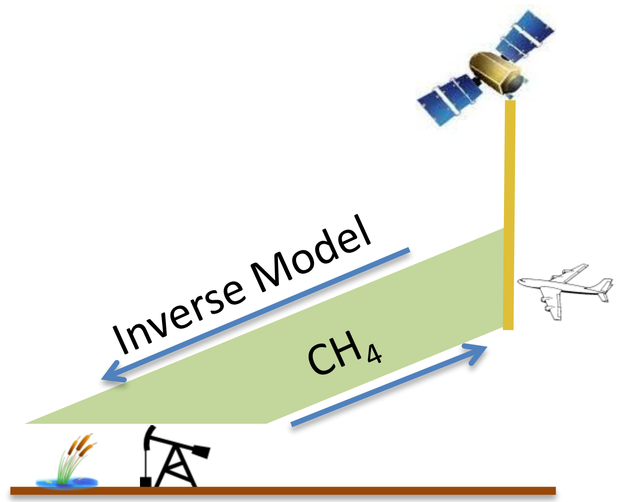
Top-down Constraints on Methane Sources using GEOS-Chem and its Adjoint

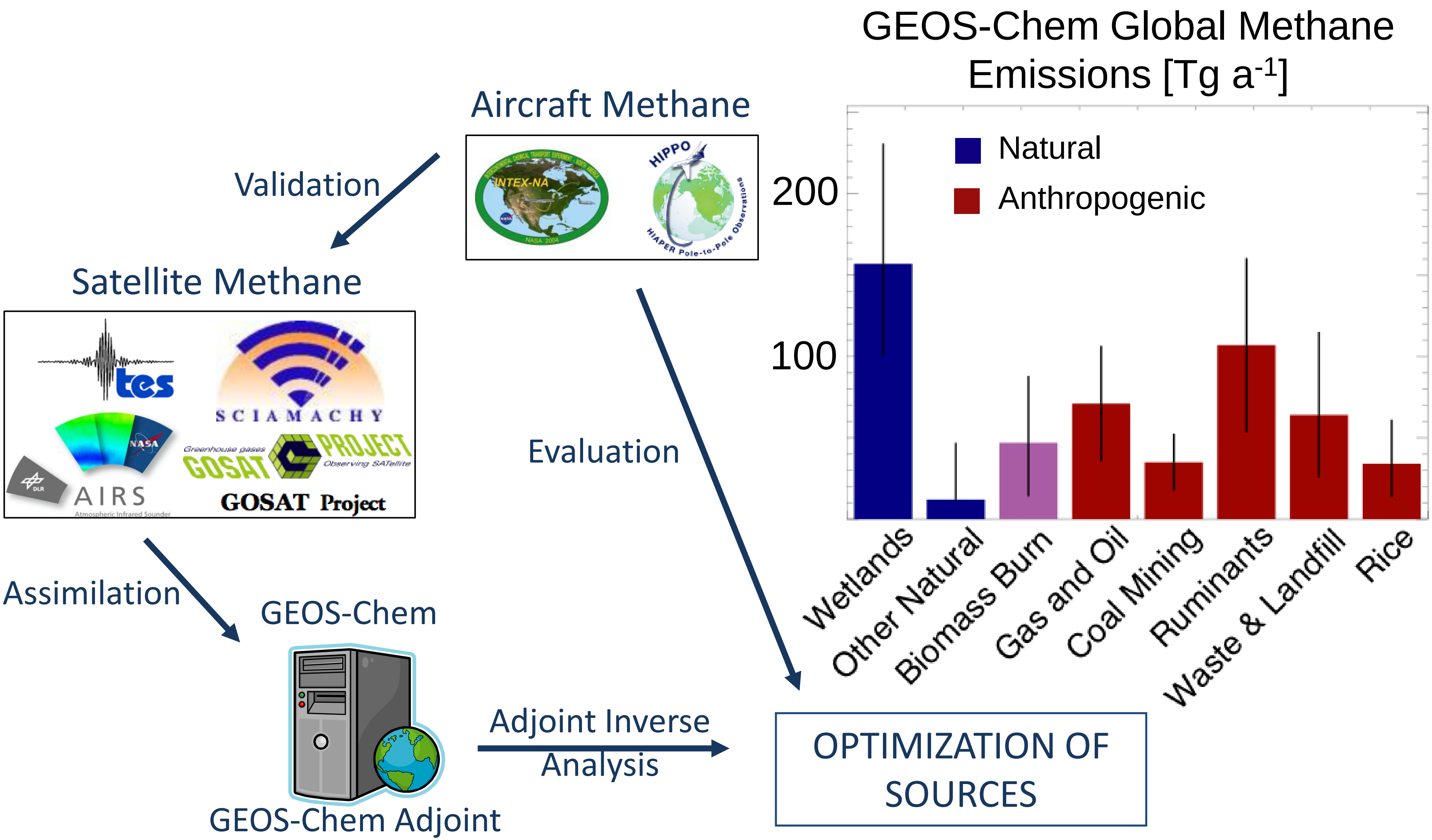


GEOS-Chem Meeting
3 May 2011

Kevin J. Wecht

DJ Jacob, SC Wofsy, EA Kort, JR Worden, SS Kulawik, VH Payne, DK Henze, M Kopacz, K Singh, C Shim

