CO2 Monitoring from Space:
TanSat and GF-5/GMI Mission Status

Yi Liu

Institute of Atmospheric Physics,
Chinese Academy of Sciences

TanSat Launching

TanSat was successfully launched on December 22 in JiuQuan Satellite launching center

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Scientific challenges for CO_2 monitor from space

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Perspective and Plan

What Controls Atmospheric Carbon Dioxide?

Natural systems including the ocean and plants on land both absorb and emit CO_2 to the atmosphere

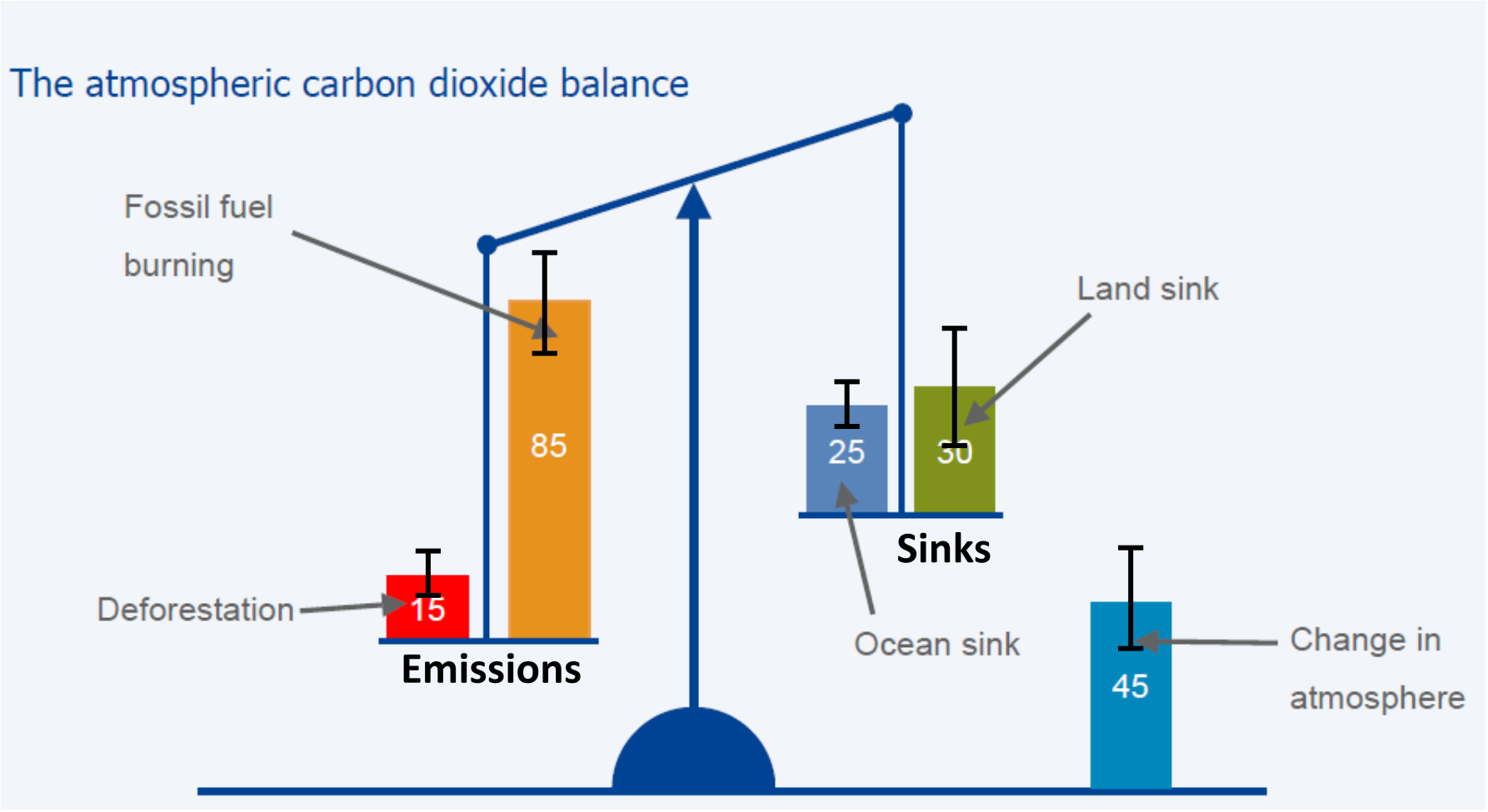
- Each year, the Land Biosphere
  - emits ~120 Billion tons carbon **(~440 Gt CO_2)**
  - reabsorbs ~122 Billion tons carbon **(~450 Gt CO_2)**
- Each year, the Ocean
  - emits ~90 Billion tons carbon **(~330 Gt CO_2)**
  - reabsorbs ~92 billion tons carbon **(~340 Gt CO_2)**

