

Evaluation of winter weather conditions from the winter road maintenance point of view – principles and experiences

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ABSTRACT

The presentation describes and discusses up to now experiences in Dept. of Climatology of Czech Hydrometeorological Institute with evaluation of winter weather conditions from view of winter road maintenance. Experiences with evaluations of these conditions with regard to winter maintenance outputs in the Czech Republic are described, too. Discussion will include different points of view on possibilities and methods of evaluation. Attention is paid to problems with retrieval of basis of road network and winter maintenance outputs.

Keywords: winter road maintenance performance analysis, winter weather conditions.

1. INTRODUCTION

The beginnings of the issuing of the so called winter index date back to year 2002, when Directory of Roads and Highways called for winter conditions evaluation on Czech roads and highways. According to examples of foreign winter road maintenance indexes and watched maintenance parameters, general winter index was created by V.Kveton and M.Zak. Further, based on meteorological, climatological, statistical and maintenance data the concrete winter index was constructed based on data of winter road maintenance (for period 1997-2003) from Mr. Ing. Havránek in spring 2004 by V.Kveton.

During winter season 2004-2005, routine application was issued for Zlin county, and 12-parts-scale of winter road maintenance severity was used (see Tab. 1 for details). In this season only one general index was issued, since season 2005-2006 also partly indexes of ploughing and scattering have been computed and evaluated as well.

This routine application has been used since that up to now, with increasing numbers of regions and roads/highways in next seasons and with partly improvements.

2. BASIC PRINCIPLES OF WINTER ROAD MAINTENANCE INDEX AND ITS INTERPRETATION

Winter road maintenance index is based on the following meteorological parameters: snow, icy road conditions (black ice, glaze, frost deposit) and snow drifts. Since the construction of the winter index is not the focus of this paper, we will not discuss concrete composition here any more. But we will focus on the performance interpretation of this winter index.

First of all, it has to be mentioned that index enables very exact evaluation of seasonal winter maintenance severity. It also enables mutual comparison, including planning of winter road maintenance under various climate conditions. Running supervision of maintenance output data is possible with this index, of course the shorter evaluated time, the worse preciseness. This index doesn't replace road meteorology center forecasts, because these forecasts are keys for effective maintenance – the more maintenance centers act up to forecasts the better agreement with seasonal winter index. It has to be stressed, that often there is tendency to precisely evaluate on daily bases and/or short parts of roads, but this approach leads to loss of statistical benefit of working with large numbers (even small mistakes of interpolation can lead to large impreciseness).

It should be noted, that problem of evaluation of these forecasts is a specific question which is not solved in this paper and that it differs from evaluation of maintenance severity.

One possible way for evaluation and improving of winter road maintenance index is using of road winter meteorological data. But these data don't enables historical comparison, working with precipitation data and there is problem with data control, besides road data are strongly influenced by state of roadway (type

maintenance, type of roadway, basement etc.). But these data are very important for road forecasts and their evaluation.

The winter index has been used in two possible ways, either as number values, when increasing number means also increasing winter road maintenance requirement, or as the 12-parts-scale, when winter road maintenance severity was used (with 0 meaning no or minimal requirement for winter maintenance and 11 total calamity on the roads, see Tab. 1). The first way enables spatial and temporal statistical analysis and comparisons but it is not easily understandable for the governments and road maintenance staff and need to be interpreted based on performance interpretation (it means, based on results of statistical analysis of winter index related to winter maintenance data (performance, cost of maintenance etc)). The second way enables to pronounce extraordinariness of the winter season or of it parts (days, weeks, months). It is user friendly because it's easily understandable.

Degree	Frequence (probability) of occurence	Road maintenance severity
0	WI=0	No or minimal requirements
1	WI>0 and p>=0.8	Very small requirements
2	0.8>p>=0.7	Small requirements
3	0.7>p>=0.6	Medium requirements
4	0.6>p>=0.5	Normal, a bit decreased requirements
5	0.6>p>=0.5	Normal, a bit increased requirements
6	0.5>p>=0.3	Increased severity
7	0.3>p>=0.2	Strongly increased severity
8	0.2>p>=0.1	High severity
9	0.1>p>=0.05	Very high severity
10	0.05>p>=0.01	Calamity
11	p<=0.01	Total calamity

Table 1. Kveton's scale of winter road maintenance index (WI).

