Authors' response to referee comments

We would like to take the opportunity to thank the referees for their time, and for their valuable feedback on the manuscript. We believe that their input has helped us to improve the manuscript where possible.

Response to comments from Referee #2

This manuscript discusses middle atmospheric CO measurements carried out by a novel ground-based microwave spectrometer, CORAM, installed at the Arctic station of Ny-Ålesund (78.9◦N, 11.9◦E). The development of this instrument and its dataset are of interest to the scientific community, as CO is a useful tool for studying mesospheric dynamics in Polar regions and the satellite coverage of CO will become scarce in the near future. In fact, the creation of a network of ground-based instruments observing middle atmospheric constituents is desirable. The paper is well written and well organized and I recommend this work be published. In my opionion, however, since this is the presentation paper for CORAM, there are few aspects of the instrumentation and the data presented that should be better discussed in the manuscript. General comments The paper lacks information on the receiver itself, possibly a photo, a sketch of the quasi-optical front end, and on the observing equations of this (total power?) instrument. As a validation paper presenting a new receiver to the scientific community, I would expect there would be more data to show and that the validation would cover a longer time period. Especially since Polar mesospheric CO changes substantially from winter to summer, as do the observing capabilities of a 230 GHz ground-based instrument installed at sea level, so the data and their analysis results and uncertainties may change significantly from winter to summer. I understand that a technical failure occurred in January 2018 but now more than 14 months have passed. Are there new data to add to the analysis?

The local oscillator broke down in January. The Element became unstable and changed its frequency randomly and with a low frequency. At the measurement site we lack equipment to diagnose such a failure and asked the manufacturer to help in the diagnosis.

The production of a new element took another 12 months, hence we will be able to start measurements again in September 2019.

Specific comments

Page: 1
Sequence number: 1
Author:
Date: 12/04/2019 11:37:32
It's not clear what is intended with "precision" here. Would it be better to indicate the estimated total uncertainty instead?
The wording has been changed to uncertainty because the value from the estimated uncertainty in the profile is used here.

Page: 2
Sequence number: 1
Author:
Date: 12/04/2019 11:47:08
have been
This has been fixed.

Sequence number: 2
Author:
Date: 12/04/2019 11:51:35
The poor vertical resolution of the datasets could be a problem for studying gravity wave-induced fluctuations. Maybe a comment
on this aspect is needed.
The introduction now refers to the limited spatial resolution of the cited ground-based and satellite-borne instruments that have been used to study periodic fluctuations in trace gas profiles.

“The positive gradient of polar CO VMRs with altitude throughout the middle atmosphere, coupled with the time resolution of the presented measurement system at Ny-Ålesund (≤ 1 hr), means that the dataset discussed here is well-suited to observing these periodic fluctuations, which are likely to be caused by vertical advection of air parcels by gravity waves (Zhu and Holton, 1997; Ekermann et al., 1998; Hocke et al., 2006). As with the ground-based and satellite-borne instruments in the works cited above, the analyses must be performed within the context of the limited spatial resolution of the measurements.”

Page: 3
Sequence number: 1

Author:
Date: 12/04/2019 12:55:04
I would provide a photo of the instrument to have an idea of its front-end and how it is installed.
The photographs of the instrument do not offer clarity on the 3-dimensional optical bench. It is more likely to confuse the reader. A schematic of the front end in Figure 1 now includes the main quasioptical components and beam paths for the signal, hot target, and cold target.

Sequence number: 2
Author:
Date: 19/04/2019 16:28:28
What materials were used for the window of the lab and the window of the cryocooler? Is it a total power instrument?
This information is now included in Section 2.1.

"CORAM is total-power radiometer housed at Ny-Ålesund, Svalbard (78.9°N, 11.9°E), and is part of the joint French-German Arctic Research Base, AWIPEV."

