Methane: Air Quality and Climate Forcing

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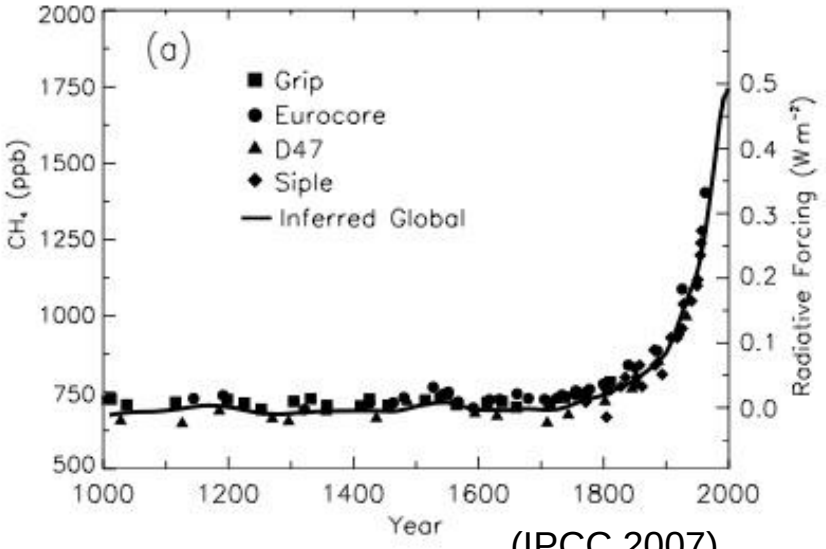
OUTLINE

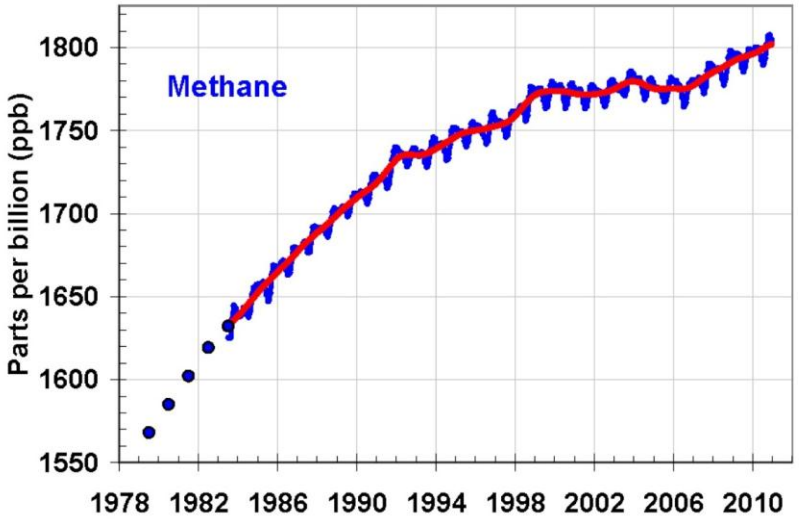
- Methane has increased substantially from pre-industrial
- Predominant precursor for background ozone
- Third largest warming agent - but short lived
- California emissions exceed current inventories
- Mitigation offers near-term benefits

Global Methane Trends

- Sharp 20th century CH_4 increase (750-1800 ppbv)
  - Anthropogenic emissions now greater than natural emissions
- Global CH_4 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



