Effects of Local CO_2 Domes and of Global CO_2 Changes on California's Air Pollution and Health

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Washington, DC, March 5, 2009

Reasons Used to Deny California's Previous 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.

No scientific study has shown either of these arguments to be correct. One study, which has not been challenged, shows by cause and effect that California's health is disproportionately damaged . Another now shows that local CO_2 enhances local air pollution and health.

Studies Linking Global Warming to Enhanced U.S. Ozone Air Pollution

Thompson et al., Atmos. Environ., 23, 519-532, 1989

Sanderson et al., J. Geophys. Res., 30, 1936, 2003

Mickley et al. GRL, 31, L24103, 2004

Stevenson et al., Faraday Disc., 130, 1-17, 2005

Murazaki and Hess, 111, D05301, 2006

Liao et al., J. Geophys. Res., 111, D12304, 2006

Brasseur et al., J. Clim 3832-3951, 2006

Unger et al., J. Geophys. Res., 111, D12313, 2006

Nolte et al., J. Geophys. Res., 113, D14307, 2008

Jacobson and Streets, J. Geophys. Res., in press, 2009

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

Studies Showing Sensitivity of Ozone or Organic Gases to Temperature in California

Aw and Kleeman, J. Geophys. Res., 108, 4365, 2003

Steiner et al., J. Geophys. Res., 111, D18303, 2006

Kleeman, Climatic Change, 87, S273-S292, 2008

Motallebi et al., J. Climate Change, 87 S293-S308, 2008

Studies Linking U.S. Temperature Increases to Ozone Health Effects

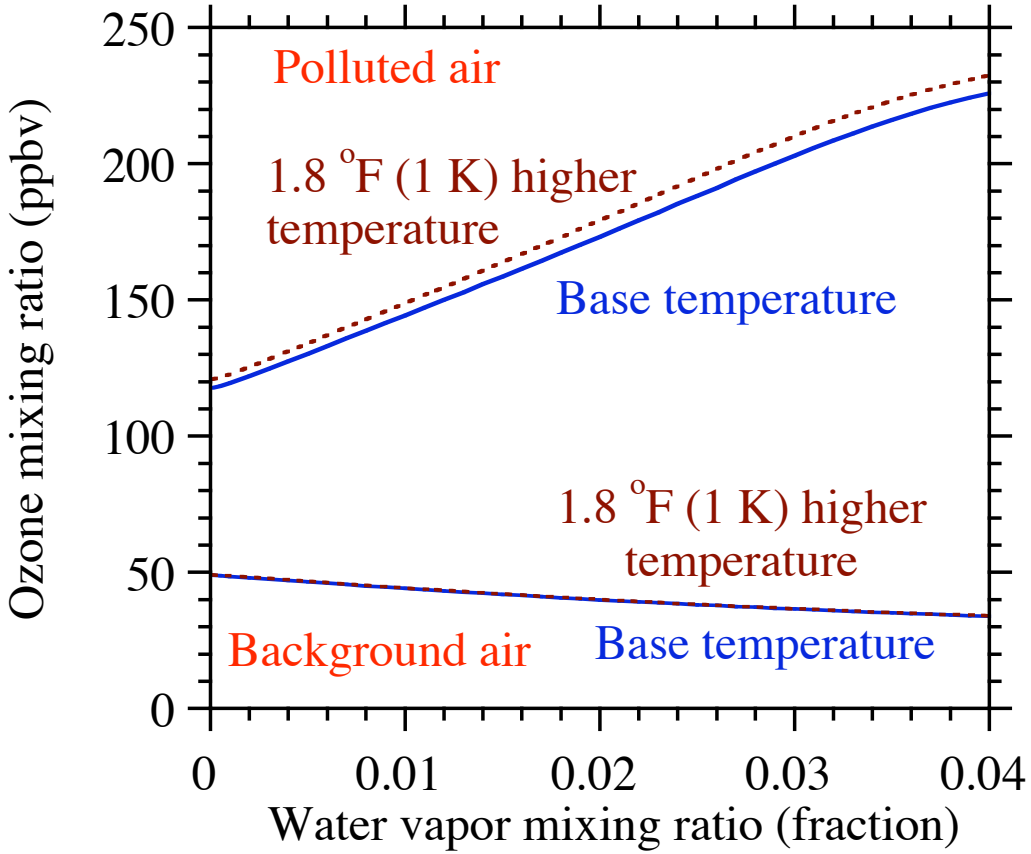
Knowlton et al., Env. Health Persp., 112, 1557-63, 2004

Bell et al. Climatic Change, 82, 61-76, 2007

Study Showing Cause and Effect Link Between Global CO_2 Emissions and U.S. Ozone and PM Health Effects Through Feedbacks to T, H_2O, Meteorology -- Different Impacts in Calif. v. U.S.

Jacobson, Geophys. Res., Lett., 35, L03809, 2008

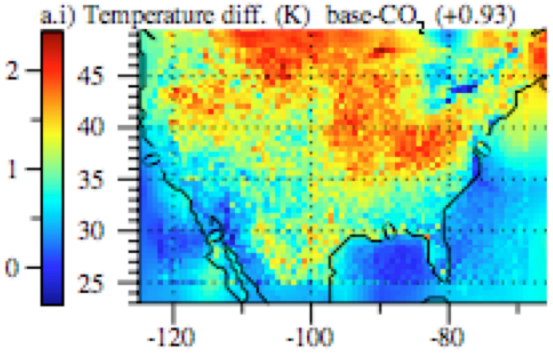
Increases in H_2O and Temperature Both Increase Surface Ozone in Polluted Air But Not Clean Air



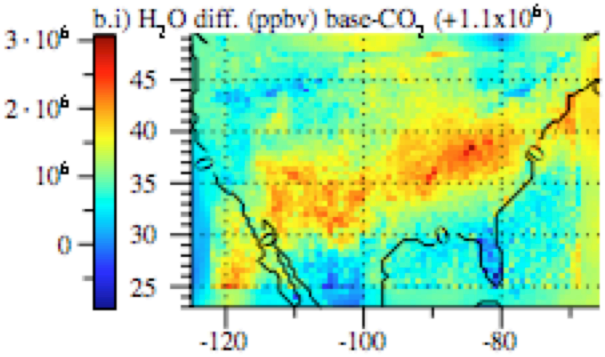
California has 6 of the 10 most polluted U.S. cities → Suffers the largest impact of higher T, H_2O among states. The impact will still be largest in California even with 60% reductions in vehicular emissions.

Changes Resulting From Historic CO_2 Alone

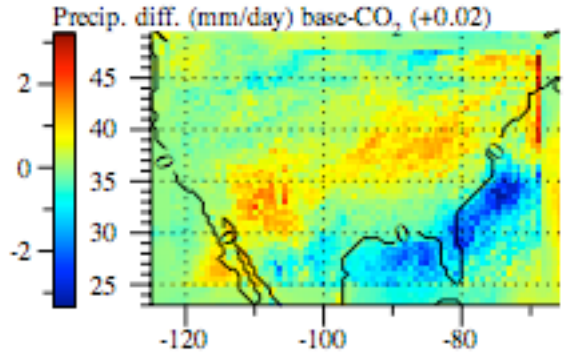
3-D simulations → CO_2 increases temperature, water vapor, precipitation, biogenic organics, carcinogens, particles



