



Methane: Air Quality and Climate Forcing

CARB Board May 24, 2012

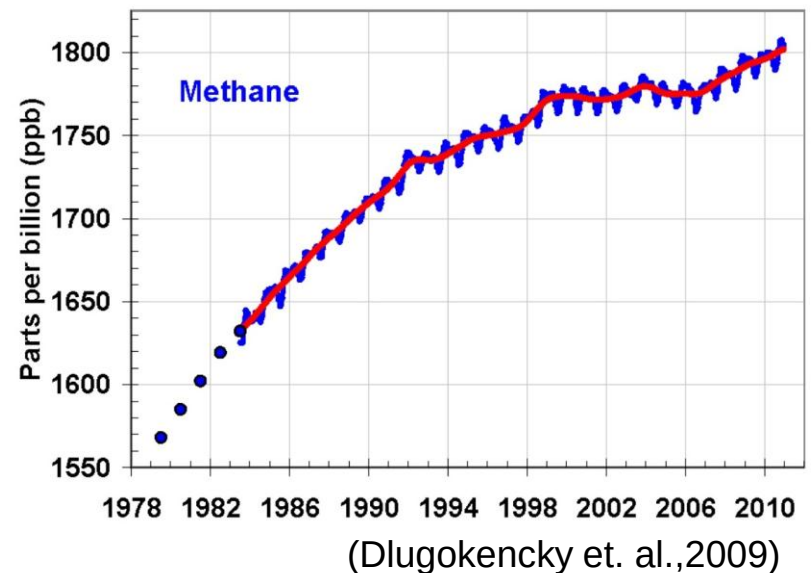
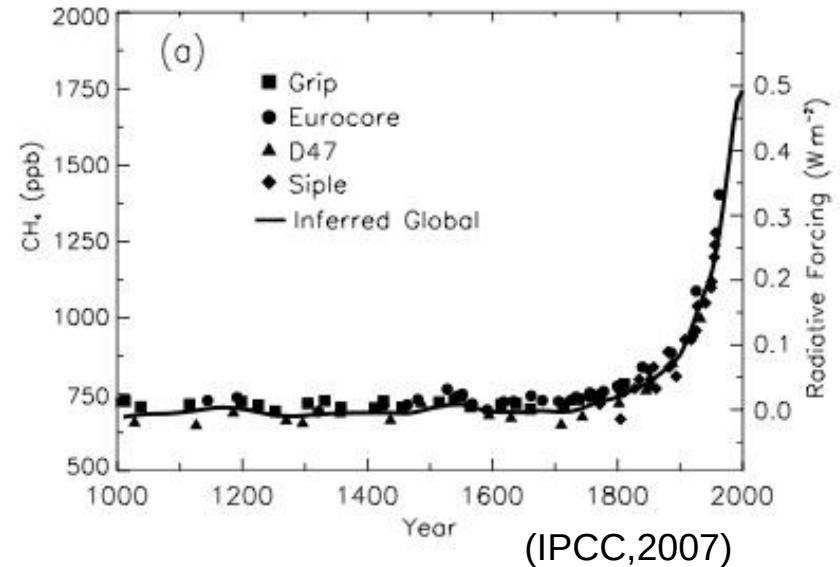
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OUTLINE

- Methane has increased substantially from pre-industrial
- Predominant precursor for background ozone
- Third largest warming agent - but short lived
- California emissions exceed current inventories
- Mitigation offers near-term benefits

