Das Augusthochwasser 2002 im Osterzgebirge und dessen statistische Bewertung

The extreme flood in August 2002 in the eastern part of the Ore Mountains and its statistical assessment

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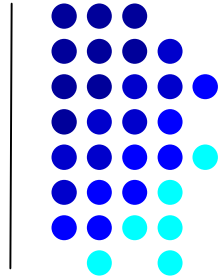
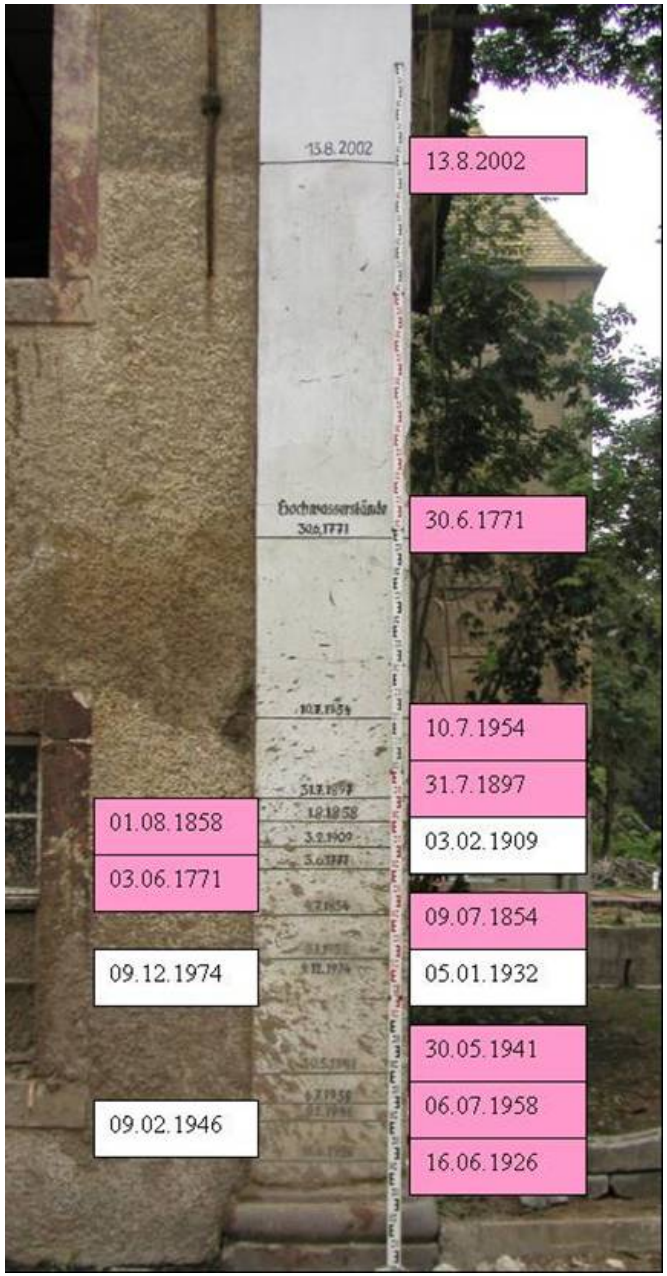
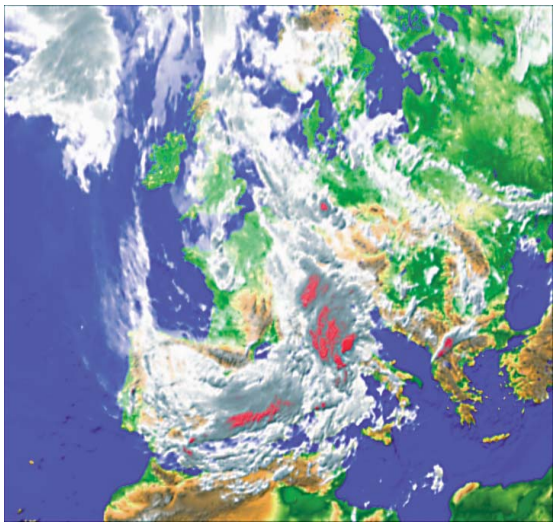
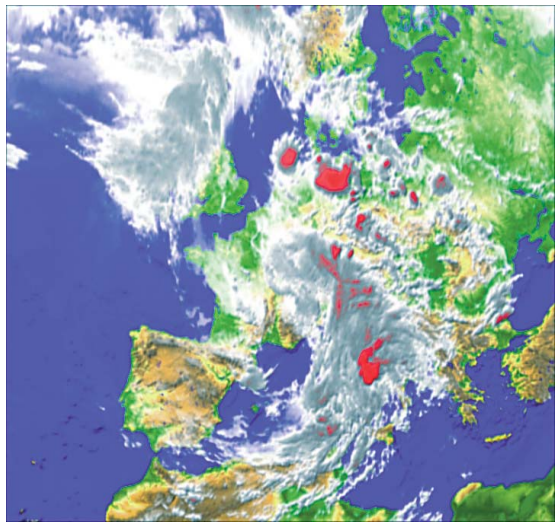
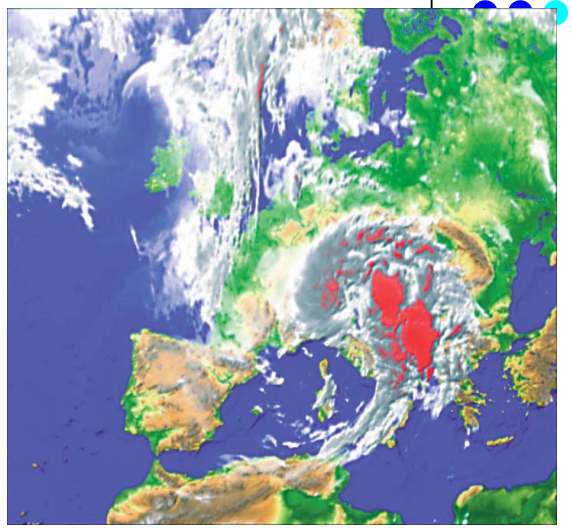
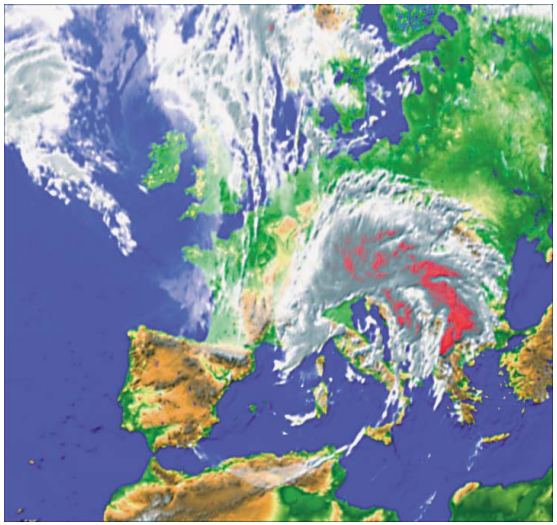
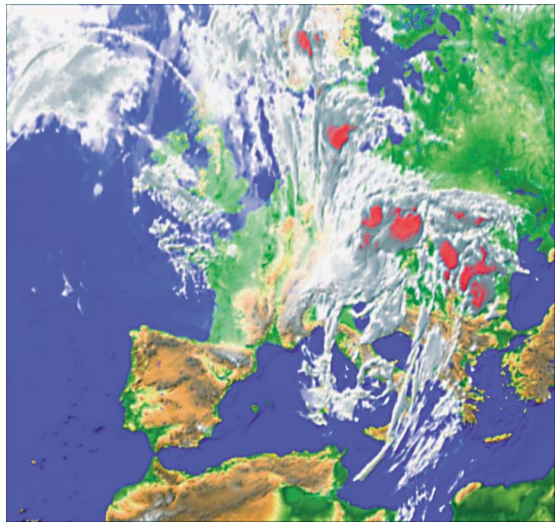


- The hydrological event
- Statistical evaluation of the flood event
- How realistic is the statistical assessment ?

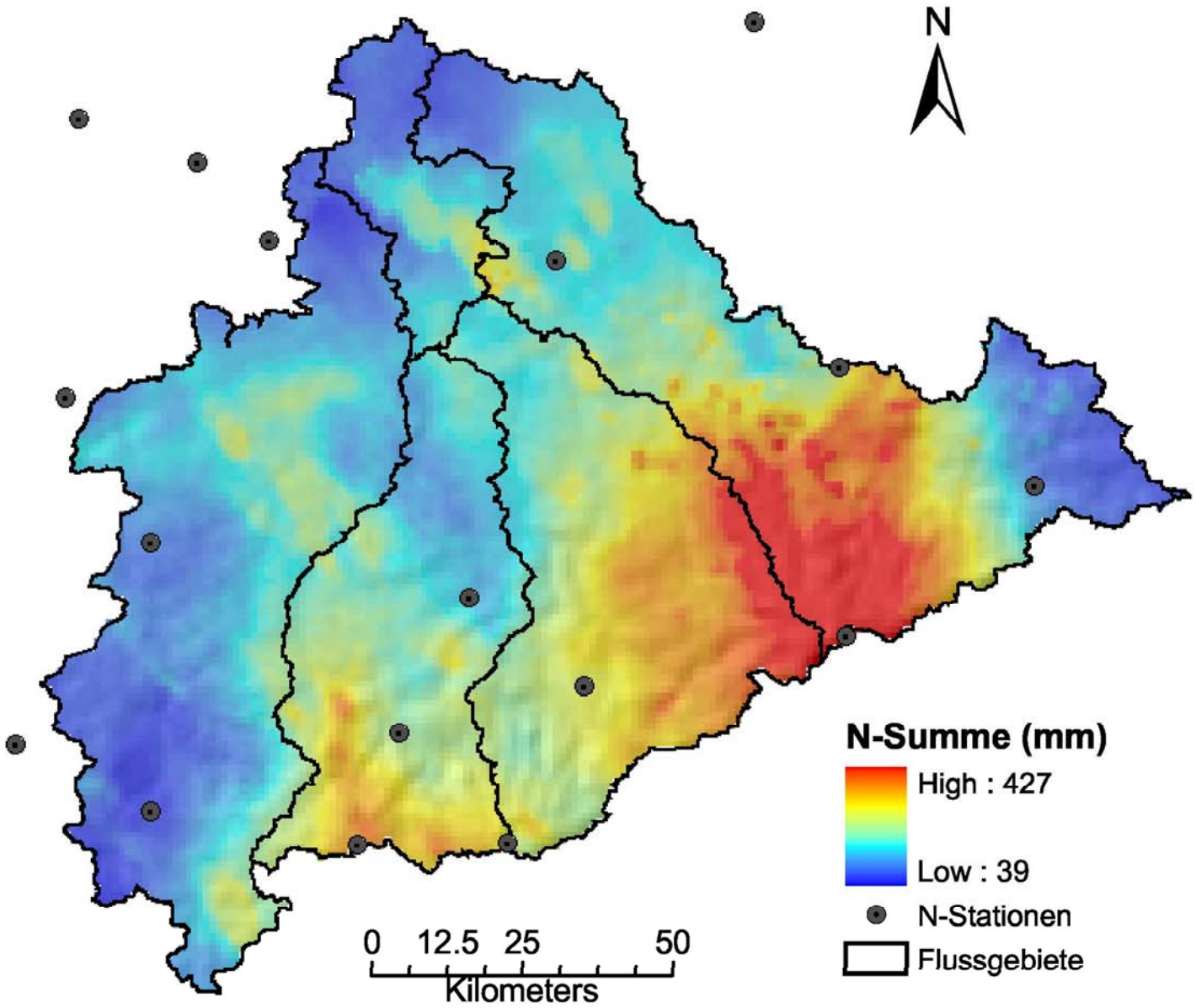


The extraordinary level of the flood 2002 in relationship to flood peaks of the past (since 1771) at an old building in the city of Grimma at the Mulde River in Germany

Meteorological reason for the floods in August 2002 - Vb-Circulation Pattern

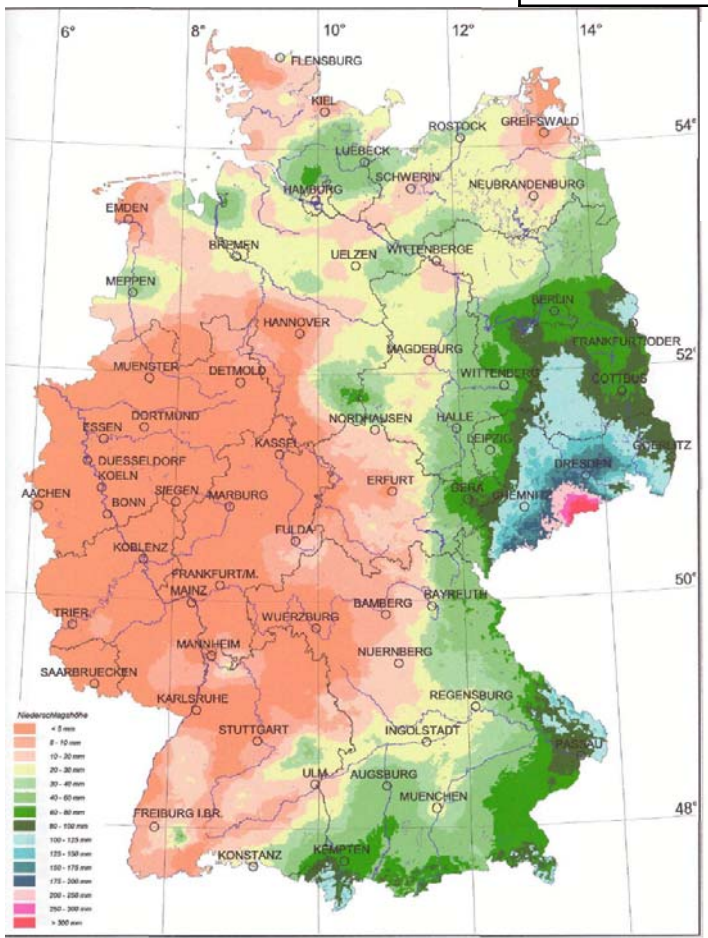






Spatial Distribution of the extreme precipitation from August 10 to August 13, 2002 in the German part of the Ore Mountains

