An Improved Retrieval Algorithm for NO_2
&
A Novel Model System to Integrate Multiple Geostationary Satellite Measurements

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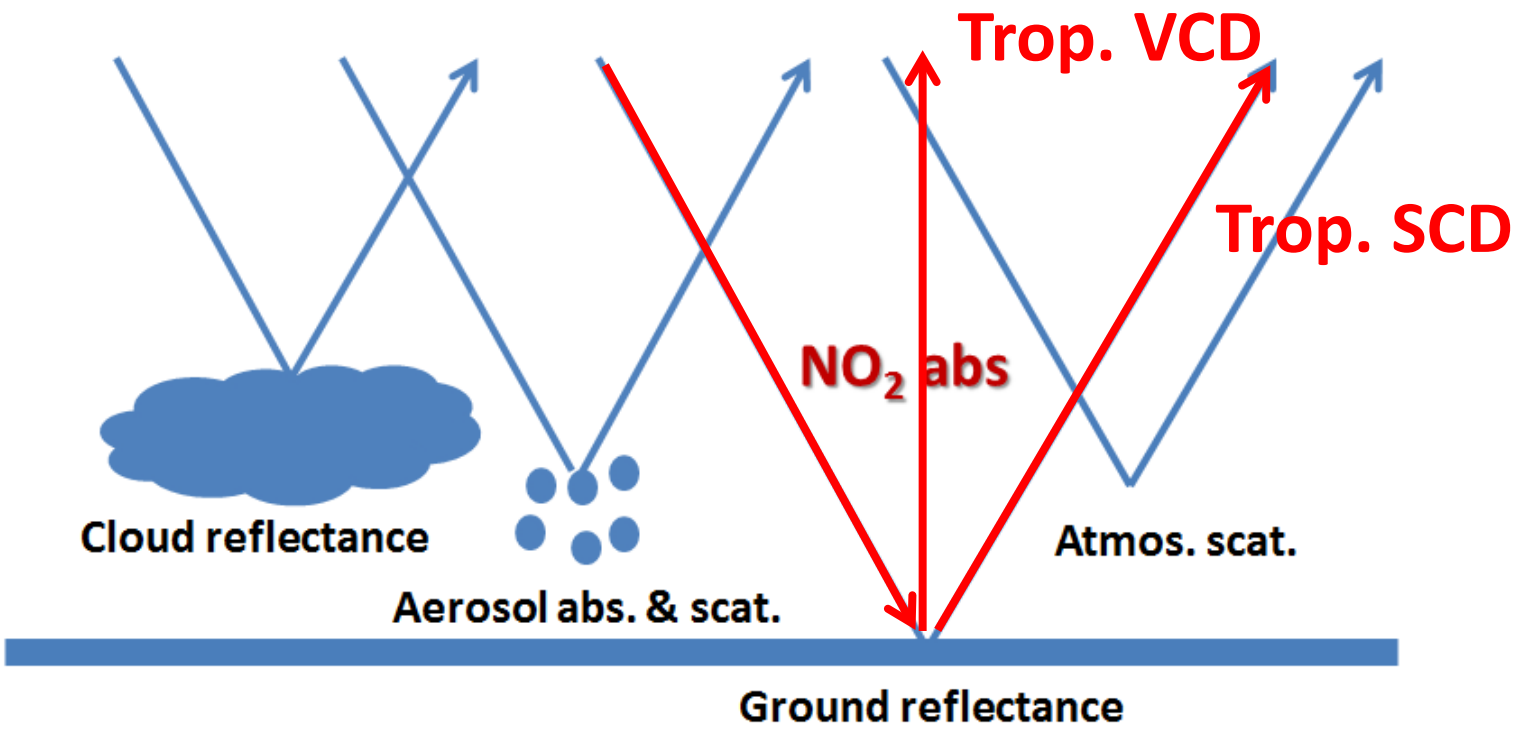
Part Ⅰ

An Improved Retrieval Algorithm for NO_2

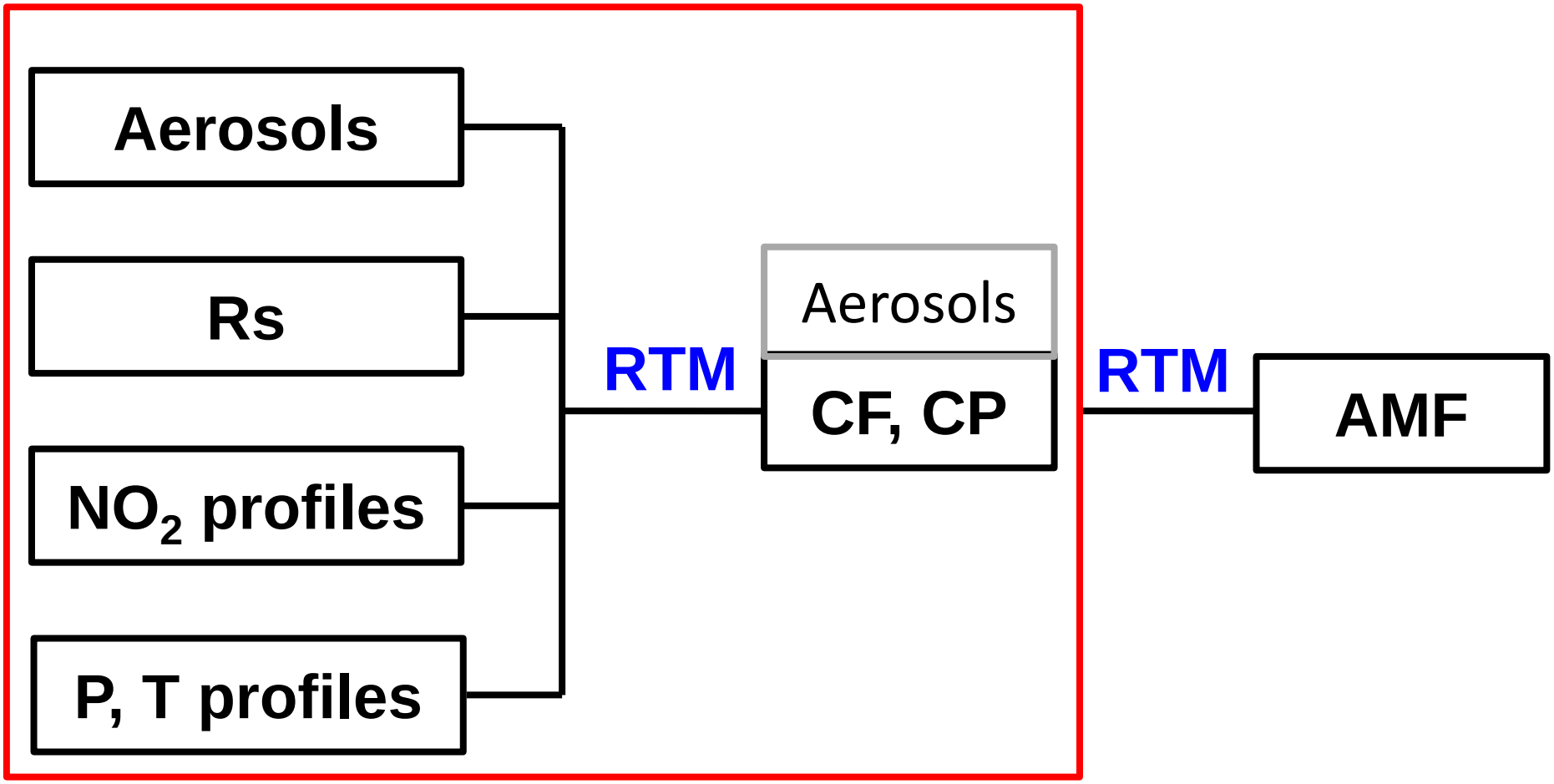
AMF is the critical factor for NO_2 retrieval

- SCD = F(radiance)
- SCD_T = SCD – SCD_S
- VCD_T = SCD_T / AMF



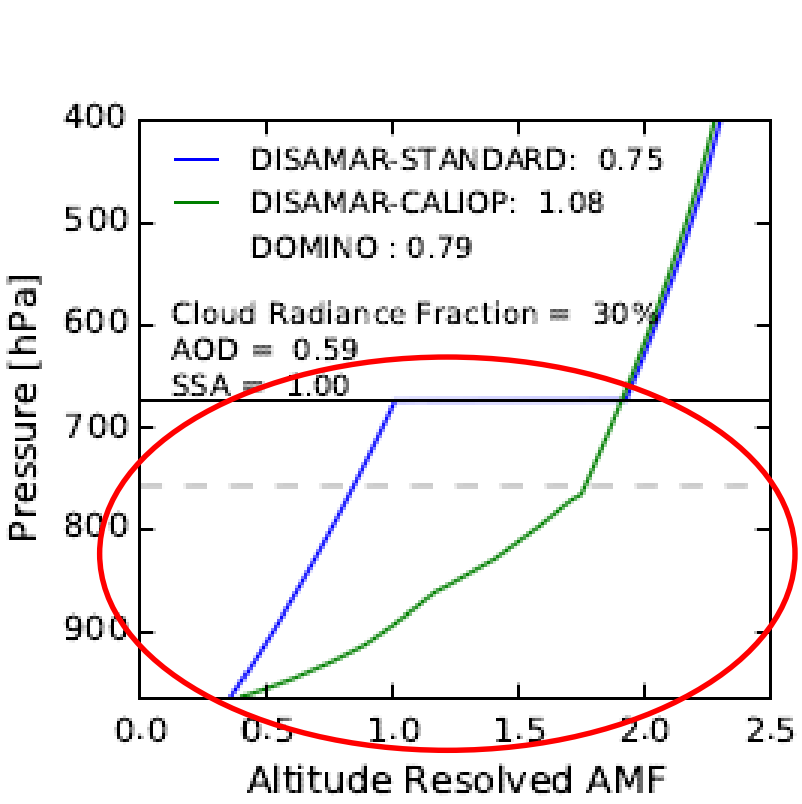
AMF illustrate the contribution of the vertical column to the slant column

