CEOS-ACC-12 meeting. Seoul, Korea

October 13th - 15th, 2016

Mission Overview GaoFen-5

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www.radi.cas.cn

Outlines

1 Background

2 Sensors of GF-5

- Atmospheric Infrared Ultraspectral (AIUS)
- Directional Polarization Camera（DPC）
- Environment Monitoring Instrument (EMI)
- Geenhouse-gases Monitoring Instrument(GMI)

3 Potential Applications

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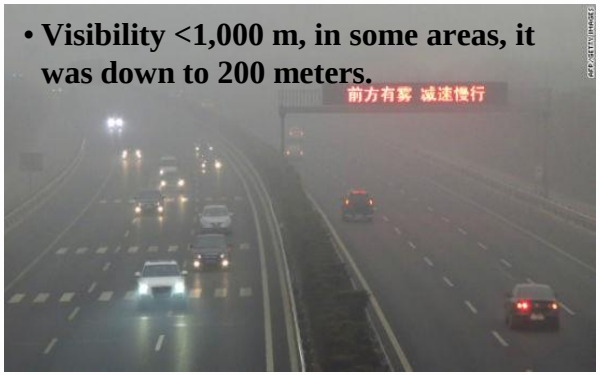
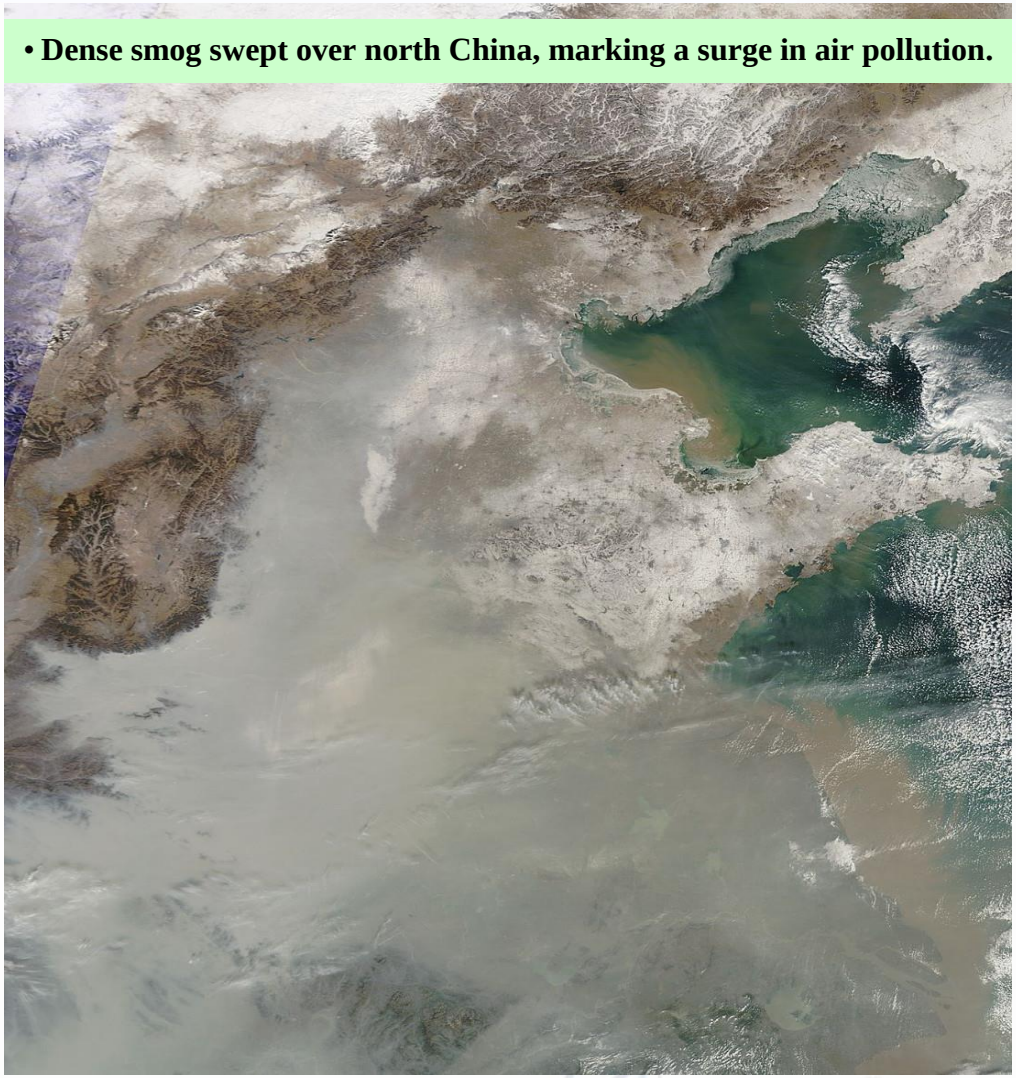
Dense smog swept over north China in Jan. 2013

- $PM_{2.5}$ >300 ug/m^3 during the daytime



- Visibility <1,000 m, in some areas, it was down to 200 meters.

- Dense smog swept over north China, marking a surge in air pollution.



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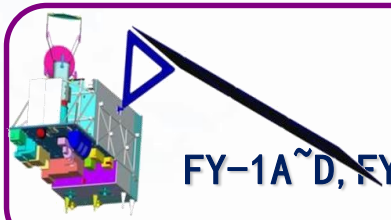
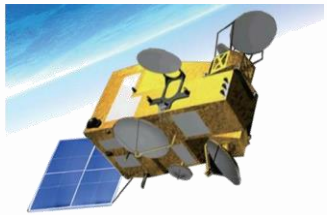
Chinese Satellites



Fengyun Satellites

FY-1A~D, FY-2A~G, FY-3A~C, FY-4



Haiyang Satellites

HY-1A, B, HY-2, HY-3

Ziyuan Satellites

CBERS-1, 2, ZY-1~3

Huanjing Satellites

HJ-1A/B/C

Gaofen Satellites

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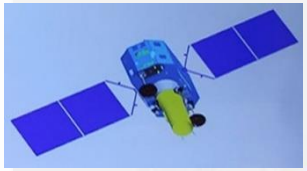
GF-5 2016*

