ESA - MOST Dragon 2 Programme

2011 DRAGON 2 SYMPOSIUM

中国科技部-欧洲空间局合作 "龙计划"二期

"龙计划"二期2011年学术研讨会

SATELLITE REMOTE SENSING ATMOSPHERIC COMPOSITIONS, PRODUCTS VALIDATION AND DATA APPLICATION IN CHINA

P. Zhang, X.Y. Zhang, W.G. Bai, W.H. Wang, F.X. Huang, X.J. Li, L. Sun, G. Wang, J. Qi, H. Qiu, Y. Zhang

National Satellite Meteorological Center/CMA

R.J. van der A c, B. Mijling

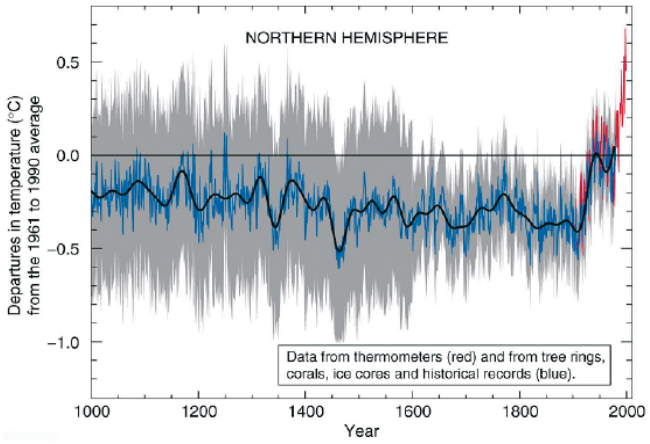
Royal Netherlands Meteorological Institute

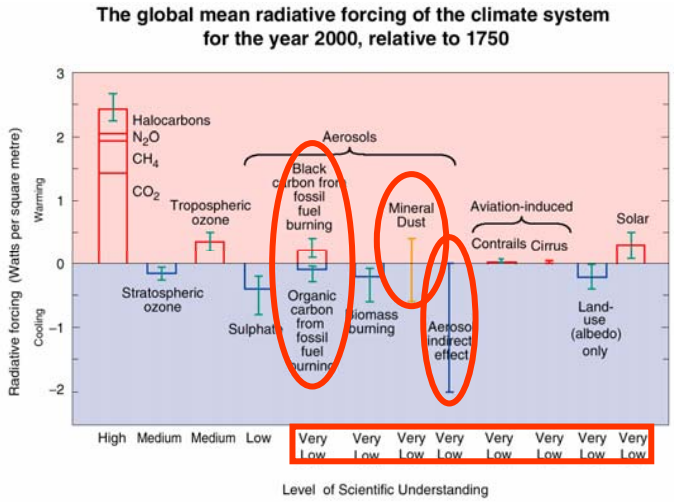
Content

1. General introduction on space-based AC remote sensing
2. ESA-MOST Dragon Program and EU FP6-AMFIC
3. AC Monitoring by Chinese Fengyun Polar Satellite and Future Plan
4. Ground-based AC remote sensing
5. Summary

1. General introduction on space-based AC remote sensing

Composition - Climate

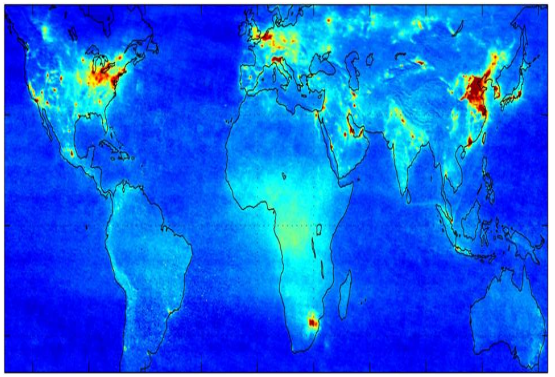


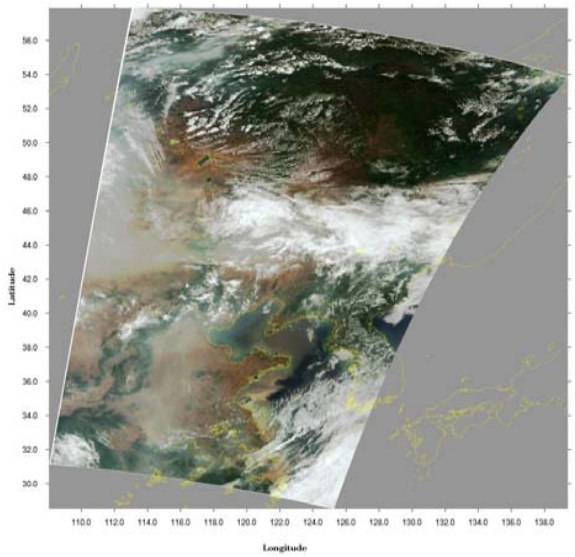


Ozone & Surface UV

- Aerosol
- Radiatively Active Trace Gases
- Chemically Active Trace Gases

Air Pollution



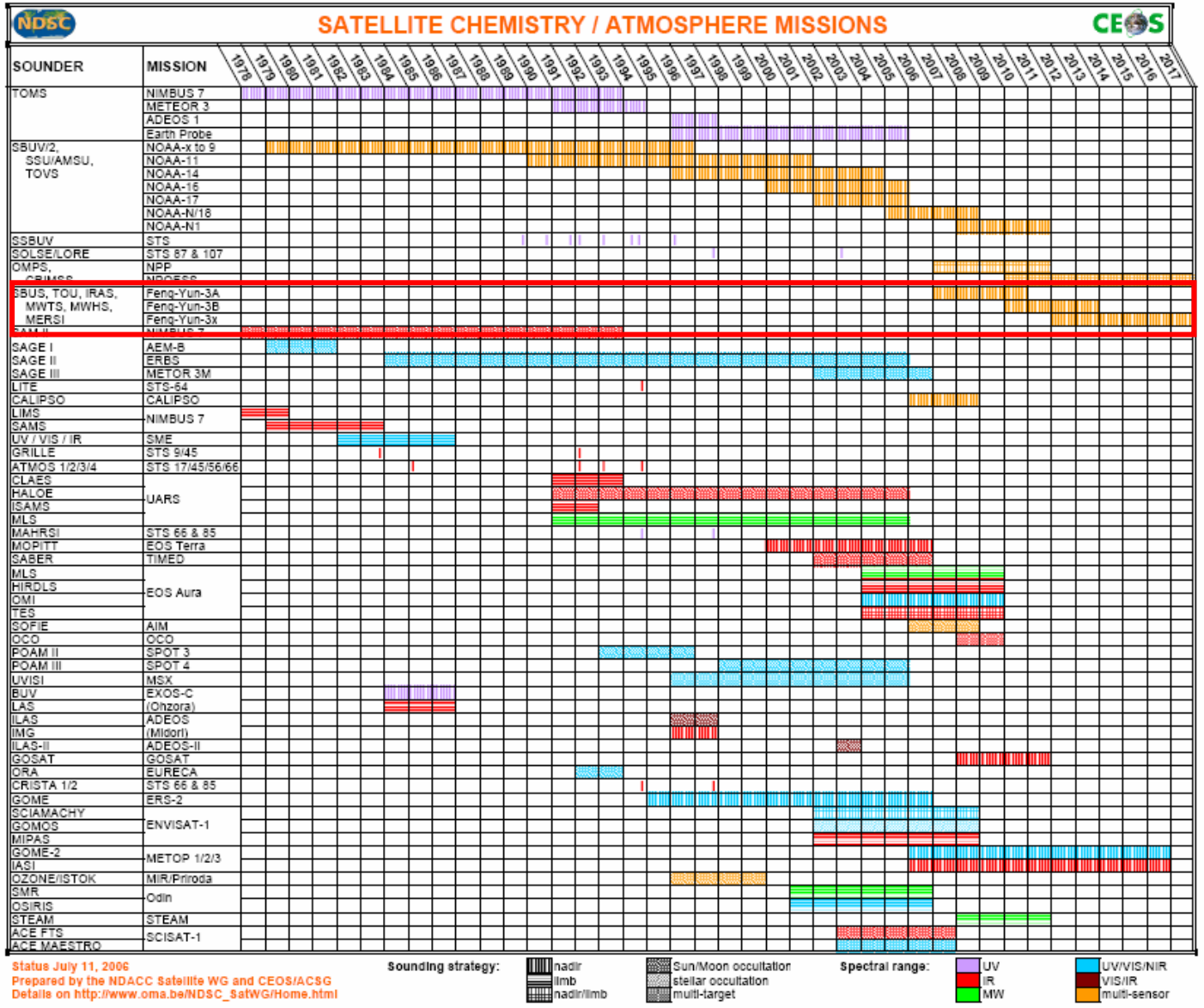


Chemical species	Air Quality	Oxidation Capacity	Climate	Stratospheric Ozone Depletion
O_3	✓	✓	✓	✓
CO	✓	✓		
UV-A j(NO_2)	✓	✓		
UV-B j(O_3)	✓	✓		
H_2O (water vapour)	✓	✓	✓	✓
HCHO	✓	✓		
C_2H_6	✓	✓		
active nitrogen: NO_x = NO+NO_2 *reservoir species*: HNO_3	✓ ✓	✓ ✓	✓	✓ ✓
SO_2	✓	✓	✓	✓
active halogens: BrO, ClO, OClO *reservoir species*: HCl, $ClONO_2$ *sources*: CH_3Br, CFC-12, CFC-11, HCFC-22				✓ ✓ ✓
aerosol optical properties	✓		✓	✓
CO_2			✓	
CH_4		✓	✓	✓

Targeted Variables IGACO

Group 1 & Group 2

Satellite Chemistry/Atmosphere Missions



FY-3

Aura

Envisat

Metop

2. ESA-MOST Dragon Program and EU FP6-AMFIC

- Dragon I 2004 - 2008
- Dragon II 2008 - 2012

:: DRAGON PROJECT ID 2580

Air Quality Monitoring and Forecasting in China

Prof. Hennie Kelder, e-mail: Kelder@knmi.nl
Dr. Zhang Peng, e-mail: zhangp@nsmc.cma.gov.cn

Prof. John Burrows, Prof. Gerrit de Leeuw, Dr. Zhao Fengsheng, Dr. JianZhong Ma, Dr. Zhang Peng, Dr. Qiu Hong, Dr. Paul Simon, Dr. Ronald van der A, Dr. Roeland van Oss

ERS 1 1991

ERS 2 1995

ENVISAT 2002

Scientific Research Progress

- Symposium
- Joint proposal
- Joint Workshop
- Scientists Exchange

图 12 中国－欧洲合作"龙计划"学术会议
The 4th dragon symp2007 in France

图 13 中国－欧洲国际合作项目AMFIC
AMFIC project meeting in France

图 14 中国－比利时合作项目专家论证会
Cooperation between the Belgian Institute for Space Aeronomy (BIRA-IASB) and National Satellite Meteorological Center (NSMC/CMA)

Air Quality Monitoring and Forecasting In China (AMFIC)

- FP6-2005-Space-1: 2007 – 2009
- PI: Ronald van der A

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demostration

Specific Targeted Research or Innovation Project

A1

Proposal Number	030940	Proposal Acronym	AMFIC

GENERAL INFORMATION ON THE PROPOSAL

Proposal Title	*Air quality Monitoring and Forecasting In China*		
Duration in months	*24*	*Call (part) identifier*	*FP6-2005-Space-1*
Activity code(s) most relevant to your topic			
Keyword code 1			
Keyword code 2			
Keyword code 3			
Free keywords			

Abstract (max. 2000 char.)

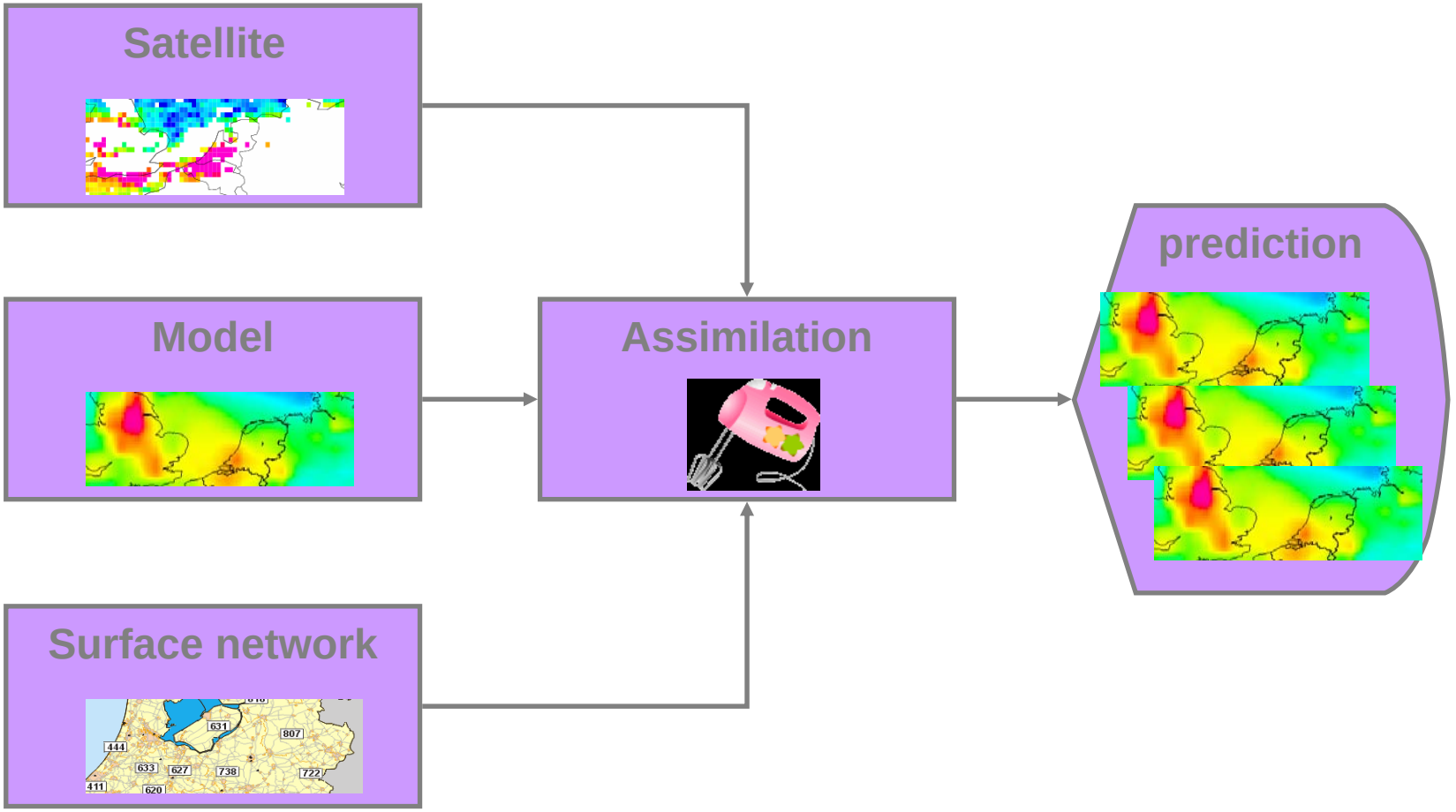
AMFIC addresses atmospheric environmental monitoring over China. The aim is to develop an integrated information system for monitoring and forecasting tropospheric pollutants over China. The system uses satellite and in situ air quality measurements and modelling to generate consistent air quality information over China. The data will cover the recent years and the actual situation including an air quality forecast for several days ahead. Air pollutants covered are ozone, nitrogen dioxide, sulphur dioxide, formaldehyde, carbon monoxide, methane and aerosol/particular matter.
The proposed system will supplement and broaden the existing ground-level monitoring and air quality assessment activities in China. Satellite data will cover regions where no ground-based stations are available; air quality models fill-in the sparse temporal and spatial sampling of the measurements and connect them in a physically consistent manner.
The system targets environmental agencies in China, some of whom are participating in AMFIC, and assists them in their reporting duties on air quality. A case study for the city of Shenyang will be demonstrated. The proposed project will also improve our understanding of the transport of air pollution within, from and to China. AMFIC builds on aspects of the ESA GMES Atmosphere Service Element PROMOTE which has a strong potential for providing the European atmospheric monitoring contribution to GEOSS.

