California's GHG Research and Mitigation Programs

Bart Croes, Chief, Research Division
bart.croes@arb.ca.gov, 1-916-323-4519

Elizabeth Scheehle, Chief
Oil & Gas and GHG Mitigation Branch
elizath.scheehle@arb.ca.gov, 1-916-322-7630

California Environmental Protection Agency

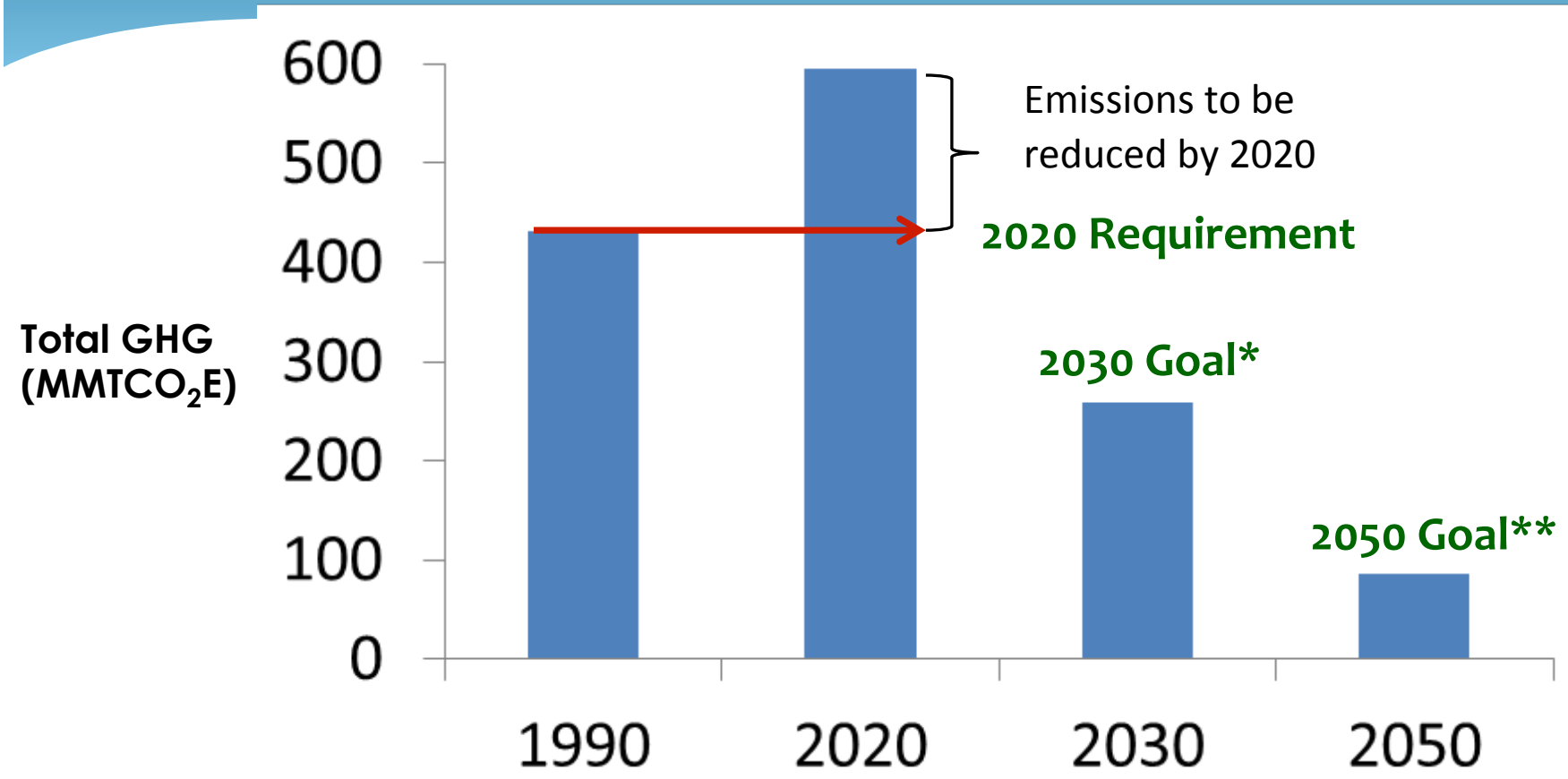
Air Resources Board

California Global Warming Solutions Act (Assembly Bill 32)

AB 32 charged Air Resources Board (ARB) to:

- Reduce 2020 GHG emissions to 1990 levels
- Monitor, report, and regulate sources of GHG emissions
- Rigorous and consistent inventory of emissions
- Monitor compliance with any rule, regulation, order, emission limitation, emissions reduction measure, or market-based compliance mechanism

