Effects of Local CO$_2$ Domes on Air Pollution and Health

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Reasons Used to Deny California's 2007 Waiver Request

Stephen L. Johnson, U.S. EPA Administrator, Federal Register, Mar. 6, 2008.

1) Globally-emitted CO_2 does not affect California's health more or less than it affects overall U.S. health.

2) Because CO_2 becomes well-mixed in the atmosphere, local California CO_2 emissions don't affect California's air pollution any more than CO_2 emissions from outside of California affect California's air pollution.

Sen. Carl Levin, EPA Waiver Hearing Mar. 5, 2009
"One ton of CO_2 emitted in California has the same effect as one ton of CO_2 emitted in another state."

Increases in Water Vapor and Temperature Both Increase Ground-Level Ozone in Polluted Air But Not in Background Air
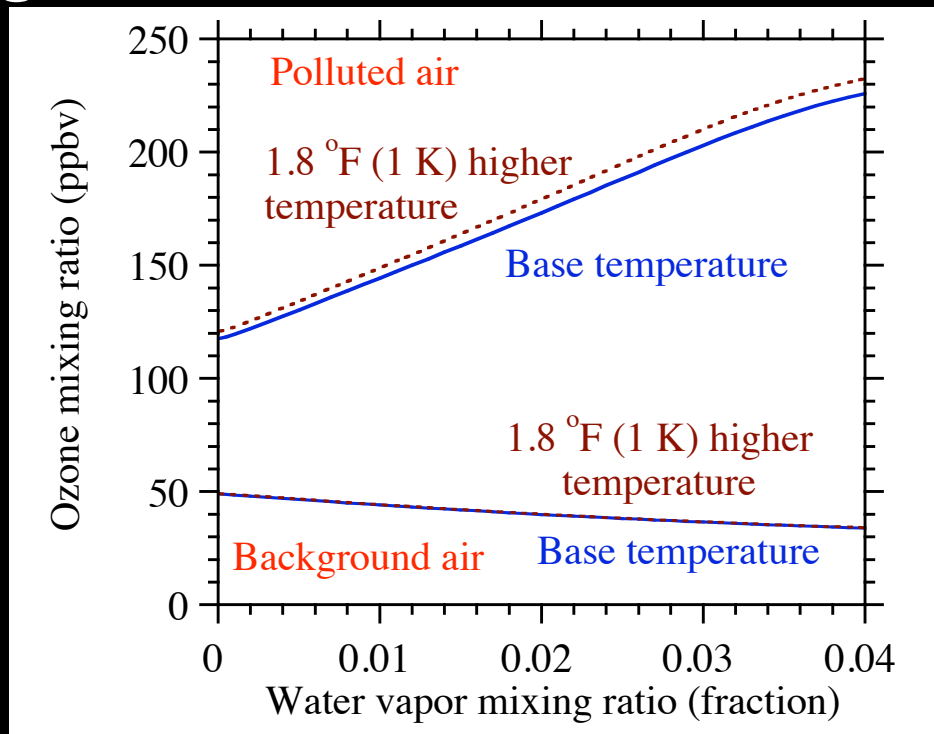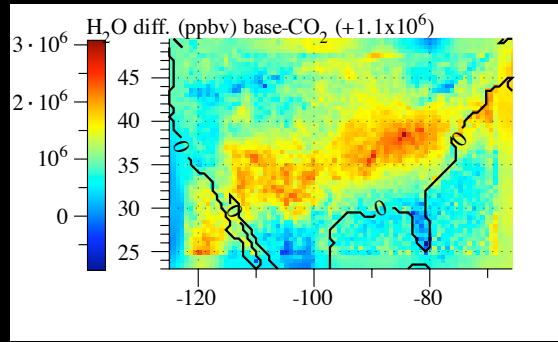

→ California has 6 of the 10 most polluted U.S. cities → Suffers largest impact of higher T, H_2O among states.

