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Climatic and physiographic controls on catchment-scale nitrate loss at different spatial scales: insights from a top-down model development approach

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Dramatic increase in nitrogen circulating in the biosphere due to anthropogenic activities has resulted in impairment of water quality in groundwater and surface water causing eutrophication in coastal regions. Understanding the fate and transport of nitrogen from landscape to coastal areas requires exploring the drivers of nitrogen processes in both time and space, as well as the identification of appropriate flow pathways. Conceptual models can be used as diagnostic tools to provide insights into such controls. However, diagnostic evaluation of coupled hydrological-biogeochemical models is challenging. This research proposes a top-down methodology utilizing hydrochemical signatures to develop conceptual models for simulating the integrated streamflow and nitrate responses while taking into account dominant controls on nitrate variability (e.g., climate, soil water content, etc.). Our main objective is to seek appropriate model complexity that sufficiently reproduces multiple hydrological and nitrate signatures. Having developed a suitable conceptual model for a given watershed, we employ it in sensitivity studies to demonstrate the dominant process controls that contribute to the nitrate response at scales of interest. We apply the proposed approach to nitrate simulation in a range of small to large sub-watersheds in the Grand River Watershed (GRW) located in Ontario. Such multi-basin modeling experiment will enable us to address process scaling and investigate the consequences of lumping processes in terms of models' predictive capability. The proposed methodology can be applied to the development of large-scale models that can help decision-making associated with nutrients management at regional scale.