The Recent Activities of Atmospheric Chemistry Remote Sensing in NSMC/CMA

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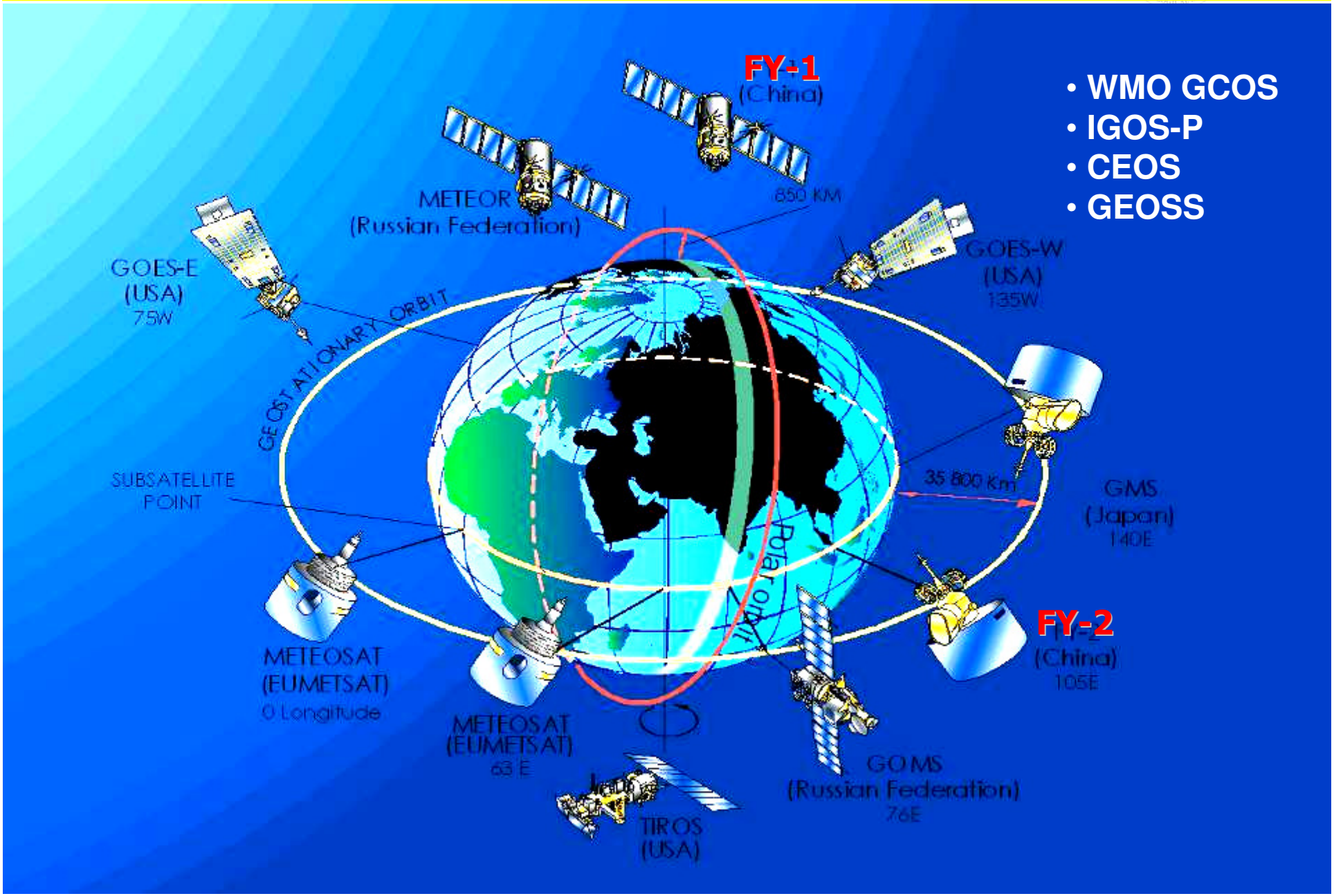
Topic

1. Current status of Chinese Meteorological Satellite
2. Research Infrastructure for Atmospheric Remote Sensing
   - Scheme
   - Data
3. Ground-based FTIR Observation (Bruker IFM120)
4. Forward Simulation and Retrieval Algorithm Development
   - Simulation and Sensitivity Study with Forward Model
   - Chemical Model
   - NO_2 Retrieval Algorithm Development
5. NO_2 Product Application in China
   - NO_2 Product Validation
   - Environmental assessment with NO_2 Product
6. Summary

1. Current status of Chinese Meteorological Satellites

Since Jan. 1969, China began to develop his own meteorological Satellite				
Leo	Launch Data		Geo	Launch Data
FY-1A	Sept. 7, 1988		FY-2A	Jun. 10, 1997
FY-1B	Sept. 3, 1990		FY-2B	Jun. 25, 2000
FY-1C	May 10, 1999		FY-2C	Oct. 18, 2004
FY-1D	May 15, 2002		FY-2D	Dec. 8, 2006

FY Series will contribute to the global observation



- **WMO GCOS**
- **IGOS-P**
- **CEOS**
- **GEOSS**

Chinese Meteorological Satellite: FengYun Series

Polar System

FY
|
1A
1B
1C
1D

First Generation

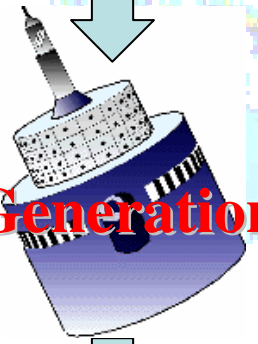
FY
|
3A
3B
3C
↓
3H

Second Generation

Geostationary System

First Generation

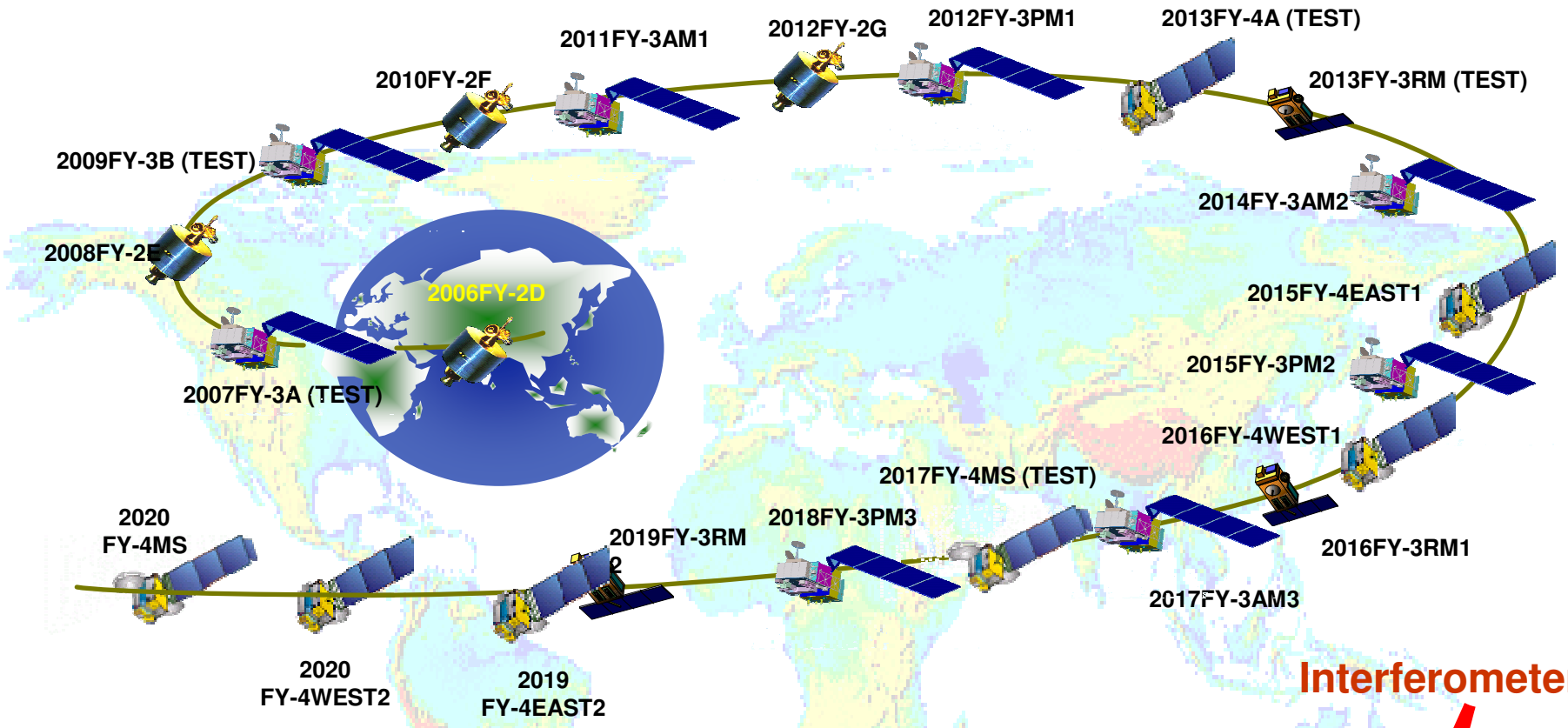
FY
|
2A
2B
2C
2D
2E



Second Generation

FY
|
4

Tentative Schedule for Future FY Series



Mission	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	.....
FY1	▲A		▲B									▲C			▲D														
FY2										▲A			▲B				▲C			▲D		▲E							
FY3																					▲A		▲B				▲C		
FY4																												▲A	

Payloads onboard on FY-3A

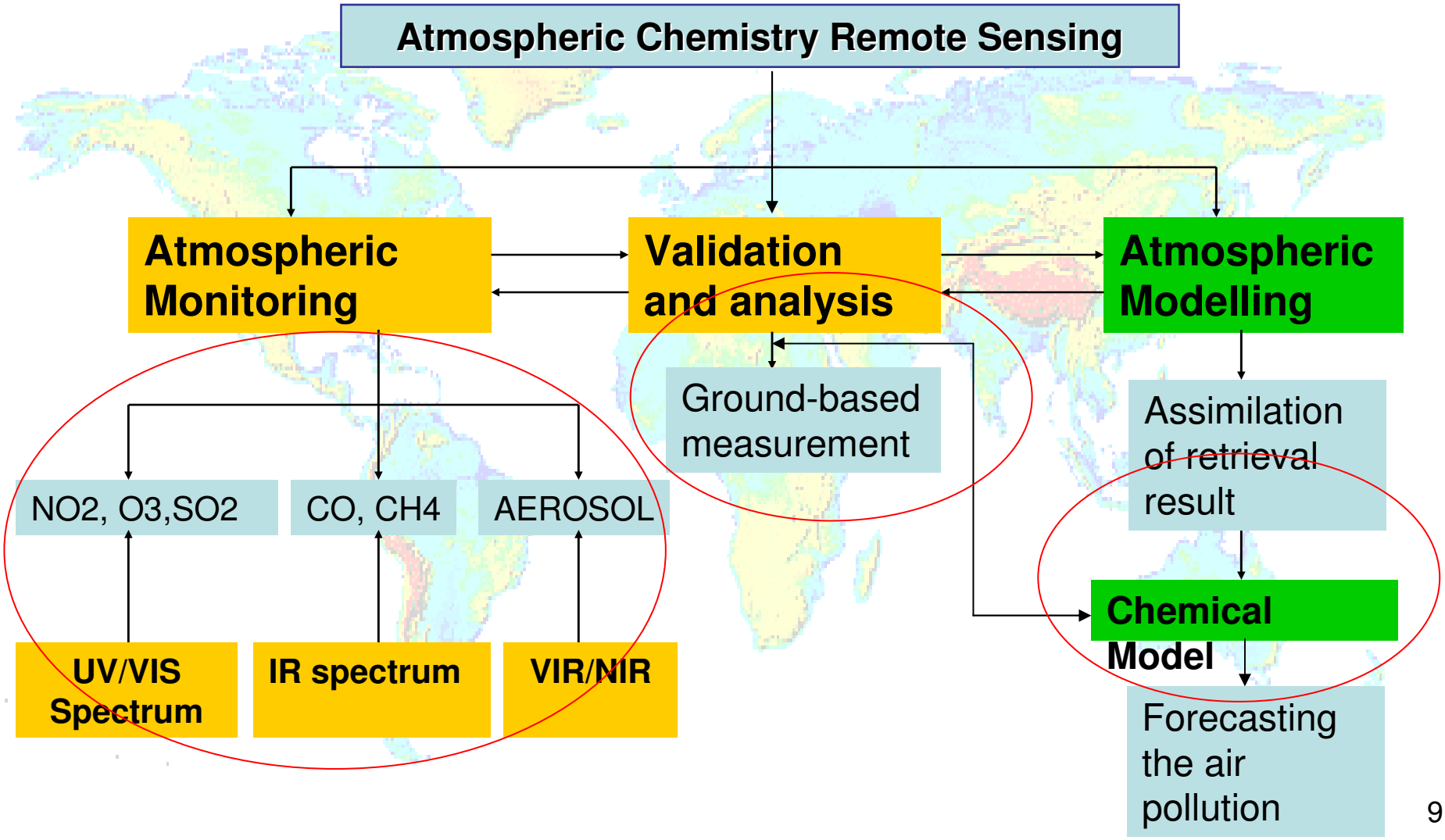
Abbreviation	*Instrument Full Name*
VIRR	Visible and InfraRed Radiometer
IRAS	InfraRed Atmospheric Sounder
MWTS	MicroWave Temperature Sounder
MWHS	MicroWave Humidity Sounder
MERSI	MEdium Resolution Spectral Imager
SBUS	Solar Backscatter Ultraviolet Sounder
TOU	Total Ozone Unit
MWRI	Microwave Radiation Imager
SIM	Solar Irradiation Monitor
ERM	Earth Radiation Measurement
SEM	Space Environment Monitor

