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16. Summary/Notes

Diurnal tidal component in the meridional wind is determined over seven stations using the data of a tidal experiment conducted on March 19-20, 1974. The amplitude and phase are compared with earlier observational and theoretical calculations. Present results confirm the earlier finding that the theoretical curve of phase versus height over a low latitude station occured on the average 3 hours earlier compared to the observed curve.

17. Remarks *To be presented in the Tenth EXAMETNET Meeting to be held at "Campo de Provas da Marambaia", Rio de Janeiro, Brazil.*

ABSTRACT

Diurnal tidal component in the meridional wind is determined over seven stations using the data of a tidal experiment conducted on March 19-20, 1974. The amplitudes and phases are compared with earlier observational and theoretical calculations. Present results confirm the earlier finding that the theoretical curve of phase versus height over a low latitude station occured on the average 3 hours earlier compared to the observed curve.

I - INTRODUCTION

The subject of atmospheric tides is one of the most extensively studied problems of atmospheric sciences. Observational studies on tides are based essentially on the surface meteorological data, which are readily available. Lack of data in the upper atmosphere prevented an accurate determination of tidal components above 30km, where the tidal oscillations attain significant amplitudes. The atmosphere above 30km is only accessible to direct measurement by rockets and such measurements are considerably less in number and more widely spaced in time.

Routine rocket measurements have been used by Reed, et al. (1966) and Reed (1967) to isolate the tidal components. The use of soundings which are irregularly distributed over the year will cause problems of trend removal. Thus consistent results could be obtained only for the meridional wind during the summer when the background winds are steadiest. Also special tidal experiments have been conducted by making soundings which are more closely spaced in time for a few days (Miers, 1965 and Beyers, et al., 1966). A review of the above mentioned measurements and others could be seen in Groves (1967). Recently Groves (1974a) used Rocket Grenade data of 24 launchings gathered during the years 1966-1968 over Natal, Brazil to analyse diurnal tidal components.

Reed, et al. (1969) compared the observed tidal components with the theoretical calculation of Lindzen (1967). It is found that in the South to North (SN) wind oscillations both in the results of Reed et al. (1969) for low latitude stations and Groves (1974a) for Natal, the theoretical curve of maxima versus height occured earlier than the observed ones. Groves (1974b) found that a significant revision of amplitudes and phases of the thermal excitation is required if theory is to be consistent with the observations.

The purpose of the present note is to present the results of a tidal experiment conducted as a special programme of EXAMETNET in collaboration with NASA and compare the results with earlier calculations. Rockets are launched at 3 hour-interval on March 19-20, 1974 starting from an afternoon hour which varied slightly from station to station (Schmidlin, et al., 1975). Rocketsonde stations used for the present analysis are shown in Table 1 along with the hours of launching. Meridional wind is subjected to harmonic analysis assuming the data are equally spaced in time with 3 hours interval. As shown in Table 1 at some stations one observation was missing and the mean of the preceding and succeeding observations is used to fill up the gap. Although the present calculations are based on one days' soundings, the general agreement with earlier results is so good that the results appear to be meaningful.

TABLE 1

TIME OF 8 LAUNCHING - GMT

STATION	1	2	3	4	5	6	7	8
1. Fort Churchill 58.7°N;93.8°W	15:00	18:00	21:00	00:00	03:00	06:00	09:00	12:00
2. Wallops Island 37.8°N; 75.5°W	16:05	19:54	22:00	01:08	04:53	07:06	10:00	12:40
3. Antigua 17.2°N; 61.8°W	15:01	18:20	21:00	-	03:00	06:00	09:00	12:00
4. Fort Sherman 9.3°N; 80°W	16:00	19:00	22:00	01:00	04:00	07:00	10:15	13:15
5. Kourou 5.1°N; 52.7°W	15:00	18:00	21:00	00:00	03:00	06:00	09:00	12:00
6. Natal 5.9°S; 35.1°W	16:00	19:00	22:18	01:00	-	07:48	10:00	13:21
7. Ascension Island 8.0°S; 14.4°W	16:00	19:00	-	01:00	04:00	07:00	10:00	13:00

II - RESULTS

The amplitudes and phases of the diurnal tidal oscillation are determined at 1km intervals and are shown in Figures 1 to 5. In all the figures the continuous curve represents the present determination. The dotted curve is Lindzen's (1967) theoretical calculation. Also shown in the figures are the calculations by Reed et al.(1969) for the corresponding latitudes. These are presented by the broken curves.

