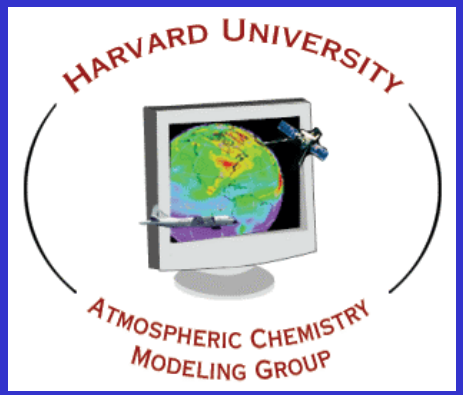
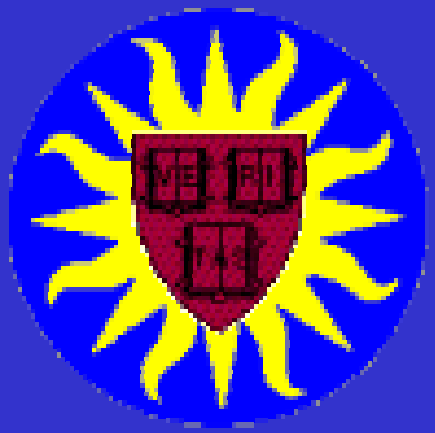
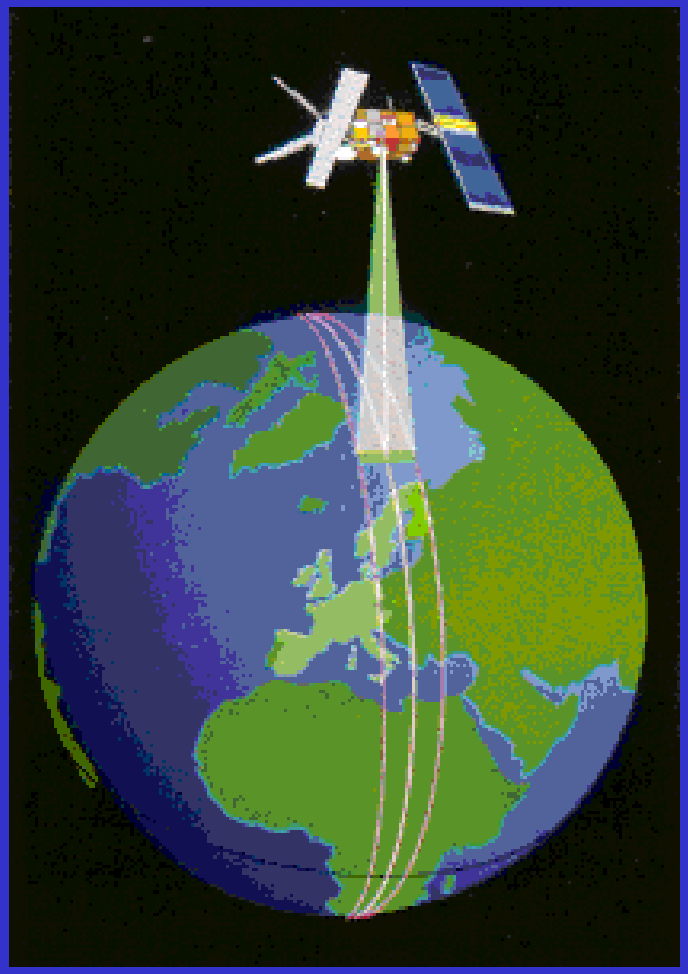
TOP-DOWN ISOPRENE EMISSION INVENTORY FOR NORTH AMERICA CONSTRUCTED FROM SATELLITE MEASUREMENTS OF FORMALDEHYDE COLUMNS

Daniel J. Jacob, Paul I. Palmer, Dorian S. Abbot
Atmospheric Chemistry Modeling Group, Harvard University
Randall V. Martin
Dalhousie University
Kelly V. Chance
Harvard/Smithsonian Center for Astrophysics