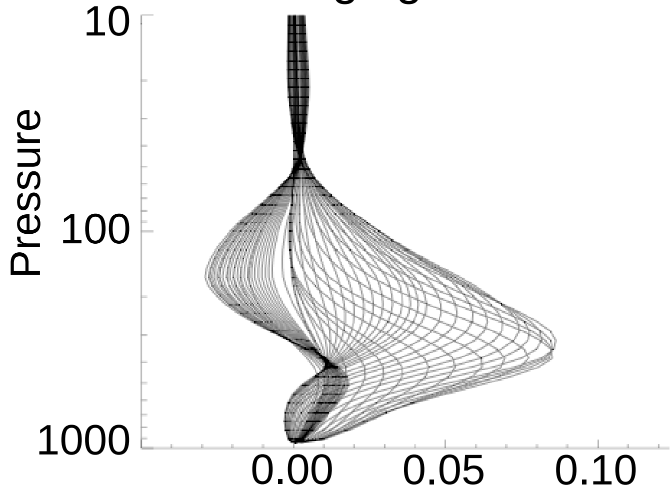
Top-down Constraints on Methane Emissions



Bottom-up inventories are highly uncertain. We use top down approach.

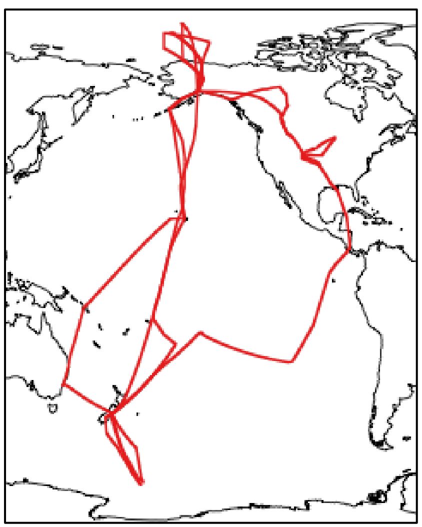
Validation of TES V004 Methane with HIPPO Observations

