AWSSI Enhancements in Support of Winter Road Maintenance

Project Summary

CLEAR ROADS

research for winter highway maintenance

Midwestern Regional Climate Center
University of Illinois

Project 1029177/CR16-02
February 2019

Pooled Fund #TPF-5(353)
www.clearroads.org

This project was conducted by the Midwestern Regional Climate Center (MRCC) at the University of Illinois and jointly funded by the Clear Roads and Aurora pooled fund studies. The project's goal was to enhance the MRCC's Accumulated Winter Season Severity Index (AWSSI) tool with data from additional locations and added functionality.

The project had four tasks:

Task 1: Add at least one additional AWSSI location to each Clear Roads state.
Task 2: Add the ability to overlay past years on the current-year AWSSI time-series plot.
Task 3: Display projected information for the remainder of the winter season.
Task 4: Determine the feasibility of an augmented "Road AWSSI" tool.

In lieu of a final report, this Project Summary briefly describes the MRCC investigators' process in completing these tasks, including methodology, research, results and recommendations.

More information on this project is available on the Clear Roads project page (http://clearroads.org/project/16-02/) and on MRCC's AWSSI page (https://mrcc.illinois.edu/research/awssi/indexAwssi.jsp).

Task 1

Task 1 in the Clear Roads project was to add at least one new location for AWSSI in each of the 35 Clear Roads states. An attempt was made to locate a station in counties requested by Clear Roads states where possible. A total of 51 new stations were added. The following locations were evaluated and added to the MRCC AWSSI calculation and map.

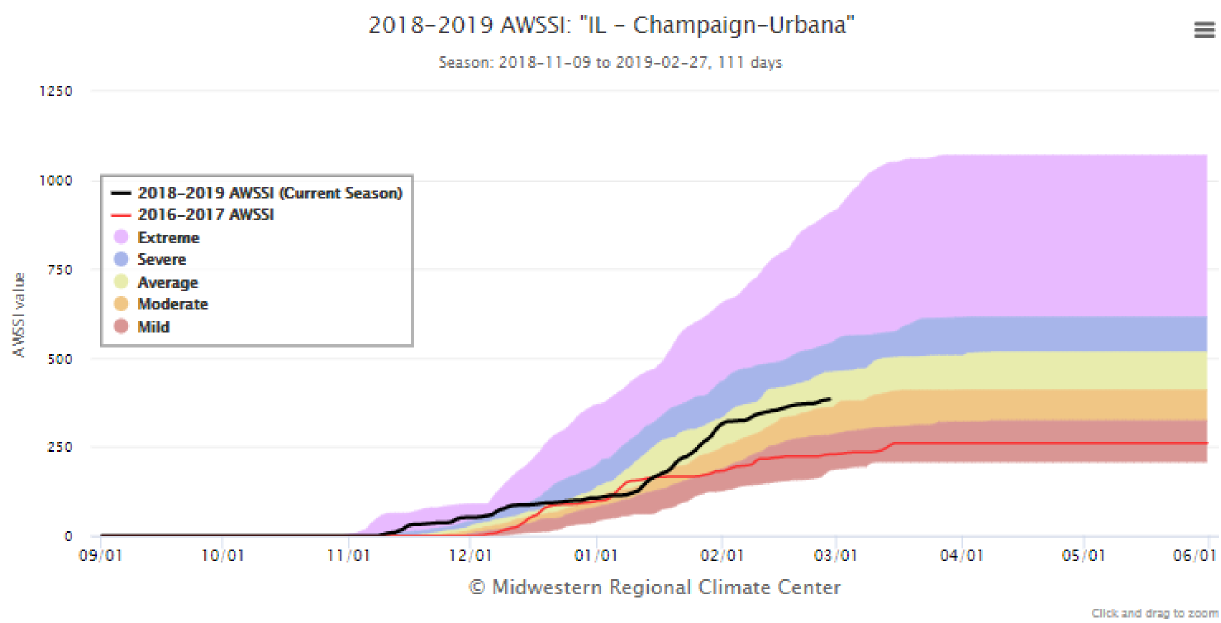
Station	State	County	POR	Number of Seasons Omitted Due to Missing Data
Bettels	AK	Yukon-Koyukuk	1950-2017	1
Payson	AZ	Gila	1950-2017	27
Cherry Valley Dam	CA	Riverside	1955-2017	18
Trinidad	CO	Las Animas	1954-2017	35
Hartford	CT	Hartford	1950-2017	21
Norfolk 2SW	CT	Litchfield	1950-2017	4
Dover	DE	Kent	1950-2017	13
Mason City	IA	Cerro Gordo	1950-2017	2
Idaho Falls 16 SE	ID	Bonneville	1955-2017	20
Effingham 3 SW	IL	Effingham	1950-2017	17
Nashville 1 E	IL	Washington	1950-2017	16
Fort Wayne	IN	Allen	1950-2017	none
Independence	KS	Montgomery	1950-2017	10
Amherst	MA	Hampshire	1950-2017	12
Birch Hill Dam	MA	Worcester	1950-2017	21
Baltimore	MD	Anne Arundel	1950-2017	none
Jackman	ME	Somerset	1951-2017	27
Muskegon	MI	Muskegon	1950-2017	4
Saginaw	MI	Saginaw	1950-2017	9
Austin	MN	Mower	1950-2017	29
Rochester	MN	Olmsted	1950-2017	none
Cape Girardeau	MO	Scott	1960-2017	16
Unionville	MO	Putnam	1950-2017	23
Kalispell	MT	Flathead	1950-2017	5
Upham 3 N	ND	McHenry	1950-2017	26
Scottsbluff	NE	Scotts Bluff	1950-2017	1
Berlin	NH	Coos	1950-2017	14

