Rayleigh lidar observations of gravity-wave activity in the wintertime upper stratosphere and lower mesosphere (USLM) above Davis, Antarctica (69S, 78E)

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Background

Gravity-wave activity throughout the Antarctic upper stratosphere and lower mesosphere (USLM) is investigated using temperature data collected with a Rayleigh lidar at Davis, Antarctica (69S, 78E). Eighty observations each of at least six hours duration during the Antarctic winters of 2007 and 2008 are used to study this gravity-wave activity.

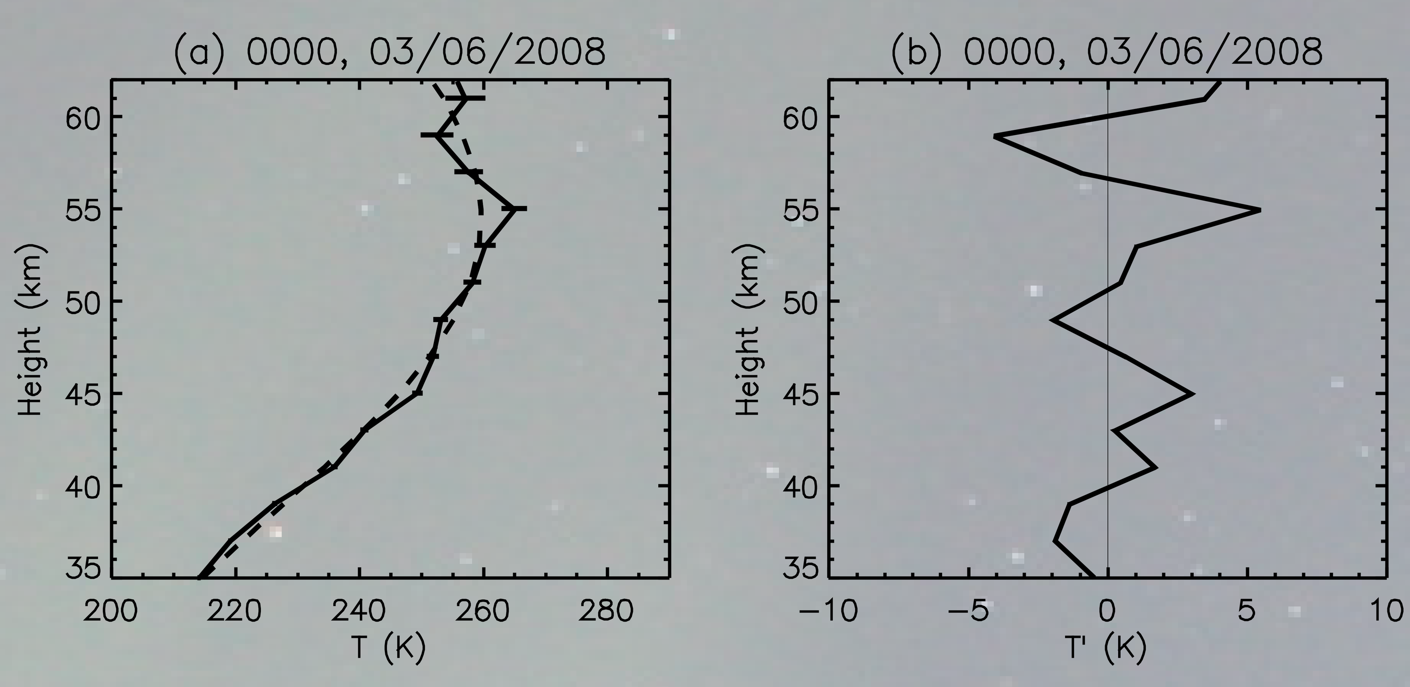

Figure 1: (a) Temperature (solid) and background fit (dashed), (b) Temperature perturbations

