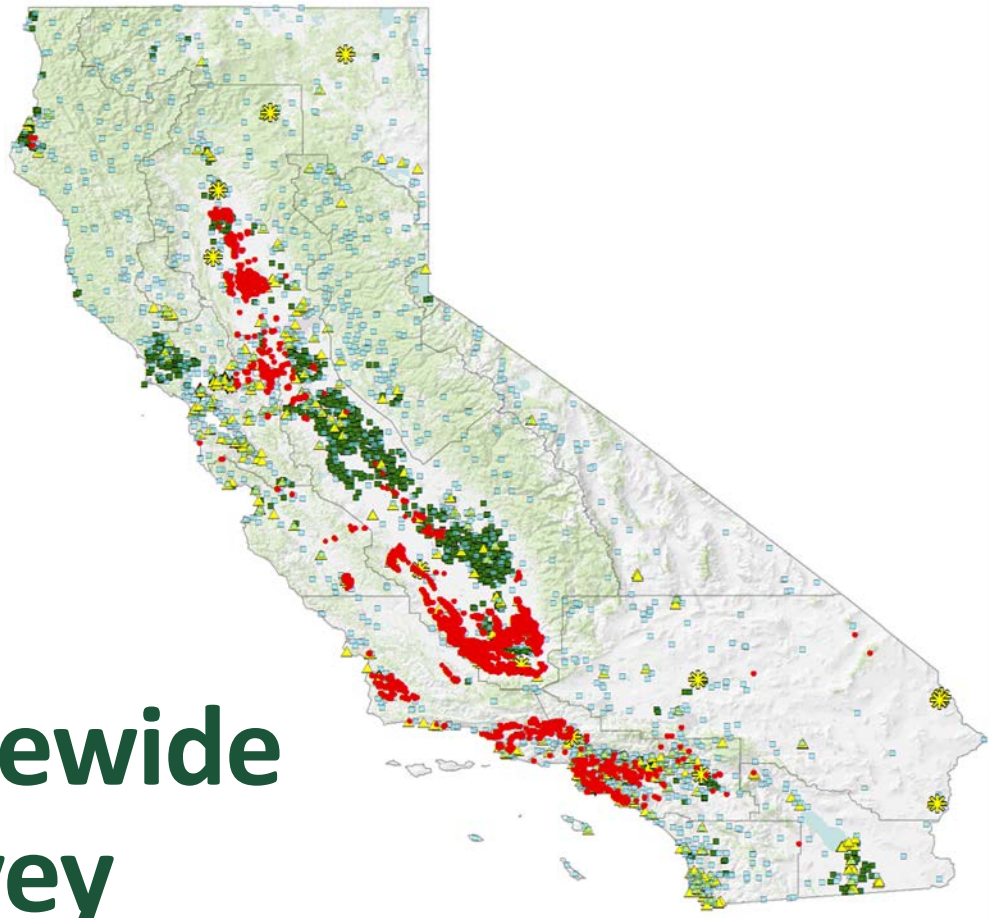


# California Statewide Methane Survey

CARB-CEC-NASA/JPL Joint Study

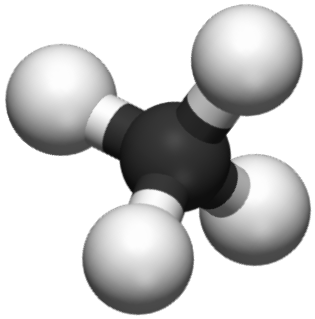
CALIFORNIA AIR RESOURCES BOARD

September 28, 2017

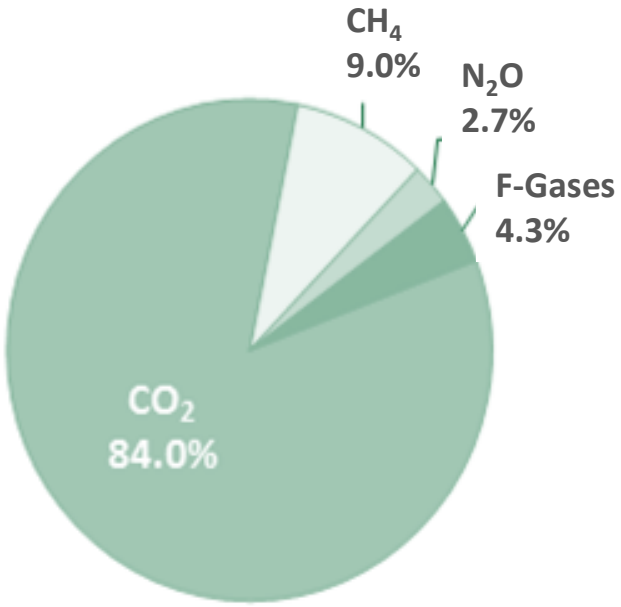
# Overview

- Background
- Technical Approach
- Results
- Conclusions

# Methane



- Second largest contributor to statewide GHG emissions
- Powerful short-lived climate pollutant (SLCP)
- Methane reduction has immediate climate benefits




**2015 Total CA Emissions (100-Year GWP)**

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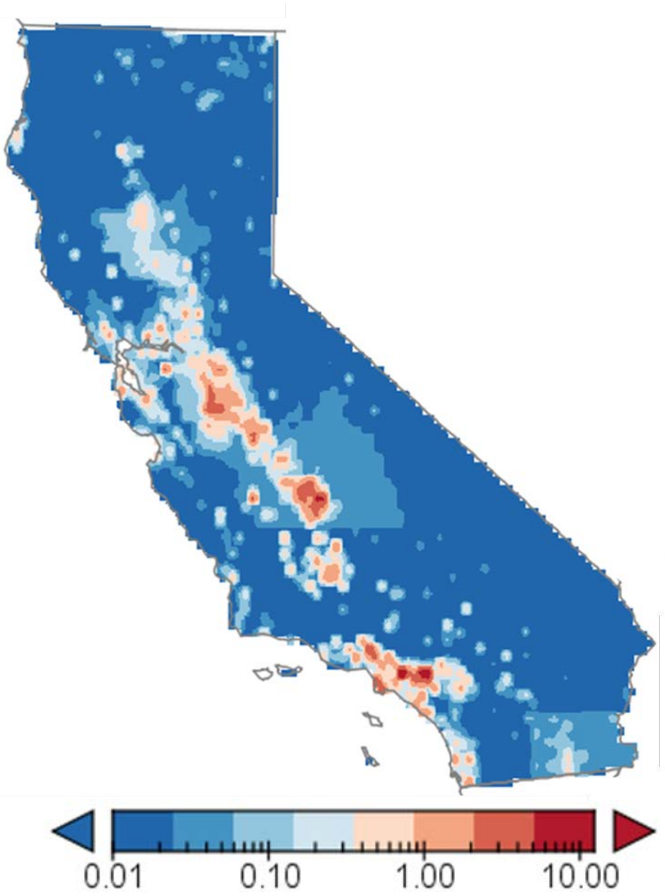
# California Methane Emissions

