Reply to Reviewer #2:

Reviewer #2 comments in red italic.

Author reply in black.

Blue bold text refers to Track-Change document line numbers.

Thank you for taking the time to read our manuscript and provide helpful suggestions. Specific comments are entered immediately following the reviewer comments.

The manuscript suggests a very interesting methodology to calibrate UHF radar wind profiler data with the help of surface distrometer observations. Getting radar reflectivity values from the hitherto uncalibrated power measurements would clearly increase the usefulness these instruments. This approach furthermore provides an opportunity for a long-term monitoring of the hardware status, which offers very welcome insights as nicely demonstrated by the authors. There are a couple of points that should be addressed in a revised version of the manuscript:

As the authors describe, it is known that excessive broadening of Doppler spectra during precipitation leads with neccessity to an incorrect estimation of the noise level by the Hildebrand and Sekhon (1974) method, because this broadening often affects the complete so-called "full-scale" velocity interval (which is bounded by the Nyquist velocity), so that the prerequisites inherent in the noise estimation algorithm are violated. Of course it is possible to address this issue by adjusting the radar settings to allow for a much wider Nyquist limit, in particular by reducing the number of coherent integrations and increasing the length of the time series for the FFT. However, this cannot be done a-posteriori.

The authors then assert that the decrease of the signal-to-noise ratio (due to the spectral broadening described above) is due to signal power leakage of the Discrete Fourier Transform (FFT) calculation. Spectral leakage due to the finite extent of time series (in the case of RWP coherently integrated I/Q data) is a well-known fact in Fourier transforms and it is usually controlled through the multiplication of the time series with some kind of window function. However, the authors unfortunately do not provide information on what particular window function was used in the ARM RWP systems. The Vaisala LAP-3000 RWP traditionally use a "von Hann" (or Hanning) window since this operation was quite easy to apply in frequency domain, but other options were possible in later versions of the Vaisala software. The authors should provide this additional detail.

However, spectral leakage of the Fourier transform is not the only explanation for the broad Doppler spectra observed with RWP during precipitation: Tests with a similar radar have shown that the broadening of the Doppler spectra is rather independent of the window function used in RWP signal processing, at least as long as a reasonable selection like the Hanning window is made. This observation is in contradiction to the assertion that the broadening is due to spectral processing. Given the dynamic range of the RWP receiver it therefore appears to be more likely that the broadening is caused by signal contributions from the antenna sidelobes. The authors should comment on this alternative explanation, even though it has no consequences for the correction methodology presented.

Very insightful comments. Thank you for these suggestions. To really understand what processes are causing the increased noise level estimates in the Hildebrand and Sekhon (1974) algorithm (HS algorithm), co-author Paul Johnston performed more simulations producing I and Q voltage time-series

data and then replicating the LAP-XM signal processing chain. The simulations support the reviewer's comments, specifically that the leakage from the FFT is not the cause of the increased noise level estimate. The simulations show that the noise level estimate is biased high when the signal spectrum is so broad that there are not enough noise-only spectral bins for the HS algorithm to get a good statistical representation of the noise. The simulations show that the signal spectrum broadening due to a von Hann time-series window (that is default windowing function in LAP-XM) and FFT processing broadens the signal spectrum by only a couple spectral bins, which is insignificant compared to spectrum broadening due to velocity aliasing and turbulence during intense convective precipitation.

The specific comments about leakage from the FFT processing have been removed from the manuscript. Text has been added to provide more details about how signal spectrum broadening limits the number of noise-only spectral bins in the spectrum and interferes with the HS algorithm making a good noise level estimate. **Please see lines 319-336 in the Track-Change document.**

A few other minor remarks:

Line 16/17: "The third step increases the signal-to-noise ratio (SNR) due to signal power leakage during the Fast Fourier Transform (FFT) calculation" - should be reformulated for more clarity, as the broadening (regardless whether this is due to the antenna sidelobes, or due to spectral leakage) leads to an increase of the noise level and thus a decrease of SNR.

Agree. There are several processes that increase the estimated noise level more than FFT leakage. The reference to FFT leakage was removed. **Please see lines 18, 188, 329, 334, and 335.**

Line 34: "At the radar measurement level, radars measure the return signal power as a function of range" - suggest a different wording

Used different wording. **Please see line 36.**

Line 37 "every radar subsection" - suggest radar hardware component

Text changed. **Please see line 39.**

Line 39 "pole mounted corner reflector calibrations" - this method is impractical for the rather large and fixed phased array antennas of the RWP and does not need to be mentioned here

Removed text and improved clarity of remaining text. **Please see lines 40-42.**

Line 57/58: "to account for radio frequency interference (RFI) that sporadically increases noise power estimates" - The effects of RFI remain largely unclear. Therefore the authors should provide more details on the characteristics of this particular RFI contamination. Not every RFI signal increases the noise power.

Correct, RFI sometimes increases noise power and other times it does not. Reference to RFI interference was removed. **Please see line 61.**

Line 96 (Table 1 Pertinent RWP operating parameters): For sake of completeness the authors should also provide an short overview of the RWP signal processing algorithms used. Was there any kind of time-domain nonlinear filtering applied ? Was the spectral integration done using Merritts (1995) statistical

averaging method? Which moment estimation algorithm was used - single peak picking or multiple peak picking?

Good idea. A paragraph was added with an overview of the RWP signal processing algorithm. **Please see lines 98-111.**

Line 243 "The impact of the TDA low-pass filter can be mitigated by applying a correction factor.." The authors could perhaps add a reference to Wilfong et al. (1999) "Optimal Generation of Radar Wind Profiler Spectra" which further discusses the TDA filter characteristics.

Included the Wilfong et al. (1999) work into this discussion. **Please see lines 282, 292, and 332.**

Line 277/278: "As the signal power magnitude increases, the FFT leakage causes the spectrum noise power to increase above the noise power produced by other radar noise sources". This statement is rather awkward and should be reformulated, also in view of the remarks made above.

Yes, this FFT leakage is not the main cause of the noise power bias. This reference to FFT leakage was removed and the first paragraph in Section 3.2 was rewritten. ***Please see lines 320-337.***

Line 312 plus multiple other occasions: "Parson's correlation coefficient" should be corrected to Pearson's correlation coefficient

Thank you for catching this error. Corrected in 5 places. **Please see lines 375, 377, 383, and 390.**

Line 645: The given link "https://github.com/ChristopherRWilliams/rwp/Python/spectra" is incorrect. The correct link is obviously https://github.com/ChristopherRWilliams/RWP_Python_moments

Thank you for seeing this error. The link has been updated. **Please see line 769.**