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Tidal asymmetries in estuaries due to channel-flat interactions, a simple model

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Characteristics of tidal motion in channels are strongly influenced by nonlinear processes. In particular, the latter cause asymmetry of tidal curves, both of sea surface and velocity. This asymmetry has profound implications for net sediment transport and thereby for the morphodynamic stability of the channel. Sources of nonlinearities are advection of momentum, bottom stresses and depth-dependent friction, but also exchange processes between the channel and tidal flat areas along the sides of the channel. Previous studies have shown that, in order to understand observed tides in e.g. the Tamar Estuary, it is necessary to account for the fact that tidal flats act as a temporal storage of mass.

In this contribution the focus is on yet another phenomenon, viz., tidal flats also act as a net sink term for along-channel momentum. This momentum loss term is a highly nonlinear function of sea surface elevation and velocity, and is significant in areas where the width of tidal flats, b, is of comparable or larger size than the width B of the main channel. The importance of momentum loss for tidal dynamics will be illustrated by discussing approximate, analytical solutions of a shallow water model that governs the principal tide, overtides, as well as residual sea surface and currents. The process of momentum loss will be analysed, and its efficiency in generating nonlinear tides will be compared with other sources of nonlinearities. By comparing model output with field data it will be shown that momentum loss generates measurable asymmetries of the tide.