California's Greenhouse Gas Measurement and Monitoring Program

November 13-15, 2018

Jorn D. Herner
Research Division

916-324-9299
jorn.herner@arb.ca.gov
www.arb.ca.gov/cc/cc.htm

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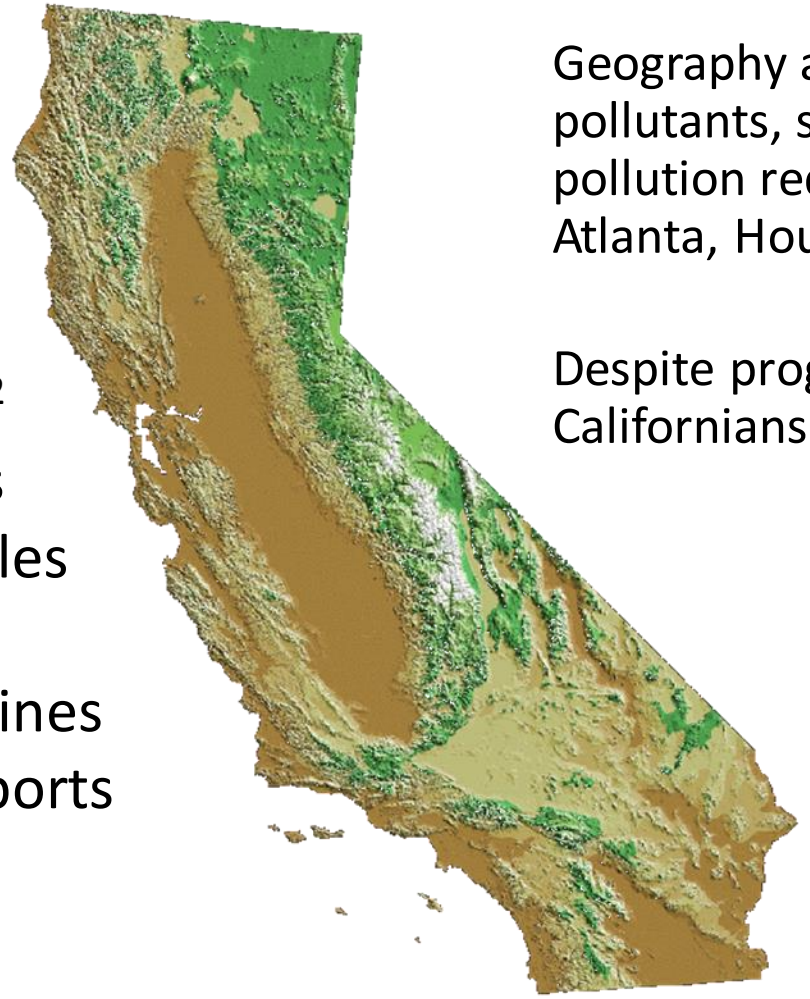
California's Air Pollution Problem

39 M people
90 people per km^2
24 M gasoline cars
1.3 M diesel vehicles
1.4 B km per day
18 M off-road engines
3 large container ports



Geography and meteorology confine air pollutants, so necessary per capita pollution reduction much greater than Atlanta, Houston, New York City, etc.

Despite progress, over 90% of Californians breathe unhealthy air

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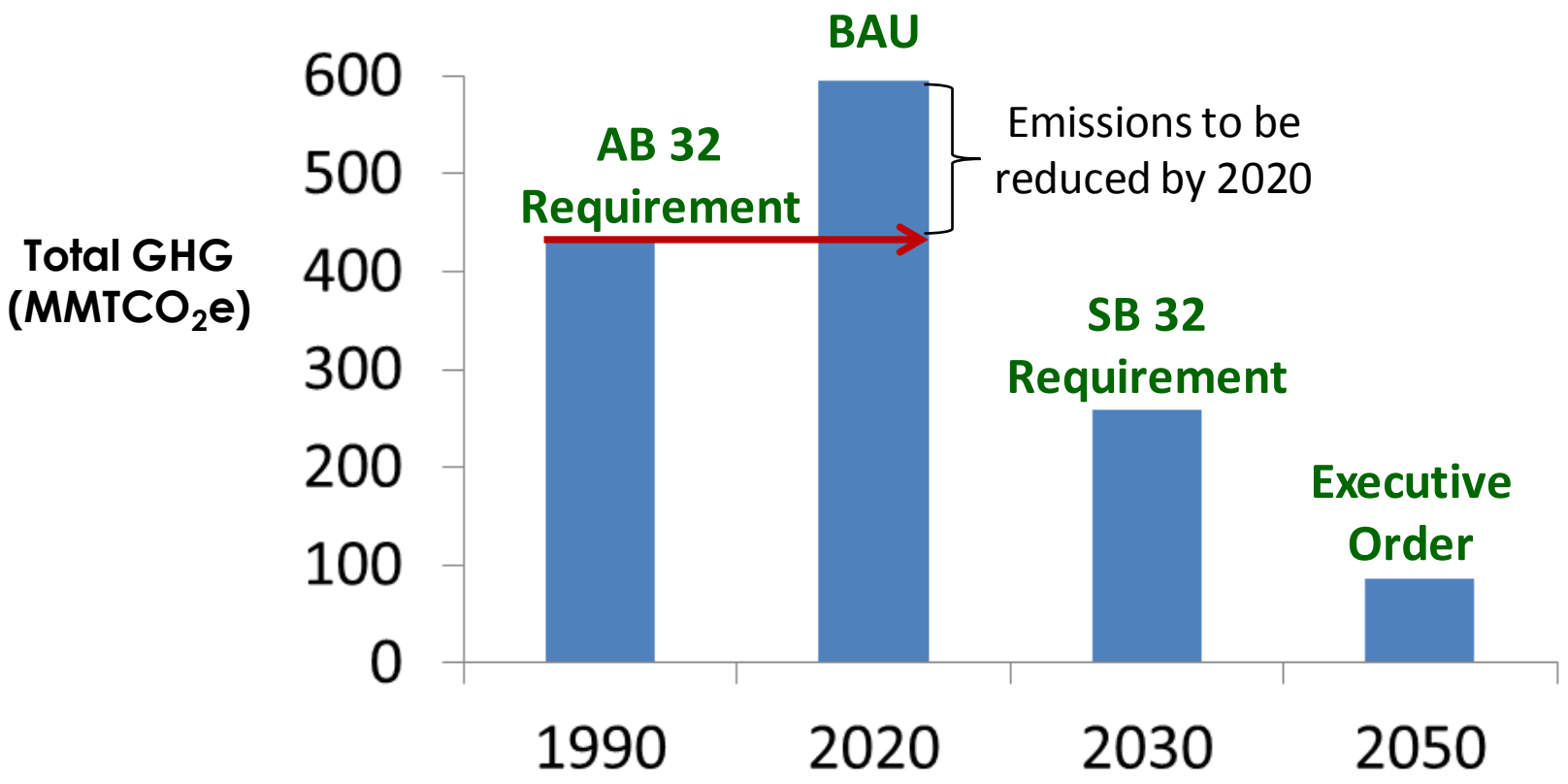
California's Climate Goals



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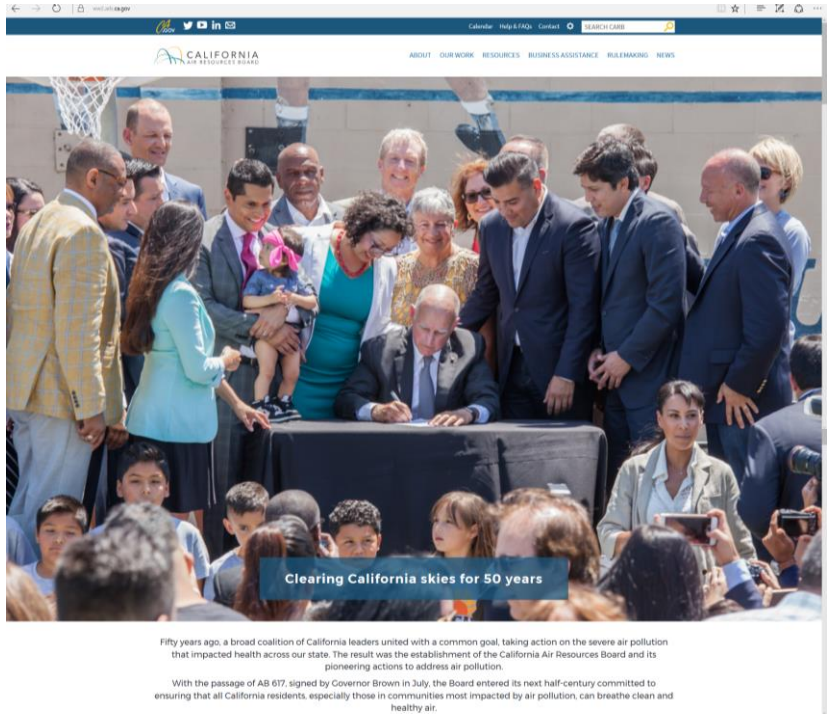
California's Climate Legislation

