Microclimate of a road studied by measurements and modeling

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Abstract

Road climatology applications have been largely limited to the fields of forecasting, thermal mapping or development of instrumentation. This thesis focuses on microscale processes close to the road surface. The road is only a very small fraction of the larger landscape, but it will still form its own microclimate, knowledge of which is essential to determine and forecast road conditions. As the wind blows onto the road a step change in surface roughness, temperature and heat flux will occur and an internal boundary layer (IBL) will build up over the road. The diurnal variation of the IBL during different weather types was studied. The influence from the surrounding vegetation was seen as a wedge of cold air that moved onto the road during nighttime cooling.

To determine what occurs at the road surface, measurements need to be done well within the IBL, something not accomplished within the current Road Weather Information System (RWIS) framework. In this study extensive measurements were performed below a height of 15 cm in order to obtain a more complete understanding of the energy exchange between the road and the atmosphere. With the Bowen Ratio method it was possible to measure sensible and latent heat fluxes. Situations of frost and evaporation were clearly identified. An eddy covariance system tended to greatly underestimate the fluxes and it was difficult to measure the latent heat flux in wintertime. Physically-based forecast models for road surface temperature normally have no means of verifying the simulated energy fluxes, but with the energy balance measurements in this thesis the models can be tested. The models examined here had difficulties in simulating the latent heat fluxes correctly. However radiation, ground heat flux and sensible heat flux was simulated quite well.

A neural network model was used to forecast the road surface temperature three hours ahead. First a statistical method was applied to select the best predictors. Then the neural network model was run with the selected predictors and with common RWIS-data. The model produced good results, especially when a forecast from the Swedish meteorological and hydrological institute was added as a predictor.

The results in this study show that by equipping the RWIS-stations with sub-surface temperature, radiation and ground heat flux sensors, better forecasts of the road surface temperature can be made. By installing an extra temperature and humidity sensor close to the surface, hazardous situations can be more readily diagnosed and predicted.

Keywords: Road climate, Internal Boundary Layer, Energy Balance, Bowen Ratio, Neural Network, Forecast.