Authors’ statement

We would like to inform you that, during a careful review of the manuscript and codes, we identified a minor miscalculation in one of the scripts, for which we sincerely apologize. This results in slight modifications to the plots in Fig. C2 in Appendix C (visible changes in chart (a)) and the rewording of two sentences—one in Appendix C and another in the spectral discussion in Subsection 3.2. These adjustments do not affect the interpretation of the results.

Review reponses

If referring to a specific line in the manuscript, we consider the revised version.

Referee #1

All the technical corrections have been incorporated in the revised version. Thank you very much for the suggestions and the review.

Referee #2

The presented study does not focus on the canonical scientific problems typically addressed in the RB community. The research had an objective to thermally characterize the chamber in terms of small-scale events. It is essential for future experiments in the Pi Chamber, providing insights into temporal scales and the magnitude of small-scale scalar variability, as well as the periodicity of the LSC under different temperature differences.

Processes occurring in the real atmosphere are neither stationary nor stable and exhibit significant variability, making them particularly challenging to study, especially at turbulence scales. Additional analysis of the results along the lines of canonical studies of RBC, despite differing convergence criteria from those traditionally recognized in the RBC community, allows to understand conditions inside the Pi-chamber in a broader and more general context. Nonetheless, the 10% range ensures satisfactory convergence for atmospheric applications. We have revised the abstract and introduction to better emphasize the paper’s objective.

Additionally, in response to the reviewer's concerns, we clarify that the choice of 3- and 19-minute measurement durations was dictated by the Pi Chamber’s operational schedule, which constrained both the number of sampled points and the range of explored conditions.

Please find below some remaining comments.

homogeneous horizontal grid spacing --> Does this mean boundary layers closer to the vertical sidewall are not explicitly resolved?

A uniform horizontal grid spacing of 2.083 mm is used for DNS. This grid spacing is lower than the thickness of the top and bottom boundary layer (~ 5 mm). The sidewall heat flux is significantly smaller than the top and bottom surfaces for isothermal sidewalls. Therefore, the horizontal resolution should sufficiently capture the sidewall boundary layer.

How many points are in the boundary layers close to the plates?

The positions of DNS grid points translated into spatial units are as follows (considering only 20 cm apart from each plate): 1.5; 3.5; 6.2; 9.1; 12.0; 15.0; 17.9; and 82.7; 85.6; 88.6; 91.5; 94.5; 96.9; 98.9 [cm].

On what is the statement that previous studies had "limited temporal resolution" based?

"…limited temporal resolution of the used instrumentation." statement refers to temporal resolution of instrumentation used in the reported RBC studies which could not have resolved full range of scales especially the smallest scales of turbulence.

"As presented in Fig. 5, standard deviation distribution in the chamber is almost symmetrical with respect to the center with a small bias near the ceiling." --> No; this does not reflect the discussion on the asymmetry as indicated in my previous report and the answer to the referee. Please update the discussion as indicated in the response to the referee

Thank you for drawing our attention to this issue. It is now incorporated in the discussion. The same applies to Appendix A.

Moreover, we rephrased some sentences to avoid being inaccurate.

Referee #3

1. The temperature fluctuation profiles in Fig. 5 (and Fig. 11) look meaningful to me. The authors cannot resolve the near-wall regions such that they miss the profile maximum at the height of the thermal boundary layer thickness. Shouldn't the third-order moment in Fig. 6 be more or less mirror-symmetric (about half-height)? It might be that 19 min of measurement time are still too short. Could the authors comment on

this. For example, how much does the LSC change in this time period, can this be detected in the experiment?

During the experiments, we used two UFT head sensors, which could not be easily repaired in the event of damage. To mitigate this risk, we intentionally limited the vertical measurement range.

Ideally, we would expect a more symmetrical skewness distribution. However, the chamber does not represent a perfect example of RBC, partly due to the top insulation design during the experiment. Additionally, we manually adjusted the sensor position each time, which required removing the foam lid at the top for approximately two minutes. The procedure, described in detail starting from line 133, likely allowed some ambient air from the laboratory to enter the chamber. This could have introduced fluctuations in the third statistical moment, which is highly sensitive to even minor disturbances.

According to Fig. 7, the LSC oscillation period varies from about 1.3 min (at 10 K) to approximately 1 min (at 20 K), corresponding to roughly 14 and 19 full cycles, respectively. Since our measurements covered only the vertical column near the axis, assessing LSC stability during that period remains challenging. We refer to relevant literature discussing this issue as a more complex phenomenon (starting from line 68).

2. On the spectra: a Bolgiano scaling should appear for scales above the Bolgiano scale L_B (which might be translated into a Bolgiano frequency f_B = u_rms L_B. Is it possible to extract such a scale (e.g. from the DNS) that separates the lowest frequencies from the rest of the spectrum? Otherwise, one might conclude that it is simply a Kolmogorov-type scaling. Bolgiano scaling is typically found in stratified turbulence, not in unstably stratified flows.

An extended discussion of the limitations of BO scaling in RBC is provided by Lohse and Xia (2010). The most significant point is that in canonical RBC, the difficulties in direct scale separation suggests that BO scaling may be limited. However, the authors in Fig. 5 showed that BO scaling has been reported in such system previously.

Moreover, Lohse and Xia discussed that Bolgiano length should be estimated locally based on energy and temperature dissipation rates. In our study, we examined scaling regimes based purely on the linearity condition (Pearson correlation coefficient), showing that within the inertial range, the slopes exhibit a slight bias toward −7/5 (particularly at 20 K). However, we also noted that the slopes of −5/3 and −7/5 are too similar to draw a definitive conclusion. Additionally, we considered the possibility of a gradual spectral transition rather than a sharp distinction between scaling regimes.

3. The discussion of the -3 range of the spectrum: can we really see fingerprints of a helicity cascade in the spectrum. The spectra are taken along (or close to) the centerline. Perhaps it just might be a crossover into the dissipative range. Please comment.

We interpret that our scaling observations in this regime are linked to the dynamics of thermal plumes according to the works of Chen and Bhaganagar. In their series of studies, they argued that the −5/3 and −3 scalings could be associated with helicity cascades. While the exact nature of this invariant remains unclear, as noted in our manuscript, it presents an intriguing direction for future research. At this stage, however, it is challenging to provide a definitive explanation.

Thank you for the suggestion though, we incorporated information on this possibility in the revised version of the manuscript.