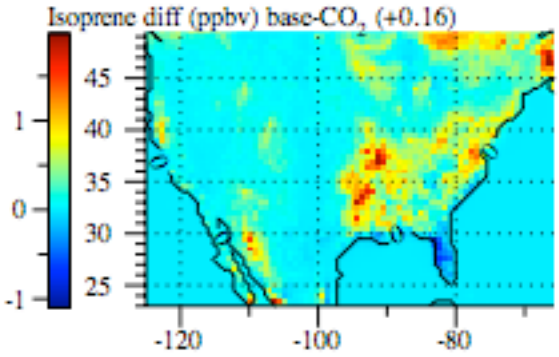
Temperature



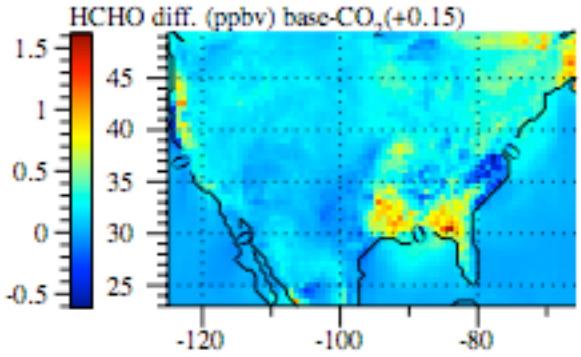
Water vapor



Precip



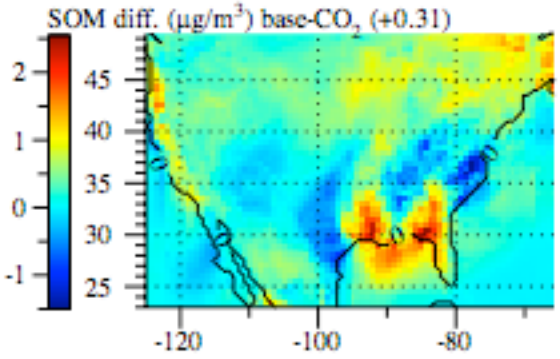
Isoprene

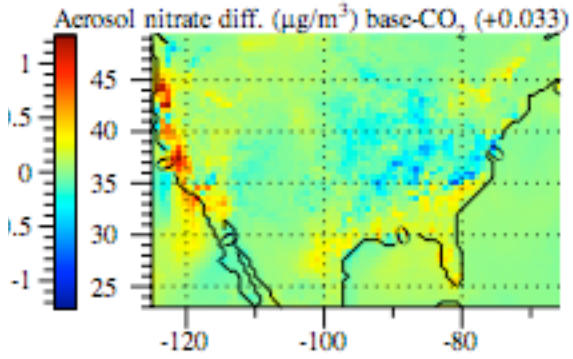


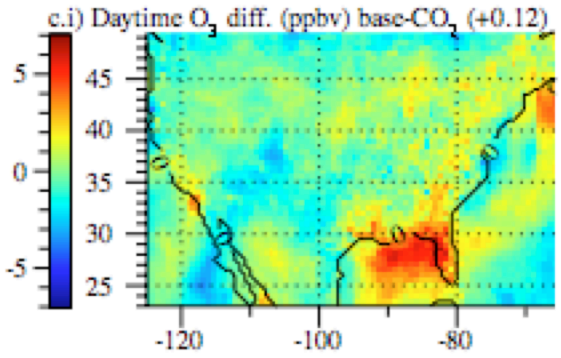
Formaldehyde

Changes Resulting From Historic CO_2 Alone

CO_2 increases particles, ozone







Aerosol SOM Aerosol nitrate Ozone

Additional U.S. pollution deaths/yr per 1.8 ºF (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 ºF (1 K) +21,600 (7400-39,000)

Data Studies Showing CO_2 Domes in Cities

Idso et al., Phys. Geography, 19, 95-108, 1998

Idso et al., Atmos. Environ., 35, 995-1000, 2001

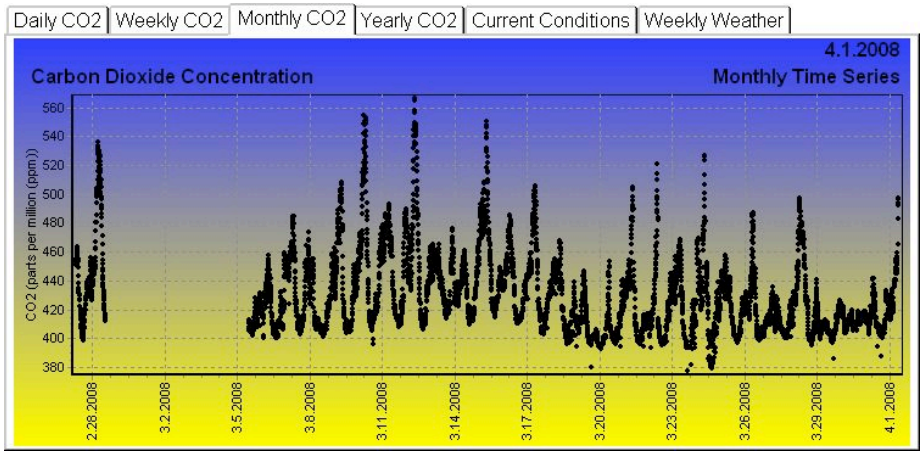
Gratani and Varone, Atmos. Env., 39, 2619-2624, 2005

Newman et al., J. Geophys. Res., 113, D23304, 2008

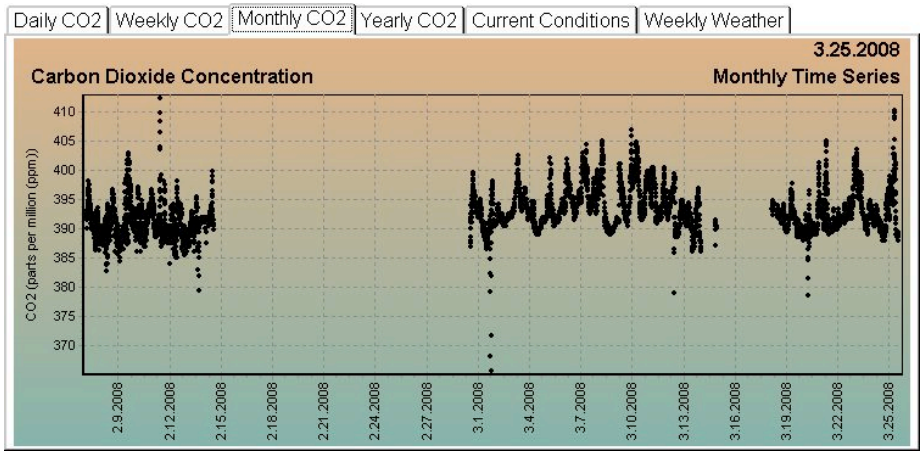
Rigby et al., Atmos. Environ., 42, 8943-8953, 2008

Measured CO_2 in a City

Downtown Salt Lake City (420-440 ppmv)



Salt Lake City



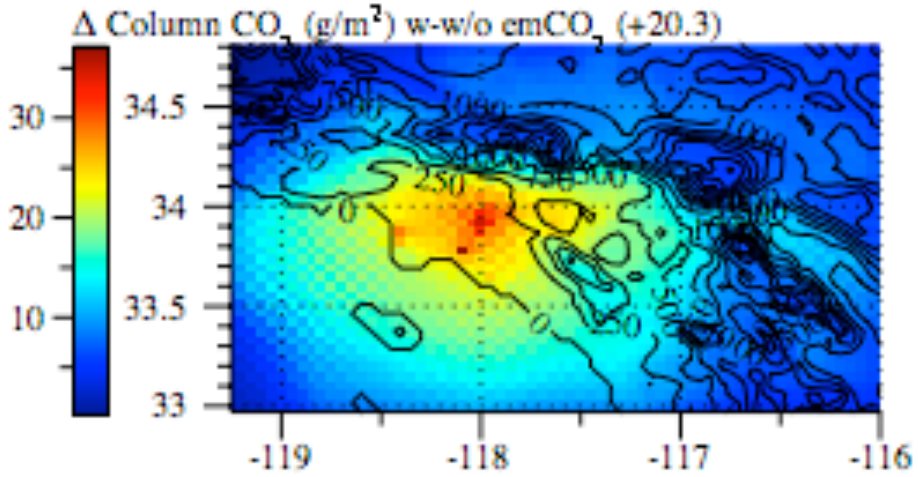
Kennecott (390-395 ppmv)

