Effects of GHG mitigation on California Climate

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Background

•California is in the top 10 largest economy of the world.

•Committed to reduce greenhouse gas (GHG) emissions by 80% relative to 1990 levels by the year 2050.

•Require adoption of low-carbon energy sources across all economic sectors

•Many previous attempts to characterize the impact of climate policies on climate.

•These previous studies have also usually performed calculations for large geographic areas without resolving details at regional scales appropriate for California.

•What effect will California's GHG mitigation policies have on California's regional climate?

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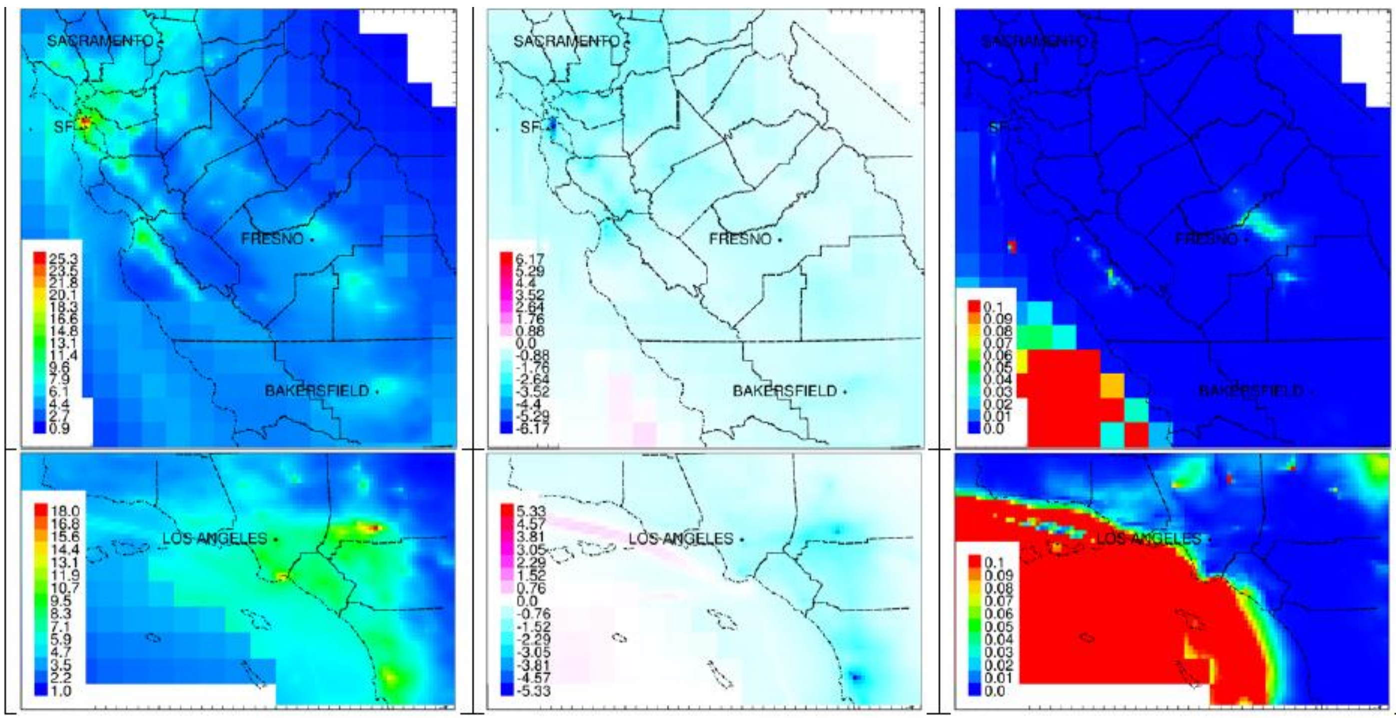
Health Effects Background: 2054 Annual Avg. PM2.5 (μg m^{-3})

BAU | GHGAi-BAU | P-value



Source: 2018 C.B. Zapata, C. Yang, S. Yeh, J. Ogden, M.J. Kleeman. Low Carbon Energy Generates Health Savings in California. Atmospheric Chemistry and Physics, 18, 4817-4830.

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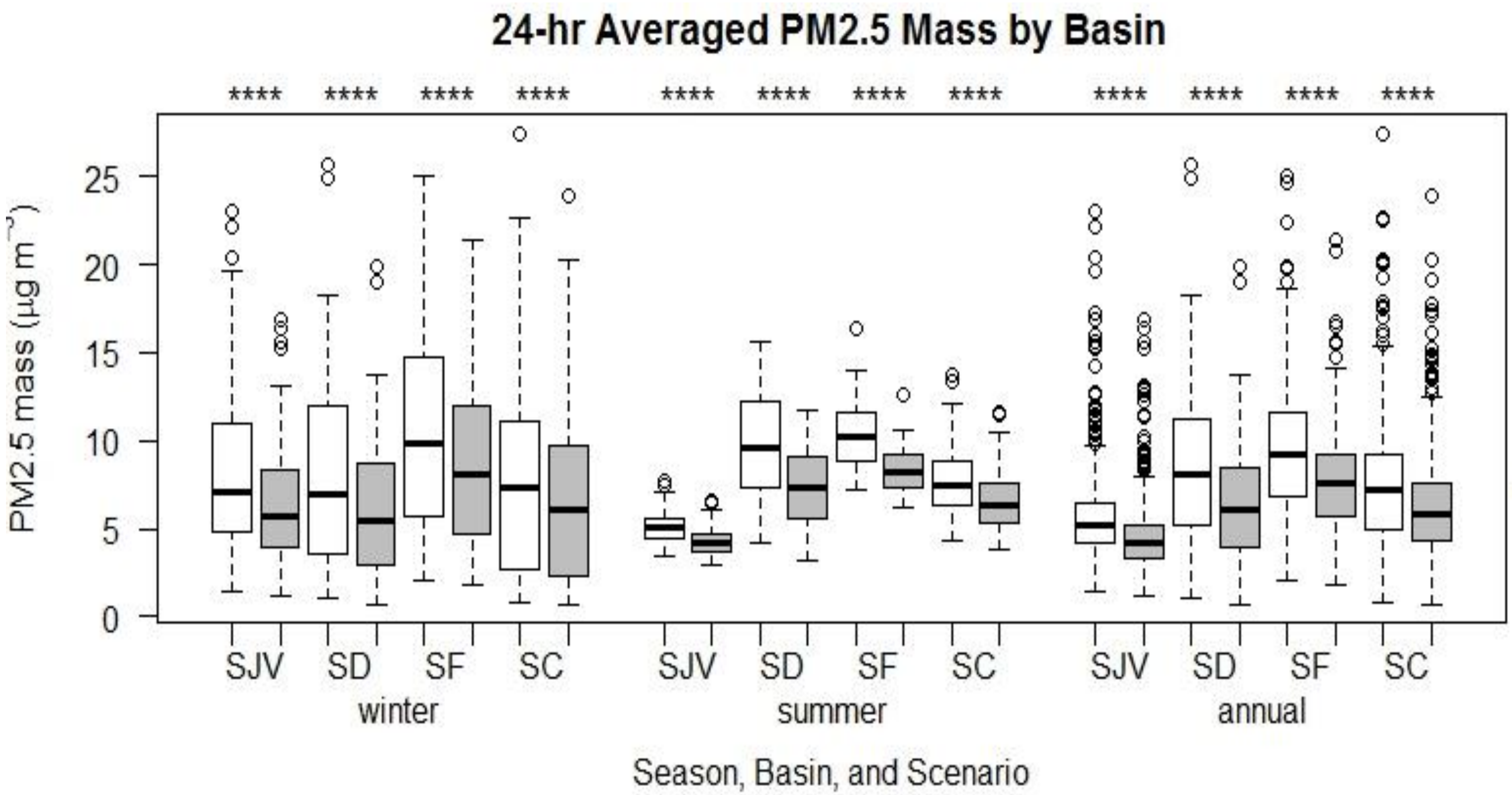
Health Effects Background: Population Weighted PM2.5 Concentrations



Source: 2018 C.B. Zapata, C. Yang, S. Yeh, J. Ogden, M.J. Kleeman. Low Carbon Energy Generates Health Savings in California. Atmospheric Chemistry and Physics, 18, 4817-4830.

