Poster ID: SA33B-3478

Diagnosing the short term variability of atmospheric of tides at the MLT region from observations and a High Altitude Meteorological Analysis System

Kathrin Baumgarten[1], Gunter Stober[1], Dimitry Pokhotelov[1], John P. McCormack[2]

[1]Leibniz Institute of Atmospheric Physics, Kuehlungsborn, Germany

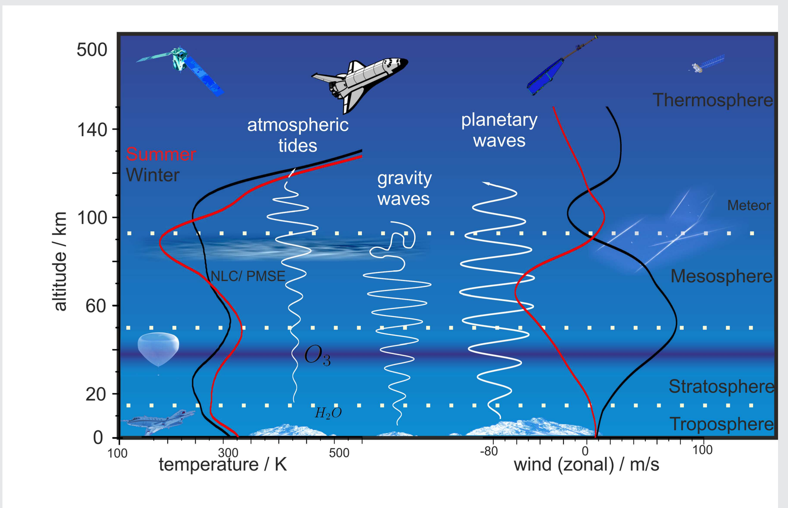
[2]Space Science Division, Naval Research Laboratory, Washington DC, USA

LEIBNIZ-INSTITUTE OF ATMOSPHERIC PHYSICS IAP

U.S. NAVAL RESEARCH LABORATORY

Leibniz Association

Motivation



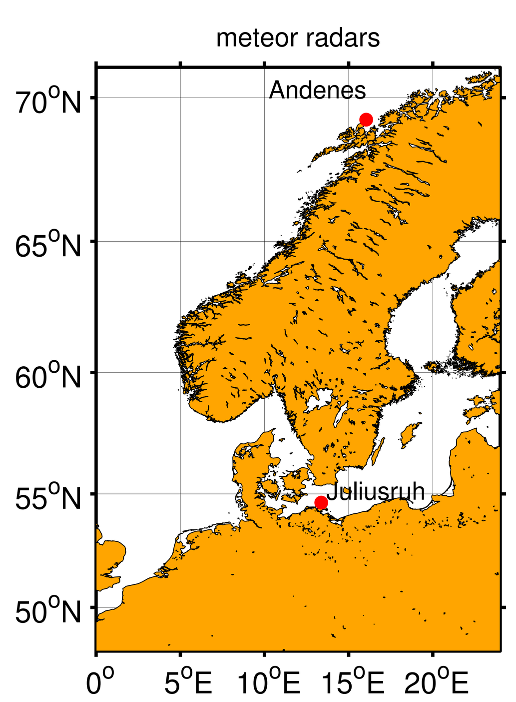
The variability of the middle atmosphere is driven by a variety of atmospheric waves covering various spatial and temporal scales. In particular, the northern winter mesosphere/ lower thermosphere at mid- and polar-latitudes shows a huge variability related to planetary waves, which can disturb the polar vortex leading to large scale coupling effects like sudden stratospheric warmings (SSWs) altering the vertical propagation conditions of tides and gravity waves.

