Comparison of tidal wind shear observed by meteor radar and sporadic E occurrence rates based on GPS radio occultation observations

Christoph Jacobi[1], Christina Arras[2]

[1]Universität Leipzig, Institute for Meteorology [2]Helmholtz-Zentrum Potsdam – Deutsches GeoForschungsZentrum GFZ

jacobi@uni-leipzig.de

1 Summary

Sporadic E occurrence rates and zonal wind shear

- Connection of sporadic E phases with nodes of negative wind shear due to Es formation process through zonal wind shear.
- Correspondence of observed Es phases and wind shear phases for SDT, TDT and QDT, but no correspondence for DT.
- Interannual variability of Es and wind shear amplitudes differ.

Main conclusion

Phases of sporadic E occurrence rates agree with those of negative wind shear for SDT, TDT, and QDT, which indicates the effect of the wind shear mechanism. Amplitudes of Es and wind shear, however, do not agree.

2 Analysis of sporadic E occurrence rates and zonal wind shear

Es occurrence rates

- COSMIC/FORMOSAT-3 radio occultations 2007 - 2016.
- Sporadic E detection based on normalized SNR profiles.
- Es height at altitude of maximum SNR standard deviation.

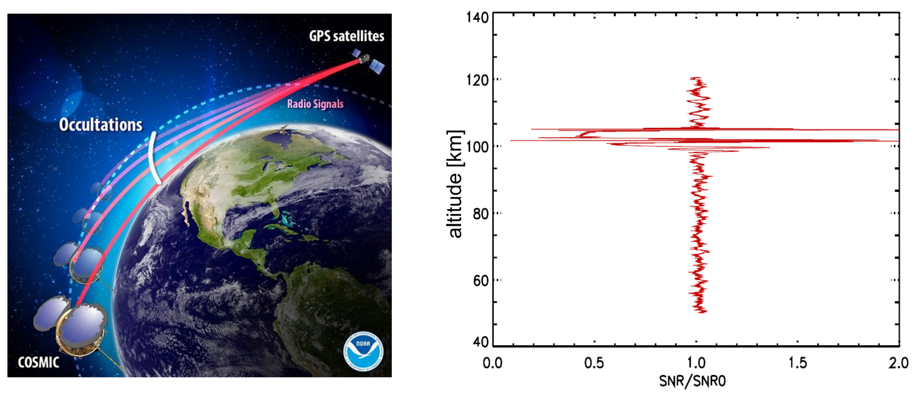

Fig. 1: Left: Principle of GPS radio occultation measurements (https://www.nesdis.noaa.gov). Right: Example height profile of standardized SNR.

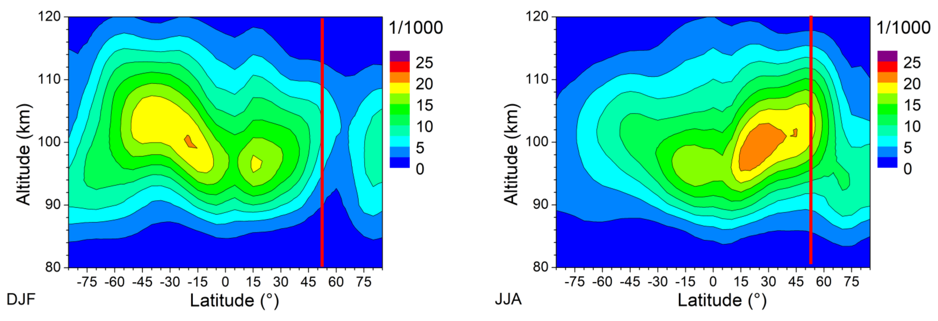

Fig. 2: 2007 – 2016 mean global distribution of sporadic E occurrence rates. Left: DJF, right: JJA. The red line shows the Collm latitude (51.3°N).

Collm VHF meteor radar

- Collm, 51.3°N, 13.0°E.
- Horizontal winds from Doppler shifted VHF signal from meteor trails.
- Vertical wind profiles at altitudes 80-100 km.

