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Solar and lunar atmospheric tides in rainfall at Poona

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ABSTRACT. The atmospheric tides in the rainfall data of the monsoon season, *i.e.*, June to September, at Poona (18° 32′ N; 73° 51′E), have been studied by using hourly mean values and bi-hourly mean values for the period 1949-1960. Both solar and lunar effects upto the 4th harmonic have been discussed. Study of the variation with lunar phase of the rainfall indicates a maximum fall near the phase 3 while there is no other regular variation with lunar phase.

1. Introduction

In recent years some workers have been investigating the variation of rainfall at a place with the lunar phase. Manchly (1954) found a significant tendency for less precipitation to fall on approximately second or third day prior to new moon. Adderley and Bowen (1962) and Bradley, Woodbury and Brier (1962) found a marked tendency for extreme precipitation to occur near the middle of the 1st and 3rd week of the synodic month, especially on the 3rd to 5th days after the new and full moon. Visagie (1966) from studies of the winter rain in South Africa inferred that the winter rain is modulated by the moon. He found a reduced solar influence and increased lunar influence in the winter rains which is not of a convective nature. He also found that the first and third harmonics of the lunar daily variation in rainfall at South African stations were significant, while the second harmonic was not.

In the present paper, the lunar daily variation in rainfall over Poona has been studied using the well known Chapman-Miller (1940) method. And also, the effect of moon's phases on rainfall, has been investigated.

2. Data and analysis

Hourly and bi-hourly rainfall data for the monsoon season (*i.e.*, June to September) at Poona (18°32′N; 73°51′E), for 1949–1960 are used in this study. The combined solar $(S=S_1+S_2+S_3+S_4)$ and lunar $(L=L_1+L_2+L_3+L_4)$ harmonics are given by:

$$S = \Sigma \ s_p \sin (pt+\theta_p) \qquad (1)$$

and $$L = \Sigma \ \ln \sin \{t(n-2)+2T+\lambda_n\} \qquad (2)$$

or $$= \Sigma \ \ln \sin (nt-2\gamma+\lambda_n) \qquad (3)$$

S, L and θ, λ are respectively amplitudes and phases of the solar and lunar tides of the four main components. L_1, L_3, L_4 are called luni-solar components; t denotes time in degrees increasing from 0° to 360° from one local lower transit of the sun (local midnight) to the next, and $\gamma=t-T$, is the phase of the moon, measured by the hour angle between the moon and the sun, increasing from 0^h at one new moon to 24^h ($1^h=15°$) at the next, and 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 analysis has been made according to the method outlined in a recent paper by Malin and Chapman (1970).

The results of the computations are given in Tables 1 and 2.

3. Results and discussion

Visagie (1966) found that L_1 and L_3 alone are significant but not L_2. But the result here obtained shows that L_2 is the dominant lunar harmonic and it is even greater than any harmonic in S unlike in any other atmospheric element where the solar harmonic far exceeds the lunar. It is the purpose of this note to highlight this fact. We offer the following explanation : The rainfall originates in neutral atmosphere and the effect of sun's ionising radiation is not present. The tidal motion due to the lunar gravitational field is greater than that due to the sun as in the case of the ocean tides. According to Adderly and Bowen that gravitational forces alone could not produce high variations of the type they observed in the study. The values obtained by them are not purely moon's effect alone but are contaminated by noise, which is a predominant factor compared to purely moon's effect.

TABLE 1

Atmospheric tides in Poona rainfall of monsoon season

(No. of days=1342)

Solar and lunar har-monies	Hourly mean data			Bi-hourly mean data		
	Ampli-tude in ·01 cm	Pro-bable error in ·01 cm	Phase (°)	Ampli-tude in ·01 cm	Pro-bable error in ·01 cm	Phase (°)
			Solar Tides			
S_1	147	56	350	96	44	340
S_2	139	36	240	88	28	230
S_3	114	46	140	72	33	130
S_4	90	42	80	62	35	90
			Lunar Tides			
L_1	153	53	290	86	41	290
L_2	162	41	150	104	34	140
L_3	118	43	330	71	39	340
L_4	95	44	310	66	30	300

TABLE 2

Variation of lunar tides at twelve phases of the moon (*i.e.*, γ=0 to 11) in Poona rainfall

Phase γ	Amplitude in ·01 cm		Phase γ	Amplitude in ·01 cm	
	Hourly mean data	Bi-hourly mean data		Hourly mean data	Bi-hourly mean data
0	40	10	6	10	10
1	36	26	7	50	42
2	448	230	8	20	30
3	1053	544	9	40	30
5	80	90	10	130	113
6	10	10	11	30	30

Note—The computed results in Table 2 correspond to zero hour of solar time

Table 2, which depicts the variation with lunar phase of lunar tidal amplitude in rainfall, indicates maximum amplitude near the lunar phase γ=3 and considerably large near γ=2 and 10. This agrees with results obtained by earlier workers: Manchly (1954), Adderly and Bowen (1962) and Bradley, Woodbury and Brier (1962) etc. Variation of amplitude with phase is irregular.

From Table 1 it is seen that the amplitude of the solar tide S_1, although larger than the amplitude of S_2, the former (S_1) is not statistically significant. Therefore, we infer that the solar thermal action is smaller compared to the gravitational action in the daily variation of rainfall, which is not of convective origin.

It is difficult to visualise how the moon can effect the daily variation in rainfall. However we hazard the following speculation. The lunar tidal winds superimposed on the prevailing winds in the troposphere modify the general circulation pattern of which the Indian southwest monsoon is a part. This modification may be manifesting itself in the form of the lunar semidiurnal variation in rainfall.

The significant result is that the amplitudes of hourly data are greater than those of bi-hourly data. Such a feature has not been noticed in case of other geophysical data, where the amplitudes are practically equal in both cases. As is well known, rainfall is highly variable from hour to hour and in this respect differs very significantly from other geophysical data.

4. Conclusions

Of the four solar tides S_1 to S_4 only semi-diurnal tide (S_2) is statistically significant. Only lunar semi-diurnal tide (L_2) is significant contrary to the conclusion arrived by Visagie (1966). Amplitude of L_2 is greater than amplitude of S_2. The maximum amplitude in the lunar daily variation of rainfall is near the phase 3 of the moon. No regular variation is seen with the phases of the moon.

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REFERENCES

Adderley, E. E. and Bowen, E. G. 1962 *Science*, 137, 749.
Bradley, D. A., Woodbury, M. A. and Brier, G. W. 1962 *Ibid.*, 137, 748.
Chapman, S. and Miller, J. C. P. 1940 *Mon. Not. R. astr. Soc. geophys. Suppl.*, **4**, 649.
Malin, S. R. C. and Chapman, S 1970 *Geophys. J. R. astr. Soc.*, **19**, 15.
Manchly, J. W. 1954 Private Distribution.
Visagie, P. J. 1966 *J. geophys. Res.*, **71**, 3345.