Measurements of Atmospheric O_2 Variations at the WLEF Tall-tower Site

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Overview: We have adapted a commercially available fuel-cell detector to make the first atmospheric O_2 measurements from the interior of a continent and to collect the first extended O_2 record in and above a forest ecosystem. The fuel-cell instrument has successfully measured O_2 concentrations at the WLEF tall-tower research site in Wisconsin, USA, continuously since June of 2000. Our automated system analyzes air from three shared lines [at heights of 396 m, 122 m, and 30 m] and from one dedicated line [30 m (no T)] every 30 minutes with a precision comparable to existing laboratory techniques. We are using these measurements to investigate biogeochemical processes, continental boundary-layer mixing, and potential means of industrial emission verification

Figure 1. a. Full 15-month record

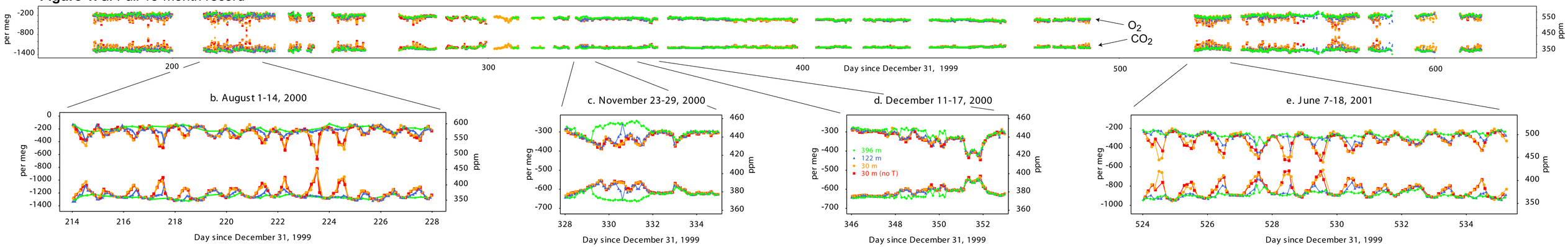
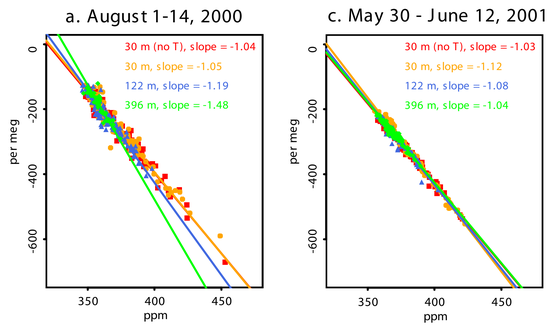


Figure 2. Atmospheric O_2 vs. CO_2

In summer (below), the correlations are strongly influenced by local photosynthesis and respiration, and the statistical errors on linear fits are very small. However, the summertime $-O_2:CO_2$ relationships are significantly lower than elemental abundance and soil studies would suggest. Possible explanations for this discrepancy include 1) rapid plant uptake and reduction of nitrogen liberated in the soil, 2) seasonal variations in the nutrient content of the microbial substrate, and 3) aliasing of photosynthesis and respiration signals with slightly different $O_2:CO_2$ ratios.



In winter (right),there is no diurnal cycle, but the influences of synoptic pollution events can clearly be seen. Because the $-O_2:CO_2$ emission ratio for coal of ~1.17 is significantly different than that for other types of fossil fuels (e.g. ~1.45 for liquid fuels), atmospheric O_2 measurements may provide a tool for verifying fuel consumption mixtures reported for various countries. As these figures show, we are readily able to distinguish between emissions from a small town (Park Falls, WI, pop. 3200) and a major industrial complex (Chicago, pop. 3,000,000) on the basis of $O_2:CO_2$ ratios.

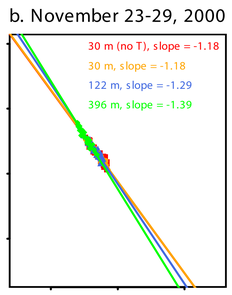


Figure 3. Back trajectories

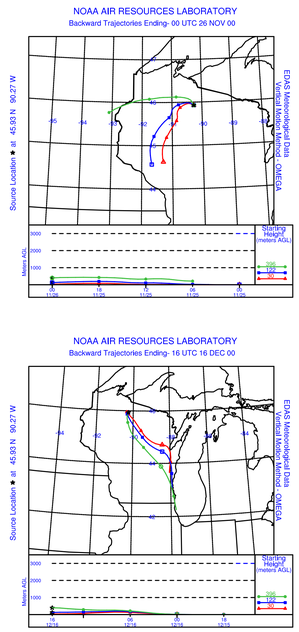


Figure 4. Comparison to MBL Measurements.

Our data show a seasonal cycle with O_2 lower and CO_2 higher during winter. By combining the O_2 and CO_2 measurements, we can derive a tracer (APO = O_2 + 1.1 * CO_2) that is approximately conservative with respect to terrestrial processes but very sensitive to oceanic gas exchange. Initial comparisons indicate that coupled atmosphere ocean models tend to underestimate the seasonal APO cycle at WLEF, suggesting that they may overestimate continental boundary-layer ventilation (Stephens et al., oral presentation).

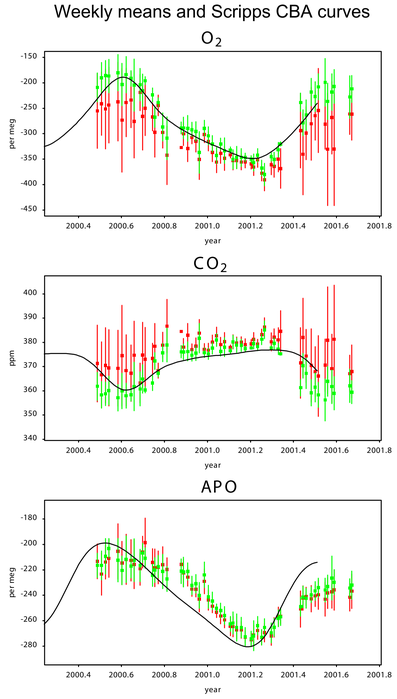


Figure 5. Average diurnal cycles for O_2 (panel top) and CO_2 (panel bottom) in each month.

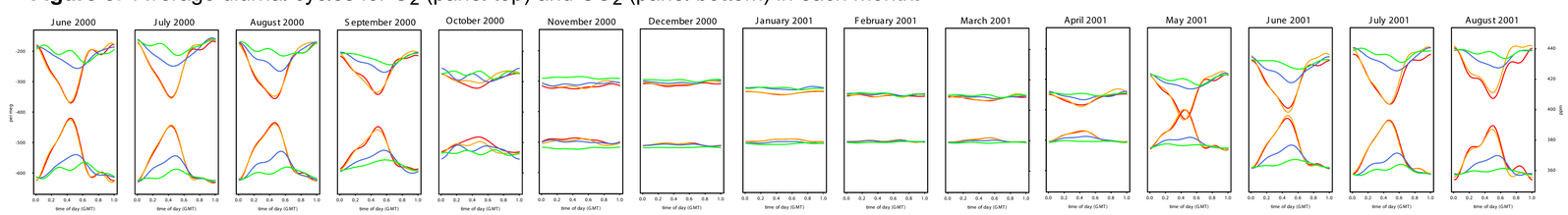


Figure 6. Monthly $O_2:CO_2$ and standard errors from ODR fit