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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Civil aircraft for the regular investigation of the atmosphere based on an instrumented container: the new CARIBIC system" *by* C. A. M. Brenninkmeijer et al.

Anonymous Referee #2

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Review of "Civil aircraft for the regular investigation of the atmosphere base on an instrumented container: the new CARIBIC system" by Brenninkmeijer et al.

General comments:

This paper describes in detail the methodology and instrumentation for the CARIBIC atmospheric chemistry measurement package. CARIBIC is an ambitious project that has the promise of delivering systematic in situ measurements of key chemical and aerosol components in undersampled regions of the atmosphere. There are 50 authors from 18 institutions contributing to this work. The paper includes needed details of the instrument methodologies and, in some cases, an estimate of measurement uncertainties. It is very helpful to have this information in one manuscript, with subsequent links and references for more detailed information. It is important to publish an overview of the entire package, since many papers using data from this experiment will follow in subsequent years. Because of this, I believe this material is appropriate for publication in ACP. The paper is generally well and clearly written.

There is a balance to achieve between technical detail and scientific usefulness for publication in a journal such as ACP. Unfortunately, this paper is weighted far too heavily toward the engineering side, and presents some information that is better left for other venues. Much of this detail is not necessary for subsequent scientific understanding of publications from these measurements. And some needed experimental detail regarding specific measurements is lacking. I therefore recommend some substantial modifications to the manuscript as follows:

1) Remove substantial portions of Section 3 and introductory material in Section 4 (details follow). These portions describe the engineering of the container, details of the methodology of electrical and plumbing connection, power consumption and heat dissipation, and cockpit interface. This is simply not useful information for evaluating the data produced from this package, and is therefore irrelevant to a scientific publication. This information may be placed in a technical report, online resource, or investigator's handbook, but it does not belong in ACP.

2) Remove Figures 4, 5, and 8 for the same reasons.

3) Reduce detailed discussion for instruments that are under development. The level of information presented is too detailed, since the methodology and uncertainties are in flux. Save these detailed instrument descriptions for a later technical paper.

4) Include uncertainties for all the measurements.

5) Ensure that references are given for each technique.

6) Propose and discuss strategies for data quality evaluation.

Detailed comments (refers to 1-6 above): 1) A. Remove lines 16-22, p. 5285.

B. Remove lines 8-19, p. 5287

C. Remove lines 11-24, p. 5288

D. Remove lines 21-29, p. 5290

E. Section 3.3–remove all except basic dimensions and weight of container and racks. The reader does not need to know about structural modifications, cooling fans, fire safety, screws used, loading methodology, cockpit indicators and controls, etc.

F. Remove lines 13-19, p. 5293.

G. Remove lines 11-28, p. 5294.

H. Remove lines 1-29, p. 5295

I. Remove lines 24-25, p. 5306 (unnecessary detail about CAATER, etc.)

J. Remove line 20, p. 5314. This sentence has no content.

K. Remove lines 12, 17, and 22. Unnecessary detail about USB, memory card, connection fitting.

L. Please peruse all the remaining text to see if the level of detail is appropriate, with the goal being to retain only that information that is useful to evaluating the data quality.

2) A. Figure 4 shows CFD modeling of the pressure distribution upon the sampling inlet. This is not subsequently used in the text, and appears to be here just to show that it was done. Please remove.

B. Figure 5 is an image of stress loads upon the inlet and supporting structure. This definitely is not needed in ACP. Please remove.

C. Figure 8 is a photograph of plumbing and connections. It is not informative (but shows neat workmanship). Please remove.

3) A. Section 4.9 spends quite some text on description of an instrument, the electrochemical cell, which is clearly still in development phase. Firstly, such an instrument should be developed and thoroughly tested in a ground-based application before attempting the difficulties of flight conditions. Secondly, this description should be saved until the technique has been further along and it is time to write a detailed instrument description with uncertainties, comparisons with other techniques, etc. Please reduce this section to one short paragraph, (" An instrument is under development. . . .") or delete it entirely.

B. Section 4.13 also describes an instrument that appears to be under development. Perhaps this description could be compressed until a detailed analysis of the technique has been prepared for publication?

4) Information on the detection limits, accuracy, and precision is provided for some instruments but not for others.

A. Section 4.1. How does the uncertainty in Td translate into ppmv error as given for the photoacoustic water measurement for typical flight conditions? These instruments both measure "water vapor" but the accuracies are not immediately comparable because of the different units. What is the cause of the very large discrepancy in Fig. 10 at 05:22? Is this within the uncertainties stated here? Please say more about how total water is measured. Surely there are major uncertainties in regards to the shadowing effect of the airplane fuselage on the precipitation sampling (e.g., Twohy, C.H. and D. Rogers, 1993: Airflow and water drop trajectories at instrument sampling points around the Beechcraft King Air and Lockheed Electra. J. Atmos. Oceanic Technol., 10, 566 578.)? Can these be described in more detail, or at least the approach being taken to quantify these major sampling issues?

B. Section 4.3. What are the CO uncertainties from calibration and error propagation (not from intercomparison tests, which are not absolute)? Is the sample dried to reduce water effects? If not, what is the uncertainty caused by these effects?