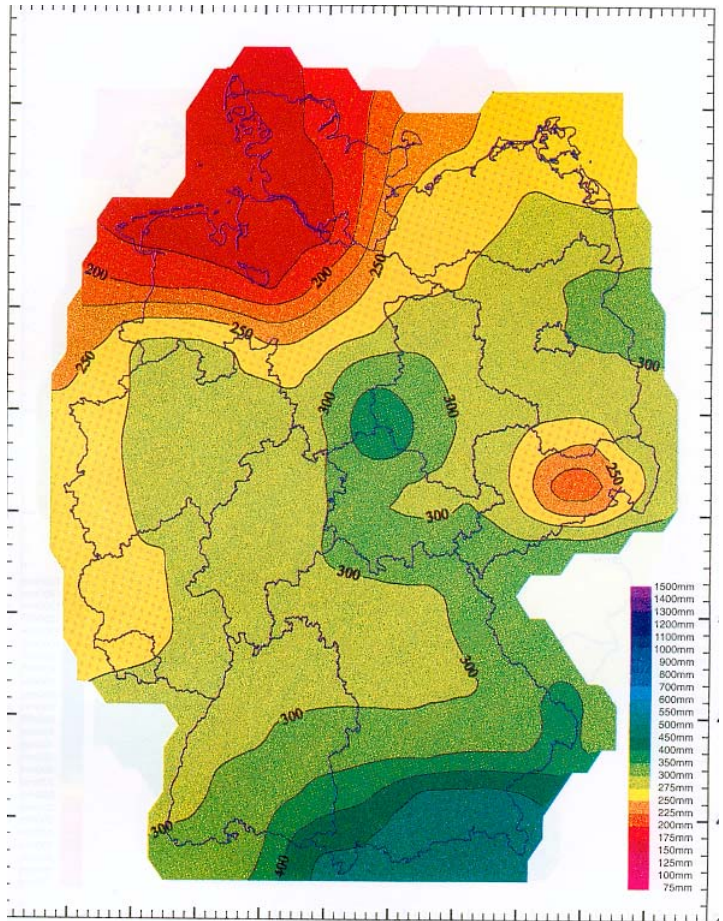


PMP and measured rainfall maxima in August 2002

Region	Area in sq.km	Duration 24 hours	Duration 72 hours
Station Zinnwald	1 to 25 km^2	350 mm **312 mm**	500 mm **406 mm**
Region Zinnwald	1.000 km^2	300 mm	450 mm
Part of the Elbe River Basin	5.000 km^2	200 mm	275 mm
Watershed Upper Elbe	12.000 km^2	160 mm	250 mm

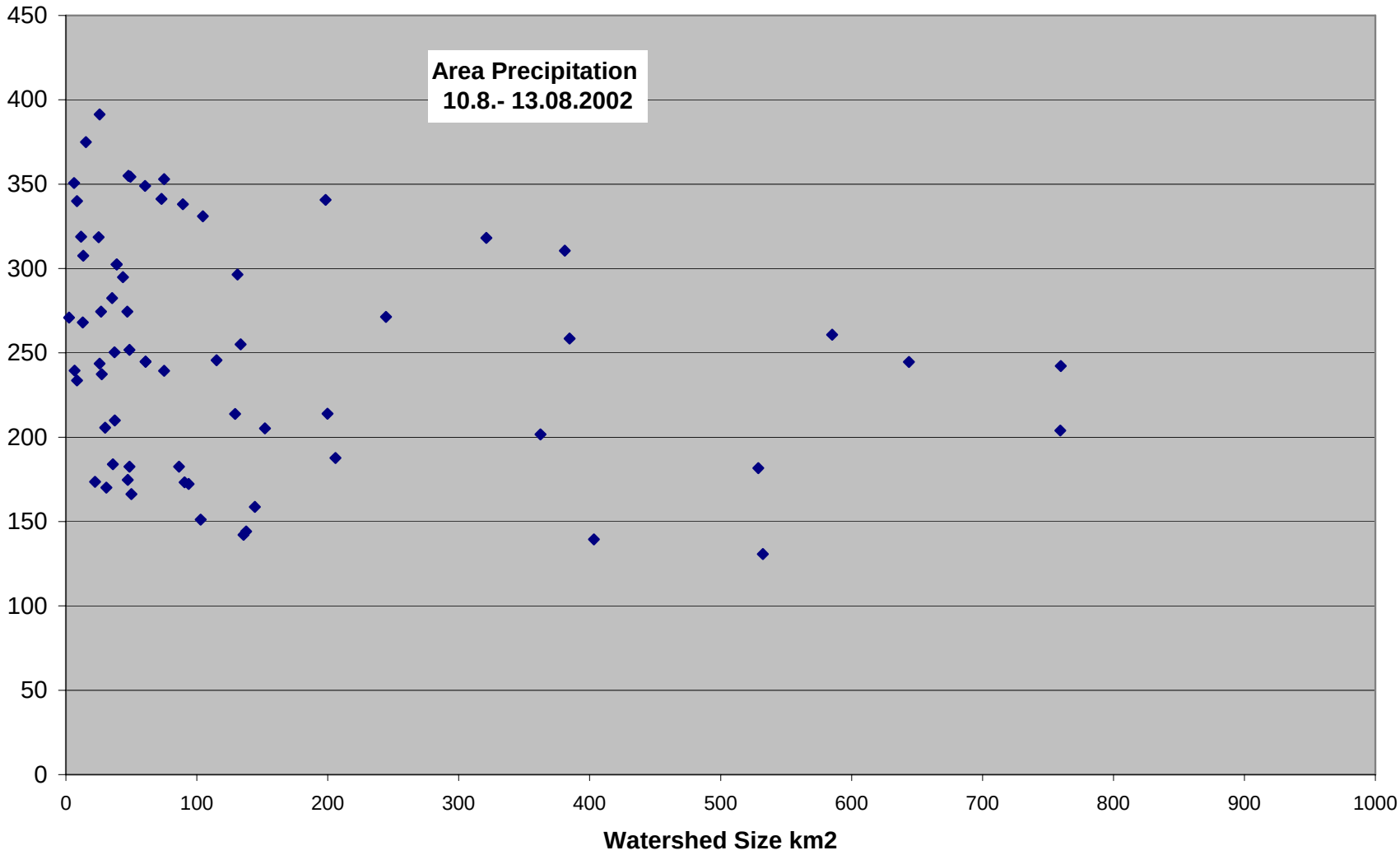


Precipitation between August 11 and 13, 2002 in mm

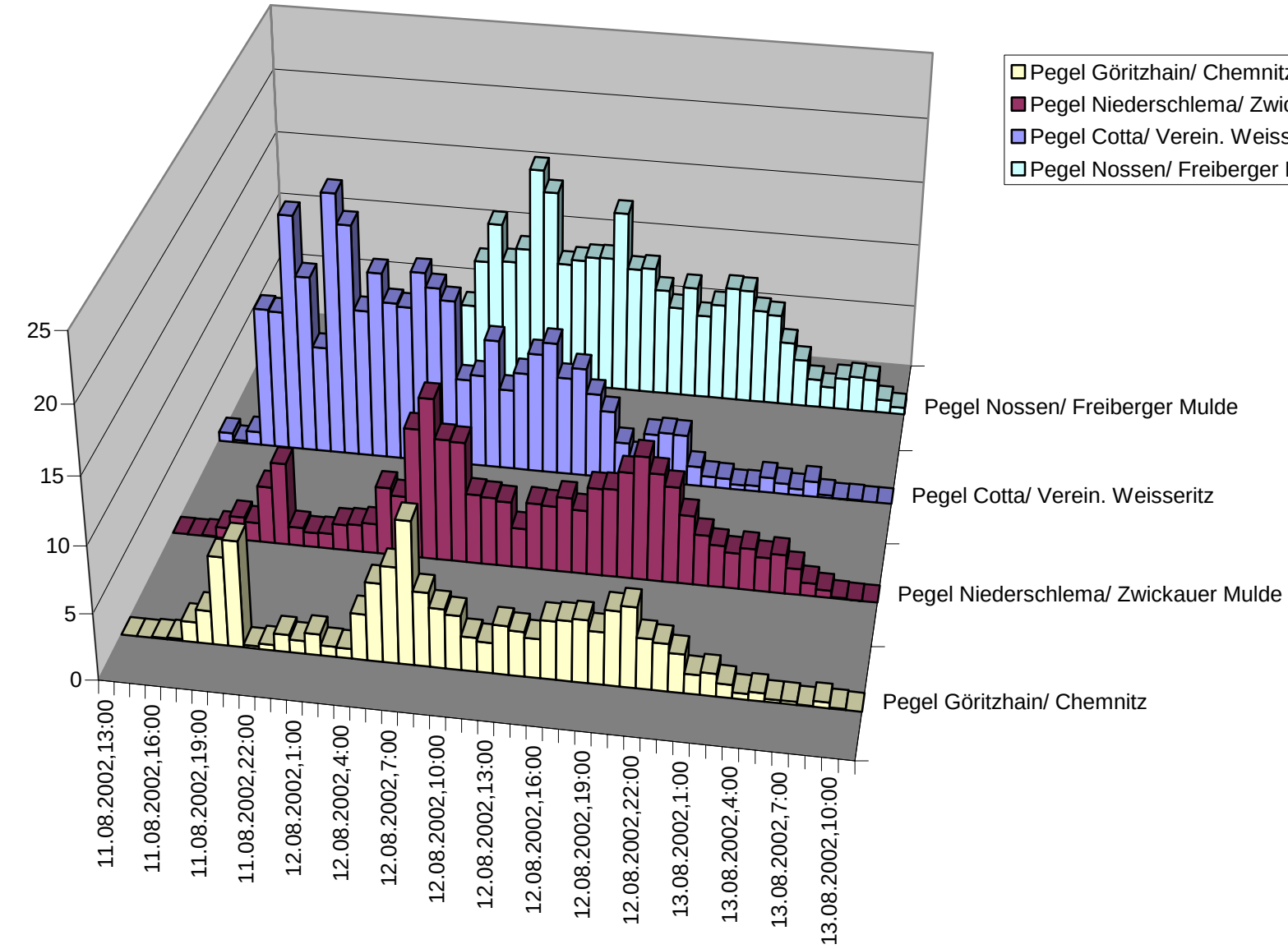


PMP with a duration of 12 hours for watersheds with 500 km^2 in size in summer (June to August)

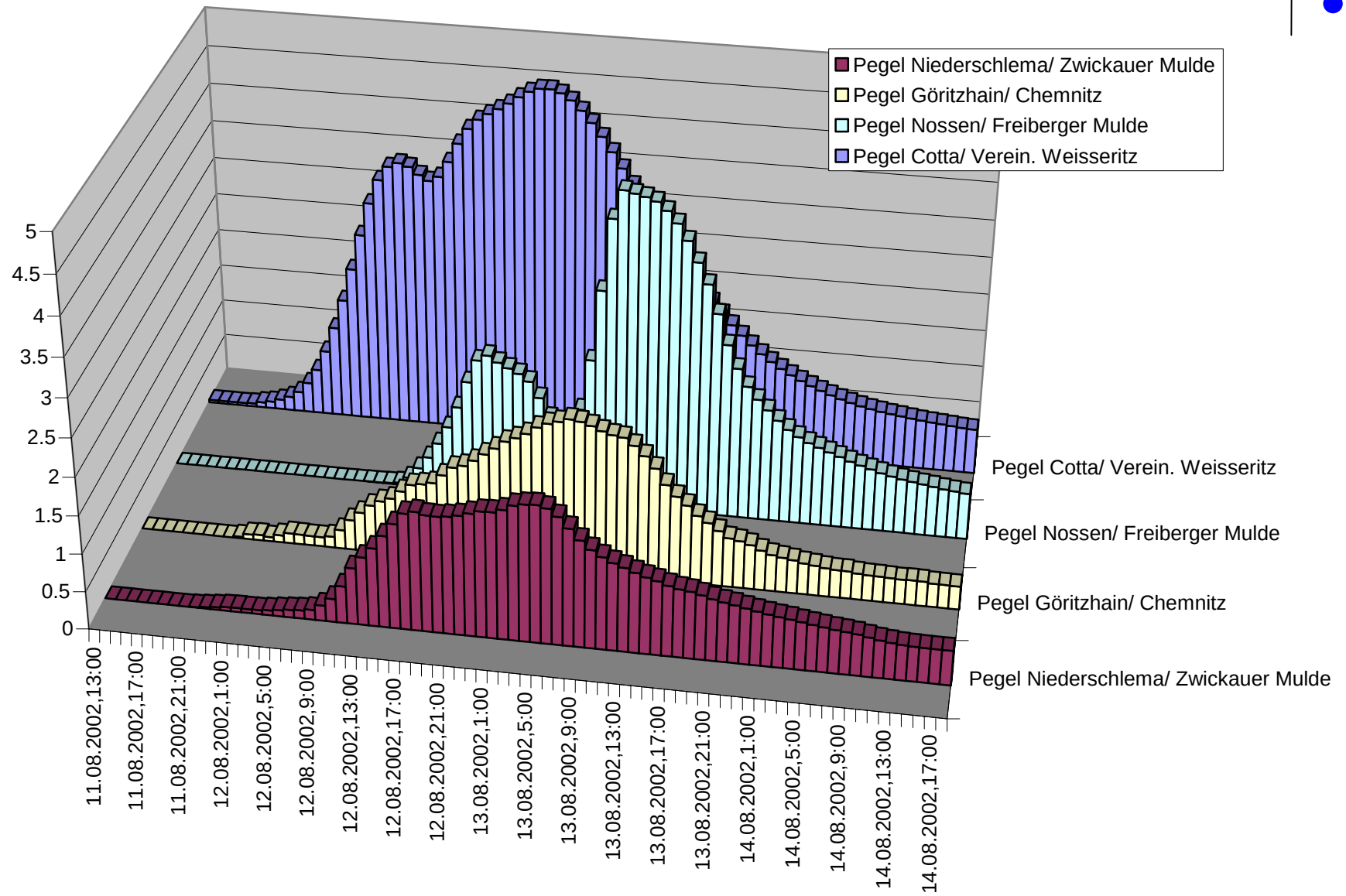
Areal precipitation values from August 10 to 13 2002 for watersheds in the Ore Mountains