GF-4 2015-12-29



GF-3 2016-8-10

GF-2 2014-8-19

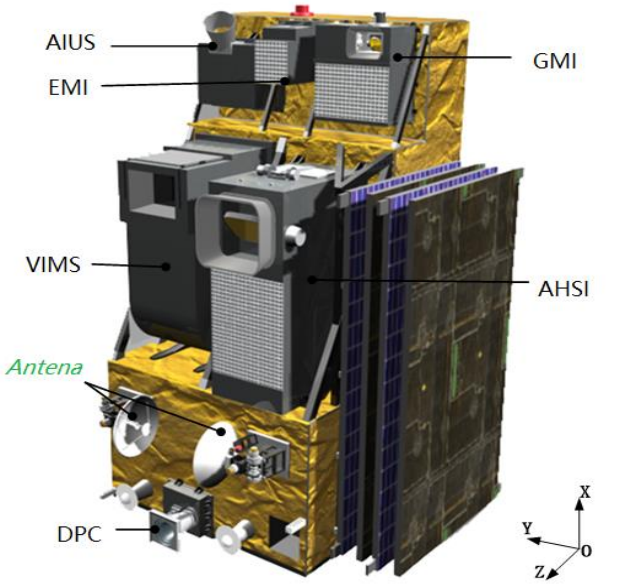
GF-1 2013-4-26

GF-5 satellite specification and major orbit parameters

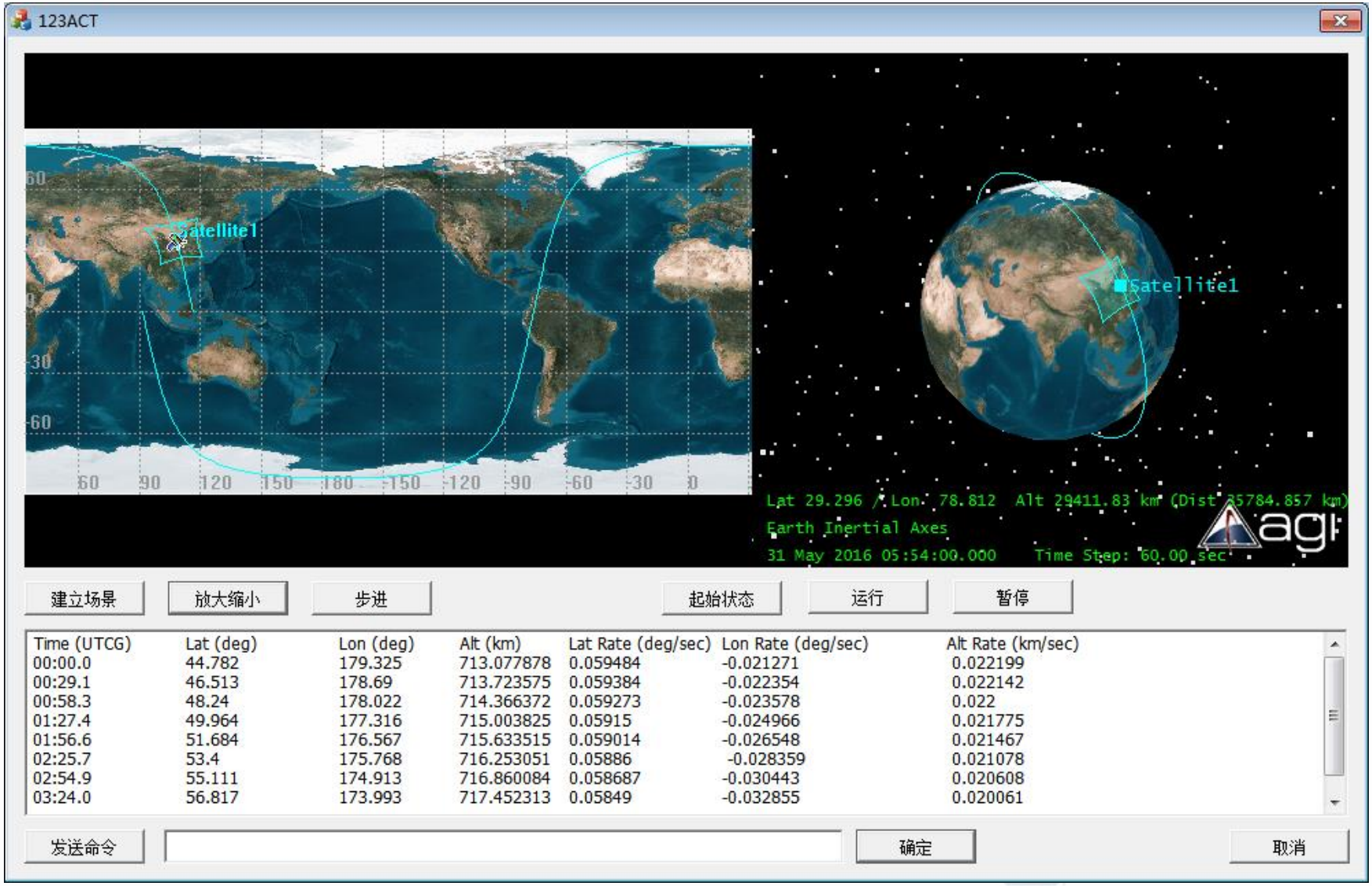
Orbital Type	Sun synchronous orbit
Nominal orbital altitude	708.45km
Dip angle	98.218
Orbital flat period	98.805min
Eccentricity ratio	E<0.0001
Flight cylinder number every day	14.57
Orbital intercept	24.731
Local time of descending node	13:30

Sensors onboard GF-5

- Advanced Hyperspectral Imager (AHSI)
- Visual and Infrared Multispectral Sensor (VIMS)
- Greenhouse-gases Monitoring Instrument (GMI)
- Atmospheric Infrared Ultraspectral (AIUS)
- Environment Monitoring Instrument (EMI)
- Directional Polarization Camera（DPC）



GF-5 observation orbit



Time (UTCG)	Lat (deg)	Lon (deg)	Alt (km)	Lat Rate (deg/sec)	Lon Rate (deg/sec)	Alt Rate (km/sec)
00:00.0	44.782	179.325	713.077878	0.059484	-0.021271	0.022199
00:29.1	46.513	178.69	713.723575	0.059384	-0.022354	0.022142
00:58.3	48.24	178.022	714.366372	0.059273	-0.023578	0.022
01:27.4	49.964	177.316	715.003825	0.05915	-0.024966	0.021775
01:56.6	51.684	176.567	715.633515	0.059014	-0.026548	0.021467
02:25.7	53.4	175.768	716.253051	0.05886	-0.028359	0.021078
02:54.9	55.111	174.913	716.860084	0.058687	-0.030443	0.020608
03:24.0	56.817	173.993	717.452313	0.05849	-0.032855	0.020061

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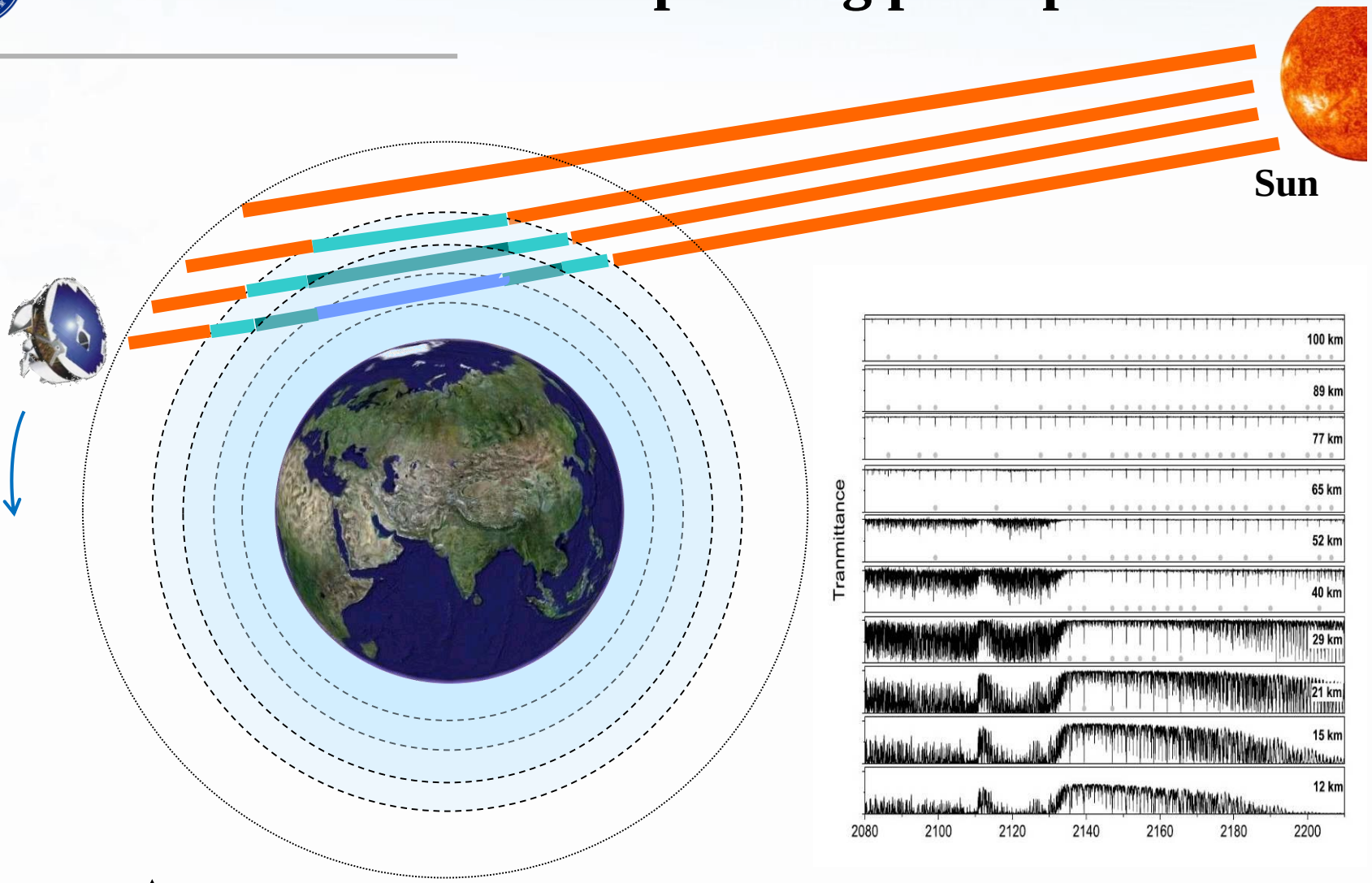
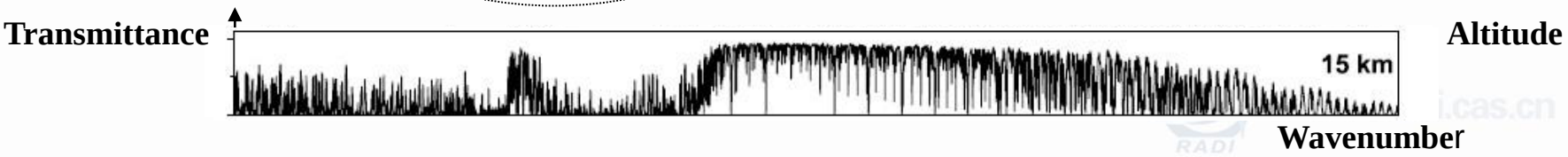
Atmospheric Infrared Ultraspectral (AIUS)

