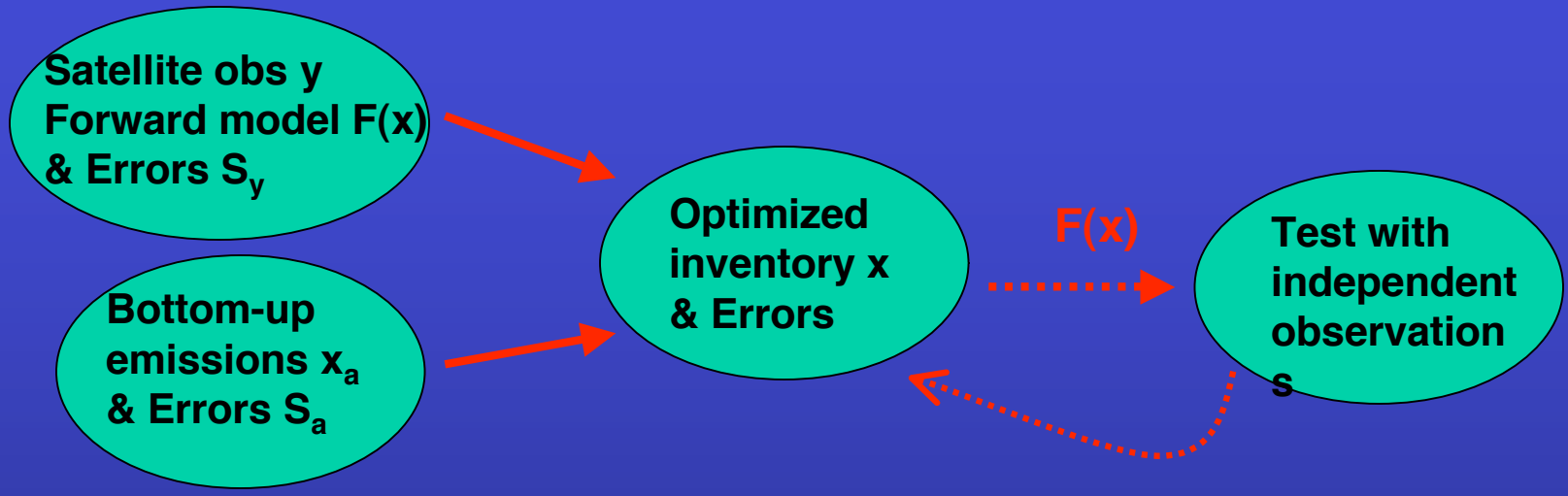
Estimation of Emission Sources Using Satellite Data

Randall Martin

DALHOUSIE UNIVERSITY

General Approach to Infer Emissions from Satellite Observations

Error Characterization Major Area for Further Improvement



$$\min \quad J(\mathbf{x}) = (\mathbf{y} - \mathbf{F}(\mathbf{x}))^T \mathbf{S}_y^{-1} (\mathbf{y} - \mathbf{F}(\mathbf{x})) + (\mathbf{x} - \mathbf{x}_a)^T \mathbf{S}_a^{-1} (\mathbf{x} - \mathbf{x}_a)$$

Error covariance matrices for

- bottom-up inventory S_a
- satellite retrieval S_i
- forward model S_m
- representativeness S_r

