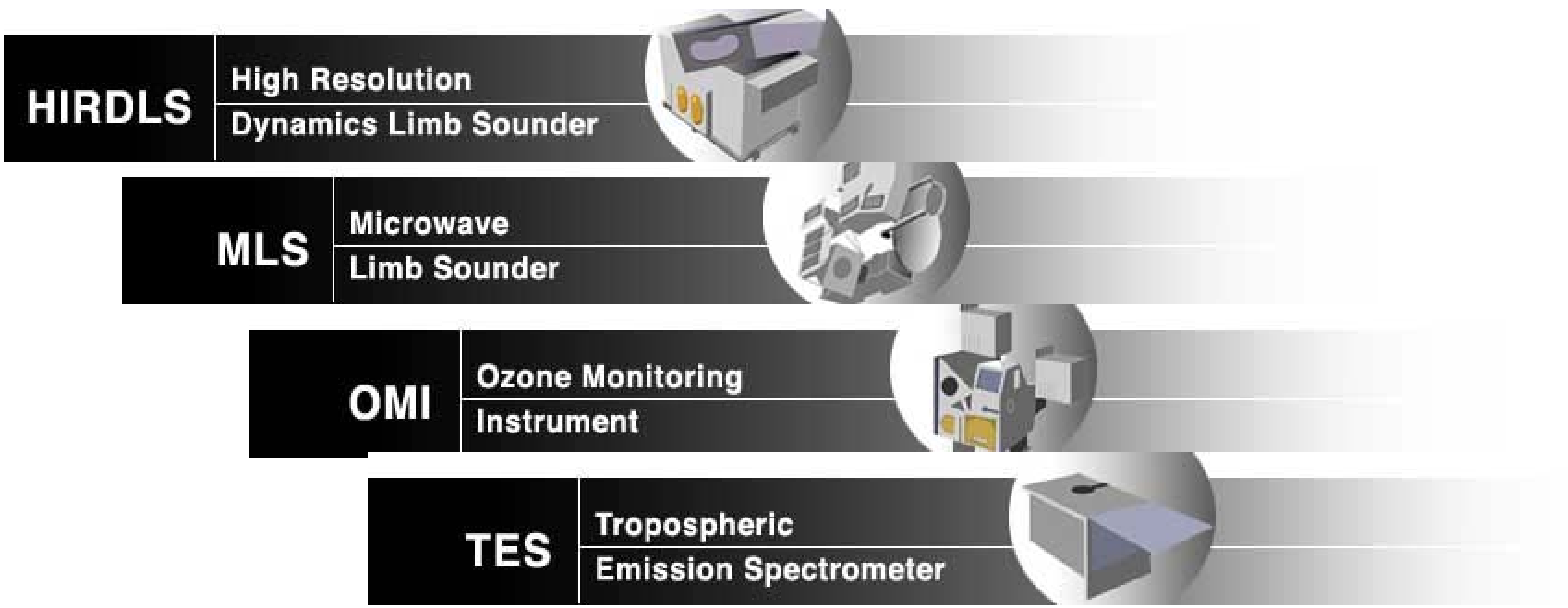
Defining a consistent UT/LS O_3 field from the Aura data

Qi Tang and Michael Prather
Earth System Science Department, UC Irvine

plus the help and support of the Aura Science Team



CESM Chem-Clim WG
28 Feb – 1 Mar 2012

Using Hindcast Validation to Build Confidence in Projections

Michael Prather
Chris Holmes
*Qi Tang**
Jordan Schnell
Earth System Science Department, UC Irvine
** now Cornell U.*

Defining a consistent UT/LS O_3 field from the Aura data

(parable: five blind men and an elephant)

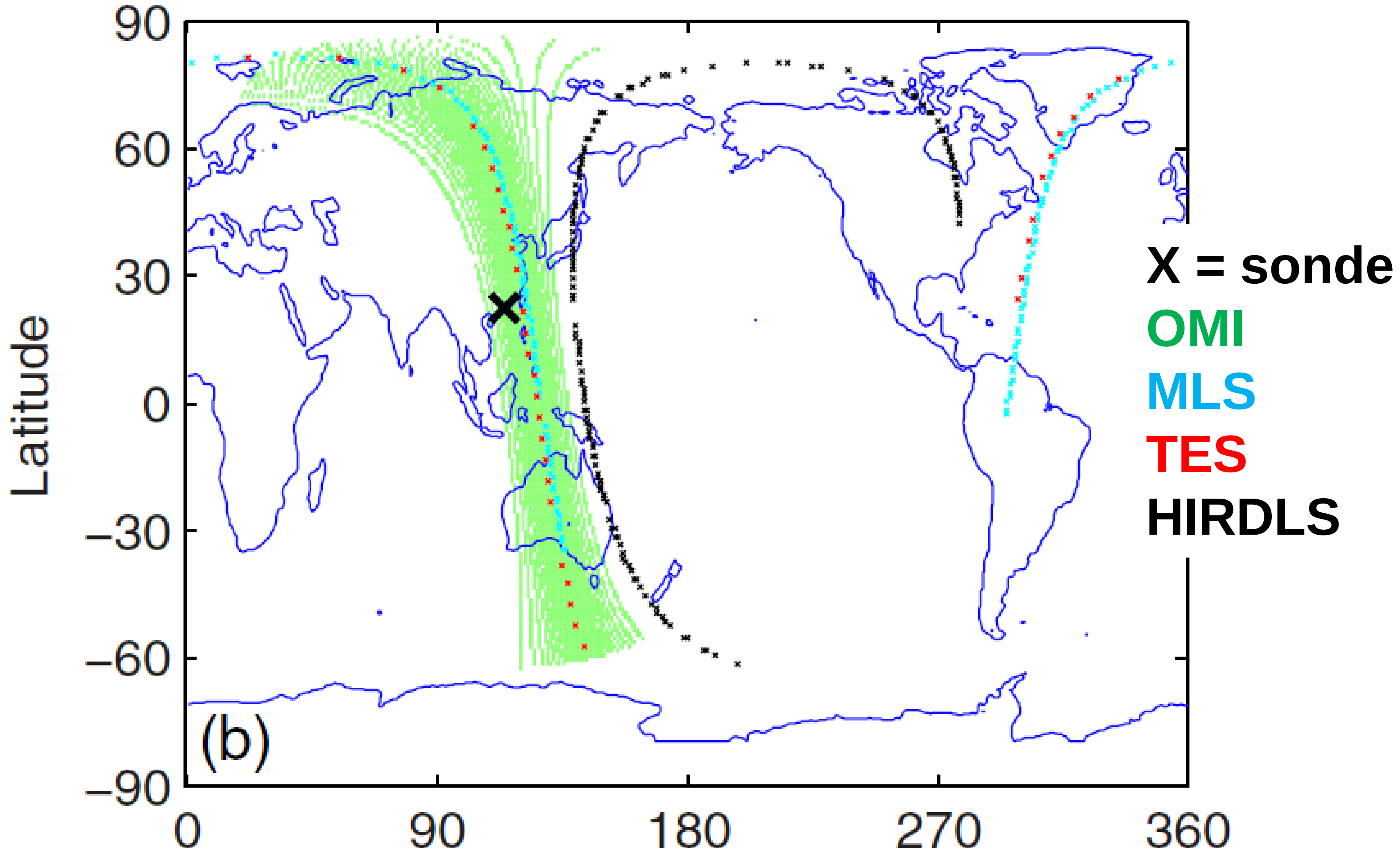
OUR WORK

UCI CTM running full chemistry at high resolution (1º x 1º x ~1 km x 30') with realistic meteorology from the ECMWF IFS (T159L4) for 2005-2006 provides a transfer standard for all "five" Aura L2 ozone measurements.

