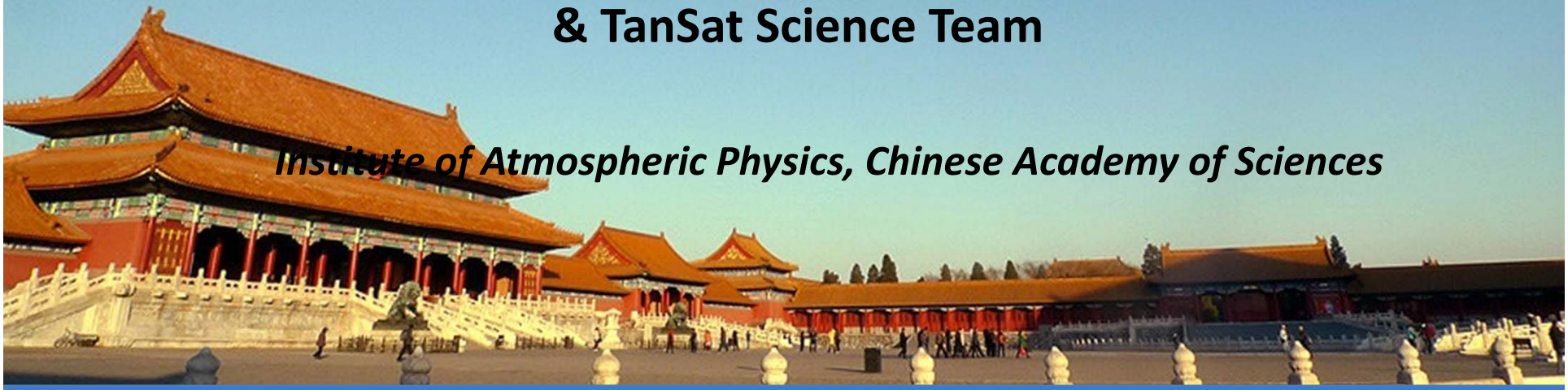
Atmospheric Composition Constellation Meeting-11

The TansSat Mission status

Yi Liu

& TanSat Science Team

Institute of Atmospheric Physics, Chinese Academy of Sciences



Tuesday 28 – Thursday 30 April 2015

ESRIN, Frascati - Italy

Outline

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

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

--- Organization of TanSat Mission

--- Provide Launch free

Tagert

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

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

TanSat

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

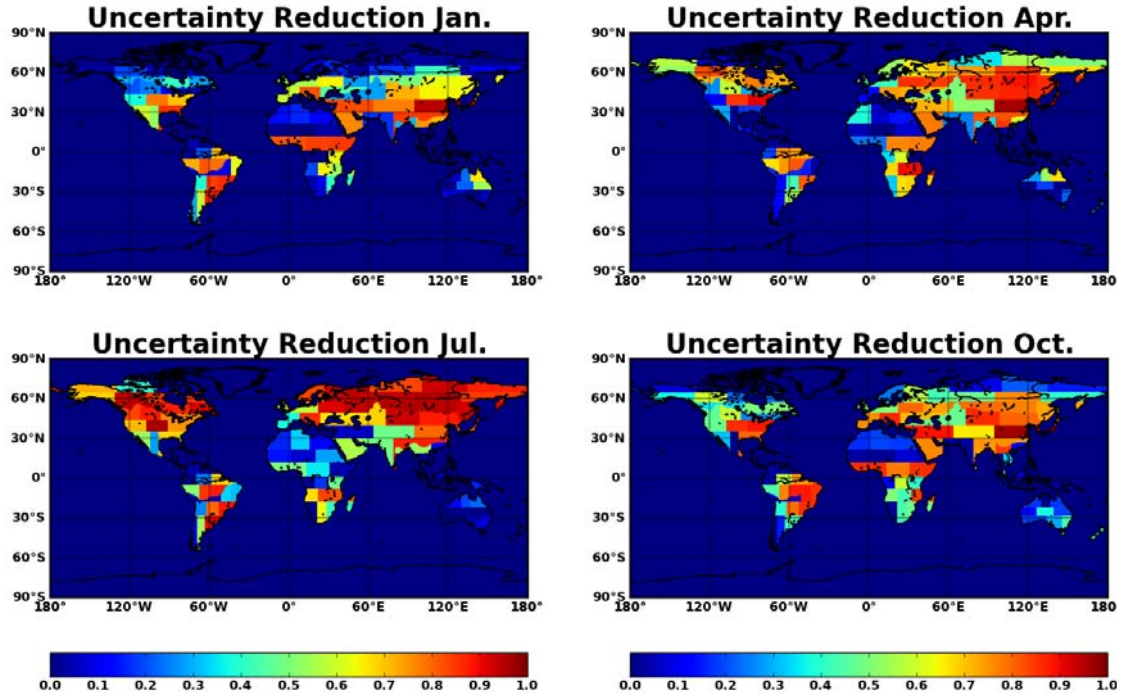
Sun-glint mode- Observation over ocean
- Sun glint track
- Principle plane track

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

Carbon flux uncertain reducing - observation TanSat

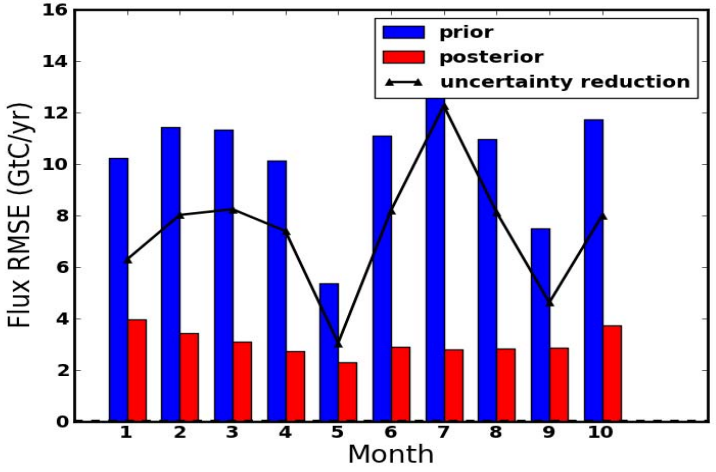
CO2 flux uncertainty reductions using simulated TanSat observations
(10 months： Jan.2009 – Dec.2009)

Regional flux uncertainty reduction ratio for different seasons



Transport model: GEOS-Chem
Prior flux: 1.8*true flux
Prior flux uncertainty: 0.5*true flux
Observation error: TanSat Characters
(XCO2 within **1ppm error**)

