**Author answers to Interactive comment on "Measurement of the Arctic UTLS composition in presence of clouds using millimetre-wave heterodyne spectroscopy"**
**by E. Castelli et al.**
**Anonymous Referee #2**

The authors gratefully thank the anonymous referee for the comments and suggestions. We think that the referee's comments help in improving the overall quality of the manuscript. The author's response to each referee comment is reported immediately after each comment and changes applied to the original text due to a reviewer suggestion or comment are reported.

**SPECIFIC COMMENTS**
Title: Only a small part of the paper actually deals with clouds (one of seven sections, or 2 of 25 text pages). And according to section 6 only one scan (51) is contaminated by clouds (see remark to p.3152 / line 12). Thus, having "clouds" in the title might be misleading. Actually there are some other terms (e.g. limb, airborne, ...) that could be (more) useful for AMT readers to pick up the paper from the journal's table of contents. Moreover temperature was retrieved as well (but this is possibly regarded as a sideproduct).

Since this is the first time that the MSSF module for modelling of clouds is used to analyse real data in presence of cloud we think that it is important to highlight this in the title. Moreover the title also refers to MARSCHALS capability to perform measurements of atmospheric composition in presence of clouds that is related to the use of long wavelength spectral range. For this reason, we think we should keep the term "clouds" in the title.

Abstract: p. 3130/line 16 It is not quite clear what the information given in parentheses really means.

With "with the potential to obscure measurements in the middle infrared spectroscopic region" we intend that measurements in the mid-infrared can be contaminated by clouds (e.g. see MIPAS-STR measurements obtained during the SCOUT-O3 campaign as reported in Dinelli et al., 2005). In case of presence of high altitude clouds, this can prevent the use of mid-infrared measurements for the retrieval of vertical atmospheric profiles.
In the revised text we have changed the sentence in line 16 p.3130 with:
"that were able to obscure measurements in the middle infrared spectroscopic region"

p. 3130/line 21 There is some redundancy / repetition in the last sentence compared to information already given.

Following the suggestions of both the reviewers, in the revised text we replaced the sentence in line 21 p. 3130:
"The performance of the retrieval are demonstrated from the results of data processing of MARSCHALS, deployed in the 2010 Arctic campaign with the M-55 Geophysica as an airborne simulator of the millimetre-wave limb-sounder proposed for the ESA Earth Explorer 7 candidate Core Mission PREMIER (PRocess Exploration through Measurements of Infrared and millimetre-wave Emitted Radiation)."
with:

“The results of MARSCHALS data analysis contributed to demonstrate the scientific relevance and technical feasibility of millimetre-wave limb-sounding of the UTLS proposed for the ESA Earth Explorer 7 candidate Core Mission PREMIER. PREMIER was not selected at the end of the Earth Explorer 7 evaluation process, but it is still being considered for future launch opportunities.”

Structure of the paper: Some (sub-)section titles are misleading, e.g. subsection 4.3 presents only instrument and general diagnostics, and the geophysical results are given in section 5 that is therefore more than just a discussion. Using section 4 only for a presentation of retrieval code and strategy and section 5 for a presentation (and discussion) of results (instrument, diagnostics, geophysical and even clouds) might be more logical. In other words, some thought of a better organization of the paper might be appropriate. I do not want to enforce the IMRAD (4 or 5 sections: Intro-duction, Methods, Results and Discussion (and possibly summary/conclusions), see https://en.wikipedia.org/wiki/IMRAD) format here, but 7 sections is a lot!

We agree with the reviewer that in subsection 4.3 we present mainly the retrieval diagnostic and the retrieval of instrumental parameters while the geophysical results are given in Sect. 5. For this reason, in the revised text we changed the title of subsection 4.3 in “MARSCHALS retrieval diagnostic” and moved the last paragraph of this section, which refers to retrieval of instrumental parameters, to the next section that now has the title “5 Results and discussion”. Consequently, we also changed the sentence in line 1 of p. 3147:
“In this section we present and discuss the results obtained for the vertically resolved quantities from the analysis of MARSCHALS data during the PREMIER-Ex campaign on 10 March 2010”
with:
“In this section we present and discuss the results obtained for the instrumental parameters and vertically resolved quantities from the analysis of MARSCHALS data during the PREMIER-Ex campaign on 10 March 2010”.
Then we moved the paragraph on the retrieval of instrumental parameters here and changed the phrase in line 4 p. 3147:
“All the results obtained will be presented ...”
with:
“All the results obtained for vertically resolved quantities will be presented ...”.
Furthermore we included the Sect. “6 Clouds” of the discussion paper into the previous section: in the revised text now we have Sect. “5.7 Clouds”. Furthermore, Sect. “7 Conclusions “ became Sect. “6 Conclusions”.