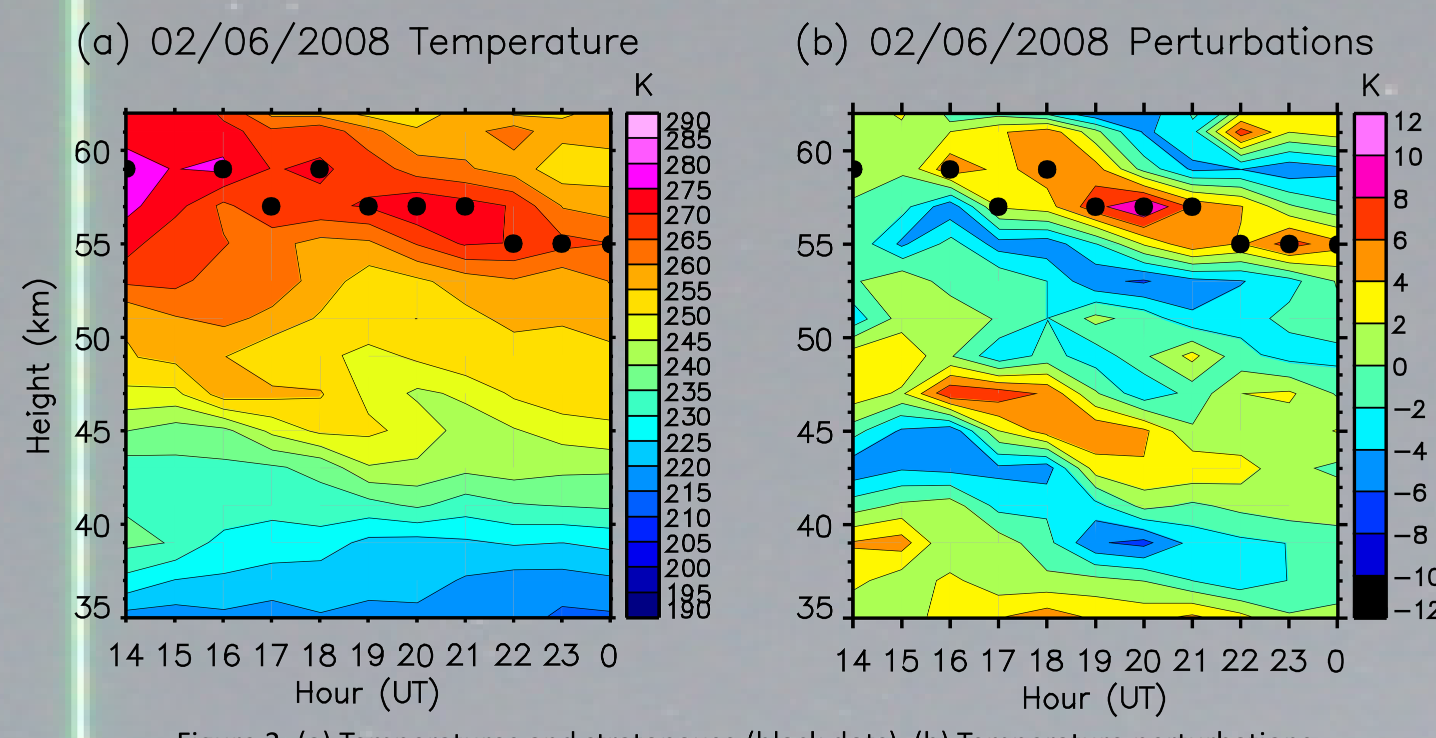

Figure 2: (a) Temperatures and stratopause (black dots). (b) Temperature perturbations

Lidar-derived temperature and gravity-wave extraction

Lidar backscatter data are used to derive the temperature in the USLM with a resolution of 1 hour and 2 km. Weighted cubic polynomial fitting functions define an hourly background temperature state, from which the temperature perturbations are obtained. These perturbations are high-pass filtered with a 20 km cut-off to minimise planetary wave and tidal effects. The potential energy E_p is calculated from these perturbations, which are assumed due to gravity waves. Figure 1a shows an individual temperature profile with the calculated background, while Figure 1b shows the resulting perturbation profile. The complete night's observations are shown in Figure 2a (temperatures, along with warm-point stratopause) and Figure 2b (perturbations).

