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Atmospheric Measurement Techniques Discussions

Interactive comment on "A simplified method for the detection of convection using high resolution imagery from GOES-16" *by* Yoonjin Lee et al.

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We would like to thank two reviewers for their valuable comments and contributions to improve this manuscript.

*Table 1 (GOES-r channel description) will be removed based on reviewer 2's comment

*Table 4 that was not included in the manuscript by mistake will be added as Table 1 in the revised manuscript. (Table 1 is added in figure)

*Figure 3 is edited to have close-up subfigure.

*Figure 5 (laying GOES detection on top of MRMS detection) will be added based on both reviewers' comments

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Discussion paper

*Line number in the parenthesis is the number in the revised manuscript.

(-is Reviewer's comment and * is answer to that comment.)

General comments

-No comparisons with past studies. It would also be feasible to compare with the results from ABI data of 15 min. on the same dates. *The code that is used in previous studies is not publically available. Although previous studies also present their POD and FAR, they are validated against different dataset (lightning data or reflectivity threshold), and it makes it hard to compare with the previous studies.

- It is hard to see the details in some figures. *Resolutions of the figures will be updated.

- A table for accuracy is not found in the manuscript. *We apologize for that mistake. It will be added in the modified version.

Specific comments

-Line 7: What is the meaning of the proper heating? *'Proper heating' means reasonable heating to drive convection in the model. This phrase will be modified as 'The ability to detect convective regions and adding heating in these regions is the most important skill in forecasting severe weather systems.' (line 6).

-Line 9: Why is the latent heating especially mentioned here? *It was mentioned because in the operational model, after convection is detected, latent heating is added to drive convection, and methods developed in this paper are also intended to be used in the short-term forecast model. The purpose of this study is more clarified (line 29-36).

-Line 11-12: Shouldn't it be more sensitive to the drop size? *This sentence is changed to "Visible and Infrared sensors on a geostationary satellite can provide data that are more sensitive to small droplets" (line 11-12).

-Line 14: I don't understand how better spatial and temporal resolutions could be a solution to the intrinsic problem that optical sensors can only get information from the

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top layers of clouds. *You're correct that it is not a perfect solution to the intrinsic problem. However, by having high spatial and temporal resolution, we can better observe clouds bubbling, which is an indicator of convective clouds. Even though we can't still see through inside of clouds, bubbling cloud top allows us to guess where convection is occurring, and it is the main feature used in this study to detect convective clouds.

-Line 15: What are the life stages to be analyzed? *Actively growing clouds in the vertical and mature convective clouds. This sentence will be modified to "This study develops two algorithms to detect vertically growing clouds and mature convective clouds using 1-minute GOES-16 ABI data." (line 15).

-Line 17-18: Does this mean that the detection accuracy of the method for the clouds at early stages was 71%? *Yes, but the accuracy increases when MRMS data up to 30min are included because MRMS tends to miss early convection with less or no reflectivity. However, these sentences in the abstract seem confusing and thus, will be modified based on changes made in 'statistical results' section.

-Line 19: How the rapid temporal evolution is identified? It needs to be clear, : : : rapid temporal evolution of what? *"the lumpy texture, and rapid temporal evolution" will be changed to "lumpy texture from rapid development" (line 19).

-Line 21: Do the convective clouds here are clouds at all different life stages? *'These convective clouds' meant convective clouds that are missed by ground-based radar. This sentence will be also changed based on changes made in 'statistical results' section.

-Line 22: It seems that the statement does not match with what is mentioned above in Line 14. *The authors are aware of the intrinsic problem of VIS and IR sensors as mentioned above. Thus, we wanted to address here that this intrinsic problem can't be solved.

-Line 26: What is 'this issue'? *This issue meansÂă'initiating convection in the right

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location and intensity'.

-Line 55: What does 'to initiate convection' mean? *In the short-term forecast model, if radar echo exceeds certain values, latent heating is added to increase buoyancy in the atmosphere and trigger or initiate convection.

-Line 71: Is cooling really not seen in mature clouds? The sentence needs to be corrected. *The whole sentence in line 70 will be changed to "Convective clouds in their mature stage sometimes do not grow much in the vertical, and Tb decrease is not a main feature that is applicable to such clouds." (line 73).

-Line 88: Where are the mesoscale sectors? What's the size? *'Mesoscale sectors' are moved around manually by a person whenever there is an interesting weather event. Its size is 2000x2000 (1000kmx1000km) for channel 2 and 500x500 for IR channels.

-Line 89-94: It seems that the last part of the introduction is a bit detailed. They would be rather explained more concisely, and the details would be addressed in the method section. *It was briefly mentioned here to describe how the methods presented in this study differ from previous studies. Literature overview is revised (line 61-70 and line 84-89) and more references are added with help from reviewer1.