Basic Information for Each Instrument

Name of Instrument	Number of Channels	Spectral range	Field of Views /line	Spatial Resolution at Sub point (km)
VIRR	10	0.43 – 12.5 μ m	2048	1.1
IRAS	26	0.69 – 15.5 μ m	56	17
MWTS	4	50 – 57 GHz	15	50/75
MWHS	5	150 – 183 GHz	90	15
MERSI	20	0.41 – 12.5 μ m	2048/8192	1.1/250
SBUS	12	252 – 280 nm	240	70/10
TOU	6	309 – 361 nm	31	50
MWRI	6	10.65 – 150 GHz	240	15-70

2. Research Infrastructure

• Scheme

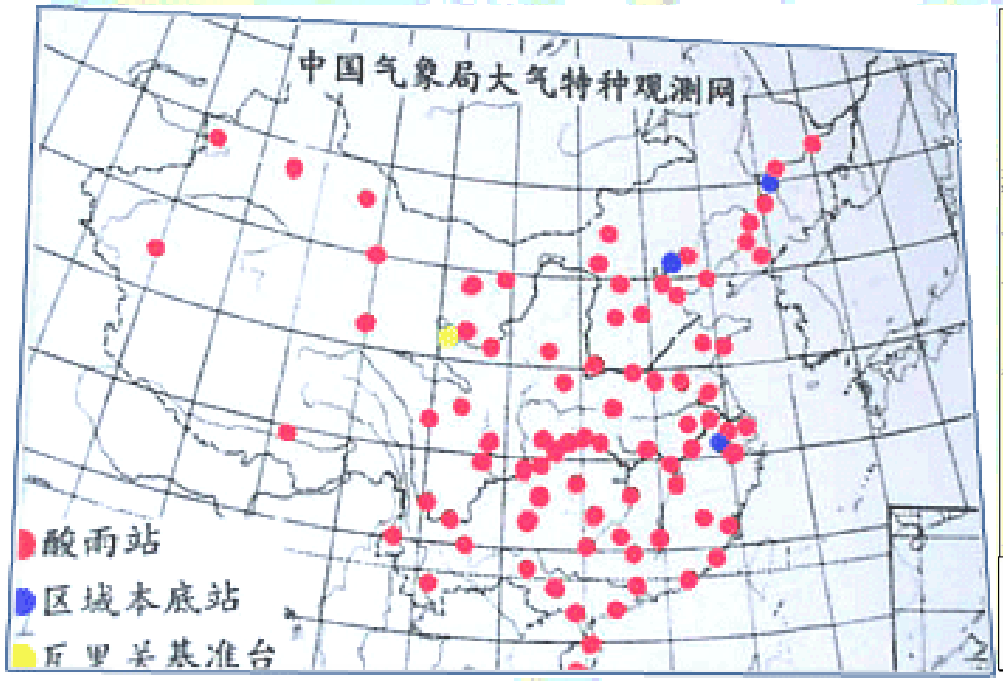


2. Research Infrastructure

• Data

- ✓ SCIAMACHY 1B: Apr, July, Oct, Dec/2004
- ✓ GOMOS L2 products: Downloaded from ESA website
- ✓ MERIS and AATSR 1B: Downloaded from ESA by FTP since Jul. of 2006
- ✓ GOME and SCIAMACHY L2 products: 10 years' NO_2 and 3 years' SO_2 has been downloaded
- ✓ OMI/Aura L2 products: global ozone mapped data is being downloaded everyday
- ✓ 5 years' In-situ measurement of NO_2 at Beijing, Shahai since 2000
- ✓ In-situ measurement at Regional Background Station (LinAn, ShangDianZi and LongFengShan) since 2005

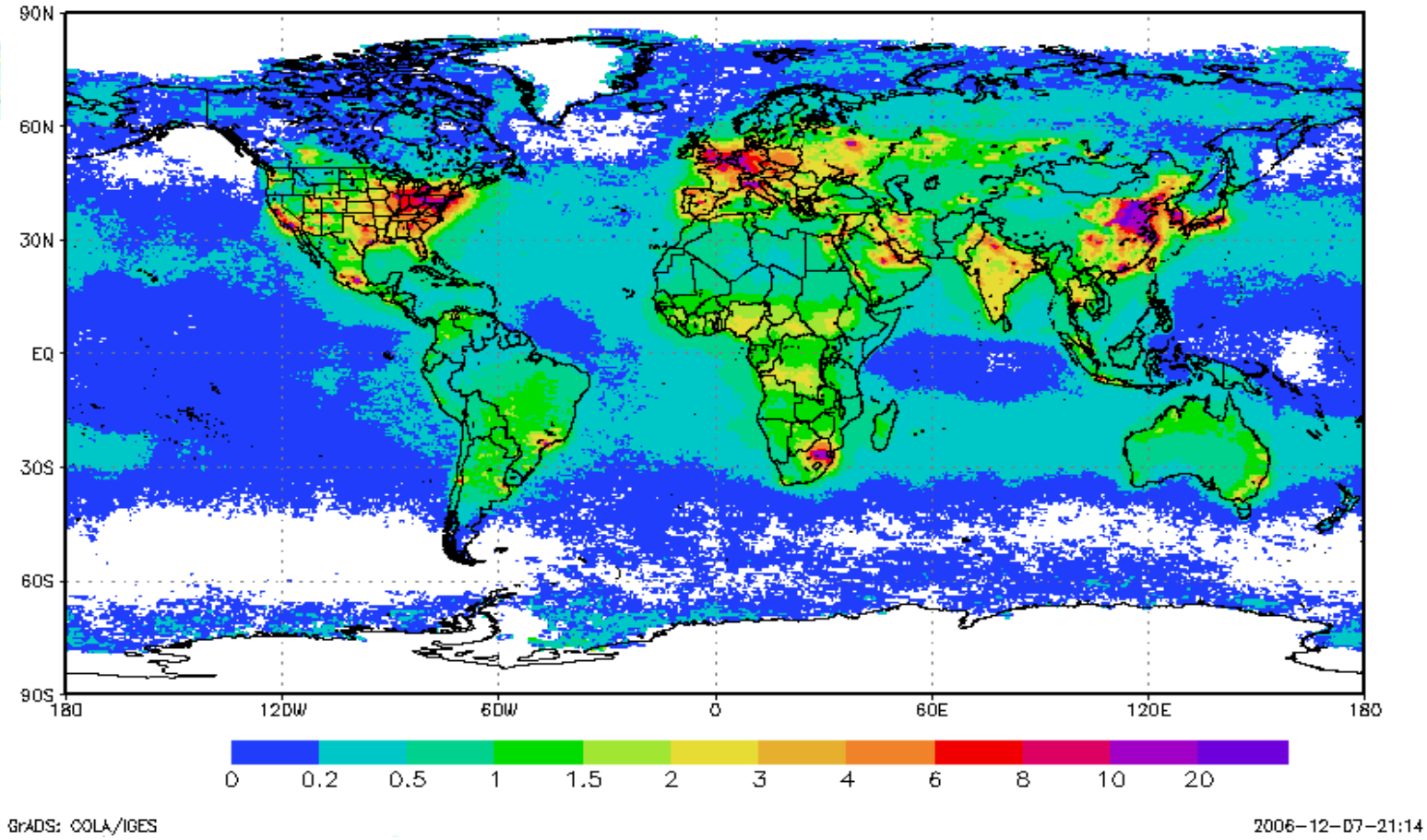
Atmospheric Composition in-situ Station by CMA



Ten-years' Average of NO_2 from 1996-2006 GOME and SCIAMACHY level2 product

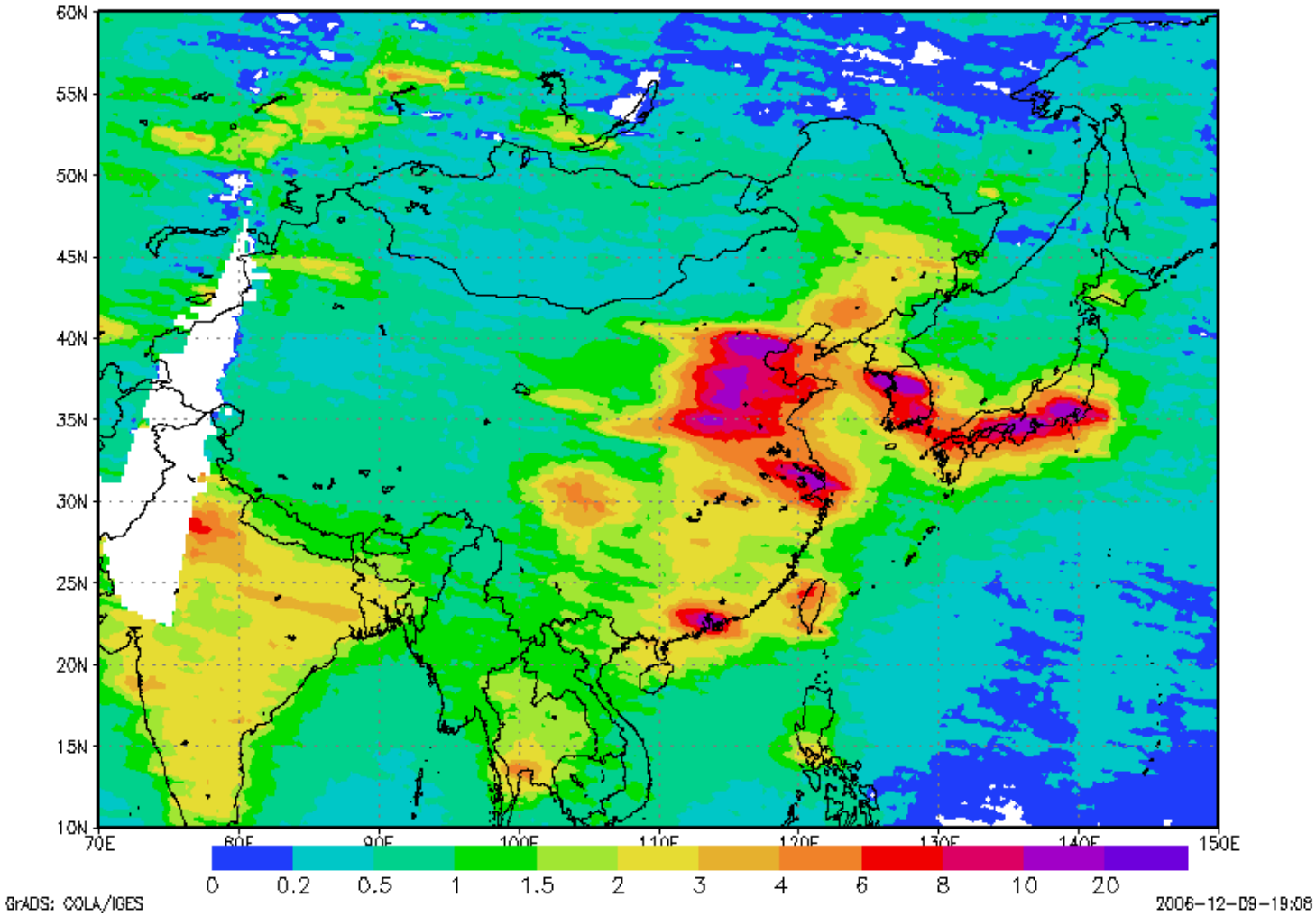
（unit: 10^{15} molecules cm^{-2}）

Data from KNMI



Annual Average of NO_2 from 1996-2006 GOME and SCIAMACHY level2 product

（unit: 10^{15} molecules cm^{-2}）　　Data from KNMI

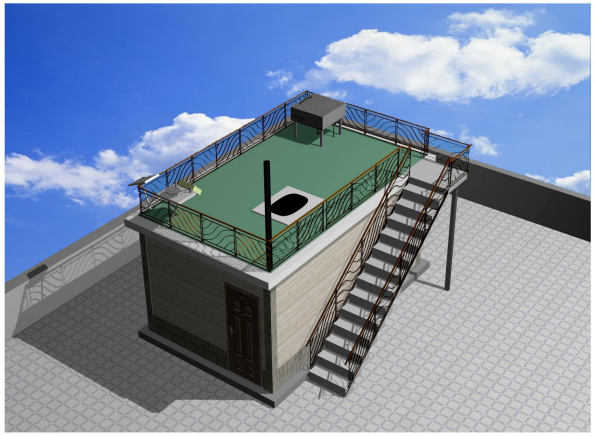


3. Ground-based FTIR Observation (Bruker IFM120)

Spectrometer in NSMC

Instrument Type	Manufacture	Main Properties
IFS120M	Germany BRUKER	Spectral Range: 0.4—16.6 μm Max. Spectral Resolution: 0.008 cm^{-1}
TR320	USA EG&G	Spectral Range: 0.40—5 μm Max. Spectral Resolution: 0.06 μm FOV: 10°
MR154	Canda BOMEN	Spectral Range: 0.70—19.5 μm Max. Spectral Resolution: 1 cm^{-1} FOV: 10°
Fieldspec FR	USA ASD	Spectral Range: 0.35—2.5 μm Max. Spectral Resolution: 3.5nm FOV: 3°
OL-754	USA	Spectral Range: 0.35—1.6 μ m Max. Spectral Resolution: 0.001 μ m FOV: 180°

