

AC-VC-13

From scientific requirement to the space born measurement :

## First Observations of TanSat Satellite

Yi Liu

*TanSat Science Team*



新华网  
WWW.NEWS.CN

Paris, June 28, 2017

# Content

**Scientific challenges for CO<sub>2</sub> monitor from space**

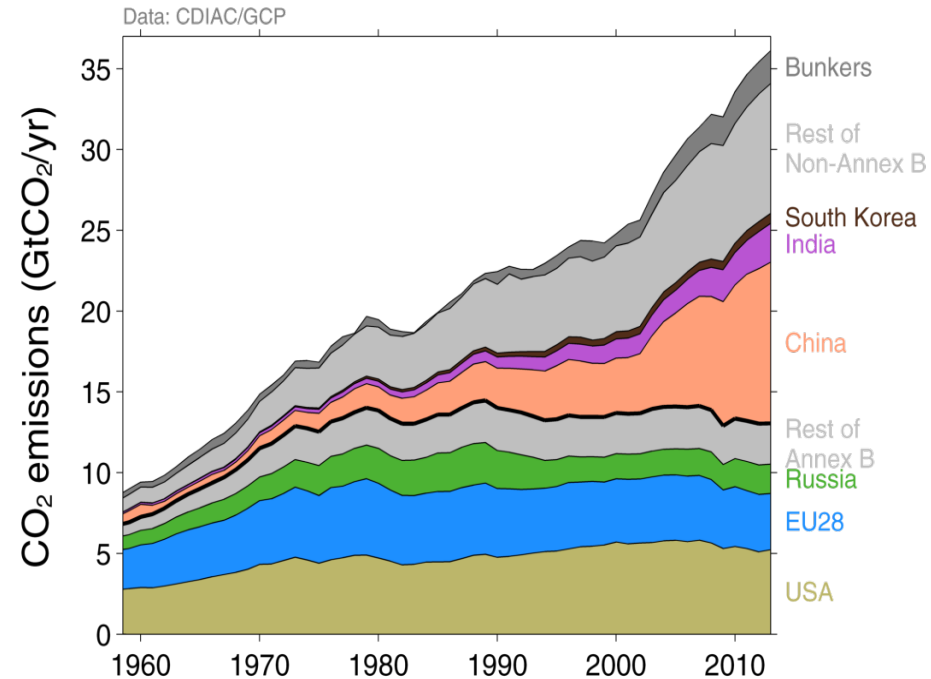
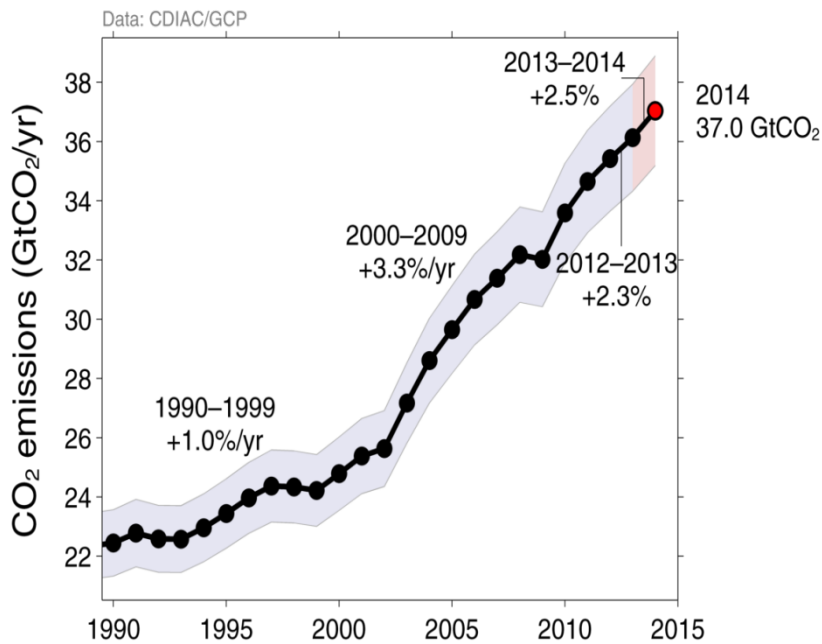
**TanSat development process review**

**First observation of TanSat**

**Perspective and Plan**

# Global Carbon Emissions

- The increase of global carbon emissions is driving climate change
- In last decade, a shift of emissions from USA/Europe towards countries with strong economic growth (especially China and India)



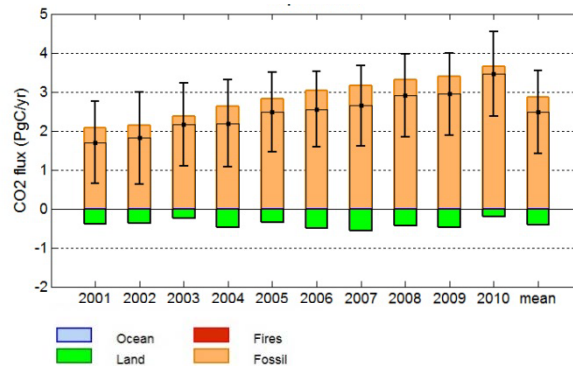
Credit: Global Carbon Project

# Carbon Budget of China

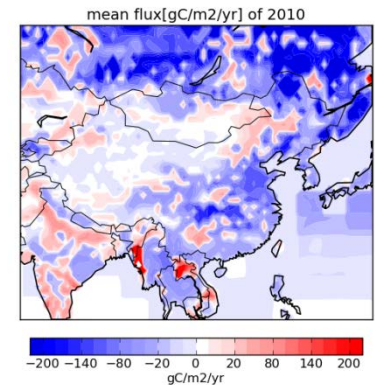
Current in-situ surface networks in background sites are used to constrain (top-down) surface fluxes but uncertainties are very large

Emissions are partly offset by uptake of terrestrial ecosystem (in South and East)

Carbon Balance for Eurasia Temperate



Natural Carbon Fluxes



Carbontracker-China

Estimates are not consistent between studies

Name	Study Period	Carbon balance (Pg C yr <sup>-1</sup> )	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)

Natural fluxes only

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

# Content

**Scientific challenges for CO<sub>2</sub> monitor from space**

**TanSat development process review**

**First observation of TanSat**

**Perspective 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** (CAS) (2015-2016)

--- Organization of TanSat Mission

--- Funding Launch fee

**Term-1(2011-2015)**  
**Measurement Goals**

**XCO<sub>2</sub>**

**1~4 ppmv**

**Monthly**

**500 x 500 km<sup>2</sup>**

**Term-2(2013-2015)**  
**Measurement Goals**

**CO<sub>2</sub> Flux**

**Relative flux error**

**20%**

**Monthly**

**500 x 500 km<sup>2</sup>**

# Team of The TanSat Project



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

# Satellite Platform - Observation Mode

Name	Characters
Orbit type	sun-synchronous
Altitude	<b>700 km</b>
Inclination	98°
Local time	<b>13:30</b>
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

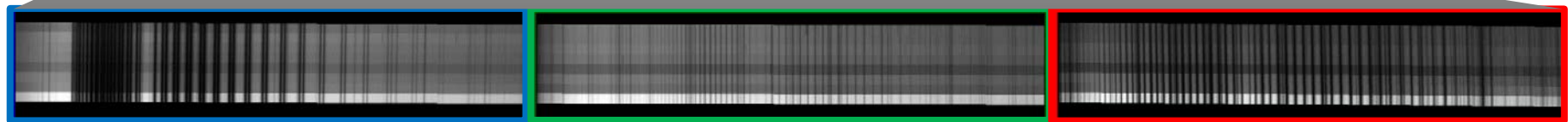


## Carbon Dioxide Spectrometer (CDS)

	O <sub>2</sub> -A	CO <sub>2</sub> , weak	CO <sub>2</sub> , 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<sub>2</sub> A-Band

