Relationship of Polar Mesospheric Summer Echoes and Ozone in middle and upper atmosphere

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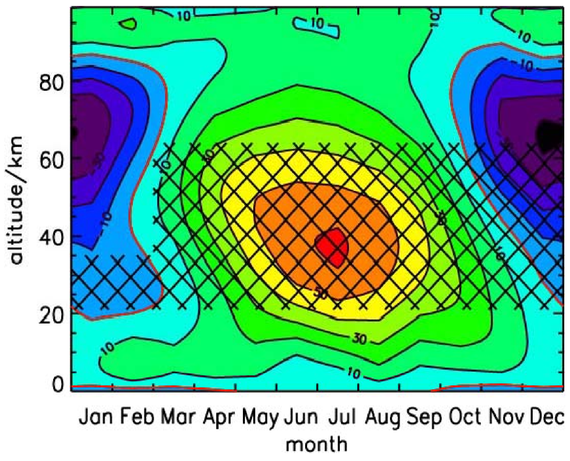
ABSTRACT

The relationship between Ozone in the upper atmosphere and planetary-wave induced perturbations in Polar Mesospheric Summer Echoes (PMSE) is examined. Ground based radiometer measurements of Ozone mixing ratio profiles at Troll station (72ºS, 2ºE) in Antarctica are compared with PMSE extracted from near range measurements of the Sanae Super Dual Aural Radar (SuperDARN) over the radiometer field of view. The the variation of Ozone with the changes in temperature are discussed, and the covariance of the frequency of occurrence of PMSE and Ozone mixing ratio are presented. The quasi-periodic fluctuations in Ozone are correlated with those in the PMSE, and temperature variations are the cause. Thus, ozone variations can be used to characterize the planetary-scale waves that reach the mesosphere during the summer and modulate PMSE.

DATA AND METHODOLOGY

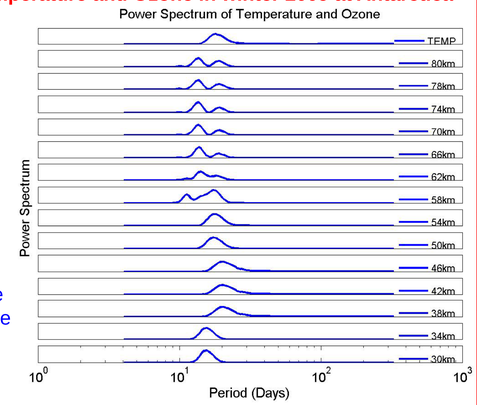
PMSE extracted from the Super Dual Auroral Radar Network (SuperDARN) data at Sanae station in Antarctica using the algorithm developed by Hosokowa et al (2005) are used to assess the distribution and occurrence of ice crystals in the mesosphere during the Antarctic summer. Daily midnight measurements of Ozone mixing ratio obtained from the British Antarctic Survey (BAS) microwave radiometer located at Troll station (72°S, 2°E) provide ozone profiles from 30 to 80 km under the radar. These are compared with the PMSE during summer, and during the winter they are compared with nightly averaged temperatures near the mesopause inferred from hydroxyl night glow measurement at Rothera (68S,68W).

The Lomb-Scargle periodiogram is used to find the significant seasonal harmonics in the temperature, Ozone and PMSE data. A Levenberg-Marquardt method was used to find the best fit of the seasonal harmonics and the effect of the solar cycle, and these were removed from the data. A Lomb-Scargle periodogram was used to identify periodic fluctuations in the residual data at periods commensurate with planetary waves. A cross covariance analysis was performed to examine the correlation between wintertime mesospheric temperature and Ozone, and between the summertime PMSE and Ozone.



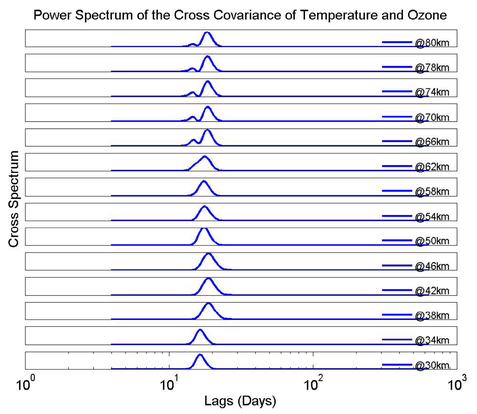
The mean zonal wind above Rothera from 0 100 km obtained from Hibbins et al 2005 are used to explain the phase shift of the waves in the middle and upper atmospher

Relationship of Temperature and Ozone in winter 2009 at Antarctica



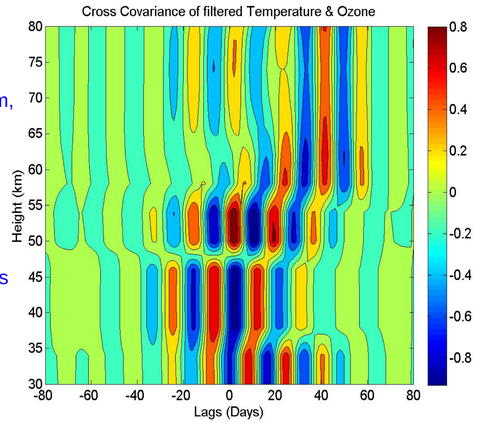
Planetary waves of about 16 days are observed in both the mesopause temperature and Ozone mixing ratio profile.