TES V004 Averaging Kernel Matrix



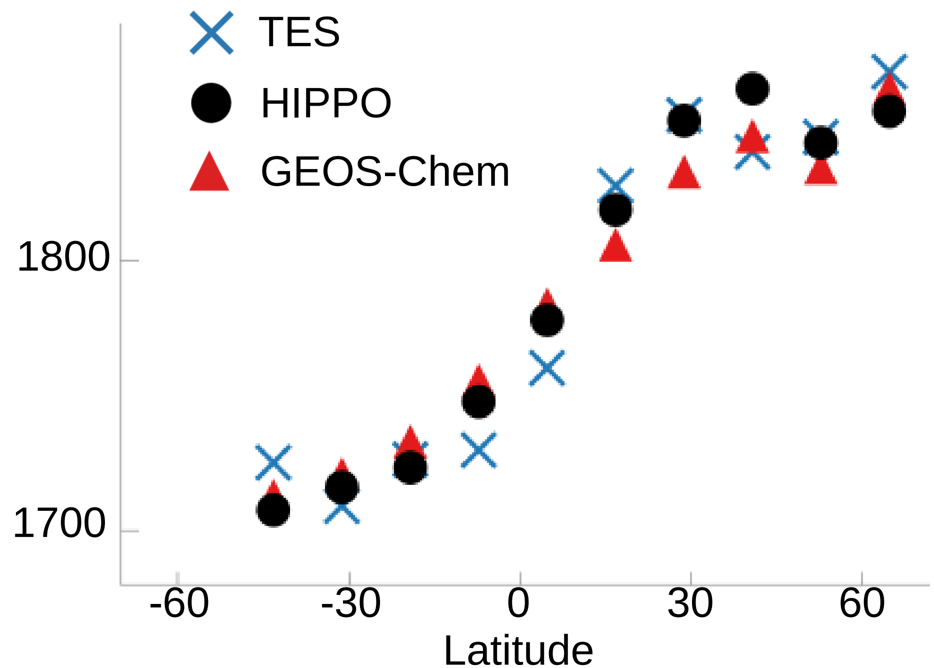
Flight Paths of HIPPO Phases I&II

January & November 2009



- Thermal IR, sun-synchronous orbit
- Sept 2004 – present
- 30,000 observations per month
- Degrees of Freedom for Signal 0.6-1.6
- Averaging kernels peak 200-400 hPa

Latitudinal Profile of TES, HIPPO and GEOS-Chem Methane [ppb]



TES Bias = 69.5 ppb, σ = 43.0 ppb. Latitudinal profile is consistent with HIPPO.

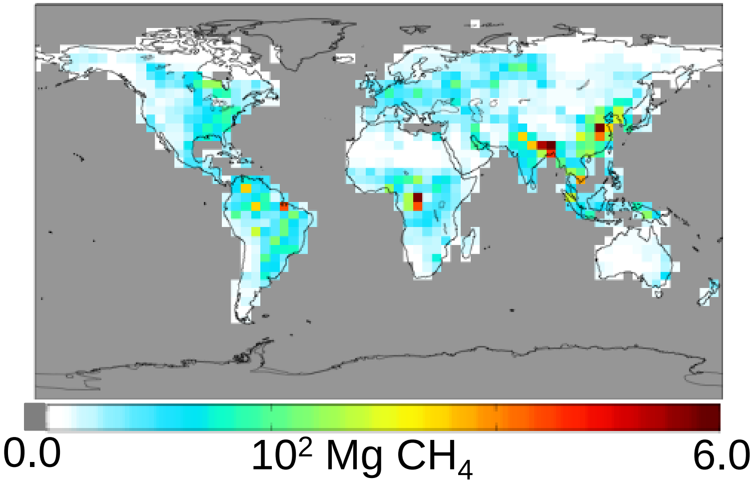
Twin Test of Inversion for Methane Sources using TES

How well can TES pseudo-observations reconstruct a known emission field?

- Test the inverse calculation
- Understand the effects of TES error and *apriori*
- Find optimum length of assimilation period

