THERMAL MAPPING IN FLAT LOWLANDS AND UNDULATING UPLANDS – A COMPARISON OF RESULTS

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Regions with ice and snow are dependent on microclimate conditions of roads, since cleaning, de-icing and treating the network is financially expensive and time consuming. Thermal mapping technique was firstly introduced to road climatology as an idea in middle 1970s, but was best described and applied to research after 15–20 years (Bogren, Gustavsson 1989; Thornes 1991; Bogren, Gustavsson 1991). Since then the technique was improved and re-evaluated (Gustavsson 1999), in order to minimize the possibility of errors and increase the quality of data received using this method.

The idea for this paper arose from thermal mapping applications to Lithuanian roads, which produced inconclusive results in some research areas and raised the question whether this technique is applicable to flatlands as effectively as to uplands. While distinctive temperature anomalies can still be observed in some places (e. g. negative temperature anomalies on bridges or overpasses), otherwise, it seemed that there were no significant patterns connected to altitude as expected beforehand. In order to determine the cause for this, a comparison between different areas needed to be done, therefore a second country with reliable thermal mapping database was chosen – Czechia. In conclusion, the aim of this paper is to discuss whether thermal mapping can be as effective in lowlands as in mountainous or hilly regions, taking Czechia and Lithuania as two examples on the opposite sides.

There were several datasets used in this study. Firstly, there was thermal mapping data from Czechia collected in 2015. All chosen sections do not contain major interchanges, are about 45–50 km in length and relatively straight. The choosing of road stretches was mostly influenced by them being in a mountainous region, and the elevation changing rapidly and constantly along the route.

Secondly, there was thermal mapping data from Lithuania, which was collected during January and February of 2015. Because of differences in type of roads that were measured, the whole dataset was divided into 4 major sections with some interchanges and other similar parts of the route being omitted. These sections varied in length – from around 78 to 118 km, but were relatively straight. The altitude was not measured, therefore the required data was derived from Lithuanian georeferenced database (acronym – GDR10LT). Thus, this data does not reflect the absolute altitude of a road, but rather represents the average absolute altitude for the area around it.

For an area as mountainous as Czechia, it is expected to observe cold air pooling in some surface depressions during extreme weather conditions. The chosen routes reflected this to some degree: overall average difference between temperatures in depressions and peaks is –0.78 °C for air temperature and –0.25

°C for road surface temperature. The difference between road and air temperature is greater by 0.52 °C on average in depressions. Nevertheless, not every depression can form cold air pools since roads might not go through the lowest part of the valley. Moreover, the higher it gets, the rarer it is for road to be colder than air. This tendency is similar in both stretches of road.

Air temperature relation to altitude is uneven across the roads. In those stretches where there's a relatively steep slope, moving correlation (with a radius of 0.5 km around the segment point) drops to 0 and in some places, reverts to negative. One of the best examples of this is a stretch of road, where the lowest points in altitude are Vltava and Brzina rivers. In this example, in areas where relative altitude of the road (compared to an average with radius of 0.5 km around the road) changes considerably, moving correlation drops from strong positive to weak and even to strong negative. Conversely, in areas where relative altitude change falls within overall noise range, relation is strong and positive. This suggests, that the strength of air temperature relation to altitude is essentially dependent on whether the area is relatively flat or has an incline. While air temperature could be partially predicted by relative altitude in former areas, the latter would have lower rate of predictability.

There are differences between different routes (CZ1 and CZ2) as well. CZ1 has less variation in absolute height, with highest peaks being at the ends of the route and several larger valleys in between, but has the highest peaks and lowest depressions in both road stretches (absolute height varies between 277–547 m). Whereas CZ2 elevation varies considerably, constantly switching between peaks and depressions, but has lower absolute height (absolute height varies between 413–526 m). Using average measurement data during extreme conditions, only 6.0 % of CZ1 and 4.7 % of CZ2 had favourable conditions for cold air pooling effect to take place (where road was colder than air and moving correlation between road temperature and altitude was +0.8 or above). Moreover, the variation (amplitude) of this index on different measurements in extreme conditions is greater in CZ2 than in CZ1: 6.7 % and 1.8 % respectively. Therefore, according to this data it is expected that a relatively flat area with sudden depressions to have more predictability value than an area with more undulating and changing landscape. For example, for altitude to be a decent predictor it is necessary to have an area with smaller depressions and less frequent overall landscape shifts, rather than a constantly interchanging hills and valleys.

Both of these results suggest that roads which lie in flatlands should have a higher predictability value, that's related to the altitude. Nevertheless, data from Lithuanian thermal mapping shows quite the opposite. The best example could be LT1 road section, which was measured 4 times during extreme conditions. Correlation between temperature difference (road surface temperature minus air temperature) and altitude in that one stretch of road during different measurement events varied from –0.76 to +0.55. This suggests that cold air pooling might not take place in relation to the area being more influenced by other variables, rather than changes in altitude. Nevertheless, the before mentioned parameter for favourable conditions for cold air pooling effect to take place is similar to Czechian roads. On average, it varied from 2.3 % to 8.0 % between different road stretches in extreme conditions. Moreover, the index was lower in areas where the landscape was flatter.

In conclusion, it appears that in flat landscapes altitude has less predictability value for road surface temperature than in undulating uplands. The former areas are being more influenced by advancing air masses and general weather changes rather than local landscape. Nevertheless, there are still some cases in Lithuanian roads, for example, where road temperature consistently dropped lower than air during most of the measurement events, therefore thermal mapping is still a valid method for determining such cold spots. However, usage of these maps for road temperature forecasting is becoming questionable and somewhat inefficient, for them being quite expensive to make and having a significantly low predictability value.

References:

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