The MOORI. A new winter index for winter road maintenance

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ABSTRACT

Winter indices, which produce an indication of the severity of a winter, have many uses. They can be used to compare salt usage from year to year, to determine, say, the influence of ice prediction systems. They can also be used to compare areas regionally, to ascertain regional salt demand.

The main winter index that has been used up to now is the Hulme winter index. This has been shown to have a relationship (almost linear) with salt usage. However, in recent winters, which have been much wetter than average, salt usage has been under estimated by the Hulme winter index, as it takes no account of salt wash off.

Using a technique known as *weather sensitivity analysis* the Met. Office statistically related various meteorological parameters to salt usage. The salt usage was in the form of number of nights turn out, rather than tonnes of salt used. Data was supplied by three local authorities (Birmingham City, St. Helens Metropolitan Borough Council and Cheshire County Council). In order to reflect the use of ice prediction technology (which is now widespread) only data after the winter of 1990-91 was used.

The resultant index became known as the MOORI (Met. Office OpenRoad Index). It has a correlation of between 88% and 93% with reported salting runs. 100% correlation is not possible as not every salting run is justified by the weather. This can be due either to inaccurate weather forecasts or incorrect decisions.

The MOORI can be presented in two ways. Long term averages (typically 20 years or longer) can be shown by summing the index across the time series. It is important to note that these are long term averages not of the salting runs that actually took place, but rather the runs that *would* have taken place given that today's ice prediction technology was in use. Monthly differences from these long term averages can also be plotted, showing at a glance which months had more salting runs than others.

The MOORI has demonstrated that it can accurately reflect salt usage in wet winters. Both the winters of 1993-94 and 1994-95 were considerably wetter than average. Despite being 'mild' in the conventional climatological sense, they both had above average salt use, and this was reflected by the MOORI.

1. Introduction

The term 'severe winter' can mean different things to different people as the weather can have different effects on different activities. Therefore, a severe winter to a daffodil producer in the Scilly Isles may not be a severe winter to a building contractor in Aberdeen. Thus, the notion of a winter index has developed, which puts statistical weights on to certain climatological values, depending on the activity that it is related to.

A generalised winter index was defined by Hulme (1982). This used readily available climatological data (such as days of ground frost over grass, and days with snow lying) to produce a winter index that could be related to many applications. In the field of winter road maintenance, the Hulme Winter Index was related to tonnes of salt used by Cheshire County Council (Thornes 1989). This was initially undertaken to show the cost effectiveness of ice prediction systems, and indicated a 20% reduction in salt usage following the introduction of an ice prediction system. The relationship looked to be almost linear.

The winters of 1993-94 and 1994-95 were much wetter than average in the UK, with the winter of 1994-95 being the third wettest of the century. In terms of air temperatures alone, they were also very mild. The winter of 1994-95 had the tenth mildest central England Temperature since 1659. However, despite these extreme values, it became clear that salt usage was slightly above the long term average. In other words, despite the mildness of the winters concerned, more salt than normal was being used.

The main reason for this increased salt usage was due to salt wash off. In a normal winter, road frosts have a tendency to occur in groups, covering several nights. If the weather is dry, then one application of salt may be

sufficient for more than one night. However, if the weather is wet, salt will be repeatedly removed from roads, and therefore have to be re-applied for every road frost that occurs.

The previous near linear relationship between the Hulme winter index and salt usage broke down in the winters of 1993-94 and 1994-95. Therefore, following requests from highway authorities, the Met. Office undertook to produce a new winter index specifically related to winter road maintenance.

2. Sources of data

The data on salt usage came from three authorities, Birmingham City Council, St. Helens Metropolitan Borough Council and Cheshire County Council. Thus, most types of terrain were covered (urban coastal, urban inland and rural coastal/inland/high ground). The data was supplied as a series of discrete dates on which salting action took place. However, if multiple salting actions took place on the same date, this would still only be counted as one day.

