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Atmospheric Measurement Techniques Discussions

AMTD

Interactive comment

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

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

-Major 1 *The introduction will be revised to elaborate more on literature overview, including suggested references from reviewer1.

-Major 2 *More discussion will be added regarding WV channels, and limitations of visible channel method will be more discussed in the text.

-Major 3 *First paragraph in the introduction will be revised to clarify the purpose of the manuscript.

-Major 4 *The whole section of 'statistical results' 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, 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.

-l.20ff: In the light of the many questions left by the presentation of the statistical evaluation/tuning chapter, the numbers here are not useful. Either present some details of the used definitions and scoring basics or leave them out. I do not understand why there is one set of values for two independent methods (major 4). *As mentioned in Major 4, now only one set of POD and FAR is provided for better readability. Since two methods are used to detect convection in different stages and validation dataset includes convection in all stages, results from the two methods are combined.

-l.28: Maybe you want to add something general like Gustafsson et al. 2018 or something very close to your motivation point like Scheck et al. 2020. (major 1) *Both papers will be added (line 29). âĂÍ -l.84: The use of geostationary VIS and IR texture signals was introduced in automatic detection already by Zinner et al. 2008 (WV texture, Zinner et al. 2013). Another important tool forming an early reference for the use of IR and WV imagery and time trends in it is the EUMETSAT RDT algorithm (Morel and Senesi, 2002, Autones et al. 2009, Guillou et al 2011, see below). (major 1) *These references will be added in the introduction (line 65 and 87).

-l.112ff: You state that Channel 2 data is “normalized by solar zenith angle”. Please tell us how you do that. This is not a simple or straightforward task. You could normalize reflectivity, but for the texture signal cos(SZA) will not do the trick. The apparent lumpiness increases following a complex dependence on SZA and is strongly dependant on the cloud top structure. (major 2) *Channel 2 data was divided by cos(SZA). A measure of lumpiness used in this study is horizontal gradients of the cloud top surface and thus, shadows (low reflectance) or even brighter surface enhanced by the effect of complexity on SZA actually helps distinguish convective regions from flat cloud top surfaces that are less affected by SZA.

-l.114f: Are you aware of Mueller et al 2019 “A Novel Approach for the Detection of Developing Thunderstorm Cells”. That should be discussed somewhere. (major 1) *It will be added (line 88).

-l.141: “GOES-R CI algorithm”. Can you please give a reference? *It is no longer operational products but, it is based on Mecikalski and Bedka (2006) or Mecikalski et al. (2010) cited in this paper.

-l.145: Shouldn’t “grids” be “grid cells”. This sounds like lab slang to my non-native English ear. *The term will be changed to “grid points”.

-l.155ff: “: : :updrafts of water vapour: : :”, “: : :GOES-ABI : : : can.” – You seem to formulate a misconception here. You cannot really see the rising water vapor. The signal is not strong enough. In a WV channel, you do see the water vapor background in midtroposphere. You cannot see low-level dry-convection below condensation level. If you start to see convection cells in this data, it is the cloud body itself you see. Only once the cloud has formed, the emissivity is large enough to dominate the thermal signal in the WV channel. The cloud top "punches through" the background water vapor. Unless the mid-troposhere is very dry, you cannot see what's going on at lower. Please clarify and adjust the discussion here. (major 2) *We agree that these sentences were misleading. "It will be modified to Operational weather radars cannot observe small cloud water, but water vapor absorption bands in GOES-ABI, are more sensitive to these small droplets. During the early convective stages, Tbs that are sensitive to water vapor will decrease due to condensed cloud water droplets aloft generated by a strong updraft." (line 163-165).

-l.176: "the difference between two matrices will be small.". Which two? Please clarify. *It will be clarified to "the absolute value of the difference between the Tb matrix and the inverse Gaussian matrix" (line 182-183).

