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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Automated ground-based remote sensing measurements of greenhouse gases at the Białystok site in comparison with collocated in-situ measurements and model data" *by* J. Messerschmidt et al.

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Response to the review from referee #2 by Janina Messerschmidt

First of all we would like to thank the referee for his detailed review. The comments and remarks helped to improve the manuscript, especially the part that describes the automation system.

General Comments:

1. The manuscript contains a high level of information and is an important contribution

to the Bialystok special edition. However, for the presented amount of information (description of the FTS system and comparison between FTS, aircraft, tower and model data) the paper is probably too short. The data analysis part should be extended. The authors mention several times variations on diurnal scale but a comparison of measurements and model simulation in for of a diurnal cycle is not presented. It would be good if the authors would illustrate this with one or two figures (mean diurnal cycles for summer/winter) and text.

Answer: I included two figures with diurnal cycles for winter and summer. With the correction already done for both other reviews the scientific part of the paper is extended.

2. Besides, Bialystok is one of a few sites that combine FTS, tall tower and aircraft measurements on a regular basis. In my opinion, the authors should put an emphasis on that and illustrate the capabilities of such a super-site and critically argue how those measurements can help to improve model simulations and the understanding of the carbon cycle. The authors submitted the paper to ACP. Hence, the technical details of the FTS might be better placed in the Appendix and the content of the manuscript itself should focus on the second part (data analysis).

Answer: The description of the automation was moved into the appendix and the manuscript focuses on the scientific analysis now.

3. The level of the technical details lacks consistency. For some parts, manufacturer and model details are presented, for most parts – even important parts (e.g. PLC, computer system) - they are missing. I suggest, the authors come up with a clear and consistent level of detail. Personally, I'd prefer a high level of technical details (for all components!) since this information can be very helpful for others. Especially the solar tracking device – which seems to be home made and very interesting – should be better explained.

Answer: The authors would like to refrain from giving more technical details. If all technical details for all parts would be given, the manuscript would transform into a

manual. For this paper it is more important to give an overview and an idea of the automation. For the first submission ,technical details were given for uncommon devices or for devices, for which it matters which model was chosen. For example, it does not matter which PLC or which computer system is chosen, as long as they are robust and long-lasting. For the motion controller of the solar tracker mirrors the manufacturer was given, as this device is not a common devise and manufacturer information can help to get more specific information. For this submission of the manuscript, all technical details are deleted, only the weather station is described in more detail. Additionally, we described the solar tracking device in more detail and included a Figure.

4. The information content of the presented figures should be revised. Many figures with high level of information are too small and hard to read. Others have only little information. The manuscript should be thoroughly revised in terms of language and understandability.

Answer: Most figures were revised.

Specific Comments:

Introduction:

1. Capabilities of FTS measurements should be better clarified (total column measurement, sensibility to local sources/sinks, link between in-situ and satellites,...) Why is the TCCON not mentioned?

Answer: The introduction was extended and FTS measurements are more explained. TCCON is mentioned as well.

Section 2 .1.:

1. in general: sub-points much too short and hard to understand. Important technical information missing

Answer: Extended paragraph about the solar tracker and revised text regarding under-

standibility

2. 2.1.2.: role of the lamp cooler unclear in this context

Answer: Lamp cooler is not explained anymore. The lamp cooler is not important. The only function of the lamp cooler is to cool the lamps when they are switched on. However, some working groups within TCCON do not even have a lamp cooler.

3. 2.1.3, p.32250, line 22: How does the fan prevent condensation? Is there an additional heater?

Answer: The fan is not explained anymore, because it is not an important part of the automation. However, the reviewer is correct, the fan does not prevent condensation. It was supposed to blow-dry the mirrors in case of condensation. No, there is no additional heater.

4. 2.1.4. This section is just a combination of part numbers, component-names and a link to a company. It does not help to understand the solar tracking device. A simple schematic drawing of the solar tracker and hutch, for instance, would increase the understandability of the working principle dramatically. How is the actual tracking of the sun realized?

Answer: The solar tracker is now better described and an additional figure is given. The tracking is realized in the solar tracker module.

5. 2.1.5. Line shape: why is it necessary to monitor it? Does it change? If yes, why? Is it sufficient to do this once a month? How does it influence the data?

Answer: These are far too many details and would need an own publication. For further information I cited a reference. In this context only the information how often we monitor the Line shape is important.

6. 2.1.6. Why do the authors state details about the tape drive and the backup software but not for the NAS? Can the tape only be read by the specific software? Why is the

data not transferred via Internet?

Answer: All technical details are deleted by now. Yes, the tapes can only be read by a specific software. The data can not be transferred via Internet because of the amount of data (∼Gbyte)

Section 2.2. /2.3. :

1. in general: The description of automation concept and software needs to be revised so it can be better understood. There should also be an illustration of the instruments (long-term) stability and precision.

Answer: We revised the text and included an additional table. The CO2 timeseries (Figure 8) gives a good illustration of the stability and precision.

2. 2.2, automation concept: Which parts of the system run automated, which have to be remote controlled? The meaning of the transition state has to be clarified. There are four modes of transition that are mentioned but not explained. What happens during these modes? How long do they take? What causes the system to automatically reset? A figure illustrating a typical daily routine (in terms of changing the modes) could help.

