Evaluating model-observation CO_2 sampling strategies: Implications for the strength of the latitudinal CO_2 gradient

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In CO_2 source inversion studies, the combination of model-simulated and observed atmospheric CO_2 concentrations suggests that the Northern Hemisphere terrestrial biosphere is sequestering approximately 1-2 PgC/yr. However, in these studies, the model simulated CO_2 concentrations are generally averaged over all times of day and meteorological conditions, whereas most of the observations are made during daylight hours and subject to meteorological restrictions, e.g., wind speed and direction criteria. We investigated the effect of different sampling strategies on modeled CO_2 distributions in two different global chemical transport models driven with different meteorological inputs. In our analysis we used diurnally varying CO_2 fluxes from the terrestrial biosphere and focused on the stations used in the Transcom intercomparison. We found that annual mean CO_2 concentrations simulated in the models were sensitive to the time of day sampling and wind speed and direction. Failing to account for the diurnal cycle of CO_2 when sampling atmospheric models leads to an overestimate of CO_2 levels at a number of continental and coastal stations. In atmospheric inversions, this bias could lead to an overestimation of the size of the Northern Hemisphere carbon sink. As more observations in non-remote locations are incorporated into model-observation comparisons, extra care will be necessary to sample model simulations in the same manner that the observations were sampled.