EGUsphere, referee comment RC3
https://doi.org/10.5194/egusphere-2022-529-RC3, 2022

Comment on egusphere-2022-529

Anonymous Referee #3

Referee comment on "Evidence-based requirements for perceptualising intercatchment groundwater flow in hydrological models" by Louisa D. Oldham et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-529-RC3, 2022

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

General comments:

It is a common fact that water actively exchanges between surface divides in regions with carbonate fractured aquifer outcrops. This have challenged the 'watertight substratum' assumption that is the foundation of many existing catchment rainfall-runoff models for long time without appropriate solutions and model conceptulizations. The main aim of this manuscript is to improve our perceptual models of intercatchment groundwater flow. The authors took advantage of their wealth of data, densely gauged river network, and geological variability from national meteorological, hydrological, hydrogeological, geological and artificial influence datasets to develop a perceptual model of intercatchment groundwater flow (IGF) and to show how it varies spatially and temporally in 80 subcatchments of the River Thames, United Kingdom (UK). The water balance, presence of gaining/losing river reaches and intra-annual dynamics were investigated through a water balance analysis.

The study is important for hydrological predictions and water resources management in groundwater-activated catchments. However, the method adopted by the authors can only provide site-specific results about qualitative water balance, it is still difficult to represent regional inter-catchment groundwater dynamics as they could not provide some essential functions that describing how groundwater between neighbor units exchanges according to different conditions of groundwater levels, different lithology, human abstractions and so on. In order to couple IGF processes into existing hydrologic models, it is important for the authors to derive the IGF functions quantitatively describing how IGF varies with time, groundwater levels and abstractions, ….

The water balance equations (1)-(4) adopted are also not rigorous as discussed by the authors themselves in Section 6.3 that input data uncertainties can lead to large computational uncertainty. In fact, equations (1) or (3) represent multiyear water balance instead of single year water balance. So $dS/dt=0$ is not strictly true, and a empirical 100 mm/yr was used by the authors to help to identify the non-conservative reach water balance. As the IGF fluxes could not be measured directly in catchment scale, empirical estimation is inevitable. However, the fudge factors e.g., 100 mm/yr as well as the physical meaning of S (groundwater storage or soil water storage?) should be discussed in depth.

The quality of many figures could be further improved e.g., to fully show the reach units are subdivided and to accompany their figures tightly with the text words to upgrade the readability. The reviewer suggests that reach units can be subdivided into two categories, the headwater reach and the internal reach. The water balance of reach units from the headwater areas which is recharged singly by precipitation in conservative catchments should be highlighted in order to identify the leakage recharge from outside catchment.

Specific Comments:

P means page, and L means lines

P4L120: Here annual average precipitation for the whole basin and its spatiotemporal distribution is needed. Discharge volume of main gauges also should be provided.

P6L144-146: “reach as the catchment area between river gauging stations. The analysis undertaken in this study is developed at the river reach scale rather than at the sub-catchment scale”. However, the title of this manuscript is “…perceptualizing inter-catchment groundwater flow…”. What is the difference between reach drainage area and sub-catchment? Are the units presented in Figure 1c the reach units? I suggest that the authors provide reach units distribution map in terms of the river gauging stations.

P7L175: Provide the cells adopted for water balance computations.

P8L175: “A limiting factor of 70% of the total reach area was assigned as an indicator of reach coverage.” What is the meaning of 70% here.

P8L217-219: S represents many storage components, e.g., groundwater storage, soil water storage, vegetation water storage, etc. how do they calculate groundwater exchanges without eliminations of other terms. It is possibly due to this reason I guess that an empirical factor 100mm/yr was adopted (see in Lines 573-576), which helps to filter disturbance from other terms? In addition, equation (1) or (3) can represent multiyear water balance instead of single year water balance. So the authors should explain the limits of using these equations.

P12L315-316: “Due to the high storage (Table 1)”. In table 1 lower greensand aquifers are with the lowest average (0.005) storage coefficients? Why you claimed the high storage in the main text? Similar expressions can be seen also in P11L290, P21L479.

P13L340-341: “The three lowest main river reaches show particularly large naturalised water balance losses (>1000 mm yr-1)”. I noticed that the average annual precipitation of Thames basin is only about 710 mm (Gabriel et al., 2022). Why so much losses of water (>1000 mm yr-1) in the main reaches in the River Thames? Do you have the losses averaged over the reach units? In P14L349-357, other values about water losses or gains seems to be regular. However, I don’t understand how do you convert the water losses into water depth. I suggest that the authors may use water losses volume in m^3 yr-1 instead of water depth since the reference reach unit area is quite difference and upstream inflow is also different from up to down river reaches.

P14L362: what is the raio of 622 mm yr-1 annual loss in total volume of precipitation in the Kennet headwater reaches. As we know, headwater reaches do not receive upland surface inflow, so the net loss of 622 mm is large compared to the annual precipitation 710 mm over the whole basin.

P19: I suggest that the total amount of groundwater exchange should be marked in Figure 8. And how do you judge the flux directions? From the method in Section 3, I do not find related algorithm for estimating the flux directions.

P20L454-455. “The Chalk of the Thames Basin can be locally sub-karstic, but fracture and fissure flow remain the primary groundwater flow”. It maybe true as you claimed, however, if the IGFs should occur in the relatively less passageways of karstic conduits?

P21L503. It is true that not including IGF as a model flux will result in many models overestimating river flows or actual evapotranspiration. But the key question may be to describe how groundwater between neighbor units exchanges according to different conditions of groundwater levels, different lithology, human abstractions and so on.

References:

Gabriel, R.K.; Fan, Y. Multivariate Hydrologic Risk Analysis for River Thames. Water 2022, 14, 384. https://doi.org/10.3390/w14030384.