- Senate Bill 350 (2015)
  - 50% renewable energy by 2030
  - Double energy efficiency
- Senate Bill 1383 (2016) – Requires reductions in SLCPs
  - 40% reduction from 2013 levels by 2030 for CH_4 and HFCs
  - 50% reduction from 2013 levels by 2030 for BC
- Assembly Bill 197 (2016)
  - GHG, criteria and toxic emissions to be posted annually, including locations
- Assembly Bill 398 (2017)
  - Extends State's cap and trade program thru 2030
- Assembly Bill 617 (2017)
  - Identification of communities with disproportionate pollution burden
  - Monitoring and mitigation
- Senate Bill 100 (2018)
  - 100% carbon-free electricity by 2045
- Executive Order B-55-18
  - Carbon Neutrality by 2045



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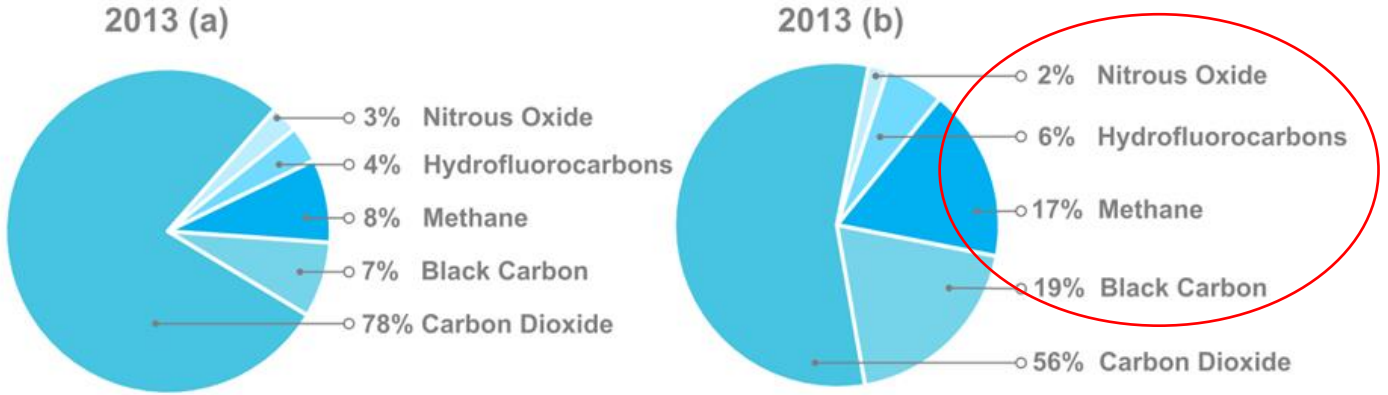
California “Super Pollutant” Legislation

- Senate Bill 605 (Lara, 2014) – Develop SLCP Strategy by January 1, 2016
- Senate Bill 1383 (Lara, 2016) – Implement SLCP Strategy by January 1, 2018
- Assembly Bill 1496 (Thurmond, 2016) – Investigate methane emission "hot spots“
- Senate Bill 888 (Allen, 2016) – Fully mitigate Aliso Canyon and any future disasters
- Senate Bill 1013 (Lara, 2018) – Adopt U.S. EPA high-GWP prohibitions vacated by federal court



(a) 100-year and (b) 20-Year Global Warming Potential values

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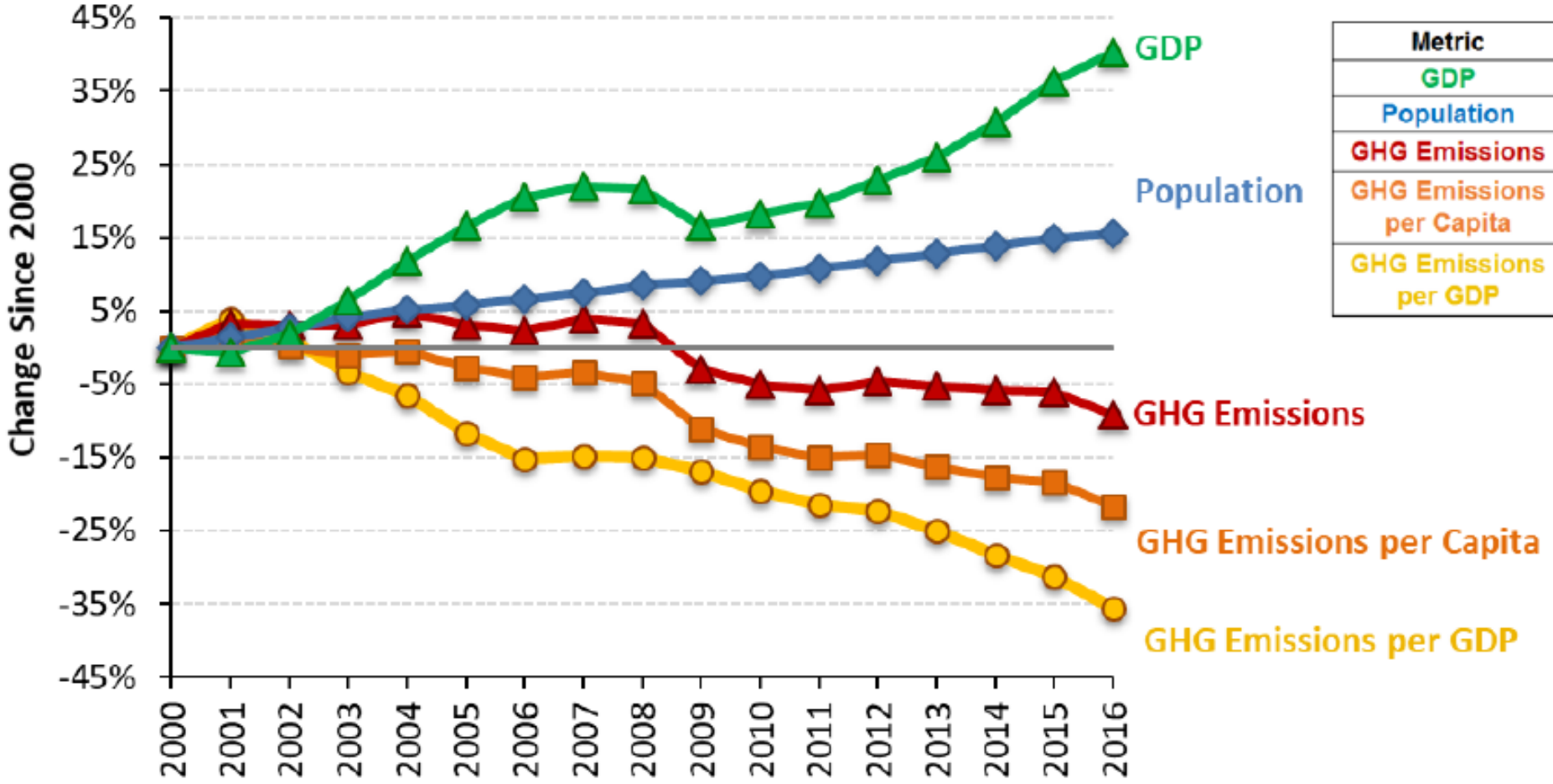
Progress to Date - Decoupling



Metric	Associated 2016 Value
GDP	2.3 trillion (2009 $)
Population	39.3 million
GHG Emissions	429.33 MMTCO_2e
GHG Emissions per Capita	10.8 metric tons CO_2e per person
GHG Emissions per GDP	187 metric tons CO_2e per million dollars

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Climate Research Program Goals

- Improve understanding of emissions
  - Inform inventories
  - Capture spatial and temporal emissions
  - Identify high-emitters
  - Provide California-specific emission factors
  - Study unknown or under-represented sources
- Find opportunities for emission reductions

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California Tiered GHG Measurement Program

CO_2, CH_4, N_2O, F-gases, Black Carbon

COORDINATION

NASA, NOAA, ARPA-E, EPA, NIST, JPL, LBNL, LLNL, Caltech, Scripps, UCs, CEC, CalRecycle, DOGGR, CDFA

