2.5. NITROUS OXIDE AND SULFUR HEXAFLUORIDE

Measurements of N_2O and SF_6 from all sites in the CCGG Global Cooperative Air Sampling Network continued during 2000 and 2001 on the MAGICC analysis system. Annual mean mole fractions are given in Table 2.3 for N_2O and SF_6.

2.6. MEASUREMENTS ON TALL TOWERS

The CCGG tall-towers program began measurements of CO_2 mole fractions on a 610-m-tall TV transmitter tower in North Carolina (NC, site code ITN) in June 1992. CCGG observations at this site were discontinued in June 1999 due to loss of the lease with the tower owner. Measurements were started on a 447-m-tall TV tower in Wisconsin (WI, site code LEF) in October 1994 and are ongoing. Site characteristics and data from the ITN and LEF were discussed by *Bakwin et al*. [1998a]. In February 2001 measurements were begun on a 505-m-tall TV tower near Moody, Texas (TX, site code WKT). Surface winds often indicate transport of air into the interior of the eastern United States from the Gulf of Mexico, especially in summer, so the WKT site may represent an upwind end member for samples obtained over the eastern United States during many periods.

The time series of daily mean CO_2 mixing ratios at the highest measurement level on each of the towers is shown in Figure 2.20. Of note is the very weak drawdown of CO_2 in summer at WKT compared with ITN and LEF. WKT is in a region of relatively dry grazing lands with very hot summers. July-August 2001 was particularly hot and dry: at Waco high temperatures in excess of 34ºC were recorded each day from July 3 through August 26, with only 25 mm of rain recorded during this period. This weather condition affected a large region of the southwest United States and apparently resulted in low activity by vegetation and soils in the area. This is reflected in the diurnal cycle of CO_2 measured at WKT (Figure 2.21). During August 2001 the accumulation of CO_2 in the shallow nighttime stable layer at TX was much less than at WI, and during the daytime the vertical gradient of CO_2 from 9 m to 457 m at TX was negligible.

Variations in the growth rates of CO_2 at the ITN and LEF towers generally lead those in the marine boundary layer (MBL) and display slightly greater amplitude (Figure 2.22). Growth rate variations at the U.S. tower sites are more similar to the MBL curve than are those at the CCGG flask sampling site in Mongolia, suggesting that vegetation changes on the North American continent had a greater influence on MBL growth rates during the period of observations than did those in Eurasia.

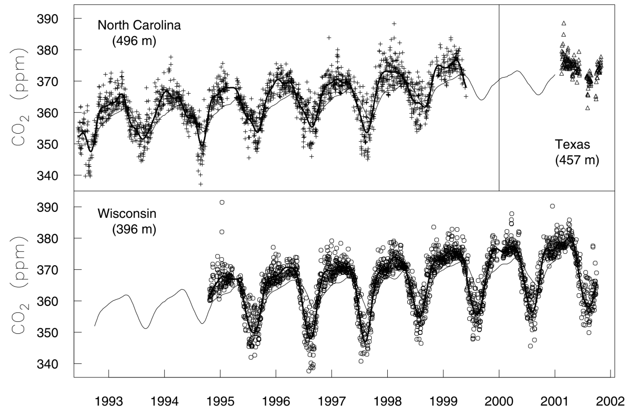

Fig. 2.20. Daily mean CO_2 mole fractions at the top measurement levels on the North Carolina, Texas, and Wisconsin towers. Heavy lines show smooth curve fits to the NC and WI tower data [*Thoning et al*., 1989], and thin lines show MBL reference curves [*GLOBALVIEW-CO₂*, 2001] for the latitudes of the NC and WI towers.

One aim of the tower program is to provide data that can be used to test and refine models of the carbon cycle at global and continental scales. A key finding from recent global model studies has been the existence of a "rectifier effect" by which covariance between atmospheric transport