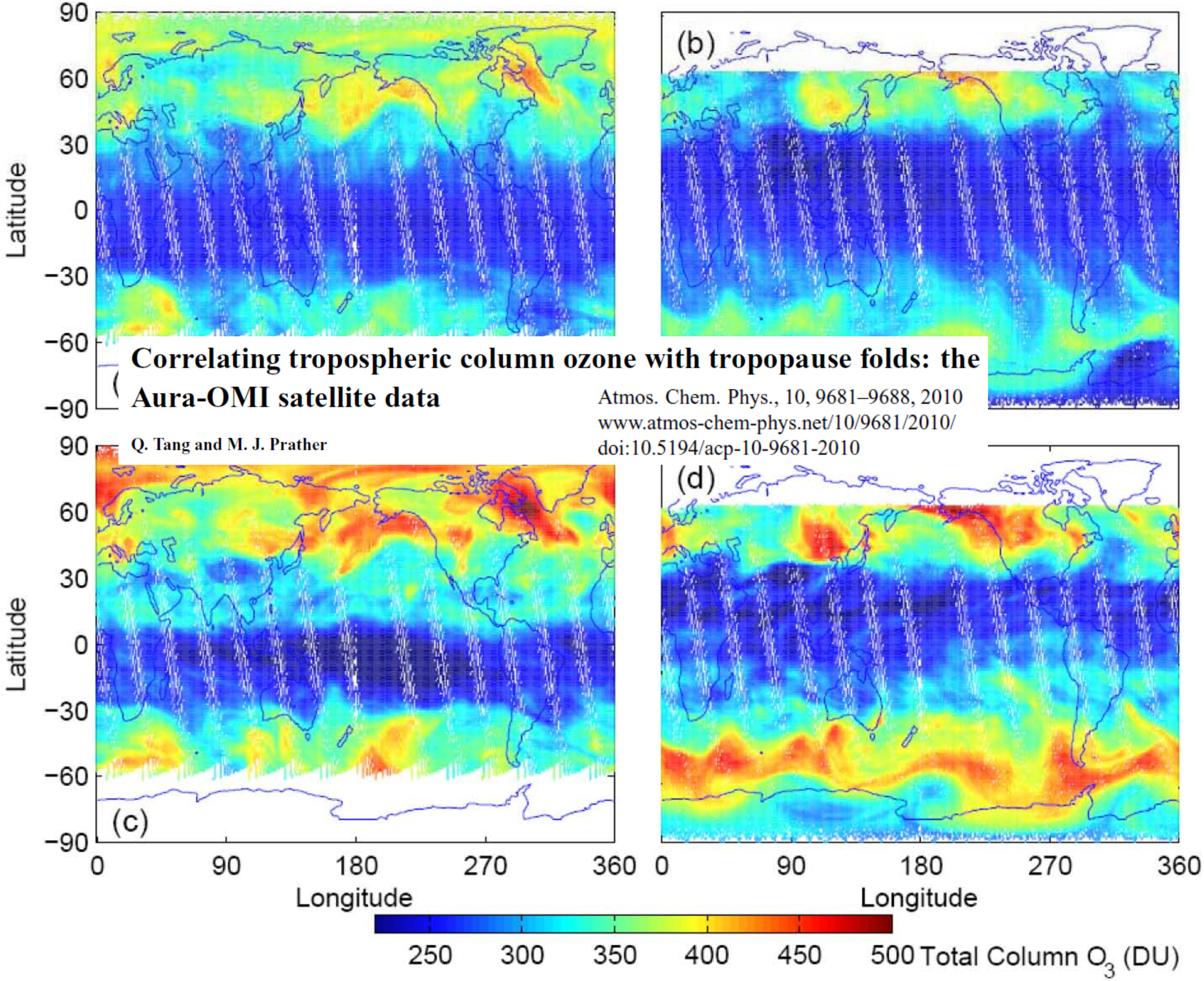
For example, the CTM is able to "see" the 4-D ozone fields with their high-frequency variability in the UT/LS and thus allows direct comparisons of HIRDLS and MLS L2 data, even though they are looking at different parts of the atmosphere.

A satellite simulator was developed for the UCI CTM: O_3 simulations are archived every 30 minutes along the Aura orbit; each orbital observation is interpolated between two of these results; the archived swath is wide enough to include the cross-track scan of OMI and the off-track viewing geometry of HIRDLS (outside the OMI swath); and thus each L2 measurement has a corresponding CTM O_3 profile.

2005 March 23 0600-0700 UTC   **L2** data



10 Jun 2005 **total column O_3** 3 Dec 2005 (25-hr of swaths)



OMI

CTM

Correlating tropospheric column ozone with tropopause folds: the Aura-OMI satellite data

