Reviewer No. 1

Response to the report of the reviewer to our paper:

'Simultaneous and co-located wind measurements in the middle atmosphere by lidar and rocket-borne techniques´

by Franz-Josef Lübken, Gerd Baumgarten, Jens Hildebrand, and Francis J. Schmidlin

submitted for publication in *Atmos. Meas. Tech.*, 2016.

Manuscript Number: amt-2016-106

Introductory remarks:

We appreciate the comments from the reviewer. We have taken his/her suggestions for improvements into account when preparing the revised version of the manuscript. In the following we respond to the reviewer's comments point by point. We have marked the changes in the revised version of the manuscript.

1. We fully agree with the reviewer who has summarized correctly the fundamental difference between lidar (Eulerian) and insitu (Lagrangian) observations. Following his/her suggestions we have inserted a comment on this topic at the beginning of section 5.

2. We thank the reviewer for addressing this topic in such detail. He/she is correct in stating that there are no vertical wind observations available during our campaign. Even worse, we don't know of any technique measuring(!) vertical winds in the mesosphere/upper stratosphere. Some few exceptions basically involve radar techniques (mainly EISCAT) in the upper mesosphere/lower thermosphere and the foil cloud technique introduced by Hans Widdel ('Vertical movements in the middle atmosphere derived from foil cloud experiments', *J. Atmos. Terr. Phys.*, 49, 723–742, 1987). Both techniques suffer from significant uncertainties. The other examples cited by the reviewer are from models and may be not be correct or not be applicable in our situation. On a long term average (more than some hours) vertical winds are presumably very small (mm/s to cm/s) and are mainly determined by the residual circulation. As the reviewer pointed out correctly, we can safely ignore these small vertical winds. On shorter terms, vertical winds are expected to be significantly larger, for example as generated by gravity waves. Therefore, some of the gravity wave features detected in our observations may indeed be due to vertical winds. As mentioned in the paper, we will perform a more detailed analysis of the gravity wave signatures in a later paper. For starutes and radiosondes, we will have to consider gravity wave modulations of background densities also, since they modify vertical movements (we will apply

the polarization relations for gravity waves for this purpose). In summary, the suggestion by this reviewer is well taken and will be considered in a future paper. We have added a note on this topic in the revised version of our paper.

3. It is indeed a good idea to characterize the apparent gravity wave features in more detail using hodograph methods. Again, we refer to the main aim of our paper, namely a comparison of instrumental techniques, whereas a detailed analysis of the entire wave field will be performed in a later paper. We hope for the understanding of the reviewer. We have added a short note regarding the hodograph technique.

4. The reviewer is correct: scattering due to air molecules only (without aerosols) was derived from Raman scattering on N_2 at 608 nm. We have added a note in the manuscript.

Technical corrections

(1) The reviewer is correct that the launches from 4/5 March and 10 March are not used in this paper. Still, we would like to keep them in Table 1 because i) it demonstrates the overall success rate of the starute flights, and b) the Table may be used for future reference.

(2) We have corrected the typos.

(3) a.: In the revised version we have added a drawing of a starute where the 'burble fence' can easily be identified. The purpose of this device is explained in the main text.
b.: We have changed the wording.

(4) We have inserted commas, as suggested.

(5) We have removed commas, as suggested.

(6) We agree and have changed the wording.

Kühlungsborn, July 11, 2016. Franz-Josef Lübken (for all coauthors)

Reviewer No. 2

Response to the report of the reviewer to our paper:

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by Franz-Josef Lübken, Gerd Baumgarten, Jens Hildebrand, and Francis J. Schmidlin

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Introductory remarks:

We appreciate the comments from the reviewer. We have taken his/her suggestions for improvements into account when preparing the revised version of the manuscript. In the following we respond to the reviewer's comments point by point. We have marked the changes in the revised version of the manuscript.

Specific comments:

- *'Comparison during daylight'*
  We have performed a few flights during daylight conditions some years ago but haven't put too much emphasis on analyzing these flights (yet) due to some technical problems with the starutes and also with DoRIS at that time. We think, however, that winds from DoRIS are also reliable during daylight conditions, since there is no apparent 'jump' in the wind field at the transition between day and night, and vice versa (see Figures 1 and 3 in the Baumgarten et al. paper from 2016). We have added a short note on this topic.

- *'Uncertainty due to radar tracking'*
  The basic information on the position of the starute comes a radar tracking the starute. If that radar track is uncertain, e. g. because of improper identifying and following the target, this results in errors in positioning the starute and thereby in uncertainties of the winds derived from the trajectory. A deeper analysis is given in the Schmidlin et al. paper mentioned in the paper (this manuscript is part of the ESA proceedings from a long-standing symposium on rocket and balloon borne techniques). In our case, we have estimated this uncertainty to be on the order of ±0.5–1.5 m/s, depending on the performance of the starute.

- *'Vertical winds from DoRIS?'*
  DoRIS can in principle measure vertical winds if we point one (or better both) telescopes into the vertical direction. However, mean vertical winds are much

smaller compared to horizontal winds and vertical winds cannot be obtained from starutes (only horiontal winds). We therefore pointed the telescopes as much as possible to the horizontal. The maximum zenith angle of the telescopes is 30 degrees and is given by mechanical constraints of the supporting structures.

- *'Datasondes'*
  We have added a drawing of a starute in the revised version which hopefully makes it easier to understand how this system works. The basic performance and the purpose of the 'burble fence' is explained in the main text.

- *'Uncertainty at 30/40 km'*

  As requested, we have added a note regarding the error bars below 40 km

- *'What is shown in Figure 7'*
  We wanted to demonstrate the natural variability of the wind field as measured by DoRIS within a certain time period of ±30 min around a given datasonde flight (SL6 in the case of Figure 7). We think that this is an important information when considering any potential difference between DoRIS and starute winds since these measurements are not made at exactly the same location and not exactly at the same point in time (e.g., due to time averaging of the DoRIS profiles). We have replaced the word 'repeatability' by 'natural variability' in the text.

Minor comments

- *'First sentence in the abstract'*
  We agree with the reviewer and have modified the first sentence in the abstract.

- *'upper stratosphere ?'*
  We agree and have added 'middle' in the revised version.

Kühlungsborn, July 11, 2016. Franz-Josef Lübken (for all coauthors)