Air Quality Management in California: Sensitivity to Changing Climate

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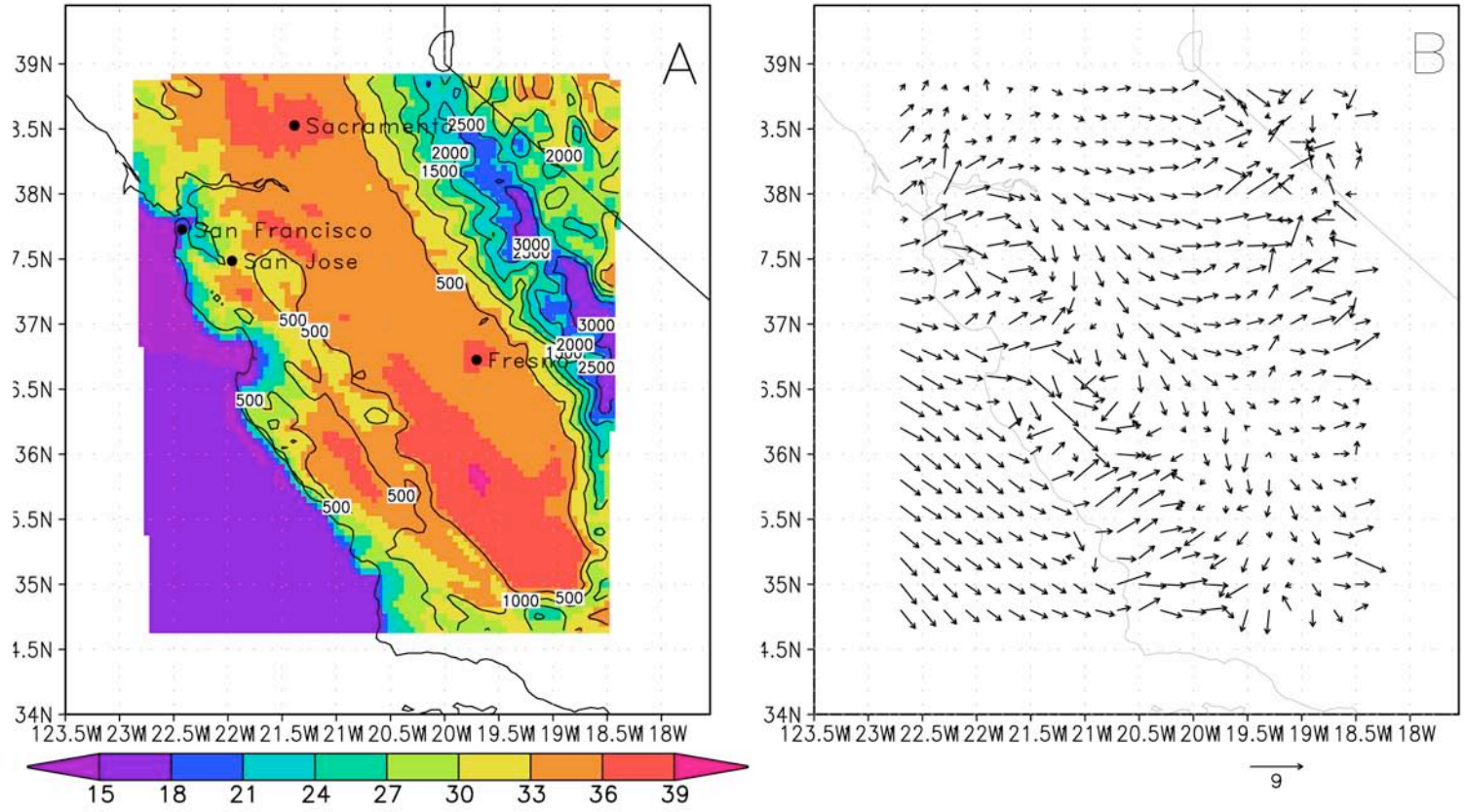
Air Quality Modeling

- Use CMAQ model with SAPRC99 chemistry to predict ozone in Central California
- Base case episode from summer 2000
- Consider effects of changes in:
  - Reaction rates (increased T)
  - Biogenic emissions (increased T)
  - Anthropogenic emissions (population growth and technology change)
  - Inflow boundary conditions (global change)

