Ratio Approach for Estimating Methane Sources and Sinks Using Satellites Measurements

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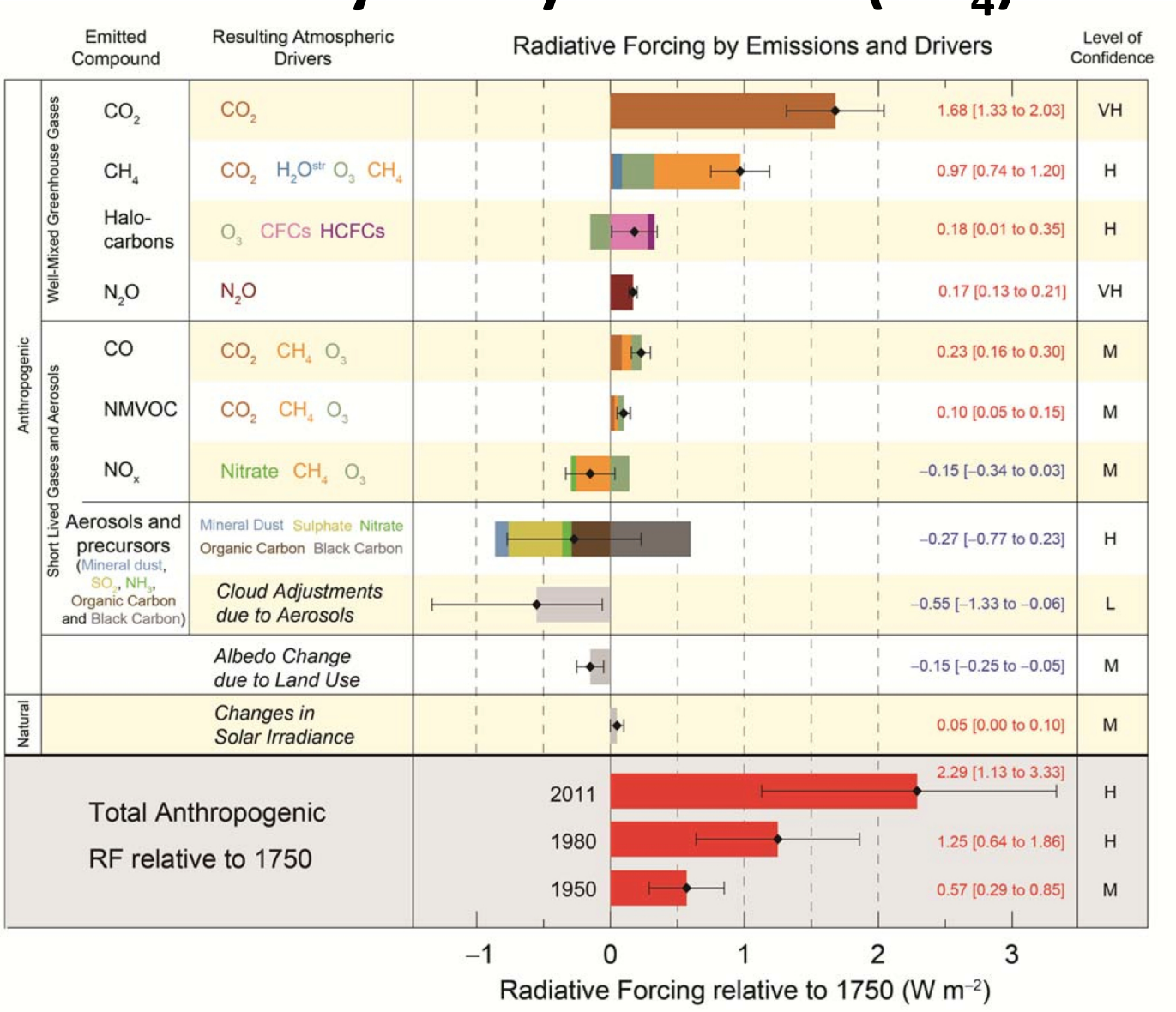
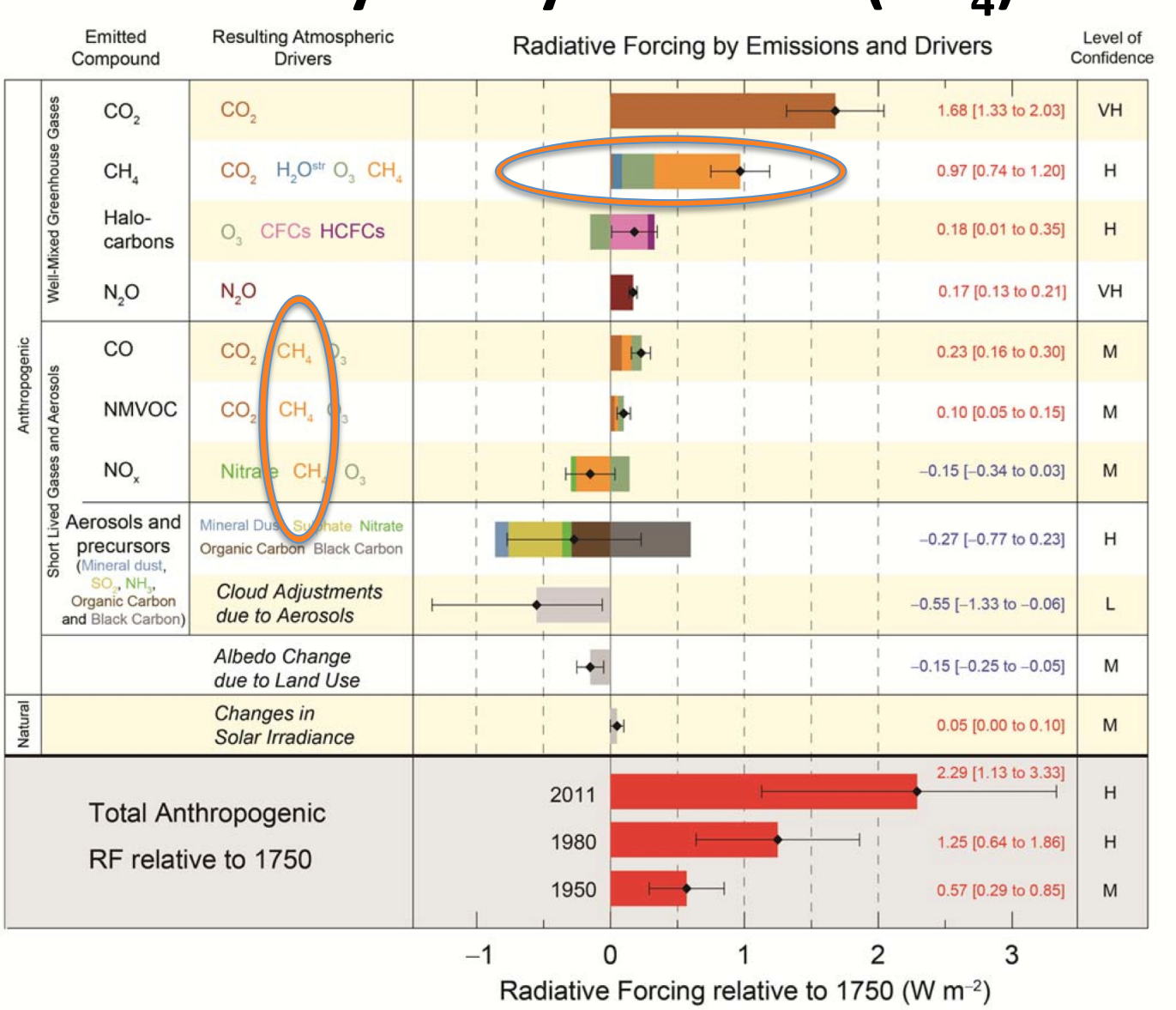
Why Study Methane(CH_4)?



