The New Progress of DQ-1 and Pre-research of DQ-2

Lu Zhang[1], Xifeng Cao[1] , Lin Chen[1], Xingying Zhang[1], Jiqiao Liu[2], Weibiao Chen[2], Minqiang Zhou[3], Lingbing Bu[4]

1.National Satellite Meteorological Center (National Center for Space Weather) , China Meteorological Administration (CMA)
2.Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences
3.Institute of Atmospheric Physics, Chinese Academy of Sciences
4.Nanjing University of Information Science & Technology

9 June 2025 Takamatsu

Contents

01 Introduction DQ-1 and DQ-2

02 The Latest Progress of DQ-1

03 The Pre-research on DQ-2

04 Summary

Introduction DQ-1 and DQ-2

2015-01
Approved in advance(DQ-1)

2017-08
Project was approved

2018-08
First Airborne CO2 -IPDA LIDAR in Sanhaiguan

2019-03
First Airborne CO2 -IPDA LIDAR in Shan Haiguan

2019-10

The First Workshop of Application of Spaceborne Lidar in Atmospheric Detection

2021-07

Second Airborne CO2 -IPDA LIDAR in Dunhuang

2022-04
Launched

2024-07

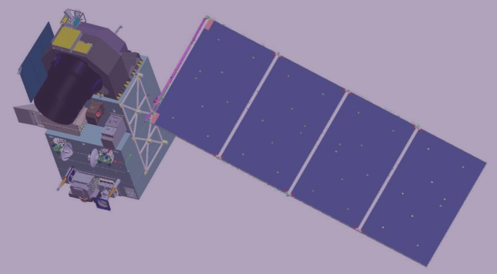
The in-orbit test has ended

DQ-2 is scheduled to be launched by the end of 2025.

Introduction DQ-1 and DQ-2

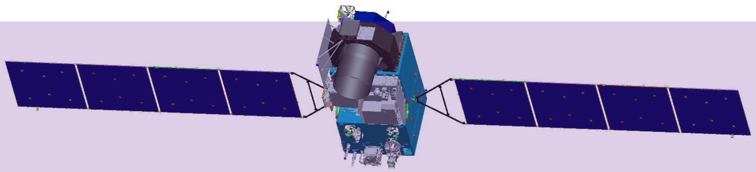
Satellite parameters

DQ-1



Specification	ACDL/DQ-1
Online wavelength	75mJ@1572.024 nm
Offline wavelength	75mJ@1572.085nm
Pulse width (on/off)	15ns
Field of view	100 μrad

DQ-2



Bands	central wavelength	spectral bandwidth	spectral resolution	SNR(0.05,60º solar zenith angle)	spatial resolution	field of view
GAS-II Parameter					≈3km	>100km
O2-A	765nm	>15nm	0.04 nm	350		
CO2	1610nm	>30nm	0.07 nm	340		
CO2,H2O	2060nm	>40nm	0.09 nm	230		
CO,CH4	2300nm	>50	0.1nm	200		

Bands	wavelength range(cm-1)	spectral resolution(cm-1)	spatial resolution
HIRAS-II			<14km
Long-IR	648.75~1169.375 (15.41~8.55 μm)	0.625	
Middle-IR	1167.5~1921.25 (8.56~5.20 μm)	0.625	
Short-IR	1919.375~2551.25 (5.21~3.92 μm)	0.625	

