1. Space-based constraints on non-methane VOC emissions in Asia

+

2. Sensitivity of summertime surface ozone to surface temperature over Southeastern U.S.: Interannual variability as a diagnostic for chemical transport models

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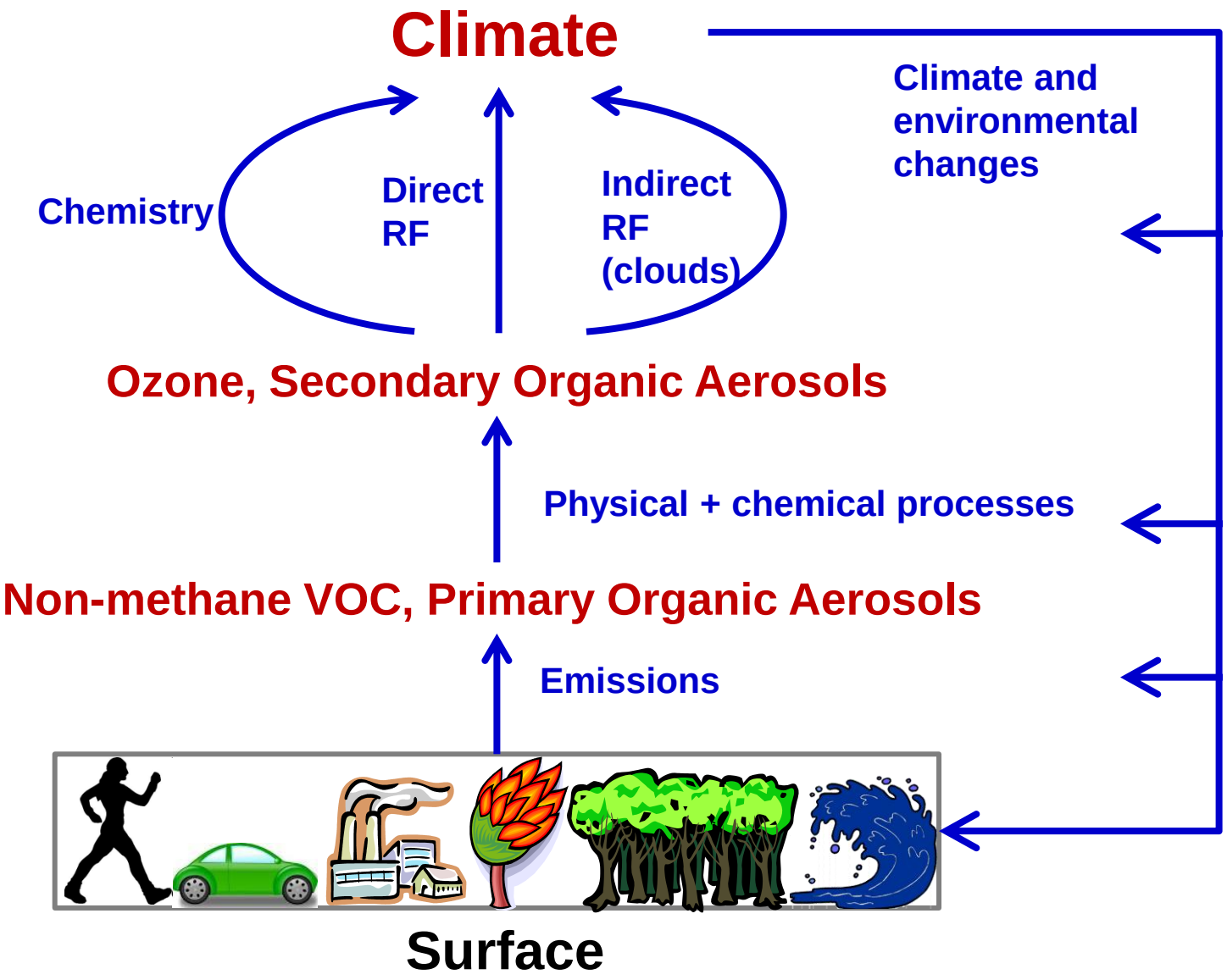
Yale + NUIST video conference

April 19, 2013

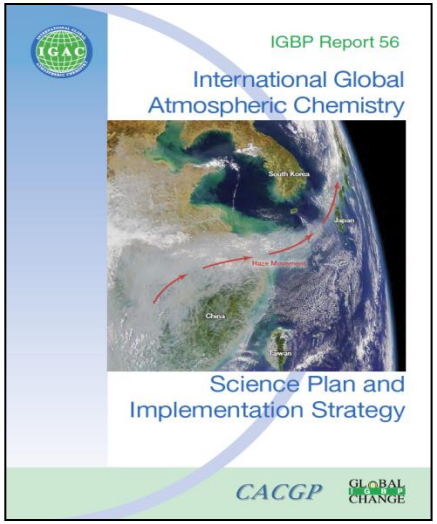
LaCOAS

北京大学气候与海-气实验室

Our research: Climate effects of reactive organics in the atmosphere

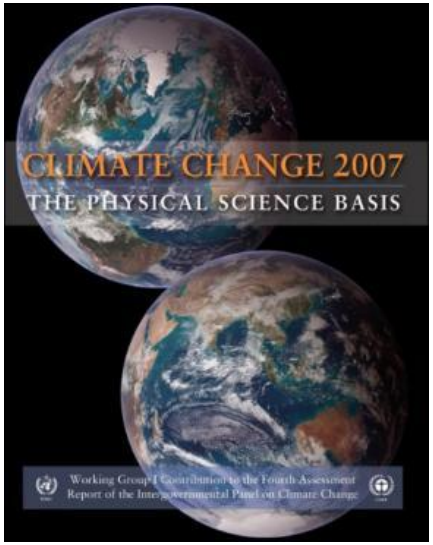


Role of atmospheric chemistry in the Earth system



International Global Atmosphere Chemistry (2006)《Science Plan and Implementation Strategy》：

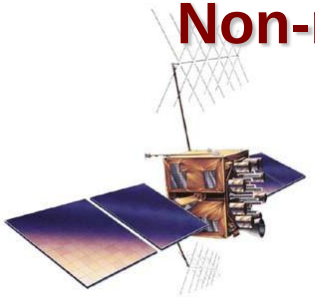
“通过整合对大气过程及地球系统响应与反馈的理解，增进对未来数十年大气化学组分的预测能力”

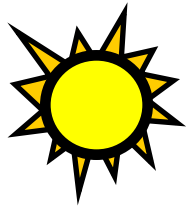


IPCC 4th Assessment (2007)：

“要准确预测未来气候变化，模式必须正确考虑气候与其他决定大气温室气体、高活性气体及气溶胶浓度过程的反馈作用”

Non-methane Volatile Organic Compounds（NMVOCs）
Precursor to tropospheric pollutants





O_3
Secondary Organic Aerosol（SOA）

Chemical processes

Anthropogenic + Biomass burning VOCs

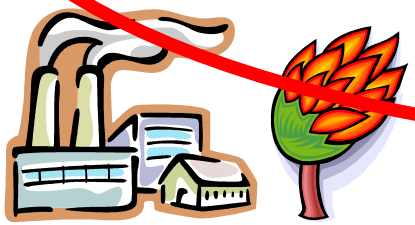
~150 Tg y^{-1}?

Biogenic VOCs 500~1200 Tg y^{-1}?

