

Climate Change's Impacts on Local Air Quality and Public Health



Mark Z. Jacobson

Atmosphere/Energy Program

Dept. of Civil & Environmental Engineering

Stanford University

California Air Pollution Control Officer's Assoc.

San Francisco, California, Aug. 31, 2010

Reasons Used to Deny California's 2007 Waiver Request

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

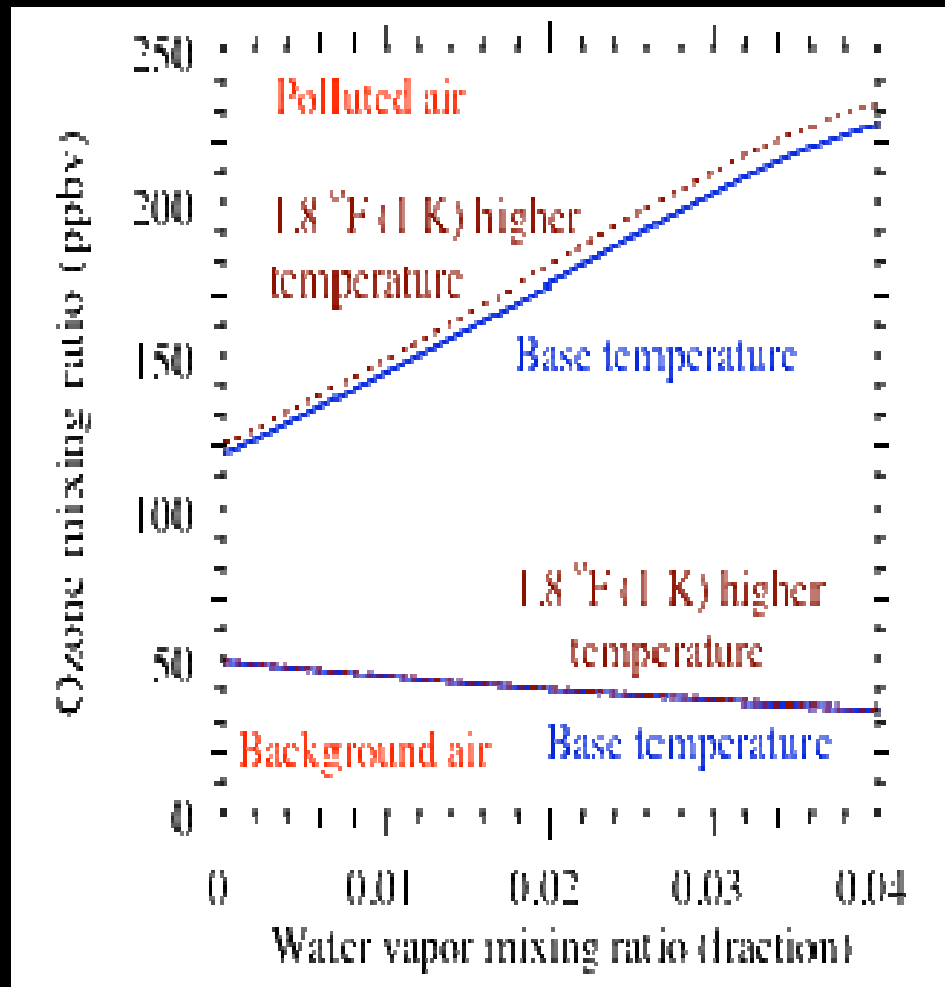
1) Globally-emitted CO₂ does not affect California's health more or less than it affects overall U.S. health.

1) Local California CO₂ emissions don't affect California's air pollution any more than CO₂ emissions from outside of California affect California's air pollution (because CO₂ is well-mixed in the air).

Sen. Carl Levin, EPA Waiver Hearing Mar. 5, 2009

“One ton of CO₂ emitted in California has the same effect as one ton of CO₂ emitted in another state.”

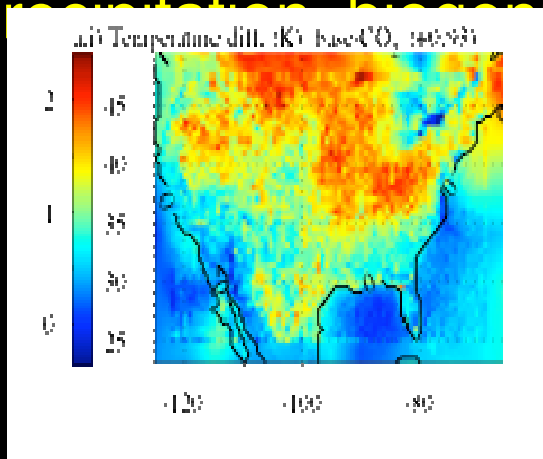
Increases in Water Vapor and Temperature Both Increase Ground-Level Ozone in Polluted Air But Not in Background Air



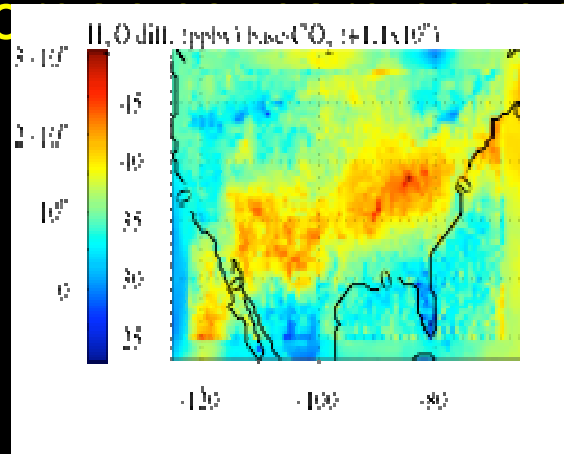
→ California has 6 of the 10 most polluted U.S. cities → Suffers largest impact of higher T, H₂O

