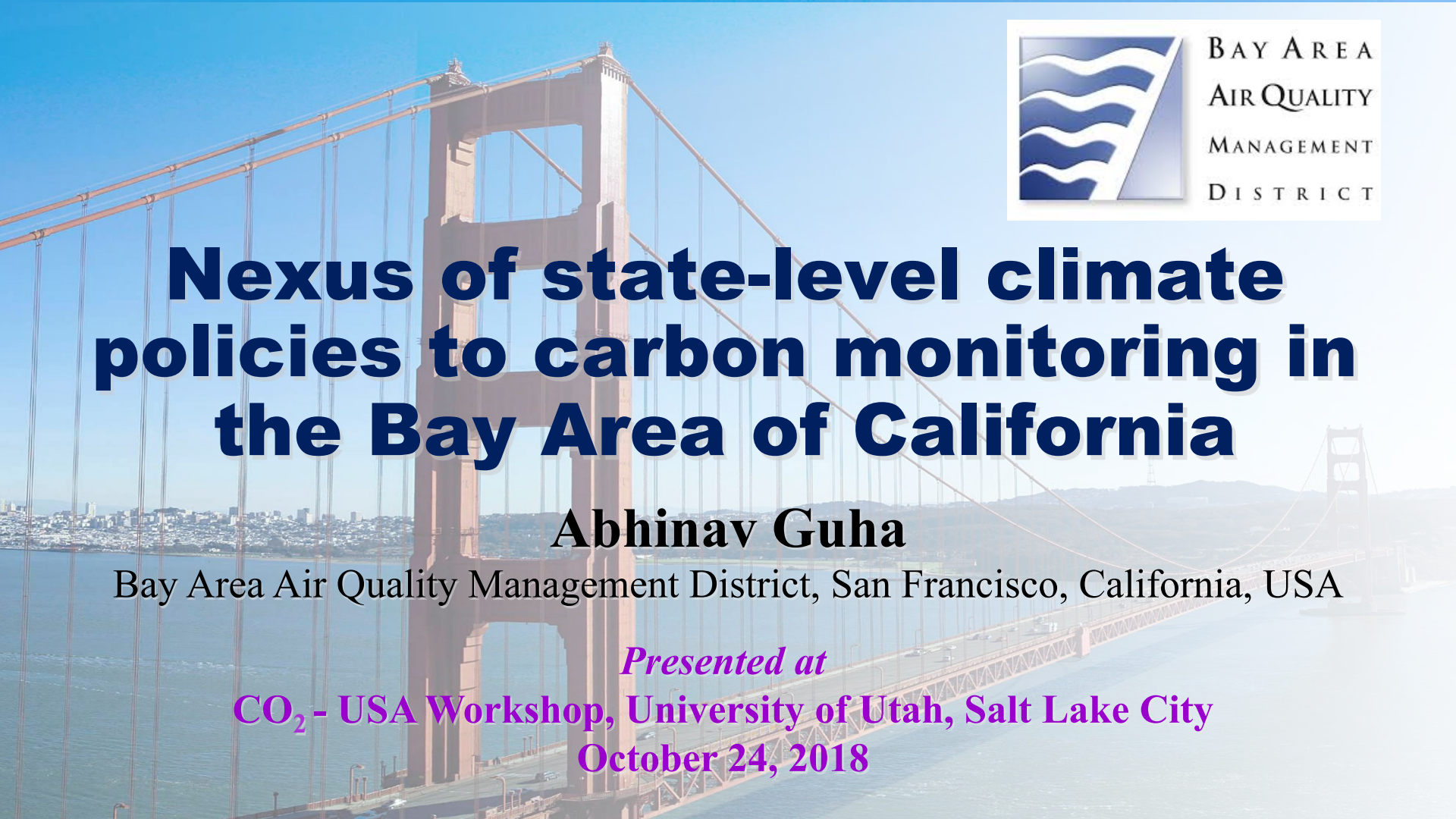


Nexus of state-level climate policies to carbon monitoring in the Bay Area of California