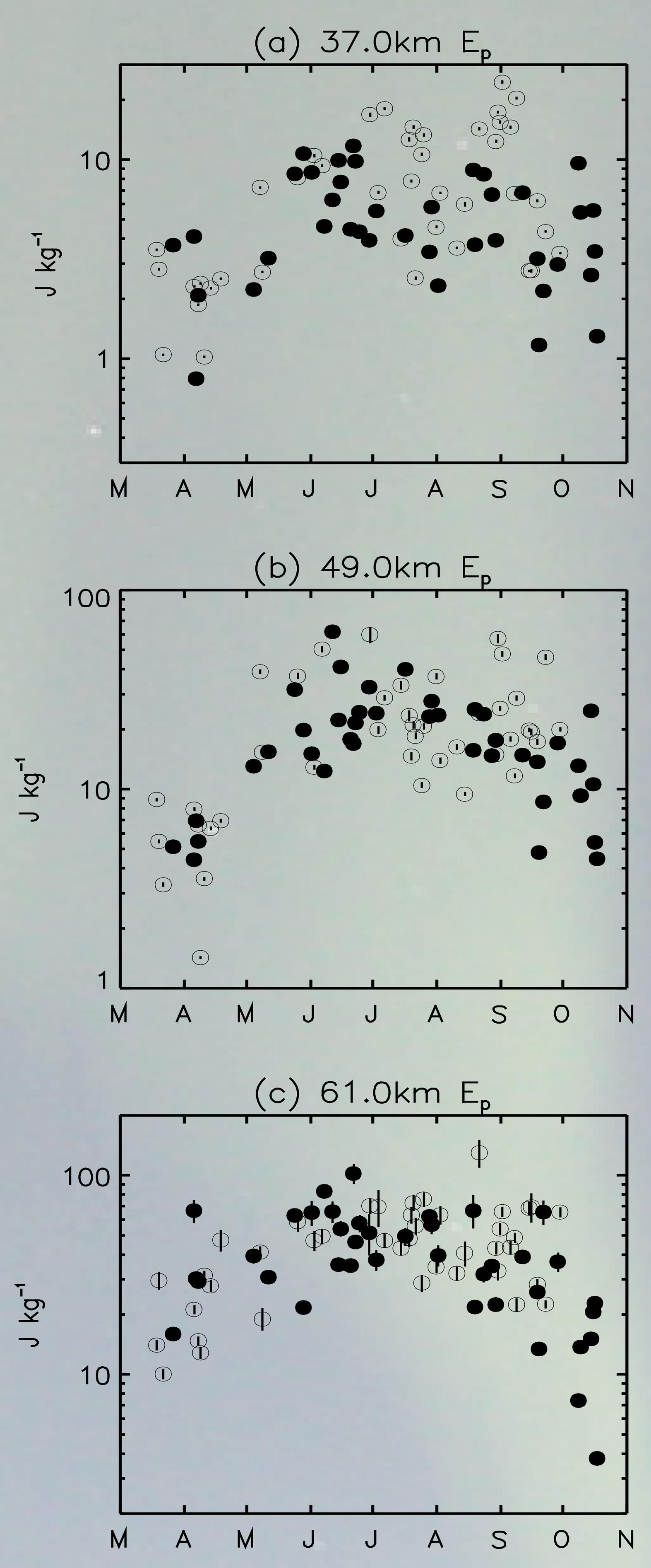

Figure 3: Seasonal cycle of E_p at three different altitudes. Filled circles: 2007, open circles: 2008