3133/26 The structure of the paper as described here is not in sync with the actual structure (e.g., conclusions now in sect. 7) ===> Update!

Following the reviewer's suggestion and the previous comment we changed the sentence in line 26 p. 3133:
“The structure of the paper is as follows: in Sect. 2 we describe the MARSCHALS instrument and its new features; in Sect. 3 we present the PREMIER-Ex campaign and the flight of 10 March 2010; results of MARSCHALS data analysis are presented in Sect. 4; intercomparisons with other instruments and discussion are reported in Sect. 5 and in Sect. 6 conclusions are given.”
with:
“The structure of the paper is as follows: in Sect. 2 we describe the MARSCHALS instrument and its new features; in Sect. 3 we present the PREMIER-Ex campaign and the flight of 10 March 2010; a description of MARSCHALS data analysis is presented in Sect.

4; results, discussion and intercomparisons with other instruments are reported in Sect. 5 and in Sect. 6 conclusions are given."

3140/14 Did you look for overpasses of A-train satellites in general or only for AURA-MLS? Later on its mostly MLS, MODIS and CALIPSO in section 6 only.

As reported in "Final Report of the Premier-Ex Study" by Spang et al. 2012, the flight was planned in order to have good coincidences with A-Train overpasses (In particular coincidences with CALIPSO and Aura).
In the revised text we added (e.g. CALIPSO, Aura) after "A Train satellites" in line 14 p. 3140 of the discussion paper.

3140/19 So strictly speaking there was no A-train overpass?

The sentence "A-Train satellite overpasses were performed at about 10:40 and 12:20UTC" principally refers to MLS, for MODIS the overpass time was at about 10:20. Since the flight was performed from 7:20 to 10:30 UTC we had precise time coincidences with MODIS but not with MLS. In the revised text we replaced the sentence above with:
"A-Train satellite overpasses were performed at about 10:20 (MODIS) / 10:40 (MLS) and 12:20 (MLS) UTC" in line 19 p. 3140 of the discussion paper.

3141/05 Are these legs identical to the legs mentioned in the previous paragraph (3140/22)?

Yes.

3141/07 So the second leg is also a mix (inside+outside)? And what means "mixed air" for the third leg?

"Mixed air" means mid-latitude air and vortex filament air. Since it is not clear we changed the sentence:
"the first leg enabled MARSCHALS Lines of Sight (LOS) to look partially inside the vortex, the second to look at air masses inside and outside the vortex and the third to look at mixed air."
with:
"the first two legs enabled MARSCHALS Lines of Sight (LOS) to look partially inside the vortex, while the third to look at air masses from mid-latitude and vortex filamentation."

3141/17 I guess the sequence is CBDCBDCBD.... and not 19*B, then 18*B, then 19*D (Maybe this can be rephrased slightly, during the first read I was a bit unsure)

Yes, the reviewer is right, the correct sequence is CBDCBD.
Following the reviewer's suggestion, in the revised text we removed:
"(19 in band B, 18 in band C and 19 in band D)" from line 17 p.3141 of the discussion paper and in line 17 p. 3141 we changed:
"The three bands were acquired in subsequent scans, first band C then band B and finally band D."
with:
"Each band was acquired in a separate scan, and the three bands were acquired in CBD sequence. In total 19 scans were recorded in band B, 19 in band C and 18 in band D."

3142/02 Are these scans shown in Fig. 2b?

Yes, in Fig. 2b we reported also the scans acquired with reduced vertical acquisition range or when the aircraft was landing or turning.

3142/14 "... Levenberg-Marquardt algorithm ... to reduce the stepwidth ..." LM does not simply reduce the step width but also considers the step direction

We agree with the reviewer that the Levenberg-Marquardt algorithm also considers the step direction, however in the text we just wanted to clarify the reason why the LM method is used into the MARC code without adding further details. More details can be found in the referenced papers, for this reason we did not add any further consideration in the revised text.