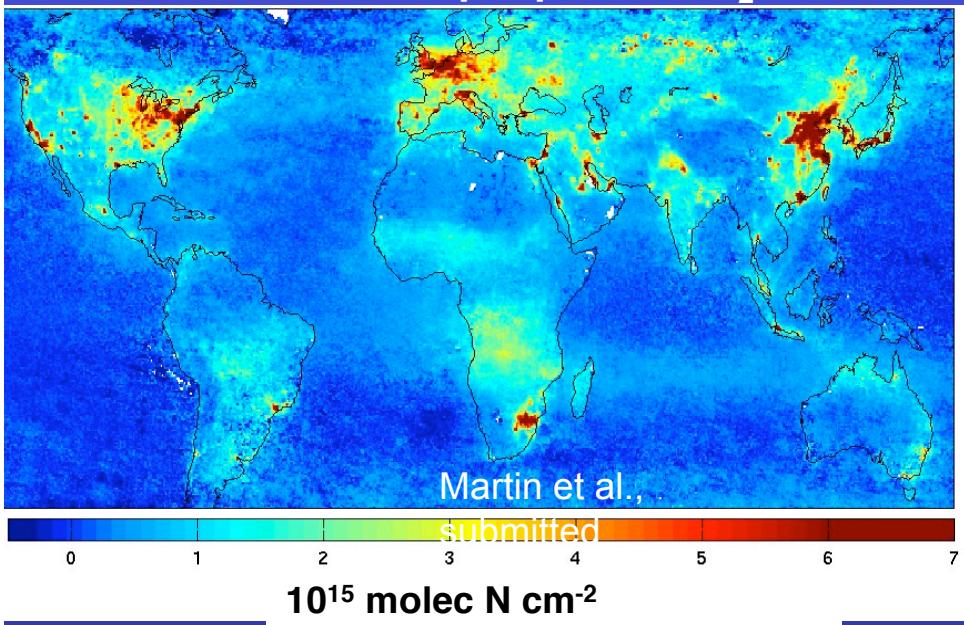
} S_y

Some Practical Issues

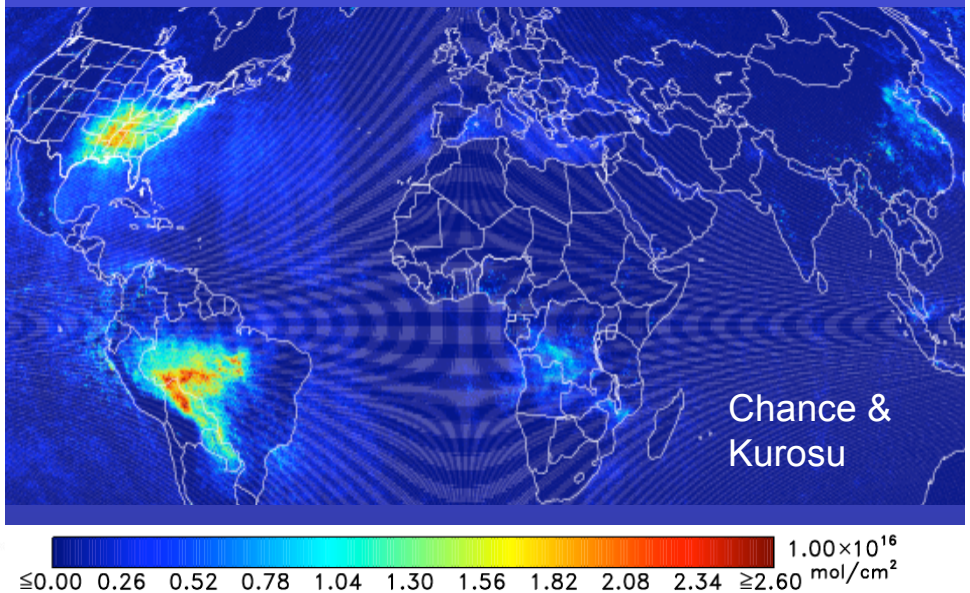
- model at resolution of desired inventory
- appropriate independent observations
- nonlinear methods

