Predicting Design Wind Speeds from Anemometer Records: Some Interesting Findings

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ABSTRACT

Designers are more frequently relying upon wind climate analyses of wind records from local meteorological sites for the design of modern structures. As a result, it is increasingly important to understand the effects that various analysis and recording techniques have on these predictions. Highlighted herein are the findings of recent studies that have raised questions on the accessibility, validity, and identity of wind records, and the problems associated with not knowing the anemometer type and exposure characteristics, incorrectly assuming the averaging time of the wind speeds, and carrying out an assessment using only one meteorological site. The findings of various case studies are presented and the implications (which in some circumstances are alarming) that the extreme value predictions from the case studies have on the design of modern structures is discussed.

INTRODUCTION

A vital part of the design of modern structures lies in the accurate assessment of design wind speeds with probability of exceedance of either 0.02 or 0.01. Designers typically rely upon either codified values or results of wind climate analyses for the wind speeds to be used in design; both of which depend upon accurate recordings of long-term wind records from meteorological sites. Almost always the wind speeds needed for design are of a return-period which is significantly longer than the wind record itself. Uncertainty in the predictions of the design wind speeds can account for variations in design loading forecasts that are greater than the value of the load factor.

Previous investigations by Arup have involved the analysis of wind records of various length, anemometer type and recording methodology for much of the world. Various analysis procedures have been employed, including those of Gumbel and Harris to derive extreme value distributions of maximum wind speeds for which estimates of design wind speeds have been made. Some advantages and disadvantages of these assessment methodologies will be discussed in this paper.

In addition, this paper aims to highlight some concerns with various wind records from different parts of the world. The discussion will range from the length of the averaging time associated with the wind speeds, the anemometer type utilized in the recording, and the standard methodology in maintaining wind records through manual and/or automatic recordings. The implications on the design wind speed predictions will be brought to light.
GENERAL PROCEDURE FOR ASSESSING DESIGN WIND SPEEDS

IDENTIFYING SUITABLE WIND RECORDS

In the studies listed herein long-term climatological wind records for periods of recording of longer than ten years are analyzed using statistical theory of extreme values. Before any assessment is begun, pictorial documents and historical auditing reports are accessed (if available) to confirm any dramatic changes. These changes would include: surroundings (i.e. development construction, tree growth), anemometer location (i.e. movement from a sheltered location to a less sheltered location), anemometer recording methodology (i.e. manual recordings to automatic recordings), and/or anemometer type (i.e. pressure tube-anemometer to rotating-cup anemometer).

The general procedure adopted for analyzing the wind records is; first - ensure the quality of measurements and then separate mixed climate records, second - apply exposure correction by transposing the wind records from the anemometer site (considering elevation, terrain, and topographical correction) to be consistent with open country (Engineering Sciences Data Unit (ESDU [1]) $z_0 = 0.03$m) or open desert terrain, third - assess the frequency of occurrence of the regular winds on a seasonal basis to gain further understanding of the parent distribution, and fourth - carry out an extreme value statistical analysis using discrete mean and/or gust wind speeds.

A standard procedure for separating mixed climate data is adopted. This involves filtering mean wind records for speeds which are greater than 15 m/s and three times greater than both the previous and post hourly recording. Wind speeds fitting this criterion are divided and analyzed separately. “Mean” wind speed records which increase sharply in this manner are attributed to thunderstorm downbursts or other convective behavior which is better suited to a gust analysis.¹

In recent years, there has been an increasing tendency to use mean speeds to predict extremes. They have become favoured over gust speeds because of the theoretical statistical stability of measurement and the known problems with interpreting and comparing gust speed records from different meteorological sites and recording systems. On the other hand, gust speeds are much less sensitive to changes or estimates of terrain roughness and site exposure and with longer data records and consistent automatic measurements the extreme value gust predictions also become reliable.

The choice between gust or mean wind speeds for the prediction of the design speed is also related to the wind climate specific to the region in question. For example, the strength of longer duration wind events (such as monsoons) is better predicted using mean wind speeds whereas shorter events (such as thunderstorms) require an analysis of gust speeds. Therefore in well-known thunderstorms climates, such as the Middle East or the eastern coat of Australia, gust records are preferred (but aren’t always available!).

Unfortunately, from the majority of meteorological sites around the world the mean speeds tend to be the most accessible wind record. Often the gust speeds are only recorded in significant storms (and are sporadic at best) and therefore, in most cases, cannot be depended upon to cross-check design wind speed predictions derived using mean speeds.

