ADAPTING TO CHANGE: THE EVOLUTION OF ROAD WEATHER INFORMATION SYSTEMS

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Summary

During significant weather variability, we consider the future of RWIS and wonder what kind of weather system our users will need going forward. The article doesn't offer specific recommendations for advancing Road Weather Information System (RWIS); instead, it seeks to inspire reflection and ideas.

We present some analyses of Road Weather Station (RWS) measurements on Slovenian roads over the last ten years. We have shown how many days per winter season the road surface temperature at each RWS reached 0 °C or less (so called 'cold days'). We also consider the high road temperatures that occur in summer. Local severe weather events with high wind gusts are becoming increasingly frequent. Record sizes of hail have been recorded. Our experience is that because severe weather events can be very localized, it happens that the national meteorological observation networks do not capture all extremes, and that additional, secondary networks of meteorological stations, such as RWSs, can be very valuable. We are of the view that RWIS have evolved beyond its initial purpose of serving merely as winter road maintenance tool. It is increasingly being recognized as essential tool for comprehensive road management throughout all seasons.

Introduction

Since 2007, Slovenia has been employing RWIS to enhance winter road maintenance. This system is especially vital during the winter months due to Slovenia's unique meteorological position, nestled among the western Alps, the northern Adriatic Sea, and the Pannonian Plain. The Slovenian Roads Agency (DRSI), which oversees main and regional roads, and the Motorway Company in the Republic of Slovenia (DARS), which manages motorways, share the responsibility for the road network's upkeep. Both entities operate their respective networks of RWSs, strategically placed on key road sections,

bridges and viaducts. In total, Slovenia boasts over 90 RWSs, predominantly distributed along motorways and regional roads. A more detailed description of the RWIS application can be found in past SIRWEC conferences.

The weather is definitely changing. As developers of RWIS for Slovenia, we're considering its future direction. We're asking ourselves: What will our users require from the system going forward? And what weather-related challenges must the system address to assist our users effectively?

Winter 2023/2024 in Slovenia

According to partial and not yet fully verified data, this year's meteorological winter was exceptionally warm at the national level. Slovenia experienced more precipitation than usual, along with an above-average number of sunny hours [2].

The deviation of air temperature from the average of the comparative period 1991/92–2020/21 was 3.2 °C at the national level, making the winter of 2023/24 slightly warmer than the winter of 2006/07, which had been considered the warmest since at least the winter of 1950/51. Winters 2019/20 (2.6 °C) and 2013/14 (2.5 °C) also had deviations above 2.0 °C. During this period, the coldest winter was 1962/63, with a deviation of –5.5 °C; the second coldest winter, 1953/54, was warmer by 1.7 °C with a deviation of –3.8 °C [2].

Spatially, this winter had the largest temperature deviation from the long-term average in higher elevations and southeastern Slovenia (between 3.3 °C and 4.0 °C), while the deviation was mostly between 2.7 °C and 3.3 °C, only falling below 2.7 °C in parts of western and northern Slovenia. At the national level, the exceptionally warm winter of 2006/07 was warmer than this year's winter in the lowlands inside the country, while the opposite was true, especially in the Primorska region and the mountains [2].

In line with the exceptionally high average air temperature, despite the above-average generous precipitation, there was little snow in the lowland and hilly world. The winter was not record-poor in terms of new snowfall and snow cover, but it was among the worst since the winter of 1950/51. Apart from moderate to heavy snowfall on January 19th in most of Slovenia, there were no other noteworthy snowfalls. The January snow in some lowland areas lasted about two weeks, but usually, in the meteorological winter, the snow cover lasts several weeks, sometimes more than half of the winter. Conditions were different in the high mountains, where an abundance of precipitation, mostly in the form of snow, ensured normal, and locally even above-average good snow conditions [2].

Winter road surface temperatures

Since we have a long series of road temperature measurements, we were interested in how many days per winter season the road surface temperature at each RWS reached 0 °C or less. When it comes to air temperature, meteorologists refer to such days as 'cold days'. Similarly, we can call them that as well. Therefore, we were interested in comparing the number of 'cold days' on the roads over the years. Namely, it is essential for winter services to be prepared for action when road temperatures approach 0 °C. It is also necessary to note that in the analysis for the winter season of 2023/2024, we have considered data up to the end of March, and that a short period of low temperatures may still occur in April. The results of the analysis for the selected RWSs are shown below.

The RWS Hrušica is located on the main road between Jesenice and Kranjska Gora at an altitude of around 590 meters. The climate is alpine. At this location, we recorded the highest number of cold days in the winter of 2012/2013, with a total of 116. In the last two years, we have recorded fewer cold days (just under 80), but the warmest winter at this location was still noted in the season of 2013/2014. The data for the 2019/2020 season is not relevant due to sensor failure.