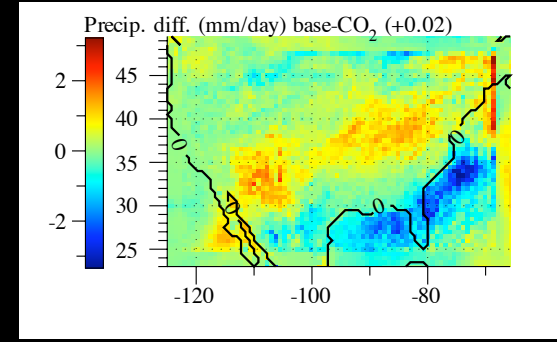# Changes Resulting From Historic CO$_2$ Alone

3-D simulations → CO$_2$ increases temperature, water vapor, precipitation, biogenic organics, carcinogens, particles
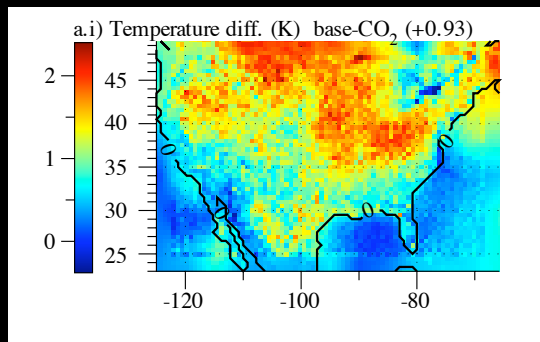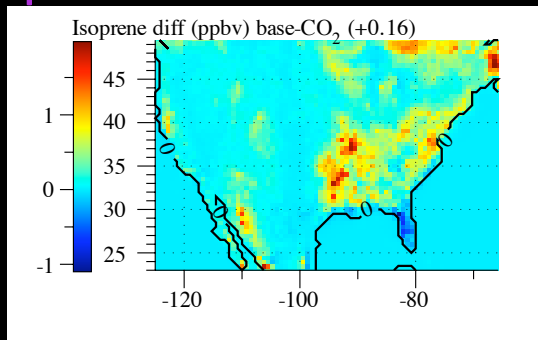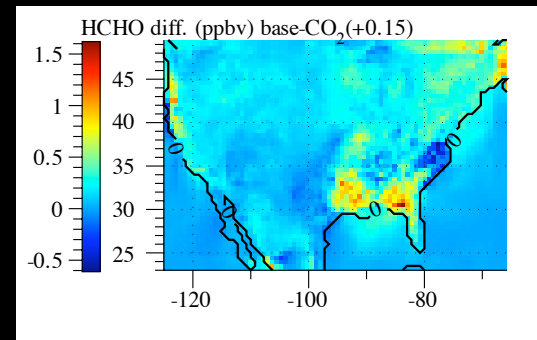

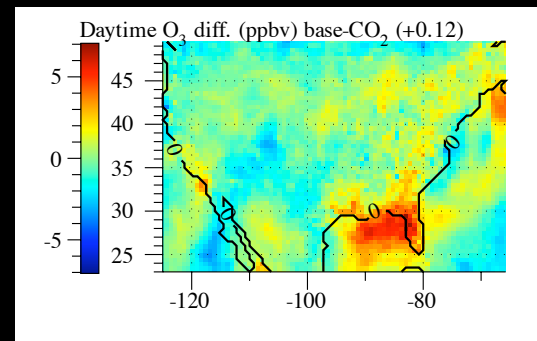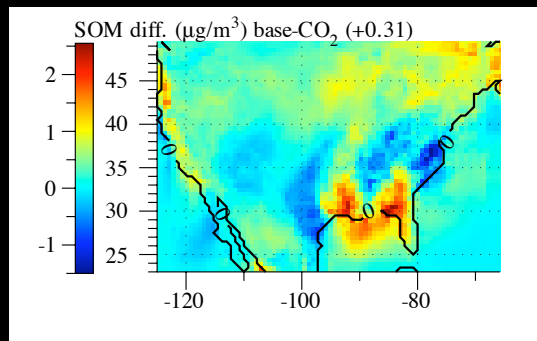Temperature

Water vapor

Precipitation

Isoprene

Formaldehyde

Changes Resulting From Historic CO_2 Alone

CO_2 increases particles, ozone

SOM diff. ($\mu g/m^3$) base-CO_2 (+0.31)

Daytime O_3 diff. (ppbv) base-CO_2 (+0.12)

