Dear Anonymous Referee#1,

We are very much grateful for your valuable and fruitful comments to improve our manuscript (hess-2010-332). The responses to each comment (blue font) are given with black font in the following.

Specific comments:

Q1. A clear definition of K independent on the particular geometry must be given. Is K defined by Eq. (1) or (7) or as the relative weights of the tide-driven and density-driven mixing mechanisms?

Ans: Van der Burgh's coefficient K is a sort of 'shape factor' influencing the shape of the salt intrusion curve (Savenije, 2005). This K is closely related to the general characteristics of an estuary such as the geometry, tidal characteristics (e.g. tidal damping) and channel roughness (Savenije, 2005). Considering this, Savenije (2005) provided the following predictive equation for K.

$$K = 0.2 \times 10^{-3} \left(\frac{E}{H_T}\right)^{0.65} \left(\frac{E}{C^2}\right)^{0.39} \left(1 - \delta b\right)^{-2.0} \left(\frac{b}{a}\right)^{0.58} \left(\frac{Ea}{A_0}\right)^{0.14}$$
(1)

Equation (1) clearly shows the dependency of K on the geometry. However, the predictive value of this equation is weak as the value of K does not always lie between zero and unity (Savenije, 2005).

K defined by Eqs. (1) and (7) are the same. In addition, *K* can also be defined as the proportion of total effective dispersion to the tide-driven dispersion, following the definition of estuarine parameter *v* of Hansen and Rattray (Savenije, 2005). This definition has inserted in the published manuscript in HESSD (page 8, line no. 1) and *K* has described as the relative weights of the tide-driven and density-driven mixing mechanisms in this study. *K* values calculated from K=1/v does not lie between 0 and 1 due to the assumption of constant cross-section (Savenije, 2005). As *K* determine the shape of salt intrusion curve, *K* can be assumed as the reciprocal of estuarine parameter *v* with an expontial function $[K=1/\exp(v)]$ for an exponentially shaped estuary or in an estuary with a non-linear salinity distribution, following the assumption of McCarthy (1993). This assumption clearly satisfy the range of *K* values (0<*K*<1) suggested by earlier researchers (Savenije, 2005, Eaton, 2007) through describing the spatially varying relative weights of tide-driven and density-driven mixing mechanisms. The value of *K* calcualted with this assumption also support *K*-based dispersion equation, which applied in 20 estuaries worldwide (Savenije, 2005), more reasonably compared to the calibrated single *K* value, shown in Figs. 6 and 7 (published in HESSD). In the revised manuscript, the definition of *K* will be clarified.

Q2. Why *K* should range between 0 and 1?

Ans:

The answer of this question is given below from Savenije (2005, page 133).

Van der Burgh's coefficient K is a sort of 'shape factor' influencing the shape of the salt intrusion curve. The application of this approach for an estuary with exponentially varying cross-section is explored as follows.

The general steady-state salt dispersion equation is given as follows (Savenije, 2005):

$$DA\frac{\partial S}{\partial x} = QS \tag{2}$$

where D is the longitudinal effective tidal dispersion coefficient, A is the cross-sectional area, Q is the river discharge and S is the tidal average salinity.

Differenciation of Eq. (2) with respect to x yields:

$$QS' = D'A'S + D'AS' + DAS''$$
⁽³⁾

where a single prime indicates first partial derivative and a double prime second order partial derivative with respect to x. Since A'/A = -(1/a) and $D = (U_f S/S')$, Eq.(3) can be elaborated as follows. U_f is the velocity of freshwater discharge.

$$D' = U_{f} - \frac{DA'}{A} - \frac{DS''}{S'} = U_{f} \left(1 + \frac{S}{aS'} - \frac{SS''}{(S')^{2}} \right)$$
(4)

