Interannual and long-term variability of the quarterdiurnal tide in the mesosphere/lower thermosphere at midlatitudes

Christoph Jacobi[1], Amelie Krug[1], Friederike Lilienthal[1], Eugeny Merzlyakov[2]

[1]University of Leipzig, Institute for Meteorology, Stephanstr. 3, 04103, Leipzig, Germany, jacobi@uni-leipzig.de
[2]Institute for Experimental Meteorology, Obninsk, Russia

Summary

Meteor radar observations of horizontal winds in the mesosphere/lower thermosphere (MLT, 80-100 km) at Collm (51.3°N, 13.0°E) and Obninsk (55°N, 37°E) have been used to analyze the seasonal variability of the quarterdiurnal tide (QDT) at middle and low latitudes.

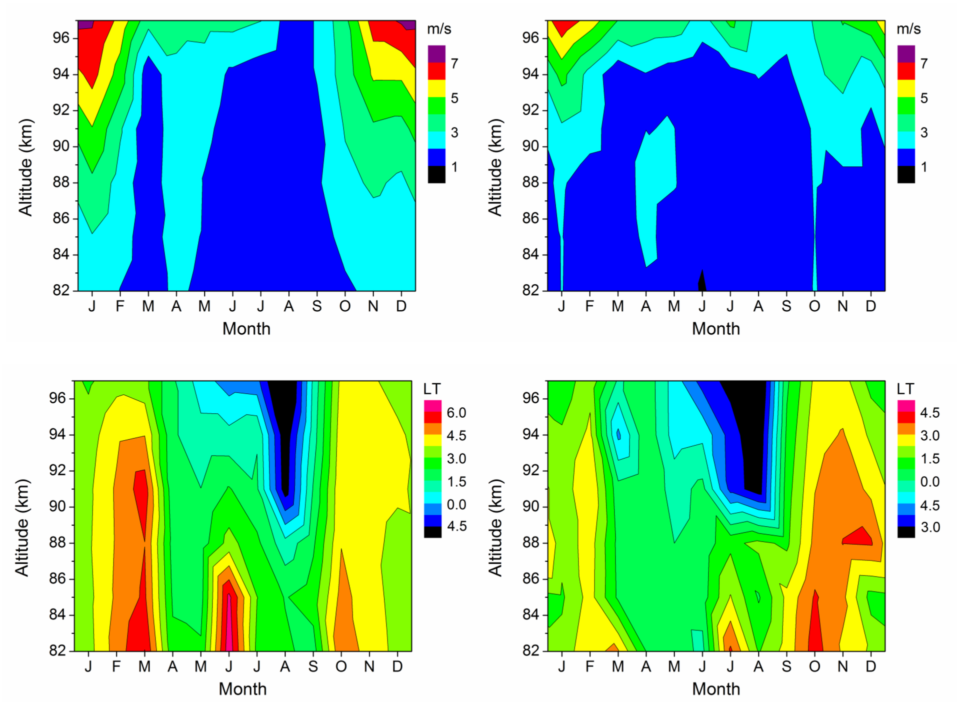
The zonal amplitudes show a maximum in winter and a weaker one during spring. Amplitudes increase with height, with up to 7 m/s at 97 km. Meridional amplitudes are weaker and show a similar seasonal cycle. Amplitudes and phases at Collm and Obninsk are similar, indicating that most of the observed 6-hour oscillation at higher midlatitudes is due to the migrating QDT.

Obninsk amplitudes show an interdecadal variation with smaller values during the 1990s and larger ones during the 2000s. This is visible above all during winter.

