Validation of satellite data of greenhouse gases based on observations of TCCON Hefei Site, China

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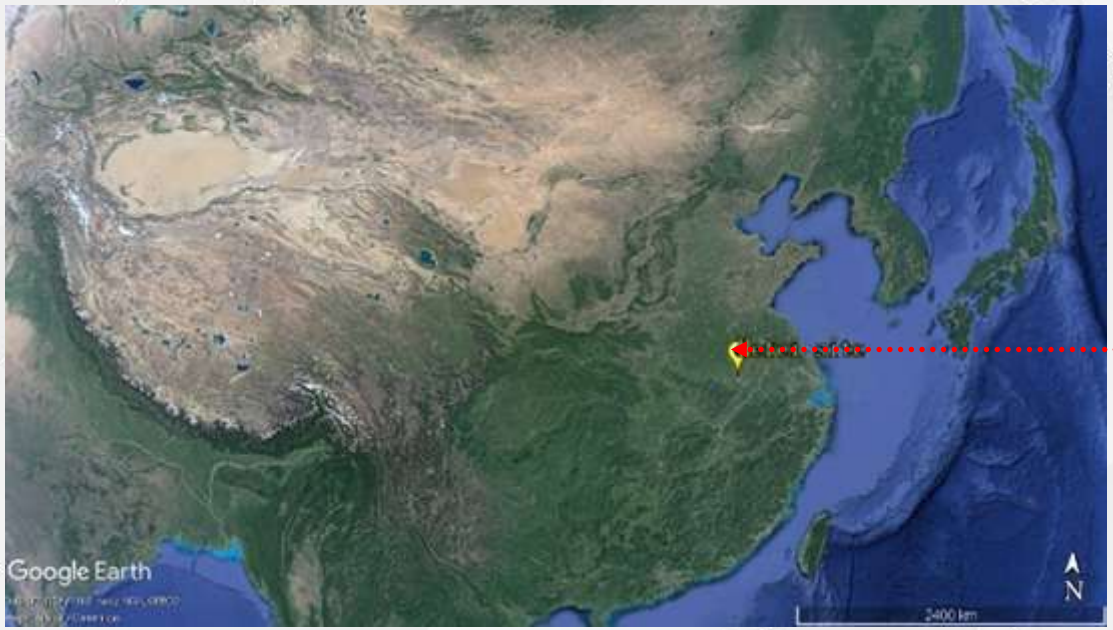
TCCON Hefei site and instruments



Site: 31° 54′N,
117° 10′E, 29 m asl

Data of TCCON Hefei site

https://tccondata.org/

TCCON Column-Averaged Dry-Air Mole Fractions of CO_2, CO, N_2O, CH_4, H_2O, HDO, and HF

Download All GGG2020 Data

Plot GGG2020 Data

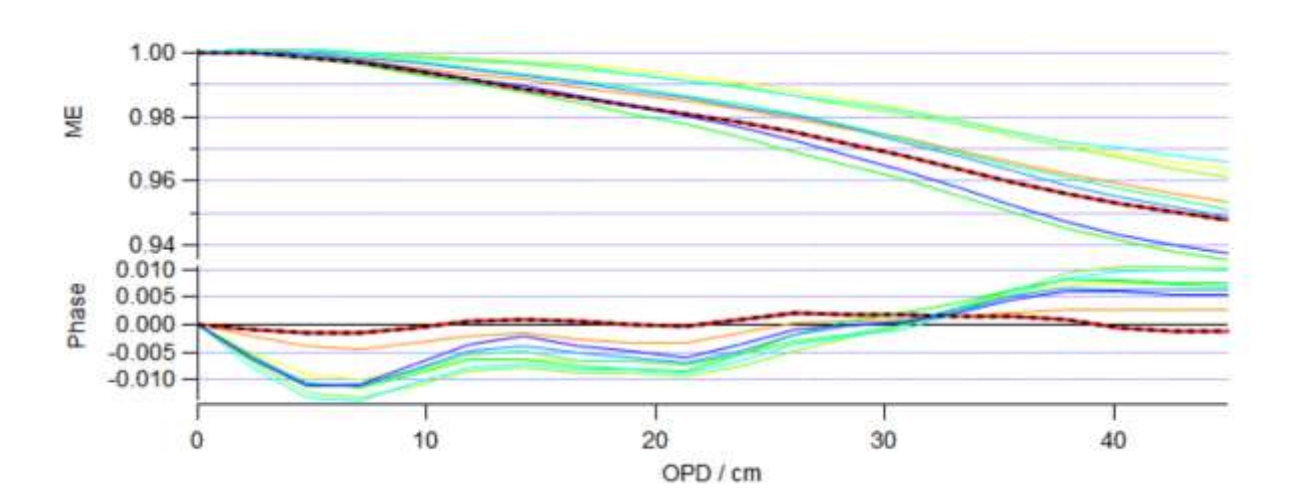
Site	Start Date	End Date
Bremen (DE) [bremen01]	2009-01-06	2021-06-24
Burgos [burgos01]	2017-03-03	2023-07-24
Bialystok (PL) [bialystok01]	2009-03-13	2018-10-01
Caltech (US) [pasadena01]	2012-09-20	2024-04-21
Darwin (AU) [darwin01]	2013-01-01	2022-12-27
East Trout Lake [easttroutlake01]	2016-10-03	2024-06-18
Edwards (US) [edwards01]	2013-07-20	2024-04-18
Eureka (CA) [eureka01]	2010-07-25	2020-07-07
Four Corners (US) [fourcorners01]	2013-03-16	2013-10-03
Garmisch (DE) [garmisch01]	2007-07-18	2023-05-04
Hefei (PRC) [hefei01]	2015-11-02	2023-12-25
Harwell [harwell01]	2021-05-30	2024-06-30
Indianapolis (US) [indianapolis01]	2012-08-23	2012-12-01
Izana (ES) [izana01]	2014-01-02	2023-08-30
Jet Propulsion Laboratory (US) [jpl01]	2007-07-01	2008-06-23

Measurement days statistics

Year	Measurements days
2015	52
2016	95
2017	112
2018	113
2019	117
2020	93
2021	124
2022	148
2023	129
2024	122

