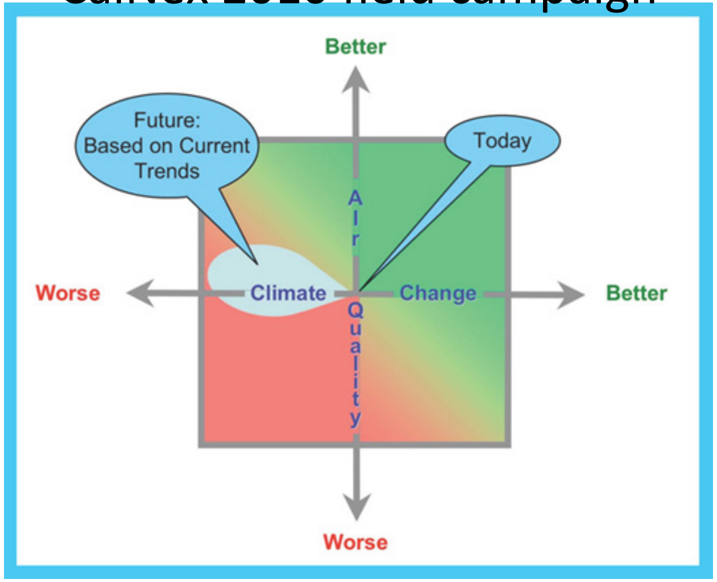
Top-down estimate of methane emissions in California using aircraft measurements

CalNex 2010 field campaign



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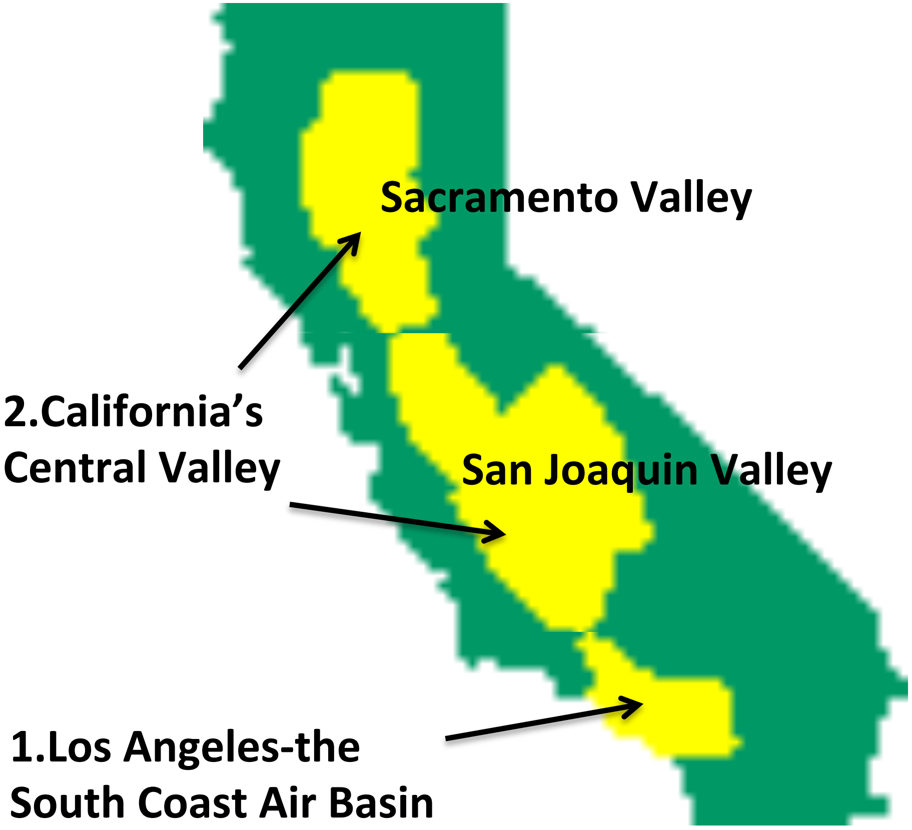
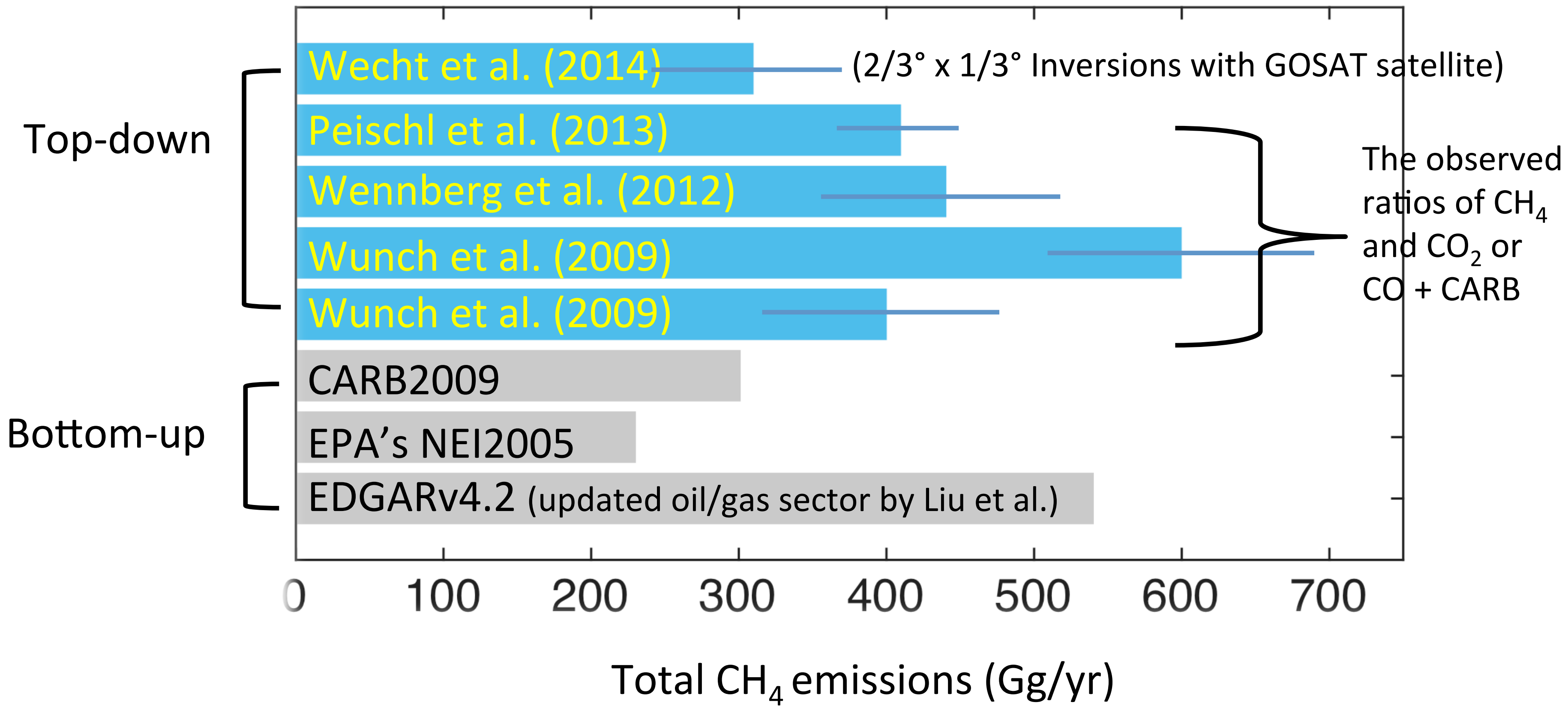
Background

