A Possible 2-Day Oscillation near the Tropical Stratopause[1]

LAWRENCE COY

Department of Atmospheric Sciences, University of Washington, Seattle 98195

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ABSTRACT

An examination of daily meteorological rocket data taken during January and February 1977 at Kwajalein, Marshall Islands (9°N, 168°E) suggests the presence of a large oscillation in the meridional wind with a period near 2 days. Some rocket data taken concurrently at other stations is also presented. The Canal Zone station (9°N, 80°W) suggests a possible 2-day oscillation, while middle- and high-latitude stations show variability with periods ranging from 2–5 days.

Little is known about high-frequency disturbances in the upper stratosphere and lower mesosphere. A previous study of daily meteorological rocket data made by Leovy and Ackerman (1973) showed the presence of disturbances at the stratopause and above to 60 km with amplitudes of about 20 m s^{-1} and periods between 1.5 and 4 days. These disturbances were seen at mid and high latitudes during December 1969. Studies of winds at these altitudes

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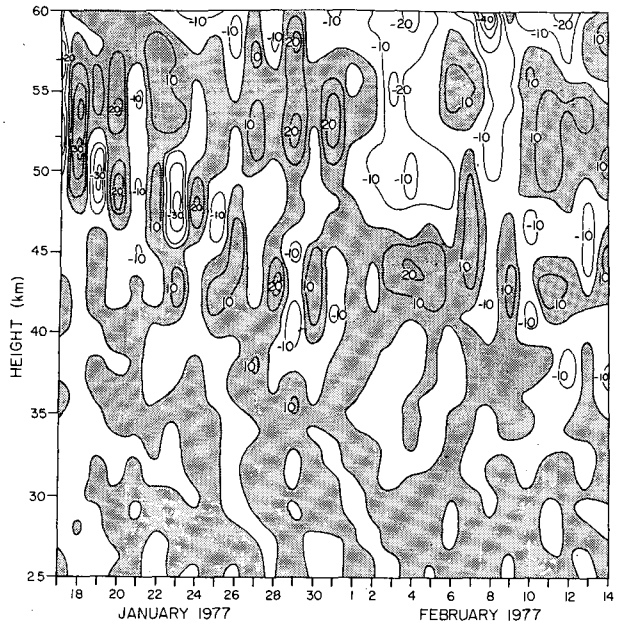

FIG. 1. Time-height section of the meridional wind at Kwajalein, Marshall Islands (9°N, 168°E). Isotachs are placed at intervals of 10 m s^{-1}. Shaded areas indicate southerlies.

on time scales of less than a week are scarce because meteorological rocket stations do not regularly launch rockets more than twice a week. However, in January and February 1977 rockets were launched daily, thus providing another opportunity of detecting high-frequency disturbances.

The most surprising feature in the January and February 1977 data is the presence of large meridional wind oscillations in the tropics. Fig. 1 shows a time-height section of the meridional wind for Kwajalein, Marshall Islands (9°N, 168°E), constructed from daily data. Each sounding was made at 2300 GMT (±2 h) so the effects of the diurnal and semidiurnal tides should not be present. Large oscillations are seen near the stratopause (~50 km) with a period of about 2 days and an amplitude as large as 30 m s^{-1}.

In order to illustrate more of the daily rocket data taken during January and February 1977 Fig. 2 presents time series for selected stations and levels. Both of the tropical stations (Kwajalein and the Canal Zone) contain a 2-day oscillation in the meridional wind at the start of the time period shown while the corresponding zonal winds show trends and variations with periods ≥2 days. No obvious correlations are seen between the u and v fields at either Kwajalein or the Canal Zone. Fig. 2 also shows the Kwajalein winds at 10 mb taken from rawinsonde data in which a small amplitude 2-day oscillation appears in the meridional wind concurrent but out of phase with the 48 km 2-day oscillation. No corresponding oscillation appears in the Canal Zone rawinsonde data (not shown). Rocket stations at middle and high latitudes typically showed wind variations with periods ranging from 2–5 days near the stratopause during January and February 1977. Time series for Wallops Island, Virginia (38°N, 76°W), and Poker Flats, Alaska (65°N, 148°W), are presented in Fig. 2 as being representative of stations outside of the tropics.