CO<sub>2</sub> 1.61μm Band

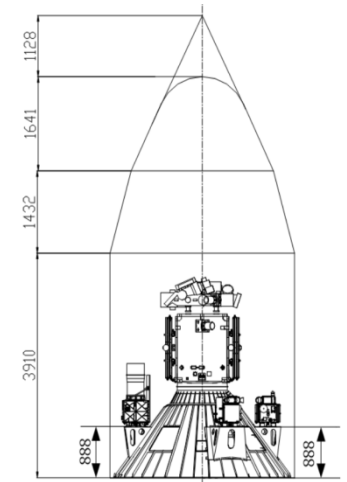
CO<sub>2</sub> 2.06 μm Band

# TanSat system composition

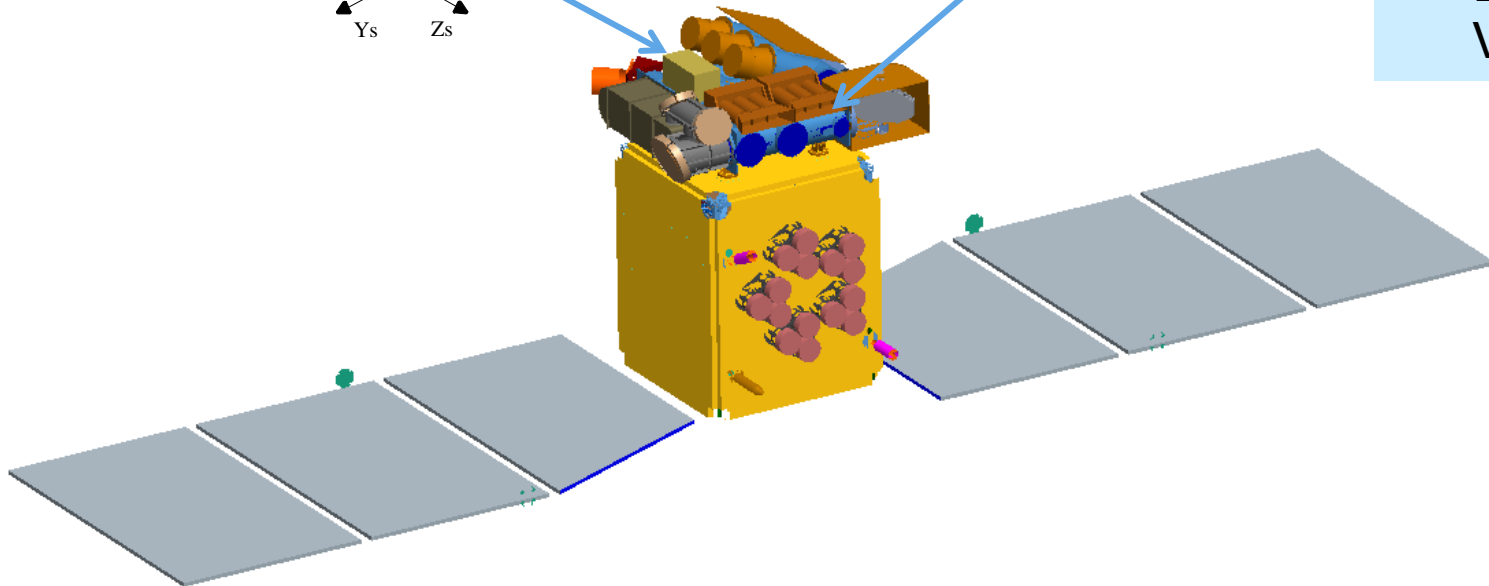
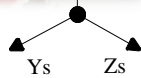
**CDS**



**CAPI**



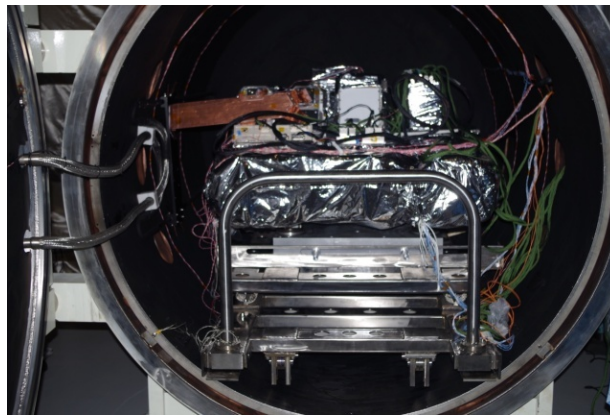
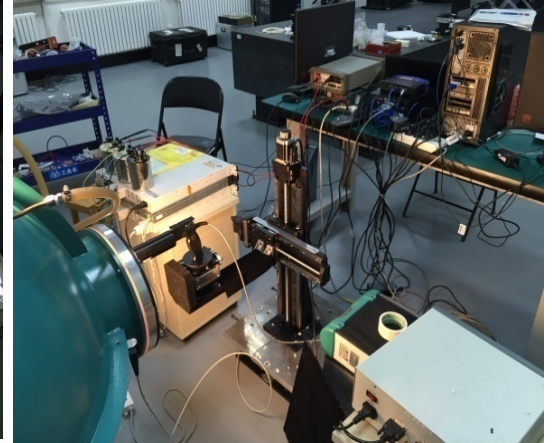
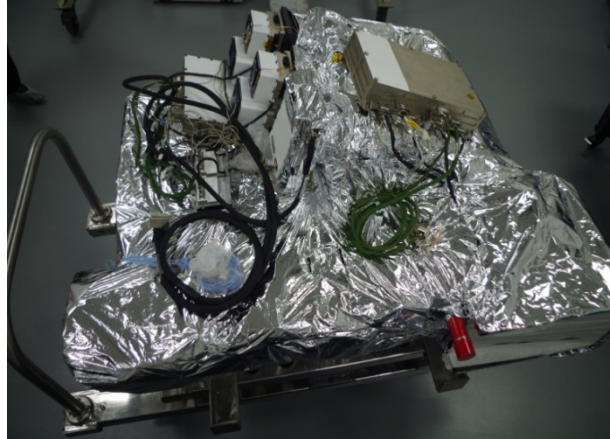
**CZ-2D  
Launch  
Vehicle**



# Preflight laboratory calibration

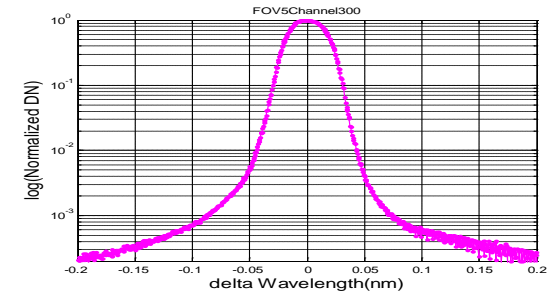
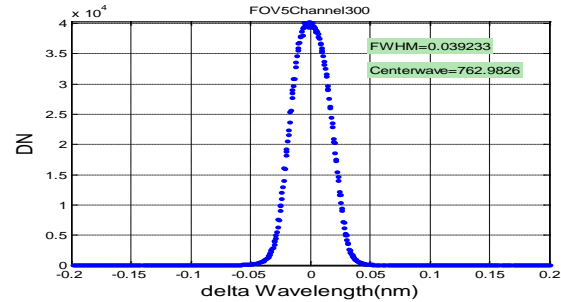
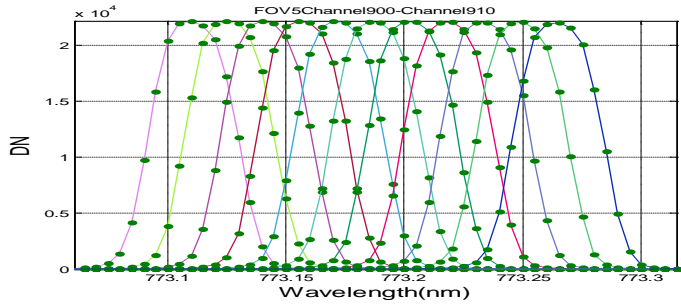
## Preflight calibration 2015-2016

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

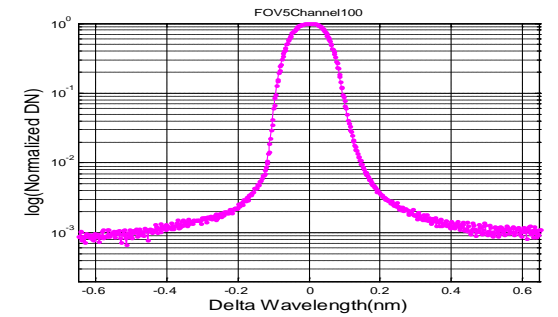
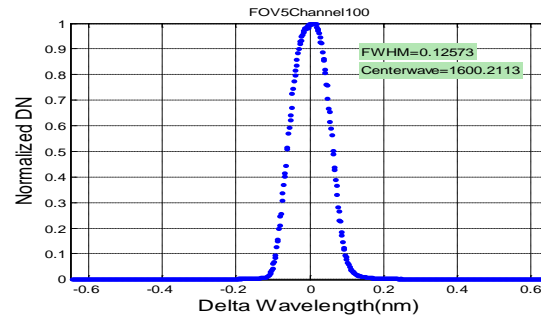
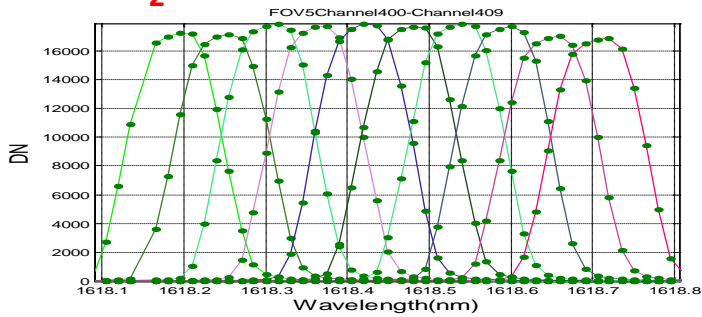


