Effects of Future Emissions and a Changed Climate on Urban Air Quality

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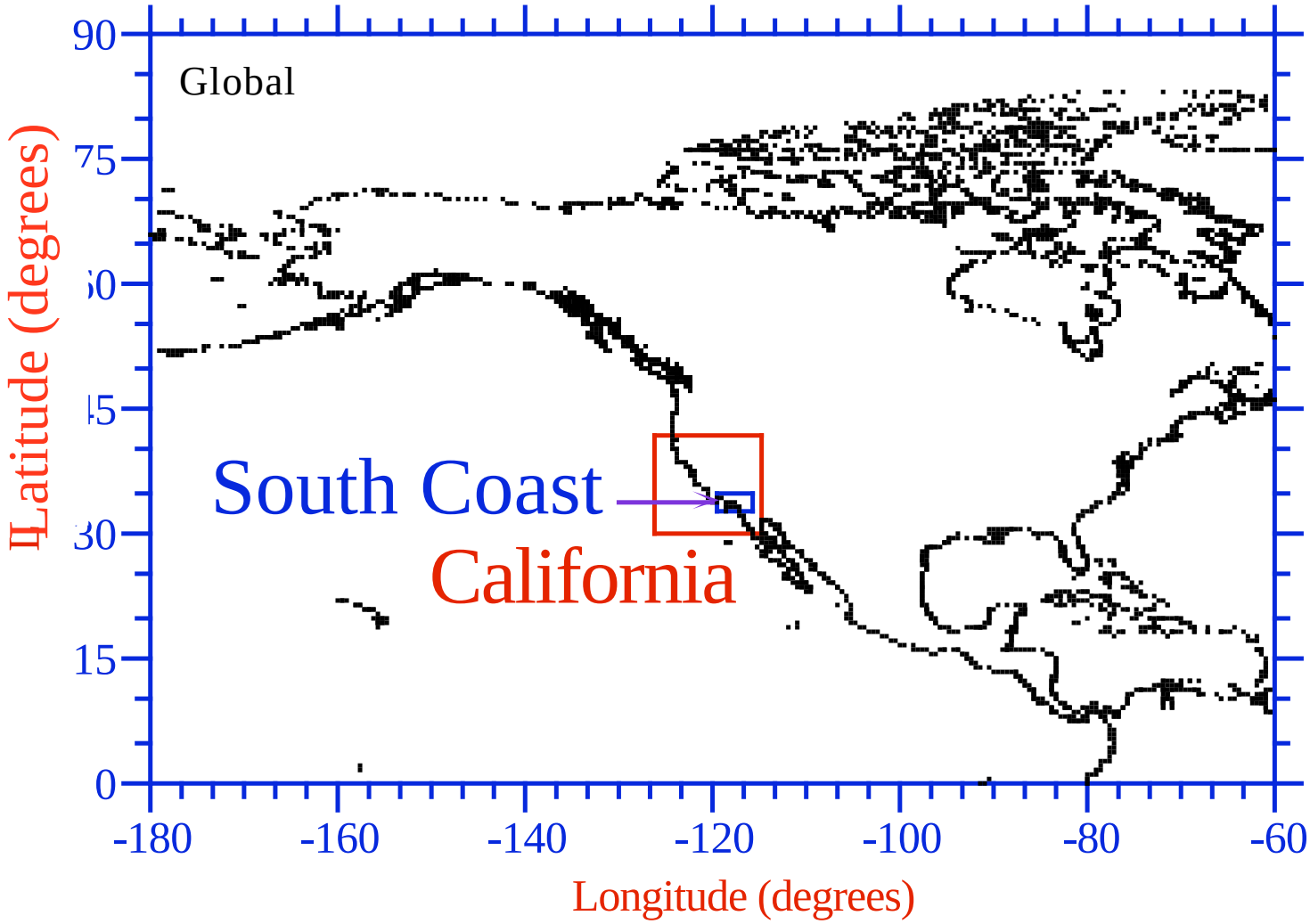
GATOR-GCMOM

Global-through-urban nesting of meteorology/gases/aerosols starting 1999-2001



GATOR-GCMOM

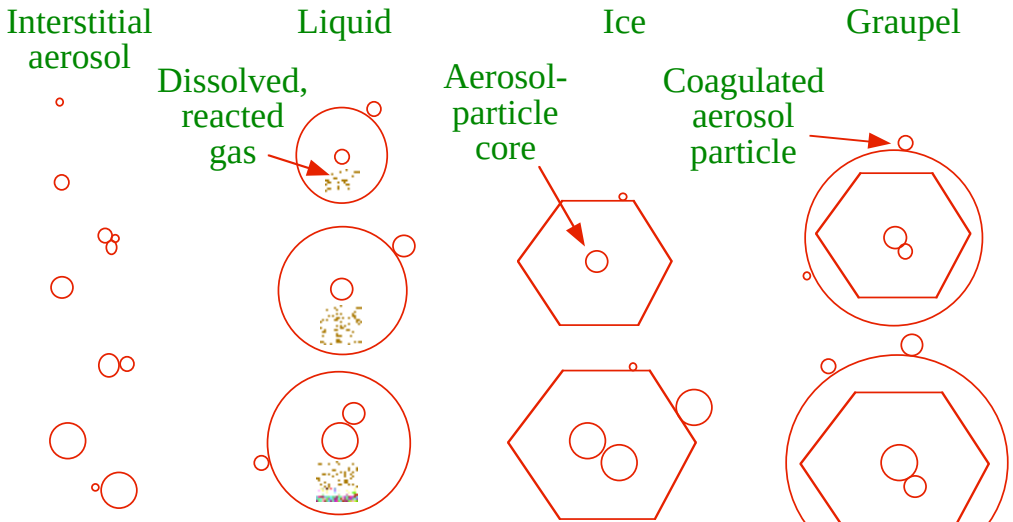
- Gas processes
  - Emission
  - Photochemistry
  - Gas-to-particle conversion
  - Cloud removal
- Aerosol processes
  - Emission
  - Nucleation/condensation
  - Gas dissolution
  - Aqueous chemistry
  - Crystallization
  - Aerosol-aerosol coagulation
  - Aerosol-cloud coagulation
  - Dry deposition
  - Sedimentation
  - Rainout/washout
- Meteorological processes
  - Pressure, winds, temp., TKE
- Cloud processes
  - Time-dependent 3-D size-res. clouds
  - Liquid/ice growth on aerosol particles
  - Liquid drop freezing/breakup
  - Hydrometeor-hydrometeor coagulation
  - Hydrometeor-aerosol coagulation
  - Precipitation, aer./gas rainout/washout
  - Below-cloud evaporation/melting
  - Lightning from collision bounceoffs
- Radiative transfer
  - UV/visible/near-IR/thermal-IR
  - Gas/aerosol/cloud scat./absorption
  - Predicted snow, ice, water albedos
- Surface processes
  - Soil, water, snow, sea ice, vegetation, road, roof temperatures/moisture
  - Ocean 2-D dynam., 3-D diffus/chem.
  - Ocean-atmosphere exchange

