Institute of Earth Sciences
Faculty of Earth and Life Sciences

Natural variability versus anthropogenic change:

modelling climatic and hydrological characteristics of the Meuse basin during the Late Holocene

ICG Symposium, Wageningen - 22nd March 2007

Philip Ward

Co-authors:
Hans Renssen, Ronald van Balen, Jef Vandenberghe (Palaeoclimatology and Geomorphology, VU); Jeroen Aerts (Institute for Environmental Studies, VU)

klimaat voor ruimte

vrije Universiteit amsterdam

Structure of Presentation

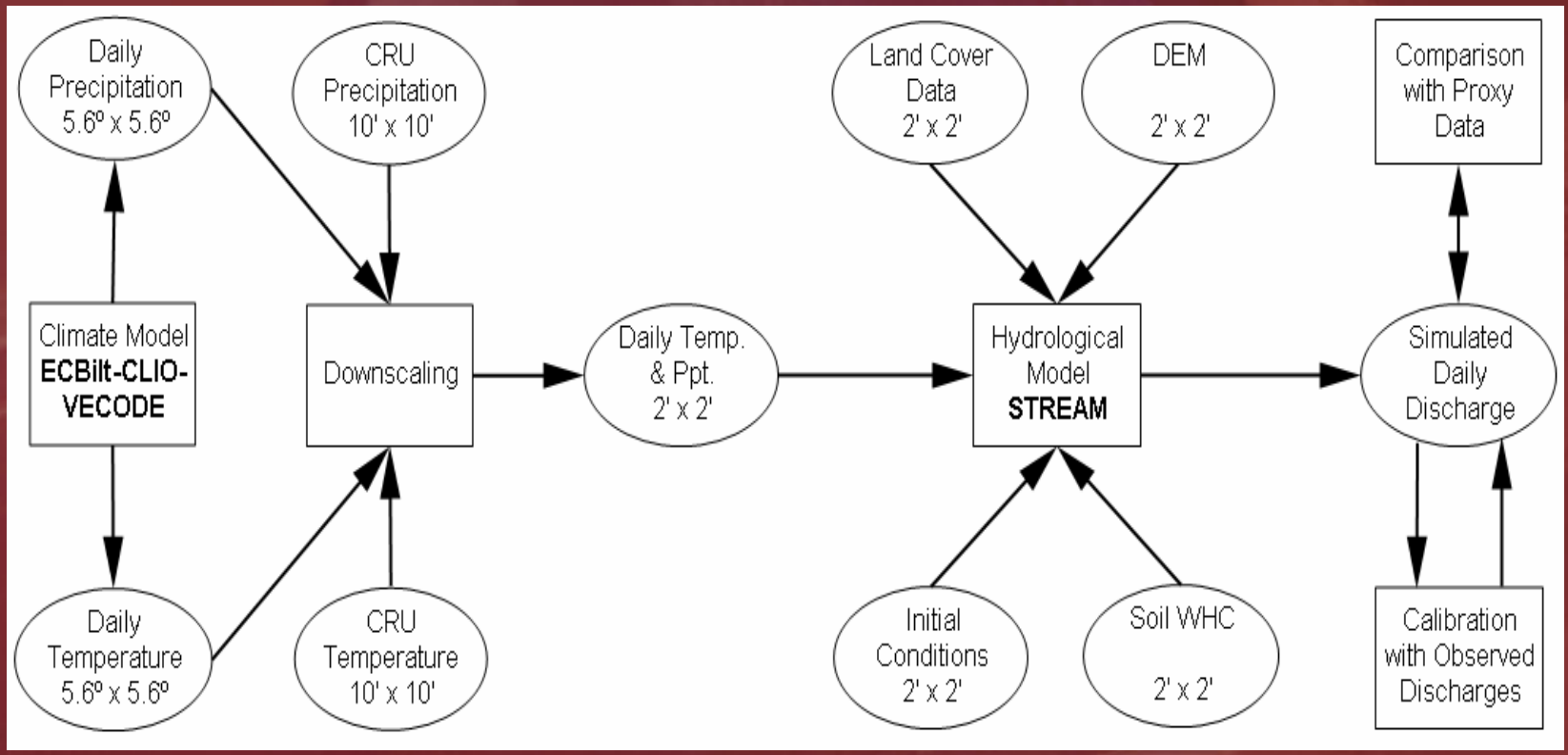
- Aims and Rationale
- Approach and Methods
- Climate Results
- Discharge Results
- Conclusions