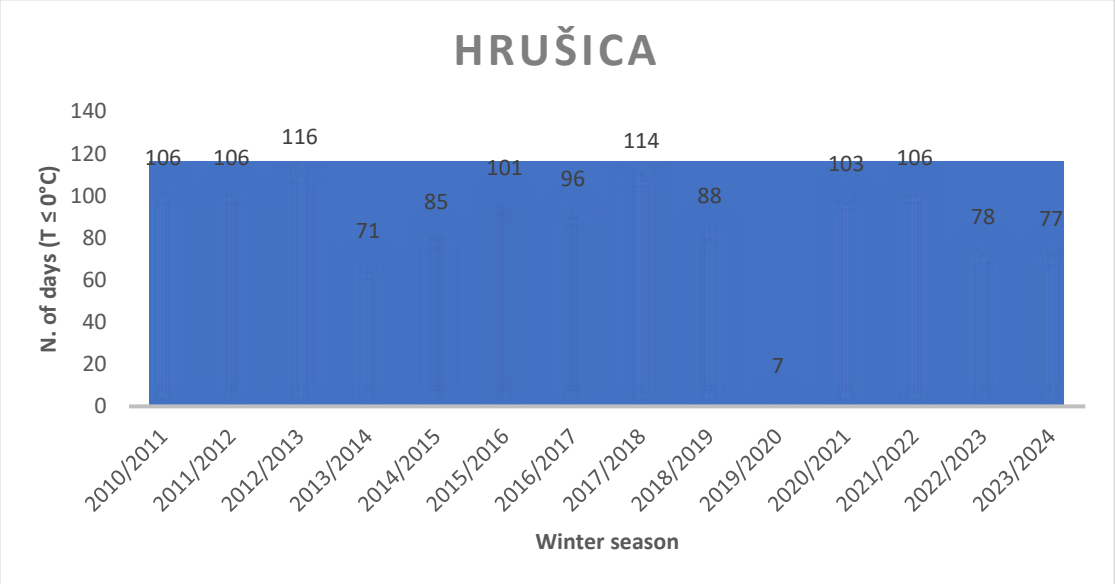

Figure 1: Number of 'cold' days in a particular winter at RWS Hrušica (source: CVIS DRSI)

RWS Vrhnika is located on the main road Ljubljana-Postojna at the southwestern edge of the Ljubljana Marsh at an altitude of 293 meters. The climate of Vrhnika is characterized by the influence of the moderate continental climate of western and southern Slovenia. At this RWS, we have recorded the lowest number of cold days in the last two

winter seasons since the beginning of our measurements in 2010, specifically between 30 and 35 days.

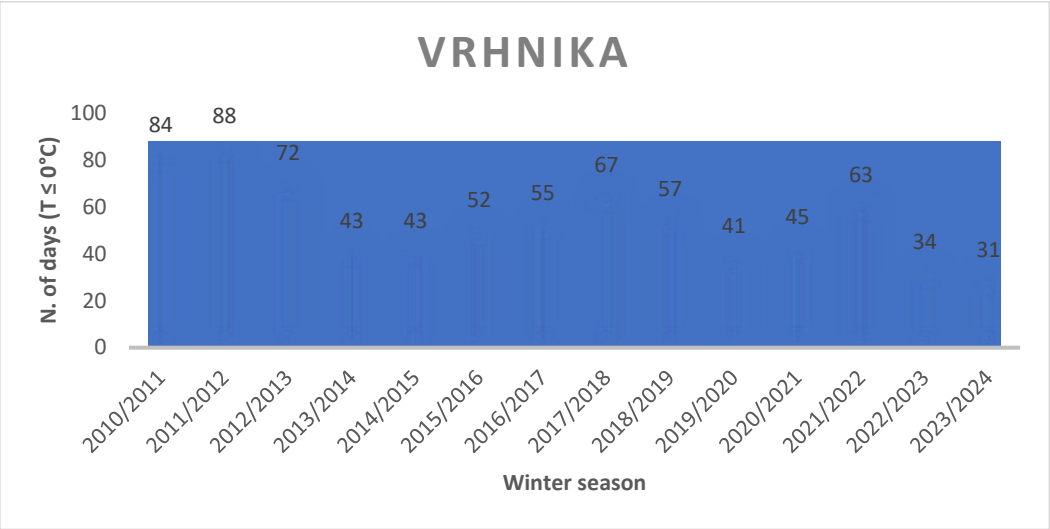

Figure 2: Number of 'cold' days in a particular winter at RWS Vrhnika (source: CVIS DRSI)

Our analysis covered all Road Weather Stations (RWS) on national roads. From the results, we can say that the trend of decreasing the number of cold days per year, when the road temperature is 0 °C or less, is difficult to confirm; we will need to wait a few more years. We expect that the trend will first become apparent at lowland RWS in Mediterranean or continental climates.