Isoprene 280 ~ 850 Tg y^{-1}?

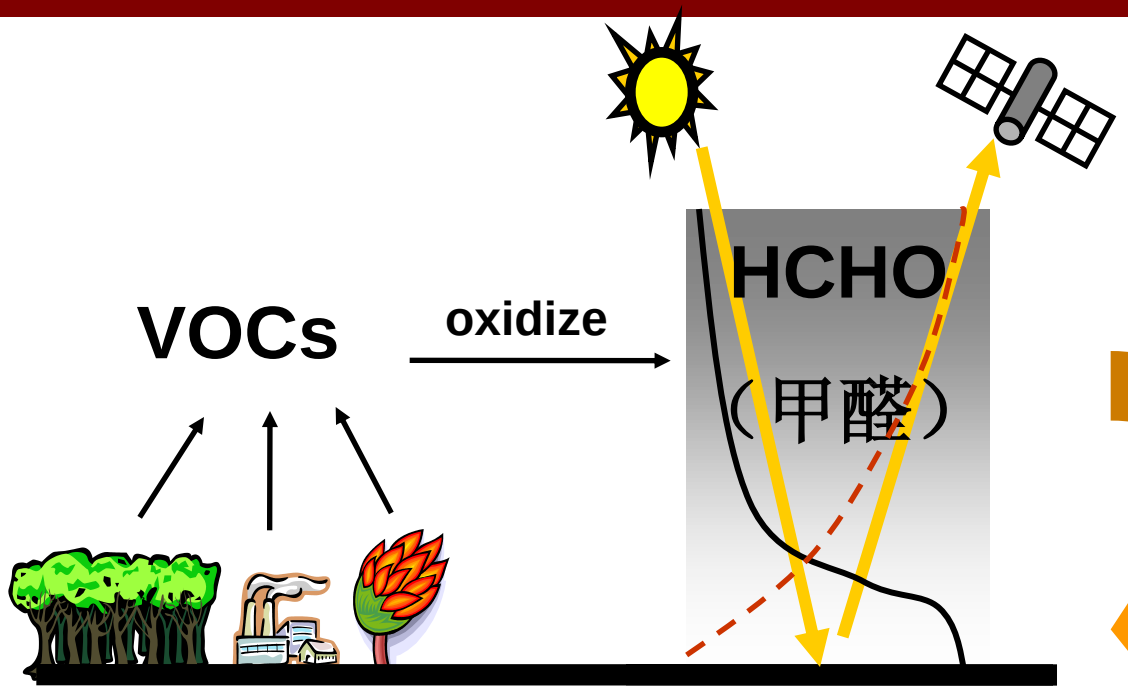
Ocean VOCs

~20 Tg y^{-1}?



Land | **Ocean**

I. Satellite observational constraints on VOC emissions



‘Top-down’ constraints on VOC emissions

[Fu et al., 2007]

Satellites observe：

- **trace gases**（O_3, NO_2, HCHO, CHOCHO, CO, SO_2, …）
- **aerosols**
- **GHG**（CO_2,CH_4）
- **meteorology & climate variables**
- **land surface**

HCHO vertical columns observed from space constrain reactive VOC emissions

GOME

Retrieve HCHO vertical column Ω_{HCHO}

Jul 1995 ~ Dec 2003 on board ERS-2

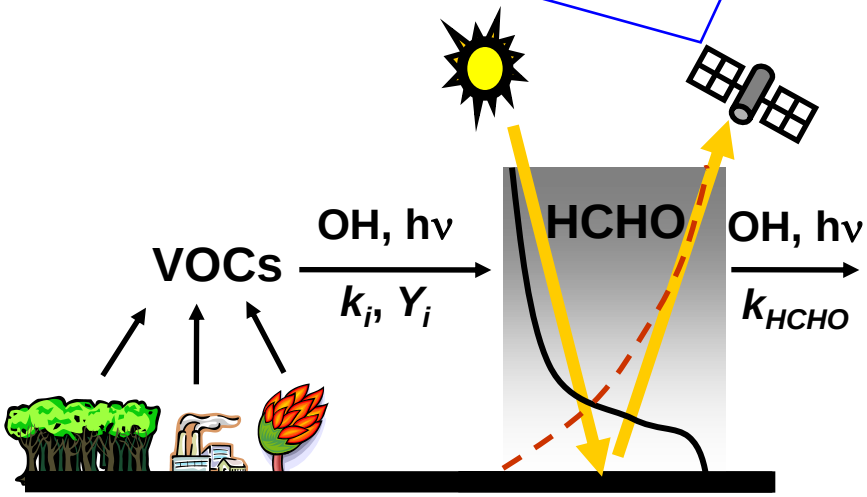
UV-backscatter

Nadir viewing

Global coverage in 3 days

Resolution 320 km x 40 km

HCHO, O_3, NO_2, BrO

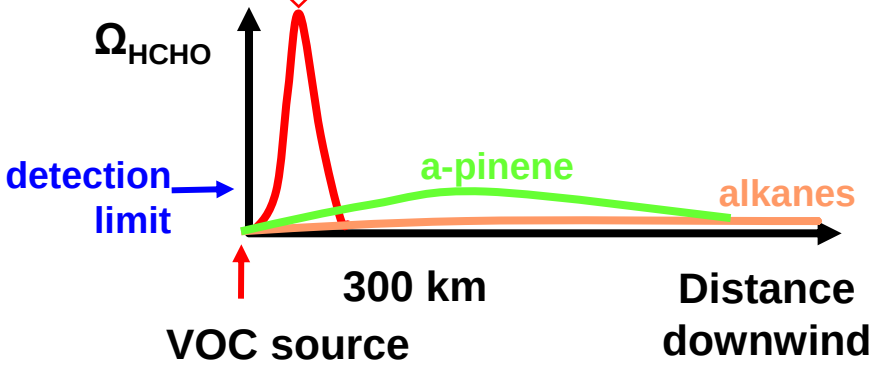


Reactive VOCs: lifetime < 1 day

isoprene, alkenes, xylenes,

HCHO (direct emission)

$$\Omega_{HCHO} = \frac{1}{k_{HCHO}} \sum_i E_i Y_i$$

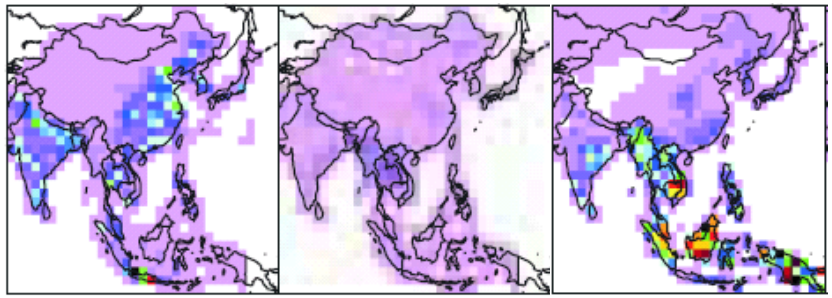


Palmer et al. [2003,2006], *JGR*

Fu et al. [2007], *JGR*

Current knowledge of VOC emissions in Asia *NOT* consistent with observations

State-of-the-art "bottom-up" reactive VOC emission inventories



Anthropogenic 40 Tg	Biomass burning 12 Tg	Biogenic 80 Tg
Streets et al. [2003]	Streets et al. [2003]	Guenther et al. [2006]