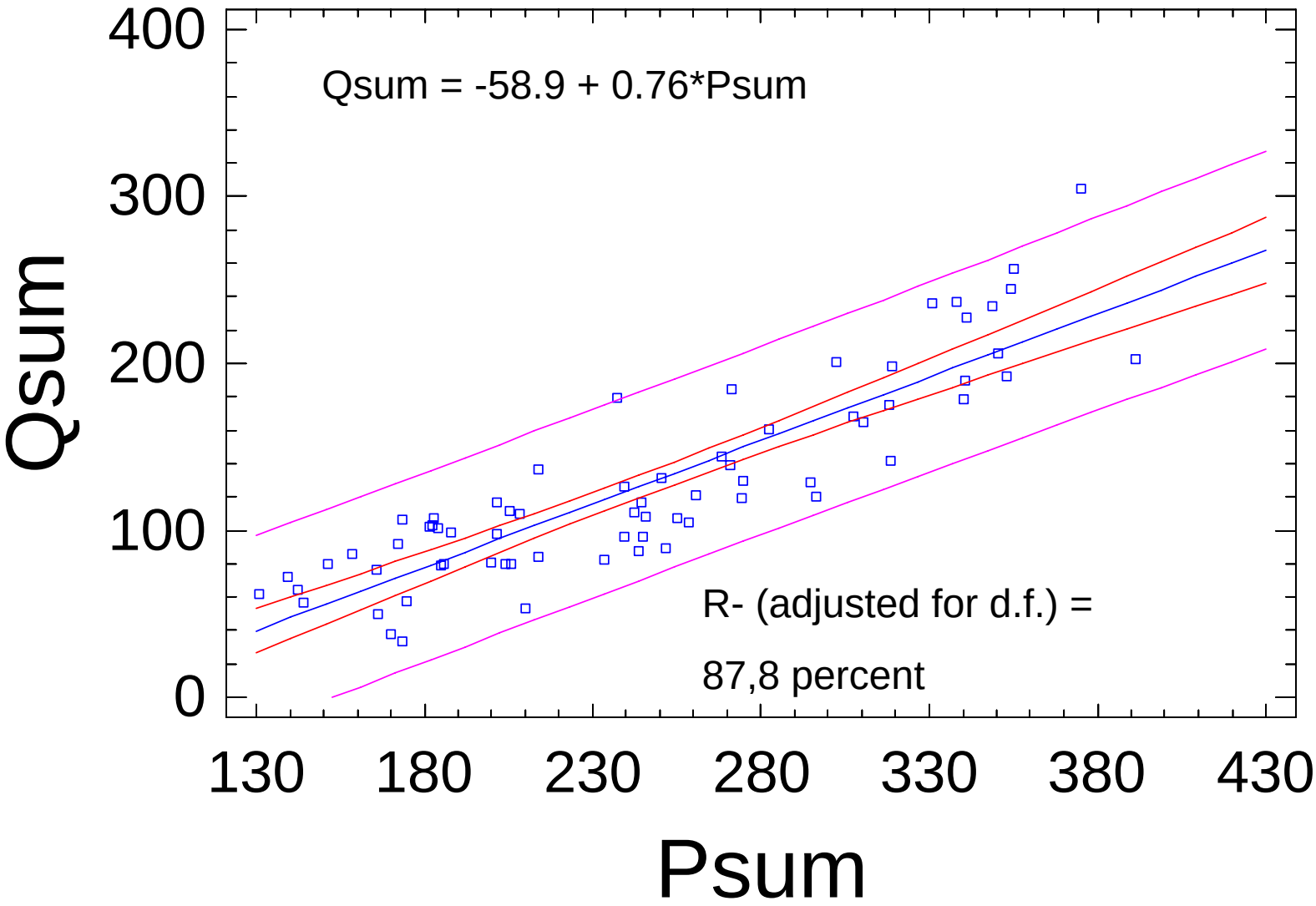
Temporal distribution of the precipitation from August 11 to 13 for different river basins in Saxonia



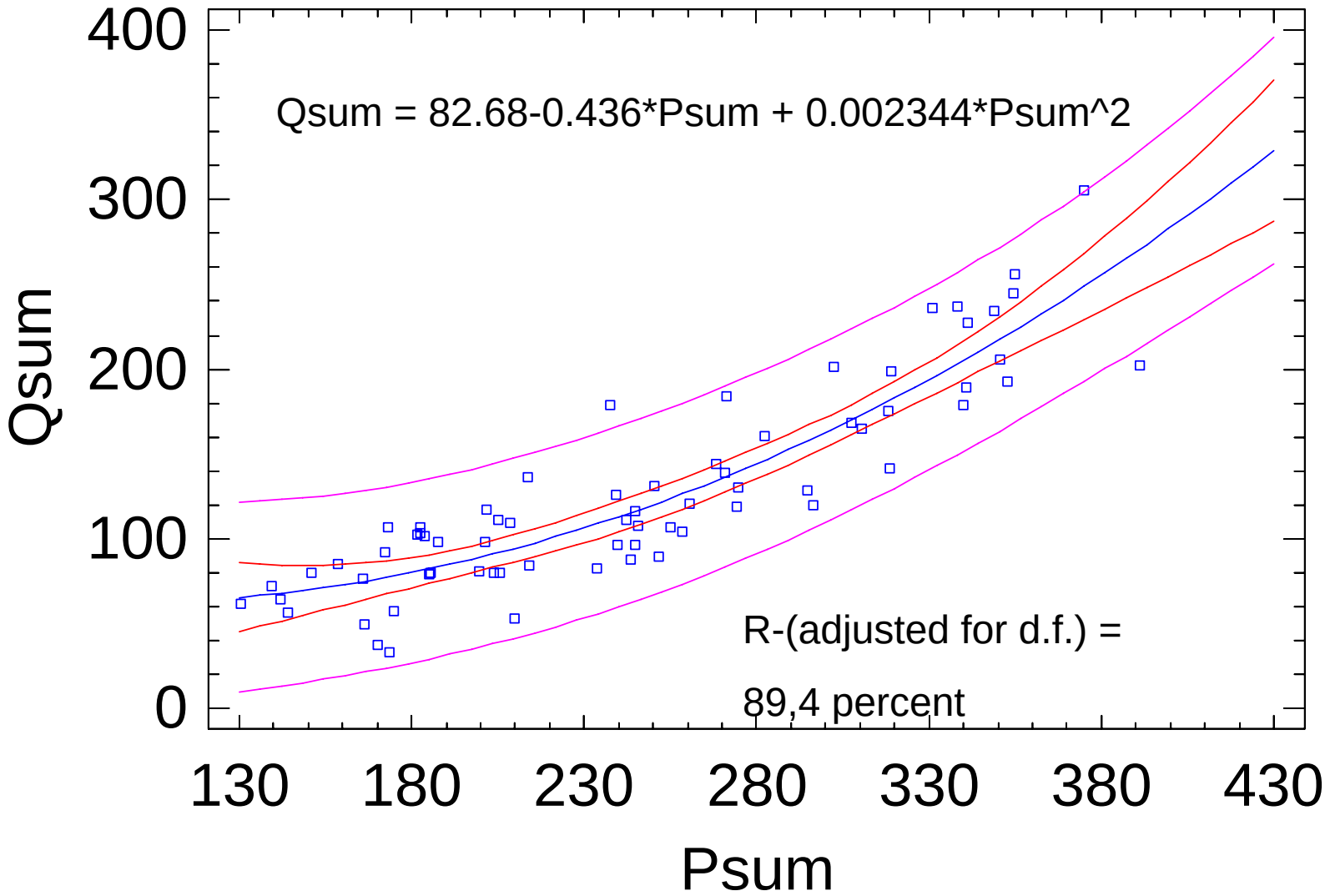
Temporal distribution of runoff from August 11 to 14, 2002 for different river basins in Saxonia

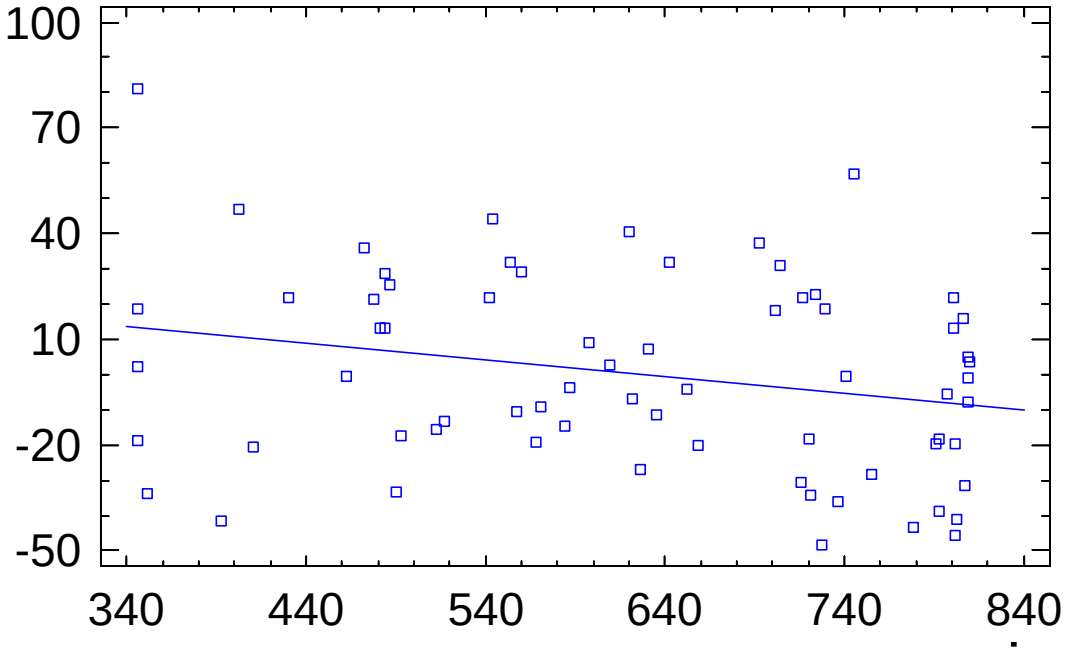


Linear regression between direct runoff (in mm) and area precipitation for the flood in August 2002



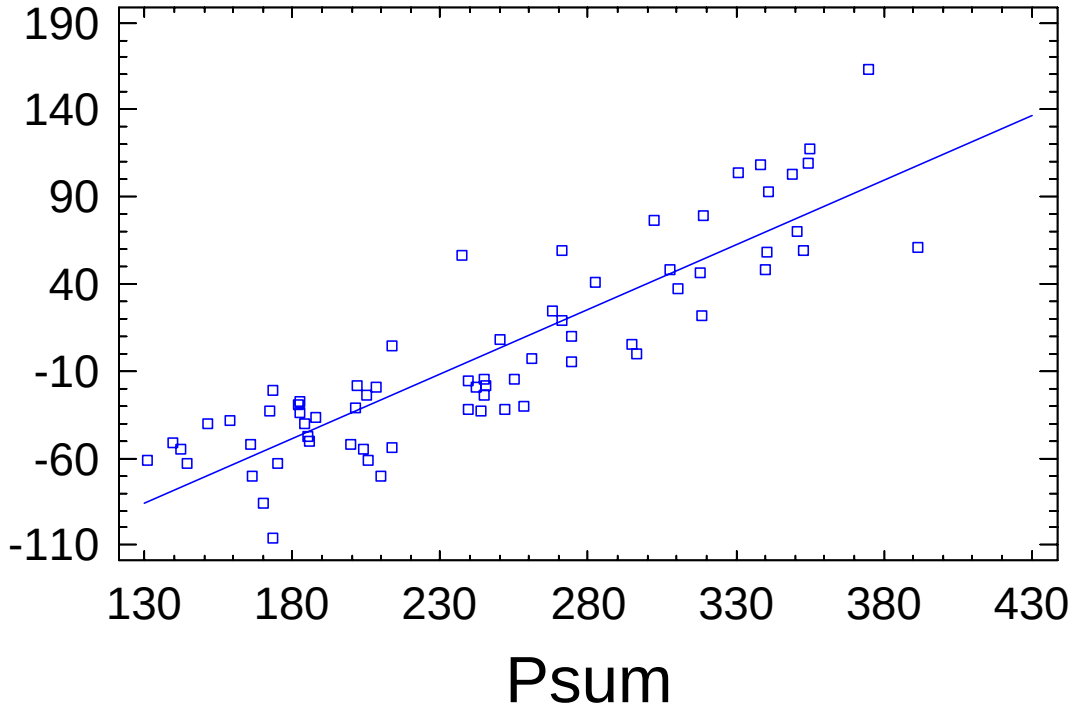
Polynomial regression between direct runoff (in mm) and area precipitation for the flood in August 2002



