Climatology of the quarterdiurnal tide in the mesosphere/lower thermosphere

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Summary

Meteor radar observations of horizontal winds in the mesosphere/lower thermosphere (MLT, 80-100 km) at Collm (51.3°N, 13.0°E), Obninsk (55°N, 37°E), Cariri (7.4°S, 36.5°W) and Cachoeira Paulista (22.7°S, 45.0°W) have been used to analyze the seasonal variability of the quarterdiurnal tide (QDT) at middle and low latitudes.

At Collm and Obninsk, the zonal amplitudes show a maximum in boreal winter and a weaker one during spring. Amplitudes increase with height, with up to 7 m/s at 98 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.

Amplitudes at low southern latitudes mainly maximize during austral winter and the equinoxes, the latter maxima are mainly seen at higher altitudes. Amplitudes over Cariri are weaker than over Cachoeira Paulista.

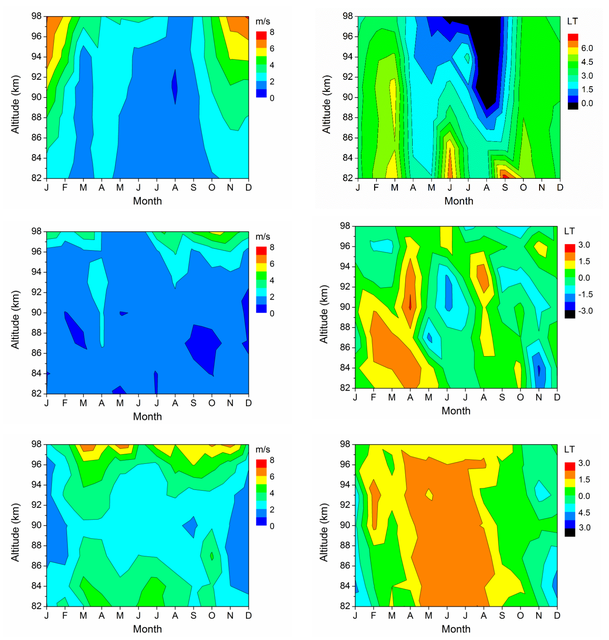
Numerical results using a simple model reproduce the winter maximum at midlatitudes as well as the equinox and winter maxima at lower latitudes at least qualitatively.

Meteor radar measurements

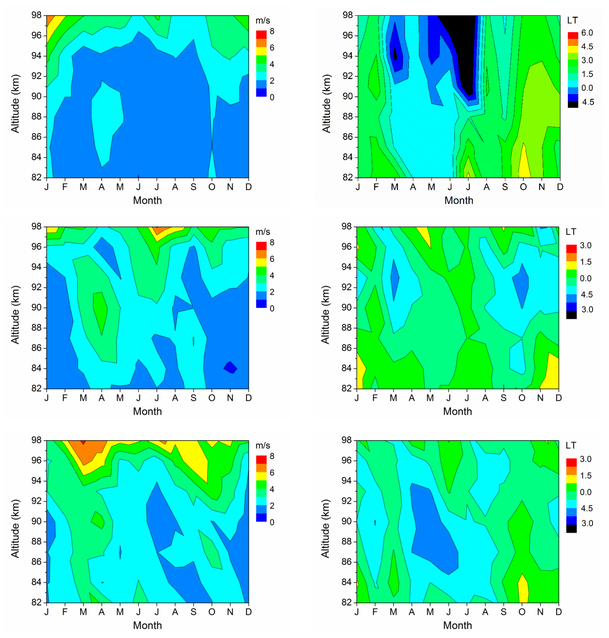
Site	coordinates	dataset used	remarks
Obninsk	55°N, 37°E	1980-2012	no height finding
Collm	51°N, 13°E	2004-2015	
Cariri	7°S, 37°W	2004-2008	
Cachoeira Paulista	23°S, 45°W	1999-2015	some data gaps

Results – 6-hour oscillation at different latitudes

1. Zonal



2. Meridional



Amplitudes (left) and phases (right) over Collm, Cariri and Cachoeira Paulista.

Reference:

Pogoreltsev, A.I., A.A. Vlasov. K. Fröhlich, and Ch. Jacobi, 2007: Planetary waves in coupling the lower and upper atmosphere. J. Atmos. Sol.-Terr. Phys. 69, 2083-2101, doi:10.1016/j.jastp.2007.05.014.

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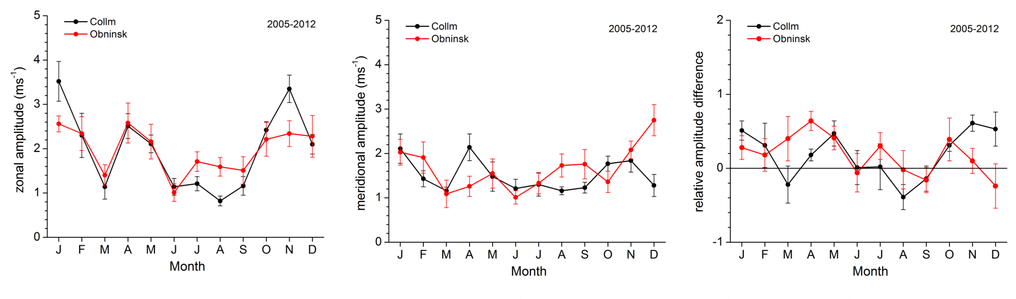
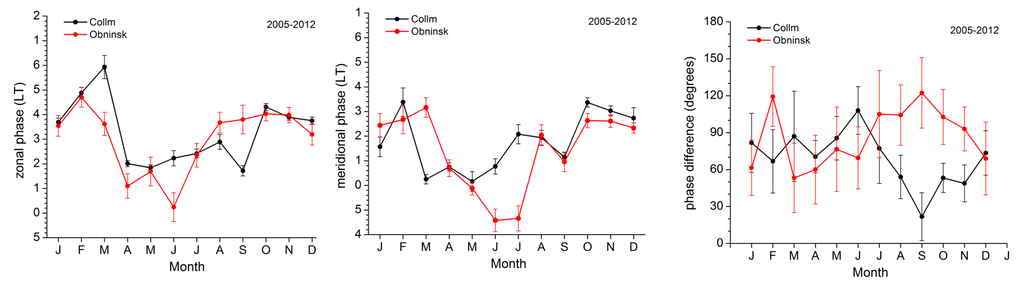
Northern midlatitudes at different longitudes

Collm data have been analysed 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).

