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Coupling soil-canopy processes to nitrogen dynamics: impacts of root moisture uptake and hydraulic redistribution

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Ecosystem productivity over seasonal to inter-annual timescales is regulated by biogeochemical cycling of nutrients critical for vegetation functioning. Nitrogen plays a crucial role in controlling photosynthetic processes, acting as a limitation on carbon dioxide uptake and thus long-term biomass storage. Modifications to the carbon dioxide uptake of vegetation in turn can affect water and energy exchange with the atmosphere through the coupling of carbon, water and heat fluxes by stomatal dynamics, resulting in a modified subsurface moisture regime. Nitrogen availability for plant processes is controlled in part by subsurface moisture and heat transport, as organic matter decomposition and nitrogen mineralization are dependent on the moisture and temperature states of the soil. The impact of root functioning, through soil moisture uptake and hydraulic redistribution, on biogeochemical cycling and land-atmosphere exchange remains an open question. Here we present a model coupling above-ground vegetation processes with below-ground soil transport mechanisms and root moisture and nutrient uptake. The above-ground vegetation component includes a Farquhar-based photosynthesis module, coupled to canopy energy balance processes through Ball-Berry-Leuning stomatal conductance relationships. The below-ground model is based on a novel mechanistic formulation coupling soil moisture transport by the Richards' equation to root water uptake and hydraulic redistribution. These equations are solved simultaneously with subsurface temperature and nutrient transport and uptake relationships. The complete model couples the soil and vegetation systems linked through biogeochemical and water flows. This model is applied to the examination of the feedbacks in the plant-soil-atmosphere system as governed by the

hydrologic and biogeochemical cycles. A particular focus is placed on the impacts of subsurface hydraulic redistribution by the plant root system on nutrient uptake and ecosystem productivity.