Modeling Domain

Temperature & Topography

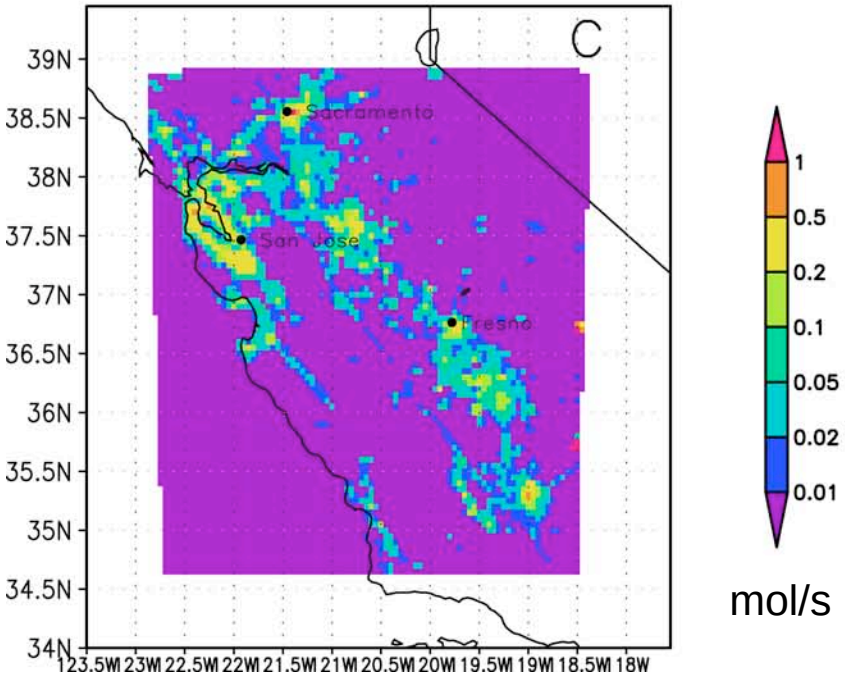
Winds



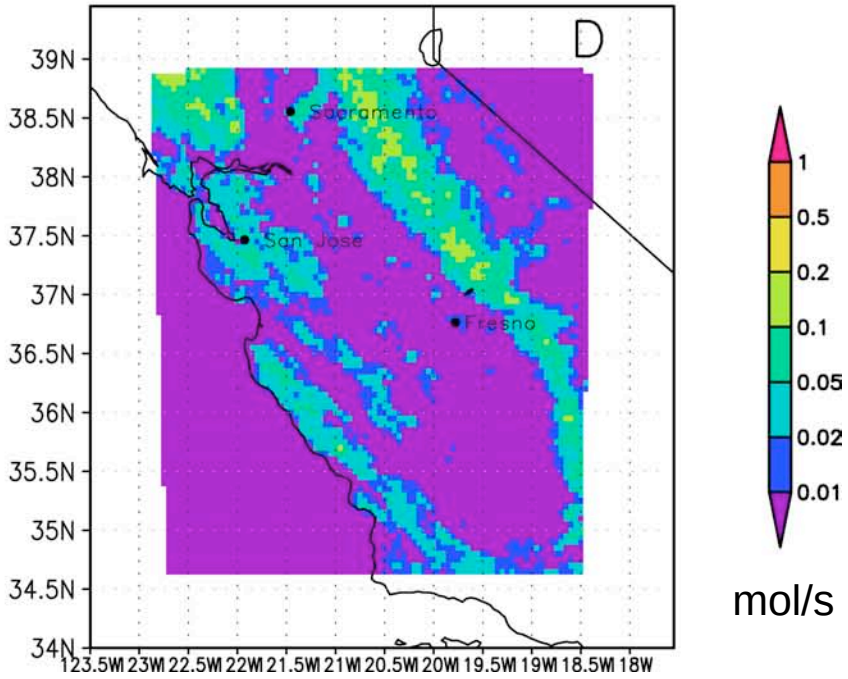
MM5 (Wilczak et al NOAA) for July 29-Aug 2, 2000

