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Modelling high-latitude urban surface energy and water balance fluxes

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To date, most urban energy and water balance studies have concentrated on mid-latitude cities with high-latitude cities receiving less attention. In the latter snow has a substantial impact on the energy and water balance as it alters surface albedo, availability of water for evaporation, and enhances the possibility for spring-time floods due to melting.

In this study the Surface Urban Energy and Water balance Scheme (SUEWS) is developed to take snow into account. Rates of evaporation-interception for a single layer, with multiple surface types (paved, buildings, evergreen trees and/or shrubs, deciduous trees and/or shrubs, irrigated grass, non-irrigated grass and water) are calculated. For each surface type, the energy and water balances are separately calculated for snow covered and snow free surfaces.

The model developments are tested using observations from the city of Helsinki, Finland. Turbulent fluxes of sensible (H) and latent heat (LE) were measured at the suburban land use SMEAR III Kumpula site. Surface runoff was monitored for two catchments with high- and low proportion of impervious cover. SUEWS is run for two years (2010 - 2011) at the three sites, with the first 6 months used as a spin-up time for the model.

The model simulates the timing of the accumulation and melting of the snow well. During mid-winter, the model is successful in simulating H, LE and runoff. Furthermore, the model is able to track the snow melt related runoff peaks well. During snow melt LE is slightly overestimated and therefore H is underestimated.

An independent test of the model's ability to simulate H, LE, and snow pack properties for urban and sub-urban sites in Montreal, Canada is conducted. Using the five study area results, the effect of different urban land uses on the water balance components is examined.