Changes Resulting From Historic CO₂ Alone

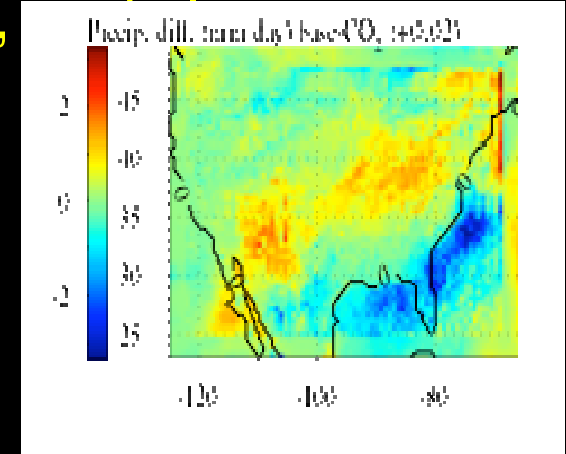
3-D simulations → CO₂ increases temperature, water vapor, precipitation, biogenic VOCs, and aerosols



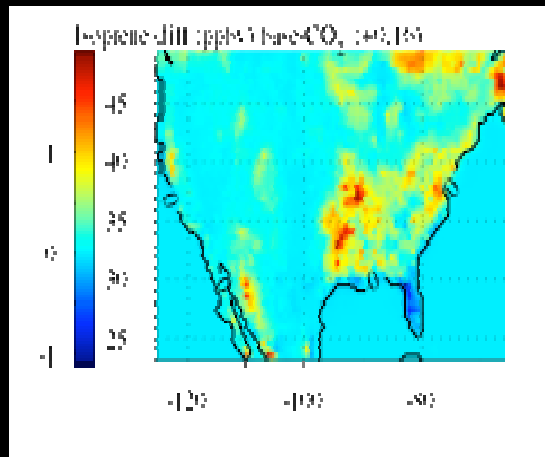
Temperature



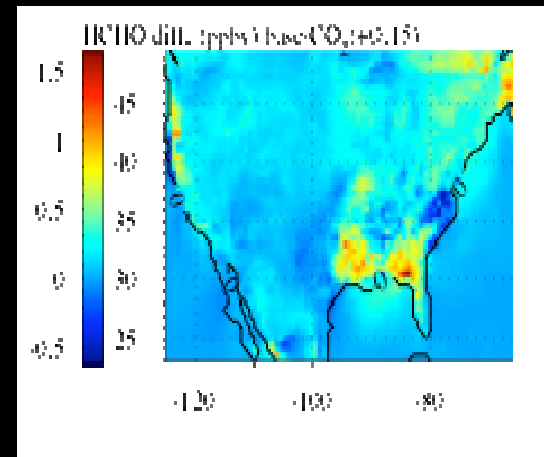
Water vapor



Precipitation



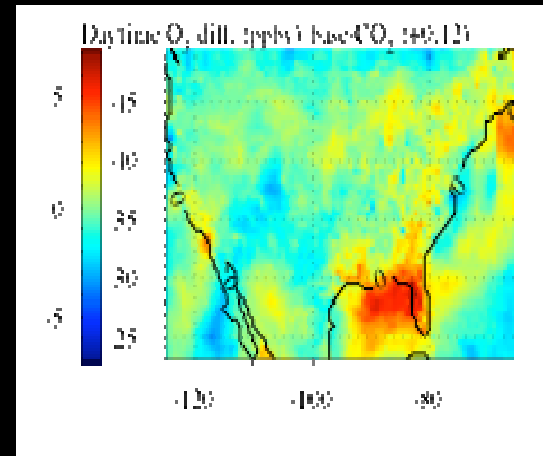
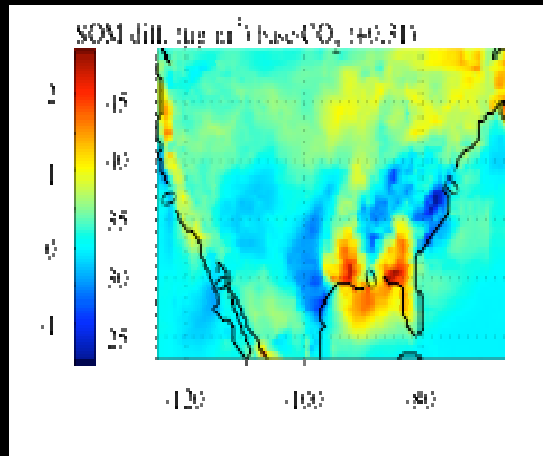
Isoprene



