A Multi-year Record of Airborne CO_2 Observations in the U.S. Southern Great Plains

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We report on 10 years of airborne measurements of atmospheric CO_2 concentrations from continuous and flask systems, collected between 2002 and 2012 over the Atmospheric Radiation Measurement Program Climate Research Facility in the U.S. Southern Great Plains. These observations were designed to quantify trends and variability in atmospheric concentrations of CO_2 and other greenhouse gases with the precision and accuracy needed to evaluate ground-based and satellite-based column CO_2 estimates, test forward and inverse models, and help with the interpretation of ground-based CO_2 concentration measurements. During flights, we measured CO_2 and meteorological data continuously and collected flasks for a rich suite of additional gases: CO_2, CO, CH_4, N_2O, $^{13}CO_2$, carbonyl sulfide (COS), and trace hydrocarbon species. These measurements were collected approximately twice per week by small aircraft (Cessna 172 first, then Cessna 206) on a series of horizontal legs ranging in altitude from 460 m to 5,500 m (AMSL). Since the beginning of the program, more than 400 continuous CO_2 vertical profiles have been collected (2007-2012), along with about 330 profiles from NOAA/ESRL 12-flask (2006-2012) and 284 from NOAA/ESRL 2-flask (2002-2006) packages for carbon cycle gases and isotopes. Averaged over the entire record, there were no systematic differences between the continuous and flask CO_2 observations when they were sampling the same air (i.e., over the one-minute flask-sampling time). Using multiple technologies (a flak sampler and two continuous analyzers), we documented a mean difference of ~0.1 ppm between instruments. However, flask data were not equivalent in all regards; horizontal variability in CO_2 concentrations within the 5-10 minute legs sometimes resulted in significant differences between flask and continuous measurement values for those legs, and the information contained in fine-scale variability about atmospheric transport was not captured by flask-based observations. The CO_2 concentration trend at 3000 m (AMSL) was 1.91 ppm y-1 between 2008 and 2010, very close to the concurrent trend at Mauna Loa of 1.95 ppm y-1. The seasonal amplitude of CO_2 concentration in the free troposphere (FT) was half that in the planetary boundary layer (PBL) (~15 ppm vs. ~30 ppm) and twice that at Mauna Loa (approximately 8 ppm). The CO_2 horizontal variability was up to 10 ppm in the PBL and less than 1 ppm at the top of the vertical profiles in the FT.

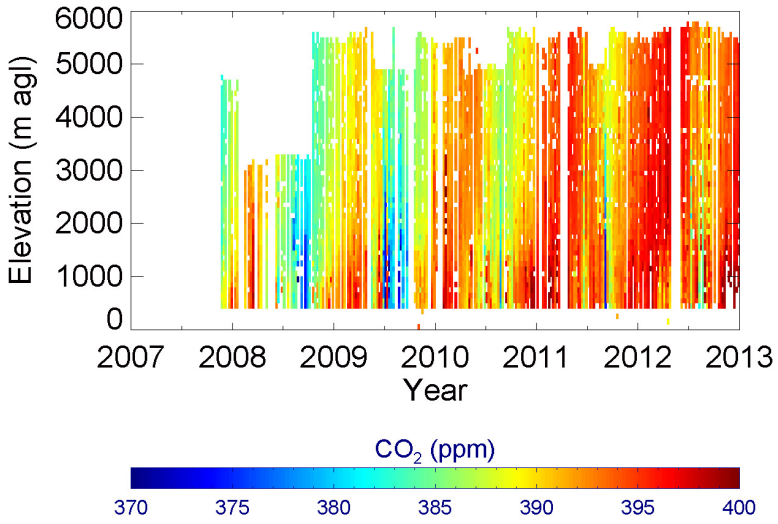

Figure 1. Weekly average continuous CO_2 concentrations collected since 2008.