

Atmos. Chem. Phys. Discuss., referee comment RC1
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Comment on acp-2021-420

Anonymous Referee #1

Referee comment on "A climatology of trade-wind cumulus cold pools and their link to mesoscale cloud organization" by Raphaela Vogel et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2021-420-RC1>, 2021

Very detailed analysis of valuable observations of cold pools in trade wind regions. I appreciate the extensive analysis, combining different measurements and allowing to compare and link cloud properties to cold pool properties. I find however, this last point could be strengthened more.

Main critique points:

- a bit more answering the "why" about correlations found, especially between cloud cover statistics and cold pool properties in conclusion would make the study more valuable (reference to theoretical or simulation studies).

- The point that cold pools are responsible for extending the daily cycle of shallow convection into the afternoon is made very prominent (abstract, result section, conclusions). However I am missing some more mechanistic explanation here. I cannot really follow the reasoning in Sec. 3.3, since the precipitation reference cited does not exclude cold pool effects. Can you extend a bit more here? Are you inferring that the cold pools are strong enough to trigger new convection later in the day (as in deep convection regions) or are you rather saying that the cold pools slow down convection and thereby stretch the convectively active time period over a longer time due to their inhibitive effects?

- Cold pool detection: it seems that the algorithm detects also very long-lasting temperature deviations that are more likely connected to meso-scale cold fronts than cold pools (Fig 2., Fish). How did you make sure that no frontal temperature drops were detected as cold pools? Did such outliers only occur in connection with the Fish pattern? Please also extend a bit on how these outliers could be avoided in your algorithm?

- Both the result and conclusion sections lack some background information regarding hypotheses and motivation about the choice of observables and tested correlations (e.g., testing the variation of cold pool properties with other variables, such as CTH).

- The Result section about cold pool properties conditioned on the different cloud types should be rewritten, since it's a bit hard to read (sentence structure).

- Convection triggering: I would appreciate some general reflection on whether you think that the measured weak updrafts (strengths of below 1m/s) that travel with the cold pool front (i.e., are not stationary) are sufficient to trigger convection?

- Section 4 is a very interesting section, since the cold pool properties conditioned on the mesoscale situation is the main new part in this study. The text is however difficult to read, some simplifying sentence structure would be beneficial, mostly l. 435 ff. The text would further benefit from being purely descriptive relating the conditional statistics to the cloud properties of the respective patterns. E.g., how is the lower cold pool fraction of Gravel compared to Flower related to the cloud and cold pool properties in the two situations? Try to connect the different panels in Figure 7.

Comments to Sections:

1. Introduction:

- missing: difference climatology (overview) winter vs. summer trades
- review about cold pools in shallow convection a bit short: there are more papers that should be cited and summarised (e.g., Glassmeier and Feingold, 2017)

2. Methodology:

- Some ambiguities with definitions of cloud variables (see comments in text)
- How are the "overall" cloud variables defined: as the mean over all pixels in a cloud entity? Please clarify.
- There is some confusion about the definition of CBH: is it a time series, indicating the cloud base height of the lowest cloud at each time step (this is how I understand the definition on l. 96), which however stands in contrast to using the "lowest CBH" as stated in the legend of Figure 2?
- vertical velocity (l. 117): are these pixel-by-pixel values or mean values over one radar profile or timeseries?
- What is morphological closing?
- Splitting of cloud cover: Based on what are the threshold values for CBH chosen? based on what is this distinction made, I assume the overall cloud variables and not the pixel-by-pixel cloud base? Can you give some more details?
- Why does the SNR have a unit, shouldn't it be without unit (l.112)? what is meant by smaller; shouldn't larger absolute values (i.e., smaller than -18.3dB) mean better SNR?
- Figure 2.3, Fish example: how do you interpret the detected cold pool existing over more than 6h. I don't think this temperature anomaly should be detected as cold pool but rather represents some meso-scale (cold) front as also indicated by the satellite snapshot? (see major point regarding cold pool detection algorithm)
- Winter vs. summer trades: the logic derived why to use winter trade statistics makes sense. However, based on what is it decided whether or not to consider only winter trades (l. 195: "for most of the analysis...")? Can you be more specific here?
- *noprevWI* criterion (Sec. 2.5): The definition of the criterion is ambiguous (l. 203): do you mean that there could be a cold pool detected in the preceding hour, but it has to be terminated, or that no cold pool can be present? How does that conflict with your discussion about the ambiguity of the algorithm about determining the cold pool end?

