Review Status: peer reviewed

<table>
<thead>
<tr>
<th>Reviewer 1 Heshun Wang Center for Satellite Applications and Research (STAR), NOAA</th>
<th>Reviewer 2 Luke Surl LPC2E &amp; LATMOS, CNRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version 1</td>
<td>Approved with revisions</td>
</tr>
<tr>
<td>Version 2</td>
<td>Approved with revisions</td>
</tr>
<tr>
<td>Version 3</td>
<td>Approved</td>
</tr>
</tbody>
</table>

Review of version 1

Reviewer 1

Sent on 15 Mar 2019 by Heshun Wang | Approved with revisions

Center for Satellite Applications and Research (STAR), NOAA

It’s an interesting topic to investigate the trace gases using a new ground based FTIR, the validation is preliminary, but the trend is impressive during such a well-known event. Some minor suggestions:

1. The author should provide more details about the key part of the research even for a letter.
   (1) The FTIR observations, does it just perform the measurements at 13:30PM under clear-sky condition? More details should be added.
   (2) How do you combine the four datasets of priori VMR profiles?
   (3) More description about the fundamental theoretical basis about the SFIT2 algorithm. What’s the input and output of SFIT2? You just use the selected micro-window
   (4) More details about the evaluation reference data, namely MAX-DOAS

2. Just curious about the FTIR equipment, the InSb detector for thermal channels while MCT used for middle infrared bands?

Response to Reviewer 1

Sent on 17 Apr 2019 by Jie Cheng

The authors would like to thank the reviewers for their valuable suggestions and constructive comments. We have revised the manuscript accordingly. The authors’ responses have been inserted below in blue text after each of the reviewers’ comments. Reviewer 1: It’s an interesting topic to investigate the trace gases using a new ground based FTIR, the validation is preliminary, but the trend is impressive during such a well-known event. Some minor suggestions: 1. The author should provide more details about the key part of the research even for a letter. (1) The FTIR observations, does it just perform the measurements at 13:30PM under clear-sky condition? More details should be added. Response 1.1) The point is well taken! The data quality is relatively better around 1:30pm, so only the data acquired on this time was used in this study. The reason is provided at the end of Section 2.1. (2) How do you combine the four datasets of priori VMR profiles? Response 1.2) First, the VMR profiles are interpolated to the pressure level of the built-in atmospheric profile of Modtran 4.0, then the VMR profiles are averaged from the interpolated VMR profiles using the data from June to October of each year. (3) More description about the fundamental theoretical basis about the SFIT2 algorithm. What’s the input and output of SFIT2? You just use the selected micro-window Response 1.3) SFIT2 is very popular in retrieving trace gases from ground-based measurements. The input sand outputs of SFIT2 are rather complex. Similar to Modtran 4.0, we need to refer to its manual and
prepare an input file to run SFIT2 each time. Here, I just follow the published articles in this field for simplicity. Trace gas retrievals are usually carried out in small microwindows that contain the spectral absorption features of the target gas as well as the absorption features of interferences. Regarding the selection of micro-windows, we can refer to the book “Spectroscopic atlas of atmospheric microwindows in the middle infra-red” that provided in the Reference. In practice, we may adjust the microwindows according to the characteristics of FTS like spectral resolution. (4) More details about the evaluation reference data, namely MAX-DOAS Response 1.4) This instrument was developed by the Anhui Institute of Optics and Fine Mechanic of Chinese Academy of Sciences. We affiliated to different institutes and carried out independent measurements at that time. We did not have too much information on MAX-DOAS and its data quality. I am regret to say I did not make a response to this comment. 2. Just curious about the FTIR equipment, the InSb detector for thermal channels while MCT used for middle infrared bands? Response 1.5) Yes, you are right. The MCT detector is for the longwave domain from 1850 to 750 cm\(^{-1}\), and InSb detector is for the shortwave domain from 4100 to 1850 cm\(^{-1}\). Thank you very much for your valuable comments and suggestions. The revised paper has been significantly improved.

**Reviewer 2**

Sent on 29 Jan 2019 by Luke Surl | Approved with revisions

LPC2E & LATMOS, CNRS

The author describes a new FTS instrument which is used to measure total atmospheric columns of ozone, carbon monoxide, methane and nitrous oxide. Testing of the instrument is performed, and the instrument appears to have potential to provide good quality data. The instrument is deployed in Beijing during the 2008 Summer Olympic Games in that city, taking daily measurements, and the temporal trends in these trace gas columns are presented.

In general, this is a well-constructed simple paper which outlines and evaluates a new instrument which may be of interest to readers of Sci. The field deployment is relatively simple and limited in scope and is best considered as a test of the instrument rather than a major contribution to the understanding of Beijing’s air quality. My only substantial concern are statements using the observations to assess the outcome of a local policy intervention which I do not believe is justified.

