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Atmospheric Measurement Techniques
Discussions

Interactive comment on "A Fourier transform spectroradiometer for ground-based remote sensing of the atmospheric downwelling long-wave radiance" *by* Giovanni Bianchini et al.

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Before proceeding, thanks for the time spent in your review, I'll try to answer to all the questions adding the requested information whenever possible, information that will be also included in the reviewed text.

The theme of the article fits well within the scope of AMT and the article is clearly written, but the current scope does not provide enough new information as compared to already existing literature. No substantial new concept or data is presented. Therefore I recommend to publish the article only after major extension/revision. In particular the performance analysis part has to clearly state the new insights gained in comparison to

earlier papers and the data section needs to present a more comprehensive overview of the Antarctic dataset.

Section 7 has been reorganized and more information has been provided to describe the available dataset and the Antarctic campaign.

Section 3 discusses instrument lineshape. Please highlight the new insights gained relative to the information provided earlier (Fig. 4 of the current paper and Fig. 17 of the Bianchini, 2008b paper seem to be identical).

Yes, actually the instrumental lineshape in the far-infrared region is expected to be quite ideal, by design, so the figure has been changed (see Figure 1 here below) showing the ILS at two different wavenumbers, both in the far-infrared and at the upper limit of the operating spectral band, for two different spectral sampling values (0.5 and 0.25 cm^{-1}). This will integrate the data presented in Figure 5 in the paper, that shows the retrieved lineshape coefficient at different wavenumbers, providing a more complete characterization of the instrumental line shape as a function of spectral sampling and wavenumber.

Section 4 discusses detectors and data acquistion electronics. What is different to the analysis performed in section 2.1 of the abovementioned paper (Figure 6 of the current paper and fig. 3 and 5 of the 2008 paper seem to convey the same information)?

Also in this case, as expected, the instrumental parameters have not changed significantly in time. A choice was made to present some data that is redundant with the published papers: as it has been noted by the other reviewer, in some cases information should be repeated in order to allow readability without having necessarily to keep at hand also all the references. Anyway, the bottom panel of Figure 6 (in the paper) is redundant and will be omitted, while the top panel which corresponds to the last performed characterization involving the current detectors will be kept since it contains new information.

Section 5 discusses radiometric performances. A statistical analysis of offset values in one atmospheric window region is presented. Again the value of this analysis in the context of the existing radiometric performance analysis needs to be stated more clearly. Instrument offset will be wavenumber dependent. An analysis of the radiometric offset in other spectral regions is of interest.

Yes, the observation is correct, but we do not have a similar check that can be performed over the whole spectral range and continuously during a multi-year deployment of the instrument. Thus this kind of estimate, even if related to a narrow spectral range, is relevant. An estimate covering the full spectral range can be obtained through an external reference blackbody placed on the instrument measurement port, but this requires dedicated measurements and cannot be performed during remote operation.

Figure 2 here below shows the results of such a calibration measurement. Even in this case the calibration accuracy is quite constant over the relevant spectral range and well inside of the measurement uncertainties. Below 300 cm^{-1} and in the correspondence of the beam splitter substrate absorption bands the measurement errors are prevalent and it is difficult to quantify the actual calibration accuracy.

Section 6 states to discuss spectroscopic performances. It then describes qualitatively the agreement between an analytical instrument model and laboratory measurements. The model is not detailed and there is no quantitative discussion of the discrepancies between model and measurement. No attempt is made to derive figures of merit and compare them with requirements. The title of the section is misleading and the description of model and results is not sufficing to provide insights. The section should either be omitted or renamed and significantly extended.

I agree that the title "Spectroscopic performances" is without doubt a misnomer, this is my fault because I left the title as it was through various changes of the text, it will be changed in "Instrument mathematical modeling". The scope of the model is to provide a qualitative analysis devoted to the understanding and, if possible, correction,

of the various instrumental effects. The main scope is to understand the effect of non-ideal beamsplitters and to devise the best way to obtain optical path difference compensation, i.e. minimizing the phase variations across the spectral range.

