

Black: referee's comments green: authors' answers

First of all, we want to thank the referee 2 for the detailed analysis of our paper.

For the details, please look into the paper with keeping track of changes.

General Comment:

The paper by Zhou et al is a report of column measurements of NO from two sites, one in a polluted area of the Northern Hemisphere (Xianghe, China), and the other in a remote part of the Southern Hemisphere (Maido, ReUnion Island). These data also represent a polluted urban area (in the troposphere) and non-polluted site. This would appear to be the first report of a successful analysis of NO in the troposphere from a ground based FTIR, a nuance that the authors do not explicitly state. Ground-based NO columns has been reported before in the literature, and invariably from NDACC sites that do not in general, see the sort of heightened levels of NO that is reported at Xianghe. So while the stratospheric columns and comparison with satellite data is not new, the tropospheric partial columns of NO are unique, at least as a first report in the literature. Similar data at other Chinese sites may exist and indeed, other potential NDACC sites near large cities that may or may not have enhanced levels of NO near the ground, but the potential is there to explore.

Thanks for the suggestion. We address the importance of this study in the revised version by adding the following sentence:

“We present the first study of a successful analysis of NO in the troposphere from a ground-based FTIR site. The tropospheric and stratospheric NO retrieval might be possible at other potential FTIR sites inside/near large cities with enhanced levels of NO near the surface.”

The methods used follow reasonably standard software procedures that have been developed over many years within the NDACC, but NO is not one of the normal target molecules reported by this network. The authors here represent an experienced team who have a very good track record in this area of atmospheric spectroscopy. The paper is not claiming to provide an extensive description of their method, but refer to a few papers in the literature where this is done. A few more details on how they derived some of the parameters used in the analysis, should be fleshed out a bit, as is mentioned below in the comments sections.

Given that NO₂ is an integral part of the NO_x family along with NO, it would have been an obvious addition to add NO₂ to this analysis. This added molecule is readily available in the FTIR spectra, as the authors know, so this would have been an obvious choice to make alongside CO. Or alternatively, in a city like Xianghe, are there air quality monitors like a NO_x box that measures NO/NO₂?

FTIR NO₂ retrievals at Maido and Xianghe are still under investigation within the EU-ACTRIS framework. Therefore, we did not discuss the FTIR NO₂ retrieval here. We are still working on the FTIR NO₂ harmonization within the NDACC-IRWG network, including Maido and Xianghe, and will present the result in a separate study.

There are no such air quality monitors measuring NO and NO₂ simultaneously. But, there is a nearby BIRA-IASB/IAP MAX-DOAS at Xianghe, providing NO₂ columns. The MAX-DOAS tropospheric NO₂ measurements at Xianghe have been used for satellite validation and atmospheric pollution studies (Hendrick et al., 2014;Verhoelst et al., 2021). In the revised

version, the co-located MAX-DOAS NO₂ measurements are compared with FTIR NO measurements in the lower troposphere at Xianghe. A good agreement between the FTIR NO and MAX-DOAS NO₂ partial columns in the vertical range between 0 and 4 km, with the R value of 0.86. The high correlation with NO₂ is encouraging.

There is also the question of why there is not a modelling component to this paper? So really the question is: is this paper about a new measurement capability (tropospheric NO), or a comparison between a polluted and non-polluted site, or a satellite comparison, or what? So before this paper is published, the purpose of this paper and the new novel aspects need to be clearly pointed out.

Thanks for the suggestion. To make the target of the study clear, the following state has been added in the introduction.

“The aims of this study are 1) to investigate whether it is possible to retrieve NO partial columns in the troposphere and stratosphere from the ground-based FTIR measurements, especially at the polluted site Xianghe; 2) to better understand the diurnal, synoptic and/or seasonal variations of NO partial columns in the stratosphere (and troposphere if possible) observed by the ground-based FTIR measurements at Xianghe and Mado, together with other measurements, such as co-located satellite measurements.”

The level of written English in general ok, but there are a few grammatical issues which are listed in the comments.

Thanks a lot for correcting the grammatical issues.

Specific comments:

1. P1, L7: “...almost not able to be retrieved ...” => “...is very difficult to retrieve...”

Done

2. P1, L20: “basically” => “mainly”

Done

3. P2, L2: “The stratospheric...” => “Stratospheric...”

Done

4. P2, L4: “...(Park et al., 2012), the stratosphere...” => “...(Park et al., 2012), stratosphere...”

Done

5. P2, L23: “...even so for ...” => “... even for...”

Done

6. P3, L4: "...to Beijing." => "...of Beijing"

Done

7. P3, L6: "...recording the near ..." => "... recording near ..."

Done

8. P4, L11: define WACCM with a reference.

Done

9. P4, L16: place this definition and reference to WACCM in line 11.

This is the definition of CAM-Chem not WACCM.

10. P4, L18: "...above that is still taken..." => "...above 50 km is taken ..."

Done

11. P4, L19: expand a bit on the Tikhonov equation. It is entered here without explaining any of the terms. Explain how a value of 50 was obtained.

Done

12. P5, L7: "The HBR cell ..." => "HBr cell ..."

Done

13. P5, L15: "...several less..." => "...several orders of magnitude less..."

Done.

14. P5, L16: this sentence would read better as; "Therefore, in the stratosphere the FTIR retrievals during the daytime are much larger than the a priori profile."

Done.

