WINTER INDEX BY USING RWIS AND MESAN

an Operational Mesoscale Analysis System

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1. Abstract

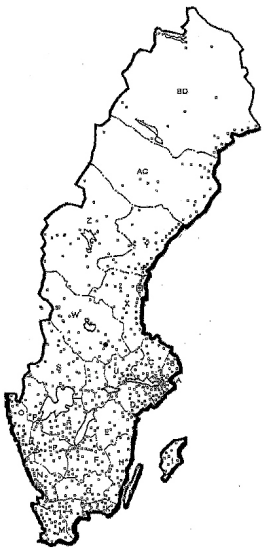
In today's road administrations it is very important to keep track of costs and the amount of chemicals and abrasives used in winter road maintenance. Variations in snow and ice conditions from year to year make it difficult to compare figures. In order to tackle this problem, the Swedish National Road Administration (SNRA) has developed a new Winter Index.

The Winter Index is based on data from our 680 Road Weather Information System (RWIS) stations as well as data provided by the Swedish Meteorological and Hydrological Institute (SMHI). Basically, we use the former for information on the air and road surface temperatures, humidity, wind and type of precipitation and SMHI data for the amount of precipitation. The RWIS data is collected every half-hour and the SMHI data every third hour. To calculate the amount of precipitation, SMHI uses a model called Mesan, which is an operational Mesoscale Analysis System. This model sub-divides Sweden into a 22 by 22 kilometre grid net, and calculations are performed for each grid individually.

The system provides data on slippery roads, snowfall and snowdrifts expressed in number of occasions; e.g., two icy road surface occasions will be registered if it is known that a skid control measure will be effective for 5 hours, and the RWIS data shows that there still is a risk of slippery roads after 6 hours. The same principle applies to snowfalls and snowdrifts. The system can detect four kinds of slippery surfaces ranging from light frost to freezing rain, and three kinds of snowfall and snowdrift, from light to heavy.

The amount of material used and the cost involved is entered in the final step of the calculation. This provides a good basis for comparing salt consumption from year to year. When calculating the Salt Index in this model, the length of road treated with salt, type of road (standard class) and our "Guidelines for Salt" are used. A Salt Index of 1.0 indicates that the contractor (or county, regional, or national road manager) has used the optimum salt dosage.

The system is also a good tool for benchmarking costs.



2. Background

When following up winter road maintenance, an important parameter for being able to compare costs and material consumption is knowing what the winter was like compared to other winters. Formerly, salt consumption was recorded in terms of tonnes per kilometre, and costs in terms of SEK per kilometre. Needless to say, figures varied from winter to winter, but it was difficult to determine exactly why. Previously, we used SMHI weather statistics in Sweden, but these statistics are based on atmospheric measurements, and as such are not directly connected to road climatology. Typical parameters obtained through this type of follow-up are days of snowfall and days of predicted hoar frost formation.

The SNRA owns 681 RWIS stations located throughout the country. An original idea was to use the data that has been stored in these stations

over the years. There would have been two advantages to this: firstly, since RWIS data is used by contractors as a trigger factor for initiating action, road maintenance measures and follow-up parameters coincide well. Further, no additional cost is involved since this data is the property of the SNRA.

However, what we want at the SNRA are parameters that reflect the predicted number of times when snow ploughing or skid control action is needed. We have therefore chosen follow-up parameters to show this. The new Winter Index can be used both for cost and salt consumption follow-up, and as a payment basis for contracted winter road maintenance. The procedure for paying contractors is described in paper no. 22 under topic #1, which also gives a more detailed description of how the Winter Index is calculated.

3. Bases and theories behind the Winter Index

As mentioned earlier, we want an index that reflects reality, i.e., one that is related to the measures actually carried out. Hence, every weather situation that would entail winter maintenance action has been divided into time periods. The weather situations studied are snowdrifts, snowfall and the risk of slippery road surfaces (hoar frost formation). This is done in hierarchical order. In other words, the system first searches for snowdrifts. In the absence of such, it searches for occasions of snowfall. If neither of these situations is found, the system then searches for occasions of slippery road surface conditions.

Snowdrifts are divided into four categories (d = snow depth in cm)
$0.0 \leq d \leq 0.3$
$0.3 < d \leq 1.0$
$1.0 < d \leq 2.5$
$2.5 < d$.

Further, the duration of a measure is calculated as 4 hours; i.e., if a snowdrift lasts between 0.5 and 4 hours, it is counted as one occasion, and as two if it lasts between 4 and 8 hours, as three if it lasts between 8 and 12, etc.

Snowfall is divided into three categories (d = snow depth in cm)
$0.3 < d \leq 1.0$
$1.0 < d \leq 2.5$
$2.5 < d$.

