Air quality impacts of electric vehicle adoption in California

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20th Annual CMAS Conference
November 2021

Georgia Tech
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Biden plans to cut emissions at least in half by 2030

The target, intended to reassert America's global leadership on climate action, would require profound changes at home

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WHITE HOUSE

Biden commits to cutting U.S. emissions in half by 2030 as part of Paris climate pact

The president announced the pledge during remarks at the White House's virtual climate summit Thursday.

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April 22, 2021 · 6:01 AM ET

SCOTT DETROW

POLITICS

At Earth Day climate summit, Biden promises 50% reduction in US greenhouse emissions

Deirdre Shesgreen USA TODAY

Published 6:01 a.m. ET Apr. 22, 2021 | **Updated 5:24 p.m. ET Apr. 22, 2021**

Transition to electric vehicles expected to play a major role in GHG reductions

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ENERGY

Biden wants millions of electric vehicles on the roads. Can the power grid handle it?

"We have to recognize that the (electric) infrastructure in parts of this country has fallen behind that in many other parts of the world," said one energy expert.

The New York Times

Here's How Biden Aims to Increase Electric Car Sales

The president wants to use pollution rules to rapidly lift sales, but there are hurdles ahead.

AP

Biden aims to juice EV sales, but would his plan work?

By TOM KRISHER April 1, 2021

California to ban sales of new internal combustion engine passenger vehicles by 2035

The New York Times

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Governor Newsom's Zero-Emission by 2035 Executive Order (N-79-20)

Executive Order calls for elimination of new internal combustion passenger vehicles by 2035

California Plans to Ban Sales of New Gas-Powered Cars in 15 Years

The proposal would speed up the state's efforts to fight global warming at a time when California is being battered by wildfires, heat waves and other consequences of climate change.

Forbes WHEELS

Wheels › News

California Governor Gavin Newsom Signs Executive Order Phasing Out Gasoline Vehicles By 2035

Andrew Wendler
Forbes Staff

Published: Sep 23, 2020

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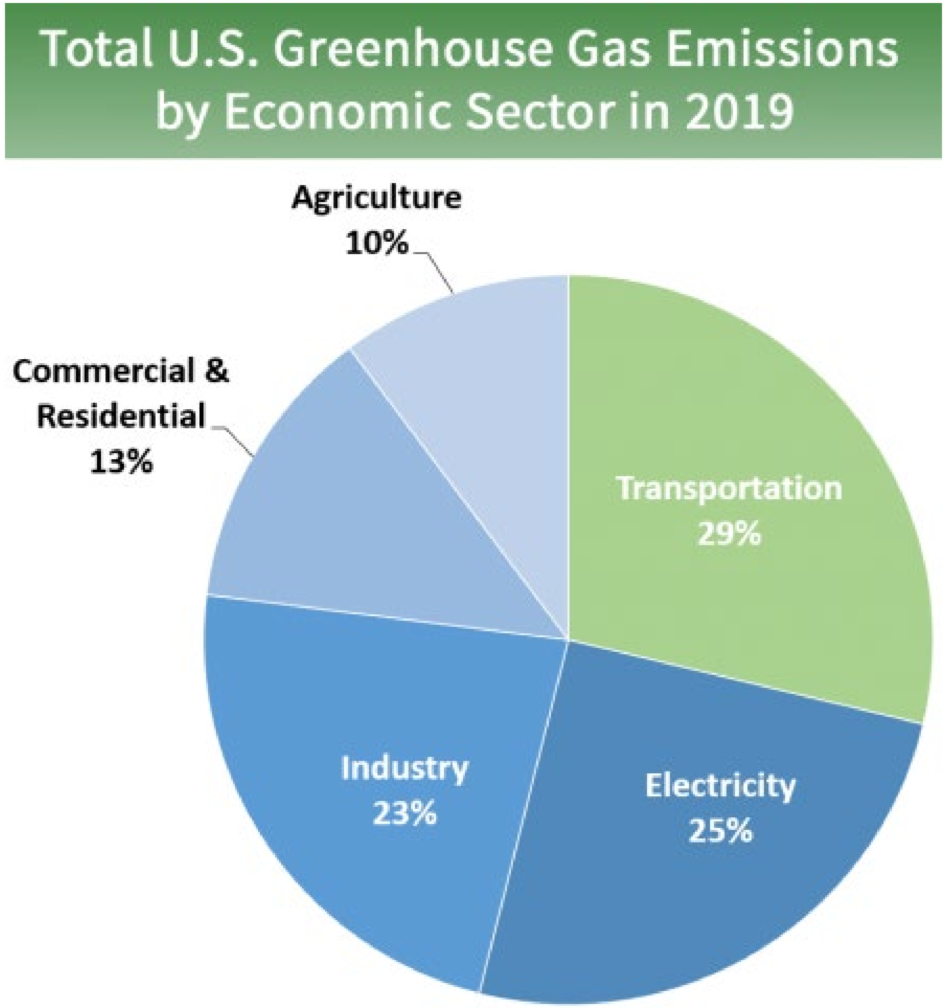
ENVIRONMENT

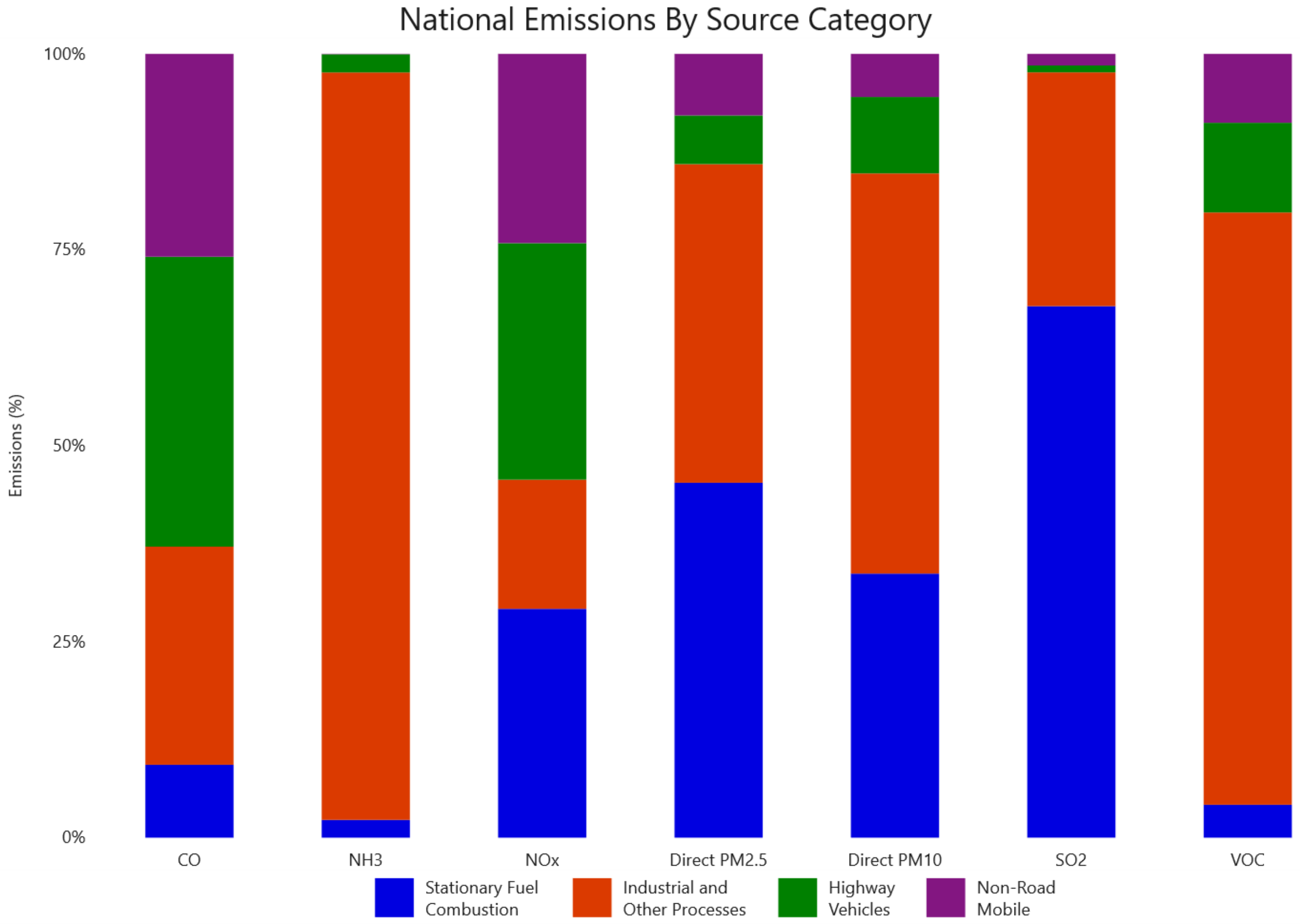
California Gov. Newsom Calls Transition To Electric Cars An 'Economic Imperative'