GEOS-Chem

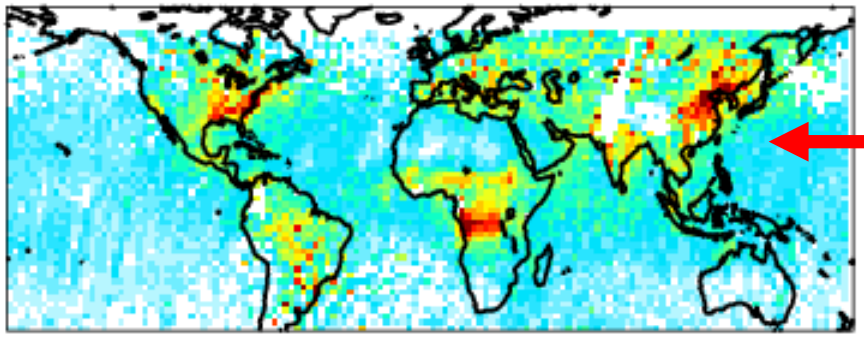
Global chemical transport model

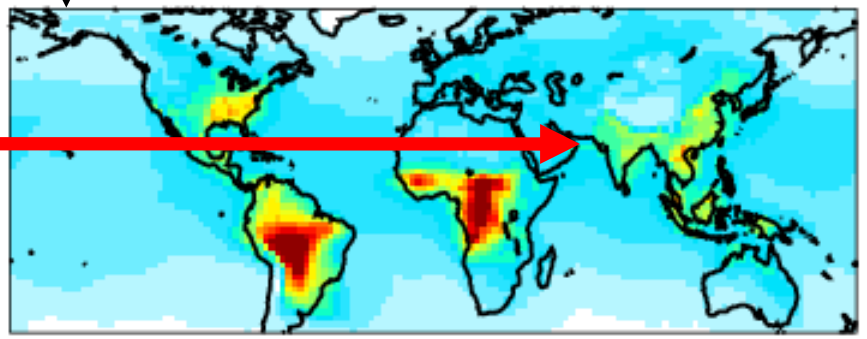
Assimilated meteorology

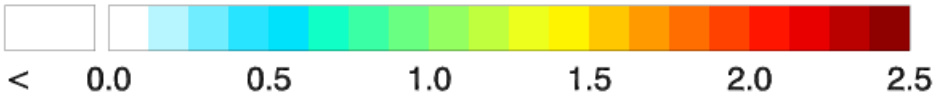
Resolution: 2.5 longitude x 2 latitude

GOME HCHO column June 1996~2001

Model HCHO column June 2001



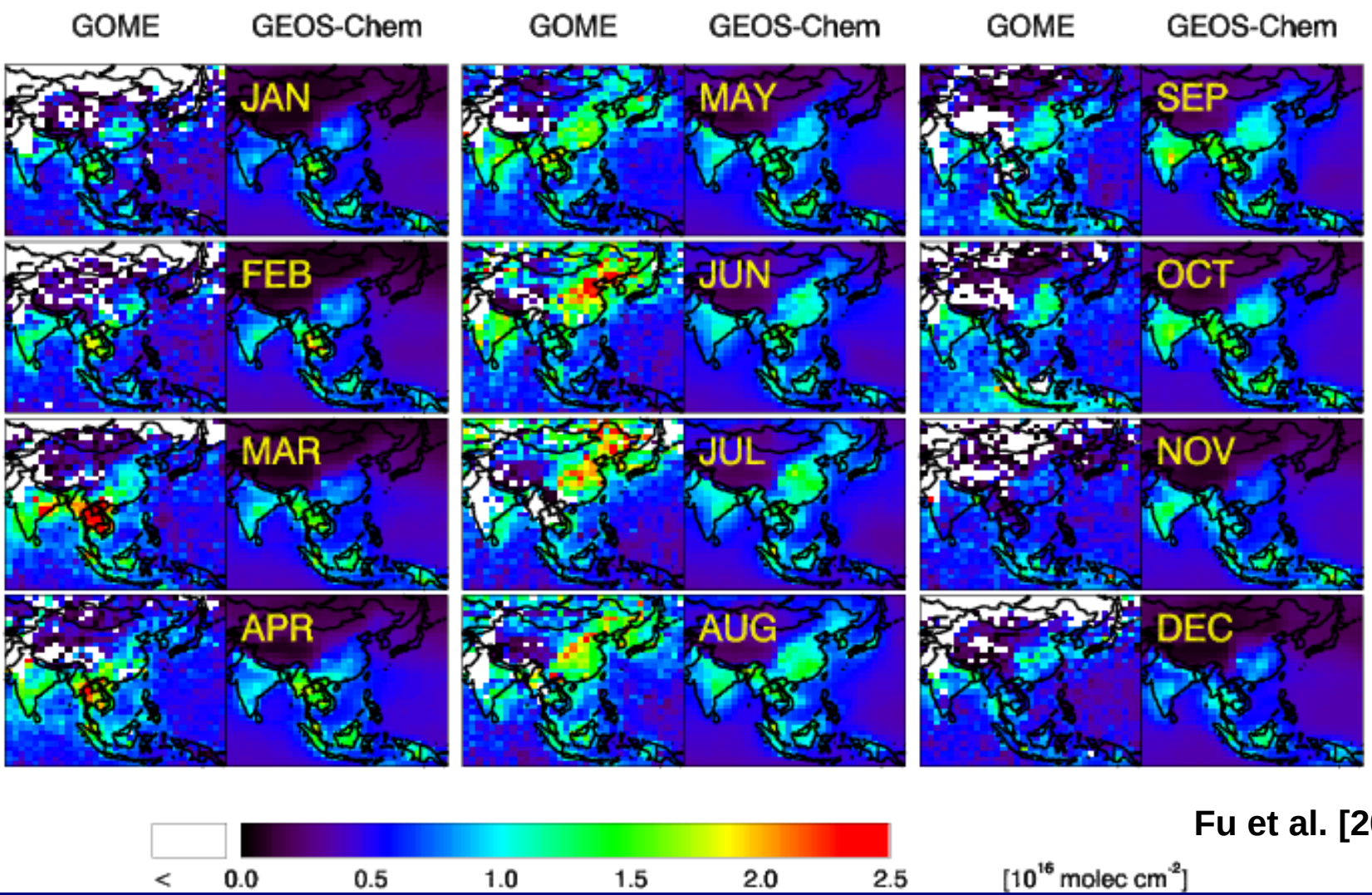




[10^{16} molec cm^{-2}]

Fu et al. [2007]

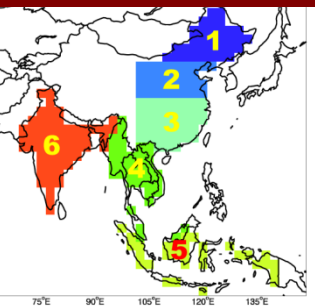
GOME HCHO Monthly Columns over Asia (1996-2001)



Fu et al. [2007]

Relationship to VOC emissions far more complex than for N. America; biomass burning, isoprene, anthropogenic VOCs, direct HCHO emission all contribute