Average:
110 days

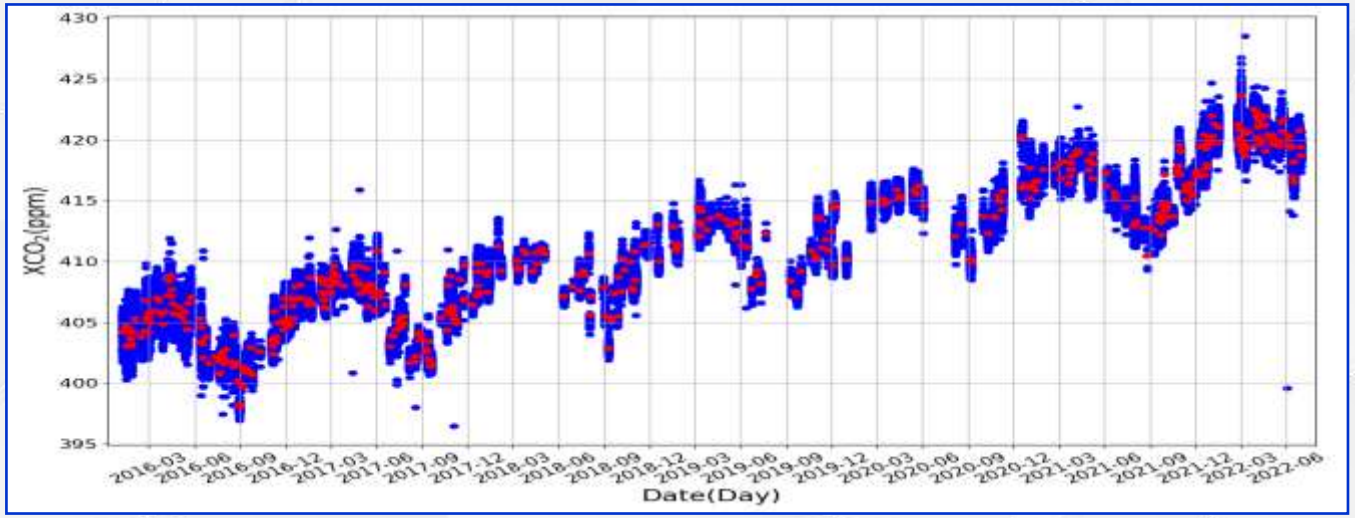
Instrumental line shape (ILS) monitoring results



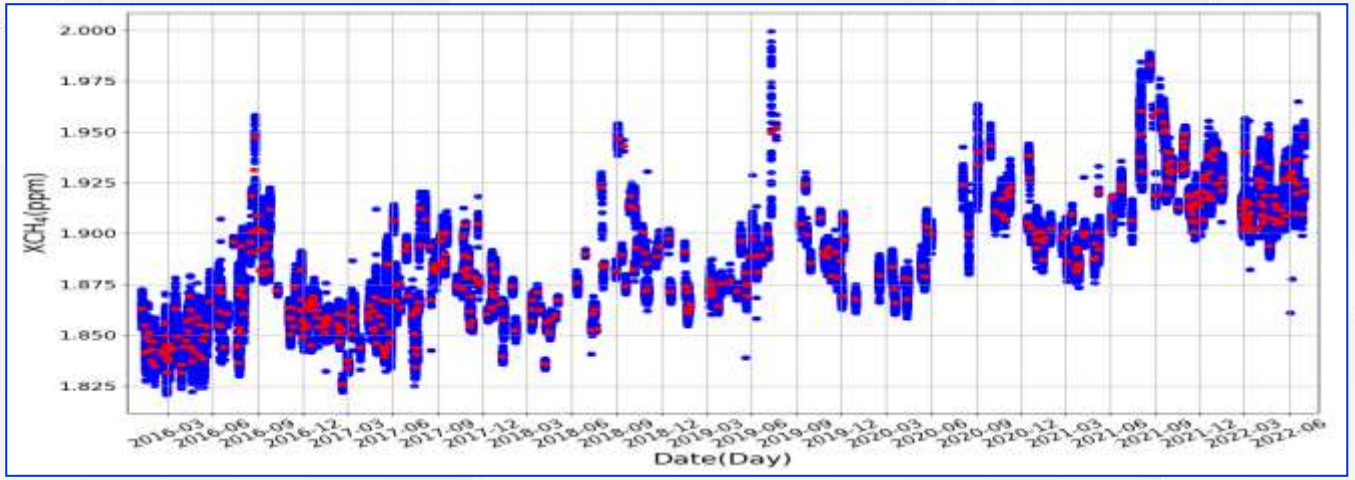
April 2023 to October 2024

- We used IFS 125HR internal light source and HCl gas cell for ILS measurements.
- We use LINEFITv.14.8 for retrieval.
- The minimal modulation efficiency is around 94% of maximal possible efficiency in this case at zero path difference.
- The phase error is less than 0.02 rad.

Time series of XCO_2 and XCH_4



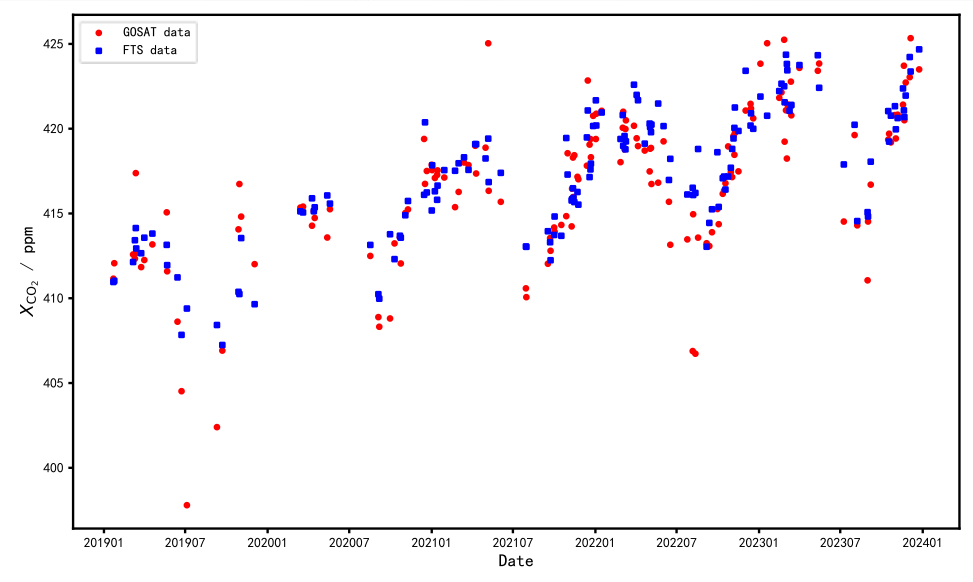
Annual variation rate of CO_2:
2.35 ± 0.41 ppm yr^{-1}



