Atmospheric ammonia and carbon monoxide observations at Hefei site, China

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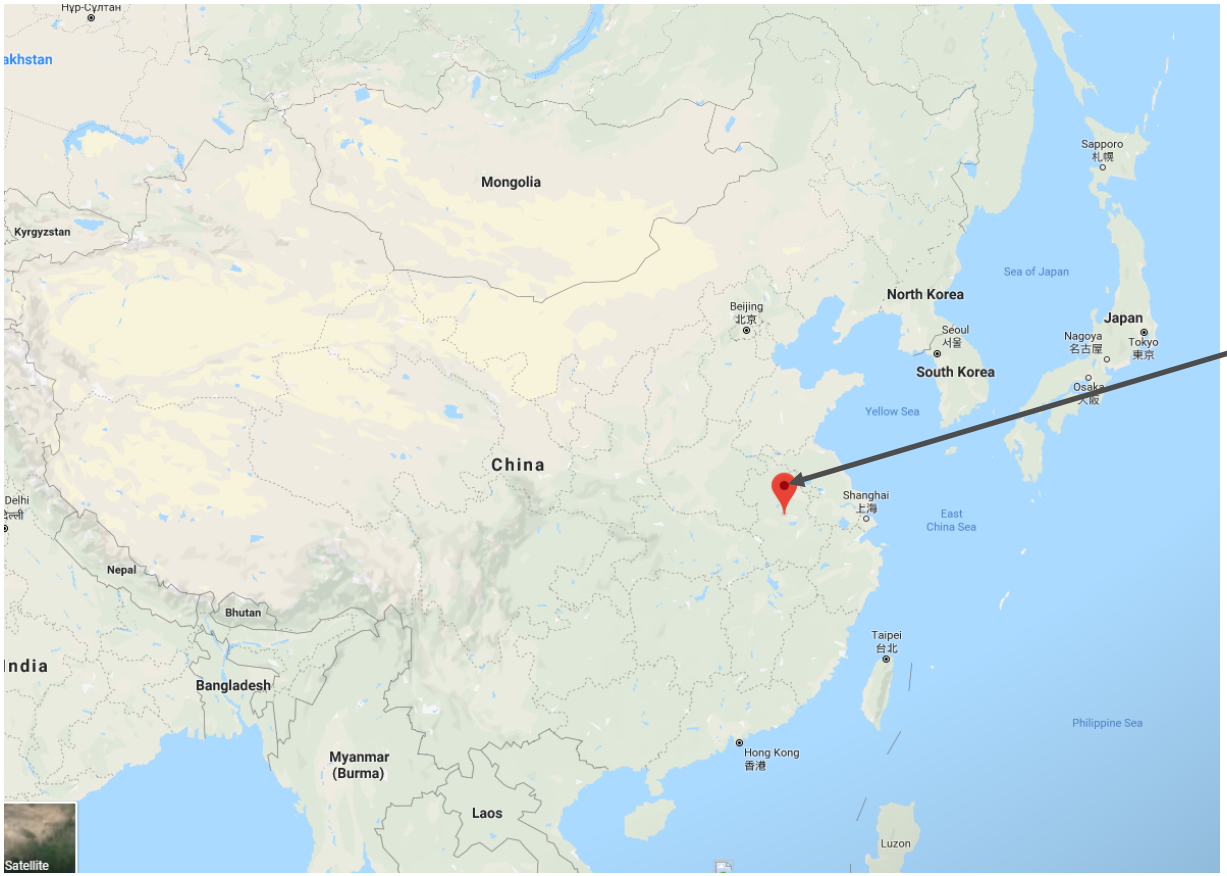
Outline

- 1. Hefei site and instruments
- 2. Current research progress
- 3. Observations of ammonia
- 4. Observations of carbon monoxide

1. Hefei site and instruments

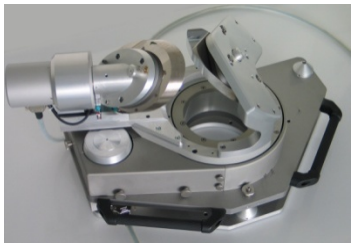


Hefei

Hefei site (31° 54′N, 117° 10′E, 30 m above sea level) is located at AIOFM, about 10 km northwest of Hefei city. Hefei city is in eastern China.

1. Hefei site and instruments

Weather station and solar tracker



IFS125HR

We started routine measurements with high resolution FTS in July 2014. IFS125HR has 9 scanner compartments, with a maximum resolution of 0.001cm^{-1}, and covers a wide spectral range of 5 ~ 50,000cm^{-1}.

2. Current research progress

◆ 1). Our instruments and observations fulfill the TCCON and NDACC-IRWG regulations.

◆2). We retrieved total columns and column-averaged dry air mole fractions of key gases from the NIR solar spectra, following the standard strategy. We have obtained long time series of key gases since 2015 .

◆3). We compared our observations with the concurrent GOSAT and OCO-2 observations.

◆4). We retrieved the vertical profiles of trace gases, such as CO, CO2, O3, HCHO, HCL ,NH3 and HNO3.