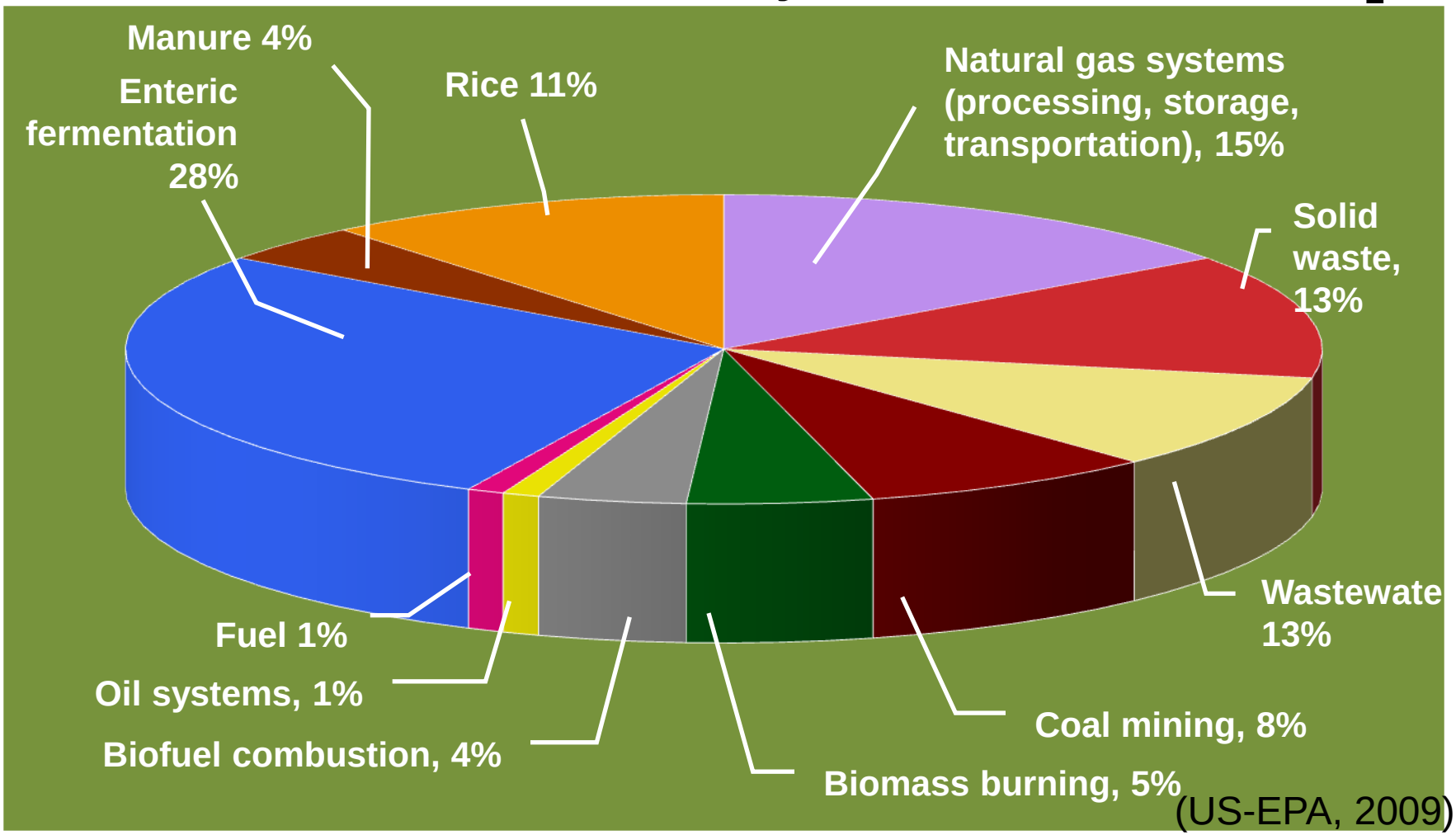
(IPCC,2007)



(Dlugokencky et. al.,2009)

