Hydrol. Earth Syst. Sci. Discuss., 12, C5666–C5669, 2015
www.hydrol-earth-syst-sci-discuss.net/12/C5666/2015/

Hydrology and Earth System Sciences
Discussions

Interactive comment on "Shift of annual water balance in the Budyko space for a catchment with groundwater dependent evapotranspiration" *by* X.-S. Wang and Y. Zhou

F. Jaramillo (Referee)

fernando.jaramillo@natgeo.su.se

Received and published: 17 December 2015

Review Fernando Jaramillo - "Shift of annual water balance in the Budyko space for a catchment with groundwater dependent evapotranspiration"

The authors study the annual water balance in the Hailiutu river basin in China by studying water and energy availability in Budyko space. They attribute values that are over the energy limit (Evaporative index=ET/P>1 to evapotranspiration from shallow and deep water. The paper is interesting in the fact that it modifies a conceptual hydrological model to include groundwater evapotranspiration and analyzes the results in Budyko's space. It also joins the debate on the "stretching" of the Budyko's hy-

pothesis for intra-annual timescale hydroclimatic analysis and understanding the role of groundwater storage change in such framework. It is also well written, with some line-exceptions.

However, I think that the article needs to be improved and revised to solve some inconsistencies:

1) I cannot understand why the authors have not just used the annual Q data from observations and simply used it to calculate the Evaporative index simply as ET/P=(P-Q)/P and plot the annual data in Budyko's space to understand the behavior of the basin from REAL data. This should be done in order to strengthen and further compare the results of their modified ABCD model and the "natural" and "irrigated" model. It is possible that the "linear" behavior seen in Budyko's space among years maybe an artifact of the model or the modifications done to it.

I agree with the other reviewer in the fact that the use of the Budyko space might be "overstretched" in this sense. I think that the explanation of the points falling above the water limit instead of being due to "groundwater evapotranspiration" as explained by the authors, can be better explained by more evident reasons such as:

a) The Budyko framework was made to be used at long-time scales and over entire hydrological basins, so that the water budget is closed; inputs of water equal outputs of water in the time period selected. It is not that the "Budyko hypothesis is not valid for the inter-annual variability of catchment water balance with groundwater dependent evapotranspiration" (conclusions), it is more that the annual time scale might not be enough to accomplish steady state conditions, especially if how the authors state, the changes in groundwater in the basin are considerable within the annual time scale. Another possibility is just that the size of the basin is too small, 2645 km2, so changes at the catchment scale of groundwater flux cannot be assumed as negligible. By the way, all this is carefully explained in the article from the other reviewer and colleagues (Donohue et al., 2007): "On the importance of including vegetation dynamics in Budyko's hydrological model".

b) The fact that irrigation and water impounded reservoirs exists within the basin. The authors mention diversion, reservoirs and irrigation within the basin (page 11622) and say that it will be "discussed in the following sections". But I could not find that discussion. Impoundment of reservoirs and irrigation may substantially increase evapotranspiration from the entire basin, regardless of the size of the area covered by these activities in the basin. These activities definitely move a basin upwards in Budyko space, probably beyond the water limit. Is the water from irrigation from groundwater resources? Please see (Jaramillo and Destouni, 2014) and the Supplementary Materials on water storage change in basins due to these activities (Jaramillo and Destouni, 2015), for just a possible approach to this issue. Again, plotting the annual data based on Q observations could shed some light on the influence of these activities on the water cycle of the HRC basin. I know that the authors are not using the Q observations to do their Budyko's space analysis, but they are indeed using these observations to calibrate the model!

c) How can you separate Zone 1 and Zone 2 and plot them in Budyko space (Figure 8). The water system is not closed when doing this. Please explain further what this means, and what assumptions need to be done to do this separation.

2) I understand the term "groundwater evapotranspiration", however, it sounds a little bit strange to the general reader and me. How can groundwater (especially deep groundwater) evaporate (and/or transpirate) on a desert that has only sparse vegetation? Maybe some important information on the type of soils, a land cover map, location of shallow or deep groundwater could be useful to understand this process, and some process description that goes beyond the equations of the model. Some other issues:

âĂć What do the authors mean by "soil water" and "groundwater", what are the boundaries differentiating them? Page 11617. If groundwater is "within" the boundaries of the basin, changes in it should not represent a flux but rather a change in storage. âĂć

The diagram of the model (Figure 1) is never called in the text. âĂć A map of land cover of the basin could be useful. It is not clear how much vegetation and where it is located, and its location in terms of the location of the shallow groundwater. âĂć What is the purpose of Figure 4, it is also hard to see anything there. âĂć What do you mean by "regime shifts detected in Q" Page 11624 âĂć "The runoff ratio was decreased in actual due to irrigation water use, which weakened the linear relationship but remained the increase trend of Q/P vs. aridity index" Page 11629. What does this mean? I think that the role of irrigation has not been properly accounted for in this analysis.

References:

-Donohue, R.J., Roderick, M.L., McVicar, T.R., 2007. On the importance of including vegetation dynamics in Budyko's hydrological model. Hydrol. Earth Syst. Sci. 11, 983–995. -Jaramillo, F., Destouni, G., 2015. Local flow regulation and irrigation raise global human water consumption and footprint. Science 350, 1248–1251. -Jaramillo, F., Destouni, G., 2014. Developing water change spectra and distinguishing change drivers worldwide. Geophys. Res. Lett. 41, 8377–8386.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 11613, 2015.