



Diurnal Variations of CO₂ Emissions during CalNex-LA: Magnitude and Sources

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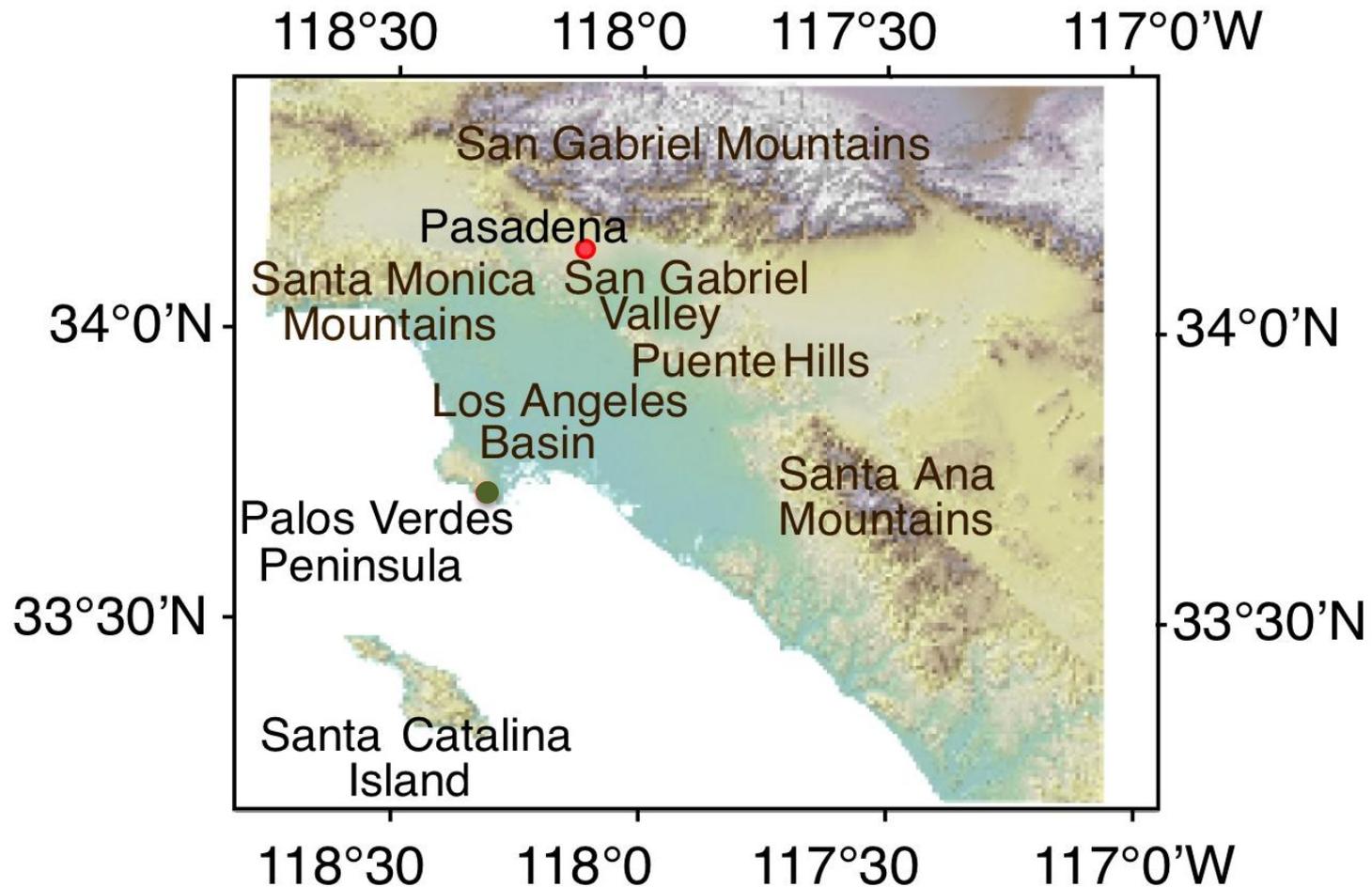
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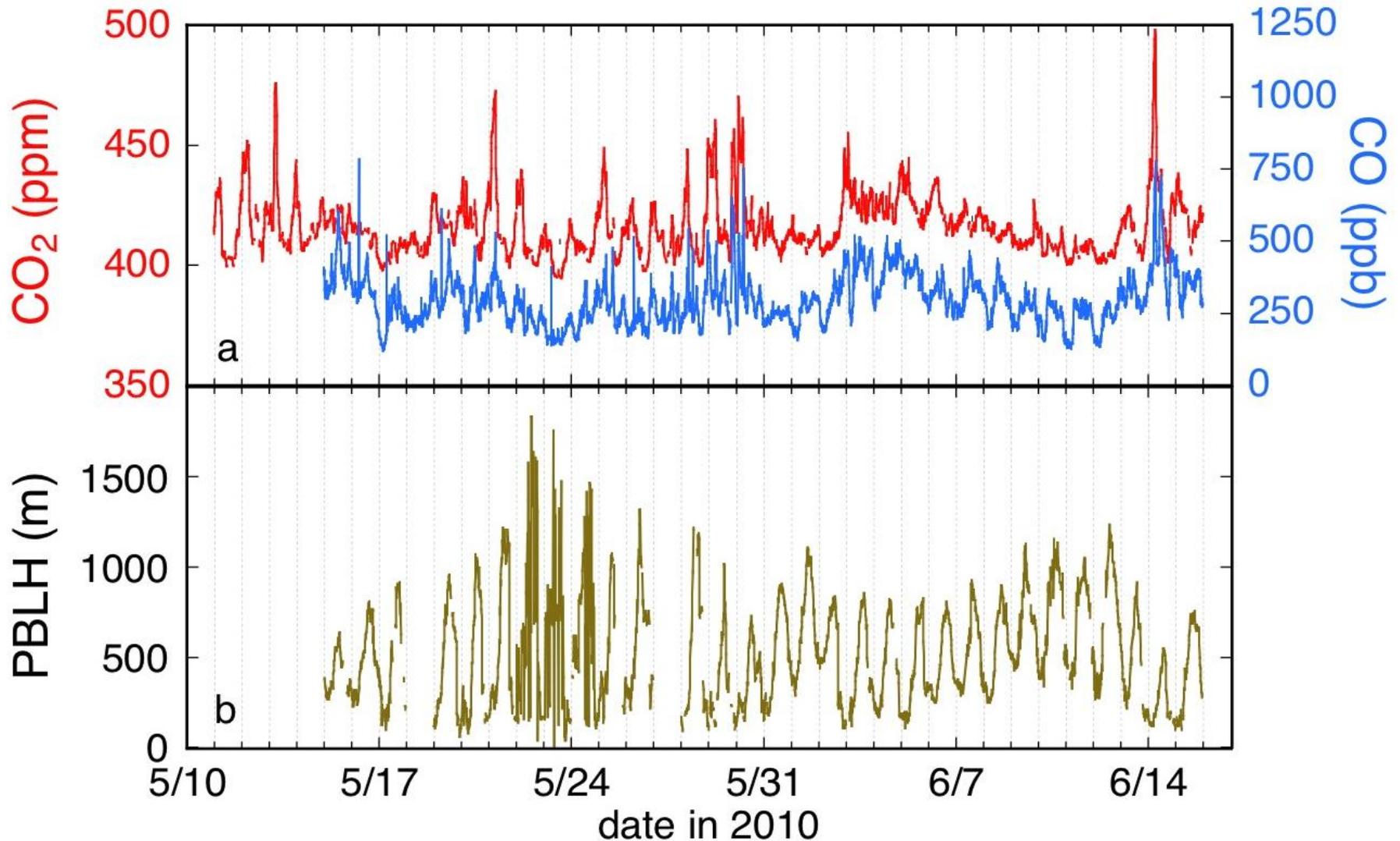
Major questions to be addressed

- How does the magnitude of CO₂ emissions vary during the course of a spring day, both in situ and in the atmospheric column?
- What is the diurnal variation of the sources of CO₂ emissions, from fossil fuel combustion and the biosphere?

