

## ***Interactive comment on “Comment on: “Spatial characterization of long-term hydrological change in the Arkavathy watershed adjacent to Bangalore, India” by Penny et al. (2018)” by Nitin Bassi et al.***

### **Anonymous Referee #2**

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Review of Comment on: “Spatial characterization of long-term hydrological change in the Arkavathy watershed adjacent to Bangalore, India” by Penny et al. (2018) by Nitin Bassi, B.K. Harish Kumara, Meera Sahasranaman, Arijit Ganguly

General comments: The authors of this comment provide a critique which mainly centers on highlighting the “choice of inappropriate methodology (for a watershed which is actually gauged) and faulty assumptions by Penny et al. (2018) for analysing the watershed scale hydrological changes, generating misleading results and inferences”. These are very strong words and I have read the comment as well as the original paper by Penny et al. and the supplementary material carefully to evaluate the arguments

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brought to the table by this comment. I have to say that while I agree that it would have been good to compare the results of the distributed remote sensing based study with the observation well data that Bassi et al. refer to, there are also some arguments that seem to be based on misunderstandings. It would be important to take another close look at these arguments, check their validity and if possible show how the conclusions of Penny et al. are wrong before the comment is published. If in the end all that is left is the statement that Penny et al. should have made the effort of obtaining the observation well data I am also not sure if this really warrants the publication of this sort of comment. In this case a comment during the discussion phase of the manuscript by Penny et al. would have probably been more useful. In general I think the comment would profit from a slightly less confrontational tone, especially as some arguments seem to be based on misunderstandings. Actually showing how Penny et al. came to the wrong conclusions concerning the spatial patterns and their links to land use by doing a similar analysis based on the data provided by Bassi et al. would make this comment much stronger, but it is not clear if the coverage and spatial resolution as well as the length of the time series is sufficient to actually do this. The two stream gauges do not seem sufficient, but you could try to do this with the 75 observation wells.

Specific comments:

p.1 l.24: what do you mean by “aggregate level changes”? Please rephrase or explain.

p.1 l.25: please clarify what spatial patterns you are referring to here. Do you mean the spatial patterns of long-term changes in runoff? Or the aggregate level changes? As I do not understand what you mean by that it would be good to phrase this more clearly.

p.1.l.29: It is not uncommon to use methods for ungauged catchments on actually gauged catchments, either because the spatial and temporal resolution of the existing measurement data is insufficient for the purpose or because the data cannot be attained. In this case Penny et al. wanted to investigate the spatial pattern of runoff changes at a higher resolution than the official stream gauges provided.

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p.2 l.8: "Often, existing resources with the official agencies to process and manage data properly are debated among the researchers" this sentence is unclear and needs to be rephrased.

p.2 l.17: what does it mean, a "fully operational WDC"? What do they do exactly? I tried to find more information on the internet, but could not find their webpage or a webpage describing their services. It is mentioned here <https://www.karnataka.gov.in/karhp/Pages/Hydrology-Project-I.aspx>, but this doesn't provide details on how to obtain data. It would be helpful if you could provide more information here.

p.2. l.24/25: I do not think it is very helpful to provide the numbers of observation sites of the Cauvery river basin here, please only focus on the study area of Penny et al., the Arkavathy catchment.

p.2. l.29: "Therefore, it is not clear which data paucity the authors are referring to." These are quite harsh words, given the fact that Penny et al. wanted to study the spatial patterns of hydrological changes in the 4250km<sup>2</sup> Arkavathy catchment. This is difficult to do if, as you state, only 2 stream gauges exist. It is admirable that there are streamflow time series starting from 1934 for the 81000km<sup>2</sup> Cauvery River, but this is also not helping much with the issue of spatial patterns in the Arkavathy catchment. I agree that it might have been helpful for the study of Penny et al. to compare their results with the 75 time series of groundwater observation wells. However, you say that this data is only available from 1996 onwards, while the Penny et al. study is focusing on changes for a longer time period between 1973 to 2010. In Table 1 you state "The requested data sets have to be obtained physically on payment of processing charges". What does this mean, "obtained physically"? Please clarify. Maybe you can also provide the information on how much the processing charges are? Please also provide the length of the time series for the two gauging stations in the Arkavathy Catchment.

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p.2/3 l. 31-2: I do not find this statement in the text of Penny et al. They state that "There is little research that addresses the emergent effects and heterogeneity of human-driven hydrological change across the watershed scales at which management decisions must typically be made. The gap in scientific understanding at management relevant scales is strongly associated with a lack of data resolution at these scales, and..." which to me refers more to the spatial resolution that is necessary to capture the heterogeneity of the patterns. I would therefore suggest to rewrite or omit this sentence as it seems to be based on a misunderstanding.

p.3 l.3-6: do these studies look at the spatial patterns of hydrological response within the catchments at high resolution? Please add this information.

p.3 l.13: Penny et al. wanted to assess the spatial pattern of the hydrological changes, not simply the integral of hydrological changes. Please rephrase and reconsider your arguments under this aspect. I think this is where the main misunderstanding lies.

p.3 l.19: There are only 5 of these reservoirs, which is probably not enough to capture the pattern and variability the authors were after.

p.4 l.1.: This is discussed in Penny et al. p. 601

p.4. l.3: or happening at  $S=S_{max}$ , so variations in overflow do not produce variations in  $S$ . (as stated in Penny et al.). Please do not oversimplify when referencing the original study, this actually weakens your arguments.

p.4. l. 12: You state "Third, the authors found that the variability in tank water extent due to precipitation across clusters spread throughout the Arkavathy watershed was similar (indicating no spatial variation in rainfall at the watershed scale) and for this they seem to have used rain gauging data for several locations (page 603 of Penny et al., 2018)." Penny et al. used rain gauge data from 62 locations and looked at trends from 1971-2010. The spatial variability of rainfall is resolved through the use of the large number of rain gauges. They show their results of the precipitation analysis in the

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supplement and state that there is significant temporal variability but no temporal trend, so the same result that you confirm in Figure 2 and p.4 l. 12-19. If I have misunderstood your argument here, please rephrase and clarify.

p.5 l. 8: "The rising water level is likely to be in wells located downstream of urban centers..." I don't understand this statement. Which of the wells are located downstream of urban centers? This is something you know, not something you have to speculate on. Please clarify.

p.5 l. 10: The issue of wastewater increasing river water levels and leading to seepage into the aquifer: This seems to me to be an issue that is not really related to decreasing water storage due to irrigation with groundwater. And isn't this mainly affecting wells and aquifers directly adjacent to the rivers downstream of the urban centers? This sounds like a more local effect. What about groundwater elsewhere?

Table 1: please only focus on the Arkavathy Catchment and the data available here, as this is the point of the comment. Providing measurement locations for the entire state of Karnataka is confusing and not really helping the discussion.

Figure 1: The figure is too small and not readable. I suggest focusing on the Arkavathy Catchment as this is where the study of Penny et al. took place. Also include the location of the 75 observation wells, possibly also indicating the length of the respective time series.

Figure 3: Is this based on simply comparing the annual mean water levels in 1996 and 2015? It might be more interesting to supply the actual time series. Please also provide the locations of these wells in the map of the Arkavathy Catchment (revised Figure 1). It would also be more useful to actually show the entire data set of groundwater time series of all 75 observations wells. That would be much more convincing than showing just a selected few.

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