Geophysical Research Abstracts, Vol. 8, 09549, 2006
SRef-ID: 1607-7962/gra/EGU06-A-09549

Using Multiple Constraints and Ensemble Model Simulations to Quantify Terrestrial Carbon Trends and Uncertainty in the Eastern United States

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The magnitude, spatial patterns, mechanisms, and uncertainty of contemporary U.S. carbon sources and sinks are not well understood and quantified. In this study, we estimate contemporary (1973-2000) carbon dynamics with measures of uncertainty in the terrestrial biosphere of the eastern United States using the spatially explicit modeling system GEMS (General Ensemble biogeochemical Modeling System). Model simulations were constrained through nonlinear inversion by many kinds of observations including detailed high-resolution (60-m) land cover change information derived from Landsat imagery, estimates of net primary productivity from MODIS (Moderate Resolution Imaging Spectroradiometer), grain yield and cropping practices from U.S. Department of Agriculture, and forest characteristics from the Forest Service's Forest Inventory and Analysis database. The spatial and temporal changes of uncertainty of the estimated carbon stocks and fluxes were quantified using the ensemble stochastic simulation mechanism embedded in the GEMS. Results indicated that the eastern U.S. has been a significant carbon sink since 1973. However, the carbon sink strength has been decreasing from 1973 to 2000. Climate variability and change was the predominant factor defining the interannual variability of the carbon sink strength. Ignoring the dynamic land use change information could lead to significant overestimation of the carbon sink strength. Uncertainties of carbon stocks and fluxes are strongly associated with land cover, land cover change, and spatial scale.