# ILS calibration results

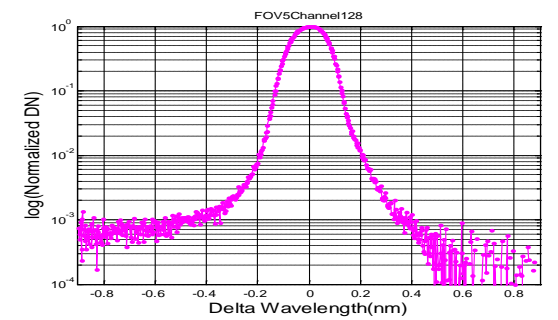
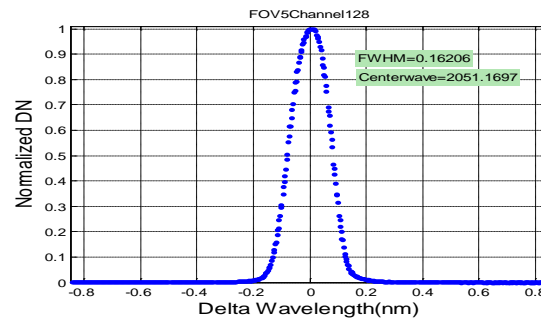
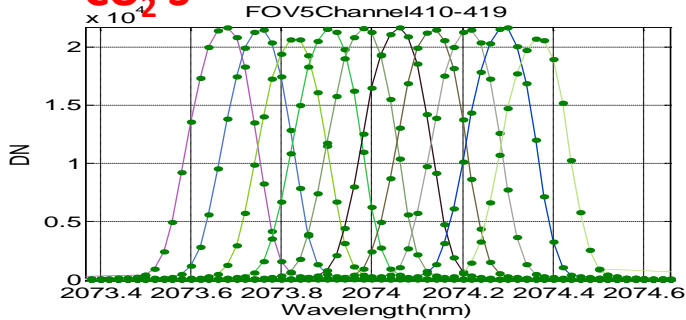
**O<sub>2</sub> A**



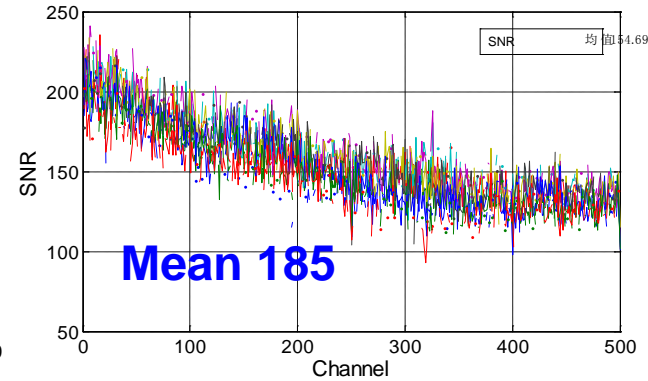
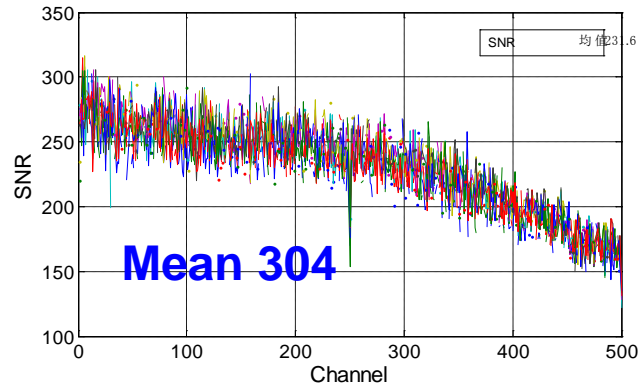
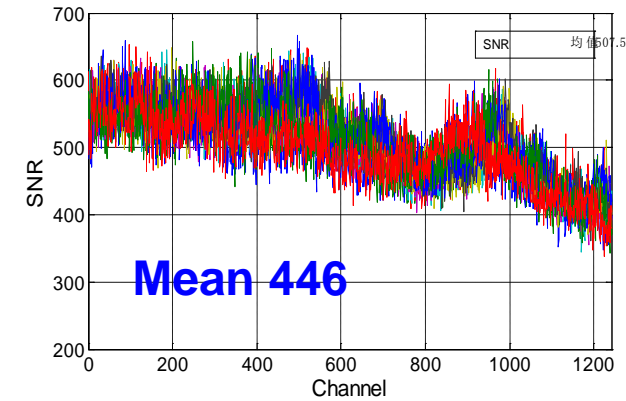
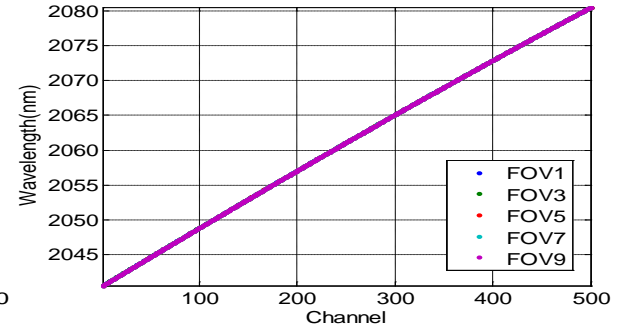
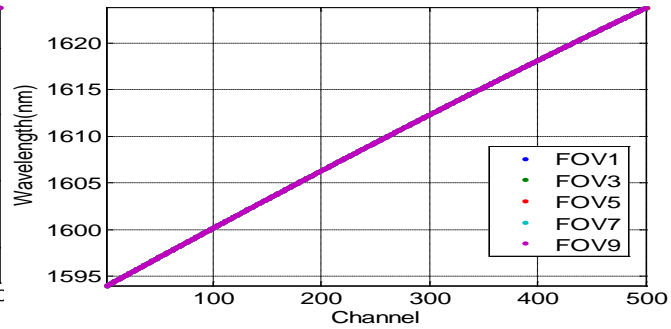
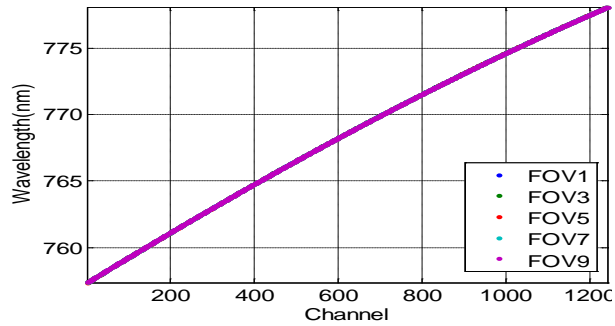
**CO<sub>2</sub> W**



