Regional Estimates of CH_4 and N_2O Emissions from Central California

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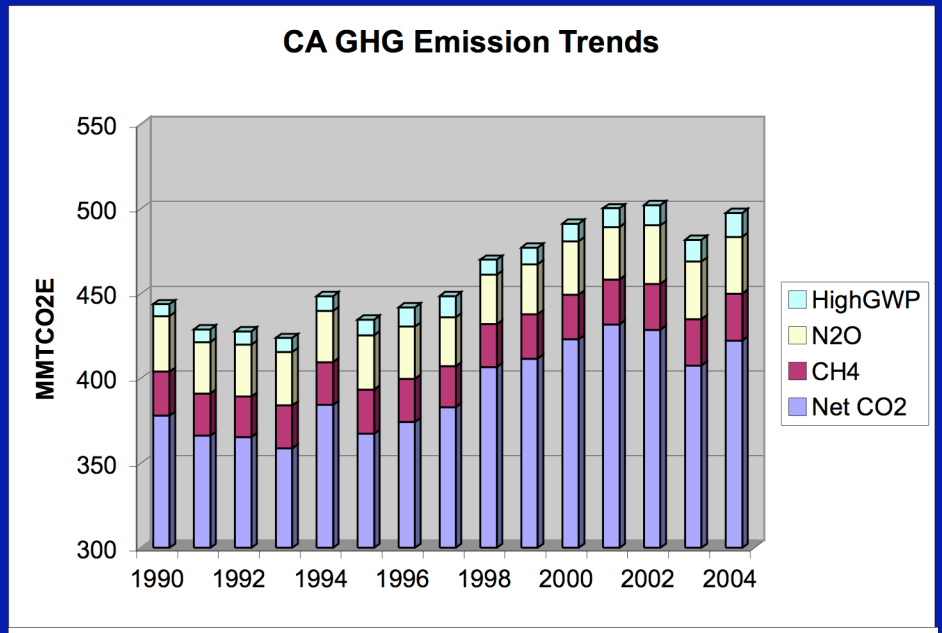
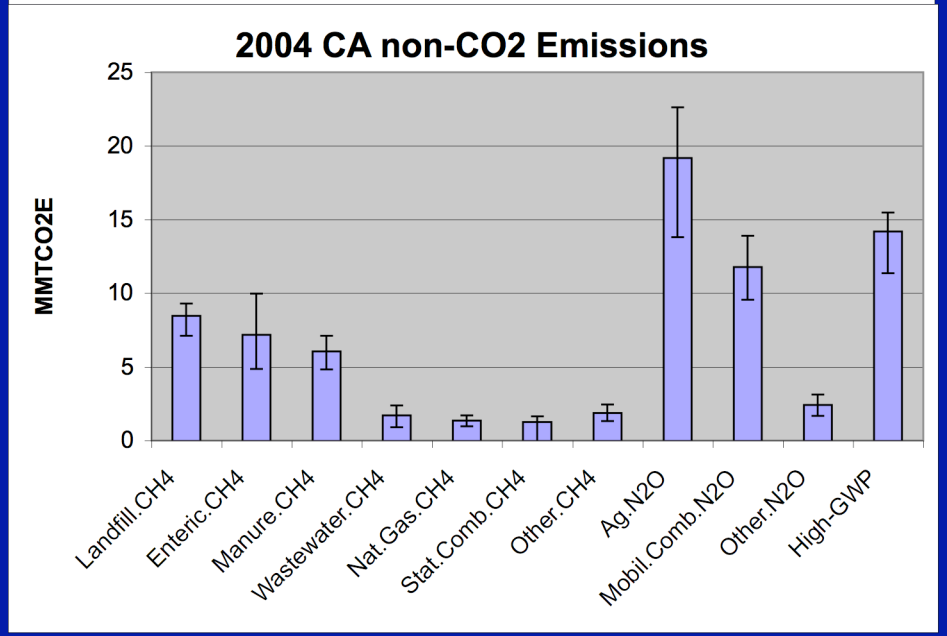
Outline

- Overview of California's GHG Emissions
- The California Greenhouse Gas Emission Measurement Project (CALGEM)
  - Tall-tower CH_4 and N_2O Measurements
  - WRF-STILT meteorology and footprints
  - Estimated CH_4 and N_2O emissions
- Design of a Regional GHG Emissions Measurement Network
- Conclusions

California GHG Emissions

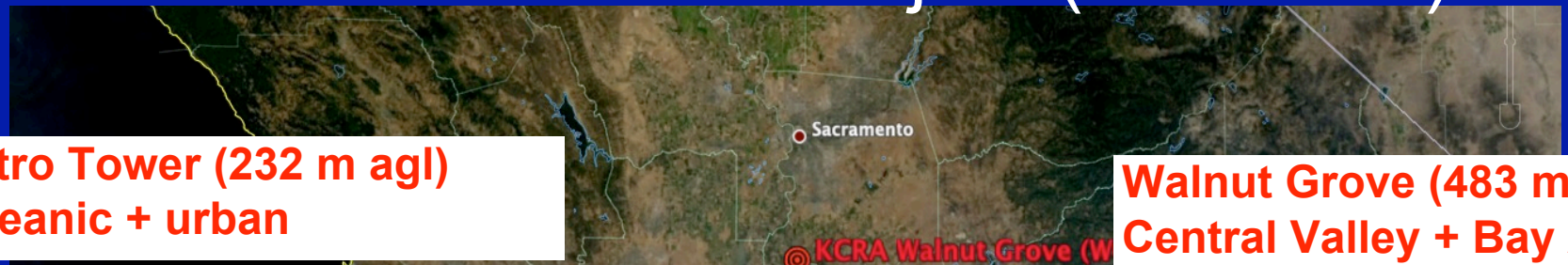
- CA assembly bill AB-32 mandates reduction to 1990 levels by 2020
- Non-CO_2 GHG emissions comparable to CO_2 but…
  - Largely from biological sources and not readily metered
  - Uncertainties in inventories are large
- Atmospheric inverse approaches provide independent
- Evaluation of uncertainties is an essential challenge