Four hours is the presumed duration of a measure here as well, and the calculation procedure for the number of occasions is the same as for snowdrifts.

There are four different categories of slippery surface.
Slippery surface due to rain or sleet on a cold road (HN).
Slippery surface due to damp/wet roads freezing over (HT).
Slippery surface due to light frost (HR1).
Slippery surface due to heavy frost (HR2).

A measure is presumed to last between 3 and 6 hours, depending on the category of slipperiness and the time of year.

4. Calculating occasions of snowfall conditions

Snowfall is divided into 4-hour periods. The reason behind this is that our winter road maintenance specifications stipulate different action completion times for different types of road (standard classes), and 4 hours was considered to be a suitable average. The division into different snow depth categories also complies with the specifications.

To exemplify this, class $0.3 < d \leq 1.0$ signifies a snowfall where it is expected that it will only be necessary to use salt to melt the snow, whereas class $2.5 < d$ signifies snowploughing on the low volume traffic network.

5. Calculating occasions of slippery road conditions

Occasions of slippery surface conditions are those where RWIS data would theoretically mean hoar frost formation. This means that the figures are directly related to road climatology and not atmospheric measurements, which is the usual way of measuring.

6. Weather presentation

Weather situations can be presented in tables or as graphs at a resolution that shows either the entire country, each winter maintenance region or each production and maintenance district. The following graphs are examples of weather situations in Sweden during the winters between 1996/97 and 2000/2001.

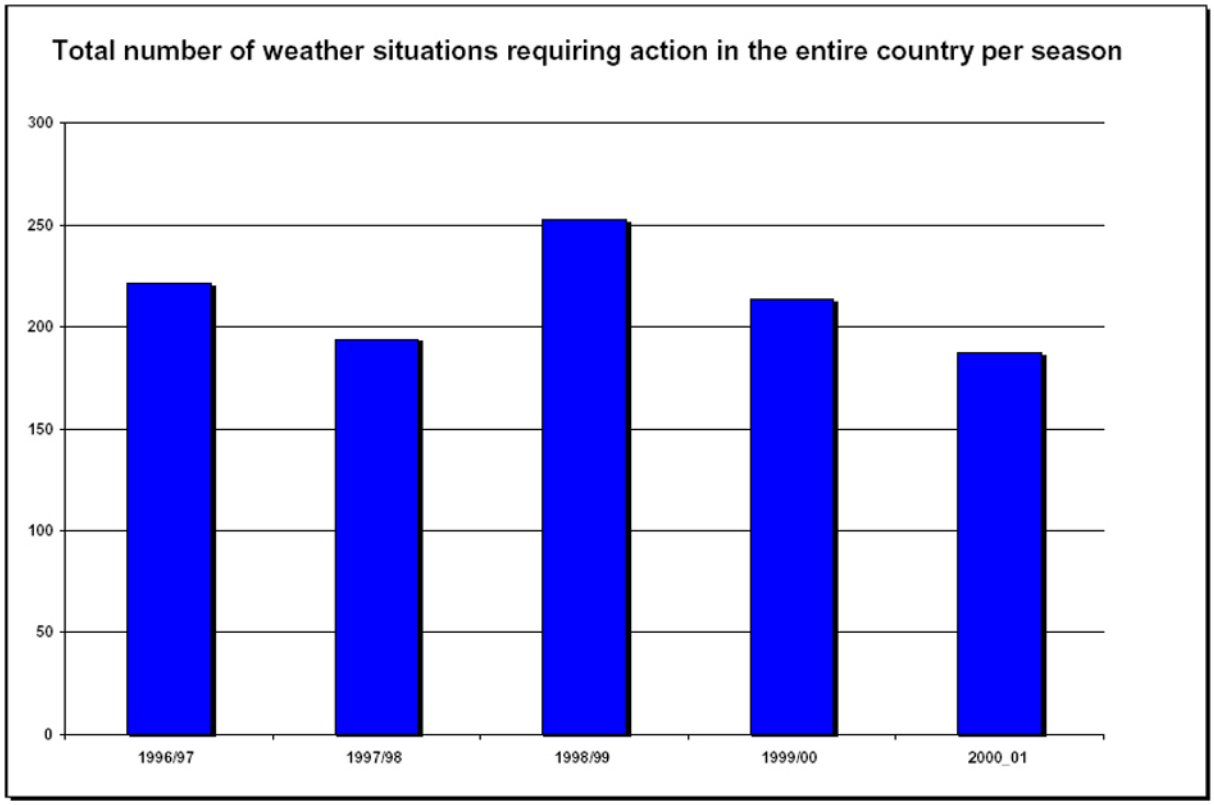


Diagram 1, Total number of weather situations requiring action in the entire country per season