List of partner institutes

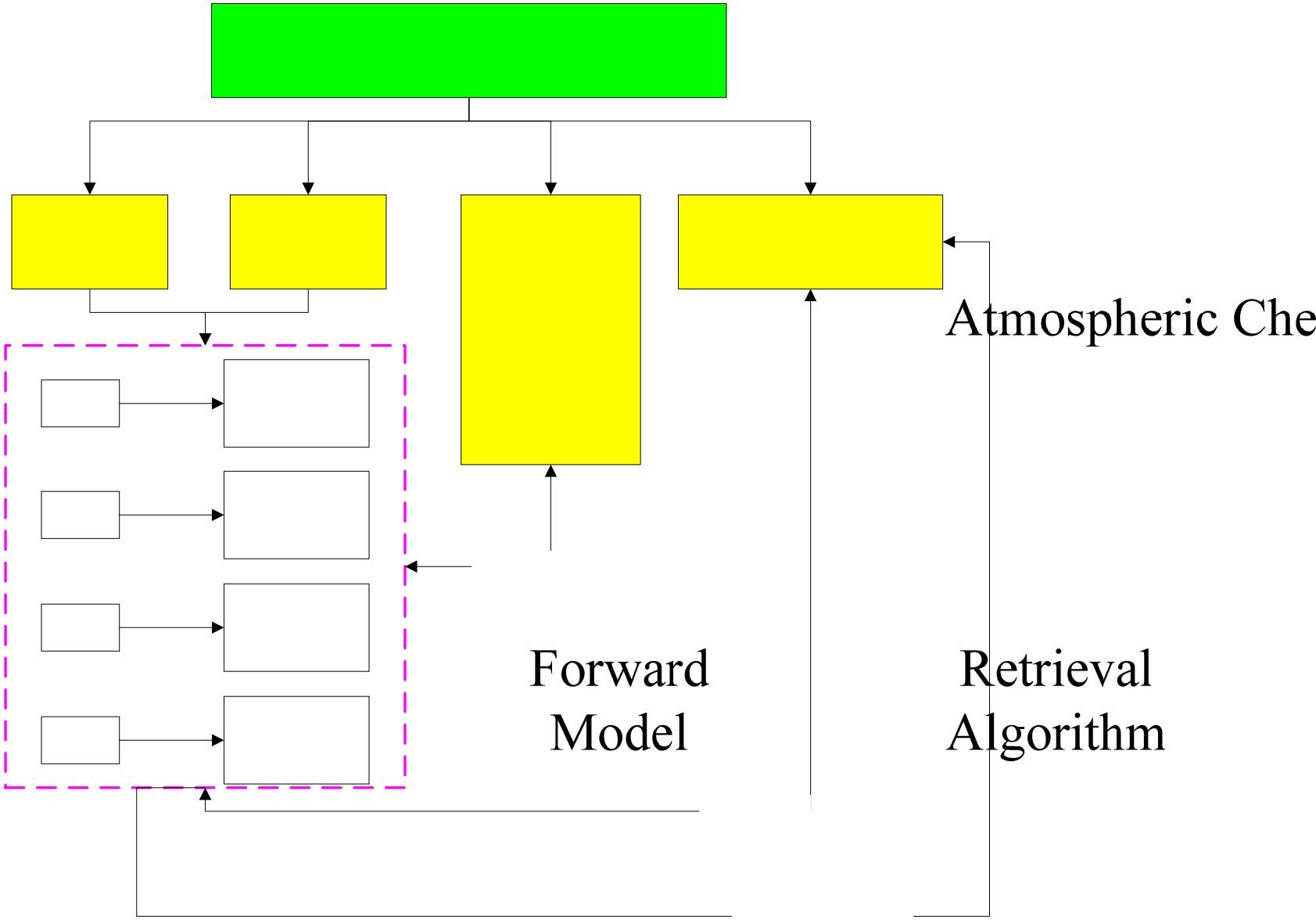
- KNMI — Royal Netherlands Meteorological Institute, **Netherlands** (PI)
- BIRA-IASB — Belgium Institute for Space Aeronomy, **Belgium**
- VITO — Flemish institute for technological research, **Belgium**
- DUTH — Democritus University of Thrace, **Greece**
- NOA — National Observatory of Athens, **Greece**
- LAP-AUTH — Lab. of Atmospheric Physics, **Greece**
- FMI — Finnish Meteorological Institute, **Finland**
- IFE — University of Bremen, **Germany**
- NSMC — National Satellite Meteorological Center, **China**
- IAP-CAS — Institute of Atmospheric Physics, **China**

AMFIC System

Improving monitoring and prediction:
improving modelling, observations, chemical data assimilation



AMFIC Infrastructure



Air Quality Monitoring and Forecasting in China

home | forecasts | satellite data | validation | participants | articles | links | internal

NRT Satellite Data

AMFIC web data base

Satellite observations over China

<< previous day
<< previous month

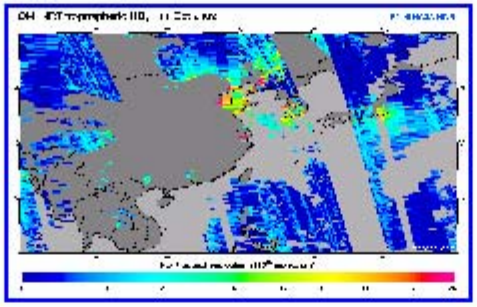
Images of 11 October 2009

next day >>
next month >>

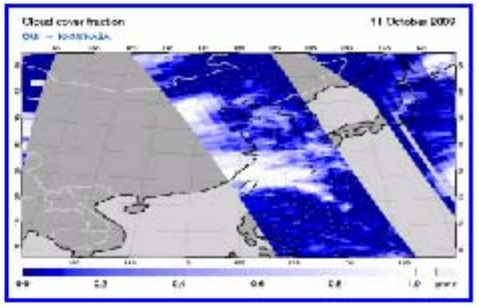
Select a day

Year: 2009
Month: October
Day: 11

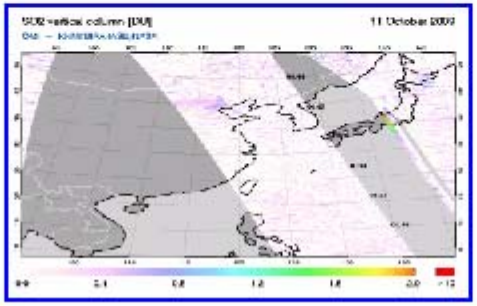
submit



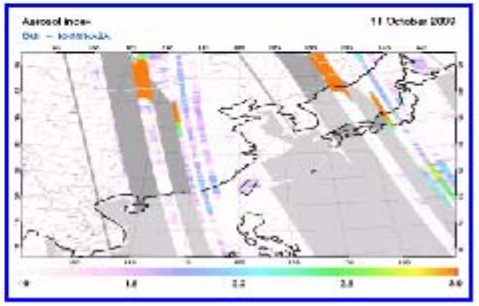
NO_2



Cloud Fraction



SO



AAI

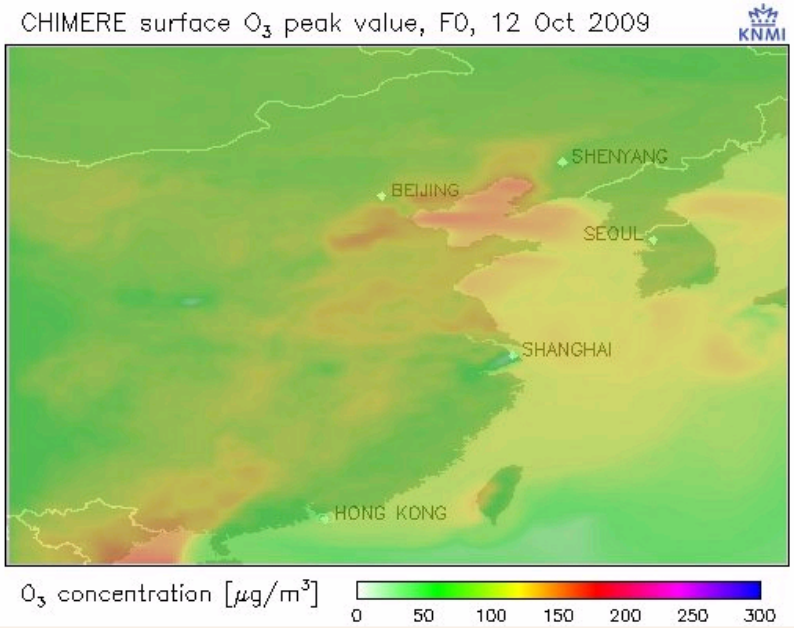
中国空气质量监测与预报

Air Quality Monitoring and Forecasting in China

主页 | 空气质量公告 | 文件 | 帮助

选择公告 区域 中国东部 类型 臭氧峰值 日 今天

中国东部 - 臭氧峰值



Beijing 2008

CHINESE OLYMPIC COMMITTEE

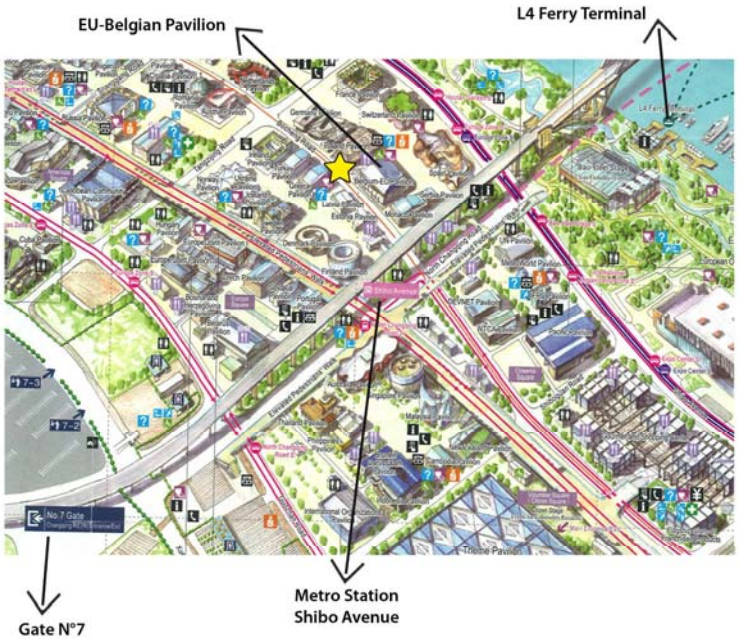
BEIJING 2008

EXPO 2010 SHANGHAI CHINA

- Dr. Peng Zhang, National Satellite Meteorological Center, China Meteorological Administration (AMFIC - Air Quality Monitoring and Forecasting in China – project partner)

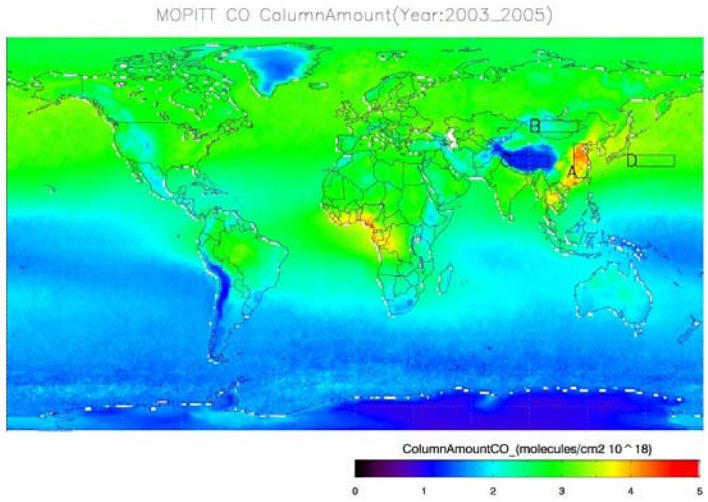
On the AMFIC project, its results (air quality forecasts for cities such as Shanghai, Beijing and Shenyang), and the experience of China-EU space research cooperation

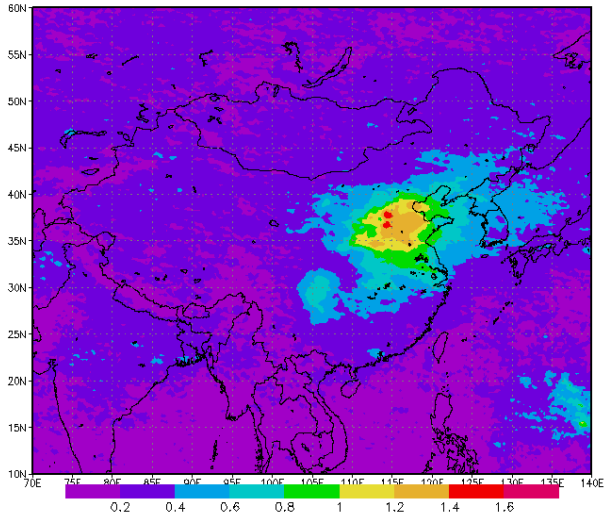
Powerpoint presentation [14 MB]

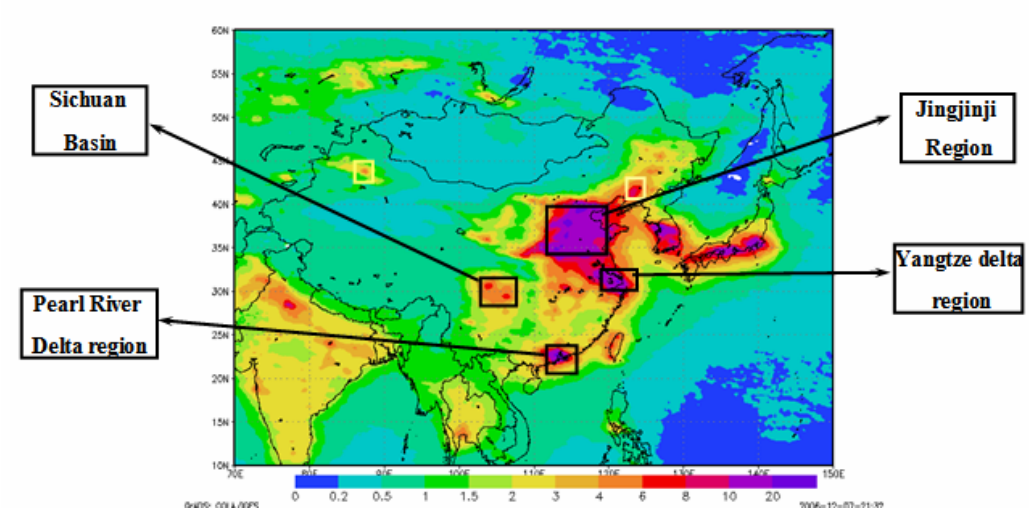


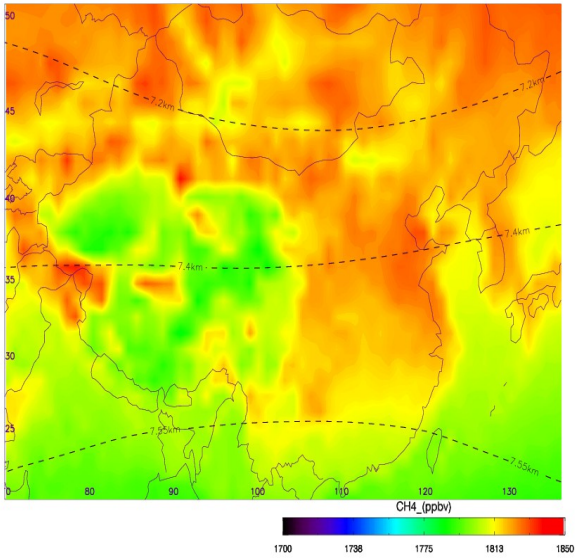
Trend, seasonal cycle, and sources of atmospheric composition by using SCIAMACHY/Envisat, IASI/Metop, MODIS & OMI & AIRS/EOS, etc.