"The atmospheric signal enters the lab through a foam window that is transparent to millimetre-wave frequencies, and meets the pointing mirror of CORAM, …"

"After the pointing mirror, the atmospheric signal is directed by a series of quasioptical components through a mylar window in a cryocooler and fed into a corrugated horn antenna."

Sequence number: 3
Author:
Date: 19/04/2019 16:27:50
Authors should draw a sketch of this serie of mirrors, show how the signal is directed to the horn, and how they account for these
multiple reflections in their estimate of the elevation angle of their signal beam.
Figure 1 has been edited and now contains a simplified version of the quasioptics that demonstrates how the signal enters the horn from the pointing mirror.

The alignment is checked using a laser positioned at the entrance to the cryocooler. Section 2.1 now contains this information.

"Figure 1 shows a schematic drawing of the receiver including the components in the cryocooler, as well as a simplified version of the quasioptical layout The alignment of the quasioptical components was checked using a laser positioned at the entrance to the cryocooler. The elevation angle of the instrument was measured using a self-levelling laser (Bosch GLL 3-80), which provides a horizontal line with an accuracy of 0.2 mm/m (0.2 mrad). Two horizontal lines, one directly from the laser and one passing through the quasioptical setup, were aligned on a screen approximately 5 m from the instrument. A sun scanning method has been used with other ground-based instruments to identify a pointing offset, e.g., for MIAWARA-C (Straub et al. 2010) and GROMOS-C (Fernandez et al., 2015), for which the offsets in the elevation angle were found to be 0.01° and 0.07°, respectively."

Sequence number: 4
Author:
Date: 12/04/2019 14:38:32
Does it enter the FFTS at 1.5 GHz?
Later on you write that the FFTS is the AC240 with a 1 GHz bandwidth, therefore the signal enters the FFTS at 500 MHz I guess. Is
this correct?
Yes, thank you. This has been fixed.

Sequence number: 5
Author:
Date: 12/04/2019 14:19:59
Why not writing the equation Tnoise = T1+T2/G1+T3/G4+...
This equation is now included in Section 2.1 to provide an estimate of the difference in noise temperature that comes with having an amplifier before the mixer.

"An estimate of the improvement in the receiver temperature (Janssen, 1993) can be made using a noise temperature cascade analysis. A variation of Friis' equation (Vowinkel, 1988) for two components in succession is $T = T_1 + T_2/G_1$*, where* T_1*, and* T_2 *are the respective noise temperatures of the first and second components,* G_1 *is the linear gain of the first component, and T is the total noise temperature. The noise temperature of the LNA plus waveguide filter was measured to be 1350 K at room temperature, and the linear gain was*

measured at 158 (corresponding to 22 dB) (Fig. 2b). The noise temperature of the sub-harmonic mixer is ~ 1500 K at room temperature and has a linear gain of ~ 0.16 (corresponding to -8 dB). Applying Friis' equation with the LNA preceding the mixer gives a noise temperature of ~ 1360 K. The same calculation with the mixer as the first component gives a noise temperature of ~ 9800 K. The dominant contribution to the noise temperature of CORAM is from the LNA/filter/mixer. Cooling the components can considerably reduce their noise temperature. Figure 2b shows the noise temperature and gain of the LNA + filter, measured at room temperature. Figure 2c shows the receiver temperature for CORAM measured at the exit of the cryocooler, with the cryocooler components at a typical temperature of 39 K. At 8.5 GHz, the receiver temperature is below 350 K. Figure 2a shows the frequency response of the waveguide filter with a suppression of ~ -45 dB at 213.5 GHz."

Sequence number: 6
Author:
Date: 12/04/2019 14:15:57
do you mean "lower cost"?
"cost" has been changed to "price" here.

Sequence number: 7
Author:
Date: 12/04/2019 14:23:19
I would write the equation that relates the receiver noise to the system noise, to make clear the difference between the two parameters.
Equations have been added to this section to clarify the difference between the receiver temperature and the system temperature. The radiometer equation is also included to relate the system temperature to the integration time.