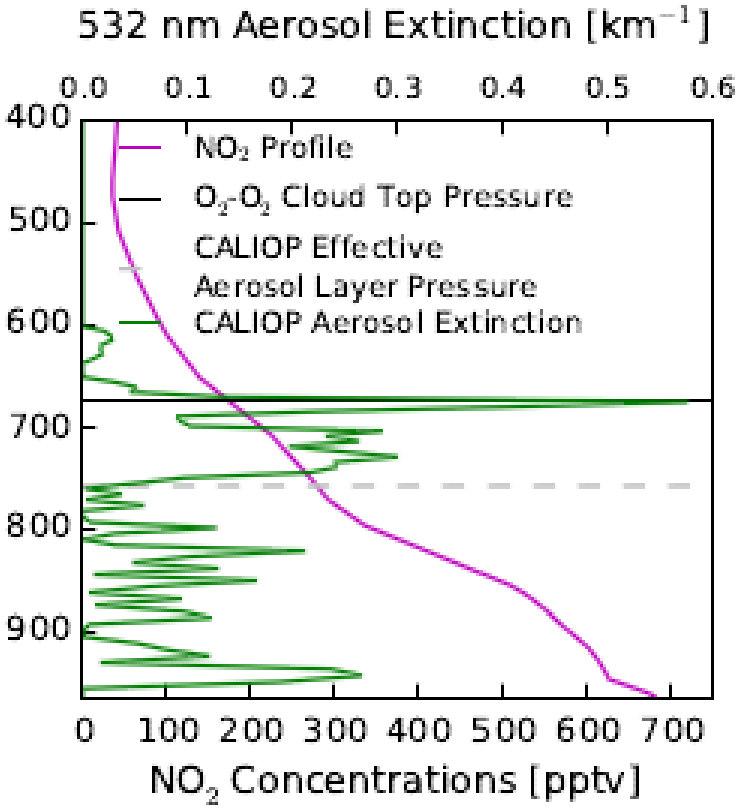
NO_2 Products don't explicitly count aerosols' effect



** " effective cloud" is Lambert reflector with albedo 0.8. cloud base starts from the ground。Effective Cloud fraction（CF）and effective cloud pressure （CP）are used to parameterize the cloud.

Aerosol profiles has a big impact on AMF profiles

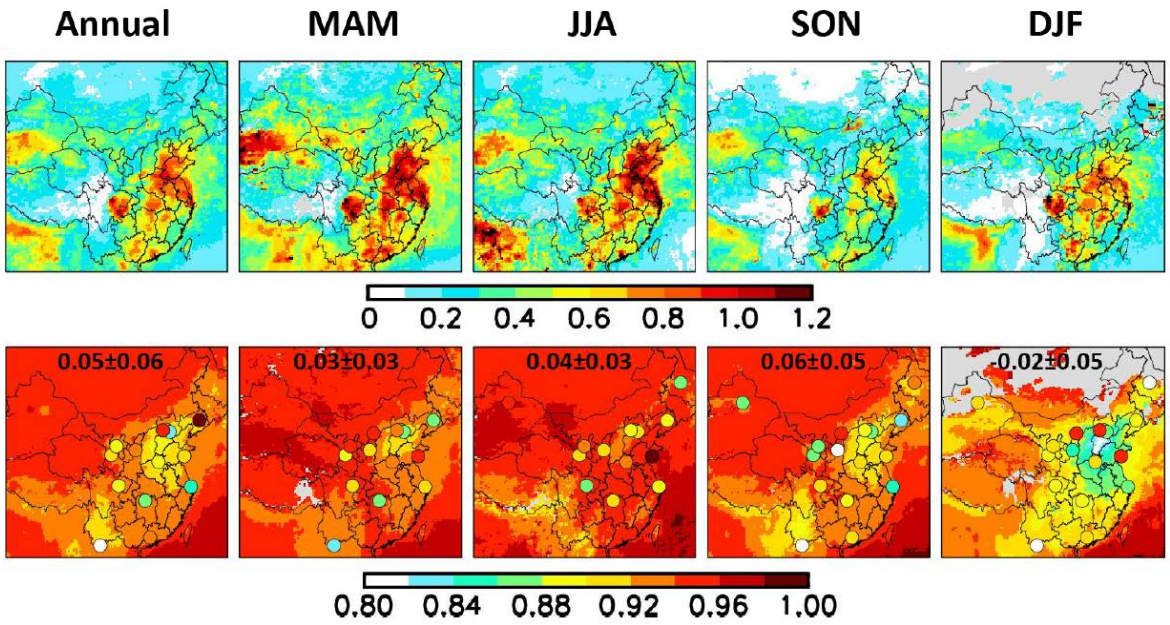




(Castellanos et al., ACP, 2015)

- **AMF profile is discontinuous near the "effective cloud" without aerosols**
- **Big difference exist under the "effective cloud"**

Aerosol Treatment is Critical over China



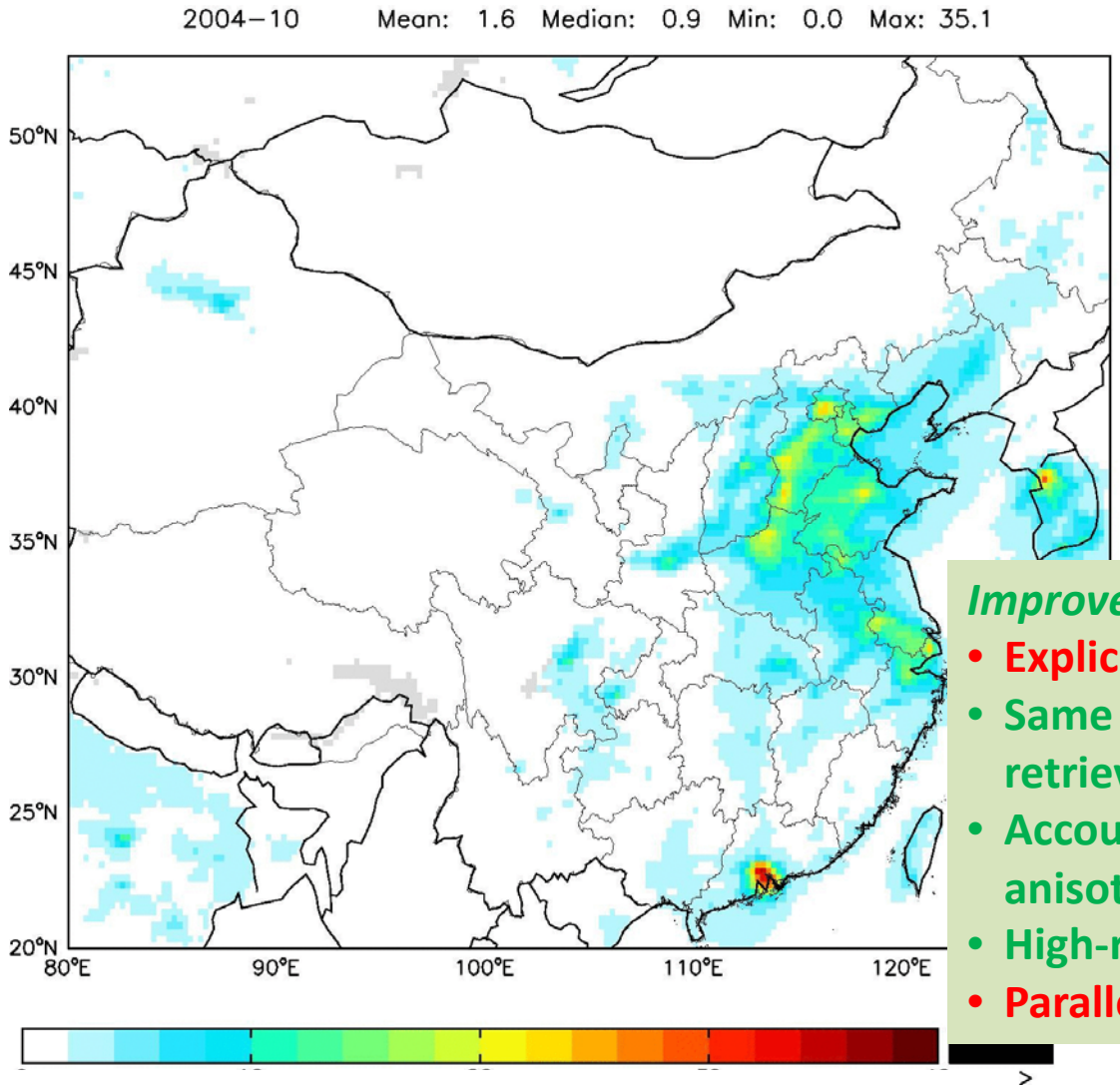
Characteristics of Chinese aerosols:

- Large amounts in key areas
- Highly absorbing in many areas
- Considerable spatiotemporal variability

Lin and Liu et al., 2015, ACP

POMINO – Peking University OMI NO_2 Product

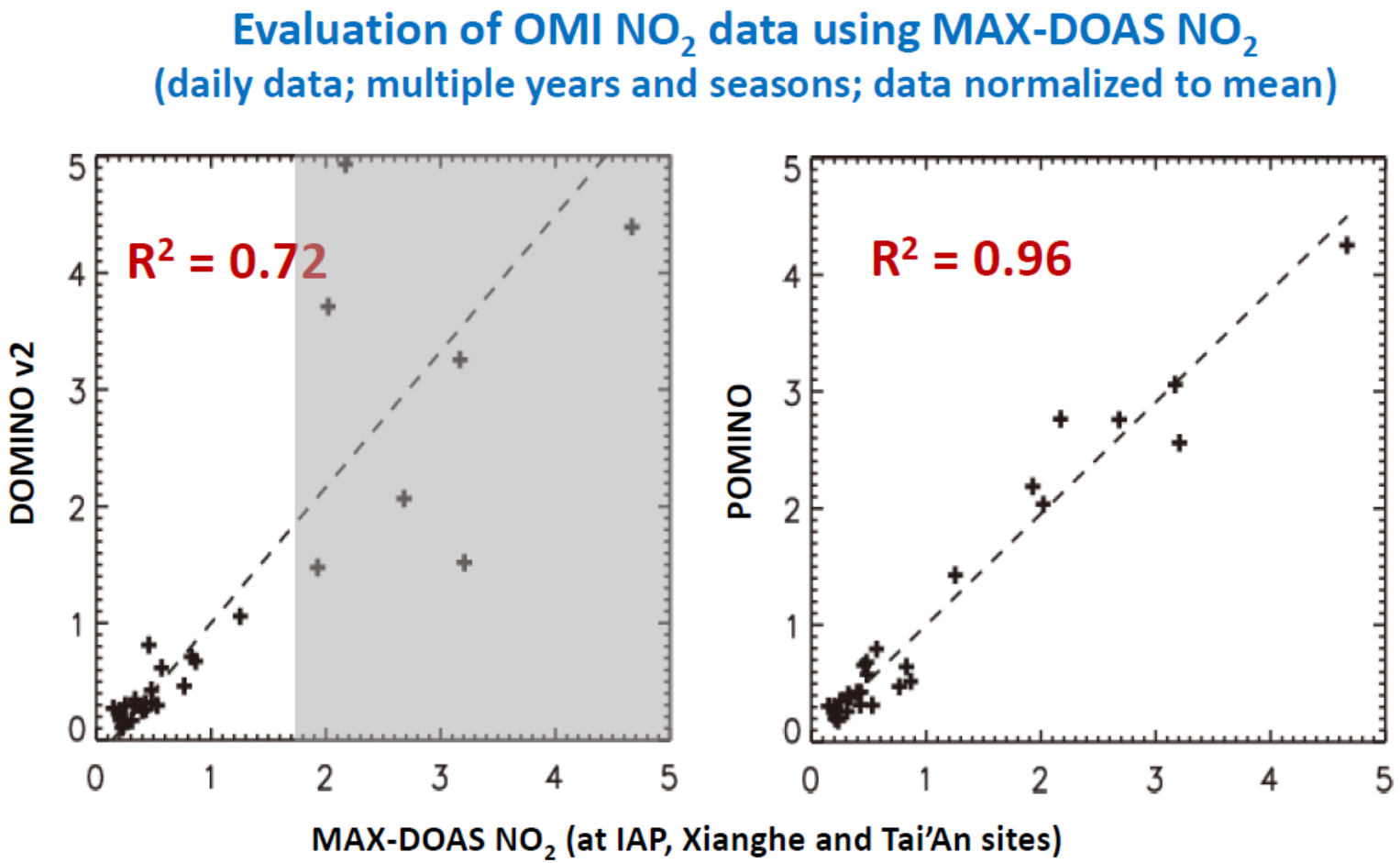
http://www.atmos.pku.edu.cn/acm/satellite_no2.html



Improvements in our POMINO:

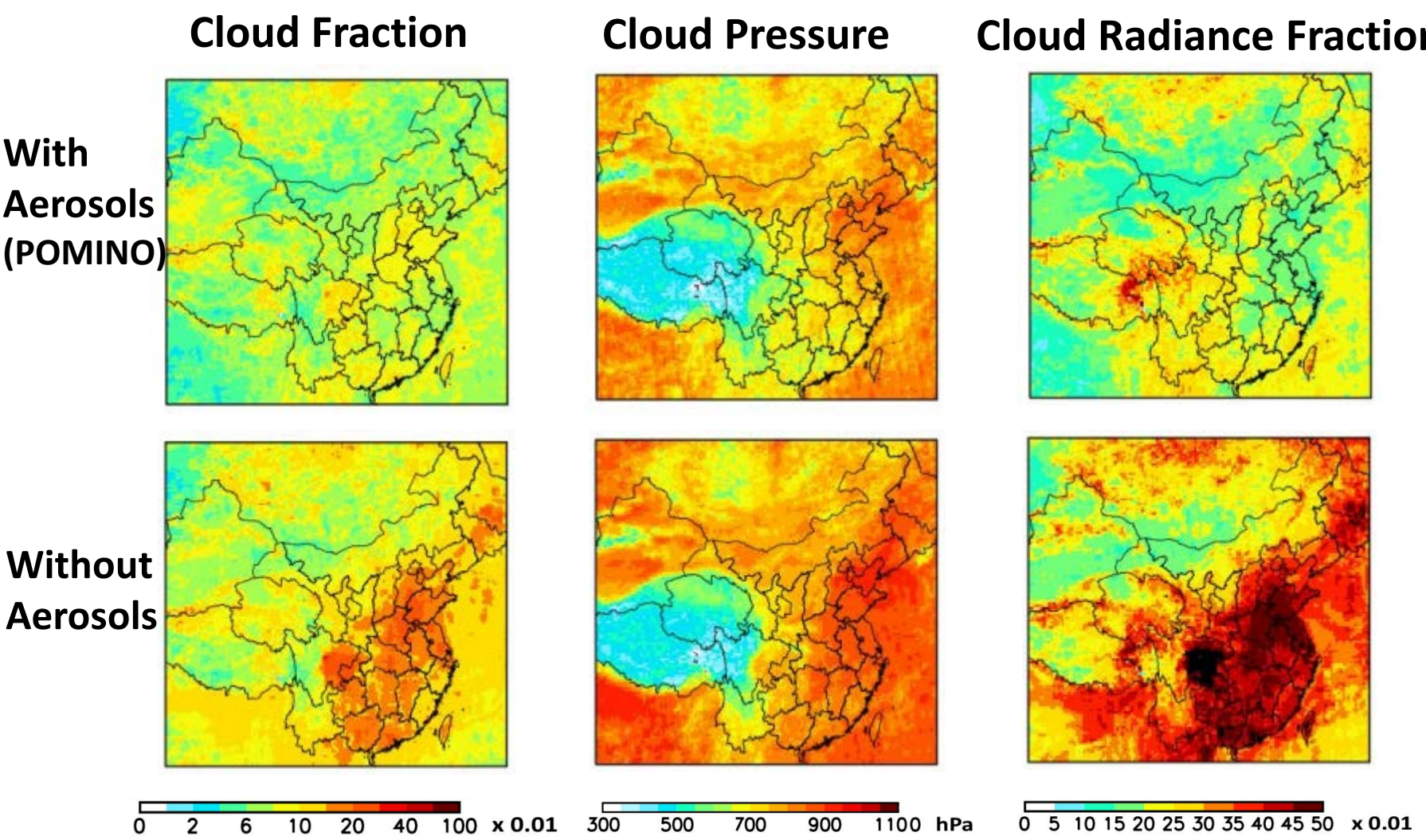
- Explicitly accounting for aerosols
- Same ancillary assumptions in retrieving NO_2 and clouds
- Accounting for surface reflectance anisotropy， use BRDF
- High-resolution NO_2 profile (50 km)
- Parallelized RTM calc. for each pixel

POMINO: Improved NO_2 Retrieval from OMI



Lin et al., 2014 ACP

Aerosols Complexly Affect Cloud Retrieval

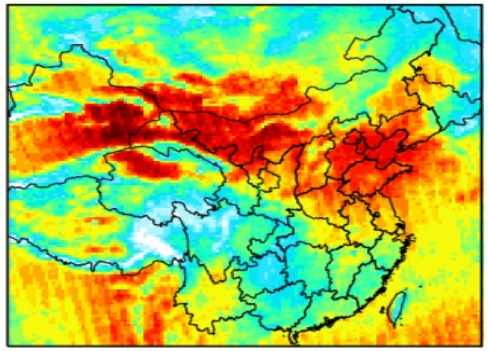


Lin and Liu et al., 2015, ACP

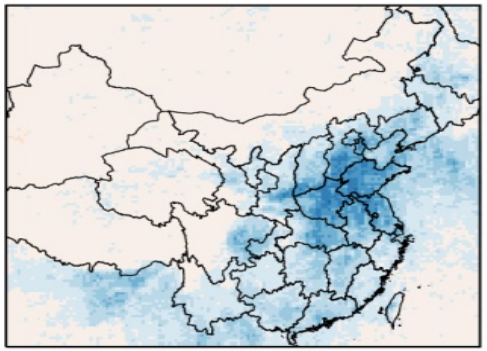
Explicit Aerosol Treatment Reduces Sampling Low Bias