2. Current research progress

Picarro gas analyzer

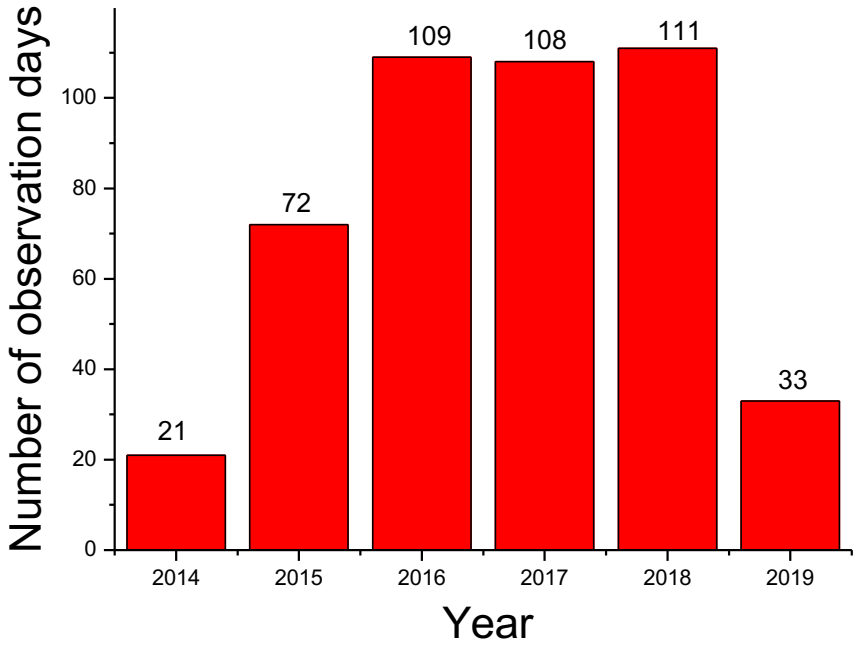
EM27

◆ 5). We performed continuous measurements of surface concentration of CO_2, CO, CH_4, and H_2O with Picarro gas analyzer, and compared the in situ data with those from remote sensing observations.

◆6). We compared the observations of EM27 with those of high resolution FTS, and took part in a Tansat validation campaign in the DunHuang desert in April 2018.

2. Current research progress

◆Observation days with FTIR



Sampling are not continuous with gaps, due to adverse weather and instrument failure.

3. Observations of ammonia

◆Retrieval strategies for NH_3

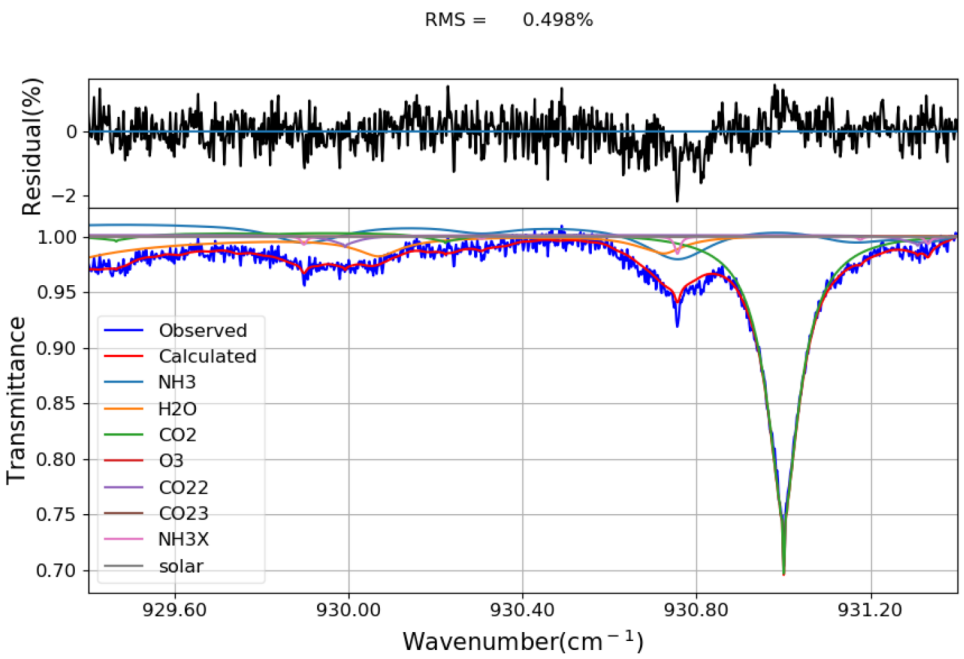
Retrieval software: SFIT4_0.9.4.4
Altitude grid: 48 layers
Spectroscopic database: HITRAN 2008
Daily temperature and pressure profiles : NCEP
A priori profile of target and interfering gases: from WACCM v.6_120_99 and measurements
A priori covariance matrices: only have diagonal values, corresponding to standard deviations of 100% for all layers with no interlayer correlation

Micro-window	Spectral range (cm^{-1})	Interfering species	Signal-to-noise ratio (SNR)
MW1	929.4-931.4	**H_2O**,O_3,CO_2, CO22,CO33	200
MW2	962.1-970.0	**H_2O**,O_3,CO_2, CO22,CO33	200

