



EGUsphere, referee comment RC2  
<https://doi.org/10.5194/egusphere-2022-678-RC2>, 2022  
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## **Comment on egusphere-2022-678**

Anonymous Referee #2

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Referee comment on "Retrieval of atmospheric CFC-11 and CFC-12 from high-resolution FTIR observations at Hefei and comparisons with other independent datasets" by Xiangyu Zeng et al., EGU sphere, <https://doi.org/10.5194/egusphere-2022-678-RC2>, 2022

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### General comments:

The authors used Tikhonov regularization to retrieve CFC11 and CFC 12 at Hefei station, China. They looked at the trend and seasonal cycle during 3 years for CFC 11 and 5 years for CFC 12. Although they mention new retrieval method in the abstract, they followed a very well know method of Tikhonov regularization. They also compared trends and the averaged retrieved profile shape with the ACE satellite as well as one NDACC station in St. Petersburg, Russia. Overall, there is a great value in creating independent ground data. However, the presentation and discussion of results needs to be improved. The information content of the retrieved data is only adequate for retrieving the total column for CFC 11 and maybe two column layers for CFC 12. But authors investigated the surface level value which is not meaningful information from the retrieval. They discussed that optimal estimation method (OEM) is not able to truly retrieve CFC data from FTIR sensors which is not correct. Authors wrote in a way that there is no way to constrain the results in OEM, however using more complex covariance matrix this is very possible. Also, I think the manuscript would benefit from adding a few more NDACC station rather one NDACC station to have a more meaningful comparison and discussion of the results. I would recommend a major correction is needed before publication of this manuscript. More detail comments are provided below.

### Specific comments:

- The general motivation of this work needs to be improved. Retrieval data has one DOF for CFC 11 and two DOF for CFC12 which means they can provide information about total column (assuming that the sensitivity is up to dominant portion of the CFC profile) and two partial columns for CFC12 (using average kernels they should identify the most meaningful layers that can be retrieved). The current motivation assumes that FTIR retrieval can retrieval a detailed profile from surface to stratosphere, which is not possible based on the sensitivity of these measurement. The motivation of the study

needs to be rewritten to clarify how the retrieved information adds to the satellite and in situ measurement and the value of data based on true sensitivity of the data.

- Retrieving CFC profile is named as of the main objective of the manuscript. However, considering the low DOF it seems one total column (or two partial columns for CFC12) can be retrieved.
- It is not clear why only 3 years of data is used for CFC 11 while 5 years for CFC 12. Authors should clarify this inconsistency in the periods and elaborate on how that could affect their conclusions. Moreover, trend analysis with only 3 and even five years of data is not a robust conclusion. If authors include more NDACC stations and use longer period for available data, then they could discuss the overall trend of all included stations, and how a few years of Hefei compares with recent years of other stations.
- Page 5, ln 146 to ln150. Authors mentioned that they did not use the optical estimation method because of the high fluctuation in their results. However, they can use more constrains in OEM by incorporating more a complex covariance matrix in the retrieval to achieve a more restricted result. It is fine to use the Tikhonov regularization, but the discussion of paper is in a way that OEM is limited which is not true in there are many ways to constrain your results to prevent high fluctuations. You can find some good examples of more complex covariance matrix to constrain the OEM results in these papers and many more online
  - Shams, Shima Bahramvash, Von P. Walden, James W. Hannigan, and David D. Turner. "Retrievals of Ozone in the Troposphere an Lower Stratosphere Using FTIR Observations over Greenland." *IEEE Transactions on Geoscience and Remote Sensing*(2022).
  - Turner, David D., and W. Greg Blumberg. "Improvements to the AERIOe thermodynamic profile retrieval algorithm." *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*12, no. 5 (2018): 1339-1354.
  
