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Lunar tides in earth current at Barrow

S. JEEVANANDA REDDY

Meteorological Office, Poona

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ABSTRACT. The lunar tides in earth current (*viz.*, Telluric current) at Barrow (71°18'N, 156°47'W) have been studied by using hourly values of N-S and E-W components for the period 1963-1965 and 1961-1962, respectively. The study shows that significant results can be obtained from data for even short periods of Telluric current. Further it has been found that there is good agreement between lunar semi-diurnal oscillations in earth currents (studied by Egedal and Rougerie) and Telluric current (present study).

1. Introduction

Lunar tidal features in earth current flow have been discussed by Egedal (1937, 1938), Rougerie (1937) and Rooney (1938). The main result of these studies is that L (Lunar tides) for any station, is predominantly semi-diurnal, the curve approaching closely a double sine wave. There is some difference, however, in phase and amplitude for different stations. The form of the mean curves seems to be independent of latitude. Further, it appears that the general features of the lunar diurnal variation in earth current flow can be determined from even a comparatively short series of records.

The lunar tidal effects on Telluric current at Barrow (Alaska-USA) have been studied in the present paper. The phase and amplitude have been evaluated by the Chapman and Miller method (1940) and the Malin and Chapman method (1970) for finding the vector probable error. In the process, the solar daily variations are also estimated.

2. Analysis

Hourly data (the hourly range is taken as the absolute sum of the greatest positive and greatest negative excursion of the trace during each hour) at Barrow for 1963-1965 of North-South (N-S) component and 1961-1962 of East-West (E-W) component of Telluric current are used in the present paper. For obtaining the mean picture of the variation due to solar and lunar tides, all days for which the records were complete have been used. As the data used here are for a short period these have not been divided into the calm and disturbed days and seasons. This would also avoid the influence by variations in the contact potentials at the electrodes, which will otherwise affect the calculations.

Both solar and lunar effects upto the 4th harmonic have been calculated. The solar and lunar factors are given in the form—

$$S = \sum_{p=1}^{4} s_p \sin (pt + \theta_p$$

and

$$L = \sum_{n=1}^{4} l_n \sin [t (n-2) + 2T + \lambda_n]$$

where, S and L are the solar and lunar factors respectively.

s_p and θ_p $(p = 1,2,3,4)$ represent amplitudes and phase angles respectively of the first four harmonics, *i.e.*, 24, 12, 8 and 6 solar hourly waves in the solar factors (24 solar hours = 1 solar day).

l_n and λ_n $(n = 1, 2, 3, 4)$ represent amplitudes and phase angles respectively of the first four harmonics, *i.e.*, 24, 12, 8 and 6 lunar hourly waves in lunar factor (24 lunar hours = 1 lunar day).

t: Solar time in degrees, increases from 0° to 360° from one local solar transit (local mid-night) to the next.

T: Lunar time in degrees, increases from 0° to 360° from one local lunar transit of the moon to the next (one lunar day = 1·03505 solar days).

The necessary corrections to λ_n and θ_p are made. The lunar and solar tidal variations of the N-S (u) and E-W (v) components are given in Tables 1 and 2 respectively. In the case of the N-S components, the data is divided into two groups. The first group contains the first 600 days and the second group contains all the 1000 days under consideration. For the N-S component L and S represent the results for the first group of data and L' and S' represent the results for the second group of data.

The lunar and solar semi-diurnal tides L_2 (u, v) and S_2 (u, v) are represented by harmonic dials in terms of lunar and solar times respectively, and

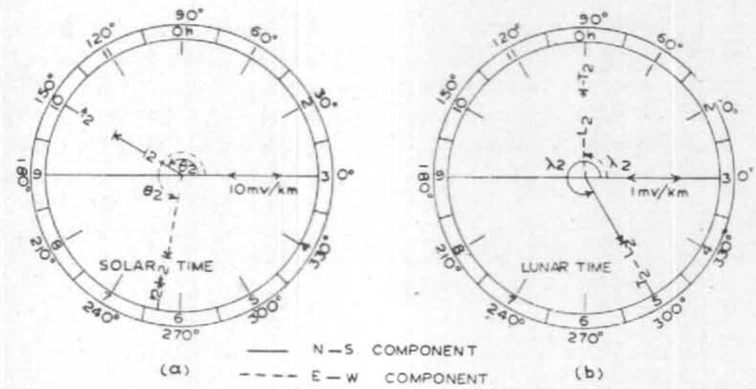

Fig. 1

Harmonic dial representation of (a) Solar semi-diurnal variation and (b) Lunar semi-diurnal variation of Telluric current activity at Barrow

TABLE 1

Lunar tides in Telluric current at Barrow

	Northward component (u)			Eastward component (v)		
	Amplitude (mv/km)	P.E. (mv/km)	Phase (°)	Amplitude (mv/km)	P.E. (mv/km)	Phase (°)
	1st group (600 days)			*(400 days)*		
L_1	0·31	0·54	129	0·52	0·52	290
L_2	1·67	0·44	300	1·72	0·34	90
L_3	0·76	0·35	140	1·00	0·40	240
L_4	0·60	0·45	300	0·70	0·39	110
	2nd group (1000 days)					
L_1'	0·50	0·48	135			
L_2'	1·80	0·38	294			
L_3'	0·66	0·37	100			
L_4'	0·56	0·50	260			

TABLE 2

Solar tides in Telluric current at Barrow

	Northward component (u)			Eastward component (v)		
	Amplitude (mv/km)	P.E. (mv/km)	Phase (°)	Amplitude (mv/km)	P.E. (mv/km)	Phase (°)
	1st group (600 days)			*(400 days)*		
S_1	25·00	0·36	280	23·00	0·40	100
S_2	16·00	0·38	150	18·00	0·42	260
S_3	5·00	0·33	270	7·00	0·38	120
S_4	1·00	0·50	90	0·80	0·46	230
	2nd group (1000 days)					
S_1'	28·00	0·38	270			
S_2'	18·00	0·32	172			
S_3'	6·00	0·35	240			
S_4'	0·80	0·42	140			

are shown in Figs. 1(b) and 1(a), for better understanding of phase angles.

3. Discussion

The results in Table 1 show that only the lunar semi-diurnal (*i.e.*, L_2) wave is significant (a determination may be regarded as a significant if the vector probable error is less than one third of the amplitude). The amplitude and phase angles at Ebro obtained in earth current data are nearly same as those obtained for Barrow, in Telluric curerent data and slightly deviate from Huancayo earth current results. The results in Table 2 show that S_1, S_2 and S_3 are significant. It is also found that the magnitude of the amplitude of S_2 is ten times that of L_2. In case of earth current data, however, except perhaps for Ebro, the magnitudes are generally lower (about five times).

The study of the two sets of values obtained for two groups of data (even though the difference is small) in N-S component shows practically no difference. It appears reasonable, therefore, to infer that the features of the lunar diurnal variations in Telluric current can be determined from a comparatively shorter series of records.

4. Summary and conclusions

The analysis shows that practically no difference is seen in phase and amplitude values due to the effects of sun and moon tides in the earth current and Telluric current. L_2 for N-S and E-W are not strictly comparable as they pertain to different periods. Also from Table 1 the phase of L_2 for N-S is 300° while for E-W is 100°. Therefore L_2 variations are not same; only, the amplitudes of L_2 are close to each other. The lunar semi-diurnal wave, L_2, alone is significant in Telluric current data. It is also seen that, significant results for Telluric current data have been obtained here even with two years data. Analysis of Telluric current data at more stations is necessary for study of latitudinal and other variations.

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