CAN MDSS SYSTEMS REALLY WORK? KM BY KM FORECASTING IMPROVING WINTER MAINTENANCE EFFICIENCY IN THE CZECH REPUBLIC

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ABSTRACT

The history of maintenance decision support system in the Czech Republic dates back to 2007 when the first pilot project started in one of the 14 regions of the country. Since the beginning state- and regional road authorities, national meteorological office and winter maintenance contractors were involved in the project. MDSS in the Czech Republic was specifically developed for local conditions by cooperating companies from the Czech Republic and Sweden.

The presentation will show the experience of operators with the implemented MDSS system including case-study of selected time windows where MDSS helped to solve the winter-related weather situations in time. Testimonials of users and statistical evaluation of short-term prediction accuracy and reliability will also be covered.

The speaker will touch the issue of quality control and accuracy evaluation of short-time road weather prediction of MDSS system that provides predictions for all the road segments including the parts where meteorological data from road weather stations or professional weather stations are not available.

MDSS has direct and substantial impact on management of winter service, especially on planning. The irreplaceable applied prediction of road slipperiness is provided by MDSS for each 1 km of road network 1-12 hours ahead. The intervention and winter maintenance can be precisely targeted to specific risk instead of the road network and using this selective maintenance or selective salting brings the users proven cost savings.

1. INTRODUCTION

Maintenance Decision Support System – MDSS is complex computer-based system that processes geographically localized information about meteorological and local conditions to provide short-time prediction of road surface status in the winter season. MDSS brings concise information in necessary for correct and timely decision-making. It provides the information in advance that allows the maintenance operators to prepare the staff and technique for fast and efficient intervention.

The key approach to winter road maintenance information support is to provide the users with overview of historical, current and future weather situation. All these factors are considered within MDSS forecast. Thanks to this, MDSS represents unique applied forecast which is build up on well-researched, expert knowledge in phenomena between pavement and surrounding atmosphere.

MDSS due to microclimatic model forecasts the air mass behavior by ALADIN numerical model to road surface behavior. All the updated data are processed every hour to produce

the road forecast including road condition, road surface temperature (RST), freezing point temperature and snow amount for upcoming 24 hours with one hour step for each 1 km segment of the road network.

2. PREPARATION OF MAINTENANCE DECISION SUPPORT SYSTEM

2.1 Prediction of MDSS model

Primary physical model implements expert knowledge of complex processes proceeding on the road surface and within its immediate surroundings. Solution of MDSS was integrated prescribed data sources, described in the paragraphs below. MDSS is a really complex system that processes large amounts of data for accurate forecast publishing.

2.1.1 Data base for static integration

Chosen data bases are integrated to MDSS at initial setup of computing and physical model, so it creates local geographical database. It stands for group of background data needed to build up and configure the model describing the selected road network (see Figure 1). It is used in order to define the initial state of the study area, its local climatological conditions and variations.

2.1.2 Data base for dynamic integration

Chosen data bases are integrated by way at each actualization of forecasts are actual data loaded for time of calculation. Online information data (see Figure 2) are necessary for describing the current and future situation in the area. The most important source is of course the numerical weather prediction model which is responsible for giving an overview of future conditions. Data from road weather and professional climate stations are also of high importance.

2.2 Function of MDSS model

MDSS model implements the principle of road surface thermal balance that think of road construction, detail model of insolation degree and height of the Sun above the horizon in combination with topography data and land use data near the roads. Model implements a special approach to forecasts for road sections leading across the bridge decks.

MDSS model further implements an advanced model of daily variability of traffic flow and advanced procedure of GPS data addressing of winter road maintenance to the individual computing of road sections.

As the MDSS is iterative and self-actuated model, there is strong need to keep reliable and never-failing data providing cooperation so there are still the most updated data in the system. MDSS model is made robust, so it can still provide valid forecasts in case of some accidentally missing data. For example, an advanced approach is implemented to substitute the individual station data from other stations in case of station failure. It is clear that the weather prediction model is indispensable.

MDSS model allows regular adjustment recalibration of all internal parameters that affect the forecasts accuracy (conformity of forecasted parameters with later measured characteristics). It is guaranteed to modificate the basic setup of MDSS model to increase forecast accuracy in the future. MDSS model also guarantees possibility of extension / extent adjustment of road network and extent of road weather stations network.

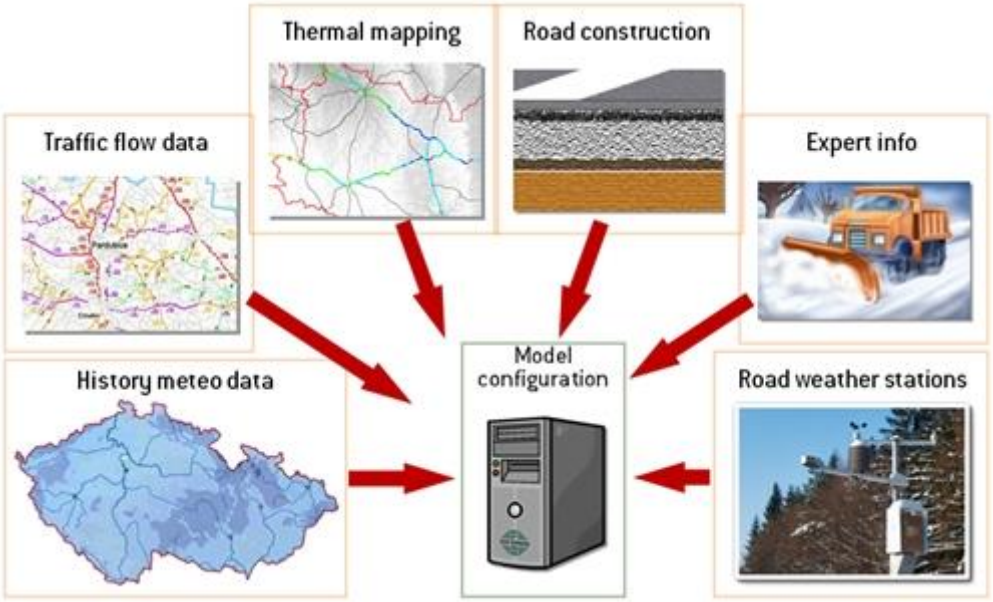

Figure 1: Input data for model configuration.

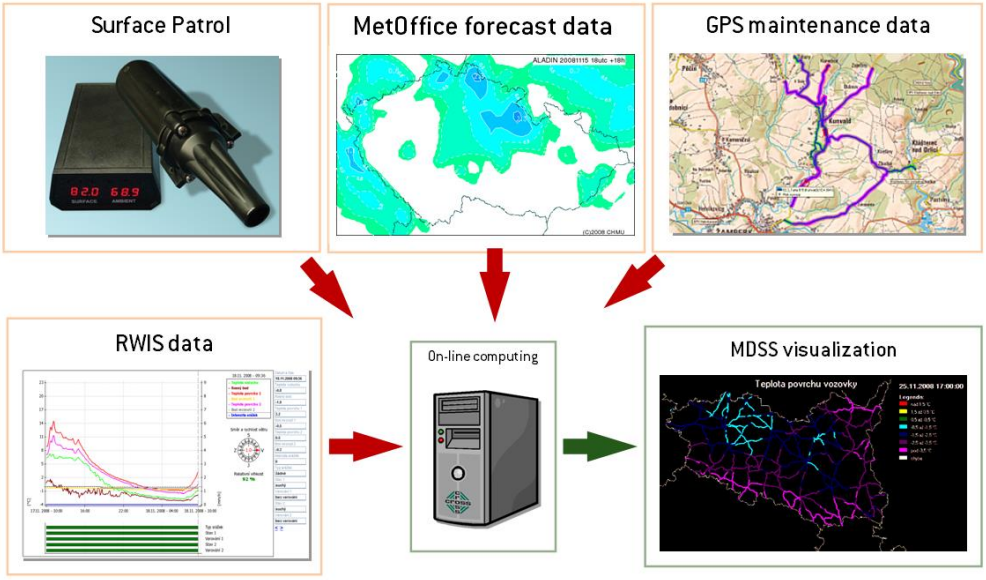

Figure 2: Input data for real-time computing.

