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Hydrodynamics and contaminant transport on a
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► **To cite this version:**

Sébastien Pouchoulin, Pedro Xavier Ramos, Emmanuel Mignot, Laurent Schindfessel, Tom de Mulder, et al.. Discussion of "Tang, H., Zhang, H., & Yuan, S. (2018). Hydrodynamics and contaminant transport on a degraded bed at a 90-degree channel confluence. Environmental Fluid Mechanics, 18(2), 443-463". Environmental Fluid Mechanics, 2018, 18, pp.1293-1295. 10.1007/s10652-018-9612-x . hal-02085882

HAL Id: hal-02085882

<https://hal.science/hal-02085882>

Submitted on 1 Apr 2019

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Discussion of “Tang, H., Zhang, H., & Yuan, S. (2018). *Hydrodynamics and contaminant transport on a degraded bed at a 90-degree channel confluence*. *Environmental Fluid Mechanics*, 18(2), 443-463”

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Abstract

The authors measured and computed the hydrodynamics and passive scalar dispersion in 90-degree open channel confluences over flat and degraded beds with a dominant upstream or tributary inflow. The present discussion essentially deals with the direction of rotation of the secondary currents, reported for the flat bed configuration with dominant tributary inflow. This rotation direction is indeed surprisingly opposite to the ones reported in the literature, both from calculations and measurements, even if present geometry slightly differs from literature geometries.

Discussion

The authors present an interesting work on hydrodynamics and passive scalar transport in asymmetric open-channel confluences both over flat and degraded beds. The paper deals notably with degraded bed configurations, which bring undoubtedly interesting new knowledge, since flat bed intersections have been more frequently addressed. The comparison of these existing flow descriptions with the authors' results motivates the present discussion. This is especially the case for the 90° angle confluences in which the three branches have a rectangular cross-section of equal width (*i.e.* a geometry which differs somewhat from the one considered by the authors, where the downstream branch has a 33% larger width than the tributary and the upstream branches). Several flow structures are reported by *e.g.* Best (1985), Shumate (1998) and Weber *et al.* (2001): the shear layer at the interface, the stagnation zone, the recirculation zone and the secondary currents in the downstream branch. In particular, as the momentum ratio between the tributary and upstream branches (which simplifies into the square of discharge ratio for equal widths of the incoming branches) exceeds 1, a helix-shaped secondary current occurs in the accelerated flow region besides the recirculation zone of the downstream branch. Further downstream, this helix-shaped current occupies most of the section of

the downstream branch. As mentioned by the authors, this secondary current strongly affects the passive scalar transport downstream from the confluence (see also *e.g.* Chen *et al.*, 2017).

For the aforementioned confluence case (*i.e.* a concordant flat bed case with equal width channels and a tributary to upstream momentum ratio exceeding 1), the flow patterns were previously measured by Weber *et al.* (2001) and Schindfessel *et al.* (2015) (with a chamfered rectangular cross-section) and computed by Huang *et al.* (2002), Shakibainia *et al.* (2010), Yang *et al.* (2013), Riviere *et al.* (2015) and Schindfessel *et al.* (2015). All these works indeed report a helix-shaped secondary current in the accelerated flow region besides the recirculation zone (and beyond) of the downstream branch. Nevertheless, the rotation direction of this helix-shaped current differs from the one computed by the authors in their scenario S3/S7. All previous works report a secondary flow coming from the tributary that passes above the upstream flow, then plunges along the opposite wall and returns towards the tributary bank along the near-bed layer. For the sake of conciseness, this rotation direction will be referred to as “classical” in the sequel. Oppositely, the authors’ S3/S7 flow pattern (plotted in figure 7, 3rd column and 3rd to 5th line) exhibits a helical motion in the opposite rotation direction, with the tributary flow plunging below the upstream flow towards the opposite wall, then rising along this opposite wall ($y/W_d \sim 1$), returning towards the tributary bank ($y/W_d \sim 1$) in the near-surface layer and finally plunging to close the loop. As this computed direction of rotation is the opposite from the classical one, it would be necessary to compare it to experimental data for verifications. Unfortunately, measured transverse velocities characterizing the secondary flow are not shown for scenario S3/S7. Therefore, discussers would be grateful if the authors can plot the secondary current measured for this scenario and discuss the computed rotation direction.

Regarding passive scalar dispersion, Riviere *et al.* (2015) in their figures 5 and 7 (right column) show that the secondary current rapidly transports by advection i) water coming from upstream towards the tributary bank along the near-bed region and ii) water from the tributary to the opposite bank along the near-surface region, *i.e.* along the classical rotation direction. The mixing efficiency is then enhanced for this tributary dominated configuration compared to the flow patterns with an upstream velocity exceeding that of the tributary. Oppositely, the scalar fields computed by the authors indicate that their tributary flow (red in figure 8c and blue in figure 9c) plunges below the upstream flow and is

transported towards the opposite bank along the near bed region, while the water from the upstream flow is transported towards the tributary bank along the near-surface region. Riviere *et al.* (2015) then conclude that “these helical motions strongly enhance the mixing process”. This is a strong contradiction with the author’s statement that “... the magnitudes of V and W components are very small, and thus they have a limited effect on the flow structure and mixing at channel confluences”. Reasons for the inverted computed helical motion by the authors cannot be attributed to the turbulence model as the authors resolve the 3D-RANS equations using a Reynolds Stress Turbulence model, similarly to Riviere *et al.* (2015), who retrieve the classical rotation direction of the secondary flow. It can neither be attributed to the free-surface calculation technique as the authors apply the VOF method, similar to Yang *et al.* (2013) in their run 5. The non-classical rotation direction may be related to the vertical profiles of transverse velocity (along y axis) in the tributary near $y/W_d \sim 0$ (Fig. 7, 1st line, 3rd row) showing a velocity maximum at a relatively low elevation above the bed, i.e. in the lower half of the water column. This could be connected, perhaps, to the authors’ channel geometry where the wider downstream branch forms a non-classical intersection compared to the literature. Again, a plot of the experimental vertical profiles of transverse velocity at the upstream and downstream ends of the tributary would be invaluable to conclude on this rotation direction being odd with the ones reported in the literature.

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