**Hydrology and Earth System Sciences Discussions**

# *Interactive comment on* "Runoff formation from plot, field, to small catchment with shallow groundwater table and dense drainage system in agricultural North Huaihe River Plain, China" *by* S. Han et al.

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The authors gratefully thank to the anonymous referee #1 for his critical comments on our manuscript which drives us to improve the manuscript greatly.

Major improvements have been made in the revised manuscript according to the Referee's comments.

1. The paper should stress out that groundwater table as a wetness indicator is a

proxy only to the soil moisture status. Rough estimation of the available water storage towards the accumulation availability of the water in the vadose zone is advised based on simple tools as retention curve derived e.g. from particle size properties assuming equilibrium distribution of the soil water content along vertical axis, if measured data are not available.

The groundwater table depth controls both the soil moisture deficit in the profile and the surface infiltration parameters (Sivapalan et al., 1987;Troch et al., 1993). In this study area, since saturation excess flow was one of the dominated processes, groundwater table is very important as a wetness indicator. In the manuscript we analyzed the relationship between runoff and initial water table depth. As pointed out by the referee, it reflected the relationship between runoff and wetness (soil moisture). But the role of antecedent soil water content in the runoff response was not stated clearly. In the revised manuscript, this will be stressed out.

In our study, measured data of soil moisture are not available except for the period from June 25 to August 28, 1999, when the soil water content below the surface 15–30 cm was monitored by TDR sensor from one point in the experimental plot, as shown in Fig. 4. The dynamics of soil moisture in the plot were similar to the dynamics of ground water table of the well in the center of the catchment.

It is a helpful advice to calculate the available water storage before each event. But the relationship between the water table depth and soil moisture dynamics is complicated. In order to give a roughly comparison, the differences between saturation water content and field capacity was used to calculate the available water storage. In the study area, the soil was divided into three layers according to its characteristics: 0∼20cm with saturation water content and field capacity 39.6% and 30.7; 20∼50cm with saturation water content and field capacity30.1% and 25.8%; 50cm∼400cm with saturation water content and field capacity 28.1% and 25%. The plots of calculated available water storage and water table depth are shown in Figure R1.

At present, the Xinanjiang model (a lumped conceptual rainfall–runoff model) (Zhao, 1992) was used to simulate the storm-runoff processes of 14 events at the catchment with calibrated parameters (including averaged soil moisture storage capacity of three layers) and antecedent soil moisture content. The performances of the model were acceptable (with Nash-Sutcliffe efficiency around 0.7). The difference between averaged soil moisture storage capacity and antecedent soil moisture content can be served as available water storage. And it was also plotted against the water table depth of the 14 events in the figure.

Although the calculation at present is not very precise, it is obvious that available water storage is closely correlated with initial groundwater table depth. Groundwater table can be served as a wetness indicator. In the revised manuscript, we will state clearly that the groundwater table data is served as a proxy to the soil moisture status. We will continue the study on the relationship between groundwater table and soil moisture status.

2. Site is described as relatively homogeneous and whole evidence is provided on one borehole anyway, so it is more of the conceptual rather than detailed spatial approach. That would nicely confront the available porous space and rainfall amounts for the listed rainfall runoff events and e.g. runoff ratios/ runoff thresholds.

Indeed, this work is conceptual. The problem is that there was no detailed spatial data on soil moisture and water table at present. We are trying to apply a new project to do detailed spatial research with more TDR sensors and groundwater monitoring wells.

3. There are papers worth mentioning to complete the literature review regarding the rainfall runoff formation on the hillslope in recent decade. Hrncir paper (HrnĔĞcíĔĞr et al., 2010) is incorrectly cited both in the text and references – this paper has three more authors.

We reviewed the literature of rainfall runoff formation on the hillslope in recent decade carefully in the revised manuscript. The reviews mainly about the importance of

groundwater table data as wetness indicator on hydrological response on the hillslope. Details can be referred to the revised manuscript. HrnĔĞcíĔĞr paper (HrnĔĞcíĔĞr et al., 2010) was recited correctly in the revised manuscript:

4. Page 4236, line 15 study makes classes of groundwater table of less than 0.5m, 0.5-2.3m and more than 2.3m however another threshold of 2.1m (e.g. p4244 line3, 26; p4247, line 25) is used sometimes during the text, please harmonize or explain this irregularity.