2.3 Service of MDSS model

Computing MDSS model has an output digital collection of forecast´s parameters in open format to facilitate use of forecasted outputs for actual road weather information systems. The collection contains all forecast´s parameters for all basic spatial computing units and all needed forecast´s horizons.

The model output for the users (see Figure 3) is the animation of two maps depicting predicted road surface temperature and road condition hour by hour for upcoming 12 hours. Digital map provides animation of forecasting horizons. Way of access to MDSS outputs is by secure access using road weather information system METIS.

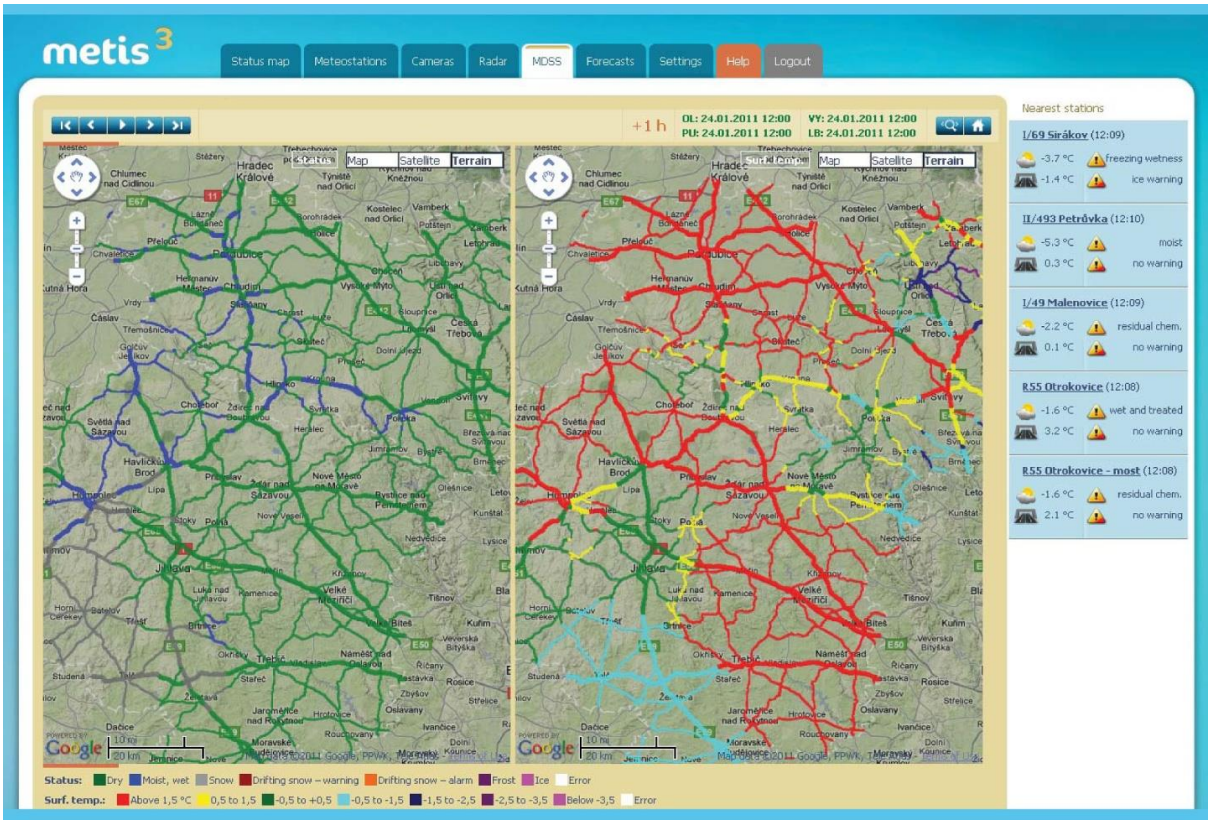

Figure 3: Screenshot of MDSS integration in METIS.

3. CASE STUDY OF MDSS WEATHER FORECAST

The support system for winter maintenance is in operation from winter season of 2007/2008 in the Czech Republic. Now more and more regions are using the MDSS road surface temperature and status prediction system for their road network – the whole country is to be fully covered by 2014 (see Figure 4).

Here it comes analysis of chosen meteorological situation in Kralovehradecky Region from the perspective of line forecast evaluation of road surface temperature and status condition, measured parameters of road weather stations, radar and camera pictures.

3.1 Kralovehradecky Region

The second week of February 2013 was normal with minimum deviation from long-term average in air temperature and rainfalls. The average daily amplitude of air temperature was about 2 °C lower than long-term average is due to dominant cloudiness. February 12th fell the most rainfalls, mostly snowy in the north and east of the Czech Republic.

During the 9 a.m. to 6 p.m. in February 12th 2013 was published the special weather forecast for winter road maintenance by Czech Hydrometeorological Institute. Forecast for Kralovehradecky Region describes cloudy sky with gradual snowing of lower intensity from southeast and wind speed 3–4 m/s. The air temperature 600 meters above sea level should reach -4 to 0 °C.

Figure 4: Regions in the Czech Republic with MDSS implemented (blue).

Hour after midnight of February 12th 2013 was also published line forecast for the next 10 hours by maintenance decision support system. Appendix 1a shows occurrence of road status and road temperature for area of region. The road weather stations I/14 Devet krizu, I/35 Klenice and I/16 Vestrev forecasted snow road status (grey color), resp. wet road status (blue color). The road temperature in area of snow cover reached -0,5 to +0,5 °C (green color).

The next source to case study interpretation was the road weather station I/16 Vestrev (see Appendix 1b). The road weather station is situated in mid altitude 339 meters above sea level. In time of seen forecast (11:00 a.m.) reached rainfall intensity 3–6 mm/h at the measurement point. Due to advection weather character outlasted air and road temperature close to -3 °C. The road sensor evaluated the road status as a freezing wetness that indicates initial phase of freezing air humidity at road surface. Realization of appropriate weather conditions was published ice warning to late afternoon hours. Snowfall and continuous snow cover on the road surface was confirmed by camera´s pictures of road weather stations I/14 Devet krizu and I/16 Vestrev (see Appendix 1c).

4. METHODS AND RESULTS OF THE FORECAST ACCURACY EVALUATION

The forecast accuracy is evaluated in relation to the road weather stations measurement situated in region. The road weather stations are one of the basic inputs for MDSS model and line forecasts deriving. Stations are also the most suitable means for forecast accuracy evaluation.

The road weather station measures the road parameters continuously in time. Measurement interval is each 6 minutes. In relation to analysis of the MDSS forecast accuracy are selected road surface status, road surface temperature and also warning data. Database contains more than 3600 forecasts for one station to winter season evaluation (November 1st – March 31th).

Evaluation is divided into two main parts:

- Analysis of the forecast accuracy of road surface status
- Analysis of the forecast accuracy of road surface temperature

4.1 Analysis of the forecast accuracy of road surface status

Analysis of the accuracy prediction of road surface status compares the predicted and appropriate later measured road surface status, respectively station warning. The result is **the error matrix**, where the rows are prediction categories and in the columns are measurement categories (see Figure 5). For each pair of measurement–forecast is increased value by 1 in the cell. The completed matrices then show the distribution of all evaluated predictions.

