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Hydrology and Earth System Sciences
Discussions

Interactive comment on "An integrated water system model considering hydrological and biogeochemical processes at basin scale: model construction and application" *by* Y. Y. Zhang et al.

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Response to the editor

Dear editor,

Thanks very much for your useful comments and suggestions on our manuscript. We have revised the manuscript accordingly, and detailed corrections are listed below. The revised manuscript is also provided in the Supplement.

Major issues:

Catchment description: Although it is mentioned that data on the human population and livestock production is used to parameterise the model (p. 9233, L. 7), no such numbers are found in the manuscript. I suggest that you include a table summarising these descriptors for the different sub-catchments. The agronomic descriptors should also be improved by providing more details. For example, dry land amounting to 84% of the watershed (p. 9234, L. 21) should be speciïňĄed in more detail: what kind of crops etc. are included? How have the crops be considered in the model?

Response: Thanks for your suggestion. In the revision, the social economic data was presented as "The average annual population (2003-2008) is 32.42 million including 23.70 million rural population. The average annual stock of big animals and livestock are 8.30 million and 178.42 million, respectively. The average annual amount of chemical fertilizer is 1.55 million ton". "These social economic data are interpolated into each subbasin based on the area percentage (Figure 8). The main crops of Shaying River Catchment are early rice, late rice, winter wheat and corn, and their agricultural management schemes are summarized by field investigation and referring to Zhai et al. (2014) and Wang et al. (2008) (Table 3)" (See P15 L1-4, Table 3 in Page 37). If we list all the descriptors of all 46 subbasins, the table would take up a large space. Thus we illustrated the descriptor data of the whole catchment in a figure (See Figure 7 in Page 49).

Urban hydrology and emission model: There is no description of the urban hydrology and the related ïňĆuxes of nutrients like NH4. Which sources and ïňĆow paths have been considered (e.g., wastewater treatment plants, leaking septic tanks etc.)? How has this model part be parameterised?

Response: Thanks for your suggestion. HEXM does not specifically consider the hydrological and emission processes in the urban area. However, the water yield is calculated in the different landuse fields respectively, which include forest, grassland, water, urban, unused land, paddy land and dry land. The values of corresponding parameter set of each landuse field are different. (See P7 L31-P8 L1)

The two sources of nutrient in the urban area are considered, e.g. nonpoint source load and point source load. The nonpoint source load is estimated using the export coefficient method, and the observed point source load is input to HEXM directly (See P11 L12; P15 L28; P61 L25-P62 L4) .

Livestock model: In analogy to the urban part, there is no description of modeling the nutrient ïňĆuxes from livestock production. If this is considered irrelevant this should be mentioned (see 9233, L. 7).

Response: Thanks for your suggestion. The nutrient loss from livestock is calculated using the export coefficient method. The equation is shown in S34(See P61 L5-12).

Nitrate leaching: According to p. 9231 L. 4 - 7, Fig. 4, and p. 9256, L. 3 nitrate leaching seems not to be included into the model. It looks like that only surface runoff is considered for transport to water bodies. If this impression is wrong, please modify the manuscript such that the relevance of the different ïňĆow paths get evident. If nitrate leaching was indeed excluded, provide arguments why this should be an appropriate simpliïňĄcation in your study region. Make it clear that this was a relevant model limitation for other situations.

Response: Thanks for your suggestion. The nitrate leaching process is considered in HEXM and added in the revision as

"Nitrate leaching: The NO3-N leaching rate is a function of clay content, organic C content and water infiltration in the soil layer.

LeachNO3=Winf . uCLAY . usoc (B14)

where LeachNO3 is the NO3-N leaching rate; uCLAY and usoc are the influence coefficient of clay content and organic C in the soil layer, respectively." (See P8 L19; P27 L4-8)

Minor issues:

Abstract: The model improvement and comparison with SWAT is not introduced as a goal, but results are shown. Please make it clear what the objectives are. The same holds for example for grain yield, which appears out of the blue (p. 9221, L. 18).

Response: Thanks for your suggestion. The objective of this study is to develop an integrated water system model considering the more accurate hydrological and biogeochemical processes with the aim to improve the simulation performance of several key elements (e.g. evapotranspiration, soil water, runoff, nonpoint source pools of nitrogen, phosphorus and carbon, water quality variables in water body, crop yield and greenhouse gas emissions) in complex basins. The model performance is presented by a case study in China and compared with that of SWAT in order to test its practicability. The model performance is shown by the key water related components in the complex catchments (e.g. runoff for hydrology, water quality and nonpoint source pollutant load for water environment, crop yield for ecology).