-l.185: "smaller than -1K/min for channel 10 or -0.5K/min for channel 8". Why is there a difference? A growing cloud top is cooling at the same rate in both channels. Unless there still is considerable (colder) WV above it. Thus, it first shows up in the channel 10, later in the channel 8. You will increase the sensitivity of channel 8 to match channel 10 detections by lowering the slope threshold. You will earn a lot of uncertainty without adding any additional insight. Once the cloud top reaches the upper mid-troposphere above WV background, they will show exactly the same temperatures and trends. Please discuss, perhaps revise. (major 2) *As you pointed out, the cooling rates are similar once clouds are mature enough because their Tbs themselves are similar. However, when clouds are in the very beginning stage, the Tb difference between channel 8 and 10 is high, and the cooling rate is observed to be different. This makes sense because in order to exhibit the same Tb at both channels at their mature stage, Tb at channel 10 which is usually lower than Tb at channel 8 has to increase faster than Tb at channel 8. Sentences "Growth rate observed at channel 8 is smaller than channel 10 due to higher absorption at channel 8. Channel 8 senses moisture at higher altitude and thus, when water vapor starts to condensate at lower levels, it is less affected, and its Tb does not decrease as much as in channel 10. As clouds grow thicker, signals in water vapor absorption bands are dominated by the clouds, less from water vapor, and their Tbs becomes similar. Therefore, it makes sense again that the growth rate at channel 10 has to be bigger to catch up lower Tb in channel 8." will be added (line 376-380).

-l.221ff: Once more : : : What about low sun lumpiness? Shadows cast onto the cloud itself might dampen VIS reflectivity below 0.8. Please discuss. (major 2) *It will be discussed using Figs. 4b and 4d. Sentences "Using reflectance threshold sometimes limits detecting shaded convective regions that exhibits lower reflectance than the threshold of 0.8, and white regions surrounded by colored regions in Fig. 4b are such regions. However, these regions are relatively small, and once they are upsampled into 2km map with nearest neighbour interpolation, some of these regions are included in the detection as shown in Fig. 4d." will be added (line 271-274). âĂÍ -L.270: ": : : most of convective regions align well with high reflectivity regions in Fig. 2c: : :", You should not only talk about false alarms, but also about the POD. You are missing large regions with coldest temperatures and, thus, a quite obvious signal just next to the region you detected along 43 N and 93 W to 94 W! These regions shows up clearly in a cold absolute 11.2 mu data and in 11.2 lumpiness! This is opposed to your above statement on IR lumpiness and is a large area completely missed by your mature storm detection. Please discuss. (major 3) *It seems like it wasn't clear from two figures being separate and thus, overlaying figure will be added as Figure 5 (with the description of the figure "For a better comparison between detection from GOES and MRMS, convective regions detected by GOES (Fig. 4d) are parallax corrected with a constant cloud top height of 10km and plotted on top of the MRMS map (Fig. 2d), and it is shown in Fig. 5. Most of convective regions align well with high reflectivity regions in Fig. 2c and convective regions in Fig. 2d." in line 276-278). You will see that over 43N and 93W to 94W, convective regions are also detected by the method.

-l.281: "Growing clouds: : :" Are these boxes result of your method or did you place them by hand as marker to talk about certain areas. You are talking about the purple and blue boxes next. What about yellow and green? Did you miss them? Please make clear. (major 4) *Boxes are clouds that were detected by the Tb method. This sentence will be changed to "Growing clouds shown in purple, blue, yellow, and green boxes are detected by the Tb method, but all starting from different time." to make it clear for readers (line 288-289). Clouds in yellow and green boxes are discussed few sentences after this sentence (line 294 and 295)

-l.295, Section 4.3, Statistical results: Please start this chapter with a clear definition of the "truth" you compare to, of a hit, miss, false alarm and false positive, all derived skill scores. What is the basic element of your scoring? Is it a grid point, a storm, or a 5x5 window? Please state that for all scores you derive for the early convection as well as the mature convection steps. Right now, this important information is (in part) hidden in the following chapter, but the reader has to guess most of the time. (major 4) *The definition of POD and FAR and its application in this study will be added in the beginning of section 4.3 (line 307-315).

