Royal Netherlands
Meteorological Institute
Ministry of Infrastructure and the Environment

Spatial Prediction of Road Temperatures

Marieke Dirksen [1,2], Raymond Sluiter [1], and Eva Kleingeld [2]. Contact: dirksen@knmi.nl

Ice formation on roads leads to a substantial increase in accidents and road damage. The Dutch Gladheidsmeldsysteem (slippery detection system) measures meteorological conditions on roads at 300+ locations. Our goal is to predict road temperatures in between the measurement locations based on environmental variables and meteorological conditions. Using a machine learning approach part of the variation in road temperatures can be explained by air- and dew point temperature, zenith angle, sky view factor and distance to the sea.

Introduction

Ice on Dutch highways leads to an increase of 77-245 % in the number of accidents (SWOV,2012). Roads become slippery when e.g. road temperatures drop below zero and surfaces are wet. This research focuses on the road temperatures.

Figure 1: *Road temperature measurement locations (RWS, 2007).*

Slipperiness can be a local phenomena. Therefore we want to predict temperatures in between measurement sides. Our goal is to explain these local variations by environmental variables and meteorological conditions using a machine learning approach.

Methods

Measurements

There are currently over 300 gladheidsmeldsysteem (GMS) stations located across all Dutch provinces, on both highways and provincial roads (Fig. 1). The GMS stations are a collection of sensors in the road and along the road which measures among others road-, air and dew point temperature (Fig. 2 & 3). The measurement frequency is 5 minutes.

Figure 2: *Road Temperature sensor. The sensors are on the car lanes.*

Figure 3: *Air Temperature sensor, next to the road.*

Ancillary Data

Meteorological data The air- and dewpoint temperature are measured at each location. The measurements are next to the road (Fig. 3). For the spatial predictions these variables are interpolated.
Sky View Factor The AHN2 point measurements of elevation were regridded on a regular grid. With the R's horizon package the sky view factor was calculated.
Distance to the sea is a virtual shoreline with values around zero near the sea and high values inland.
The solar angle was calculated using the R's insol package.

Training set

On the 23th of January 2010 temperatures are around freezing point. Figure 4 shows there is a large spread in road temperature observations. Missing values and large outliers are removed.

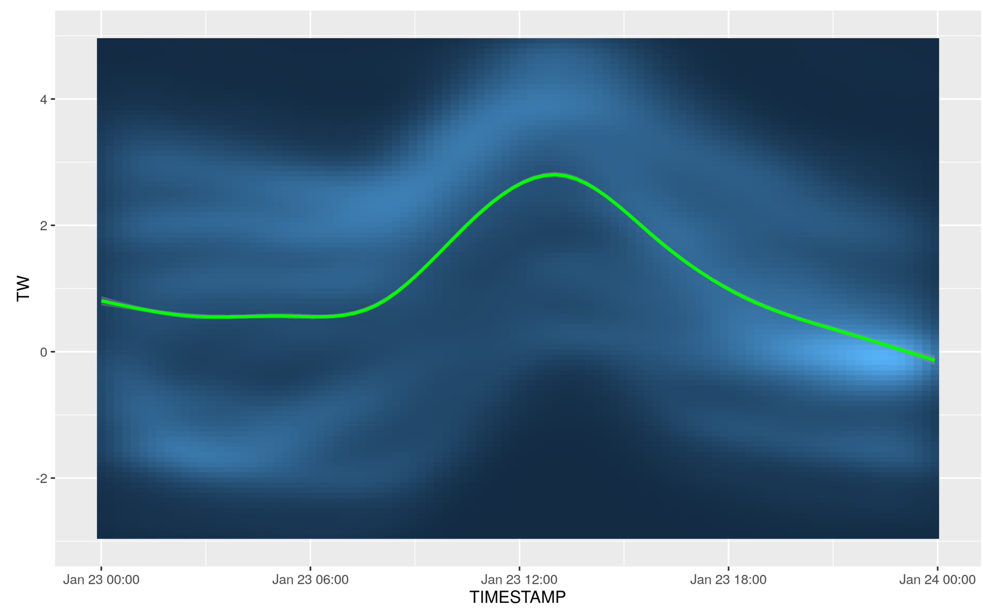

Figure 4: *Road Temperatures on the 23th of January 2010. In green the mean road temperature, the background indicates the point density. A more blueish color indicates more points.*

Data Processing

Machine learning algorithms can build models with non-linear data relationships (Kuhn & Johnson, 2013). The R's caret package is used to build a linear regression and a decision tree (rpart). All the data is Scaled, Centered and Transformed.

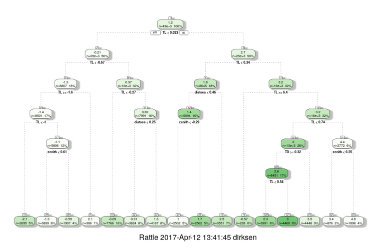

Figure 5: *rpart decision tree.*

Results

The linear model and tree model show different variable importance's The variable importance of the linear model is expressed as the absolute value of the t-statistic for each variable. The variable importance of the tree is expressed as the reduction in mean squared error attributed to each variable. The results are shown in table 1.