In the present calculation in all the figures some small (vertical) scale irregularities could be seen. This is understandable because the present calculation is based on only one day soundings.

The discussion will now be made for each figure.

FIGURE 1: Fort Churchill

Here, up to 45km the agreement in amplitude between the 3 curves is good and above 45km the present calculations have shown some irregularities. Coming to the phase the agreement between the 3 curves is quite good above 40km. Below 40km there are larger deviations in the present experiment and the phase determination may be relatively less accurate because of the small amplitudes at these levels.

FIGURE 2: Wallops Island

Over this station again there is general agreement in amplitude up to about 40km. However, above 40km the amplitude remained less than 4m sec^{-1} up to 50km in the present calculations and then it increased rather rapidly. On the other hand both in Lindzen's (1967) and Reed et al's (1969) calculations the amplitude increased continuously up to about 55km and then decreased. In the case of phase above 45km the maximum south wind occured a few hours later compared to both theoretical and Reed et al's (1969) results. Below 45km the phase variation is rather irregular.

FIGURE 3: Antigua

Over this station the amplitude of the oscillation in the present calculations is higher at lower levels compared to both theoretical and Reed et al. (1969) values. The maximum at 47km and the minimum at 53km is also not found in them. However, the phase variation with height is rather regular from 43km up to 55km; the maximum in the present calculation occured earlier compared to both theoretical and Reed et al's (1969) results. Above 55km theoretical phase occured earlier compared to observed ones. Below 40km Reed et al. (1969) found opposite phase behaviour in their results compared to the theory. In the present study, however, above 35km the phase variation compared better with the theory.

Below 35km the differences between the present calculations and the theory and Reed et al's (1969) results are considerable.

FIGURE 4: Fort Sherman and Kourou

In this figure the results of both the low latitude N.H. stations are depicted. Thin continuous line represents Fort Sherman and thick continous line represents Kourou. As before dotted line represents theoretical results of Lindzen (1967).

The amplitude variation with height appears to be rather irregular over Kourou and above 45km it appears to be more than the theoretical values. The amplitude over Fort Sherman decreased above 45km and is less than the theoretical value. At almost all levels up to 55km theoretical phases are earlier than those over Kourou. Compared to values over Fort Sherman, at lower altitudes from 35 to 40km and at higher levels from 47 to 55km theoretical phases are earlier.

FIGURE 5: Natal and Ascension Island

In this figure continuous thin line represents the values for Natal and thick continuous line represents Ascension Island. As before dotted and broken lines represent Lindzen's (1967) theoretical and Reed et al's (1969) values respectively. All the observed amplitudes appear to be larger below 37 and above 55km than the theoretical values. Amplitude values around 50km over Ascension Island are higher in the present calculation compared to all others. Above 55km theoretical values are considerably less compared to all the observed values. Above 45km, as found by Reed et al. (1969), theoretical phases are too early compared to all observations. At lower levels although there are relative differences in the observations, the phase change with height is in general agreement with each other. But the theoretical phases changed in the opposite sense.