Here we investigate the tidal variability during SSWs in the mesosphere/lower thermosphere (MLT) region using the high altitude meteorological reanalysis from NAVGEM-HA and two meteor radars located in Andenes (69°N, 16°E) Norway and Juliusruh (54°N, 13°E) Germany. We focused on the following questions:

- **How well does tidal variability from NAVGEM-HA compare to the local meteor radar observations applying the same diagnostic?**
- **How representative are local tidal measurements compared to the global fields?**
- **How variable are tidal phases due to changes in the background mean winds?**

Database and analysis tools

Meteor radar observations and data analysis



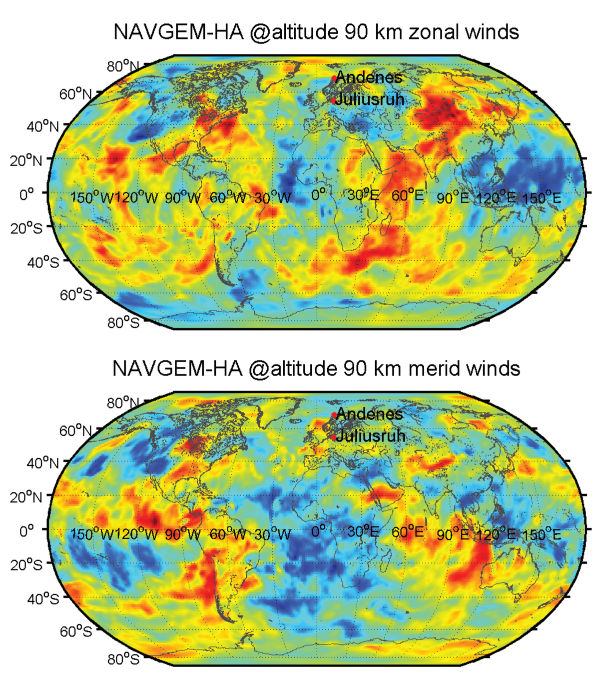
wind measurements

- non-linear error propagation
- full Earth geometry (WGS84) - every meteor is projected into its local geodetic coordinates to account for the Earth curvature
- wind fields are Laplace filtered in space and time
- vertical resolution 2 km, temporal resolution 1 hour

adaptive spectral filter (ASF)

- decomposition of obtained winds into mean winds, tidal wind (diurnal, semi-diurnal and terdiurnal) and gravity wave residuum
- tidal amplitudes and phases are obtained by adapting the window length to the period of the tide considering a variable background and a vertical phase consistence/smoothness
- applicable to unevenly sampled data

Navy Global Environmental Model (NAVGEM)



- extended vertical domain up to 116 km altitude (geopotential)
- hybrid four-dimensional variational (4DVAR) data assimilation system
- assimilates both standard operational meteorological observations in the troposphere and satellite-based observations of temperature, ozone and water vapor in the stratosphere and mesosphere
- some initial validation to meteor radar observations (McCormack et al., 2017 (JASTP))
- temporal resolution 3 hours, vertical resolution pressure coordinates

