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Atmospheric Measurement Techniques Discussions

Interactive comment on "Strato-mesospheric ClO observations by SMILES: error analysis and diurnal variation" *by* T. O. Sato et al.

T. O. Sato et al.

sato.t.ak@m.titech.ac.jp

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Reply to L. Froidevaux

Thank you very much for the valuable comments and questions. We deeply appreciate that. We have improved the manuscript according to your comments, and also underwent careful spell-check and proof-reading by the native speakers. Furthermore we plan to have a final English correction by another native speaker after revision of all the scientific comments by all the reviewers.

General comments

[Question and comment] ———————————

However, a few issues need some clarification so that readers can better understand the nature of the SMILES ClO observations and their quality at this stage, all the way down to 100 hPa (or to the tropopause) – and also for polar winter enhanced conditions (e.g., by a sample comparison to other observations, at least), even if this is not meant to be a more detailed validation and intercomparison paper. > In particular, some more information should be provided for the lower stratosphere, or, at a minimum, the paper should state why such information is not being provided for pressures between 10 and 100 hPa, or for the lower stratospheric polar regions during winter (for example). See my related comments regarding Table 3, for example. The focus seems to be more on the diurnal change for the upper portions of the stratosphere (and for the mesosphere). Will the other regions (and more validation) be part of another planned paper in the future? This might be good to point out.

[Our answer]

You are right. We did not show the polar region. Actually, SMILES measured the polar winter atmosphere near 65N. The ClO enhancement at lower stratosphere (at about 50 hPa) was clearly observed in the polar vortex. It was consistent with that observed by Aura/MLS when we performed the comparison of coincident data. This result is planned to be submitted to AMT with discussion of precision/accuracy for the polar enhanced ClO VMR profiles. The SMILES L2r version 2.1.5 has not been optimized for retrieving ClO at UT/LS. The retrieval algorithm was optimized to the altitudes above 100 hPa (employing optimizations such as using the spectral range only within 200 MHz from the ClO line for the ClO retrieval, etc.) because of uncertainties in the non-linearity gain correction of the spectrum brightness temperature and in parameters in forward model such as continuum absorption coefficient and antenna sidelobe. These issues will be improved in the next version of the SMILES L2r processing.

[Modification in the manuscript]

p. 4670 l. 24 We added a new paragraph at the end of the introduction section. "The

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retrieval algorithm of L2r version 2.1.5 is optimized for the middle stratosphere up to mesosphere. We focus on the ClO in the middle stratosphere and mesosphere at the equator and mid-latitude regions. A polar enhanced ClO at lower stratosphere is not discussed in this paper. Several issues for retrieval at lower stratosphere are planned to be improved in the next version of L2r product."

[Question and comment] ————————————

> Also, and probably in relation to the above comment, is there not a pointing-related uncertainty that still remains to be better characterized for SMILES measurements in general and if so, should this not at least be mentioned, even if it is still part of the "unknown" error estimates?

[Our answer]

We divide the error from pointing issue into the systematic and random errors. The systematic error (bias) is retrieved with ClO VMR at the same time in the L2r retrieval version 2.1.5. The random error is due to uncertainty in measurement of tangent height and is estimated to be 40 m (0.001 deg in the ISS attitude) by Ochiai et al., (2012b). The uncertainty corresponds to 0.5% in brightness temperature, which is much smaller than the total random error presented in Fig. 4.

[Modification in the manuscript]

p. 4674 l. 18 We added a new paragraph. "The tangent height is geometrically measured from the antenna elevation angle and the ISS attitude. Bias in the measured tangent height is retrieved in the L2r retrieval analysis. Random uncertainty is due to measurement error of the ISS attitude, and was estimated to be about 0.001 deg (Ochiai et al., 2012b). It corresponds to 40 m in tangent height and 0.5% in brightness temperature, which is much smaller than the total random error discussed later. Therefore the error due to uncertainty in tangent height is not taken into account in this paper."