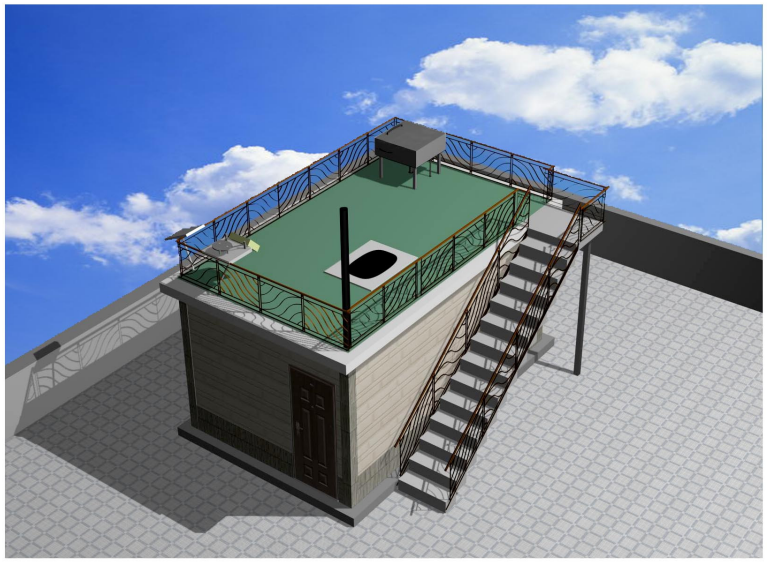
NSMC Building Top Section Structure



大气观测实验室竣工图

北京美标装饰有限公司

Field experiment design
for Bruker IFM 120



大气观测实验室竣工图

北京美标装饰有限公司

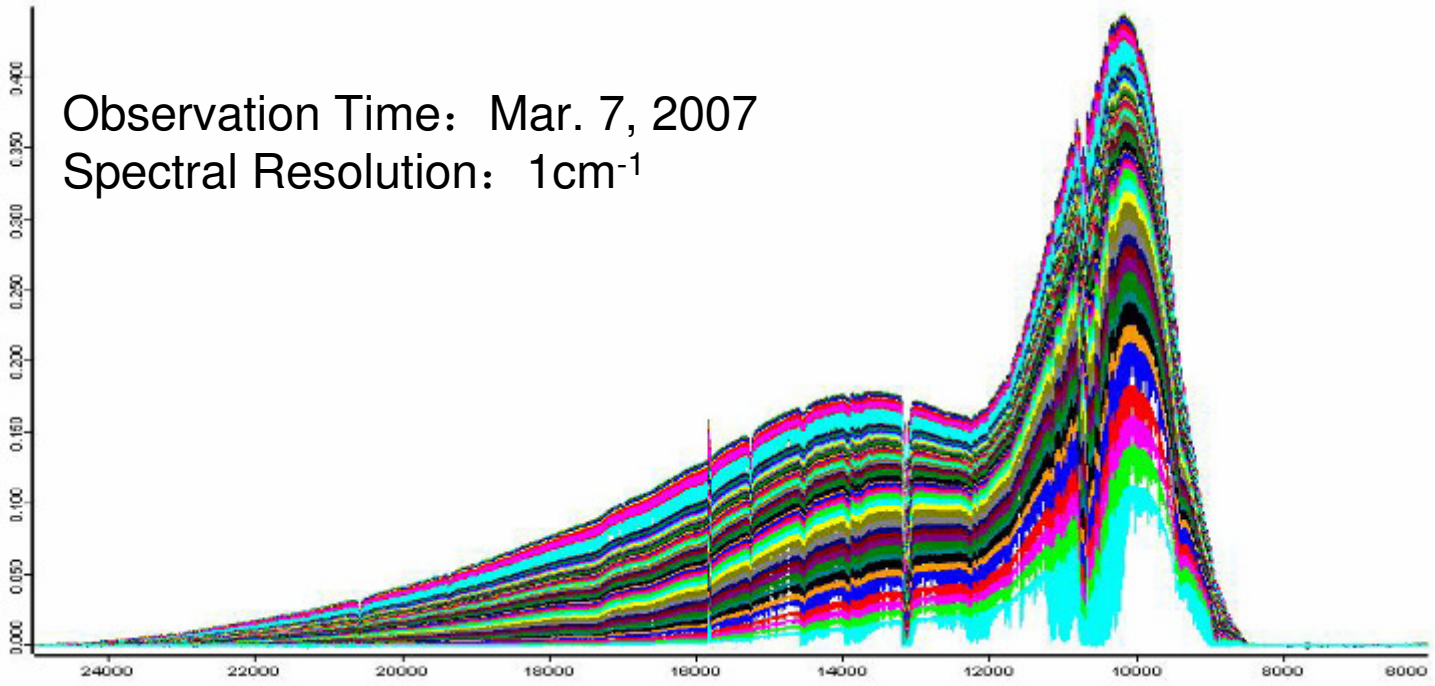
Sept,2006: Completing construction

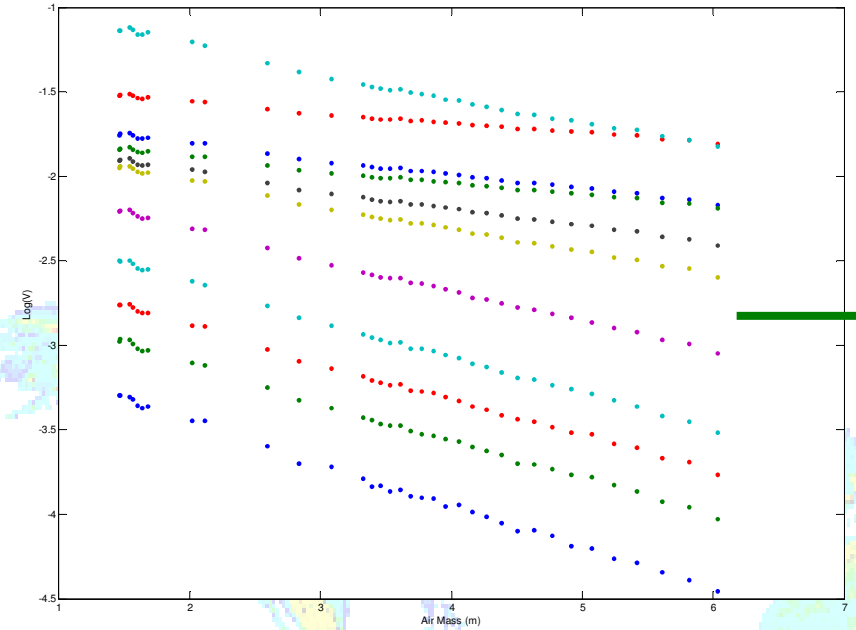
Oct, 2006: Transiting Bruker

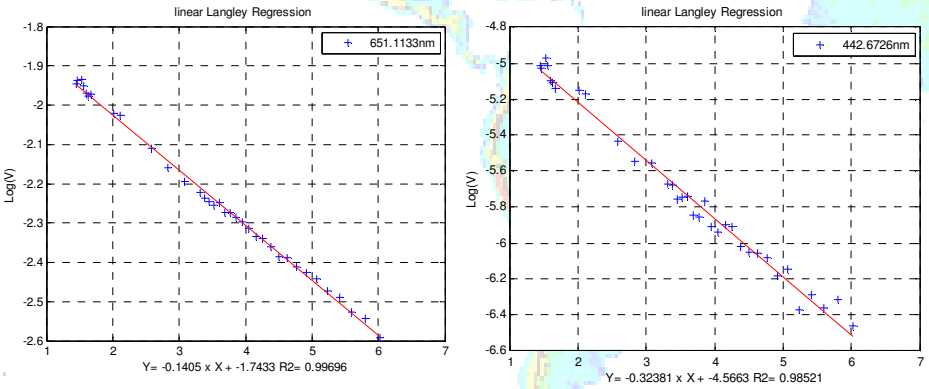
Nov, 2006: Adjusting Bruker

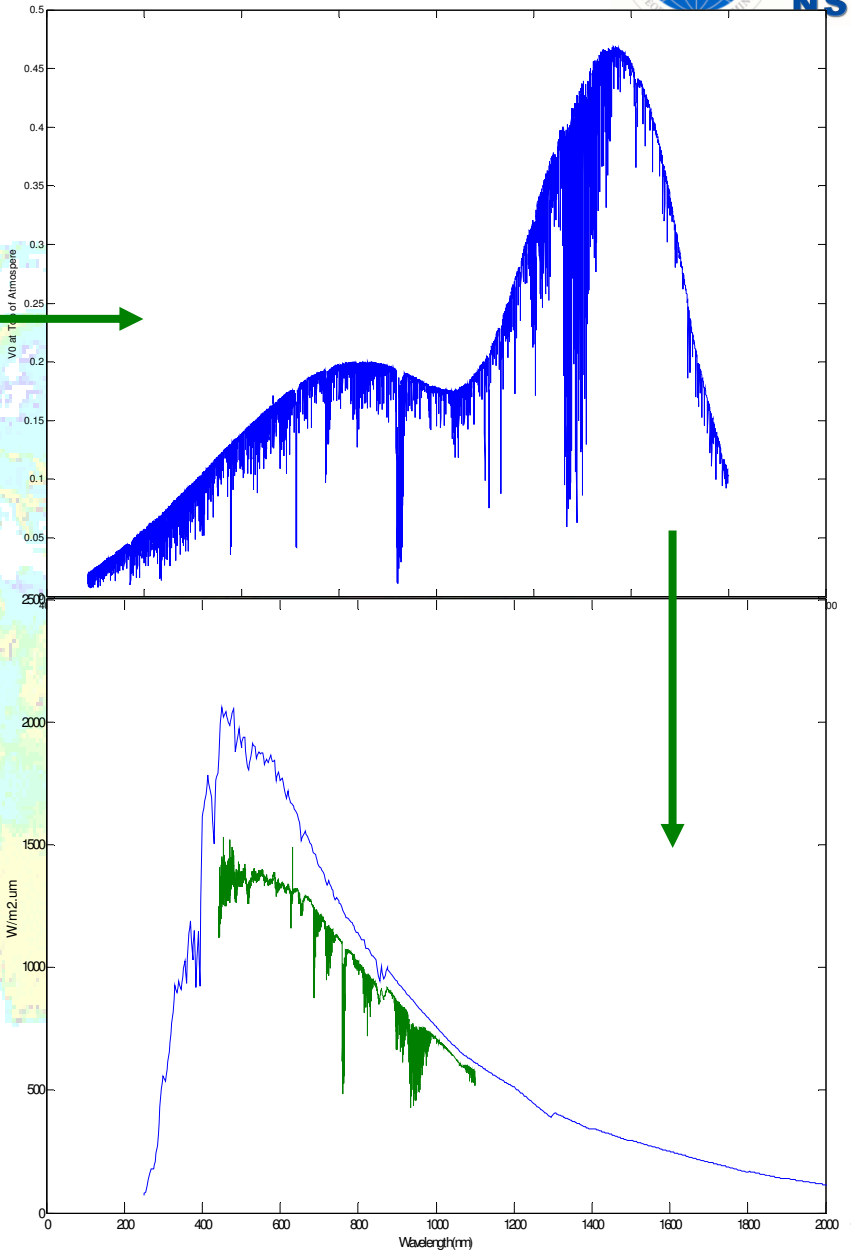
Dec. 1, 2006: Collecting data

Clear day, Spectral Coverage: 400—1150nm



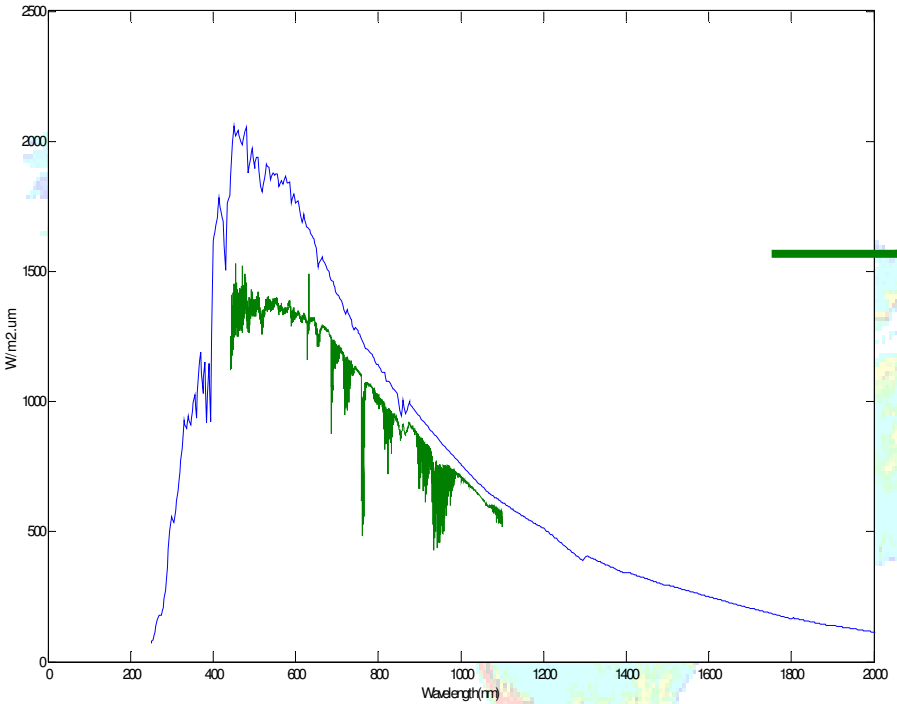


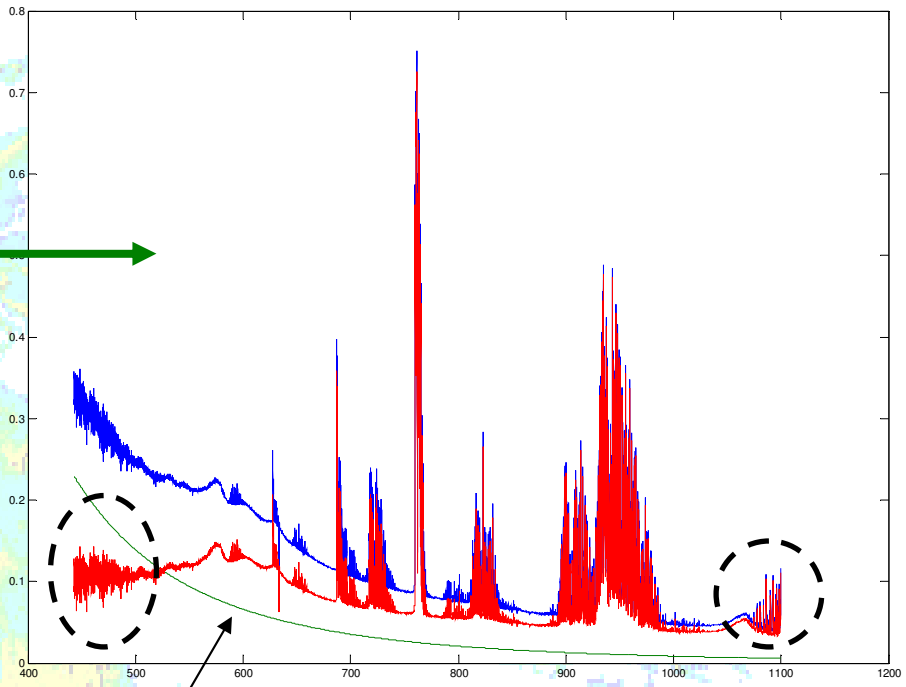




Radiance calibration with Langley Plot