**CO<sub>2</sub> S**



# Wavelength grid and SNR



O<sub>2</sub> A band

CO<sub>2</sub> weak band

CO<sub>2</sub> strong band

# IAPCAS algorithm and application

Institute of Atmospheric Physics, Chinese Academy of Sciences

**IAP Carbon Dioxide Retrieval Algorithm for Satellite Observation – IAPCAS**

Application

**TanSat algorithm**

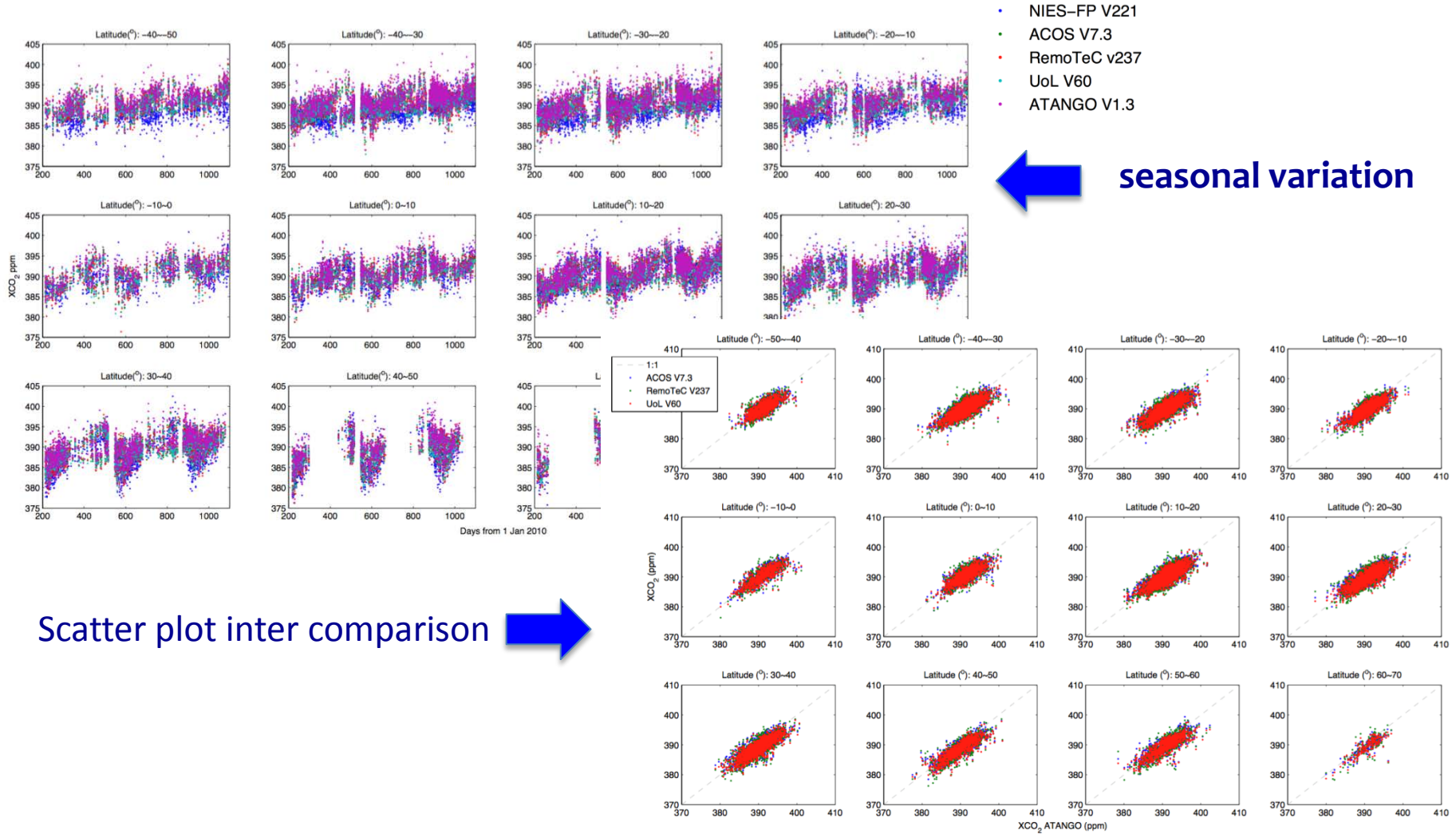
Similar observation characters

**aTanGO**  
**Application of TanSat algorithm on GOSAT Observation**

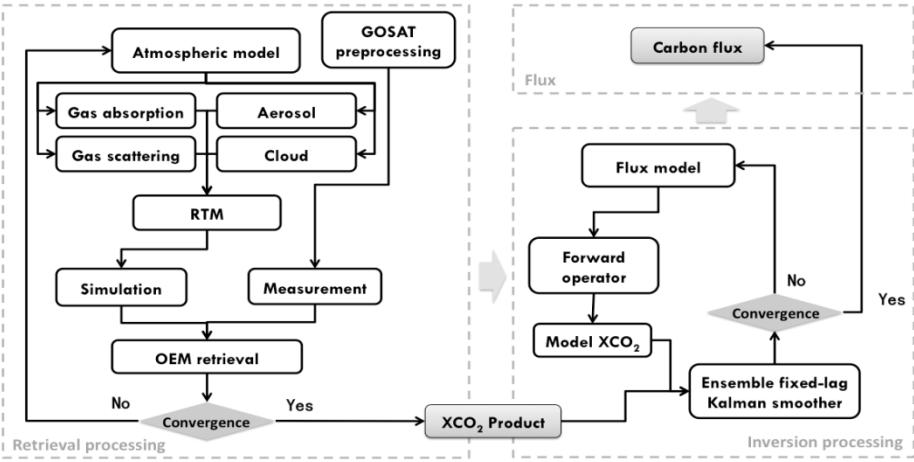
Other observation

OCO-2

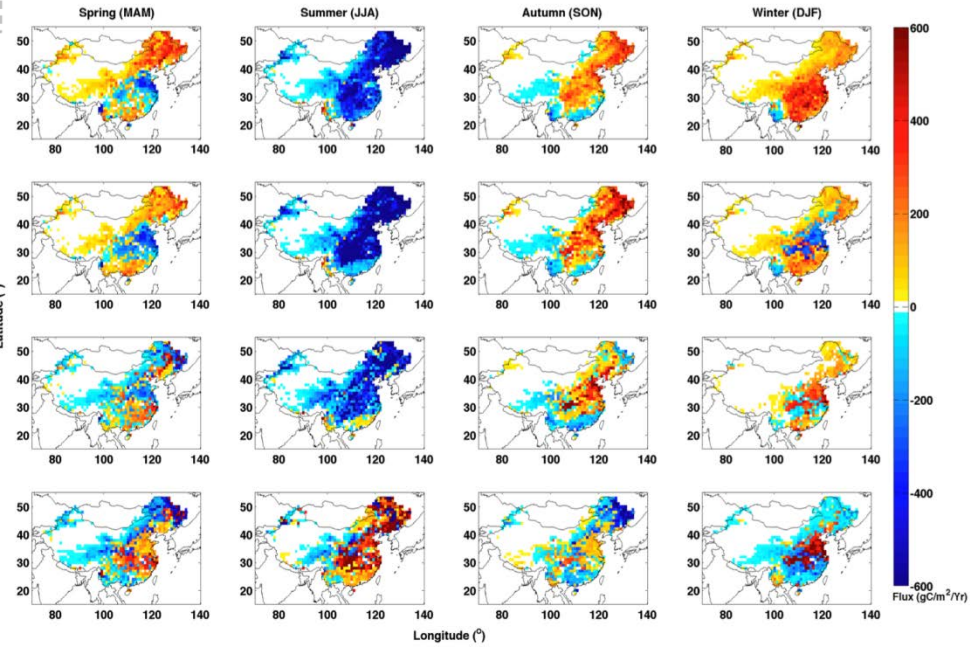
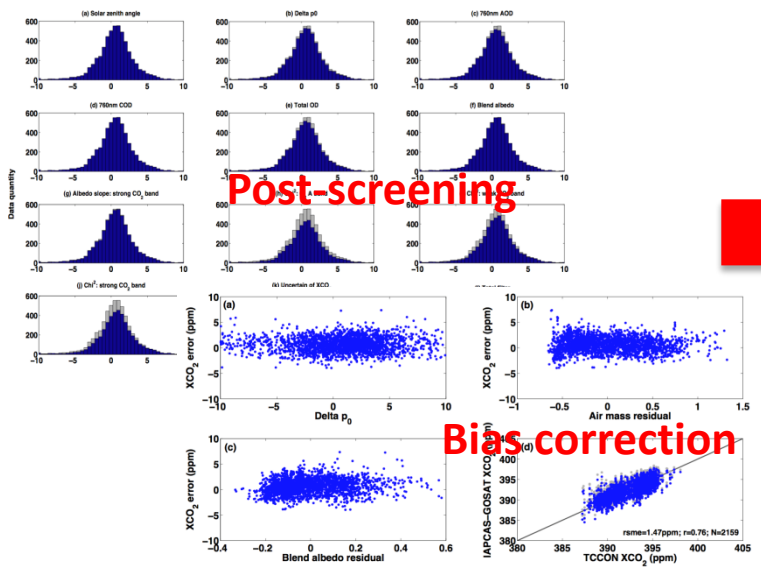
# Inter comparison: GOSAT retrieval