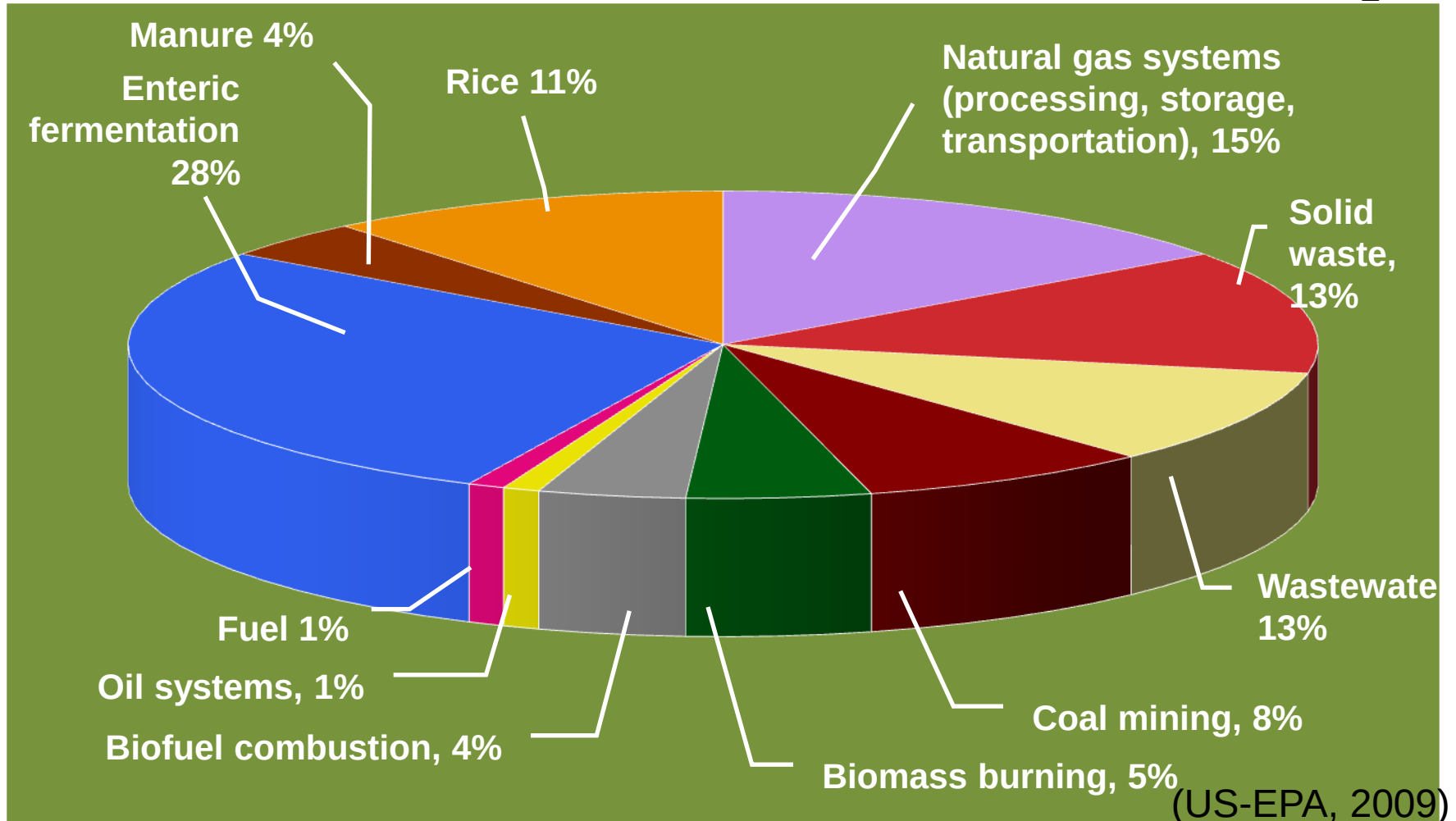
Global Methane Trends

- Sharp 20th century CH₄ increase (750-1800 ppbv)
 - Anthropogenic emissions now greater than natural emissions
- Global CH₄ increase slowed dramatically for a decade but now rising again
 - Also increasing in No. California (Trinidad Head & Point Arena)
 - Reaction with OH is primary sink



