Air quality observations from EMI

Reporter：C. Liu

China's first hyperspectral satellite

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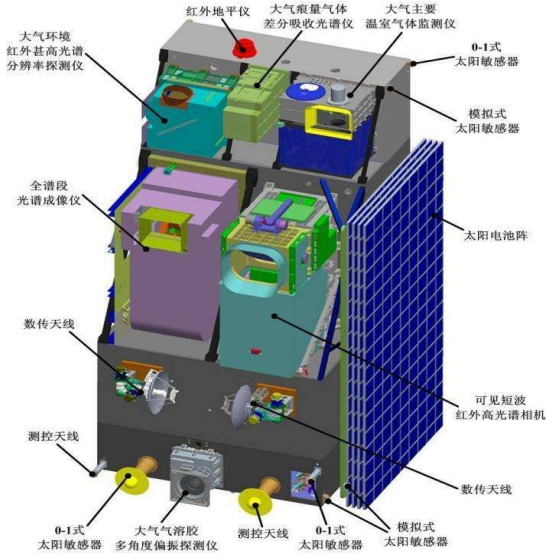

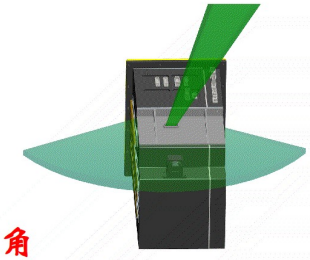

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China's first hyperspectral satellite

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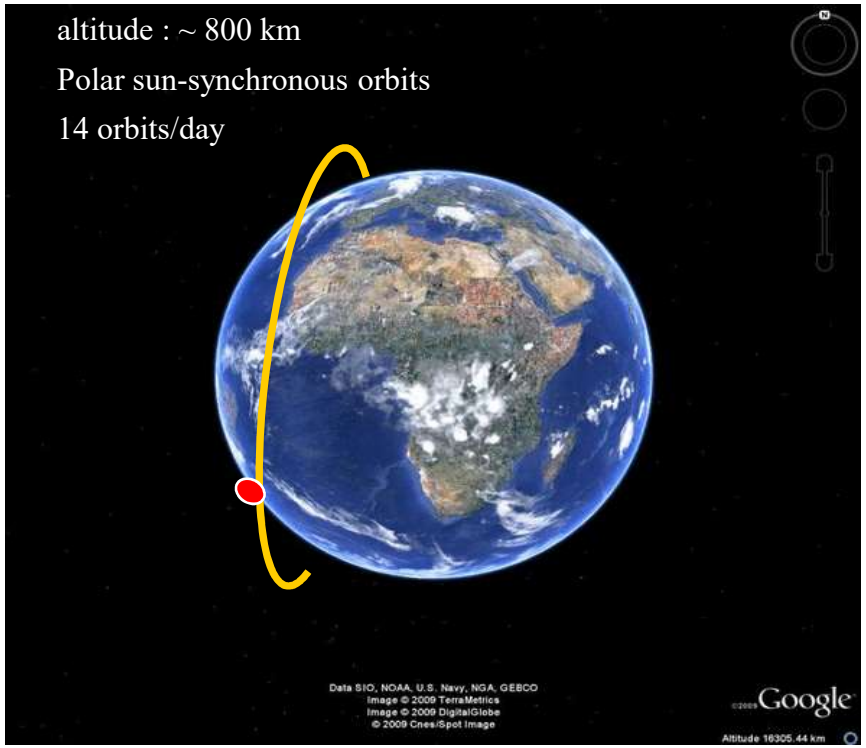

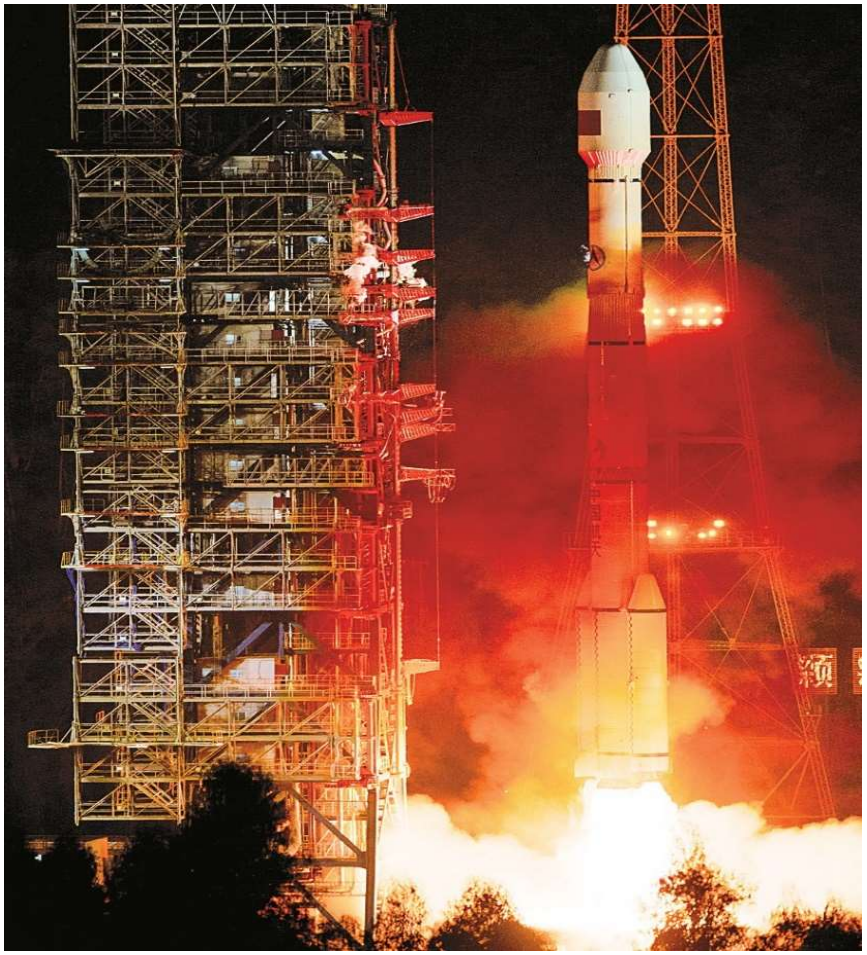

China's first hyperspectral satellite was Launched in May 9, 2018
We got Operational measurements since Sep, 2018, and responsible for it’s official product