Valid pixels:
CRF ≤ 50%

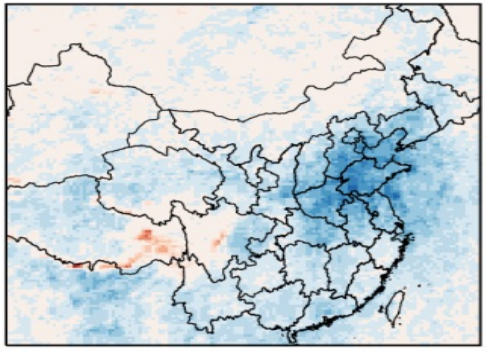
Days per month w/ valid data in POMINO



noAER – POMINO



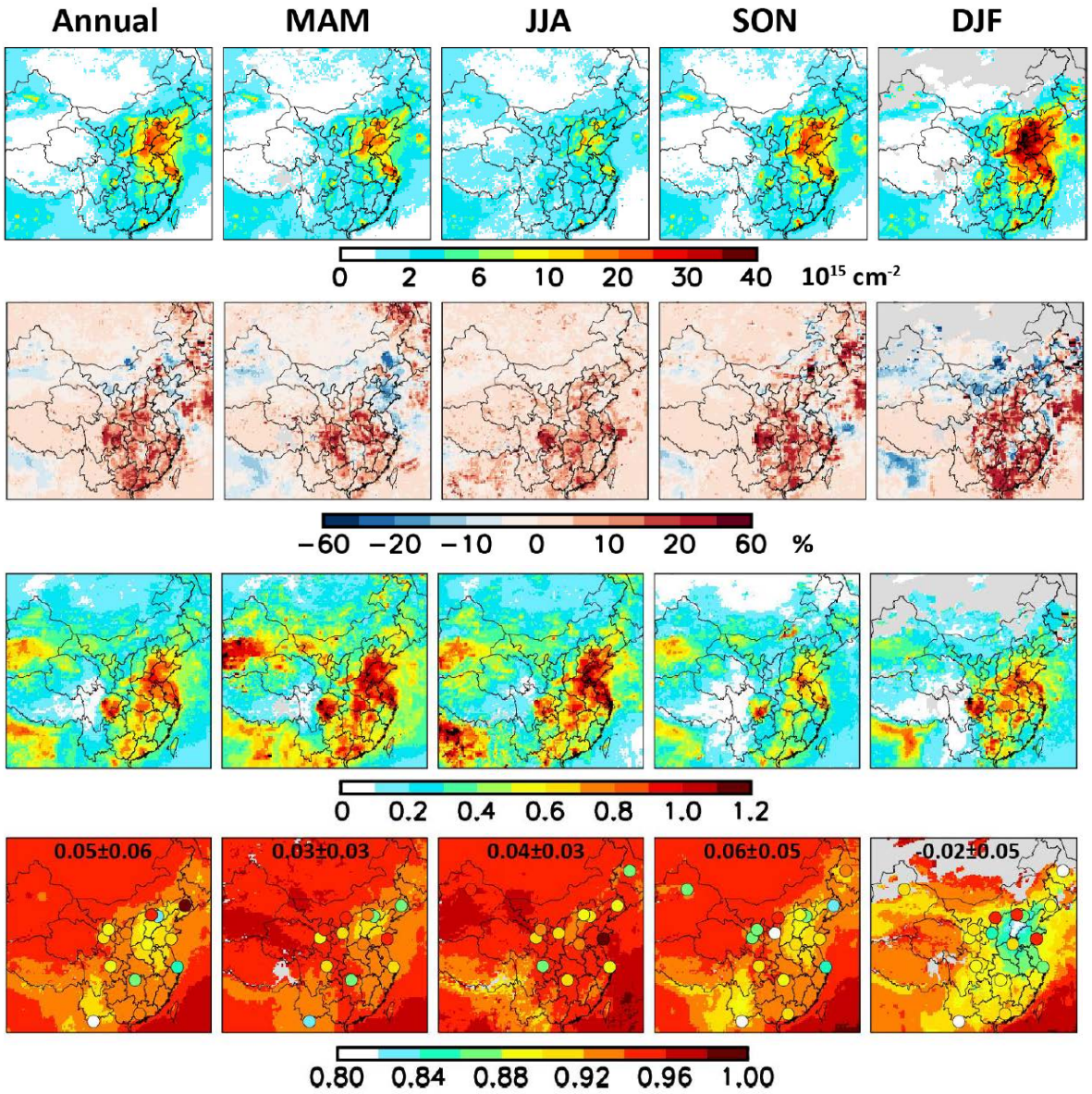
DOMINO – POMINO



- **An explicit treatment better accounts for high-pollution days**

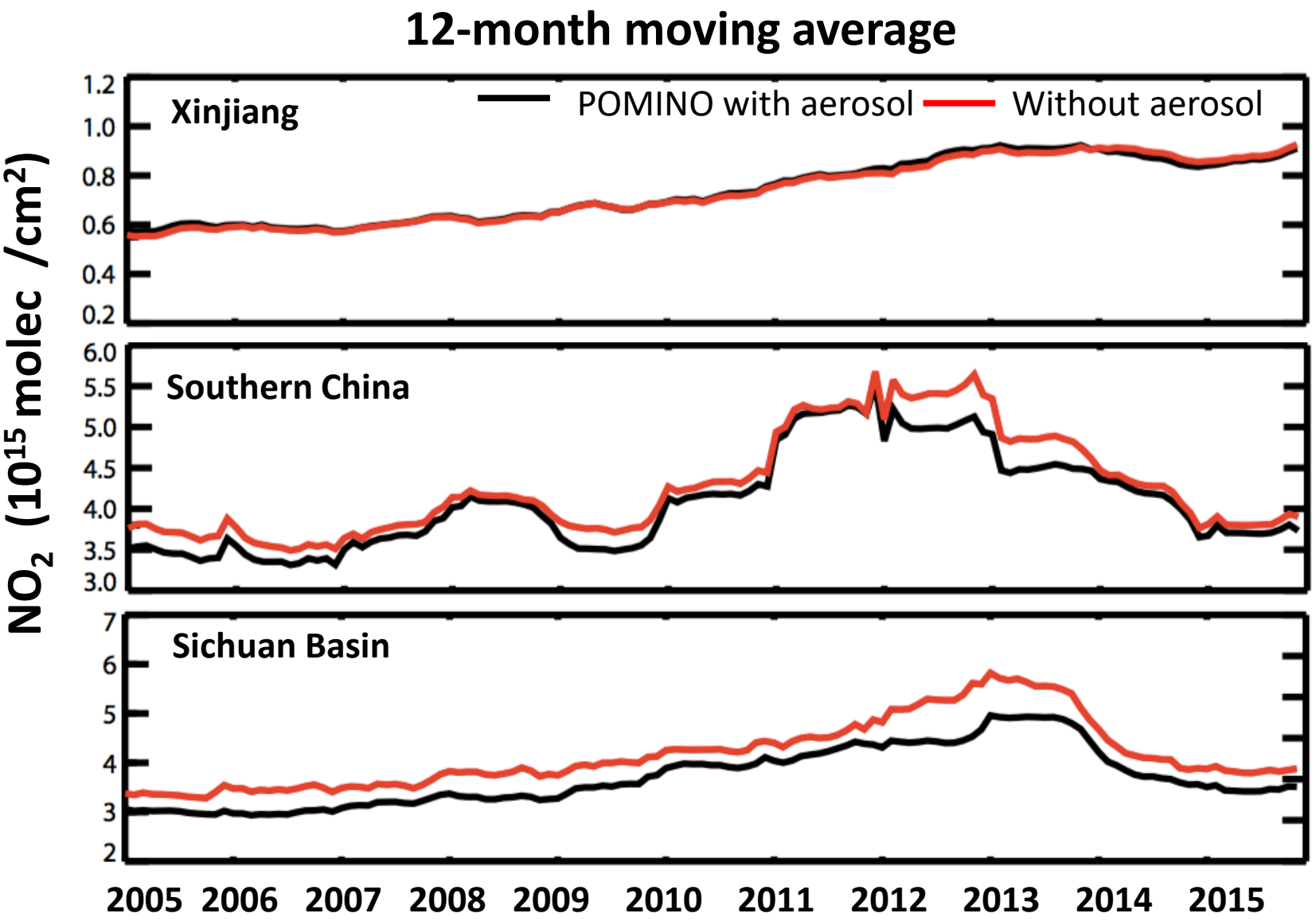
Lin and Liu et al., 2015, ACP

Explicit Aerosol Treatment Improves NO_2 Retrieval



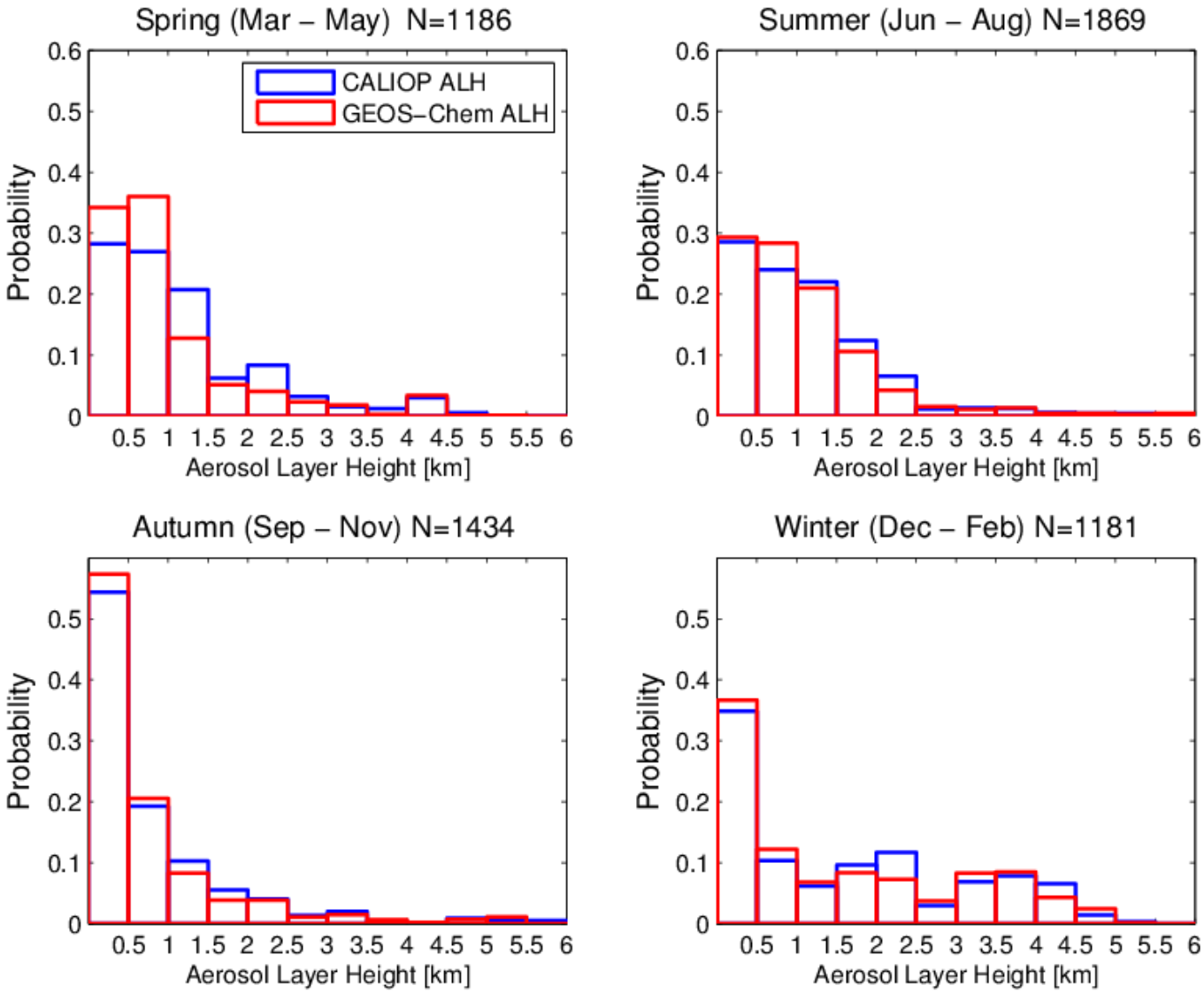