Annual variation rate of CH_4:
11.67 ± 2.50 ppb yr^{-1}

Wang&Liu et al., AMT, 2017; Tian&Liu et al., AE, 2018; Sun&Liu et al., AMT, 2018; Shan&Wang et al., OE, 2021; Shan&Wang et al., AE, 2025

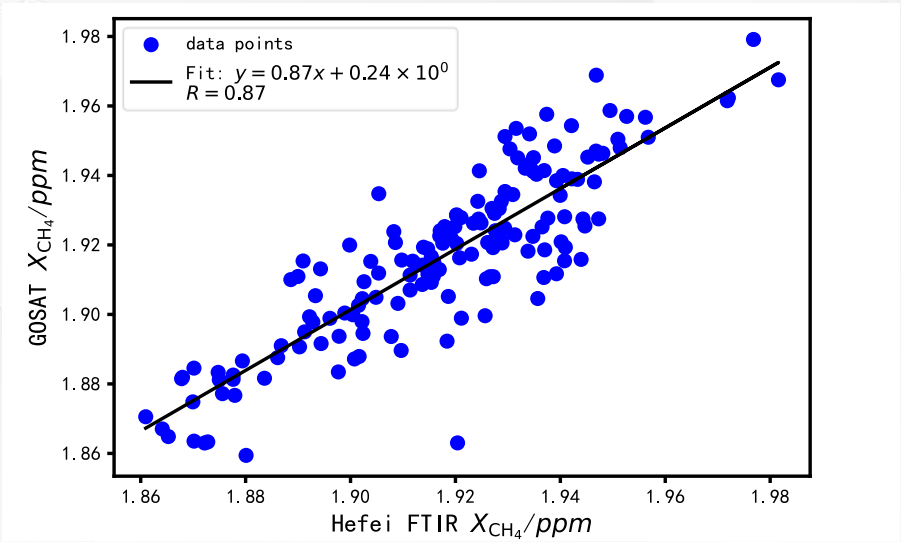
Validation of GOSAT CO_2 data



Filtering criteria for GOSAT data

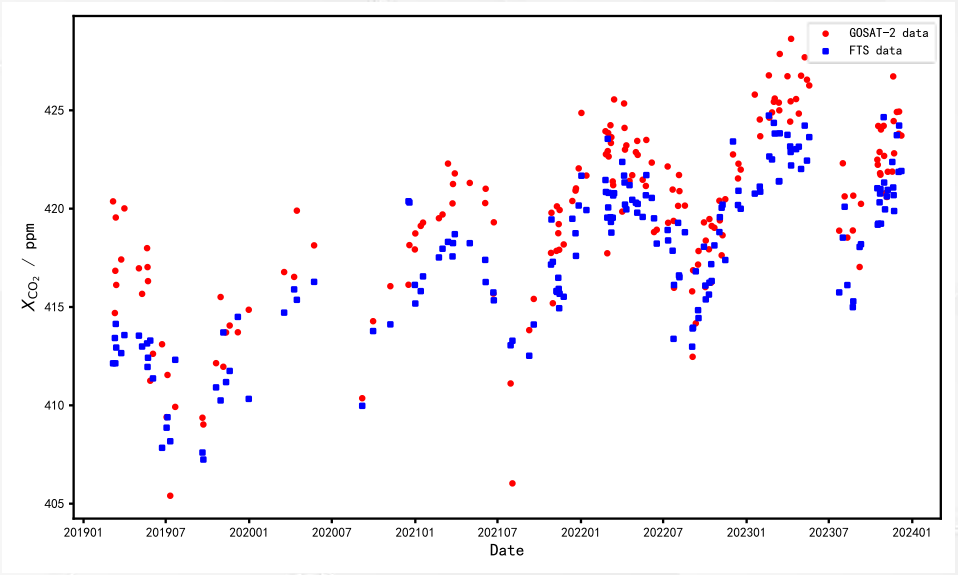
Variable	Criteria
xco_2_quality_flag	0
Snr_valid	[0,1000]
Cloud_outer_valid	[0,2000]
Cloud_inner_valid	[0,2000]

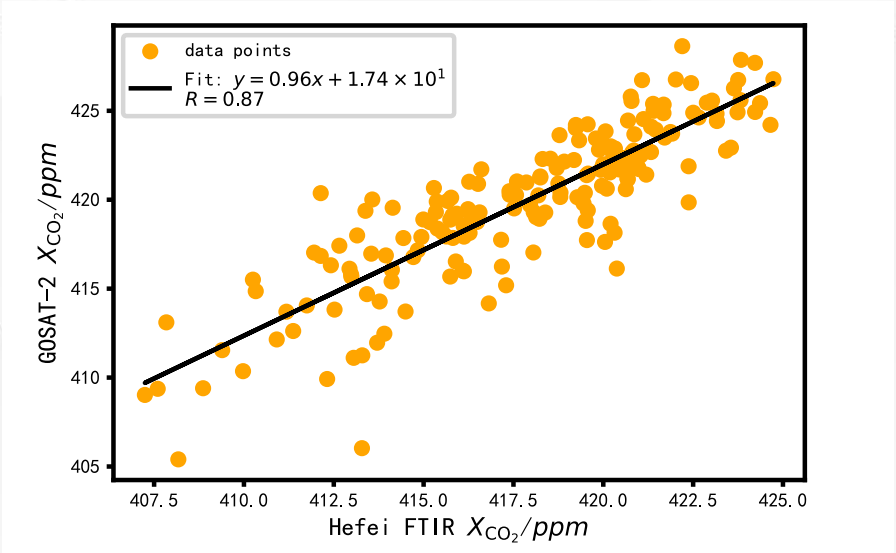
Satellite Data: ± 5 ° latitude and ± 5 ° longitude



