ACPD-13-11023-2013: Aircraft observations of cold pools under marine stratocumulus by Terai and Wood

This manuscript investigates the properties of cold pools found under marine stratocumulus on small and large scales from an extensive set of aircraft and satellite-based observations. The manuscript is very well written and provides a useful overview of cold pool properties that were known before but probably not documented as extensively as done here. I recommend minor revisions that mostly concern a more concise write-up of the composite results and a further exploitation of the observations to study an interesting aspect that the authors touch upon, that is, the clustering of multiple cold pools, as well as how the clustering affects the composite properties of the cold pools on smaller scales in the second part of the paper.

General comments

1. One of the first interesting results that the authors point out is the clustering of cold pools i.e., one often finds smaller cold pools within larger cold pools. This immediately triggered questions such as whether the localized cold pools inside larger cold pools show enhanced drizzle rates, a different cloud depth, etcetera. Such questions could be addressed with this dataset, but do not come out in detail using the composite analysis that the authors perform, because the anomalies of the smaller cold pools will be much smaller than that of the larger cold pools. In Figure 11 and 12a the authors do plot anomalies calculated using the edge of each cold pool, but for the other variables no anomalies are taken. For something such as the precipitation rate, any difference across a small cold pool edge will therefore be overshadowed because it is embedded in a larger cold pool that already has a different precipitation environment. Would it be helpful to instead scale or normalize precipitation and cloud tops/LWP's by its value at the cold pool edge?

2. In section 4 of the paper, and especially from section 4.3 onwards, the writing gets rather descriptive and long, and the manuscript would benefit from a more concise write-up, and possibly (some of) Figures 11-15 could be combined into one larger panel Figure. I also recommend moving the analysis at the end of 4.4 (the two box calculation and its discussion) into a separate paragraph/section, where both the enhanced chemical tracers as well as the temperature depressions and humidity enhancements are simultaneously addressed after a clearer description of how the box calculations are performed, what assumptions are made, and what questions it can address. Can you state that you solve the temporal increase of a given tracer over a given depth by the surface flux, and be more clear about what you mean with the different heights of the two boxes (line 23, P 11043). Since it is such a simple calculation, why don't you do it separately for the decoupled layers and the coupled layers, that have different mean mixed layer heights? (first paragraph section 11044)

Specific comments

- Figure 7 and Figure 8: Would it be interesting to scale the size of the individual markers by the mean size of the cold pools along each leg? This would bring out relationships between the cold pool size and drizzle rates respectively cloud top heights or depth, and would provide an interesting link between the analysis shown in Figure 4 and 5 and those in the subsequent figures.

- P. 11027, line 26: It would be interesting if the authors can provide a few short notes of the large-scale conditions experienced during this period and in this region, e.g. by how much do large-scale parameters such as SST and LTS change across the region used?

- P. 11032, line 24: What is meant by outside the cold pool? Is it just outside the edge of the cold pool (mentioned later in section 4.1), or some average over a certain distance outside the cold pool?

- P. 11032, line 25: The authors write that larger cold pools require sustained cooling. What is their thought on the causality of the relationship between cold pool size and cooling? Would it be better to write that more cooling leads to larger cold pools?

- P. 11034, line 6-10: The fact that precipitation and cold pools not necessarily need to be correlated (i.e., there is a time lag involved) is an interesting one that is not mentioned again when studying the composite precipitation characteristics inside and outside the cold pools in section 4.3. One could even imagine that precipitation rates and temperature depressions are de-correlated because once most of the precipitation has evaporated (low precipitation rates) the air is the coldest. The authors do not correlate precipitation rates and temperature depressions alone, which would be interesting to see, and is not evident from the composites per se.

- P. 11035, section 3.4: The authors have clearly stated that regions with higher cloud tops are characterized by more rain (and thus more cold pools). The obvious question here in finding out what makes certain areas more prone to cold pool formation than other regions is thus what (large-scale parameters) allow for clouds to become deeper initially? The authors do not mention factors such as lower tropospheric stability, SST or subsidence rate, and although that goes beyond the scope of this study, it would be a good question to mention when discussing explanations of why one region has more cold pools than others.

- P. 11040, line 1-8: How I interpret the writing in this section is that the vertical velocity field can have perturbations or anomalies that are as large as the differences in mean vertical velocities between different flight legs. But I may be misinterpreting this. The authors may want to specify what is the standard deviation of vertical velocity within one flight leg, which as I read it can be quite small (”negligible ascent or descent away from the edge”).

- P. 11040, line 23-27: I do not follow this train of logic entirely. Do the authors mean that the lower cloud base could be due to the radar misinterpreting drizzle below clouds as cloud base? Probably not, because they use the lidar to derive cloud base height. If the authors mean that the lowered cloud base could be a thermodynamic effect of the cold pools produced by heavy drizzle (lowered LCL), then they should say so, or is there another effect that I am missing?

- P. 11045, discussion: it would be nice to have the discussion aligned according to the investigation of cold pools on large scales and on small scales. Line 16-17: ”we first examined the large-scale environment that accompanies cold pools”, i.e., what makes a region more prone to cold pool formation, and then investigate the cloud and environmental properties across the cold pool edge in more detail. One interesting difference that does not come out that clearly in the discussion, is the fact that clouds are deeper (which I interpret as clouds having greater cloud top heights) in regions with cold pools offshore, from a large-scale perspective. From a small scale perspective, there is however no discernible difference in cloud top heights.

Typo’s/errors/graphics

- P. 11044, line 4: strange sentence: rewrite to: ”... and qv is lower in the cloud layer than in the surface layer”

- Figure 3: why are not all cold pool edges marked by a red triangle? is the yellow cold pool an example of a cold pool that gets excluded from the analysis because its rightmost edge is not detected?
- Figure 5: y-axis reads ”di erence” instead of ”difference”
- Figure 11-15: It may be helpful to put: ”Inside cold pool” and ”Outside cold pool” on the top of each figure.