A new algorithm for predicting water-driven sediment erosion on the Canadian Prairies

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Water-driven sediment erosion is a perennial problem on the Canadian Prairies and globally. Sediment transported from agricultural regions provides a conduit for phosphorus migration to waterways and lowers water quality through turbidity. Load from sediment erosion is typically calculated with the Universal Soil Loss Equation (USLE) or its derivatives, or with sediment transport models developed in temperate climates. These approaches do not represent frozen soils, snowmelt and flashy runoff over level terrain well, making their application to cold regions uncertain. Here, a new formulation that captures the unique and critical aspects of Canadian cold-regions hydrology is proposed and evaluated for application on the Canadian Prairies. In contrast to other formulations, the spring freshet period is treated as an evolving process of snowmelt and soil thawing, sub-daily runoff fluctuations for flashy basins are accounted for, rainsplash and overland flow are considered separately, and parameters are chosen to reflect Canadian agricultural systems. The model structure follows the seminal detachment-transport separation approach of Foster et al. Foster's segmented process-oriented approach gives stronger conceptual backing than USLE-based formulations. The sediment erosion algorithm was incorporated into the Cold Regions Hydrological Modeling platform, leveraging parallel efforts to model phosphorus transport and prairie hydrology. Initial evaluation using observations from South Tobacco Creek, Manitoba includes a sensitivity analysis and evaluation of the impact of temporal resolution. The sediment transport algorithm incorporated is expected to improve simulations of water quality and permit more robust calculations of the impact of cold regions land use and climate changes on phosphorus runoff.