Cloud Microphysical and Chemical Processes

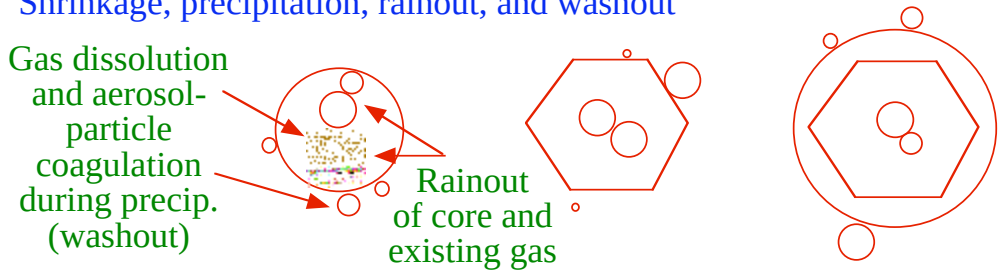
Condensation/deposition of water vapor onto aerosol particles

Coagulation: Aerosol-aerosol, Aerosol-liquid, Aerosol-ice, Aerosol-graupel, Liquid-liquid, Liquid-ice, Liquid-graupel, Ice-ice, Ice-graupel, Graupel-graupel

Gas dissolution. aqueous chemistry, hom.-het. freezing, contact freezing



Shrinkage, precipitation, rainout, and washout



Cloud evaporation --> interstitial aerosol plus evaporated cores

Natural Emissions Treated

Lightning NO, N_2O
Sea spray constituents
Ocean bacteria
DMS from phytoplankton
Soil dust
Biogenic gases from vegetation (isoprene, monoterpenes, NMVOC)
NO_x from soils
Pollen
Spores
Land bacteria
Natural fire gas and particle emissions
Volcanic emissions

Lightning NO, N_2O Emissions

$$\frac{dQ_{b,m}}{dt} = \left[\sum_{J=1}^{N_H} \sum_{j=1}^{N_C} \sum_{I=J}^{N_H} \sum_{i=j}^{N_C} B_{Ii,Jj} \frac{\left(\upsilon_{Ii} n_{Ii,t} n_{Jj,t-h} + \upsilon_{Jj} n_{Ii,t-h} n_{Jj,t} \right)}{\upsilon_{Ii} + \upsilon_{Jj}} \Delta Q_{Ii,Jj} \right]_m$$

Charge separation per unit volume of air in model layer

N_H = number of hydrometeor distributions

N_C = number of size bins in each hydrometeor distribution

n = number concentration of hydrometeor particles

υ = single-particle volume

B = bounceoff kernel

ΔQ = charge separation per bounceoff

Pollen, Spore, Bacteria Emissions

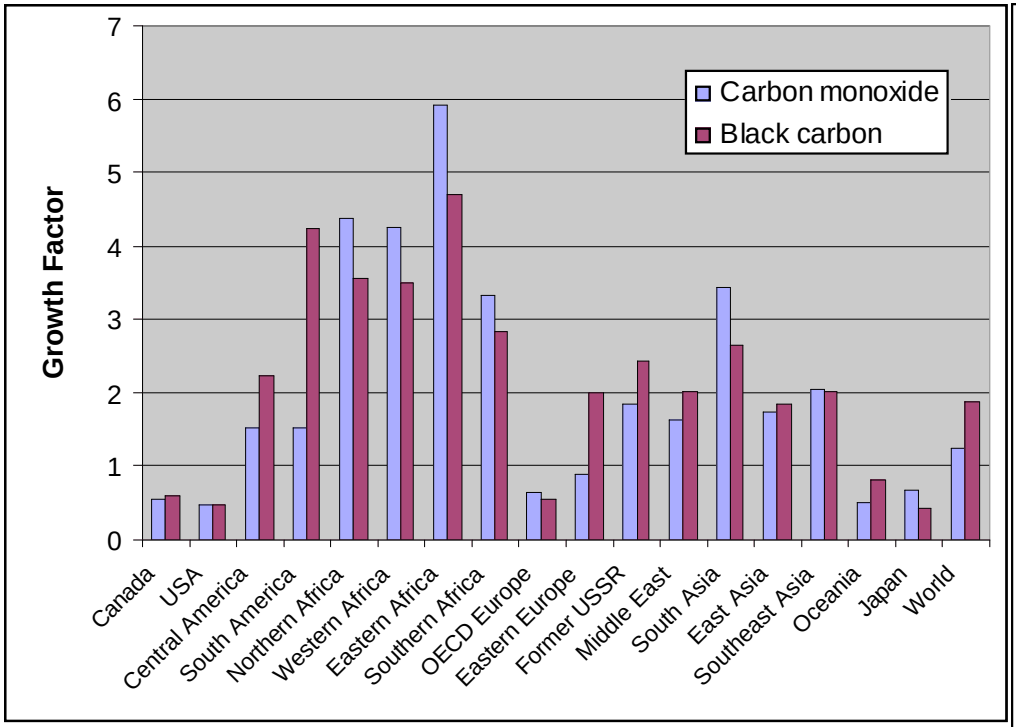
$$E_{po,i} = E_{po,\max} R_{TKE} R_{h,po} R_{m,po} R_{n,i,po} \sum_{j=1}^{N_s} L_{T,j} f_{v,j}$$

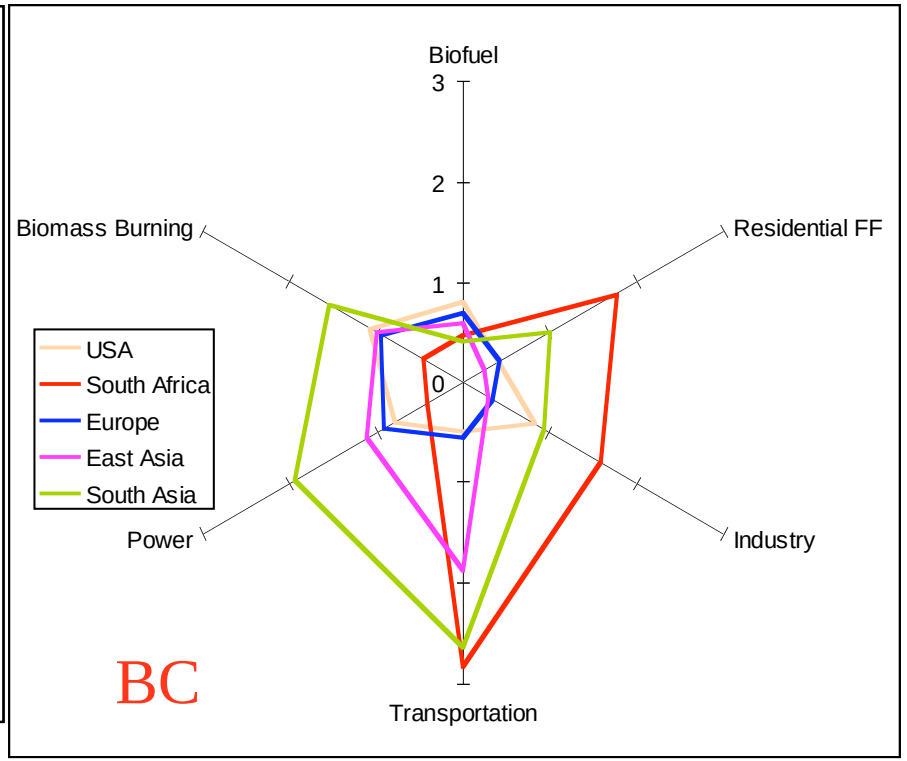
$$E_{sp,i} = E_{sp,\max} R_{TKE} R_{RH} R_{m,sp} R_{n,i,sp} \sum_{j=1}^{N_s} L_{T,j} f_{v,j}$$

$$E_{lb,i} = E_{lb,\max} R_{TKE} R_{m,lb} R_{n,i,lb} \sum_{j=1}^{N_s} f_{v,j}$$

R_{TKE} = TKE-dependent emission factor
R_{RH} = RH-dependent emission factor
R_h = hour of day-dependent emission factor
R_m = month-dependent emission factor
R_n = size-dependent emission factor
N_s = number of soil types in each grid cell
L_T, f_v = one-sided leaf-area index, vegetation fraction