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References The following paper is added. Ochiai, S., Nishibori, T., Kikuchi, K., Mizobuchi, S., Manabe, T., Mitsuda, C., Baron, P., and Ueno, S.: Tangent height accuracy of Superconducting Submillimeter-wave Limb-emission Sounder (SMILES) on International Space Station (ISS), Proc. IEEE Int. Geosci. and Remote Sens. Symp., 1290–1293, 2012b.

[Question and comment] ————————————

There are many editorial or English-related comments that need to be addressed or corrected; it would be (or have been) much nicer if some of the co-authors who are more fluent in English than other co-authors had helped through this part of the internal manuscript review process (and read it more carefully) before submission of the manuscript, as this can be a lot of work for reviewers, and should not have to be that way. See the long list of minor comments below.

[Our answer]

We corrected the English language according to all of your comments.

[Modification in the manuscript]

We summarized the modifications at the last part of this response.

A few questions and clarification requests

[Question and comment] ————————————

p7, line 17. It is not clear why the FOV can change by so much (3.2 to 4.4 km) for the 10-60 km range of tangent heights - please explain or correct this statement.

[Our answer]

We re-calculated the FOV with a condition of the ISS height ranging from 333 to 370 km, which were measured value during the SMILES observation period, and the FOV should be from 3.2 to 4.0 km.

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[Modification in the manuscript]

p. 4673 l. 27 - p. 4674 l. 1 "... the field-of-view is around 3.2-4.4 km at tangent heights ranging from 10 to 60 km." -> "... the field-of-view is around 3.2-4.0 km at tangent heights ranging from 10 to 60 km in the condition of the ISS height ranging from 333 to 370 km."

[Question and comment] ————————————

- In relation to this, please specify the angular step angle (line 26) in km as well (e.g., 0.3 km), to have the same units for convenience (in addition to the angular value).

[Our answer]

We added the statement as follows.

[Modification in the manuscript]

p. 4674 l. 11 "0.009375 deg." -> "0.009375 deg (0.3 - 0.4 km)."

[Question and comment] ————————————

A mention of how often the calibrations are performed (cold space in particular) should be provided, for completeness, given the amount of detail that is already provided in this manuscript (and in other related past or concurrent papers that are referenced).

[Our answer]

The spectrum calibration is performed for every scan (53 s period). We added the explanation in our manuscript.

[Modification in the manuscript]

p. 4678 l.5 We changed "... , the cold reference (space) and the hot (CHL) references (Ochiai et al., 2008)." -> "... , the cold (space) and hot (CHL) references. These cold and hot references are measured every 53 s (Ochiai et al., 2008)."

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[Question and comment] ————————————

- p10 (bottom) and p11 (top). Is there not a potential error source from signals outside the spectrometer passbands (but within the mixer and IF amplifier passbands)? How could this be (or is this) accounted for?

[Our answer]

We measured a gain-compression parameter, alpha, using a spectrally flat signal inside and outside the spectrometer passbands as a receiver input signal in the pre-launch test (Ochiai et al., 2012a). The power levels at the mixer and IF amplifiers at in-orbit limb observations can be approximated to be the same with those in the pre-launch test, if the averaged output of inside the spectrometer passband is equivalent to that of a pre-launch measurement. A spectral variety in the limb observations may cause an error in the estimated power levels. But this error is minor because the power levels are mostly controlled by the receiver noise and an atmospheric continuum emission. The 20% uncertainty in alpha includes both the uncertainties in the parameter itself and in the estimation of the power levels.

[Modification in the manuscript]

p. 4677 l. 27 - p. 4678 l. 28 "We conservatively estimated the uncertainty in alpha as 20%." -> "We conservatively estimated the uncertainty in alpha to be 20% including the error from signals outside the spectrometer passbands."