As shown in Table 1, the groundwater table of the second group was shallower than 2.06m, and the third group was deeper than 2.38m. The groundwater table of the two groups is discontinuous. There was no event observed with groundwater table between 2.06m and 2.38m. In the revised manuscript, the threshold of 2.1m is used.

5. Harmonize expression groundwater and ground water throughout the text.

In the revised manuscript, the expression "groundwater" is used throughout the text.

6. How are the rainfall runoff events separated from the rest of the time, esp. at the end of the event (e.g. by reaching certain flow threshold in the stream?)

The stream-flows of the catchment and field were measured using a flow meter, and the stream-flow of the plot was measured using the float method. All the measurements were conducted manually with variable intervals. Since the flow was ephemeral, the events were also considered being separated from the rest of the time when there was no observed flow. The rainfall runoff events were separated from the rest of the time by reaching 0.08m3/s at the catchment scale, 0.003 m3/s at the field scale and there was no observed flow at the plot scale.

7. Page 4240, line 9: saturation conductivity: use saturated hydraulic conductivity, instead

"saturation conductivity" was replaced by "saturated hydraulic conductivity" in the revised manuscript.

8. Page 4240, line 11: do not use approximate expression as "very little variability", specify in statistical measures

In the revised manuscript, it was deleted and replaced with "the field capacity of surface soil is between 27%-34% with an average value 30.7%"

9. Page 4240, line 19: float method is mentioned, how do you achieve the integral result – is it manually measured during the whole event and if – how often?, please specify

The streamflow at the plot was manually measured using the float method at the furrow outlet. The measurement was conducted according to the change of the flow in at the furrow out. When obvious changes were observed, it was measured intensively. The smallest time interval was 20 minutes. The largest time interval was more than two hours. Because the runoff events at the plot were discontinuous, the event was separated from the rest of the time when there was no observed flow.

10. Page 4242: how do you justify discrepancies in amounts and dynamics of the runoff formation at three scales. Are there processes which are not captured at all three scales? : plot, field and catchment scale. Please make hypotheses in the results and discussion, the location of the three, where plot and field lie on the very edge of the catchment might explain different travel times and dispersion of the peak discharge in the hydrograph.

First, all the thirty events were carefully checked to avoid obvious error. Second, the discrepancies in amounts and dynamics of the runoff at three scales can be interpreted. Runoff coefficient decreased from the field to the catchment. It is consistent with previous studies (e.g., Cerdan et al., 2004). For the plot, only surface runoff was collected and observed. Since subsurface flow took a great role in the total streamflow, the runoff at the plot would be smaller than that the other scales.

The catchment is isolated from the outside region with roads and ditches. The west

C2362

and south edges of the field are isolated from the outside region, and the east and north edges are isolated from the catchment with roads and ditches. It is believed that all the processes were captured at the catchment and field. The plot is isolated from the outside with furrow, and it is believed that the processes related surface runoff was captured.

Yes, the plot and field lie on the very edge of the catchment, and it might explain different travel times and dispersion of the peak discharge in the hydrograph. We made hypotheses in the discussions, and we will study it in detail afterwards.

11. Page 4244, line 5: is the word "interception"used in the meaning of the rainfall interception on vegetation? if the word is used in the meaning of soil moisture storage it is suggested to use different expression esp. when the next chapter relates to the crops on the study area.

The word "interception" should be "intercept". It is the intercept of the linear rainfall-runoff relationship in Table 2 and Fig. 5.

12. Page 4245, line 4 & Page 4247, conclusion 2: do not use expression as: "water table rose a lot", provide the mathematical measures or relative to typical groundwater behavior

In the revised manuscript, it was modified as "After the storm-runoff event, the groundwater table depth was shallower than 0.6 m for 25 of the 30 events. For the other five events with deep initial water table, the water table rose more than one meter." "After the storm-runoff event, the groundwater table rose up to about 0.6 m close to the surface for 25 of the 30 events."

13. Page 4246, line 12: ditch or ditches instead of ditche – 2x

It was revised in the manuscript according to the comment.

14. Page 4247, line 21: found instead of founded

C2363

It was revised in the manuscript according to the comment.