Aerosol Optical Depth from extinction spectrum





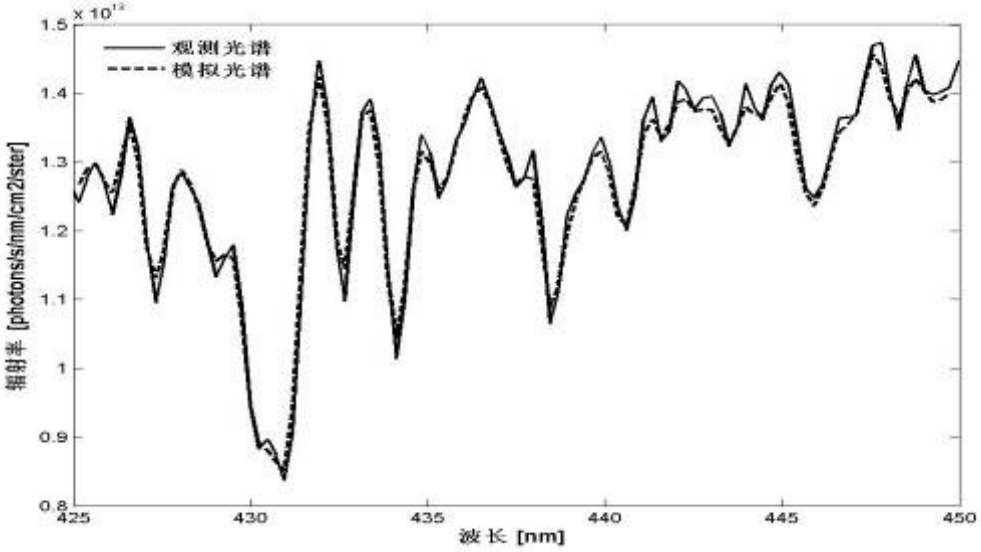
Extinction from Molecular Rayleigh Scattering

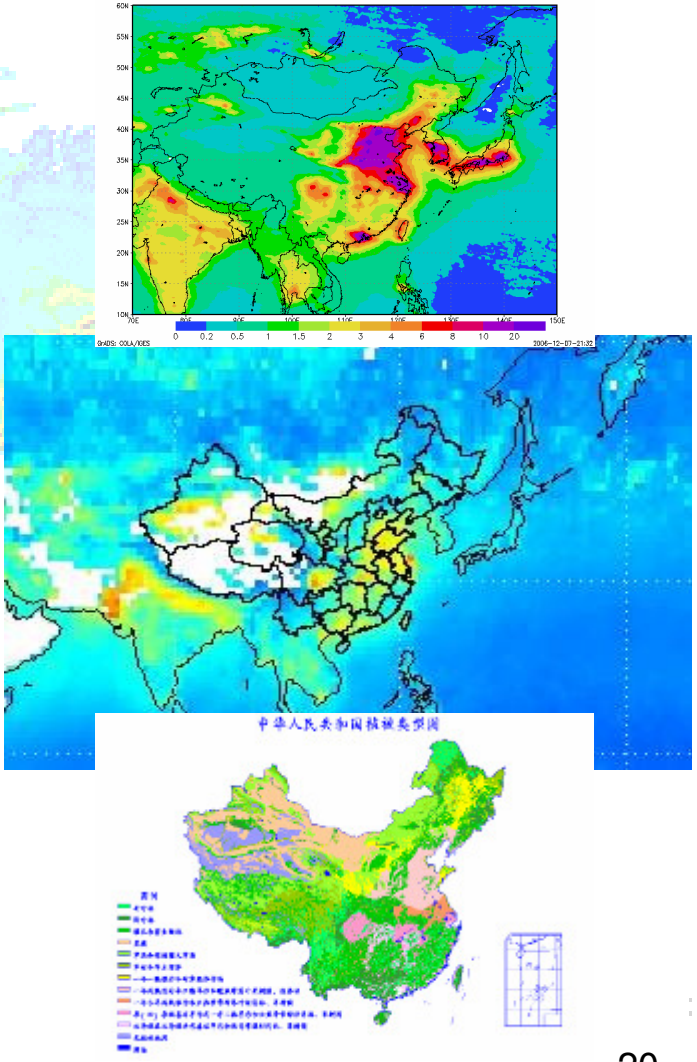
4. Forward Simulation and Retrieval Algorithm Development

- **Simulation and Sensitivity Study with Forward Model**

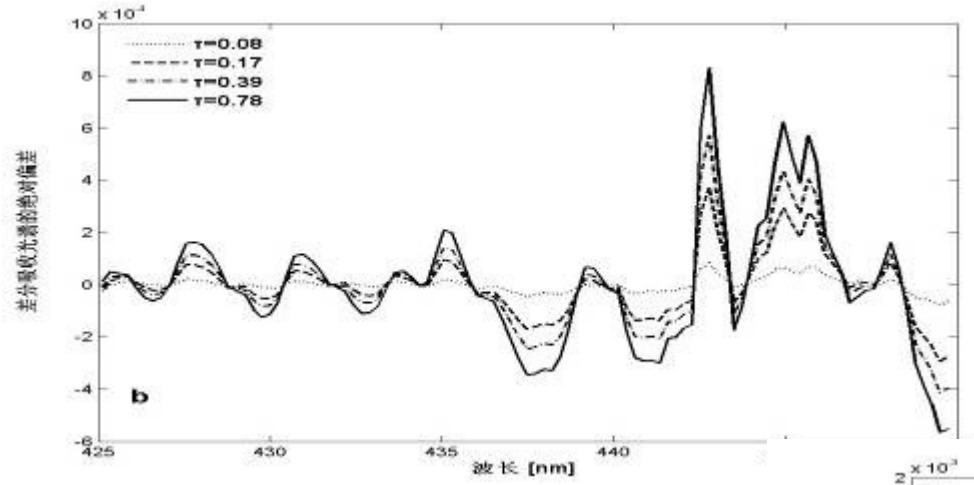
Investigating how surface albedo, aerosol and NO_2 are sensitive to the reflected DOAS at TOA with SCIATRAN model

The paper has been accepted by *ACTA METEOROLOGICA SINICA*

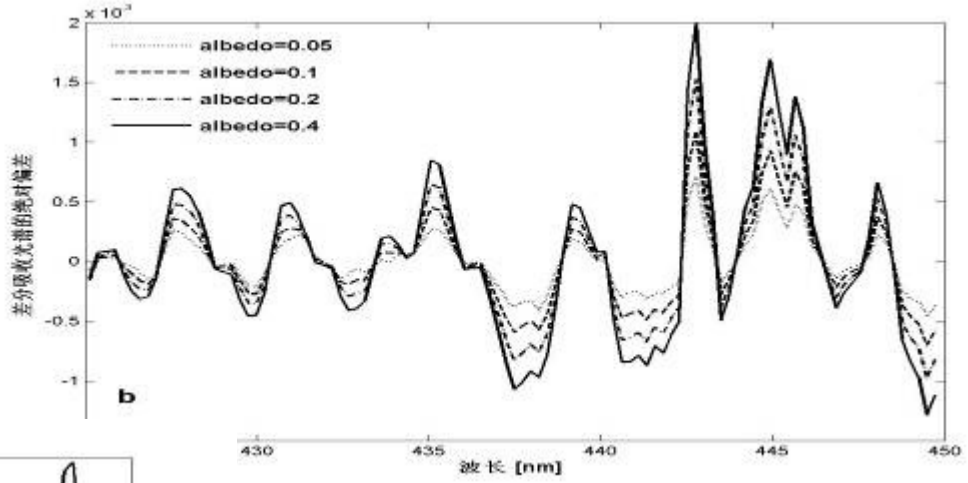




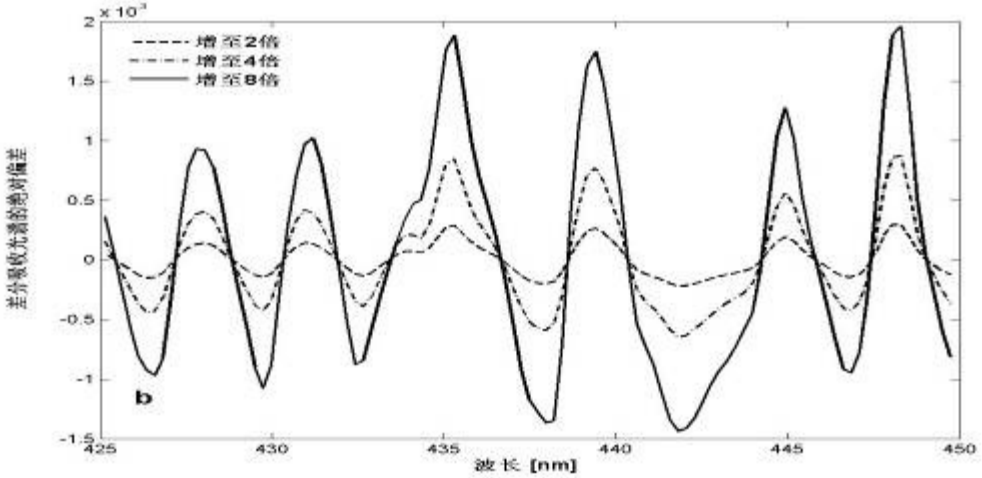
Effects of three factors on NO_2 retrieval from satellite (425 nm - 450 nm)



