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Rivers in an uncertain future

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Jord J. Warmink, Anouk Bomers, Vasileios Kitsikoudis, R. Pepijn van Denderen & Fredrik Huthoff (eds.)

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Long-term bed level change in the Dutch Rhine branches and its impacts to water availability

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Background

Large-scale erosion of the river bed of the Dutch Rhine branches threatens (and sometimes encourages) several river functions (Visser, 2000, Ylla Arbos et al., 2020). However, the Delta-scenarios for 2050 and 2100 do not consider the impacts of further bed-level degradation. Although bed degradation is a slow process, it indirectly influences water levels, and moreover it modifies the distribution of discharges at the Pannerdense Kop and IJsselkop bifurcations (due to uneven rates of degradation of the downstream branches). The new strategic program "Integral River Management" (IRM) has adopted bed-degradation as a central theme and urges to implement approaches to stabilize the river bed. Still, the indirect impacts on river functions have only be estimated very roughly (quick-scans), without using models and most recent forecast of bed-level change.

As part of the project "Klimaatbestendige Netwerken", Rijkswaterstaat and Deltares have studied the sensitivity of water-availability (fresh-water distribution) to a refined version of the most recent forecasts of bed-level degradation. The main research questions are:

- What will be the possible future erosion of the river bed along the branches that is relevant for hydraulic response?
- What will be the impact on the long-term availability of water and the navigability during low-flow conditions.

Method

The use of a 1D hydrodynamic model allows a much better estimate than previous analytical and data-driven estimates. The approach in this study consists of 2 parts:

1. Forecast of bed-level degradation along the branches, based on observations.
2. Make use of the "Nationaal Water Model" (using a 1D hydraulic SOBEK model) to simulate the impacts on flow distribution.

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Results

Prediction of large-scale bed-level degradation of the Rhine is highly uncertain. The degradation process is not a linear trend, but irregular in time and space. It reacts on floods (acceleration), on decaying impacts of past river-training, sediment extraction, and Room for the River works (deceleration). Ten Brinke (2019) and Ylla-Arbos et al. (2019) presented section-average forecasts based on extrapolation of observed historic trends. This represents the business-as-usual-scenario, reference for IRM studies. However, as these are step-wise averages of long sections, they cannot be applied to the 1D model.

In our study (Sloff, 2019) we re-assessed the historic trends with consideration of gradual variation along the branches, and accounting for observed deceleration of the trends (confirmed by model simulations). For consistency with other programs (IRM) our prognosis does not significantly differ from the previous ones. Note that the prognosis cannot be based solely on results of morphological models. The existing models provide understanding in the processes and responses to ongoing developpments, but the models have not yet been well validated for long-term (>30 yrs) autonomic evolution of the river bed due lack of data and resources.

Figure 1 shows examples of the resulting estimated annual bed-level change until 2050, and the comparison to observed trends of the last 20 years (from processed multibeam measurements, P-Map data). For hydraulic response the scale of backwater curves, order of tenths of kilometres, allows us to use the smoothened lines presented in the figures. Important is that the Waal will continue to erode faster than the Pannerdensch Kanaal, and erosion in the Waal decreases downstream (hence slope will decrease). Figure 1 shows large variations in trends along the river. The smooth line is a representation to be used only for hydraulic impacts. The real complexity of erosion is for instance illustrated in Figure 2: the erosion in the upper Waal has only occurred in four inner bends. It is unknown how the fixed layers in outer bends at Erlecom and Nijmegen have contributed to this spatial variation.

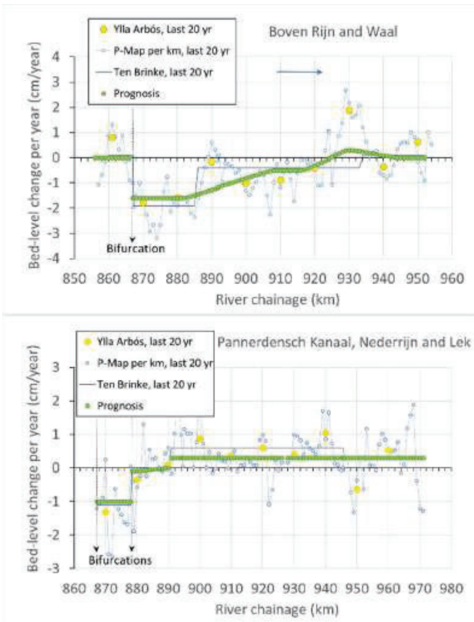

Figure 1. Prognosis for large-scale degradation (Sloff, 2019)

