A Local Climatological Model for Stretchwise Road Surface Temperature Information

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1 Introduction

Data on road surface and air temperature is very useful for road maintenance and can assist in slipperiness surveys of winter roads. The use of road weather information systems has therefore rapidly increased. The idea behind a road surveillance system is that stations measuring temperatures, humidity and wind should be located in such areas that an early warning of road icing can be achieved. This requires that the stations have various types of locations as different weather situations result in different temperature patterns. The background idea behind the Local Climatological Model (LCM) developed at the Department of Physical Geography is that a stretchwise temperature information can be calculated, increasing the available information and leading to a more efficient surveillance of winter roads. If the decision about salting action is based upon more diversified information, compared to that received only from the locations of the field stations, the right decision is made more easily. The road attendant can, for instance, decide whether an action needs to be taken or not, and give priority to certain stretches as well.

2 Principles behind the local climatological model

To be able to calculate the temperature pattern along roads using the LCM, several factors need to be considered. For an adaptation of the LCM to a specific area the following data is used for segmentation of the road stretches.

Thermal mapping: Basic background information is received from thermal mapping of the road net in the actual county under different weather conditions. The results from thermal mapping give valuable information about magnitude and frequency of road surface temperatures (RST) variations along the road caused by different topographical features.

Topographical maps and field surveys: From topographical maps and field measurements, information about topography and geographical aspects is considered together with the temperature information from the thermal mapping. The fundamental topographical parameters used as input for the calculations of these variations are: Valleys - where the size (width and depth) determine the gathering and pooling of cold air. Exposure to wind is also an important factor for the formation of pooling and stagnation. Shaded areas - the objects causing shadow can be described by form and size parameters in combination with orientation and distance from the road. Altitude - variations in altitude along the road are determined at 50-m intervals. Bridges - construction material, length and volume, and type are factors affecting the temperature pattern.

RWIS: information from the RWIS field stations gives the possibility of considering historical recordings to confirm the temperature variations determined from the thermal mapping.

The integration of these factors results in a classification and separation of different segments along the stretches of road. The most important features influencing the temperature of the segments are: valleys, screened areas, variations in altitude and bridges. Proximity to water and regional climate are also taken into account when a certain area is considered. These fundamental topoclimatological parameters, which must be known in order to calculate temperature variations along a stretch of road have been described in previous papers (Bogren and Gustavsson 1986; Bogren et al. 1992; Gustavsson et al. 1987; Bogren 1990; Gustavsson 1990).

When the basic background information is adopted into the model it is possible to start the calculation and extrapolation of the temperature pattern. This process can be divided into three parts. Firstly, the variables measured at the RWIS are collected and stored for a trend analysis together with the cloudiness information. Secondly the algorithm in the model compares air and road surface temperatures for determining the type of temperature variations currently existing in the area in question, to each field station there is also a cloud forecast produced together with the RST forecast (1 - 4h).This information forms a very important part when the model determines the present weather situation.

Until today the local climatological model have distinguished between five different conditions:

(i) Night - calm - clear: the variation in temperature is calculated with respect to the local topography and corrections are made according to the reduced lowering of the road surface temperature at closed sites.

(ii) Night - windy - clear: the measured temperatures from RWIS stations in wind-exposed and wind-sheltered locations are used together with the empirical formulae for reduction by dense vegetation.

(iii) Day - calm/windy - clear: temperature differences owing to screening of the road surface are calculated by use of a well exposed station as a reference. Orientation, composition and extension of the screening object are considered together with solar elevation to determine the screening effect. Temperature differences prevailing after sunset due to the screening effect during the day are dealt with by calculating the difference between the screened and exposed site.

(iv) Day/night - calm/windy - cloudy: profiles across the area are used for calculation of the temperature variations and the air and road surface temperatures are extrapolated in respect of the variation in altitude and vegetation.

(v) Day/night - calm/windy/ - partly cloudy: the reduction of the temperature variations is determined from comparison of the recorded temperatures at RWIS stations, otherwise the formulae for each group are used.

These aspects, however, requires that the regions considered are subdivided into smaller areas which is most likeley to have the same weather. Figure 1 shows a flow chart of the main components in the LCM.

The following section describes how the LCM is developed to avoid this internal division and theirby receiving a more dynamic model.

3 Development of the LCM

By use of a LCM it is clear that the information available for the maintenance people has increased providing a useful tool for decision making. Further development will make the model even more dynamic and adjustable to the prevailing road conditions.

The present work with the development of the LCM includes RST prognosis and an integration of meso-scale detailed weather forecasting models. Meso-scale weather modelling is in a process of very fast development. Within the last years, meso-scale weather models have become practicable, with potential to further improve road weather forecasts. The meso-scale models are similar to synoptic (wide-area) weather models, except that they are more detailed. Today the development has reached to the scale of sizes as low as 10 km, rather than the 100 km or more used at national and international levels. The accessibility of increased data power and available weather data makes the science of weather modelling to develop very fast. Meso scale weather models fuse multiple data inputs including national supercomputer data, satellite images, radar and other sources. It is also possible that the feedback provided by the RWIS-systems can increase the accuracy and resolution in a significant way.

It will be very beneficial to integrate the output from a meso scale weather model into the LCM to achieve a support for the algorithm when analysing the present weather situation. By this approach it will be possible to model road conditions and the need of maintenance in closer detail.

The new approach with the LCM is to involve more information regarding such parameters as wind and cloudiness on a regional scale. Prognosis for each RWIS station is another example. By use of a weather forecast it is possible to have a more dynamic model. Especially if a prognosis of the kind used in Sweden are considered. This prognosis is given in a grid net of the size 5 * 5 km and thereby can each area of the size of a country be subdivided in several parts having its own weather pattern.

Information from prognosis of road surface temperature can further be used to calculate prognosis for stretchwise temperatures. Combination with weather prognosis also gives the opportunity to calculate risk of slipperiness both in real time an for the coming 1 to 4 hours.

This part will be further developed through combination of statistical models and the likely turn-out of temperature and slipperiness pattern. This is possible by use of the large amount of stored data from the RWIS.

During the winter season 95/96 the LCM is operationally run in the county of Jönköping in the southern part of Sweden. One of the important objectives during this test season is to perform extensive thermal mappings while the model is running to verify the calculations. Another part is to evaluate and develop the presentation system. Questions about resolution, spatial and temporal, as well as what colours that are suitable for the presentation are dealt with. By using a questionnaire the users view will be highlighted and analysed hopefully giving an important feedback for further model development.

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