A Hierarchy of Snowmelt Models for Canadian Prairies: Temperature-Index, Modified Temperature Index and Energy-Balance Models

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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 snow-pack 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 0°C. After re-setting model parameters so that SDSM-MTI degenerated to SDSM-TI (effect of Tg is completely removed), the latter performed poorly, 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.