VOC Emissions

Anthropogenic



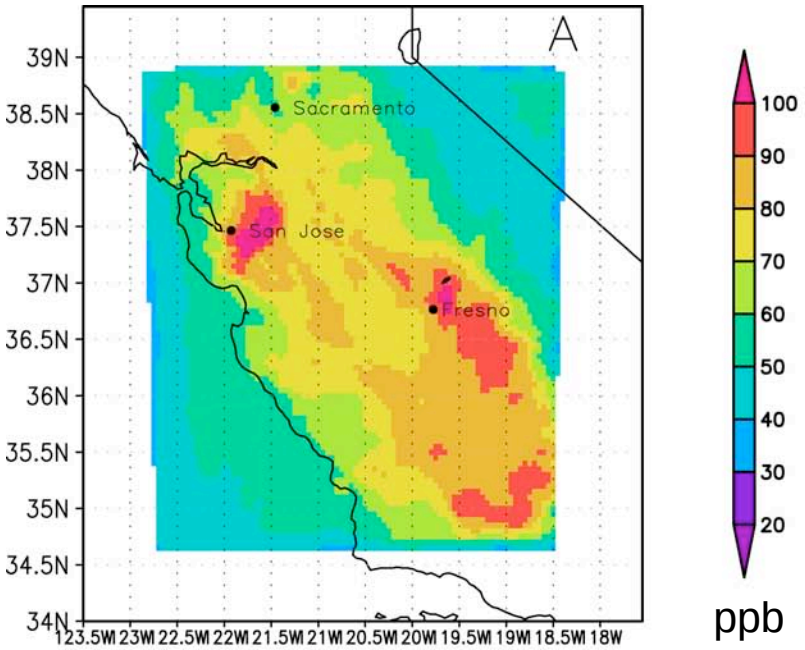
Biogenic



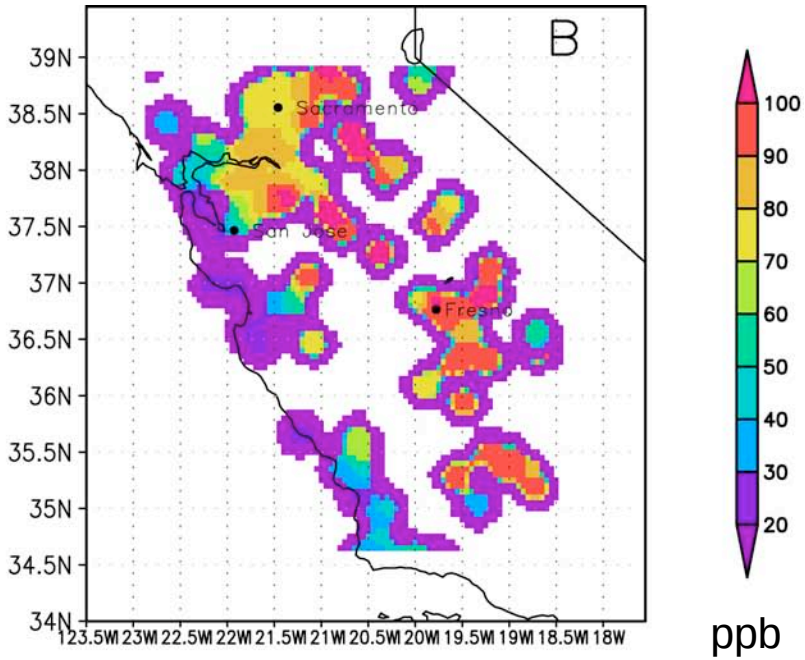
Emission rates shown for 3 PM

Base Case Results

Predicted O_3



Observed O_3



Ozone at 3 PM for 3rd-5th days of Jul 29-Aug 2 episode

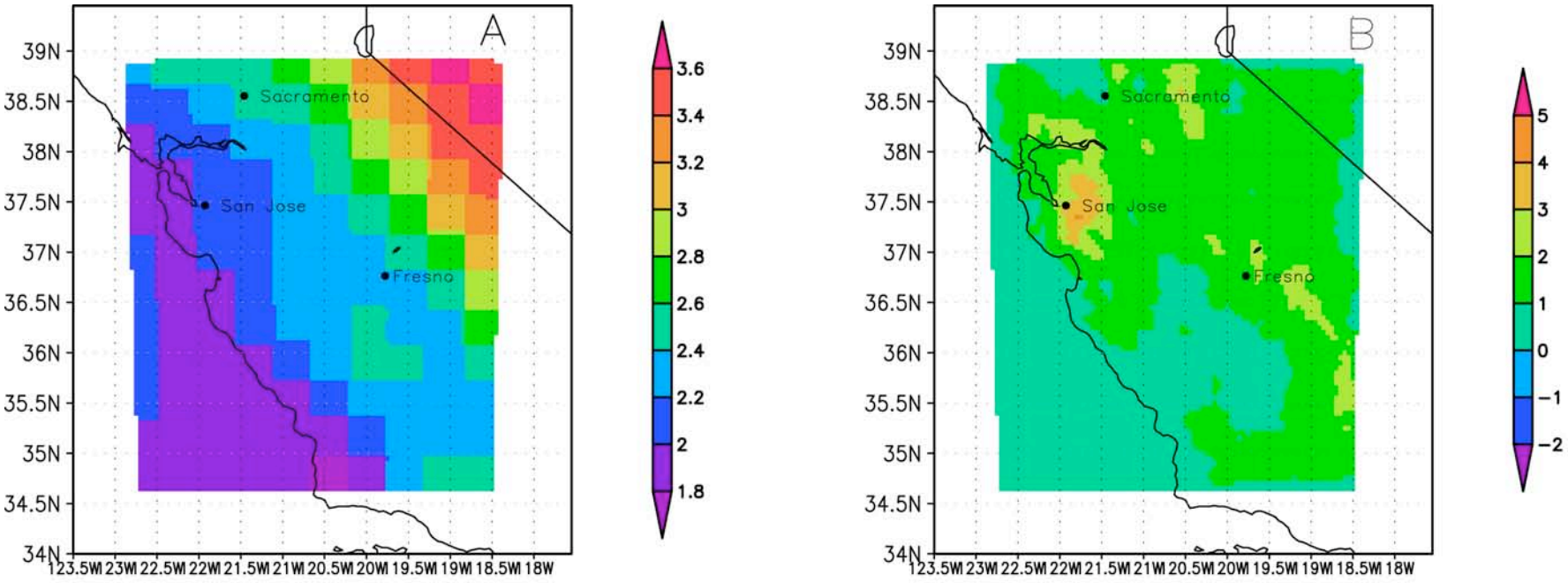
Climate Change