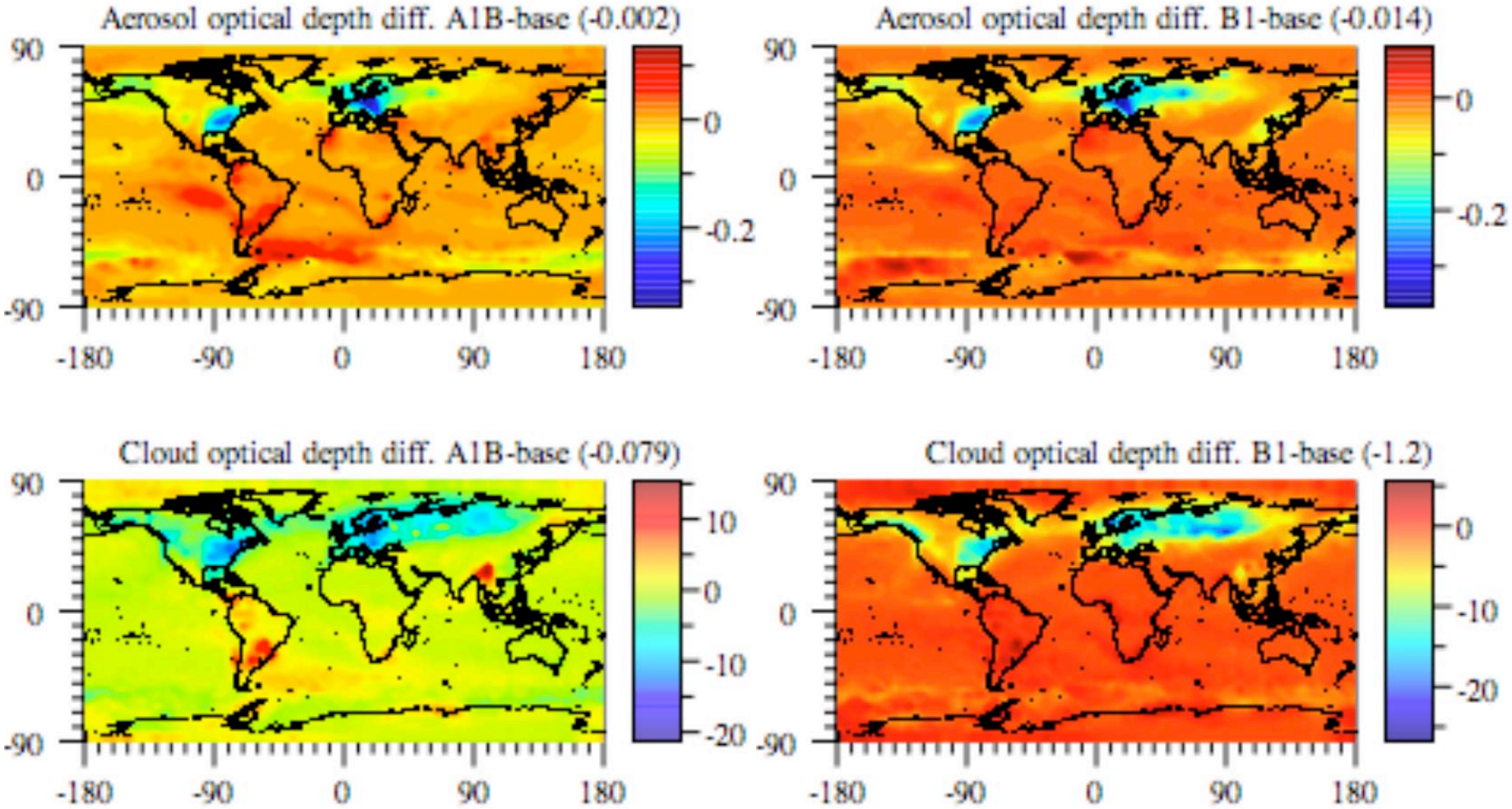
2030 A1B CO/BC Growth Factors





D.G. Streets

Differences 2002-2030
Under A1B and B1 Scenarios



Differences 2002-2030
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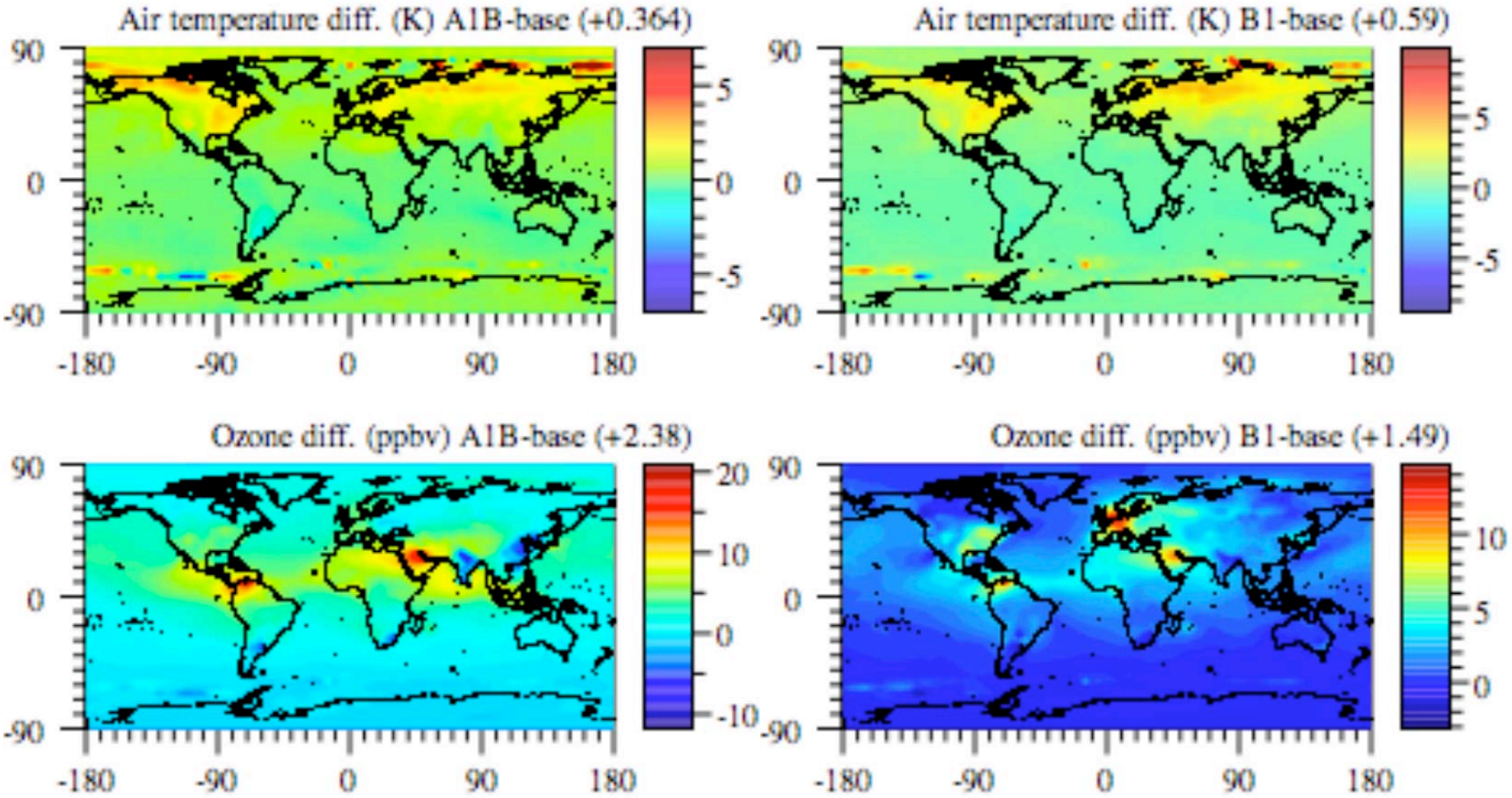
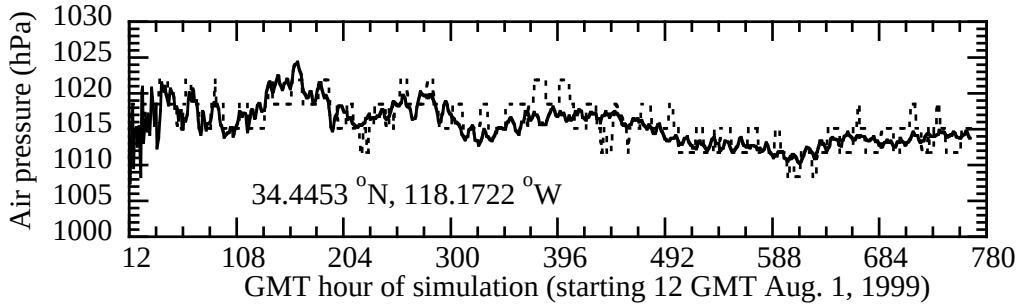