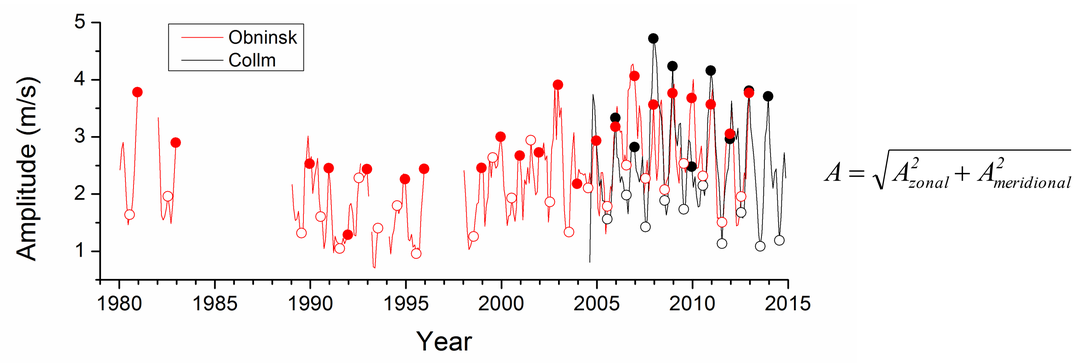
$$\Delta A = 2\frac{A_{zonal} - A_{meridional}}{A_{zonal} + A_{meridional}}$$



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).

Long-term variability

There are larger amplitudes in the early 1980s than in the 1990s. After 2000, amplitudes both in winter and summer tend to increase again. After 2010, there is a tendency that the summer amplitudes decrease again.

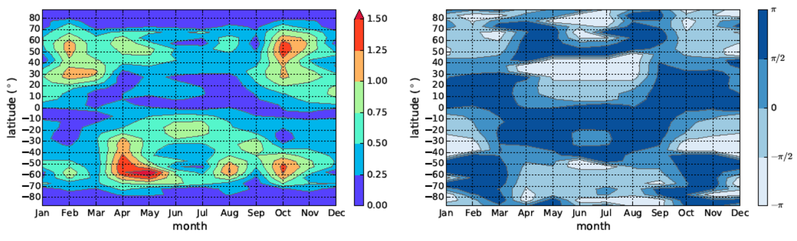


$$A = \sqrt{A_{zonal}^2 + A_{meridional}^2}$$

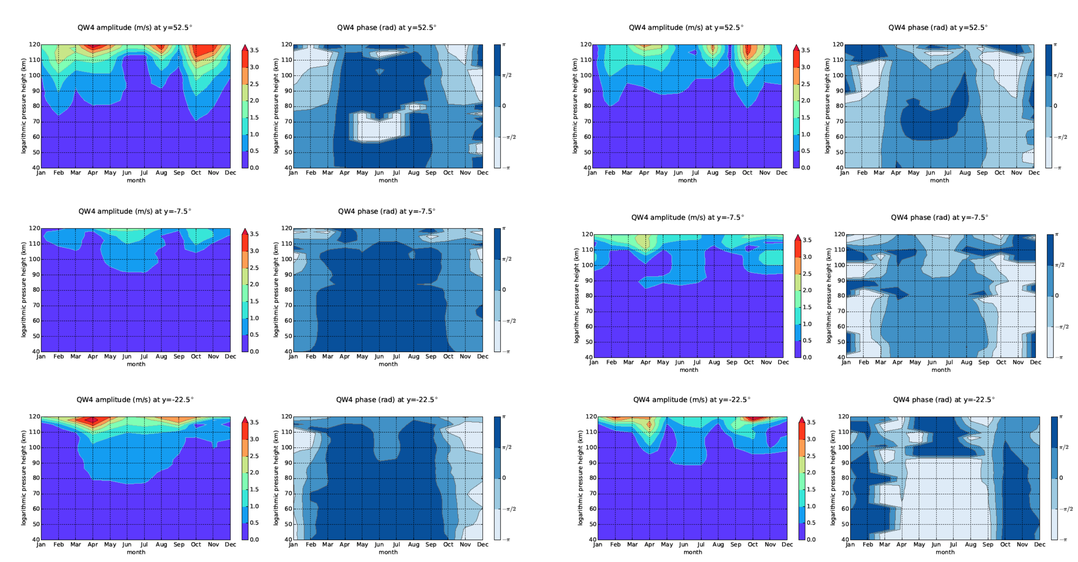
3-monthly mean amplitudes over Obninsk and Collm. November-January values are highlighted as solid circles, while June-August means are shown as open circles.

Modeling

MUAM mechanistic circulation model (Pogoreltsev et al., 2007). Primitive equations in log-pressure heights, 56 levels from the ground to 160 km. 5° x 5.625° horizontal resolution in latitude/longitude. Parameterizations of solar and infrared radiation and gravity waves.



Modeled zonal amplitude (left) and phase (right) at ~95 km.



Modeled zonal (left) and meridional (right) amplitudes and phases at 52.5°N, 7.5°S and 22.5°S.

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