Several sentences were revised in the abstract as "In this study, an integrated water system model (HEXM) was developed by coupling multiple water related processes including hydrology, biogeochemistry, environment and ecology, as well as the interference of human activities. The model was tested in the Shaying River Catchment, the largest, highly regulated and heavily polluted tributary of Huai River Basin in China. The results showed that: HEXM was well integrated with good simulation performance on the key water related components in the complex catchments (e.g. runoff for hydrology, water quality and nonpoint source pollutant load for water environment, crop yield for ecology). "," The simulation performances were also compared with the SWAT's results from a previous study to test its practicability, and our model showed better simulation performances in both calibration and validation, particularly for daily runoff and water quality. " (See P1 L20-28; P2 L8-11)

Introduction: Make it more explicit why you consider current models as insufficient for an integrated watershed management. As it is written now it appears as a claim without much factual support. Once you have pointed out existing deficits you should make clear which of them you will try to tackle with your approach.

Response: Thanks for your comments. The section of introduction was revised to focus on the water issues faced in the integrated watershed management, the current models and how the proposed integrated water system model addressed these issues. More related references were added to support the claims (See P2 L16-17,21-22, 24-32; P3 L7-16,18-24;P4 L8-27; P5 L1-9; P28 L20-21; P29 L1-2,12-14, 22-23, P31 L9-11, 16-18, 27-30; P31 L1-4, 10-14; P33 L1-3, 17-19).

p. 9222, L. 2 - 11: This paragraph evokes the impression that water problems are the prime cause of non-sustainable development and that integrated watershed models will solve this problem. I think the wording in this paragraph (and elsewhere in the manuscript) should be chosen such as to be realistic about the relevance of water issues and the tools used for water management.

Response: Thanks for your comments. This paragraph was revised to " Severe water crisis hinders sustainable development in many regions all over the world nowadays, including flooding (Milly et al., 2002. Schiermeier et al., 2011), water shortages (Pimentel et al., 2004; Wilhite et al., 2005), water pollution (Jordan et al., 2014; Zhou et al., 2014) and ecological degradation (Revenga et al., 2000; Vörösmarty et al., 2010) . It is impossible to address these water problems using only the traditional single disciplinary approach (viz., hydrology, environmental sciences or ecology) because of the interconnections between water and the other related environment in the complicated water system (Kindler, 2000). The integrated river basin management might be one of the most sensible frameworks to comprehensively tackle these problems at basin scale. Thereinto, the integrated water system model is a reasonable practice to simultaneously simulate water related elements (flow regimes, nutrient loss, sediment and water pollution) (Kirchner, 2006), and also an effective tool to support water resource allocation, environment flow management, and river ecological restoration (Arthington, 2012). "(See P2 L16-29).

p. 9222, L. 26: This is not really new.

Response: Thanks. It was revised as " multidisciplinary research provides an effective way to make the possible breakthrough in water system modeling." (See P3 L11-13)

p. 9223, L. 13: The nomenclature is misleading: the environment comprises the hydrological cycle as well as ecological aspects. Hence, the three terms cannot be used to denote distinct things. Please improve on the selected terms.

Response: Thanks. The "environment" in the manuscript was replaced by "water quality" (See P18 L18) or "water environment" (See P1 L27; P3 L26; P5 L24-25; P6 L20; P10 L26,27; P13 L5,8,12; P18 L29; P22 L5; P43 L4,11; P44 L3; P47 L3) to present more clearly.

p. 9225, L. 6 - 9: Based on what do have these expectations?

Response: Thanks. It was removed following the suggestion of reviewer 2.

p. 9226, L. 6: Why is calibration a post-processing tool?

Response: Thanks for your comment. It was revised as "Parameter analysis tool (PAT) is a useful tool for HEXM calibration and is independent from other modules ".(See P5 L30-31)

p. 9228, L. 13: This is rather conceptual and not process based.

Response: Thanks for your comment. According to Reviewer 2's comment, we put less emphasis on whether a model is process-oriented or not. The "process based" was deleted in the manuscript.

p. 9228, L. 5: How do you link the site scale with the catchment scale?

Response: The multi-scale solution was explicated in the 2.6 section. Each subbasin was divided into several landuse fields according to the landuse classification, and further divided into different crop cells. Most processes of HCM, SEM, SBM and CGM were simulated at the site or field scales. The outputs were summarized at the catchment scale based on the area percentage of different cells (See P13 L5 -P14 L4).

p. 9230, L. 5: it should read phenological.

Response: Thanks. It was changed. (See P10 L15)

p. 9232, L. 8: Is no regulation a calculation method?