Global Anthropogenic Methane Emissions

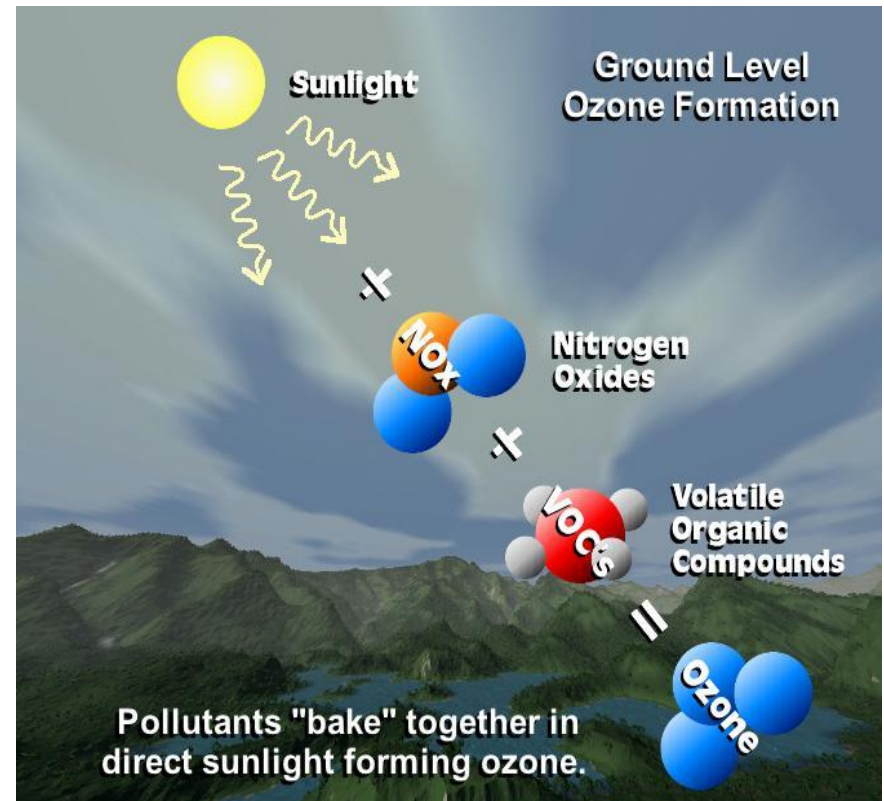
Numerous sources not readily “metered” as with CO₂



Total (2000): ~6 GtCO₂e (compared to ~33 Gt fossil CO₂)

Air Quality Problem: Methane Forms Ozone

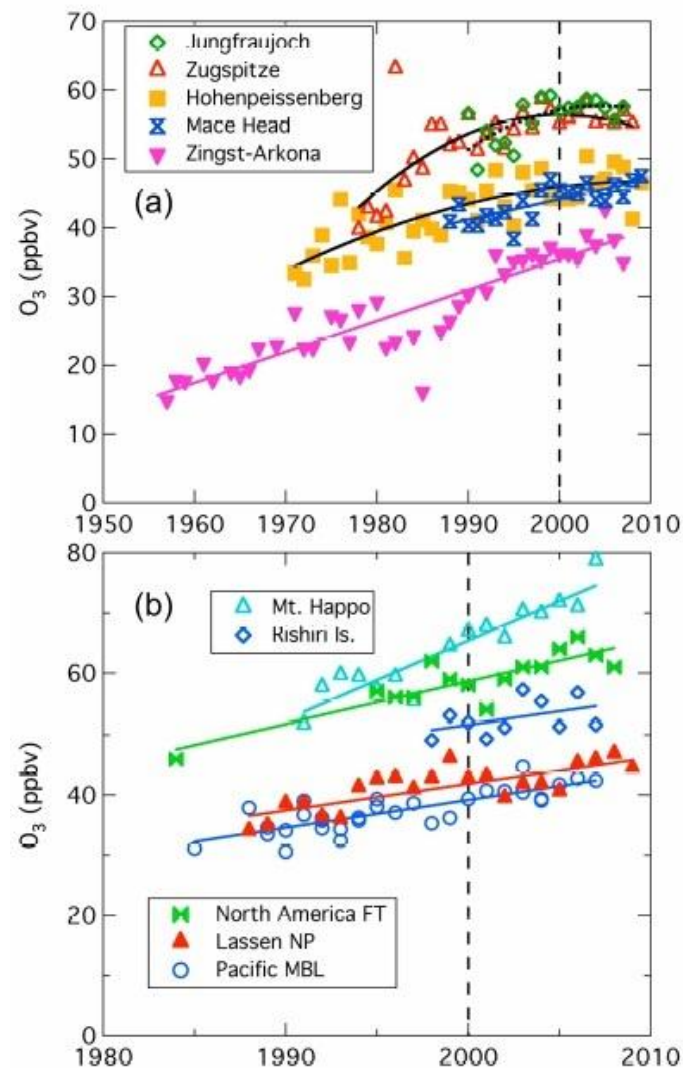
- Ozone formed by photochemical reactions of NO_x and VOC
- CH_4 is simplest VOC
 - OH loss gives ~10 yr lifetime
 - Responsible for ~1/2 global O_3



Background Ozone Concentrations

- Background O₃ increasing at most sites around world
- Background O₃ doubled over Europe in 20th Century
- Background O₃ has altitudinal and regional dependencies
- Modeling predictions suggest background O₃ could exceed CA 8-hr standard before 2100