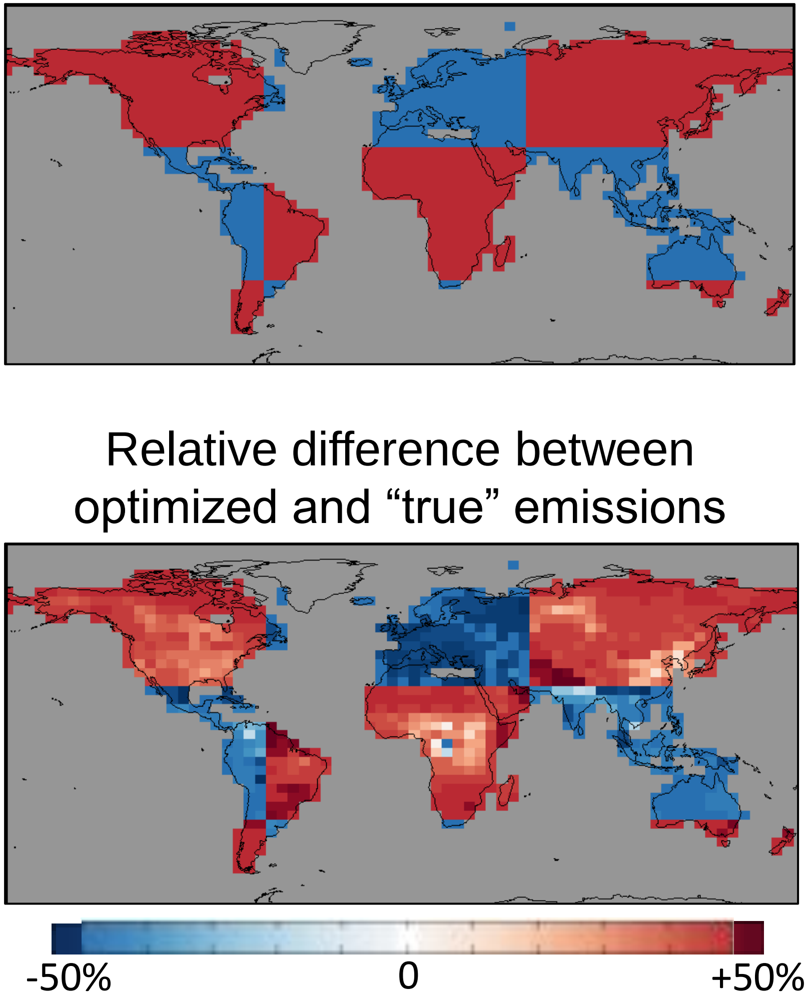
Time	Assimilation Length	# observations
July 2008	1 month	22038

"True" July 2008 CH_4 Emissions



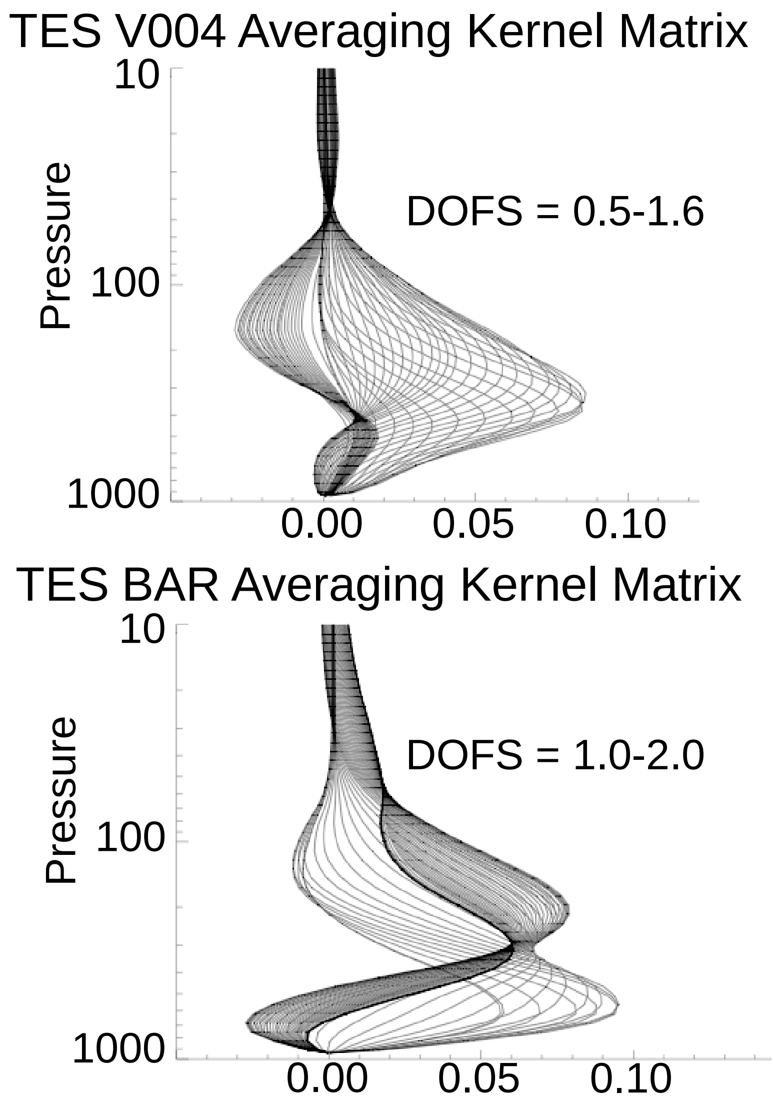
Relative difference between apriori and "true" emissions

