The 12th CEO S AV-VC

TanSat Mission Status

Yi Liu

TanSat Science Team

Institute of Atmospheric Physics,
Chinese Academy of Sciences

14 Oct 2016
Yonsei University, South Korea

Outline

1. Science requirement for TanSat
2. TanSat Mission
3. Satellite platform & Payload--Current Status
4. Retrieval algorithm
5. Ground based validation
6. Schedule and Plan

3 Feburary 2011 | VOL 470 | NATURE |

CAS Innovation 2020

POLICY

China sets 2020 vision for science

Goals include commercialization of research and emphasis on energy, biomedicine and information technology.

BY JANE QIU IN BEIJING

China is betting that an ambitious programme of applied research will help to secure its future as an economic superpower. Innovation 2020, unveiled last week by the Chinese Academy of Sciences (CAS), maintains support for basic research. But the plan will place a new emphasis on translating the research into technologies that can power economic growth and address pressing national needs such as clean energy, said Bai Chunli, vice-president of the CAS, at the academy's annual conference in Beijing, where the plan was announced.

Innovation 2020 is an extension of the Knowledge Innovation Programme (KIP) launched by the CAS in 1998. Under the KIP, the academy streamlined its often overstaffed and outdated institutes, attracted outstanding Chinese researchers who had trained abroad, and tightened up the way it evaluated project proposals and performance. But the CAS now needs to support new priorities, says Duan Yibing, a policy researcher at the CAS Institute of Policy and Management in Beijing. China has become a global economic power, and the world's financial crisis has made scientific innovation more important to economic success than ever before, he says. "Things are a lot different now compared to 13 years ago."

Although the budget of Innovation 2020 is yet to be announced, insiders say it will be part of a continuing surge in the nation's science spending (see 'Spend, spend, spend'). Indeed, the CAS's expenditure on research and development (R&D) in 2009 was about 20 billion renminbi (US$3 billion), seven times the level in 1998, according to a KIP assessment report also released last week. This year's budget for the National Natural Science Foundation of China will increase by 70%, from 10 billion renminbi last year.

Innovation 2020 will kick off with new projects this year in seven key areas, including nuclear fusion and nuclear-waste management; stem cells and regenerative medicine; and calculating the flux of carbon between land, oceans and atmosphere. Other priority areas include materials science, information technology, public health and the environment.

To coordinate resources better and to foster multidisciplinary research, the academy will set up three research centres for space science, clean coal technologies and geoscience monitoring devices. It also plans to build three science parks — in Beijing, Shanghai and Guangdong province, respectively — to accelerate the conversion of basic research into marketable products, especially in renewable energy, information technology and biomedicine.

Pan Jiaofeng, deputy general secretary of the CAS, says the KIP's track record bodes well for the success of the new programme. By the CAS's reckoning, in 2009, researchers that it funded published 3.5 times as many papers in journals listed by the Science Citation Index (SCI) as in 1998. Crucially, the number of papers published in the top 1% of SCI journals, as judged by their impact factor, was 12 times that in 1998. The CAS also calculates that research and development by the KIP generated an income of 140 billion renminbi and tax revenue of 22 billion renminbi in 2009 — respectively 19.5 and 14.5 times the levels in 2000.

But the report acknowledges that there is substantial room for improvement. For example, CAS researchers should aim to become leaders of the international scientific community, and shift their focus away from generating as many papers as possible and towards genuine originality and innovation.

With its emphasis on applied research, the new initiative also "presents a major challenge to the management and organizational capabilities of the academy", says Richard Suttmeier, a science-policy researcher at the University of Oregon in Eugene. He notes that most CAS institutes are focused on academic disciplines and lack the infrastructure needed for commercializing research or directing it towards national needs.

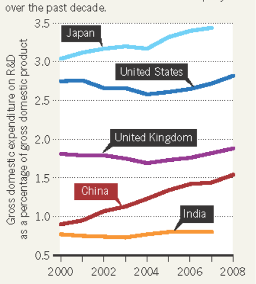
Others think that the emphasis on applied research, national needs and revenue could stifle curiosity-driven research. Without that, says a Shanghai-based researcher who declines to reveal his identity, "it would be very difficult to have genuine innovation". ■

CHINA DAILY/REUTERS

China is investing heavily in renewable-energy research as it builds its capacity in, for example, solar power.

SPEND, SPEND, SPEND

China's investment in science has risen rapidly over the past decade.



SOURCE: UNESCO

NATURE.COM
For all the latest research from China, see: www.nature.com/nchina

Strategic Priority Research Program of the Chinese cademy of Sciences

Climate Change: Carbon Budget and Relevant Issues

PI : Daren Lv, CI : Yi Liu

5 year funding : 800 million

Strategic Priority Research Program of the Chinese Academy of Sciences (CAS)

Climate Change:Carbon Budget and Relevant Issue

Missions-1 GHGs emission measurement over China

Carbon emission measurement system in energy, cement and other industries, and land use

Missions-2 GHGs absorption measurement

Carbon sequestration rate and potential increment of carbon sink of ecosystems

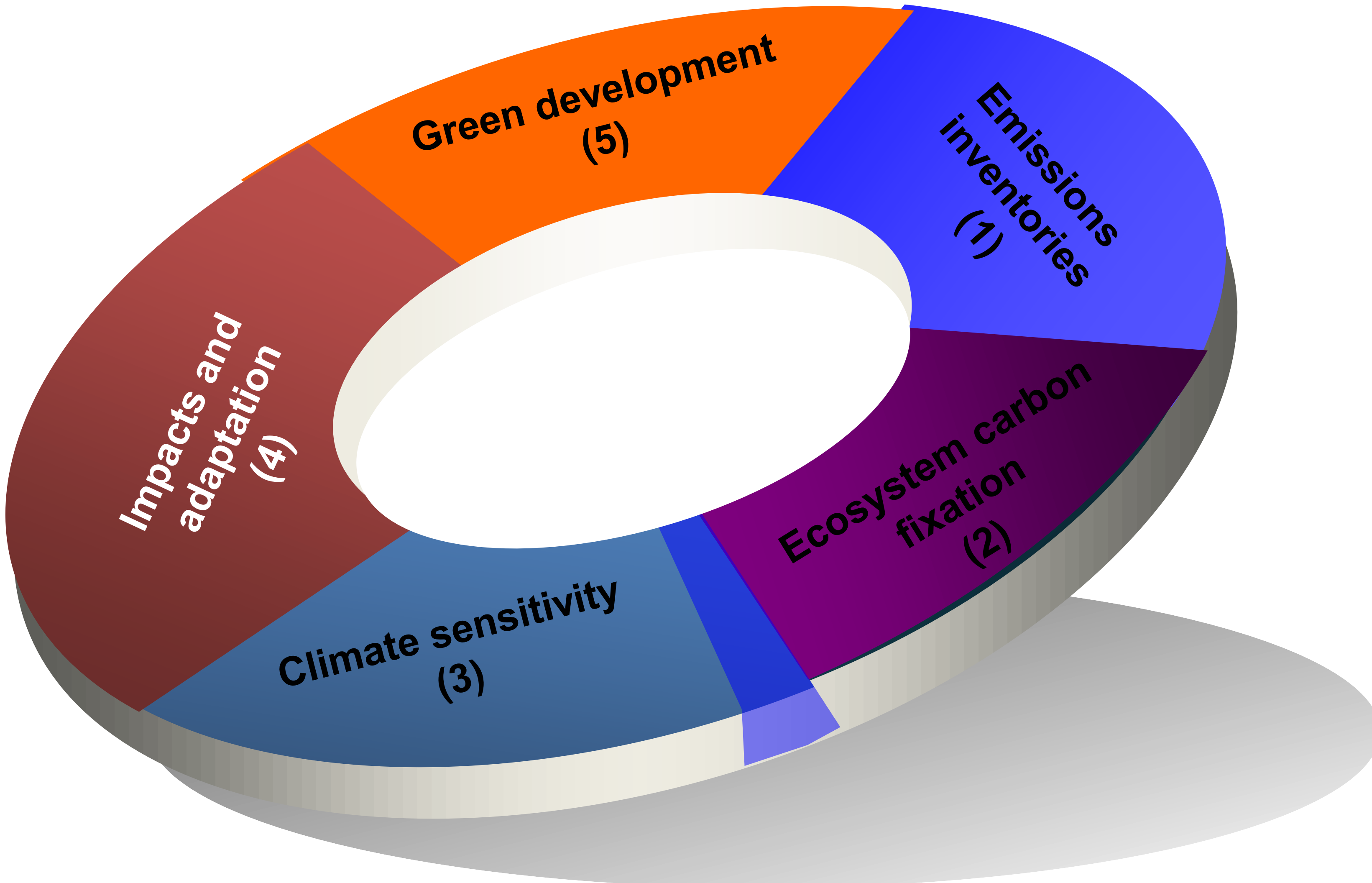
Missions-3 Satellite observation of GHGs flux

Support TanSat project in retrieval algorithm, validation, and flux inverse model

Missions -4 Climate Model

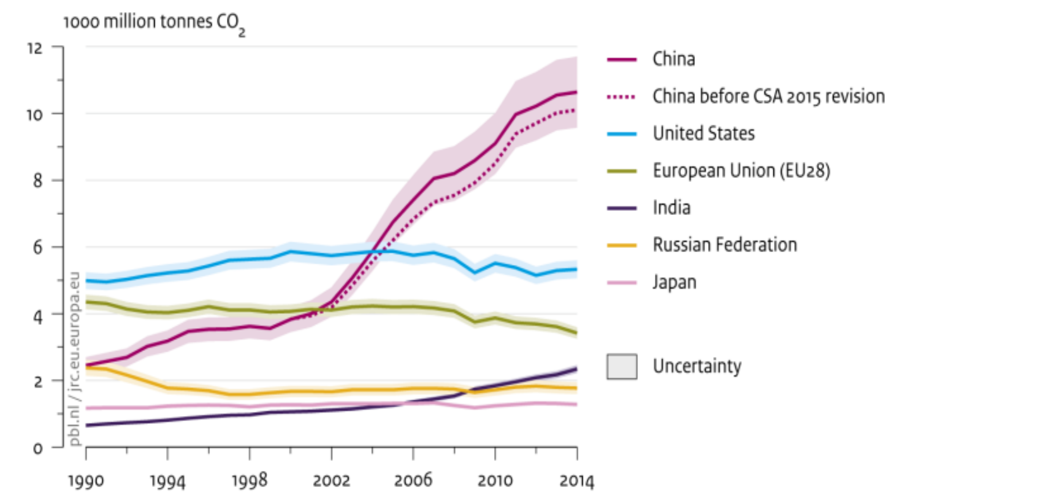
New generation climate system model, long term aerosol observation

Five major themes of the program (15 projects)

