Author's response on "Mesospheric temperature soundings with the new, daylight-capable IAP RMR lidar" by Gerding et al.

Referee #1

Initial review of Mesospheric temperature soundings with new, daylight capable IAP RMR lidar by Gerding et al.

This paper provides a technical description and sample data and measurements of the daylight-capable Rayleigh-Mie-Raman (RMR) lidar at the Institute of Atmospheric Physics (IAP). This lidar system is a state-of-the-art instrument and the daytime measurement capabilities are a major contribution to the observation of the middle atmosphere. The instrument is not just significant because of it's measurement capabilities that allow observations over full diurnal cycles, but also because of it's stable operation that allows ready acquisition of observations (~1000 h per year). The work is appropriate to Atmospheric Measurement Techniques and will be of interest to researchers. The paper serves as an important technical companion paper to the recent paper by Kopp et al. (JASTP 2015) that presented measurements of the tides by the RMR lidar and highlighted the importance of full-day and multi-day operation in accurately characterizing the tides and their variability. I would like to see some of the technical and operational details expanded.

We thank the reviewer for the helpful comments. Below we cite each comment (indicated by italics) followed by our answer. Line numbers are given with respect to the manuscript with marked changes.

1) Can the authors add a raw data profile showing the signals in all four channels (3 Rayleigh, and 1 Raman)? A plot showing raw data profiles (that shows total signal including signal and background) representing observations over one hour at midnight and noon would be a valuable addition to the presentation.

We have added a new Figure 4 in the revised manuscript, showing the raw data with and without background correction. We have chosen a one hour period near highest solar elevation from the same sounding also used in Figure 3 and 6 (old Figure 5), and a period 12 h later. Cf. page 4, lines 28-33.

2) Can the authors discuss the stability of the system in terms of the following key elements; a) Line center and line width of the laser transmitter. What is the accuracy and precision of the wave meter? Is the wave meter wavelength recorded on a pershot basis?

The seeder was stabilized to 532.096 nm (in air) until June 2015. Since then we use another iodine line for stabilization, resulting in a wavelength of 532.110 nm (cf. Table 1). The line center of the pulsed laser can actually not be measured. A so-called Laser Pulse Spectrometer is under construction, allowing such a measurement in future (cf. Baumgarten, AMT, 2008). Line width is (45 fm), estimated from pulse length as later described in Section 3. The Wave meter (30 MHz accuracy) is only used for coarse adjustment of the seed laser wavelength to the desired iodine line, while the fine control of the wavelength is done by iodine absorption spectroscopy. Wavelength stability of the seed laser is ~0.5 fm rms, i.e. much below the expected rms of the pulse laser. Wave meter and iodine measurements are logged once per second. We have slightly changed the manuscript to make this clearer (new page 3, lines 12/13).

b) Line center of the pressure tuned Fabry-Perot etalons. What is the sensitivity of the line center to changes in pressure and temperature? How are the temperature and pressure monitored and maintained?

Pressure and temperature are not directly monitored, but the transmission of the etalons is measured continuously during the soundings. Room temperature is conditioned to 1 °C with insulation and large optical table as additional heat sink. The pressure is kept "constant" using a sealed housing. Transmission changes are below ~1% rms over a single day. Pressure is re-adjusted at max. ~10% transmission reduction of the double etalon, according to ~0.2 pm wavelength shift. This wavelength shift may result in 0.4 K over-correction of temperatures near the stratopause and less above and below. We have expanded the description of the double etalon and the discussion of the temperature correction accordingly (new page 4, lines 10/11 and page 6, lines 27-29).

c) Pointing jitter in the steering mirrors. How does the jitter compare with the 12 micro-radian margin between the receiver field-of-view (62 micro-radian) and transmitter beam divergence (50 microradian)?

The remaining pointing jitter is 3-5 microradian (cf. Eixmann et al, IEEE, 2015 and new page 3, line 20).

d) Do any of the variations (a-c) impact the narrowband filter correction, and if so can you characterize this uncertainty in the temperature retrievals?

We thank the reviewer for pinpointing some weaknesses in the manuscript. As described above in topic 2 c, we have added some sentences about potential temperature errors due to mis-adjustment of the etalons.

3) The presentation of the narrowband filter correction is valuable (Figure 5). A third curve showing the difference between Tnew-uc and Tnew-c would be useful. The authors could also cite maximum, minimum and typical differences in the uncompensated and compensated temperatures.

Many thanks for this suggestion. While we would like to avoid another curve for the sake of clarity of the figure, we will mention typical numbers for the correction instead (new page 6, lines 23-27).

4) The presentation of the filter and line shape in Figure 4 might be clearer if the intensity and transmission were plotted on a logarithmic scale. Several of the curves are hard to distinguish.

We follow this suggestion and show the left figure with logarithmic scale (new Figure 5).

5) The temporal resolution of the temperature measurements in Figure 7 is not reported. From the pixels it appears to be about 15 minutes. Can the authors please cite the resolution of the measurement?

We are sorry for this omission. The temperatures in this case are calculated every 15 min with 2 h integration (cf. new caption of Figure 8).

6) While comparison with ECMWF is interesting, is it possible to show a comparison with SABER?

We thank the reviewer for this suggestion. Instead of the ECMWF 00 UT profile we will show the coincident SABER profile (new Figure 7). SABER confirms the large temperature variation with altitude, even if the phase is somewhat different. This is not surprising, taking the spatial separation of lidar profile and SABER tangent point (900 km) into account. We will change the description of the figure accordingly (new page 7, lines 25-27).

7) Is Figure 7 the downward phase progressions appear to change phase speed above 70 km. The authors report tidal amplitudes unto 75 km. Do the authors feel that the change in phase above 70 km is geophysical in origin or perhaps reflects the initialization of the temperature retrievals at 85km?

We apologize for the misprint, but the temperature retrieval was initialized at 80 km. For our previous RMR lidar in combination with a K resonance lidar we have checked whether wave retrieval is influenced by the temperature seeding (true temperature or climatology). We found only little effects. Therefore we feel the wave parameters to be realistic up to 75 km.