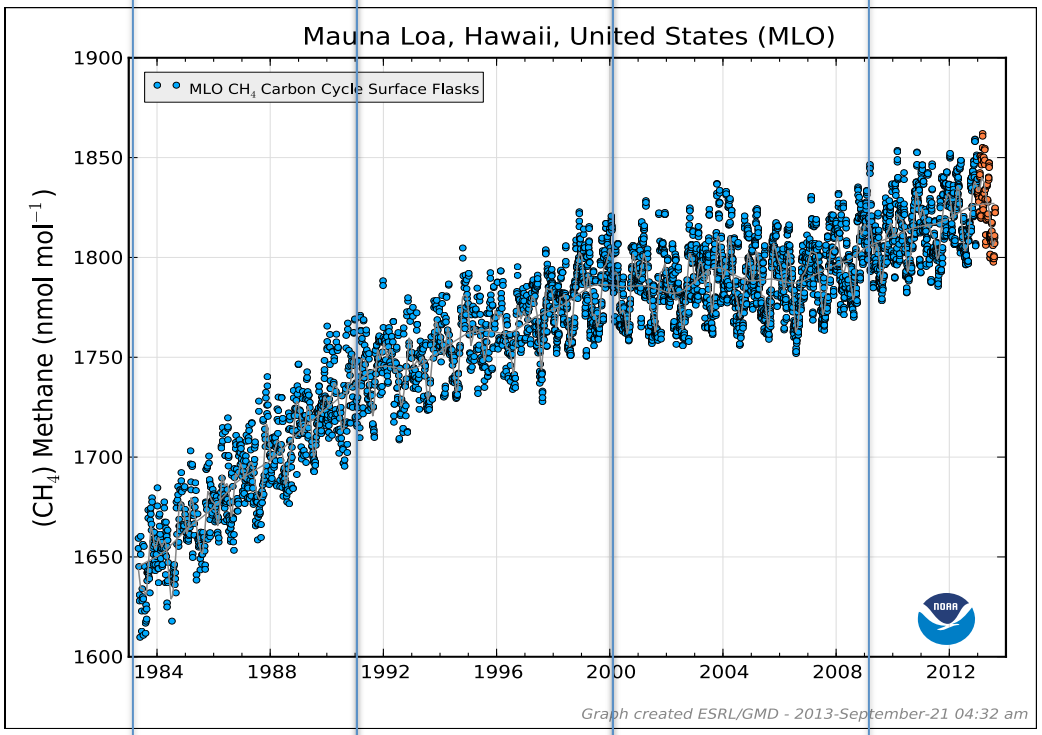
IPCC : Fifth Assessment Report

Why Study Methane(CH_4)?



IPCC : Fifth Assessment Report

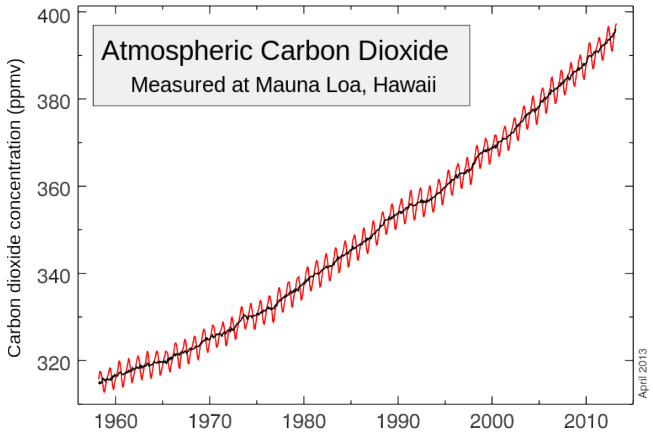
Mysteries around Methane



1983-1989: 12±6 ppb/yr

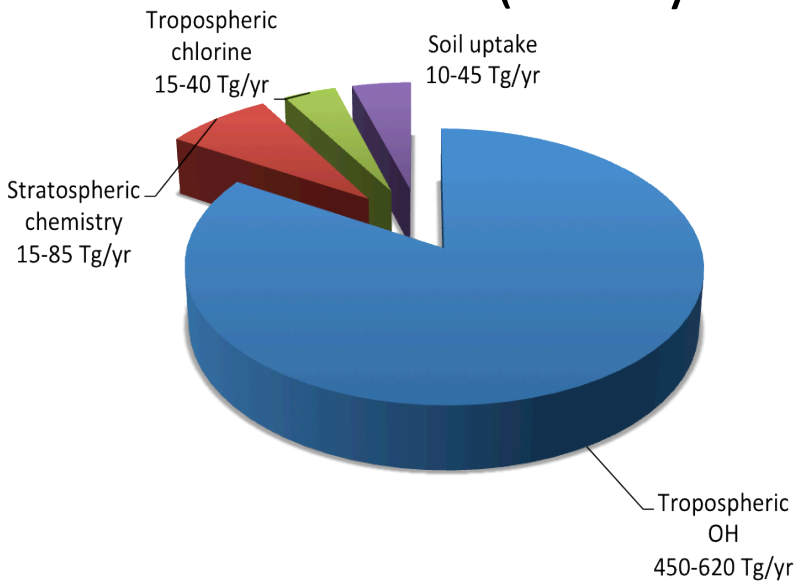
1990-1999: 6±8 ppb/yr

2000-2009: 2±2 ppb/yr

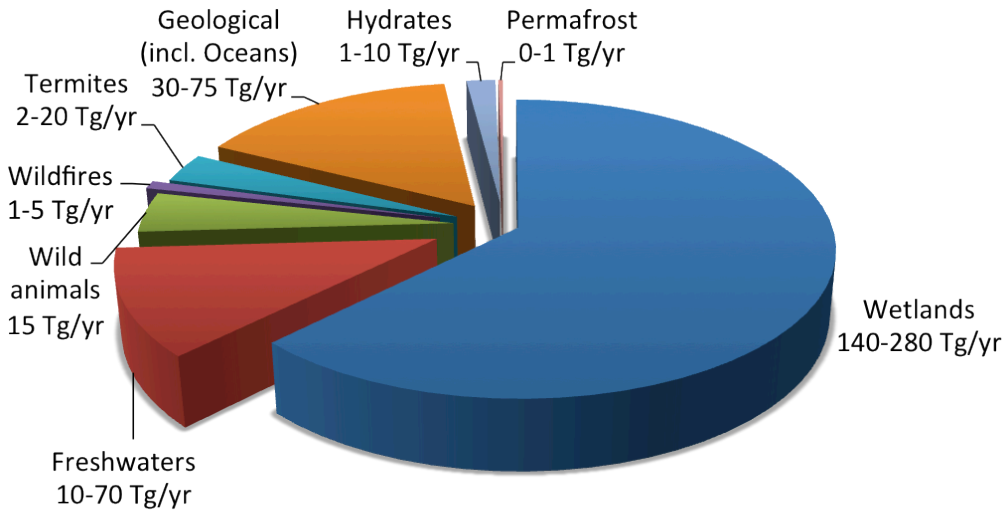


Methane Budget

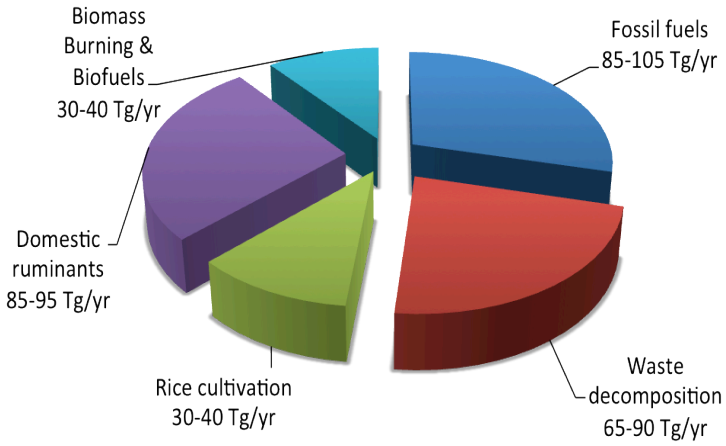
Sinks (Mostly Natural)