Location of CalNex-LA Ground Campaign

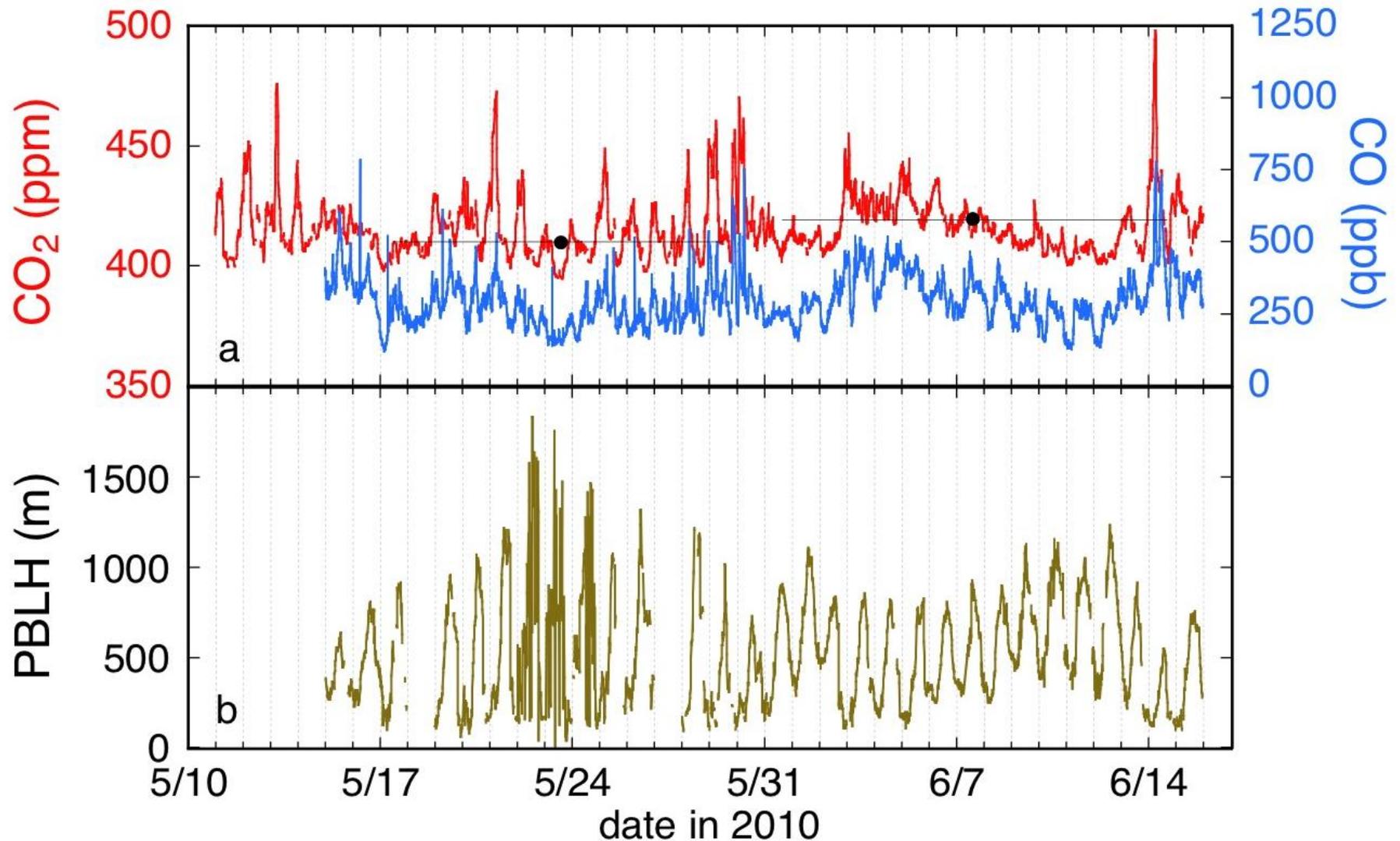


Time Series of CO₂, CO, and PBLH



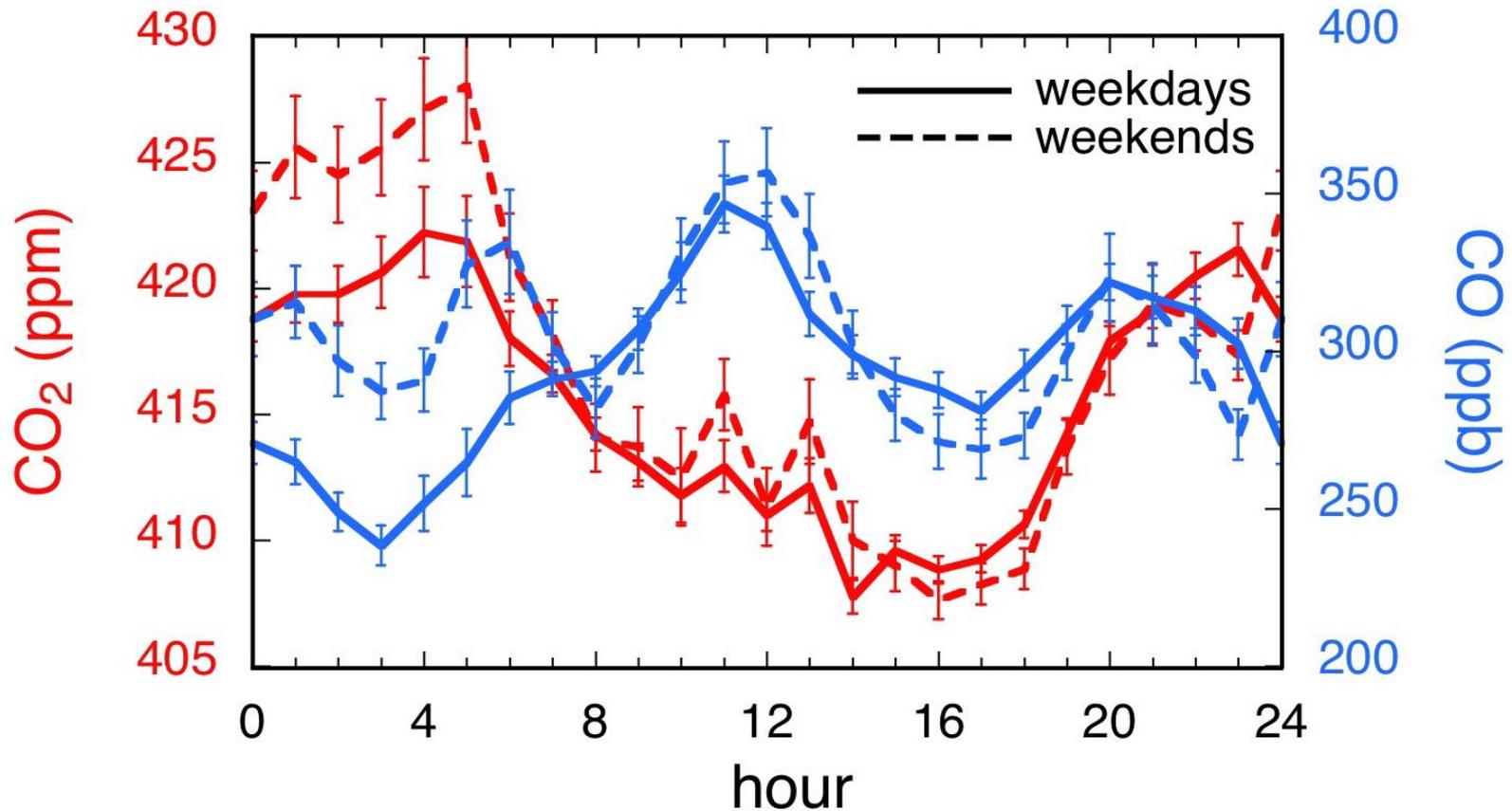
CO₂ by cavity ring-down spectroscopy, CO by vacuum ultraviolet fluorescence, PBLH by Lidar