Prior, posterior and reductions of flux uncertainty

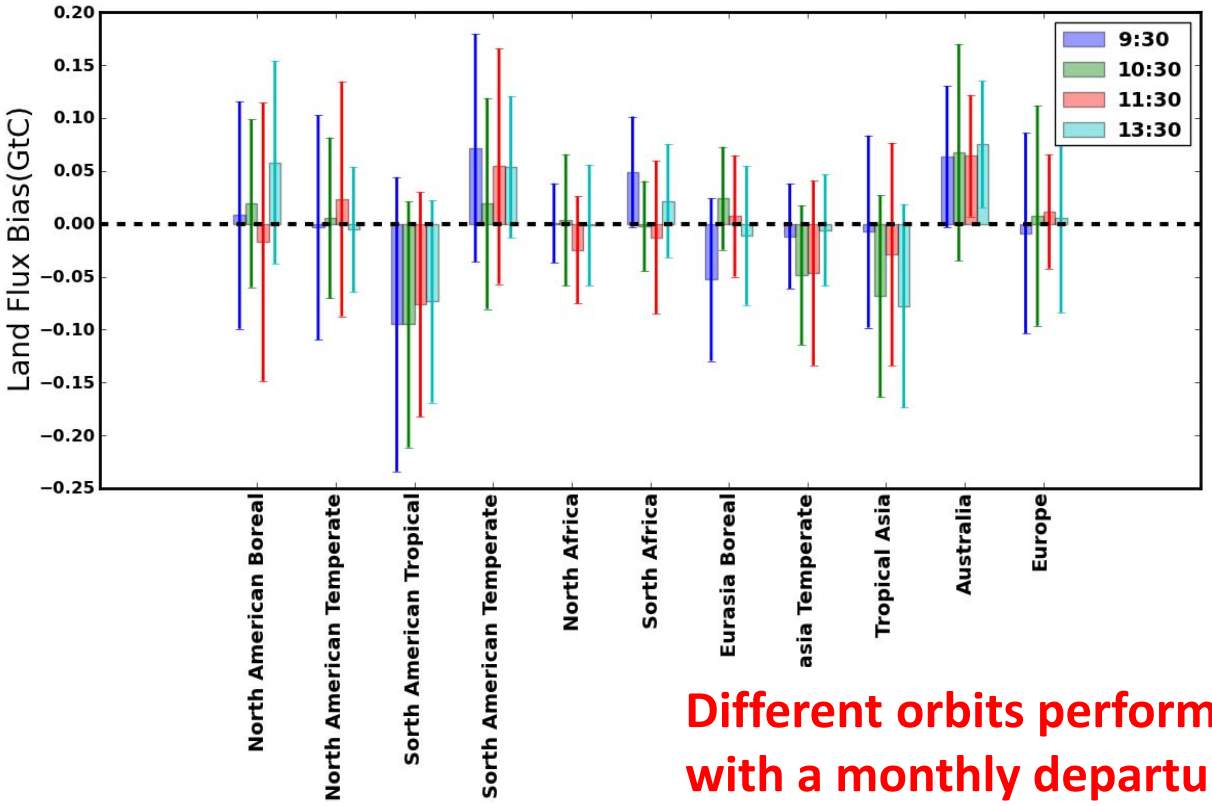


Monthly terrestrial flux uncertainty reduce 50%-80%

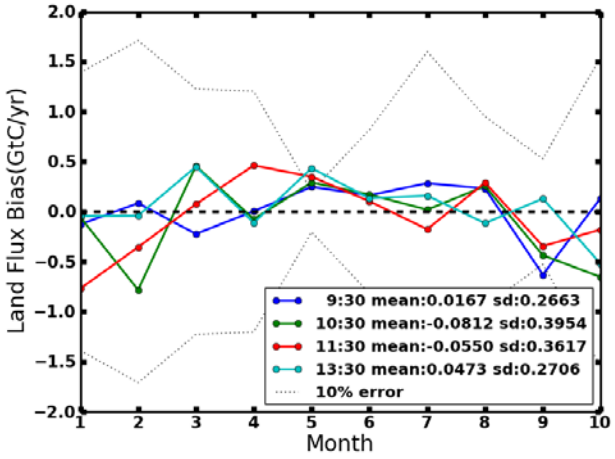
TanSat orbit character analysis

Regional CO2 flux errors for orbits with different equator crossing time (Jan.2009 – Dec.2009)

Bias of regional fluxes from ‘true’ fluxes



Monthly flux error for different orbits



Different orbits performed no significant discrepancy with a monthly departure within 0.1GtC/yr

TanSat Instrument

Carbon Dioxide Sensor

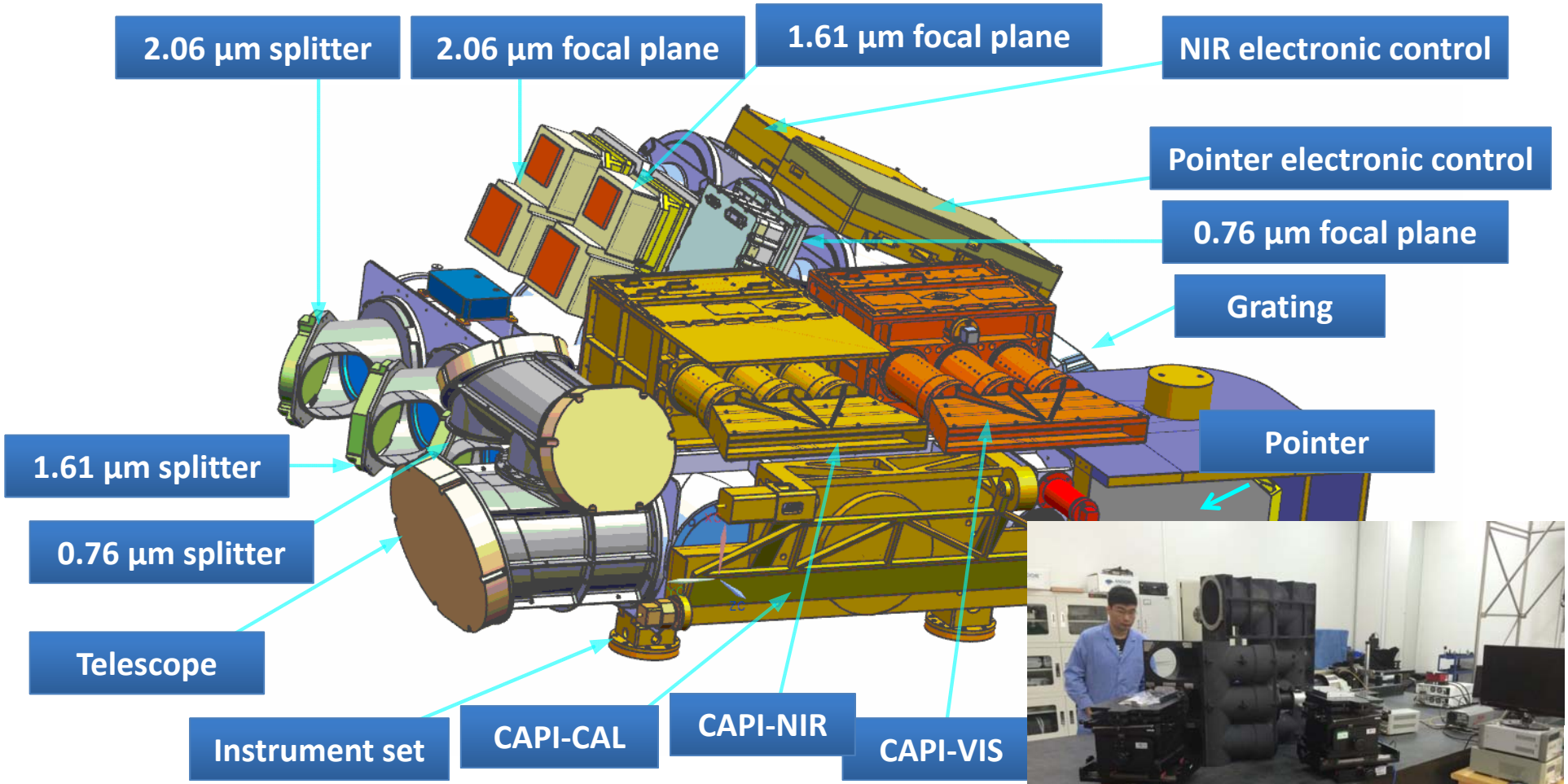
- 0.76 μm, O2 A-band
- 1.61 and 2.06 μm, CO2 bands

	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**

TanSat instrument



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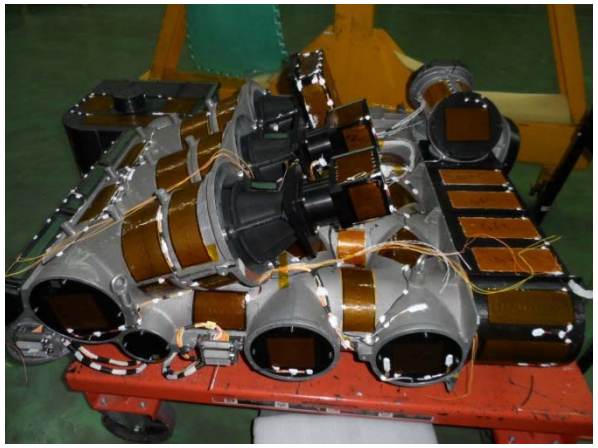
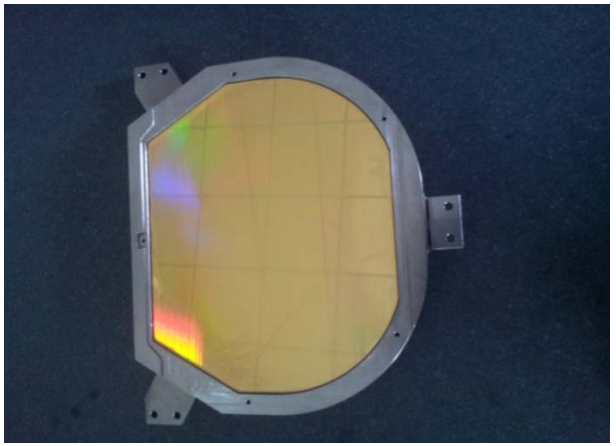
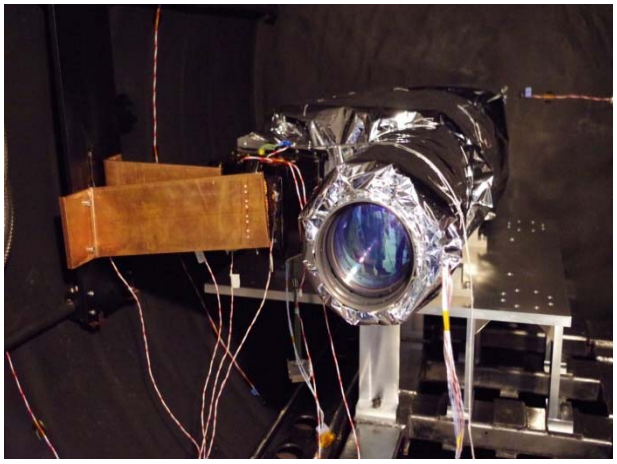
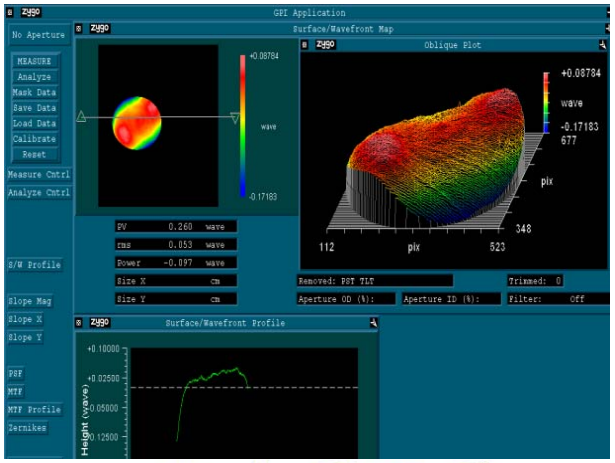
The progress of TanSat instrument