-Line 91: What are the errors from cloud movements? *Previous studies use atmospheric motion vector to track clouds, and there can be errors in its algorithm.

-Line 107: It seems that Table 1 is not really necessary. It can be removed and explained in the text. *As you suggested, this table will be removed because they're already explained in section 2.1.

-Line 118-120: Need to add references. What about using channel differences? Past studies on detecting convective initiation have widely used channel differencing between water vapor channels and IR channels (c.f. Mecikalski2006, Lee2017) *Mecikalski paper was already mentioned in the introduction, but since Lee 2017 paper wasn't mentioned, this paper will be added in the introduction. As mentioned above,

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literature review will be revised.

-Line 140-141: Clouds do not necessarily reach the tropopause. Clouds form when air parcels reach the equilibrium level. *You're correct that not all clouds reach the tropopause. However, when clouds are mature enough, they sometimes reach tropopause and move horizontally, rather than vertically. (refer to Zinner et al., 2013; Validation of the Meteosat storm detection and nowcasting system Cb-TRAM with lightning network data – Europe and South Africa)

-Line 142-143: How can the availability of higher temporal resolution data simplify the method to use two channels? *It's worded in a wrong way. This sentence will be removed.

-Line 159: What height does each channel usually reflect? *There is no certain height that can represent each channel since height can vary depending on the situation. However, as mentioned in line 125∼127, the height that channel 8 represents is higher than channel 10 because channel 8 is more sensitive to water vapor. Figure 4 below (Figure_wv_height) is a "realtime" weighting function obtained from https://cimss.ssec.wisc.edu/goes/wf/. You can see from this figure that weighting function of channel 8 peaks at higher altitude.

-Line 189-190: "Clouds that develop into deep convective clouds are eventually captured by these thresholds in later times even if they had small decrease in the beginning." This sentence is a bit unclear. *This sentence will be changed to "Clouds that develop into deep convective clouds are eventually captured by these thresholds in later times as they show rapid intensification sooner or later." (line 196-197).

-Line 227-229: "It is intentionally chosen so that the method considers warmer convective clouds without those features in the next step when evaluating lumpiness of cloud top." This sentence is a bit unclear. *This sentence is changed to "Warmer threshold is intentionally chosen so that the method considers warmer convective clouds without those features in the next step when evaluating lumpiness of cloud top." (line 233-234).

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-Results -> Results and Discussion *It is changed to Results and Discussion.

-Line 253: It is almost impossible to see the Gaussian shape in Figure 3c. Maybe a close-up subfigure could be used here. *Subfigure is added.

-Line 258-259: “Since the same method is used in each time step, the same window can be captured throughout an overlapping time period despite the starting time. Therefore, this method can be used continuously in time.” This sentence is a bit unclear. *These sentences are removed.

-Line 261-275: It would be better to move this paragraph to the beginning of this section. *Paragraphs before these sentences were descriptions of the scene used to derive the results, and we think that they should come before the results.

-Line 269-271: It would be much better to illustrate this as one Figure in the manuscript by merging both figures together. *Figure 5 that shows convective regions by GOES on top of MRMS convective regions is added in the manuscript with the description of the figure (line 276-278).

-Line 288-290: “These results show that even though the thresholds for the Tb method can be strict for some growing clouds, the thresholds were adequate for detecting convective storms in their earliest stages.” This sentence is a bit unclear. *It was changed to “These results show that even though the thresholds for the Tb method can miss some convective clouds that grow slowly in the beginning, the thresholds were adequate for detecting rapidly growing convective storms which are of more interest during the forecast.” (line 296-298).

*Note that the whole section 4.3 will be modified based on two reviewers’ comments. It will be modified to present one-month results first and then discuss results choosing different thresholds for the methods. Definitions of POD and FAR will be provided in the beginning of this section. The authors agree that providing results using different period of MRMS data in the validation separately can be confusing to readers. Therefore,

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in the revised manuscript, only one set of POD and FAR will be presented from the contingency table that is recreated validating results from the reflectance method against 10 minute MRMS data and results from the Tb method against 30 minute (including future 20minute) MRMS data.

-Line 299: “Since clouds do not grow at the same speed, : : :”, which is a bit unclear. *It is changed to “Since growth rate can vary depending on the surrounding environment and different evolution stages” (line 361).

-Line 302: Why is the number of samples different? *It is because channel 8 and 10 have different sensitivity to water vapor and represent different height of moisture.

-Line 311: Why is it important to have the ability to detect convection earlier than radar? You mentioned earlier that the method of this study is to complement ground-based networks for either off-shore or other regions lacking coverage of radar data. *Radar reflectivity is observed from bigger drops (eg. rain), and thus it takes time for radar to observe signals as cloud water becomes rain. On the other hand, Tbs are sensitive to water vapor, and they are expected to observe condensation by updrafts of water vapor before cloud water becomes rain. It is important to detect convection as early as possible because the ultimate goal of convection detection is to help forecast models to produce precipitation in the right place at the right time.

