Extreme palaeoflood discharges of the river Rhine during the Mid-Holocene

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TNO

Deltares
Enabling Delta Life

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INTRODUCTION

To estimate a minimum discharge value for the very highest floods that passed down the Rhine in the Holocene, we ran a hydrological model, predicting stage-discharge relations. We tuned this model with data from slackwater deposits of the terraced floodplain of the Lower Rhine.

Estimates for the value of the upper envelope of maximum palaeoflood discharges are necessary to assess present day safety levels of the dikes in the low-lying Netherlands. Previously, the size of the 1/1250 design-flood has been extrapolated from a 100-yr gauge record, which introduces a high level uncertainty as it is likely that no 'real' extreme floods have occured in this reference period.

MODEL SCENARIOS

With either the Manning's or the Chezy formula, the minimum values of palaeodischarges are calculated. A reference run on the extreme floods of 1993 and 1995 indicates an accuracy of our model of ~95%.

As a further sensitivity test, separate scenarios were run for;

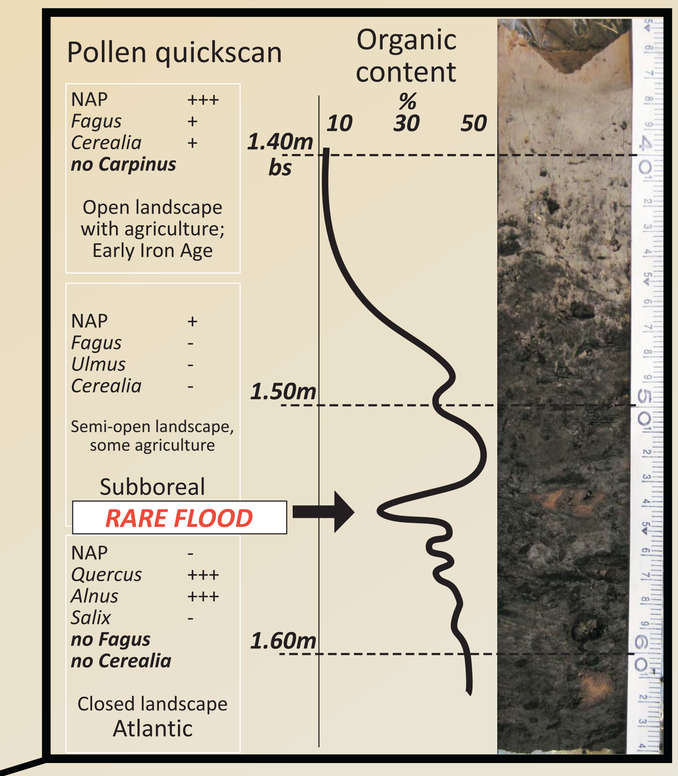
* Summer versus winter vegetation (SUM vs WIN)
* Large and small channel dimensions (Ch+ vs Ch-)