Specific Approaches Often Depend on Species Lifetime

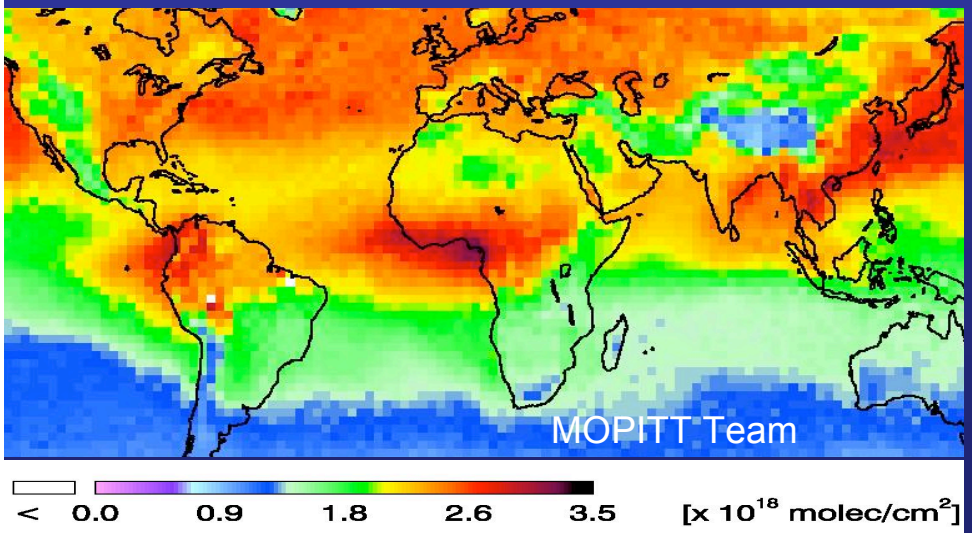
SCIAMACHY Tropospheric NO_2



OMI HCHO



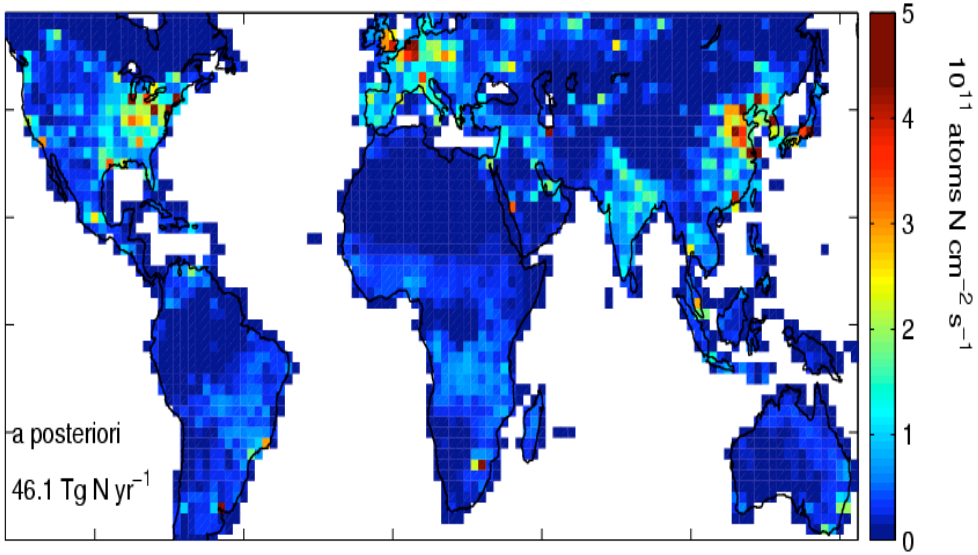
MOPITT CO



Species	Lifetime	Issue
NO_x	~hours - day	Representing NOx lifetime (chemistry)
HCHO & isoprene	~hours	Identifying HCHO source
CO	~month	Accounting for transport

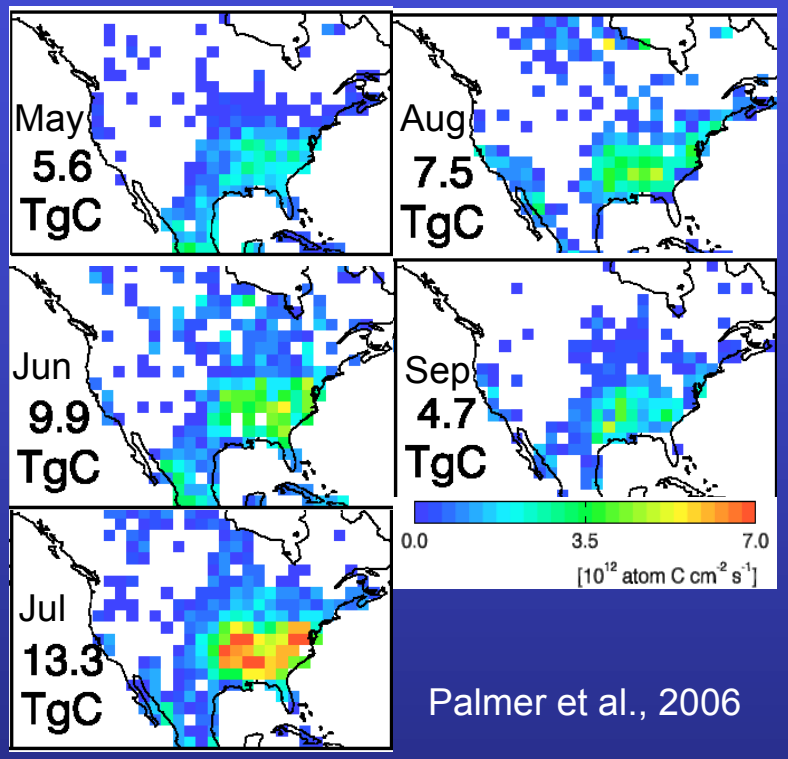
… and Have Yielded Promising Results

SCIAMACHY NOx Emissions (2004-2005)
East Asia Becomes Dominant Emitter (50% increase) Resolution?