Aerosol Secondary Organic Matter   Ozone

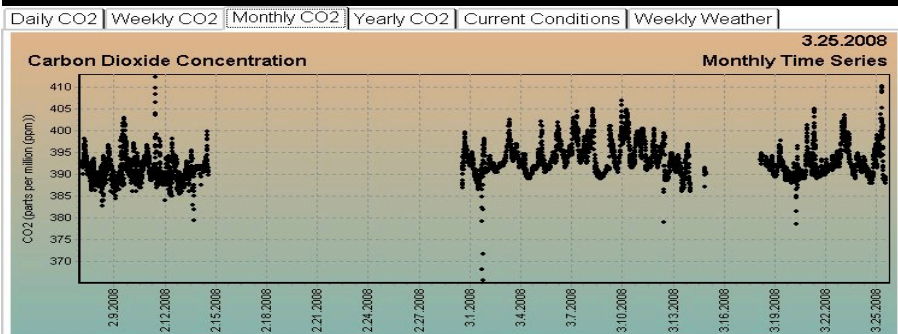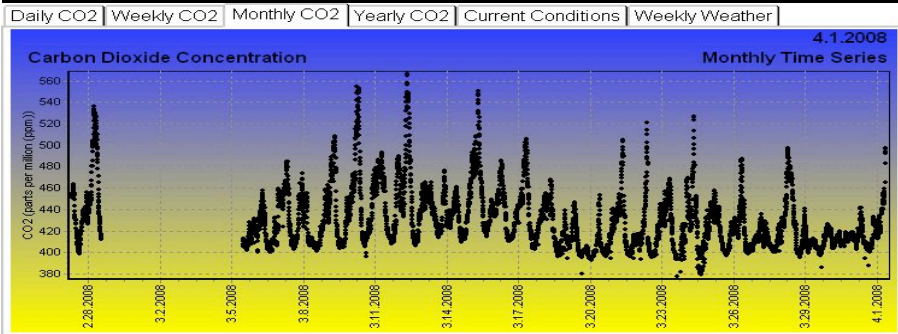Additional U.S. pollution deaths/yr per 1.8 °F (1 K) +1000 (350-1800)
40% due to ozone; 60% due to aerosol particles
30% of deaths in California, which has 12% of U.S. population

Additional world deaths/yr per 1.8 °F (1 K)   +21,600 (7400-39,000)

Measured CO$_2$ in a City

Downtown Salt Lake City (420-440 ppmv)

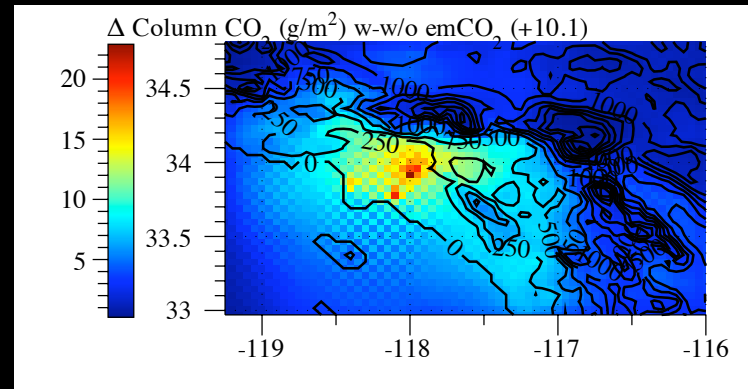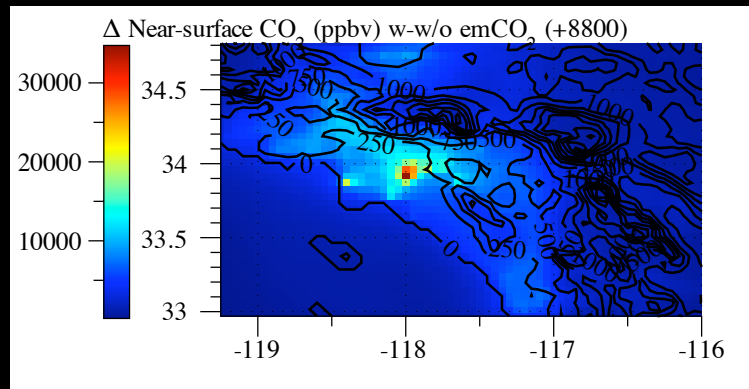Kennecott (390-395 ppmv)

Salt Lake City

Global background 385 ppmv

http://co2.utah.edu/
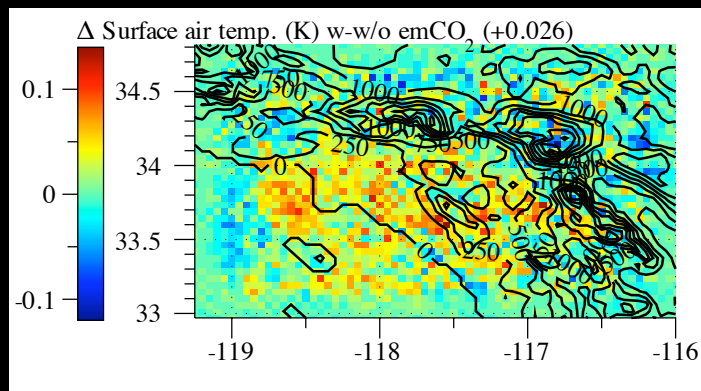
Feb-Apr L.A. Changes Due to Local CO_2

