Interactive comment on "Cloud height measurement by a network of all-sky-imagers" *by* Niklas Benedikt Blum et al.

Anonymous Referee #3

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The manuscript presents an interesting use of a network of all-sky-imagers (ASIs) to derive mean cloud-base-height over a wide area. The method presented is interesting and, overall, the proposed system seems robust of probable practical use. The authors offer practical suggestions about the optimal layout of future ASIs installations, thus providing some useful information to the user. Reading the manuscript, it is clear that a lot of interesting work has been done, but unfortunately this has not been distilled enough yet to be clearly presented to the scientific community. The new algorithm is poorly presented, the novel contributions are not clearly identified, and the discussion of the results lacks focus. The authors should drastically revise the manuscript, trying to clearly present the essence and motivation of their work and separate it from implementation details.

To my understanding, there are three technical aspects presented: a) Implementation of three different approaches to calculate CBH from a pair of ASIs b) Evaluation of CBH retrievals from ASI-pairs. c) The use of a network of multiple ASI-pairs to derive a robust CBH estimate for the region.

Each of these aspects should be discussed and evaluated one by one, or references should be given in studies evaluating their performance. Otherwise, the reader cannot properly interpret the results.

Major comments:

Sections 3.3 and 3.4 should be rewritten. The sections seem like a direct translation of computer code into words, with no effort to describe why each step was implemented, what is essential, and what is just an implementation detail or even an experiment that happened to work. E.g. why use the three-gaussian filters? Why use the specific σ thresholds? Why add an offset of 0.5 in low frequency bins (why not 0.01 or 1)? Implementation details could be even moved into an appendix.

A similar comment goes also for the discussion part: It should be made much more concise, focusing on key results. Moreover, the stated aim of the proposed method is to assist nowcasting, and thus the authors should add an evaluation of the single measurement accuracy of the network. I.e. if the network outputs a CBH value of h, what is the uncertainty of this estimate? It is good that the network shows small overall biases in a three month period, but it wouldn't be of much use if the correct CBHs were measured at the wrong times.

Specific comments:

Line 85: Is the 3-month period enough to monitor all available conditions? What would be a suggestion to other users about the range of conditions that needs to be captured for good training?

Line 108: "by arbitrary selecting a tuple of ASIs". From the text, you seem to be

selecting all possible combinations of ASIs not only some arbitrary pairs. Moreover, I am not sure if tuple is the propre name as, in my mind, a tuple could include more than 2 objects. Consider rephrasing.

Line 111: "Camera axis". Does this refer to the line connecting the two ASIs that form a pair? If yes, then it should be called "pair-axis" or similar. "Camera axis" sound to me as the name for the direction that a single camera is looking.

Line 116: For completeness, please provide some more information about the instrument: E.g. Is the instrument part of DWD network you mentioned before? How is the CBH calculated from the data? Are you using the manufacturer's algorithm or a custom one? What is the minimum overlap height? What is the minimum height that CBH can be detected? References?

Line 116: Are you using the color or B&W version of Q25?

Line 130: Please mention what is the total time required to get a processed image (including data transfer and processing)?

Line 141: *optically* thick clouds.

Line 141-144: How exactly do you distinguish if the first cloud layer is thick, to exclude the other detected cloud layers? Do you always keep only the first layer when multiple layers are detected?

Line 143-144: The accuracy discussion is not enough for an instrument sued as reference. The differences reported in Martucci et al. 2010 seem to be coming from different algorithm or even definition of CBH used by each instrument. Moreover, the bias they find is not only 160 meters, but also has a range component (Y=0.925X + 160). Finally, Martucci et al used a rather old model of the instrument you are using here. Therefore, you should give more details about the CBH algorithm used with Ceilometer data and discuss the possible differences in definition of CBH as used for ceilometer and for ASIs. Lines 161 - 176: The description of the algorithm is not very clear. Please add a

new figure (or add a panel in Fig.) showing the image of the second ASI, highlighting the matched window. Also, a small flowchart could be helpful.

Lines 161 – 176: Have you compared the results from the three method (center box, side boxes, full image) to validate your expectation that they yield similar results?

Lines 161 – 176: Please provide the relations connecting a) the ASI-pair distance with b) the minimum altitude that each method can be applied, due to purely geometric considerations.

Line 186: Specify that this analysis is based on the ceilometer. Is the CBH analysis based only on the lowest layer detected by the ceilometer?

Line 200: How are TanDEM-X data used in this study? This seems the wrong place of the manuscript to introduce a new dataset.

Line 187-206: How is this analysis of CBH stability relevant to this study? Does your algorithm work only in these conditions? Maybe the stability excludes some possible errors in transition periods? Please mention the context and usefulness of this part of the manuscript.

Line 228: "..., where N is the number of vertical bins used for the analysis" or similar.

Line 303: Why use theta for true CBH and not a symbol based on h?

Lines 350-354: The uniformity constraint is very reasonable during algorithm training, not so during evaluation! It is very interesting to evaluate the algorithm in variable cases and understand what the outputs are, if it is biased towards the low or high clouds etc.

Line 360: Why not reverse the two plots in Figure 6, to discuss them in order?

Line 377: As shown from the two pairs, in cloud-free conditions some ASI-pairs output the value of 12km, while others 2km (probably due to local low clouds). Why do you suggest that the 4km output of the network is a reasonable prediction of a layer coming at least 30 minutes later? Is this layer captured by any pair in the network? It could

also be a lucky combinations of these two extreme values? In general, how does the network handle cloud-free conditions?

Line 395: The main ASI-based CBH retrieval limits the instrument to a maximum zenith angle of 67 degrees. For the CLO-FLE pair, given the 4.2km distance of the instruments, the minimum detectable clouds should be around 1.4 km (if I calculate correctly). In the September cases many clouds are below this limit, so probably the second or third sub-algorithm was used (using e.g. the complete FOV of the camera). Could this be the reason of the overestimation? If yes, does the full-FOV retrieval add anything to the estimate or could just be skipped?

Line 405: What I understand from the plot is that the low clouds are detected by the ceilometer and not by the ASI-pair, not the other way around. If this is true, the ceilometer site should have persistent low not present over the ASI-pair. Is this reasonable from the local meteorological conditions? What seems more reasonable is that ASI-pair cannot detect low clouds, e.g. due to geometric and algorithm considerations. Please provide more details.

Line 408-410: This doesn't sound very surprising since the minimum altitude where your ASI have overlapping images at 67deg FOV should be around 1.7km. Please discuss such issues, preferable in a previous section, before presenting the results.

Line 417: "in the dataset used for modelling" ?

Line 418-422: The text is not well written, and it is not clear what you mean. Please rephrase.

Technical comments:

Lines 42-54: As written now, the paragraph starts as if to present ceilometers but ends up presenting various CBH estimation techniques and ends up with ASI-based forecasting requirements. A slight editing is needed to make the text clearer.

Line 71: Better use "Most ASI-based monitoring systems. . ." or similar.

Line 202: "For example, Tabernas, . . ."

Line 355: "Then, the coincidence, . . ." . The sentence needs rewording.