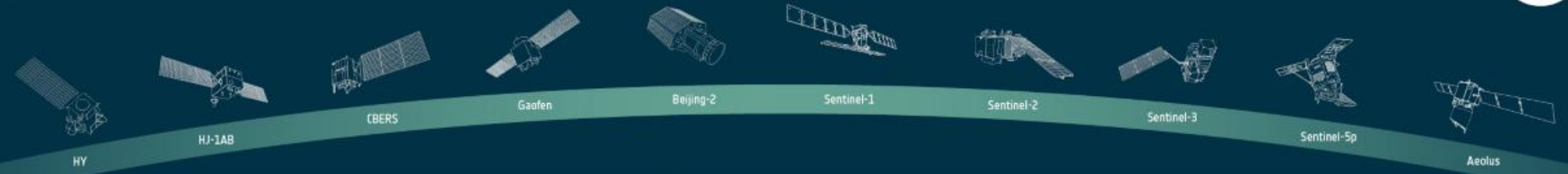


2022 DRAGON 5 SYMPOSIUM

MID-TERM RESULTS REPORTING

17-21 OCTOBER 2022

PROJECT ID. 59327

GROUND-BASED REMOTE SENSING MEASUREMENTS AT XIANGHE: DEVELOPMENT AND APPLICATIONS

Dragon 5 Mid-term Results Project

20/OCT/2022: 10:20AM-11:50AM · SESSION: VR1 ORAL

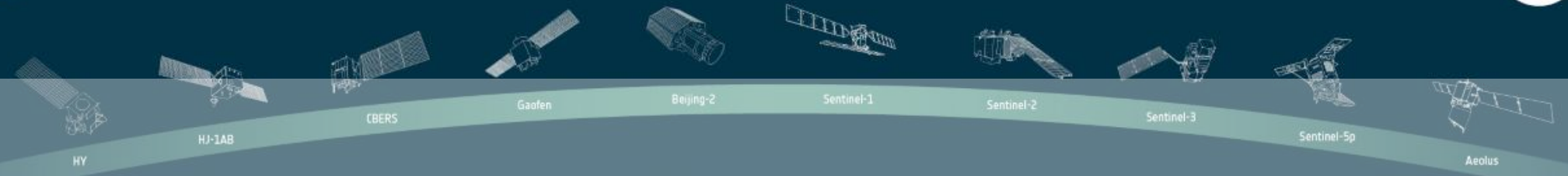
ID. 172

PROJECT TITLE: VALIDATION OF CHINESE CO2-MEASURING SENSORS AND EUROPEAN TROPOMI/SENTINEL-5 PRECURSOR USING FTIR AND MAX-DOAS DATA AT XIANGHE (VCEX)

PRINCIPAL INVESTIGATORS: DR. BART DILS, PROF. DR. PUCAI WANG

CO-AUTHORS: BART DILS, PUCAI WANG, MINQIANG ZHOU, MICHEL VAN ROOZENDAEL, MARTINE DE MAZIÈRE, MARTINA FRIEDRICH, FRANCOIS HENDRICK, BAVO LANGEROCK, WEIDONG NAN, GAIA PINARDI, MAHESH KUMAR SHA, CORINNE VIGOUROUX, TING WANG

PRESENTED BY: BART DILS



1. BACKGROUND

2. ATMOSPHERIC REMOTE SENSING ACTIVITIES AT XIANGHE

3. VALIDATION ACTIVITIES AT XIANGHE

Background

Royal Belgian Institute for Space Aeronomy
Brussels

- UV-VIS DOAS group (Dr. M. Van Roozendael)
- FTIR group (Dr. M. De Mazière)

Institute of Atmospheric Physics – Chinese Academy of Sciences
Xianghe

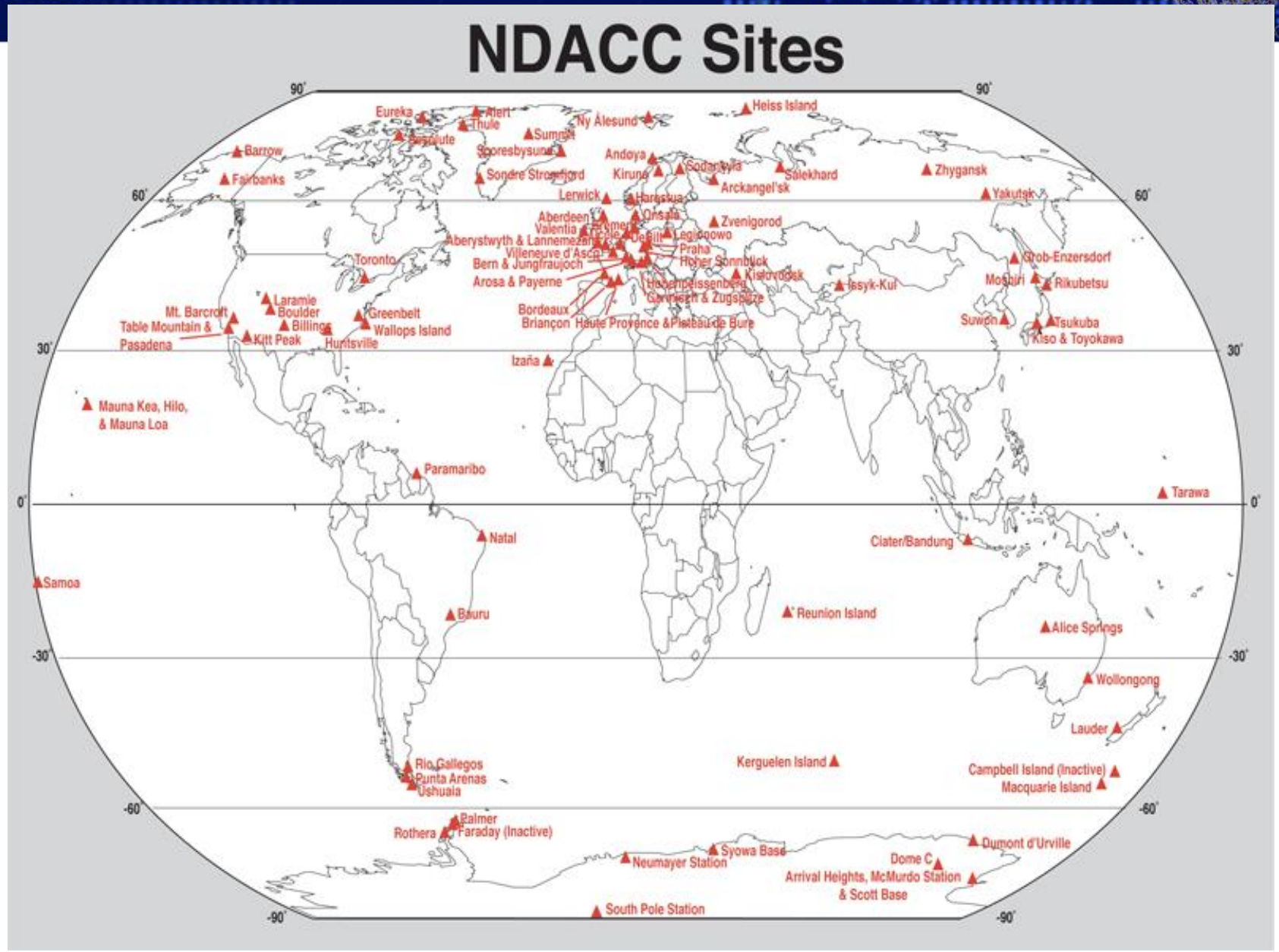
Prof P. Wang

Collaboration goal

TOTAL CARBON COLUMN OBSERVING NETWORK (TCCON)

- Snapshot 2008
- Little to no coverage in South America, Africa and mainland Asia