15. P5, L19: "...have the sensitivity..." => "...have sensitivity..."

Done

16. P5, L20: This is a little misleading the way this is written. Not all layers are sensitive to the stratosphere, since there is no information in the troposphere. A more correct way to put this is that there is sensitivity to NO in the layers in the stratosphere. Note also some sensitivity in the upper troposphere between 10 and 16km, particularly at Mado.

Agree, the sentence is reworded now.

17. P6, L2: Presume this is the average dofs over the entire datasets?

Yes, "over the entire datasets" is added now.

18. P7, L9: "...to the HITRAN2016..." => "...to the HITRAN2016 linelist..."

Done

19. P8, fig 4 caption: "...DOF equalling.." => "...DOF's equal ..."

Change to "DOF of 0.5"

20. P8, L4: "...estimated 13.5%..." => "...estimated to be 3.5%..."

Done

21. P8, L8: "...less than that of NO..." => "...less than the NO..."

Change to "The random uncertainty of NO stratospheric partial column is less than the random uncertainty of NO total column"

22. P8, L9: "...less ..." => "smaller"

Done

23. P9, L5: suggest this sentence reads "Due to photochemical reactions (Kondo et al., 1990), a large diurnal variation of the stratospheric NO is expected."

Accepted.

24. P9, L7: "...SZA of measurements." => "...SZA of the measurements."

Done

25. P9, L7: "...2 order..." => "... 2nd." There are a few other locations where this appears.

Done

26. P9, L8: "...t is in a fraction of local hour)." => "...t is a fraction of the local hour)."

Done

27. P9, L12: "...with the time." => "...with time."

Done

28. P9, L18: "...formed NO..." => "... NO formed..."

Done

29. P9, L20: "...stratosphere, then ..." => "...stratosphere, so..."

Done

30. P9, L23: "...and of 0.74..." => "...and 0.74..."

Done

31. P10, error budget: what about inferring species? A solar model is used (but not mentioned as part of the retrieval strategy, for example table 1) so presumably this is part of the retrieved parameters. But does this solar model include both solar line strength and shift?

Added now.

32. P11, fig 7 caption: "The R is the ..." => "R is the ..."

Done

33. P12, L1: "...t is in fraction of year..." => "...t is fraction of the year..."

Done

34. P12, L2: "...which is relative..." => "...is relative..."

Done

35. P12, L10: "...on one hand..." => "...on the one hand..."

Done

36. P12, L29: "...both start measuring..." => "...both started measuring..."

Done

37. P12, L34: "...smoothed with FTIR..." => "...smoothed with the FTIR..."

Done

38. P13, L5: "...are similar observed..." => "...are similar as observed..."

Changed to "The seasonal variations of the stratospheric NO partial columns observed by MIPAS and FTIR measurements are similar, with a high value in summer and a low value in winter"

39. P13, L9: "...The possible reason is that..." => "...The possible reason for this difference is that..."

Done

40. P14, figure 9: The key needs to be reasonably self-explanatory. The numbers and trends in the key should be in the figure caption. For example the black dot entry should read MIPAS daily means, and the number of points can go into the figure caption. Same comment for all the other entries. The colour coding is also not consistent between what is described in the caption and what appears on the graph. For example, the blue shadow for MIPAS is actually purple, the blue solid line for MIPAS is green, while the purple shadow for the FTIR is pink. This could be related to the way colours are displayed in the pdf reader.

Done. Color is corrected, and More information is added in the figure caption.

41. P14, L2: "...which is corresponding..." => "...which corresponds..."

Done

42. P15, figure 10 caption: "Scatter plots between..." => "Scatter plots at Xianghe between..."

Done

43. P15, figure 10 caption: a comment about the way this plot is presented and captioned. The explicit way of knowing that this figure represents Xianghe is the caption title, which is fine But the caption explanation should be more explicit about what the data is and where is from since there is more than one site.

Thanks for the comments. More information is added in the caption.

44. P15, L8: "...slightly large..." => "...slightly larger..."

Done

45. P15, L8: "It is because that the..." => "The reason for this increased correlation is ..."

Done

46. P15, L7-9: The underlying reason is the increased cross-relation between the tropospheric and stratosphere layers, due to the individual averaging kernels being broader.

Right, it is also added now.

47. P15, L11: why are there no tropospheric NO measurements in summer? This maybe explained later (high water?), but a reference could be placed here that this will be explained later in the paper.

Done.

48. P15, L12: would this normally be expressed as mean (std) is $1.4 (1.0) \times 10^{16}$, as it is in the abstract.

Done

49. P16, figure 11 caption, last sentence: this colour is not yellow, more light green.
Maybe this is a function of the pdf viewer?

The colors are fine on my PC.

50. P16, figure 12 caption: "...CO tropospheric partial columns." => "CO tropospheric partial columns at Xianghe."

Done

51. P16, L2: "...combustion for..." => "...combustion from ..."

Done

52. P16, L4: individual => independent

Done

53. P17, L25: depend => dependent

Done

References

Hendrick, F., Müller, J.-F., Clémer, K., Wang, P., De Mazière, M., Fayt, C., Gielen, C., Hermans, C., Ma, J. Z., Pinardi, G., Stavrou, T., Vlemmix, T., and Van Roozendaal, M.: Four years of ground-based MAX-DOAS observations of HONO and NO₂ in the Beijing area, *Atmos. Chem. Phys.*, 14, 765–781, <https://doi.org/10.5194/acp-14-765-2014>, 2014.

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