Aims

- Set up and validate a coupled climate-hydrological model of the Meuse
- Analyse Meuse discharge characteristics in 4000-3000 BP (reference period) and 1000-2000 AD
- Examine effects of climate and land-use change on discharge

Rationale

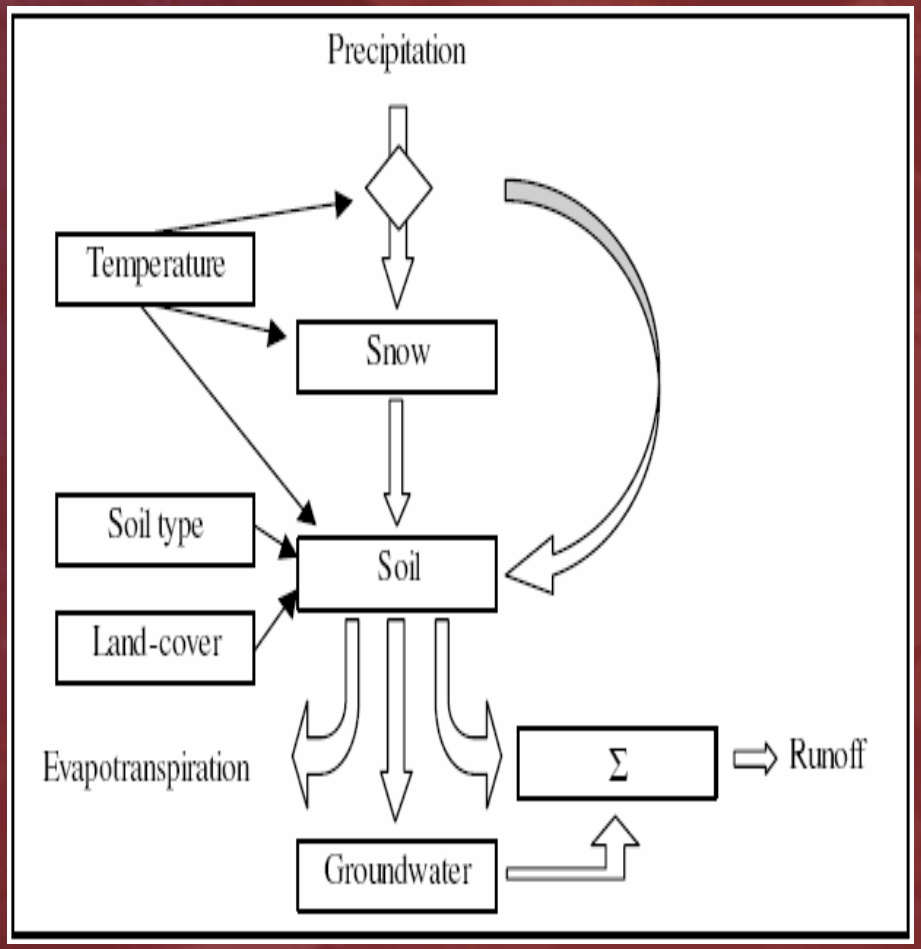