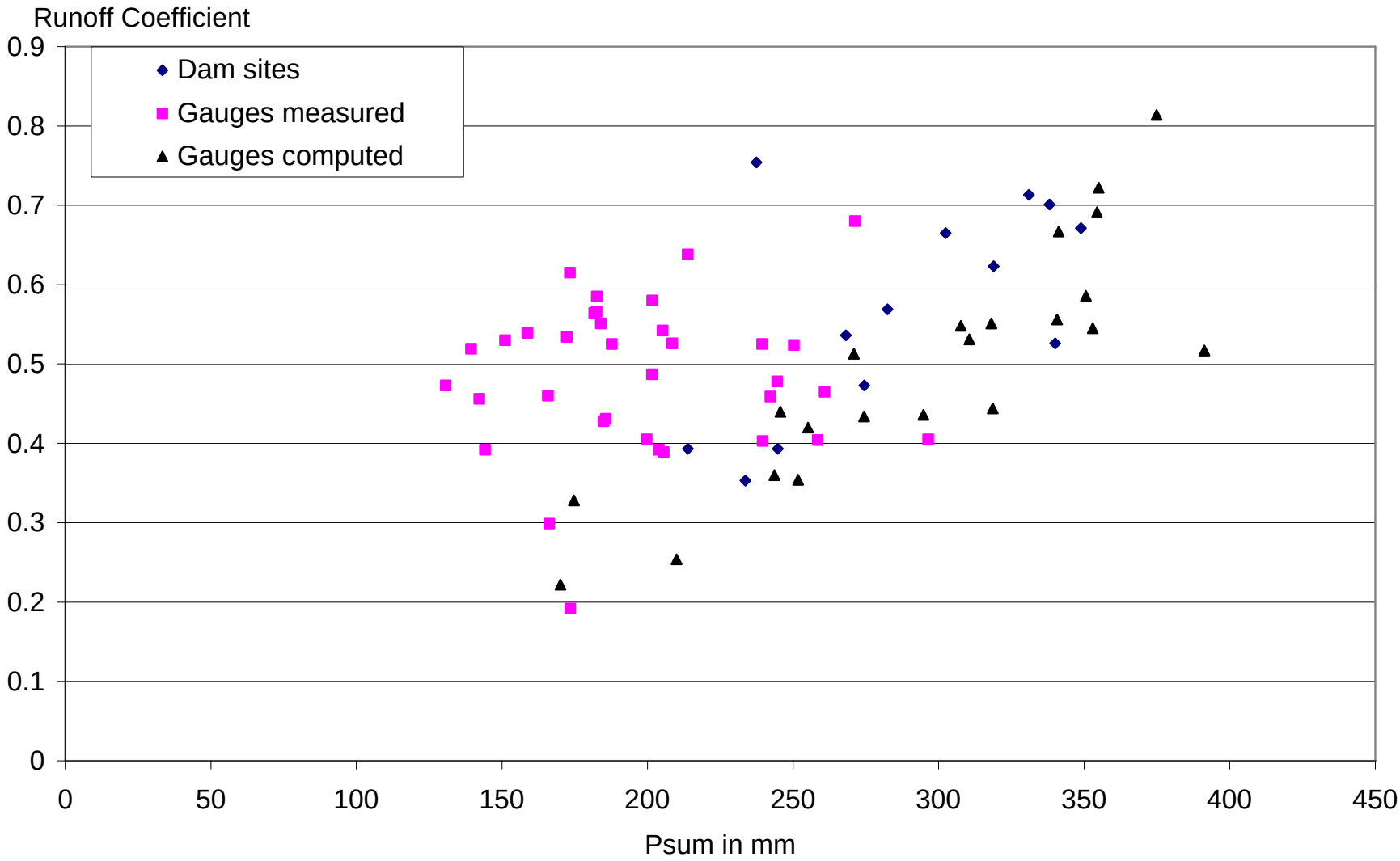


Qsum = -24.4309 +
0.741528*Psum - 0.0472646*SBE

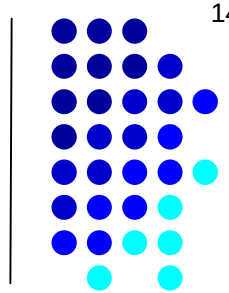
Impact of the soil storage capacity SBE in mm and the total sum of precipitation PSUM on the direct runoff



Runoff coefficients in relationship to sum of precipitation



The extreme flood in August 2002 in the eastern part of the Ore Mountains and its statistical assessment



- The hydrological event
- Statistical evaluation of the flood event
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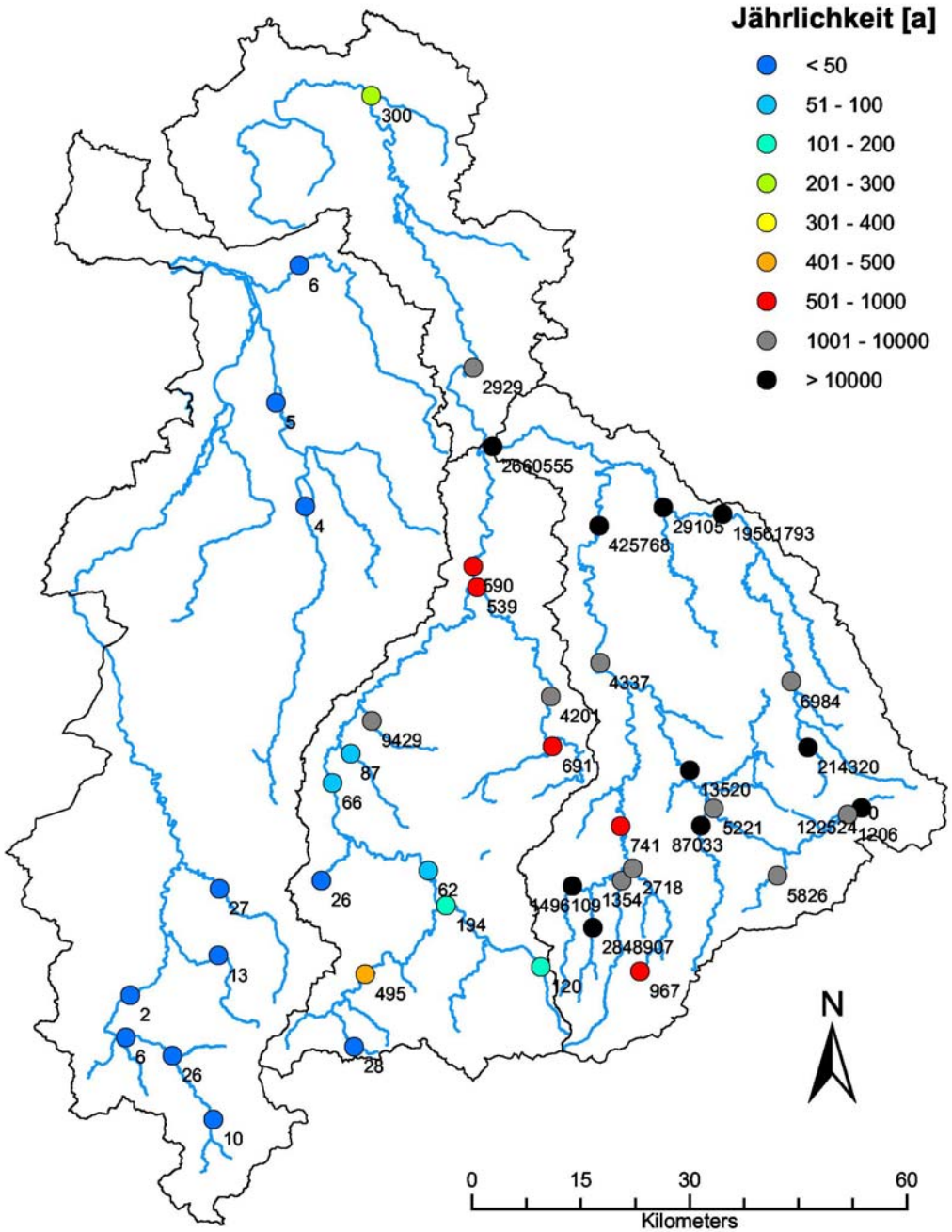
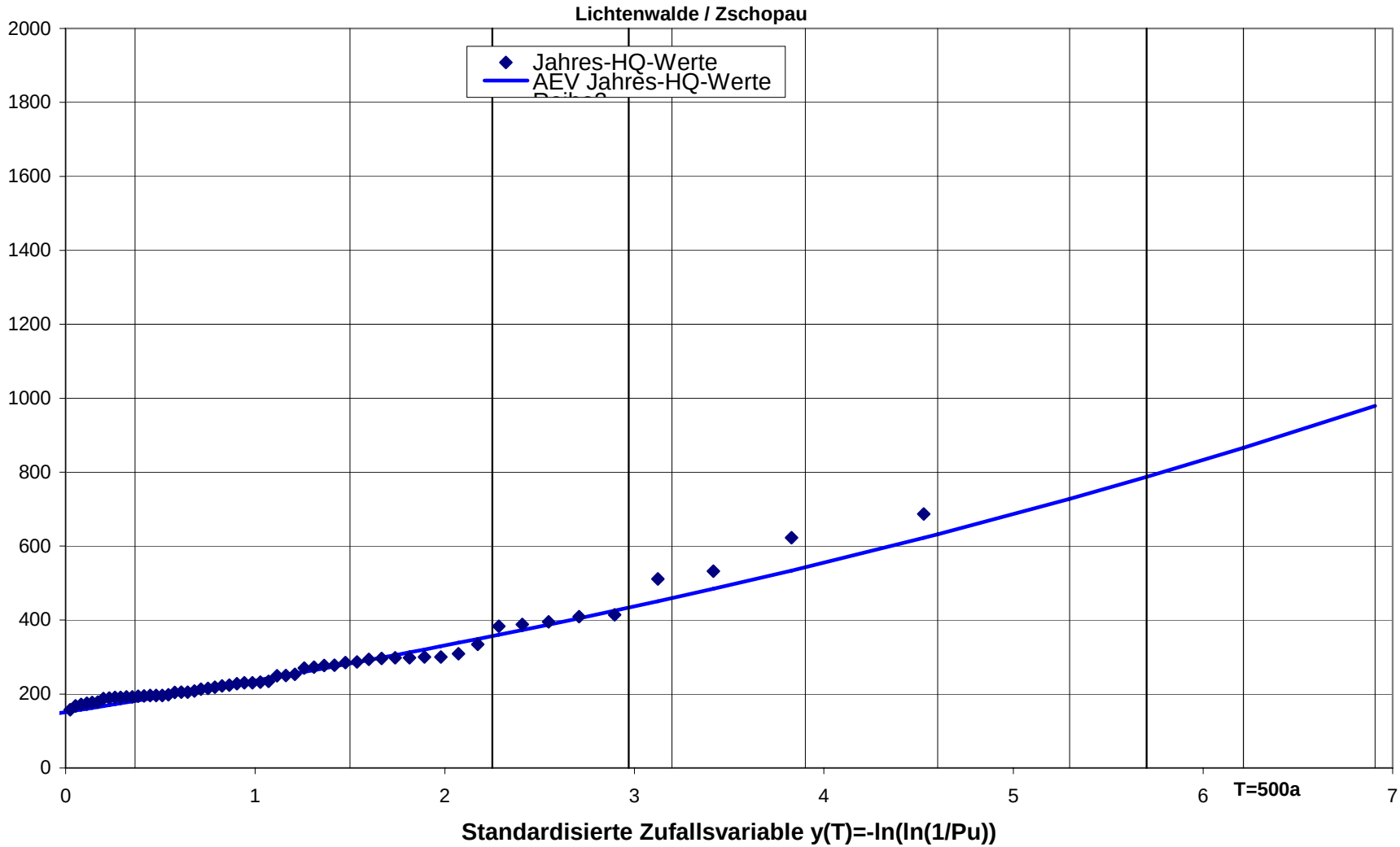
Characterisation of the inflow flood peaks in August 2002 in relationship to the assumed 1.000 and 10.000 yrs flood for 7 reservoirs in Saxonia

Reservoir	Catch-ment size in km^2	Assumed Design Flood 1 HQ(1.000) m^3/s	Assumed Design Flood 2 HQ(10.000) m^3/s	Max. Inflow in August 2002 m^3/s	Max. Release during the flood in August 2002 m^3/s	Precip-itation in mm within 48 h	Max. Inflow / 1.000 yrs flood	Max. Inflow / 10.000 yrs flood
Lehnmühle	60.4	85.4	125	130	120	295	**1.52**	**1.04**
Klingenberg	90.4	90	150	160	150	314	**1.78**	**1.07**
Malter	130.5	147	200	220	220	251	**1.50**	**1.10**
Altenberg	6.8	9.2	11	7	7	392	0.76	0.64
Lichtenberg	38.4	39.2	60	60	48	228	**1.53**	**1.00**
Saidenbach	60.7	39.8	46	63	20	204	**1.58**	**1.37**



Return Period of flood peaks in August 2002, estimated on the basis of time series ending 2001

Uncertainty of statistical assessments of flood risks showing at the example of the flood in August 2002 in Saxonia



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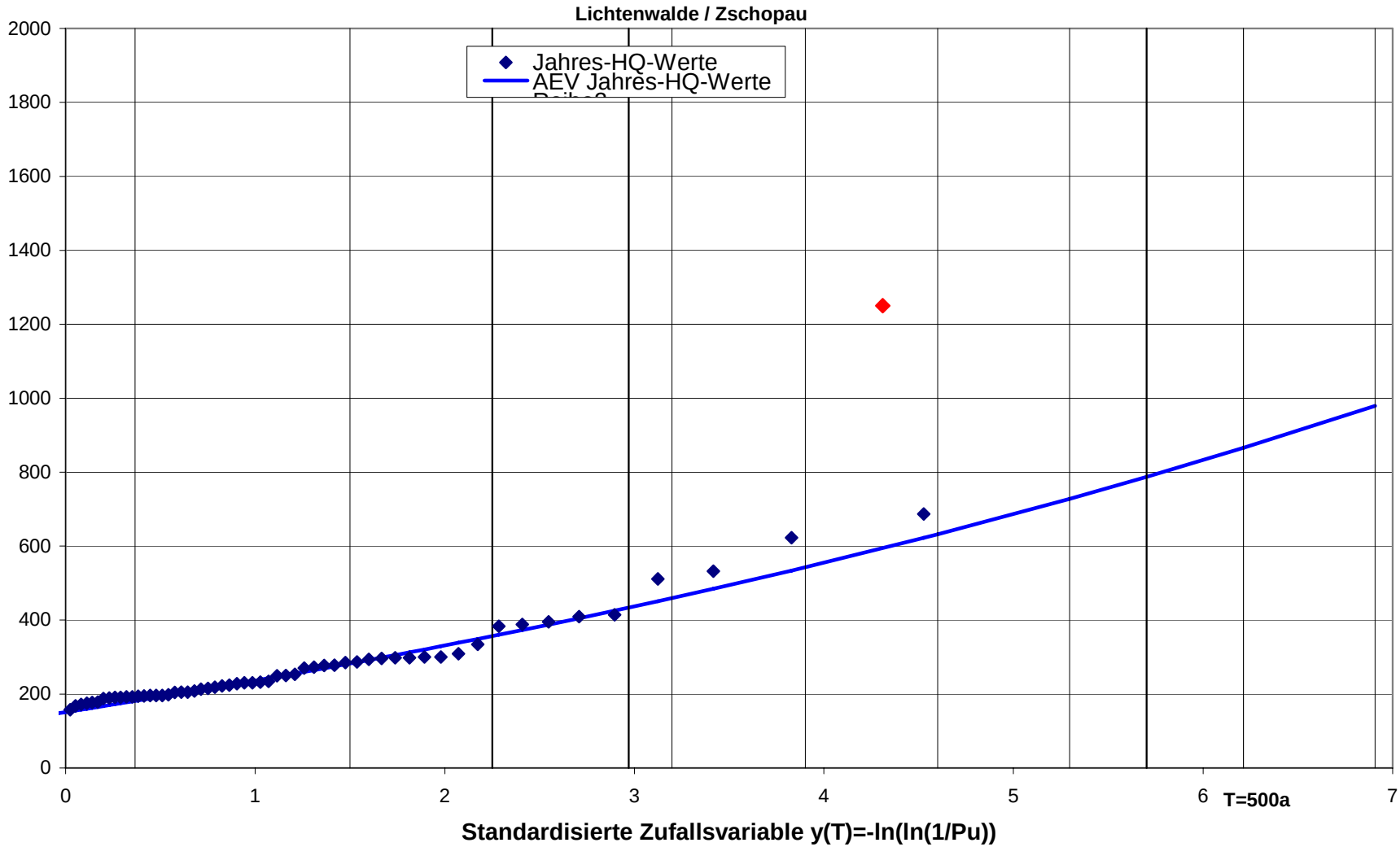

