A Lower Rhine flood chronology based on the sedimentary record of an abandoned channel fill

Deltares
Enabling Delta Life

W.H.J. Toonen, T.G. Winkels, M.A. Prins, L.V. de Groot, F.P.M. Bunnik, K.M. Cohen

Universiteit Utrecht
Faculty of Geosciences

INTRODUCTION

Flood frequency analysis in general and specific estimations on the magnitudes of extreme events can be improved by adding data from times before modern measurement started (1901 AD for the Lower Rhine). Both historical and sedimentary records can be used to estimate historical flood magnitudes.

We show that the combination of historical and sedimentary data provides detailed information on floods that occurred after 1300 AD. Hereto we used the Bienener Altrhein, a meander bend that was abandoned in the late 16th century, and has presently been filled with ~8.5m of laminated flood deposits.

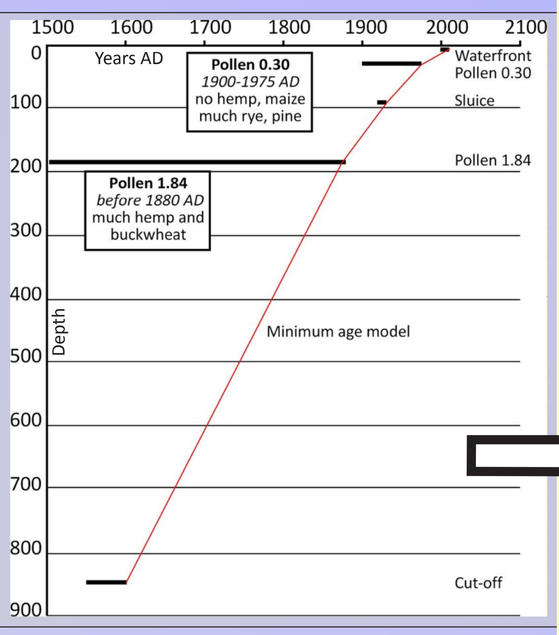
Initial age model

No accurate radiocarbon dating possible

* Radiocarbon plateau
* Insufficient terrestrial carbon
* Industrial pollution

Inputs for intial age model

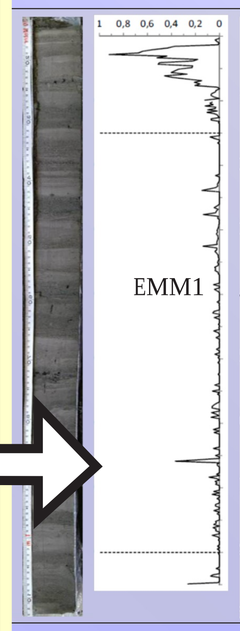
* Channel abandonment (1550-1600 AD)
* Construction sluice (~1920's)
* Waterfront (present)
* Palynological information
* Palaeomagnetic dating

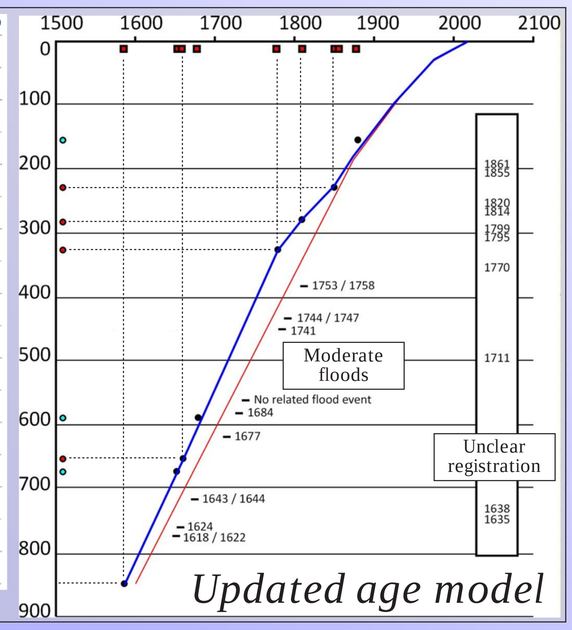


HISTORICAL RECORDS

The age model was updated with most catastrophic floods from historical records, acting as tie-points. Largest floods correspond with coarsest deposits in the channel fill.