Research Approach



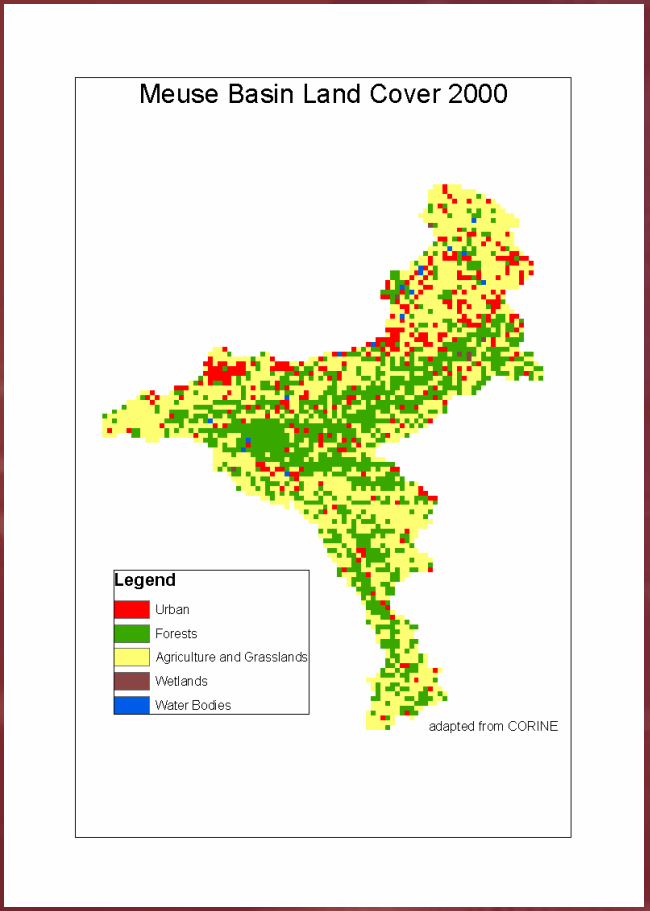
STREAM Meuse – Input Data

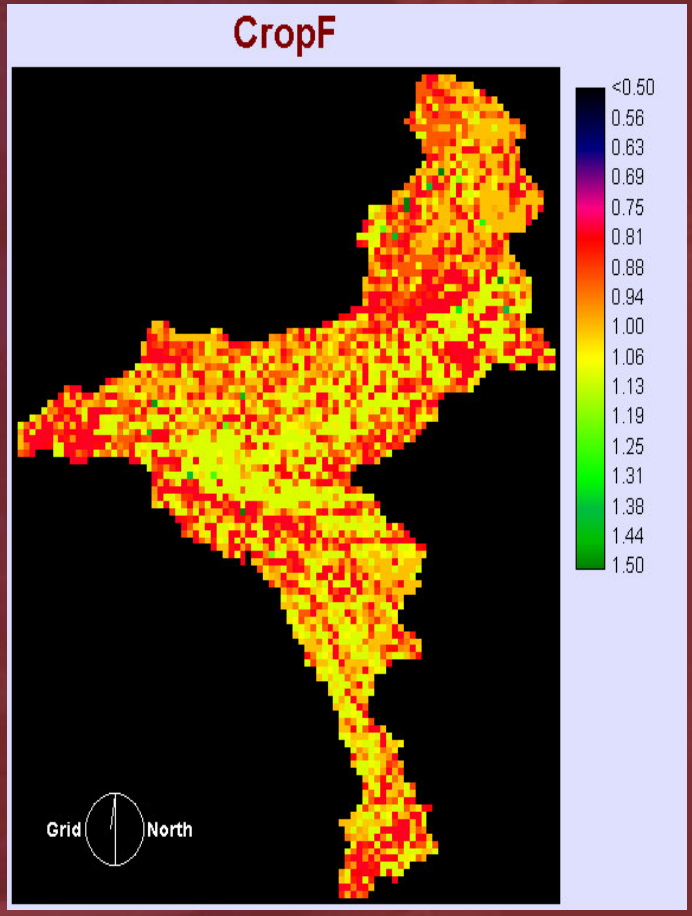
GIS raster database: 2’ x 2’

- Daily climate data (temperature and precipitation)
- DEM / River Routing Network
- Land-Cover
- Soil Water Holding Capacity