Currently, these natural systems are

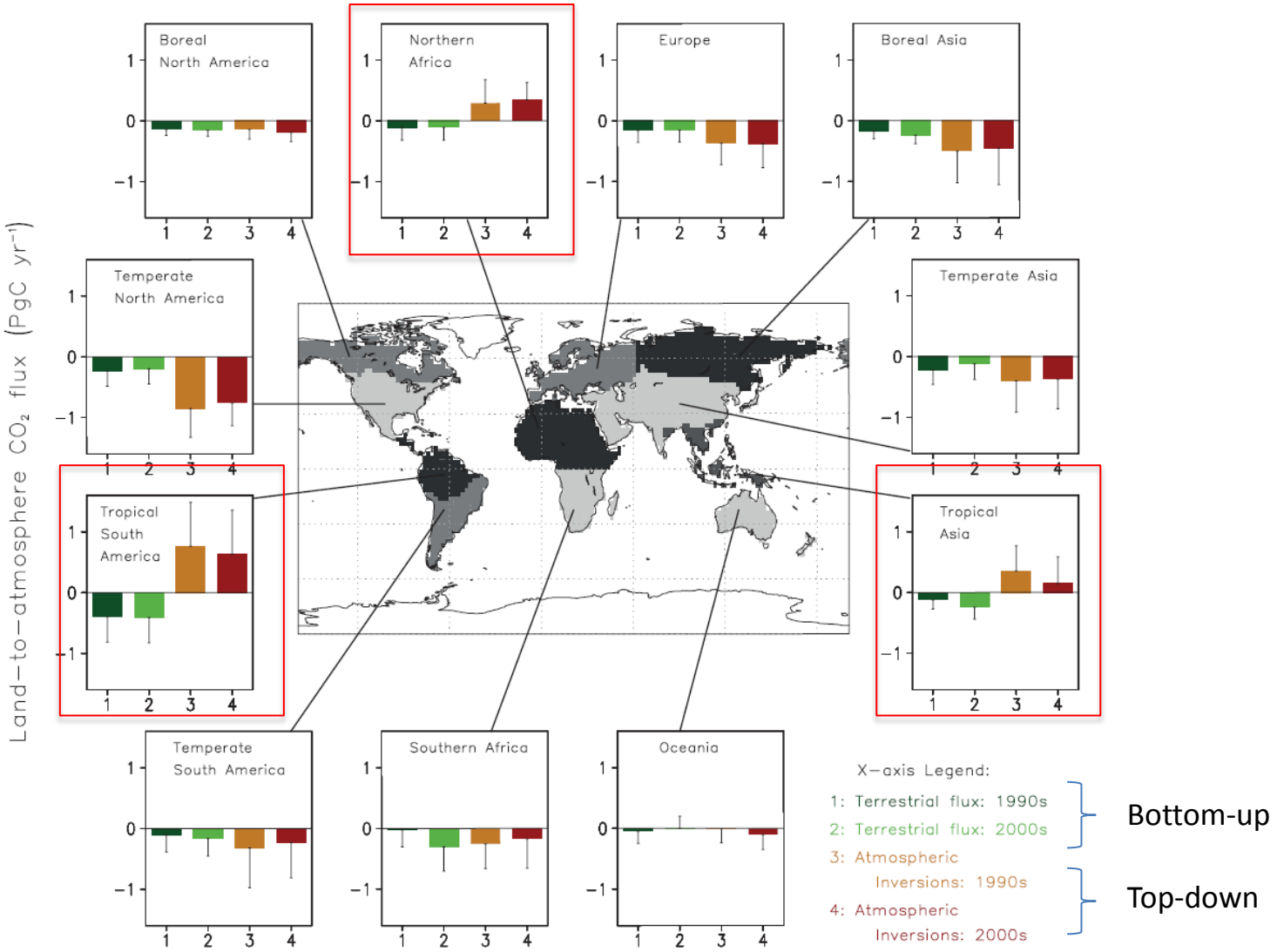
- absorbing **more than** half of the 40 Gt of carbon dioxide emitted by human activities
- limiting the rate of carbon dioxide buildup and its impact on the Earth's climate