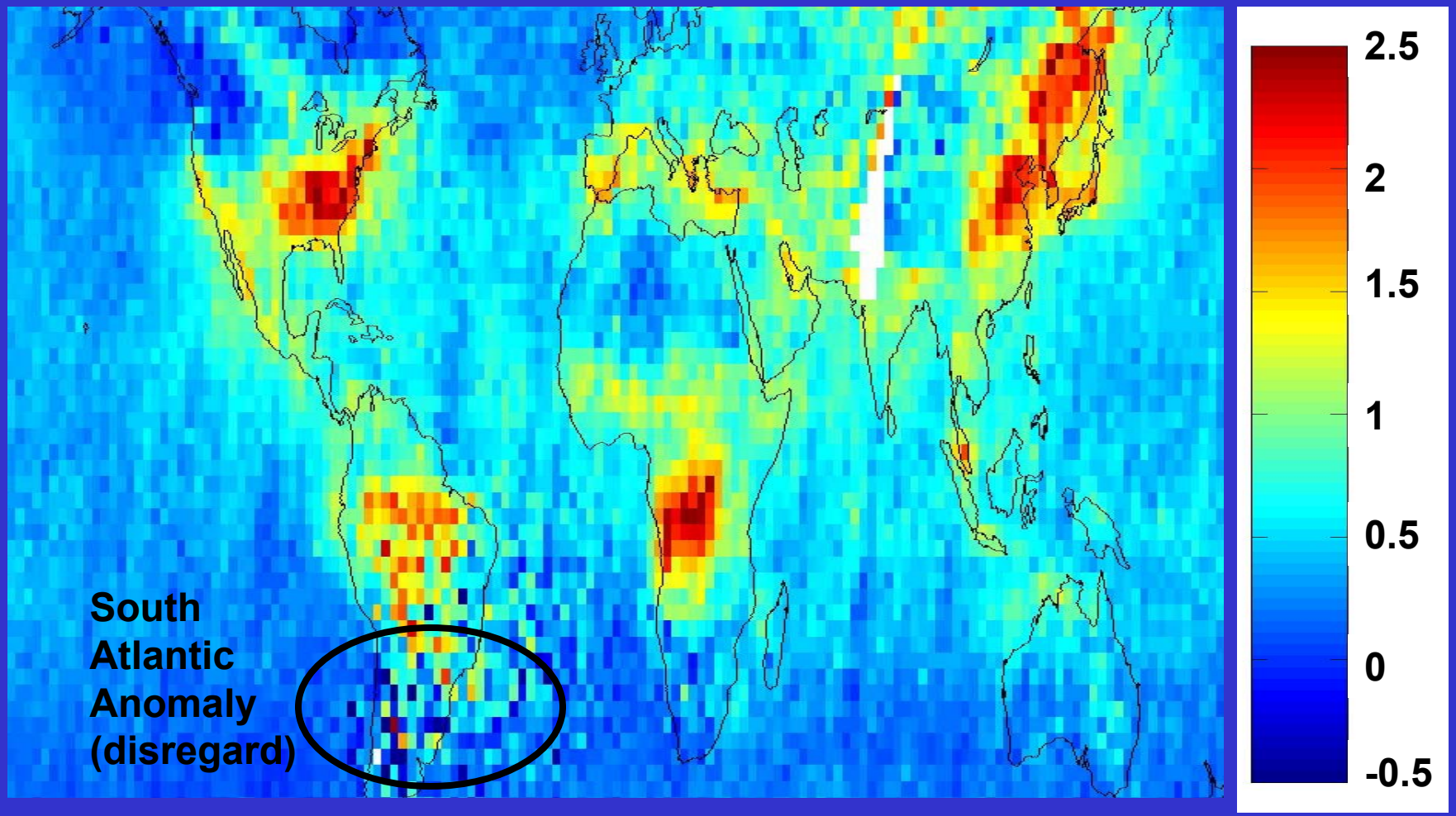
MEASUREMENT OF HCHO COLUMNS FROM THE GOME SATELLITE INSTRUMENT



- HCHO column is determined from backscattered solar radiance in 340 nm absorption band
- Instrument is in polar sun-synchronous orbit, 10:30 a.m. observation time
- 320x40 km^2 field of view, three cross-track scenes
- Complete global coverage in 3 days
- Operational since 1995

HCHO COLUMNS MEASURED BY GOME (JULY 1996)

Units of 10^{16} molecules cm^{-2};
Uncertainty ~ $1x10^{16}$ molecules cm^{-2} (1-2 ppbv in 2-km boundary layer)

