Seasonal variation of the prevailing wind direction in Britain

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If you ask most people what the prevailing wind direction is in Britain, they will say 'south-west'. This is almost a part of our culture and it comes as a slight shock to visit places like Greece, say, on holiday and find that the prevailing wind there is northerly. But is the mean wind direction in the UK the same in all places and at all times of the year? This question is of relevance to the long-distance walker or cyclist planning in which direction to tackle one of the many long-distance trails or the yachtsman planning a coastal cruise around our shores.

Figure 1. Surface instrumentation at the Cardington field site.

Variation with location

A glance at a compendium of wind data (Shellard, 1968, 1976) or a climatological atlas (Johnson, 1952) shows that the annual mean wind direction varies considerably over the British Isles. The major cause of these variations is topography. The high ground over Wales, northern England and Scotland has a pronounced overall effect on the mean isobars, which back (turn anticlockwise) over the western coasts and veer (turn clockwise) over the eastern half of the country. An even greater effect, however, is caused by relatively local topographic effects. Thus the mean annual wind direction at Exeter is northwesterly, while at Tynemouth it is westerly and at Manchester it is southerly. Nevertheless, the prevailing wind at the majority of sites in Britain lies somewhere between west and south.

Seasonal variation

Perhaps a more significant variation in mean wind direction is the seasonal variation. To investigate this in detail, data was used from the instrumented field site maintained by the Met Office at Cardington (Figure 1). The site is situated in the middle of a relatively flat region in the East Midlands of England and the plotted wind rose is fairly typical of those at many sites in the country. To further ensure its representivity, wind data were only used for readings taken between the hours of 1100 UTC and 1400 UTC. Previous measurements have shown that the boundary layer is most likely to be convective at all times of the year during this part of the day. The direction of stable flows is extremely sensitive to any local obstructions. Grant (1994) showed that for this particular site, stable flows tended to move in south-west or north-east directions, parallel to the low (100-m-high) ridge 5 km to the south-west of the site. In fact, the site has a good exposure in most directions except to the north where two large hangars lie within 400 m. Digitized data was readily available for two periods, one between 1969 and 1987 from a cup anemometer mounted on a 40 m mast while a second set covered the period 1997 to 2007 from a sonic anemometer mounted on a 10 m mast. Non-digitized data were also available for an intermediate period 1988–1996 from another cup anemometer mounted on a 10 m mast.

An annual mean wind rose using observations between 1100 UTC and 1400 UTC for the period 1997–2007 is shown in Figure 2; this is also typical of the earlier period. The main features are a large lobe in the south-westerly direction with a secondary, but significant, lobe to the north-east. A wind rose constructed using data from all hours shows a tendency for flows to concentrate more in the north-east and south-west directions in agreement with Grant's results.

Plots were made of the monthly mean wind directions for both the southwesterly quadrant and the northeasterly quadrant for the combined 1969–1987 and 1997–2007 periods; these are shown in Figure 3. It can be seen from this that while a southwesterly wind prevails for winter, summer and autumn, this is not necessarily true in spring. For the months of April and May in particular, the frequency of northeasterly winds increases while that of southwesterly winds decreases so that the frequency of northeasterlies is about equal to that of southwesterlies. In fact, during some decades, the prevailing wind at many sites during these months is northeasterly.

Data from other sites in Britain (Shellard, 1968, 1976) show a similar pattern, with the frequency of winds in the northeasterly sector increasing markedly in spring. A map of mean isobar patterns (Johnson, 1952) during spring indicates little mean flow. This is not because April and May are windless but rather because about a third of the winds are from the north-east, while another third are from the opposite direction.