Carbon Budget Picture

There is large uncertainty remain among these 3 systems

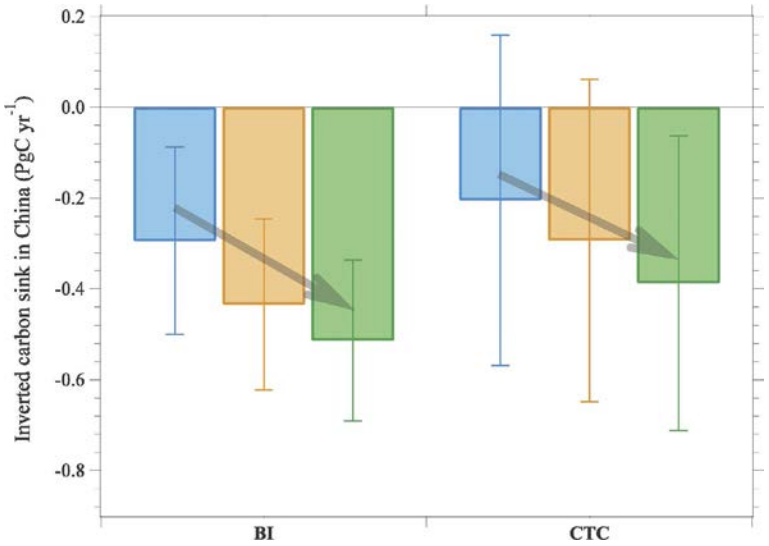


Uncertain remained in carbon flux estimation



Carbon Budget from Top-down and Bottom-up Approaches

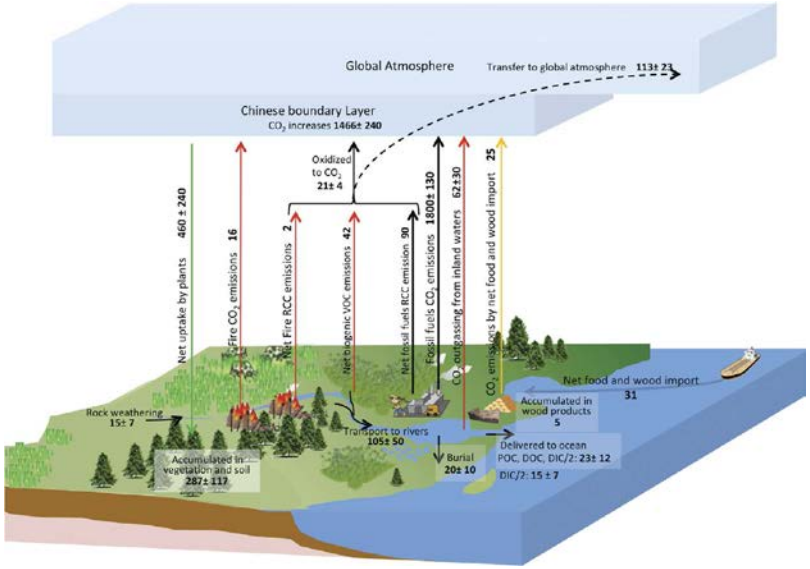
Adding new CO_2 measurements within or around China, the inverted CO_2 sink in China gets larger and its uncertainty is reduced.



Bayesian Inversion CarbonTracker China

Blue: GLOBALVIEW-CO2 and/or WDCGG
Orange: +3 additional stations from China Meteorological Administration
Green: +CONTRAIL aircraft CO2 measurements.

Carbon budgets of China's terrestrial ecosystems from 2006 to 2009.



Jiang et al, Nature Sc. Rep., 2016

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The TanSat Mission

(1) National High Technology Research & Development Programs by Ministry of Science and Technology of China (MOST)

Term-1 (2011-2015)

Term-2 (2013-2015)

(2) Strategic Priority Research Program -Climate Change: Carbon Budget and Relevant Issue by Chinese Academy of Sciences (CAS) – (2011-2015)

(3) Strategic Priority Research Program – Space Science: Scientific Research Satellite (CAS) (2015-2016)

--- Organization of TanSat Mission

--- Funding Launch fee

Term-1(2011-2015)

Measurement Goals

XCO2

1~4 ppmv

Monthly

500 x 500 km^2

Term-2(2013-2015)

Measurement Goals

CO2 Flux

Relative flux error

20%

Monthly

500 x 500 km^2

Satellite Platform - Observation Mode

Name	Characters
Orbit type	sun-synchronous
Altitude	700 km
Inclination	98°
Local time	13:30
Weight	500Kg

Nadir mode- Observation over land
- Push broom
- Principle plane track

Sun-glint mode- Observation over ocean
- Sun glint track
- Principle plane track

Target mode- Validation
- Surface target track
- Multi angles for one target

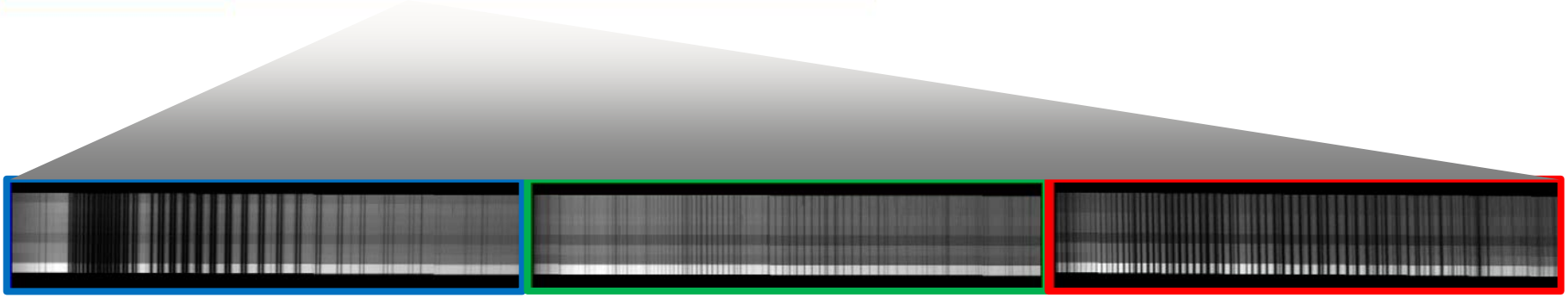
TanSat Instrument

Carbon Dioxide Sensor (CDS)

