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Numerical modelling of hydro-morphodynamic channel processes at decadal timescales using optimization methods: an application to the Dijle River, Belgium

Sardar Ateeq-Ur-Rehman, Nils Broothaerts, Ward Swinnen, and Gert Verstraeten
KU Leuven, Earth and Environmental Sciences, Heverlee Leuven, Belgium (sardar.ateeq@kuleuven.be)

Numerical hydro-morphodynamic models can simulate the impact of future changes in climate and land cover on river channel dynamics. Accurate predictions of the hydro-morphological changes within river channels require a realistic representation of controlling factors and boundary conditions (BC), such as the sediment load. This is, in particular, true where simulations are run over longer timescales and when sparse data on sediment load is available. Using sediment rating curves to reconstruct the missing sediment load data can lead to poor estimates of temporal variations in sediment load, and hence, erroneous predictions of channel morphodynamics. Furthermore, when simulating channel morphological changes at longer timescales, this comes at a high computational cost making it impossible to run various scenarios of changing boundary conditions to long river reaches with sufficient spatial detail. Here, we apply different methods (morphological factors (MFs) and wavelet transform (WT)) to overcome these problems and to arrive at faster and more accurate predictions of long-term morphodynamic simulations.

We modelled river channel bed level changes of the River Dijle (central Belgium) from 1969 to 1999. Detailed cross-sectional surveys every 20 to 25 m along the river axis were collected in 1969, 1999 and 2018. Since 1969, the river has been incised by about 2 m most probably as a response to land-use/land-cover changes and subsequent changes in discharge and sediment load. Daily discharge and water level measurements are available for the entire period; however, daily suspended sediment load was only collected between 1998 and 2000. Therefore, WTs were coupled with artificial neural networks (WT-ANN) to calculate long-term sediment load BCs (1969-1999) from the short-term collected suspended sediment concentration samples. Sediment load predictions with sediment rating curves only obtain an R^2 of 0.115, whereas WT-ANN predictions of suspended sediment load data show an R^2 of 0.902.

Using MFs the reference hydrograph was condensed with a factor of 10 and 20. WT is a mathematical tool that can convert time-domain signals into time-frequency domain signals by passing through low and high-level filters. Passing sediment load time series through these filters

create another synthetic BCs containing the frequential and spatial information with half the original signal's temporal length. Thus we also compare the modelling performance using WT generated synthetic BCs with MFs. Similarly, 36x1 to 36x10 processors of an HPC was used to simulate 16 km river reach containing 3,33,305 mesh nodes (with 1.5 m mesh resolution). Interestingly, with a significant reduction in computational cost, there was a mild difference (R^2=0.802 using MFs 10 and R^2=0.763 using MFs 20) in model performance without using MFs during initial trials. Surprisingly, generating a synthetic time series using WT did not perform well. Therefore, hydrograph compression using MFs is found the best option to reduce the computational cost, significantly. Although the computational time reduced from 30 days to only 3 days using MFs and more precise BCs calibrated model with R^2=0.70, WT poor performance needs to be still investigated.