Lin and lin et al., 2015, ACP

Aerosols' influence on NO_2 trends are time and place dependent



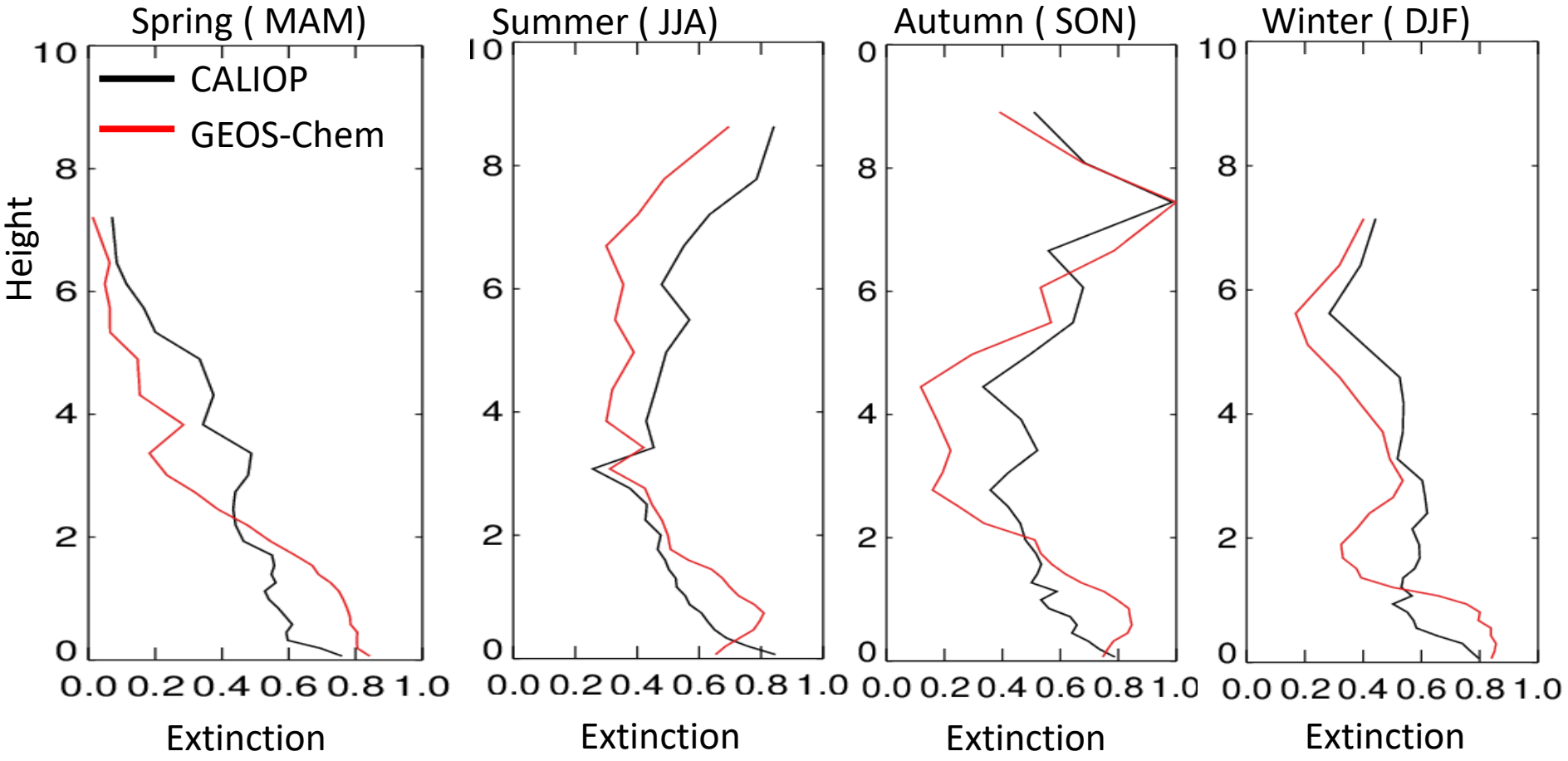
Model capture aerosol layer heights fairly well

Aerosol Layer Height in Eastern China from 2007 to 2012 (obs vs model)



Aerosol profiles is dependent on time and space

Relative Aerosol Extinction Profiles in Eastern China: 2007-2012 (obs vs model)