- Aerosol
- Ozone
- NO_2
- SO_2
- CH_4
- CO
- CO_2



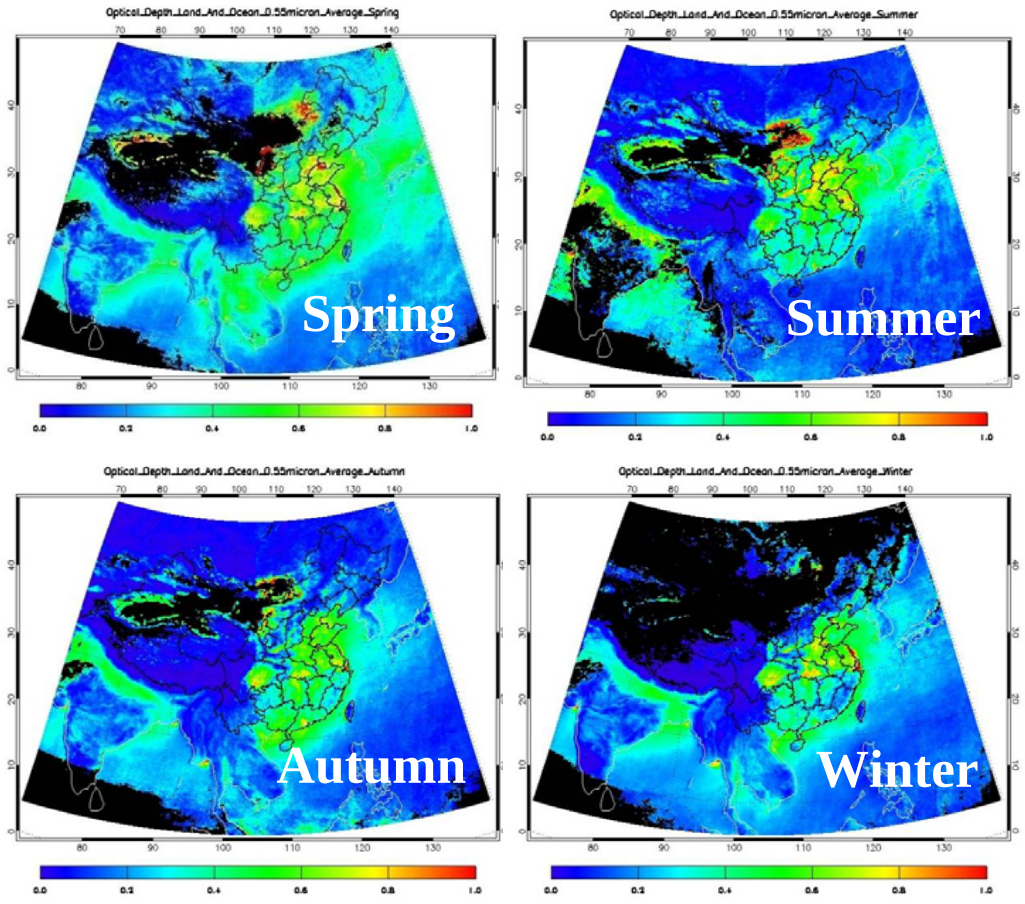




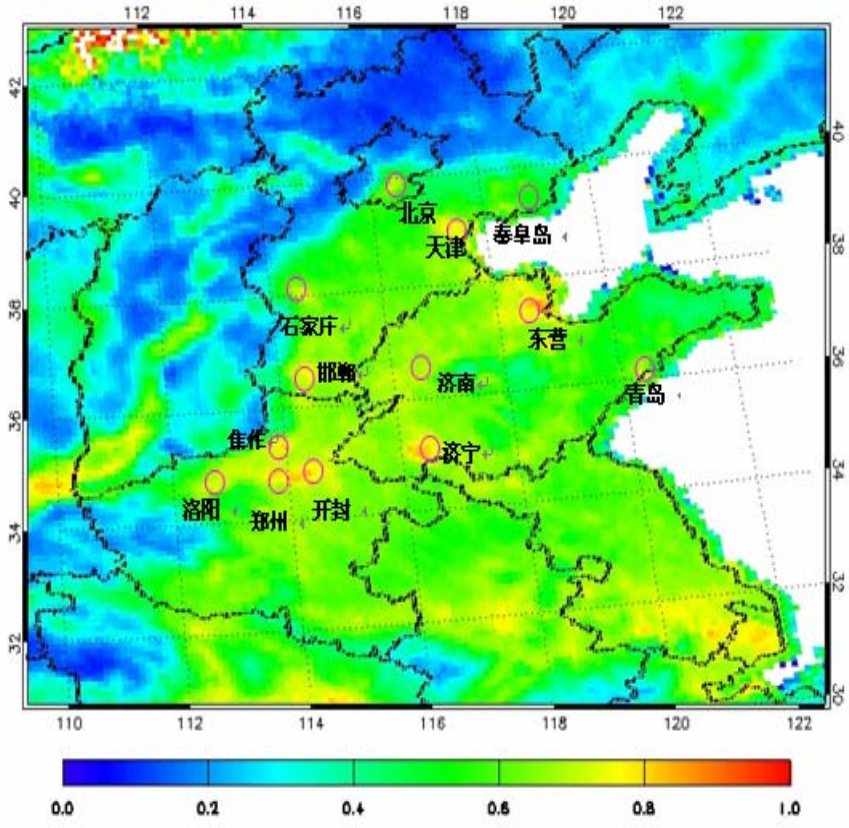


Aerosol Pattern over China by MODIS AOD 2005-2008

Seasonal Averaged

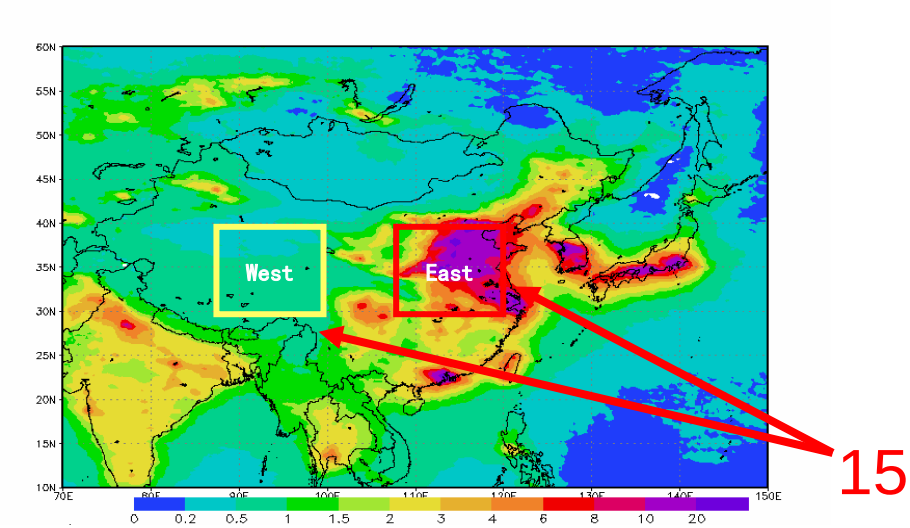


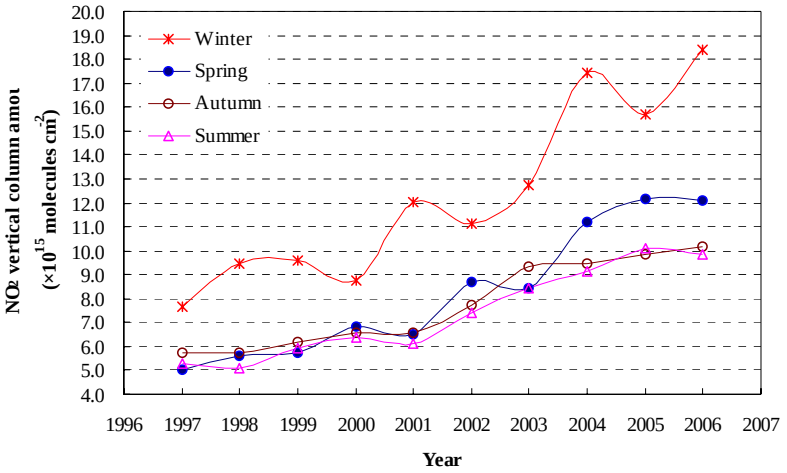
North East Part of China Year Averaged



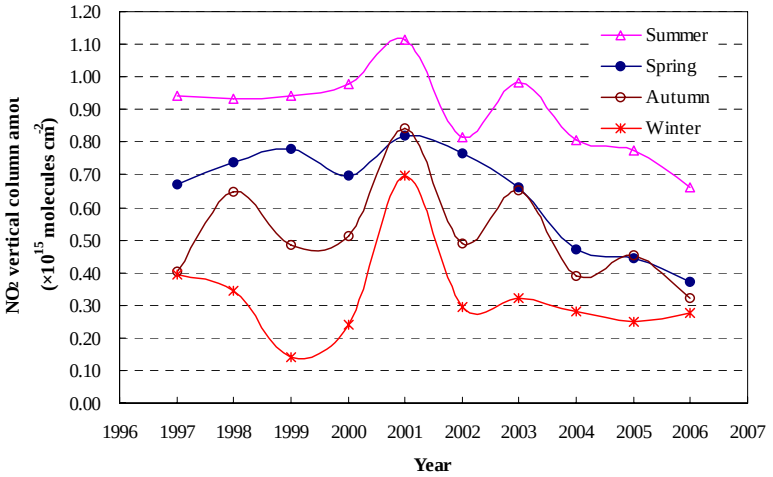
NO_2 1996-2010 from GOME and SCIAMACHY

Zhang X., Zhang P., Zhang Y., Li X., Qiu H.，**2007**，The trend, seasonal cycle, and sources of tropospheric NO_2 over China during 1997~2006 based on satellite measurement，Sci China Ser D-Earth Sci, vol. 50(12), 1877-1884 .**(SCI)**





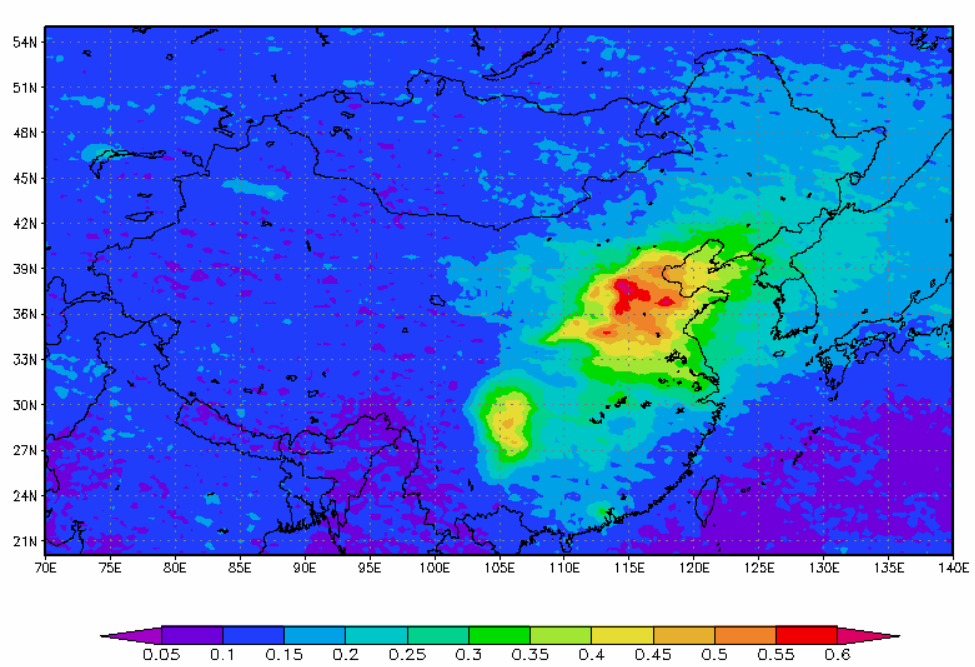
East area (110–1230E, 30–400N)

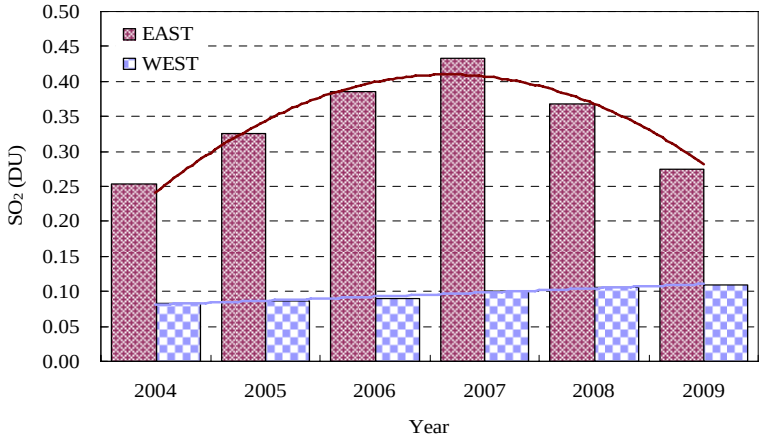


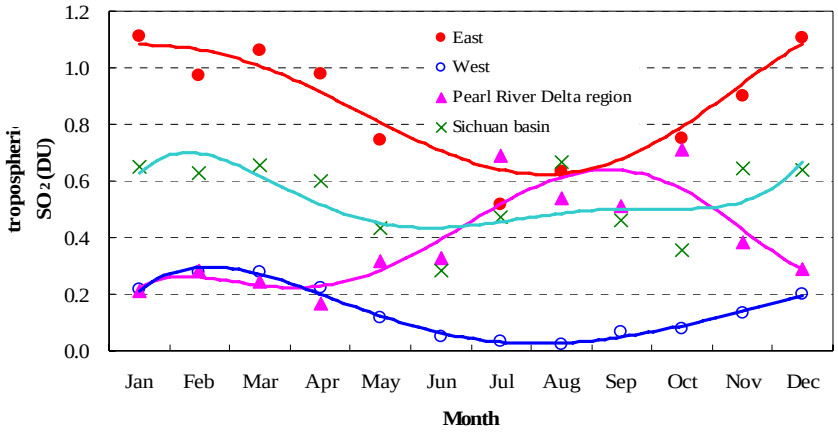
West area (80–1000E, 30–400N)

SO_2 2004-2010

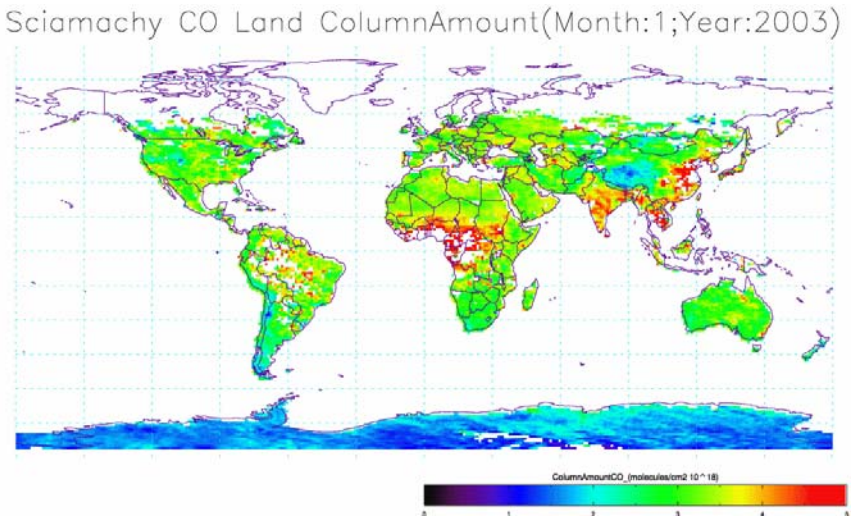
Xingying Zhang, Jos van Geffen, Peng Zhang , Jing Wang, **2010,** TREND SPATIAL & TEMPORAL DISTRIBUTION, AND SOURCES OF THE TROPOSPHERIC SO2 OVER CHINA BASED ON SATELLITE MEASUREMENT DURING 2004~2009, Proceedings of the Symposium Dragon 2 Programme Mid-Term Results 2008-2010, Guilin, China, 17-21 May 2010, ESA publications division SP-684, ISBN 978-92-9221-248-3 **(EI)**

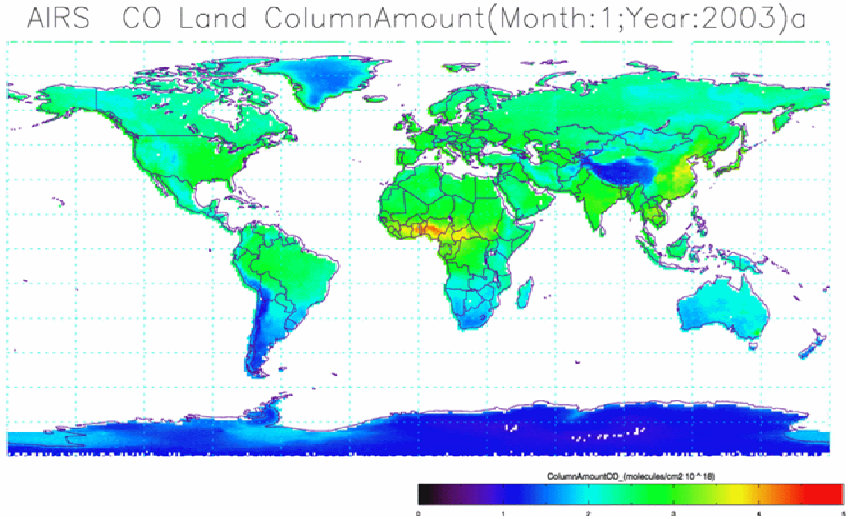


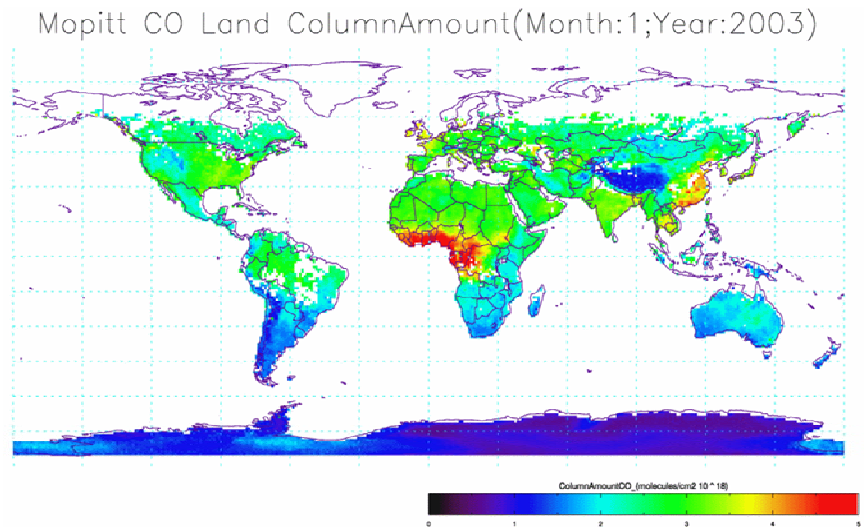




CO from SCIAMACHY, MOPITT, AIRS





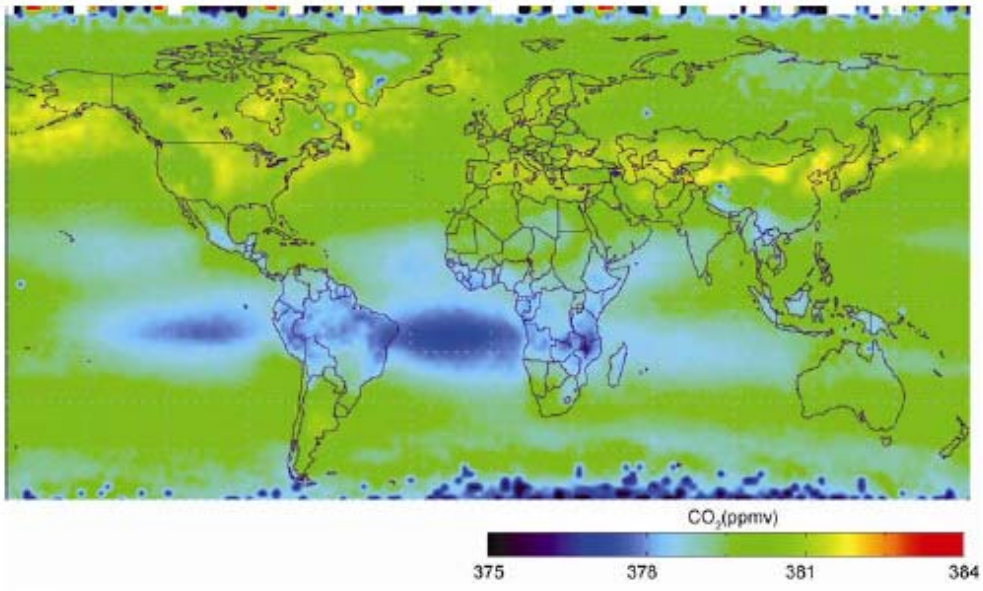


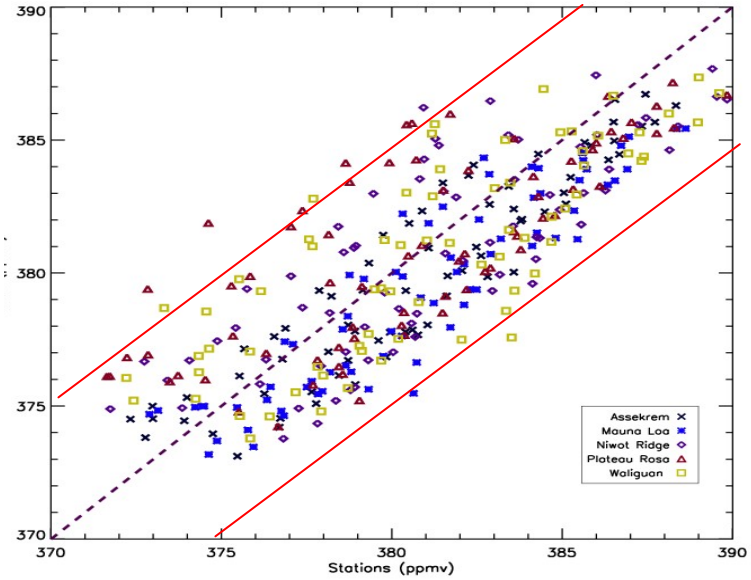
CO column amount (average over year 2003) retrieval by SCIAMACHY and MOPITT show agreement at most places, but still some differences occur. Especially over sea surface SCIAMACHY product is higher than the MOPITT result.

