Geophysical Research Abstracts,
Vol. 11, EGU2009-2051, 2009
EGU General Assembly 2009
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A Hierarchy of Snowmelt Models for Canadian Prairies: Temperature-Index, Modified Temperature Index and Energy-Balance Models

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June, 2008

Abstract
Three semi-distributed snowmelt models were developed and applied to the Paddle River Basin (PRB) in the Canadian Prairies: (1) A physics-based, energy balance model (SDSM-EBM) that considers vertical energy exchange processes in open and forested areas, and snowmelt processes that include liquid and ice phases separately; (2) A modified temperature index model (SDSM-MTI) that uses both near surface soil temperature (Tg) and air temperature (Ta), and (3) A standard temperature index (SDSM-TI) method using Ta only. Other than the "regulatory" effects of beaver dams that affected the validation results on simulated runoff, both SDSM-MTI and SDSM-EBM simulated reasonably accurate snowmelt runoff, snow water equivalent and snow depth. For the PRB, where snowpack is shallow to moderately deep, and winter is relatively severe, the advantage of using both Ta and Tg is partly attributed to Tg showing a stronger correlation with solar radiation than Ta during the spring snowmelt season, and partly to the onset of major snowmelt which usually happens when Tg approaches 0oC. After re-setting model parameters so that SDSM-MTI degenerated to SDSM-TI (effect of Tg is completely removed), the model performance worsened, even after re-calibrating the melt factors using Ta alone. It seems that if reliable Tg data are available, they should be utilized to model the snowmelt processes in a Prairie environment particularly if the temperature-index approach is adopted.