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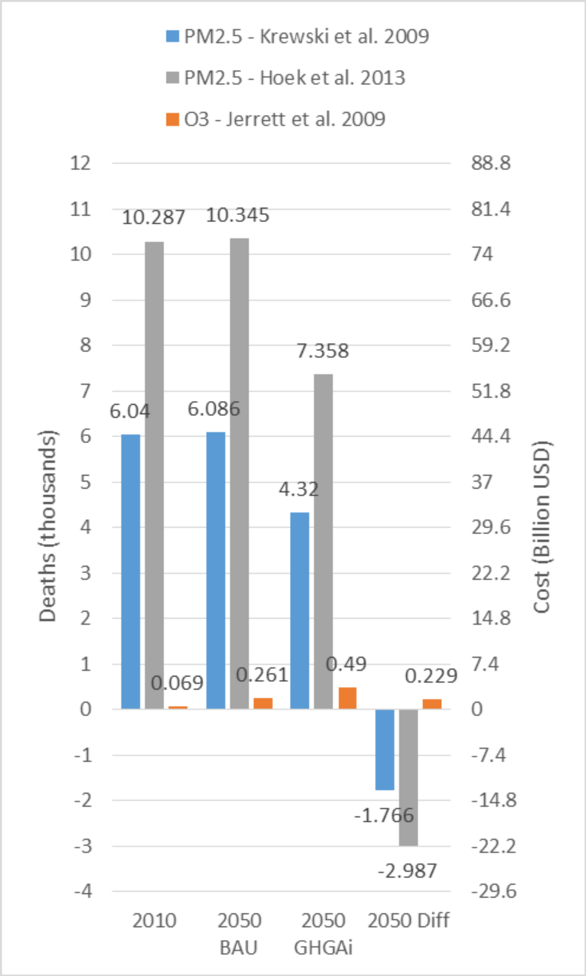
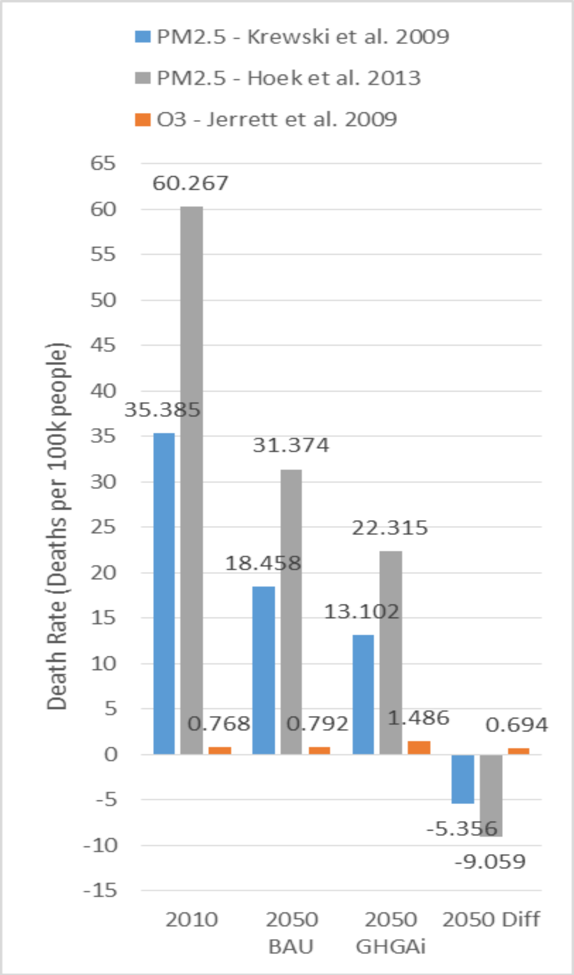
Health Effects Background

Death and Cost



Death Rate



Source: 2018 C.B. Zapata, C. Yang, S. Yeh, J. Ogden, M.J. Kleeman. Low Carbon Energy Generates Health Savings in California. Atmospheric Chemistry and Physics, 18, 4817-4830.

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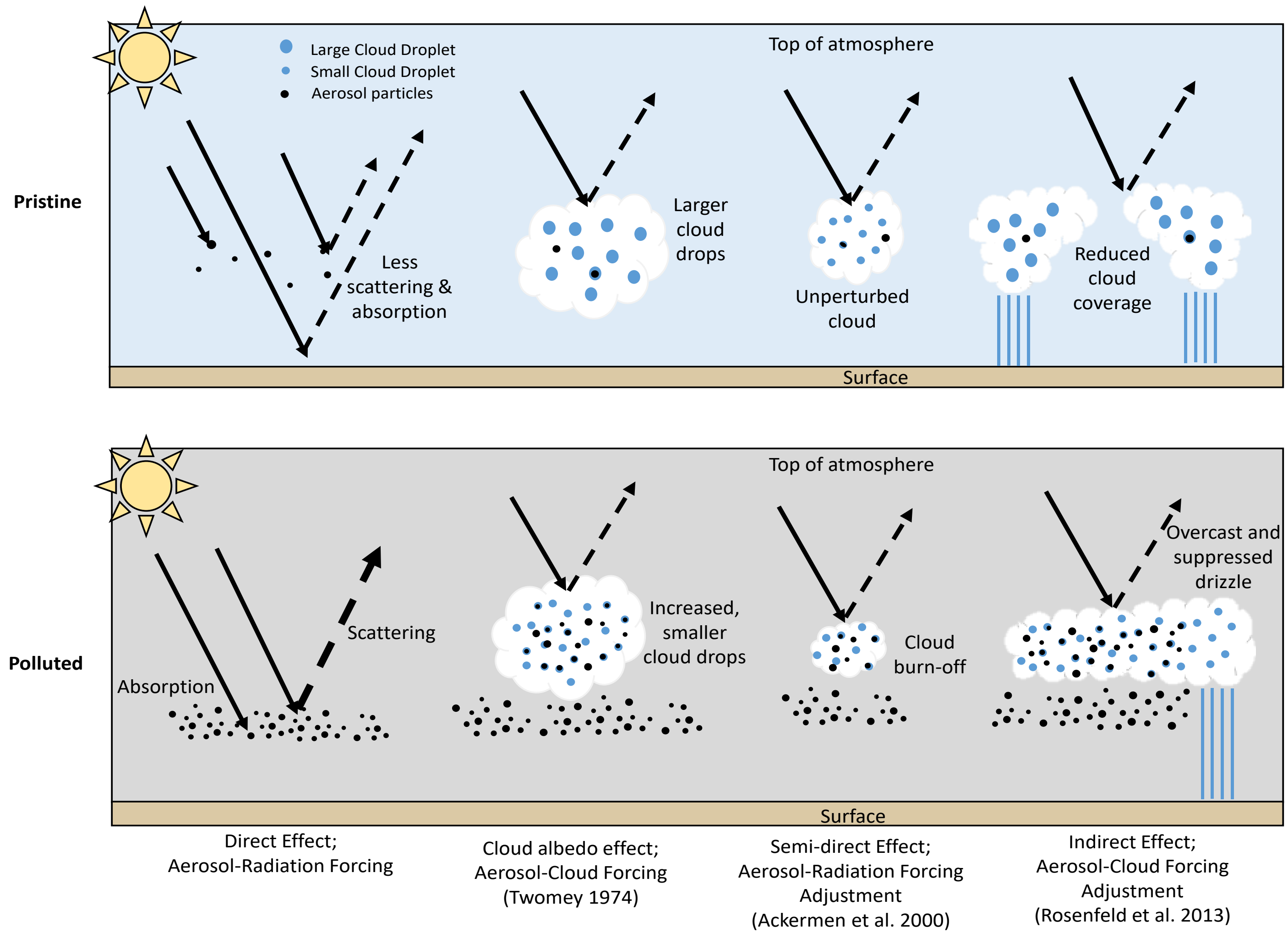
Climate Objective

- Examine the effect of GHG mitigation strategies on <u>airborne PM concentrations</u> and climate over California at the <u>regional scale</u>



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Climate Methodology

•The source-oriented WRF/Chem (SOWC) model is used to track a six dimensional aerosol variable (*X, Z, Y,* Size bin, Source type, Species) through explicit simulations of atmospheric chemistry and physics.

