Reply to acp-2017-167-RC2, a review of the manuscript ACP-2017-167 “Winds and temperatures of the Arctic middle atmosphere during January measured by Doppler lidar”

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The paper presents wind and temperature measurements by lidar technique at the arctic location of Andoya (69° N). The data are from three Januarys in 2012, 2014 and 2015. The measured night time profiles extend form approx. 30km to 85 km altitude with a temporal resolution of 1 hour. Profiles are compared with corresponding ones from ECMWF and HWM07. Significant differences in temperature and wind between the models and the measurements are reported. In a second part of the paper the authors deduce potential and kinetic gravity wave energy densities based on the measured temporal fluctuations of temperatures and winds.

The paper is carefully and clearly written and easy to follow. Figures are clear and document well the results.

It has to be noted, and the authors clearly summarize this in the introduction, that measured wind profiles are very rare and accordingly very few papers present measured data. Further, the number of publications showing datasets over some extended periods are even more scarce. This paper presents extended data for three Januarys and therefore significantly contributes to an area of middle atmospheric research where the data amount is small so far. This is particularly important as in recent years experimental techniques suffer from declining interest and more weight is put on modeling. Data with high quality as presented in this paper are therefore of extreme value for the validation and improvement of models and they merit to be published. This is particularly true for the data discussed in the current paper.

I therefore recommend to publish the paper with some minor modifications or corrections.

Comments

1. In the section about data, page 3, lines 28 etc. it is not clear how the measurement uncertainties are defined. On the one hand they say that typical values are 0.5K and 3m/s for temperature and wind resp. However then it is said that data with uncertainty values roughly ten times higher are also considered. Please clarify why

this large range of uncertainties exists and why you take all these data with high uncertainty into consideration.

Measurement uncertainties arise from the statistics of the backscattered laser photons detected. As less photons are recorded for higher altitudes (as there are less air molecules), the measurement uncertainty increases with altitude. Therefore, values with a certain range of measurement uncertainties have to be taken into account. As can be seen in Fig. 5 the thresholds mentioned in Sect. 3 are exceeded for 1 h profiles at $\approx$ 88 km and $\approx$ 78 km altitude for temperatures and winds, respectively, while nightly mean profiles exceed the thresholds at higher altitudes (since more data are taken into account).

We expanded the respective paragraph in the manuscript.

2. Section 4 about results shows high variability in temperature and wind from night to night. The January variability particularly in wind significantly depends on where the measurement is taken with respect to the vortex edge. Indeed the authors several times say that the position of the vortex is important but they do never show where it actually is. Unfortunately it is not possible to find out when the measurement was inside or outside of the vortex. I strongly recommend that the authors separate the data set in two, one with profiles from inside and the other one from outside the vortex. Also the comparison with the models might then change. The large differences between model and data might be explained by such an inappropriate comparison. Section 4.2 as well is linked to the polar vortex and the authors say that a reformation of the vortex took place. Unfortunately again it is not clear how the situation was at Andoya where the observations took place. Please expand this section regarding the vortex.

   To get information about the position of the polar vortex relative to ALOMAR, we examine the potential vorticity at a given potential temperature level, as suggested by *Rex et al.* (1998) and applied by, e.g., *Grooß and Müller* (2003): The edge of the polar vortex is defined as potential vorticity of 36 PVU at the 475 K potential temperature (Θ) level. Using ECMWF data we derive the potential vorticity at $\Theta = 475$ K for each 1 h profile of each night (linear interpolation of potential vorticity from model/pressure levels to Θ levels). A night is then considered as "inside" or "outside" of the polar vortex, if all (or all but one) 1 h profiles have potential vorticity smaller or larger 36 PVU, respectively; during nights with multiple "inside" and "outside" profiles the vortex edge lies above the site. It has to be noted that the polar vortex might bend and twist and therefore the vortex location as defined at 475 K ($\approx$ 19 km altitude) may not always represent the situation in the upper strato- and mesosphere.

   Figure 1 shows the same data as Fig. 3 of the manuscript but split depending on relative vortex positions. In the cumulated data (panel d) temperatures are higher inside the vortex than outside, according to expectation. This behaviour is not seen in January 2012 with lower "inside" than "outside" temperatures below 50 km altitude and January 2014 with only very small differences between "inside" and “outside” temperatures. Note that the “vortex edge” profiles are not intermediate profiles between the “inside” and “outside” profiles. Hence, the temporal development of the dynamics (as discussed in Sect. 4.2 for January 2012) seem to surface more dominant than the – somewhat static – distinction between being inside or outside the polar vortex; furthermore, each data subset consists of few nights only. Therefore, and because the lidar-to-ECMWF comparison seems not to differ fundamentally for the separated data sets, we don’t discuss all the aspects mentioned in the manuscript for the separated data.

