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Atmospheric Measurement Techniques
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Discussions

Interactive comment on "Evaluation of methods for gravity wave extraction from middle atmospheric lidar temperature measurements" *by* B. Ehard et al.

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The paper addresses an important issue in understanding the weather and climate of the middle atmosphere. While gravity waves have a significant impact on the circulation of the atmosphere, the estimates of gravity wave activity (i.e., potential energy per unit mass) are very sensitive to the inversion or retrieval methods used to quantify their activity. Thus the situation where ground-based lidar measurements are sparse (i.e. a global view based on observations in less than a dozen sites world-wide) is further compromised by uncertainties in the retrieval methods that reduces the significance of comparisons of wave activity at different sites. The challenges are not insignificant given that the gravity wave fluctuations can represent variations of 1% in temperature

and density. While single site (or single research groups) yield measurements that are locally consistent and allow studies of wave activity under different meteorological conditions (e.g., consistent increases and decreases in wave activity associated with changes in the mean winds), and allow comparisons of seasonal variations between sites, unambiguous direct comparisons are not robust. The current paper highlights the impact of different established methods used in the retrieval of gravity wave fluctuations and estimate of gravity wave activity showing an order of magnitude variation in the estimates of gravity wave activity, based on different background removal schemes.

The authors consider the classic retrieval of temperature from Rayleigh lidar measurements, and the determination of the wave-induced fluctuations from those temperature retrievals. The authors present a comparison of four commonly used methods (i.e., subtraction of observation mean, subtraction of temporal running mean, subtraction of sliding spatial polynomial fit, and high-pass Butterworth spatial filter). The authors show that the Butterworth fit yields the most accurate retrieval from simulated data sets.

The authors highlight the fact that lidar data can be more uniform in height than time, and thus spatial filtering-fitting techniques may be more robust than temporal filtering-fitting techniques. The case study showing real data shows that the sliding polynomial and the Butterworth filter yield similar fluctuations (Figure 6 e and f). However, the 3 h running mean clearly captures waves with different vertical phase speeds, and highlights the importance of understanding what wave periods and scales are contributing to the resolved wave-field. Analysis of the two-dimensional gravity wave spectrum would help address this issue. Future 2-d Spectral analysis of Rayleigh lidar data sets (without gaps) could provide valuable insights.

The results in Figure 7 would be enhanced by showing errors or uncertainties in the potential energy per unit mass profiles. Are the profiles significantly different above 60 km? The addition of error bars would allow the reader assess these differences.

The estimate of relative temperature fluctuations is sensitive to two distinct issues; the choice of background profile, and the wave scales included in the fluctuations. The former may yield systematic changes of 10-20%, however the latter may yield changes on order of over 100%. In the presentation of the temperature fluctuations in Figure 6 , it may be useful to add a presentation of the relative temperature fluctuations. Furthermore, subtle filtering effects can yield differences in estimates of gravity wave activity by a factor of 2-3.

The authors note the use of a reflection technique to minimize the discontinuities in the temperature profiles that would yield artifacts in the spectral estimates. Have the authors considered the use of established windowing techniques to address these issues.

The authors discuss the limited bandwidth of temperature fluctuations due to the fact that the Nyquist frequency is limited by the temporal resolution of the lidar measurements. Temperature measurements can be limited by the need to have sufficient signal at the upper altitudes to allow reliable temperature profiles. Use of lidar density measurements can allow higher resolution measurements at lower altitudes. Can the authors cite recent density-based retrievals of gravity wave activity.

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 9045, 2015.