3. Results:

- Horizontal wind anomaly (l. 242): the value of 14m/s seems very low, specifically since you're measuring the combination of cold pool propagation speed and its internal circulation. Do you have any thoughts on that?

- You state that the front duration explains a lot of the variation in temperature anomaly. Is the front duration correlated with horizontal wind anomaly, such that longer duration can be translated to spatially wider cold pool front, such that your finding can be expressed as that colder (stronger) cold pools have wider fronts? Do you have an understanding, what causes differences in the front duration? Is it correlated with it correlated with the rain duration or intensity?
- Temperature recovery time of 16min (l. 277): how can I see this numerical value from the figure (or elsewhere)? How did you derive it?
- Humidity recovery (l. 28): I do not fully understand your reasoning here. Are you speaking about enhanced surface fluxes in the cold pool interior that are trapped in the boundary layer?
- Updraft strength: I am not sure I agree with your conclusion on l. 312 about the convection triggering. Do you think updraft strengths of below 1m/s that travel with the cold pool front (i.e., are not stationary) are sufficient to trigger convection?
- Comparison to DYNAMO (l. 320ff): please complement the qualitative comparison with quantitative indications / statements.
- Figure 3: connection between variables (within cold pool) should be discussed more in text
- Figure 4b: Is a decrease in CBH an indicator of different cloud type? Why is the CC larger for stronger compared to weaker cold pools? Are parent clouds that formed the weaker cold pools already dissipated?
- Figure 4c: How do you interpret that the cloud cover increases immediately over the cold pool front and rain is falling during front passage? Are the cold pool fronts close to the rain cell, almost as if the meso-scale arcs form squall-line like structures with the cold pools propagating right ahead of the arc? Do you relate the precipitation falling "over" the front to the parent rain cell (that produced the cold pool) or can it be attributed to a new rain cell that was triggered by the cold pool?
- Figure 5: How can the pretty pronounced negative values in $U-U(t_{max})$ in the wake of the cold pool fronts be interpreted?
- Comparison to "average" winter trades: please complement text with numerical values and references (l. 360, 361)
- Figure 6a: Not being familiar with trade shallow convection diurnal cycle: can you extend a bit on how the strong increase in cold pool frequency right before midnight can be explained (Fig. 6a)? Is it related to the increased CTH during the night, leading to an increase in rain intensity and thus increased frequency (and strength) of cold pools? Please extend a bit.
- Daily Cycle: are there any conclusions be drawn regarding the causal structure of the cold pool - cloud coupling? Would you, combining the reasoning in paragraph 3.3 and the observed diurnal cycle, conclude that the cold pool - cloud coupling is mainly a "one way street", where the cold pools are strongly influenced by the clouds (strength etc.), while there is a minor feedback from the cold pools back to the clouds pointing to a negligible cloud triggering effect due to cold pools?
- Figure 6b, c: Panels b, c show large jumps in the mean timeseries right at 19-20:00. Is that an artefact of the splitting of the time series at that hour?
- Figure 6: in contrast to the previous paragraph, where stronger cold pools are associated with higher CTH, this correlation doesn't show up here: higher CTH 20:00-08:00 vs. (slightly) stronger cold pools 08:00-17:00. How should that be understood?

4. Relationship to mesoscale pattern

- Figure 8: The same arrangement of sub-panels according to the variables as in Fig. 4 would be helpful for easier comparison. Why aren't you showing all variables shown in Fig. 4?
- Figure 8e-h: colorbar missing
- What are the main findings of Fig. 8? Can you highlight this more in the text?
- Number of cold pools (Figs. 7a, 9a): wouldn't it make sense to show some kind of normalised number of cold pools that allows to understand how the cold pools "density" varies among the different mesoscale patterns? E.g., normalising the number of cold pools shown (which is, if I understand correctly, the sum of all detected cold pools given a certain weather situation?) by the relative occurrence of the cloud pattern.
- Fig. 8, 9: how is the number of cold pools related to the number of clouds (entities) in the different trade cumuli patterns?

5. Conclusions:

- Summer cold pools: How do the weaker updrafts fit with stronger temperature drops?

Please also note the supplement to this comment:

<https://acp.copernicus.org/preprints/acp-2021-420/acp-2021-420-RC1-supplement.pdf>