Further it exists scale matrix assessing the level of error individual pairs of measurement–forecast (see Figure 6). Value of the error is zero on the imaginary diagonal matrix – e.g. when the dry road status is predicted and dry status is also measured later. On either side of the diagonal of the error value increases in the case of a road condition up to 4 and in the case of warning stations to 3 – e.g. when the icy road status is predicted and later measured dry status. Individual categories of errors are highlighted in matrix by coloring cells.

Status	DR	TR	MO	WE	WT	SN	PF	FR	IC	ER
Dry	2347	0	1743	29	0	0	56	0	0	3510
Wet	145	0	1682	119	0	0	41	0	0	828
DriftLow	0	0	0	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0	0	0	0
Snow	0	0	20	2	0	0	23	0	0	232
Slipp	25	0	63	3	0	0	30	0	0	349
Hazard	87	0	82	0	0	0	12	0	0	224
ER	0	0	0	0	0	0	0	0	0	36

Warning	noW	R	S	F	W	A	ER
Dry	4095	4	0	42	15	0	3529
Wet	1868	18	0	0	101	0	828
DriftLow	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0
Snow	22	0	0	10	13	0	232
Slipp	87	0	0	21	12	0	350
Hazard	171	0	0	2	8	0	224
ER	0	0	0	0	0	0	36

Figure 5: Error matrix – pattern.

Forecast: Dry, Wet, DriftLow – Snow drifts warning, DriftHigh – Snow drifts alarm, Snow, Slipp – Frost, Hazard – Ice, ER – Error.

Status measurement: DR – Dry, TR – Residual chemicals, MO – Moist, WE – Wet, WT – Wet and treated, SN – Snow, PF – Possible frost, FR – Frost, IC – Ice, ER – Error.

Warning measurement: noW – No warning, R – Precipitation, S – Snow, F – Frost, W – Ice warning, A – Ice alarm, ER – Error.

Dividing the inner product of error matrix and dividing scale matrix by number of cases can be derived so-called **the error index**. It takes the values from 0 to 4 for road surface status and from 0 to 3 for warning stations. The lower error index is the more accurate the

predictions were evaluated. Similarly it is possible deduce the error index only for non-zero errors and the proportion of cases in each category of errors.

It should be noted that not all errors allocated under the diagonal must be errors predictions. It is not possible at the moment of forecasts release to predict winter road maintenance activity. In other words the status is predicted which can´t take into account the unexecuted winter road maintenance yet. For example, when it is predicted the frost status for +3 hours and winter maintenance vehicle grits the road one hour after the forecast, it is clear that the frost status does not actually occur.

Status	DR	TR	MO	WE	WT	SN	PF	FR	IC
Dry	0	0	0	1	1	2	3	3	4
Wet	1	1	0	0	0	1	2	2	3
DriftLow	2	2	1	1	1	0	1	1	2
DriftHigh	2	2	1	1	1	0	1	1	2
Snow	2	2	1	1	1	0	1	1	2
Slipp	3	3	2	2	1	1	0	0	1
Hazard	4	4	3	3	1	1	1	1	0

Warning	noW	R	S	F	W	A
Dry	0	1	2	3	3	3
Wet	0	0	1	2	2	2
DriftLow	1	0	0	1	2	2
DriftHigh	1	0	0	1	2	2
Snow	1	0	0	1	2	2
Slipp	2	1	1	0	1	1
Hazard	3	1	2	1	0	0

Figure 6: Scale matrix.

Evaluation of the road surface status is done for one winter season from November 1st to March 31th. The evaluation splits into six sub-analysis within it´s a limited number of cases evaluated:

- Analysis of the first 3 hours forecast (identifier „em3“)
- Analysis of the first 6 hours forecast (identifier „em6“)
- Analysis of the first 12 hours forecast (identifier „em12“)
- Analysis of the first 3 hours forecast + Measured RST below +3 °C (identifier „em3u3“)
- Analysis of the first 6 hours forecast + Measured RST below +3 °C (identifier „em6u3“)
- Analysis of the first 12 hours forecast + Measured RST below +3 °C (identifier „em12u3“)

Appendix 2 shows the error indexes derived from error matrices in relation combination of status and warning and all and chosen pairs measurement–forecast for the winter season 2012/2013 in Zlinsky Region. In each combination of status and warning and all and chosen pairs measurement–forecast there are three data points appropriating of analysis the first 3, 6 or 12 hours of forecast for each station. There is always listed item „All“ as last, its together represents all stations of region. The graphs in most cases show higher

error for forecasts at more distant horizons. It means error in the first 12 hours is higher than the first 3 hours.

Appendix 3 presents error matrices for all stations and all six sub-analysis. Appendix is totally processed for the winter season 2012/2013. There is an identifier of station on the top left. The list contains 6 times (em3 to em12 u3) two tables (evaluation of status and warning). It is performs the classification of error categories using coloring error matrix in all tables.

4.2 Analysis of the forecast accuracy of road surface temperature

Analysis of the forecast accuracy of road surface temperature compares predicted and corresponding later measured road surface temperature (predicted minus measured). The result is a derivation of the average error alias average absolute error in determining the temperature. Average errors are evaluated for each forecasting horizons in the first 12 hours of forecast.

Evaluation of the road surface temperature is done for one winter season from January 1st to March 31th 2013. Evaluation splits into two sub-analyzes:

- Analysis of all pairs of measurement–forecast
- Analysis of chosen pairs of measurement–forecast when it was measured RST below +3 °C

Boundary +3 °C was set intentionally. It is an increased risk of snow and freezing symptoms at temperatures below +3 °C so it placed increased demands on the winter road maintenance. Therefore it is increased the demand for quality and accuracy of forecasts in such situations. Analysis evaluating the number of cases with the measured temperature below +3 °C can be said that the average road surface temperature (derived from all the considered stations) forms below the specified limit of +3 °C about 65% share in each of the regions.

The evaluation is divided into two sub-analysis. The analysis of all pairs measurement–forecast (identifier „T“) and the analysis of chosen pairs measurement–forecast when the RST was measured under 3 °C (identifier „T u3“). The absolute characteristics are quoted by identifier „abs“. The characteristics are performed for all stations in Zlinsky Region (Appendix 4). The smallest absolute divergences were reached at the station R55 18,2 (cm1112) in the winter season 2012/2013.

Interesting results has stations I/69 Sirakov (cm0002) and I/35 Horni Becva (cy17) in tables labeled „T“ and „T u3“. The average error of temperature determine at I/69 Sirakov station is practically the most pessimistic forecast side of all stations in all months. The opposite is seen at the station I/35 Horni Becva where the most average error is at the optimistic side from November 1st to March 31th, standard in later forecasted hours.

It is possible to read in Appendix 4 the forecast accuracy of road surface temperature is significantly better for measuring under 3 °C. It is good news because MDSS is forced for the winter conditions with negative temperatures.

5. CONCLUSION

Winter maintenance support as a very complex issue where it is necessary to combine various data inputs and to bring the desired output to the final users. Growing number of road weather stations and the meteorological data they produce represents only the first level of the “meteo-pyramid”. As there are more and more outstations, it is useful to have a road weather information system to visualize the data. The maintenance operators also benefit from road prediction model or decision support system because it can simplify all the data needed to describe the road weather into clear and bright information. In the end there is a system for cross-controlling the performance of maintenance made by different contractors to reach the optimal extent and intensity of the maintenance.

Obviously, we had to overcome initial hesitation and little disbelief of a few old local professionals but our long-term excellent results and accuracy convinced them… Yes, it is possible to simplify the prediction of road weather and even to use smart way of winter road maintenance.