Abhinav Guha

Bay Area Air Quality Management District, San Francisco, California, USA

Presented at

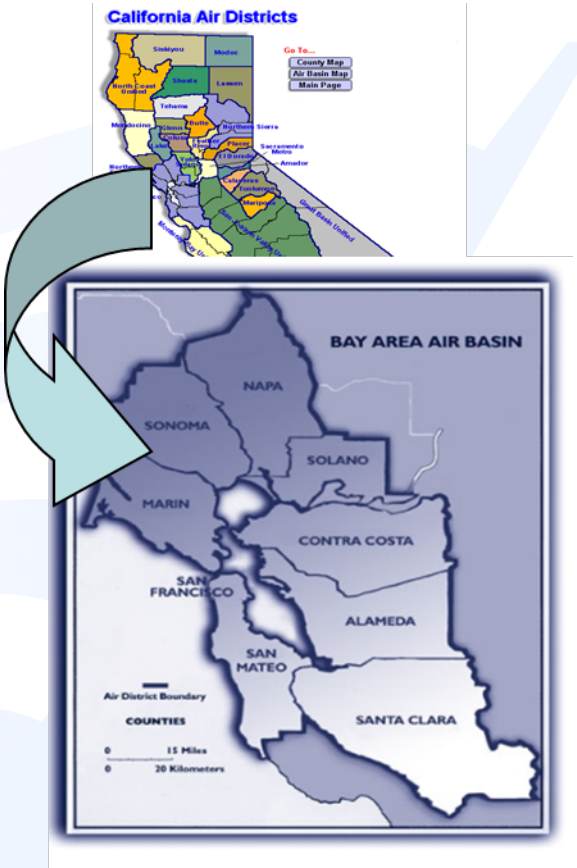
CO_2 - USA Workshop, University of Utah, Salt Lake City

October 24, 2018

Bay Area Air Quality Management District

Jurisdiction

- 9 counties / 101 cities
- 7 million people
- 2.6 million households
- 5 million vehicles



Mission

- Attain air quality standards
- Protect public health
- Protect the climate

Authority

- Stationary sources of air pollution
- Permit over 10,000 facilities and equipment
- Criteria pollutants, toxics and greenhouse gases*

California Climate Statutes

- **Assembly Bill, AB 1493 ("Pavley Law") in 2002**
  - required California Air Resources Board (ARB) to develop regulations to reduce tailpipe emissions of greenhouse gases (GHGs) emitted by passenger vehicles and light-duty trucks.
  - state's "Clean Car" fuel-efficiency standards denied waiver from EPA's Clean Air Act in 2008, then granted in 2009, and back to being debated and possibly blocked now.

California Climate Statutes

- **Executive Order S-3-05** – reduce GHGs 80% below 1990 levels by year 2050

- **Assembly Bill, AB 32** (California Global Warming Solutions Act 2006)
  - statewide GHG emissions reduction to 1990 levels by year 2020 (~15%).
  - required reporting and verification of statewide GHG emissions to enforce compliance with this program.
  - required ARB to adopt regulations to achieve the technologically feasible and cost-effective GHG emission reductions.
  - institute a cap-and-trade program with an overall limit on GHG emissions from capped sectors. From 2012, facilities subject to the program able to trade permits (allowances) and purchase offsets to emit GHGs.

California Climate Statutes

- **Executive Order B-30-15 (2015)**
- **Senate Bill, SB 32 (2016)**

} 40% below 1990 levels by year 2030

California Climate Strategy

- 50% of electricity from renewable sources by 2030; up from 33% by 2020 goal **[Senate Bill, SB 350; 2015]**.
- 50% reduction in petroleum use in cars and trucks by 2030.
- Double the energy efficiency savings in end-use electricity and natural gas at existing buildings by 2030 **[SB 350]**.

Regional Climate Action Planning

Air District Board of Directors -

- **adopted State's 2030 and 2050 GHG reduction goals**
- **adopted the 2017 Clean Air Plan**

Regional Stakeholder Partners

- Plan Bay Area 2040 - transportation and land-use / housing strategy
- Bay Regional Energy Network (BayREN) – energy efficiency

City/County Governments

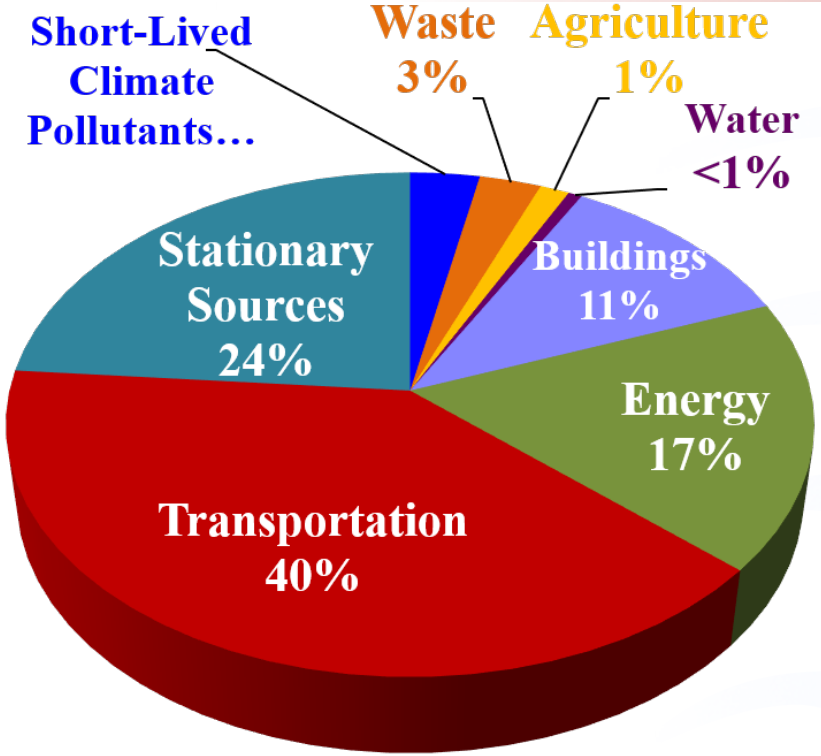
- 65 local climate action plans
- community-wide GHG inventories
- CEQA guidance
- funding for developing and implementing policies