September 24, 2020 · 7:59 PM ET
Heard on All Things Considered

SACHA PFEIFFER

Vehicles are a major source of GHG but also of other air pollutants





https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

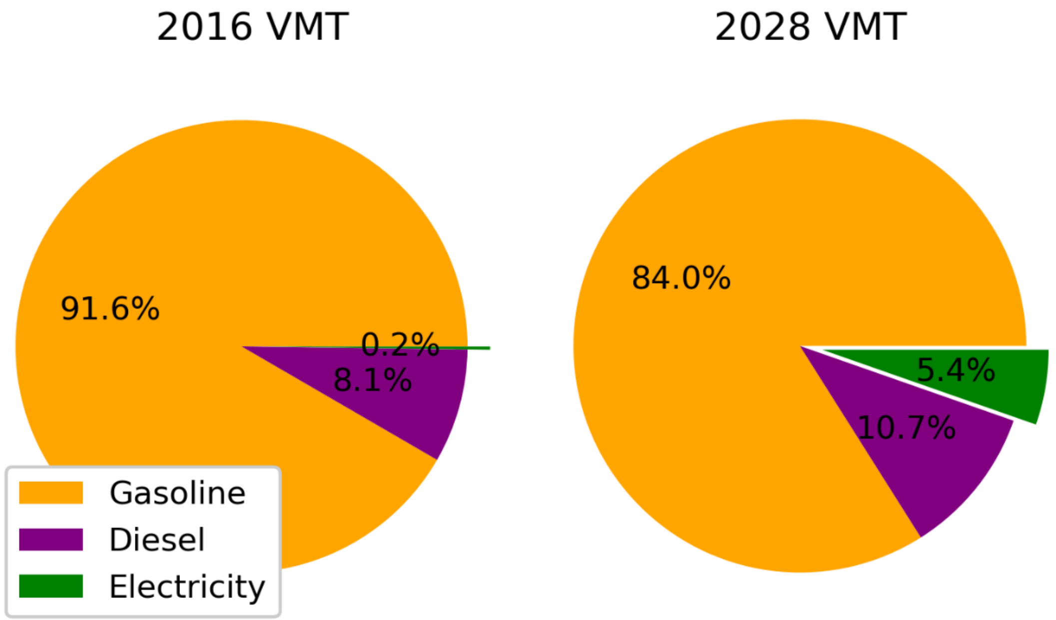
https://gispub.epa.gov/air/trendsreport/2021

Want to estimate the potential impacts on air quality from switching to EVs in California

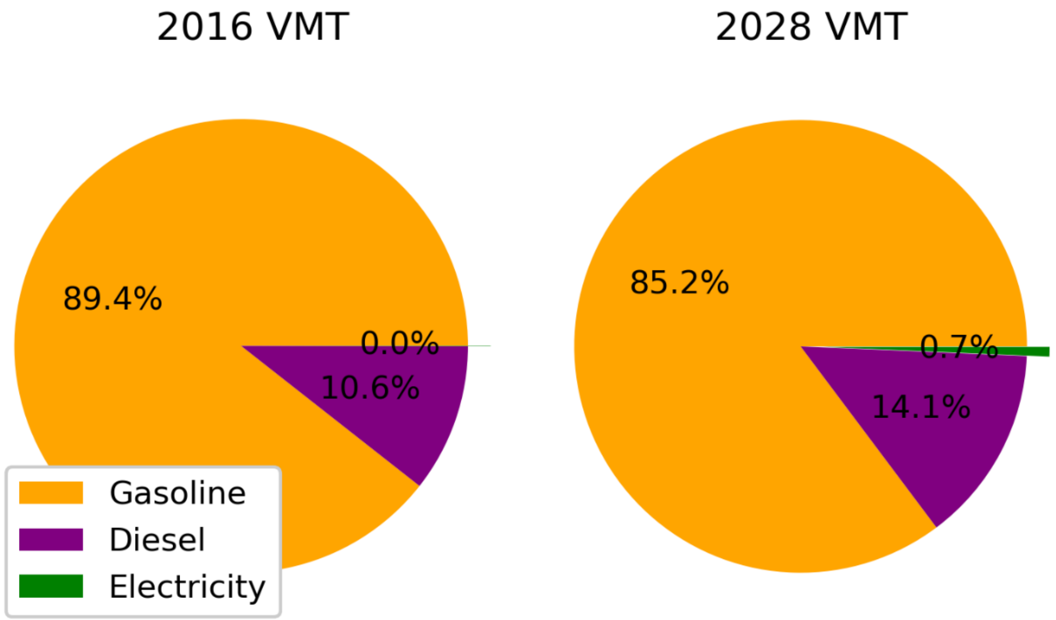
- Use CMAQ to simulate a series of EV adoption scenarios in **2016** and **2028**
  - **BASE** – Base case with default EV population in emissions inventory
  - **EV25** – Electrification of 25% of onroad vehicles in California
  - **EV50** – Electrification of 50% of onroad vehicles in California
  - **EV100** – Electrification of 100% of onroad vehicles in California
  - **EV100_LDB** – Electrification of all passenger cars and trucks, light commercial trucks, transit buses, and school buses in California (2016 only); **LDB = light duty + buses**
- Scenarios to estimate effects of brake wear (BW) and tire wear (TW)
  - **EV100_NOBTW** – EV100 scenario with BW and TW zeroed out
  - **EV100_NOBW** – EV100 scenario with BW zeroed out but with TW included
  - **EV100_NOTW** – EV100 scenario with TW zeroed out but with BW included

EV use in base emissions inventory

California



rest of US



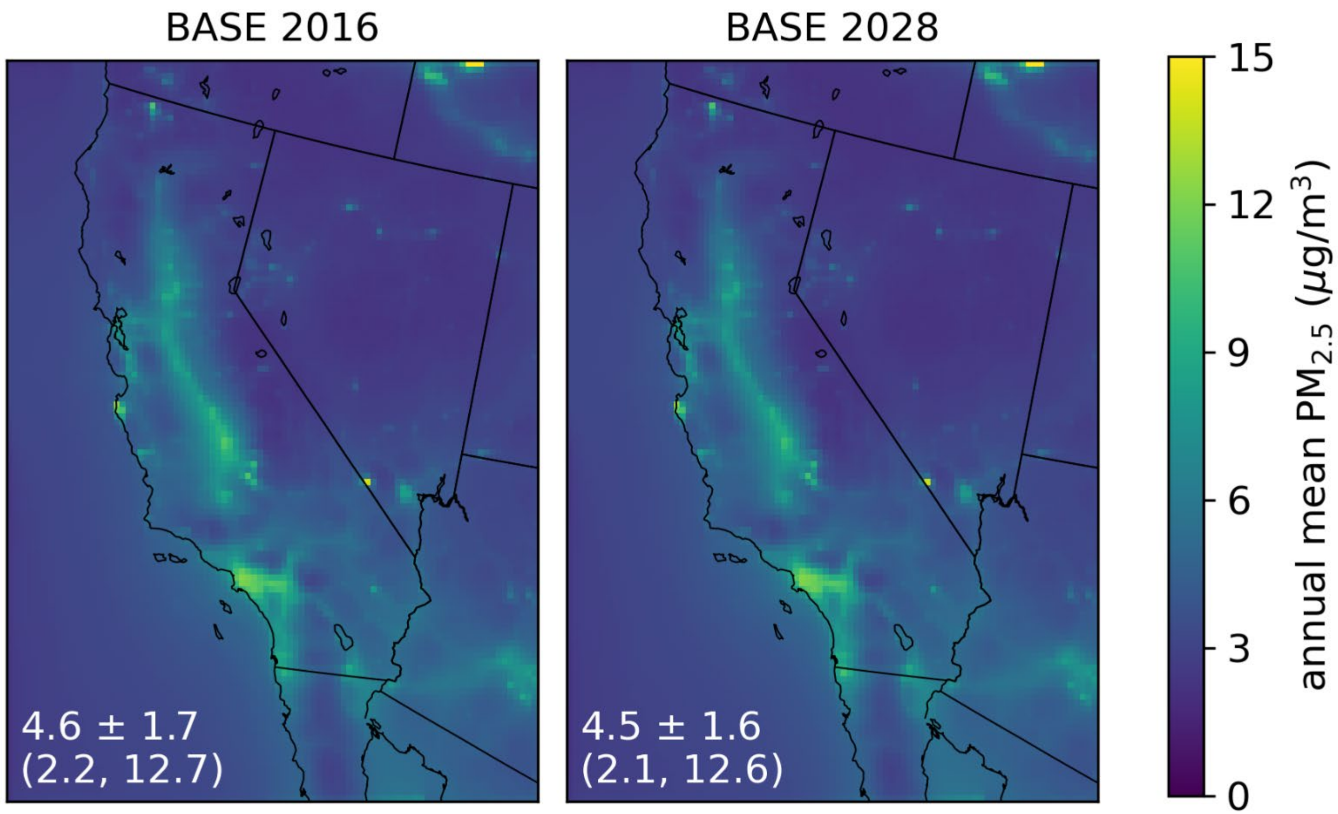
Percentage of VMT by fuel type across all vehicle categories.