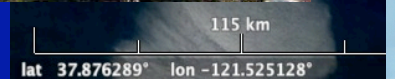


CEC, 2006 ; USEPA, 2007

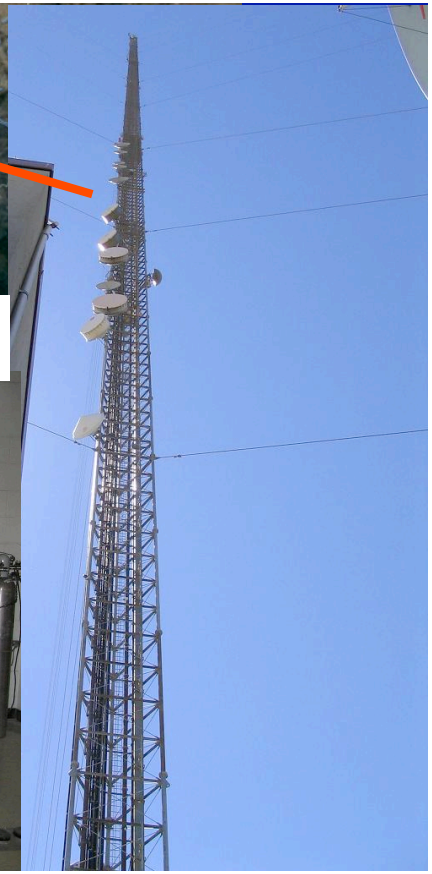
LBNL-NOAA Collaboration: California Greenhouse Gas Emissions Measurement Project (CALGEM)



Sutro Tower (232 m agl)
Oceanic + urban



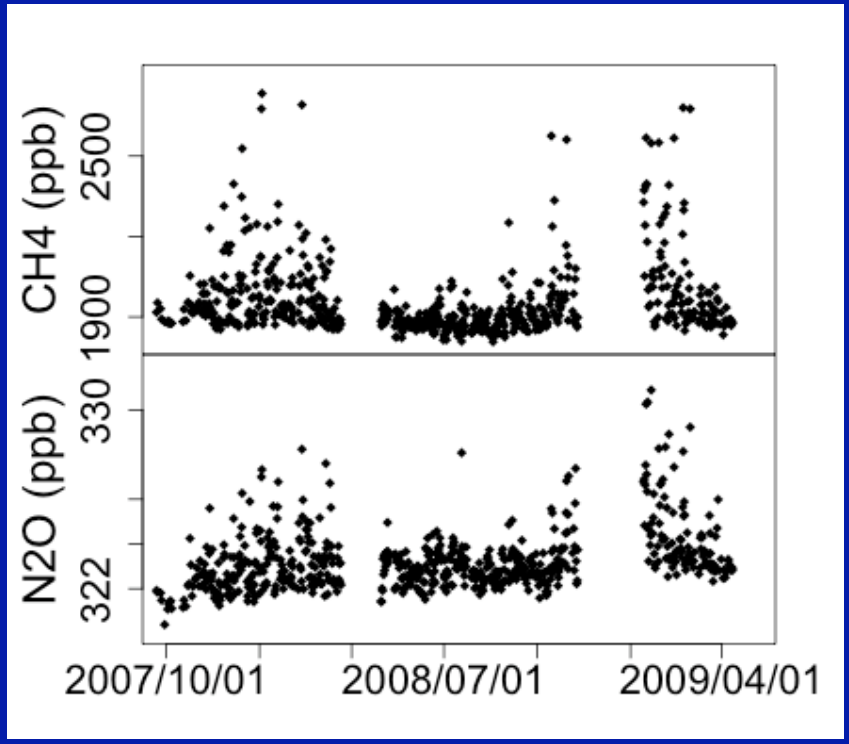
Walnut Grove (483 m agl)
Central Valley + Bay Area



