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Association of the geomagnetic and meteorological parameters in tropics

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सार – अलीबाग पर के भूचुम्बकीय क्षेत्र के प्रेक्षण की दीर्घश्रृंखला और कोलाबा (बम्बई) के दाबमापी के दाबों से बनी श्रृंखला का उपयोग करके क्रॉस स्पेक्ट्रल विश्लेषण तकनीक से द्विवर्षी ध्रुवज्वार, वार्षिक, अर्धवार्षिक संकेतों की व्युत्पत्ति की गई है । इन आवधिक परिवर्तनों के संभावित सूर्य-मौसम भूचुम्बकीय संबंधों में विचरणों का विवेचन किया गया है । समय प्रान्त में वार्षिक और अर्धवार्षिक चक्रों में भूचुम्बकीय क्षेत्र एवं दाब में आपेक्षित कला साहचर्य से इस संबंध के अनुप्रयोग पहलू के अध्ययन को बढ़ाये जाने का सुझाव भी दिया गया है ।

ABSTRACT. Using long series of the geomagnetic field observations at Alibag and corresponding series formed from barometric pressure at Colaba (Bombay), biennial, pole-tide, annual and semi-annual signals are derived by cross spectral analysis technique. The possible solar-weather geomagnetic relations at these periodic variations are discussed. It is suggested that a study on the relative phase associations between the geomagnetic field and the pressure at annual and semi-annual cycles in time domain can be pursued towards the application aspect of the relationship.

1. Introduction

Many researchers have indicated in the past that there exists a strong connection between the weather and the changes in radiation (electromagnetic and/or corpuscular) associated with a whole range of solar phenomena. Several of these studies have shown that the sun-weather relationship is most pronounced in the vicinity of the auroral zone, emphasizing the importance of the role of earth's magnetic field in the relations. Latitudinal variation of the change in surface pressure (averaged around the earth at particular latitudes) between sunspot minimum and maximum is found to be particularly large in the auroral belt (Van Loon *et al.* 1973, Miles 1974). Also a striking similarity between the spatial variations of some of the meteorological parameters and the intensity of the geomagnetic field is shown by King (1974).

If the earth's magnetic field in some way controls the morphology of the lower atmosphere, changes of the field which occur as the non-dipole component 'rotates' or as the dipole field itself changes, may well be accompanied by climatic variations. Wollin *et al.* (1973, 1974) have shown that the temporal variations of the magnetic field intensity and temperature at various places are inversely correlated. High negative correlations were also noticed not only over decades-period but over even longer time spans.

Thus, long term associations like 11-year, 22-year, biennial (2¼-year) and 27-day solar rotation periods as well as short term associations, *i.e.*, responses within a few days on either side of the solar events, have been extensively discussed in the literature. Here we report the relationships between the solar and the low-latitude geomagnetic parameters and the tropical meteorological parameters at periodicities corresponding to the biennial variation, the pole-tide signal and the annual and semi-annual cycles. Monthly mean values of the geomagnetic elements (H — Horizontal component, Z—Vertical component and D — Declination) from Alibag (Geographic Lat. 18° 38′ N) for the period 1906 to 1968 and the corresponding monthly mean values of surface barometric pressure, P, from nearby Colaba-Bombay (Geographic Lat. 18° 54′N) form the basic data for the analysis. Monthly mean Zurich sunspot number, R_z, is considered as the index of solar activity. Auto-and cross-spectra, *via* Fast Fourier Transform (FFT), between each of the geomagnetic field components and the surface pressure as well as the field components and R_z are computed choosing the resolution frequency to be 0.0098 cycles per month.

