Event coordinators:
Lauryna Šidlauskaitė Justas Kažys Jonas Kaminskas

PROCEEDINGS OF THE 20TH SIRWEC CONFERENCE, DRUSKININKAI, LITHUANIA (14-16TH JUNE 2022)

2022

AN ADAPTED ACCUMULATED WINTER SEASON SEVERITY INDEX (AWSSI) FOR LITHUANIAN WINTER EVALUATION

Lauryna Šidlauskaitė [a], Justas Kažys [b], Silvija Pipiraitė-Januškienė [b]

[a] AB Kelių priežiūra, Savanorių pr. 321C, 50120 Kaunas, Lithuania, *lauryna.sidlauskaite@keliuprieziura.lt*, ORCID: 0000-0001-7753-2951

[b] Institute of Geosciences, Vilnius University, 3 Universiteto St., 01513 Vilnius, Lithuania

Summary

Winter severity evaluation has been a difficult task to crack for climatologists for decades. This task becomes even more burdensome once this evaluation needs to represent a certain application or task effectiveness, like winter road maintenance. Thus, the Accumulated Winter Season Severity Index (AWSSI) has been calculated in hopes to get an accurate and objective index for winter road maintenance task difficulty assessment.

After initial evaluation, it was noted, that AWSSI performed a lot better than previously used indices, thus it was decided to improve the methodology and make it a bit more suitable for Lithuanian climate, more applicable to Lithuanian RWIS network and less dependent to climate change. A several methodology changes were performed and an adaptation of AWSSI was created.

The resulting adapted AWSSI is a great tool to determine winter severity for road maintenance. It was shown that the index correlates well with performed winter road maintenance tasks and material usage. Thus, it can be used in various fields, e.g., long-term forecasts and planning, and currently is being used to determine a part of worker wages.

Introduction

It is of no surprise that winters vary significantly from season to season. Everyone who is affected by winter weather conditions in any way undeniably will try to evaluate a certain winter's severity at some point. However, opinions and memories are subjective, so an accurate and objective evaluation method has been in pursuit of many researchers for a long time, especially in winter road maintenance field. An accurate winter severity evaluation or index could be benefited from on many occasions, e.g., winter road maintenance financing adjustments, insurance evaluations, or even long-term weather forecasting for material usage planning.

Lithuania is no exception, especially when it comes to winter road maintenance. Thus, first tries at creating such an index were performed in 2015 – Lithuanian national winter road maintenance manual included a winter adversity index (WAI, in Lithuanian – "*Žiemos sunkumo indeksas"* or *ŽSI*) [1]. However, over the years WAI proved to be inaccurate and, most importantly, it did not correspond with performed winter road maintenance tasks well enough for it to be used in further evaluations.

To either increase the usefulness of WAI or replace it entirely, AB Kelių priežiūra, Lithuanian road maintenance company, financed a research study in 2020, titled "Evaluation study of winter weather conditions index" [2]. In this study, various evaluation methods were researched, including the Accumulated Winter Season Severity Index (AWSSI) [3] which is used in the USA for winter season evaluation [4]. This index is unique, because the evaluation can be performed on any day, continuously, and it uses only simple meteorological parameters and does not require special measurements or devices.

To apply AWSSI to winter road maintenance field was not a new idea – researchers at Midwestern Regional Climate Center (University of Illinois,

USA) have performed enhancements and achieved greater correlations with winter road maintenance costs than the previous version [5]. The new version was called RAWSSI.

Adaptation of AWSSI to Lithuanian climate

Daily AWSSI scores are calculated based on scores assigned to temperature, snowfall, and snow depth thresholds. The daily scores are accumulated through the winter season, allowing a running total of winter severity during a season as well as a final, cumulative value characterizing the full season. Also, either daily or final scores can be compared between historical AWSSI database using quintiles, to determine the winter season severity category – from mild, to extreme.

