bhat S. and Jacobs J.M. (2005) Measurements and modeling of throughfall variability for five forest communities in the southeastern US. J. Hydrol., 312, 95-108.

Crockford R.H. and Richardson D.P. (2000) Partitioning of rainfall into throughfall, stemflow and interception: effects of forest type, ground cover and climate. Hydrol. Processes, 14, 2903-2920.

Kim, K., Jun, J., Yoo, J., and Jeong, Y. (2005) Throughfall, stemflow and interception loss of the natural old-growth deciduous and planted young coniferous in Gwangneung and the rehabilitated young mixed forest in Yangju, Gyeonggido(I) – with a special reference on the results of measurement, J. Korean For. Res., 94(6), 488-495 (in Korean with English abstract).

3. Estimated annual water balance of Q, ET, E_I and T in Han River basin was shown in Table 1 over a long period between 1966 and 2007 and it, as already mentioned above, fundamentally depended on a regression between Q and ET defined by observations in relatively short period between 1966 and 1979 with missing 3 years. A simple question is if the catchment characteristics affecting precipitation partitioning have not changed over the full evaluation period. Present land use of Han River basin was briefly described but its temporal change possibly induced by urban and cropland development during the study period was not shown in the paper. Deforestation and reforestation were active after big wars in last Century commonly in Asian countries and probably also in Korea. These changes in land use, forest cover and/or biomass must modify interception, drainage to river and transpiration. Probable variations or reliability ranges of the estimates should be predicted and discussed.

Reply:

We appreciate this practical comment that needs to be considered in the *P*-*Q* relationship. For the study area, data are not available to examine possible temporal variability of the *P*-*Q* relationship. To incorporate the reviewer's suggestion, we examined the *P*-*Q* relations based on the long-term data for the Ohio River in USA. The *P* and *Q* data from 1929 to 1999 were used to derive the *P*-*Q* relationship for every decade and it turned out that the correlations changed with time. We estimated *Q* from *P* using various *P*-*Q* correlations determined for each decade and compared the results. The calculated *Q* from various *P*-*Q* relations varied with less than ±10% in the range of

P from 1000 to 2000mm. The uncertainties tend to increase for *P* being less than 1000mm and greater than 2000mm. Although this observation may not be the exact analogy of the study area, we take ±10% as the possible extent of uncertainty related to the change in climatic and landcover characteristics. In the revised manuscript, we have incorporated discussions on the observed uncertainties as a reference and indicated possible errors in estimating *Q* from *P*-*Q* relationship associated with the temporal change in climatic and landcover characteristics of the catchment (from page 15 line 5 to line 17).

4. A limited information was shown on the biometric *NPP* evaluation method and its data source (Kim, 2006) is also not easily accessible, which is, inferred from its title, based on tree ring analysis. Inter-annual change of *NPP* over a few decades depends not only on climatic condition or water stress change but also on stand growth. Tree ring growth is potentially able to reflect the components of *NPP* including woody biomass growth, litter production and stem density decrease however the relationships are changeable in different growing stages. From the reverse sight, sensitivity of *NPP* to tree ring growth must be variable by the growing stages. I wonder if you could successfully reproduce the growth dependent *NPP* change by using tree ring analysis.

Reply:

The data reported by Kim et al. (now is '*in press*' in Ecological Research) is the Wood Biomass Production (WBP) rather than *NPP* determined using the tree ring growth data and biometric equations. We corrected *NPP* into WBP in Fig. 5 and the associated text. The importance of Fig. 5 lies in the fact that the ratios between WBP and transpiration may indicate possible extent of variability of *WUE* since there is no other long-term productivity data in the study area. We have clarified the implications of Fig. 5 in the revised manuscript (from page 23 line 12 to page 24 line 2).