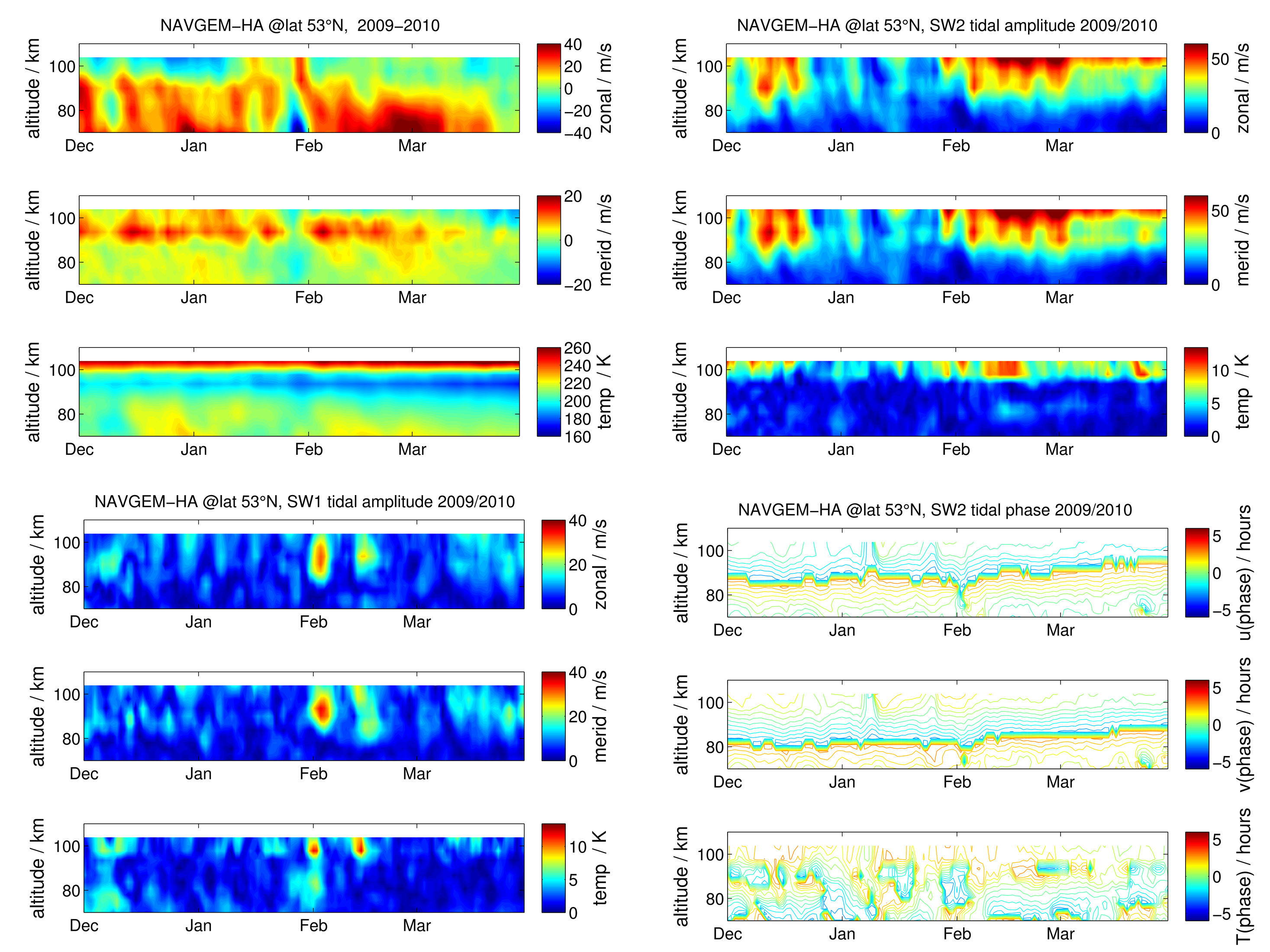
Migrating and non-migrating tides from NAVGEM

- global tidal analysis during winter seasons 2009/2010 and 2012/13
- analysis of migrating and non-migrating tides
- NAVGEM-HA wind (zonal and meridional) and temperature fields are decomposed

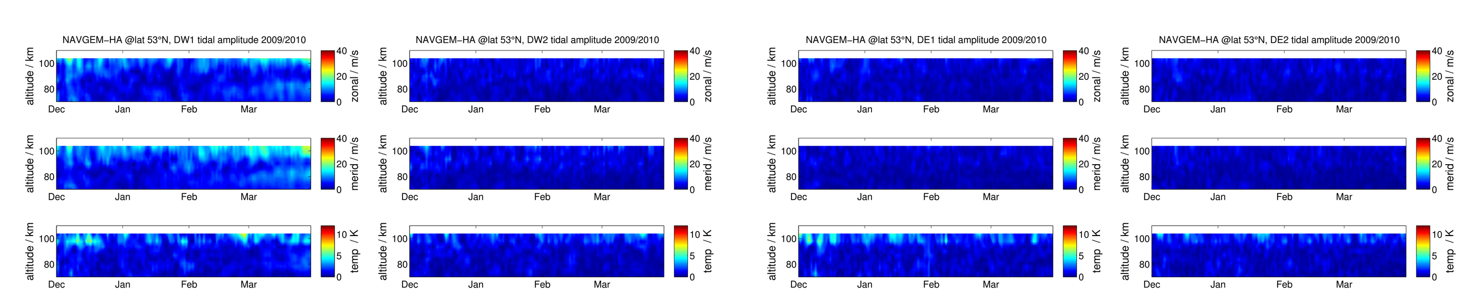
$$u, v, T \ = \ \overline{u}, \overline{v}, \overline{T} + \sum_{s=-3}^{3} \sum_{i=1}^{2} \Big(a_{si} \cdot \sin(s \cdot \lambda - \frac{2\pi}{T_i} \cdot t) + b_{si} \cdot \cos(s \cdot \lambda - \frac{2\pi}{T_i} \cdot t) \Big)$$

Here are $\overline{u}, \overline{v}, \overline{T}$ the zonal mean zonal and meridional wind and temperature, λ is the longitude, T_i are the diurnal and semidiurnal tide period, s is the zonal wavenumber and a_{si} and b_{si} denote the amplitude of the tidal components.