Weather data had two potential sources. Firstly, the national climatological database, managed and archived by the Met. Office (but also containing information from auxiliary observers) and secondly the network of road sensors accessed by the highway authorities.

Initially, the road sensor network looked quite promising as a data source for weather. There are now over 600 road sensors, covering nearly all parts of the UK. Their relevance to winter maintenance operations is obviously very high, as they form a key part of the decision making process. However, there were numerous problems with this data source.

- The data time span was short. The earliest sensors were installed around 1984, and most sensor date from around 1988 or later.
- There is a problem with archiving. No national archive exists. Local authority archives are incomplete and the Met. Office only archives data from sites for which it provides forecasts (around 260 at present).
- The data is not quality controlled and does have gaps in the record.
- The number of meteorological parameters measured was restricted

On balance, therefore, it was decided to use data from the Climatological Network. This had the advantage of quality controlled data, with longer time series (typically around 20 years).

2. Weather Sensitivity Analysis

In order to link climatological parameters to other non-meteorological variables, such as days of salting action, it is necessary to use a technique known as *weather sensitivity analysis*. Methodology used has been described by Taylor (1972) and Lehman et al (1994). The technique, which has been used extensively in the retail trade uses multiple regression techniques to establish the significance of single elements or a combination of elements. This ensures that even if one element does not show a high positive or negative correlation, it could be included if in combination with another it does produce a high correlation.

The following climatological elements were tested:

- Days of rain (>0.2mm)
- Days of rain (>1.0mm)
- Days of sleet or snow falling
- Days of snow lying at 0900
- Day maximum air temperature
- Night minimum air temperature
- Daily mean temperature
- Monthly mean temperature
- Concrete slab minimum temperature
- Days of concrete frost
- Grass minimum temperature
- Days of ground frost (over grass)
- Hours of sunshine

The final format of the index, which became known as the MOORI (Met. Office OpenRoad Index) showed between an 88% and 93% correlation between its values and the data on days of salting action as supplied by the three local authorities. This was the best fit that could be obtained. It was not possible to achieve 100% correlation because not every salting run is justified by the weather. This can be due either to inaccurate weather forecasts or to decisions to salt taken on other criteria apart from the weather.

3. Presenting the results

For each climatological station that measures sufficient parameters (around 100 in the UK) it is possible to produce monthly values for each month in the time series (although meaningful values are only produced in the months of October to April). Having produced this data, it can be presented in two ways, either as a long term mean or graphically (for each month from October to April) as a departure from the mean.

To obtain the long term mean, all the values for a particular month are summed across the entire time series and divided by the number of years in the time series. The data is then presented, usually as a histogram, showing long term monthly means of days of salting action. An example is shown at figure 1.

It is important to note that these are *not* averages of the actual salting runs that took place. They are, in fact, an estimate of the number of salting runs that *would* have taken place, given that today's ice prediction technology was in use. Thus, an important feature of the MOORI, is that it eliminates the effect of declining salt usage due to improved technology. This means that benchmark severe winters, such as 1962-63 and 1978-79 can be included in any analysis, even though ice prediction was not in use at the time.

To obtain the departures from the mean, the long term monthly mean is subtracted from each MOORI value for the corresponding months in the time series. This can be plotted to graphically to show at a glance whether an individual month had more or less salting runs than average. An example of this is given at figure 2.

4. Future developments

With instruments such as Geographical Information Systems (GIS) now becoming available, it is hoped to obtain multiple regressions of the MOORI with other variables such as height above sea level, distance from the sea, average land use and average topography (to account for frost hollows). This would eventually enable estimates of the number of gritting runs to be produced for any road anywhere within the UK. Work is under way at present to produce this.