2017 Clean Air Plan

- Multi-pollutant emissions control strategy
- Reduce Bay Area's greenhouse gas (GHG) emissions 80% below 1990 levels by 2050
- Reduce air pollution and related health impacts.
- 85 Control Measures and over 250 Implementation Actions including policies and ordinances, rule-making proposals, incentives and grants, outreach etc.

http://www.baaqmd.gov/plans-and-climate/air-quality-plans/current-plans

Bay Area 2015 GHG Emissions



Total Emissions = 88 MMT CO_2e

Distribution by pollutants

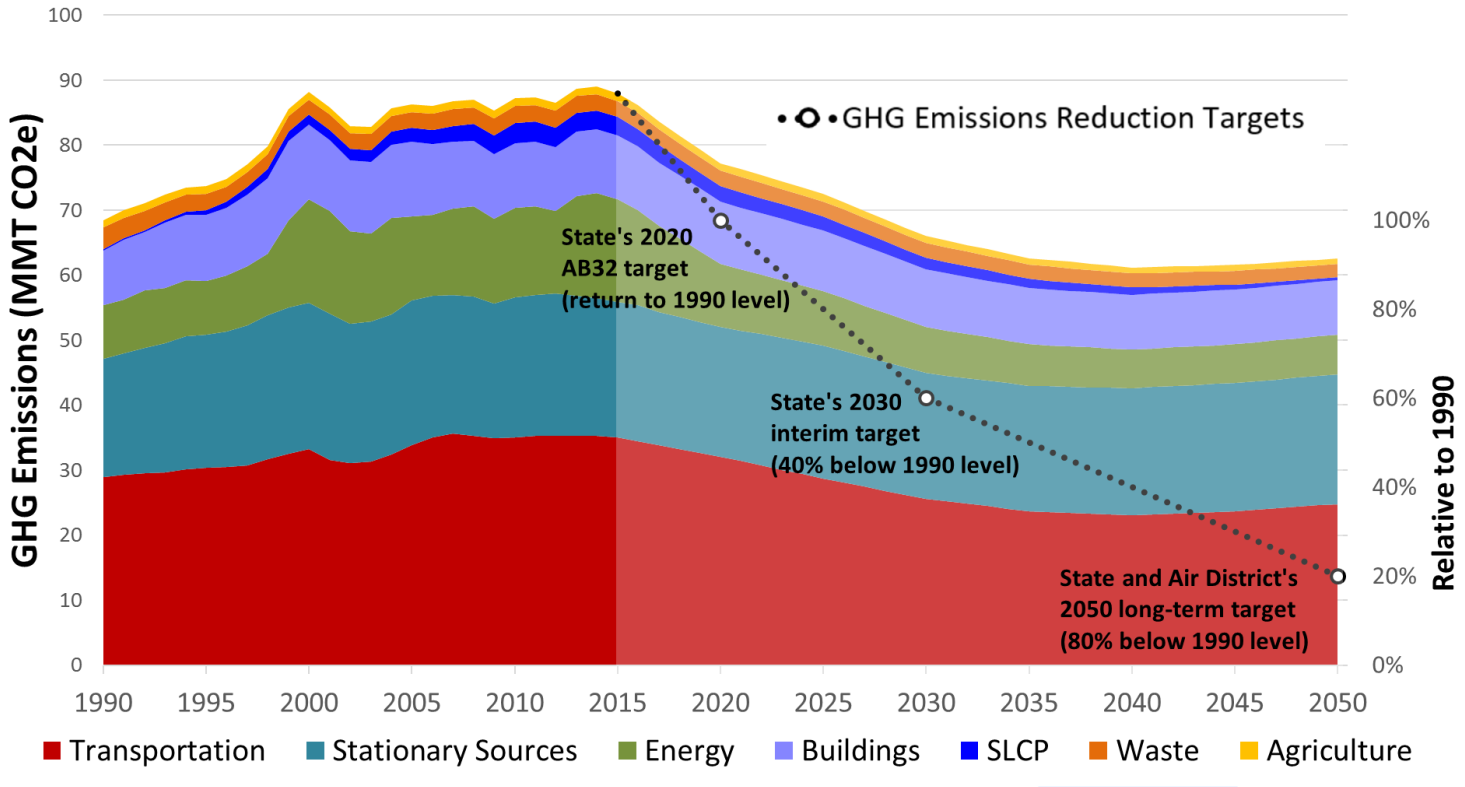
Carbon Dioxide (CO_2) ~ 90%

Methane (CH_4; 100-year GWP) ~ 5%

High Global Warming Potential (GWP) gases ~ 3.5%

Nitrous Oxide (N2O) ~ < 2%

GHG Projection to 2050 with key state programs



California Methane Statutes

- **Senate Bill 605 (2014)**
  - directed ARB to develop a comprehensive short-lived climate pollutant (SLCP) strategy.
- **Senate Bill 1383 (2016)**
  - set statewide 2030 emission reduction targets for methane and HFCs (40% below 2013), and anthropogenic black carbon (50% below 2013).
  - diversion of organic material from the waste stream to address landfill methane emissions.
- **Assembly Bill 1496 (2015)**
  - undertake monitoring and measurements of methane 'hotspots'
  - perform life-cycle GHG analysis of natural gas systems in California

BAAQMD GHG Monitoring and Measurement Program

- Track GHG trends over time
- Evaluate and improve the regional GHG emissions inventory
- Determine facility-level and process-level GHG emissions estimates
- Educate and inform the public
- Provide data and resources to promote climate change research
- Create a reproducible model for other regional agencies

