Comment on "Porewater flow due to near-bed turbulence and associated solute transfer in a stream or lake sediment bed" by M. Higashino et al.

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In their recent work, *Higashino et al.* [2009] have presented an analysis of the surface-subsurface exchange of water and solutes caused by near-bed turbulence. In particular, the authors have discussed the exchange driven by pressure waves induced by coherent turbulent structures on a sediment bed. Given the ubiquity of turbulence in free-surface flows, the subject of the study is very relevant for the ecology of both surface and subsurface waters. Unfortunately, we have found some problems in the mentioned work that could limit the validity of their findings. These problems lay in the scaling laws they adopted to describe the near-bed pressure field and in the interpretation of their experimental results. We discuss both issues below, with the aim of suggesting how to establish the relevance of their findings.

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In *Higashino et al.* [2009] the authors point out that the velocity fluctuations occurring within a permeable bed underlying a turbulent open channel flow are induced by the unsteady pressure field generated at the sediment-water interface. They assume that the spatial and temporal scales characterizing such a pressure field are dictated by the spatial and temporal scales of near-bed coherent structures typical of hydraulically smooth open channel flows. These include flow structures which scale with "inner" flow parameters such as the viscous length and the friction velocity (equations (1)-(3)). This assumption can be challenged for two reasons: first, recent experiments and numerical simulations show that the r.m.s. of velocity and pressure fluctuations within a permeable bed are mostly due to the passage of large coherent structures scaling with "outer" flow parameters, such as the flow depth (boundary layer thickness) and the friction velocity (*Vollmer et al.* [2002]; *Breugem et al.* [2006]; *Manes et al.* [2009]). Typically, such structures are one flow depth high, one flow depth wide and 4-6 times the flow depth long (*Shvidchenko and Pender* [2001]; *Roy et al.* [2004]). Furthermore, *Vollmer et al.* [2002] point out that most of the pressure fluctuations induced by near-bed coherent structures (i.e. the "inner" coherent structures considered in the work of *Higashino et al.* [2009]) into a gravel bed are filtered out in the uppermost layer of the sediment bed (within the first 4 grain-diameters), whereas the large scale pressure fluctuations persist within the whole bed thickness. On the basis of these results it seems that the interstitial flow within a permeable bed is controlled by "outer" rather than "inner" flow structures.

More importantly, the presence of the viscous length in equation (1) poses a problem for its following application to the interpretation of the experimental results. As correctly stated by *Higashino et al.* [2009], the equation is valid for a sediment bed with a smooth surface, while their experiments were conducted on a gravel bed and in hydrodynamically-rough flow conditions. The application of a smooth-wall law to such experiments is clearly inappropriate and cannot provide reliable predictions of the exchange flux.

Another issue with the interpretation of the results is the graphical representation of Figure 13 which makes it difficult to understand whether or not the results agree with the model predictions. The late-time value of the in-stream concentration depends on the ratio between the volumes of stream and pore water and not on the magnitude of the exchange flux V_0 – defined in equation (19) – which can only influence the rate of concentration decrease. Thus, the model should be able to reproduce the progressive decay of normalized in-stream concentration and not only its asymptotic value. Unfortunately, the concentration decay is partially obscured by the fluctuations caused by the initial tracer mixing in the surface water volume, as correctly pointed out by the authors. This fact makes even more necessary to verify the fit between predicted and observed tail of the concentration curve, which is still controlled by the exchange flux without the noise introduced by the initial mixing. This comparison is difficult because dimensionless concentrations vary between 0.8 and 1, which is only a small part of the full axis range (0-1) shown by *Higashino et al.* [2009] in Figure 13. The concentration decay could be appreciated more easily by using a closer zoom on the higher values of concentrations in a similar way to the analyses presented by previous works of the authors [*Qian et al.*, 2008, 2009a, b], or possibly adopting a semilogarithmic scaling as in *Boano et al.* [2009].

The described procedure would allow to estimate values of the exchange flux V_0 from the observed concentrations, and these values could then be compared to those predicted by the model with the choice of proper scaling laws instead of equations (1) and (3).

A mismatch between calibrated and modeled values of V_0 would indicate that turbulent pressure fluctuations were not the only cause of the stream-sediment exchange observed by *Higashino et al.* [2009]. Actually, *Boano et al.* [2009] have observed that unstable density gradients caused by concentration differences between surface and pore water can induce water flow through the streambed. The experiments of *Higashino et al.* [2009] were conducted in much more permeable sediments than those of *Boano et al.* [2009], and the observed increase of water conductivity for the whole sediment bed in Figure 12 suggest that gravity-driven flow could have played a role in the experiments. In such a case the calibrated values of V_0 would show some degree of correlation with the stream concentration, and care should be taken to avoid confusion between the different exchange processes.

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