

## ***Interactive comment on “Retrieving clear-air turbulence information from regular commercial aircraft using Mode-S and ADS-B broadcast” by J. M. Kopec’ et al.***

### **Anonymous Referee #2**

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This is an interesting paper to read. It describes how automatic and selected transmissions made by aircraft may be utilized to indicate the presence of atmospheric turbulence. The work describes three methods which utilize these transmissions to obtain an indication of turbulence. However, I felt that there was insufficient evidence to support the final conclusions this being due to the limited verification undertaken. The turbulence metric EDR cannot distinguish between clear air turbulence and other forms of turbulence. It essentially only indicates the presence of turbulence and its intensity. Further analysis of the aircraft trajectory is required to determine the class of turbulence. The methodology is reasonably clear but there are some points that further explanation or supplementary notes would help: the processing used for synthetic

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Mode-S (would need the algorithm if this is to be reproducible), the assumption that a linear track can be considered as an ensemble - an illustration. The work appears to have the main references (one or two more are suggested). The conclusions seem reasonable given the limitations of the available data. Most aircraft will report low level turbulence but would avoid areas of moderate and high - whether forecast or reported. It is not clear to me how these methods would be implemented routinely. Moreover, I doubt that these methods would be suitable for operational applications. But these are different questions. Nonetheless, I would recommend publication, if only to guide other researchers in this area on the best route to further development of the methods or to provide a means to improve upon the method of verification.

Before publication I recommend that the following comments noted below are addressed.

- PP11818 Title - no need for broadcast since this is the 'B' in ADS-B.
- PP11818 L1 De Haan notation uses Mode-S EHS. Please check. Make this clear in the abstract
- PP11818 L2 Suggest rephrase "as new and valid source" to "a new source" There is insufficient verification to support 'valid'
- PP11818 L The abstract should indicate that the Mode-S EHS data used was synthetic.
- PP11818 L5 "All the necessary parameters ..." needs to be rephrased since the characteristic constants need to be estimated or determined for each method.
- PP11818 L9 Suggest rephrasing "... accelerometer indicate a significant potential of those methods ..." to "... accelerometer indicate the potential of the methods described ..." [I would argue that further verification is needed to support the stronger claim.]

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- PP11818 L17 "rely solely on forecasts or any slight visual characterizations" Pilots also listen into the "radio chatter" where they can be alerted by lead aircraft encounters with turbulence.
- PP11819 L2 "due to the turbulent energy cascade" a suitable reference would be helpful
- PP11819 L9 "buoyancy waves breaking" - e.g. Gravity waves
- PP11819 L10 "All of those mechanisms ..." suggest "All of these mechanisms ..."
- PP11819 L13 ".. at the same time it is impossible to detect it" ... Suggest "detection of CAT is difficult." If impossible then say why it is impossible. "using ordinary weather radar" suggest "using weather radar" if cannot detect using ordinary then this means require extra-ordinary radar.
- PP11819 L15 "by using active optical sensing" - need to give an example of what this means. I would say looking out the window would be a form of active optical sensing.
- PP11819 L23 " only drawback of the EDR data is that it still is not an industry standard." suggest "only drawback of EDR reporting is that it is not in widespread use." I would argue that (a) a standard for reporting exists (ICAO/WMO) (b) in the US EDR is being used (c) FAA are developing a reference standard (d) EDR is specified as a parameter for ADS-B in RTCA DO-339 Aircraft Derived Meteorological Data via Data Link for Wake Vortex, Air Traffic Management and Weather Applications - Operational Services and Environmental Definition (OSED) )
- PP11819 L24 "hence its availability is an effect of negotiations with the individual Airlines" suggest "; and its availability is by negotiation with individual airlines"
- PP11820 L When referring to Mode-S please use de Haan notation Mode-S EHS.

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- PP11820 L9 "with a very high sampling rate ranging from" I find this statement troubling. It is not a sampling rate as such. The frequencies quoted are rotation rates.
- PP11820 L10 "frequencies 1090 and 1030 MHz" - 1090 is the downlink while 1030 is the uplink. Could be confused with the preceding statement on sampling rate. Was the transmission of synthetic Mode-S emulated?
- PP11820 L24 " decoded by a relatively simple hardware" see also Stone and Pearce (<http://dx.doi.org/10.1175/JTECH-D-15-0184.1>) "and is relatively cheap" suggest "and is relatively inexpensive."
- PP11820 L18 I do not think that ADS-B is a spontaneous transmission this suggests it is a random process suggest replacing the word spontaneous with automatic.
- PP11820 L13 "Mode-S carries a very high frequency wind information." No, de Haan shows how to derive high frequency wind information."
- PP11820 L23 " ... available information since very significant part of civil aviation" suggest ".. available information since a very significant part of the commercial civil aviation ..."
- PP11821 L11 "Mode-S-like form" suggest synthetic Mode-S EHS messages were generated." This also should be indicated in the abstract.
- PP11821 L17 "track angle parameter" Please clarify what is this represents" Ground direction with respect to true north"
- PP11822 L27 "The original Mode-S data recorded by KNMI were then used as a reference for evaluating the successfulness of the processing on the overlapping flight fragment" suggest "The original Mode-S data recorded by KNMI was used

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as a reference for evaluating the success of generating synthetic Mode-S EHS on the overlapping flight fragments."