The Latest Progress of DQ-1

□ The progress of one year's work

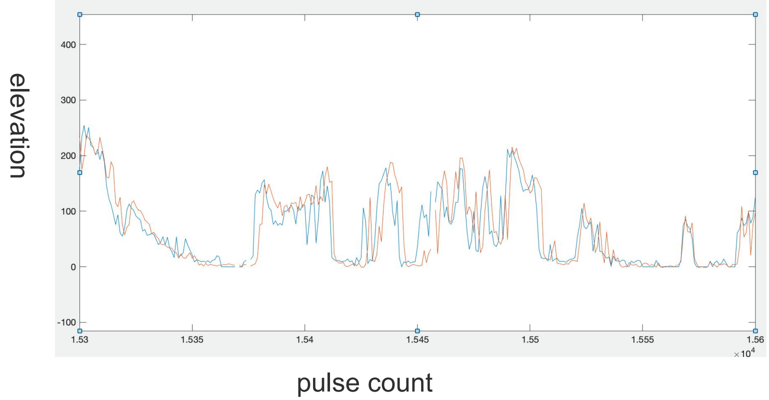
- **Evaluated the impact of water vapor for XCO2 measurement**

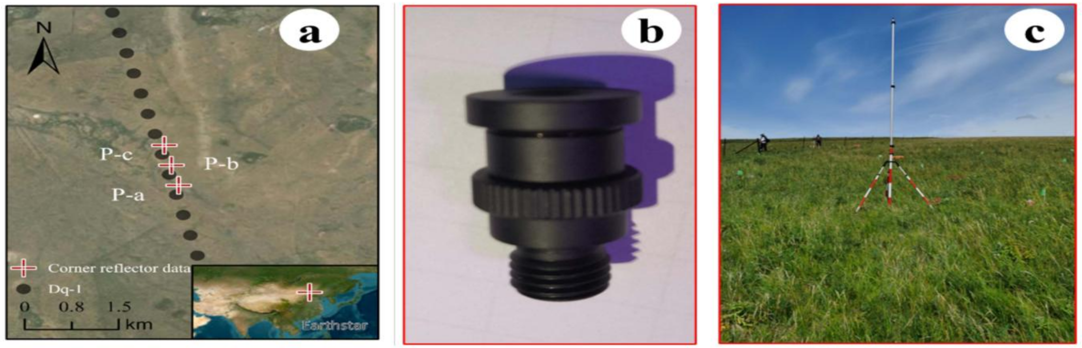
  1.The absorption cross-section of carbon dioxide

  2.The differential optical thickness DAOD

  3.The Weight function

- **Completed the geometric calibration of DQ-1/ACDL**





Chen C, Fan C, Wu Z, Xie Y, Hu J, Yang J, Zhu X, Zhang L, Wang Z, Liu S, Liu J, Chen W. Evaluating the impact of water vapor for aerosol and carbon dioxide detection lidar CO2 measurement onboard the atmospheric environment monitoring satellite. Opt Express. 2024 Dec 30;32(27):48340-48352. doi: 10.1364/OE.546903.

