A simplified approach to describe the flow field on vegetated intertidal platforms

T. Van Oyen¹, S. Lanzoni², A. D’Alpaos³, S. Temmerman⁴, P. Troch¹ and L. Carniello²

¹ Department of Civil Engineering, Ghent University, Belgium. tomas.vanoyen@ugent.be
² Dipartimento di Ingegneria Civile e Ambientale, University of Padua, Italy.
lanzo@idra.unipd.it, carniello@idra.unipd.it
³ Department of Geosciences, University of Padua, Italy. adalpaos@idra.unipd.it
⁴ Ecosystem Management research group, University of Antwerpen, Belgium. stijn.temmerman@ua.ac.be

1. Introduction

Lagoonal and estuarine environments, typically, host striking intertidal features such as tidal salt marshes and mangroves. These geomorphological landscapes consist of periodically flooded vegetated platforms, dissected by a network of channels.

Two-dimensional models have been developed (e.g. D’Alpaos et al., 2007) to describe the planimetric evolution of the intertidal platform. These studies, however, neglected the impact of vegetation variations on the flow field, considering the hydrodynamic approach introduced by Rinaldo et al. (1999).

Here, we describe and analyse a new simplified approach which is able to reasonable model the flow field on an intertidal platform taking into account also the impact of spatial variations of vegetation (friction).

2. Model and solution

The flow field on the platform is described by the depth-averaged conservation equations of mass and momentum, which, in dimensionless form, read

\[ \alpha \left( \frac{\partial u}{\partial t} + r (u \cdot \nabla) u \right) = -e V \xi - \frac{\gamma}{\chi D} u, \]  
\[ \frac{d \xi}{dt} + e \frac{\partial \xi}{\partial t} + r V \cdot (Du) = 0. \]

In (1) - (2) four non-dimensional parameters appear \((\alpha, r, e, \gamma)\) which, considering typical length- and velocity scales, are found to be \(\alpha < \gamma, e < \gamma\) and \(r \sim O(1)\). Based on these values, solutions to (1) - (2) are considered as an expansion in the small parameters \(\alpha\) and \(e\).

At each order of approximation, by combining the momentum and conservation equations, a linear diffusion equation is obtained, governing the variations in the free surface elevation, while the flow velocity is related to the spatial gradients of \(\xi\).

3. Results

To investigate the capability of the simplified approach, the flow field obtained by the introduced approach is compared with results found by using a numerical model (Carniello et al., 2011). In Figure 1, a comparison of the flow velocity on a flat intertidal platform with a cross-channel length of 400 m is provided for two instants during the flooding phase of the tidal wave. In the channels, a tidal wave with amplitude of 1 m and mean sea level of 0.25 m is considered; \(H^* = 0.25 + \cos(\omega t)\). In addition, between 100 and 110 m the friction coefficient \(\chi\) is decreased to mimic the presence of a vegetation patch.

A good comparison is obtained between the simple and numerical approach even though the simple model underestimates the flow field during the initial flooding of the tidal flat and the wake at the lee side of the patch is smaller for the simplified approach.

4. Conclusions

A simplified approach is described to model the flow field on frication dominated intertidal platforms. A comparison with a numerical model supports the adopted simplified method.

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References