Bias: -0.65±2.41 ppm
Relative bias: -0.16 %
Correlation coefficient R: 0.87

Validation of GOSAT-2 CO_2 data



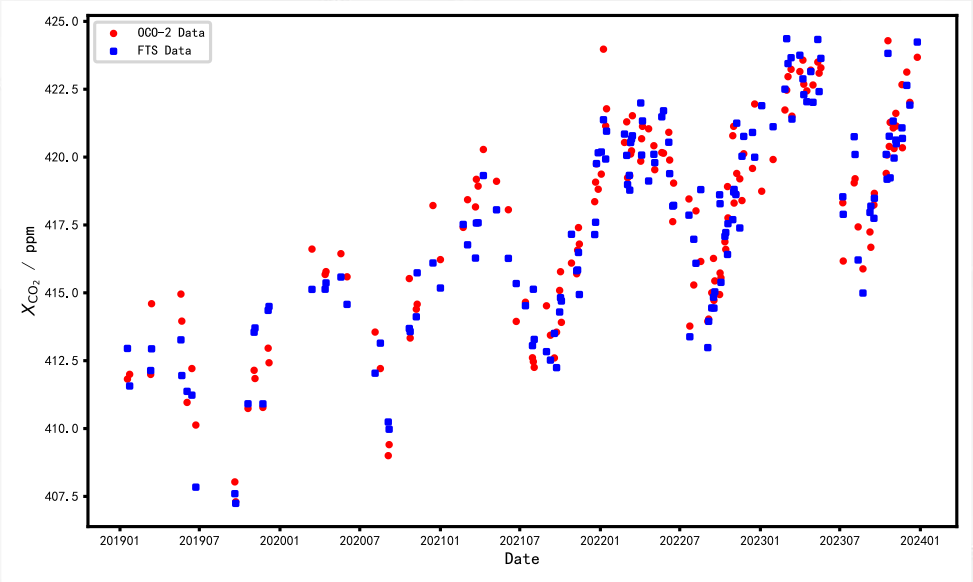


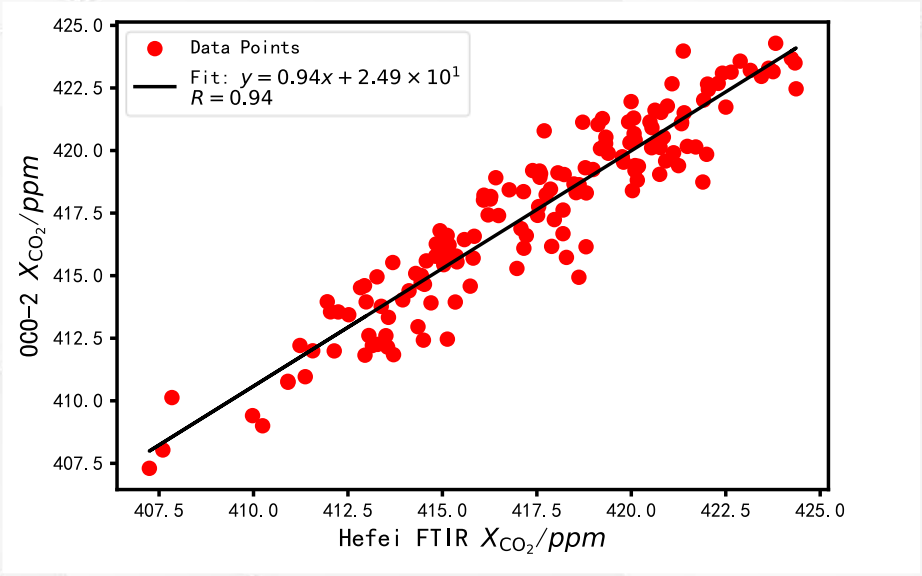
Filtering criteria for GOSAT-2 data

Variable	Criteria
xco_2_quality_flag	0,1,2,3
Spike_flag	[0,1]
Missing_flag	≠1
Interferogram_flag	[0,1]