Natural Sources



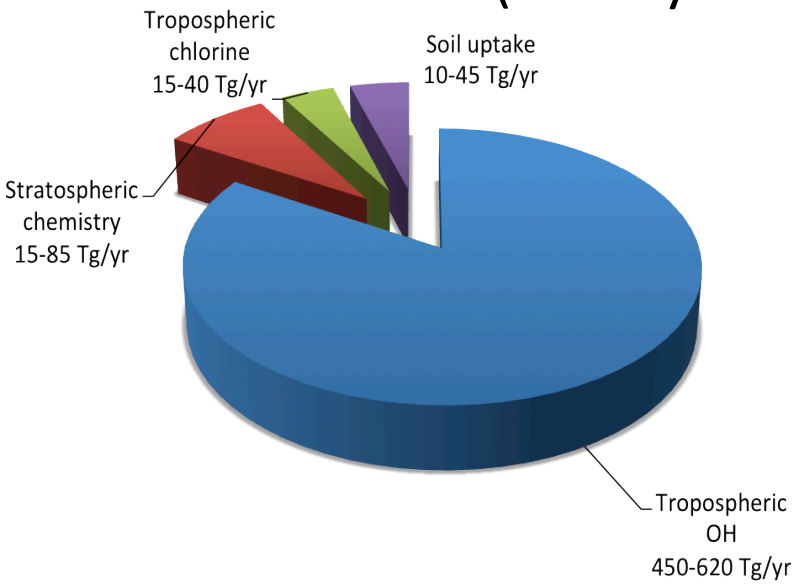
Anthropogenic Sources



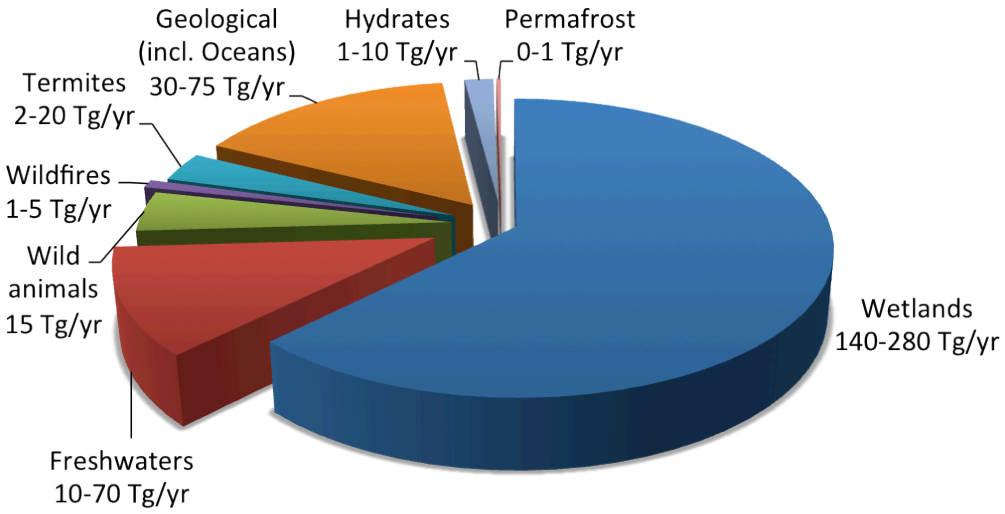
Methane Budget

Category	Uncertainty
Natural wetlands	50%
Other natural sources	100%
Agriculture	30%
Global sinks	40%

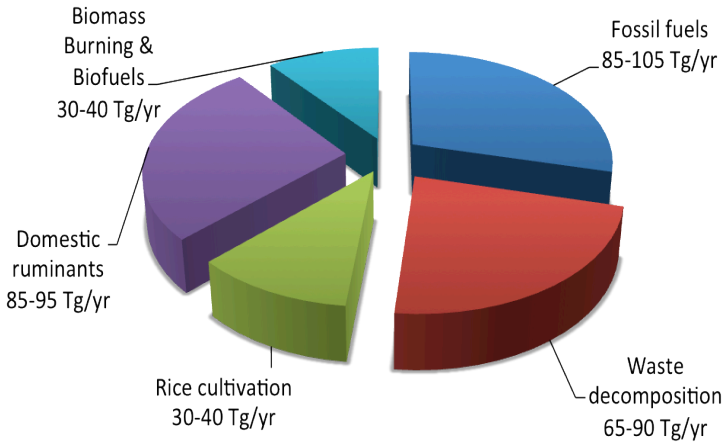
Sinks (Mostly Natural)