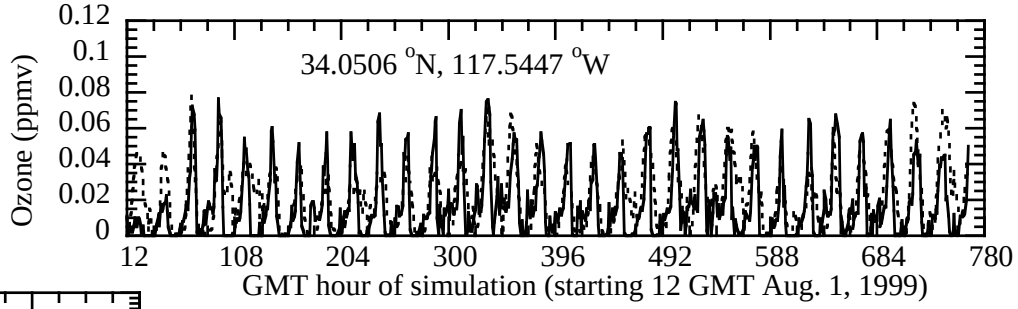
30-Day Weather Predictions vs. Data

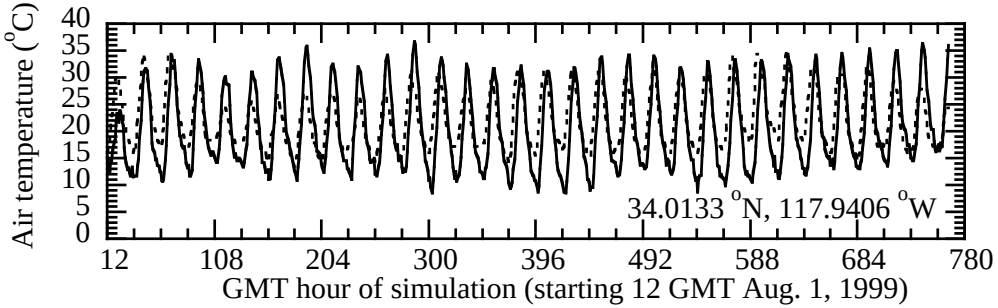
Results with no model spinup or data assimilation



