Summary & Evaluation

The focus of this analysis was to apply a tracking method to machine learning-based predicted 3D radar reflectivity structures for distinguishing convective core and system lifecycle characteristics. Data used were passive remote sensing channels from SEVERI on board Meteosat and reflectivity profiles from the Cloud Profiling Radar on board CloudSat. Despite the short time sample of using only six months of data, 375,000 convective systems were detected which made it a sufficient analysis for generating statistics, at least for capturing the diurnal cycle of convection and their differences between land and ocean. It would be worth highlighting potential known limitations in extracting a seasonal cycle given that only one year of data was used for the analysis. Overall, the analysis is consistent with what is already known of the convective lifecycle and potentially adds new insight into the lifecycle features of convective cores. The paper would benefit from improving upon and clarifying the analysis section, and details for doing so are outlined in both the General and Specific comments. Finally, it would be greatly appreciated if the authors comment on any limitations regarding interpreting the lifecycle of predicted radar reflectivity structures as "truth".

General Comments

Introduction: It is best practice to choose the earliest references that support statements. The authors appear to have chosen very recent papers, which are still valid to keep, but it is recommended to find more sources that are older. In particular, I am referring to *L18* [Roca et al., 2010], *L19* [Chen et al., 2021], *L20* [Kukulies et al., 2021; Haberlie and Ashley, 2018], *L22* [Prein et al., 2024], *L33* [Fiolleau and Roca, 2013], *L47* [Haberlie and Ashley, 2018], *L132* [Prein et al., 2024]. A good reference for background on cloud feedbacks and climate sensitivity is Sherwood et al., (2020). Leary and Houze, (1979) goes into detail on the convective cloud lifecycle.

Data and Method: It would be beneficial if you just focused on describing all the data used in the Data section and then had a separate section in the Methods that described the ML algorithm that was published previously. It is unclear if the details in *L106-128* are summarizing the ML algorithm described in your previous paper. Please also clarify the following:

- It is discussed how CloudSat, but not how Seviri, data are being used. Are both CloudSat and Seviri data used to train the model?
- Could you briefly describe how you computed the average error of the model?
- How do you test the model to evaluate its performance, if at all?
- It should be clearly stated that the methodology outlined in the "Methods" section (as it currently stands) are applied to the predicted radar reflectivities outputted from the ML model.
- Descriptions of both Sections 3.2 (Detect convective core regions) and 3.3 (Extract cloud and core properties) should be clarified greatly. Details for how they should be clarified are under Specific Comments.

Results: The descriptions and wording in the analysis are somewhat vague and need to be clarified. For example, it is not understood how "convective activity" is defined, and this phrase is used several times throughout the text. More clarifications to the results can be found under Specific Comments.

Seasonal cycle: Are there any potential limitations in your statistical analysis of the seasonal cycle given that you are only using one year of data? Can you comment on if interannual variability (e.g. ENSO) might have impacted such results?

Specific Comments

L8, L360: What is meant by "absolute" cooling?

L42-43: Bacmeister and Stephens, (2011) is not a good reference that investigates "the temporal evolution of MCSs. A study using geostationary satellite observations or other such measurements that capture the temporal evolution is preferred.

L67: Why is it that single convective cells are typically tracked using data from active remote sensing sensors? And specifically which sensors? Are different measurements typically used to track single-cell systems compared to MCSs?

L113: Could you please clarify what a "spatio-temporal matching scheme" is?

L149—"weighted mean": Weighted by what?

L154-155: It is unclear what "The value of each pixel is decreased towards its local minimum using a threshold of -15 dBZ" means.

L163: Why do you need to define a system as "elongated"? Is it under the assumption that a system should be near circular, and that it is elongated due to the merging of multiple systems?
Section 3.2: Have you validated your core detection method? It would be interesting if you apply your core detection method to physical 2B-GEOPROF radar reflectivities and then see how it compares to cores detected using the Conv_strat_flag from 2C-PRECIP-COLUMN (Pilewskie and L'Ecuyer, 2022; data description here) for a month of data, if possible.

L194: Why do you expand the threshold?

L194-195: What is "the first criterion"?