Although the 2–5 day wind variations at mid and high latitudes appear similar to those found by Leovy and Ackerman (1973), the 2-day oscillation in the tropical meridional wind seems to be more regular than any variations previously observed in rocketsonde data. This apparent regularity in the tropics may or may not be real as problems occur when attempting to analyze a 2-day oscillation found in a short time series of daily data.

Aliasing is one possible problem when an apparent 2-day oscillation is seen in daily data. The observations could be the result of any of an infinite number of higher frequencies if such frequencies are present in the atmosphere. In addition to the lowest possible frequency of 0.5 day^{-1}, frequencies such as 1.5, 2.5, 3.5, day^{-1} etc., would also be capable of explaining the observations. However, while it is impossible to rule out the existence of higher frequencies, the presence of such high frequencies with periods of a fraction of a day would seem even more surprising than a 2-day oscillation.

Another difficulty caused from having only daily data is that cross-spectrum analysis between the zonal wind, meridional wind and temperature fields is unable to give phase information for an oscillation near 2 days. Such information could support the reality of a 2-day oscillation if it revealed that the oscillation had a definite structure. Clearly, data needs to be taken more frequently than once a day for a study of an oscillation near 2 days to be complete.

Assessing the statistical significance of power spectra constructed from the January–February 1977 data is difficult not only because of the shortness of the data record available but also because of the *a posteriori* detection of the apparent 2-day oscillation. No 2-day oscillation was expected before the data were examined. In order to examine data on an *a priori* basis two previously unexamined data sets were searched for 2-day oscillations. The first data set consisted of daily rocketsonde data taken at the Canal Zone station from 16–31 July 1977. This rocket data showed variations with periods ranging from 2–5 days but no clear 2-day oscillation was found. Since the data at 10 mb for Kwajalein shown in Fig. 2 suggests a possible 2-day oscillation at rawinsonde levels the second data set examined *a priori* consisted of 10 and 30 mb time series constructed from four times daily rawinsonde