- There are large uncertainties in the spatial distribution, magnitude and trends of CH_4 emissions.
- Some of CH_4 sources have been changing rapidly in recent years (natural gas).
- In California, CH_4 emissions have been regulated.
- Understanding of California's CH_4 sources is incomplete, leading to uncertainty in the application of mitigating regional CH_4 emissions.



1.The South Coast Air Basin (Los Angeles)



➢ Natural gas pipelines, geologic seeps, and the oil and gas industries accounted for most of the underestimation in current regional bottom-up CH_4 inventories (Peischl et al. 2013).

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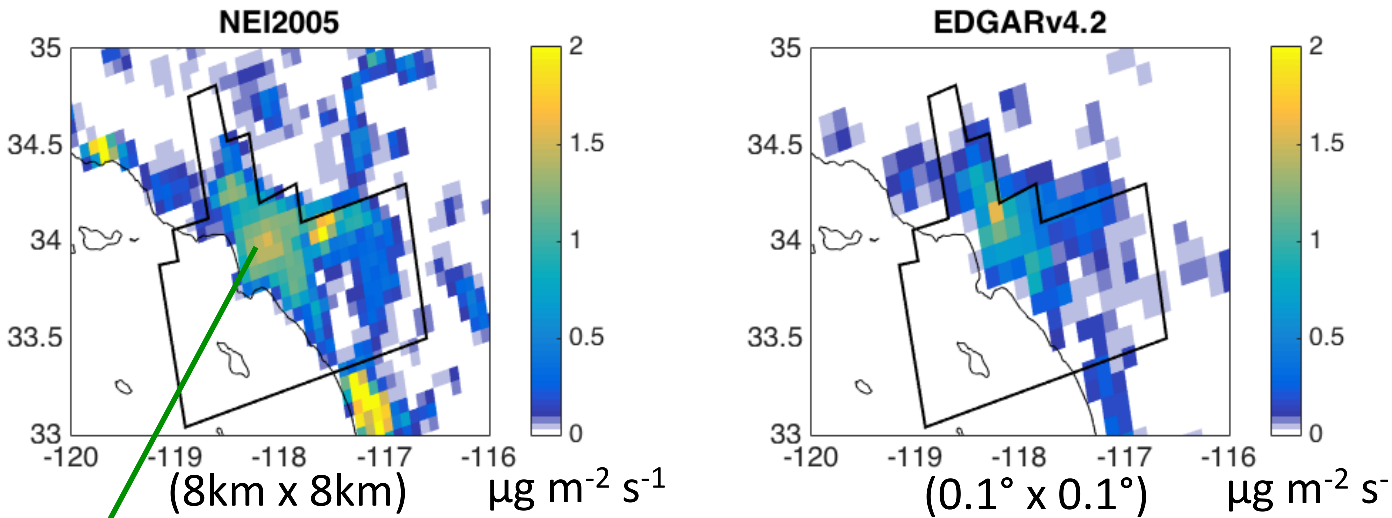
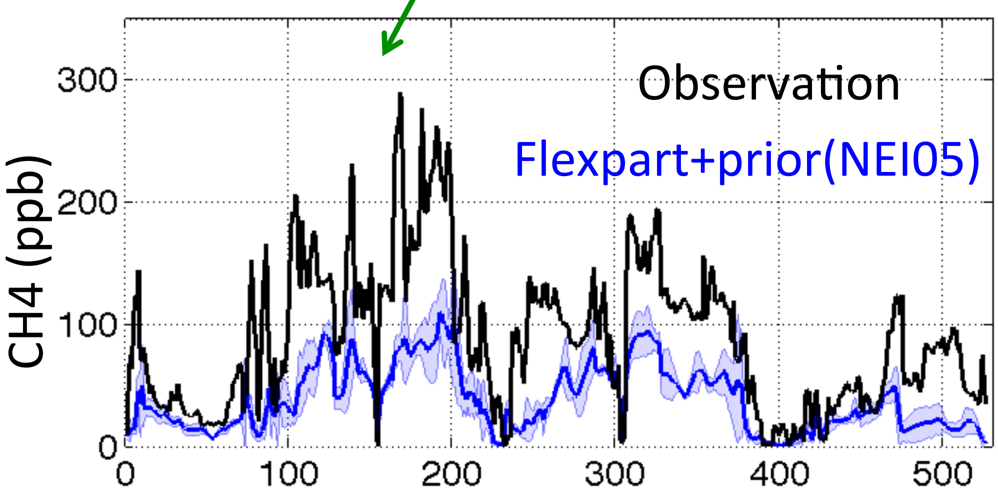
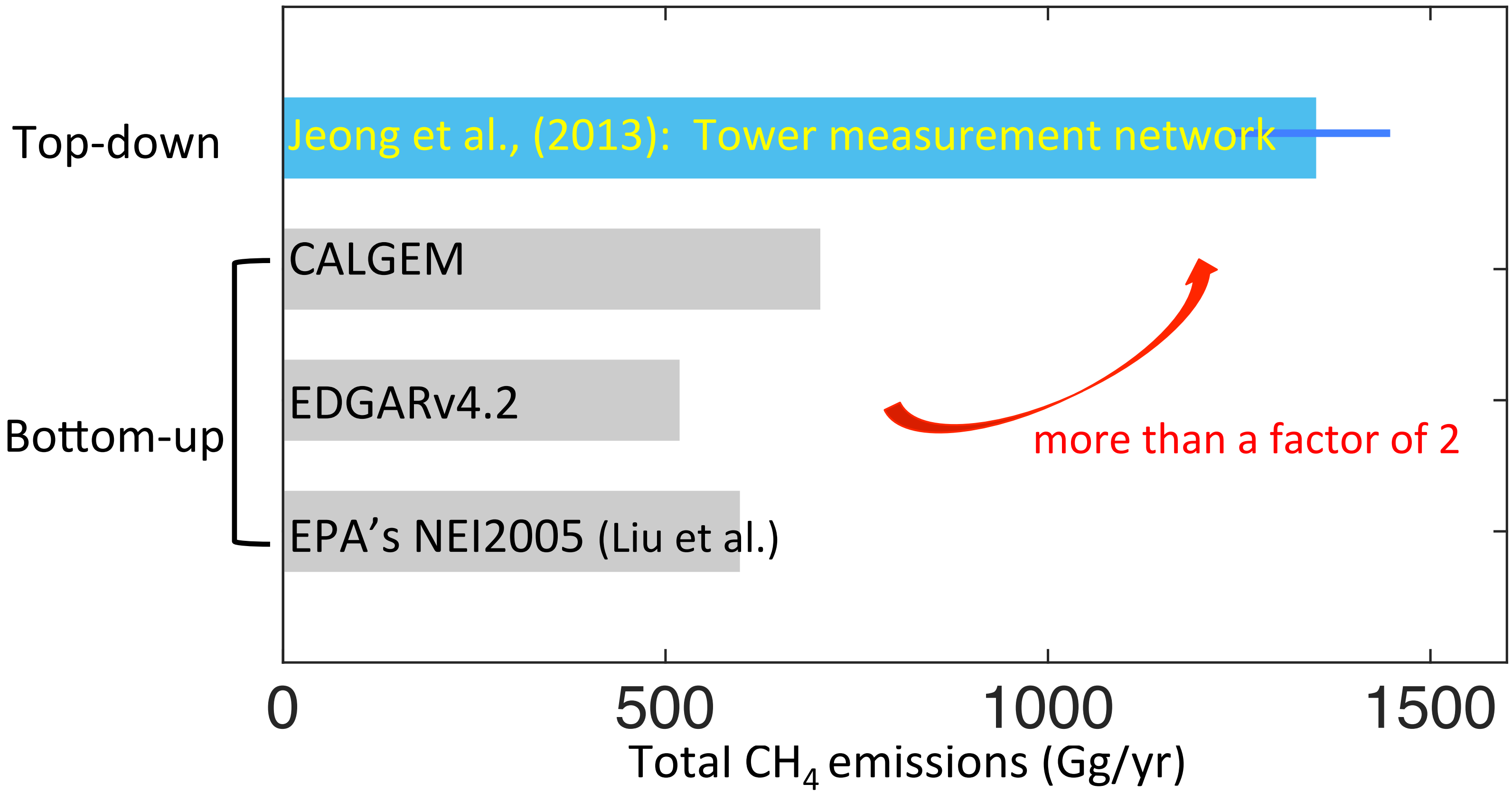




