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From terrestrial to aquatic fluxes: Integrating stream dynamics within a dynamic global vegetation modeling framework

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Integrated terrestrial ecosystem models simulate the dynamics and feedbacks between climate, vegetation, disturbance, and hydrology and are used to better understand biogeography and biogeochemical cycles. Extending dynamic vegetation models to the aquatic interface requires coupling surface and sub-surface runoff to catchment routing schemes and has the potential to enhance how researchers and managers investigate how changes in the environment might impact the availability of water resources for human and natural systems. In an effort towards creating such a coupled model, we developed catchment-based hydrologic routing and stream temperature model to pair with LPJ-GUESS, a dynamic global vegetation model. LPJ-GUESS simulates detailed stand-level vegetation dynamics such as growth, carbon allocation, and mortality, as well as various physical and hydrologic processes such as canopy interception and through-fall, and can be applied at small spatial scales, i.e., 1 km.
We demonstrate how the coupled model can be used to investigate the effects of transient vegetation dynamics and CO_2 on seasonal and annual stream discharge and temperature regimes. As a direct management application, we extend the modeling framework to predict habitat suitability for fish habitat within the Greater Yellowstone Ecosystem, a 200,000 km^2 region that provides critical habitat for a range of aquatic species. The model is used to evaluate, quantitatively, the effects of management practices aimed to enhance hydrologic resilience to climate change, and benefits for water storage and fish habitat in the coming century.