- Consider effects of CO_2 doubling
  - » Pre-industrial = 280 ppm
  - » Future year (~2050) = 560 ppm

- Snyder et al. (*GRL* 2002) used community climate model (CCM3) to drive regional climate simulations for California at 40 km resolution

Effect of ΔT on Chemistry

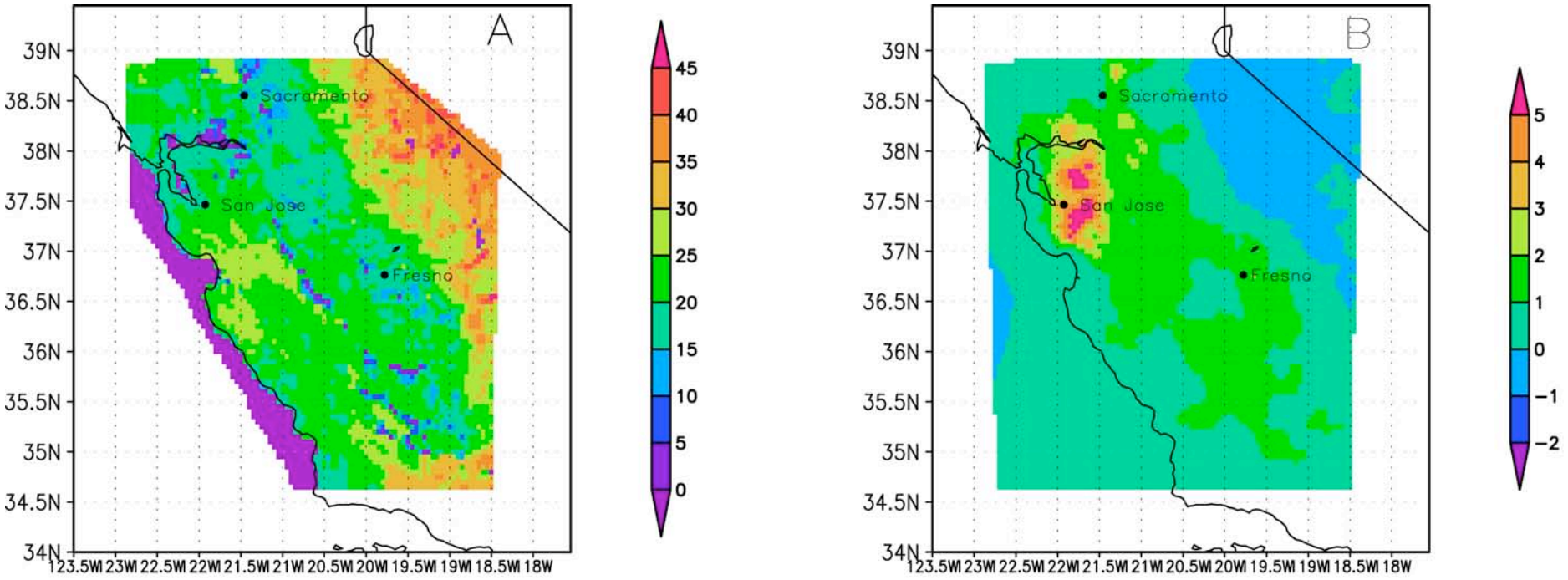
Change in T (℃) ⟶ Change in O_3 (ppb)