"The system temperature can be described as $T_{sys} = T_{rec} + T_a$ (Parrish et al., 1988, Janssen, 1993, Stanimirović et al., 2002). The receiver temperature, T_{rec}, considers the contributions from CORAM, and the antenna temperature, T_a, considers the contributions from the atmospheric background and signal being measured. The system temperature is related to the measurement time through the so-called radiometer equation: $\sigma_T = T_{sys} / (Bt)^{1/2}$, where σ_T is the statistical noise on a measured spectrum, B is the frequency bandwidth of the measurement, and t is the integration time for the measurement."

Page: 4
Sequence number: 1
Author:
Date: 12/04/2019 14:40:49
I would add a short description of the observing equations (total power, correct?) and how the main unknowns in the equation are estimated/measured.

Section 2 has been edited to include a description of the inversion problem and how it relates to the measurements made with CORAM:

"2.2.1 Defining the inversion problem

Schwarzchild's equation describes radiative transfer through a medium in local thermodynamic equilibrium. In the millimetre-wave region, at a given frequency, the measured intensity can be expressed in terms of brightness temperature, T_b, where

$$T_b = T_{b_0} e^{-\tau(l_0)} + \int_0^{l_0} T(l)\alpha(l)e^{-\tau(l)}dl, \tag{1}$$

with l denoting the path through the atmosphere from a point l_0 to the measurement point at $l = 0$. The initial intensity is T_{b_0}, the optical depth of the atmosphere is described by τ, and the absorption coefficient is defined as α. More details can be found in Janssen (1993) and references therein. T_b in equation (1), as a function of frequency, is generally the mathematical description of the calibrated atmospheric spectrum, the antenna temperature (T_a) from Sect. 2.1. For a total power radiometer such as CORAM, the calibrated antenna temperature is found using:

$$T_a = \left(\frac{V_{atm}-V_c}{V_h-V_c}\right)(T_h - T_c) + T_c, \tag{2}$$

where T_h and T_c are the temperatures of the hot and cold calibration targets (Sect. 2.1), V_h and V_c are the measured voltages when observing the hot and cold targets, respectively. V_{atm} is the measured voltage when observing the atmosphere.

The desired quantity, the VMR of a trace gas, is contained within the description of the absorption coefficient, α. Equation (1) must be inverted to retrieve this information. The form of Equation (1) is that of a Fredholm integral of the second kind and is inherently sensitive to small perturbations (like noise on a spectrum). To overcome this, the numerical inversion here is performed iteratively using a maximum a posterieri probability estimation.

2.2.2 Inversion method

Altitude profiles of CO VMR are retrieved from the measured spectra using an optimal estimation inversion technique (Rodgers, 2000). The method uses some a priori information of the state of the atmosphere to constrain the profile that is retrieved from the measured spectrum. The linear solution to the inversion problem can be expressed as $\hat{\boldsymbol{x}} = \boldsymbol{A}\boldsymbol{x} + (\boldsymbol{I} - \boldsymbol{A})\boldsymbol{x}_{\boldsymbol{a}}$*, where* $\hat{\boldsymbol{x}}$ *is the retrieved state vector (VMR profile),* $\boldsymbol{x}$ *is the true atmospheric state vector,* $\boldsymbol{x}_a$ *is the a priori state vector, and* $\boldsymbol{I}$ *is the identity matrix.* $\boldsymbol{A}$ *is the averaging kernel matrix, which describes the sensitivity of a retrieved state to the true state (Rodgers, 2000). The sensitivity of the retrieved state at altitude i, to the true state at altitude j, is given by* $\boldsymbol{A}_{ij} = \partial\hat{\boldsymbol{x}}_i / \partial\boldsymbol{x}_j$*.”*

Sequence number: 2
Author:
Date: 12/04/2019 15:38:21
Given the large seasonal variability of mesospheric CO over polar regions, what will you do with summer data? Since you're
describing an instrument that is designed for long-term measurements you should plan for an entire year of data analysis.
The CO concentrations during the summer are very low and are not detectable by CORAM. Clarification on this is now included in the abstract and in Section 2.1.