•Goddard Space Flight Center (GSFC) scheme for shortwave radiation and a comparable GSFC longwave radiation module

•The SOWC model is applied for one year from Jan, 2054 to Dec, 2054 with 12 km resolution over California.

Initial and boundary conditions

- meteorological initial and boundary conditions
    - CESM with RCP8.5 scenario
- chemical species
    - MOZART.

Emissions

- Future emission scenario using CATIMES
- MEGAN 2.1 Biogenic emissions

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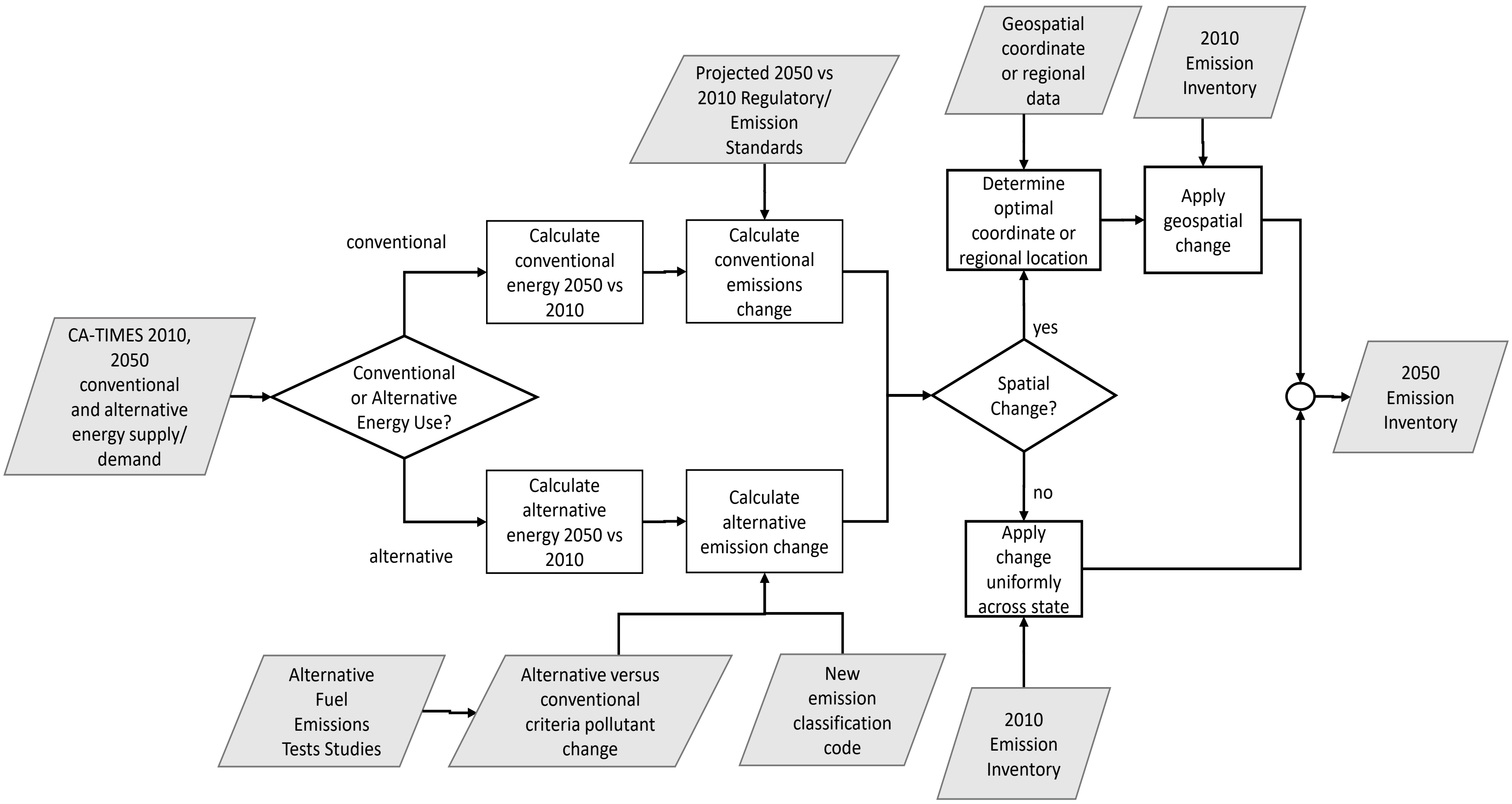
Criteria Pollutant Emissions Estimation Process



Source: 2018 C.B. Zapata, C. Yang, S. Yeh, J. Ogden, M.J. Kleeman. Estimating criteria pollutants using the California Regional Multisector Air Quality Emissions (CA-REMARQUE) model. Geoscientific Model Development, 11, 1293-1320.

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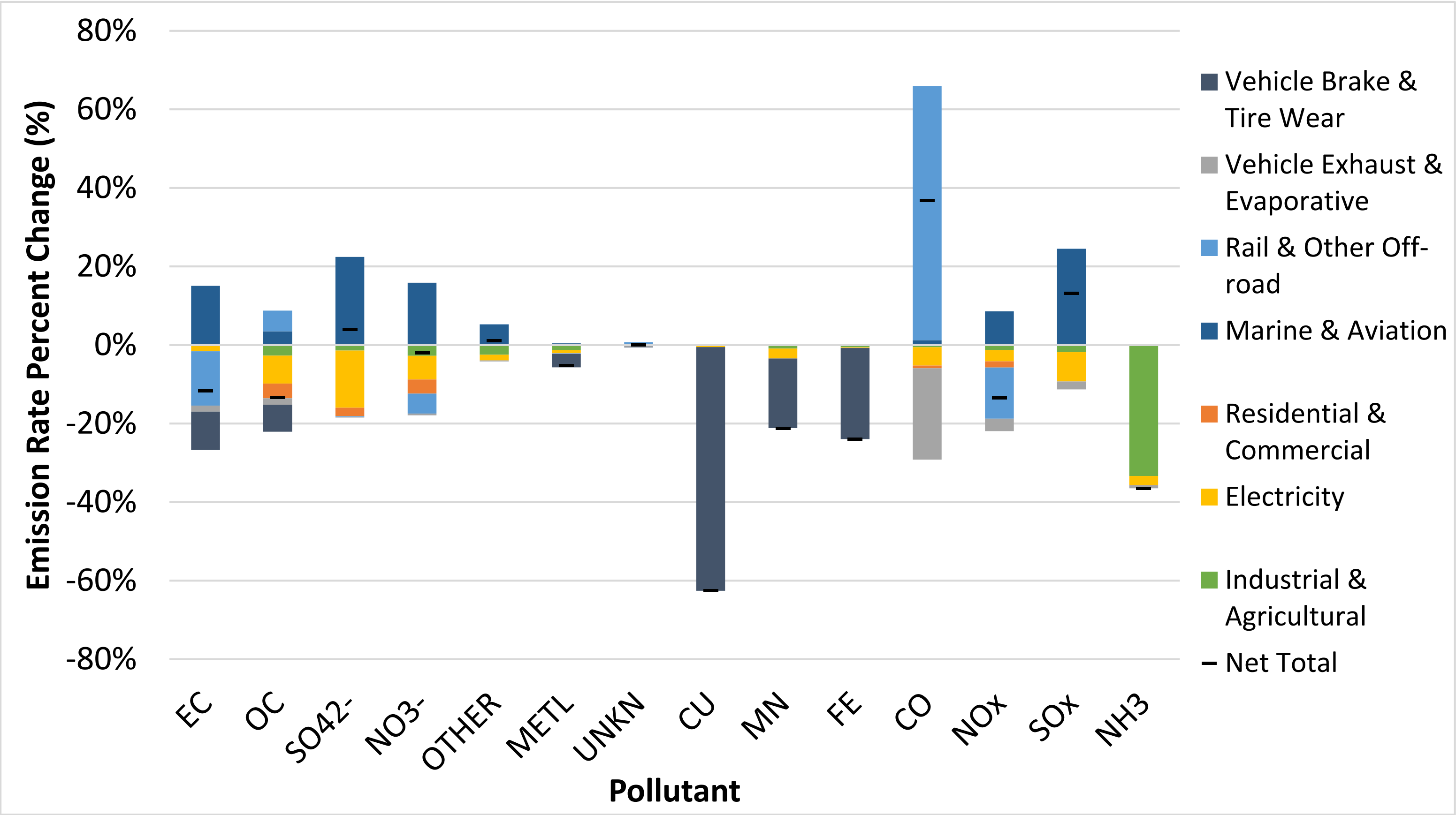
Change in Statewide Emissions Relative to BAU



Source: 2018 C.B. Zapata, C. Yang, S. Yeh, J. Ogden, M.J. Kleeman. Estimating criteria pollutants using the California Regional Multisector Air Quality Emissions (CA-REMARQUE) model. Geoscientific Model Development, 11, 1293-1320.