There are often several consecutive days of northeasterly winds in these months because they are associated with blocking anticyclones to the north and west of the country. This persistence is an important feature as there is a high inter-annual variability

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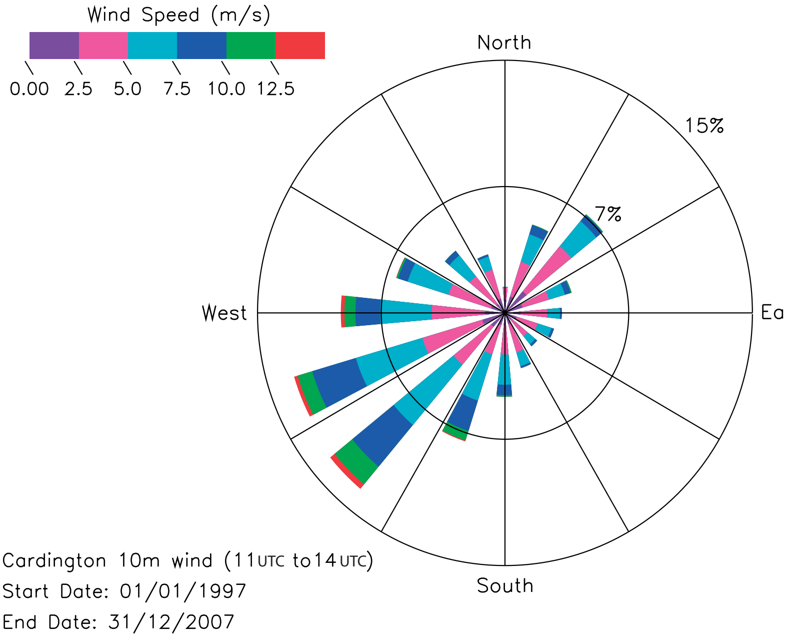

Figure 2. Mean wind rose for the Cardington site over the period 1997–2007.

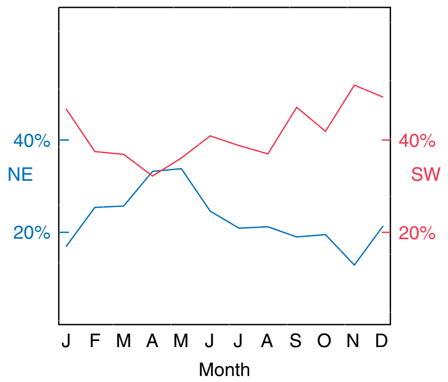

Figure 3. Monthly mean wind direction frequencies at Cardington for the northeasterly sector (blue line) and southwesterly sector (red line) over two periods between 1969 and 2007 (see text).

about the mean especially in May so that in some years there may be several weeks of continuous northeasterlies. This is unfortunate for cyclists going from Land's End to John O'Groats in spring of such years, who may have been under the impression that they are more likely to get a following wind. The features of the Northern Hemisphere atmospheric flow giving rise to this pattern of winds are described in the following section and this is followed by a discussion of inter-annual variations.

Blocking

The flow at the 500 mb level in the Northern Hemisphere shows a fairly stationary, horizontally waving pattern of low-pressure troughs and high-pressure ridges which are known as Rossby waves encircling the Pole. The number of waves varies with season as the wavelength is dependent on the Pole-Equator temperature gradient. This wavelength is shorter in summer and longer in winter. Features of the pattern tend to be fixed relative to Northern Hemisphere topography such as the Rocky Mountains. Much shorter wavelength baroclinic waves flow eastwards through this wave pattern along the high-velocity jet stream. These are associated with the mid-latitude cyclones and surface westerly winds.

At times, the amplitude of one of the Rossby waves increases to such an extent that the northern part of the wave becomes cut off and a pool of relatively warm air with an anticyclonic circulation is embedded in cooler air. The flow is said to be blocked and the jet stream flows round the cut off pool. There are generally two types of block (Sumner, 1959) – either the warm pool is cut off symmetrically with two low-pressure areas to the south to form an omega block, or the Rossby wave breaks to form a dipole with a high-pressure warm pool to the north of a single low-pressure area. In either case, a fairly stationary high-pressure area forms at the surface, with associated stationary low-pressure areas in the case of the omega block.

In the Northern Hemisphere only certain longitudes are prone to blocking. The one with the highest blocking frequency is over Europe and for most of the year the region of blocking is centred at a longitude of 25 ^{o}E (Pelley and Hoskins, 2003). There is a secondary maximum over the eastern Pacific. During the spring, however, when the Rossby wavelengths are shortening but the trough and ridge pattern is relatively fixed over North America, the area of blocking activity moves westwards to a longitude of around 10 ^{o}W (Ratcliffe 1968; Pelley and Hoskins, 2003). In June, the wave pattern breaks and reforms with a larger number of waves and the European blocking area re-establishes itself to the east. It is during the spring that this movement of the blocking area results in frequent surface high-pressure ridges to the north and west of Britain bringing winds from the north and east.

