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Is tidal flat hydrodynamics dominantly dissipative?

Chiara De Capitani di Vimercate, Nicoletta Tambroni, and Giovanni Seminara
University of Genova, Italy (chiara.decapitani@unige.it)

The hydrodynamics of tidal flats adjacent to tidal channels has been widely investigated, both theoretically (e.g. Speer & Aubrey, 1985; Canestrelli et al. 2007; Rinaldo et al., 1999; Tambroni and Seminara, 2008; Seminara et al., 2010) and experimentally (De Capitani et al. 2009). In particular, it is well known that the presence of tidal flats tends to accelerate the tidal currents in the channel and make the channel hydrodynamics ebb-dominated. The presence of tidal flats also affects the morphodynamic equilibrium of the channel. The storage effect of flats was accounted for in the simple theory of Seminara et al. (2010), who have shown that the equilibrium length of the tidal channel for a given inlet depth is reduced.
In order to investigate the possible existence of a long term equilibrium state for a tidal system consisting of a channel flanked laterally by flats, one would strongly benefit from the availability of a simple, physically sound, model of channel-flat hydrodynamics. Rinaldo et al. (1999) were the first Authors to achieve this goal, assuming that flat hydrodynamics (ignoring the role of wind) is dominated by dissipation, such that the streamlines would be directed as the gradient of free surface elevation. We revisit the latter problem considering, for the sake of simplicity, a configuration consisting of a straight rectangular channel, flanked laterally and symmetrically by two rectangular flats. The channel is closed at one end and is forced by a tidal oscillation at the channel inlet. We then couple the fully analytical 1-D model of Seminara et al. (2010) for the hydrodynamics of a 'short' tidal channel to a 2-D formulation for the tidal flat hydrodynamics based on the theoretical solution of the classical shallow water equations. No restriction on the size of the amplitude of the tidal wave relative to the flat depth is imposed. Results appear to be of interest. In fact, disregarding the effect of dissipations, i.e. letting the flow in the flat be dragged by the channel velocity only, we are able to derive a fully analytical solution for the tidal flat hydrodynamics which compares fairly well with the complete numerical solution of the shallow water equations. This suggests that dissipations, at least in general, are not crucial in determining the flow field in the flats, hence the flow direction is not aligned with the vector gradient of free surface elevation. Further developments are in progress and will be reported at the meeting.