Battle Mountain 4 SE	NV	Lander	1950-2017	10
Mohonk Lake	NY	Ulster	1950-2017	2
Watertown	NY	Jefferson	1950-2017	13
Akron	OH	Summit	1950-2017	1
Wilmington 3 N	OH	Clinton	1950-2017	5
Portland	OR	Multnomah	1950-2017	19
State College	PA	Centre	1950-2017	3
Kingston	RI	Washington	1950-2017	5
North Foster 1 E	RI	Providence	1974-2017	none
Lemmon, SD	SD	Perkins	1950-2017	34
Watertown	SD	Codington	1950-2017	6
Lubbock	TX	Lubbock	1950-2017	none
Echo Dam	UT	Summit	1950-2017	13
Richmond	UT	Cache	1950-2017	16
Blacksburg	VA	Montgomery	1952-2017	9
Charlottesville 2 W	VA	Albemarle	1950-2017	8
Rutland	VT	Rutland	1950-2017	11
Bellingham	WA	Whatcom	1950-2017	8
Wenatchee	WA	Chelan	1950-2017	24
Wausau	WI	Marathon	1950-2017	none
Clarksburg 1	WV	Harrison	1950-2017	22
Lewisburg 3N	WV	Greenbrier	1950-2017	29
Alta 1 NNW	WY	Teton	1950-2017	12
Gillette 4SE	WY	Campbell	1950-2017	10

Stations were selected based on data availability. A station had to be currently reporting temperature, snowfall, and snow depth. Preference was given to stations that had 30 or more years of winter season data. Most locations had one or more seasons omitted from the analysis due to missing data.

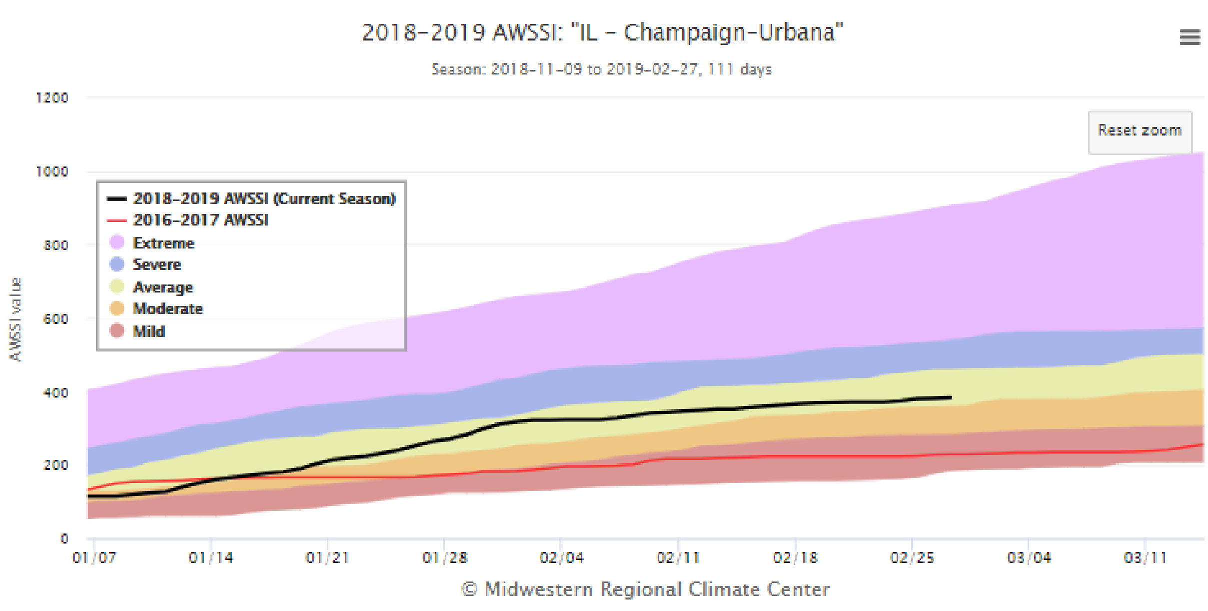
Task 2

Task 2 in the project involved making past seasons available on the time-series plots along with the current season. The current season is shown with a black line on top of shading which represents the five quintiles (based on available seasons from 1950-51 to last season). We added a red line to show a historical season which is chosen by the user. The user selection can be made from an additional menu with all seasons from 1950-51 to last season available.



