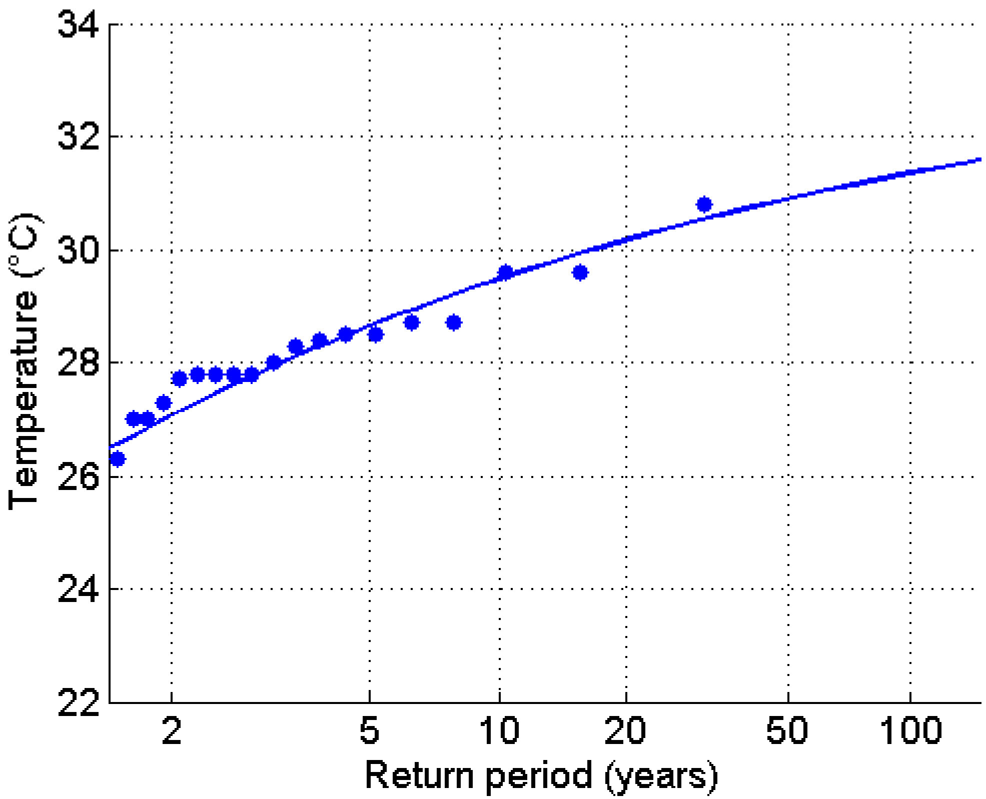
Have we underestimated climate extremes?

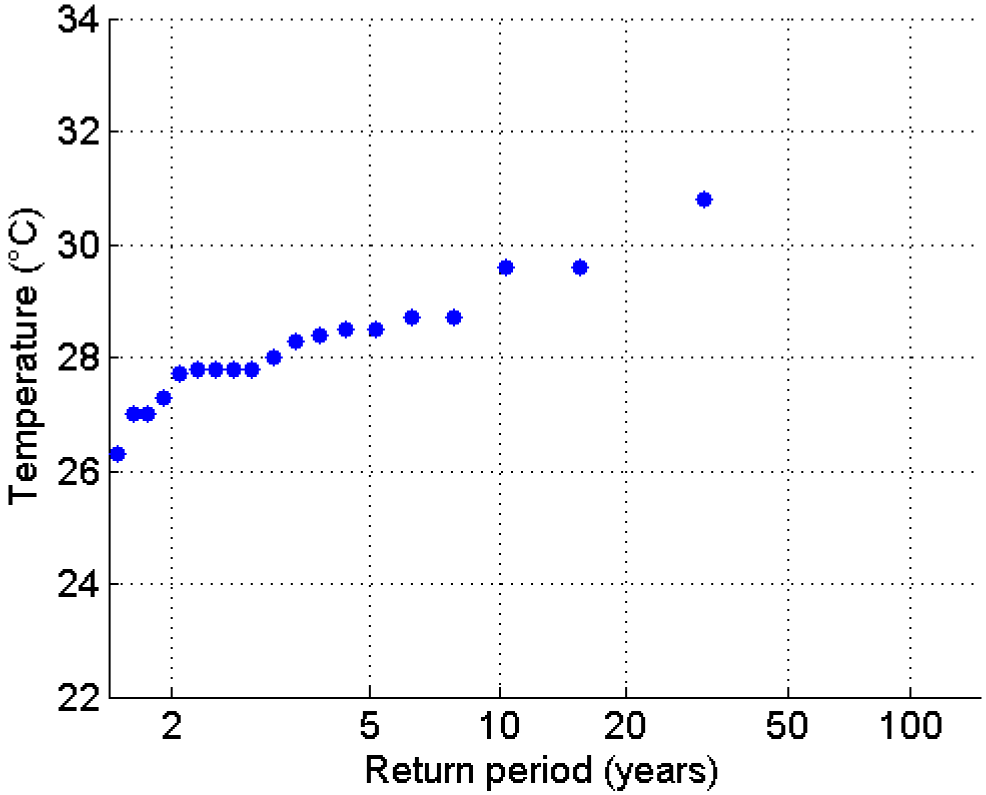
Lasse Makkonen
VTT Technical Research Centre of Finland