¹ Convective activity is best recorded through comparison of both mean and gust wind speeds; although gust data is not always available. For taller buildings, convective activity can often be disregarded since the strong horizontal winds associated with these events are localized towards the ground [2] and have relatively little impact on the upper portions of tall buildings where loading is most important for structural design.
**INSTRUMENTATION**

Since the early 1900’s gust and mean wind speeds around the world have been monitored using either pressure-tube anemometers (most commonly used in British Commonwealth countries) and rotating cup anemometers. In more recent years many meteorological sites have been replacing pressure-tube anemometers with rotating-cup types, as the latter is thought to provide a more accurate estimate of the gust wind speed. Previous research has shown that although the two recording instruments exhibit little variation in the recordings of mean wind speeds, the pressure-tube anemometer tends to record gust speeds 6-7% higher than the rotating-cup anemometer [3]. The ‘Papillion’ anemometer utilized throughout France in the 1970s is also well known for over recording wind speeds [4], but the mean wind speeds in this case.

In the move to upgrade legacy wind sensors in meteorological sites around the world many places are moving to automated recording systems. A prime example of this is the Automated Surface Observing System (ASOS) program which, in the 1990’s, moved to replace all weather monitoring stations across the United States with an automated recording and statistical processing system. This is in contrast to other areas around the world, such as parts of China and most of the Middle East, which still continue to depend on manual recording methods. In addition to the difficulty of understanding the anemometer types and recording methodology, it can also be difficult to ascertain the averaging times associated with the wind records. Even for mean wind speeds there are (at least) four averaging times in use: an hourly mean, a 10-min continuous mean, or a 10-min mean measured over a 10-min period near the hour or before every three-hour period. These are clearly not the same thing, yet they are commonly treated as being the same during processes of analysis when the exact acquisition process is unknown.

**ENVIRONMENTAL COEFFICIENTS**

Meteorological sites are seldom homogenous in their environment and rarely similar in their surroundings. To account for the environmental variations it is necessary to correct wind records to obtain a reference wind speed which is independent of local surrounding particularities, such as nearby obstacles and terrain characteristics. These particularities are dependent upon wind direction. Meteorologically homogeneous sites would be recorded over terrain with the same roughness characteristics (over the duration of the record), at a standard height above ground and averaged over the same time interval.

The generation of a standard reference speed allows for the like-for-like comparison of wind speeds from meteorological sites with differing exposure and provides a basis for comparing wind speeds recommended for design (i.e. hourly mean wind speed, in open-desert ($z_o = 0.005m$), at 10 m height, 50-year return period). Often the height of the anemometer is not explicitly stated and although the standard height is 10 m, anemometers are sometimes mounted higher in an attempt to compensate for the shelter of surroundings, although the accuracy of this adjustment is obviously uncertain.

To review inconsistencies in wind records, regional analyses are preferred. This requires the acquisition of wind records from a minimum of three meteorological sites, and ideally a significant number more. In these cases the wind records from each of the regional sites are considered separately to ensure that local topographical shelter is not influencing the wind speeds recorded. Depending on the quality of the recordings, the proximity of the anemometers and the suitability of the terrain correction factors it is possible to combine the various anemometers into a ‘super-station’, where mutually independent wind records from these nearby
meteorological sites are consolidated into a single wind record. The ‘super-station’ approach enables the reduction of sampling errors. In this type of assessment it is imperative that independence of extreme events is ensured.

**Terrain Roughness Adjustments**

The widely accepted Deaves and Harris wind model of the atmospheric boundary layer, as defined in ESDU Item 01008 [1], is commonly used to assess the upwind effects of ground roughness.

Detailed surveys of terrain roughness are carried out for each meteorological site using satellite imagery to assess roughness length. The analysis is completed for twelve sectors of wind direction and up to a distance of 100 km from the meteorological site. Surface roughness length, z₀, is chosen to be consistent with the model used in ESDU. Some researchers in the past have opted to not correct for the effect of variation in upwind terrain, however, it can be observed in numerous wind records that a trend in time exists that correlates well with development of upwind building density.

Due to the balance between gain/loss of turbulence and loss/gain of kinetic energy over a rough/smooth surface, correction factors for the gust speeds are smaller than those for the mean speeds.