Preflight evaluation of the performance of the EMI (Xenon lamp)

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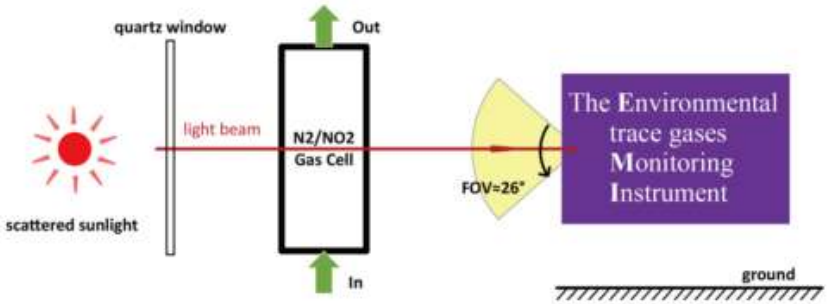
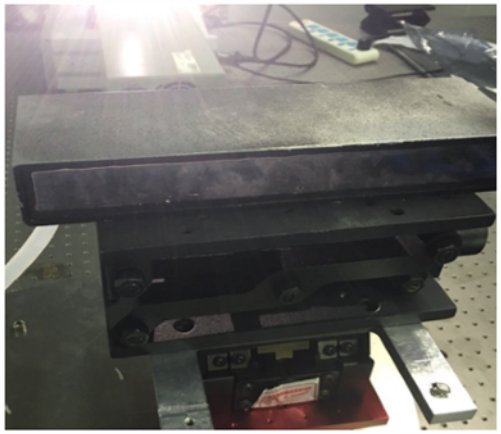
Schematic of the experimental setup



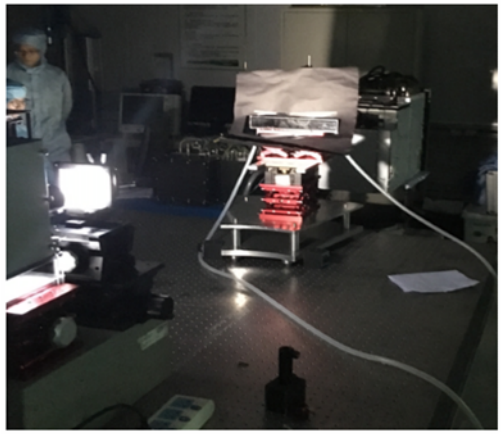
gas tank

flow rate control

sample cell



experiment shortcut



Put the known concertation of NO2 into the cell, let light pass through it , then retrieval the observed spectrum, compare the retrieved results with NO2 concentrations in the cell

Preflight evaluation of the performance of the EMI (Xenon lamp)

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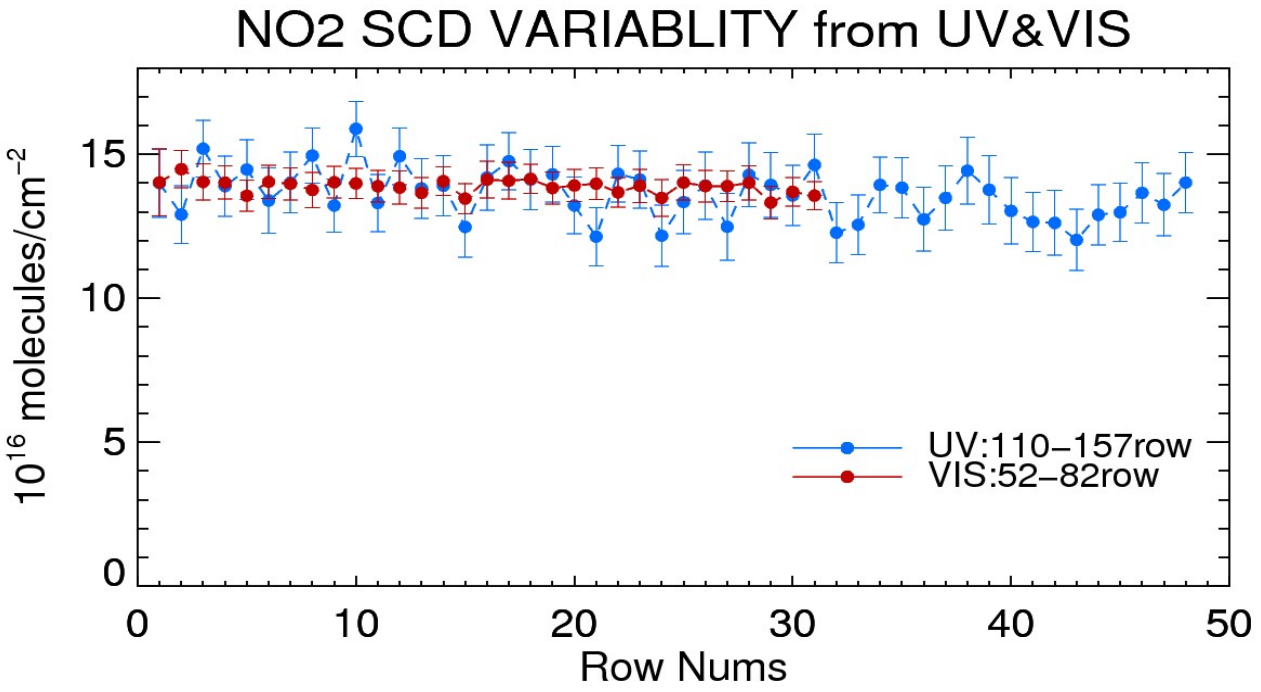

- ✓ The retrieved NO_2 results by both UV and visible spectra were $(1.41+0.1)*10^{17}$ molec/cm ^{2}, the true concentration of the standard gas is $1.40*10^{17}$ molec/cm^2. It indicated that both channel can meet the accuracy requirements for NO_2 observation.
- ✓ The results indicate that the variability of the corrected NO2 SCDs for different spatial rows is less than 3% in general.

