Model study of the impact of soil carbon displacement by water erosion on ecosystem carbon cycle

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Transport of soil organic matter by water erosion plays a substantial role in biogeochemical cycles of terrestrial ecosystem, but its impact on carbon budget has not been evaluated at broad scales. Because climatic change and land use change will affect the water erosion regime, I developed a terrestrial carbon cycle model including soil carbon displacement by water erosion. The terrestrial carbon cycle model, Sim-CYCLE, estimates major carbon flows of plant and soil such as photosynthesis, respiration, and decomposition on the basis of ecophysiological relationships. The water erosion model, RUSLE, includes hydroclimatic, topographic, geological, and human factors (land cover change and conservation practice), which were empirically parameterized for practicality. Simulations considering the climate and land-cover changes were performed in two phases, from 1901 to 1990 on the basis of historical data, and from 1991 to 2100 using projection scenarios. In this study, a climate projection by the high-resolution coupled atmosphere-ocean biosphere model (MIROC-high) for the IPCC-SRES A1B emission scenario was used. Historical land use was obtained from a dataset by Ramankutty and Foley (1999), and future land use was simply estimated by extrapolating linear trends in the 1980s. During the first phase, global lateral displacement of soil carbon or sediment yield was estimated to be 1.7 +- 0.1 Pg C y-1 with remarkable geographical heterogeneity. It was gradually intensified in regions where forests were converted into croplands, such as tropical rainforests in Amazon Basin and Southeast Asia. During the second phase, both projected rainfall and land-use changes affected the erosion regime in many regions. Consequently, the total amount of soil carbon displacement increased by 30-58%, implying an intensified vulnerability to soil loss and further perturbations in the carbon cycle. A comparative experiment revealed that the climatic change and human land-use change influenced the water erosion regime in comparable magnitudes. The simulation implied that Monsoon Asia is an important area in terms of soil carbon loss by water erosion, because of its steep topography, abundant precipitation, and intensive human land use. However, to reduce uncertainties, further studies are required in terms of the interaction process between hydrological cycle and carbon cycle.