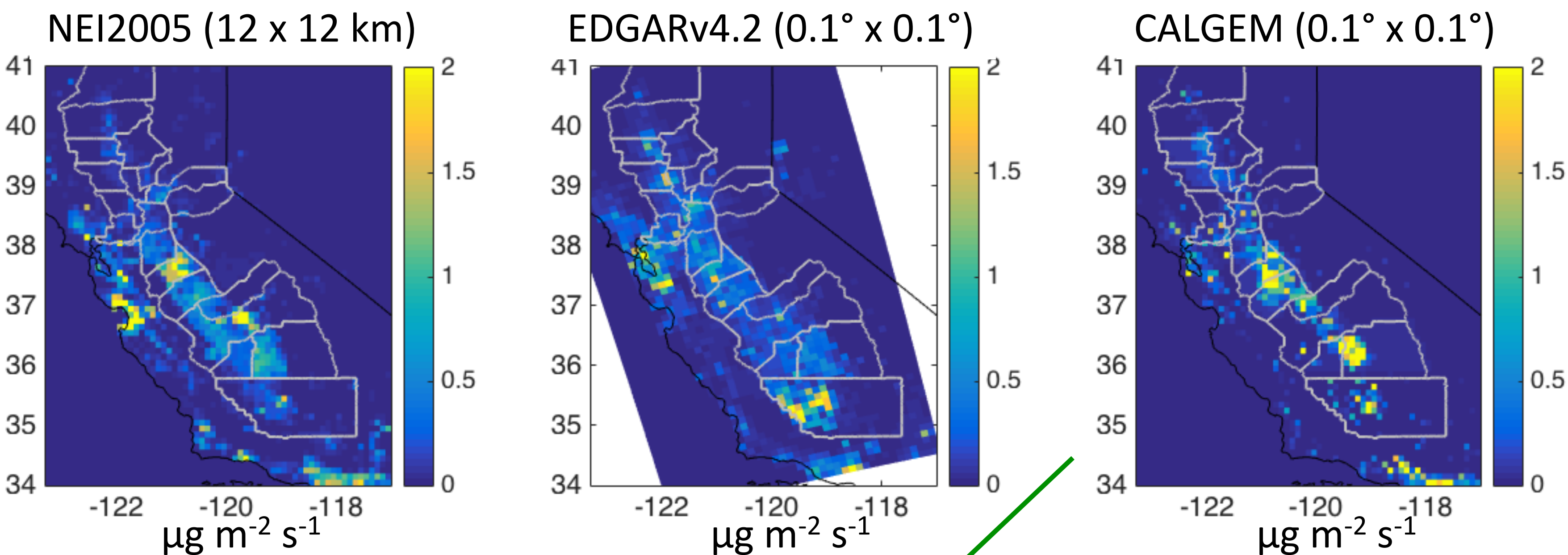
- Atmospheric transport modeling using NEI2005 underestimate CH_4 mixing ratios in atmosphere.
- The mean bias is ~50 ppb.
- Need to optimize spatially-resolved CH_4 emission inventories