ESF-COST High-Level Research Conference
Extreme Environmental Events

Probability plotting



Probability plotting



Plotting method	Reference	Return period (m=N=30)
m/N	Anon (1923)	∞
$(m-0.5)/N$	Hazen (1914)	60
$m/(N+1)$	Weibull (1939)	31
$(m-0.31)/(N+0.38)$	Beard (1943)	44
$(m-0.375)/(N+0.25)$	Blom (1958)	48
$(3m-1)/(3N+1)$	Tukey (1962)	46
$(m-0.44)/(N+0.12)$	Gringorten (1963)	54
$(m-0.35)/N$	Landwehr et al. (1979)	86
$\eta^{-1}[0.577+3\ln 2\ (2m/(N+1)-1))]$	Barnett (1975)	13
$(m-0.3)/(N+0.4)$	Mischke (1979)	43
$(m-0.4)/N$	McClung & Mears (1991)	75
Numerical method	Harris (1996)	53
Numerical method	Jones (1997)	45
$(m-0.28)/(N+0.28)$	De (2000)	54

”IT IS CLEAR THAT THE OPTIMUM PLOTTING POSITION DEPENDS ON THE USE THAT IS TO BE MADE OF THE RESULTS AND MAY ALSO DEPEND ON THE UNDERLYING DISTRIBUTION”

Harter, H.L. (1984): Another look at plotting positions. Commun. Statist. - Theor. Meth. (13), 1613-1633.

Castillo, E. (1988): Extreme Value Theory in Engineering

Jordaan, I. (2005): Decisions under Uncertainty

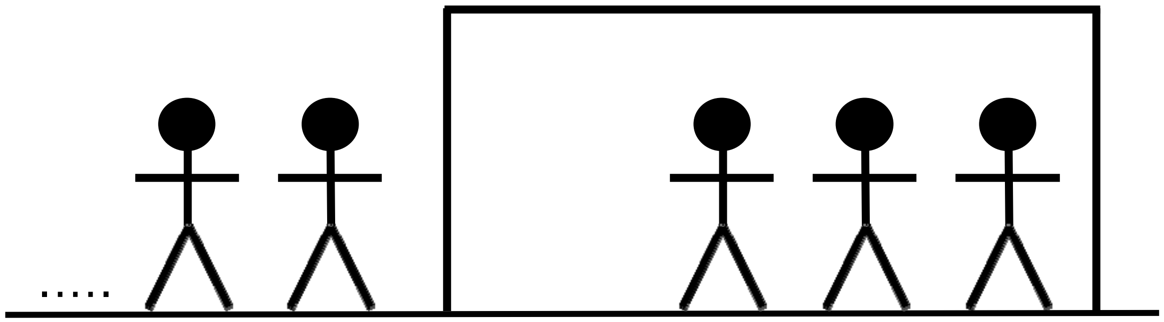
NIST Engineering Handbook (web) (2006)

MATLAB©

Coles, S. (2001): An Introduction to Statistical Modeling of Extreme Values

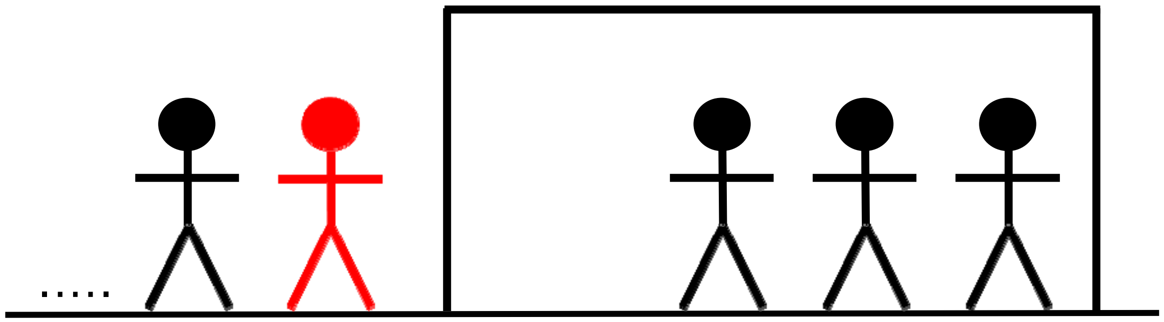
”For any one of the $x_{(m)}$, exactly m of the N observations have a value less than or equal to $x_{(m)}$, so an empirical estimate of the probability of an observation being less than or equal to $x_{(m)}$ is $P(x_{(m)}) = m/N$ ”

”A slight adjustment to $P(x_{(m)}) = m/(N+1)$
is usually made to avoid having $P(x_{(N)}) = 1$