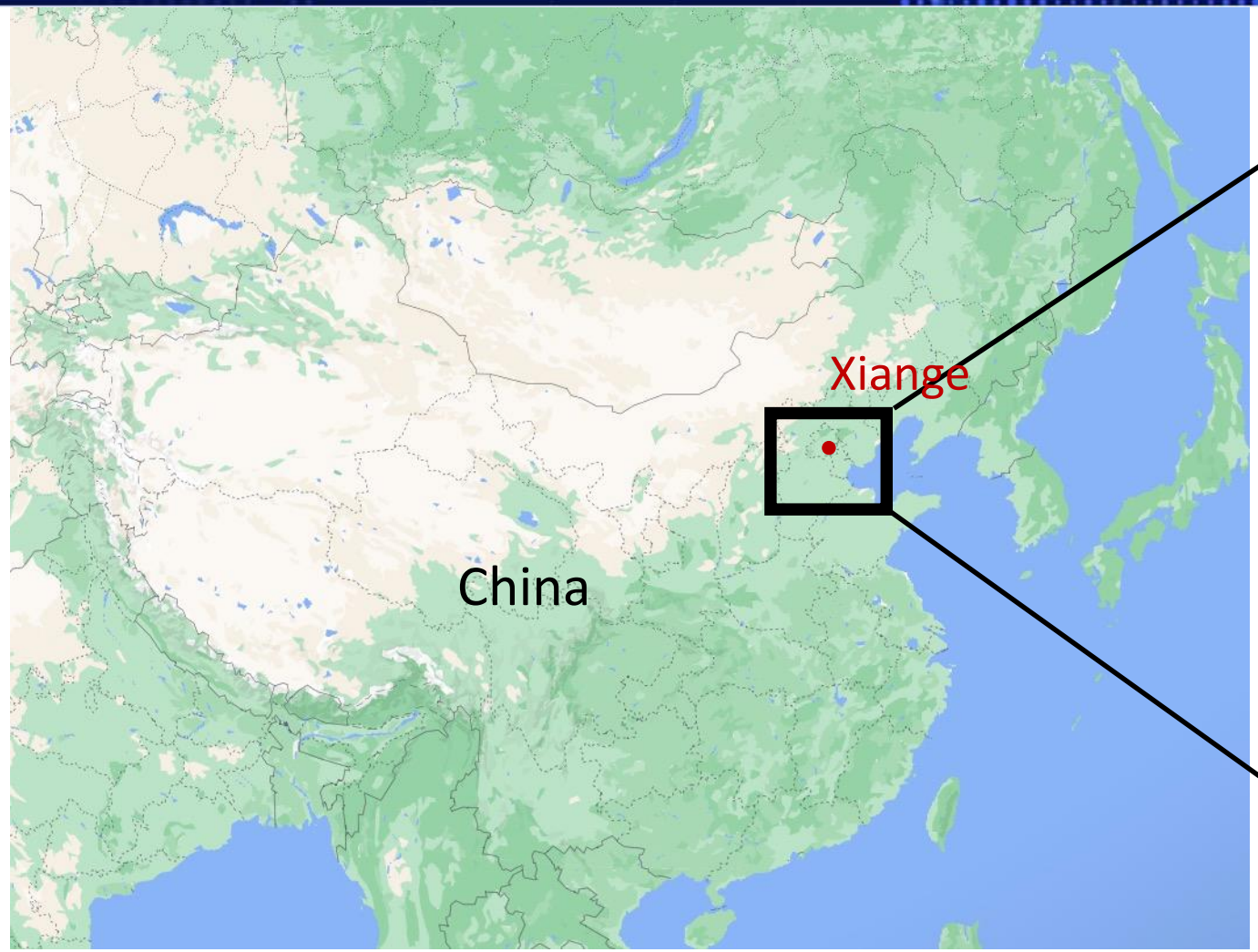
BIRA

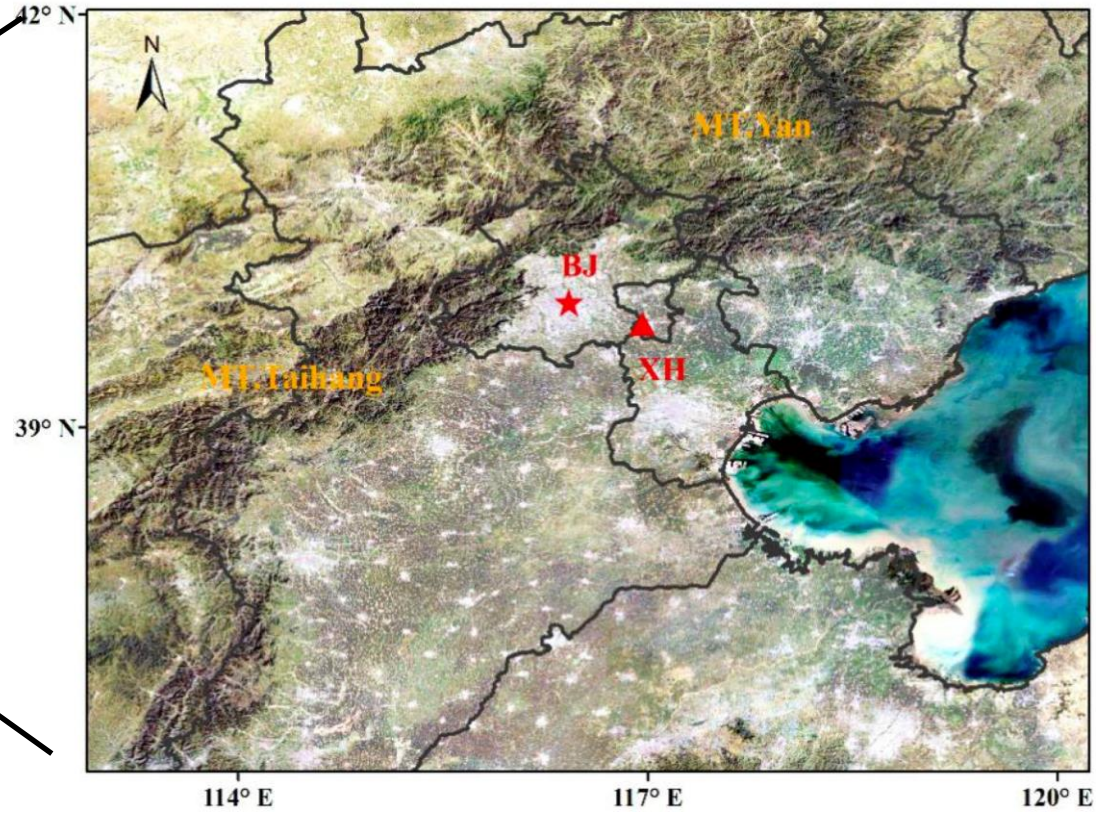


Network for the Detection of Atmospheric Composition Change (NDACC)

- Quasi-Global coverage is vital for model assimilation, satellite validation etc
- Strong need for these networks to incorporate sites in China

The measurement site





50km to the east-southeast of Beijing
and 70 km to the north-northwest of Tianjin

First Collaboration

BIRA-IASB MAX-DOAS instrument

- 2-channel MAX-DOAS spectrometer developed at BIRA in 2008 and permanently installed in Xianghe in Feb. 2010
- Continuously operated until Aug. 2022 in collaboration with IAP/CAS
- Instrument due to be replaced
- Total columns of O_3 and NO_2
- Tropospheric profiles of NO_2, HCHO, glyoxal, HONO and SO_2
- Aerosol AOD and extinction profile

status Bruker 125HR FTIR instrument

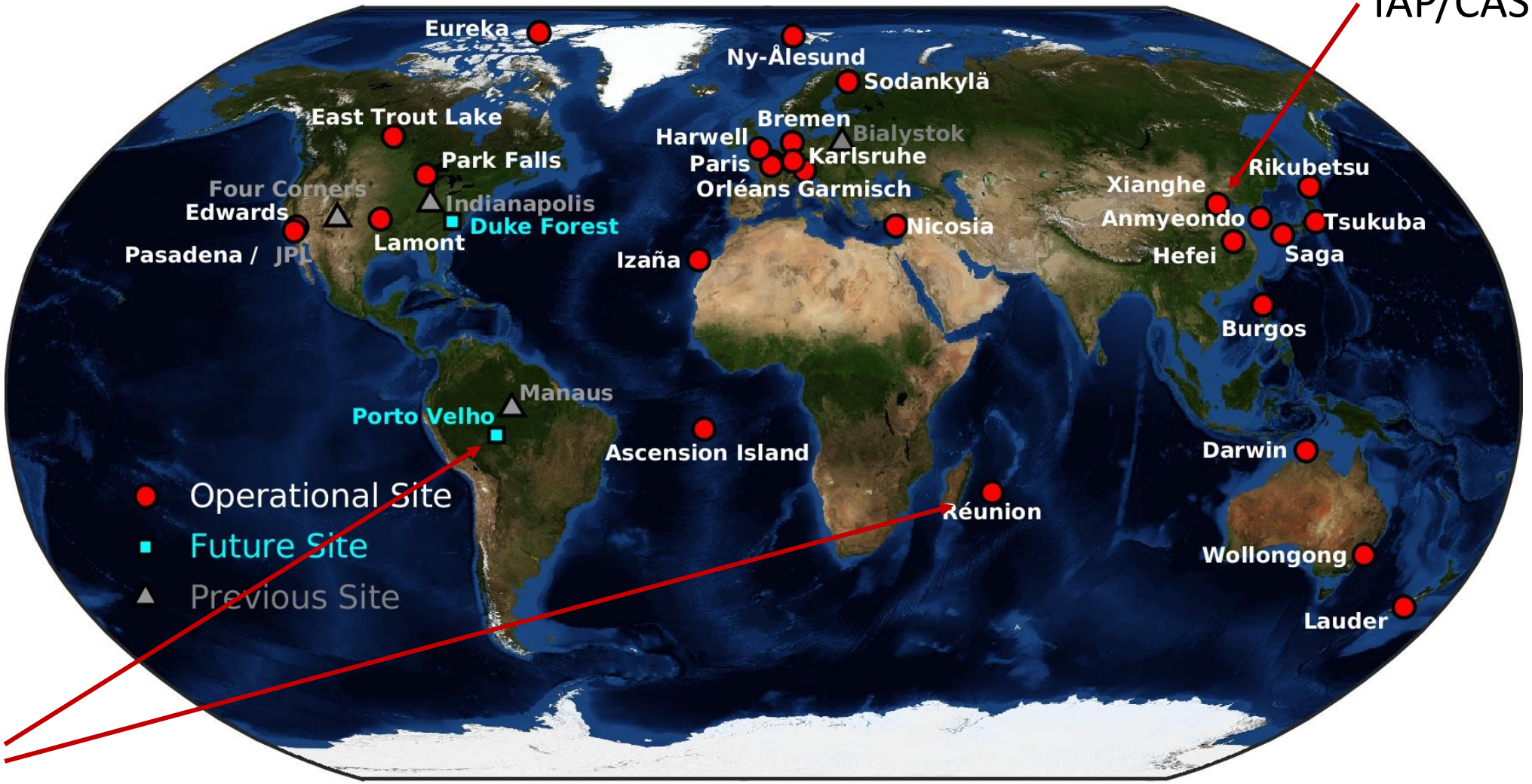
- TCCON type measurements since August 2018
- **Became a formal TCCON site 3 September 2021!**
- Dr. Minqiang ZHOU (ex-BIRA [2015-2021], currently at IAP in the team of Prof. WANG) became a member of the Steering Committee of TCCON on the same day

