

## ***Interactive comment on “Ground-based assessment of the bias and long-term stability of fourteen limb and occultation ozone profile data records” by D. Hubert et al.***

**Anonymous Referee #2**

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### GENERAL COMMENTS

This is an excellent and well written paper. It is a long paper but I think that it needs to be this long. It is a paper that people will reference and I don't see how the information provided in the paper could be cut back without loss of value. The paper is as long as it needs to be. I have made some minor suggested corrections below. The paper is very close to being acceptable for publication in AMT and I commend the authors for writing a paper that will be of wide interest to the ozone measurements and research community.

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### SPECIFIC COMMENTS

Page 6664, line 8: Was there a specific reason why you decided not to include SAGE I in the mix?

Page 6664, line 10: It is not clear to me what you mean by 'harmonized' in this context. You may need to state more clearly what you mean by this.

Page 6664, line 17: Do you mean that the \*differences\* in the short-term variabilities are better than 5–12%?

Page 6667, line 2: Saying "to another profile representation" is a little too vague and I suspect that many readers will not know what you mean by this. I would suggest that you be more specific and say "from pressure to geopotential height (or vice versa) as the vertical height coordinate".

Page 6667, line 5: But how many of the limb and/or occultation data sets that you are assessing extend down to the ground?

Page 6667, lines 15-18: Will readers know what you mean by "native" and "non-native" in this context?

Page 6670, lines 4-5: When converting between vertical coordinate systems, do you assume that geometric height=geopotential height or do you also account for that difference?

Page 6670, line 25-26: Are these the total number of profiles measured over the analysis period, or the total number of profiles analyzed over the analysis period? i.e. were some measured profiles excluded though QA/QC before being used in this analysis?

Page 6671, line 12: Is this a geopotential height grid or a geometric height grid?

Page 6671, lines 22-24: Is this a true bias or is it simply that the diurnal cycle in ozone results in the sunrise profiles being 8-10% below the sunset profiles above 35 km? i.e. would a state-of-the-art chemistry-transport model also show such a bias? The same

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question applies to the sunrise-sunset biases seen in HALOE as mentioned on page 6673, line 8.

Page 6672, line 14: How is it that the SAGE III data are useable to 85 km altitude while the SAGE II data are usable to only 60 km altitude? What does SAGE III do differently that extends the uppermost altitude coverage?

Page 6673, line 10: 10% per decade is a very large drift that would significantly compromise trend analyses. So if the drift between SAGE and HALOE was 9% per decade I certainly wouldn't refer to this as insignificant.

Page 6673, line 19: Does this latitude range apply to both hemispheres?

Page 6673, line 25: It is not clear to me how you can retrieve a profile of geopotential height.

Page 6675, line 14: Is this a fixed geopotential height grid or a fixed geometric height grid? Likewise for Page 6676, line 5, and elsewhere.

Page 6675, line 16: The UKMO acronym needs to be expanded here and, if possible, an additional phrase needs to be added regarding exactly which UKMO reanalyses were used for this purpose. Likewise for page 6676, line 7.

Page 6677, line 18: I don't know what is meant by "the Chalmers v2.1 ozone profiles". Shouldn't this be "SMR v2.1 ozone profiles"?

Page 6677, line 27: What is the procedure for determining when noise is an issue?

Page 6680, line 5: It's not clear to me what you mean by "scientific MIPAS data". Is there another kind of MIPAS data i.e. non-scientific data? The same applies to the term "scientific ozone data" on line 24. How do "scientific ozone data" and "ozone data" differ? If they're the same thing, I would suggest that you just refer to "ozone data". The same applies to the reference to "scientific SCIAMACHY data" on line 24 of page 6714.

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Page 6683, line 20: I am not sure exactly what you mean by "atmospheric cycles". Do you mean the diurnal cycle in ozone? I think that you need to be more specific here.

Page 6683, line 21: I don't know what an "ozone coordinate" is.