GHG Emission Reduction Goals



* Executive Order B-30-15 and Senate Bill 350
** Executive Order S-3-05

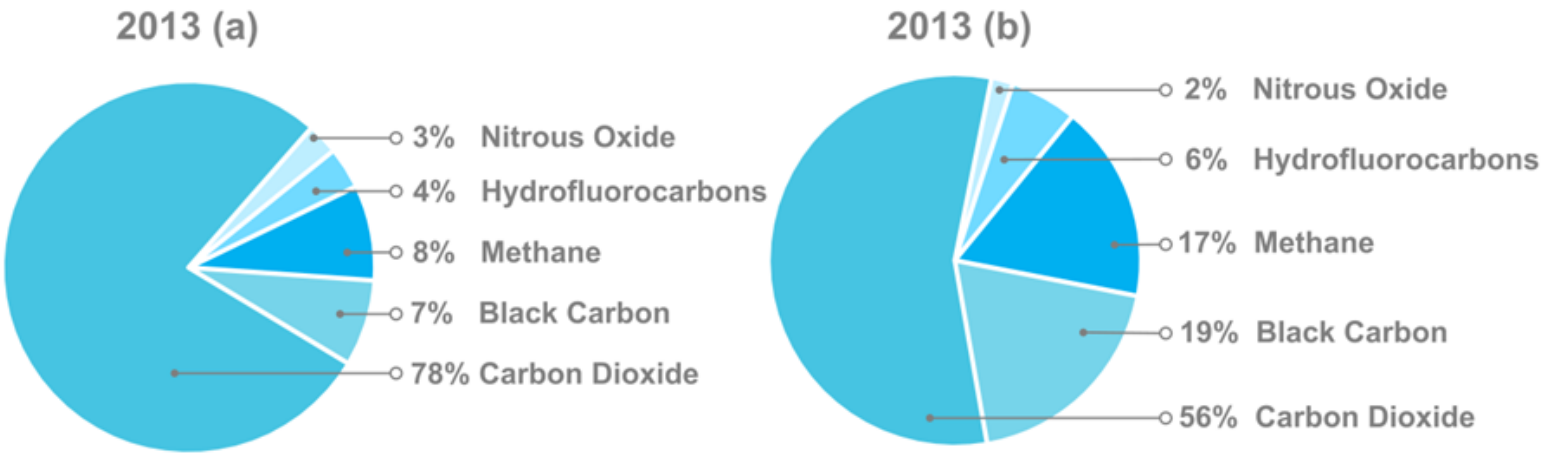
Existing Regulations and Policies

- Cap and trade program for all large sources (cap drops 2-3% per year)
  - Offset protocols for ODS, forestry, urban forestry, dairy digesters, mine methane
  - 25% of revenue goes to disadvantaged communities
- Transportation
  - 54.5 mpg fleet average by 2025
  - 1.5 million zero emission vehicles by 2025
  - 10% lower carbon intensity for fuels by 2020
  - ~7.6% per capita VMT reduction by 2020, ~12% by 2035 (SB 375)
- Electricity generation and energy efficiency
  - 33% renewable by 2020, energy efficiency audits
  - No imported coal power after 2025 (SB 1368)
  - 12,000 MW renewable self-generation by 2025
  - Appliance standards
  - $2.5B for school retrofits (Prop 39), retrofit existing buildings (AB 758)
  - Zero energy new residential buildings by 2020, commercial by 2030
- Short-lived climate pollutants
  - Six regulations covering all F-gases (CFC, HCFC, HFC, SF_6, PFC, NF_3)
  - Methane controls on landfills, oil and gas production (pending)
  - Diesel retrofit/repower requirements, local fireplace controls
- Water and waste
  - 20% per capita water consumption reduction by 2020
  - 75% waste diversion by 2020 (AB 341)

Short-Lived Climate Pollutant Plan

Senate Bill 605 – Develop SLCP strategy by 1/1/16

- Concept paper released 5/7/2015, draft strategy 9/30/15
- Board consideration in December 2015
- Final in spring 2016



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

SLCP Targets

From current (2013) levels:

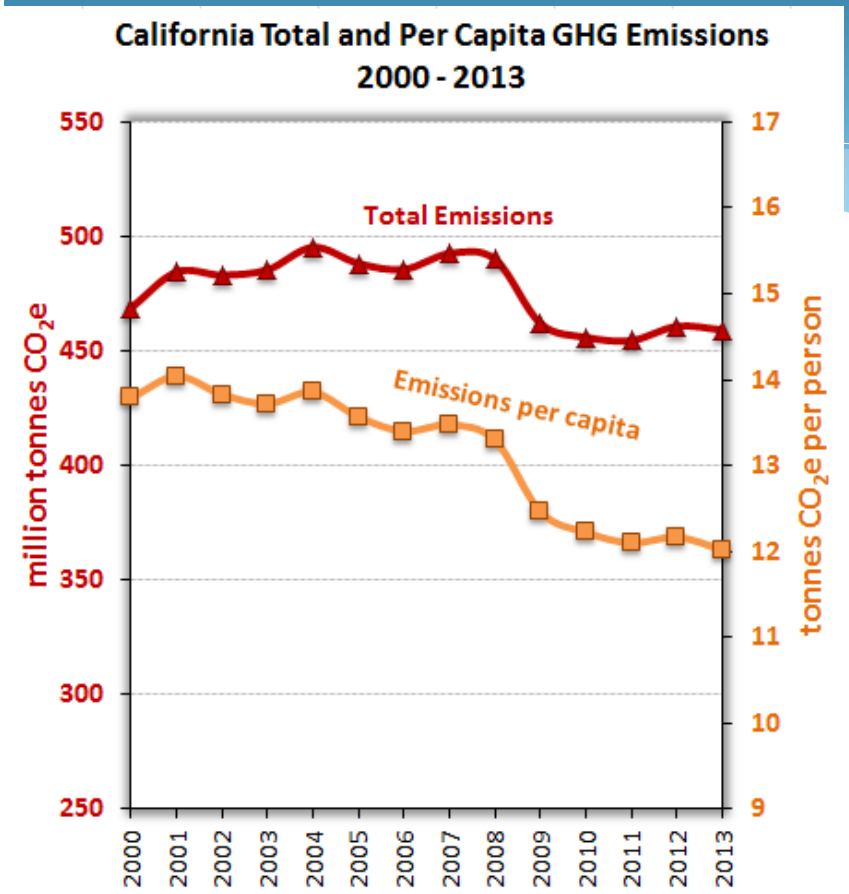
- Reduce black carbon emissions (non-forest) 50% by 2030
- Reduce methane emissions 40% by 2030
- Reduce F-gas emissions 40% by 2030