# Application ATANGO retrieval in Carbon flux inversion



Simulation	CO <sub>2</sub> flux			Flux uncertainties		
	Prior flux (Pg C yr <sup>-1</sup> )	Post. flux (Pg C yr <sup>-1</sup> )	flux difference (Pg C yr <sup>-1</sup> )	Prior error (Pg C yr <sup>-1</sup> )	Post-error (Pg C yr <sup>-1</sup> )	Error reduction* Relative (%)
n-situ-only	-0.05	-0.51	0.46	0.49	0.38	22%
CAS-GOSAT	-0.05	-0.34	0.29	0.49	0.08	84%





# CAPI: Aerosol information analysis

Characters	CAPI				
Bands (nm)	365-408	660-685	862-877	1360-1390	1628-1654
Polarization angle	0°/60°/120°		0°/60°/120°		
SNR	260	160	400	180	110
Spatial resolution	1 km × 1 km				
Scanning range	-16° ~ 16°				
Swath	400 km				

Well mixed

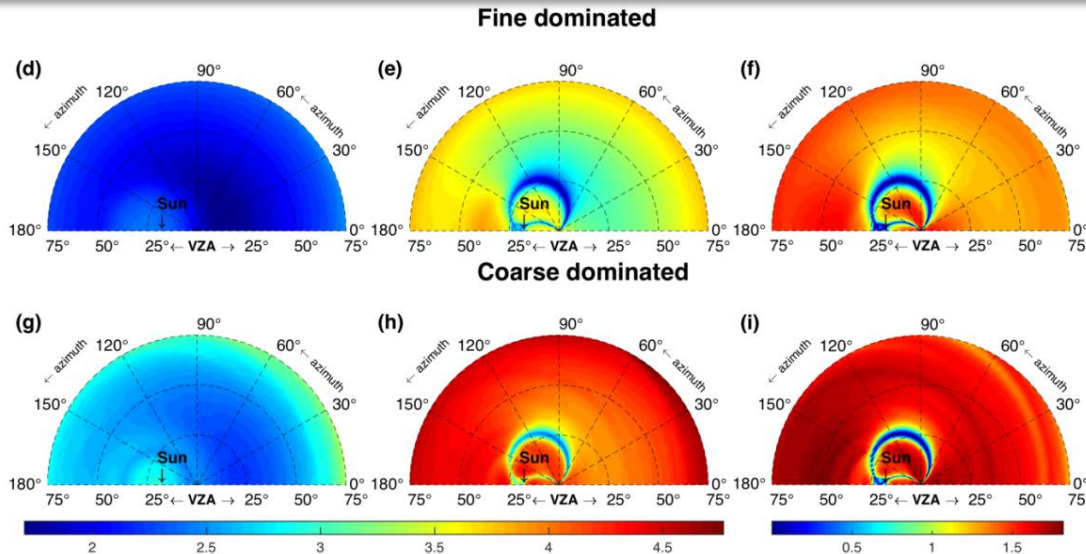
Forward model



Optimal estimation

Averaging kernel (DFS)

Polarized measurements of CAPI can provide additional 1~1.8 aerosol DFS, mainly improve the information of aerosol total volume and fine mode fraction ( $fmf_v$ )



# Surface CO<sub>2</sub> validation Stations



# The schedule of TanSat

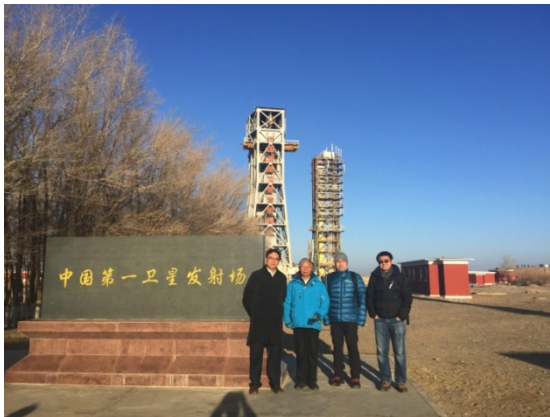
- 2011.11 kick off of project-major milestone
- 2011.09 SRR-Science Requirement Review
- 2013.03 PDR-Preliminary Design Review
- 2013.07: Kick off phase C-major milestone
- 2014.06: Electromechanical Integration
- 2014.12 CDR- Critical Design Review
- 2016.01 CO2 Spectrometers Finish-major milestone  
Assemble, debug, integrate, a series of test:  
calibration\environment
- 2016.11 SRR- Satellite Readiness Review-major milestone



**2016.12.22 Launching**

# TanSat Launching

TanSat was successfully launched on Dec. 22 in JiuQuan Satellite launching center by CZ-2D Launch Vehicle



# Content

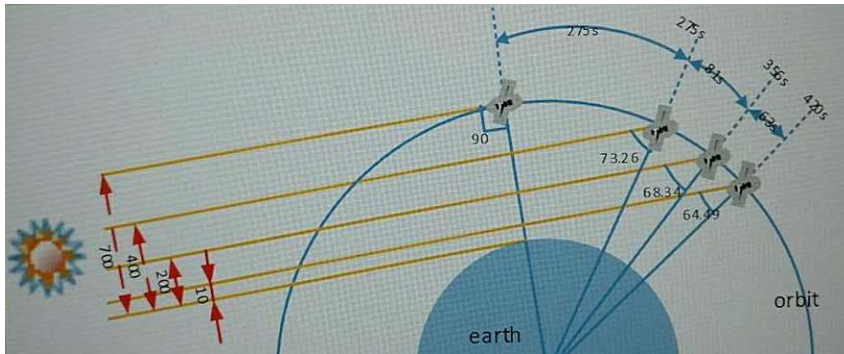
**Scientific challenges for CO<sub>2</sub> monitor from space**

**TanSat development process review**

**First observation of TanSat**

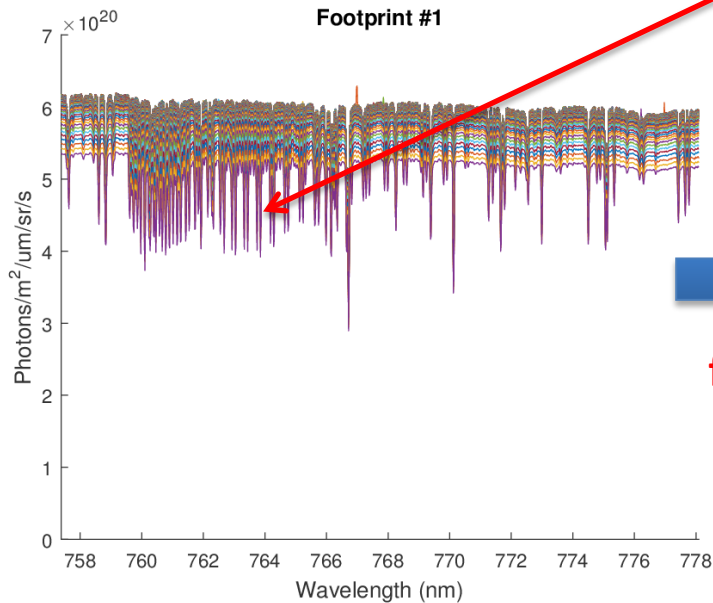
**Perspective and Plan**

# Inter-comparison of solar measurements between TanSat, OCO-2 and solar model

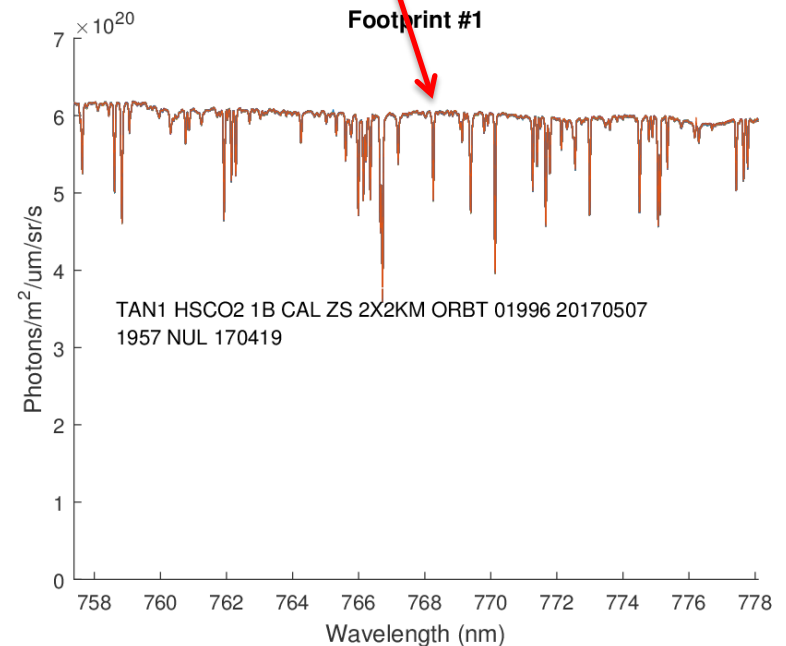


## TanSat solar mode

- Typically acquired once per orbit now once per day later.
- Typically last 8 min.