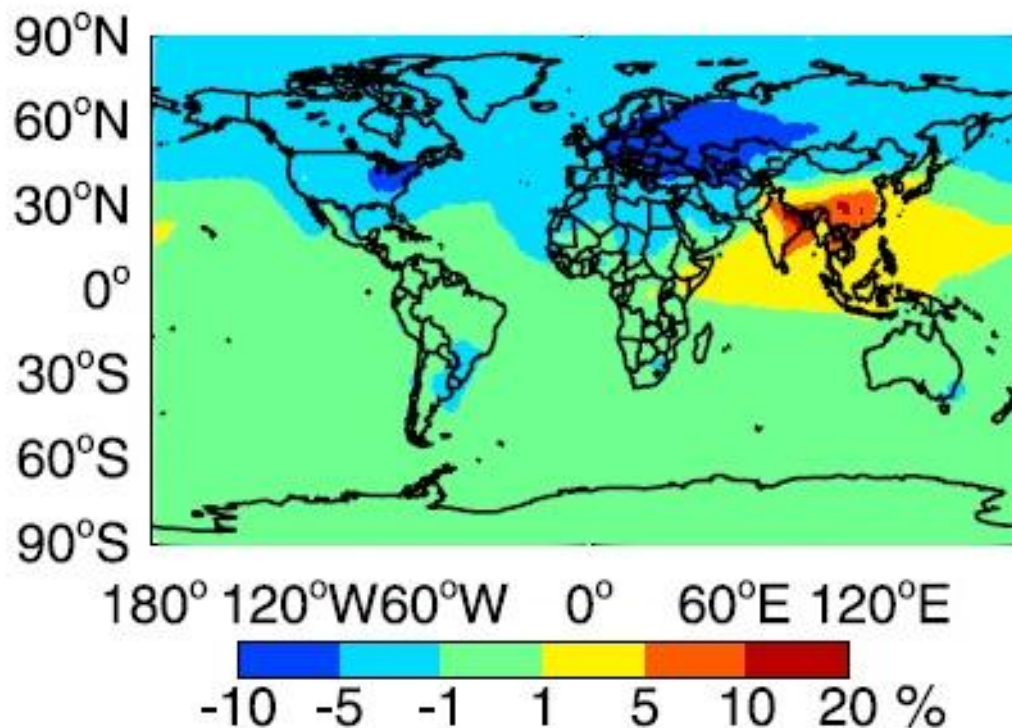
Range of predicted ozone concentrations (ppb)			
Year	Lower	Mean	Upper
2040	35	42	48
2060	38	55	71
2080	41	64	87
2100	42	63	84



(HTAP , 2010)

Methane Mitigation Improves Ozone

- Predicted annual mean MDA8 O₃ reduced ~5% by an ~20% CH₄ reduction
- More OH left available for atmospheric cleansing
- Larger benefits likely over areas with high CH₄ emissions