Sequence number: 3
Author:
Date: 03/04/2019 13:02:25
This is true only if you consider the central part of the spectral line and not its broad wings which are produced from the emission of
stratospheric CO.
A new line has been added directly after this to clarify that the broad wings of the spectral line are produced at altitudes lower than the retrievable altitude limit of CORAM.

“The broad wings of a CO spectral line are produced by CO molecules at altitudes below the retrievable altitude limit of CORAM (approximately 47 km, see Sect. 2.3).”

Sequence number: 4
Author:
Date: 15/04/2019 16:14:11

it would be useful to see an example of the sinewaves that are being removed
An example of the fit to the baseline is included in Figure 3.

Page: 5
Sequence number: 1
Author:
Date: 03/04/2019 15:06:58
It's not clear whether the spectrum showed had already the sinewaves subtracted or not
The spectrum shown is the original measurement. The fit to the baseline (baseline fit), which includes the sinewaves, forms part of the inversion fit. The baseline fit is not separately subtracted from the measurement.
The caption to Figure 3 has been edited to emphasise that the baseline fit in the lower panel is a part of the overall fit shown in the upper panel.

From Section 2.2
"Qpack2 provides the capability to fit a series of functions to the baseline of the measured spectra (a baseline fit) to account for errors in the baseline which are likely caused by standing waves in the instrument. The baseline fit is included in the optimal estimation and forms part of the overall fit to the measurement (inversion fit)."

"Figure 3: (a) Upper: an example spectrum measured by CORAM on Dec 24th 2017 between 20:04 and 21:03 UTC. The inversion fit to the measurement is shown (smoother red line). Lower: the residual of the measurement and the inversion fit (solid black line). The dashed red line shows the baseline fit for the inversion, which is part of the inversion fit shown in the upper panel (Sect. 2.2). (b) The CO profile retrieved from the measurement (solid blue) and the a priori profile that is used as input to the inversion (dashed black)."

Sequence number: 2
Author:
Date: 15/04/2019 17:38:50
I think authors should be a little more precise here
Section 2.2 has been edited to contain a more detailed description of the averaging kernels.

"Altitude profiles of CO VMR are retrieved from the measured spectra using an optimal estimation inversion technique (Rodgers, 2000). The method uses some a priori information

of the state of the atmosphere to constrain the profile that is retrieved from the measured spectrum. The linear solution to the inversion problem can be expressed as $\hat{x} = Ax + (I - A)x_a$*, where* $\hat{x}$ *is the retrieved state vector,* $\mathbf{x}$ *is the true atmospheric state vector,* $\mathbf{x}_a$ *is the a priori state vector, and* $\mathbf{I}$ *is the identity matrix.* $\mathbf{A}$ *is the averaging kernel matrix, which describes the sensitivity of a retrieved state to the true state (Rodgers, 2000). The sensitivity of the retrieved state at altitude i, to the true state at altitude j, is given by* $\mathbf{A}_{ij} = \partial\hat{x}_i / \partial\mathbf{x}_j$*."*

Sequence number: 3
Author:
Date: 15/04/2019 17:40:41
It's unclear to me how you can reach a 87 km altitude limit considering the Doppler broadening and with a 61 kHz channel resolution.
The averaging kernels, which describe the distribution of sensitivity of the instrument are used. Section 2.3 outlines that a measurement response of 0.8 is often used to determine the altitude range of an instrument, as is done here. Later in Section 2.3, the peaks of the averaging kernels are discussed, and how this affects the interpretation of the CO profiles above ~70 km. This topic is discussed in more detail in Hoffmann et al. (2011) for ground-based CO measurements and this is also cited in Section 2.3.

