

Interactive comment on “Middle-atmospheric zonal and meridional wind profiles from polar, tropical and mid latitudes with the ground-based microwave Doppler wind radiometer WIRA” by R. Rüfenacht et al.

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Reply to comments from referee #1

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- blue: referee's comments
- green: author's replies

General Comment:

The paper is well written and pleasant to read. It describes a novel and unique method to derive wind in the upper strato- lower mesosphere. The paper builds on and significantly improves a previous work by Ruefenacht et al., 2012.

Technical corrections:

It would be helpful if the temporal and altitude resolution and the accuracy are given in the summary and the abstract. Otherwise readers will extract their own numbers and these will likely not be as good as they are.

The abstract has been modified and now reads as: "... periods between 5.5 and 11 months. The data presented in this paper are daily average wind profiles with

typical uncertainties and resolutions of 10 to 20 m s^{-1} and 10 to 16 km , respectively. A comparison between the data series...”

In the introduction a reference to radar data seems to have gotten lost, leading to a statement that is wrong: “... However, in the middle atmosphere the only continuous source of wind data so far were models. A gap region with a lack of measured ...” MF Radars are performing continuous wind measurements in the middle atmosphere sometimes down to 50 km , usually down to 70 km e.g. Singer et al., (2003), Hoffmann, JASTP, 2007 or <http://www.atrad.com.au/products/scientific-radars/mf-radar/>. I suggest to correct the statement.

The references to rocket aided techniques seem to be biased to recent results. Older references could be: Finger et al., Compatibility of Meteorological Rocketsonde Data as Indicated by International Comparison Tests., Journal of the Atmospheric Sciences, 1975, vol. 32, Issue 9, pp.1705-1714 or regarding TMA: Edwards, H. D., M. M. Cooksey, C. G. Justus, R. N. Fuller, and D. L. Albritton, Upper-atmosphere wind measurements determined from twelve rocket experiments, J. Geophys. Res., 68, 3021–3032, 1963.

Regarding Microwave wind retrievals one could add: Baron et al., Observation of horizontal winds in the middle-atmosphere between 30° S and 55° N during the northern winter 2009–2010. ACP, 2013

The part describing the other measurement techniques has been re-written citing the references suggested. I could find the information of radars measuring down to 50 km in none of the references you had indicated, nor in any other publication. The lowest limit I have found for radars is 60 km (Nicolls et al., 2010). The manuscript now reads as: “Only very few measurement techniques covering parts of this altitude range are or have been operated on campaign basis. Measurements from Rayleigh lidars (Baumgarten, 2010), rocket aided techniques (e.g. Goldberg et al., 2004; Chu et al., 2007; Finger et al., 1975) have been presented. Different upper atmosphere radar techniques provide data above 70 km altitude. Under special atmospheric conditions

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measurement ranges extending as low as 60 km have been reported (Jacobi et al., 2007; Hoffmann et al., 2007; Nicolls et al., 2010). For a limited time microwave wind measurements have been performed from space by the microwave limb sounder SMILES (Baron et al., 2013)”

Figure 11 is correctly discussed in the text, but the figure itself is misleading. Above and below the trustable altitude range the standard deviation of the resulting profiles in the Monte Carlo simulation does not correspond to the “Wind observation error” that is given as axis label. I suggest just not showing the data outside the trustable altitude region. I would also expect that the trustable altitude range is different for each of the curves shown.

Absolutely. The label has been changed to “Wind uncertainty [m/s]”. The dashed horizontal lines corresponded to the worst case for the double sideband receiver with 0.2 K noise. The figure has been modified so that it just shows data lying inside the trustable altitude range.

Page 7721, lines 7-9: sentence should be checked “in order” is used twice. Second “in order” skipped.

Page 7726, line 2-3: “winds are calculated from the difference between the retrieved wind profiles for east and west ...” I suggest re-writing this sentence to clarify the procedure. Reading the sentence as it is one could also conclude that the difference between the wind profiles east and west should be zero.

This is an issue of defining the positive/negative direction in the observation geometry. Wind blowing towards (away from) the receiver is defined as positive (negative). Therefore the observations taken in east and west (north and south) generally have opposite signs so that their difference divided by two corresponds to the mean wind. The sentence has been re-written: “...applied to each direction, with wind blowing towards (away from) the receiver defined as positive (negative). The zonal and

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meridional wind velocities are thereafter..”