ΔT for month of August from Snyder et al. (2002)
Other meteorological variables & emissions unchanged

Effect of ΔBVOC on Ozone

% Increase in BVOC → Change in O_3 (ppb)

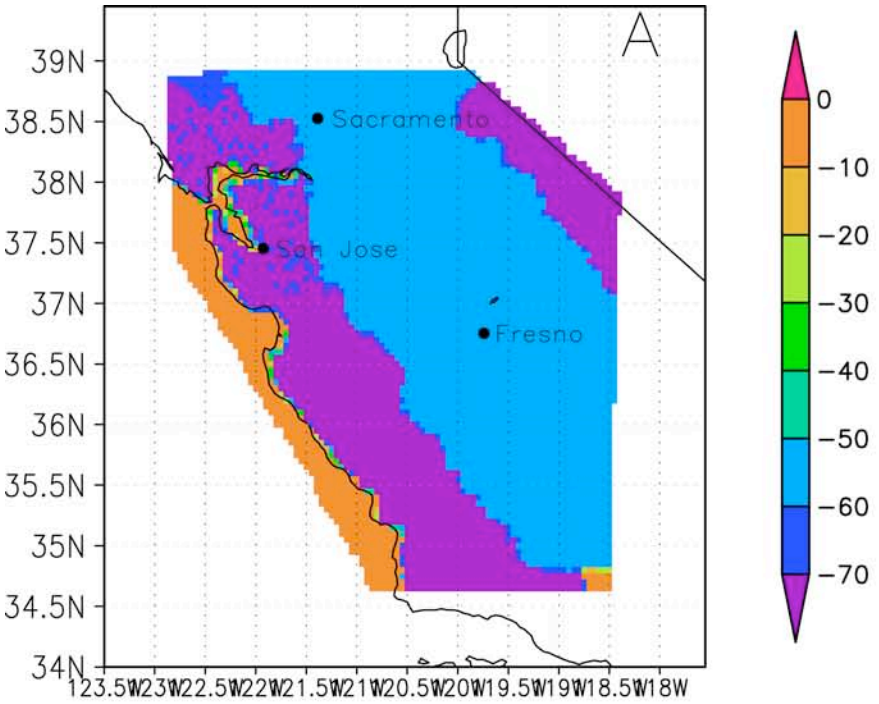


Biogenic emissions of isoprene & MBO peak at 37ºC

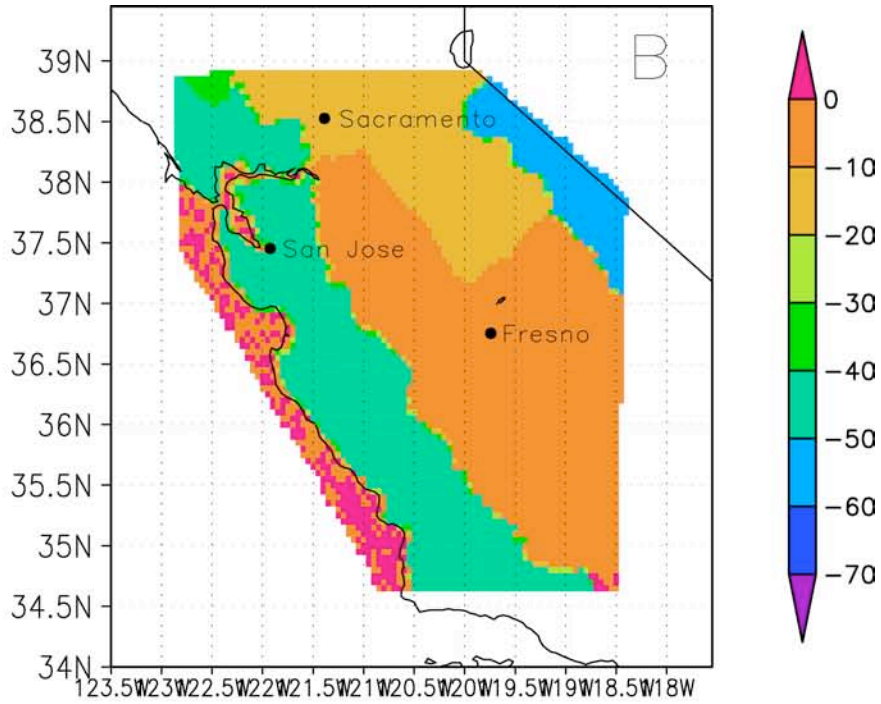
Terpene emissions increase exponentially with T