If the historical season chosen has insufficient data to compute the AWSSI for that season, an alert message pops up to notify the user. After dismissing the alert box, the plot will be draw without the red line for the season with insufficient data.

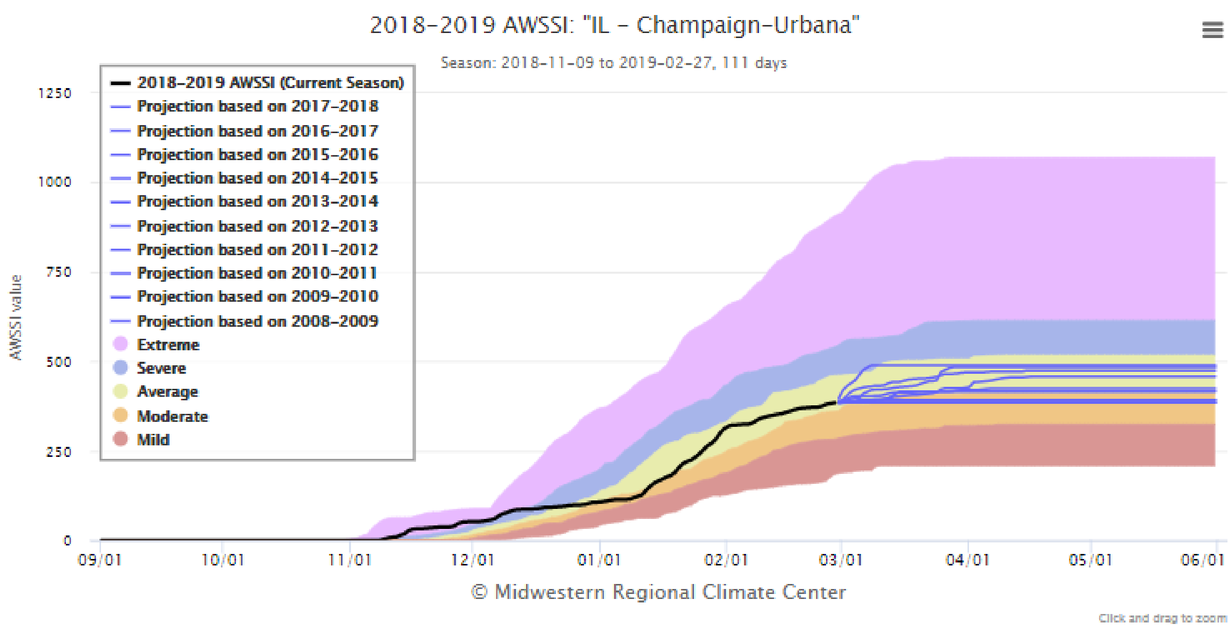
The plots can be zoomed into a specific date range by clicking and dragging the cursor over the wanted date range. To zoom back out to see the full season, click on the "Reset zoom" button in the upper right (the button only appears if the plot is zoomed in).



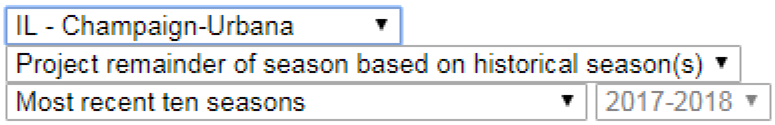
The availability to plot the last 5/10 seasons or the closest 5/10 seasons was added later during work on Task 3. As it was determined that the least confusing interface option would have the same choices in the historical and projection options, we added these options to the historical despite it not being in the task 2 specifications. See task 3 description for details on the menus available to select historical seasons and projections based on those seasons.