Parameters	Specifications
Spectrum range	750 – 4100 cm^{-1} （2.4 – 13.3μm）
Spectral resolution	0.03 cm^{-1}
Relative spectral stability	0.0002cm^{-1} /2 sec（4100 cm^{-1} ） 0.003cm^{-1} /3min（4100 cm^{-1} ）
Dynamic range	800K～5800K
SNR	>100:1（@5800K）
Scanning period	2 sec@25cm/s）
Refrigerator temperature and power	100mW@85K
FOV trace coverage	±10°
Spectrometer FOV	1.25mrad
Solar trace precision	0.1mrad
Solar trace stability	25μrad
Digitalizing bit	18bits
Bit rate	8.9Mbps

Occultation mode

Occultation Operating principle





ACE-FTS Level2 v3.5 Data Products

Product	Altitude(km)	Product	Altitude(km)
O_3	5-95	HF	10-50
H_2O	5-89	CO	5-105
CH_4	5-62	CFC-11	5-22
N_2O	5-60	CFC-12	6-28
NO_2	13-45	N_2O_5	15-40
NO	12-105	$ClONO_2$	12-35
HNO_3	5-37	Temperature	0-150
HCl	8-57	Pressure	0-150

- Tracers: H_2O, O_3, N_2O, NO, NO_2, HNO_3, N_2O_5, H_2O_2, HO_2NO_2, N_2
- Halogen-containing gases: HCl, HF, $ClONO_2$, CFC-11, CFC-12, CFC-113, COF_2, $COCl_2$, COFCl, CF_4, SF_6, CH_3Cl, CCl_4, HCFC-22, HCFC-141b, HCFC-142b
- Carbon-containing gases: CO, CH_4, CH_3OH, H_2CO, HCOOH, C_2H_2,C_2H_4, C_2H_6, OCS, HCN as well as pressure and temperature from CO_2 lines
- Research species: ClO, acetone, PAN, HFC-23, acetonitrile, SO_2, etc

http://www.ace.uwaterloo.ca/

AIUS Proposed Level2 Data Products

Product	Accuracy	Altitude(km)
Temperature	2K	15-90
Pressure	20%	15-90
H_2O	2 g/kg	15-90
O_3	15%	10-95
CO	15%	10-90
N_2O	15%	15-52
NO	20%	15-52
NO_2	20%	15-52
HCl	15%	15-52
HF	20%	15-52

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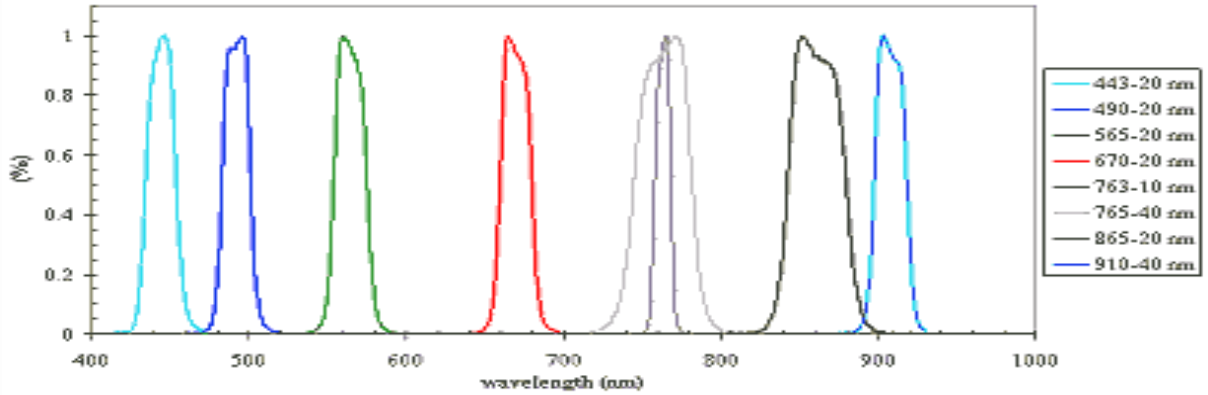
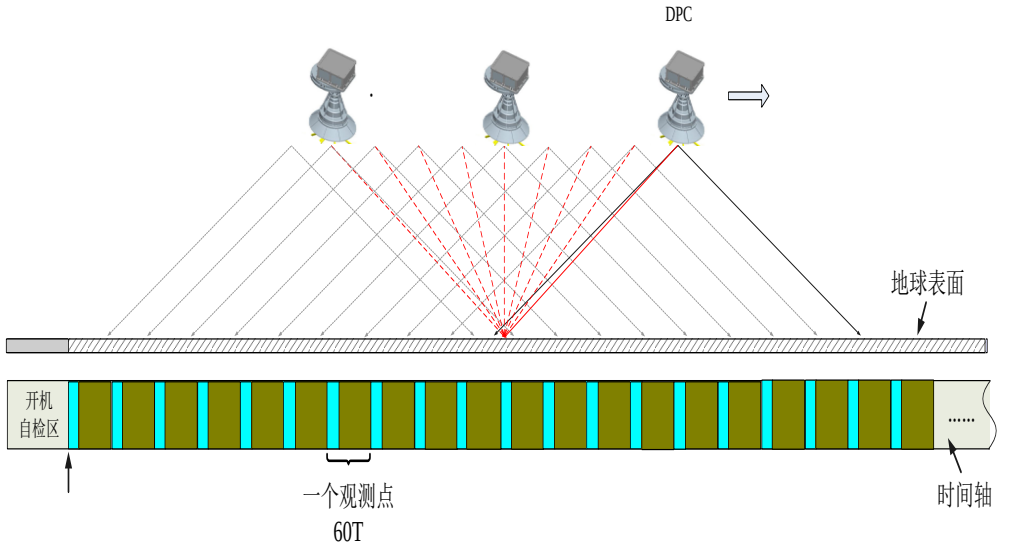
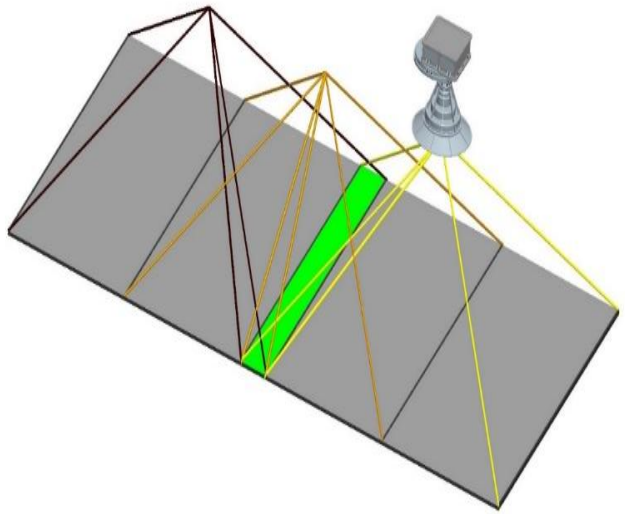
Directional Polarization Camera(DPC)







Directional Polarization Camera（DPC）

Parameters	Specifications
Channel	433nm~453nm、480nm~500nm（P） 555nm~575nm、660nm~680nm（P） 758nm~768nm、745nm~785nm 845nm~885nm（P）、900nm~920nm
SNR	Better than 500(Land)
Polarization Analysis	Linear polarization，Three directions:0°、60°、120°
FOV	－50°～＋50°
Multi-angular Measurements	9 angles along track
Spatial Resolution	Better than 3.5 km(at nadir)
Calibration	Better than 5%
Polarization Calibration	Better than 2%
Digitalizing Bit	12bits
Bit Rate	9.45Mbps

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DPC VS POLDER-3

	POLDER/PARASOL	DPC
Operation Mode	• Frame imaging • Wide field of view imaging optical system • Polarizer and spectral filters, Acquisition of information of spectral and polarization channels	The same as the left
Detector	• CCD matrix(242 X 274)	CCD matrix(512 X 512)
Channel	• Visible-Near infrared band • Three Polarized Channel + 5 Non-polarized Channel	The same as the left
FOV		The same as the left
IFOV	• 6 X 7 km	3.29 km

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POLDER/PARASOL Data Products and Data Access

