Disentangling spatial scales of morphological development

The river bed continuously changes on various spatial and temporal scales. Migrating river dunes are an example of local and relatively fast change. At the same time, engineering measures from the last decades cause the river bed to degrade to present date. To be able to predict the development of the river bed, it is important to distinguish between, and disentangle the various spatial and temporal scales.

Data and methodology

The bed level in the navigation channel of the Waal river is measured biweekly. This gives an unique dataset, which is hardly used, to describe the morphological behaviour of the river. A wavelet transform is able to distinguish between various spatial scales and to couple these to causes of bed level changes (Figure 1). With this method, both small-scale and large-scale bed-level changes can be visualised separately. This provides new insight in the behaviour of the river and offers opportunities for design and construction of new interventions as well as valuable insights for the river manager.

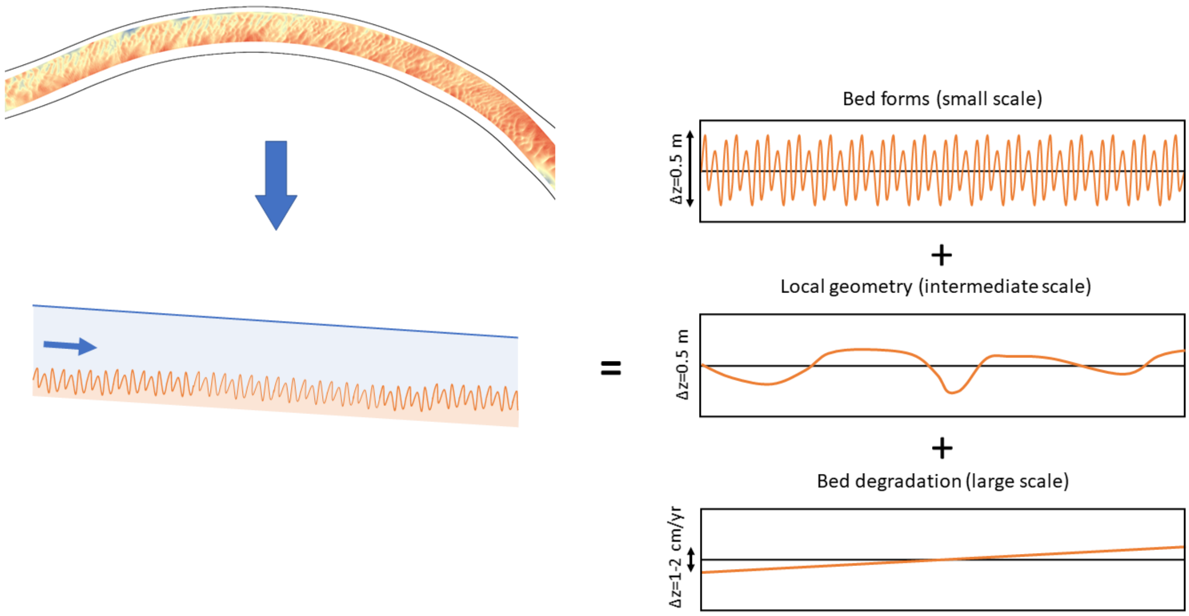

Figure 1: The biweekly bed level measurements are used to derive a 1D longitudinal transect. Using a wavelet analysis, we are able to disentangle small, intermediate and large spatial scales and developments.

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Aim

The aim is to get insight in the various processes that drive bed-level changes in the river. The vast and detailed biweekly dataset enables studying various spatial and temporal scales and coupling this to possible causes. We present three applications: (1) The relation of bed level changes with the river's hydrograph. (2) Studying the large-scale bed-level changes in the Waal and IJssel Rivers. (3) Comparing the measured bed profile and theoretical morphological equilibrium to assess hydrodynamic and morphological models. For each application, we first give a short summary of the theory.

1. Local dynamics and river interventions

Before the constructions of interventions in the Room for the River programme, the river bed was in a quasi-equilibrium state (on the intermediate spatial and temporal scale). During this period, bed-level changes resulted from an interaction between a variable hydrograph and variations in the river's geometry. The strongly varying hydrograph causes variations in bed level in the order of 50 cm. Insight into the natural variation of the bed level can be used to understand the river's behavior and reduce the morphological impact of interventions. Fine-tuning the location of interventions may reduce this impact and provide advantages for other river functions.