	O2-A	CO_2 weak	CO_2 Strong
Spectral Range (nm)	758-778	1594-1624	2041-2081
Spectral Resolution	0.044	0.12(0.081)	0.16(0.103)
SNR	360	250	180
Spatial Resolution	1km×2km, 2km×2km		
Swath	20km		

Cloud and Aerosol Polarization Imager - CAPI

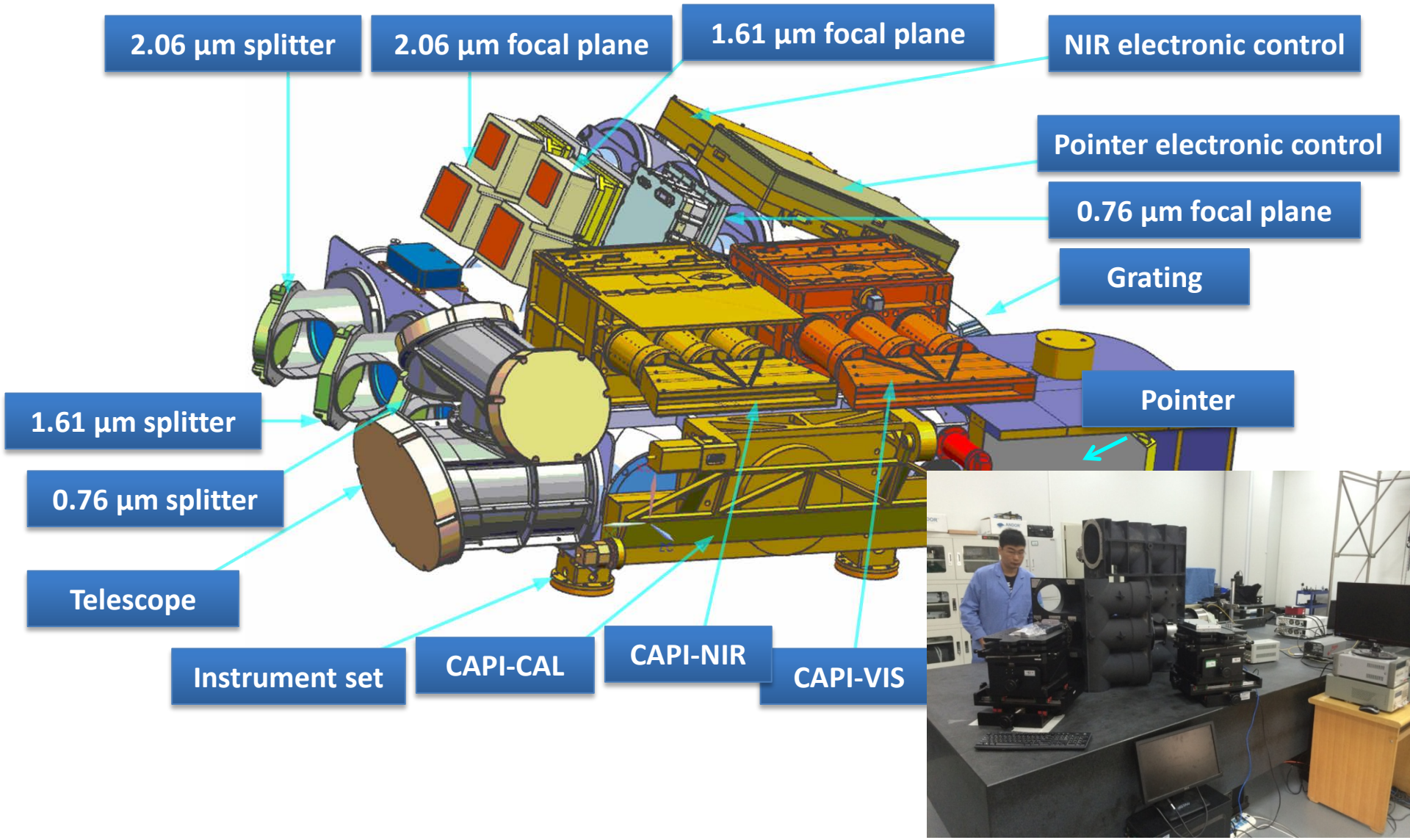
- Ultraviolet: 0.38μm
- Visible: 0.67μm
- Near infrared: 0.87, 1.375 and 1.64μm
- **Polarization: 0.67 & 1.64 μm**



0.765μm O_2 A-Band | CO_2 1.61μm Band | CO_2 2.06 μm Band

Carbon Dioxide Sensor (CDS)

TanSat



TanSat XCO2 Retrieval Algorithm-Apply to GOSAT

Validation

Bias: -1.9 ppmv (~0.48%)