白文广，张鹏，张兴赢，王维和，齐瑾，刘辉，张文建，边巴次仁，2010：用卫星资料分析中国区域CO柱总量时空分布特征。应用气象学报，21(4)，473-483。

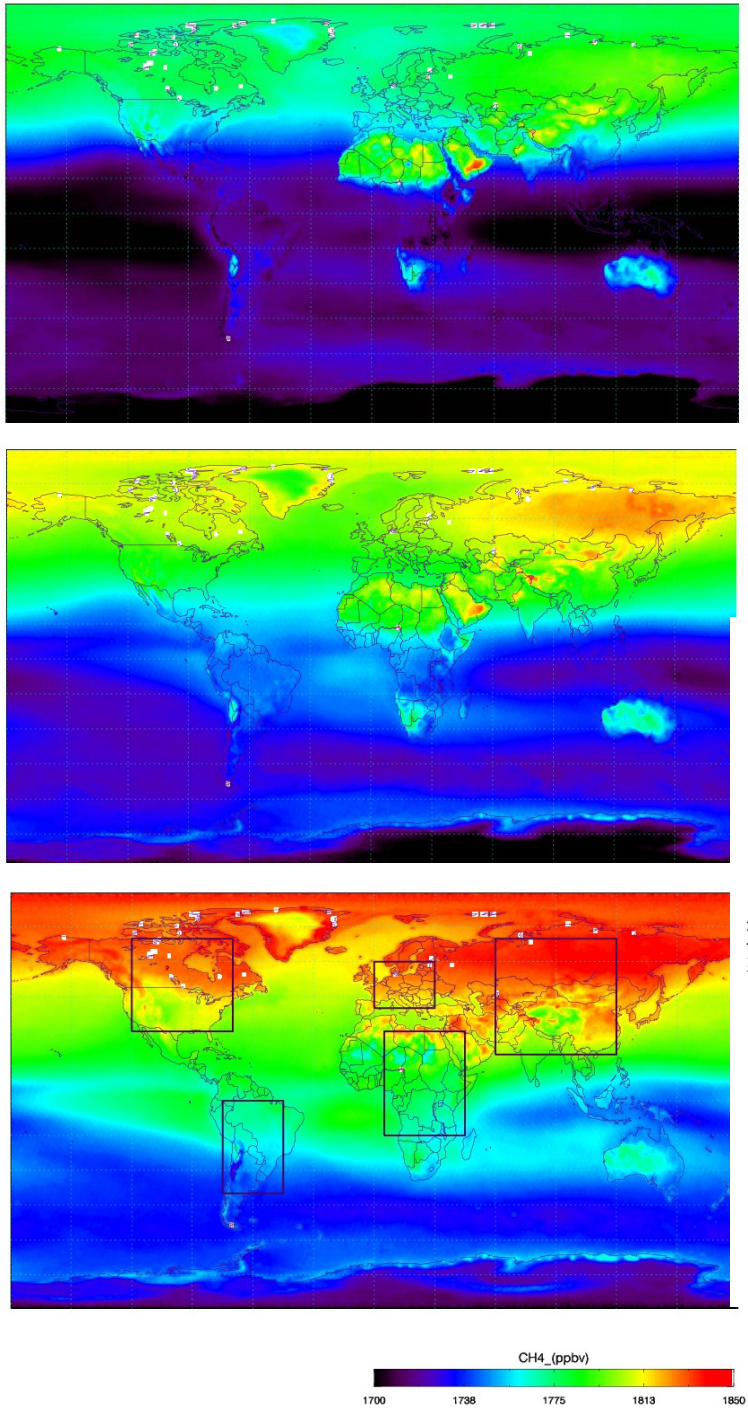
CO_2 2003-2008

Wenguang Bai, Xingying Zhang, Peng Zhang, 2010, Characterization of carbon dioxide over China based on Satellite measurement, Chinese Science Bulletin，Vol.55 No.31: 3612–3618 (SCI)



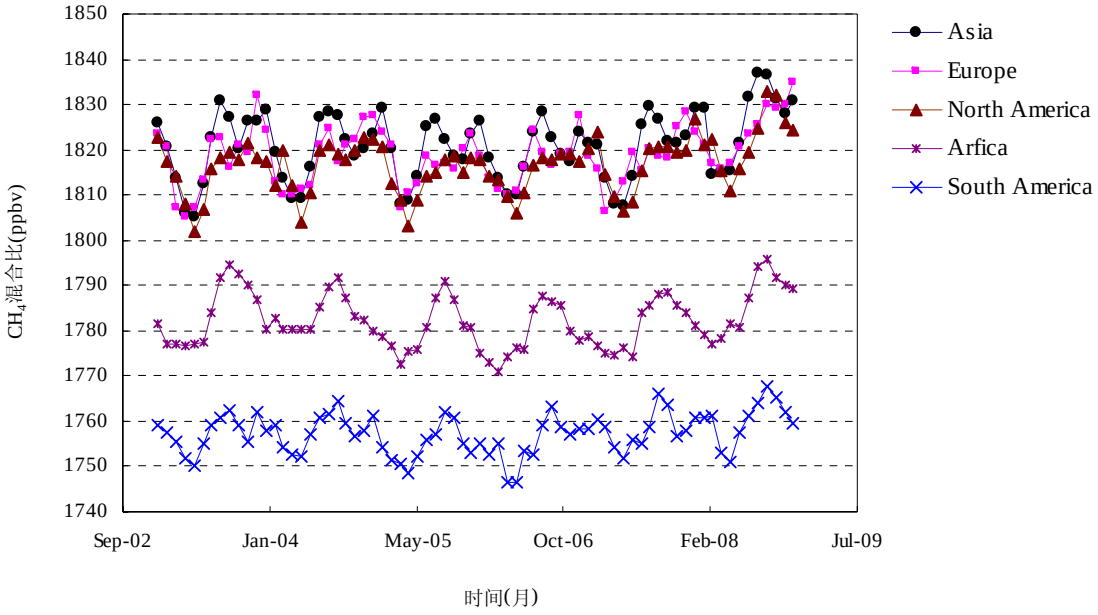


	Area		Mean (ppmv)	Monthly average variance (ppmv)	Annual growth rate (ppmv/a)	Seasonal fluctuation (ppmv)
	Longitude	Latitude				
America	122.5°–72.5°W	33°–48°N	381.00	3.76	2.11	3.70
Canada	130°–90°W	50°–65°N	381.04	4.21	2.26	7.72
China	90°–120°E	22°–42°N	380.36	3.75	2.09	4.06
Russia	45°–135°E	56°–70°N	380.04	4.76	2.32	10.99
Australia	120°–150°E	30°–20°S	379.83	3.71	2.09	2.87
Europe	0°–30°E	40°–60°N	381.00	3.82	2.10	5.02
India	72.5°–85°E	14°–30°N	379.70	3.63	2.03	2.94



CH_4 2003-2008

Xingying Zhang, Wenguang Bai, Peng Zhang, **2010**, Study on three-dimensional structure of tropospheric methane over China based on satellite observations, Chinese Science Bulletin，in review **(SCI)**



Papers published

30 Papers, **10** in SCI/EI within recent 5 years

1. Zhang, X., Jos van Geffen, Peng Zhang , Jing Wang, **2010**, TREND SPATIAL & TEMPORAL DISTRIBUTION, AND SOURCES OF THE TROPOSPHERIC SO2 OVER CHINA BASED ON SATELLITE MEASUREMENT DURING 2004~2009, Proceedings of the Symposium Dragon 2 Programme Mid-Term Results 2008-2010, Guilin, China, 17-21 May 2010, ESA publications division SP-684, ISBN 978-92-9221-248-3 **(EI)**
2. Weihe Wang, Xingying Zhang*, Xingqin An et al., **2010**, Analysis for retrieval and validation results of FY-3 Total Ozone Unit(TOU), Chinese Science Bulletin，2010 Vol. 55 (26): 3037-3043 **(SCI)**
3. Weihe Wang, Xingying Zhang*, Yongmei Wang et al., 2010, Introduction to the FY-3A Total Ozone Unit (FY-3A TOU): Instrument, Performance, and Results, International Journal of remote sensing, 10.1080/01431161.2010.489073 **(SCI)**
4. Wenguang Bai, Xingying Zhang*, Peng Zhang, **2010**, Characterization of carbon dioxide over China based on Satellite measurement, Chinese Science Bulletin，Vol.55 No.31: 3612–3618 **(SCI)**
5. Huang fuxiang, et al , **2010**, Vertical Ozone profiles deduced from measurements of SBUS on FY-3 satellite, Chinese Science Bulletin, 55(10): 943-948 **(SCI)**
6. Zhang, X., Guoshun Zhuang，Kenneth A Rahn, Hui Yuan, Zifa Wang，**2009,** The aerosol particles from dried salt-lakes and saline soils in dust storm in Beijing, Terrestrial, Atmospheric & Oceanic Sciences, Vol. 20, No. 4，619-628. **(SCI)**
7. Zhang, X., P. Zhang, Y. Zhang, X. Li and H.Qiu, **2008**, THE TREND, SPATIAL & TEMPORAL DISTRIBUTION AND SOURCES OF TROPOSPHERIC NO2 OVER CHINA BASED ON SATELLITE MEASUREMENT DURING 1997 TO 2006, Proc. Dragon 1 Programme Final Results 2004–2007, Beijing, China, 21-25 April 2008, ESA publications division SP-655, ISBN 978-92-9221-219-3 **(EI)**
8. Zhang X., Zhang P., Zhang Y., Li X., Qiu H.，**2007**，The trend, seasonal cycle, and sources of tropospheric NO2 over China during 1997~2006 based on satellite measurement，Sci China Ser D-Earth Sci, vol. 50(12), 1877-1884 .**(SCI)**
9. Zhang, X., Zhuang, G., Guo, J., Yin, k., Zhang, P, **2007**，Characterization of aerosol over the Northern South China Sea during two cruises in 2003, Atmospheric Environment, 41(36), 7821-7836.**(SCI)**
10. Zhang, X., Zhuang, G., Chen, J., Wang, Y., Wang, X., An, Z., Zhang, P., **2006,** Heterogeneous reactions of sulfur dioxide on mineral particles. Journal of Physical Chemistry B, 110(25), 12588-12596. **(SCI)**

3. AC Monitoring by Chinese Fengyun Polar Satellite and Future Plan

Polar System

FY
|
1A
1B
1C
1D

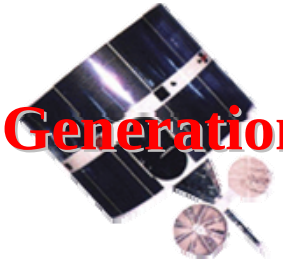
First Generation

FY
|
3A
3B
3C
|
3F

Second Generation

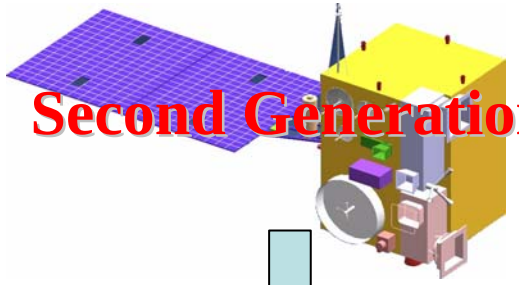
Geostationary System

First Generation



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

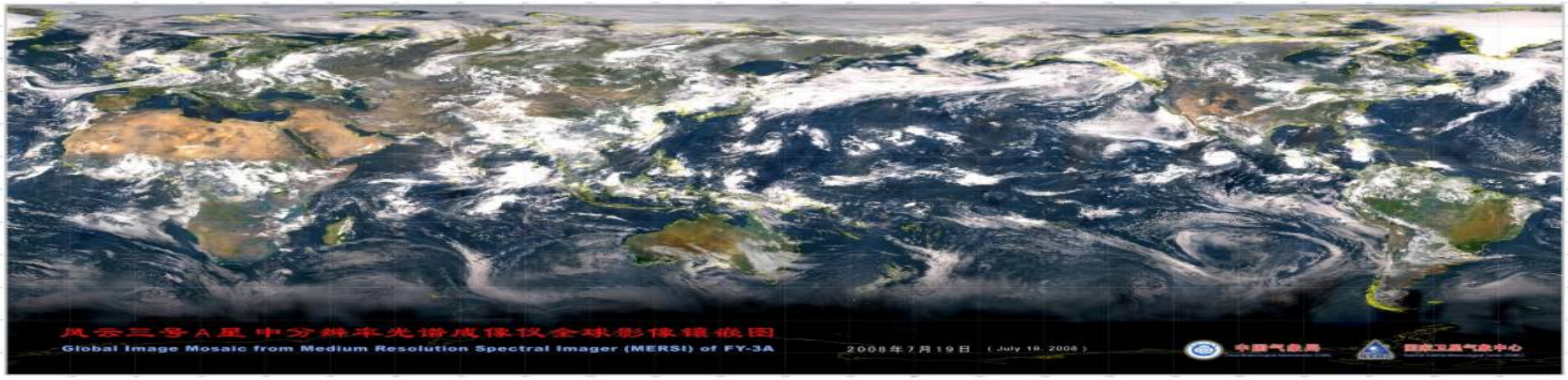
Second Generation



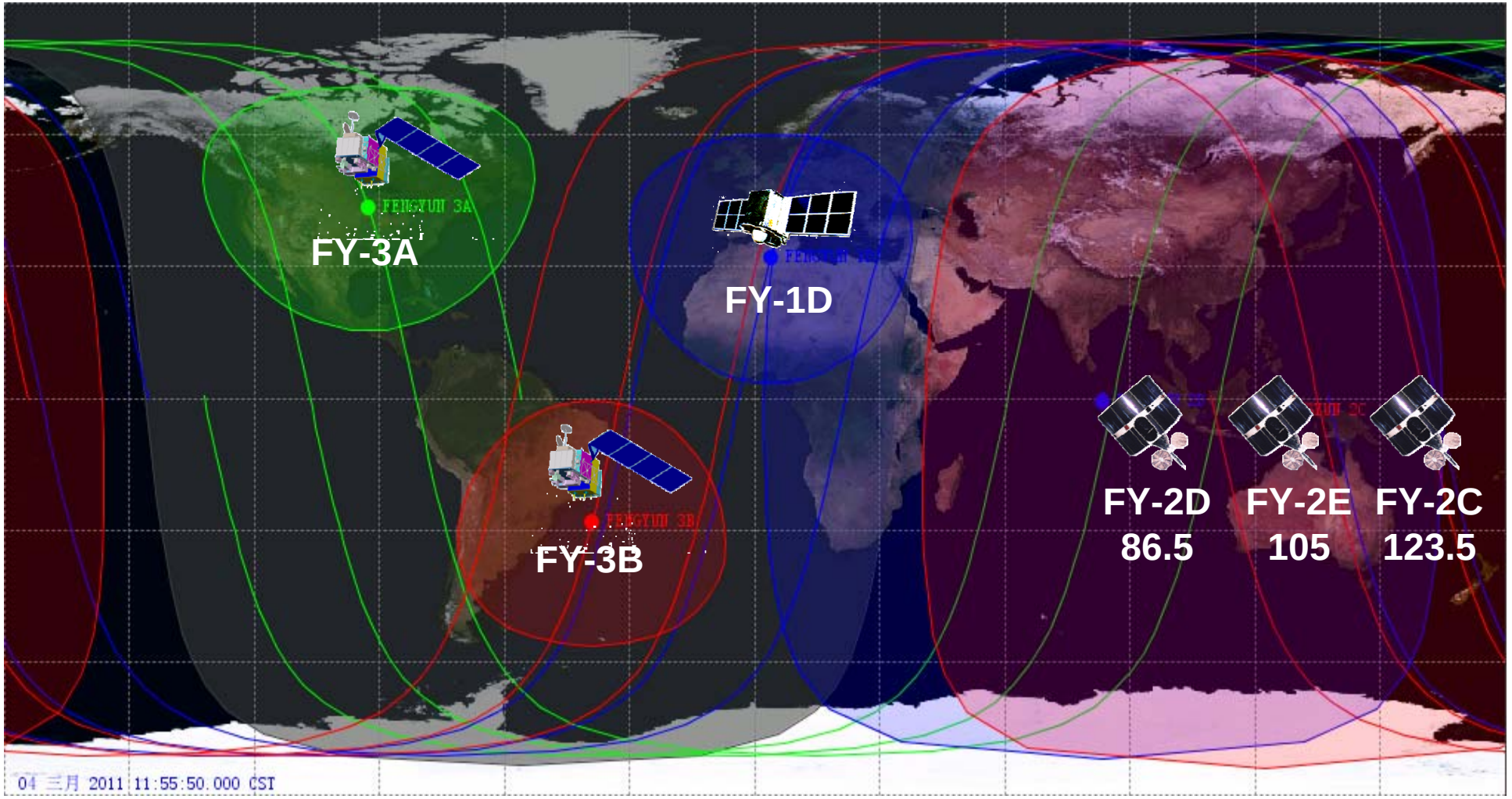
FY
|
4A
4B
4C
…

Launched 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-3A	May 27, 2008		FY-2E	Dec. 23, 2008
FY-3B	Nov 5, 2010			