Global background 385 ppmv

http://co2.utah.edu/

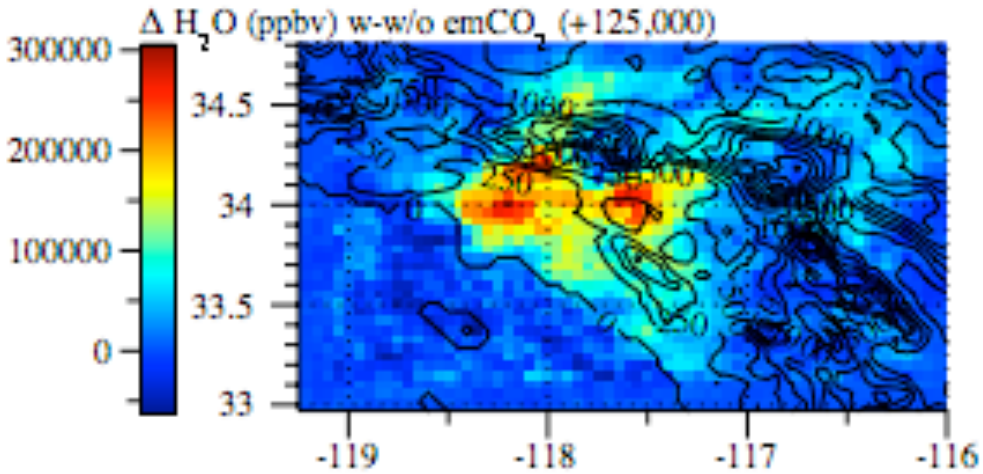
Aug-Oct L.A. Changes Due to Local CO_2

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



Change in column CO_2 from local CO_2 emissions "CO_2 Dome"

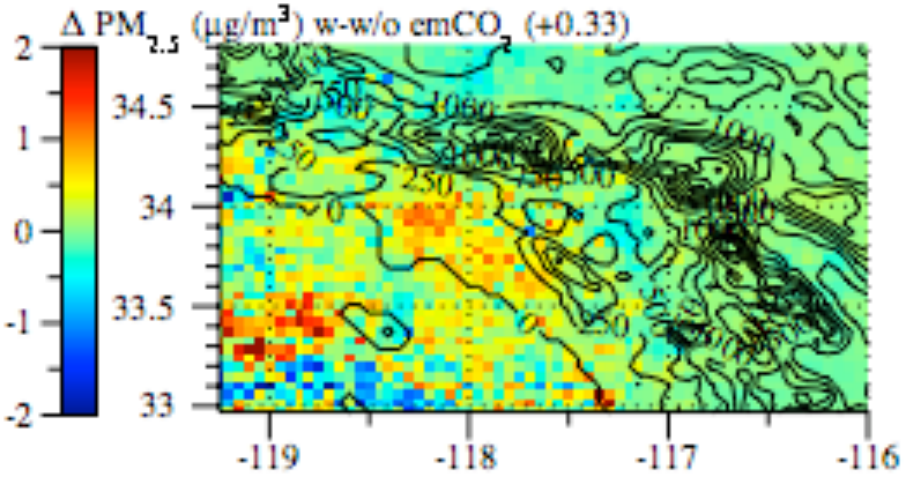
Change in surface H_2O



CO_2 emissions increase population-weighted column water vapor

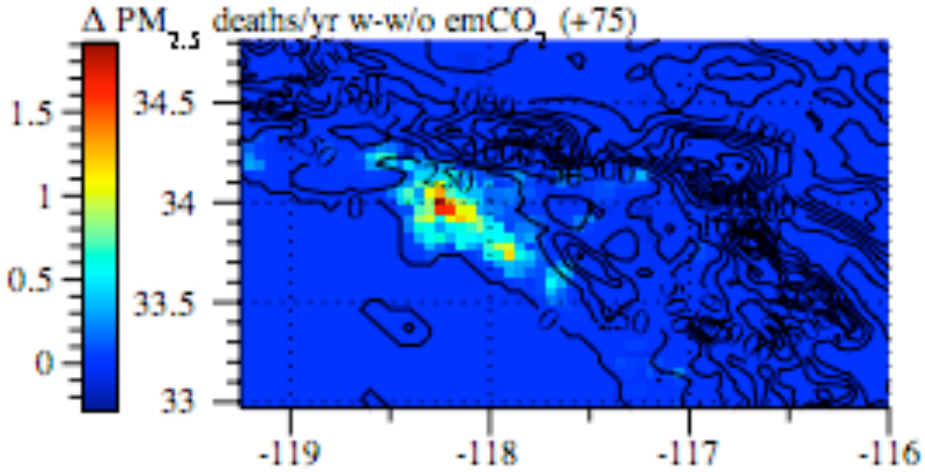
Aug-Oct L.A. $PM_{2.5}$ Deaths From CO_2 Dome

