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Interactive comment on "Multi-factor controls on terrestrial carbon dynamics in urbanised areas" *by* C. Zhang et al.

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General Comments : Comment #1: "First, in simulating the all-factor combined effects (SUBNZ in Table 1), same factors such as temperature, [CO2], and N deposition rate are manipulated at the same time for both the global environmental changes (GECs) and urbanization-induced environmental changes (UECs). In parameterizing the model, how were the values of these variables determined separately for GECs and UECs that are happening concurrently in reality? For example, temperature and [CO2] data listed in Table S1 should be derived specifically for the region. Do those input data reflect global change effects or urbanization effects, or both?"

Our response: We added the following description to the 1st paragraph in in the section 3.3 of the revised manuscript to clarify the methodology. "In model simulation, the background climate, atmosphere, and land use drivers were modified by urbanization-induced environmental changes whose value were estimated based on literature reviews (Table 2). The background environmental drivers provide global change information because they are transient datasets that changed annually or daily from 1945 to 2007. To control a certain global change driver, we fixed its value to the year 1945. For example, in the climate only scenario (SCLM in Table 1), only the climate data changed from 1945-2007, the values of other drivers (CO2, N deposition, O3, and land use) were fixed to the value of 1945. If a certain urbanization-induced environmental change factor is considered in the simulation, the corresponding background value will be modified by its parameter from the Table 2." Datasets described in the Table S1 in the supplementary material only provide the background information of climate, atmosphere, and land-use change information. To prevent confusion, we changed the table title to "Table S1 Model inputs for the case study âĂŤ the background environmental drivers" in the revised manuscript. To isolate the global background environmental changes, we used the global background CO2 data from the National Oceanic and Atmospheric Administration (NOAA) (www.esrl.noaa.gov). Both the background ozone AOT40 data and N deposition data were retrieved from global datasets generated by global atmospheric transportation models (Felzer et al., 2005; Dentener, 2006). These atmospheric simulations have coarse resolutions of 0.5°-1°, and do not contain information of urbanization-induced environmental changes. The climate dataset was developed based on two regional scale datasets – the NARR (North American Regional Reanalysis; 32 km resolution) dataset and the PRISM (Parameter-elevation Regressions on Independent Slopes Model; 4 km resolution; 1895-present) climate data. Like most reanalysis data, the surface temperature and precipitation of NARR were estimated from the atmospheric values by regional climate modeling, thus were not sensitive to changes in land surface (Kanamitsu et al., 2002). PRISM is a knowledge-based system to interpolate climate elements under the assumption that for a localized region, elevation is the most important factor in the distribution of temperature and precipitation. To make predictions, PRISM dynamically calculates a linear climate–elevation relationship for each DEM (Digital Elevation Model) grid cell using a moving-window, a procedure that smooth out signals of urbanization-induced climate changes (Daly et al., 2008). Therefore, the background climate datasets used in this study are also isolated from local-scale urbanization-induced climate changes. We provided a detailed description for the background datasets in section "3.3.1. The background climate, atmosphere, and land use dataset" of the revised manuscript.

Comment #2: "Second, the parameter values describing urban managements and urban-induced environmental changes in Table S2 seem too arbitrary to me, although these had been published in Zhang et al. (2012). I strongly suggest that the authors provide some scientific bases for adopting the values of these key input parameters. Otherwise, the study is more of a model parameter sensitivity analysis than an urbanization effect analysis"

Our response: As requested by the reviewer, we added very detailed descriptions for how the parameter values of urban-induced environmental changes were estimated. Please see section "3.3.2. Urban-induced environmental changes" and section "3.3.3. Urban managements" in the revised manuscript for our literature reviews, which provide the scientific bases for the values used in this study.

Comment #3: "Third, modeled carbon balance is essentially a result of the interactions among model assumptions, empirical and mechanistic relationships, and model parameterization. Therefore, discussions on the modeling results, especially those with respect to different vegetation types (forest, grass, shrub), should also be linked to the built-in mechanisms/ assumptions of the model, not only to the general conclusions of previous studies as in the current form of the Discussion section."