Time Series of CO₂, CO, and PBLH



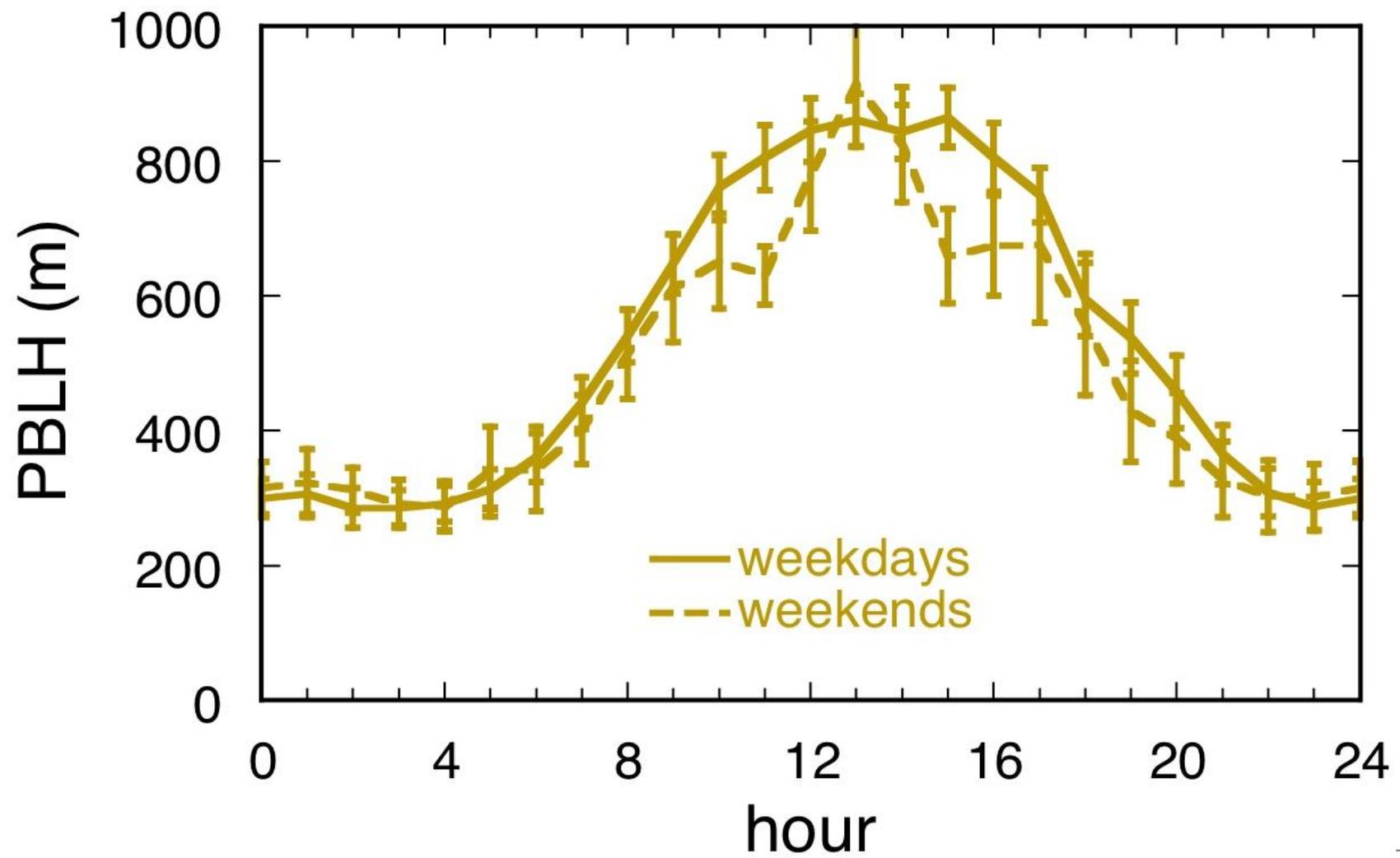
CO₂ by cavity ring-down spectroscopy, CO by vacuum ultraviolet fluorescence, PBLH by Lidar, $\Delta^{14}\text{C}$ by accelerator mass spectrometry

Diurnal variations in CO₂ and CO mixing ratios

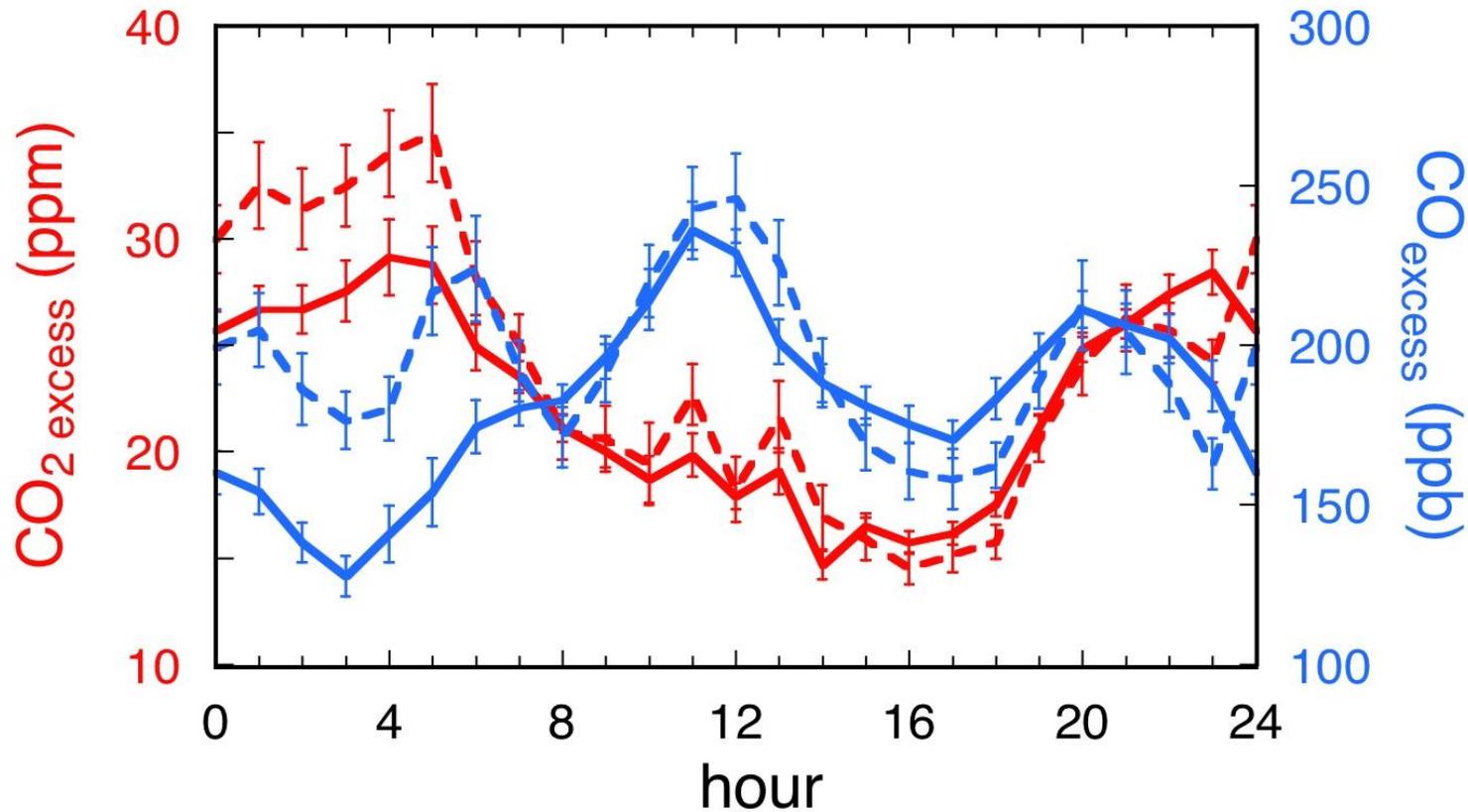


The CO₂ pattern differs from that of CO because of daytime photosynthetic uptake. Concentrations are higher during early mornings on weekends than weekdays.