Numbers in parentheses are population-weighted values



Change in surface $PM_{2.5}$

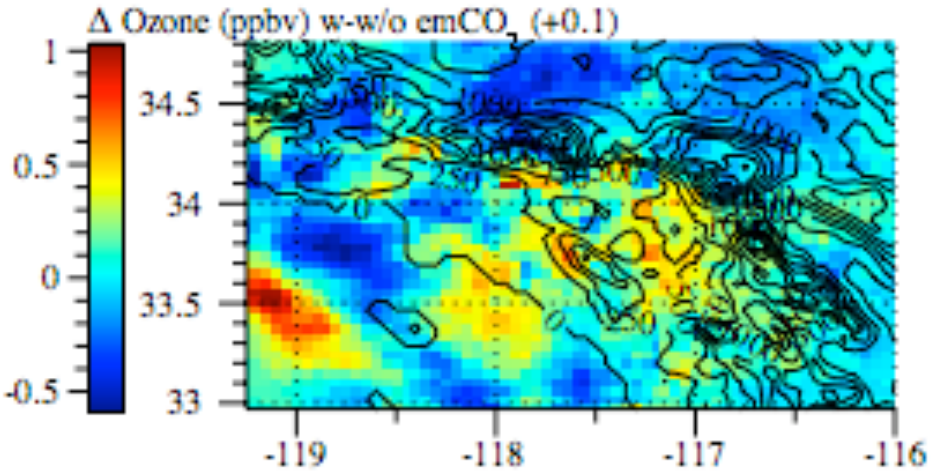
Additional PM deaths/yr



CO_2 emissions increase population-weighted $PM_{2.5}$ and $PM_{2.5}$ deaths

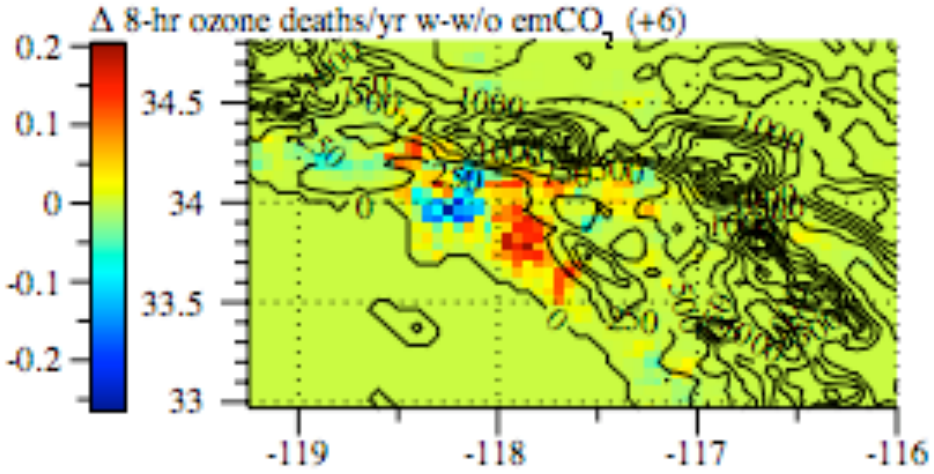
Aug-Oct L.A. O_3 Deaths From CO_2 Dome

Numbers in parentheses are population-weighted values



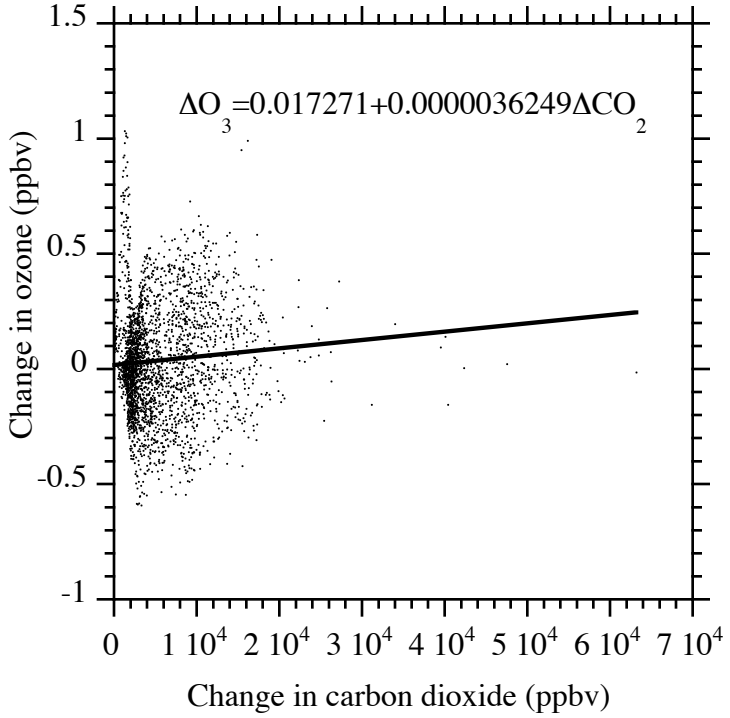
Change in surface O_3

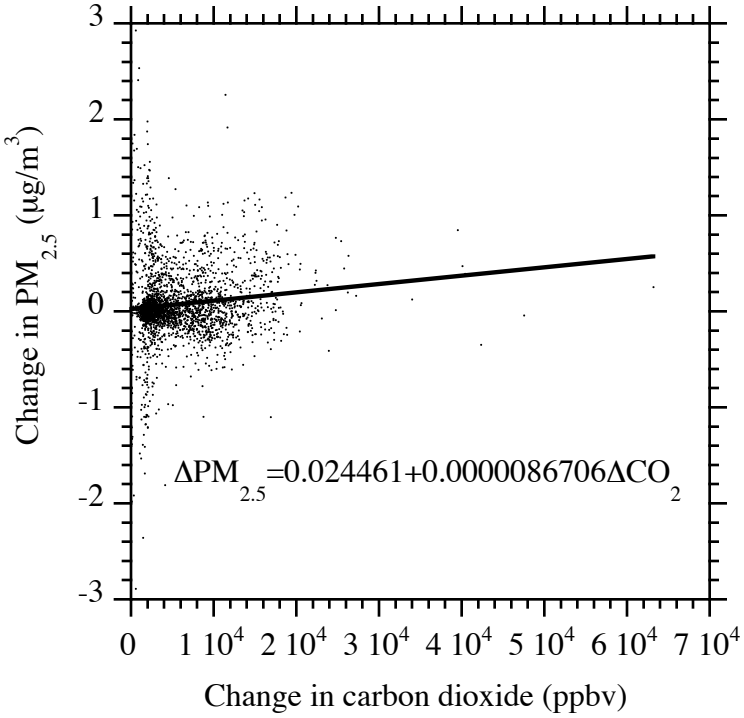
Additional O_3 deaths/yr



CO_2 emissions increase population-weighted O_3 and O_3 deaths

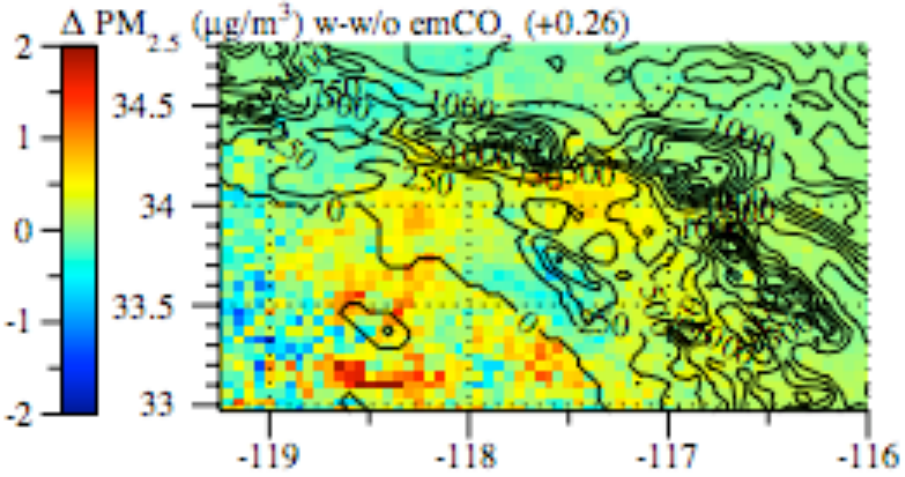
Spatial Correlation Between Increased Local CO_2 and Increased Local O_3 (left) & $PM_{2.5}$ (right) in Los Angeles





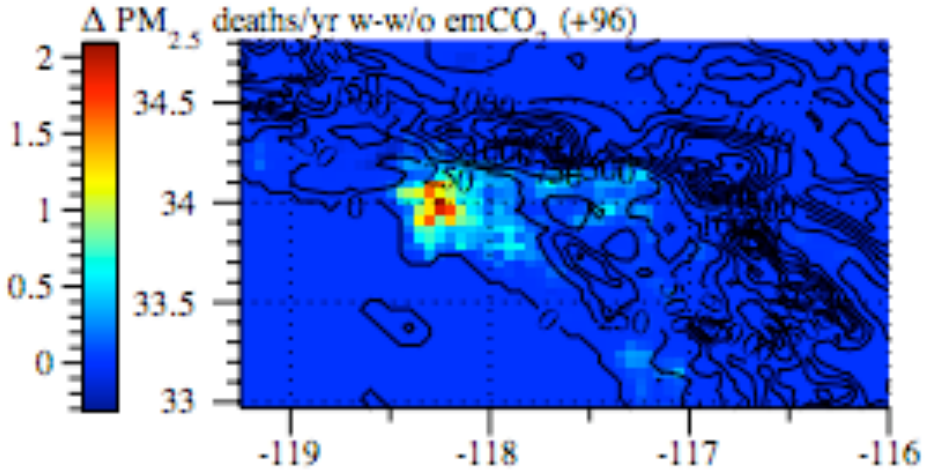
Feb-Apr L.A. $PM_{2.5}$ Deaths From CO_2 Dome