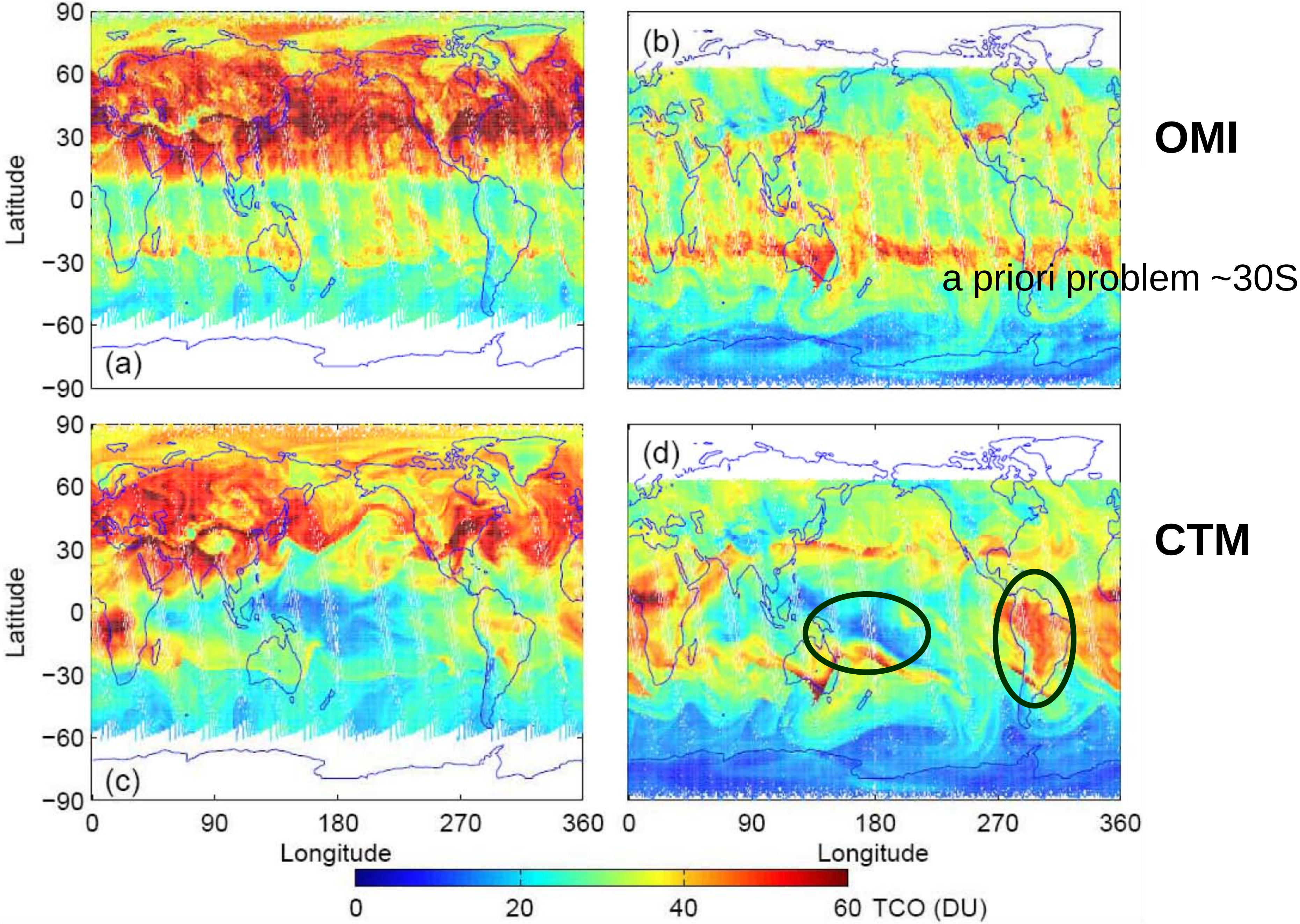
Q. Tang and M. J. Prather

Atmos. Chem. Phys., 10, 9681–9688, 2010
www.atmos-chem-phys.net/10/9681/2010/
doi:10.5194/acp-10-9681-2010

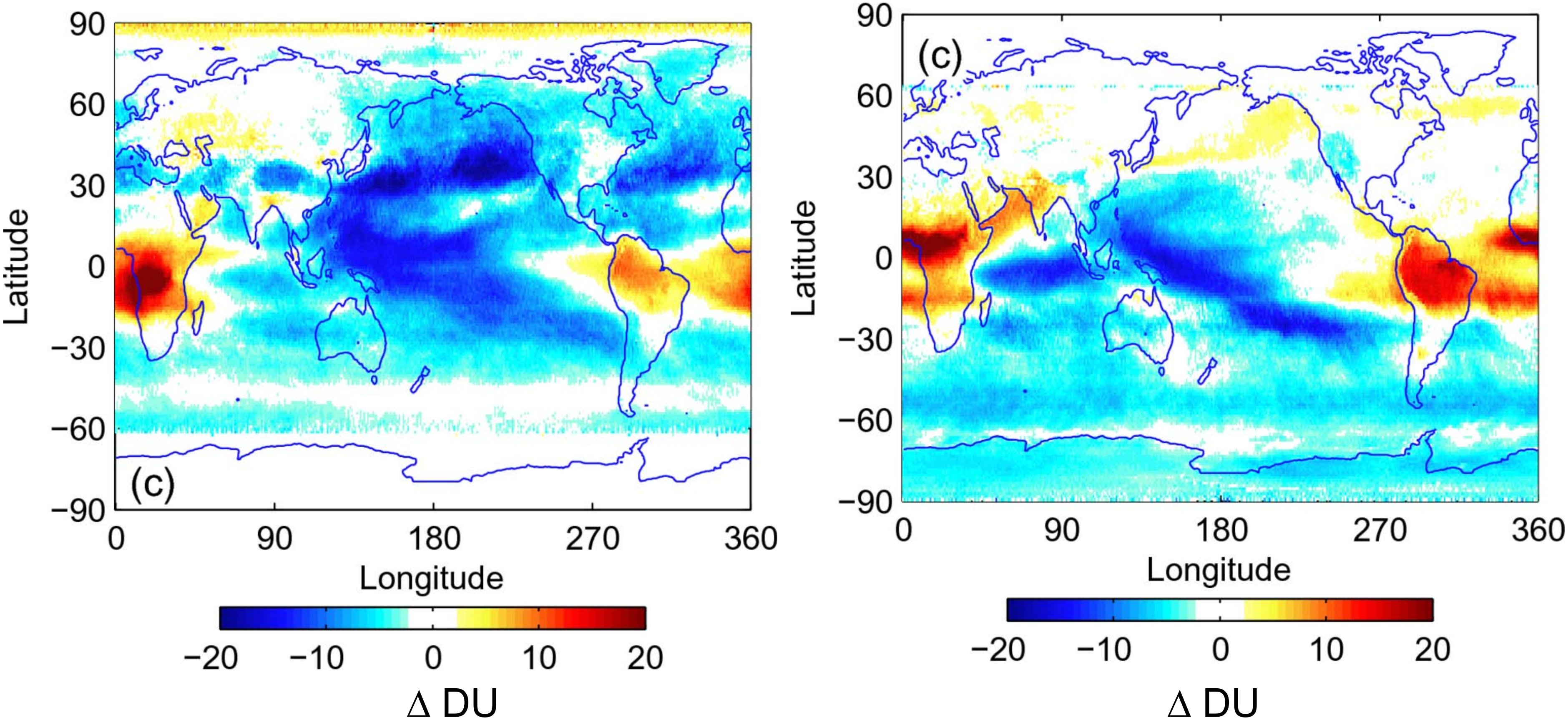
10 Jun 2005

Tropospheric Column O_3

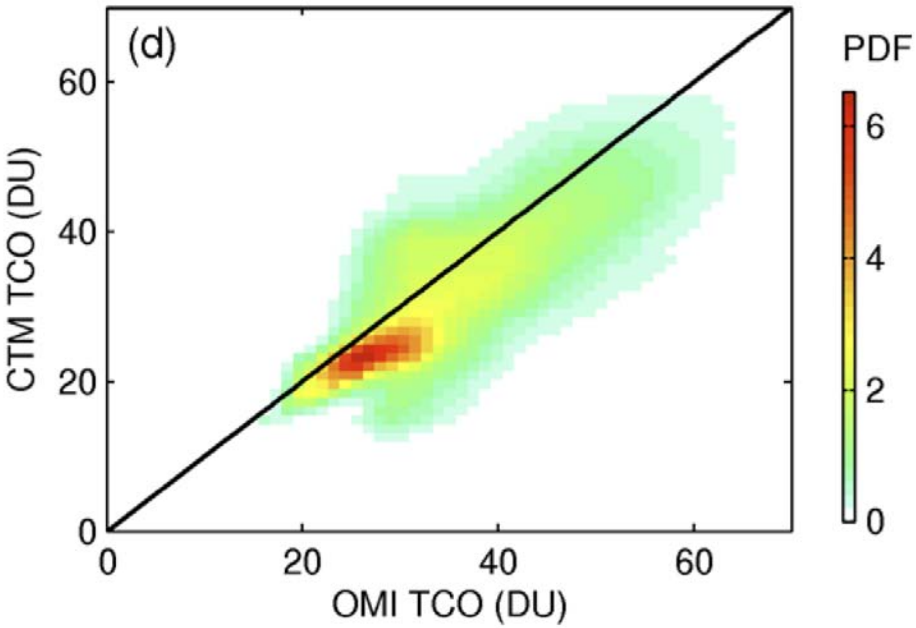
3 Dec 2005 (25-hr of swaths)