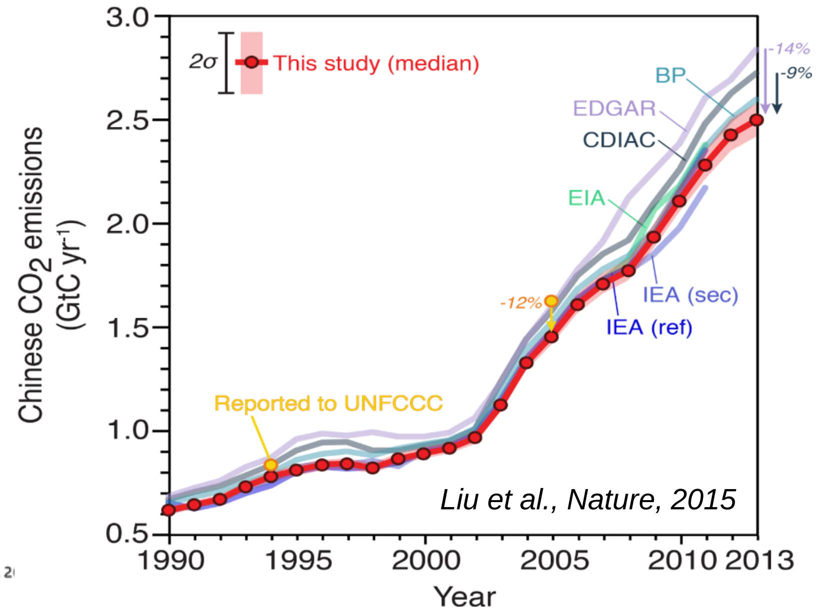


Emissions of Carbon

CO_2 emissions from fossil-fuel use and cement production in the top 5 emitting countries and the EU



Source: EDGAR 4.3 (JRC/PBL, 2015) (1970-2012; notably IEA 2014 and NBS 2015); FT2014 (2013-2014): BP 2015; GGFR 2015; USGS 2015; WSA 2



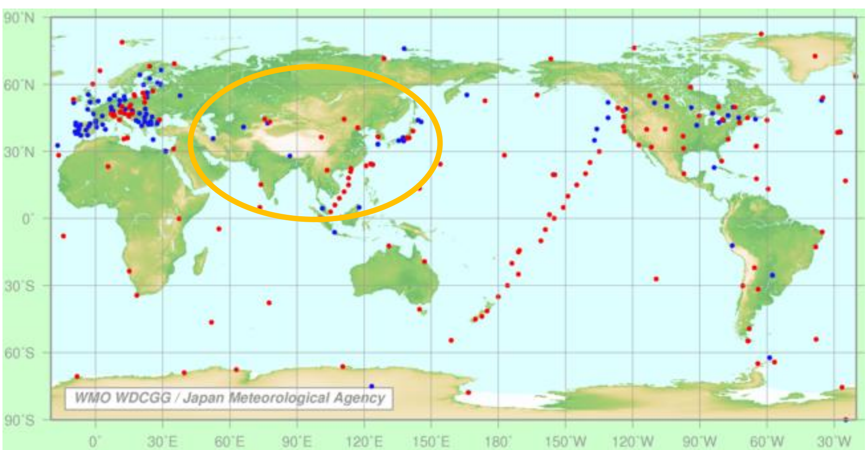
- *This 14% correction of emissions translates into adjusting the global land sink (residual) by 0.4 $GtC\ yr^{-1}$ (~30%)*

- Global CO_2 emissions are still increasing
- Shift towards emerging economies
- Emission inventories are becoming more uncertain

Carbon Cycle of China not Well Constraint

- Emissions are embedded in natural carbon cycle which takes up >50% of emissions globally
- Most of our knowledge about natural sinks are based on observations from global surface in-situ networks

CO_2 surface network of the World Data Centre for Greenhouse Gases (WDCGG)



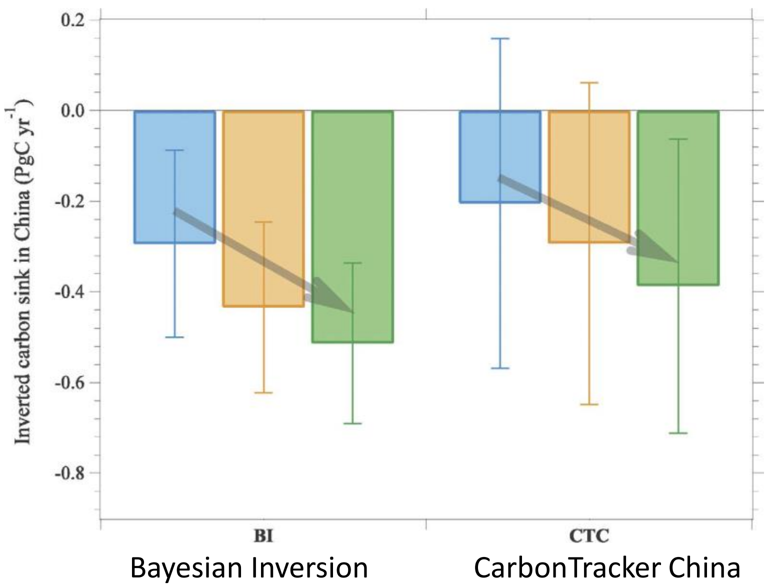
Estimates of natural fluxes are not consistent between studies

Name	Study Period	Carbon balance ($Pg\,C\,yr^{-1}$)	Reference
C13_CCAM	1992–2008	−0.997	Law et al. (2006)
C13_MATCH	1992–2008	0.416	Rasch et al. (1997)
JENA_S96	1996–2009	−0.930	Rödenbeck et al. (2003)
JMA_2010	1985–2008	0.201	Taguchi (1996)
NICAM	1988–2007	−0.404	Satoh et al. (2008)
NIES	1993–2007	−0.641	Maksyutov et al. (2008)
PYVAR	1988–2008	−0.376	Chevallier et al. (2005)
CTRACKER_US	2000–2009	−0.312	Peters et al. (2007)

East-Asia Carbon Budget from Atmospheric Inversions (Piao et al., 2012)

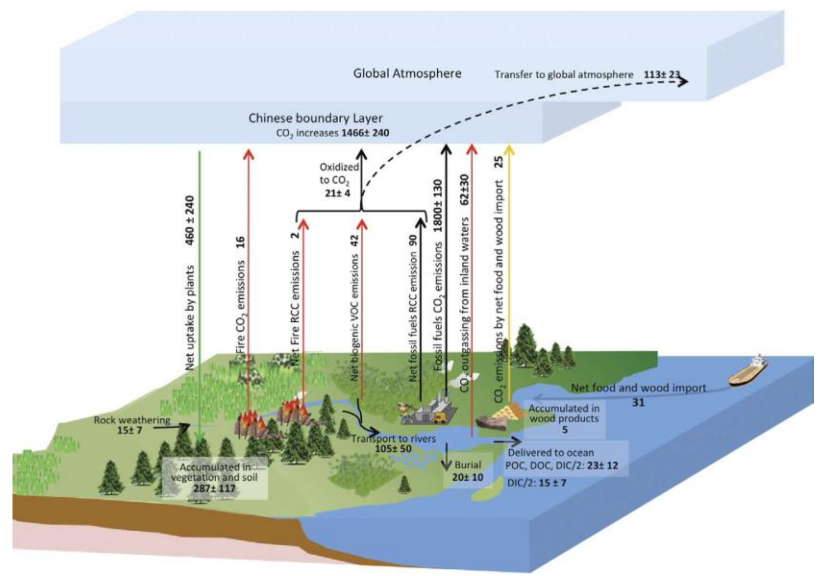
Carbon Budget from Top-down and Bottom-up Approaches

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



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

TanSat

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

Term-1 (2011-2017)

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

Term-1(2011-2017)

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

Team of The TanSat Project

Team Leader	Mission
Zengshan Yin Shanghai Engineering Center for Microsatellites	Team leader and Satellite platform
Yuquan Zheng Changchun Institute of Optics, Fine Mechanics and Physics	Carbon Dioxide Spectrometer
Changxiang Yan Changchun Institute of Optics, Fine Mechanics and Physics	Cloud and Aerosol Polarization Imager (CAPI)
Zhongdong Yang National Satellite Meteorological Center, CMA	Data receiver, Calibration and Operational Process
Yi Liu Institute of Atmospheric Physics, CAS	Science requirement， CO2 Retrieval Algorithm, Validation and Application
Xiangjun Tian Institute of Atmospheric Physics, CAS	CO2 Flux inversion
Chengcai Li Bekjing University	Aerosol and cloud Retrieval Algorithm for CAPI

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

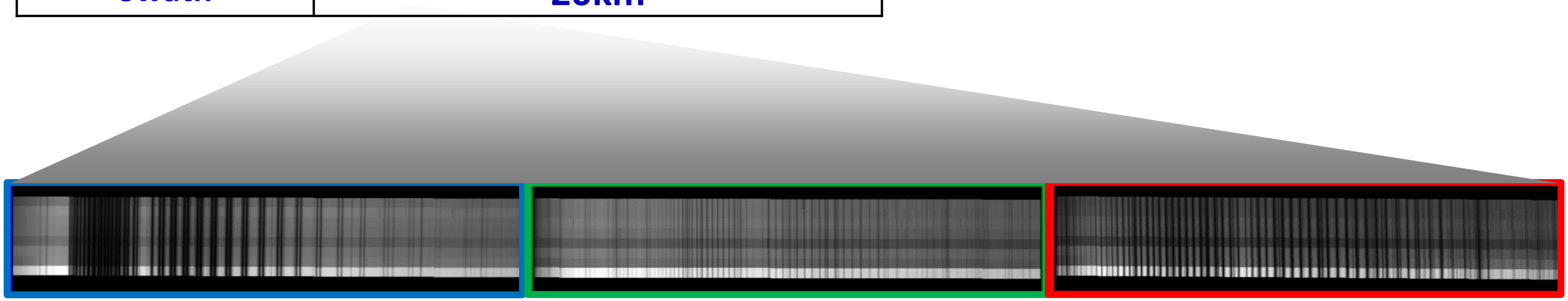
TanSat Instrument

Carbon Dioxide Sensor (CDS)

	O_2-A	CO_2 Weak	CO_2 Strong
Spectral Range(nm)	758-778	1594-1624	2042-2082
Spectral Resolution(nm)	0.038-0.047	0.120-0.142	0.160-0.182
SNR	360	250	180
Spatial Resolution	2kmx2km		
Swath	20km		