Formaldehyde

Changes Resulting From Historic CO₂ Alone

CO₂ increases particles, ozone



Aerosol Secondary Organic Matter

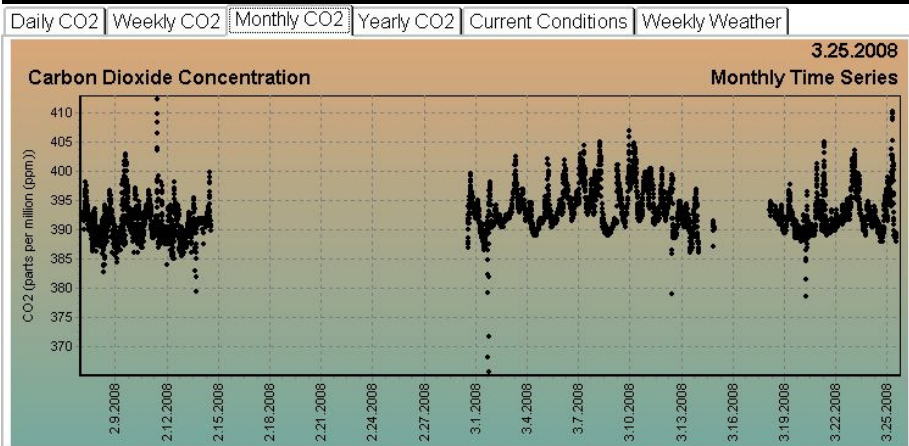
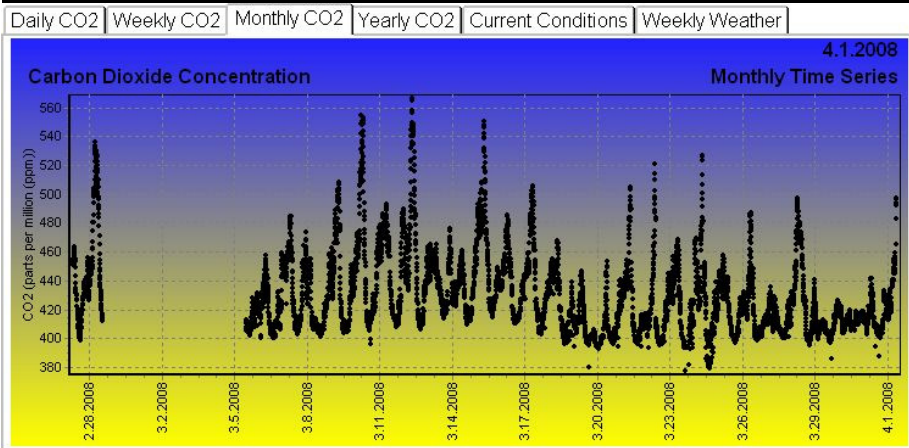
Ozone

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 CO₂ in a City

Downtown Salt Lake City (420-440 ppmv)



Kennecott (390-395 ppmv)

Salt Lake City

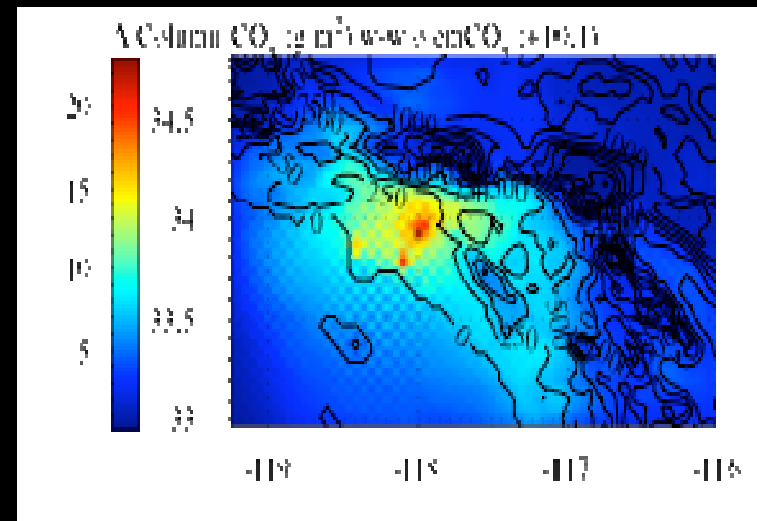
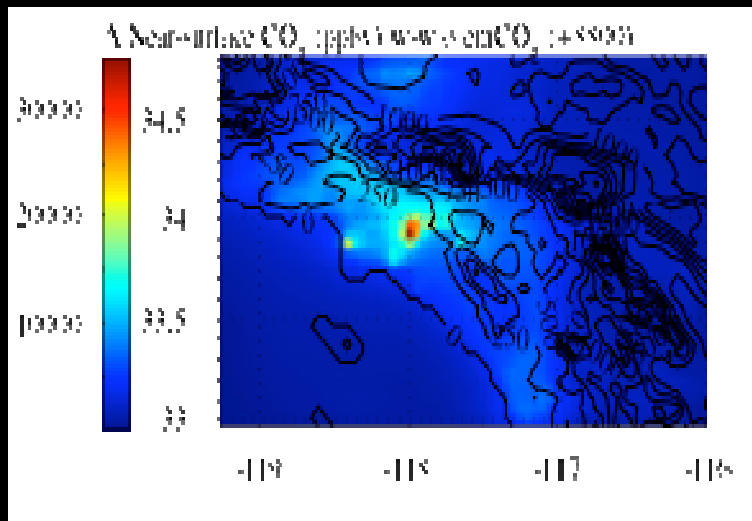


Global background 385 ppmv

<http://co2.utah.edu/>

CO₂ Domes Over Cities

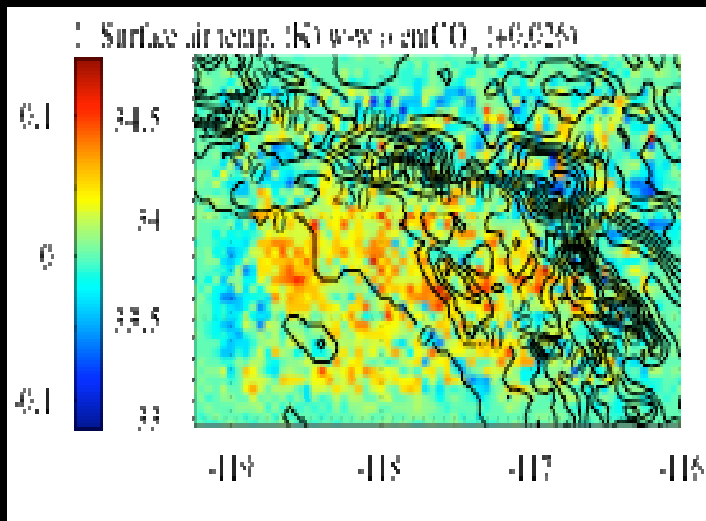
3-D modeled increases in CO₂ due to local emissions for February-April in Los Angeles - numbers in parentheses are population-weighted values



