Integrated Hydro-biogeochemical Modeling for Comprehensive Environmental Impact Assessment in Agricultural Lands

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Greenhouse gas emissions due to anthropogenic activities continue to alter the climate, and the induced changes of hydrological and ecological processes (i.e., water, carbon, and nitrogen cycles) attract a growing public concern. Process-based numerical models in environmental science can help understand and quantify the terrestrial material cycles in nature. However, the existing models usually focus on the cycles of one element (e.g., water, carbon, or nitrogen). For example, hydrological models such as Soil and Water Assessment Tool (SWAT) focus on the water cycle at watershed scale, whereas biogeochemical models such as DayCent (i.e., daily CENTURY) emphasize carbon storage and fluxes of ecosystems at landscape scale. Therefore, using either one of the two categories of models is not enough for understanding/solving the current complex environmental issues that involve multiple aspects such as water quantity and quality, soil water/carbon storage, and plant productivity. Therefore, this study was to 1) develop an integrated model implementation coupler that aims to drive both SWAT and DayCent—the two representative models in hydrology and biogeochemistry, respectively—to accomplish the simultaneous simulation of water and carbon cycle modeling, and 2) evaluate the comprehensive environmental consequences caused by large-scale biofuel production-induced land-use changes such as increased frequency of corn growth in crop rotation, corn residue harvesting, and land cover change for cultivating dedicated energy crops at regional scale. Our developed SWAT-DayCent Coupler was examined with a case study of an agricultural area in the Midwestern United States. The study results could be valuable for understanding the water and carbon dynamics of ecosystems and informative for decision-makers when seeking the sustainable watershed management in multiple ways (e.g., water resources protection, carbon sequestration, and plant/crop productivity).