Numbers in parentheses are population-weighted values



Change in surface $PM_{2.5}$

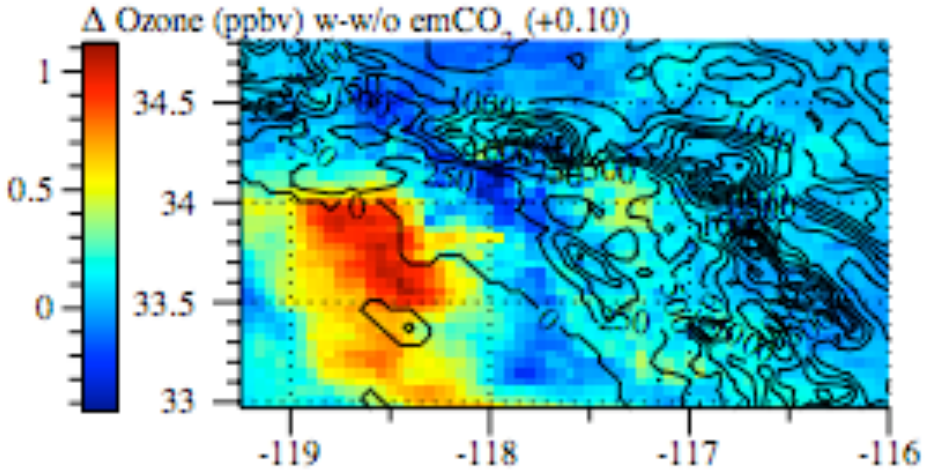
Additional PM deaths/yr



CO_2 emissions increase population-weighted $PM_{2.5}$ and $PM_{2.5}$ deaths

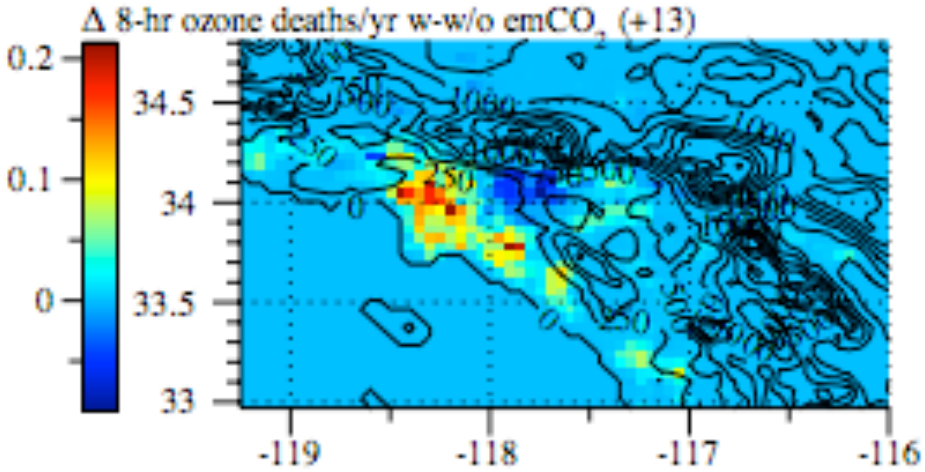
Feb-Apr L.A. O_3 Deaths From CO_2 Dome

Numbers in parentheses are population-weighted values



Change in surface O_3

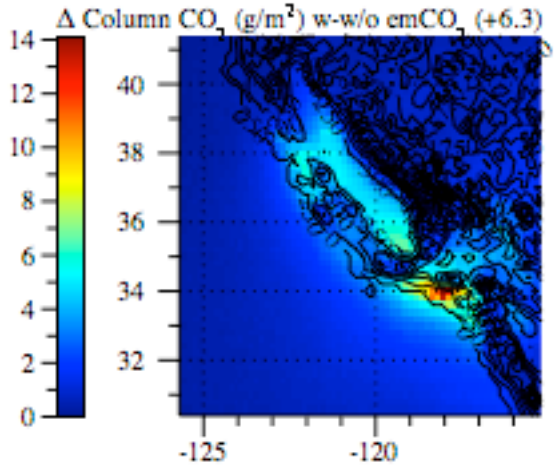
Additional O_3 deaths/yr



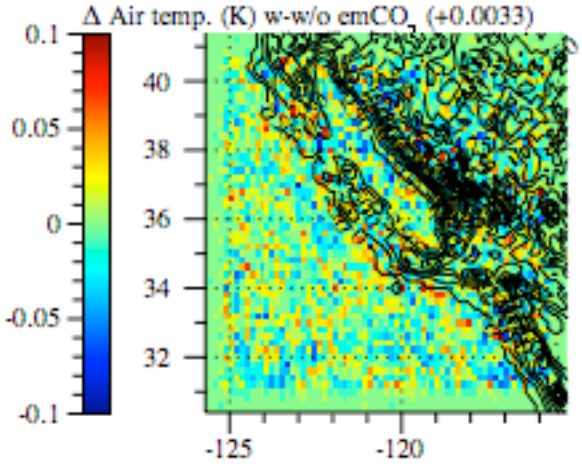
CO_2 emissions increase population-weighted O_3 and O_3 deaths

1-Year Changes in California Due to Local CO_2

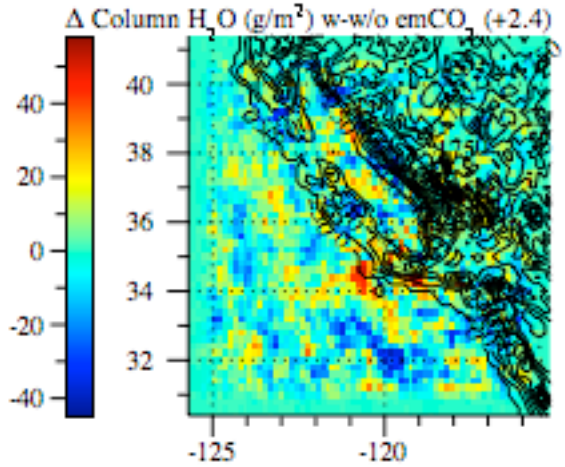
Numbers in parentheses are population-weighted values



Change in column CO_2
"CO_2 Domes"