Table 1: *Variable Importance.*

	Linear Model	Tree model
Air Temperature	76	2.7
Dewpoint Temperature	22	1.7
Distance to the sea	58	1.4
Zenith Angle	62	1.2
Sky View Factor	18	0.3

Model validation

The models are trained using cross validation. After finetuning the models are validated with an independent test set. The result of the model validation is shown in Fig. 6.

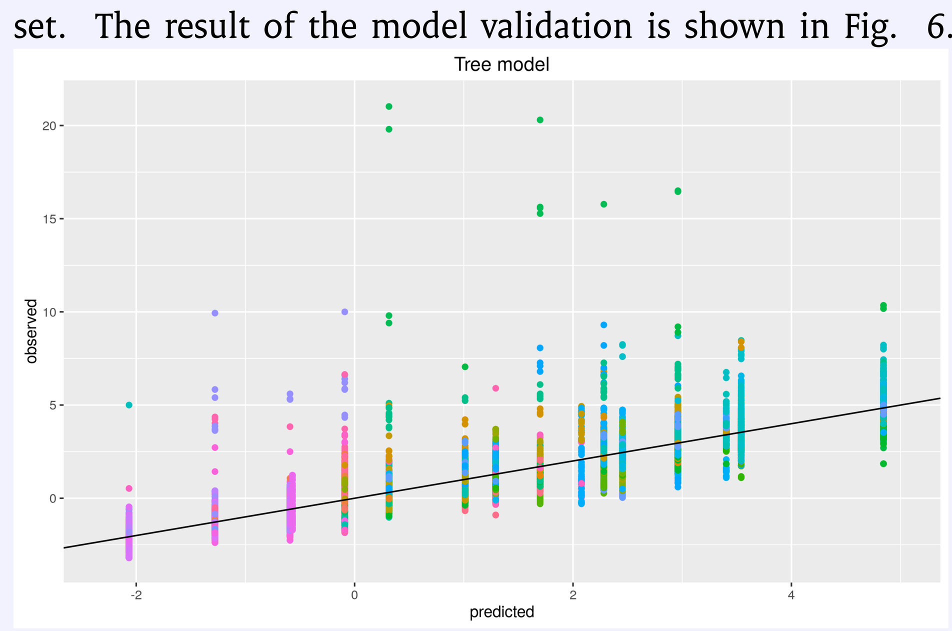

Figure 6: *Prediction of the Tree model compared with observed values.*

The 1:1 line fits the largest part of the test-set. Some of the observations from the test-set have bias, the prediction from the tree model predicts lower values for these outliers.

Table 2: *Statistical summary.*

	R^2	$RMSE$
Linear	0.31	1.7
Tree	0.77	0.98

Predicting Road Temperatures

The goal is to use the model to predict road temperatures on the highway. First results are shown in Fig. 7.