Page 6684, line 1: And, for higher altitudes, rarely coincide perfectly with regards to the diurnal cycle in ozone.

Page 6684, line 13: I don't understand what is meant by "reduction of smoothing". Do you just mean where the application of smoothing plays a central role?

Page 6684: Regarding dealing with co-location. I am not suggesting that you implement what I have detailed below in your paper, but you may want to give this idea some thought when next dealing with the issue of co-location. One option is to systematically account for lack of perfect coincidence when two measurements ( $V_1$  and  $V_2$ ) are being difference as:  $V_1 - V_2 = a \times d\_lat + b \times d\_long + c \times d\_alt + d \times d\_time + e \times d\_SZA + f$  where the separation in latitude, longitude, altitude, time and SZA between the pair of measurements is  $d\_lat$ ,  $d\_long$ ,  $d\_alt$ ,  $d\_time$ , and  $d\_SZA$  respectively. By training this equation on a large ensemble of pairs of differences over some prescribed space and time domain, the systematic bias between the two data sets, and its uncertainty, is obtained via the  $f$  term. The remaining fit coefficients ( $a$  to  $e$ ) capture the sensitivity of the differences to gradients in space and time. Coincidence criteria still need to be selected and used, but these can now be far more inclusive since absolute coincidence is no longer a requirement for determining the systematic bias. The key assumption that the application of this equation makes is that gradients in the field of interest (e.g. ozone concentrations) are linear in the space and time domain defined by the choice of coincidence criteria. An additional advantage of the use of such a method is that a robust estimate of the uncertainty on the systematic bias is also obtained. Such an approach would minimize mismatch uncertainties.

Page 6684, line 28: But 6h is far too large for higher altitudes where the diurnal cycle in ozone is strong. Isn't there a need to impose a rather strict SZA coincidence criterion

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at altitudes where ozone shows a strong diurnal cycle?

Page 6691, lines 2-3: But 6%/decade is the maximum uncertainty in the drift not the minimum uncertainty in the drift.

Page 6693, line 2: Mitigation of what? Likewise for line 19.

Page 6699, line 14: I think that it is incorrect to refer to these as metrological uncertainties. Metrological uncertainties can relate only to the measurement process itself e.g. to calibration standards and the like. Differences in airmasses therefore cannot be included in a metrological uncertainty. The same is true for the use of the word on line 16.

Page 6700, line 6: But, given the structure of the diurnal cycle in ozone, is it expected that the sunrise and sunset ozone profiles will be identical?

Page 6700, line 7: I think that you need to be careful here, and throughout the manuscript, with your sign nomenclature i.e., for me, an underestimate of -10% is the same as an overestimate of +10%. So when you say an underestimate of -(10-15)%, I am no longer sure if the ozone is underestimated or overestimated.

Page 6706, line 4: ERA-Interim definitely cannot be considered as an "actual measurement". It is no more an actual measurement than any of the reanalyses data sets included as auxiliary data with some of the satellite-based instruments.

Page 6706, line 21: I presume that this climatology is an annually repeating climatology and therefore does not incorporate in any way inter-annual differences in temperature and pressure profiles nor long-term trends in temperature and pressure profiles?

Page 6708, line 27: Why would there be increasing biases in the pressure readings?

Page 6709, line 10: I would have thought that a lower signal to noise ratio would have caused the differences between ozone records to become less obvious.

Page 6712, line 3: Again, I think that the term "metrological uncertainties" is not being

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used correctly here. Natural variability cannot be a component of metrological uncertainty.

Page 6717, line 18: I don't know what is meant by "due to quality features in the pressure and/or temperature information". What, specifically, is a "quality feature".

#### GRAMMAR AND TYPOGRAPHICAL ERRORS

While the paper is very well written, there are some places where the grammar could be improved. I have made some suggestions to that effect below. The suggested changes may, however, also simply reflect my own writing style and the authors should take these changes as suggestions. I commend the authors on taking the time to develop a polished manuscript. Both reviewers and readers will greatly appreciate this.