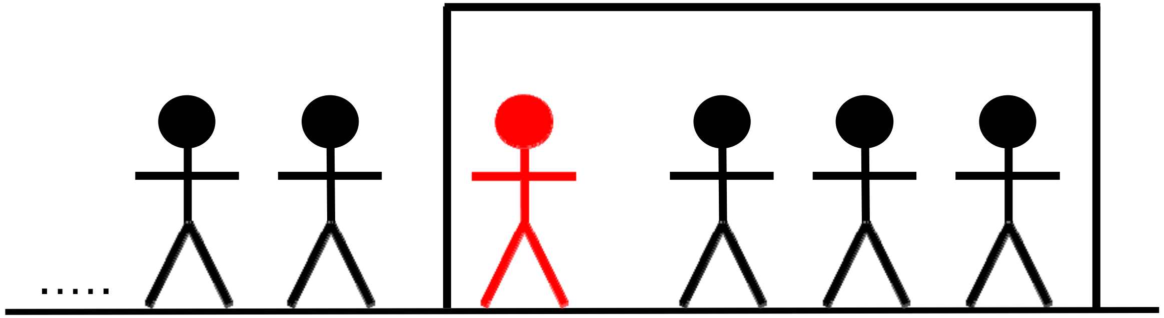


Probability that a person is shortest in the sample?

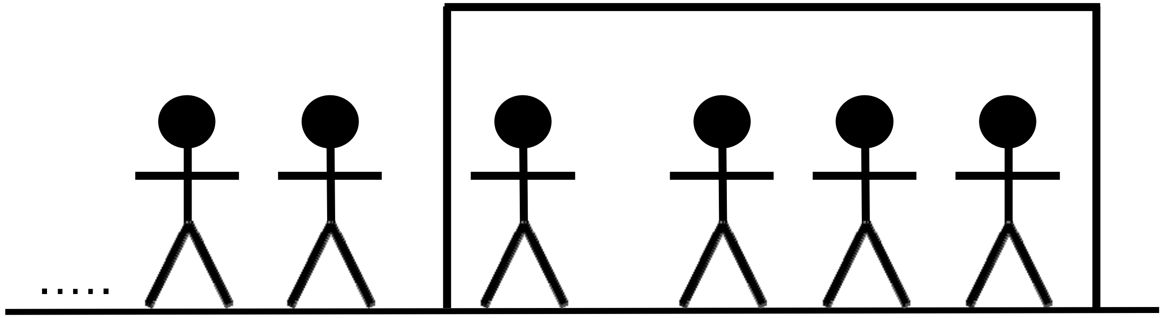
$m = 1, N = 3 \qquad P = m/N = 1/3$



CDF: ”Next observation drawn from the population”



Probability that the new person is shorter than anyone in the original sample?



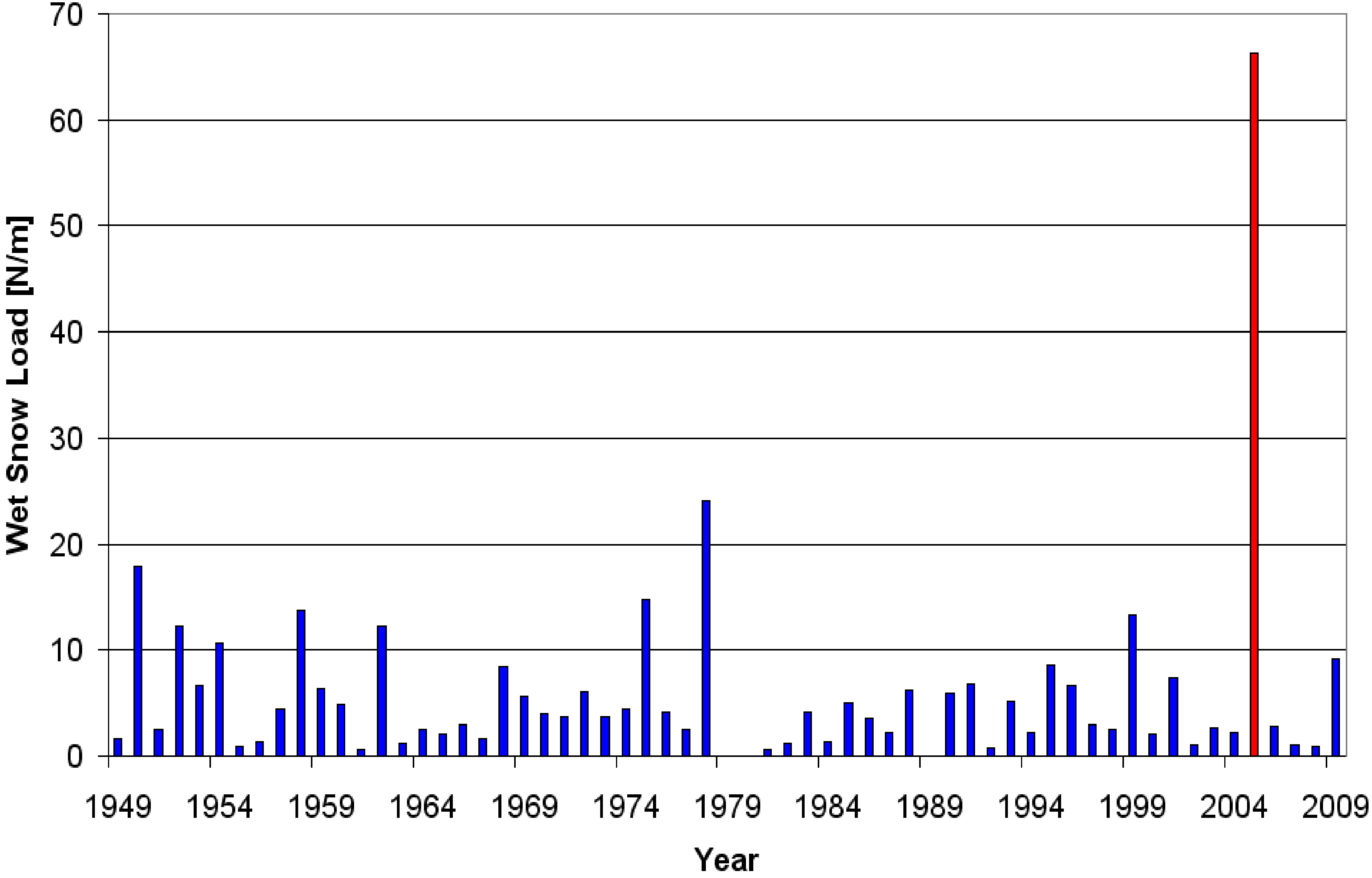
Probability that the new person is shortest in the new sample?