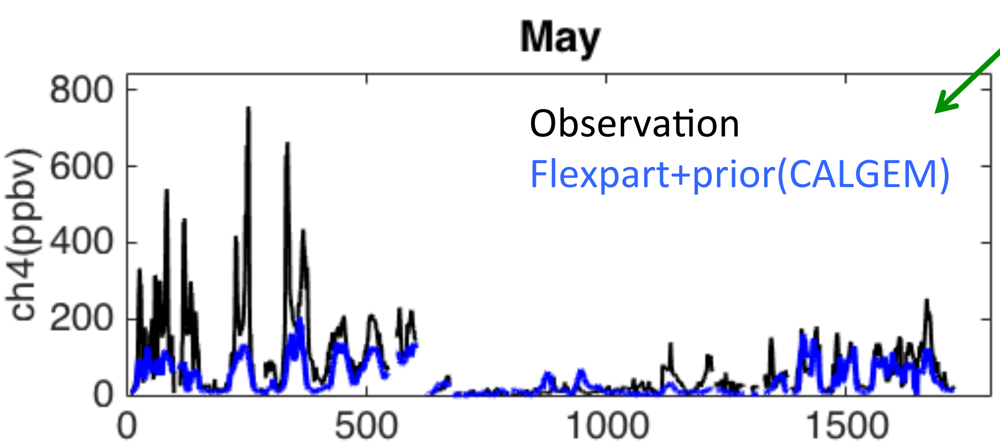
2.Central Valley: San Joaquin Valley



- Much less top-down CH_4 emission studies in the Central Valley because of insufficient atmospheric measurements in complex terrain.
- The contribution of CH_4 sources to the underestimation in bottom-up inventories remains unclear

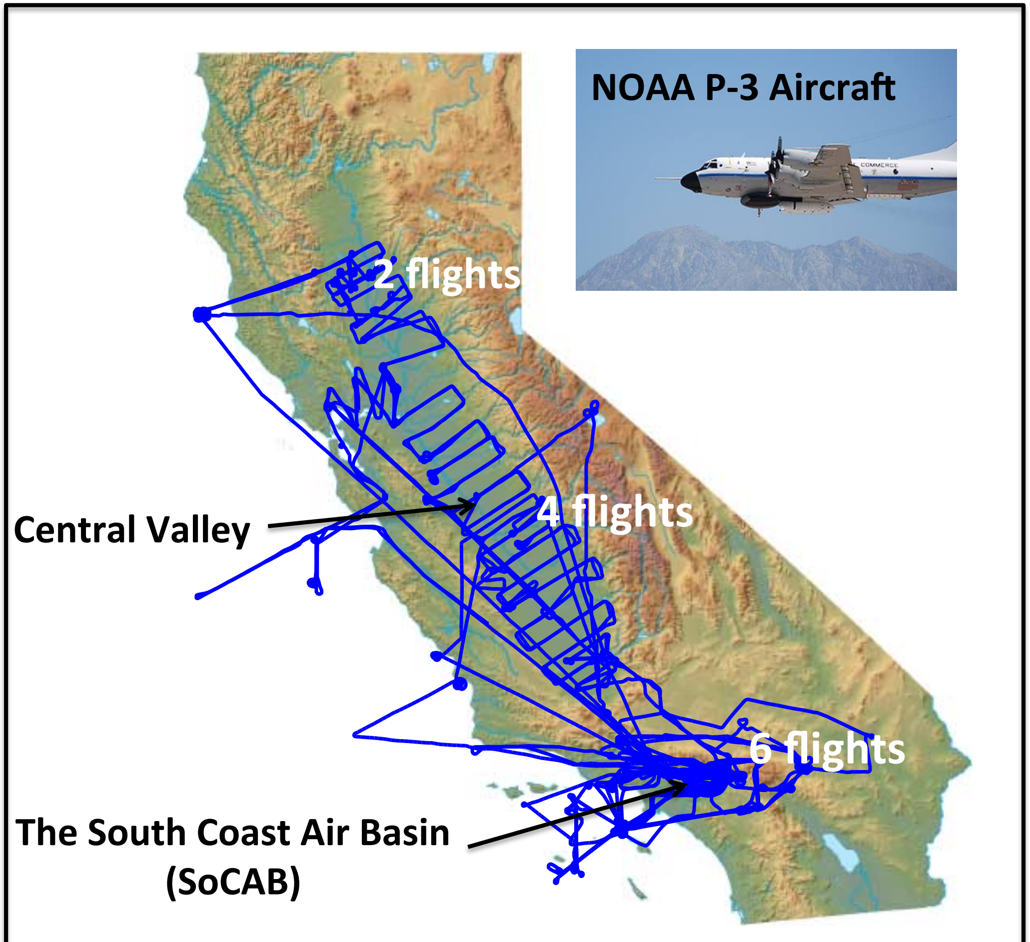
2.Central Valley: San Joaquin Valley





- CALGEM inventory is best among bottom-up inventories
- Using CALGEM, model underestimate CH_4 mixing ratios for observations. Mean bias is ~30 ppb
- Need better spatially-resolved CH_4 emission inventory

