An analysis of New Zealand extreme winds and comparison with AS/NZS 1170.2

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Summary

Gust speeds at a 20-year return period for 50 New Zealand anemometer stations are compared with winds given by the joint Australia/New Zealand loading code AS/NZS 1170.2. In most cases, the data-based value is within 20% of the code wind speed with a tendency to be below, especially on steep hills. Direction effects are also discussed.

Introduction

The New Zealand loading code NZS 4203: 1992, following the Australian code AS 1170.2 – 1989, introduced large topographical multipliers for the estimation of site wind speeds at hill and mountain sites. Wind speed variations over a hill were determined by a hill-shape multiplier, this could add over 50% to the basic speed at a site. Unlike the Australian code, NZS 4203 gave directional wind speed data in seven geographical zones and had three additional multipliers for the effects of elevation, channelling, and mountain lee winds.

Further joint action has now produced a single code covering both countries. The hill-shape multiplier has been allowed to increase with steepening hill slope over a wider range than in the earlier codes. The channelling multiplier which has been found to vary with return period, has been combined with the basic wind speed. This has led to a special wind zone for Wellington, where the channelling effect is most obviously important. The other multipliers are unchanged. This paper compares wind speed and direction data prescribed by the joint Australia/New Zealand loadings code, AS/NZS 1170.2, with measurement-station data.

Data and instrumentation

The New Zealand wind data used in these analyses come from daily maximum gust records. These were acquired by inspection of wind strip charts produced by Munro anemographs. Each day an observer unrolled the portion of chart from midnight on the previous day to midnight on the day in question and read off the maximum excursion of the recorder pen trace and the wind direction for the same time. These have been recorded in the daily climate record on an electronic data base from 1 January, 1972.

The method of recording daily gust data has changed again during the 1990's as the Munro anemographs have been replaced by sensors with electronic recorders. There has been a change in the site of the wind sensors in many cases, and the electronic data differs in nature from the excursions of the pen recorder, so is expected to lead to a different extreme wind climatology. The period from 1972 to the cessation of the Munro anemograph records constitutes the period of New Zealand wind records which is most likely to provide a good basis for extreme value analyses and is used in the present analysis.

Speed analyses

The speed analyses are based on annual maxima over all directions from years in which there is a complete record or nearly so. Only stations with 10 years or more data have been used. The speeds expected at a return periods of 20 years have been obtained as Lieblein unbiased linear fits to the data sets. Data from eight other calculation procedures have also been inspected for comparison purposes; these typically have a spread of the 20-year speed over about 10%. The 20-year value is within or close to the range of return periods represented by the data, so that the errors involved in extrapolating to high return periods do not affect this analysis.