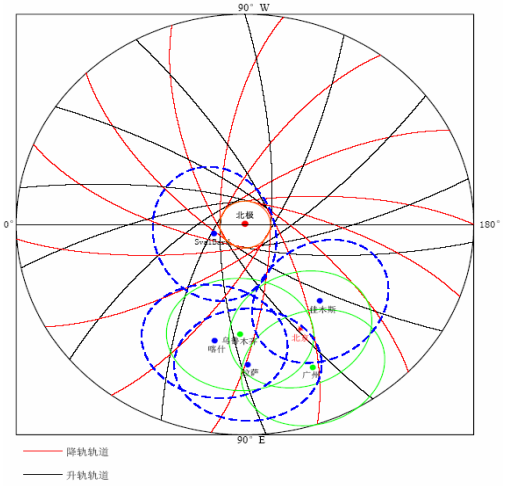


On-orbit Satellites



FengYun LEO. Satellites: FY-3

11 instruments on board FY-3A/B, including:
VIRR: Visible and Infra-Red Radiometer
MERSI： Medium Resolution Spectral Imager
IRAS： Infrared Atmospheric Sounder
MWTS：MicroWave Temperature Sounder
MWHS: MicroWave Humidity Sounder
MWRI: MicroWave Radiation Imager
SBUS: Solar Backscatter Ultraviolet Sounder
TOU: Total Ozone mapping Unit
SIM: Solar Irritation Monitor
ERM: Earth Radiation Monitor
SEM: Space Environment Monitor



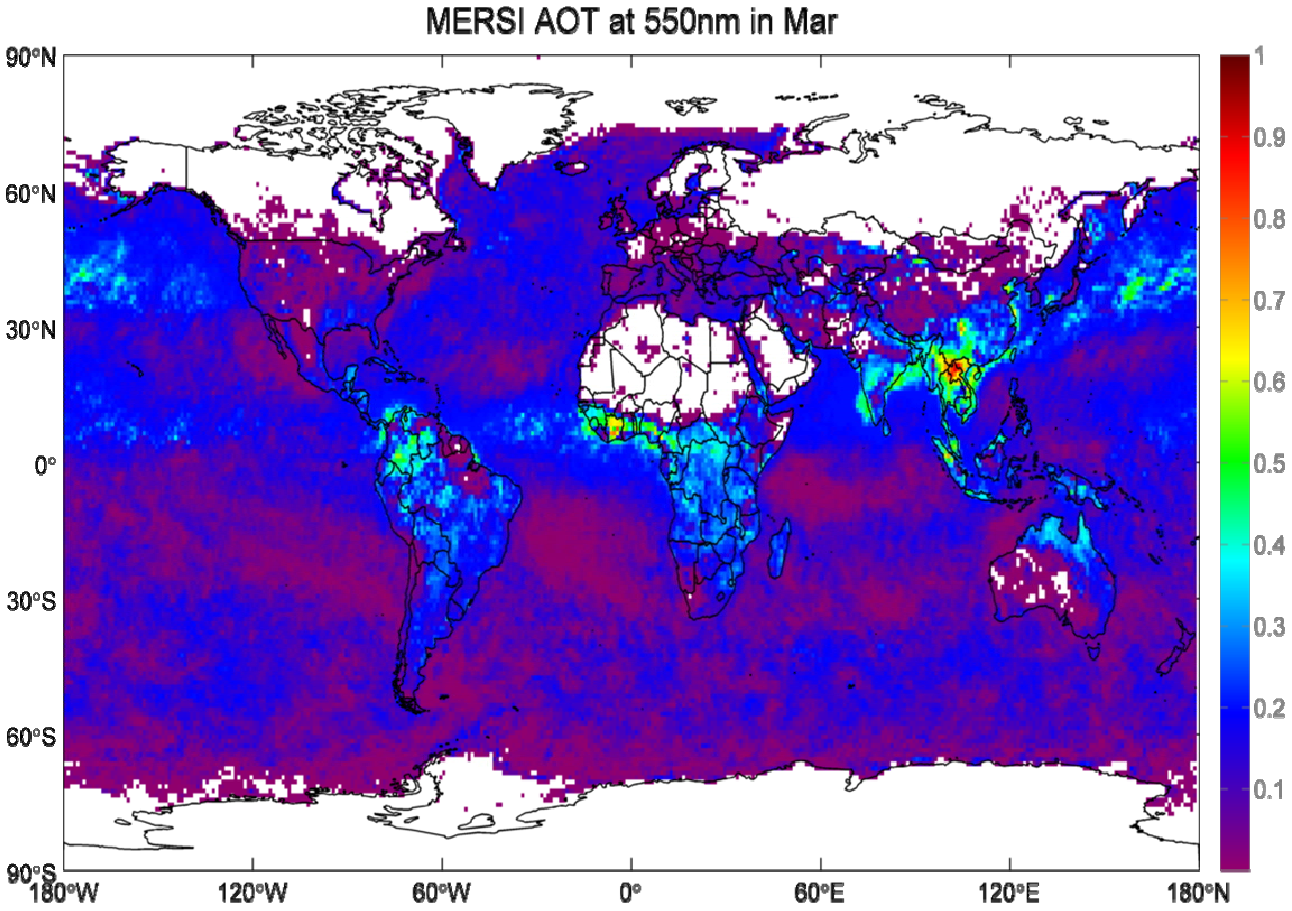
Station Name	Longitude	Latitude
Beijing Station	116° 16′ 36″ E	40° 03′ 06″ N
Guangzhou Station	113° 20′ 20″ E	23° 09′ 52″ N
Wulumuqi Station	87° 34′ 08″ E	43° 52′ 17″ N
Jiamusi Station	130° 22′ 48″ E	46° 45′ 20″ N
Kiruna Station	21° 02′ E	67° 32′ N

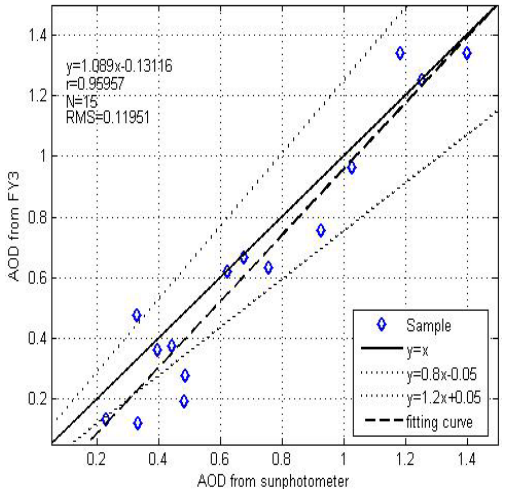
FY-3A/B Instruments Specification

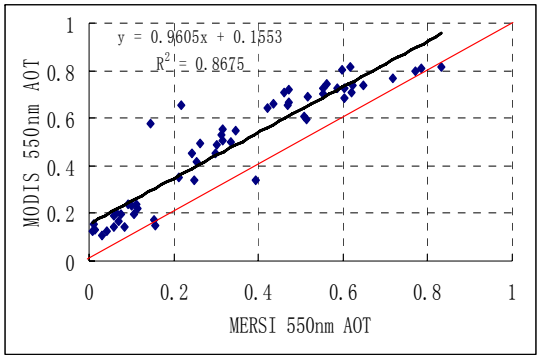
Name of Instrument	Number of Channels	Spectral range	Swath Width (Km)	Spatial Resoluation at Sub point (Km)
VIRR	10	0.43 – 12.5 μ m	2800	1.1
MERSI	20	0.41 – 12.5 μ m	2800	0.25 ~ 1
MWRI	10	10 – 89GHz	2800	15 ~ 85
IRAS	26	0.69 – 15.5 μ m	2250	17
MWTS	4	50 – 57 GHz	2200	50 ~ 75
MWHS	5	150 – 183 GHz	2700	15
SBUS	12	0.16 – 0.4 μ m	---	200
TOU	6	0.3～0.36 μ m	3000	50
ERM	4	0.2～50 μ m	2300	28
SIM	1	0.2～50 μ m	---	---
SEM	---	---	---	---

- **atmospheric sounding**
- **Microwave Imaging**
- **Optical Imaging from Km to 250m**
- **Atmospheric composition: Ozone**
- **Radiation budget for earth system**

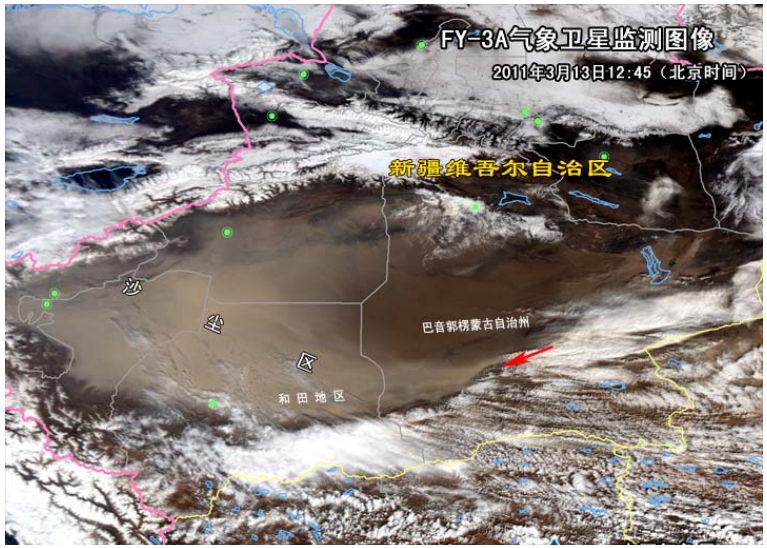
AOD Month Average Global from MERSI/FY-3A

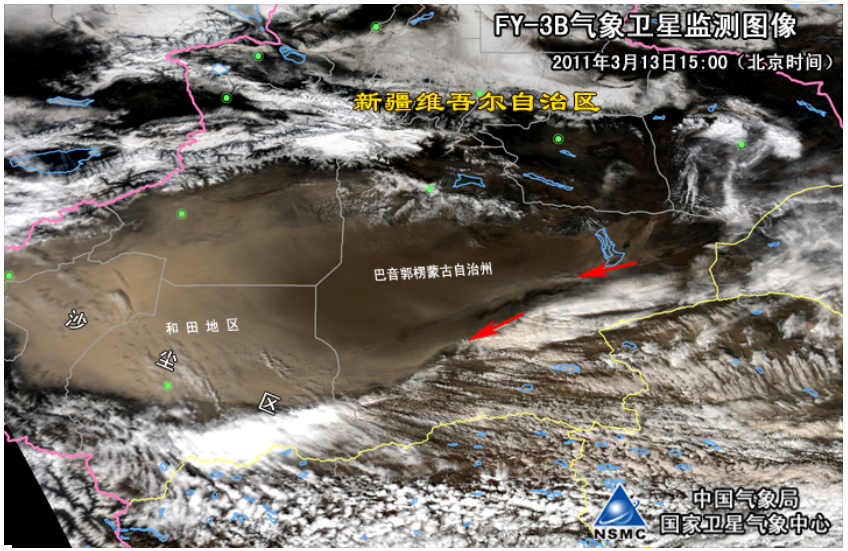


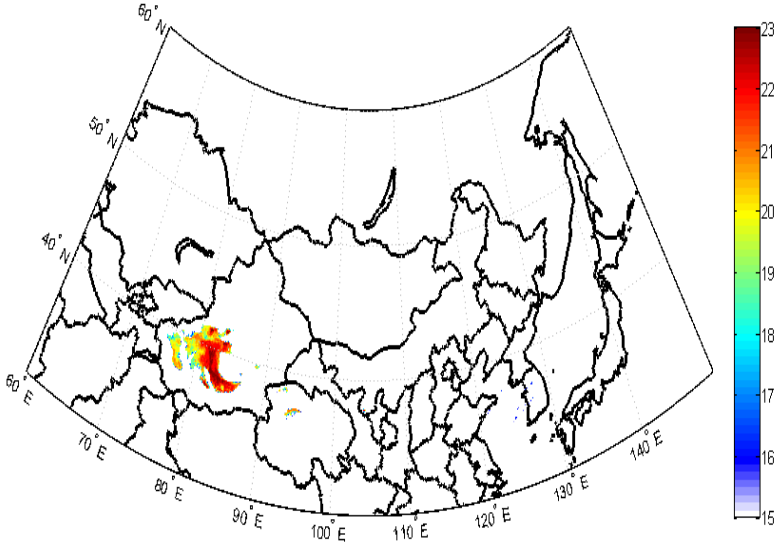


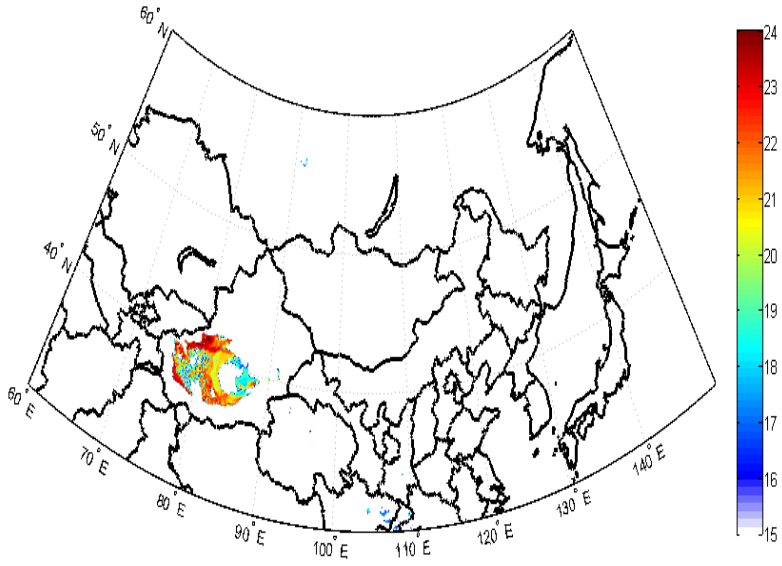


Dust Monitoring monitoring by FY-3B comparing with FY-3A



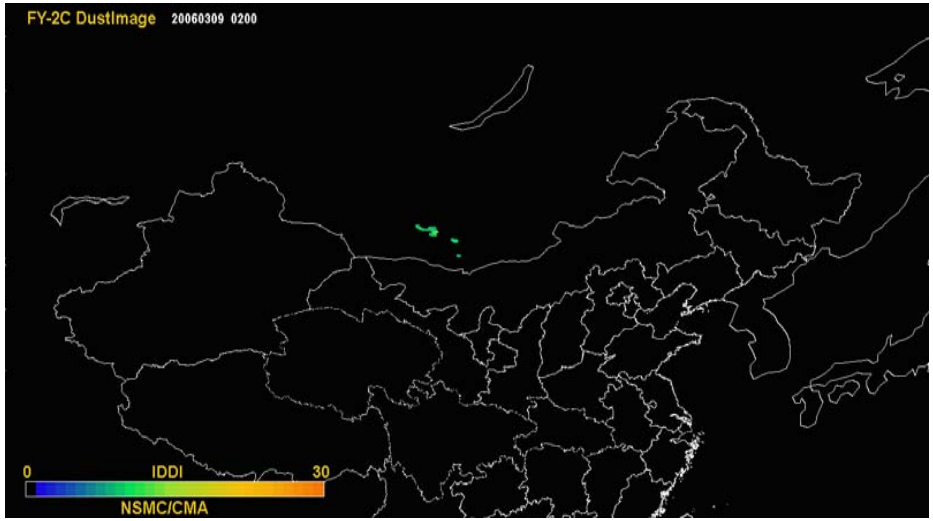






Dust spread its area in the afternoon

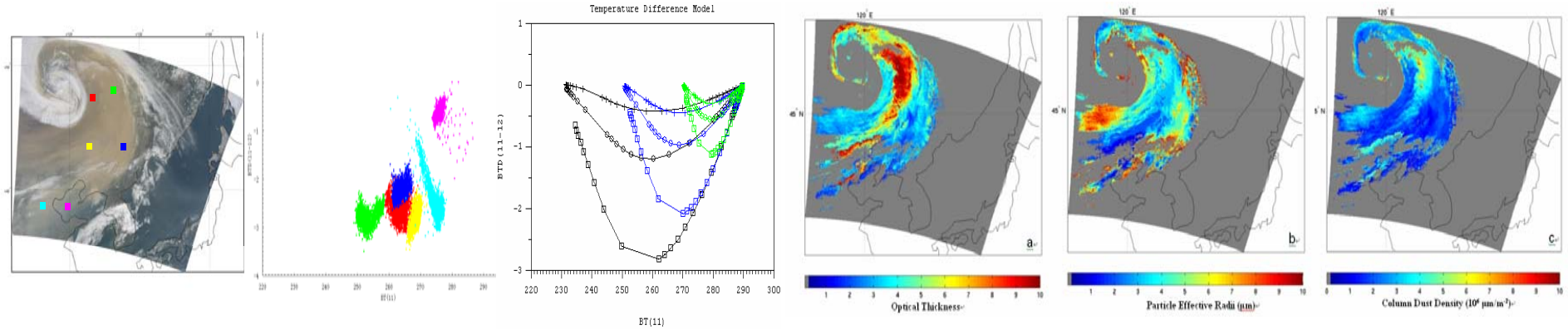
IDDI (infrared Difference Dust Index)



Hu, X. Q., N. M. Lu, T. Niu, and P. Zhang, 2008: Operational retrieval of Asian sand and dust storm from FY-2C geostationary meteorological satellite and its application to real time forecast in Asia. Atmos. Chem. Phys., 8, 1649–1659.