Cx. Zhang, C.Liu,, et al., Transactions on Geoscience and Remote Sensing , 2018

Comparisons of EMI and TROPOMI instrument Performance

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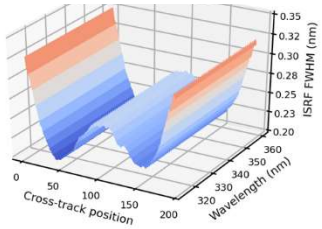
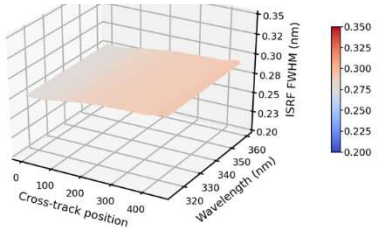
FWHM

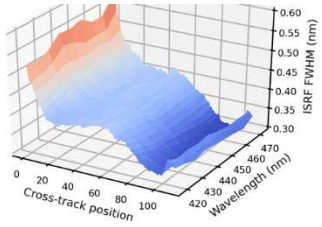
EMI UV ISRF FWHM



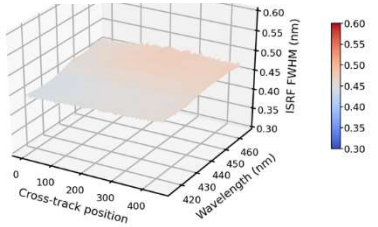
TROPOMI BAND3 ISRF FWHM



EMI VIS ISRF FWHM

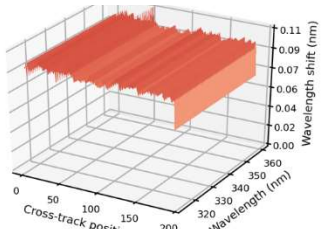


TROPOMI BAND4 ISRF FWHM

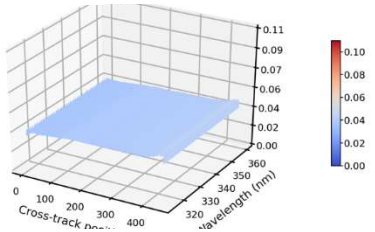


Shift

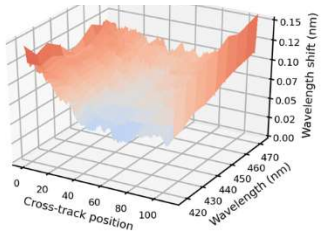
EMI UV Shift



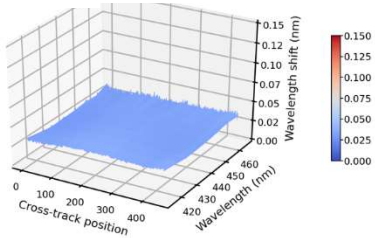
TROPOMI BAND3 Shift



EMI VIS Shift

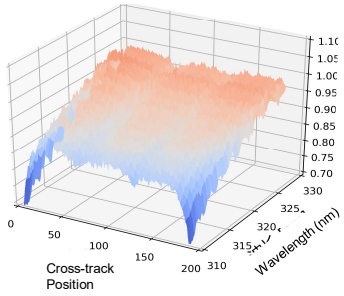


TROPOMI BAND4 Shift

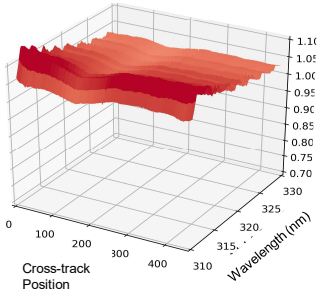


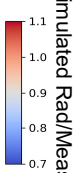
Radiometric Calibration

EMI UV



TROPOMI BAND3





Instrument Performance	EMI	TROPOMI	Ratio (TROPOMI/EMI)
Variations of FWHM with row	>0.25nm	< 0.03nm	~8.3
Variations of FWHM with time	8.09%	0.01%	~80.9
Wavelength shift	0.1nm	0.003nm	~33.3
Bias of radiometric calibration	<40%	< 10%	~0.4
UV SNR	<250	>850	~3.4
Irradiance	Once six months	daily	~182.5

EMI NO_2 retrieval

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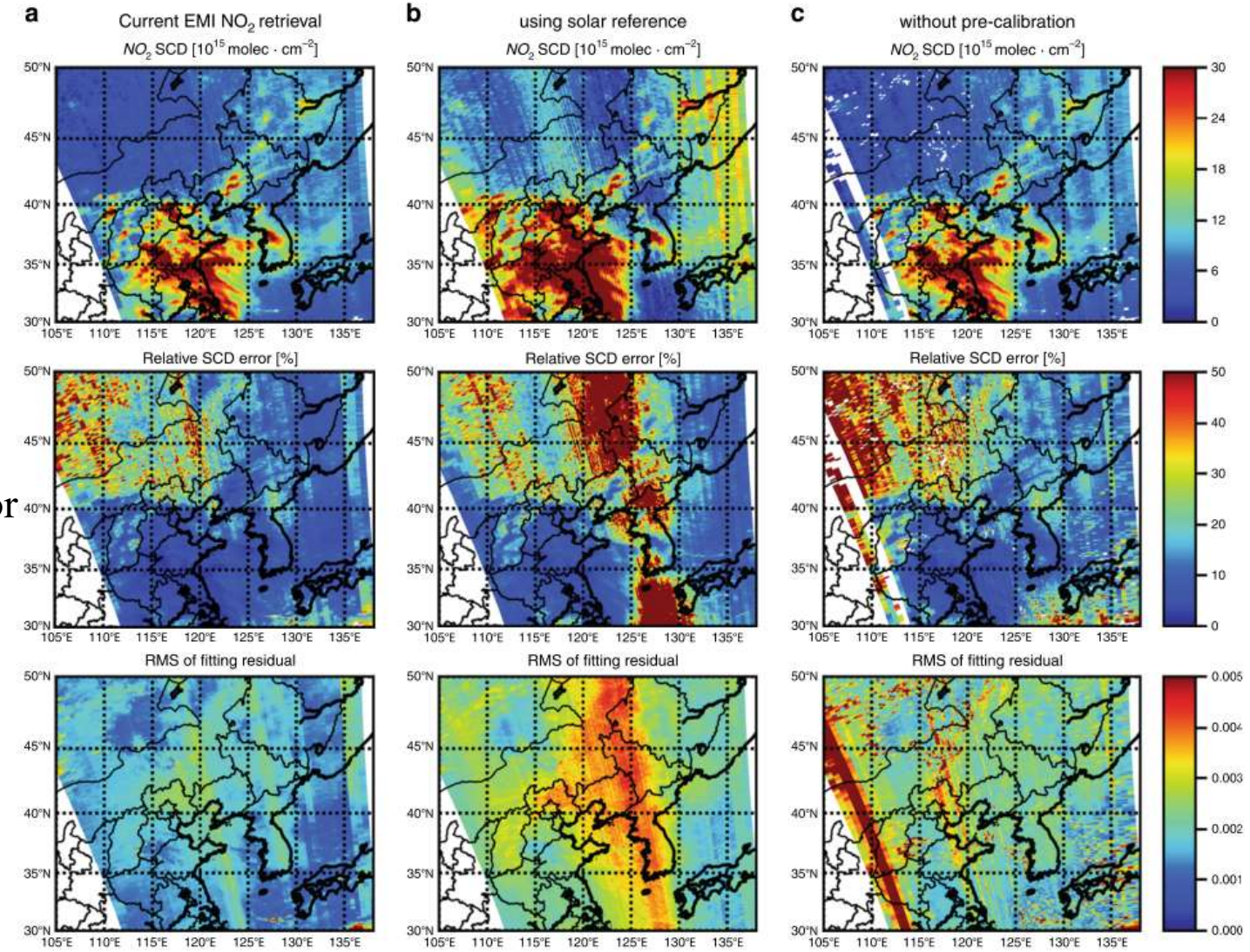
2018/12/17