Overall I am happy to recommend approval of this publication. I have a few specific and relatively minor comments and revisions which I outline below:

**Introduction section**

- The sentence “To data, many satellites have the capability of freely providing the products of the trace gases [2–5]” is badly phrased. I suggest “There exist several satellite products of atmospheric columns of various trace gases [e.g. 2–5]”
- Grammar: change “…the ground-based Fourier Transfer Spectrometer (FTS)…” to “…ground-based Fourier Transfer Spectrometers (FTS)…”.
- “cannot satisfy the requirements of monitoring purpose” change to “cannot satisfy the monitoring requirements”.
- The geographical coordinates should be given to two or three decimal places.
- I suggest adding “in situ” in the description of the “traditional chemistry sampling instruments”.

**Atmospheric Trace Gas Measurements section**
· The reader should be told what B3M-IR stands for.
· I suggest either or both of a) highlighting the position microwindows from table 1 on Figure 2 or including the SNR for the specified microwindows in a column on Table 1.
· Grammar: change “is start” to “was started” and “end” to “ended”.
· The units of phase error on figure 1b are not specified (degrees, radians?). The y-axis limits for the phase error should be chosen to better display the range of the data.
· “Above this, the mid-latitude Summer atmosphere is used.” – please specify the source of this atmospheric profile.
· Table 1 would benefit from horizontal lines separating the gases.
· Also in table 1 it is unclear if the first and third microwindow for CH4 have no interfering gases or if H2O, O3 and HCl apply for these also. This should be made clear.
· “If the RMS residual value is very small…” – please include a rough numerical value for what “very small” means in this context.
· RMS values should be expressed as numbers rather than % (unless this is the style preference of the journal)
· In Figures 3, 5, and 7 “calculated” is misspelled.

Results
· “…we could not acquire the ozonesonde data.” Change to “we could not acquire ozonesonde data.”
· Please include time zone for the times given. 24-hour format would be preferable.
· 12:00 AM would be interpreted by many readers to mean midnight. To avoid doubt it may be better to write “noon”.
· The date format for figures 12-15 should be changed, MM/DD/YY is not a good format for an international journal. YYYY-MM-DD is preferable (the author may wish to omit the year as all data is from 2008).
· Figures 12-15 show that there is no data for some days. These gaps should be explained in the text.
· The temporal trend in the trace gas concentrations should be quantified – simple trendlines and R²-values should be sufficient. Without numerical assessment it is difficult to evaluate the validity of the analysis the author makes.
· I disagree with the author’s assessment that “The total column amount of CO at the end of July, 2008 is the highest, and then it began to decrease gradually.” Figure 13 appears to show a sharp drop after the first few measurements an then a mostly stable profile after this. The data may be too sparse to make strong conclusions about trend, and are certainly too sparse and the trends too weak to make an evaluation of a specific policy. References to the Beijing traffic control policy should be removed.

References
· Article titles are all in lower case after the first letter, which is incorrect in some gases (e.g. “gome” and “no2”)

Response to Reviewer 2
Sent on 17 Apr 2019 by Jie Cheng
The authors would like to thank the reviewers for their valuable suggestions and constructive comments. We have revised the manuscript accordingly. The authors' responses have been inserted below in blue text after each of the reviewers' comments. Comments and Suggestions for Authors

The author describes a new FTS instrument which is used to measure total atmospheric columns of ozone, carbon monoxide, methane and nitrous oxide. Testing of the instrument is performed, and the instrument appears to have potential to provide good quality data. The instrument is deployed in Beijing during the 2008 Summer Olympic Games in that city, taking daily measurements, and the temporal trends in these trace gas columns are presented. In general, this is a well-constructed simple paper which outlines and evaluates a new instrument which may be of interest to readers of Sci. The field deployment is relatively simple and limited in scope and is best considered as a test of the instrument rather than a major contribution to the understanding of Beijing's air quality. My only substantial concern are statements using the observations to assess the outcome of a local policy intervention which I do not believe is justified. Overall I am happy to recommend approval of this publication. I have a few specific and relatively minor comments and revisions which I outline below:

Introduction section
• The sentence “To data, many satellites have the capability of freely providing the products of the trace gases [2–5]” is badly phrased. I suggest “There exist several satellite products of atmospheric columns of various trace gases [e.g. 2–5]” Revised.
• Grammar: change “…the ground-based Fourier Transfer Spectrometer (FTS)…” to “…ground-based Fourier Transfer Spectrometers (FTS)…” Revised.
• “cannot satisfy the requirements of monitoring purpose” change to “cannot satisfy the monitoring requirements”. Revised.
• The geographical coordinates should be given to two or three decimal places. Revised.
• I suggest adding “in situ” in the description of the “traditional chemistry sampling instruments”. Revised.