BAAQMD GHG Monitoring Network

Fixed-site GHG monitoring network

- Upwind / downwind sites looking at long-term CO_2 and CH_4 trends

- Determine trends of GHG concentrations over time
- GHG data website provides data access to general public

Mobile Measurement Platform (Research Van)

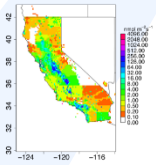
- CH_4 and N_2O hotspot detection
- Tracer based GHG source identification
- Region-wide source-specific surveys to inform Emissions Inventory, Compliance/Enforcement and Rule Development work

BEACO2N
The BErkeley Atmospheric CO_2 Observation Network

UC Berkeley

Harvard - Munich EM27s

NASA-JPL AVIRIS / Sigma Space TOWDL



CALGEM

UC Davis / Scientific

GHG Fixed-site Network

Track long-term regional patterns of GHG concentrations

- Background site at Bodega Bay
- Three downwind sites at regional plume exit locations – Bethel Island, Livermore and San Martin
- Measure CO_2, CH_4, CO & H_2O
- Data available through Air District's webpage: http://www.baaqmd.gov/ghgdata

GHG Mobile Monitoring Platform

➢ **Identify emission 'hotspots', perform source attribution, and improve the emissions inventory**

- CH_4 and N_2O hotspot detection.
- Methane source attribution with chemical tracers
  - **Ethane** : fugitive oil and gas
  - **$^{13}C/^{12}C - CH_4$** : biological vs fossil
  - **CO**: combustion
- Investigate under-inventoried / unknown sources

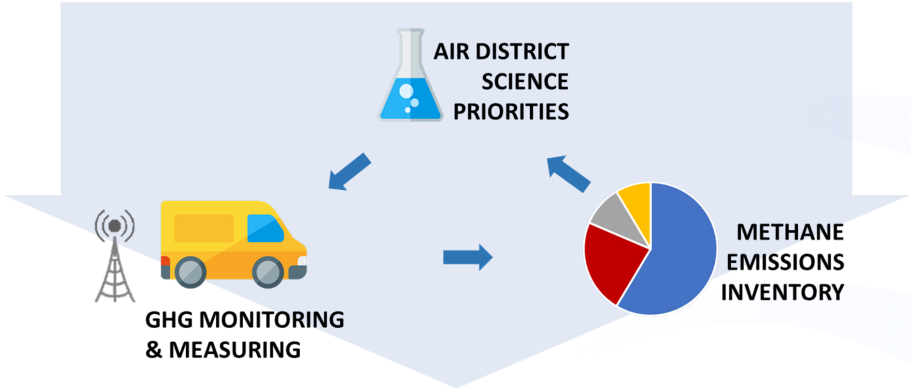
Turning Point…

- **Assembly Bill 398 (2017)**
  - extends and improves the Cap and Trade Program to 2030.
  - **prohibit an Air District from adopting emission reduction rule for carbon dioxide from sources subject to market-based compliance mechanism.**