Using of MDSS brought small direct cost saving as a planning of night and weekend readiness in Pardubice Region – e.g. the dispatcher who has a MDSS readiness at home costs less than the dispatcher who works at the winter maintenance office.

In the upcoming winter season 2013/2014, the road meteorology eagerly await the arrival of a new version of the MDSS. Simultaneously, the predicted data of the surface temperature and road conditions will be added by information about the recommended method of winter maintenance for up to 24 hours, the amount of applied de-icing materials and timeline of made and plan activities associated with maintaining safe passable roads.

REFERENCES

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2. POSPISEK, T., BALAJKA, M., KONECNY, D. (2009). Maintenance Decision Support System. ITS Prague ’09, conference proceedings, 30 March – 1 April 2009, Prague.
3. POSPISEK, T., KONECNY, D. (2010). METIS: Road Weather Monitoring and Presentation System. Lakeside 2010, conference proceedings, June 2010, Lakeside Austria.

APPENDIXES

Appendix 1a: Road surface status and road surface temperature (12th February 2013 at 01:00 a.m. +10 hours).

Appendix 1b: Line graph of the I/16 Vestrev road weather station and radar picture of the Czech Republic in time 10:00 a.m. UTC.

Appendix 1c: Overview camera pictures of the I/14 Devet krizu and I/16 Vestrev road weather stations.

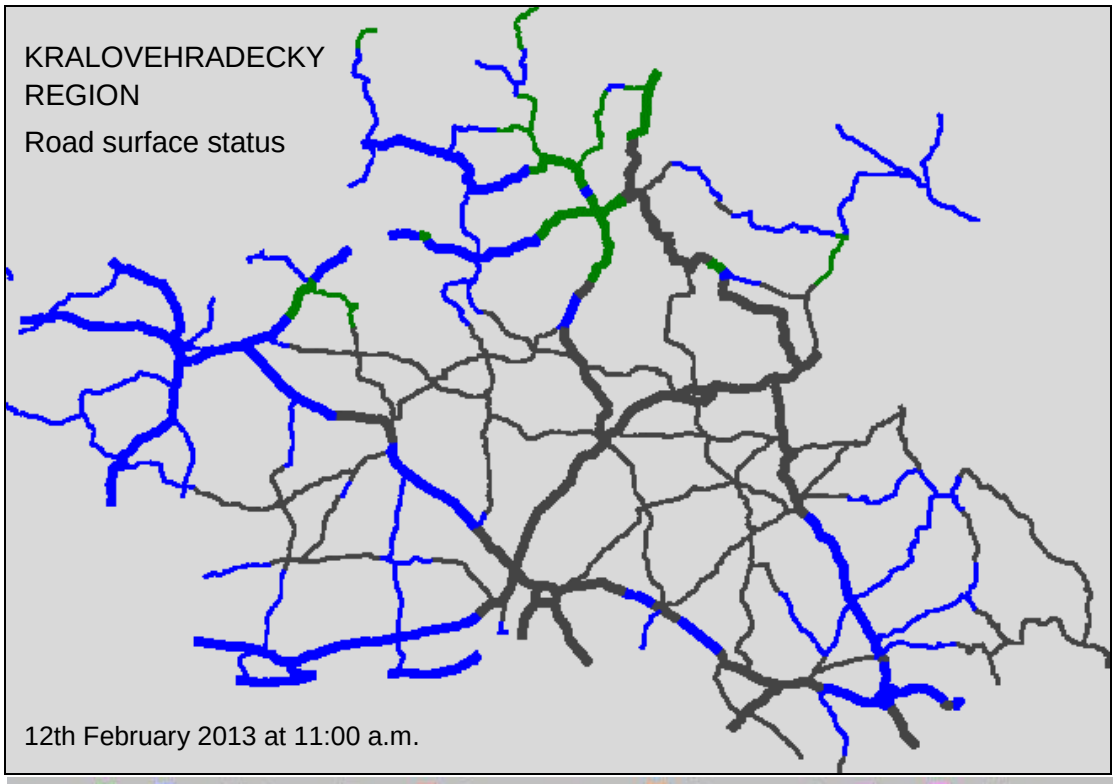
Appendix 2: The forecast accuracy evaluation of road surface status. Zlinsky Region. Winter season 2012/2013.

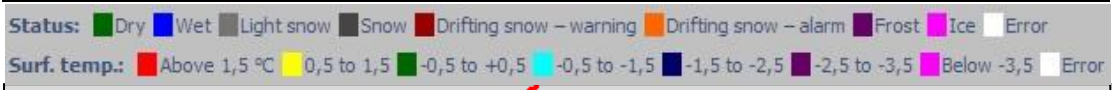
Appendix 3: Error matrices of all road weather stations. Zlinsky Region. Winter season 2012/2013.

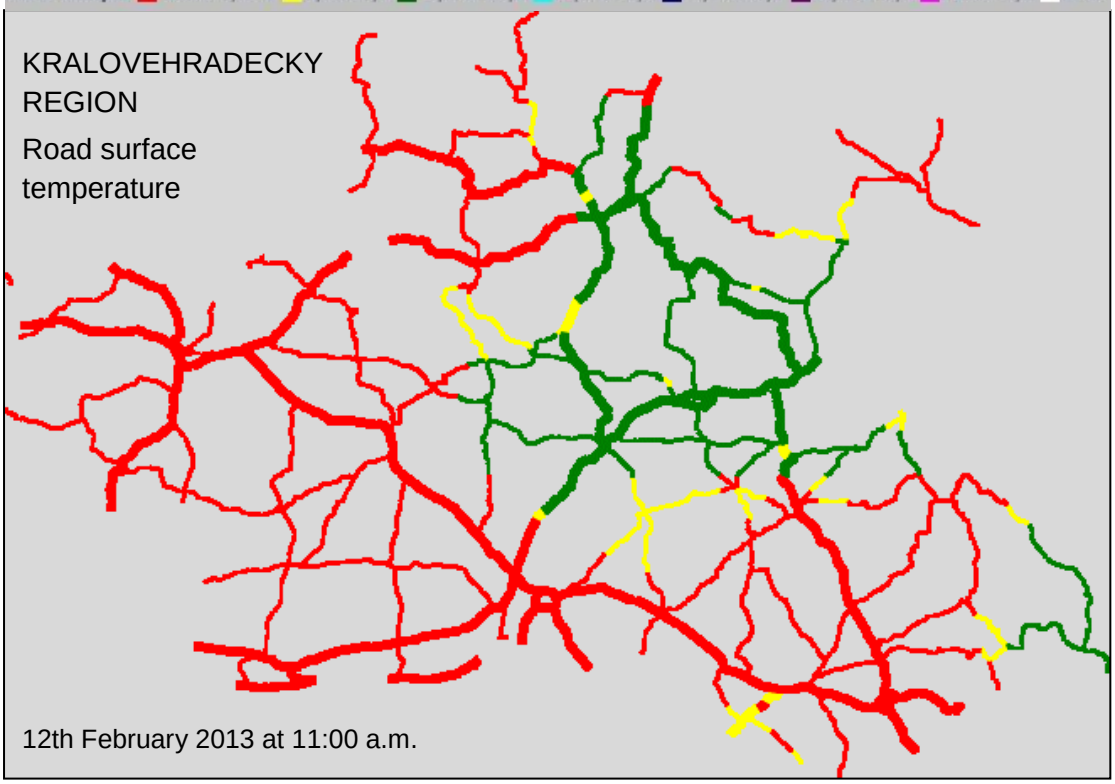
Appendix 4: The forecast accuracy evaluation of road surface temperature. Zlinsky Region. Winter season 2012/2013.

