

# ATMOSPHERIC CO<sub>2</sub>, O<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, AND SF<sub>6</sub> CONTINUOUS MEASUREMENTS FROM A MID-CONTINENTAL EUROPEAN TALL TOWER

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## ABSTRACT

Continuous atmospheric measurements from tall towers have the capability to bridge an observational gap between hemispheric and local scales. We present first results from measurements made at such a tower in Germany. We show anti-correlated O<sub>2</sub> and CO<sub>2</sub> high frequency temporal variations which are caused by regional land biotic and fossil fuel emissions. We also show correlated changes in CO<sub>2</sub> concentration with air mass back trajectories, for example showing elevated CO<sub>2</sub> from air masses derived from eastern Europe, and lower, “background” concentrations from air masses derived from the North Atlantic.

## INTRODUCTION

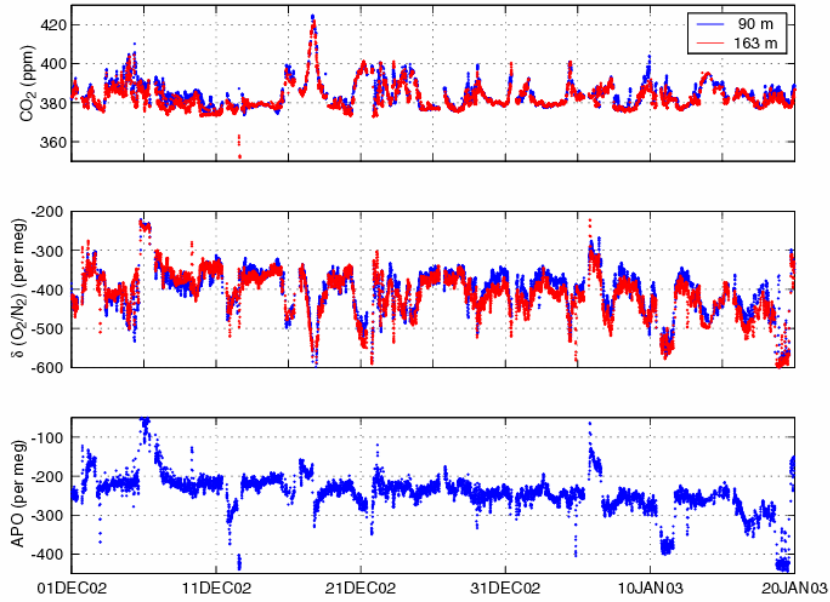
Traditional approaches to understanding the interactions between climate change and terrestrial ecosystems have relied on either an atmospheric perspective, utilising background observations of gas species’ concentrations or, alternatively, taking a terrestrial perspective which utilises local observations of fluxes or changes in ecosystem status. Missing from these two approaches is information on a regional or continental perspective. It has thus proven difficult to determine convincingly the spatial distribution of the net global land carbon sink for atmospheric CO<sub>2</sub> of  $1.2 \pm 0.8$  Pg C/y for the 1990s.

Continuous measurements from a network of mid-continental tall towers (>100 m) are a candidate for bridging the observational gap between hemispheric and local scales on land. This is because they typically sample the diurnal mixed layer of the planetary boundary layer and thus the net exchange in air masses of large, sub-continental regions. In addition to atmospheric CO<sub>2</sub>, measurements of the thermodynamical state of the air column and additional tracers such as O<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, and SF<sub>6</sub> can help further to disentangle source-sink signatures in the atmospheric CO<sub>2</sub> signal.

## METHODOLOGY

We have developed the capability for continuous, tall tower measurements and have installed a first test station at Ochsenkopf, Germany (50.05°N, 11.82°E), a 1000 m mountain located at the intersection of three plains separated by mountain ranges with height up to approximately 1000 m. Ochsenkopf should thus sample air masses which have travelled over quite different regions before arriving at the station.

We alternately analyse air from three heights (23, 90 and 163 m) for CO<sub>2</sub>, O<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, and SF<sub>6</sub> concentration. We use an NDIR CO<sub>2</sub> analyser (LI-COR, model LI-6262) in series with a fuel cell O<sub>2</sub> analyser (Sable Systems International, model “Oxzilla”), and on independent inlet lines we employ a GC (Agilent Technologies, model 6890) equipped with FID and ECD detectors measuring CH<sub>4</sub>, N<sub>2</sub>O and SF<sub>6</sub>. All air samples are pre-dried to a dewpoint of about -80°C using cryogenic cooling. Calibrations of all analysers are performed daily, and our calibration gases, stored in high pressure cylinders oriented horizontally in a thermally insulated enclosure, are traceable to the WMO scales (in the case of CO<sub>2</sub> and CH<sub>4</sub>) and to the Scripps scale, in the case of O<sub>2</sub> concentrations.