Page 7726, lines 7-11: Please consider adding a statement why the wind retrievals are not affected by inaccuracies of the actual ozone profiles. Due to the statement on Page 7724, line 10-12: “... Therefore we can state that the effect of wind variations on the measured brightness temperature spectra is approximately thirty times smaller than for species profile retrievals.” One might (falsely) conclude that if the species retrieval fails the results of the wind retrieval might even be worse.

The effect of ozone variations on the wind profile retrieval is now discussed in a new paragraph in Sect. 4.3 which was added to the manuscript in reply to the comments from referee #3. The text on p. 7726 has been adapted as follows: “Therefore we can state that the effect of wind variations on the measured brightness temperature spectra is approximately thirty times smaller than the effect of typical ozone variations. However, the wind retrieval is fairly independent of the ozone retrieval as will be shown in Sect. 4.3.”

Page 7727, lines 10-11: “measurement response” is used before it is defined on in the next section (line 21)

Measurement response is indeed defined in detail only in the following section. Therefore the following footnote has been added: “For the definition of the measurement response, please refer to Sect. 4.2.”

Page 7729, line 12: In the text zenith opacities are discussed, but the figure shows noise levels. I suggest adding a sentence how the quantities are related.

The following explanation has been added to the manuscript: “On days with more liquid water the enhanced tropospheric opacity attenuates the radiation originating from the middle atmosphere leading to a lower line amplitude. Therefore it is more likely that spectra from single measurement cycles do not meet the minimal signal to noise ratio conditions (ratio between line amplitude and measurement noise), so that

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less single measurements contribute to the daily average spectra. This leads to a higher signal to noise level on the spectra input to the retrieval algorithm. Under such conditions the dashed lines in Fig. 11 better characterise the error than the full lines.”

Page 7732, line 18: “The results from La Réunion are not plotted ...”. The reader would be grateful for a plot of the absolute differences to ECMWF in zonal and meridional direction.

The absolute differences between WIRA and ECMWF zonal wind are displayed in Figs. 14 and 15 (Fig 15b for La Réunion).

The discrepancies between meridional wind from WIRA and ECMWF are within the errors of WIRA, maybe also because of the small absolute fluctuations in meridional wind speed. Therefore we would not like to bother the reader with a plot with little information gain. In case of interest in the behaviour of the meridional wind in some special situations the reader can always refer to Fig. 13 to compare WIRA measurements to ECMWF.

Page 7733, line 18: “mesoshperic” should read “mesospheric”
Corrected.

Page 7734, line 8: The statement “... good agreement in the daily average meridional wind” is not quantified, having a plot of the absolute differences (see comment Page 7732, line 18) would help here.

The statement has been adapted to “... agreement within the errors of WIRA in the daily averages of meridional wind”.

Figures:

Fig. 1: Extend the caption to describe the components of the instrument that can be seen (e.g. mirrors, moving mirrors, . . .)

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The first prototype of WIRA has been described in Rüfenacht et al. 2012. As the present paper aims to focus on the retrieval and atmospheric measurements the instrument is not described in detail again. We decided to just state the principal changes since the version described in 2012 in order to keep the instrument part concise and not repeating ourselves. Therefore the reader should refer to Rüfenacht et al. 2012 for instrumental descriptions and especially for the (unchanged) optical part.

Fig. 4, 5: Axis labels to small

These figures (and their axes labels) will be larger in the final version to be published in AMT.

Fig. 6: Axis labels missing. The altitude is given in km, but in text altitudes are discussed in pressure level. I suggest to add the pressure level.

Thank you for pointing this out. The figure has been adapted in this sense.

Fig. 7 to 16 would benefit if an approximate altitude scale in km is given, or the axis limits are given in km in the figure caption.

Where possible (no interference with colourbars or other subplots) an approximative altitude scale has been added as a second y-axis.

Fig. 8: axis labels to small, the explanation of the sub-figures should be given in the caption not in the figure.

The figures will be larger in the article published in AMT and their readability re-checked at the time the typeset manuscript is ready. The explanation of the subfigures was included to the figure caption.

Fig. 11: Description of horizontal dashed lines missing.

The dashed lines were the altitude limits of the trustable altitude range for the worst case (double sideband with 0.2 K noise). The figure has been adapted in the sense

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that the data displayed are cropped when they lie outside the trustable altitude range (according to your above comment).

Fig. 12, 14, 15: the figures are much to small.

This is a problem of the page format of the discussion paper. These figures will be much larger in the final version to be published in AMT.

Fig. 14: Description of dashed lines should be given in figure caption not text.

The manuscript has been adapted in this sense.

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