Hu, X. Q., N. M. Lu, P. Zhang, 2007: Remote Sensing and Detection of Dust Storm in China Using the Thermal Bands of Geostationary Meteorological Satellite. J. Appl. Meteor. Sci., 18(3), 266-275.

Retrieving AOD, Particle Size and Dust amount

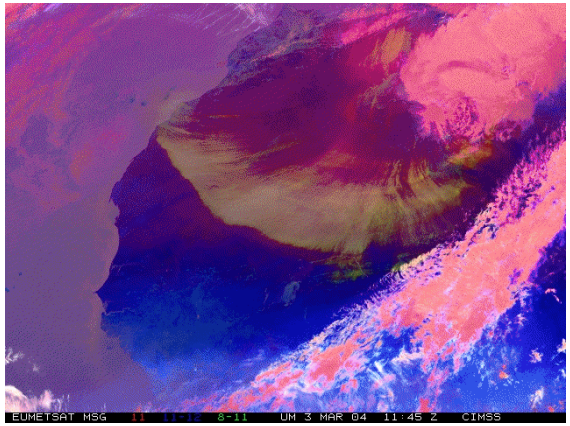


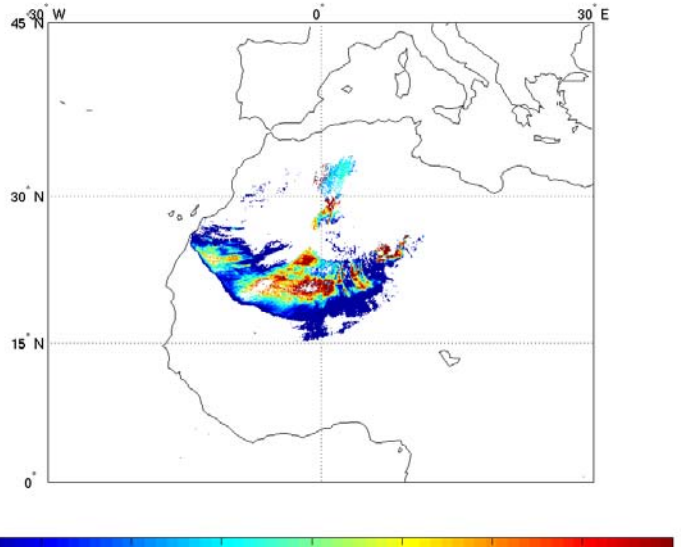
Zhang, P., Zhang X. Y., Hu X. Q., et al, 2007: Satell ite Remote Sensing and Analysis of a Dust Event in 2006. Climatic and Environment Research, 12(3), 302-308.

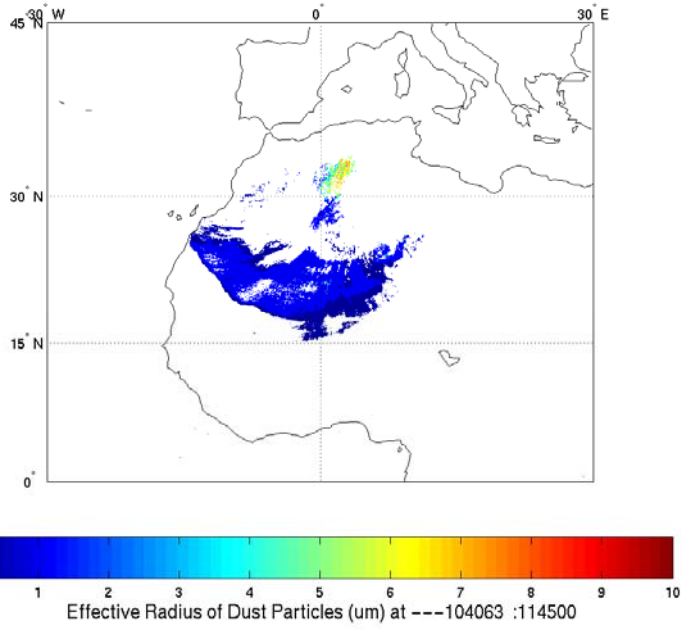
Li, J., **P. Zhang**, T. J. Schmit, et al., 2007: Quantitative monitoring of a Saharan dust event with SEVIRI on Meteosat-8. International Journal of Remote Sensing, 28(10), 2181-2186.

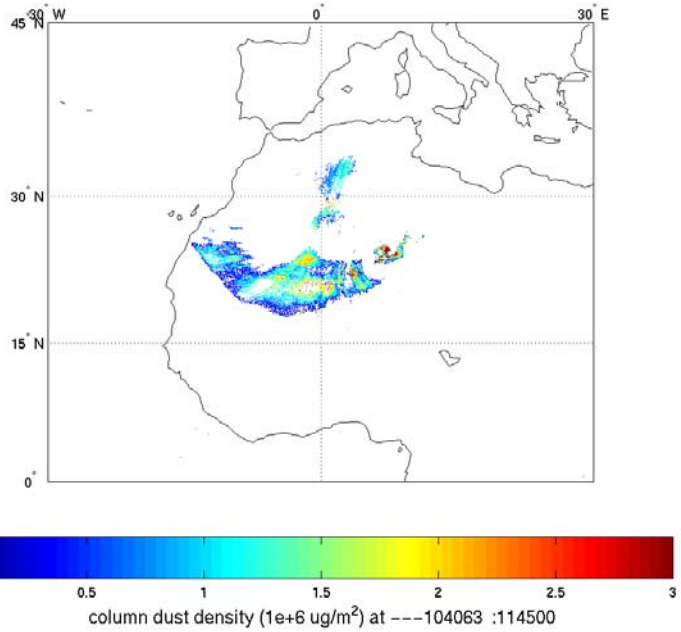
Zhang, P., N. Lu, X. Hu, C. H. Dong., 2006: Identification and physical retrieval of dust storm using three MODIS thermal IR channels. Global and Planetary Change, 52, 197-206.