Governor Brown "5 Pillars"

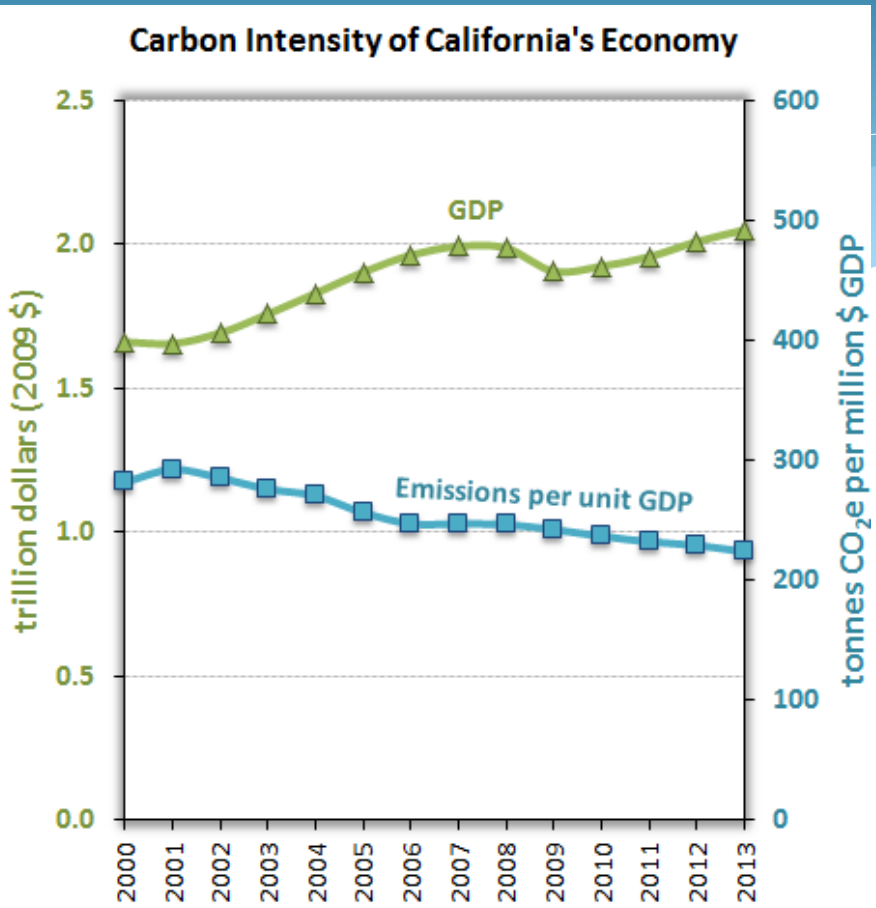
* Set in 4th Term Inaugural Address – January 5, 2015
* By 2030:
  * Increase renewable electricity to 50%
  * Double energy efficiency of existing buildings and make heating fuels cleaner
  * Reduce petroleum use in cars and trucks by 50%
  * Reduce methane, black carbon, and other potent pollutants (short-lived climate pollutants)
  * Increase carbon sequestration in farms and rangelands, forests and wetlands

Assembly Bill 1496

* Measurements of high emission methane "hot spots" in California using aerial surveys and ground-based measurements
* Life-cycle greenhouse gas emissions analysis of natural gas produced and imported into California
* Review atmospheric reactivity of methane as a precursor to the formation of photochemical oxidant
* Update relevant policies and programs to incorporate the information