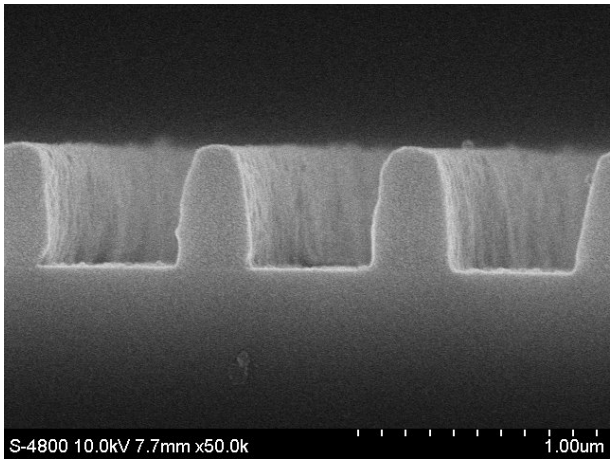
Spectrometers prototype, 1.61 and 2.06 μm diffraction grating

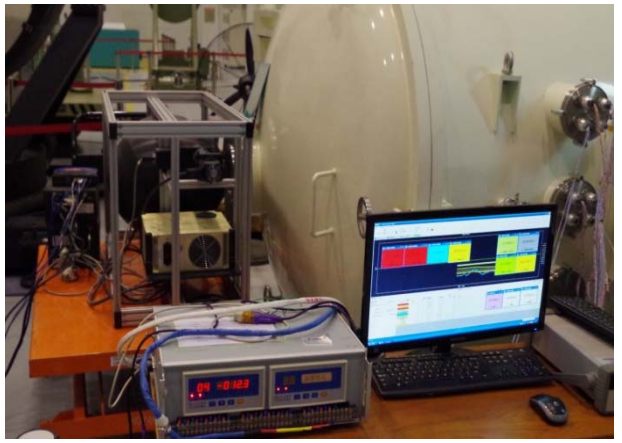






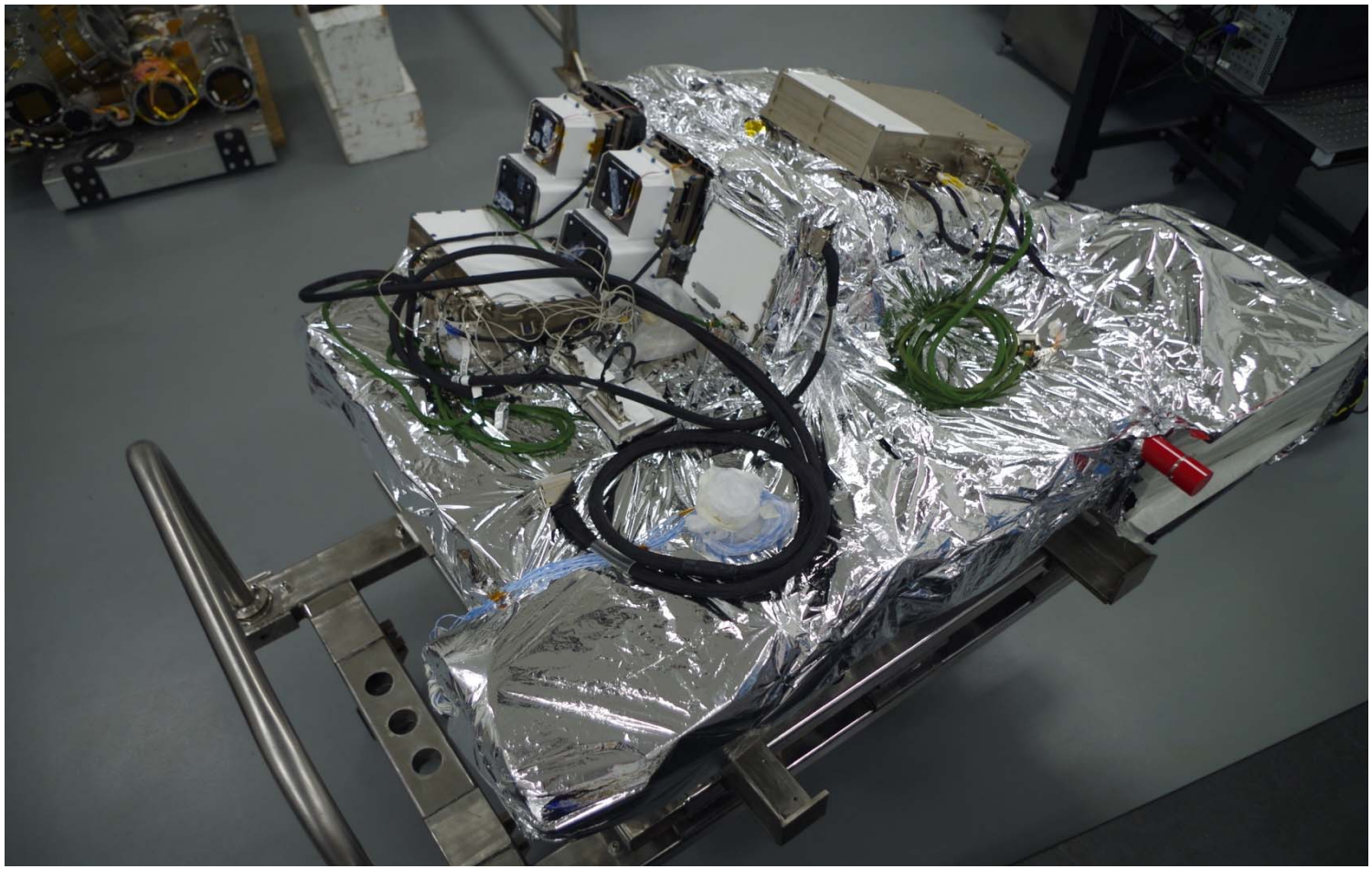






The progress of TanSat instrument

CO_2 Spectrometers prototype-assemble & test



Laboratory testing of ILS and SNR (760nm)