- Agricultural sector contributes roughly 60%
- Waste and Industrial sectors contribute roughly 20% each
- Atmospheric measurements indicate statewide methane emissions may be greater than estimated




Fischer, M.L. (2016). "Atmospheric Measurement and Inverse Modeling to Improve GHG Emission Estimates", CARB Contract No. 11-306

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# Aliso Canyon Natural Gas Leak

- Aliso Canyon leak at its peak added 30% to daily statewide emissions
- Leak large enough to be detected from space
- CARB determined full mitigation would need a reduction of 109,000 metric tons of methane

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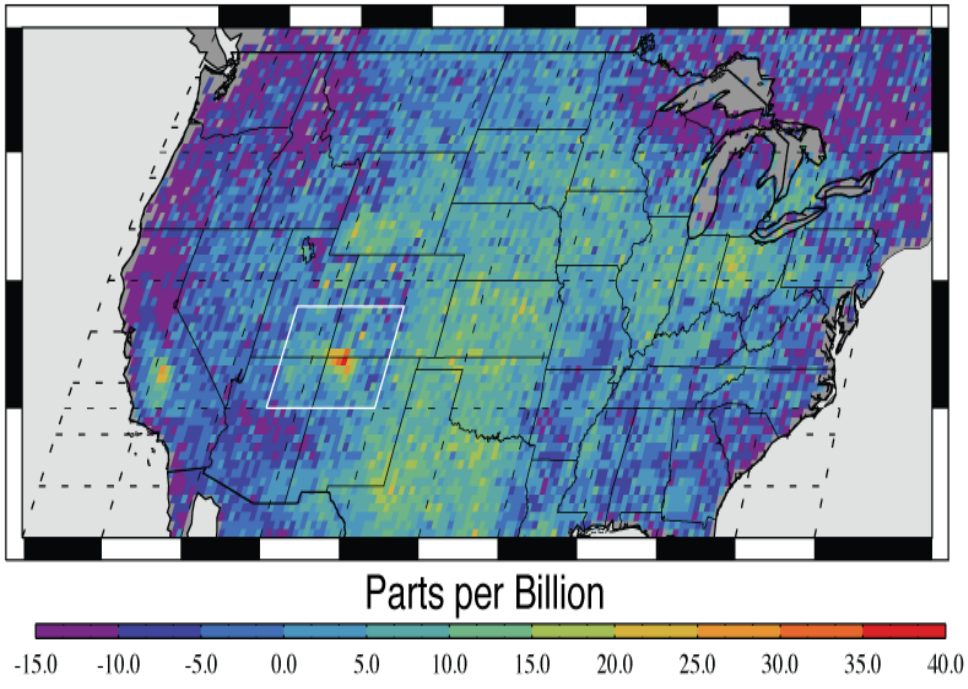
# Methane "Hot-Spots"

- Two large persistent methane "hot-spots" in the U.S.
  - Four Corners region
  - San Joaquin Valley
- San Joaquin Valley (SJV) methane "hot-spot" region has the highest concentration of methane sources in the State
- Large number of small sources and/or small number of large sources




2003-2009 Satellite Methane Signal
(Kort et al., 2014)

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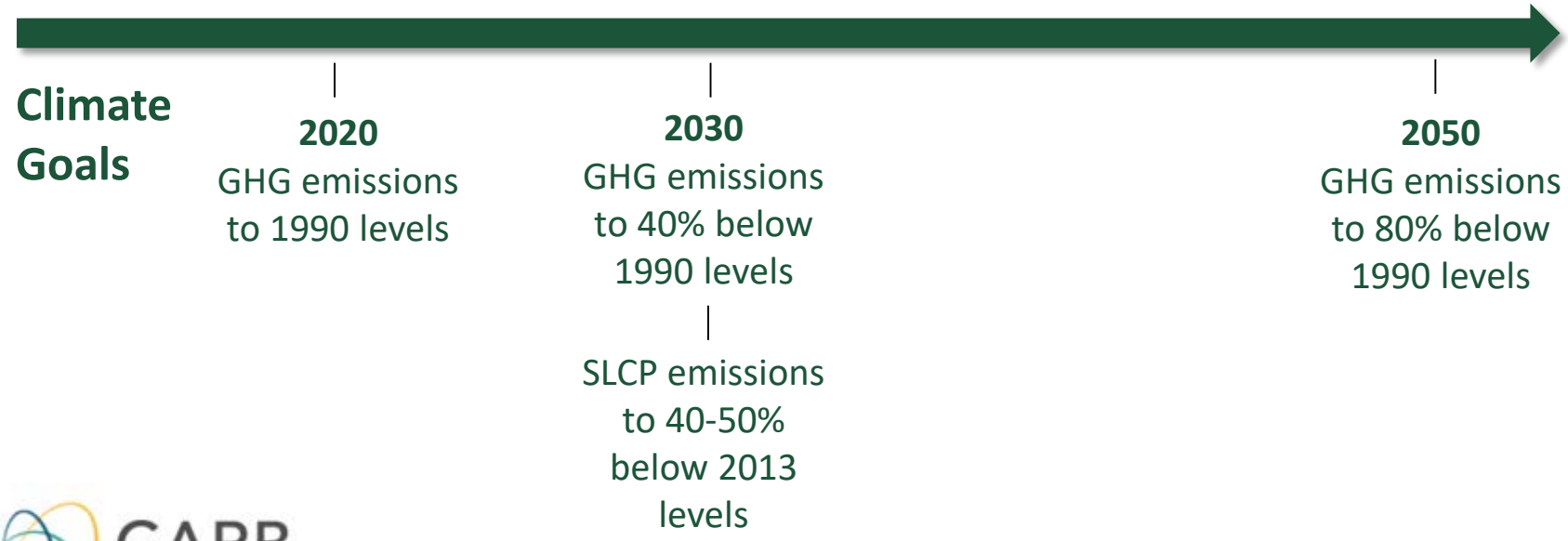
# California's Methane Program

- California Law for Methane and other SLCPs
  - SB 605 (Lara, 2014) – Develop SLCP Strategy by January 1, 2016
  - SB 1383 (Lara, 2016) – Implement SLCP Strategy by January 1, 2018
  - SB 888 (Allen, 2016) – Fully mitigate Aliso Canyon and any future disasters
  - AB 1496 (Thurmond, 2015) – Investigate methane emission "hot spots"