$m = 1, N = 3$ $\quad P = m/(N+1) = 1/4$

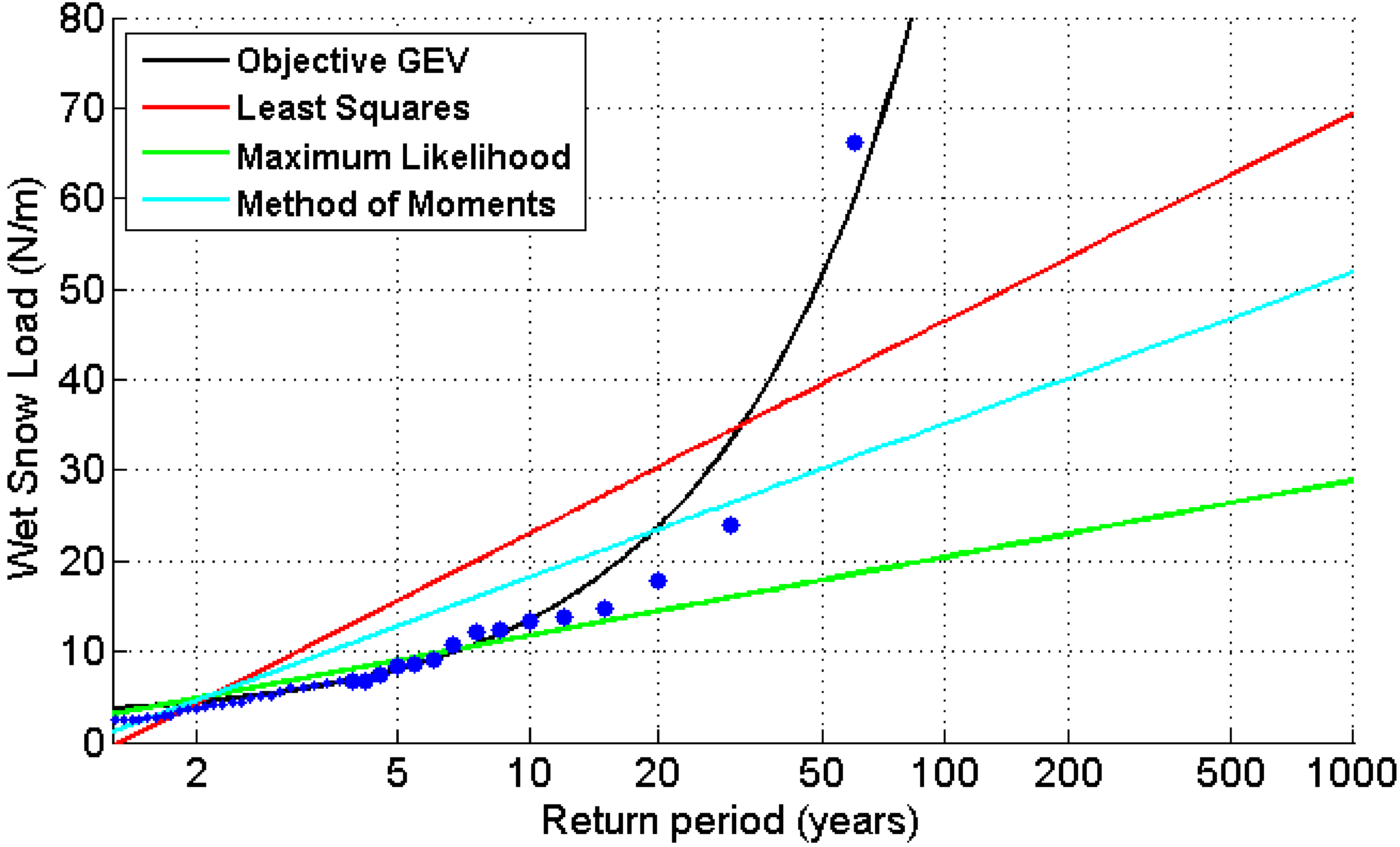
In order-statistics the probability $P(x_{(m)})$ is known.