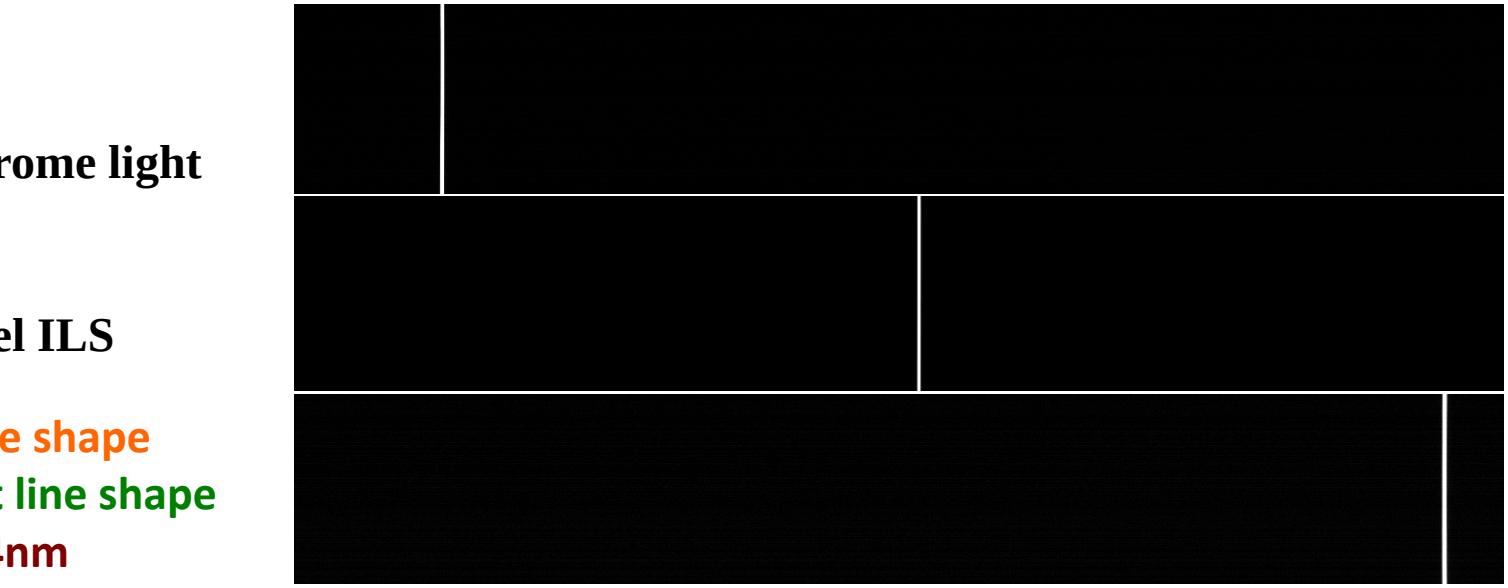
Input monochrome light

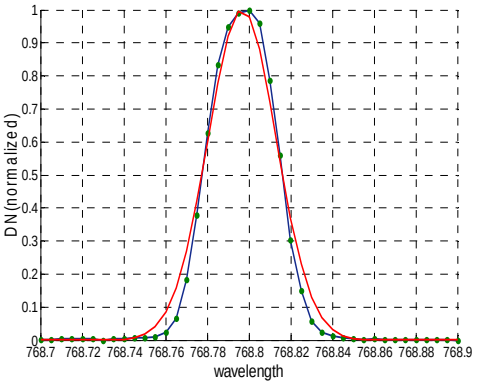
760nm Channel ILS

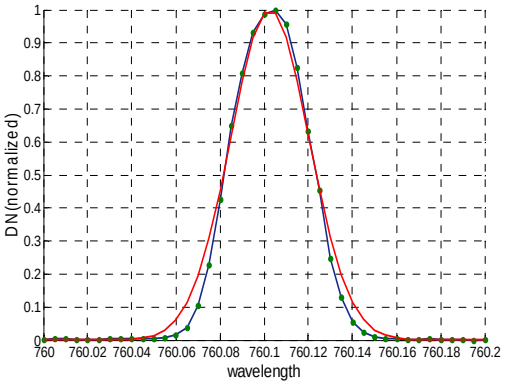
Simulation line shape

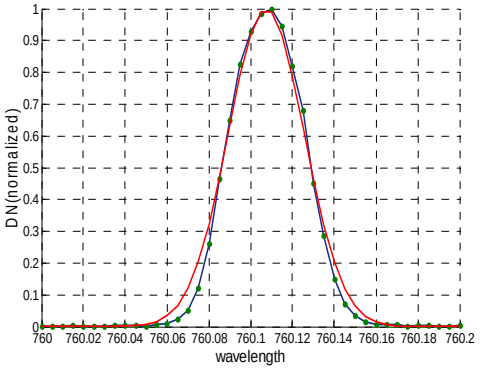
Measurement line shape

FWHM – 0.04nm



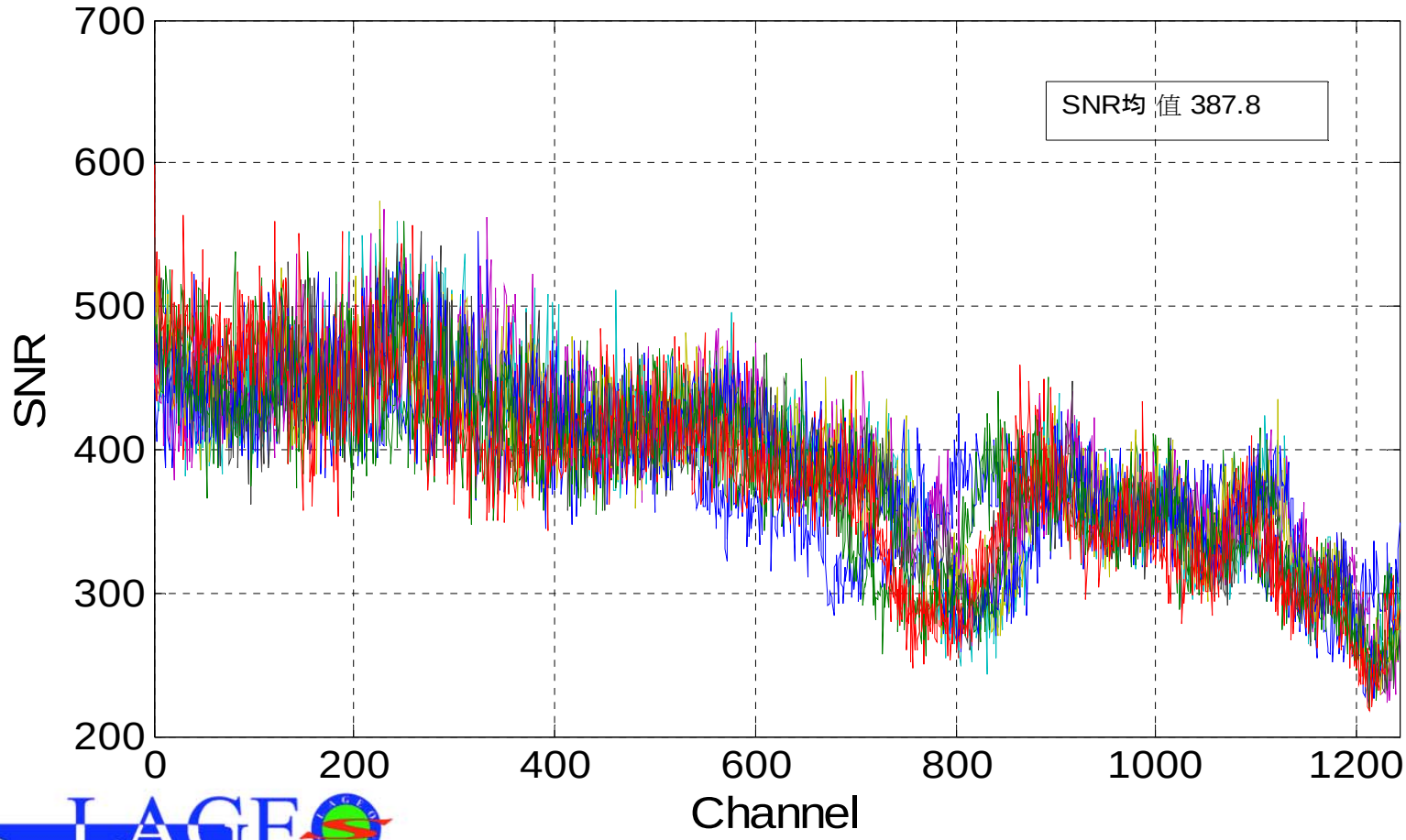






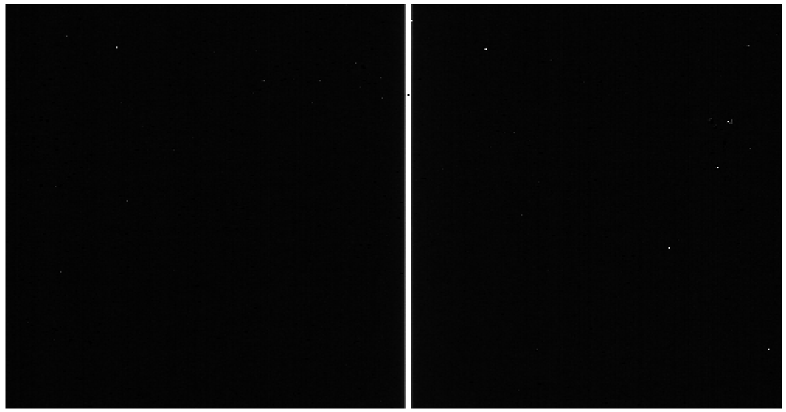
Laboratory testing of ILS and SNR (760nm)

760nm channel SNR Results (Average 387)



Laboratory testing of ILS and SNR (1610nm)