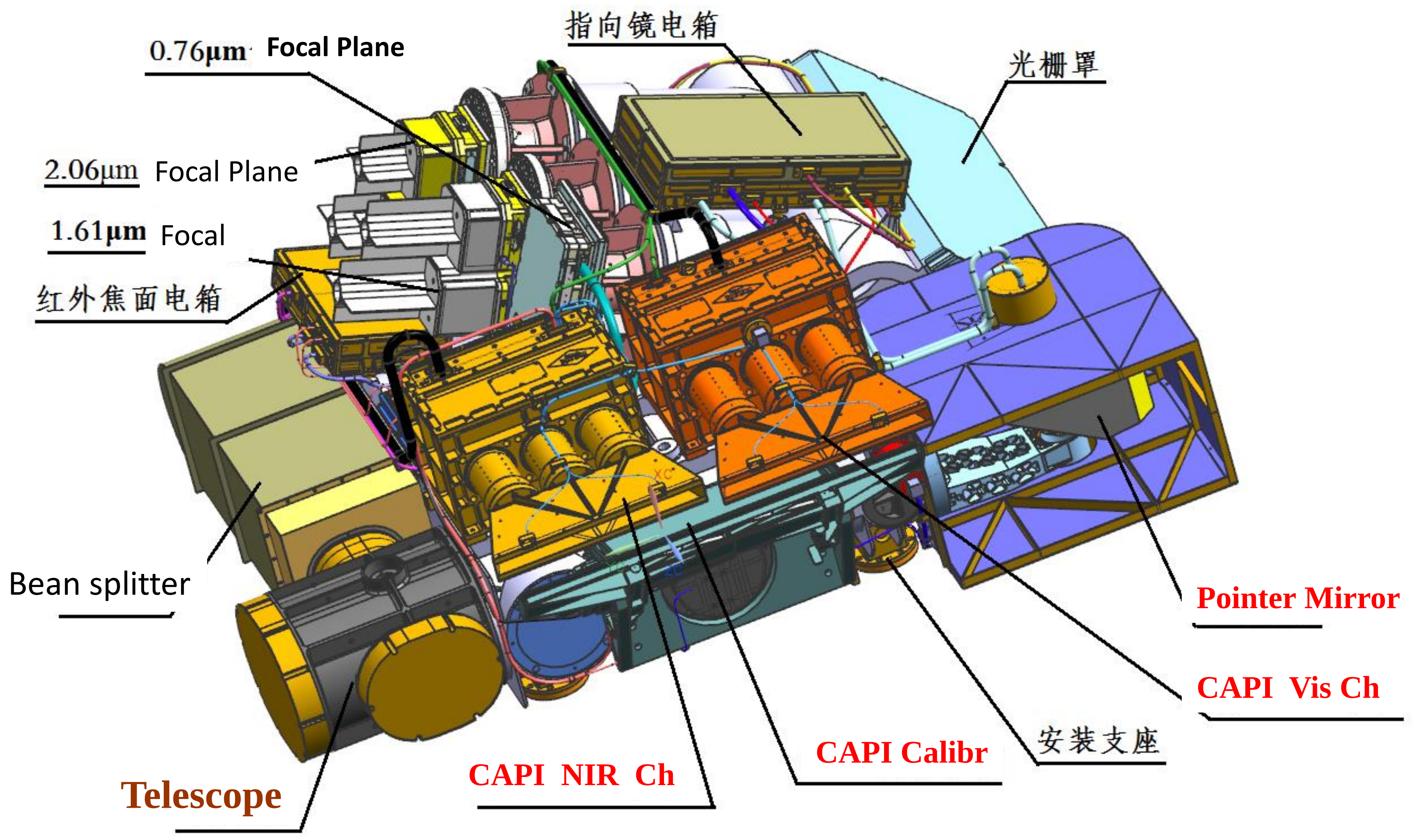
Cloud and Aerosol Polarization Imager (CAPI)

Ultraviolet: 0.38μm
- Visible: 0.67μm
- Near infrared: 0.87, 1.375, 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

CDS and CAPI



0.76μm Focal Plane
指向镜电箱
光栅罩
2.06μm Focal Plane
1.61μm Focal
红外焦面电箱
Bean splitter
Pointer Mirror
CAPI Vis Ch
安装支座
CAPI Calibr
CAPI NIR Ch
Telescope

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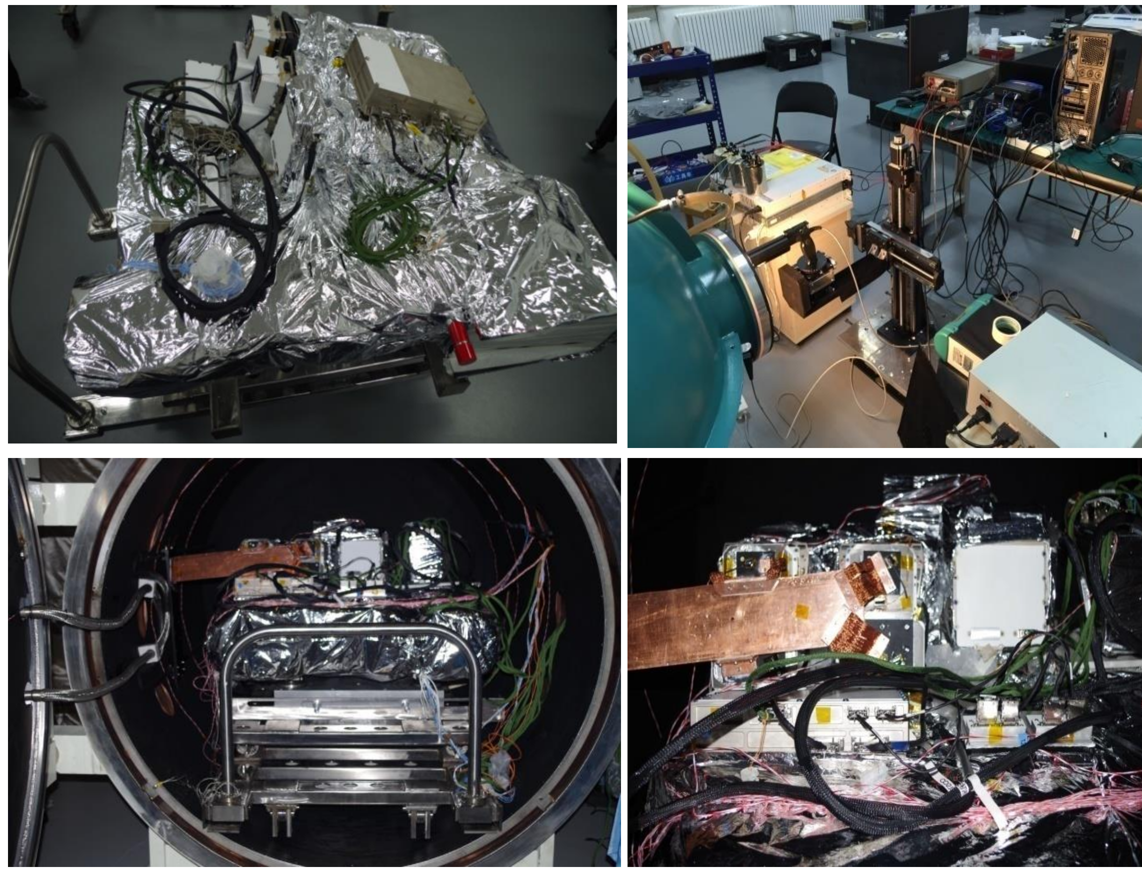
Preflight calibration in laboratory

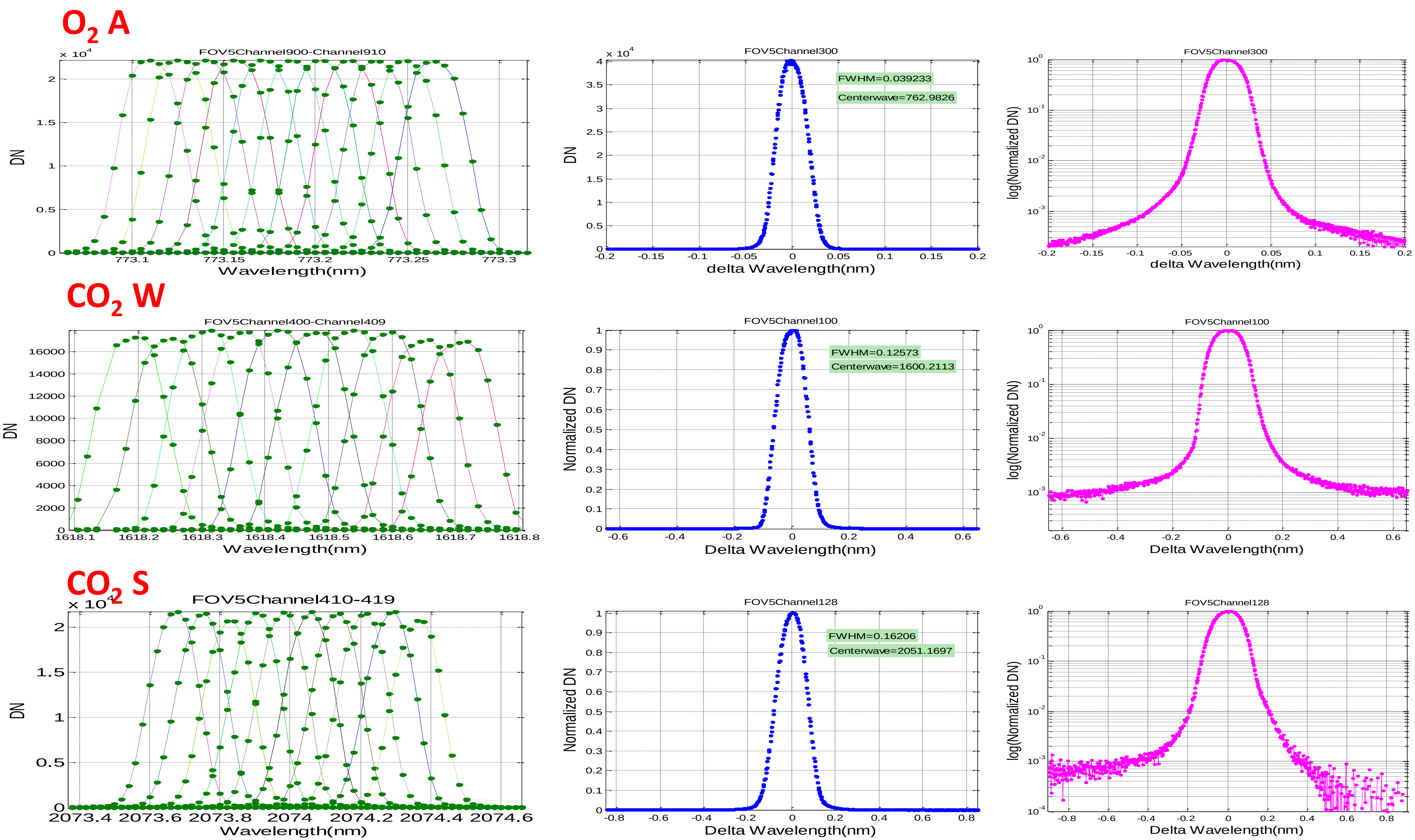
Preflight calibration

2015-2016

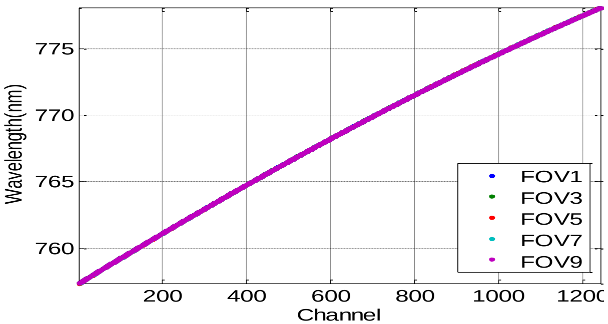
- **Radiometric Cal.**
- **Spectral Cal.**
- **Polarization Cal.**
- **Geometric Cal.**
- **SNR**

