USING CONTINENTAL, CONTINUOUS CO_2 OBSERVATIONS IN A TIME-DEPENDENT GLOBAL INVERSION TO INFER REGIONAL FLUXES IN NORTH AMERICA

M.P. Butler[1], A.S. Denning[2], K.R. Gurney[2], S.R. Kawa[3], A.E. Andrews[4], and K.J. Davis[1]

[1]*The Pennsylvania State University, Department of Meteorology, University Park, PA 16802-5013; mpbutler@met.psu.edu, davis@met.psu.edu*

[2]*Colorado State University, Department of Atmospheric Science, Fort Collins, CO 80523-1371; denning@atmos.colostate.edu, keving@atmos.colostate.edu*

[3]*NASA Goddard Space Flight Center, Greenbelt, MD 20771; kawa@maia.gsfc.nasa.gov*

[4]*Climate Monitoring and Diagnostics Laboratory, NOAA, 325 Broadway, Boulder, CO 80305-3328; Arlyn.Andrews@noaa.gov*

ABSTRACT

Spatial and temporal characteristics of land and ocean sources and sinks of carbon remain elusive. Better understanding of the anthropogenic influences on these carbon cycle dynamics is a common goal. This experiment is one of the efforts to reach a middle ground of flux estimates for regions larger than experimental plots and flux tower footprints, but smaller than continents and ocean basins. This work tests the hypothesis that including well-calibrated continuous North American continental CO_2 measurements in the observation data used in a global inversion will provide a constraint that improves inversion estimates of the source and sink regions within North America. These continuous data are collected at tall towers and flux towers. The experiment follows the TransCom 3 synthesis inversion framework, using the NASA Goddard Space Flight Center Parameterized Chemistry and Transport Model (PCTM) with Goddard Earth Observing System, version 4 (GEOS-4) meteorological data. Seasonal fluxes are estimated for a recent year for sub-regions within North America and at continent and basin scale globally. Methods of preparing the continental continuous CO_2 measurements for the inversion will be tested. Initial inversion results will be presented along with recommendations for applicability to other global regions and use of the method to evaluate additional sites for the measurement network.

INTRODUCTION

The global inversion method has been used successfully with the primarily marine-sampled global CO_2 observation network to estimate the latitudinal distribution of global sources and sinks of carbon. However, as pointed out by many researchers [for example, see *Gurney et al*., 2002], a lack of continental CO_2 observations makes it difficult to determine with any certainty the longitudinal distribution of sources and sinks. CO_2 mixing ratio measurements are made at every flux tower where net ecosystem exchange of CO_2 (NEE) is calculated, but these measurements are not necessarily well-calibrated. These observations are also made within the surface layer, and so are subject to diurnal boundary layer and vegetation-induced changes. The current sophistication of tracer transport models using reanalyzed meteorological data makes it possible for synoptic scale variations in atmospheric composition to be detected. Here we make use of top-down and bottom-up diffusion theory within the convective boundary layer (CBL) [*Wyngaard and Brost*, 1984; *Moeng and Wyngaard*, 1984; *Patton et al*., 2003] to adjust well-calibrated surface layer CO_2 mixing ratio observations to simulate values in the mixed layer above the surface layer, where synoptic- and seasonal-scale variability should dominate. Thus we can make flux towers into Virtual Tall Towers (VTT) to simulate measurements that are made at tall towers which do sample the mixed layer of the CBL [*Davis*, 2003].

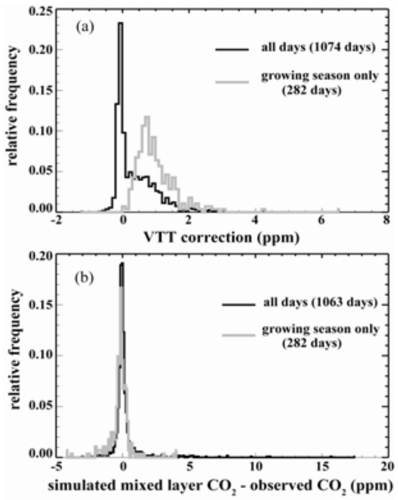

Fig.1 (a) Histogram of daily mean VTT corrections to 30m CO_2 mixing ratio (ppm) (black-all days; gray-growing season only); (b) Histogram of residuals of VTT corrected daily mean mixing ratio and observed 396m daily mean mixing ratio (ppm)

TESTING THE VTT CONCEPT AT WLEF

We have taken 5 years of mid-day (11-16 LST) hourly observation data at the WLEF tall tower in northern WI, USA, when the surface layer is most likely to be well-mixed and representative of the overlying mixed layer. We calculated the VTT correction to the 30m observed CO_2 mixing ratio data using a rough approximation of the top-down and bottom-up gradient functions [*Wyngaard and Brost*, 1984]. Daily mean values for the simulated mixed layer CO_2 mixing ratio are calculated and compared to the 396m observed mixing ratio data, which we take here as representative of the mixed layer. Histograms of the daily mean VTT corrections and the residuals of the difference in simulated and observed mixed layer CO_2 mixing ratios for the 5 years (1997-2001) are shown in Fig.1. The corrections (Fig. 1(a)) are on the order of 1 ppm during the growing season and smaller during other seasons. The residuals (Fig. 1(b)) are biased low during the growing season (-0.15 ppm, standard deviation 0.85) and high on an annual basis (0.22 ppm, standard deviation 1.35). Even with the long-tailed positive distribution of residuals, the bulk of the VTT simulations are within 1 ppm of the observations, which is less than horizontal gradients seen over the continent during synoptic events. These results may be improved with refinements to the VTT correction algorithm.

NEXT STEPS

Similar VTT corrections will be applied to top-of-tower CO_2 mixing ratio observations from the few flux towers in North America which currently have well-calibrated mixing ratio observations (e.g., Harvard Forest, Howland Forest, Northern Old Black Spruce, ARM OK). These data will be included along with the usual global observation data in a global inversion using the NASA PCTM tracer transport model [*Kawa et al.*, 2004] with reanalyzed meteorological data for the year 2002. The hypothesis is that these added data will permit more certain longitudinal resolution of surface fluxes across North America. Additional sites where calibrations are currently being established or planned will also be sampled in the transport model. Initial results will be available at the meeting.

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