

Review of **Characterization of Free Tropospheric Layers With Polar Radio Occultation Data** by Kubar et al.

This paper presents an analysis of upper tropospheric and lower stratospheric structure using polarimetric radio occultation data, focusing on cloud-top heights (CTOP), lapse-rate-derived metrics (LRMAX, LRMIN), and the cold point tropopause (CPT). They find that LRMAX aligns closely with the tops of heavily precipitating tropical clouds and propose that it serves as a reliable proxy for the TTL base. Additionally, the authors introduce a “modified CPT” definition based on the sharpness of the lapse rate profile.

In its current form, the manuscript is not yet ready for publication, but I believe it has the potential to be a valuable contribution pending substantial revision. There are some worthwhile analyses throughout the study and have no doubt that polarimetric RO data is a valuable tool deserving of increased attention in the coming years. However, this paper spends a lot of its time focusing on tropopause definitions in ways I find to be problematic, and the overall purpose of the study gets lost in this.

General Comments:

1. In the title, “Polar” should really be “Polarimetric” in order to not be confused with the polar regions. Also, “Characterization of Free Tropospheric Layers” doesn’t feel like it accurately describes most of the work presented in this paper.
2. While your introduction is a thorough literature review of relevant work, it is quite dense and difficult to follow at times, and it doesn’t provide strong motivation for *why* you are performing this work. Why does this study matter? What is missing from the previous literature that you are working to rectify? I would suggest revamping this entire section to feel more cohesive and to ensure the motivation for your study is clearly defined.
3. Much of the focus of this paper (Sections 3.1 through 3.3) focuses on this “Modified CPT” and its use as a tropopause definition. It is unclear how this metric (minimum of the second derivative of temperature profile) represents a modification of the CPT, and it may be better framed as a novel tropopause definition altogether. Throughout these sections, you tend to compare this modified CPT with the CPT in scenarios where the CPT has no applicability. It is well known that the CPT decouples from the composition transition associated with the actual separation between troposphere and stratosphere outside of the tropics and therefore should not be used outside of the tropics as it has no real physical meaning. Therefore, any work showing how the modified CPT is better than the CPT outside of the tropics is not very compelling in my opinion. I strongly urge you to reconsider whether this new definition is necessary, and if other definitions may suit your purposes well

enough (WMO, PTGT, etc). All of this aside, I don't think these sections feel super relevant to the rest of the work looking at CTOP.

- a. Somewhat associated with this, I want to provide a note of caution to ensure that you are implementing the WMO definition correctly. Multiple times in the paper you describe the definition as being “the lowermost height at which an LR threshold of 2 C/km is sustained for at the least 2 km”, while the exact definition from the WMO is “the lowest level at which the lapse rate decreases to 2 C/km or less, provided also the average lapse rate **between this level and all higher levels** within 2 km does not exceed 2C/km”. I only mention this because the WMO definition is unfortunately frequently misapplied in published works.
4. I find the sections of the manuscript focused more on CTOP comparisons with temperature profile structure metrics to be more compelling, but this gets a bit lost due to the length and somewhat disorganized nature of the paper. Additionally, I think these sections would be even more compelling if it was more thoroughly motivated in the introduction.
5. The figures throughout the paper are quite messy and hard to digest, I would recommend thinking about different ways to show the wealth of information you are trying to convey in a more concise and digestible manner.
6. Throughout the paper, it is unclear how much of your analysis is focused upon the tropics versus the extratropics. For example, in the third paragraph of the introduction, you go from talking about the TTL, which is in the tropical regions by definition, to the tropopause inversion layer, which is a primarily extratropical feature. Please ensure that in your methods, analysis, and discussion that you are clear if you are focusing on the tropics, the extratropics, or both.