VOC Measurements from OMI
HCHO and CHO-CHO

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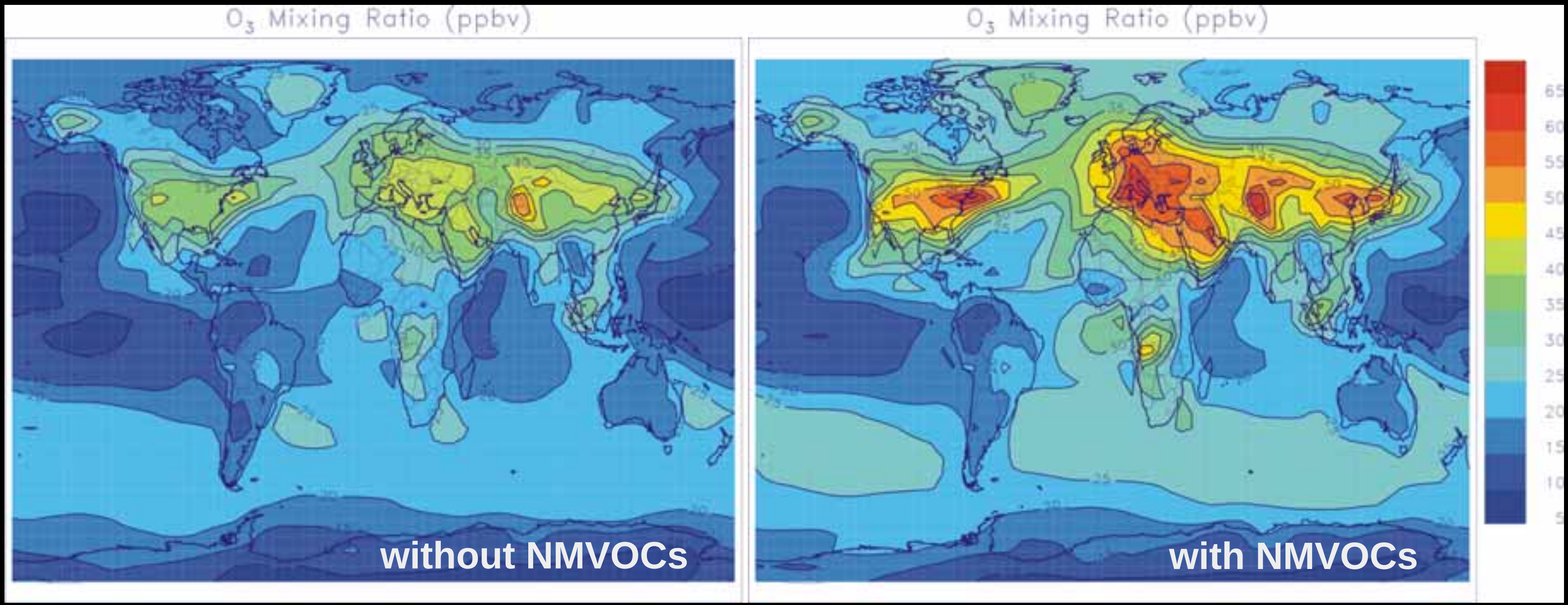
Why do we care about non-methane volatile organic compounds like HCHO and CHO-CHO?

Because they make great tropospheric Ozone!



Impact of NMVOCs on O_3 mixing ratios, July 1997

Simulations performed with the IMAGES global CTM, by J. Stavrakou and J.-F. Muller (BIRA)

(Figures provided by M. v. Roozendael, BIRA)

OMI — Instrument Overview and Data Availability

OMI (07/2004)

- On EOS Aura (part of A-Train); sun-synchronous orbit; 1338h equator crossing time
- Daily global coverage; ground pixel size $13 \times 24\ km^2$ at nadir
- Standard data products (publicly available): O_3, NO_2, HCHO*, SO_2, BrO*, OClO*, aerosols, clouds, UV-B
- Science data products: CHO-CHO*, O_3 profiles* and tropospheric ozone*‡

OMI VOC Data Availability

- HCHO: OMI standard data products are available from http://daac.gsfc.nasa.gov/Aura/OMI/
- CHO-CHO: Still science product but will become an operational product. For data contact the developer (tkurosu@cfa.harvard.edu)

OMI VOC Data Accuracy

- ~50-100% error on individual total column retrieval. 3-5 day averaging required for most applications

*Development lead by SAO (‡and UMBC)

HCHO, CHO-CHO — Overview

HCHO

VOC; produced from methane oxidation and isoprene emissions; main sinks are photolysis and reaction with OH; life time ~1.5h

Proxy for isoprene emissions
(plenty of GOME-1 and OMI studies with the Harvard Modeling Group of D. Jacob)

CHO-CHO

VOC; second-order oxidation product, produced from of a large number of other, mostly aromatic VOCs; main sinks are photolysis and reaction with OH; life time ~1.3h (polluted), ~4h (unpolluted)