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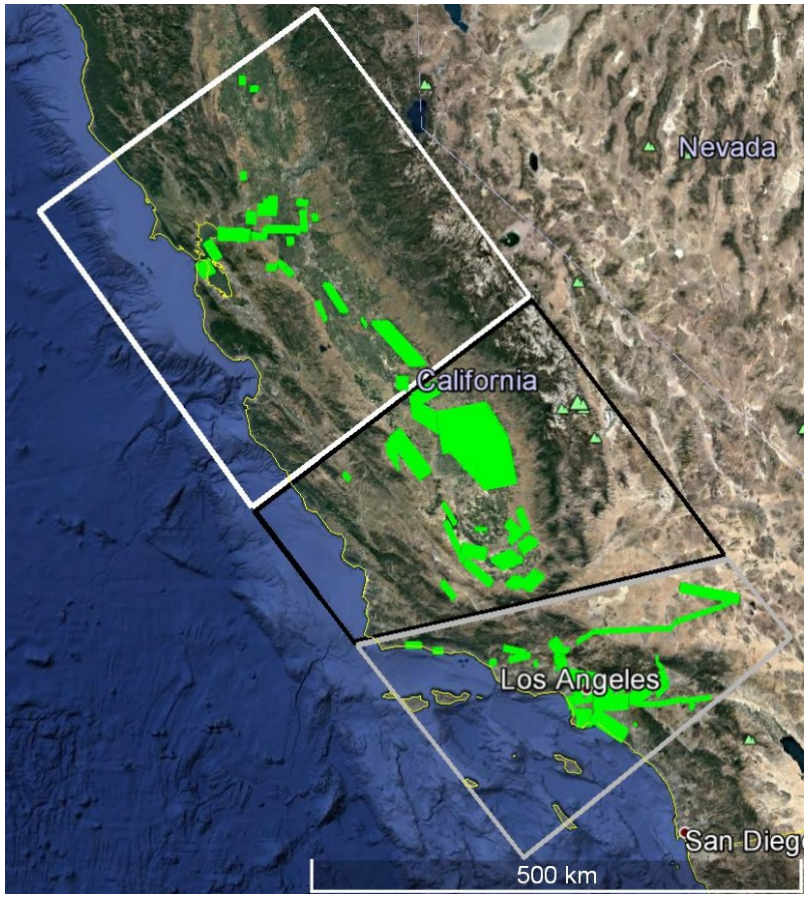
# California Statewide Methane Survey

- Joint collaboration between CARB, CEC, and NASA/JPL
- Timeline:
  - Phase 1 completed in 2016
  - Phase 2 ongoing in 2017
  - Additional funds from NASA for enhanced data analysis (2018)
- Additional ground surveys by CARB

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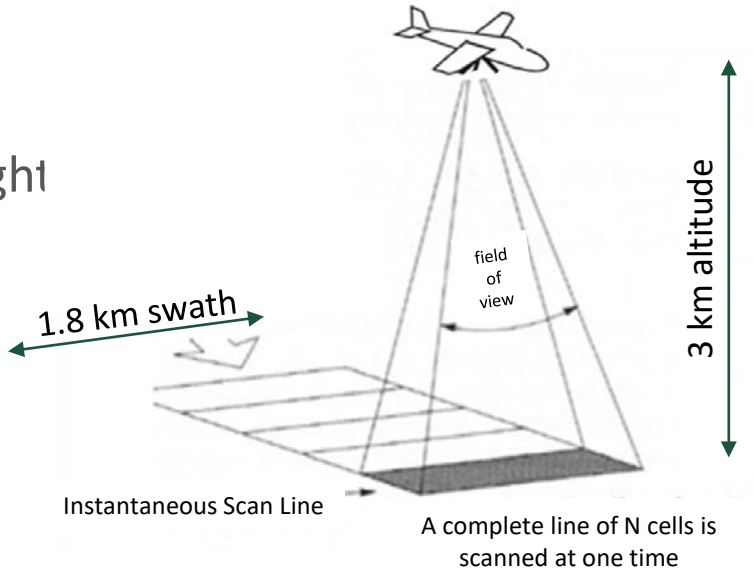
# Technology Overview

- Airborne methane imaging with JPL's AVIRIS-NG instrument
  - "Pushbroom" sensor measures reflected solar radiation along the flight path
  - Infrared absorption by methane to detect plumes
  - Point source detection within meters
  - Quantifies methane in kg for each plume
- Different airborne approach than used for CARB's Aliso Canyon quantification

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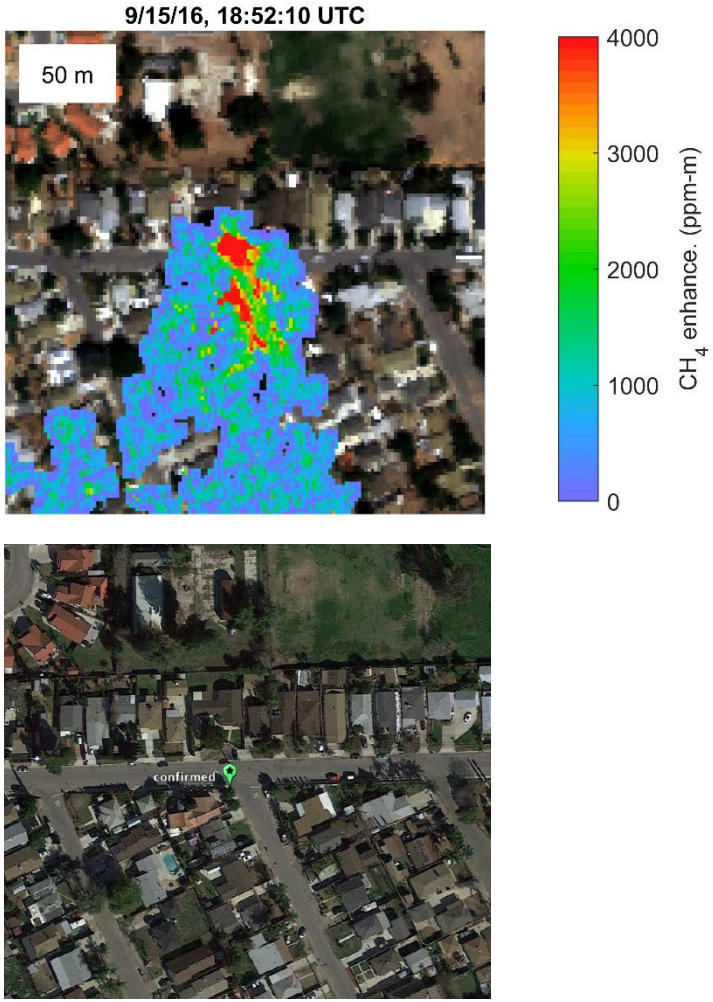
# Methane Point Source Detection Capability

- Point source detection method (< 10 meters location accuracy) for large sources
- Snapshot in time – robust emissions estimate from point sources is challenging
- Not sensitive to area sources
- Phase 1 reports only methane enhancements not emissions

