Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC2
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Comment on amt-2022-31

Anonymous Referee #2

Referee comment on "A semi-Lagrangian method for detecting and tracking deep convective clouds in geostationary satellite observations" by William K. Jones et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-31-RC2, 2022

General comments

The paper addresses detection and tracking of deep convective clouds using geostationary satellites. Various satellite instruments, including lightning flash detectors and radars are used for DCC detection, as well as various wavelengths ranging from visible to thermal infrared. The main novelty in the paper is the use of 'semi-Lagrangian' method to better account for cloud motion in a sequence of satellite images. Existing image processing methods can then be better applied for DCC cloud detection and tracking, leading to a significant improvement in correct classification of convective and non-convective clouds throughout their life-cycle.

The paper is well written, the methods seem sound, and in my opinion the results are interesting and valuable to the scientific community. The paper is clearly structured and cites the related previous research properly. The language is very clear, but there are a few typos here and there. However, some clarifications are needed. For example, I find that the typical challenges for the 'optical flow' and AMV techniques, and how they are tackled by the presented approach, are not sufficiently discussed in the methods part. Also, the limitations of the presented methods and their applicability to different situations should be briefly addressed. Some more detailed questions related to this are given in the 'specific comments' below.

I can recommend publication of the manuscript after a minor revision.

Specific comments

Page 3, line 38: The text says "Composite RGB images from a combination visible and near-IR channels” but the figure label says “visible RGB composite”. The image does look like a regular (semi-)true-color satellite image. Please clarify.

Fig 2: What exactly is the cross section pictured here? Is the distance measured along a straight line from the mentioned origin to some direction (if so, please give also the end point of this line). Please clarify. It would help to show the position of the cross section on the map in Fig 1.

Page 4, line 93: What does “over anvil area” mean here? Do you mean “overall/whole anvil area”? Please clarify.

Page 4, line 96: What is meant by ‘active detection method’ in this context?

Page 6, line 105: Please give the temporal extend of the data (year 2019) already here.

Page 8, line 149: I would expect that SWD would also be high for other cloud types, e.g. low level (optically thin) water clouds, which might cause false detections (unless combined with other methods, as in this case). Please clarify in the text.

Page 8, section 3: Some more general comments on the methods section:

I would suggest that the authors consider adding a very brief introduction to the methods section summarizing in a few lines the steps that are needed (e.g. with bullet points), to help the reader. The goal is to detect and track DCCs; existing image processing methods are used, but need to be refined in order to track DCCs, etc… 1) detection of AMV, 2) defining a semi-Lagrangian frame using the AMV, 3) careful selection of the channels used for anvil detection 4) applying the existing methods, but with the refined frame.

Typical problems in detection of specific atmospheric features such as plumes or clouds are related to the effect of the background, and specifically to the contrast between the background and the features being tracked. It is easier to detect and track high altitude cold clouds against a background of warm cloud free ocean than, say, against a cold land surface with possible low altitude cloud fields etc. Only one example is discussed in detail in the paper, but the method is applied over one year and over areas of varying conditions. Some of these issues are discussed in the text, but can the authors comment on the general applicability of the methods?

Likewise, methods based on tracking difference between images using cross correlation usually perform well when the features being tracked have sufficient contrast to the background, and also sufficiently variable texture. In other words, it would be easier to track the edges of an object with clear boundaries than, say, the central parts of a large cloud which have the same brightness temperature as the surrounding cloud. However, in Fig. 4 b) the optical flow vectors on different parts of the cloud agree surprisingly well. I would imagine this might be due to the mentioned use of 'increasingly smaller subsets of the image' in the Farnebäck method. If so, maybe this could be briefly elaborated.

Page 8: section 3.1:

Cross-correlation based methods typically have issues when applied to large features with homogeneous surface reflectance/brightness temperature. Are there any conditions where setting an AMV fails, or thresholds applied e.g. to minimum acceptable correlation? In other words, are there gaps in the AMV field that might affect your approach (or is AMV simply set to zero in uncertain cases)? Also, to clarify, are the AMV are constructed for the full image, not only clouds?

What are the major errors sources in the AMV calculations and can you estimate the resulting uncertainty? I would imagine that change in the cloud shape between the sequential images has an effect, and more notably the vertical motion can change the observed brightness temperatures, making it difficult to track the horizontal motion. Can you comment on the uncertainties?

Page 9, Fig 4: Could you use a different color for the '+30min' dashed blue line for better separation form the solid blue line?