3. Observations of ammonia

◆Spectral fitting of NH_3 in microwindow1

mw1: 929.4 – 931.4cm-1



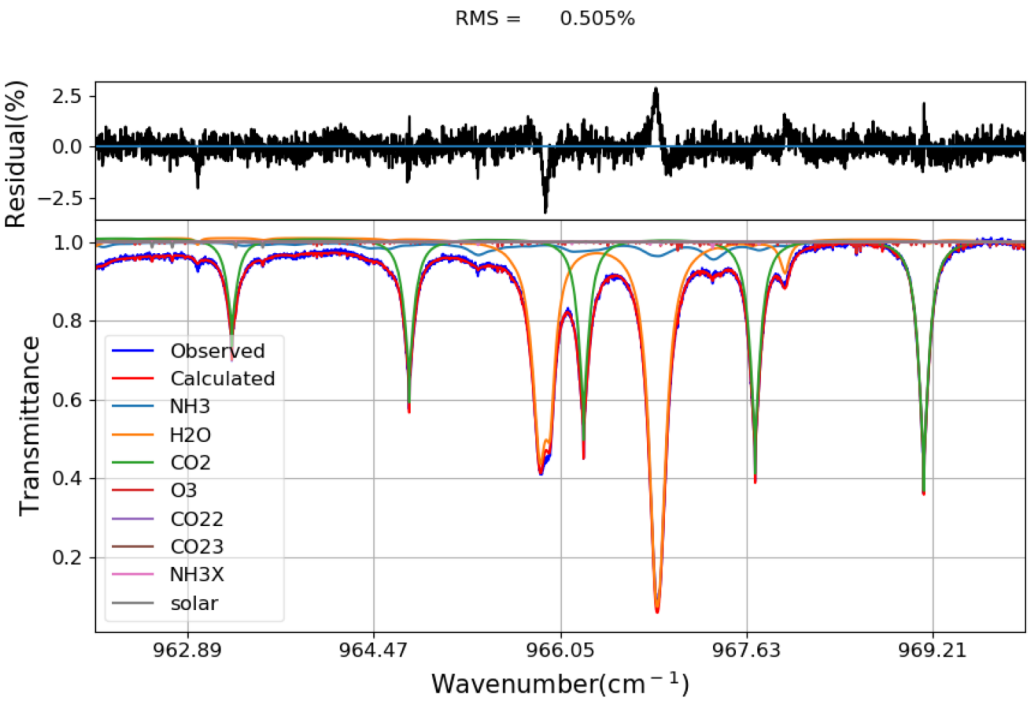
Date: 20180830
Local time: 10:33:18
SZA: 32.34

NH3 Total Column = 1.64×10^{16} molecules cm^{-2}
RMS = 0.498%
DOFS = 1.105

3. Observations of ammonia

◆Spectral fitting of NH_3 in microwindow2

mw2: 962.10 – 970.00 cm-1



Date: 20180830
Local time: 10:33:18
SZA: 32.34

NH3 Total Column = 1.64×10^{16} molecules cm^{-2}
RMS = 0.505%
DOFS = 1.105

3. Observations of ammonia

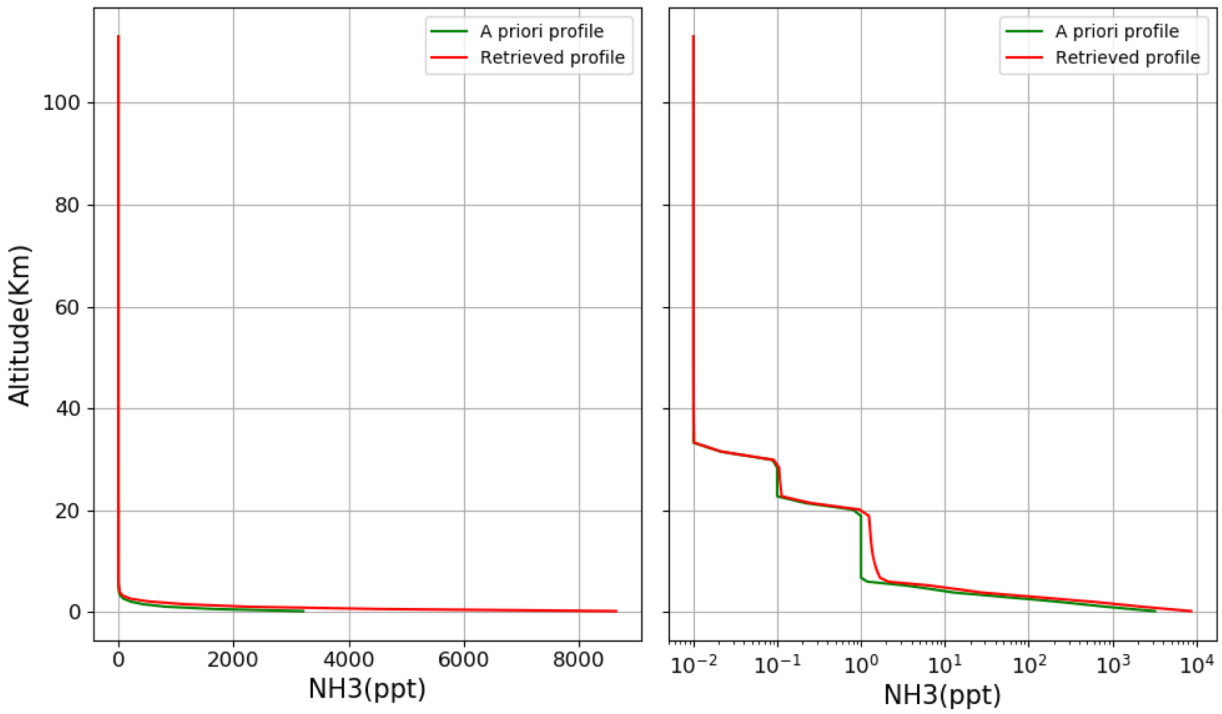
◆Error analysis for NH_3 retrieval

Parameter	Random error(%)	Systematic error(%)
Temperature	1.775	2.613
Solar zenith angle	0.022	0.022
Phase	0.011	0.011
Zero level		
Measurement noise	0.960	
Interfering species	0.312	
Retrieval parameters		
Background curvature		
Smoothing error	0.142	
Spectroscopy		10.697
Subtotal error	2.395	11.092
Total error	11.348	

The total error is about 11.3%, combining the systematic and random errors in quadrature.