Substitution of Van der Burgh's equation yields:

$$K = 1 + \frac{S}{aS'} - \frac{SS''}{(S')^2}$$

The influence of K and a on the shape of the salt intrusion curves can be made clearly by scaling. The dimensionless salinity is obtained by scaling with the sea salinity:

$$\varsigma(\xi) = \frac{S}{S_0} \tag{5}$$

where $\xi = x/L$. Elaboration of Eq. (5) then leads to:

$$\frac{\zeta \varsigma''}{(\varsigma')^2} = (1 - K) + \frac{\varsigma}{\varsigma'} \frac{L}{a}$$
(6)

where ς' is the first derivative of ς with respect to ξ and ς'' is the second order derivative. The left hand side is the shape function influenced by two terms of right hand side. It can be easily seen that the shape function is positive if the curvature ς'' is positive (because $\varsigma \ge 0$ for all ξ on [0,1]).

In the integration of the steady-state salt balance equation the boundary condition used is that $\zeta' = 0$ where $\zeta = 0$, at the upstream end of the intrusion curve. Since, in a positive estuary, the gradient of the salinity is negative for all ξ on [0,1], ζ' can only become zero at the toe of the intrusion curve if somewhere within this interval the curvature ζ'' , and hence the shape function becomes positive. Because the second term of the right-hand side of Eq. (6) is always negative in a positive estuary (since $\zeta' < 0$), the curvature can only become positive in the interval [0,1] if the first term on the right hand side is positive; this is the case when K<1. Hence there is an upper limit to the value of K. Since the lower boundary of K is zero, it follows that 0 < K < 1.

Q3. Equation (5) introduces a strong relationship between K and v. This relation has no theoretical justification. The hypotheses are unclear and the value of K computed in that way does not add any additional information that was not already known from v. In that respect, the figures 3-5 just repeat in a different way the results already published in Shaha et al. (2010). Also, the fact that spatial variations of v would provide a better description of the transport in the estuary translates here in terms of K. So what's the point ?

Eq. (5) is mathematically derived equation from a number of equations (Savenije, 2005). Only the limitation of Eq. (5) is that the value of K does not lie a range between 0 and 1. This limitation might be due to the assumption of constant cross-section (Savenije, 2005). Following the hypothesis of McCarthy (1993) where an exponential function has been used with a proportion of the dimensionless diffusion length scale to the tidal dissipation length scale for an exponential shaped estuay, an exponential function is also used in this study to limit the K value between 0 and 1. This assumption not only limited the range of K values between 0 and 1, but also described the relative weights of spatially varying salt transport mechanisms reasonably well. The purpose of this study was not to seek out additional information what did not find from v. The main purpose of this study is to calculate the spatially varying K from v maintaining the recommended range to describe the relative weights of spatially varying salt transport mechanisms in stead of a single K value. This is because single K value used in the previous studies does not describe the spatially varying salt transport mechanisms. The second purpose is to strengthen the application of Eq. (7), that applied in about 20 estuaries worldwide, using spatially varying K value in stead of single K value. This is because the spatially varying K demonstrates the density-driven circulation more prominently at the strong salinity gradient location compared with a single K value, shown in Figs. 6 and 7 (published in HESSD).

Figures 4 and 5 (published in HESSD) are not repeatation of Shaha et al. (2010), although those figures look similar. The parameters used in *Y* axis are different. Figures 1 and 2 attached here show that there are no linear relationship between *K* and flushing rate in each segment because tidal effect (F_{int}) is different in each segment. This supports that Figures 4 and 5 are not repeatation. Savenije (2005, page 168) reported that *K* is not a time-dependent factor. Figs. 4 and 5 (published in HESSD) show a new findings of time-dependency of *K*. Thus, this study clearly reveals that *K* is not only a spatially varying factor but also a time-depency factor. This study provides the following new suggestions:

- i) a new relation between K and v, and
- ii) K varies not only spatially but also temporally.

Minor comments

Two minor comments will be fixed in the revised manuscript.



Fig. 1. Plot of flushing rate against Van der Burgh's coefficient for various segments of the Sumjin River Estuary during spring tide.



Fig. 2. Plot of flushing rate against Van der Burgh's coefficient for various segments of the Sumjin River Estuary during neap tide.