Pressure

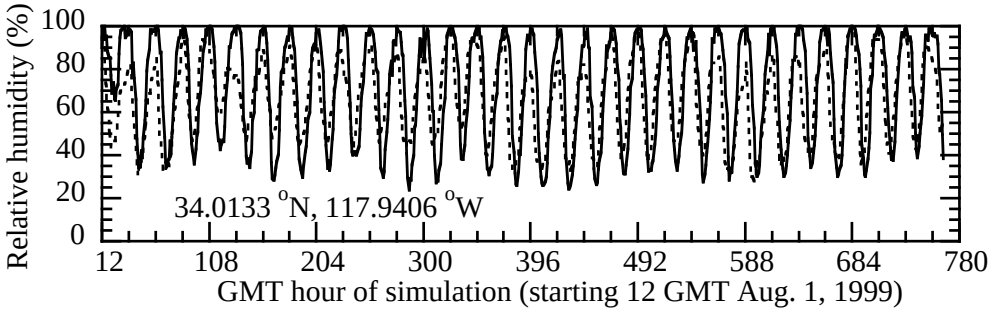
Ozone





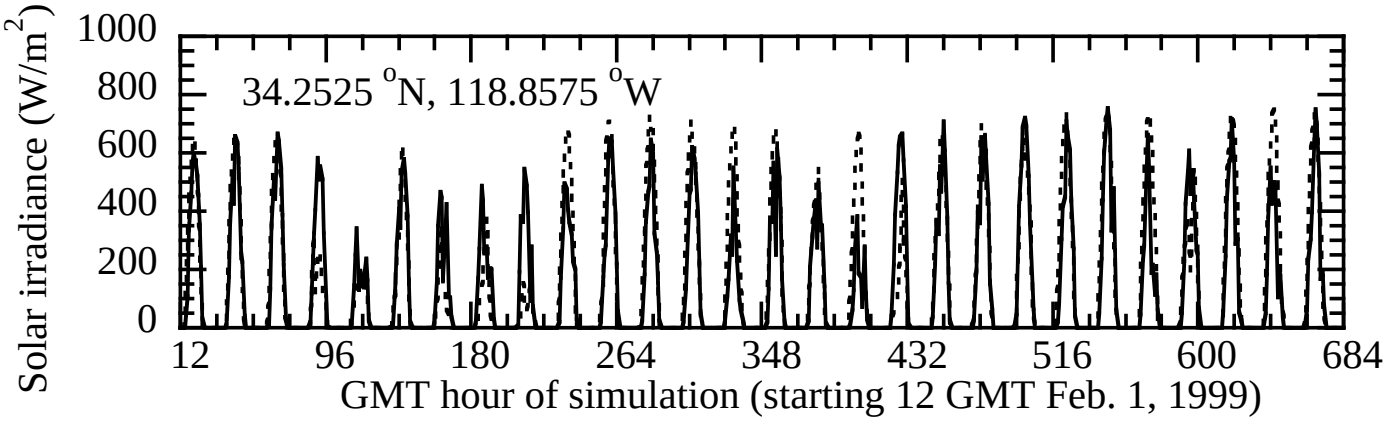
Temperature

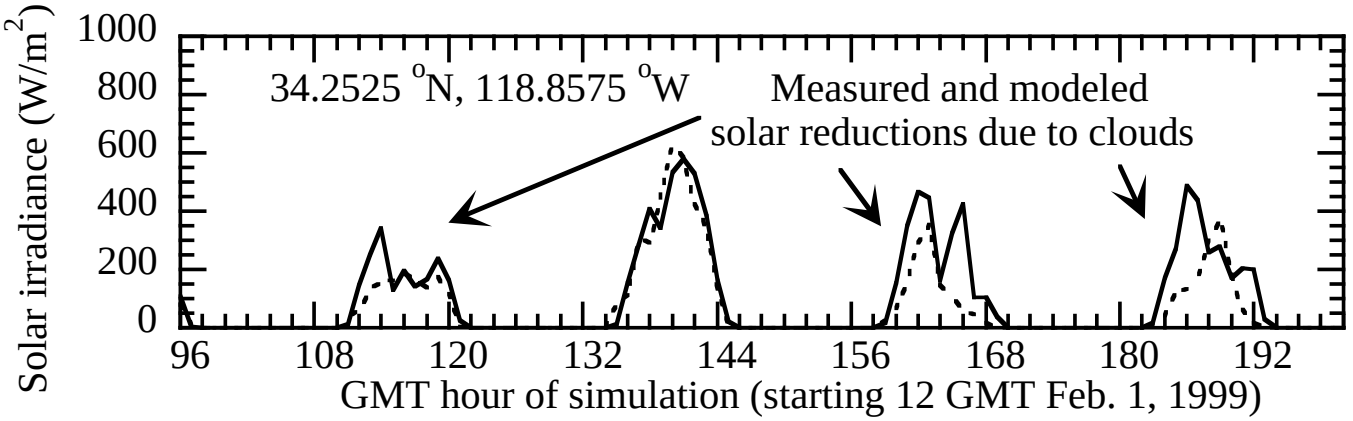
RH



Model vs. Measured Solar Radiation

Model predicted the location and magnitude of cloud reduction of sunlight for four days in a row

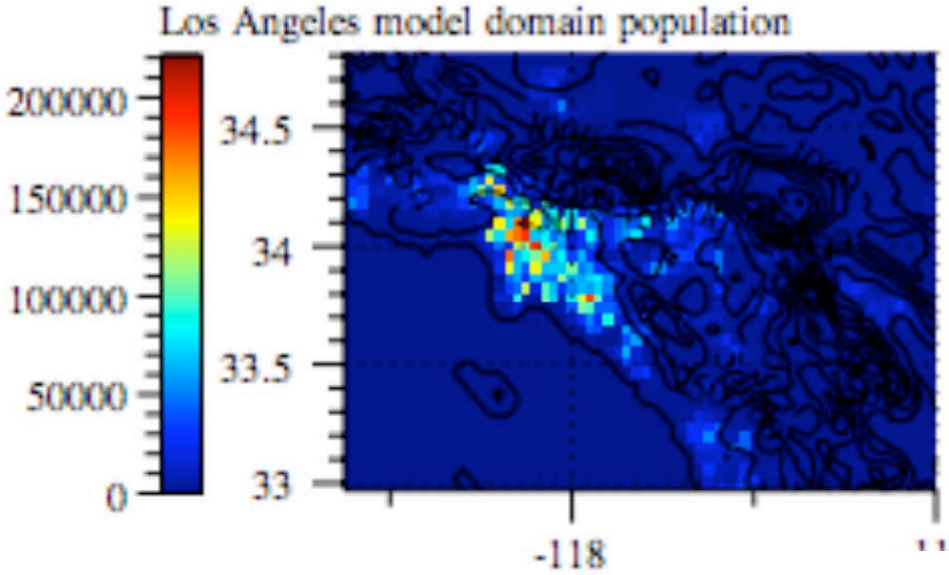


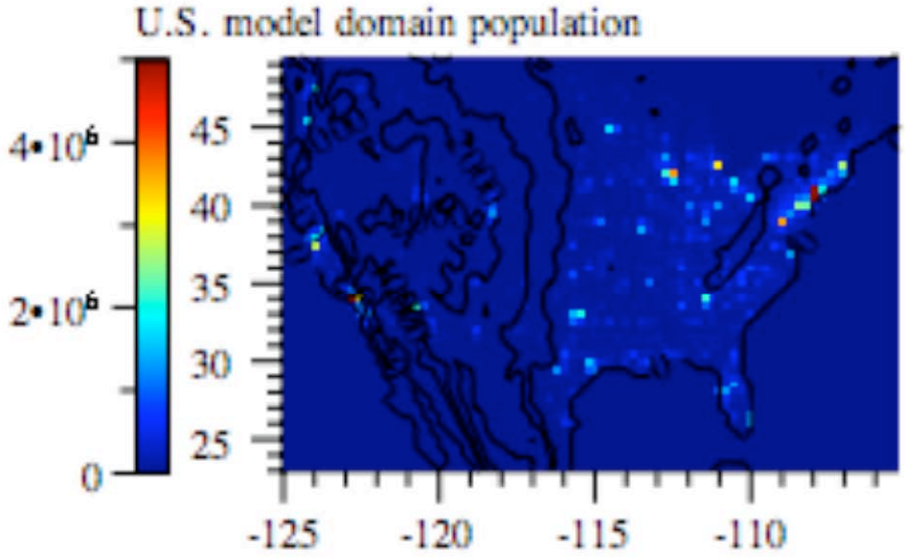


Emission Differences E85:Gas From Field/Laboratory Data

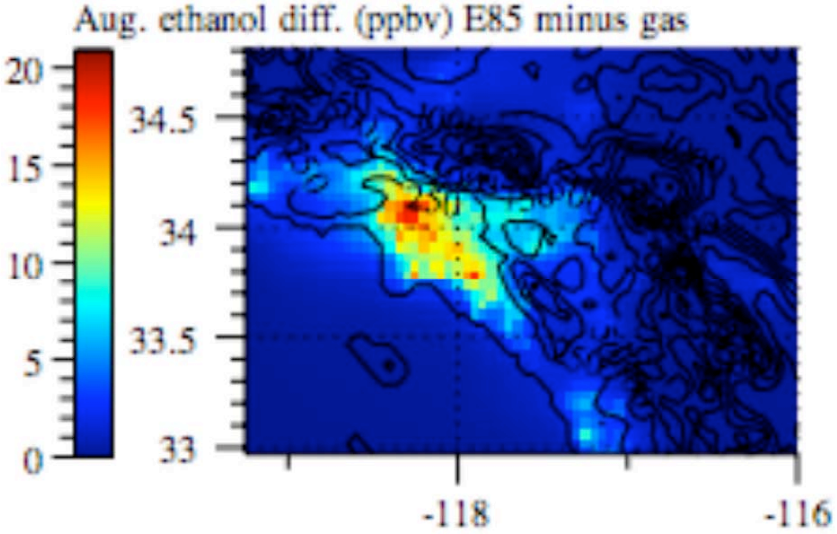
	Percent change
Oxides of nitrogen	-30 (-59 to +33)
Carbon monoxide	+5 (-33 to +320)
Total organic gas	+22 (+38 to +95)
Methane	+43 (+43 to +340)
Nonmethane organic gas	+43 (0 to +63)
Formaldehyde	+60 (+7 to +240)
Acetaldehyde	+2000 (+1250 to +4340)
1,3-butadiene	-10 (0 to -13)
Benzene	-79 (-62 to -85)
PM number	0 (+100)
PM mass	0 (+31)