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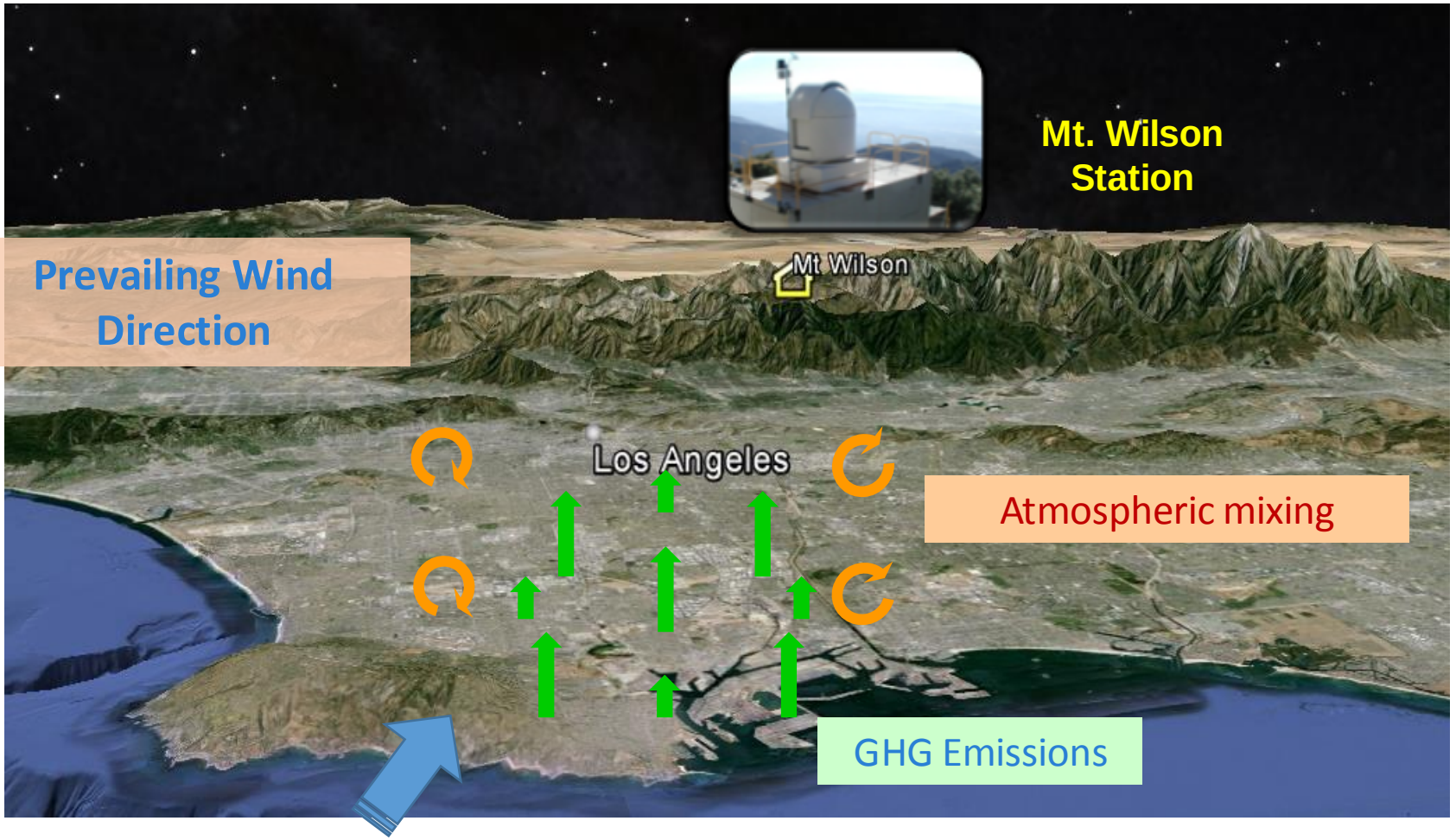
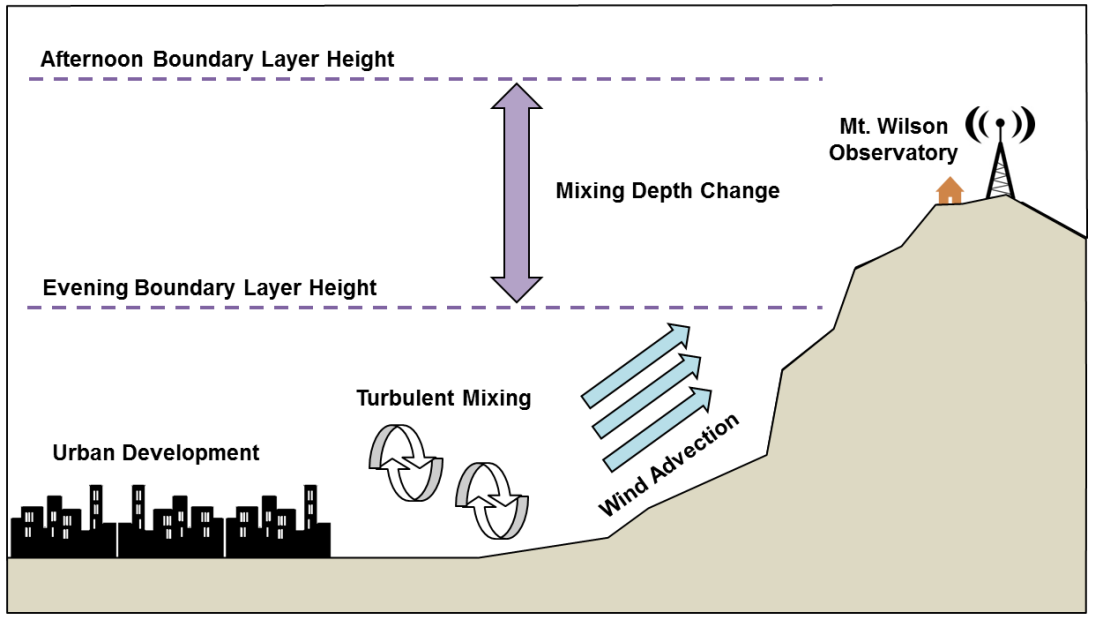
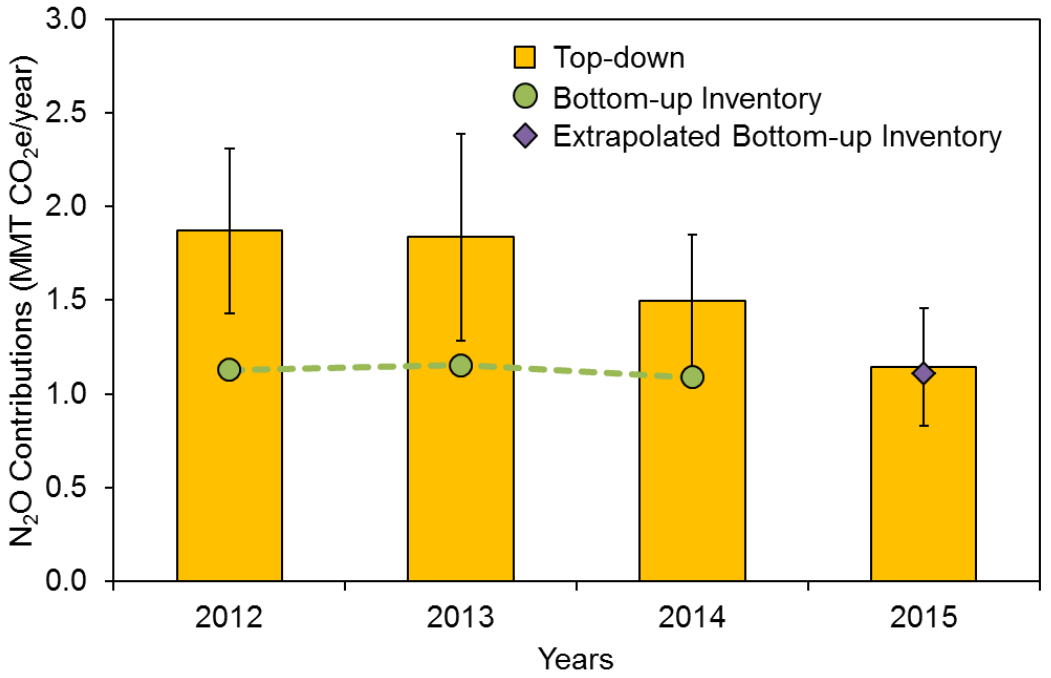
Mt. Wilson Observatory Station
Los Angeles County



