17 April 2025

We appreciate the comments raised by the two reviewers, and thank them for the time and energy they spent on our paper. Their comments below are in black text*, and our replies to each comment are in blue italics. Any text directly added to the manuscript will be shown in green italics in our reply below.*

Reviewer #2:

The present paper compares the propagated uncertainties retrieved with observations and with a priori data; in order to account for the information content of the derived geophysical variables. In particular, this is done to propagate the uncertainties of water vapor and temperature advection estimated from the measurements of six different instruments. The scientific content of this paper is relevant and rigorously assessed and most of the explanations are clear and well structured. Moreover, it does provide a novel quantification of the information content of a variable of crucial interest in atmospheric dynamics, which is advection. And this is of great interest given that the growing tendency of remote sensors around the world has a great potential to estimate this variable given the synergistic use of ground-based sensors and this needs to be carefully evaluated to make sure that a proper quantification of this variable is performed. For all these reasons, my recommendation is to accept the present paper. However, I do have some comments that have to be addressed before its publication, I address them in the following lines.

We thank the reviewer for their comments and their time!

Line 124 and : Add the "°" to 20°C and 4.5°C

Done

Lines 130-135 and Figure 1: The location of the three facilities is shown; however it is not very clear from the figure. It reads "Note that the distances from E37 to C1, C1 to E39, and E39 to E37 are approximately 50, 45, and 78 km, respectively" But this is not clearly noted by the figure as there is no any length scale in it. Please add one. Moreover, it is a quite big area that is shown surrounding this triangle of facilities and nothing special is shown in that area, so I would suggest either to make more a zoom into the facilities or add the important information that the authors want to show with such a big area. The map is from Google Earth, and the green and brown colors might stand for the vegetation and ground in general but this is not mentioned nor of importance as far as the authors are explaining. So my suggestion for them is to please

provide a more accurate map in which the important information is presented and the no necessary features do not occupy most of the area.

Good suggestion. We have markedly improved figure 1 to show both the larger domain, as well as the three sites with distances between them.

Figure 2: This figure already has a lot of valuable information, however I think that it should be mentioned somewhere that it is in time UTC and what is the corresponding local time, because the diurnal cycle is quite visible but it is of course shifted due to the UTC time in the US. Please clarify this either on the figure itself or in its explanation around lines 135-140.

We added this to the caption: "The time (x-axis) is UTC; local time is UTC – 5."

In general I think that the authors have a lack of citations, and although most of the work is already explained with the current references; I think that there are some aspects that would become more clear how the state of the art is if authors provide more information about previous works. For example in line 59 where they say: "Often, geophysical variables retrieved from remote sensors are used to derive estimates of other geophysical variables." And from lines 65 to 70, authors could provide a wider overview of the geophysical variables that are estimated via multiple remote sensors each with their own uncertainty. What other variables have been propagated their uncertainties besides the information content?

There are many (many) papers that show the derivation of variables from retrievals; for example, CAPE has been derived from space-borne thermodynamic soundings, cloud properties from satellite radiances, etc. However, there are relatively few examples where uncertainties in retrievals have been propagated to provide uncertainties in derived variables. The Blumberg et al. 2017 paper is the only example for which we are aware.

Figure 3: fast temporal variations appear to be visible in this figure, please specify if the temporal resolution of these uncertainties is the same one as that of its variables in figure 2. Additionally, the AERI retrievals (with TROPoe) temporal resolution is not specified and it should be. Please add this information, maybe around line 81 where the AERI is introduced.

We added the temporal resolution of the TROPoe and DLoe retrievals to the first paragraph of section 2.1, as suggested.

Lines 196-200: The authors say: "The uncertainties in the both the temperature and water vapor advection for this day (13 June 2019) are small near the surface, and generally increase with height. In particular, the uncertainty in the temperature advection above 1.2 km from 0000 to 0700 UTC is quite large, suggesting that the cold air advection shown in this time period (Fig 2e) has a lot of uncertainty." Although the actual values of "small", "quite large" and "a lot" are seen in Fig 3, these sentences together sound rather qualitative, so I suggest that the authors

put some numbers on this and maybe comment on how small or large are these uncertainties compared with the actual advection values on figure 2.

We have added some specificity to the paragraph with "(less than 0.3 K hr^{-1} and 0.5 g kg^{-1} hr^{-1}, respectively)" and "(larger than 1.5 K hr^{-1})".

Figure 4: in its caption specify the hour, it's UTC again. And what do the colors in the map stand for? That should be clear.

We believe you are referring to Fig 5 here. As the caption of Fig 5 says "Same as Fig 2", which has an explanation of the time, we believe that the time is clear.

Lines 201-203: The authors say "However, there are particularly low uncertainties in the derived advection from approximately 0900 to 1500 UTC from the surface to nearly 1500 m that seem associated with the change in the synoptic pattern. "This idea is not fully clear, please elaborate more: What kind of change are you referring to in the synoptic pattern? How does it relates to the advection of temperature and water vapor and subsequently to their uncertainties? Please clarify this.

We have added this phrase to the end of that sentence: "(i.e., the change in direction of the low winds shown in Fig 4)".

As a general comment: on section 4 *Examples,* the authors carefully assess the information content and, through plotting the degrees of freedom (DFS) they identify the regions (times and heights) for which the uncertainty of the profiles and the subsequent thermal and water vapor advection are smaller and therefore they could be trusted. Moreover, on section 5 Statistical summary, the authors explore how this uncertainty assessment can be utilized to investigate temporally larger datasets and how it would change for cool and warm seasons. Additionally, the authors mention more than once (for example in line 334) that a large information content implies that the magnitude of any true perturbation would be captured by the present assessment. However, I think that it would be useful to mention if there has been any attempt to show if this is really the case when comparing the present advection estimation with other assessments of this variable performed with very different techniques, such as models like large eddy simulations or via in situ measurements. This comparison does not necessarily needs to be presented in the current paper, but I think it is an important aspect to consider, given that datasets as large as almost 2 years are considered and in the present paper and so far only retrievals from ground-based remote sensors and their uncertainties are considered. Therefore, a mention on these other comparisons would be elucidating.

The original paper on the advection method used here, namely the Wagner et al. 2022 paper, includes some analysis relative to the High-Resolution Rapid Refresh (HRRR) model.

The conclusion is generally clear and well-structured, so no big changes are suggested for it. However, it seems that it assumes that the current approach is the only one possible to retrieve advection and its uncertainties from ground-based remote sensors, and this is not necessarily the case. Also, regarding the information content, it is true that to the best of our knowledge there is no other work that determines how to propagate information content from multiple remote sensors; but in line 316 it seems to be assumed that this is the one and only way to do it, when in reality other techniques can also be developed for other remote sensors that may not be exactly the AERI and DWL. This suggestion is not mandatory, but I would recommend to soften some of these sentences. And as examples of previous works deriving advection from remote sensors, please refer to: Schween, Crewell, and Löhnert: "Horizontal-humidity gradient from one single-scanning microwave radiometer"

We have removed the phrase "for the first time" in the first paragraph in the conclusions. Additionally, we have added two new sentences at the end of the paper that hopefully captures this suggestion. "However, it has been shown that a single microwave radiometer making azimuth scans can identify spatial gradients of water vapor (Schween et al. 2011). If this was paired an instrument measuring horizontal wind profiles, potentially water vapor advection could be derived, but the propagation of uncertainties and information content could be performed the same way as shown here."