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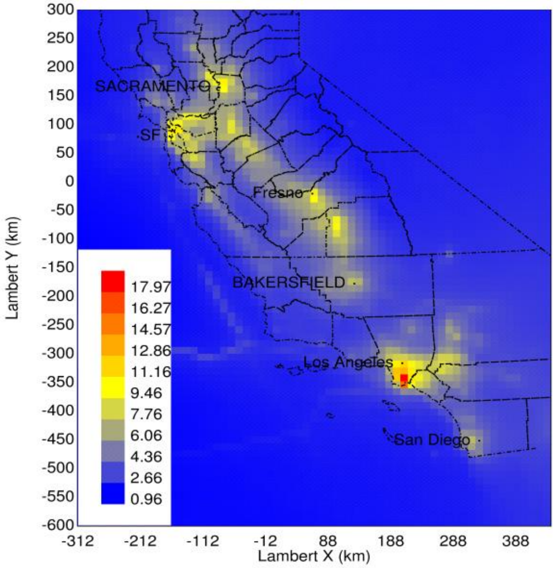
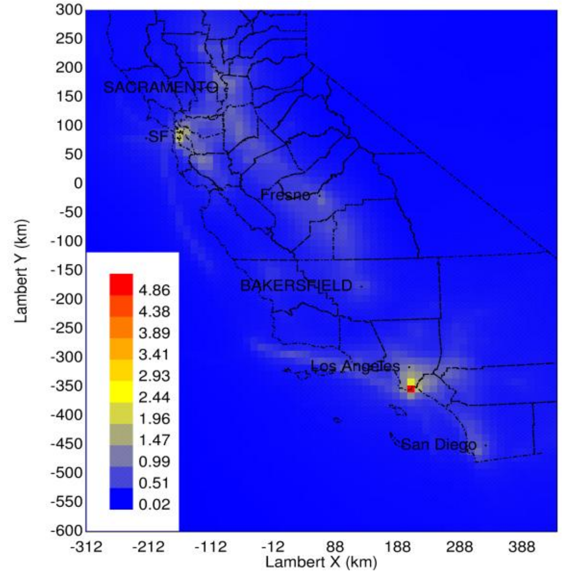
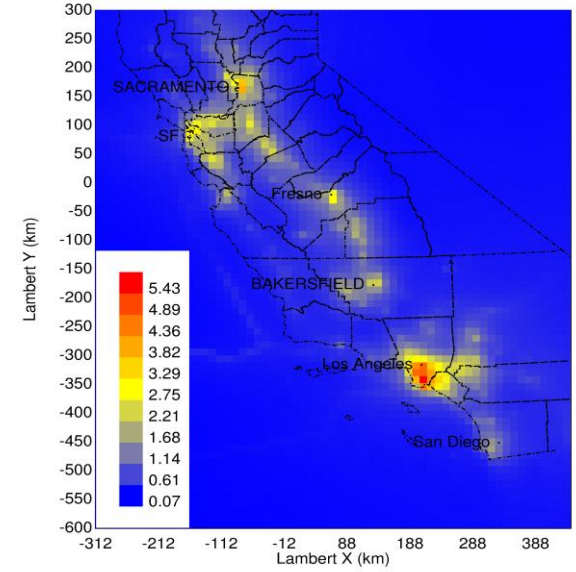
Source-Oriented WRF/Chem Results



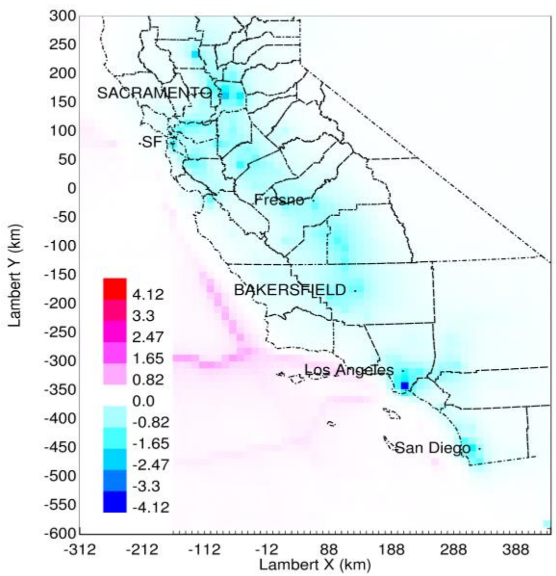
PM2.5 Mass (μg/m^3)



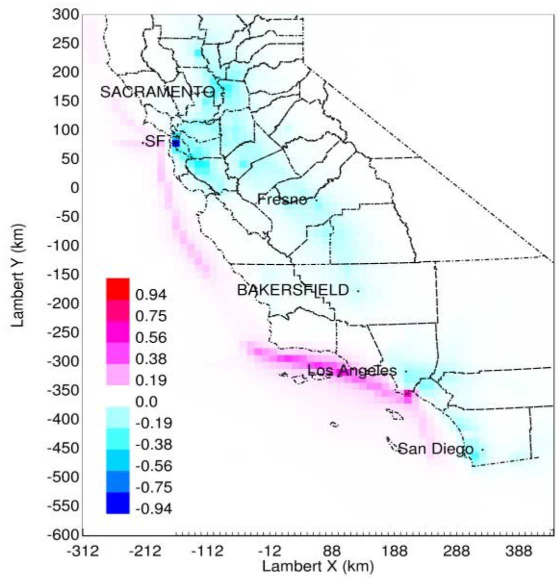
EC (μg/m^3)



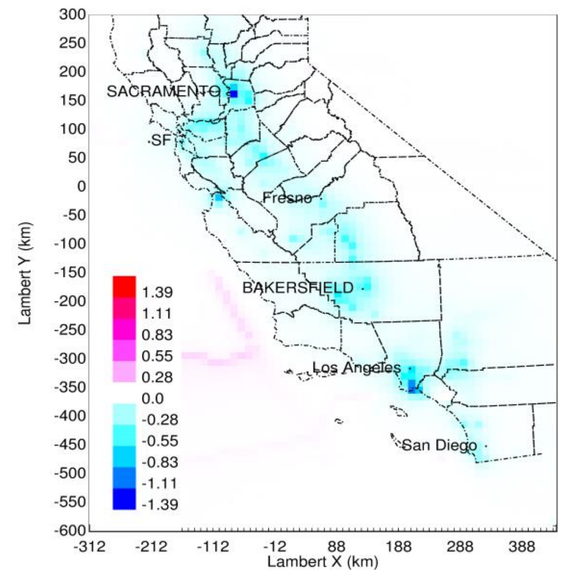
OC (μg/m^3)



Δ PM2.5 Mass (μg/m^3)
(ld=-0.24, oc=+0.0647)



Δ EC (μg/m^3)
(ld=-0.033, oc=+0.014)



Δ OC (μg/m^3)
(ld=-0.074, oc=+0.0)

