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Palaeoflood extremes of the Lower Rhine

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Assessment of the magnitude of design discharges (floods with an expected recurrence of 1/1250-yr) requires knowledge on the frequency and magnitude of extreme events. The current estimate of the size of the design flood for the Lower Rhine is based on the discharge record of the last 100 years, but it is improbable that its extrapolation is optimal for prediction of the magnitude of extreme events, as larger floods than those in the observational records have not been measured. Reconstructing palaeoflood magnitudes and frequencies from sedimentary records may provide insight in the potential maximum magnitude of extreme Rhine discharges. This helps to improve the determination of the design discharge with a reduced uncertainty, especially for extreme values.

We reconstructed the magnitude of a Middle-Holocene flood in the Lower Rhine valley (Germany) based on the highest slackwater deposits on elevated terrace levels and in a palaeochannel fill in a section across the valley. A Chézy-based hydraulic model was used to calculate the palaeoflood discharge out of carefully evaluated geological data; e.g., palaeochannel dimensions, Middle-Holocene natural floodplain landscape, surface roughness, and palaeostage indicators. To account for the uncertainty in the reconstructed input variables, we considered an ensemble of 10 sets of input variables. These represent a realistic range of model inputs and results. From this set we determined a 'best guess' estimate for the minimum magnitude of floods that left the highest registered slackwater deposits in the cross section. The calculated discharge is 13,250 m3s-1 with an estimated recurrence time of 1,250 to 2,500-yr. The recurrence time is based on AMS dating and palynological analysis of the organic palaeochannel fill, which occasionally contains flood event layers.

The use of the calculated discharge in flood frequency analysis for the present-day situation is not straightforward, as the Middle-Holocene flood was generated in a still forested natural catchment. According to present-day records, such discharges date roughly to a recurrence time of $\sim$1/150-yr (e.g., the 12,600 m3s-1 flood of 1926 AD). At present, discharge waves are much steeper than millennia ago, due to deforestation since prehistoric times, and a managed river network. Correcting for these human impacts, the reconstructed palaeoflood would relate to a significant larger discharge, probably matching the current design discharge of the river dikes in the Netherlands. Although geological-based calculations of palaeoflood discharges are often less accurate than modern measurements, they provide unique information to bracket magnitudes of extreme events. Instead of accurate point-data, palaeodischarge outcomes can be used to verify previous estimates on the size of extreme events, and as thresholds of minimum discharge values, which can be used to narrow down uncertainty in previous estimations.