The original methodology was simple to apply, however, presented some issues, e.g., it is calculated using meteorological station data. For the index to correlate well with road maintenance costs these stations need to be close to the roads, which usually is not the case. Also, the network of meteorological stations is a lot too sparce to be able to get an accurate index for every maintenance sub-unit. These and some other issues led to several modifications, some of which were:

- Abandon the snow depth indicator as irrelevant for winter road maintenance. Snow does not stay on the road surface for long because they are continuously cleared in accordance with existing procedures. In the USA, the modified RAWSSI index [5], which discarded the snow depth indicator, showed higher correlations with road maintenance costs. Daily precipitation accumulation when air temperature is ≤ 2 °C will be used.

- Change units of measurement: for air temperature, from Fahrenheit (°F) to Celsius (°C); for snow, from inches (in) to millimetres (mm).
- Modify the estimates of air temperature and snowfall to reflect the climatic conditions in Lithuania (Table 1).

In the winter weather conditions index study [2] four indices were calculated and had different correlations with seasonally used salt amount (Fig. 1):

- WAI, using Lithuanian meteorological station data, Pearson's correlation coefficient $r = 0.42$, however, not statistically significant (when $\alpha = 0,05$),
- AWSSI, using Lithuanian meteorological station data, $r = 0.91$, statistically significant (when $\alpha = 0,05$),
- Adapted AWSSI, or aAWSSI, using Lithuanian meteorological station data, $r = 0.89$, statistically significant (when $\alpha = 0,05$),
- aAWSSI, using Lithuanian road weather information system data, $r = 0.85$, statistically significant (when $\alpha = 0,05$).

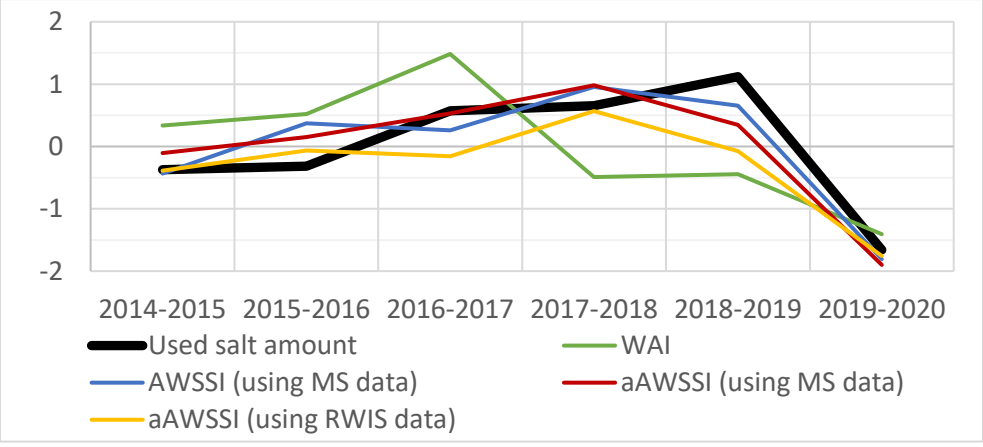

Fig. 1. The variation of various versions of AWSSI and WAI indices, and salt amount used during the winter maintenance tasks (values are standardized)