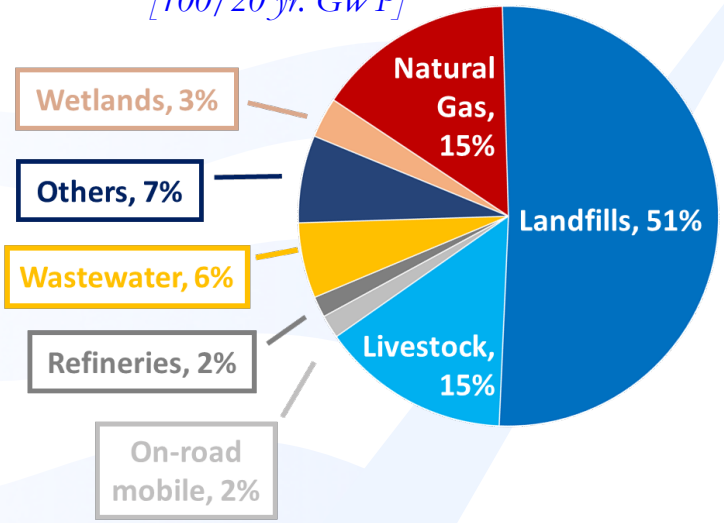
- **Assembly Bill 617 (2017)**
  - measure and reduce air pollution at neighborhood scale in communities most impacted by air pollutants and toxic air contaminants.
  - **ARB and local Air Districts to establish community-scale air quality monitoring networks and analysis.**
  - **Air Districts to implement plans to reduce emissions and track progress.**

Air District's Methane Strategy

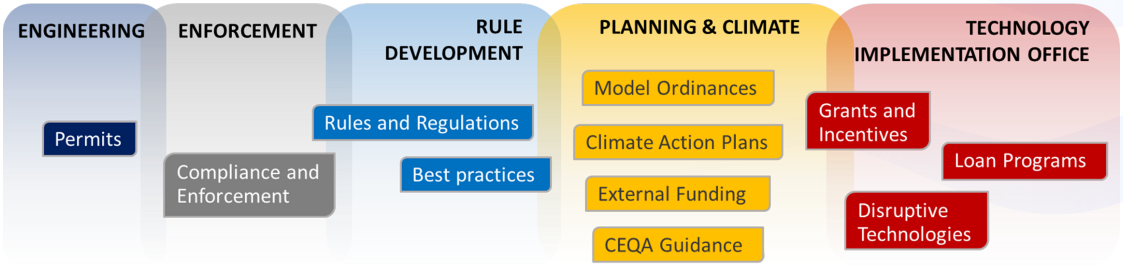
METHANE QUANTIFICATION EFFORTS



4.3/10 Million MT CO_2e (5 to 12%) [100/20 yr. GWP]



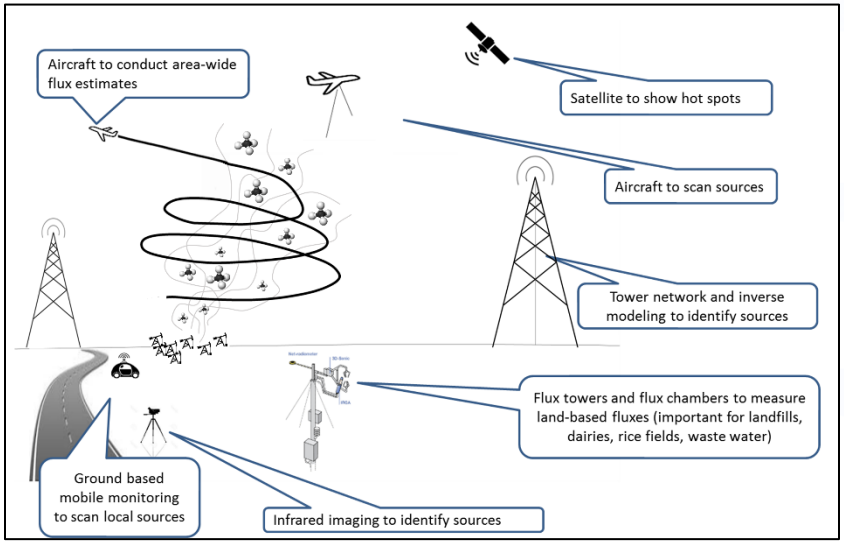
METHANE REDUCTION EFFORTS



Top down studies indicate Bay Area methane emissions may be 1.3 – 2.3 times higher [Fairley and Fischer 2015; Jeong et al., 2017]

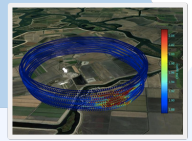
Air District's Methane Strategy

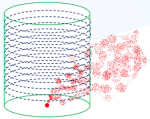
Tiered Observation System



Courtesy: California Methane Research Program, CARB

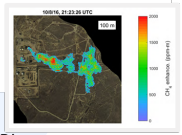
1. "Methane curtain flights" estimate mass emissions at the facility level





An aircraft equipped with a methane instrument flies concentric circles around facility at different altitudes. Facility emissions are estimated assuming all methane passes through this "curtain".