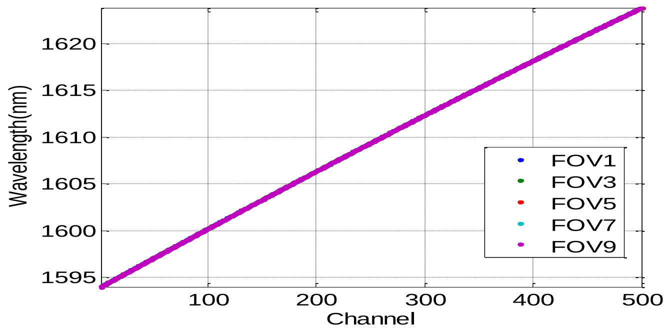


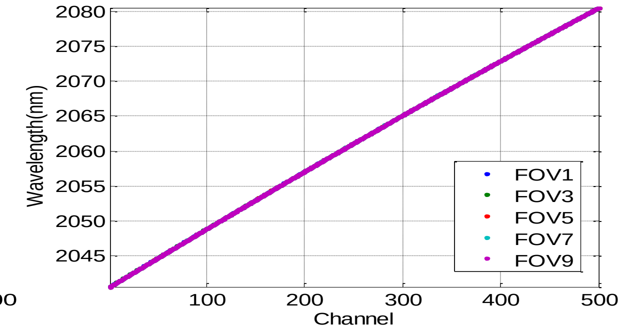
ILS calibration results

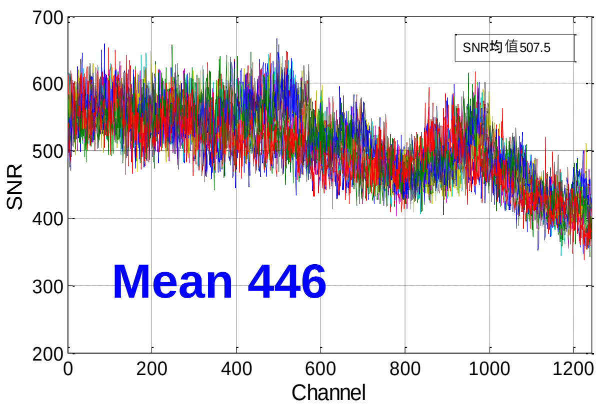


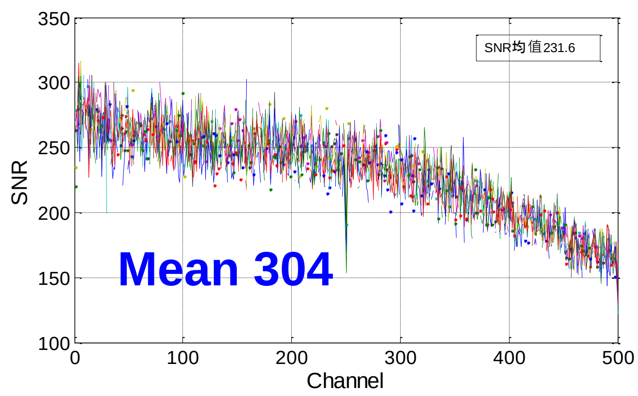
Wavelength grid and SNR

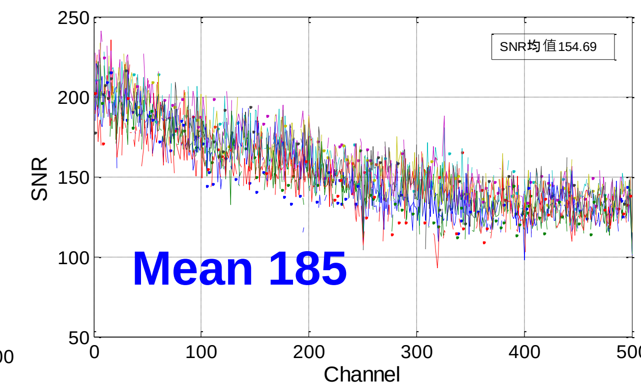










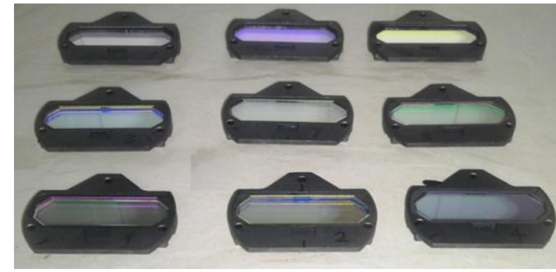


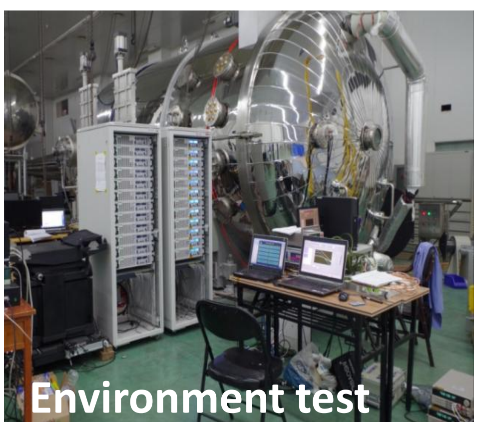
O_2 A band

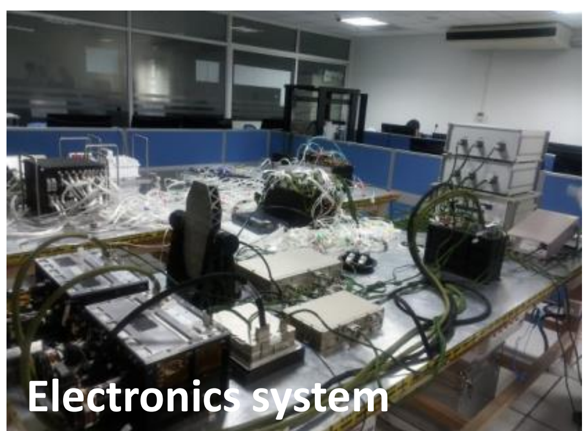
CO_2 weak band

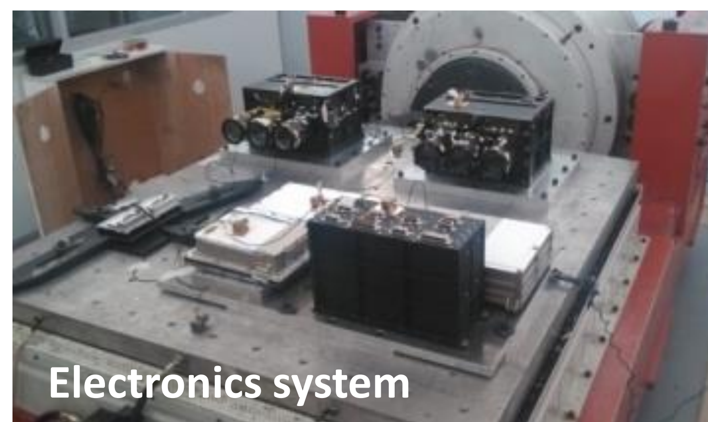
CO_2 strong band

CAPI preflight test

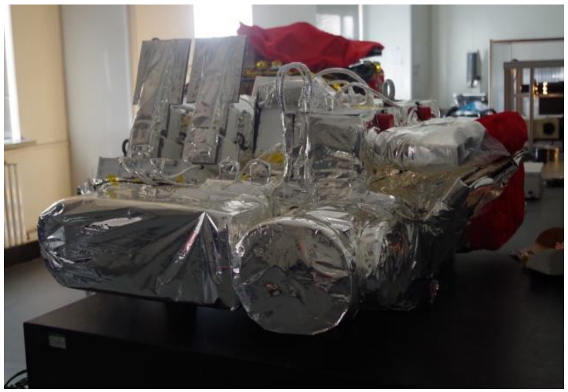


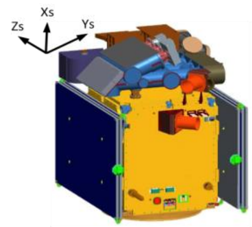


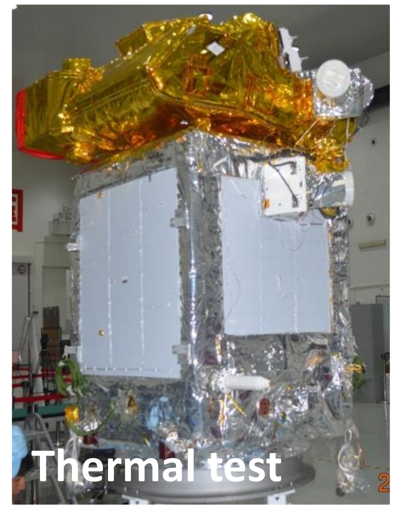


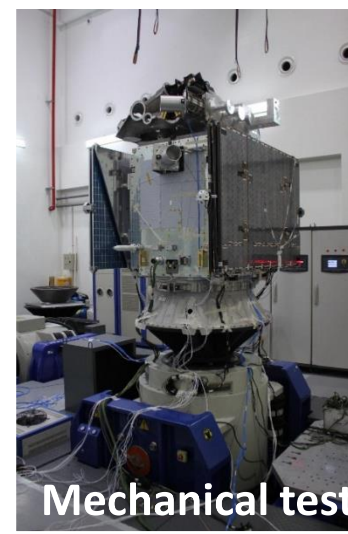


Preflight instrument integration



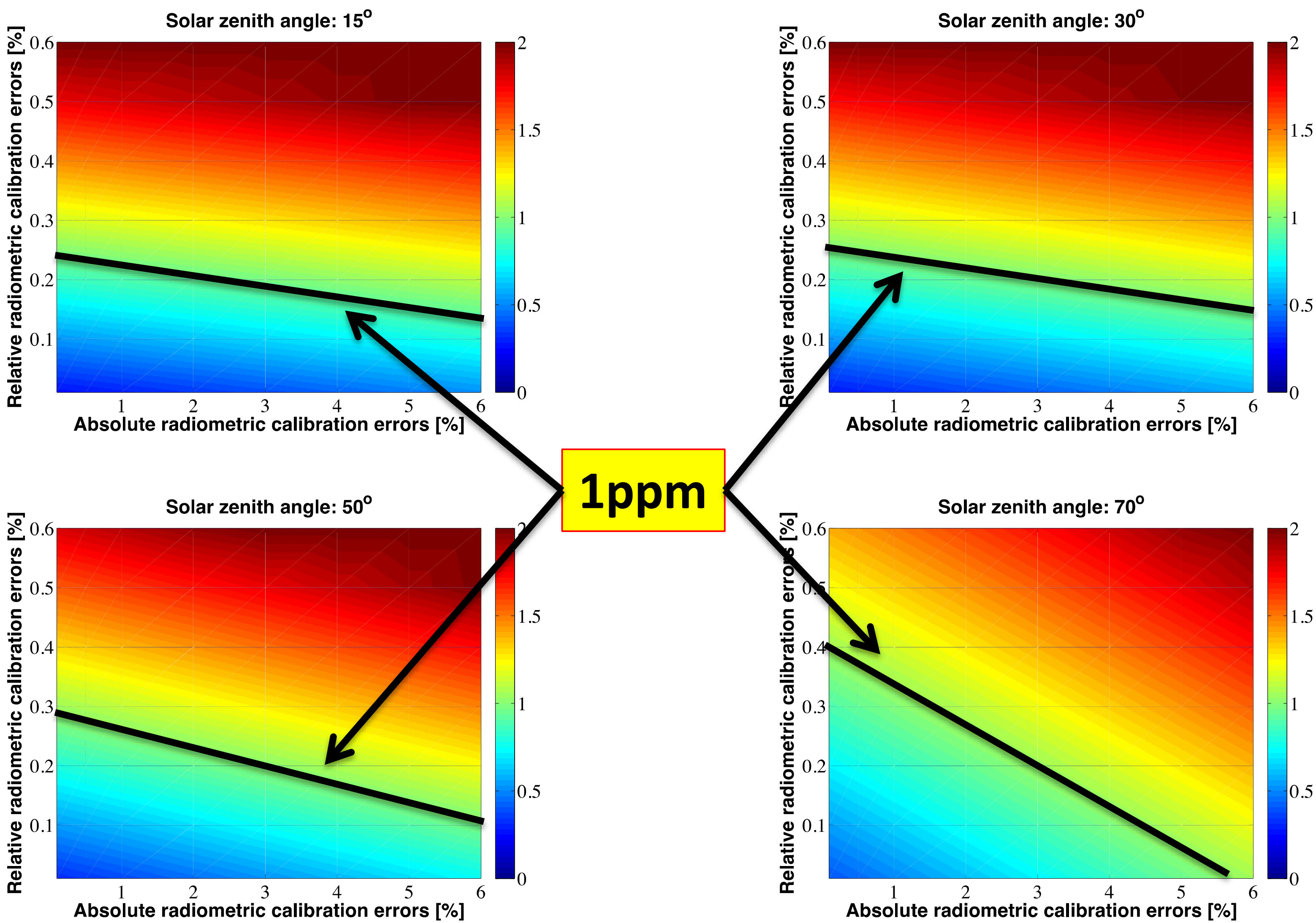




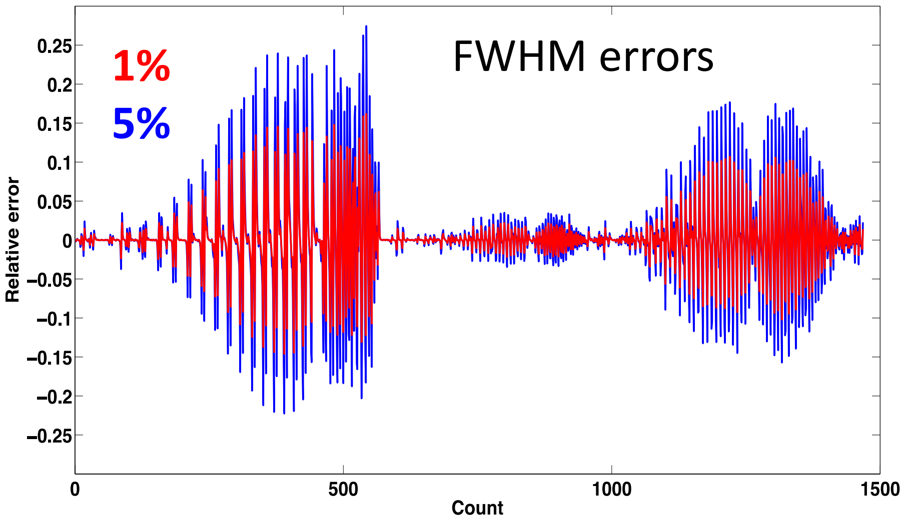