Appendix 1a: *Road surface status and road surface temperature (12th February 2013 at 01:00 a.m. +10 hours).*

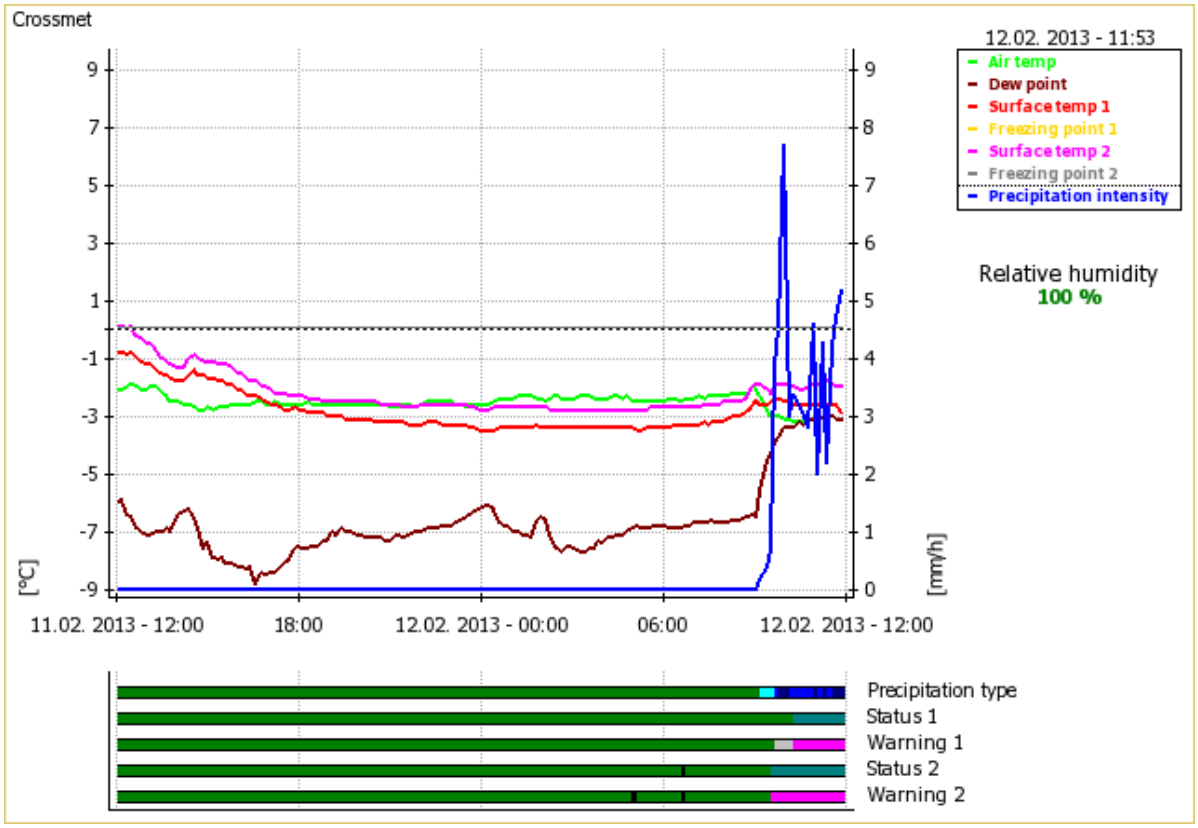
Forecast issued on 12th February 2013 at 01:00 a.m. +10 hours, i.e. on 12th February 2013 at 11:00 a.m.