Task 3

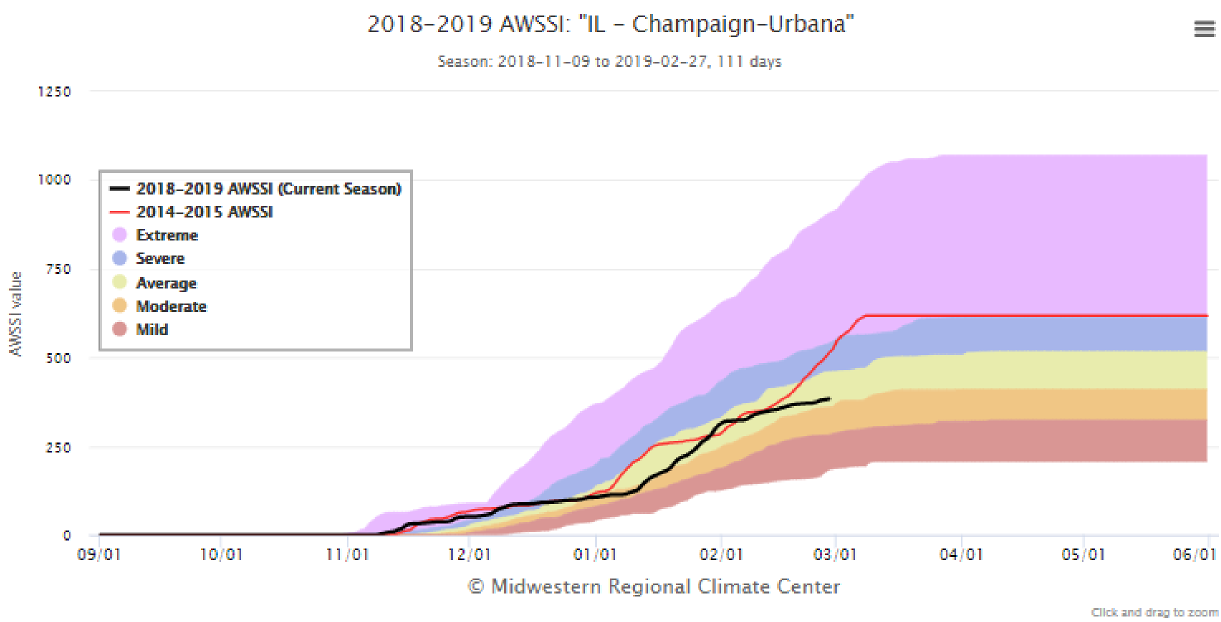
Task 3 in the project was to make projections for the remainder of the current season using historical seasons. There were two types of projections included, the most recent seasons and the closest seasons. The most recent seasons use the last 5 or 10 seasons. The closest seasons choose 5 or 10 seasons with the closest score, on the same date, as the current season. We also made the option available to choose a specific season to use for the projection to be consistent with the task 2 option. Projections for the remainder of the season are shown with blue lines.

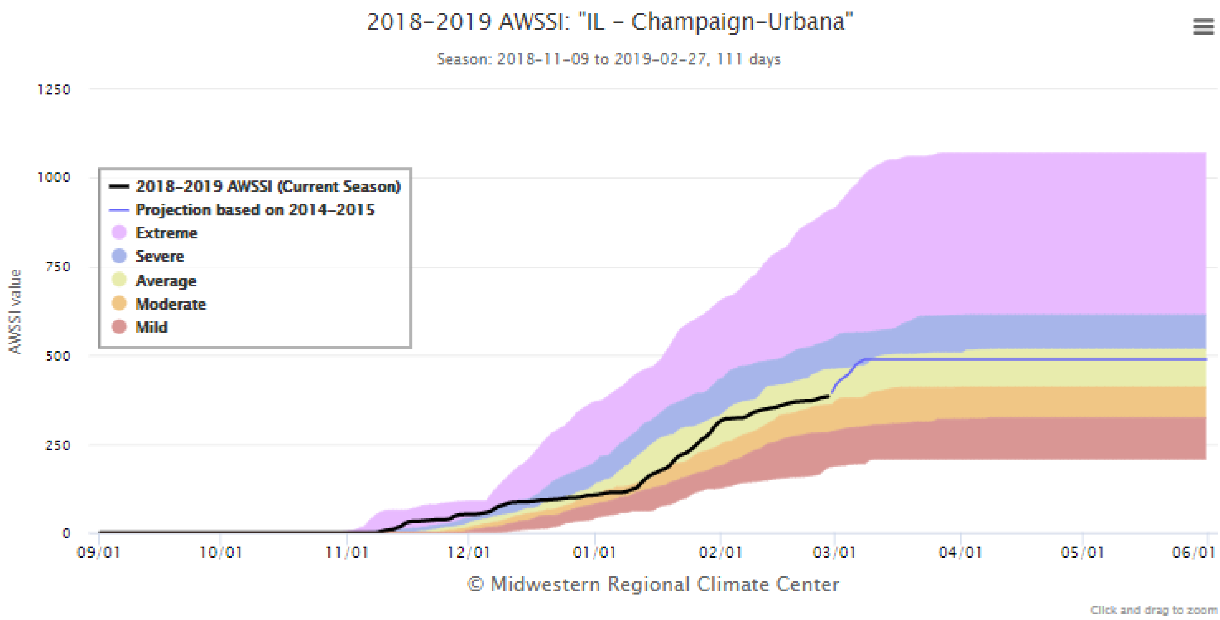


With the enhancements in task 2 and task 3 made available, the user now has up to 4 menus to choose values. The first is the station. The second allows for the current season only, historical (full) seasons, or projections of the remainder of the season based on historical seasons. The third menu has five choices: a specific season, last 5 seasons, last 10 seasons, closest 5 seasons, and closest 10 seasons. The third menu is unavailable if the second menu is set for current season only. The fourth menu is available only if the third menu is set to a specific season and allows the user to choose any season from 1950-51 to the last season.