Super site in Los Angeles



*Illustrated depiction of air mass transport to Mt. Wilson Observatory

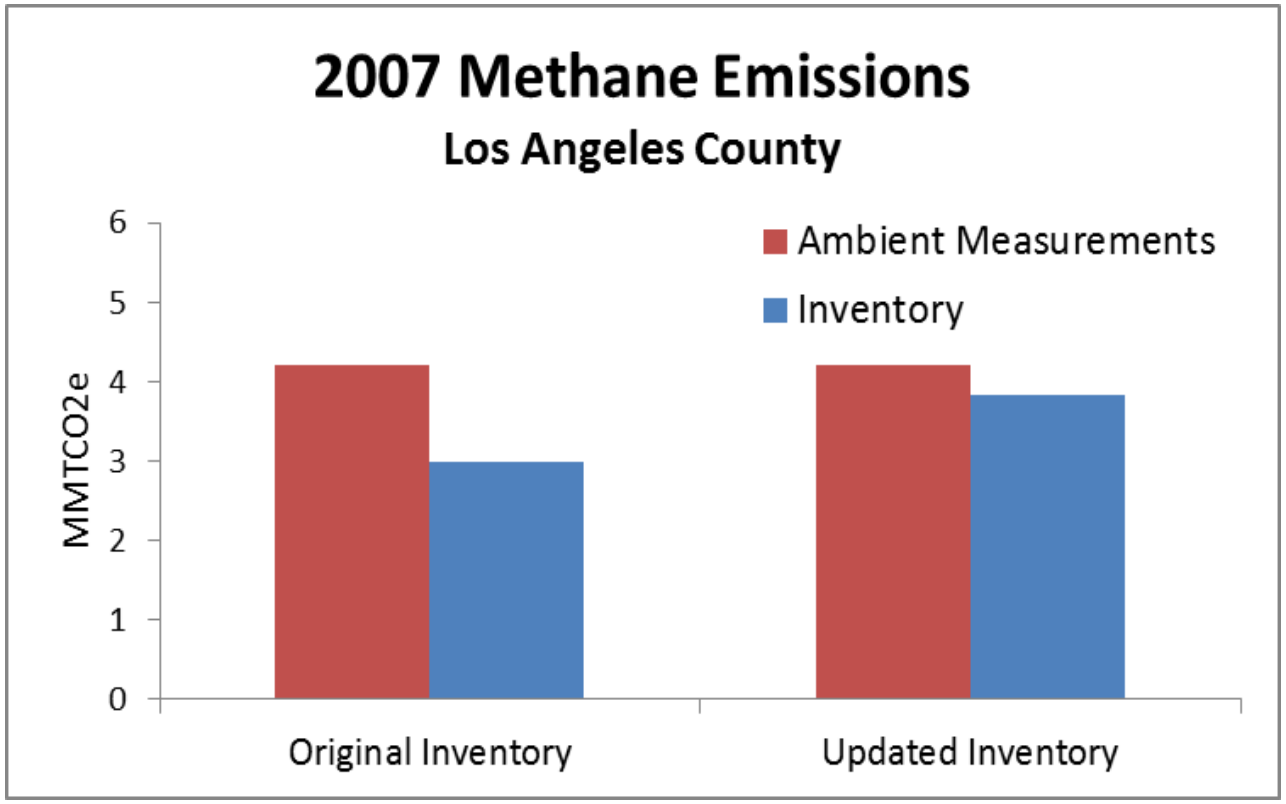


Ideal for tracking long-term trends in urban emissions

Source: Kuwayama, et al. 2018 manuscript in preparation

Super site in Los Angeles

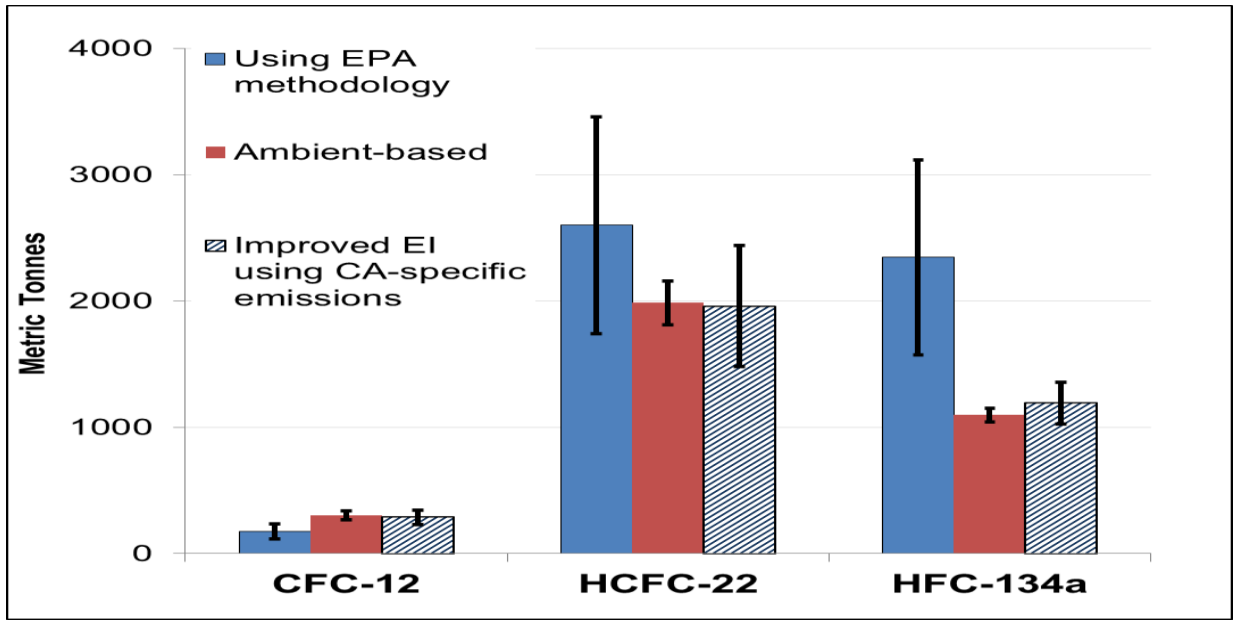
Spatial disaggregation of inventory improved



Reference: Hsu, et al. (2010) *Atmospheric Environment*, pp. 1–7

Super site in Los Angeles

Additional research improved models and inventory



Reference: Gallagher, et al. (2014) *Environmental Science & Technology*, pp. 1084-1093

- Results from national EPA-based method differed significantly from 2007 Mt. Wilson measurements
- New California-specific emissions inventory is consistent with 2007 Mt. Wilson measurements

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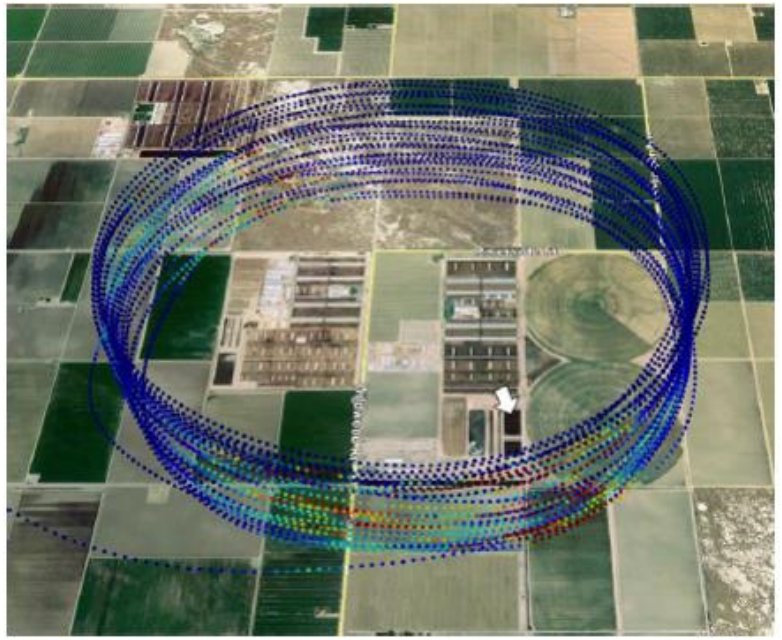
Individual Point Source Characterization