3142/21 Forward model description Presumably a line-by-line code. It would be useful to have some information on line data (HITRAN|GEISA|JPL), line shape, (CKD|Liebe|...) continuum, etc. (Actually this information is also missing in the MARC JQSRT paper)

In the revised text we added a reference to MARC radiative transfer forward model: Bianchini, G., Carli, B., Cortesi, U., Del Bianco, S., Gai, M., and Palchetti, L.: Test of far-infrared atmospheric spectroscopy using wide-band balloon-borne measurements of the upwelling radiance, J. Quant. Spectrosc. Ra., 109, 1030–1042, doi:10.1016/j.jqsrt.2007.11.010, 2008.
In this paper the parametrization of the atmosphere of the atmospheric line shape are described in details.
Furthermore, in the revised text we added the following sentence at line 24 p. 3142:
“A description of the parametrization of the atmosphere and of the atmospheric line shape used into the MARC code can be found in Bianchini et al., (2008).”
Then we added “spectroscopic” after “ molecular continuum model developed together with a specific” in line 22 p.3142 of the discussion paper.

3143/11 reduced chi squared: Final chi squared (i.e. after convergence)? Later on some numerical values are given, so it would be useful to provide the exact definition, i.e. is it simply the sum of squared residuals or does it include some extra factors (noise level, number/length of measurement vector, ...). Similarly, precise definition of the information content could be useful for completeness.

The reduced $\chi^2$, as defined in Rodgers, (2000), is equal to:

$$\left(y - F\left(\hat{x},\hat{b}\right)\right)^T S^{-1}\left(y - F\left(\hat{x},\hat{b}\right)\right)$$

where S is the variance covariance matrix (VCM) of the residuals $\left(y - F\left(\hat{x},\hat{b}\right)\right)$, $\hat{x}$ is the state vector, and $\hat{b}$ are the estimates of the forward model parameters.

The Information Content, as defined in Rodgers, 2000 is equal to:

$$\frac{1}{2}\ln|S_a| - \frac{1}{2}\ln|S_x|$$

where $S_a$ and $S_x$ are the VCM of a-priori information on the state vector and on the retrieved state vector (evaluated at the last iteration) and where the symbol |...| denotes the determinant of the matrix.
In order to clarify this in the revised text at line 11 p. 3143 we added:
" (both defined as in Rodgers (2000))" after "The reduced $\chi^2$,the information content"

3144/14 Are there any other interfering gases to be considered?

The list of main targets in each MARSCHALS band was given in Table 1. The main molecules in MARSCHALS bands are $H_2O$, $O_3$, $HNO_3$, $N_2O$ and CO. It is worth noting that in each band the targets are retrieved exploiting the MTR approach in order to reduce the impact of interference.
However, as suggested by the reviewer, we looked at possible interfering species and found that $CH_3Cl$, that is an interfering gas in CO retrievals, caused negative residuum in band D spectra. For these reason, we updated the analysis using a more realistic $CH_3Cl$ profile and revised the paper with the obtained results. This point is extensively discussed in the answers to referee's #1 comments.

3145/19 The subsection title suggests that ALL results are discussed here. But actually only instrument and general diagnostics are presented here.

As already discussed, we followed the reviewer's suggestion, changed the subsection title in "MARSCHALS retrieval diagnostic" and moved the sentence on instrumental parameters in the next section that in the revised paper is "Results and discussion".

3146/12 Any reasons for the different chi squared values in the third leg?

Band C shows stable chi squared values through all the flight apart from scan 6 and 51 at the beginning and at the end of the flight. Chisquared values for band B and D in some scans of the third leg of the flight show larger values. In some cases as for example scan 47 in band D, this can be due to the vertical measurement distribution (see also the low information content for this scan as compared with the previous ones in band D). In other cases as for scans 37, 43 and in particular for scans 51, 52, 53 the high chisquare values are related to variations in the latitude longitude distribution of the tangent points that show some oscillations at the end of the flight related to aircraft oscillations and movements.

3147/07 Vertical resolution: How reliable is the FWHM estimate in view of the retrieval grid point spacing as large as 4km

Vertical resolution is usually calculated trough the AK as the full width at half height (FWHM) of the AK rows. The values of the FWHM of the AK shown for each target refer to the spacing of the altitude retrieval grid. In this sense, the vertical resolution is connected to the grid spacing of the retrieval and provides information on possible effects as the over-sampling.

3148.26 What defines "best performance" and "worse/worst performance"? The information content is always high!

We agree with the reviewer that the information content is high. In this part of the text, we referred to the ozone individual information content that is shown in Fig. 6c of the discussion paper. Looking at this figure, it can be seen that scans in band B (e.g. scan 25) had a higher individual information content (greater than 3.5 over the whole retrieval range for scan 25) compared to scans in band C and D (e.g. scans 26 and 27 with individual information content lower than 3.5 over the whole retrieval range).
In order to clarify this point, in the revised text we replaced:
“The information content”
with:
“The individual information content” in line 25 p. 3148 and in line 2 p. 3149 of the discussion paper.

