Review of Oldham et al: Evidence-based requirements for perceptualising intercatchment groundwater flow in hydrological models.

RC2: 'Comment on egusphere-2022-529', Anonymous Referee #2, 10 Oct 2022 reply		
1.	Non-conservative reaches and catchments are popular in groundwater-dominated regions and karst areas. Perceptualizing of hydrological processes in these regions is of great importance as it enables us to recognise where intercatchment groundwater flow (IGF) may be occurring and highlights the need for local investigation. In this study, a framework is proposed to evaluate the spatial and temporal IGF and applied to the River Thames with wealth of data and densely gauged river network. It is an interesting topic in hydrology, and the manuscript is well organized. However, there are still several problems and deficiencies in the paper and further revision is needed.	The authors would like to thank the reviewer for their detailed and constructive comments on our paper. In response:
2.	The water balance is the basic metric to recognize the IGF and the term AET plays a key factor in determine the metric. However, the estimation of the AET contains great uncertainty and AET has great spatial variability in large mountainous basin. The uncertainty in estimate of AET and then water balance metric should be analyzed.	For the purposes of quantifying why we can state that our interpretation of IGF processes via water balance (WB) anomalies are justifiable, rather than just uncertain, we will present an uncertainty evaluation of not just AET but the P, Q and AET time series estimates. This will use a simple error model to generate multiple time series for an example catchment as per Lloyd et al. 2016 and calculate the resultant WB uncertainty range. From this we will be able to state more categorically why our thresholds for considering a WB anomalous, and thus attributed to IGF type processes, can be stated. Lloyd, C.E.M., et al., Discharge and nutrient uncertainty: implications for nutrient flux estimation in small streams. Hydrological Processes, 2016. 30(1): p. 135-152. DOI: 10.1002/hyp.10574
3.	Line 393-410. The analysis of water balance at inter-annual scale should be careful, as the temporal variation of water balance metrics is more complex than that for the multi-year average condition. For example, the soil water storage is a nonnegligible term for water balance. Further, the change of groundwater level is mainly controlled by local hydrogeological conditions. That's for sure, there are significant differences in the temporal variation of hydrological factors among	Firstly to say we are answering this reviewer comment by assuming they meant intra-annual not inter-annual. We agree that intra-annual analysis of water balance is indeed challenging but we would argue that one can still explore seasonal patterns of behaviour if the assumptions are recognised when doing so. However, we have re-focussed our temporal analysis sections into a review of the climatic and river flow components of the water balance, and groundwater levels. We made edits to the text to clarify that we are not

	hydrogeological units. But I don't catch that how these reflect or indicate the differences in IGF.	quantifying metrics of IGF from this analysis, as we do not believe that is possible from a reach-length based water balance analysis. However, we are inferring that by presenting information on the hydrological and hydrogeological characteristics of (and between) the different hydrogeological units that these are evidence of the fact that IGF flows might be important and such analysis has value for the hydrological modeller when considering where IGF processes may be needed.
4.	The perceptual model of the Thames is of great importance in the paper (Figure 8). But it seems confusing as too many lines and explanatory text. I suggest authors reorganize the figure 8.	We purposefully designed a perceptual model diagram that incorporated the visual mapping and qualitative information elements common in hydrogeological conceptual models, to illustrate the approach commonly taken by hydrogeologists and the method of presenting a wealth of information in one figure. We admit that the figure is busy but think that reducing or reorganising it would reduce its impact.
5.	A description of climate, especially the spatial and temporal variability of P and AET, is needed for the basin in the section of study area. A brief introduce of the runoff depth and its temporal varation for the basin is also needed.	We have added text on rainfall, PET and runoff in the Study Area section and added a figure in our new Supplementary Information document showing their spatial variability across the catchments. AET is one of the products of our analysis, as is the investigation of temporal variability, so we feel that these elements should be introduced later than in this Study Area section.
6.	It will be helpful to understand the degree of losing and gaining of reaches.	We agree that this is of high interest given the subject topic of IGF, but again is a product of our results and therefore we feel it appropriate to only be discussed in the Results section.
7.	Line 220. "A positive residual" is , which should be pointed out clearly.	Done.
8.	Line 265. More explanatory text is needed for figure 2.	We have developed the text to strengthen the link between the literature quoted and the figure (section 3.2.3), and further explained the use of the perceptual roadmap in the identification of IGF.
9.	Line 380. In figure 5, the water balance metric is greater than 1000 mm/yr in several catchments. The value seems too large for the region. The authors may check it carefully.	The unusual water balance results stem from the combination of a number of different factors, all highlighting the challenges when undertaking such an analysis. Firstly, we are calculating water balance at the reach, not catchment, scale. Significant differences between the topographical surface water catchment and the underlying groundwater catchment are

		exacerbated when discretising datasets based on topographic boundaries. In addition, the uncertainties associated with the location of, and scale of, human influences are considerable when assigning reach-scale impacts. We discuss how the >1000 mm/yr results in the Lower Thames are likely as a result of these surface water abstraction and discharges in section 5.1, directing the reader to the more detailed discussion on the topic of naturalisation in section 6.3.
10.	Line 413. In figure 7, what are the means of shadows in the sub-figures (a)-(g) and different colors of curves in (h)-(o).	An explanation of the shadows and different coloured lines was indeed missing and has been added to the figure caption. Thank you for raising this omission.
11.	Lines 600-6015. In this section, the authors should focus on what you have found in the paper rather than suggestions.	The authors feel that a combination of both a summary of what we have found and suggestions for further work are of merit in this section, in particular as our subsequent papers will be aiming to address some of the issues and “further work” topics we make note of.