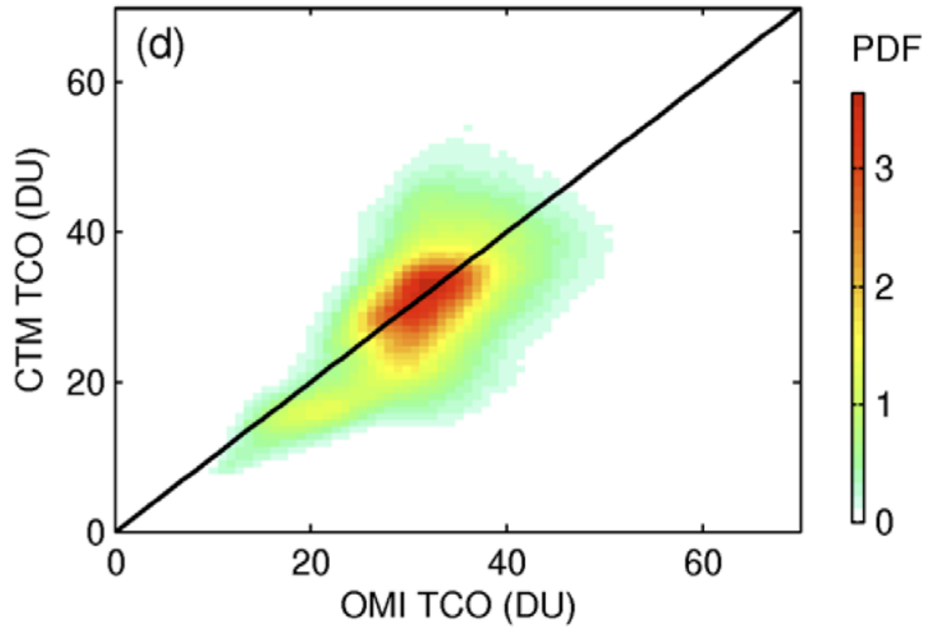


<Jun> 2005 **CTM – OMI TCO (DU)** <Dec> 2005



<Jun> 2005 pdfs: **CTM vs. OMI TCO (DU)** <Dec> 2005





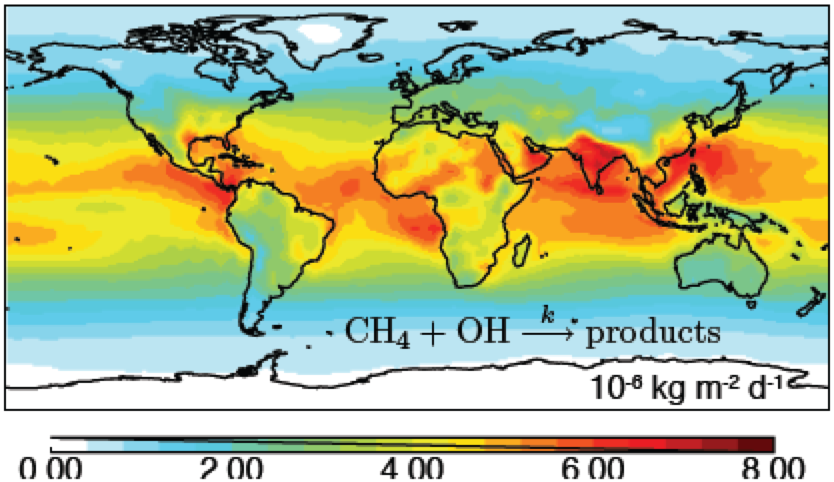
GLOBAL comparison for all OMI L2 data in 1°x1° grid,
approx. 2×10^6 pts/month

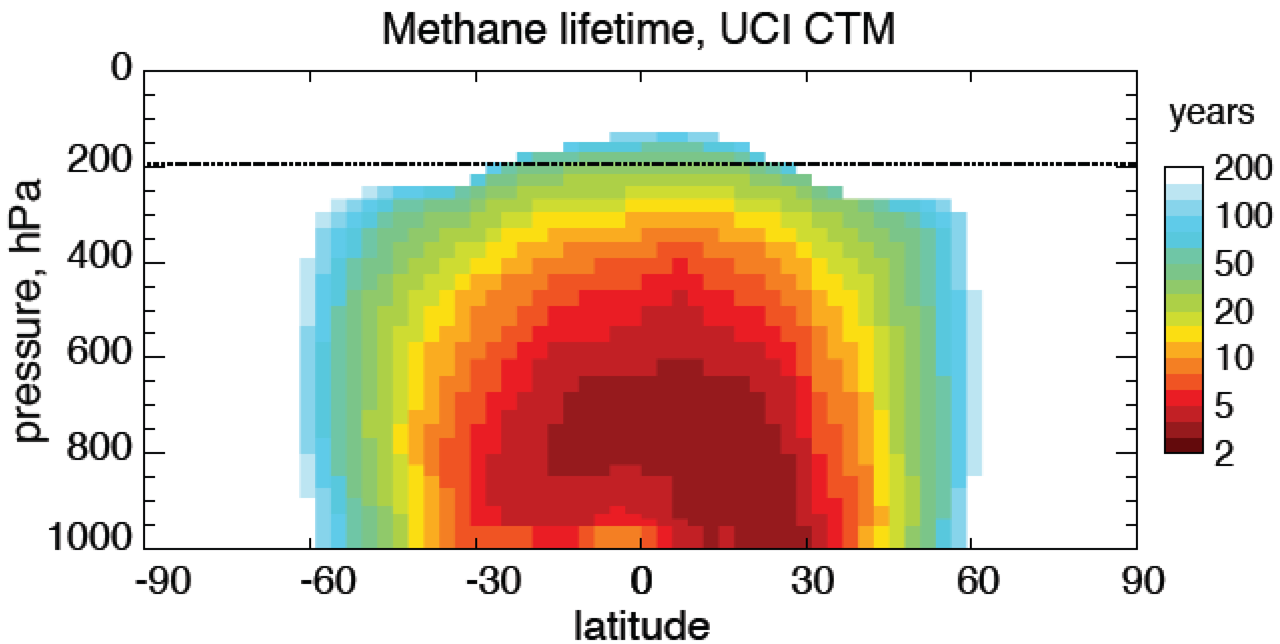
Future methane, OH, and their uncertainties: parametric relations with emissions and climate change