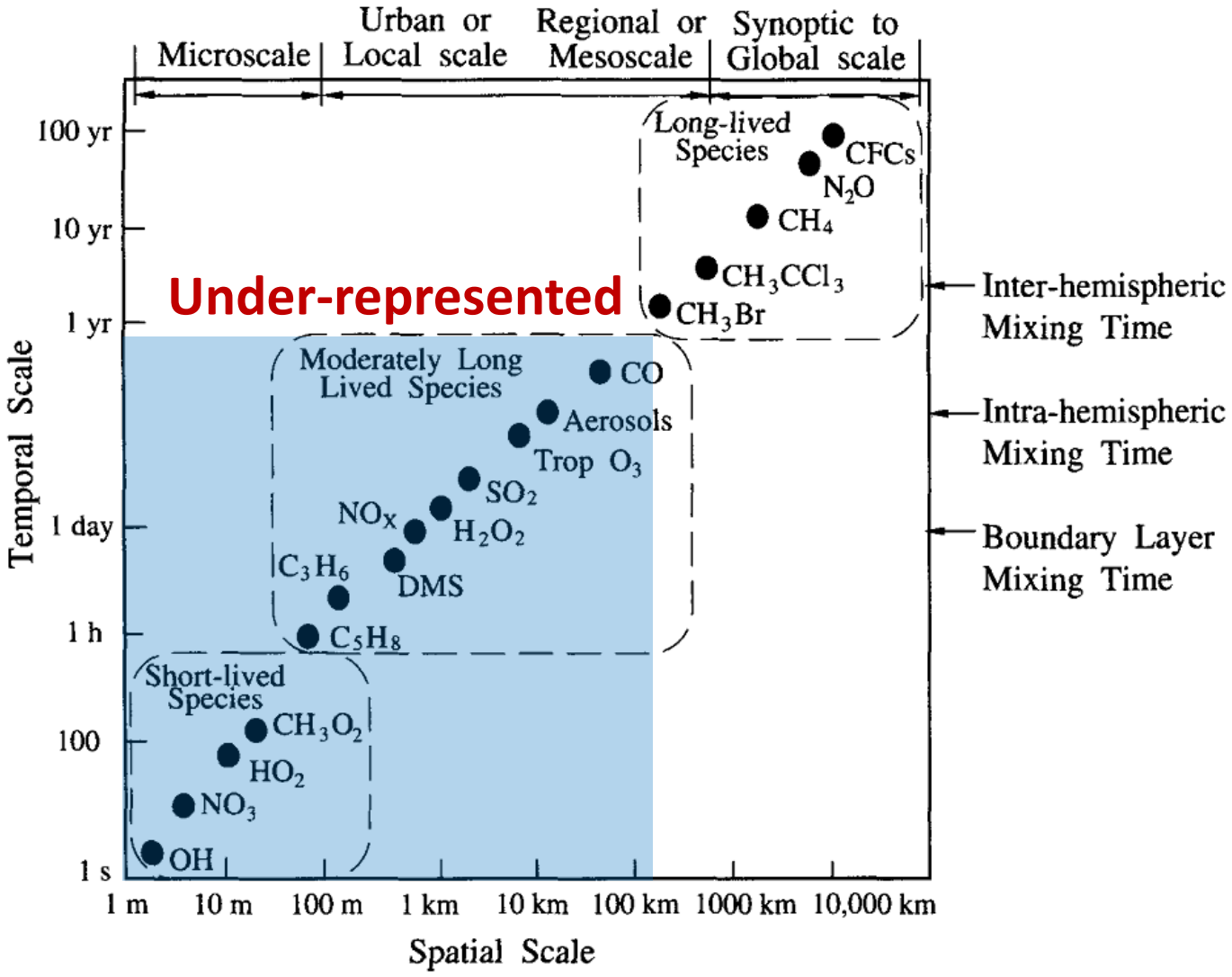


- Aerosol profiles varied significantly in different seasons
- Model capture variability of aerosol extinction profiles

Part Ⅱ

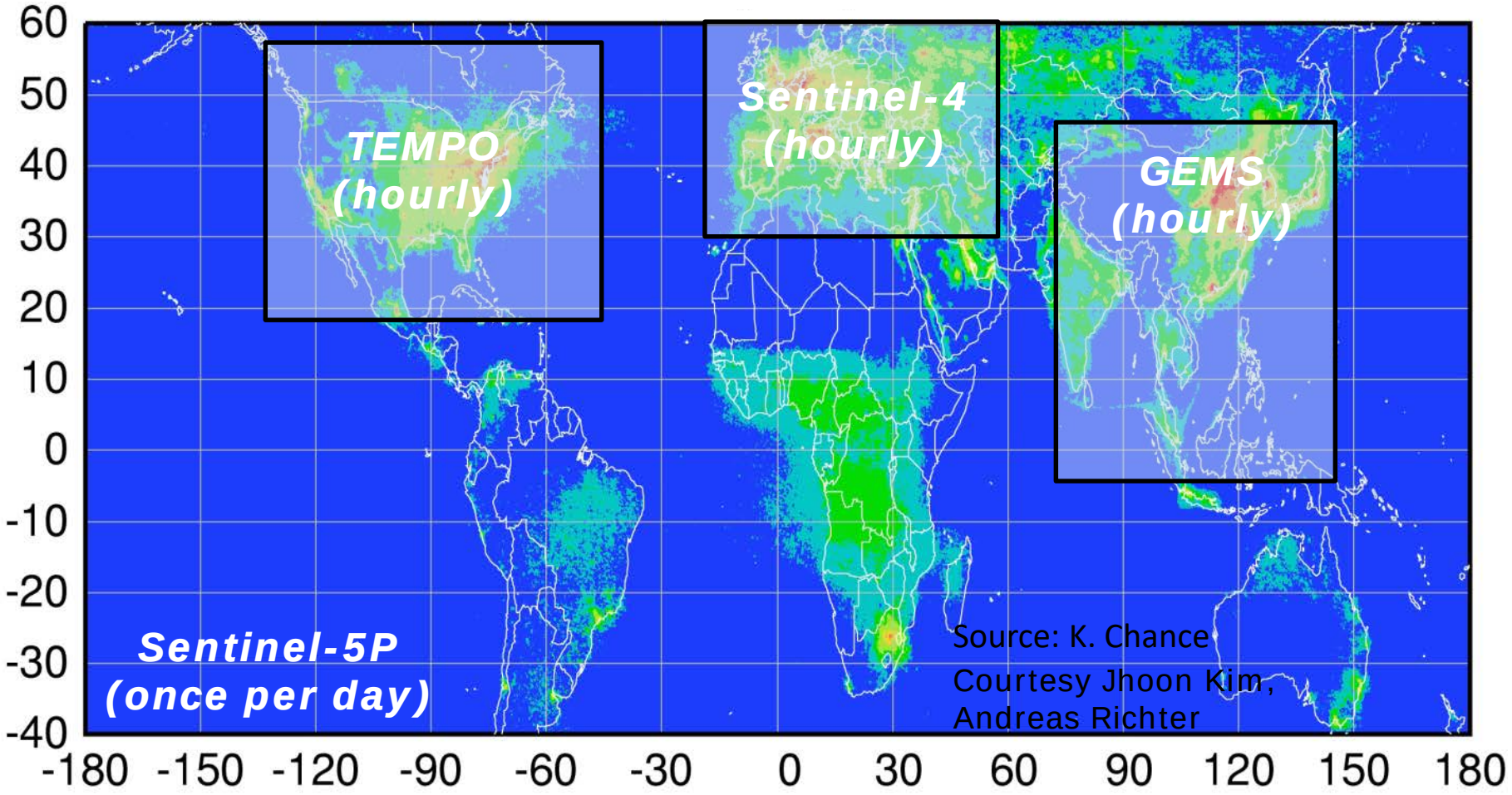
Two-way Coupled Model to Integrate Multiple Geostationary Satellite Measurements

Coarse Models Under-represent Small Scales



Seinfeld and Pandis, 2006

A Fast and High-res Global Modeling System is Needed to Interpret Geostationary Satellite Measurements

