How Much Can Atmospheric Data Tell Us About the North American Land Sink?

S. Feng[1], T. Lauvaux[1], K. Keller[2,3], M. Butler[1], K.J. Davis[1,3], A.E. Schuh[4], S. Basu[5,6], D.F. Baker[4], J. Liu[7], C. Williams[8], Y. Zhou[8], T. Oda[9], K. Gurney[10] and A.E. Andrews[6]

[1]Department of Meteorology and Atmospheric Science, The Pennsylvania State University, University Park, PA 16802; 813-658-8196, E-mail: sfeng@psu.edu
[2]Department of Geosciences, The Pennsylvania State University, University Park, PA 16802
[3]Earth and Environmental Systems Institute, The Pennsylvania State University, University Park, PA 16802
[4]Cooperative Institute for Research in the Atmosphere (CIRA), Colorado State University, Fort Collins, CO 80521
[5]Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, CO 80309
[6]NOAA Earth System Research Laboratory, Global Monitoring Division (GMD), Boulder, CO 80305
[7]NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109
[8]Clark University, Worcester, MA 01610
[9]NASA Goddard Space Flight Center (GSFC), Earth Science Technology and Research, Greenbelt, MD 20771
[10]Arizona State University, Tempe, AZ 85287

We use a newly-developed ensemble-based mesoscale modeling system to analyze the cause of the large uncertainties in atmospheric estimates of the terrestrial biospheric fluxes over North America. We first quantify the uncertainty from biospheric fluxes, transport, boundary conditions, and fossil fuel emissions on the simulated atmospheric carbon dioxide (CO_2) concentrations, based on the ESRL/GMD tall tower measurements of CO_2 concentration. We determine the optimal time scale for atmospheric inversions to inform terrestrial biospheric flux estimates. The monthly-to-seasonal scale maximizes the potential to detect and potentially improve flux estimates for the terrestrial biosphere contribution. We demonstrate the importance of fossil fuel emissions uncertainties. The fossil fuel emissions uncertainty may have been underestimated in past inversions, limiting the ability to isolate the biospheric contribution from total atmospheric CO_2. Our results demonstrate the potential of regional atmospheric modeling systems to improve the phenology and climate response of the terrestrial biosphere to climate anomalies and, in turn, provide more accurate estimates of carbon sinks at national to continental scales. Our finding can inform the design of sampling strategies for atmospheric CO_2 mixing ratios, specifically where and when to observe in order to optimally constrain the different contributors of the overall observation uncertainty.

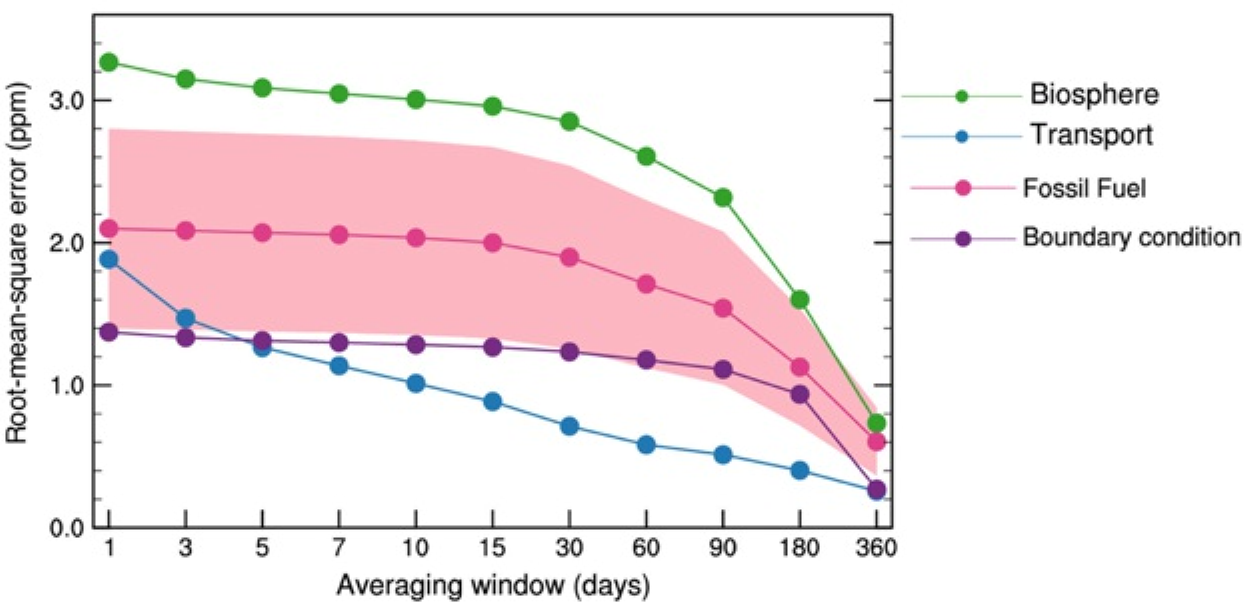

Figure 1. Root-mean-square errors of modeled atmospheric CO_2 mixing ratios varying with time scales against the ESRL/GMD tall tower CO_2 mixing ratio measurements, presented for four modeling components of the domain-limited simulations, i.e. uncertainties from transport model, biogenic fluxes, fossil fuel emissions, and the boundary conditions.