Geophysical Research Abstracts
Vol. 21, EGU2019-16933, 2019
EGU General Assembly 2019

A new bio-geomorphic model approach accounting for subgrid-scale heterogeneity of biogenic structures

Olivier Gourgue (1), Jim van Belzen (1,2), Christian Schwarz (3), Tjeerd J. Bouma (2), Johan van de Koppel (2), and Stijn Temmerman (1)

(1) Ecosystem Management Research Group, University of Antwerp, Belgium, (2) Department of Estuarine and Delta Systems, Royal Netherlands Institute for Sea Research, Yerseke, Netherlands, (3) Department of Physical Geography, Faculty of Geosciences, Utrecht University, Netherlands

In hydrodynamic and morphodynamic models, the effect of biogenic structures (such as vegetation, mussel beds or oyster reefs) on flow and sediment transport is generally expressed through the hydraulic roughness. The accuracy of bio-geomorphic model predictions depends on their ability to represent the spatial complexity of these biogenic structures, which is largely limited by computational power. This requires practical model choices, such as limiting the spatial resolution (that is, the model grid size), usually assuming a uniform spatial distribution at the subgrid scale. In this communication, we show that this uniformity assumption leads to considerable overestimation of the flow resistance if the subgrid distribution of biogenic structures is spatially correlated (that is, presenting clustered patterns). We also introduce a novel model approach that solves this multiscale issue by redefining the hydraulic roughness to account for this subgrid heterogeneity.

Our approach builds on the similarity between the Chézy formula in fluid dynamics and Ohm's law in electricity. Taking the analogy further, we recalculate the coarse-scale hydraulic roughness just as the total resistance of an electronic circuit that combines resistors (equivalent to subgrid-scale biogenic structures in our analogy) connected in series (along-flow) and in parallel (across-flow). Although very simple, our approach improves considerably the flow routing in hydrodynamic models that operate at coarser scales than the scale at which biogenic structures are defined. As a result, fine-scale biogenic heterogeneity can now be accounted for at a reasonable computational cost, increasing the accuracy of large-scale bio-geomorphic model predictions.

In this communication, we illustrate the effectiveness of our subgrid approach by considering the flow deviation around expanding patches of tidal marsh vegetation. This process is a crucial mechanism for the initiation and development of channel networks in tidal marshes, which then facilitate the delivery of sediments to the vegetated platforms, hence building up elevation and increasing resilience to sea level rise. With our new subgrid approach, accounting for all these feedback mechanisms between tidal hydrodynamics, sediment transport and salt marsh vegetation dynamics is now possible, even when considering large-scale systems.

Our new subgrid method has also potential for further applications in large-scale modeling of river flood plains, estuaries and other coastal shallow waters. For instance, it would provide improved model predictions quantifying the impact of large-scale coastal wetlands (tidal marshes and mangrove forests) on the landward propagation of storm surges, giving deeper insights in essential ecosystem services provided by biogenic structures.