3. Observations of ammonia

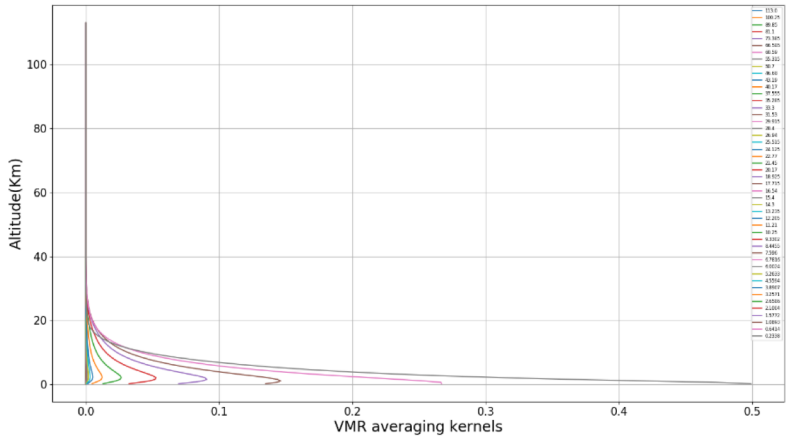
◆Profile of NH_3

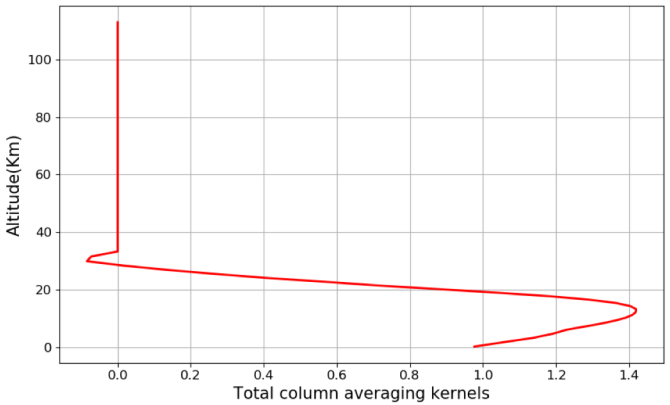


The a priori surface volume mixing ratio is estimated to be 3.2 ppb.
Most of the NH3 at Hefei site is in the lowest layers.

3. Observations of ammonia

◆Averaging kernels of NH_3

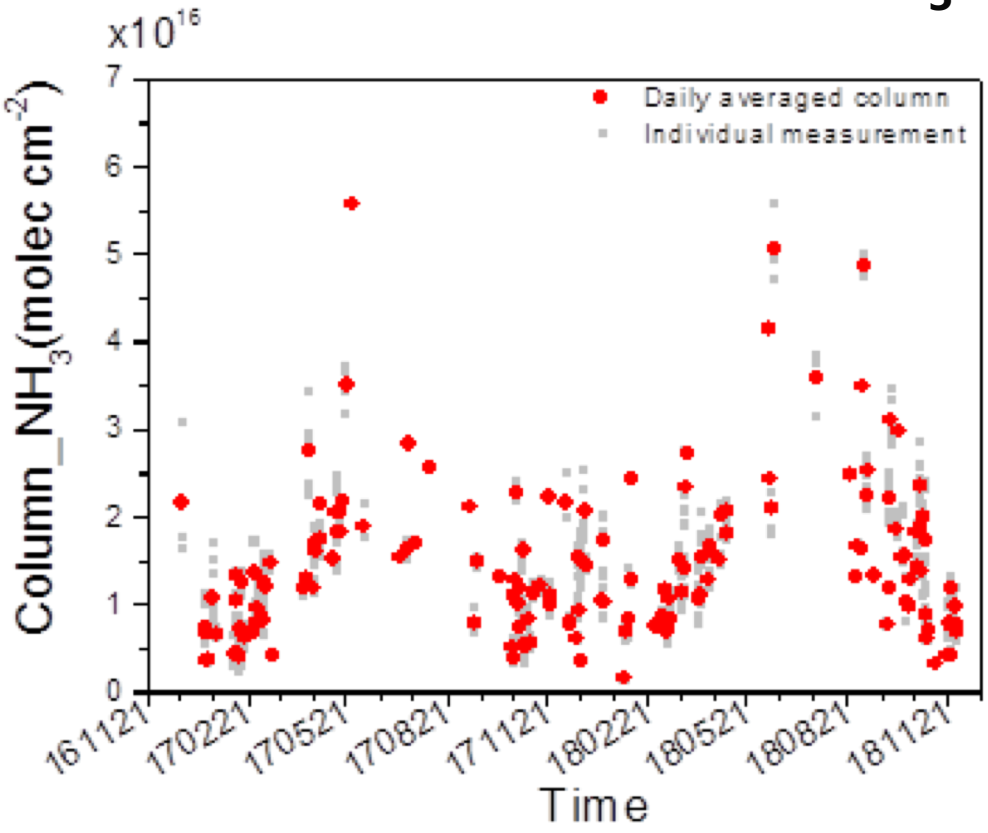




- The averaging kernels peak near the surface, showing that the retrieval is most sensitive to ammonia in the lowest layers.
- A DOFs of 1.015 means that there is only vertical information for multiple layers during summer with increased NH3 total columns.

3. Observations of ammonia

◆Time series of total column of NH_3



- The retrieved total columns of NH3 range from 1.47×10^{15} to 5.57×10^{16} molecules cm^{-2}.
- Total columns of NH3 show an obvious seasonal cycle, and peak in summer due to high temperature. NH3 sources mainly include agriculture and local traffic.