Atmospheric Trace Gas Measurements section
• The reader should be told what B3M-IR stands for. The company did not provide the full name of this FTS at that time. “BM” may denote Bomem, “3” may denote the third generation, and “IR” may denote infrared. The company developed the FTS was merged by another company. So we did not consult them again. I suggest either or both of a) highlighting the position microwindows from table 1 on Figure 2 or including the SNR for the specified microwindows in a column on Table 1. The selected microwindows are highly narrow, and cannot be identified if we highlight its positions in Figure 2. Therefore, the approximately SNRs are added to Table 1.
• Grammar: change “is start” to “was started” and “end” to “ended”. Corrected.
• The units of phase error on figure 1b are not specified (degrees, radians?). The y-axis limits for the phase error should be chosen to better display the range of the data. The units of phase error is degree. “Above this, the mid-latitude Summer atmosphere is used.” – please specify the source of this atmospheric profile. Revised. It is the built-in atmosphere in the radiative transfer code Modtran 4.0.
• Table 1 would benefit from horizontal lines separating the gases.
• Also in table 1 it is unclear if the first and third microwindow for CH4 have no interfering gases or if H2O, O3 and HCl apply for these also. This should be made clear. Thanks for your advice. We have revised the format of Table 1.
• “If the RMS residual value is very small...” – please include a rough numerical value for what “very small” means in this context. RMS values should be expressed as numbers rather than % (unless this is the style preference of the journal) RMS residual value is a qualitative index. I follow the published papers in this field.
• In Figures 3, 5, and 7 “calculated” is misspelled. Corrected!

Results
• “...we could not acquire the ozonesonde data.” Change to “we could not acquire ozonesonde data.” Corrected!
• Please include time zone for the times given. 24-hour format would be preferable.
• 12:00 AM would be interpreted
by many readers to mean midnight. To avoid doubt it may be better to write “noon”. Revised! • The date format for figures 12-15 should be changed, MM/DD/YY is not a good format for an international journal. YYYY-MM-DD is preferable (the author may wish to omit the year as all data is from 2008). Revised! • Figures 12-15 show that there is no data for some days. These gaps should be explained in the text. FTS cannot get transmitted solar spectra in cloudy sky condition. The reason is provided in the text. • • The temporal trend in the trace gas concentrations should be quantified – simple trendlines and R2-values should be sufficient. Without numerical assessment it is difficult to evaluate the validity of the analysis the author makes. A linear trend is added to the Figures 12-15. • I disagree with the author’s assessment that “The total column amount of CO at the end of July, 2008 is the highest, and then it began to decrease gradually.” Figure 13 appears to show a sharp drop after the first few measurements an then a mostly stable profile after this. The data may be too sparse to make strong conclusions about trend, and are certainly too sparse and the trends too weak to make an evaluation of a specific policy. References to the Beijing traffic control policy should be removed. The point is well taken! I only have one and half month’s observations. The effect of the Beijing traffic control policy has been evaluated and verified by national research institutes (for example the Institute of Atmospheric Physics of Chinese Academy of Sciences, Research Center for Eco-Environmental Science of Chinese Academy of Sciences, and Anhui Institute of Optics and Fine Mechanic of Chinese Academy of Sciences). So we do not remove it. References • Article titles are all in lower case after the first letter, which is incorrect in some gases (e.g. “gome” and “no2”) Revised. Thank you very much for your valuable comments and suggestions. The revised paper has been significantly improved.

Review of version 2
Reviewer 1
Sent on 09 Apr 2019 by Heshun Wang | Approved with revisions
Center for Satellite Applications and Research (STAR), NOAA

As the author replied, in Figure 2, (a) should be MCT while (b) is InSb.
No other comments apart from this.

Response to Reviewer 1
Sent on 17 Apr 2019 by Jie Cheng
Thank you for your valuable comment! It has been corrected.

Reviewer 2
Sent on 12 Apr 2019 by Luke Surl | Approved
LPC2E & LATMOS, CNRS

I believe the revisions that the author has made have addressed my minor concerns with the manuscript and this is ready for publication.

My only remaining issue is with the final sentence of the draft regarding whether the data shows a policy impact - I made a suggestion that the author declined to make. While other studies have shown an impact from this policy, I am not confident that this particular study is sufficiently substantial to be a significant piece of evidence for this. However this is a minor concern, and, if
the editor decides to keep this sentence, readers of this paper will be able to decide what they think of this conclusion based on the well-presented results of the rest of the paper.

**Response to Reviewer 2**
Sent on 17 Apr 2019 by Jie Cheng
Thank you very much for your valuable suggestions, comments and great efforts on our manuscript!

**Review of version 3**
**Reviewer 1**
Sent on 16 Apr 2019 by Heshun Wang | Approved
Center for Satellite Applications and Research (STAR), NOAA
I have no other comments