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Atmospheric Measurement Techniques Discussions

AMTD

Interactive comment

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

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0.0.1 Reviewer:

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.

0.0.2 Authors' response:

We really appreciate the reviewer's time and effort spent on reviewing our manuscript, their insightful comments and suggestions. We have addressed all comments and incorporated the suggestions as good as possible to us and we believe, these changes led to valuable improvements of our manuscript. In particular, we have strongly revised the sections on modelling and validation.

In the following, we will address the reviewer's comments point-by-point. Changes to the manuscript are extracted from the adapted manuscript within which changes were highlighted using latexdiff. Blue indicates insertions, red indicates deletions. Please note, that the order of Sect. 3.3 and Sect. 3.4 has been reversed as suggested by Reviewer Comment 1, General Comment 5. This change has been excluded from the markup, as it would have obscured all other changes.

We recommend viewing the PDF version of this response which contains the changes in the manuscript. See bottom of this document. It was not possible to include all changes as figures, here.

0.0.3 Changes in manuscript:

See below.

1 Major comments

1.1 Major comment

1.1.1 Reviewer:

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.

1.1.2 Authors' response:

Based on the reviewer's feedback we revised Sect. 3.3 and 3.4 drastically. Especially regarding the modelling of conditional probability distributions, we moved the exact description of the procedure to the appendix and focused more on describing the idea behind the procedure and every filter. We further gave a reason for the value assigned to each of the parameters. However, we also stated that these parameters may still be optimized in a future work and are so far only rough approximations. Similarly, we reworked Sect. 3.3. In particular, we focused on pointing out for each step of the procedure, what the intention of each equation/ calculation step was.

1.1.3 Changes in manuscript:

Sections 3.3 and 3.4: pp. 12-20,

Appendix A, pp. 35-37.

1.2 Major comment

1.2.1 Reviewer:

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.

1.2.2 Authors' response:

We reworked the validation part strongly, intending most of all to focus on the key results. Still, we also needed to add passages at some points as further discussions or clarifications were suggested by the reviewers. As suggested, we included an additional subsection which evaluates the accuracy of an ASI-pair and of the ASI network for the nowcasting application as suggested above. We agree with the reviewer that this is an interesting aspect, which attests a certain advantage of the ASI network for this application. In particular, we made the following larger changes to the discussion part (Sect. 4): The behavior of the ASI network during mostly clear periods has been detailed and described more precisely. The discussion of exemplary time series of CBH has been limited to a single day. Descriptions and visualizations of 06 August 2019 have been moved to Appendix B. To give the reader a faster overview of the results (and also based on Reviewer Comment 1, Minor Comment 7) scatter-density plots have been enhanced to include performance metrics and quantiles Discussion of minimum CBH has been condensed and has been placed in Sect. 4.2.1 also relating it to the expectation from geometry. Sect 4.3, evaluating accuracy in a nowcasting context, was added Based on Reviewer Comment 1, General comment 3, we described which portion of the validation data set was filtered out Based on Reviewer Comment 1, General comment 7, we discussed the relationship between the accuracy of CBH and the resolution of irradiance maps created by a nowcasting procedure. We merged the prior "Sect. 4.4" with the present Sect. 4.4, intending to shorten discussions as far as possible. We hope to have found a reasonable trade-off regarding the length of this section. As another measure to shorten the discussion part, Sect. 4.1, which analyzes time series of CBH from the different sources, could still be moved to the Appendix. This section is majorly intended to give the reader concrete examples of the effects discussed thereafter by statistical tools.

1.2.3 Changes in manuscript:

pp. 20-34,

Appendix B, pp. 38-39, ll. 943-953.

2 Specific comments

2.1 Specific comment

2.1.1 Reviewer:

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?