NO2 SCD

Relative SCD error

RMS

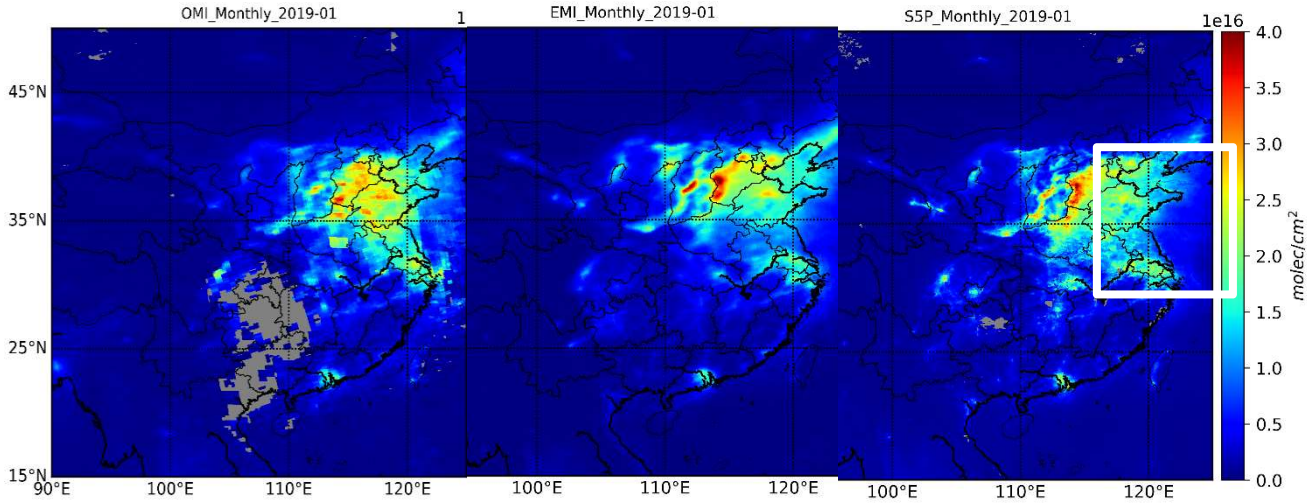


Cx. Zhang, C.Liu,, et al., Light: Science & Applications, 2020

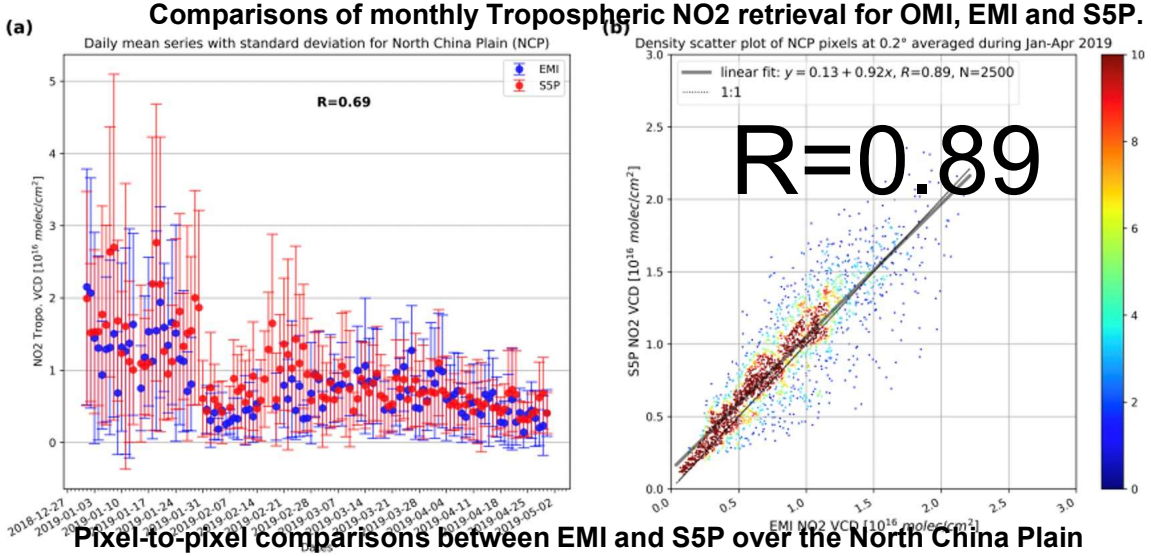
EMI NO2 Retrieval: cross-validations

中国科学技术大学 University of Science and Technology of China

OMI: 48*13 km EMI: 24*13 km S5P: 7*3.5 km



Comparisons of monthly Tropospheric NO2 retrieval for OMI, EMI and S5P.