Our response: We modified the Discussion section in according to the comments of the reviewer. For example, in depth analysis of the mechanisms/assumptions underlying the complex interactive effects among factors in urban ecosystem is provided in section 5.2 of the Discussion. Following is a sample of the revised discussion: ". . . Our

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case study found the overall interactive effects of major control factors could increase C sequestration in the SUS by about 39.9 Tg, larger than the effect of urbanization-induced environmental changes (29 Tg) (Fig. 1). This C sink mainly located in the forested areas, which in average gained 411 gC m-2 due to the overall interactive effects of urbanization from 1945-2007. Compared to the pre-urban forests, urban trees in general had higher biomass and productivity, because they were protected (by human managements) from disturbances (such as commercial logging) that caused the high turnover rates and low biomass of the rural forest in SUS (Birdsey 1992). Our simulations shows that these larger trees are more responsive to urbanization-induced environmental changes and can fix more C, a phenomenon confirmed by recent observations from Escobedo et al. (2010) and Stephenson et al. (2014). The underlying mechanism is related to the relatively large total leaf area of big trees. According to the Pipe model (Shinozaki et al., 1964) that controls photosynthate allocation in woody plant, total tree leaf mass increases as the square of trunk diameter. A typical tree that experiences a tenfold increase in diameter will therefore undergo a roughly 100-fold increase in total leaf mass. Larger leaf mass means the tree has higher growth potential if not limited by water and nutrient availability. Therefore, bigger trees are more sensitive to elevated CO2 and N deposition in urban. In rural forest stand, the high C sequestration rate of large, old trees could be offset by intensified mortality related to light competition. The urban forest, however, has relatively open canopy, and are able to support large trees (see section 3.3.3). Therefore, when a rural forest became a remnant forest in urban, its trees could grow bigger, faster, and were more sensitive to the increased urban CO2 and N deposition because of the urban management effect that suppressed disturbances (commercial logging) and light competition."

Comment #4: "In short, the authors should provide more specific descriptions on model parameterization and conduct some evaluations on the major model output (i.e. NCE) of interest, although the parameterization part was referred to a previous paper by the authors. I understand that rigorously validating all aspects of the model for various ecosystem types in such a large area is almost impossible and beyond the scope of

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this study, but even some rough comparisons between the modeled and observed NCEs (e.g. in the Discussion section) are helpful for me/readers to believe that your simulated numbers are at least in the ballpark."

Our response: As requested by the reviewer, we added very detailed descriptions for how the parameter values of urban-induced environmental changes were estimated. Please see section "3.3.2. Urban-induced environmental changes" and section "3.3.3. Urban managements" in the revised manuscript for our literature reviews, which provide the scientific bases for the values used in this study. We also added a section ("5.4 Uncertainties") to the end of the Discussion to discuss the uncertainties related to model parameterization. Furthermore, we validated the model performance against 16 field observations from 12 studies that located in or close to the case study area. Please see the newly added Table 4 "Comparison of model predictions against observed carbon pools and fluxes of urban ecosystems" (attached to the end of this response letter). Following is the newly added paragraph related to model evaluation: "Previously, we validated the DLEM simulated C and water fluxes, nitrogen cycle, and soil processes and trace gas emission against intensively studied ecological research sites (Tian et al., 2011a,b). Because urbanization does not change genetic characteristics of plants or fundamental mechanisms of ecological processes (Niemela, 1999), former validation results indicated that DLEM can correctly simulate ecosystem's responses to multiple environmental stresses in urbanised areas. To evaluate DLEM performance for simulating C processes in urban ecosystems, we further compared model predictions with 16 field observations (including VEGC, SOC, and NPP) from 12 studies that were located in or close to the SUS (Table 4). For those studies with sample variance, all of our model predictions fall in the range of one standard error."

Minor comments: (1) Page 7 line 20, soils are disturbed. (2) Page 7 line 13, UHI, spell out in its first appearance. (3) Page 8 Line 11, takes place (5) Page 17 Line 8, large amount of C loss? Not clear (6) Page 18 Line 26, considerably reduced byâĂŤ-.