Linear regression can separate biomass burning and biogenic emissions

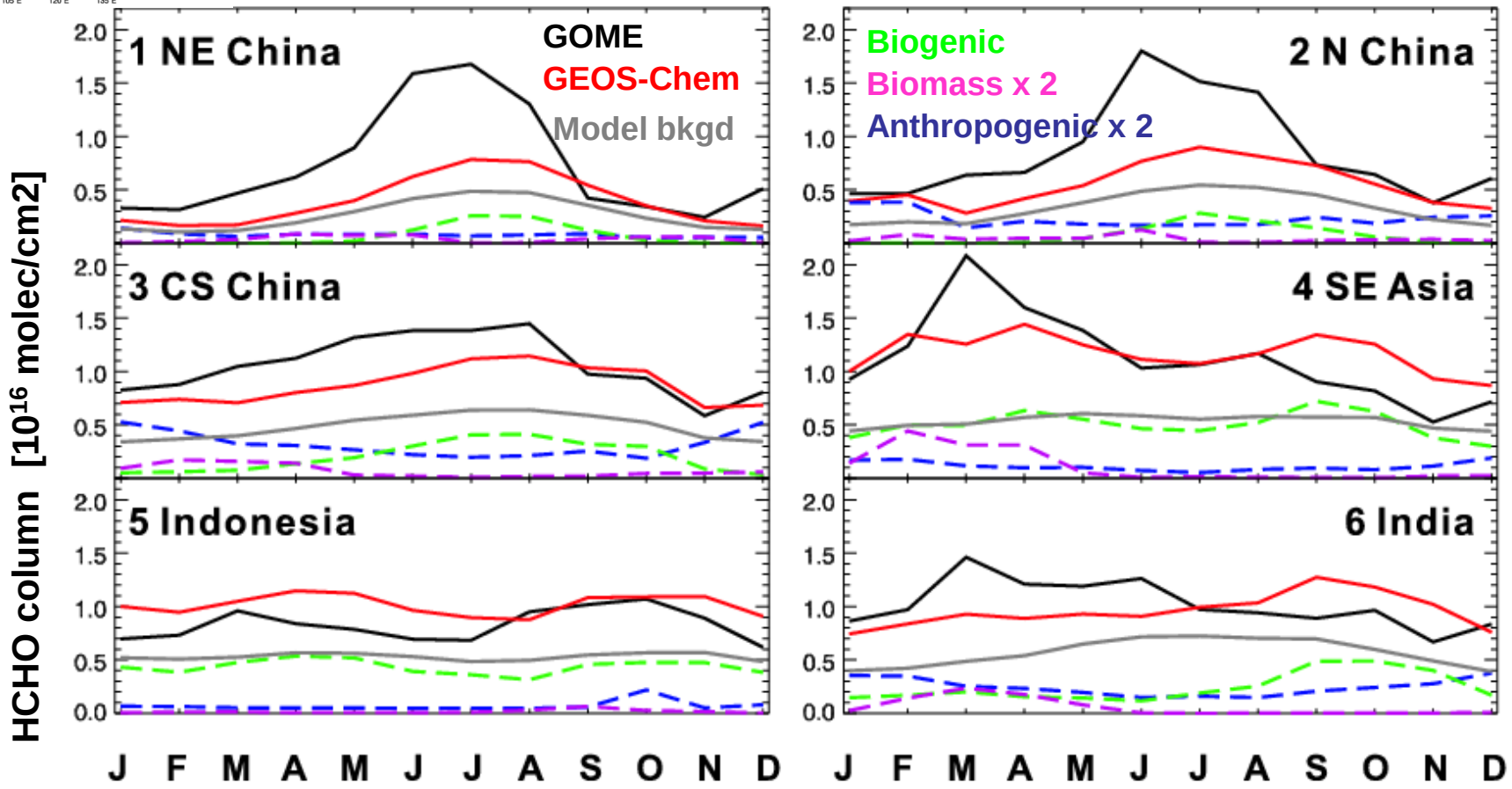


$$\Omega_{GOME} = \Omega_0 + \sum_{i=1}^{3} \beta_i \Omega_i + \text{+ nonlinear terms}$$

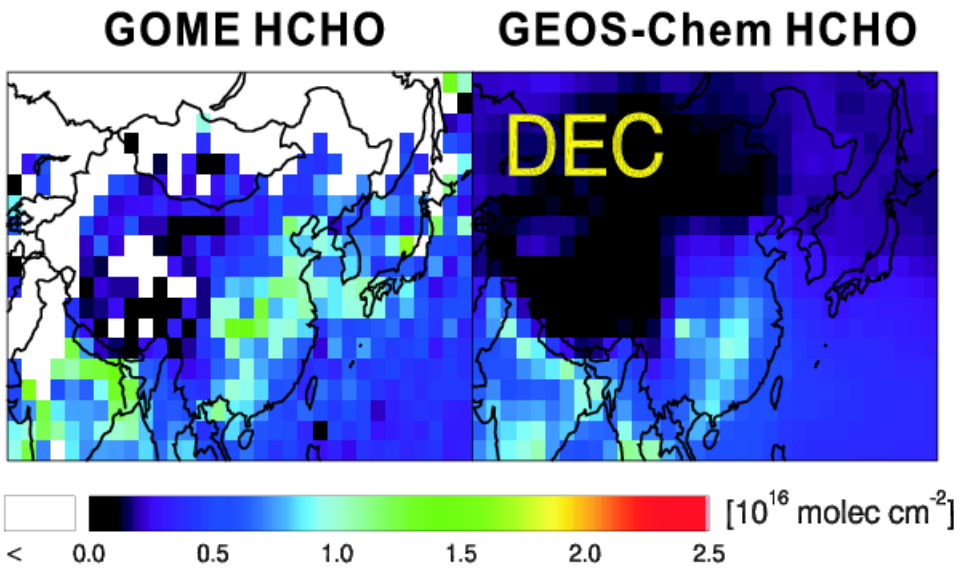
GOME – Model background = β_1 x biogenic + β_2 biomass