Input monochrome light

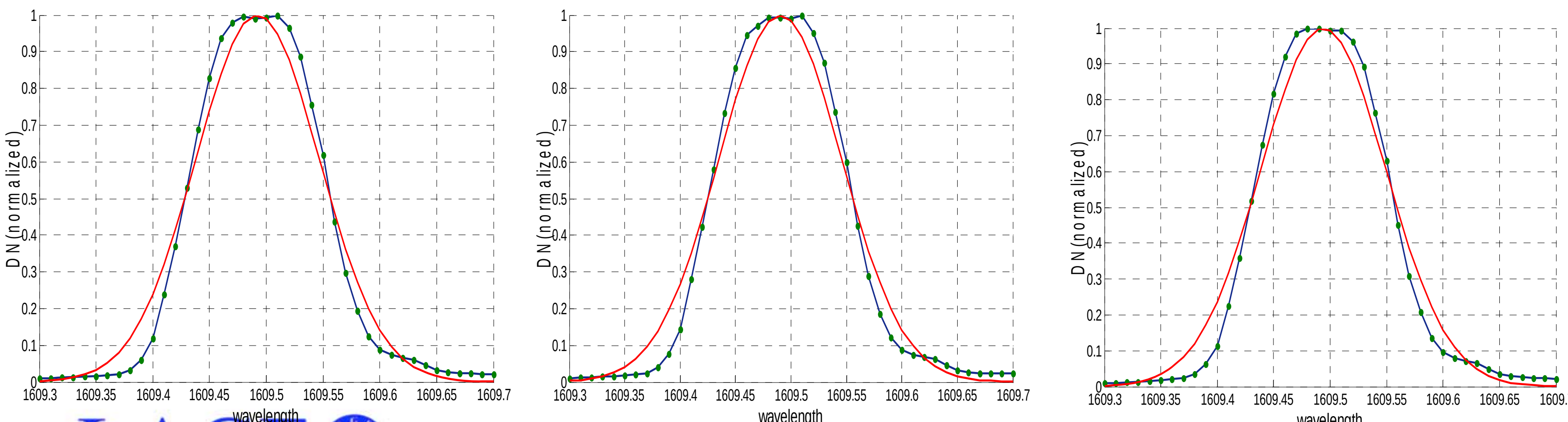


1610nm Channel ILS

Simulation line shape

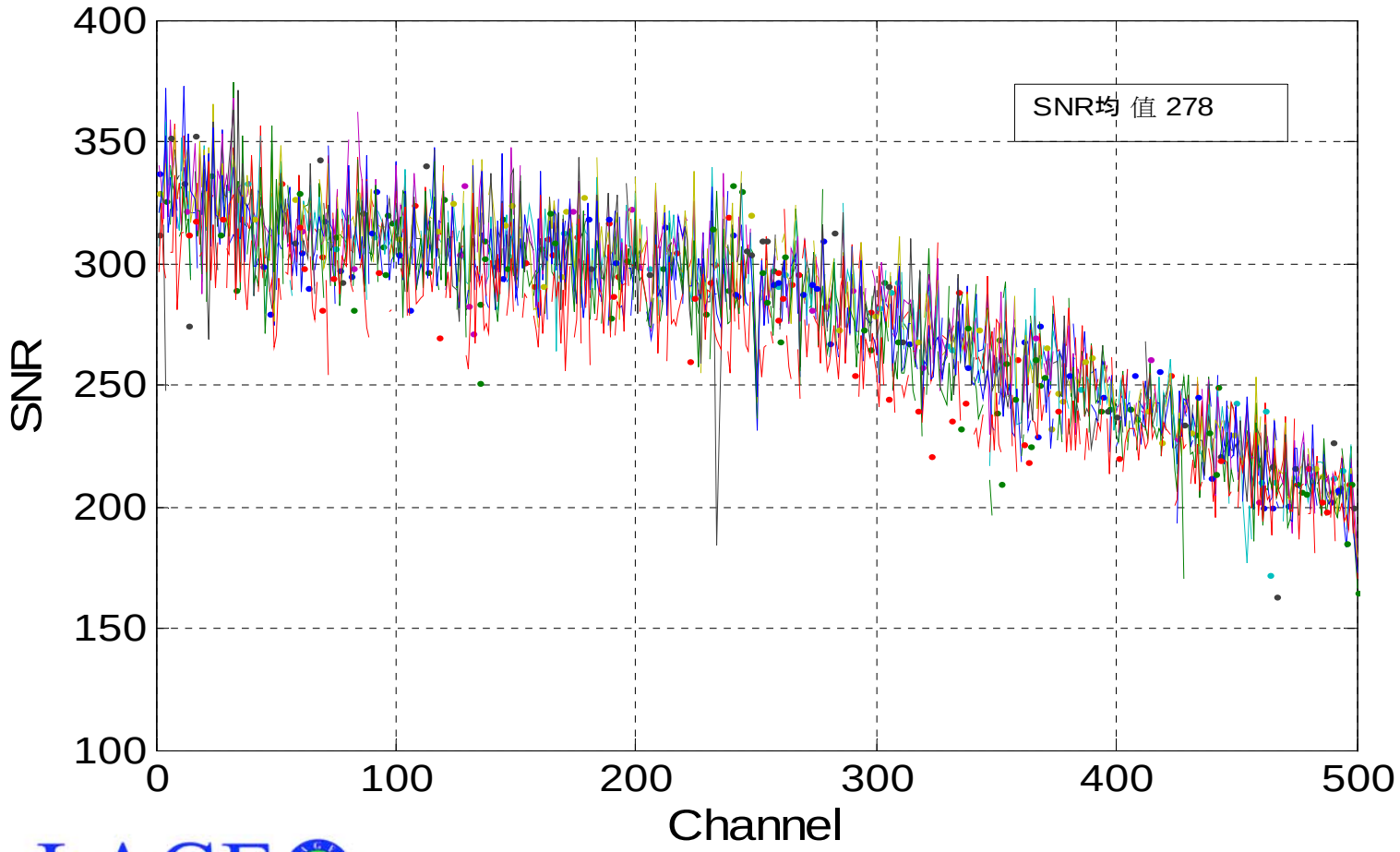
Measurement line shape

FWHM – 0.13nm



Laboratory testing of ILS and SNR (1610nm)

1610nm channel SNR Results (Average 278)



Laboratory testing of ILS and SNR (2060nm)

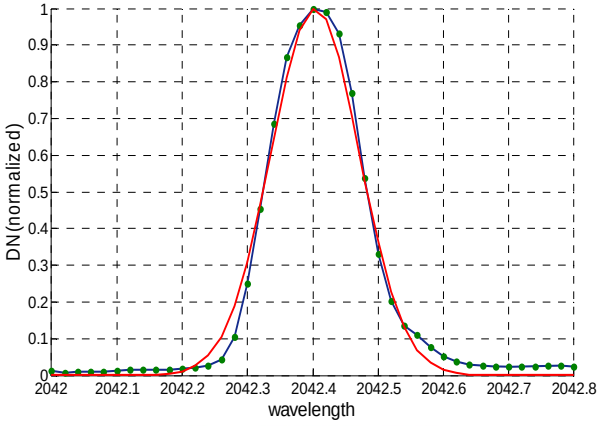
Input monochrome light

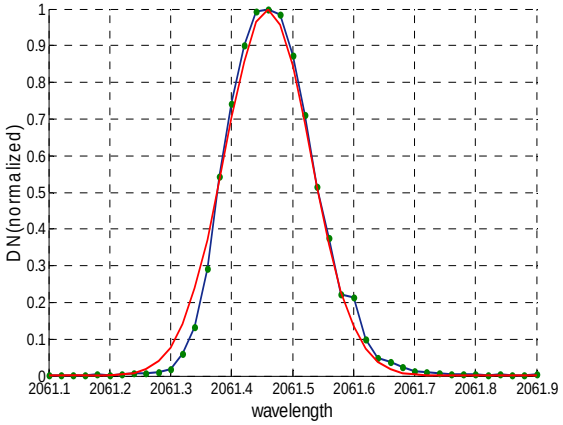
2060nm Channel ILS

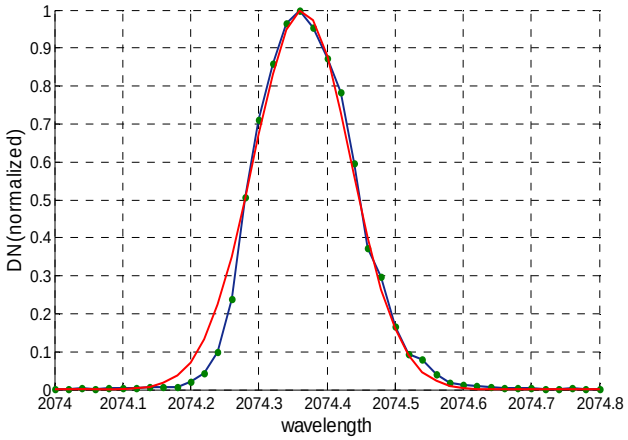
Simulation line shape

Measurement line shape

FWHM – 0.16nm



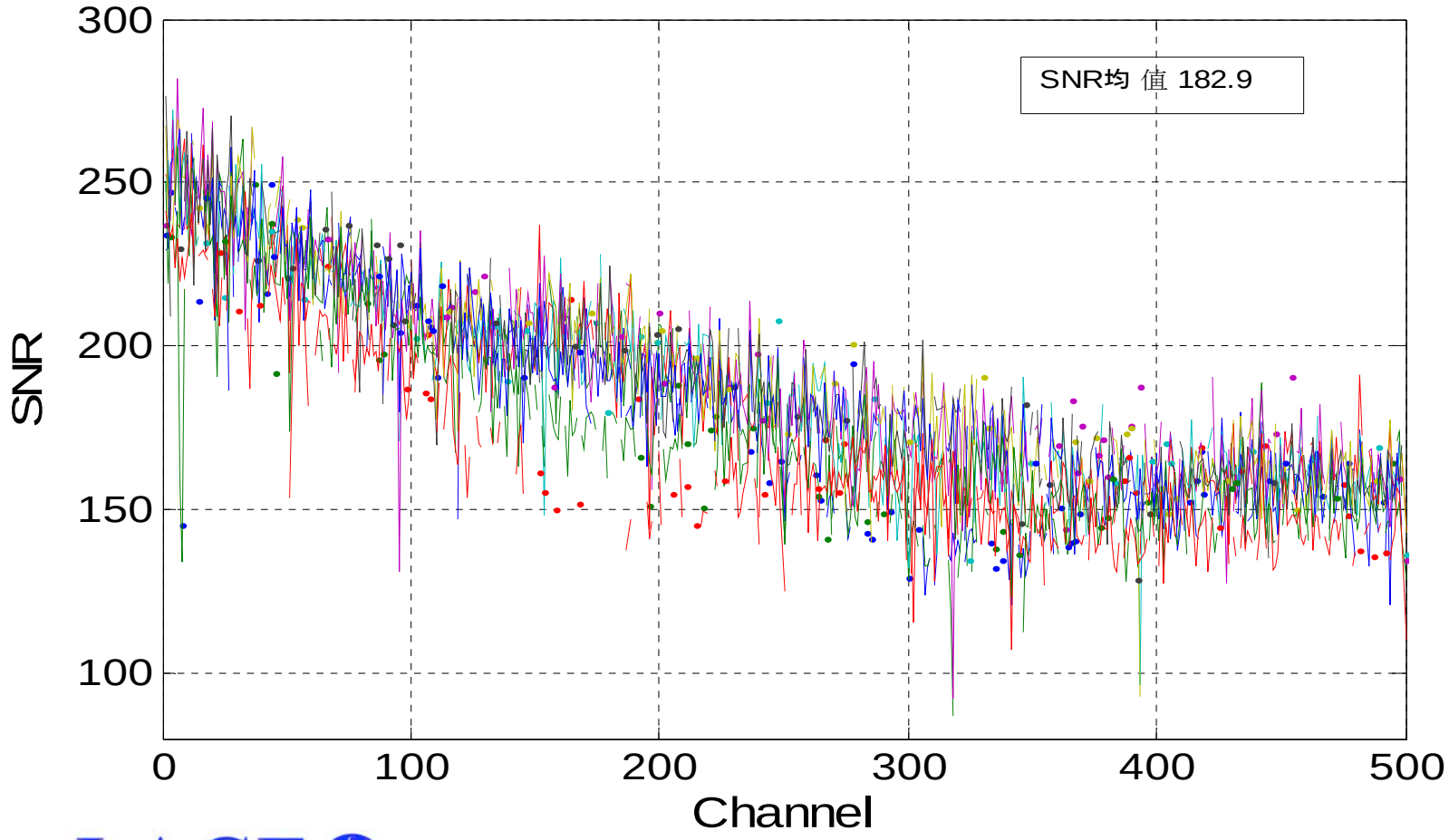




LAGEOS

Laboratory testing of ILS and SNR (2060nm)