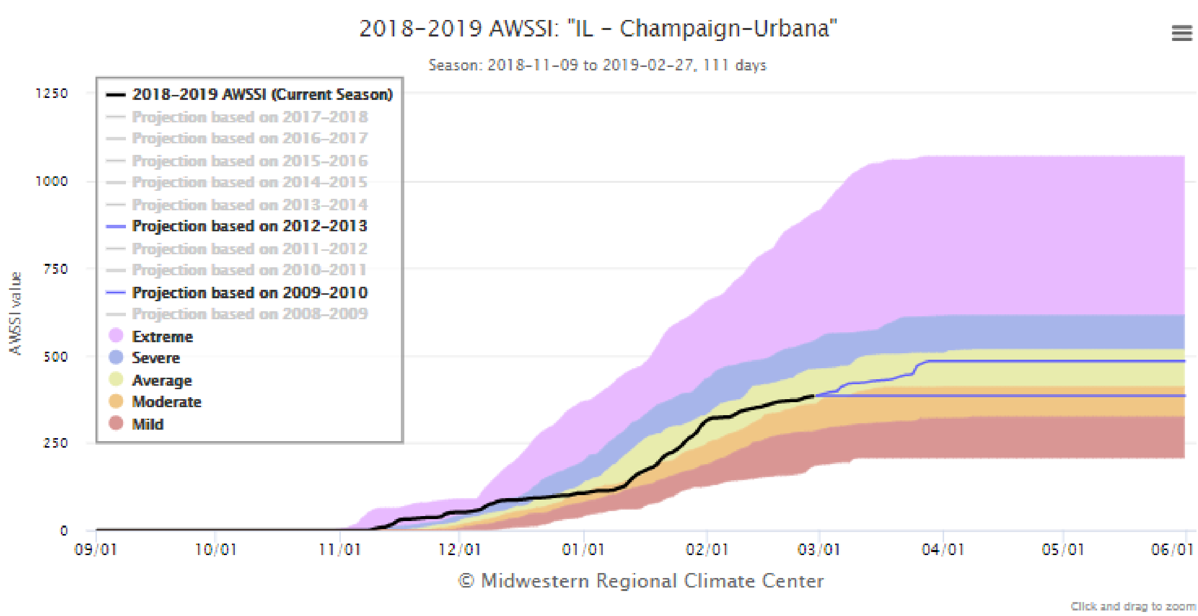


The projections of the remainder of the season are created by taking historical seasons and adjusting the values for the remainder of the season by the offset between the current season score and the historical season score on the last day that the current season score is available. This adjusts the historical season to start where the current season ends with the offset applied throughout the remainder of the season. In the example below, the score for the 2014-15 season was 29 points higher than the current season on February 27th. The projection for the remainder of the year took the 2014-15 AWSSI scores and subtracted 29 from each value so the projection smoothly extends from the end of the current season.





Zooming is available as described in the Task 2 write-up. Another option that is available if for the user to turn off the display of certain lines in the figure. Simply by clicking on a line of the legend, the associated line in the plot will disappear. Clicking on the line in the legend again will redisplay the associated line. Moving the cursor over the figure will also show the values of the quintiles and the lines plotted for that date.



Task 4

One of the tasks outlined in the project for Clear Roads was to determine if the AWSSI can be optimized to correlate better to winter road maintenance costs.

Approach

We requested winter road maintenance operations data from a number of states for a five to ten year period, broken down by the transportation districts in each state if possible. This data included costs, amounts of labor hours, equipment hours, and materials used. Since costs change often, we used quantities of hours and materials to correlate against.

The data were normalized by computing an average for the years available, and then computing the percent change for the individual years for all parameters. Separate averages were computed for solid (salt, sand) and liquid materials, and these were then averaged to obtain a figure for all materials.

Correlations were run for the whole state, and for the individual districts in each state that had an AWSSI station available in that district.

Results

Correlations were run against the AWSSI and initially against the AWSSI snow score component. Correlations against the snow score alone were generally lower than with the AWSSI, and so that approach was discarded. We developed a separate scoring that isolated snow events that did have a better correlation than to the AWSSI itself in some cases. We called this the RAWSSI. This score was calculated by summing the temperature score and the snowfall score for a day only on days where there was measurable snow. Total snow on the ground was not included in this calculation. In addition, we tallied the days with measurable snow (snow days) for each season as additional information. Correlations were not run against snow days.