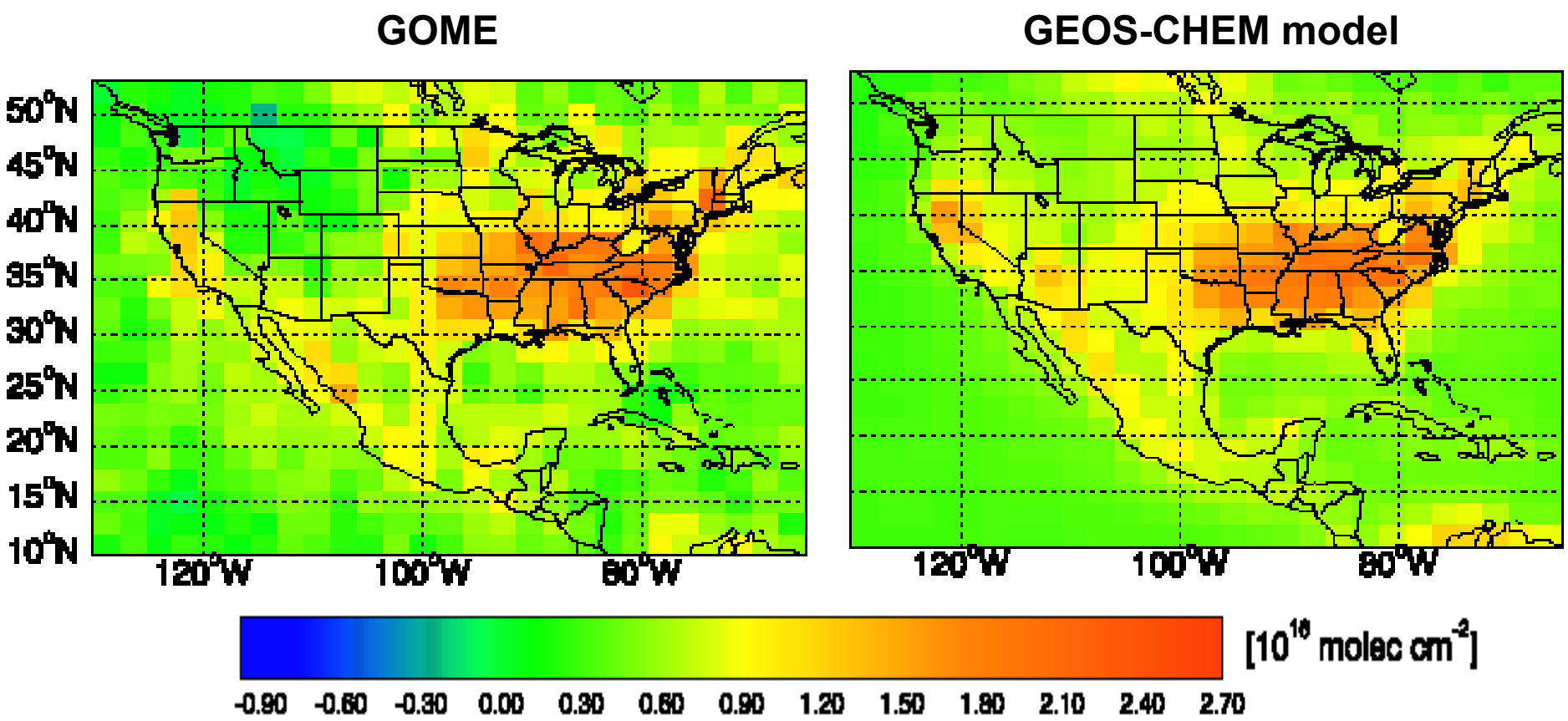


High HCHO regions reflect VOC emissions from fires, biosphere, human activity

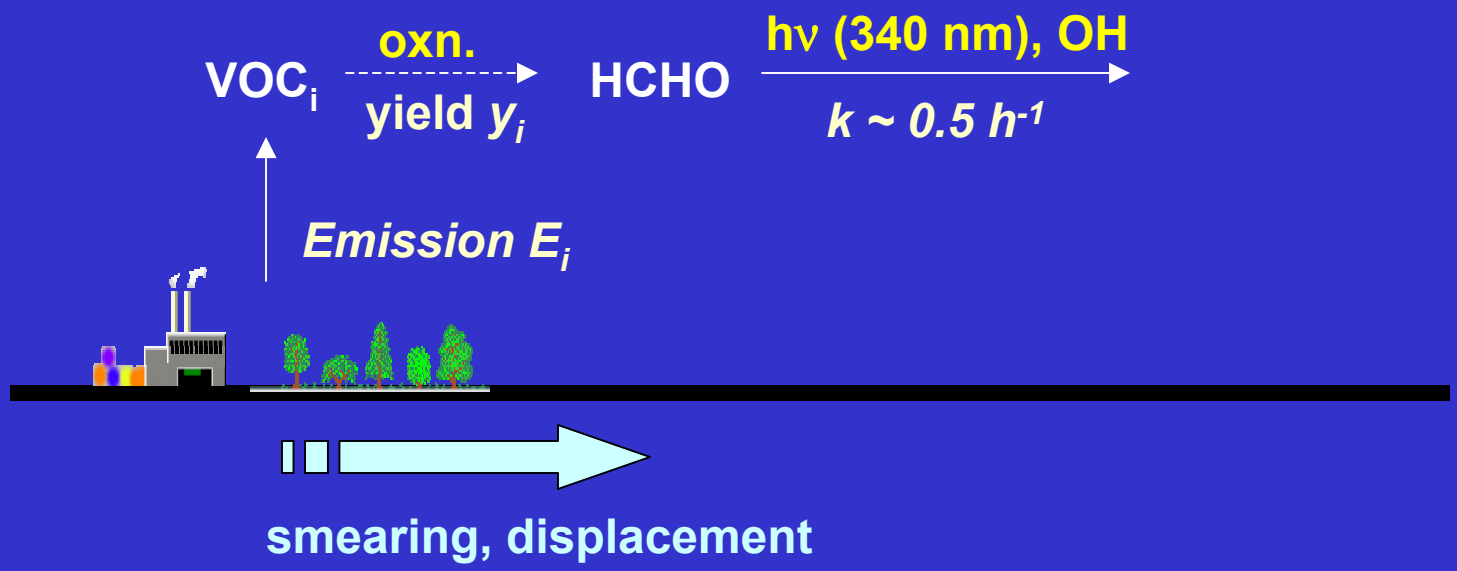
GOME HCHO COLUMNS OVER NORTH AMERICA
July 1996 means

…compare to GEOS-CHEM global atmospheric chemistry model simulation including GEIA biogenic VOC emissions [Guenther et al., 1995] and EPA anthropogenic VOC emissions

GEOS-CHEM vs. GOME: R = 0.83, bias = +14%



RELATING HCHO COLUMNS TO VOC EMISSION



In absence of horizontal wind, mass balance for HCHO column Ω_{HCHO}:

$$\Omega_{HCHO} = \frac{\sum_i y_i E_i}{k}$$

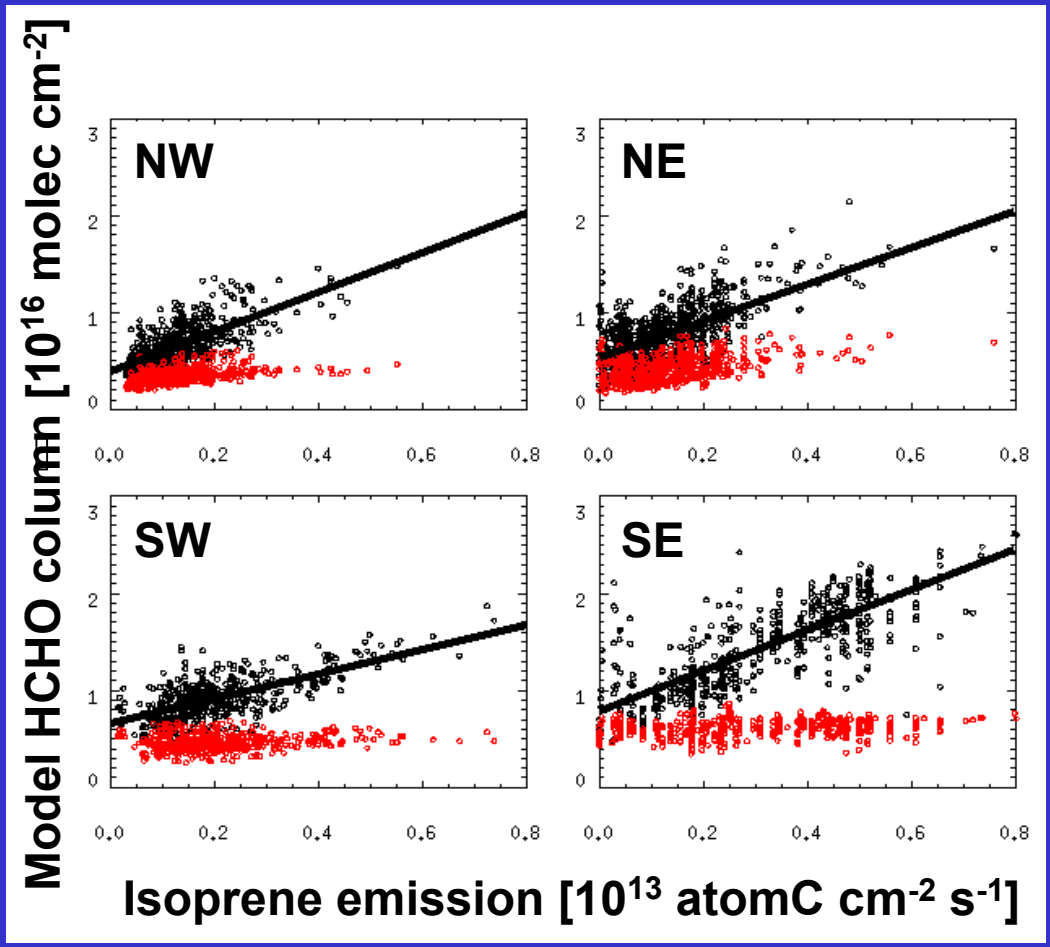
Local linear relationship between HCHO and *E*

… but wind smears this local relationship between Ω_{HCHO} and E_i:

- For VOCs with lifetime >> 1 day, all structure in Ω_{HCHO} is lost
- For isoprene (lifetime ~ 1h), smearing < 100 km; regional structure in Ω_{HCHO} is preserved

HCHO COLUMN vs. ISOPRENE EMISSION RELATIONSHIP IN GEOS-CHEM MODEL

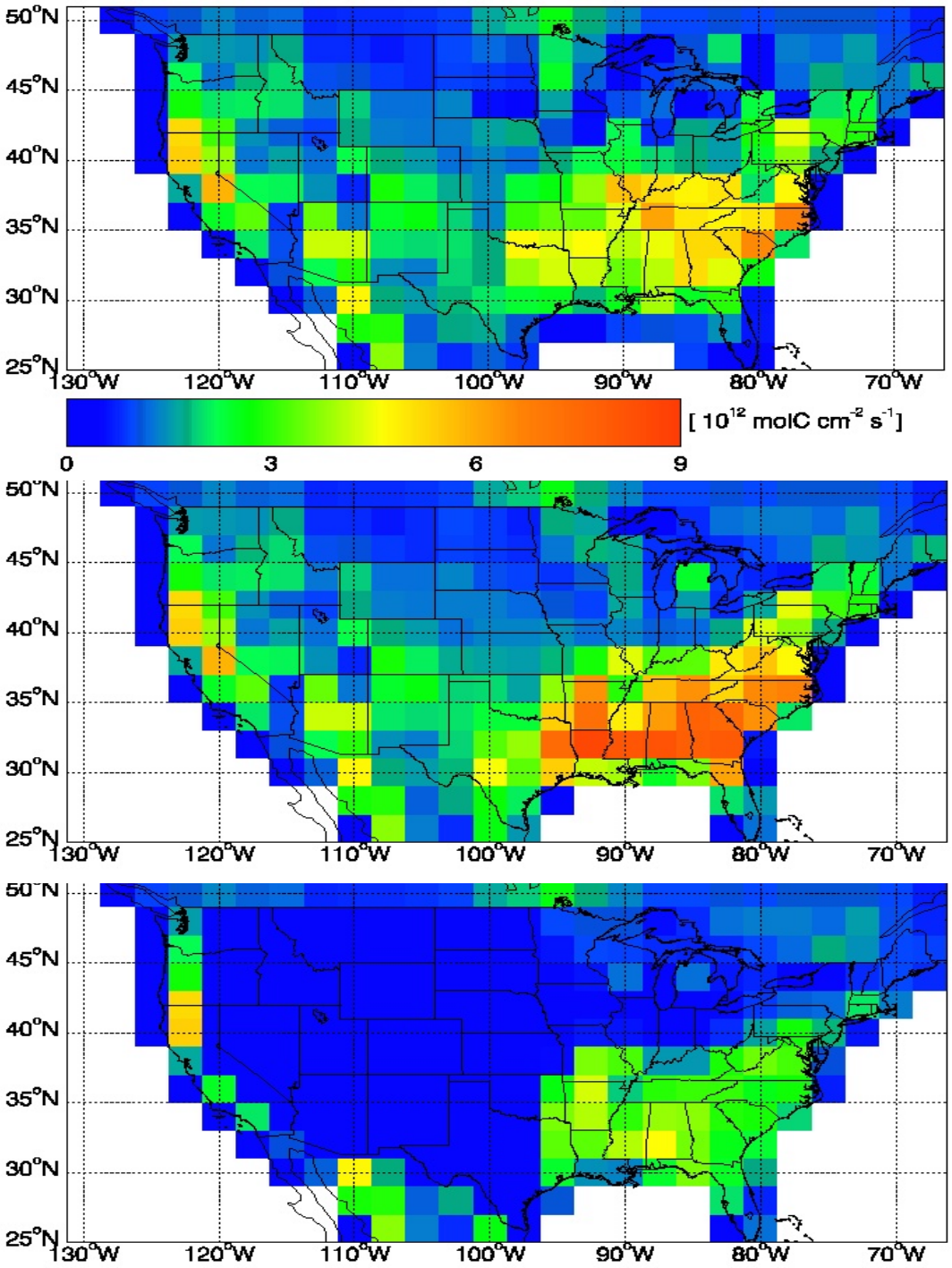
Results for U.S. quadrants in July 1996 simulation w/ 2°x2.5° horizontal resolution show: (1) dominance of isoprene emission as predictor of Ω_{HCHO} variability;
(2) linear relationship between the two