Response: Thanks for your comments. This method is deleted. (See P12 L12)

p. 9233, L. 7: Why do you need GDP, orchard area etc.? How does it feed into the simulations?

Response: Thanks for your careful review. GDP, secondary industry GDP and orchard area did not feed into HEXM. All of them were deleted.

p. 9233, L. 13: How do you test the crop yield at field scale with catchment data?

Response: Thanks for your comment. The crop yield was simulated at the crop cell scale and output at subbasin scale according to the area percentage of crop cells in each subbasin. The model performance was assessed by comparing with the data from statistical yearbooks from 2003 to 2005. It was given in the revision as "The yield of each administrative region was summarized and compared with the data from statistical yearbooks from 2003 to 2005 (Henan Statistical Yearbook, 2003, 2004 and 2005) to test the simulation performance" (See P20 L23-26)

p. 9233, L. 22: What is a minimum simulation cell?

Response: Thanks for your comment. Three levels of spatial calculation cell were designed, i.e. subbasin cell, landuse cell and crop cell from largest to smallest. The processes of HCM (e.g. flow routing in both land and instream), MMM, WQM and DRM were simulated at the subbasin scale. The processes of HCM (e.g., water yield, infiltration, interception and evapotranspiration) and SEM were simulated at the landuse cell scale. Moreover, the processes of SBM and CGM were simulated at the crop cell

scale (See P13 L5 -P14 L4) .

The minimum simulation cell is revised to "the spatial calculation cell" which designed for the simulation of all the water related processes considered in our model.

p. 9235, L. 4: Which socio-economic data is point data that has to be interpolated?

Response: Thanks for your comment. The interpolated social economic data includes populations in urban and rural area, breeding stock of large animals and livestock, chemical fertilizer amount. (See P15 L21-24)

p. 9239, L. L. 15 - 16: This sentence is not clear to me.

Response: Thanks for your suggestion. The sentence was revised as "The pollutant concentration usually reduced obviously at the upstream of dams or sluices, due to the degradation and settlement of large water storage." (See P19 L25-26)

p. 9239, L. 21: Should yield rates not be replaced by loads?

Response: Thanks for your suggestion. The sentence was revised as "The modeled annual yield rates ranged from 0.048 t km-2 year-1 to 11.00 t km-2 year-1 with a mean of 0.73 t km-2 year-1." (See P19 L31-32)

p. 9239, L. 24: I have some problems with these correlations. First, it seems that you correlate NH4 loads calculated for a unit area with the total area of paddy fields in a subcatchment (Fig. 10). Why should the intensive quantity load per area correlate with the extensive quantity area of a specific crop? Second, you mention a strong correlation between the NH4 load and rice yield (Fig. 10). However, this correlation disappears if you remove the largest value. In fact, one observes a negative correlation without this data point. Please, be more cautious in presenting the results.

Response: Thanks for your suggestion. The correlations were tested between NH4-N load and Paddy area, between NH4-N load and Rice yield of each subbasin, respectively. The correlation coefficients were 0.506 and 0.799, both of which passed the significance test (p<0.001) (Figure 1a). If the outliers were deleted, the correlation coefficients increased to 0.825 (p<0.001) and 0.912 (p<0.001) (Figure 1b). The sentence was revised as "The spatial pattern was significantly correlated with the distribution of paddy fields (r=0.506, p<0.001) and the rice yield (r=0.799, p<0.001) ." (See P20 L7)

Figure 1.The correlation between NH4-N load and Paddy area, between NH4-N load and Rice yield (a: original relationship; b: the relationship after deleting the outliers) (supplied in Figure 1)

p. 9239, L. 26 - 27: Under intensive cropping, nitrogen use efficiency (NUE) is much lower than the values you indicate here. Globally, NUE of cereal production (including rice) is estimated to be in the order of 33% (see e.g., Meng et al., 2014; Raun et al., 1999). Please provide convincing data supporting the exceptionally high NUE values. Otherwise, check whether the simulated N balances are correct.

Response: Thanks for your comments. We compared the nitrogen losses coefficient in paddy field with that in dry field. In China, the average percent of nitrogen losses was just 30∼70% in paddy fields, which was much greater than that in the dry field (20∼50%) (Zhu, 2000; Xing and Zhu, 2000). The sentence was revised to "The fertilizer loss of paddy fields might be the primary contributor to the nonpoint source NH4-N load, possibly because the average nitrogen losses coefficient in China was just 30∼70% in paddy fields, which was much greater than that in the dry field (20∼50%) (Zhu, 2000; Xing and Zhu, 2000). The nitrogen was prone to loss by volatilization to air, dissolution and drainage into rivers with runoff in paddy fields." (See P20 L7-12)

p. 9240, L. 6, 13 - 17: How are they simulated? What kind of data is used for calibration?