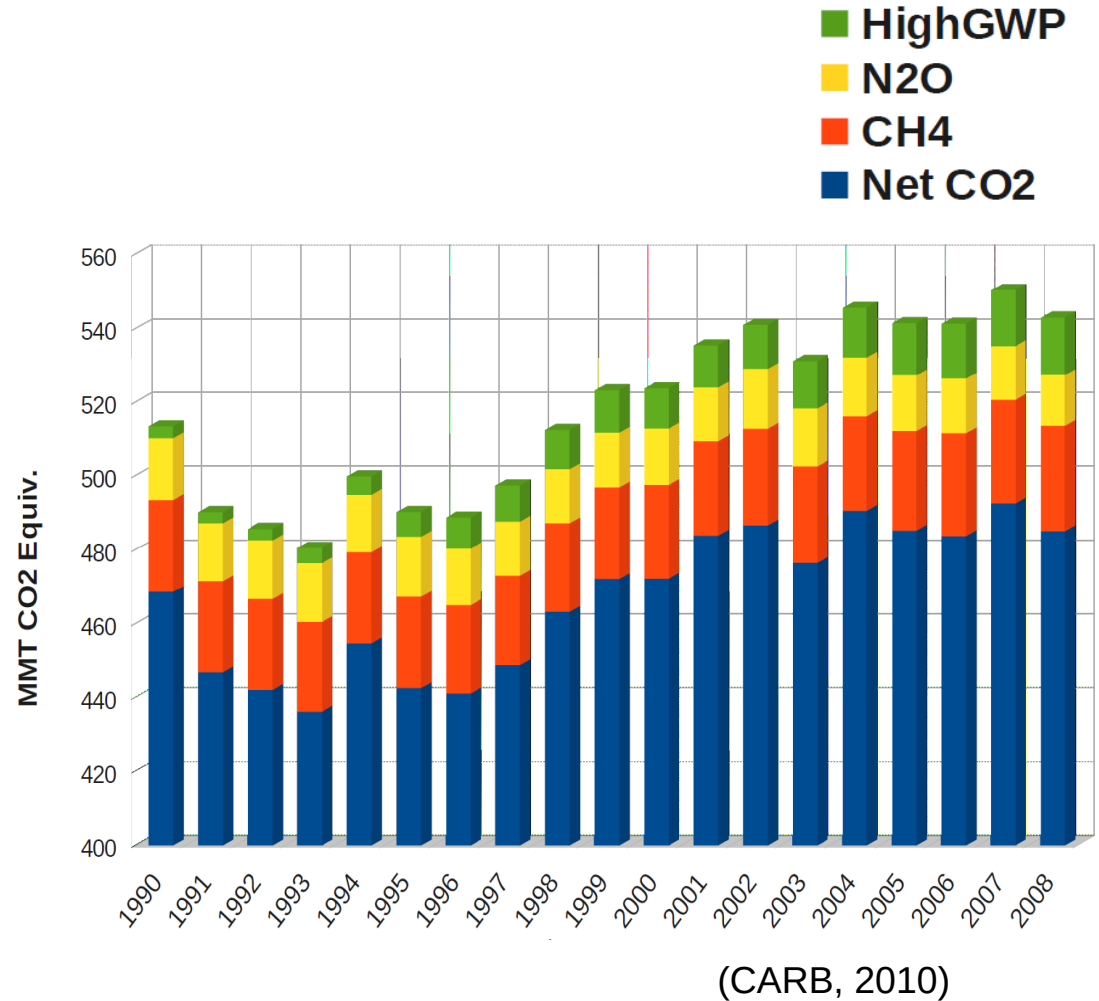


Fiore et al., 2008

Fiore Model: Ozone pollution reductions 11 years after Asian anthropogenic sources

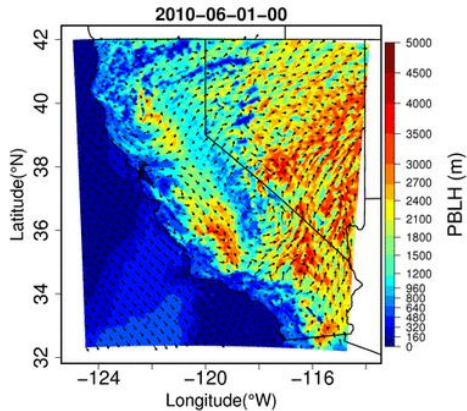
California's Non-CO₂ GHG Emissions

- Most sources not readily metered
 - New estimates suggest some sectors have uncertainties 10% to >100% (NRC, 2010)
- Atmospheric inverse method provides independent check

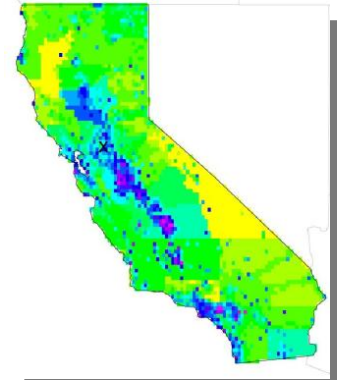
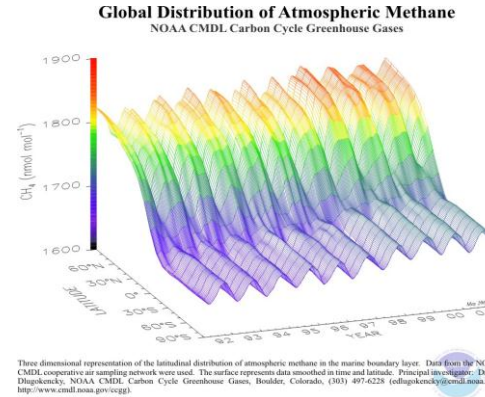