Standard simulation

HCHO from simulation w/o Isoprene emission

We use this relationship to derive "top-down" isoprene emissions from the GOME HCHO column observations



ISOPRENE EMISSION INVENTORIES, JULY1996

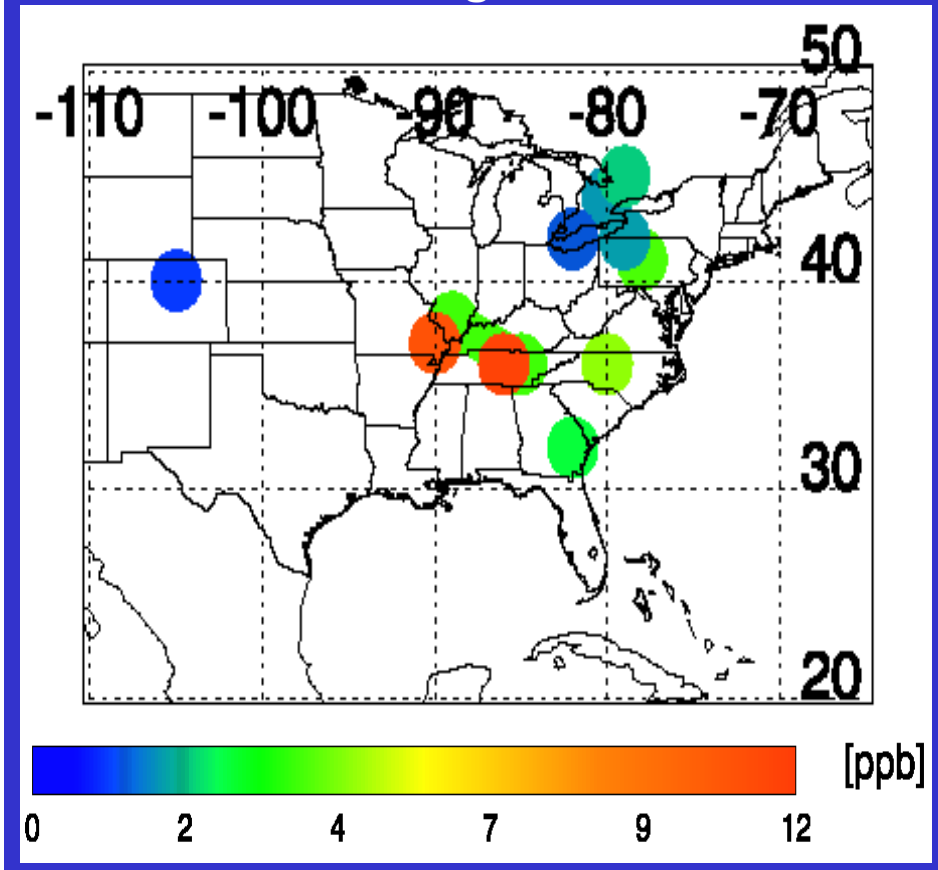
GOME top-down (5.7 Tg)

GEIA (7.1 Tg)

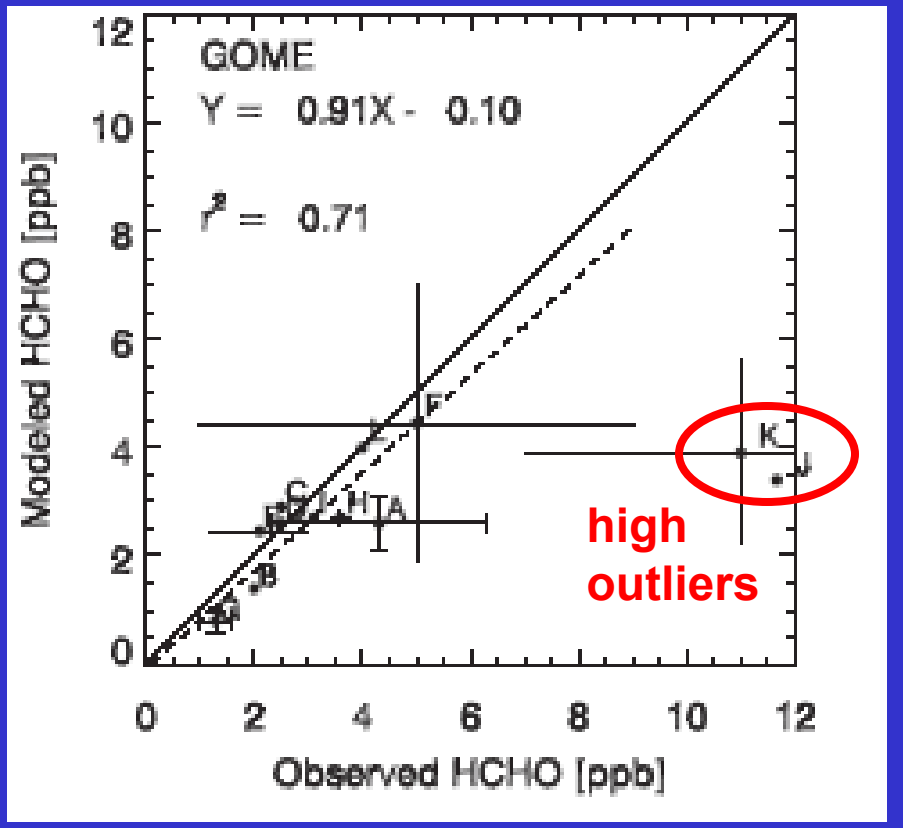
BEIS2 (2.6 Tg)