Retrieval Results from SEVIRI/MSG over Sahara

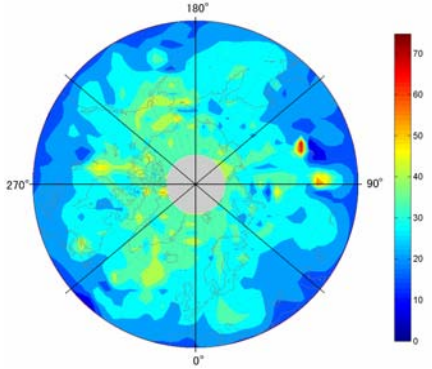




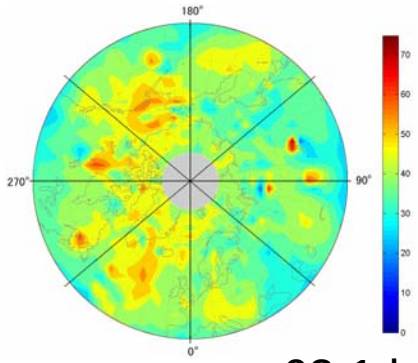




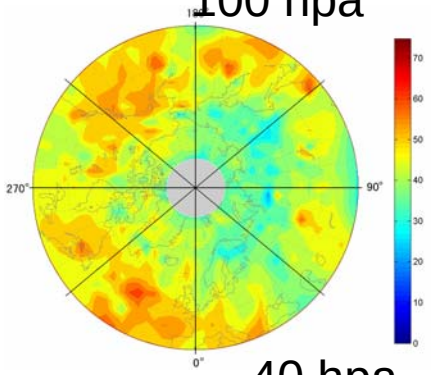
Ozone Profile from SBUS/FY3



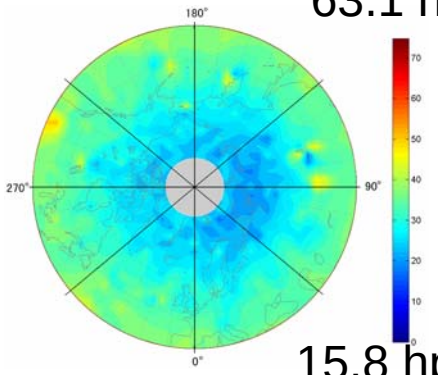
100 hpa



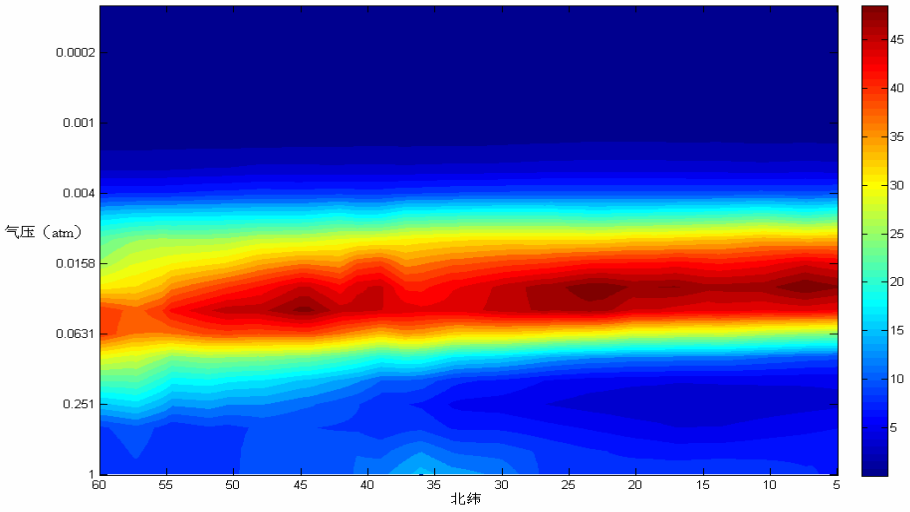
63.1 hpa

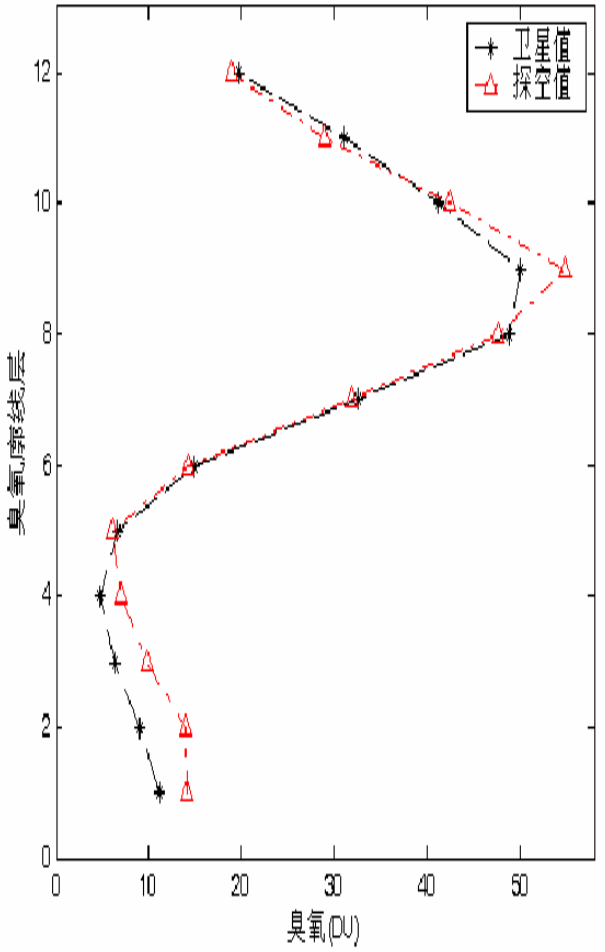


40 hpa

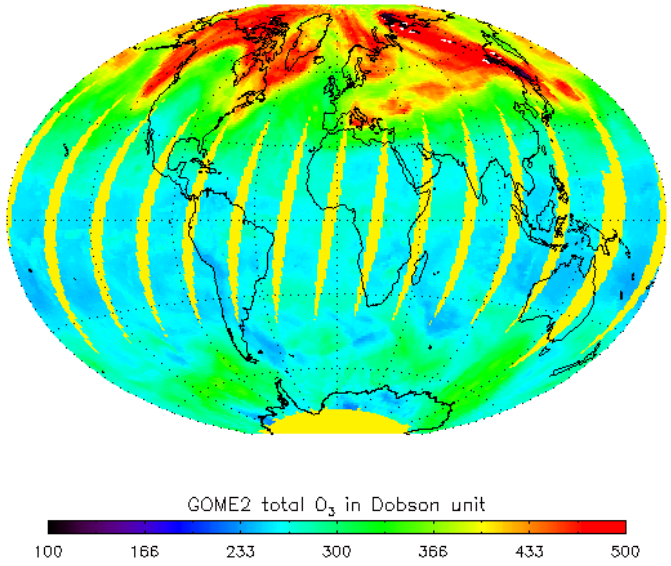


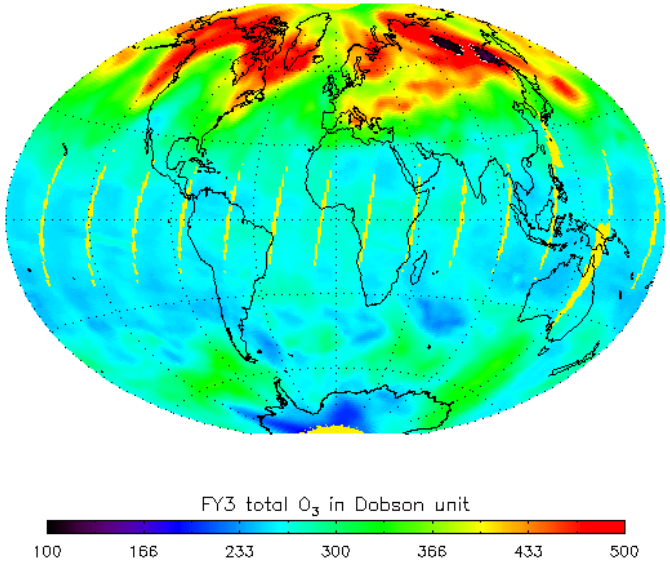
15.8 hpa

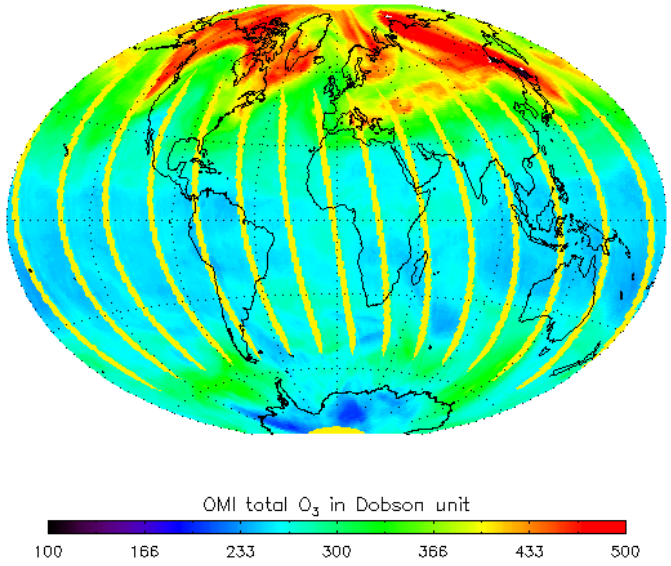


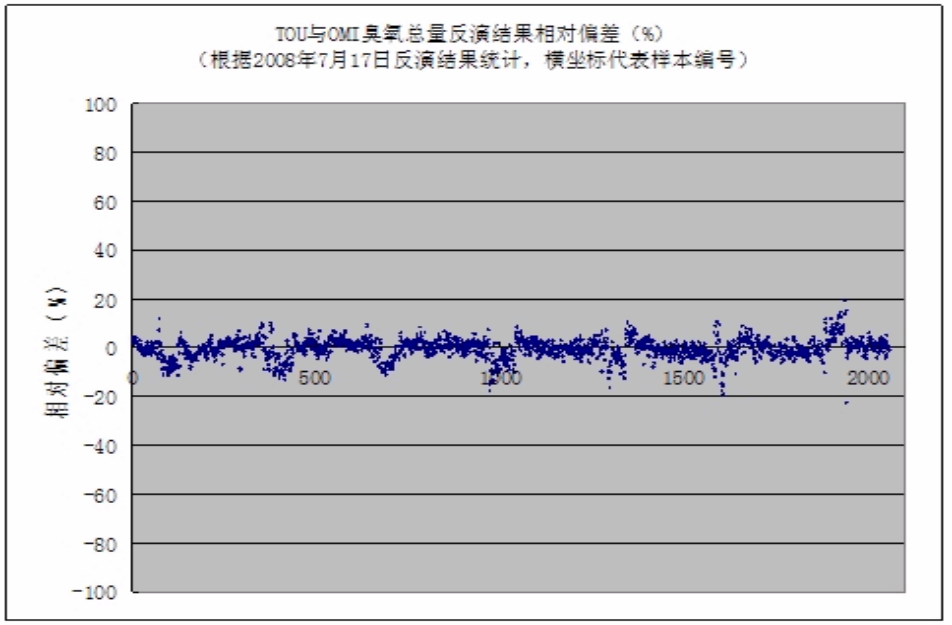


Ozone Amount from TOU/FY-3 compared with GOME-2 and OMI



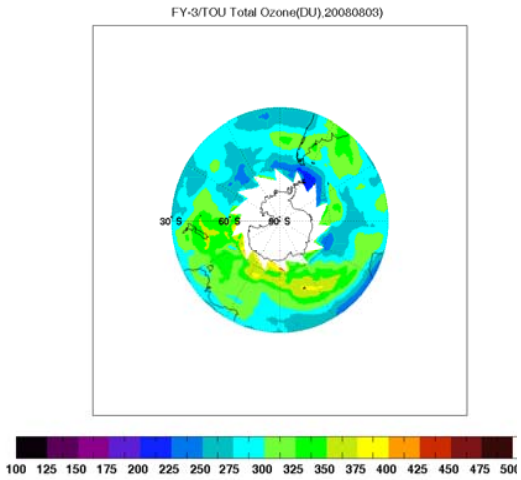




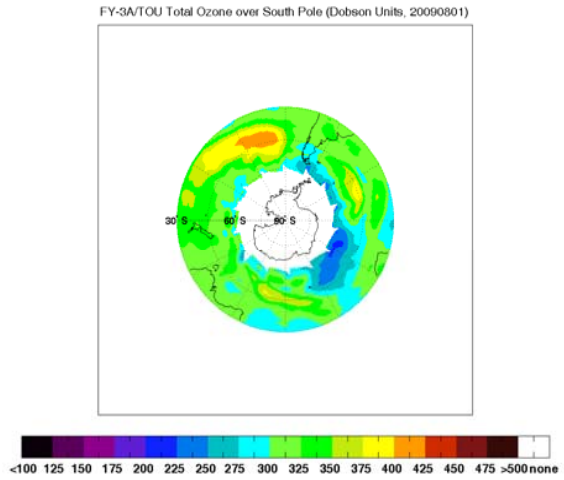


Ozone hole in Antarctic monitored by TOU/FY-3

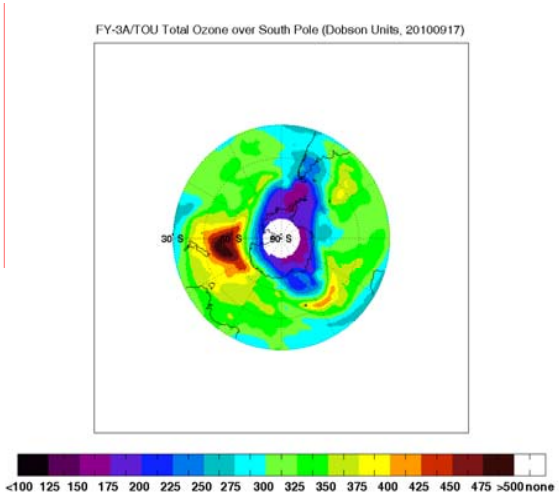
2008



2009

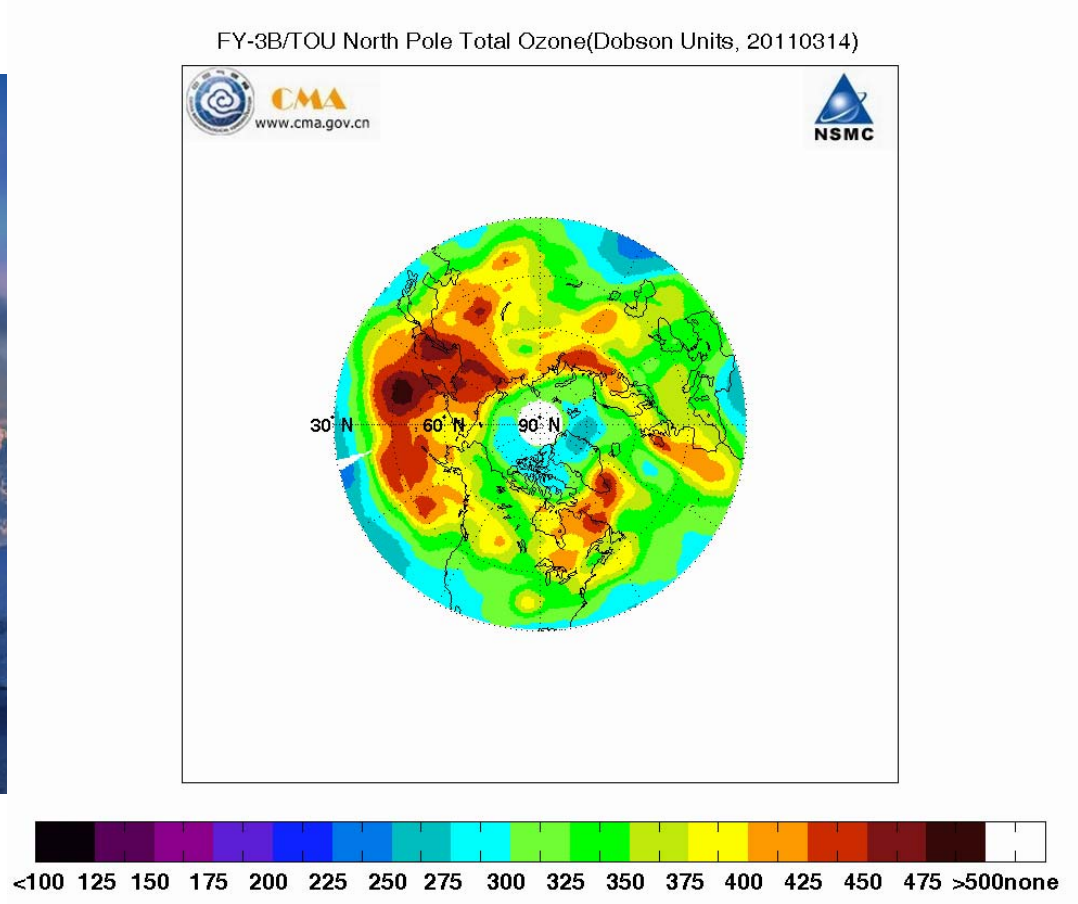


2010



1. Weihe Wang, Xingying Zhang*, Xingqin An et al., **2010**, Analysis for retrieval and validation results of FY-3 Total Ozone Unit(TOU), Chinese Science Bulletin， Vol. 55 (26): 3037-3043 **(SCI)**
2. Weihe Wang, Xingying Zhang*, Yongmei Wang et al., **2010**, Introduction to the FY-3A Total Ozone Unit (FY-3A TOU): Instrument, Performance, and Results, International Journal of remote sensing, 10.1080/01431161.2010.489073 **(SCI)**

Ozone hole near the arctic area

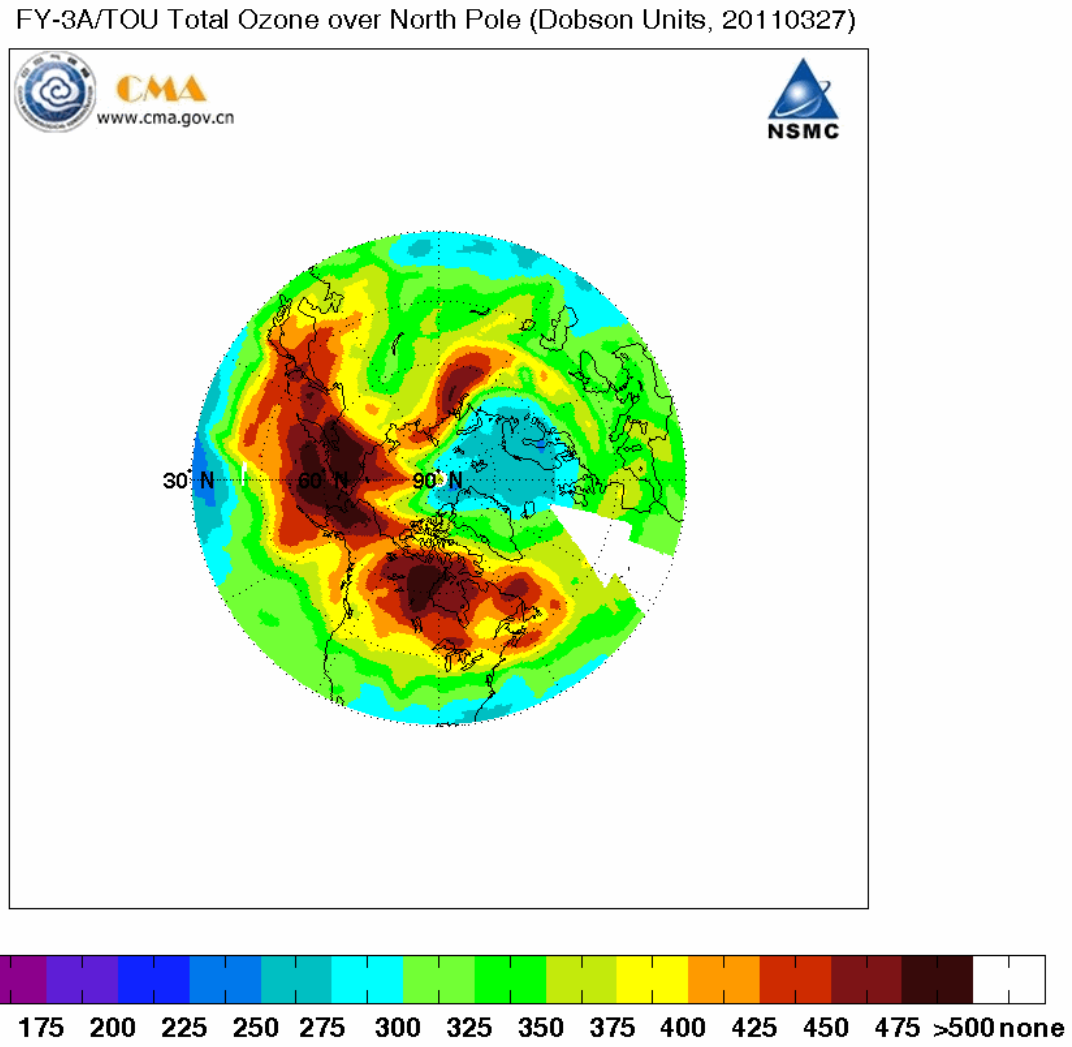


Polar stratospheric clouds

Total ozone amount

polar stratospheric clouds generated by polar vortex release **Halogen atoms**

Ozone Amount from 27 March to 5 April, 2011 from FY-3



Satellite Retrieval Algorithm Development

- Atmospheric Profile
- Total Ozone Amount
- Ozone Profile
- Aerosol
- Dust
- NO_2 (not for Fengyun)
- SO_2 (not for Fengyun)
- CH_4 (not for Fengyun)

developed

- CO_2
- CO

on going

Enhanced Capabilities for FY-3 Operational Satellites

- Improve global optical imaging capabilities (MERSI II);
- Advancd Hyper-spectral sounding of atmosphere temperature and humidity profile (IRAS -> IHSAS) ;
- **Atmosphere Chemistry sounding;**
- Sea surface wind microwave scatterometer

FY-3 OPERATIONAL SATELLITE INSTRUMENTS	FY-3C	FY-3D	FY-3E	FY-3F
MERSI – Medium Resolution Spectral Imager (Ⅰ , II)	√ (I)	√ (II)	√ (II)	√ (II)
MWTS (to be Improved)	√	√	√	√
MWHS – Microwave Humidity Sounder (to be Improved)	√	√	√	√
MWRI – Microwave Radiation Imager	√	√		√
SWMR -Sea Wind Measurement Radar			√	
GGM - Greenhouse Gas monitor		√		√
IHSAS – Infrared Hyper-spectral Atmospheric Sounder		√	√	√
UHOMI – Ultraviolet Hyper-spectral Ozone Mapping Instrument			√	
GRO – GPS radio occultation	√	√	√	√
ERM – Earth Radiation Measurement	√ (I)		√ (II)	
SIM – Solar irritation Monitor (Trace to the Sun)	√ (I)		√ (II)	
SES – Space Environment Suite	√	√	√	√
IRAS – Infrared Atmospheric Sounder	√			
VIRR – visible and Infrared Radiometer	√			
SBUS – Solar Backscattered Ultraviolet Sounder	√			
TOU – Total Ozone Unit	√			

FY-3C/D/E/F Payload Configuration

FY-3 Greenhouse Gas Monitor (GGM)

- To monitor global CO_2 and CH_4,with emphasis on troposphere
- To better understand global carbon cycle

Near IR hyper-spectral Greenhouse Gas monitor				
Band	1	2	3	4
Spectrum	0.75-0.77μm	1.56-1.72μm	1.92-2.08μm	2.20-2.38μm
Target	O_2, Aerosol	CO_2 CH_4 （H_2O）	CO_2 （H_2O）	CH_4、CO 、N_2O
Spectrum Res.	0.6 cm^{-1}	0.27 cm^{-1}	0.27 cm^{-1}	0.27 cm^{-1}
S/N	＞300:1			
Cal. Error	<2%			
IFOV	0.685°			

FY-3 Infrared Hyper-spectral Atmospheric Sounder (IHSAS)

- To monitor the temperature and moisture profile
- To monitor the trace gases

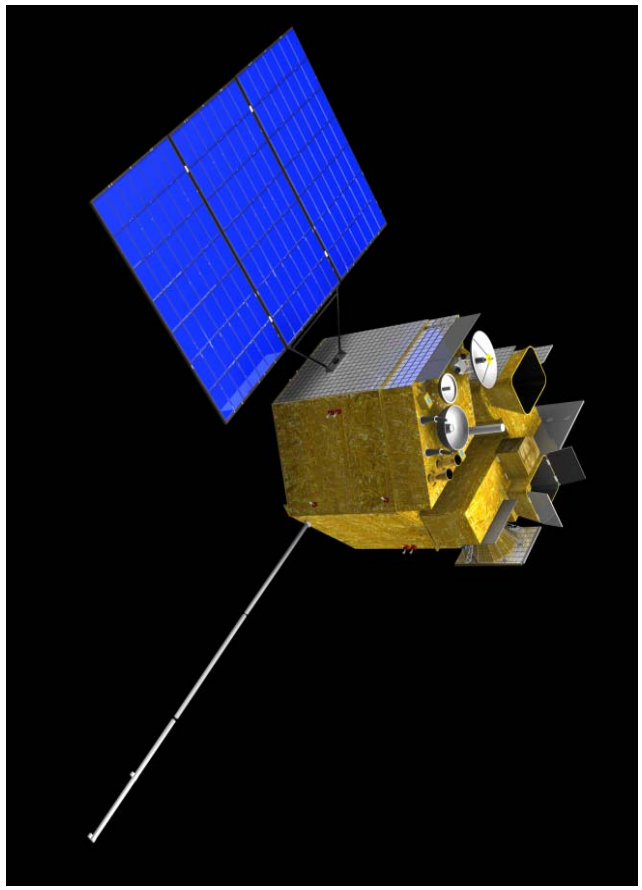
Band	Spectrum (cm^{-1})	Spectrum Res. (cm^{-1})	S/N NE Δ T@250K	Channel Num.
FTIR	650* – 1136 （15.38-8.8 μm）	0.625	0.15-0.4K*	778
FTIR	1210 – 1750 （8.26-5.71 μm）	1.25	0.1-0.7K	433
MTIR	2155-2550（4.64-3.92 μm）	2.5	0.3-1.2K	159

FY-3 Ultraviolet Hyper-spectral Ozone Mapping Instrument (UHOMI)

- To monitor the ozone amount, ozone profile globally
- To monitor the chemical active trace gases to understand the chemical process in the atmosphere

	Nadir		Occultation
	Amount	**Profile**	
Spectrum	300~500 nm	250~310 nm	290-500 nm
Purpose	O_3, NO_2, SO_2, HCHO, BrO, OClO, aerosol	O_3 Profile	O_3, NO_2, SO_2, HCHO, BrO, OClO, aerosol in the stratosphere
Spectrum Res.	300~365nm×0.4nm 365~500nm×0.6nm	250~310nm×0.4nm	290-500nm×0.6nm
Spatial Res	15 (orbit along)×25 (orbit cross) km	34 (orbit along)×60 (orbit cross) km	3 km in vertical res.
FOV	FOV: 112º	IFOV: 2.3 º (orbit along)×0.045 º (orbit cross)	IFOV: 2.3 º (orbit along)×0.045 º (orbit cross)
Cal. Error	5%	5%	5%
Spectral Cal. Error	0.01nm	0.01nm	0.01nm
S/N	≧300	>100	>300

Next Generation of GEO satellite FY-4



Prototype structure of FY-4A

4 main instruments

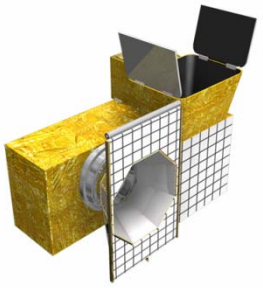
Advanced Geo. Radiation Imager

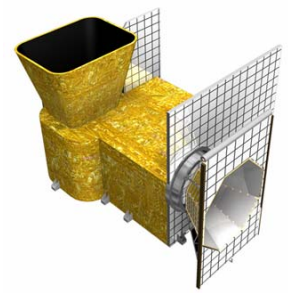
Geo. Interferometric InfraRed Sounder

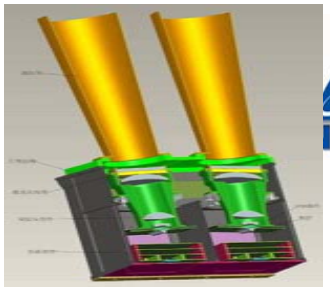
Lighting Mapping Imager

Solar X-EUV imaging telescope
(not available on 1st satellite)

No.	Plan Launch	Design Life	Status
FY-4A	2014	5 years	R&D
FY-4B	2017	7 years	Op.
FY-4C	2019	7 years	Op.