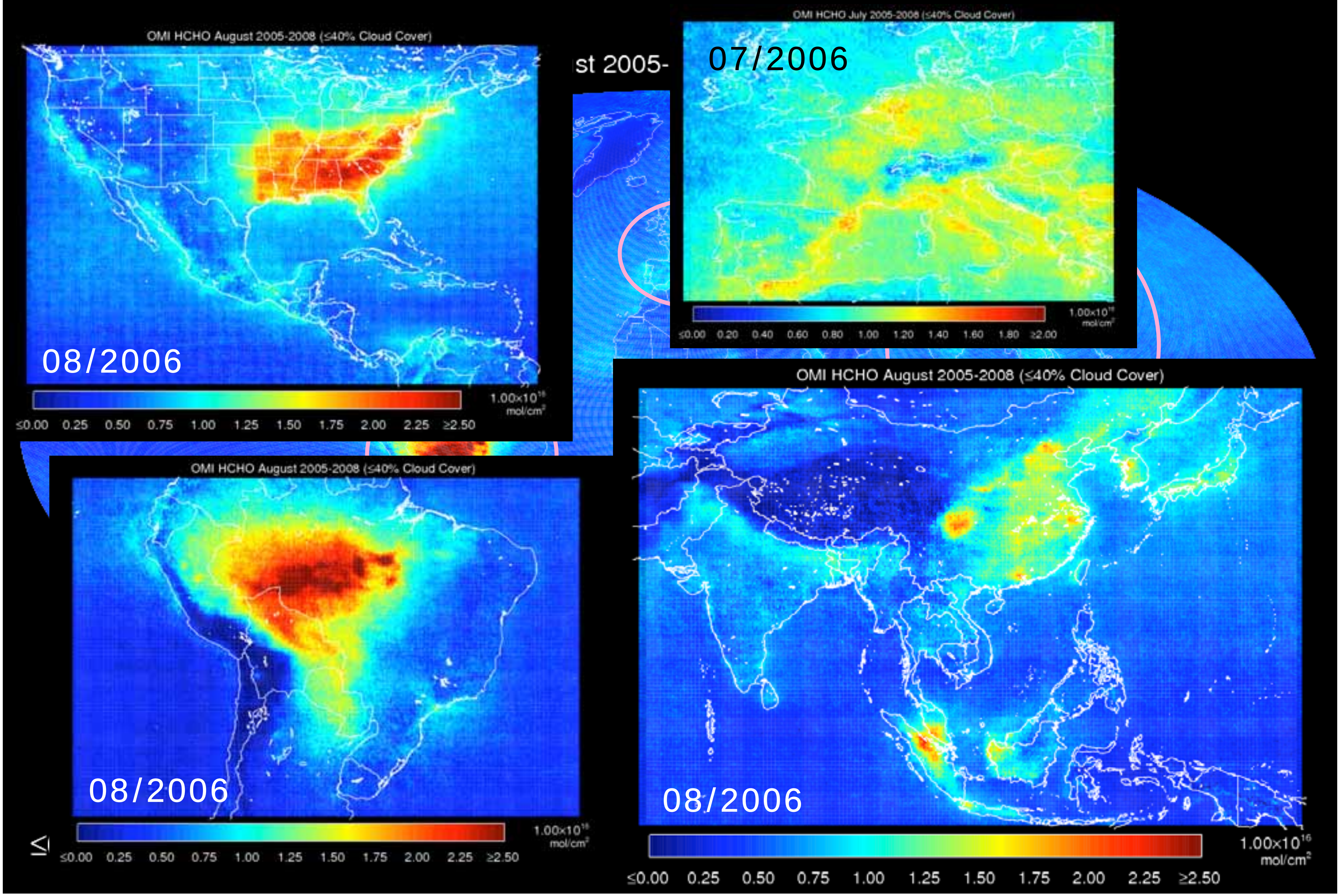
Ground-based observations in Mexico City during MILAGRO, and in the Pearl River Delta (R. Volkamer, U. Colorado Boulder)

Unlike HCHO not directly affected by vehicle emission, hence a better indicator for VOC oxidation (photochemical smog)

