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Atmospheric Measurement Techniques Discussions

Interactive comment on "On sampling uncertainty of satellite ozone profile measurements" *by* V. F. Sofieva et al.

Anonymous Referee #3

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General comments

The paper under discussion presents a method to quantify the uncertainty on climatological ozone concentration values that is caused by non-uniform sampling of the atmosphere, which is common in satellite-borne remote sensing of the limb, since it is difficult to obtain perfect uniformity due to orbital specifics. The problem is particularly acute for geolocations and time periods characterized by strong temporal and spatial gradients in the ozone field (e.g. the edge of the polar vortex). The proposed method estimates the sampling uncertainty from (1) the asymmetric distribution of sampling points within a geotemporal climatology bin, and (2) the entropy of the sampling distribution, the latter a method that has been applied successfully in the past within the field of information theory (Shannon entropy). From these two quantities, the so-called

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inhomogeneity measure is calculated, which is shown to be the proportionality factor between the natural variability of the ozone concentration and the sampling uncertainty. Estimation of sampling uncertainty therefore becomes straightforward, from knowledge on (1) the natural ozone variability and (2) the sampling distribution. Although the paper only discusses ozone, the method should be considered as more general, and can be applied to other species as well.

The goals, methods and results are convincingly presented in the paper. The text is well written and figures are clear. There are no major problems and, in view of the fact that the novel method is also of interest to other fields, I recommend to publish the paper after minor revisions (see details below) in AMT, which is the appropriate journal for this paper.

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?

2. 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. 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.

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 [50°N-60°N] shows very small sampling uncertainty, while the inhomogeneity measure is quite large.

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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?

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

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.

Technical corrections

The following corrections and changes are suggested to improve the readability of the paper.

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; . . .”

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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) . . .”

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