



2-day tidal modulation: evidence for nonlinear coupling in the MLT region over São João do Cariri (7.4°S, 36.5°W), Brazil



Lourivaldo Mota Lima (lmlima@uepb.edu.br) - UEPB, Campina Grande-PB, Brazil

R. A. Buriti and A. F. Medeiros – UFCG, Campina Grande-PB, Brazil

P. P. Batista, B. R. Clemesha, H. Takahashi - INPE, São J. dos Campos-SP, Brazil



Introduction

The fact that the amplitude and phase of the atmospheric tides show long- and short-term variations in the MLT region is already well-known. From theoretical (Teitelbaum and Vial, 1991) and observational studies (see Pancheva et al., 2002), the nonlinear interactions between tides, or tides and planetary waves, have been proposed to explain the tidal variability with the same periods as observed in the winds or experimentally.

The amplitudes of the semidiurnal and diurnal tides in the region of mesosphere and lower thermosphere show variations with time scales of days to years.

In the present study, we investigate some aspects of the two-day tidal modulation in the meridional winds obtained in the equatorial latitude MLT region of the Southern Hemisphere, during January-February 2005.

Meteor winds and data analysis

This study is based on hourly mean wind measurements collected over São João do Cariri (7.4° S, 36.5° W), Brazil. The data series cover the time interval from January to February obtained during 2005. The winds data were obtained by meteor radar. The system, a SKIYMET radar, operate at a frequency of 35.24 MHz and use an interferometric receiver antenna array. From the relative phases of the signals at the various antennas together with the echo range information, the position of the meteor is accurately located. The radial wind velocity is determined from the Doppler shift.

Figure 1 shows the time-height cross section of the hourly mean meridional wind data obtained for time interval from 01 January to 13 February during 2005. It is possible to observe that the quasi-2-day wave predominate during the time interval considered.

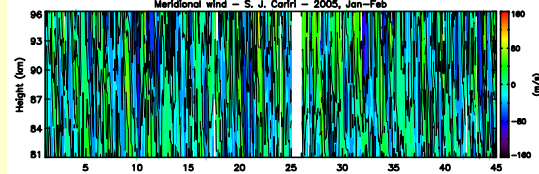


Figure 1 – Time-height cross section of the hourly mean meridional winds data observed over S. J. Cariri during 01 January- 13 February 2005.

Spectral analysis

To investigate in more detail the temporal behavior of the quasi-two-day wave, the Morlet wavelet transform were calculated for meridional wind observed during January-February 2005.

Figure 2 shows the results for periods between 0.25 to 4 days for three height gates. From this analysis, the diurnal tide can see to be weaker (stronger) when quasi-2-day wave is stronger (weaker), indicating an anti-correlation between the 2-day and the diurnal tide oscillations

The spectral power are larger for quasi-two-day and diurnal periods, indicating additional peaks around these periodicities.

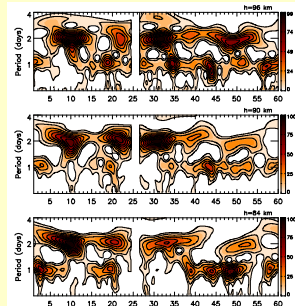


Figure 2 – Morlet wavelet transform for meridional wind component observed at S. J. Cariri in the interval 1 January-28 February for 2005 for three height gates. Heights are indicated in each panel.

Summary and Conclusions

Measurements of meteor winds, obtained at S. J. do Cariri, were used for investigate the relationship between 2-day wave and tidal variability during January-February 2005.

Spectral analysis for meridional component shown peaks associated with periods near 1.0, 2.0 days oscillations during the period investigated.

Amplitude of the 2-day, diurnal and semidiurnal tides exhibited variability with time;

Anti-correlation between the quasi-2-day wave and the diurnal tide was found;

Lomb-Scargle periodogram analysis shows the presence of additional peaks with periods near 16-h.

The peaks near 16-h are suggestive of a nonlinear coupling between 2-day and 1-day waves or between 2-day and 12-h waves.

Bispectral analysis confirm the quadratic coupling between 2-day and 1-day waves, generating a 16-h wave.

The tidal variabilities observed in the equatorial region, during January-February 2005, can be interpreted in terms of nonlinear interactions between 2-day wave and tides.

48-h, 24-h, 12-h and 16-h amplitudes

Figure 3 shows the hourly amplitudes of the 48-h, 24-h, 12-h and 16-h oscillations for meridional wind observed during January-February 2005 for three height gates as indicated.