2.1.2 Authors' response:

One idea of our method was that it should not be necessary to train the model based on a dataset which represents the conditions during the operation or validation. The method should work best if the ASI-pairs exhibit the same behavior at a given reference CBH during model development and validation. I.e. distributions of conditional probabilities at a given reference CBH should be comparable for both data sets. Apart from that the data sets used for modeling and validation are both considered to be qualitatively representative of the months which are of greatest interest to solar applications at the studied latitude, as they may provide the greatest energy yield, based on sky conditions and sun elevation.

2.1.3 Changes in manuscript:

p. 17, ll. 412-418.

2.2 Specific comment

2.2.1 Reviewer:

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 proper name as, in my mind, a tuple could include more than2 objects. Consider rephrasing.

2.2.2 Authors’ response:

The description we used was misleading and should be understood as indicated by the reviewer. We replaced the term by “iteratively”. Further we now pointed out in the same paragraph, that all 42 ASI-pairs are considered for the estimation procedure. Indeed, the term tuple is not precise. Throughout the text, tuples are intended to have only two members. We replaced the term in general by “tuple of 2 ASIs”.

2.2.3 Changes in manuscript:

p.1 l.10,

p. 5 ll. 127-131,

p. 6, caption of Fig. 6,

p. 17 l. 419.

2.3 Specific comment

2.3.1 Reviewer:

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.

2.3.2 Authors’ response:

Indeed, the term is ambiguous and was adapted now to “ASI-pair’s axis”. The nomenclature was originally motivated by the one used by Kuhn, P., B. Nouri, S. Wilbert, N. Hanrieder, C. Prahl, L. Ramirez, L. Zarzalejo, T. Schmidt, Z. Yasser, D. Heinemann, P. Tzoumanikas, A. Kazantzidis, J. Kleissl, P. Blanc and R. Pitz-Paal (2019). "Determination of the optimal camera distance for cloud height measurements with two all-sky imagers." Solar Energy 179: 74-88.

2.3.3 Changes in manuscript:

pp. 5-6 ll. 132-135, caption Fig. 2,

p. 33 ll. 798, 800, 803, 805.

2.4 Specific comment

2.4.1 Reviewer:

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?

2.4.2 Authors' response:

We added a short description about the used instrument. It is operated by DLR since 2018. The manufacturer's algorithm is used with the default configuration. The algorithm is outlined in the instrument's manual. The firmware version is v0.747. A prior study stated that full overlap is given at a CBH of 1500 m and above. Based on an overlap correction, the manufacturer allows to set a minimum CBH down to 0 m. We use the default setting of 45 m. We also contacted the manufacturer for further information on the used algorithms in the meantime but did not receive a response, yet. If required, this can be handed in at a later time.

2.4.3 Changes in manuscript:

p. 6, ll. 137-141.

2.5 Specific comment

2.5.1 Reviewer:

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

2.5.2 Authors' response:

We use the daylight version of Mobotix Q25 6MP. This is the RGB/color version. We now also attached a reference to the instrument's specification.

2.5.3 Changes in manuscript:

p. 6, l. 142.

2.6 Specific comment

2.6.1 Reviewer:

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

2.6.2 Authors' response:

We now specified the overall time required for image acquisition, transfer and processing, as suggested. Note that a further addition was made here based on Reviewer Comment 1, Minor comment 3.

2.6.3 Changes in manuscript:

p. 7, ll. 156-158.

2.7 Specific comment

2.7.1 Reviewer:

Line 141: *optically* thick clouds.

2.7.2 Authors' response:

As suggested, we now specified this more accurately.

2.7.3 Changes in manuscript:

p. 7, l. 171.

2.8 Specific comment

2.8.1 Reviewer:

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?

2.8.2 Authors' response:

This is the case. We now specified this more clearly.

2.8.3 Changes in manuscript:

p. 7, l. 172-173.

2.9 Specific comment

2.9.1 Reviewer:

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.

2.9.2 Authors' response:

Indeed, there have been several updates to the firmware after 2010. Some of these indicate changes to the algorithm of CBH measurement. We now summarized the results of two more recent studies which evaluated the CBH measurement by the ceilometer type used here. Based on these authors' findings, we also provided differences in the algorithms used by the manufacturers. Further, we explained that prior validations of the method used in this study to measure CBH by the ASI-pairs, were performed by an instrument of the same type. This may avoid inconsistencies when comparing the results of the present study to those prior ones.