Our response: Thanks for point out the mistakes. These errors are corrected in the revised manuscript.

(4) Page 12 Line 9, please use the same unit of C storage (Pg or Tg) in the main text and in Figs.

Our response: This passage focuses on comparing the influences of different vegetation types on urban C dynamics. Because different vegetation type has different area, it will be difficult to compare them based on their regional total C fluxes (in unit Tg). Therefore, we conducted the comparison based on their C density (g C m-2).

(7) Page 33, I don't think Fig. 5 is necessary, since the main ideas have been given in Fig. 1 and those numbers can be summarized in a table or a figure for better comparisons.

Our response: As requested by the author, we merged the Fig. 5 with Fig. 1, and replaced the Fig. 6 with a table (Table 3) in the revised manuscript.

Reference Heimann, M., and M. Reichstein (2008) Terrestrial ecosystem carbon dynamics and climate feedbacks, Nature, 451, 289–292, doi:10.1038/nature06591. Tian, H. Q., Xu, X., Lu, C., Liu, M., Ren, W., Chen, G., Melillo, J., and Liu, J. (2011a) Net exchanges of CO2, CH4, and N2O between China's terrestrial ecosystems and the atmosphere and their contributions to global climate warming, J. Geophys. Res., 116, G02011, doi:10.1029/2010JG001393. Tian, H. Q., Melillo, J., Lu, C., Kicklighter, D., Liu, M., Liu, J., Ren, W., Xu, X., Chen, G., Zhang, C., Pan, S., and Running, S. (2011b) China's terrestrial carbon balance: contribution from multiple global change factors, Global Biogeochem. Cy., 25, GB1007, doi:10.1029/2010GB003838. Young, R. F. (2010) Managing municipal green space for ecosystem services. Urban Forestry & Urban Greening 9:313-321. Ji, HX., Shi, Y., Zhu, YM., Wen, JS., Tang, YL., Ge, Y., Chang, J. (2011). Tree growth and carbon sequestration in different land-use types in Hangzhou City. Shengtaixue Zazhi, 30: 2405-2412. (in Chinese with English abstract) Springer, T. L. 2012. Biomass yield from an urban landscape. Biomass & Bioenergy 37:82-87.

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Interactive Comment

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/10/C9491/2014/bgd-10-C9491-2014-supplement.zip

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Interactive comment on Biogeosciences Discuss., 10, 17597, 2013.

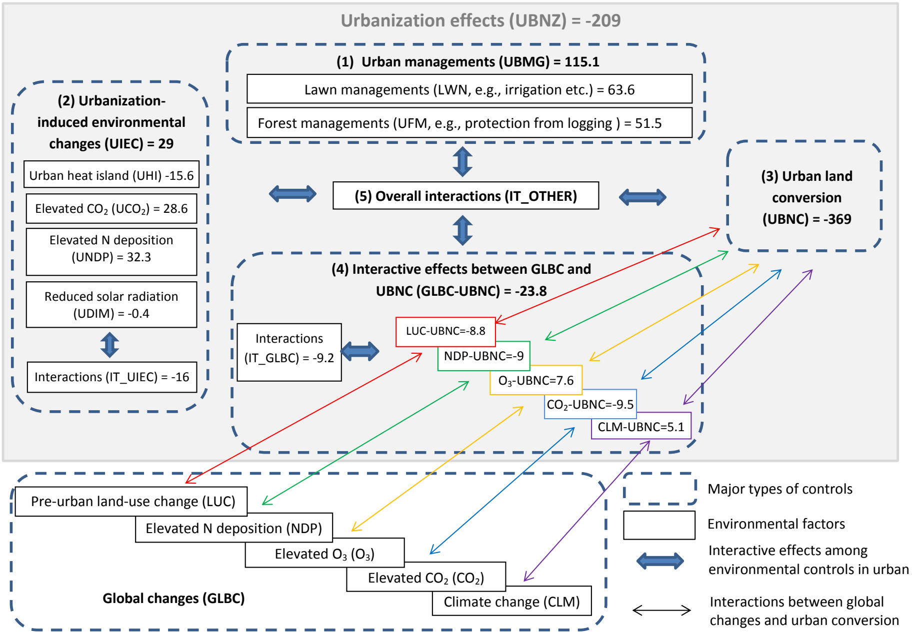

FIG. 1

Fig. 1.