Selected historical events	
1595	
1651	MULTIPLE DIKE BREACHES
1658	
1682	REGIONAL EXTENT
1784	
1809	MAJOR DAMAGE
1845	
1850	>10k CUMECS DISCHARGE
1882	





FLOOD MAGNITUDES

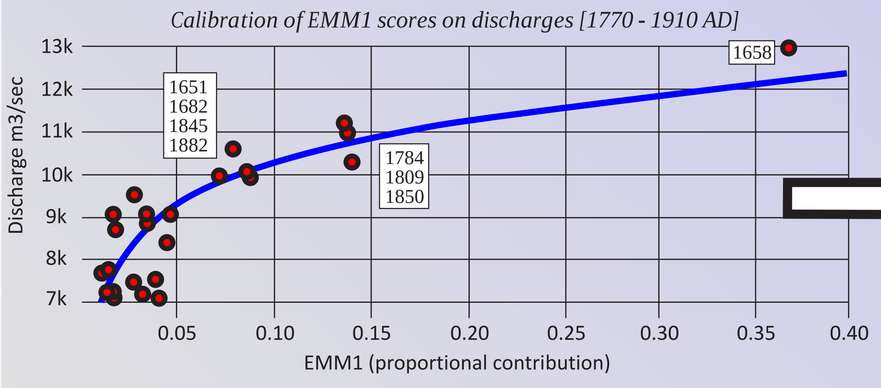
* Based on a comparison of the EMM1 scores, the 1784 / 1809 / 1850 AD floods appear larger than the 1682 / 1882 AD floods - previously estimated to be floods of similar magnitudes (based on historical records).

* Independent estimates on the magtitude of the 1658 AD flood of ~13k discharge seem plausible.

* No extreme floods occurred in 1682 - 1784 AD, although multiple moderate floods are recorded.

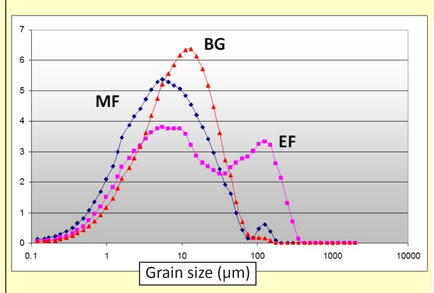
* Calibration of EMM1 scores on discharges, allows to generate a ~400 year flood chronology out of sedimentary data.

Calibration of EMM1 scores on discharges [1770 - 1910 AD]

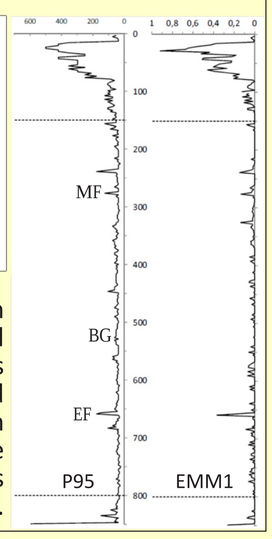


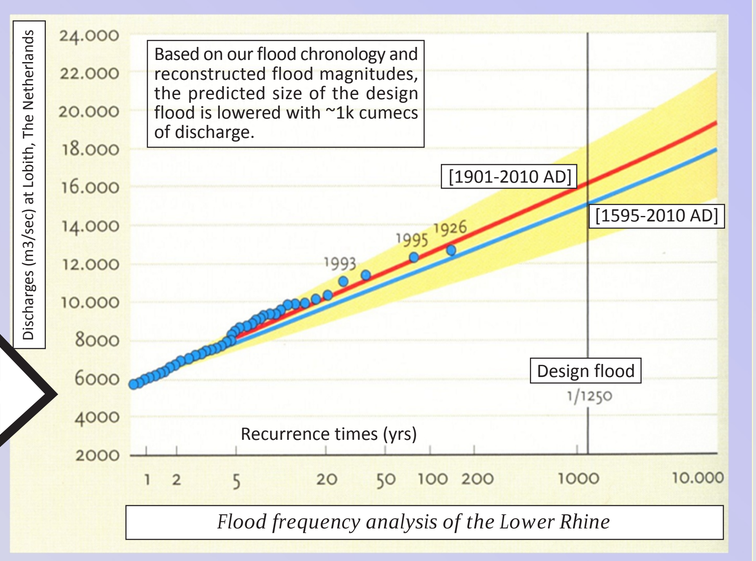
GRAIN SIZE MEASUREMENTS

Variation in the coarser tail of grain size distributions is highlighted by showing the 95th percentile values and End Member Modelling (EMM) results.



EMM is used to 'unmix' different grain size populations. Compared to annual floods (background noise; BG), layers from moderate floods (MF) and extreme floods (EF) have coarser grain populations admixed. Displaying the coarsest End Member (EMM1) allows to focus on large floods specifically.





CONCLUSIONS

* Sedimentary records in abandoned channels are very suitable sites for constructing flood chronologies.

* Combining sedimentary and historical data;
  - Highly accurate age-depth models.
  - Historical records provide information about origin of flood deposit (ice damming or rainfall events).
  - Deposits give information on relative flood sizes.

* Calibration of sedimentary characteristics on discharge data allows reconstruction of palaeoflood magnitudes.

* Flood frequency analysis is supported by sedimentary and historical data:
  - Longer reference period for recurrence times.
  - Addition of data points in realm of extreme events.
  - Information on non-stationarity of flooding regime.

Dept. Physical Geography, Utrecht University. w.h.j.toonen@uu.nl