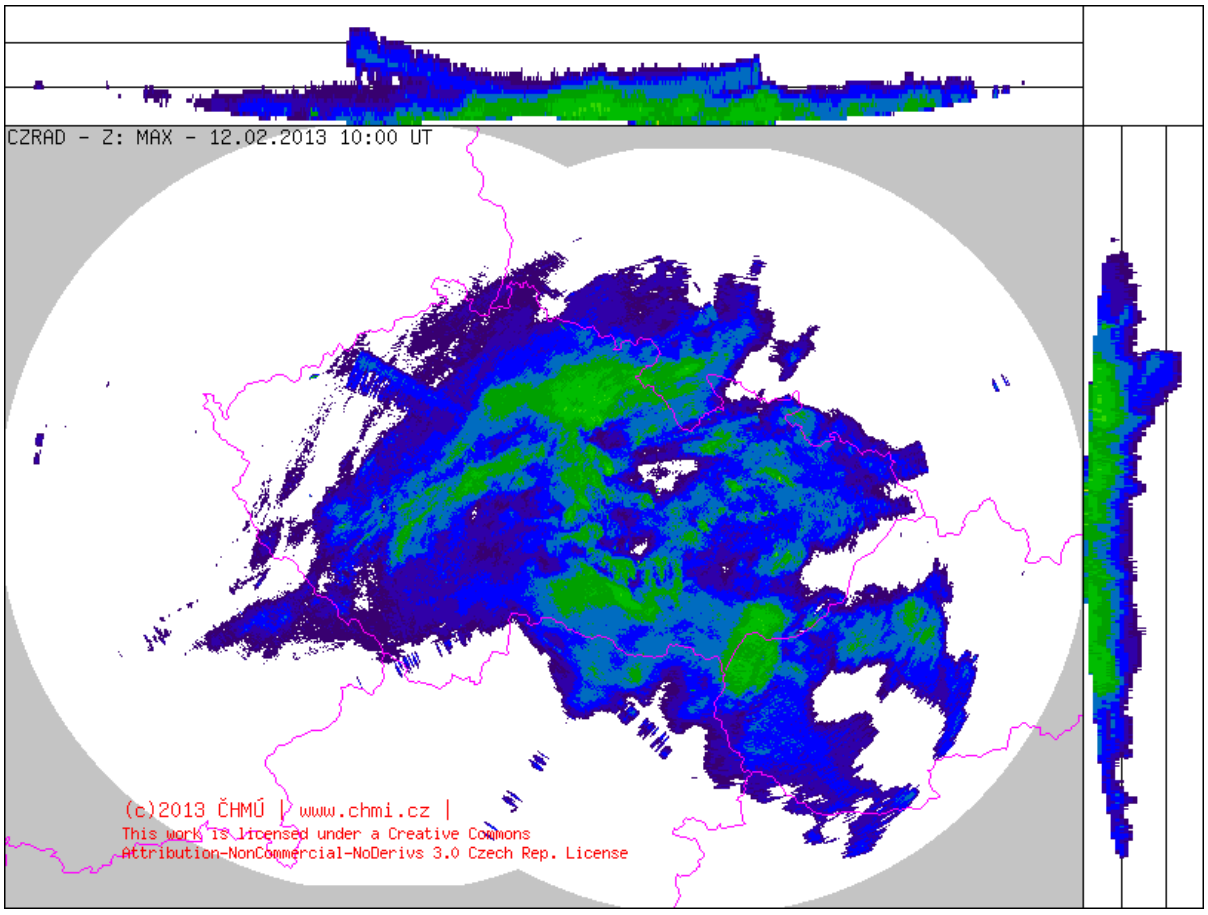






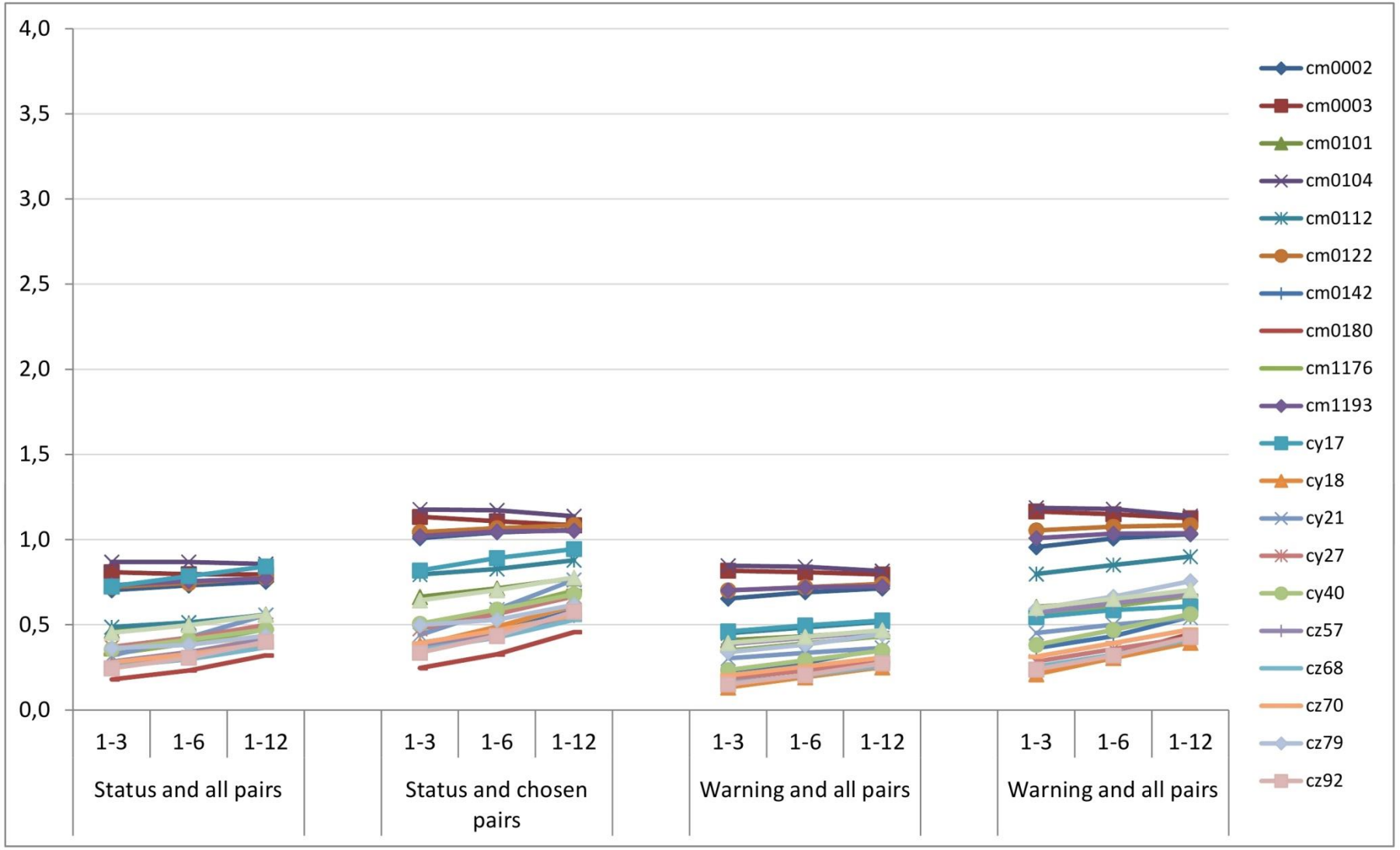
Appendix 1b: *Line graph of the I/16 Vestrev road weather station and radar picture of the Czech Republic in time 10:00 a.m. UTC.*





Appendix 1c: *Overview camera pictures of the I/14 Devet krizu and I/16 Vestrev road wether stations.*

Appendix 2: *The forecast accuracy evaluation of road surface status. Zlinsky Region. Winter season 2012/2013.*



Apendix 3: *Error matrices of all road weather stations. Zlinsky Region. Winter season 2012/2013.*

All

em3

RCST1	DR	TR	MO	WE	WT	SN	PF	FR	IC	ER
Dry	88211	16788	32913	6834	6248	837	7598	4988	391	1467
Wet	2311	1607	5059	5089	3435	64	502	10	3	141
DriftLow	0	0	0	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0	0	0	0
Snow	581	829	746	1584	4527	2377	3826	541	104	309
Slipp	1233	2627	1563	542	1619	182	1850	231	45	22
Hazard	188	181	254	281	757	34	550	5	0	4
ER	167	358	303	165	619	81	1	0	0	598

RCW1	NW	RW	SW	FW	IW	IA	ER
Dry	139171	8252	637	12633	3893	222	1467
Wet	16393	1138	95	217	237	0	141
DriftLow	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0
Snow	3499	4604	2002	1207	3620	183	309
Slipp	5882	1362	176	1856	586	30	22
Hazard	1011	716	72	138	313	0	4
ER	1143	335	63	12	141	0	598

em6

RCST1	DR	TR	MO	WE	WT	SN	PF	FR	IC	ER
Dry	172785	31471	63050	12939	11433	1496	13535	9487	733	2956
Wet	5565	3005	9961	9711	6345	197	1293	25	6	330
DriftLow	0	0	0	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0	0	0	0
Snow	1417	2020	1755	3273	9402	4888	8216	1247	245	682
Slipp	4425	6905	5160	1607	3907	345	4454	769	121	108
Hazard	613	601	1132	1147	2155	50	1184	14	0	11
ER	328	714	609	322	1240	162	1	0	0	1208

RCW1	NW	RW	SW	FW	IW	IA	ER
Dry	269335	15300	1163	23573	7144	414	2956
Wet	32224	2429	247	600	608	0	330
DriftLow	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0
Snow	7781	9729	4097	2875	7583	398	682
Slipp	18157	3045	329	4774	1324	64	108
Hazard	4106	1667	124	315	684	0	11
ER	2287	660	126	24	279	0	1208

em12

RCST1	DR	TR	MO	WE	WT	SN	PF	FR	IC	ER
Dry	331550	57594	1E+05	24374	21099	2663	22550	16841	1389	5971
Wet	15923	5879	20663	17927	11390	438	2850	51	12	755
DriftLow	0	0	0	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0	0	0	0
Snow	3833	5475	4711	7167	20037	9912	18267	2946	529	1566
Slipp	15698	17301	15528	4512	8958	911	11038	3186	316	416
Hazard	1822	1702	3451	3488	5220	88	2662	48	0	36
ER	719	1447	1223	634	2505	324	18	0	0	2298

RCW1	NW	RW	SW	FW	IW	IA	ER
Dry	511124	27634	2021	41521	12574	795	5971
Wet	67056	4865	560	1426	1225	1	755
DriftLow	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0
Snow	19306	21103	8331	7339	15979	819	1566
Slipp	52321	7342	842	13222	3583	138	416
Hazard	12442	3537	229	763	1510	0	36
ER	4694	1333	252	57	534	0	2298

em3 u3

RCST1	DR	TR	MO	WE	WT	SN	PF	FR	IC	ER
Dry	43343	15099	19681	3568	4953	837	7595	4988	391	0
Wet	942	1029	2535	2446	2318	64	502	10	3	0
DriftLow	0	0	0	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0	0	0	0
Snow	439	821	727	1518	4483	2377	3826	541	104	0
Slipp	1213	2617	1539	538	1612	182	1850	231	45	0
Hazard	178	181	251	281	755	34	550	5	0	0
ER	102	312	253	84	472	81	1	0	0	0

