U.S. CLIMATE CHANGE SCIENCE PROGRAM SYNTHESIS AND ASSESSMENT REPORT 2.2, THE FIRST STATE OF THE CARBON CYCLE REPORT (SOCCR): NORTH AMERICAN CARBON BUDGET AND IMPLICATIONS FOR THE GLOBAL CARBON CYCLE

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North America is currently a net source of carbon dioxide to the atmosphere, contributing to the global buildup of greenhouse gases in the atmosphere and associated changes in the Earth's climate. In 2003, North America emitted nearly two billion metric tons of carbon to the atmosphere as carbon dioxide. North America's fossil-fuel emissions in 2003 (1856 million metric tons of carbon ± 10% with 95% certainty) were 27% of global emissions. Approximately 85% of those emissions were from the United States, 9% from Canada, and 6% from Mexico. The combustion of fossil fuels for commercial energy (primarily electricity) is the single largest contributor, accounting for approximately 42% of North American fossil emissions in 2003. Transportation is the second largest, accounting for 31% of total emissions.

There are also globally important carbon sinks in North America. In 2003, growing vegetation in North America removed approximately 500 million tons of carbon per year (± 50%) from the atmosphere and stored it as plant material and soil organic matter. This land sink is equivalent to approximately 30% of the fossil-fuel emissions from North America. The imbalance between the fossil-fuel source and the sink on land is a net release to the atmosphere of 1350 million metric tons of carbon per year (± 25%).

Approximately 50% of North America's terrestrial sink is due to the regrowth of forests in the United States on former agricultural land that was last cultivated decades ago, and on timberland recovering from harvest. Other sinks are relatively small and not well quantified with uncertainties of 100% or more. The future of the North American terrestrial sink is also highly uncertain. The contribution of forest regrowth is expected to decline as the maturing forests grow more slowly and take up less carbon dioxide from the atmosphere. But, how regrowing forests and other sinks will respond to changes in climate and carbon dioxide concentration in the atmosphere is highly uncertain.

The large difference between current sources and sinks and the expectation that the difference could become larger if the growth of fossil-fuel emissions continues and land sinks decline suggest that addressing imbalances in the North American carbon budget will likely require actions focused on reducing fossil-fuel emissions. Options to enhance sinks (growing forests or sequestering carbon in agricultural soils) can contribute, but enhancing sinks alone is likely insufficient to deal with either the current or future imbalance. Options to reduce emissions include efficiency improvement, fuel switching, and technologies such as carbon capture and geological storage. Implementing these options will likely require an array of policy instruments at local, regional, national, and international levels, ranging from the encouragement of voluntary actions to economic incentives, tradable emissions permits, and regulations. Meeting the demand for information by decision makers will likely require new modes of research characterized by close collaboration between scientists and carbon management stakeholders.

CCSP (2007), The first state of the carbon cycle report: the North American carbon budget and implications for the global carbon cycle. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [King, A.W., L. Dilling, G.P. Zimmerman, D.M. Fairman, R.A. Houghton, G. Marland, A.Z. Rose, and T.J. Wilbanks (eds.)]. National Oceanic and Atmospheric Administration, National Climatic Date Center, Asheville, NC, USA, 242 pp.

Vertical Profiles of CO_2 and the Latitudinal Partitioning of Carbon Fluxes

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Measurements of midday vertical atmospheric CO_2 distributions reveal annual-mean vertical CO_2 gradients which are inconsistent with atmospheric models that estimate a large transfer of terrestrial carbon from tropical to northern latitudes. The 3 models that most closely reproduce the observed annual-mean vertical CO_2 gradients estimate weaker northern uptake of -1.5 $PgCyr^{-1}$ and weaker tropical emission of +0.1 $PgCyr^{-1}$ compared to previous consensus estimates of -2.4 and +1.8 $PgCyr^{-1}$ respectively. This suggests a smaller role for northern terrestrial uptake of industrial CO_2 emissions than previously thought and, after subtracting land use emissions, that tropical ecosystems may currently be strong sinks for CO_2. Adding airborne flask data to existing inverse models without first fixing their transport biases will not improve their flux estimates. Future inverse models must be validated against available metrics, including vertical profiles of CO_2, SF_6, and other tracers.

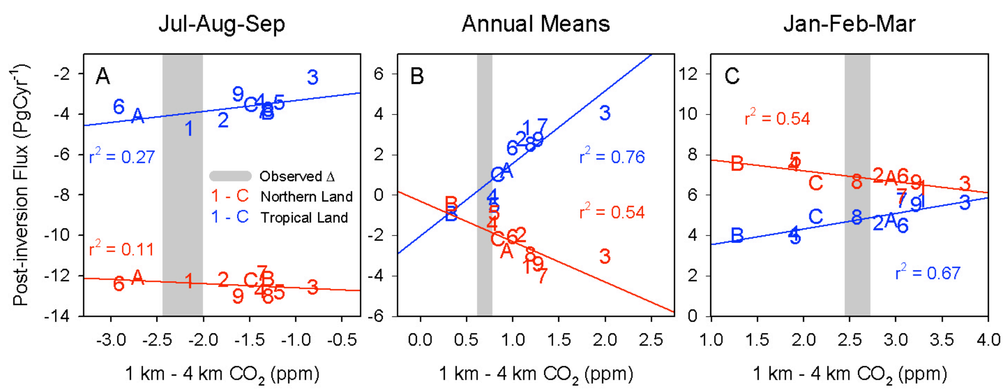

Figure 1. Model estimated fluxes plotted versus predicted vertical profiles. The observed vertical profiles and uncertainties are indicated by gray bars.

References

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