**Topography (Orography) and Altitude Adjustments**

A rough upwind terrain can act to slow wind speeds down and a large mountain or a steep cliff may act to steer or accelerate the winds. Several methods exist for assessing mean speed-up or slow-down flow over hills, including the methods of Jackson and Hunt (eg. FLOWSTAR [7]), wind tunnel testing and code methods that have been derived from these. It is however in practice impossibly to parameterize all the factors of hill-shape that can be important, especially when the hill slopes become steeper than about 30%, where wind flow may detach from the surface. There are even greater difficulties with assessing the turbulence, especially in regions of intermittent flow detachment. Depending on the size of the hills, mountains, valleys, cliffs, etc., topographic effects can be very difficult to correct and data from such regions is probably best applied only locally.

In the UK and Eire, wind records are corrected for the local effects of altitude. The altitude factor (Sₐ) of the UK codes, is based on the elevation above sea level of the anemometer as recommended in Cook [6]. The altitude factor follows the form:

\[ Sₐ = 1 + 0.001 * A \]  

Where A is the elevation above sea level in meters. This can be a useful correction for residual effects of topography not covered by other code methods. This approach is believed to work reasonably well over relatively short distances within the UK, but is known to be unreliable for larger scale changes. More research into this and better methods of topography corrections in general could help to clear up a number of interesting inconsistencies.

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2 This process of creating a ‘super-station’ should be done with care. In a recent study carried out in the Emirates a super-station was generated from 20-year gust records from four meteorological sites. The records were corrected for terrain and merged into an equivalent super-station to obtain an enlarged gust database. The analysis resulted in a 50-year open desert design gust speed equivalent to 37.8 m/s; this corresponds well with previous published literature [5], however, upon further inspection it was revealed that 91% of the gust speeds used in the independent storms analyses were recorded at one of the contributing four stations. Therefore, the design gust speed is more representative of one area of the region and not necessarily the entire region.
Obstacles such as warehouses or aircraft hangers in the immediate vicinity of meteorological sites can also have a significant effect on wind speed measurements. Minor effects of these obstacles can be specifically accounted for, however, for directions in which major shelter is obvious, wind speeds and directions need to be adjusted conservatively.

**Extreme Value Predictions**

Until the last twenty-thirty years, the estimate of extreme winds around the world was mostly based on classical extreme value theory [8], and this is still used. However, statistical extreme value analysis (EVA) has evolved in the last thirty years to include analysis techniques which potentially offer more accurate predictions of the tails of the EVA distribution. Two EVA techniques (modified Gumbel [10], and independent storms (proposed initially by Cook [11] and improved by Harris [12]) are used herein to determine the probability of exceeding a given wind speed in a given return period.

Design wind speeds depend on both the mean and the variability of the time series, the design wind speed being positively correlated with both of these. The accuracy of the estimated design speed generally improves with the length of the time series but this also depends on the consistency and accuracy of the records.

In the majority of synoptic wind climates the parent wind distribution, irrespective of wind direction, is reasonably well represented by a Weibull distribution (specific characteristics of the distribution function were analyzed by Holmes and Moriarty [13]).

\[ P_v = 1 - \exp\left(-\left(\frac{V}{c}\right)^k\right) \]  \hspace{1cm} (2)

The extreme value \( x \) is equated to the wind velocity (mean or gust) squared, the distribution of which is closer to exponential, as recommended in Cook [10] (to ensure a rapid convergence to the extreme value distribution and to reduce the methodological bias).\(^3\) The work of Cook and Harris shows that the fastest convergence to a standard Gumbel Fisher-Tippett Type-I (FT-I) extreme value occurs if the underlying function is exponential and this would be achieved by fitting wind speed to the power of \( k \). Subsequent work by Cook [14] has shown that fitting velocity squared (dynamic pressure) is likely to be at least as valid.

If attempts are made to fit velocity to a FT-I curve, then the resultant data fits will tend to curve downwards in the tail. Clearly for a given number of data points it is possible to vary the form of the Gumbel curve (using the second parameter) and get an equally good statistical fit. [Occam's Razor would say it is best to use the simplest model that fits the data.]

Theoretically, for a set of data conforming to a Weibull distribution the cumulative distribution function of the extremes will converge towards a FT-I distribution of the form:

\[ P_x = \exp\left[-\exp(-y)\right] \]  \hspace{1cm} (3)

Where the reduced variate \( y \), is given by:

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\(^3\) The methodology of fitting the Gumbel distribution to the dynamic pressure has been championed by a number of researchers ([11], [12], [15]) as offering statistically the best fit (a Rayleigh distribution) to extreme wind speed distributions, further researchers ([13],[17]) have shown the reverse Weibull distribution to be a more appropriate probabilistic model of extreme wind speeds.

