ABSTRACT
In coastal seas and estuaries, the presence of periodic forces, e.g., tides, results in the fluctuation of sediment transports. Therefore, the study of residual sediment transport in a tidal environment is more practical rather than sediment transport itself. Based on the assumption that sediment transport is proportional to an exponential power of current velocity ($u^p$), a simplified analytical expression is derived for residual total load sediment transport in a tidal environment. The tidal current is represented by tidal current constituent series of $M_0$, $M_2$, $S_2$, $N_2$, $M_4$, $MS_4$, $MN_4$, $M_6$, $K_1$, and $O_1$. The expression can be adapted to quantify the sediment transport in areas with significant residual current and diurnal tidal regimes.

KEY WORDS: residual sediment transport; total load; tidal current constituents; residual current; Yangtze Estuary.

INTRODUCTION
In coastal seas and estuaries, sediment transport, which is closely related to morphological changes, is greatly influenced by runoff, tidal currents, waves and human activities. In such areas, the presence of periodic forces, e.g., tides, results in the fluctuation of sediment transports. However, the morphological changes are principally determined by the residual sediment transport without the influence of periodic factors (Postma, 1961; van der Wegen and Roelvink, 2008). Previous studies have shown that tide wave is distorted as it propagates into estuaries and coastal seas influenced by water depth, run off and landform (Prandle, 1985; Friedrichs and Aubrey, 1994). Tidal current asymmetry and tidal pumping effects play major roles in residual sediment transport (Dronkers, 1986; van de Kreeke and Robaczezska, 1993; Friedrichs and Aubrey, 1988; Wang et al., 1999). A flood-dominant tidal asymmetry leads to a landward residual sediment transport, and an ebb-dominant tidal asymmetry causes a sea ward residual sediment transport (Boon and Byrne, 1981; Speer and Aubrey, 1985).

Assuming the transport of sediment to be proportional to the power of the depth-averaged local current speed (Bagnold, 1966; Englund and Hansen, 1967), van de Kreeke and Robaczewska (1993) analyzed the influence of residual current $M_0$ and tidal current constituent series of $M_2$, $M_4$, $S_2$ to residual sediment transport. They derived an analytical expression for residual transport of coarse sediment in terms of the amplitudes and phases of the tidal current constituents. van de Kreeke and Robaczezska (1993) further adopted the tidal current constituents of $M_0$, $M_2$, $M_4$, $M_6$ and the full tidal current constituent series to drive the model of the Ems Estuary with the comparable model results of residual sediment transport. The results are regarded as the theoretical basis for the reduction of tidal signals from the full constituents series to the simplified series of $M_0$, $M_2$, $M_4$ and $M_6$ in coastal morphodynamics modelling applications (van de Wegen, 2005; Guo, 2014).

For an estuarine environment with dominant mean flow due to river discharge, Chu et al. (2015) proposed the analytical expression of residual coarse sediment transport with the tidal current constituent series of $M_0$, $M_2$, $S_2$, $N_2$, $M_4$, $MS_4$, $MN_4$, $M_6$, $K_1$, and $O_1$. They showed that tidal interactions of compound tides with their basic constituents i.e. $MS_4$ with $M_2$ & $S_2$ and $MN_4$ with $M_2$ & $N_2$, contribute to residual sediment transport. For diurnal tidal regimes, Hoitink et al. (2003) analyzed the residual transport induced by the $K_1$, $O_1$, and $M_2$ tides and derived analytical expressions of residual coarse and total load sediment transport.

Guo et al. (2014) proposed the analytical expression of residual total load sediment transport with constituents of $M_0$, $M_2$, $M_4$ based on the total load sediment transport formula (Englund and Hansen, 1967). They studied the impact of the runoff and tidal asymmetry on the geomorphology in the one-dimensional model of the Yangtze River. However, Chu et al. (2015) demonstrated other tidal interactions contribute to the residual coarse sediment transport. This conclusion is also applicable to the residual transport for total load sediment transport. Therefore, the aim of this paper is to propose an analytical expression of residual total load sediment transport with tidal current constituents of $M_0$, $M_2$, $S_2$, $N_2$, $M_4$, $MS_4$, $MN_4$, $M_6$, $K_1$, $O_1$. In order to use the analytical expression, the simplified expression with a manageable numbers of terms is presented instead of the full expression with more than 900 terms. Based on this expression, the contributions of residual current and tidal interaction to residual total load sediment transport were quantitatively analyzed for the Yangtze Estuary case.