Anthropogenic Emissions: 2050

% Change in VOC & CO



% Change in NO_x



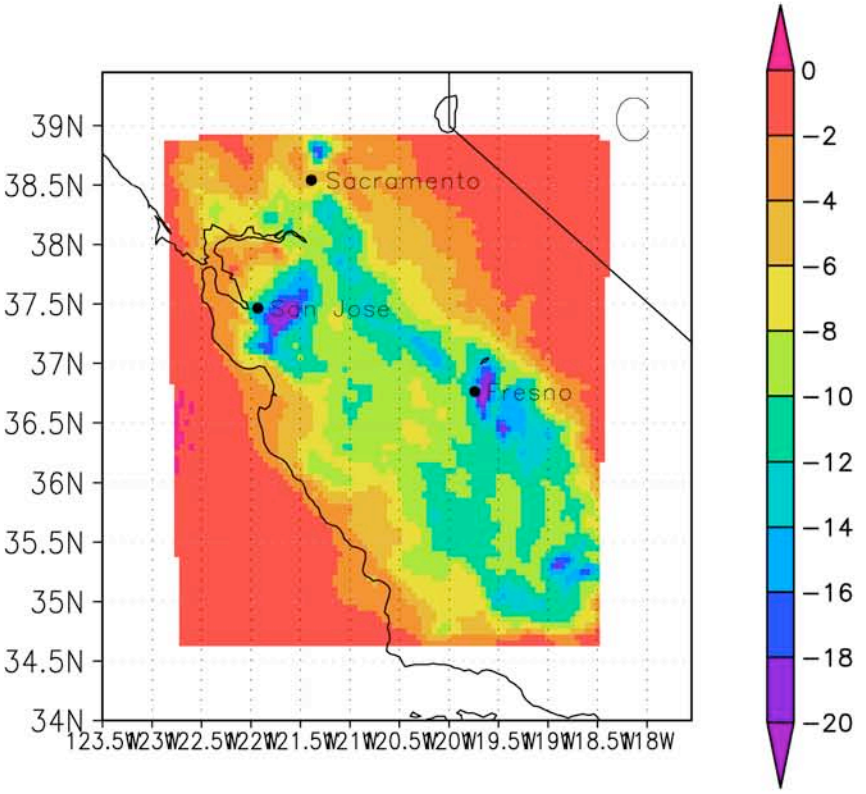
Population forecasts: faster growth in Central Valley

Growth factor for NO_x is 2× that for VOC & CO

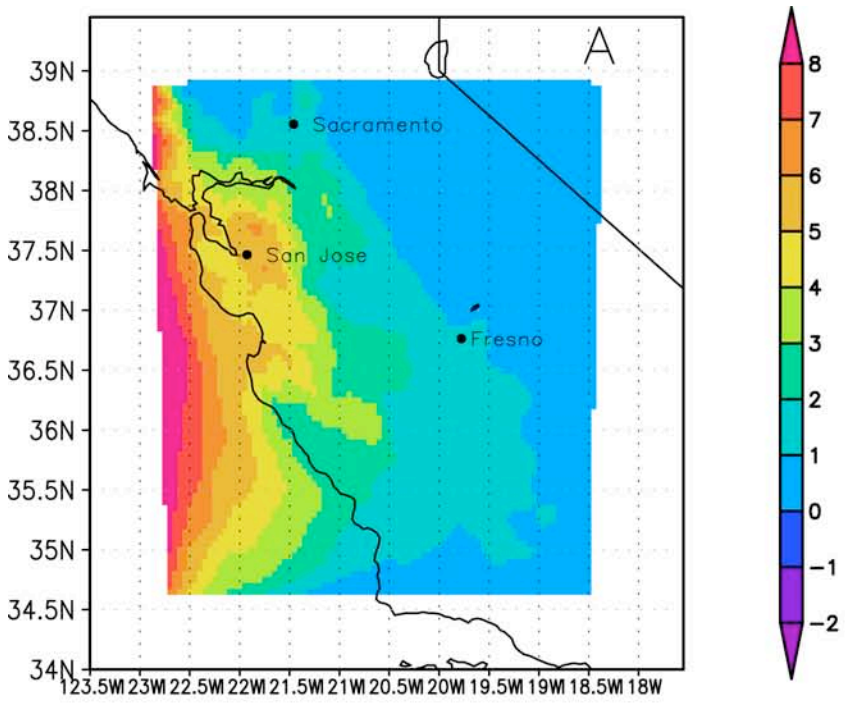
80% reduction in present-day emission factors for CO, VOC & NO_x