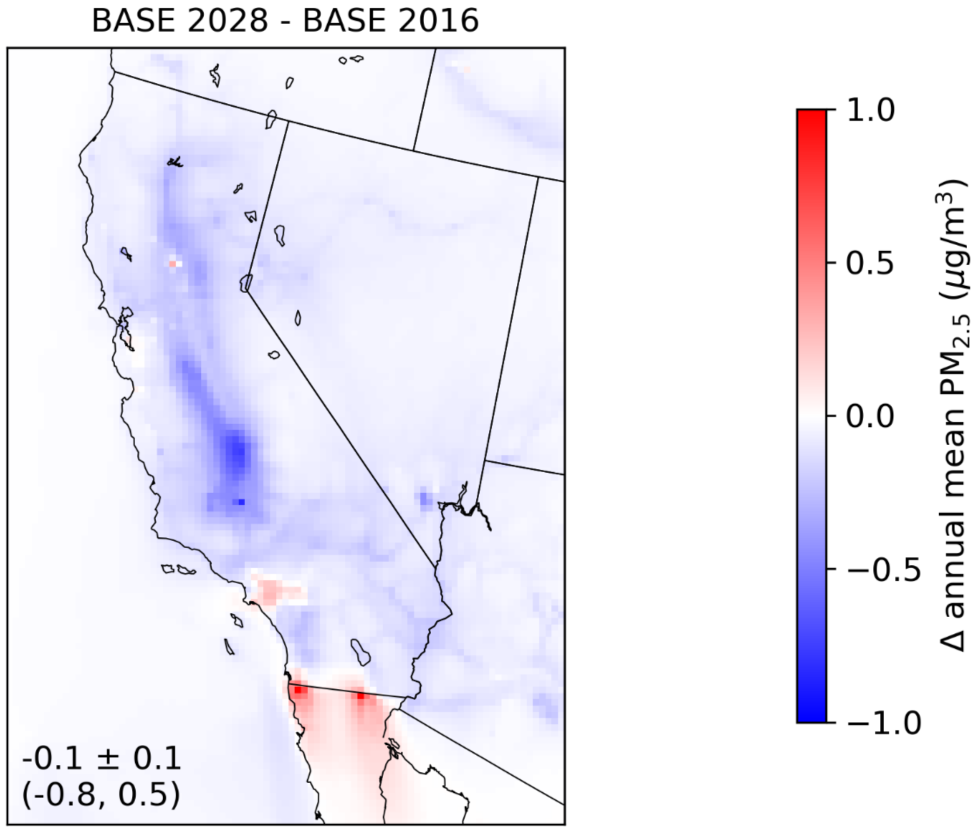
Note: Compressed natural gas and E-85 ethanol fuel types are included in inventories, but the use is very small for all inventory years.

Other model setup information

- **WRF v3.9.1.1**
  - 2016 meteorology used for 2028 run so the only effects are from emissions
- **CMAQ v5.3.2**
  - Detailed Emissions Scaling and Diagnostic (DESID) module to scale onroad California emissions
- Boundary conditions from seasonal averages of HCMAQ run (by EPA)
- Emissions from **2016v1 inventory** using pre-generated files by EPA
  - Use base year (2016) as well as one future year projection to 2028
  - Use 2016 fire emissions for 2028 runs

Base case PM2.5 annual average

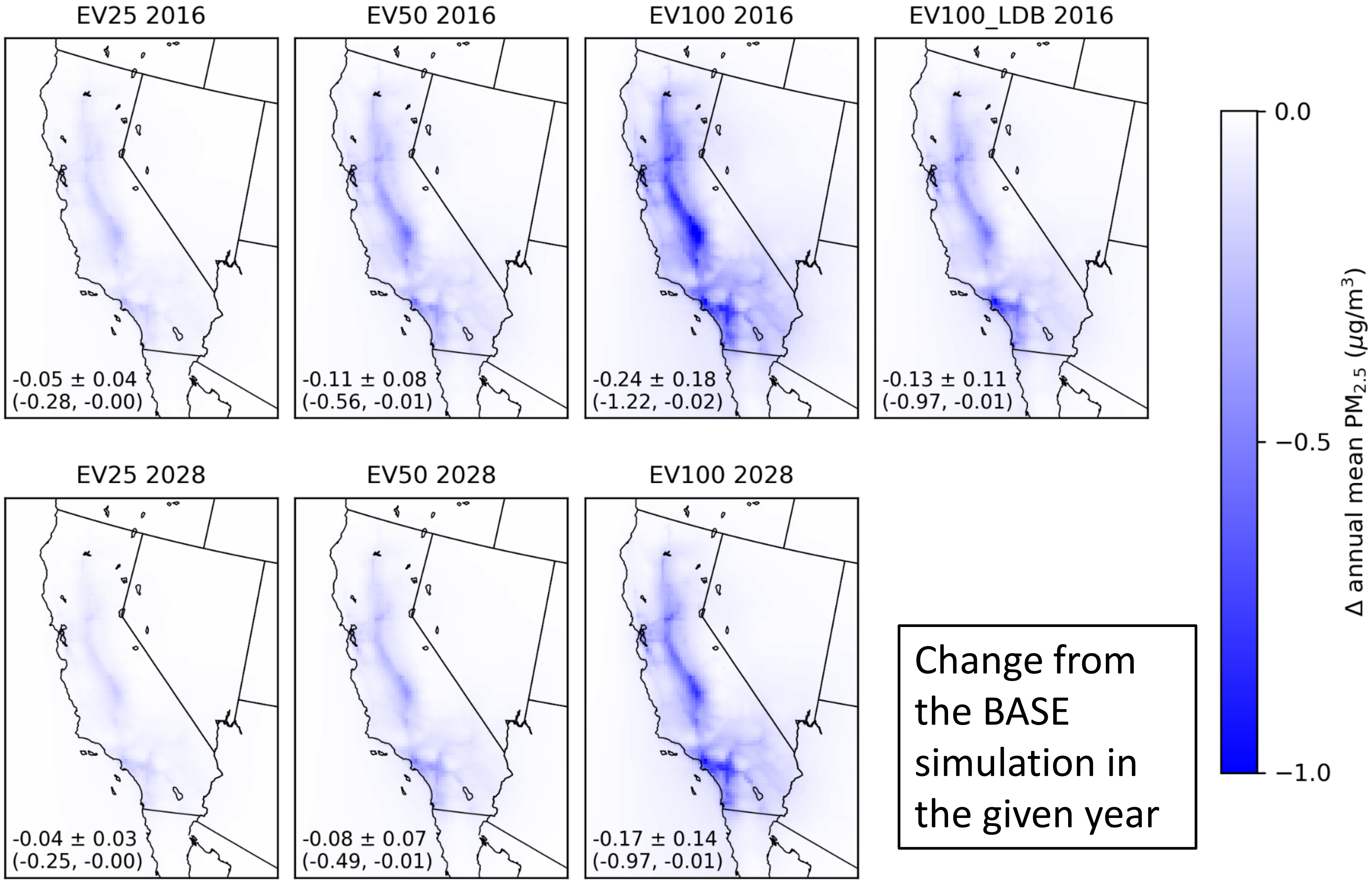




Increases near LA are from organic aerosol.