In order-statistics the probability is $P(x_{(m)}) = m/(N+1)$

There is no reason to use an estimate of any kind.



70
60
50
40
30
20
10
0
Wet Snow Load [N/m]
1949
1954
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004
2009
Year



Objective GEV
Least Squares
Maximum Likelihood
Method of Moments
Wet Snow Load (N/m)
Return period (years)
0
10
20
30
40
50
60
70
80
2
5
10
20
50
100
200
500
1000

PROBLEMS:

- The distribution of extremes drawn from limited data does not necessarily fit well to any asymptotic extreme value distribution
- Extremes may originate from different populations
- Extremes may not be independent
- Weighing the points?
- Which fitting method to use?

Errors in terms of the return period

- Wrong plotting positions (largest values): -45 to 175 %
- Selecting the fitting method: Typically 100% to 1000 %
- Effect of climate change (this century): Typically 100 - 200 %

AMERICAN METEOROLOGICAL SOCIETY
NEWS RELEASE
Headquarters
45 Beacon Street
Boston, MA 02108-3693

Contact(s): Stephanie Kenitzer, AMS
(425) 432-2192
Kenitzer@dc.ametsoc.org

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NATURAL HAZARDS ARE MORE COMMON THAN STATISTICS INDICATE

Does it seem like the 100-year severe weather events are happening more often than every 100 years? That's because they do, according to an analysis published in the American Meteorological Society's February issue of the *Journal of Applied Meteorology and Climatology*.

The analysis done by Lasse Makkonen of the Technical Research Centre of Finland, shows that natural hazards such as hurricanes, floods, earthquakes and snow storms actually occur more often than the statistics indicate.

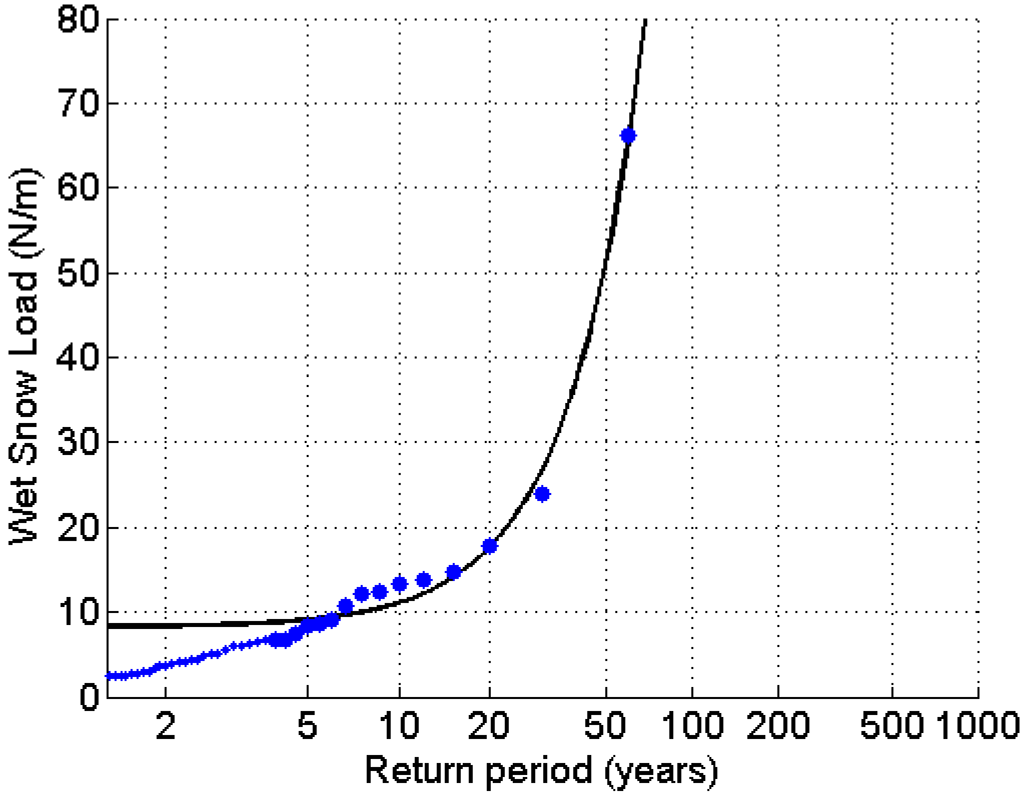
The return, or reoccurrence, of a potentially catastrophic natural disaster is typically measured using historical data ranked in order – called an extreme value analysis. But this age-old way of measurement actually underestimates the risk when applied in its presently common form.