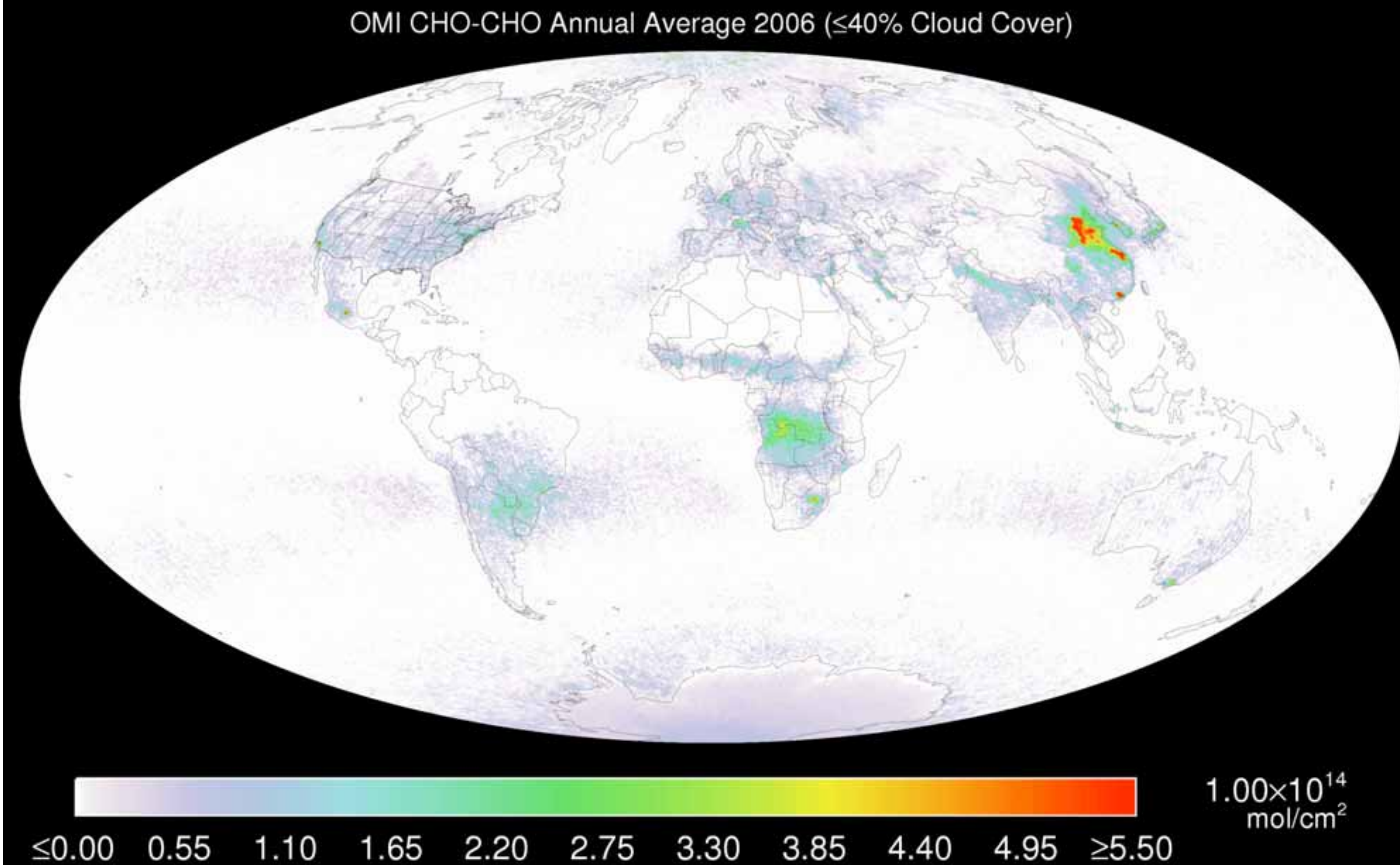
Source of SOA

First space-based CHO-CHO observation reported by OMI

