The authors appreciate two reviewers' valuable comments once again.

Response to Reviewer #1

Main changes in figure and table

- Figure 2 is added.
- Figure 7 is added.
- Figure 2c is modified.
- The order of tables is changed and tables 1 and 2 have updated values using different one-month dataset based on Reviewer #1's comment. Table 2 and 3 in the previous manuscript used to show the number of convective windows including previous time period (e.g. "convective within 10min" would be the sum of the number for "convective at 10-min detection period" and the number for "convective within 10-min after the detection period"), but Table 1 and 2 in the revised manuscript only shows the number for each 10-min period. And additional column is created to show overall accuracy, which is the sum of the 3,4,5th columns divided by the sum of 2,3,4,5th columns. Note that the numbers are different from previous manuscript because different data are used.

Major issue 2 and minor issues regarding limitation of visible channel method:
Limitation of visible channel method (mature cloud detection method in the revised manuscript) is more discussed more broadly in the revised manuscript. The dependency on SZA is discussed in line 345.

Major issue 3:
The clarification only clarifies the use of latent heating nudging in models. It still does not explain the aim of this manuscript. The title suggest it is storm detection and not provision of heating fields for data assimilation. This issue comes down to a simple question: What is your paper aiming at? Please give this answer in the introduction.
You do not give a clear aim in the introduction and you do not state whether you reached any in the final conclusions. Your method is too simple to be a detection or warning tool. It is not a full algorithm, but only proposing and testing concepts. In the current state, the paper still does provide neither a closed concept nor an independent validation (you use the month data set to "calibrate" your method). You are missing more than 50% of all convective cell, according to MRMS-C radar data. The quality of your Tb algorithm for early convection is still unclear to me, because of the limitations of your presentation. Does it add any lead time compared to radar MRMS-C detection? Or is this all not important for you, because you aim for latent heat nudging fields?
We now discuss the ultimate goal of this work, which is to identify convection for use in weather forecast model initialization. This matters because it skews the algorithm towards avoiding false negatives (i.e. assigning convection where there is none) while not penalizing the algorithm excessively for missing convection. The authors agree that this is a testing concept and it might need more modification to be used in operation and this is now clearly stated in lines 93-94 and 433-435.

The authors agree that it might have sounded as if the same month data were used to calibrate the actively growing cloud, but actively growing cloud method calibration also included data during nighttime hours while results for combined methods are only evaluated data during day since the mature convective cloud detection method uses reflectance data. Since it can cause confusion, different one-month data are used to provide a reason for choosing the two thresholds for channel 8 and 10.

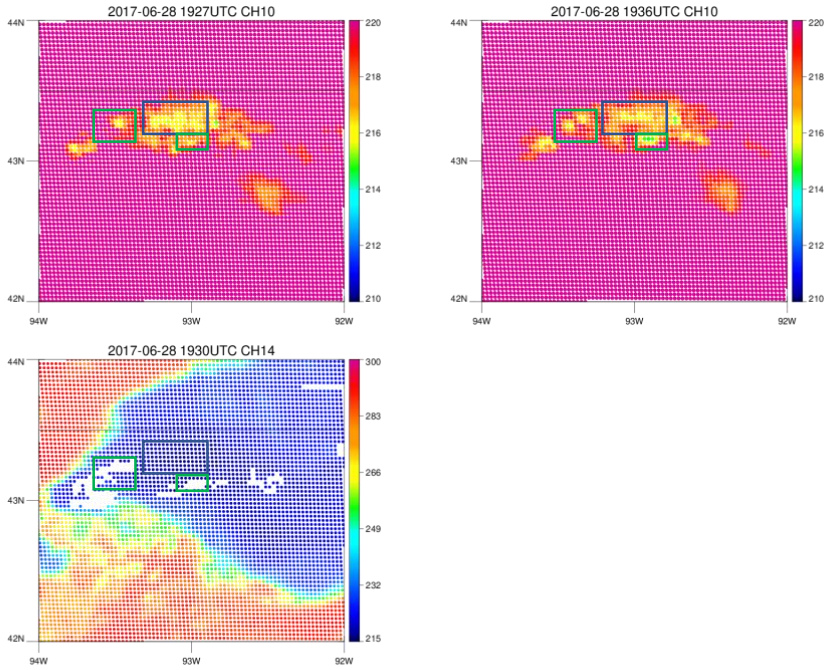
Even though the two tables (table 2 and 3) were given to show the ability of the method to detect convection earlier than MRMS, there wasn't a clear lead time compared to the MRMS product. Lines 214-215 are added.