in situ CH_4, CO_2, CO, ^{222}Rn

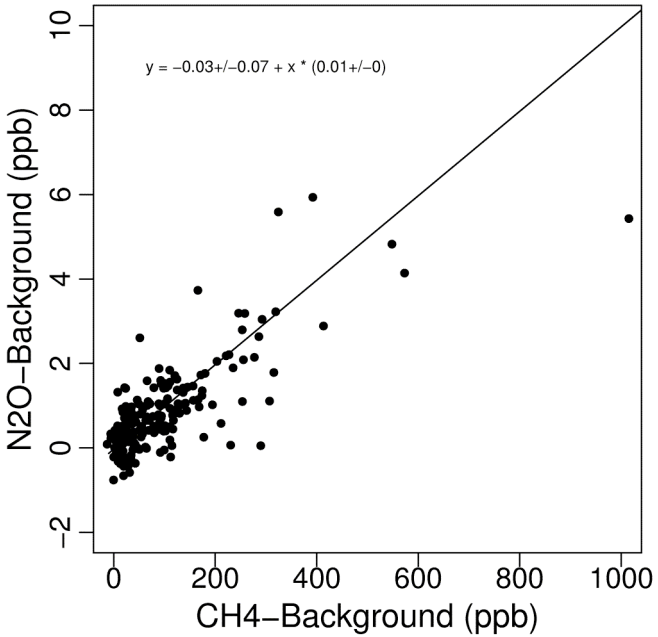
Daily Flasks

Walnut Grove CH_4 and N_2O



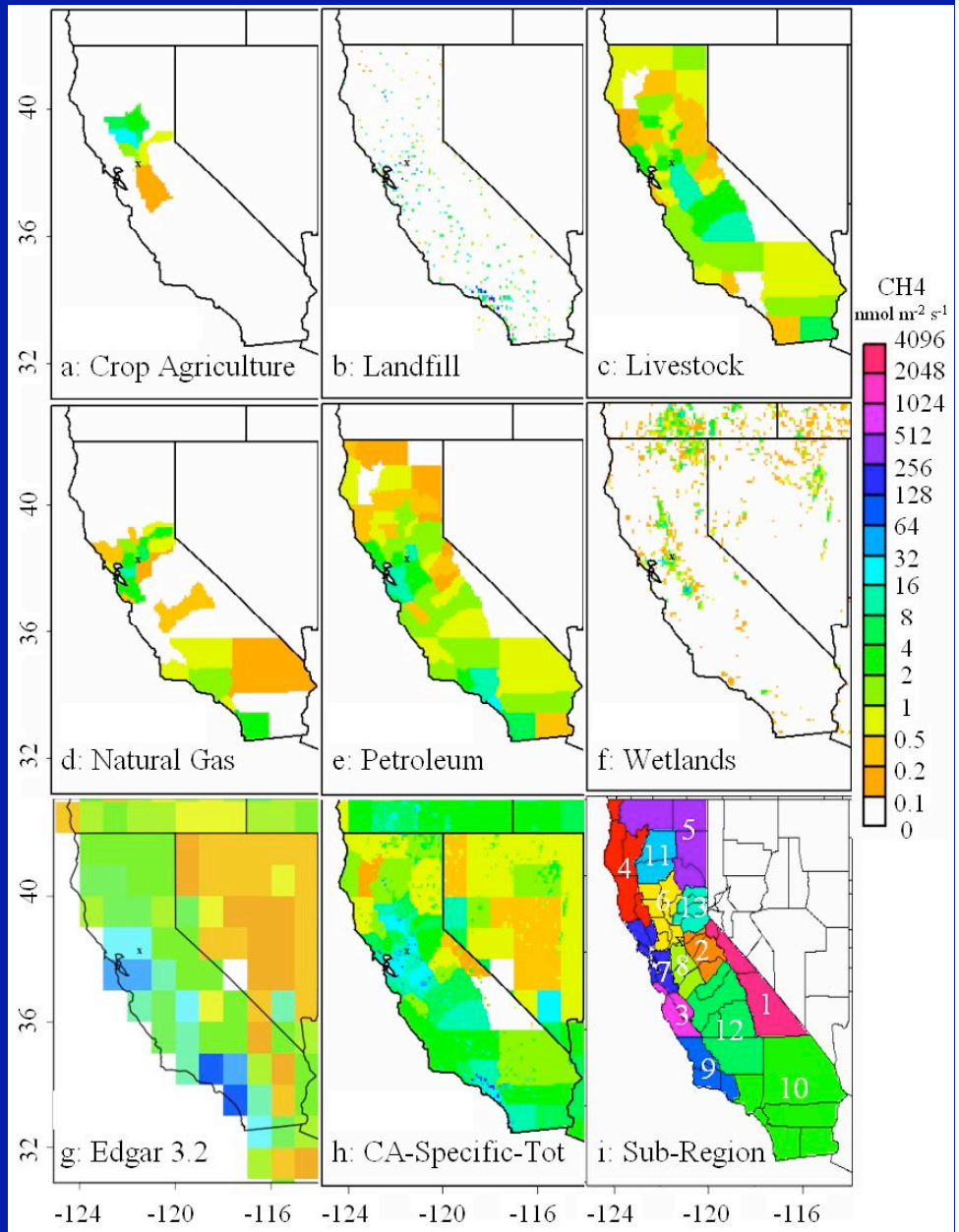
- Seasonal cycles due to changing emissions and mixed layer depth
- CH_4 and N_2O share similar patterns (both dominated by valley emissions)

Fall-Winter (Oct - Dec, 2007)
WGC 91 m, Well Mixed, 1400 Local



a priori CH_4 Flux Maps

- Crop Agriculture (Salas)
- Landfill (point sources)
- Livestock (USDA)
- Natural gas dist./use
- Petroleum refining and use
- Wetlands (Potter et al.)
- Above sum to CA-specific
- EDGAR3.2 (1x1degree)
  - Landfills and petroleum extraction and refining ~ 2 x CA estimates
- Also: regional subdivision for spatial analysis