This is achieved mainly with the correct orientation of the beam splitters, but also small layer thickness differences can give a measurable effect. All this will be better explained in the revised text, along with a more in-depth description of the model used and the corrected title.

Section 7, last sentence: I do not think that one offset measurement at 835 cm-1 is sufficient to derive a relative uncertainty for the whole wavenumber region from 200-667 cmôĂĂĂ1. The deduction could possibly be made with the help of the instrument model, but then this needs to be demonstrated.

A new figure (number 2 in this document) showing a characterization of the radiometric uncertainty over a wider spectral range will be added to the revised paper. Nevertheless, the results shown in Figure 7 in the paper (which has been updated with a better selection of the analyzed measurements, Figure 3 here below) have their specific purpose in providing a way to check the consistency and stability of the calibration without the need of dedicated measurements. This is of particular importance in case of a remote deployment of the instrument. The sentence will be rephrased to clarify this.

Section 8 shows an exemplary L2 data set. Yet no comprehensive data set is presented (e.g. a time series of measurements), no scientific interpretation is provided and no quality assessment (e.g. validation through other data) is made. There is no supplement with data or information about where the data could be accessed. It is mentioned in section 8 / L2 products that the retrieval of methane requires a hardware modification of the instrument. In the conclusions section, Methane is mentioned as provided data product, though.

For what concerns data validation, this has been performed during previous campaigns, see [Fiorucci et al. JGR 113 (2008)], [Bianchini et al. JGR 116 (2008)], [Turner et al. GRL 39 (2012)] in which REFIR-PAD measurements and retrievals have been compared with other instruments, both FTS and microwave radiometers.

The presented level 2 data examples were meant more as a way to show the capability of the instrument/data analysis process to operate across a wide range of atmospheric conditions (in terms of temperature and water vapor content) rather than showing a long-term time series.

While a complete discussion of a long term time series of data would need a complete scientific discussion on its own (and it's possibly out of the scope of this "instrument" paper), however a data set covering a period of about an year will be provided, showing all the level 2 products that are available at the moment (temperature and water vapor profiles, N_2O and O_3 columns, see Figures 4, 5 and 6 here below).

Please note that due to research project constraints, the actual data set cannot be released at the moment, since there is a clause that restricts the access to project participants for the whole project's duration and the following two years.

Unfortunately, for what concerns methane, no data can be provided since the Polypropylene-based beamsplitters even if realized, have not still been used on the field. For what concerns nitrous oxide, it is a secondary output of the temperature and water vapor profile retrieval, it makes use of the 595 cm^{-1} band and just rescales the initial guess profile (constant in value throughout the troposphere). The values shown in Figure 6 here below are expressed in ppm of VMR at ground due to the nature of the rescaled profile. Ozone fitting is performed separately using the 920-1070 cm^{-1} spectral range and a 3-point vertical profile, the results shown in Figure 6 are compared with the available OMI data for the Dome C site.

Section 9 (conclusions) reiterates the properties of the instrument without providing real conclusions or an outlook.

The conclusions section will be rewritten in order to cite explicitly the importance and

uniqueness of the long-term dataset that has been and is still being acquired by the REFIR-PAD instrument. Outlooks for future development of the instrument (like the use of Polypropylene based beamsplitter and the new possibilities opened by this) and for future uses of the acquired dataset will also be presented.