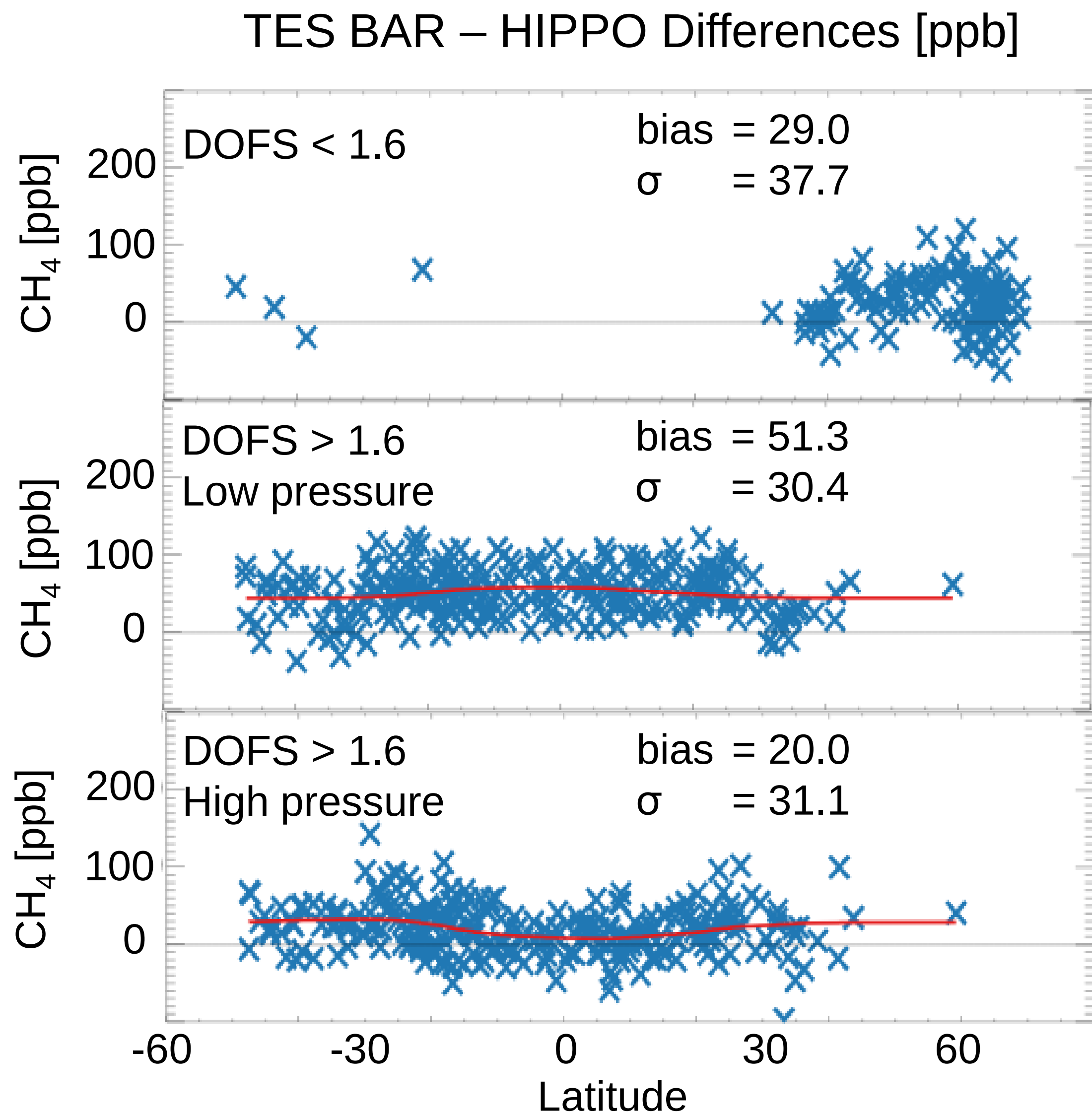
Relative difference between optimized and "true" emissions



TES alone is not sufficient for use in a global adjoint inversion.