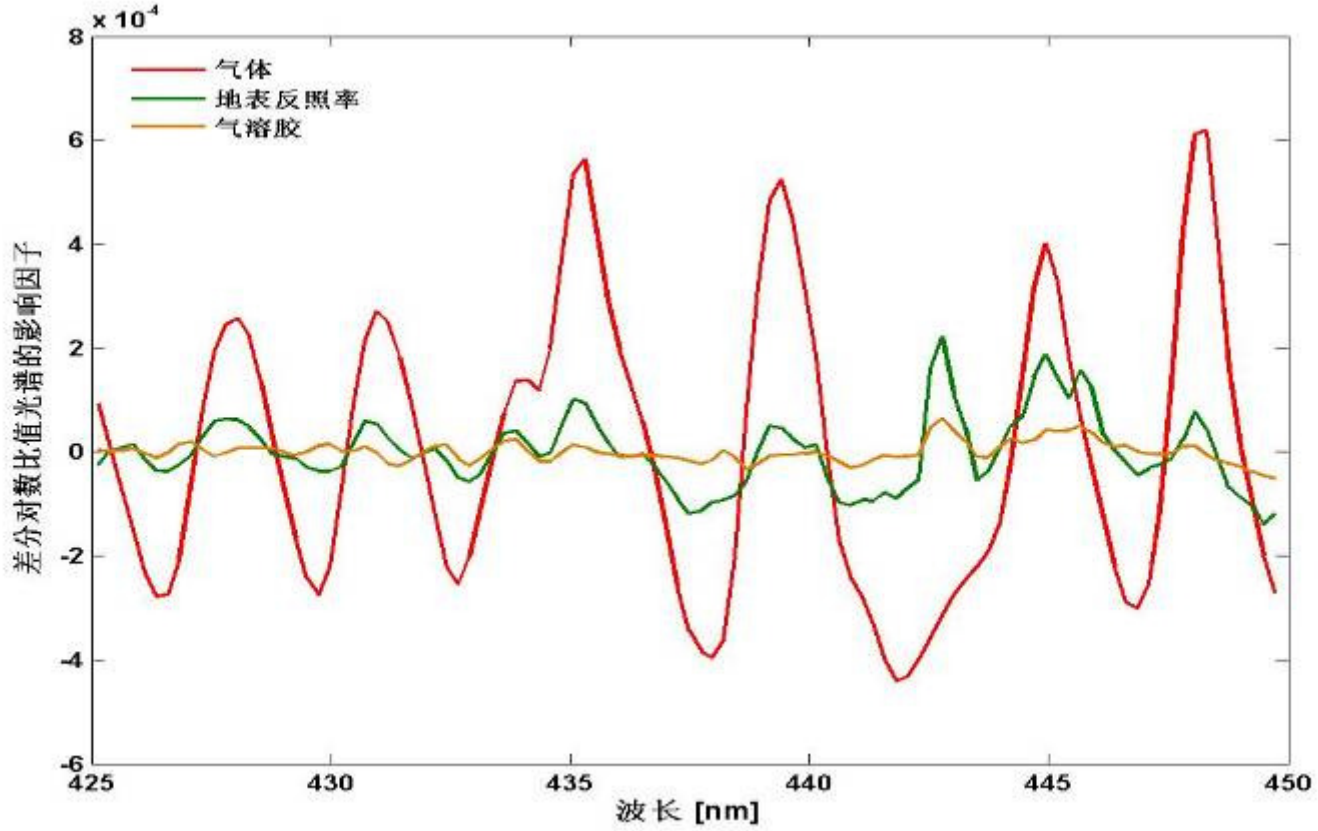
Aerosols



Surface Albedo



Trace gases

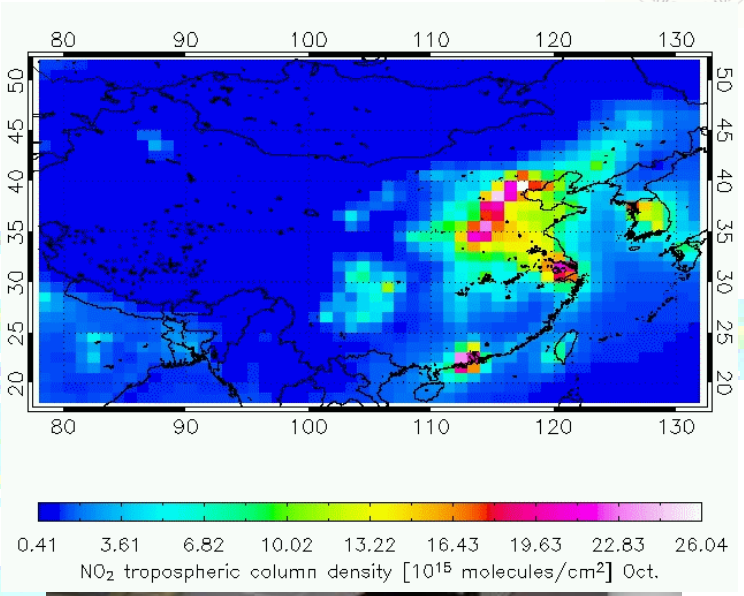


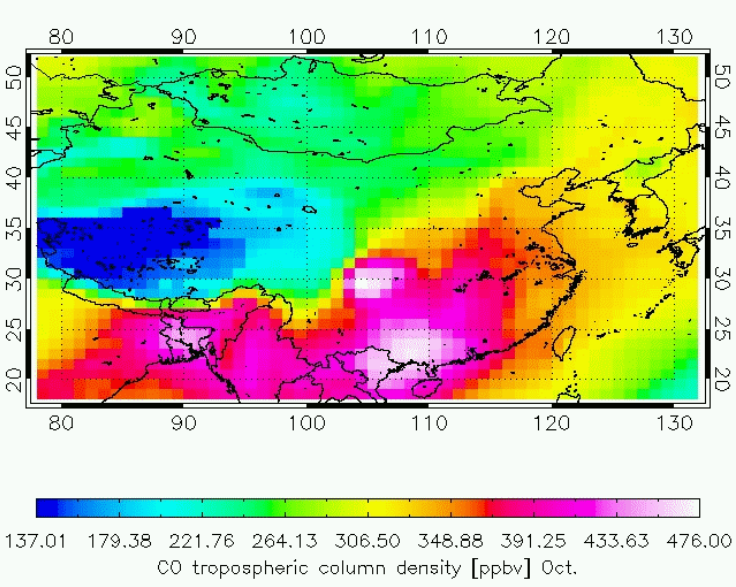
Conclusion: After DOAS processing, errors from aerosol and albedo still remains, we call ‘residue from aerosol and albedo effect’

- **Chemical Model**

CO、NO2 over China in year 2003（by TM5）

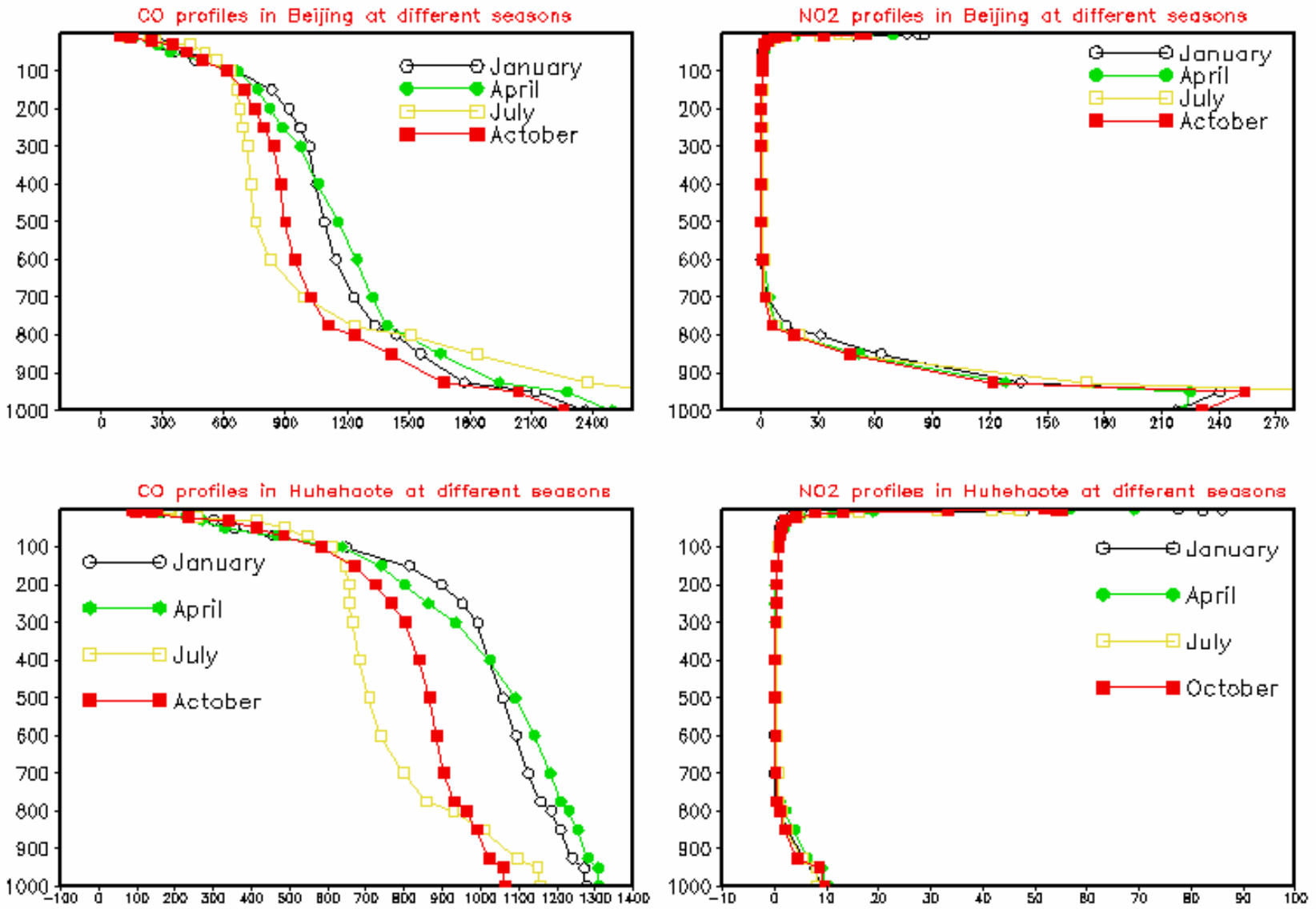
Paper has been published in *Remote Sensing Information, 2007*





GOES-Chem Model is utilized in NSMC

NO2 and CO profile for different season at Beijing and Huhehaote from TM5 model



- **NO_2 Retrieval Algorithm Development**

Optical Thickness

Gases Absorption

Rayleigh Scattering

Mie Scattering

$$\tau = -\ln \frac{I_{sat}(\lambda)}{I_0(\lambda)} = \sum_i (\sigma_i^{'}(\lambda) + \sigma_i^{B}(\lambda)) SCD_i + \sigma_{Ray}(\lambda) A_{Ray}(\lambda) + \sigma_{Mie}(\lambda) A_{Mie}(\lambda)$$

Fast Change Part

Slow Change Part

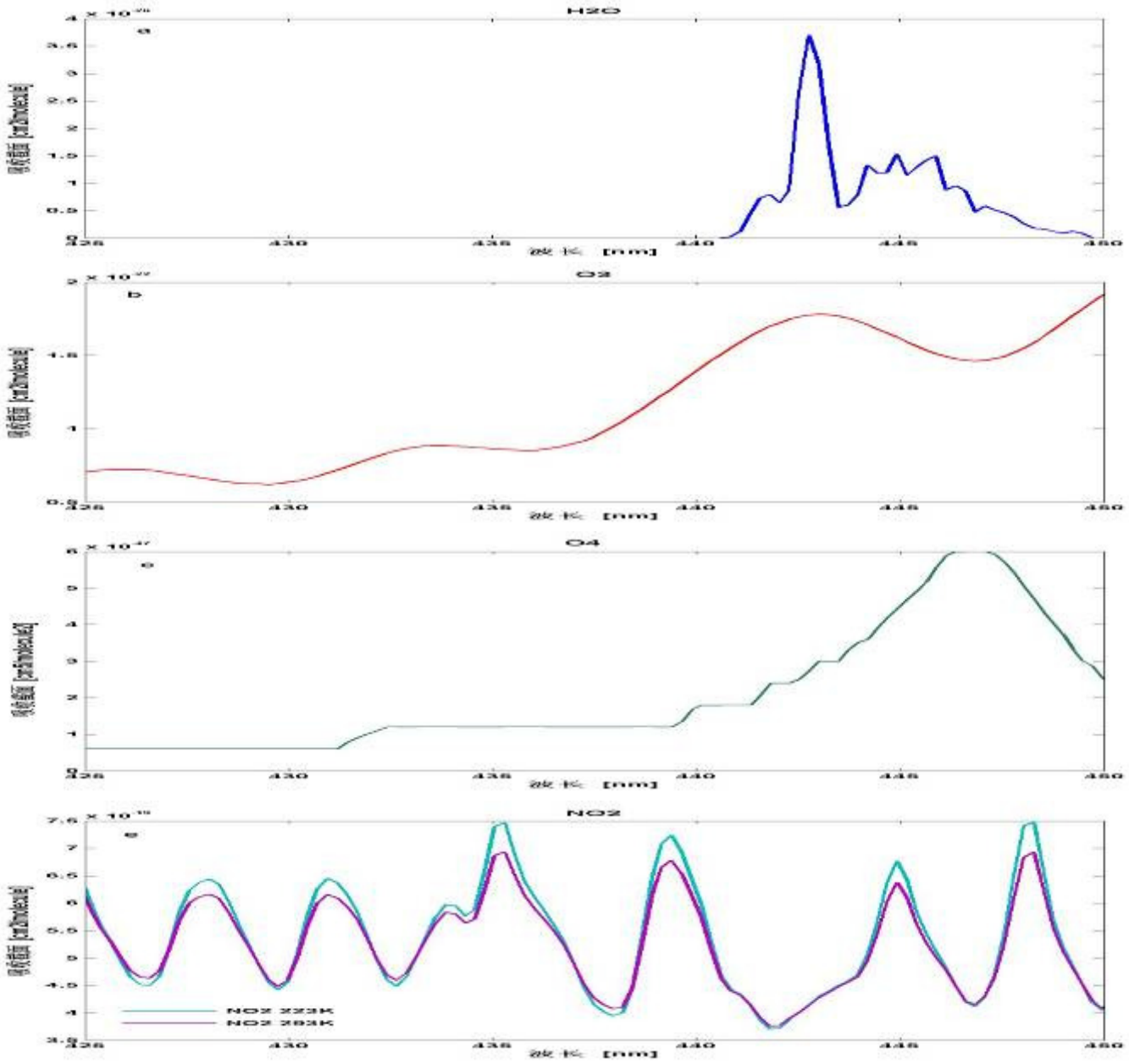
$$\tau = -\ln \frac{I_{sat}(\lambda)}{I_0(\lambda)} = \sum_i \sigma_i^{'}(\lambda) SCD_i + \sum_{k=0} b_k \lambda^k$$