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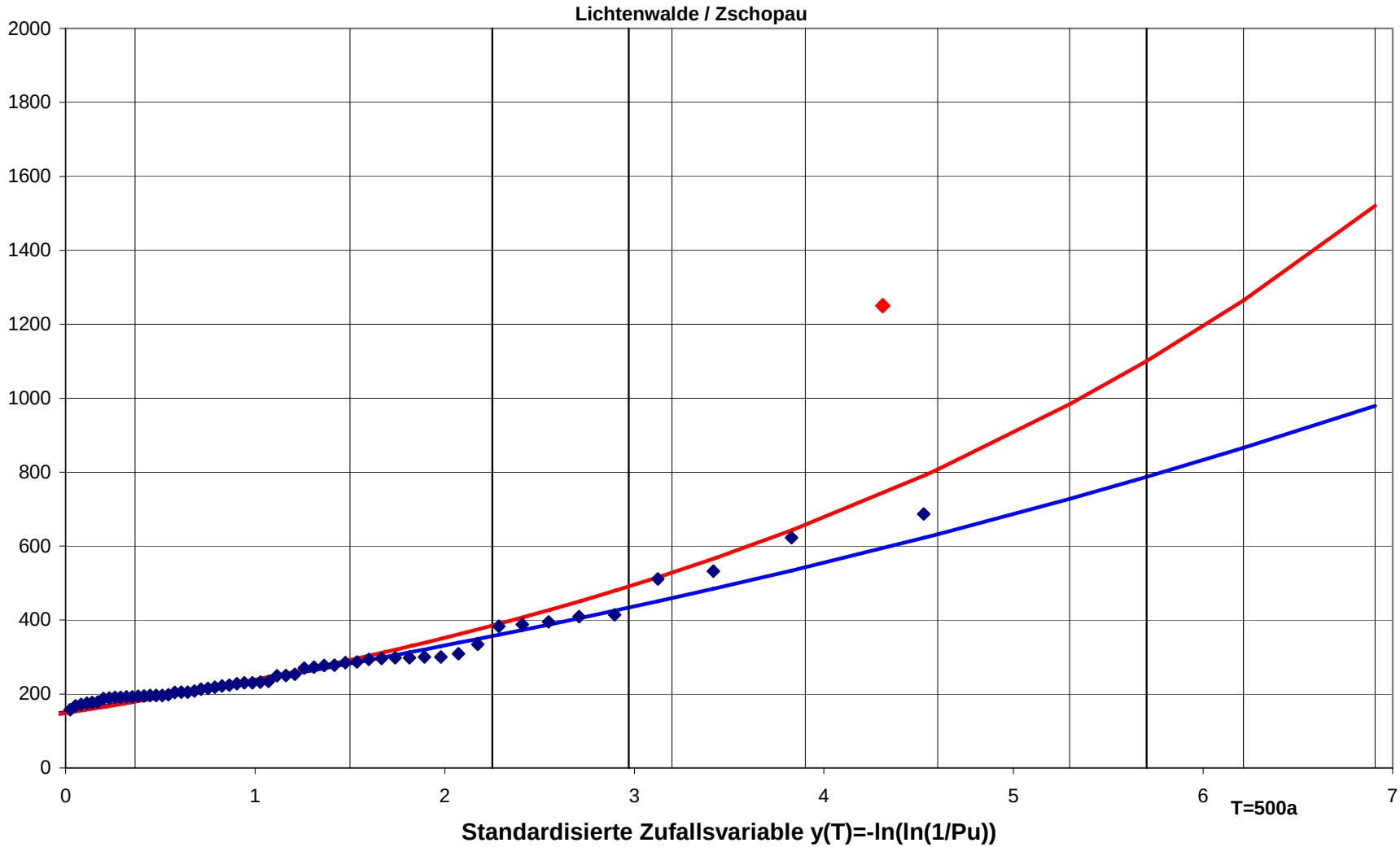
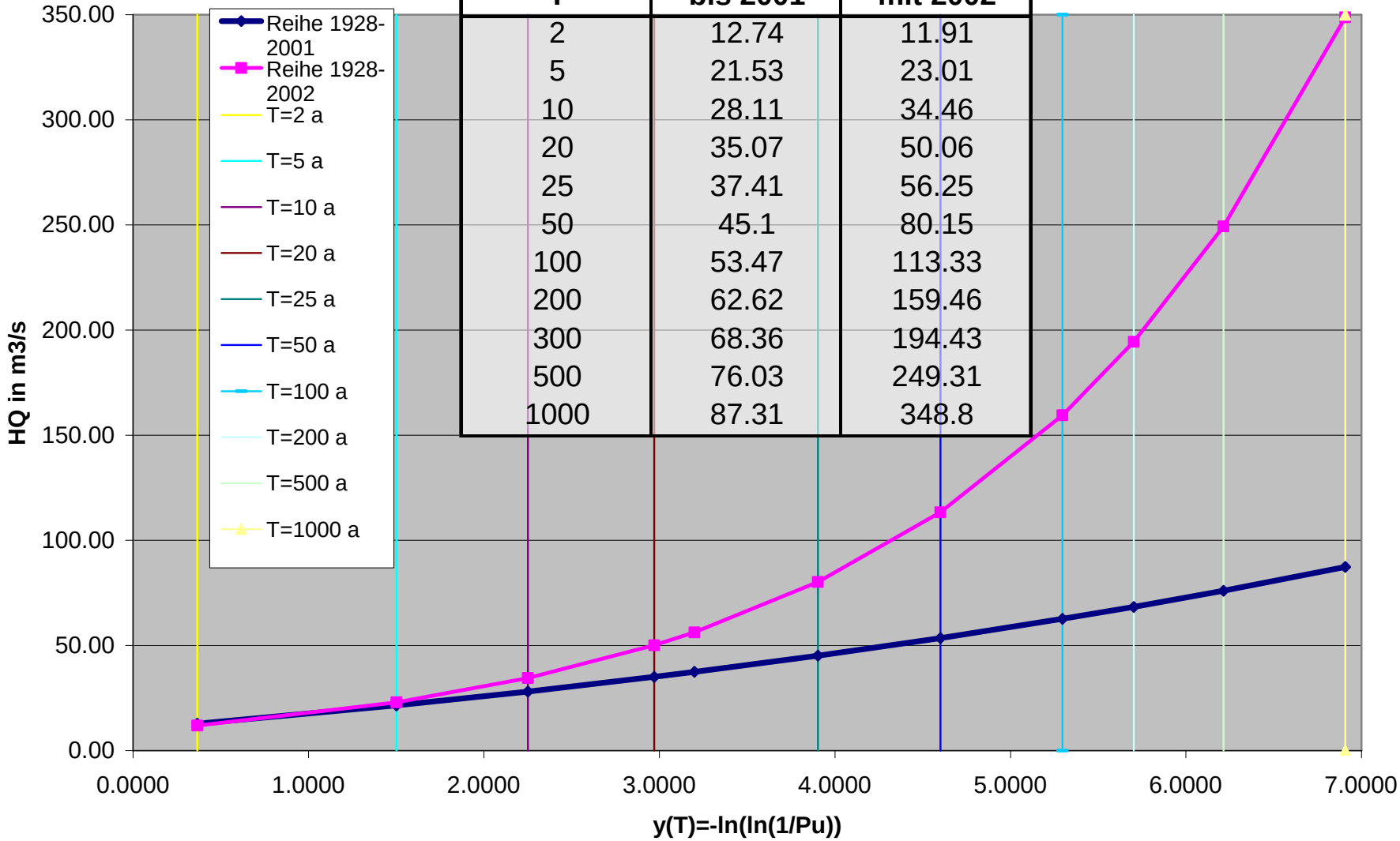


Modification of the flood statistics at the gauge Hainsberg 1/ Rote Weisseritz

T	bis 2001	mit 2002
2	12.74	11.91
5	21.53	23.01
10	28.11	34.46
20	35.07	50.06
25	37.41	56.25
50	45.1	80.15
100	53.47	113.33
200	62.62	159.46
300	68.36	194.43
500	76.03	249.31
1000	87.31	348.8



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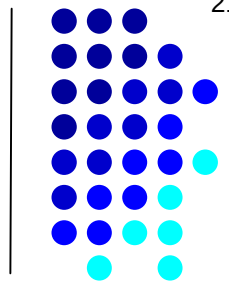

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Yearly flood values at the gauge Dohna/ Mueglitz River

Return Period T	Risk of 3 events in 106 years
1000	1:5600
500	1:780
200	1:571

Evidence of „record-breaking floods“

(Vogel et al. 2001)

Yearly flood observations $X_1, X_2, \ldots, X_i$

Counting of the highest flood peaks from the begin of observation with a yearly extension of the series

$$Y_i = \begin{cases} 1 & X_i = \max(X_1, X_2, \ldots, X_i) \\ 0 & \text{andernfalls} \end{cases}$$

Number of record breaking floods in a series of n years

$$R = \sum_{i=1}^{n} Y_i$$

Probability of r record-breaking floods in a series of n years

$$P[R = r] = \frac{\left|S_n^r\right|}{(n)!}$$

with S- Stirling‘s numberl

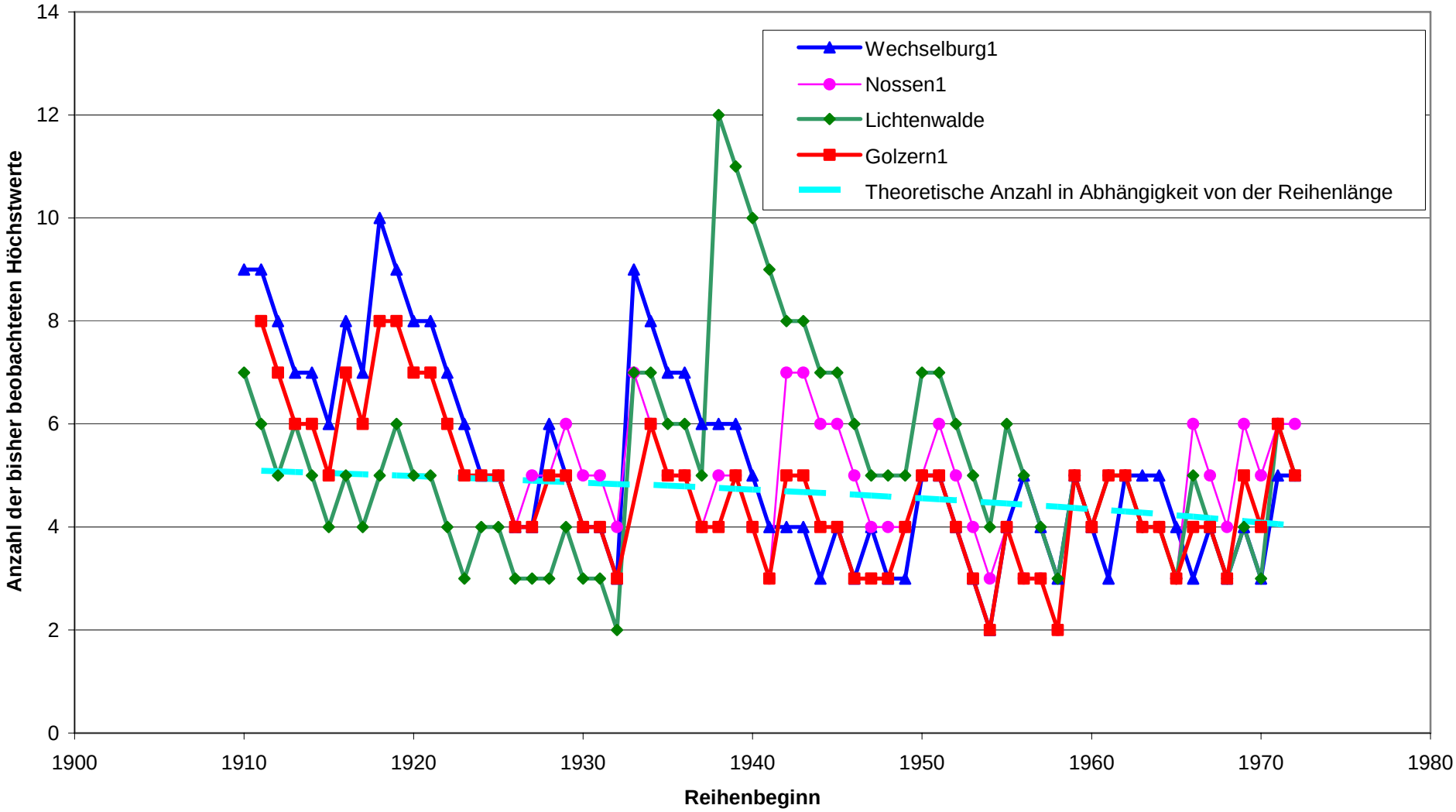
$$S_n^r = \sum_{k=0}^{n-r} (-1)^k \binom{n-1+k}{n-r+k} \binom{2n-r}{n-r-k} \cdot \left[\frac{1}{k!} \sum_{j=0}^{k} (-1)^{k-j} \binom{k}{j} j^{n-r+k} \right]$$