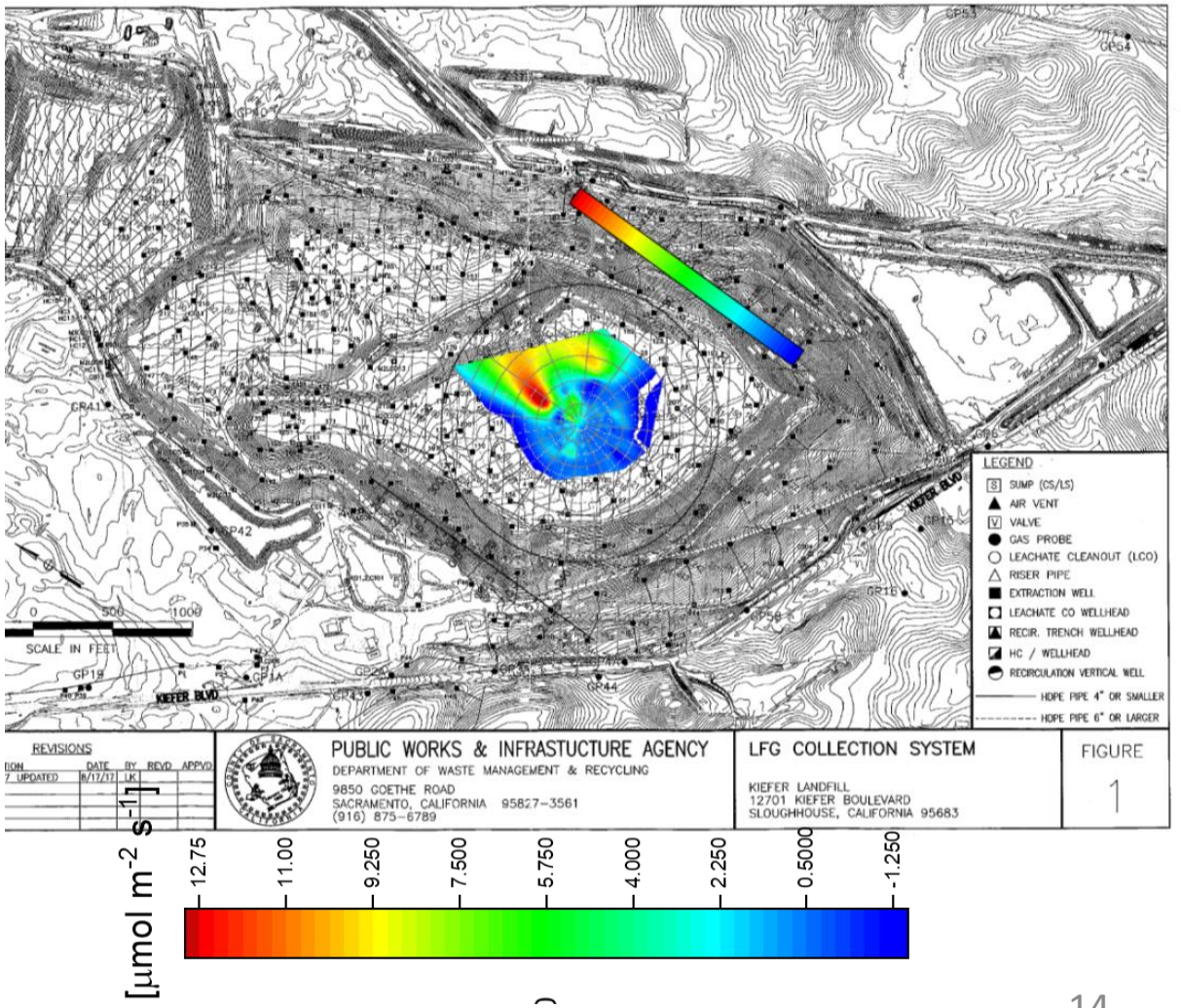
Facility Name	Latitude	Longitude	Air Basin	Sector	Facility Type	Date	CH4 Emission (kg/hr)	Uncertainty (kg/hr)	Data Status
Zero Waste + San Jose Wastewater + Zanker Landfill	37.4313	-121.9478	San Francisco Bay	Waste Management	Wastewater Treatment	10/05/2017	630.5	139.8	Final
Newby Island Landfill	37.4585	-121.9413	San Francisco Bay	Waste Management	Landfill	10/05/2017	2075.4	586.7	Final
Altamont Landfill	37.7539	-121.6517	San Francisco Bay	Waste Management	Landfill	10/06/2017	2976.8	653.2	Final
Keller Canyon Landfill	38.0039	-121.9365	San Francisco Bay	Waste Management	Landfill	10/06/2017	639.6	208.8	Final
Potrero Hills Landfill	38.2134	-121.9819	San Francisco Bay	Waste Management	Landfill	10/06/2017	2292.2	385.0	Final
Toland Landfill	34.4015	-118.9907	South Central Coast	Waste Management	Landfill	10/16/2017	3200.3	767.2	Final
Sunshine Canyon Landfill	34.3273	-118.5149	South Coast	Waste Management	Landfill	10/16/2017	1434.6	282.8	Final
Chiquita Canyon Landfill	34.4295	-118.6466	South Coast	Waste Management	Landfill	10/17/2017	2153.3	679.2	Final
Simi Valley Landfill	34.2945	-118.7954	South Central Coast	Waste Management	Landfill	10/17/2017	489.4	88.0	Final
Scholl Canyon Landfill	34.1560	-118.1937	South Coast	Waste Management	Landfill	11/09/2017	70.7	15.5	Final
Olinda Alpha Landfill	33.9416	-117.8331	South Coast	Waste Management	Landfill	11/09/2017	1698.6	327.8	Final
BKK West Covina Landfill	34.0364	-117.8995	South Coast	Waste Management	Landfill	11/09/2017	93.0	9.9	Final
Puente Hills Landfill	34.0161	-118.0146	South Coast	Waste Management	Landfill	11/09/2017	360.9	55.3	Final
Foothill Landfill	38.0378	-120.9372	San Joaquin Valley	Waste Management	Landfill	11/18/2017	680.1	146.0	Final
Ostrom Road Landfill	39.0731	-121.3935	Sacramento Valley	Waste Management	Landfill	11/18/2017	504.3	217.8	Final