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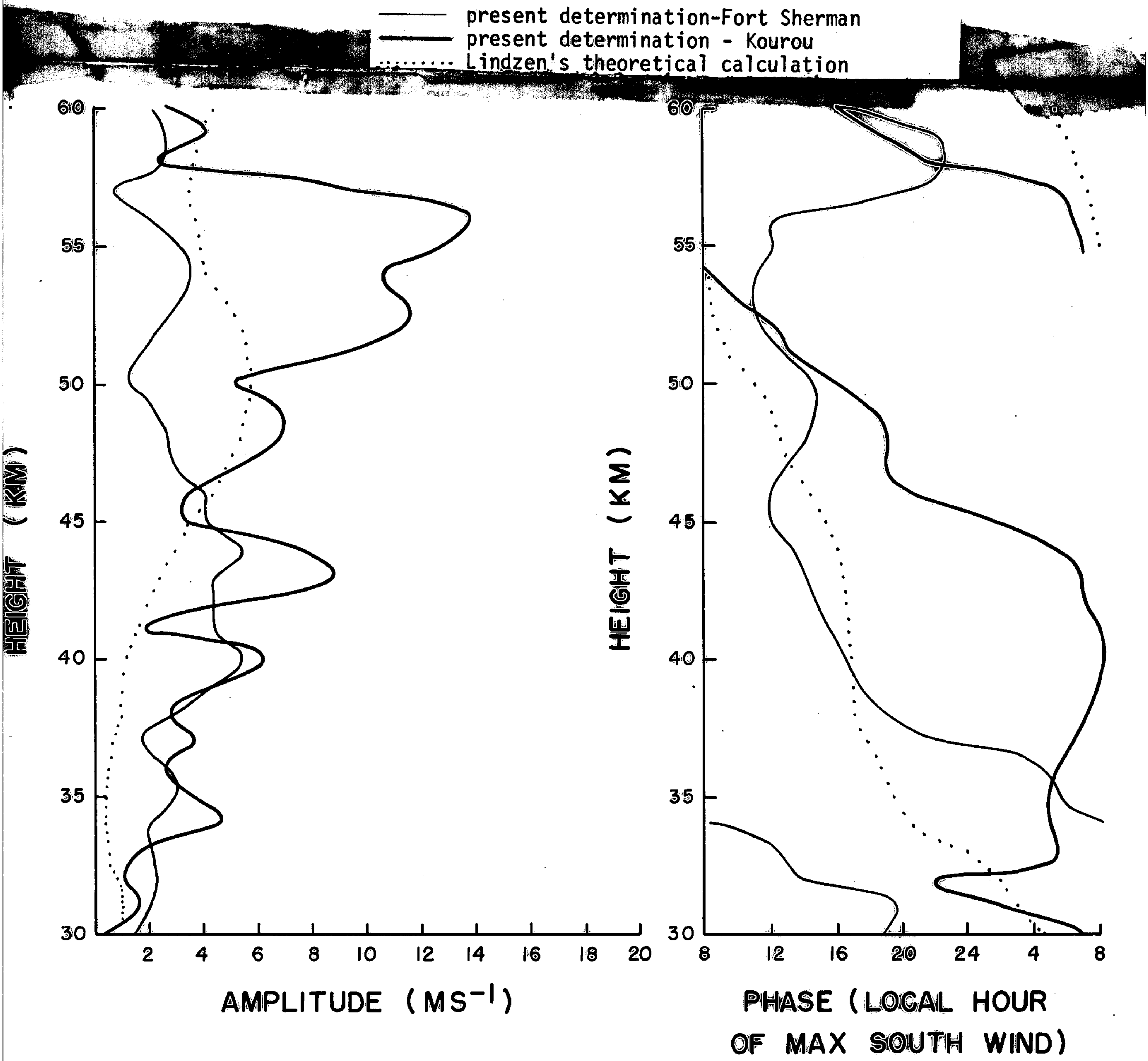

Fig. 4

Amplitude and phase of diurnal variations of meridional wind component over Fort Sherman (9.3°N, 80.0°W), and Kourou (5.1°N, 52.7°W).