3148.24 "O3 can be retrieved ... from the three bands" Are the results shown here from concurrent multi-band retrievals and/or did you perform any single band analysis? If yes, what about O3(band B) vs O3(band C) ... vs O3(B+C+D)?

As reported in line 3 p. 3144 “Each MARSCHALS scan was analysed individually” and in line 6-7 p. 3144 we found “Because of the different spectral coverage of the three bands, the vertically resolved targets are scan dependent.” In order to clarify this when discussing ozone results in the revised text we added:
“for single scan analysis” in line 25 p.3148 after “the obtained results”.
The simultaneous $O_3$ retrieval exploiting the three bands can't be performed since each scan has different observation geometry (pointing angle and flight altitude). During the data analysis, we tried to simulate the multi-band approach by using a recursive approach: the retrieval of $O_3$ uses the ECMWF a priori only for the scans of band B, while the analysis of band D and C uses as a priori the results of the analysis of the previous scan. The results obtained exploiting this approach can be found in Cortesi et al., 2012. This approach produced an improvement in ozone retrieval in band C compared to single scan analysis.

3151/17 "... without including CO ..." According to Fig. 13 CO is included in the forward model/radiative transfer (at low or IG2 values), but not fitted.

Yes, this is correct.
However, this part is no more present in the revised text (see also answers to reviewer #1).

3152/12 "In one case only, for scan number 51, ..." Why only scan 51? What about the other outliers in Fig 3a?

The retrieved external continuum values for the other outliers in Fig. 13a of the discussion paper (e.g. scan 39 and 52) did not reach values indicating that we were in presence of clouds whose opacity was such to deserve MSSF simulations during the retrieval procedure. Only for scan 51 we reached these high external continuum values.
Actually, as discussed in Del Bianco et al. (2007), if the fitted linear extinction coefficient is lower than $10^{-3}$ $km^{-1}$, the external continuum retrieval is sufficient to correctly model the cloud effects during the retrieval. During PREMIER-Ex Campaign, the external continuum was always lower than $10^{-3}$ $km^{-1}$ except that for scan 51 for which it was slightly higher ($1.4\times10^{-3}km^{-1}$). This was highlighted by the small chisquare values reached during the analysis. In order to clarify this point in the revised text we added “slightly higher than the 1. x $10^{-3}km^{-1}$ threshold, (Del Bianco et al.,2007)” in line 12 p. 3152 of the discussion paper

after “( $1.4\times10^{-3}km^{-1}$”.

3154/23 "The quality of the retrieval products obtained from MARSCHALS ... is relevant ... IRLS of PREMIER." Why is the present MARSCHALS retrieval relevant for the future (proposed/failed/...) IRLS-PREMIER? The lessons learned from the MARSCHALS analysis, or from the synergetic MARSCHALS + MIPAS-STR retrievals? As a guide for future IRLS + STREAMR retrievals?

We made this statement to highlight the fact that the lesson learned from the MARSCHALS analysis is important to evaluate the quality of the retrieval products from mm-wave limb sounding and to compare with the quality of the fused data from mm-wave and infrared limb measurements. In a separate paper, currently in preparation, we discuss the results of the comparison between the performance (estimated by using specific quantifiers such as the total error budget, the degrees of freedom and the information content) of individual retrieval from mm-wave and infrared limb sounding and that of the data fusion process. Part of these results are also presented in the Final Report of the PACD project (available for download at http://www.ifac.cnr.it/ , link Editorial Activities – TSRR Vol.34 (2012)).

p. 3161, Table 1. There is a slight asymmetry in the signal and image bands of band B (317.46-294.00 vs. 341.00-317.46)

The Band B definition in Table 1 was erroneous, this was the one before the UAMS upgrade. In the revised text we replaced :
“Signal band: 294.00 GHz - 305.46 GHz
Image band: 329.46 GHz - 341.00 GHz”
with:
“Signal band: 293.86 GHz - 305.46 GHz
Image band: 329.46 GHz - 341.06 GHz”
and we also added a line with:
“IF Band [GHz]: 12.0 – 23.6, 12.0 – 21.0, 12.0 – 18.6”
before the informations on signal band.

TECHNICAL CORRECTIONS

Remark: there is a mix of lower and upper case nouns throughout the paper, e.g. "Northern polar" vs. "northern Polar" or "level 1" vs. "Level 2". This is also true for the table entries, e.g. the first column in Table 1.