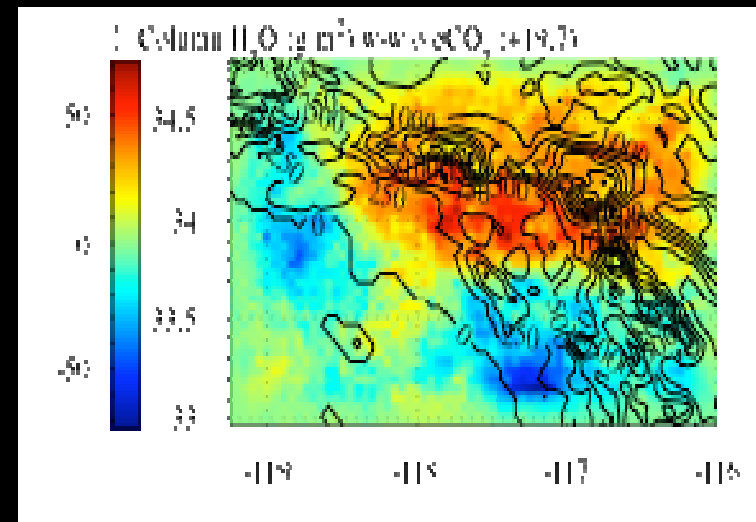
Change in surface/column CO₂ from local CO₂ emissions = "CO₂ Dome"