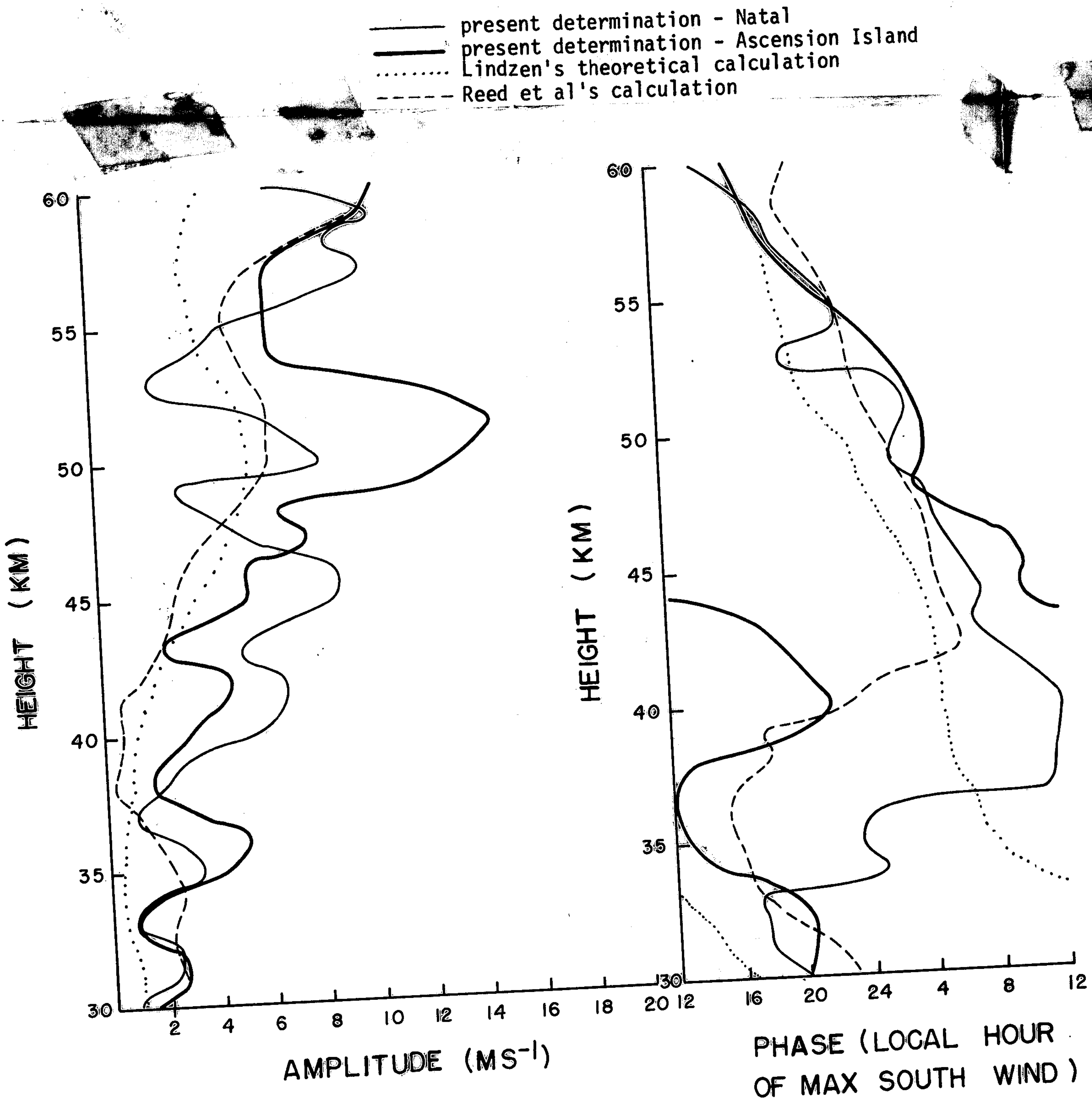

Fig.5

Amplitude and phase of diurnal variations of meridional wind component over Natal (5.9°S, 35.1°W), and Ascension Island (8.0°S, 14.4°W).