"The way we estimate the probability of a natural hazard reoccurring is fundamentally wrong unless we can associate the historical extreme events with their correct probabilities," said Makkonen. His research shows that there is only one correct formula to do that, the one used by Emil Gumbel in his classical book "Statistics of Extremes" in 1958.

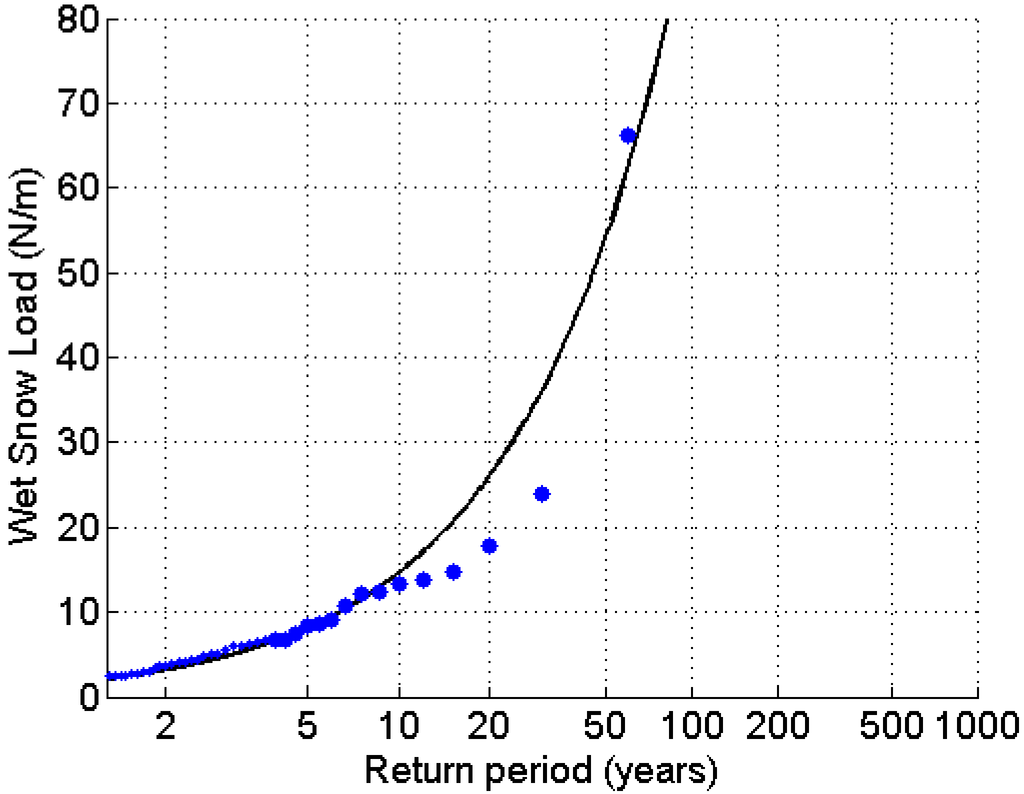
As an example, according to Makkonen the largest of 50 annual extremes should, in the analysis, be associated with the return period of 51 years instead of values up to 100 years that are given by several presently commonly used formulas and corresponding numerical methods. Such errors can very dangerous when applied in the structural design, for example.

According to Makkonen, the improper formulas appear in many text books and commercial software as well as many engineering handbooks, governmental recommendations and building codes and must be revised to show a more accurate risk of natural hazards to communities.