Validation of New TES Methane with HIPPO I & II Observations





New TES is more precise with sensitivity lower in the troposphere than TES V004.

Optimizing Methane Sources from United States

Why United States?

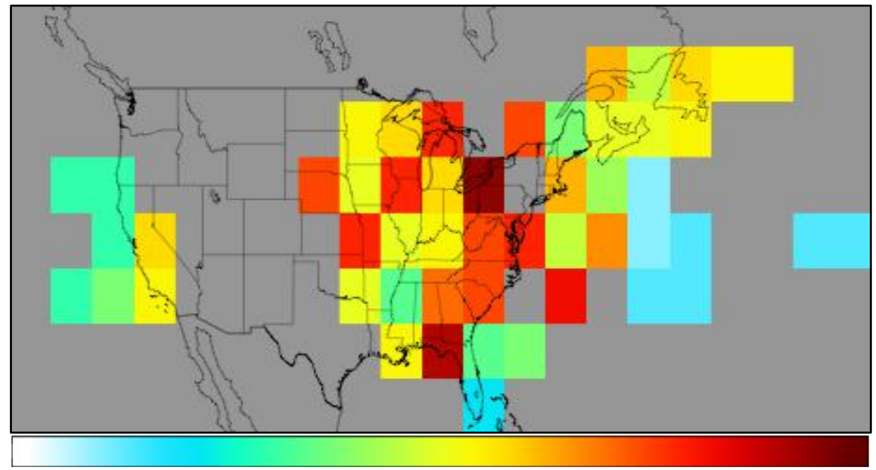
- Bottom-up inventories inconsistent with observations
- Relatively well observed
  - NOAA GMD, INTEX-A, SCIAMACHY, AIRS
- GEOS-Chem nested grid capability

2000-2004 sources [Tg a^{-1}]	US Anthro	US Fossil Fuel
EDGAR v3	40.1	21.9
EDGAR v4	26.5	10.6
EPA	30.7	13.7
Kort	49.0*	---
Xiao	---	15-20
Katzenstein	---	12-18**