Page 6664, line 20: Delete the comma.

Page 6664, lines 20-21: This would be clearer as "In regions of the stratosphere a few records deviate from the preceding general remarks;".

Page 6665, line 11: Replace "and to a lesser extent in the" with "and to a lesser extent also in the" and then delete the "as well" on the next line.

Page 6665, line 14: Replace "abundancies" with "abundances".

Page 6665, line 17: It would be clearer as "the ozone layer is recovering from the effects of ozone depleting substances".

Page 6668, line 15: I think that it would be simpler and more accurate to say "by balloon-borne ozonesondes" rather than "by ozonesondes onboard small meteorological balloons launched".

Page 6669, line 27: Replace "cross-section" with "cross-sections".

Page 6670, line 1: Replace "sensitive from" with "sensitive to ozone from".

Page 6670, lines 22-23: Replace "have been or still are operational in the NDACC

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network" with "have been, or still are, operational in the NDACC".

Page 6671, line 3: Replace "Aerosols" with "Aerosol".

Page 6674, line 27: Replace "after that" with "thereafter".

Page 6675, line 19: Replace "PSC" with "PSCs".

Page 6678, lines 4-5: Replace "instrument Global Ozone Monitoring by Occultation of Stars (GOMOS) (Bertaux et al., 2010)" with "Global Ozone Monitoring by Occultation of Stars (GOMOS) (Bertaux et al., 2010) instrument".

Page 6679, line 6: Replace "aboard" with "onboard". Likewise on line 4 of page 6698.

Page 6679, line 15: Replace "(Laeng et al., 2015), here" with "(Laeng et al., 2015); here".

Page 6680, line 3: Replace "timeseries" with "time series".

Page 6680, line 26: Should this be "SGP 5.02 profiles"?

Page 6681, line 5: Replace "mid infrared" with "mid-infrared".

Page 6681, line 16: Replace "ozone data is reduced" with "ozone data are reduced".

Page 6682, line 14: Replace "profiles, these can" with "profiles; these can".

Page 6685, line 26: Replace "see Fig. 1. Mainly because" with "see Fig. 1., mainly because" otherwise the sentence does not make grammatical sense.

Page 6686, line 17: Replace "In this, way" with "In this way,".

Page 6691, lines 9-10: Do you mean "due to the increased contribution of noise from natural variability and instrumental noise"?

Page 6691, line 23: Replace "can not" with "cannot". Likewise on line 15 of Page 6700 and elsewhere in the manuscript.

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Page 6692, line 18: Replace "are not discrepant however" with "are not inconsistent however". And likewise a few lines below, replace "dscrepant" with "inconsistent".

Page 6692, line 27: Replace "the stability" with "the stability of UARS MLS".

Page 6693, line 21: Replace "its low sampling" with "its infrequent sampling".

Page 6694, line 18: Replace "minimal drift uncertainty" with "minimum drift uncertainty".

Page 6695, line 23: Replace "topping out" with "maximizing".

Page 6696, line 6: Replace "error bars" with "uncertainties".

Page 6696, line 16: Replace "maximal drift" with "maximum drift".

Page 6696, line 17: Replace "much below" with "well below".

Page 6697, lines 4-5: Replace "If the user wants to include FR data as well for trend analyses" with "If the user also wants to include FR data trend analyses".

Page 6697, line 22: Replace "drift of SCIAMACHY" with "drift in SCIAMACHY".

Page 6697, line 24: Replace "like" with "such as".

Page 6697, lines 24-25: Replace "that the latter study considers a diffent Level-2 processor than here, but there have been" with "that while the latter study considers a different Level-2 processor than here, there have also been" and then delete the "as well" later in the sentence.

Page 6698, line 17: Replace "lower stratosphere" with "lower stratosphere, respectively".

Page 6698, line 20: Replace "Again, like for" with "Again, as for".

Page 6699, line 15: Replace "is valid for the bias b as well" with "is also valid for the bias b".