Gas distribution line

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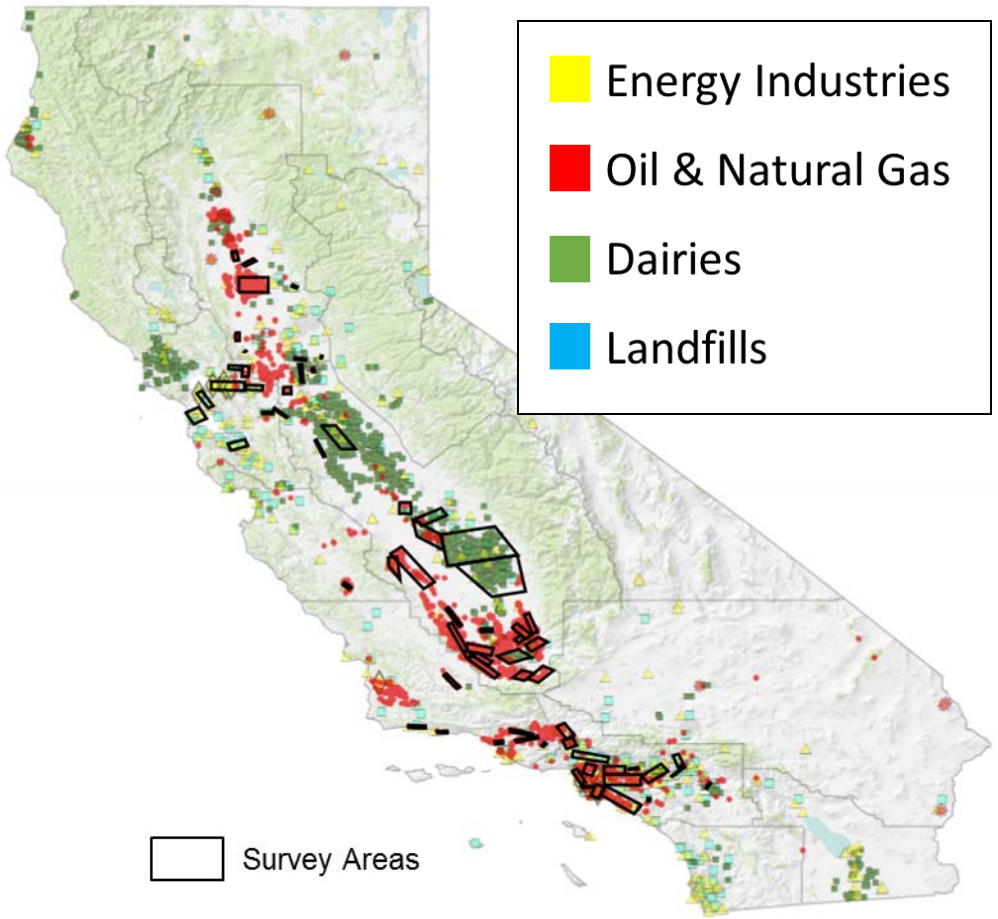
# Survey Area

- Survey area selected to capture majority of methane point sources in California
- CARB-funded Phase 1 study completed in 2016
  - 15,000 $km^2$
  - Phase 2 study started in August 2017

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# Study Results – All Sectors

- 180,000 individual facilities
- Survey completeness
  - 100% of refineries and underground gas storage facilities
  - 35% of power plants
  - 38% of high emitting landfills
  - 50% of dairies
  - 45% of oil and gas wells
- Fraction of surveyed facilities with source detection
  - Refineries: 94%
  - Power plants: 0%
  - Landfills: 86%
  - Dairies: 22%
  - Oil and gas production (including wells): 0.00056%

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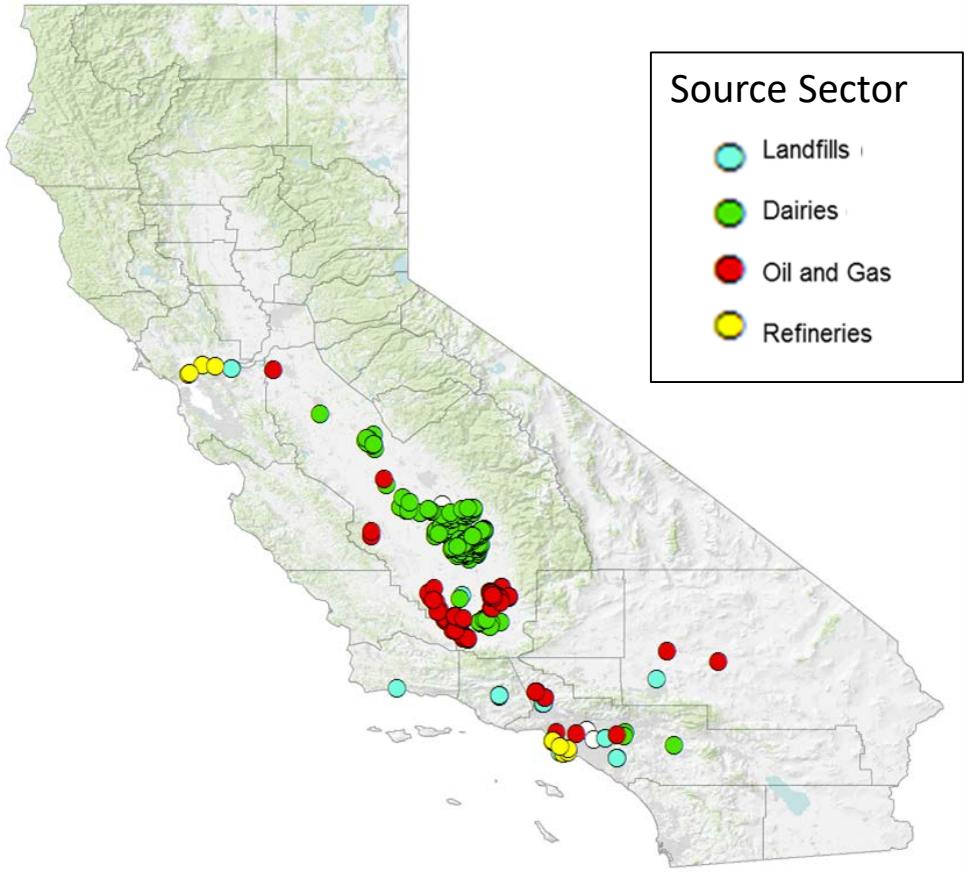
# Study Results