Atmospheric Approach to Estimate Emissions

California and Background CH₄



Meteorology



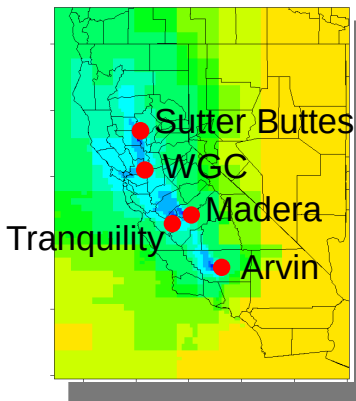
Measurements

Emission Model

Footprints

Bayesian Inversion

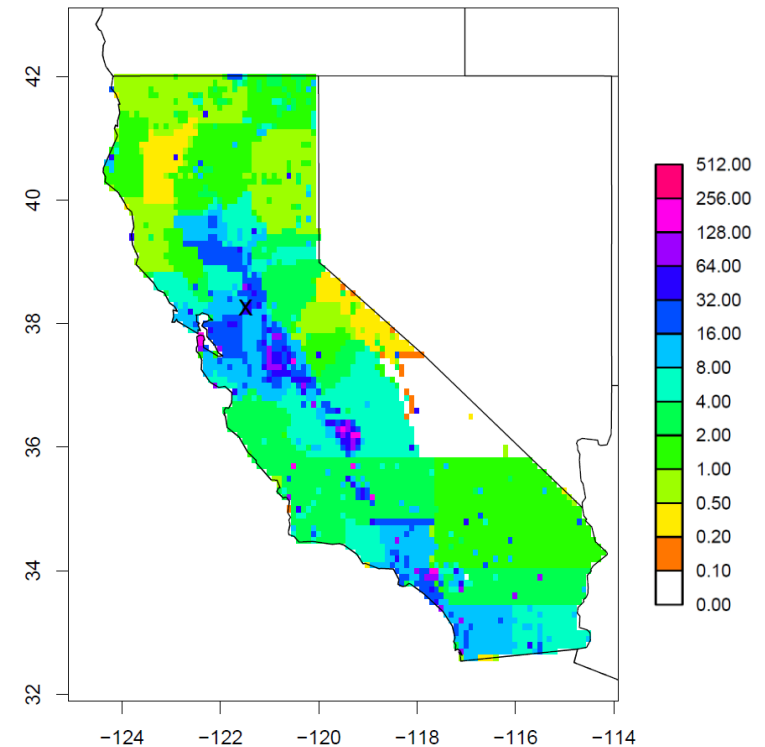
Improved Emission Estimate



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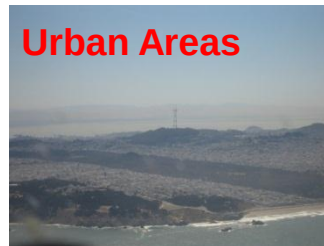
California CH₄ Emission Mapping

- Source Specific Maps
 - Landfills (CARB)
 - Livestock (DWR, CEC, CARB)
 - Natural gas – CARB
 - Petroleum - CARB
 - Waste water treatment - CARB
 - Mobile source CH₄ (from CO₂)
 - Wetlands
 - Agriculture
- Source maps scaled to match CARB inventory totals by source sector



(Jeong et al., 2012)

