Road Weather Forecast using High Resolution Data from the Danish Height Model Database

Kai Sattler, Claus Petersen, Alexander Mahura, Bent Sass, and Torben Pedersen

Road Weather Modelling (RWM) Team

Danish Meteorological Institute (DMI), Research Department, Lyngbyvej 100, Copenhagen, DK-2100, Denmark

Introduction

The operational road weather forecasts performed by the DMI Road Weather Model (RWM) system is an important product for the end-user community. Continuous observations from synoptic weather and road stations of the Danish road network along with meteorological output from the DMI's numerical weather prediction High Resolution Limited Area Model are used in this system to generate forecasts every hour. Data assimilation from a dense network of road stations ensure perfect initial conditions for the road model which predict the road surface temperature and amount of water/ ice on the road. Also satellite data are used to improve the amount of cloud cover which is important for short-range forecast of road surface temperature

Recently, the system provides forecasts not only at positions of the road stations (357 in total/ or 456 sensors) but also at points along 153 roads (almost 23000 road stretches located at distances of about 250 m from each other). Previously, a description of physiographic conditions in the RCM was possible to do manually as the number of points were limited, but with 23000 points in the new system automatization was necessary. Here, the use of the so-called Danish Height Model (DHM) will be illustrated and how it is used to calculate shadows and skyview angle which is important for the energy budget of the road surface.

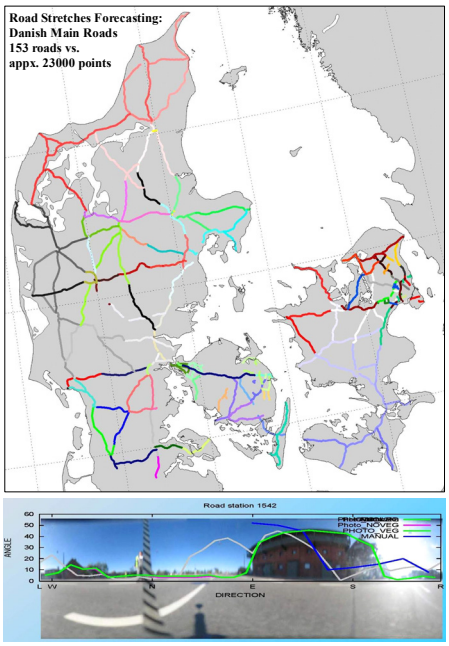

Figure 1. Four methods to obtain shadow and skyview angle from the Danish road station N-1542.

Shadow and Skyview Calculation

Due to the DHM database from the *Kort og Matrikel Styrelsen* it is possible to access details of topography and surroundings at much higher resolution compared with previously used datasets. This allows to take into account shadowing effects (without making manual observations at each point) when forecasting the road surface temperature. These effects were estimated by scanning the surrounding by sectors (32 by 11.25 deg each) up to max distance of 10 km from the road station geographical position. The scanning was performed within 3 ranges of 0–100 m, –1 km, and –10 km with a horizontal mesh of 1.6 m. For each sector, an average angle of the highest point was calculated as a horizon angle representing a shadowing effect due to terrain and nearby obstacles (Fig. 6). Figs. 1-2 shows a 360 deg photo from the urban road station N-1542 located in the suburban area near Copenhagen (Fig. 6). The main contribution to shadows and skyview angle is from high buildings and low vegetation as seen in Fig. 3 (skyview angle is also seen in Fig. 6). Fig. 4 shows an example of 12 h forecast for road station N-1542. The shadowing effect can especially been seen on the direct short-wave radiation on the road (when road come in/out of the shadow zone). The skyview angle also has importance for reducing the incoming diffusive radiation and reducing the angle for incoming and outgoing long-wave radiation. A sudden change in diffusive radiation at about 11:30 am is due to increasing cloud cover.

Figure 2. Panoramic view of surroundings for the Danish road station N-1542 (extracted from Google-Earth).

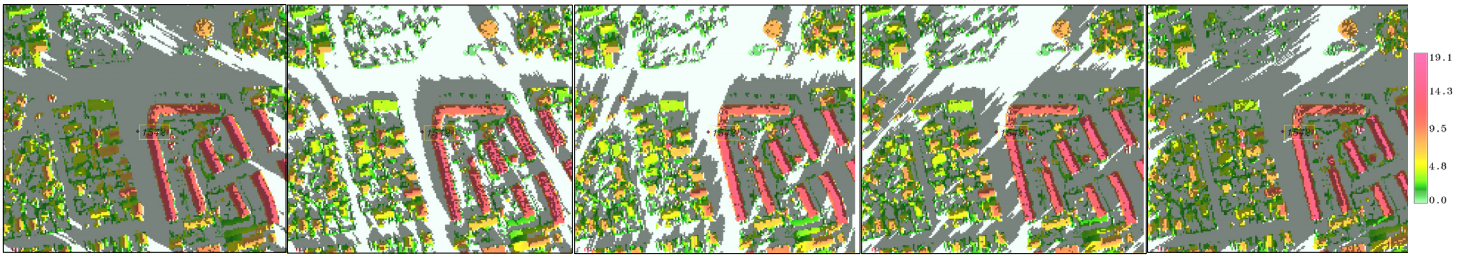

Figure 3. Shadowing effects due to surroundings for the road station N-1542 during 13 Feb 2009 at 07:30, 09:30, 13:00, 14:30; and 15:30 UTC /scale—height of surroundings/.

Land-Use/ Cover Classification

Figure 5. Example of dominating land-use/cover for the selected Danish road station placed in surroundings of forest, agricultural fields, urban environment, and combined.

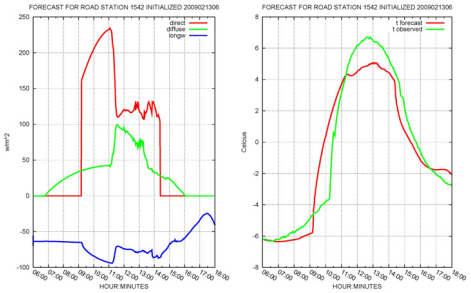

Figure 4. 12 hour forecast for road station N-1542 — (left) direct, diffused, and long-wave radiation; and (right) forecasted and observed road surface temperature — during 13 Feb 2009.

Shadowing Effects due to Surroundings

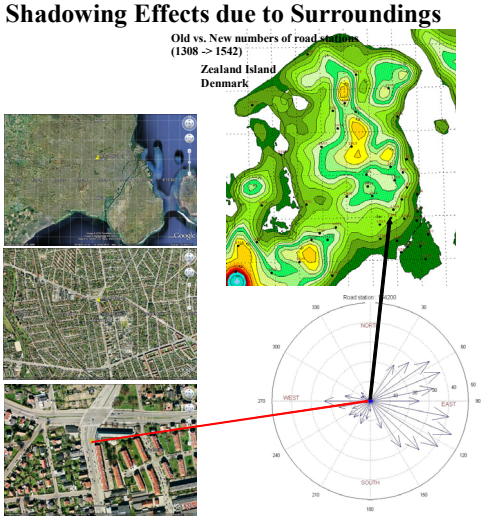

Figure 6. Example of estimated shadowing effects — horizon angle due to terrain + surroundings for road station N-1542 (domination of surroundings vs. terrain) /size of the arrows show the size of the skyview in each direction/.

References

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