In the revised text, we replaced “Northern polar” and “northern Polar” with “northern polar” and when describing data Levels we used “Level” instead of “level”. We leave “Northern Hemisphere” as it is (line 1 p. 3132).In Table 1 in the first row we replaced “1st LO Frequency” with “1st LO frequency”, “Band” with “band”, “Bandwidth” with “bandwidth”, “Upgrade” with “upgrade”.

3130/07 "PREMIER": move acronym definition up from end of abstract to first occurance

OK. We moved the acronym definition after “In March 2010 MARSCHALS was deployed on-board the M-55 Geophysica stratospheric aircraft during the PREMIER”

3130/14 "... vertical profiles of CO and N2 ..." for consistency with the previous sentence

use names (carbon monoxide) here.

OK, in the revised text we replaced:
“vertical profiles of CO and $N_2O$”
with:
“vertical profiles of carbon monoxide and nitrous oxide”

3130/18 "information ... extracted from the retrievals" —> "information ... extracted from the data/observations/..."

OK, in the revised text we replaced:
“extracted from the retrievals"
with:
“extracted from the data"

3131/08 "Tropopause height" —> "tropopause height"

OK

3131/22 "Northern polar vortex" —> " northern polar vortex" (compare 3140/05)

OK

3133/23 rephrase to avoid the double "code"

In the revised text we replaced:
“by the MARC (Millimetre-wave Atmospheric Retrieval Code) code.”
with:
“by  MARC (Millimetre-wave Atmospheric Retrieval Code). ”

3133/24 use math italic for "T" (temperature)

OK

3134/22 rephrase sentence to avoid the double "antenna control loop" at the start and end

In order to avoid repetition we replaced:
“The antenna control loop measures the instrument (aircraft) roll angle with high precision and corrects for it in the antenna control loop.”
with:
“The antenna control loop measures the instrument (aircraft) roll angle with high precision and corrects for it in the loop.”

3135/01 genitive: "... the bands’ frequency range …"

OK

3135/05 no genitive: "... its …"

OK

3135/06 there are two "upgrades" in the subsection title, rephrase?

We changed the subsection title “UAMS instrument upgrades” in “UAMS instrument updates”

3136/08 3136/17 3137/01 three almost identical sentences, ideally rephrase?

We leave the sentence in line 8 p. 3136 as it is, while we changed the sentence in line 17 p. 3136 in “The position of band C receiver is shown in Fig. 1” and the sentence in line 1 p. 3137 with “The layout of the instrument after the UAMS project and the position of the receiver are shown in Fig. 1”

3136/24-26 double "... has now been replaced with ..."! rephrase?

In the revised text we replaced:
“The failed doubler has now been replaced with a new RAL doubler ..”
with:
“The failed doubler has been substituted with a new RAL doubler”

3137/06 "a number of software modifications has …"

OK

3137/22 3138/23 "lab" —> "laboratory"

OK

3138/15 "... this repeated test is ..." or "... these repeated tests are …"

In the revised text we used "... these repeated tests are …"

3139/22 "... 1.5 GHz, channel spacing ..." comma? or simply "and"?

In the revised text, we used: "... 1.5 GHz and channel spacing ..."

3140/05 "northern Polar region" —> " northern polar region" (compare 3131/22)

OK

3140/11 "... above Scandinavia …"

OK

3140/16 rephrase to avoid the double "model"

In the revised text, we replaced:
“Using European Centre for Medium-range Weather Forecasts (ECMWF) assimilated forecast model data and the Chemical Lagrangian Model of the Stratosphere (ClaMS) model,”
with:
“Using European Centre for Medium-range Weather Forecasts (ECMWF) assimilated forecast model data and results from the Chemical Lagrangian Model of the Stratosphere

(CLaMS)”

3141/18 "level 1" vs. 3141/20 "Level 2"

OK, we used “Level” through the whole revised text when indicating the data levels.

3142/10 "... retrieval of ... spectra" —> "... analysis of ... the spectra" or something similar (its the atmospheric state to be retrieved from the spectra)

In the revised text we replaced:
“.. retrieval of ... spectra"
with:
“.. analysis of ... spectra"

3142/14 "step width"

OK

3143/02 new paragraph?

OK

3143/09 plural "parameters"

OK

3143/22 "during the PrEx1 campaign"

In the revised text we replaced:
“during PrEx1 campaign"
with:
“during the PrEx1 flight”

3143/25 swap "... the presence of all three bands for the first time …"

OK

3144/22 "find a better retrieval strategy" or "find the best retrieval strategy" ?