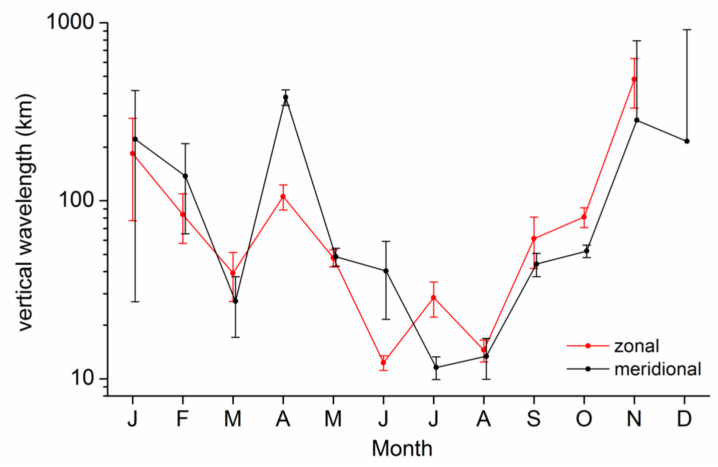
Meteor radar measurements

Site	coordinates	dataset used	remarks
Obninsk	55°N, 37°E	1980-2012	no height finding
Collm	51°N, 13°E	2004-2016	

Quarterdiurnal tide at 82 – 97 km at Collm



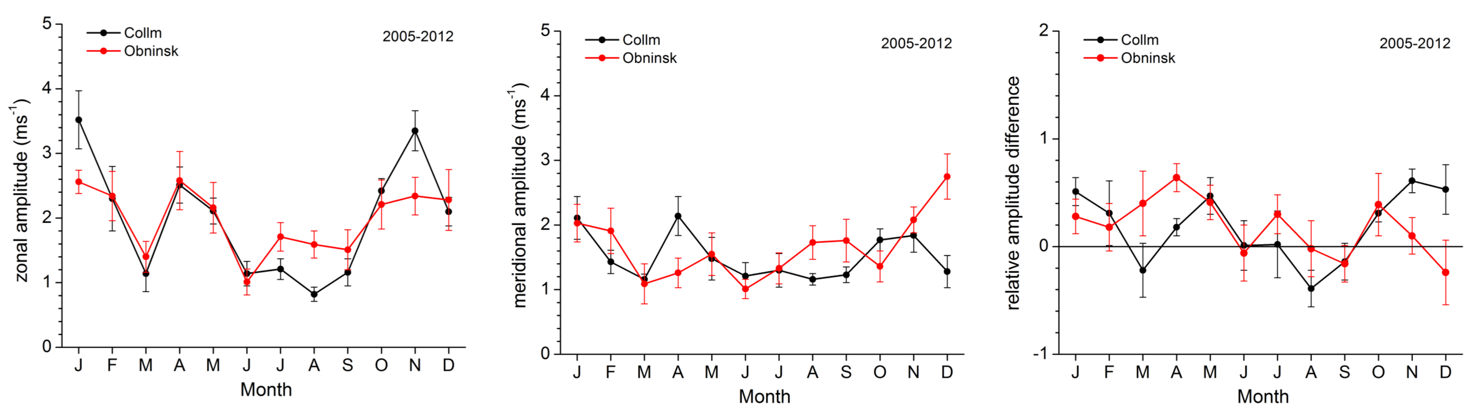
Zonal (left) and meridional (right) amplitudes (top) and phases (bottom) over Collm (51°N, 13°E).



Vertical wavelengths of the QDT over Collm. Wavelengths are short in summer but very long in winter.