3. PERFORMANCE INTERPRETATION OF WINTER INDEX

Using of winter index in road maintenance praxis needs corresponding interpretation based on results of statistical analysis of winter index related to winter maintenance data (performance, cost of maintenance etc). Example of this shows Fig. 1. Straight lines and relevant regression equations represent two examples of linear regression dependence of some type of maintenance performance on winter index. The values lying on straight lines are named as expected values and represent requested performance interpretation of winter index for given maintenance parameter. Expected value is average value of maintenance (e.g. some performance parameter) based on regression statistical analysis. Real (observed) values are depicted as point (circles, triangles). The tighter dependence (R^2 higher) the more exact is the performance interpretation of winter index or (if you like) the better validation of performance data can be done by using this winter index. On this place, it should be said there was a good agreement between expected and real values when testing this winter index, so one can assume good quality (and ability of winter index) for evaluation of winter severity performance, or of the selected performance parameter. For example, for highways coefficient of determination for most evaluated parameters oscillates between 95 and 99 % for the whole season (scattering, ploughing, amount of used scatter materials). Values on straight lines are very useful for long-term maintenance planning, deviation of real performance value from expected value should be analysed from a view point road maintenance quality and effectiveness. Performance analysis of winter index is related to unit of maintained road area. It enables to compare maintenance between different centres and in different years (changes in road network/area size). This interpretation depends on the way of using of index like running issuing of index, back-evaluation for month, season, more years, long-term planning etc.

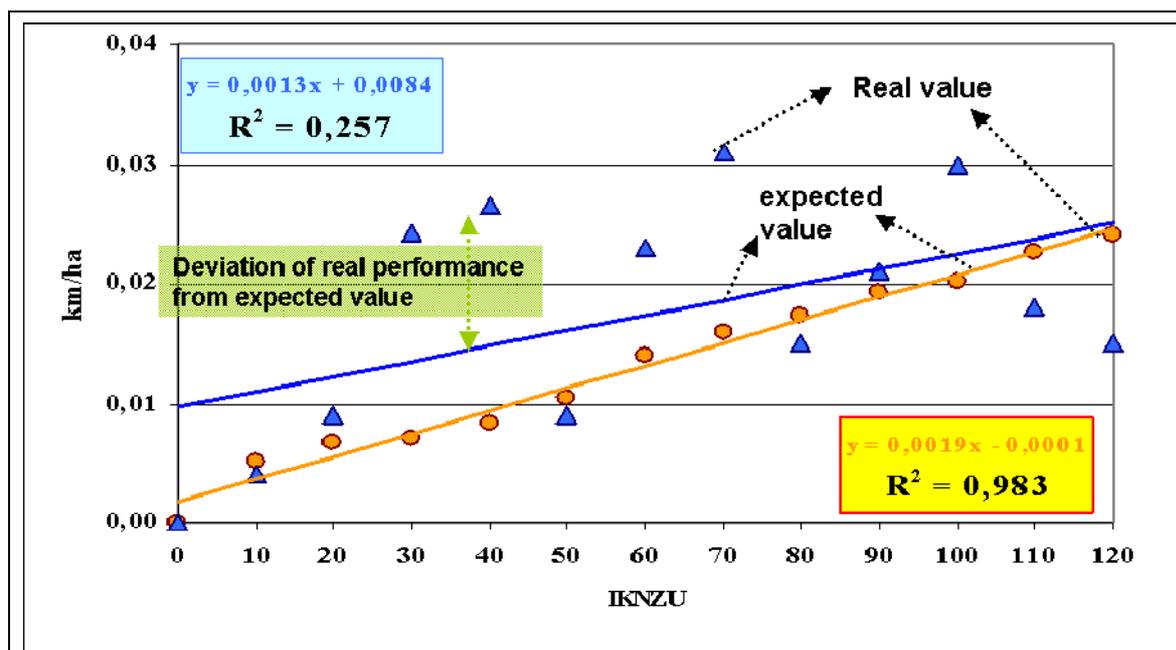


Fig. 1: The performance interpretation. X-axis: cumulative winter index, y-axis: parameter of road maintenance performance (e.g. road ploughing in km/ha). Regression straight lines represent the winter severity maintenance for given maintenance parameter. Circles and triangles represents real (observed) values of performance. Red colour depicts very good (close) dependence of maintenance relate to winter index (high determination coefficient R^2 , blue colour represents very bad dependence (low determination).