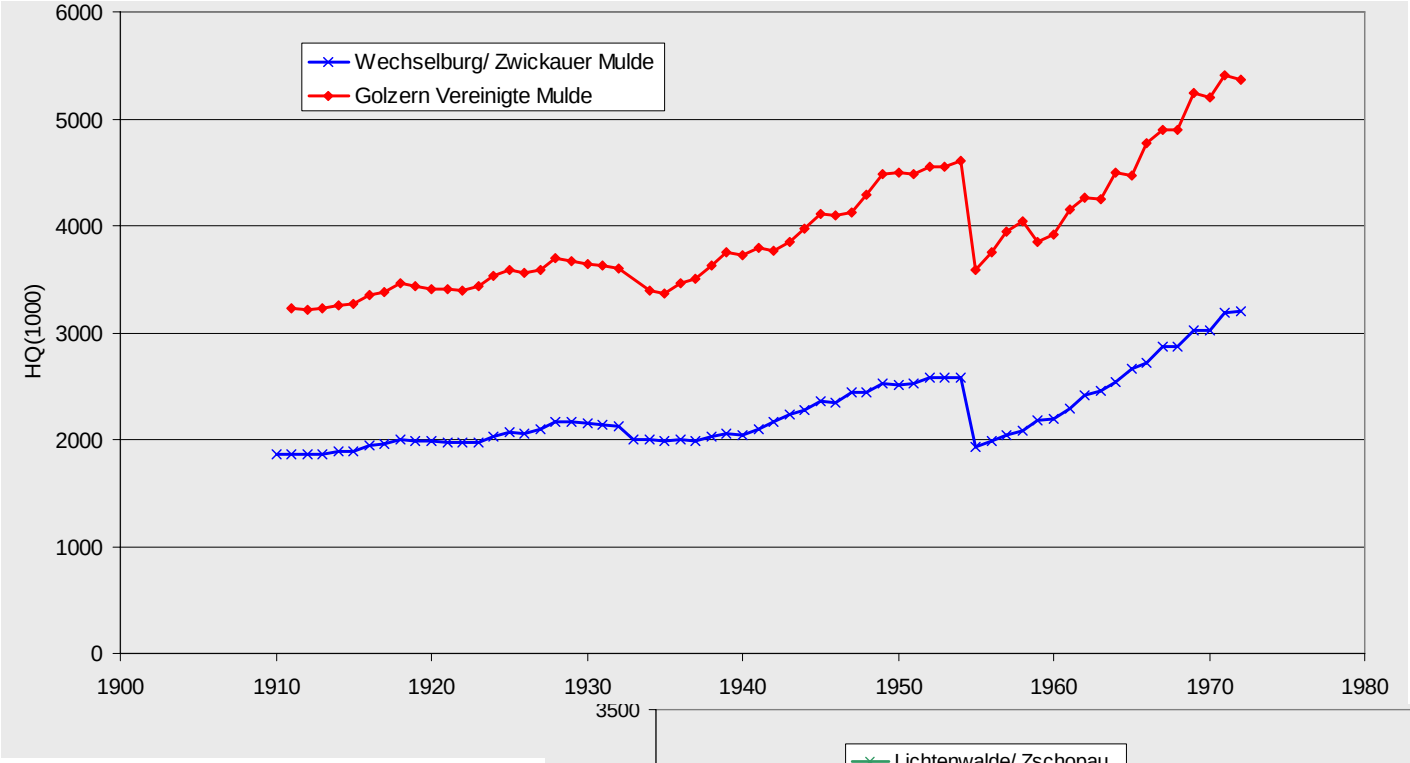
Approximation for n>20 yrs

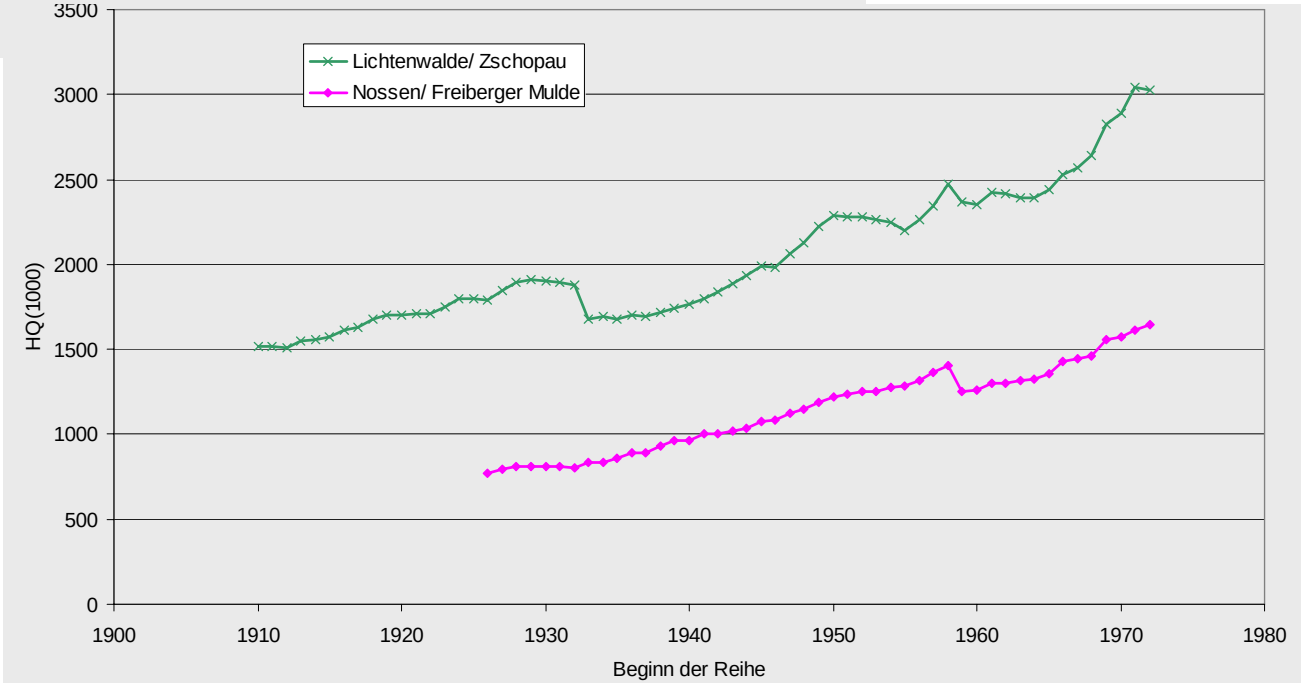
$$P[R = r] = \frac{[\ln(n)]^{r-1}}{n \cdot (r-1)!}$$

$$\mu_R = \sum_{i=1}^{n} 1/i, \sigma_R^2 = \sum_{i=1}^{n} 1/i - \sum_{i=1}^{n} 1/i^2$$

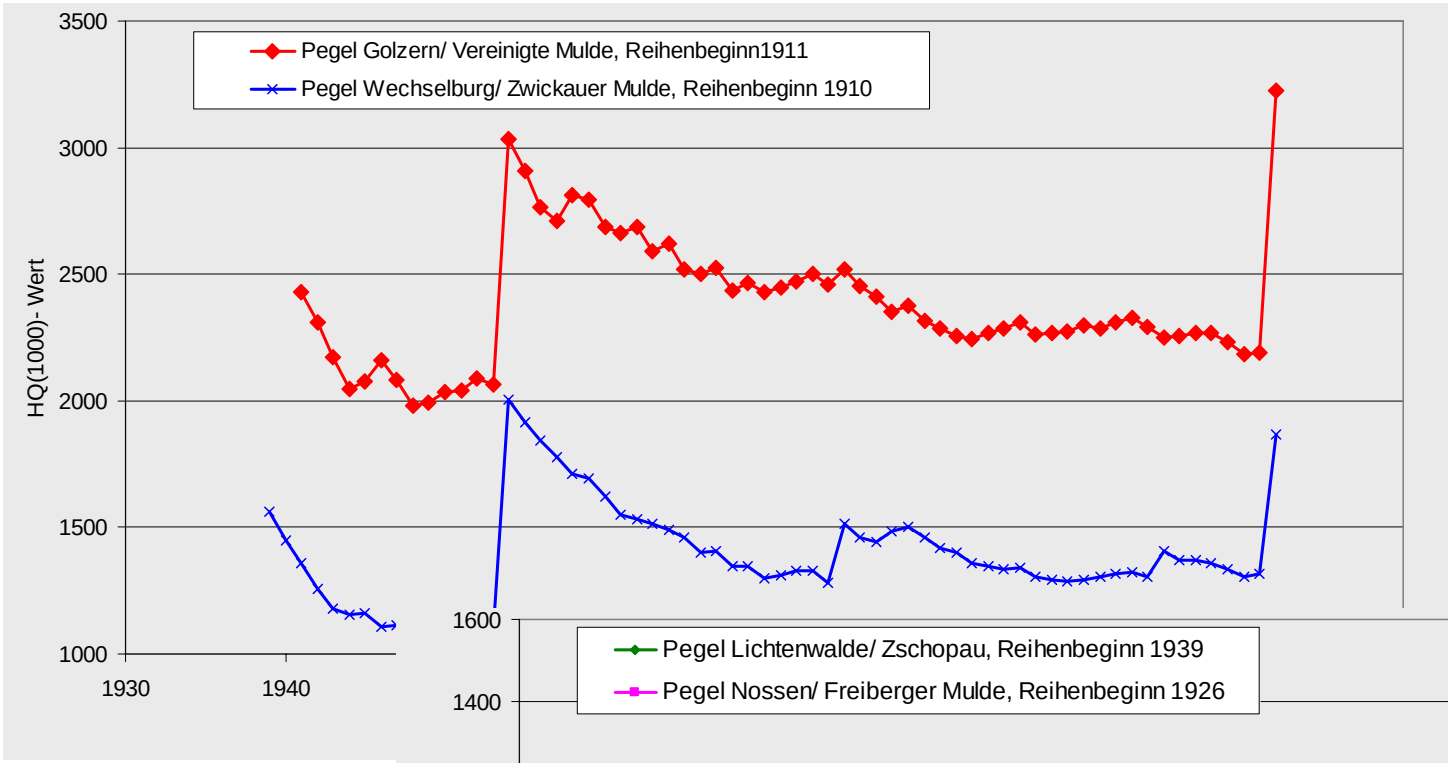
Number of „record breaking floods“ dependent on the starting point of the series in the Mulde River basin