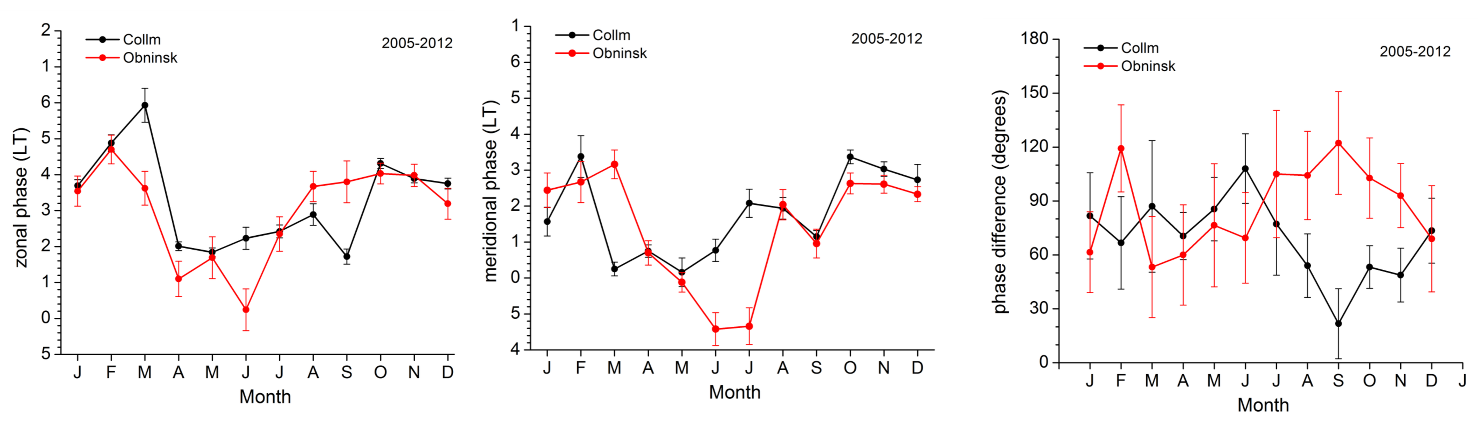
Comparison of Collm and Obninsk QDT climatology

Collm data have been analyzed here without height finding to allow comparison with Obninsk tides. Overall agreement of amplitudes and phases is found, i.e. large part of the wave is due to the migrating QDT.



Zonal (left) and meridional (middle) amplitudes A and relative amplitude difference ΔA (right) of the QDT over Collm (51°N, 13°E) and Obninsk (55°N, 37°E).

$$\Delta A = 2\,\frac{A_{zonal} - A_{meridional}}{A_{zonal} + A_{meridional}}$$



Zonal (left) and meridional (middle) phases in LT and phase difference in degrees (right) of the QDT over Collm (51°N, 13°E) and Obninsk (55°N, 37°E).

Acknowledgements:

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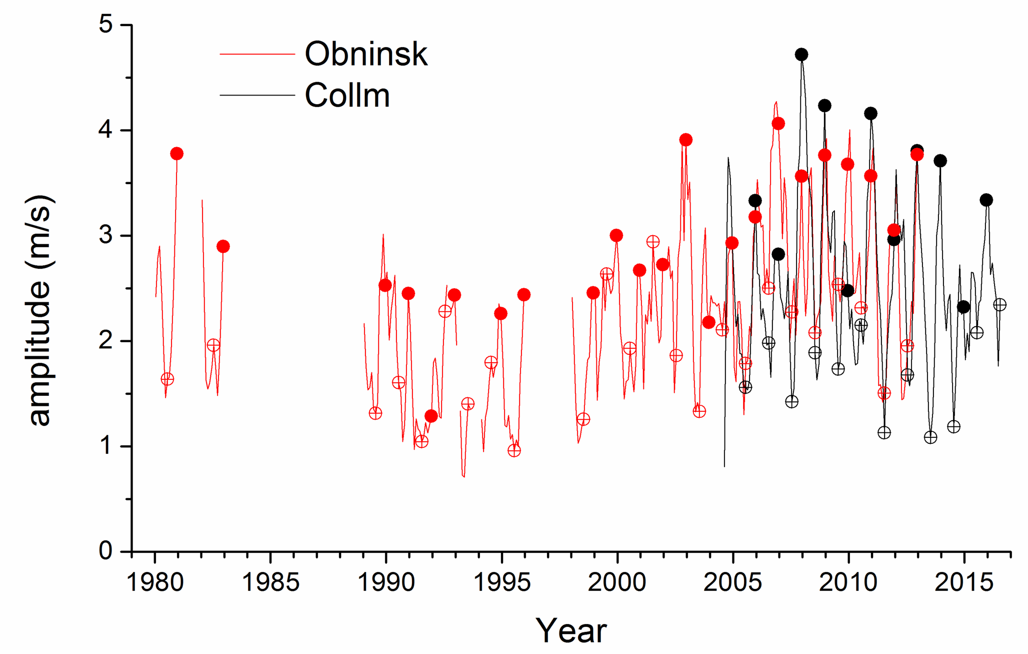
Long-term variability (Obninsk / Collm)