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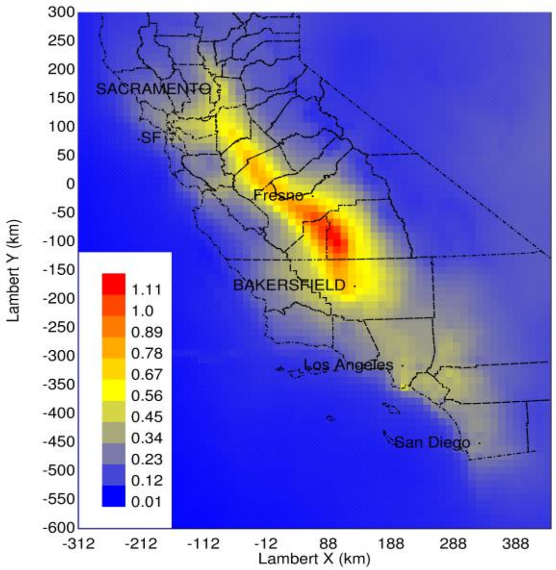
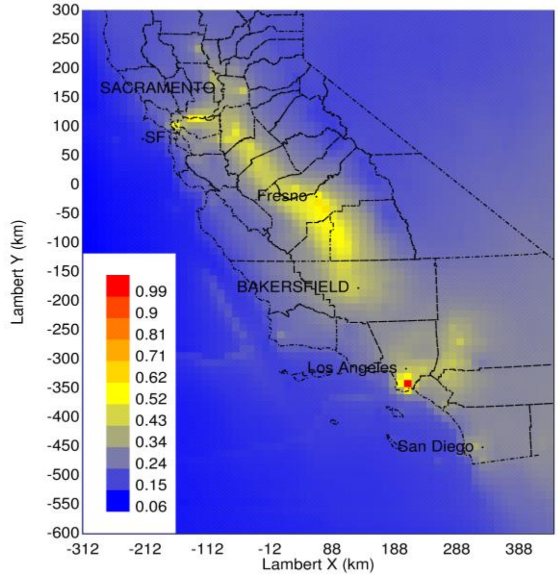
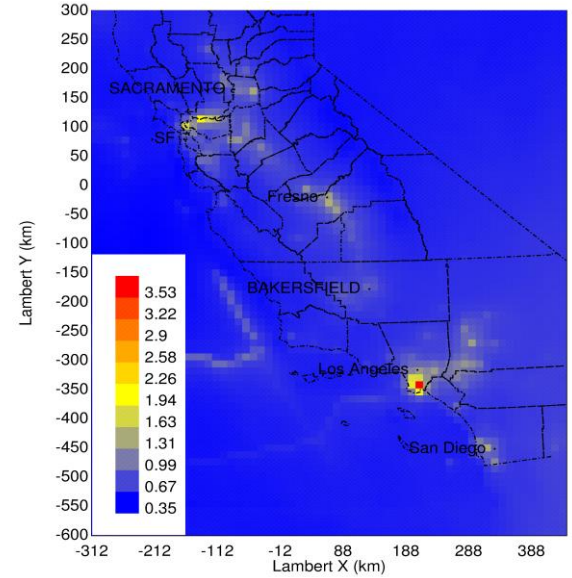


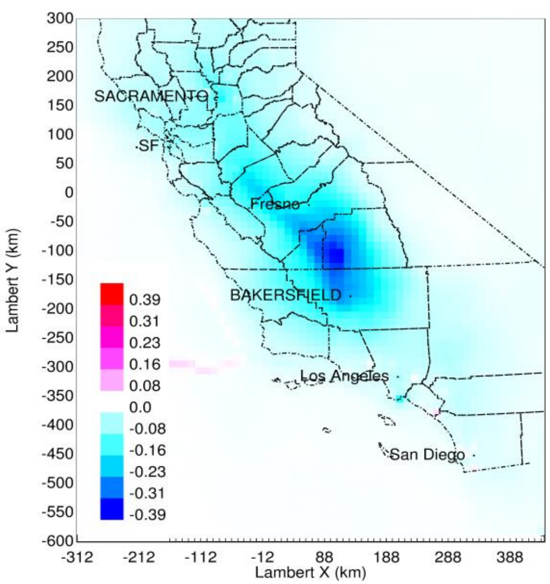
N(V) (μg/m³)



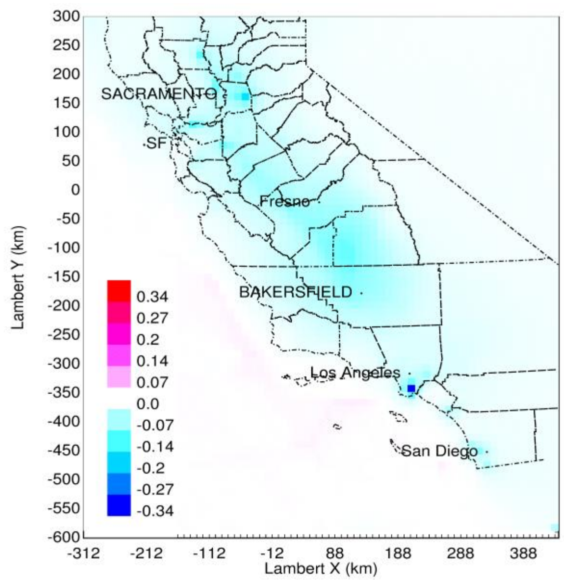
N(-III) (μg/m³)



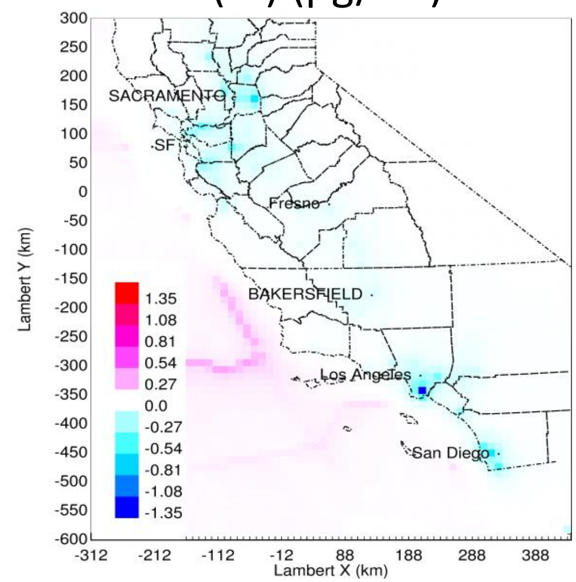
S(VI) (μg/m³)



Δ N(V) (μg/m³)
(ld=-0.060, oc=-0.007)



Δ N(-III) (μg/m³)
(ld=-0.024, oc=-0.001)



Δ S(VI) (μg/m³)
(ld=-0.027, oc=+0.026)

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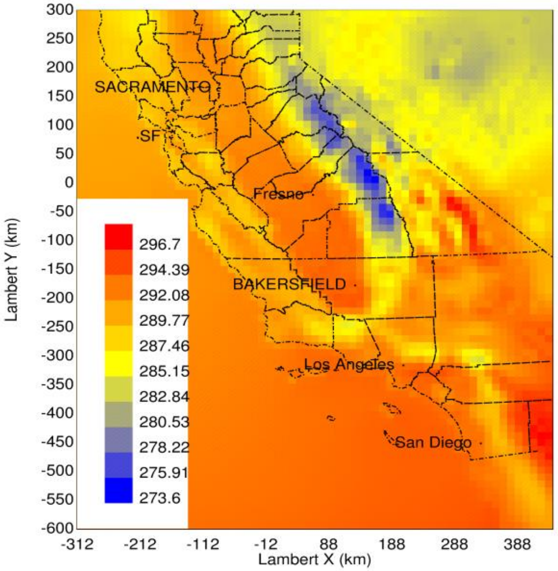
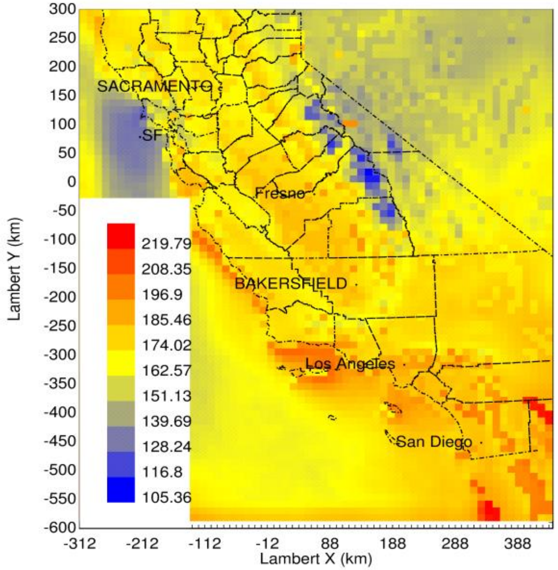
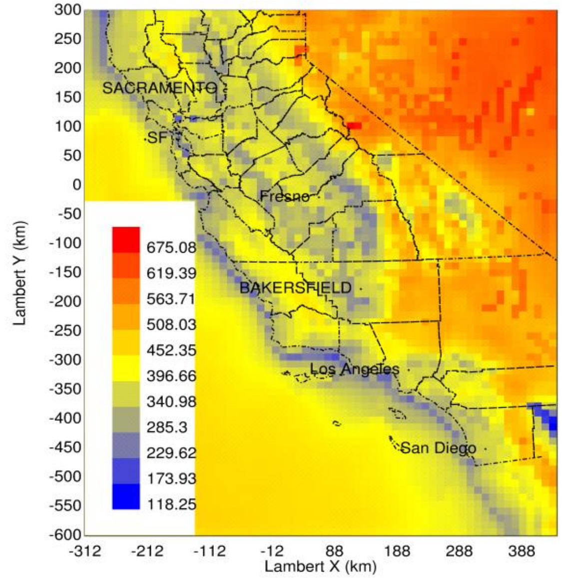