Increase in
Surface air
temperature

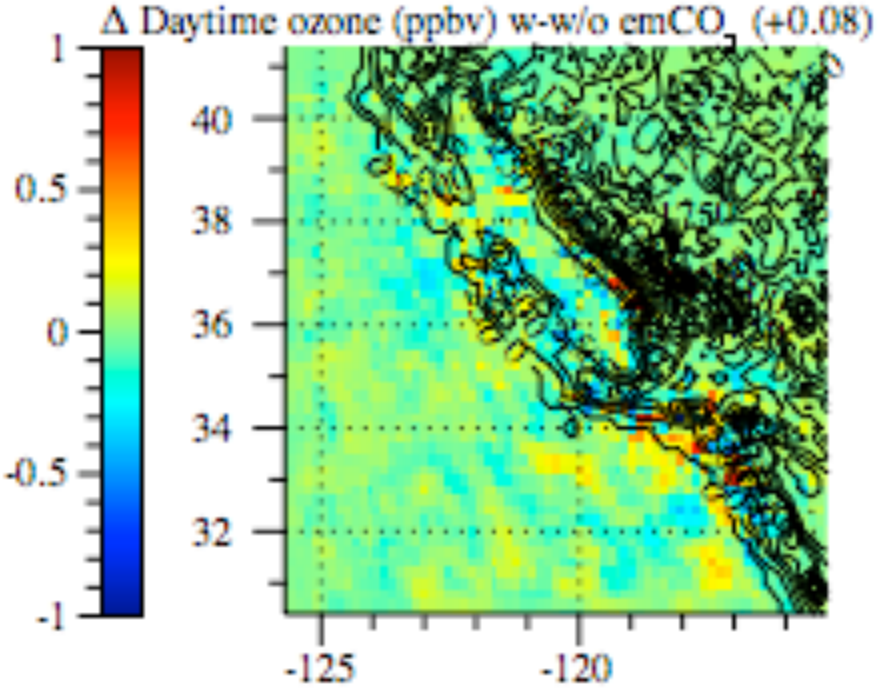


Increase in
Column H_2O

CO_2 emissions increase population-weighted temperatures, water vapor

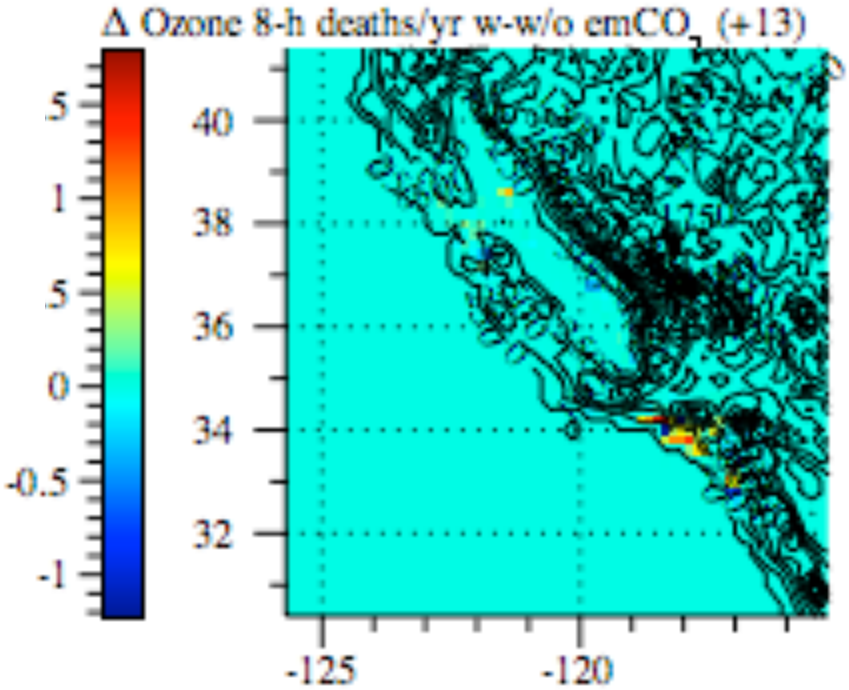
1-Year Changes Due to Local CO_2

Numbers in parentheses are population-weighted values



Increase in surface O_3

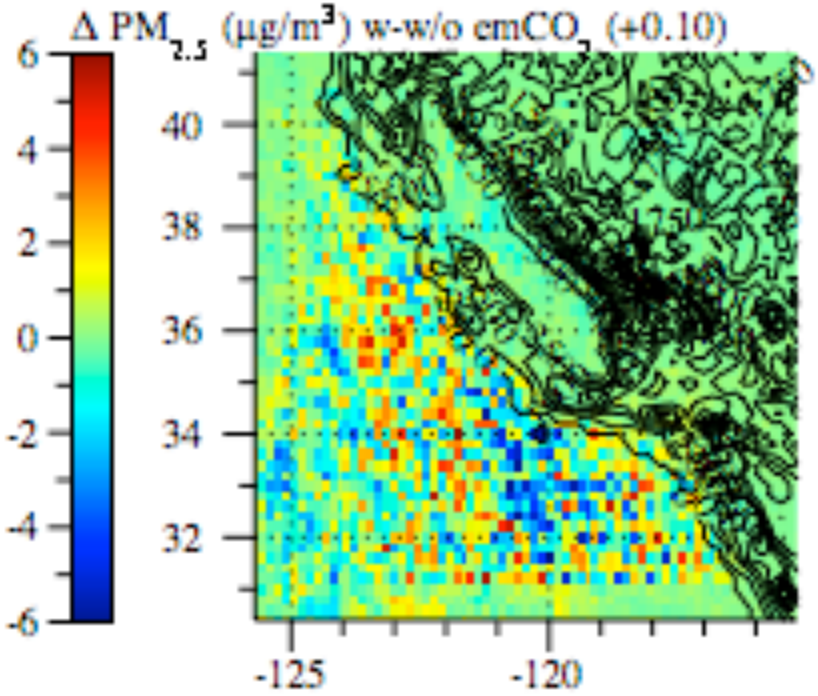
Additional O_3 deaths/yr



CO_2 emissions increase population-weighted O_3 and O_3 deaths

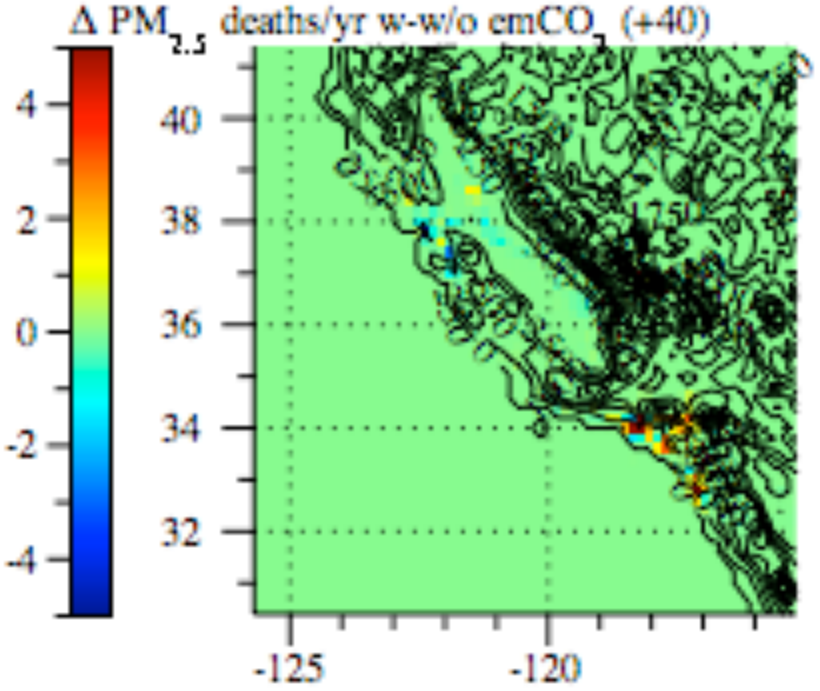
1-Year Changes Due to Local CO_2

Numbers in parentheses are population-weighted values