3-D model results - numbers in parentheses are population-weighted values
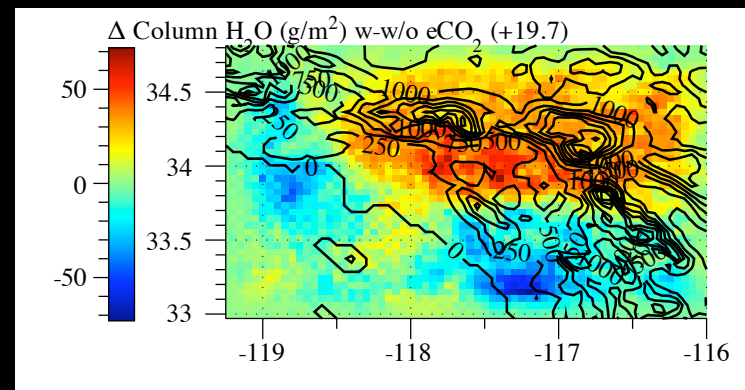

Change in surface/column CO_2 from local CO_2 emissions = "CO_2 Dome"

Feb-Apr L.A. Changes Due to Local CO_2

3-D model results - numbers in parentheses are population-weighted values
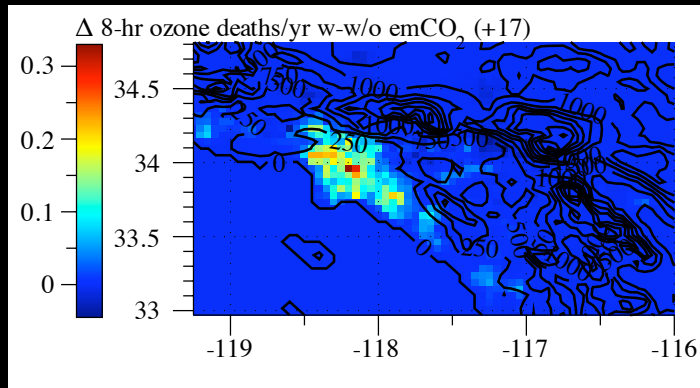

Change in surface T

Change in column H_2O

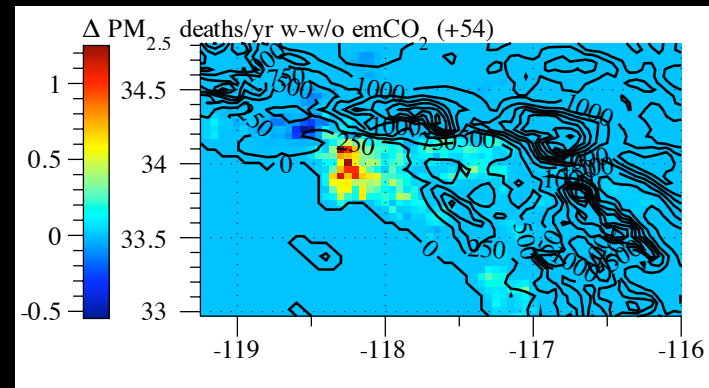Local CO_2 emissions increase surface temperature and column water vapor