Although the two methodological assessments have been pitted against each other for some time, Simiu has clearly shown in a very informative research study ([18]) that the probability plot coefficients (PPCC) goodness of fit tests, which were used to measure the suitability of the reverse Weibull and the Rayleigh distribution of fitting extreme wind speeds, were similar for the two distributions, varying only slightly in most cases on the third-significant digit. This difference has limited significance when it is well known that there is a scatter-band of reliability on the predictions at least an order of magnitude higher!
\[
y = -\ln[-\ln(P_x)]
\]

And \( P_x \) is the probability that an extreme value will be less than a value \( x \) in any one year.

The modified Gumbel analysis makes use of the annual maximum wind records, whereas the independent storms analysis uses the maximum ‘2.4 x years of data’ wind records [19] from the same wind mechanism. The major advantage of the independent storms method over the modified Gumbel method is that more wind records are available for the extreme value assessment, including those which might otherwise be hidden by a more extreme storm which happens to occur in the same year. This leads to a greater confidence in the estimation of design wind speeds.

The Harris independent storms methodology applies a probability weighted least squares to each dynamic pressure to associate lower confidence to wind speeds occurring less frequently.

Statistically independent observations exceeding a certain threshold wind speed are considered in the analysis. Pairs of wind records separated by three days or less are treated as one event to ensure that only independent storm maxima are retained. A reasonably high threshold is adopted to ensure that only events arising from extreme storms are included in the analysis. Gross et al. [18] has shown that extremes cannot be inferred from weaker winds, these winds can often be considered to be noise which obscures the extreme processes of interest; ‘let the tails speak for themselves’.

**DESIGN WIND SPEED PREDICTIONS, INTERESTING FINDINGS**

**EFFECT OF ANEMOMETER TYPE**

In one recent study wind time histories (of length up to 50 years) of hourly mean and daily gust wind speeds for a dozen near-by meteorological sites were utilized to predict 50-year design wind speeds for the region. All of the meteorological sites were initially equipped with a Dines pressure tube anemometer; these were replaced with either a Vaisala or a Vector rotating cup anemometer at a mid-way point in the record. Concurrently to the anemometer change the weather stations became automated and all of the wind statistics (hourly means and daily gusts) were calculated using automated software. About half of the sites converted to the Vaisala-cup and the other half to the Vector-cup. There was no other significant change to any of the meteorological stations at the time of conversion.

The time histories of the wind records were separated by the type of recording instrument and extreme value analysis was carried out on each wind record independently. This was possible as the length of the shortest record was seven years; the shortest length of record needed to permit a reasonable estimate of design winds [20]. The results of the analysis revealed significant variations in the 50-year design wind speed predictions from the three anemometer types.

The sites which moved to the Vector-cup showed considerable reduction in the estimated 50-year design wind speed. Similar reductions were not observed at the sites that moved to the Vaisala-cup.

The average reduction in the hourly-mean design wind speed predictions from the records of the Vector-cup anemometer was approximately 15% less than the predictions from the Dines. A similar percent reduction is observed for both the daily gust and hourly mean speeds (as shown in the left plot of Figure 1). This reduction in design wind speeds can not be explained by changes in terrain or simply by the frequency and strength of storms.
From the right plot shown in Figure 1 it can be observed that the sites that were changed to the Vaisala-cup anemometers show markedly different results. The hourly mean and daily gust design wind speed predictions were similar with only small changes from certain directions that can be attributed to changes in the upwind terrain.

It is hypothesized that the Vector-cup anemometer is predicting relatively low hourly mean and daily gust wind speeds. Reasons for this are not yet clear but might include a calibration or instrument matching issue or possibly some unintended influence of wind turbulence.4

Clearly such discrepancies could have a serious impact on the design of structures if only the most recent wind records are used to quantify the design wind speeds or if a mixed record from the two anemometers was used without initially separating the records by anemometer type.

**Figure 1** - 50-year directional design wind speed predictions, comparing Dines pressure tube anemometers with Vector and Vaisala rotating cup anemometers.

**Effect of Data Source (NCDC vs. Local Authorities)**

It is a standard procedure of wind tunnel laboratories and consultancy groups to purchase wind records from meteorological sites around the world through the National Climatic Data Centre’s (NCDC) website. These wind records are then often used to predict wind speeds to be used in the design of substantial structures.