https://ww2.arb.ca.gov/our-work/programs/methane/ab1496-research

Area Source Characterization

Flux Towers

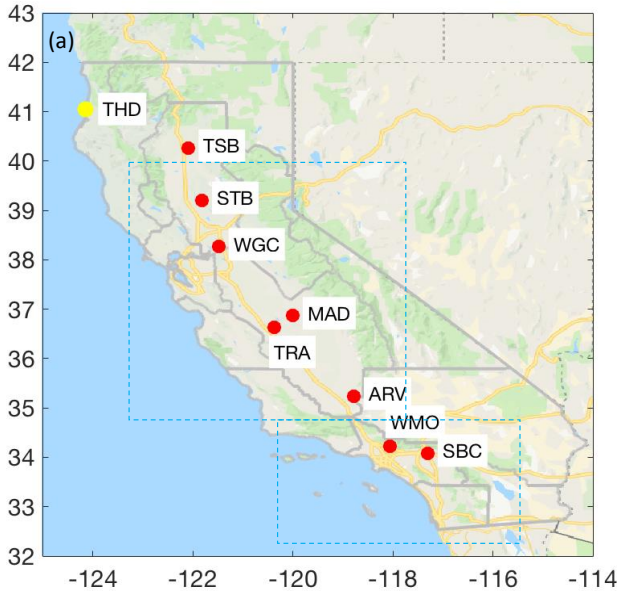
- Landfills
- Dairies

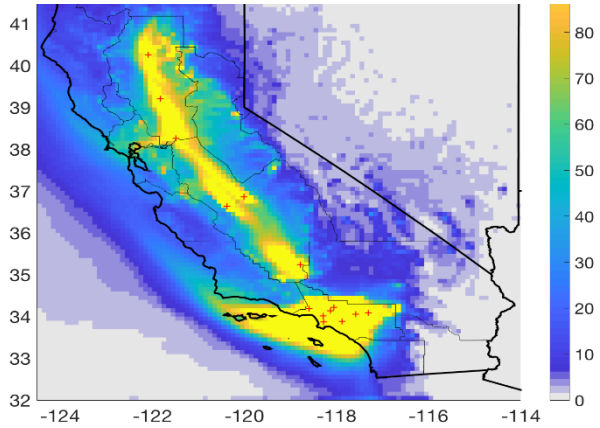


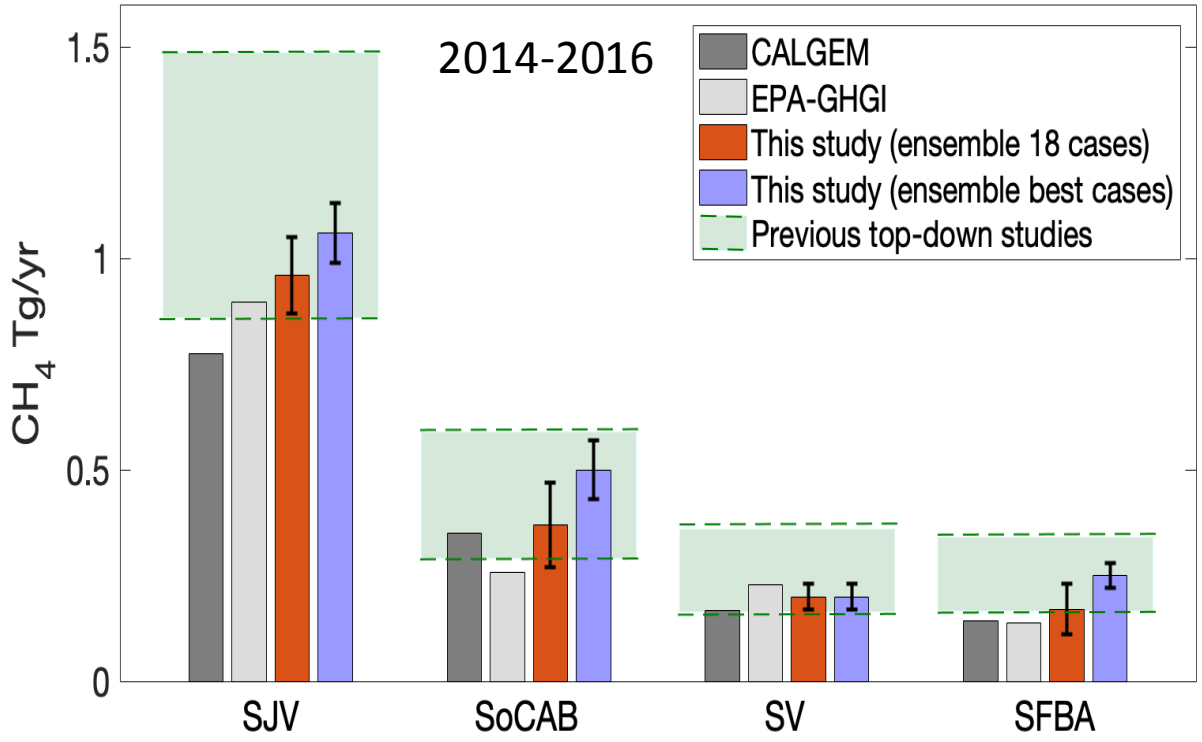
California GHG Monitoring Network

- Network started in 2010
- Current network
  - 7 CARB-managed stations (more coming)
  - Additional collaborated sites
- Measurements
  - Picarro CH_4, CO_2, H_2O
  - LGR N_2O, CO, H_2O
  - BC, F-gases, VOC (Mt. Wilson)
  - PBLH/wind profilers (red circles)
  - Adding real-time GC/MS at selected sites
- CARB data available to research community
  - https://www.arb.ca.gov/aqmis2/res/aqdselect.php

CARB Inverse Modeling Program





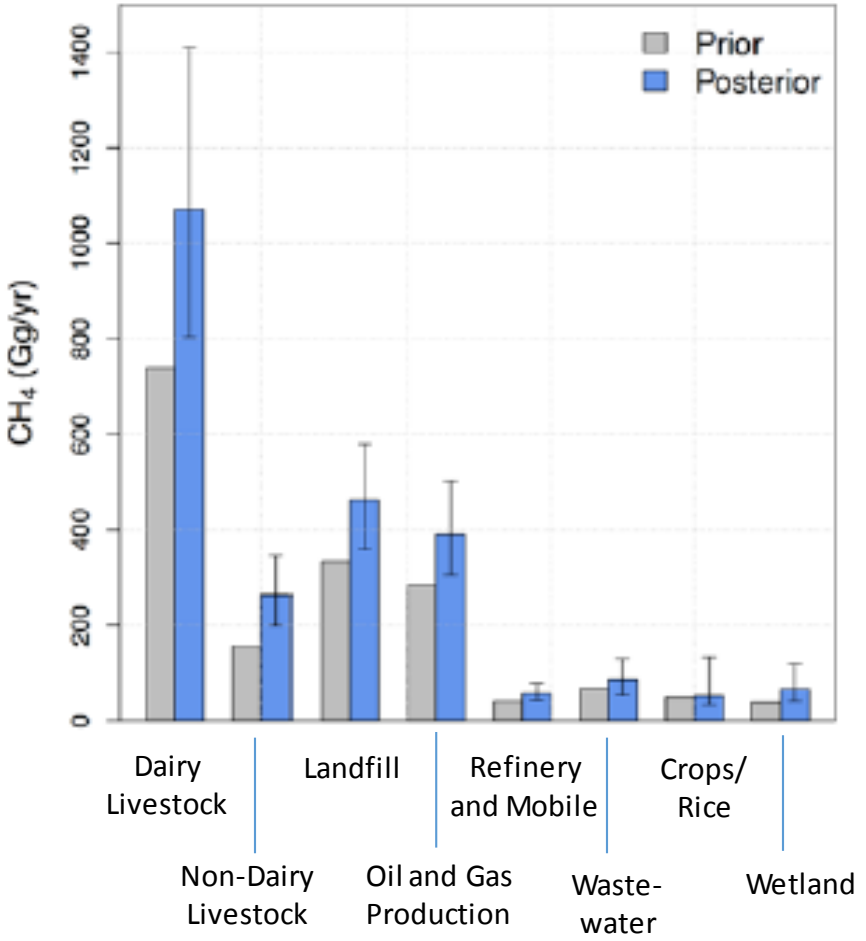


Source: Cui, et al. 2018 manuscript in preparation

Top down approximately 30-50% > Bottom up in California

Top down inventory comparisons

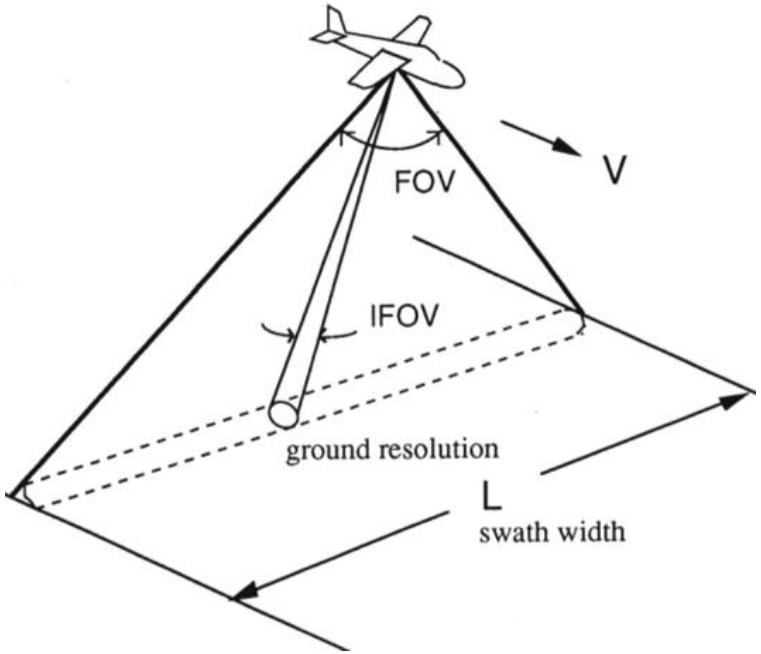
- Based on geography of emissions ⟶
- Working on adding VOC observations
- Initiated research to characterize methane emissions at dairies and develop California specific manure management and enteric fermentation emission factors and to develop mitigation options

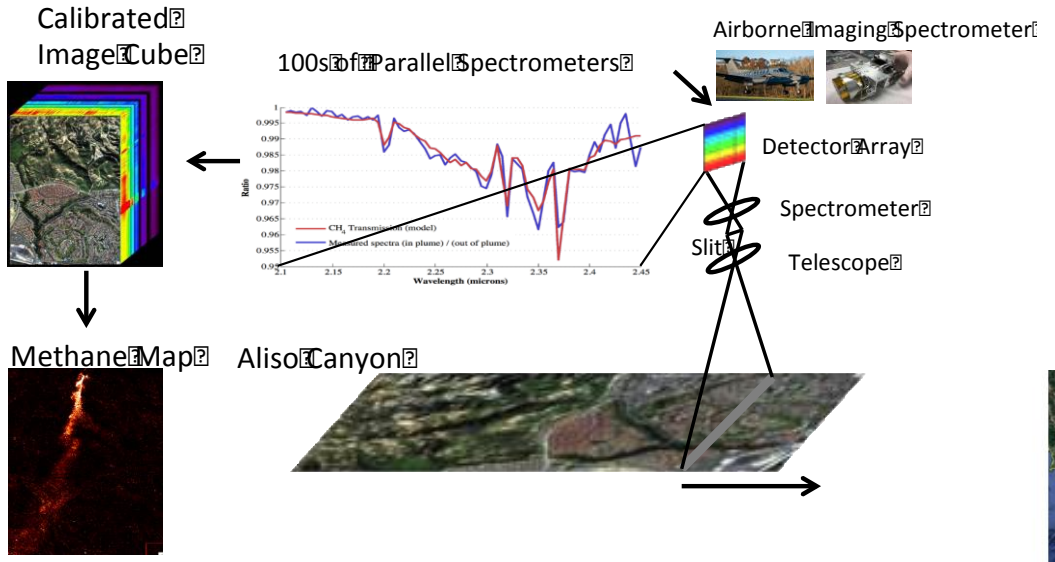


Source: Marc Fischer, Final Report ARB research contract 11-306, https://www.arb.ca.gov/research/apr/past/11-306.pdf