Weekday and Weekend Diurnal Variation of Boundary Layer Height above Ground Level



Diurnal Variation of CO₂ and CO in Excess of Background Levels

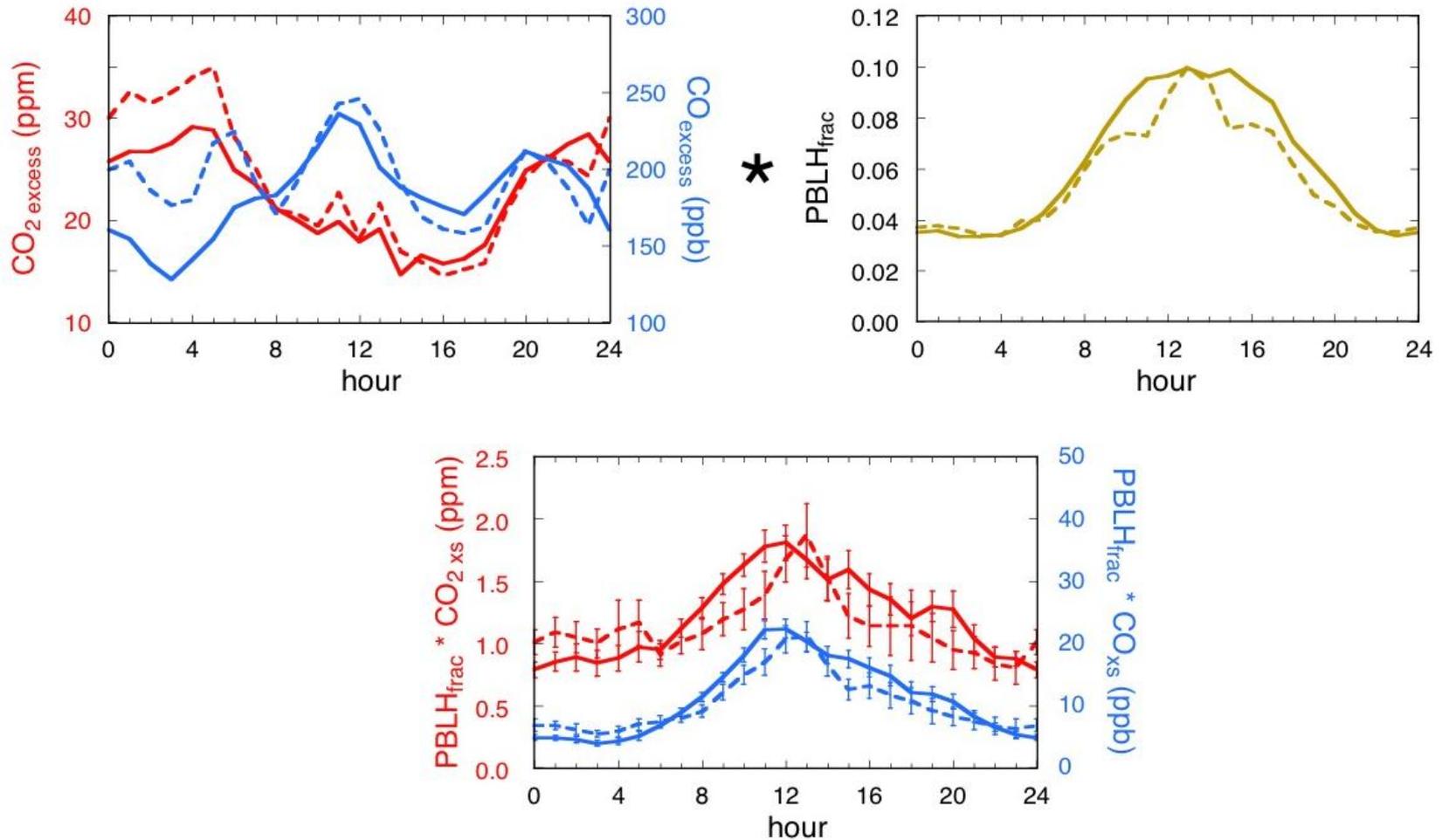


Background for CO₂ = 393.1 ppm, from Palos Verdes

Background for CO = 110.8 ppb, from NOAA THD and POC30N

15-35 ppm CO₂ and 125-250 ppb CO were added at the surface.

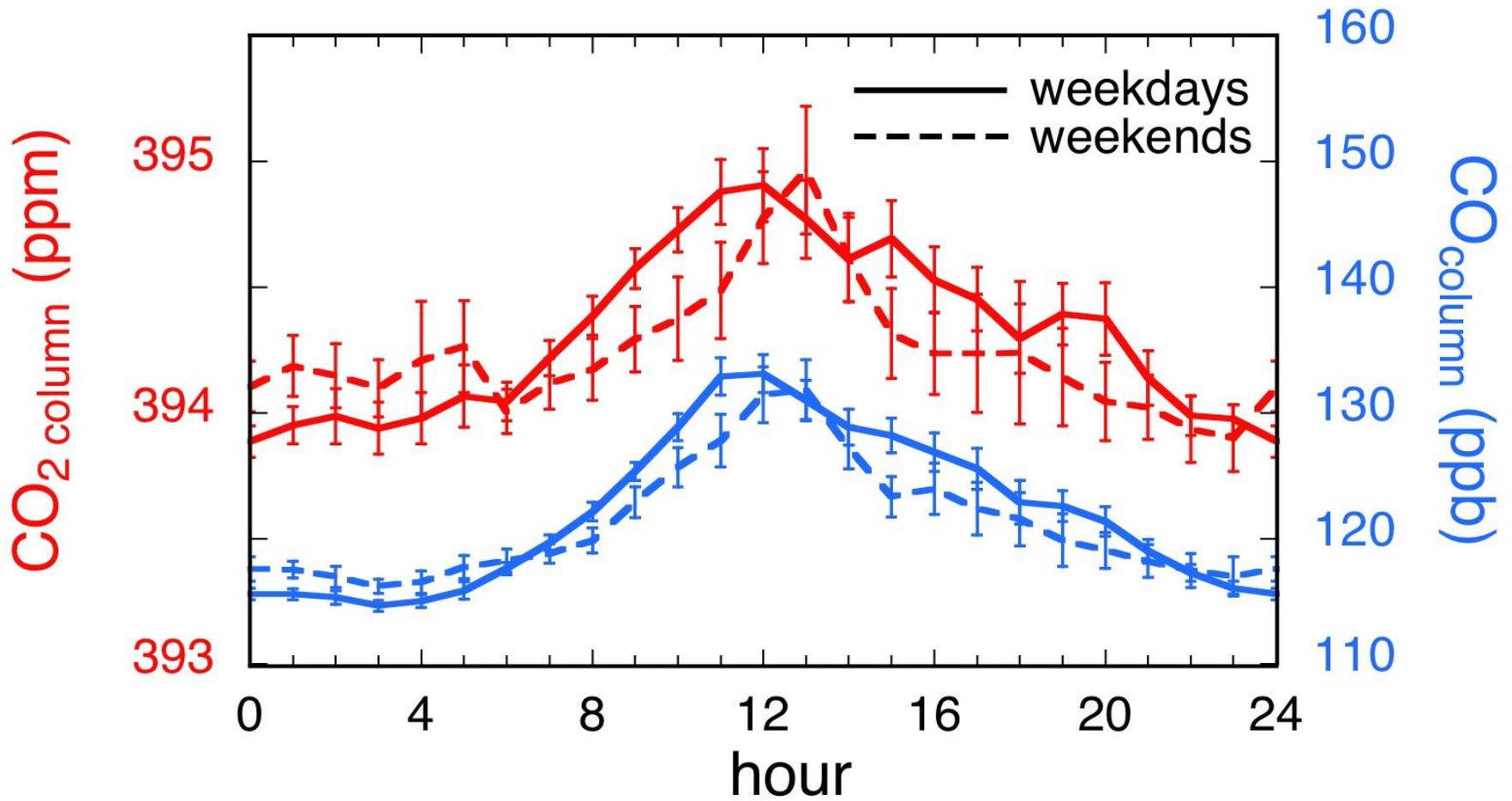
Calculation of Local Contribution to Column CO₂ and CO