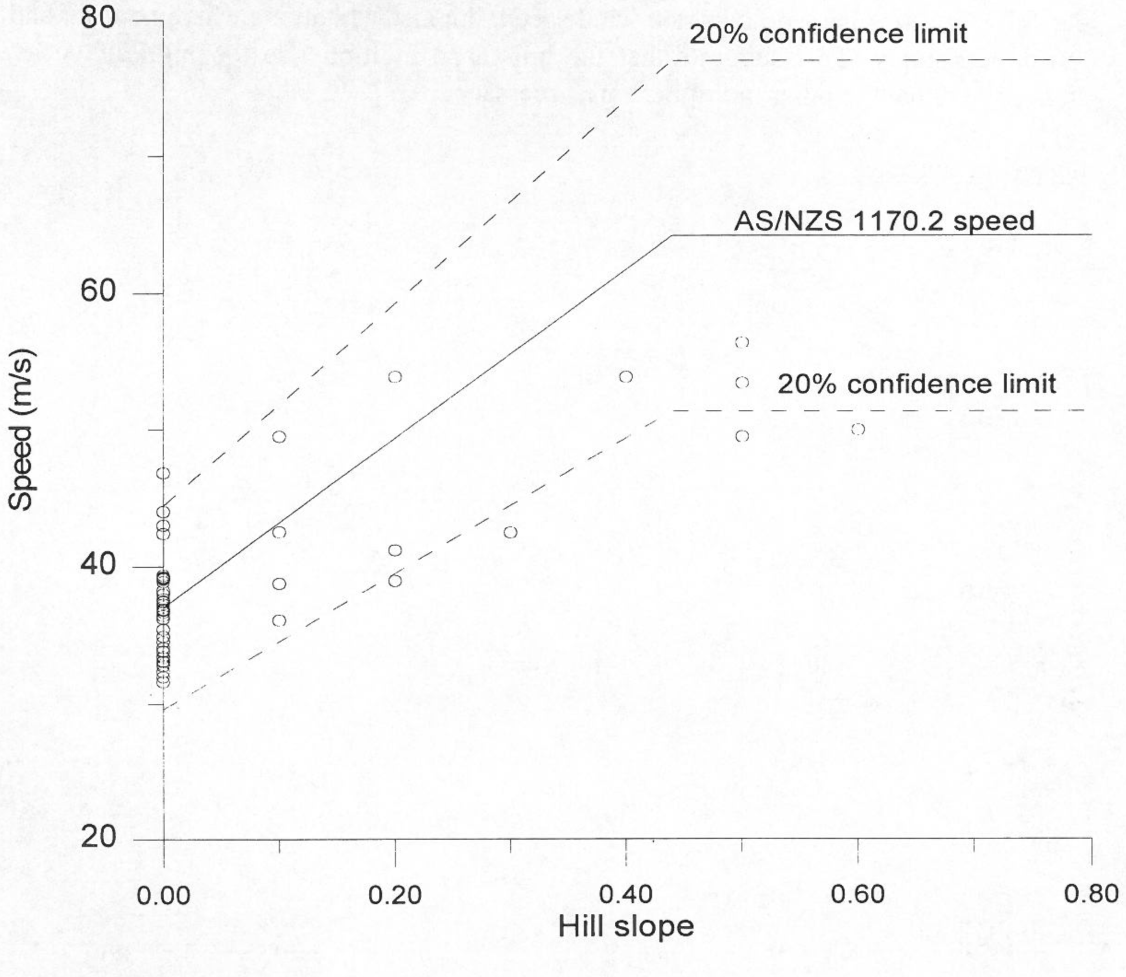

Fig. 1: Corrected 20-year gust speeds (m/s) for 50 New Zealand wind stations plotted against hill slope ($H/2L_u$) where H is the hill height and L_u the upwind half width. The corrections

made to the data would lead to all points lying along the AS/NZS 1170.2 speed lines, if the code prescriptions were correct.
The 20-year station data have been corrected to a standard exposure, i.e. at 10 m above ground in terrain category 2. In order to compare them with code values, three other corrections have been made. These allow for the lee and elevation multipliers which apply at some sites, and make an adjustment for the channelling increment applied in the Wellington zone. The data have been plotted against the hill slope (as defined in the code) and are shown in Fig. 1.

The interpretation to be placed on Fig. 1 is that all data points would lie along the AS/NZS 1170.2 speed lines, if the code method were correct. In fact, the bulk of the station data is clustered around the line at zero hill slope. One station has a wind speed above the upper 20% confidence limit at zero hill slope, this station is Castlepoint, on the east coast of the North Island , and probably should have a lee multiplier. Strong winds are a common feature of the area. On the other hand, at high hill slopes, the code tends to overestimate the speeds by about 20%. This occurs, not only at stations at which additional multipliers (such as elevation and lee) have reduced the wind speed, but also at stations where no such additional multipliers apply. This suggests that the hill-shape multiplier is too high at the available stations and that the other multipliers are necessary.