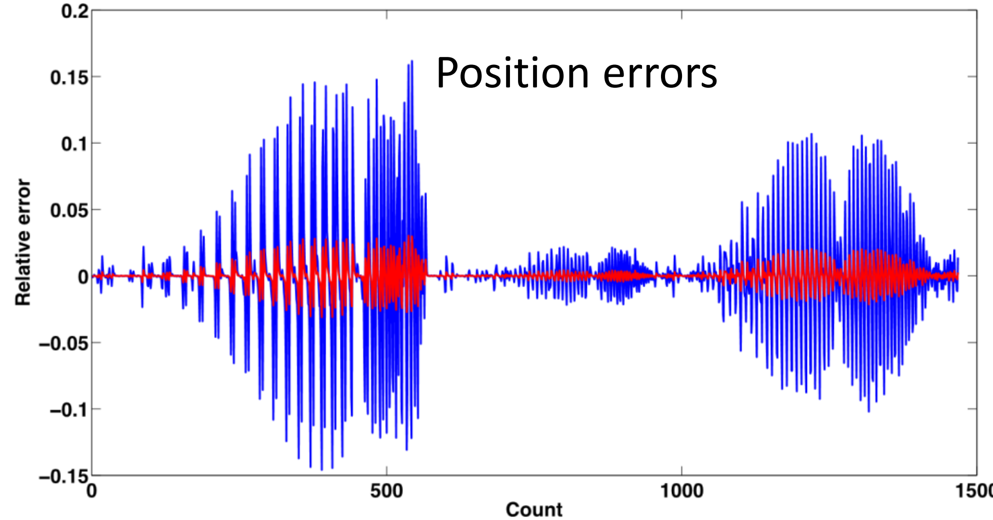
Theoretical investigation on Pre-flight calibration

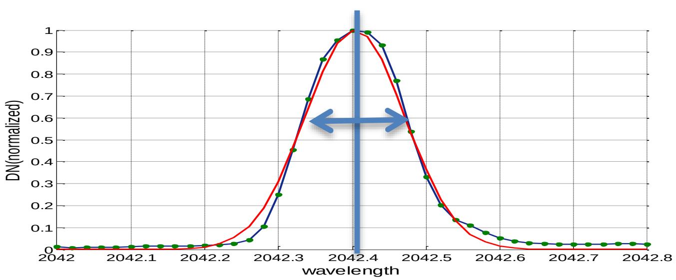
XCO_2 errors .VS. Calibration accuracy



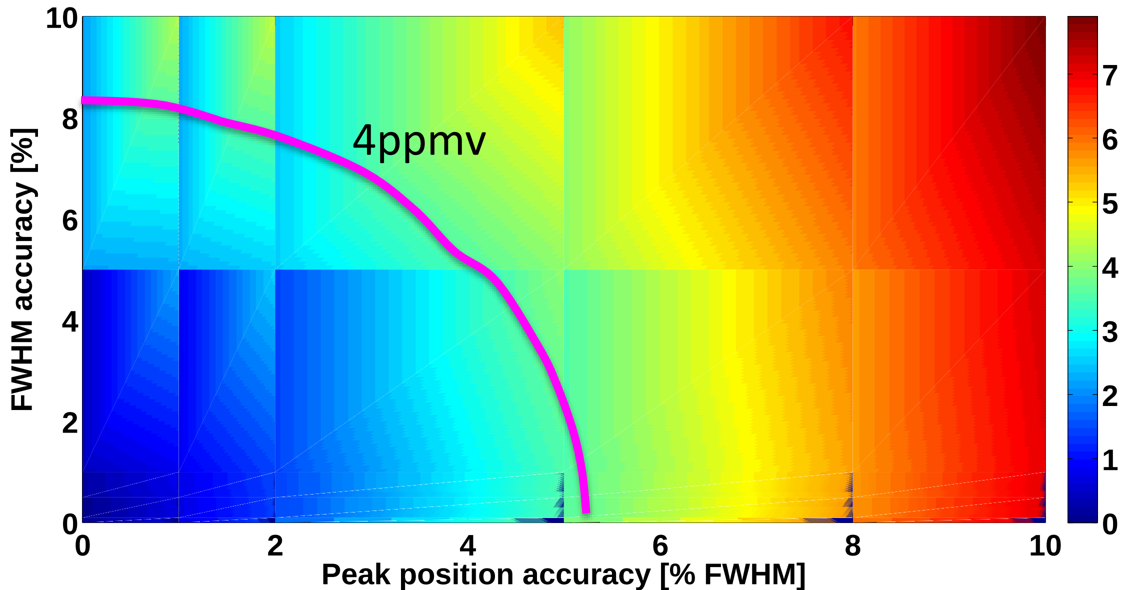
Spectrum calibration

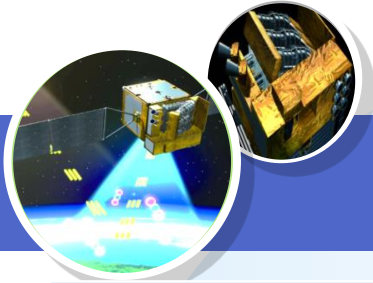






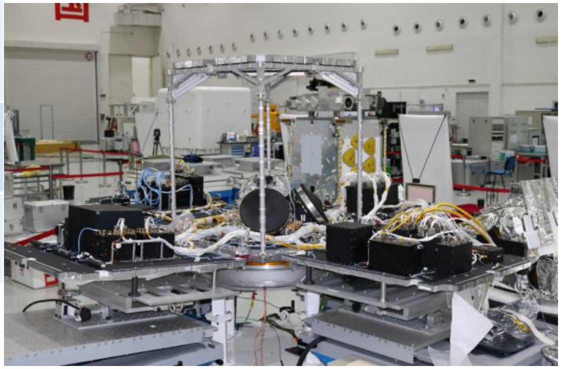
$$\mathrm{ILS} = \frac{1}{\sqrt{2\sigma^2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

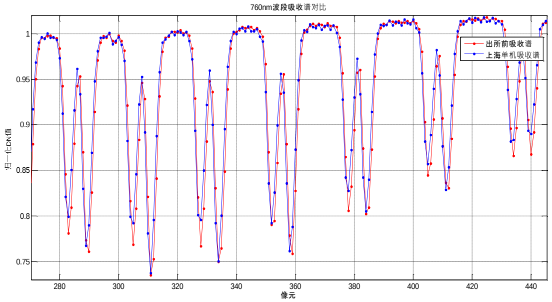




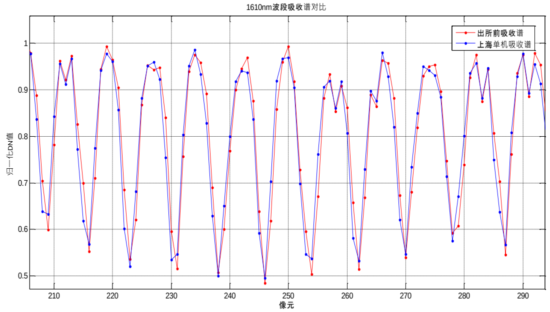
Schedule after receive CDS\CAPI

Date	Item
Feb 29, 2016	CDS\CAPI transport to Shanghai
March 1 to March 3	Integration texting
March 28 to 29	CAPI Optical texting
April 6 to 8	CDS Optical texting
April 30	Satellite flight simulation testing
May 20	Satellite thermal testing
June ~ Aug	Repeat test after payload delivery

