We thank the reviewers for their attention and helpful comments on this manuscript.

We have made substantial revisions, including restructuring the sections and recreating or consolidating figures. In particular, the dataset from 1 October 2019, which was taken without a GPSDO, has been replaced with a dataset from 11 May 2022. The eclipse discussion has also been removed in order to improve the focus of the paper.

Our responses to Reviewer 2 are included inline below.

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The paper presents three events and analysis to understand Doppler shifts observed using a few different methods, including by amateur radio operators. One event corresponded to the eclipse of 2017, and two other events corresponded to Doppler shifts associated with the terminator.

While the work that forms the investigation has merit and presents some novel observations, particularly with respect to the fact that the equipment used is amateur radio equipment, the new method being presented in the paper is unclear. I could not determine what was really the new science or the new technique/methodology presented in the paper. From the science perspective, there have been previous investigations of Doppler shifts during eclipses, at minimum, but those were not compared with the current results. There are two new aspects from this investigation which are important and should be emphasized. First, the observations were made with amateur radio equipment, so presumably some of these calibrations could be described and it is possible for others to replicate these results. Second, using ticks with WWV forms a new technique.

I recommend that this paper focuses a little bit more or adds some text to tie these events together into a more cohesive story.

The paper has been restructured to focus on the two methodologies applied: the estimation of layer height from Doppler shift and the measurement of time of flight via WWV second ticks.

I have the following major comments:

1. **The paper is disconnected in terms of connecting these three experiments together. Frankly, they seem like three discrete experiments that are loosely connected, although the second and third experiment seem different than the eclipse experiment. There needs to be more effort put toward having a cohesive line of logic for the reader. One suggestion might be to simply not**

talk about the eclipse results and focus instead on the second and third experiment since these seem like a more cohesive story.

We have removed the eclipse results and significantly restructured the flow of the paper in keeping with this recommendation.

2. **The paper seems to suggest estimating the virtual height using Doppler observations. From a pure radar signal processing perspective this doesn't make sense since a narrow band CW signal has an infinite range resolution.** That is correct. We are measuring change in virtual height, not the virtual height itself.

   If the intent is instead to correlate Doppler variations with virtual height variations, more modeling effort or theory is required to demonstrate that this can be done feasibly. In particular in Section 2, there should be some additional figures that demonstrate this methodology more clearly and what sort of results are being found. So for example, do you see systematic trends in the virtual height relative to Doppler? Those should be explained clearly and including figures. If this is the crux of the new technique, there should be more justification demonstrating that this technique works.
   Three figures from the original manuscript (5, 8 and 9) have been replaced with analogous subfigures in Figure 7, in order to more coherently present the steps of the integrated Doppler methodology by example.

3. **You should quantify the errorbars on the virtual height estimation. This also may illustrate my point that if you use Doppler alone, you will end up with enormous errorbars. If that is the case, what conclusion can you draw about the virtual height? Regardless, the errorbars would help in terms of the quality of the investigation.**
   Error bars have been added to the spectrogram analysis, and a more extensive discussion of error has been added.

4. **The flow charge in Figure 3 and the enumerated list in Section 2 are confusing. I could not understand how this method/technique actually worked. This needs to be clarified and elaborated, perhaps with an example. What is the basis for equations 2 and equation 3? This was not explained.**
   The flowchart has been rewritten and more text has been added to contextualize the steps and add clarity. The corresponding plots have been organized into a set of ordered subfigures, which are referenced within the flowchart, in order to improve the flow of this section.

5. **Near line 185, you have a sentence that states "Figures 8 and 9 show changes in the path velocity and length calculated…" this is a single sentence that describes two figures. What are the key take away points you want the reader to see in each of these figures? The single sentence is insufficient in the description. Also how were these quantities calculated in Figure 8? There are a lot of arrows and other things happening in the figure without a clear description in the text.**
   The purpose of these figures was to illustrate intermediate steps in the Doppler layer height method. The figures have been replotted and consolidated as subfigures in Figure 7. The python code used to produce the new versions is available in the Open Research section.

6. **Figure 5 shows some eclipse data for a control day and the day of the eclipse. During 1400-1600 UT, the Doppler measurements appear to have similar magnitudes on the control day versus the day of the eclipse? Why is that the case? I think this would benefit from using some temporal smoothing – like a running mean or median. The trends should be clearer.**
   The eclipse section has been removed.

7. **In Figure 9 and 10, I am confused when the Ionosonde data is used relative to your estimates of the virtual height? It does seem cyclic to me to use ionosonde data for a virtual height and then is your algorithm modifying the virtual height to match the doppler observations? Please clarify this in the text.**
   A clarification has been added to Step 6. "[T]he Boulder ionosonde is used as a validation tool: the frequency profiles calculated from the Doppler shift and a single initial measurement are compared to the profiles measured subsequently by the ionosonde."

8. **Figure 12 should have error estimates associated with the data points.**
   For the time of flight measurements (plotted in Figure 12 in the original manuscript), the measurement uncertainty is considered negligible. This is discussed in greater detail in Section 3.5.2 of the revised manuscript.