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Atmospheric Measurement Techniques Discussions

Interactive comment on "Is it feasible to estimate radiosonde biases from interlaced measurements?" *by* Stefanie Kremser et al.

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We appreciate the suggestions and constructive comments provided by both reviewers. Below, the reviewer's comment is repeated in bold with our response in black.

Response to Reviewer 2

Page 2, line 21: Kobayashi et al. (2012) also give a very good example of dual sounding program (a total of 115 dual soundings for four different seasons) at a GRUAN site, Tateno when they changed from Meisei RS2-91 to Vaisala RS92.

We added the reference to the revised manuscript as suggested by the reviewer.

Page 2, around line 21: WMO conducted several radiosonde intercomparison campaigns in the past (e.g., Nash et al., 2011; Jeannet et al., 2008 and the references therein). It would be fair to mention these and discuss its usefulness and/or limitations.

We included both references and the following sentences in the revised manuscript:
"In the past, WMO conducted several radiosonde intercomparison campaigns (e.g. Jeannet et al. 2008 and Nash et al. 2011) with the objective of investigating the performance of operational radiosonde systems. The results of these campaigns are used, in part, to improve the accuracy of daytime operational radiosonde measurements and the associated correction procedures to provide temperature and relative humidity accuracies currently possible with night time measurements. The knowledge of the performance that can be expected from various radiosonde systems allows the users to make a well informed decision on the choice of future equipment. For a measurement network like GRUAN, it is essential to have more than one good quality radiosonde type for operations."

Figure 1, caption. Please add the explanation on the dotted and blue lines in the upper two panels.

We have clarified what the dashed and blue lines in Figure 1 represent.

Page 4, Equation 4: Why the delta-hat is not E[delta]? A sentence explaining the reason for this at line 28 may be useful for readers.

E[delta] is the expectation value (sometimes called 'true' value) of the constant offset delta, conceived as a random variable. $delta_{hat}$ is its estimator, used to obtain an estimate for the unknown true value from observations.

Page 5, Equation 5: Why there is a phase component "-pi/2"? Also, in general, there should be cosine components as well for both diurnal and semi-diurnal variations? If, for this simulation study, it is enough to consider sine components only, mention that perhaps at line 23.

Combining sine and cosine of the frequency w is equivalent to using sine OR cosine with a phase shift phi, e.g. a*sin(w) + b*cos(w) = A*sin(w+phi) with A=sqrt(a^2 +b^2) and phi=atan2(b/a), see also the text book of Daniel Wilks Statistical Methods for the Atmospheric Sciences (2010), Chap. 8.4.3

Page 5, lines 20-21: The key word "weather" has already appeared at line 10, but it would be useful to mention it again when "a" first appears here, so that the readers are reminded that "a" is the one related to the magnitude of high frequency weather variability which is "noise" in this study. Something like: "(or the magnitude of weather related variability, larger for smaller a)"

We followed the suggestion by the reviewer and added: 'a is the autocorrelation coefficient which describes the degree of persistence in the time series at the weather time scale, e.g. the fluctuations show a day to day dependence, . . .'

Page 6, line 13-14: "larger persistence lead to larger uncertainties" – isn't it possible to show an equation for this using "a"?

Such an equation is given in the text book of von Storch and Zwiers (1999), Chap. 17, which we include as a reference. At this point we do not see it to be useful to discuss this basic issue here. It refers to 'arithmetic mean' calculations as stated in the paper.

Page 7, lines 10-13: It would be nice to have some more explanation on the

GAMs. (Are the GAMs a class of statistical distributions that Tt,AB would follow? What factors/ components determine the degrees of freedom here?) This is in part because the authors mention the GAMs again at the second line of the Conclusions, as a key component for this study.

Generalized additive models are a fundamental class of regression models which, other than generalized linear models, allow for nonlinear but smooth components - such as splines. A very good introduction is given in the text book of Simon Woods which we cited. We changed the text in Sect 2.3 to:
'The statistical model described in Eq. (12) belongs to the class of generalized additive models (GAMs, e.g. Chambers and Hastie, 1992), a fundamental class of regression models. GAMs extend generalized linear models (or "linear regression) by introducing additionally to the classical linear components a smooth term s. This term can be estimated using a smooth spline fit with its degrees of freedom (its flexibility of smoothness) determined by generalized cross validation (Wood, 2006).'

Page 7, line 30: I assume that 300 hPa at Lindenberg (a midlatitude site) would give near-largest weather-related variability, i.e., minimum "a", compared to other height regions and other latitude regions. But, I think it would be useful to actually show this by showing the values of "a" for other height regions at Lindenberg (and perhaps at a tropical site as well).

We agree with the reviewer and we have now added a new figure to the manuscript (Figure 5). This figure shows vertical profiles of autocorrelation coefficients determined from ERA5 reanalyses interpolated to the locations of 6 GRUAN sites, including sites in the tropics, middle and high latitudes. We chose to calculate the autocorrelation coefficients from ERA5 data rather than from radiosondes as long-term continuous measurements are required to obtain a robust estimate of the seasonal cycle of the temperature time series before calculating the autocorrelation coefficients. Such

continuous observations, covering at least 2 years of daily radiosonde flights, are currently only available at a small subset of GRUAN sites, which does not cover all latitude bands. ERA5 is the latest reanalysis data set provided by ECMWF and it is expected that the calculated autocorrelation coefficients provide a good estimate of the autocorrelation coefficient at each of the selected sites. The estimated autocorrelation coefficient at 300 hPa for the radiosonde measurements made at Lindenberg (0.5 as described in the manuscript), agrees very well with the coefficient determined from the ERA5 reanalyses.

Page 8, lines 9-10: Please also add explanation on M here.

We assumed that the reviewer referred to line 18 and included an explanation for M in the revised manuscript.

Page 10, line 25, and lines 28-29: Showing a figure on this might be useful?

While we agree with the reviewer that an additional figure might be useful, we decided not to perform additional calculations for other synthetic time series with increased measurement noise as the focus of this paper is on describing the method for determining the differences in the instrument bias, and an in-depth analysis of the applicability of this method for different variances or persistence is considered to be beyond the scope of this short paper. As the software used in this study can be obtained from the authors, the calculations can be repeated by others for their specific measurement time series as variance and persistence vary from site to site.

Also, stratospheric water vapor measurements may be an example for this?

We agree with the reviewer that stratospheric water vapour might have a higher persistence than temperature and it could be tested whether or not the described

interlacing approached is applicable to deriving differences in biases in measurements obtained from, e.g. frost point hygrometers. Radiosondes measurements of stratospheric water vapour, however, are highly uncertain and have limited value in this context. Therefore, we have not discussed the applicability of this interlacing method to water vapour measurements in this paper, which focuses on radiosonde temperature measurements.

Page 12, Competing interests: The period is missing at the end of the sentence.

Done.

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