Response to an Interactive comment by J.-H. Kim

Dear Dr. Kim,

Thank you for your interest as well as for your comments and suggestions. We have tried to take into account your recommendations. Especially valuable were the suggestions regarding potential further data analysis. Some of the ideas we have tried already on the data used in the manuscript (see the details below). Those trials demonstrated clearly that to conduct full quantitative analysis we need more data, especially more records of turbulence encounters. Because of that we could not feature the quantitative approach in the present manuscript but we certainly find your recommendations valuable for our further work.

Please find detailed responses to your comments below.

On behalf of the authors,
Jacek Kopeć

Introduction

The response to the comment is structured as follows: the comments are first reproduced in **bold font** followed by authors' responses and indication of appropriate changes in the manuscript.

Response to the comments by J.-H. Kim

This paper describes the first attempt to see how the ADS-B or Mode-S wind data can estimate the signal of turbulence using different methodologies. History and back- ground study in introduction, and motivation and discussion of the dataset and methodology in section 2 and 3 has been very well documented in this study. Although authors have done to discuss several advantages and disadvantages in suggested EDR estimations using ADS-B and Mode-S emulations, the analysis from suggested methods in section 4 needs to be improved using more qualitative statistical tests to show how each method has different performance quantitatively. Detailed comments and suggestions are as follows.

1) Page 11819, Line 28: EDR is ICAO standard (WMO 2010), which is robust and aircraft independent measurement for atmospheric turbulence. Only matter is how can we implement this EDR technique to all aircraft and how can we transmit this EDR sig- nals to ground or other aircraft more efficiently and economically. I hope authors may need to emphasize the importance of the suggested new method somewhat conservatively until this method will be confirmed to be useful for accurately and independently measuring atmospheric turbulence.

Thank you for pointing this out. The formulation we have used was not appropriate. This issue has been also indicated in both reviews and we have reformulated the relevant fragment.

Manuscript change

Prevoius: (P11819 L28) The only drawback of the EDR data is that it still is not an industry standard, hence its availability is an effect of negotiations with the individual airlines.

Current: (P11819 L28) The only drawback of the EDR data is that it still is not in widespread use, and its availability is by negotiation with individual airlines.

2) Page 11822, Lines 14-16: Definition of the reference EDR (WMO 2003) is not clear. Did author use Cornman (1995)'s methodology for the DELICAT EDR ?

In fact yes, we have used the Cornman et al. (1995) methodology for the DELICAT EDR. The

document (WMO, 2003) is citing the article by Cornman et al. (1995). We have verified that the content of the WMO document is in alignment with (Cornman et al., 1995).

3) Page 11823, Line 13: Authors may want to mention the horizontal resolution of finally sampled data. For example, considering the airspeed is about 250 m/s, 2 Hz data will be 125 m horizontal resolution to calculate the estimate EDR.

Added indicative information about the horizontal resolution.

Manuscript change

Prevoius: (P11823 L13) Discretization is performed using simple floor function.

Current: (P11823 L13) Discretization is performed using simple floor function. The resulting spatial resolution is 125 m for synthetic ADS-B and 1 km for synthetic Mode-S EHS (assuming the aircraft velocity is 250 ms^{-1}).

4) Page 11823, Line 13: Authors may need to setup more objective definition of classifying the resulting data into 3 groups here. For example, RMSE of air speed or ground speed smaller than certain value during certain period time falls into group 1. Others fall into group 2 or 3 depending on RMSE or bias of air speed or ground speed.text

Each approach to classification (even the more objective ones) requires some arbitrary choice to be made. Because of the limited amount of data at our disposal we aimed at simplicity rather than finding the optimal method. Optimizations conducted on very small datasets tend to produce results that are rather questionable. That is why we think that there is no need to use RMSE or any other statistical tool here. The categories are clearly defined and in fact the difference between them in KNMI data is very well pronounced. Because of this we did not see any need for categorizing the data in any more sophisticated way. Also note that the categories hold data types and not any particular time ranges since the discrepancies (and their characteristics) were almost constant in time.

Of course this remark is very important when treating larger datasets. We will certainly make sure to try this approach in the next stage of our research.

5) As authors know, structure function method (3.2) is highly depending upon horizontal resolution of the data. 0.025 and 0.094 Hz corresponding 10 and 2.6 km horizontal resolution seem too low to get the reliable EDR result. Sensitivity to horizontal resolution would necessary to show how this method are sensitive to the data sampling frequency.

The present manuscript explores the use of Mode-S EHS data - and this determines our sampling rate choices (approx. 0.25 Hz). We could theoretically explore other sampling rates but there seems to be no point in doing it in the scope of this manuscript.

As for the filtering choices please note that our sampling rate is 2 orders of magnitude smaller than that of the typical data used in determining ϵ (e.g. Cho et al., 2003). That means the Mode-S EDR wind is reported approx. every 1 km of flight. The upper filter bound was chosen to eliminate noise and stray peaks. Please note it is still very close to the Nyquist frequency of the data (0.125 Hz). In further work we will evaluate other filtering options.

6) In table 3 and in section 4, several statistical tests like bias and Root Mean Square Error (RMSE) for four suggested EDRs against DELICAT EDR can be calculated to see how each method perform differently. Based on this, authors may say something more qualitatively. And, if some of them has biased constantly, authors may set up regression or matching function to convert one to another. Residuals can be also calculated from the regression function.

We have tried this kind of approach. However, there are two obstacles for this information to have

any meaning. First, ADS-B methods results as well as DELICAT EDR are known up to a constant. In order to relate anything to the reference data we have to determine this constant. This is usually done with help of some optimization procedure. Depending on the procedure (or the parameters) chosen the RMSE, bias, etc. will vary (sometimes significantly). Second, we have very low amount of turbulence encounters. This implies it is pretty straightforward to determine the constants so that the calm air EDR is consistent and disregard the peaks. This usually gives very low RMSE, bias, etc. but is really meaningless. If one wants to represent the peaks well we are back to the first point where the choice of method/parameters will determine the results. That is why we have settled for qualitative comparison instead.

The presence of constants also implies that one needs to do regression before anything else. However, the comprehensive quantitative evaluation is a must in our furter research. This requres more data which were not available for the present manuscript.

7) In conclusion section, mentioning of suggestions for future research to overcome the current problems of ADS-B/Mode-S based EDR observation like the aircraft dependency and selecting the filtering frequency for building up more reliable EDR results, and so on.

Added an appropriate sentence to the conclusions.

Manuscript change

Prevoius: (P11835 L16) ... the Maastricht Upper Area Control Centre (MUAC) airspace sector in near future.

Current: (P11835 L16) ... the Maastricht Upper Area Control Centre (MUAC) airspace sector in near future. The more comprehensive study may also help determine ways to overcome the main concerns about the practical use of the proposed methods namely potential aircraft dependence (mainly ADS-B), determination of better filtering and treatment of missing/less regular data.

8) If the mode-S or ADS-B based EDRs still have constant bias against reference EDR, I would recommend to check whether the Probability Density Functions (PDFs) of the mode-S and ADS-B based EDRs follow well the log-normal distribution. If they follow the log-normal distribution well, then authors can convert the mode-S or ADS-B EDR scales to reference EDR scale, as NWP model-based individual turbulence diagnostics are converted to a reference EDR-scale (Sharman et al. 2014).

Thank you for this suggestion. I am sure it will be useful in our further research.