2. Aircraft imaging surveys identify methane sources inside facilities



To identify large methane plumes, NASA JPL uses an airborne imaging spectrometer to survey vast areas of California with key infrastructure, such as landfills and natural gas pipes.

3. On-site leak detection (mobile van) and quantification (source testing)

The Air District uses different tools to quantify methane emissions from processes or equipment at facilities.

California Greenhouse Gas Emission Measurement (CALGEM) project - LBNL

- **State & regional inverse estimates of GHG (CO_2, CH_4, & N_2O) emissions**

  Impact: Quantitative evaluation of GHG inventories

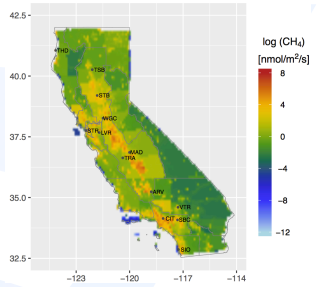
  - Fossil fuel CO_2 consistent to ~ 10% (Graven et al., 2018)
  - Inventory underestimates CH_4 (1.2-1.8 x @ 95% CI) and N_2O (1.5-2.5 x @ 95% CI) (Jeong et al., 2016; 2018)
  - Multi-species quantification of Bay Area CH_4 to biological, natural gas, and petroleum sources (Jeong, et al. 2017)

- **Source Specific CH_4 Emission Measurements**

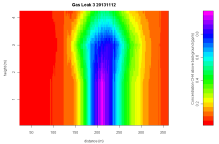
  Impact: Quantify source emissions for mitigation

  - Airborne flux integration documents NG storage & refinery emissions (Mehrotra et al., 2017)
  - Mobile plume integration quantifies leaks in up and down-stream O&G infrastructure (Fischer et al., 2017), with ongoing collaboration on CA dairies
  - Quantify post-meter NG CH_4 emissions from homes and their appliances (Fischer et al., 2018), with ongoing collaborations on commercial and industrial infrastructure

2013 CA Tower Network

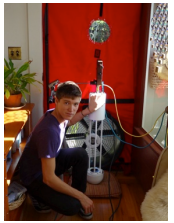


LBNL Mobile Plume Integrator



UCD Airborne Flux Measurements

CA Homes

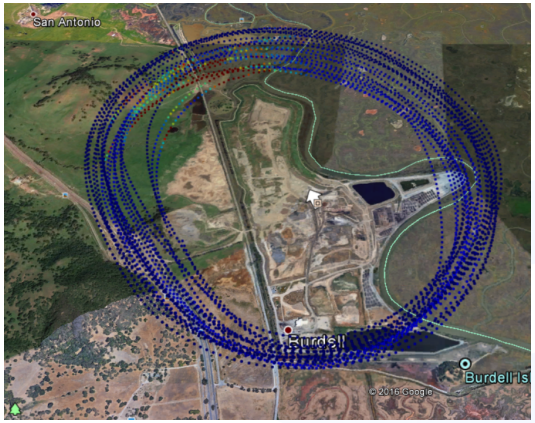


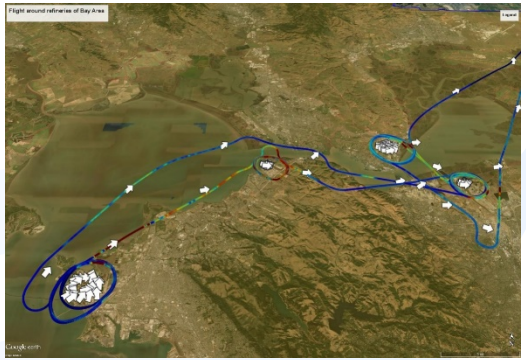
Airborne CH_4 Mass Balance

Scientific Aviation (2016-18)