Major issue 4 and minor issues regarding combining two methods:
The two methods were combined because precipitation flags from MRMS do not separate convective clouds in different stages, but POD and FAR for each of the two methods are added along with the combined POD and FAR in line 369-370.

l.141: "GOES-R CI algorithm". Can you please give a reference?
Since it's not operational anymore it is replaced with previous studies.

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).
What is "small cloud water"? Probably droplets. It's not always liquid water! "WV bands are more sensitive to small droplets". Discussable. "During early convective ... Tb WV will decrease ... by strong updraft ..."? You replace the statement that WV updrafts are visible in WV channels, by the statement that strong updrafts create water droplets and are visible in WV channel due to that. Weak updrafts create the same signal in WV, even cirrus anvil clouds create the same signal. Your argumentation is not precise.

"Small cloud water" is changed to "small hydrometeor" and the corresponding sentence is modified in line X. "Strong updrafts" was used as strong updraft is what distinguishes convective core from cirrus or anvil clouds, and the method uses large T_b decrease to detect convection. We do not think that large decrease in T_b is observed in cirrus or anvil clouds. One example is shown below. It's the same scene from Fig. 4a and 4b but the anvil cloud over 93W is zoomed in and color bar is set to observe Tb decrease more carefully. Note that the color bar is set to 210K-220K which is 10K difference between two time steps. Lower figure is the zoomed in figure of Fig. 5d. Anvil clouds over blue box regions or around the blue box regions didn't really show change in T_b, while some clouds show larger decrease (still less than 10K), and these clouds are detected by the mature cloud detection method.



By showing this overlay, at least, one can see better that for the most western parts of the GOES detection there are convective radar matches. However "Most of convective regions align well …" is not true. Most (= the majority) of the convective radar area does not show overlap with your detections. You can argue (in the manuscript), but you cannot simply deny it!
We have changed the text to properly interpret the scene. It now reads that the convective regions while not perfectly aligned due to a number of dynamic geometric reasons, do have a high degree of correspondence between the two detection methods.

Sorry, I missed the description of yellow and green obviously.
Still the problem of this figure and section is that it is purely descriptive and confusing. It still sounds as if you labelled four arbitrary clouds in these two images at two arbitrary points of

time. Two clouds were detected early enough, i.e. before MRMS convective flag (purple, yellow), one late (blue), for one the reader can't tell whether detected in time (green) and at least one can be seen for which no Tb detection was issued at all (98W, 38.3 N). If you want to demonstrate the functioning of your method, you have to think about a different way to show it. Maybe time-step-by-time-step image series with automatic display of Tb detection at exactly the moment they happen.
Times of detection by GOES and MRMS are added in the figure.

Improved but still not complete. You give this strange mixed contingency table now. It is not useful. You have to do that separately for both your methods. You have to describe all parameters. See next points. What is the basis of your comparison? My question still is: Is it a grid point, a storm, or a 5x5 window.?
We have tried to clarify by providing FAR and POD for each method as suggested by the reviewer, along with the combined results. These are calculated based on MRMS's grid as mentioned in lines 350 and 354.

What is 100% accuracy? This is still not defined. Does that mean 100% of Tb method warnings are MRMS-C cases within 20 min? Or is it 100% of all MRMS-C cases have been detected before. Or is it something else?
We have changed the explanation for the table in lines 203-217 to make this cleaer.