L195: In the case of significant attenuation within a convective core region, the CBH may reach up to 5 km. Have you looked into this? How do you account for attenuation in core profiles?

L195-196—"if the vertical profile shows no convective pixels for more than 50% of the CTH": Please clarify what is meant by this statement. Firstly, how are the convective pixels defined? There is a definition for DCCs in *L190-192*, but it is not sufficient as it does not give any thresholds to the maximum "column-wise aggregated radar reflectivity" nor the "difference between the CTH and CBH" used to isolate DCCs. Secondly, what is meant by "more than 50% of the CTH"?

L196-197: It is not understood what is meant by “we add the mean radar reflectivity of the vertical profile to the derived vertical depth of the column”. Please clarify.

L212: Please specify what is meant by “We employ the radar reflectivity at a fixed altitude of 10 km as a measure of convective activity”. What defines “high” versus “low” convective activity?

L219, L232-233: It is not understood if there is a general CTH threshold applied to the clouds for isolating convective systems. As it currently reads, it seems clouds need to have a CTH of at least 10 km; however, clouds during the convective initiation (CI) often have cloud tops below 10 km. For this reason, I am not convinced that you are capturing systems during the CI stage.

L220: Please describe the assumptions made for using the “difference between the radar reflectivity at 10 km height at CI and the current time step” to approximate cooling? Also, what is meant by cooling, is it at the top of the atmosphere, atmospheric cooling, or with regards to the surface?

L221-222: These sentences would be better understood if they were merged. Also, what is meant by “difference between the CBH and CTH at CI for each time step, compared to CI”?

L223—“difference of the radar reflectivity”: difference with respect to what exactly?

L238: If I am interpreting correctly, are the convective clouds that are identified actually "real", as in you would be identifying these systems in SEVIRI if you were to be just tracking them in 2D? It's just the 3D cloud fields that are predicted, hence not “real”?

L240: What is considered "high reflectivity"? 0 dBZ at cloud top is not necessarily a "high" radar reflectivity.

L250-252: From the statistics stated in the text, it does not seem intuitive that only 10% of the population contain 2-10 cores. What are the exact counts in each bin? When studying the histogram in Figure 6, it looks like single-cell systems make up more like 65% of the population, and systems with ten or more DCCs is only ~3%, meaning that there is a larger population containing 2-10 cores than what is being inferred in the text. How do these statistics compare to other studies that have assessed the statistics on the number of cores in systems?

Figure 5: It would be easier to distinguish cores from the rest of the cloud if there was a larger contrast between the colors. Perhaps make the cores a deeper red.

Figure 6—“surface type derived from a land-sea mask compared to the location at CI”: I don’t understand this distinction.

L268—“0.5 dBZ higher over the ocean than over land”: How might this tie into the notion of differences in intensity over land versus ocean? Does this suggest oceanic convection is more intense of land, which differs from our general understanding of tropical convection?

L272-273: The sentence beginning with "The core lifetime…" is somewhat challenging to interpret. Please clarify.

L276-277—"especially for convective clouds over land": It appears that both regions show this, not just land.

L286-287: Have other studies shown that continental clouds have a larger anvil area and lower reflectivity compared to clouds over the ocean for the region and time period you are studying?

L287-288: Please clarify this explanation—differences in cloud properties would cause a local thermal instability—is that how it is to be read?

L291-294: Please include references here, and are you describing the diurnal cycle for this specific region?

L298: Figure 9 a-d does not show the eccentricity of clouds.

L304-305: Second maximum in what, exactly? Where is the first maximum? Also, please use a more scientific word than "powerful" in "afternoon peak is consistently more powerful". Also, what afternoon peak are you referring to?

L315, L371: How do you define convective activity? Is this shown in Figure 11?
L315-316: Are you explaining that this is occurring over time, and witnessed over both land and ocean and for all cores?

L316-317: Do you mean to imply that the number of DCCs increases as the months progress? There is a sharp drop though between July to August over sea.

L318-319: Perhaps use wording other than "less distinct" to make your point clearer. It seems like sea has more cores than land starting in May.

L322-323: Where do you get the anvil extent being larger over land than ocean?