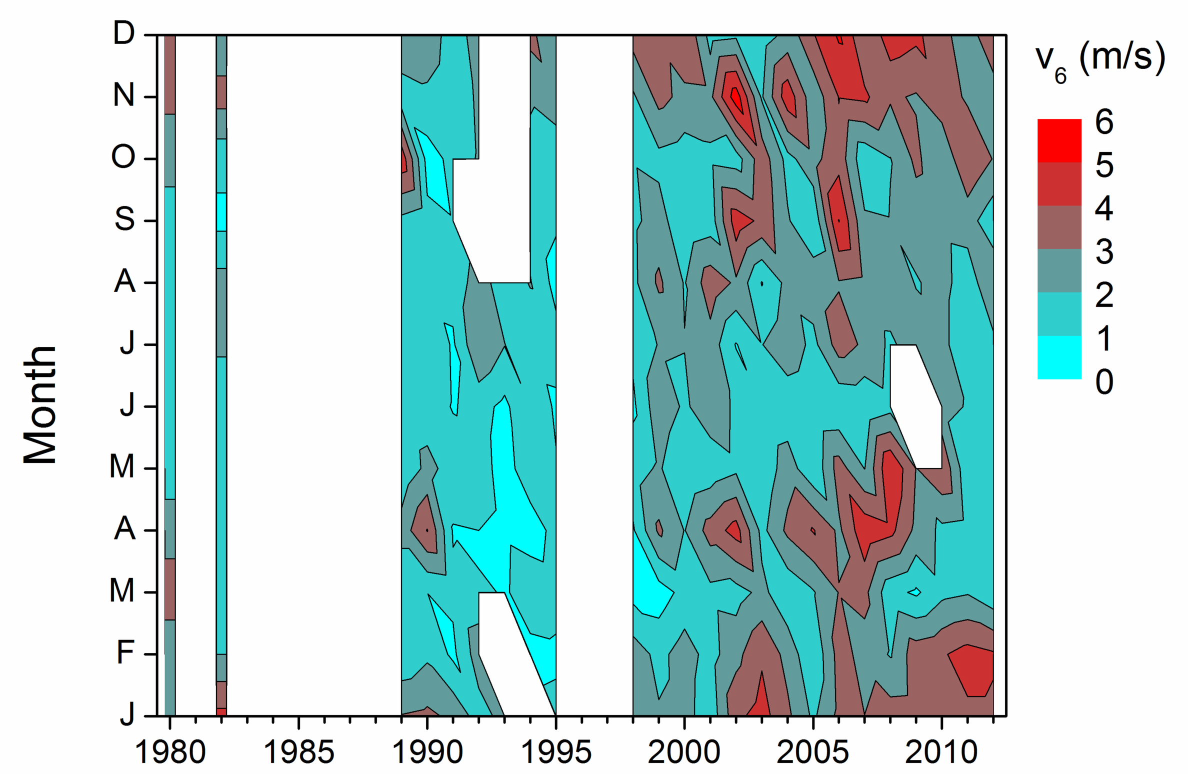
There are larger amplitudes in the early 1980s than in the 1990s. After 2000, amplitudes both in winter and summer tend to increase again.