-Line 318-322: It seems to be redundant. *It will be put in the parenthesis (line 324-326).

-Line 326: “The upper threshold does not change results much, : : :” The result for upper threshold is not shown here. *We thought that it is not necessary to put figure for this because it did not have much change. But ‘(not shown)’ will be added (line 330).

-Line 328: However, the choice of 0.4 seems to lose a lot of convective regions. *We preferred to have less POD and less FAR for its potential use in the short-term forecast model.

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-Line 342-343: ": : : in preventing the method from detecting convective regions.", which needs to be corrected *This sentence sounds misleading so it will be changed to "Therefore, regions that were missed are evaluated further to investigate which threshold contributed most to missing those regions." (line 348-349).

-Figure 8 caption: ": : : due to only one of the thresholds.", which is a bit unclear. *It will be changed to "Histograms of Tb, reflectance, and texture values when the pixel was not detected by the GOES detecting method due to each of the thresholds." Note that Figure 8 will be Figure 9 in the revised manuscript.

-Line 345: ": : : have flat cloud top surfaces." What percentage was this case? It would be good to provide quantitative values for one-month data. *It was visually shown in figure 8 (now figure 9 in the modified version of the manuscript), but as you suggested, the percentage will be presented (line 350).

-Line 348: Q: Why are convective clouds in a decaying mode not considered? *The main purpose of application of this method is to add latent heating in active convective regions and produce precipitation in the forecast model. If convective clouds are in a decaying mode, precipitation will slow down, and therefore no need to add heating.

-Line 349-350: "It is also possible that it is due to a misclassification of trailing stratiform regions using radars. Previous studies (Qi et al. 2013; Shusse et al. 2011) have indeed tried to improve the radar classification schemes." The sentences are a bit unclear. *It will be changed to "It is also possible that it is due to a misclassification of trailing stratiform regions using radars. It is indeed an ongoing research in the radar community since better convective/stratiform classification scheme improves QPE retrieval (Qi et al., 2013; Veljko et al., 2019)." (line 355-357).

-Line 355-360: Reporting accuracy would be placed at the beginning of this section. *As the whole section is revised, it will be placed in the beginning.

-Line 354: to avoid FAR -> to avoid high FAR *It will be changed.

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-Line 356: There is no Table 4 in the manuscript. *It will be added as table 1 since “POD and FAR” are now placed in the beginning.

*All “technical corrections” has been made.

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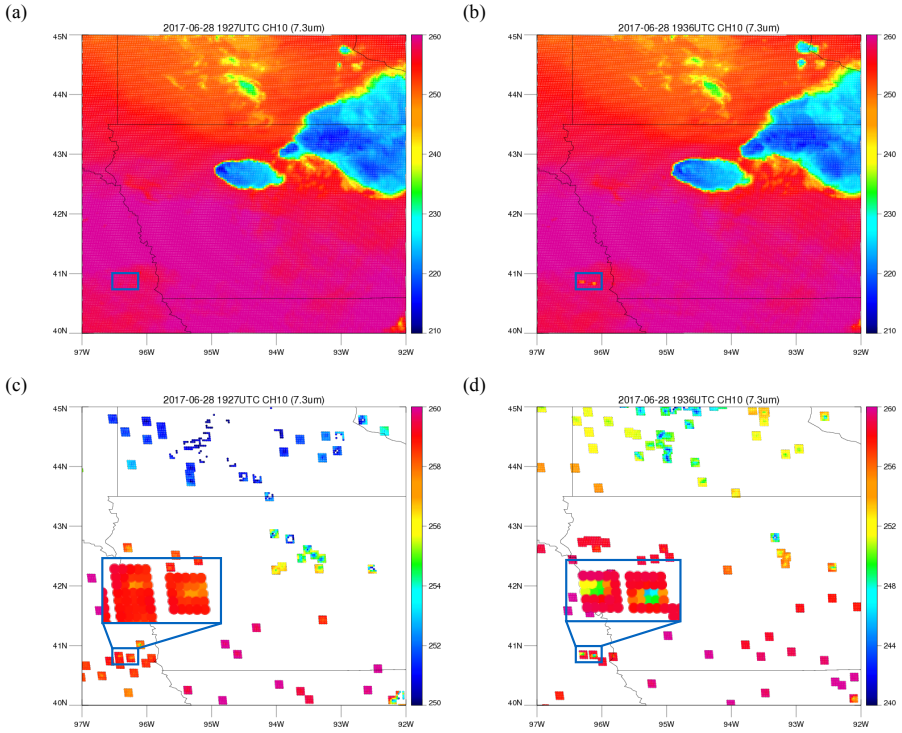