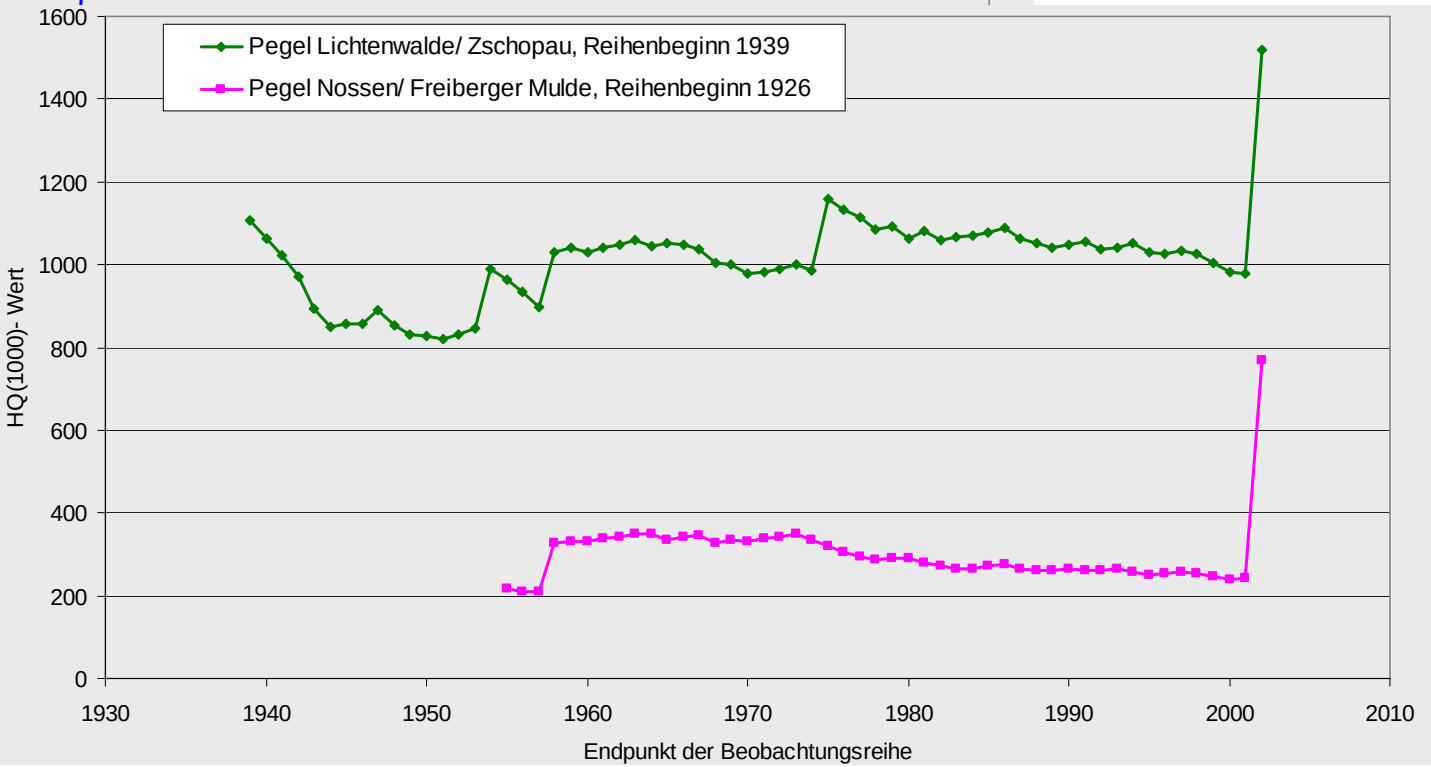




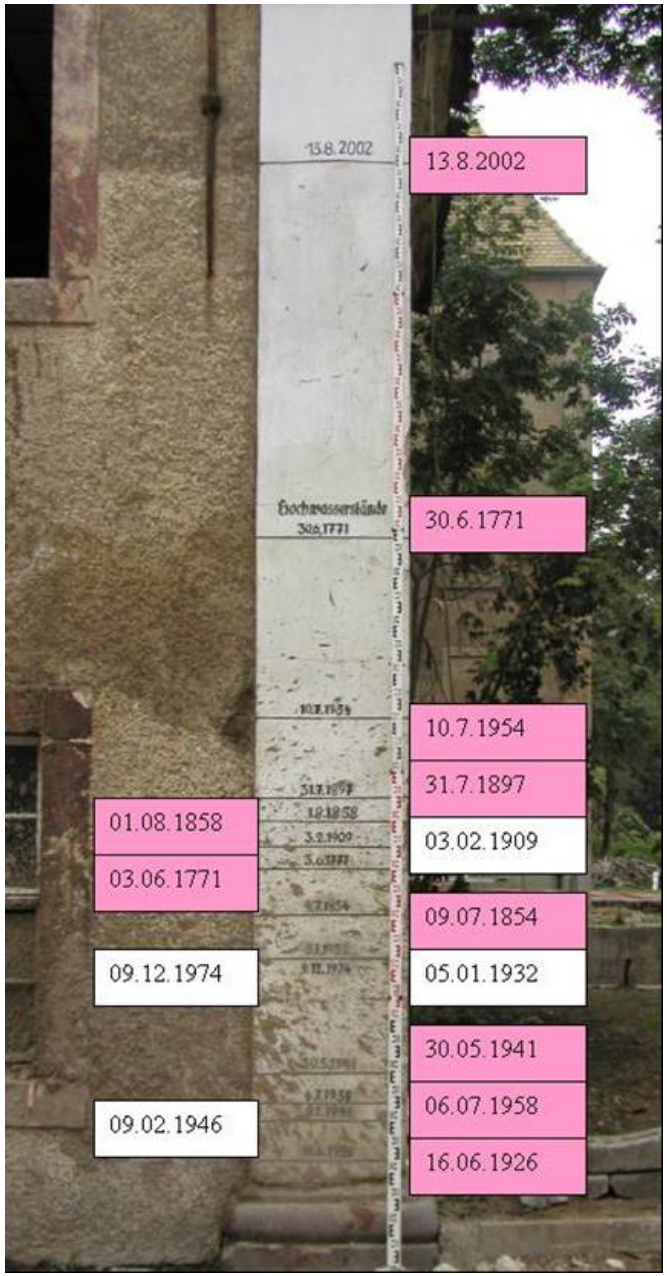


Effect of random samples on flood statistics, Dependency of the 1000 yrs- flood from the starting point of the flood series



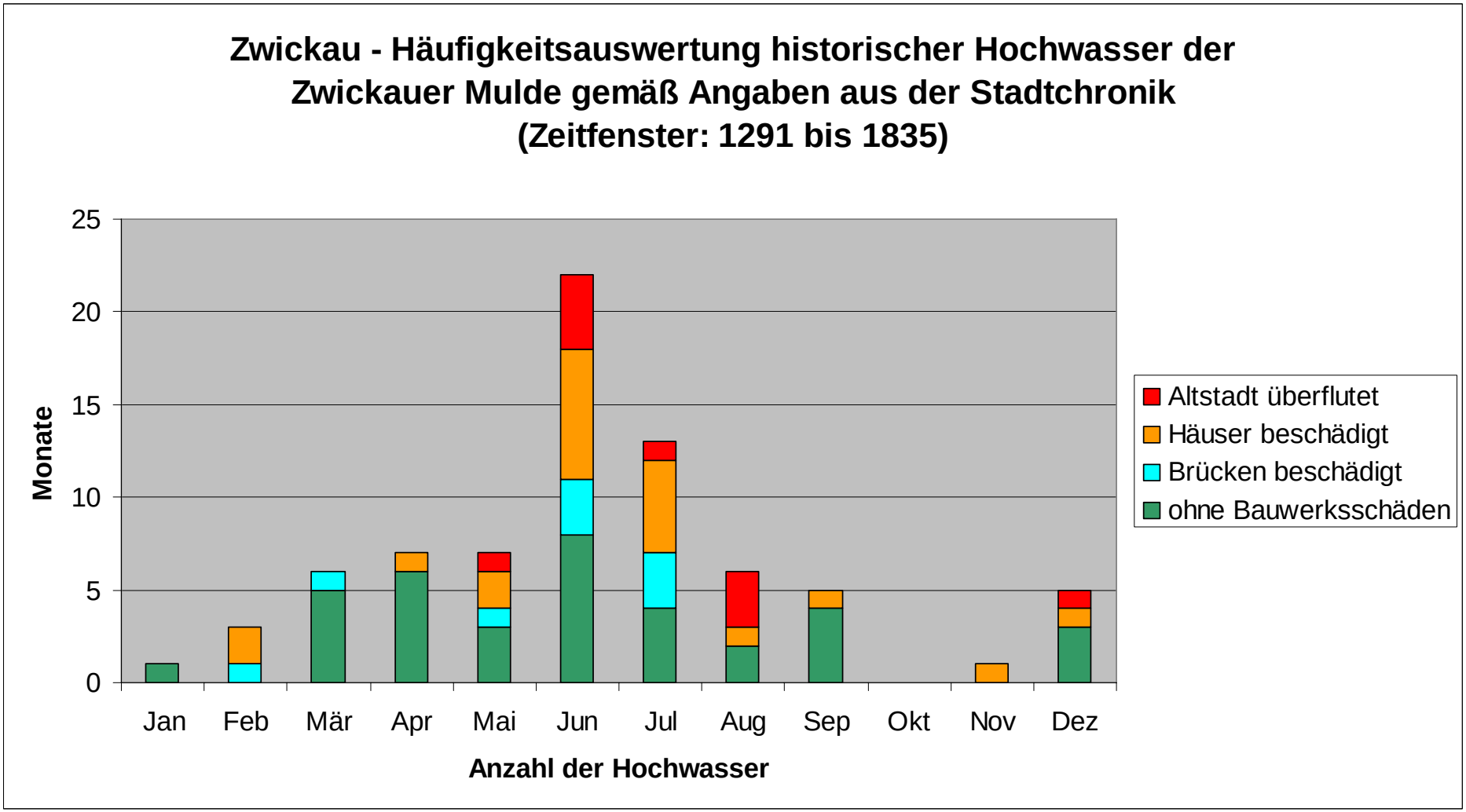


Effect of random samples on flood statistics, Dependency of the 1000 yrs-flood from the ending point of flood series

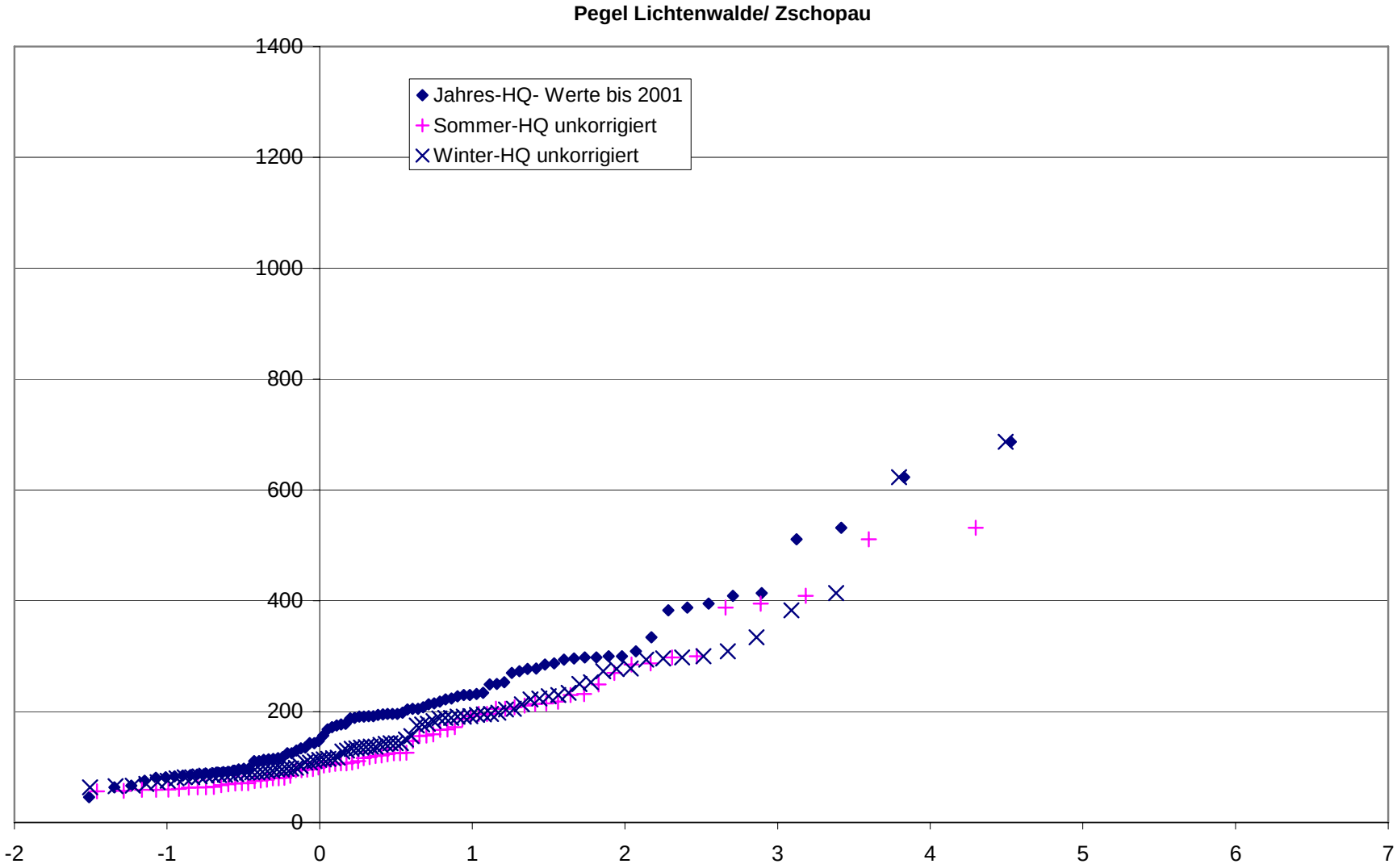


Flood Levels since 1771 at an old building in the city of Grimma at the Mulde River in Germany, differentiated between winter and summer flood events

Seasonal Distribution of Catastrophic Floods in the history of the City of Zwickau between 1291 and 1835



Example for a seasonal flood statistics
Gauge Lichtenwalde/ Zschopau



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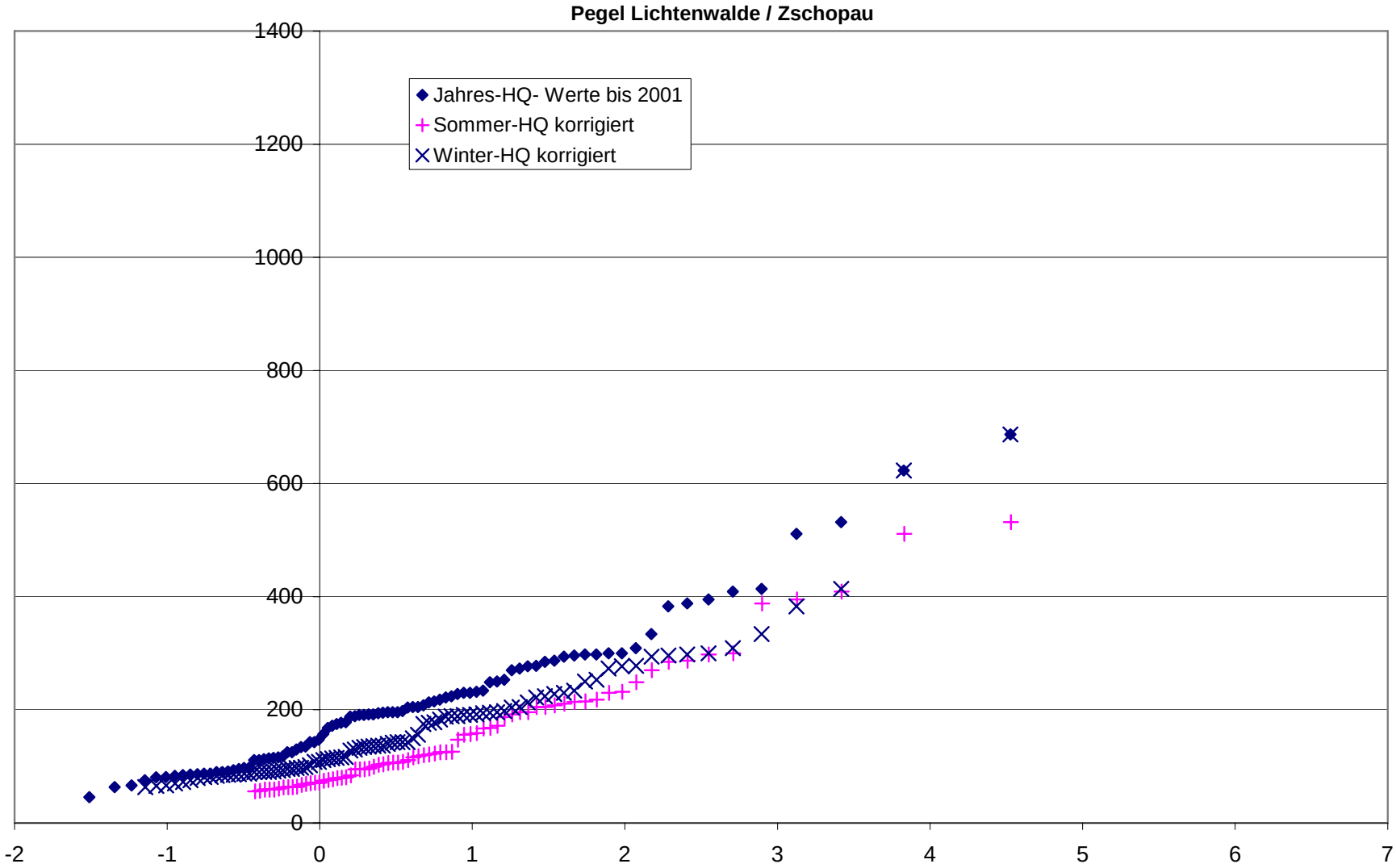