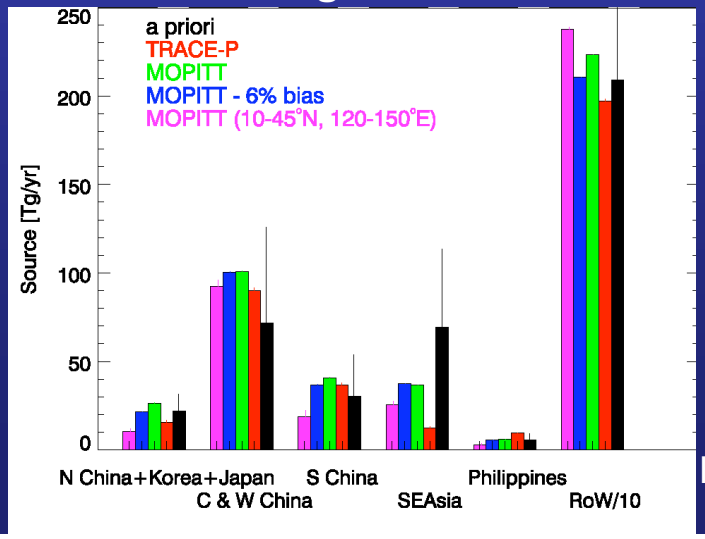
Martin et al., submitted

GOME Isoprene Emissions (1998)
Within ~10% of MEGAN



Palmer et al., 2006

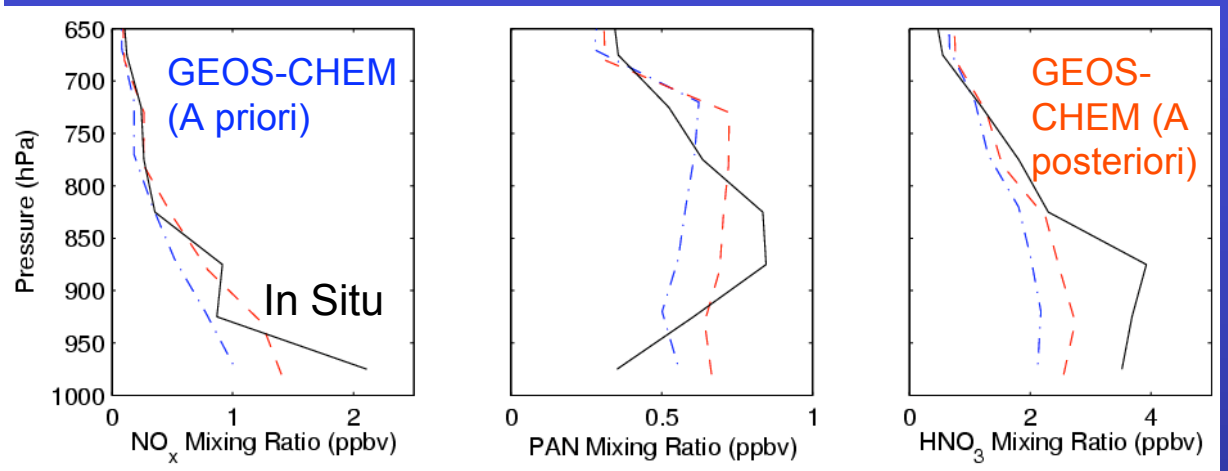
MOPITT CO Regional Emissions



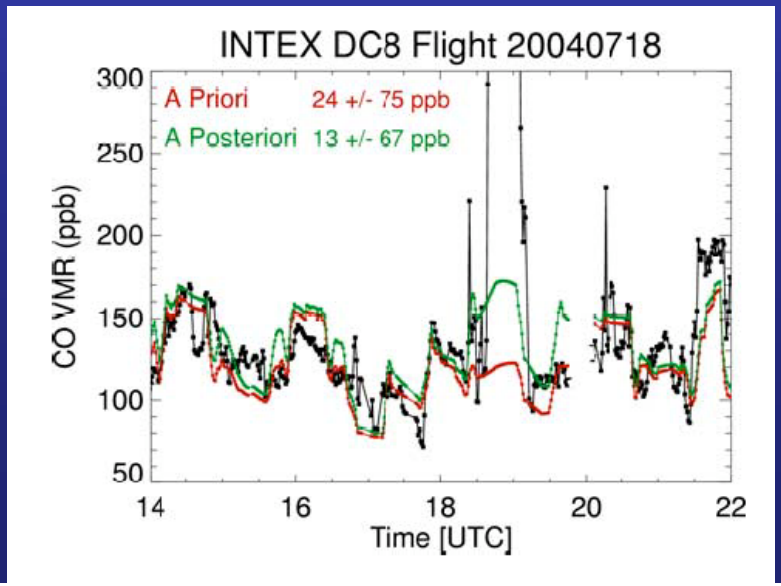
Heald et al., 2004

In Situ Measurements Support Satellite-based Inventories
Additional Measurements Critical for Inventory Evaluation