Vertical Column Amount

Slant Column Amount

Airmass factor

$$VCD_i = SCD_i / AMF_i$$



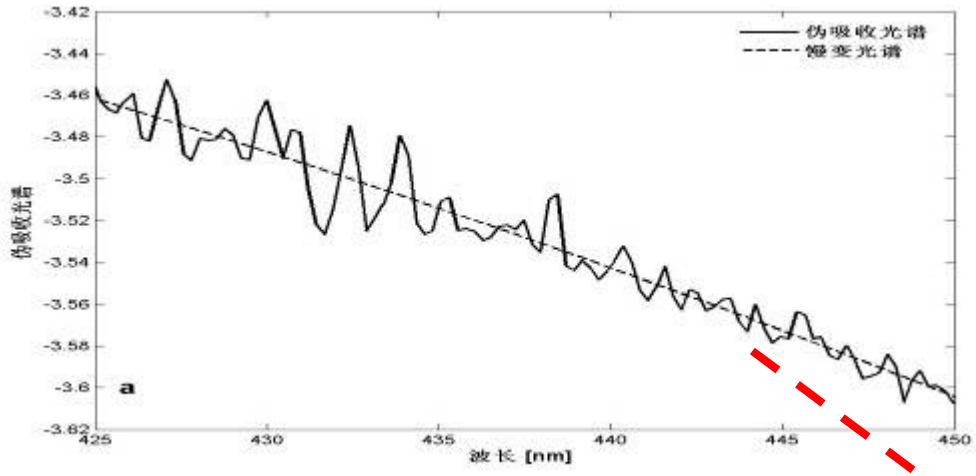
-26

-22

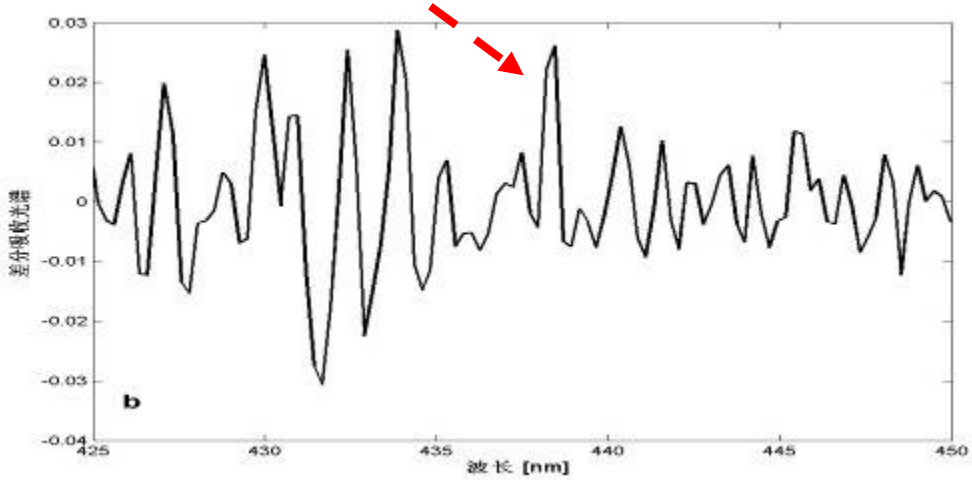
-47

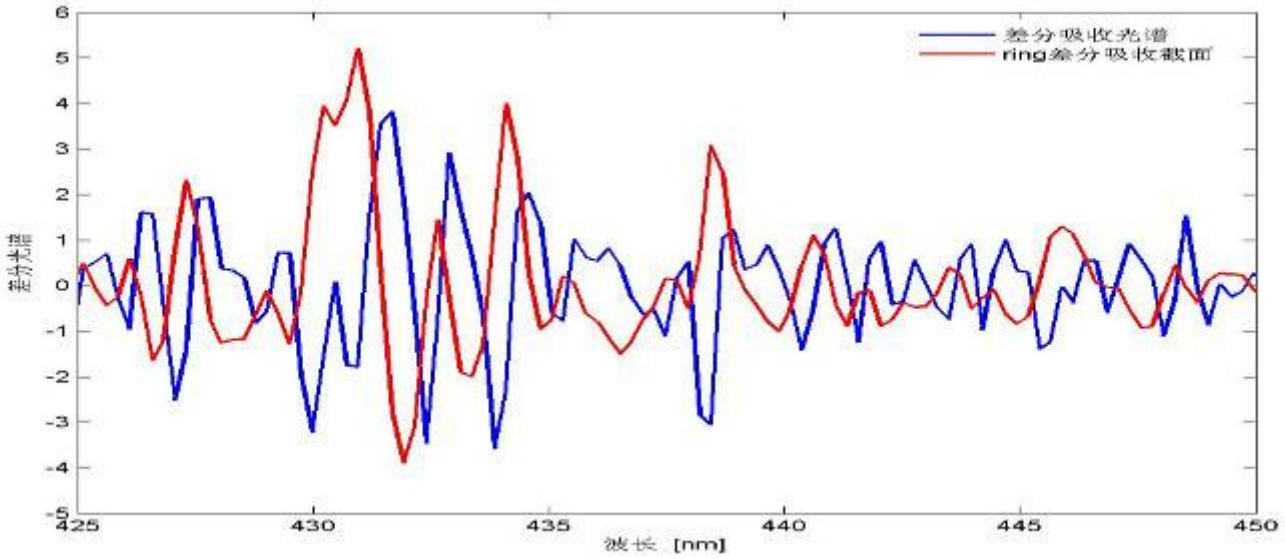
-19

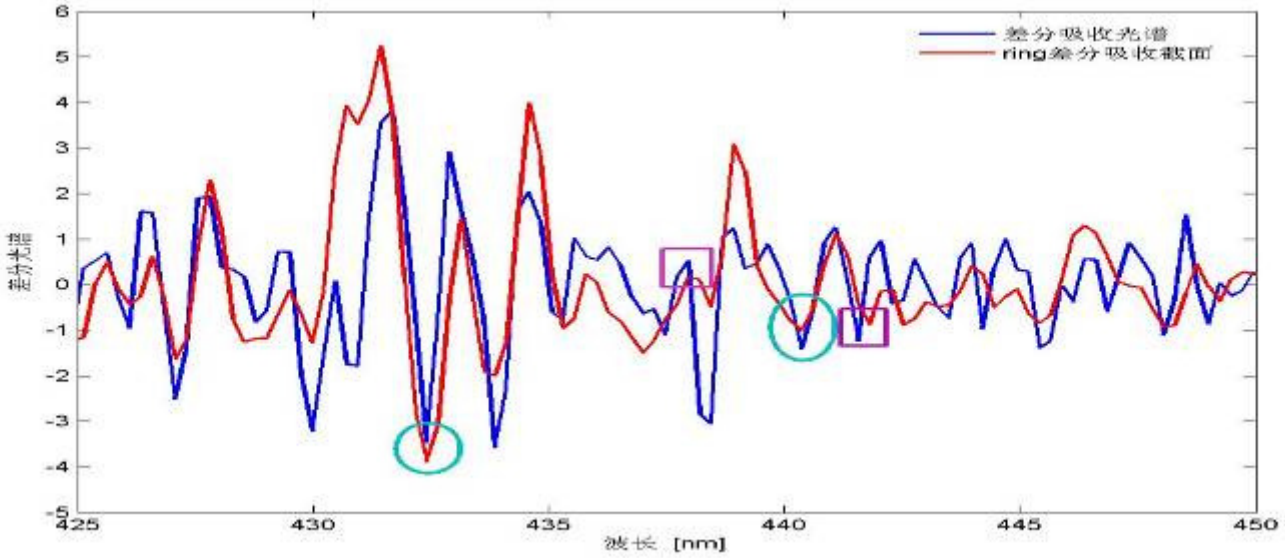
425 – 450 nm gas absorption section from HITRAN



