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A GLOBAL MODEL OF CARBON-NUTRIENT INTERACTIONS

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ABSTRACT

This presentation describes the theory, structure and results of a global biogeochemical cycling model developed jointly by our two institutions. The model has two primary objectives. First, it characterizes natural elemental cycles and their linkages. Second, it describes changes in these cycles due to human activity.

The strategy we use to represent global nutrient cycles is to study them within the drainage basins of several major world rivers on each continent. Our initial study region is the Mississippi drainage basin.

The initial model of the Mississippi River basin is a watershed model of large scale nutrient dynamics across diverse ecosystems and land uses, and is the test case for the global biogeochemical cycling model. The strategy for both global and regional models is the use of watersheds as linking mechanisms between the terrestrial, aquatic and atmospheric components of each ecosystem, and among the many ecosystems within a drainage basin.

The model structure is composed of several submodels (land use, terrestrial, aquatic) which are linked together within the hydrologic network of the basin. The data planes used by the various submodels include vegetation, soils, land use, state boundaries, river network, lakes/reservoirs, regional drainage basins, and subregional basins, and all are expressed at 0.5x0.5 degree grid cell resolution.

The model first utilizes a land cover data set which assigns the percentages of 15 types of land use to each grid cell. The terrestrial submodel then determines the amount of nutrients (kg/ha) mobilized by each land use within each cell through the use of nutrient budgets. Each land cover type has a 'spread sheet' with several of the nutrient outputs expressed as a function of inputs. This total represents the nutrients lost from the grid cell, and becomes input to an atmospheric component, and to the aquatic submodel where physical and biological processes retain portions of the terrestrially derived nutrients within each cell. The model presently mobilizes nitrogen, with intended later addition of C, S, and P.

In the aquatic submodel, the nutrients mobilized from terrestrial ecosystems are attenuated by contact with aquatic systems. This is done by first defining a series of sub-catchments within the larger Mississippi basin. In each, a major water course is assigned and the characteristics of all smaller rivers are specified. In both small and large rivers exogenous nutrients are loaded and later retained through biotic and chemical processing. Simple mass balance, involving the loading rate and the aquatic processing potential, is used to calculate nutrient mass transport at any point within the drainage basin. The model distinguishes between processes taking place in river and impoundments. The distribution of mobile nutrients over the entire basin therefore involves the processing capacity of a mosaic of linked aquatic ecosystems. The model is used to contrast the pre-settlement and contemporary distribution of DIN within the Mississippi drainage basin and compare the contemporary distribution to independent data sources. We also describe the model's sensitivity to the physical aspects of the drainage network, the placement and intensity of loading and uncertainties associated with the aquatic processing estimates.

Results of a pre-settlement and a contemporary scenario of land cover are contrasted in this paper, including contribution of land use types to river nutrient loads, soil organic matter depletion patterns in agricultural lands, and fate of heavy fertilizer inputs in aquatic streams.