The Quasi-Biennial Oscillation of the Atmosphere Between 30 and 50 km Over Ascension Island[1,2]

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The recent completion of two years of rocket wind soundings at Ascension Island (7°55′S, 14°25′W) makes it possible to obtain, for the first time, a preliminary idea of the behavior of 26-month, or quasi-biennial, oscillation at heights above 30 kilometers. The behavior of the cycle at the higher levels is of particular interest because of its apparent downward propagation from these levels and because of the suggestion of Staley (1963) and others that the cycle has its origin in a possible 26-month fluctuation in solar ultraviolet radiation. Since the ultraviolet radiation is absorbed primarily in the upper part of the ozone layer, in the vicinity of 50 km, it seems reasonable to presume that the oscillation should increase upward to this level if the ultraviolet hypothesis is correct.

Fig. 1 shows zonal wind speed plotted with respect to time for all available measurements at seven levels, spaced four kilometers apart, between 28 and 52 kilometers. Solid circles represent the individual observations; open circles are monthly means. Linear interpolation has been used to fill record gaps at the higher levels. The data for October 1962 to June 1964, inclusive, were taken from published reports of the Meteorological Rocket Network Committee (1962, 1963, 1964) and the Meteorological Working Group, Inter-Range Instrumentation Group (1963, 1964). The writer gratefully acknowledges the assistance of the meteorology group at the U. S. Army Electronics Research and Development Activity, White Sands Missile Range, New Mexico, in obtaining the data for July to October 1964.

The existence of the quasi-biennial oscillation at 28 kilometers is apparent from visual inspection of Fig. 1. Easterly winds of about 30 m sec^{-1} at the beginning of the two-year period are replaced a year later by light westerlies, and these in turn are replaced by easterlies of the original strength at the end of the period. The behavior at this level is in accord with results of other studies of the oscillation based on routine balloon data (U. S. Navy Weather Research Facility, 1964). At 32 kilometers the quasi-biennial cycle is already difficult to discern, and at higher levels it is practically impossible to distinguish visually because of the presence of sizable shorter period fluctuations. Between 36 and 40 kilometers a pronounced annual cycle, with strong easterlies in summer and weaker easterlies or light westerlies in winter, is evident. Above 40 kilometers a six month variation becomes increasingly prominent. These interesting features will be discussed at greater

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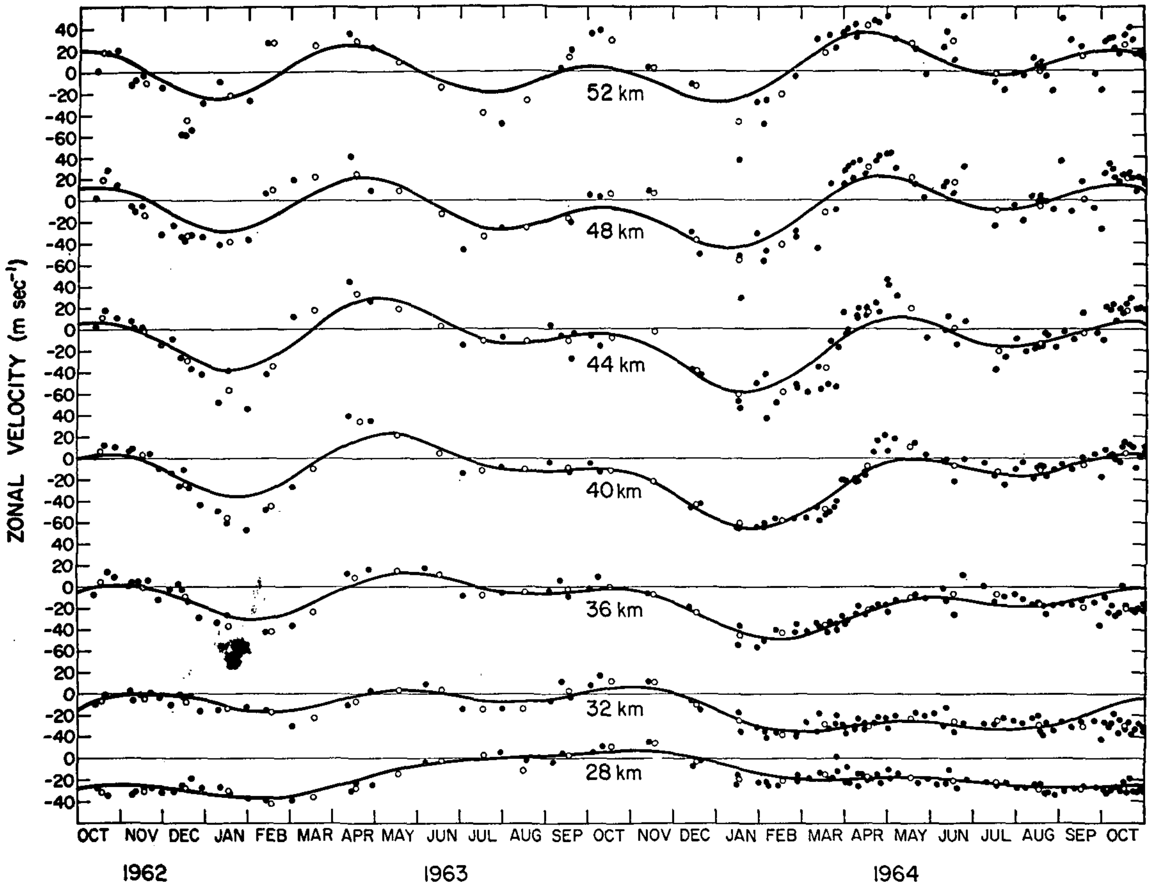