3. Observations of ammonia

◆Comparison with IASI satellite data

The IASI-NH3 data are filtered through the criteria as below:

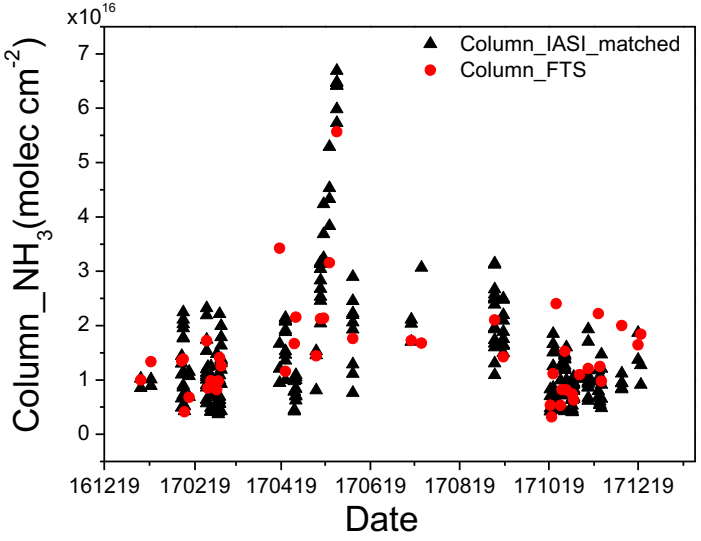
Filter	Filter criteria
IASI-NH3 retrieval error	⩽50%
Cloud cover fraction	⩽25%
Profile type	Land
Spatial sampling difference	50km
Temporal sampling difference	⩽90min

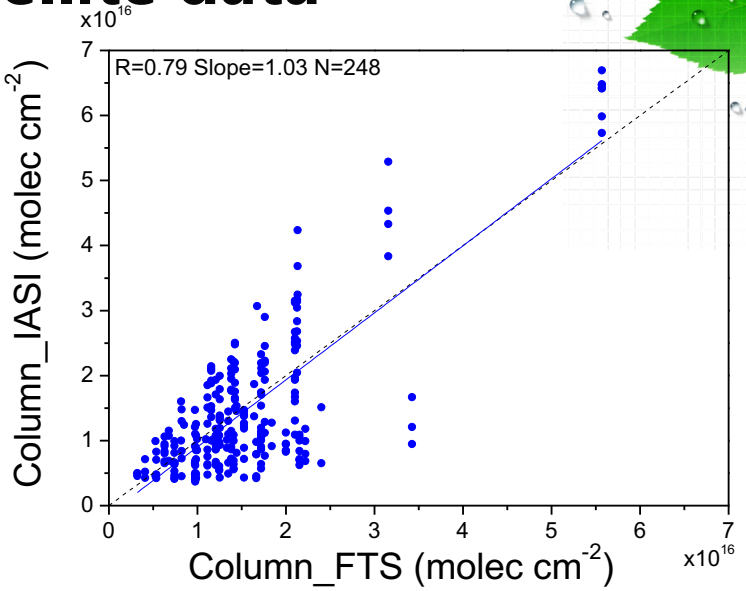
$$RD = \frac{(\text{IASI column} - \text{FTIR column}) \times 100}{\text{FTIR column}}.$$

Outliers : RD>100%

3. Observations of ammonia

◆Comparison with IASI satellite data





- Time series of retrieved columns of NH3 are in good agreement with the corresponding IASI-NH3 data.
  - Number of matched data=248
  - Mean RD= -3.32%
  - Std RD=42.92%
- There is strong correlation between our observations and IASI data. The correlation coefficient (R) is 0.79.

4. Observations of carbon monoxide

◆Retrieval strategies for CO

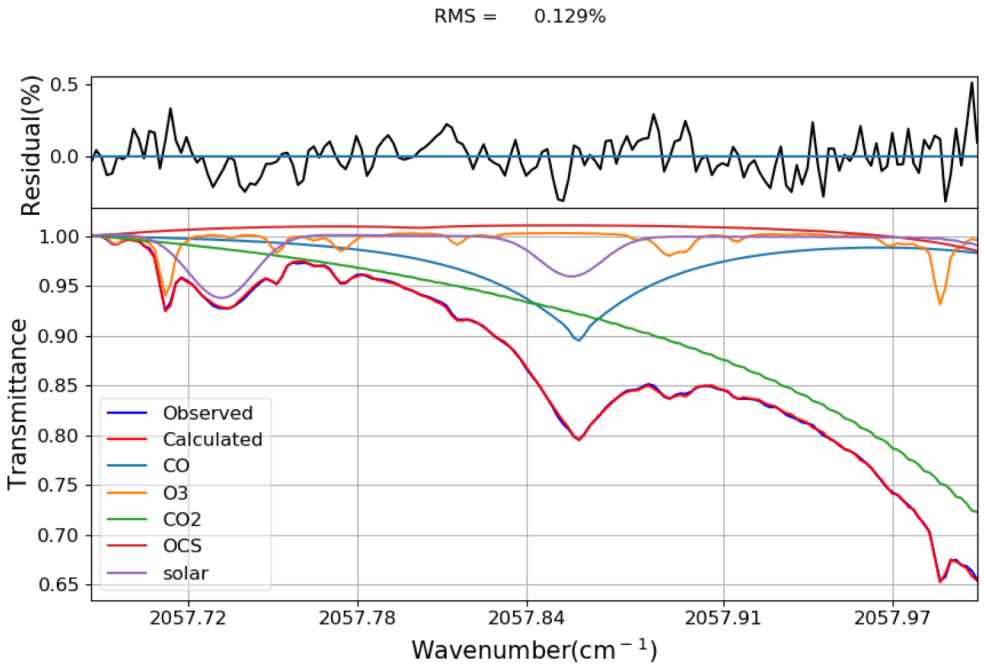
Retrieval software: SFIT4_0.9.4.4
Altitude grid: 48 layers
Spectroscopic database: HITRAN 2008
Daily temperature and pressure profiles : NCEP
A priori profile of target and interfering gases: from WACCM v.6_120_99 and measurements