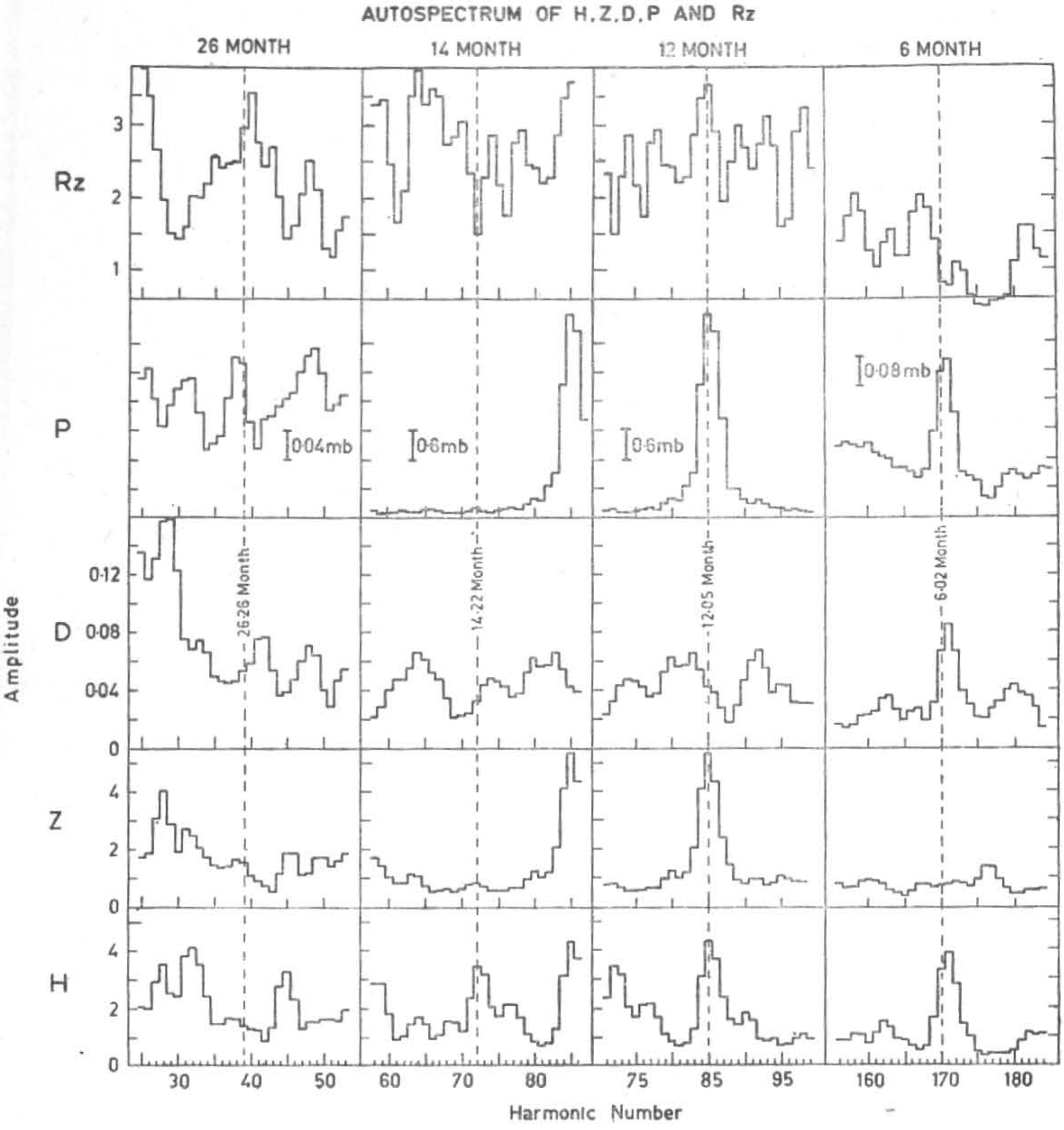

Fig. 1

TABLE 1

Autospectrum results — Amplitudes

Period (month)	*H* (*nT*)	*Z* (*nT*)	*D* (min)	*Rz* (No.)	*P* (mb)
26.26	1.46	1.56	0.05	2.97	0.21
14.22	3.49	0.85	0.03	1.49	0.17
12.00	4.36	5.34	0.04	3.59	4.24
6.00	3.37	0.78	0.07	0.81	0.40

TABLE 2

Relative phases and coherences between H, Z and D *vs* P and H, Z and D *vs* R_z

Period (month)		P			R_z		
		Relative phase (Deg.)	Coherence	Lead of P over the element (months)	Relative phase (Deg.)	Coherence	Lead of R_z over the element (month)
26.26	H	—96	0.72	7.0	—135	0.27	9.9
	Z	43	0.92	—3.2	49	0.07	—3.6
	D	144	0.67	—10.5	172	0.60	—12.5
14.22	H	172	0.85	—6.8	—179	0.57	7.1
	Z	152	0.87	—6.0	171	0.86	—6.7
	D	127	0.25	—5.0	—109	0.69	4.3
12.00	H	137	0.97	—4.6	51	0.97	—1.7
	Z	156	0.94	—5.2	32	0.98	—1.1
	D	98	0.95	—3.3	94	0.78	—3.2
6.00	H	139	0.99	—2.3	163	0.04	—2.7
	Z	—14	0.61	0.2	—17	0.62	0.3
	D	—48	0.97	0.8	—107	0.12	1.8

2. Results and discussion

Amplitudes of H, Z, D, R_z and P obtained from the respective autospectra are given in Table 1 corresponding to Quasi-Biennial Oscillation (QBO) (26.26 months period) pole-tide signal (14.22 months or $\sim$427 days period), annual (12 months) and semi-annual (6 months) cycles, In Fig. 1, the amplitude spectra with ten estimates on either side are shown. Cross-spectrum results, *viz.*, relative phases and coherences, between R_z as well as P and each of the geomagnetic field components at the above periodicities are given in Table 2.

