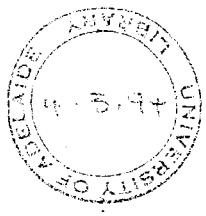

LARGE-SCALE DYNAMICS OF THE UPPER MESOSPHERE AND LOWER THERMOSPHERE

By

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Contents

Abstract

Observations in the upper mesosphere and lower thermosphere of a planetary scale wave known as the quasi-two-day wave (or simply the 2-day wave) have been made over several years at a mid-latitude site near Adelaide (34.5° S, 138.5° E), and over two years at a low-latitude site on Christmas Island (2° N, 157° W). These results, their interpretations and the consequences for current theory are presented in this thesis. In addition, an attempt is made to define and determine a response time for the solar tides. A number of data analysis techniques were also considered during the course of this thesis. An understanding of the usefulness and shortcomings of these different techniques is invaluable in any research. It is hoped that this thesis also contributes to this end.

The opening chapter gives the background in which contributions of this thesis are set. The atmosphere in general, and its remote sensing in particular, are discussed, with emphasis on the role of the tides and other planetary waves. The theory of atmospheric normal modes is also considered at this stage.

This is followed by some theory and discussion on various analytical techniques relevant to the research work. These include discussions on Doppler and Spaced-Antennae radars; full correlation analysis; Fourier techniques; the handling of missing data; the separation of wind components from a heterogenous wind field; sensitive measures for determining the period of a wave oscillation; moving power spectra; and higher-order spectral estimates. As all the wind data used in this thesis was derived by use of a full correlation analysis some time is spent in explaining this technique. The effects of varying some critical parameters in a general full correlation analysis algorithm are then investigated in Chapter 3 and comparisons made between three different algorithms.

Chapter 4 covers the main research work performed in this thesis — the investigation of the quasi-two-day wave. This is a large amplitude planetary scale wave whose wind perturbations maximise each year at mid-latitudes in the summer hemisphere. The term "quasi-" refers to previous observations that this wave has a period slightly longer than two days in the northern

hemisphere during the July solstice. As the period appears to be very close to two days in the southern hemisphere during the December solstice, the "quasi-" prefix is often dropped. The observed properties of the 2-day wave are investigated in some depth in this chapter.

Firstly, using 12 years of data from Adelaide, typical properties at mid-latitudes in the southern hemisphere were considered. These included the average vertical wavelength and mean and decile amplitudes. The concept that the wave is locked in phase to local time was also investigated.

Due to the amplitude structure of the wave, sites near the equator can observe the 2-day wave during both solstices. Therefore differences in the wave properties of the 2-day wave during its period of maximum amplitude in each hemisphere were investigated using observations at the equatorial site of Christmas Island. Other wave components, possibly harmonics of the 2-day wave, were observed and their properties determined. The presence of these additional waves suggested some non-linearity in the 2-day wave during times of large wave amplitude. Therefore interactions between the 2-day wave and the mean flow, and with the diurnal tide were also investigated. Finally, its zonal wavenumber and the impact of the 2-day wave on the atmospheric angular momentum budget were estimated at the end of the Chapter 4.

Chapter 5 details a preliminary study of the variability of the solar diurnal and semi-diurnal tides. Some measure of the response time for these tides was sought and an analysis scheme developed. Experimental estimates of a "minimal response time" were obtained and critically compared to the latest theoretical estimates. Further investigations were then suggested.

In summary, this work supports the theory that the 2-day wave is a manifestation of the atmospheric $(3,0)$ normal mode and is present in some form throughout the year. It also shows that considerable hemispherical assymetry exists for this particular planetary wave. If this is the case for one normal mode then it may easily be the case for all, reinforcing the need for more southern hemisphere and equatorial observations. The non-linear behaviour of this large amplitude oscillation has also been shown and the need for more non-linear, non-stationary, non-Gaussian analytical tools is highlighted. Lastly, an important contribution is made to the question of tidal response times, and it is suggested that *in situ* tidal modes play an important role in the observed variability of the solar tides.

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Signed:  dated: 5/10/93

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