Micro-window	Spectral range (cm^{-1})	Interfering species	Signal-to-noise ratio (SNR)
MW1	2057.684-2058.0	O3,CO2,OCS	200
MW2	2069.56-2069.76	O3,CO2,OCS	200
MW3	2157.5-2159.15	O3,CO2, N2O,H2O	200

4. Observations of carbon monoxide

◆Spectral fitting of CO in microwindow1

mw1: 2057.684 – 2058.0 cm-1



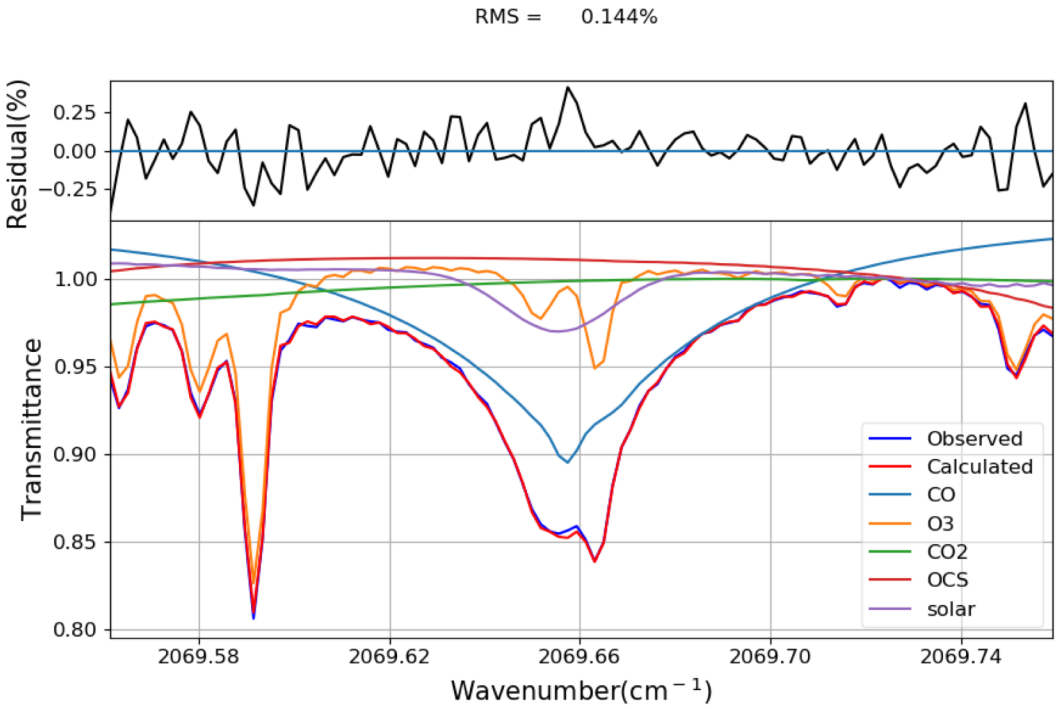
Date: 20180629
Local time: 10:35:48
SZA: 23.50

CO Total Column = 2.87×10^{18} molecules cm^{-2}
RMS = 0.129%
DOFS = 3.394

4. Observations of carbon monoxide

◆Spectral fitting of CO in microwindow2

mw2: 2069.56 – 2069.76 cm-1



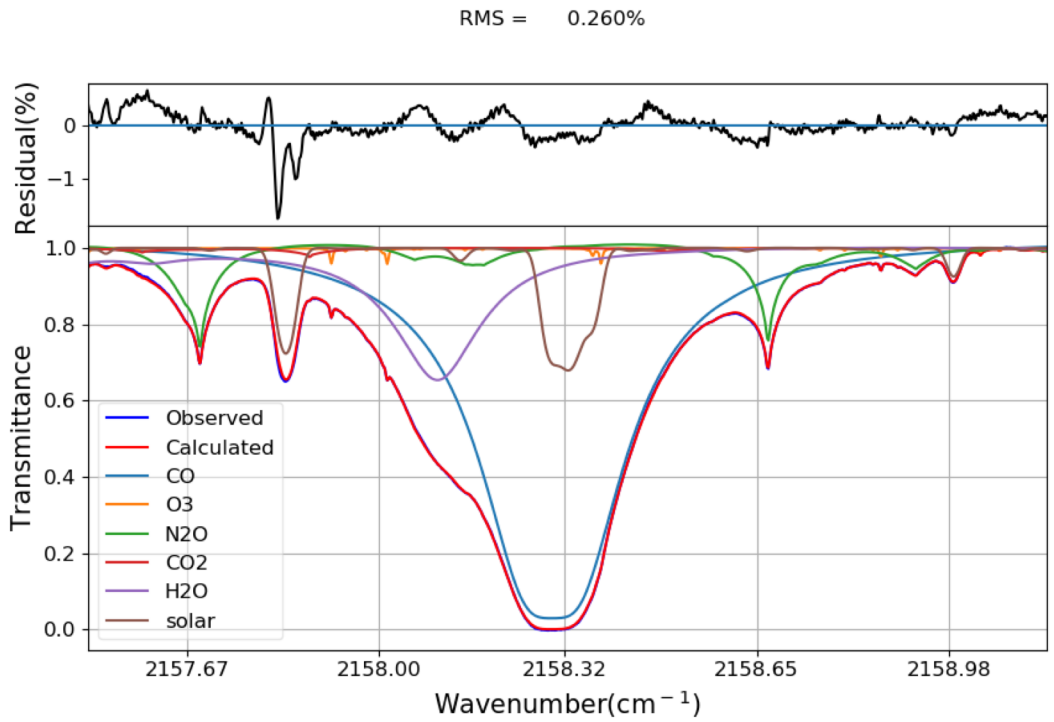
Date: 20180629
Local time: 10:35:48
SZA: 23.50