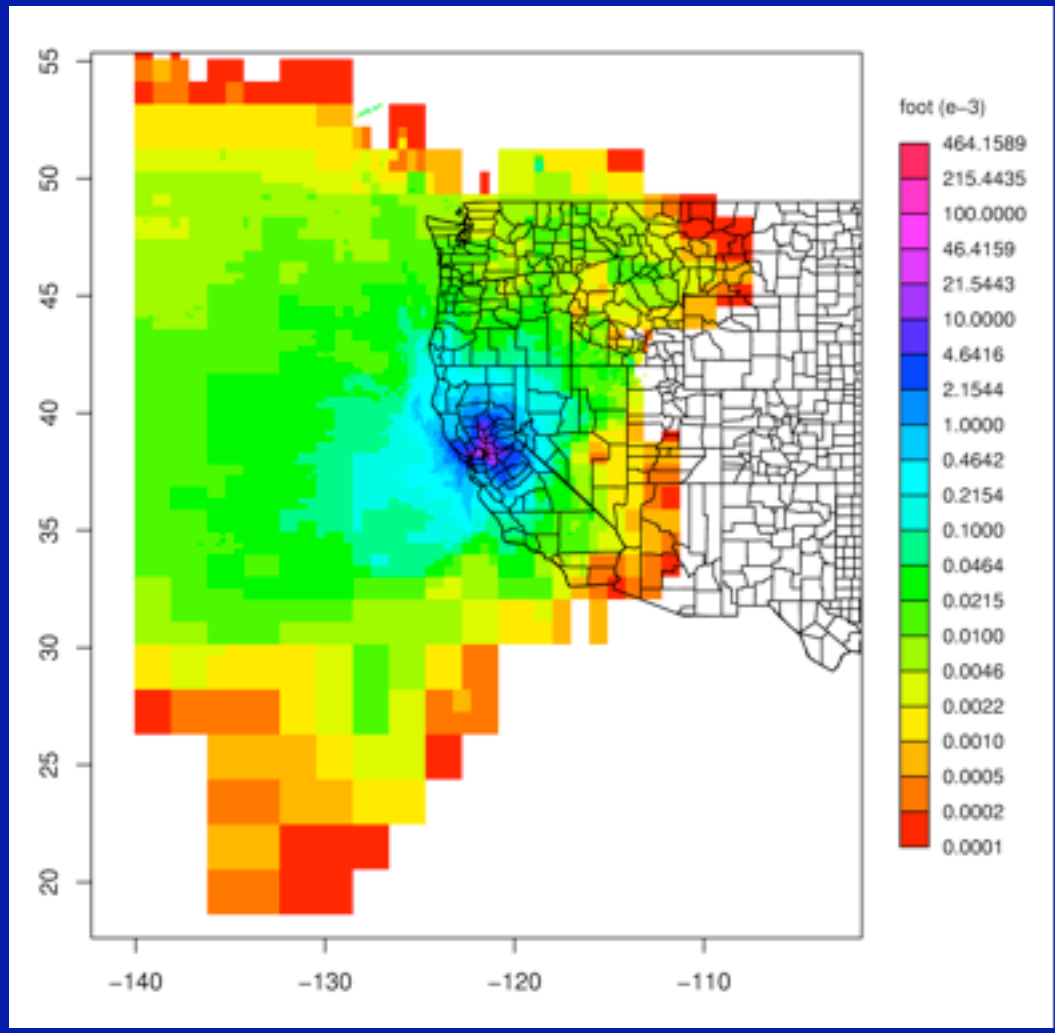


WRF-STILT Footprints for WGC Tower

- WRF meteorology:
  - Nested grids (40,8,1.6 km)
  - NARR boundary forcing
  - Hourly averaged fields
- Example of average footprint for Oct-Dec, 2007 (from hourly maps)
- Largest surface influences (purple) for Bay Area and Central Valley
- Predict CH_4 signal =