Global Anthropogenic Methane Emissions

Numerous sources not readily "metered" as with CO_2

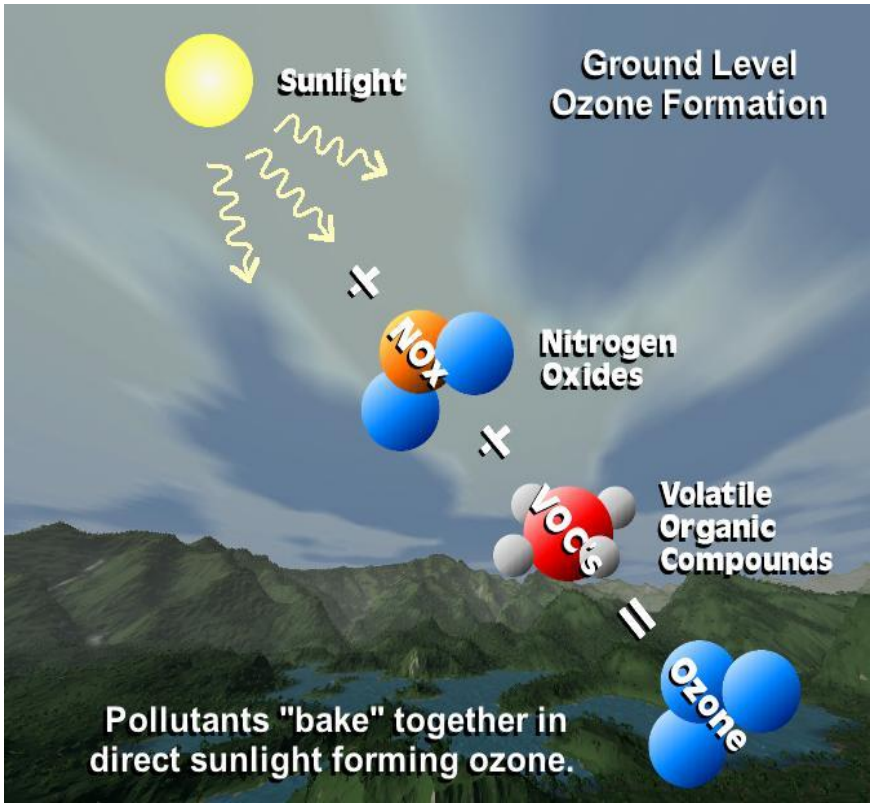


(US-EPA, 2009)

Total (2000): ~6 $GtCO_2e$ (compared to ~33 Gt fossil CO_2)

Air Quality Problem: Methane Forms Ozone

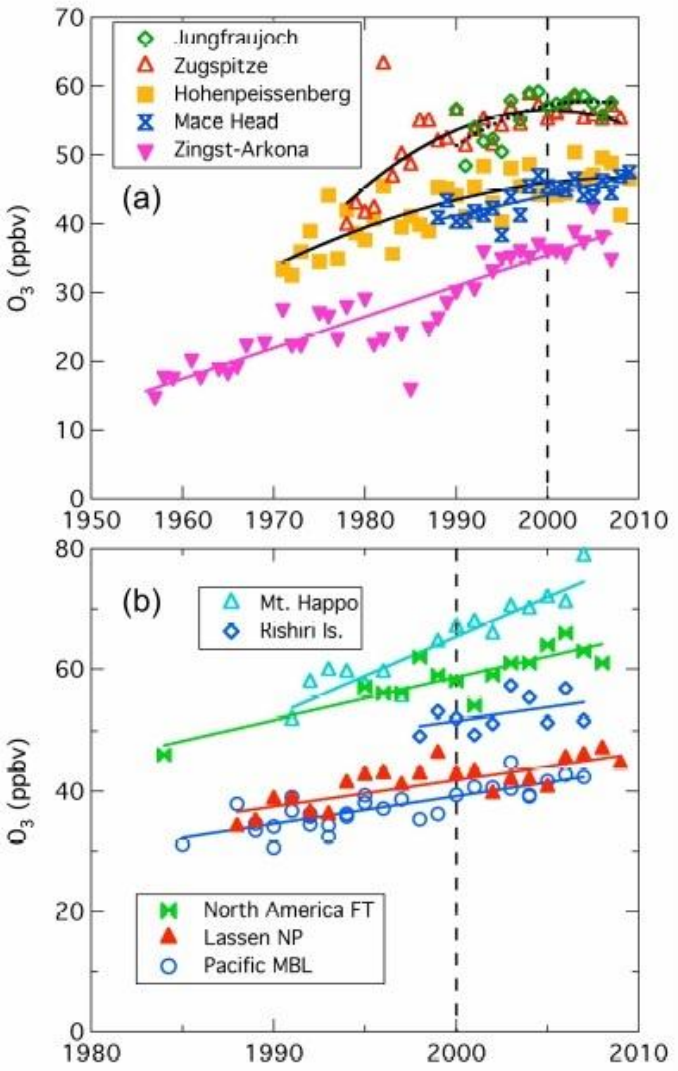
- Ozone formed by photochemical reactions of NO_X and VOC
- CH_4 is simplest VOC
  - OH loss gives ~10 yr lifetime
  - Responsible for ~½ global O_3