Answer: All parts of the system run automated. The transition states are not described anymore. In a typical daily routine the modes do not change at all. As long as the system has no error, it remains in the run mode. We explained this run mode and the second mode, the sleep mode, better.

3. 2.2.1. should be merged with 2.2.

Answer: Sections merged.

4. 2.2.1., p.32253, line 26: what causes errors or alarms and how is that dealt with? Is there an automated error handling?

Answer: It would be far too many details to describe what causes errors or alarms. In general, any instrumental failure leads to errors and alarms. We mentioned that we

have an automated error handling.

5. 2.3. The authors state the software that is used for programming the PLCs – why is that more important then the PLC hardware (which is not mentioned)? Is the number of subroutines important? The authors should rather focus on the main functions. Figure 2 completely lacks information. Do the individual fields interact, is the position/size of a field important? It should be left out.

Answer: The PLC hardware is a standard hardware. The naming of the software gives an idea in which language the PLC was programmed. Most of the automation systems within TCCON have a PLC, but all are programmed in other languages. Therefore the software was named. The number of subroutines is important to get an idea how many programs are interacting in such a system. The authors wanted to give an idea of the complexity. Figures werer revised.

6. 2.3.1., p.32254 ,line 20: is only the opening of the hutch controlled by the master program?

Answer: I do not understand the question. The paragraph states a lot of functions of the master program: "The Master program initializes measurements, commands the opening of the hutch and the tracking of the sun, requests the setting of FTS parameters and organizes the collection and storage of the measurement data. Additionally, it logs the system state at all times and provides an interface for local and remote operators."

7. 2.3.1, Figure 3 lacks information. Do the right and the left part run simultaneously? What is the Bruker loop, what is the HMI loop? Is the loop time of the loops on the left different from the loop time of the master loop? Do the boxes in the master loop run at the same time, or from left to right? In terms of understandability, this figure needs major revision (axis, arrows, colors...).

Answer: Figure was revised.

8. 2.3.1., p.32255, line 9: The authors should try to better illustrate the function of the

matrix-system. Maybe Fig. 3 can be replaced by a figure that helps understanding this.

Answer: Matrix was described in a better way and an example is given.

9. 2.3.2. Is the FTS module collecting the measurement data in form of full interferograms or raw data (see 3, line 20)? What is the difference between this raw data and a “real” interferogram?

Answer: The difference is that the raw data of one interferogram are about 12 data files. To get the "real" interferogram, these files have to be merged. The FTS module collects the measurement data in form of raw data and the data retrieval software merges them.

10. 2.3.3., p.32256, line 8: what are the criteria to start a measurement? How many are typically made on one day? Is one measurement follow directly by the next?

Answer: Sunny weather conditions are the criteria to start a measurement. How many measurements are done depends on the weather conditions. Yes, one measurement follows directly the next.

11. 2.3.4. Tracker module/software should be described in more detail since it seems to be a non-commercial system.

Answer: Tracker was better described and a Figure was included.

Section 3:

3. p.32258, line 9: how can the outliers and the huge variations (350-420ppm) be explained? Is there an error budget?

Answer: An error budget is given in Wunch, D., Toon, G. C., Blavier, J.-F. L., Washenfelder, R. A., Notholt, J., Connor, B. J., Griffith, D. W. T., Sherlock, V., and Wennberg, P. O.: The Total Carbon Column Observing Network,Philosophical Transactions of the Royal Society A: Mathematical,Physical and Engineering Sciences, 369, 2087–2112, doi:10.1098/rsta.2010.0240, 2011.

Section 4:

The authors mention the diurnal scale but do not show a diurnal cycle. A mean diurnal cycle for summer and winter for the tower levels and FTS would be interesting and would also illustrate the sensibility of the FTS to variations in the planetary boundary layer. Fig. 6. Explain the big variations (more than 30ppm in the 5m level) shortly before the gap in the tower measurements – is this an artifact? It would be interesting to see the diurnal cycles for this period.

Answer: Two new figures with diurnal ccycles are given for the tall tower and the model.

Section 5:

1. Fig. 7: legend for the axis on the right is missing. The corresponding profiles for CO2 would be helpful.

Answer: Legend inserted. For further details please refer to Wunch et. al, 2011.

2. Fig. 8: Way too small. A correlation plot (FTS vs. model) would illustrate the comparison better.

Answer: Figure revised.

3. 5.3., p.32264, line 11: What can be learned from the different results of the comparison of FTS/ model and FTS/aircraft+model? The authors should give a conclusion on how the FTS and aircraft measurements can improve the model (as stated in the introduction). So far the numbers (p.32264, line 11) show an offset between model and FTS (0.8ppm) but a rather good precision (+/- 0.5ppm). If more “truth”(aircraft data) is added to the model, the precision gets worse (by almost 62%) but the offset is reduced by 40%. Is that good / bad? Should every FTS station have aircraft profiling? Does every tower need a FTS? Since Bialystok is one of the few sites that has all of the three, the authors should really focus on those questions.

Answer: The conclusion tries to focus on these questions now.

Conclusion:

1. p.32664, line 16. The statement of low maintenance, safeness and robustness was not sufficiently illustrated in the previous text. How is this achieved? If this were main points designing the system there should be an emphasis on this in the description.

Answer: The automation is not mentioned anymore in the conclusion.

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