The NOAA ESRL Tall Tower Observing Network: New Results and Planned Expansion

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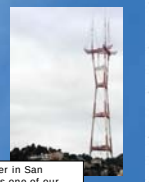
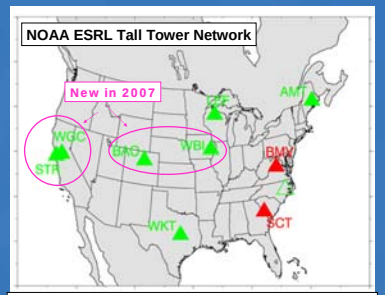
ABSTRACT: Four tower sites have been added to the NOAA tall tower network since the beginning of 2007, bringing the total number of sites to seven. In addition to continuous monitoring of CO_2, CO, and meteorological parameters, daily flask sampling using automated samplers has been implemented at several sites. The flask samples are analyzed for a large variety of species including CH_4, N_2O, SF_6, $^{13}CO_2$, COS, a suite of halocarbons, and some hydrocarbons. O_3 was measured at 10m and 400m above ground level at the Texas tower site during the summer of 2006 and has proven to be a useful indicator for urban and power plant pollution events. Radon-222 is measured at two sites and provides an indicator of surface influence. Several of the towers are directly underneath or near NOAA aircraft profiling sites. We present an overview of results from the growing network, including comparisons with results from NOAA's CarbonTracker CO_2 data assimilation system.



Sutro Tower in San Francisco is one of our newest sites. This site mainly samples clean air coming off the ocean.

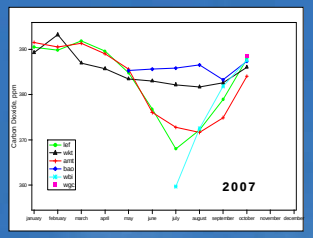


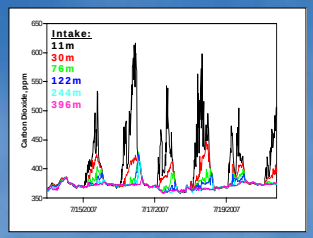
The KWKT-TV tower near Waco, TX mainly samples air coming from the south. The data show plumes from nearby power plants and urban areas.

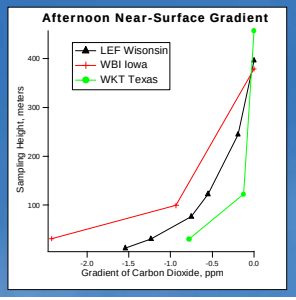
The WBI site in West Branch, Iowa provides information about agricultural ecosystems.

This is a view from the top of the Boulder Atmospheric Observatory, a 300m tall tower dedicated to atmospheric research and operated by NOAA ESRL.

Signatures of biological CO_2 uptake and release





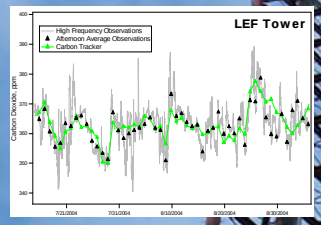


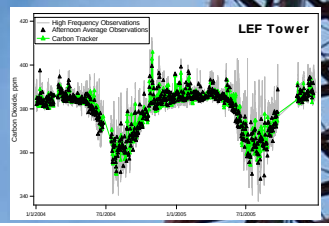
Top Left: Monthly mean CO_2 values for each of the tall tower sites. The strength of the summertime drawdown reflects the relative uptake by photosynthesis upwind of each site. WGC, BAO and WBI are new sites in 2007.

Lower Left: Several days of data from LEF during July 2007. The strong diurnal cycle at the lower sampling heights is caused by accumulation of CO_2 respired from plants and soils in the shallow nighttime boundary layer.

Above: The mean afternoon vertical gradient for three sites. The magnitude of the gradient reflects the strength of the local photosynthetic uptake of CO_2.

CarbonTracker:





Data from the tall tower network is a primary driver for NOAA ESRL's CarbonTracker CO_2 Data Assimilation System. The plots above show that CarbonTracker accurately simulates day-to-day and seasonal-to-interannual variability at LEF. CarbonTracker's estimates of the regional distribution of North American CO_2 fluxes will improve as data from new sites are incorporated. We are planning to add five or more tower sites over the next several years distributed across the USA.

Measurement System

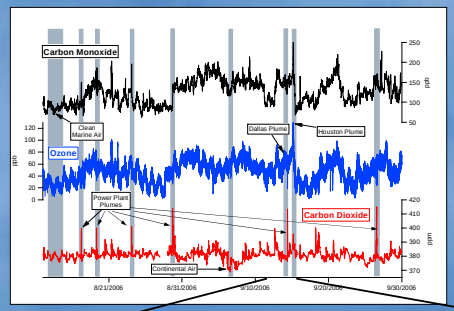
Continuous Observations:
CO_2, CO, horizontal wind, T, RH
3 levels: 30, 100, 500m
PAR, Rainfall, Surface Pressure

Automated Flask Sampling:
One twelve-pack per week
Weekly aircraft profiles at some sites

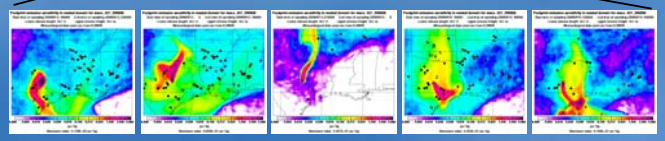
Species: CO_2, CO, CH_4, N_2O, SF_6, isotopes, halocarbons, COS, ...

Our custom built continuous trace gas system for measuring CO_2 and CO is shown above. A complete profile, consisting of measurements from three sampling heights is measured every 15 minutes. The precision is 0.1 ppm or better for CO_2 (30-sec avg) and 4 ppb or better for CO (2-min avg). The instruments are calibrated several times per day with baseline measurements every 45 to 120 minutes for CO_2 and every 15-20 minutes for CO. Both analyzers are temperature controlled to better than ±0.1° C for improved stability. The instrumentation is housed in the transmitter building or in a trailer at the base of the tower. Air is sampled through long inlet tubes attached to the tower. A meteorological measurement system monitors wind speed and direction, air temperature, and relative humidity. Programmable flask sampling packages identical to those used on NOAA ESRL aircraft flights are used for automated flask sampling. These packages have 12 flasks each, which enables one midday sample per day plus an additional five each week that can be used, e.g., for targeted sampling of pollution plumes.

A multiple-species approach for studying pollution



A snapshot of data from the WKT tower site illustrating the impact of wind direction on the measurements and the usefulness of measuring multiple species. Urban plumes are characterized by high CO and high O_3, while most power plants have high CO_2 but little or no enhancement in CO. Interestingly, fresh plumes are depleted in O_3 as expected due to rapid reaction with oxides of nitrogen. At WKT, lower than normal CO_2 indicates transport of air from the north, where photosynthesis is stronger. Computer simulations driven by weather models can be used to map upwind influences. The case below shows a weather system moving through Texas. These data were obtained during the Texas Air Quality Study 2006. The NOAA P-3 aircraft flew over the tower on September 13, while tracking the Dallas plume.



Sampling Footprints from the FLEXPART Model 12 – 15 September 2006 (courtesy of A. Stohl, Norwegian Institute of Air Research)

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