List of (mostly) more minor rewriting/clarifying issues

[Question and comment] ————————————

Add “the” before “ClO diurnal” (line 2), “Superconducting” (line 2), “International” (L3), “ClO diurnal” (L4), “Microwave” (L6), “Upper Atmosphere” (L7), L5, “The SMILES observations reproduces the diurnal variation of stratospheric ClO, with peak values at midday, observed previously by the Microwave Limb Sounder on the ... Mesospheric ClO shows a different diurnal behavior, with nighttime values larger than the daytime

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values. A ClO enhancement of about 100 pptv is observed at 0.02 to 0.01 hPa (about 70-80 km) for 50N-65N in January-February, 2010. These observations of mesospheric ClO were realized thanks to a 10-20 times better signal-to-noise ratio than that of past or ongoing microwave/submillimeter-wave limb emission sounders. We performed a quantitative error analysis for stratospheric and mesospheric ClO from the Level 2 research (L2r) product . . .” L16, “over the range of 0.01 to 100 hPa, with a total error estimate of 10-30 pptv (about 10%) for averages of about 100 profiles. The SMILES ClO vertical resolution is 3-5 km and 5-8 km for the stratosphere and mesosphere, respectively. The performance of SMILES ClO observations provides a new opportunity to investigate ClO up to the mesopause.”

Page 2: - L5/6, “produced the strong Arctic ozone depletion during the winter of 2010/2011 (Manney et al., 2011).”

Page 3: - L2, “There have been four satellite instruments. . .” - L5, “1993); UARS/MLS measured the ClO transition at . . .” - L7, change “and observed” to “and has been observing” - L8, change “and has observed” to “and has been observing” - L15, “2) the most sensitive observations of short-lived atmospheric species with diurnal variation, which is achieved by. . .” - L20, “achieves a low system noise. . .” - L22, “using conventional . . .” - L23, can stop the sentence at “in the 500-600 GHz region.” - L24, this sentence can be deleted (nothing new is added). - L25, “The SMILES target species are O3,. . . “

Page 4: - L3, add “or” in front of “Bands C and A”. - L4, change “performed for Band C” to “performed using Band C.” - L5, define “JEM/ISS” (if not done before this point) - L7, change “per day” to “daily” - Could also change “The tangent height. . .” to “The SMILES antenna limb scans were nominally performed from 0 to 100 km.” - L9, change “ClO observation” to “ClO observations” - L10, add “and” before “uncertainties”. - L14, change “sturdy” to “study” - L16, “In Section 3, we describe the results of the error analysis.” - L18, I suggest “SMILES measured the global diurnal. . .” - L20, “We have performed an error analysis for ClO VMR profiles. . . The error in the ClO profile comes

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from spectral statistical noise but also from inaccuracy in the spectrum synthesis using the forward model and spectral calibration."

Page 5: - L6, change "(Urban et al. 2004)" to "Urban et al. (2004)"; also, "The radiance intensity at frequency ..." - L16, define "VMR" earlier in the manuscript, as this appeared before. - L17, "The self-broadening effect for ClO is much smaller than the air-broadening effect since xvmr is much smaller than 1 (for ClO, the VMR is of order 10-9)." I would therefore add something like "Equation 15 therefore reduces to gamma(air)*P."

Page 6: - L1, add "the" before "HITRAN". - L4, any reference to "private communication" probably needs a better written reference in the text such as "X,private communication, 2000", and probably no reference at the back in the ref. section – but you will need to check with the editors, if this is not clear. This applies to other "Read" or "Ozeki" or others later on also. - L5, no need to repeat the Rothman reference every time you mention HITRAN (and already mentioned in line 1). - L6, "and laboratory measurements (Drouin,...)" - L8/9, I suggest "The ClO spectroscopic parameters relevant to the SMILES observations are given in Table 1." - L11, change "was" to "is". - L12/13, "The continuum absorption coefficients of humid and dry air are based on ..." - L15, "...theoretical estimates (e.g., Boissoles et al., 2003)"