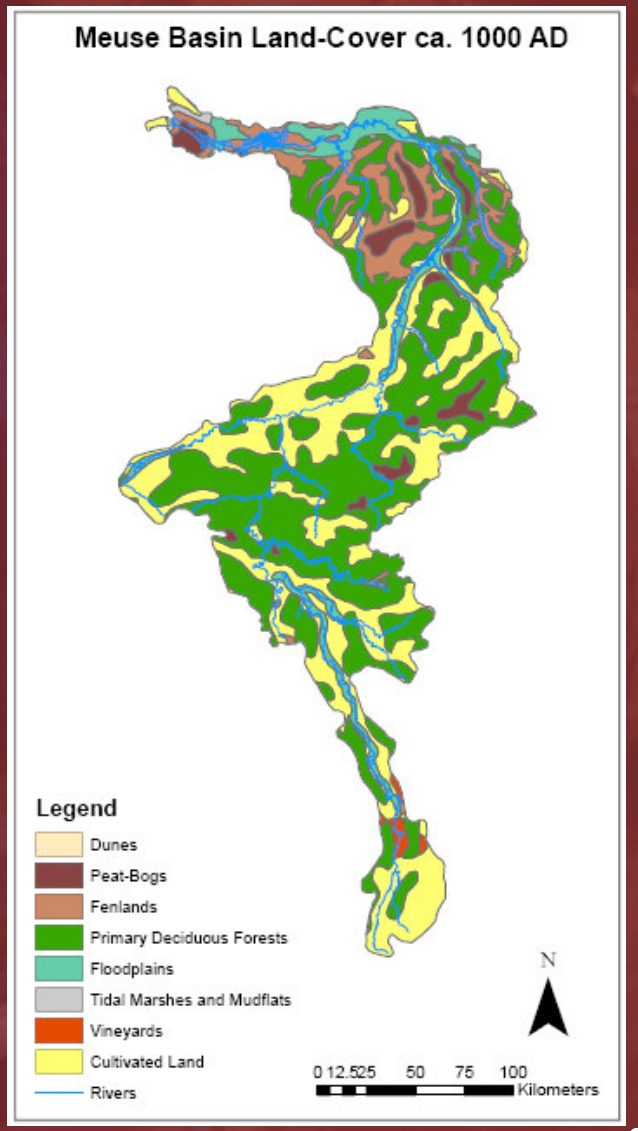
Land-Cover Data



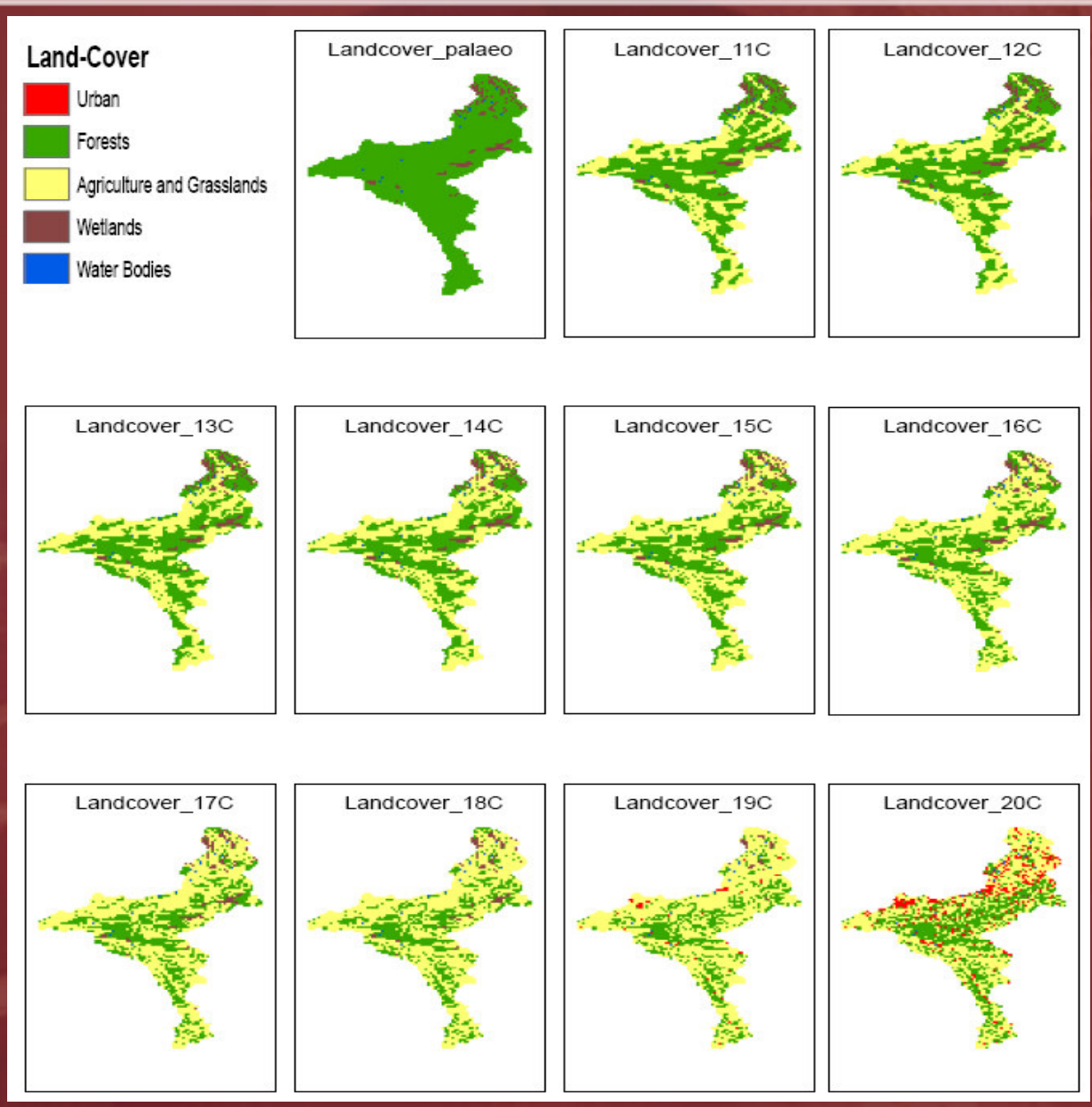


Land-Cover Data

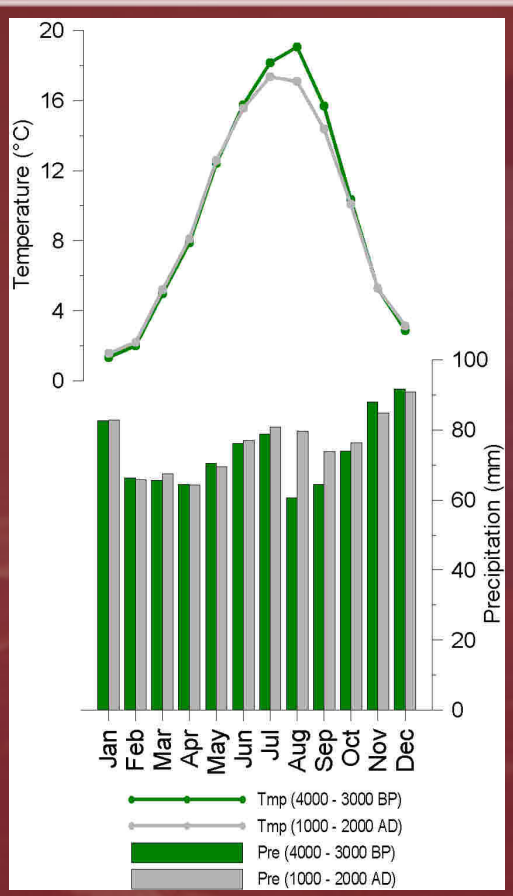
- Present: CORINE 250 m
- 1000 AD: RWS Limburg/IWACO (2000)
- 1000 - 2000 AD:
  - Historical Maps
  - Historical Records
  - Pollen Analysis