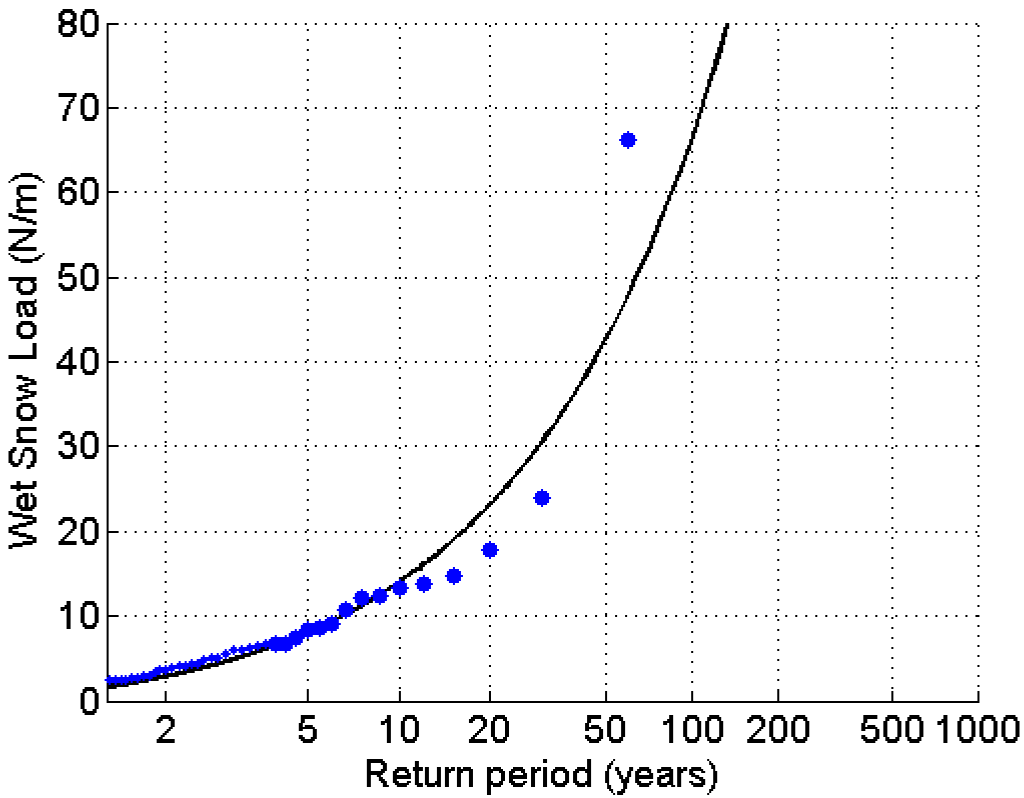
Example: Wet snow load in Münsterland, Germany (1. iteration)



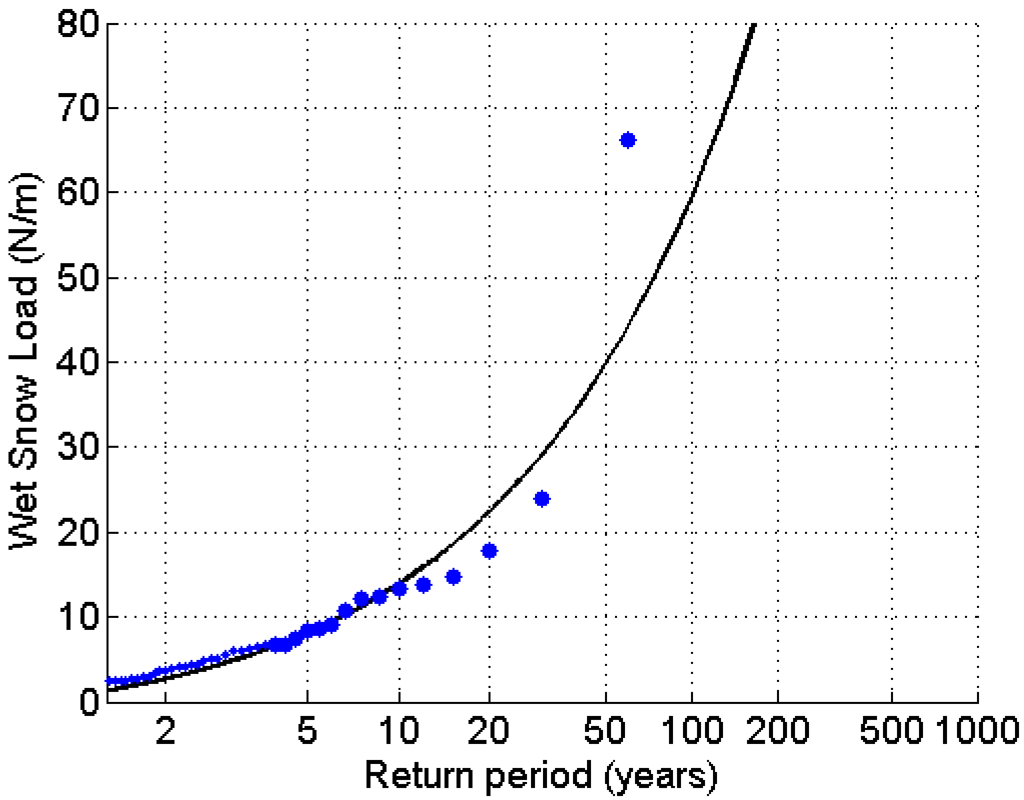
Example: Wet snow load in Münsterland, Germany (2. iteration)