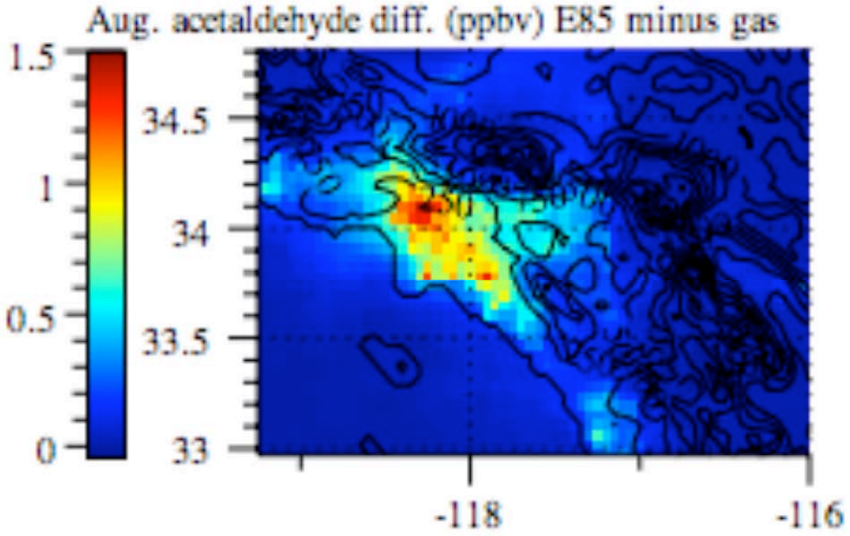
Los Angeles / U.S. Population Distributions



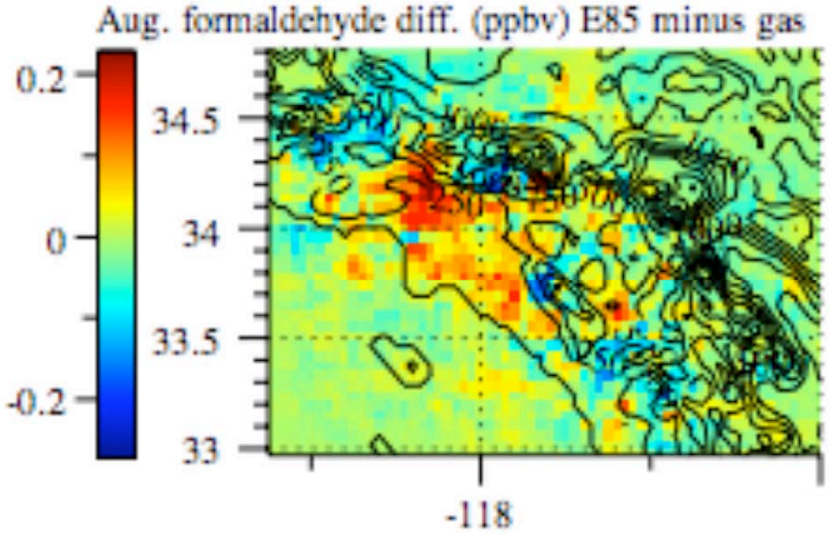


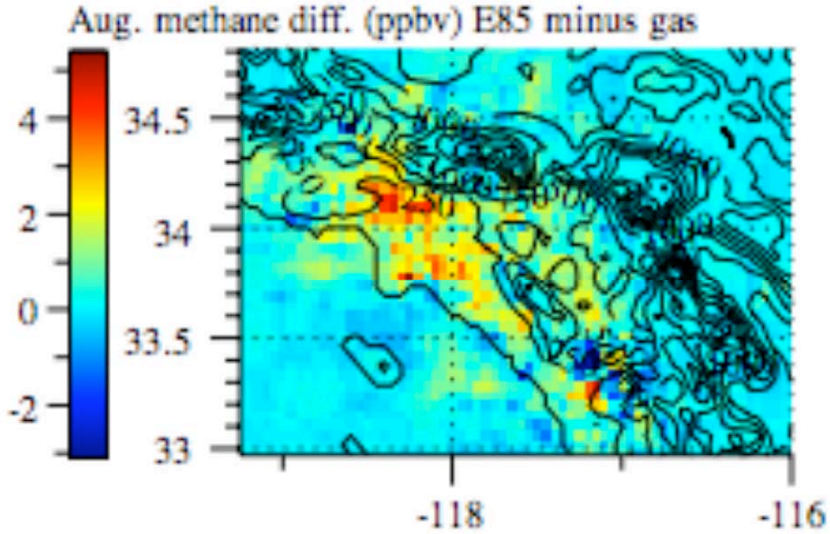
Effect in 2020 of E85 vs. Gasoline on Ethanol and Acetaldehyde



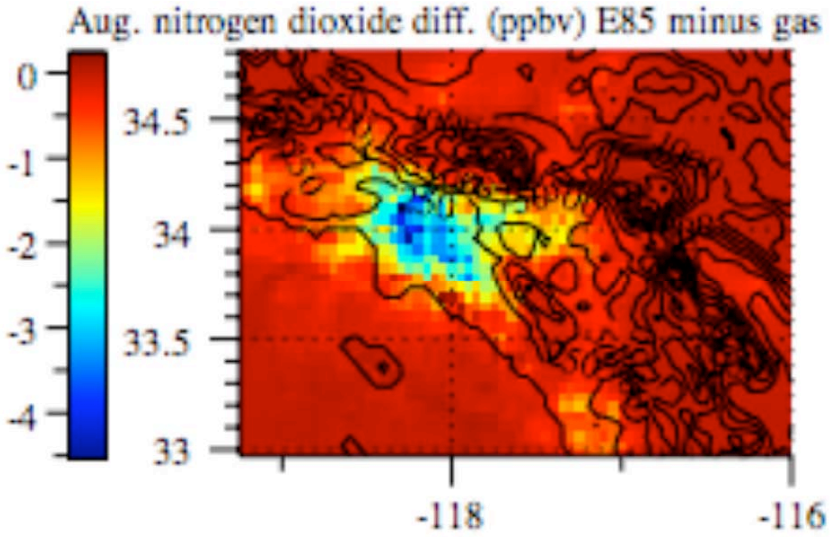


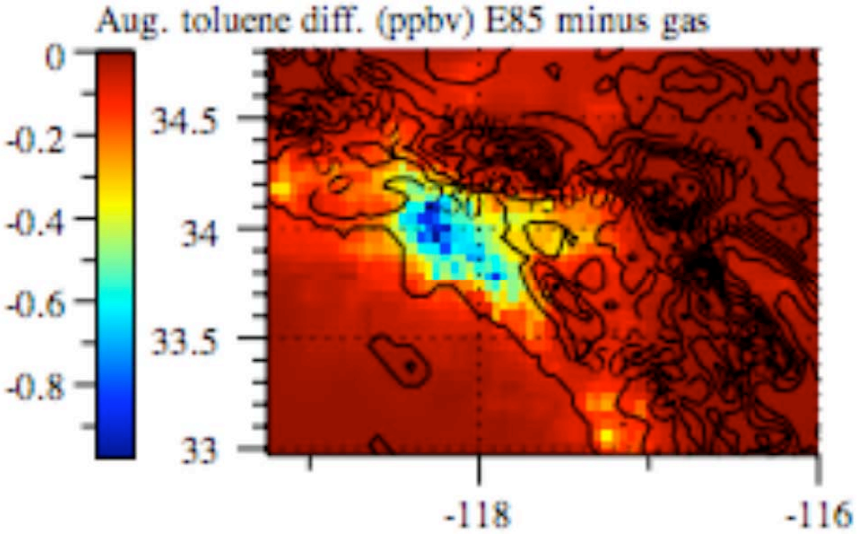
Effect in 2020 of E85 vs. Gasoline on Formaldehyde and Methane