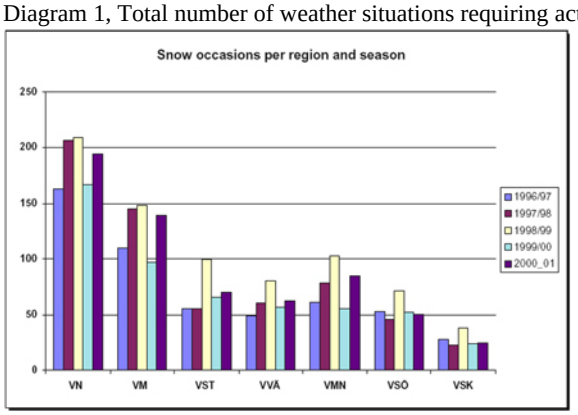


Diagram 2, Snow occasions per region and season

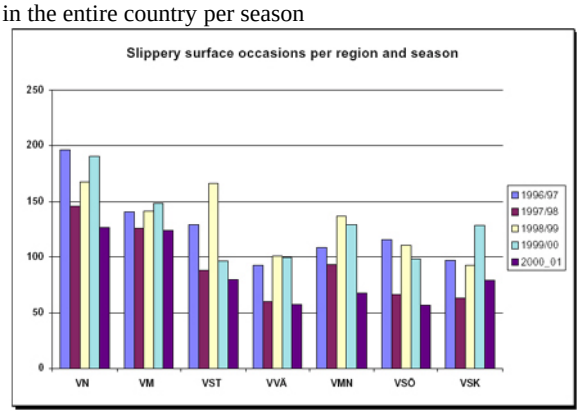


Diagram 3, Slippery surface occasions per region and season

7. Presentation of the salt index

The salt index is calculated on the basis of the weather data above, taking into consideration the length of the road network treated with salt and the recommended salt dosage for different weather conditions. The salt dosage values used in the calculation model are based on the SNRA's Guidelines for De-Icing, which is an official document that describes different salting methods and dosages based on different conditions. For instance, a salt solution shall be used in connection with light frost (HR1). During other weather situations, pre-wetted salt is permitted. The table below shows the recommended salt dosage in grams per metre 2-lane road for different weather situations.

Type of slipperiness				**Snowfall** amount of snow (cm)		
HR1	**HR2**	**HT**	**HN**	**SNOW1** 0.31-1.00	**SNOW2** 1.01-2.50	**SNOW3** 2.51-
24	36	48	60	36	90	120

Table 1. Recommended salt dosage in grams per metre 2-lane road during different weather situations.

Based on this, the salt index is calculated as follows:

⇒ salt consumption during the period for the area in question.

⇒ km of road treated with salt. For motorways and 4-lane roads, both directions are counted.

⇒ number of HR1, HR2, HT, HN, snowfall and snowdrift occasions as per the following table for the area in question.

$$\text{Salt index} = \left(\frac{\left(\frac{\sum \text{Salt consumption, kg}}{\sum \text{Length of road salted, km}} \right)}{(HR1 * 24) + (HR2 * 36) + (HT * 48) + (HN * 60) + (SNOW1 * 36) + (SNOW2 * 90) + (SNOW3 * 120)} \right)$$

The salt index can be presented in tables or as graphs at a resolution that shows either the entire country, each winter maintenance region or each production and maintenance district. The following graphs are examples of weather situations in Sweden during the winters between 1996/97 and 2000/2001.