- 2nd Chinese TCCON site after Hefei (Anhui Institute of Optics and Fine Mechanics (AIOFM), Hefei Institutes of Physical Science) formally a TCCON site since 2018

TCCON status Bruker 125HR FTIR instrument

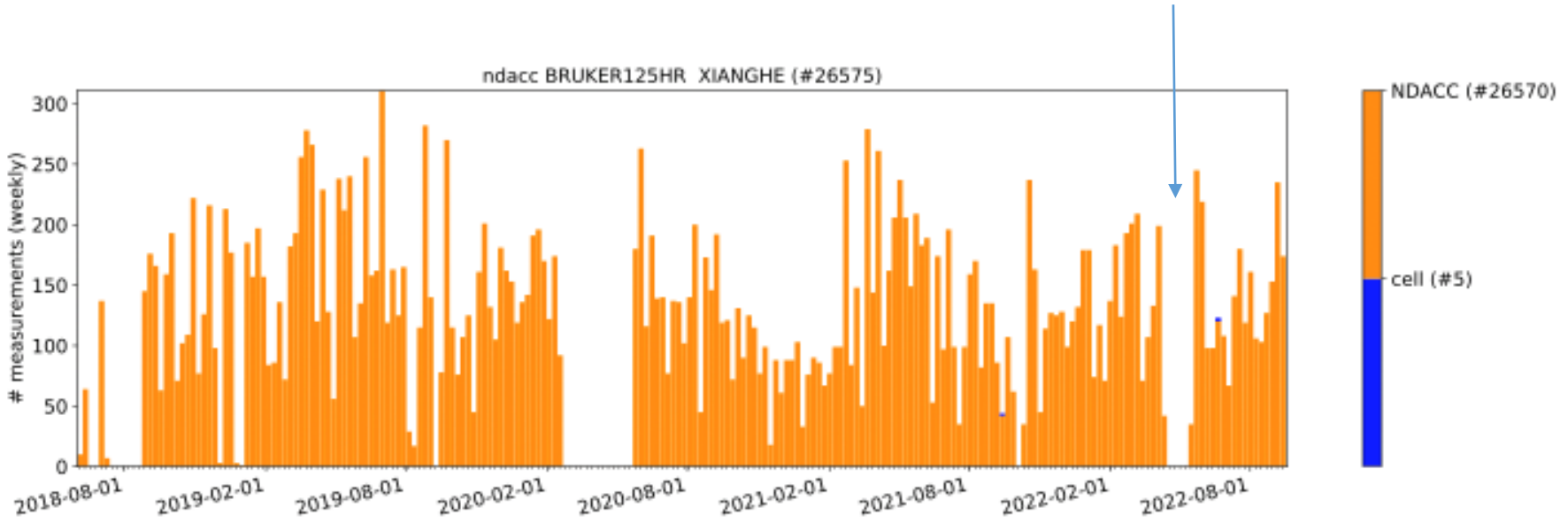
Current TCCON

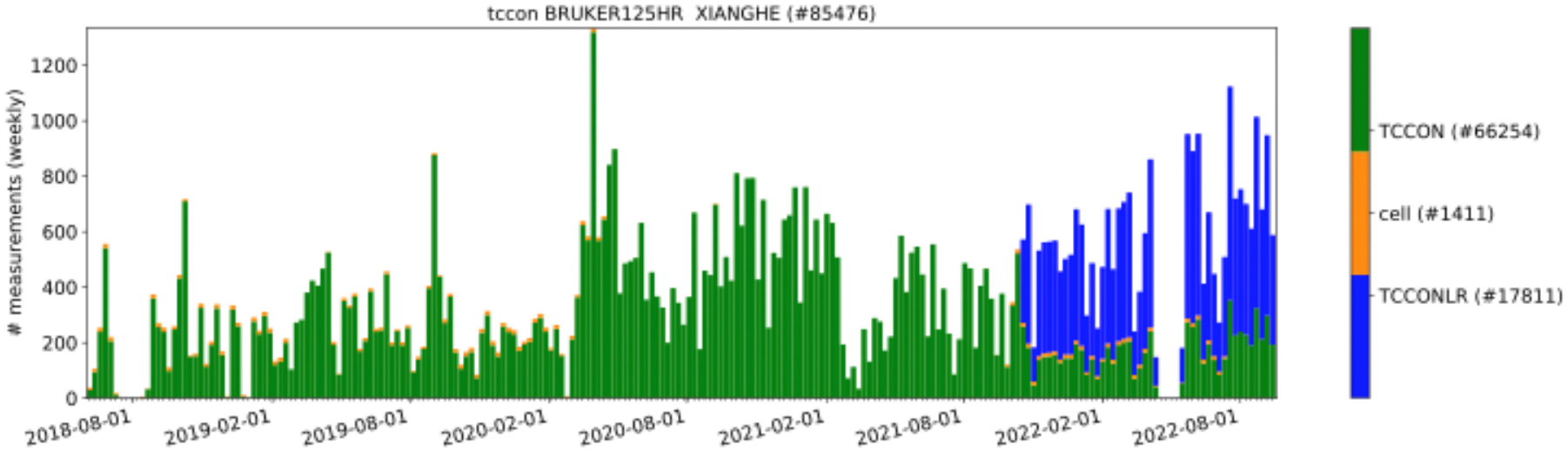
IAP/CAS



BIRA

Remote sensing instruments

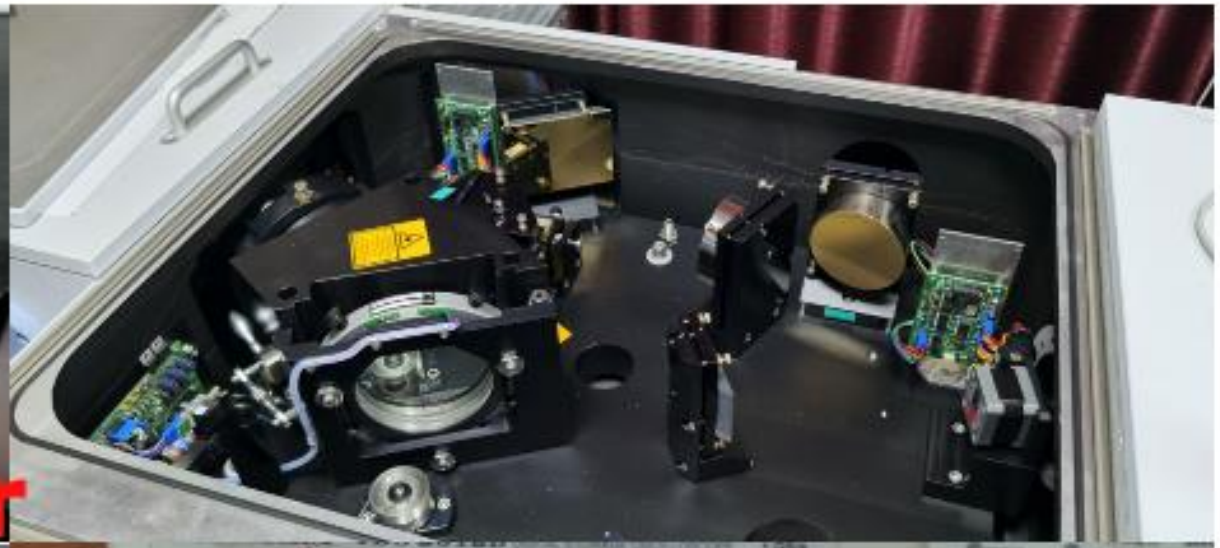


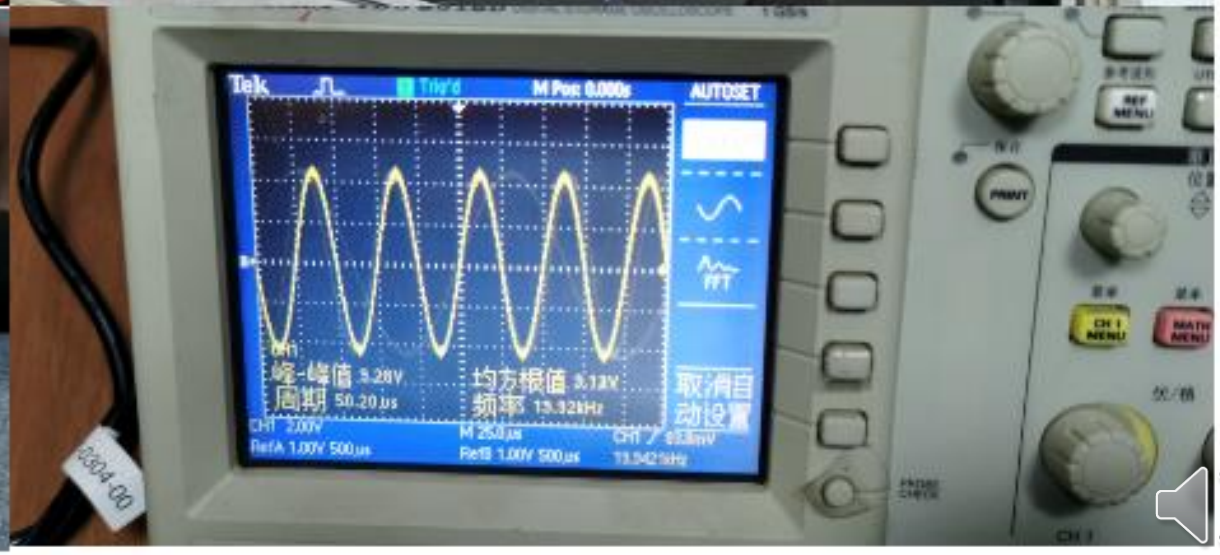


- TCCON – LR mode added since Nov 2011
- ~150 spectra for NDACC per week
- ~ 200 spectra for TCCON per week
- ~ 400 spectra for TCCON- LR per week

BRUKER 125HR

LASER replacement for Bruker 125HR instrument





Remote sensing instruments

Bruker 125HR FTIR


Pandora


Microwave CIMEL-318


Bruker EM27/SUN


Brewer

MIN-DOAS MAX-DOAS


Remote sensing instruments

XIANGHE remote sensing activities affiliated or collabrated with international networks

Instrument	Networks	Status	Insturment note (last year)
Bruker 125HR	TCCON	Operational	Laser down (2 month gap)
Bruker 125HR	NDACC	Application	Laser down (2 month gap)
Bruker EM27/SUN	COCCON	Operational	-
Pandora	PNG	Application	-
Cimel 318	AERONET	Operational	-
Brewer	WMO	Operational	-
MAX-DOAS	NDACC	Operational*	Detector fail since Aug 2022

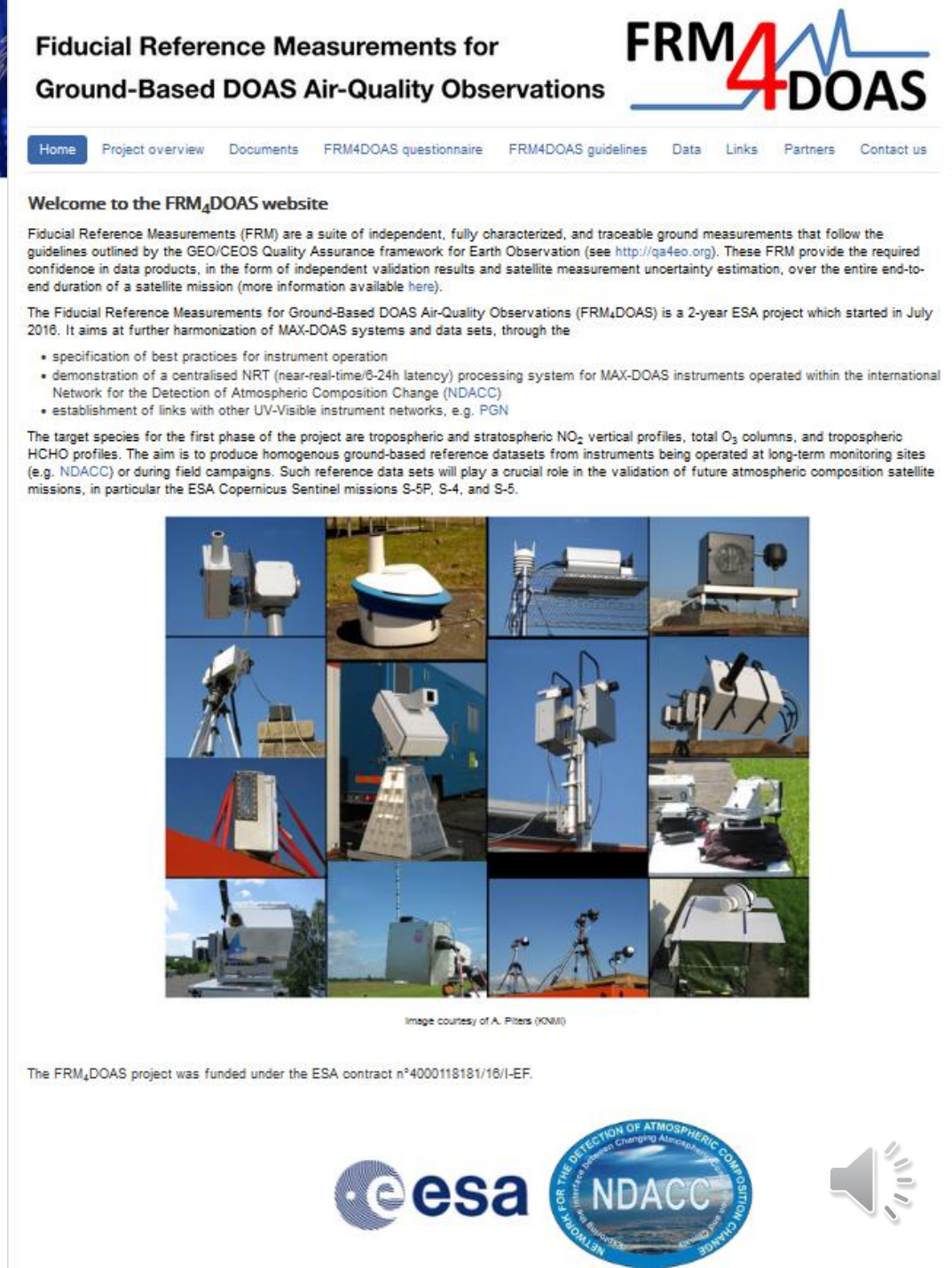