Feb-Apr L.A. Changes in Temperature and Water Vapor Due to Local CO₂

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



Change in surface T



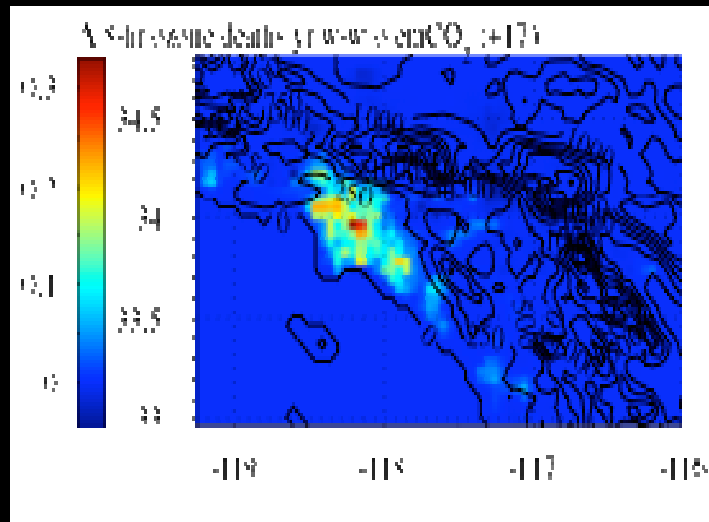
Change in column H₂O

Local CO₂ emissions increase surface temperature and column water vapor

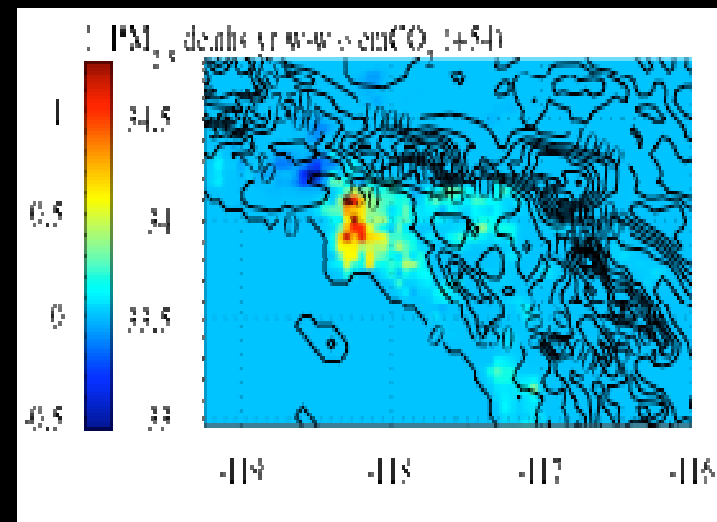
Feb-Apr L.A. Death Increases Due to CO₂

Domes

3-D model results



Additional O₃ deaths/yr

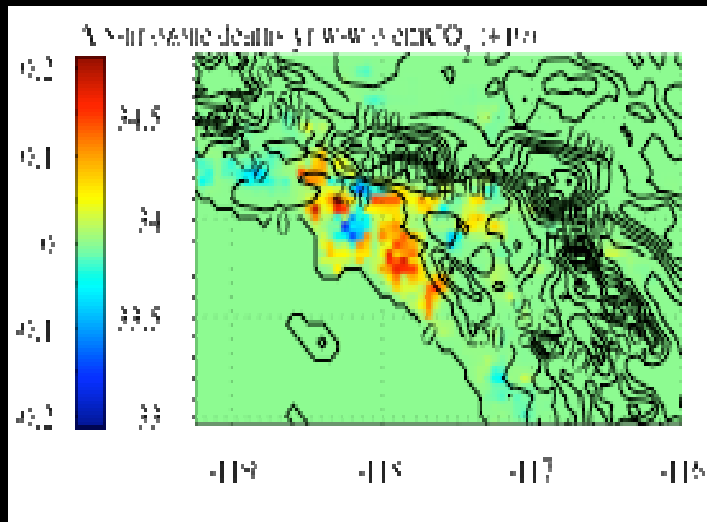


Additional PM deaths/yr

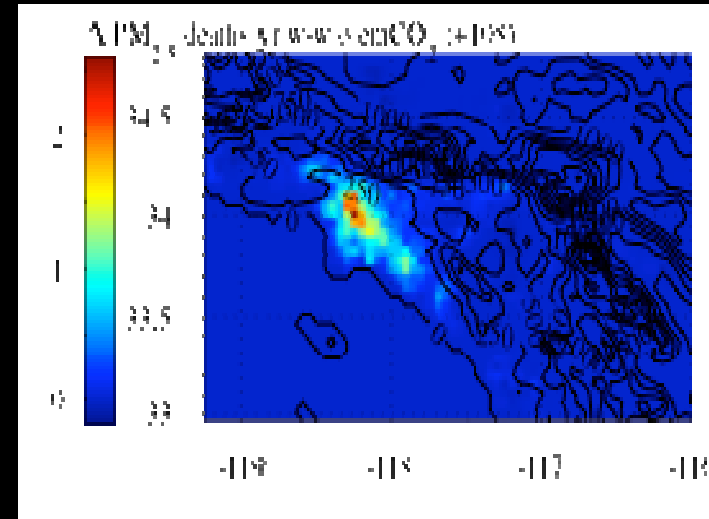
Local CO₂ emissions increase ozone and PM deaths

Aug-Oct L.A. Deaths From CO₂ Dome

3-D model results



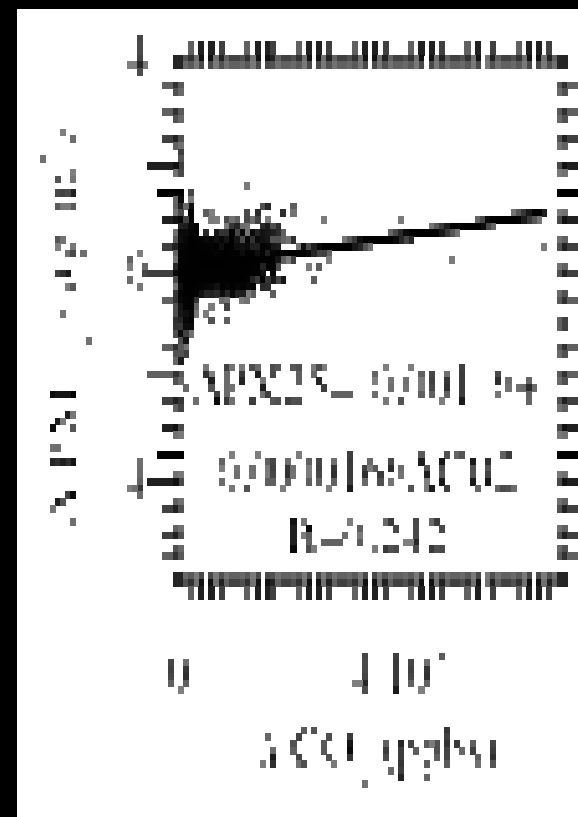
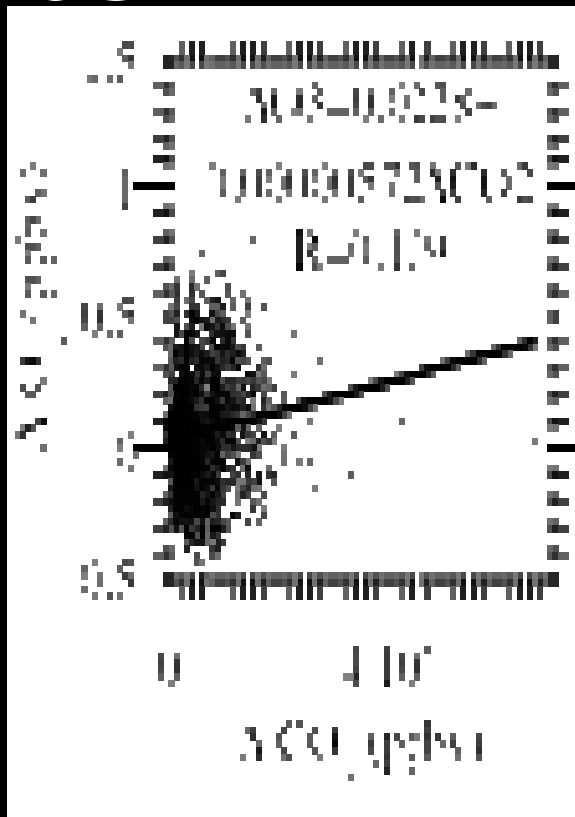
Additional O₃ deaths/yr



Additional PM_{2.5} deaths/yr

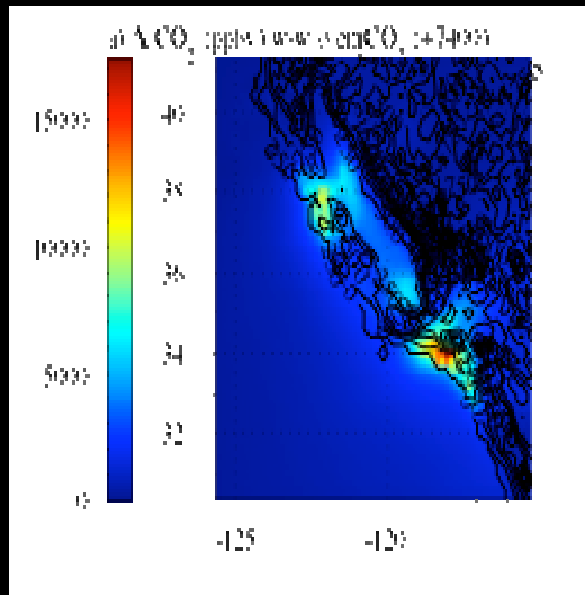
Local CO₂ emissions increase ozone and PM deaths

