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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Measurement of the tropical UTLS composition in presence of clouds using millimetre-wave heterodyne spectroscopy" *by* B. M. Dinelli et al.

Anonymous Referee #1

Received and published: 27 September 2008

1) General comments

a) Scientific significance: good

The paper describes first measurements taken during a tropical campaign with a newly developed millimetre-wave instrument installed on board a high-flying research aircraft, sounding thermal emission at the atmospheric limb below the flight altitude (of about 20km) in the upper troposphere and lower stratosphere altitude region. The authors demonstrate a substantially new observation method using field measurements, which is potentially suitable for publication in ACP, although I think rather as a technical note since the focus is clearly on the demonstration of the measurement concept (in view of

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development of satellite sensors) than on a direct contribution to atmospheric sciences which would require much deeper analysis of tropical campaign data.

b) Scientific quality: fair

The authors demonstrate that the measurements by the new airborne mm-wave receiver allow to obtain vertical profile information in the altitude range of interest (upper troposphere) and in the presence of clouds, with clearly better sensitivity as an infrared instrument on the same aircraft, despite limitations due to instrument problems even during the single flight providing atmospheric data.

Unfortunately the authors do not fully convince in how the measurement capabilities of the new instrument are derived and discussed. The mainly employed diagnostical criterion is the "individual information content" of the measurements, based on the ratio of the apriori uncertainty (knowledge prior to the measurement) to the error of the retrieved volume mixing ratios. This quantity is used to estimate the approximate altitude range where the measurements provide information. However, in order to decide whether a measurement system provides useful information it is essential to also consider other obvious parameters such as for example the retrieval errors (absolute, relative, random and systematic) and the achieved altitude resolution. For example, discussion of the relative error (with respect to a retrieved or climatological value) would give further insight concerning the usefulness of the new instrument for observing a particular target species and altitude range.

Concerning the rather limited information content found by the authors, a particular problem might lie in the weighting between measurement and apriori information used in the employed "Optimal Estimation" retrieval due to an inadequate choice of weights. This issue should be addressed.

Finally, systematic uncertainties of the instrument are only partly discussed. For example, whilst the critical uncertainties in pointing are described in detail, there is hardly any information about other critical parameters such as the antenna characteristics,

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among others (see also my specific remarks). The impact of such uncertainties in the instrument characterization on the retrieved volume mixing ratio profiles needs to be addressed.

I would therefore recommend major revisions to the manuscript.

c) Presentation Quality: fair

The presentation quality is judged as "fair" since sections 2 and 3 could be considerably shortened if only the relevant information is presented. Another issue is the limited readability of some of the figures (axis labels) (see suggested technical corrections below).

2) Specific comments

Abstract: Please provide quantitative results, e.g. measurement capabilities in terms of altitude range, altitude resolution, measurement uncertainties for the studied target species.

Introduction: Limitations of present meteorological mm-wave nadir sounding capabilities (MHS, AMSU, IASI) in the middle and upper troposphere for the here relevant species could be briefly discussed in the introduction in order to set the scene for this study.

Section 2 (2.2-2.4): The right balance (level of detail) needs to be found. For example, whilst the critical uncertainties in pointing are described in detail (section 2.4 might even be shortened slightly), there is hardly any information about other critical parameters for limb-sounding measurements such as for example the antenna characteristics. All typically important sources for systematic uncertainties of the measurement (related to pointing, antenna, optics, sideband filter, spectrometer, calibration, baseline ripple, etc) could here briefly be discussed and (if possible) quantified. This is so far only partly done. The impact on the retrieved profiles needs also to be addressed.

Section 3: The whole paragraph (3.0) about the Scout campaign could be considerably

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shortened. The relevant background information for the single successful flight with Marschals can easily be summarized in only one or two lines.

Section 4: (2. on "individual information content (IC)"): Since this quantity is used later in the manuscript as the main diagnostical tool, the authors should indicate which values of IC indicate a useful measurement, i.e. how large is IC when information is mainly from the measurement and not from the apriori information of a retrieval parameter. From the definition it is moreover evident that an increase in the apriori uncertainty would ultimately lead to a higher information content (for a given measurement error). The choice of the apriori uncertainty is therefore of primary importance and may have considerably affected the outcome of this study. This needs to be discussed and clarified in the manuscript.

Section 5.5: The above mentioned issue is also important for the discussion of the retrieval results in Section 5.5 where changes are needed accordingly.

3) Recommended technical corrections

Title: in case this paper should be revised for ACP, I suggest publication as "technical note".

p14170

l5: provide frequency range of Marschals

l11: temperature

l16: "using measurements made" (remove "a few")

l17: M-55, during

l19: remove "the" (2x)

p14171

l1: inadequate citation "ricaud 2007"

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l13: 2 references for IASI, but other instruments need also to be briefly discussed (in a general way)

l24: "since the majority of instruments are blinded by clouds ... in this region". Certainly incorrect, suggest to reformulate. Spatial resolution and sensitivity is also a limitation of todays satellite sensors.

14172

l1: write out acronym (ESA)

l7: "capability of the mm waves" (?)

l11: explain acronyms (MAS, ATLAS)

l17: "was not enough to" (?)

l20: "ODIN". Explain acronym.

l10-20: All space sensors mentioned measured quite a large range of constituents, not only the few here mentioned species. This should be corrected. The authors may focus on the here relevant target species (H2O, O3, HNO3, temperature).

l28: the

14173

l18: the

l20: in the range of

14174

l2: aliased radiances (?)

l4: the

l15: Suggest to remove figure 2. Otherwise explain in more detail what the reader is

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supposed to see.

l19: This high value

l20: is expected to bring this value down to

14175

l1: can present one of (?)

l5: the

l16: the

14176

l10-17,following page: please shorten.

l20-22: Darwin is not in Western Australia.