Pixel-to-pixel comparisons between EMI and S5P over the North China Plain

- ✓ EMI captures similar spatial patterns and amplitude of NO2 distribution to TROPOMI.
- ✓ EMI NO2 data shows better performance than OMI in the smoothness and coverage, yet lower spatial resolution than TROPOMI.
- ✓ Good correlation was found between pixel-to-pixel daily comparisons of EMI and TROPOMI NO2 observations over the North China Plain.

Cx. Zhang, C.Liu,, et al., Light: Science & Applications, 2020

EMI HCHO Retrieval

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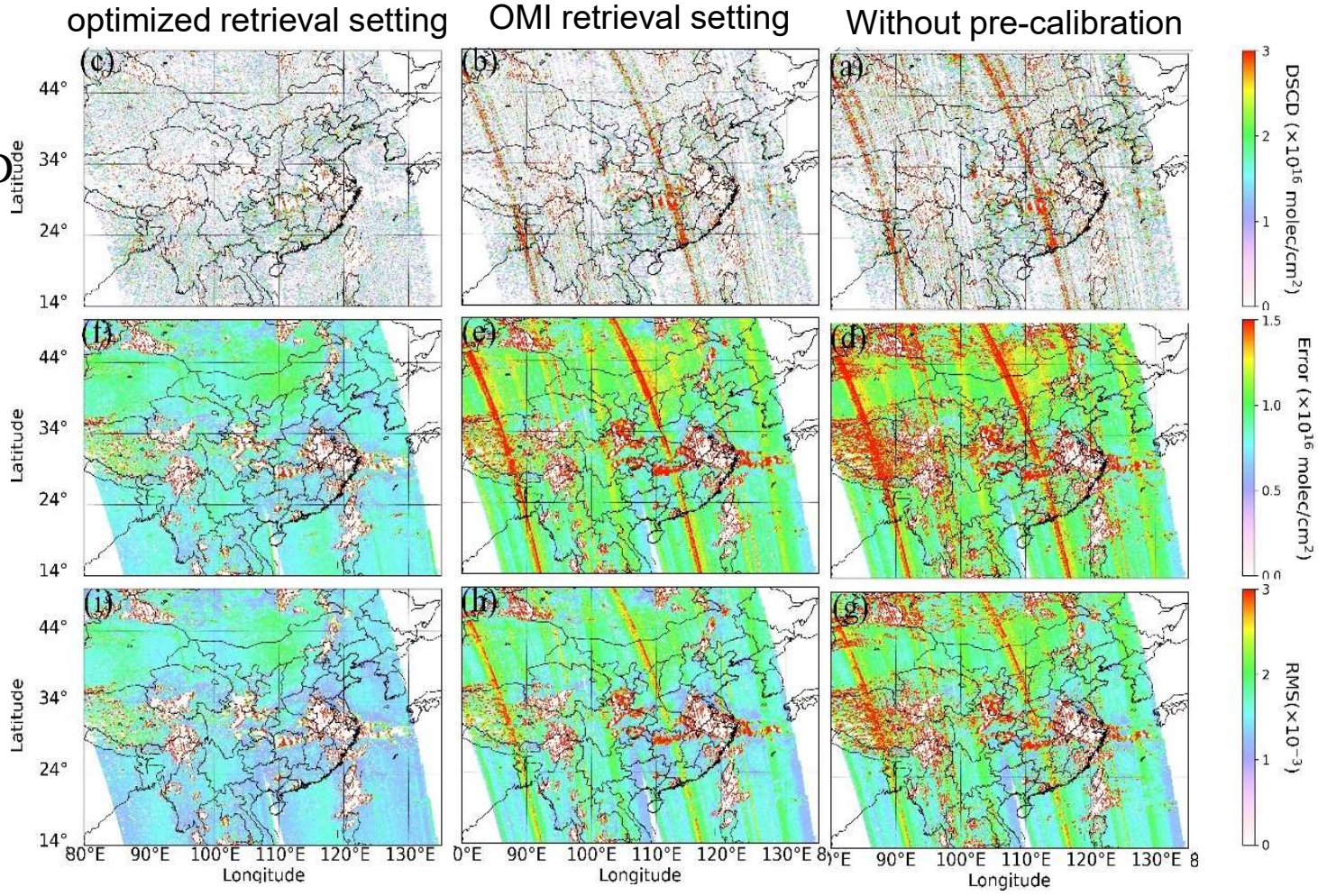
2019/05/15

HCHO DSCD

SCD error

RMS



EMI HCHO: in preparation

EMI HCHO Retrieval: cross-validations

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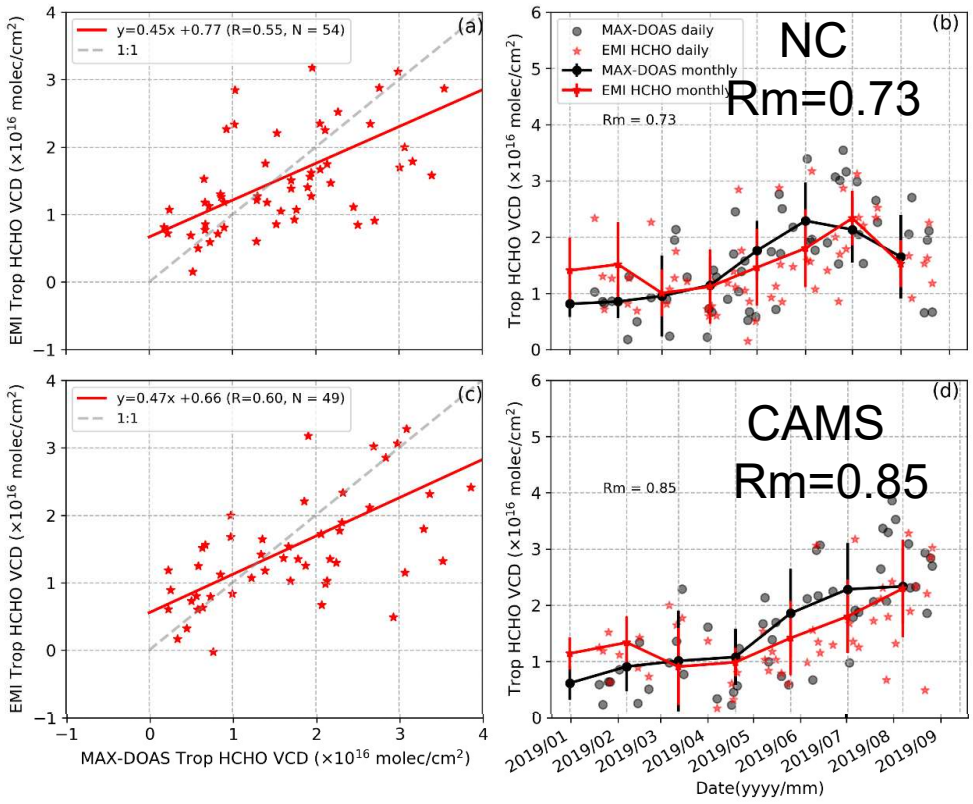

