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Quantifying the consequences of changing hydroclimatic extremes on protection levels for the Rhine

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The Dutch method for quantifying the magnitude and frequency of occurrence of discharge extremes in the Rhine basin and the potential influence of climate change hereon are presented. In the Netherlands flood protection design requires estimates of discharge extremes for return periods of 1000 up to 100,000 years. Observed discharge records are too short to derive such extreme return discharges, therefore extreme value assessment is based on very long synthetic discharge time-series generated with the Generator of Rainfall And Discharge Extremes (GRADE).

The GRADE instrument consists of (1) a stochastic weather generator based on time series resampling of historical f rainfall and temperature and (2) a hydrological model optimized following the GLUE methodology and (3) a hydrodynamic model to simulate the propagation of flood waves based on the generated hydrological time-series. To assess the potential influence of climate change, the four KNMI'14 climate scenarios are applied. These four scenarios represent a large part of the uncertainty provided by the GCMs used for the IPCC 5th assessment report (the CMIP5 GCM simulations under different climate forcings) and are for this purpose tailored to the Rhine and Meuse river basins. To derive the probability distributions of extreme discharges under climate change the historical synthetic rainfall and temperature series simulated with the weather generator are transformed to the future following the KNMI'14 scenarios. For this transformation the Advanced Delta Change method, which allows that the changes in the extremes differ from those in the means, is used. Subsequently the hydrological model is forced with the historical and future (i.e. transformed) synthetic time-series after which the propagation of the flood waves is simulated with the hydrodynamic model to obtain the extreme discharge statistics both for current and future climate conditions.

The study shows that both for 2050 and 2085 increases in discharge extremes for the river Rhine at Lobith are projected by all four KNMI'14 climate scenarios. This poses increased requirements for flood protection design in order to prepare for changing climate conditions.