California Methane Survey

Joint CEC – CARB – NASA/JPL Study





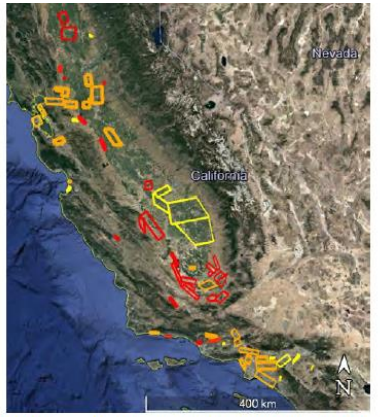


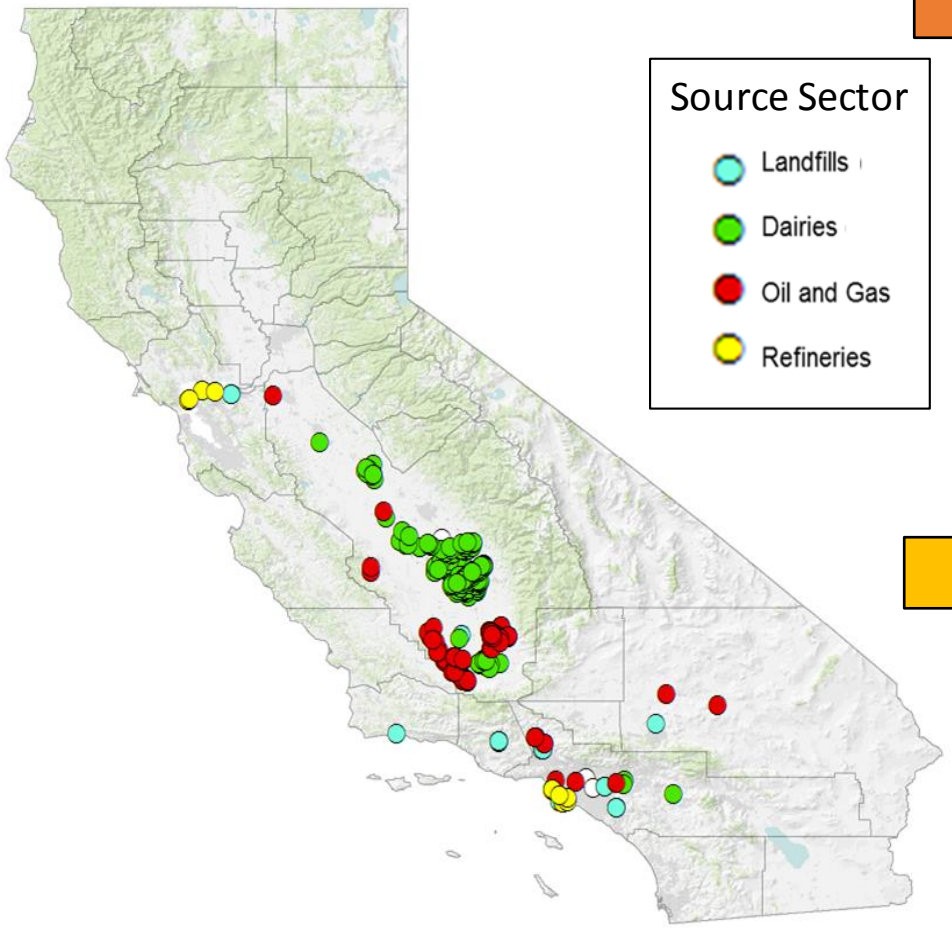
Figure 3-6. AVIRIS-NG flight boxes for Fall 2016 campaign surveying the energy sector (red), non-energy sector (yellow), and mixture of these categories (orange).

- Survey area selected to capture majority of methane point sources in California
- Phase 1 study completed in 2016, covering 15,000 km^2, (~3% of CA area)

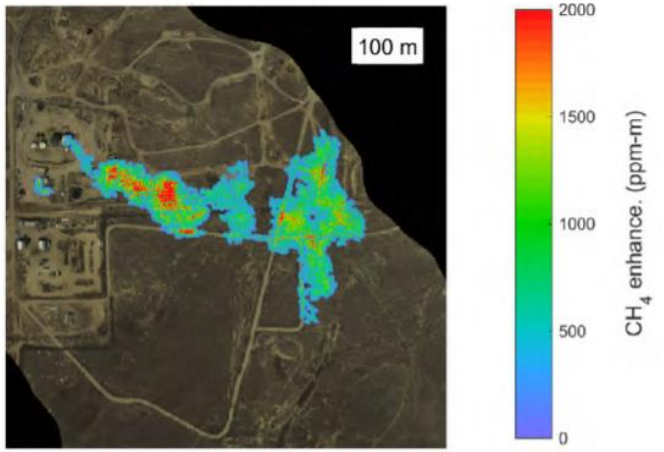
Report available at: https://www.arb.ca.gov/research/methane/CA_CH4_Survey_Phase1_Report_2017.pdf?_ga=2.67533009.1778891176.1542106381-362007903.1522798261

California Methane Survey - Study Results

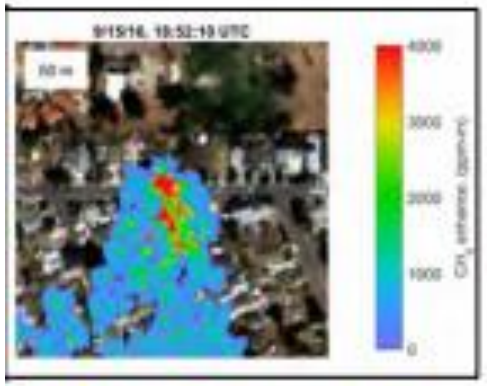
This study identified 329 point sources across the State



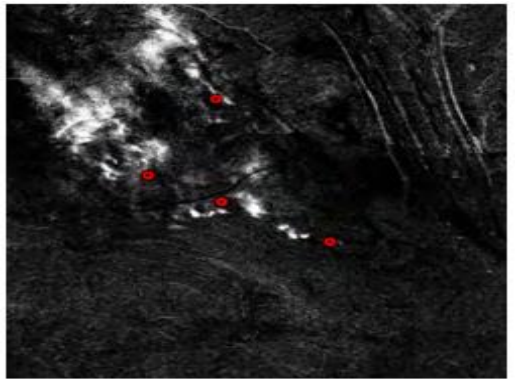
Methane plumes from storage tank



Gas leaks in communities



Methane emissions from landfills



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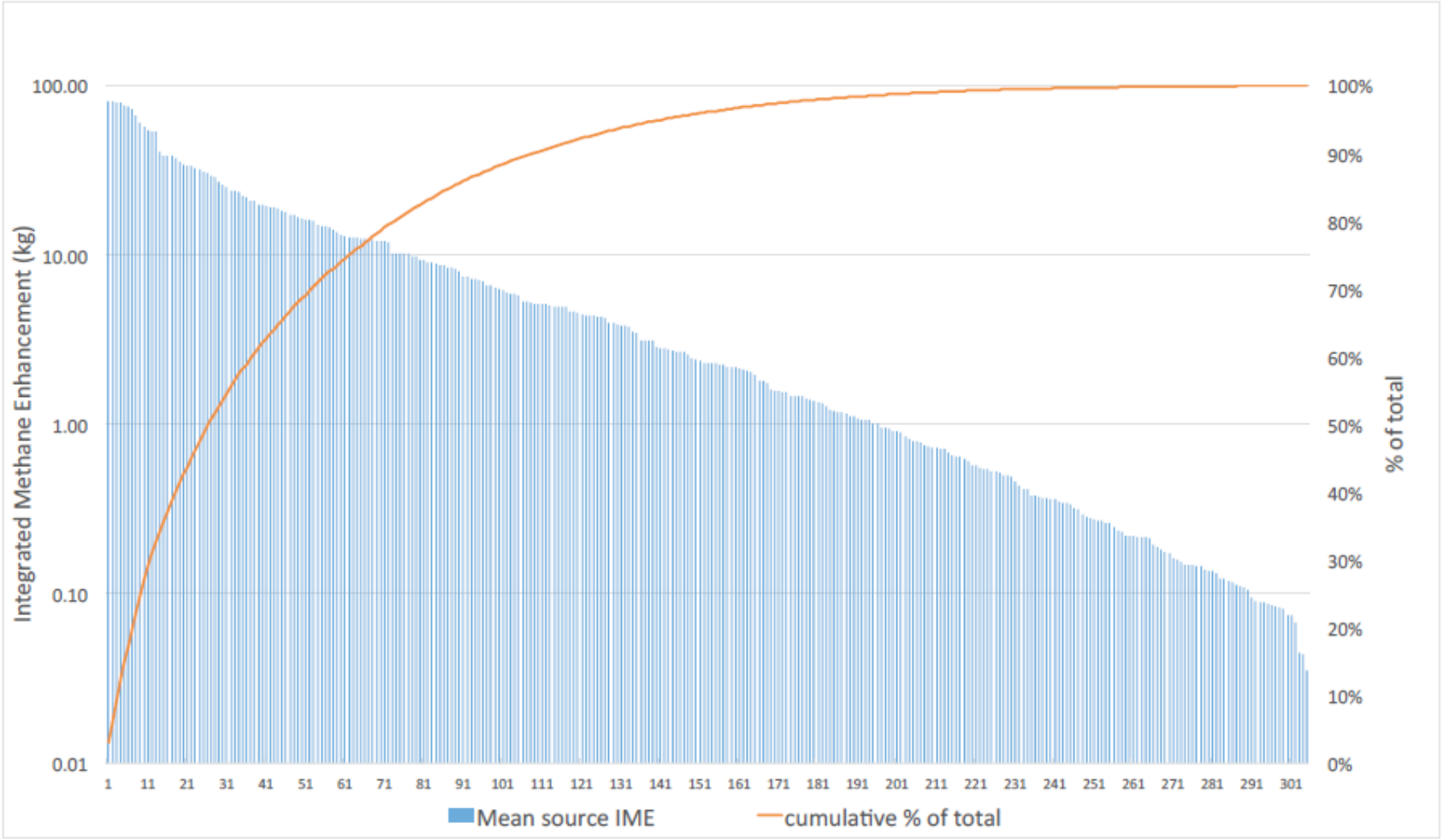

Figure 4-5 Distribution of mean Integrated Methane Enhancements (IMEs) for most of the point sources detected in phase 1 and their cumulative contributions to the total.