Direction analyses

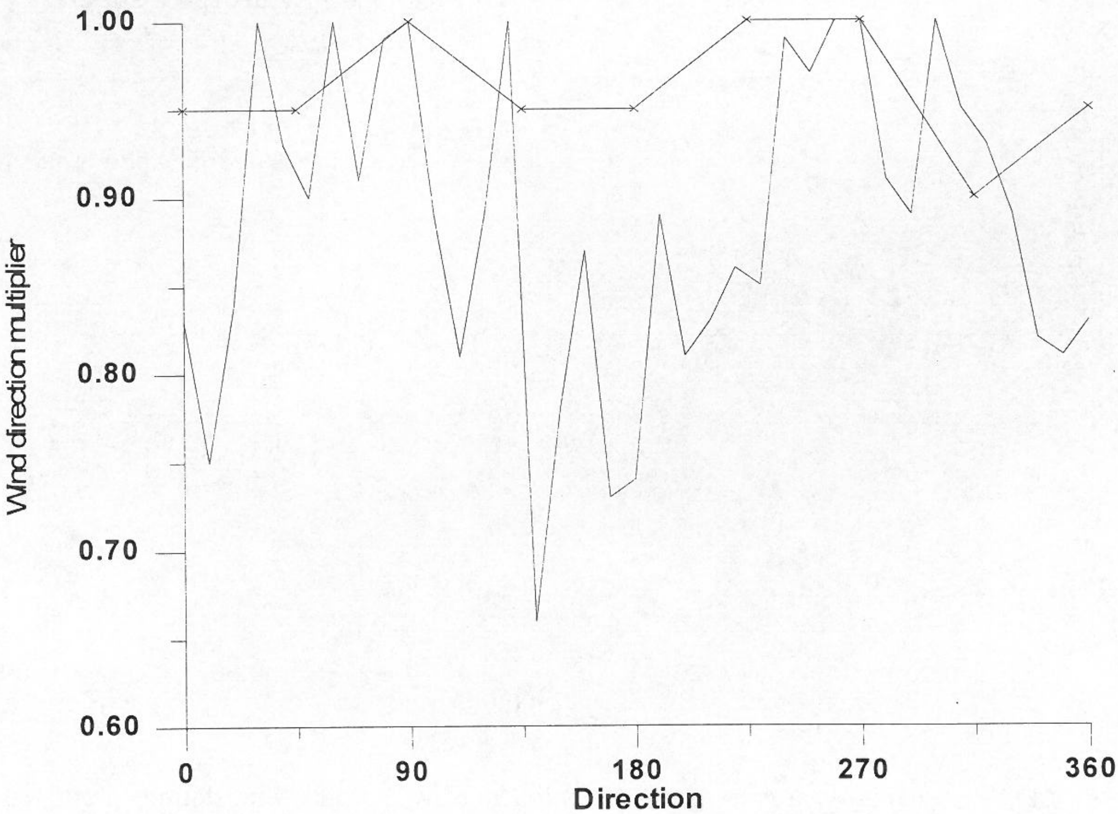

Fig. 2: Wind direction multipliers for direction sectors for Region A6 (Northland and Auckland). The 90%-ile multiplier as obtained from all gust data in the region is plotted for each 10 degree. The code direction multiplier is shown for each 45-degree sector.

The complete set of daily maximum gust data on the climate data base for the decade 1980 – 1990 was surveyed and the total count of data and the maximum gust speed for each direction were extracted. There is a wide range of data coverage, ranging from stations with just a few tens of reports to the stations with an almost complete tally of daily readings, which were used for the speed analyses. In order to obtain the maximum geographical coverage, all stations are used in an analysis of directional variation. Data from over 100 stations were used. The data have been subdivided into code wind regions and for each station the maximum gust speed has been obtained for each 10-degree direction sector. These data are used for determining the relative speeds in each direction sector. The sets of directional speed maxima have been normalised so that the maximum speed for each station is 1.0. Then for each direction sector, the 90%-ile speed has been obtained. The 90%-ile speeds have then been plotted against the code wind direction multiplier in Figs. 2-4.

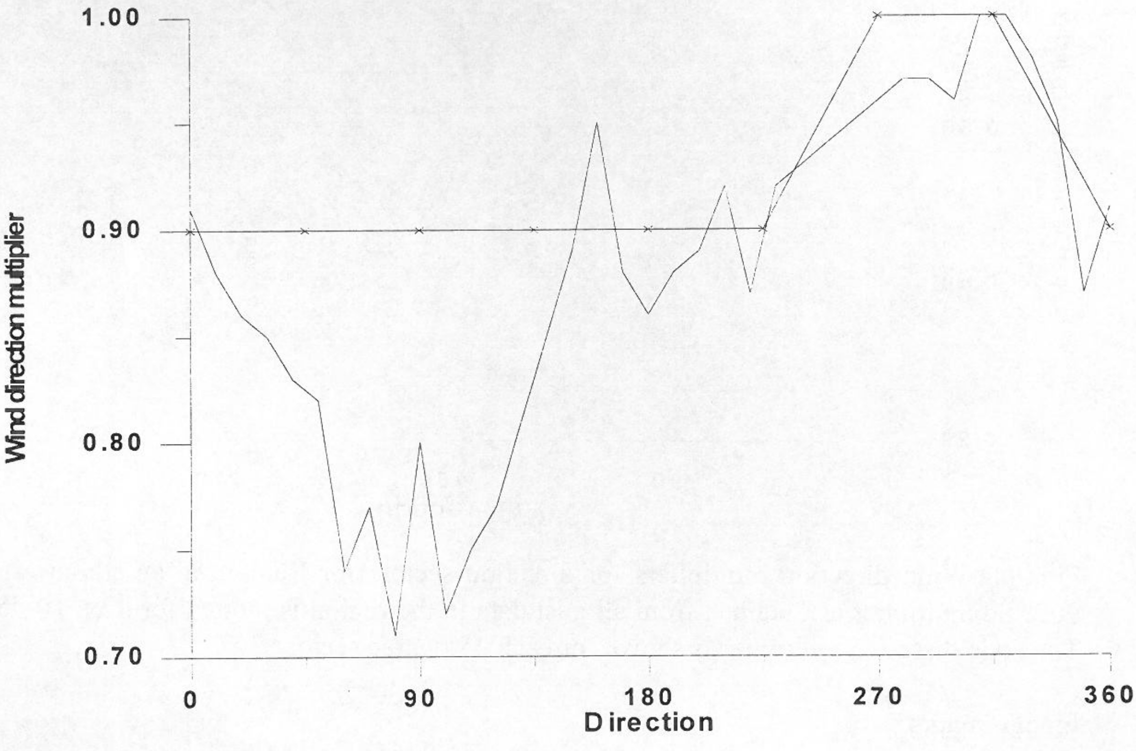

Fig. 3: Wind direction multipliers for direction sectors for Region A7 (all New Zealand except Wellington, Northland and Auckland). The 90%-ile multiplier as obtained from all gust data in the region is plotted for each 10 degree. The code direction multiplier is shown for each 45-degree sector.