Statistically significant signal in the autospectra at 90 per cent and above confidence level when compared with the continuum at QBO is noticed only in the barometric pressure, P, series. Currie (1966) has shown a peak near 26-months only in 5 out of 57 stations trend-free spectra of the mean daily values of the geomagnetic elements, H, Z and D, and those too are no higher than the adjacent fluctuations in the continuum. Yacob and Bhargava (1968) have made a search for the QBO in geomagnetic field at Alibag using the monthly mean diurnal ranges on I.Q. days from 1905 to 1965. They find a small but significant amplitude in the quiet-day range in H at 26-month period and a peak of marginal significance in the monthly mean R_z spectrum and conclude that the QBO in the earth's magnetic field appeared to be of solar origin. Rangarajan (1981) has recently shown that the QBO signal in geomagnetic field at Alibag is weak during quiet and strong during the disturbed periods particularly in the late evening hours. Based on this, he suggests a solar origin for QBO.

The spectra of H, Z and D whose amplitudes are given in Table 1, have been computed using 'all days' monthly mean time-series. These spectra are, therefore, likely to be contaminated by the disturbance component resulting in the enhanced level of continuum. Also, it can be noticed from the results in Table 2 that at the QBO wavelength the coherence between H and Z against P is relatively higher, when compared to the coherences against R_z. However, the coherences between D *vs* P and D *vs* R_z are high and almost equal in magnitude. The geomagnetic analogue for the QBO, *viz.*, whether the source can be identified in the stratospheric zonal wind (Stacey and Westcott 1962) by virtue of the association with P or it is of solar origin by the association with R_z, has to be further investigated by dividing the data into shorter intervals.

The equilibrium pole-tide signal was earlier identified at a period around 14.22 months in the geomagnetic elements H and Z at Alibag (Rao and Rangarajan 1978). It was suggested by them that the source of excitation might be the 'ocean-dynamo'. From the results in Table 1, it can be seen that the signal at 14.22 months is significantly derived only in the H-spectrum and it is totally absent (*see* Fig. 1) in the R_z spectrum. The amplitudes at this wavelength in the spectra of Z, D and P are not statistically significant although they stand out as peaks against the continuum. The fact that no significant line at this frequency is noticed in the R_z spectrum suggests that the modulation for the signal in the geomagnetic field is not solar in origin. If, on the other hand, the source is considered to be in the ocean dynamo, the singal should have been identified clearly in the barometric pressure series also. However, at this wavelength, the coherence between H and P is higher than that of H and R_z. These aspects have to be taken into account while drawing inferences regarding the origin of this signal.

Greenhow and Neufeld (1960) reported an hour to hour correlation between ionospheric wind and surface pressure. A comparison of 12-monthly running means of ionsopheric wind data with surface pressure at Kew and Eskadalemuir suggests that the correlation may extend to longer periods. An examination of the barometric pressure data for Apia has, however, not revealed any spectral peaks longer than 12 months (Stacey and Westcott 1962). Asnani and Mishra (1975) studied the annual pressure oscillation from sea level to 100 mb in the northern hemisphere from climatological normals of about 250 upper air observatories. The features of the semi-annual oscillation in the same data were discussed by Asnani and Verma (1975).

The annual wave obtained by us (Table 1) is based on a longer series of monthly mean barometric pressure which is more or less the same as the surface pressure of the above study, and it has the largest amplitude, $\simeq 4.2$ mb, in the entire spectrum. Significant annual and semi-annual cycles are, however, noticed (Fig. 1) in all the parameters excepting the semi-annual signals in Z and R_z. Also, there is very high coherence, at the annual cycle, between the pressure and each of the geomagnetic elements considered and it is considerably higher at the semi-annual cycles between H and P as well as D and P. The relative phase angles are significant only when the coherence are quite high. Thus, all the phase angles of the annual and semi-annual cycles are significant except the relative phase angle against the semi-annual cycle between Z and P.

The presence of an annual and a semi-annual variation in the earth's magnetic field is well known. By an extensive analysis of H and Z data of several stations (Currie 1966) has shown that the generating mechanisms of the annual and semi-annual lines are different, and that an ionospheric dynamo action is probably responsible for the annual component of the field, which is a seasonal effect caused by an amplitude modulation in solar radiation incident on the summer and winter hemispheres. Longer series of barometric pressure data and simultaneous geomagnetic field measurements can, therefore, be utilized through cross correlation analysis at the annual and semi-annual cycles to work out the amplitude assocation and phase lead or lag of one series over the other. The time domain studies of these associations properly interpreted, can be utilized for forecasting the annual cycle in the rainfall because atmospheric pressure distribution primarily controls the distribution of wind and rain. The study of this aspect of geomagnetic-weather association, when established, would be of immense help in the economy of many countries in southern Asia as they are directly dependent on the annual cycle of rain.

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