The temperature score was included in the RAWSSI to help account for the "character" of the event. Snow falling at or around freezing may melt as it falls (depending on rate) or result in slushy accumulations, requiring road treatment but perhaps no plowing. Snow falling when the temperature is well below freezing will likely all accumulate and may require both plowing and road treatment with deicing materials.

An analysis was completed for the following states: Arizona, Idaho, Maine, Maryland, North Dakota, and Pennsylvania. For each state labor hours, equipment hours, and quantity of materials were available for the state as a whole and for the DOT districts in each state. Only districts that corresponded with a weather station for which the AWSSI could be calculated were used. The available operations data ranged from five to 14 years.

An average was calculated for each operations parameter for the period of years available, and for each year a percent difference was calculated. The same calculation was made for the AWSSI and RAWSSI. For the state aggregated analysis, the AWSSI for the available stations was averaged for each year to come up with a "statewide" average, and percent change calculations were made from this average. For the individual state DOT districts percent change calculations were made from the AWSSI for the weather station in the district.

For materials, averages were calculated for dry materials and for liquid. The percent change in each for each year was averaged to come up with a percent change in materials use for that year. The percent change in each operations parameter was plotted against the percent change in the AWSSI and RAWSSI.

A table of correlation values for each state are included in Appendix A.

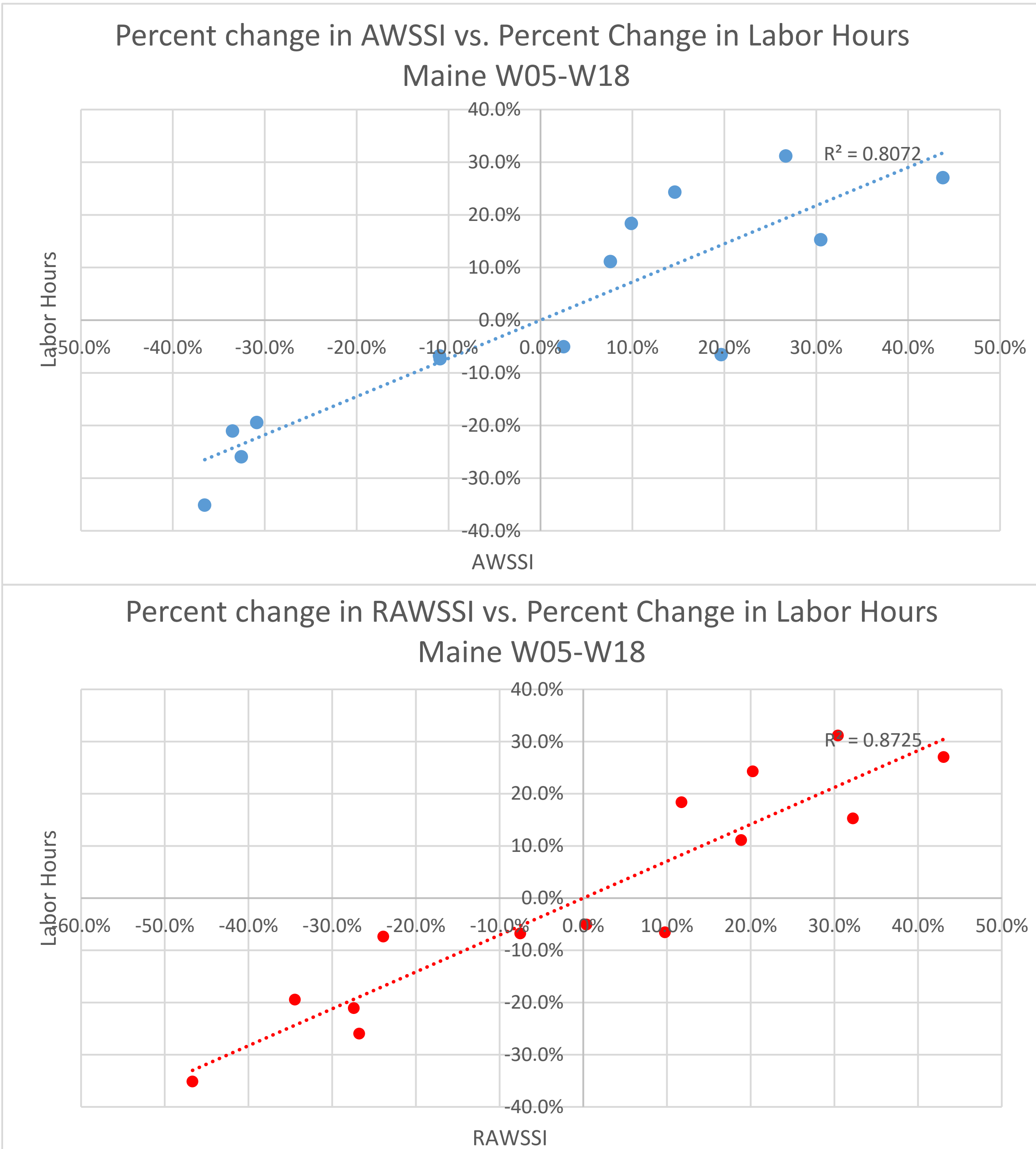


Figure 1. The percent change in labor hours plotted against the percent change in AWSSI and RAWSSI for Maine for the winters of 2004-2005 through 2017-2018.