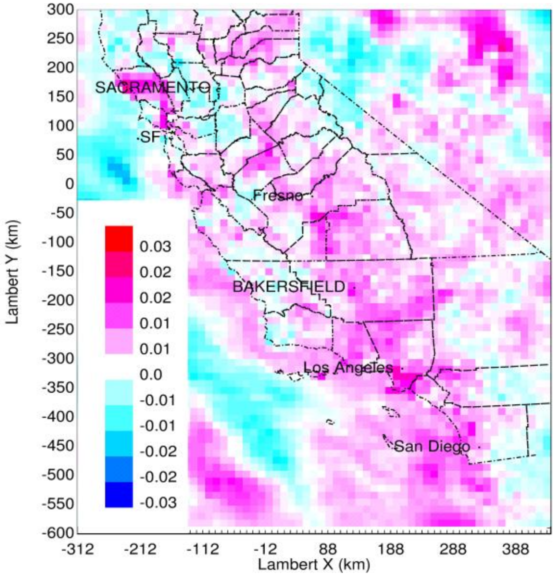
Temp at 2m (K)



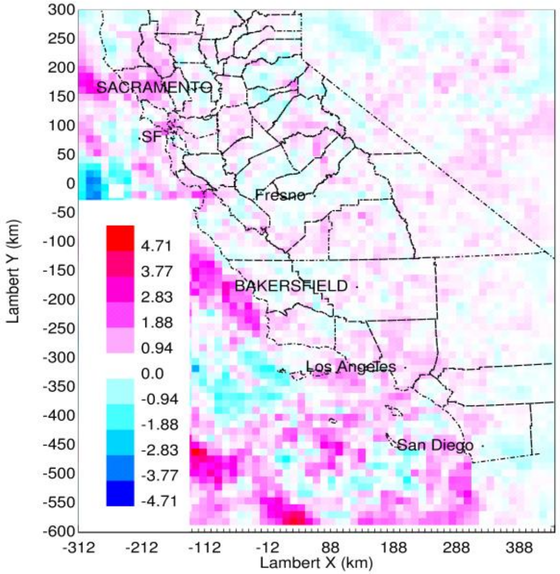
Top of Atmosphere (W/m^2)



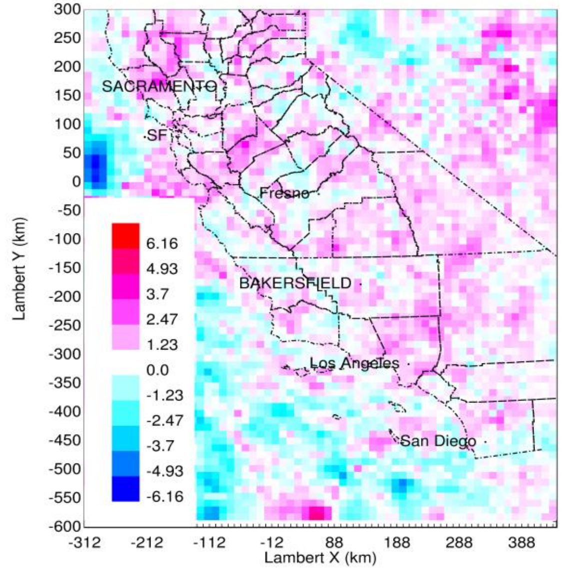
PBLH (m)



Δ T2 (K) (ld=+0.002, oc=-0.0005)



Δ TOA (W/m^2)
(ld=+0.066, oc=+0.215)



Δ PBLH (m)
(ld=+0.383, oc=-0.513)

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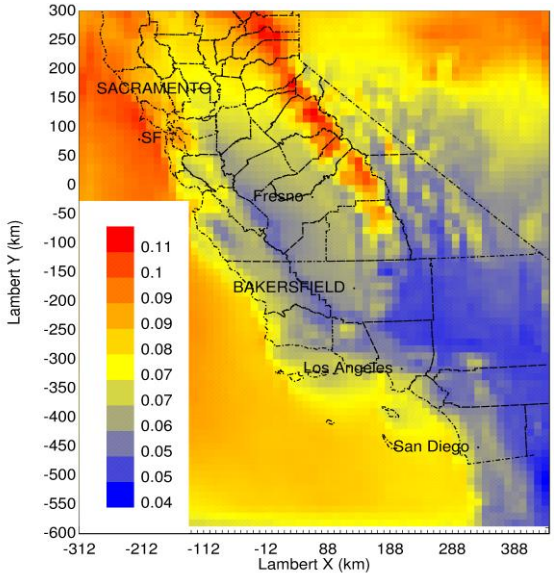
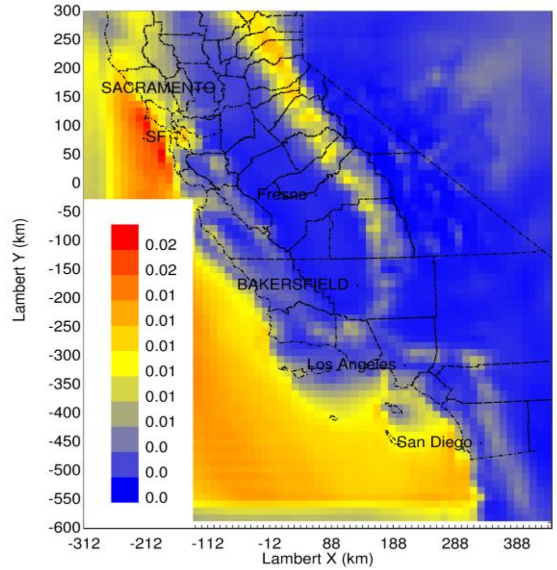
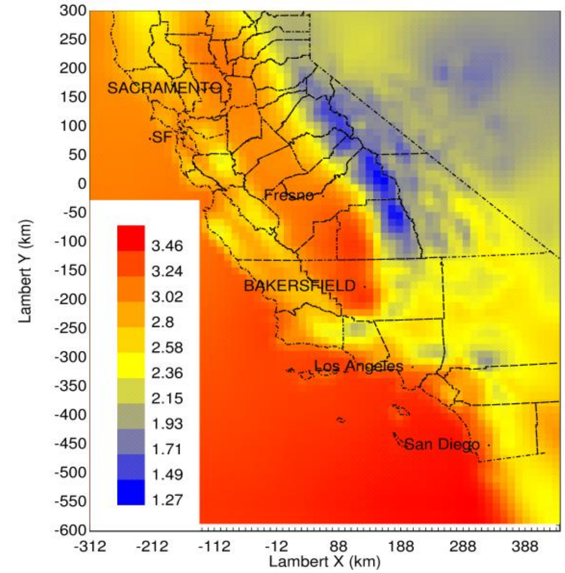


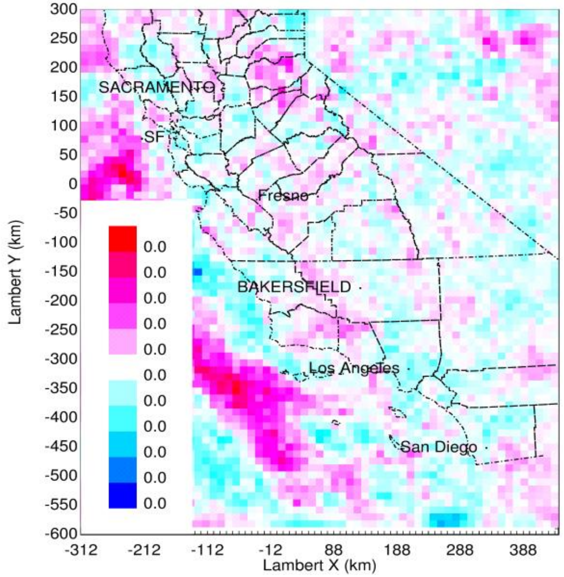
CLDFRA



QCLOUD (Kg/Kg) (#1000)

