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Planetary Waves at Equatorial Stratopause

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The rocketsonde meteorological data for the Thumba equatorial station are examined to study wave periods of planetary wave disturbances at stratopause. The temperature, density and the height data obtained every Wednesday, regularly over the period 1972-74 are used to identify the stratopause. Power spectral analysis of the stratopause height and density is carried out. Dominant peaks in spectral power are observed at periods of 20 and 40 days.

1. Introduction

Wave motions in the upper atmosphere, with time scales of the order of several days and length scales of the order of a few thousands of kilometres are known to exist and they are referred to as planetary waves. These waves propagate momentum and energy through the entire atmosphere with little redistribution in the mass. They originate at lower atmospheric heights and propagate to thermospheric levels, have great influence on the dynamics of meteorology.[1] These waves can be studied by monitoring any meteorological parameter such as pressure, temperature and wind, and such studies are meagre, particularly in equatorial latitudes. In some of the earlier studies[2-4] carried out for different seasons, waves with periods of the order of 30 days were identified for 30-70 km altitudes.

2. Analysis of Rocketsonde Data of Thumba

Rocketsonde monitoring of meteorological parameters such as density, pressure, temperature and wind has been carried out almost regularly at Thumba using M-100 meteorological rockets. These flights are carried out every Wednesday, around 2000 hrs. The data are obtained at every 1-km altitude interval. Using this altitude profile of tempera-