In most cases the RAWSSI had a slightly better correlation to the operations data than the AWSSI. This is likely because the RAWSSI is event-based (scores only on days it snows). The highest correlations with the AWSSI and RAWSSI were with labors hours. The lowest correlations were typically with Materials Used (see appendix with tables for each state). This may have to do with the type of materials used and/or the frequency with which they must be applied. Locations that deal with mostly snow will have better correlations than those that regularly deal with a variety of winter weather types. The AWSSI/RAWSSI does not account for freezing rain, freezing drizzle, and freezing fog, all of which can create dangerous driving conditions that require treatment of roads and more labor hours, equipment hours, and de-icing and traction materials. Treatment of roads because of blowing or drifting snow on days where snow is not actually falling will not be correlated as well, since the AWSSI has no wind component.

Correlation of operational parameters with the AWSSI or RAWSSI will not work well in an area where snow is infrequent but where road crews and equipment may be used for other winter maintenance. If the available weather station in a district is not truly representative of the entire district with respect to topography, road types, weather across the district, etc. then correlation with operational data will be poor. We attempt to select stations that are representative of a county or district, but a limited number of stations are available that have sufficient data with which to calculate the AWSSI.

Navajo County, AZ has a long north to south extent (approximately 236 miles) and a maximum east to west extend of 51 miles. Show Low, AZ, the station selected for Navajo County, AZ had no measurable snow in the winters of 2008-2009 and 2009-2010 (RAWSSI was 0). Yet, labor hours were 27.9 percent and 4.9 percent higher than the ten-year average, respectively, and equipment use was 50.5 percent and 52.5 percent higher than the ten-year average. Equipment hours in 2009-2010 in Navajo County were the highest of the ten year period, yet the AWSSI was 27 percent below average. Show Low is in the very southern part of Navajo County, with the northern border about 188 miles away. Data from the National Operational Hydrologic Remote Sensing Center (NOHRSC) and the MRCC indicate that there was significant snow during that winter across portions of central Arizona extending to the southeast across the southern part of Navajo County, but to the south of Show Low. This likely resulted in the increase in road maintenance parameters for Navajo County but was not reflected in the Show Low AWSSI.

Recommendations

The AWSSI and its derivative, RAWSSI, show significant correlation to road maintenance operations parameters, particular the number of labor hours. There are variations from state to state depending on topography, climate, and road maintenance parameters. A single index value that correlates across all states, and even district to district within states is not feasible given the operational considerations that may exist from state to state. Instead, we propose to provide additional AWSSI parameters that state DOTs can use to compare/correlate to their road maintenance parameters. In addition to the total AWSSI score for each season, we will provide the temperature score component, the snow score component, the RAWSSI, and the total number of events (days with snowfall of 0.1 inch or greater).

Correlation Coefficient (R^2)

Percent change in AWSSI and RAWSSI vs. percent change in operations parameters

Arizona No. Years: 10

	AWSSI	RAWSSI
Labor Hours	.451	.391
Equipment Hours	.644	.493
Materials Used	NA	NA

Coconino County (Flagstaff)

	AWSSI	RAWSSI
Labor Hours	.543	.607
Equipment Hours	.746	.810
Materials Used	NA	NA

Gila County (Payson)

	AWSSI	RAWSSI
Labor Hours	.176	.329
Equipment Hours	.126	.268
Materials Used	NA	NA

Apache County (Canyon De Chelly)

	AWSSI	RAWSSI
Labor Hours	.296	.160
Equipment Hours	.002	.158
Materials Used	NA	NA

Navajo County (Show Low)

	AWSSI	RAWSSI
Labor Hours	.004	.020
Equipment Hours	.149	.061
Materials Used	NA	NA

Correlation Coefficient (R^2)
Percent change in AWSSI and RAWSSI vs. percent change in operations parameters

Idaho No. Years: 7

	AWSSI	RAWSSI
Labor Hours	.445	.475
Equipment Hours	.681	.655
Materials Used	.633	.618

District 1 (Moscow)

	AWSSI	RAWSSI
Labor Hours	0	.049
Equipment Hours	0	.010
Materials Used	.418	.279

District 3 (Boise)