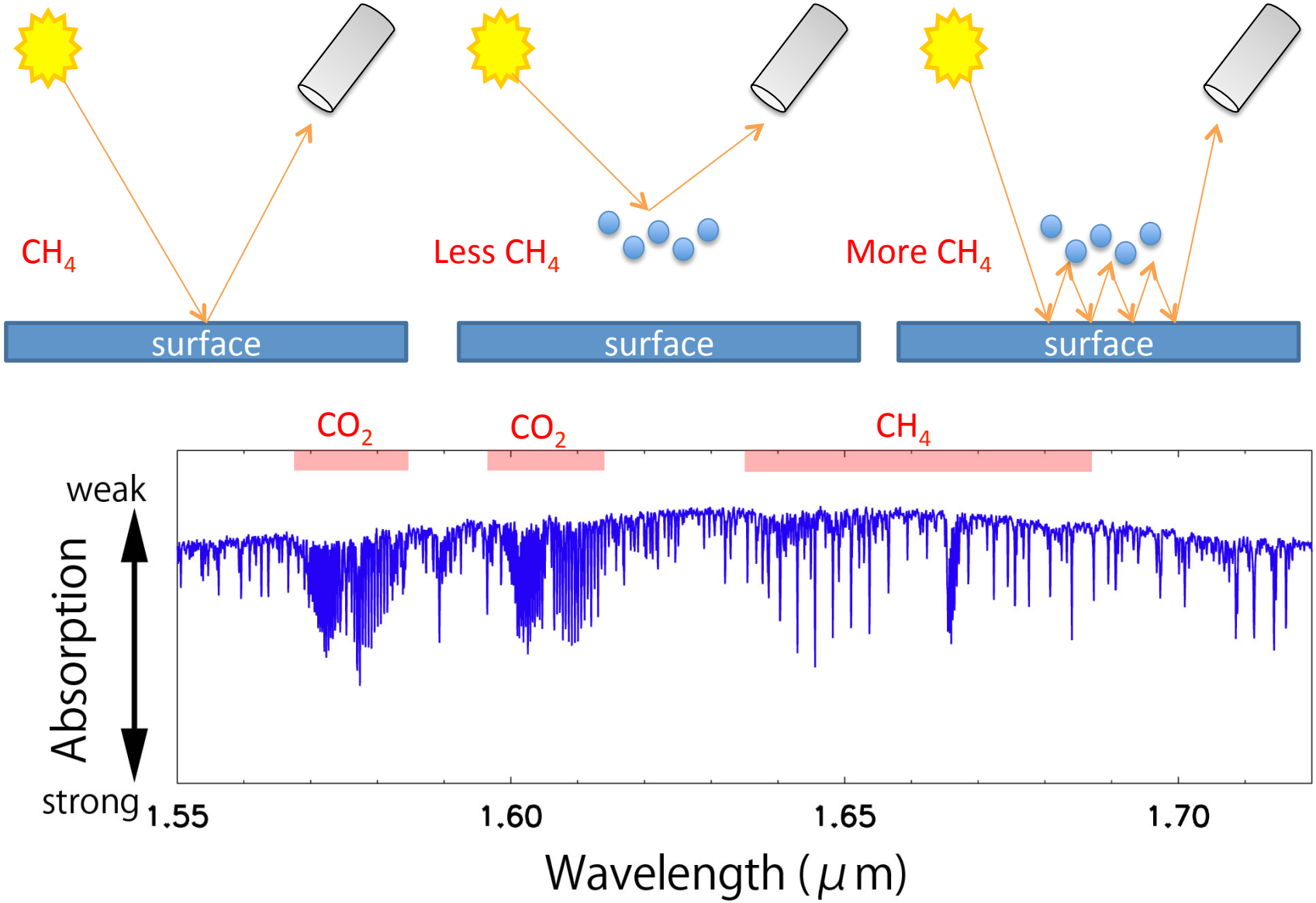
Natural Sources



Anthropogenic Sources



The Problem of Aerosols



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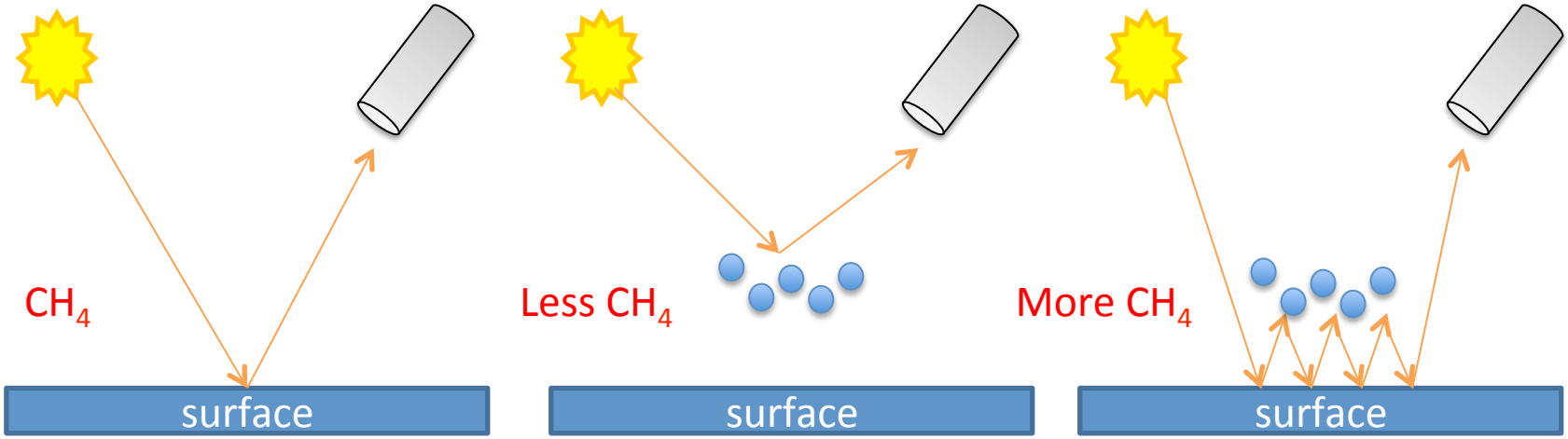


$$[CH_4]_{obser} = \left[\frac{CH_4}{CO_2}\right]_{obser} \times [CO_2]_{model}$$

Proxy Method

Assumption about $[CO_2]_{model}$:

1. Doesn't vary much
2. The associated error is less

Opportunity for Improvement

$$[CH_4]_{obser} = \left[\frac{CH_4}{CO_2}\right]_{obser} \times [CO_2]_{model}$$

Error In satellite measurements

Error in the known CO_2 values

- Inversion with $\left[\frac{CH_4}{CO_2}\right]_{obser}$
- Remove error due to $[CO_2]_{model}$

Comparison setup

Direct Optimization

$$[CH_4]_{obser} = \left[\frac{CH_4}{CO_2}\right]_{obser} \times [CO_2]_{model}$$

- Linear observation operator

CONGRAD **: Conjugate gradient method**

- Most efficient in term of no of iterations needed.
- Gives posterior error covariance
- Not good for non-linear case.

Ratio Optimization

$$\frac{[CH_4]_{init}}{[CO_2]_{init}}$$

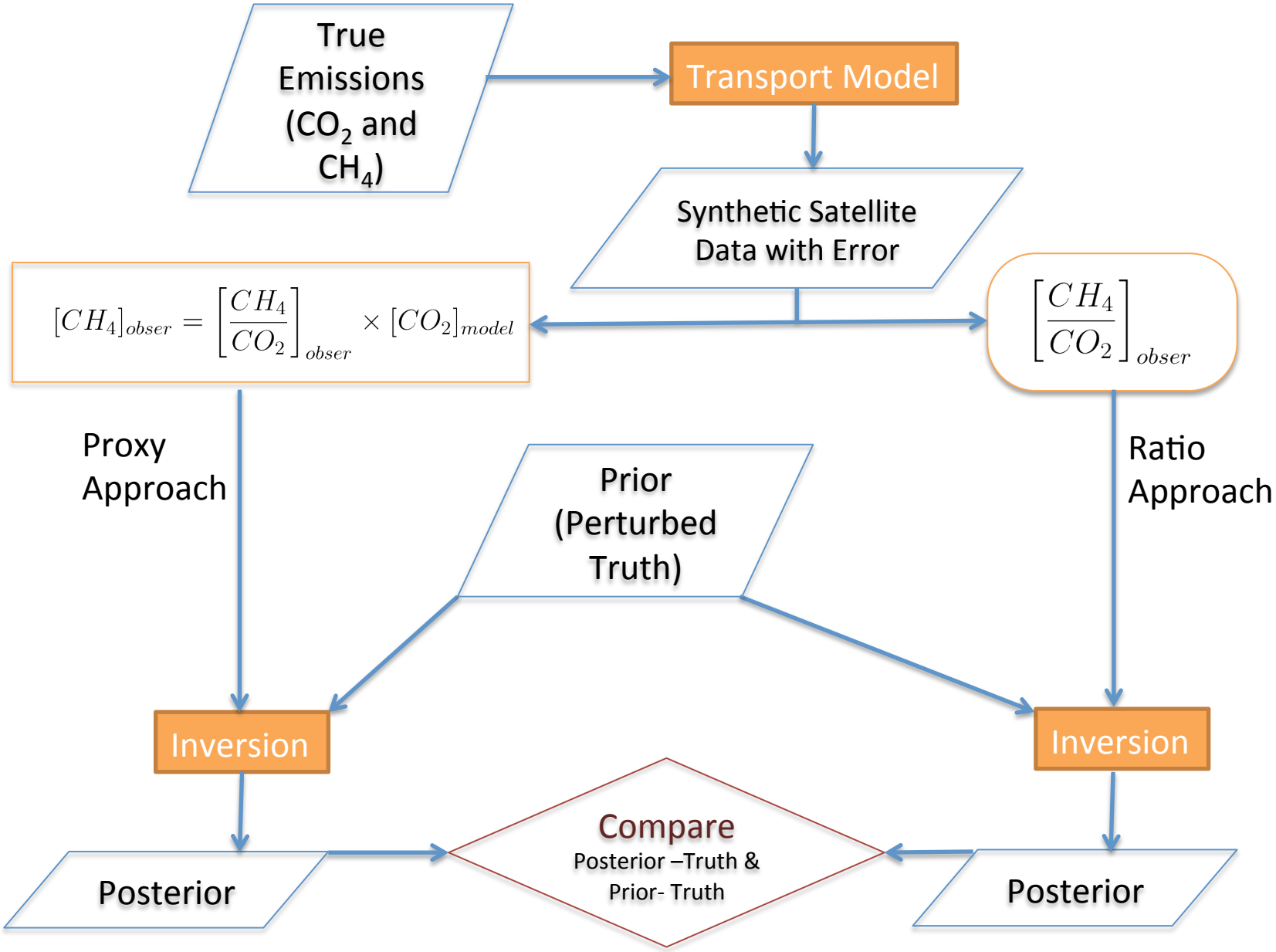
- Nonlinear observation operator

M1QN3: Quasi Newton method

- Pros : can be used for Non-linear case.
- Posterior error covariance is not calculated.
- Computationally more demanding.