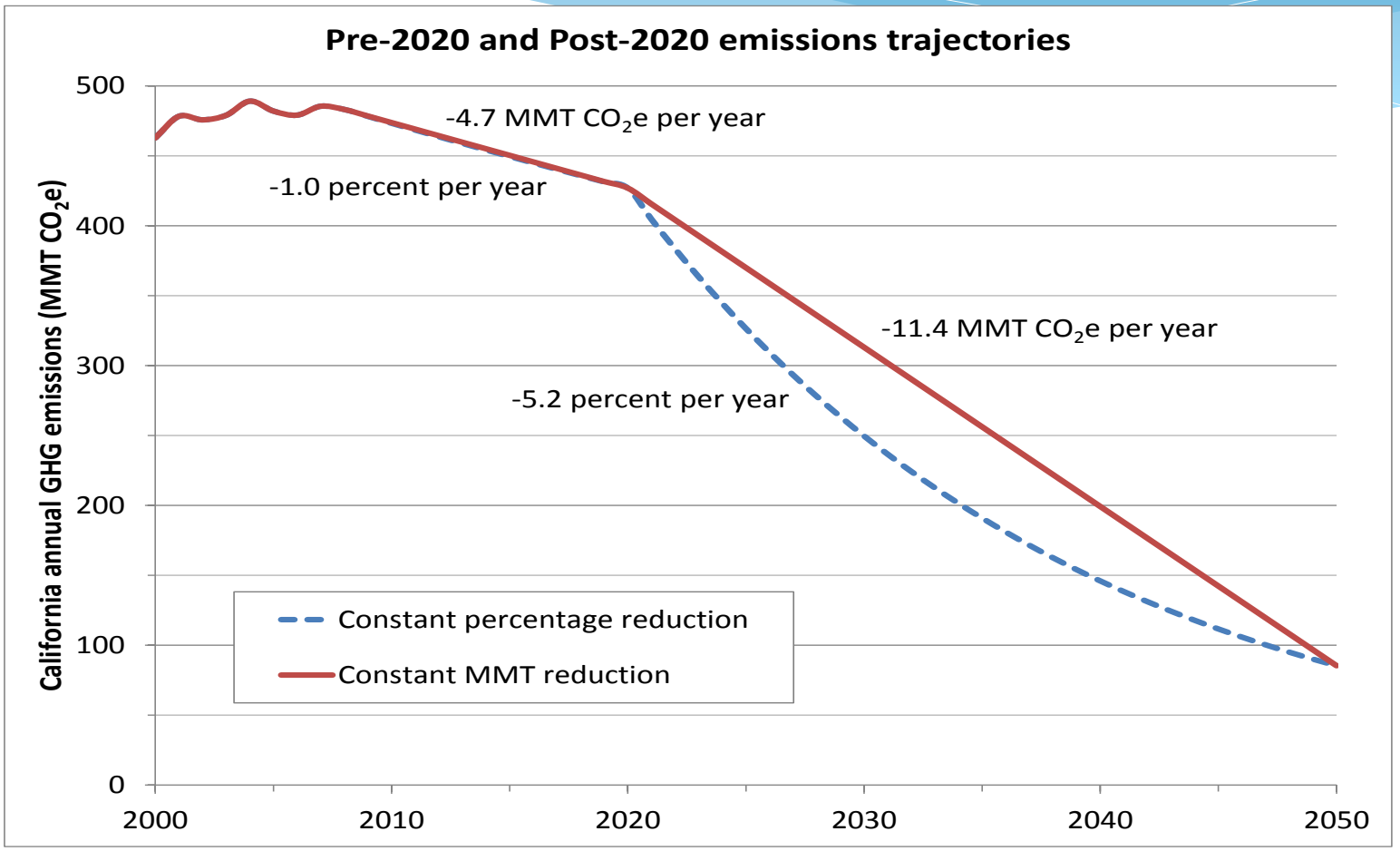


The total GHG emissions decreased by 0.3% while GHG emissions per capita decreased by 1%



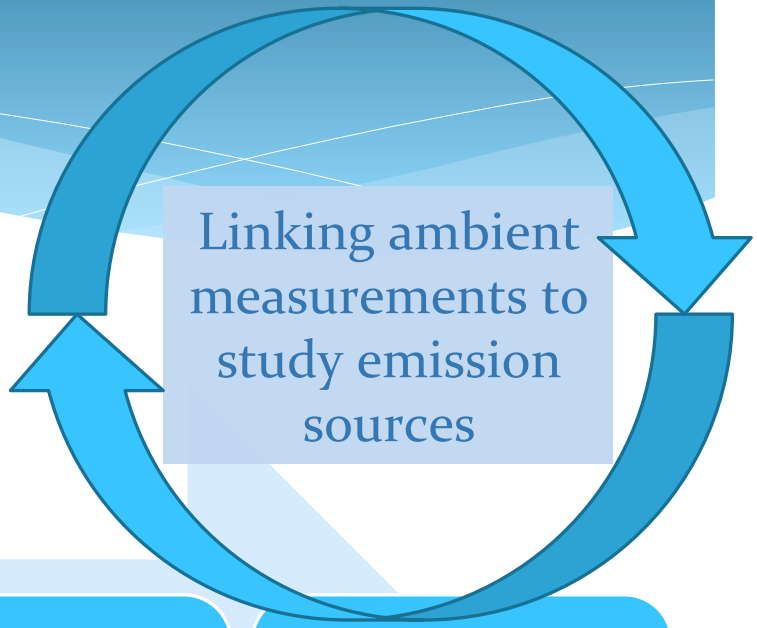
While California's economy and GDP continued to grow in 2013, the GHG carbon intensity of the economy (emissions per GDP $) continued to decline

Challenge of meeting 2050 target



ARB's GHG Research Program

ARB's greenhouse gas measurement program is designed to support California's GHG reduction efforts



Identify Specific Sources

Evaluate Source Emissions

Identify GHG Reduction Opportunities

Track Emission Reductions

Measurement Feedback

California Research Collaborators

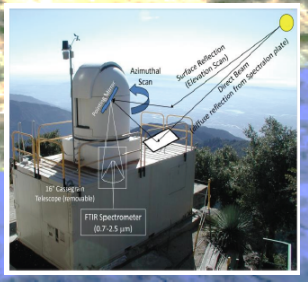
Satellite Measurements (700 km)

NASA

Aerial Measurements (<1 km)