Page 7: - L9, I suggest "Further details of the SMILES instrument are described by..." - L16, add year for Manabe ref. - L20, "is the normalized antenna beam pattern and omega0 is the boresight solid angle, defined in Level-1 processing as the angular range within ..." - L23, "coming from outside omega0, which is estimated...Level-1 processing; more details on related uncertainties are provided below." [so the next sentence can be deleted]

Page 8: - L6, add "the" before "antenna", also before "SBS" on next line. - L8, "The SBS configuration is described...". - L22, "transitions... are typically located around AOS channel number 535; the related full width at half... is about 1.06 MHz. [then,

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you can delete the next sentence, just skip to “The uncertainty in the FWHM. . .”]

Page 9: - L5, “which are directed toward space, Earth...body, respectively, and Tspace,. . .of space, Earth, and the SMILES. . .” - L21, change “process” to “processing”. Also, why not use 2.7K for space (not 0K)? - L24, “represents typical variations. . .” - L25, “The Joule mirror losses are taken into account. The brightness temperatures due. . .are calibrated” [as opposed to are “not” calibrated]

Page 10: - L2, change “switch” to “switching” - L4, change “at atmospheric measurement” to “for atmospheric measurements” - L8, is the assumption of one Tmirror value justified because the antenna is inside a thermally stable enclosure, shielded from the sun? Are there any in-flight engineering data to confirm this? Please comment in the text. - L12, “is the transmission coefficient of SWM,. . .” - L15, “estimated from laboratory reflection measurements of materials that have identical surfaces as the reflectors.” - L19, “AOS, deviates from a linear. . .” - L26, “12000 and 22500 for the cold and hot references in this error analysis.” [or rewrite the sentence so the 2 numbers clearly refer to something specific]

Page 11: - L3, “We call alpha a “gain compression parameter”. - L17, “as tuning parameters to obtain a stable retrieval.” - Maybe the last sentence in this section (or an appropriate sentence) could be placed earlier (e.g., after equation 16), so that the retrieval grid spacing is understood. We also need to more clearly understand that the retrieval grid is altitude, if this is indeed the case.

Page 12: - L3-5, please clarify if you mean one elevation angle per full scan is retrieved (or one per viewing position within the scan – probably not?). Just to clarify. - L4, delete “and” before “an offset” - L5, “the H2O profile is also retrieved, in order to try to improve the baseline fit.” [suggested wording]. As you mention that T is not retrieved, this would be a good place to remind the reader what is used for the T profiles. - L8, hopefully the “weighting functions” can be clarified slightly (radiance derivatives with respect to state vector parameters or what?). - L21, change “and removes” to “as this removes”.

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Page 13: - L9, change “is about” to “are about”.

Page 14: - L2, change “is constraining” to “arises from”. - L5, change “sturdy” to “study”

Page 15: - L9, “The error due to . . .” - L11, “difference between the value using the calibration parameter from L1b . . . with the added uncertainty.”

Page 16: - L10, “where ClO can become enhanced.” - L13, L15, and L22, change “higher” to “larger” [meaning lower altitudes, as this is what you mean. . .or use “pressures smaller than” if you mean at higher altitudes] - L14, please clarify “smaller temperature uncertainties”

Page 17: - Again, I recommend using “smaller” for “lower” (L5, L19), and “larger” for “higher” (L21, L22) - L21, change “increased” to “increases”

Page 18: - L4, add “and” before “characteristics”, and add “the” before “antenna” and before “SBS”; also function probably should read “functions” (for SBS and AOS). - Same comment as before for “lower” pressures (e.g., L7,L8) [use “smaller”]. - L12, change “ah” to “at”. - L16, instead of “instruments”, do you mean “instrumental errors”? Also, change “SBS has small contribution” to “SBS has the smallest contribution.” - L27, “It can have a contribution as large as about 5%...”