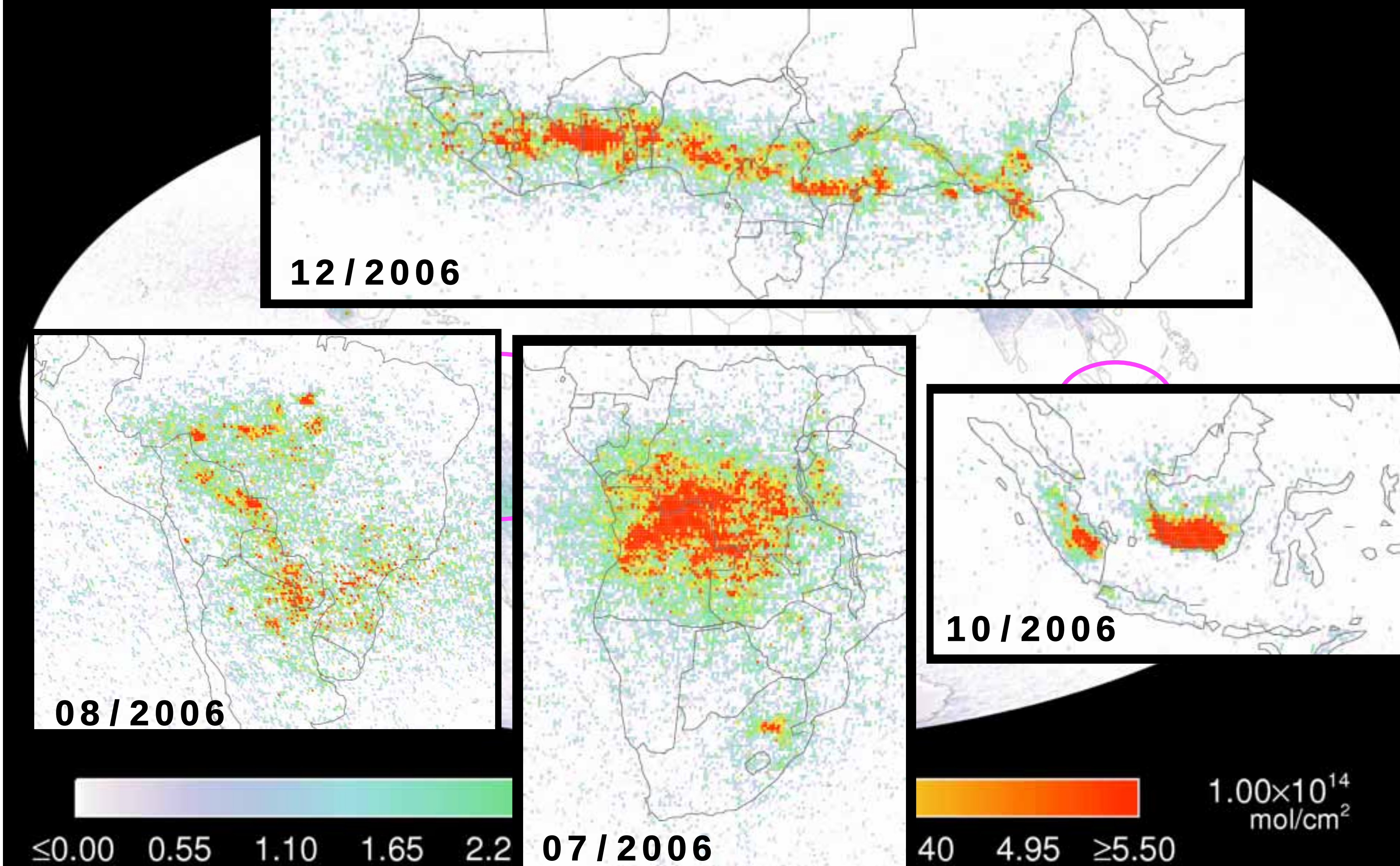
OMI HCHO — August 2005-2008



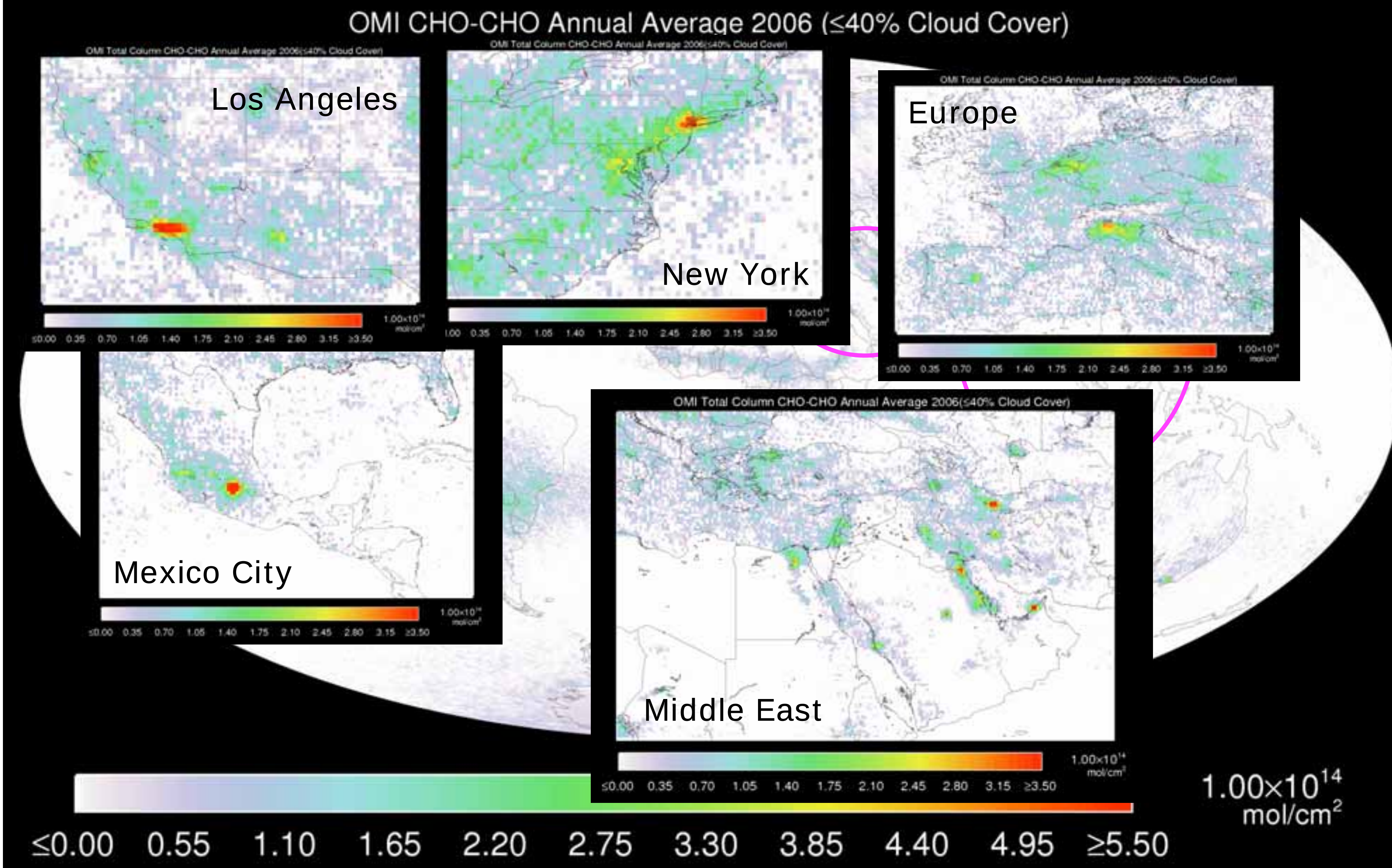