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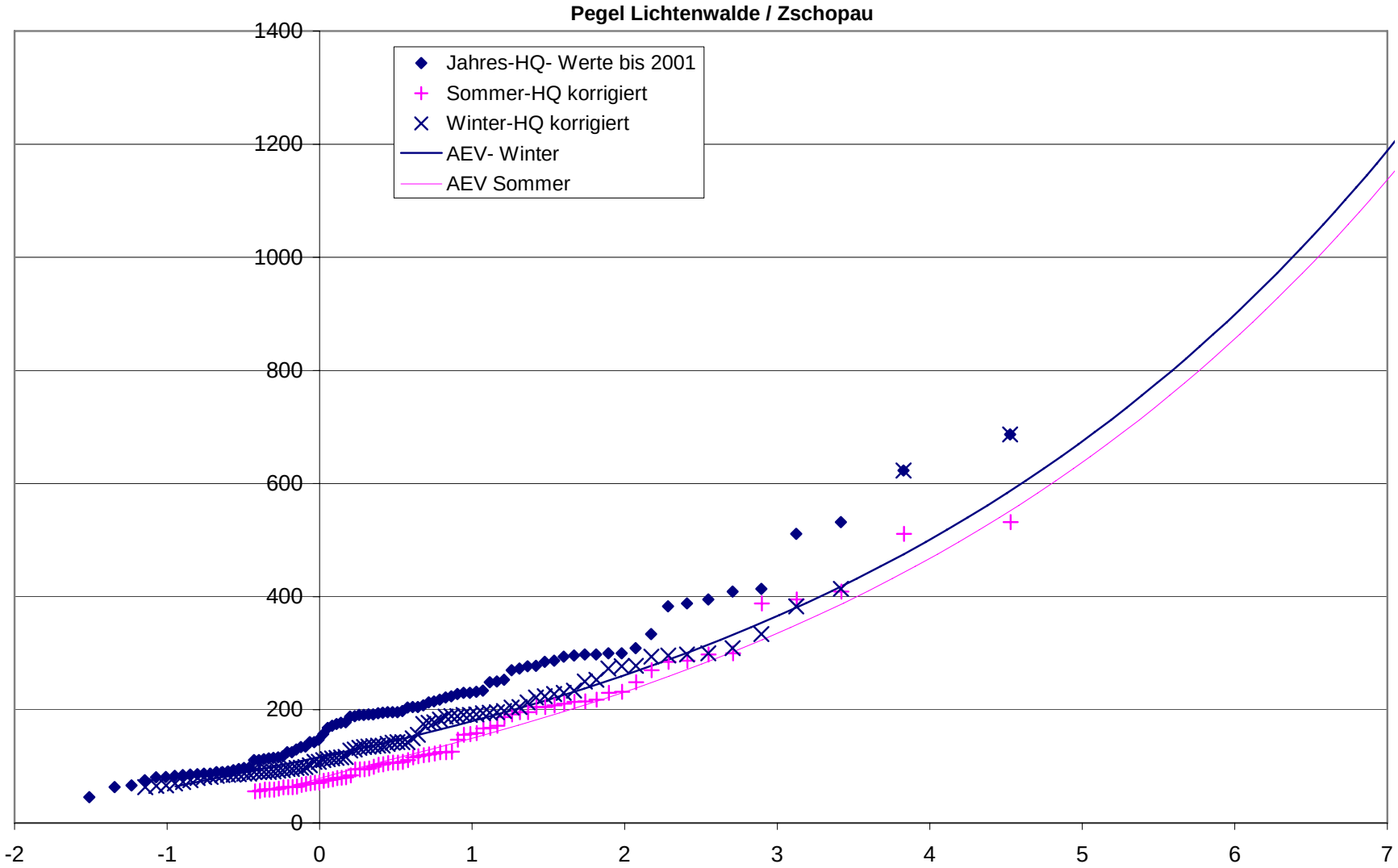

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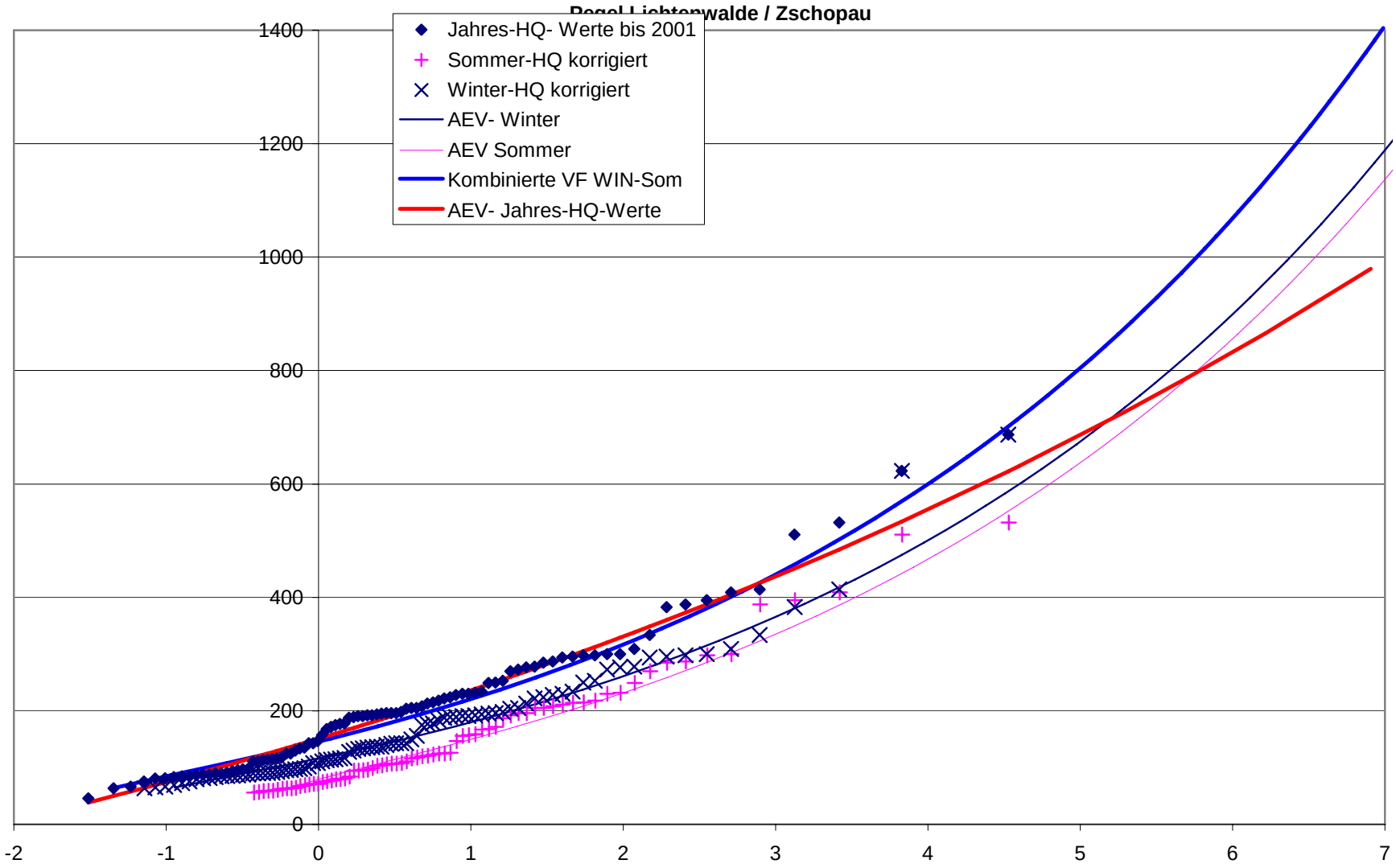
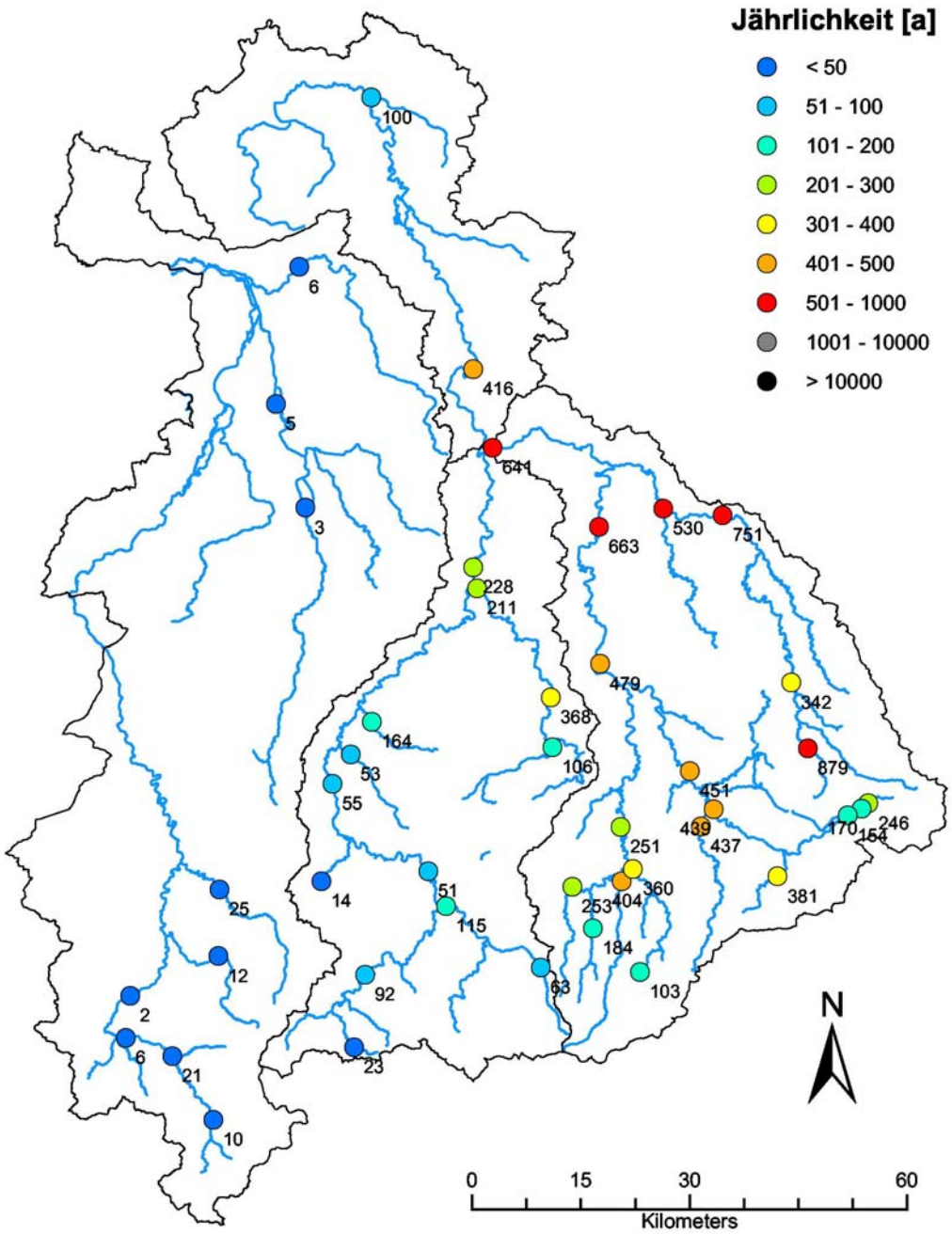


Differences of statistical assessments of a flood peak of 30 times of the mean annual discharge utilizing a combined seasonal based distribution or the distribution of annual flood

			Return Period T in Jin years			
Pegel	Watershed in km^2	Discharge (30 times MQ) in m^3/s	Annual maxima	Based on winter and summer maxima	D.F. of summer maxima	D.F. of winter maxima
Golzern1/ Vereinigte Mulde	5442	1842	**353**	**150**	**189**	**733**
Niederschlema/ZwickauerMulde	759.4	375	**53**	**55**	89	141
Wechselburg/ ZwickauerMulde	2106.8	777	**133**	**104**	147	358
Aue1/ Schwarzwasser	362.5	187.2	**42**	**40**	67	99
Goeritzhain/ Chemnitz	532.3	186.9	**97**	**67**	91	251
Lichtenwalde/ Zschopau	1574.6	648	**111**	**71**	157	130
Streckewalde/ Preßnitz	205.9	90	**165**	**114**	**137**	**682**
Pockau1/ Flöha	384.6	177.6	**89**	**52**	114	95
Rothenthal/ Natzschung	75	41.4	**89**	**57**	90	158
Zoeblitz/ SchwarzePockau	129.2	69.3	**279**	**126**	**131**	**3240**
Berthelsdorf/ Freiberger Mulde	244.4	105.9	**86**	**81**	**86**	**1320**
Nossen1/ Freiberger Mulde	585.2	202.8	**283**	**99**	**108**	**1170**
Wolfsgrund/ Chemnitzbach	37.2	19.83	**1102**	**280**	**436**	**782**
Niederstrieg/ Striegis	283	80.1	**179**	**87**	**90**	**1977**



Return Period of flood peaks in August 2002, estimated on the basis of time series ending 2002

Thank you very much for your attention !

Vielen Dank für Ihre Aufmerksamkeit !