The Latest Progress of DQ-1

☐ The progress of one year's work

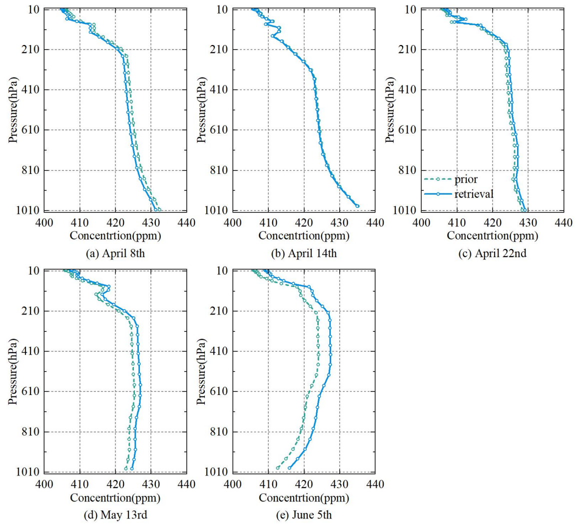
- **Cal/Val**

① Method

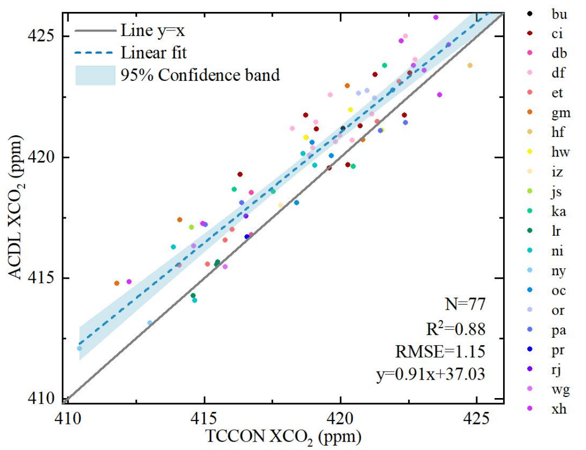
$$\frac{\int_{P_G}^{P_A} a\cdot\rho'_{CO_2}(p,T)\cdot WF(p,T)dp}{\int_{P_G}^{P_A} WF(p,T)dp} = \frac{1}{2}\,\frac{\ln\left[\frac{P(\lambda_{on},R_A)\cdot P_0(\lambda_{off})}{P(\lambda_{off},R_A)\cdot P_0(\lambda_{on})}\right]}{\int_{P_G}^{P_A} WF(p,T)dp}$$

$$\rho_{CO2}\ (p,T)\ = a\cdot\rho'_{CO2}\ (p,T)$$

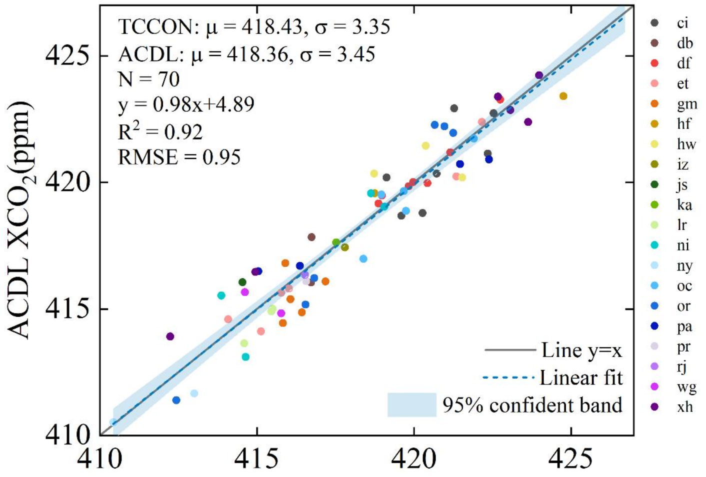
② Scaling the prior profile of CO2

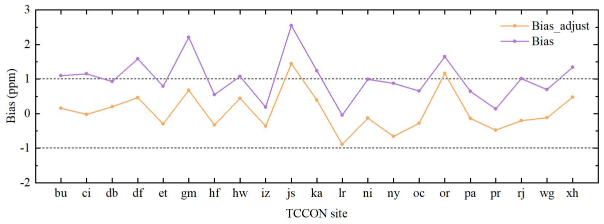


③Direct comparison with ground-based TCCON



④after scaling prior profile ,comparison with ground-based TCCON





The R-Square (R2) between the ACDL and TCCON sites is **0.92**, and the Root Mean Squard Error (RMSE) is **0.95** ppm

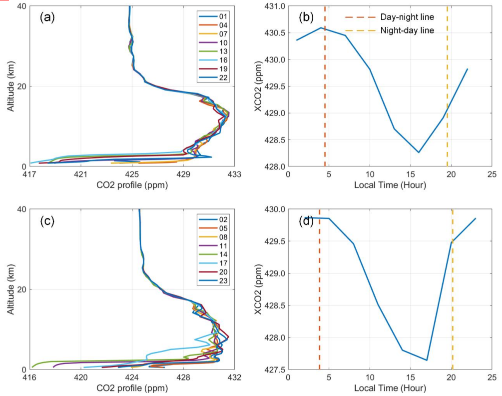
The paper will be submitted to AMT in this month..named(ACDL/DQ-1 calibration algorithms – Part 2)