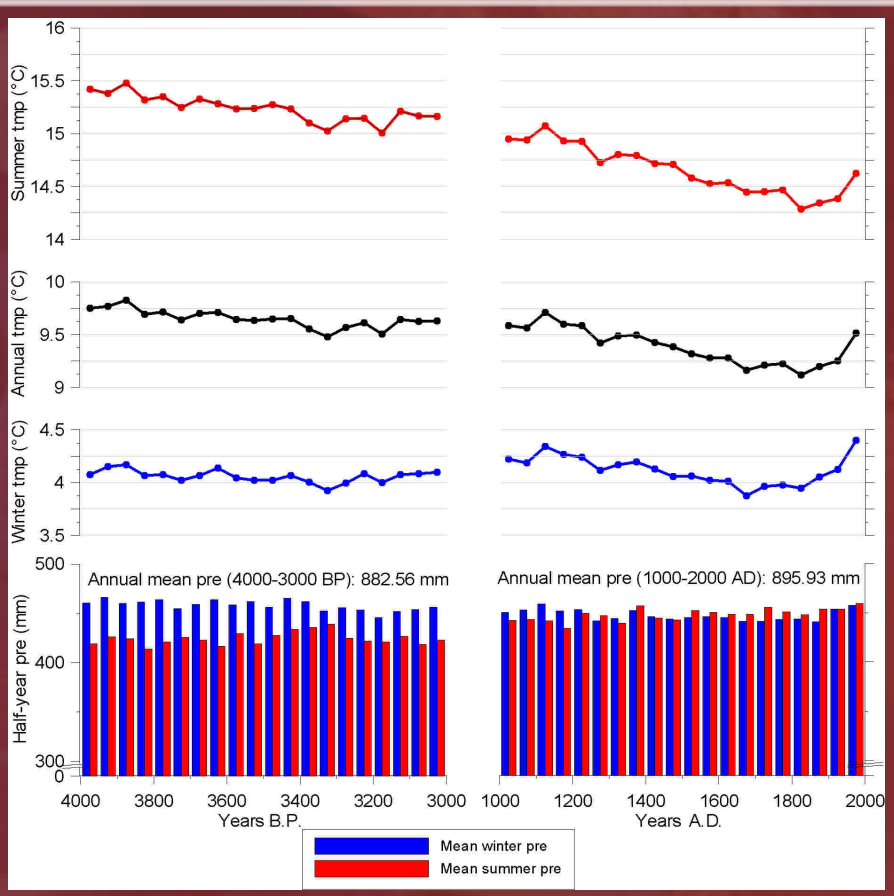


Land-Cover Data



Climate Results





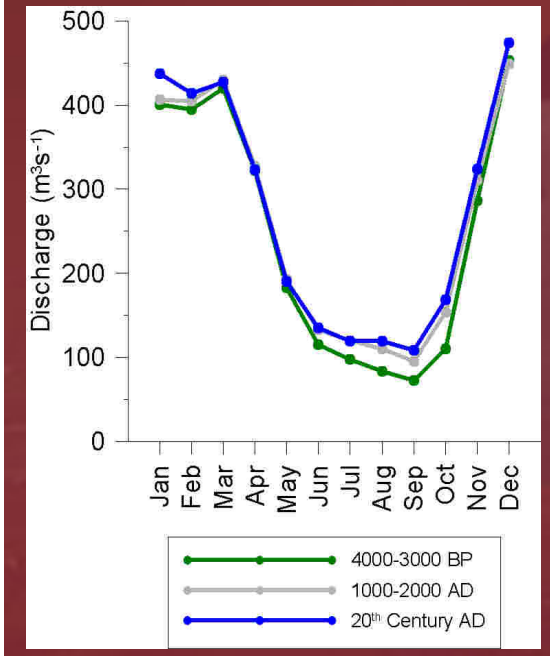
Recent annual and summer pre > *Mid-Holocene* annual and summer pre (*t-test: p < 0.001*)
Recent winter pre < *Mid-Holocene* winter pre (*t-test: p < 0.001*)

