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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Seasonal variation of temperatures between 1 and 105 km altitude at 54° N observed by lidar" *by* M. Gerding et al.

M. Gerding et al.

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We thank referee #1 for the positive feedback. We discuss the comments point by point in the following:

Comment 1 (Using CIRA/MSIS as geographical transfer): The referee is right that we give only qualitative comparisons of the harmonic analysis with results from other latitudes. The data set presented by us is the first comprehensive temperature data set for the latitude of 54° N. Even if the data evaluation methods are similar to previous works, latitude and time period differ from all previous publications. Therefore all quantitative comparisons have to account for latitudinal differences, atmospheric trends and solar cycle effects. There are some publications presenting comparisons of a single latitude with either CIRA or MSIS (e.g. She et al., GRL, 1995; Leblanc et al., JGR, 1998; Lübken, JGR, 1999; Xu et al., JGR, 2007). Typically the differences in the upper mesosphere and lower thermosphere are larger than 10 K and vary with season. Unfortunately, the comparisons of lidar and CIRA/MSIS data from different latitudes can not be directly compared as the time periods differ as well as the used reference data set. We agree with the referee that a comprehensive study of the application of different reference data sets as a quantitative geographical transfer standard is desired. But a sophisticated study on this topic is outside the scope of this paper.

Comment 2 (stratopause/mesopause identification): The referee is right on the problem of possible false interpretations of temperature extrema as stratopause or mesopause. Even in the nightly mean profiles wave perturbations, effects of lidar transition or natural variability may remain that shall not be interpreted as variability of stratopause or mesopause. Therefore, we have limited our interpretation to the temperature profiles taken from the harmonic analysis (cf. p. 16189, ll. 12-13). Furthermore we will add a description of our algorithm: 'The identification of the stratopause is limited to the altitude range 30–60 km and of the mesopause to 75–105 km in order to avoid false interpretations. Within this ranges the absolute temperature extrema will be interpreted as stratopause/mesopause.' In Fig. 8 we compare the results from the nightly mean profiles and the harmonic analysis. As also mentioned in the text there is generally good agreement between both data sets. The largest discrepancies arise in the winter stratopause region, where the altitudes of temperature maxima vary strongly around the stratopause altitude taken from harmonic analysis. This is connected with a large variation in absolute temperatures. We interpret these with stratospheric disturbances due to movements of the polar vortex. We add an appropriate phrase in the final text.

Comment 3 (differences to ECMWF): In Fig. 9 we have averaged all ECMWF data for the period June 2002 to July 2007. By this we got a most representative data set for the region 0–70 km for the time period covered by the lidar. Part of the differences in upper stratospheric temperatures are due to some incomplete sampling by lidar especially

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in winter, as mentioned in the text. ECMWF temperatures are higher, if only nights with simultaneous lidar soundings are considered. On the other hand direct comparison during usual warm periods often reveal an underestimation of the temperature in ECMWF compared to our data. We have reduced this effect of stratospheric disturbances by using harmonic analyses of temperatures (cf. Fig. 6b). We will re-phrase a part of Sec. 6 to make the various contributions to the plotted lidar-ECMWF difference more clear.

Comment 4 (differences to MSIS below 70 km): We agree with the reviewer that the NRLMSISE-00 is a valuable reference also for the lower mesosphere and stratosphere. We will add the following paragraph in the manuscript: 'The lidar–MSIS differences for the region below about 70 km (not shown here) are partly lower than the lidar–ECMWF differences. Especially in the winter stratopause region the NRLMSISE-00 data show only $\sim$5 K lower temperatures. On the other hand the NRLMSISE-00 is warm-biased in the upper stratosphere by up to $\sim$7 K for the rest of the year. The differences between lidar and NRLMSISE-00 decrease towards the tropopause region. The general picture is comparable to the results of Schöch et al. (Ann. Geophys., 2008) for 69° N, with their differences about twice as large compared to 54° N.'

Comment 5 (NLC effects on temperature): The referee is right that NLC could affect the Rayleigh temperature retrieval in a limited altitude range, but we have removed these profiles carefully before temperature calculation. The combination of Rayleigh and aerosol signal in NLC height would produce a cold bias at the upper edge of NLC and at the same time a warm bias at the lower edge. We have removed all profiles with NLC signatures down to about $\beta(532) = 0.1 \cdot 10^{-10} m^{-1} sr^{-1}$. As described by Gerding et al., JGR, 2007, the error induced by such a weak NLC is smaller than the statistical uncertainty of the temperature measurement. In this paper we only deal with nightly averages. The error of the nightly mean temperature profile induced by a remaining sporadic, i.e. short-period, NLC of $\beta(532) < 0.1 \cdot 10^{-10} m^{-1} sr^{-1}$ is much smaller than the statistical uncertainty of the nightly mean temperature profile and is therefore

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negligible. We will provide an appropriate description of this topic in the discussion section.

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