SD: 1.1 ppmv (~0.28%)

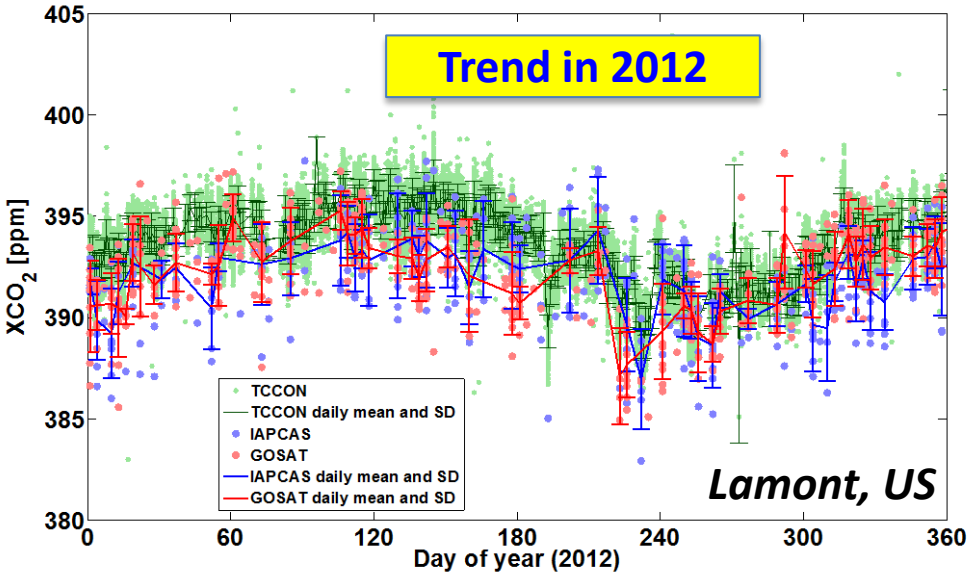
Inter-comparison

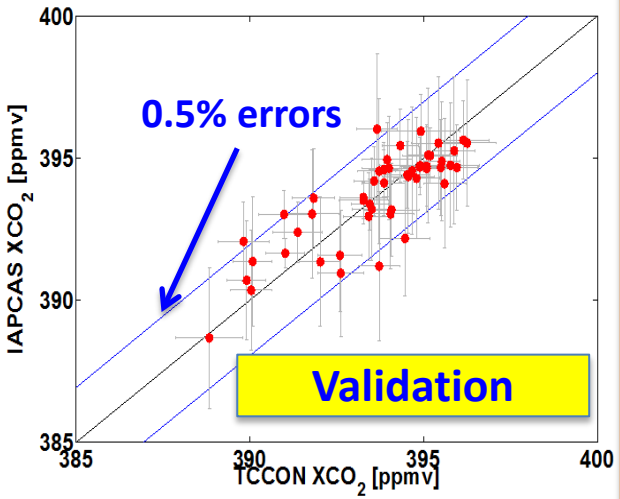
P0: 1.2hPa (~0.1%)bias

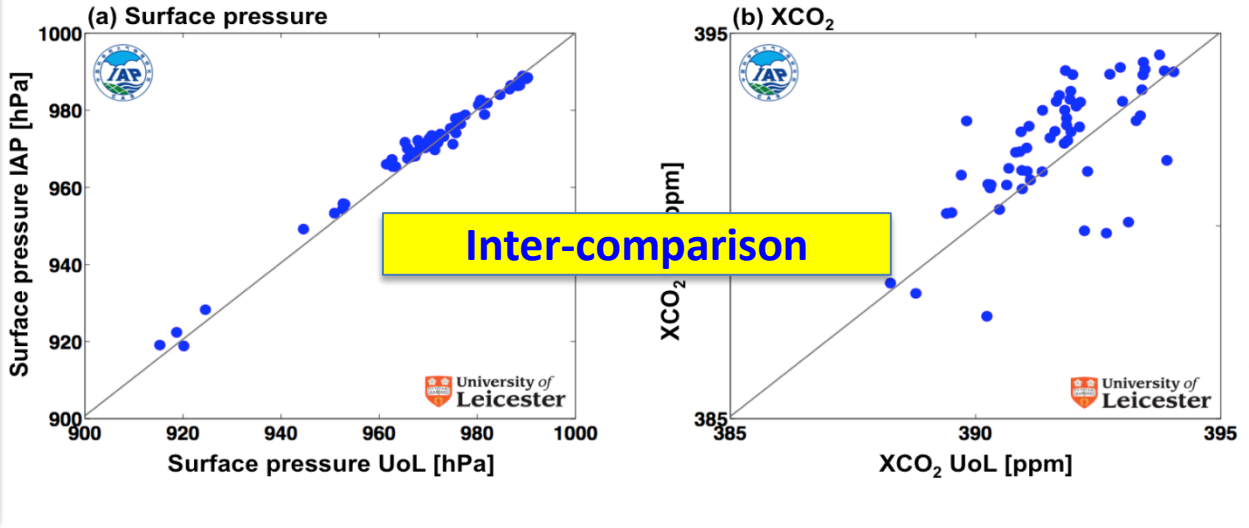
2.8hPa (~0.28%)SD

XCO_2: -2.4 ppm (~-0.6%)bias

1.23 ppm (~0.3%)SD



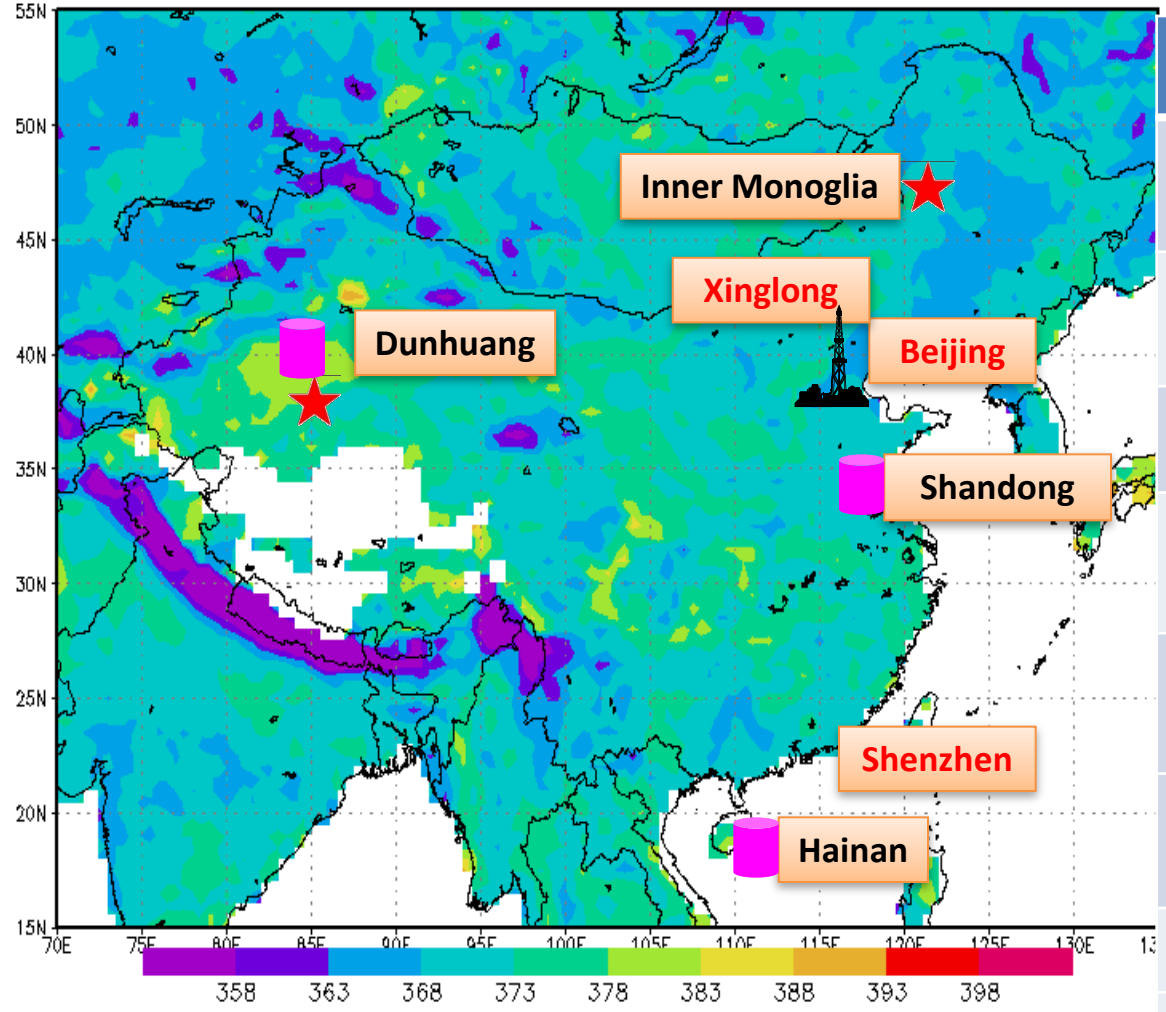




Ground based measurement network

TanSat

Ground-based Measurement Sites in China



Calibration, Validation

Ground sites

Site	Instrument
Beijing	IFS125/HR +325mTower+7 Licor
Shenzhen	IFS125/HR CIMEL+MWR
Xinglong	IFS 125/M
Shandong	Optical Spectrum Analyzer(OSA)
Dunhuang	Optical Spectrum Analyzer(OSA)
Hainan Island	Optical Spectrum Analyzer(OSA)
Urumqi	FGGA/LGR
Waliguan	FGGA/LGR

Surface CO_2 validation Stations

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Chinese Satellites: GF-5

Higher resolutions satellite series

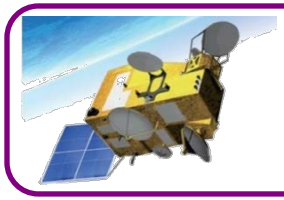
Gaofen Satellites

GF-1, GF-2, GF-3, GF-4, GF-5

Fengyun Satellites

Meteorological Satellite

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



Haiyang Satellites

Oceanic Satellite

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

Ziyuan Satellites

Resource Satellite

CBERS-1, 2, ZY-1~3

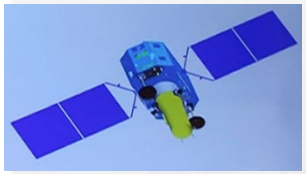
Huanjing Satellites

Environmental Satellite

HJ-1A/B/C

GF-5 2017.6 ???