Feb-Apr L.A. Changes Due to Local CO$_2$

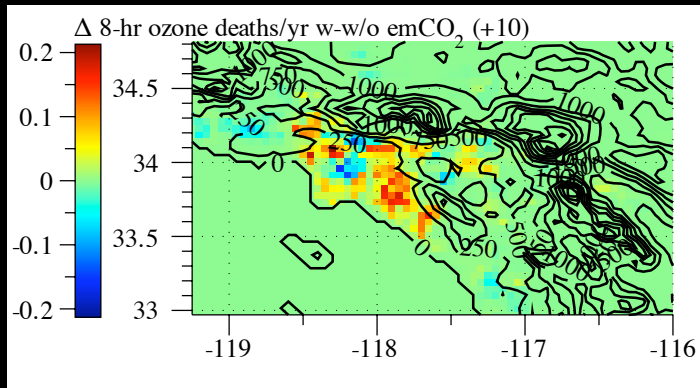3-D model results

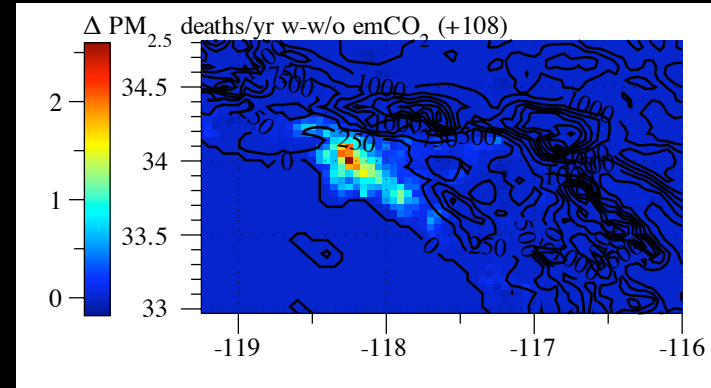Additional O$_3$ deaths/yr

Additional PM deaths/yr

Local CO$_2$ emissions increase ozone and PM deaths

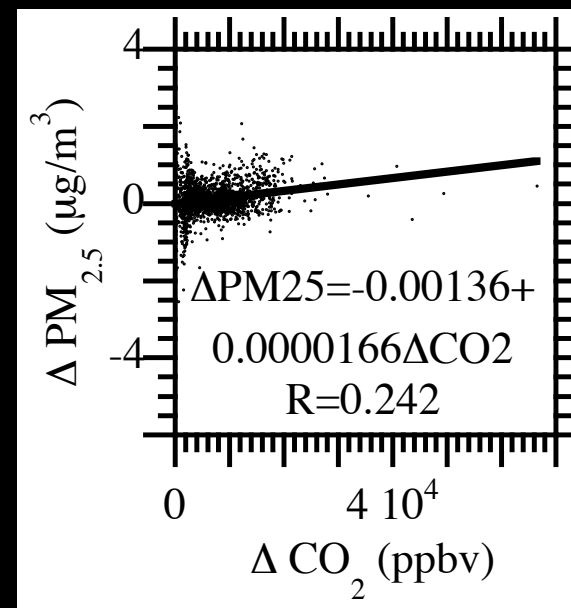# Aug-Oct L.A. Deaths From CO_2 Dome
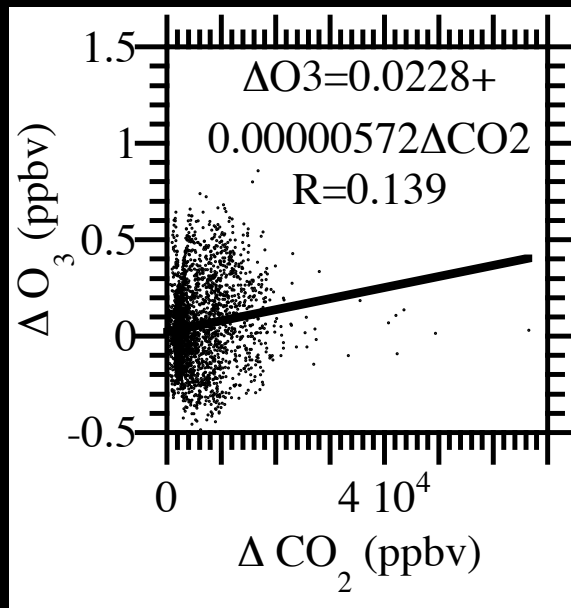
3-D model results

Additional O_3 deaths/yr
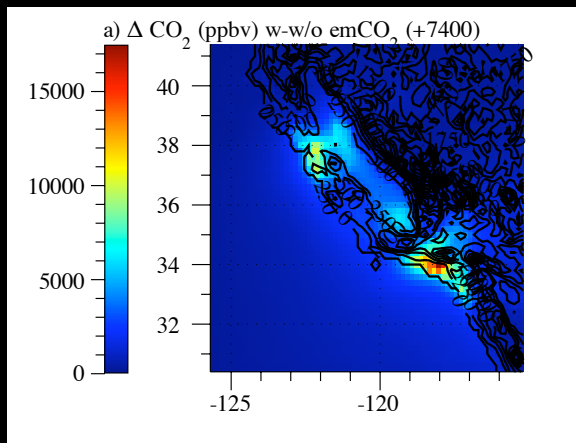
Additional $PM_{2.5}$ deaths/yr