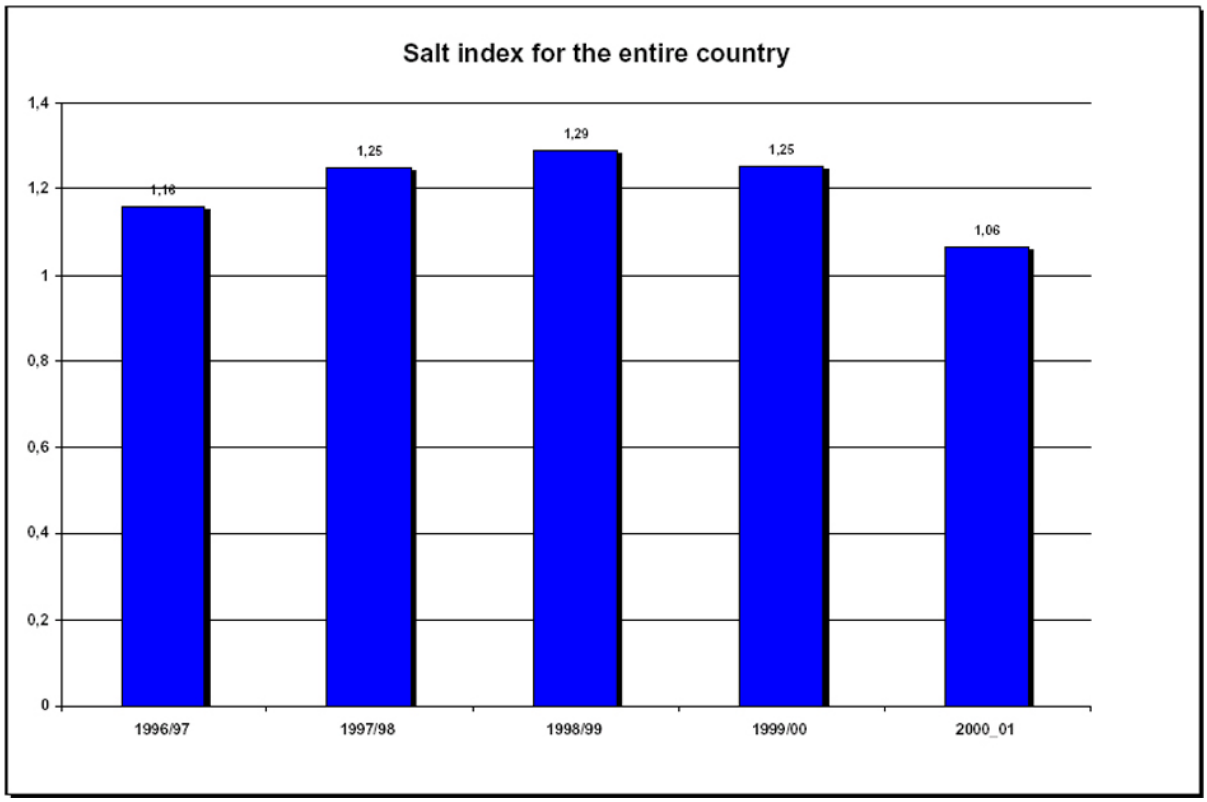


Diagram 4. Salt index for the entire country

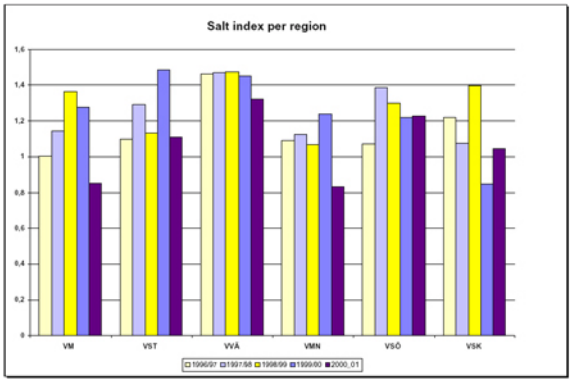


Diagram 5. Salt index per region

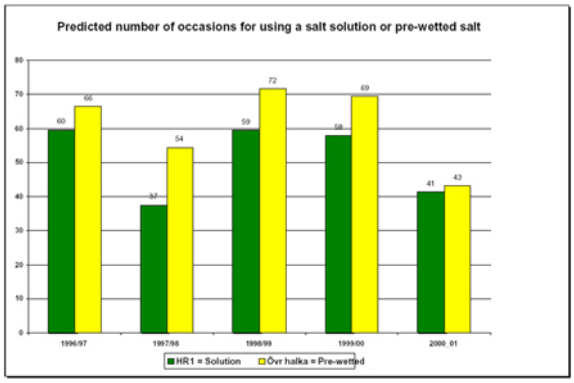


Diagram 6. Predicted number of occasions for using a salt solution or pre-wetted salt

Diagram 6 is intended to show that it probably is also possible to follow up how the contractor has complied with the recommendations concerning the use of different methods for different conditions. Since more and more skid control vehicles are being equipped with GPS, which also records salt dosage and method, this follow-up can probably be done automatically in the future.

8. The future

In preparation for the coming winter, 2001 – 2002, further testing will be done to determine if we have used the right parameters in our evaluation. There is a some uncertainty concerning the figures in the SNRA's Guidelines for De-Icing.

Moreover, we will be developing a similar system to follow up costs for winter road maintenance. At present, 100% of winter road maintenance is contracted in open competition, and the SNRA does not have any ploughs or skid control equipment of its own. This would appear to make it even more important today to follow economic trends.

Considering today's demands on environmentally sound and rational road management, it is essential to have follow-up tools that indicate whether or not we are making improvement. This is important for ecologically sound development (it is not only in Sweden that the use of salt on roads has come into question) as well as to show our principal – the Ministry of Industry Employment and Communication – as well as road users that we are taking these matters seriously.