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LESSONS LEARNT FROM ROUTE-BASED FORECAST VERIFICATION

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Summary

The high resolution route-based forecast is crucial for optimising preventive road measures in winter. We at CGS Labs have developed and are continuously improving our RBF model. The latest contribution to that end was the acquisition of Marwis mobile measurement sensor. The accuracy of the route-based forecast was verified using the Marwis mobile sensor on carefully selected motorway section. We drove the section in different weather conditions and times of the day and compared the measurements with the forecasted values. The results will help us understand more accurately which parameters impact the localized road temperature differences.

Introduction

Forecasting the meteorological condition of the road surface is crucial for carrying out preventive treatment. Preventive treatment uses less salt and is therefore more cost-effective and environmentally friendly. In recent years, developers of RWIS/MDSS systems have been faced with the technical challenge of how to convert point-based weather forecasts from weather station locations into a continuous (route-based weather forecast - RBF). Several papers on this topic have been presented at SIRWEC [1, 2, 3], as well as at PIARC conferences [4, 5]. In fact, the road can be very variable in terms of temperature. On a typical winter night, the temperature differences on a short stretch of road (e.g. 1 km) can vary by up to 10 °C. As a consequence, some stretches may be below the freezing point while others may not. The patterns and distribution of warm and cold sections are established and determined by local environmental factors and prevailing weather conditions. Therefore, a high-resolution RBF makes sense as it represents a step forward in optimising salting (allowing for sectional treatment) and will be of even greater value when autonomous vehicles are on the roads.

RBF has also been a subject of development at CGS Labs for many years. RBF verification is key to this. In this paper, we present the results of the verification we have carried out over the last winter.

Methods

RBF was tested on the Ljubljana - Trojane motorway section (approx. 30 km). The section of the motorway closer to Ljubljana is 13 km long and runs on flat terrain, while the other part of the selected section is more rugged and 17 km long. There are also 5 DARS road weather stations on this section of the road.

The RBF is calculated in reference points. A reference point is a geo-location on the motorway. At each reference point, a forecast of the road surface temperature is calculated every hour for 12 hours ahead. There are approximately 12,000 reference points on the entire motorway network in Slovenia. On the test section, there are 509 reference points, which are located approximately every 50 metres.

Measurements of road temperature, road condition, water film thickness and coefficient of friction were made with a contactless Marwis sensor from Lufft (OTT Hydromet). The Marwis was mounted on the rear of the vehicle at a height of 1 m from the ground, as required by the manufacturer for this model of sensor. The motorway section was driven in either one or both directions.

To make it as easy as possible to compare the Marwis measurements with the forecasts at the reference points, the measurement interval was set to 1 second and the test section was driven at speeds of up to approximately 90 km/h (25 m/s).

Quality measurements are highly dependent on the correct calibration of the sensor before each test section is measured. Following the measuring equipment manufacturer's instructions exactly means that, after cleaning the optical parts of the sensor, the calibration is carried out at a suitable temperature (or the sensor is warmed up to operating temperature), on a dry asphalt substrate comparable to that of the test section and that the calibration time is set to 60 seconds. Given the timing of the measurements (late winter/early spring), the 'AVG' (average) model was used among the pre-set models to calculate the road condition. This ensured the most reliable measurements.

The measurements were carried out in March and early April. During this time, 14 runs were carried out at different times of the day and under different weather conditions.

For the first analysis, we wanted to compare the Marwis measured mobile road temperature with our RBF road temperature model. From the data of each run, we found the closest measurement point for each reference point on the motorway. Since the time of the measurement is known (T_1), we found for the reference points the forecasts for the time T_1 calculated at T_1 - 1h, T_1 - 2h, T_1 - 3h, ... T_1 - 10h, T_1 - 11h and T_1 - 12h in the second step. An analysis of the difference between the measured temperatures and the forecasted temperatures is shown in the next section.

For the second analysis, we wanted to compare the measured mobile road temperature with the measured sensor temperatures at the five road weather stations located on the section. From the data of each run, we found the closest measurement point for each station on the motorway. For the time of the mobile measurement (T_1), we found the closest measurement in time from the station and compared the values. This analysis gave us a measure of confidence in the mobile measurements.

Results

The results of the first analysis showed that the difference between the measured temperature and the forecasted temperature increases with the forecast time difference. Interestingly, the forecasts for 1 to 3 hours ahead are quite similar. It is only when we forecast 4 hours ahead or more that the accuracy decreases and the error increases.

For forecasts 1 to 3 hours ahead is:

- The average difference is 1.5 degrees Celsius.
- Half of all forecasts have a difference of less than 2 degrees Celsius.
- For 75% of forecasts, the difference is less than 4 degrees Celsius.

The results of the second analysis can be seen in the table below and show that the mobile sensor measurements do not deviate significantly from the road weather station measurements. However, as we are only comparing two measurements against each other, there are also significant differences in some places, which should not be given too much weight as there are too many variables that affect the measurement during driving.