Throughout presentation, annotations show the mean ± std. dev. (min, max) over California grid cells.

Change in annual mean PM2.5 from BASE



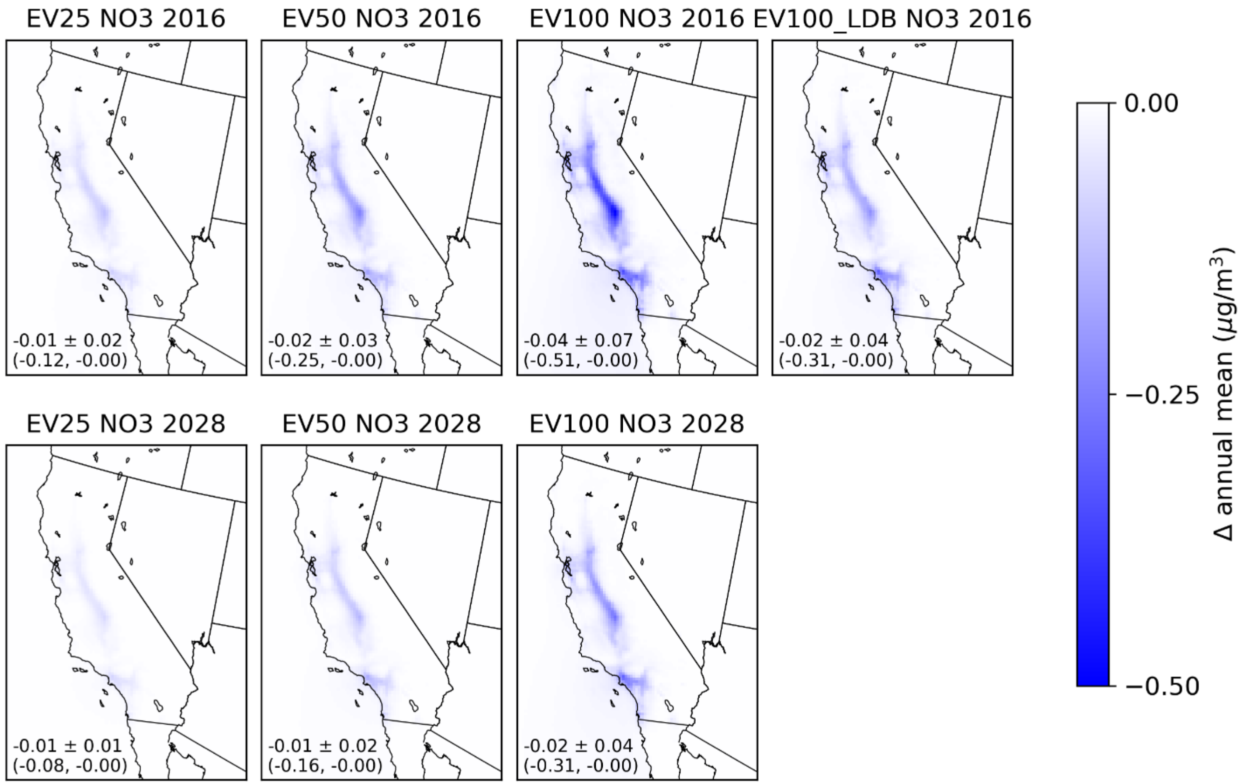
Change from the BASE simulation in the given year

Decreases in PM2.5 scale approximately linearly with increasing EV adoption.

LDB scenario is comparable to EV50, though in LA it looks somewhere in between EV50 and EV100.

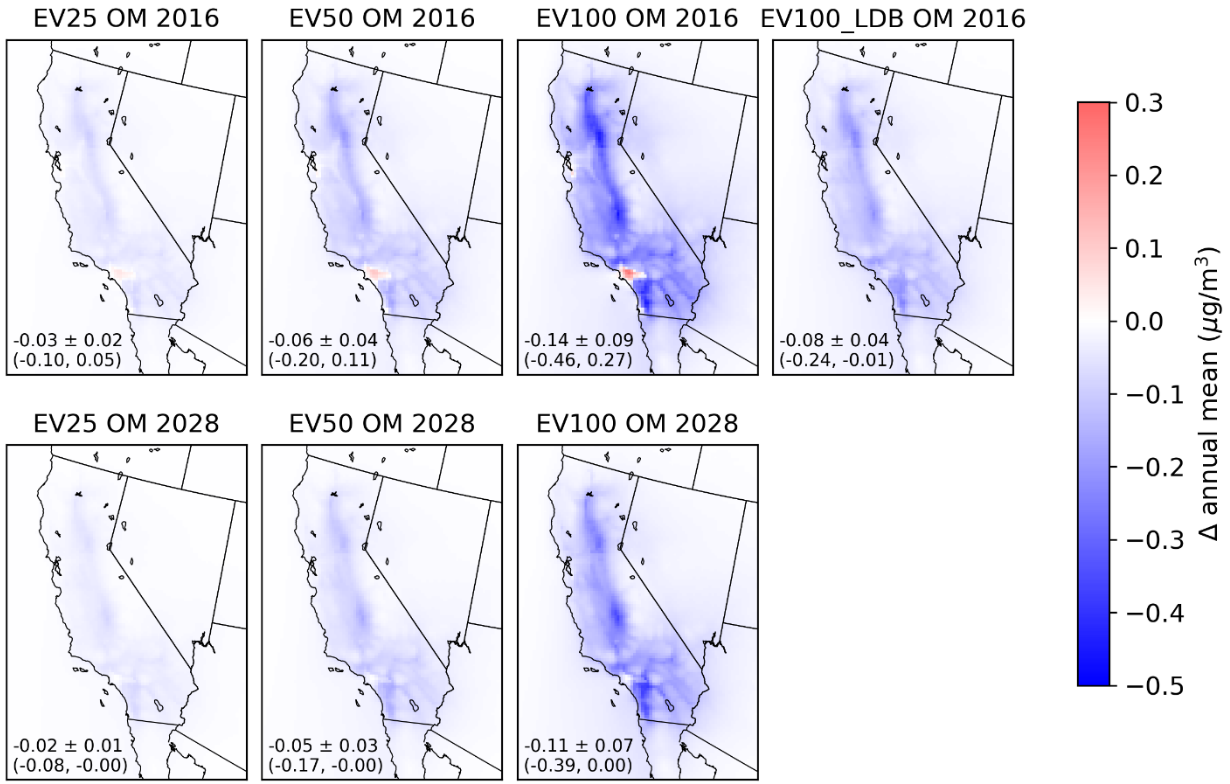
Change in annual mean for selected species