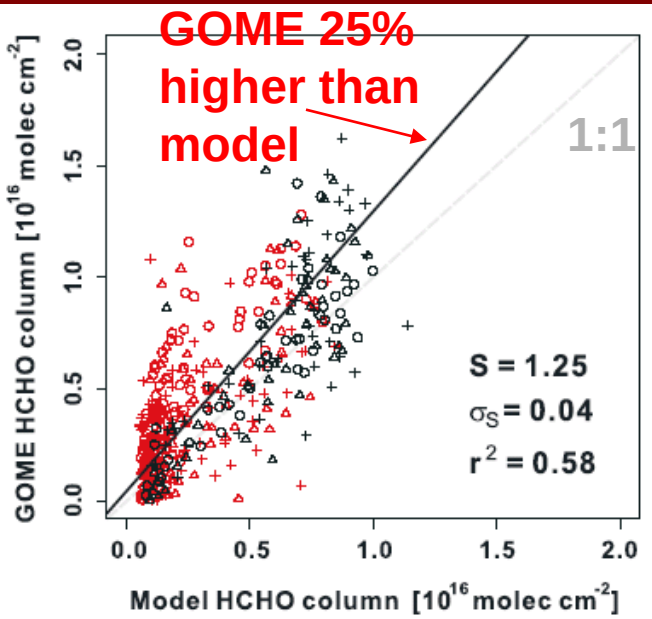
r^2 = 0.80 ~ 0.93

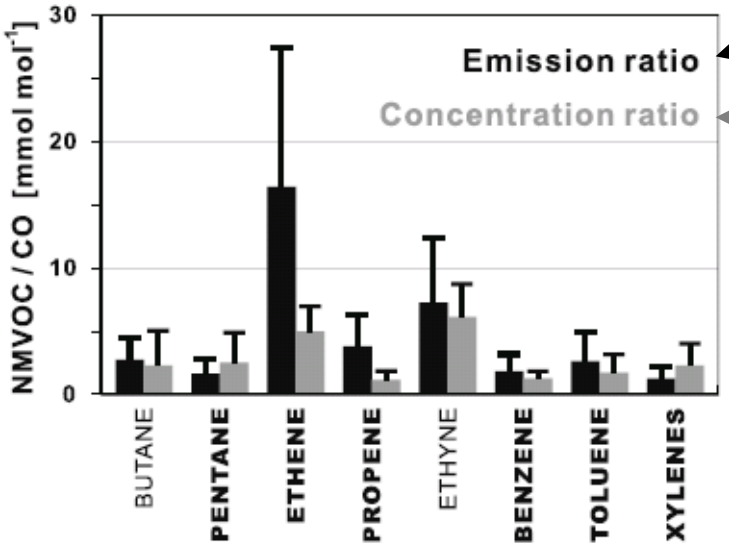
Fu et al. [2007]



Excess winter GOME HCHO due to Chinese vehicle emissions







Inventory by Streets et al. [2003]

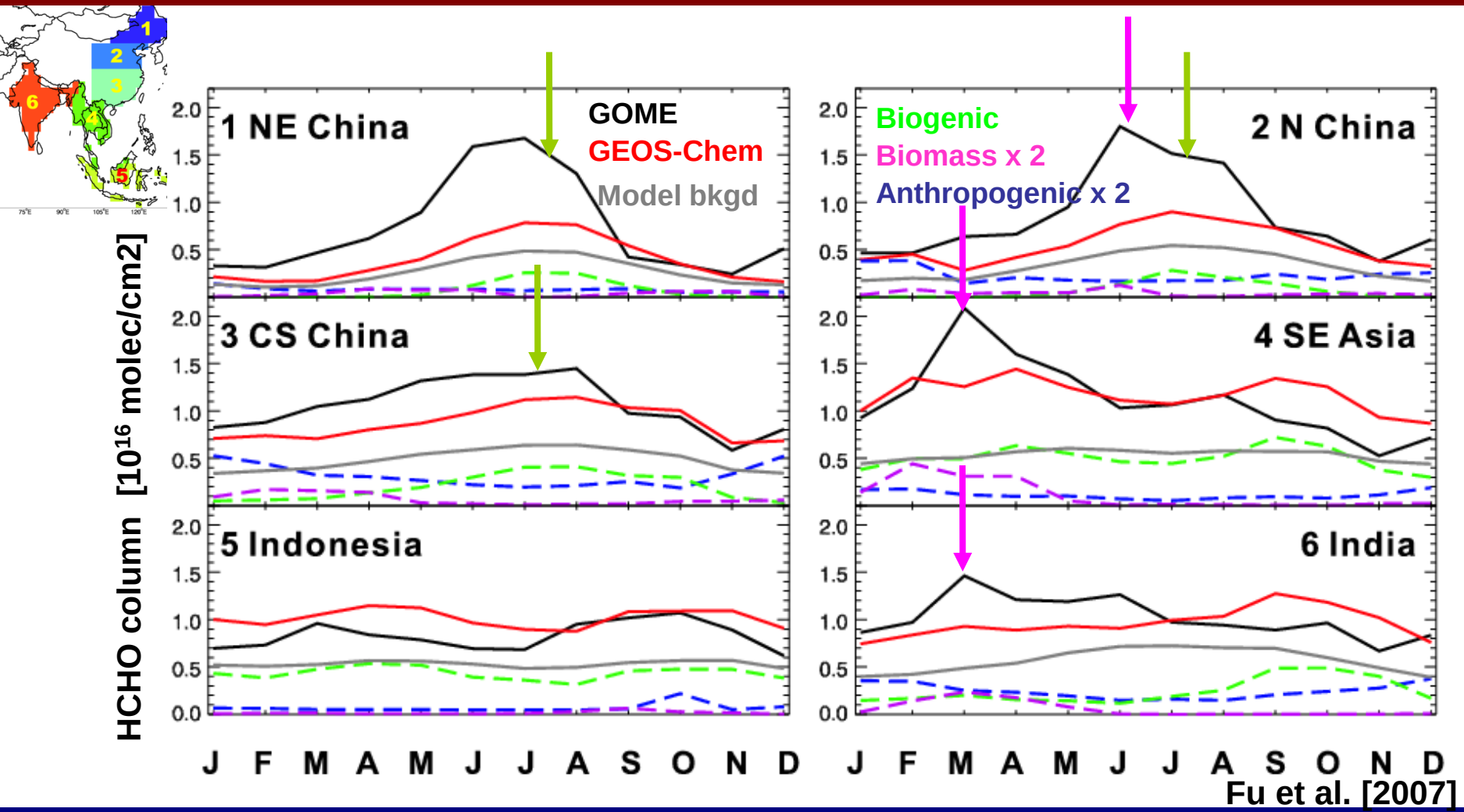
Observation by Barletta et al. [2005]
Sampled 43 Chinese cities
in Jan and Feb 2001

Inventory underestimates pentane & xylenes

→ Underestimates vehicular emissions

Fu et al. [2007]

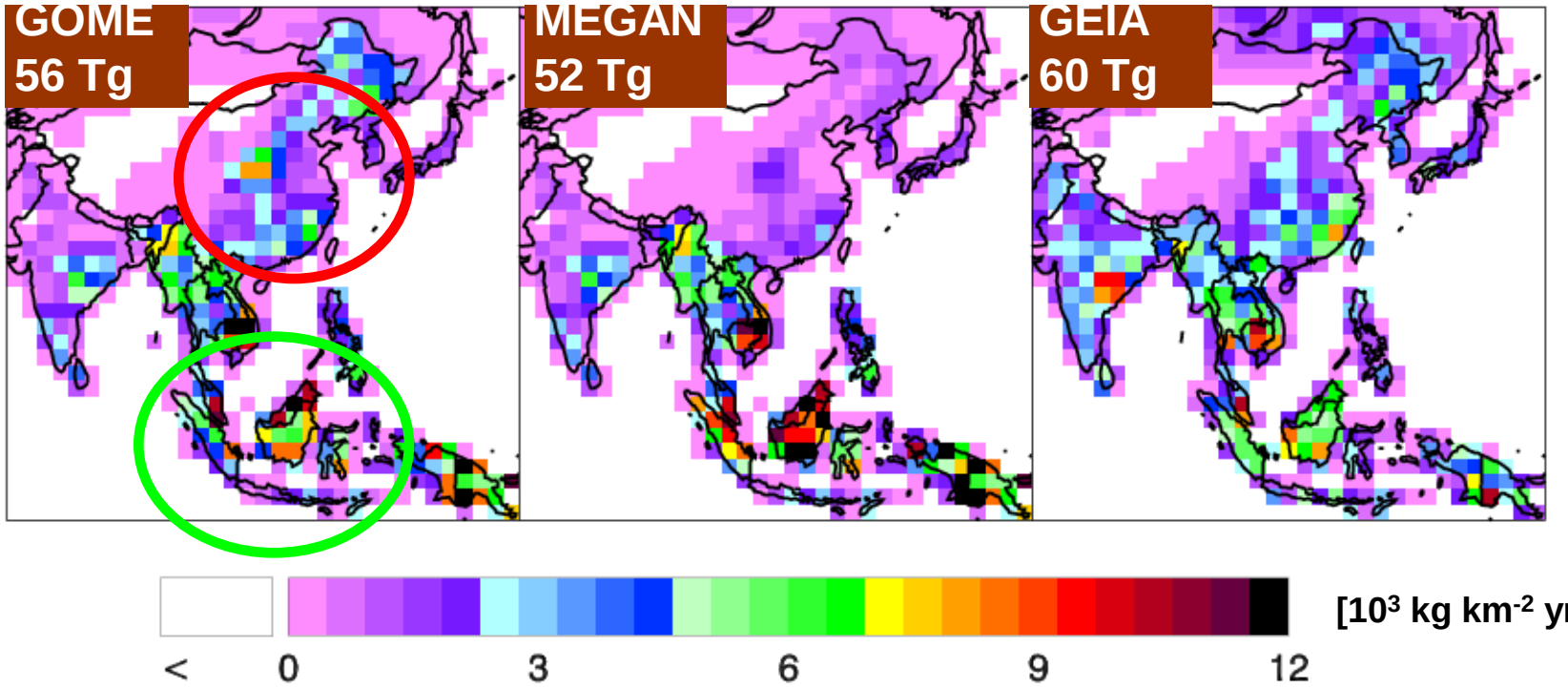
HCHO seasonal variation dominated by biogenic and biomass burning emissions



