

Dear Reviewer,

Thank you very much for your comments on our paper “On sampling uncertainty of satellite ozone profile measurements”. Below we present the replies to your comments.

Reviewer #3.

Specific comments

1. Eqn. 1 on page 2389 represents the definition of the inhomogeneity. In this sum, the asymmetry A and entropy E (actually 1-E) contribute equally to the inhomogeneity H. Is there a rational argument why they contribute equally? If so, can the authors mention this in the text?

Authors:

The asymmetry and entropy are conceptually different measures. Therefore, we take A and (1-E) with equal weights. Perhaps, other weighting, e.g., 0.6 and 0.4 or something similar, without a strong skew towards of one of measures, can be used as well.

Reviewer #3:

The definition of entropy E (Eqn. 3, page 2390) depends on the chosen data sub-bins within the larger bin (latitude, time etc.). This is clearly visible on Fig. 3c, where a homogeneous data point distribution leads to a value of $E=0.602$. Increasing the bin size in order to get one point per bin would lead to the case on Fig. 3a, with $E=1$ (perfect homogeneity). The authors should elaborate some more on the choice of the sub-bins.

Authors:

In the revised version, we have added: “The size of the bins for evaluating entropy should be selected according to the variability of a considered parameter: within a bin, the natural variations should be small.”

Related to this question: how do the authors deal with an empty bin, since this leads to a term in Eqn. 3 that equals zero times minus infinity.

Authors:

In case of $n(i)=0$, the corresponding term in the sum Eq.(3) contributes with its limit value, $\lim_{x \rightarrow 0} x \log x = 0$. We added the corresponding note in the revised version.

Reviewer #3:

3. Page 2391, line 15: I would suggest to change the word “perfectly” by “strongly”. The correlation does not seem to be perfect. See for example the GOMOS panel on Fig. 4, where the latitude bin [50N-60N] shows very small sampling uncertainty, while the inhomogeneity measure is quite large.

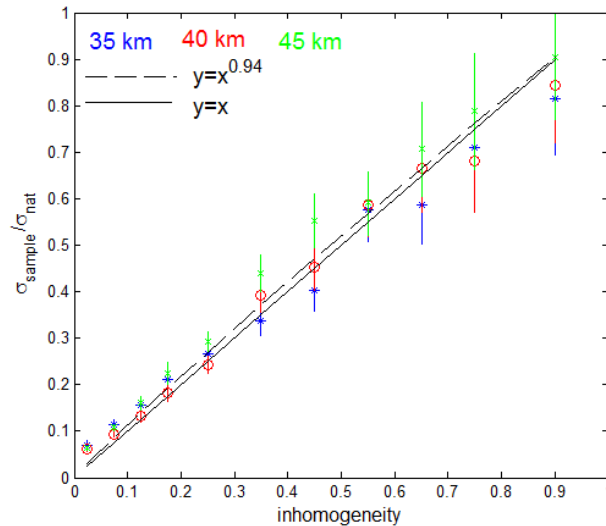
Authors: Changed as suggested.

Reviewer #3:

4. On page 2393, the natural variability is discussed. It is estimated from the LLM climatology, which of course forms an extra data source. Would it be possible to estimate natural variability from the FinROSE ozone fields themselves? It seems to me that the ozone variability within one geotemporal bin is easy to evaluate. Perhaps I am missing something?

Authors:

For the stratospheric altitudes considered in our paper, the FinROSE ozone fields can be used as well. We have studied using natural variability estimates directly from FINROSE field instead of the variability from the LLM climatology and found practically the same results of the sampling uncertainty parameterization (Figure below shows the results of sampling error parameterization when natural variability was estimated from FinROSE, for comparison with Figure 5 of our manuscript).



In general, the natural variability can be estimated from any reliable source: model, climatology or data with very good coverage (see also the reply to the next comment). If using model fields, the adequacy of representation for natural variability should be checked (in particular, problematic behaviour is expected close to lowermost and uppermost altitudes).

In the revised version, we have added the corresponding notes on the estimates of natural variability.

Reviewer #3:

5. At the end of section 5, it is discussed how to calculate the total uncertainty on the ozone. It is evaluated from the inhomogeneity and the natural variability of the ozone (Eqn. 6). An important question remains: where to get the natural variability? Do the authors implicitly suggest to get this from an external source, such as the abovementioned LLM climatology? Please specify in the text.

Authors:

The natural variability in Eq.(7) should be a realistic estimate of natural variability. In some cases, it is not necessary to get the information about the natural variability from an external source. If the data distribution is homogeneous and uncertainty estimates are realistic, the natural variability can be estimated as $\sigma_{\text{nat}}^2 = \text{var}(x) - \sigma_{\text{noise}}^2$, where $\text{var}(x)$ is the sample variance and σ_{noise}^2 is estimated data uncertainty variance. If any of the abovementioned requirements is violated, we would recommend using an external source. We added this note in the revised version.

Reviewer #3:

6. An additional remark for possible further investigation: Eqn. 7 somewhat suggests that it would be possible to optimize the total uncertainty on the monthly zonal mean data, by deliberately leaving out some data points. Indeed, discarding points that increase H (because of their asymmetry or homogeneity) would make the sampling uncertainty smaller, while the standard error of the mean would probably increase (less points available). Perhaps an optimal choice of data points can be found.

Authors:

We disagree with this suggestion. As explained in reply to the previous comment, the estimate of natural variability should represent the real natural variability, not the sample variance. Therefore, any reduction of data leads to increasing H , and, because σ_{nat} remains the same, this results in increased sampling uncertainty.

Reviewer #3:

Technical corrections

Page 2384, line 18: change to “using ECMWF temperature fields (Foelsche et al., ...”

Page 2384, line 20: change to "...such an approach cannot completely remove sampling ..."
Page 2385, line 11: change to "...work of the ESA Ozone_cci project ..."
Page 2386, line 1: change to "...best sampling is obtained by MIPAS and SCIAMACHY; ..."
Page 2388, line 8: change to "The reason for the appearance of such oscillations is that some of the longitudinal ..."
Page 2389, line 17: change to "... characterize the inhomogeneity ..."
Page 2390, line 9: change to "Anisotropy or entropy separately do not always ..."
Page 2391, line 9: change to "was simulated with a high resolution ..."
Page 2391, line 13: change to "... between the full ..."
Page 2393, line 3: change to "... FinROSE ozone field averages) ..."

Authors:

Corrected, thank you.