AGRI	GIIRS	LMI
Advanced **G**eo. **R**adiation **I**mager	**G**eo. **I**nterferometric **I**nfrared **S**ounder	**L**ighting **M**apping **I**mager
14 Channels within 0.55~13.8μm	538 LWIR Channels 375 S/MIR Channels	Central Frequency: 777.4nm
500mx1;1Kmx2 2Kmx4; 4Kmx7	16Km	7.8Km
S/N : 90 ~ 200 NEΔT : 0.2 ~ 0.7K	Radiometric Calibration accuracy: 1K Spectral Calibration accuracy:10ppm	S/N > =6
Full Disk < =15min	Meso-scale : 35min(1000x1000km) China area: 67min(5000x5000km)	2ms

Other Satellite Project Related with AC

1. Chinese Carbon Satellite Project by MOST (2015)

   - CO2 by OCO-like
   - Aerosol by MODIS-like

2. Chinese Hyperspectral Environment and Climate Satellite Project by CNSA (2015)

   - Greenhouse Gases by GOSAT-like
   - Chemical active Gases by OMI-like
   - Aerosol by POLDER-like
   - Stratospheric Trace Gases by Solar Occultation

Main parameters of MAX-DOAS and FTIR

Instrument Type	FTIR	MAX-DOAS
Manufacture	Germany BRUKER	China AIOFM/CAS
Measured Spectrum	700 - 5000cm^{-1} (IR/NIR)	300 – 700nm (UV/VIS)
Spectral Resolution	0.0035 cm^{-1} (Max)	0.4 – 1.5 nm
Detected Target	O_3, NO_2, SO_2, OClO, BrO …	O_3, H_2O, NO, N_2O, NO_2, HNO_3, CO, CH_4, CO_2, HF, HCl, $ClONO_2$ ...

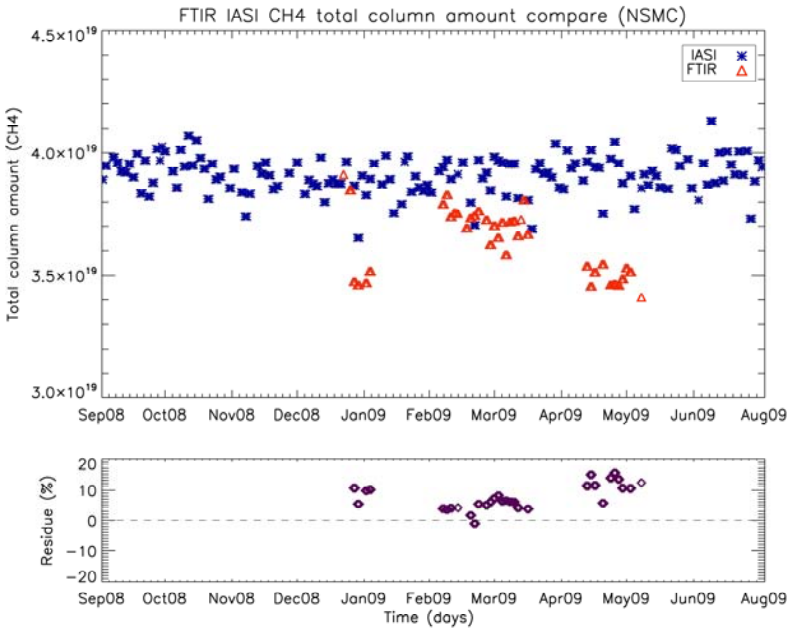
Ground Based Remote Sensing by hyperspectral Radiometer

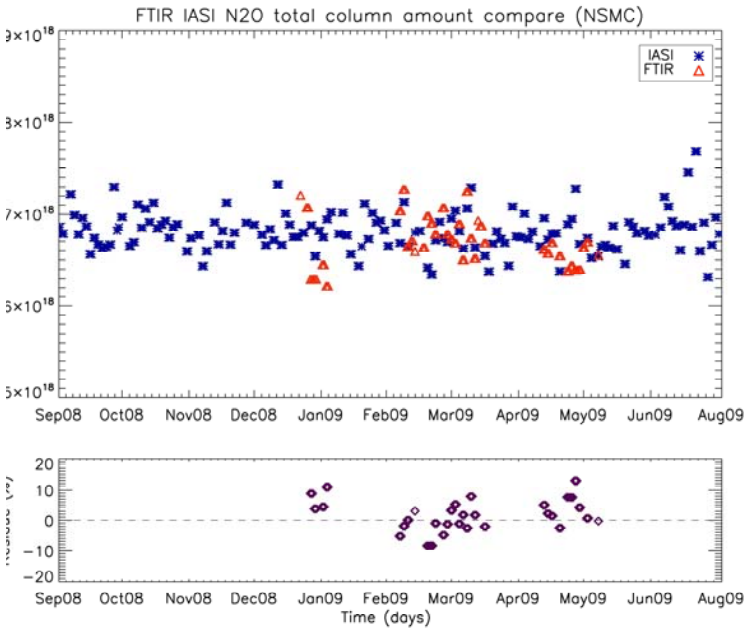
Ultraviolet

Thermal Infrared

IASI CH_4, N_2O validated with ground-base FTIR measurement

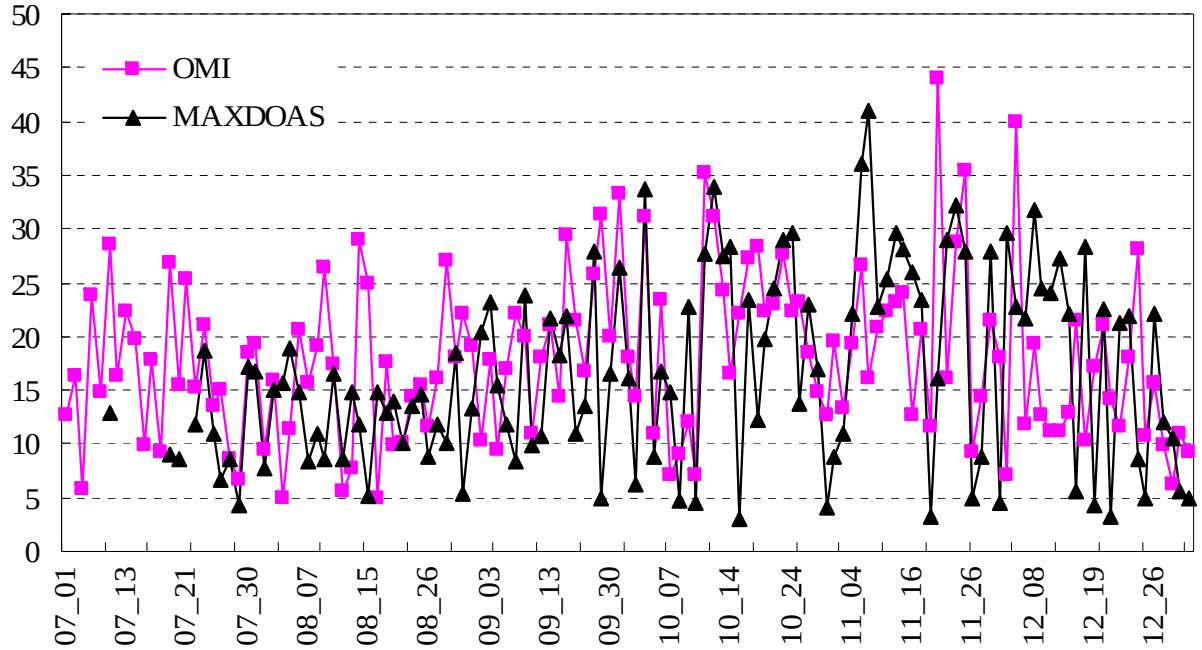
Courtesy of IMK/KIT for their FTIR retrieval software Proffit 9.5

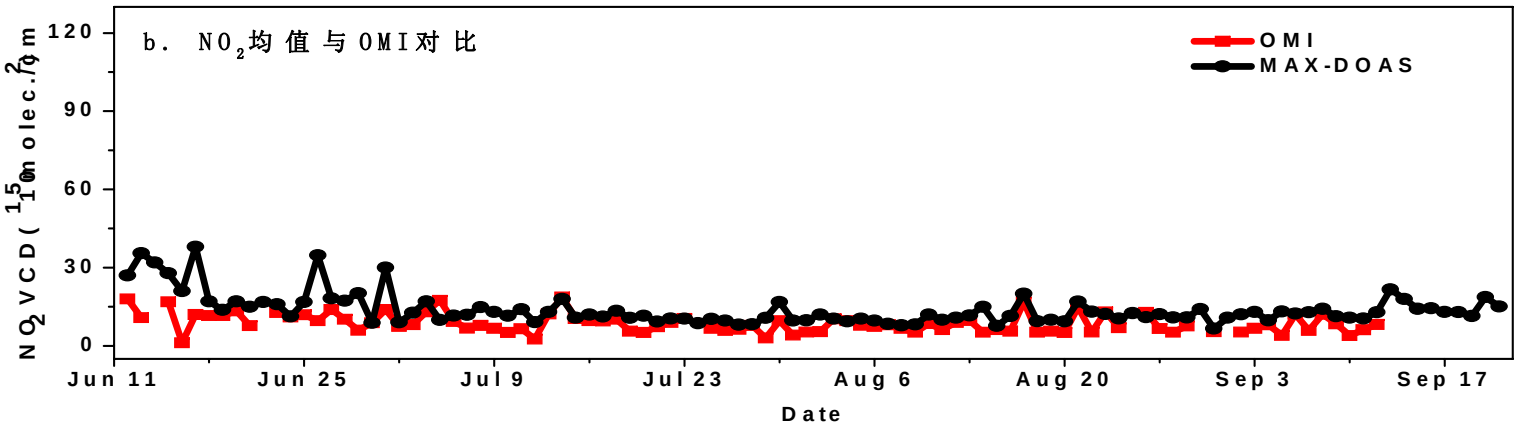




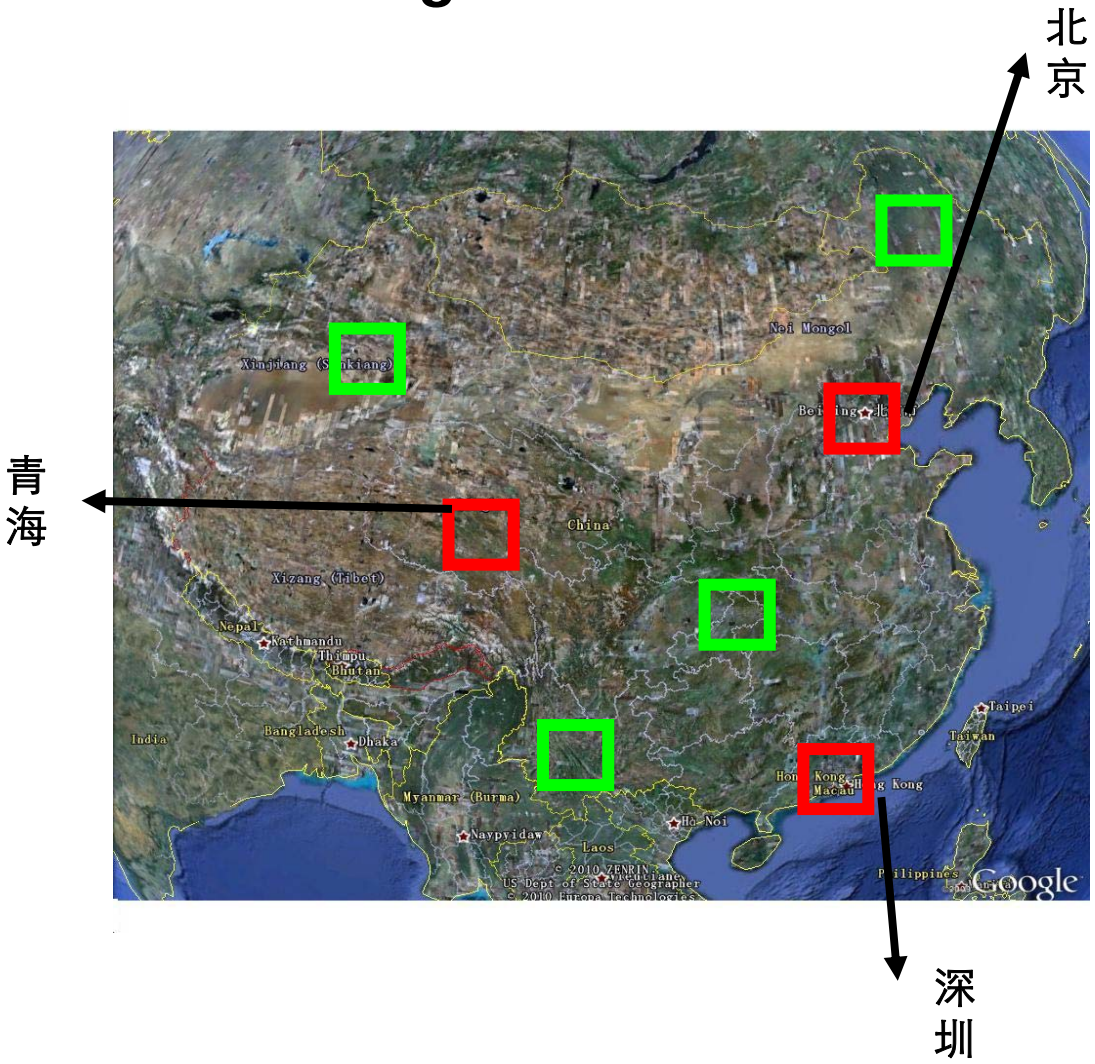
Result shows: the total column amount deviation for CH4 is less than 20%, IASI results higher than FTIR measurement; deviation for N_2O is less than 10%.

OMI NO_2 validated with MAX-DOAS of NSMC





Future Consideration on Ground-based Remote Sensing



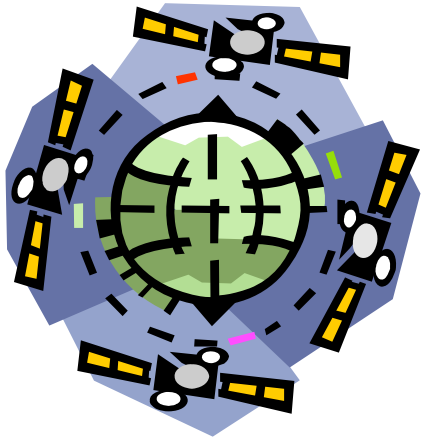
5. Summary

- European-Sino cooperation improve the AC remote sensing in China. ESA-MOST Dragon, EU FP AMFIC, etc is the good example. The activities cover the retrieval algorithm, product validation and data utilization related with AC remote sensing.

- The payloads onboard on FY-3A and FY-3B provide the capability to monitoring atmospheric aerosol, total ozone amount and ozone profile. These products have the similar accuracy to the ones derived from similar instruments amounted on EOS, Envisat and Metop;

- There are unprecedented opportunity for AC remote sensing in China currently. One important component will be the successor in FY-3 series. The AC monitoring will be strengthened with the hyper-spectral techniques.

- Spectroscopy, atmospheric radiation transfer in hyper-spectral resolution, etc are the basis of AC remote sensing. However, they are almost the blank area in China.



- ESA-MOST Program
- EU project FP6: Air quality Monitoring and Forecasting In China (AMFIC)
- National Basic Research Program of China “973” Project (Grant No. 2005CB422200)
- National Nature Science Foundation of China Project (Grant No. 41075021)