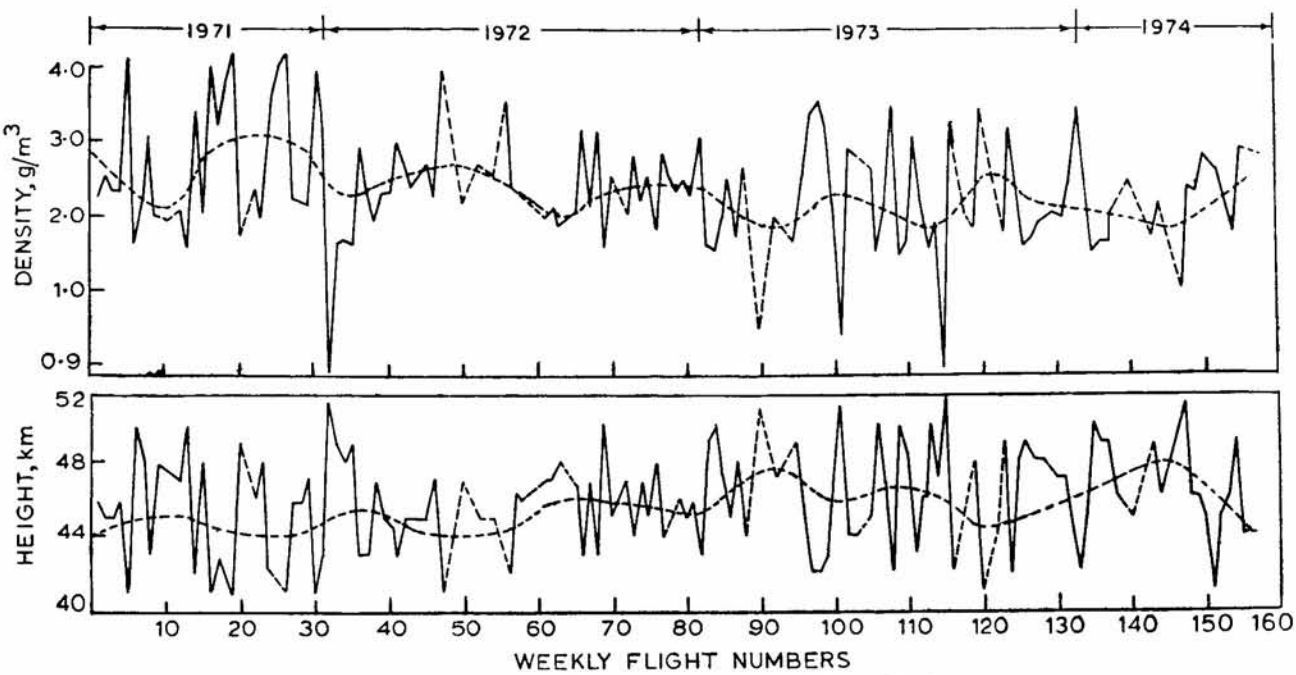

Fig. 1—Plots showing variation of density and height with time

ture, the stratopause is identified as the height of maximum temperature in the stratosphere, and the parameters of density and height of the stratopause are tabulated for the entire 3-yr period. Assuming these data as a time series, analysis is carried out. Fig. 1 shows plots of density and height of the stratopause varying with time. From Fig. 1, besides some regular seasonal variations, large period fluctuations of the order of a few weeks are easily indentifiable in all the seasons. Noting such wave trains in the plots, a power spectrum analysis is carried out for each parameter to identify the prominent wave periods present.

The power spectrum analysis is a useful tool to study the dominant periods present in any time series. This technique has been widely used for meteorological and ionospheric parameters to identify wave periods.[5] The technique in computing the spectral power, $S(f)$, is the same as that given by Blackman and Tukey.[6]

In order to remove possible seasonal and long term periodicities in the density and height variation with time shown in Fig. 1, visual mean lines are drawn in the case of both observations as can be seen in the same figure. The deviations in height and density about this mean line are then noted and the autocovariance function of the time series for each parameter is computed for a desired number of lags.

The cosine transform of this autocovariance function at various lags is calculated, giving the raw spectral density which is then smoothed by hanning the spectral window. Uncertainty $\sigma[S(f)]$ in the estimation of the spectral power is calculated as given by Rastogi and Bowhill.[5] The missing data are filled by interpolation and the error in the present case is estimated to be 36 % for both the parameters. The power spectra so obtained are shown in Fig. 2.

In the analysis, spectra is obtained for 20 lags. As the data were fed at 7-day intervals, the minimum period obtained is 14 days and the maximum is 280 days. The frequencies obtained are multiples of 0·0035 days^{-1}, clearly indicating prominent peaks at 0·05 and 0·025 days^{-1} in density and height plots. The corresponding periods of 20 and 40 days are very distinct. Another peak at 70 days appears to be uncertain because of the large error.

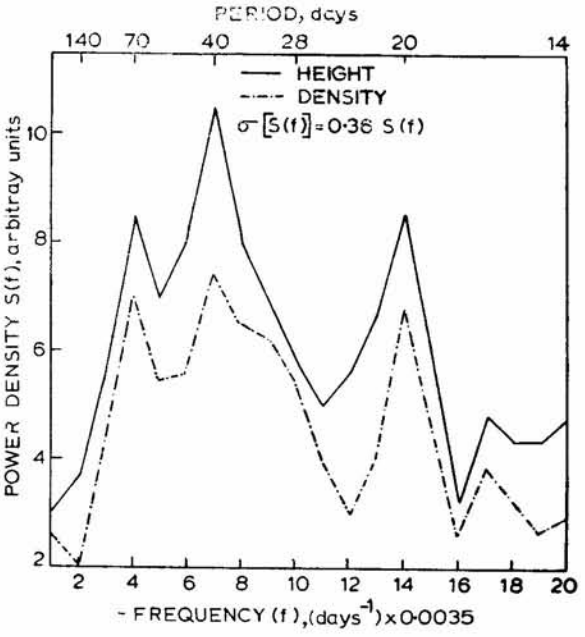

Fig. 2—Power spectra for height and density of equatorial stratopause

3. Conclusion

It may be concluded that planetary wave disturbances with periodicities of 20 and 40 days exist at the equatorial latitudes. These periods which fall into the categories of travelling and stationary planetary wave periods, respectively, indicate their presence in all the seasons. Studies on seasonal variations will be carried out with more data and the results of this study will be published later.

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