Christopher D. Holmes

Michael Prather, Qi Tang, Mingquan Mu,
Ivar Isaksen, Amund Sovde

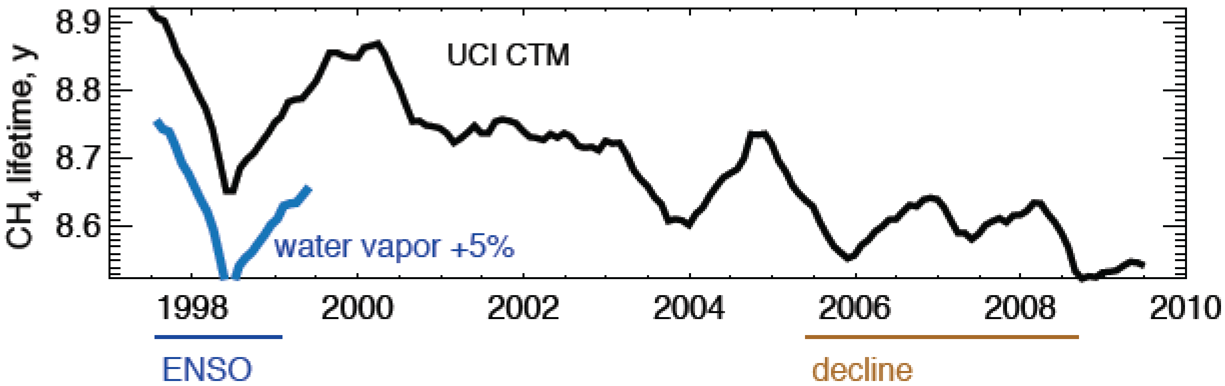
Methane oxidation, UCI CTM 1997-2009

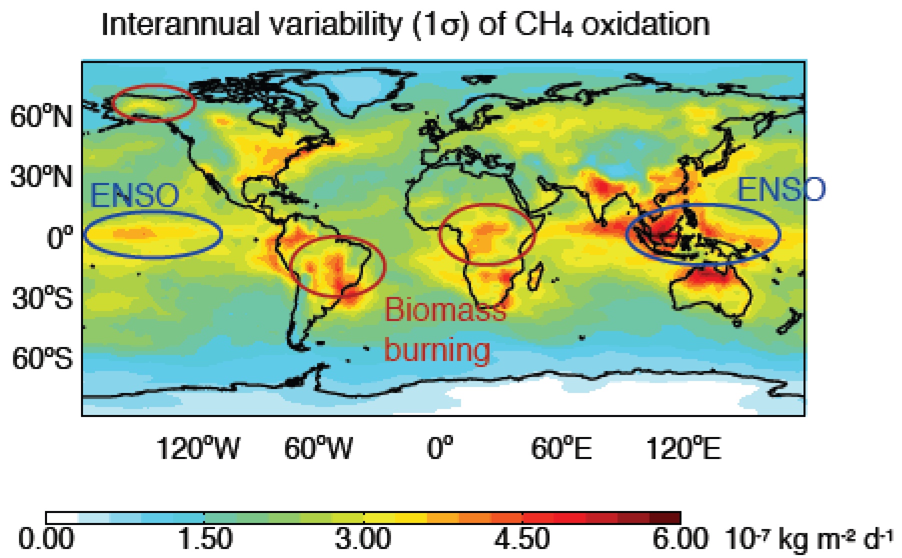




Methane loss in troposphere above 200 hPa
0.5% in UCI CTM
1.5% in GEOS-Chem (larger due to acetone?)

Interannual variability of CH_4 lifetime





Sensitivity tests

water vapor
temperature
cloud OD
biomass burning
lightning NOx

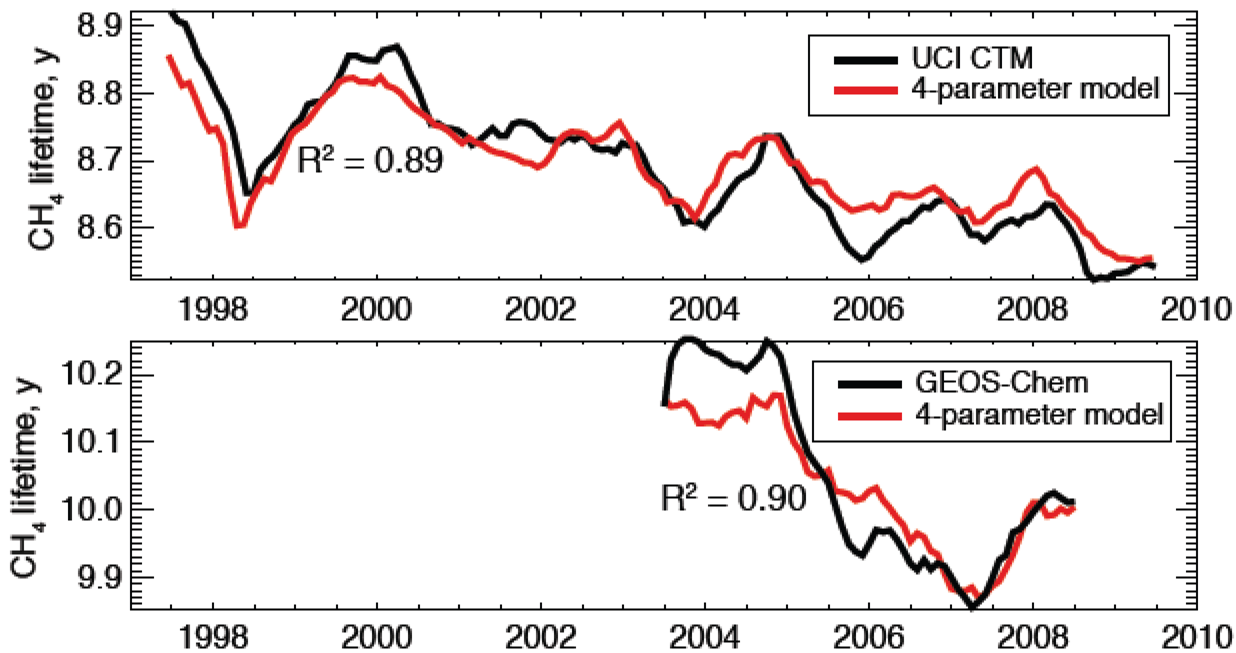
Factors affecting CH_4 lifetime

Forcing	Forcing variability (%)	τ_{CH4} Response (%) UCI CTM	τ_{CH4} Response (%) GEOS-Chem	Important for interannual variability?
temperature	0.25	-5.2	-3.0*#	yes!
water vapor	3	-0.32	-0.34	yes!
lightning-NOx	15	-0.14	-0.23	yes!
biomass burning	30	+0.023	+0.03#	yes!
OD (water cloud)	2	-0.025		no
OD (ice cloud)	2	+0.013		no
surface NOx	-	-0.15	-0.23	yes, on decadal time scale
CH_4 feedback	-	+0.369 (f = 1.49)	+0.274 (f = 1.32)	yes, on decadal time scale