MODEL vs. OBSERVED SURFACE HCHO

Mean daytime HCHO observations Jun-Aug 1988-1998



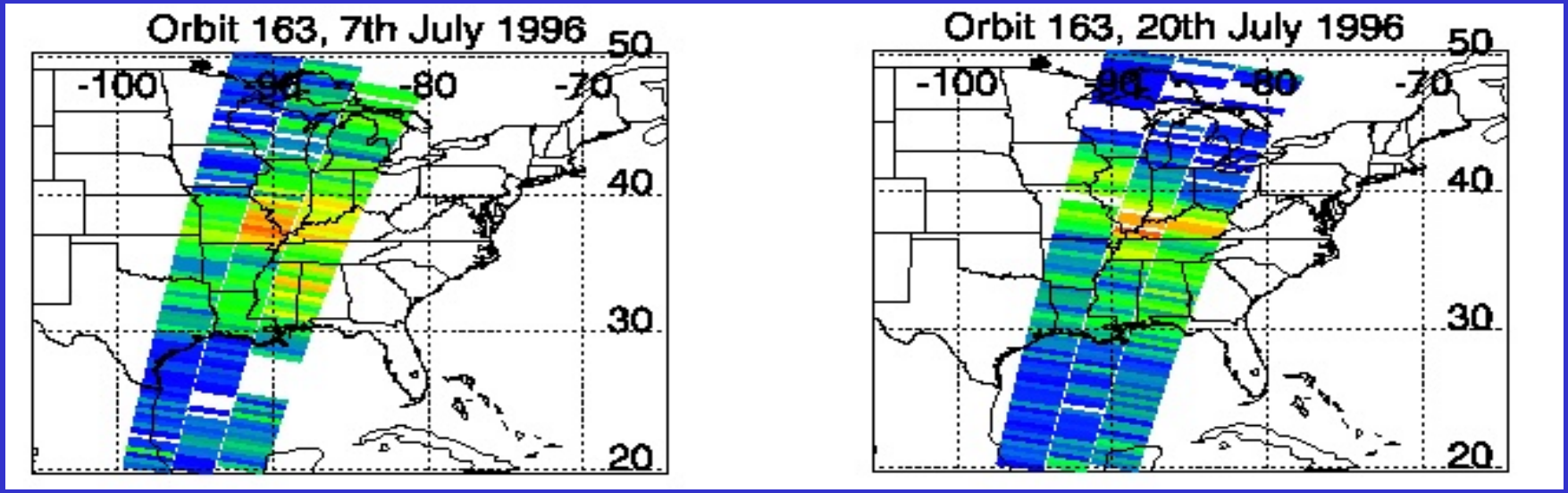
GEOS-CHEM simulation with "GOME" isoprene emissions

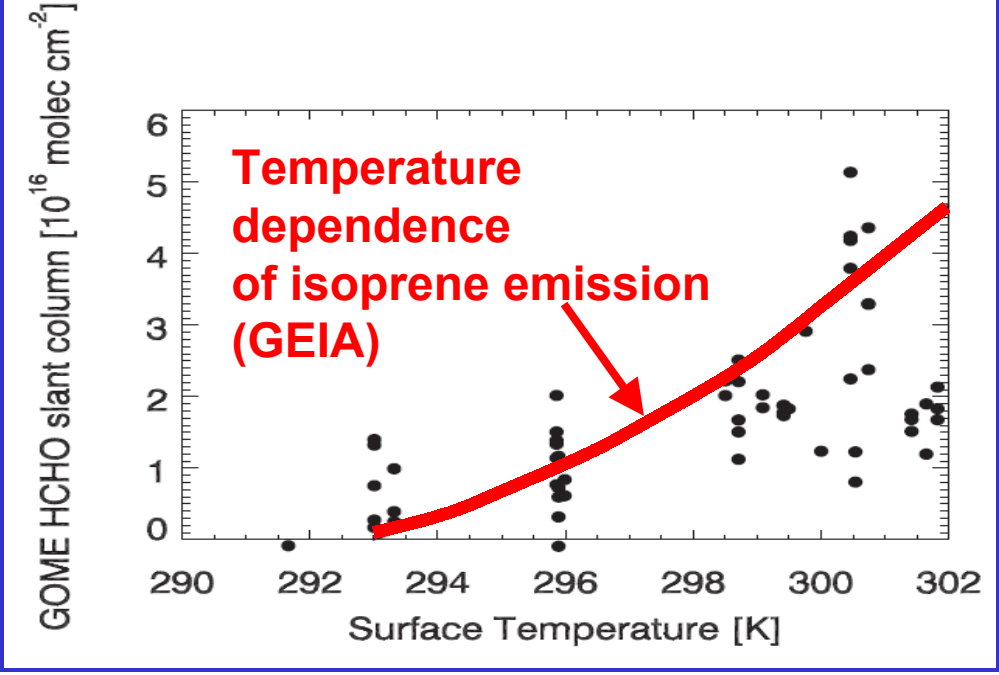


GOME isoprene emission inventory gives better fit to surface HCHO data than either GEIA or BEIS2