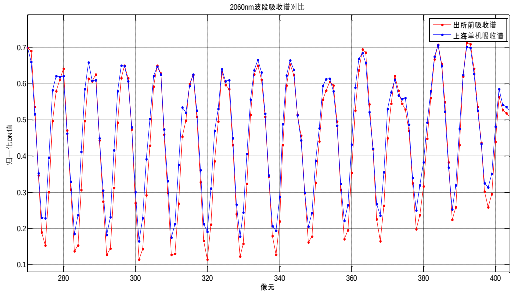




760 nm



1610 nm



2060 nm

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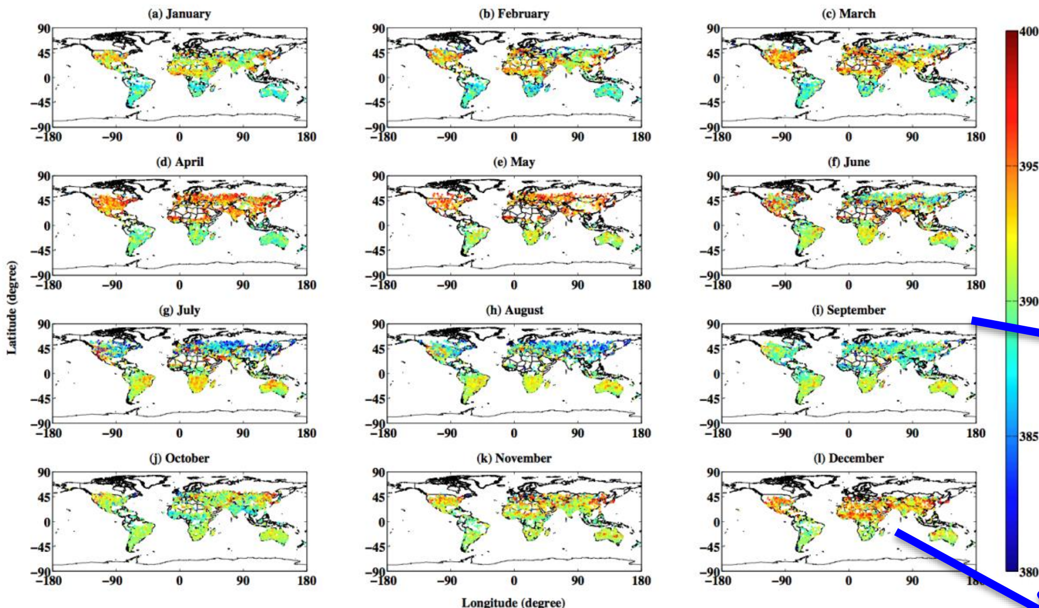
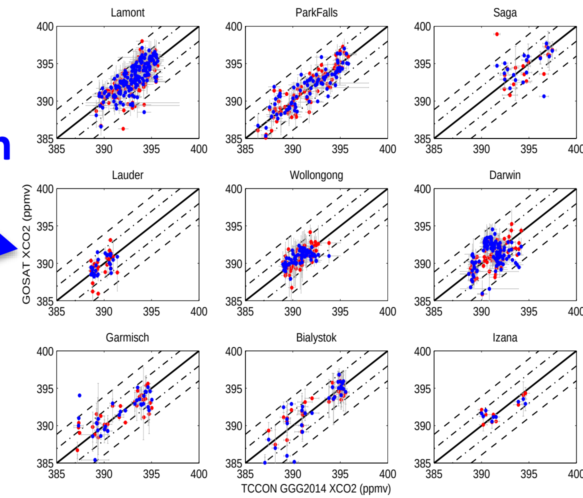
TanSat Retrieval algorithm

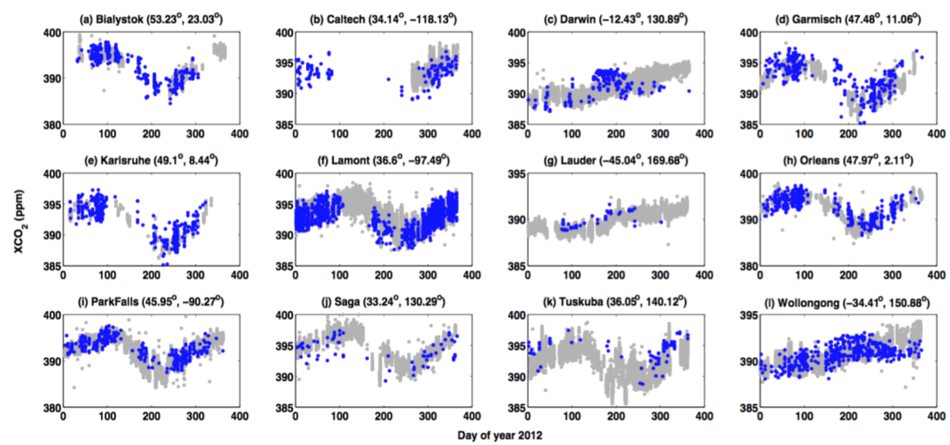


Validation

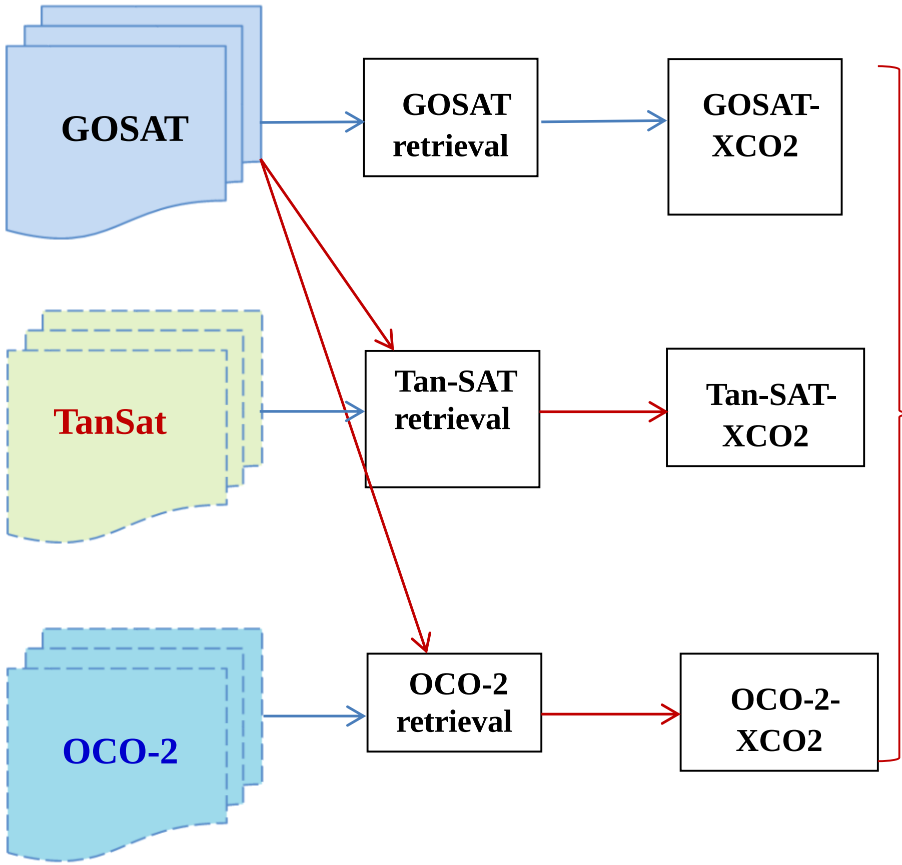


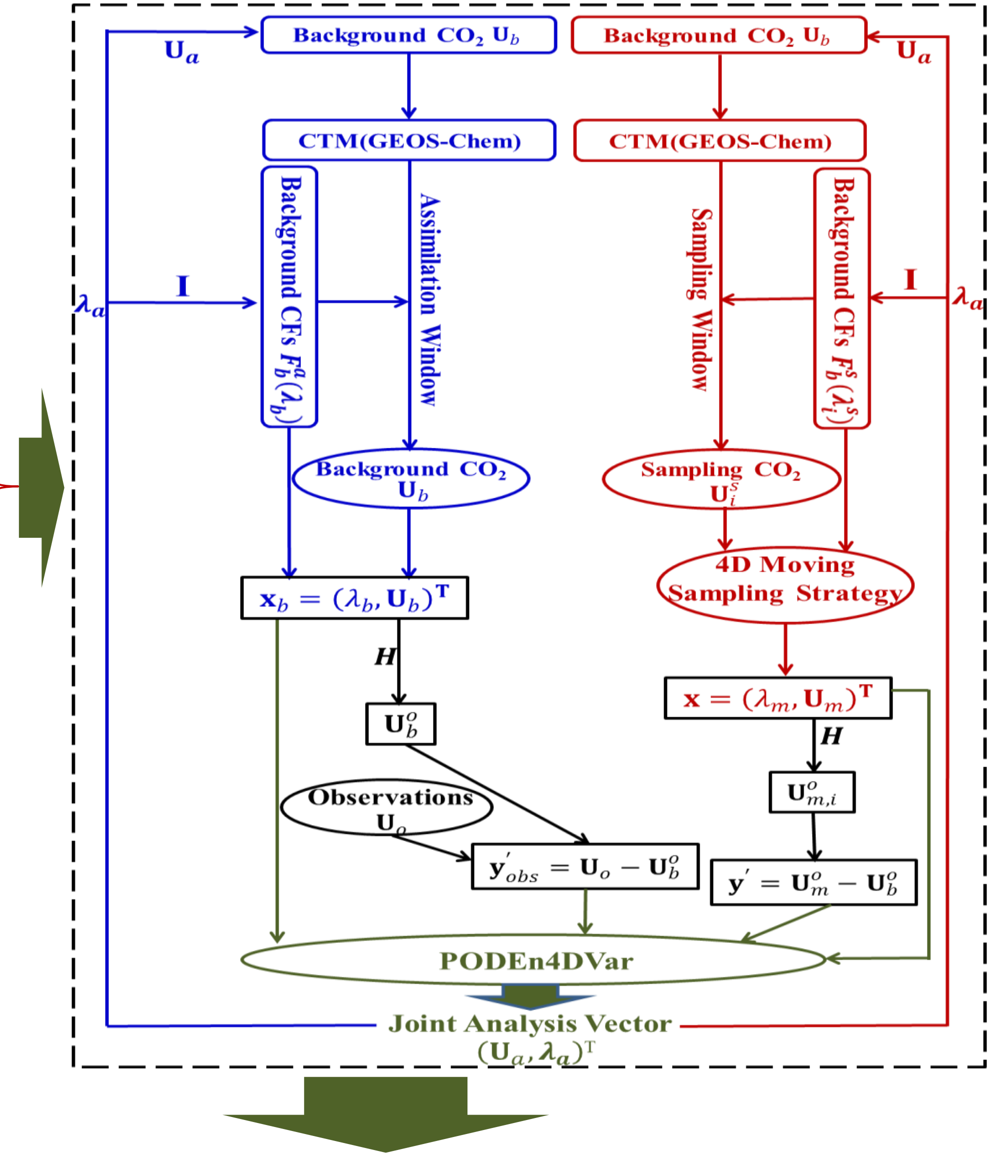
Variation

TCCON site	Latitude (°)	Longitude (°)	IAPCAS-GOSAT	
			Bias (ppmv)	RMSE (ppmv)
Lamont, USA	36.60	−97.49	−0.58	1.41
Park Falls, USA	45.95	−90.27	0.29	1.29
Saga, Japan	33.24	130.29	1.13	2.08
Lauder, New Zealand	−45.04	169.68	−0.11	0.90
Wollongong, Australia	−34.41	150.88	−0.77	0.95
Darwin, Australia	−12.43	130.89	0.62	1.99
Garmisch, Germany	47.48	11.06	2.02	1.89
Bialystok, Poland	53.23	23.03	0.01	1.50
Izana, Tenerife	28.30	−16.50	−1.22	1.31
Mean	–	–	0.15	1.48