CIRPAS
JPL
NOAA

Ground-level Measurements



CEC

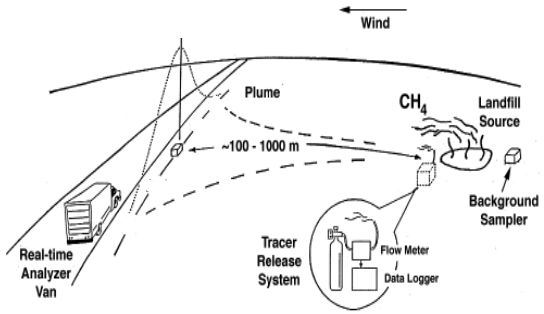
Towers	Mobile	Field Studies	Remote Sensing	Laboratory
ARB, Caltech	ARB	UC Berkeley	Caltech	Caltech
LBNL, LLNL	LBNL, Picarro	UC Davis	JPL	NOAA
Scripps	UC Irvine	Other UCs		UC Irvine

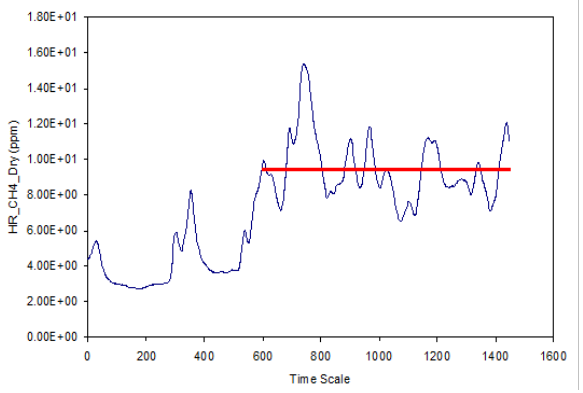
California's GHG Monitoring Network

Source-level Emissions Research

Measurement Tools

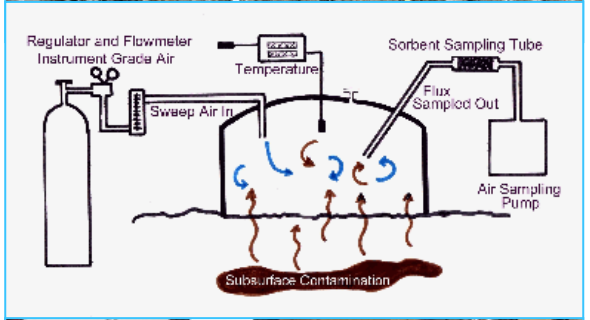
ARB Mobile Platforms





Jakober et al. (2015) Mobile measurements of climate forcing agents: Application to methane emissions from landfill and natural gas compression, *JAWMA*, 65:4, 404-412