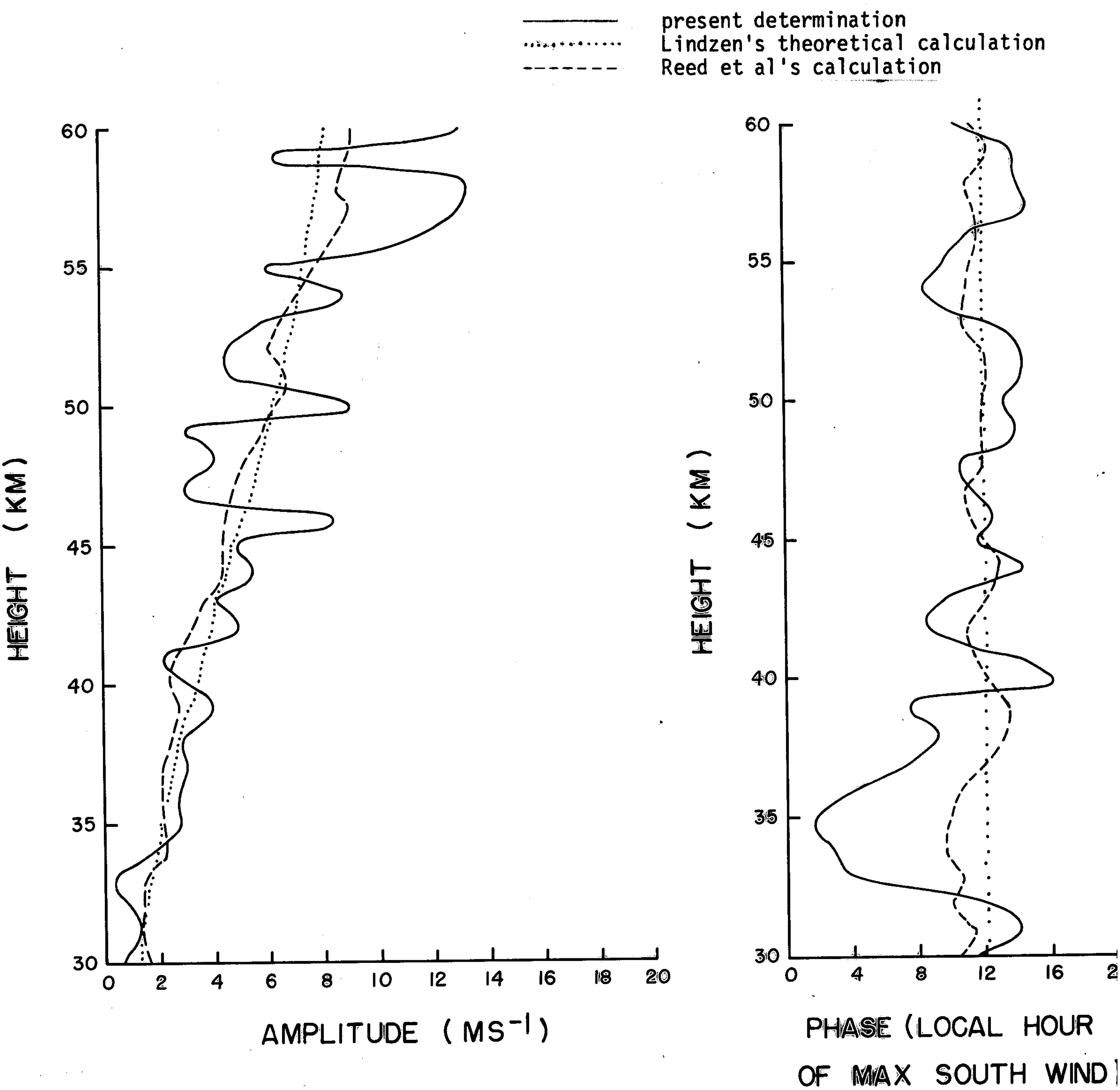

Fig. 1

Amplitude and phase of diurnal variations of meridional wind component over Fort Churchill (58.7°N; 93.8°W).