RCW1	NW	RW	SW	FW	IW	IA	ER
Dry	74972	8104	631	12633	3893	222	0
Wet	8274	1029	92	217	237	0	0
DriftLow	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0
Snow	3224	4602	2000	1207	3620	183	0
Slipp	5817	1362	176	1856	586	30	0
Hazard	996	716	72	138	313	0	0
ER	760	329	63	12	141	0	0

em6 u3

RCST1	DR	TR	MO	WE	WT	SN	PF	FR	IC	ER
Dry	84218	27925	36808	6474	8732	1496	13529	9487	733	0
Wet	2069	2014	4773	4403	4249	197	1293	25	6	0
DriftLow	0	0	0	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0	0	0	0
Snow	1143	2009	1720	3150	9327	4888	8216	1247	245	0
Slipp	4250	6886	5070	1585	3885	345	4454	769	121	0
Hazard	557	596	1100	1105	2115	50	1184	14	0	0
ER	196	620	503	160	946	162	1	0	0	0

RCW1	NW	RW	SW	FW	IW	IA	ER
Dry	142101	15019	1151	23573	7144	414	0
Wet	15383	2197	241	600	608	0	0
DriftLow	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0
Snow	7273	9724	4092	2875	7583	398	0
Slipp	17829	3045	329	4774	1324	64	0
Hazard	3935	1663	124	315	684	0	0
ER	1509	650	126	24	279	0	0

em12 u3

RCST1	DR	TR	MO	WE	WT	SN	PF	FR	IC	ER
Dry	159914	50286	66974	11540	15399	2663	22538	16841	1389	0
Wet	4585	4050	8790	7581	7561	438	2850	51	12	0
DriftLow	0	0	0	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0	0	0	0
Snow	3271	5453	4643	6912	19893	9912	18267	2946	529	0
Slipp	14614	17277	15077	4339	8890	911	11038	3186	316	0
Hazard	1613	1686	3287	3108	5046	88	2662	48	0	0
ER	357	1252	988	310	1928	324	18	0	0	0

RCW1	NW	RW	SW	FW	IW	IA	ER
Dry	263553	27104	1997	41521	12574	795	0
Wet	28321	4397	548	1426	1225	1	0
DriftLow	0	0	0	0	0	0	0
DriftHigh	0	0	0	0	0	0	0
Snow	18281	21086	8322	7339	15979	819	0
Slipp	50527	7336	842	13222	3583	138	0
Hazard	11528	3508	229	763	1510	0	0
ER	3017	1317	252	57	534	0	0

Apendix 4: *The forecast accuracy evaluation of road surface temperature. Zlinsky Region. Winter season 2012/2013.*

T	Celkem	cm0002	cm0003	cm0101	cm0104	cm0112	cm0122	cm0142	cm0180	cm1176	cm1193	cy17	cy18	cy21	cy27	cy40	cz57	cz68	cz70	cz79	cz92
Předpověď+1	**0,03**	-0,12	0,10	0,08	0,17	0,57	-0,02	-0,01	-0,02	-0,40	-0,26	0,25	0,02	0,10	0,02	-0,42	0,68	-0,02	0,02	-0,06	-0,03
Předpověď+2	**0,05**	-0,27	0,16	0,14	0,31	0,53	-0,04	-0,03	-0,01	-0,34	-0,23	0,46	0,05	0,13	0,02	-0,38	0,69	-0,01	0,05	-0,12	-0,03
Předpověď+3	**0,04**	-0,44	0,20	0,16	0,40	0,45	-0,11	-0,10	-0,02	-0,31	-0,26	0,63	0,05	0,12	0,00	-0,35	0,68	-0,03	0,04	-0,19	-0,06
Předpověď+4	**-0,01**	-0,62	0,19	0,11	0,42	0,36	-0,20	-0,21	-0,07	-0,32	-0,34	0,73	0,02	0,07	-0,06	-0,37	0,63	-0,07	0,01	-0,30	-0,12
Předpověď+5	**-0,07**	-0,78	0,16	0,06	0,41	0,25	-0,31	-0,31	-0,14	-0,35	-0,43	0,76	-0,02	0,01	-0,11	-0,40	0,57	-0,14	-0,05	-0,39	-0,19
Předpověď+6	**-0,14**	-0,92	0,11	0,00	0,40	0,14	-0,41	-0,42	-0,22	-0,40	-0,52	0,75	-0,08	-0,06	-0,19	-0,44	0,51	-0,21	-0,12	-0,49	-0,26
Předpověď+7	**-0,21**	-1,04	0,07	-0,05	0,37	0,04	-0,50	-0,51	-0,31	-0,46	-0,60	0,73	-0,14	-0,13	-0,26	-0,49	0,45	-0,28	-0,18	-0,58	-0,33
Předpověď+8	**-0,27**	-1,15	0,02	-0,11	0,34	-0,05	-0,60	-0,61	-0,39	-0,50	-0,68	0,71	-0,20	-0,19	-0,33	-0,54	0,39	-0,35	-0,25	-0,66	-0,39
Předpověď+9	**-0,33**	-1,25	-0,02	-0,16	0,31	-0,14	-0,68	-0,69	-0,46	-0,55	-0,75	0,69	-0,25	-0,25	-0,39	-0,58	0,34	-0,41	-0,30	-0,72	-0,44
Předpověď+10	**-0,39**	-1,35	-0,07	-0,21	0,28	-0,22	-0,77	-0,76	-0,53	-0,61	-0,81	0,67	-0,29	-0,30	-0,45	-0,62	0,29	-0,47	-0,36	-0,79	-0,50
Předpověď+11	**-0,45**	-1,43	-0,12	-0,26	0,26	-0,30	-0,84	-0,83	-0,59	-0,65	-0,86	0,64	-0,34	-0,35	-0,50	-0,67	0,24	-0,53	-0,41	-0,85	-0,55
Předpověď+12	**-0,49**	-1,51	-0,15	-0,30	0,24	-0,37	-0,90	-0,88	-0,64	-0,69	-0,91	0,63	-0,39	-0,40	-0,55	-0,71	0,20	-0,58	-0,46	-0,91	-0,60

T abs	Celkem	cm0002	cm0003	cm0101	cm0104	cm0112	cm0122	cm0142	cm0180	cm1176	cm1193	cy17	cy18	cy21	cy27	cy40	cz57	cz68	cz70	cz79	cz92
Předpověď+1	**1,03**	1,08	0,99	1,04	0,98	1,03	1,01	0,96	0,95	1,14	1,15	1,05	0,98	0,99	1,04	1,25	1,14	0,95	0,92	1,06	0,95
Předpověď+2	**1,55**	1,71	1,53	1,71	1,62	1,37	1,61	1,54	1,50	1,61	1,69	1,71	1,46	1,46	1,55	1,70	1,46	1,41	1,37	1,59	1,43
Předpověď+3	**1,94**	2,19	1,92	2,18	2,07	1,67	2,08	1,98	1,93	1,98	2,09	2,20	1,82	1,77	1,94	2,04	1,75	1,76	1,70	1,98	1,78
Předpověď+4	**2,22**	2,54	2,19	2,50	2,36	1,91	2,43	2,29	2,25	2,26	2,37	2,53	2,08	1,97	2,22	2,28	1,96	2,00	1,94	2,27	2,02
Předpověď+5	**2,42**	2,78	2,38	2,72	2,57	2,08	2,68	2,51	2,47	2,45	2,55	2,76	2,26	2,11	2,42	2,44	2,12	2,18	2,10	2,47	2,18
Předpověď+6	**2,54**	2,94	2,51	2,88	2,71	2,19	2,85	2,67	2,62	2,57	2,68	2,91	2,37	2,19	2,56	2,53	2,21	2,29	2,22	2,60	2,28
Předpověď+7	**2,62**	3,03	2,58	2,98	2,80	2,24	2,95	2,76	2,70	2,63	2,75	3,00	2,43	2,24	2,65	2,58	2,26	2,36	2,28	2,68	2,33
Předpověď+8	**2,66**	3,10	2,62	3,03	2,85	2,27	3,01	2,80	2,75	2,67	2,79	3,05	2,46	2,27	2,69	2,60	2,28	2,40	2,33	2,73	2,36
Předpověď+9	**2,68**	3,14	2,64	3,04	2,87	2,28	3,05	2,83	2,77	2,68	2,81	3,08	2,49	2,28	2,73	2,61	2,29	2,43	2,36	2,77	2,38
Předpověď+10	**2,70**	3,17	2,64	3,04	2,88	2,29	3,08	2,85	2,79	2,70	2,84	3,08	2,50	2,29	2,75	2,62	2,30	2,44	2,38	2,79	2,39
Předpověď+11	**2,71**	3,20	2,63	3,04	2,87	2,29	3,10	2,87	2,80	2,71	2,85	3,08	2,51	2,30	2,76	2,62	2,31	2,45	2,39	2,81	2,41
Předpověď+12	**2,71**	3,22	2,63	3,03	2,86	2,30	3,12	2,88	2,81	2,71	2,86	3,08	2,52	2,30	2,76	2,63	2,32	2,47	2,40	2,83	2,42