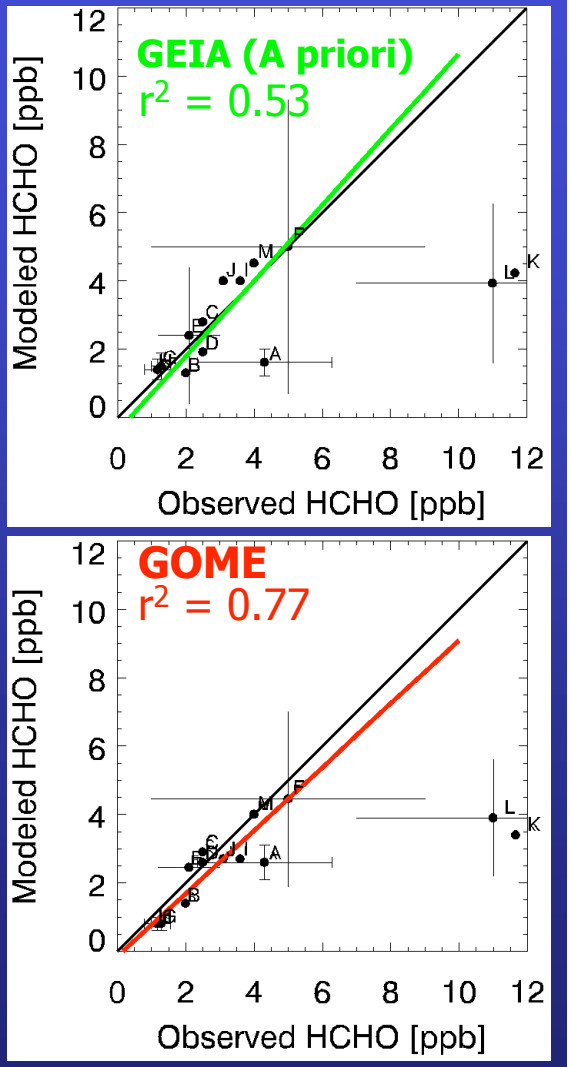
NOAA P-3 Measurements (Ryerson, Flocke, Neuman)