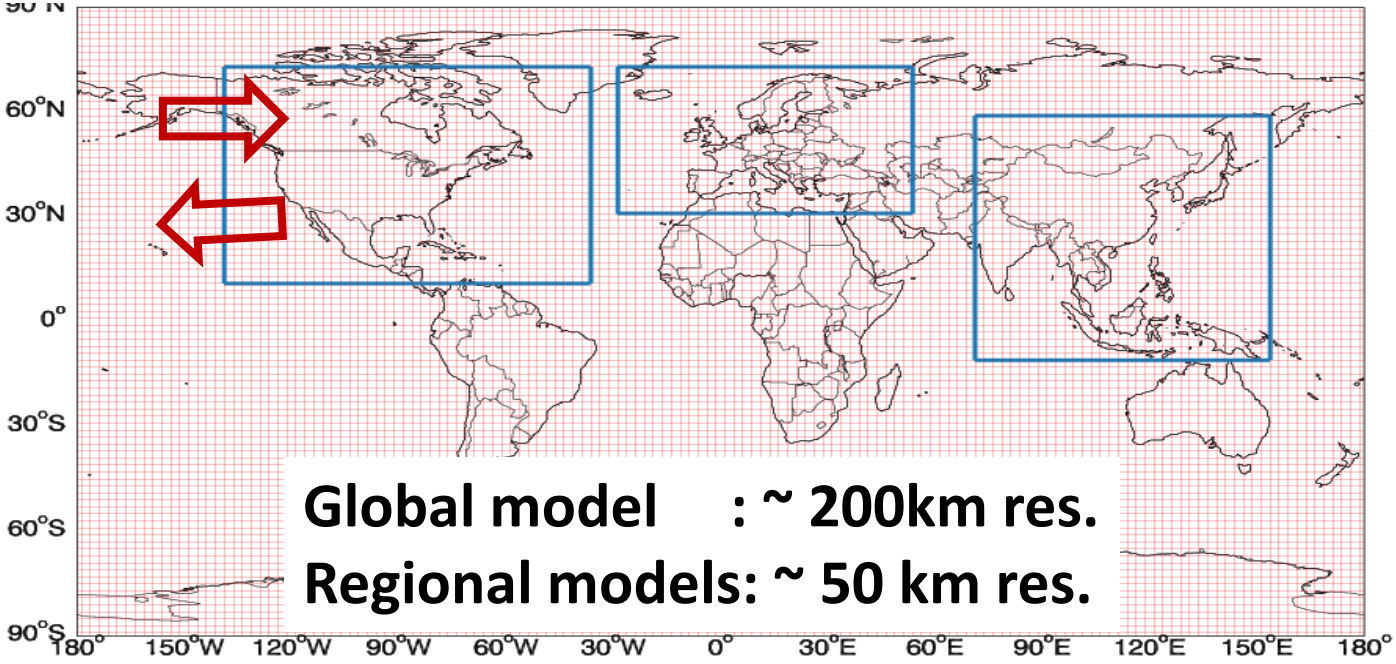


- Most global models are too coarse (200 km) to simulate fine processes

First Global-multi-regional Two-way Coupled Modeling

Based on GEOS-Chem

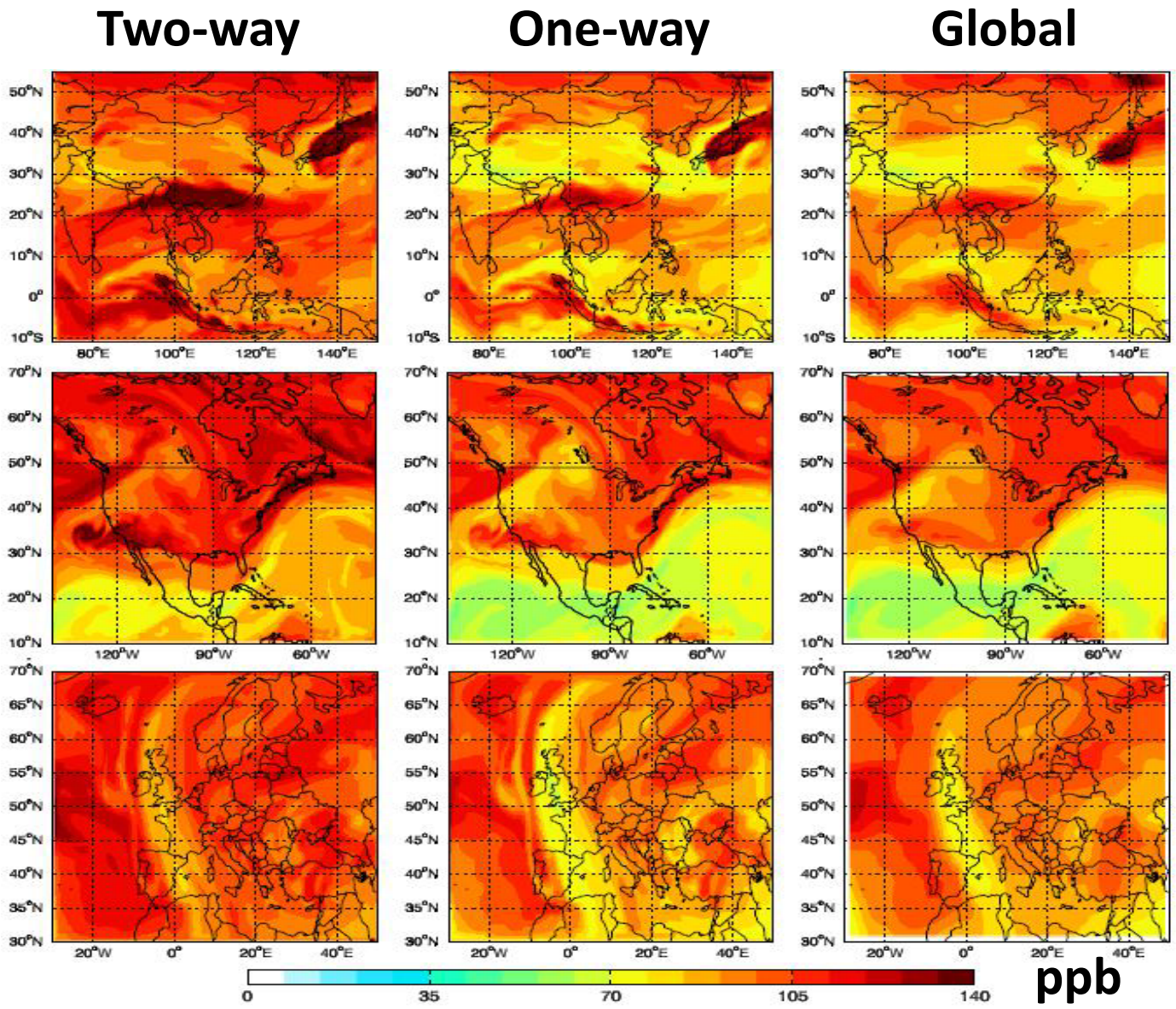
- High-res regional nested simulations 'correct' global model
- Global and multiple regional models interact simultaneously
- High computation efficiency and low model complexity