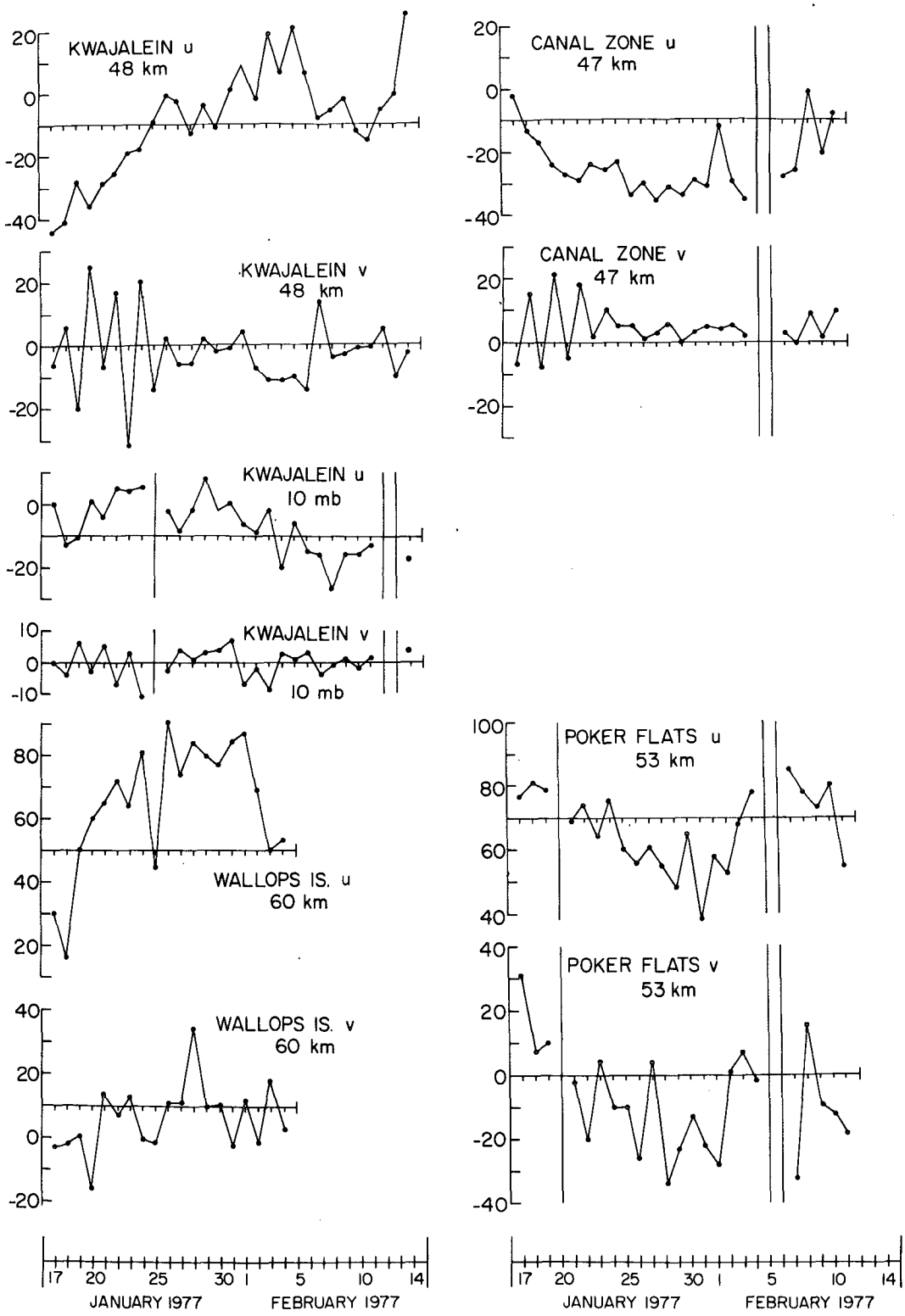

FIG. 2. Time series of u (zonal) and v (meridional) wind at selected stations and levels as shown. All winds are in m s^{-1}. Vertical lines denote missing data. The lines connecting data points are to aid in viewing the data as a time series and are not intended as interpolations. The approximate time of day (GMT) for the rocket launch was 2300 for Kwajalein (9°N, 168°E), 1700 for the Canal Zone (9°N, 80°W), 1600 for Wallops Island (38°N, 76°W) and 2200 for Poker Flats (65°N, 148°W).

data taken at Eniwetok (11°N, 162°E) during 1956 and 1958 and the Canal Zone (9°N, 80°W) during 1967–68. The data were broken down into several time series each time series being about four months long. Zonal wind, meridional wind and temperature autocorrelation functions were computed for each time series. None of the autocorrelation functions showed large peaks at a lag of 2 days. In summary, the possible 2-day oscillation seen near the tropical stratopause in the January and February 1977 rocketsonde data was not observed in either of the two data sets examined on an *a priori* basis.

The significance of the 2-day tropical stratopause disturbances presented here is still in doubt. It should be noted, however, that oscillations near 2 days have been reported in other types of atmospheric data. Meteor wind measurements have shown oscillations with a period close to 2 days at high altitudes (80–100 km) and mid to high latitudes (Clark, 1975; Glass *et al.*, 1975; Müller and Nelson, 1978) and a study of partial reflection radiowave wind observations (60–110 km) by Stening *et al.* (1978) taken at Saskatoon, Canada (52°N, 107°W), has also reported oscillations with a 2-day period. Muller and Nelson (1978) summarized the meteor wind data and concluded that the 2-day oscillation is most likely a wavenumber 3 and that its largest amplitude occurs during summer. The relationship between these high-altitude oscillations and the tropical stratopause oscillations presented here is not clear. More observations are likely to be needed before a theory can be formed but it is interesting to note that a mechanism has been proposed by Orlanski (1976) in which the diurnal changes in static stability of the tropical boundary layer can excite gravity waves with a period of 2 days.

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