Over the past couple of months, after acquiring wind records from local meteorological sites directly, some alarming discoveries have been made. Attempting to directly correlate wind statistics between the NCDC and the local meteorological sites has proved impossible.

Shown below in Figure 2 is a 19-year time history (1986 – 2004) of yearly maximum hourly mean wind speeds acquired from the NCDC and the Australian Meteorological Bureau (AMB). Both records are for Melbourne Airport and uncorrected for terrain. The NCDC record is provided as hourly mean speeds in miles per hour whereas the AMB records are given in kilometers per hour (both are shown in meters per second below for comparison).

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4 From conversations the authors have had over the years, this is not a unique example, see also [3].
The expectation is that the yearly maximum values are identical from the two data sources, however in actuality only 5 of the 19 (~20%) records are synonymous. In some cases, even the dates when the yearly maximum storm occurred are dissimilar (shown on the top and middle of the Figure for the NCDC and AMB respectively; format MM,DD).

It has been noted anecdotally that the NCDC is given, through international agreements, not the time history of the wind records from the meteorological sites around the world but an hourly updated log file. This log file may often be composed of manually transcribed wind records.\textsuperscript{5}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2.png}
\caption{Maximum yearly mean wind speeds for Melbourne airport from two sources, time history showing storm dates.}
\end{figure}

As a further example, twenty-three years of yearly maximum hourly mean wind records (1983 – 2005) were acquired from the Don Muang Airport in the north of Bangkok from both the Thai Meteorological Department (TMD) and the NCDC. Unfortunately in this case the dates of occurrence of the strongest yearly winds were not available from the TMD and therefore a date of occurrence correlation to the records from NCDC was not carried out.

Gumbel extreme value analysis was used to determine the 50-year open-country mean hourly design wind, as shown in Figure 3 (yearly wind speeds are shown corrected for terrain). The results of the analysis show that using the NCDC wind record, design wind speed

\footnote{In at least one case in recent history a wind laboratory has utilized a 20-year wind record acquired from NCDC from solely one meteorological site to predict design wind speeds for a tower approximately 400 m tall. This can be significantly unconservative in light of the fact that there is a level of uncertainty in what the NCDC is providing. Further problems with the NCDC wind records, to do with unit conversion, have been reported in Gatey and Miller [21].}
predictions of the order of 36 m/s are derived; this is compared to less than 32 m/s derived from the TMD wind record.\(^6\)

In this case the NCDC wind record has erred on the conservative side, however a similar analysis was carried out for a meteorological site in northern China and the design wind speeds given by NCDC were approximately 20% lower than those quoted by the Chinese Meteorological Administration. A 20% difference in wind speed results at least a 44% difference in loading and possibly a 70% difference in accelerations! Under-predicting wind speeds to this order very quickly removes the risk coverage given by the load factor.

![Figure 3 - Maximum yearly mean wind speeds for Bangkok airport from two sources, basic Gumbel plot with 50-year return period prediction.](image)

Another issue with wind records is that they are often “binned” or rounded, resulting in significant numbers of records of the same value. For such records it is necessary either to randomize the values inside the box (for which some knowledge of the expected distribution is required) or, perhaps better, to fit at the ends of each box. Unfortunately current Harris/Cook fitting methods are not suitable for the latter, and the Lieblein BLUE methodology [22, 23] may give better results.

\(^6\) Interestingly, these values are 44% and 28%, respectively, in excess of the 25 m/s 50-yr open-country hourly mean design wind speed specified in the Thai Wind Loading Code (1311-50). It is believed that both the NCDC and the TMD yearly maximums shown in Figure 3 are mean speeds confounded with short duration gust speeds (as opposed to strictly consisting of hourly mean speeds). This was found to be the case after running the NCDC wind record through a mixed climate analysis which identified almost 30% of the yearly maximums included in Figure 3 as suspicious mixed record outliers.
It can misleading to rely solely on the point estimate from the independent storms EVA of the longer return period events. There is a significant chance that the true longer return period wind speed is larger than the point estimate. This is at least a normal result of variability within the wind records.

In his 2000 paper [25], Harris suggests a way of generating artificial storms, assuming an underlying exponential distribution of dynamic pressure and an arbitrary number of storms per year (e.g. 100). The simulation of thousands of wind storms has become a popular area of research in recent years as a greater attempt to demonstrate both the goodness of fit of the various extreme value techniques as the reliability of design wind speed predictions has become more important in structural design. By comparing the fit in an arbitrary period of records (say 20 years) over a large number (say 10,000) of sets of 20 year records this demonstration is possible.