"A common way to estimate the altitude limits of a retrieved profile is to define the sum of the rows of the averaging kernels as the measurement response and assign a cut-off value. The choice of the cut-off value is rather arbitrary but 0.8 is regularly used (e.g., Forkmann et al., 2012; Straub et al., 2013, Schranz et al., 2018), and is also used here. With the above definitions, the CO profiles from CORAM during winter 2017/2018 have an average altitude range of approximately 47 – 87 km, with an average altitude resolution varying between approximately 12.5 and 28 km over that range. The retrieval range can change depending on the distribution of CO in the atmosphere (the lower limit can decrease in altitude when there are higher CO values at lower altitudes) and the value provided here is the mean range over the time span of the data.
The retrieval limits will vary from measurement to measurement and individual profiles should be considered in combination with the accompanying averaging kernels. The centres of the averaging kernels, when represented in VMR, are shifted down in altitude compared to a representation in relative units (Hoffmann et al., 2011). The lower limit of the retrieval here is defined by the SNR in the measurement and the upper limit is set by a transition from a pressure broadening regime to a doppler broadening one. The result of this change is that,

above approximately 70 km in the VMR representation, the centres of the averaging kernels do not increase in altitude with their corresponding retrieval altitudes. The retrieved CO values above ~ 70 km altitude do contain information from the atmosphere that corresponds with the retrieval altitude, but the VMR representation of the profile should be considered with care. Hoffmann et al. (2011) provides a detailed discussion on the representation of data for ground-based CO measurements. Hoffmann emphasises that the limited vertical resolution of the data must be taken into account for the use and interpretation of the data by considering each realisation of the averaging kernels, and so the a priori and averaging kernels form an essential part of the dataset."

Sequence number: 4
Author:
Date: 03/04/2019 15:26:27
Call figure 4
This has been added.

Sequence number: 5
Author:
Date: 15/04/2019 17:56:15
This sentence is unclear to me. As I see it, upwards of 70 km altitude you can't retrieve a profile anymore but have basically a
partial column content. This suggests that on top of using the measurement response between 0.8 and 1.2 in order to identify the
altitude range where the data sets is reliable, you should possibly use also the close correspondence between nominal and retrieval altitudes.
The area under the averaging kernels (the sum of the rows) is used to define a limit. Then, later in Section 2.3, the correspondence between 'nominal and retrieval altitudes' is discussed. The location of peaks of the averaging kernels are discussed, and how this affects the interpretation of the CO profiles above ~70 km. This topic has been covered in more detail in Hoffmann et al. (2011) for ground-based CO measurements and this is also cited in Section 2.3.
"The retrieval limits will vary from measurement to measurement and individual profiles should be considered in combination with the accompanying averaging kernels. The centres of the averaging kernels, when represented in VMR, are shifted down in altitude compared to a representation in relative units (Hoffmann et al., 2011). The lower limit of the retrieval here is defined by the SNR in the measurement and the upper limit is set by a transition

from a pressure broadening regime to a doppler broadening one. The result of this change is that, above approximately 70 km in the VMR representation, the centres of the averaging kernels do not increase in altitude with their corresponding retrieval altitudes. The retrieved CO values above ~ 70 km altitude do contain information from the atmosphere that corresponds with the retrieval altitude, but the VMR representation of the profile should be considered with care. Hoffmann et al. (2011) provides a detailed discussion on the representation of data for ground-based CO measurements. *Hoffmann emphasises that the limited vertical resolution of the data must be taken into account for the use and interpretation of the data by considering each realisation of the averaging kernels, and so the a priori and averaging kernels form an essential part of the dataset."*

To make this clearer to the reader, the caveats on altitude range are now also included in both the abstract and the conclusion.

Abstract:
"The profiles in the current dataset have an average altitude range of 47-87 km, with special consideration to be given to data at > ~70 km altitude."

Conclusion:
"The mean of the averaging kernel matrix for the CORAM dataset gives an average retrieval altitude range of 47-87 km with an average altitude resolution of 12.5 to 28 km over this range. Data at higher altitudes should be treated with care as the VMR representation of the averaging kernels do not peak at the corresponding retrieval grid points above ~70 km altitude."