Summer road surface temperatures

The 2018 ARSO report, "Assessment of Climate Change in Slovenia by the End of the 21st Century," states that a rise in temperature will significantly increase heat stress [1]. In the case of an optimistic emissions scenario, the number of hot days in Slovenia by the end of the century will increase by about 6 days, in the case of a moderately optimistic emissions scenario by about 11 days, and in the case of a pessimistic emissions scenario by about 27 days. In all emissions scenarios, there will be an increase in the number and duration of heatwaves. In the case of a moderately optimistic emissions scenario, by the end of the century, we will have on average at least one heatwave annually, which will be comparable in intensity or worse than the heatwave experienced in the summer of 2003.

The summer of 2022 was exceptionally warm in Slovenia. The highest road surface temperature was recorded on Saturday, July 23, at 15:30, measuring 56,44 degrees Celsius at the RWS Rimske Toplice (source: CVIS DRSI). On the highways, the temperatures were slightly lower (54 degrees Celsius at the RWS Prilipe (source: CVIS

DARS)). Asphalt temperatures above 50 °C persisted for more than 5 hours daily at numerous RWSs.

The escalating temperatures of asphalt, pose significant challenges for road management and maintenance. High temperatures can lead to a softening of the asphalt, making it more susceptible to deformation under the stress of traffic, resulting in ruts and potholes that compromise road safety and necessitate frequent repairs. Moreover, the increased heat can accelerate the oxidation of asphalt, leading to brittleness and cracks, further exacerbating maintenance issues. The aspect that high temperatures of road surfaces heat up the surroundings and represent heat islands in an urban environment is also not negligible. To combat these effects, innovative solutions such as high-reflectivity surface treatments and the use of modified binders that withstand higher temperatures are being explored.

Wind gusts

In Slovenia, we have witnessed stronger weather events in recent years, including strong winds that can occur very locally. Last summer, we even witnessed a tornado that developed on August 1st in the area of Ilirska Bistrica and caused significant damage along the narrow path it travelled.

The national meteorological network of weather stations in Slovenia was updated and densified in the Bober project, which took place from 2010 to 2015. This network operates excellently and significantly contributes to better weather monitoring and also to improved meteorological forecasts. However, we notice that because severe weather events can be very localized, it happens that this network does not capture all extremes and that additional, secondary networks of meteorological stations, such as RWSs, can be very valuable. As an example, we cite the stormy gusts of wind on August 18, 2022, which were measured by RWS, but were not recorded by the national meteorological network.

On that particular day, we were surprised by a very strong wind ahead of the storm system that arrived from the north of Italy. At some meteorological stations, ARSO reported record measured values (for example, Ljubljana Bežigrad 102 km/h). In the RWS network on the highway (DARS), we measured gusts of wind that were extremely high and dangerous for traffic: The record value that day at 12:50 was measured at the Malence junction near Ljubljana, specifically 125.5 km/h. High wind speeds were also measured at the Reber viaduct on the Dolenjska highway at that time, 107 km/h. Strong gusts of wind were measured by DARS's RWSs practically all over Slovenia: RWS Ajdovščina 116 km/h,

RWS Peračica and RWS Šentožbolt 94 km/h, RWS Ribnik 93 km/h... Especially if the wind is from the side and vehicles are moving at higher speeds, these values can already be very dangerous. Wind measurements on RWSs can thus be very valuable throughout the year.

Hail

According to the European Severe Storms Laboratory (ESSL, 2023), in 2023 records were broken not just concerning the amounts of large and very large hail, but also in terms of the maximum hail sizes. Europe's largest (photographed) hail record was broken twice in a mere 5 days in Italy. On 19 July, 16 cm hailstone was reported, followed by 19 cm hail on 24 July. Giant hail fell also in Slovenia (the largest hail reaching 13.8 cm) [3].

Hailstorms pose a substantial risk to road safety, impairing visibility, inflicting damage on vehicles, and making road surfaces treacherous. Additionally, they can lead to hazardous driving behaviors; drivers, in a state of panic, might abruptly halt on the roadways or rush to find cover in tunnels or beneath overpasses. Consequently, it's crucial for traffic authorities to accurately monitor these hail occurrences and swiftly communicate the data to the traffic control centers to ensure drivers are promptly warned and can take necessary precautions.

To measure the type of precipitation at RWSs in Slovenia, we use 'compact - all in one weather stations' from various manufacturers. We have observed that the measurements of hail at our RWSs are not reliable. It is necessary to consider upgrading the RWSs with hail sensors to improve accuracy.

Conclusion

Our experience indicates that weather is becoming an increasingly significant factor in traffic management and road maintenance, and that reliable weather information is something road managers need more than ever before. We believe that RWIS is no longer just a support tool for winter road maintenance but is becoming a year-round traffic management aid due to intense weather events.

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