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Development of the Surface Urban Energy and Water Balance Scheme (SUEWS) for cold climate cities

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Abstract. The Surface Urban Energy and Water Balance Scheme (SUEWS) is developed to include snow. The processes addressed include accumulation of snow on the different urban surface types: snow albedo and density aging, snow melting and re-freezing of meltwater. Individual model parameters are assessed and independently evaluated using long-term observations in the two cold climate cities of Helsinki and Montreal. Eddy covariance sensible and latent heat fluxes and snow depth observations are available for two sites in Montreal and one in Helsinki. Surface runoff from two catchments (24 and 45 ha) in Helsinki and snow properties (albedo and density) from two sites in Montreal are also analysed. As multiple observation sites with different land-cover characteristics are available in both cities, model development is conducted independent of evaluation.

The developed model simulates snowmelt related runoff well (within 19% and 3% for the two catchments in Helsinki when there is snow on the ground), with the springtime peak estimated correctly. However, the observed runoff peaks tend to be smoother than the simulated ones, likely due to the water holding capacity of the catchments and the missing time lag between the catchment and the observation point in the model. For all three sites the model simulates the timing of the snow accumulation and melt events well, but underestimates the total snow depth by 18–20% in Helsinki and 29–33% in Montreal. The model is able to reproduce the diurnal pattern of net radiation and turbulent fluxes of sensible and latent heat during cold snow, melting snow and snow-free periods. The largest model uncertainties are related to the timing of the melting period and the parameterization of the snowmelt. The results show that the enhanced model can simulate correctly the exchange of energy and water in cold climate cities at sites with varying surface cover.

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