***This study identified 329 point sources across the State***

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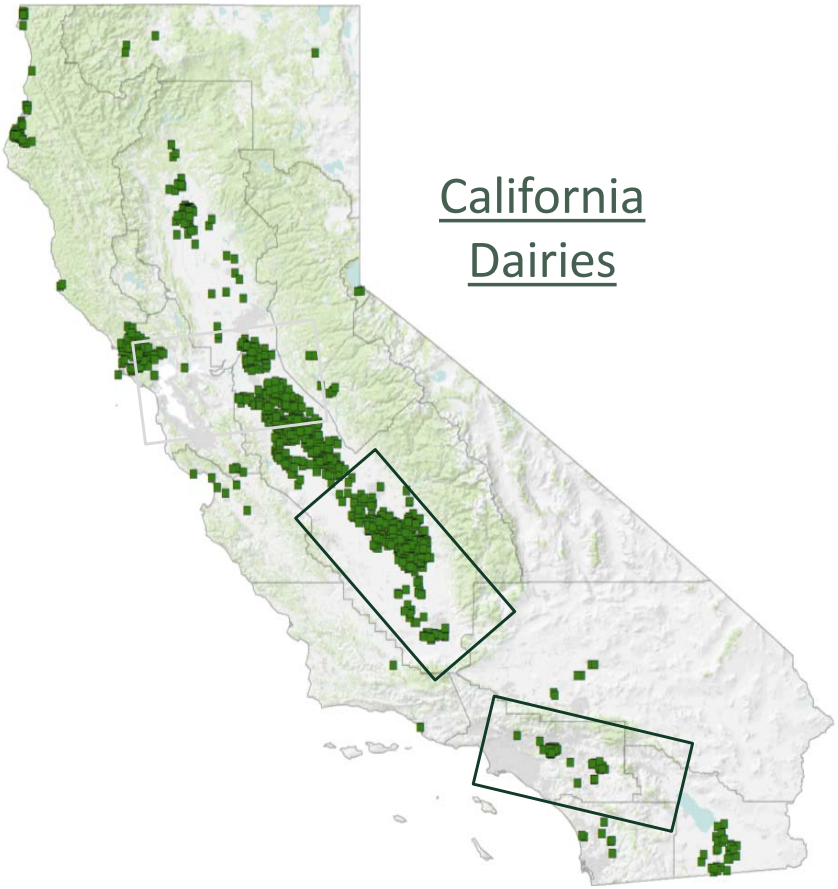
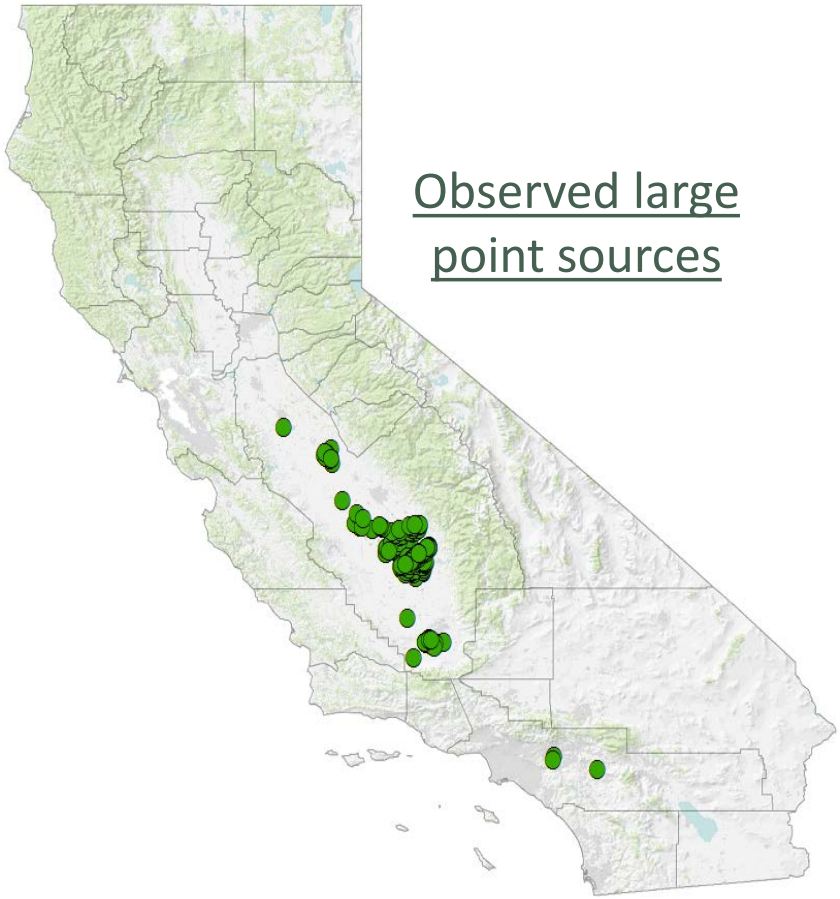
# Study Results – Dairy Sector