- PP11823 L15 What is DADC" Digital Air Data Computer" As a general note please make sure that acronyms are expanded on first use.
- PP11824 L18 "In summary the reference data collected by the KNMI receiver proved to be insufficient for conducting tests of the post-processing methods." Are you saying here that the KNMI data could not be used for the CAT estimate algorithms" Hence the need to simulate Mode-S using the DELICAT data" Please clarify this statement.
- P11825 L19 "as finite difference between the consecutive observations." What is the expected maximum elapsed time between consecutive observations." What happens in the event of signal drop-outs or a long elapsed time between messages?
- P11826 L3 "Is the airspeed V the mean value, expected value, maximum value over the set time period T""
- P11826 L22 Reference for example "Mulally, D. and Anderson, A. Correction of Aircraft Flux Valve Based Heading for Two-Dimensional Winds Aloft Calculations Using Weather Model Comparison."
- P11826 L26 Please provide a suitable reference that describes the Butterworth band pass filter in the context used for this paper.
- P11827 L10 "Treating B as a constant" this is a significant limitation of the method.
- P11827 L23 "both of those publications authors mean ensemble average as an average over many realizations of the similar conditions." This does not make

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sense. Are you saying that the authors define the ensemble mean as the average value obtained from many realizations of the similar conditions.

- P11827 L26 "processing of individual aircraft flight record we make an assumption that a series of consecutive observations of sufficient length forms such an ensemble" It is not clear how this assumption arises along a single trajectory. Perhaps a diagram would assist the explanation for this method.
- P11828 L17 "... we have chosen a band better covering the expected CAT scales" suggest "... we have chosen a frequency range covering the expected CAT scales."
- P11829 L17 This section seems to suggest that the chosen method will depend on the available transmission medium for the data source. The referring to "methods" seem to be mixed with the transmission "method". Suggest that this paragraph is redrafted to make it clear the advantages and disadvantages of each EDR method for each mode of transmission.
- P11831 L9 Delete "As well as the threshold crossing method" suggest rephrase "the structure function based approach results in an underestimation" as "the structure function based approach also results in an underestimation when using ...."
- P11831 L14 "...small business jet thresholds in (Sharman et al., 2014) one must .." suggest rephrasing as "... small business jet thresholds as reported in Sharman et al. (2014) one must ..."
- P11831 L23 "... the roll off the aircraft was exceeding 7 ..." suggest rephrase " if the roll angle exceeded 7 ....). How does this roll angle compare with that used for AMDAR reporting and de Haan Mode-S EHS

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- P11832 L17 "the length of period of moving variance calculation" suggest rephrasing "the time-window for the moving variance calculation ..."
- P11832 L26 " As for indicator function too small window ..." suggest rephrasing "An indicator function window that is too small (less than 10s) causes stray peak signals to arise whereas for longer periods the indicator function do not damp the signal."
- P11833 L When discussing this point please make clear references to which parts of figure 9 apply.
- P11833 L17 " for the correct differentiation of its intensity .." suggest "... for the correct discrimination of its intensity ..." (differentiation could be interpreted as the rate of change) The methods described can only provide a qualitative indicator for turbulence.
- P11833 L27 " ...Butterworth filters with limiting frequencies that are as much based on physics as possible .." suggest rephrasing as "... Butterworth filters with expected frequencies that are based on turbulence physics ..."
- P11834 L3 ""however we had to few cases at our disposal to try to find such filter as ...." suggest rewriting as "however, we had too few cases at our disposal to refine the filtering as ..."
- P11834 L5 " ... areas of use for those methods." suggest "... areas of use for these methods."
- P11834 L6 "allow a potential observer to use quite cheap and simple set-up for observing" suggest "allow a potential observer to use inexpensive equipment for observing ...."

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- P11834 L10 "In most of the highly developed regions the implementation of this technology is well under way. Most newly produced aircraft are properly equipped. However, older aircraft in less developed regions of the world can be quite useless." I would suggest removing or rephrasing - this seems to express a value judgment, which I am sure the authors do not intend. Suggestion is "For the highly developed routes the implementation of this technology is well under way. Most newly produced aircraft are properly equipped. However, older aircraft require to be retrofitted before they can provide the necessary data."
- P11841 Table 2 "Define IRS and DADC, indicate the precision of the recorded data."
- P11843 Figure 2 It would be useful to add labels on the time axis to indicate the time of day or at least the date and time at take-off. This may indicate the type of turbulence encountered during the flight.
- P11845 Figure 3 KNMI data - indicate if this is the Mode-S EHS data. DELICAT data - indicate if this is the synthetic Mode-S EHS. Rephrase (note that for clarity 97% of the ...)
- P11846 Figure 4 Please indicate the type of IRS. Gyro-magnetic systems are more prone to drift. Inertial Navigation Systems are far more precise (see Mually). If IRS then the 2km drift does not make sense.
- P11848 Figure 6 Suggest " ....For reference the indicative turbulence levels ...." Add a scale on the y-axis. Put a small horizontal gap between each plot otherwise it is quite confusing and difficult to interpret.
- P11849-50 Figures 7 and 8 See comments for figure 6 - small gap required.
- P11851 Figure 9 "Label events light CAT-1, light CAT-2, etc so that these can be referenced in the corresponding text in the main article."

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