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 369).
As before, wording is still imprecise. The strength of the updraft (the vertical wind) can not be seen in the WV channels. It can be seen only (in cloud top cooling), if the cloud top is high enough. If you agree, you have to write this. If not, you have to convince me.
This sentence is changed in line 220-221.

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' is modified to reflect this comment.
This problem still exists unchanged.

l.220: Please state which VIS channel!
The section is modified so the VIS channel is mentioned before.

Section 4.3: You need to split the analysis into section “4.3.1 Mature convection detection method” and “4.3.2 Early convection method”. It makes no sense to mix up the results as you do now.
Part related to the early convection method is moved to methodology section, and FAR and POD for each method are provided separately.

l. 306: What is both methods? You should give unique names to the methods and use them throughout the manuscript. GOES-C seems to be the VIS maturity detection. You do not state this. Do these numbers refer to pixel? To area? To objects? Not clear. And I asked this in the review 1.
The name for the methods are given as growing cloud detection method and mature cloud detection method. GOES-C stands for GOES convective (results combining the two methods). Line 352-354 is added to explain the numbers.

l.322: “(reflectance at channel 2 … cloud top surfaces)” - This all has to be defined and fixed in section 3.2. Otherwise you have to make it clear there that you intend to tune all these parameters here.
It was defined in line 257 and 238 in section 3.2 of the previous manuscript.

l. 337 ff: You should not show this test. Your maturity detection is aimed at detecting mature convection at the time t of detection. Obviously you include MRMS-C cases of the time "t+10min" IN ADDITION to MRMS-C cases at time "t", right? Otherwise not all the numbers would improve.
If this is the case, this is just number tuning. If you would include time "t+5min" and "t+15" and so on, it would always improve numbers without any improvement of quality of the mature convection detection. And I requested not to do this in review 1.
Figure 8b is removed.

l.360: “27971 and 73204” This means the basis of your analysis is everything your method detects as convection? With which thresholds? How do you get these “windows”? If this is right you can not derive a POD, because you do not analyse an independent truth. Please state this in the manuscript.
It wasn’t explained well enough and thus it is modified.

l.366: What about the +30 min you just mentioned?
30 minutes meant including next 20-minute after the detection period of 10min. But since it sounds confusing, it’s changed.

l. 368: “Accuracy” is still not defined.
It is modified.

l.372: “Growth rate observed”: You rather mean “Cooling rate observed”. Similar in line 375.
They are modified.

L385: “14.4% is achieved, and 96.4% of false alarm pixels”. Can the reader check this statement anywhere in the presented results? Please tell him in the manuscript.
96.4% was mentioned as an additional information after analysis.

Fig. 2: Do (c) and (d) really show the same point in time as stated? The two precipitation fields (d) and the derived product (d) do not look like! The precipitation areas north of 44 N have hardly any matching feature.
Fig. 2c is replaced with the MRMS product so that it matches with Fig. 2d.
Fig. 5: Suddenly it’s 2230 UTC and not 1930 UTC as before? Something wrong with the time and date?
Sorry for the typo. It’s been changed.
Fig. 7: Please give all parameters kept constant in the caption or image. And please extend caption with some information on method discussed. Reflectance method for mature convection detection.
They were added.
Fig. 8: Skip figure b. And again. Extend caption as before.
Fig. 8b was removed and the extended caption is added.
Fig. 9: “when the pixel was” ...Should better read “…if a pixel was assigned to be convective by MRMS, but not detected by method XXX …“ Correct?
It was changed.
Tab. 1: Please extend caption again. This is too short to be understood.
It is extended.

Response to Reviewer #2

Line 7: As a suggestion, "The ability to detect convective regions and to add latent heating to drive convection in weather forecast models is the most important skill in forecasting severe weather systems."
It's been changed in line 7.

Line 12-15: As a suggestion, "Relatively new geostationary satellites, Geostationary Operational Environmental Satellites-16 and -17 (GOES-16 and GOES-17), along with Himawari-8, can make up for this lack of vertical information through the use of very high spatial and temporal resolutions, allowing to better observe bubbling features on convective cloud tops."
It's been changed in line 13.