In the revised text we replaced:
“find the better retrieval strategy”
with:
“find the best retrieval strategy”

3145/03 "(along to the other targets)" —> (with the other targets)"

OK

3145/22 "... for all vertically resolved targets." (delete "the")

OK

3146/10 plural "The values ... are reported"

OK

3146/12 "a part" —> "apart"
OK

3146/10 plural "The values .... are reported …"

OK

3146/19 plural "scans"

OK

3147/19 no comma after the parentheses

OK

3148/18 "a part" —> "apart" no comma "... flight that justifies …"

OK

3148/26 "... even if the best performances ..." —> "... although the best performances …"

OK

3149.01 "the worst ones" ?

We replaced:
“worse ones”
with:
“worst”
in the revised text

3149.04 "but also due to …"

OK

3149.12 plural "profiles"

OK

3149.14 significant

We replaced:
“significative”
with:
“significant”
in the revised text

3149.19 delete the first "and" in this listing

OK

3149.22 find —> found

OK

3149.24 The "HNO3 data have been compared ..." sentence starts a new topic, so it seems to be more appropriate to start the paragraph here, not after this sentence.

We slightly changed this sentence in the revised text following a reviewer's #1 suggestion. However we still started a new paragraph here.

3150/08 "a weak constraint on"

We replaced:
"a weak constraint to"
with:
"a weak constraint on"
in the revised text

3150/13 "... with respect to / compared to / relative to ..." "other instrument"

In the revised text we replaced “respect to the others instruments” with “with respect to other instruments”

3151/03 3151/15 Quite a long paragraph! Maybe split for new paragraphs here.

The text is changed in this point in the revised text.

3151/06 "... one of the bands …"

Possibly the referee refers to line 7 p. 3151: “...one of the channels...” . In this case, we referred to a single channel and not to a full band.
In the revised text we changed:
“In addition, after the TC9, the spectral response functions of the channeliser measured in the laboratory show that one of the channels with variable spectral response function was located near the CO line (Spang et al., 2012),
and for this reason a channeliser re-ordering was performed before the PREMIER-Ex Campaign”
with:
“In addition the analysis of the spectral response functions of the channeliser measured in the laboratory, performed after the TC9 flight, showed that one of the channels with variable spectral response function was located near the CO line (Spang et al.,2012), and for this reason a channeliser re-ordering was performed before the PREMIER-Ex Campaign”

3152/05 no comma after the parentheses

OK

3152/03 Two very long paragraphs in this section. Two improve readability please consider further splits.

In order to improve readability and following the reviewer's suggestion we split the first paragraph in three paragraphs. We started a new paragraph in line 8 p. 3152 before “As can be ...” and in line 3 p. 3153 of the discussion paper before “In Fig. ...”.

3152/06 The cross section unit cm**2 better fits in the figure caption

In the revised text we removed “(units $10^{27}cm^2$).” from line 6 pag. 3152. We also added the units into the figure above the colorbar.

3152/26 "... of the external …"

OK

3153/27 ".... one sequence ..." scan?

OK

3154/01 Another long paragraph. Splitting in some paragraphs could help. A mix of present and past tense. Make it consistently.

Split in line 3 before “ For..” in line 18 before “As ..” in line 28 before “The potential ..”
Line 6 “allows” → “allowed”, line 10 “reveals” → “revealed”, line 21 “provide” → “provided”

3154/15 swap: "... was applied for the first time …"

OK

3154/22 "onboard the ... satellite" (or spacecraft or …)

We removed:
“on-board the PREMIER mission” (more details on this are given in the reply to reviewer's #1 comments.) in the revised text

p. 3166, Fig. 2: axis labels missing (lat/lon)

OK, we added “Latitude (deg)” and “Longitude (deg)” on the y and x-axis respectively.

p. 3167, Fig. 3b: To make an assessment of the DOF easier please provide the length of the state vector

The state vector was composed of 63 elements in band C, 59 elements in band B and 57 in band D. As suggested by the referee, in order to make the assessment of the DOF easier, in the caption of Fig. 3b of the revised text we added:
“The length of the state vectors is 59 elements in band B, 63 in band C and 57 in band D.”

The axis labels of the contour plots are relatively small. Ensure appropriate size for the final paper.

We changed the dimension axis labels of Fig.s 4, 5, 6, 8, 10. 12, 14 of the discussion paper.