Page 19: - L6, “ClO concentrates” is not a good choice of words. Please clarify what you mean here. - L8, change “at lower pressures lower than 0.1 hPa” to “at pressures less than 0.1 hPa.” - L14, “The value of xa decreases rapidly at pressures less than 2 hPa (40 km) and the relative error peak is located at about 1 hPa (45 km).” - L16, “Totally,. . .” -> “Overall,. . .” - L21, change “remains as large error sources” to “is the largest error source” [or one of the largest error sources. . .if this is what you mean].

Page 20: - More similar comments here for “higher” and “lower” pressures, to help clarify (L1,L2 for example). - L9, change “are the same” to “are of the same”. - L12, “vertical resolution of SMILES is slightly larger than. . .” - L15, change “SMILES ClO observations of zonal mean profiles for” to “SMILES zonal mean ClO for. . .” - L17, I

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also suggest "(60 km) for Jan.-Feb. 2010 averages." [and delete the next sentence]

- L20, The numbers of zonal mean SMILES profiles are 43-299. . ."; also, there is no need to repeat the lat. bin ranges when you give the lat. regions, so "for the mid-latitude and equatorial regions, respectively." - L26, "for the UARS/MLS ClO observations."

Page 21: - L1, add "are" before "near zero" - L2, "regions" [plural] - L5, "This shows that the error analysis results are realistic." - L10, "between the diurnal variations in stratospheric ClO deduced from SMILES and UARS/MLS observations as shown in Fig. 10." - It might be better to move lines 22-23, maybe modified as "There are no SMILES ClO observations in December 2009 because only bands A and B were used that month." To right after the L16-17 sentence (ending in "65N"). - L17, "The contour intervals in Fig. 11 are 25 pptv, which is the total error estimated for an average of 100 profiles." - L19, "The SMILES orbit does not provide . . ." - L23, "In the stratosphere, ClO is enhanced during the day and falls. . ." - L24, "This is consistent with the diurnal variation observed by UARS/MLS (Fig. 10)." - L25, "The lower stratospheric ClO enhancement is strongest in the polar regions and fades at low latitudes." [one needs to say lower stratosphere, I believe] - L27, A dent? This is not very obvious in the figures, and most panels have a gap at SZA=0 anyway. . . Maybe you could circle this on a panel where it seems more apparent. You also do not point out at which altitude (or pressure) this is apparent. . .

Page 22: - L2-4, this sentence needs some rewriting also (and the "column" might be better stated as simply the "top of"). - L4, "the causes of this apparent dent structure." - L5, change "a diurnal" to "the diurnal" - L9/10; this seems somewhat too speculative, something "appears"? Does this mean in a simulation, or just a potential explanation (needs rewording)? I would keep this speculation even more brief; line plots may be better to actually see this feature. The details can indeed be left for a future investigation. - Parag. before the Conclusions, delete "contrastive" [not good wording]. - "A feature with larger mesospheric ClO is observed . . ." - "The amplitude of this ClO enhancement. . .total estimated error. . .70 km, for averages of 100 profiles." - Conclu-

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sions, “SMILES observed stratospheric and mesospheric ClO between 38S and 65N.”

Page 23: - L1, “which contributes up to 8% to the total systematic error . . .” - L3, “We have presented SMILES global ClO diurnal variations in the stratosphere and mesosphere.” - L4, “. . .ClO shows good agreement with that of UARS/MLS.” - L6, change “were obtained” to “was obtained” - L8, change “over the near polar region” to “at high northern latitudes” - L9, “error analysis provided here shows that these ClO features are atmospheric in nature.”

[Our answer] and [Modification in the manuscript]

We revised all that you mentioned according to your suggestions.

[Question and comment] ————————————

Figure 6: - Can you comment more regarding the oscillation between 3 and 1 hPa? Is this understood?

[Our answer]

We need more precise analysis to understand the source of making oscillation between 3 and 1 hPa. It might be due to the ClO VMR which decreases rapidly with altitude in this region. But please note that the amplitude of the oscillation is small and the amplitude is about 6 pptv at 1 hPa (the error from gamma_air or n_air is about 15 pptv at 1 hPa).