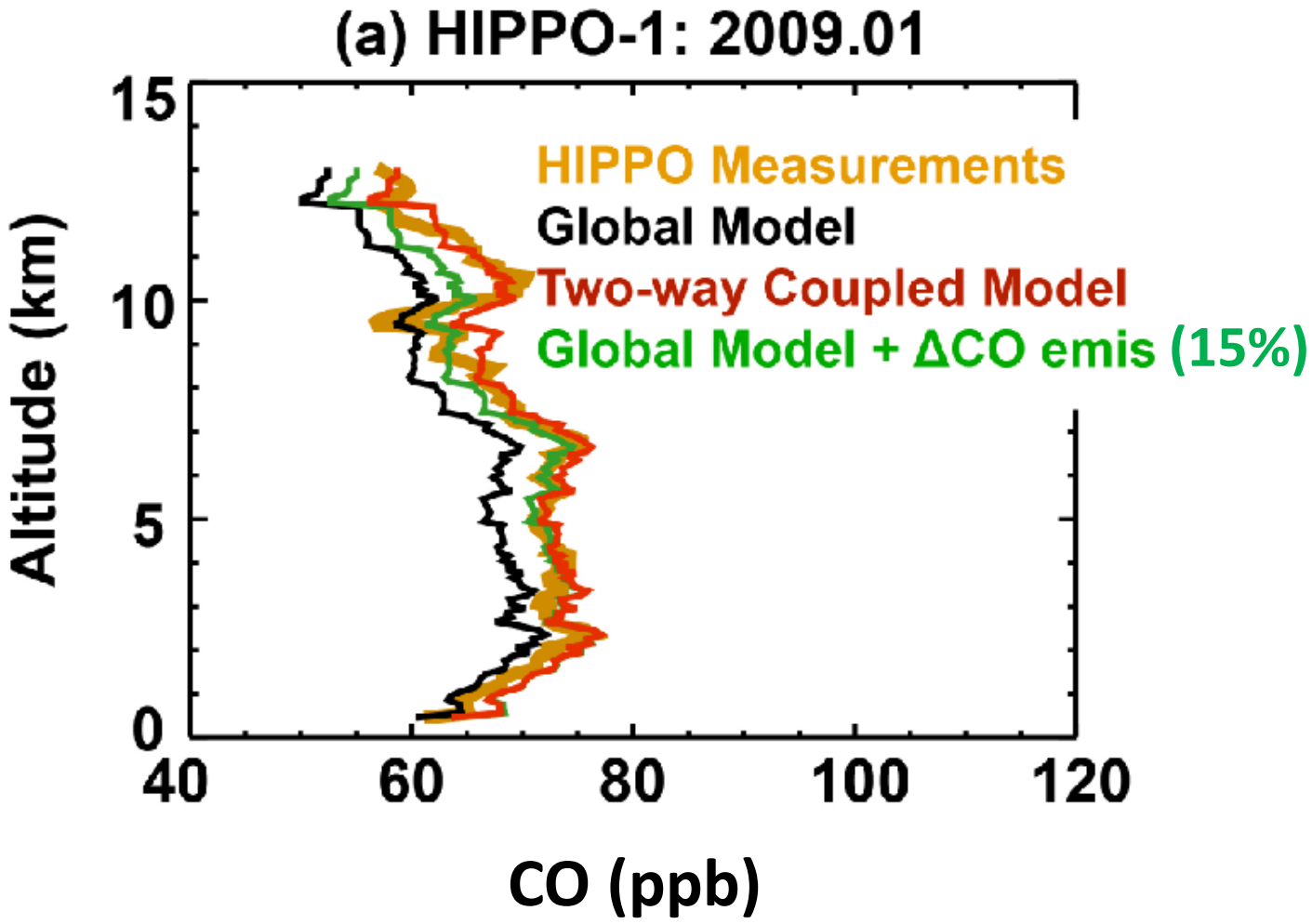
Yan Y.-Y. et al., 2014, ACP

2-way Coupling Better Simulates Regional CO

CO at 6.5 km altitude at 2009/01/31 3:00UTC

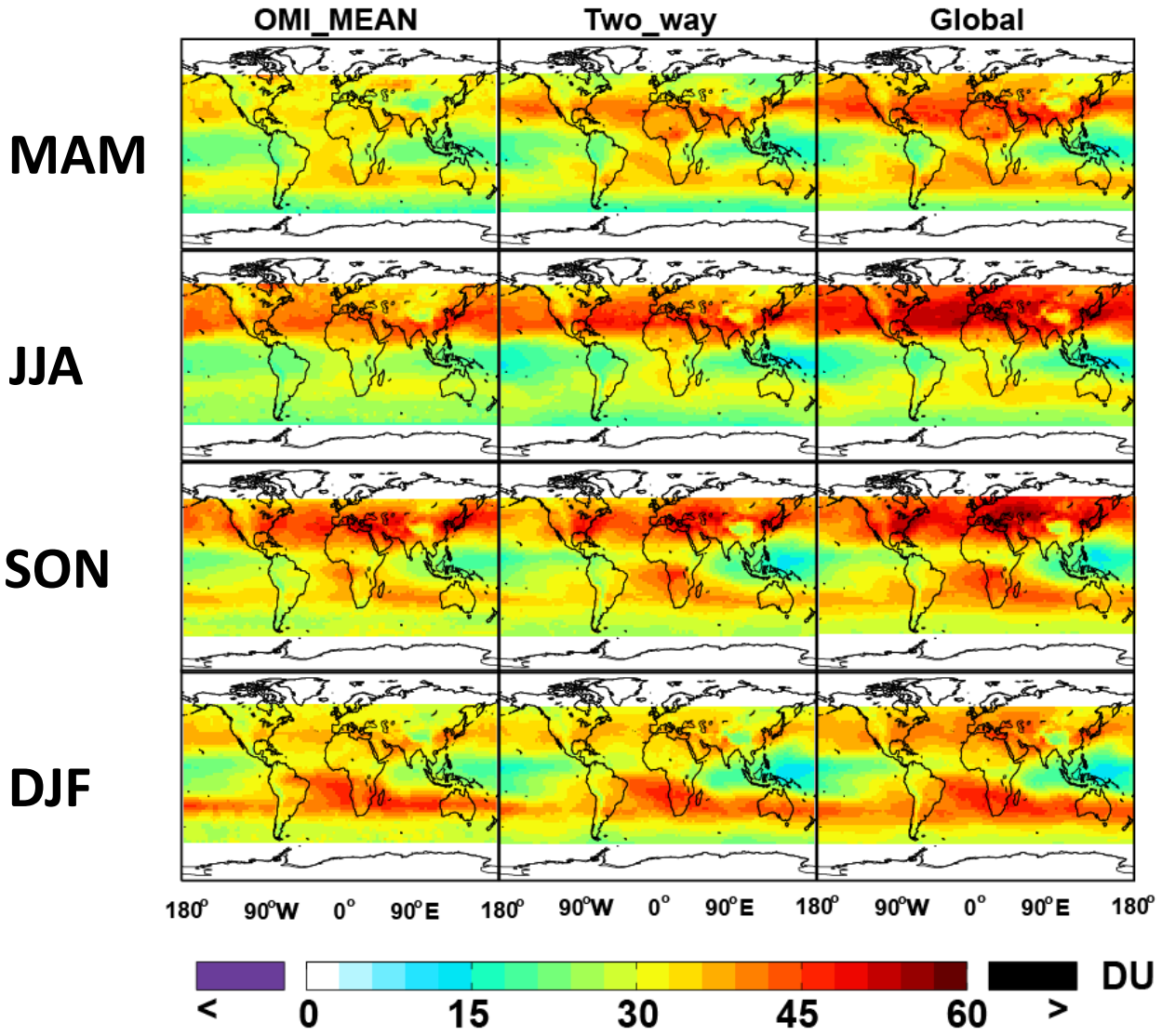


2-way Coupling Improves CO Simulation over the Pacific



Yan Y.-Y. et al., 2014, ACP

2-way Model Better Simulates O_3 Columns



2-way Coupling Improves Tropospheric Simulation

	Global Model	Two-way Model	'Observation'
OH (10^5 cm^{-3})	11.8	11.2 (– 5% *)	10.4 – 10.9
MCF lifetime (yr)	5.58	5.87 (+ 5.2%)	6.0 – 6.3
CH_4 lifetime (yr)	9.63	10.12 (+ 5.1%)	10.2 – 11.2
O_3 (DU)	34.5	31.5 (– 8.7%)	31.1 ± 3 (OMI/MLS)
O_3 (Tg)	384	348 (– 9.4% #)	
NOx (TgN)	0.169	0.176 (+ 4.1%)	
CO (Tg)	359	398 (+ 10.8%)	
NMVOC (TgC)	10.1	10.2	

* Greater than its interannual variability (2.3%)

\# Greater than the change from 2000 to 2100 under RCP6.0

Yan Y.-Y. et al., 2014, ACP; 2016, ACP

Summary

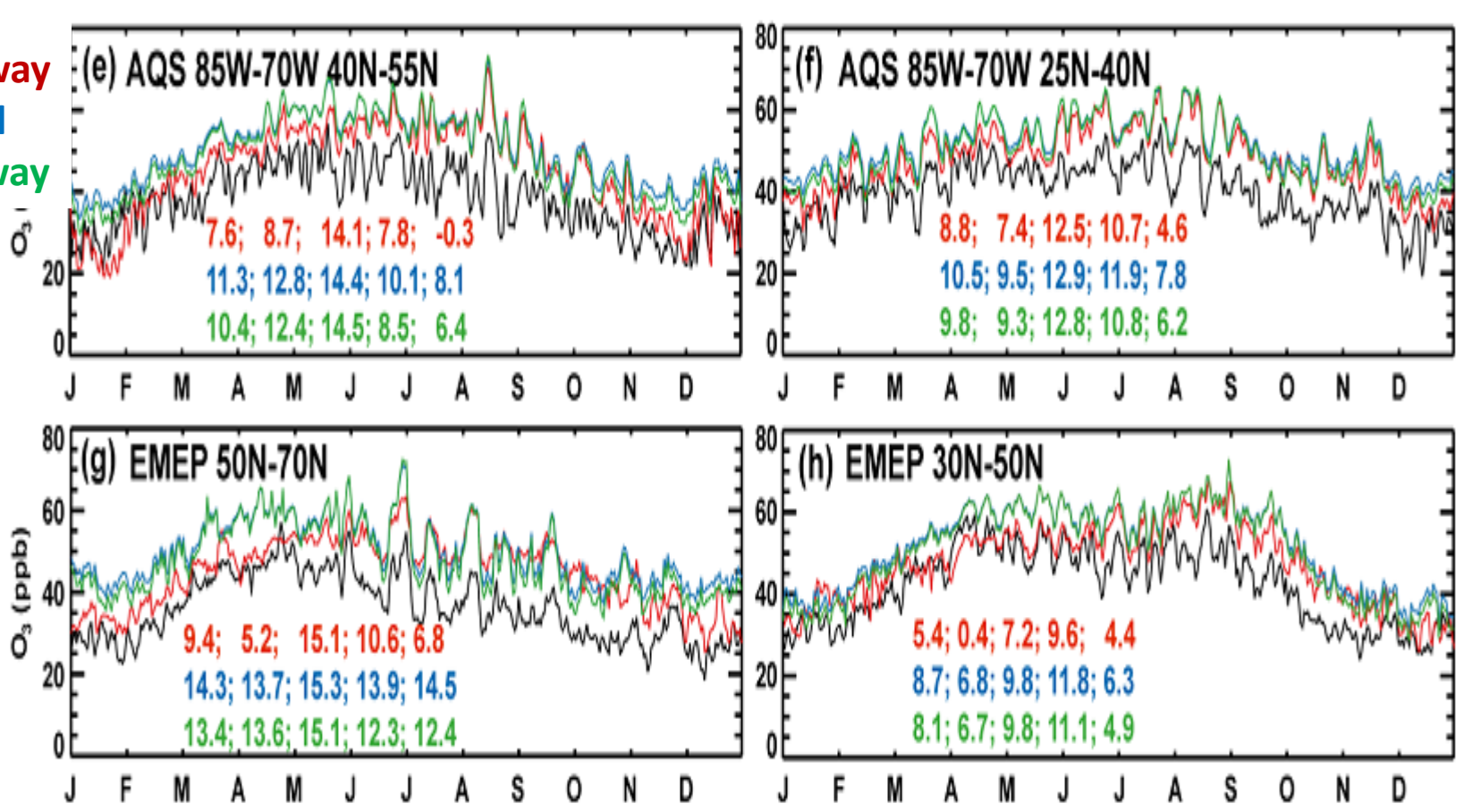
- **POMINO: Our improved OMI NO_2 product**
  - **Fully account for aerosol optical effects**
  - **Fully account for surface reflectance anisotropy**
  - **Account for high-res vertical profile of NO_2**
  - **Consistent retrievals of cloud properties and NO_2**
  - **Line-by-line radiative transfer calculation (no LUT)**
- **POMINO data notably affect NOx emis variability estimate**
- **Our retrieval can apply to SO_2, HCHO, CHOCHO, etc.**
- **A high-res model system to integrate global satellite data**

More analyses can be found at
http://www.atmos.pku.edu.cn/acm/acmProduct.html

2-way Model Better Simulates Surface O_3

Comparisons with AQS and EMEP observations:

- **Improvement is most significant in cold season**
- **Improvement from 1-way to 2-way is 1-7 times that from global to 1-way**



Yan Y.-Y. et al., ACP, 2014, 2016