Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2016-553-RC1, 2017

Hydrology and
Earth System
Sciences
Discussions

Interactive comment on “The physics behind Van der Burgh’s empirical equation, providing a new predictive equation for salinity intrusion in estuaries” *by* Zhilin Zhang and Hubert H. G. Savenije

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Received and published: 4 February 2017

The author gives an emphasis on the physical foundation of Van der Burgh’s equation, K, that makes a connection between the empirical equation and theoretical literature, which limits K value between 0.5 and 0.66 keeping within the feasible range ($0 < K < 1$). Additionally, a one-dimensional predictive equation has been developed for salinity dispersion along the estuary which subsequently provide a new predictive equation for the longitudinal salinity distribution. Finally this equation has applied to 18 estuaries among which the three estuaries have the constant depth. This paper can attract a great deal of attention. However the manuscript has critical issues in applying of the model to the real estuary.

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Major comments:

1. This new equation limits K value between 0.5 and 0.66. If K is 0.5, then density-driven dispersion occurs and dispersion is proportional to salinity gradient (page 10, line 24-25). If K is 0.66, dispersion is dominated by lateral exchange in wider part of estuaries and proportion to the square of salinity gradient (Page 10, line25-26). In addition, the calibrated K values of 18 estuaries ranged from 0.45 to 0.78. Does it mean only density-driven or lateral exchange in the 18 estuaries? New K suggests that dispersion is dominated by density-driven in most estuaries where were classified as tide-driven dispersion (see example in Table 1). What happen in real estuaries? This should be addressed.

2. What sort of mechanisms are responsible for dispersion downstream of Maputo (10 km from the mouth, Fig. 4), Kurau (5 km from the mouth, Fig. 4) and Endau (10 km from the mouth, Appendix C) where there is no horizontal salinity gradient? In addition, the larger the K value, the stronger the lateral exchange (Page 10, line 28-29). Previous literature (Savenije, 2005, 2012) implies that if K is larger, the stronger gravitational circulation exist near the toe of salt intrusion. Is it contradict with the previous literature? Moreover, the new equation narrowing the range of K, and makes contradiction with the K value of some estuaries (Table 5.4, 5.6 Savenije, 2012).

3. The author suggested the constant K value spatially if the depth is constant (Line 22, page 10: “yet, from Eq. (10), the K value should be constant if the depth is constant”). Among 18 estuaries where the newly developed Van der Burgh’s equation has been applied to, only three estuaries (7, 8, and 14, Table 1) have the constant depth as the values of a and b are the same (line 3, page 9, Table 1). Moreover, K is affected by tide, geometry (Gisen, 2015) and freshwater discharge (Shaha and Cho, 2011; this study also) (line 19 page 10). What is the justification to suggest the constant K for an estuary? This would be better to explain for understanding clearly by the reader.

Minor comments:

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1. The tidal excursion length E appears first in Eq. (10). This would better to define here rather than after Eq. (12). 2. In line 5, page 6: The lateral exchange is proportional to longitudinal (Fischer, 1972). This should be longitudinal salinity gradient. 3. In line 3, page 10: “A” smaller value. “A” should be small letter. 4. Figure 2: S1, S2, S3, SL and SR are not clear. 5. Table 3: Kcalibrated would be better instead of K.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-553, 2016.

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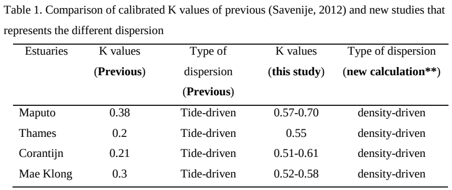

Table 1. Comparison of calibrated K values of previous (Savenije, 2012) and new studies that represents the different dispersion

Estuaries	K values (**Previous**)	Type of dispersion (**Previous**)	K values (**this study**)	Type of dispersion (**new calculation****)
Maputo	0.38	Tide-driven	0.57-0.70	density-driven
Thames	0.2	Tide-driven	0.55	density-driven
Corantijn	0.21	Tide-driven	0.51-0.61	density-driven
Mae Klong	0.3	Tide-driven	0.52-0.58	density-driven

Fig. 1.