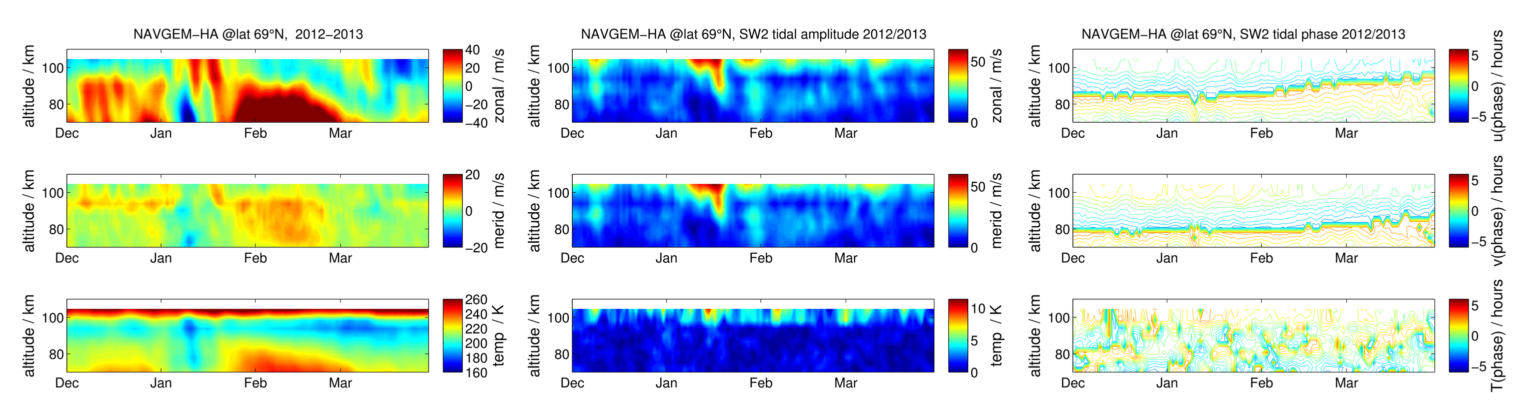
SSW 2009/2010 displacement event - mid-latitudes