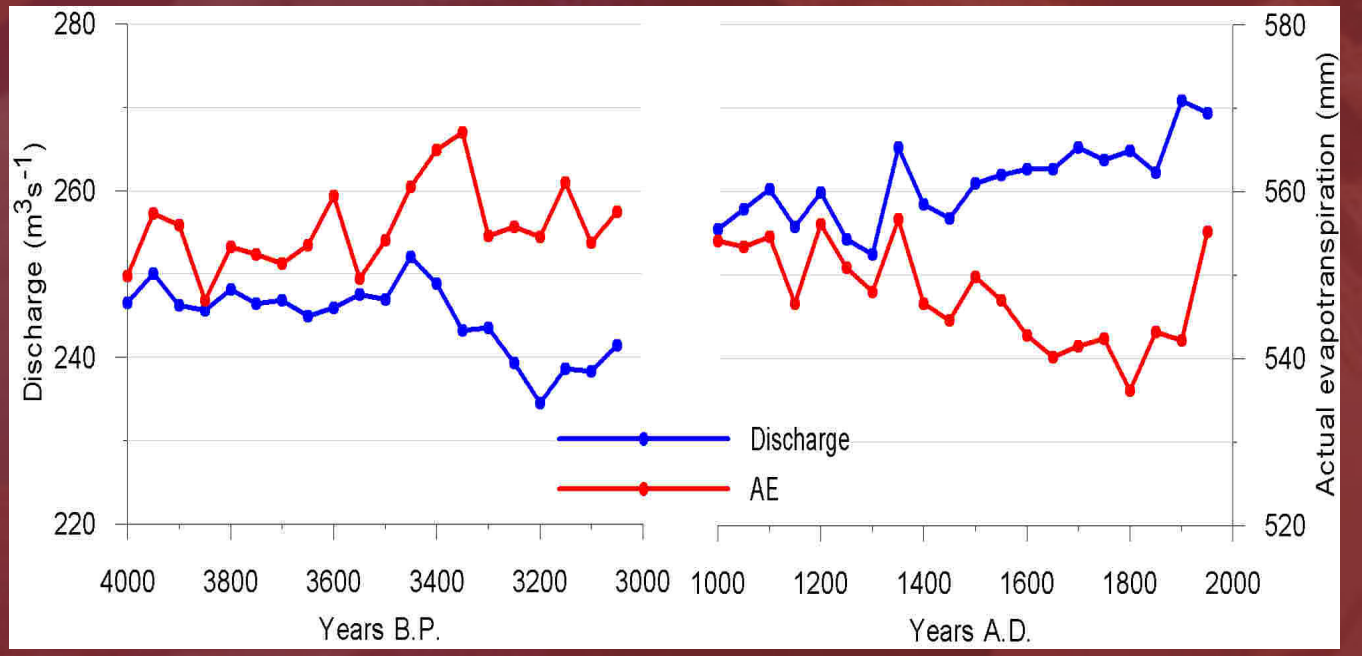
Recent: no **trend** in precipitation series