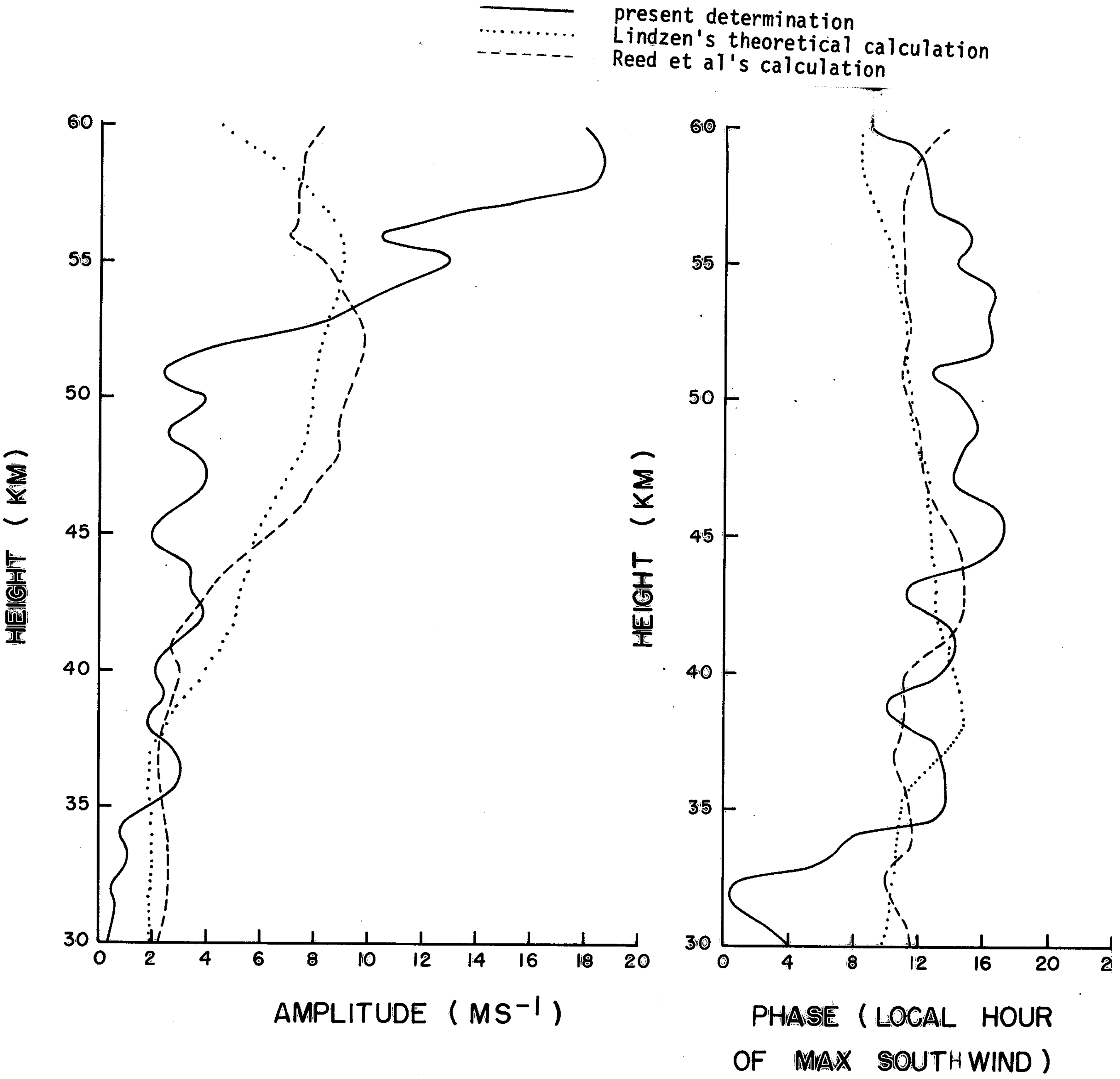

Fig. 2

Amplitude and phase of diurnal variations of meridional wind component over Wallops Island (37.8°N, 75.5°W).