[Modification in our manuscript]

p. 4685 l. 17 "... root-sum-square value of these errors." -> "... root-sum-square value of these errors. It seems that the error from ANT is oscillated between 3 and 1 hPa, although the amplitude is small of about 6 pptv."

[Question and comment] ————————————

Figure 7: - You should be a bit more clear regarding the cyan curve. Unlike the other

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error sources shown in the plot, this non-linearity effect is not an error source on the retrieved ClO values, as you are modeling this effect and not neglecting it [although it may not be modeled perfectly]. This curve is not included in the total for Figure 8. Please make sure that this is stated explicitly in the text, not just the Figure caption.

[Our answer]

We modified the statement that describes the cyan curve in Fig. 7

[Modification in our manuscript]

p. 4686 ll. 5-10 "We calculated the effect from taking into account the nonlinearity between the AOS output V and brightness temperature T , which is shown by the cyan line in Fig. 7 named “Non Lin.”. It has the contribution of as large as approximately 5% relative error in the ClO retrieval, which is about five times larger than the total error from the uncertainty in calibration parameters. It clearly indicates that careful consideration of 10 the nonlinearity between V and T is essential for spectrum calibration." -> "We calculated the effect by taking into account nonlinearity between AOS output V and brightness temperature T, which is indicated by the cyan line in Fig. 7 labeled “Non Lin.”. Note that it is not included in the total error of the ClO retrieval in this error analysis. It makes a contribution as large as approximately 5% relative error in ClO retrieval, which is about five times that of the total error from uncertainty in the calibration parameters. This clearly indicates that it is essential to carefully consider nonlinearity between V and T in spectrum calibration."

[Question and comment] ————————————

Figure 9: The color you refer to as “yellow” is not that close to yellow. . . (and yellow is not a good color choice anyway).

[Our answer] and [Modification in our manuscript]

We changed the colors of both random and systematic errors in Fig. 9. Also we are pointed out the color in figure by Anonymous Referee #1 as " Figure 4: the cyan

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Interactive Comment

symbols are difficult to see, maybe use larger symbols or a different color." We changed Figures 4, 5, 7-9 according to the comments from you and Anonymous Referee #1.

[Question and comment] ————————————

Figure 10: On the 2nd line of the caption, you do not need to give the latitude ranges twice. On line 4, you could delete “of the observation data.”

[Our answer]

We would change the caption of Fig. 10 according to your comment.

[Modification in out manuscript]

The caption of Fig. 10 was changed as follows. "ClO diurnal variations observed by SMILES and UARS/MLS at pressures of 0.18, 0.46, 1, 2.1, 4.6 and 10 hPa for zonal mean. Red: SMILES at 40N-50N. Blue: SMILES at 5S-5N. Gray: UARS/MLS at 40N-50N. The data are averaged within a local time bin of 1 h intervals. The vertical error bars represent 1-sigma standard deviations. The numbers of profiles averaged at each local time for SMILES observations at 40N-50N and 5S-5N are indicated at the top of the left and right panels, respectively. The vertical grids for SMILES were adjusted to the UARS/MLS grids with linear interpolation. The SMILES data were taken for the observation period from January to February 2010, while UARS/MLS data were taken by averaging February data for the seven years from 1991 to 1997. The UARS/MLS data were taken from Fig. 1 in Ricaud et al. (2000). We respectively added arbitrary offsets to the UARS/MLS data of 100, 200, 400, 200 and 100 pptv at 0.46, 1, 2.1, 4.6 and 10 hPa, since UARS/MLS data have a negative bias."

[Question and comment] ————————————

Figure 11: line 3 of caption, “The color contour levels are separated by 25 pptv.” On line 5, “Only retrieved VMR values that satisfy. . .” Last line, change “at in” to “in”. Delete the last sentence (already mentioned). You should also explain what a negative SZA means (as SZA should be positive) [is one side a.m. and one side p.m.? and which?].

