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Hydrology and Earth System Sciences Discussions

# *Interactive comment on* "A fluid-mechanics-based classification scheme for surface transient storage in riverine environments: quantitatively separating surface from hyporheic transient storage" *by* T. R. Jackson et al.

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Paper: A fluid mechanics based classification scheme for surface transient storage in riverine environments: quantitatively separating surface from hyporheic transient storage.

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This manuscript is exciting in its efforts to create a new classification scheme for ecosystem structure and function. It seeks to characterize the mean flow structure



and scaled-geometry in 8 geomorphic features, referred to as surface transient storage (STS) zones, common to rivers. The STS is considered by the authors as 1 of 2 zones where solutes can reside when not in the main channel (MC) flow regime, the other zone being the hyporheic transient storage (HTS) zone. Ideally, the characterization would allow for a predictive estimate of STS residence time based on geomorphic geometry and solute break through curves of total transient storage (TS), and from that scientists would be able to determine the fraction of solute residence time and volume spent in the MC, the STS, and the HTS. In prior experimental and analytical work the authors developed such a relationship between geometry and STS residence time for the river embayment STS. In this manuscript they classify the embayment as an emerged lateral cavity, which they contrast with submerged lateral cavities, both belonging to the first of the 8 geomorphic features, and provide their predictive equation. The other 7 geomorphic features are: Protruding in-channel flow obstructions (backward and forward facing); Isolated in-channel flow obstructions (emerged and submerged); Cascades and riffles; Aquatic vegetation (emerged and submerged); Pools (vertically submerged cavity, closed cavity, recirculating reservoir); Meander bends; and Confluence of streams. The manuscript does not establish predictive relationships between these 7 geomorphic features and STS residence time. However, for most of these 7 other features the manuscript provides a list of the explanatory variables thought to control the residence time.

This study is presented as providing foundation for future studies in areas of fluid dynamics, geomorphology, and hydrology. The manuscript suggests specific terminology of geometries may help clarify discussions in hydrology about structure and function relations (pool example and the hydraulic reversal theory). The manuscript suggests the use of a fluid mechanics approach to characterize STS and use key hydromorphic parameters (mean flow structure) to influencing mean RT. Hydromorphic parameters will be used to estimate mean RT for each STS (width to length ratio, Re ranges). The authors did a wonderful job illustrating and explaining the idea around coherent structures formed in the velocity shear region by instabilities (Kelvin Helmholtz, etc), and then illustrated 3 types of free shear flows – jets, wakes, and mixing layers.

Suggestions:

The manuscripts conceptual model of solute residing in the MC, STS, or HTS zones is common, however it may be flawed in the application around high turbulence zones and with unsteady flow typical to these geomorphic structures. The data collected in our field work and the subsequent testing of this MC, STS, or HTS conceptual model suggest solute spends significant time in transition through intermediary locations linking the MC and STS zones. As one example, if we propose the MC and STS are each well-mixed, we should see solute leaving one zone and entering the other, but our data show that the solute spends time in several intermediate zones along the shearing fringe. I suggest the manuscript examine the weaknesses in this conceptual model for MC-STS exchange. If the STS has indistinct boundaries with the MC and there is no exact method of delineating the zones, how do we account for significant (> than median residence time) transition times between these two zones?

The reader would benefit greatly if the manuscript could provide a list of variables and their definitions that are used in the equations; this will help the reader readily find the definition of these variables.

The manuscript cites Bukaveckas 2007 regarding the impact of hydromorphic parameters on in-stream structure design. I caution the reference to this citation without contacting the author and asking about some odd data results where that study found the OTIS model required significant lateral inflow (q), creating huge increases in streamflow along the reach, to explain the transient storage around in-stream structures. It is not clear if the author would have a new explanation for that model result given the new research results over the past 8 years, and perhaps the new explanation would be that this large lateral inflow suggests large STS around the structure.

Questions:



The structure of the flow obstruction to STS function relationship is attractive but not enough functional examples were provided to determine if the 8 distinct flow obstruction structures are related to 8 distinct functions – are they likely to be distinct?

Eq 2 is a wonderful relationship to move from geometry to RTD, but Eq 3 is only a list of variables that are likely to influence RTD. The authors might try to determine direct vs inverse relationships for the variables. Eq 10 provides timescale of the wake zone in submerged aquatic vegetation.

Why limit the discussion to 8 flow obstruction structural classes – are there other interesting combinations that are common in natural rivers? I think of any of these structures in series or parallel.

Are the hydraulics really coherent structures? These are perhaps identified as such in very large rivers or ideal situations with flumes when the roughness of the bed and the discharge does not vary in time or space. In natural rivers the bed roughness likely varies in space and discharge often varies, so the coherence of the hydraulic structures is not certain.

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Table 2 parameters are not consistently present in the illustrative figures; for example Figure 12 (pools), Figure 13 (meander), and 14 (confluence) have none of the case specific parameters listed in the corresponding rows of Table 2. Again, the entire suite of these parameters should be defined somewhere in the text.

Figure 2 has 4 components (3 at top in plan view, 1 at bottom in oblique view) that could be labeled A - D. When Figure 2 is introduced with the text in section 2.2 (line 25) the top planview parts of the figure doesn't clearly illustrate the 3 zones using the same terms – detachment, reattachment, and counter-rotating gyres; in the bottom figure it has 2 of these terms, but uses recirculation region in the text and primary gyre in the figure. Try to harmonize these elements; also consider if you need to show the adverse pressure gradient you take care to note in the same section of text. Consider illustrating the entrained vortices that cause the recirculation.

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