POLDER/PARASOL Level-2 science products					
Retrieved parameter	**Product Name**	**Sensor**	**Spatial Resolution**	**Temporal Coverage**	**Time period**
Aerosol over ocean					
• Aerosol optical thickness (AOT) • Uncertainty of AOT • Angstrom exponent • Effective radius • backscattering coefficient • Non-sphericity index	OC2	PARASOL	1/6 deg	1 file/orbit	March 2005 - Oct. 2013
Aerosol over land					
• Aerosol optical thickness • Angstrom exponent • Aerosol altitude	LS2	PARASOL	1/6 deg	1 file/orbit	March 2005 - Oct. 2013
Earth radiative budget, Water vapor and clouds					
• Shortwave broadband albedo • Visible narrowband albedo • Cloud fraction • Cloud albedo • Cloud thermodynamic phase • Cloud optical thickness • Cloud oxygen pressure • Cloud Rayleigh pressure • Cloud effective radius • Cloud geometrical extent • Water vapor integrated content	RB2	PARASOL	1/6 deg	1 file/orbit	March 2005 - Oct. 2013

http://www.icare.univ-lille1.fr/order/

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DPC Proposed Level2 Data Products

Retrieved parameter	Sensor	Temporal Coverage
Aerosol		
• Aerosol optical thickness (AOT) • Angstrom exponent • Backscattering coefficient • Non-sphericity index	DPC	1 file/orbit
Water vapor and clouds		
• Cloud fraction • Cloud thermodynamic phase • Cloud optical thickness • Cloud oxygen pressure • Cloud effective radius • Water vapor integrated content	DPC	1 file/orbit

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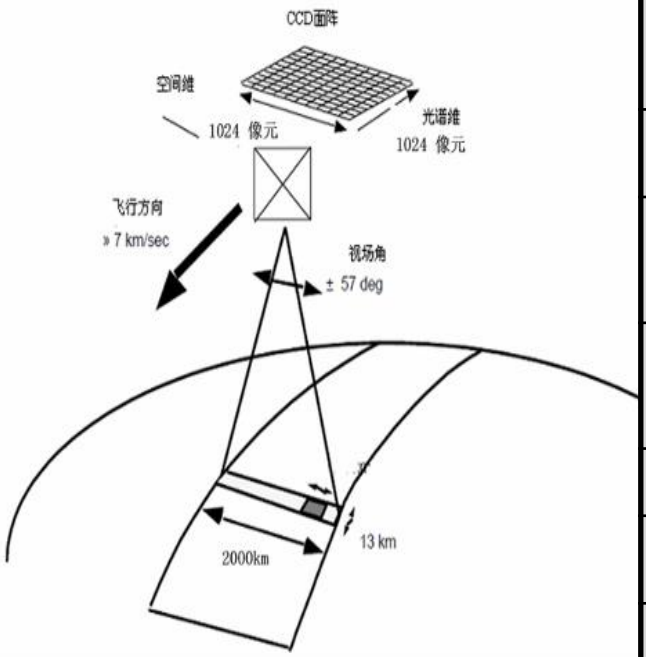
Environment Monitoring Instrument(EMI) characteristics

technical parameter	Technical index
Spectrum range	240－315nm、311－403nm、 401－600nm、590－790nm
SNR	>200@UV>312nm（Radiance=1.27μW/cm2·sr-1·nm-1） >2000@VIS（Radiance=10.89μW/cm2·sr-1·nm-1）
Dynamic range	10^6
Spectral resolution	0.3-0.5nm
Radiometric calibration accuracy	absolute accuracy=5%，relative accuracy=3%
Spectral calibration accuracy	>0.05nm
Stray light	$<10^{-3}$
Work mode	Nadir push broom、calibration mode
FOV	114°（cross track）
Spatial resolution	>48km（perpendicular to track）×13km（along track）
Digitalizing bit	14 bits
Bit rate	48Mbps

Environment Monitoring Instrument（EMI）



technical parameter	EMI	OMI
Spectrum range	240-710nm（470nm）	270--500 nm（230nm）
SNR	>200@UV>312nm(Radiance=1.27μw/cm²sr nm) >1300@VIS(Radiance=10.89μw/cm²sr nm)	300-480nm: 200-1270
Spectral resolution	0.3-0.5nm	0.45-0.64 nm
Radiometric calibration accuracy	absolute accuracy=5%, relative accuracy=3%	
Spectral calibration accuracy	>0.05nm	
Stray light	$<6\times10^{-4}$	
FOV	114°（cross track）	114°（cross track）
Spatial resolution	< 48km(perpendicular to track)×13km (along track)	<48km(perpendicular to track)×13km (along track)
Digitalizing bit	14bit	12bit

OMI Level2 Products

Product	Description
Aerosol	Aura Aerosol Optical Parameters 1-orbit L2 Swath 13x24 km
NO_2	Aura Nitrogen Dioxide (NO_2)Total & Tropospheric Column1-orbit L2 Swath 13x24 km
SO_2	Aura Sulphur Dioxide Total Column 1-orbit L2 Swath 13x24 km
Ozone	Aura Ozone (O_3) Total Column 1-orbit L2 Swath 13x24 km
Ozone Profile	Aura Ozone Profile-1-orbit L2 Swath 13x48 km
HCHO	Aura Formaldehyde (HCHO) Total Column 1-orbit L2 Swath 13x24 km
BrO	Aura Bromine Monoxide Total Column 1-orbit L2 Swath 13x24 km
OClO	Aura Chlorine Dioxide Slant Column 1-orbit L2 Swath 13x24 km
Clouds	Aura Cloud Pressure and Fraction 1-orbit L2 Swath 13x24 km

http://disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI

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Geenhouse-gases Monitoring Instrument(GMI)

	technical parameters			
	O_2	CO_2	CH_4	CO_2
Central wavelength(um)	0.765	1.575	1.65	2.05
Band width(um)	0.759-0.769	1.568-1583	1.642-1.658	2.043-2.058
Spectral resolution	0.6cm^{-1}	0.27cm^{-1}		
SNR	300@ =30%		250@ =30%	
Radiation calibration	5% （relative，~2%）			
Size	790mm（X）×690mm（Y）×575mm（Z）			
Field of view	14.6mrad IFOV<10.3km@708km			
Sample	5、7、9-pints			
Observation mode	nadir(mainly)/glint			
Weight	109kg			
Power	120W			
Data transfer rate	30Mpbs			

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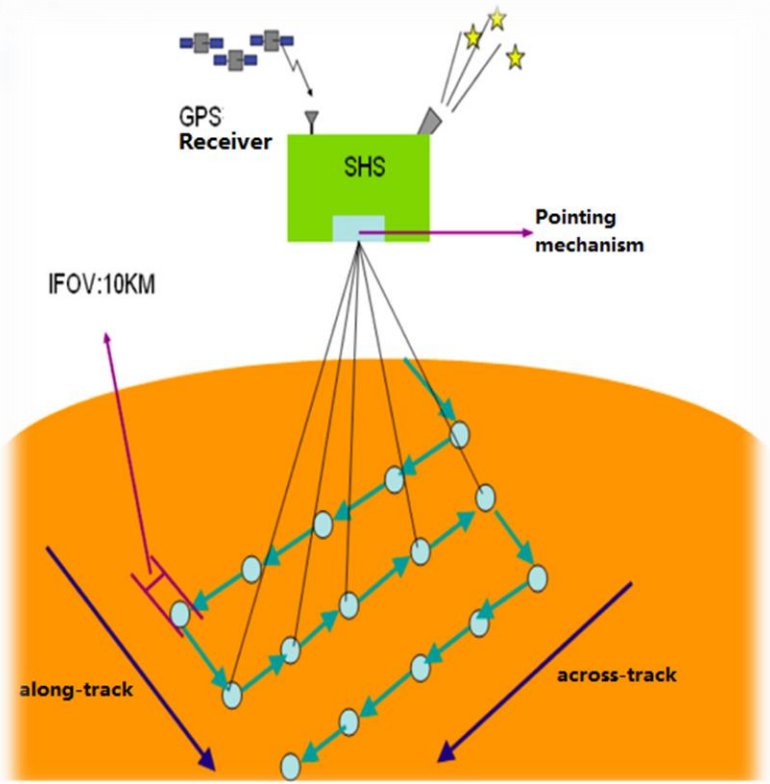
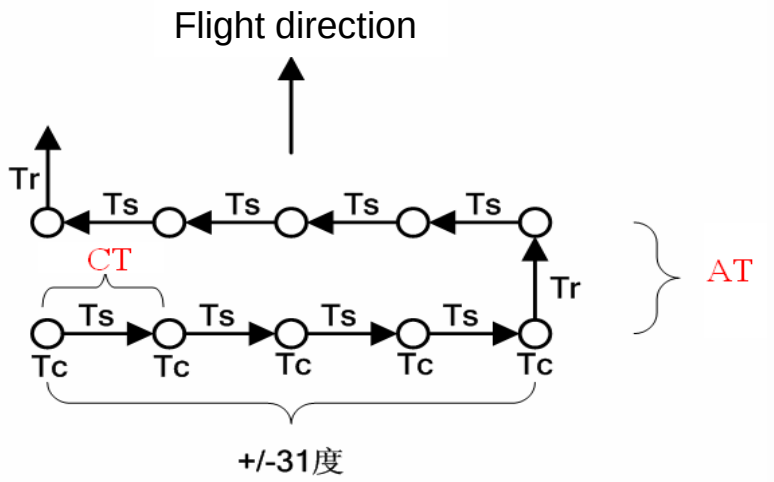
GMI