Fu et al. [2007]

"Bottom-up" inventories capture the *timing* but not the *magnitude* of emissions

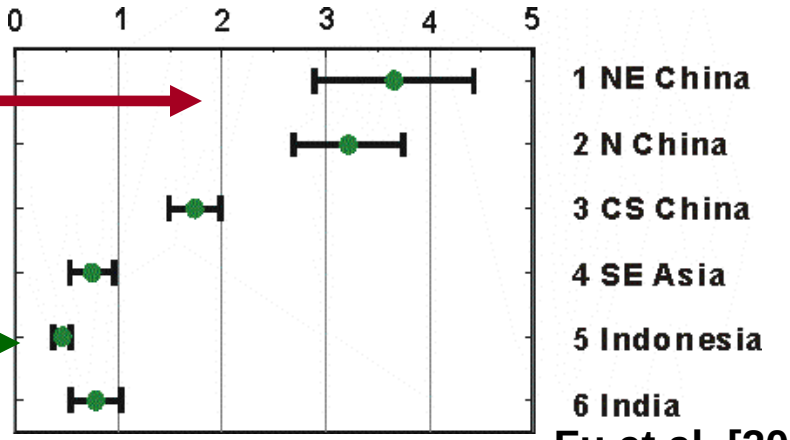
Redistribution of biogenic isoprene



Higher emission from the deciduous broadleaf forests in China

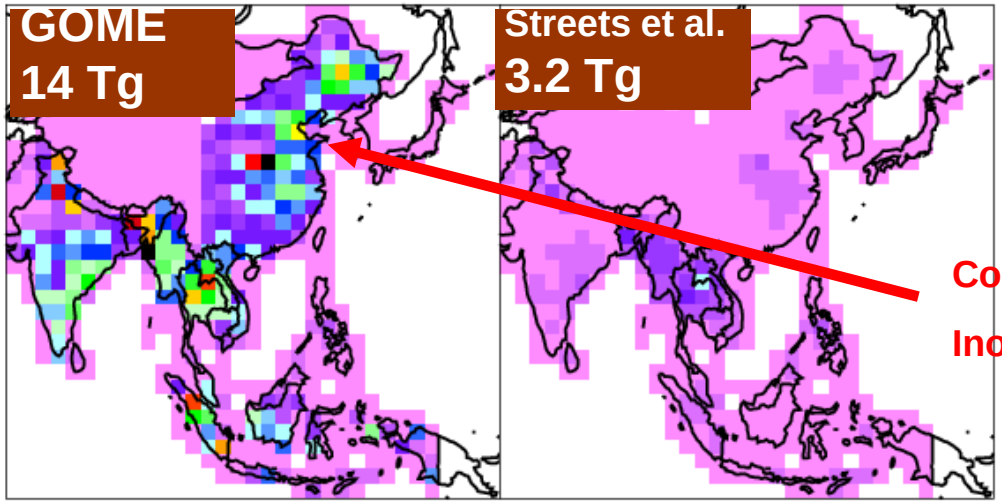
Lower emission from the evergreen broadleaf forests in Indonesia

Scaling factors GOME vs MEGAN

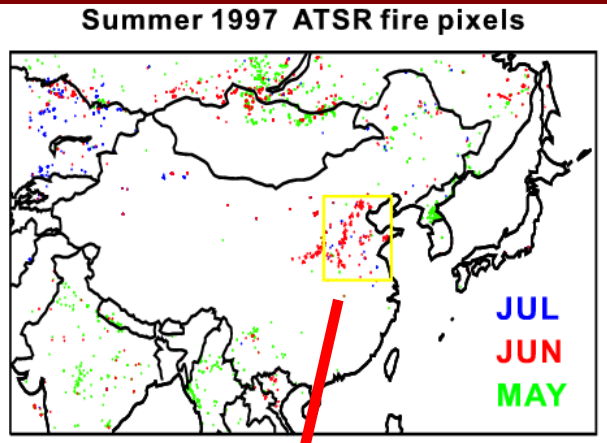


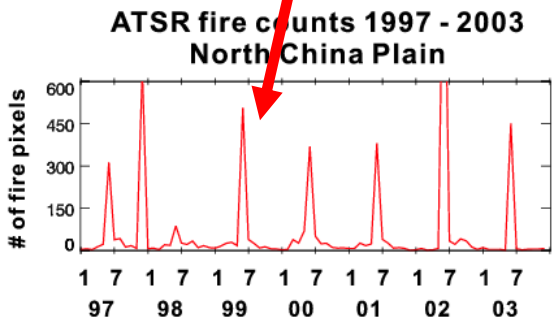
Fu et al. [2007]

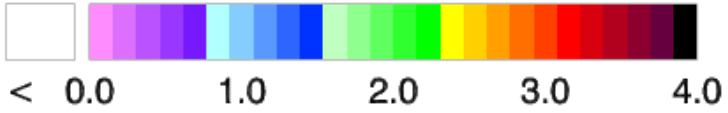
Biomass burning emission ~ 5 X current inventory!