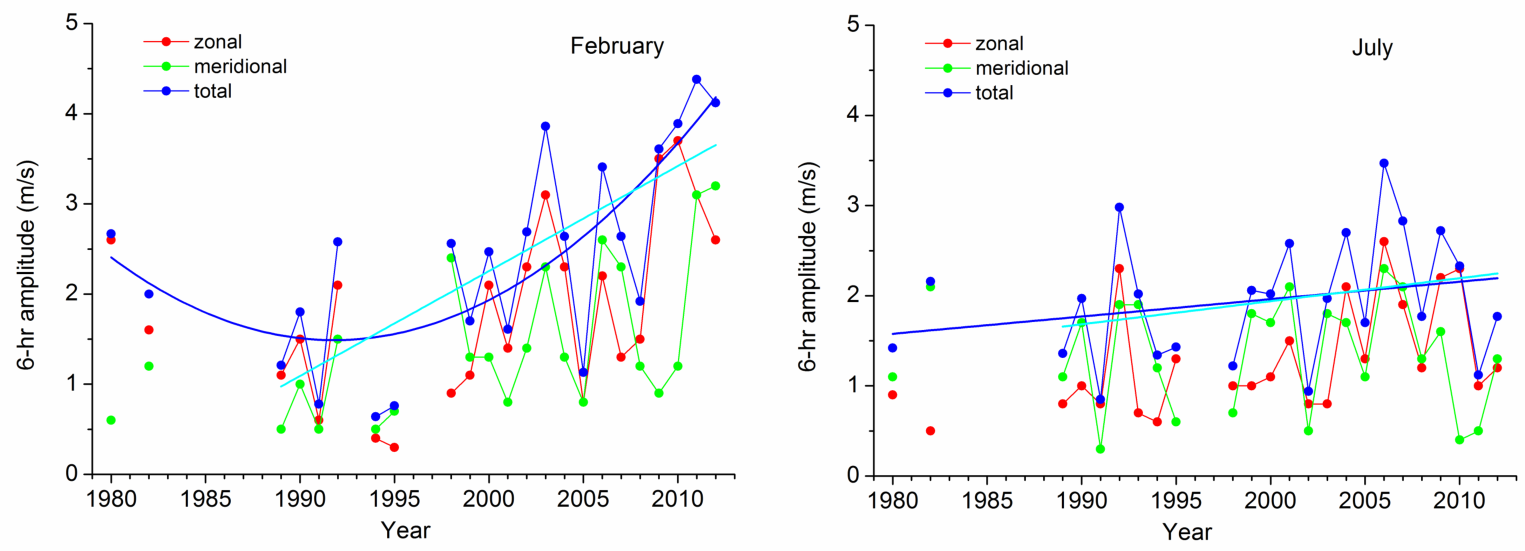
$$A = \sqrt{A_{zonal}^2 + A_{meridional}^2}$$

3-monthly mean amplitudes A over Obninsk and Collm. November-January means are given as solid circles, while June-August means are shown as open circles with crosses.

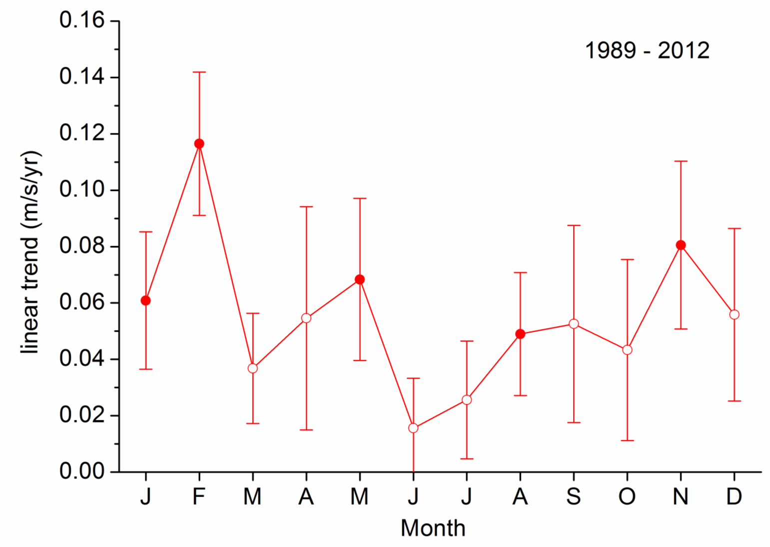
Long-term tendencies / Obninsk



Monthly QDT amplitudes over Obninsk 1980 – 2012. There is a tendency for larger amplitudes after 2000 in winter.