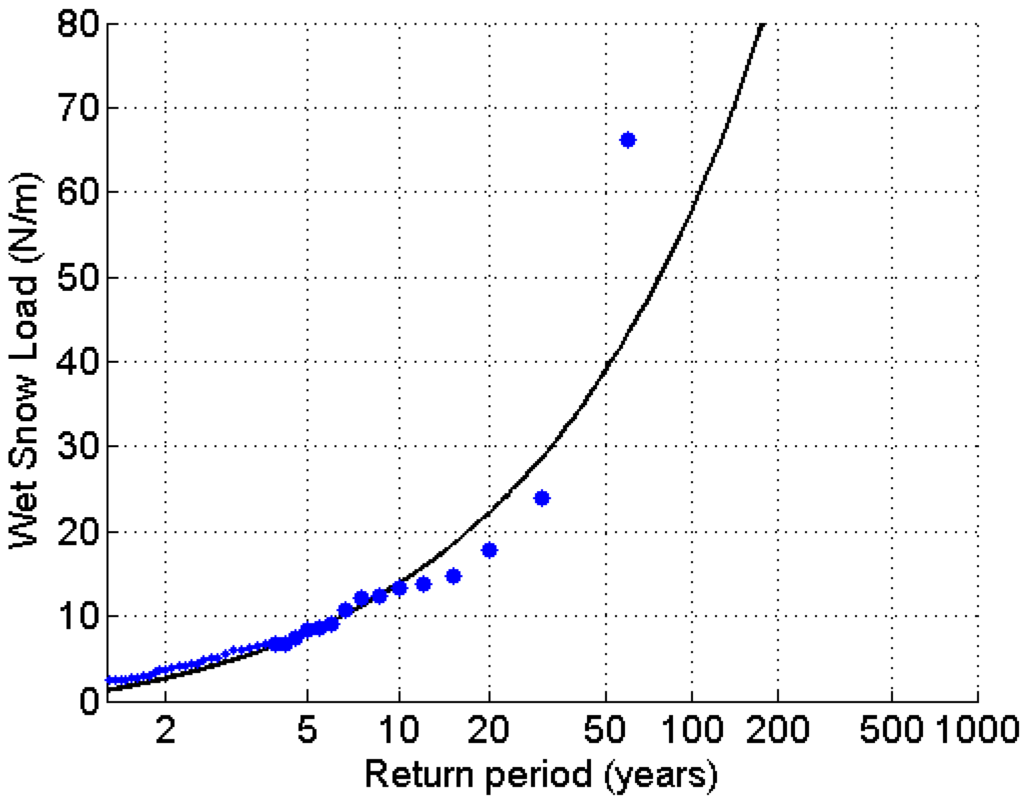
Example: Wet snow load in Münsterland, Germany (3. iteration)



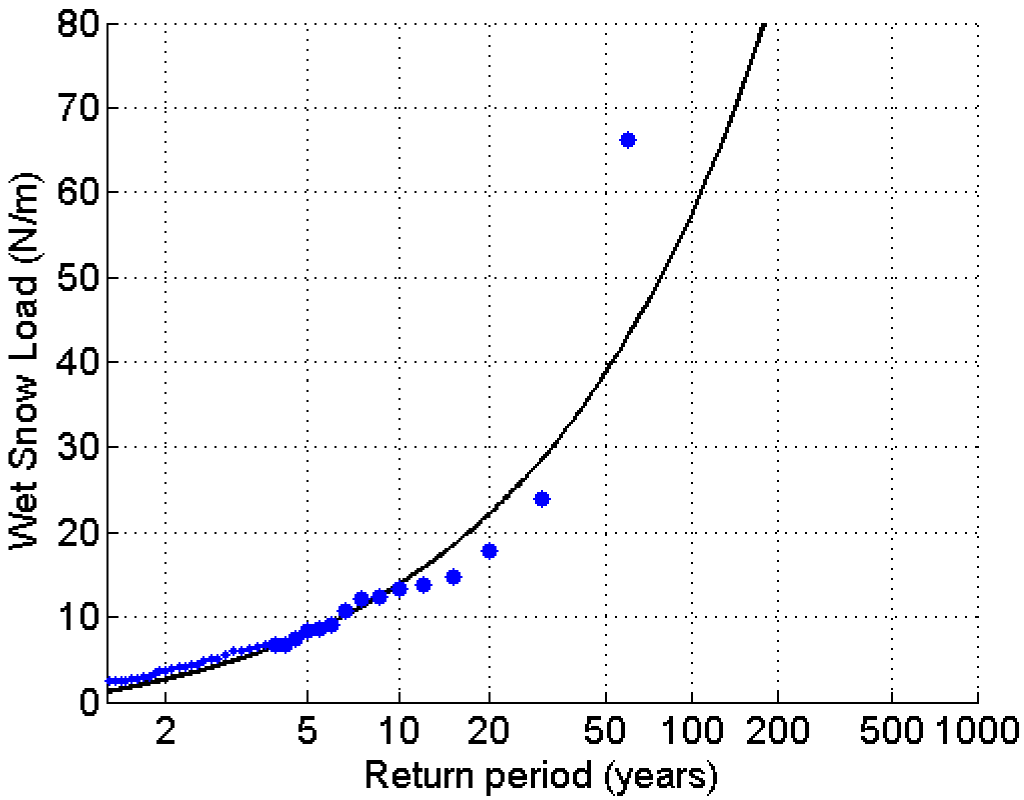
Example: Wet snow load in Münsterland, Germany (4. iteration)



Example: Wet snow load in Münsterland, Germany (5. iteration)



Example: Wet snow load in Münsterland, Germany (6. iteration)



Example: Wet snow load in Münsterland, Germany
Final result