Response: Thanks for your comments. The yields of nonpoint source load and crop yield were output at the subbasin scale in HEXM. However, the actual yield values was always summarized for the administrative region in the statistical yearbooks or some official reports (HRC., 2011; Henan Statistical Yearbook, 2003, 2004 and 2005). Thus

the simulated yield of each region was summarized properly from the subbasin scale according to the area percentage of subbasins in each city and compared with the statistical values (See P 19 L32 ; P20 L23-26) .

p. 9241, L. 1: Provide evidence for this claim!

Response: The section of conclusions was replaced by the section of conclusions and discussion and restructured greatly(See P21 L4-P22 L30). This sentence was removed.

p. 9242, L. 12, Fig. 11: Here, the same comments holds as for Fig. 10. If one removes the largest value from the data set the correlation disappears. Hence, it seems that your statement regarding the good performance of the yield simulation is not very robust. Please comment.

Response: Thanks for your comments. In fact, for crop yield simulation, we only used bias , not correlation coefficient, to evaluate the simulation performance in the administrative region, as well as the whole study area. The explanation was given in the revision as " The yield of each administrative region was also summarized and compared with the data from statistical yearbooks from 2003 to 2005 (Henan Statistical Yearbook, 2003, 2004 and 2005) to test the simulation performance. The high-yield regions were Luohe, Fuyang and Zhoukou regions in the middle and down reaches, whose primary land use were dry land (93.12%, 95.87% and 93.18%, respectively). The yields of Luohe, Nanyang, Kaifeng regions were well simulated. The total yield was underestimated in the whole basin with the bias of 19.93%. The boundary mismatch between the administrative region and subbasin might contribute to the discrepancies, as well as the different cropping patterns in such huge region. Higher resolution remote sensing image and field investigation might further improve the model performance." (See P 20 L23- P21 L1).

p. 9242, L. 13 - 14: I could not find the data for the urban fluxes.

Response: Thanks for your comments. We made a mistake about "the cities" and "the administrative regions". In fact, we didn't simulate the urban fluxes. This sentence presented that the simulated nonpoint source pollutant load and corn yield were good agreements with the statistical value of each administrative region in this study area (See P 19 L32-P21 L4). The sentence was removed because this section was replaced by conclusions and discussion (See P21 L4-P22 L30) .

Conclusion: Please respond to all of the comments and explain how you intend to revise the manuscript in order to address the issues raised by the reviews.

Response: All the comments of two reviewers and editor have been replied point by point. All the changes in the paper were marked with light blue.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/11/C4685/2014/hessd-11-C4685-2014-supplement.pdf

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 9219, 2014.

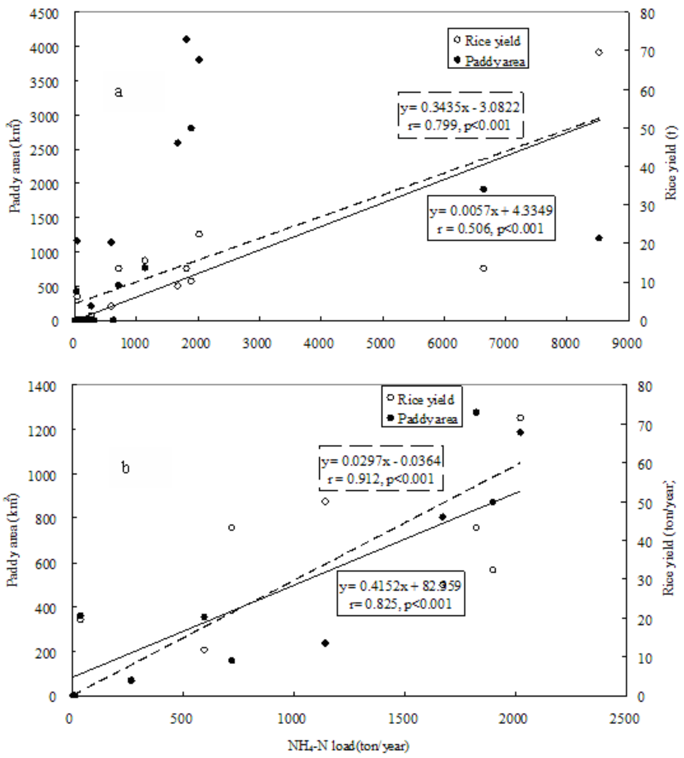

Fig. 1. The correlation between NH4-N load and Paddy area, between NH4-N load and Rice yield (a: original relationship; b: the relationship after deleting the outliers)