Observation patterns	Along track direction AT（km）	Across-track direction CT（km）
1		
5	100	212
7	130	142
9	130	106

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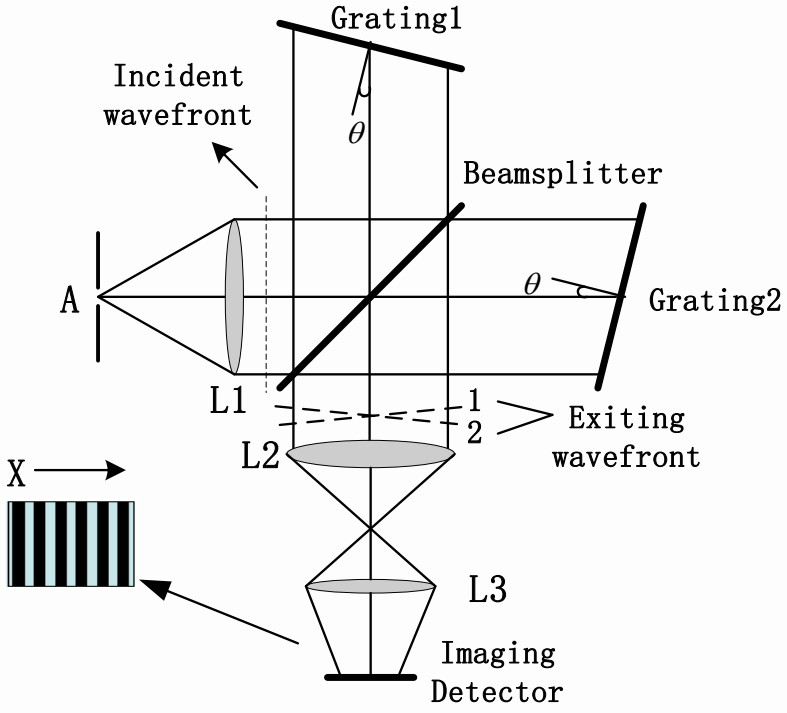
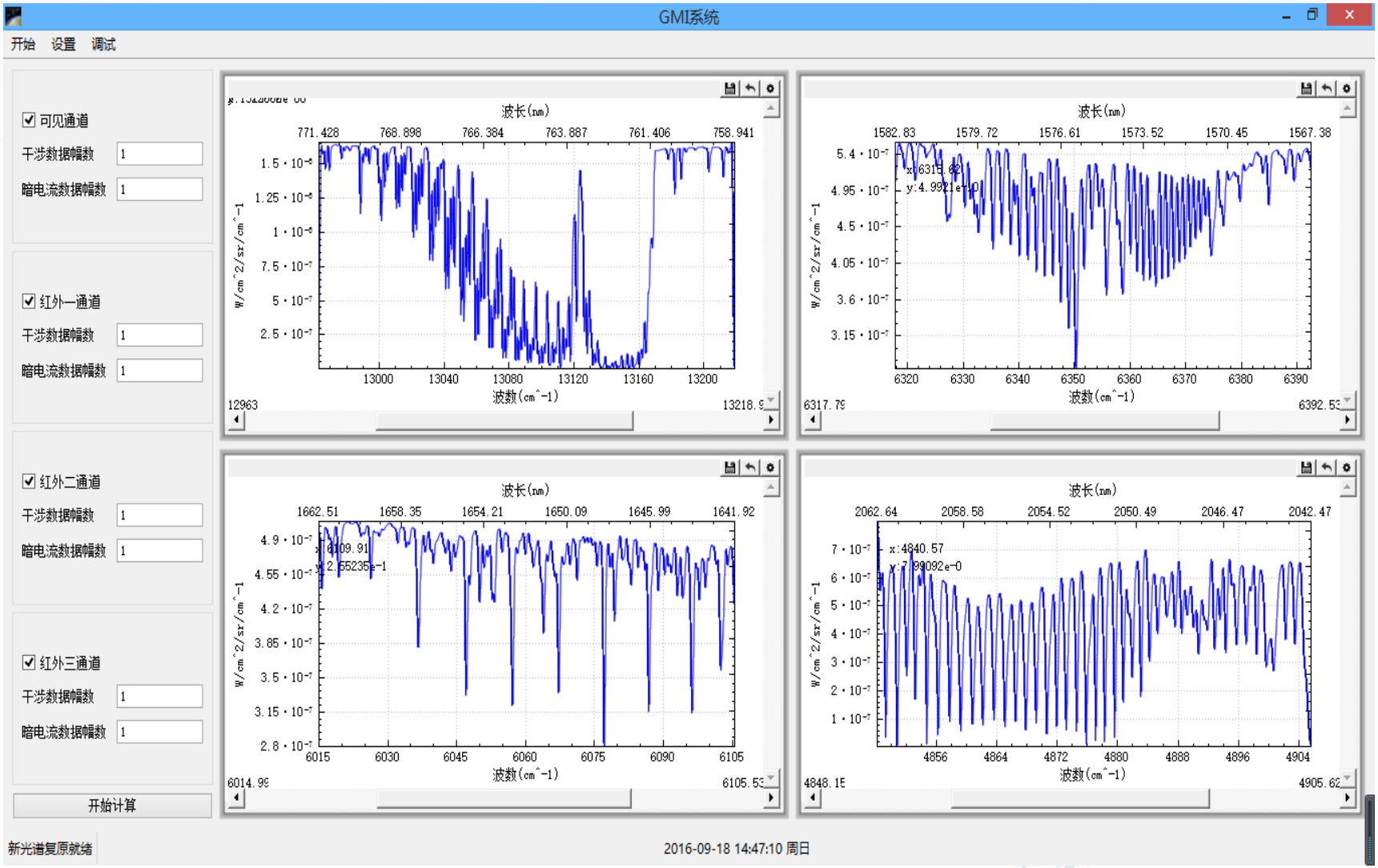
GMI Instrument Characteristics

- **Spatial heterodyne spectroscopy** is a new spectroscopic technique which can obtain high spectral resolution.
- A spatial heterodyne spectrometer has a two beam dispersive interferometer which includes a diffraction grating as a beam splitter/combiner. An incoming beam is collimated and passed to the grating in the interferometer where it is split into two beams which are recombined such that the angle between the wavefronts in the recombined beam at a particular wavelength is directly related to the deviation of that wavelength from a null wavelength at which the wavefronts are parallel. The recombined output beam is focused and imaged to produce Fizeau fringes across the output aperture, with these fringes being recorded on an imaging detector. The spatially varying intensity output of the imaging detector is Fourier transformed to yield an output indicative of the spectral frequency content of the image which is related to the wavelength content of the incoming beam from the source



Green gas retrieval with weak reflectance

GMI simulated signal



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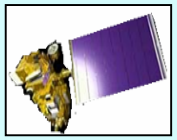
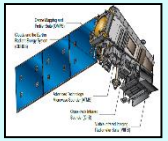
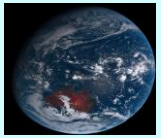
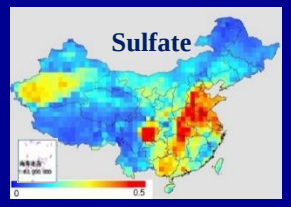
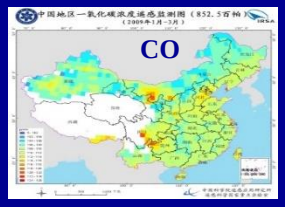
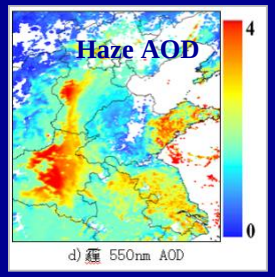
Haze monitoring system

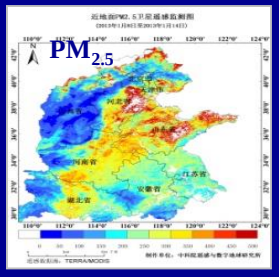
Aqua	Aura	Aqua	FY-3A/B	Soumi-NPP	HWI
					
MODIS	OMI	AIRS	MERIS	VIIRS、Cris、OMPS	

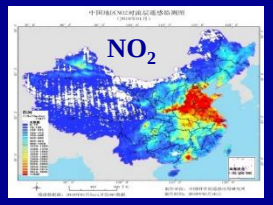
Aerosol optic depth、haze、$PM_{2.5}$、NO_2/SO_2、CO、O_3、biomass burning、dust
Atmospheric temperature/water vapor profile/