## RESULTS

Fig. 1 (left) shows  $\text{CO}_2$ ,  $\text{O}_2$ , and APO concentrations for a 7 week period in December 2002/January 2003 from 90 and 163 m heights on the tower. APO is “Atmospheric Potential Oxygen” a tracer calculated by combining  $\text{O}_2$  and  $\text{CO}_2$  concentrations, and is essentially conservative to land biotic processes. Thus APO changes capture variability caused by the distant oceans, or from fossil fuel emissions.  $\text{O}_2$  and  $\text{CO}_2$  can be seen to be largely anti-correlated, resulting in much smaller variability in APO. We suspect that some of the remaining large APO excursions are artefacts due to problems with the analytical system. All species show excursions which can be attributed to local fossil fuel emissions. In addition,  $\text{CO}_2$  concentrations are increasing

slowly, and  $\text{O}_2$  concentrations are decreasing slowly due to the seasonal activity of the land biosphere. APO can be seen to be decreasing slowly, as part of a seasonal cycle caused by the distant oceans.

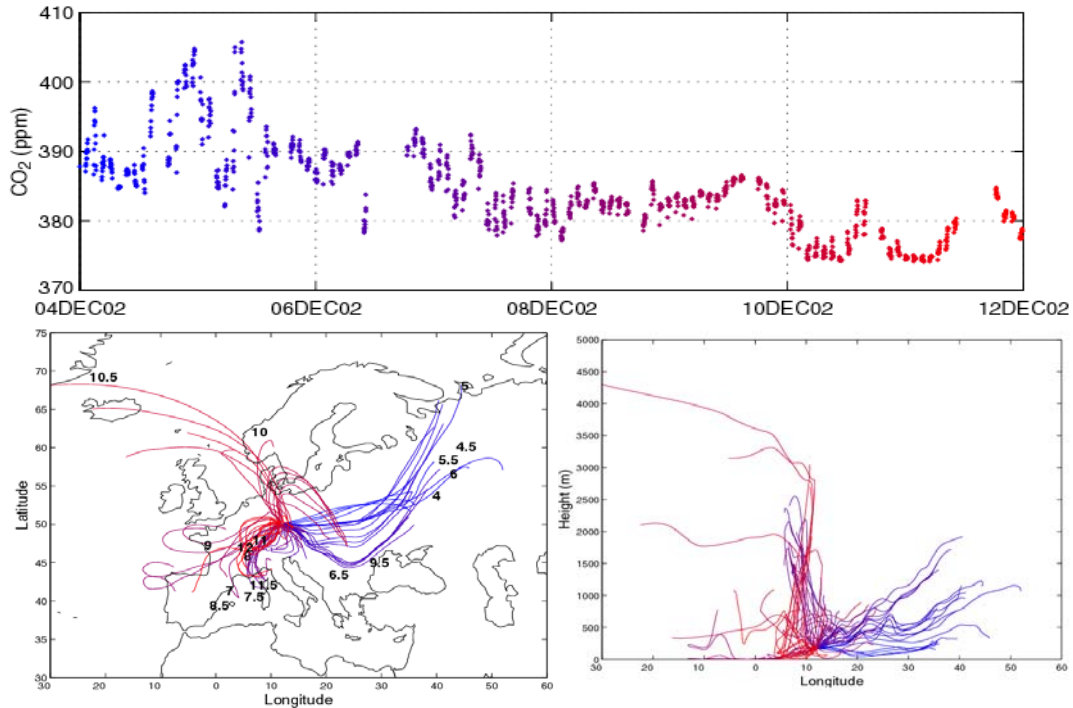


Fig. 2 shows 4-day back trajectory analyses of air masses arriving at Ochsenskopf calculated every 12 hours over an 8-day period. The bottom-left panel shows the horizontal distribution of the trajectories, where labels indicate the calendar day in December when the air arrived at Ochsenskopf. The bottom-right panel shows the altitudinal origins of the air masses. The top panel shows corresponding  $\text{CO}_2$  concentrations at Ochsenskopf, which illustrates that the early part of the record, when air masses were derived from eastern Europe exhibited elevated  $\text{CO}_2$  concentrations, whereas the latter part of the record, when air masses were derived from the North Atlantic and from higher altitudes, exhibit lower, “background” levels of  $\text{CO}_2$ . Background  $\text{CO}_2$  concentrations from Mace Head, Ireland at the same time were about 376 ppm, in good agreement with the background values found here.