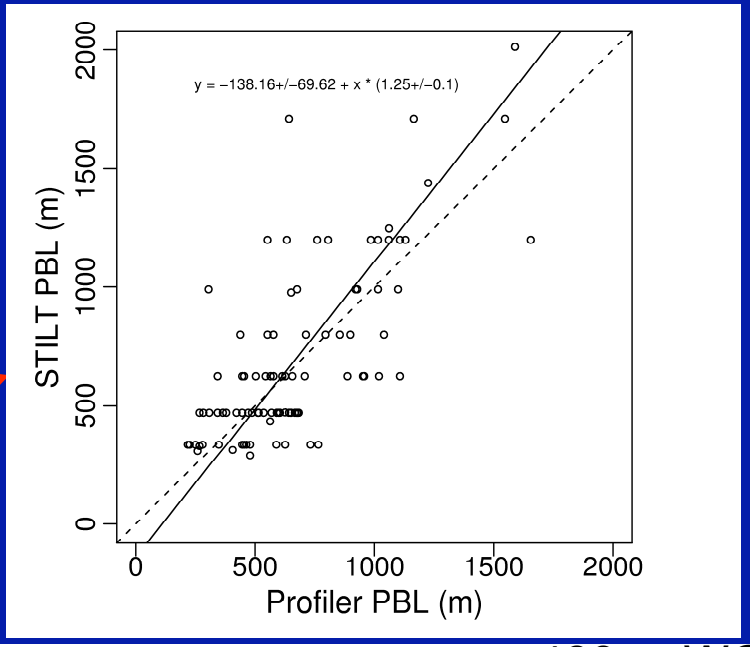
  F_{CH4} * footprint +

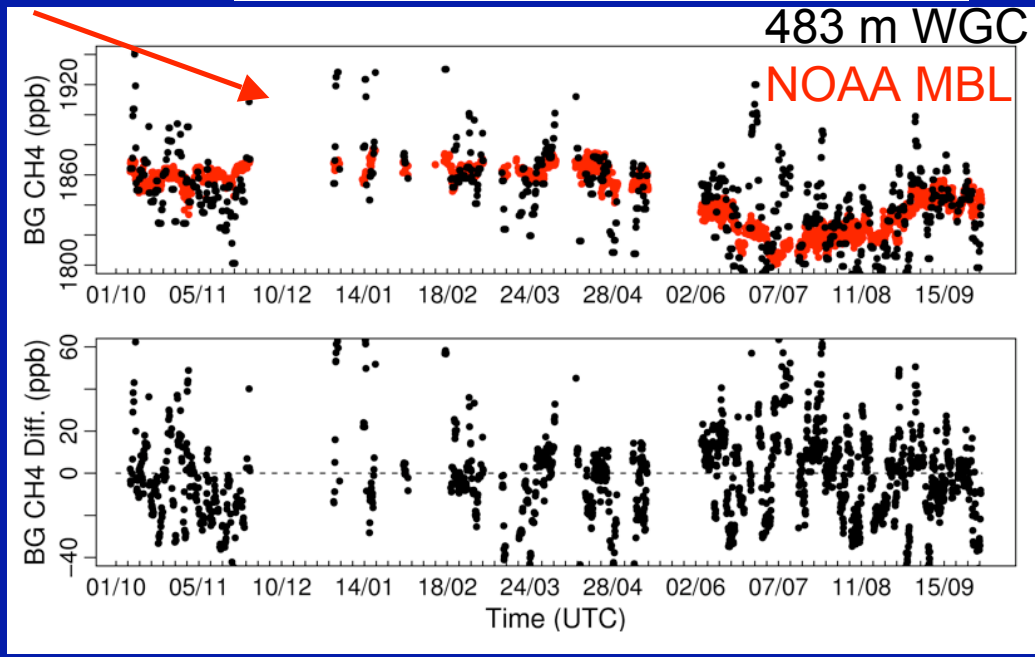
  Marine Background



Uncertainty Estimates

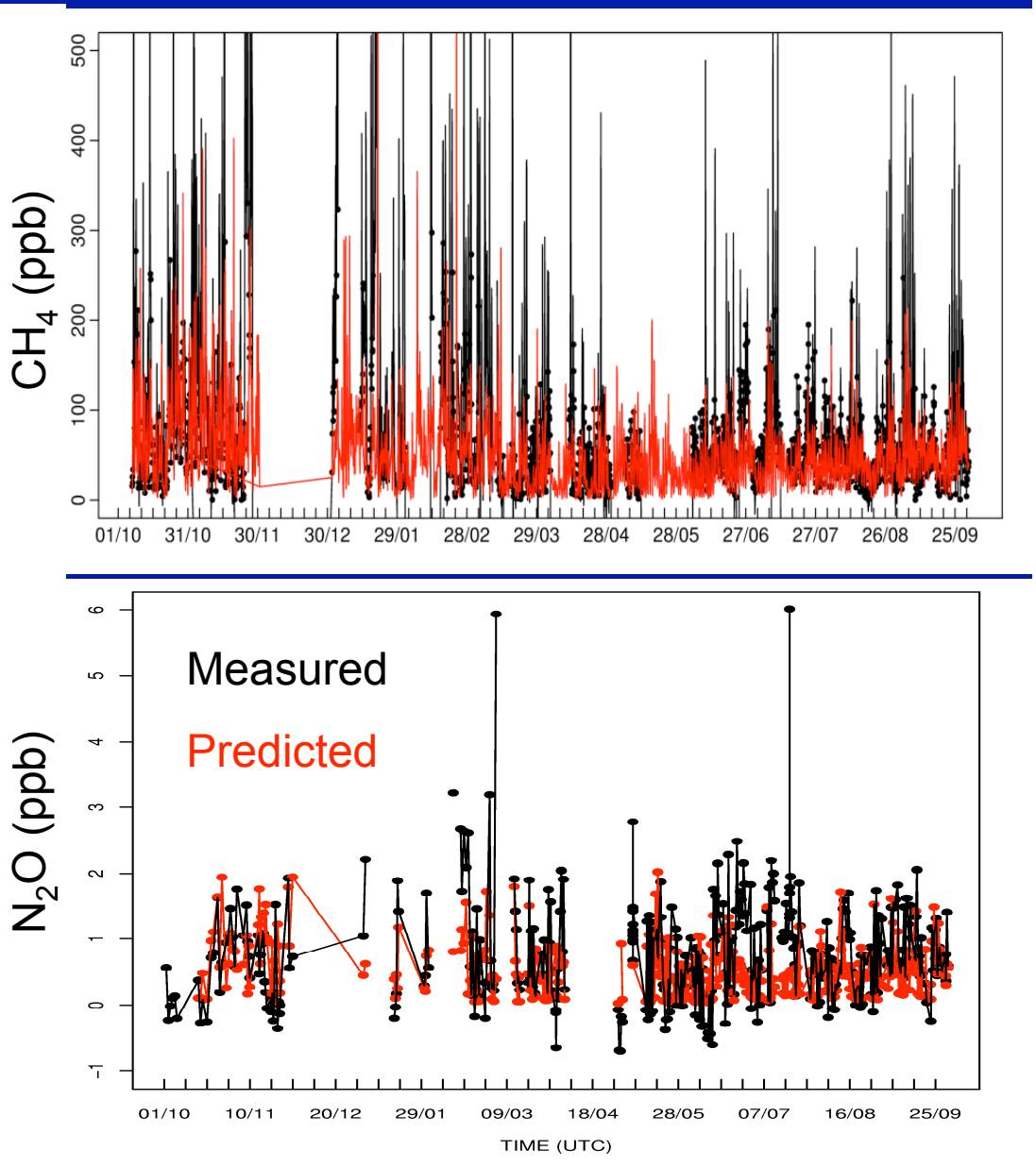
- In all cases, estimate error in underlying variable and propagate through model to expected error in predicted - measured signal difference
- Summary:
  - PBL errors ~ 25 %
  - Background error ~ 15 %
  - Wind errors ~ 10%
  - Emissions aggregation ~ 8 %
  - Others ~ 8%
- Quadrature sum ~ 32%