Bias: 2.07±2.18 ppm
Relative bias: 0.5 %
Correlation coefficient R: 0.87

Validation of OCO-2 CO_2 data



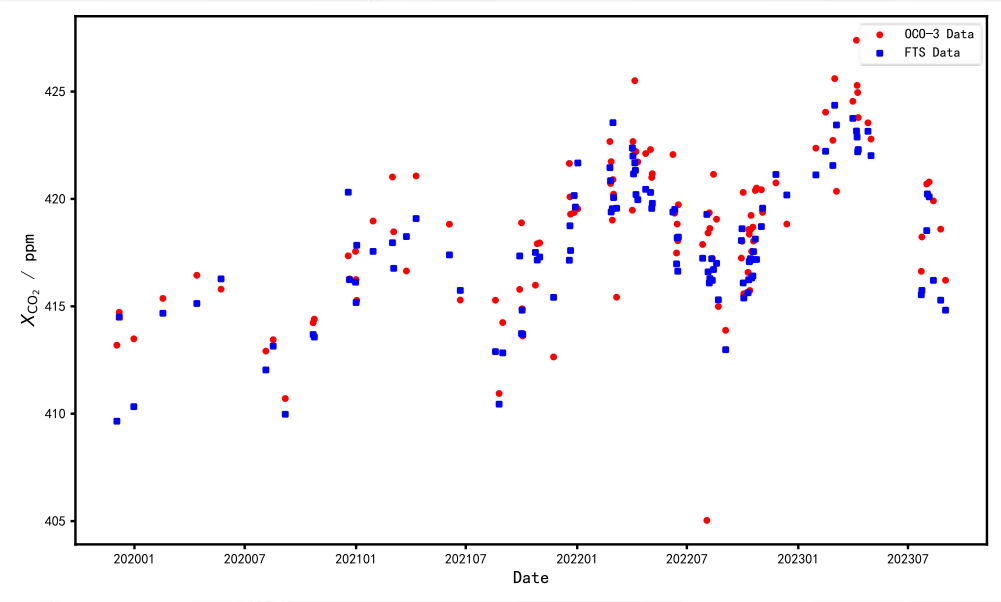


Filtering criteria for OCO-2 data

Variable	Criteria
xco_2_quality_flag	0
xco_2_qf_simple_bitflag	0

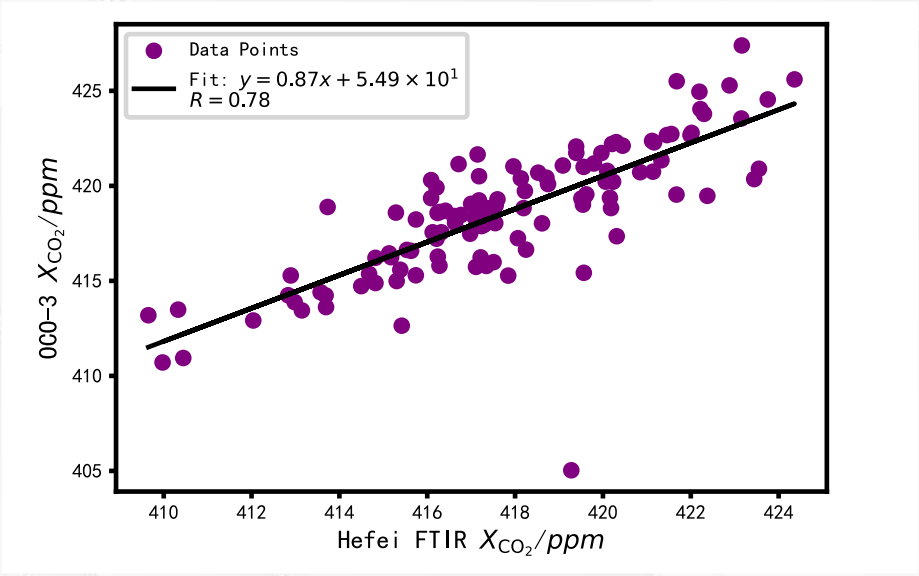
Bias: 0.14±1.25 ppm
Relative bias: 0.03 %
Correlation coefficient R: 0.94

Validation of OCO-3 CO_2 data



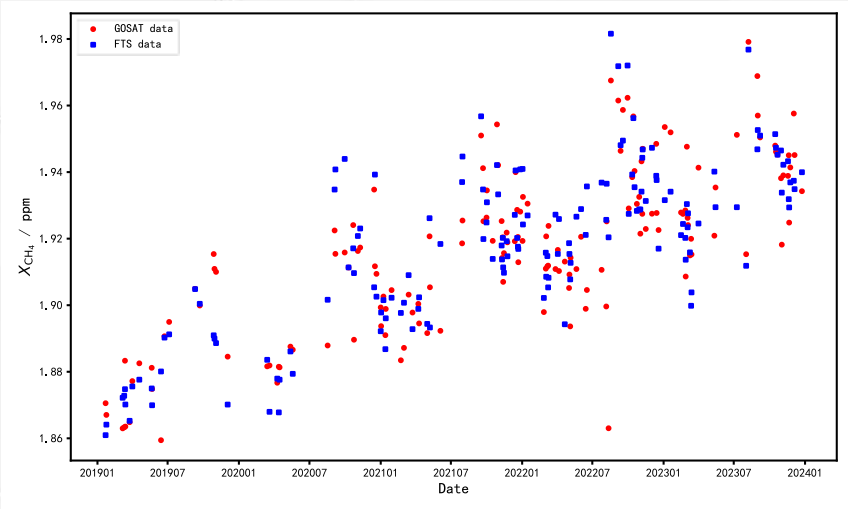
Filtering criteria for OCO-3 data

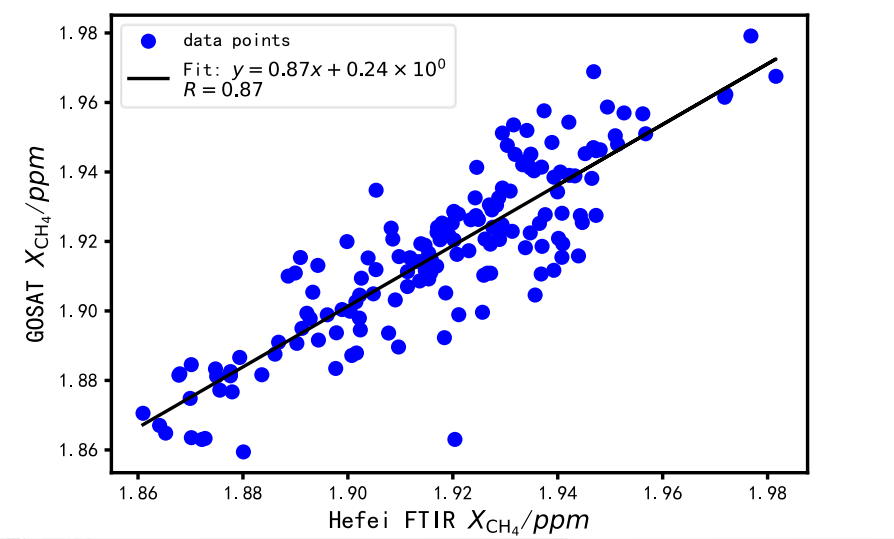
Variable	Criteria
xco_2_quality_flag	0
xco_2_qf_simple_bitflag	0



