

## ***Interactive comment on “WIRA-C: A compact 142-GHz-radiometer for continuous middle-atmospheric wind measurements” by Jonas Hagen et al.***

### **Anonymous Referee #2**

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The manuscript “WIRA-C: A compact 142-GHz-radiometer for continuous middle-atmospheric wind measurements” by Hagen et al. presents an important upgrade of the middle-atmospheric wind profiler WIRA. This new version is a compact and fully autonomous radiometer that can be easily transported and operated remotely. The hardware, the observation procedure and the retrieval method have also been optimized in order to improve the wind measurement performances.

The validation with the lidar observations is frustrating since only seven coincident profiles are available. Also a comparison with the well-validated original WIRA would have been interesting. However we can consider that the good results with the lidar

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comparison and the good agreement between ECMWF and WIRA-C over a period larger than 1 year demonstrate the instrument potential. I hope that further validation will be presented in a future manuscript.

The paper is well written though I think some explanations are missing in order to fully understand the retrieval setting. The manuscript should be published in a journal like AMT and minor comments are given here below.

- A table summarizing the instrument and observation characteristics (bandwidth, resolution, integration time, system temperature, line-of-sight elevation range, ...) would help the reader.

- The following equations need further explanations:

Equation 3: Is the term “-sin(eta)” missing in the right side of the equation? The way to estimate  $T^{bg}$  should be described. I also think that its definition (line 18) is too far from Eq 3.

Equation 5: Is  $M = 2$  or  $6$  (P 13, Line 13) or other? Is-it the same  $M$  for all retrievals? If  $M=2$ , the setting looks like a normal retrieval. How the 3-dim retrieval is done? Do the authors quantitatively assess the improvements compared to a normal retrieval?

Equation 10 corresponds to the linear OEM equation with the forward model  $y = K * x$ , but it is stated that a non-linear retrieval is used (P 12, Line 15). Some explanations are needed to clarify the apparent contradiction. I also assume that only  $K$  and  $G$  are updated in the iterative process and not  $x_a$ . Am I right?

- Page 10, lines 5-14: The observation strategy is not clear for me. Do the authors compute equation 4 with data obtained over short periods and, then average the calibrated spectra over 12 hours? If yes what is the time period to get a calibrated spectrum?

- P13, Line 15: More information are needed to understand how the statistics are calculated (which climatology is used, spatial and time ranges to compute statistics, ...) The authors use different a priori errors for the meridional and zonal components of the

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wind vector according to the wind variability. As stated in the text, such an approach leads to different retrieval performances (retrieval precision and vertical resolution) for both components. This is a choice of the author since the measurement does not depend on the LOS orientation. The authors should explain more clearly the motivations for choosing this setting instead of using the same one for both components. The wind variability is multiplied by factor 2 to construct the covariances, which let me think that having covariances representing the variability is not a key issue. Personally I would use a similar a priori error as that used for the zonal wind for both components in order to keep the vertical resolution close to 10 km given that the retrieval precision can be improved by averaging profiles but the vertical resolution cannot. Vertical resolution is an important issue for a site at La Reunion latitude since tides can induce vertical patterns on the meridional winds with vertical scales of 15-20 km and an amplitude that can be larger than 10 m/s.

- P13, Line 20: As for the wind climatology, we need more information on how the statistics are performed to compute the mean and the covariances of O3. How the six ozone profiles are used?

- P13, Line 25: Is-it really indicated in Sect. 4.3 that the O3 covariances are height independent?

- P14, Line 2, no need of "hat" in the second " $\hat{x}$ "

- P14, Line 33, Should "Sect 4.3" be "Sect 4.4"?

- P15, Line 22, correct "to to"

- P15, Fig. 9: The ozone line is shifted toward the right side of the band. The first 20 MHz range on the left side of the spectrum should contribute to the wind retrieval at the lowest retrieved altitudes. Combining the two spectra with opposite directions provide antisymmetric wind signature. Is this frequency range a significant contribution to the retrievals? If yes, the wind retrieval might be sensitive to different errors on the

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amplitudes of the two calibrated and tropo-corrected spectra? If yes, the statement that wind are not sensitive to amplitude calibration errors should be weakened.

- P17, Tab 1: How is the perturbed profile computed? Is the same perturbation applied at all altitudes or is it altitude dependent? ( $x_p[i] = eps + x[i]$  or  $x_p[i] = eps[i] + x[i]$  ?) If it is the second case what is the vertical resolution of the perturbation and the vertical correlation?

- P19, Sect. 5.3: Does the time series in Figures 11-14 include the day and night data?

- P21: Does "smoothed in time" mean 12 hours average? The size of the pictures could be increased.

- P24-P25: The starting time for the observations should be indicated in Fig 15 caption. I think local time is more relevant than UT (Fig. 16 caption). Why some WIRA meridional profiles are cut below 55 km? Fig.16 caption: correct "measuremnts" at the end of the second line.

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