Local CO_2 emissions increase ozone and PM deaths

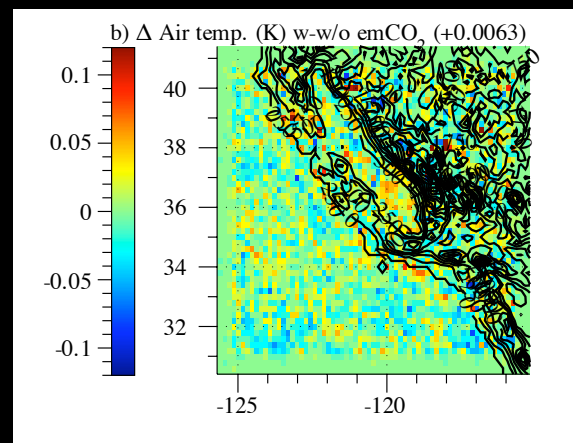# Spatial Correlation Between Increased Local CO_2 and Increased Local O_3 (left) & $PM_{2.5}$ (right) in Los Angeles

Changes in California Due to Local CO_2

Numbers in parentheses are population-weighted values

a) $\Delta\ CO_2$ (ppbv) w-w/o $emCO_2$ (+7400)

b) Δ Air temp. (K) w-w/o $emCO_2$ (+0.0063)

c) Δ Column H_2O (g/m^2) w-w/o $emCO_2$ (+4.3)

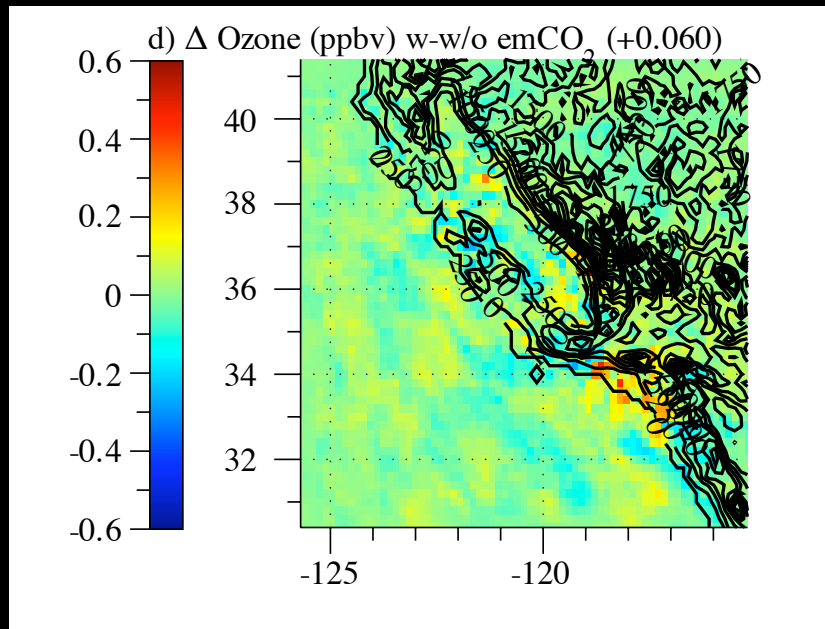Change in column CO_2
"CO_2 Domes"

Increase in Surface air
temperature
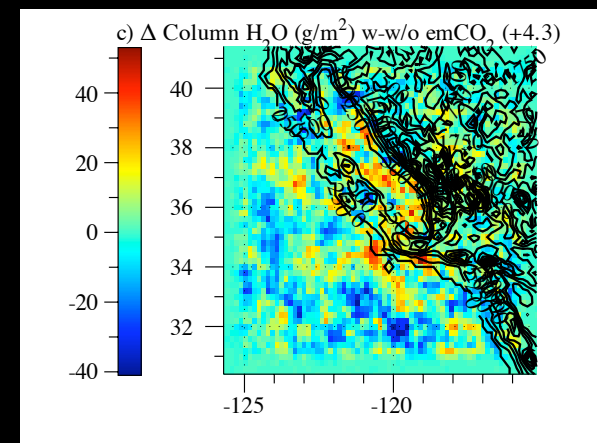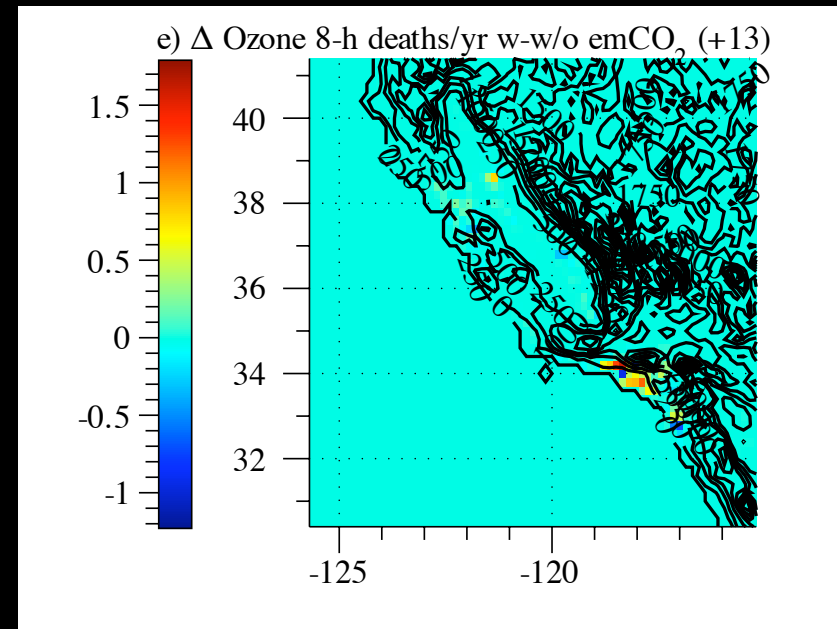
Increase in
Column H_2O