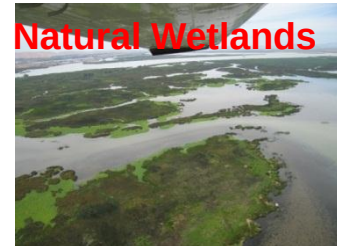
Urban Areas



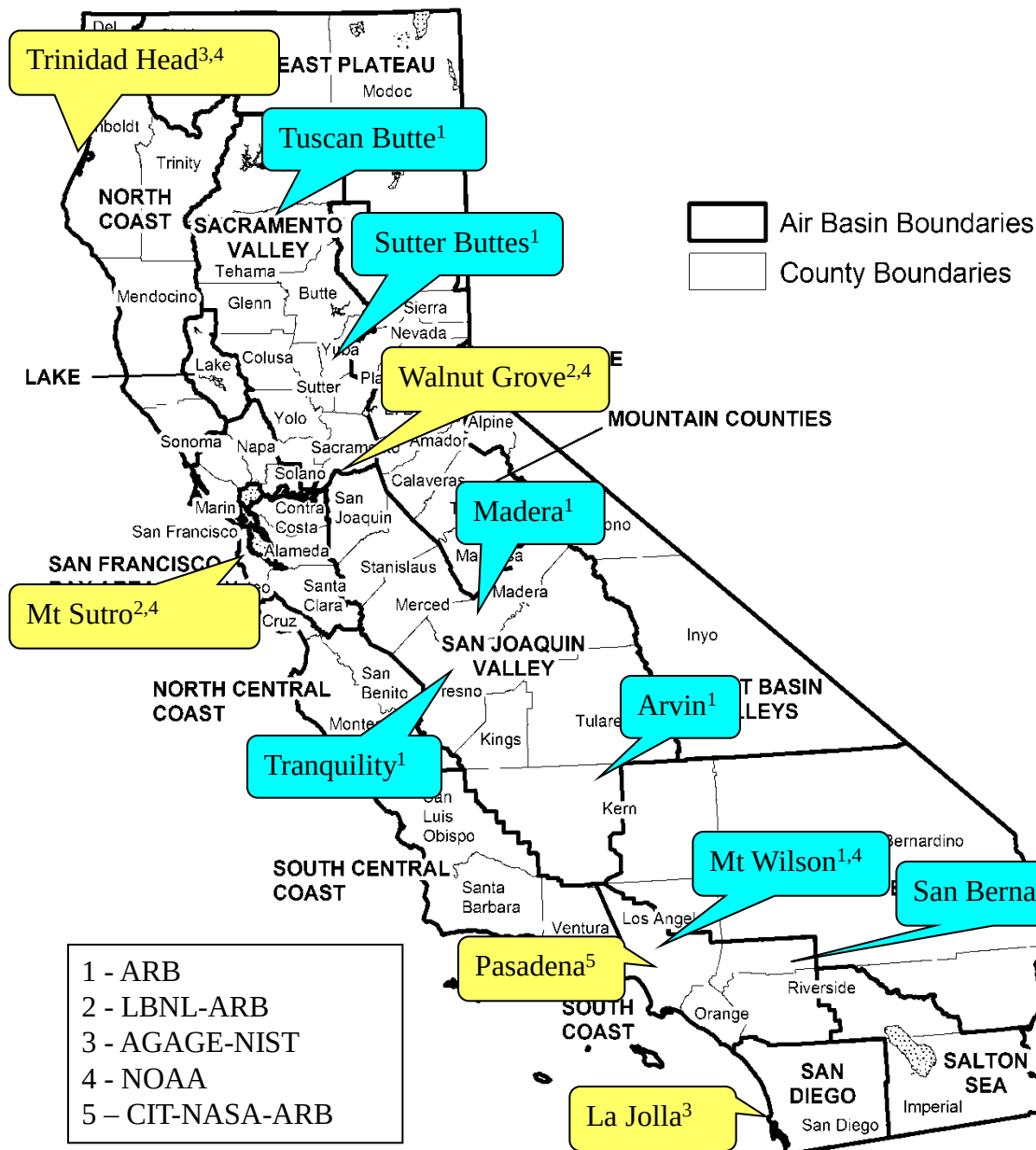
Livestock



Natural Wetlands



California's GHG Monitoring Network



Measurements

Most sites now: CH₄, CO₂, H₂O (+N₂O, CO soon)