15. Page 4247: conclusion on: groundwater table is a proxy of soil moisture and it is not the factor, but consequence of the processes in the vadose zone. The relations to runoff formation and groundwater table can be found, but they do not prove the actual physical cause.

It was revised as "The antecedent soil water availability which can be detected by the initial groundwater table depth was the main factor influencing rainfall-runoff relationship in the study area."

16. Table 2: mistype: Catogory* v. Category* (in the heading and in the subtitle)

It was revised in the manuscript according to the comment.

17. Fig.7: legends: growht v. growth

It was revised in the manuscript according to the comment.

18. Fig. 8: everage v. average

It was revised in the manuscript according to the comment.

19. If the research is to be continued, natural behavior of stable isotopes in the water molecule is advised to utilize in order to distinguish overland flow and groundwater discharge processed forming the total runoff and precise the present findings

There has been a study on runoff formation in the study area using stable isotopes (Tan et al., 2008). In that study, hydrograph separation of rainfall-runoff events was carried out using stable isotopes oxygen-18 and deuterium, electrical conductivity (EC) and specific concentration of calcium as hydrological tracers. It is a helpful advice to use stable isotopes to distinguish overland flow and groundwater discharge. We are trying to apply a new project to continue the research with stable isotopes and more TDR sensors and groundwater monitoring wells.

C2364

References Sivapalan, M., Beven, K., and Wood, E. F.: On Hydrologic Similarity 2. A scaled model of storm runoff production, Water Resour Res, 23, 2266-2278, 1987. Tan, Z., Lu, B., and Wang, J.: Hydrograph Separations Based on Isotopicchemical Mixing Models, Advances in Water Resources and Hydraulic Engineering–Proceedings of 16th IAHR-APD Congress and 3rd Symposium of IAHR-ISHS, Nanjing, China, 2008, 231-235, Troch, P. A., De Troch, F. P., and Brutsaert, W.: Effective water table depth to describe initial conditions prior to storm rainfall in humid regions, Water Resour Res, 29, 427-434, 1993. Zhao, R.: The Xinanjiang model applied in China, J Hydrol, 135, 371-381, 1992.
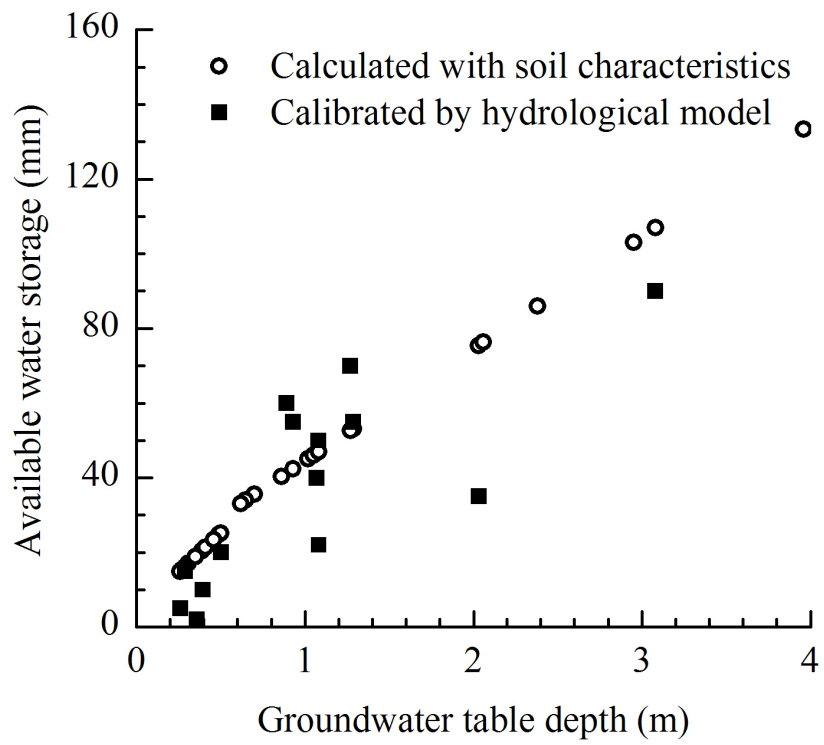
**Fig. 1.** Figure R1. Relationship between estimated available water storage and initial water table depth

C2366