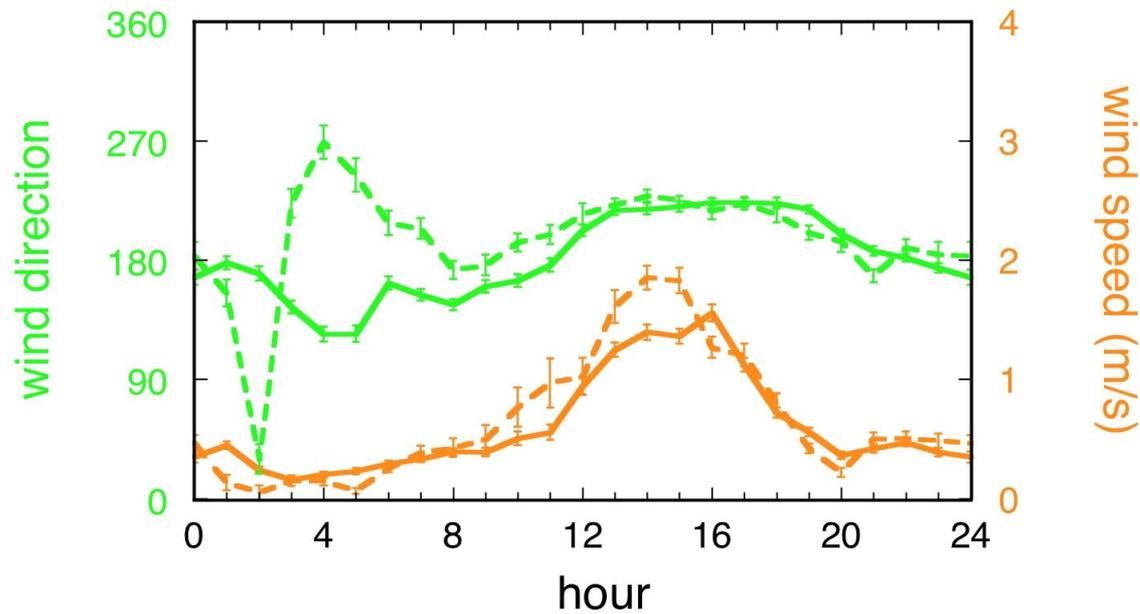
Variation in the planetary boundary layer height dominates the observed CO₂ pattern.

0.8-1.9 ppm CO₂ and 4-22 ppb CO were added to the column.

Diurnal Column CO₂ Mixing Ratios



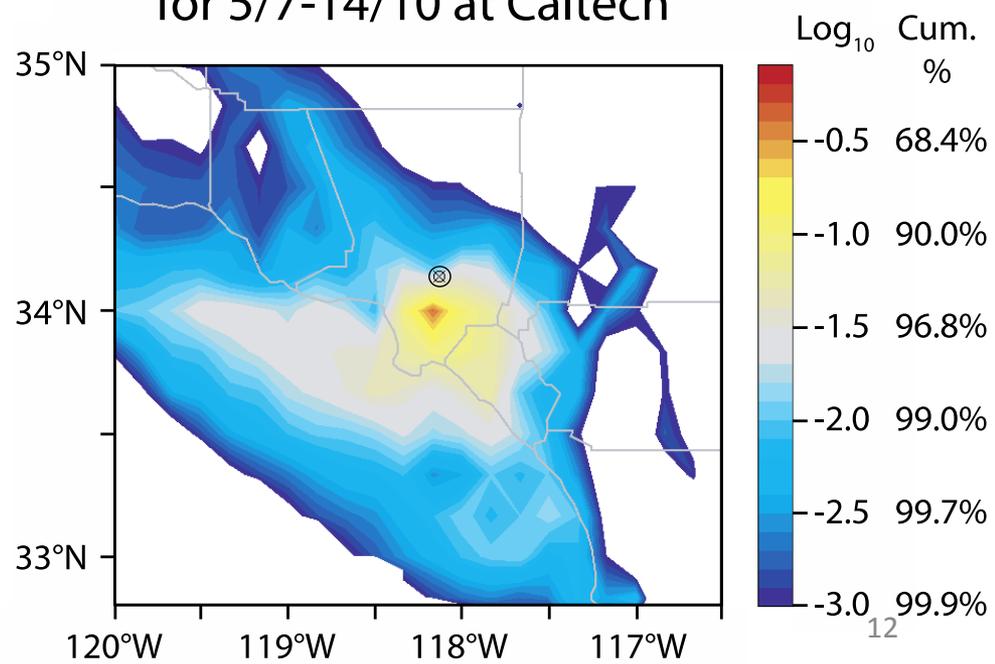
Is it reasonable, to first order,
to assume no entrainment or
advection?



Overnight, there was minimal wind to move air masses or disturb the stable planetary boundary layer.

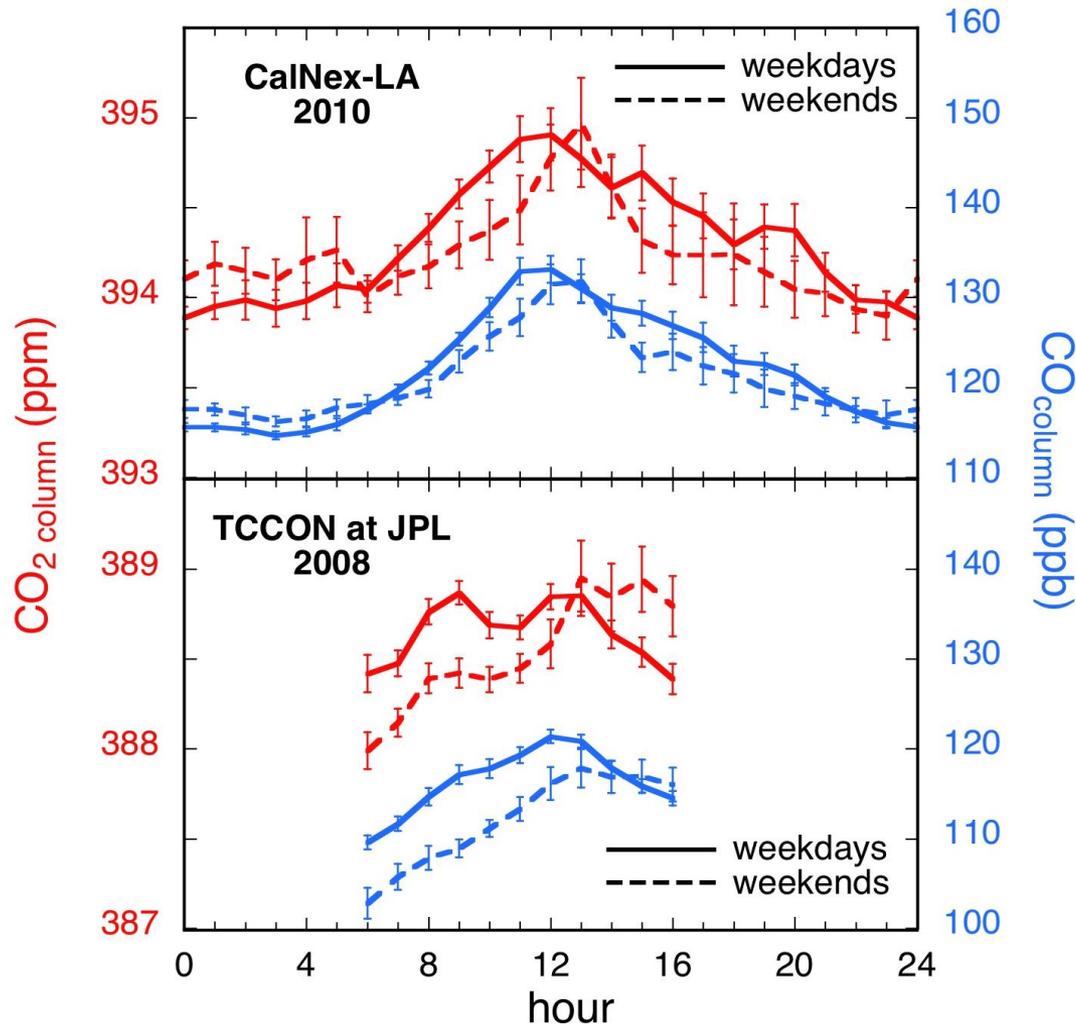
Average Footprint for 10:00, 12:00, 14:00 for 5/7-14/10 at Caltech

During the day, the footprint at this time of year was very limited.



Modeling by Eric Kort, Harvard. Met fields from Wayne Angevine, NOAA.