Which images are used to produce the shown atmospheric motion vectors (two successive images, I suppose, but at which time)?

Also, while the direction of the AMV arrows seems to agree with the change seen in contours, it is difficult to estimate if the magnitudes agree. From the caption I guess the 'reference arrow' at the bottom of the image corresponds to 1 pixel per frame i.e. 60 km/h in terms of velocity, but the length on the map is arbitrary. Also, the map does not have a length scale so it is difficult to say how much the contours change in the 30 min interval. Perhaps it would be more illustrative (in this particular case) if the length of the arrows was scaled so that it would correspond to the motion of a 'cloud particle' in the 30 minute interval, i.e. the particle would travel from the tail of the arrow to it's tip in this time period. Or, if this is technically too complicated, maybe briefly describe in the text how well these two methods agree on the magnitude of the motion.

p. 10, line 192: "By comparing the predicting flow vectors to the future evolution of the cloud field (dashed line), we can see that the algorithm correctly estimates the future evolution of the anvil cloud."

It is not entirely obvious what is meant here. From the text it sounds like you use three time steps: steps 1 and 2 to calculate 'predicting flow vectors', and steps 2 and 3 to illustrate the 'true evolution of the cloud field', apparently using just BT thresholds. Please clarify.

p. 11, line 212: "Several implementations of common image processing operations have been developed using this Lagrangian convolution framework, including:"

Just to be sure, clarify what you have done in this work, and what has been developed and published before. Do you mean "We have applied this Lagrangian convolution framework to develop several new implementations of (existing) common image processing operations, including: ..."?

p. 13, line 253: Here you must mean WVD-SWD, instead of 'WVD field'? Please explain carefully at this point in the text why this subtraction is done. (It is to separate the edge of course, and described later in the text, but the way it is now written is confusing, and it takes several readings to understand what was actually done.)

p. 13, line 262: Please give a brief motivation why this classification between thin and thick anvil clouds is made. I suppose it is related to the evaluation process.

p. 13, line 263: "By subtracting the SWD field from the WVD field, we are able to isolate only the thick regions of the anvil. By adding the SWD field to the WVD field, we are able to detect both the thick and thin anvil regions." Add a reference to Fig 7 a) here. (Would it be useful to also show the case SWD+WVD?) Please describe in more detail how the thin and thick regions are detected (by some thresholds?) in Fig 8. Please also consider if these combinations of VWD and SWD could be shown and briefly introduced already in connection with SWD and WVD definitions in section 2.1?

p. 14, Fig 7: Figures 3 and 7 show the same case, but slightly different areas are shown. Would it not be better to use the same format/area in all images?

p 14. Section 4: Evaluation is naturally focusing on the DCC cores, which are associated with the lightnings. This type of evaluation does not really work for the full extend of the anvil clouds, especially the thinner parts and dissipating phase. I suppose this is also the motivation for separating the detected clouds to thick and thin parts (see previous comments). I see that with the lightning data it is not possible to evaluate the extend of the thinner dissipating parts of the anvil clouds, which are naturally not associated with the lightnings. Including the thin parts to comparison in Fig. 9 would certainly degrade the statistics, and other forms of validation are required for the thin parts. As you mention, these dissipating parts may still have important role in e.g. climate studies. These points should be discussed in the text.

Fig. 9: The labels for panels c) and f) are rather misleading, in that 'core and anvil' refers to a detected thick anvil region which can be associated with a DCC core at some point of it's lifetime. You should somehow emphasize also in the figure caption that b) corresponds to the 'old' simple threshold method while c) corresponds to the 'new' improved method which includes tracking of the DCCs.

p. 16, line 290: How is the distance calculated? Is it zero if flash is within the detected anvil polygon, and the shortest distance to cloud edge outside the cloud polygon?

p. 17, line 296: What is a 'CONUS scan region'?

p. 17, Line 308: "We also evaluate the accuracy of detecting a fixed threshold of the WVD only to compare the detection of anvils without detecting growing cores, as used by Müller et al. (2018)."

Do you mean: "For comparison, we also evaluate the accuracy of detecting anvils only by a fixed threshold of the WVD without detecting growing cores, as in Müller et al. (2018)."?

p. 17, line 311: Maybe also highlight here the number of clouds detected using the simple method (n=323,618), and with the improved method developed in this work (n=14,717), showing how many non-convective clouds are included in the simple thresholds method.