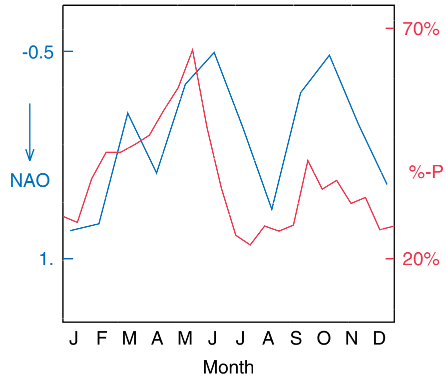

Figure 4. Monthly mean values of negative 'P' index for Britain (red line) over the period 1873–1964 together with monthly values of the negative NAO index (blue line) over the same period.

One of the earlier attempts to quantify the frequency of blocking was by Murray and Lewis (1966) who used a scoring system for surface-pressure charts classified into Lamb categories to form a P (progression) index. Negative values of P indicate blocking. Figure 4 shows the seasonal variation of the negative P index frequency (Murray and Benwell, 1970) and it can be seen that it shares several features of Figure 3, with high values associated with an increase of blocking in spring and then falling off sharply in June. There is a secondary, but lower, maximum in autumn. The high-pressure areas associated with the block tend to extend over Scotland, and this is related to the fact that Scottish weather is usually better (although cooler) in spring and autumn than in summer.

A measure of westerly flow that has become more fashionable in recent years is the North Atlantic oscillation (NAO) index which is the mean pressure difference between Iceland and the Azores. Monthly values of the index are available on the University of East Anglia Climate Research Unit website. The negative of this index is also shown in Figure 4 and has maxima in spring and autumn.

Inter-annual variations

As mentioned above there is considerable year-to-year variability in the frequency of the northeasterly April and May winds measured at Cardington. The variability is particularly high in May. A time series plot of the negative of this frequency for May winds over the period 1969–2007 is shown in Figure 5. In this figure, winds are taken to be northeasterly if they lie within the quadrant between north and east. Because the frequency of northeasterly winds is related to the incidence of blocking and to the phase of the North Atlantic oscillation, the time series of the NAO index for May has also been plotted in this figure. It can be seen that there is a fairly good correlation between these two time series and this is also true for corresponding plots for April.

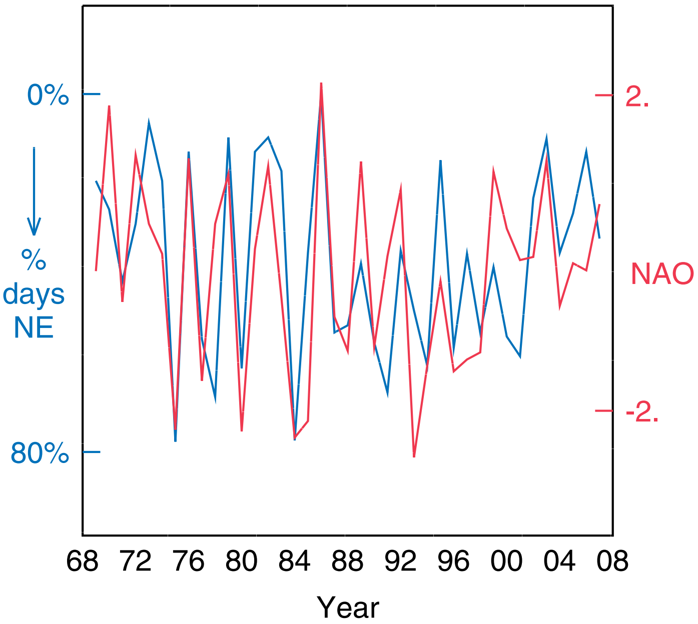

Figure 5. Negative percentage frequency of northeasterly winds at Cardington for the month of May plotted against year over the period 1969–2007 (blue line) together with May values of the NAO index (red line).