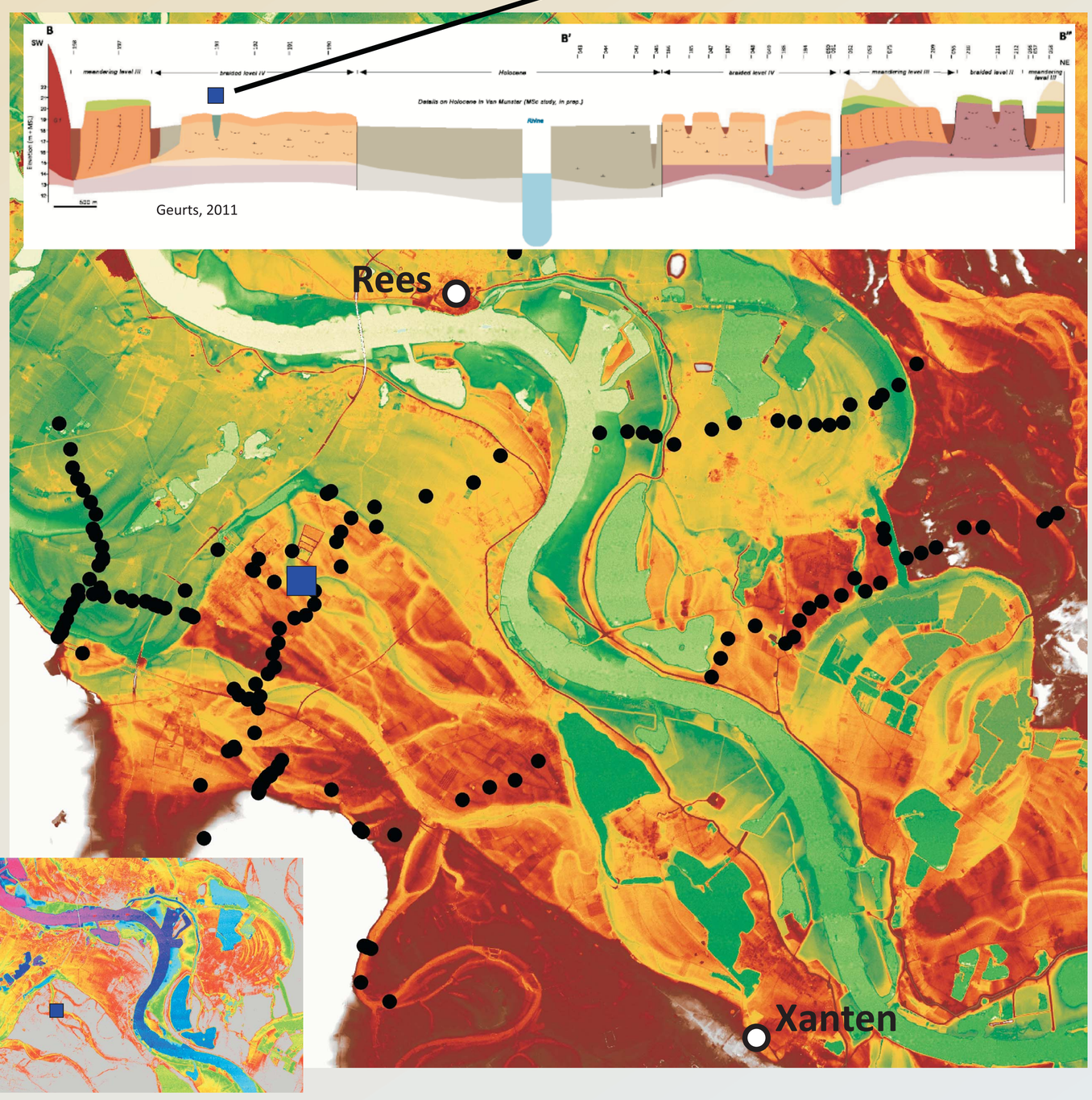
Mannings	*Mid-Holocene discharge*
Sc.M1 SUM Ch+	20407 m3/sec
Sc.M2 SUM Ch-	14364 m3/sec
Sc.M3 WIN Ch+	20815 m3/sec
Sc.M4 WIN Ch-	14601 m3/sec
Chezy	
Sc.C1 SUM Ch+	14705 m3/sec
Sc.C2 SUM Ch-	12709 m3/sec
Sc.C3 WIN Ch+	14999 m3/sec
Sc.C4 WIN Ch-	13217 m3/sec

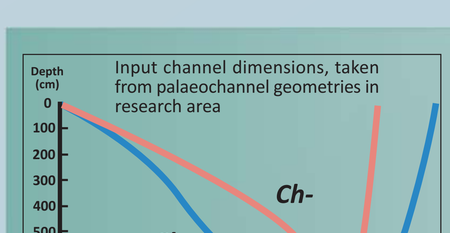
MODEL INPUT

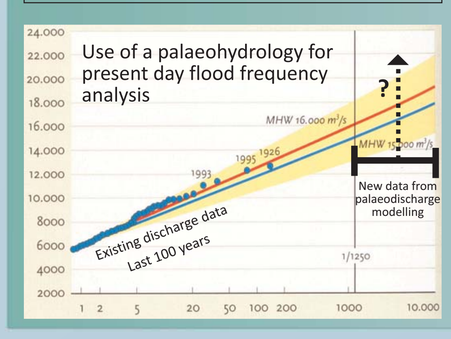
* DEM & Borehole data
  - Floodplain width and morphology
  - Palaeotopography
  - Channel widths
  - Valley slope

* Channel fill data
  - Vegetation roughness
    (fixed for semi-open forests of the Subboreal)
  - Elevation of slackwater deposits
  - Timing of extreme palaeofloods









DISCUSSION

* Uncertain palaeochannel dimensions greatly affect flood magnitude outcome

* Water height on top of slackwater deposit is unknown

* How do Mid-Holocene discharges translate to the present?
  - Deforestation
  - Non-stationarity in climate and flooding mode
  - River management/adjustments

* What is the recurrence time of extreme palaeofloods?

CONCLUSIONS

* Palaeofloods of the Rhine in the Mid-Holocene reached a discharge of at least ~13000 m3/sec

* Channel dimensions do influence model output greatly, effects of seasonal changes in vegetation roughness are only minor

* Mannings formula seems to be inaccurate for large channel hydraulics

* Additional research is needed to transfer Mid-Holocene discharges and recurrence times to present day situation

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