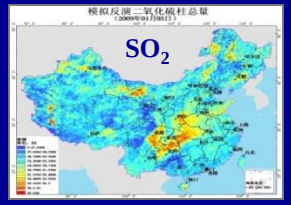


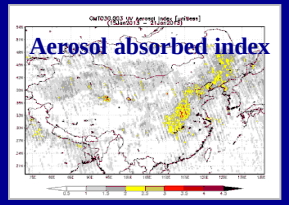


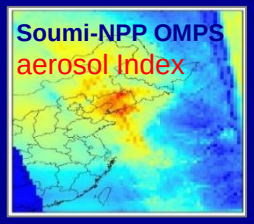


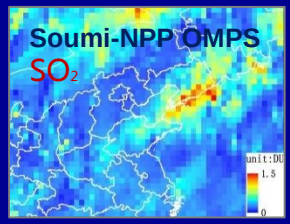


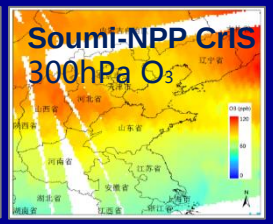


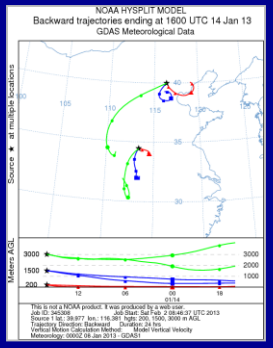


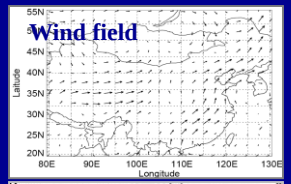


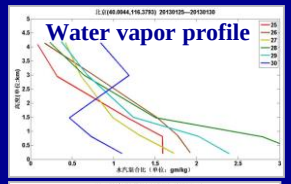


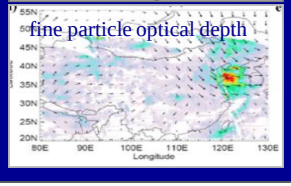


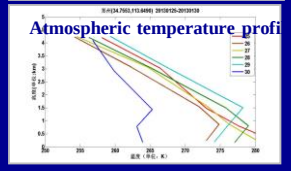


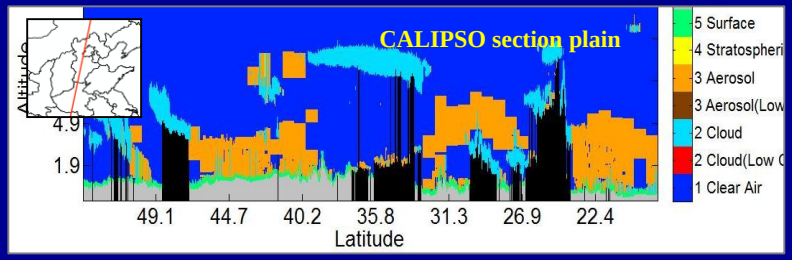






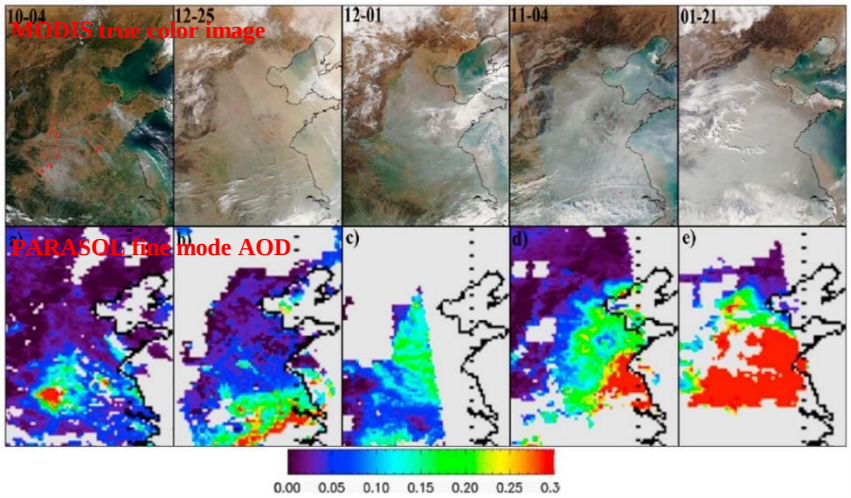




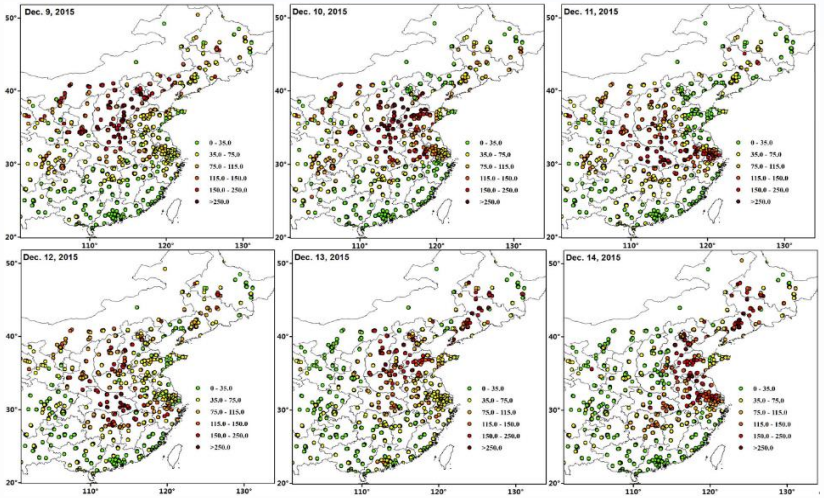


Still many challenges

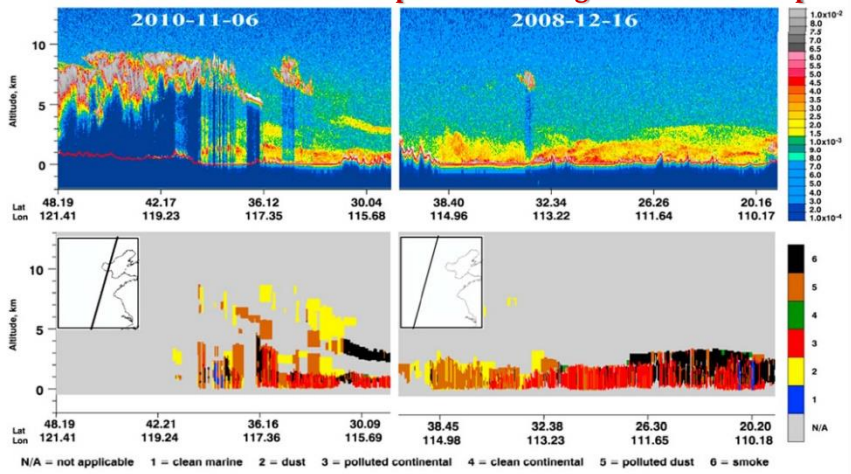
Dense haze layers with distinct optical properties



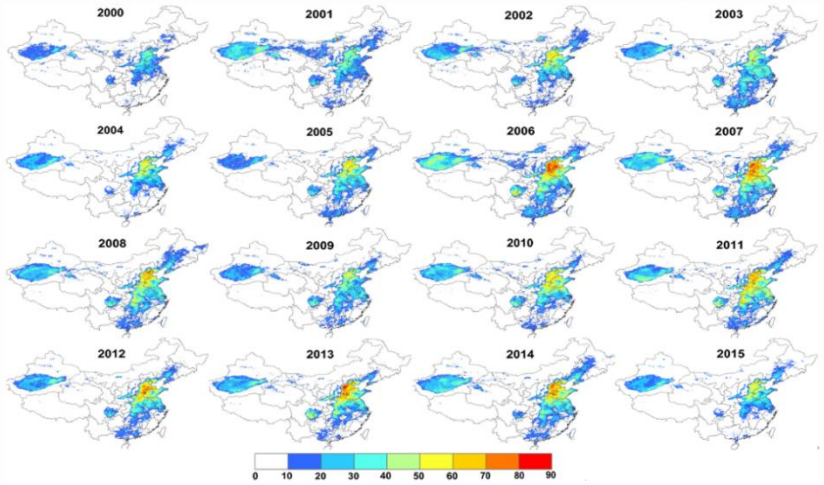
Daily spatial oscillation of the particle pollution in winter