Page: 6
Sequence number: 1
Author:
Date: 19/04/2019 18:02:11
This sentence suggests that the pointing azimuth of the instrument is unknown. Could you please clarify? Please explain how you
measure the elevation angle of the signal beam, how you set the zero elevation. Do you perform a sun scan? Authors write "The
atmospheric signal enters the lab at 20° elevation
and is directed by a series of mirrors through a window in a cryocooler". How do you measure the elevation angle above the

horizon of your beam?
The sentence has been edited to clarify that the overestimate is used to account for changes that may occur in the orientation of the instrument table.
"An uncertainty of 1° is chosen for the pointing of the instrument to the sky, an overestimate of the motor (Faulhaber 3564K024B CS) uncertainty by an order of magnitude, to account for changes that may occur in the orientation of the instrument table."

Section 2.1 now includes information on the measurement of the elevation angle.
"The alignment of the quasioptical components was checked using a laser positioned at the entrance to the cryocooler. The elevation angle of the instrument was measured using a self-levelling laser (Bosch GLL 3-80), which provides a horizontal line with an accuracy of 0.2 mm/m (0.2 mrad). Two horizontal lines, one directly from the laser and one passing through the quasioptical setup, were aligned on a screen approximately 5 m from the instrument. A sun scanning method has been used with other ground-based instruments to identify a pointing offset, e.g., for MIAWARA-C (Straub et al. 2010) and GROMOS-C (Fernandez et al., 2015), for which the offsets in the elevation angle were found to be 0.01° and 0.07°, respectively."

Sequence number: 2
Author:
Date: 19/04/2019 11:17:37
Are there temperature sensors measuring the various temps?
This is now clarified in Section 2.1.

"The measured signal is calibrated using two blackbody targets at known temperatures (measured with mounted sensors): a cold target in the cryocooler at ~ 70 K and a warm target at ~ 293 K."

Sequence number: 3
Author:
Date: 03/04/2019 15:25:30
Somewhere here there should be a call to Figure 5
Figure 5 is called on line 13 of the original manuscript.
"The error estimates, including the average of the error arising from statistical noise on the spectrum, are plotted in Fig. 5."

Page: 7
Sequence number: 1
Author:
Date: 19/04/2019 18:03:04
This smoothing process involves the CORAM apriori profile as well. For this reason, you cannot really calculate a correlation
coefficient between the MLS smoothed profiles and CORAM profiles as if the two datasets were independent. If you wish to do so, you should use the MLS original profiles or perform a smoothing process of MLS profiles which does not involve CORAM AVK or apriori.
The correlation between the unsmoothed MLS data and CORAM data is now included in Figure 6. Section 3.1 has been edited to include the following.

"After smoothing, the MLS and CORAM data are not truly independent, so the correlation of CORAM with the unsmoothed MLS data is also calculated and shows more variation over the retrievable altitude range, with a minimum of 0.59 and a maximum of 0.81."

Page: 9
Sequence number: 1
Author:
Date: 19/04/2019 12:45:25
I am uncomfortable with the overall statement that the valid altitude range for the retrieval is up to 87 km when it is well known that
above about 70 km altitude the Doppler broadening takes over and you cannot obtain a vertical distribution of CO from its line
shape.
To clarify, the caveats on altitude range are now also included in both the abstract and the conclusion.

Abstract:
"The profiles in the current dataset have an average altitude range of 47-87 km, with special consideration to be given to data at > ~70 km altitude."

Conclusion:
"The mean of the averaging kernel matrix for the CORAM dataset gives an average retrieval altitude range of 47-87 km with an average altitude resolution of 12.5 to 28 km over this

range. Data at higher altitudes should be treated with care as the VMR representation of the averaging kernels do not peak at the corresponding retrieval grid points above ~70 km altitude."