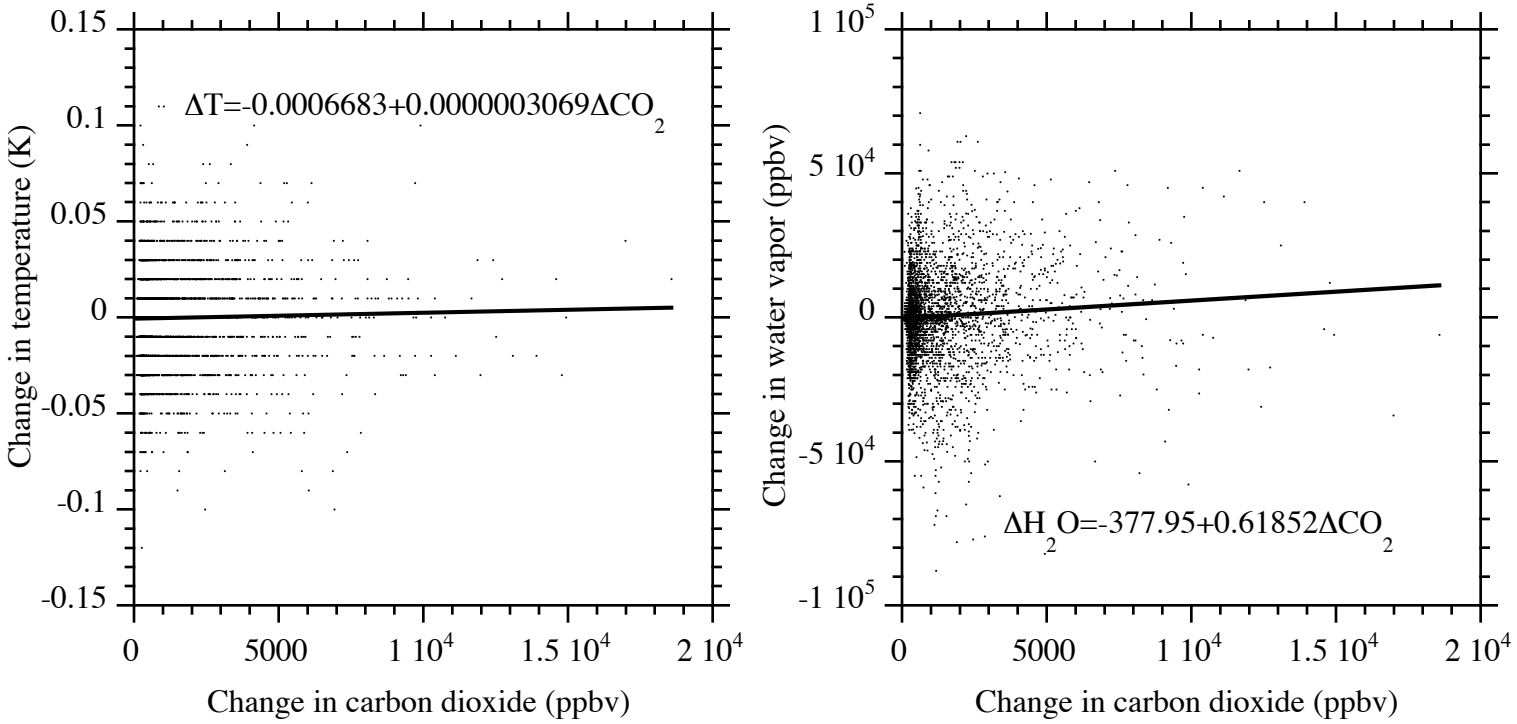
Net increase in surface $PM_{2.5}$

Additional PM deaths/yr

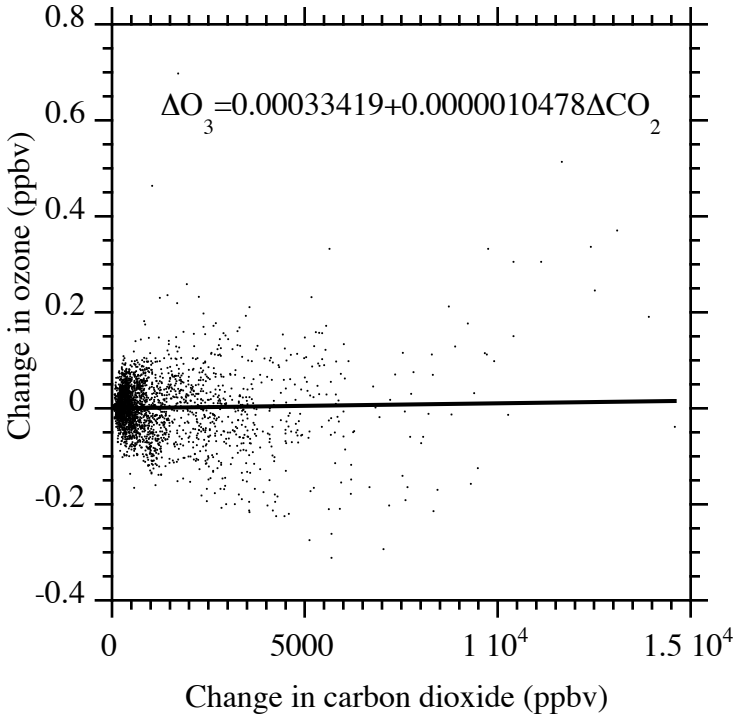


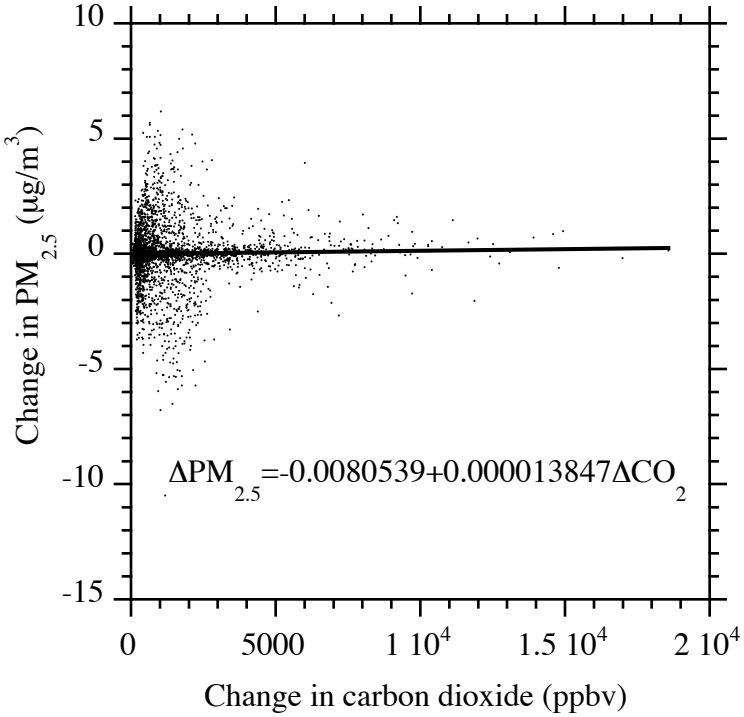
CO_2 emissions increase population-weighted $PM_{2.5}$ and $PM_{2.5}$ deaths

Spatial Correlations Between Increased Local CO_2 and Increased Temp. (left) & H_2O (right) in California

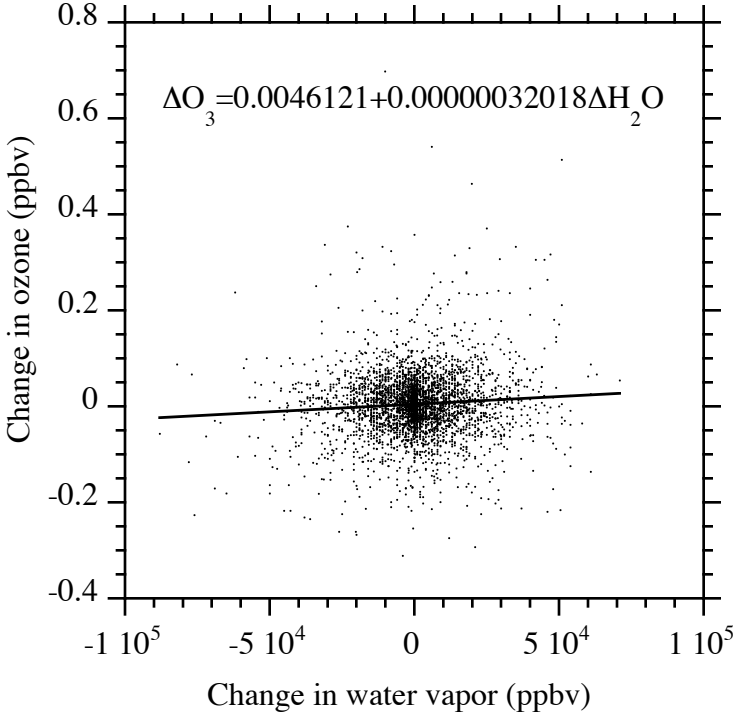


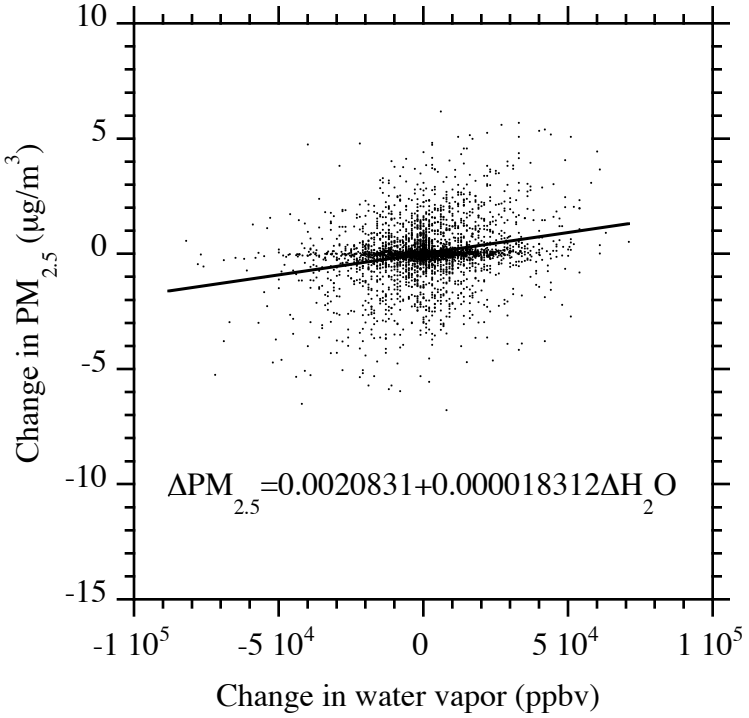
Spatial Correlations Between Increased Local CO_2 and Increased O_3 (left) & $PM_{2.5}$ (right) in California