The Latest Progress of DQ-1

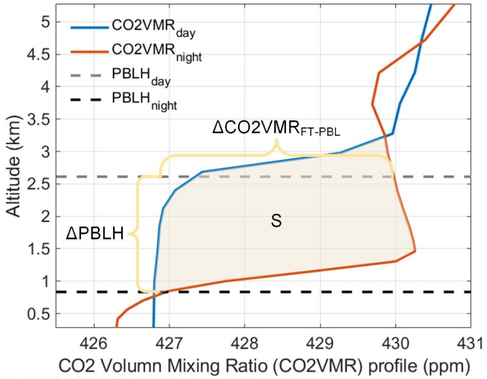
☐ The progress of one year's work

- **Day and night difference ΔXCO2**

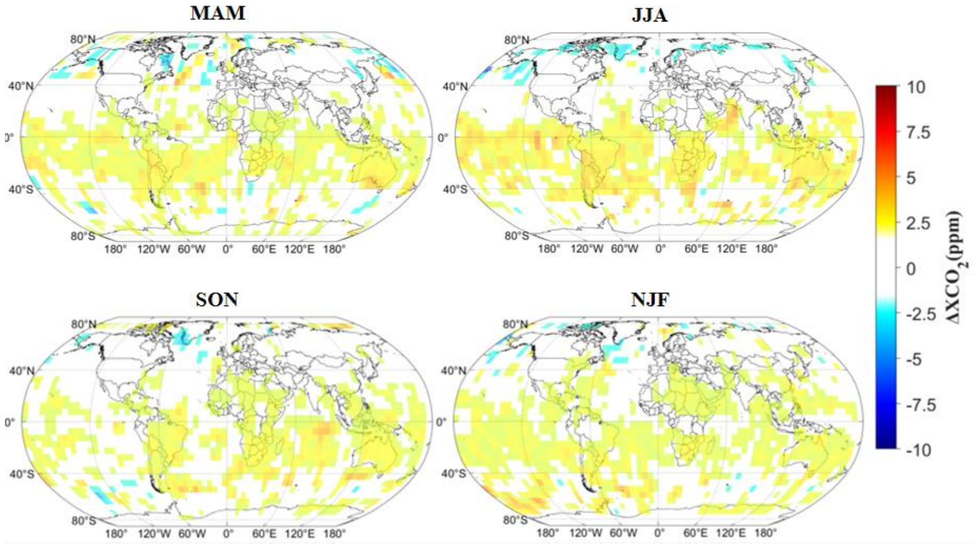
① The simulation demonstrates that the changes in near-ground CO2 can be captured by the DQ-1 (**ΔXCO2>1ppm)**



② The boundary layer height (ΔXCO2)