Background Ozone Concentrations

- Background O_3 increasing at most sites around world
- Background O_3 doubled over Europe in 20th Century
- Background O_3 has altitudinal and regional dependencies
- Modeling predictions suggest background O_3 could exceed CA 8-hr standard before 2100

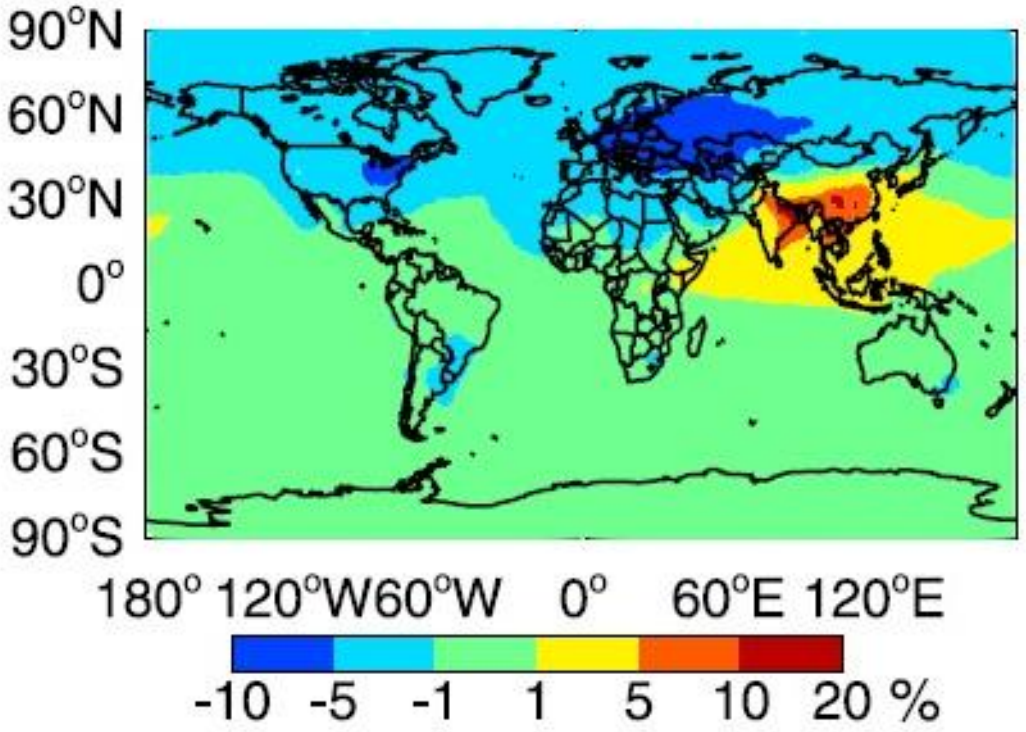
Range of predicted ozone concentrations (ppb)			
Year	**Lower**	**Mean**	**Upper**
2040	35	42	48
2060	38	55	71
2080	41	64	87
2100	42	63	84



(HTAP , 2010)

Methane Mitigation Improves Ozone

- Predicted annual mean MDA8 O_3 reduced ~5% by an ~20% CH_4 reduction
- More OH left available for atmospheric cleansing
- Larger benefits likely over areas with high CH_4 emissions