-l.298ff: Again, it is still unclear for the reader, why you use both WV channels? Are there any channel 8 detection windows not contained in the channel 10 detected windows already? Please clarify or simplify. *Yes, there were windows detected by one channel but not by the other channel. It will be discussed in the text using convective cloud in the blue box in the second case study. (line 293)

-l.303ff: "Future MRMS convective flags up to 30 minutes were included : : :" I do not fully understand. It was your goal to detect convection before the radar, wasn't it? That means, it is just logical to check the next 15 minutes/30 minutes. You should check the lliterature on MRMS and give us some details here. Using it, you have to discuss the choice of the future time span : : : the longer it is, the better your scores. (major 4) *As you pointed out, clouds detected by the Tb method are often detected earlier than radar while clouds detected by the reflectance method are usually detected at the detection time by radar, although figure 8 suggests that it still has an ability to detect

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earlier. This was why two sets of POD and FAR were given in this section, and it was confusing for readers. Therefore, as mentioned earlier when major 4 was discussed, it will be changed to show one set of POD and FAR from combined results by validating results from the reflectance method using only 10 minute data and results from the Tb method using 30 minute (including additional future 20 minute) data. This result will be presented in the beginning of section 4.3.

-l.306: Where do you get the "constant speed" from? Please add information. *This sentence will be changed to "assuming convection moves at the same speed that clouds moved during the initial ten minutes" (line 368).

-l.310: What is the "accuracy" you are talking about? You have to introduce it. It seems to be the correct positives. Please clarify in the beginning of the chapter. (major 4) *It will be clarified "100% accuracy of detecting convection as in MRMS" (line 372).

-l.311: "because most of early convection does not have such a strong updraft". No. It's because it is detected late. See my comment on the WV channels misconception above. In some situations, convection has to reach a considerable height before it can be detected. This is the reason why Mecikalski, Zinner or Guillou did not just use a WV channel to detect early stages. (major 2) *This sentence was misleading as well. It will be changed to "it misses much of the convection and loses an ability to detect convection earlier than radar because not all convective clouds have such a strong updraft." (line 374).

-l.315f: The reasoning here is unclear. What about virga? I would just say, it is the typical turbulent, highly statistical nature of the chances of convective cells. Some just do not do it the moment latter. *It is modified to "This would be due to mixing between convective cells and their dry environment or highly non-linear nature of chances of precipitation." (line 381-382).

-l.335: For the reader, in order to be able to understand the impact on data assimilation, you have to give proper references or explain a lot more. *It is modified to "To make this method effective and reduce FAR as much as possible for its potential use in the short-term forecast" line 339-340, and suggested reference (Gustafsson et al. 2018) is added in the introduction.

-l.333f: "improvements in both FAR and POD (lower FAR and higher POD) when later data are included." This is not surprising and it is just tuning values. It would improve further, if you would include another 10 minutes, or even -10 minutes. Unless you can tell us a very good reason resulting from the function of the MRMS algorithm, I would suggest not showing the alternative numbers. They are not much different anyway. (major 4) *The whole section of 'statistical results' will be modified to reflect this comment.

-l.345ff: Checking of just one of the two examples you show, it is obvious how to improve it. In addition, the missed regions there are neither cirrus covered nor in decaying mode. You should accept and talk about shortcomings of your very simple method. There are good reasons out there that full detection and warning schemes are far more complex than your approach. Please discuss that. (major 3) *Its limitations are elaborated in section 4.3 using different thresholds. As mentioned in section 4.3, most of the missed regions had a flat cloud top surface, which is a key feature of stratiform clouds in this study. And since the results are compared with radar products observed from the ground, convectively raining pixels might not perfectly align with bubbling pixels. However, as you can see from the two case studies, the locations of convective cloud clusters detected by GOES and MRMS are very close to each other, and most convective regions in each scene are detected by GOES. Nevertheless, limitation regarding the reflectance threshold will be added based on your comment in "l.221ff" and it will be mentioned again in the last paragraph of section 4.3 (line 384-388).