* Data on NDACC Rapid Delivery site, Consolidated pending

MAX-DOAS

- Optimization and standardization of retrieval strategies for NO_2, HCHO, glyoxal and SO_2

Important to have a wide range of stations operating under different conditions!

- Operational centralized processing of Xianghe UV-Vis MAX-DOAS data for NO_2 and HCHO using FRM_4DOAS system
- Exploitation of Xianghe MAX-DOAS data series for the validation of GOME-2, OMI, TROPOMI and GEMS satellite data, with a focus on NO_2, HCHO, glyoxal and SO_2 data products



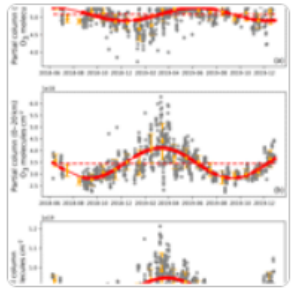
FTIR

- Like with MAX-DOAS we see a strong push towards ever more harmonized retrieval strategies

Research article

09 Oct 2020

Ground-based Fourier transform infrared (FTIR) O_3 retrievals from the 3040 cm^{-1} spectral range at Xianghe, China



Minqiang Zhou[1], Pucai Wang[2,3,4], Bavo Langerock[1], Corinne Vigouroux[1], Christian Hermans[1]
Nicolas Kumps[1], Ting Wang[2], Yang Yang[2], Denghui Ji[2], Liang Ran[2], Jinqiang Zhang
Françoise Posny[5], Valentin Duflot[5,6], Jean-Marc Metzger[6], and Martine De Maz

Deriving Temporal and Vertical Distributions of Methane in Xianghe Using Ground-based Fourier Transform Infrared and Gas-analyzer Measurements

