Joint Transportation Research Program

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Road Weather Severity Based on Environmental Energy

Introduction

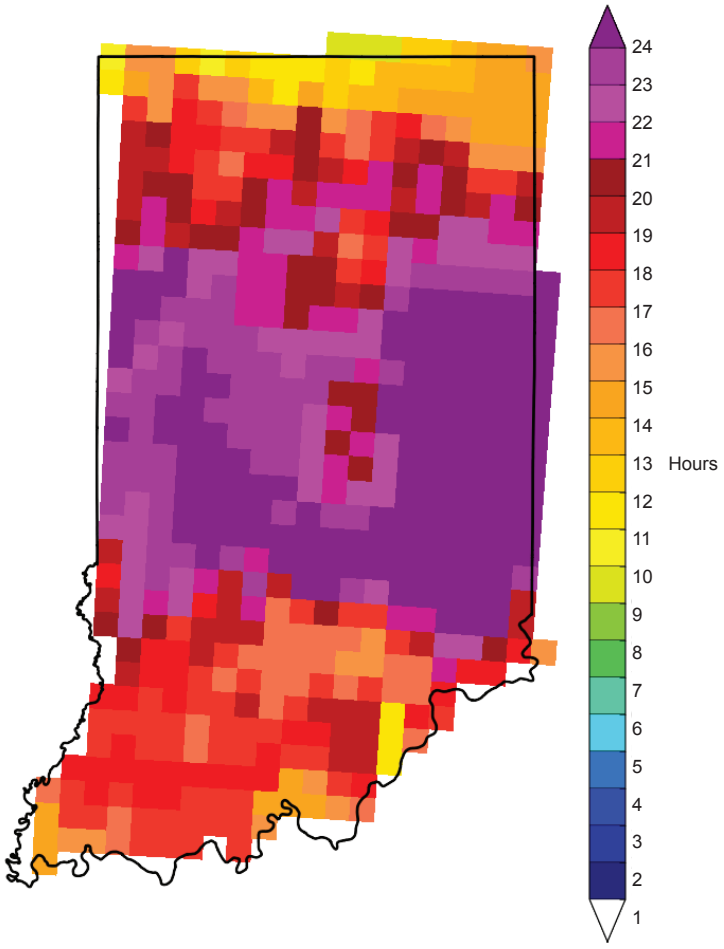
Winter weather conditions that occur across different regions vary substantially from hour to hour, storm to storm, and season to season. The methods of road maintenance for fighting snow and ice can also vary between different maintenance units. It is important for organizations that perform road maintenance to be able to quantify the severity of the winter weather conditions for the purposes of monitoring, planning, and evaluating their performance.

The Indiana Department of Transportation (INDOT) currently uses estimates of winter weather hours to quantify the severity of winter weather. The definition of *weather hour* is fairly straightforward: any hour when wintry precipitation (snow, ice pellets, freezing rain) is falling with air temperatures below 35°F. While this definition is reasonable, it does not take into account numerous factors that can strongly affect road conditions and subsequent efforts needed for road treatment, such as precipitation rate, wind speed, and availability of sunshine. Consequently, INDOT has determined that the information provided by the weather hour estimates results in wide variations in roadway treatment expenses across Indiana.

To more accurately and effectively evaluate the performance of winter maintenance, it is important to have detailed data related to winter weather conditions that provide useful information regarding the impact of winter weather on road conditions. State-of-the-art weather information can provide a clearer understanding of the severity of the weather, allowing INDOT to better evaluate its performance, assist with after-action review of recent storms, and improve its reaction to future weather events.

Findings

- Energy is required to remove snow and ice from road surfaces. This energy could be in the form of mechanical energy to plow snowfall off the surface or spread salt across the roadway. Energy could also be in the form of heat from the sun, air, or road surface that is transferred to the snow and ice by a



Estimated total hours of snow during the January 5–7, 2014, period.

variety of physical processes. Each of these sources of energy have different degrees of economic costs associated with them, some of which are quite difficult to estimate, while energy from the environment is available at no cost. The Road Weather Severity Based on Environmental Energy (RWSBEE) index is based upon the idea that winter severity can be derived by finding the additional energy required to melt snow and ice that has been deposited on the surface beyond the energy that is freely available from the environment. This additional energy can be considered an amount of work that is required to maintain the road surfaces.

- The amount of energy needed to raise the temperature of the mass of new snow or ice that has fallen (or has been deposited by blowing snow) onto a square meter of road surface during the past hour to the melting point, and then change the phase of that snow or ice from solid to liquid, can be computed. This will be a positive number, larger for greater values of snowfall and also for colder surface temperatures. The amount of energy available from the environment to warm the surface can also be computed. This will be either a positive or a negative value, depending on whether the environmental conditions are acting to warm or to cool the surface. Calculating the difference between these two energy values yields the additional energy required to melt the snow and ice that has accumulated on the road surface over the past hour. This energy value can be thought of as the additional work necessary to remove this new snow or ice from the roadway and is the defined in this work as the Road Weather Severity Based on Environmental Energy (RWSBEE) index, expressed in units of MJ/m^2.
- Examining the normalized change in the difference in cost between each area versus the statewide average value, nearly half of the areas moved closer to the state average when viewed in terms of costs per lane mile per RWSBEE than costs per lane mile per weather hour. Nearly 75% of the areas across the state were either closer to the state average or within ±5% (minor difference) of the value when viewed in terms of costs per RWSBEE instead of costs per lane mile. Roughly 25% of the areas were viewed as significantly further away (more than 5%) from the state average when analyzed as cost per RWSBEE instead of cost per weather hour. Although the overall variation across the state increased more when doing the cost analysis per RWSBEE than per weather hour, the majority of the areas across the state were viewed as either closer to the state average or only slightly worse (±5%).
- Non-weather-related factors are also important in determining the maintenance costs, such as salt usage, at the unit, sub-district, and district levels. These factors cannot be accounted for using a severity index that is based solely on weather information.

Implementation

New spatially detailed datasets for analyzing winter weather severity across the state will be provided to INDOT in a form that will allow easy implementation into INDOT operations. We recommend that INDOT begin using the more detailed analysis datasets to analyze the performance of maintenance operations for upcoming and previous winter seasons.

Recommended Citation for Report

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