Comparison of Column CO₂ Determined in situ and by TCCON FTS

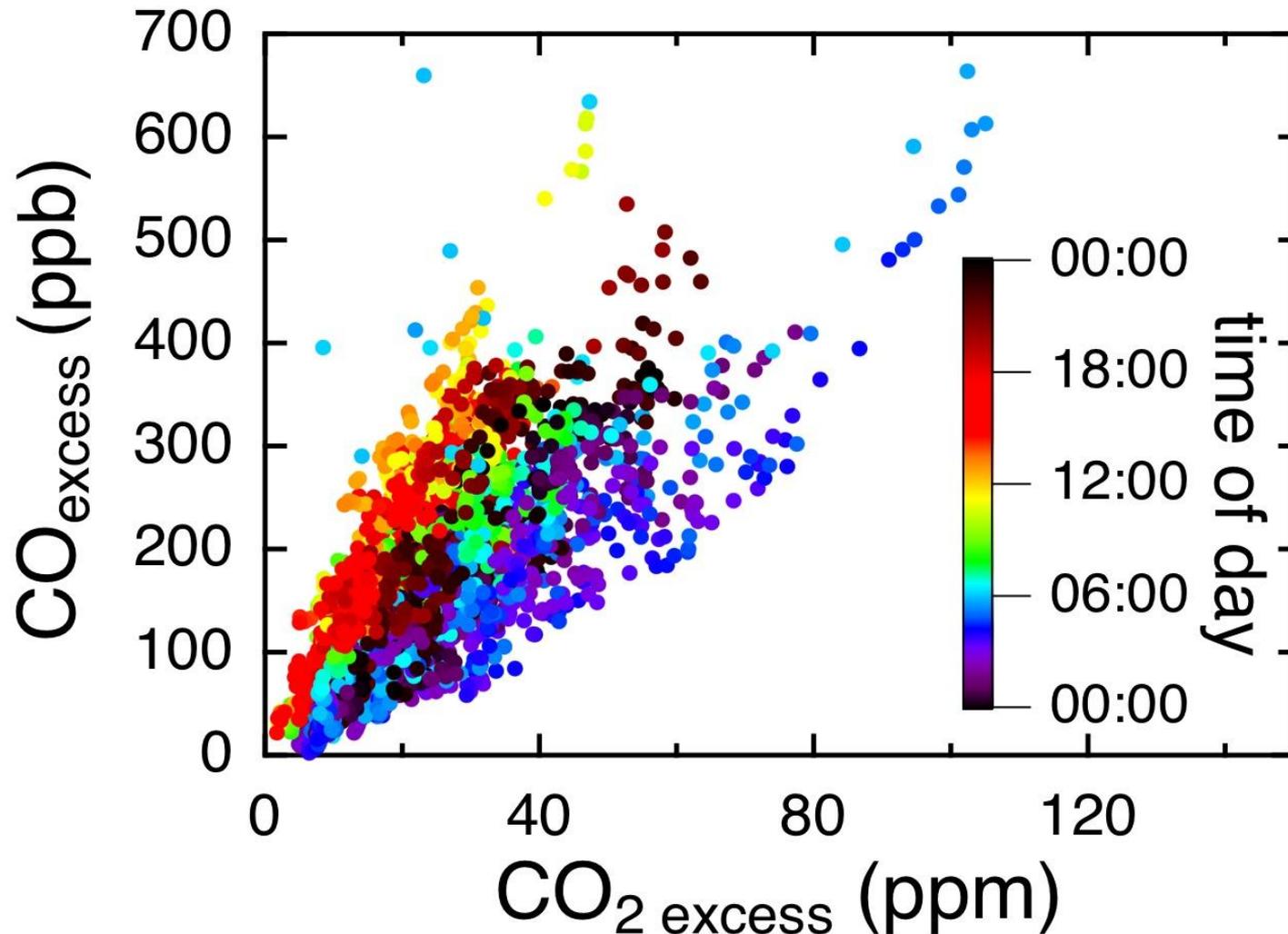


Favorable comparison with TCCON data from JPL during the same time of year supports neglect of advection and entrainment, to first order.

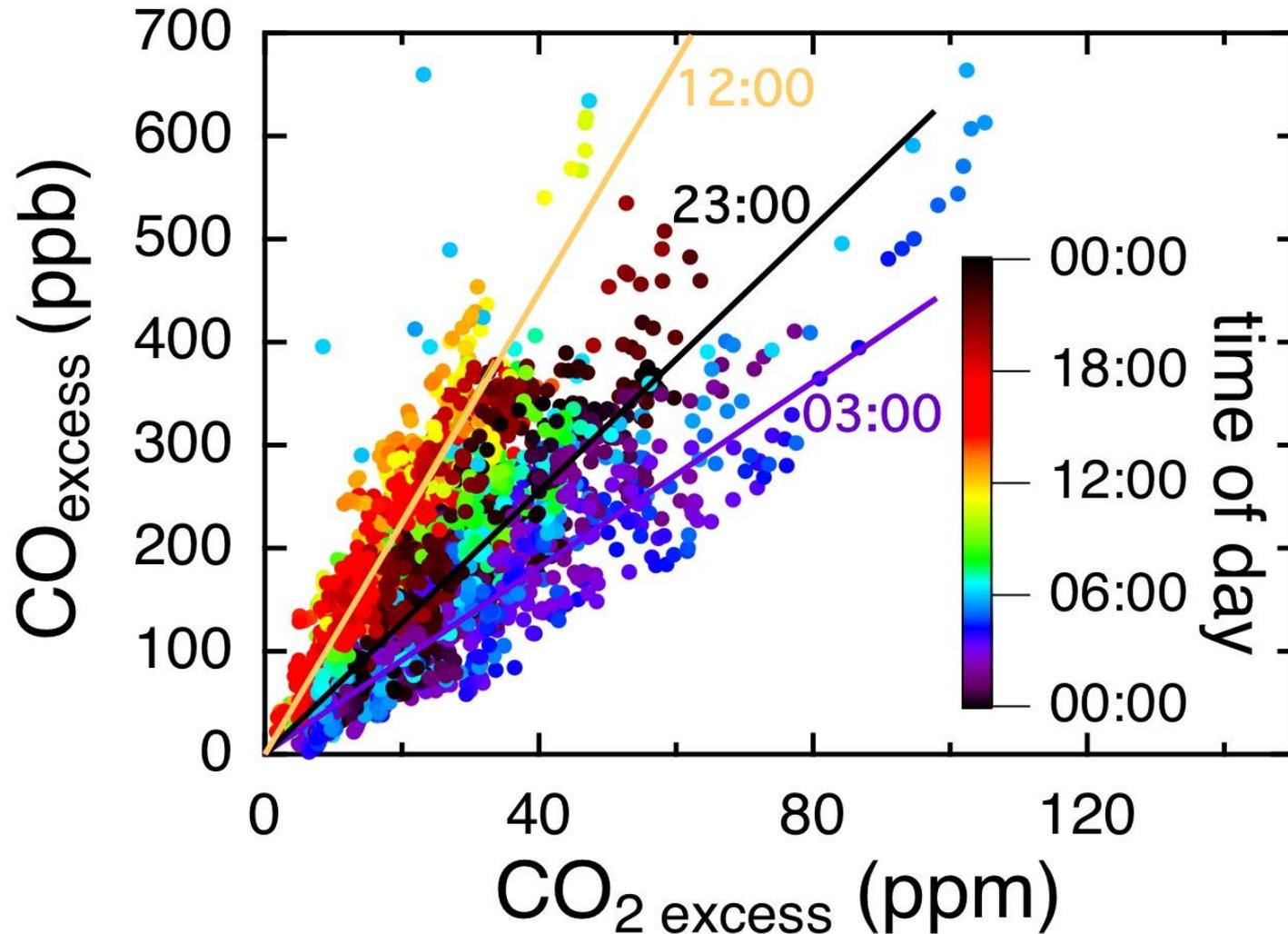
Using CO/CO₂ measurements to determine the amount of total CO₂ emissions from burning of fossil fuels.