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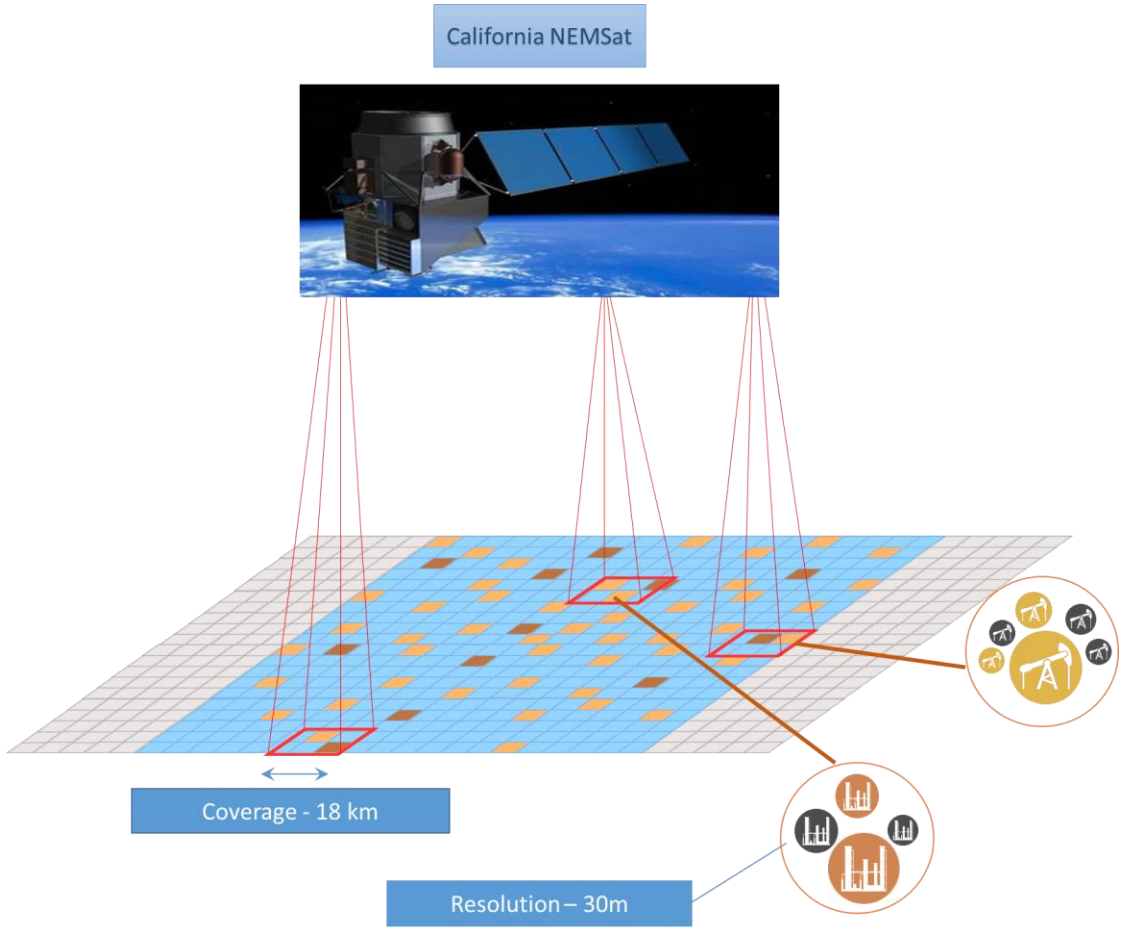
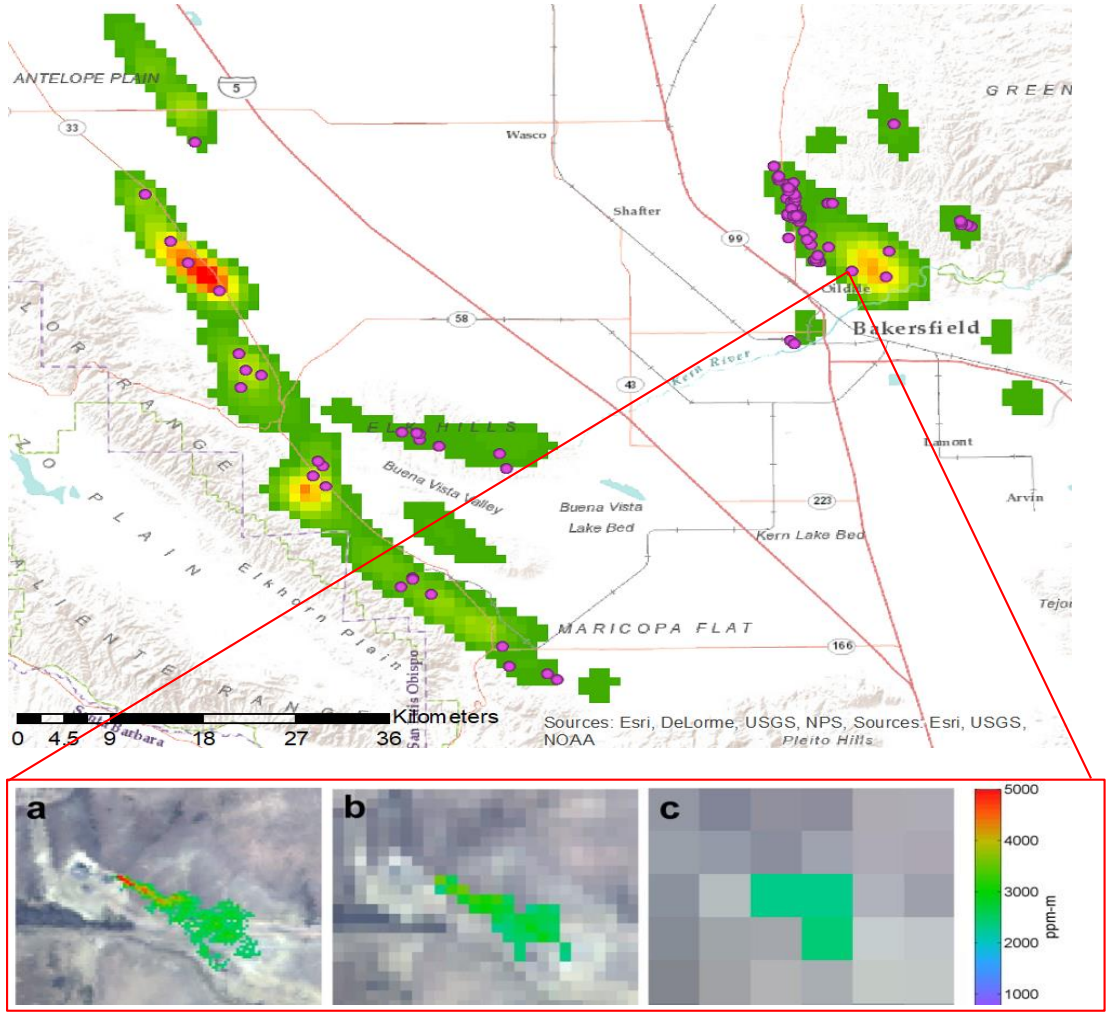
Satellite for Continued Observations - Mitigation





Los Angeles Times

Sep. 14, 2018, 2:22 p.m.

JERRY BROWN

By EVAN HALPER

'We're launching our own damn satellite' — Gov. Jerry Brown says California will go to space to fight climate change

California Gov. Jerry Brown is shown at the Global Climate Action Summit in San Francisco on Thursday. (Gina Ferazzi / Los Angeles Times)

Gov. Moonbeam is finally sending California into space.

Jerry Brown closed his climate summit in San Francisco on Friday with a dramatic

Summary and Challenges