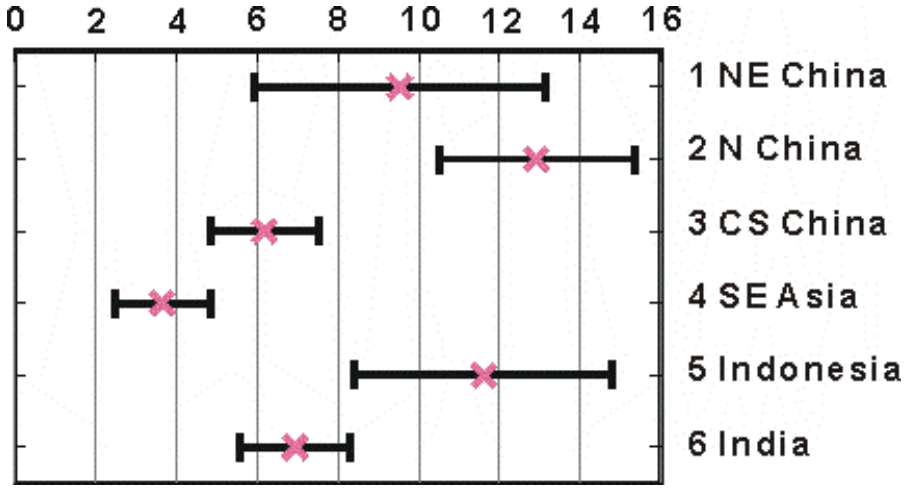
Confirmed in Inomata [2007]



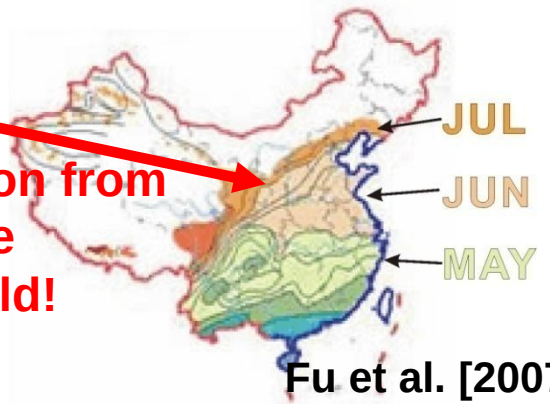




Scaling factors GOME vs Streets



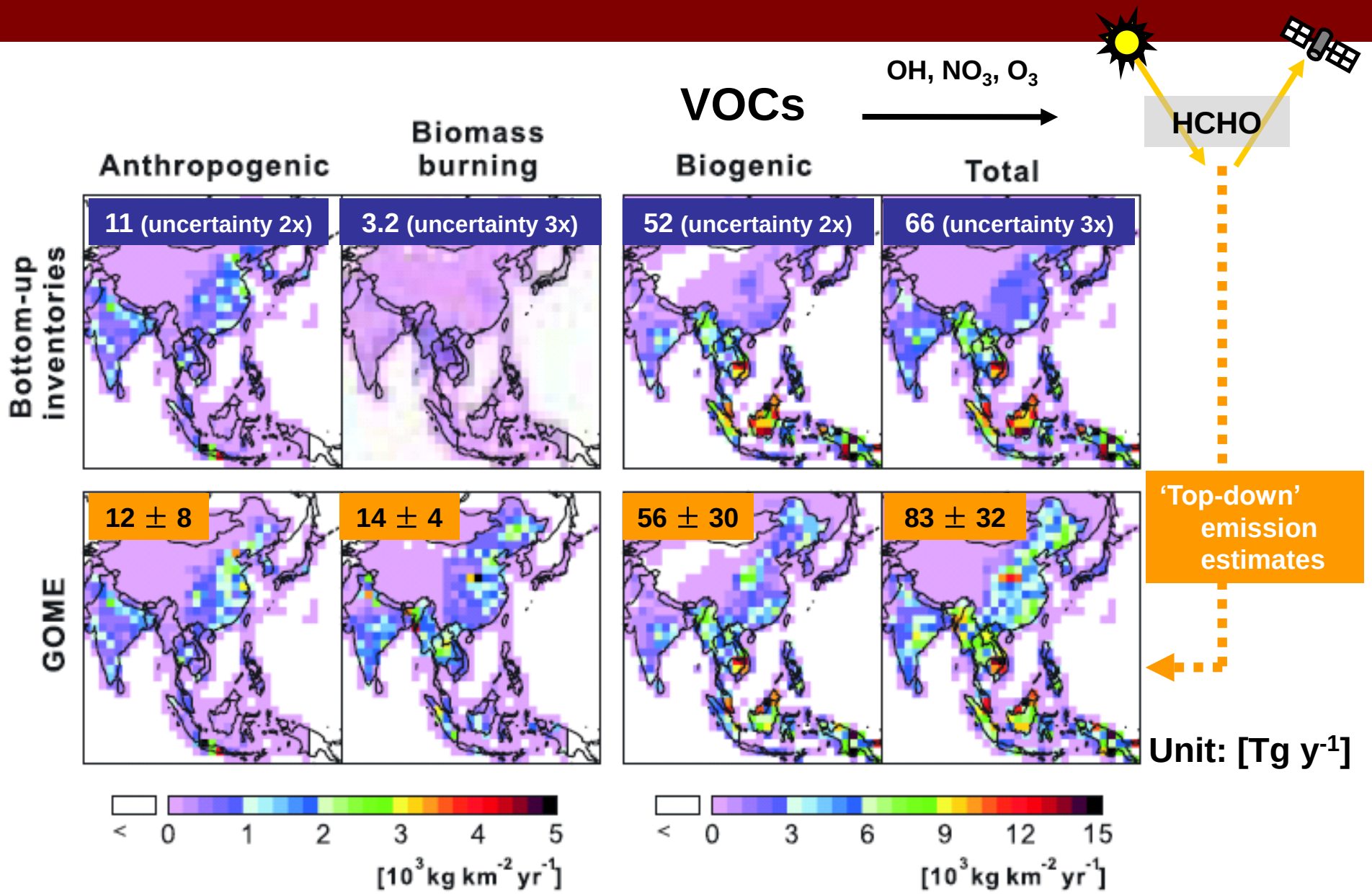
Winter wheat harvest



Large emission from wheat residue burning in field!

Fu et al. [2007]

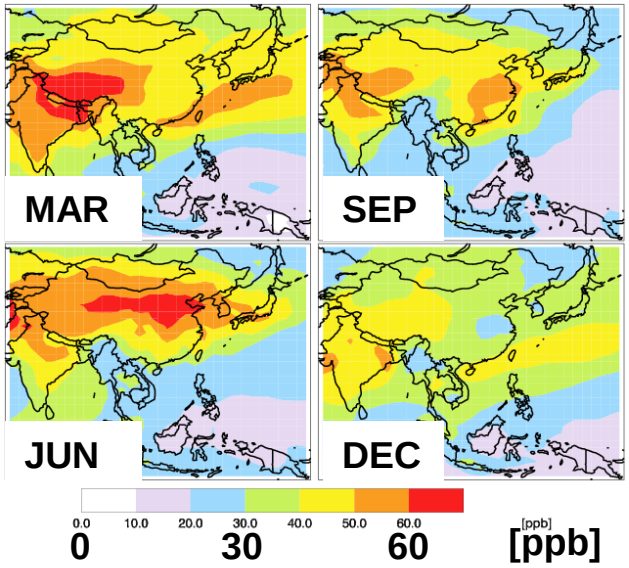
E & S Asian reactive VOC emissions



Fu et al. [2007]

