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MODELLING FLOW ROUTING ON A TIDAL MARSH DUE TO SPATIAL VARIATIONS IN FRICTION: A SIMPLE APPROACH

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1. Introduction

Tidal saltmarshes are dynamic ecosystems occuring abundantly in estuaries, lagoons and tidal embayments. These regions are characterised by vegetated platforms which are periodically flooded and are intertwined by networks of channels. Besides acting as a first buffer agains storm surges, tidal saltmarshes provide the lion's share of primary productivity in the coastal zone and host an extremely high biodiversity (Mitsch, 2000). Recent field observations (Temmerman *et al.*, 2005) demonstrated that spatial variations in friction (vegetation) on the platform strongly impact the flow field. Here, we present a simplified model approach which is able to describe the effect of the spatial variations in vegetation (friction) on the flow field. A comparison with a numerical model appears to support the introduced approach.

2. Models

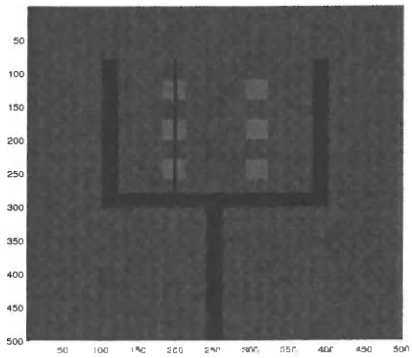
The simplified model follows from an expansion of the depth-averaged equations of mass and momentum in small dimensionless parameters (ε and α) which appear after suitable scaling of the equations (Van Oyen *et al.* 2012). In particular, the solution S is expanded as

$$S = S_0 + \varepsilon S_{11} + \alpha S_{12} + \varepsilon^2 S_{21} + \varepsilon\alpha S_{22} + \alpha^2 S_{23} + h.o.t. , \quad [1]$$

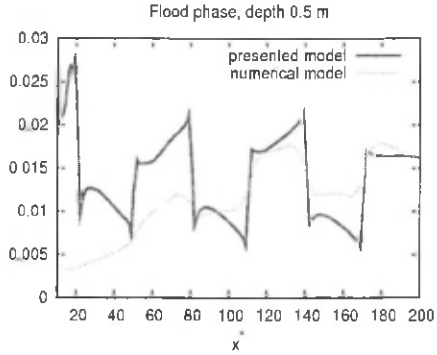
where *h.o.t.* denotes the higher order terms. At the first order of approximation the flow field $\boldsymbol{u} = (u,v)$ is governed by

$$u_{11} = -\frac{\chi^2 D_0}{\gamma\lambda}\frac{\partial\tilde{\eta}_0}{\partial x}, \quad v_{11} = -\frac{\chi^2 D_0}{\gamma\lambda}\frac{\partial\tilde{\eta}_0}{\partial y} \quad , [2]$$

$$\frac{d\eta_{11}}{dt} + \frac{\partial\tilde{\eta}_0}{\partial t} - r\left(\frac{\partial}{\partial x}\left[\frac{(\chi D_0)^2}{\gamma\lambda}\frac{\partial\tilde{\eta}_0}{\partial x}\right] + \frac{\partial}{\partial y}\left[\frac{(\chi D_0)^2}{\gamma\lambda}\frac{\partial\tilde{\eta}_0}{\partial y}\right]\right) = 0. \quad [3]$$



a. Domain



b. Flow velocity

Figure 1. a) Domain considered in the comparison, red regions are channels, blue is the platform. Light (dark) blue denotes a region with more (less) friction. b) Comparison of flow velocity obtained by the numerical and the simplified model along the black line shown in figure a.

Here, X denotes the Chezy friction coefficient and r, γ and λ are dimensionless parameters which follow from the introduced scaling. Moreover, η represents the free surface elevation and is split into a part which is spatially averaged and a part that represents the spatial variations of the free surface with respect to the average: denoted respectively with the superscript ^ and ~. Linking the tidal wave in the channel to $\eta(t)$, equation [3] can be solved for η_1 after which the flow field is readily evaluated using equation [2]. Similar systems of equations are obtained at the higher order contributions.

3. Results and discussion

Figure 1 presents a comparison of the simplified approach with a numerical finite element model (Defina, 2000, Carniello *et al.* 2011). The considered domain is presented in figure 1a: red regions are channels and blue areas are platforms. The regions in lighter (darker) blue are characterised by stronger (less strong) friction; i.e. a Chezy coefficient of 10 (25). In figure 1b, the magnitude of the flow velocity is shown at the instant the tidal wave in the channels is 0.5 m above the platform. The figure shows that the simplified model reasonably describes the flow field: i.e. higher (lower) velocities where the friction is lower (higher); although, clearly, some quantitative differences are present.

4. Conclusions

A simplified model is introduced to describe the flow flood, due to spatial variations in friction, on the platform of a tidal marsh. A comparison with a numerical model is performed and appears promising.

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