Bias: 0.80±2.23 ppm
Relative bias: 0.19 %
Correlation coefficient R: 0.78

Validation of GOSAT CH_4 data



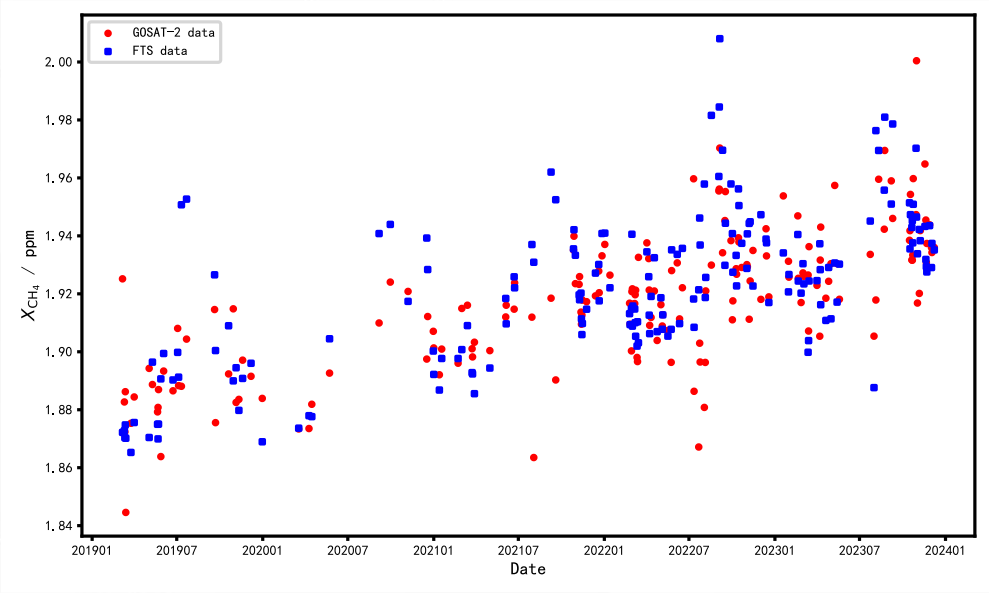


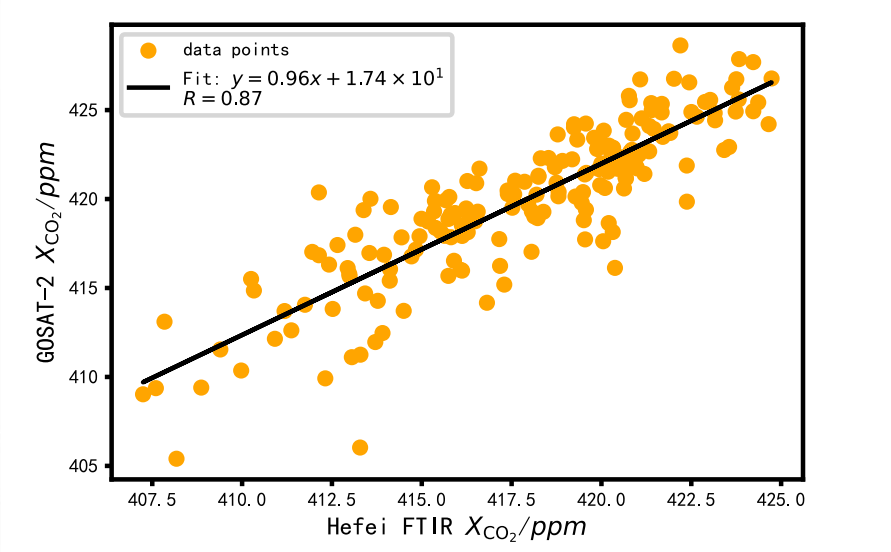
Filtering criteria for GOSAT data

Variable	Criteria
Xch_4_quality_flag	0
Snr_valid	[0,1000]
Cloud_outer_valid	[0,2000]
Cloud_inner_valid	[0,2000]

Bias: -0.93±12.66 ppb
Relative bias: -0.05 %
Correlation coefficient R: 0.87

Validation of GOSAT-2 CH_4 data



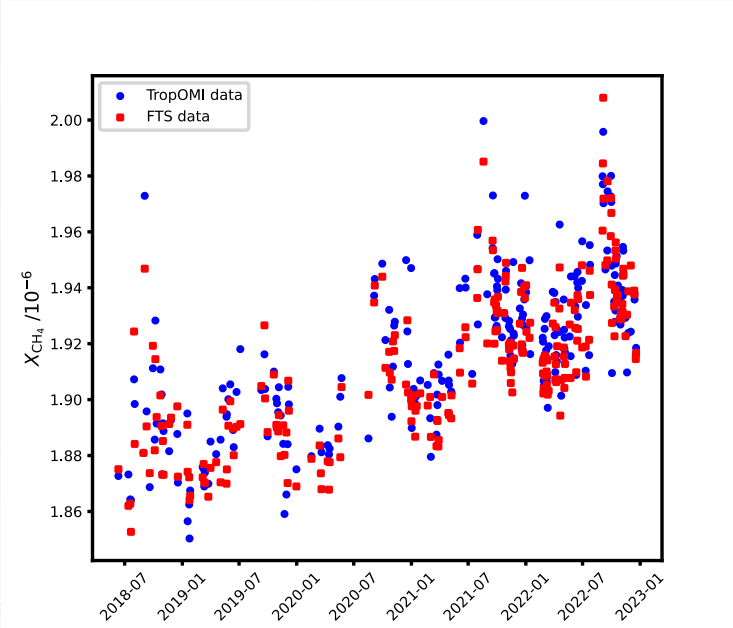


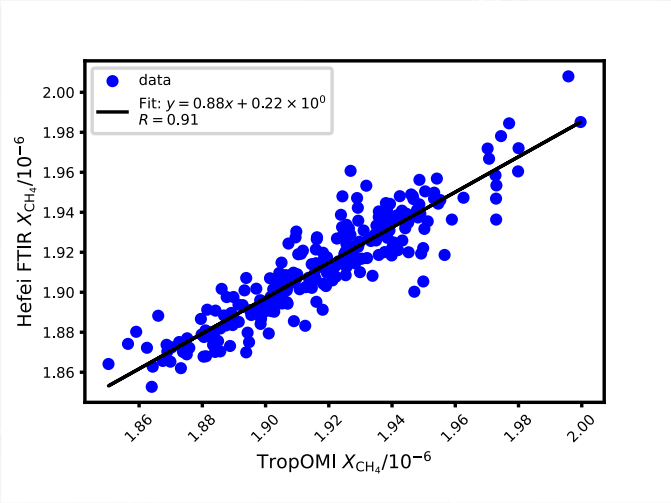
Filtering criteria for TROPOMI data

Variable	Criteria
Xch_4_quality_flag	0,1,2,3
Spike_flag	[0,1]
Missing_flag	≠1
Interferogram_flag	[0,1]