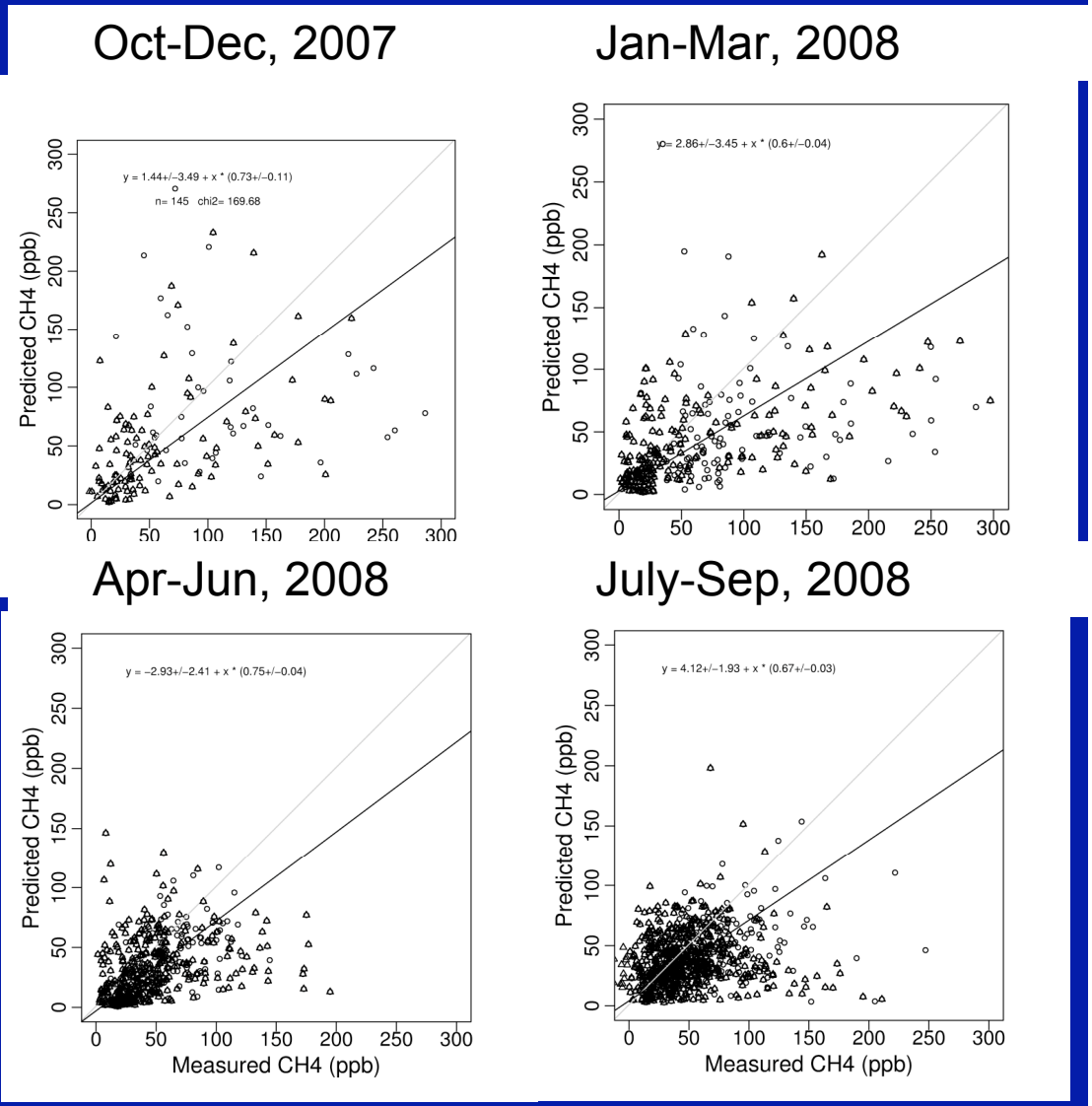
Measured and Predicted CH_4 and N_2O

- 91 m Walnut Grove measurements
- Select well mixed periods using CH_4
  - 91 and 483 m CH_4 agree to 100 ppb
- Flask N_2O are subset on same periods