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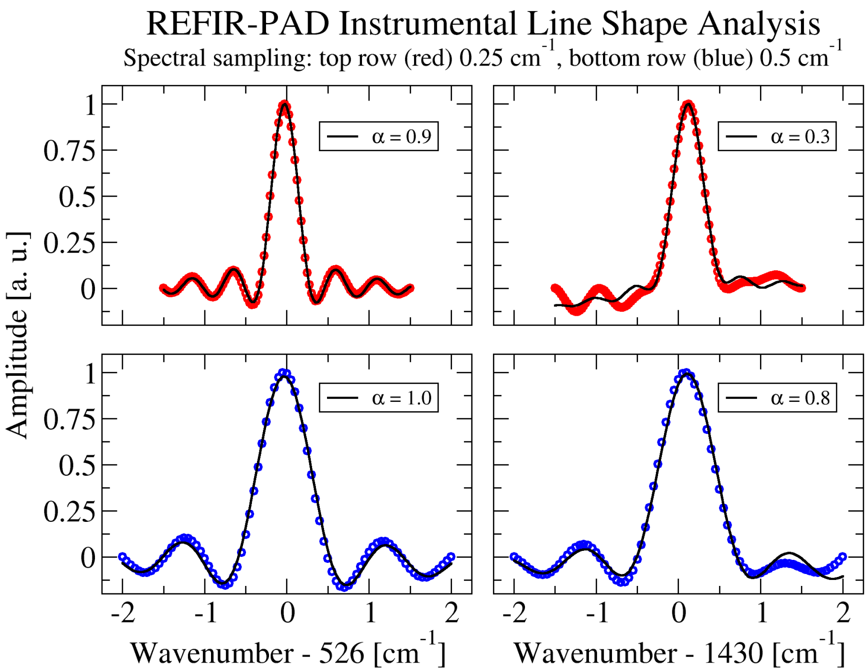
REFIR-PAD Instrumental Line Shape Analysis
Spectral sampling: top row (red) 0.25 cm-1, bottom row (blue) 0.5 cm-1
α = 0.9
α = 0.3
α = 1.0
α = 0.8
Amplitude [a. u.]
Wavenumber - 526 [cm-1]
Wavenumber - 1430 [cm-1]

Fig. 1.

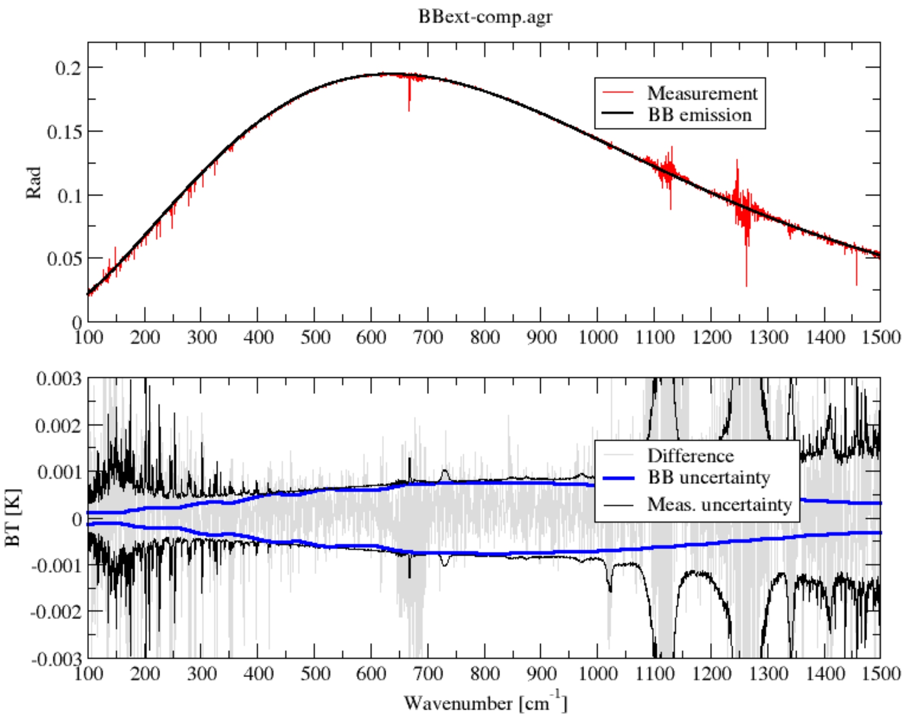
BBext-comp.agr
Measurement
BB emission
Rad
Difference
BB uncertainty
Meas. uncertainty
BT [K]
Wavenumber [cm-1]

Fig. 2.