Bias: -4.45±19.92 ppb
Relative bias: -0.22 %
Correlation coefficient R: 0.87

Validation of TROPOMI CH_4 data



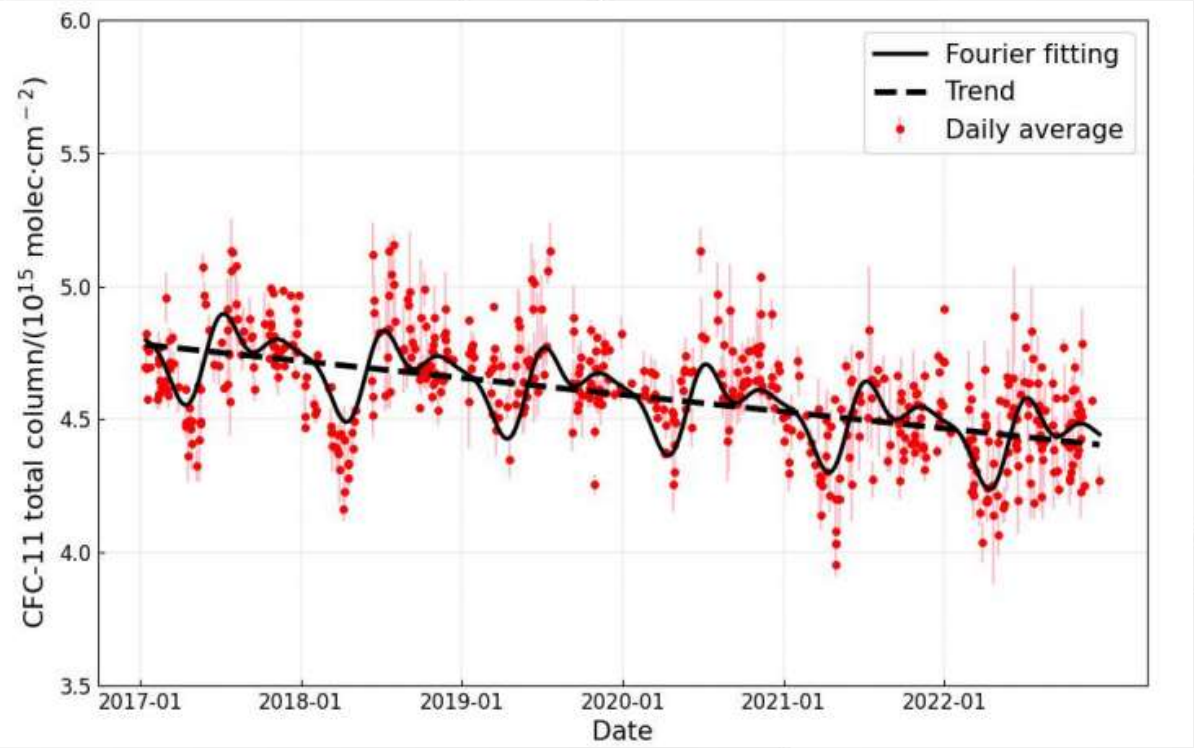


Filtering criteria for TROPOMI data

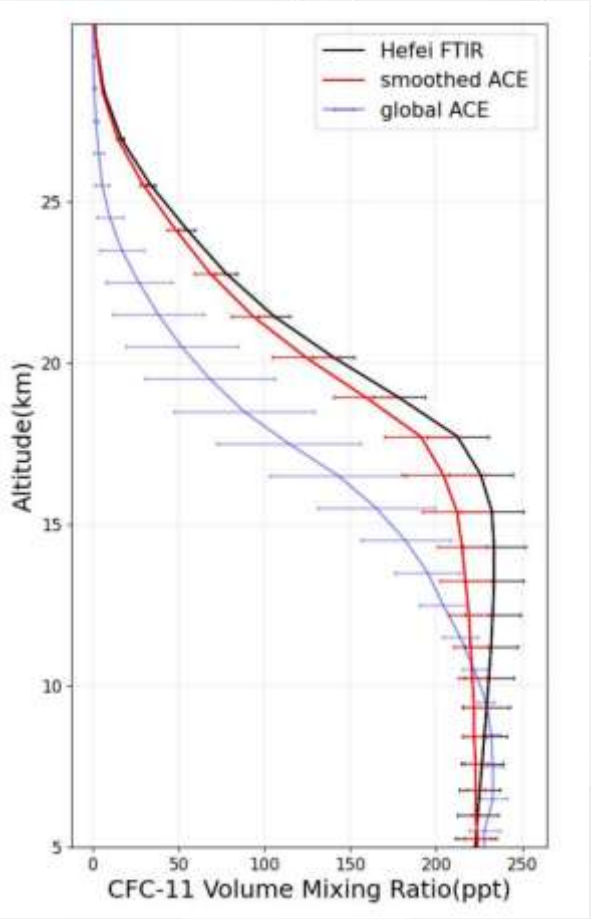
Variable	Criteria
Qa_value	≥0.5

Bias: 4.80±7.68 ppb
Relative bias: 0.25 %
correlation coefficient R: 0.91

Validation of ACE-FTS CFC-11 data

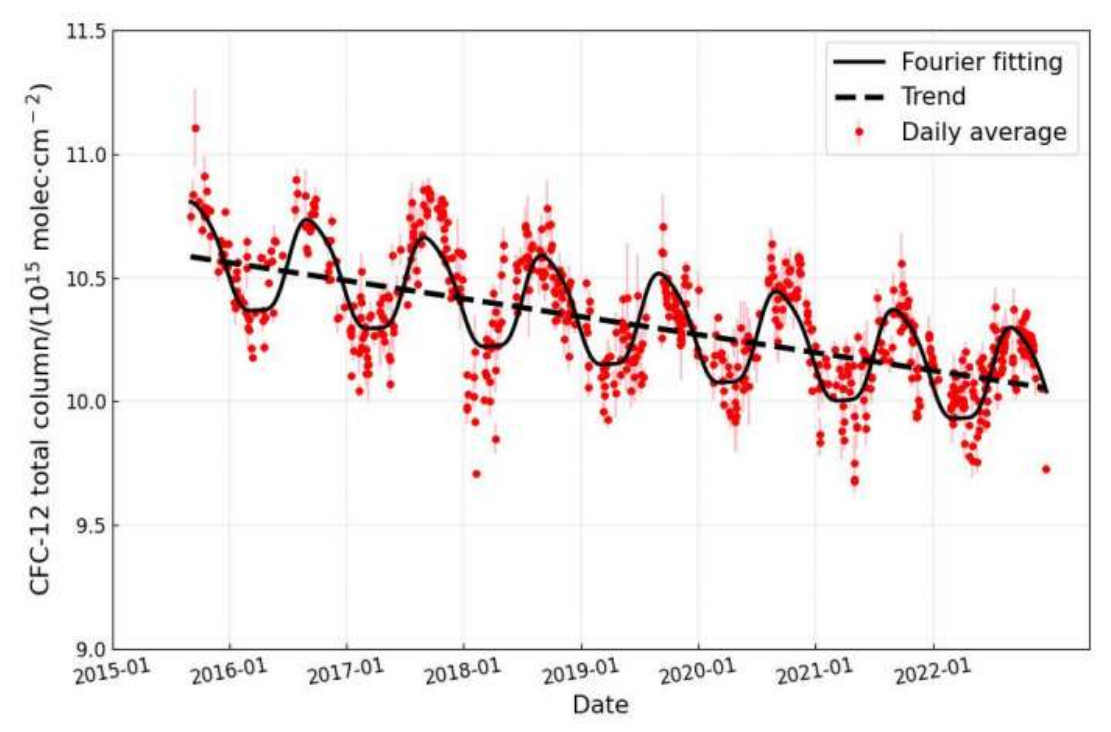


For CFC-11, the annual rate of total column is -1.40% year^{-1} from 2017 to 2022.

