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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Changes of evapotranspiration and water yield in China's terrestrial ecosystems during the period from 2000 to 2010" *by* Y. Liu et al.

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We sincerely appreciate your efforts to review our manuscript and give us the constructive suggestions.The following is the answer one by one:

1. How land use change and LAI change have altered ET and water yield in ET? Some modeling experiments by fixing climate or landuse (LAI) may answer this type question. Answer: This is a good suggestion. We will conduct simulation experiment to assess the effects of land use change and LAI change on ET and water yield by fixing climate or LAI. 2. ET is controlled by many factors as identified by the

authors. But, in discussion, the authors separate each factor and thus can result in erroneous conclusions, such as the role of LAI in affecting ET. At the continental scale, the author should look at multiple variables (LAI, P, Temp) in looking at the ET or water yield gradient in China. Answer: We thank the referee for this valuable comment. In the revised manuscript, we will analyze partial correlations between the multiple variables (LAI, P, Temp) and ET to identify the respective role of different variables in regulating ET. 3. What are the advantages of the BEPS's model? I was not clear the unique contribution of this study? The validation for the cropland site was not at all, but no explanation what cause the underestimation. The model validation with the large basin was not very convincing due to the size of the basin. Answer: This is a very constructive comment. We will seriously adopt it in revising the manuscript. What are the advantages of the BEPS's model? Answer: Boreal Ecosystem Productivity Simulator (BEPS) (Liu et al., 1997; Liu et al., 1999;Chen et al., 1999) is a process-based terrestrial ecosystem model designed to simulate carbon, water, and energy budgets over a large area (at continental or landscape scale). One of the unique characteristics of this model is the tight coupling between remote sensing information and the processes of water and carbon cycles. BEPS is driven by spatially explicit datasets of meteorology, remotely sensed land surface parameters (e.g., leaf area index and land cover type), and soil data (e.g., soil texture and water holding capacity) (Liu et al., 1999;Liu et al., 2003). This model includes a two-leaf (sunlit and shaded leaves) photosynthesis module for calculating carbon fixation an energy balance and hydrological module for simulating evapotranspiration (ET) and soil water content dynamics, and a soil biogeochemical module for simulating soil carbon, water, and nitrogen dynamics. The photosynthesis module is developed on the basis of Farquhar's instantaneous leaf biochemical model (Farquhar et al., 1980) with a new spatial and temporal scaling scheme (Chen et al., 1999) to calculate daily carbon fixation by the canopy. Water and carbon cycles are coupled through the simulation of leaf stomatal conductance that is controlled by environmental factors including photosynthetic photon flux density (PPFD), temperature (T), vapor pressure deficit

(VPD), and soil water content (Jarvis, 1976). Although initially developed to estimate gross/net primary productivity (GPP/NPP) for boreal ecosystems in Canada, BEPS has been advanced in various aspects (Ju et al., 2006;Chen et al., 2007;Sonnentag et al., 2008;Govind et al., 2009a;Govind et al., 2009b) and successfully applied to estimate regional water and carbon fluxes in China (Sun et al., 2004;Wang et al., 2005;Feng et al., 2007;Zhou et al., 2009;Ju et al., 2010;Liu et al., 2013), East Asia (Matsushita and Tamura, 2002;Zhang et al., 2010;Zhang et al., 2012b), North America (Liu et al., 1999;Ju et al., 2006;Sonnentag et al., 2008;Sprintsin et al., 2012;Zhang et al., 2012a), Europe (Wang et al., 2004), and the globe (Chen et al., 2012). BEPS has shown strong performances in several model intercomparison studies that evaluated ecosystem models with carbon and water flux measurements (Amthor et al., 2001;Potter et al., 2001;Grant et al., 2005;Grant et al., 2006;Schwalm et al., 2010;Schaefer et al., 2012). For example, in an intercomparison among 9 models, BEPS ranked the 2nd lowest RMSE (root mean square error), in ET simulation over a boreal forest (Amthor et al., 2001). In a recent North American Carbon Program (NACP) study, BEPS ranked the 8th lowest RMSE among 24 models in GPP simulation (Schaefer et al., 2012). Above information regarding to the advantages of the BEPS model was added in the current version of this manuscript in Lines 4-33, P5. I was not clear the unique contribution of this study? Answer: There are two major contributions of this study. First, daily ET and water yield were simulated at a spatial resolution of 500 m with improved leaf area index (LAI) and the well calibrated and validated process-based BEPS model. Therefore, the uncertainties in calculated ET and water yield could be well constrained. Second, the spatial and temporal variations of ET and water yield in different regions of China during the period 2000-2010 were analyzed. The major factors driving these variations were identified. So, the findings from this study will hence our knowledge about how the water cycle of terrestrial ecosystems responds to climatic variability (temperature, precipitation) and vegetation dynamics (LAI). Above information has been clarified in Lines 35-40, P4 in the current version of the manuscript (Above information will be clarified in the revised manuscript). The

