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Atmospheric Measurement Techniques Discussions

Interactive comment on "A neural network approach to estimate a posteriori distributions of Bayesian retrieval problems" *by* Simon Pfreundschuh et al.

Anonymous Referee #2

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Summary:

This paper introduces a new neural network retrieval approach that is capable of obtaining an a posteriori distribution of retrievals – providing an estimate of uncertainty in retrieved parameters. While the development of the algorithm is the primary focus of this paper, there is also an extensive effort to compare this approach to existing Bayesian approaches.

General Comments:

This paper represents a substantive contribution to the usage of machine learning techniques in remote sensing. The introduction of estimates of uncertainty in this im-

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plementation increases the value of Neural Network solutions to remote sensing problems. In particular, the extensive comparison between Bayesian retrieval approaches and the QRNN highlights the power of this approach. It is particularly promising that this QRNN approach can provide insight into non-gaussian retrieval uncertainties, anything that challenges the reductive gaussian paradigm is fine in my book.

This paper certainly deserves to be published, but I have just a few minor concerns I think may help to make the paper more accessible to readers.

1) While I think that examining bias histograms of retrieval variables is a useful way of evaluating retrieval quality, it would be useful to provide readers a picture of the behavior of the original histograms. To that end, I think that, in addition to figure 8, a 1-D histogram (pressure on the vertical axis) of predicted cloud top pressures should be shown (including each of the 3 approaches).

2) I understand the usage of the CDF's in figure 3 to demonstrate the statistical value of the retrievals, but again, I think you need to directly show at least an example of a 1-D histogram of the retrieved variable. It gives readers a more direct sense of the variable being retrieved and provides context.

Specific Comments:

Irrespective of the outcome of this review process, I hope these specific comments can help the author improve their manuscript.

1. Page 2, Line 31: Abbreviations of MAP and 1DVAR are undefined.

2. Page 4, Line 15: The sentence at the beginning of section 2.2 would almost be better suited as a conclusory sentence at the end of section 2.1. As a matter of formatting, I think it's best to avoid a section being a single sentence long.

3. Page 9, Line 5: Can you provide an explanation for this restriction of latitudes in the dataset?

4. Page 10, Line 8: The formatting of this citation for Typhon seems like it might be incomplete or incorrect for the type of source being cited.

5. Page 10, Line 19: I don't follow the statement, "not smaller than and larger than 100, respectively". I read that as a logical statement that can't be possible because of the usage of "and." Do you perhaps mean "or?"

6. Page 10, Line 24: Missing word. Need to insert as into, "It is also released as part of the typhon package.

7. Page 15, Line 30: NN-CTTH is an undefined abbreviation. Because of the similarity to the abbreviation for cloud top height (CTH) I almost didn't notice that I didn't understand the name of the algorithm until later in the paper.

8. Page 17, Line 2: This feels like an incomplete sentence. Perhaps if you reorder it a bit it will make more sense. For example: "The NN-CTTH algorithm and the QRNNN are trained using the exact same data set. This training set consists. . ."

9. Page 17, Line 7: I also recommend reorganizing this sentence: "In Håkansson et al. (2018) neural networks are trained using different combinations of input features (e.g., [example from paper goes here]) in order to evaluate network performance with different inputs."

10. Page 17, Line 12-14: I don't follow along with this paragraph. Is the "testing under development" dataset the same as the AVHRR version? Could you clarify this paragraph some? Right now it seems that the confusion stems from the discussion of two different datasets within the space of only three sentences – making I difficult to clarify the difference between them. Is the first sentence referring to the first paragraph?

11. Page 17, Line 16-17: This sentence is a little confusing to read.

12. Page 18, Line 6-7: Could you expand on how the performance for low and high clouds differs here? Because you're discussing in terms of low and high clouds and cloud top pressure it's useful to highlight that a negative CTPpred-CTPref means that

the cloud is higher than the reference. Basically, for the NN-CTTH low clouds have a high-bias and high clouds have a low-bias. It's useful to say that explicitly.

13. Page 23, Line 20: For the sake of clarity for a more general audience can you provide an example of a vector-valued retrieval quantity.

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