Fig. 1. Figure3

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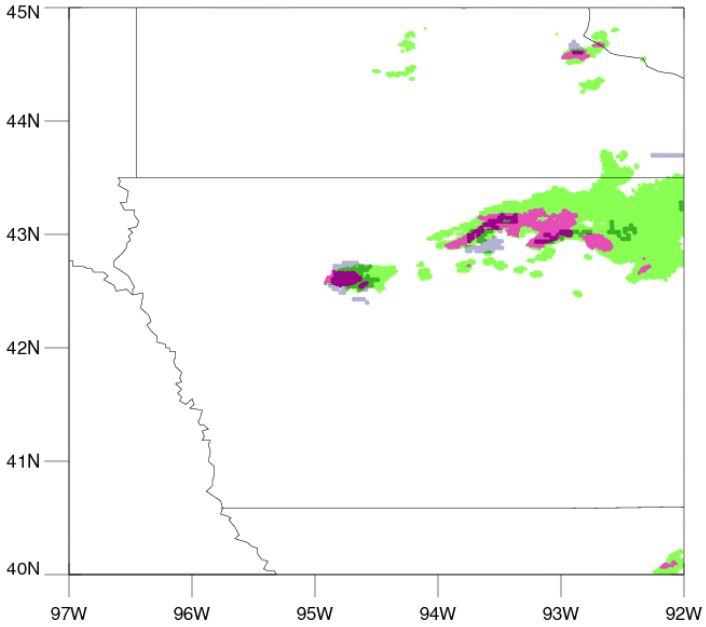

Fig. 2. Figure5

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	MRMS-C	MRMS-NC
GOES-C	2.73%	0.46%
GOES-NC	3.30%	93.51%

Fig. 3. Table1

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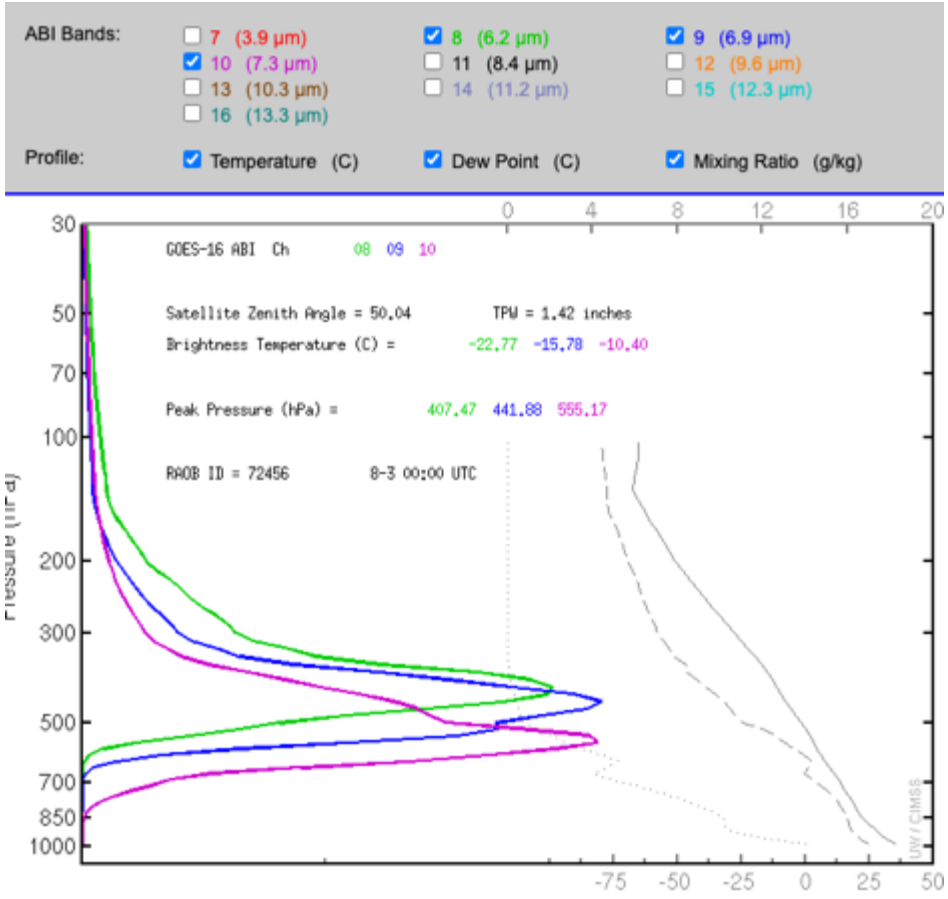

Fig. 4. Figure_wv_height

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