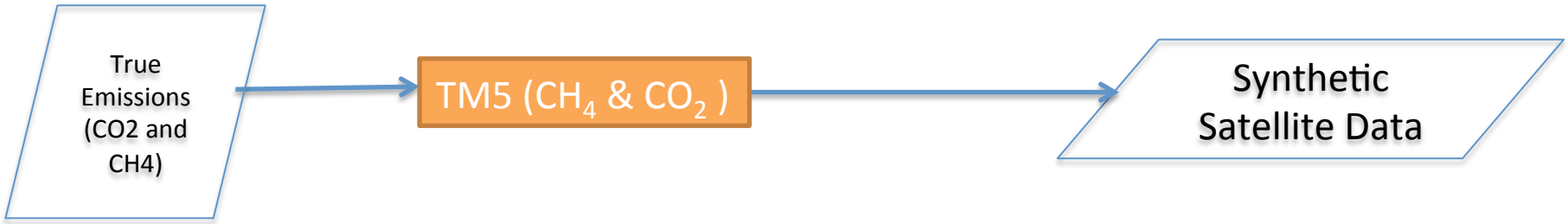
Good for our case !!!!!!!!!!

Comparison Test: Setup

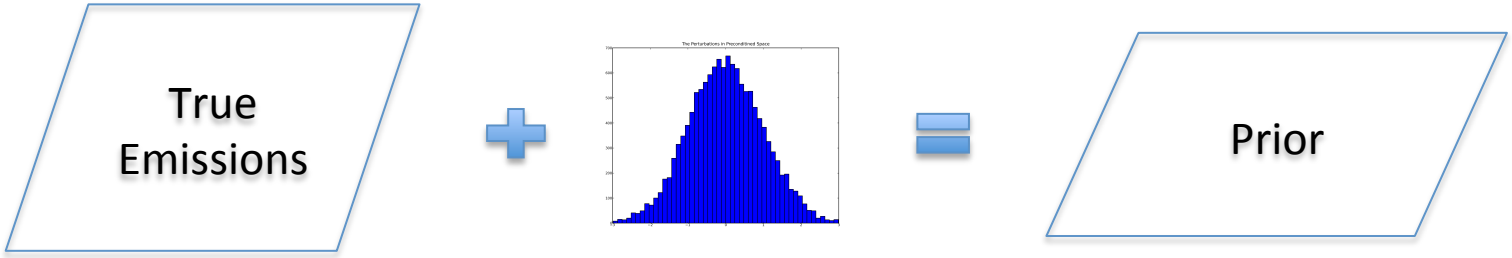


Prerequisites

- Transport model which can run for CO_2 and CH_4 in parallel

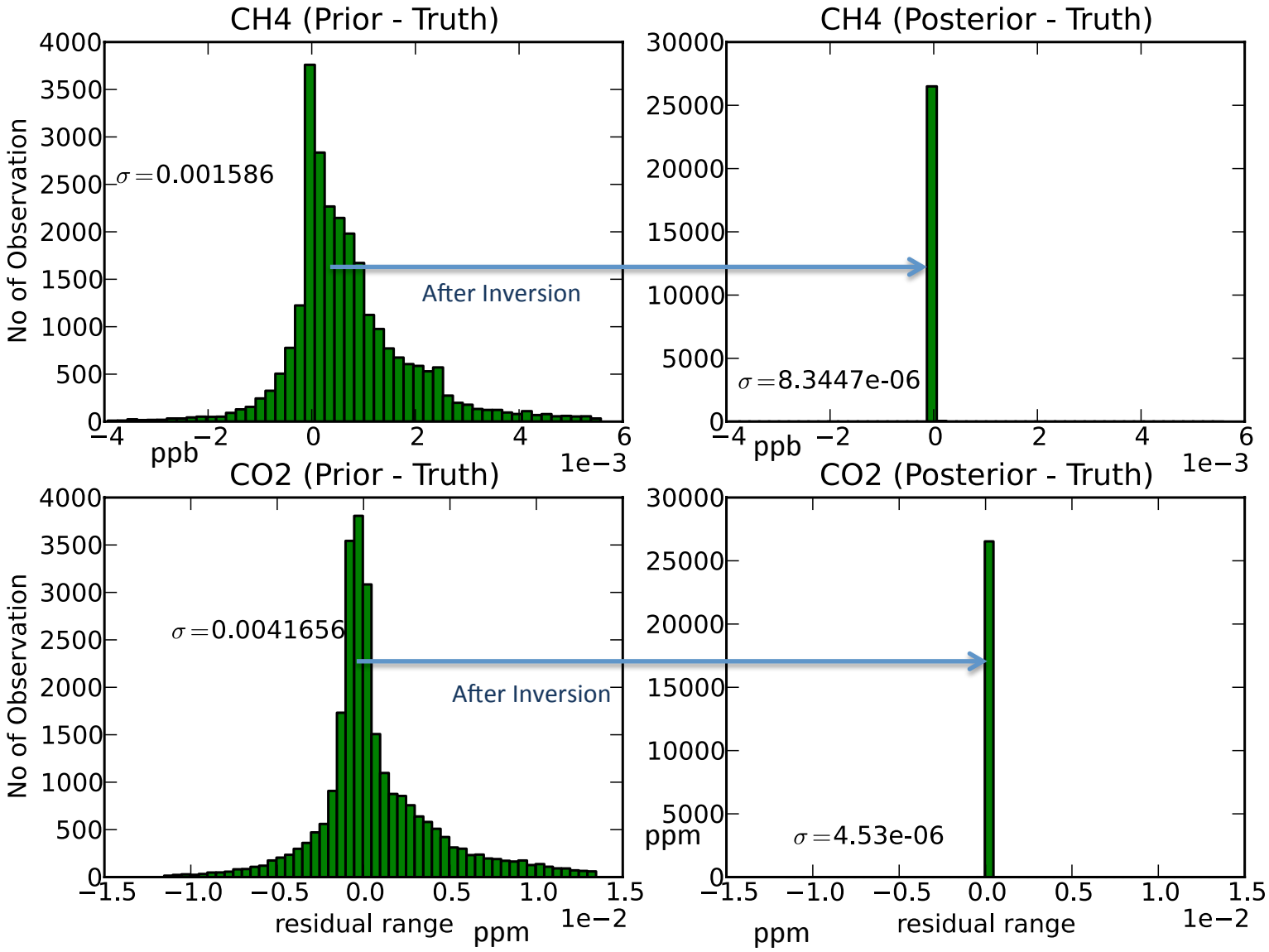


- Prior emissions

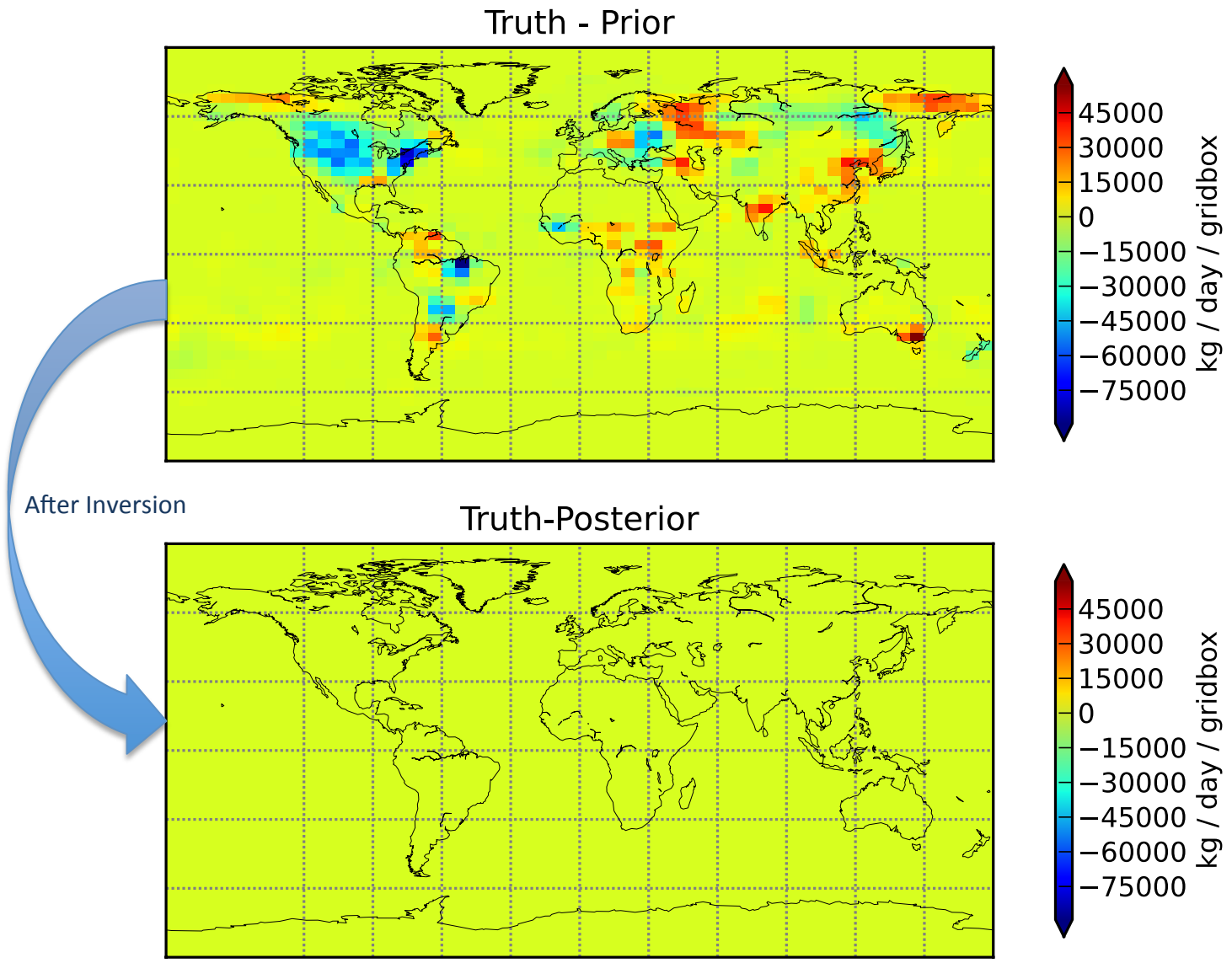


Gaussian Perturbations

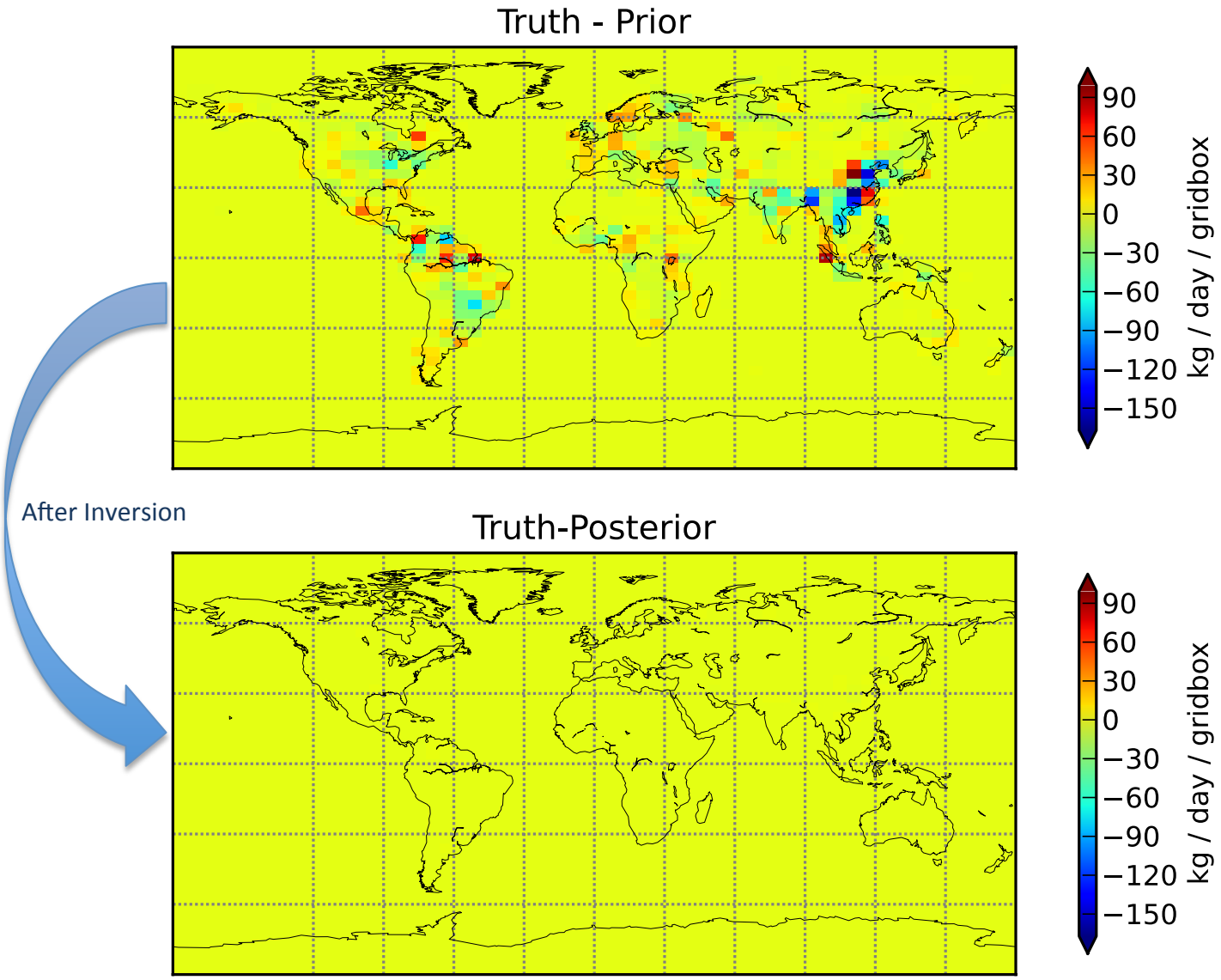
