Using Multiple Constraints to Quantify Carbon Dynamics over Large Areas With Uncertainty Measures

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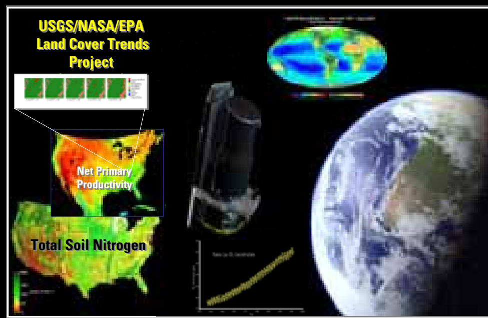
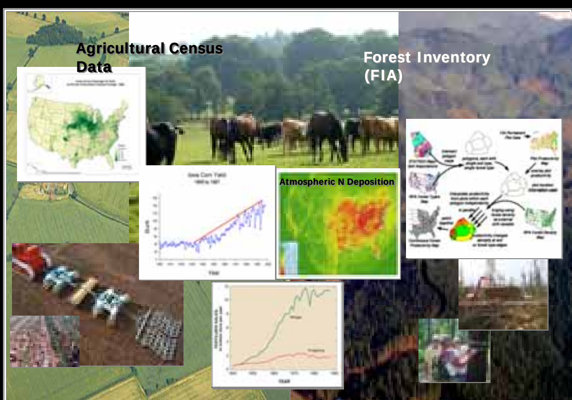
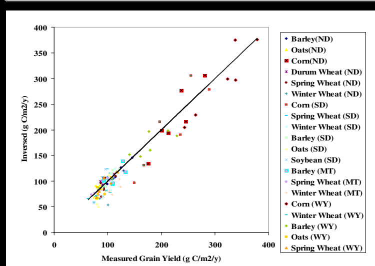
Upscaling carbon dynamics from sites to large areas has been challeneging. We have developed a General Ensemble Biogeochemical Modeling System (GEMS) to better integrate well-established ecosystem biogeochemical models with various spatial databases for the simulations of the biogeochemical cycles over large areas. It uses a Monte-Carlo-based ensemble approach to incorporate the variability (as measured by variances and covariance) of state and driving variables of the underlying biogeochemical models into simulations. Consequently, GEMS can not only simulate the spatial and temporal trends of C and N dynamics such as CO2 exchange between the terrestrial biosphere and the atmosphere, but can also provide uncertainty estimates of the predicted variables in time and space.

Inherent drawbacks exist on the measurement and modeling of ecosystem carbon dynamics at the plot to global scales. Measurements are usually patchy in space and discontinuous in time, while modeling is always built on some principles with assumptions and imperfectly-defined parameters. Advanced data assimilation techniques based on statistics or optimal theory have been implemented with GEMS to overcome these drawbacks.

GEMS has been applied to simulate carbon and nitrogen dynamics in the United States, Africa, Asia, and Central America.

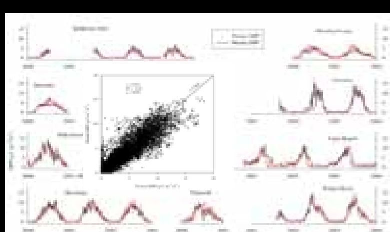




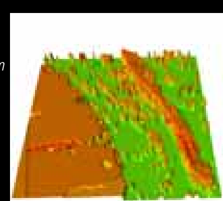


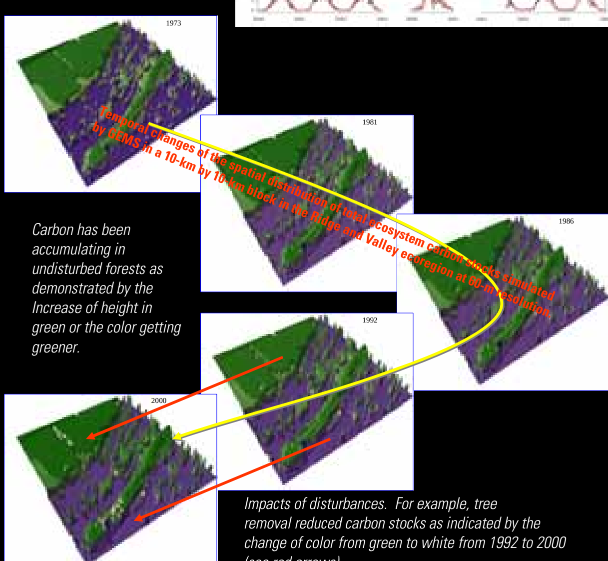
Comparison of model simulated and observed historical grain yields of major crops

Comparison between the predicted and observed daily gross primary productivity at 25 Ameriflux tower sites covering a wide range of ecosystem types (e.g., various forests, savannas, and grasslands) from Florida to Canada.



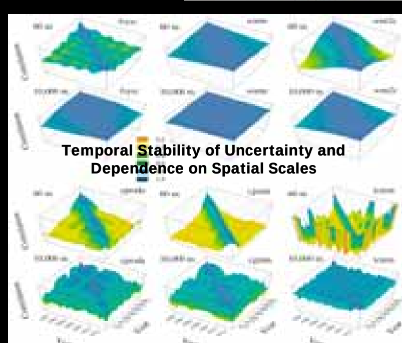
Carbon stock (height) and uncertainty (color) simulated by GEMS in a 10-km by 10-km block in the Ridge and Valley ecoregion at 60 m resolution. Cooler colors indicate lower uncertainty.

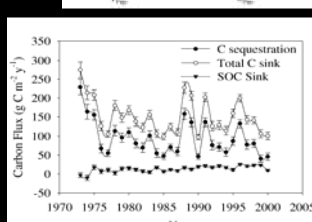




Carbon has been accumulating in undisturbed forests as demonstrated by the Increase of height in green or the color getting greener.

Impacts of disturbances. For example, tree removal reduced carbon stocks as indicated by the change of color from green to white from 1992 to 2000 (see red arrows)





Carbon sources and sinks, carbon sequestration in ecosystems, and soil organic carbon sink strengths from 1973 to 2000 in the Ridge and Valley ecoregion.