An intensive two-week study of an urban CO$_2$ dome in Phoenix, Arizona, USA

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◆ Outline

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1. Background

- **Urban CO$_2$ Dome**
  Concentrations diminished from the city center towards the outlying rural areas. *(Idso et al. 1998)*

- **Why to choose Phoenix**
  The CO$_2$ dome over Phoenix were considerably larger than the few enhancements measured over other cities *(Clarke and Faoro, 1966; Berry and Colls, 1990a, b; Reid and Steyn, 1997)*
Sources of urban CO$_2$ Dome (of Phoenix)

Vehicles (79.9%), soil respiration (15.8%), power plants (2.2%), human respiration (1.6%), landfills (0.5%), airplanes (less than 0.1%) Koerner and Klopatek (2002)

Consequence of urban CO$_2$ Dome

Do they significantly impact local temperatures and/or vegetative productivity?
Impact local temperatures?
The high urban near-surface air temperatures are not the result of a local CO$_2$ enhanced greenhouse effect. Balling et al. (2002)

Impact vegetative productivity?
2. Objective

To conduct an intensive investigation of Phoenix's urban CO₂ dome to more rigorously determine its strength and stability.
Fig. 1. Street density map of the Phoenix metropolitan area showing the locations of the four transect routes and the points where the CO$_2$ concentration data were obtained. Solid gray denotes regions where street density is high. Travel across the routes was from southeast to northwest.

3. Experiment

Transects nos. 1 and 2 pass through the central portion; Transects nos. 3 and 4 weave in and out of the city.
Each of the four transects was simultaneously traversed by four separate automobile crews, starting at 0500 and 1400 LST.

Outside air (2 m above the ground) was drawn into CO$_2$ measurement system, and the concentrations were measured by Model LI-800 Gas Hound infrared gas analyzers.
4. Result & Discussion

To display the nature of the Spatial and temporal variability

Mean weekend value measured at the northernmost point was 369 ppm

**Fig. 2.** CO$_2$ concentration values at each of the measurement locations of the ten weekday and four weekend pre-dawn data acquisition runs of Transect 1. The named locations along the abscissa divide the route into four equal-length segments.
Fig. 3. Seven-term running-average means and standard errors of the means for the pre-dawn and mid-afternoon data acquisition runs of Transect 1. The named locations along the abscissa divide the route into four equal-length segments.

pre-dawn near-surface: Weekday/weekend=29.0%/22.9% =1.266
Fig. 4. Seven-term running-average means and standard errors of the means for the pre-dawn and mid-afternoon data acquisition runs of Transect 2. The named locations along the abscissa divide the route into four equal-length segments.

Weekday traffic and commercial activities increased pre-dawn near-surface \( \text{CO}_2 \) concentrations about 30% more than weekend \( [(26.6\% + 33.6\%)/2 = 30.1\%] \)

predawn near-surface:
Weekday/weekend = 31.8%/23.8% = 1.336
Little built-up areas to either the south or west, in the afternoon, the mini-CO\textsubscript{2} domes were essentially swept away by the combined action of vertical mixing and the prevailing surface airflow from the southwest.

**Fig. 5.** Seven-term running-average means and standard errors of the means for the pre-dawn and mid-afternoon data acquisition runs of **Transect 3**. The named locations along the abscissa divide the route into four equal-length segments.
Mini-CO$_2$ domes were preserved in the afternoon by the advection of city-produced CO$_2$ from the south and west.

Fig. 6. Seven-term running-average means and standard errors of the means for the pre-dawn and mid-afternoon data acquisition runs of Transect 4. The named locations along the abscissa divide the route into four equal-length segments.
5. Conclusions

- Cities produces a sizeable increase in the CO$_2$ concentration of the near-surface boundary layer air.

- Over the extended portion of the city, weekday-weekend dichotomy was more pronounced; over the primarily residential areas of the city, no significant differences between weekday and weekend.
Vertical mixing and airflow will influence near-surface CO₂ concentrations over the city.

What remains to be learned

What happens throughout the rest of the year and over a complete diurnal cycle?
Seasonal and diurnal variations of near-surface atmospheric \( \text{CO}_2 \) concentrations within a residential sector of the urban \( \text{CO}_2 \) dome of Phoenix, AZ, USA.

--Sherwood B. Idso, Craig D. Idso, Robert C. Balling Jr.
What was done

Measured atmospheric CO$_2$ concentration, temperature and wind speed two meters above the ground every minute of most of an entire year (315 days of the year 2000) in a residential neighborhood of a suburb of Phoenix.
Fig. 7. Daily maximum and minimum values of 30-min averages of near-surface atmospheric CO$_2$ concentration over the course of year 2000.

Fig. 8. Mean diurnal courses of near-surface atmospheric CO$_2$ concentration (2-month averages of 1-min data) for the coldest Two months of the year (December-January) and the warmest 2 months of the year (July–August).
What was learned

A mean cold-season maximum atmospheric CO$_2$ concentration: at the center of the city, enhancement 67%; at the residential site, enhancement 33%;

Averaged over the entire night enhancement: 25% in the cold season, 11% in the warm season; over the complete daylight period: 10% in both seasons;

The maximum weekday-weekend CO$_2$ differential was 40 ppm in the cold season and 22 ppm in the warm season.
The **primary** controlling factors of the strength of the CO$_2$ dome:

(1) the presence of air temperature inversions at night and in the early morning;

(2) solar-induced convective mixing during the midday period.

**Secondary** controlling factors:

(a) wind speed; (b) wind direction.
What it means

Near-surface atmospheric CO$_2$ concentrations in large cities may often be much higher than those of surrounding rural areas. But they tend to drop off rapidly with distance from the city-center and major roadways.
Thank You