GF-4 2015-12-29



GF-3 2016-8-10

GF-2 2014-8-19

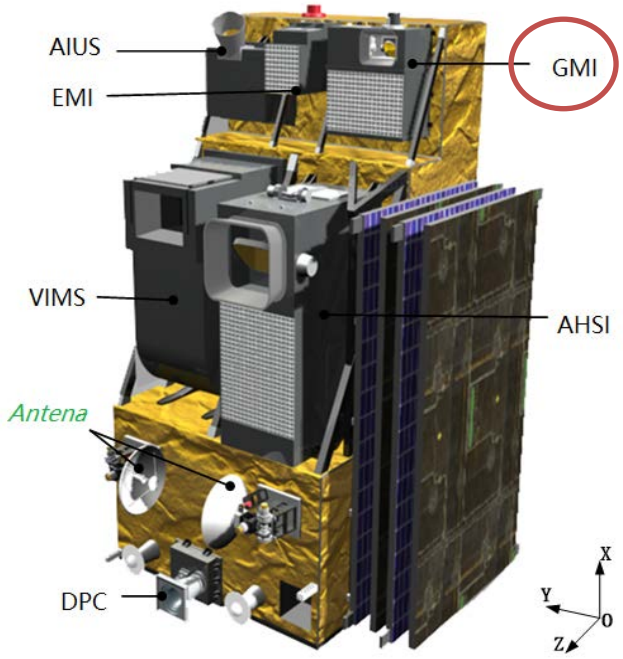
GF-1 2013-4-26

GF-5 satellite specification and orbit parameters

Orbital Type	Sun synchronous orbit
Orbital altitude	708 km
Local time	1：30

Sensors onboard GF-5

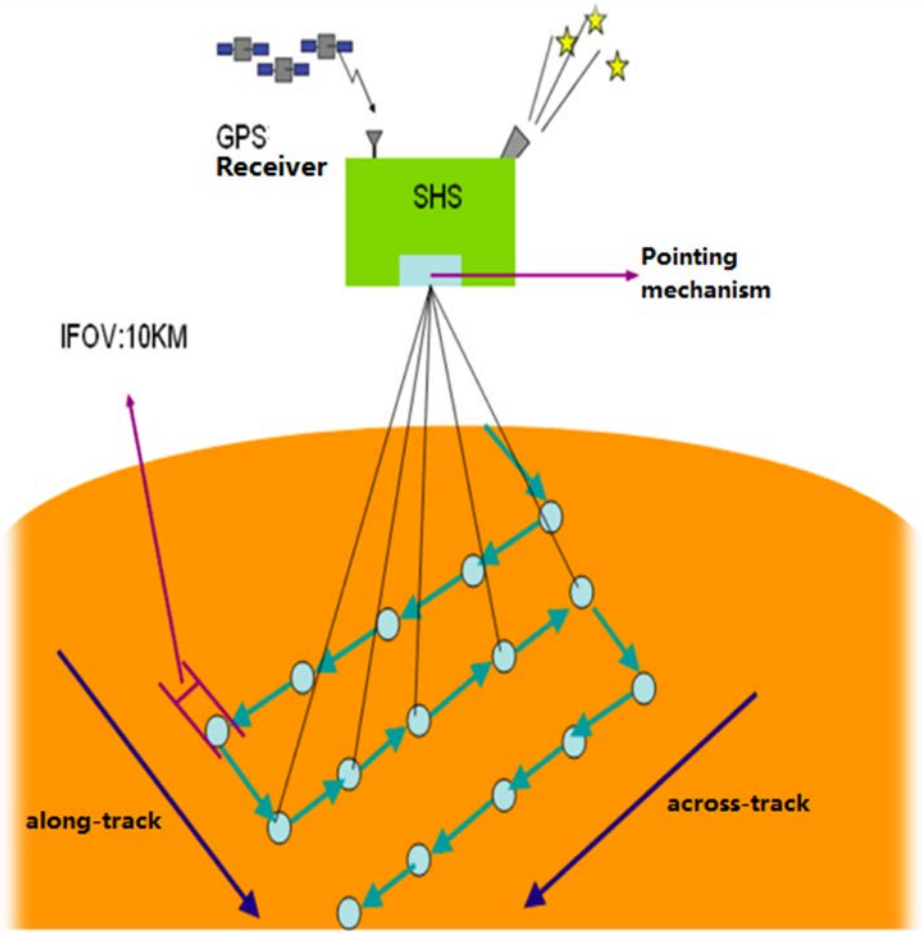
- Advanced Hyperspectral Imager (AHSI)
- Visual and Infrared Multispectral Sensor (VIMS)
- Greenhouse-gases Monitoring Instrument (GMI)
- Atmospheric Infrared Ultraspectral (AIUS)
- Environment Monitoring Instrument (EMI)
- Directional Polarization Camera（DPC）