Inventory	r^2	Bias
GOME	0.71	-9%
GEIA	0.47	+17%
BEIS2	0.58	-40%

OZARKS "ISOPRENE VOLCANO" AS SEEN BY GOME

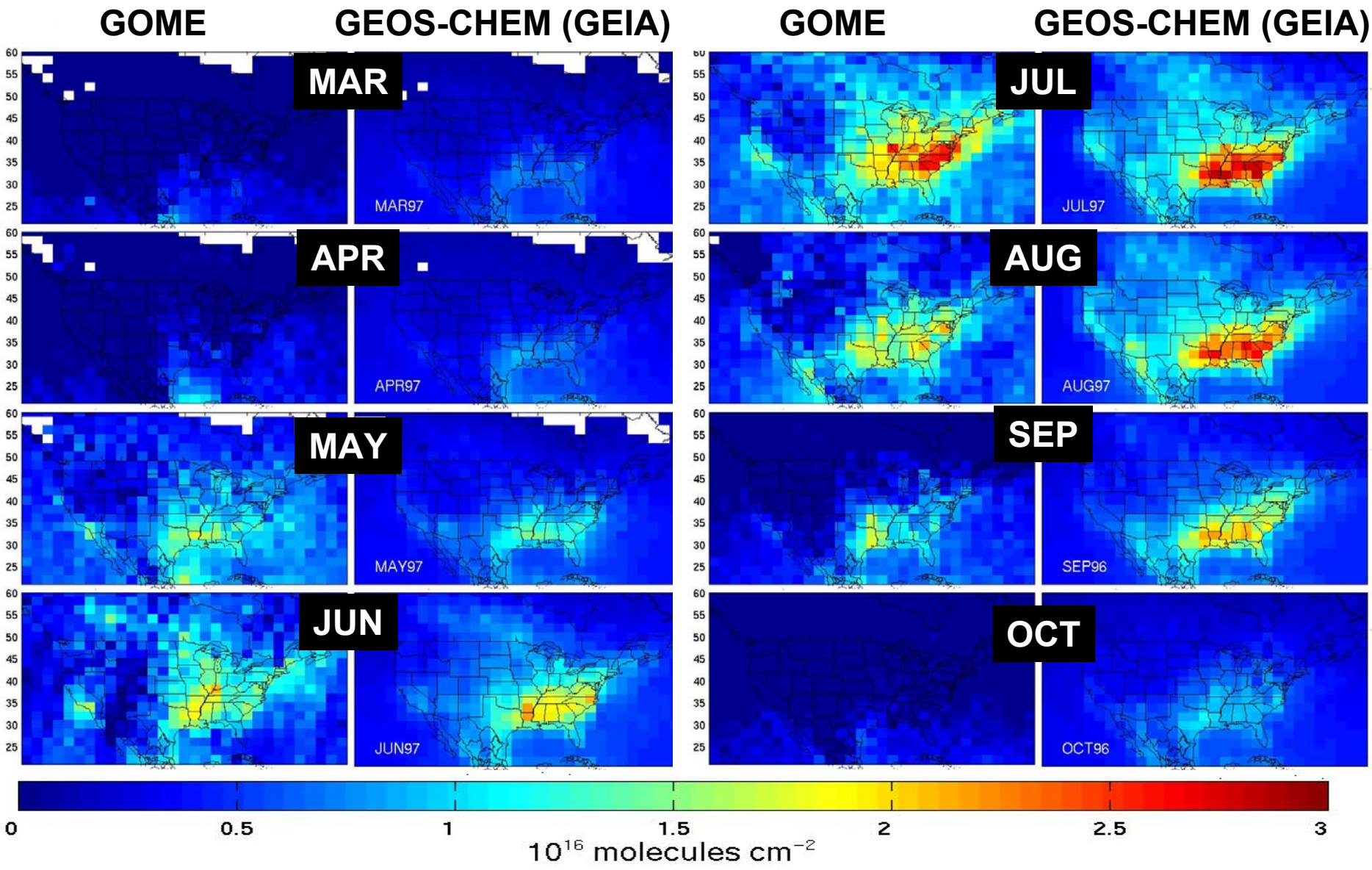




GOME HCHO columns over the Ozarks, July 1996: daily orbits and relationship to temperature