California Dairies



Observed large point sources

Over 50% of point sources associated with livestock manure management

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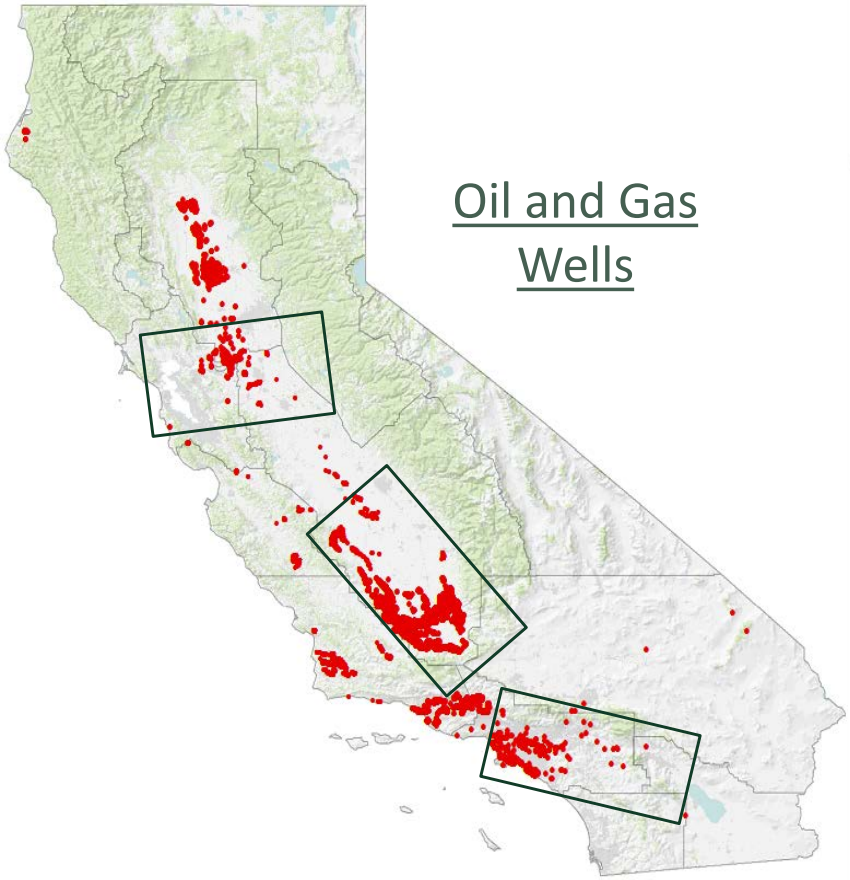
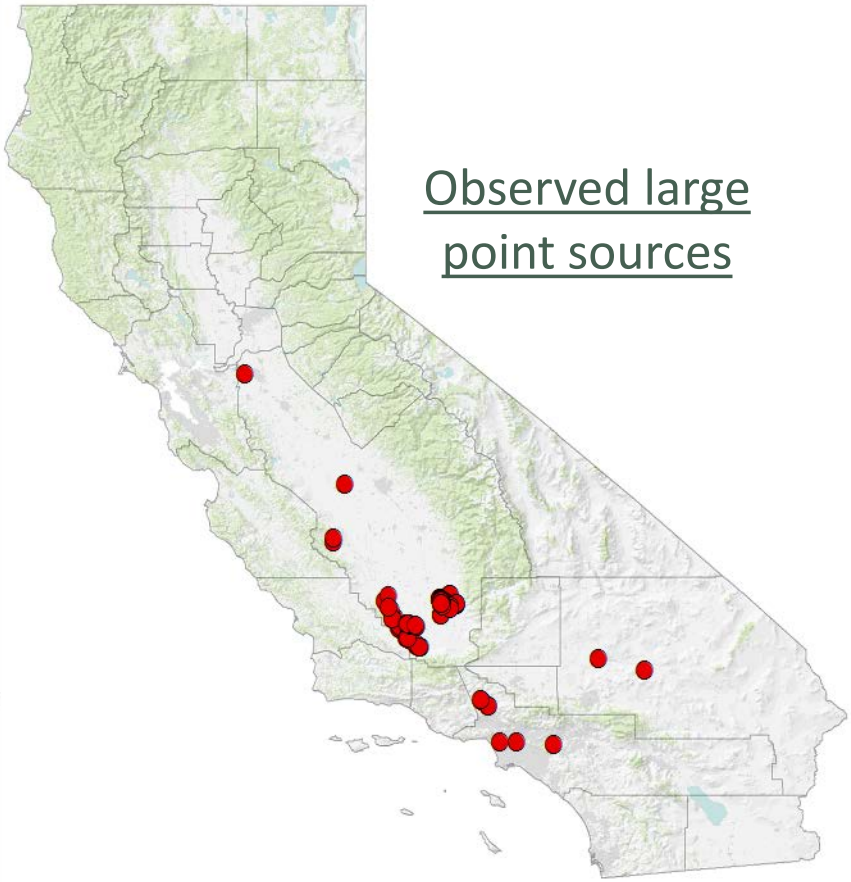
# Study Results – Oil and Gas Sector



Oil and Gas Wells



Observed large point sources

Storage tanks and wellheads responsible for the largest fraction of plumes, most methane sources were found in Kern County oil fields

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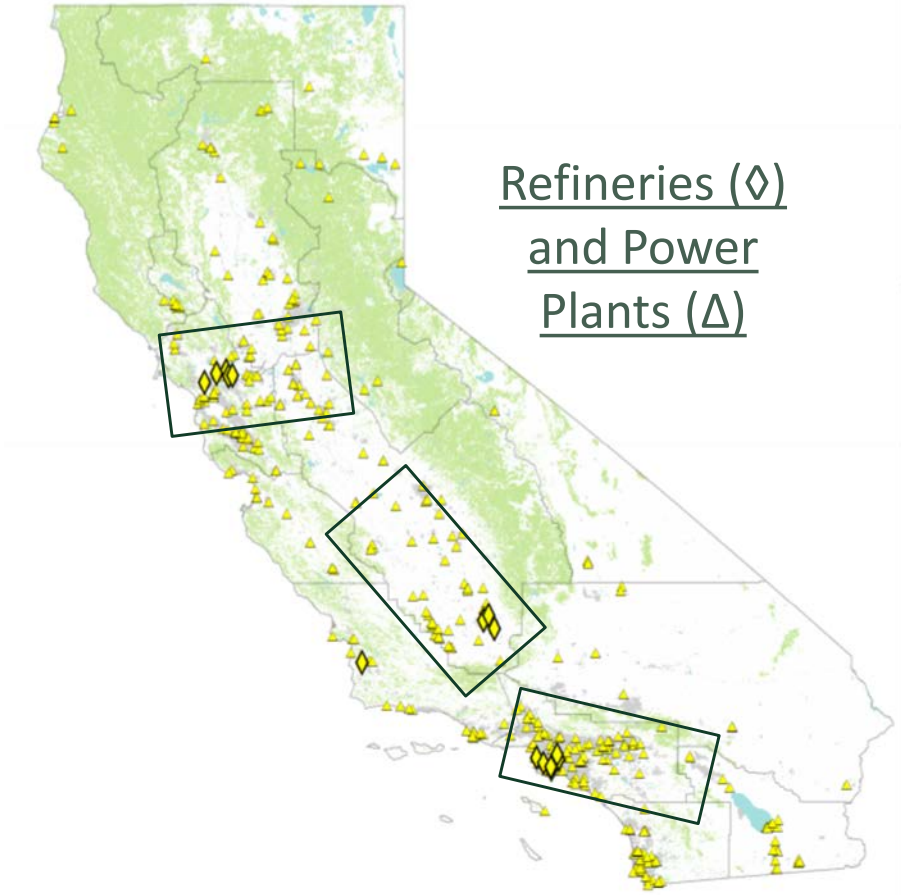
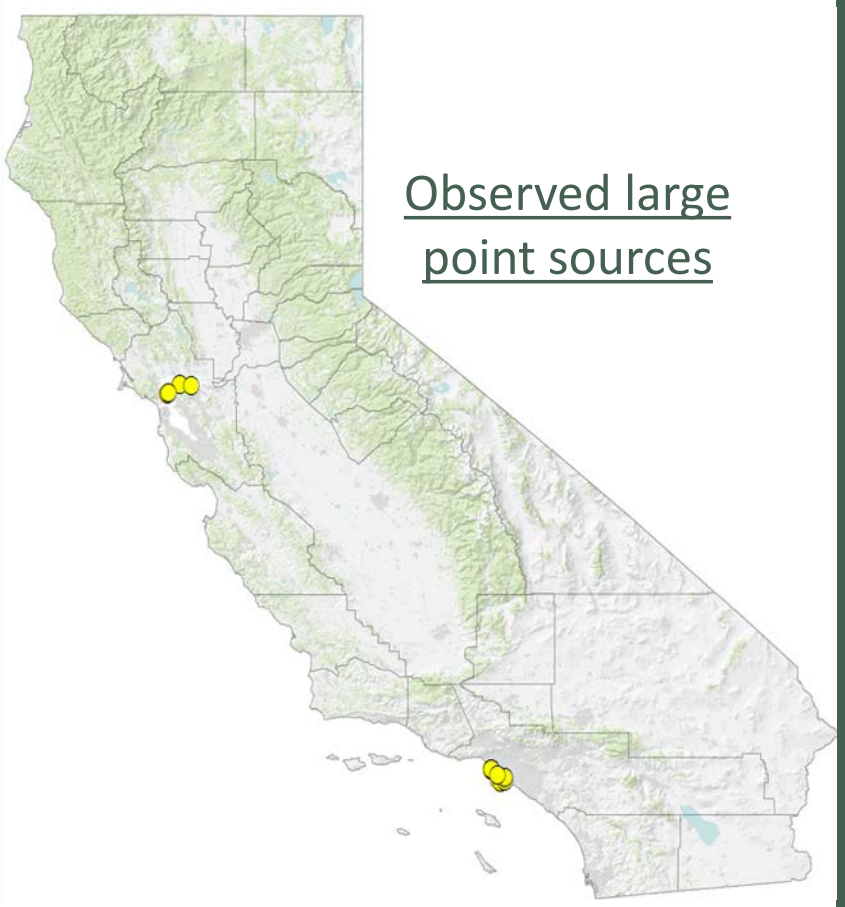
# Study Results – Refineries, Power Plants