Nevertheless, we expanded Sect. 4.2 about the SSW in January 2012 and mention for each profile in Fig. 2 of the manuscript to which class (“inside”, “outside”, “vortex edge”) it belongs.

Technical corrections

1. Abstract line 16: The sentence “The total LWED.” does not make sense. Something is lost here . page 3, line 25: . . . was acquired during the nights in January 2012. . .

   done; done

2. page 6, line 12: either use “this discrepancy” or “these discrepancies”

   done

References

Grooß, J.-U., and R. Müller, The impact of mid-latitude intrusions into the polar vortex on ozone loss estimates, *Atmos. Chem. Phys.*, *3*(2), 395–402, doi:10.5194/acp-3-395-2003, 2003.

Rex, M., P. von der Gathen, N. R. P. Harris, D. Lucic, B. M. Knudsen, G. O. Braathen, S. J. Reid, H. De Backer, H. Claude, R. Fabian, H. Fast, M. Gil, E. Kyrö, I. S. Mikkelsen, M. Rummukainen, H. G. Smit, J. Stähelin, C. Varotsos, and I. Zaitcev, In situ measurements of stratospheric ozone depletion rates in the arctic winter 1991/1992: A lagrangian approach, *J. Geophys. Res.*, *103*(D5), 5843–5853, doi: 10.1029/97JD03127, 1998.

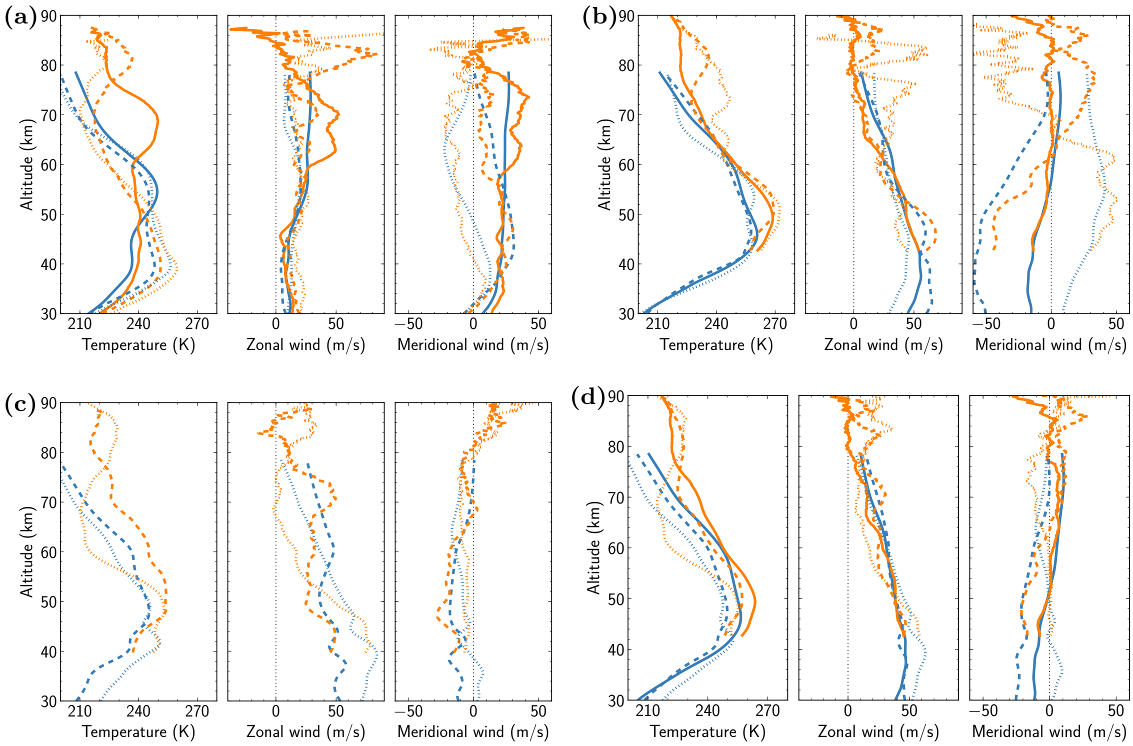

Figure 1 Like Fig. 3 of the manuscript, but data set split depending on relative vortex positions. January mean temperatures and horizontal winds for the years 2012 (a), 2014 (b), and 2015 (c), and cumulated data (d). Orange: ALOMAR RMR lidar, blue: ECMWF. Solid lines: inside the polar vortex, dashed lines: outside the polar vortex, dotted lines: vortex edge.