L332-333: Again, has this definition of cooling been used previously in literature? Please explain the assumption.

L352: Did you quantify "the cooling and area growth appear earlier during the relative cloud lifetime" to determine it? It is not clear based on the figure.

L357-358: For cooling, there is a morning peak at 0100 over both land and ocean. Is it statistically larger than the mean for the next several hours? There are dips at 6 pm over both land and ocean, and an additional dip at 12 pm over land. Again, are these statistically different and indicative of the diurnal cycle? The diurnal cycle of vertical growth seems to be much more pronounced over land, but not noticeable over ocean. Please make this distinction.

L359-360: Which convective characteristics are you referring to?

L361-363: Is this suggesting that as the number of DCCs increases, the total cooling and vertical growth per DCC is less than that of the initiation phase?

L365: How about the peaks in the early morning?

L367: Aside from the dip in July over land.

L368-369: Why do you think the cooling and vertical growth are higher for clouds with a single core?

L371-372: Are you referring to the larger variability in area and vertical growth of convection over land? In other words, the seasonal cycle of convection is more pronounced over the ocean, but the diurnal cycle of convection is more pronounced over land?

Section 5.1: This section is great, I appreciate the connection between your results and previous literature. Could you also add a few sentences on discerning the characteristics between isolated and multi-cellular convection within previous literature, and how it is consistent with what you are finding?

L405-407: Had you considered also using CALIPSO observations to capture thin ice clouds?

L429-431: Convection as a self-maintenance mechanism has been suggested in previous literature, but which signatures in your results are pointing to this conclusion?

L432-433: What do you mean by "weaker convective activity"?

Technical Corrections

L12-13: The way that this sentence reads is a bit confusing. I'd suggest "…more intense over land than ocean during both seasons, despite an increase in convective activity over the ocean during summer".

L58—"Early studies": Change to "Some studies" as a study provided in the next sentence was published earlier than Masunaga and Luo, (2016).

L70—"Contrasting": Change to "Contrastingly" or "Alternatively"

L93—"diverging convective development": "Diverging" is not the best descriptor here, so rephrase to say that convection develops differently in the extra-tropics compared to tropics.

L95-96: sentence beginning with "Clouds…" seems out of place in this paragraph.

L161: Does "width" refer to the vertical cloud thickness? Please clarify that here and in the workflow figure (Figure 1).

L204: ", e.g."

L206-209: Although important, this information is already addressed in the introduction, so can be removed to make the paper more succinct.

L240: Morocco

L271: Replace "connected" with "associated with"

L273: Replace "come along" with "associated with" or an alternate phrase

L273: By more extensive, you mean larger horizontal area, not more extensive in the vertical direction? Please clarify.

L274: Please modify the phrase "increases stronger".

L300: Does "temporal shift of the afternoon peak" mean that the peak occurs later in the day?

Figure 9: Add units to the "Cloud lifetime" axis.

Figure 10: Label axis "core eccentricity" for consistency.

L371: Can delete sentence beginning with "Clustered clouds…" because this was implied from the previous sentence.

Figure 15: Make the y-axes ranges consistent between single and multiple DCCs so it is easier to compare them.

L378: In addition to specific horizontal or vertical dimension, you can also include that there is a limitation in the temporal dimension if trying to exclusively use CloudSat data.

References

Leary, C. A., and R. A. Houze, Jr., 1980: The contribution of mesoscale motions to the mass and heat fluxes of an intense tropical convective system. *J. Atmos. Sci.,* **37**, 784-796.

Pilewskie, J. A., & L'Ecuyer, T. S. (2022). The global nature of early-afternoon and late-night convection through the eyes of the A-Train. *Journal of Geophysical Research: Atmospheres*, 127, e2022JD036438. https://doi.org/10.1029/2022JD036438

Sherwood, S. C., Webb, M. J., Annan, J. D., Armour, K. C., Forster, P. M., Hargreaves, J. C., et al. (2020). An assessment of Earth's climate sensitivity using multiple lines of evidence. *Reviews of Geophysics*, 58, e2019RG000678. https://doi.org/10.1029/2019RG000678.