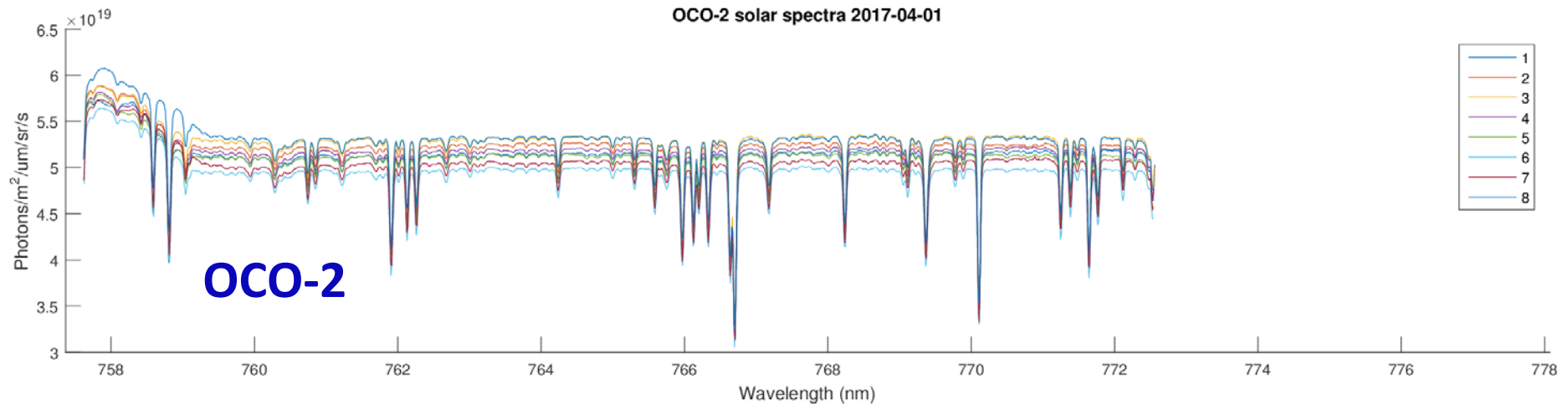
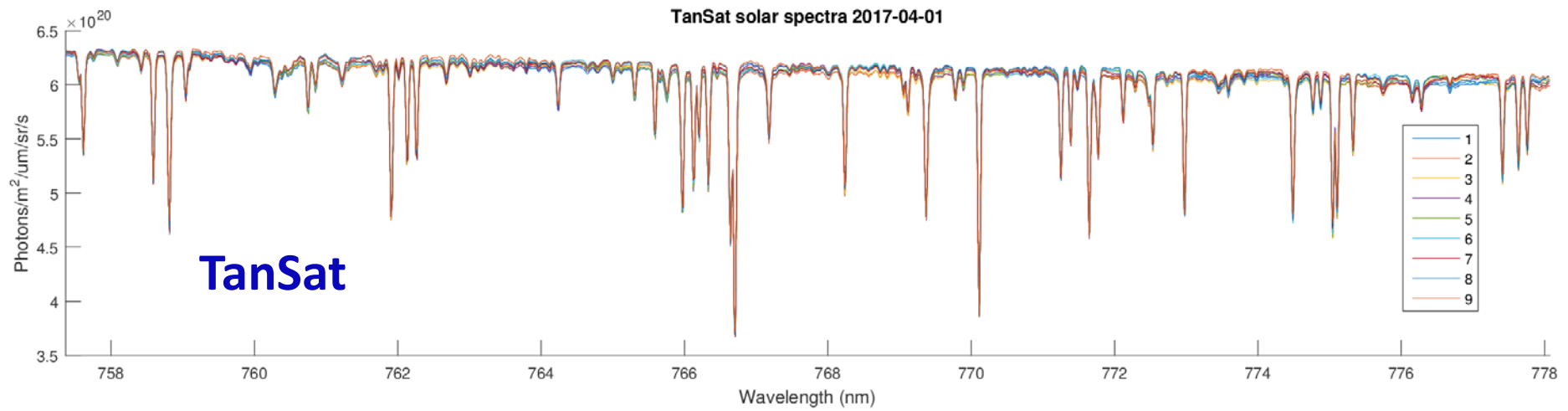


filtered



# The solar measurements of TanSat and OCO-2 on 04/01/2017

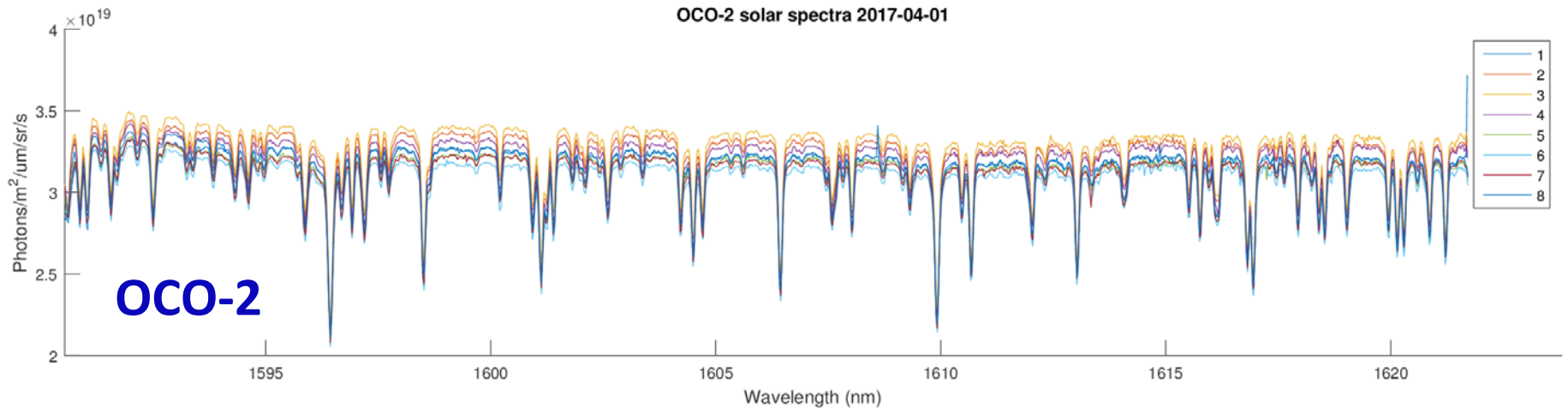
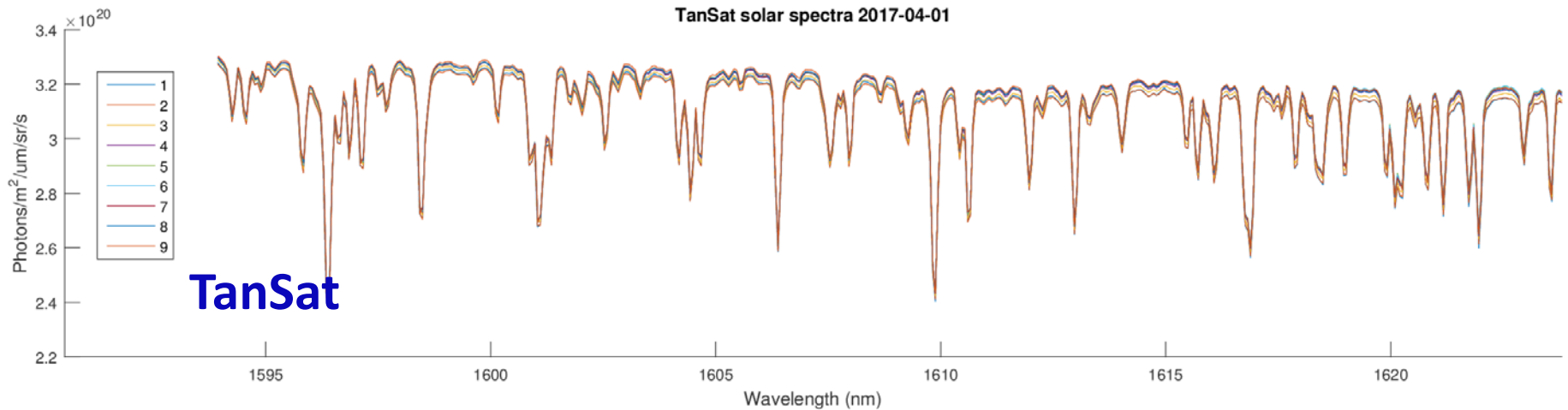
O2-A