CO_2 Flux—inversion model---→ Tan-Tracker

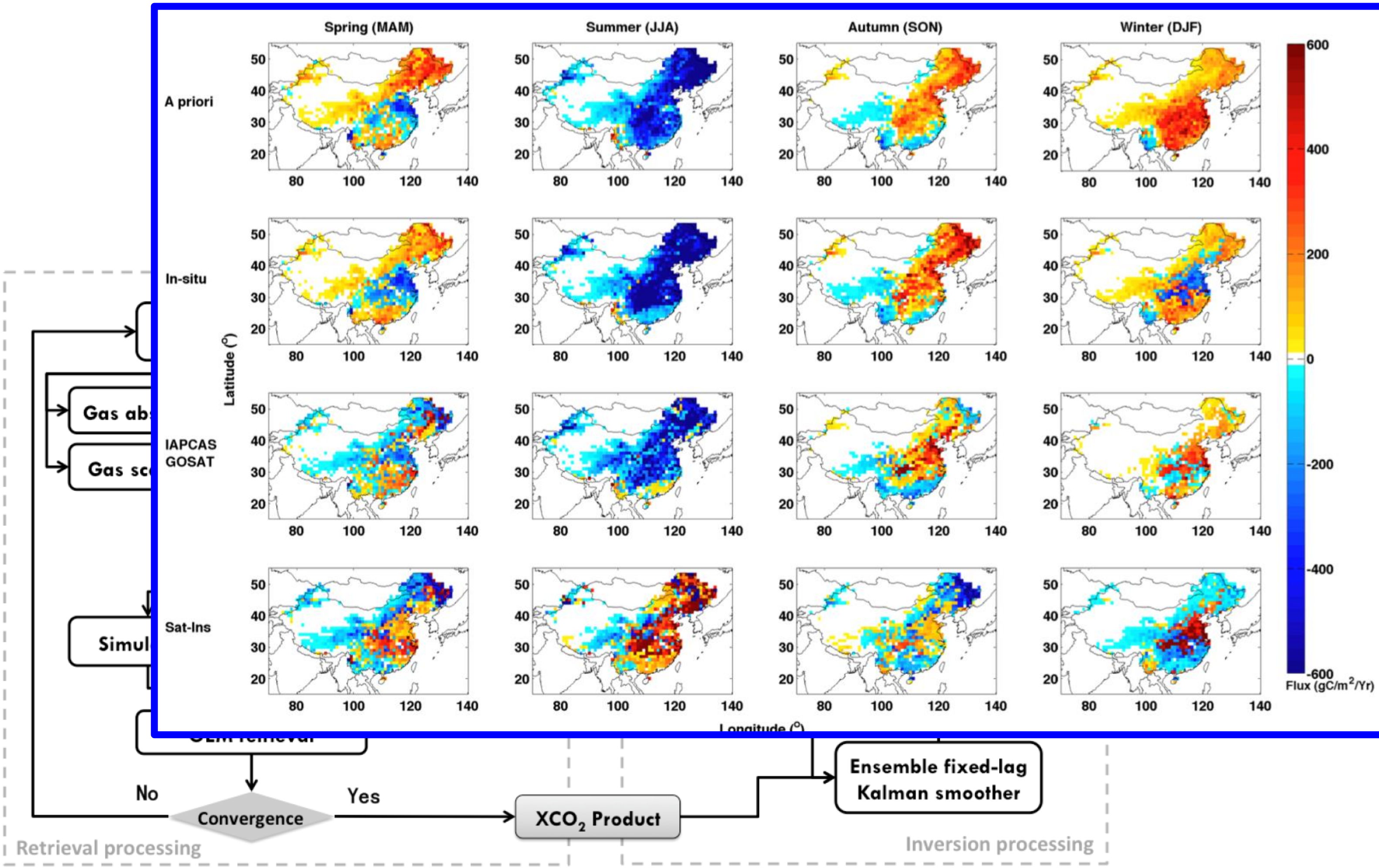




By Xiangjun Tian. ACP 2014

Simultaneously Estimate Surface CO_2 fluxes and 3-D Atmospheric CO_2 Concentrations

CO2 flux from TanSat system



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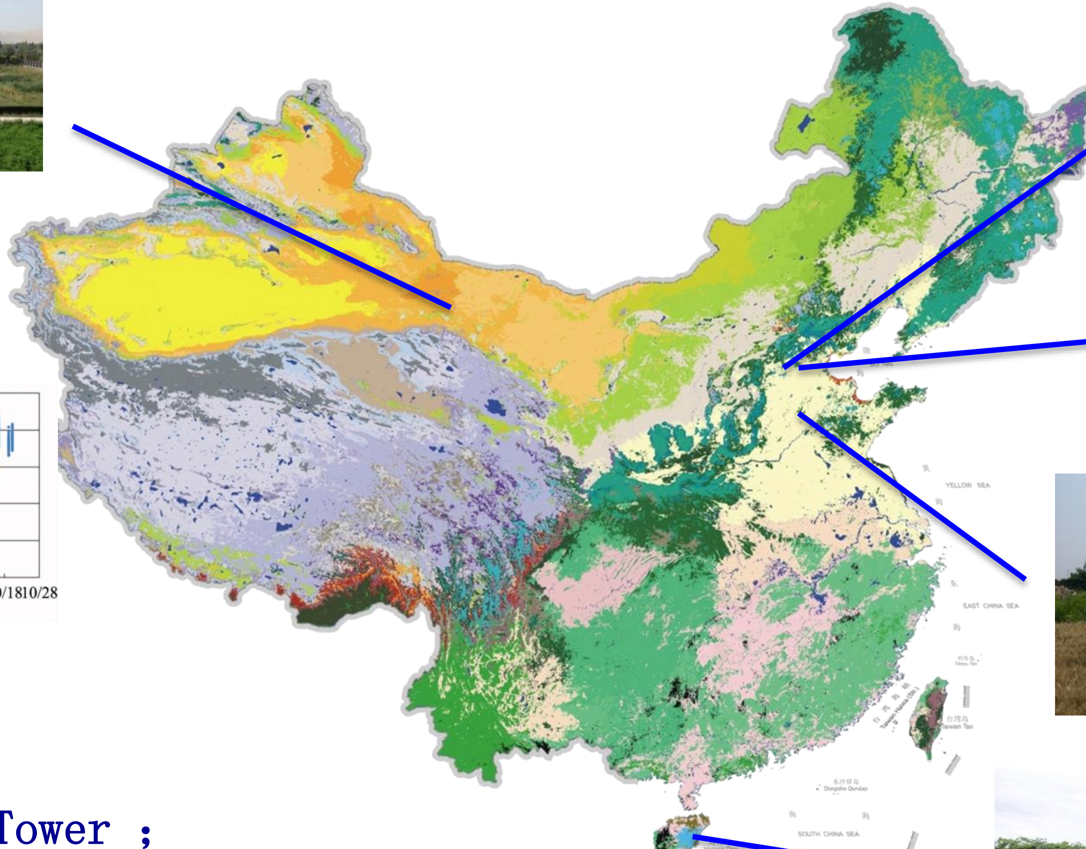
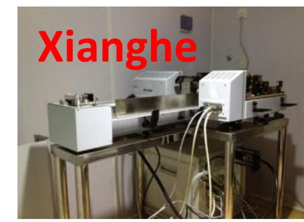
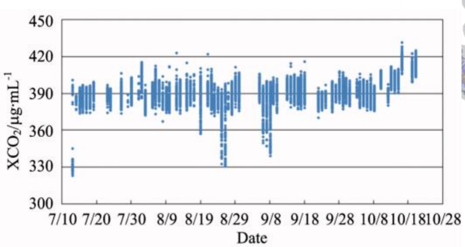
Surface CO2 validation Stations



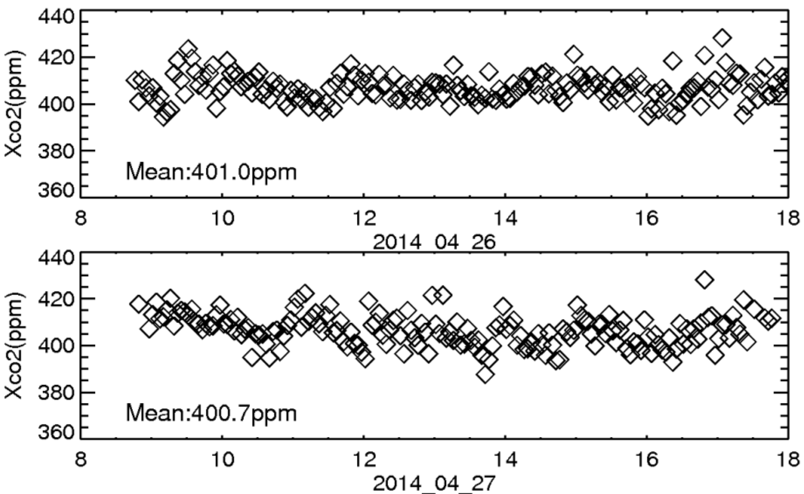


OSA观测结果

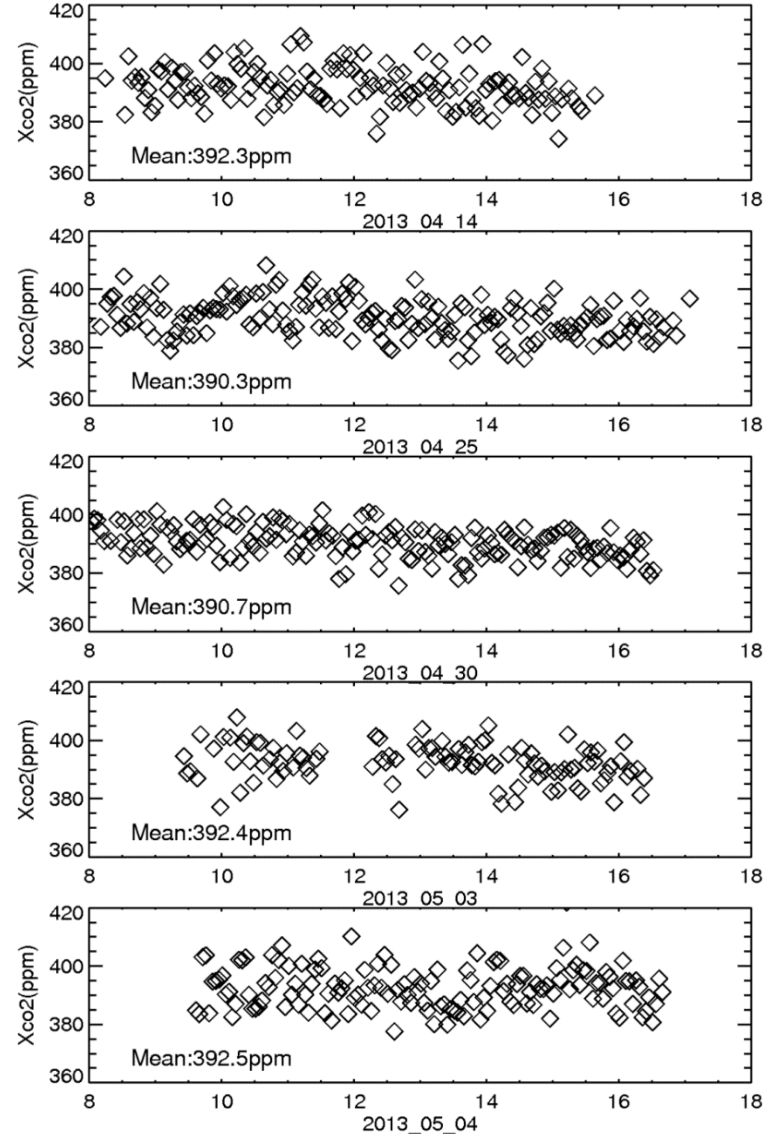


- Beijing High Tower ;
- FTS （Xianghe）;
- Mobil observation system;
- Surface stations（Dunhuang、Yucheng、Qionghai）;