Denghui Ji, Minqiang Zhou, Pucai Wang, Yang Yang, Ting Wang, Xiaoyu Sun, Christian Hermans, Bo Yao & Gengchen Wang

Advances in Atmospheric Sciences **37**, 597–607 (2020) | Cite this article

- Exploitation of Xianghe data for the validation studies

Xianghe satelite validation acitivities

FTIR - TCCON – TROPOMI/OCO

- CO (Sha et al., 2021)
- CH4 (Sha et al., 2021)
- CO2 (Zhou et al., 2022)

https://acp.copernicus.org/articles/21/12561/2021/acp-21-12561-2021.html

https://amt.copernicus.org/articles/14/7775/2021/

FTIR - NDACC – TROPOMI

- HCHO (Vigouroux et al., 2021)
- NO2 (Vigouroux et al., in preparation)

https://www.mdpi.com/2072-4292/14/1/214

https://amt.copernicus.org/articles/13/3751/2020/amt-13-3751-2020-discussion.html

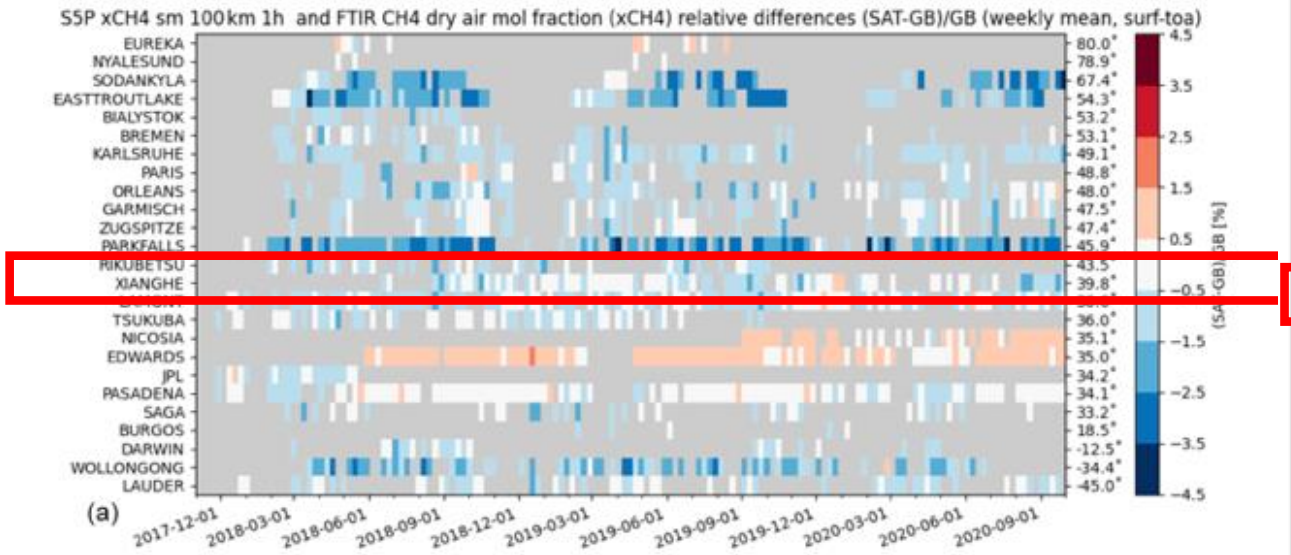
DOAS - NDACC – TROPOMI/OMI

- NO2 (Wang et al., 2022)
- HCHO (De Smedt et al., 2021)
- CHOCHO (Lerot et al., 2021)

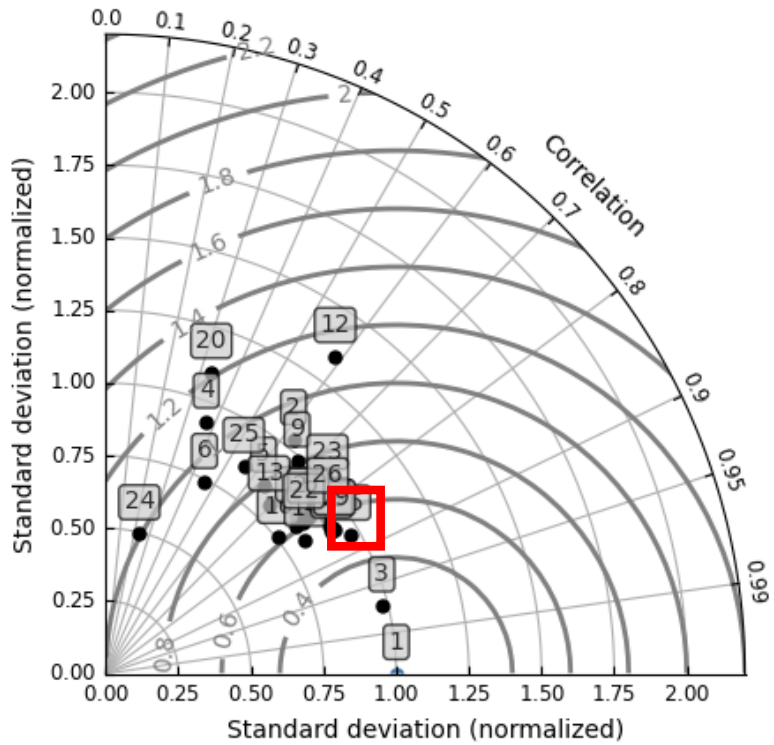
https://www.mdpi.com/2072-4292/14/15/3769

https://amt.copernicus.org/articles/14/6249/2021/amt-14-6249-2021-discussion.html

TROPOMI-FTIR- CH4 validation



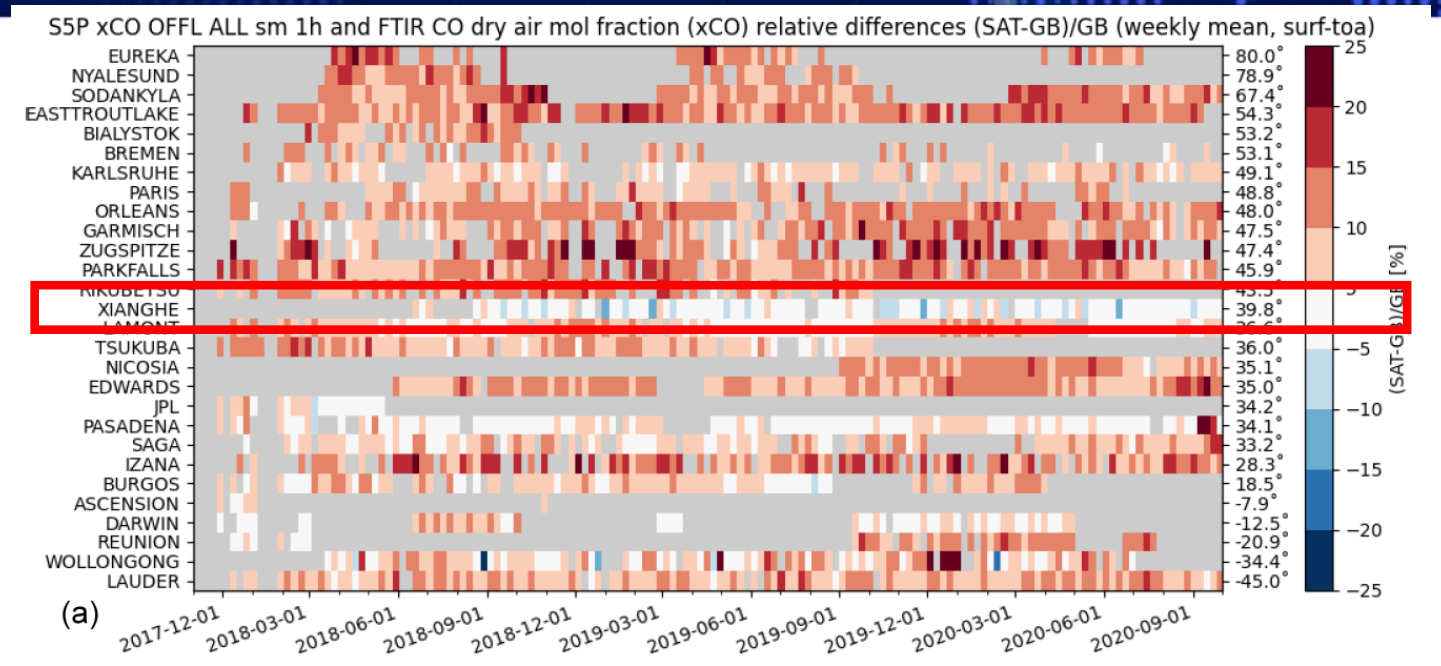
1: S5P xCH4 sm 100km bc 1h
2: EUREKA (1384)
3: NYALESUND (113)
4: SODANKYLA (5915)
5: EASTTROUTLAKE (12302)
6: BIALYSTOK (1821)
7: BREMEN (1150)
8: KARLSRUHE (4592)
9: PARIS (4999)
10: ORLEANS (5984)
11: GARMISCH (3149)
12: ZUGSPITZE (578)
13: PARKFALLS (7201)
15: XIANGHE (4395)
17: TSUKUBA (4655)
18: NICOSIA (3414)
19: EDWARDS (24350)
20: JPL (3233)
21: PASADENA (20646)
22: SAGA (2539)
23: BURGOS (417)
24: DARWIN (3598)
25: WOLLONGONG (4765)
26: LAUDER (6708)