An independent storm simulation (as suggested by Harris [24]) was carried out to assess the reliability of the point estimate of the 50-year design wind speeds that wind tunnel laboratories and consultancy groups often depend upon. Ten thousand sets of 2000 storms (20 years * 100 storms per year) were generated. An independent storms EVA was carried out using the maximum forty-eight (2.4 * 20 years) storms for each 20 year simulation.

The range of the 50-year predictions (99% confidence limits) varied by approximately 50% on the dynamic pressure; the 99th percentile design wind speed was approximately 20% greater than the 1st percentile design wind speed, and 10% greater than the 50th percentile design wind speed! Variations as great as these can result in an under-(or over-)prediction of the along-wind loads of 20% and the across-wind loads up to 50%. Under-predictions of loads by magnitudes as great as these have obvious implications on the design of modern day structures, remembering that some of this is built into typical design safety factors.
Two examples of the independent storms analysis of the simulated wind records (resulting in upper and lower design wind speed predictions) are shown in Figures 5 and 6; the storm maxima are shown as black squares. The results of the EVA of those storm maxima is shown in a black dotted line, the 50-year wind speed prediction is 25 m/s [Figure 5] and 20.9 m/s [Figure 6] (the actual value of the design wind speed is 22.6 m/s (shown as a thick solid black line); the basis of the storm simulation). Also shown in the figures are the 99% confidence bounds on the simulated wind records and the 99% range of the design wind speed predictions (black triangles).

Figure 5 - Wind storm simulation, an example of an independent storms assessment of one 20 year data set (upper range of predictions).

\[ \text{Fit parameters} \ \alpha U = 3.6, \ \text{mode} = 299 (\text{m/s})^2, \ V_{50\text{year}}^2 = 623 (\text{m/s})^2. \ 99\% \text{ bounds.} \]

7 In the wild it is found that recorded wind maxima are outside reasonable confidence limits. There are three common reasons accounting for these obscure wind records. Firstly, the value may originate from an event with a different mechanism (maybe not even a wind event) and a study which correlated the date of the occurrence of the extreme event with meteorological records would need to be employed. Secondly, the event may have a smaller probability of occurrence than the analysis would indicate, due to the finite record length not containing other intermediate storm events which would occur eventually (i.e. a single storm of ~1000 year return). Thirdly, the value could be associated with a manual recording/rounding error. In the case of this simulation only the second explanation applies.
Figure 6 - Wind storm simulation, an example of an independent storms assessment of one 20 year data set (lower range of predictions).

From these independent wind storm simulations it has been observed that:

a) The statistical expected value in a 20 year period is of 36 year return and similarly for other exposure periods. (This can also be predicted from extreme value theory, without the Monte-Carlo simulation by factoring by the exponential of 0.5772).

b) In reality, the slope (mode/ dispersion) of the fit of the dynamic pressure should be equal to the natural log of the number of storms per year (in the UK the slope is \(\sim 5 = 148\) storms/annum).

c) The main element of scatter in the predictions from the various 20 year sets of data is associated with the prediction of the slope (see Figures 5 and 6) and not with the prediction of the annual mode. It is proposed, that in microclimates with known slope (e.g., slope = 5 in the UK); the slope is used to establish the 50-year design wind speed from the annual mode, thereby enhancing the reliability of the prediction. This has the potential to reduce the scatter of the design wind speed predictions from 0.044 to 0.021.\(^8\)

\(^8\) To take account of this it is necessary to be confident of the slope through a regional, rather than a local, climatic study.
Final Comments
The above is a guide to the practical use of real wind data. In many cases a subjective judgment about whether particular data should be used or not has to be made. In general, the following is recommended:

- Check sources of wind records and wind record consistency thoroughly.
- Separate storm types as far as is practical.
- Never rely on only one meteorological site.
- Check the slopes of the EV predictions against regional expectations.

With designers more frequently relying upon wind climate analyses (which utilize these wind records from local meteorological sites) for the design of modern structures it is increasingly important to understand the effects that various analysis and recording techniques have on design wind speed predictions. Even a relatively small difference in design wind speed can result in a dramatic difference in design wind loads and calculated building motions. This can have significant financial and/or safety implications.

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