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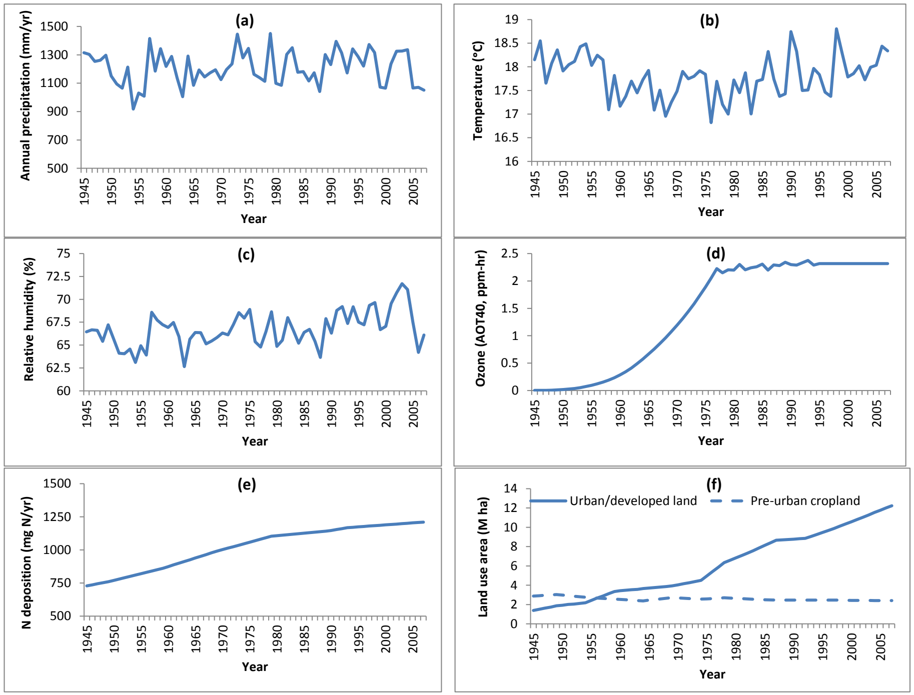
(a)
Annual precipitation (mm/yr)
Year
(b)
Temperature (°C)
Year
(c)
Relative humidity (%)
Year
(d)
Ozone (AOT40, ppm-hr)
Year
(e)
N deposition (mg N/yr)
Year
(f)
Urban/developed land
Pre-urban cropland
Land use area (M ha)
Year

FIG. 2

Fig. 2.

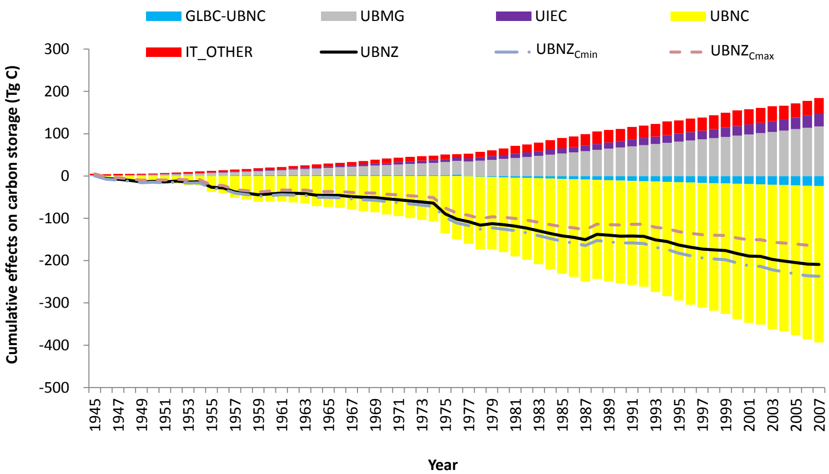

FIG. 3

Fig. 3.

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