Refineries (◊) and Power Plants (Δ)



Observed large point sources

Strong $CH_4$ plumes observed at nearly every refinery sampled, highly episodic

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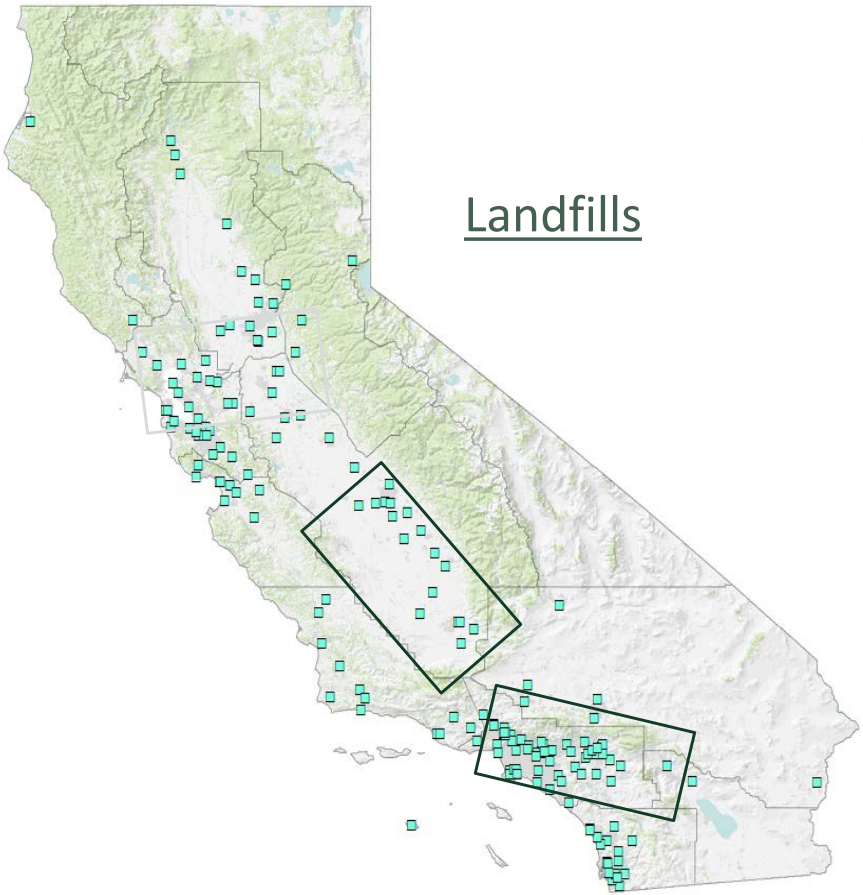
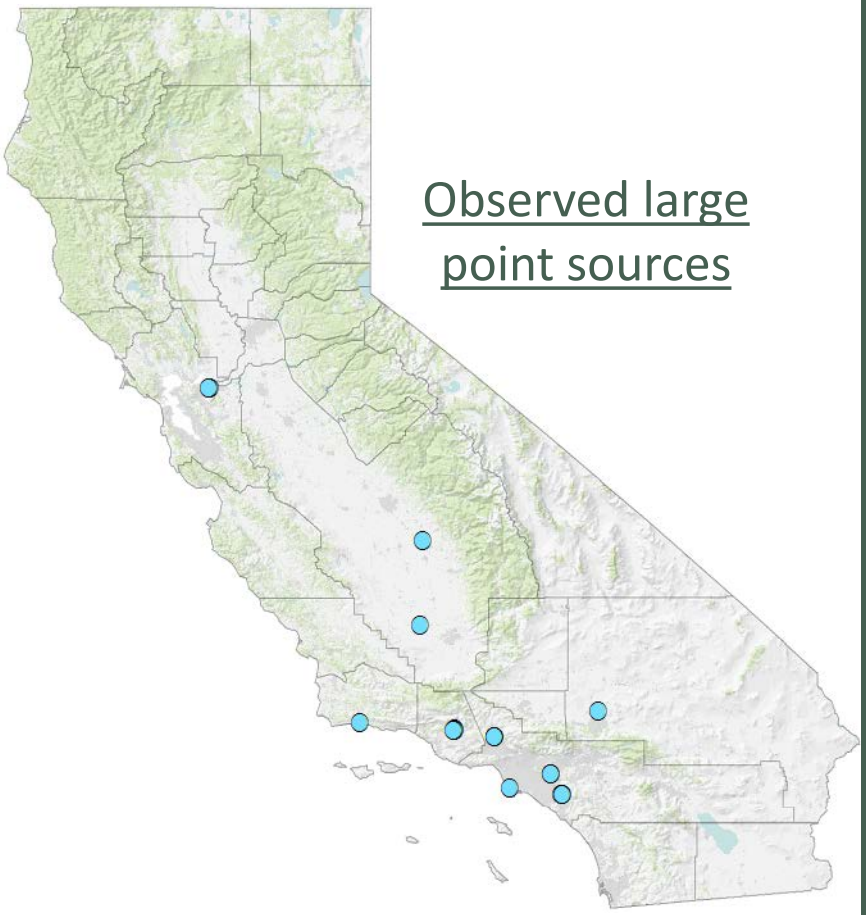
# Study Results – Waste Sector



Landfills



Observed large point sources

Small fraction of landfills present persistent large plumes, but some show almost no methane