* 6.5% would be expected from k($OH+CH_4$) alone

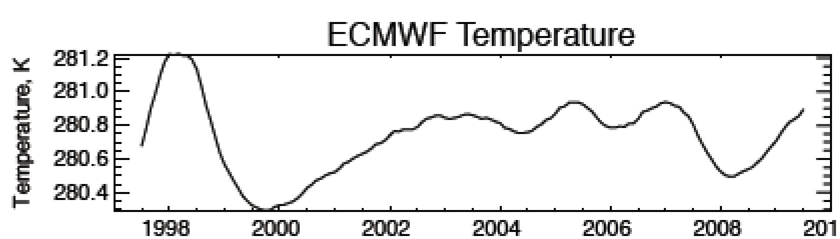
preliminary value, based on < 2 years simulation

Parametric model evaluation

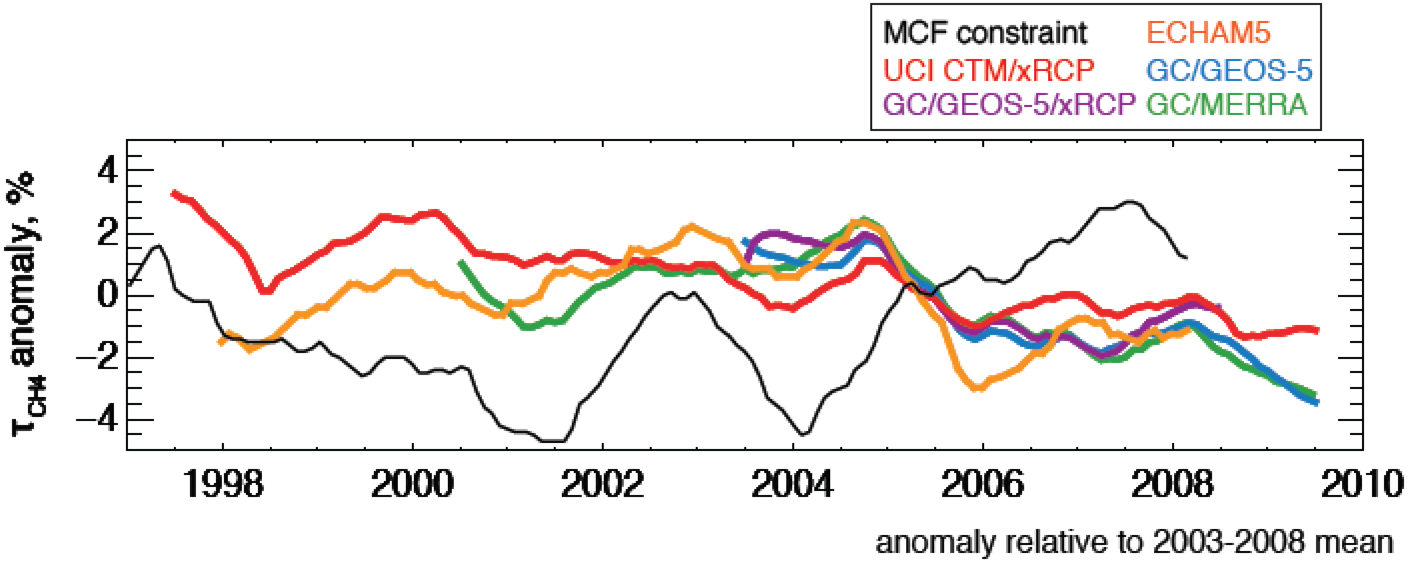


Parameters used:

1. Temperature (tropics, up to 400hPa)
2. Water vapor (tropics)
3. Lightning NOx
4. Biomass burning



Model intercomparison



Similar variability in many models...
even with varying biogenic and anthropogenic emissions, so...
the same parameters likely control OH in other models.

References:
MCF constraint (Montzka et al. 2011)
ECHAM5 (Montzka et al. 2011)
UCI CTM/xRCP (this work)
GC/GEOS-5/xRCP (this work)
GC/GEOS-5 (courtesy M. Mu)
GC/MERRA (courtesy M. Mu)

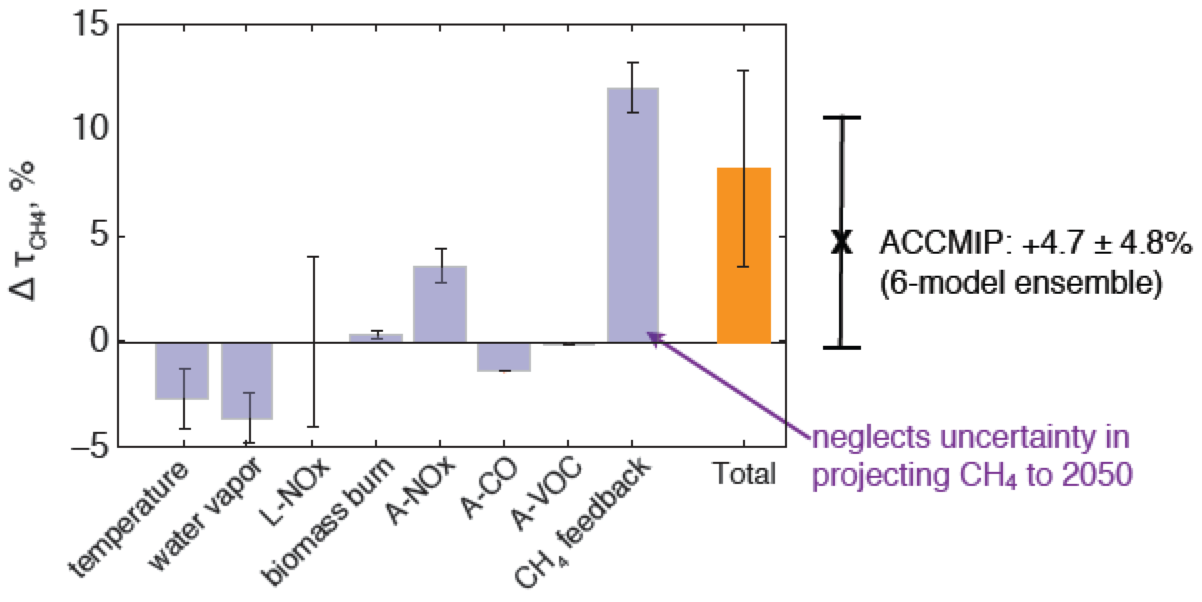
Tropospheric OH in 2050

Example: RCP8.5

Forcing	Forcing Change (2050-2000)	Reference	$\Delta \tau_{CH4}$ (2050-2000)
temperature	+1.5 ± 0.5K	IPCC AR4 (A1B)	-2.7 ± 1.4%
water vapor	+11 ± 3.5%	from temperature	-3.6 ± 1.2%
lightning NOx	0 ± 20%	speculative	0.0 ± 4%
biomass burning	-15%	RCP8.5	+0.35 ± 0.17%
anthro NOx	-19%	RCP8.5	+3.6 ± 0.8%
anthro CO	-12%	RCP8.5	-1.4%[a]
anthro VOC	-2%	RCP8.5	-0.1%[a]
CH_4 abundance	+56%	RCP8.5	+12 ± 1.2%
total (IPCC TAR)			*+14%*[a]
total (this work)			**+8.2 ± 4.6%**

[a] Calculated with IPCC TAR sensitivity, which neglects uncertainty.