Spatial Correlations Between Increased H_2O and Increased O_3 (left) & $PM_{2.5}$ (right) in California





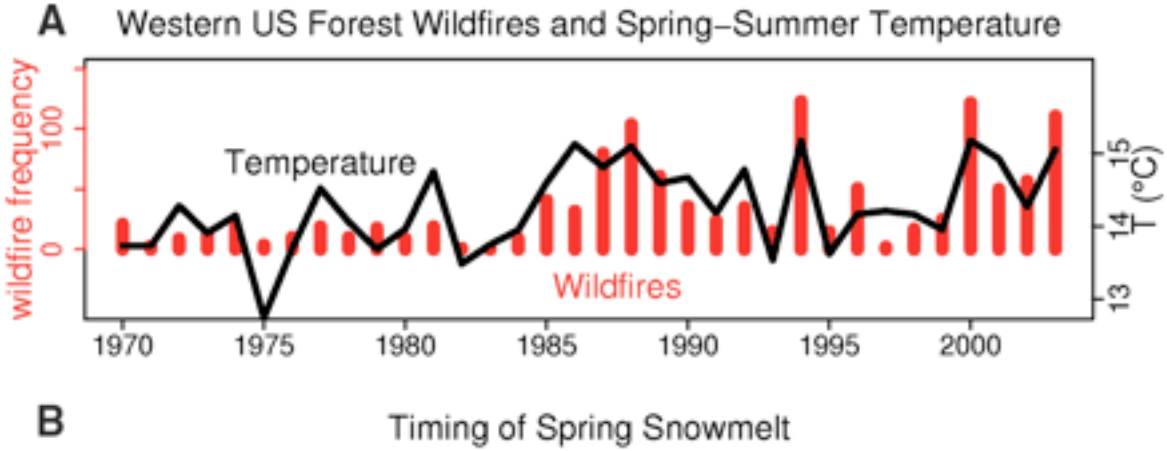
Correlation Between Wildfires and Local Ozone Increases

Jaffe et al., Environ. Sci. Technol, 42, 5885-5891, 2008

Each 1 million acres burned increased regional O_3 by 2 ppbv

Correlation Between Higher Temperatures Temperatures and Wildfire Increases

Westerling et al., Science, 313, 940-943, 2006



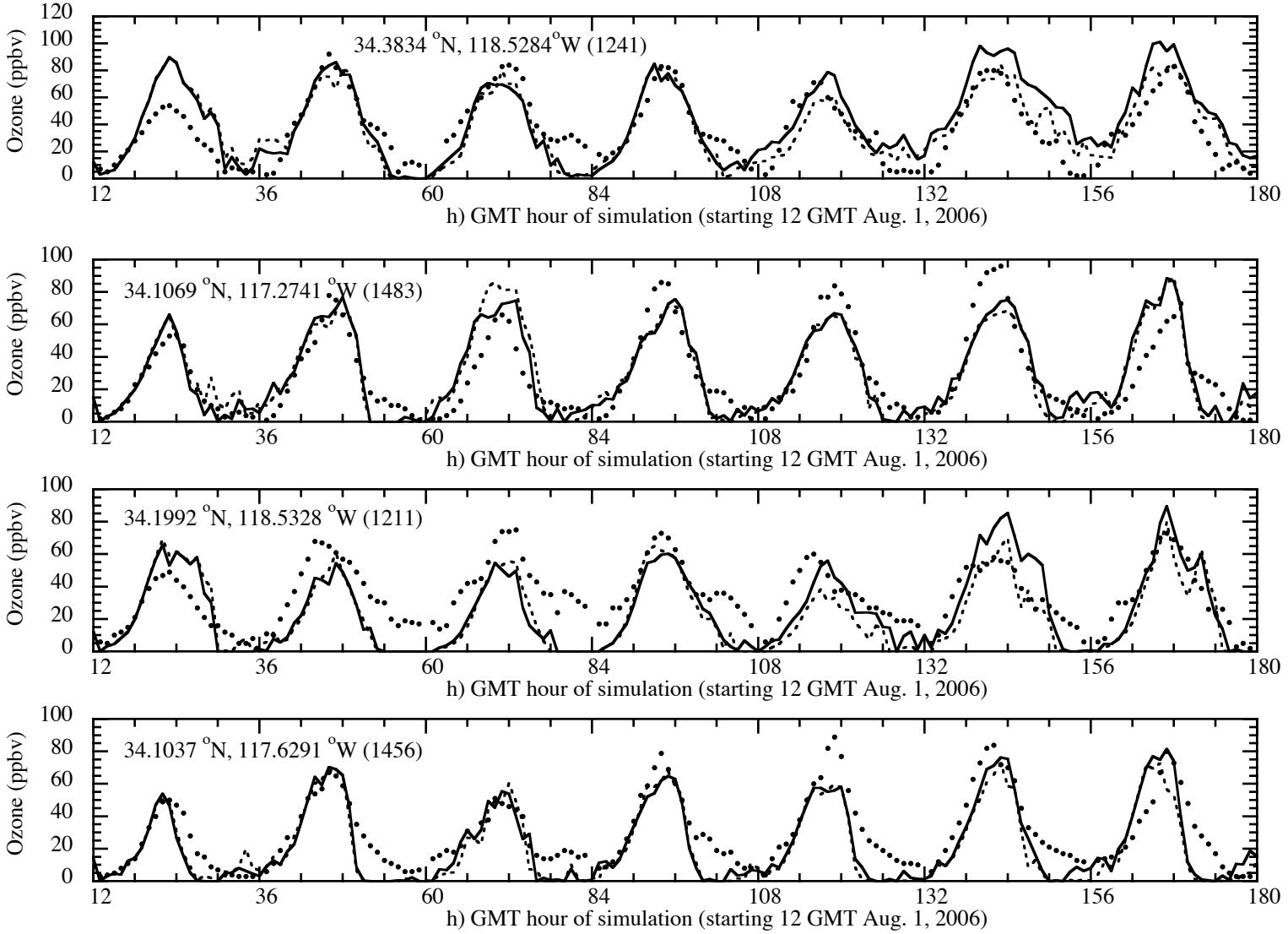
Summary

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.

Globally-emitted CO_2 increases temperatures and water vapor, which increase ozone and $PM_{2.5}$, increasing U.S. annual air pollution deaths by about 1000 (350-1800) and cancers by 20-30 per 1 K rise in CO_2-induced temperatures, with 40% due to O_3 and 60% due to $PM_{2.5}$. Increases in annual worldwide deaths are ~22,000 (7400-39,000) per 1 K. Ozone and $PM_{2.5}$ from wildfires triggered by higher temperatures due to CO_2 should enhance this death rate.

30% of the additional U.S. deaths from global CO_2 changes occur in California, which has 12% of the population. These deaths are occurring today, as temperatures have risen 0.75 K. Thus, enhanced global CO_2 damages California more than it damages other states.

Modeled (w/ & w/o emCO_2) vs. Obs L.A. O_3



Solid=with emCO_2; dashed=no emCO_2; dots=data (EPA)