

Interactive comment on “Quantifying the value of redundant measurements at GRUAN sites” by F. Madonna et al.

Anonymous Referee #1

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This manuscript describes several metrics from information theory for quantifying the uncertainty and redundancy of observations of the same atmospheric variable, and it applies these metrics to upper air water vapor observations from several GCOS Reference Upper Air Network (GRUAN) sites. I learned a lot from reading this paper and feel it introduces some potentially important concepts to the atmospheric measurement and climate research communities. Although the paper is a little hard to follow at times, I feel it would be acceptable for publication in AMT after the comments below are addressed.

General comments

1. Acronyms. There are too many new acronyms, which make the paper difficult to

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read. They include a set for instrument types, a set for GRUAN station names, and a set for statistical measures. I suggest limiting acronyms to the statistical measures only and spelling out all other words. That will both make the key concepts (the statistical measures) stand out and make for smoother reading.

2. Interpretation of concepts from information theory. In discussion of mutual correlation (MC) and distance (D), the authors should recognize that these concepts are probably new to many readers. The descriptions and interpretation are generally good, but adding some illustrative examples, using simple data distributions (not GRUAN data), would help explain how to interpret MC and D. Please consider illustrating MC and D by plotting from some invented datasets, with known means, variances, ranges, biases, etc., plotting those (maybe both as series and as scatterplots) then computing and interpreting MC and D. Some points worth illustrating include: linear vs non-linear redundancy (6333/7-9); whether $0 < D < 1$, as one might guess from Figure 4; relationship between the information theory variables and more familiar statistical measures.

3. Data detrending (6337/13) and vertical averaging (6339/10). The motivation for removing linear trends in the datasets is not explained, and it seems possible that the results might depend on this data processing choice, particularly if the trends in different sets of observations are unequal. Either an explanation for this choice is needed, or the data should not be detrended. Similarly it does not seem kosher to perform vertical averaging of the profile data before computing normalized entropy ($H/\log(n)$) or MC. The resulting smoothing must change the numerical values of $H/\log(n)$ and MC, doesn't it?

4. GRUAN uncertainty estimates. A major hallmark of "GRUAN data products" is that quantitative and complete uncertainty estimates accompany all observations. I recognize that some of the observations used in this investigation have not yet become GRUAN data products, but I think some have (e.g., column water vapor from GPS). I'd like to see the uncertainty of observations plotted along with the measured values, to judge whether other observations fall within the GRUAN uncertainty estimates, in

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Figure 2, for example.

5. Figures. The figures are generally good, but a few need to be reconsidered and redesigned. In Fig. 4, the grouping of histogram bars is problematic for Potenza, in part because of the way the x axis is designed and labeled. Figure 7 is not effective in communicating the way normalized conditional entropy changes with grouping of measurement methods. Some other way of displaying this information is needed, although I don't have a good suggestion for an alternative graph.

6. Conclusions. I'd suggest including some concluding statements about the merit of using information theory, in general, and specific statistics from information theory, in particular, to quantify measurement redundancy.

Specific comment and suggestions (by page and line)

7. 6327 Avoid using an acronym in the title.

8. 6328/5 Specify what humidity parameters are used and whether they are column-integrated or profile parameters. Are these variables measured directly or calculated from some other observed quantity?

9. 6328/10 The 8% number is meaningless without information about the variable in question and the typical uncertainty of a given measurement.

10. 6328/12 How can one instrument be considered to have the "highest redundancy?" Doesn't redundancy depend on the existence of at least two instruments?

11. 6328/16-15 The fact that data from one instrument are used to "condition" data from another seems more of a problem than a benefit. The abstract refers to the "best reduction of random uncertainty" but that feels a bit like cheating to me.

12. 6328/22-23 This first assertion in the Introduction is highly debatable. Understanding processes can be advanced through both theoretical and observational approaches, and among observational approaches it has long been the case that field

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experiments tend to favor a suite of measurements of different, related parameters, not a redundant set of measurements of one or more parameters.