Polynomial fitting to remove the slow variation part from spectrum



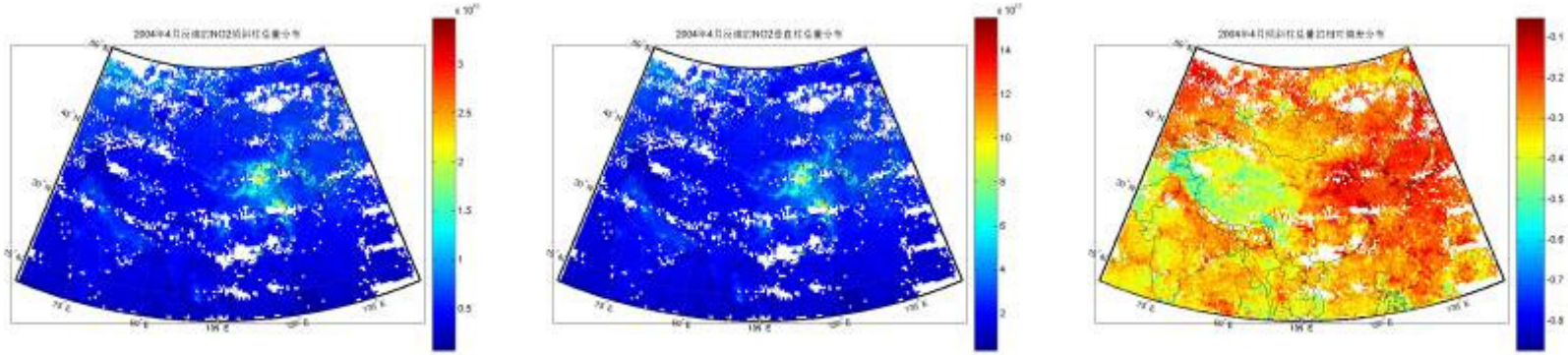




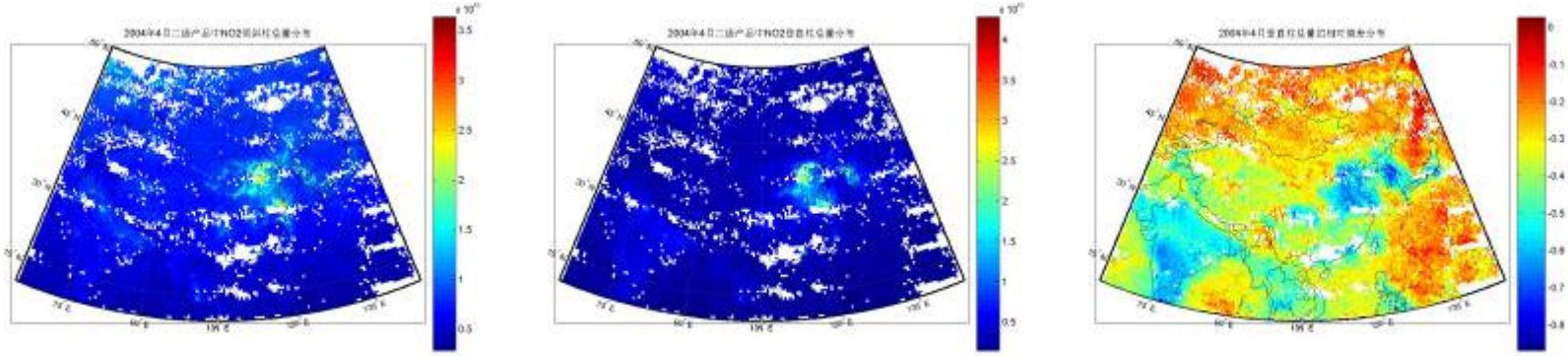
Spectral calibration by Ring Structure

Our Results | **Sciamachy Products** | **Difference**

slant column density



vertical column density

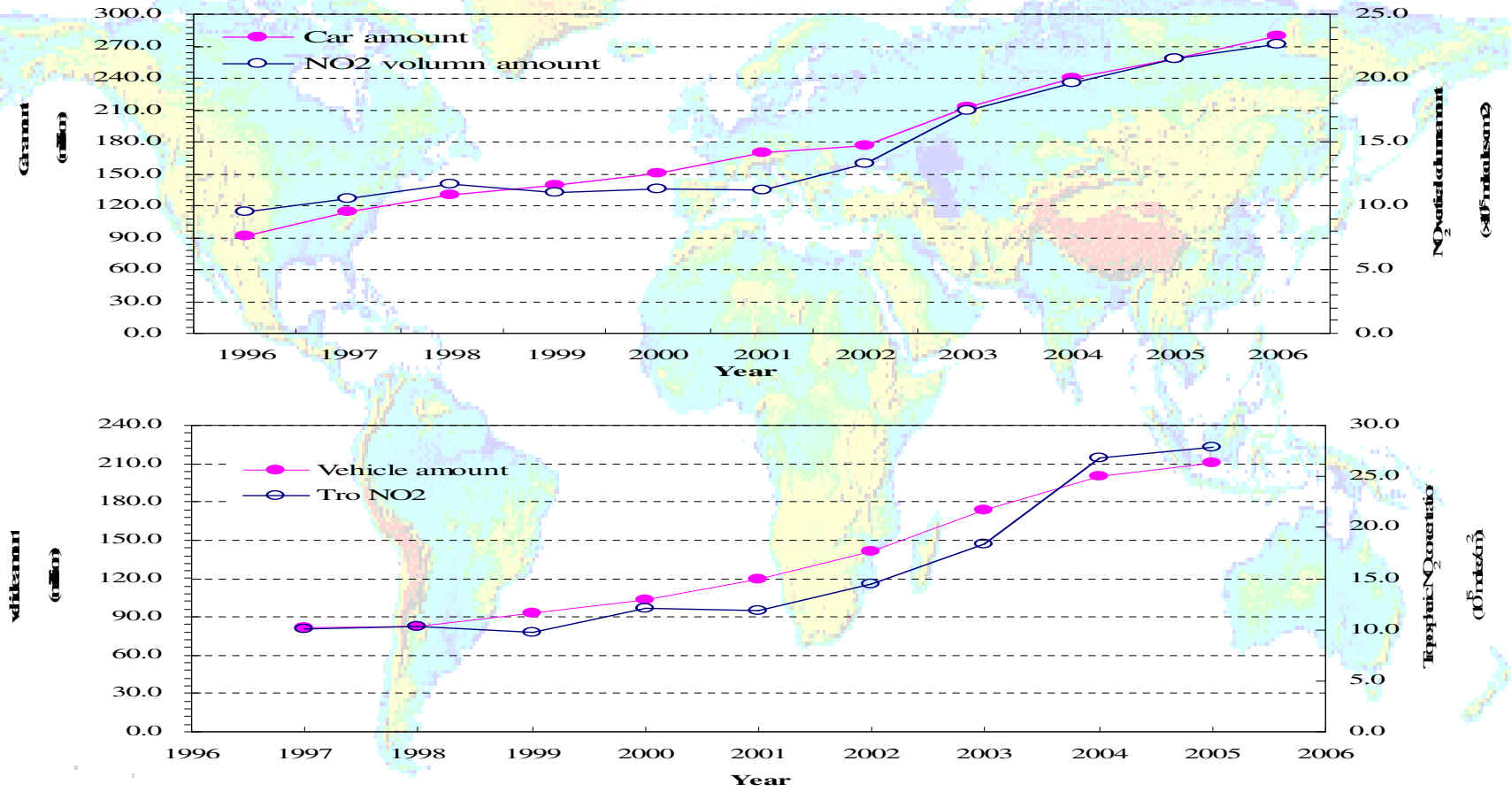


Reason:

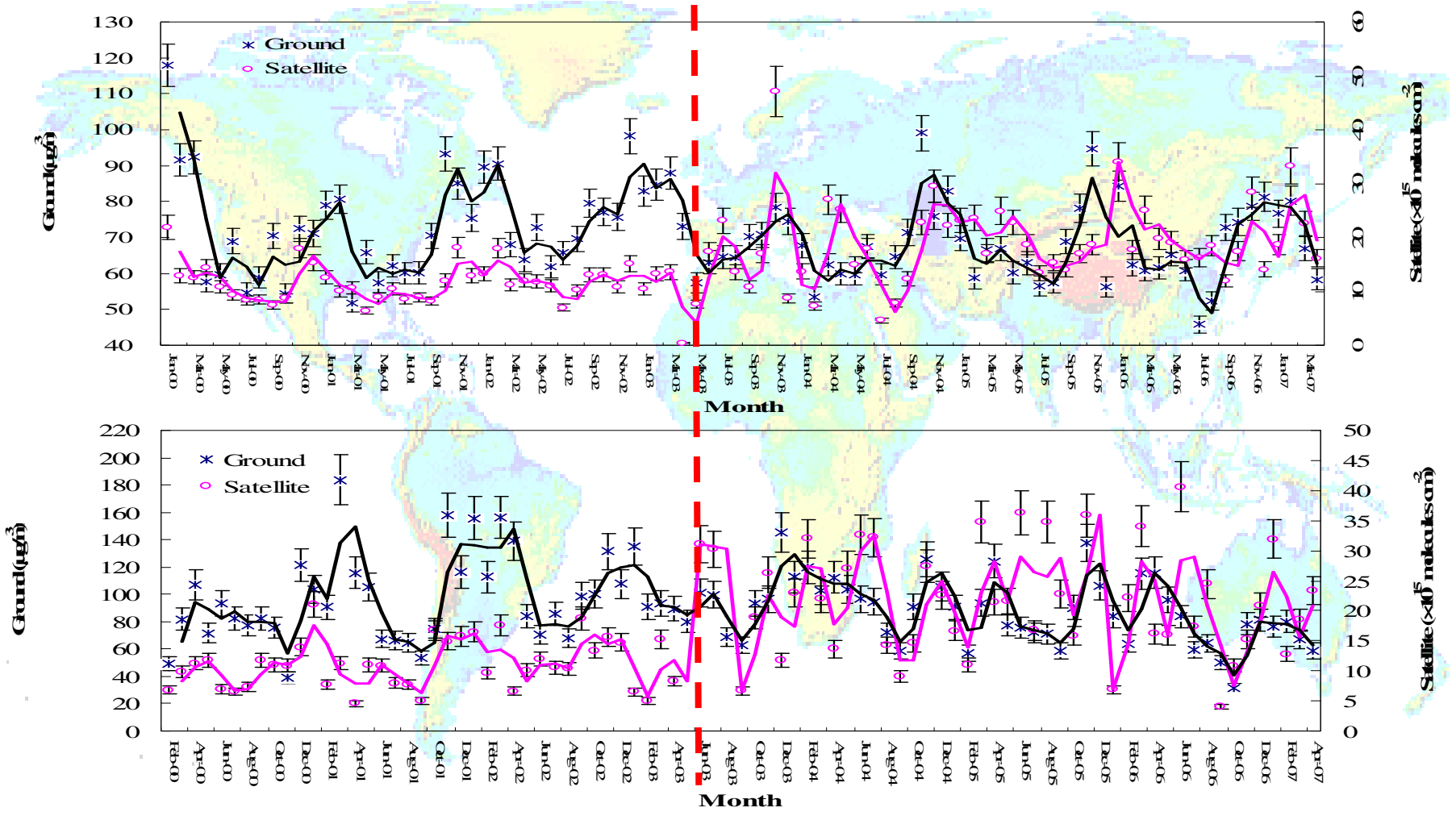
- **Temperature Dependence**
- **AMF from real water vapor or aerosol**
- **Ring effect, water vapor, O4**

5. NO_2 Product Application in China

NO_2 validation with vehicles population during 1996~2006 in Beijing (up) and Shanghai (down)

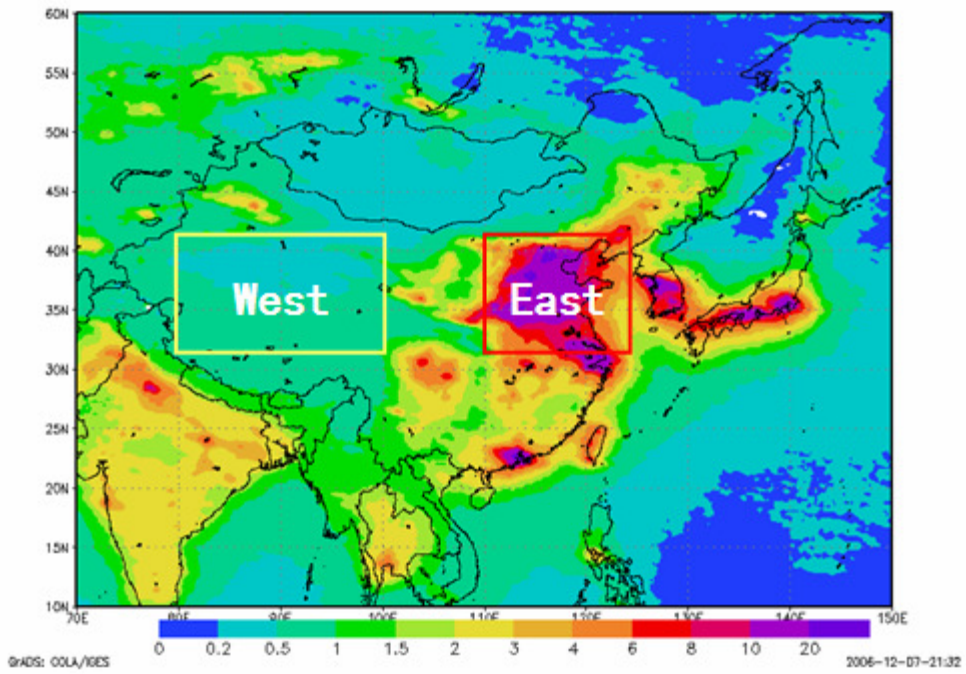


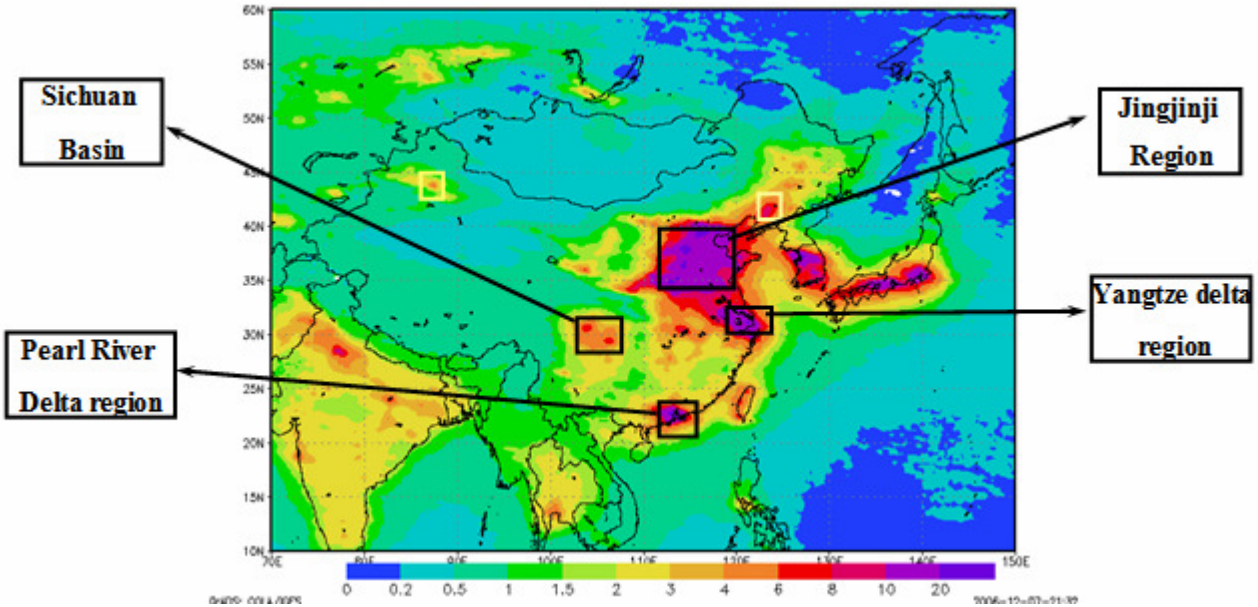
NO_2 Validation with in-situ API（air pollution index）in Beijing (up) and Shanghai (down) area during 2000~2007