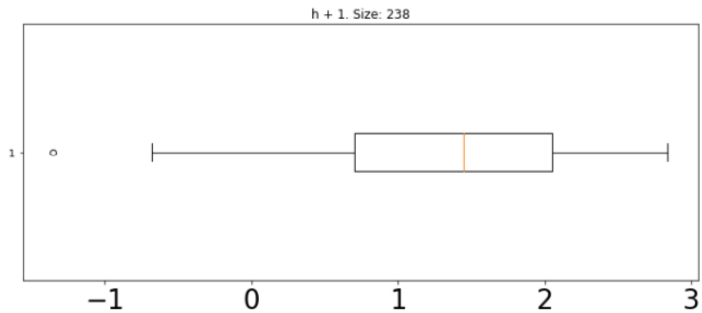

Fig. 1. Difference between the measured temperature and the predicted temperature 1 hour ahead on a flat section

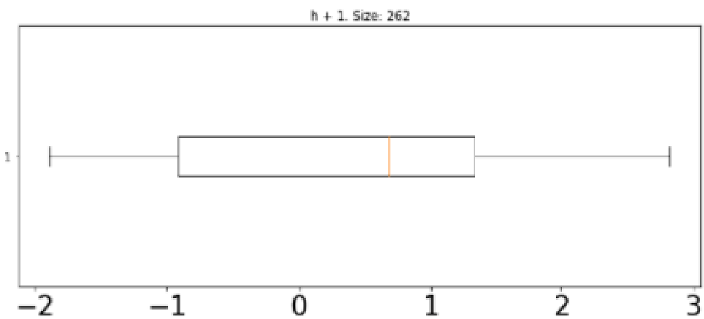

Fig. 2. Difference between the measured temperature and the predicted temperature for 1 hour ahead on a rugged stretch

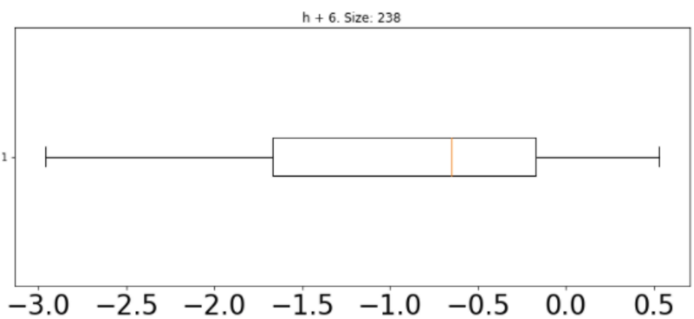

Fig. 3. Difference between the measured temperature and the predicted temperature 6 hours ahead on a flat section

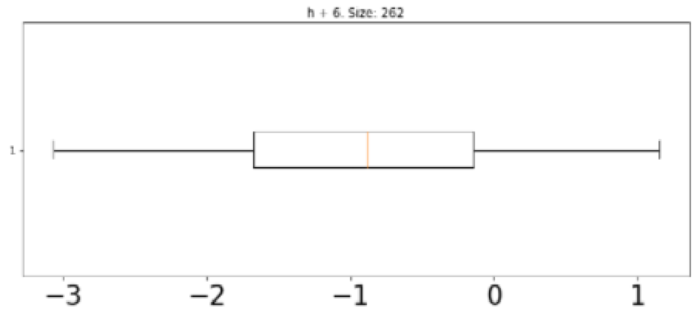

Fig. 4. Difference between the measured temperature and the predicted temperature for 6 hours ahead on a rugged stretch

Table 1. Difference in temperature measured at a road weather station and measured with a mobile meter (source for RWS measuremens DARS d.d.)

	Station 1	Station 2	Station 3	Station 4	Station 5
Drive 1	0.01	0.70	3.40	2.60	1.79
Drive 2	0.99	1.36	4.32	2.09	1.44
Drive 3	0.47	1.61	1.0	0.51	0.73
Drive 4	0.34	--	0.84	0.37	1.02
Drive 5	0.10	1.28	1.73	1.62	0.53
Drive 6	0.08	0.92	1.65	0.96	0.72
Drive 7	1.29	4.07	0.45	0.80	1.48
Drive 8	0.06	1.71	2.76	2.93	0.83
Drive 9	1.10	0.76	2.29	2.43	0.87
Drive 10	0.34	0.43	2.53	1.69	0.80
Drive 11	0.58	0.01	2.14	1.60	0.44
Drive 12	0.23	0.13	0.03	0.18	0.40
Drive 13	0.08	0.29	0.73	0.15	0.34
Drive 14	0.03	0.93	0.90	0.62	0.26

Conclusions

The mobile measurements and the analysis are a welcome insight into the state of the RBF. We have this year's forecast accuracy indicator. In the future, we will have to carry out a more detailed analysis, from which we will also be able to draw out patterns that can be used to further improve the RBF.

We assume that the forecast error is due to the second subsection, which is more rugged and has more shaded parts. Further studies are likely to show that the lowland sub-region has better prediction accuracy precisely because of its more uniform topography.

Acknowledgements

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