13. 6329/3-4 This sentence, if pulled out from the manuscript, could be criticized as ridiculous. In common language, if something is redundant, it is probably not needed at all, because the need is already being met in some other way. So it provides no added value and would be considered instead a waste of resources.

14. 6329/10-11 I don't understand this bullet

15. 6329/19 Is the Thorne et al. 2013 a citable, peer-reviewed, easily accessed reference? If not, use another reference that gives an overview of GRUAN, for example Seidel et al. (2008, BAMS).

16. 6329/20 The use of the adverb “soon” to describe the network expansion is both vague and optimistic.

17. 6329/24 Avoid using a web-based brochure as a reference.

18. 6330/7-8 and 6331/15-18 These two sentences seem somewhat contradictory, offering different views of ways in which measurements are compared. Consider consolidating these statements as part of a more general discussion of traditional, parametric methods of approaching the task of comparing datasets.

19. 6330/13 Is “This study” the present study or the one just mentioned by Fasso et al?

20. 6330/18 Should “correlate the value with” be changed to “relate the value to”? The latter suggests a description approach, while the former suggests a quantitative one.

21. 6331/5 None of the five sites have been certified as GRUAN sites, and it seems unlikely that at least one of them will be. Consider using language such as “candidate GRUAN sites” or “sites currently affiliated with GRUAN (but not yet certified)”.

22. 6331/20 I don't understand the meaning of “of the freedom in selection of an event”.

23. 6332/5 What is the antecedent of “these”? Is it H and sigma? Would it be clearer to say “they”?
24. 6332/17-18 Consider saying more directly that MC is a more general measure than rho, because it does not assume linear or even monotonic correlation.
25. 6332/25 Should “information” be replaced with “correlation”?
26. 6333/18 Either state the triangle equality or remove this mention of it, but do not assume the reader is familiar with it or that the connection to D will be obvious.
27. 6338/20 This sentence is confusing. Why bring up variance and correlation in this discussion of MC? Consider keeping all the discussion of the advantages of MC over more conventional, parametric methods in the beginning of this section?
28. 6334/3 What is the axiom of information theory?
29. 6334/9 Be clear that you are addressing water vapor observations only, not other parameters measured by radiosondes or other instruments.
30. 6334/13 At least some of the instruments do not sample the “complete column”. Their vertical ranges are limited. This should be stated explicitly, and described quantitatively, because it is a source of non-redundancy of the measurements.
31. 6334/21-23 I don’t think this statement is true. Other GRUAN data (e.g., from Lindenberg) are flowing into the GRUAN archive. Maybe I’m missing the point here.
32. 6335/4 What is meant by “passive” instruments. Aren’t radiosondes also passive, in that they don’t send signals out as part of their measurement method?
33. 6335/27-28 This last sentence seems unconnected to the rest of the paragraph.
34. 6336/9 What do you mean by “selected by stations”?
35. 6336/23 Considering replacing “Starting at 25 bins” with “Between 25 and 100 bins”.

36. 6337/9 Does solar radiation affect humidity observations (or only temperature)? If so, specify which instruments suffer from this source of bias.
37. 6338/18-26 This discussion of D raises some questions that should be clarified here. Does the value of D always range from 0 to 1? Is “redundancy” a function of D, and D alone, as suggested. What value of D (or what other quantitative measure) is typically used, or is used in this paper, to judge that techniques “show good redundancy”?
38. 6339/19 Change “entropies retrieved” to “entropies computed” or “entropies estimated”.
39. 6339/23 Insert “only” before “20”.
40. 6339/29 The entropy values don’t seem so very similar to me, particularly near the ground. A qualitative term like “similar” should either be avoided or supported with quantitative results. See also 6340/14.
41. 6340/23 Consider changing “reported” to “shown” or “illustrated”, since you are discussing a figure.
42. 6341/24 Should “normalized over” be changed to “normalized by”?
43. 6341/29 I’m not sure it is fair to say that MC is “more accurate” than linear mutual correlation (LMC). They are different, and MC may be more appropriate and more general, but both measures accurately measure what they are intended to measure.
44. 6342/4 Explain Taylor’s diagrams.

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