Modelling historic floods to validate present and future design discharges: the 1926 case

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Introduction

Floods are a major source of disasters in Europa. Recent floods of large rivers show the need for accurate design of flood defences according to an appropriate safety level. Safety levels are determined based on a statistical return period of discharges. At present, flood frequency analysis are used to estimate design discharges (Benito et al., 2004). This analysis is based on extrapolation of measured annual extreme discharges.

In the Netherlands, discharges have been measured since 1900. The largest measured discharge at Lobith equals 12.600 m^3/s in 1926. This discharge was computed based on measured water levels and an estimation of the profile of the river. However, doubts exist about the reliability of this value.

Since the dataset of measured discharges is relatively short, the discharge in 1926 highly influences the flood-frequency curve and therefore the design discharges along the Dutch river branches. Therefore, the flood of 1926 will be reconstructed to study the discharge that has entered the Netherlands at Lobith. Additionally, the reconstructed 1926 discharge will be released over modern topography to investigate the consequences of such an event in modern times. The model approach developed can be used to reconstruct other historic floods (before discharge measurements were performed) to extend the dataset of observed discharges and to be able to decrease the uncertainty bandwidth of the GRADE-flood-frequency curve. which is now used in determining design discharges.

Method

Topography

To be able to reconstruct the flood event in 1926, firstly the topography must be reconstructed. The study area stretches from Andernach up to the Dutch coastal areas. Of this area the topography in 1995 is known. This dataset will be peeled off to the situation in 1926. The largest changes between 1926 and 1995 are (Klijn and Stone, 2000; Silva et al., 1998)

- Erosion summer bed
- Sedimentation winter bed
- Construction of weirs and sluices
- Construction of a closed dike system along the IJssel
- Bend cut off near Rheden and Doesburg (Fig. 1) of the IJssel
- Widening Pannerdensche Kop

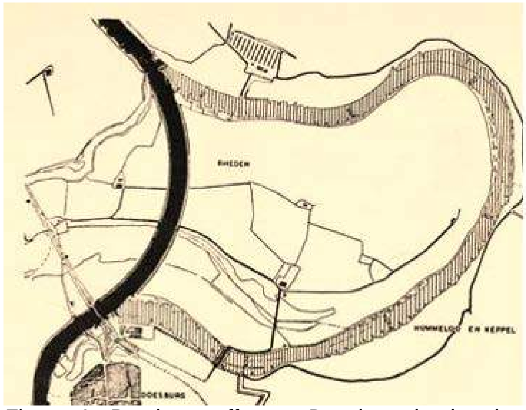

Figure 1. Bend cut off near Doesburg in the river IJssel.(van Heezik, 2006)

Hydrodynamic modelling

After these changes (and possibly others, related to changes in vegetation and land use) have been implemented, the dataset can be used as input for a 2D hydrodynamic model. In our study, D-Flow Flexible Mesh will be used to carry out the two dimensional hydrodynamic calculation. Different grid types will be used to discretize the model domain. Three grid types will be compared based on model results (water levels and discharges) and computation time:

- Completely curvilinear grid (traditional method)
- Completely triangular grid (fast to develop)
- Coupled curvilinear in summer bed - triangular in winter bed grid (Fig. 2)

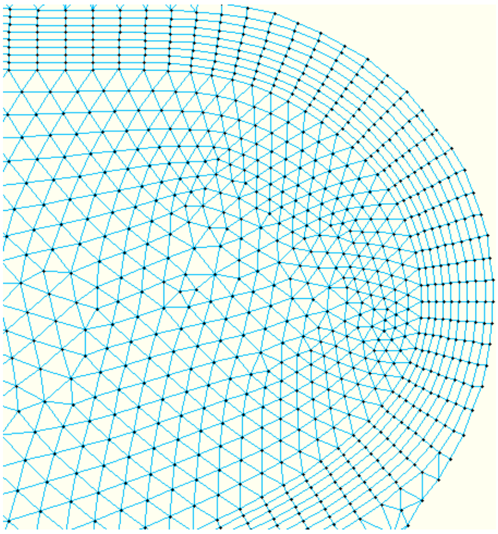

Figure 2. Example of a coupled curvilinear - triangular grid in a sharp bend.

Calibration procedure

After a grid type has been selected to perform the simulations, the model needs to be calibrated. For this, we use the measured water levels and if available, historic data (e.g. inundation of houses, flooding of railroads, etc.) The roughness of the summer bed and the lateral withdrawals will be used as calibration parameters. The lateral withdrawals represent the dike collapses/breaches and spillways that were present during the 1926 flood.

Results

The computed discharge at Lobith will be compared with measured data and possible reasons for differences will be explained. The study also reveals information about the usage of a flexible grid, with respect to accuracy and computation times.

Finally, the 1926 discharge wave will be released over modern topography to investigate the effects of such a flood event over modern topography. Additionally, this will show the consequences of measures performed in the 20th century on flood wave propagation and discharge division along the Dutch river branches. It gives information about flood patterns via the Oude IJssel which may also occur in present times at sufficiently high discharges and which may affect the discharge ratio considerably.

Conclusion

Reconstruction of the 1926 flood event will give insight in the occurred discharge during that event. Additionally, the modelling approach can be used to reconstruct older flood events in the same manner to be able to extend observational record of discharges. This information can be of high value since it may decrease the uncertainty bandwidth of the flood frequency curve.

Acknowledgements

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