TanSat: The irradiance of nine cross-track show good consistency

# The solar measurements of TanSat and OCO-2 on 04/01/2017

1.6  $\mu\text{m}$  – WCO<sub>2</sub>

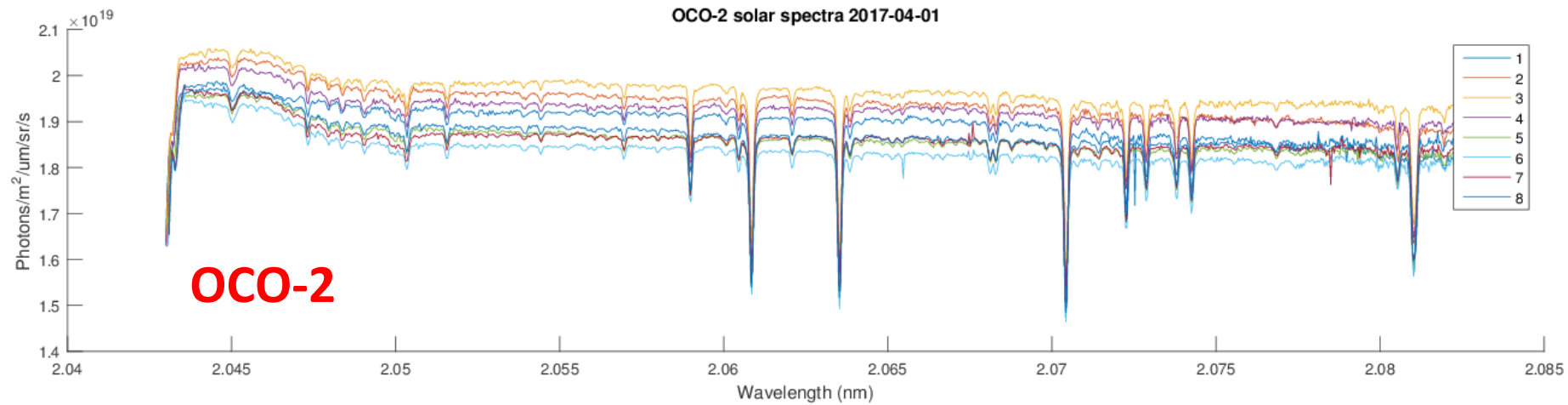
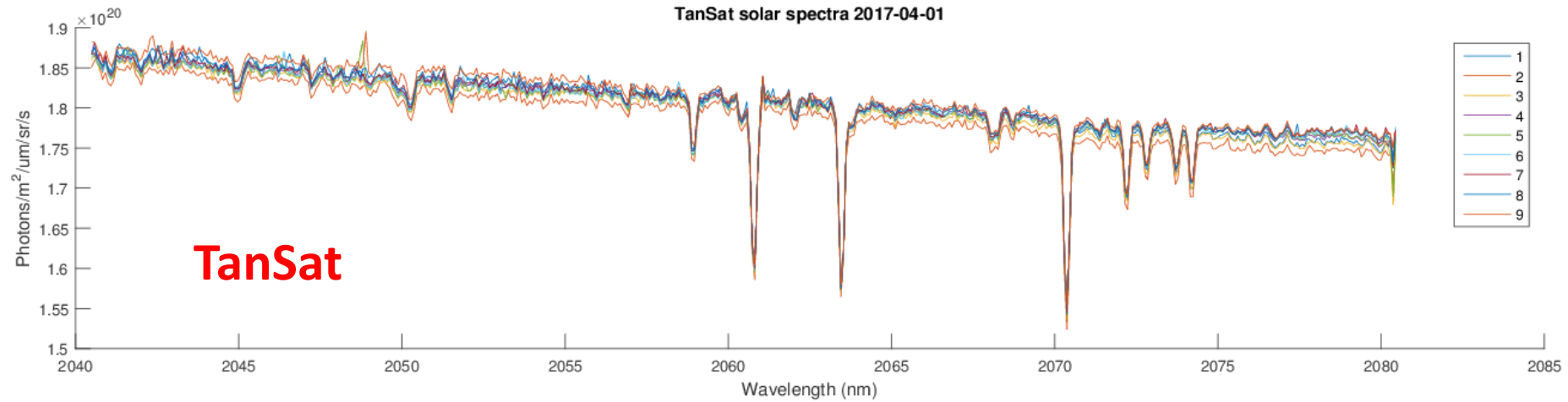