OMI CHO-CHO — 2006 Annual Average



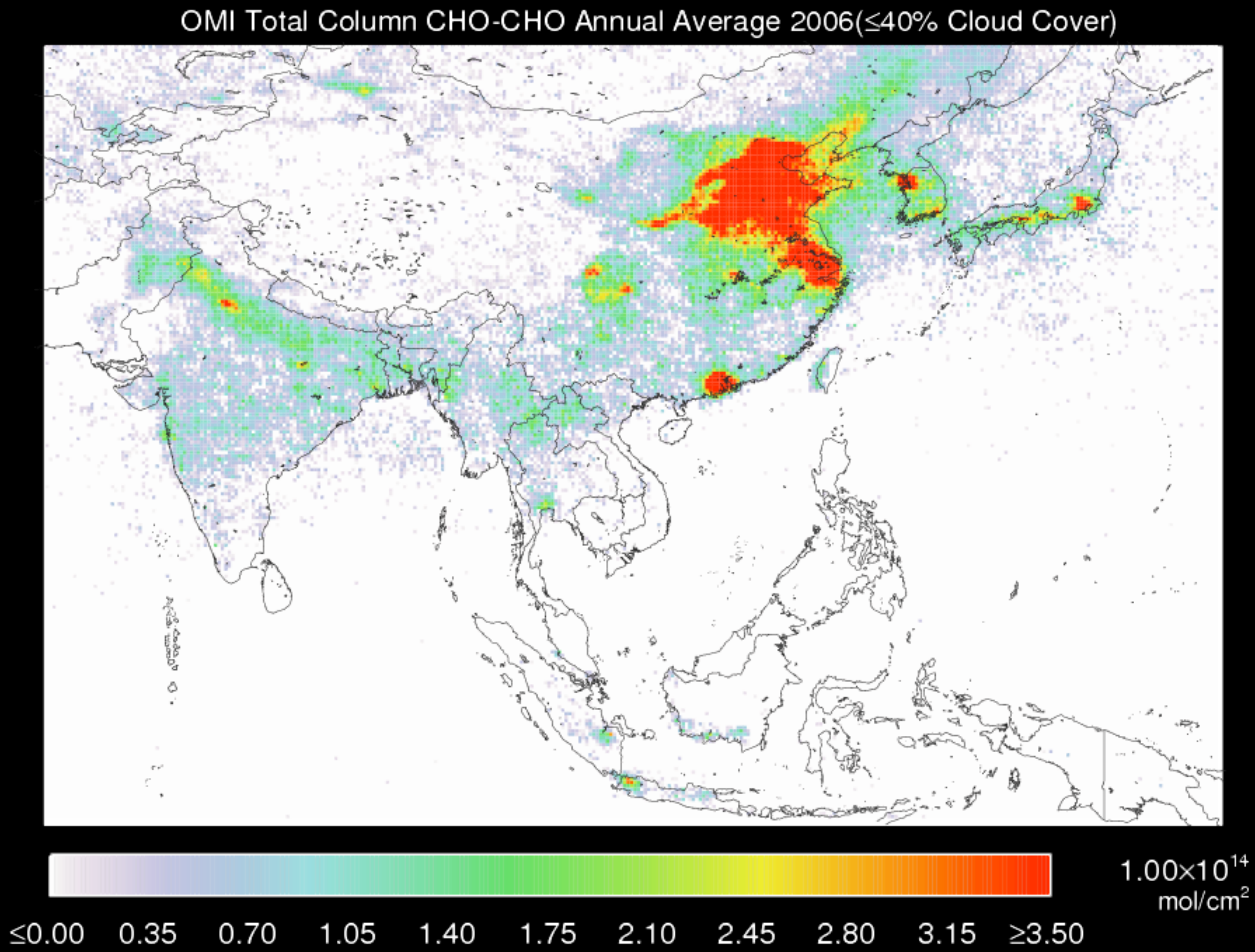
OMI CHO-CHO — 2006 Annual Average, Biomass Burning