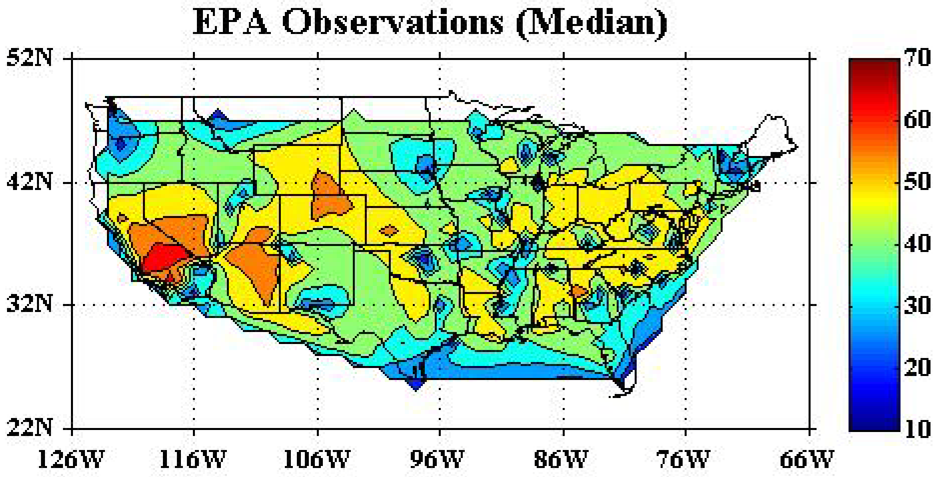
Large difference from TAR projection

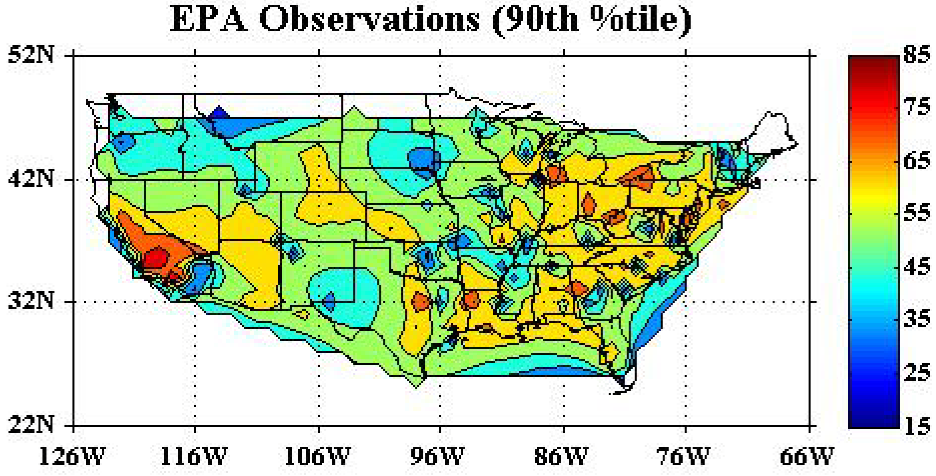


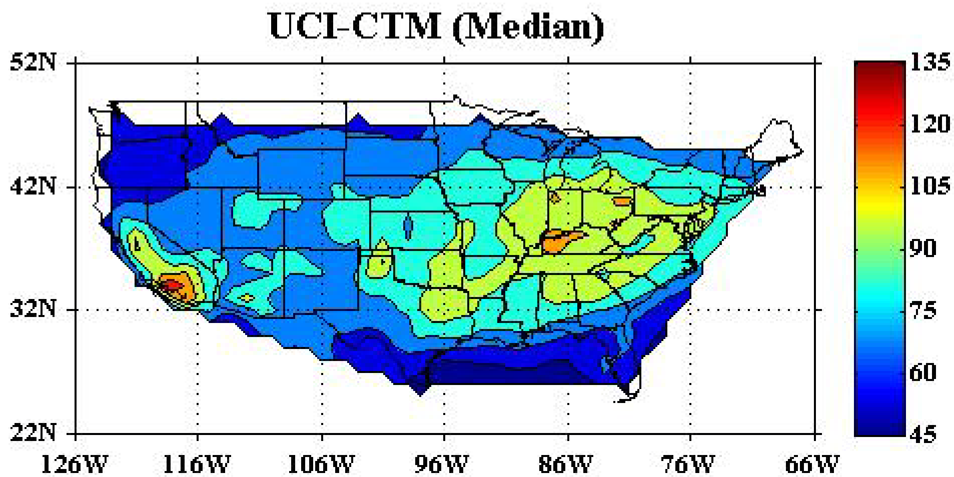
Diagnosing and Hindcasting Major Ozone Pollution Episodes