Martin et al., submitted

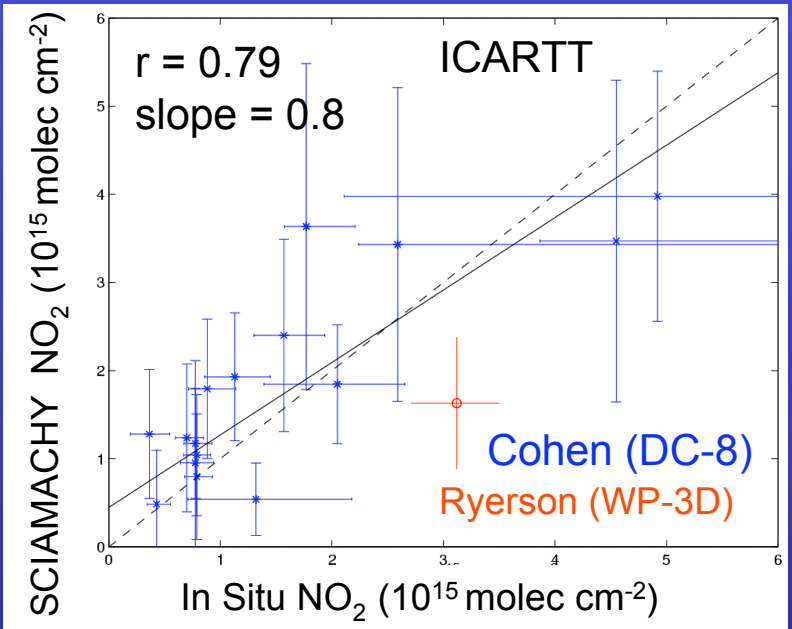


Pfister et al., 2005

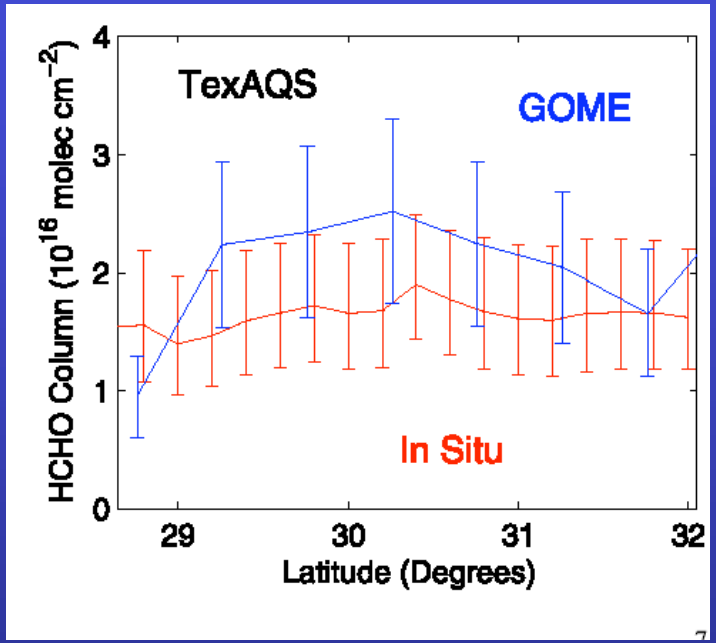


Palmer et al., 2003

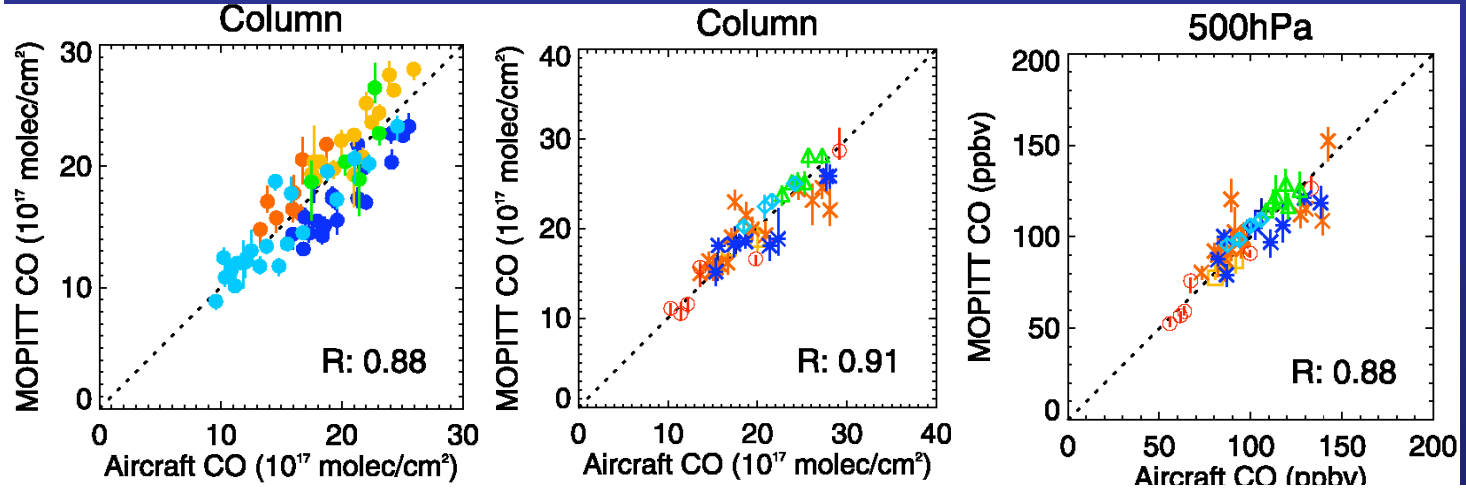
Thorough Validation of MOPITT CO
Validation of NO_2 and HCHO Where Possible
Remaining Issues in Temporal Variation and Subpixel Variability



