FLOODS OF THE PAST, DESIGN OF TOMORROW – PROJECT INTRODUCTION

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A joint research project (two PhD's, 2016-2020) has been granted to Utrecht University and the University of Twente, on the topic of detailed hydraulic modelling of selected largest-known historic river floods affecting the Lower Rhine valley and delta (The Netherlands and adjacent Germany). Besides the abstract authors, a wide group of advisors from academic, engineering and river management (government) positions takes part in the project, that contributes to the Water Safety theme.

Design standards for flood protection in deltas require magnitude estimates of extreme (millennial) floods. For the Rhine River, design discharges of 16,000 to 18,000 m^3/s are considered appropriate (upper) values (for the station at the Dutch-German border). However, annual peak discharge observational records are insufficiently long, and the actual recurrence times of the adopted design values that result from statistical extrapolation are quite uncertain. In recent years, major advances have been obtained in the GRADE (Generator of Rainfall and Discharge Extremes) project, where using a weather generator in combination with a runoff model for the Rhine basin, long (50.000 years) time series of Rhine discharge have been produced (Hegnauer et al. 2014). This creates plenty extreme discharge scenarios, but relies on stochastic resampling of modern (20^{th} century) data, shifting the statistical uncertainty from discharge to weather and not fundamentally reducing it. Extending the observational record by using historic and sedimentological archives provides a complementary way to assess recurrence times and to reduce uncertainty (e.g. Toonen et al. 2016). For a selection of historically-known and geologically-geomorphologically evidently largest floods of the 1500 years, our project will quantify flood magnitudes, so that recurrence statistics are better tied and more accurate.

Numerous historic flood marks exist along the Lower Rhine, and further such markers can be harvested from sedimentary and archeological field data, notably on the extreme floods in 1926, 1809, 1651, 1374, 1342 and ~784/5 AD (e.g. Herget & Meurs 2010; Toonen et al. 2015). We now aim to *quantify magnitudes of large historic floods* of the lower Rhine, building on recent advances in paleoflood reconstruction (refs above) and hydraulic modelling (e.g. Warmink et al. 2013). Hereto, the interdisciplinary projects will combine (i) measured, (ii) archeo-sedimentary and (iii) historic written archives of river activity with (iv) state-of-the-art reconstructions and (v) 2D hydrodynamic modelling of past events that are (vi) calculated over a grid that narrowly mimics that designed for present-day binational flood modelling. A scenario-approach is advocated which includes sensitivity testing of land-reconstruction and flow-hydraulics uncertainties, and evaluates the consequences of historical discharges in present time. For each case-schematization (scenario), a best-fit hydraulic simulation of historic flood wave dispersal (v, vi) over historic landscape (iv) in the area from Cologne well into the Dutch delta apex region, honoring the data of i-iii), will associate to an upstream-incoming extreme discharge wave ('at Andernach'), drawn from GRADE output (ref. above), yielding a set of best-fitting waves per case to specify uncertainty. These set of waves can also be released over present day landscapes (vi), converting (correct, modulate) past discharge to would-be-present values at any station along the modern river (Cologne, Duisburg, Lobith). That serial modeling fulfills the extreme flood frequency-magnitude data need felt from in modern design discharge rating curves. Furthermore, quantitative exploration of model-simulated historic extremes serves to evaluate limits to design-flood potential magnitudes, and allows to test inundation cascades in the present situation.

Keywords: Design discharge, hydraulic modelling, historic flood reconstruction, physical geography

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