14178

l9: explain "incoherent flight pattern"

l12-13: contradiction in statement "Marschals was compromised although the instrument was again operational"

14180

l5-16: please provide quantitative results (for MIPAS-STR error budget for the here relevant species).

14182

l1-5: Provide additional information (see specific remarks)

l16: per limb view ?

14183

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l2: NET=4k, 250ms, 200MHz gives roughly a Trec of 28000K. Please check and make consistent throughout paper.

l20: remove "since", insert "and only band C"

14184

l23-24: integrate in paragraph

14185

l3-4: indicate typical values (relative or absolute)

l11: define/explain "external continuum"

l11: insert "the"

l12: short definition/explanation of pointing bias, instrumental offset, gain correction factor needed

l17: Optimal Estimation Method (OEM)

l18: the

14186

l2: guarantees (?)

l6: among the sweeps of the same scan (?)

l9: removed from the analyzed data set (?)

l11: as a compromise between the details (?)

l16: remove "the"

l19: temperature was retrieved. Why is it "NOT a target"?

14187

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l6: spectrally averaged noise (?)

l15: external continuum (?)

l23: "indicating a good radiometric performance". Good linearity?

14188

l1: temperature

l1-25: Clearly, a quantitative discussion is required for each retrieved species, evaluating diagnostics such as information content, absolute and relative retrieval errors as well as altitude resolution. What is the lower limit for the information content required for a retrieved parameter being determined by the measurement, and not by the apriori information? Which is the altitude range where the information content is high enough and at the same time the relative error sufficiently small (say, below ˜50% of a climatological value)? How many independent levels can be retrieved in this range, considering the altitude resolution provided in Fig. 16?

l6: information content (for T) is larger than 1 from 8-9 to 16-17km (please check).

l12: down to about 8-10km, depending on the scan.

l19: A possible reason for the low information content for HNO3 is the insufficient signal-to-noise ratio of the measurement (limited sensitivity), related to the assumed climatological (apriori) uncertainty.

l29: suggest to reformulate "the boundaries of the apriori errors applied to the initial guess profile"

l9, l20: time (UTC, x-axis) could be indicated for the sake of simplicity

l20: "clouds were not detected at millimetre waves" (reformulate)

l23-24: suggest "... cloud coverage, detected by OCM, MIPAS-STR, and the Falcon lidar." (or similar)

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l24: remove "the"

14190

l1: remove "the"

l2: indicate time of scan

l11: It is certainly incorrect to name this single comparison "validation" (which would require much deeper analysis). Suggestion: "Intercomparison with MIPAS-STR"

l12: obtained from Marschals scans

l17: the

l23: profiles within their error bars (?)

14191:

l7 (and Figure 17): Was Marschals water vapour retrieved as log(VMR), in contrast to MIPAS-STR water vapour? the symmetric error bars in the log-plot seem to suggest this. Please clarify or correct possible inconsistencies!

l27: spectral error (radiometric error? statistical error?, noise?)

14192

l2: acquisition (integration? averaging?)

l10: retrieval of an absorption profile (define terms such as "absorption profile", "unaccounted continuum", "external continuum")

l12: altitude range of the retrieval to about 12 km ... between ... and ... .

l13: remove "So"

l15: The information content does not depend on the constituent abundances, just on their uncertainties!

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l17: due to the larger

l18: consistent with expectation (which expectation?)

l23: validation (intercomparison)

l24: Sampling the same air masses, the results ...

l25-27: Capabilities of the retrieval system? Is this relevant for ACP?

Table 1:

The receiver noise temperature during the flight should be clearly stated in the table, since this is a key engineering quantity.

Instantaneous bandwidth (of the spectrometer?): 12 GHz (appears to be inconsistent with width of spectral bands given above?)

Db -> dB

Table 2:

The table provides a column for accuracy. How was this derived? I did not find where this was discussed in the manuscript.

Number of retrieved altitudes (parameters): add 3 for the scalar quantities and sum up (58 parameters were retrieved, 31 degrees of freedom).

All figures, with exception of Fig. 1,4,7-9, are hard to read. Although this is partly due to ACPD formatting, it is required that axis labels are enlarged to be readable in the final version.

Figure 2: Is this figure really required for this paper? The focus is here more on the measurement capabilities, the instrument is described in the references (Moyna et al., Oldfield et al.).

Figure 4: Please indicate latitude and longitude (coordinate system).

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Figure 5: Indicate date, time, latitude, longitude for this snap-shot in the caption. Moreover, it would be highly useful if the MIPAS-STR cloud index data would be presented in a similar way and for the same time, allowing to directly compare mm-wave, mid-infrared and near-infrared sensitivity to clouds.

Regrouping of Figs. 7-9 would reduce the overall number of figures and allow to have all the retrieval diagnostics in one plot.

Figure 10-14: replace "biased error" or define/explain in the manuscript.

Figure 17: It would be much better is only the relevant data with sufficient information content were plotted (please blank out not relevant parts of the profiles, for better readability of the figure).

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 14169, 2008.