Martin et al., submitted



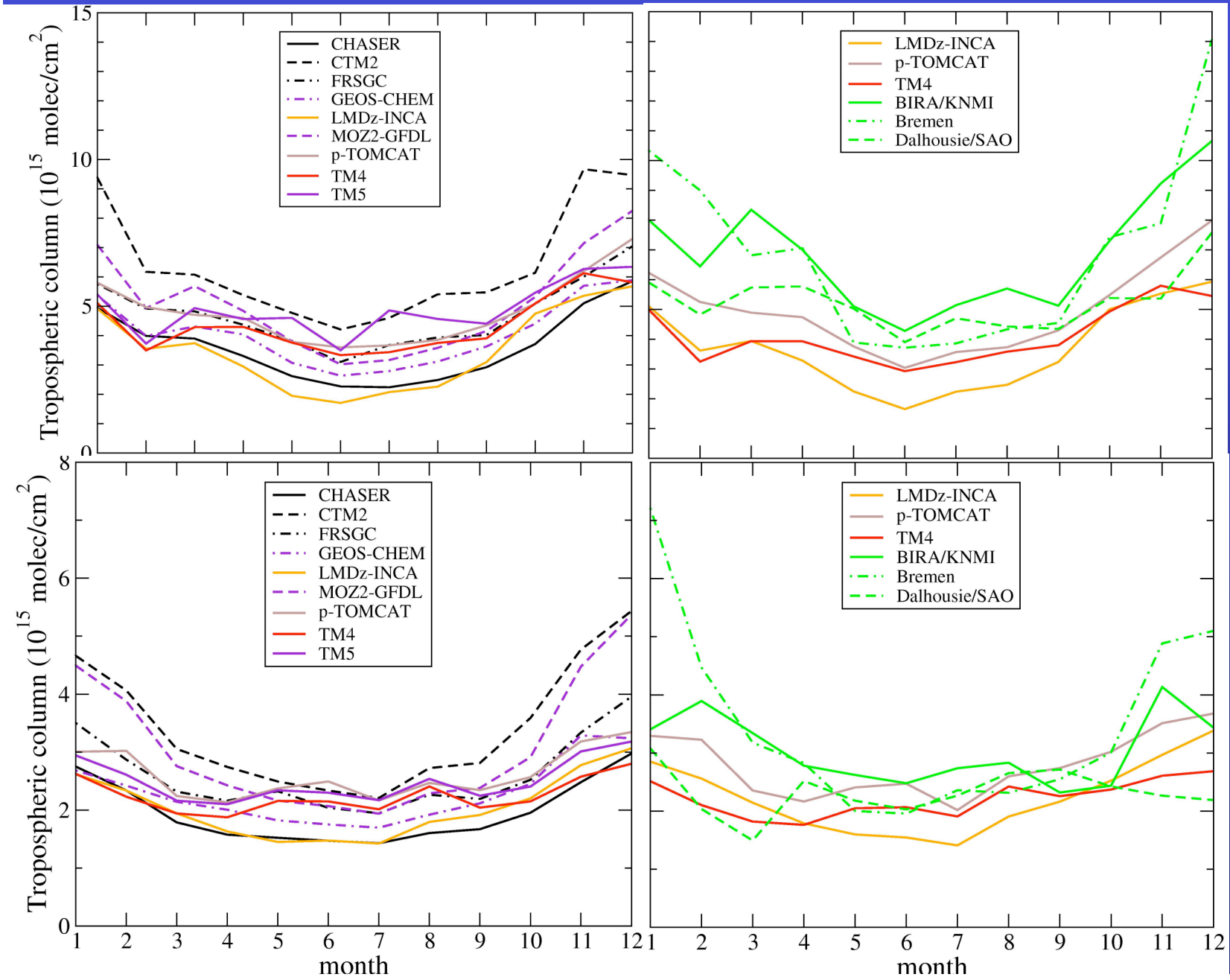
Martin et al., 2004



Emmons et al., 2004

Discrepancy in Wintertime GOME NO_2 Columns Over Industrial Regions

Need to Better Understand Retrieval and Model Errors



Year 2000

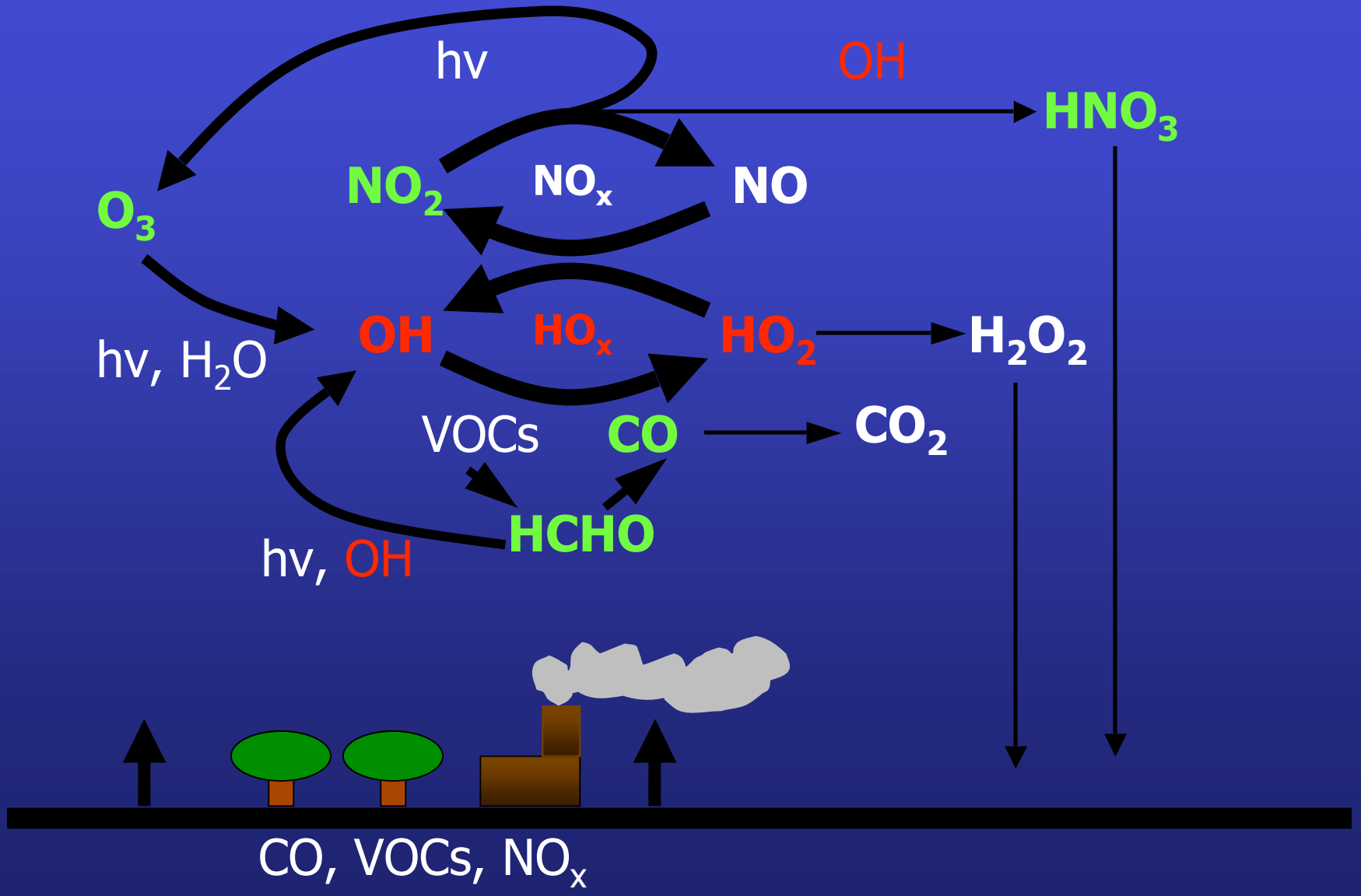
Eastern US

Europe

van Noije et al., submitted

Develop Simultaneous Inversion for Local CO, NOx, VOC Emissions from Observations of NO_2, HCHO, CO, O_3, HNO_3

Will Require Iterative Solution (i.e. Adjoint)



Value of Spatial and Temporal Resolution of Measurement from Emissions Inventory Perspective

Species	Lifetime	Value of Horizontal Resolution	Value Vertical Resolution	Value of Temporal Resolution	Comments
NO_2	Hours-day	High	Medium	High	Most NO_2 near surface, strong horizontal variation
HCHO	Hours	High	Medium	High	Local urban sources, variable biogenic sources
SO_2	~day	High	Medium	Medium	Additional retrieval development
CO	~Month	Low-Medium	High	Medium	Critical to Resolve Lower Troposphere
O_3	~days – month	Medium	High	Medium	Critical to Resolve Lower Troposphere
HNO_3	~week	Medium	Medium	Medium	Column measurement would be valuable

Acknowledgements

Chris Sioris, Thomas Kurosu, Kelly Chance (Smithsonian Astrophysical Observatory)
Paul Palmer (University of Leeds)
Twan van Noije (KNMI)
Andy Neuman, Tom Ryerson (NOAA/CIRES)
Ron Cohen, Colette Heald (Berkeley)
Louisa Emmons, Frank Flocke, Gabriele Pfister, Aaron Swanson, (NCAR)

Funding:

National Aeronautics and Space Administration (NASA)