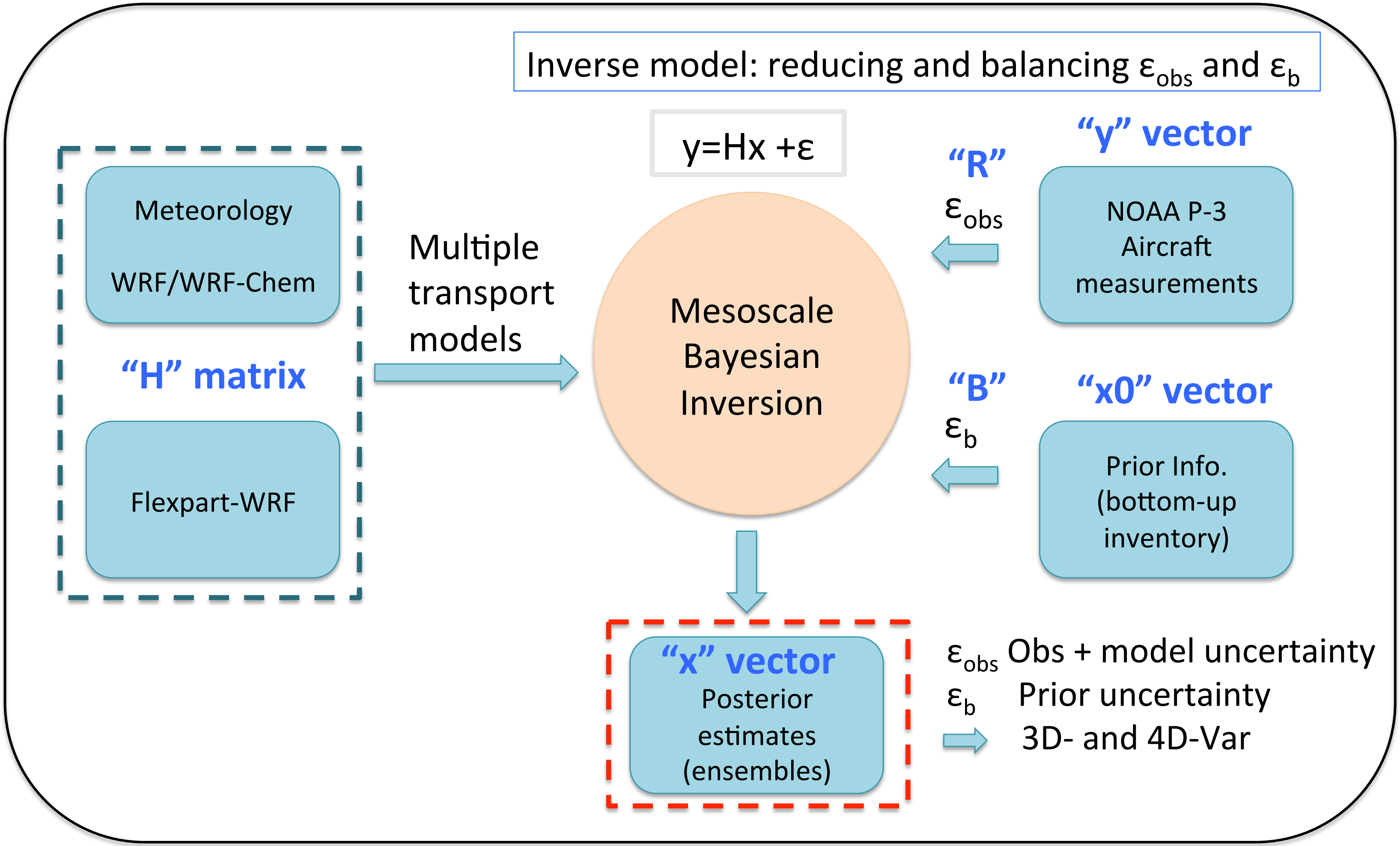
Aircraft measurements CalNex 2010



- Aircraft can accurately measure CH_4-mixing ratios near surface sources with extensive spatial coverage and identify contributions from individual sources, thereby complementing ground-based and remote-sensing measurements, especially for areas with complex terrain and multiple emission sources.

Inverse Modeling

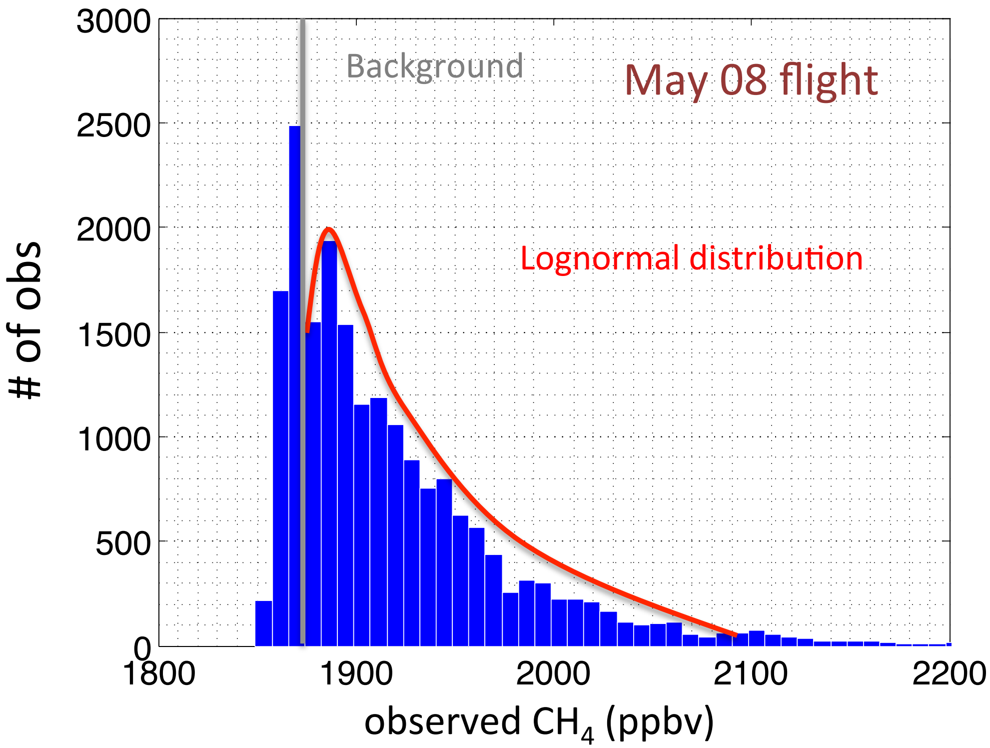
Lagrangian inverse system in Mesoscale



Cui, YY et al., JGR, 2015

Inversions in the lognormal framework

$$J = \frac{1}{2}(\ln(y_o) - \ln(Hx))^T R^{-1}(\ln(y_o) - \ln(Hx)) + \frac{1}{2}(\ln(x) - \ln(x_b))^T B^{-1}(\ln(x) - \ln(x_b))$$