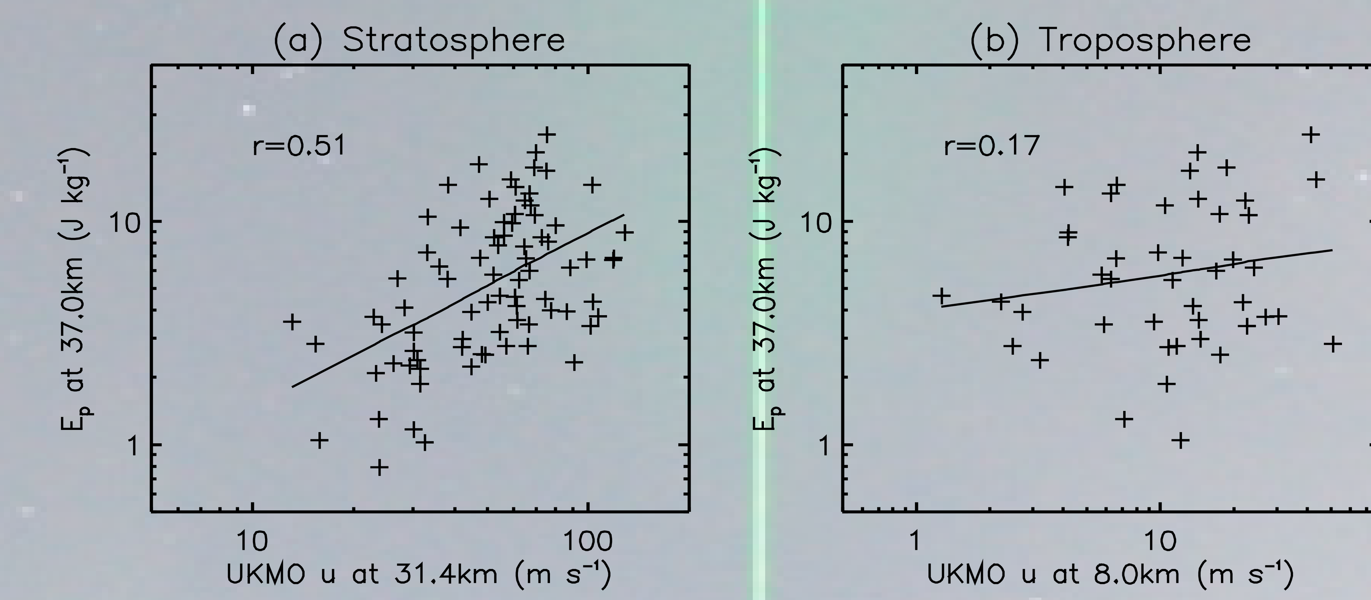

Figure 4: 37 km E_p relationship with (a) stratospheric wind and (b) tropospheric wind