Line 20: Please provide a long name of MRMS.
It's added in line 21.

Line 21: Please specify accuracy measures reported here.
It's been changed in line 22.

Line 46: The 'peakedness' and 'surrounding area' criteria are not well explained by the following sentence.
More explanation is added in line 48-50.

Line 50: Please replace "at -10°C or higher" to "at -10°C height or above"
Its' been changed in line 52.

Line 50-51: Does Zhang and Qi (2010)'s method use the threshold for convective precipitation?
6.5kg/m2 was their threshold. But since it wasn't explained well enough, the phrase has been changed in line 52.

Line 62: Tb has not yet been defined.
It was defined in line 64.

Line 87: Please specify which Meteosat series.
It's been changed in line 90.

Line 93: Please explain how "mesoscale sectors" is defined.
Explanation is added in line 97.

Line 96 "errors from cloud movements": Could you please elaborate on the errors from cloud

movements?
Explanation is added in line 100-104.
Line 99: Change “Tb” to “Tb from IR channels”
It’s been changed in line 105.

Line 140-142 “It is a rather sophisticated classification…”: Shouldn’t this sentence be moved after the sentence “Details of the classification can be found in Zhang et al. (2016).” in line 137.
It’s been moved to line 143.

Line 182 “inverse Gaussian”: It might be misleading with the term, inverse Gaussian distribution used in probability theory. Please use a different term.
It’s been changed to “upside down Gaussian”.

Line 183: Please change “Tb shape” to “the Tb matrix”
It’s been changed.

Line 190-191 “Since one-minute data can be noisy, the decreasing trend was considered instead of an actual difference in Tb during 10minutes.”: would leave this sentence out.
It’s been removed.

Line 199 “Using two channels help find the same clouds in different levels.”: How are both channels used to find the same clouds? Does it mean that both channels need to satisfy the conditions? Please clarify, and change “help” to “helps”.
Phrase is modified. The fact that both channels don’t need to satisfy the conditions is mentioned in line 97-98.

Line 202: Change “make” to “makes”
It’s been changed.

Line 221: Change “relative to” to “due to”
It’s been changed.

Line 223: Please correct “texturs”.
It’s been changed.

Line 236: It would be better to put the paragraph for the Sobel operator after the paragraph that describes screening scenes with VIS and IR channels (i.e., lines 223-234).
It’s been changed.

Line 238: Please mention how the thresholds, 0.4 and 0.9, were obtained. Change “implies” to “imply”
It was mentioned in the text that results using different thresholds are compared in section 4.3.

Line 239: "... with very high gradients." to "... with very high gradients, respectively."
It's been changed.

3. Methodology: It would be good to have a flowchart for the methodology so that readers can have an overview of the methods used in this study.
Flowchart for the growing cloud detection method is added in Figure 2.

Line 246: Isn't it southwest, not southeast?
It's been changed.

Line 248-249: The radar data could be described in section 2.2, and the sentence would be something like "The two cells appeared in the composited NEXRAD radar data…"
Fig. 2c is changed to MRMS SeamlessHSR product.

Line 254: "channels 10" to "channels 10 (7.3 μm)". Please correct "the white circle".
It's been changed.

Line 259-260: Change "The only two matrices in this scene that satisfied both criteria of maintaining the shape of developing cells and growing vertically over ten time steps were the two in blue circles." to "The two matrices in the blue box satisfied both criteria of maintaining the shape of developing cells and growing vertically over ten time steps.", or please revise it better.
It's been changed in line 291-292.

Line 276: Please describe what parallax correction is and how it is calculated/corrected.
Description is added in line 309-313.

Line 289 "from different time": It would be better to provide the times when each coloured box was detected.
Times of GOES and MRMS detection for each box are added in Figure 6 and text corresponding to Figure 6 is modified in line 322-335.

Line 291: "minute" to "minutes"
It's been changed.