- ✓ EMI HCHO VCDs good correlation with MAX-DOAS HCHO VCDs with the Pearson correlation coefficient of 0.73 and 0.85 at NC and CAMS sites.
- ✓ The normalized mean biases (NMB) between EMI and MAX-DOAS HCHO VCDs are 7.65 % 14.50 % at NC and CAMS sites.

EMI HCHO: in preparation

EMI HCHO Retrieval: cross-validations

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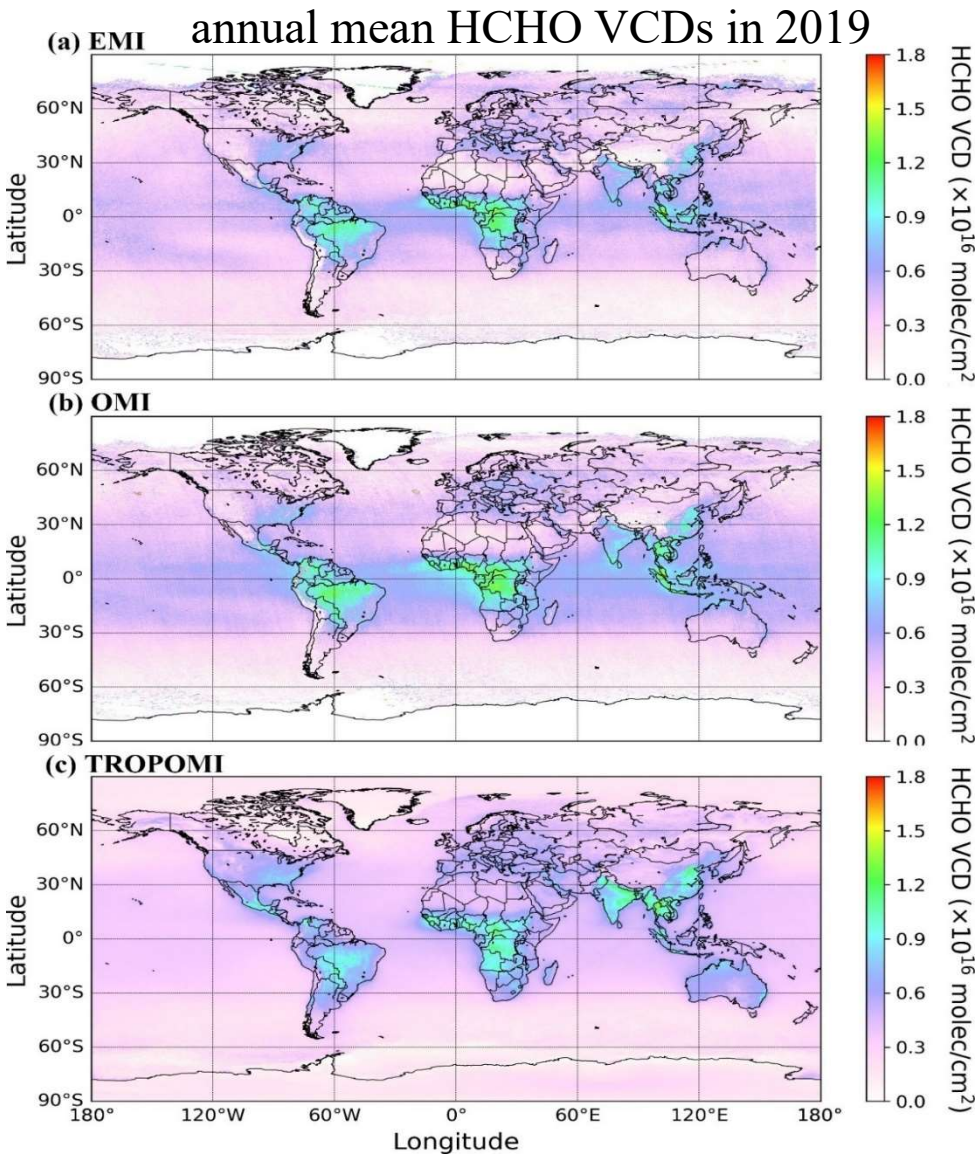

- ✓ Annual mean HCHO VCDs measured by EMI, OMI and TROPOMI instruments show similar spatial patterns and amplitudes.
- ✓ Hotspots in Amazon basin, Equatorial Africa and Southeast Asia are detected by EMI instruments successfully.