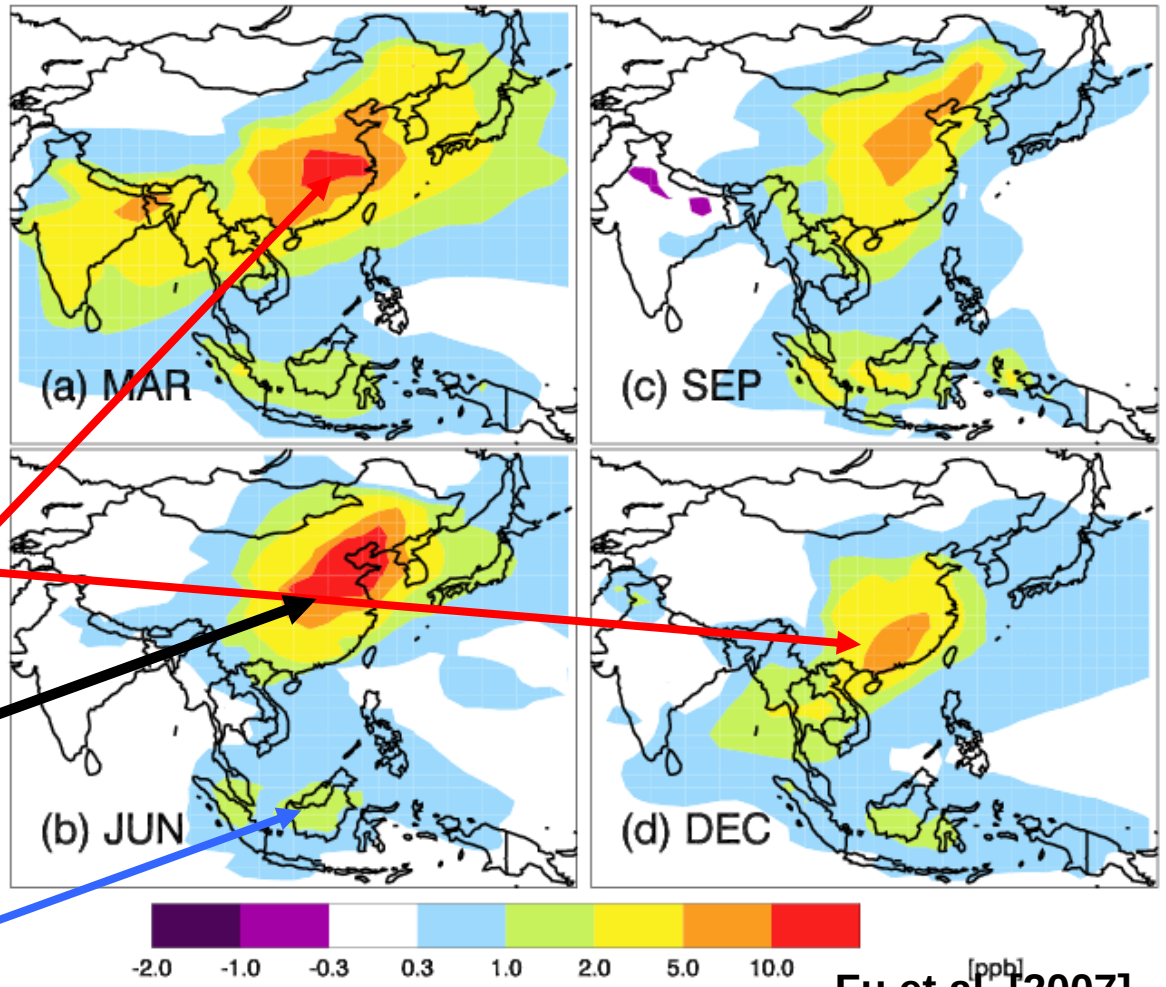
More NMVOCs → + 5 ~ 20 ppb O_3 in China

Mean afternoon O_3 at sfc w/ current inventories



[O_3] using new inventory consistent with measurements [Gao et al., 2005]

ΔO_3 at surface w/ GOME – w/ current inventories

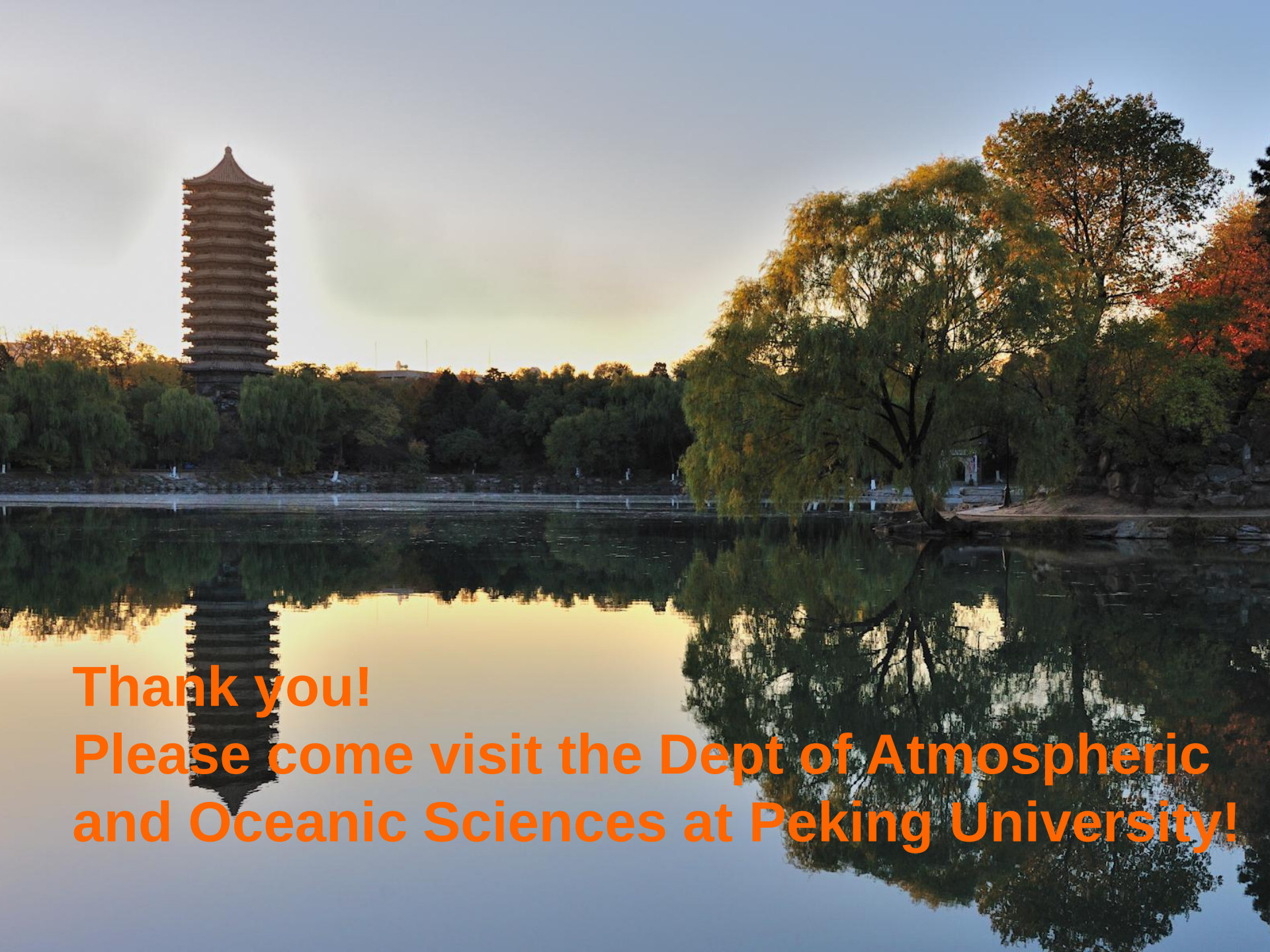


chemistry NO_x-saturated → large ΔO_3

NO_x-limited, but large increase in NMVOC emission still drives HO_x chemistry → significant ΔO_3

Strongly NO_x-limited → small ΔO_3

Fu et al. [2007]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