CALIPSO vertical detection show prevalent mixing of dust and local pollution



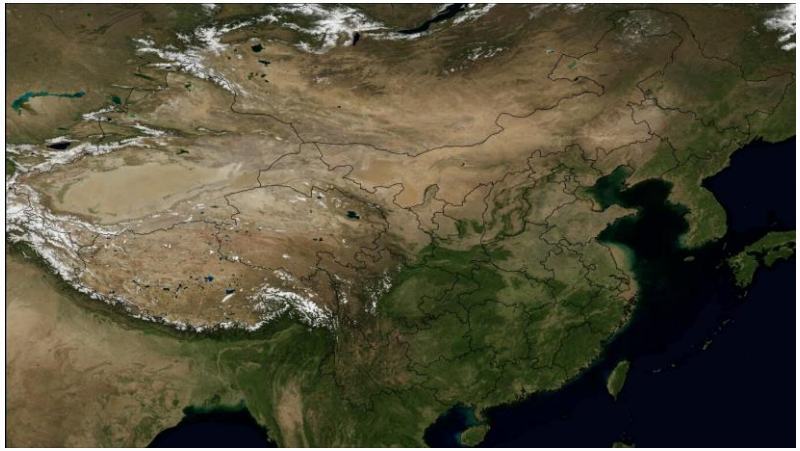
Atmospheric circulation influences annul trends of haze pollution



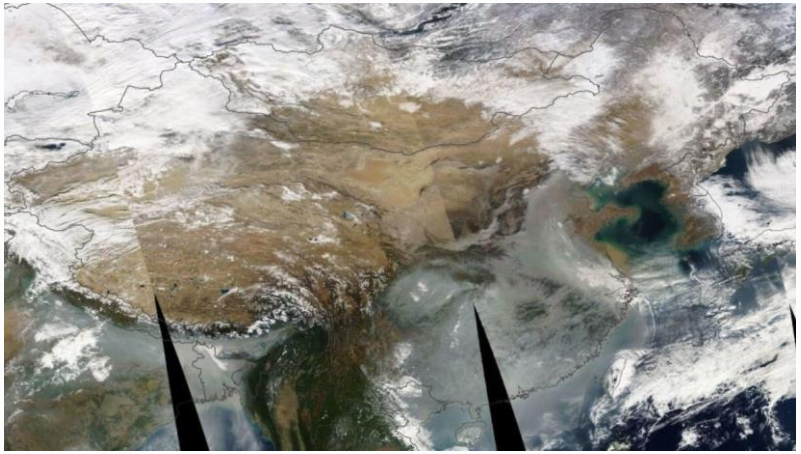
- Widespread haze pollution driven by interactions of diverse emissions and atmospheric circulation
- (Tao et al., 2012, 2013, 2014, 2016)