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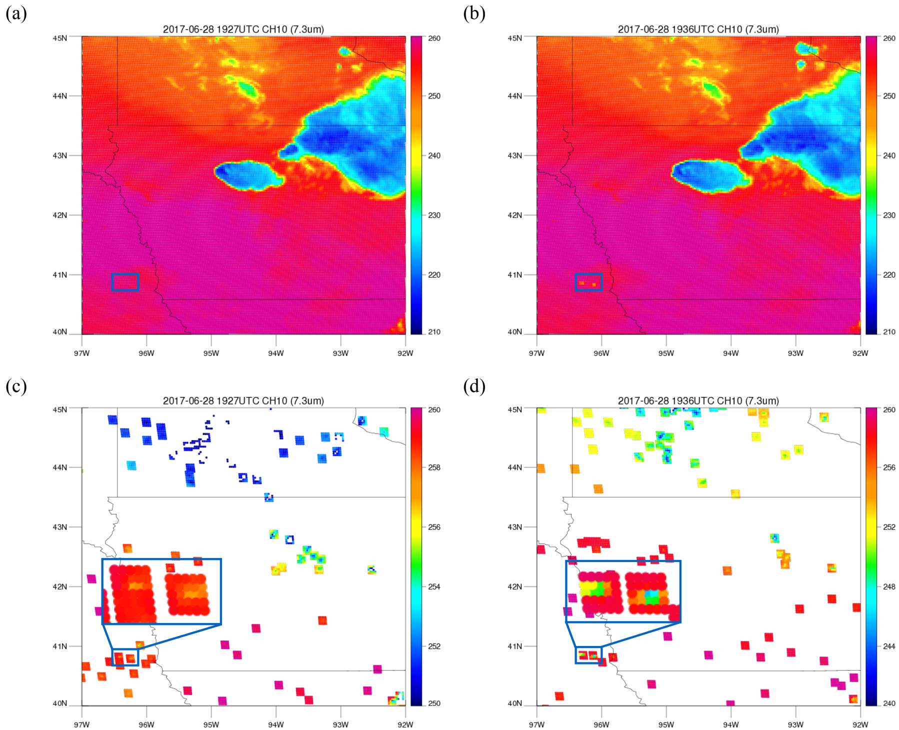

Fig. 1. Figure3

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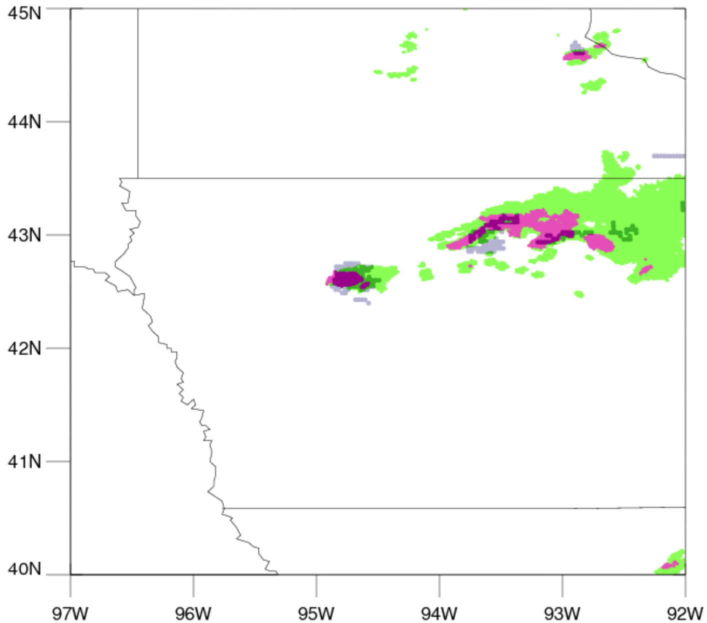

Fig. 2. Figure5

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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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