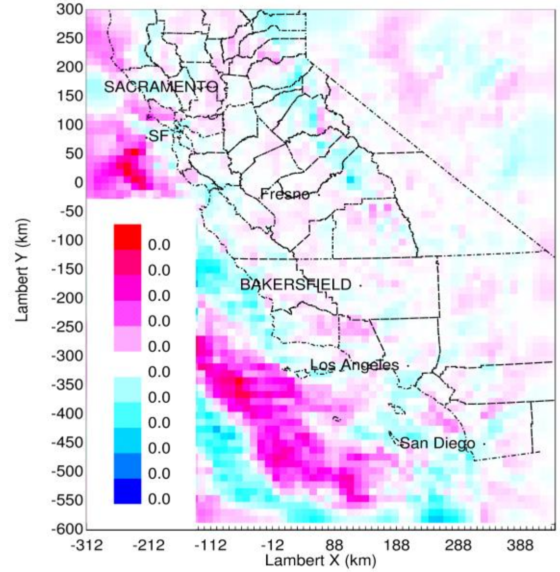


QVAPOR (Kg/Kg) (#1000)



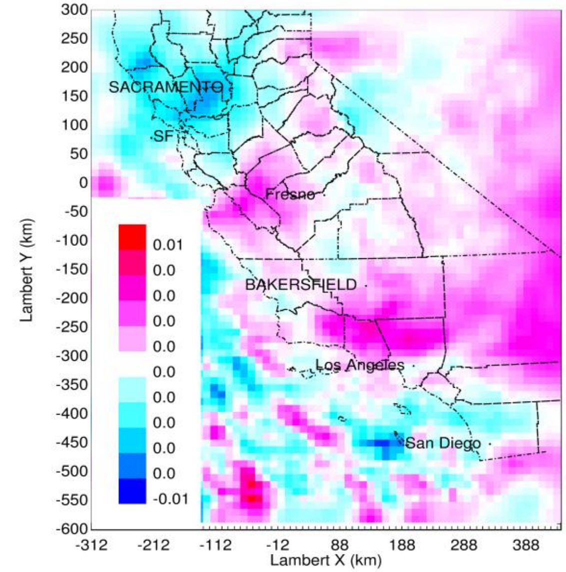
Δ CLDFRA

(ld=-3.7662e-05, oc=+1.0571e-04)



Δ QCLOUD (Kg/Kg) (#1000)

(ld=-8.8125e-7, oc=+4.7552e-05)



Δ QVAPOR (Kg/Kg) (#1000)

(ld=+3.3293e-04, oc=-3.2043e-04)

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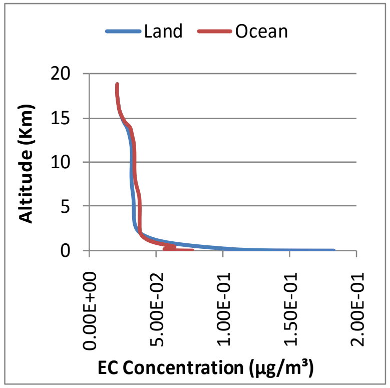
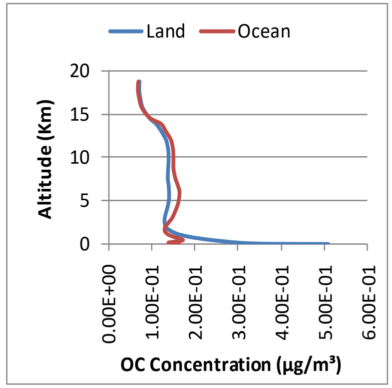


BAU



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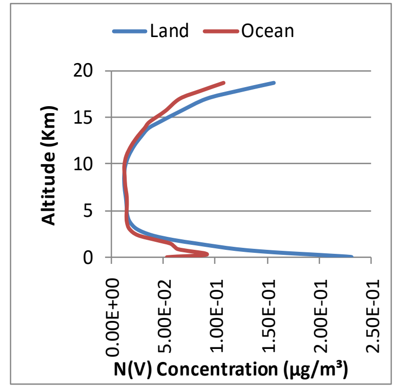
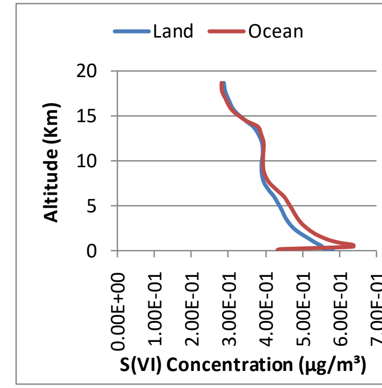


BAU



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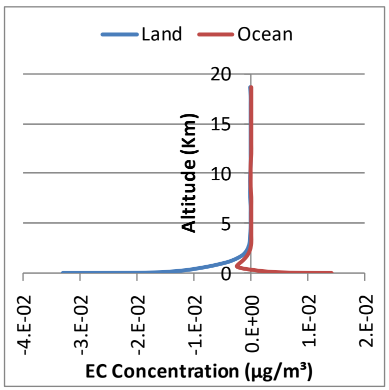
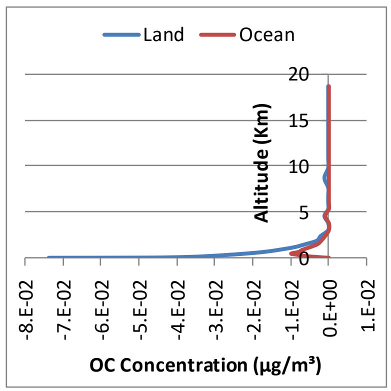


Δ GHGAi-BAU



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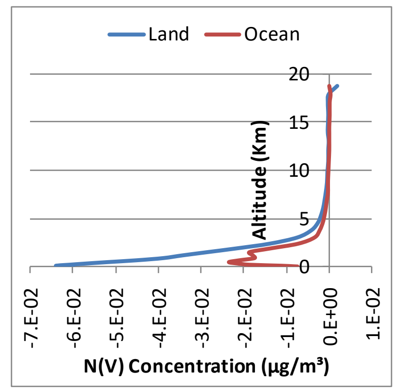
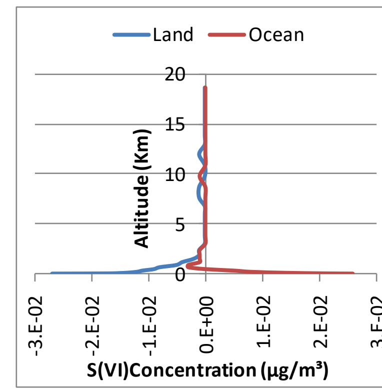


Δ GHGAi-BAU



Δ GHGAi-BAU

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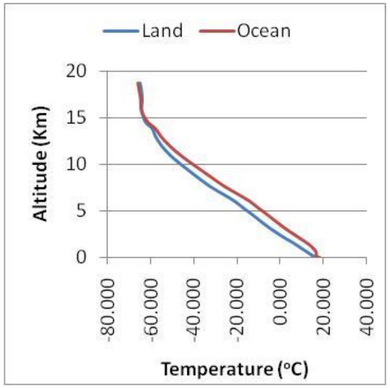

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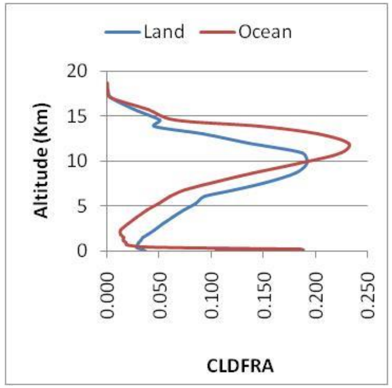

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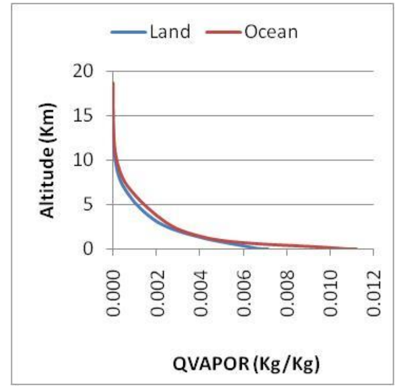