Diurnal migrating and non-migrating tides



SSW 2012/2013 vortex splitting event - polar-latitudes



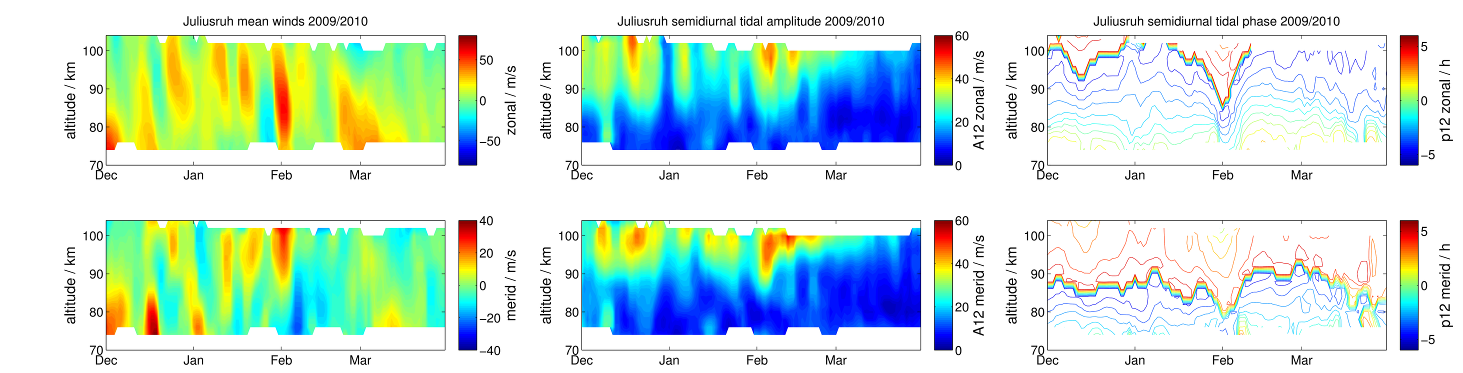
Summary NAVGEM-HA global tidal fits

- SW2 dominating tide during the winter seasons 2009/10 and 2012/13
- other migrating and non-migrating tides are almost negligible at these latitudes
- SW2 phase is altered due to background wind changes, in particular during SSWs
- SW1 appears to be amplified during SSW

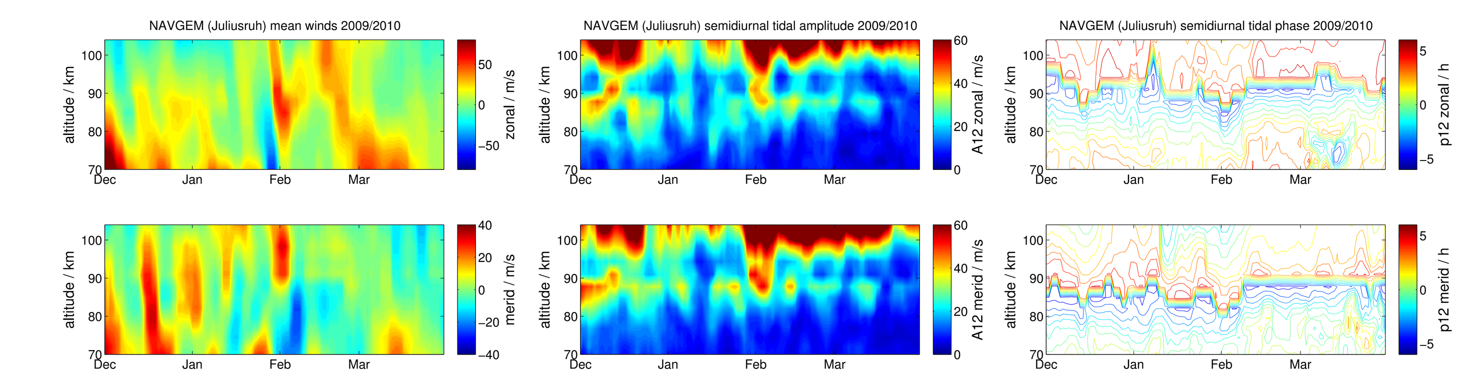
Comparing NAVGEM-HA and meteor radar observations

Comparison of meteor radar and meteorological reanalysis applying the ASF on both data to determine the day-to-day variability of mean winds, tidal amplitudes (diurnal, semi-durnal and terdiurnal) as well as their phase variability during the 2009/10 SSW (displacement event). The ASF preserves the original resolution of the input time series.