Acknowledgements

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25 Year MOORI Averages for Birmingham

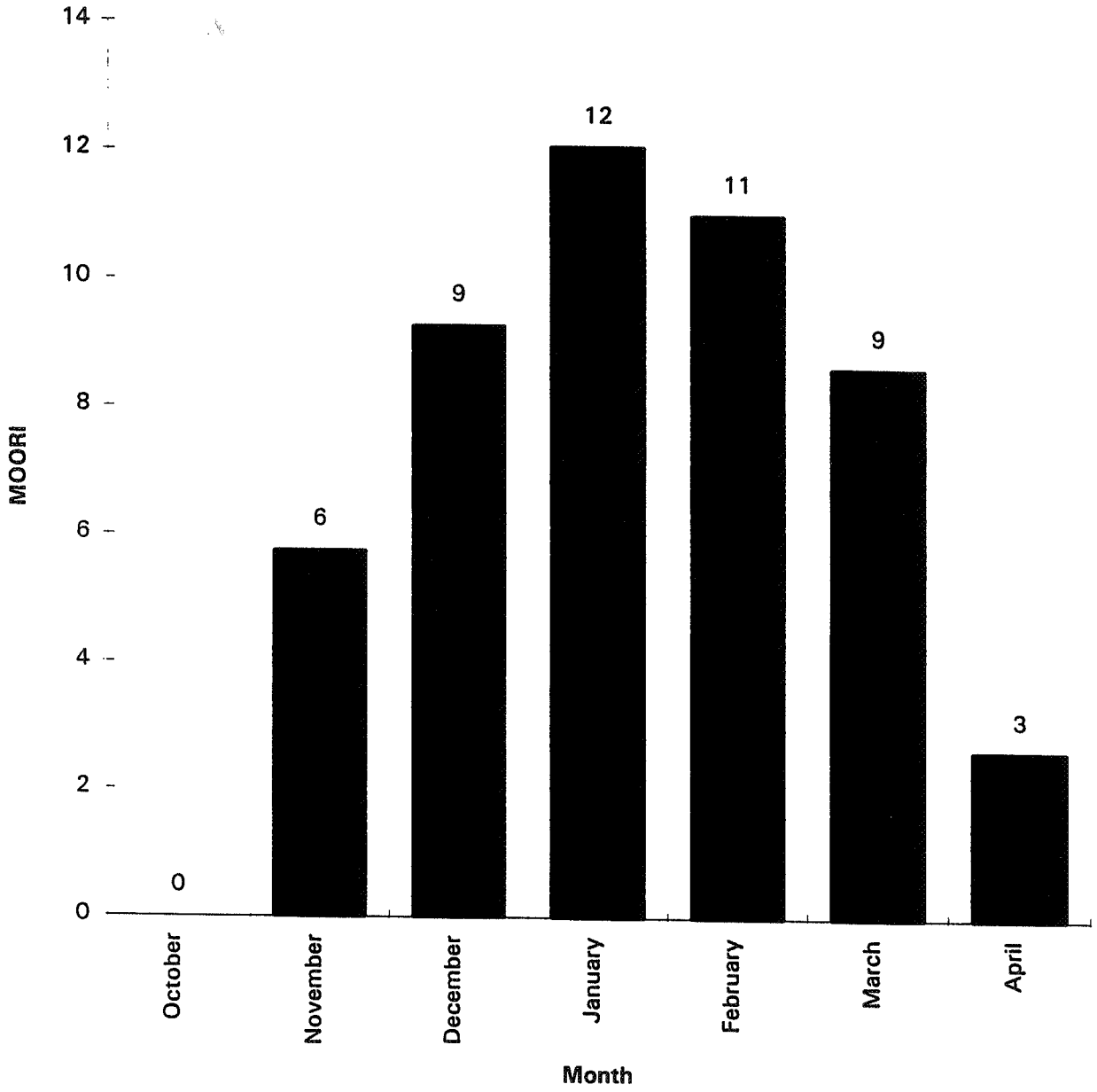