Local CO_2 emissions increase temperatures, water vapor

Additional O_3 deaths/yr From CO_2 Domes

d) Δ Ozone (ppbv) w-w/o emCO$_2$ (+0.060)

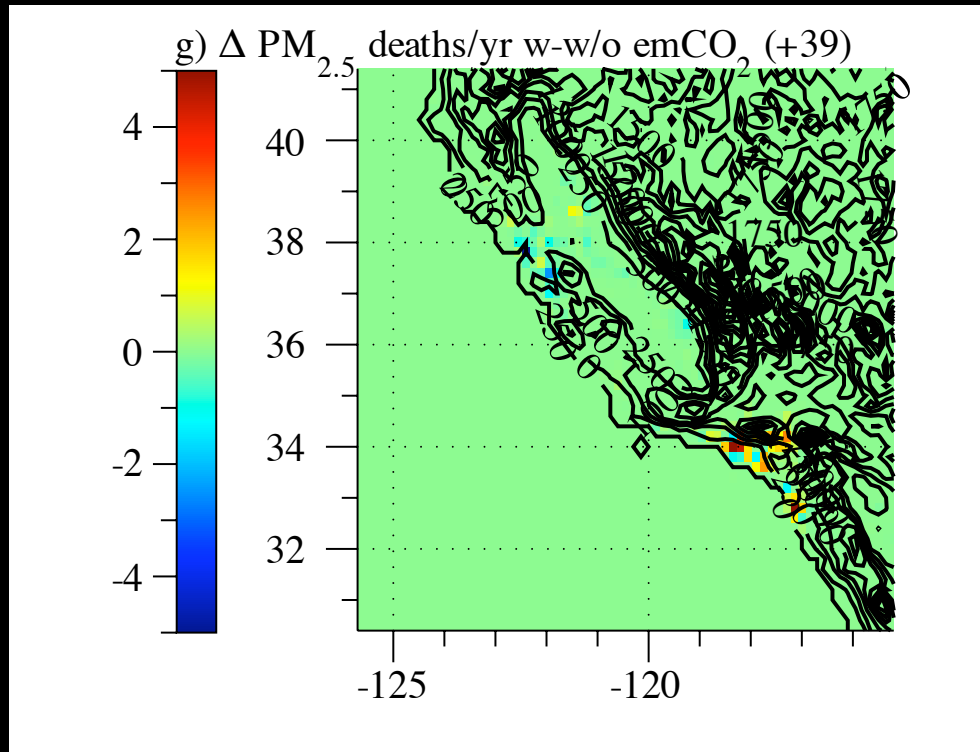e) Δ Ozone 8-h deaths/yr w-w/o emCO$_2$ (+13)