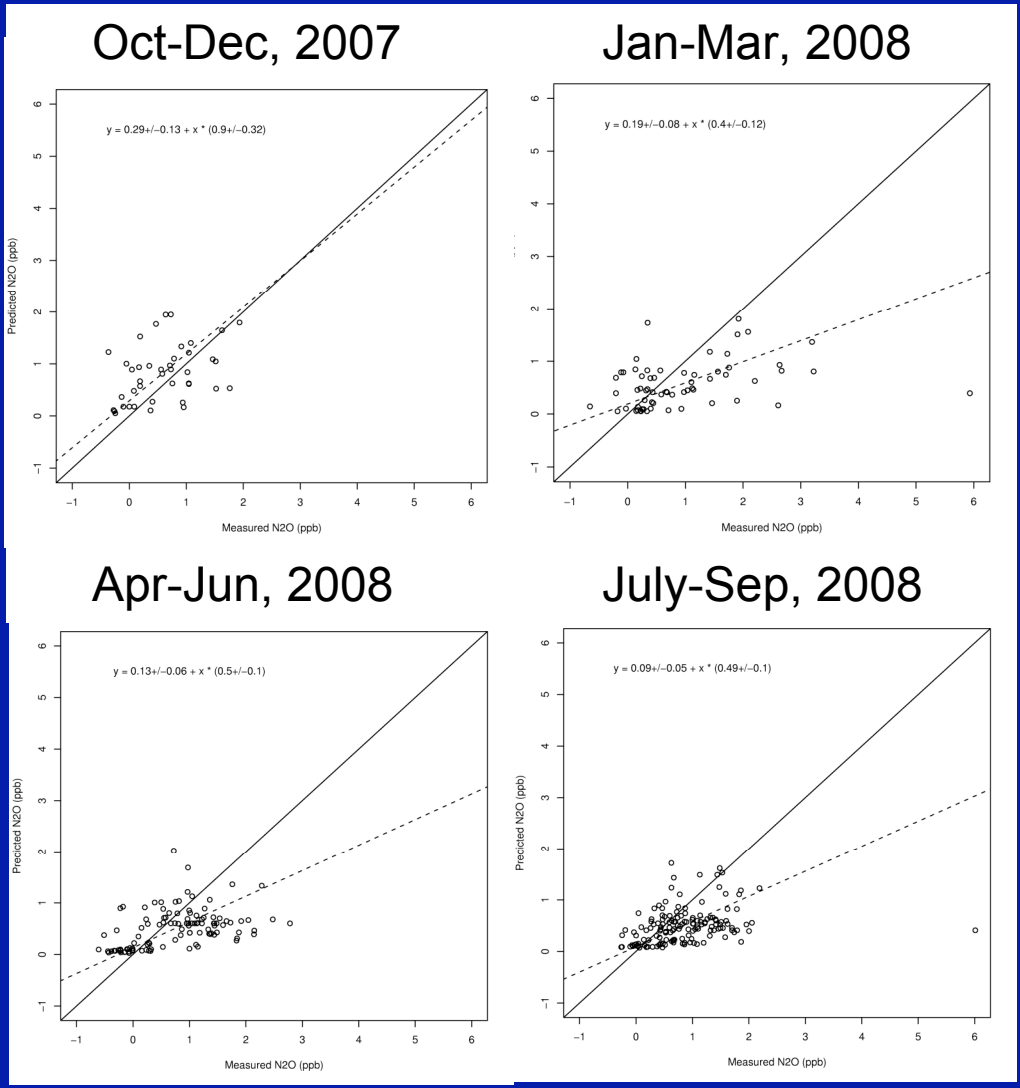
Predicted vs. Measured CH_4 By Season

- Large scatter ~ consistent with estimated uncertainties and emissions model error
- CH_4 emissions appear underestimated in CA inventory for all periods studied



Measured and Predicted N_2O

- N_2O flask data is sparse compared to *in situ* CH_4
- Slopes and estimated emissions vary with season
  - Fall 07 near unity: emissions not far off
  - Other seasons: slope ~ 1/2, suggesting emissions ~ 2 x Edgar inventory