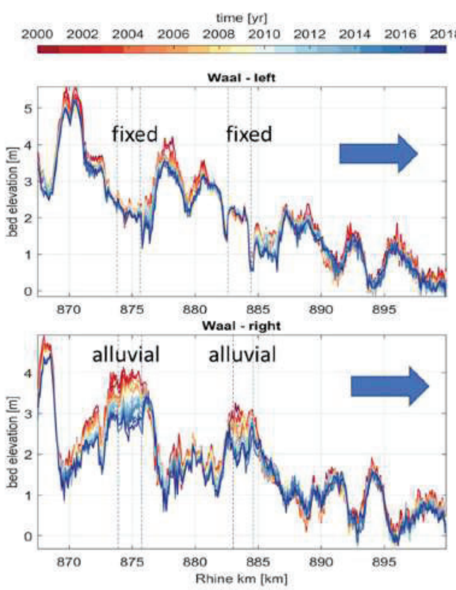

Figure 2. Erosion in alluvial inner bends in upper-part of the Waal. Dashed lines indicate the fixed layers

The 1D hydraulic simulations with adjusted bed show that the discharge to the Waal will have increased in 2050 with 20 to 30 m^3/s for the low flows and 40 to 120 m^3/s for high flows. See Figure 3. This is caused by the asymmetric development of branches downstream of the bifurcations. All scenario's show a significant reduction of water levels in the upper reaches, with several decimeters, maximal at low flows.

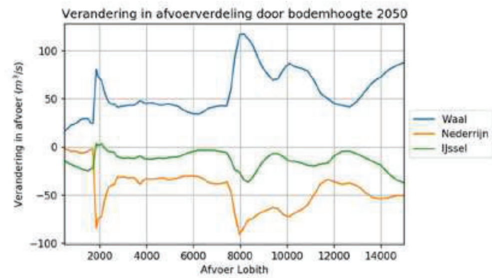

Figure 3. Change in discharge in 2050 compared to present

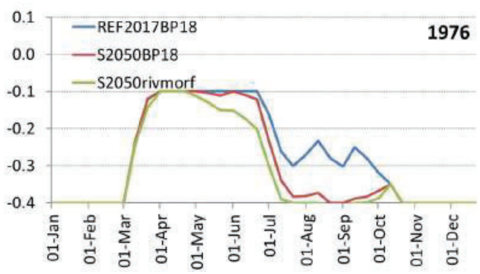

Figure 4. Computed level of IJsselmeer for dry year 1976, with reference scenario (REF2017BP18), climate change 'stoom' (S2050BP18) and climate change with bed-level degradation (S2050rivmorf), Source: Marjolein Mens

Figure 4 shows the impact on lake levels in Ijsselmeer for the extremely dry year 1976. The climate-change impact is dominant, but for return periods > 10 year the effect of bed-degradation becomes quite relevant.

Conclusions

Forecast of bed-level degradation shows that a shift in discharge distribution at bifurcations, and further decrease of water levels can be inferred. The computations show that impact on water availability in extreme dry years (T>10 year) is significant. There are still a lot of unknowns in the causes of bed degradation to make more accurate (model) predictions.

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References

Brinke, W. ten (2019) Effecten morfologische ontwikkelingen op functies Rijn en Maas. Blueland Consultancy BV. Rapport B19.01, Okt. 2019.

Sloff, C.J. (2019) Prognose bodemligging Rijntakken 2020-2050. Deltares 11203738-005-8GS-0008. Dec. 2019.

Visser, P.J. (2000) Bodemontwikkeling Rijnsysteem. TU-Delft, Fac. CiTG, Oct. 2000.

Ylla Arbós, C., A. Blom, S. van Vuren, R.M.J. Schielen (2019) Bed level change in the upper Rhine Delta since 1926 and rough extrapolation to 2050. Delft University, Nov 2019.