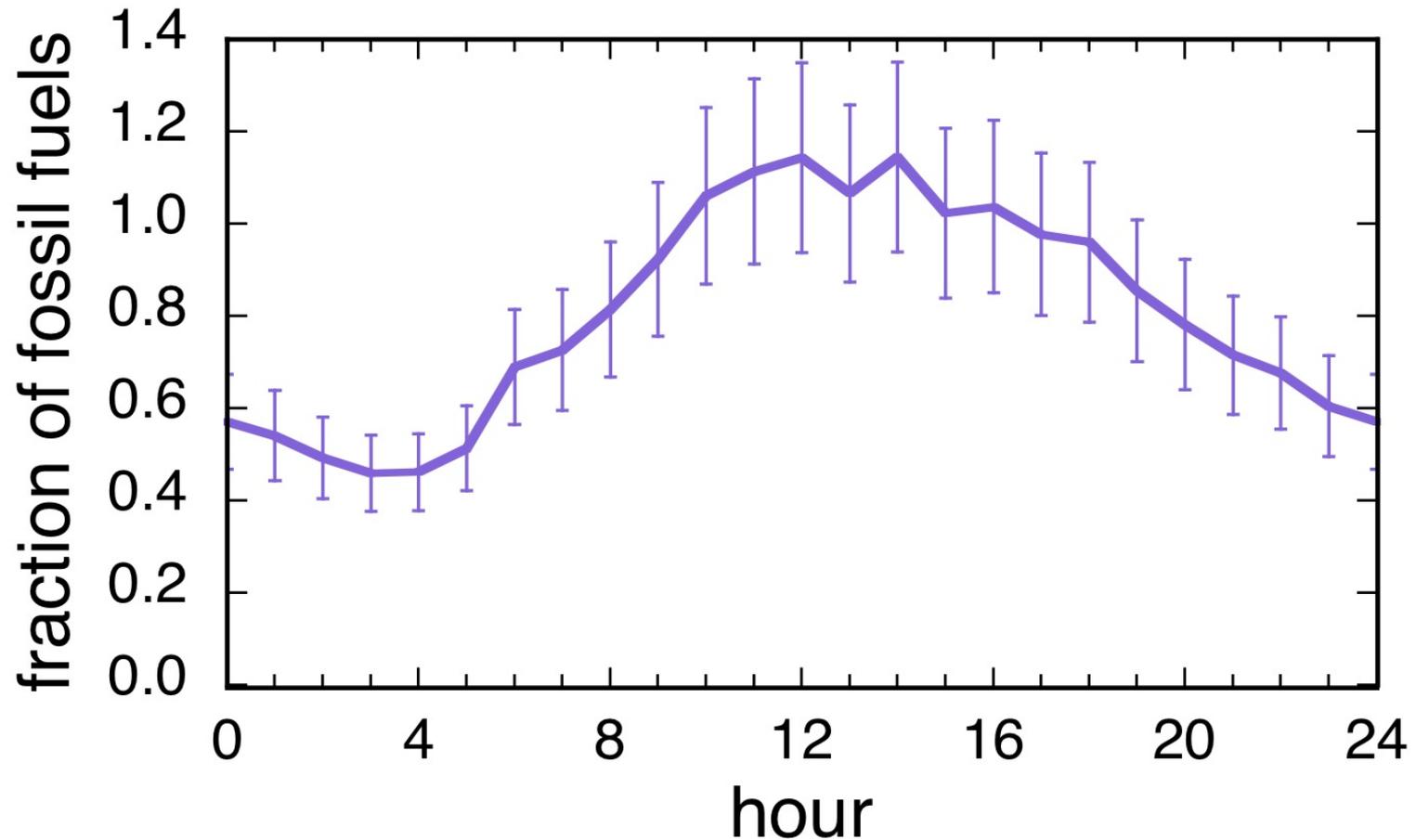
Variation of CO and CO₂ Local Contributions with Time of Day



The ratios vary significantly with time of day.