Flux Chambers



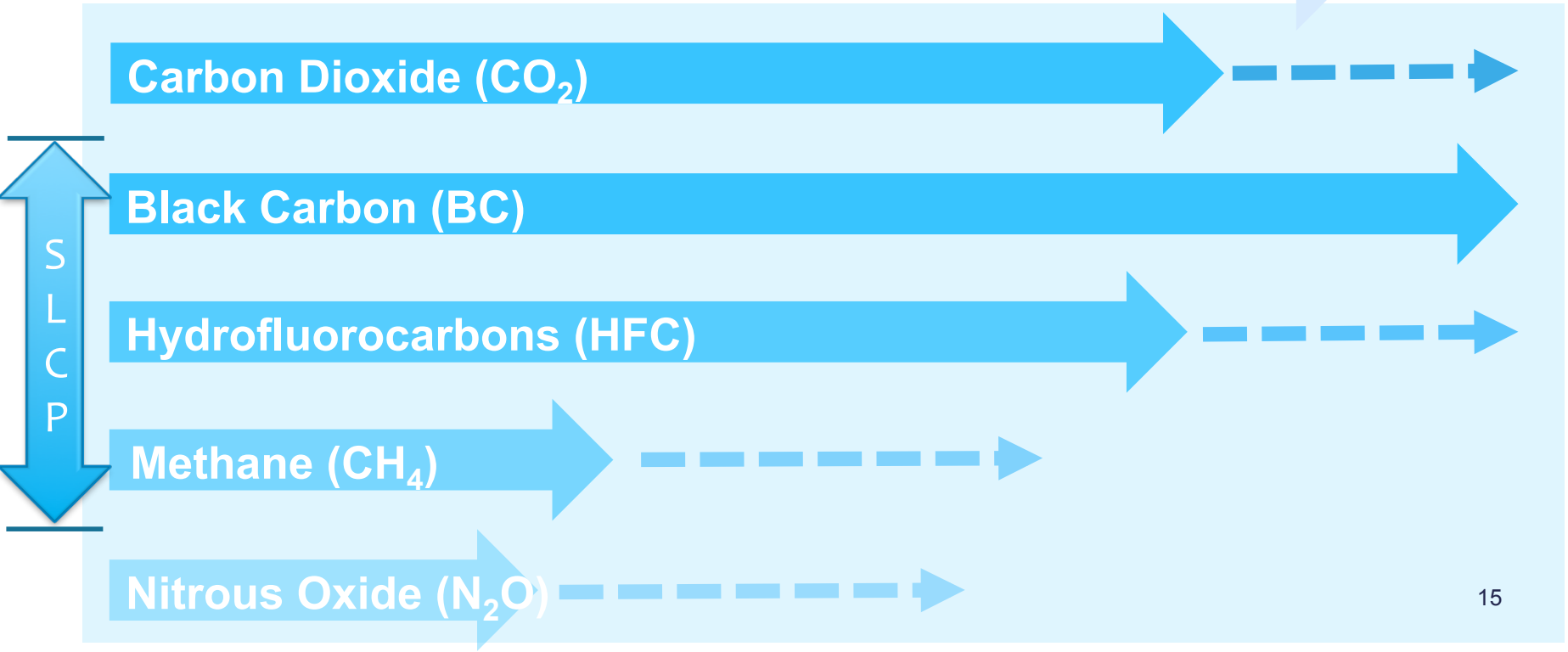
Current Progress

Identify Specific Sources

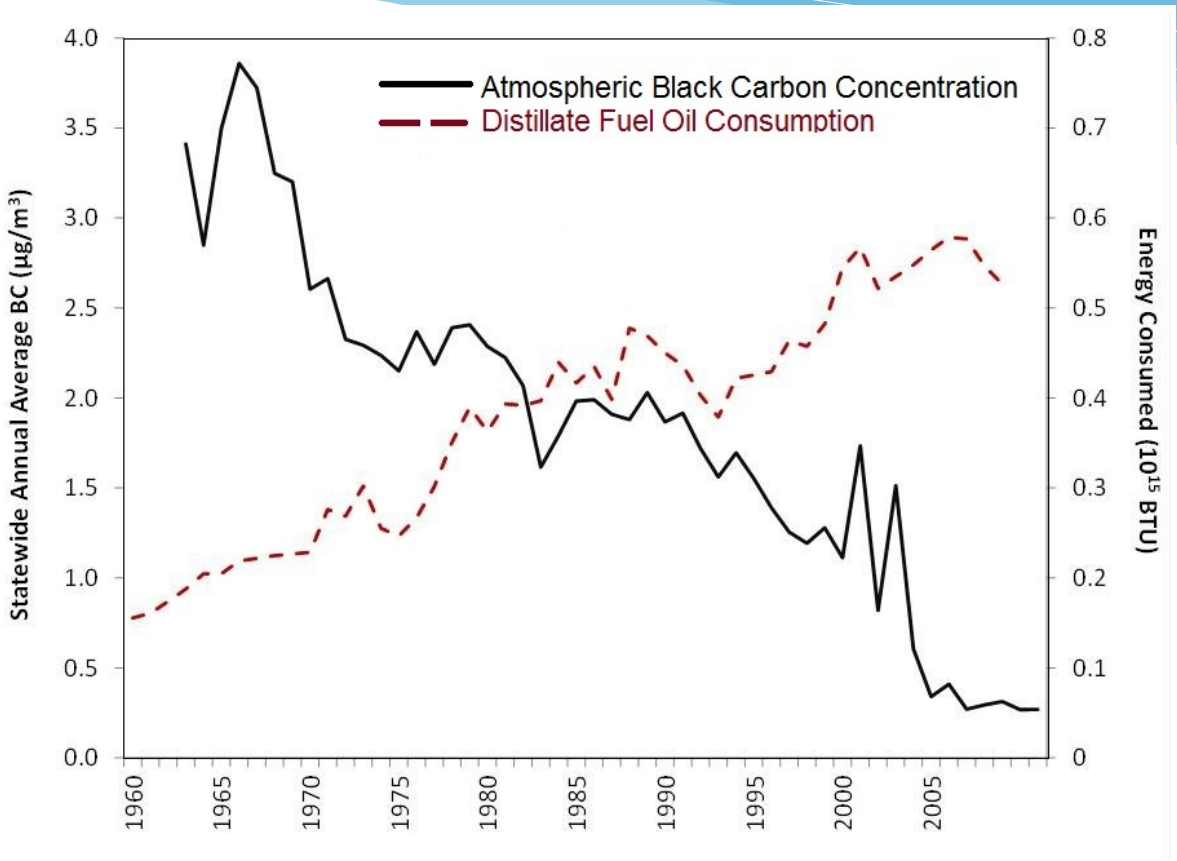
Evaluate Source Emissions

Identify GHG Reduction Opportunities

Track Emission Reductions



45 Years of Progress on Black Carbon

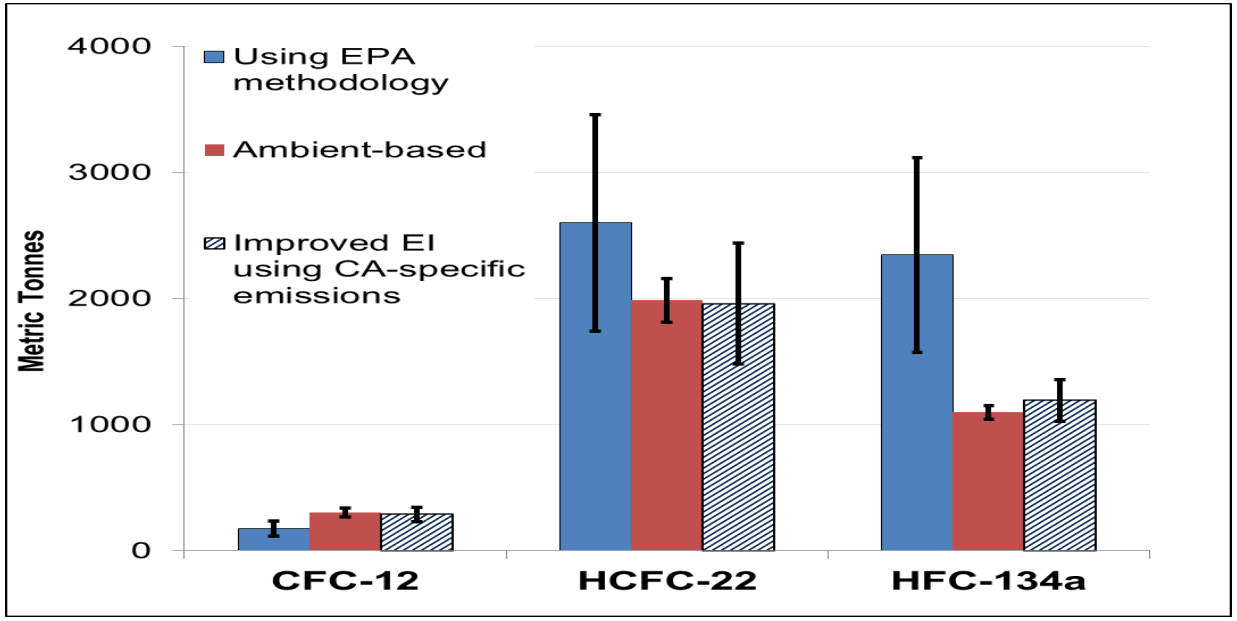


Reference: Ramanathan, Kirchstetter, et al. (2013) Black Carbon and the Regional Climate of California, CARB Contract No. 08-323

Hydrofluorocarbon Findings

Los Angeles Basin