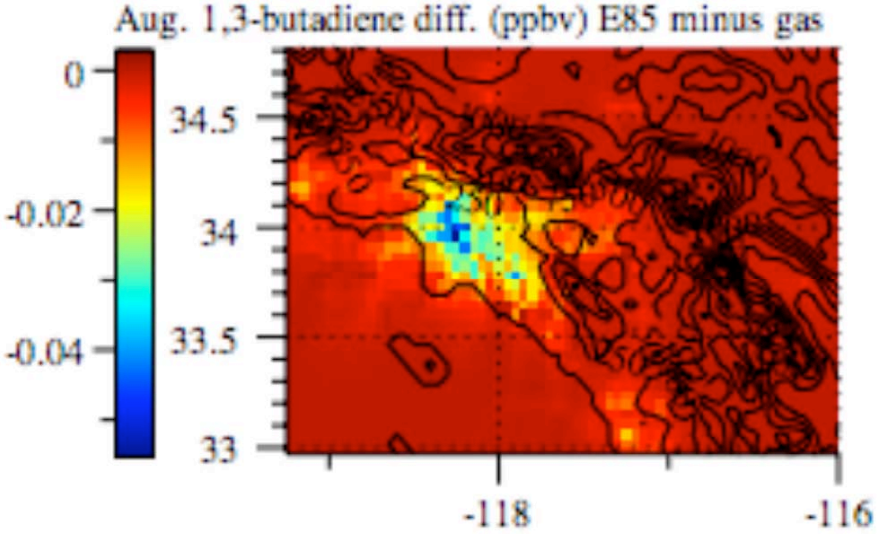


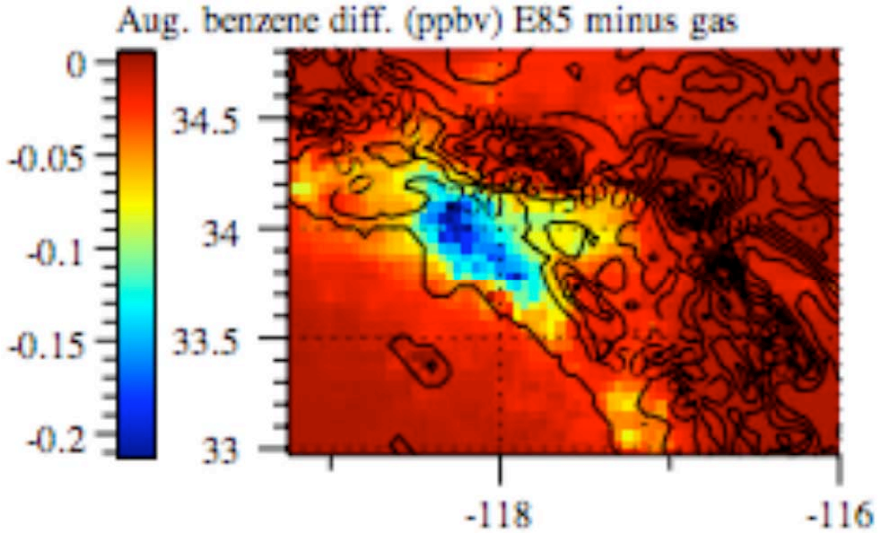
Effect in 2020 of E85 vs. Gasoline on Nitrogen Dioxide and Toluene