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C. Section 4.4. Is it possible to estimate NOy uncertainties that might be caused by interferences, such as HCN conversion, and by other in-flight artifacts? By not making standard addition calibrations to the sample flow in flight, there is a possibility for various artifacts, including changing sample line losses, that are very difficult to quantify otherwise. The uncertainties derived from pre- and post-flight calibrations are surely the very minimum uncertainties possible. See Ridley, B.A., J.G. Walega, J.E. Dye, and F.E. Grahek, 1994: Distributions of NO, NOx, NOy, and O3 to 12 km altitude during the summer monsoon season over New Mexico. J. Geophysical Research, 99 25,519-25,534.

D. Sections 4.5 and 4.6 do not provide any uncertainty information regarding the particle concentration measurements. It is stated that particle transmission within the CPCs limits the maximum particle size measured, but how is this known? There is no data provided on inlet transmission efficiency, and this surely is a very, very turbulent system. Stokes numbers for even small particles are large at the operating pressures of the aircraft, so the common assumptions about lack of inertial loss for submicron particles needs to be reexamined. Substantial ram heating will change the thermodynamic state of the particles, driving water off liquid particles. Is the sample line actively dried prior to measurement? Also, section 4.5 states that CPC concentrations are corrected for losses in the inlet and sampling line, but is this not a highly particle-diameter dependent correction? Since particle sizes in the CPC size range are not measured, how can this be done? This section needs more quantitative evaluation of uncertainties, measurement procedures and artifacts.

I am not convinced of the absence of ice shattering effects on aerosol sampling. The example cited shows no evidence of such artifacts within cloud. But in precipitation with larger cloud particles with more inertia, this may be more likely. For example, in Fig. 12, the number concentration of ultrafine particles increases immediately below a cirrus cloud layer. Is this really particle formation, as suggested? It may more likely be shattering of falling ice crystals below cloud, as is typical for this cloud type (Murphy

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et al., Particle Generation and Resuspension in Aircraft Inlets when Flying in Clouds, Aerosol Science and Technology, 38:400-408, 2004). To interpret such observations, the investigators must be able to demonstrate that such artifacts are not occurring.

E. Section 4.7 does not describe the accuracy with which ambient aerosol mass concentration can be determined from analysis of the sampling foils. Is this really feasible? The comparison shown in Fig. 13 really does not look very encouraging. Can independently derived uncertainties be provided? If not, this becomes a composition measurement, not a mass concentration measurement. Please amplify on the uncertainties.

F. Section 4.8. Is there a possibility of nonlinear response that is not seen by using only two calibration gases? Please provide some detail on this.

G. Section 4.10. Please provide a precision and error estimate. Has sample line and pump losses of reactive gaseous mercury been evaluated?

H. Please provide precision and error estimates for each of the gases listed. How is the non-specificity of the technique dealt with?

I. Line 5, page 5312. Please specify the flushing time of the cylinders at typical cruise conditions.

J. Section 4.15. What is the realistic accuracy and precision of the DOAS sensors? Please provide.

5) Please make sure that references are provided for each sensor, if available. Possibly adding a column to Table 1 would be the most compact way to accomplish this.

6) I would like to see a section added, perhaps in the Conclusions, that discusses the need for an ongoing data quality evaluation process. For example, there should be blind submission of the data to an archive, and an independent researcher whose job it is to investigate the consistency between datasets. Is the reactive nitrogen budget and partitioning consistent with the ozone observations within the stated experimental un-

certainty? Are the aerosol measurements consistent within experimental uncertainty? The water vapor measurements? These are critical evaluations for which a formal, continuing program needs to be in place.

Furthermore, with the difficulty in providing in-flight calibrations for many of the instruments, an effort should be made to produce an intercomparison program. Clearly, the airline will not permit a formation flight with other aircraft during commercial service, and the cost of dedicated non-passenger flights is prohibitive. However, a flight planned with, for example, the DLR Falcon aircraft to follow in standard air traffic spacing behind a CARABIC flight could allow tracer/tracer comparisons. Ratios of O3/CO, NO/CO, NOy/CO, and CO/CO2 ratios could be compared. Similar comparisons are possible between the hydrocarbon and aerosol measurements and tracer compounds like CO and CO2.

Technical Corrections:

1) line 28, p. 5281, replace "basis" with "base"

2) lines 13 and 14, p. 5292, replace "bilge" with "belly".

3) lines 24-25, p. 5292, ". . . is led through a 3/4 " O.D. aluminum tube kept at 40C and lined with a thin-walled PFA tube."

4) line 1, p. 5293, please state the source of this conductive PTFE tubing.

5) line 4, p. 5294, remove "called base power supply . . . 22.5 kg)". Unnecessary detail.

6) line 11, p. 5296, please provide a reference for this issue.

7) line 17, p. 5299, what is meant by "crossing the LS"?

8) line 26, p. 5306, replace "as projected" with "than projected".

9) line 24, p. 5310, replace "to increase the" with "an increase in the". line 13, p. 5311,

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Interactive Comment

"Collecting air samples is as simple as it is powerful."

10) line 5, p. 5312, what is "retrospective sampling"? Non-standard terminology.

11) line 29, p. 5312, place "pigeon holes" in quote marks. Slang term.

12) line 8, p. 5313, "such as nitrates and DMS, are preserved in the glass flasks."

I have not proofed the cited references.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 5277, 2007.