Some sites: ¹⁴CO₂, N₂O, halocarbons, VOC

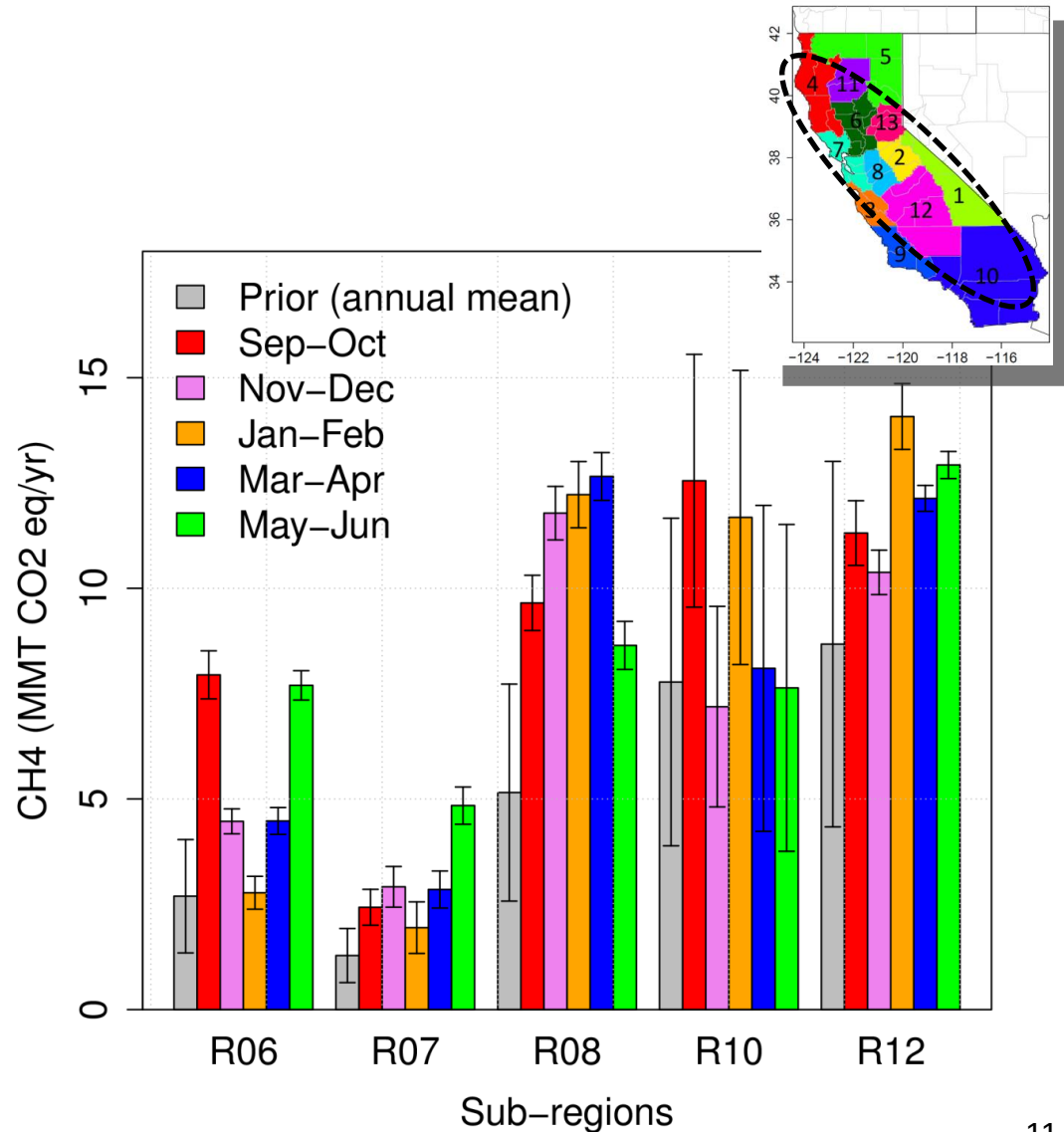
NOAA standards for calibration

NOAA sampling at some sites (WGC, San Francisco, Mt. Wilson)

Inverse Emission Estimates

CARB-LBNL CH₄ Tower Network, 2010 - 2011

- CA network captures ~90% of CH₄ emissions
- Estimated emissions 1.6 ± 0.1 times CARB inventory
- Most significant uncertainty reduction obtained in Central Valley
- Additional towers will improve constraint in Southern California region



Summary of Multiple Measurement Results

- LBNL-ARB-NOAA tower measurements in rural-urban areas (Jeong et al, in prep)
 - Top down: 44.8 +/- 3.6 MMTCO₂e for CA
 - CARB inventory: 28 MMTCO₂e
- CARB SoCal (Mt Wilson) measurements find inventory low by ~ 30% (Hsu et al, 2010)
- NOAA aircraft confirm landfill methane emissions (Peischl, 2012, in prep)
- UCI VOC and isotopic suggest SoCal gas/oil sources significant (Townsend-Small, 2011)

Co-Benefits of Reducing Methane

- Improved air quality
 - public health
 - Reduced mortality
 - Robust crops and forests
- Comparatively powerful lever on short-term climate forcing
 - Warming potential ~70x greater than CO₂ @ 20 yr
 - Protection of natural carbon “sinks”
- Increased fuel quantity & diversity

Conclusions

- Methane is important
 - Global methane increases global background ozone
 - Third largest global warming agent - but short lived
- California emissions exceed current inventories
 - Observation-derived emissions ~50% greater on average
 - Atmospheric methods can diagnose sources
- Mitigation offers near-term benefits
 - Large near-term (20 years) climate benefit (GWP ~ 70 times CO₂)

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