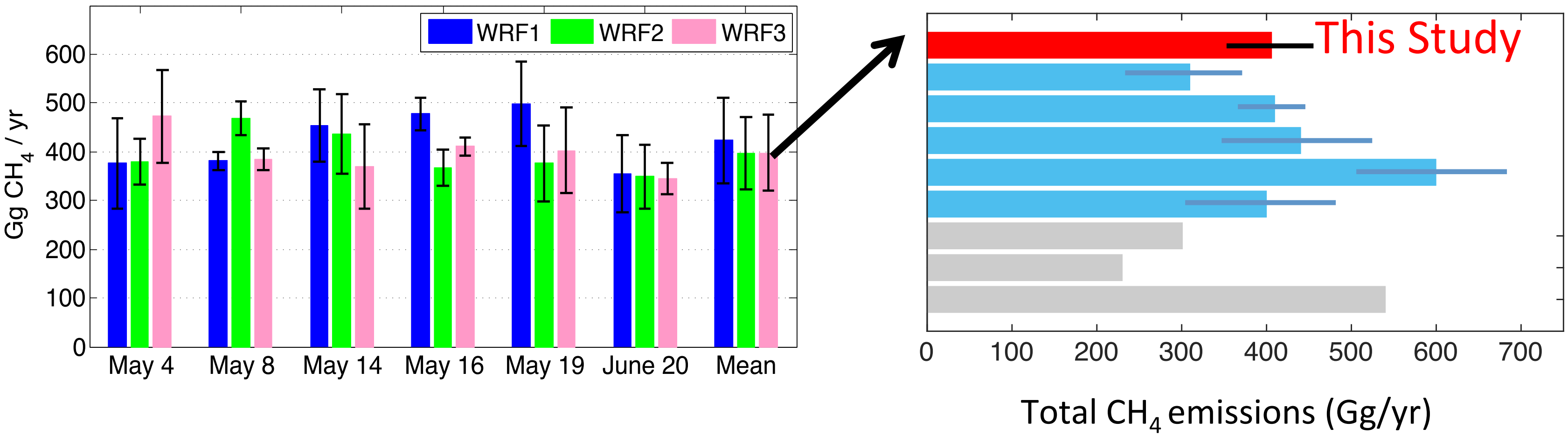


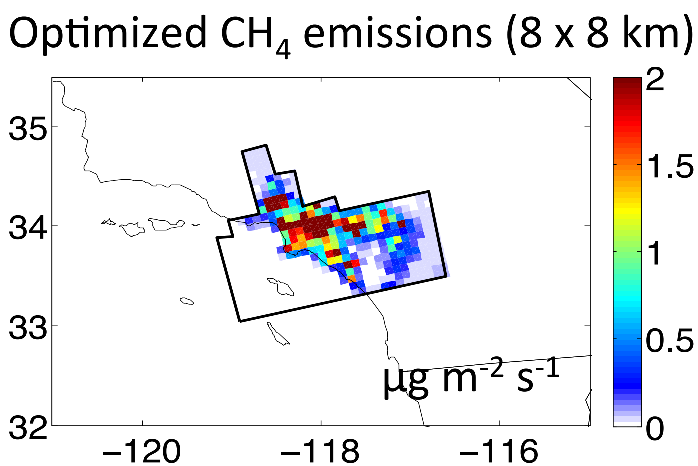
- Numerical solution
- For each flight we give a background value
- No negative fluxes, obtain a minimum variance solution

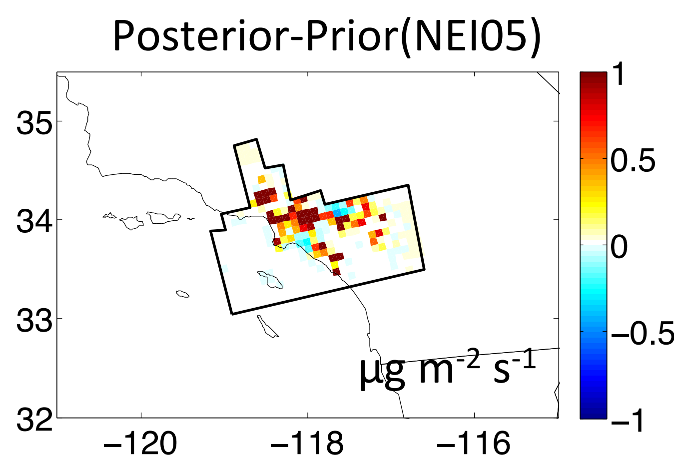
Cui, YY et al., JGR, 2015

Results

The South Coast Air Basin (Los Angeles)



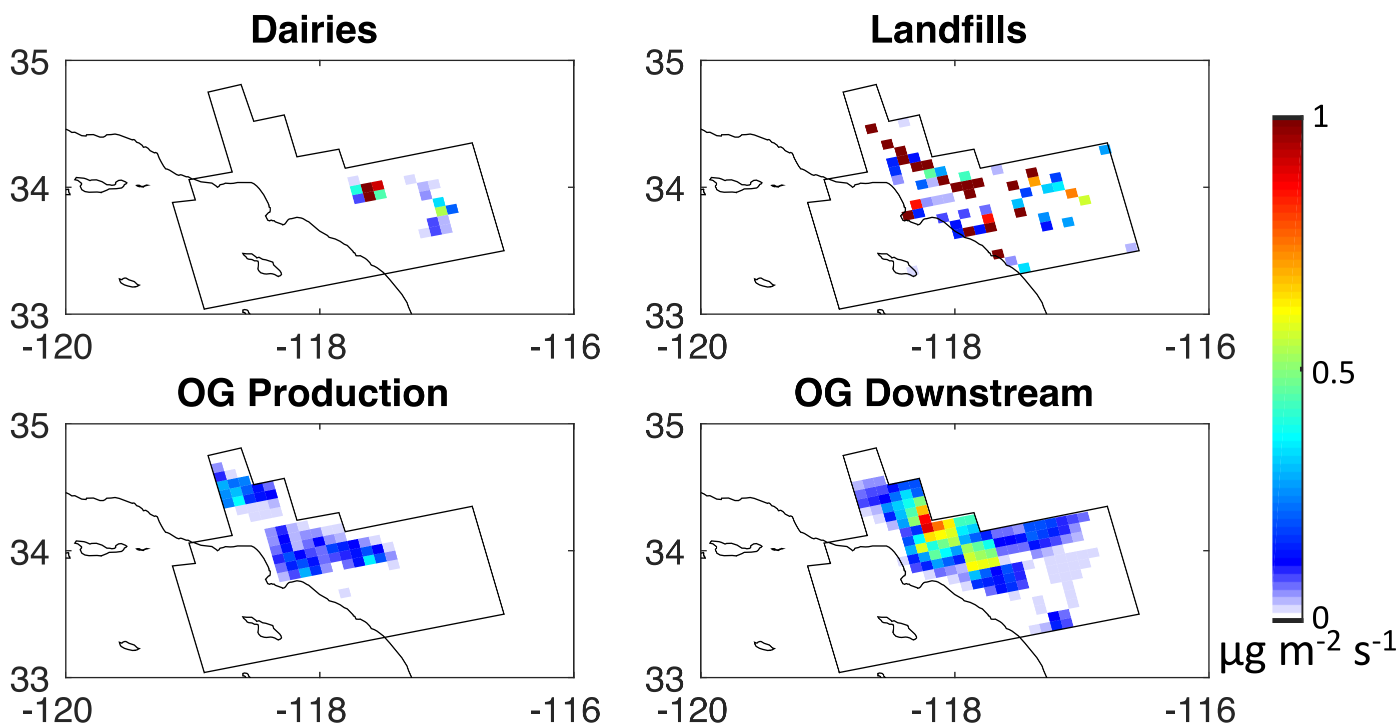




- We estimate total CH_4 emissions in SoCAB is 406± 81 Gg/yr, which is consistent with previous top-down studies