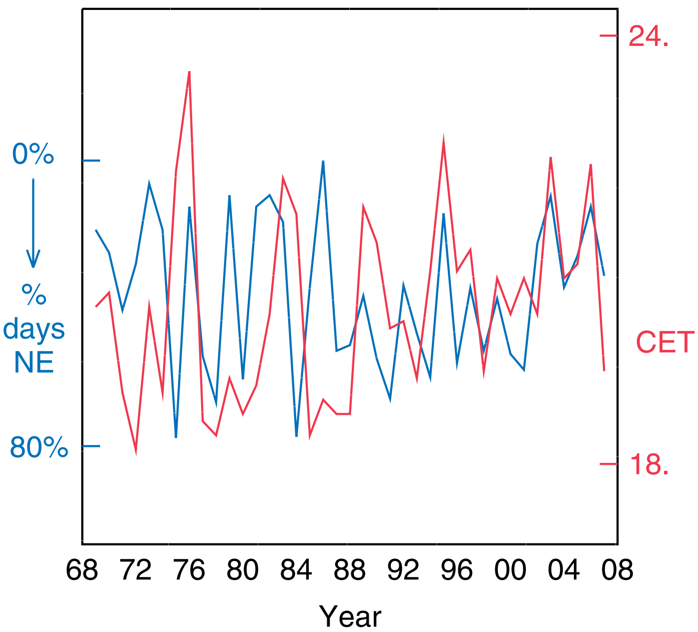

Figure 6 . Negative percentage frequency of northeasterly winds at Cardington for the month of May plotted against year over the period 1969–2007 (blue line) together with mean summer CETs (red line).

Summer temperature correlations

The variation from year to year of the NAO, and hence, presumably, the northeasterly wind frequency is probably influenced to some extent by sea-surface temperature (SST) anomalies. In fact, the winter values of the NAO have been shown to be correlated with preceding springtime Atlantic sea-surface temperatures and this is used as part of a long-range forecasting technique (Rodwell and Folland, 2002). In addition, Colman (1997) has shown that springtime Atlantic SST patterns correlate fairly well with British summer temperatures. Because of these two links, it seems possible that the frequency of northeasterly winds in spring may themselves correlate, if only weakly, with summer temperatures in the UK. To test this, Figure 6 shows a plot of negative northeasterly wind frequencies in May together with a plot of mean daily maximum Central England Temperatures (CET) in summer (i.e. June, July and August). Monthly values of the CET are available on the Hadley Centre website. It can be seen that there is some correlation between the two plots, and the correlation has been fairly good in the last 15 years. In particular, 1995, 2003 and 2006 had relatively few northeasterly winds in May and in each year spring was followed by a hot summer. Improved correlations between the two plots can be obtained for shorter periods of the time series by adjusting the parameters of directions and dates, and a correlation coefficient of 0.97 has been obtained for the most recent decade by such tuning. Overall, the long-term reliability of using such a method for making a long-range forecast for summer seems likely to be poor. It has, however, the considerable advantage for the amateur of relying on only a point measurement!* Murray and Ratcliffe (1968) seem to have noticed a similar type of correlation with summer temperatures, although in their case they used blocking as defined by P indices in conjunction with northerly winds rather than wind-direction frequencies.

Conclusions

The main conclusion to be drawn is that in Britain, northeasterly winds are at least as common in spring as southwesterly winds, and in some years are considerably more so. Furthermore those years with a low frequency of northeasterly winds in May are slightly more likely to precede a warmer summer than usual. To return to matters raised in the introduction, this has implications for a long-distance walker making the journey on footpaths from Land's End to John O'Groats. Owing to the length of this trip, which can take four months, and the limited period of summer weather, especially in the far north, the walker must start in May. However, the trip along the exposed cliff tops of the north coastal path of Cornwall has then to be made against the prevailing wind. If it turns out that most of this part of the trip is against the wind, then the walker has the further misfortune to realize that the rest of the trip is likely to be in poor weather!

* As this article was going to press, the May 2008 figures for Cardington winds became available. They show that 52% of May winds were from the north-east sector. Figure 6 indicates that it would be unlikely for this to be followed by an exceptionally hot summer (as was shown to be true).

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Altocumulus stratiformis perlucidus as seen from Puymoyen, Charente, France, at 0930 local time on 9 August 2006. (© Charlie Davison.)