An interactive atlas of river morphodynamics

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Introduction

The bed level in the navigation channel of the Waal River is measured biweekly. This gives a unique dataset that describes the morphological behaviour of the river. We use a wavelet transform, a filtering technique that is able to determine bed level changes on various spatial scales, to analyse this data and explore relations to causes of bed level changes. With this method, both small-scale and large-scale bed-level changes can be visualised separately. Results show that different causes for bed-level changes can be disentangled such as interventions (Van Denderen et al., 2020), discharge fluctuations (Van Denderen et al., 2021) and the normalization measures of the past (Huthoff et al., 2021). This provides new insight in the behaviour of the river and offers opportunities for design and construction of new interventions with minimal negative morphological effects as well as valuable insights for the river manager.

The extensive dataset and complex methodology make it impractical for daily usage and less accessible for a wider group of users. Therefore, we developed a digital and interactive atlas for bed-level changes at different spatial scales that can be used to quickly evaluate local and large-scale bed-level changes. This RWS Wavelet Tool (RWT) is developed in Dutch and based on the results of the TKI Deltatechnologie research project (UTW01).

Wavelet method

A wavelet transform identifies wavelengths or frequencies in a wave-like signal. A wavelet transform can be compared to the better-known Fourier transform. A Fourier transform decomposes a wave-like signal into sinusoidal waves with different frequencies that are periodic and do not decay. This allows for determining the main frequencies that occur within a signal. This is not a problem for, for example, analysing tidal records in which the main tidal components always occur at the same frequencies. In the case of analysing bed levels, spatially varying conditions along the river, e.g., flow velocity, channel geometry and sediment characteristics, can result in large variations of the dominant frequencies in space. In contrary to the Fourier transform, a wavelet transform can reveal the wavelength of bed level changes and its spatial variation along the river.

The wavelet transform results in a wavelet power spectrum (wavelet power as function of frequency and space), from which the signal can be reconstructed resulting in the original signal. In addition, we can reconstruct the signal for a selection of wavelengths and thereby use the wavelet transform as a filtering technique.

The RWS Wavelet Tool (RWT)

Figure 1 shows a screenshot of the digital and interactive atlas, i.e., the RWS Wavelet Tool (RWT). The RWT can be controlled by three sliders with which a selection is made from the database and the figures are generated. The three sliders control the study area, the time period and the wavelengths. Four figures are generated:

(1) The bed-level profile. This is the reference bed level (time-averaged between 2005-2014) and the bed level associated with a selected discharge category.
(2) The bed level variation in time
(3) The bed level variation with discharge, this shows the average bed level per discharge category in which cat. 0 corresponds with a discharge at Lobith <1200 m^3/s and cat. 7 with a discharge >6800 m^3/s.
(4) The rate of bed-level change shows per discharge category the average bed-level change.

The bed level variation in time (2) can be used to identify bed level changes and the migration of bed features in time. The bed level variation with discharge (3) shows the range between which the bed level varies for various discharge levels. With this figure the bed-level

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development in the river is shown as a function of the occurred discharge levels, which is especially useful for shallow areas that can hinder navigation. The rate of bed-level change (4) can help to derive the time scales over which these shallow areas develop.

Conclusion

The RWT gives a wide range of users quick and easy access to valuable bed-level measurements. This insight into the bed-level dynamics and the physical processes can improve decision making and intervention design in the operation and management (from morphological point of view) of the rivers.

References

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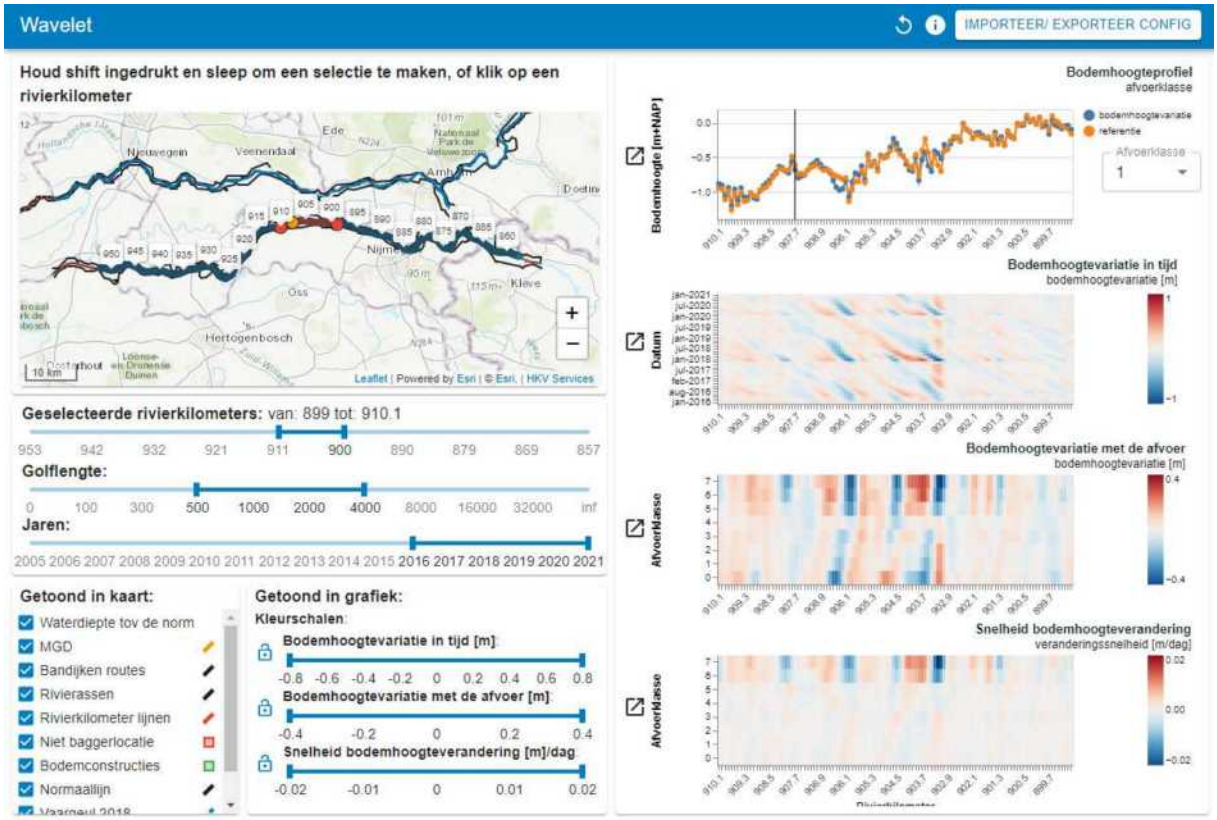

Figure 1. A screenshot of the RWS Wavelet Tool (RWS).