③ Preliminary result of ΔXCO2



The ΔXCO2 less than 1ppm was masked out

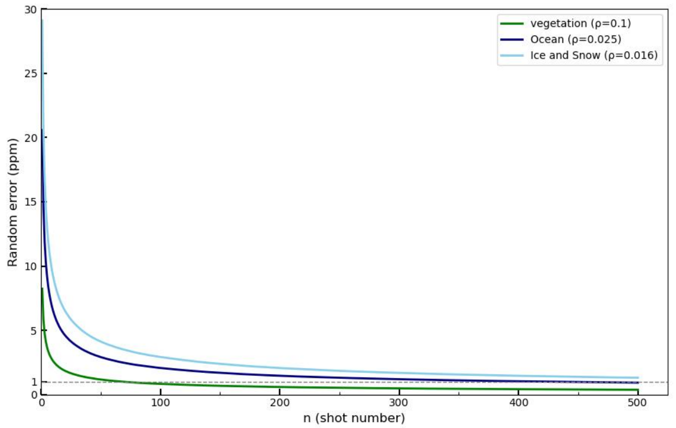
prepared

The Latest Progress of DQ-1

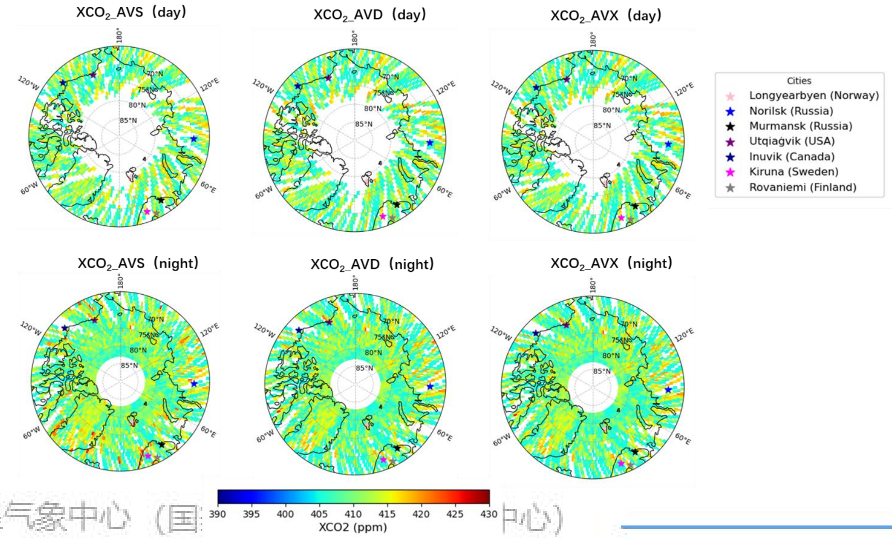
The progress of one year's work

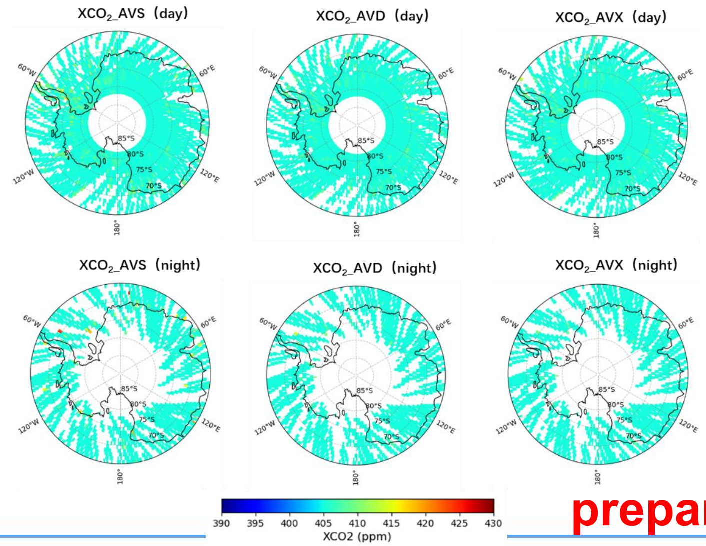
- **South and north pole XCO2**

①The surface of ice and snow has a low reflection at a 1.5um, so we need more pulse for averaging (500s)