TanSat: The irradiance of nine cross-track show good consistency



# The solar measurements of TanSat and OCO-2 on 04/01/2017

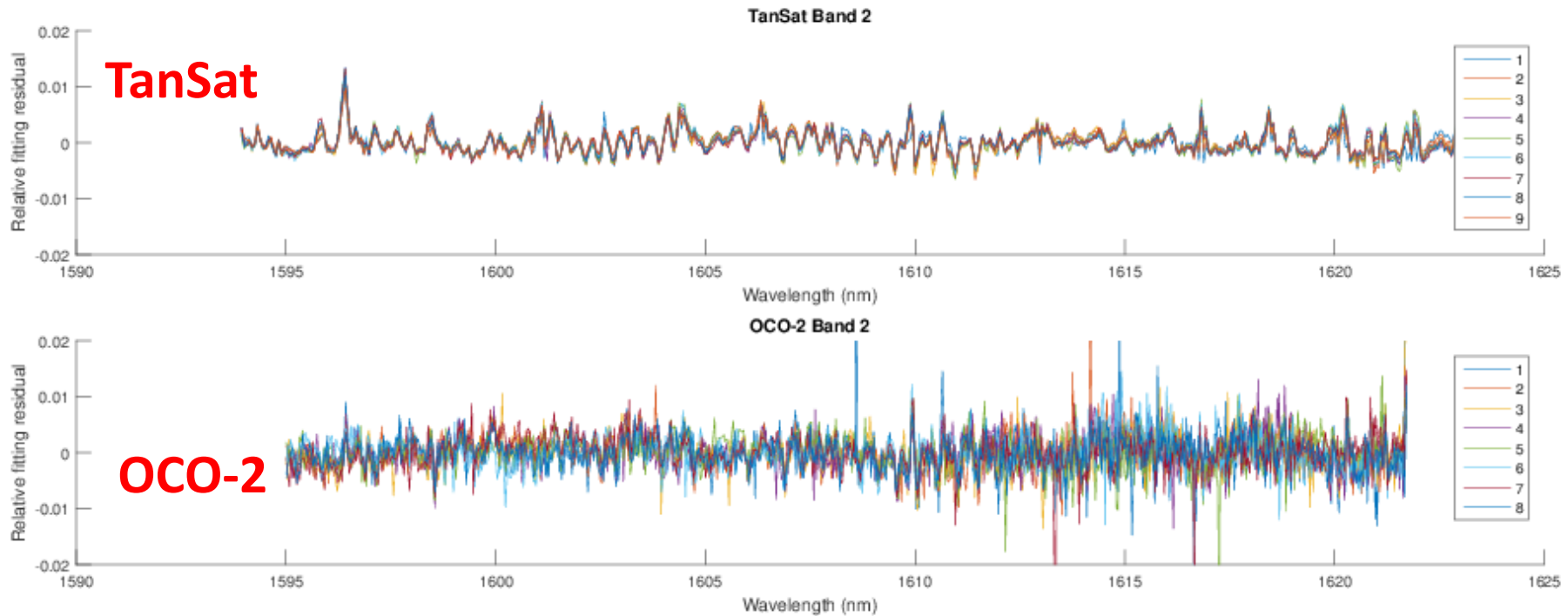
2.06  $\mu\text{m}$  – SCO2



TanSat: The irradiance of nine cross-track show good consistency

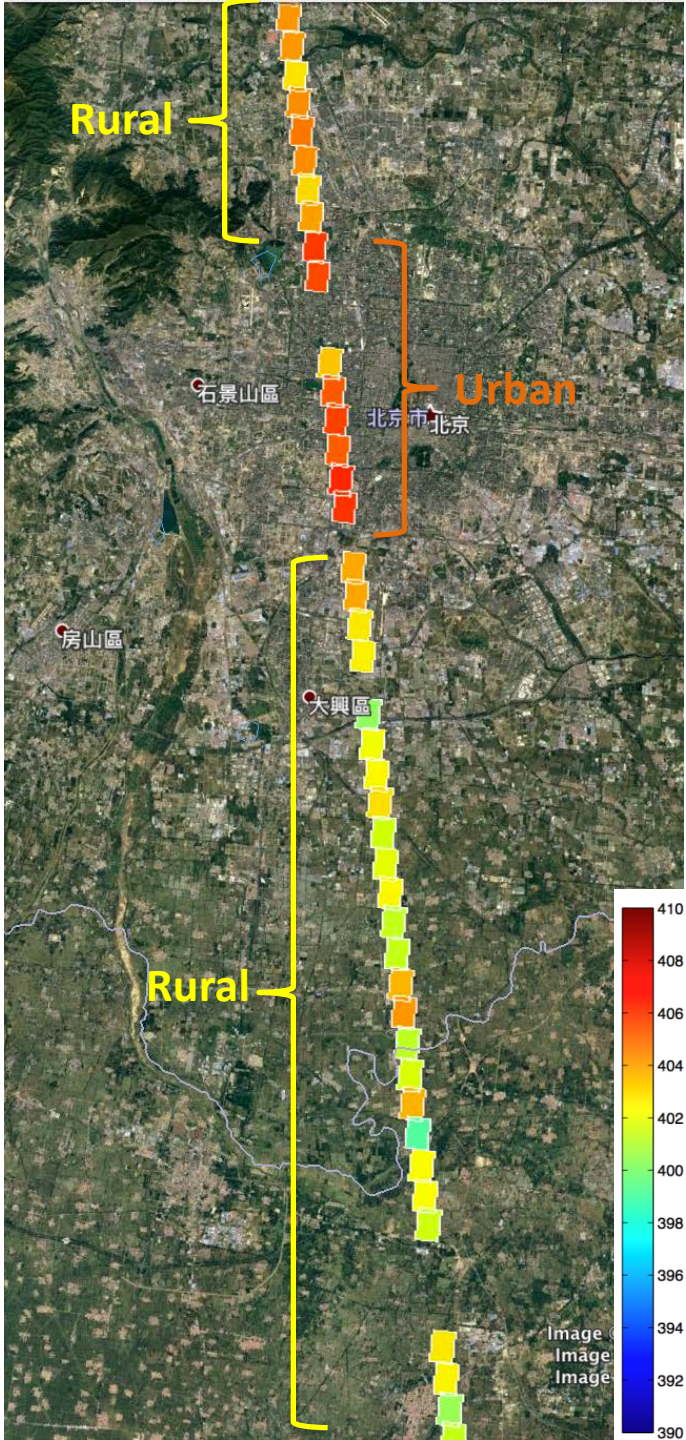
# Inter-comparison of solar measurements with solar model

## Fitting residual of 1.6 $\mu\text{m}$ band



- The fitting residuals of TanSat are less noisy
- Better consistency between nine cross-track positions

# Case study over Big City of China-Beijing



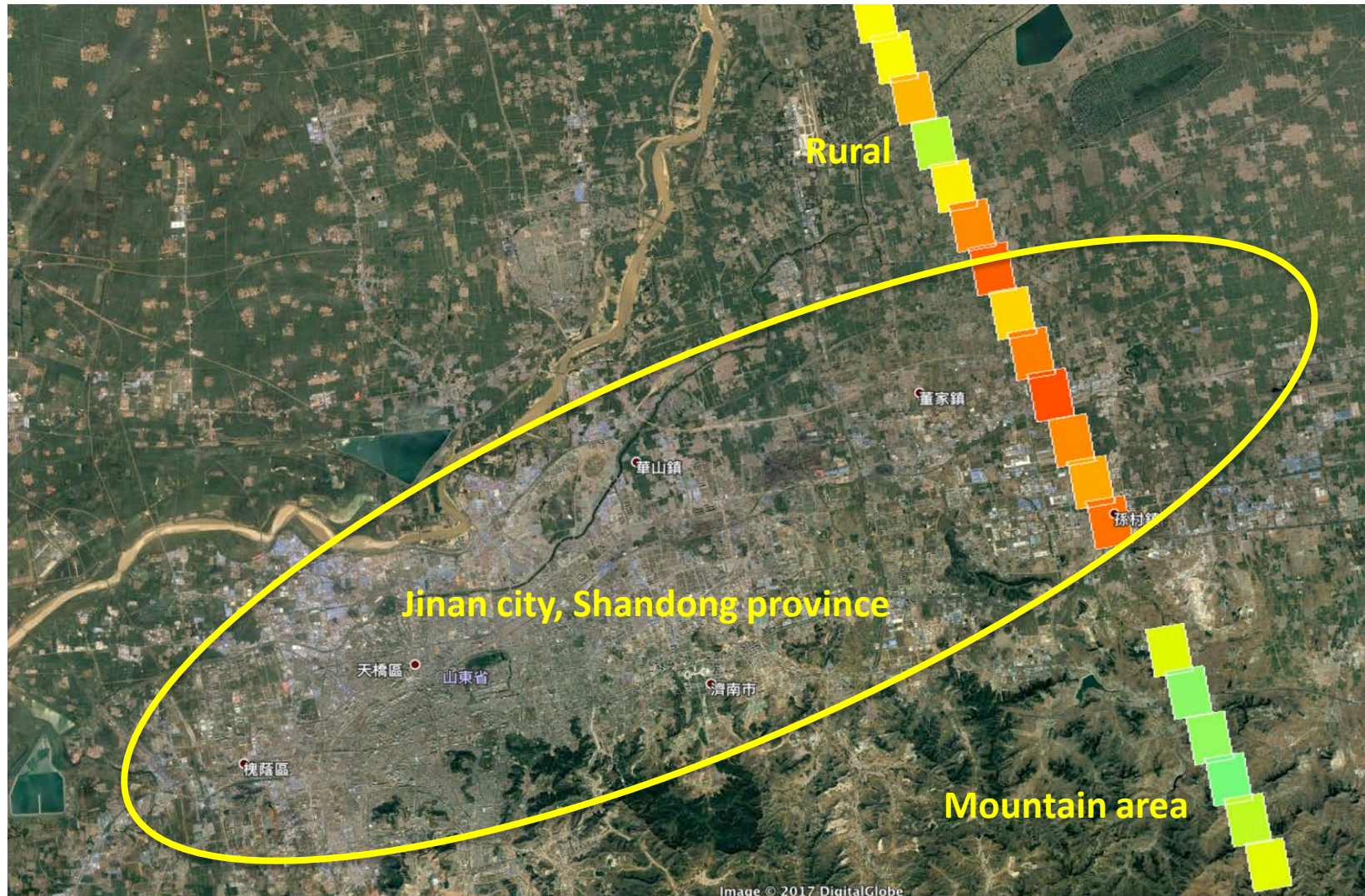
Preliminary retrieved XCO<sub>2</sub> over Beijing during April 23, 2017.

It show there is 3~4ppm variations between the urban and rural area.

XCO<sub>2</sub>

# Case study over Big City of China

--Jinan City, Shandong Province during April 23, 2017.



# Content

**Scientific challenges for CO<sub>2</sub> monitor from space**

**TanSat development process review**

**First observation of TanSat**

**Perspective and Plan**

# Summary and Future outlook



1. **TanSat was successfully launched on December 22 in JiuQuan Satellite launching center by CZ-2D**
2. **TanSat spacecraft operations are “NOMINAL”**
3. **On-orbit calibration has been conducted according to the plan**
4. **Surface Cal\Val stations have been set up and first TanSat Cal\Val experiment was conducted during April 18 to 30 in Dunhuang station.**

## TanSat data policy from MOST

The satellite is currently on-orbit calibration. When it operates stably, TanSat data policy will be published, and the data will be open to everyone. The TanSat data will be released at China GEOSS DSNNet Portal

(<http://www.chinageoss.org>)

We hope that scientists can make full use of the data and make more contributions. Meanwhile, we expect to conduct international cooperation with more countries, under the frameworks of GEO, Dragon Cooperation Programme, etc.

**AC-VC-13**

---

**Thank You for Your Attention  
Questions?**

**[liuyi@mail.iap.ac.cn](mailto:liuyi@mail.iap.ac.cn)**

**Paris, June 28, 2017**

---