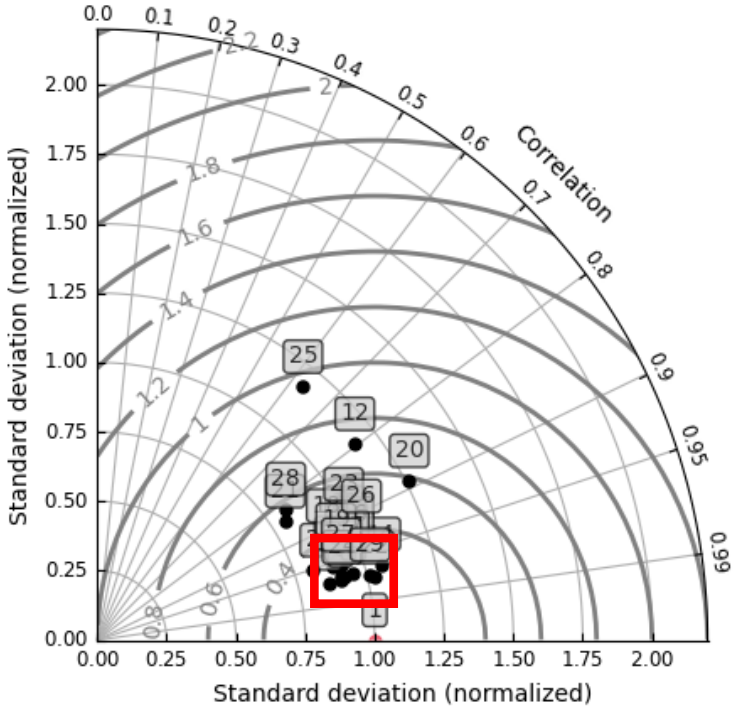


Overall:

- Small mean bias < 0.5%
- Consistent: no seasonal variatition in bias
- Good correlation R>0.8
- Stds observed by sat and g-b are in the same order

TROPOMI-FTIR- CO validation

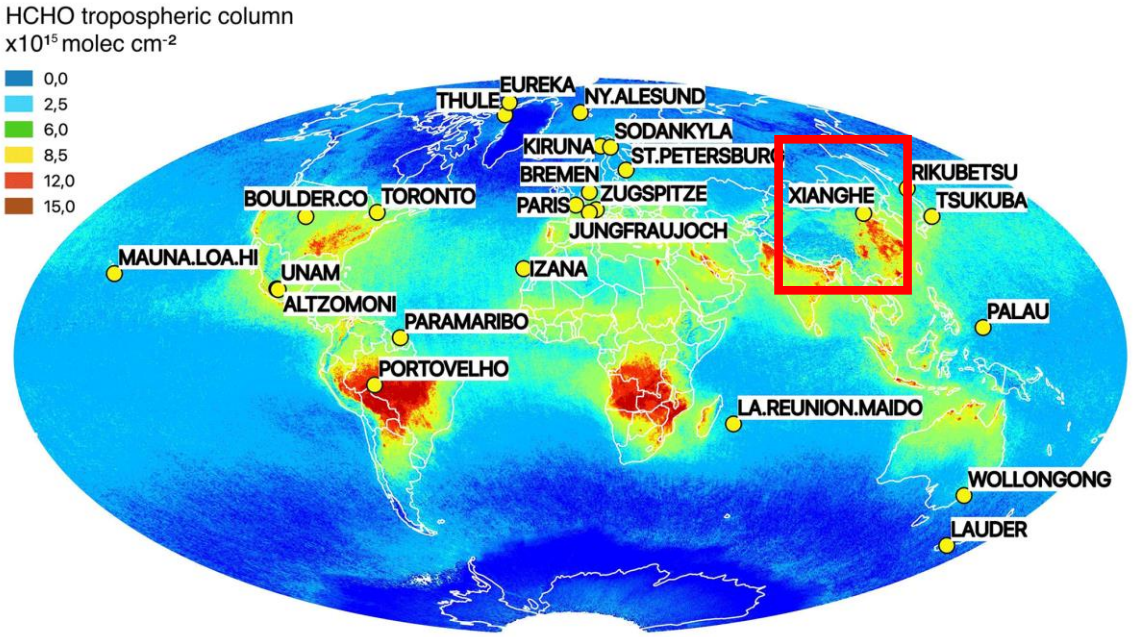


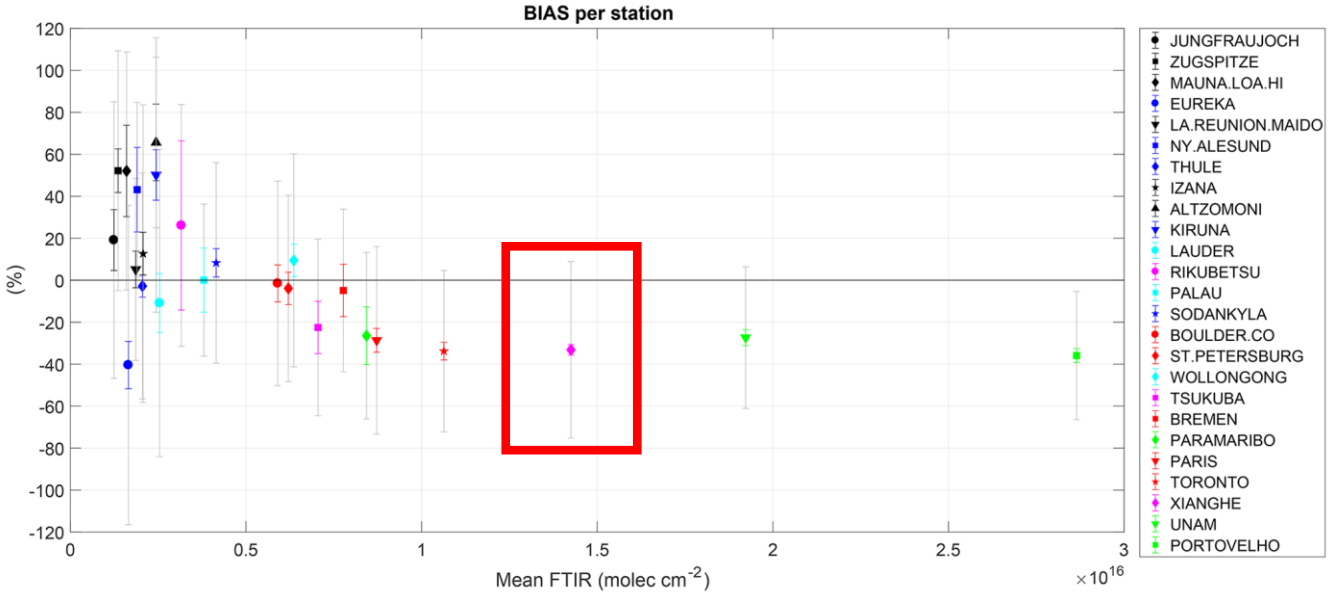


Overall:

- One of the two megacity sites (Xianghe and Pasadenia) show smallest bias
- Consistent: no seasonal variatition in bias
- Good correlation R>0.95
- Stds observed by sat and g-b are in the same order