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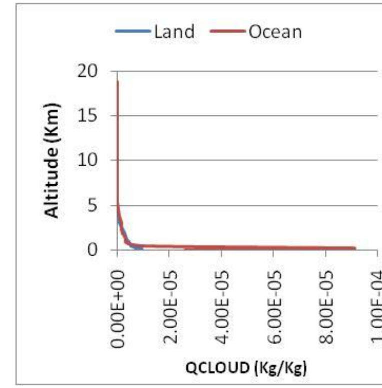

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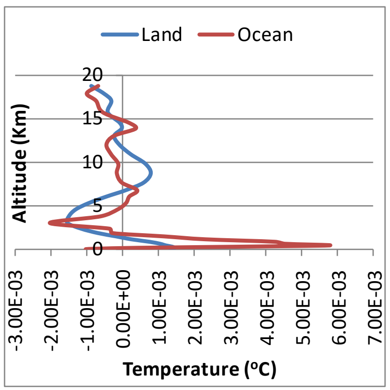

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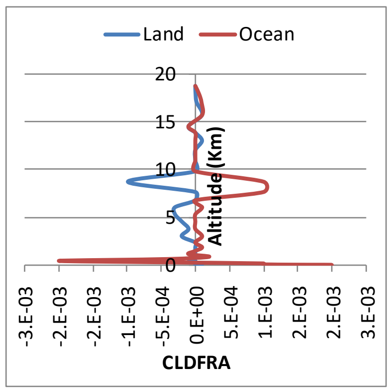

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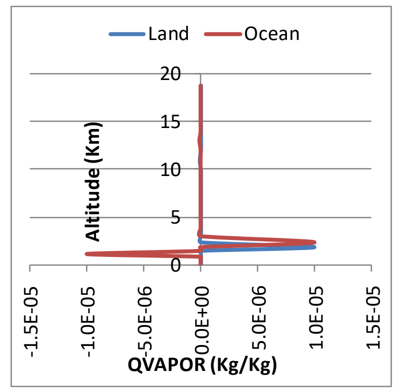

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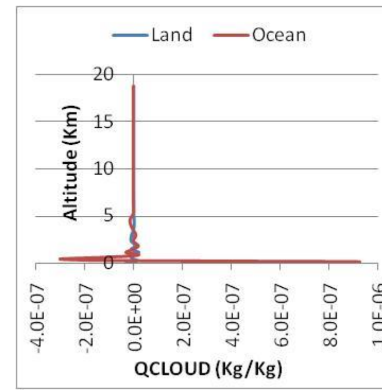

Δ GHGAi-BAU

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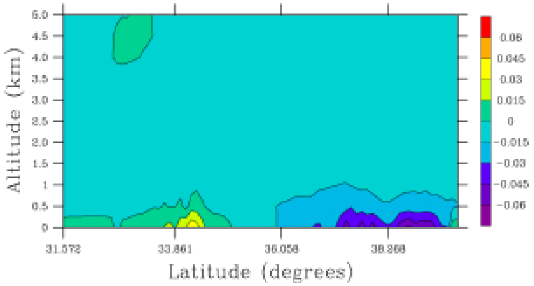
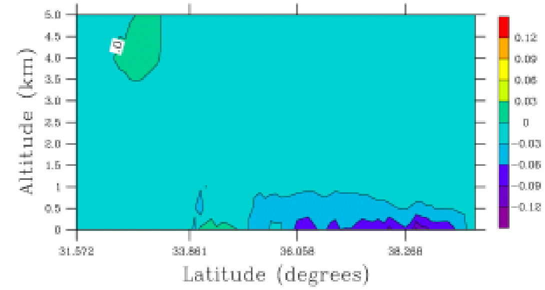
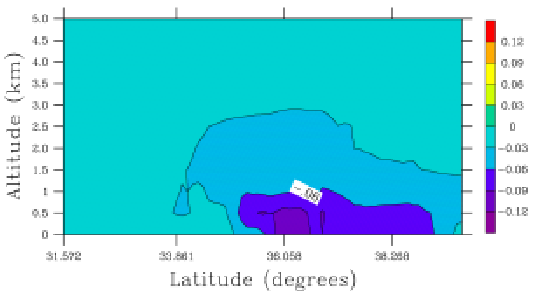


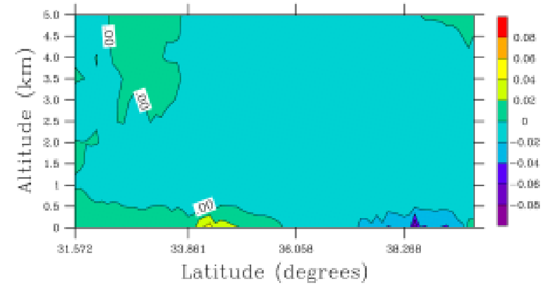
Δ Zonal EC



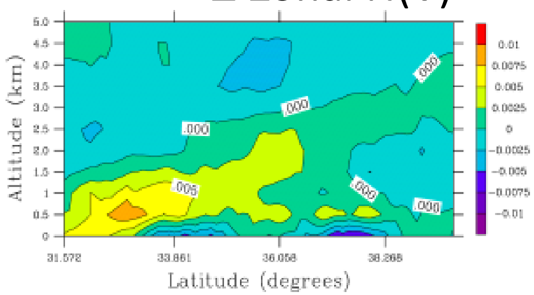
Δ Zonal OC



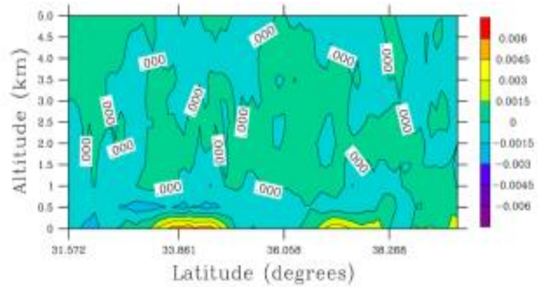
Δ Zonal N(V)



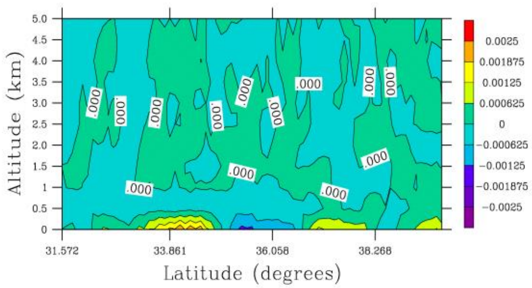
Δ Zonal N(-III)



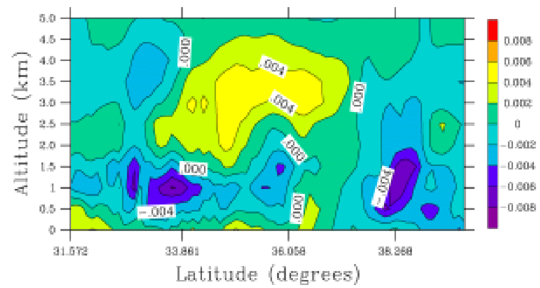
Δ Zonal T



Δ Zonal CLDFRAC



Δ Zonal QCLOUD



Δ Zonal QVAPOR

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Conclusions

•Switching to the GHG-Step scenario reduces surface PM2.5 mass over most inland locations, with changes of -0.5 to -1.5 µg m^{-3} in northern California and -4.12 µg m^{-3} at the Port of Los Angeles.

•Surface temperature (+0.001 K) and top of atmosphere forcing (+0.15 W m^{-2}) increases due to GHG scenario in comparison to BAU scenario.

•Most of the air pollutants as well as meteorological variables change only in lower 1-2 km of the atmosphere.

•Zonal plots suggest that temperature and Qvapor increase in the lower atmosphere. However, CLDFRAC and QCLOUD decrease in the lower atmosphere.

Limitations

- The CO_2 and CH_4 effects on climate were not evaluated in the current study. GHG mitigation strategies will reduce CO_2 and CH_4 concentrations leading to reduced climate forcing.

Acknowledgements

- National Center for Sustainable Transportation
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