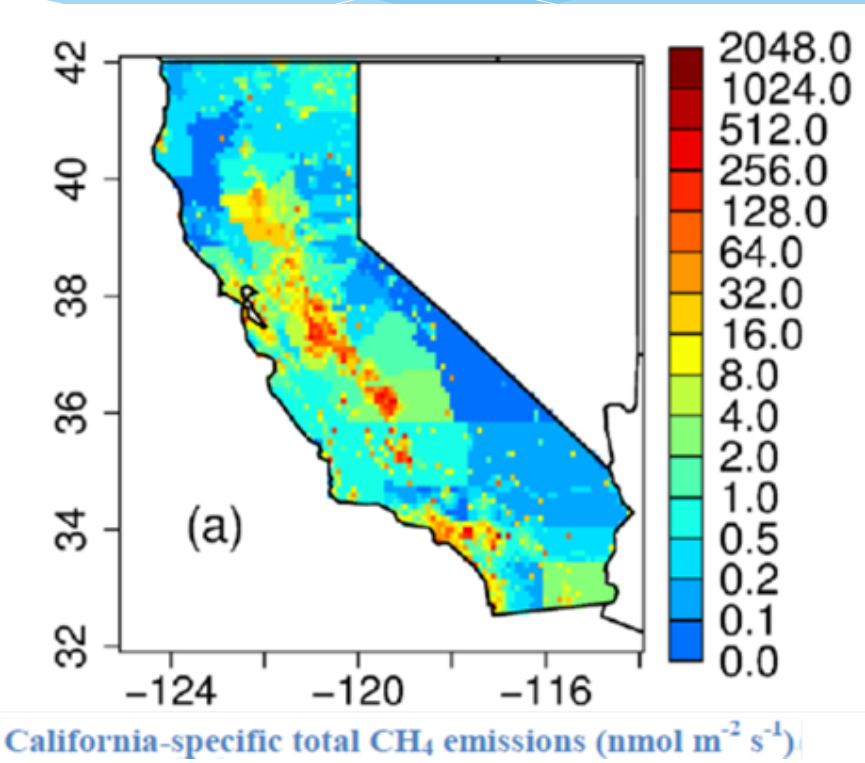
* Results from national EPA-based method differed significantly from 2007 Mt. Wilson measurements
* New California-specific emissions inventory consistent with measurements



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

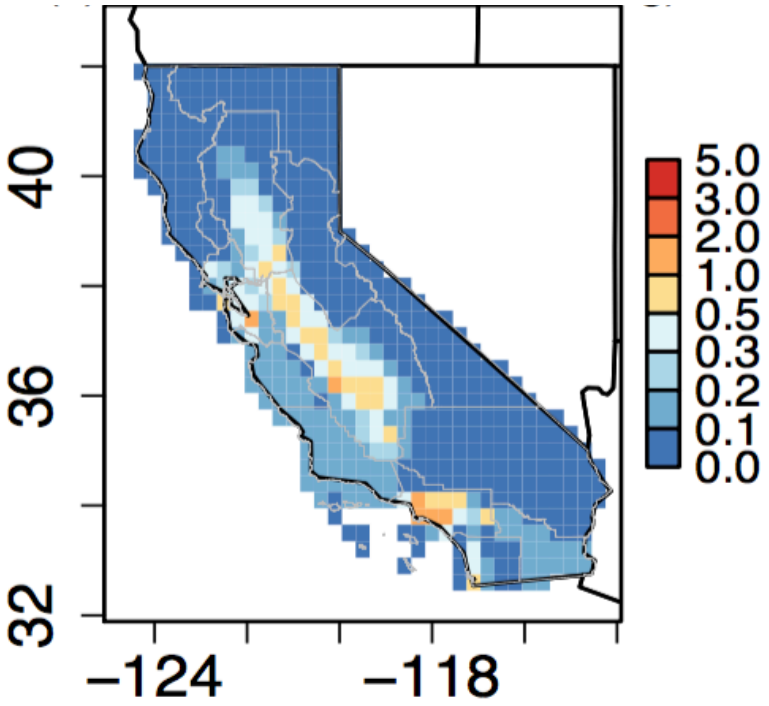
Statewide Methane Findings

* Estimated methane emissions 1.3 - 1.6 times the ARB inventory
* AB 1496 requires investigation of methane hotspots/super-emitters to inform policies and programs