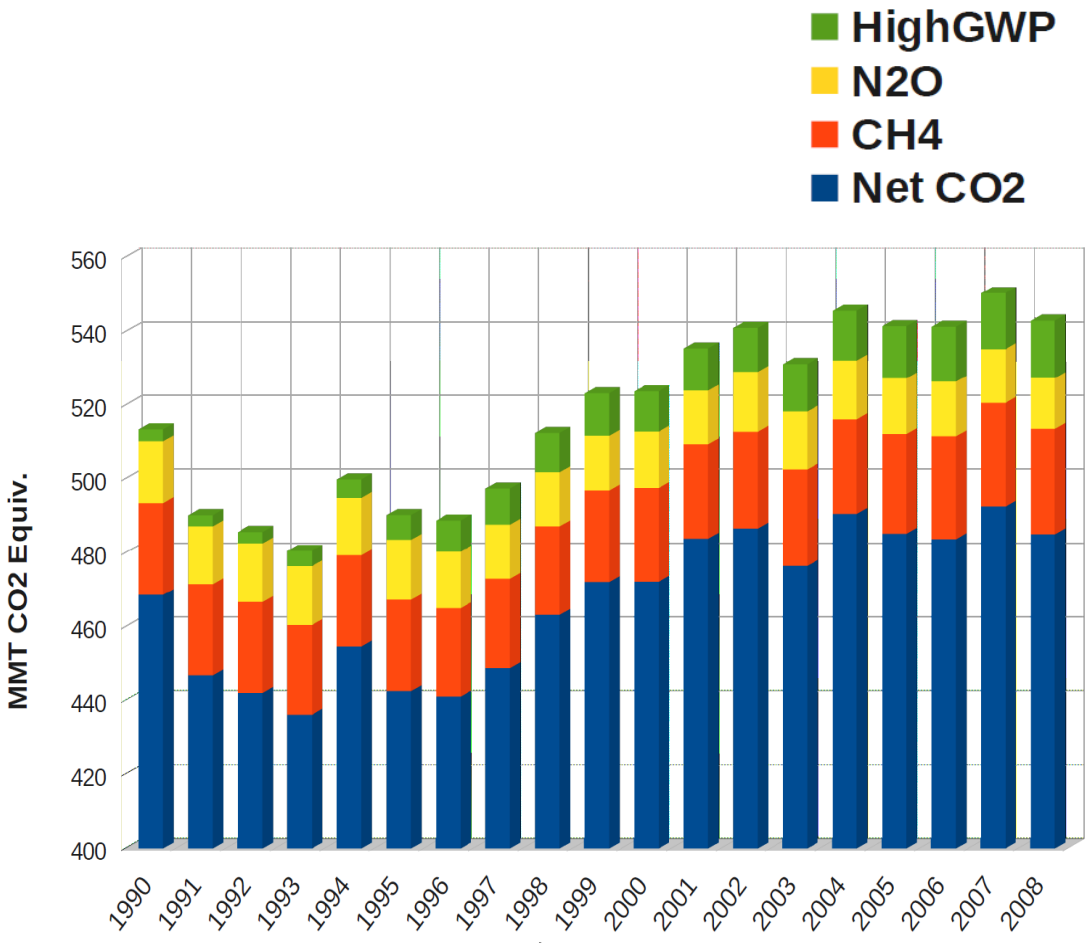


Fiore et al., 2008

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

California's Non-CO_2 GHG Emissions

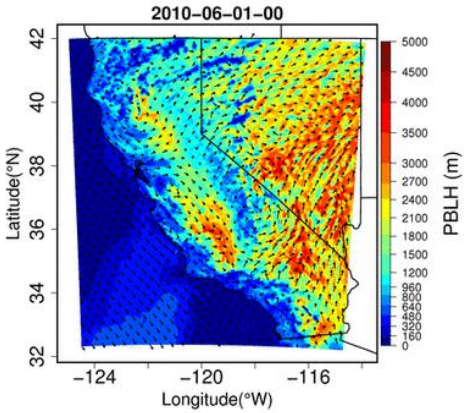
- Most sources not readily metered
  - New estimates suggest some sectors have uncertainties 10% to >100% (NRC, 2010)
- Atmospheric inverse method provides independent check