Examples of monthly amplitudes during February (left) and July (right) over Obninsk. Linear (cyan) and quadratic (blue) fits are added.

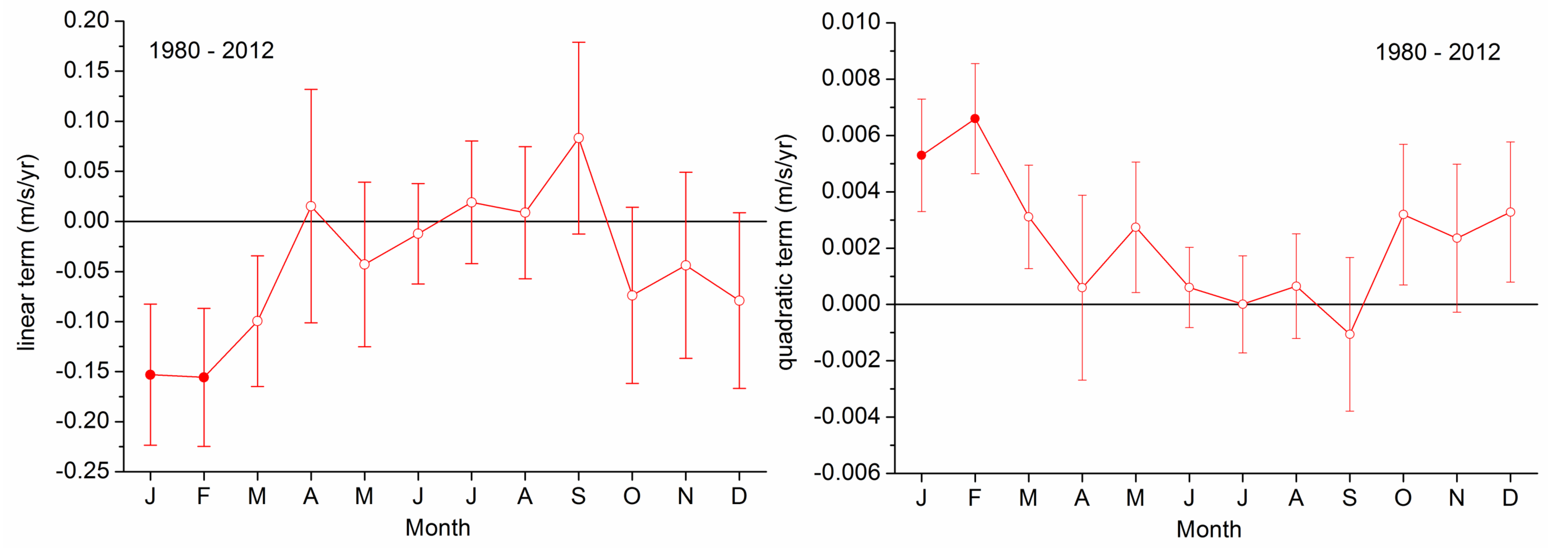


$$A = A_0 + a \cdot yr$$

Linear trends of Obninsk amplitudes, calculated from data 1989 – 2012. Solid symbols denote significant trends at the 95% level.

Trends are positive throughout the year, but small in summer.

$$A = A_0 + a \cdot (yr - 1980) + b \cdot (yr - 1980)^2$$



Results from quadratic fits of Obninsk amplitudes 1980 – 2012. In winter, linear terms are (left) negative and quadratic terms (right) are positive, indicating a change in trend. In summer, trends are small and insignificant.

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