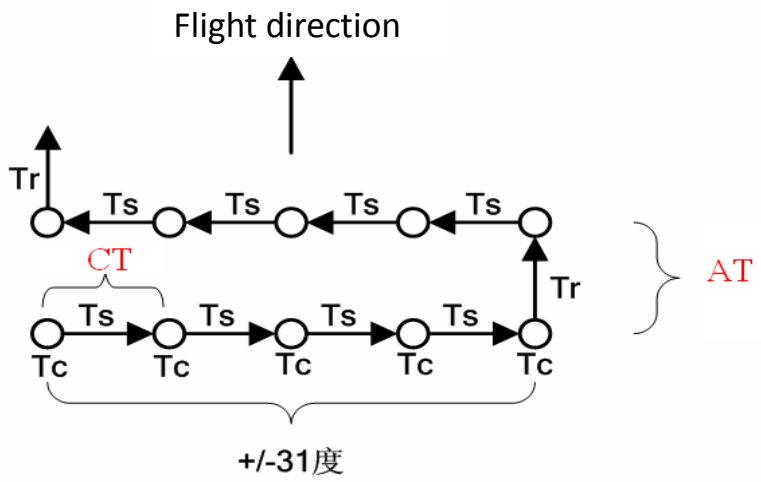


GMI parameters

	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-points			
Observation mode	nadir(mainly)/glint			
Weight	109kg			
Power	120W			
Data transfer rate	30Mpbs			

Greenhouse-gases Monitoring Instrument(GMI)



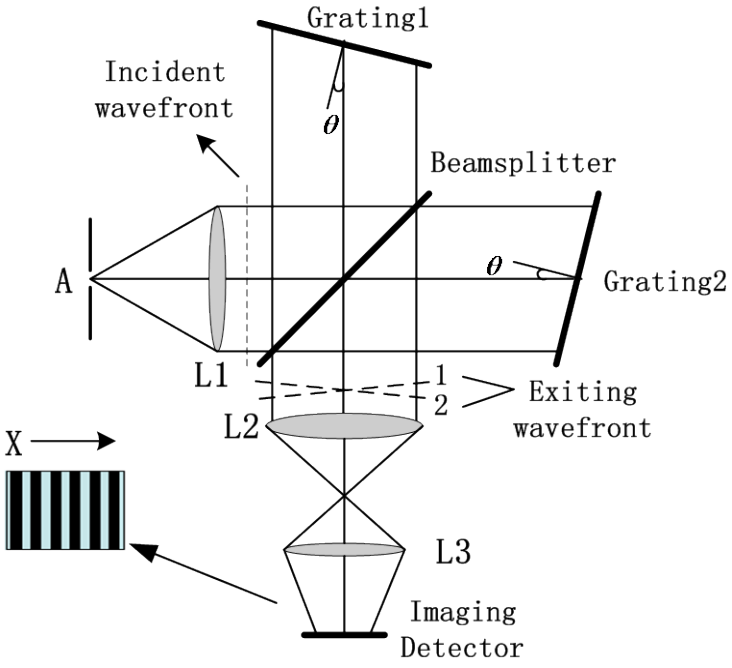


Observation patterns	Along track direction AT （km）	Across-track direction CT （km）
1		
5	100	212
7	130	142
9	130	106

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.



The instrument PI : **Yanli Qiao**
Anhui Institute of Optics and Mechanics,
Chinese Academy of Sciences

The GMI is planning to be launched in the middle of 2017

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Future outlook

1. TanSat will provide L1, L2, L3 CO_2 data to different users-Scientist, Policy Makers， Common User,…→Open data policy for GHG data will be approved soon.
2. TanSat will work together with GOSAT, OCO-2 to fill the gap of global GHGs observations.
3. GF-5/GMI will provide CO_2 and CH_4 observation data in the near future.
4. Chinese CO_2 and CH_4 data from space will support the overall goals of GEO and will provide prototype systems supporting the implementation of the GEOSS GHGs

TanSat Data Policy

1. TanSat will provide L1 products after 6 months of launch and will release L2 products after 9 months of launch to different Scientific users, and then the verified higher lever products (L2¥L3¥L4) will be provided to policy makers, common User.
2. TanSat data policy have been proposed by the TanSat science team, and will be soon approved by the MOST.
3. TanSat Science team will apply OCO-2, GOSAT data as an important source of cross-calibration. More close cooperation among space agencies on GHGs will be achieved.

The 9TH GEOSS Asia-Pacific Symposium

Tokyo, Japan, 11 – 13 January 2017