The 16 day PW are clearly defined throughout the ozone and in the mesopause temperature.



Phase coherent oscillations in the Ozone and the temperature occur at periods near 16 days.

Cross covariance of Temperature and Ozone in winter 2009 Antarctica



-At zero lag, the cross covariance is positive at higher altitude above 50 km, indicating that the temperature is correlated with the Ozone.

- The phase shifts due to zonal wind maxima observed as reported by Hibbins 2005

-PW of about 16-18 days are evident.

References

Hosokawa, K., T. Ogawa, N. F. Arnold, M. Lester, N. Sato, and A. S. Yukimatu, 2005: Extraction of polar mesosphere summer echoes from SuperDARN data, Geophys. Res. Lett., 32, L12801, doi: 10.1029/2005GL022788

Hibbins R.E., Shanklin J.D., Espy P.J., Jarvis M.J., Riggin D.M., Fritts D.C., & Lübken F.-J., 2005. Seasonal variations in the horizontal wind structure from 0-100 km above Rothera station, Antarctica (67oS 68oW). *Atmospheric Chemistry and Physics*, **5**, 2973-2980.

Acknowledgements

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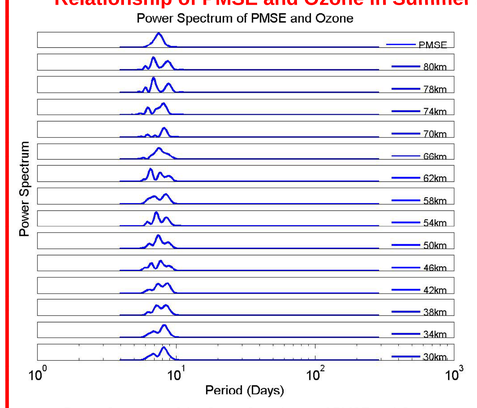
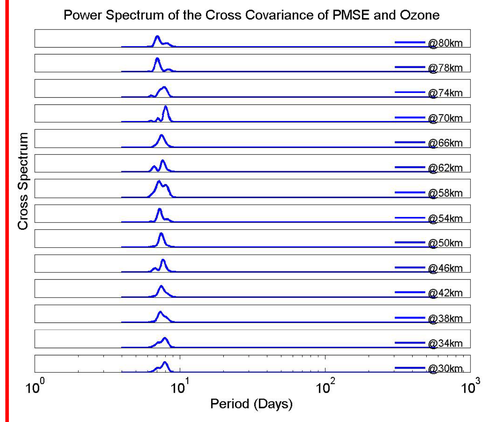
Relationship of PMSE and Ozone in Summer 2009 at Antarctica

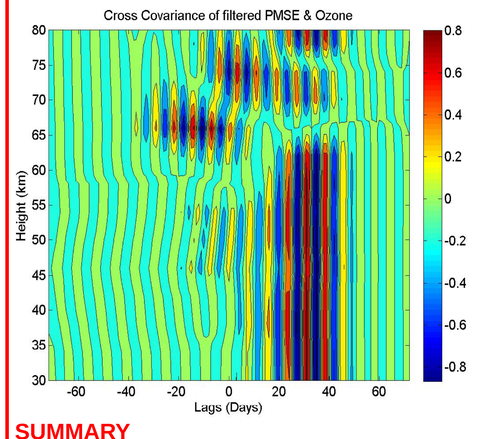


Planetary waves of less than ten days are observed in both the PMSE and Ozone mixing ratio data at all levels.



PMSE waves due to temperature fluctuation also show up as waves in Ozone

Cross covariance of PMSE and Ozone in Summer 2009 Antarctica



-A phase shift due to zonal wind maxima around 65 km as reported by Hibbins 2005

SUMMARY

•Ozone can be used to characterize waves reaching mesopause and PMSE.

•Vertical structure of the cross covariance of PMSE and Ozone suggests traveling Rossby waves create the temperature variations in both the ozone and PMSE

•The phase relationship shifts throughout the ozone profile due to Doppler shifting by zonal wind maxima..