Fischer and Jeong (2012) Inverse Modeling to Verify California's Greenhouse Gas Emission Inventory, ARB Contract No. 09-348

Statewide Nitrous Oxide Findings



Estimated annual anthropogenic N_2O emissions (Gg N_2O/yr)

* Estimated N_2O emissions 1.7 - 2.2 times the ARB inventory
* Ongoing research to better characterize agricultural and mobile source emissions

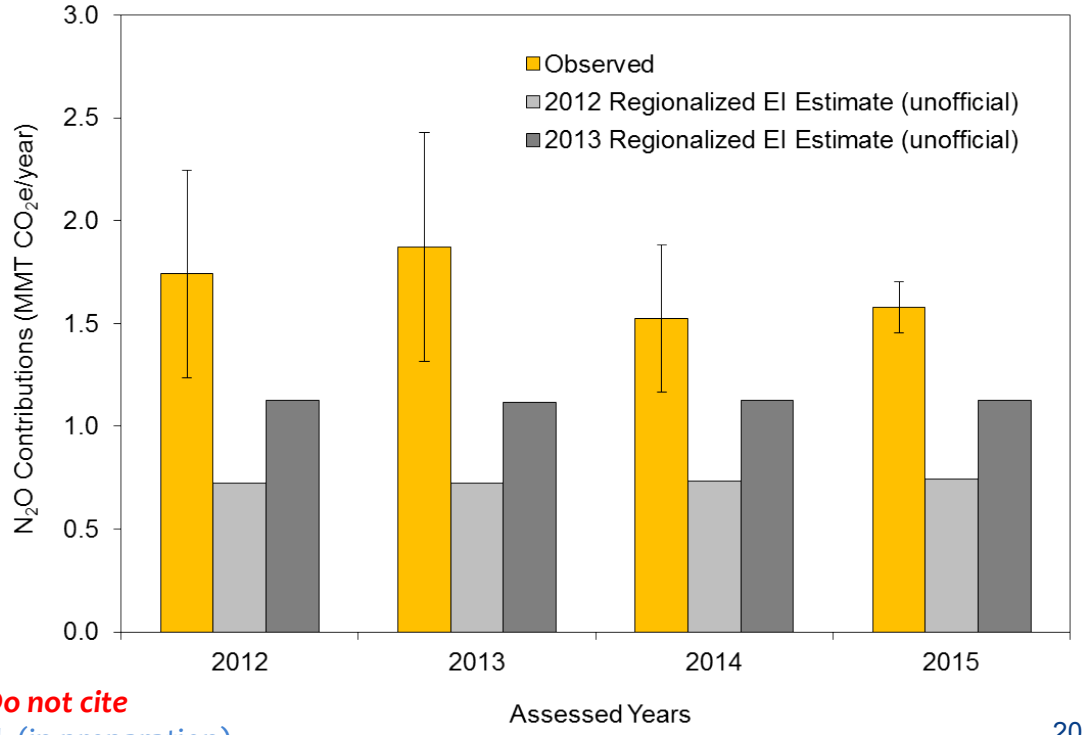
Draft – Do not cite

Fischer, et al. (2015) Draft ARB Research Contract Report (11-306)

Nitrous Oxide Findings
Los Angeles Basin

* Estimate based on Mt. Wilson N_2O:CO correlation 130±24% greater than earlier ARB emission inventory

* Recent ARB inventory update reduces discrepancy to 49±15%
* Annual emission trends (2012-2015) stable at 1.68±0.16 MMT CO_2e/ year.



Draft – Do not cite

Kuwayama, et al. (in preparation)

California Data Needs

Meeting Air Quality Standards

* Role and source of ozone aloft (2016 field study)
* Role of stratospheric intrusions and transport from East Asia

Meeting Greenhouse Gas Targets

* Track Statewide and sector/source-specific GHG mitigation
* Track co-pollutant trends in disadvantaged communities
* Highly resolved CO and GHG inventories for inverse modeling
* Quantify CH_4 emissions from dairies, landfills, oil/gas sector
* Quantify N_2O emissions from fertilized fields/lawns, dairies, other sources
* Identify remaining sources of BC and BrC
* Land-use changes (urban, working, natural)

Forest Carbon Stock

* Statewide inventories of carbon stocks for forests and other lands
* Screening for carbon-depleted or high carbon-containing natural areas for priority management

Data Product Considerations

Spatial Resolution

* Geographic specificity to target reductions and convince stakeholders
* Role of super-emitters to design regulation/enforcement
* Proper accounting of natural sources (e.g., oil seeps)
* Ability to track individual facilities for compliance and upset conditions
* Landscape carbon accounting at the scale of offset projects

Timeliness

* Regulatory development phase takes 1-3 years
* Decisions on funding for working and natural lands year-to-year

Continuity

* Long-term commitment to measurements and analysis products
  * Inform mitigation program over next few years
  * Help track compliance and effectiveness to 2020, 2030, and beyond

Summary

* California GHG Research Program critical for success of AB 32 programs
  - Evaluate and inform ARB GHG inventory
  - Identify, implement, and validate effective emission mitigation strategies
  - Track GHG emission trends in the state
* Current efforts are helping improve emission inventories and source attribution
* Continued research collaborations invaluable to help California meet its short- and long-term climate goals