Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2016-424-AC3, 2016

Hydrology and Earth System Sciences Discussions
Open Access

Interactive comment on "A Budyko framework for estimating how spatial heterogeneity and lateral moisture redistribution affect average evapotranspiration rates as seen from the atmosphere" *by* Elham Rouholahnejad and James W. Kirchner

Elham Rouholahnejad and James W. Kirchner

elham.rouholahnejad@usys.ethz.ch

Received and published: 20 October 2016

Hydrol. Earth Syst. Sci. hess-2016-424

Response to Referee #3

General comment We thank Referee # 3, for her/his comments on the manuscript.

Specific comments

- First concern We share the reviewer's concern about redistribution assumptions. In the manuscript we have tried to be very clear (page 12, lines 18-25) that our analysis of redistribution effects is inherently hypothetical; it is a "what if" analysis, not a prediction of how much redistribution will actually occur. The manuscript presents examples showing why, in the real world, the redistribution may not occur in the ways that we assumed it would, and we clearly emphasize that estimating the potential effects of lateral redistribution on ET in real-world cases are beyond the scope of this paper.

The reviewer's first point is that lateral movement is constrained by P-ET; that is, that only water that is "left over" after evaporative losses is available for redistribution. Many hydrologists will naturally adopt this as a starting assumption, or even as a simple statement of fact. But in reality all hydrological partitioning results from a competition between ET and gravitational drainage (to deep groundwater or streams), and it is not clear that ET always wins, or that ET's demands are always filled first, particularly when precipitation is seasonal or episodic. Precipitation that drains to great depth, or to streams, before it can be transpired becomes unavailable for evapotranspiration. Thus although it is conventional to think of Q+GW (discharge and net groundwater recharge) as being constrained by P-ET, it is more physically accurate to say that ET, Q, and GW are all constrained by water availability, which in turn is constrained by mass balance (P-ET-Q-GW).

Our analysis of redistribution effects assumes that lateral transfers will reduce the available water at the source location by the same amount that they increase it at the receiving location (Page 12, L9-12). We make this assumption because it is the most conservative, in the sense that it minimizes the net effect of a given amount lateral redistribution on average evapotranspiration.

On page 12, line 11, we discuss the case that the reviewer mentions: if the redistributed water were assumed to come only from surplus that is "left over" after evapotranspiration, the available water (and thus ET) in the source location would not be reduced while the available water (and thus ET) in the receiving location would be increased. As we point out in the manuscript, that scenario would lead to larger redistribution effects on average ET.

The reviewer also points out that lateral subsurface flows are likely to be captured by streams and thus unavailable for evapotranspiration at other locations. Of course we agree, but we have carefully defined "lateral redistribution", for the purposes of our paper, not as all lateral subsurface flow (regardless of its ultimate fate), but rather as water that does become available for ET elsewhere (either as groundwater flow, or as streamflow that re-infiltrates into valley aquifers). This is obviously only a fraction of all groundwater flow, as the reviewer points out.

- Second concern We agree that there is not a simple analogy between averaging over spatial heterogeneity and averaging over temporal heterogeneity, for the simple reason that the Budyko approach only makes sense over time scales for which storage changes can be ignored. We will make this clear in the revised manuscript. Greve et al. (1) have explored the possibility of using Budyko under unsteady conditions by modifying the Budyko framework, and we will mention this in the text.

Reference: 1. P. Greve, L. Gudmundsson, B. Orlowsky, S. I. Seneviratne, A two-parameter Budyko function to represent conditions under which evapotranspiration exceeds precipitation. Hydrol. Earth Syst. Sci. 20, 2195-2205 (2016).

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-424, 2016.