Long-term trends of upper mesosphere gravity waves at midlatitudes

Ch. Jacobi[1], P. Hoffmann[2]

[1]University of Leipzig, Institute for Meteorology, Stephanstr. 3, 04103, Leipzig, Germany, jacobi@uni-leipzig.de
[2]University of Rostock, Leibniz-Institute of Atmospheric Physics, Schlossstr. 6, 18225 Kühlungsborn, Germany, hoffmann@iap-kborn.de

Summary

Mesosphere/lower thermosphere (MLT) winds over Germany measured with different radar systems (MF radar, LF) have been analysed with respect to variations at the time scales of gravity waves. Background winds are also registered to analyse gravity-mean flow interactions at decadal time scales.

In both winter and summer an increasing mesospheric zonal wind jet with time is registered, which is connected with increasing gravity wave variances. At greater altitudes in summer, the mean wind jet trend reverses, and negative trends of gravity wave variances are found over Collm. This connection between gravity waves and mean wind is also observed on a decadal scale: during solar maximum a stronger mesospheric zonal wind jet leads to larger gravity wave amplitudes. This results in a solar cycle modulation of gravity waves with larger amplitudes during solar maximum.

The connection between gravity waves and mean zonal wind may be explained by wave filtering within linear wave theory, such that stronger mesospheric zonal winds are connected with larger gravity wave amplitudes.

Collm results are qualitatively confirmed by Juliusruh data. Over both stations, zonal gravity wave amplitudes are larger than meridional ones. Trends after 1990 are similar over both stations.

Measurements

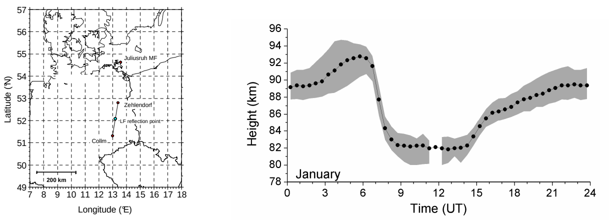

Fig. 1: Left panel: Map of central Europe with Collm and Juliusruh sites. Right panel: Collm LF January 1984 – 2007 corrected median heights (Jacobi, 2011), with upper and lower quartiles.

	Juliusruh	Collm
Coordinates	54.6°N 13.4°E	52.1°N, 13.2°E (reflection point)
Frequency	3.18 MHz	177 KHz
Dataset	1990-date	1983-2007

Table.1: Some parameters describing the measurements at Collm and Juliusruh.

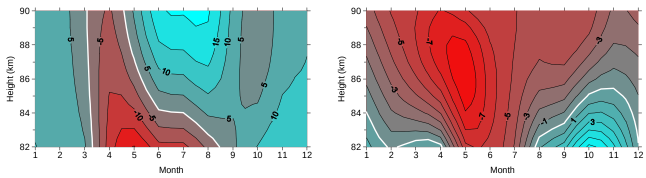

Fig. 2: 1984-2006 mean zonal (left panel) and meridional (right panel) prevailing winds over Collm, according to a multiple least squares fit with quadratic height dependence and circular polarised tidal components assumed.

Gravity wave proxy calculation

Juliusruh: Variances of hourly wind values (period band 3-6h) after removing tides (Hoffmann et al., 2011).

Collm: Squared differences of subsequent half-hourly mean winds (period band 0.7- 3h) (Jacobi et al., 2006).

Long-term mean gravity wave proxies over Collm

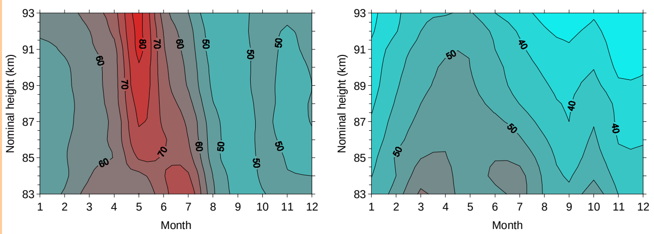

Fig. 3: 10/1983-9/2007 mean zonal (left panel) and meridional (right panel) variances over Collm, calculated from half-hourly wind differences (see Jacobi et al., 2006).