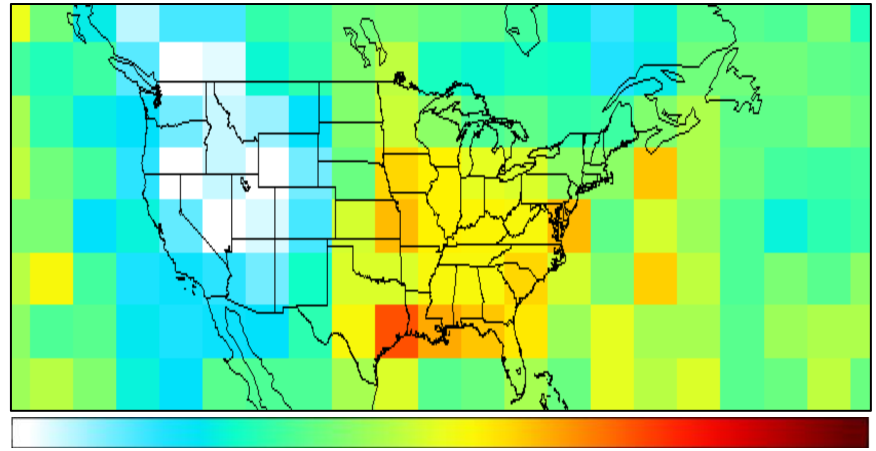
* Includes Canada

** Only natural gas

INTEX-A Boundary Layer Methane
July 1 – August 14 2004

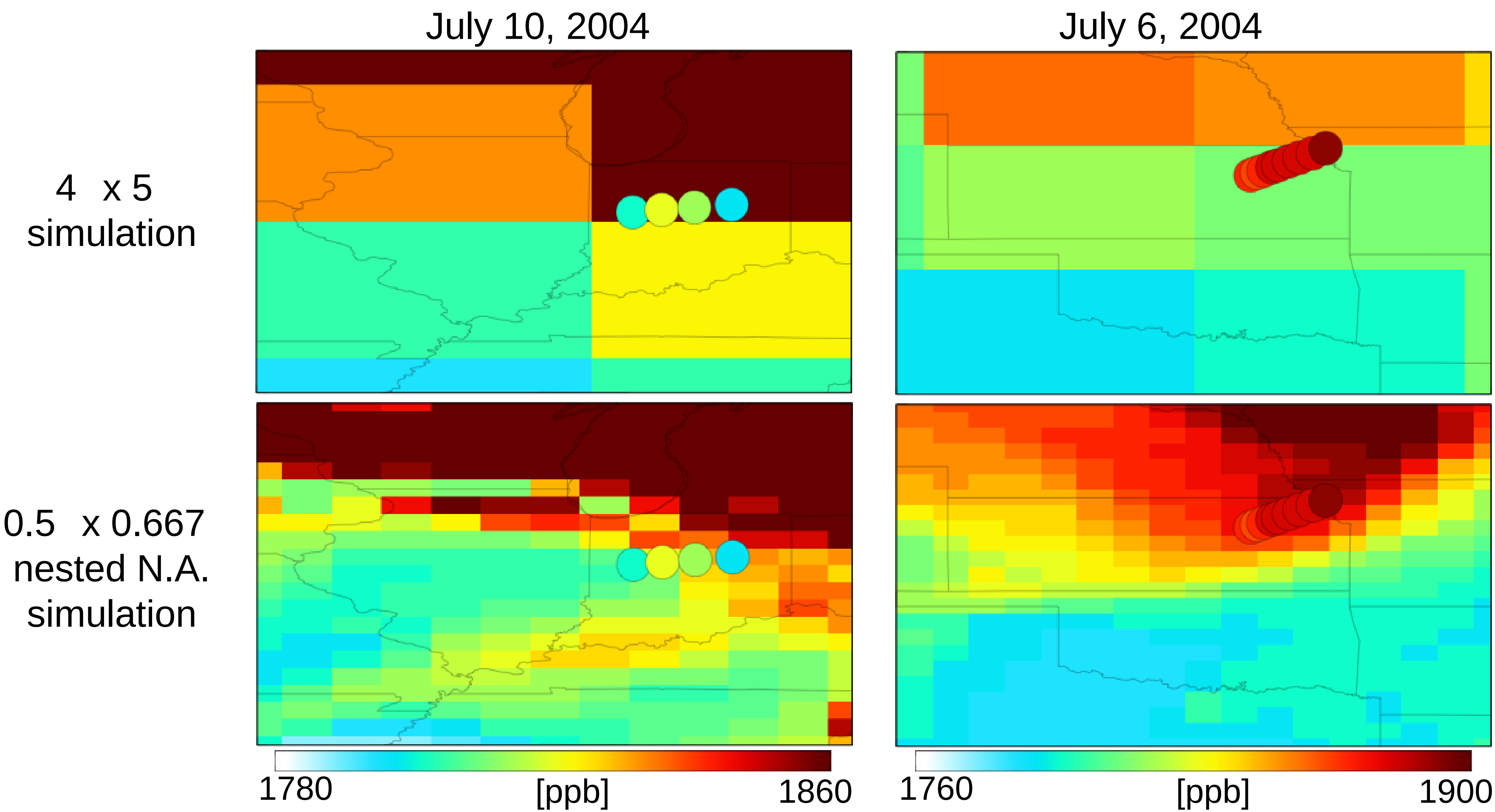


SCIAMACHY Methane July-Aug 2004



GEOS-Chem Nested Grid Simulation Allows for Emission Estimates at Fine Spatial Scales

Boundary Layer GEOS-Chem and INTEX-A Methane



Coarse resolution cannot capture fine structure in observations and may bias emission estimates.

Thank You!

TES CH_4

- Enabling Inverse Modeling:
  - Validation of TES methane with HIPPO observations
  - Robust latitudinal gradient with greater coverage than surface stations
- TES methane alone is insufficient to identify methane sources
- Validation of new TES methane product with HIPPO

United States CH_4

- Known deficiencies in bottom-up inventories
- Nested GEOS-Chem simulation valuable for source identification

Future Work

- Global and nested N.A. adjoint inversions using new TES product, SCIAMACHY, possibly AIRS or GOSAT
- Combine thermal IR and solar backscatter instruments to isolate lower tropospheric enhancements