Nitrate



Largest reductions are from nitrate.
Less NOx → less nitrate

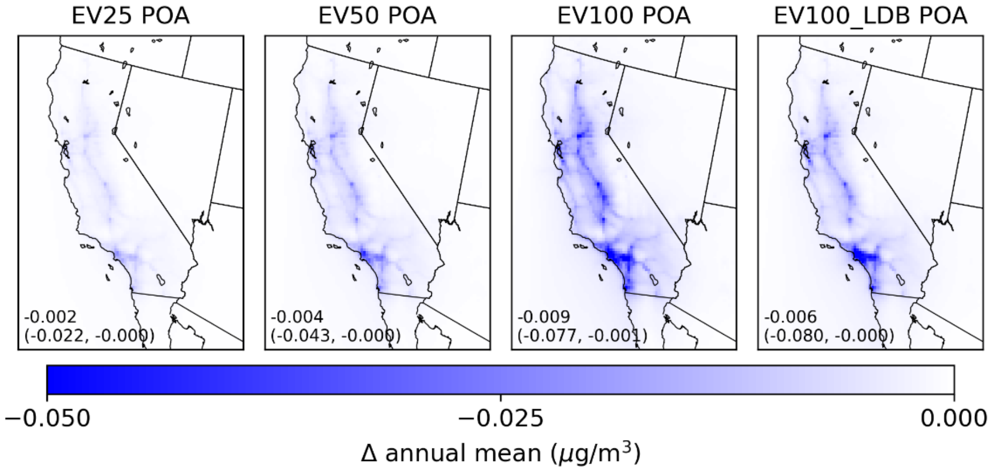
Organic aerosol



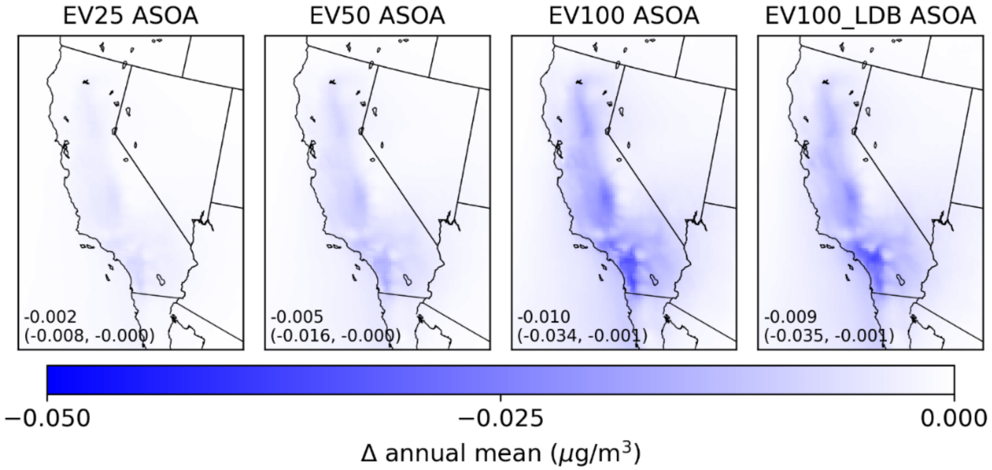
Reduction in organics, except near LA.
Because of NOx effects on SOA formation.

Changes in organic aerosol (2016)