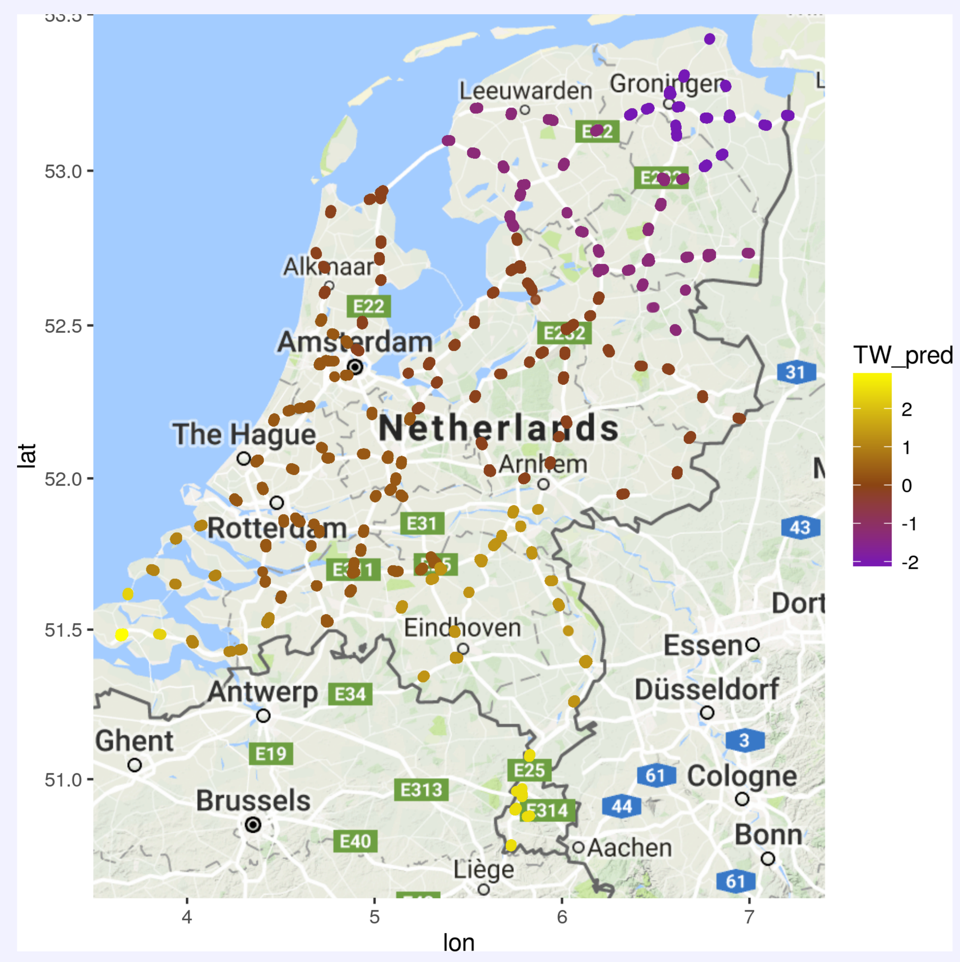

Figure 7: *Road temperatures predicted on a highway, time=2010-01-23 23:50:00.*

Discussion and Conclusion

1. **The model is built for a single day, ideally several representative meteorological situation are included in the model.**
2. **The model now uses five different variables. Depending on the situation other variable like traffic intensity or road type, should be included.**
3. **Compared with the linear model the tree model is found to be less insensitive for outliers (Fig. 6).**
4. **Statistically the tree model shows good results (Table 2) and seems unbiased (Fig. 6). First steps are made to use the model for spatial predictions (Fig. 7).**

Ongoing: calculate the sky view factor for the entire Netherlands

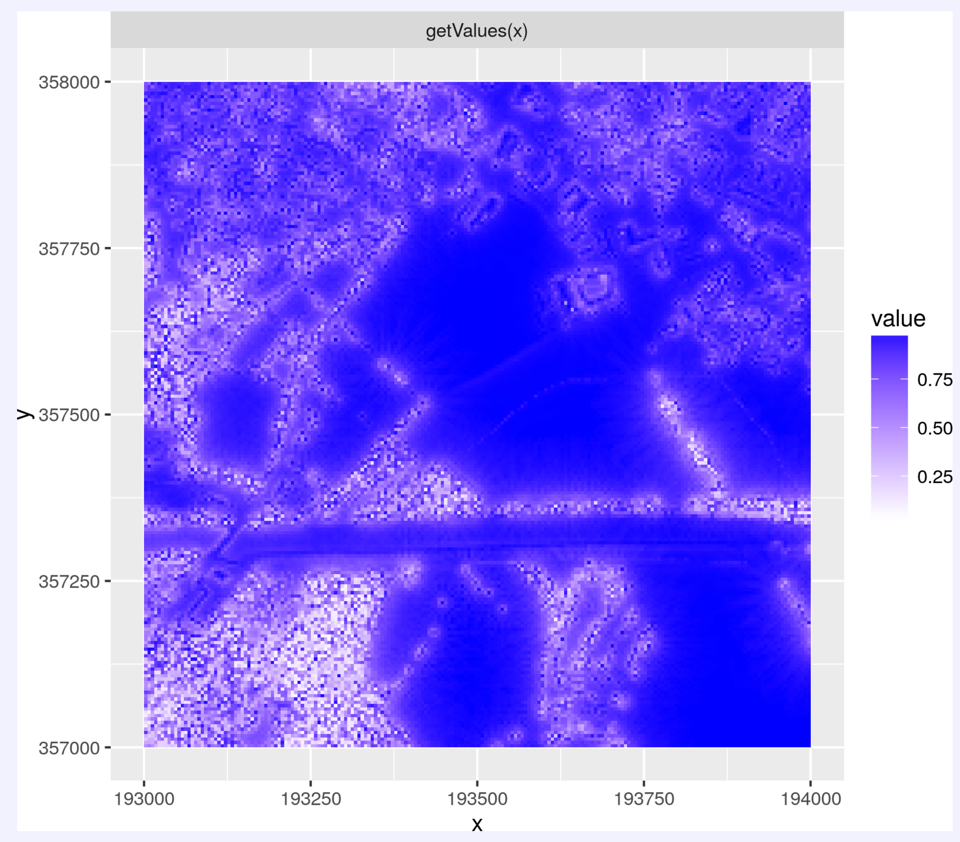

Figure 8: *Example of the skyview factor, calculated for a small area*

References

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SWOV. SWOV-Factsheet, De invloed van het weer op de verkeersveiligheid. Technical report, Leidsendam, 2012.

WAGENINGEN UNIVERSITY & RESEARCH

[1] Royal Netherlands Meteorological Institute (KNMI). PO Box 201, 3730 AE De Bilt, The Netherlands. [2] Wageningen University & Reserach (WUR). 6708 PB Wageningen, The Netherlands.