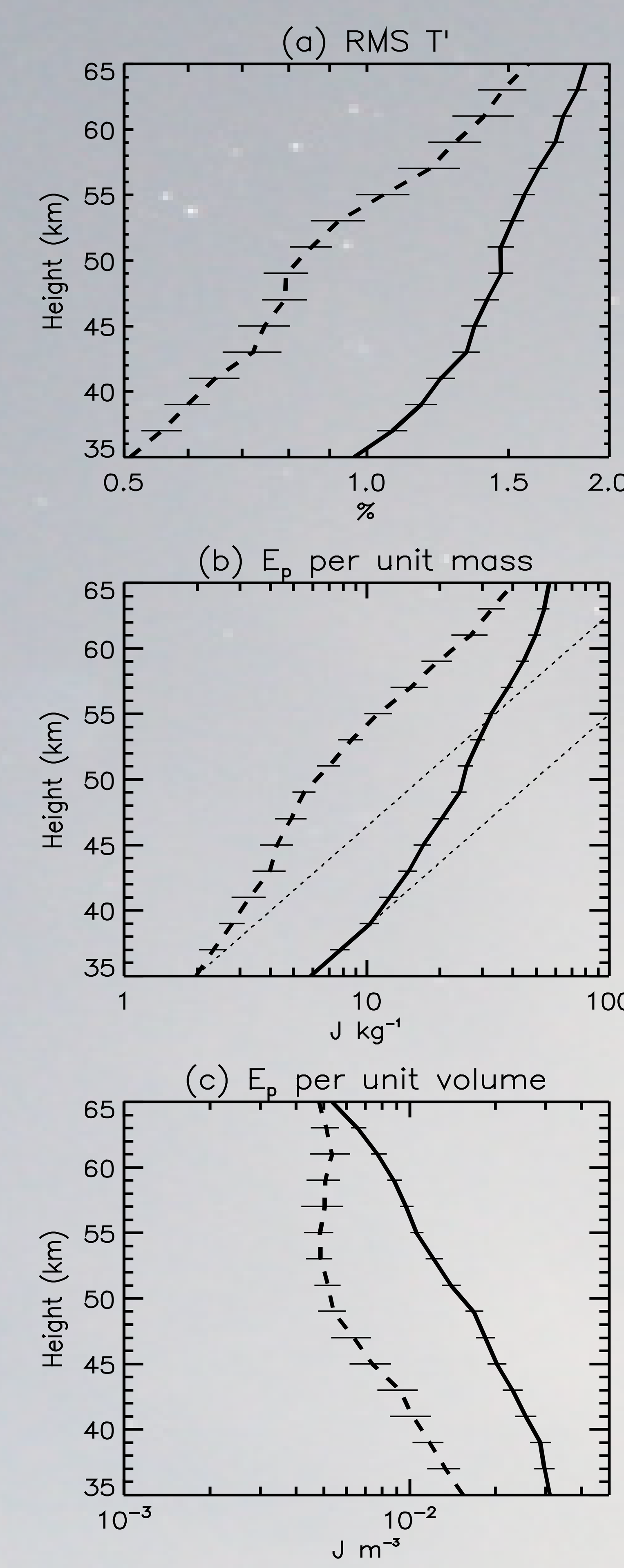

Figure 5: Winter (solid) and autumn (dashed) mean profiles of gravity wave activity.

Wintertime gravity-wave activity

The seasonal cycle of gravity-wave activity is evident at all USLM altitudes in Figure 3, with peak activity occurring during the winter. Larger potential energy E_p at high altitudes is observed in both years. In addition to this seasonal cycle, large (up to half an order of magnitude) variability in gravity-wave activity occurs over short time periods (scales of days to a few weeks).

Stratospheric gravity-wave potential energy is correlated with stratospheric zonal wind speed (Figure 4a), demonstrating the role of Doppler-shifting by the background winds in explaining some of the observed potential energy. However the relationship is not 1:1, indicating that source variability, transmission of low phase speed waves and stratospheric wave generation by an unbalanced jet may contribute to some of the observed stratospheric potential energy. Plotting the stratospheric gravity-wave potential energy against tropospheric winds (Figure 4b) shows virtually no relationship, indicating that orographic wave forcing is not likely to be important at Davis.

Seasonal mean RMS temperature perturbations, potential energy per unit mass and potential energy per unit volume are shown in Figure 5. Gravity wave growth is conservative below 40 km during winter but wave dissipation occurs throughout the winter USLM. There is no detectable dissipation during autumn in the lower mesosphere (above about 50 km altitude).

Conclusions

Gravity-wave dissipation is evident throughout the winter USLM above 40km at Davis, Antarctica. Maximum gravity-wave potential energy occurs during winter, which can partially be explained by Doppler-shifting of waves by the strong background winds. We also note here that wintertime gravity wave parameters observed above Davis are generally similar to those reported at other high-latitude sites.

The results presented here are discussed in more detail by Alexander et al. (2011).

Reference:

Alexander et al., 2011, *JGR*, **116**, doi:10.1029/2010JD015164, *in review*