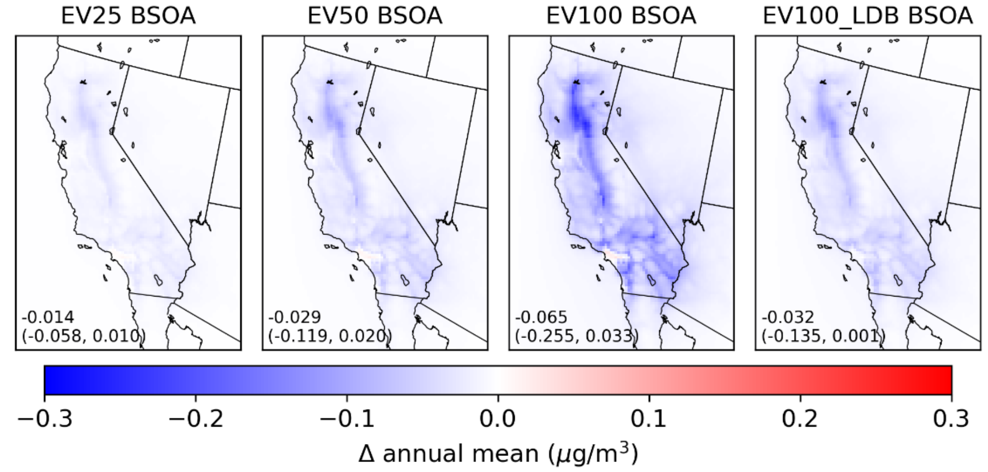
Primary OA



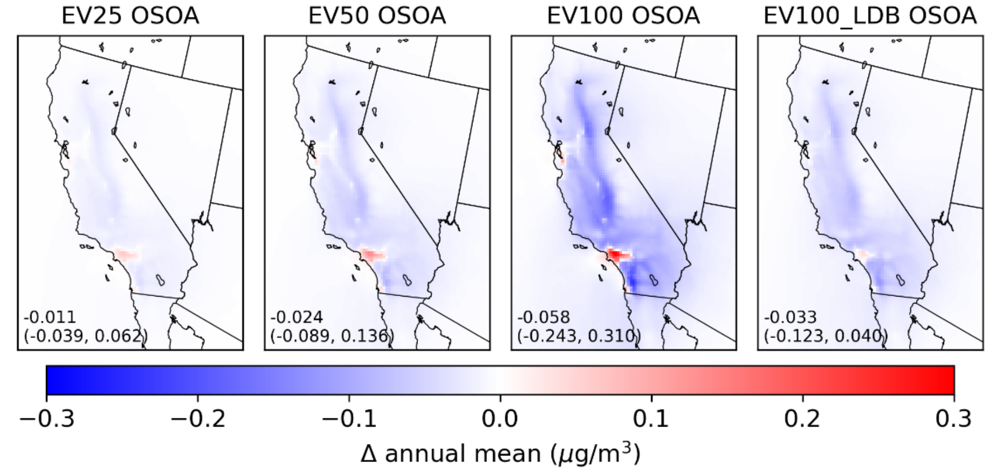
Anthropogenic-VOC SOA



Biogenic-VOC SOA



Other SOA

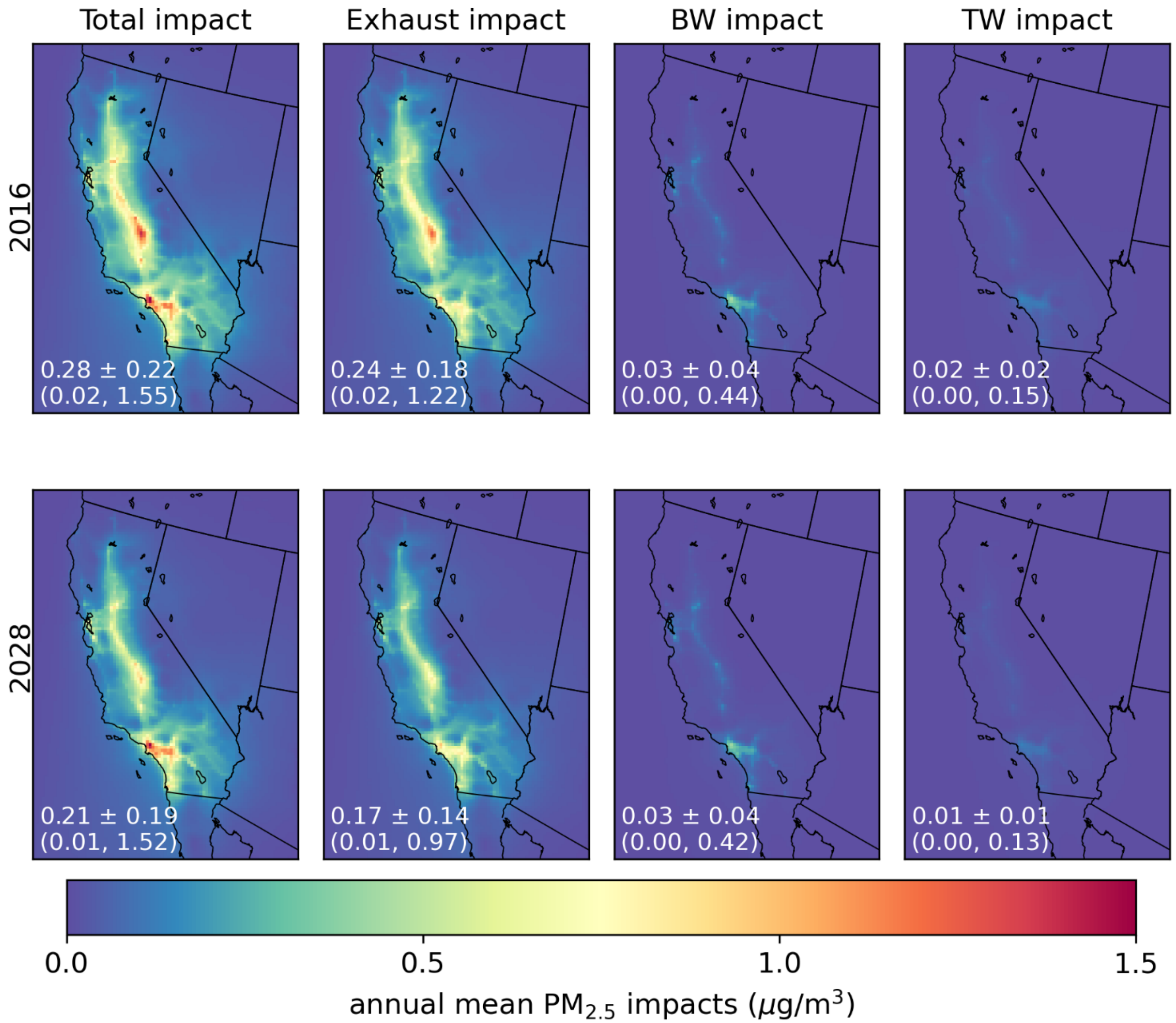


Other SOA is any SOA that does not originate from VOC.

Comes from primary OA that volatizes, then is further oxidized, then condenses.

For those interested, the specific CMAQ species are: ALVOO, ASVOO, APCSO.

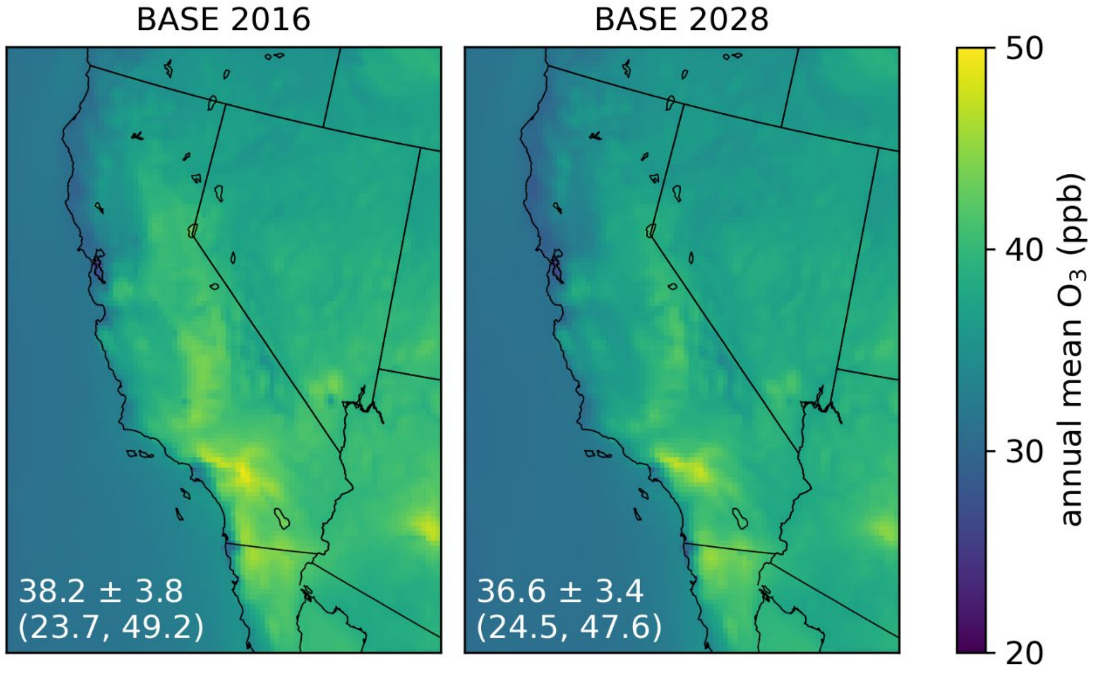
PM2.5 impacts from exhaust, BW, and TW



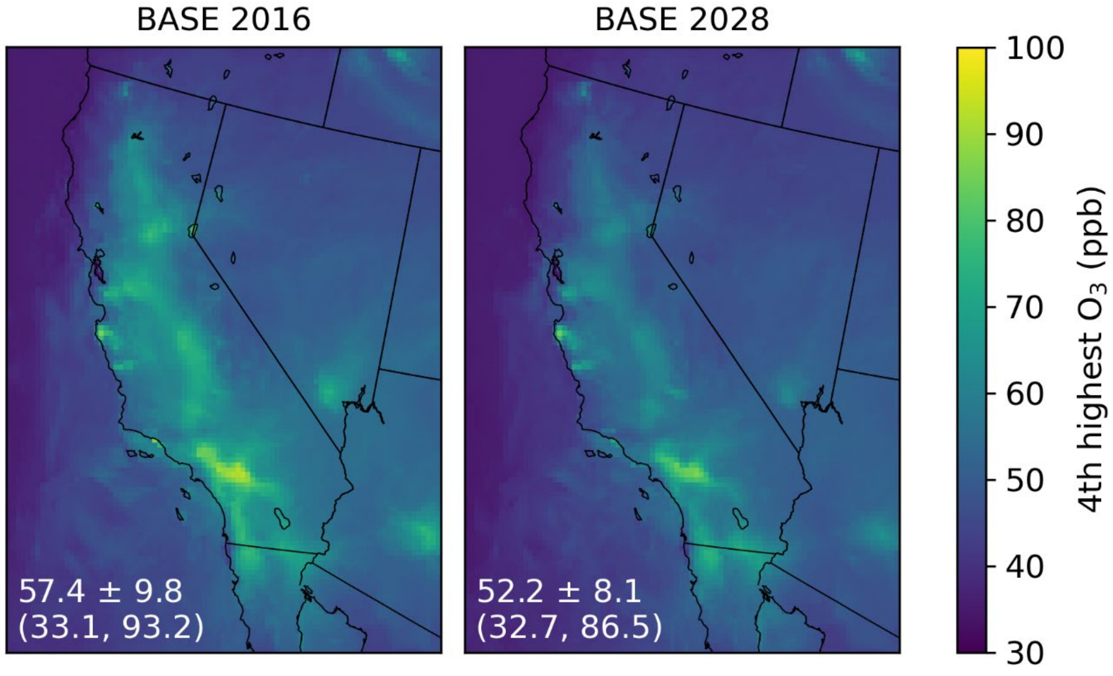
- Impacts from BW are up to 0.4 µg/m^3 and are similar in 2016 and 2028.
  - May not be accurate considering that regenerative breaking should reduce BW.
- Impacts from TW are up to about 0.1 µg/m^3 and are similar in 2016 and 2028.
- BW and TW are not negligible components of onroad vehicle impact.