2005-2006

Jordan Schnell, Chris Holmes, Michael Prather






UCI-CTM (Median)
52N
42N
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22N
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116W
106W
96W
86W
76W
66W
135
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105
90
75
60
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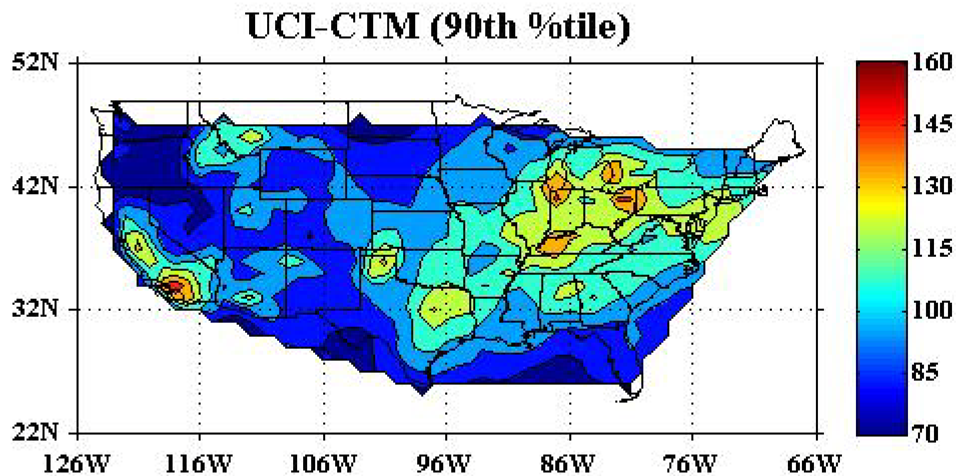
UCI-CTM (90th %tile)
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126W
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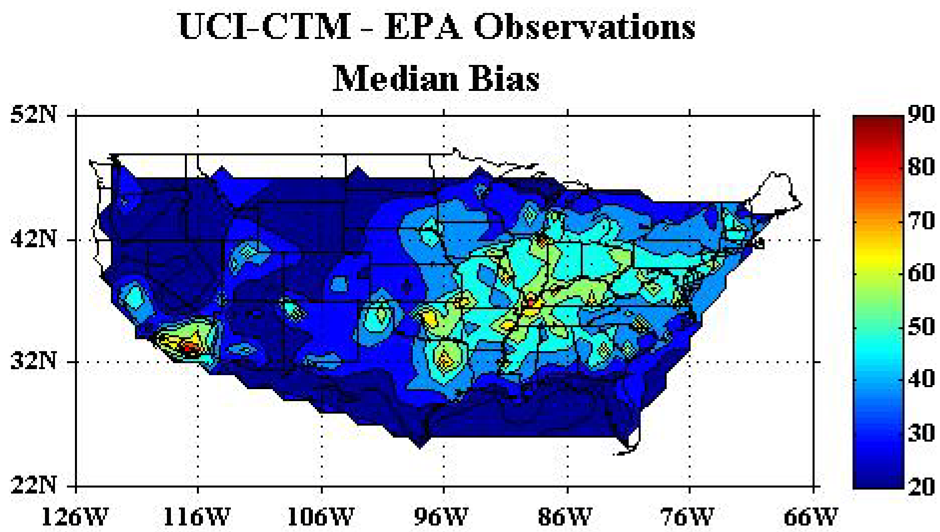
UCI-CTM - EPA Observations
Median Bias
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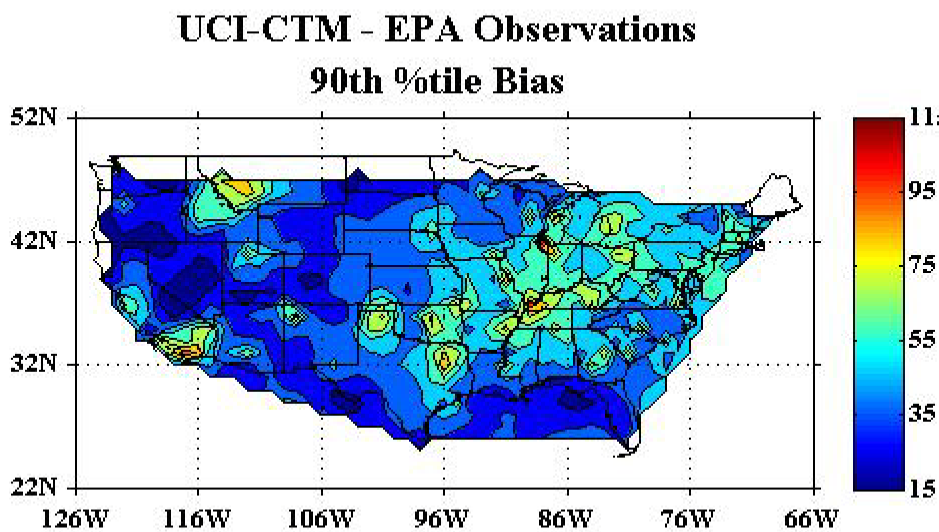
UCI-CTM - EPA Observations
90th %tile Bias
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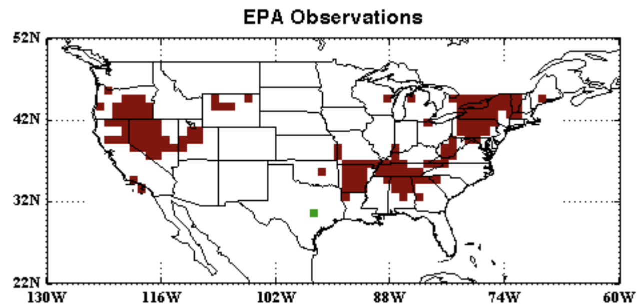
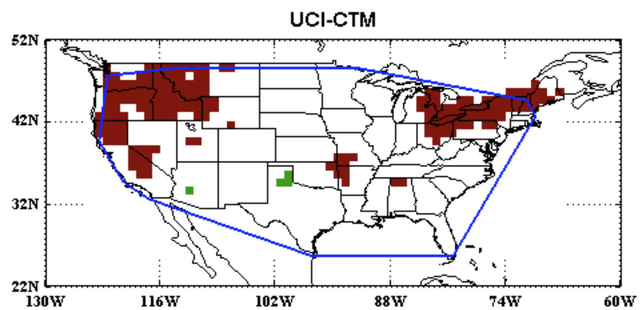
08/18/2006





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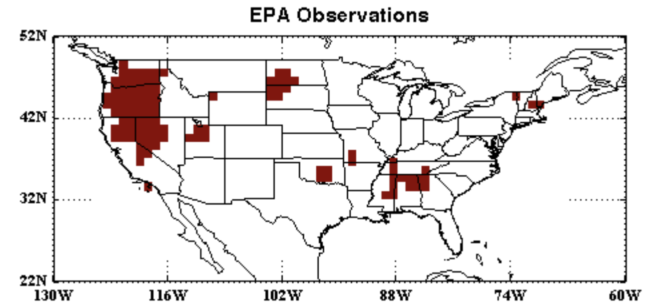
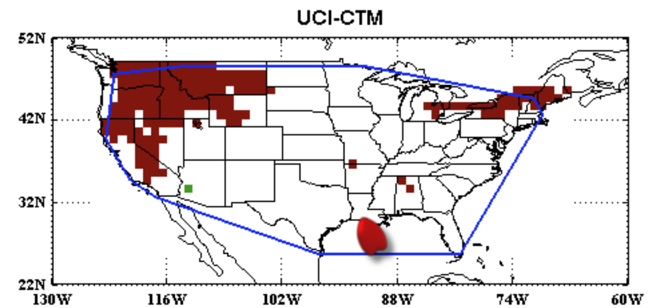
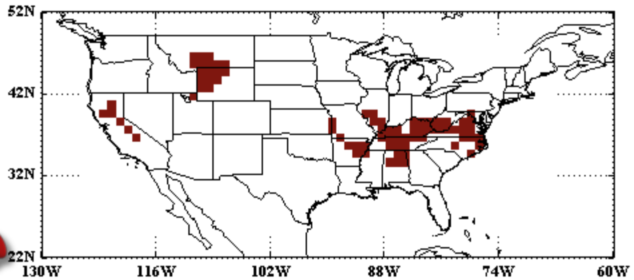


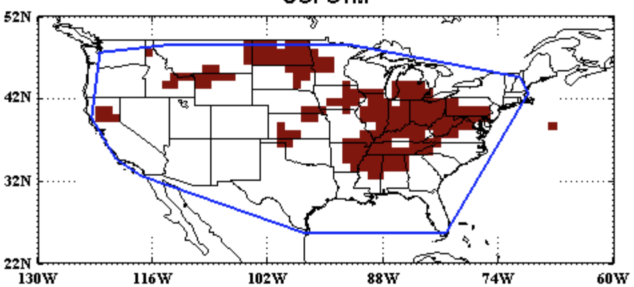


EPA Observations

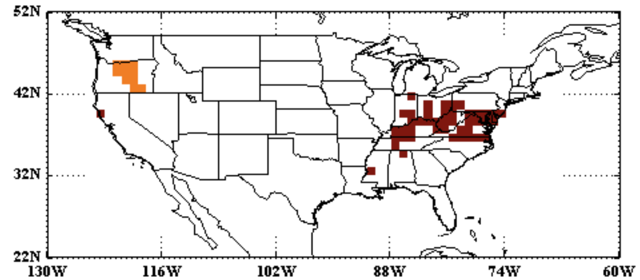


08/24/2006

UCI-CTM



EPA Observations



08/25/2006

UCI-CTM