Trends and solar cycle

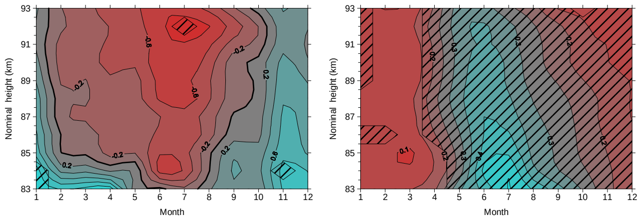

Fig. 4: Linear trend b ($m^2s^{-2}yr^{-1}$) (left) and solar effect c ($m^2s^{-2}sfu^{-1}$) (right) of GW variance according to a regression analysis $\sigma^2 = a + b\cdot yr + c\cdot F10.7$ based on 1984 - 2007 3-monthly means over Collm.

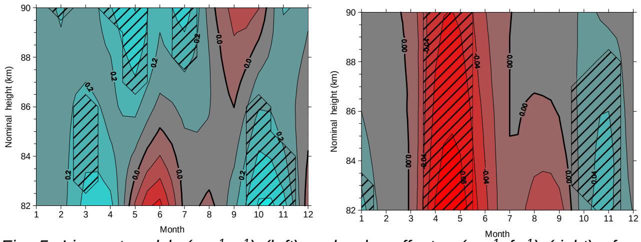

Fig. 5: Linear trend b ($ms^{-1}yr^{-1}$) (left) and solar effect c ($ms^{-1}sfu^{-1}$) (right) of zonal prevailing wind according to a regression analysis $v_{zon} = a + b\cdot yr + c\cdot F10.7$ based on 1984 - 2007 3-monthly means over Collm.

Time series

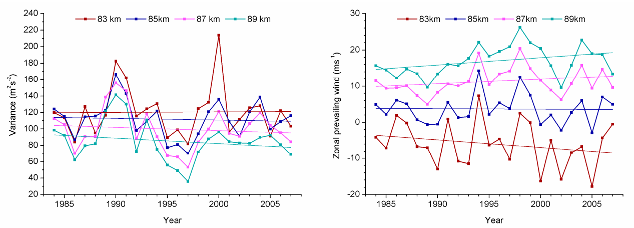

Fig. 5: May-July mean time series of variance (left) and zonal prevailing wind (right) over Collm. Variances at 85 / 87 / 89km have been shifted by -10 / -20 / -30m^2s^{-2}.

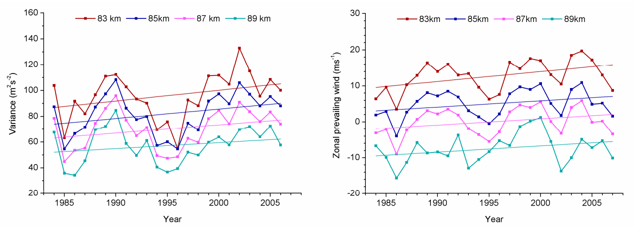

Fig. 6: October-December mean time series of variance (left) and zonal prevailing wind (right) over Collm. Variances at 85 / 87 / 89km altitudes have been shifted by -10 / -20 / -30m^2s^{-2}. Mean winds at 85 / 87 / 89km have been shifted by -5 / -10 / -15ms^{-1}.

Collm-Juliusruh comparison

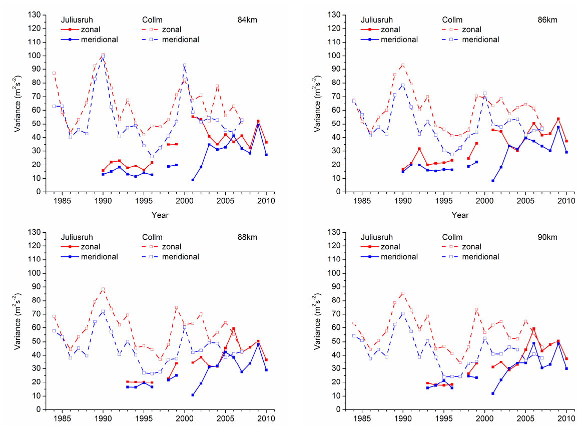

Fig. 7: June-August mean time series of zonal and meridional variances over Collm and Juliusruh at different altitudes.

References:

Jacobi, Ch., et al., 2006: J. Atmos. Sol.-Terr. Phys., 68, 1913-1923.
Hoffmann, P., et al., 2011: J. Geophys. Res., doi:10.1029/2011JD015717.
Jacobi, Ch., 2011: Adv. Radio Sci. 9, 335-341.

Acknowledgements:

This study was supported by Deutsche Forschungsgemeinschaft under grant JA 836/22-1 and under grant SI 501/5 in the frame of the CAWSES priority program SP1176.

printed at Rechenzentrum Leipzig

poster available on http://www.uni-leipzig.de/~jacobi/collm/poster.htm