CO Total Column = 2.87×10^{18} molecules cm^{-2}
RMS = 0.144%
DOFS = 3.394

4. Observations of carbon monoxide

◆Spectral fitting of CO in microwindow3

mw3: 2157.5 – 2159.15 cm-1



Date: 20180629
Local time: 10:35:48
SZA: 23.50

CO Total Column = 2.87×10^{18} molecules cm^{-2}
RMS = 0.260%
DOFS = 3.394

4. Observations of carbon monoxide

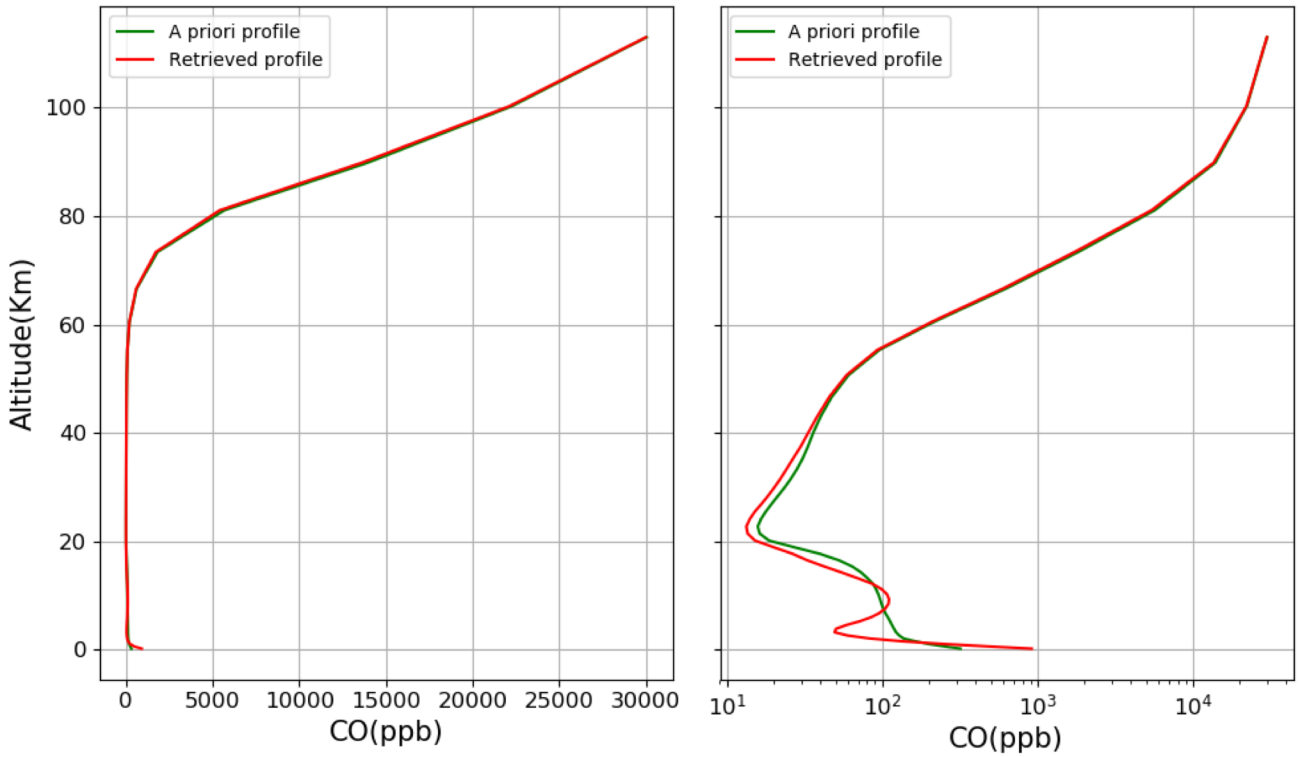
◆Error analysis for CO retrieval

Parameter	Random error(%)	Systematic error(%)
Temperature	1.187	2.033
Solar zenith angle	0.011	0.011
Phase	0.002	0.002
Zero level		
Measurement noise	0.304	
Interfering species	0.027	
Retrieval parameters		
Background curvature		
Smoothing error	0.115	
Spectroscopy		2.004
Subtotal error	4.628	5.330
Total error	7.059	

The total error is about 7.1 %, combining the systematic and random errors in quadrature.