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# Prevalence of Large Methane Sources

- All sectors have members in the top 10% of sources, which together contain 60% of the found methane enhancement
- Strong methane plumes observed at a relatively small fraction (< 0.2%) of California's infrastructure
- Emissions from identified large sources could contribute significantly to statewide methane emissions (a robust emissions estimate is planned for the end of phase 2)

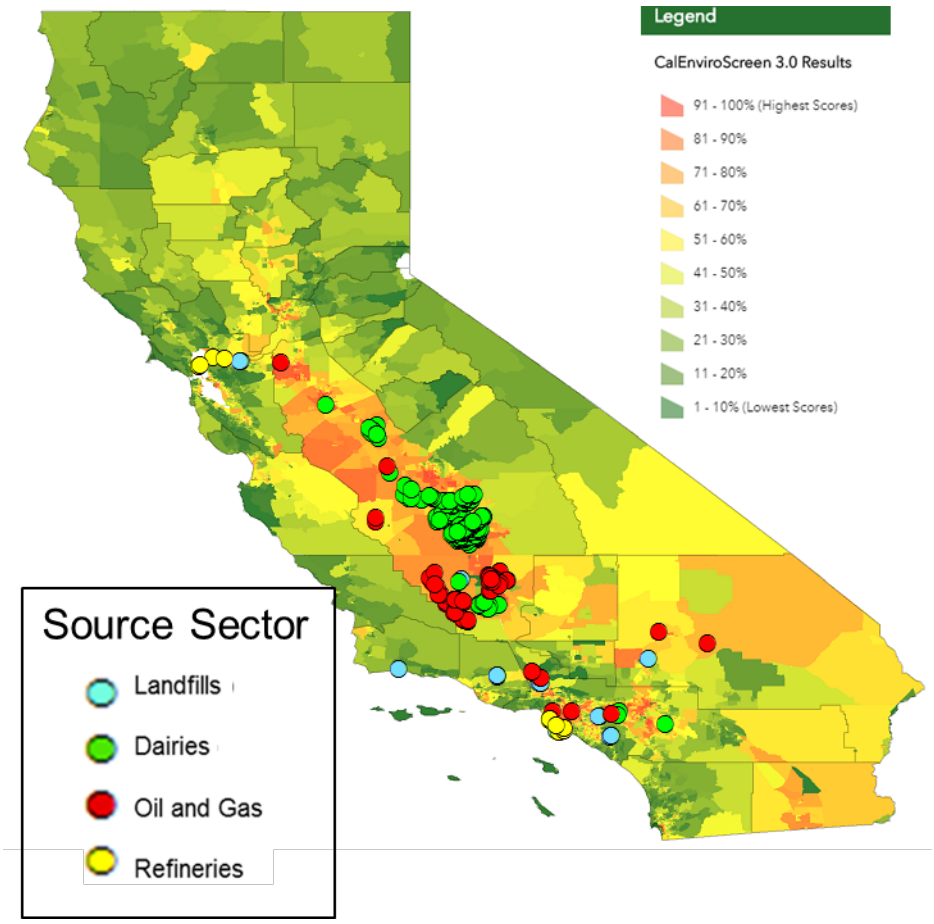
# Relevance to CARB programs

## *Informing programs and policies*

- Oil and Gas Regulation
  - Pre-regulatory baseline and enforcement aid
- Manure management mitigation
  - Helps prioritize investments
- Natural gas underground storage and distribution
  - Leak detection for public safety
- Environmental Justice

# Environmental Justice

- Methane itself is non-toxic
- Study results informative to reduce cumulative emissions, exposure, and health impact from associated pollutants
- Follow-up research to measure toxics emissions from super-emitters, and impacts in disadvantaged communities
- Informing community selection for Oil and Gas Community Monitoring efforts

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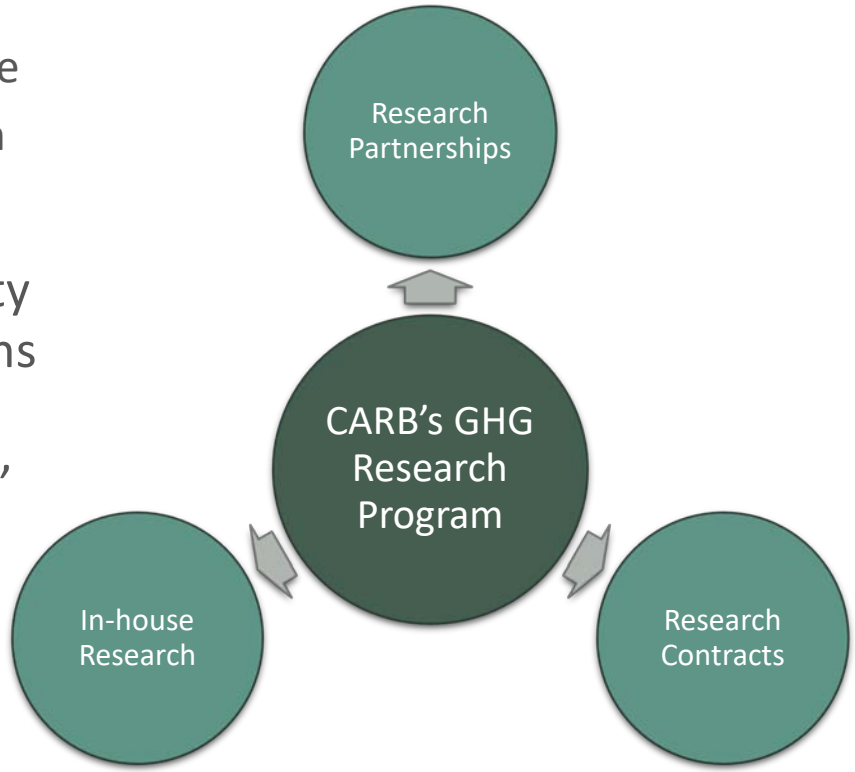
# Continuing Research

- California Methane Survey Phase 2
  - Focus on energy sector and persistence
  - NASA/JPL to complete robust emission estimation
- CARB funding projects to study facility level methane and air toxics emissions
- Dairy mitigation and research efforts, coordinated with CDFA (SB 1383)
- CEC funding large field studies to detect and quantify methane emissions in San Joaquin Valley
- CARB in-house methane emissions research and modeling

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# California Methane Research Program


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# Challenges and Future Work

- Study suggests large emitters could be a critical contributor to statewide emissions
  - Opportunity for emission mitigation
- Need to understand the persistence and episodic nature of the emissions in order to produce robust emission estimates
- Further analysis needed to distinguish normal process emissions from leaks or other malfunctions
- Concerns over cuts to federal programs (such as NASA-JPL earth observation resources) could affect progress
- New technologies expected to improve leak detection and mitigation efforts