Increase in surface O_3

Additional O_3 deaths/yr

Local CO_2 emissions increase O_3 and O_3 deaths
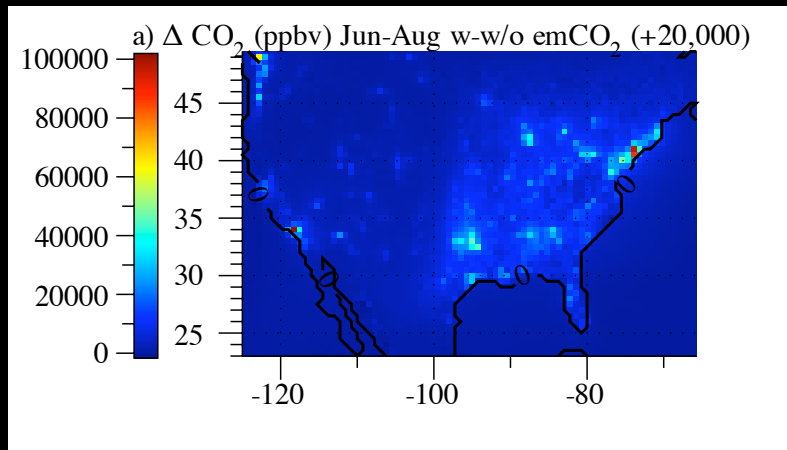
Additional PM deaths/yr From CO_2 Domes

g) $\Delta PM_{2.5}$ deaths/yr w-w/o emCO_2 (+39)

Local CO_2 emissions increase $PM_{2.5}$ deaths

1-Year Changes Due to Local CO_2

Additional ozone deaths/yr

b) Δ O_3 deaths Jun-Aug w-w/o emCO_2 (+100)

Increase in CO2 from local emissions

a) Δ CO_2 (ppbv) Jun-Aug w-w/o emCO_2 (+20,000)

c) Δ $PM_{2.5}$ deaths Jun-Aug w-w/o emCO_2 (+660)

Additional PM deaths/yr
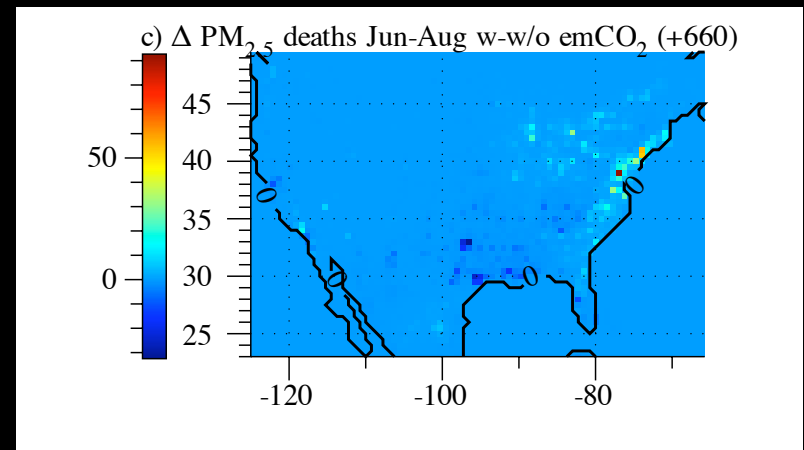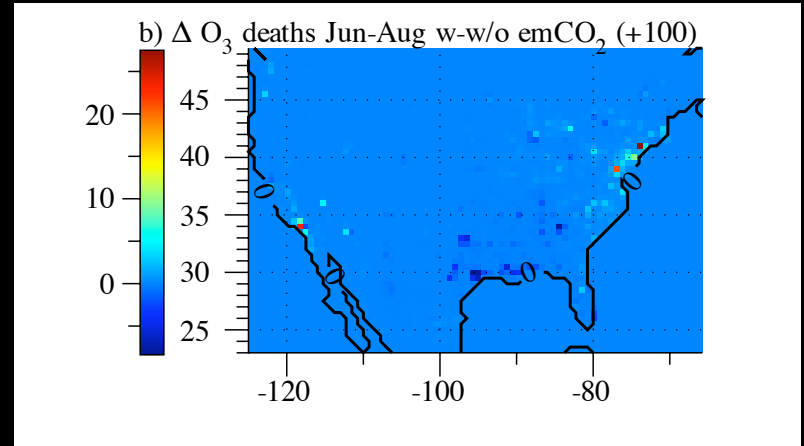
Local CO_2 emissions increase $PM_{2.5}$ and O_3 deaths

Summary

Locally-emitted CO_2 produces CO_2 domes, which increase local ozone and $PM_{2.5}$ premature deaths in California by ~50-100/yr. Thus, reducing locally-emitted CO_2 will reduce local air pollution and mortality. This result contradicts the basis for all previous local air pollution regulation worldwide, which has ignored CO_2, thus it provides the basis for controlling CO_2 due to its local health impacts.

The result also implies that the main assumption behind "cap and trade" that CO_2 impacts are the same regardless of where CO_2 is emitted, is incorrect.

Journal papers:

http://www.stanford.edu/group/efmh/jacobson/urbanCO2domes.html