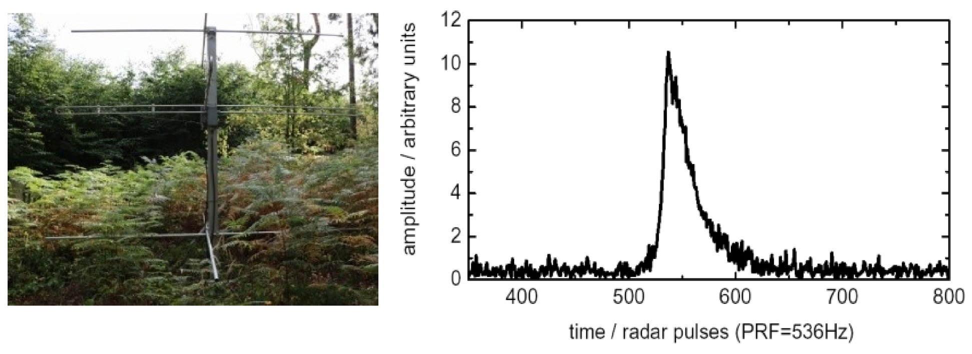

Fig. 3: Left: Radar antenna. Right: Example of meteor registration.

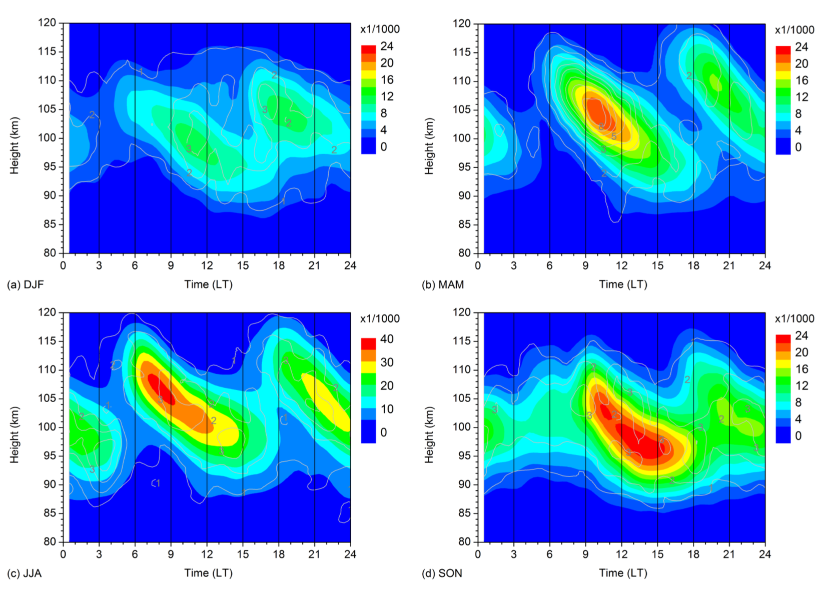

Fig. 4: Zonal and seasonal mean Es occurrence rates for four seasons. Data are averages over 2007 - 2016. Note the different scaling for summer. The grey contour lines show standard deviations.

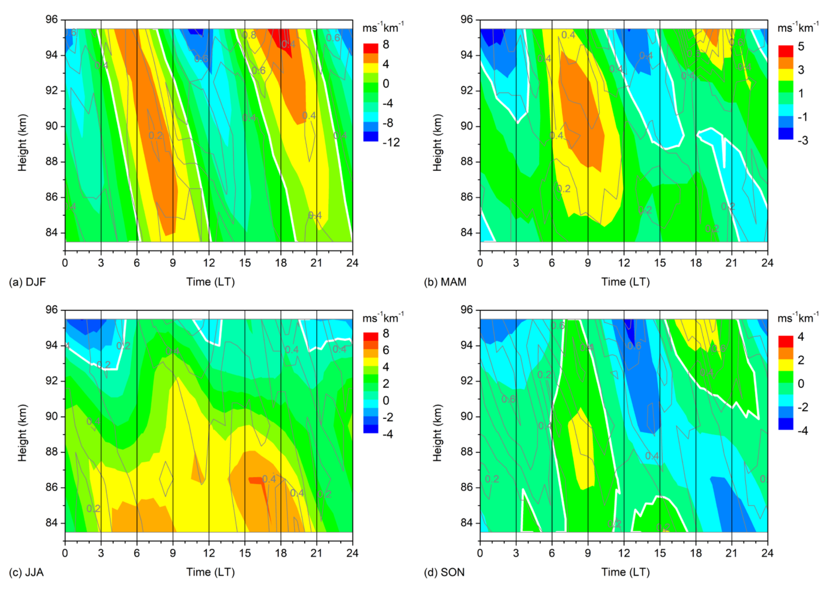

Fig. 5: Seasonal mean zonal wind shear over Collm for four seasons. Data are averages over 2007 - 2016. The grey contour lines show standard deviations.