OMI CHO-CHO — 2006 Annual Average, Megacities

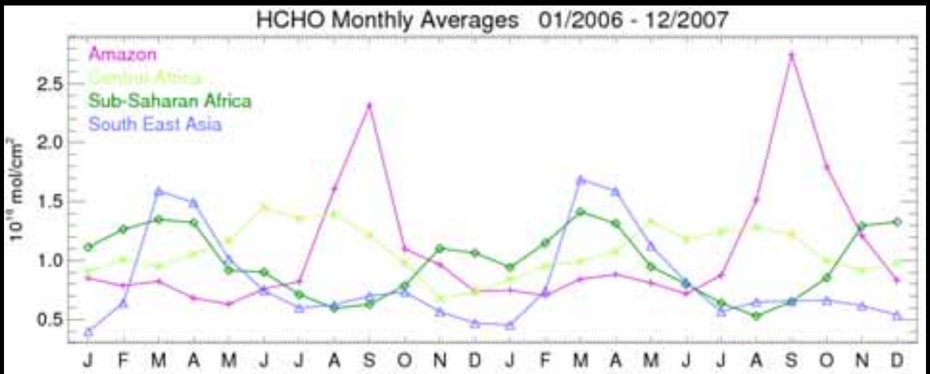


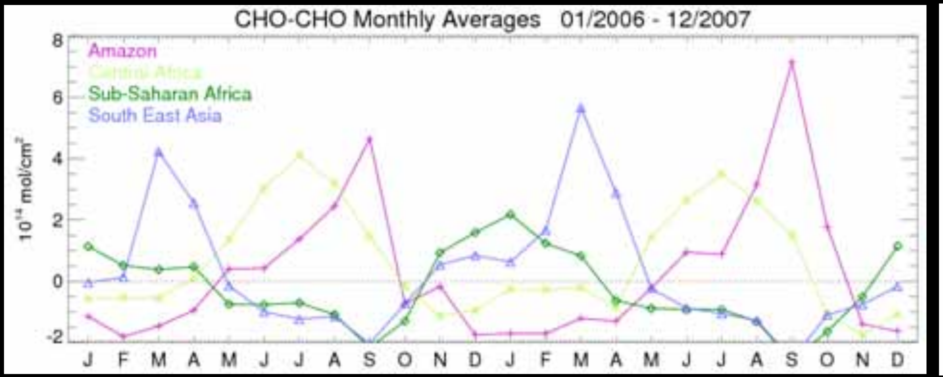
OMI CHO-CHO — 2006 Annual Average, Megacities



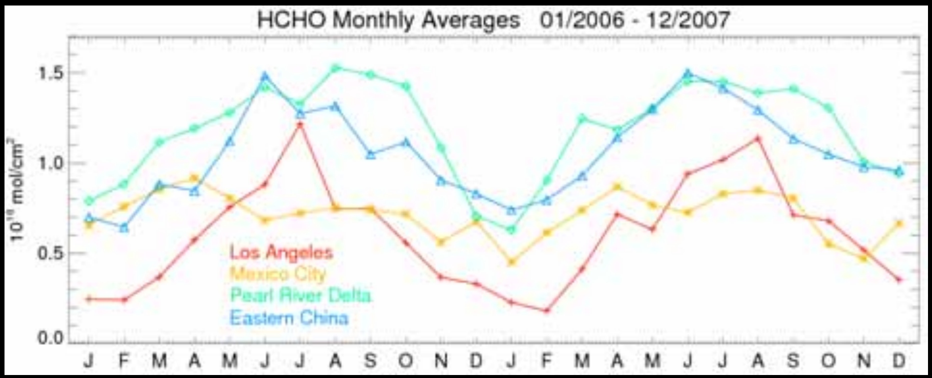
OMI HCHO and CHO-CHO — Seasonal Variation 2006-2007

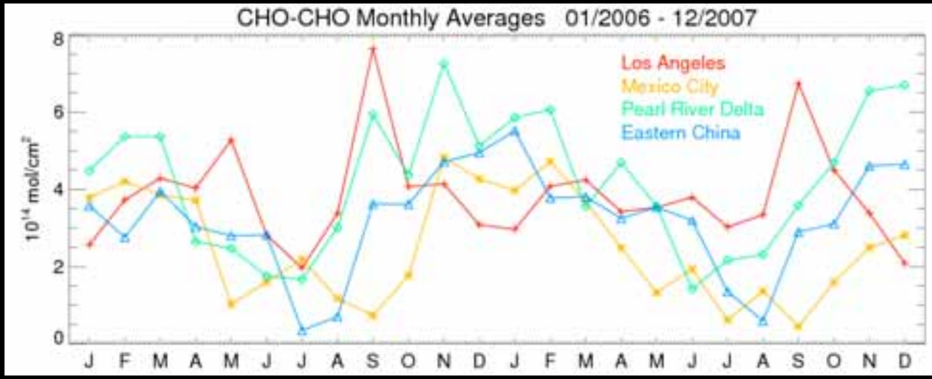
Biomass Burning





Megacities





Strong seasonal BB signals in both gases:

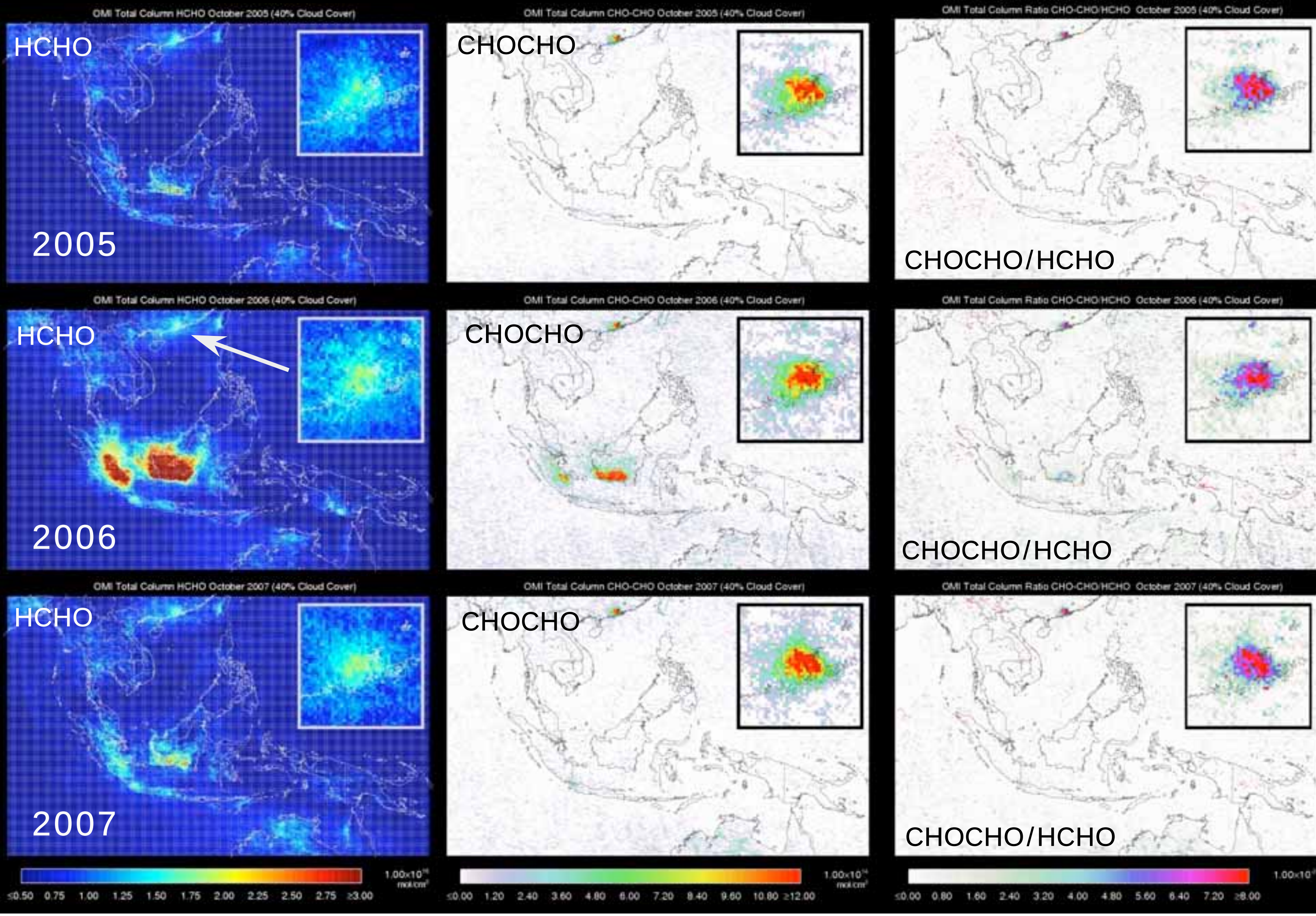
Amazon	ASO
South-East Asia	FMA

Somewhat shifted MC signals:

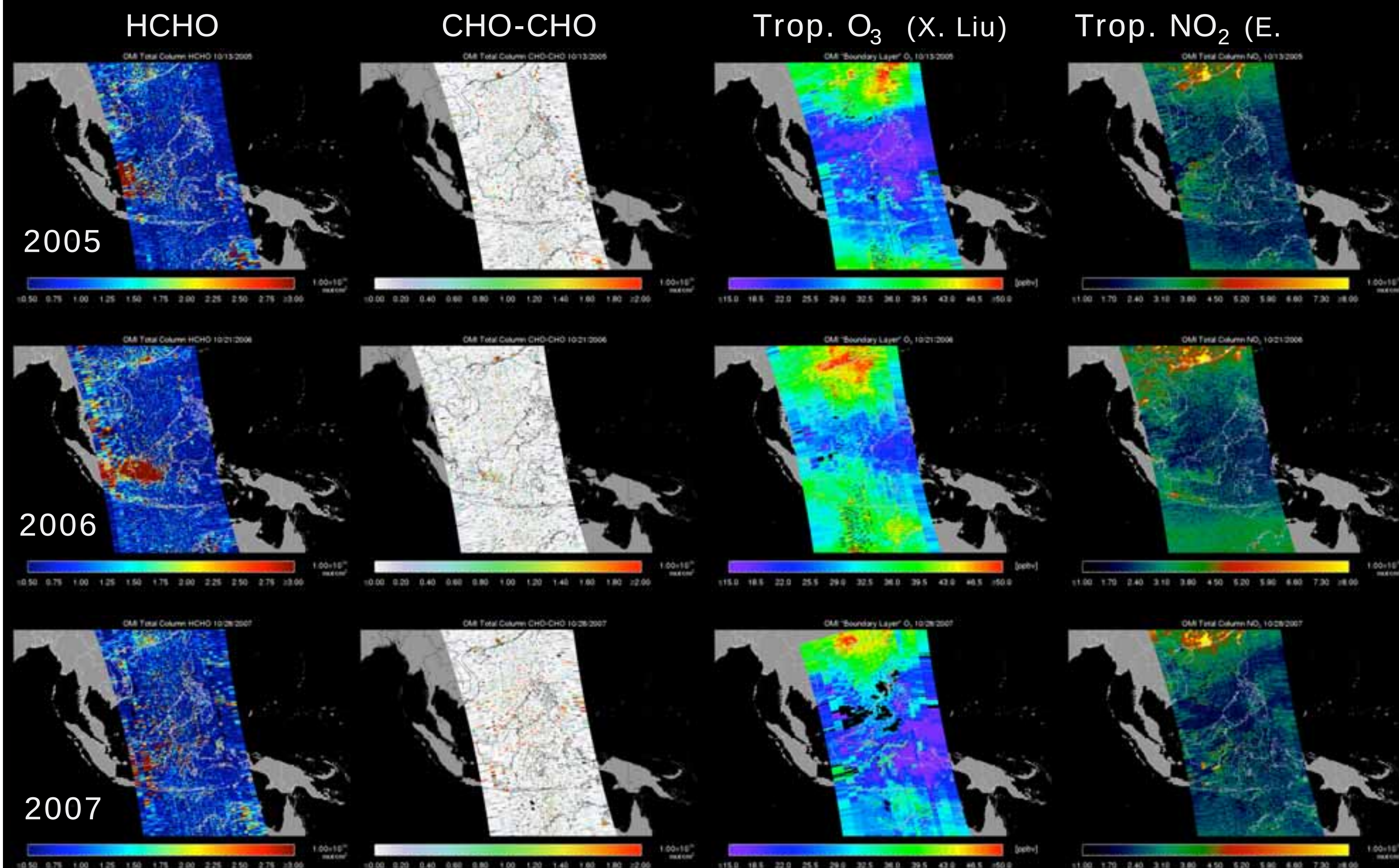
HCHO in JJA vs. CHO-CHO in DJF

Cloud Cover?

OMI HCHO and CHO-CHO — Indonesia 10/2005 – 10/2007



Indonesia 2005-7: OMI HCHO, CHO-CHO, tropospheric O_3, NO_2 Granules



USE of OMI VOC Data Products

1. Currently Ongoing

- Spatial distribution of isoprene emissions from North America derived from HCHO columns (D. Millet, U. Minnesota)
- Seasonal variations of isoprene emissions using OMI and GOME-2 HCHO columns (E. Marais, D. Jacob; Harvard U.)
- Temperature dependence of factors (e.g., drought, ozone) that control isoprene emissions (B. Duncan; NASA)
- Use of OMI HCHO/NO_2 ratios as an indicator of the instantaneous ozone production rate (B. Duncan; NASA)
- Top-down emission estimates for VOCs over Asia using OMI HCHO columns (M. Fu; Hong Kong Pol. U.)

USE of OMI VOC Data Products

2. Planned

- Comparison of OMI CHO-CHO columns with observations from ship-campaigns in the tropical Pacific and ground-based measurements in Mexico City and Pearl River Delta (R. Volkamer; U. Colorado/Boulder)
- Study of biogenic VOC emissions over tropical ecosystems (P. Palmer; U. Edinburgh)
- Use of OMI HCHO columns during aircraft campaign in western North Atlantic to characterize the chemistry in biomass burning plumes during transport (P. Palmer; U. Edinburgh)
- Combination of MLS ice-water and O_3 measurements with OMI HCHO to asses the impact of convected isoprene on the ozone budget in the tropical upper troposphere (R. Doherty; U. Edinburgh)
- VOC emissions from natural oil and gas fields (EPA, SAO)

- Creation of a contiguous, consistent data set of HCHO and CHO-CHO from GOME-1, SCIAMACHY, OMI, and GOME-2 (SAO)

Air Quality Observation Sensitivity Drivers*

Molecule	Vertical Column [mol cm^{-2}]	Sensitivity Driver
O_3	2.4×10^{16}	~10ppbv in PBL; reality (profiling) is more complicated
NO_2	3.0×10^{16}	distinguish clean from moderately polluted scenes
SO_2	1.0×10^{16}	distinguish structures for anthropogenic sources
HCHO	1.0×10^{16}	distinguish clean from moderately polluted scenes
CHO-CHO	4.0×10^{14}	tracking of most urban diurnal variation

*In PBL. One of two issues needing the most work (traceability from AQ reqs and modeling)

Measurement Requirements

Molecule	Fitting Window [nm]	Vertical Column [mol cm^{-2}]	Slant Column [mol cm^{-2}]
O_3	315-335	2.4×10^{16}	2.4×10^{15}
NO_2	423-451	3.0×10^{16}	1.1×10^{15}
SO_2	315-325	1.0×10^{16}	1.5×10^{15}
HCHO	327-356	1.0×10^{16}	2.3×10^{15}
CHO-CHO	433-465	4.0×10^{14}	1.5×10^{14}

The slant column measurement requirements come from full multiple scattering calculations, including gas loading, aerosols, and the GOME-derived (Koelemeijer *et al*., 2003) albedo database, and assume a 1 km boundary layer height.

Optics Sizing for a 10×10 km^2 Footprint, 1 Second Integration Time

Molecule	|Rad|	φ cm-2 px^{-1}	RMS	φ px^{-1}	a×Eff
O_3	3.57×10^{12}	2.51×10^{4}	1.40×10^{-3}	1.28×10^{3}	5.09
NO_2	6.25×10^{12}	4.87×10^{4}	8.99×10^{-3}	3.09×10^{3}	0.063
SO_2	2.94×10^{12}	2.06×10^{4}	7.25×10^{-3}	4.76×10^{3}	0.230
HCHO	5.65×10^{12}	3.97×10^{4}	5.51×10^{-4}	8.23×10^{5}	20.8
CHO-CHO	6.22×10^{12}	4.85×10^{4}	3.56×10^{-4}	1.98×10^{6}	40.7

Formaldehyde (HCHO) is the driver for almost any conceivable choice of requirements! (Unless VOCs are considered unimportant, in which case O_3 would be the driver, with the above as a low estimate).

20.76 cm^2 is a 16-cm diameter telescope @ 10% optical efficiency (GOME, a much simpler instrument, is 15–20% efficient in this wavelength range).

IR needs (CO, maybe O_3) must be addressed.