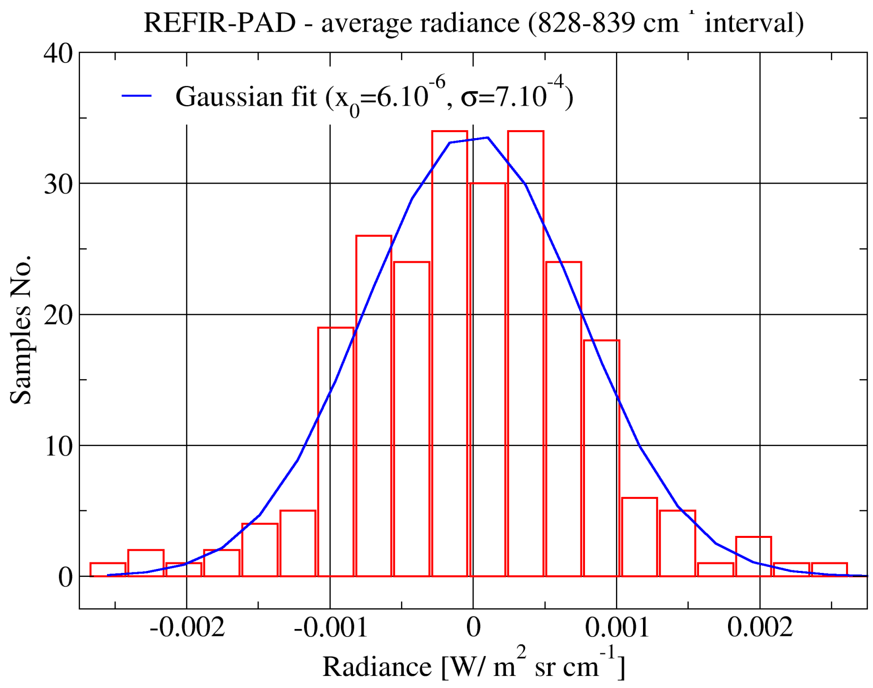
REFIR-PAD - average radiance (828-839 cm interval)
Gaussian fit (x_0=6.10^{-6}, σ=7.10^{-4})
Samples No.
40
30
20
10
0
-0.002
-0.001
0
0.001
0.002
Radiance [W/ m^2 sr cm^{-1}]

Fig. 3.

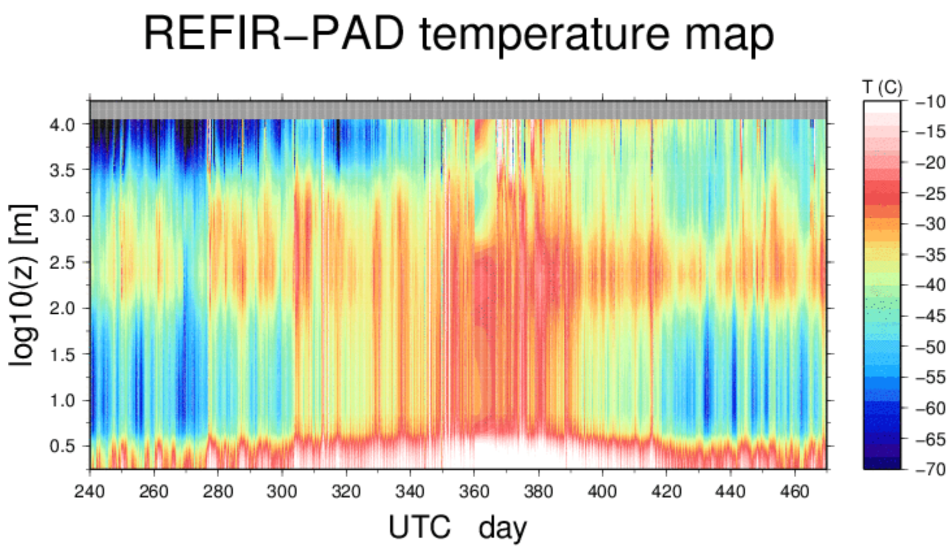
REFIR−PAD temperature map
log10(z) [m]
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
240
260
280
300
320
340
360
380
400
420
440
460
UTC day
T (C)
−10
−15
−20
−25
−30
−35
−40
−45
−50
−55
−60
−65
−70

Fig. 4.