2.9.3 Changes in manuscript:

pp. 7-9, ll. 174-203,

pp. 9, l. 210.

2.10 Specific comment

2.10.1 Reviewer:

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.

2.10.2 Authors' response:

As suggested by the reviewer, we added another row to Fig. 3 showing the raw and processed image simultaneously recorded by ASI FLE. For a flow chart of the method we would like to refer to Nouri, B., P. Kuhn, S. Wilbert, N. Hanrieder, C. Prahl, L. Zarzalejo, A. Kazantzidis, P. Blanc and R. Pitz-Paal (2019). "Cloud height and tracking accuracy of three all sky imager systems for individual clouds." Solar Energy 177: 213-228. We revised the description of the algorithm and hope that it is clearer now. Further, we aimed to point out clearer that the CBH measurement of the ASI-pairs is only modified very slightly over the one described and validated in the publication given above. We further provided validation results of that study.

2.10.3 Changes in manuscript:

p. 8, Fig. 3,

pp. 9-10, ll. 204-251.

2.11 Specific comment

2.11.1 Reviewer:

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?

2.11.2 Authors' response:

Unfortunately, we did not validate these sub-algorithms separately. As described in our response to Specific Comment 9 we now pointed out clearer that the method to estimate CBH, used by the ASI-pairs, is only modified very slightly over the publication which introduced this method and implementation: Nouri, B., P. Kuhn, S. Wilbert, N. Hanrieder, C. Prahl, L. Zarzalejo, A. Kazantzidis, P. Blanc and R. Pitz-Paal (2019). "Cloud height and tracking accuracy of three all sky imager systems for individual clouds." Solar Energy 177: 213-228. Therefore, we would like to refer to this study for further validation results. As part of a future study, it would be interesting to investigate the characteristics of these sub-algorithms. In our expectation, CBH will be measured more accurately by matches which are detected at small zenith angles.

Further, CBH measurement received for this central image area, which is used here, were also in the focus of the validation carried out in the publication named above, due to the cloud conditions at that site and due to the positions chosen for ASIs and ceilometer.

2.11.3 Changes in manuscript:

p. 10, ll. 243-248,

p. 11, l. 266-269.

2.12 Specific comment

2.12.1 Reviewer:

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.

2.12.2 Authors' response:

We calculated the expected minimum CBH which can be detected relying on the central window as well as when relying on all of the nine windows inside the cropped image of the main ASI. We additionally calculated the minimum CBH which is achieved if matches only succeed if matched windows cover zenith angles not larger than 67°. We further stated that the third iteration of the matching procedure in which the ASI image is evaluated up to a zenith angle of 77.8° is not expected to reduce minimum CBH as this step matches a very large windows.

2.12.3 Changes in manuscript:

p. 10, ll. 236-242,

p. 10-11, ll. 252-265.

2.13 Specific comment

2.13.1 Reviewer:

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?

2.13.2 Authors' response:

We added the statement as suggested. As in the complete study, we carried out this analysis only based on the lowest recognized cloud layer.

2.13.3 Changes in manuscript:

p. 12, ll. 284-285.

2.14 Specific comment

2.14.1 Reviewer:

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

2.14.2 Authors' response:

TanDEM-X data are needed by the nowcasting system to create irradiance maps. For this study the data set is only relevant for this estimation of the maximum elevation of the topography. We rephrased as shown below.

2.14.3 Changes in manuscript:

p. 12, ll. 299-300.

2.15 Specific comment

2.15.1 Reviewer:

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.

2.15.2 Authors' response:

The meteorological conditions described in this paragraph motivated the development of a method which aims to estimate CBH of the most dominant cloud layer more accurately. We added a conclusion to this paragraph which puts the analysis into the context of this study. Further as suggested by Reviewer Comment 1, General comment 2, we outlined at this point the scope of the method to estimate CBH and how it may be enhanced in the future.