Spatial Correlation Between Increased Local CO₂ and Increased O₃ (left) & PM_{2.5} (right) in Los Angeles

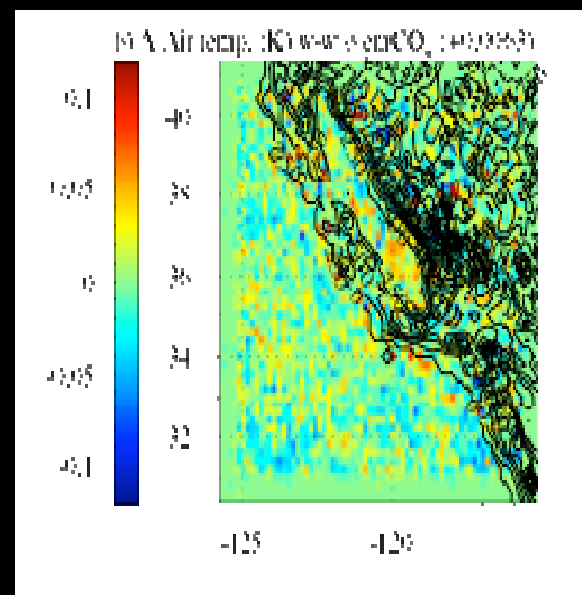


Changes in California Due to Local CO₂

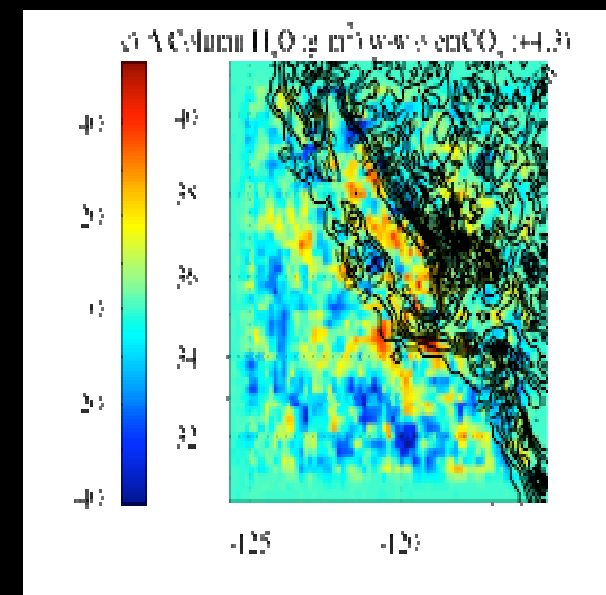
Numbers in parentheses are population-weighted values



Change in column CO₂
"CO₂ Domes"



