Geophysical Research Abstracts
Vol. 19, EGU2017-16157, 2017
EGU General Assembly 2017

Age and transit time distributions of carbon in a nonlinear global model perturbed by nonautonomous fossil-fuel emissions signals

Holger Metzler, Markus Müller, and Carlos A. Sierra
Max Planck Institute for Biogeochemistry, Dept. of Biogeochemical Processes, Jena, Germany (hmetzler@bgc-jena.mpg.de)

Carbon fluxes in the ocean-atmosphere-biosphere system are governed by nonlinear processes, which are usually modeled by a system of ordinary differential equations. It is very difficult to analyze such nonlinear models and to predict their future behavior, particularly their internal age structure: How old is the carbon in different pools (ages) and how old is the carbon that leaves the system (transit times)? How is this age structure modified by the addition of fossil fuel emissions?

To answer these questions, we developed a new mathematical approach that allows us to compute and visualize the age structure of models of well mixed pools even if they are nonlinear and nonautonomous. We do not only consider mean ages and mean transit times, but entire distributions. Consequently, we can consider important statistics such as the median, quantiles, or the variance.

We applied this mathematical approach to a nonlinear global carbon model consisting of three pools (atmosphere, surface ocean, and terrestrial biosphere) and driven by four emission scenarios (RCP3-PD, RCP4.5, RCP6, RCP8.5). Results showed that the addition of fossil fuels modifies the age structure of C in the atmosphere by drastically increasing its proportion of young carbon. We found little differences among predicted mean ages for the four emission scenarios, but changes in the overall distributions were large with effects on median, quantiles and variance. In the short-term, fossil-fuel emissions have an important effect on the amount of carbon that is exchanged among Earth's main C reservoirs. In the long-term, most added C will eventually end up in the deep ocean, but the time required to return to pre-industrial C age distributions is largely dependent on emission scenarios.