FIG. 1. Zonal wind velocity at Ascension Island (7°55′S, 14°25′W). Solid circles: individual observations; open circles: monthly means. Curves were drawn objectively by summing the first, second and fourth harmonics obtained from harmonic analyses of the monthly means.

length in a subsequent paper. Our purpose at this time is merely to show the behavior of the quasi-biennial component with height, and for this purpose it is obvious that harmonic analysis is needed.

The variations of the phase and amplitude with height, as revealed by harmonic analysis of the monthly mean values plotted in Fig. 1, are shown in Fig. 2. Amplitudes and phases for the rocket data are depicted by the dots and crosses, respectively. Corresponding balloon data, taken from *A Climatology of Wind and Temperatures in the Tropical Stratosphere Between 100 mb and 10 mb* (1964), are indicated by the circled dots and crosses. The smoothed curves in the figure were drawn subjectively.

From Fig. 2 it is apparent that the oscillation has its maximum amplitude in the vicinity of 25 km and that it diminishes gradually with height in the 30–50 km layer. The kinetic energy density, which may be of greater dynamic significance, has its peak amplitude at a somewhat lower level and decreases considerably more rapidly with height. There seems little doubt that the oscillation is strongest in the lower equatorial stratosphere. It is also apparent from the figure that the phase of the biennial oscillation becomes increasing earlier with height in the layer between 30 and 50 km. This behavior is qualitatively the same as in the lower layers, but the downward phase propagation is considerably faster at the higher levels, being about 2 km mo^{-1} as compared with often quoted figure of 1 km mo^{-1} lower down.

Obviously a longer period of record at Ascension Island and rocket soundings from other sites are required before the behavior of the 26-month cycle in the middle and upper equatorial stratosphere can be regarded as firmly established. The preliminary results reported here suggest two tentative conclusions: (1) the amplitude of the oscillation is largest near 25 kilometers and diminishes gradually above this level to a height of 50 kilometers or more, (2) the downward propagation noted at lower levels is characteristic of the 30–50 km layer, as well, but the phase speed is about twice as great at the higher levels.

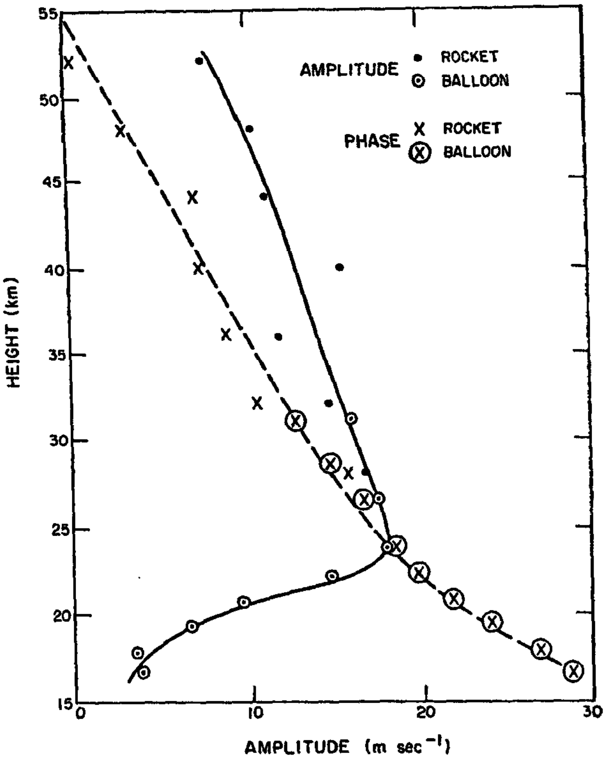

FIG. 2. Variations of phase and amplitude of the biennial oscillation with height at Ascension Island.

The rocket soundings have brought to light a further interesting feature of the equatorial circulation: the possible existence of a pronounced semiannual cycle in the zonal wind component at a height of 40 km and above.

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