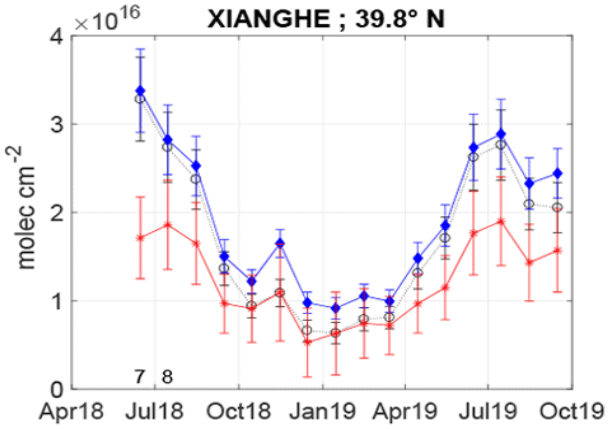
TROPOMI-FTIR- HCHO validation



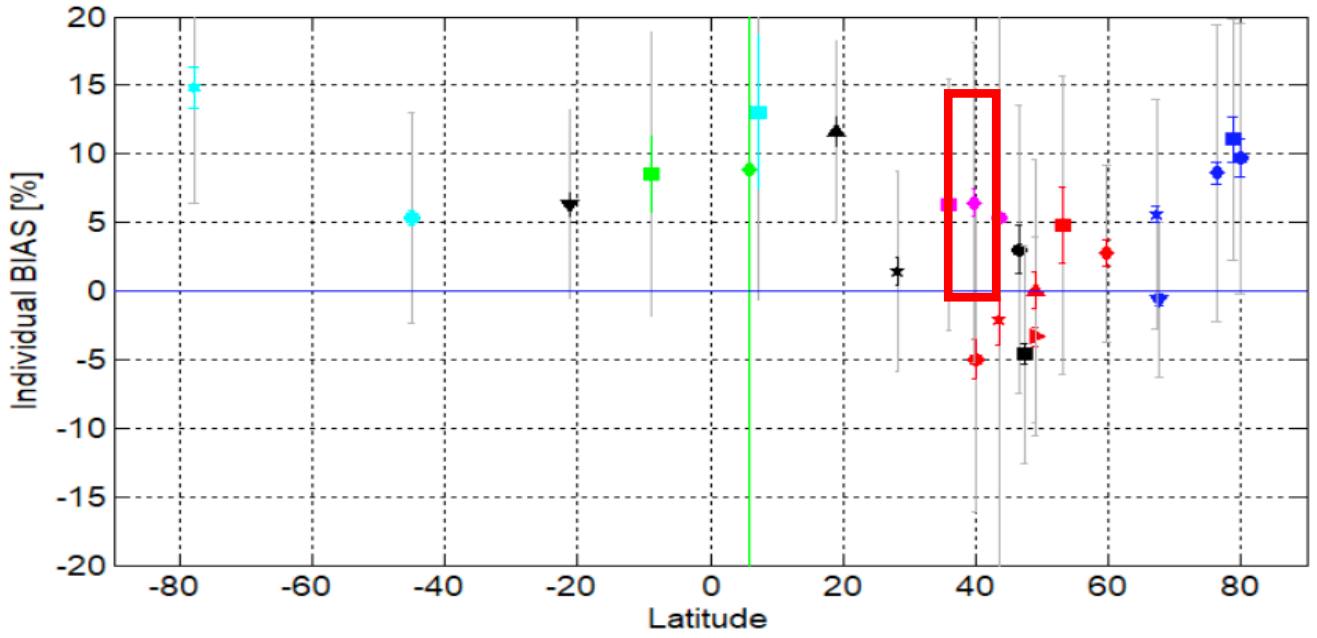


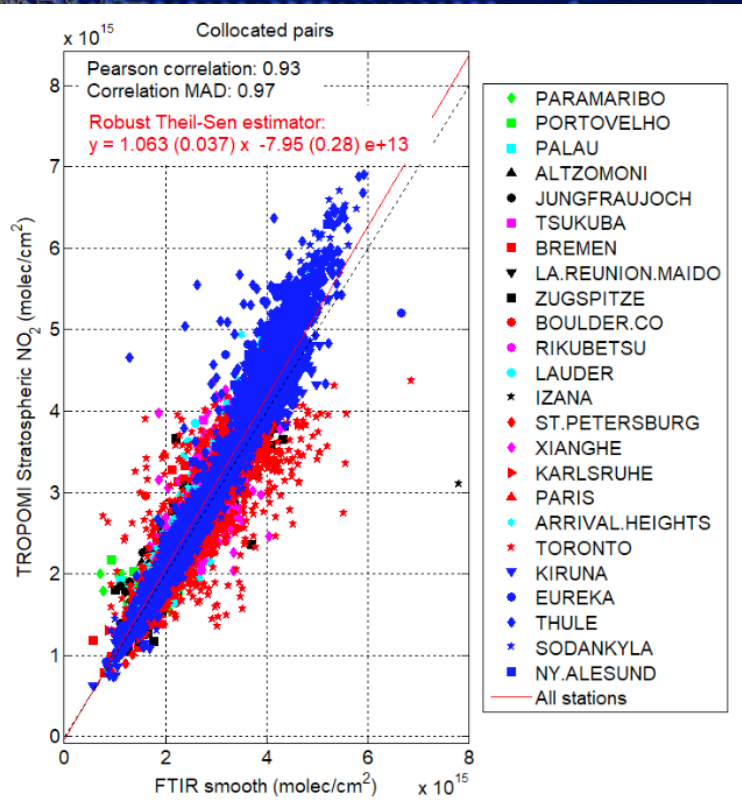
Overall:

- Typical urban high HCHO site
- Xianghe shows that TROPOMI has a underestimation when HCHO is high
- Good correlation R>0.9
- Same seasonal variation



TROPOMI-FTIR- NO2 validation

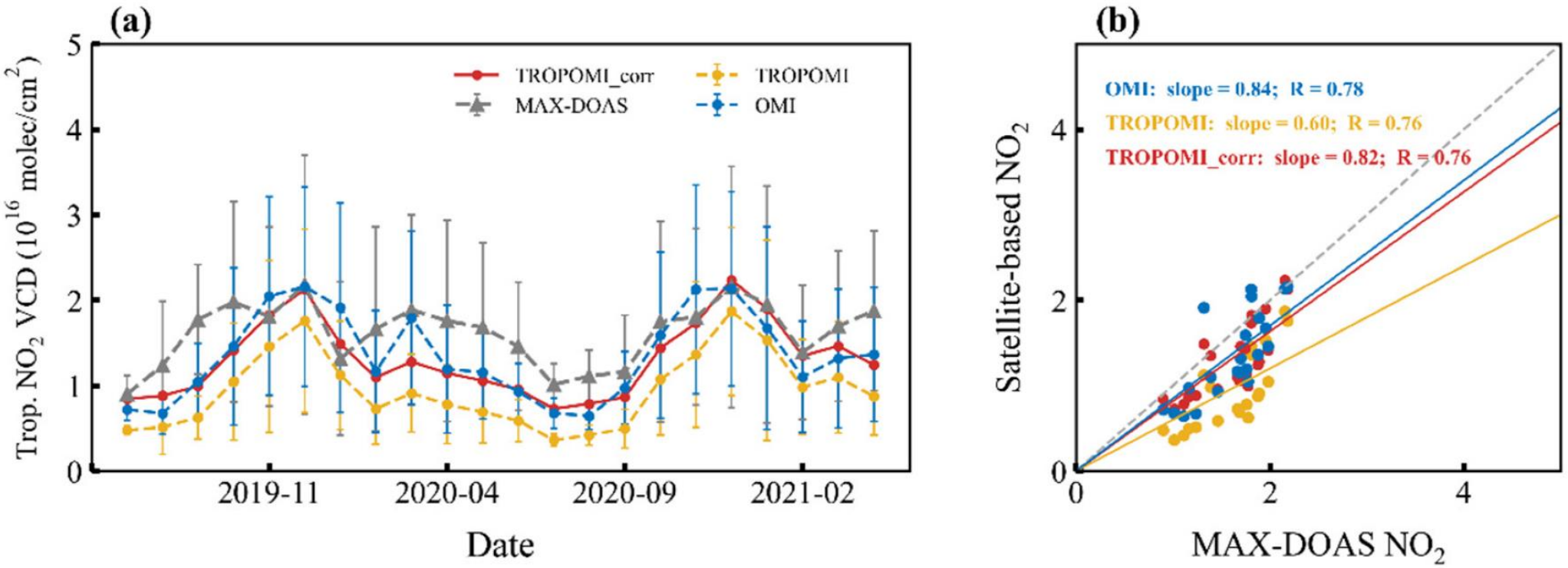




Overall:

- Typical northern-hemisphere mid-latitude site;
- mainly from the stratospheric partial columns
- The mean bias is close to what we see at Xianghe