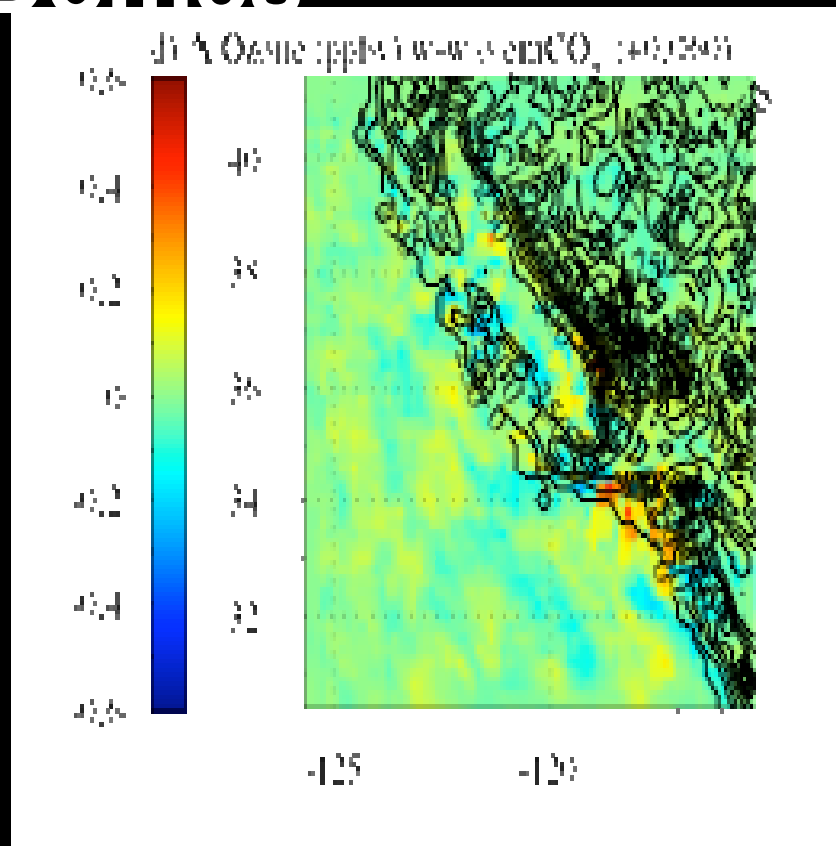
Increase in surface
air
temperature



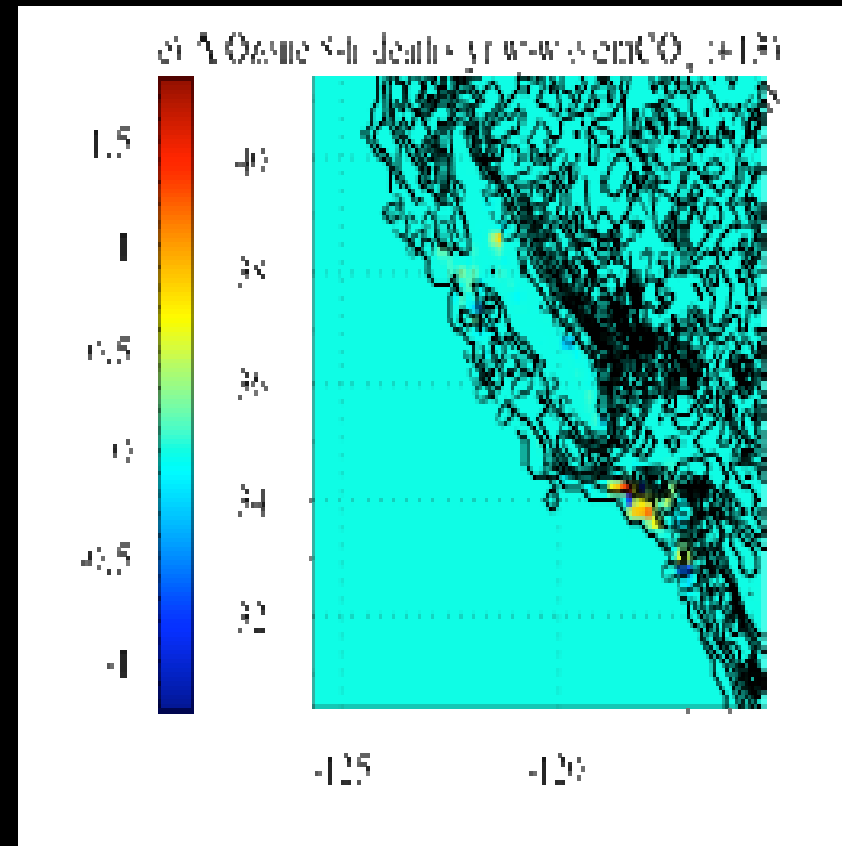
Increase in
column H₂O

Local CO₂ emissions increase temperatures, water vapor

Additional O₃ deaths/yr From CO₂ Domes



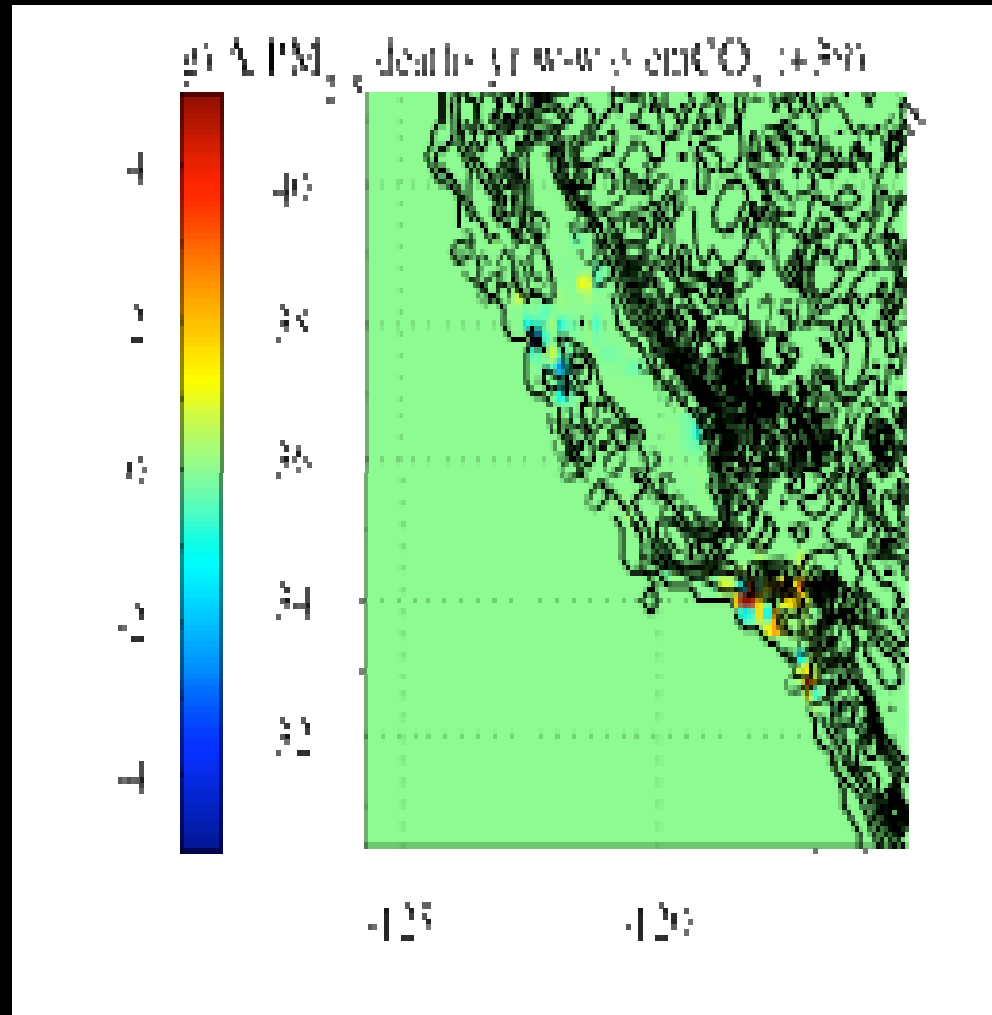
Increase in surface O₃



Additional O₃ deaths/yr

Local CO₂ emissions increase O₃ and O₃ deaths

Additional PM deaths/yr From CO₂ Domes

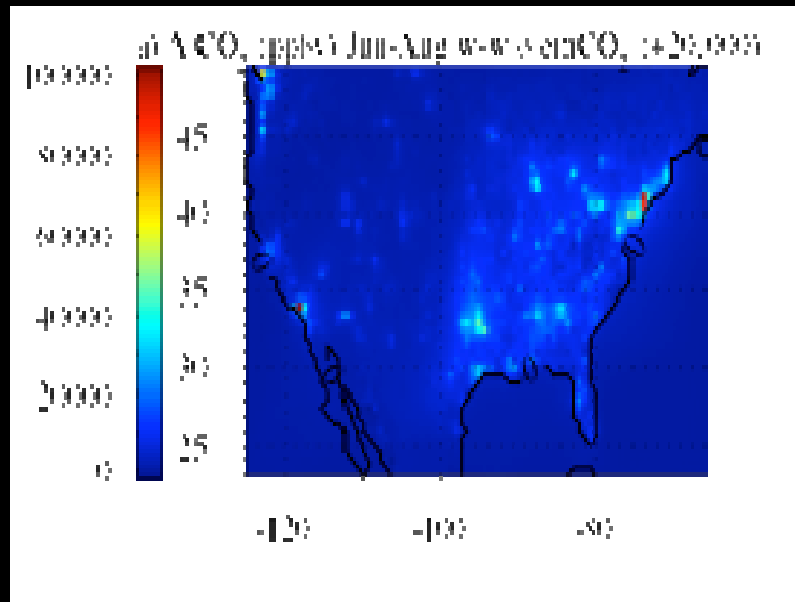


Local CO₂ emissions increase PM_{2.5} deaths

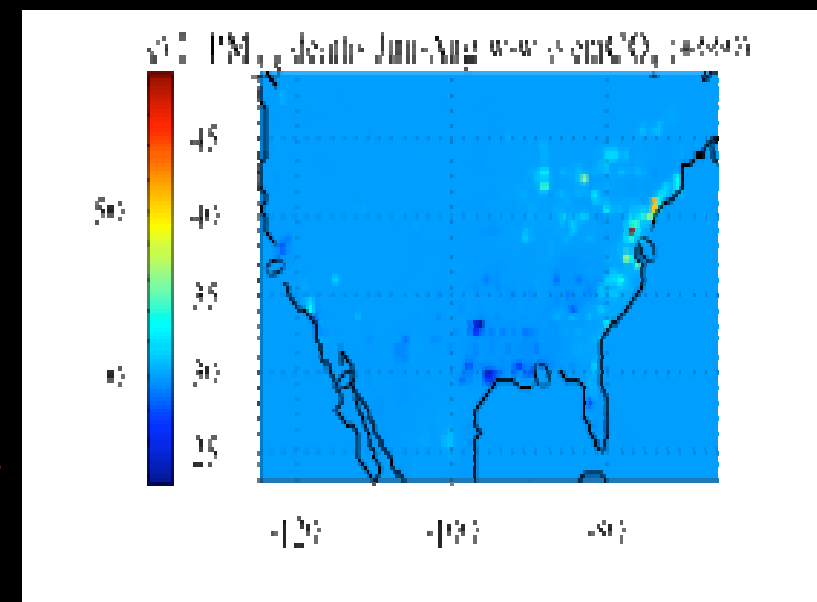
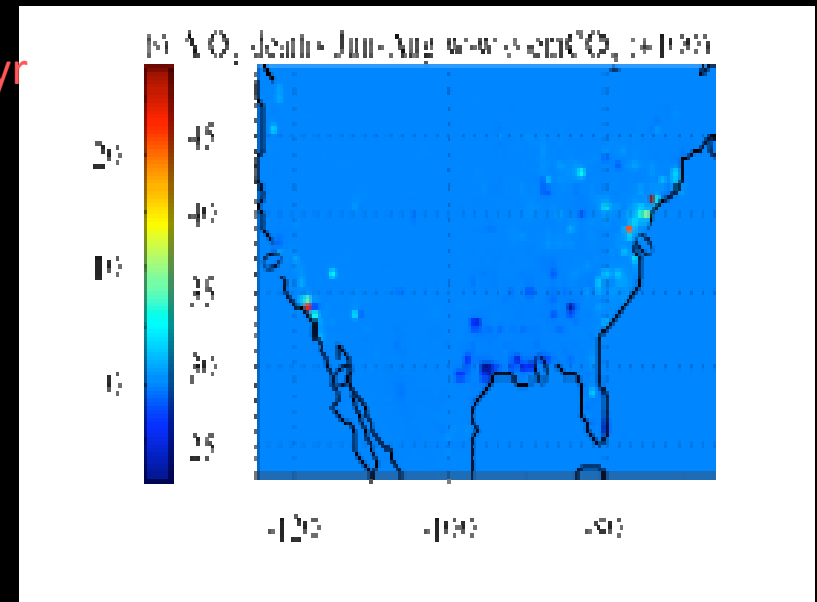
1-Year Death Increases Due to CO₂ Domes

Additional ozone deaths/yr

Increase in CO₂ from local emissions



Additional PM deaths/yr



Local CO₂ emissions increase PM_{2.5} and O₃ deaths

Summary

Locally-emitted CO₂ produces CO₂ domes, which increase local ozone and PM_{2.5} premature deaths in California by ~50-100/yr. Thus, reducing locally-emitted CO₂ will reduce local air pollution and mortality. This result contradicts the basis for all previous local air pollution regulation worldwide, which has ignored CO₂, thus it provides the basis for controlling CO₂ due to its local health impacts.

The result also implies that the main assumption behind “cap and trade” that CO₂ impacts are the same regardless of where CO₂ is emitted, is incorrect.

Journal papers:

<http://www.stanford.edu/group/efmh/jacobson/Ve.html>

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