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Analytical description of tidal dynamics in convergent estuaries

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Analytical solutions of the one-dimensional hydrodynamic equations for tidal wave propagation are presented in explicit equations. For given topography, friction and tidal amplitude at the downstream boundary, the velocity amplitude, the wave celerity, the tidal damping and the phase lag can be computed. The simple harmonic solution is based on the full non-linearised St. Venant equations applied to an exponentially converging channel, which may have a bottom slope. Two families of solutions exist. The first family consists of mixed tidal waves, which have a phase lag between zero and ð/2, which occur in alluvial coastal-plane estuaries with almost no bottom slope; the second family consists of standing waves, which develop in short estuaries with a steep topography. Special cases are presented for progressive waves, frictionless waves, waves in channels with constant cross-section, and waves in ideal estuaries where there is no damping or amplification. The analytical method is accurate in the downstream, marine, part of estuaries and particularly useful in combination with ecological or salt intrusion models. The solutions are compared with observations in the Schelde, Elbe and Hau estuaries.