Still many challenges

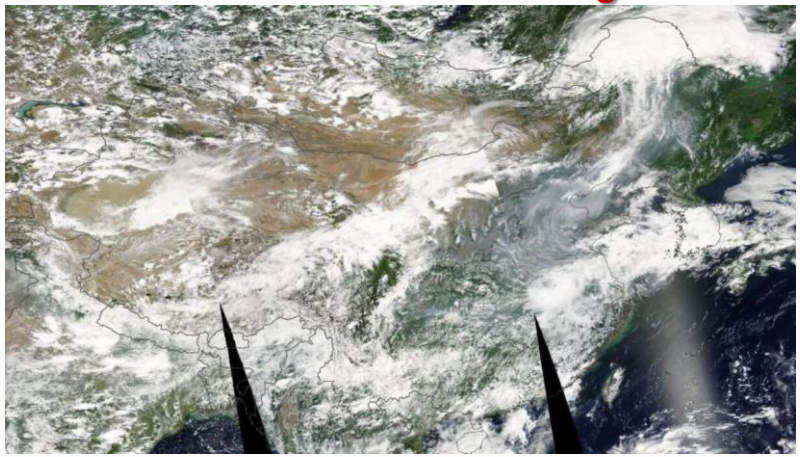
Complex surface types



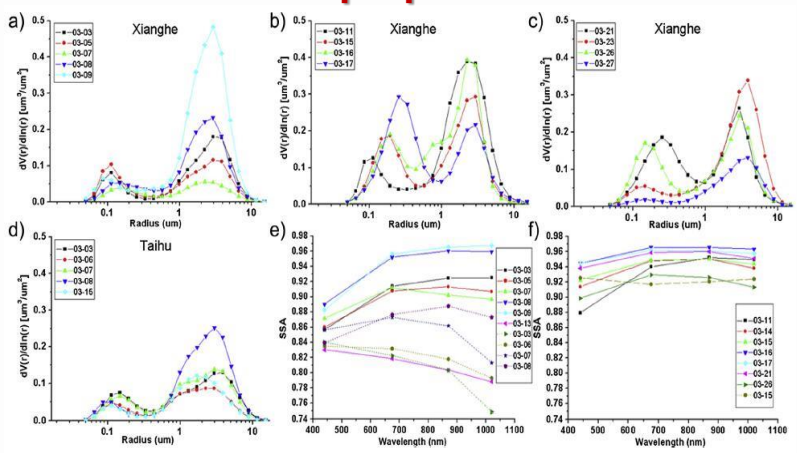
Widespread heavy aerosol loading



Prevalent aerosol-cloud mixing

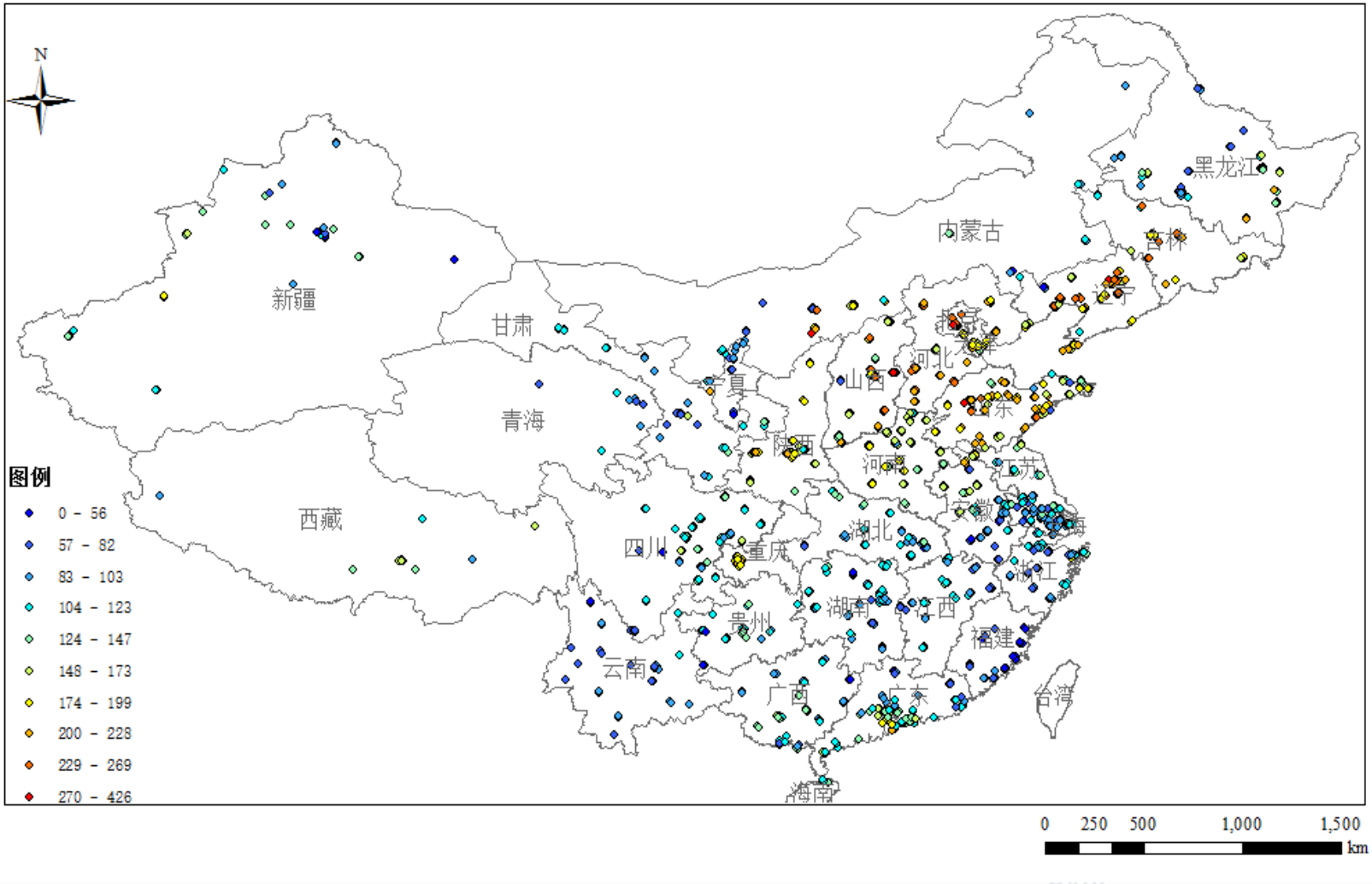


Intricate aerosol properties



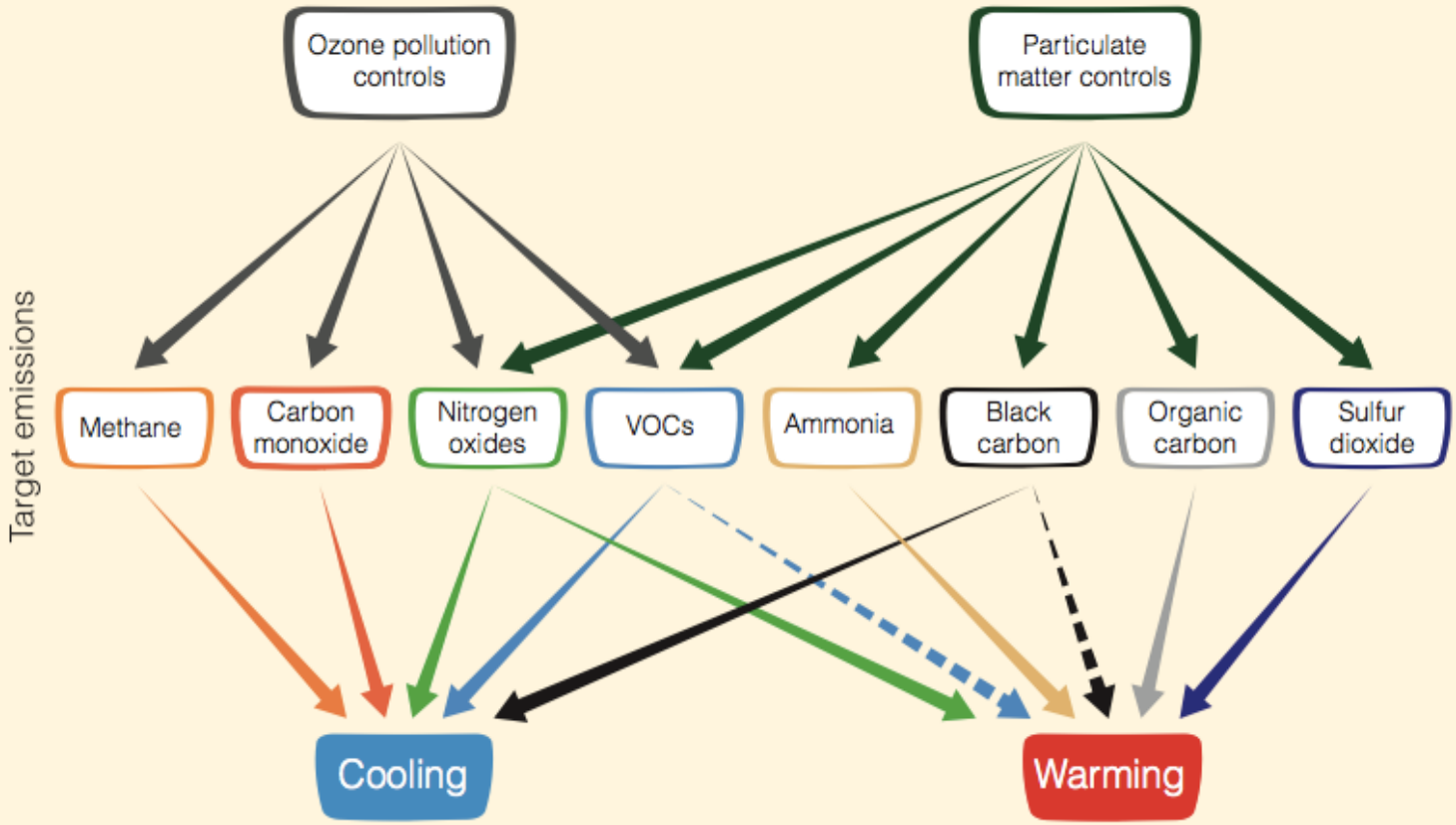
- Satellite retrievals still have large biases and limitations in the complex background of China. (Li et al., 2013; Tao et al., 2015)

Ground-measured O_3 (ug/m^3)



Air quality & climate change

FAQ： Do improvements in air quality have any effect on climate change ?



FAQ 8.2, Figure 1 | Schematic diagram of the impact of pollution controls on specific emissions and climate impact. Solid black line indicates known impact; dashed line indicates uncertain impact.

——IPCC AR5

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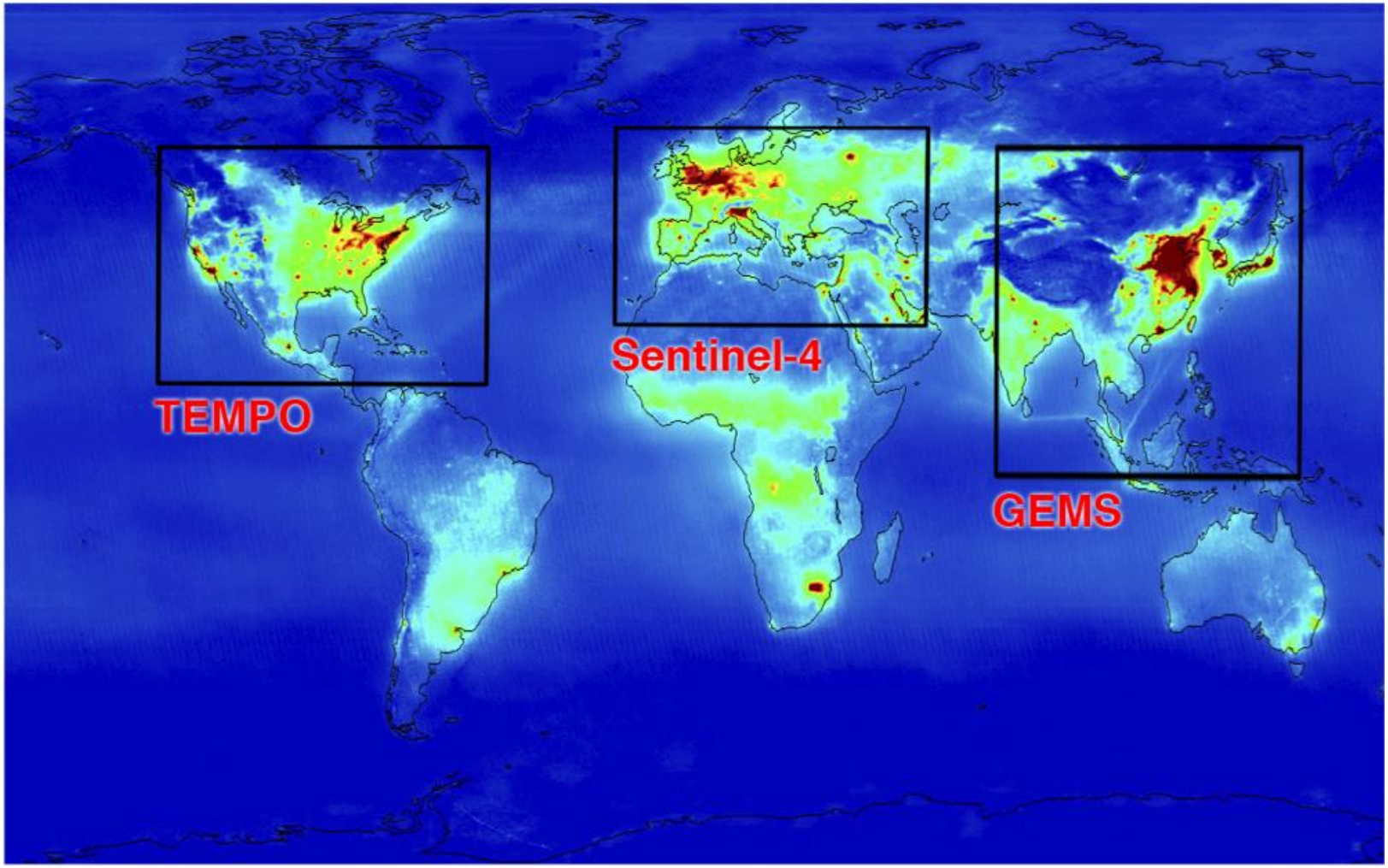
Look forward to future cooperation…



Credits: Image Courtesy of Andreas Richter (University of Bremen) and Jhoon Kim (Yonsei University)

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- Particle component
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Thank you!

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