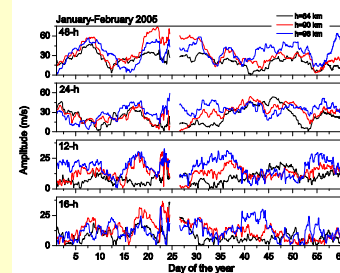


Figure 3 – Hourly amplitudes of the 2-day, diurnal, semidiurnal and 16-h oscillations in São João do Cariri for meridional wind observed during January-February 2005.

The amplitudes were obtained by harmonic analysis. The analysis was performed in sliding four-day segments of hourly winds stepped by one hour and the wave parameters determined in the least mean square sense, supposing that 16-h, semidiurnal, diurnal and 2-day oscillations were present in the meridional wind at all times.

We can see an anti-correlation between 2-day, 24-h and 12-h tidal amplitudes. Also, it is possible to observe presence of 16-h amplifications for interval considered.

Lomb-Scargle periodogram

Figure 4 shows Lomb-Scargle periodogram for three 10-day segments, stepped by 5 days, obtained during January-February 2005 for three height gates.

The results show the presence of peaks in the ~2-day and ~1-day and ~0.5-day in the panels.

Peaks near 16-h also are present in some panels.

The presence of the secondary peaks near 16-h suggest the nonlinear interaction between ~2-day and ~1-day waves, or between ~2-day and ~12-h.

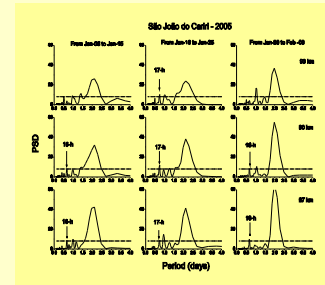


Figure 4 – Lomb-Scargle periodogram for 10-day segments, obtained for meridional winds during Jan-Feb 2005, at Cariri.

Bispectral analysis

To confirm the frequency and phase coupling between 48-h, 24-h, and 12-h oscillations, the bispectral analysis was used. Figure 5 shows the bispectral analysis results of the meridional winds observed at S. J. Cariri, for 87, 90 and 93 km heights, obtained during January-February 2005.

The figure shows presence of significant peaks with maximum energy that suggest nonlinear coupling between ~0.5 cycle/day (~48-h) and ~1 cycle/day (24-h) frequencies.

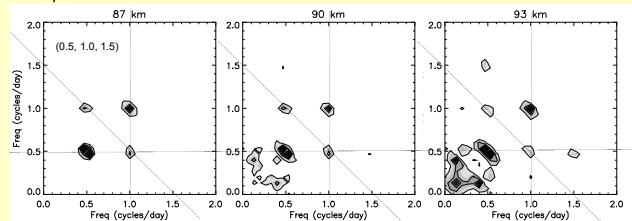


Figure 5 - The bispectral analysis results of the meridional winds observed at São João do Cariri, for 87, 90 and 93 km heights, obtained for January-February 2005

Acknowledgments

We gratefully acknowledge the Fundação de Amparo a Pesquisa do Estado de São Paulo – FAPESP, the Programa de Apoio a Núcleos de Excelência – PRONEX and Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq. We are also grateful to the Observatório de Luminescência Atmosférica da Paraíba – OLAP, UFCG.

References

- Lima, L. M.; Batista, P. P.; Takahashi, H.; Clemesha, B. R., 2004. Quasi-two-day wave observed by meteor radar at 22.7oS. *J. Atm Sol-Ter Phy.* 66 (6-9), 529-537.
- Pancheva, D. et al., A. N. Global-scale tidal variability during the PSMOS campaign of June-August 1999: interaction with planetary waves. *Journal of Atmospheric and Solar-Terrestrial Physics.* v. 64, n. 17, p. 1865-1896, Nov. 2002.
- Teitelbaum, H.; Vial, F. On tidal variability induced by nonlinear interaction with planetary waves. *Journal of Geophysical Research.* v. 96, n. A8, p. 14,169-14,178, Aug. 1991.
- Pancheva, D.; Mitchell, N. J.; Younger, P. T., 2004. Meteor radar observations of atmospheric waves in the equatorial mesosphere/lower thermosphere over Ascension Island. *Annals Geophysicae*, 22 (02), 387-404.