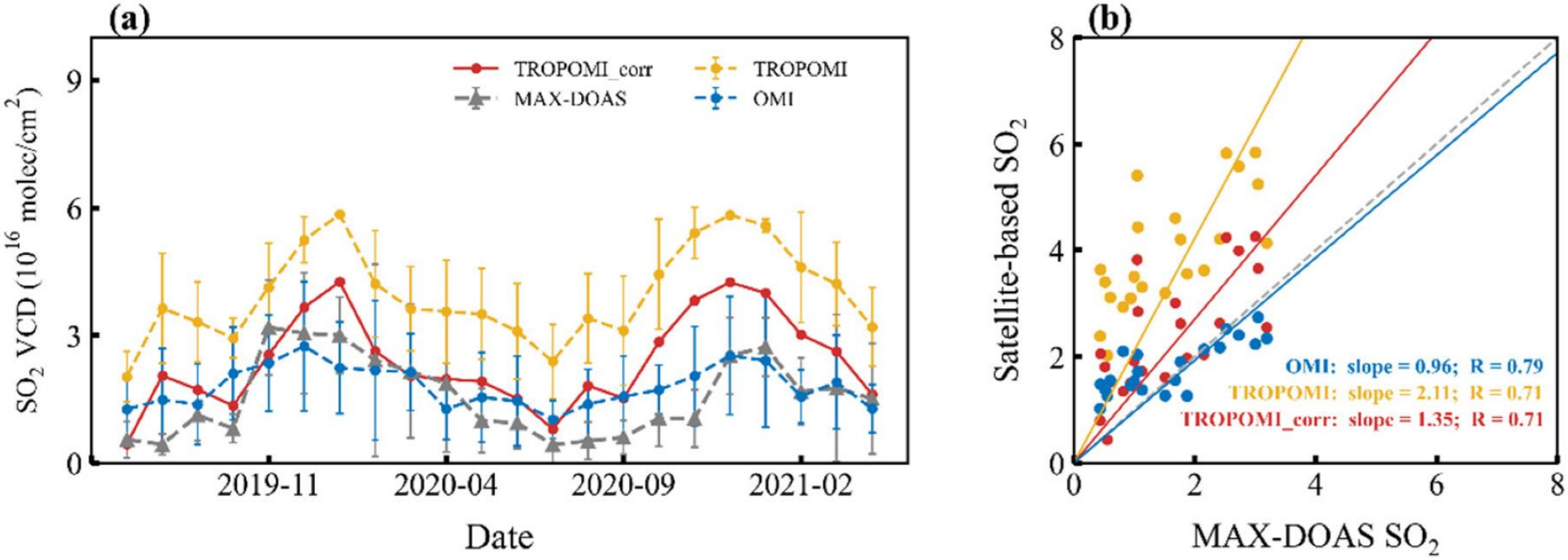
TROPOMI-MAXDOAS- NO2 validation



Overall:

- Similar seasonal variation observed by MAX-DOAS, OMI, TROPOMI
- MAX-DOAS is close to OMI, but TROPOMI NO2 is underestimated

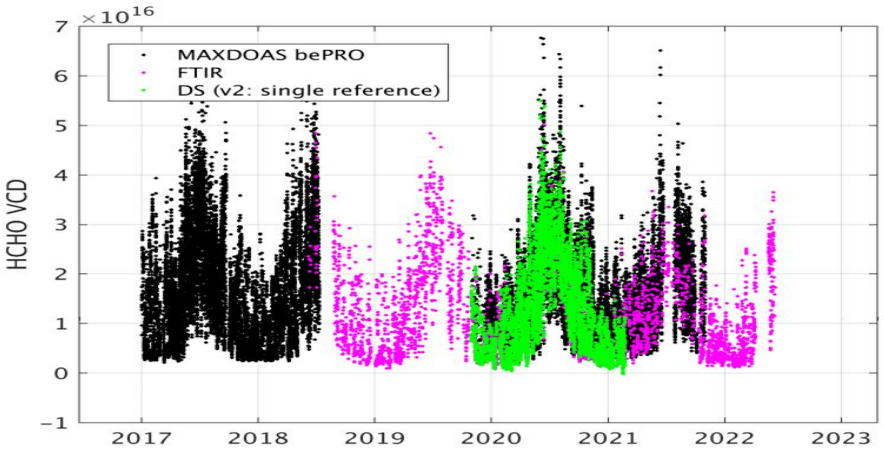
TROPOMI-MAXDOAS- SO2 validation



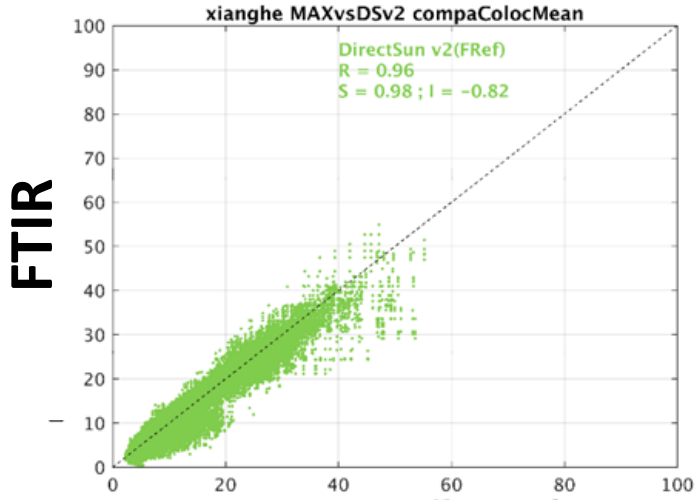
Overall:

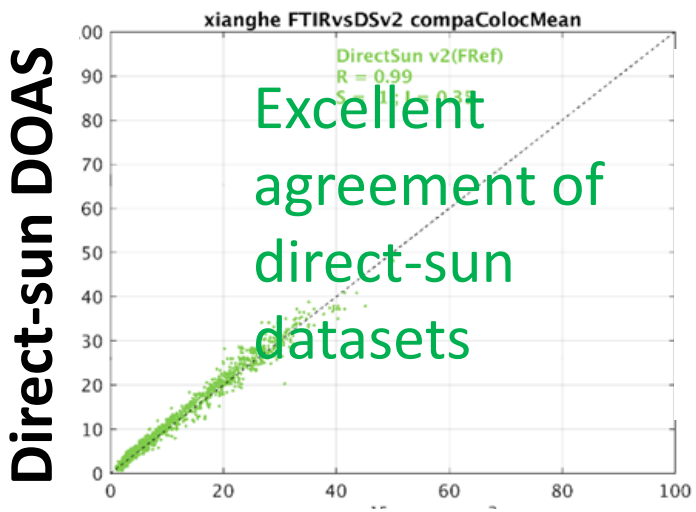
- Similar seasonal variation observed by MAX-DOAS, OMI, TROPOMI
- MAX-DOAS is close to OMI, but TROPOMI SO2 is overestimated

HCHO VCD intercomparison: MAXDOAS vs. FTIR

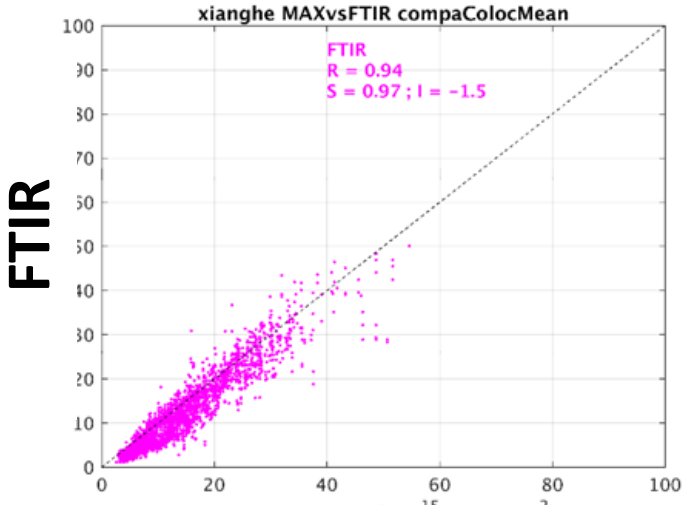


Instrument, processing	Time Period and sampling	viewing direction	Retrieval details
MAX-DOAS	(Since 2010) 1/2017-10/2021 (gap between 7/2018 and 10/2019)	Up to 2018: 165° azimuth After 11/2019: -1°azimuth	bePRO OEM retireval Clémer et al., 2010; Vlemmix et al., 2015
FTIR	06/2018-6/2022	Pointing the sun	Vigouroux et al., 2018
DirectSun	11/2019-2/2021*	Pointing the sun	Fitting interval: 324.5-359 nm





Excellent agreement of direct-sun datasets



CONCLUSIONS

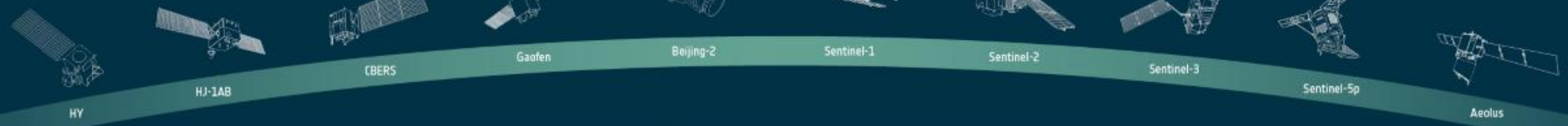
- The Xianghe site is a very important component within the global ground-based remote sensing landscape
  - Under-sampled region
  - Close to a mega-city (rare)

- It has proven to be able to measure high-quality data over prolonged periods of time
- Used within a validation context it has already provided very useful information to algorithm developers to improve their products

FUTURE PLANS

- Replace the MAX-DOAS instrument at XIANGHE
- Continue providing high quality data to TCCON
- Continue performing NDACC type FTIR measurements

- Xiange's official TCCON status, clears it for use in validation studies within projects such as CCI-GHG+, CAMS, etc.



Thank you for your attention