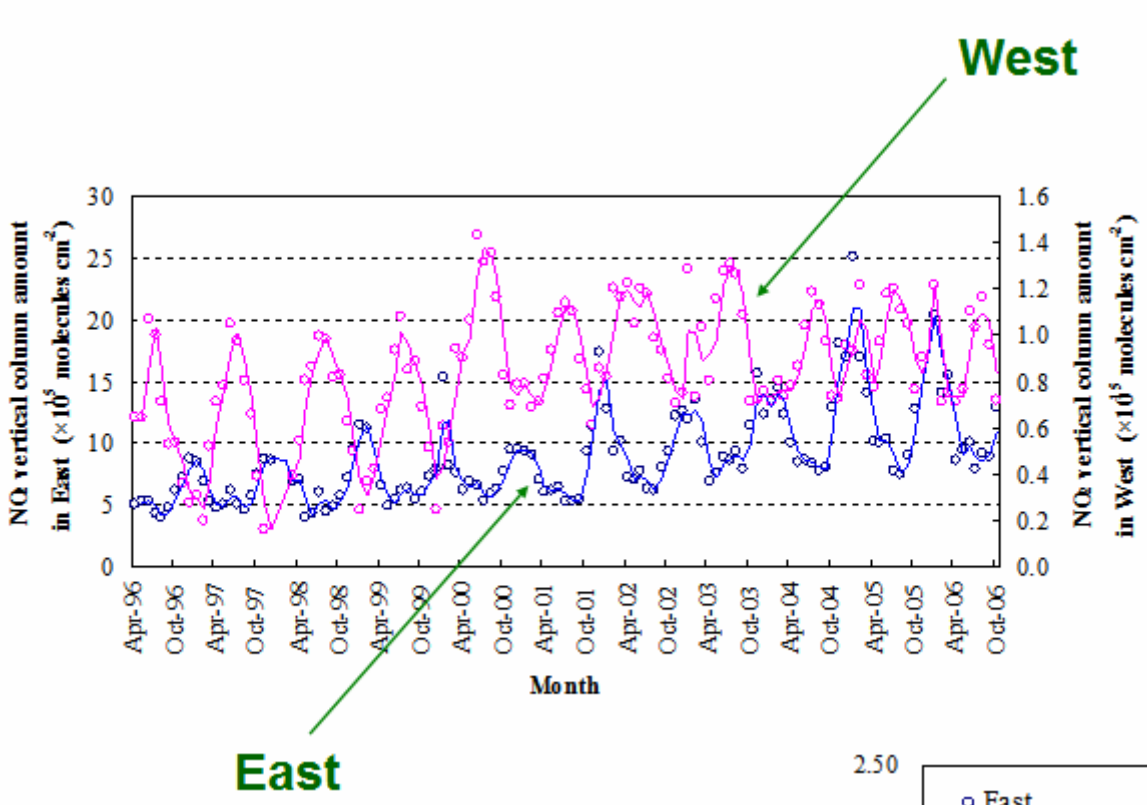


Environment Assessment with NO_2 Product in China

- The paper has been accepted by *Sciences in China: D*
- Special presentation will be given in this symposium

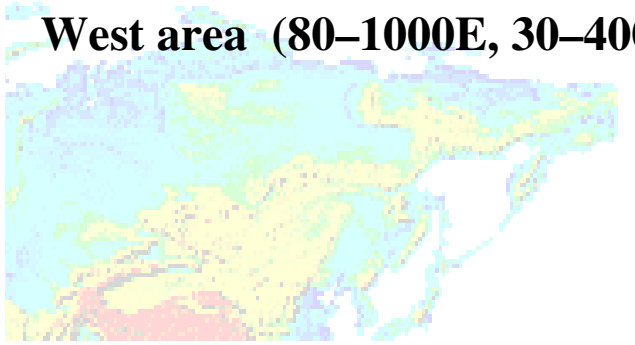


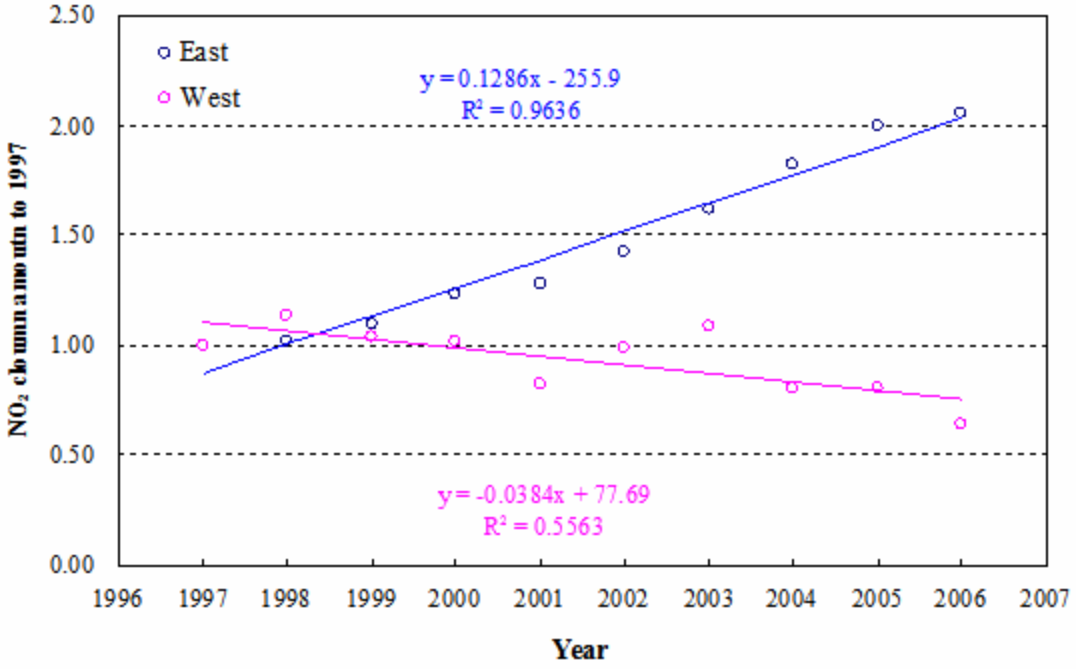




East area (110–123^{0}E, 30–40^{0}N)

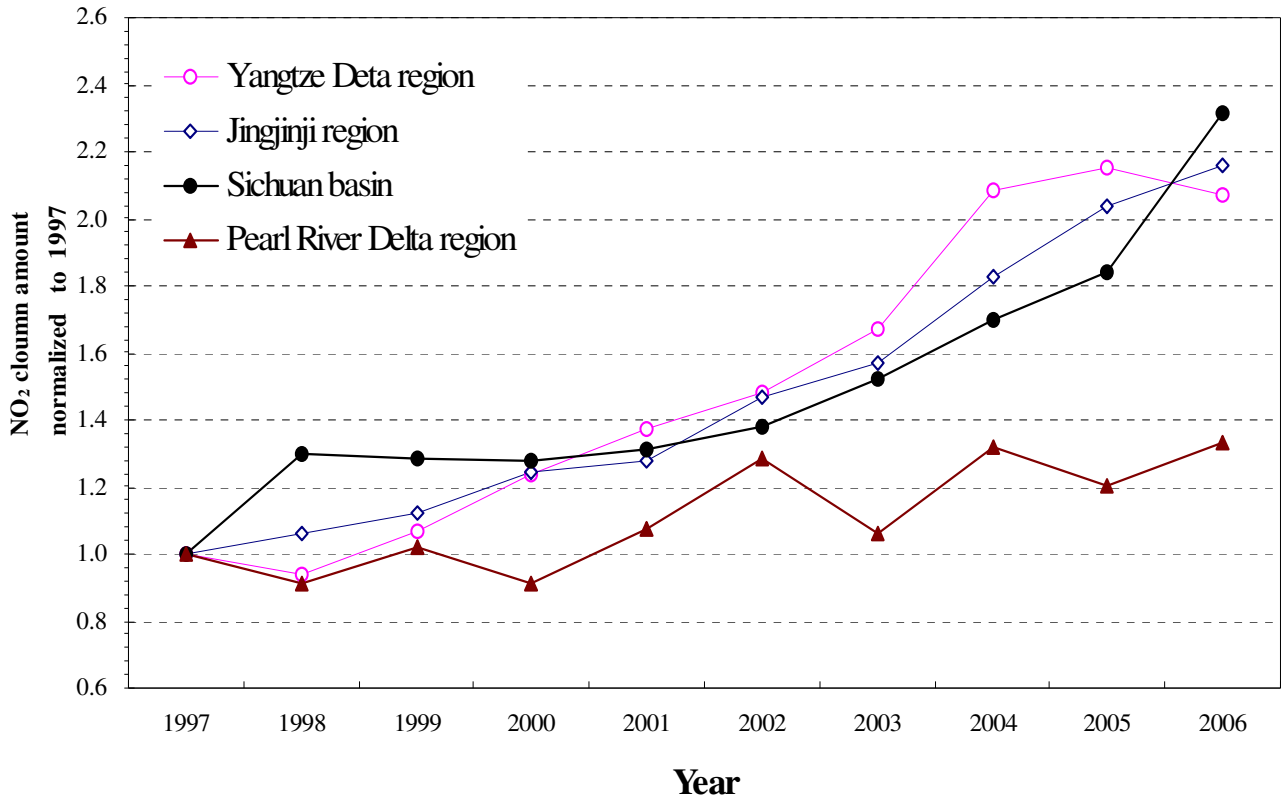
West area (80–1000E, 30–400N)

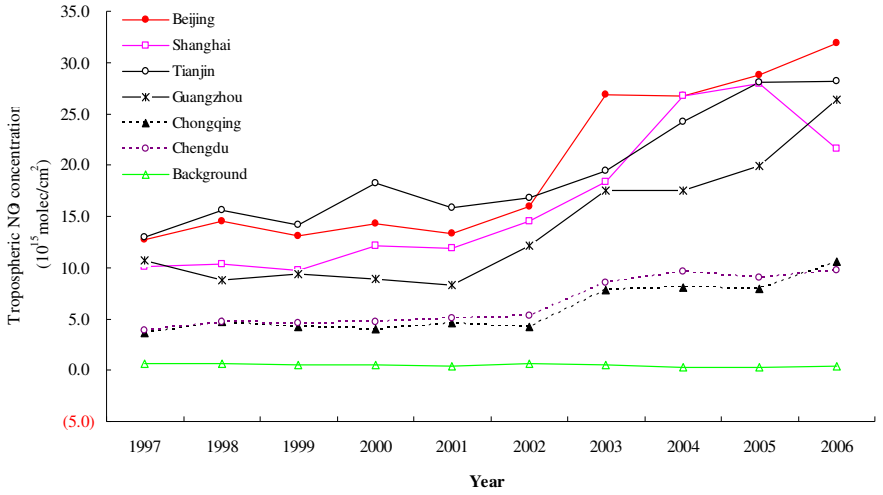




Temporal evolution of tropospheric NO_2 columns for four typical regions

Jingjinji Region (111–1200E, 30–400N)
Yangtze delta region (116–1220E, 29–340N)
Sichuan Basin (104–1070E, 29–310N)
Pearl River Delta region (111–1160E, 21–240N)





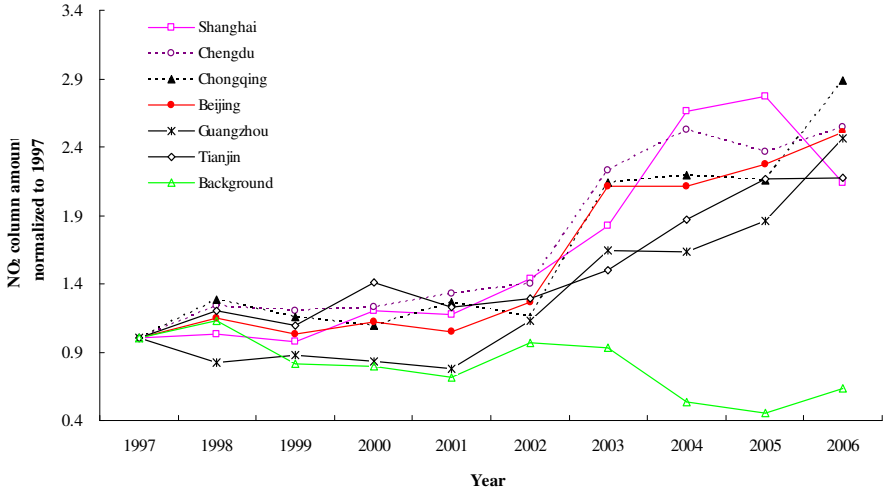


Table 1 Tropospheric NO_2 vertical columns over megacities in China

	Mean Concentration NO_2 in 1997 (10^{15} molec/cm^2)	Linear Trend in NO_2, (10^{15}molec/cm^2/year)	Growth (Reference Year 1997) %	Regression coefficient
Beijing	12.7	2.3	18.0	0.82
Shanghai	13.0	2.0	20.0	0.77
Tianjin	10.1	1.7	13.1	0.85
Guangzhou	10.7	0.9	16.4	0.59
Chengdu	3.8	0.7	19.1	0.85
Chongqing	3.7	0.7	19.0	0.78
Background (86±0.5^{0}E ×40±0.5^{0}N)	0.6	-0.03	-5.2	0.56

6. Summary

1. Chinese Meteorological Satellites have been important composition of global observation system to support sustainable developments.
2. The next generation polar series of FengYun 3A will be launched in the second half of 2007 or in the first half 0f 2008. The retrieval algorithms have been developed to provide the ozone and aerosol products.
3. Ground-based FTIR observations have been operated since Dec., 2006 with Breuker IFM120 to obtain the aerosol information.
4. NO_2 products from GOME and SCIMACHY are only validated in temporal series. Value validation hasn't been done with the in-situ data since there is uncertainty for the comparison. The products have been applied to assess the environmental effects from economical growth.

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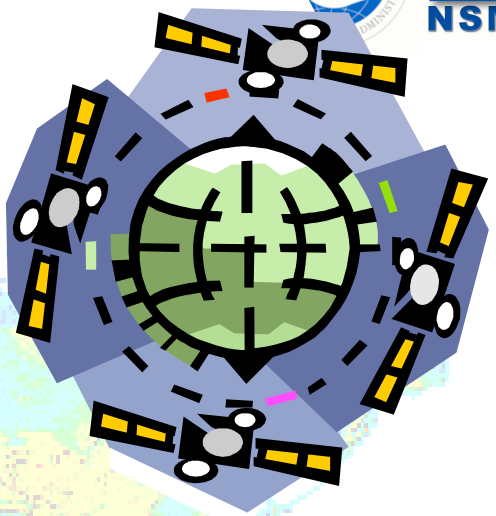

Thank you!