Sequence number: 2
Author:
Date: 19/04/2019 12:56:52
If you degrade MLS using CORAM averaging kernels and apriori the two datasets are then not independent and you can't really
talk about their "correlation". See earlier comment.
The statement has been edited to include information on the smoothed and unsmoothed data.

"Correlations between the instruments range from 0.80 to 0.92 over CORAMs retrievable altitude range for MLS data smoothed with the CORAM averaging kernels, and from 0.59 to 0.81 when using the unsmoothed MLS data."

Page: 15
Sequence number: 1
Author:
Date: 03/04/2019 12:23:03
Remove "in"
This has been fixed.

Sequence number: 2
Author:
Date: 12/04/2019 14:23:52
why was this measurement carried out at 8.5 GHz and not at the FFTS?
The measurement was made by RPG as part of the production process for the new components. The system temperature of CORAM of ~600 K is now also included in the caption.

Page: 16
Sequence number: 1
Author:
Date: 03/04/2019 13:07:32

I do not understand whether the dashed red line represents what was subtracted from the original spectrum. Authors should
explain/show this subtraction a little better as this is always a touchy topic.
The dashed red line is the fit to the baseline that is included in the inversion fit (the overall fit of the line). A separate subtraction is not made and is purposefully not mentioned in the description in Section 2.2 nor in the caption to Figure 3. It is now emphasized in the caption that the baseline fit is a part of the inversion fit shown in the upper panel.

From Section 2.2
"Qpack2 provides the capability to fit a series of functions to the baseline of the measured spectra (a baseline fit) to account for errors in the baseline which are likely caused by standing waves in the instrument. The baseline fit is included in the optimal estimation and forms part of the overall fit to the measurement (inversion fit)."

"Figure 3: (a) Upper: an example spectrum measured by CORAM on Dec 24th 2017 between 20:04 and 21:03 UTC. The inversion fit to the measurement is shown (smoother red line). Lower: the residual of the measurement and the inversion fit (solid black line). The dashed red line shows the baseline fit for the inversion, which is part of the inversion fit shown in the upper panel (Sect. 2.2). (b) The CO profile retrieved from the measurement (solid blue) and the a priori profile that is used as input to the inversion (dashed black)."

Page: 17
Sequence number: 1
Author:
Date: 15/04/2019 16:45:24
In my understanding measurement response values larger than 1.2 are as critical as those below 0.8. Is this correct?
The measurement response can be thought of as a rough measure of the fraction of the retrieved state that comes from the data, instead of from the a priori. That is why it is often used to determine a cutoff where the data contribution is considered too little. It is only a rough measure though, as seen, and as you pointed out, by the measurement response often exceeding 1 at some altitudes.

More information has been added to Section 2.3 and reference to Rodgers (2000) and Payne et al. (2009).

"The measurement response can generally be thought of as a rough measure of the fraction of the retrieved state that comes from the data, rather than the a priori (Rodgers., 2000). As noted by Payne et al. (2009), this is only a rough measure, and the measurement response often exceeds 1 at some altitudes."

Page: 18
Sequence number: 1
Author:
Date: 19/04/2019 18:04:53
I am very surprised that a pointing uncertainty of 1° leads to such a small uncertainty in the retrieved profile.
The calculations were checked and the same result was found. It is likely that the pointing is more critical for systems that use a tipping curve method to calculate the atmospheric opacity for use in correcting the measured spectrum. And also for systems that use atmospheric measurements at one or more specific angles as the hot/cold targets to calibrate the signal data.

Page: 20
Sequence number: 1
Author:
Date: 19/04/2019 18:19:27
I think authors should show these time series at various altitudes so that the reader can better evaluate the difference between
CORAM and MLS datapoints. The vertical scales here are so different from altitude to altitude that it is really difficult to grasp useful
info.
It is unclear what is meant here. The time series is shown at 5 altitudes between 48 and 88 km. To clarify, the figure caption has been expanded to include the specific altitudes.

"Figure 7: Time series of the daily CORAM and MLS CO VMR values at altitudes of 48, 58, 68, 78, and 88 km."