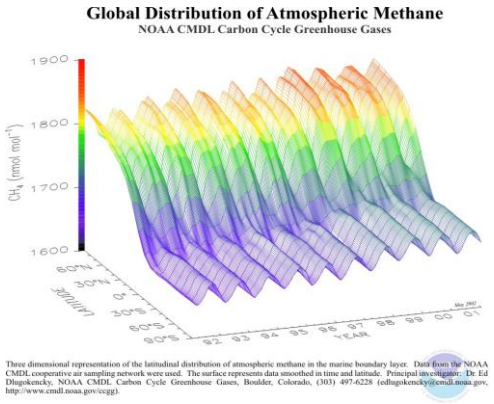


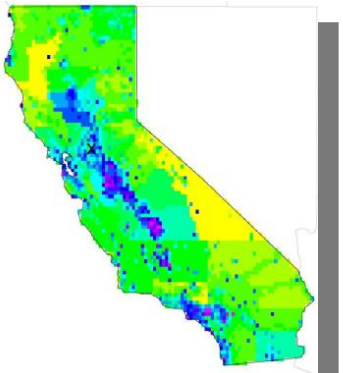
(CARB, 2010)

Atmospheric Approach to Estimate Emissions

California and Background CH_4



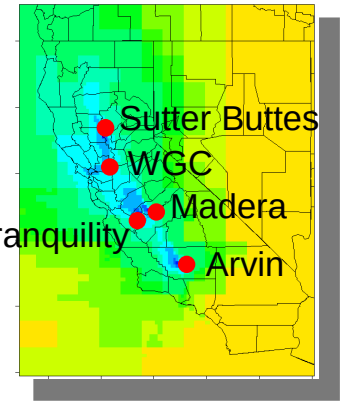




Meteorology

Measurements

Emission Model



calgem.lbl.gov

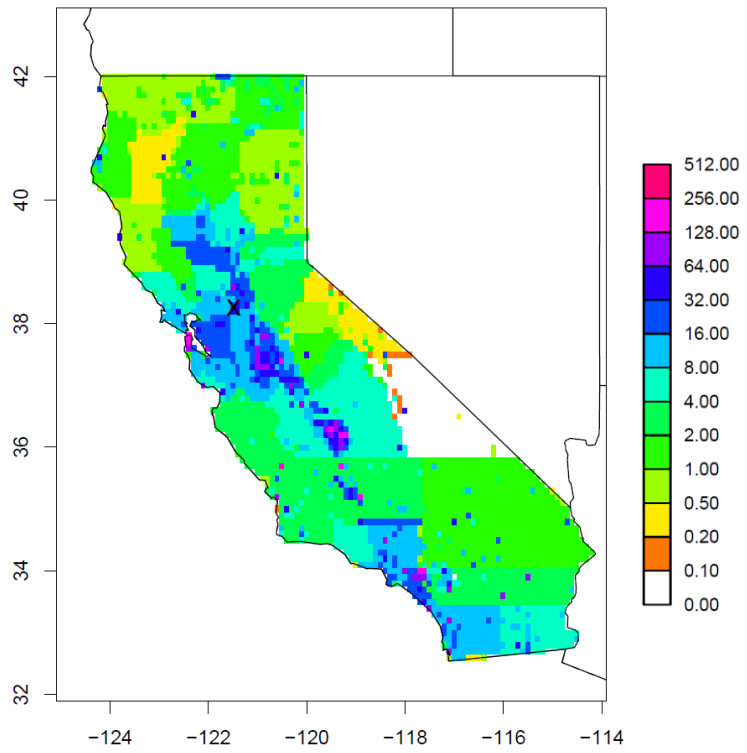
Footprints

Bayesian Inversion

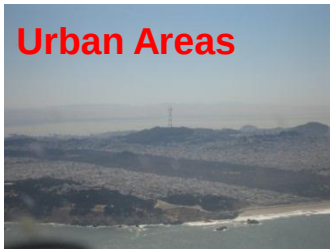
Improved Emission Estimate

California CH_4 Emission Mapping

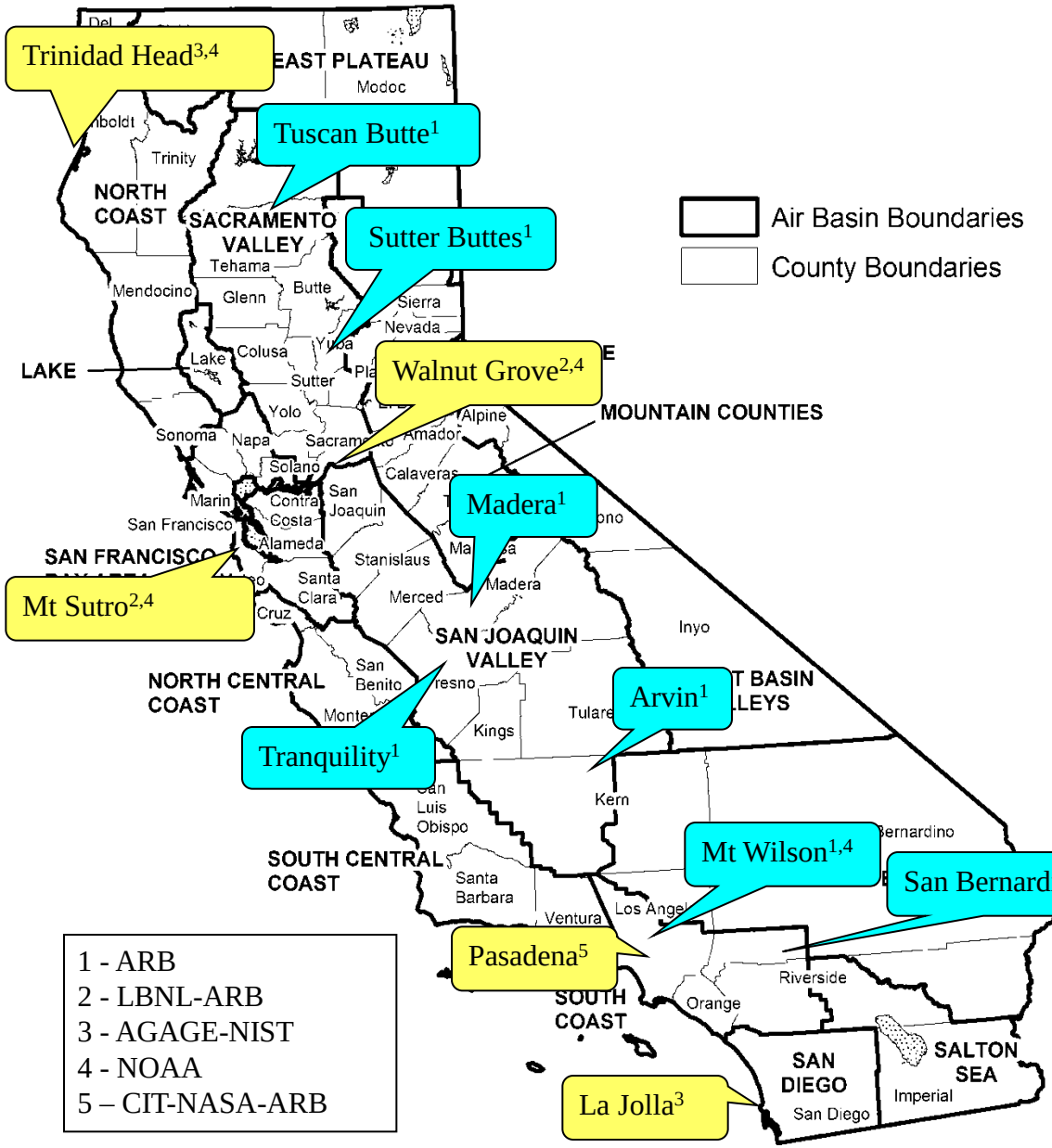
- Source Specific Maps
  - Landfills (CARB)
  - Livestock (DWR, CEC, CARB)
  - Natural gas – CARB
  - Petroleum - CARB
  - Waste water treatment - CARB
  - Mobile source CH_4 (from CO_2)
  - Wetlands
  - Agriculture
- Source maps scaled to match CARB inventory totals by source sector



(Jeong et al., 2012)



California's GHG Monitoring Network



1 - ARB
2 - LBNL-ARB
3 - AGAGE-NIST
4 - NOAA
5 – CIT-NASA-ARB

Measurements

Most sites now: CH_4, CO_2, H_2O (+N_2O, CO soon)