Measurement Departures



CO_2 Emissions

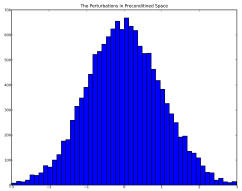


CH_4 Emissions



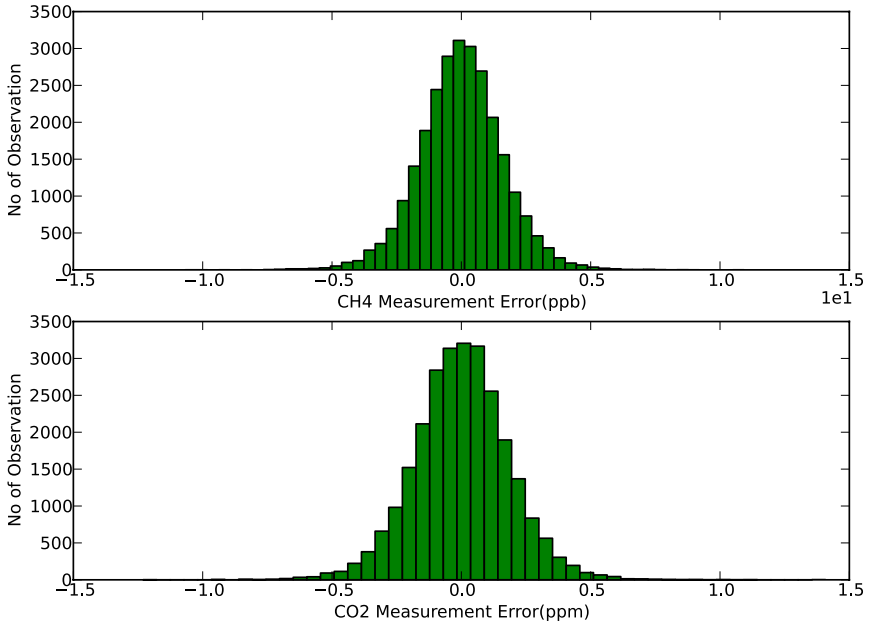
Satellite Measurements Errors

Synthetic model Output



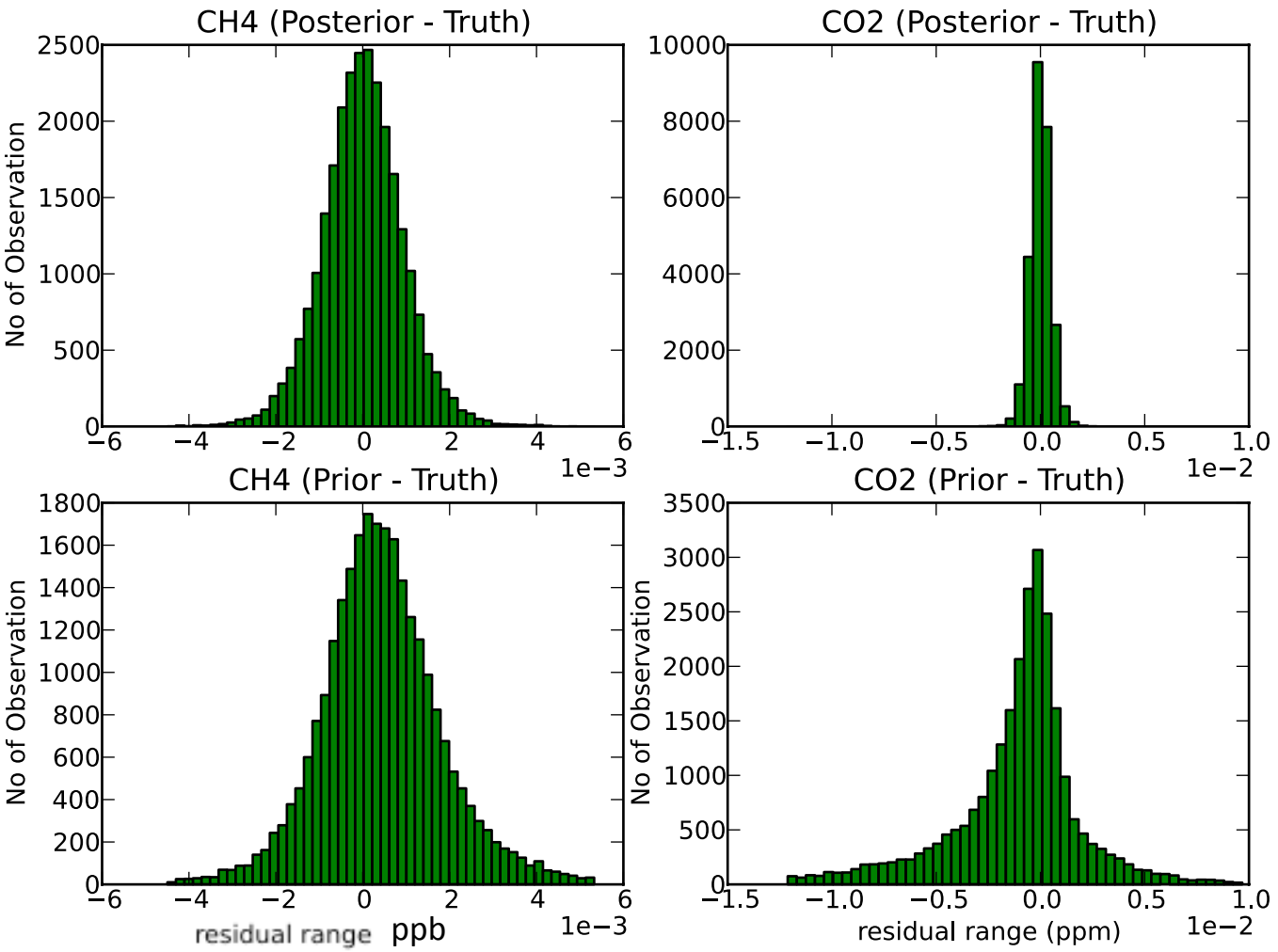
Satellite Measurements with Errors

Gaussian Perturbations

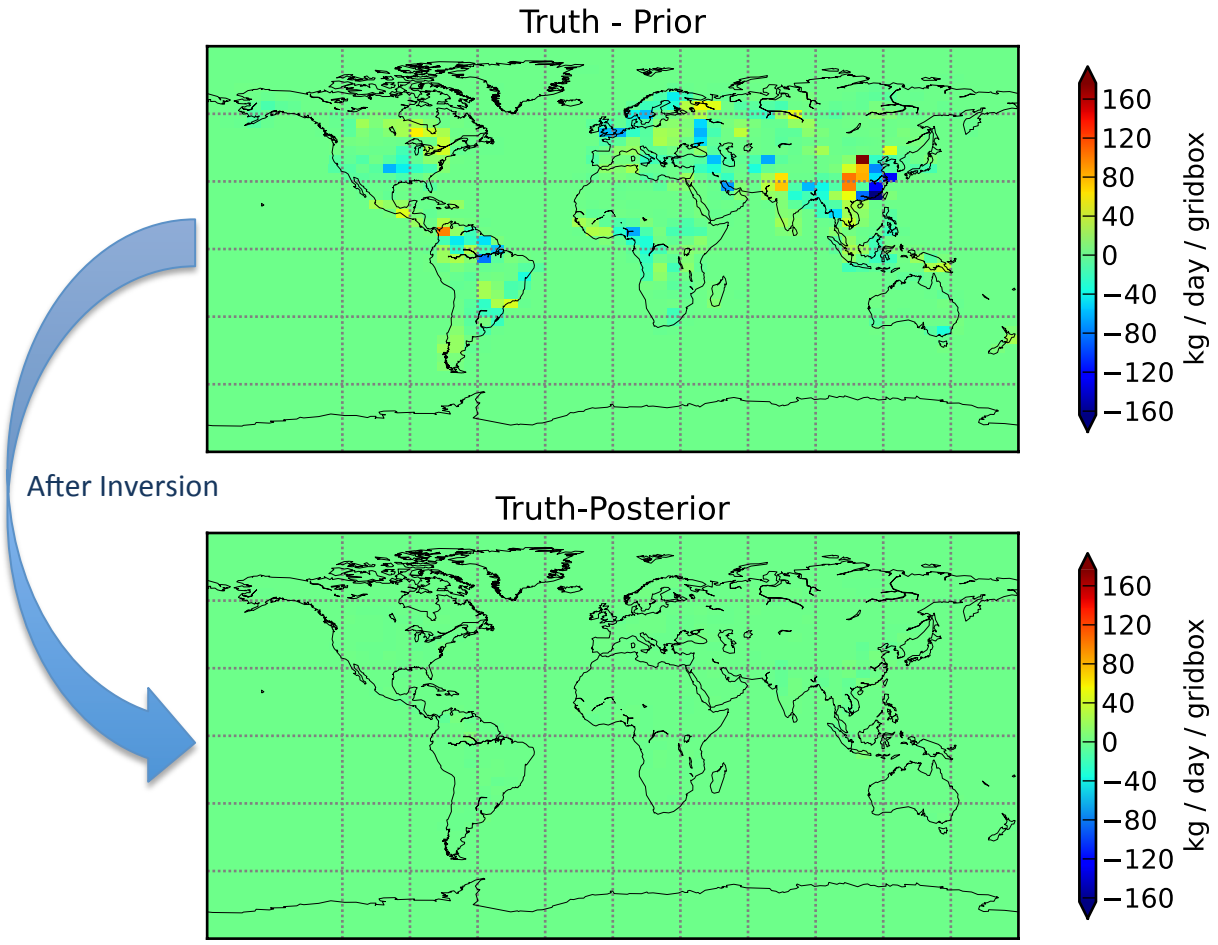


Measurement Departures