	AWSSI	RAWSSI
Labor Hours	.535	.366
Equipment Hours	.623	.538
Materials Used	.766	.901

District 5 (Pocatello)

	AWSSI	RAWSSI
Labor Hours	.508	.376
Equipment Hours	.565	.459
Materials Used	.424	.475

District 6 (Idaho Falls)

	AWSSI	RAWSSI
Labor Hours	.839	.878
Equipment Hours	.523	.483
Materials Used	.199	.186

Correlation Coefficient (R^2)
Percent change in AWSSI and RAWSSI vs. percent change in operations parameters

Maine No. Years: 14

	AWSSI	RAWSSI
Labor Hours	.807	.873
Equipment Hours	.857	.864
Materials Used	.453	.485

District 1 – Southern (Portland)

	AWSSI	RAWSSI
Labor Hours	.561	.738
Equipment Hours	.550	.713
Materials Used	.217	.166

District 2 – Midcoast (Waterville – W12, W13 no AWSSI)

	AWSSI	RAWSSI
Labor Hours	.525	.635
Equipment Hours	.535	.716
Materials Used	.506	.460

District 3 – Western (Farmington – W11, W12 no AWSSI

	AWSSI	RAWSSI
Labor Hours	.529	.600
Equipment Hours	.568	.758
Materials Used	.394	.261

District 4 – Eastern (Bangor – W15, W16 no AWSSI)

	AWSSI	RAWSSI
Labor Hours	.631	.812
Equipment Hours	.812	.621
Materials Used	.523	.242

District 5 – Northern (Caribou)

	AWSSI	RAWSSI
Labor Hours	.676	.670
Equipment Hours	.644	.601
Materials Used	.285	.207

Correlation Coefficient (R^2)

Percent change in AWSSI and RAWSSI vs. percent change in operations parameters

Maryland No. Years: 5

	AWSSI	RAWSSI
Labor Hours	.979	.973
Equipment Hours	.961	.930
Materials Used	.926	.950

District 4 (Aberdeen)

	AWSSI	RAWSSI
Labor Hours	.880	.889
Equipment Hours	.860	.888
Materials Used	.848	.863

District 5 (Baltimore)

	AWSSI	RAWSSI
Labor Hours	.893	.899
Equipment Hours	.938	.965
Materials Used	.824	.845

District 6 (Oakland)

	AWSSI	RAWSSI
Labor Hours	.746	.622
Equipment Hours	.693	.513
Materials Used	.789	.638

District 7 (Emmitsburg)

	AWSSI	RAWSSI
Labor Hours	.940	.811
Equipment Hours	.898	.720
Materials Used	.898	.798

Correlation Coefficient (R^2)

Percent change in AWSSI and RAWSSI vs. percent change in operations parameters

North Dakota No. Years: 7

	AWSSI	RAWSSI
Labor Hours	.839	.689
Equipment Hours	.117	.311
Materials Used	.013	.119

District 2 – Minot (Upham)

	AWSSI	RAWSSI
Labor Hours	.929	.718
Equipment Hours	NA	NA
Materials Used	.003	.097

District 4 – Grand Forks (Grand Forks)

	AWSSI	RAWSSI
Labor Hours	.381	.254
Equipment Hours	NA	NA
Materials Used	.026	.079

District 6 – Bismarck (Bismarck)

	AWSSI	RAWSSI
Labor Hours	.926	.860
Equipment Hours	NA	NA
Materials Used	.061	.082

District 8 – Fargo (Fargo)

	AWSSI	RAWSSI
Labor Hours	.622	.588
Equipment Hours	NA	NA
Materials Used	.179	.094

Correlation Coefficient (R^2)

Percent change in AWSSI and RAWSSI vs. percent change in operations parameters

Pennsylvania No. Years: 5

	AWSSI	RAWSSI
Labor Hours	.832	.801
Equipment Hours	.738	.693
Materials Used	.854	.827

District 1 (Erie)

	AWSSI	RAWSSI
Labor Hours	.772	.800
Equipment Hours	.604	.657
Materials Used	.511	.519

District 2 (State College)

	AWSSI	RAWSSI
Labor Hours	.870	.905
Equipment Hours	.477	.449
Materials Used	.654	.668

District 3 (Williamsport)

	AWSSI	RAWSSI
Labor Hours	.794	.912
Equipment Hours	.749	.874
Materials Used	.839	.939

District 6 (Philadelphia)

	AWSSI	RAWSSI
Labor Hours	.649	.653
Equipment Hours	.571	.575
Materials Used	.656	.647

Pennsylvania

District 12 (Pittsburgh)

	AWSSI	RAWSSI
Labor Hours	.620	.568
Equipment Hours	.914	.772
Materials Used	.880	.738

research for winter highway maintenance

Lead state:

Minnesota Department of Transportation
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