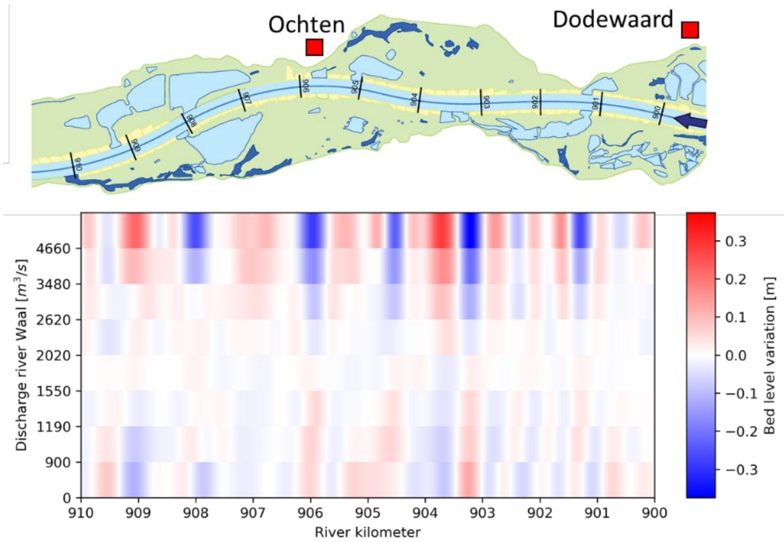

Figure 2: An example of bed-level variations in the Waal river as a function of discharge.

2. Large-scale bed-level changes

The wavelet method can also be used to study large-scale bed-level changes in the river, instead of the intermediate scale. Filtering out the small and intermediate scale variations reveals information about the large-scale trends of aggradation or degradation, which are unaffected by the local interventions or migrating bed waves. The acquired results are more robust than without filtering.

Figure 3: Large-scale bed-level variation on a certain location (river kilometre 870) of the Waal River, using a 5 km moving average (orange), wavelet filtering (green) versus unfiltered results (blue).

3. Verification of hydrodynamic and morphological models

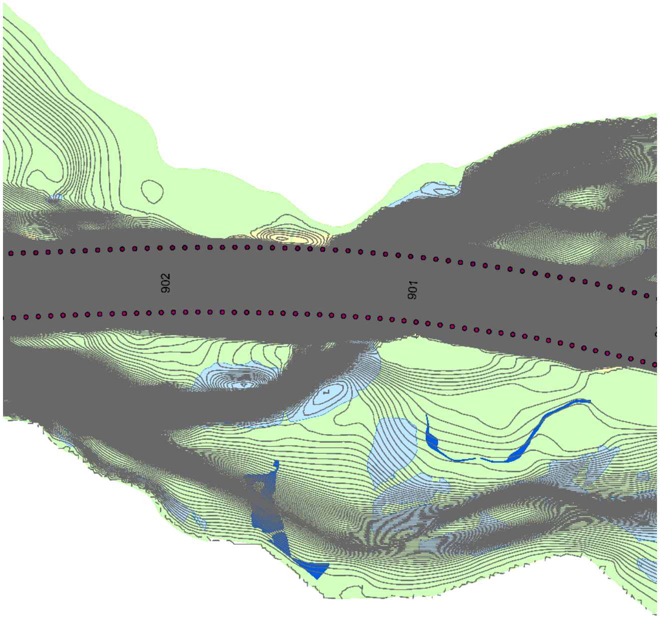

Figure 1 The partitioning of the discharge between the main channel and floodplain is an important parameter in determining the morphological equilibrium.

Before the constructions of measures in the Room for the River programme, the river bed was in a quasi-equilibrium state. This is to say that on the intermediate spatial-scale the time-averaged bed level is constant. Using theoretical equilibrium formulations, we can calculate this quasi-equilibrium. An important component in these formulations is the discharge partitioning between the main channel and the floodplain. This is the output of the hydrodynamic WAQUA model. Comparing the calculated and measured morphological equilibrium reveals possible misinterpretations or flaws in the schematization of the hydrodynamic model. The morphological equilibrium and other morphological processes are, in contrast to hydrodynamic calculations, very sensitive to misinterpretations and flaws in the schematization. Hence, these insights can be used in a rapid tool to map inconsistencies and offers opportunities to improve future morphological models.

Opportunities for river management, and operations and maintenance

1. Identifying the effect of interventions or large-scale changes using smart filtering
2. Improved insight in the morpho-dynamical state of the river
3. Reducing unwanted morphological effects on river functions when constructing new interventions
4. Verification of models and schematizations by disentangling spatial scales

The TKI project (UTW01) is a cooperation between TKI Deltatechnologie (Rob Koster), University of Twente (Pepijn van Denderen & Denie Augustijn), Rijkswaterstaat (Ralph Schielen) and HKV (Andries Paarlberg, Freek Huthoff & Hermjan Barneveld) and aims for applications of scientific results and innovations in practice.

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