3.1 Running issuing of index

It is designated for preliminary evaluation of winter maintenance severity from the distinguished maintenance centres point of view. It enables basic current analysis of reasons of outlier values of maintenance parameters, e.g. too small/large maintenance, mistakes in maintenance data evidence etc. When evaluating it has to be taken into account greater disperse of maintenance values to expected average for given meteorological conditions, smaller stability of meteorological values (more rough data, less count of used station, less interpolation preciseness and less statistical stability) and last but not least time shift between meteorological conditions and maintenance action. The winter index issuing is operated by Czech Hydrometeorological Institute. Maintenance data collection and running interpretation of index is operated by firm CROSS Zlin (in detail see paper [1]).

3.2 Seasonally/monthly evaluation

Back-evaluation enables finer and more exact analysis. It is based on more stations, better checked data, more stable statistical approach and enables to use cumulative processing which prevents short time shifts between meteorological and maintenance data. It is usable for evaluation of performance of centres and for long-term planning. Finally, it is possible to evaluate winter extremity of different seasons from the winter road maintenance point of views.

3.3 Some aspects of results interpretation

In the following paragraphs, we would like to point out some specifics that need to be taken into account when doing performance interpretation. Following aspects should be accounted:

- good or bad reaction on weather conditions
- determination of optimal maintenance performance
- problem of high/small performance then optimum

3.3.1 Good or bad reaction on weather conditions

Closeness or relationship between winter index and some maintenance parameter could be expressed by determination coefficient (square of correlation coefficient, see Fig. 1). Scattering of observed values around average (expected) value can be depicted by “scattering figure” or “shooting target” (see Fig. 2). The target on the left corresponds to low determination (blue colour on Fig. 1), target on the right to high determination (orange on Fig. 1). The middle target represents very close relationship in single maintenance centres, but huge differences between centres. Middle and right target represent an excellent reaction to weather. Differences between centres (middle target) can be caused by

- constant different properties by that time not yet accounted in maintenance versus winter index analyses, e.g. traffic density, maintenance priority, special terrain conditions, different shape of maintained region etc.,
- different efficiency of maintenance,
- bad comparability of used performance parameter etc..

In the case of different staffs working in the same centre only point b) has to be taken into account.

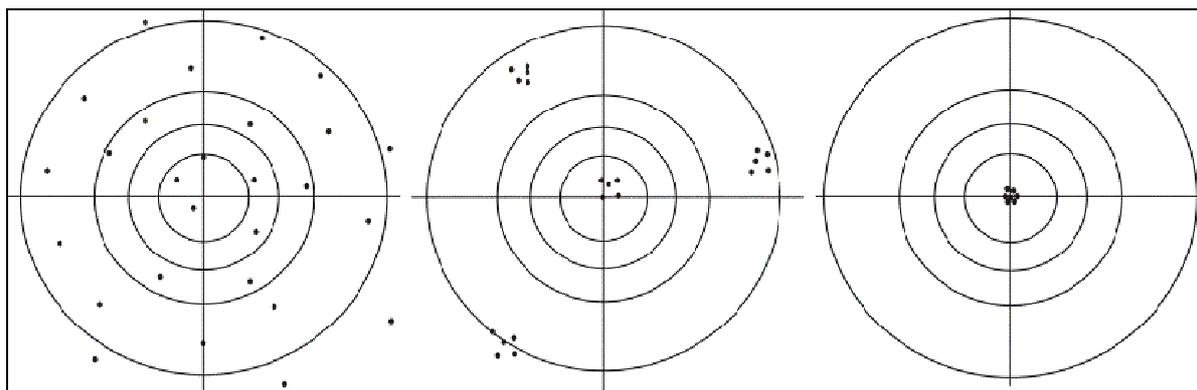


Fig. 2: Types of maintenance centres reaction for winter conditions. (left: chaotic reaction; middle: excellent, but different reaction in different centres; right: excellent and same reaction in all centres).

3.3.2 Determination of optimal maintenance performance

Deciding, if the road is optimally maintained regarding traffic safety, must be done independently on winter index (e.g. by independent checking persons, by number of traffic accidents and traffic fluency etc.). Average (more precisely named “expected (theoretical) value” of maintenance performance represent not optimal maintenance, but average maintenance computed from statistical analyses between given maintenance parameter and winter index based on older “training” data sample.

3.3.3 Problem of high/small performance then optimum conditions

Of course, it is not always possible to say that in the case of overestimating (greater performances than average), workers in that centre are either doing badly their job or perhaps they show higher performances than they really do. Sometimes, there can be special conditions causing this enhancement (increased requirements from different reasons). And of course, these conditions should be involved in the computation of winter index. But it has to be stressed here, that not always these conditions are known when computing the index and we don't have such data available. When doing more years-comparison between centres it is possible to pronounce specific features of centres by distance between separate clusters on the middle target (Fig. 2) and this distance use as a correct factor when comparing performances of single centres (of course supposing that performance quality is in all centres comparable). Of course, it is important to stress that this is possible only if there are no or little changes of borders between maintenance centres and of maintenance operators (firms). Of course, it is possible to make inter-seasonal comparison in given centre and find out inter-seasonal variations in performance of some region caused by different work efficiency.

