Combined multi-year observations of internal gravity waves with ionospheric drifts and meteor radar at Collm, Germany

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1 Aims of the study

- Digital filters are used for determining intensities of internal gravity waves (IGWs) with periods 1- 6 hr from observational data on wind velocity at altitudes 80 - 110 km with meteor radar in 2004-2016 and with the ionospheric inhomogeneity drift method in 1983-2008 at Collm Observatory (51.3°N, 13.0°E) of the University of Leipzig.
- Height-temporal changes in IGW intensities during the mentioned years are studied.
- Seasonal and interannual changes in IGW intensities are studied.

Main conclusion

Long-term variations of gravity wave proxies can be studied using combined LF and VHF radar observations at Collm (51.3°N, 13.0°E).

2 Data: Collm LF drifts and VHF winds

LF drift measurements

- Ionospheric drift velocity at altitudes 80 – 100 km 1959 - 2008.
- Radio signals going from commercial transmitters with frequencies 177, 225 and 270 kHz. 177 kHZ is used here.
- Since late 1982, the virtual height h is measured on177 kHz.
- The data are combined to half-hourly zonal and meridional mean drift velocity values.

Collm VHF meteor radar

- Collm, 51.3°N, 13.0°E.
- Horizontal winds from Doppler shifted VHF signal from meteor trails.
- Hourly mean winds through least-squares fit on radial winds.
- Vertical wind profiles at altitudes 80-100 km.

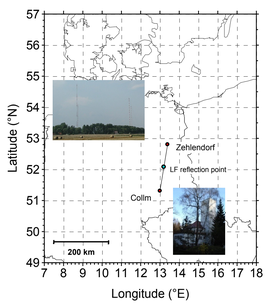

Fig. 1: Map of Eastern Germany with positions of the LF transmitter and the Collm VHF radar.

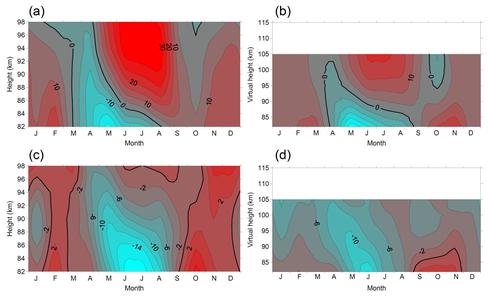

Fig. 2: Seasonal cycles of zonal (a,b) and meridional (c,d) mean wind observed by VHF meteor radar (a,c) and LF (b,d) observations (form Jacobi, 2011).

3 Combination of wind data

GW proxy analysis

- Hourly differences used as a proxy for gravity wave amplitudes (See Gavrilov et al., 2002; Jacobi et al., 2007; Jacobi 2014).
- LF data applied for height differences < 3 km between hourly means.
- Meteor radar data used for meteor count rates > 20/hr.

$$u_i' = (u_{i+1} - u_i)/2;$$

$$H^2 = \frac{\sin^4(\sigma T/2)}{(\sigma T/2)^2},$$

$$T = t_{i+1} - t_i = 1\text{hr}.$$

$$LF: \quad z_{i+1} - z_i < 3\text{km};$$

$$MR: \quad N_{meteor} > 20$$

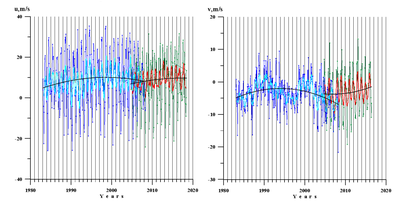

Fig. 3: Uncorrected mean zonal (left) and meridional (right) winds.

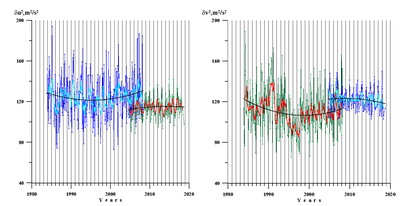

Fig. 5: Uncorrected zonal (left) and meridional (right) hourly difference variances.

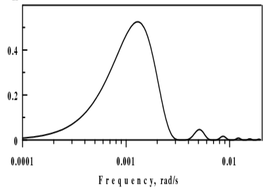

Fig. 4: Filter characteristics of hourly difference amplitude calculation.

LF wind and variance correction

- overlap 04/2007 – 08 / 2007.
- LF data corrected using mean LF-meteor radar differences.
- Gradual change from LF to meteor radar winds and variances during the time of overlap.

4 Long-term wind and GW variance

Results: Long-term time series of Collm winds and variances

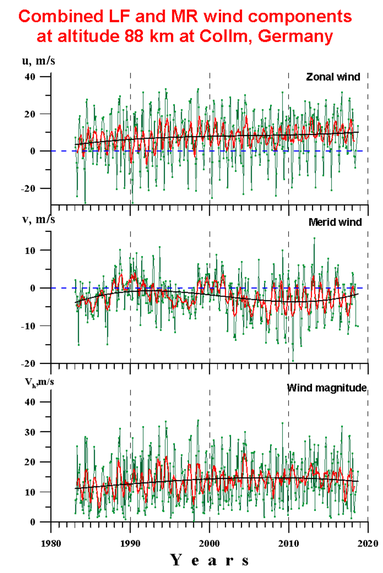

Fig. 6: Monthly mean zonal wind (top panel), meridional wind (middle panel) and wind velocity (lower panel) from combined LF and meteor radar wind observations. Black lines show cubic polynomial fits.

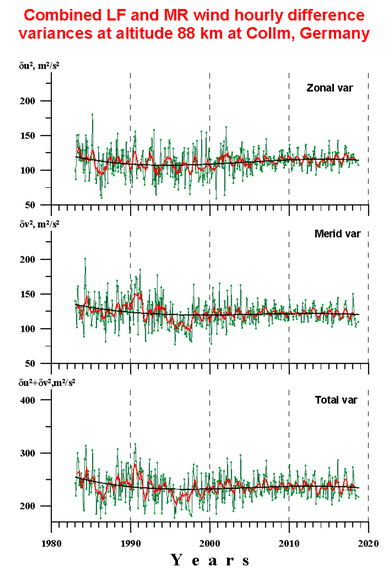

Fig. 7: Monthly mean zonal variances (top panel), meridional variances (middle panel) and total variances (lower panel) from combined LF and meteor radar wind observations. Black lines show cubic polynomial fits.

5 Conclusions and final remarks

Conclusions

- HD variances give information about gravity wave intensity in the middle atmosphere.
- LF and MR agree at 86 – 90 km. LF and MR data can be combined to obtain information about multi-year climatological data.
- The mean eastward wind is increasing during years 1984 – 2018. The meridional wind is generally directed to the south with periodically changing magnitude.
- The annual average level of IGW intensity does not show large changes, and during the considered time interval.

References

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