

Hydrol. Earth Syst. Sci. Discuss., referee comment RC2  
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## **Comment on hess-2021-55**

Anonymous Referee #2

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Referee comment on "Drivers of drought-induced shifts in the water balance through a Budyko approach" by Tessa Maurer et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2021-55-RC2>, 2021

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This paper investigates how the partitioning of precipitation into streamflow and evapotranspiration in 14 catchments in California responds differently to drought versus normal meteorological conditions. The main analysis these catchments undergo is based on the Budyko framework; the response of catchments along a calibrated parametric Budyko curve are assumed to be caused by climate, whereas other movements purely in the vertical direction (i.e. E/P or Q/P) that not follow the Budyko curve are assumed to be caused by a change in the hydrological functioning of the catchment. The results suggest that most runoff changes in catchments are caused by "predictable" shifts along the Budyko curve, but substantial effects of regime shift changes are also observed in many of the catchments. These results are further analyzed by examining the correlation between partitioning shifts catchment properties; low aridity index, high baseflow, shift from snow towards rainfall, and the resilience of high-elevation runoff correlate to increased runoff as a fraction of precipitation during droughts.

Better understanding the effects of drought on the precipitation partitioning across catchments is a relevant research goal. The use of the Budyko framework to study these changes has been widely applied for other aspects of the hydrological cycle (e.g. human versus climatic effects).

While the purpose of the study appears suitable and relevant for HESS, and the methods are largely similar to those widely applied elsewhere in hydrology, I have some questions and comments about the paper that would be good to address

The paper distinguishes between "regime" shifts, which result from changes in the aridity index along the same Budyko curve, and "partitioning shifts", which imply a change in the Budyko calibration parameter and thus to the relationships between evaporative demand, precipitation, and ET that govern partitioning of available water. However, what is the physical basis for assuming this? The Budyko framework is developed for characterizing long-term water balances, without any clear theory or evidence that the curve is also appropriate to characterize hydrological change of an individual catchments. I understand that many other papers use a similar approach, and it would be unfair to put the burden of proof on you (and not on the dozens of other previous papers), but I struggle to see how application of the framework like this is justified without any clear theoretical or empirical basis that this is a reasonable assumption.

Half of the catchments seem to violate the conservation of mass (i.e.  $ET > P + \Delta S$ ) in drought conditions. Does this not suggest that there is something off with the estimates on which all conclusions are based?

### **Detailed comments**

L15: would it be possible to say something more precise than this very generic closing part of the statement?

L26-27: I think this statement needs to be backed up by some references that support this is a widely accepted fact. Personally, I am aware of the possibility this is true, this stating it as an almost universal fact seems like a bit of a stretch (to me).

L201: How can the relative error have units mm, and are these relative errors calculated adding up over and underestimations of runoff, causing the overall relative error to be small?

L201: is the accurate simulation of runoff an assumed indication that the other fluxes (ET and  $\Delta S$ ) also are reliable?