4. PROBLEMS WITH RETRIEVAL OF BASIS OF ROAD NETWORK AND WINTER MAINTENANCE OUTPUTS

Before beginning of every new winter season, the basis data of road network has to be innovated as well as the data about distinguished centres of road maintenance and about types of maintenance. For this reason, digitalized data in GIS are needed (describing the roads, their routing, sections, widths, length, crossroads etc.). But some centres have data in paper (maps) format available, only, sometimes also not for all sites etc. Sometimes problems with borders between centres occur, then it can be difficult to decide which centre maintain the selected part of road (see such e.g. on Fig. 3). Or data are available late, during or at the end of the

winter season. This all can be source of possible misunderstandings and has to be handled very carefully. And last, but not least, problems with identification of maintenance centres appear as well (different names, data formats etc.).

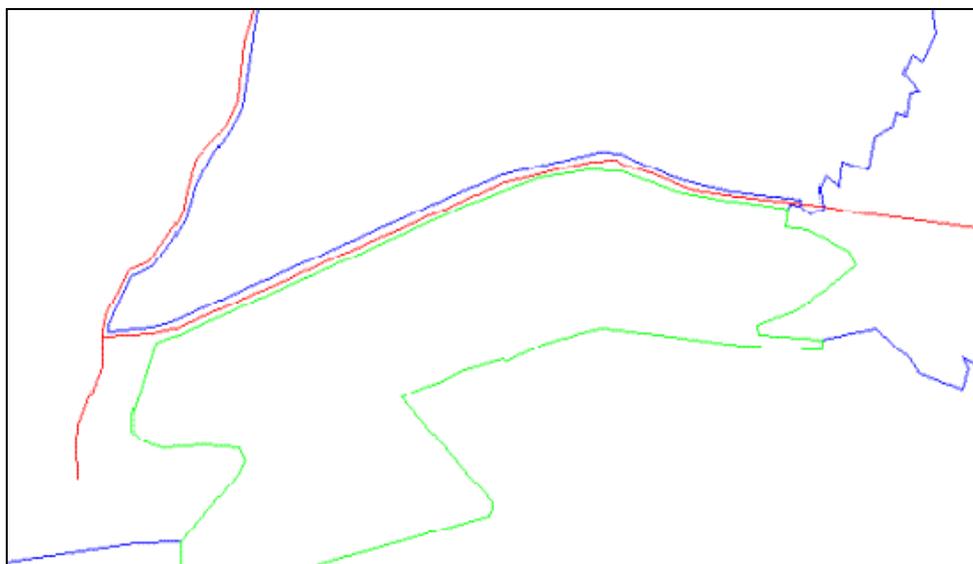


Fig. 3: Indecisiveness of decision for road maintenance centre (red – road, blue and green – borders of maintenance centre).

Special problem is setting of suitable parameters for evaluating of maintenance severity. Very useful are some performance parameters (see [1]). In some cases, e.g. using of salt solution there are problems of comparability of data when using different concentration of the solution in different centres and in different meteorological conditions (dependence of solution concentration efficiency on air temperature).

5. CONCLUSION

This winter index evaluates very well winter severity from the maintenance point of view. It enables mutually comparison of maintenance centres. Also, it enables to make inter-seasonal comparison in given centre and find out inter-seasonal variations in performance of some region caused by different work efficiency.

The longer part of season is evaluated the more fine results and more exact analysis can be obtained.

Regarding using of road meteorological stations some data from these stations are influenced by the way and quality of maintenance. They are very good help for issuing forecasts and for operative organizing of maintenance, they are not suitable for evaluating of maintenance efficiency and severity.

The winter index in the CHMI is issued every season from 1st November to 31st March, if not later needed. The output values are discussed with customers in some cases. And we have already 4th season of routine issuing without any failure.

In the following seasons, further development and improvement of winter index is planned, as well as further automatization.

6. REFERENCES

- [1] Kveton, V., Pospisek, T., Jurik, T. and Balajka, M., 2008. *Winter Maintenance Index – Next Level of Road Winter Maintenance Analysis*, SIRWEC Conference 2008, Prague.

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