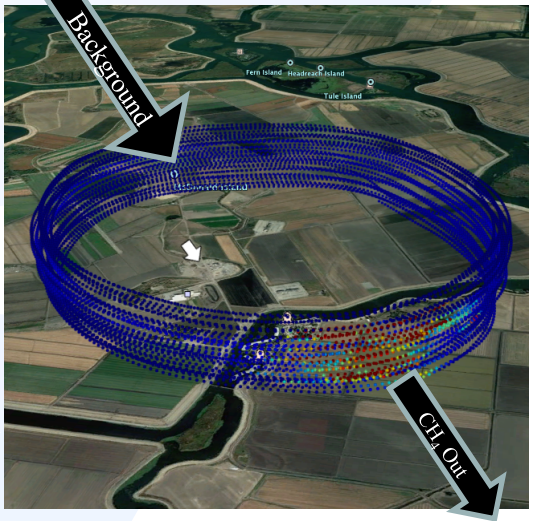
- Circular vertical-profile curtain flights around a facility
- Airborne CH_4, CO_2, C_2H_6 and CO concentrations and wind velocity measurements
- Facility-scale CH_4 emission rates using flux divergence

AGU talk, Fri, Dec 14 15:25-15.40





- Facilities covered include landfills, refineries, dairies, wastewater treatment plants, composting etc.
- Refinery and landfill CH_4 emissions consistently underestimated in the bottom-up estimates



CH_4 Infrared Imaging with Wind Lidar

AVIRIS-NG-TOWDL (2018)

- NASA JPL performed high-res airborne infrared imaging of CH_4 plumes over several Bay Area sources.
- Follow up to the statewide California Methane Survey.
- Simultaneous real-time surface wind field measurements by a second aircraft in tandem (Sigma Space Corporation).
- Plume images useful to identify missing sources and sub-facility scale location of leaks / emission hotspots.
- Quantitative methane plume emission rate estimates will inform methane compliance, rule development and emissions inventory activities.

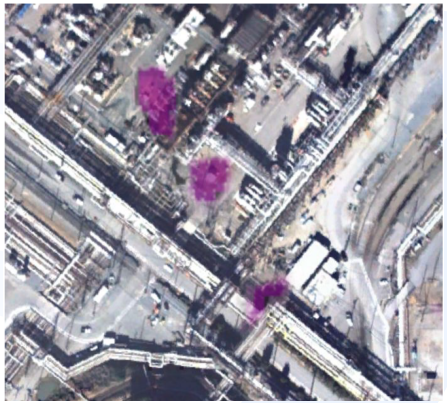
Aerial CH_4 imaging

Kairos Aerospace study (2017-18)

- Aerial methane imaging survey over Bay Area sources
- Temporal nature of emissions evaluated through multiple visits over same target
- Focus sources include major landfills and refineries.
- Methane plume imagery provides qualitative sub-facility scale emission information for follow-up ground-based investigations and site visits

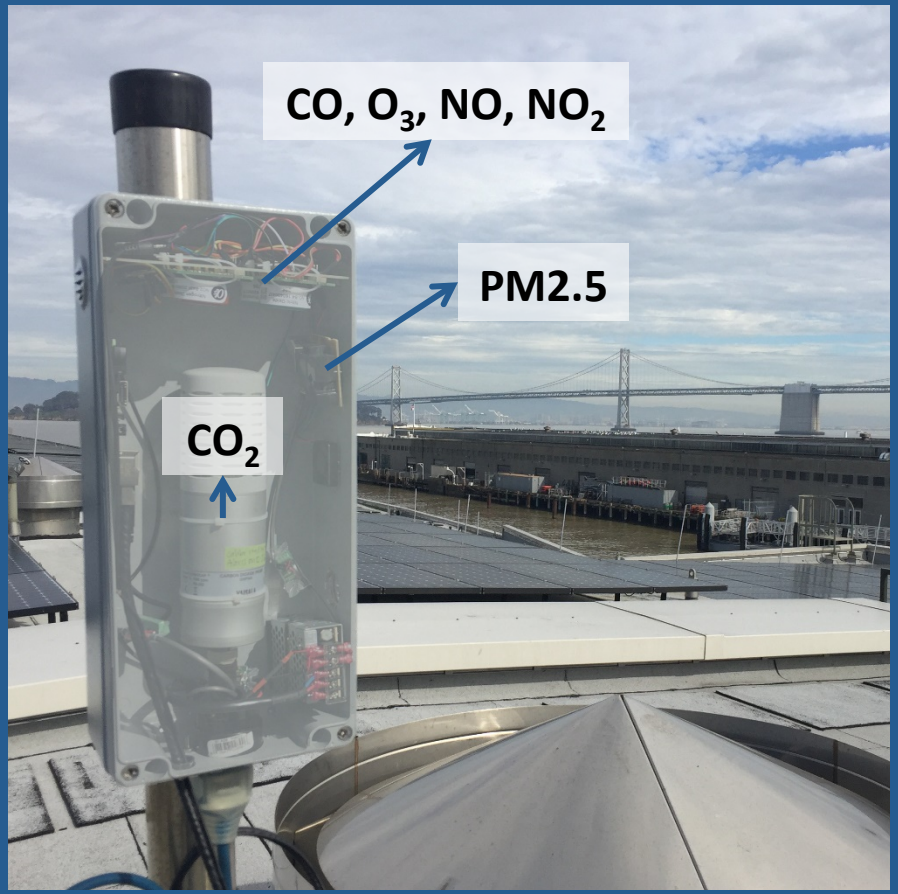
Landfills

Refineries



Wastewater treatment plants

BErkeley Atmospheric CO_2 Observation Network (BEACO_2N)