- There are multiple NDACC stations, it is not clear why data is only compared with St Petersburg? It looks subjective, rather than rigorous research to find relevant and meaning full stations to compare. What is the impact of transportation and local sources. I would recommend authors use multiple station data for comparison to provide a more detail context for their comparisons. Specially that seasonal cycle has a lag time in their cycle. Having a clear discussion on different sources and sinks could cause these differences.
- Page 6, ln 146 to ln156. Your methodology is very similar to Polyakov et al, 2019. Please discuss if there is any difference in the method that you used. Otherwise, I would suggest to just reference their paper as the same methodology is used and there is no need to repeating the same information. Especially that authors did not show any of these matrixes in the plots. As suggested in later comments, adding plots of DOF, average kernel, and Jacobian matrix is a nice way to characterize the sensitivity of the measurements. You can add formulation of those variables to clarify their meaning. Instead use the formulation to elaborate the errors that used in the text.
- Page 12, ln 250, authors investigate surface level CFC 11 and CFC 12 in multiple plots. The measured FTIR data has 1 DOF for CFC11, thus there is not enough information to extract the near-surface value. Because a profile is incorporated as a priori, there is a profile output, however, there is no meaningful information at all levels of the profile. That's why DOF and averaging are useful information to indicate the sensitivity of the retrieval and the vertical resolution of the results. All the investigation of surface level needs to be excluded. Instead, if the DOF and average kernel show that the

measurement has adequate sensitivity to one tropospheric column, the authors can analyze that data.

## Writing/presentational comment

- Hefei is not part of the NDACC. (Could be a great addition though)
- page 3, Ln 71 to 75. It is mentioned that Yi et al, 2021 used in situ measurement. Are these measurements still active? What is the in situ temporal resolution? Again, the text implies that the retrieval can provide surface-level information, which is not correct. The text needs to be updated. Moreover, authors can include those surface measurements in their plots to compare with local measurements. On page 3, Ln 78 to 88 for each satellite, please include the vertical and spatial resolution of the retrieved CFC.
- Page 4, Ln 108. Add solar before FTIR remote sensing site.
- Page 4. Ln 108 to 117: a map of the study area can be very helpful, to illustrate the location of Hefei and other NDACC stations will be added to the study.
- Page 4, Ln 123. It is not clear if the authors used the monthly climatology of CFC as the prior or if they used a specific prior for each month that they retrieved. (12 different profiles for each year of each gas.) also, it would be helpful to write the WACCM spatial resolution that is used in the study. I suggest the look at How the monthly variability and cycle of seasons of the received data is similar or different from prior information that is used.
- Page 8, Ln 225. De Maziere et al., 2018 did not talk about the trends. Clarify which citation is related to each part of statement in this line.
- Page 13, Ln 260. The reasons behind the one-month phase delay need to be clarified. Look at other datasets (grand measurements in particular) and investigate if this delay is persistent there.
- Page 18, Ln 365. The seasonal cycle in St. Petersburg happens in fall which contradicts your explanation of the seasonal cycle in Hefei on page 13, Ln 265. "In addition, more use of air conditioning and other refrigeration equipment in summer, and foams releasing more CFCs 265 at high temperatures lead to high concentrations of atmospheric CFCs." Authors need to further explain the seasonal cycle and its subjectivity to locations especially by adding more stations to the study it would be interesting to see how they vary and if that could lead to an interesting conclusion.

## Fig

- Add a figure of study location as well as selected NDACC data stations.
- Page 7. Fig 1. The total column average kernel is not very easy to comprehend I would suggest including the DOF profile, mean averaging kernel profile, and the Jacobian matrix presentations to fully characterize the retrieval information.
- fig 3, and fig 5 (must check all the plots) axis has ccl2f2 on their axis while the caption says CFC. The same acronym should be used.
- Fig 5. Please include the averaged seasonal cycle from WACCM and ACE for the same period to show what information this study is bringing to the table.
- Fig 6 and fig 4. the information content of these measurements is not sufficient to have

meaningful surface value from the FTIR retrieval to investigate the results.

- Fig 8. It is not clear what information is depicted in this plot and what research questions are targeted here. There is so much subjectivity in two-point FTIR retrieval especially when they are located this far apart. I suggest removing this figure instead create some harmonic analysis of time series based on monthly CFC data for each station (as suggested before at lead 4 sites that are distributed in a different location) and discuss how the harmonic time series are similar or different.