Figure 1

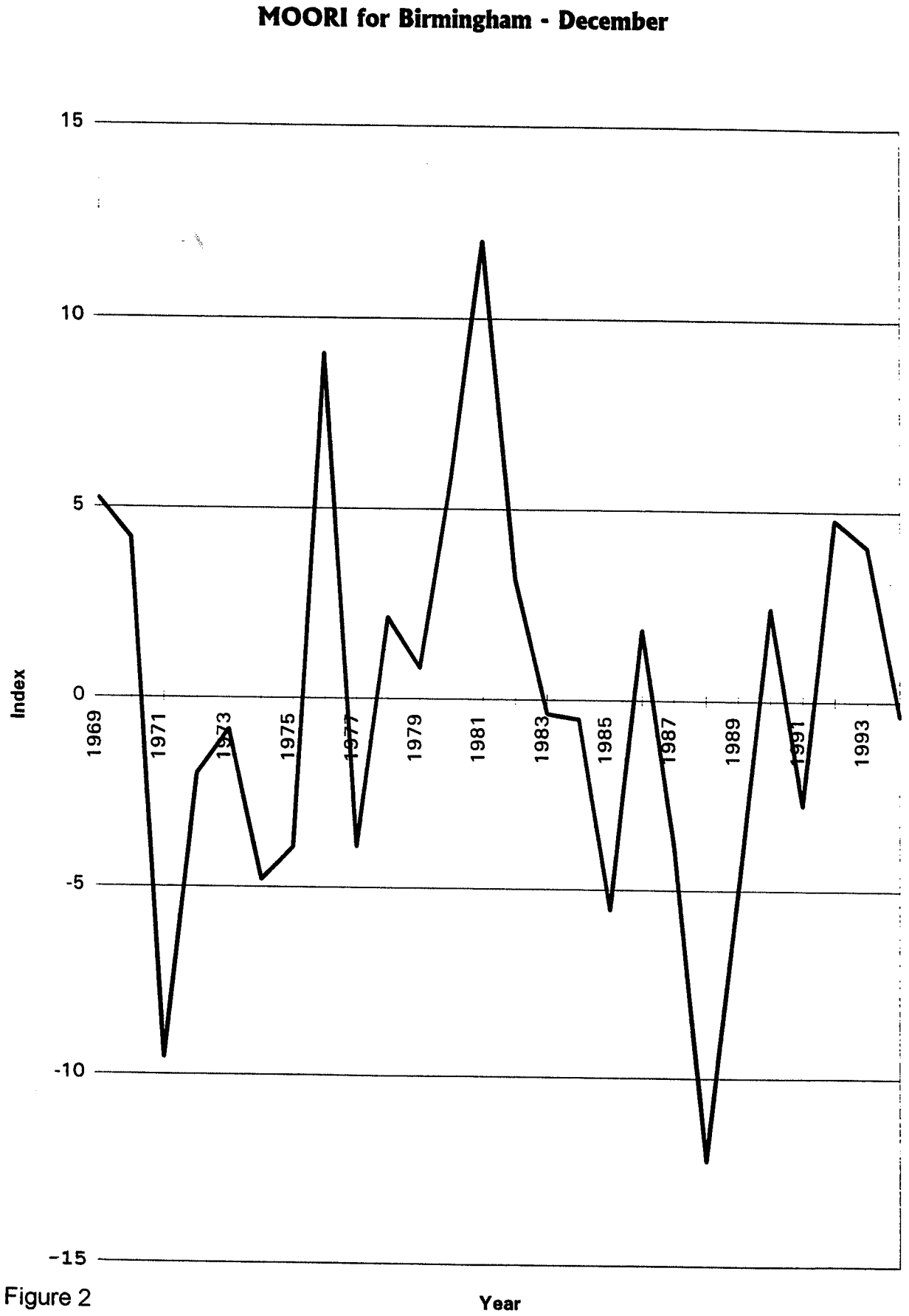

Figure 2

Reference Site: Elmdon

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