XCO2 retrieved from Optical Spectrum Analyzer (OSA)

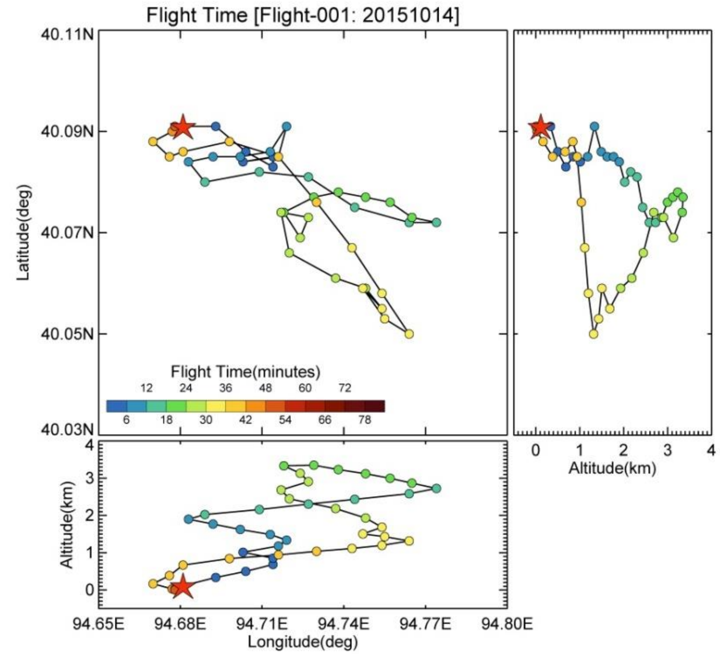


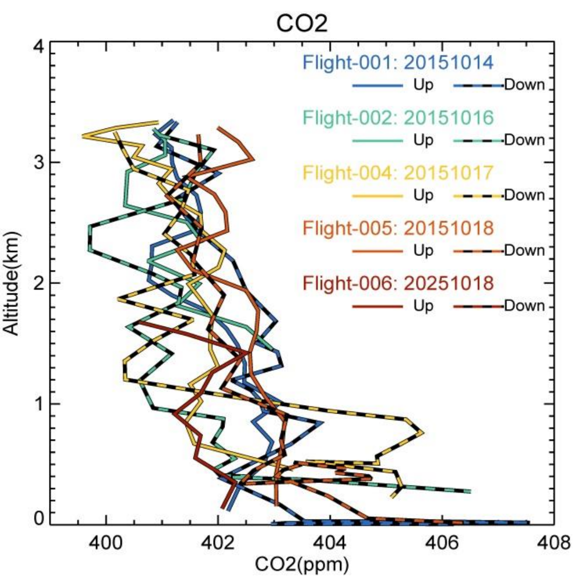
XCO2 from OSA measurement in Dunhuang

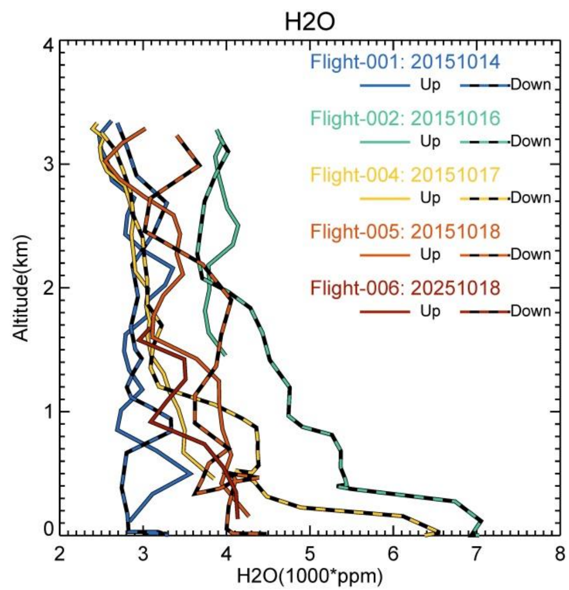


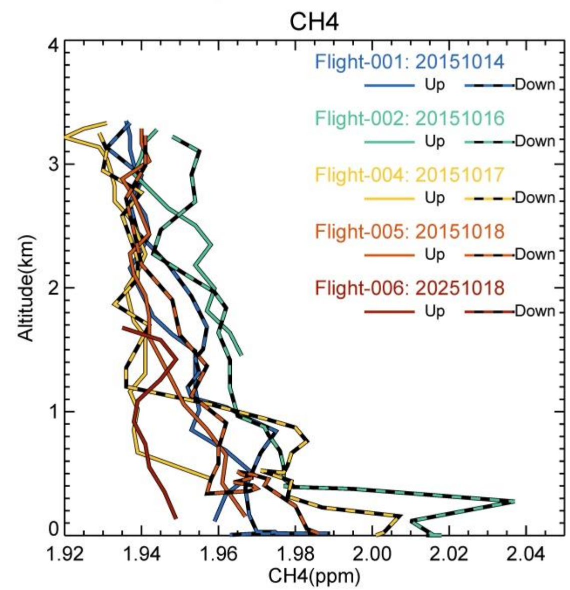
XCO2 from OSA measurement in Shandong

Aircraft measurement of CO_2 profile in Dunhuang





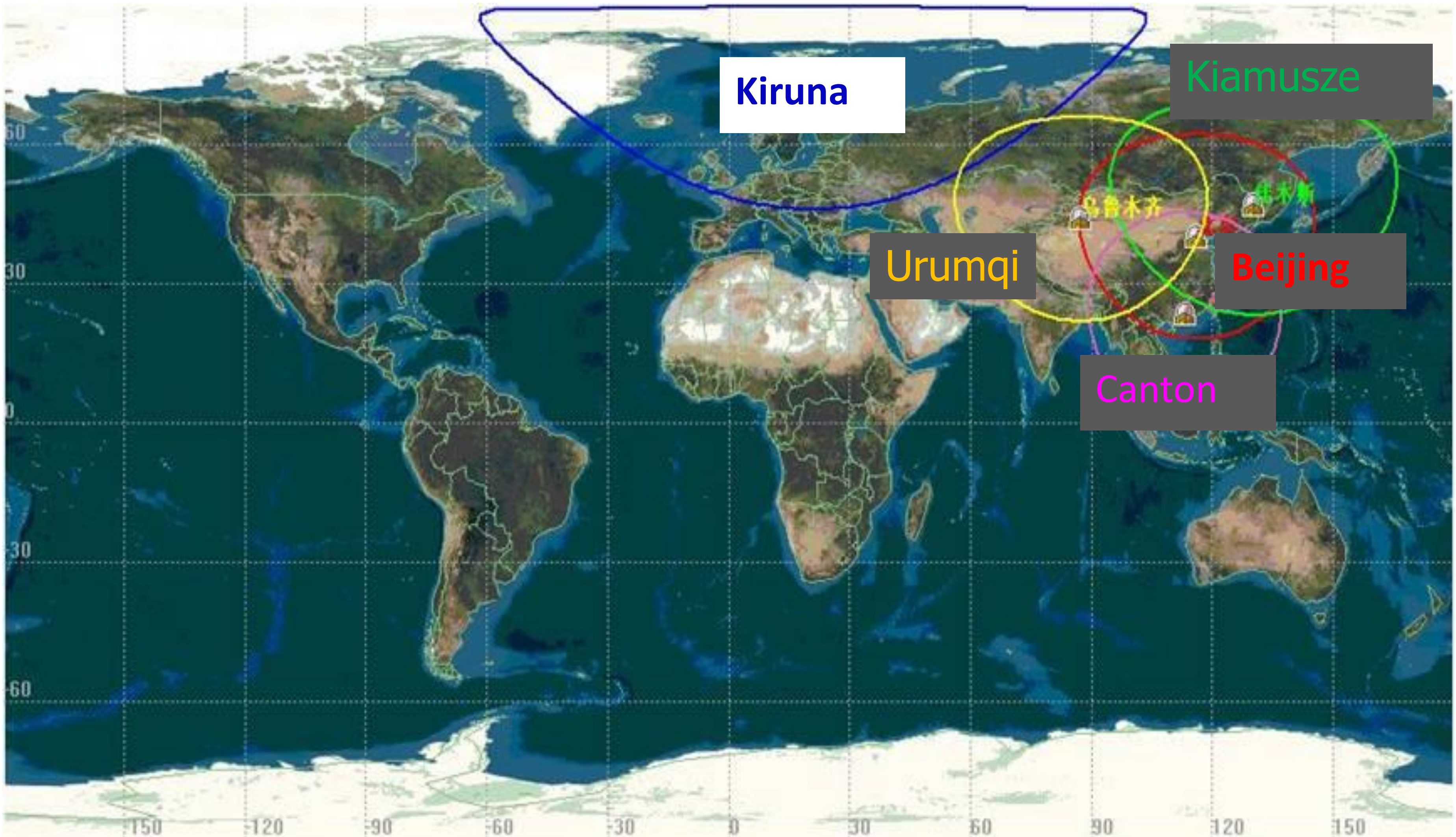




Ground satellite receiving stations —FY Meteorological Satellite system

Five receiving stations:

1. Beijing in China 2. Canton in China 3. Urumqi in China 4. Kiamusze in China
5. Kiruna in Sweden



Outline

TanSat

1. Science requirement for TanSat
2. TanSat Mission
3. Satellite platform & Payload--Current Status
4. Retrieval algorithm
5. Ground based validation
6. Schedule and Plan

The schedule of TanSat

2011.02 kick off of project

2011.09 SRR-Science Requirement Review

2013.03 PDR-Preliminary Design Review

2013.06: Kick off phase C

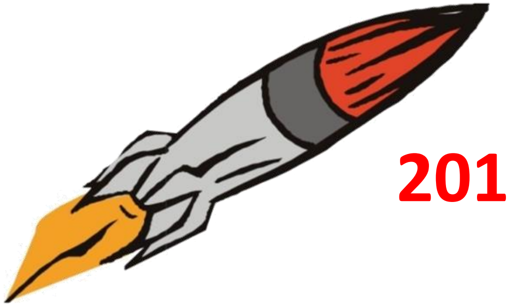
2014.06: Electromechanical Integration

2014.12 CDR- Critical Design Review—major milestone

2015.10 CO_2 Spectrometers Finish

Assemble, debug, integrate, a series of test: calibration\environment

2015.12 SRR- Satellite Readiness Review



2016.06 Launching

NASA-CAS meeting on Data sharing of CO2 Observations

Dr. Michael Freilich, Director of the Earth Science Division, NASA Visited IAP to participate CAS-NASA data sharing Meeting on Sept 29, 2015.

Dr. Michael Freilich visited IAP again on July 12, 2016 to discussion the future plan.