validation for the cropland site was not at all, but no explanation what cause the underestimation. Answer: Two rotations crops (winter wheat and maize) are cultivated at the YC crop site. The underestimation of simulated ET mainly occurred in the period from the jointing stage to blossoming stage of winter wheat. It was mainly caused by the inversed LAI used to drive the BEPS model. For example, the inversed LAI ranges from 2 to 4 while the LAI measured at flux tower ranged from 4.2 to 7.5 from the jointing stage to blossoming stage of winter wheat in 2004. When the measured LAI was used to drive the BEPS model, the underestimation of simulated ET will be removed. The disagreement between inversed and measured LAI was possibly caused by the scale effect and heterogeneity of land cover in the growing season of winter wheat. The spatial resolution of LAI data used was at a spatial resolution of 500 m while the footprint of the flux tower at this site is normally just 190 m (Mi et al., 2006) .The 500 m pixel is a mixture of winter wheat, roads, bare soil. Consequently, inversed LAI will be lower than the value measured close to the tower, which will definitely cause simulated ET to be lower than measured values. This issue was discussed in Lines 5-16, P 11 in the current version of this manuscript. The model validation with the large basin was not very convincing due to the size of the basin. Answer: The validation of simulated regional ET is a challenge. Many previous studies, such as Zhang et al. (2009), Vinukollu et al. (2011), and Liu et al. (2008; 2012), used the ET estimated using the water balance method to validate simulated ET at the watershed scale. In the previous version of this manuscript, we used the ET estimated using the water balance method to validate modelled ET in 10 major basins in China. As pointed out by the reviewer, ET estimated using this method contains some uncertainties related to the sizes of basins and the assumption that the annual change of soil water storage is zero. Following the suggestions from the first and third reviewers, we removed this content in the current version of the manuscript. ReferenceïijŽ Amthor, J. S., Chen, J. M., Clein, J. S., Frolking, S. E., Goulden, M. L., Grant, R. F., Kimball, J. S., King, A. W., McGuire, A. D., Nikolov, N. T., Potter, C. S., Wang, S., and Wofsy, S. C.: Boreal forest CO2 exchange and evapotranspiration predicted by nine ecosystem process models: Intermodel comparisons and relationships to field measurements, J. Geophys. Res.-Atmos., 106, 33623-33648, 10.1029/2000jd900850, 2001. Chen, B. Z., Chen, J. M., and Ju, W. M.: Remote sensing-based ecosystem-atmosphere simulation scheme (EASS) - Model formulation and test with multiple-year data, Ecol. Model., 209, 277-300, 2007. Chen, J. M., Liu, J., Cihlar, J., and Goulden, M. L.: Daily canopy photosynthesis model through temporal and spatial scaling for remote sensing applications, Ecol. Model., 124, 99-119, 1999. Chen, J. M., Mo, G., Pisek, J., Liu, J., Deng, F., Ishizawa, M., and Chan, D.: Effects of foliage clumping on the estimation of global terrestrial gross primary productivity, Global Biogeochem. Cycles, 26, GB1019, 10.1029/2010gb003996, 2012. Farquhar, G. D., Caemmerer, S. V., and Berry, J. A.: A biochemical-model of photosynthetic CO2 assimilation in leaves of C3 species, Planta, 149, 78-90, 1980. Feng, X., Liu, G., Chen, J. M., Chen, M., Liu, J., Ju, W. M., Sun, R., and Zhou, W.: Net primary productivity of China's terrestrial ecosystems from a process model driven by remote sensing, Journal of Environmental Management, 85, 563-573, 10.1016/j.jenvman.2006.09.021, 2007. Govind, A., Chen, J. M., and Ju, W. M.: Spatially explicit simulation of hydrologically controlled carbon and nitrogen cycles and associated feedback mechanisms in a boreal ecosystem, Journal of Geophysical Research-Biogeosciences, 114, -, 2009a. Govind, A., Chen, J. M., Margolis, H., Ju, W. M., Sonnentag, O., and Giasson, M. A.: A spatially explicit hydro-ecological modeling framework (BEPS-TerrainLab V2.0): Model description and test in a boreal ecosystem in Eastern North America, J Hydrol, 367, 200-216, 10.1016/j.jhydrol.2009.01.006, 2009b. Grant, R. F., Arain, A., Arora, V., Barr, A., Black, T. A., Chen, J., Wang, S., Yuan, F., and Zhang, Y.: Intercomparison of techniques to model high temperature effects on CO2 and energy exchange in temperate and boreal coniferous forests, Ecol. Model., 188, 217-252, 10.1016/j.ecolmodel.2005.01.060, 2005. Grant, R. F., Zhang, Y., Yuan, F., Wang, S., Hanson, P. J., Gaumont-Guay, D., Chen, J., Black, T. A., Barr, A., Baldocchi, D. D., and Arain, A.: Intercomparison of techniques to model water stress effects on CO2 and energy exchange in temperate and boreal deciduous forests, Ecol. Model., 196, 289-312, 10.1016/j.ecolmodel.2006.02.015,

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