Table 1. aAWSSI score thresholds

Max. air temperature, °C			Min. air temperature, °C			Accumulated precipitation, mm (when air temp. ≤ 2°C)		
From	**To**	**Score**	**From**	**To**	**Score**	**From**	**To**	**Score**
…	-28.7	65	…	-41.7	56	0	0.2	0
-28.7	-28.2	58	-41.7	-41.5	50	0.2	0.6	1
-28.2	-27.3	51	-41.5	-41.1	44	0.6	0.8	2
-27.3	-26	44	-41.1	-40.4	38	0.8	1.3	3
-26	-23.9	38	-40.4	-39.1	33	1.3	1.8	4
-23.9	-20.5	32	-39.1	-36.2	28	1.8	2.4	5
-20.5	-15.1	26	-36.2	-29.8	23	2.4	3	6
-15.1	-9.9	19	-29.8	-21.5	19	3	3.7	7
-9.9	-7.3	15	-21.5	-16.7	16	3.7	4.5	8
-7.3	-4.5	13	-16.7	-11.4	14	4.5	5.7	9
-4.5	-2.8	11	-11.4	-8.1	12	5.7	7.5	10
-2.8	-1.5	9	-8.1	-5.8	10	7.5	9.3	12
-1.5	-0.5	8	-5.8	-4	9	9.3	13.2	14
-0.5	0.3	7	-4	-2.6	7	13.2	18.5	17
0.3	1	5	-2.6	-1.4	6	18.5	23.6	22
1	1.7	4	-1.4	-0.4	5	23.6	28.5	32
1.7	2.4	3	-0.4	0.6	4	28.5	33.3	41
2.4	2.9	2	0.6	1.1	3	33.3	38.1	51
2.9	3.4	1	1.1	1.6	2	38.1	42.7	61
3.4	3.7	1	1.6	1.8	1	42.7	47.2	71
3.7	3.8	0	1.8	1.9	0	47.2	51.8	81
						51.8	56.2	91
						56.2	60.6	92
						60.6	65	101
						65	73	111
						73	…	130

aAWSSI application to winter road maintenance activities in Lithuania

Modifications of aAWSSI allowed the methodology to be applied further and even made it possible to be implemented into IT systems. Thus, AB Kelių priežiūra automated the calculation of aAWSSI for each road maintenance sub-unit. This was done by assigning each sub-unit 3-5 RWIS stations, calculating aAWSSI daily scores for each RWIS station, and averaging those scores to receive a value for the territory of the sub-unit. This way it is easy to apply the received aAWSSI score to any other statistic of the sub-unit or to use it to influence another index.

It was found, that the new aAWSSI correlates even better: average statistically significant correlation (when $\alpha = 0,05$) between the index scores and monthly parameters:

- used salt amount was 0.95,
- used brine amount was 0.94,
- used fuel amount was 0.75.

Also, a small part of the variable salary component of worker wages is now determined by aAWSSI. The score is calculated monthly and compared with 10 years of historical data. If the month's score is determined to be in the lowest quintile, that means that winter conditions were very mild, and workers' wages are lessened (of that sub-unit). If the month's score is determined to be in the highest quintile, that means that winter conditions were extreme, and they receive more salary than usually.

References

[1] Lietuvos automobilių kelių direkcija. **2015**. Lietuvos valstybinės reikšmės automobilių Kelių priežiūros žiemą vadovas (in English: *Lithuanian*

national winter road maintenance manual) *https://lakd.lrv.lt/uploads/lakd/documents/files/Paslaugos/Inforinkmenos/Keliu_prieziuros_ziema_vadovas.pdf* Retrieved April 28, 2022 (in Lithuanian).

[2] Kažys J., Pipiraitė-Januškienė S. **2020.** Žiemos sezono meteorologinių sąlygų indekso vertinimo studija (PU-7157/20). Final report (in Lithuanian).

[3] Mayes Boustead B. E., Hilberg S. D., Shulski M. D., & Hubbard K. G. **2015**. The Accumulated Winter Season Severity Index (AWSSI), Journal of Applied Meteorology and Climatology, 54(8), 1693-1712. *https://journals.ametsoc.org/view/journals/apme/54/8/jamc-d-14-0217.1.xml* Retrieved April 28, 2022.

[4] Midwestern Regional Climate Center. Research: Accumulated winter season severity index (AWSSI). *https://mrcc.purdue.edu/research/awssi/indexAwssi.jsp* Retrieved April 28, 2022.

[5] Clear Roads. **2019**. AWSSI Enhancements in Support of Winter Road Maintenance. Project Summary, Project 1029177/CR16-02, Midwestern Regional Climate Center University of Illinois. *https://clearroads.org/project/16-02/* Retrieved April 28, 2022.

[6] Kilpys J., Pipiraitė-Januškienė S., Rimkus E. **2020**. Snow climatology in Lithuania based on the cloud-free moderate resolution imaging spectroradiometer snow cover product. Int J Climatol. 2020; 40: 4690– 4706. *https://doi.org/10.1002/joc.6483* Retrieved April 28, 2022.