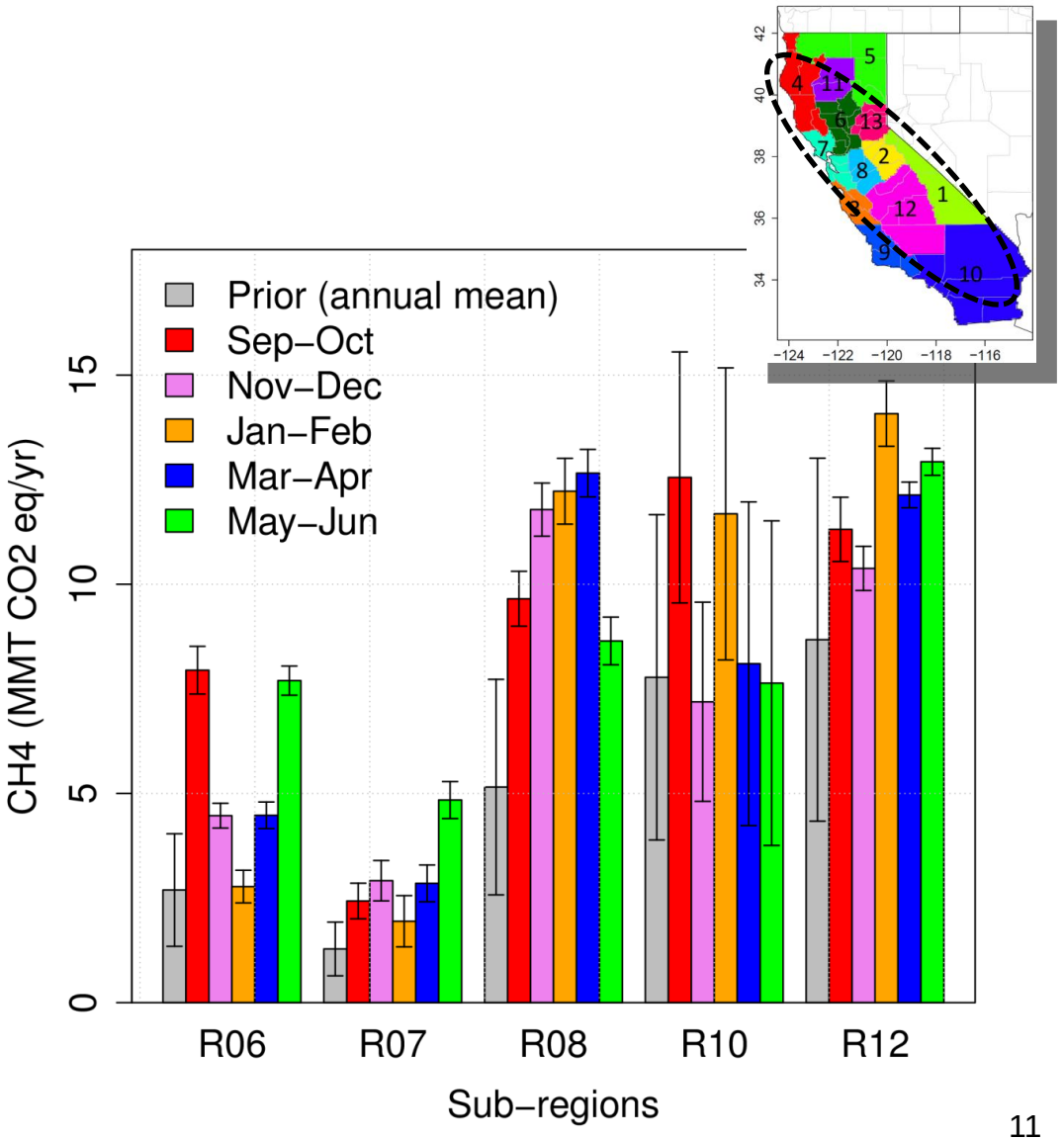
Some sites: $^{14}CO_2$, N_2O, halocarbons, VOC

NOAA standards for calibration

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

Inverse Emission Estimates
CARB-LBNL CH_4 Tower Network, 2010 - 2011

- CA network captures ~90% of CH_4 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 $MMTCO_2e$ for CA
  - CARB inventory: 28 $MMTCO_2e$
- 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 CO_2 @ 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 CO_2)

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