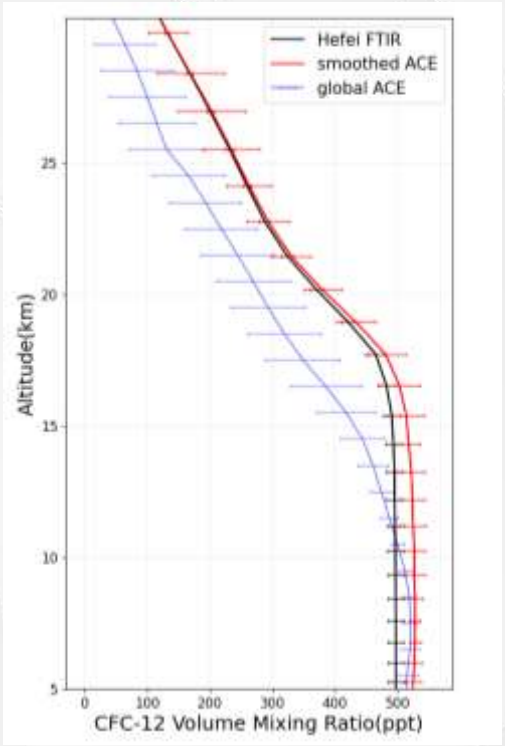


- The vertical profile of CFC-11 measured by ground-based FTIR is slightly **larger than** that of ACE-FTS below 30 km.
- For CFC-11 profile from 5 to 23 km, the average relative difference between the two data is **-6.29±4.19%.**

Validation of ACE-FTS CFC-12 data

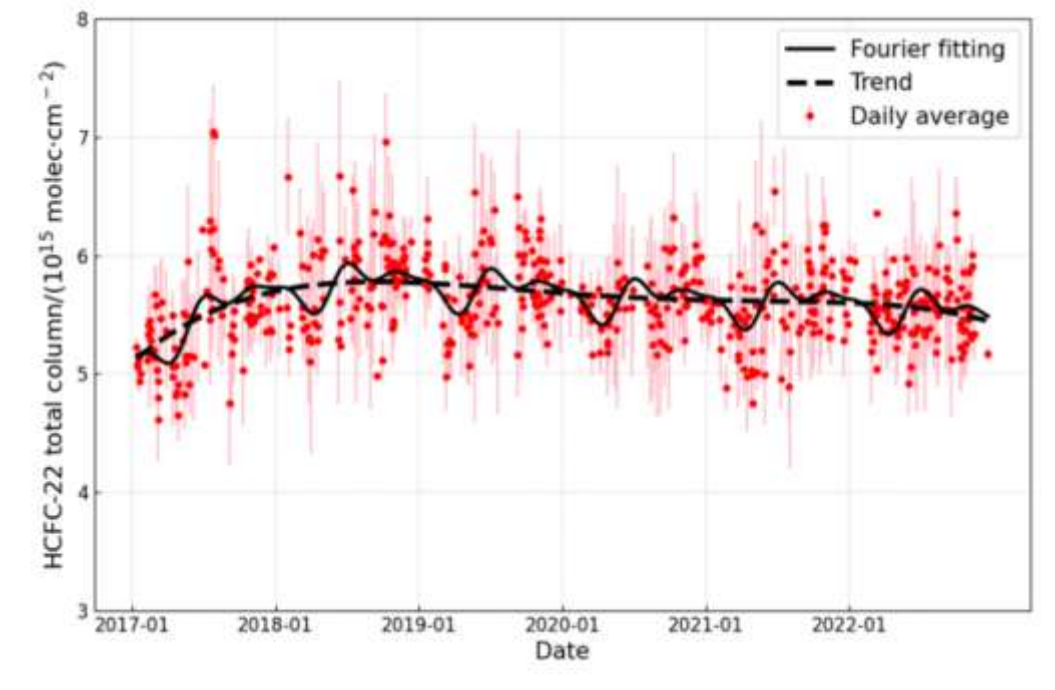


For CFC-12, the annual rate of total column is -0.70% year^{-1} from 2015 to 2022.

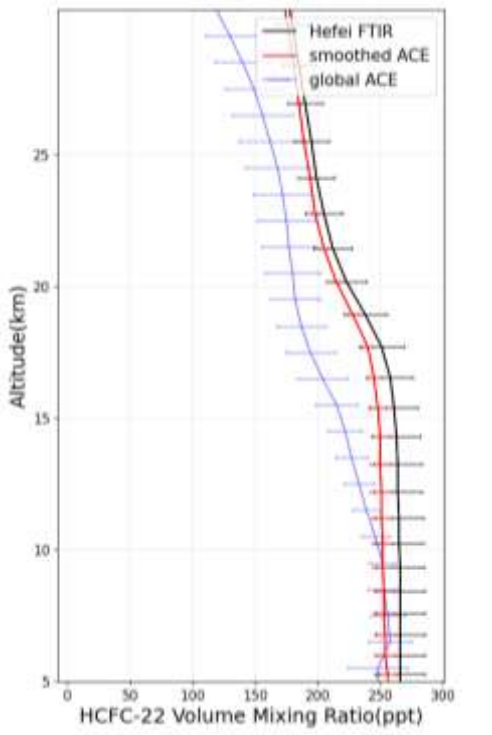


- The vertical profile of CFC-12 measured by ground-based FTIR is **slightly smaller** than that of ACE-FTS below 30 km.
- For CFC-12 profile from 5 to 30km, the average relative difference between the two data is **3.95±2.12%.**

Validation of ACE-FTS HCFC-22 data



HCFC-22 total column increased from 2017 to 2018 with an annual variation rate of 5.98%, and gradually decreased from 2018 to 2022 with an annual variation rate of −1.02%.



- The vertical profile of HCFC-22 measured by ground-based FTIR is **slightly higher** than the profile of ACE-FTS below 30 km.
- For HCFC-22 profile from 5 to 30 km, the average relative difference between the two data is **-4.38±0.83%.**

Zeng&Wang et al., AMT, 2022; Zeng&Wang et al., RS, 2023

Future plans

- We will do alignment of the IFS125 interferometer in Hefei site in June, with the help of professor David Griffith from UOW.
- We have ordered a new IFS125HR FTS instrument, plant to install it in October, in the southern part of Anhui province, about 200km away from the Hefei site.

Thank you for your attention