Future Emissions & Inflow BCs

ΔO_3 (ppb) with
2050 Emissions



ΔO_3 (ppb) with
2050 Inflow BC



CO: 80 → 104 ppb

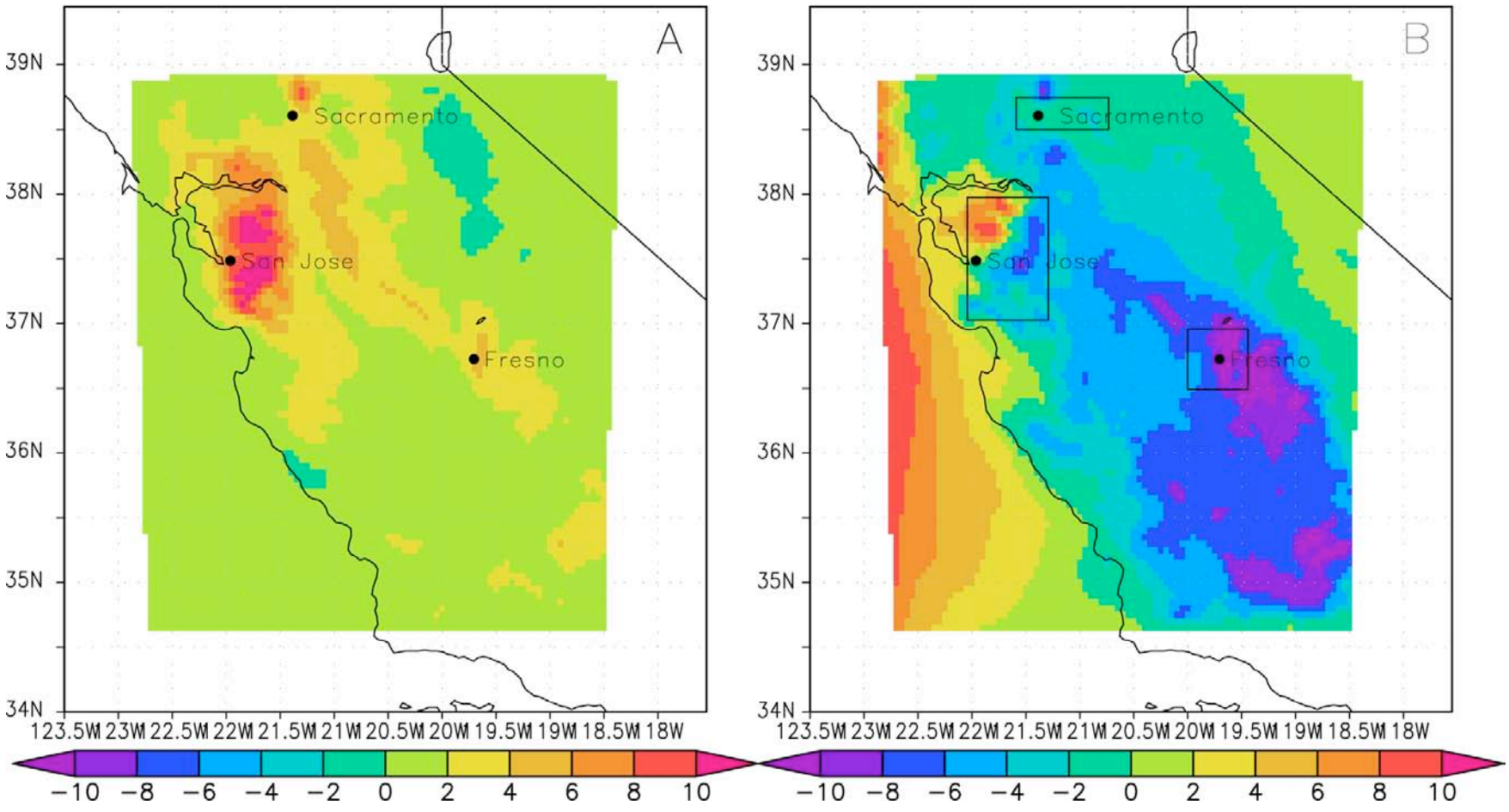
CH_4: 1.7 → 2.4 ppm

O_3: 30 → 40 ppb

Combined Simulations

Temperature Effects

ΔT + 2050 Emissions/BCs

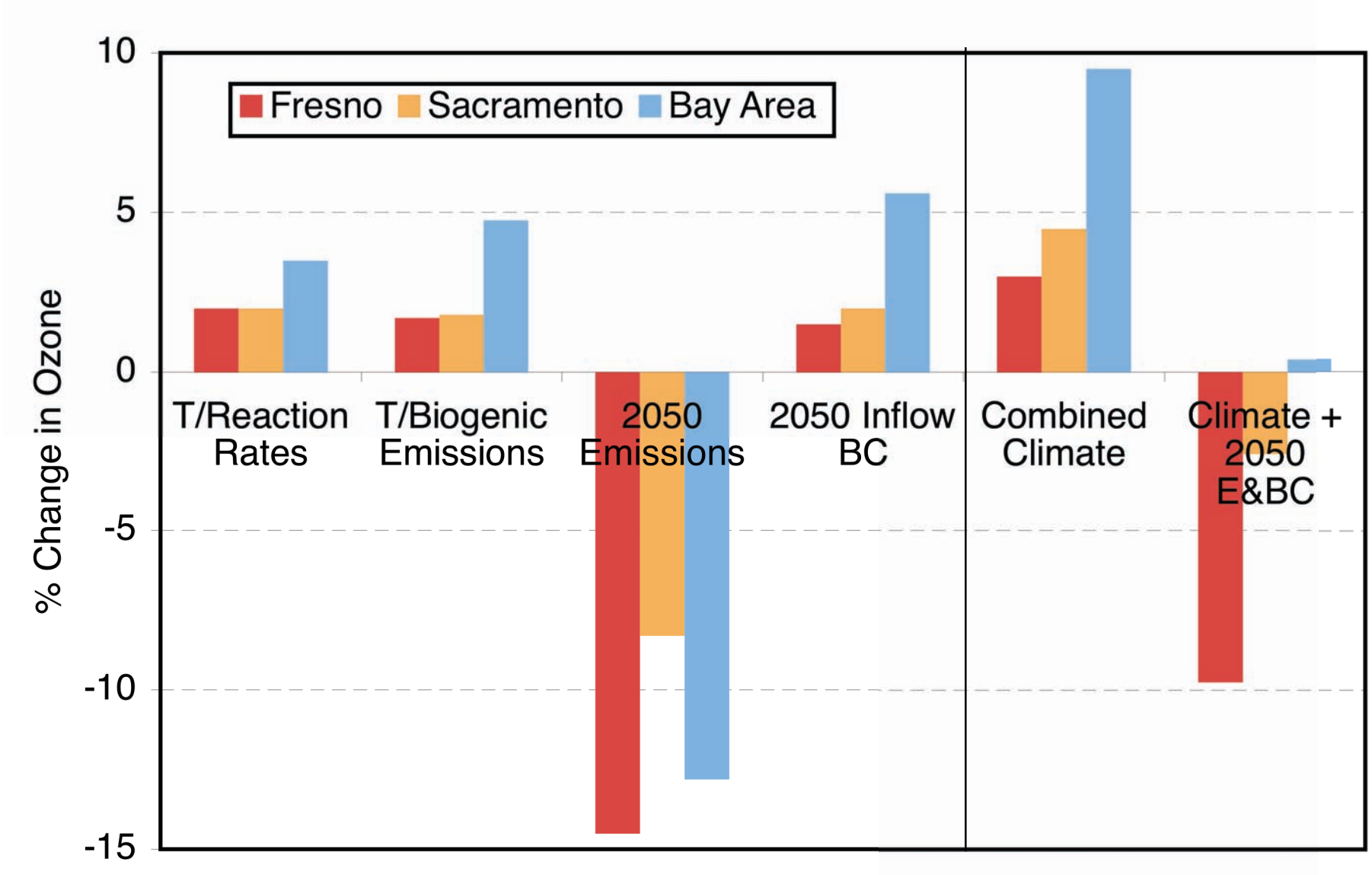


ΔO_3 (ppb)

Other Effects

- Effects on water resources (see Snyder et al.)
  - » rainfall increases up to 20% in northern California
  - » snowpack decreases ~80% by end of Feb
- Sea level rise
- Changes in forest fires
- Changes in $PM_{2.5}$ & winter season air quality
- Ecosystem and land use change
- Health effects of extreme hot weather
- Changes in frequency of O_3-conducive meteorology & length of high-O_3 season

Summary of O_3 Effects



Key References

- Snyder et al. (2002). Climate responses to a doubling of atmospheric CO_2 for a climatically vulnerable region. Appears in *Geophysical Research Letters (GRL).*
- Steiner et al. (2006). Influence of future climate and emissions on regional air quality in California. Appears in *Journal of Geophysical Research (JGR).*