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Page 6699, line 21: Replace "we only showed a" with "we show only a".

Page 6700, line 17: Replace "SAGE II, about 5%" with "SAGE II i.e. about 5%".

Page 6700, line 18: Up until this point you have been using the style 35-40 km but now switch to 35/40 km. Does this mean something?

Page 6701, lines 10-11: Replace "increases fast, topping" with "increases rapidly, maximizing".

Page 6701, lines 20-21: Replace "but extend to higher latitudes and altitudes as well" with "but also extend to higher latitudes and altitudes".

Page 6702, line 11: The MS and US acronyms have not yet been defined. They should be expanded at the site of their first appearance in the manuscript.

Page 6702, line 20: Replace "within +-4% from correlative" with "within +-4% of correlative".

Page 6703, line 5: I would prefer that you maintain a constant formatting style and either go with "5-10%", as you seem to do through most of the manuscript, rather than "5 to 10%". But definitely don't chop and change.

Page 6703, line 8: Replace "characteristics" with "characteristic".

Page 6703, line 12: Replace "more important negative" with "more negative" - I didn't understand how the bias was more "important".

Page 6703, line 21: Replace "noisy, at 15km" with "noisy; at 15km".

Page 6703, line 22: Should the word be "opacity" rather than "opaqueness"?

Page 6704, line 3: Replace "50–200 hPa, here a" with "50–200 hPa where a".

page 6704, line 6: Replace "representation, if one uses" with "representation i.e. if one uses".

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Page 6704, lines 14-15: Replace "The Arctic data are peculiar as well" with "The Arctic biases are also peculiar".

Page 6705, line 3: Replace "exceeds the 5%" with "exceeds 5%".

Page 6706, line 7: Replace "There is hence no" with "There is, therefore, no".

Page 6706, line 23: Replace "extent of the bias as well" with "extent also of the bias".

Page 6707, line 18: Replace "ground records" with "ground-based records".

Page 6708, line 6: Replace "features for other records as well" with "features also for other records".

Page 6708, line 9: Replace "bump" with "anomaly". I would also suggest finding an alternative to "bump" on line 18 of Page 6709.

Page 6708, line 12: Replace "possibly related" with either "as possibly related" or "possibly relate".

Page 6708, line 19: Replace "cross sections" with "cross-sections".

Page 6708, line 29: Do you mean "transfer standard" or "inter-comparison standard"?

Page 6709, line 13: Replace "done by" with "made by".

Page 6709, line 21: Replace "blow" with "inflate".

Page 6710, line 11: Replace "may drift as well" with "may also drift".

Page 6712, line 13: Replace "focal" with "focus".

page 6712, line 27: Replace "may perhaps allow" with "may perhaps also allow" and delete the "as well" at the end of the sentence.

Page 6712, line 28: Replace "Also longer time series will help, but" with "Longer time series will also help, but".

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page 6715, line 14: Replace "is a clear need" with "is also a clear need" and delete the "as well" at the end of the sentence.

Page 6716, line 22: Correct the spelling of "following".

Page 6717, line 5: Replace "It depends on" with "It also depends on" and delete the "as well" at the end of the sentence.

Page 6717, line 9: Replace "10% increase (decrease) in bias and spread in boreal winter (summer)" with "10% increase in bias and spread in boreal winter and a 10% decrease in bias and spread in boreal summer".

Page 6717, line 10: Replace "scales, most records" with "scales i.e. most records".

Page 6717, line 21: Replace "important biases" with "significant biases". It is not clear in what way a bias can be important.

Page 6717, line 27: Replace "negative drift" with "drift" since you already have a negative sign on the quoted drift value.

Page 6717, line 28: Replace "however, in the" with "however. In the".

Page 6718, line 10: Replace "perhaps in the lower" with "perhaps also in the lower" and delete the "as well" at the end of the sentence.

Page 6718, line 17: Replace "prerequisite" with "required".

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