② Preliminary result



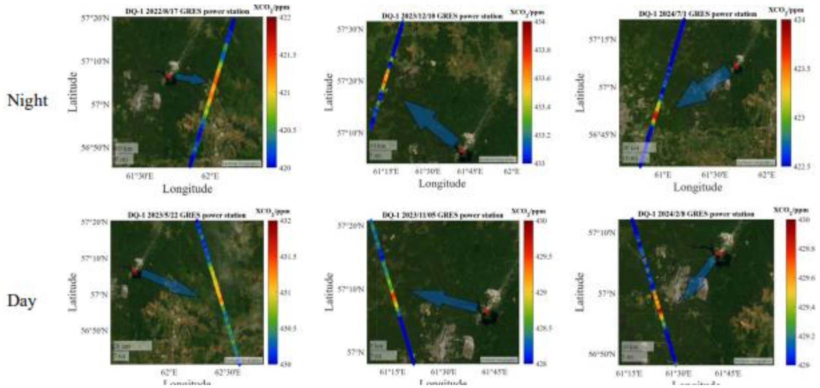


prepared

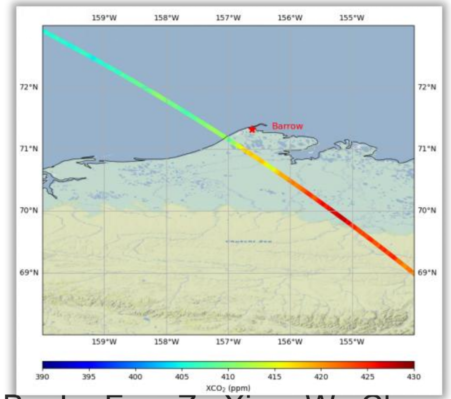
The Latest Progress of DQ-1

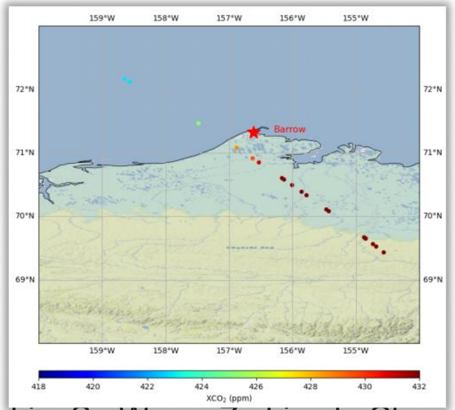
☐ The progress of one year's work

- Emissions of CO_2 from power plants（high-latitude area）



- Measurement of CO_2 Column Concentration Above Cloud Tops
- Method for CO_2 Column Concentration in Sub-cloud area





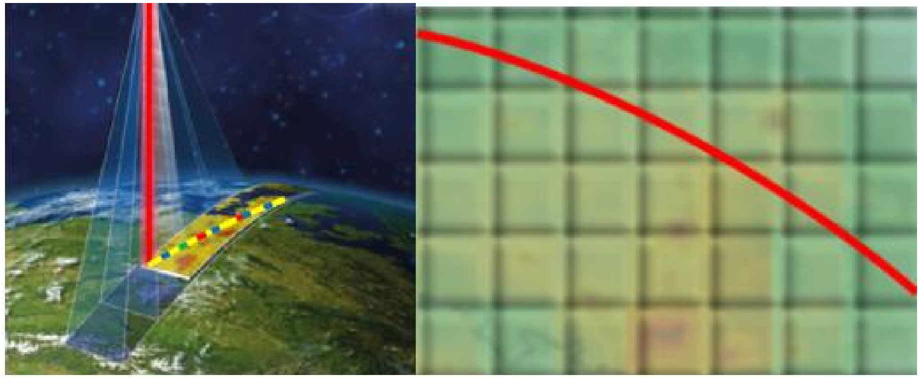
Zhang, X., Yang, H., Bu, L., Fan, Z., Xiao, W., Chen, B., Zhang, L., Liu, S., Wang, Z., Liu, J., Chen, W., and Lee, X.: Estimation of diurnal emissions of CO2 from thermal power plants using spaceborne IPDA lidar, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2024-3152, 2024
Zhihua Mao, Yang zhang, Lingbing bu, et al, Measurement of CO2 column concentration above cloud tops with a spaceborne IPDA lidar. Geophysical Research Letters,51, 2024