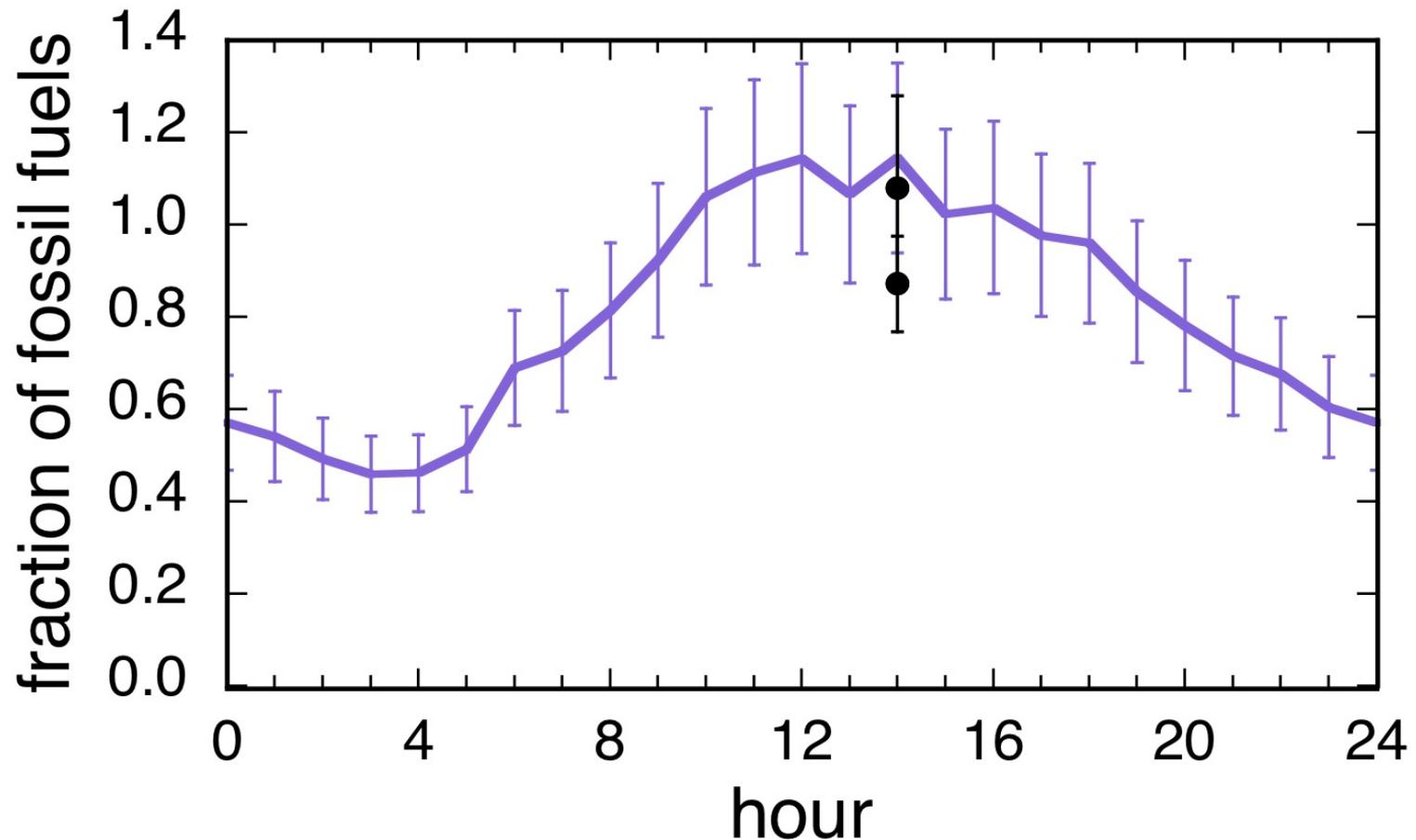


Variation of the Fraction of Local Emissions of CO₂ from Fossil Fuels



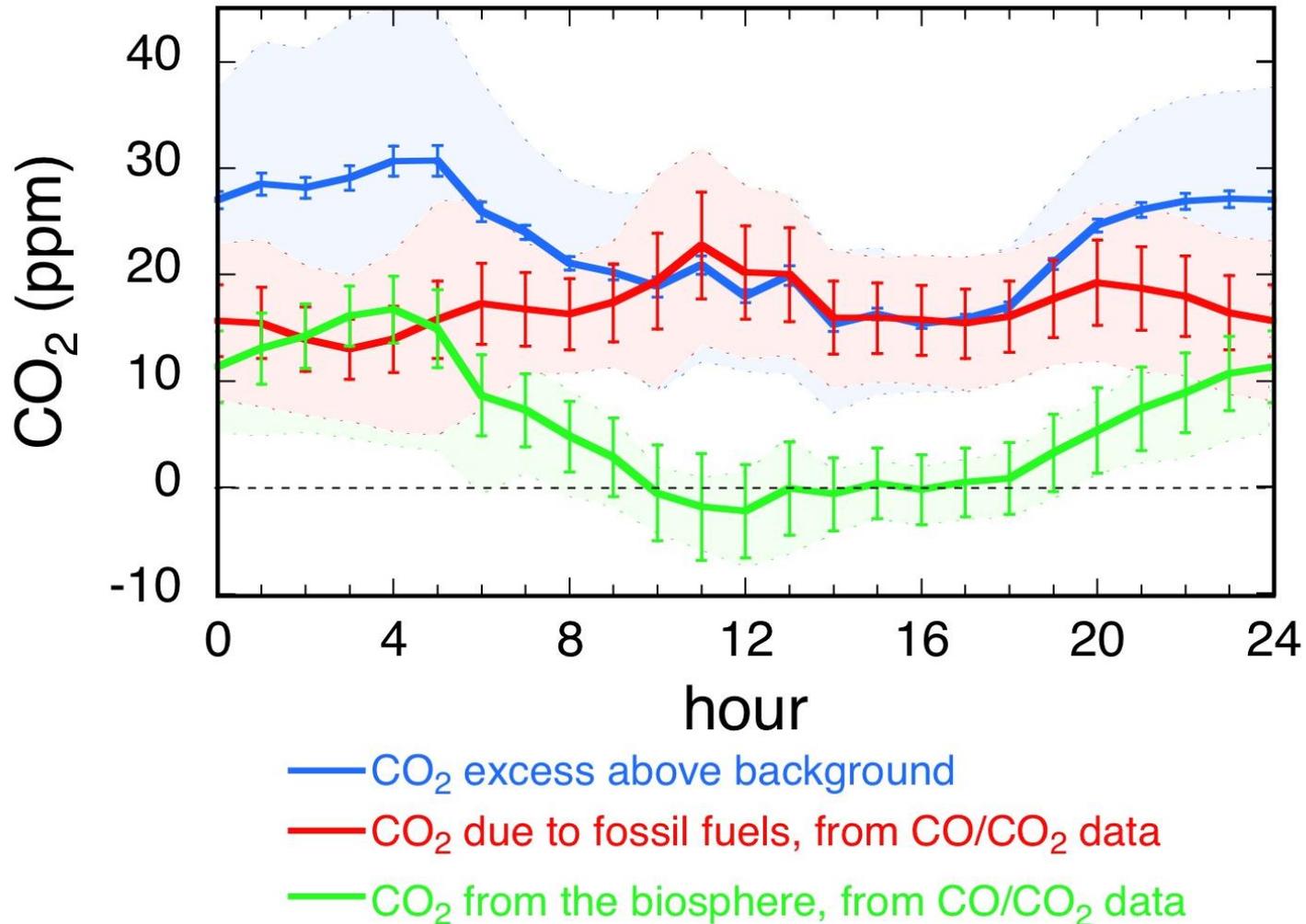
Assuming an emission ratio of CO/CO₂ from fossil fuels of 0.011 ± 0.002 (Wunch et al., 2009)

Adding Results from $^{14}\text{CO}_2$



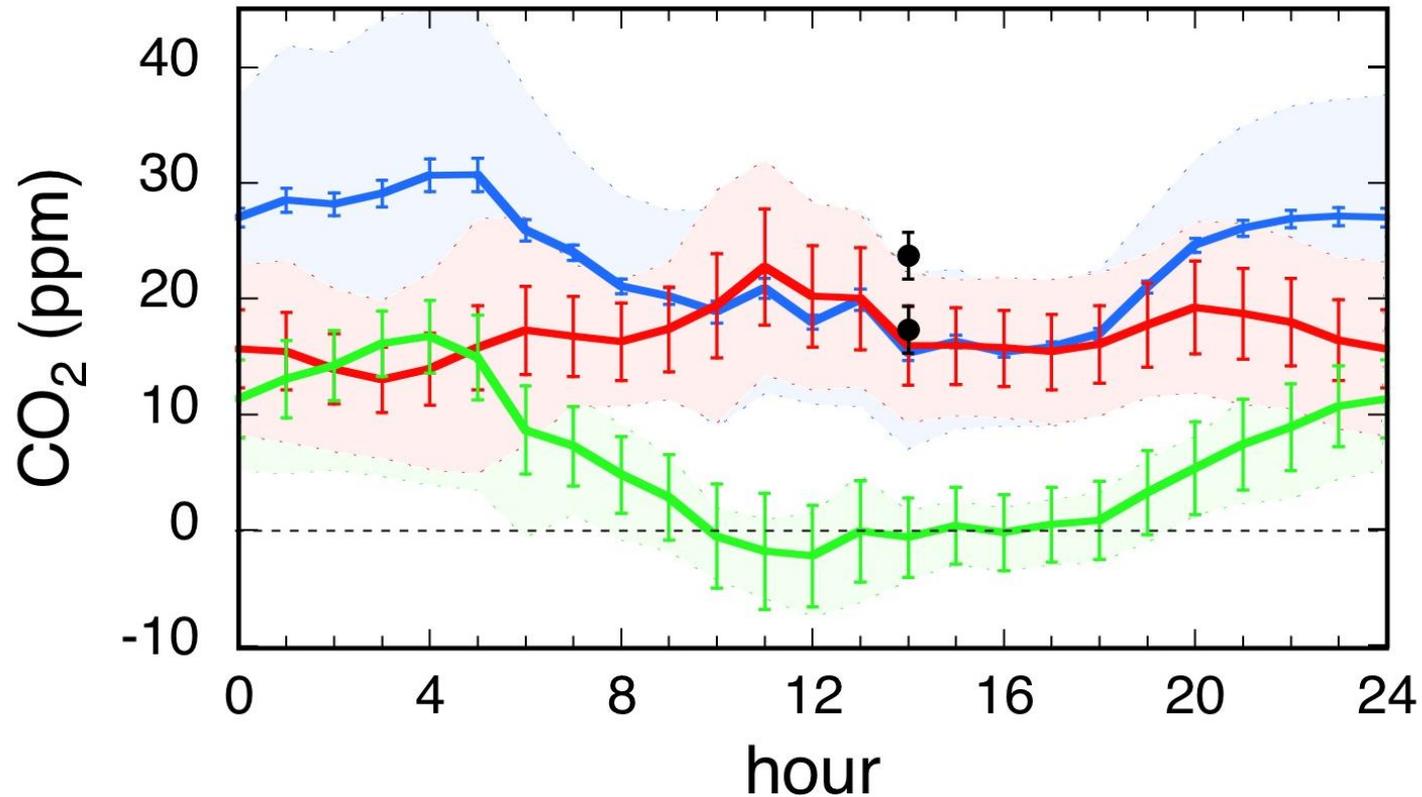
Black circles are from $\Delta^{14}\text{C}$ from flask samples aggregated from alternate day mid-afternoon collections.

Allocation of Sources of Local CO₂ Emissions



There is significant variation in the sources of CO₂ emissions on a diurnal timescale.

Adding Fossil Fuel CO₂ from ¹⁴C Data



- CO₂ excess above background
- CO₂ due to fossil fuels, from CO/CO₂ data
- CO₂ from the biosphere, from CO/CO₂ data
- CO₂ due to fossil fuels, from ¹⁴CO₂ data

Conclusions

- How does the magnitude of CO₂ emissions vary during the course of a spring day, both in situ and in the atmospheric column?

In situ CO₂ varies 15-20 ppm during the day, whereas total column CO₂ only varies 1-1.1 ppm at this time of year.

Diurnal patterns are due mainly to variations in boundary layer height, with superimposed anthropogenic and biogenic influences.

- What is the diurnal variation of the sources of CO₂ emissions, from fossil fuel combustion and the biosphere?

Fossil fuel combustion contributes 50 – 100% of the local emissions, ranging from 13 to 23 ppm, whereas the biosphere contributes up to 17 ppm at night and is a sink of up to 2 ppm during the day.

The CO/CO₂ ratio is an important tool for determining the contributions of anthropogenic vs biological sources on a time scale as fine as an hourly diurnal pattern. These species can be measured much more frequently and cheaply than the gold standard of ¹⁴C.