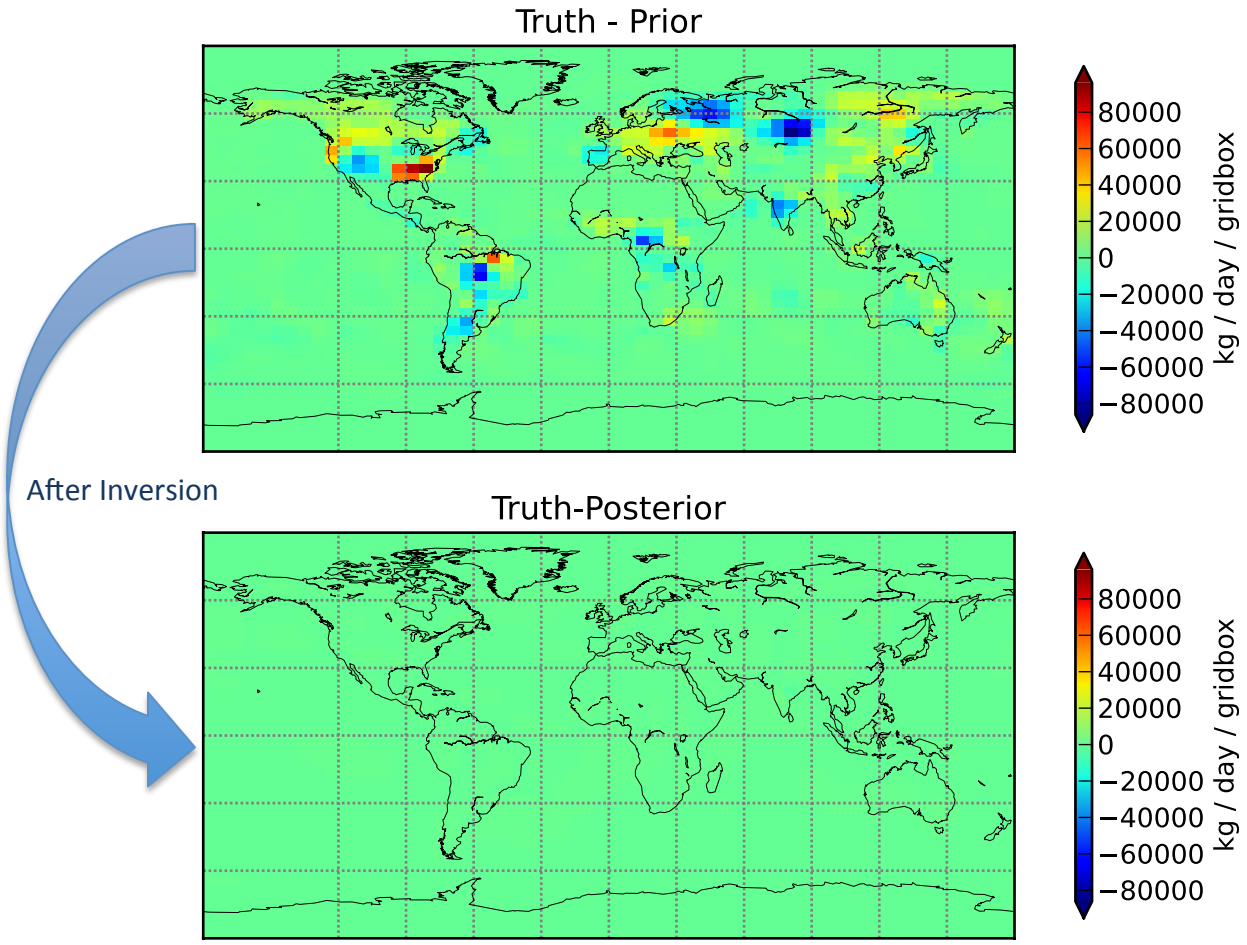
After Inversion



With Measurement Error (CH_4)



With Measurement Error (CO_2)



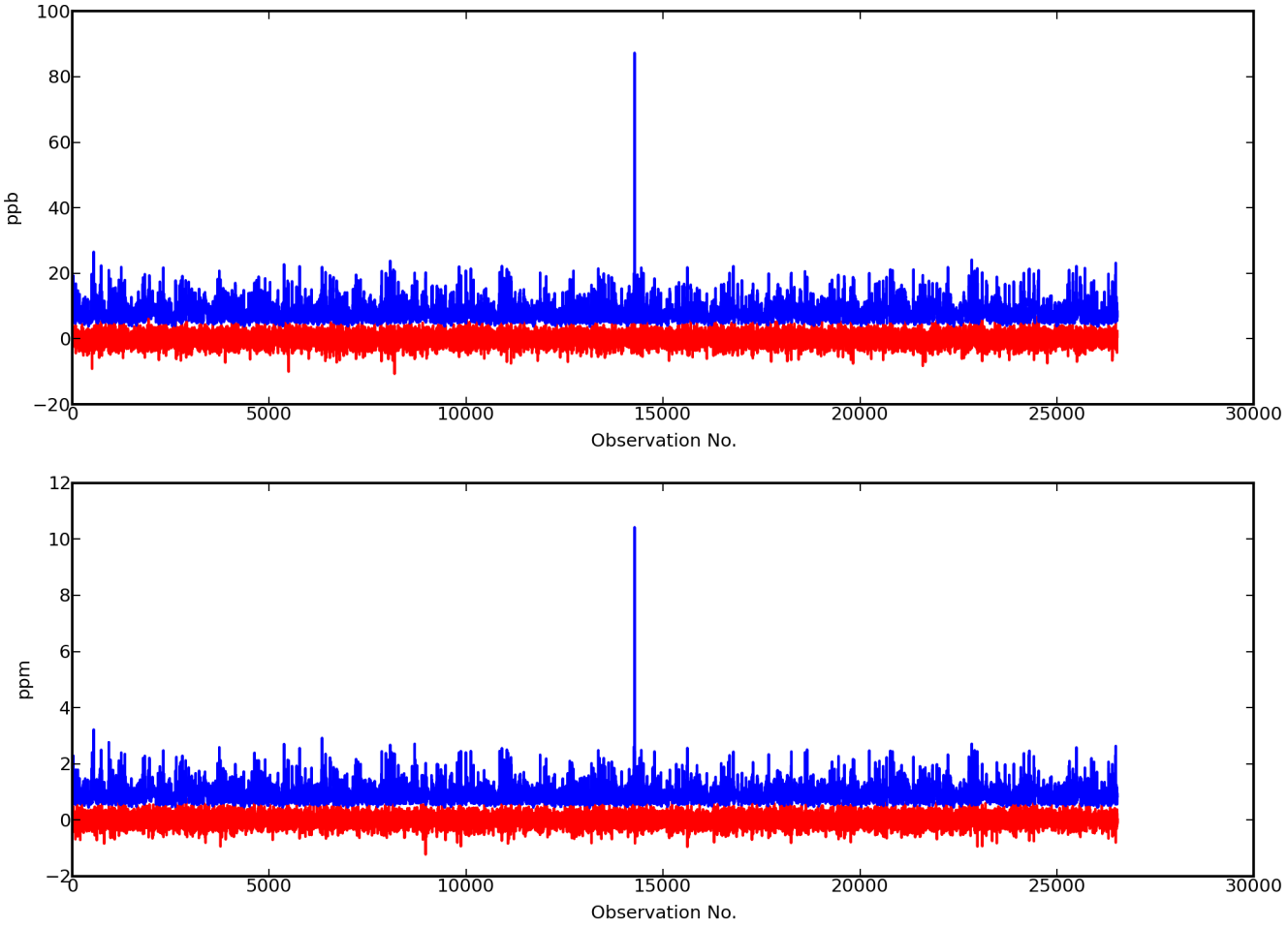
Conclusion

- There is a potential of reduction in posterior errors of methane by using ratio method
- TM5 is implemented to invert CO_2 and CH_4 fluxes in parallel

Next step

- Implement the ratio approach and comparison with the traditional inversion.
- Finally, apply ratio approach for real measurements

THANK YOU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ppb
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Observation No.
12
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8
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4
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