2.15.3 Changes in manuscript:

p. 12, ll. 305-310.

2.16 Specific comment

2.16.1 Reviewer:

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

2.16.2 Authors' response:

We adapted this statement as suggested.

2.16.3 Changes in manuscript:

Appendix A, p. 35, l.886.

2.17 Specific comment

2.17.1 Reviewer:

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

2.17.2 Authors' response:

We adapted the nomenclature as suggested, as it may be clearer (replacing $\theta, \theta, \hat{\theta}_{likeliest}, \hat{\theta}_{refined}$ by $h_{true}, \hat{h}_{true}, h_{likeliest}, h_{refined}$). Theta was used as this symbol may be used frequently with maximum likelihood estimation for the true/ estimated parameter.

2.17.3 Changes in manuscript:

p. 14-15, ll. 337-350,

pp.15-16, ll. 364-401.

2.18 Specific comment

2.18.1 Reviewer:

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.

2.18.2 Authors' response:

First of all, we would like to apologize as a statement in the manuscript was misleading. The filter excluding variable situations is applied in the modelling of conditional probabilities (now Sect. 3.4) and in Sect. 4.4 to compare performance metrics from ASI-pairs and ASI network. In Sect. 4.1-4.3 this filter is not applied. We now corrected this statement and moved it from Sect. 4.1 to Sect. 4.4. The scatter-density plots shown in Sect. 4.2 may provide insights regarding effects occurring in variable cases. Based on Reviewer Comment 1, minor comment 7 we also added performance metrics to these plots. To enable the reader to evaluate the performance of the ASI-based estimation of CBH under these conditions (e.g. concerning biases) more quickly, we also added percentiles to all scatter-density plots.

2.18.3 Changes in manuscript:

pp. 20-21, ll. 531-535,

p. 28-29, ll. 691-695,

p. 24, Fig. 8.

2.19 Specific comment

2.19.1 Reviewer:

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

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2.19.2 Authors' response:

We appreciate the suggestion. However, as suggested by Major Comment 2, to shorten Sect. 4.1, this figure and related descriptions have been moved to Appendix B.

2.19.3 Changes in manuscript:

p. 21, Fig. 6,

p. 21, ll. 544-545,

p. 22, Fig. 7,

p. 22, l. 553,

p. 23, ll. 572-581,

p. 23, ll. 588-589,

Appendix B, pp. 38-39, ll. 943-953.

2.20 Specific comment

2.20.1 Reviewer:

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 combination of these two extreme values? In general, how does the network handle cloud-free conditions?

2.20.2 Authors' response:

Our description may not have been precise in this point. We now added a plot (Fig. B1) in the appendix which shows the measurements of CBH from the ASI-pairs and from the ASI network as well as from the ceilometer during this clear period in more detail. We also added a short passage in Sect. 4.1 to describe closer which period we referred to. From Fig. B1 it is visible that the ASI-pairs measure a broad range of values between the extreme values of 2 km and 12 km, before around 17:00. Most ASI-pairs measure an intermediate CBH. After 17:00 the spread between the measurements of the ASI-pairs reduces. From around 17:05 the ASI network and some of the ASI-pairs measure a CBH of around 3 km. This CBH (3.1 km) is later also measured by the ceilometer. During this period the approaching cloud layer may be detected before its arrival in the urban area. During very clear periods, the ASI network is likely to return a CBH which is very large, in the range of 10 km. For an application this is not problematic, in our opinion, because another image processing step is used which is able to detect the absence of clouds. We added a short explanation on this.

2.20.3 Changes in manuscript:

p. 22, ll. 564-571,

Appendix B, p. 38, ll. 940-942, Fig B1.

2.21 Specific comment

2.21.1 Reviewer:

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?

