

## ***Interactive comment on “Analyzing precipitationsheds to understand the vulnerability of rainfall dependent regions” by P. W. Keys et al.***

**Anonymous Referee #1**

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This is a well written and fascinating paper. I recommend that it proceeds further in the review process to make it a more rigorously presented and vetted work. My comments below are mainly as a first-cut without checking in detail the numbers (which should be done after the paper goes through major revision)

My first comment is on the use of the term ‘precipitationshed’. I think this is very interesting but it needs a section of its own for elaboration. As the authors state, the term is coined as an analogy of the watershed and surface water processes. However, more definition and quantification are desired, assuming that most readers will be thinking from the biased mindset of having prior knowledge of a watershed. It seems the precipitationshed is basically to define the ‘divide’ or boundary within which most of the recycling of precip takes place. The whole earth could be considered one universal

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precipitation shed with a recycling ratio of 1 (or 100%). So what exactly is the authors’ quantitative definition here? In figure 3 authors use both ‘absolute’ and 70% contribution to define boundaries. I think both could be very dangerous if not associated with qualifiers. What is really absolute without stated assumptions? If you consider ENSO and any other teleconnected phenomenon that results in precipitation, then the definition of the ‘absolute’ boundary does not stand. For example, one could argue that the East African monsoon is contributed by South Indian ocean/Arabian sea evaporation (neither is in the absolute boundary for West Sahel precipitationshed), which consequently affects the following season’s rainfall in West Sahel through soil moisture and terrestrial evaporation feedbacks. So, I suggest, the assumptions are made very clear up front and let the readers know what ‘absolute’ really means. The same goes for the 70% (which I guess it relative to the absolute?)

On the same comment of precipitationshed – I think it’s important to highlight the ‘dynamic’ nature of the ‘shed’ or boundary unlike watersheds where the topographic boundaries are very static even at climate timescales (unless one wants to go to geologic/paleoclimate timescales and incorporate erosion/subsidence etc.). So it seems to me that what the authors are aiming at is a more ‘climatologic’ definition of the boundary (not at the weather scale but not at the very long epochs either). Their shed delineation can only be as good as the reanalysis data they use (which should comprise a few decades). For example, I may accept the current precipitationshed for West Sahel as shown in Figure 3, but how can we be sure that this was the case before the Industrial revolution or even early 20th century when land use /land cover and atmospheric composition of green house gases hadn’t changed as much? So this means more qualifiers, discussion of assumptions and limitations upfront and in the conclusion section. Lastly, I think some in-situ ‘match-up’ would be preferable to show that the authors analysis agrees somewhat with observations. I don’t know how exactly to do this and there may not be a clear way – but perhaps greater use of MODIS vapor products, tracking them and using in-situ pan evaporation/weather station data, modeling etc. might help. For example, is it possible to show that the evaporation in Congo

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as well as in Botswana remains within the precipitation shed for West Sahel as Figure 3 indicates using observational data? Perhaps the recent paper of Gangoiti et al. (2011) in JGR might provide some guidance to authors.

Gangoiti et al. (2011). Origin of the water vapor responsible for the European extreme rainfalls of August 2002, JGR, vol . 116

The authors refer to a work of Millan (who is a co author above) and also of Knutsmann who has recently tied some vapor tracking work for the Volta basin to find out the contribution of lake volta evaporation to downwind precipitation (which is in the range of 7-10%). I suggest the authors read and then cite these papers as well.

On the boundary of the shed, does water balance work better than at the watershed scale? Authors should attempt to do the simple  $P-E=Q$  type of water balance over the domain defined by the precipitation shed, including the ocean evaporation, and river discharge into oceans to prove that their precipitation shed boundaries are physically consistent and have value for water management.

I also like the connection between upwind and downwind eco-systems, although that argument gets lost later in the narrative. It seems the focus of the study is mostly on the pure rain-fed ecosystems. I doubt if there is such pure rain-fed ecosystems of the scale of the West Sahel given how connected everything is. Perhaps an oasis in the middle of a desert may qualify. So I urge the authors to be more thoughtful of this issue. If there is rain, there may be some infiltration and ground water contribution to the ephemeral and perennial streams for future interaction in the local water cycle. West Sahel does include large parts of the Niger River where there is an inland delta, dynamic wetlands (also known to affect convective initiation – see Chris Taylor's work on this). I think discussions of the complex interactions or assumptions will suffice in this case.

The vulnerability discussion and analysis is really useful. It makes sense for 'pure' rainfed systems to do such an analysis. But as the authors state, perhaps it is better to

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call the assessment a sensitivity analysis rather than a vulnerability assessment.

Finally – figure 4 is a fascinating map alongwith the discussions on transboundary management. Just like transboundary water management, it makes more sense for more (far away but within the shed) nations to know what their precipitation sheds are and get together for a wiser and scientific utilization of the water resources. It might be wishful thinking, but it won't hurt for the authors to elaborate extensively on this point.

Side note: Elaboration on data (itemized) that was used in the study in the form of a dedicated subsection would be useful.

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Interactive comment on Biogeosciences Discuss., 8, 10487, 2011.

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