Line 293 "This shows a need to use both channels in the detection.": Does it mean that both channels need to be satisfied together in the detection? Please clarify.
The phrase is modified in line 334-335.

Line 296 "the Tb method": It would be good to name the two methods for growing cloud detection and mature cloud detection method, respectively, in the Methodology section beforehand and use them in the following discussions.
It's been changed throughout the manuscript.

Line 300 “Black regions superimposed on the brightness temperature map in Fig. 6c represent…”: It would be good to also superimpose the detected mature convective clouds on the MRMS map, same as in Figure 5 for a better comparison.
The figure is added as Figure 7.

4.3 Statistical results with one-month data: The part that explains the method seems to be quite huge, so it might be better to move them to the Methodology section.
The part where thresholds for the growing cloud detection method are discussed is moved to methodology section, but the part where thresholds for the mature cloud detection method are discussed stays in this section because it uses FAR and POD.

Line 329: Using a threshold of 0.5 looks a reasonable compromise as well. It would be good to discuss the optimal balance between POD and FAR. It would be good to explain which one is the more important factor and why.
Few sentences are added in line 380-383.

Line 333 “... mature convective clouds in the earlier stage…”: Does it mean detecting clouds that grow into mature convective clouds?
This sentence is modified in line 386.

Line 335-336 “... for its potential use in the short-term forecast, …”: Is it okay to have small POD in the short-term forecast. Please give an explanation on it.
More explanation is added in line 391-392.

Figure 7: Please remove “(a)”.
It’s removed.

Line 337-338 “Figure 8b shows results including MRMS data 10 minutes after the detection period.”: What does it mean to include MRMS data 10 min. after the detection period? Why were the data 10 min. after the detection period included? Please clarify.
From the decreased FAR and increased POD, it can be implied that false alarms that were detected by GOES but not by MRMS during the detection period were actually convective clouds defined by MRMS at later time. However, authors agree that it can be confusing to readers therefore, Figure 8b is removed.

Line 339-340 “Fig. 8b still shows its ability to detect convection earlier than MRMS.”: It is unclear how Fig. 8b shows the ability of detecting convection earlier than MRMS.
Figure 8b is removed.

Figure 9: Please add labels for x-axis with units.
Labels are added in the figure.

Line 360: When all the windows were first collected, what were the thresholds used for each channel?

It was added in line 204.

Line 365: Please add "... for channel 8 and 10, respectively." at the end.
It was added.

Table 2 and 3: How are the first two columns obtained? How is the overall accuracy calculated? Please more clarify how the experiment is conducted for Table 2 and 3.
Clarification sentence is added in line 209-214.

Line 375-376 "Therefore, it makes sense again that the growth rate at channel 10 has to be bigger to catch up lower Tb in channel 8.": Why does the growth rate at channel 8 needs to be caught by channel 10?
Growth rate at channel 8 doesn't need to be caught by channel 10. This sentence was to explain in a mathematical sense that since channel 8 usually has lower Tb than channel 10 because it sees high-level water vapor and as clouds grow, those channels exhibit similar Tb, Tb change over time at channel 8 should be larger than Tb change in channel 10. But we understand that this sentence can confuse the readers and therefore, this sentence is removed.

Line 377-378: Please give a reference.
This was just authors' opinion on why clouds don't precipitate even with rapid growth.

Line 382-383: Could you explain more why false alarms are most detrimental to data assimilation? and please give a reference.
The sentence is added in line 391-392.

Line 385-387: What if the POD is so small that only a few convective clouds with most precipitation are detected? Could you please explain more on the last two sentences?
Lines 410-419 are changed.

Line 390: "...to detect convective clouds" to "...to detect convective clouds in two different stages…"
It's been changed.

Line 403 "extremely": It sounds a bit too strong. Please remove it or replace it with another word.
It's been removed.

Results and Discussion: The labels in most figures are so small that can hardly be identified.
Labels in the figures are enlarged.

Please check typos and tense throughout the manuscript.
Sorry for the typos. They were checked.