4. Observations of carbon monoxide

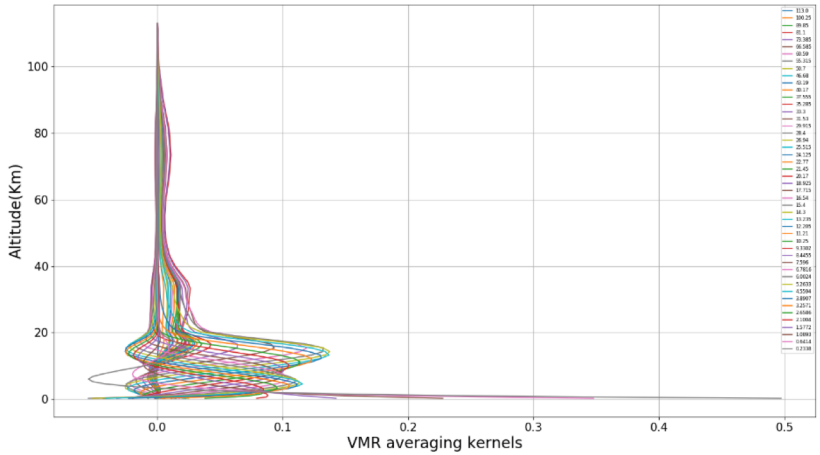
◆Profile of CO

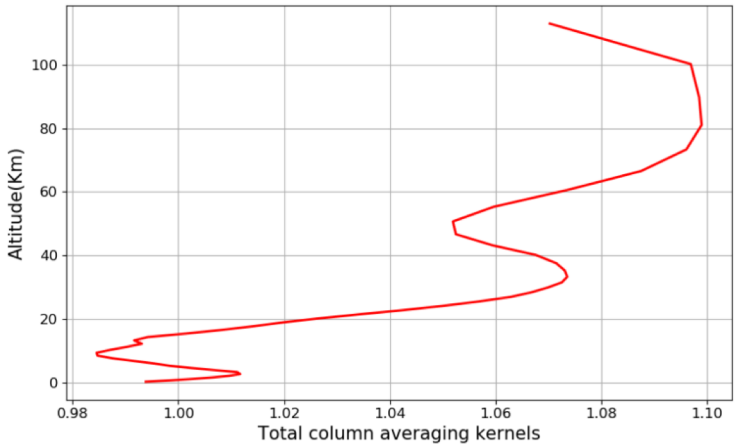


The a priori surface volume mixing ratio is estimated to be 318 ppb.

4. Observations of carbon monoxide

◆Averaging kernels of CO

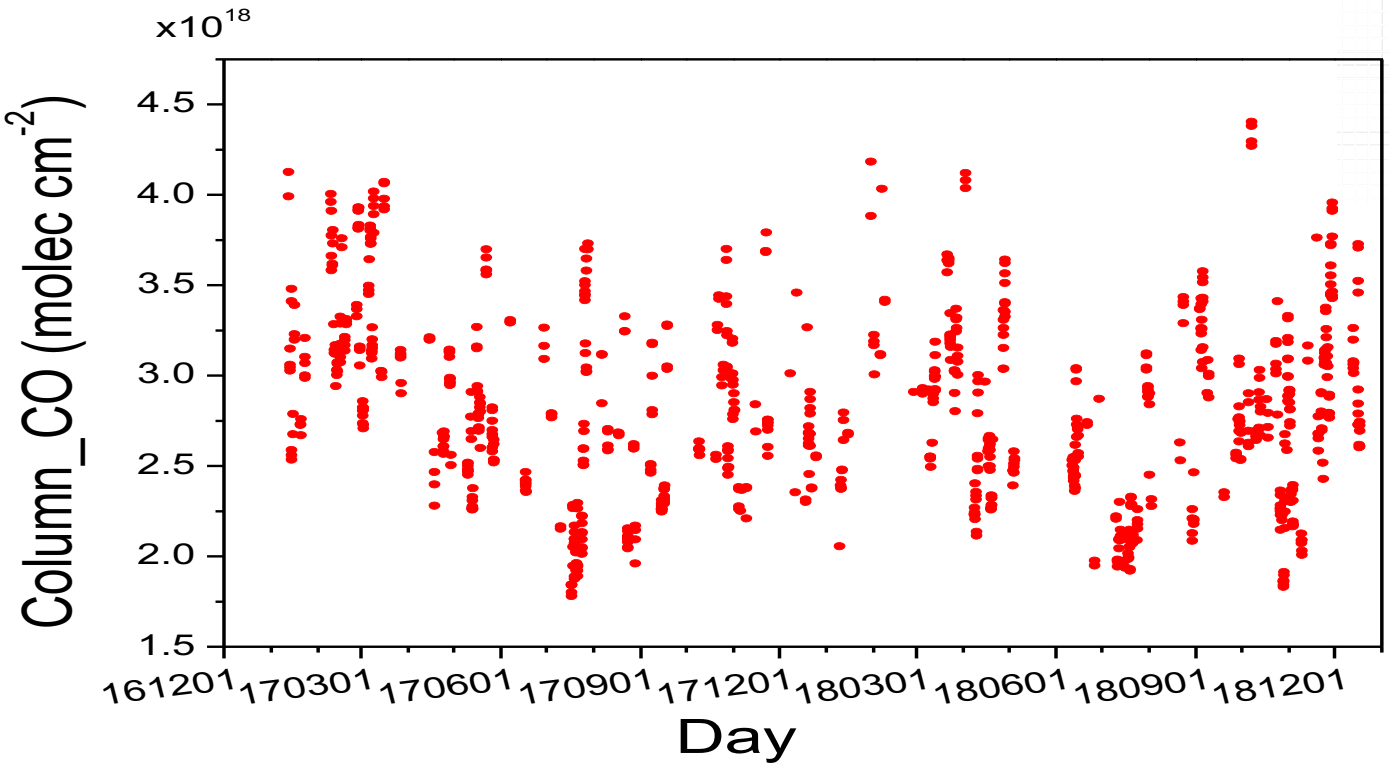




- The averaging kernels peak between the surface and about 20 km, showing that the retrieval of CO is mainly sensitive in the troposphere and lower stratosphere.
- A DOFs of 3.394 means that three independent vertical layers can be retrieved.

4. Observations of carbon monoxide

◆Time series of CO



- The retrieved total columns of CO range from 1.78×10^{18} to 4.40×10^{18} molecules cm^{-2}.
- Total columns of CO show obvious seasonal cycle, peak in early spring and reach the minimum in summer.

Acknowledgement

We appreciate the science team from **the university of Wollongong and the university of Bremen** for providing the help in retrieval of the key gases. Especially, I would like to thank **Nicholas Jones, David Griffith and Voltaire Velazco** for continued help.

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