Interactive comment on "New interpretation of the role of water balance in an extended Budyko hypothesis in arid regions" by C. Du et al.

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Dear Referee #2,

Thank you very much for your comments and constructive suggestion in order to improve our manuscript. The attached file is the point by point response to each of the comments and suggestions.

Response to the comments

1. *The authors extended the Budyko hypothesis (BH) to an arid basin, by taking inflow and storage change into account. Considering inflow from upper basins as part of the total water supply to evaporation in an unclosed basin is quite novel. The authors found that accounting for the inflow in BH is beneficial to improve BH performance both in annual and monthly time scale. This paper is well written, clearly structured. And it matches well with the scope of HESS, will be of interest for HESS readers. I recommend minor revision. But some parts need further clarification before it can be published.*

Thank you.

2. *Clarify how the authors calculate the Q_{in}. Accounting Q_{in} in BH is the most novel part of this paper, to my point of view. Maybe I missed it, but I did not get the clear definition of Q_{in} and how the authors do the calculation, especially for the basins in downstream. I guess the authors estimated Q_{in} by channel inflow and outflow, which implicitly takes all types of water consumption into account, such as irrigation, domestic and industrial water usage, but neglect the capillary rise from groundwater reservoir. I personally suggest the authors confirm this important term is well defined and clearly described.*

Yes, good idea. As guessed by the referee, we estimated $Q_{in.}$ by channel inflow that is from the upper basin and/or inter-basin water transfer. And in the estimate of the available water we neglected the capillary rise from groundwater reservoir.

To make a clarification, we rewrite the part in defining $Q_{in.}$ Page 11018, line 9, we replace "the transferring water with other basins" by "channel inflow that is from the upper basin and/or inter-basin water transfer".

3. *Page 11018 Line 9: The term deltaS is not well defined. It is defined as "soil water storage change" in the article. But what is the depth of the soil? Since soil depth in some places may be deeper than 50 meters, i.e. on Loess Plateau, which is obviously not what the authors*

intended to say. And I think the authors mean the top soil layers which can be used for ecosystem to absorb water by roots. I recommend using root zone storage (Gao et al., 2014) change as a clearer definition, which is the dynamic part in soil.

Good idea, we agree and we specifically mean "root zone water storage". We have replaced "soil water" by "root zone water storage" in the relevant part of our manuscript.

4. *Page 11024 Line 13-14: ": : :The runoff data set includes monthly runoff at 4 stations located at the inflow or outflow of the six sub-basins." How 4 gauge stations can observe the inflow and outflow of six sub-basins? Please clarify.*

Sorry, we think it is to do with the way how we wrote the manuscript. Now we clarify them. For the two upper streams, Gauge #S1 controls Region I and Gauge #S2 controls Region II. For the two middle streams, Gauge #S1 and #S3 control Region III, and Gauge #S3 and Gauge #S4 control Region IV. For the two downstream Region V and Region VI without any runoff flowing out, Gauge #S2 and Gauge #S4 control their inflow respectively. (See Figure 3 in the main text). We clarify it in the main text (Line 14 Page 11024)

5. *Section 4.1. The role of abcd model in this study. To my understanding, it provides the time series of monthly "soil water storage change" and "monthly inflow" in downstream basins (due to the influence of hydraulic engineering), which are necessary for the new BH model. Am I right? Please do clarification in the revised manuscript. And how was the abcd model applied to calculate the water balance of Regions III and IV? The authors used evaporation observation to do calibration in Regions III and IV. But basin III and IV is the downstream of basin I and II. How does the abcd model handle the inflow from upstream? And how is the abcd model conducted in Region V? I did find it in Section 4.1.*

The outputs from the abcd model being used include soil water storage and actual evapotranspiration. Only over the two upper sub-basins (Region I and Region II), the streamflow is used for the calibration and validation purpose.

Over Regions III, IV, and also V being concerned by the referee, large areas of artificial oasis (cropland) is distributed and the streamflow was intensely disturbed by hydraulic engineering. Hence it becomes almost impossible to validate the abcd model by directly comparing the simulated and observed streamflow. Instead, we used the actual evapotranspiration by remote sensing to calibrate and validate the abcd model. For the new BH over Regions III, IV, and V, we use the observed Qin from the upper sub-basin as the input. That is to be consistent with the remote sensing data, which are observed and hence human disturbed.

A key point of this paper is that inflows from upper sub-basins can be considered as a new and important source of available water for evapotranspiration.

To clarify it, we modify Lines 21 to 27 in page 11025.

6. *Page 11025 Line 21: ": : : completely controlled by hydrological stations: : :". Do you mean "hydraulic engineering"?*

We accept this comment in the manuscript.