Cui, YY et al., JGR, 2015

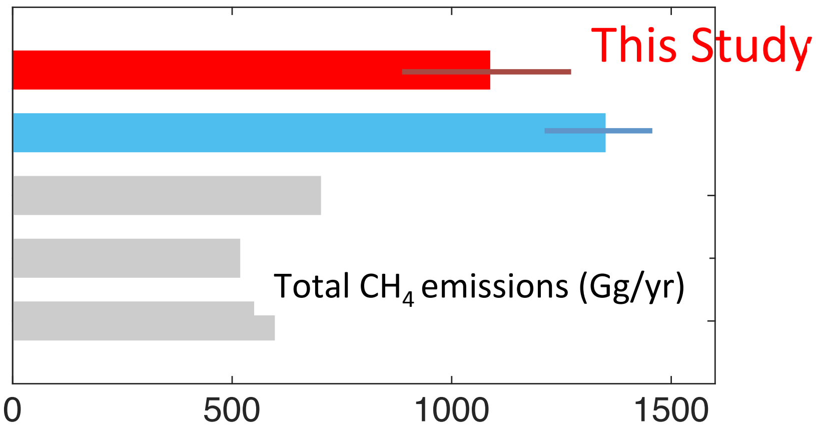
The South Coast Air Basin (Los Angeles)

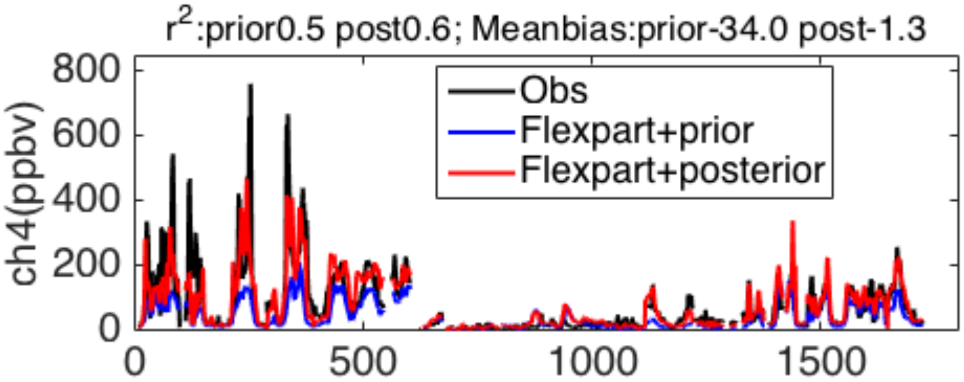


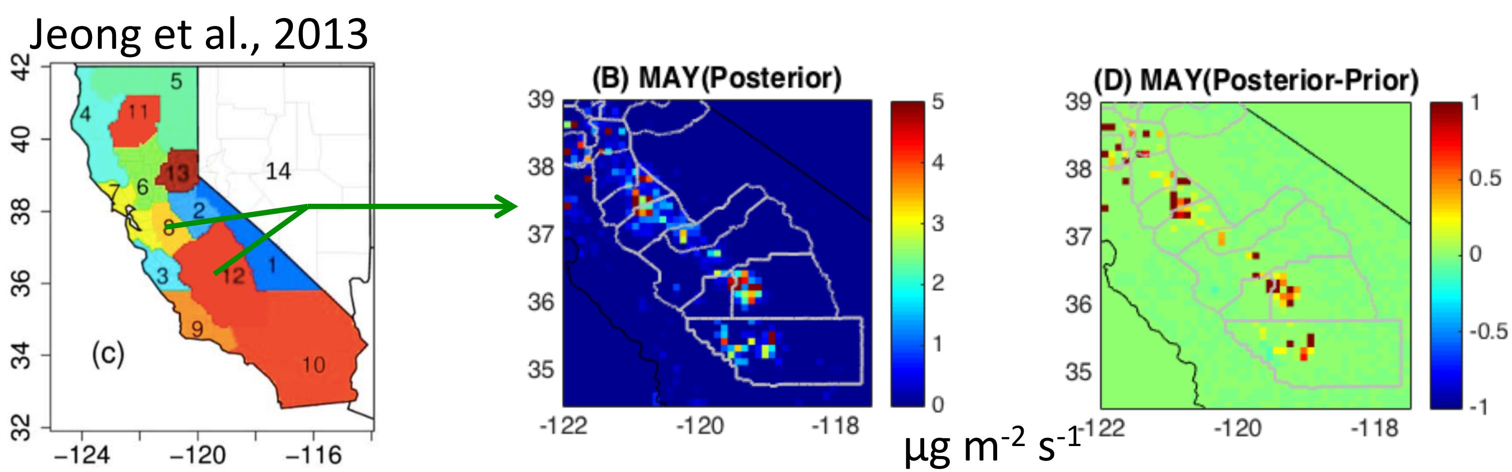
- The largest differences between posterior and prior estimates are from oil and gas sector and landfills together.
- Oil/gas and landfill: 347 ± 71 Gg CH_4/yr (1.8 higher than the prior)
- Dairy: 52 ± 15 Gg CH_4/yr (twice the prior)