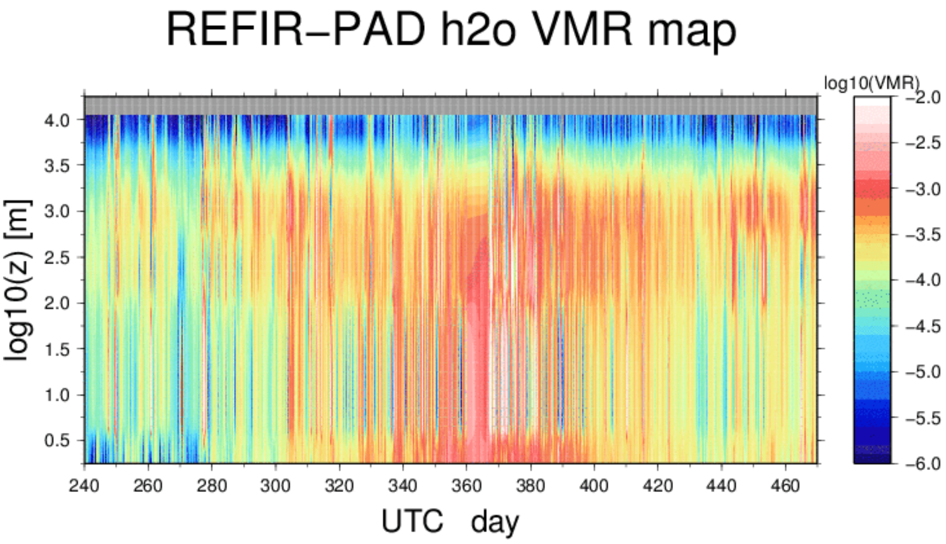
REFIR−PAD h2o VMR map
log10(VMR)
log10(z) [m]
UTC day
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-5.0
-5.5
-6.0

Fig. 5.

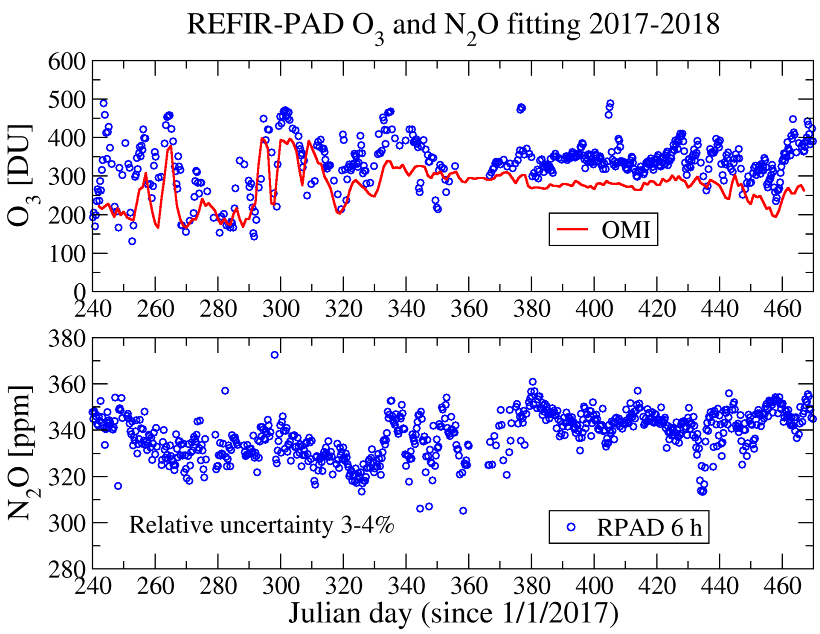
REFIR-PAD O_3 and N_2O fitting 2017-2018
O_3 [DU]
OMI
N_2O [ppm]
Relative uncertainty 3-4%
RPAD 6 h
Julian day (since 1/1/2017)

Fig. 6.