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Credibility of statistical modeling of extreme wind speed

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This paper deals with credibility of statistical modeling of extreme wind speed. The work has been done in the framework of Project KJB300420905 - Analysis of extreme wind speed in the Czech Republic (2009-2011, AV0/KJ).

Statistical modeling of extreme wind speed is based on the extremal types theorem. The theorem states that extreme values converge to so-called Generalized extreme value (GEV). Depending on one parameter, usually called k, the distribution is usually called Fréchet ($k > 0$), Gumbel ($k = 0$) or Weibull ($k < 0$).

Using upper tail of these distributions, it is simple to estimate wind speed with return period N years. The most important value for technical applications is the case $N = 50$.

Fréchet distribution has an upper limit, while Gumbel and Weibull distributions have not. Consequently, Fréchet distribution is considered not to be suitable for extreme wind speed applications, because there is no physical reason for such an upper limit However, the extreme wind speed based on Fréchet distribution enables arbitrary high upper tail of distribution, so the previous reason is by not sufficient for excllusion of the distribution from extreme wind modeling by some authors.

The most applied method is Gumbel distribution. There is not any theoretical reason for this fact. But the value of wind speed with return period of 50 years is strongly affected by thickness of right tail of GEV distribution and, consequently, by value of parameter k. Limitation of Gumbell distribution is keeping this value equal to zero, so estimated values of extreme wind are expected to be less scattered.

Extremal types theorem has two presumptions: stationarity and extremity of modeled data.

Stationarity strongly depends on quality of the measured data, however this issue will not be addressed here. Instead we will suppose that all measured data are of good quality

Other problems preventing stationarity are due to time correlations of wind speed. Possible reasons are as follows: 1. Similar synoptic situation over several days 2. Families of depressions 3. Annual course 4. NAO and other climate oscillations 5. Climate change.

Two types of extreme data are used: Block Maxima and Peak Over Threshold. Statistical extremity is established in both these cases, provided relevant time interval is sufficiently long, respectively chosen threshold is sufficiently high. However, both these values are limited by length of measured time series.

According to published papers, good convergence to GEV distribution is not warranted even in case of maxima from sample of size 10000 independent measurement.. In the Czech Republic, we distinguish two basic types of extreme wind events – thunderstorms and front passes (mostly cold fronts in winter). Typically we select at least one extreme event per year. But only tens of these events occur per year, much less than theoretically required amount.

Statistical modeling assumes that wind gusts have the same physical mechanism on both, "usual" and extreme front passes or thunderstorms. . It is evidently false assumption in case of thunderstorms with tornadoes. It is naive to assume that magnitude of wind gust of tornadoes can be statistically modeled on the basis of data from storm without tornadoes.

Regarding the fact, that wind measurement are very unreliable and values of modeled extreme wind gusts with return period of 50 years could not be credibly checked, we must be very cautious in assessing magnitudes of extreme wind gusts obtained by statistical modeling.