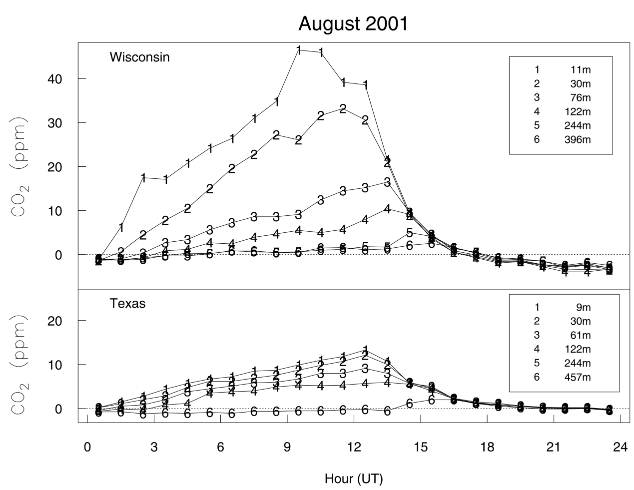

Fig. 2.21. Mean diurnal cycles for each measurement level on the Wisconsin and Texas towers for August 2001. For each day the average value for the top measurement level (plotted as a number) has been subtracted from all data in order to remove synoptic variability.

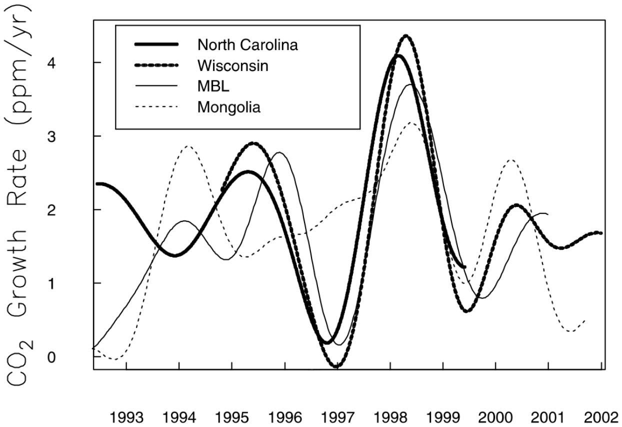

Fig. 2.22. Growth rate from smooth-curve fits [*Thoning et al.,* 1989] to daily mean CO_2 mole fractions at the North Carolina and Wisconsin towers and the CCGG flask site at Ulaan Uul, Mongolia, and from the MBL reference curve for 40ºN [*GLOBALVIW-CO_2*, 2001].

and surface fluxes of CO_2 lead to mean horizontal and vertical gradients of CO_2 mixing ratios [*Denning et al.*, 1995]. In order to balance the global atmospheric CO_2 budget, models that have a strong rectifier effect require a northern hemisphere CO_2 sink that is larger than seems reasonable based on current understanding of the global carbon cycle [*Law and Simmonds,* 1996; *Denning et al.*, 1999]. At ITN surface exchange of CO_2 is measured [*Berger et al.*, 2001; K.J. Davis et al., The annual cycles of CO_2 and H_2O exchange over a northern mixed forest as observed from a very tall tower, submitted to *Global Change Biology*, 2002], as well as the dynamics of the atmospheric boundary layer (ABL) [*Yi et al.*, 2001]. Therefore the strength of the rectifier forcing for this site can be evaluated. The observations are compared with output from the global tracer transport model of *Denning et al.* [1995], which exhibits a strong rectifier effect. The model underestimates the diurnal covariance and the resulting difference between ABL and free troposphere (FT) CO_2 when compared with the observations. At seasonal time scales, however, the model overestimates the covariance and ABL-FT CO_2 difference. The seasonal covariance is responsible for the bulk of the predicted rectifier forcing on the global scale. Hence, the rectifier forcing in the model appears to be too strong. There are uncertainties in this analysis regarding seasonality of transport between the continental and marine boundary layers, representativeness of the single observing site, and a bias toward fair-weather observing conditions. This work has been submitted for publication (C. Yi et al., Is the simulated forcing of the CO_2 rectifier effect too strong?, submitted to *Geophysical Research Letters*, 2002).

In collaboration with scientists at Colorado State University, CCGG has made progress in the use of the tower data to constrain regional-scale carbon cycle simulations. The work couples a revised version of the Simple Biosphere Model (SiB2.5) with a nested-grid regional transport model, the Regional Atmospheric Modeling System (RAMS). Physiological properties of the vegetation and phenology were specified from satellite imagery. Encouraging results have been submitted for publication (I. Baker et al., Simulated and observed fluxes of sensible and latent heat and CO_2 at the WLEF-TV tower using SiB2.5, submitted to *Global Change Biology*, 2002; A.S. Denning et al., Simulated and observed variations in atmospheric CO_2 over a Wisconsin forest, submitted to *Global Change Biology*, 2002). This work represents the first step toward an inverse modeling scheme for the regional-scale carbon cycle.