NSMC NCSW

The Pre-research on DQ-2

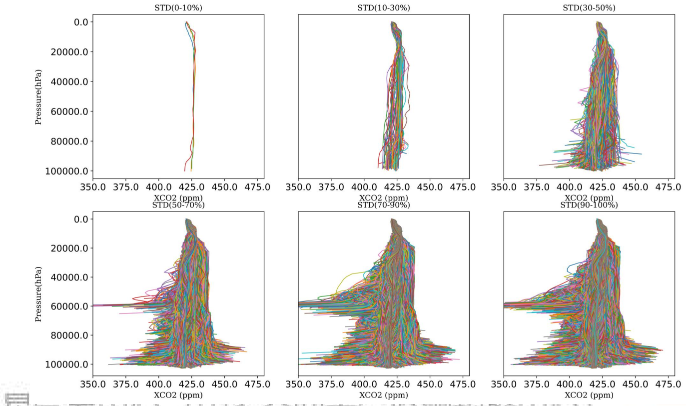
☐ The differences between active and passive

- A very narrow observation bandwidth, as well as a very long observation range (for averaging)



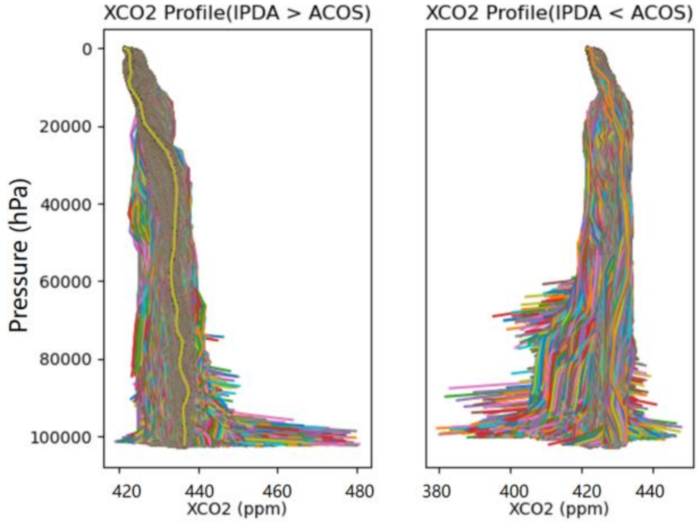
- Both are XCO2,but they are different.

The more vertical the profile is, the closer the active and passive states are （simulation） .



- **Simulations of CO2 column concentration and profile**

DQ-1 and passive (ACOS algorithm)



Weight function for DQ-1: $$WF(p,T)=\frac{[\sigma(\lambda_{on},p,T)-\sigma(\lambda_{off},p,T)N_A]}{[1+\rho_{H2O}(p,T)]gM_{dry}}$$

Weight function for Passvie(ACOS): $$c(p,T)=\frac{1}{[1+\rho_{H2O}(p,T)]gM_{dry}}$$

Relationship: $$WF(p,T)=c(p,T)\cdot[\sigma(\lambda_{on},p,T)-\sigma(\lambda_{off},p,T)N_A]$$

O'Dell,et.al., Atmos. Meas. Tech., 2012., https://www.eumetsat.int/co2m

prepared

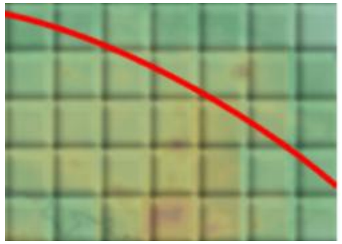
Summary

☐ The data quality of DQ-1 is good

1.Cal/val
2.Day and night difference ΔXCO_2
3.South and north pole XCO_2
4.Emissions of CO_2 from power plants （high-latitude area）
5.Measurement of CO_2 Column Concentration Above Cloud Tops
6.Method for CO_2 Column Concentration in Sub-cloud area

☐ The DQ-2 has active and passive payload

1.Different between Passive and active
The intensity of the sink can be measured?



Pay attention to the observation modes

☐ More ground-based observations for Cal/Val

☐ Data Open

It is expected that the one-year L2C DQ-1 data might be released by the end of this year.


THANKS
NSMC
NCSW