SSW 2009/10 - Juliusruh - meteor radar

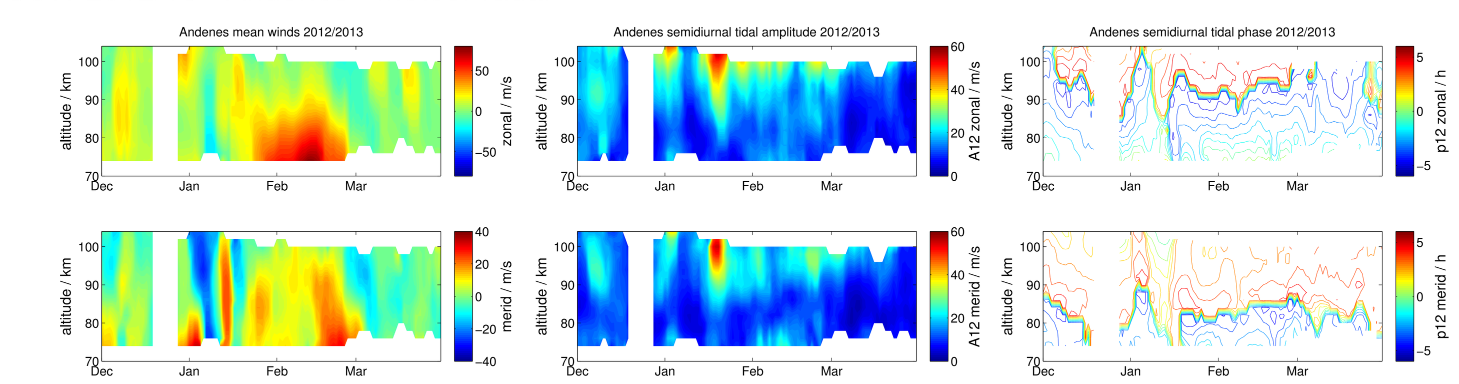


NAVGEM-HA reanalysis above Juliusruh

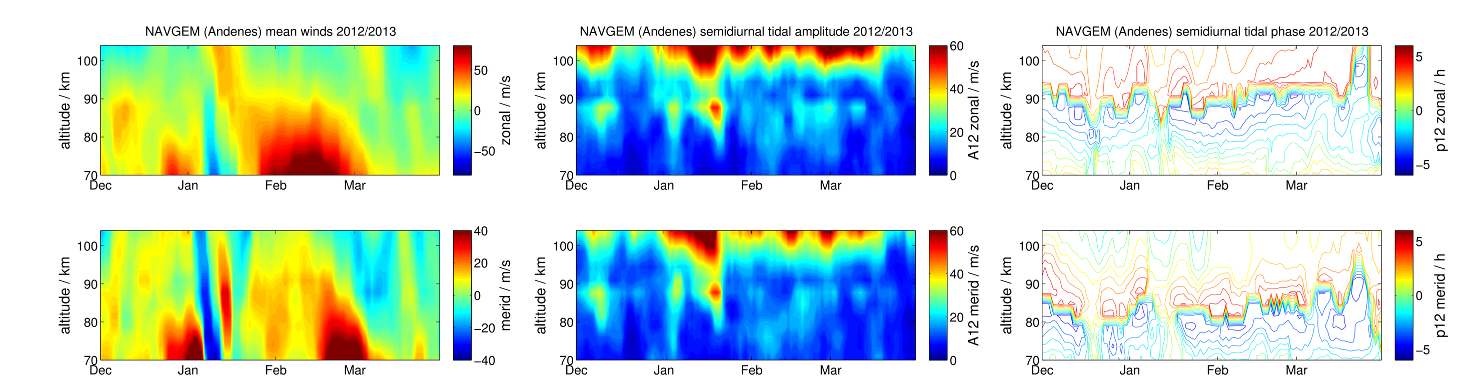


The same as above but for the SSW event in 2012/13 (vortex splitting).

SSW 2012/13 - Andenes - meteor radar



NAVGEM-HA reanalysis above Andenes



Conclusion

- local tidal measurements are representative for the global tidal field
- remarkable agreement between NAVGEM-HA and meteor radar
- SW2 tidal amplitudes in NAVGEM-HA are larger compared to meteor radars
- significant phase drifts of tidal phases due to changes in the background wind in global and local tidal observations
- SSW events cause significant changes to the SW2 tidal propagation
- SW2 tidal phase variability on time scales of days may cause issues in analyzing the lunar tide M2 or extracting tides from satellites

References

- G. Stober, V. Matthias, C. Jacobi, S. Wilhelm, J. Höffner und J. L. Chau, Exceptionally strong summer-like zonal wind reversal in the upper mesosphere during winter 2015/16, Ann. Geophys., 35, 711-720, doi:10.5194/angeo-35-711-2017, 2017.
- J. McCormack, K. Hoppel, D. Kuhl, R. de Wit, G. Stober, P. Espy, N. Baker, P. Brown, D. Fritts, C. Jacobi, D. Janches, N. Mitchell, B. Ruston, S. Swadley, K. Viner, T. Whitcomb und R. Hibbins, Comparison of mesospheric winds from a high-altitude meteorological analysis system and meteor radar observations during the boreal winters of 2009-2010 and 2012-2013, J. Atmos. Solar-Terr. Phys., 154, 132-166, doi:10.1016/j.jastp.2016.12.007, 2017.