Cui, YY et al., JGR, 2015

Central Valley: the San Joaquin Valley



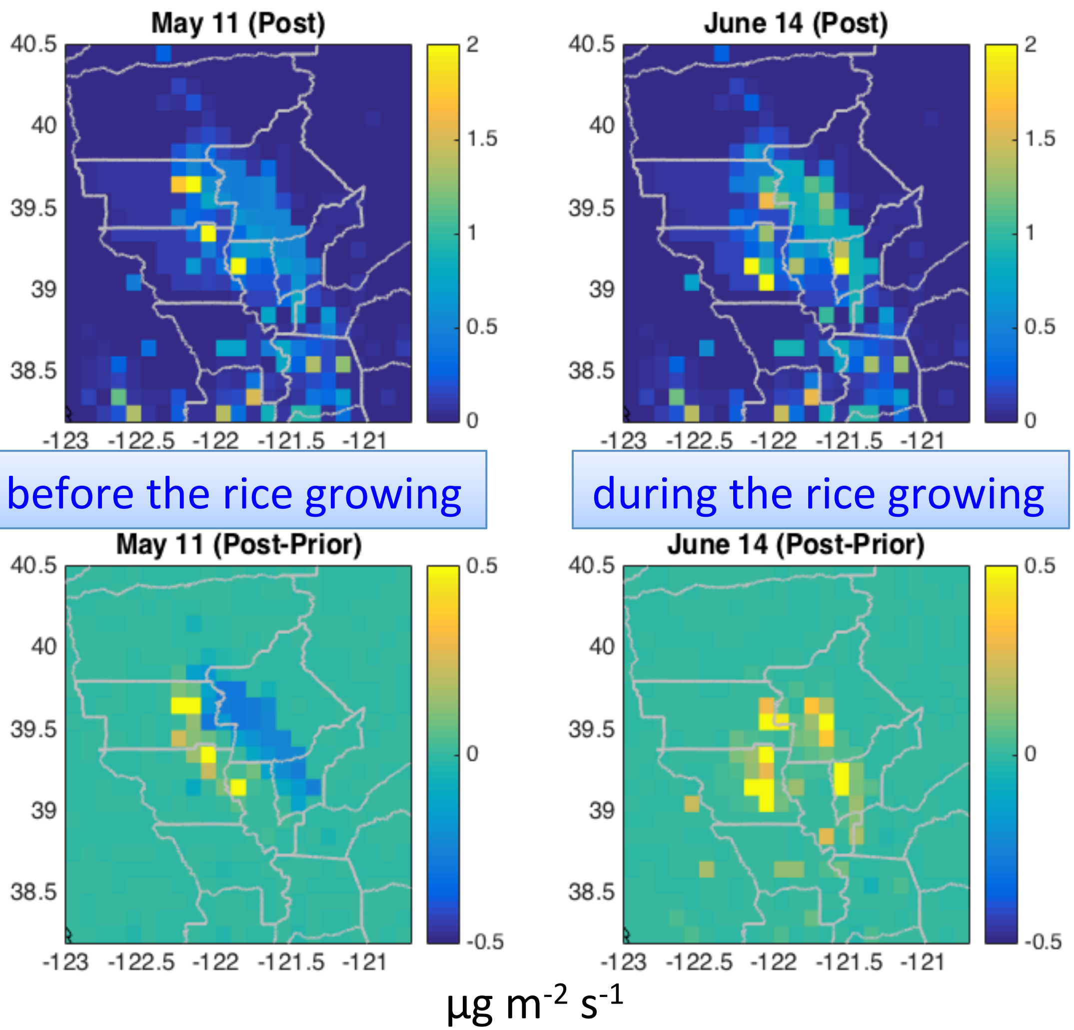




- We estimate total CH_4 emissions in the San Joaquin Valley is 1086± 350 Gg/yr
- The optimized CH_4 emission estimates improve correlations between simulations and observations and reduce the mean bias.

Cui, YY et al., in revision, 2016

Central Valley: the Sacramento Valley

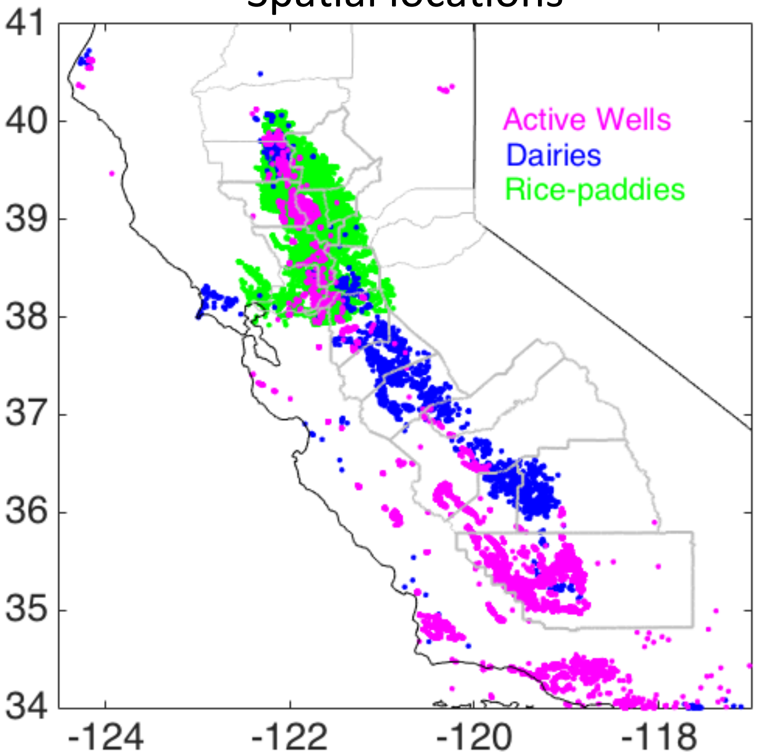


- We focus on CH_4 emissions from rice paddies
- Inverse modeling capture the variations of CH_4 emissions between before and during the rice growing season
- We estimate 11±2 Mg CH_4/hr attributed to rice during the growing season in June 2010, a factor of 3.7 higher than the prior

Cui, YY et al., in revision, 2016

Central Valley

Spatial locations



- Livestock sources contribute 75% and oil/gas productions contribute 15% in the San Joaquin Valley. Rice paddies contribute 60% in the Sacramento Valley.
- CH_4 emissions from livestock are higher by 50% than the prior (CALGEM), and oil/gas productions are higher by 70%.
- Livestock sources contribute the most of the discrepancies between the posterior and the prior inventories.

Domain Mg/hr	Livestock					Active Wells					Rice		
	Prior	Inv		Contrib		Prior	Inv		Contrib		Prior	Inv	Conrib
		May	June	May	June		May	June	May	June		June	June
SJV	61	91±31	95±27	73%	78%	12	23±9	17±6	19%	14%	3	-	-
SV		-	-	-	-		-	-	-	-		11±2	61%

Cui, YY et al., in revision, 2016

Conclusions

We take advantage of aircraft measurements to optimize spatially-resolved CH_4 inventories:

SoCAB (Urban)

- A mesoscale inversion ensemble is used to optimize CH_4 emissions. Total emission estimates are consistent with previous top-down estimates. Posterior inventory improve simulations of CH_4 mixing ratios.

- Oil and gas sources and landfills together explain most of the differences between posterior and prior inventories.

Central Valley (Agriculture)

- A mesoscale inversion ensemble is used to optimize CH_4 emissions, complementing inversions using tower measurements.

- Dairy and livestock management contribute the most of the differences between posterior and prior inventories.

- We estimate CH_4 emissions from rice growing season in the Sacramento Valley are higher by factor of 3.7 than the bottom-up inventory (CALGEM).