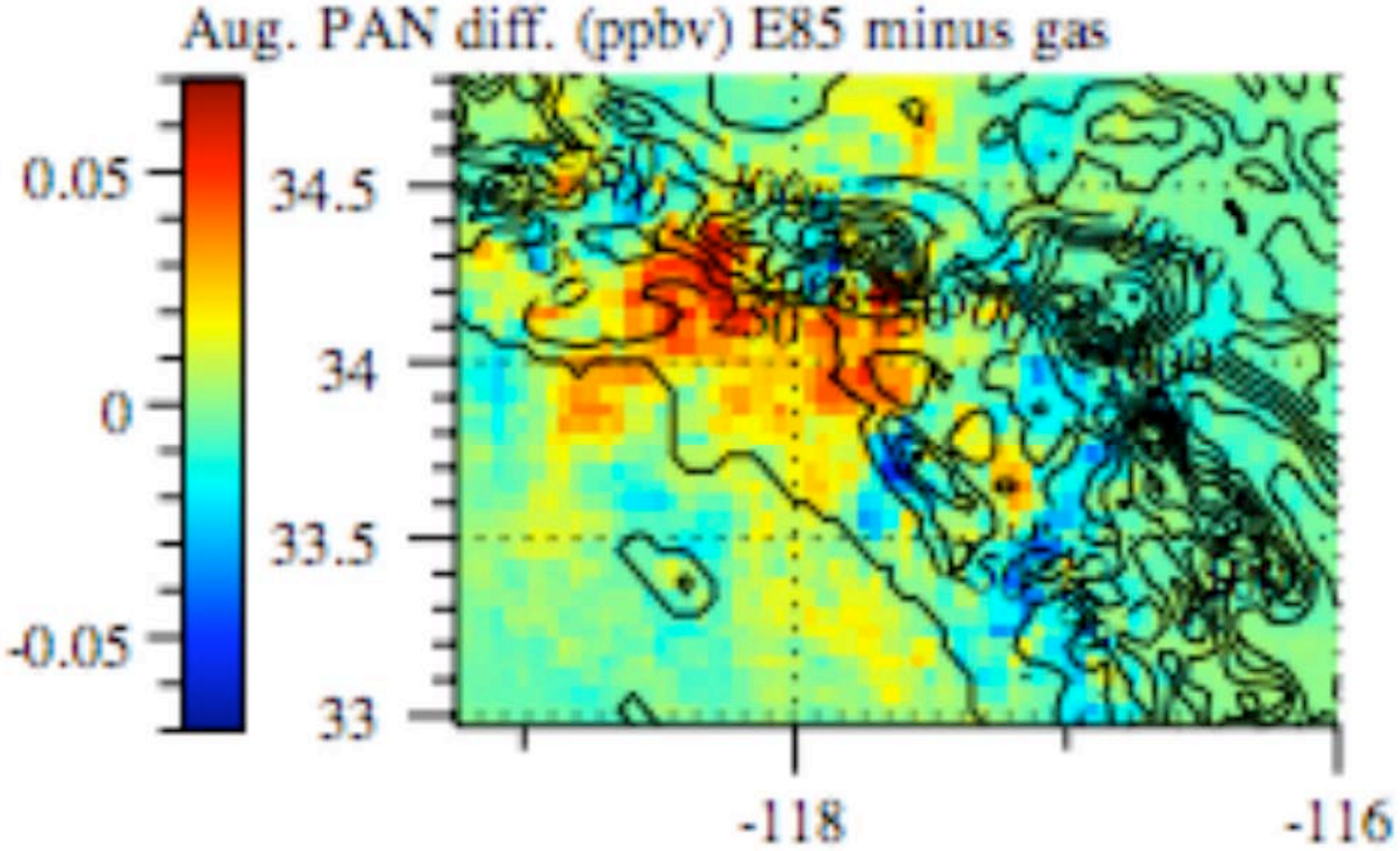


Effect in 2020 of E85 vs. Gasoline on 1,3-Butadiene and Benzene

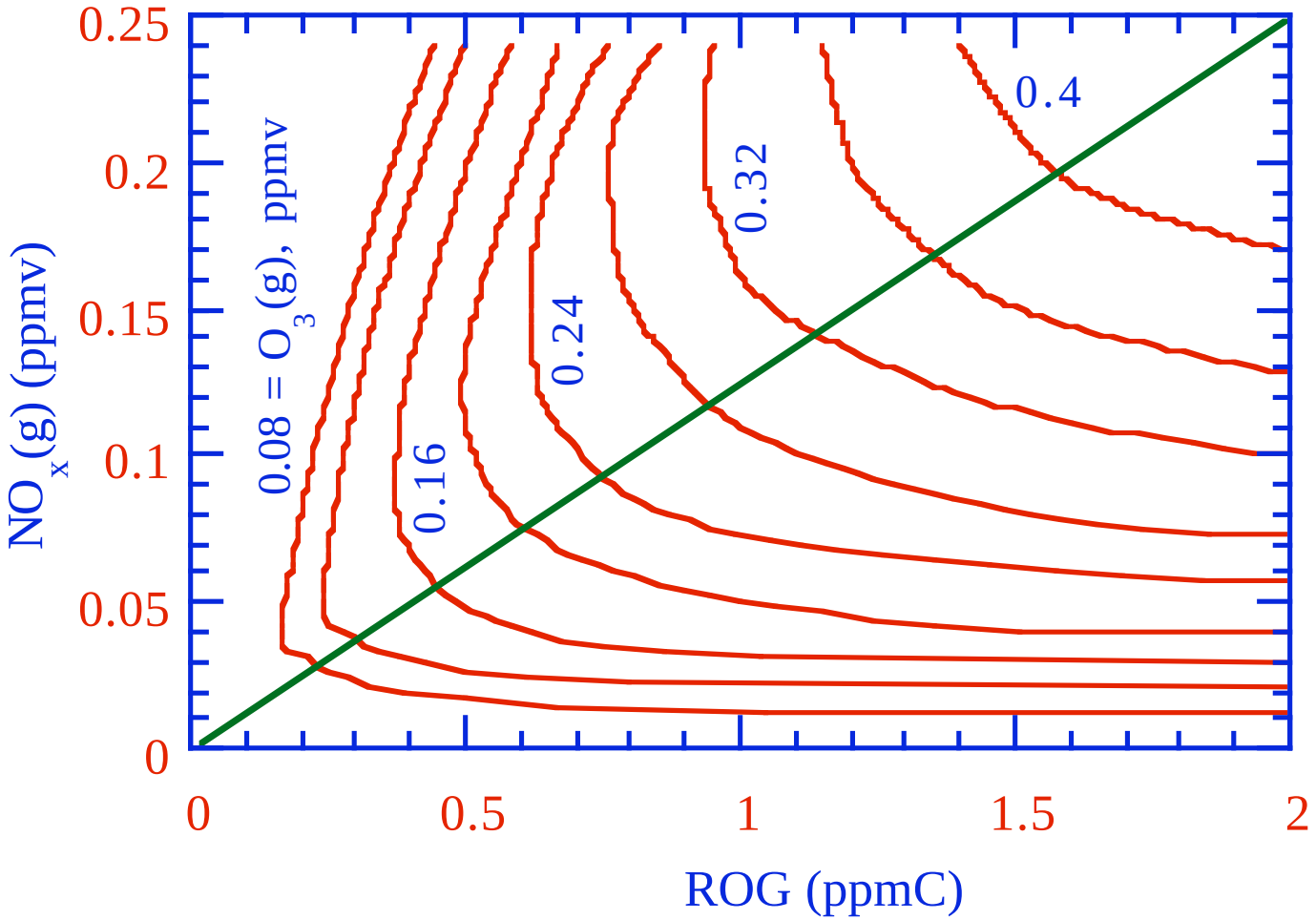




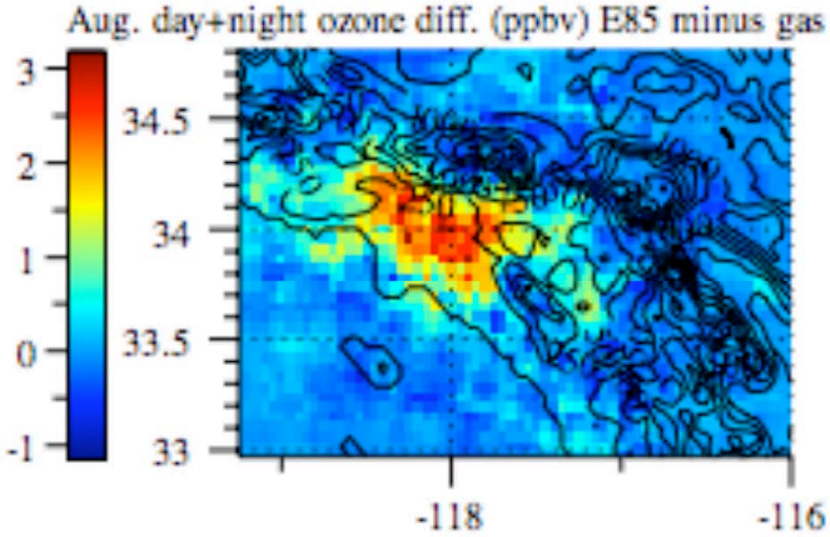
Effect in 2020 of E85 vs. Gasoline on PAN



Ozone isopleth



Effect in 2020 of E85 vs. Gasoline on Ozone and Health



Δ Pop-weighted ozone ≥ 35 ppbv E85 minus gas:	+1.33 ppbv
Δ Ozone deaths/yr:	+120 (+9%)
Δ Ozone hospitalizations/yr respiratory illness:	+650
Δ Ozone-emergency-room visits/yr for asthma:	+770
Δ Cancer/yr USEPA CUREs - for carcinogens:	+0.3
Δ Cancer/yr OEHHA CUREs - for carcinogens:	-3.5

Work for Project

Develop 50-year emission factors for A1B and B1 scenarios.

Develop 50-year emission factors for E85, plug-in-hybrid, wind-hydrogen fuel cell scenarios.

Simulate climate and emission changes and their feedback to air quality in Los Angeles, the Central Valley, and Atlanta over 50-year period.

Quantify the effects of climate change on natural emissions in the same scenarios.