~100 nodes
(SF Bay area 70, Houston 15, NYC 10)

2×2km grid

CO_2, CO, O_3, NO, NO_2 and PM2.5

R.C. Cohen, Professor, UC Berkeley
http://beacon.berkeley.edu/
http://cohen.cchem.berkeley.edu/

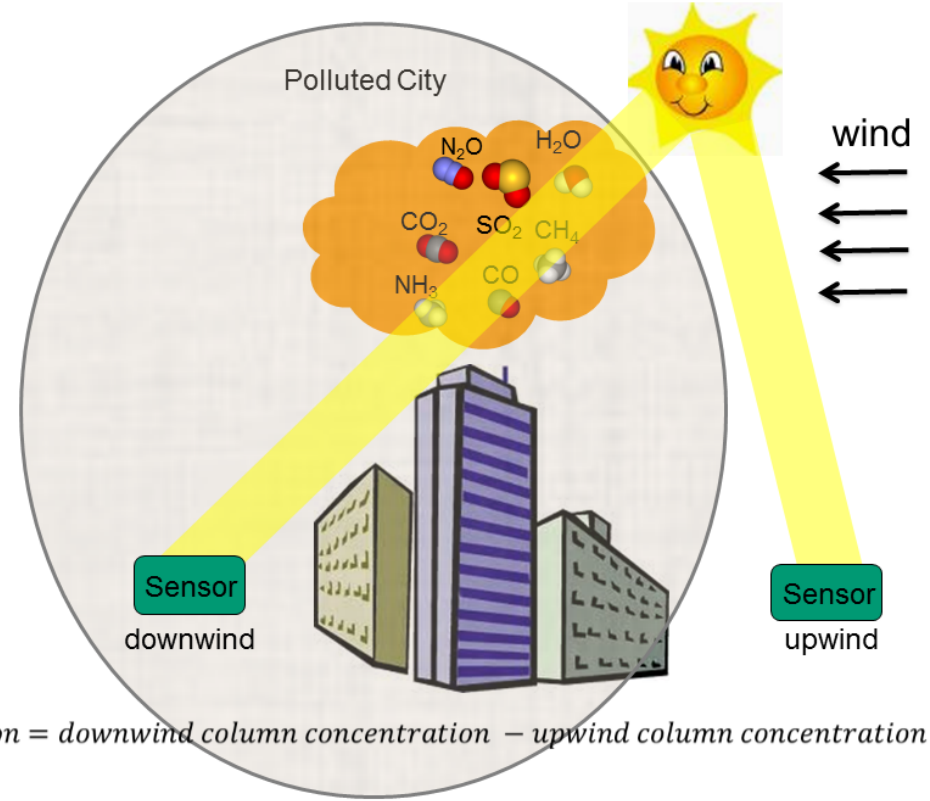
Column CO_2 and CH_4 measurements

Harvard / TU Munich
(Oct - Nov, 2016)

- Total column CH_4 and CO_2 using six solar tracking spectrometers

- Combine data with weather research forecast model and atmospheric transport model

- Top-down CO_2 and CH_4 regional emission estimates



$$Emission = downwind\ column\ concentration - upwind\ column\ concentration$$

State of BAAQMD's GHG Measurement Program

- CO_2 regulatory authority restricted by state mandates
- CO_2 monitoring and emissions inventory evaluation seen less impactful for near-term emission control
- Increased focus on community-scale air quality monitoring efforts.
- Toxic and criteria pollutant emission reduction seen as indirect but effective tool for reducing CO_2 emissions.

State of BAAQMD's GHG Measurement Program

- Air District has regulatory authority on SLCPs.
- CH_4 in the region is underestimated.
- CH_4 research focused on facility and sub-facility scale measurements with large underestimation seen in the landfill and refinery sector.
- Air District in active CH_4 rulemaking phase focused on preventing large releases/leaks; and mandating best practices in the composting, organics waste handling and at landfills.

Question

In the light of legislative uncertainties, is it more practical and effective for urban-scale GHG measurement networks to be developed, implemented and operated by the atmospheric science community, with local stakeholder input in design, funding, and applied use of data products?

Acknowledgements

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