Wj.Su, C.Liu et al., Tropomi HCHO, AMT, 2020
EMI HCHO: in preparation

EMI O3 Retrieval: cross-validations

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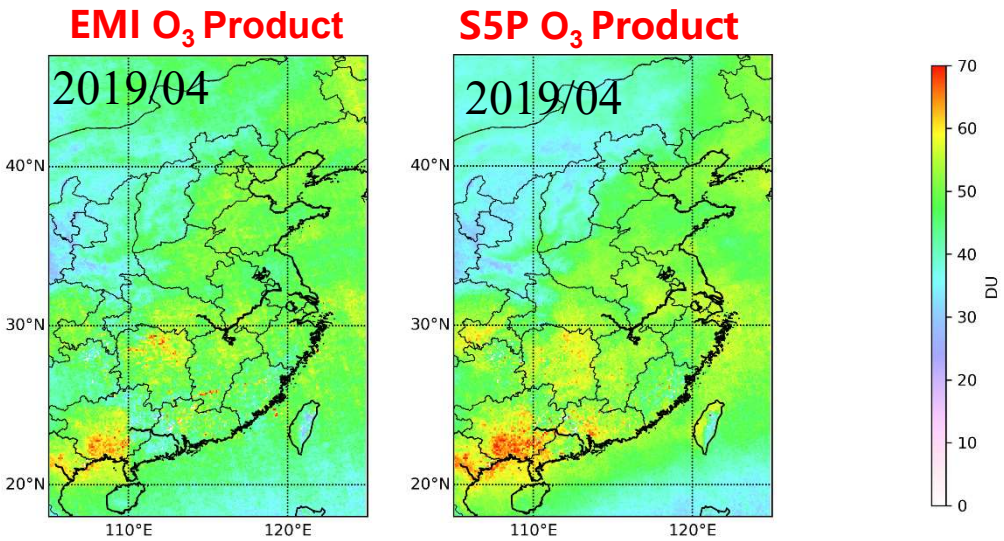
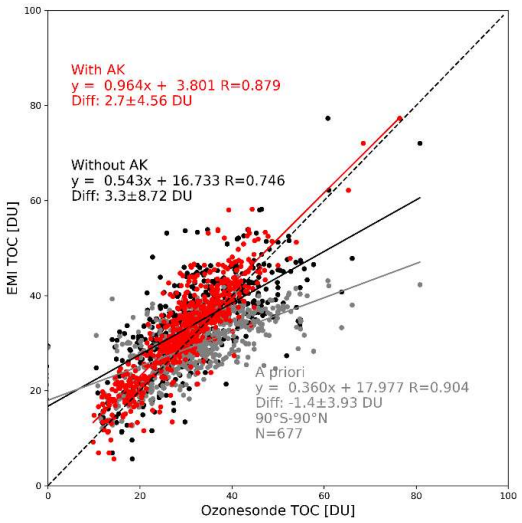


USTC: Optimal Estimation (OE) algorithm
Ref: Liu et al., Atmos. Chem. Phys. 2010;

Monthly a priori profiles from GEOS-Chem simulations;



Validations with ozonesonde O3 products:

1. Spatial comparisons:
   [-90S ~ 90N, 180W ~ 180E]
2. Correlation is 0.879 with the mean bias of 2.7 DU with EMI AKs

F. Zhao, C.Liu et al., Tropomi O3 profile: STOTEN, 2020
EMI O3: in preparation

EMI SO2 Retrieval: cross-validations

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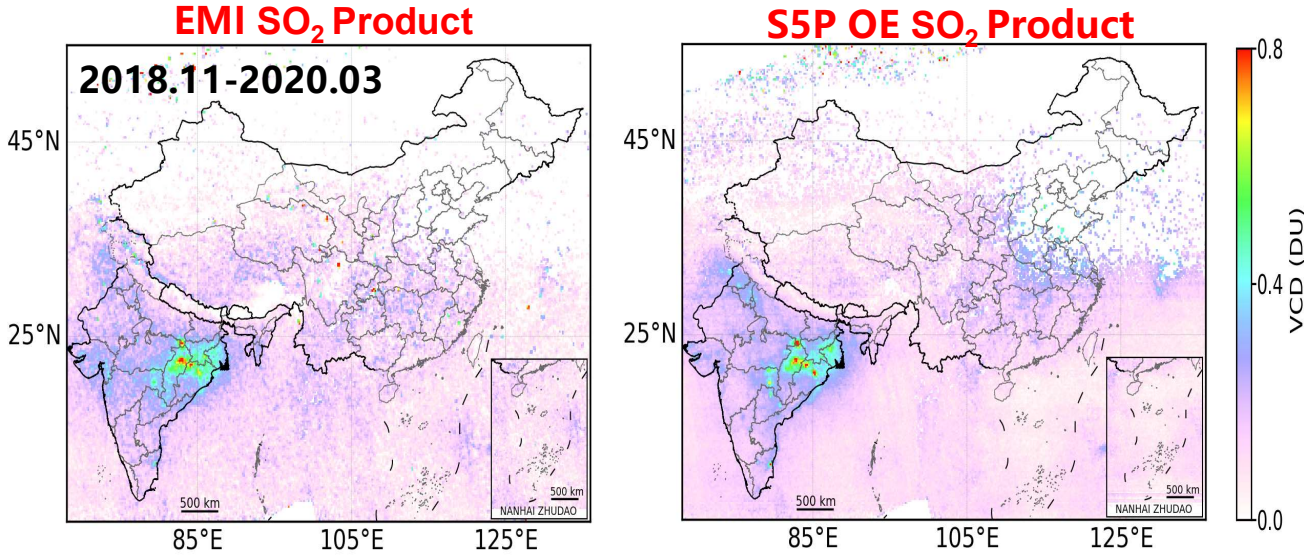
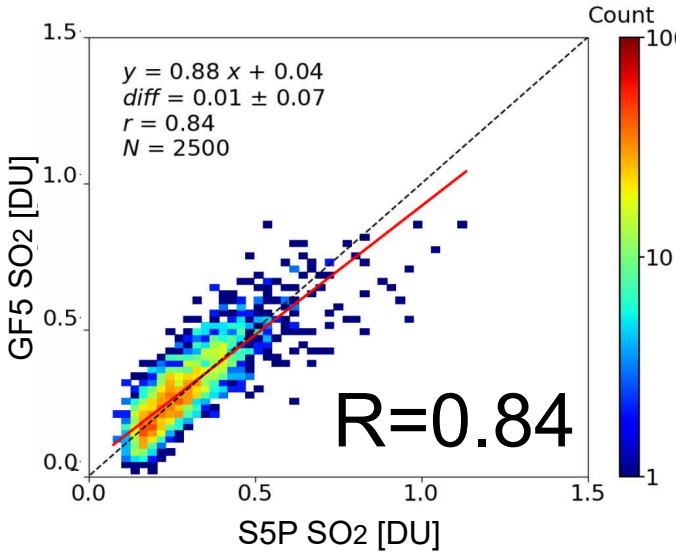
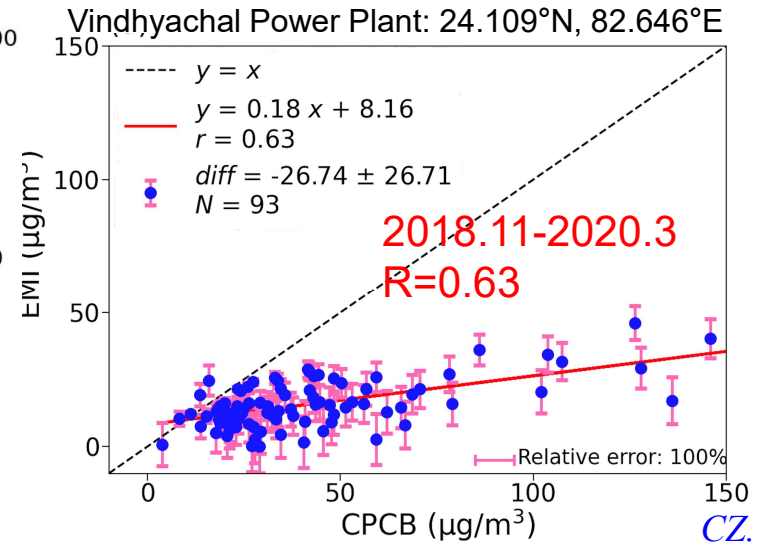
GF5 SO_2: compared with S5P SO_2 over India