T u3	Celkem	cm0002	cm0003	cm0101	cm0104	cm0112	cm0122	cm0142	cm0180	cm1176	cm1193	cy17	cy18	cy21	cy27	cy40	cz57	cz68	cz70	cz79	cz92
Předpověď+1	**0,04**	-0,07	0,11	0,06	0,12	0,68	0,00	0,04	-0,02	-0,41	-0,29	0,25	0,01	0,10	0,05	-0,44	0,64	-0,02	0,02	0,00	-0,02
Předpověď+2	**0,00**	-0,26	0,11	0,04	0,15	0,60	-0,08	-0,02	-0,12	-0,41	-0,32	0,41	-0,06	0,05	-0,03	-0,47	0,60	-0,10	-0,06	-0,11	-0,09
Předpověď+3	**-0,09**	-0,49	0,08	-0,03	0,15	0,46	-0,23	-0,14	-0,27	-0,48	-0,43	0,53	-0,17	-0,05	-0,14	-0,55	0,52	-0,23	-0,18	-0,28	-0,21
Předpověď+4	**-0,22**	-0,73	0,00	-0,15	0,10	0,31	-0,41	-0,30	-0,45	-0,59	-0,56	0,58	-0,31	-0,16	-0,28	-0,67	0,39	-0,38	-0,32	-0,48	-0,35
Předpověď+5	**-0,35**	-0,95	-0,07	-0,26	0,05	0,15	-0,59	-0,45	-0,63	-0,71	-0,70	0,58	-0,44	-0,29	-0,42	-0,79	0,29	-0,51	-0,46	-0,67	-0,48
Předpověď+6	**-0,46**	-1,13	-0,16	-0,36	0,01	0,01	-0,74	-0,59	-0,79	-0,81	-0,83	0,54	-0,56	-0,39	-0,55	-0,89	0,19	-0,63	-0,58	-0,83	-0,59
Předpověď+7	**-0,56**	-1,28	-0,23	-0,43	-0,04	-0,11	-0,88	-0,70	-0,92	-0,91	-0,93	0,50	-0,65	-0,48	-0,66	-0,97	0,11	-0,74	-0,68	-0,95	-0,69
Předpověď+8	**-0,63**	-1,41	-0,29	-0,51	-0,08	-0,22	-1,00	-0,80	-1,04	-0,97	-1,02	0,47	-0,72	-0,54	-0,73	-1,04	0,04	-0,82	-0,75	-1,04	-0,76
Předpověď+9	**-0,69**	-1,52	-0,34	-0,57	-0,11	-0,30	-1,09	-0,89	-1,12	-1,03	-1,09	0,45	-0,77	-0,59	-0,78	-1,08	0,00	-0,88	-0,81	-1,10	-0,81
Předpověď+10	**-0,75**	-1,61	-0,38	-0,63	-0,14	-0,38	-1,17	-0,96	-1,20	-1,07	-1,14	0,44	-0,82	-0,64	-0,83	-1,11	-0,05	-0,94	-0,87	-1,16	-0,86
Předpověď+11	**-0,79**	-1,69	-0,42	-0,68	-0,15	-0,44	-1,23	-1,03	-1,26	-1,11	-1,19	0,42	-0,86	-0,69	-0,86	-1,14	-0,09	-0,99	-0,91	-1,20	-0,91
Předpověď+12	**-0,83**	-1,76	-0,45	-0,72	-0,17	-0,50	-1,28	-1,07	-1,32	-1,14	-1,24	0,42	-0,90	-0,73	-0,90	-1,18	-0,12	-1,03	-0,95	-1,25	-0,95

T u3 abs	Celkem	cm0002	cm0003	cm0101	cm0104	cm0112	cm0122	cm0142	cm0180	cm1176	cm1193	cy17	cy18	cy21	cy27	cy40	cz57	cz68	cz70	cz79	cz92
Předpověď+1	**0,91**	0,96	0,88	0,97	0,92	1,00	0,90	0,85	0,81	1,01	1,08	1,03	0,78	0,82	0,88	1,11	1,00	0,78	0,77	0,85	0,77
Předpověď+2	**1,36**	1,52	1,37	1,57	1,47	1,24	1,43	1,35	1,26	1,38	1,56	1,64	1,17	1,24	1,33	1,46	1,24	1,15	1,15	1,28	1,17
Předpověď+3	**1,68**	1,96	1,70	1,98	1,84	1,44	1,83	1,72	1,59	1,67	1,89	2,09	1,47	1,48	1,67	1,72	1,45	1,43	1,41	1,59	1,45
Předpověď+4	**1,91**	2,26	1,93	2,25	2,07	1,62	2,11	1,98	1,85	1,90	2,11	2,38	1,68	1,65	1,90	1,91	1,60	1,63	1,60	1,83	1,66
Předpověď+5	**2,08**	2,48	2,08	2,45	2,25	1,77	2,32	2,16	2,04	2,05	2,27	2,58	1,83	1,77	2,06	2,05	1,73	1,78	1,73	2,00	1,80
Předpověď+6	**2,19**	2,63	2,18	2,58	2,36	1,87	2,47	2,29	2,17	2,16	2,37	2,71	1,94	1,86	2,17	2,14	1,80	1,89	1,83	2,12	1,89
Předpověď+7	**2,26**	2,73	2,25	2,67	2,43	1,93	2,57	2,38	2,26	2,22	2,44	2,78	2,01	1,92	2,24	2,20	1,85	1,96	1,89	2,19	1,95
Předpověď+8	**2,31**	2,80	2,29	2,71	2,48	1,96	2,64	2,43	2,33	2,26	2,49	2,83	2,07	1,95	2,29	2,24	1,87	2,02	1,94	2,26	1,99
Předpověď+9	**2,34**	2,85	2,32	2,72	2,50	1,98	2,69	2,45	2,37	2,30	2,52	2,85	2,10	1,98	2,33	2,27	1,89	2,05	1,99	2,31	2,03
Předpověď+10	**2,37**	2,89	2,33	2,73	2,51	2,00	2,73	2,48	2,41	2,32	2,55	2,87	2,13	1,99	2,36	2,30	1,90	2,08	2,02	2,35	2,05
Předpověď+11	**2,39**	2,93	2,34	2,74	2,51	2,01	2,76	2,49	2,44	2,35	2,57	2,87	2,15	2,01	2,39	2,32	1,92	2,09	2,03	2,40	2,07
Předpověď+12	**2,40**	2,96	2,35	2,75	2,51	2,01	2,79	2,51	2,46	2,36	2,58	2,88	2,17	2,01	2,41	2,33	1,94	2,11	2,05	2,42	2,09