2060nm channel SNR Results (Average 183)



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IAPCAS algorithm and application

Institute of Atmospheric Physics, Chinese Academy of Sciences

IAP Carbon Dioxide Retrieval Algorithm for Satellite Observation – IAPCAS

Application

TanSat algorithm

Similar observation characters

aTanGO
Application of TanSat algorithm on GOSAT Observation

Other observation

OCO-2

CarbonSat

esa

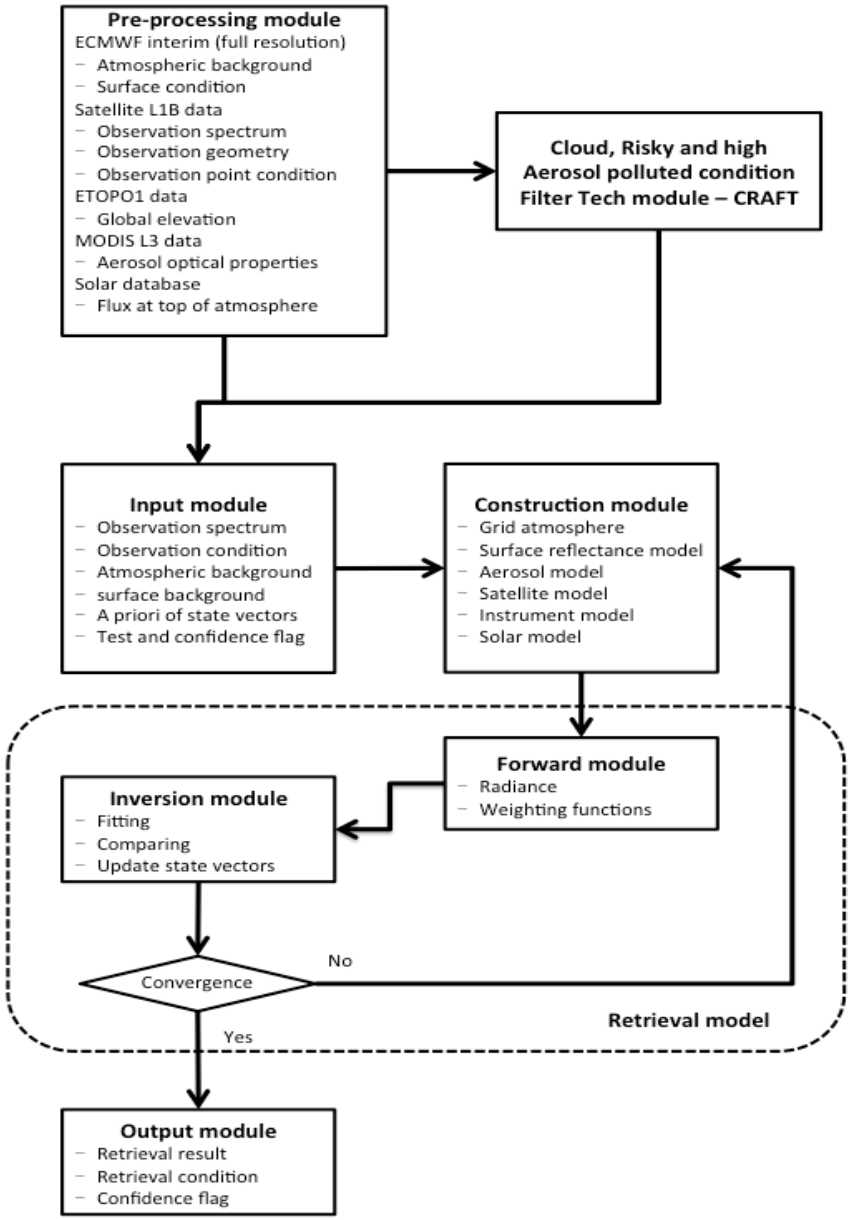
GaoFen-5

The new features of IAPCAS

- Multi-bands algorithm – O_2A band
- Algorithm structure
- Speed optimized

- Pre-processing L1B
- Cloud screening

- Aerosol model
- Cirrus cloud model
- Gas absorption
- Solar irradiance
- State vector list
- Apriori



IAPCAS-aTanGO validation and application

Inter-comparison

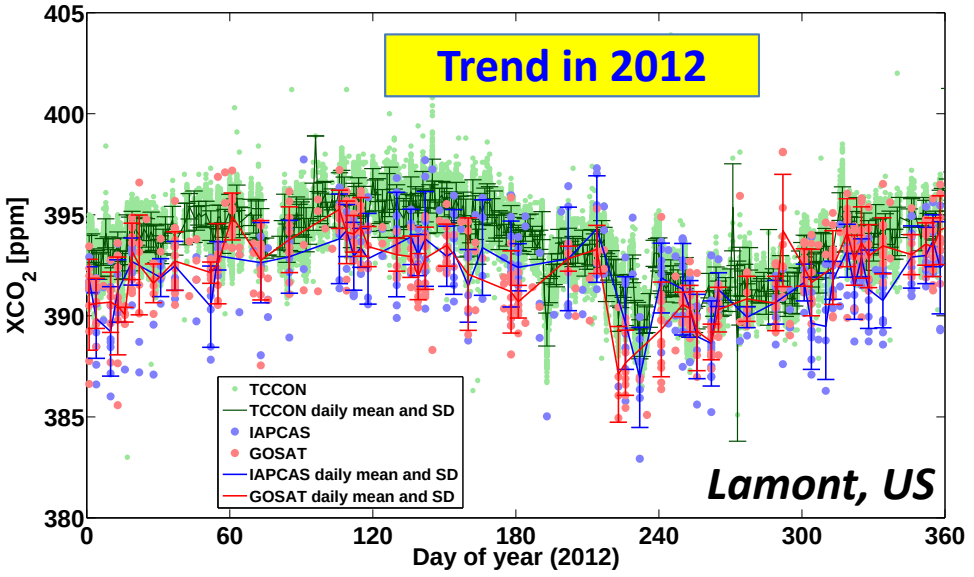
P0: 1.2hPa (~0.1%)bias
2.8hPa (~0.28%)SD

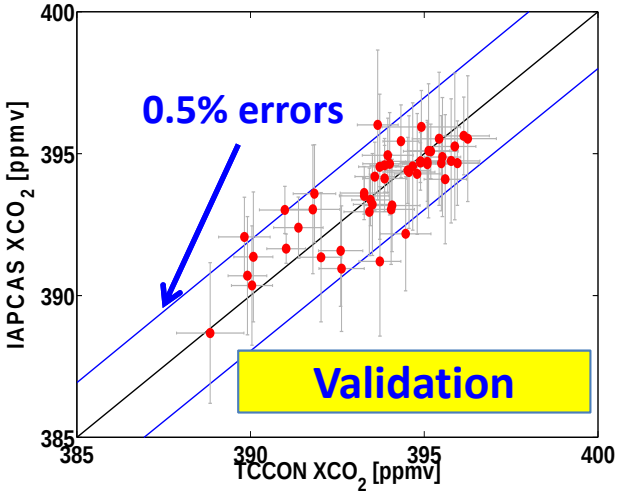
XCO_2: -2.4 ppm (~-0.6%)bias
1.23 ppm (~0.3%)SD

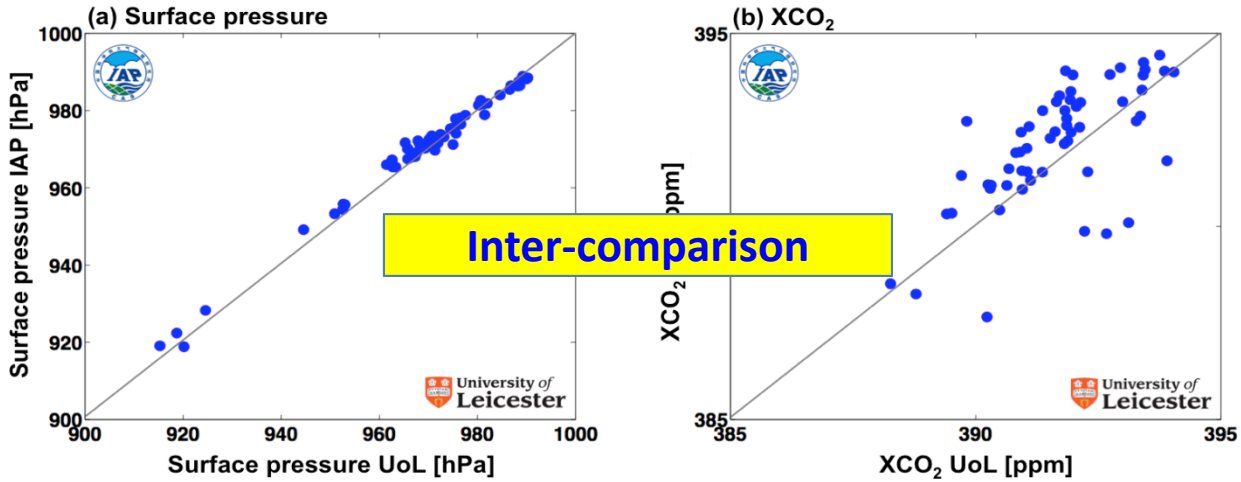
Validation

Bias: -1.9 ppmv (~0.48%)