USTC: Optimal Estimation (OE) algorithm

Monthly a priori profiles from GEOS-Chem simulations;

Validations:

1. Spatial comparison:
   With S5P OE SO_2 Product
   [18N ~ 26N, 78E ~ 90E]
   Correlation is 0.84 with the mean bias of 0.01 DU

2. Temporal comparison:
   With in situ measurements
   Correlation is 0.63 with the relative mean bias of 54%

CZ. Xia,C.Liu et al., Sci Bull. 2021

TanSat Introduction

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TanSat (CarbonSat)

TanSat (CarbonSat):

- the first dedicated carbon mission of the Chinese space program
- Launched in December 2016, flies in a sun-synchronous, 700 km altitude orbit with a 3-year lifetime and a 16-day revisit period
- Carries two instruments: ACGS and CAPI
- Can monitor atmospheric O_2 and CO_2 in three bands
- Spatial resolution is 2 km × 2 km and spectral resolution is 0.044 to 0.16 nm.

Technical Characteristics of TanSat-ACGS

Band	O_2-A	Weak CO_2	Strong CO_2
Spectral coverage (nm)	758–778	1594–1624	2042–2082
Spectral resolution (nm)	0.044	0.12	0.16
Pixels number	1242×9	500×9	500×9
Spatial resolution	2 km × 2 km		
Data coverage	Feb 2017 to present	Feb 2017 to Oct 2018	Feb 2017 to Oct 2018

TanSat Research

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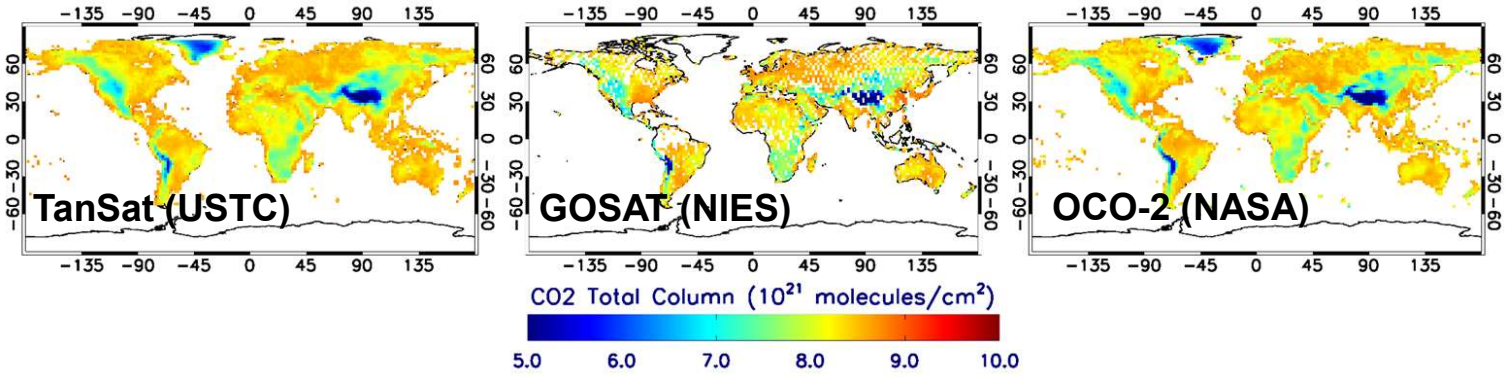
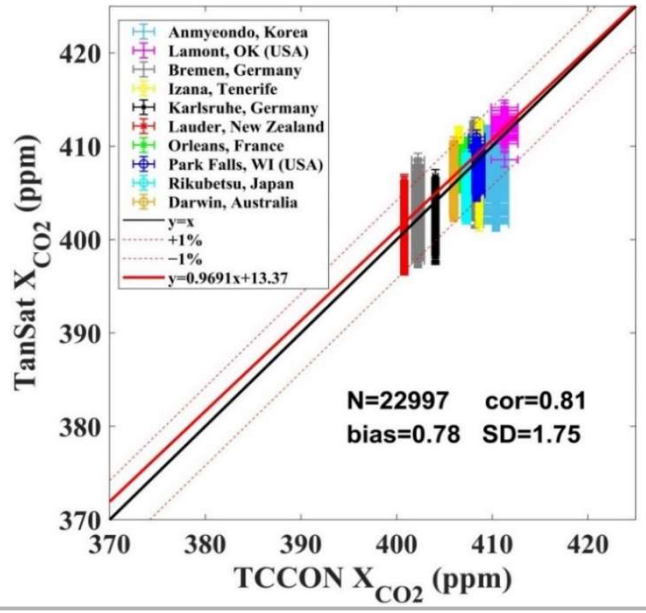
Annual average distribution of global total CO2 column of TanSat, GOSAT and OCO-2 (Sep.2017 to Aug. 2018)



Validation of TanSat X_{CO2} retrieval with TCCON



- Cross-satellite validations of TanSat with GOSAT and OCO-2 showed consistently spatiotemporal trends and a better coverage than GOSAT.
- Comparisons between TanSat X_{CO2} retrieval and TCCON indicated a good correlation with the mean bias of -0.78 ppm, the standard deviation at 1.75 ppm.

X. Hong et al., P.zhang,C.Liu.IEEE TGRS, 2021

Thank you for your attention!