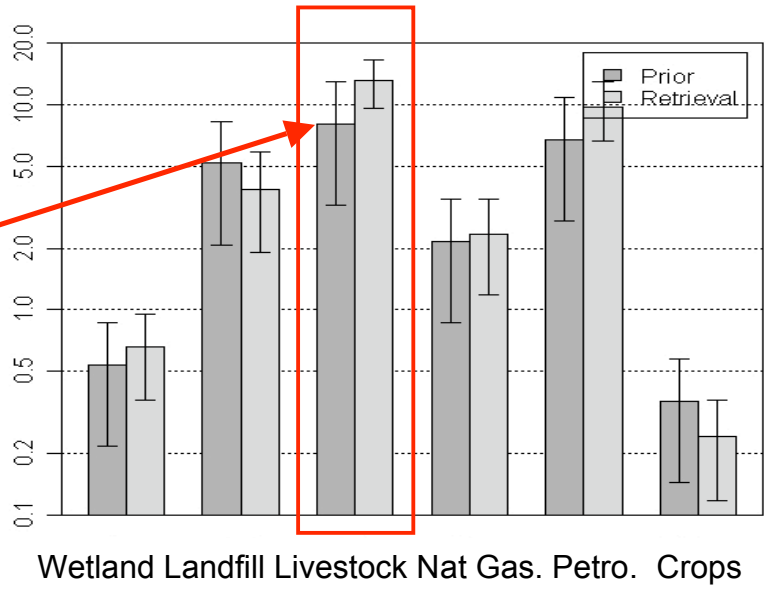


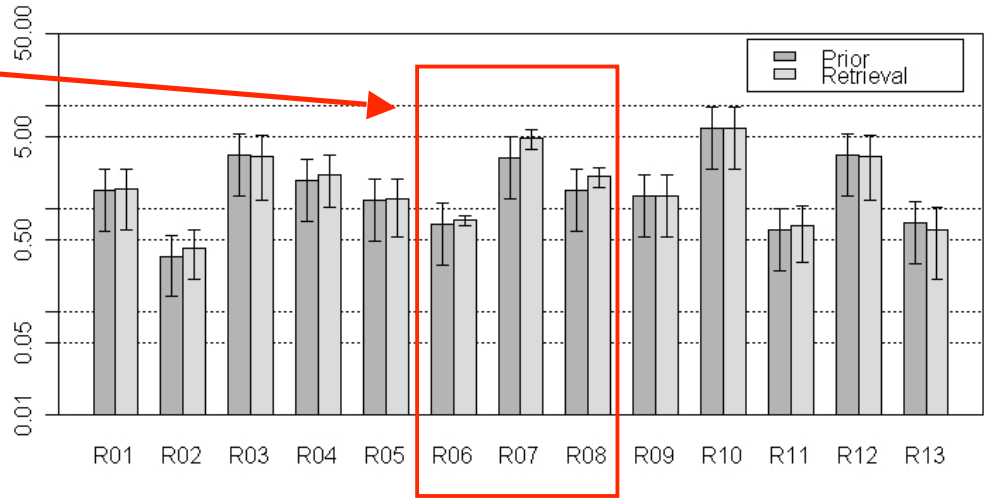
Estimated CH_4 Emissions (MMT CO_{2equiv})

- Baysian estimate of scaling factor for each emission source or region (*a priori* errors assigned at 30%)

- Source analysis: only livestock significantly different from prior (x 1.6 ± 0.15)

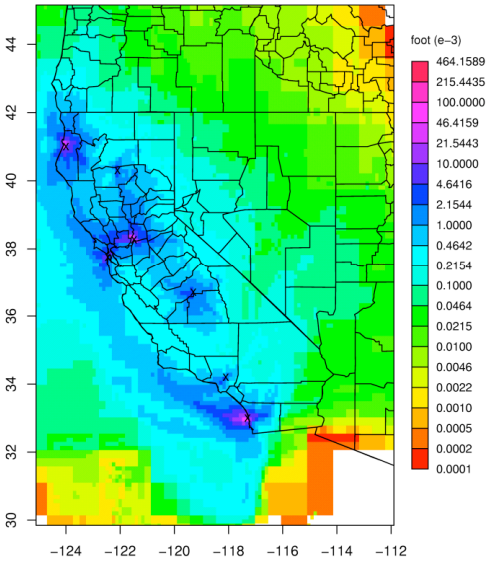
- Region analysis:
  - only regions near WGC tower have errors reduced
  - regions 7 & 8 are larger than prior, consistent with source analysis

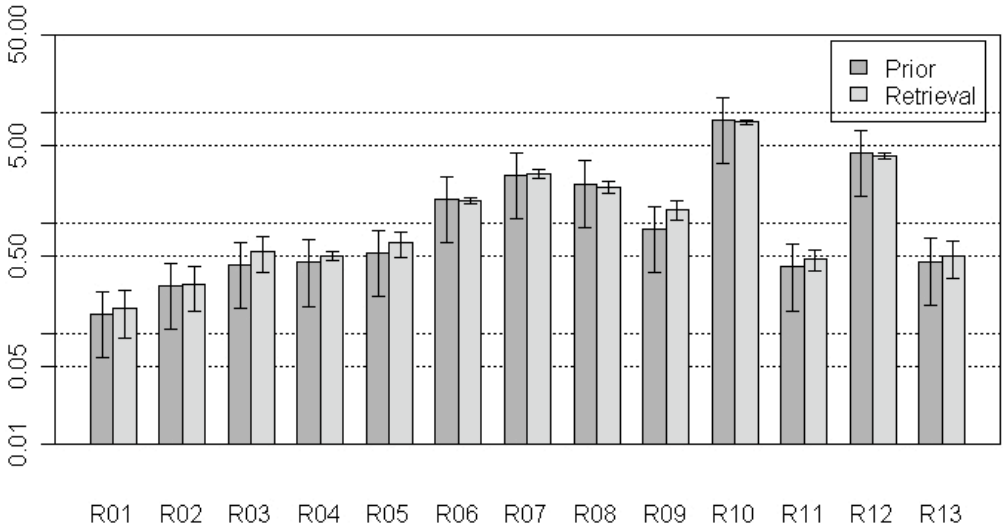




Measurement Network Design

- Estimate effect of seven (3 valley, 4 costal) tower network
- WRF-STILT footprints show predicted regional coverage for Oct, 2007
- Psuedo-data generated from footprints, inventory CH4 emissions, and 32% random noise as estimated above
- Regional inverse estimates of posterior scaling factors show reduction in uncertainties for most regions





Conclusions

- Careful attention to uncertainties essential for quantitative emission inventory assessment
  - Measurement errors are now small compared to other sources
- Meteorological uncertainty assessment requires multiple measurement sites and methods (e.g., wind profilers, tracer gases)
- Initial inverse estimates suggest:
  - CH_4 emissions underestimated in Central CA Valley region
  - N_2O emissions also underestimated but vary significantly with season
- Even tall-tower measurements in valley appear to only constrain ~ 100-200km region surrounding tower (483 m height decouples)
- Network of towers required to capture regional emissions from California