The 10-degree direction data shows the winds have a clear difference between regions A6 and A7: high winds from directions about 90 degree which are clearly present in A6 are absent from A7. Region W also has important differences from both A6 and A7 because of winds from directions near 180 degrees.

The code direction multipliers follow the observed gust maxima fairly well, but could be lowered in some of the sectors. In some cases of wind measurements on hill sites, the shape of the hill determines the direction having the maximum speed. The topographical multiplier will be large in this sector. This is particularly important in Region W where many of the measurement sites are on hills and at these sites northwesterlies predominate. A peak in the southeast sector in regions A6 and A7 is to some extent influenced by high wind speeds in cyclone Bola in March 1988.

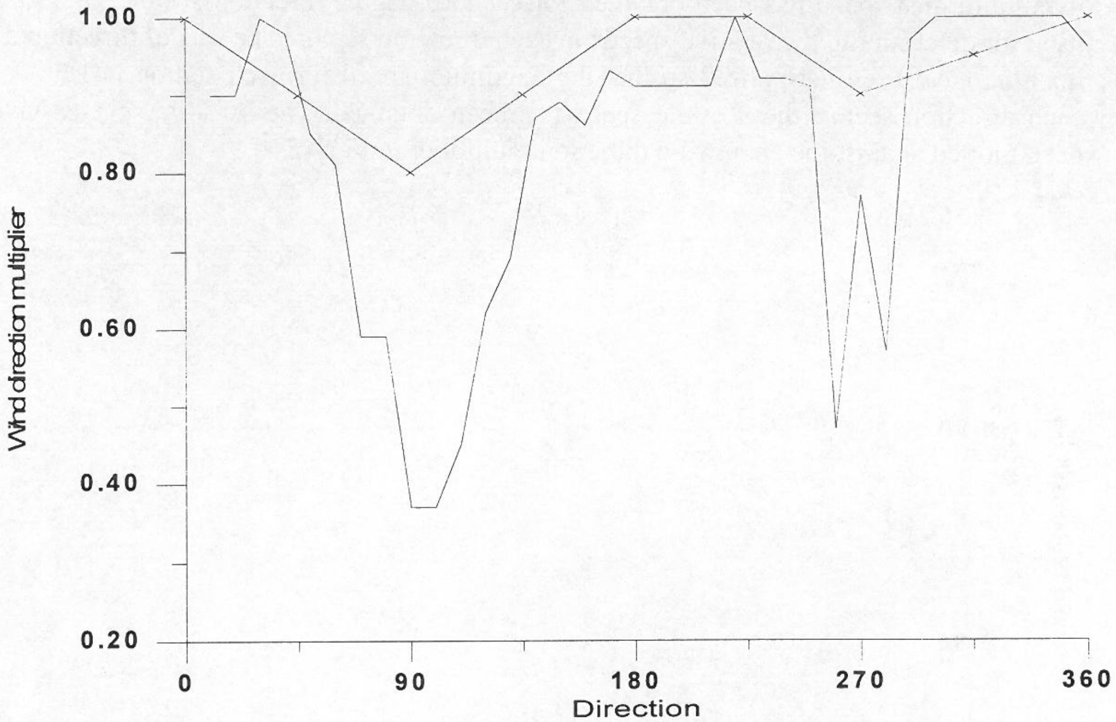

Fig. 4: Wind direction multipliers for direction sectors for Region W (Wellington). The 90%-ile multiplier as obtained from all gust data in the region is plotted for each 10 degree. The code direction multiplier is shown for each 45-degree sector.

Final remarks

In this paper, factors other than the hill-shape multiplier have been removed from all 20-year gust speed data based on substantial data sets for New Zealand stations. The results indicate that observed speeds increase less quickly with hill slope than is given by the code. This finding applies whether other topographical factors are present or not. It is generally recognised that hills within large complexes affect airflows in different ways than do small, isolated promontories. New Zealand is composed of large complexes of hills and mountains and there is a need for further development of code multipliers for this case.

An analysis of wind direction multipliers shows that high winds from the east are confined to the north of New Zealand and that northwest winds form the dominant high wind case in other parts of the country. Southerly winds are important in Wellington.