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World-wide extreme wind speeds.
Part 2: examples using various methods of analysis

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THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item was monitored and guided by the Wind Engineering Panel. This Panel, which took over the work on wind engineering previously monitored by the Fluid Mechanics Steering Group, first met in 1979 and now has the following membership:

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WORLD-WIDE EXTREME WIND SPEEDS. Part 2: examples using various methods of analysis

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WORLD-WIDE EXTREME WIND SPEEDS. Part 2: examples using various methods of analysis

1. NOTATION

		Units	
		SI	*British*
A_m , B_m	Lieblein best linear unbiased estimators		
c k	constants in Weibull distribution given by $P_V = 1 - \exp[-(V/c)^k]$	m/s	kt
m, M	order value within set of wind speed maxima with $m = 1$ denoting smallest value and $m = M$ denoting largest value		
n_s	number of independent storms in record		
P_V	cumulative probability of wind speed being less than a value V		
P_x	probability of an extreme value being less than a value x in any one year		
T	mean recurrence interval or return period; $T = 1/(1 - P_x)$	yrs	yrs
U	mode of x in data set	$(\text{m/s})^2$	kt^2
V	hourly-mean wind speed	m/s	kt
$\hat{V}$	gust speed	m/s	kt
x	standard variable representing maximum values such as V^2 or $\hat{V}^2$	$(\text{m/s})^2$	kt^2
y	reduced variate; $y = -\ln(-\ln P_x)$		
Y_i	set of random numbers in range $0 < Y < 1.0$		
$1/\alpha$	dispersion of extreme value distribution (see Equation (3.1))	$(\text{m/s})^2$	kt^2
σ_x	standard deviation of x at given value of y	$(\text{m/s})^2$	kt^2
Subscripts			
A, B	relate to storm mechanism A and B respectively		
m	mth ranked value in data set		
T	relates to value having mean recurrence interval of T yrs		
50	relates to value having mean recurrence interval of 50 yrs		

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2. INTRODUCTION

The purpose of this Item is to illustrate the application of the methods detailed in ESDU 87034[1] to some practical examples. The three worked examples given in this Item do not cover all possible applications but they are typical of practical situations encountered in the estimation of extreme winds for design purposes.

The first example considers the comparatively simple problem of estimating a design wind speed for a site with a wind climate dominated by frontal depression storms. An extreme value analysis is performed starting with daily maximum wind speeds above a certain threshold recorded over a period of 12 years.

The second example illustrates the procedure to follow when the local wind climate has two principal storm mechanisms, in this case thunderstorms and frontal depressions, and the wind speed record is comparatively short. Annual maximum gust data for each storm mechanism are generated for a 50-year period using a Monte-Carlo simulation technique. These data are then used to provide estimates of extreme winds for a particular confidence level and range of mean recurrence interval (or return period). These values are compared with the corresponding wind speeds obtained by erroneously assuming that all the recorded annual maxima originate from a single storm mechanism.

The third example tackles the problem of estimating extreme wind speeds from recorded wind speeds over a period of several years only. In this case the method in ESDU 88038[2] is used in reverse to estimate an extreme value from the Weibull probability distribution parameters formed from the continuous wind speed record taken over the several-year period.

3. EXAMPLE FOR CLIMATE WITH SINGLE DOMINANT STORM MECHANISM

The purpose of this example is:

(i) to demonstrate the procedure for analysing wind speed maxima taken from individual storms to obtain an extreme value for design purposes,

(ii) to show how the amount of data that needs to be processed can be reduced by considering only those wind speeds above a certain threshold,

(iii) to illustrate the calculation of confidence limits on the estimated extreme wind speed.

3.1 Example 1

Given a set of daily maximum hourly-mean wind speeds for a 12-year period, it is required to find the extreme value distribution parameters for a site in Waddington (Lincolnshire, England) and to estimate the hourly-mean extreme wind speed at the site (z = 10 m) having a mean recurrence interval (often called return period) of 50 years. It is also required to find the range of wind speeds for this probability of occurrence corresponding to a confidence level of 68.3% (±1 standard deviation).

The method chosen for obtaining the required results is the modified version of the procedure described in Section 5.4 of ESDU 87034[1] applicable to individual storm maxima but modified to consider only daily maximum wind speeds above a certain threshold, thus reducing the volume of data to be analysed. The threshold chosen in this case is 27 kt (14 m/s) which produces the following daily maximum values of hourly-mean wind speed (V).

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TABLE 3.1

Day no.	V kt	Day no.	V kt	Day no.	V kt	Day no.	V kt
25	36	1119	30	1847	28	3303	28
270	31	1124	29	2474	28	3324	27
367	48	1176	28	2475	(28)	3325	(27)
368	(47)	1178	(27)	2476	(27)	3326	(27)
379	30	1350	27	2519	27	3349	31
385	28	1460	29	2626	28	3350	(28)
757	30	1461	(29)	2906	30	3754	31
1046	30	1471	(29)	2910	27	3755	(31)
1047	(29)	1472	30	2926	30	4032	(29)
1049	31	1791	27	2954	33	4033	32
1050	(29)	1809	32	3003	33	4037	33
1089	38	1810	(29)	3253	29	4101	37
1099	33	1812	29	3282	28	4371	27
1107	31	1813	(29)	3300	33		
1108	(30)	1822	31	3301	(31)		

Step (1c) of Section 5.4 in ESDU 87034

The smaller value of pairs of data points separated by two days or less are bracketed in Table 3.1. To ensure that only independent storm maxima are included in the subsequent analysis, these values are now ignored leaving 41 maxima.

Steps (2) and (3)

The average number of storms per year (r) with an hourly-mean wind speed in excess of 27 kt is thus $r = 41/12 = 3.417$.

As recommended in ESDU 87034 the remainder of the analysis is carried out in terms of V^2. Ranking the remaining individual maxima by value gives the results summarised in Table 3.2 in terms of $x = V^2$ and the reduced variate $y = -\ln(-\ln P_x)$ where $P_x = \{m_s/(n_s + 1)\}^r$.

It is necessary to consider only those maxima for which $y > -1$.

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