CO$_2$ and O$_2$ Concentration Measurements

Britton Stephens, NCAR/ATD
Peter Bakwin, NOAA/CMDL

- Global carbon cycle
- Regional scale CO$_2$ measurements
- Potential biases in NDIR CO$_2$ measurements
- Results from the WLEF O$_2$ measurement program
- Hands on: Calculating ppm from volts using different techniques
Atmospheric CO₂ and O₂ Exchange

\[ R_{tb} \sim -1.1 \frac{\text{mol O}_2}{\text{mol CO}_2} \]

\[ R_{ff} \sim -1.4 \frac{\text{mol O}_2}{\text{mol CO}_2} \]

\[ R_{oc} \sim \text{variable} \]
La Jolla, California

[Flask data]

Fitted curves

[CO₂ (ppm)]


[R. Keeling, SIO]
Methods for measuring atmospheric $O_2$ variations

- Interferometer (R. Keeling, 1988)
- Mass spectrometer (M. Bender, 1994)
- Paramagnetic (A. Manning, 1999)
- Vacuum ultraviolet (B. Stephens, 1999)
- Gas chromatography (Tohjima, 2000)
- Fuel cell (B. Stephens, 2001)
Previous results:

-1.2 from a soil incubation study
[J. Severinghaus]

-1.05 from a wood composition survey
[R. Keeling]
December 11-17, 2000

Day since December 31, 1999

-700 -600 -500 -400 -300

346 348 350 352

per meg

360 380 400 420 440 460

ppm

December 11-17, 2000

30 m (no T), slope = -1.45
30 m, slope = -1.48
122 m, slope = -1.50
396 m, slope = -1.41

NOAA AIR RESOURCES LABORATORY
Backward Trajectories Ending- 16 UTC 16 DEC 00

Source Location ■ at 45.59 N 90.27 W

EPA Meteorological Data - OMEGA

Starting Height (nearest AGL)

Meters (AGL)

-3000 -2000 -1000 0 1000 2000 3000

12/17 12/18 12/19 12/20 12/21
NOAA AIR RESOURCES LABORATORY
Backward Trajectories Ending: 00 UTC 26 NOV 00

EDAS Meteorological Data
Vertical Mole fraction - OMEGA

Source Location: at 45:59 N 80:27 W

30 m (no T), slope = -1.18
30 m, slope = -1.18
122 m, slope = -1.29
396 m, slope = -1.39
Average diurnal cycles for O₂ (panel top) and CO₂ (panel bottom) in each month.
Monthly $\text{O}_2:\text{CO}_2$ and standard errors from ODR fit

30 m (no $T$)
Atmospheric Potential Oxygen

\[ \text{APO} = \text{O}_2 + 1.1 \times \text{CO}_2 \]
WLEF Comparison to Scripps CBA Curves

![Graph showing comparison between WLEF and Scripps CBA curves for O2 over the years from 2000 to 2001. The graph includes data points and fitted curves for SIO data and extrapolation. The x-axis represents the years (2000.4 to 2001.8), and the y-axis represents per mg CO2. There are also annotations for fit to SIO data, extrapolation to fit, and WLEF weekly means and standard deviations.]
Seasonal CBA-LEF APO Difference

Observations

Models

year fraction

per meg
Conclusions

• WLEF Atmospheric $O_2$ measurements began in spring of 2000 and are presently ongoing

• Data provide insights into:
  – Plant physiology and nutrient cycling
  – Industrial emission characterization
  – Continental-scale atmospheric mixing
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