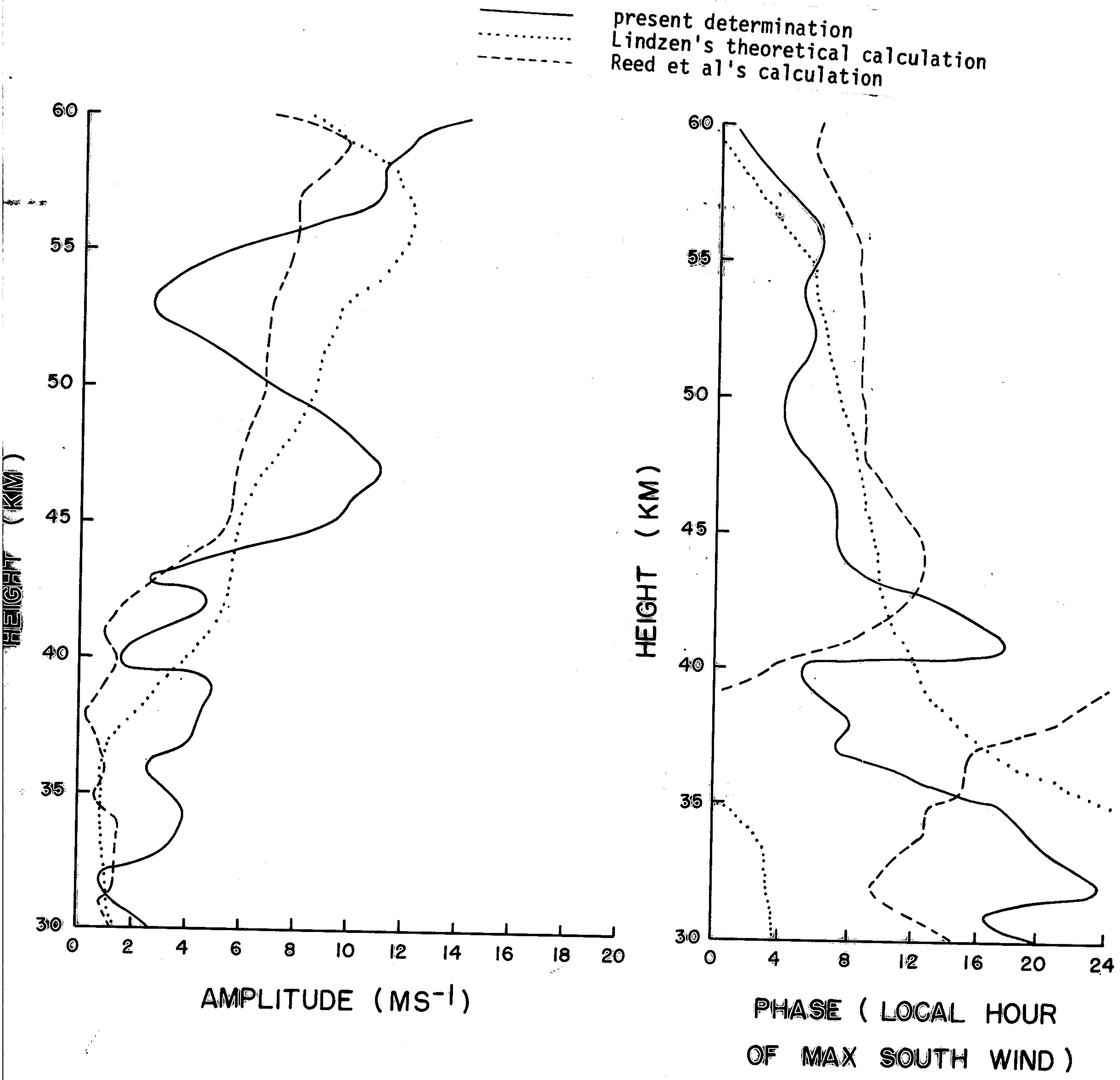

Fig. 3

Amplitude and phase of diurnal variations of meridional wind component over Antigua (17.2°N, 61.8°W).