2.21.2 Authors' response:

We share the reviewer's opinion, that the behavior seen for CLO-FLE in situations with CBH much smaller than 2 km is connected to the minimum CBH which this system can detect. This minimum CBH may indeed be determined by the sub-algorithm relying on the main ASI's cropped orthogonal image. The usage of the full FOV to retrieve CBH is not expected to improve an ASI-pairs capability to detect very low clouds noticeably. We now pointed out in Sect. 3.1, that this sub-algorithm is mainly intended to increase the robustness of the method. It may yield a valid measurement in some cases when the first sub-algorithms failed. We condensed the discussion of the minimum CBH in Sect. 4.2 as shown below. See also our response to Specific Comment 22.

2.21.3 Changes in manuscript:

p. 10, ll. 236-242,

p. 10-11, ll. 252-265,

p. 25 ll. 614-632.

2.22 Specific comment

2.22.1 Reviewer:

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.

2.22.2 Authors' response:

We assume that the reviewer refers to the areas on the far left of the scatter-density plots (e.g. reference CBH < 0.5 km for DON-MAR and reference CBH < 2 km for UOL-HOL) and we agree with the analysis of the reviewer. At this point, we intended to discuss another area of these plots and now indicated these areas more precisely in the manuscript. When reference CBH ranges around 3…12 km, the ASI-based systems frequently detect low clouds close to the 5-percentile line, i.e. far below the main diagonal of the plot. In these cases, the ASI-based systems provide a CBH which is too small. As described in previous sections, we expect that in these cases the ASI-based systems recognize low clouds present in their field of view. At the same time there might be a gap in the low cloud layer at the location of the ceilometer. Therefore, the ceilometer may recognize a larger CBH.

2.22.3 Changes in manuscript:

pp. 24-25, ll. 605-610, Fig. 8.

2.23 Specific comment

2.23.1 Reviewer:

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.

2.23.2 Authors' response:

As suggested by Specific Comment 11, we now calculated the minimum CBH which may be related to the sub-algorithms in Sect. 3.1. We reworked the discussion of minimum CBH in Sect. 4.2. and adapted it to refer to these values of minimum CBH expected from geometry.

2.23.3 Changes in manuscript:

p. 10, ll. 236-242,

p. 10-11, ll. 252-265,

p. 25 ll. 614-632.

2.24 Specific comment

2.24.1 Reviewer:

Line 417: “in the dataset used for modelling”?

2.24.2 Authors’ response:

As we understand the comment, it is not clear at this point why the “dataset used modelling” is discussed in this context. As also suggested by the following Special Comment 24, we rephrased this passage. We hope this makes the intended statement clearer, also in this perspective.

2.24.3 Changes in manuscript:

p. 26, ll. 642-650.

2.25 Specific comment

2.25.1 Reviewer:

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

2.25.2 Authors’ response:

We rephrased the passage as shown below.

2.25.3 Changes in manuscript:

p. 26, ll. 642-650.

3 Technical comments

3.1 Technical comment

3.1.1 Reviewer:

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.

3.1.2 Authors' response:

We rewrote this paragraph in part to put a stronger focus on possible sources of CBH to be considered for nowcasting. We moved this specification of nowcasts up.

3.1.3 Changes in manuscript:

p. 2, ll. 34-35,

p. 2-3, ll. 45-58.

3.2 Technical comment

3.2.1 Reviewer:

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

3.2.2 Authors’ response:

We adapted ASI system to ASI-based nowcasting system

3.2.3 Changes in manuscript:

p. 3, l. 79.

3.3 Technical comment

3.3.1 Reviewer:

Line 202: “For example, Tabernas,...”

3.3.2 Authors’ response:

We inserted accordingly.

3.3.3 Changes in manuscript:

p. 12, l. 302.

3.4 Technical comment

3.4.1 Reviewer:

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

3.4.2 Authors’ response:

We reformulated as shown below.

3.4.3 Changes in manuscript:

p. 21, ll. 537-539.

Please also note the supplement to this comment:
https://amt.copernicus.org/preprints/amt-2020-430/amt-2020-430-AC2-supplement.pdf

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2020-430, 2020.