SD: 1.1 ppmv (~0.28%)







Aerosol Retrieval with CAPI– a Test with MODIS Observations

STEP 1. Pre-processing

MOD02, MOD03, MOD35

PRE-PROCESSING:
- Cloud/Ocean screening
- Elevation correction
- Geometry determination
- Downscaling to $10\text{km} \times 10km$

INPUT:
- $R^*_{0.47}, R^*_{0.67}, R^*_{0.87}, R^*_{1.64}$
- Geometry Information

STEP 2. Retrieving

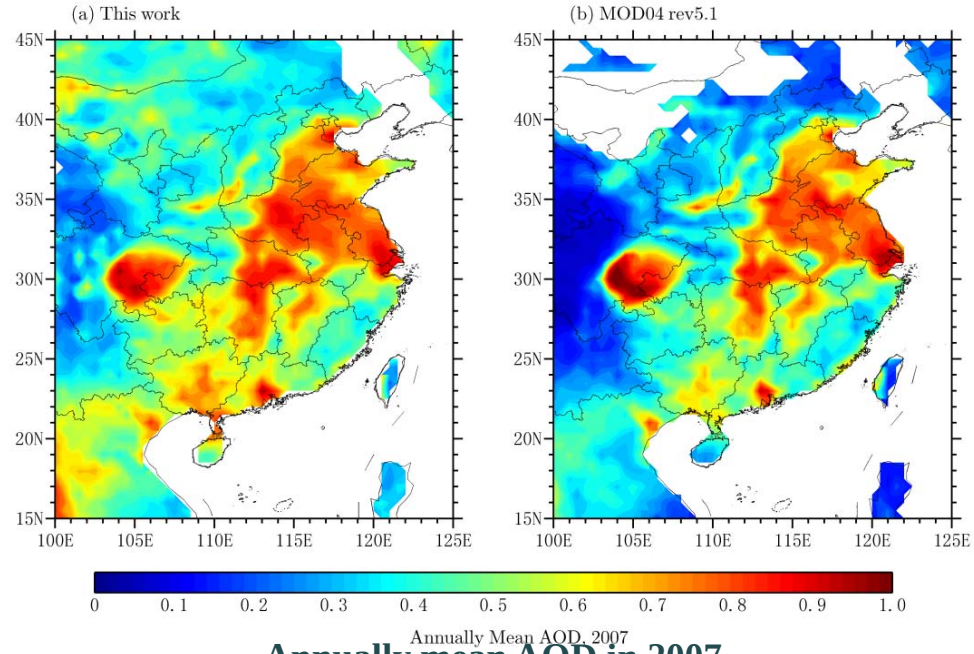
FOR EACH $\eta = -0.1, 0, 0.1, \ldots, 1.1$, FIND $\tau^{\eta}_{0.55}$, $R^{Surf,\eta}_{0.67}$, $sNDVI^{\eta}$, MAKES:
- $R^*_{0.67} = R^{LUT,\eta}_{0.67}$, $R^*_{0.87} = R^{LUT,\eta}_{0.87}$, $R^*_{1.64} = R^{LUT,\eta}_{1.64}$.

CALCULATE $\varepsilon^{\eta}_{0.47} = \left|R^*_{0.47} - R^{LUT,\eta}_{0.47}\right| / R^*_{0.47}$, FIND MINIMUM $\varepsilon^{\eta}_{0.47}$ TO DETERMINE η_0.

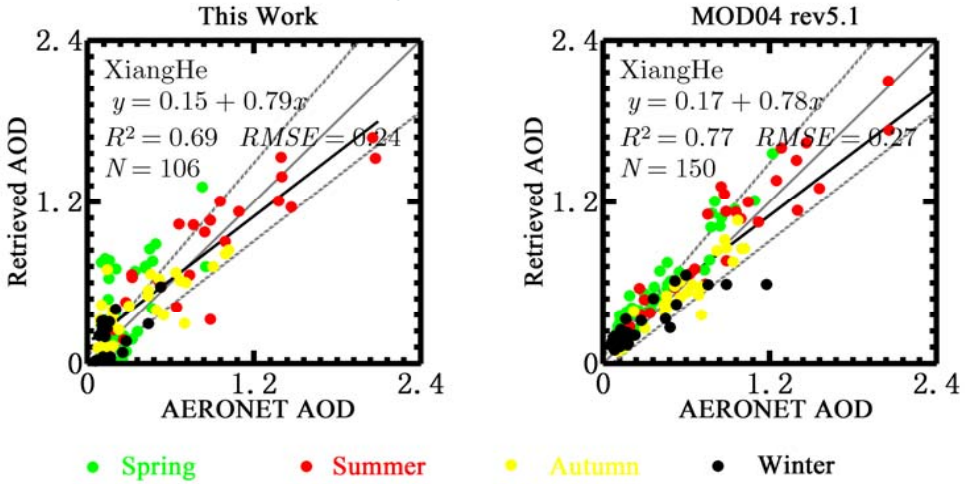
STEP 3. Outputting

OUTPUT:
- IF $\varepsilon^{\eta_0}_{0.47} < 0.05$, OUTPUT $\tau^{\eta_0}_{0.55}$, $R^{Surf,\eta_0}_{0.67}$, $sNDVI^{\eta_0}$, η_0.
- ELSE, RETRIEVE FAILED.