Base case ozone

annual mean

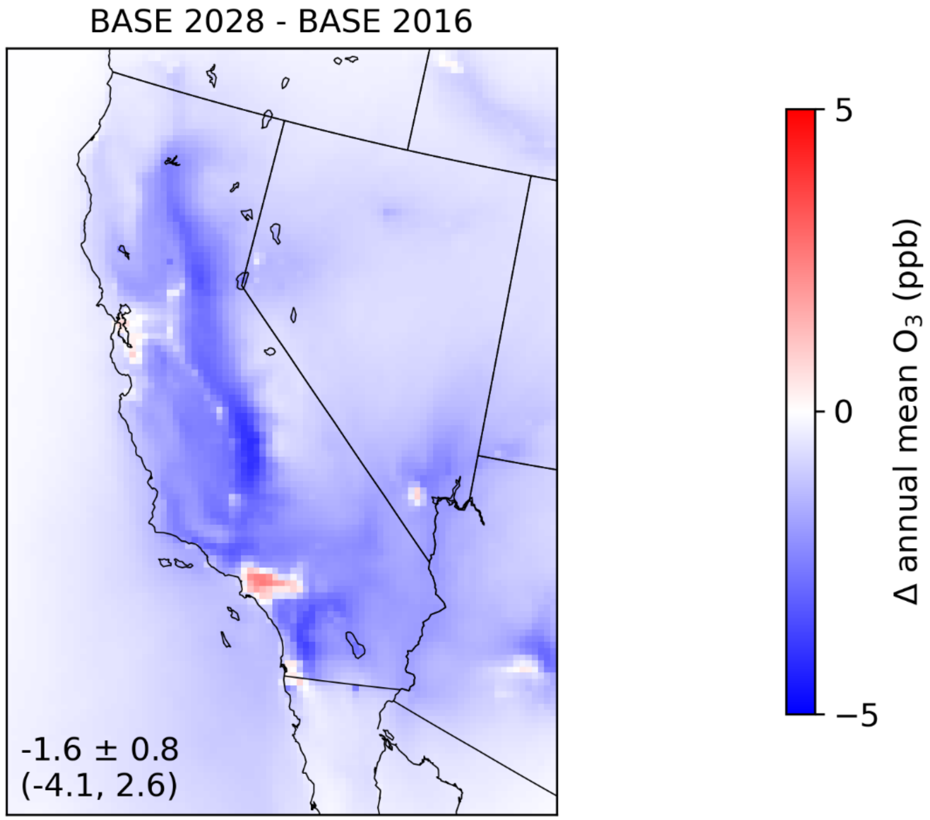


4th highest

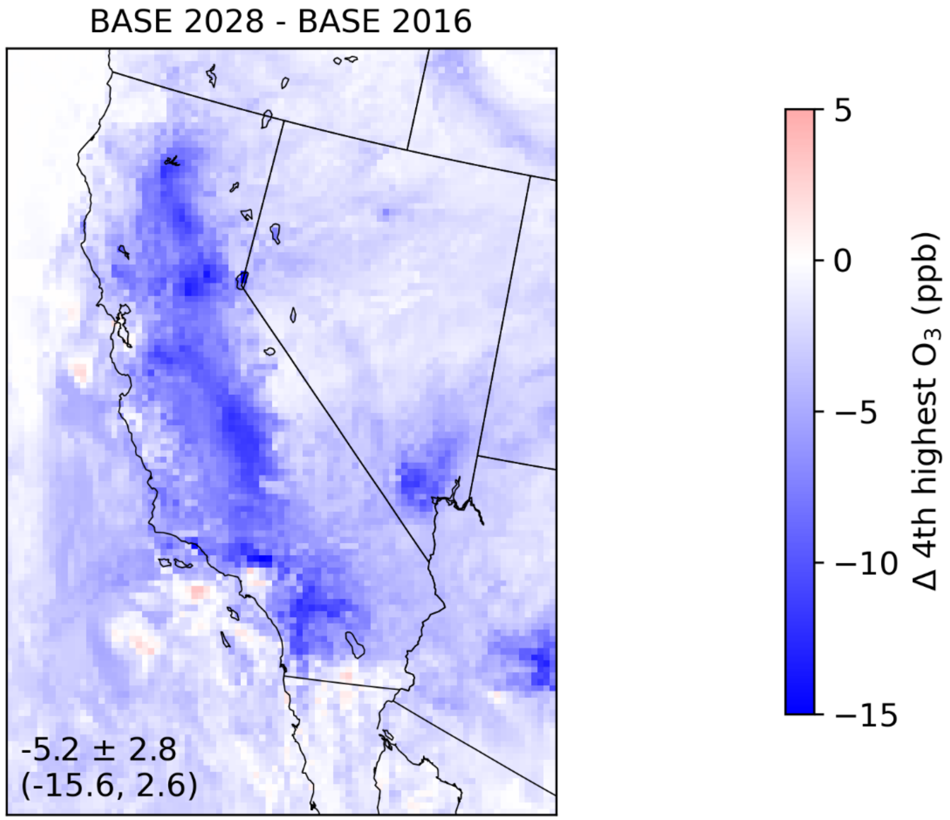


Change in ozone from 2016 to 2028

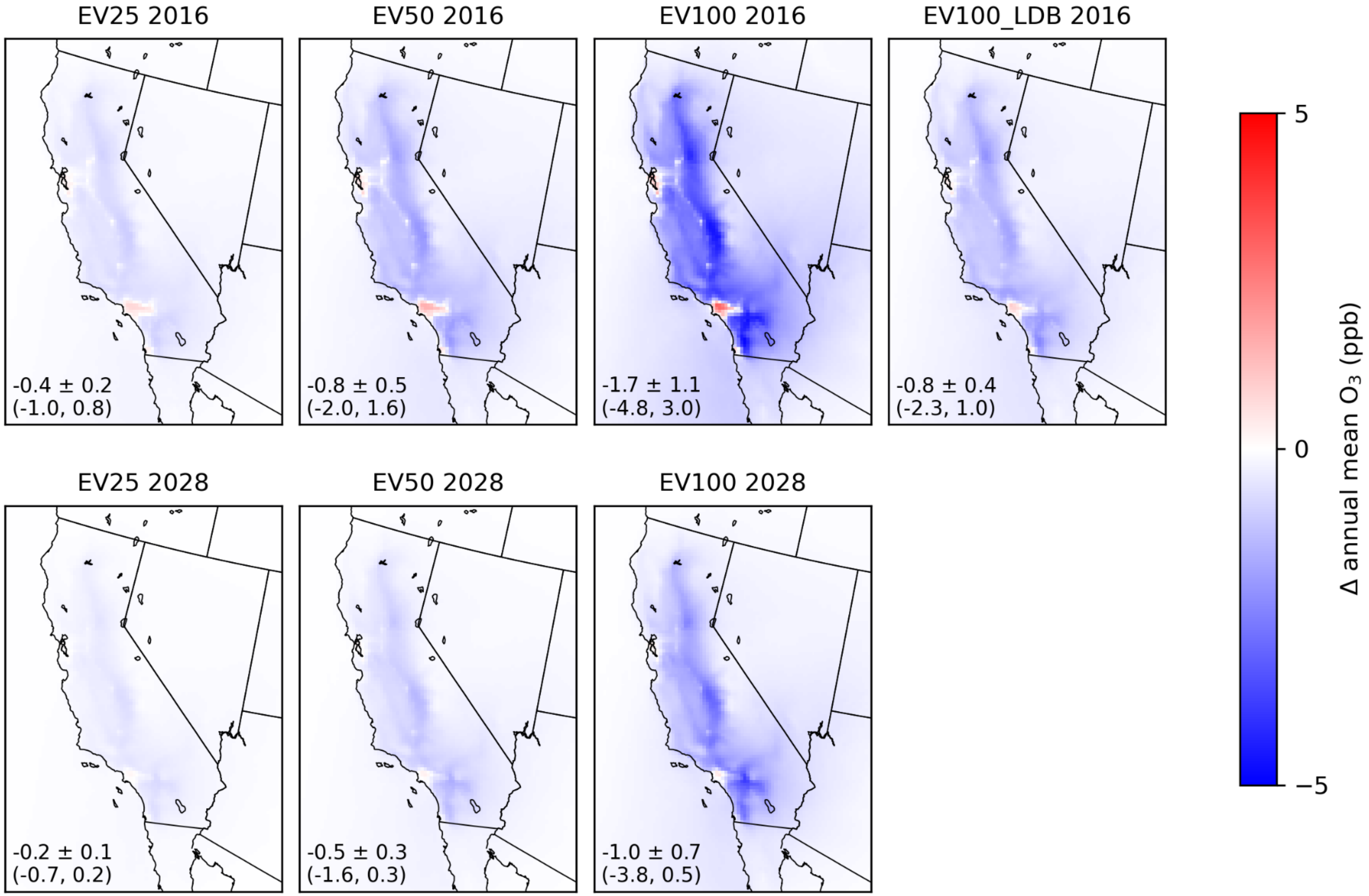
annual mean



4th highest



Change in annual mean ozone from BASE



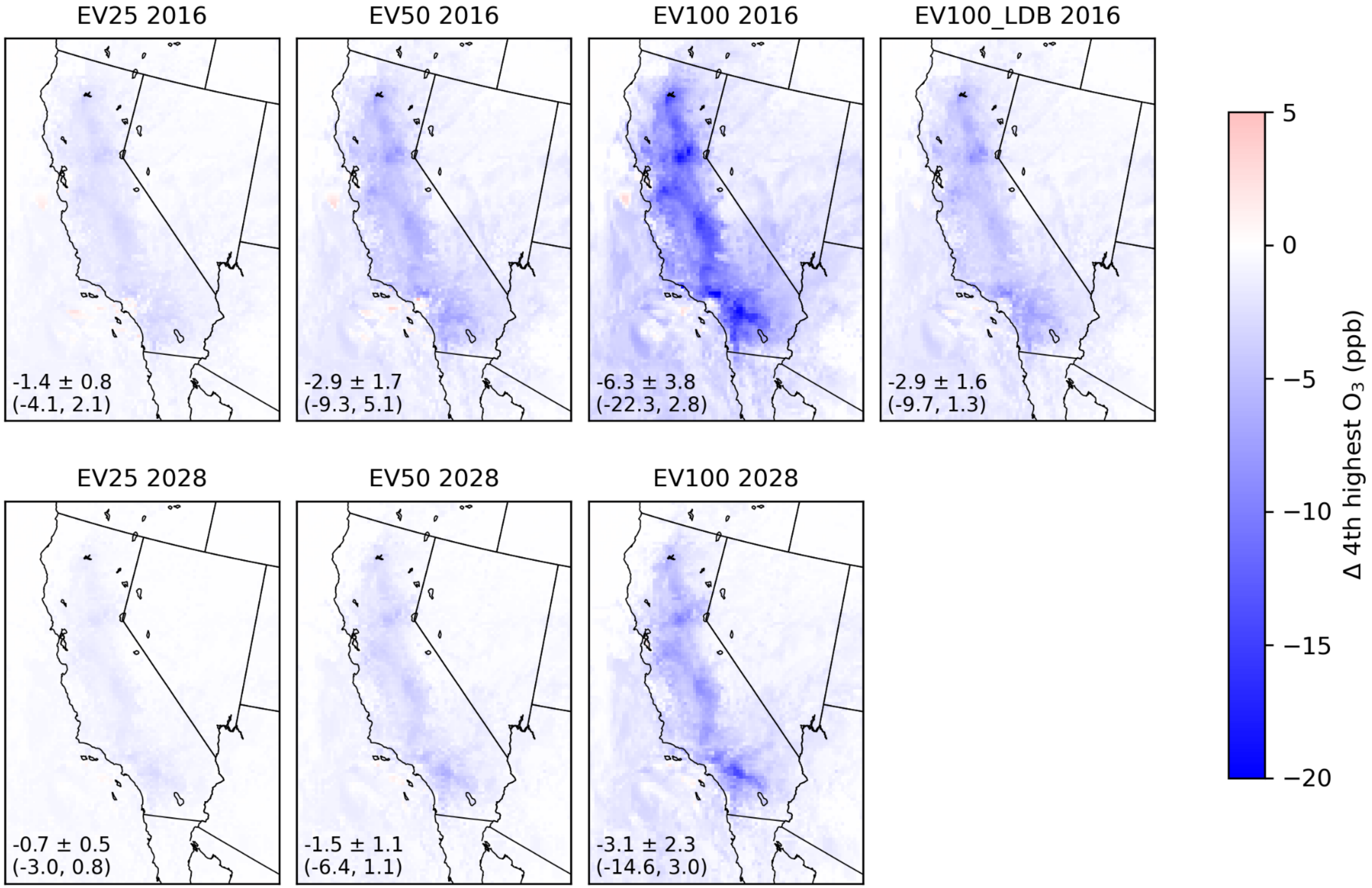
Decreases (and increases) in ozone scale about linearly with increasing EV adoption.

LDB scenario is comparable to EV50, though increases in LA area are lessened.

Increased ozone in LA due to decrease of NOx titration loss pathway.

NOx disbenefit is smaller in 2028 simulations.

Change in 4th highest ozone from BASE

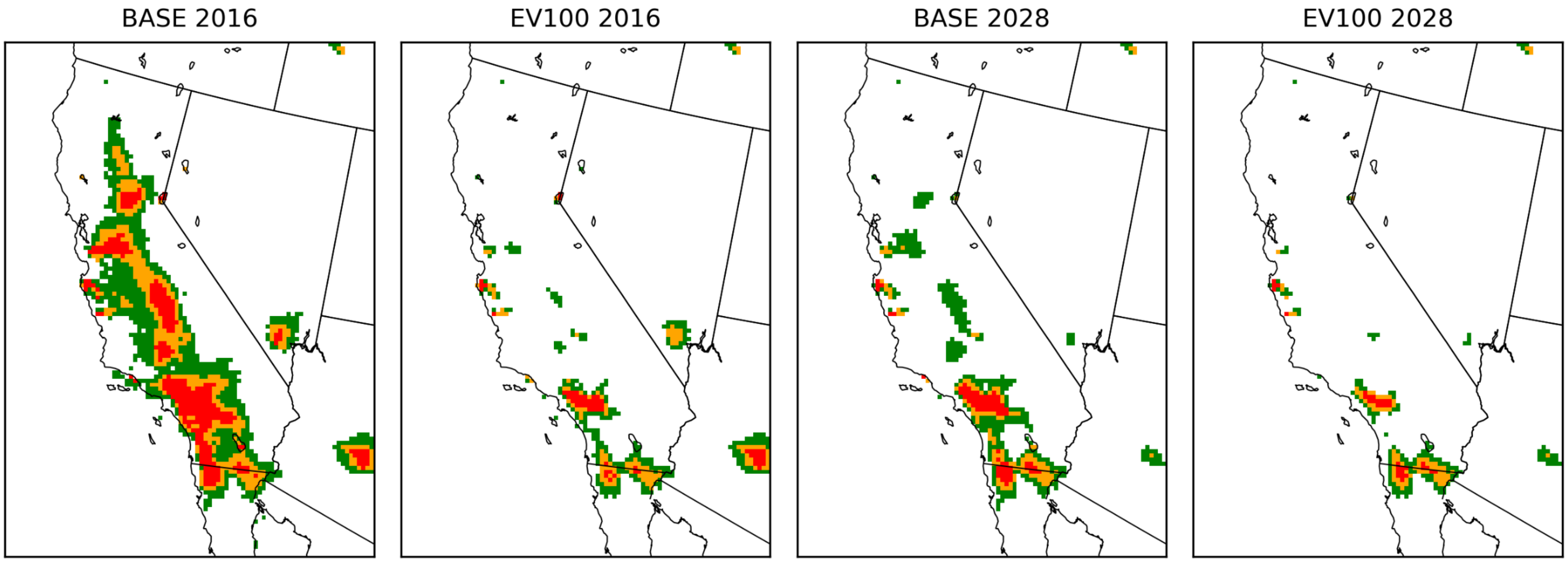


Decreases in ozone scale about linearly with increasing EV adoption.

NOx disbenefit near LA is lessened when going from 50% to 100% EV adoption.

LDB scenario similar to EV50, except the ozone increases are smaller.

Potential ozone non-attainment areas



<u>4th highest 8-hr avg. ozone</u>

Green – exceeds 60 ppb

Orange – exceeds 65 ppb

Red – exceeds 70 ppb

Other controls besides converting to EVs will be needed to reach attainment in some places.

Some limitations

- EV adoption in other states is not considered. It is unlikely that EV adoption in California would not have effects on the vehicle fleets in nearby states.
- Effects of regenerative braking and increased vehicle weights on BW and TW emissions are not considered.
- Does not account for any changes in EGU emissions to provide the additional electricity for EVs. Assumes that any incremental electricity is generated by renewable energy sources with zero emissions.

Conclusions

- For both PM2.5 and ozone, simulated air quality improvements scale approximately linearly with increased EV adoption.
  - No diminishing of returns
- Based on current projections of vehicle inventories, there will still be air quality improvements available from adopting EVs in the future.
- Tailpipe emissions dominate the contribution to PM2.5, but non-tailpipe emissions need to be considered.
  - Up to 0.5 μg/m^3 impact from BW+TW.
  - BW contains metals (e.g., iron & copper) that are associated with oxidative potential.
  - Effects of regenerative braking and increased vehicle weights on BW/TW emissions need to be considered in emissions modeling.