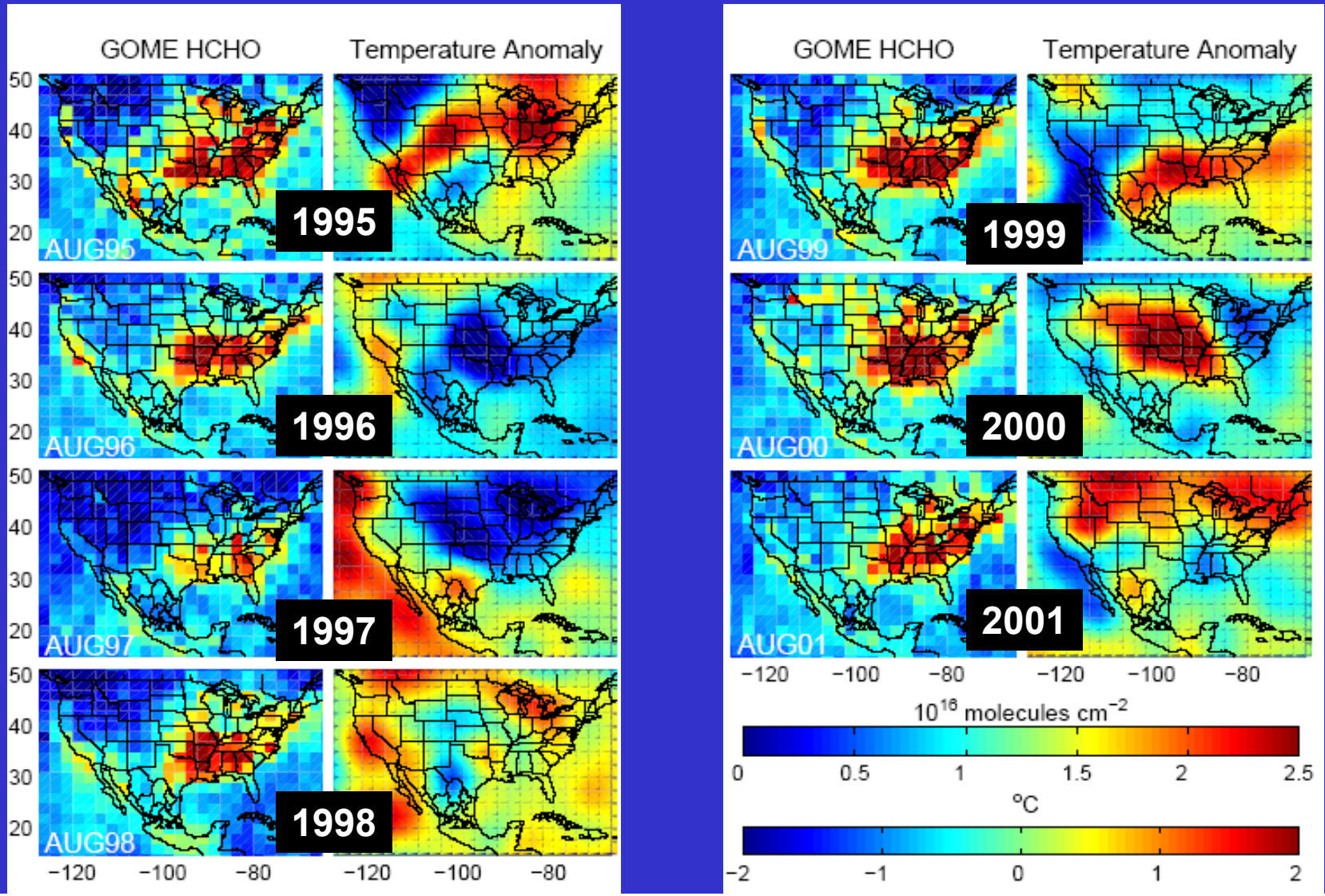
SEASONALITY OF GOME HCHO COLUMNS (9/96-8/97)

Largely reflects seasonality of isoprene emissions;
general consistency with GEIA but also some notable differences



INTERANNUAL VARIABILITY OF GOME HCHO COLUMNS

Augusts 1995-2001: correlation with temperature anomaly explains some but not all of the HCHO column variability



TO KNOW MORE:

• Abbot, D. S., P. I. Palmer, R. V. Martin, K. V. Chance, D. J. Jacob, and A. Guenther, *Seasonal and interannual variability of isoprene emissions as determined by formaldehyde column measurements from space*, Geophys. Res. Lett., in press.

• Palmer, P. I. D.J. Jacob, A. M. Fiore, R. V. Martin, K. Chance, and T. Kurosu, *Mapping isoprene emissions over North America using formaldehyde column observations from space*, J. Geophys. Res., 108, 4180, doi:10.1029/2002JD002153, 2003.

• Palmer, P. I., D. J. Jacob, K. Chance, R. V. Martin, R. J. D, Spurr, T. P. Kurosu, I. Bey, R. Yantosca, A. Fiore, and Q. Li. *Air mass factor formulation for spectroscopic measurements from satellites: application to formaldehyde retrievals from GOME*, J. Geophys. Res., 106, 14,539-14,550, 2001.

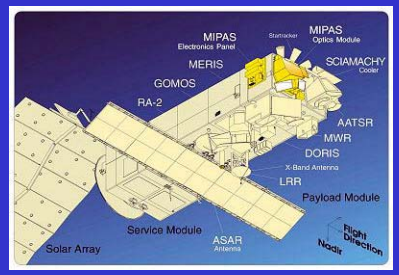
• Chance K., P. Palmer, R.J.D. Spurr, R.V. Martin, T. Kurosu, and D.J. Jacob. *Satellite observations of formaldehyde over North America from GOME*, Geophys. Res. Lett., 27, 3461-3464, 2000.

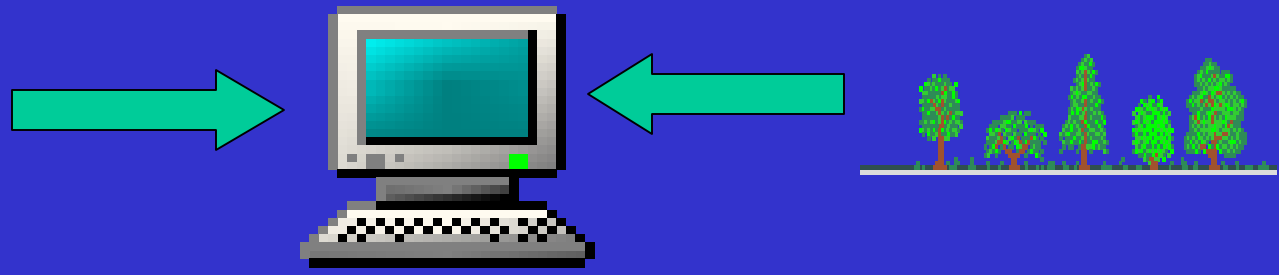
ONGOING AND FUTURE WORK

Retrieve HCHO columns from SCIAMACHY solar backscatter instrument on board Envisat (launched 3/2002): 30x60 km² field of view

Increase resolution of GEOS-CHEM model, use a regional model (CMAQ), better describe terpene chemistry, address smearing

Implement new-generation MEGAN isoprene emission inventory from A.B. Guenther





Optimize VOC emission estimates by blending of bottom-up and top-down information