3 Comparison of sporadic E and wind shear

Wind shear mechanism

- Vertical ion drift is upward (downward) for eastward (westward) horizontal neutral winds.
- Accumulation of ions at the nodes of negative wind shear.
- Wind shear mainly due to tides, therefore phases (times of maximum) of Es occurrence are expected to match negative wind shear phases.
- Observations show that this is the case for SDT, TDT, and QDT especially for altitudes > 90 km.
- DT in Es reflects diurnal background ionization.

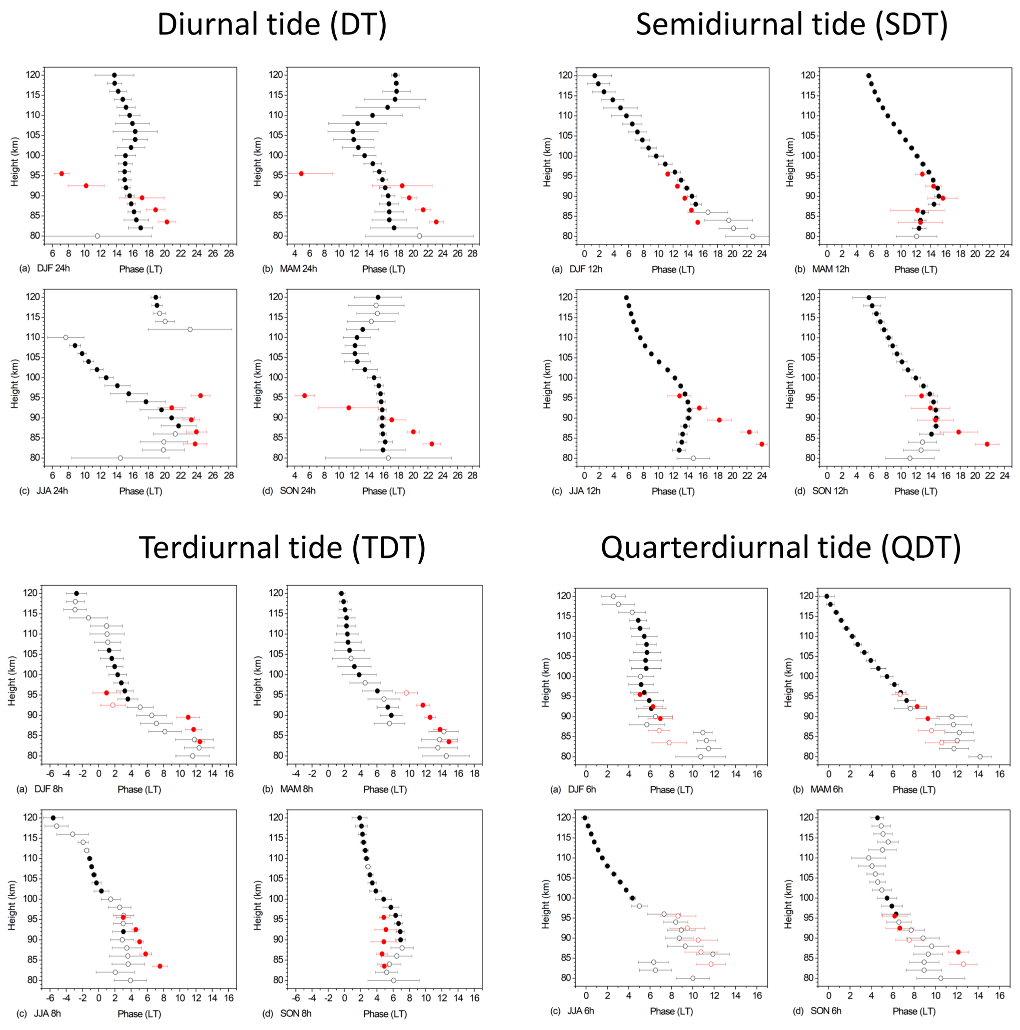

Fig. 6: 2007 – 2016 mean Es occurrence rate phases for the DT, SDT, TDT, and QDT (in black) for four seasons each. Red dots show corresponding phases of negative zonal wind shear (Jacobi and Arras, 2019).

- Time series of Es and wind shear amplitudes show only weak similarities in winter, and nearly no correspondence in summer.