Extreme precipitation events: more common in *Mid-Holocene*

vrije Universiteit amsterdam

Discharge Results



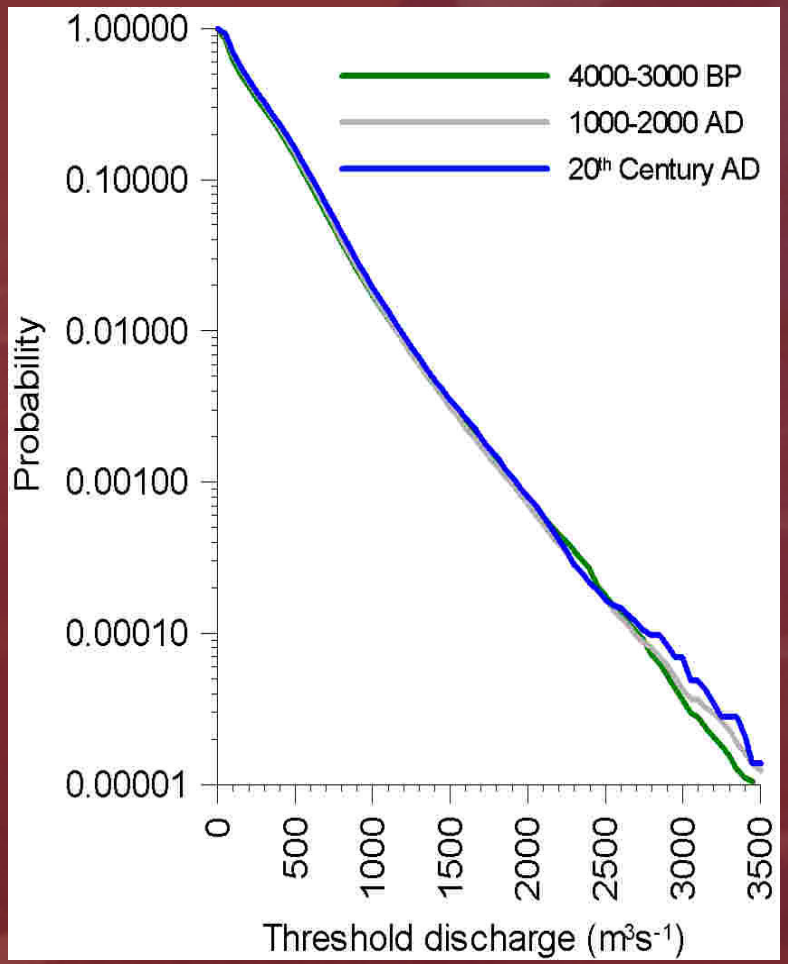


Recent Q = 261.0 m^3s^{-1} / *Mid-Holocene* Q = 244.8m^3s^{-1}
Recent Q: increasing **trend** (*Mann-Kendall, p < 0.001*)

Recent AE < *Mid-Holocene* AE (*t-test, p < 0.001*)
Recent AE: decreasing **trend** (*Mann-Kendall, p < 0.001*)

Discharge Results

Probability of discharge over a threshold



Recurrence times of specific discharge magnitudes

	Discharge (m^3s^{-1})		
	>800	**>1300**	**> 3000**
3999 - 3000 BP	26 days	165 days	77 years
1001 - 2000 AD	25 days	168 days	65 years
1901 - 2000 AD	22 days	150 days	40 years

vrije Universiteit amsterdam

Discharge Results

Percentage change in discharge magnitude due to changes in climate and/or land-cover

	Q_{ann}	Q_{75}	Q_{90}	Q_{95}	Q_{99}
4000-3000 BP → 20th Century AD					
Climate and Land use	+12.5 %	+11.3 %	+7.1 %	+5.6 %	+4.1 %
Climate only	+0.1 %	-0.4 %	+0.6 %	+0.1 %	-0.6 %
Land Use only	+12.4 %	+11.7 %	+6.6 %	+5.5 %	+4.8 %
19th Century AD → 20th Century AD					
Climate and Land use	+3.5 %	+4.3 %	+2.9 %	+3.2 %	+4.0 %
Climate only	+4.5 %	+5.5 %	+3.6 %	+3.8 %	+4.8 %
Land Use only	-1.0 %	-1.1 %	-0.8 %	-0.5 %	-0.2 %

Conclusions

- Mean discharge and high-flows significantly greater in 1000-2000 AD than 4000-3000 BP (dominant mechanism: deforestation)
- Effect of climate change between 4000-3000 BP and 1000-2000 AD insignificant
- 20th Century: relatively large increases in mean discharge and flood frequency despite increased AE (reforestation and increased temperature)
- Flood frequency in 20th Century increased due to significant increase in precipitation, especially in winter half-year

Publications

- Ward, P.J., Aerts, J.C.J.H., de Moel, H., Renssen, H., 2007. Verification of a coupled climate-hydrological model against Holocene palaeohydrological records. *Global and Planetary Change, doi:10.1016/j.gloplacha.2006.12.002*.

- Aerts, J.C.J.H., Renssen, H., Ward, P.J., de Moel, H., Odada, E., Bouwer, L., Goosse, H., 2006. Sensitivity of global river discharges under Holocene and future climate conditions. *Geophysical Research Letters, 33, L19401, doi:10.1029/2006GL027493*.

E-mail: philip.ward@falw.vu.nl

vrije Universiteit amsterdam