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[Our answer]

Thank you very much for correcting the English. We used the negative SZA for a.m. and the positive SZA for p.m. in this manuscript. We would add the explanation for the definition of SZA.

[Modification in our manuscript]

p. 4688 l. 27 We add the statement after "... 50N-65N." as "Note that we define SZA with a range of -180 deg to 180 deg in this paper. A negative SZA is used for the a.m. condition and a positive one is for p.m.." Caption of Fig. 11 We changed the caption of Fig. 11 as follows. Seasonal and latitudinal variations in ClO diurnal variations as a function of SZA and pressure for October-November 2009, January-February 2010 and March-April 2010 and latitudes (50N-65N, 20N-50N, 20S-20N and 40S-20S). The color contour levels are separated by 25 pptv. The altitude is represented by the white dotted line. The number of averaged profiles in an SZA bin of 10 deg is indicated at the top of each panel. Only retrieved VMR values that satisfy chiˆ2 < 1 and m > 0.8 are used. The observation points in the top row are represented by dots of different colors for each month. The numbers of scans in an SZA bin of 10 deg and a latitude bin of 10 deg are represented by bars at the top and above and to the right. The total number of scans is given at the upper right.

[Question and comment] ——————————

Table 2: It would be good to also show a lower stratospheric error estimate, not just 2.5 hPa. Is there a reason not to do so? If so, please explain.

[Our answer]

Please see the answer to the first question and comment of "General comment". The lower stratosphere would be discussed after developing the next version of the SMILES L2r product.

[Modification in our manuscript]

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Nothing was changed.

[Question and comment] ————————————

Table 3: Same comment as above. . . why not also show a row for 50 hPa, not just the upper stratosphere and lower mesosphere? - also, if one looks carefully at the figure in Livesey et al. (2011), or the original reference (Santee et al., 2007, which should be referenced), for Aura MLS ClO, one should (or one can) use a slightly lower (less conservative) value for the additive bias, which is referred to as 0.05 ppbv in the error Tables from these references. Indeed, the bias curve in Figure 4 from Santee et al. shows something closer to bias error < 30 pptv, but one should the add (as root sum square) the multiplicative error estimate from that set of plots; for typical ClO mixing ratios (say 400 pptv for 2 hPa and 200 pptv for 10 hPa) and a 10% uncertainty therein, one then obtains an uncertainty of about 25 pptv for 2 hPa and 20 pptv (rounded up from 18 pptv) for 10 hPa, which is what I would recommend you use for this Table summary. Similarly, when one considers the UARS MLS errors (rss of bias estimate and the 15% multiplicative error), somewhat larger values are obtained, namely 60 pptv for 2 hPa and 30 pptv for 10 hPa (rounded up from 58 and 29 pptv, respectively). These numbers should take into account the 2-sigma versus 1-sigma estimate issue (meaning that I have divided the referenced values by two to match the 1-sigma values discussed in your Table 3). If you provide the proper references (above) and explanations, these recommended MLS ClO error values should be somewhat better than the numbers you have used, and I think they are realistic; in the end, they are not too different from the numbers you were planning to use.

[Our answer]

The reason why we did not show the lower stratosphere is the same as the first question and comment of "General comment". Thank you very much for pointing out the correct values for the error of MLS. We changed the values according to your suggestion.

[Modification in our manuscript] In Table3 SE at 2 hPa -> "60", SE at 10 hPa -> "30" for

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UARS/MLS. SE at 2 hPa -> "25", SE at 10 hPa -> "20" for Aura/MLS (unit: pptv)

References

We updated the references as follows.

Manabe, T., Nishibori, T., Mizukoshi, K., Otsubo, F., Ochiai, S., and Ohmine, H.: Measurement of the offset-Cassegrain antenna of JEM/SMILES using a near-field phase-retrieval method in the 640 GHz Band, IEEE T. Antenn. Propag., 60, doi:10.1109/TAP.2012.2201080, accepted, 2012.

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