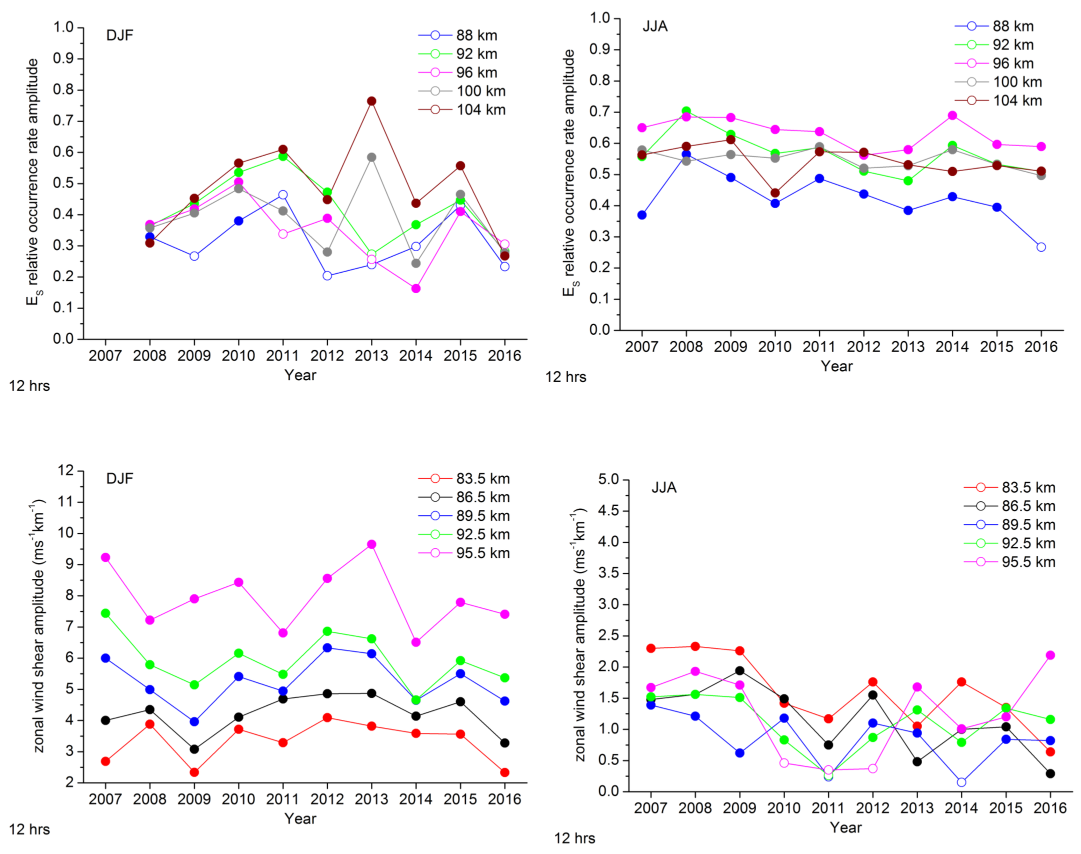

Fig. 7: Time series of seasonal mean SDT components of sporadic E occurrence rates (upper row) and zonal wind shear (lower row). Left: winter, right: summer.

4 Conclusions and final remarks

Conclusions

- SDT, TDT, and QDT phases of Es and zonal wind shear agree. This indicates that the wind shear mechanism is responsible for Es tidal signature formation.
- Interannual variability of amplitudes does not agree. Other effects like changing background ionization or interannual variability of meteor flux may be responsible for the disagreement.

Perspectives

- Analysis of nonmigrating tides, which may contribute to the Collm wind shear signal.

References

- Jacobi, Ch., and C. Arras, 2019: Tidal wind shear observed by meteor radar and comparison with sporadic E occurrence rates based on GPS radio occultation observations, Adv. Radio Sci., in press, available at http://home.uni-leipzig.de/jacobi/docs/2019_Jacobi_ARS_corrected_proofs.pdf.

Acknowledgements

- The provision of FORMOSAT-3/COSMIC data by University Corporation for Atmospheric Research is gratefully acknowledged. Christoph Jacobi acknowledges support through the Deutsche Forschungsgemeinschaft (DFG) under grants JA 836/30-1 and JA 836/34-1. Christina Arras acknowledges support by the DFG Priority Program DynamicEarth, SPP 1788. Printed at Rechenzentrum Leipzig.