Algorithm Flowchart



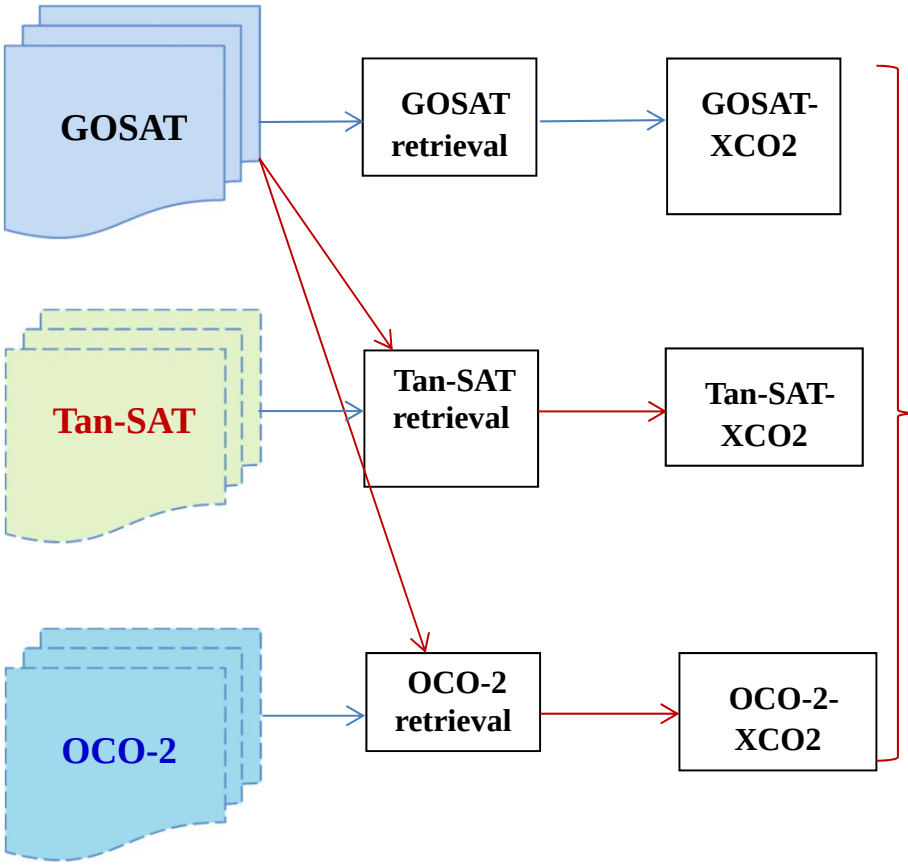
Annually mean AOD in 2007

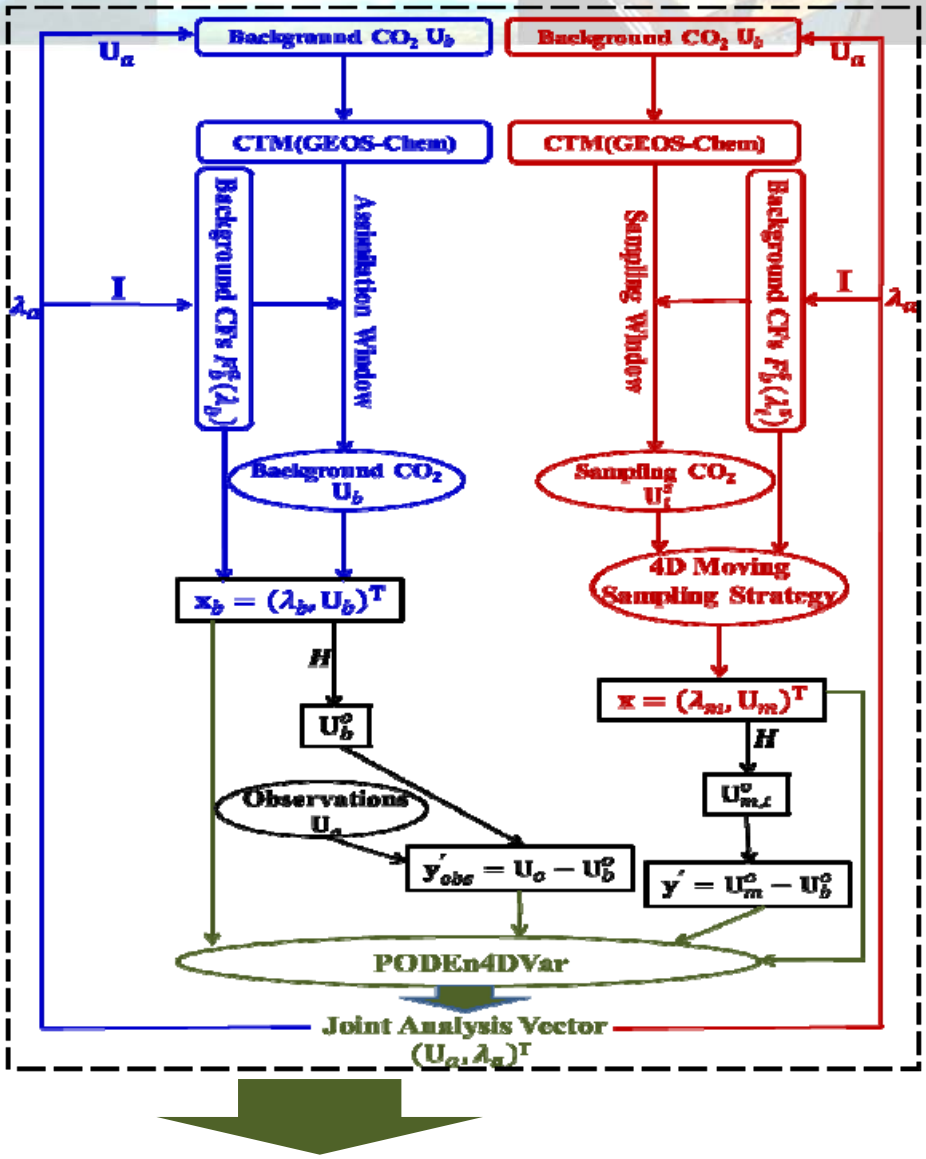


Comparing with AERONET AOD

G.M. Shi, C.C.Li et al., Retrieval of Atmospheric Aerosol and Surface Properties Over Land Using Satellite Observations, submitted to IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, 2014

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





Tian. APC 2014

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

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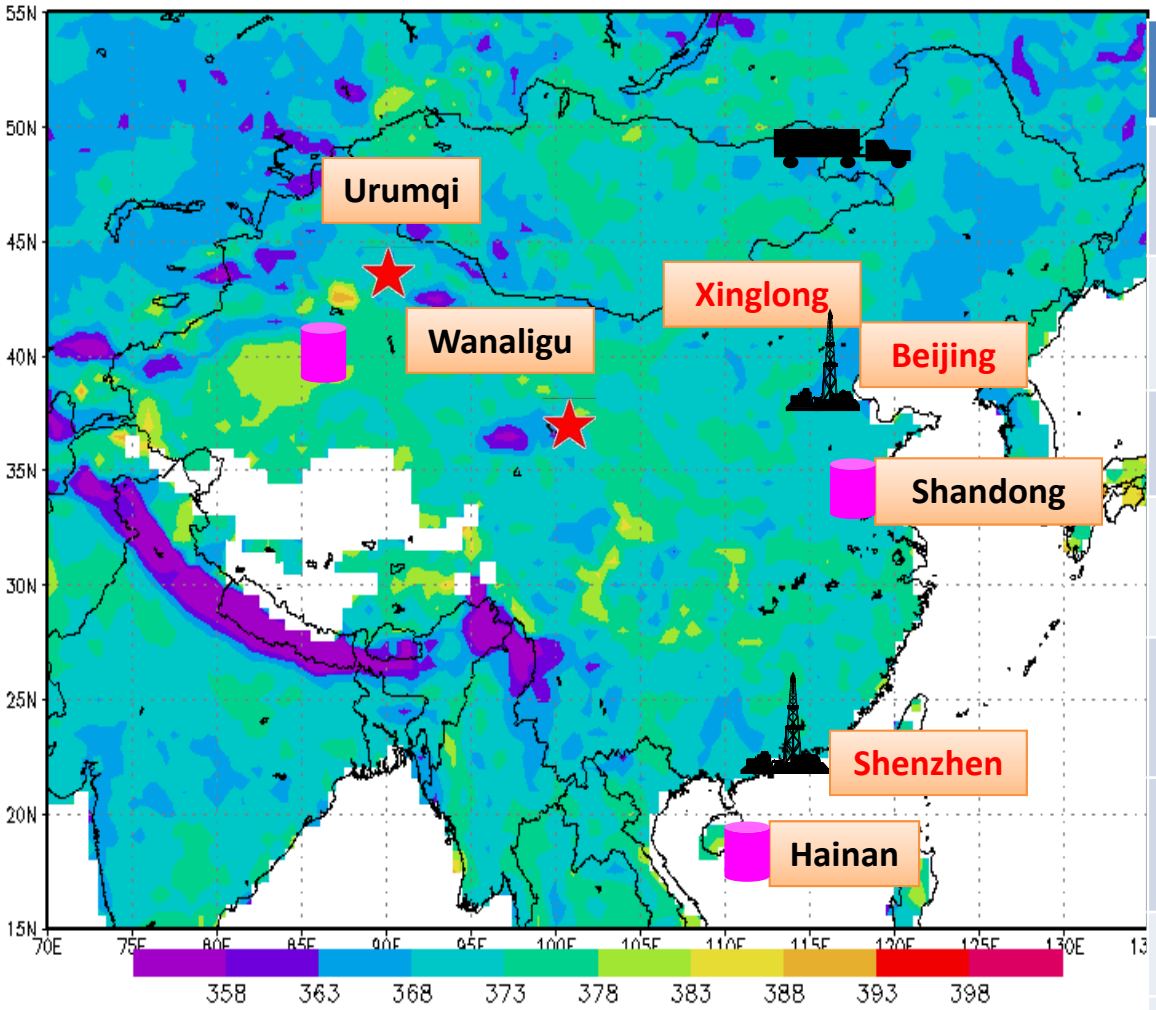
Ground based measurement network

TanSat

Ground-based Measurement Sites in China



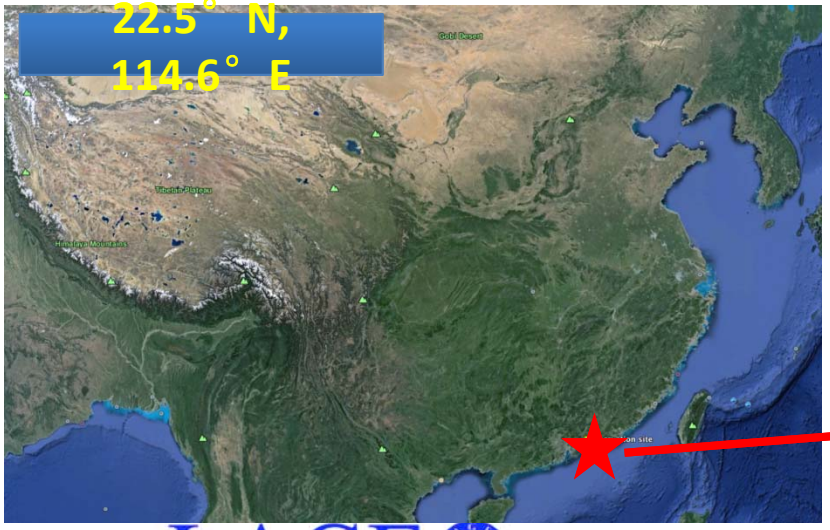
Ground sites

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

Calibration, Validation & priori data

Ground based instrument and observation

- Shenzhen, China
- Begin from *Sep. 2011*
- FTS IFS125HR
- Clear sky condition



Shenzhen Xi'chong Astronomical Observatory

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CO_2 Spectrometers plan

- Finished Initial prototype assemble
- 2015.6, Finish Initial prototype
- 2015.7, Finish Formal prototype assemble
- Test and preflight calibration will take a couple of months to obtain parameters and ensure the stability.
- 2015.10, Finish Formal prototype

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 CO2 Spectrometers Finish

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

2015.12 SRR- Satellite Readiness Review

2016.06 Launching

Atmospheric Composition Constellation Meeting-11