

Poster #38

Implications of Uncertainty in Fossil Fuel Emissions for Terrestrial Ecosystem Modeling

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Given observations of the increase in atmospheric CO₂, estimates of anthropogenic emissions and models of oceanic CO₂ uptake, it is possible to estimate net global CO₂ exchange between the atmosphere and the terrestrial biosphere as the residual of the balanced (closed) global carbon budget. These calculations show that global terrestrial ecosystems are a growing sink for atmospheric CO₂ (averaging 2.12 Gt C y⁻¹ for the period 1959-2015 with a growth rate of 0.03 Gt C y⁻¹ per year) but with considerable year-to-year variability (standard deviation of 1.07 Gt C y⁻¹). Within the uncertainty of the observations, emissions estimates and ocean modeling, this residual calculation is a robust, current best estimate of the global terrestrial sink for CO₂. A task of terrestrial ecosystem science is to explain the trend and variability in this estimate. However, the “[w]ithin the uncertainty” is an important caveat. The uncertainty (2σ; 2 standard error; 95% confidence interval) in fossil fuel emissions previously estimated as part of the Oak Ridge National Laboratory TES-SFA is 8.4% (9.9±0.8 Gt C in 2015). Combined with uncertainty in the other carbon budget components, this results in a 2σ (95% confidence interval) uncertainty surrounding the global net atmosphere-biosphere CO₂ exchange of ±1.6 Gt C y⁻¹. If one ignores the uncertainty, the carbon-budget estimate of net atmosphere-biosphere exchange includes 2 years (1987 and 1998) in which the terrestrial biosphere is a small source of CO₂ to the atmosphere rather than a sink. However, within the 2σ uncertainty, the terrestrial biosphere may have been a source in 18 of the 57 years. We examine how well global terrestrial biosphere models simulate the trend and interannual variability of the global-budget estimate of the terrestrial sink within the context of this uncertainty (e.g., which models fall within 1σ or 2σ of the estimate). The models are generally capable of reproducing the trend in net atmosphere-biosphere exchange, but are less able to capture interannual variability, particularly the magnitude of year-to-year variations. Analysis of the carbon-budget estimate indicates that the trend is primarily associated with the increase in atmospheric CO₂, while interannual variation is related to variations in global land-surface temperature with weaker sinks in warmer years. We examine whether these relationships are reproduced in the models. Their absence might explain weaknesses in model simulations, or models might simulate similar sinks but show different relationships with the apparent drivers of global net atmosphere-biosphere CO₂ exchange. We consider the implications of these comparisons for terrestrial ecosystem science: for both process understanding and representation in models.