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STRUCTURE OF THE ACTIVE-BREAK CYCLE OF THE INDIAN SUMMER MONSOON WITH AROUND 40-DAY PERIOD

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INTRODUCTION

Through the analyses of cloudiness fluctuations by the present author (Yasunari, 1979; 1980), a predominant periodicity of 30 to 40 days was confirmed as a quasi-stationary mode over and around India during the summer monsoon period. The fluctuation of this periodicity shows a marked northward phase propagation from the equatorial zone to the mid-latitudes (around 30°E) over Asian monsoon area, most apparently over Indian subcontinent-Indian Ocean sector, as shown in Fig. 1. It may represent a latitudinal shift of ITCZ cloud band at the longitudinal sector over India through Southeast Asia. The major active-break cycle of monsoon activity over India seems to be attributed to this mode.

In the most recent paper (Yasunari, 1981), we discussed the horizontal and vertical structures of the fluctuation of this mode, especially along the latitude- height section over India, by using the aerological data for 1969. Spectral analysis of the geopotential and wind field revealed the predominant periodicity of about 40 days especially in the lower and upper troposphere. As well as the cloudiness fluctuation of the same periodicity (Yasunari, 1980), these elements except the geopotential height in the upper troposphere showed a northward propagation from the equatorial zone toward the Himalayas. The geopotential height in the upper troposphere showed, in contrast, a standing oscillation over India. Cross-spectral analyses revealed that the vertical structure of the atmosphere is gradually modified during the northward phase shift of the anomaly cloudiness with this mode. The modification is most apparent in the temperature field. The change of the vertical structure from south to north over India may be attributed to the gradual enhancement of cumulus convection from south to north. A preliminary analysis on the circulations over the southern Indian Ocean suggests that the forcing of this mode in monsoon activity may be derived from the large-scale westerly wave motions (such as the index cycle or vacillation) in the Southern Hemisphere, which periodically bring about the cold (or warm) air outbreak toward the equatorial region over the Indian Ocean.

In the present paper, the lateral coupling of the oscillation of this mode is discussed over the Indian monsoon region by using surface pressure data during the summer MONEX'79. The horizontal structures of pressure waves or oscillations over the equatorial zone and the subtropical latitudes in the Southern Hemisphere are also examined, which are closely associated with the active to break (or break to active) transitions of monsoon activity of this mode.

OSCILLATIONS OF SURFACE PRESSURE DURING THE SUMMER MONEX'79

Latitude time section along 80°E

Fig. 2 shows the latitude time section of the surface pressure from May to August of 1979 along 80°E. To eliminate the short-period fluctuations, the data was smoothed with 5-day moving average. It is distinctly noticed that the monsoon trough (20-25°N) oscillates dominantly with the time scale of 30 to 50 days. The onset phase of monsoon over southern India corresponds with extent of the low pressure area (note the area, for example, of less than 1000 mb) on around the 10th of June. After the onset phase, "break" phases appeared with a relatively high pressure values on around the 20th of July and late in August. Between these two "break" phases, one "active" phase appeared with the extended monsoon trough in early August. It is noteworthy to state that the fluctuation of pressure at the monsoon trough area (20-25°N) is highly correlated with those of the equatorward area and even of the the Southern Hemisphere subtropics, though some phase lags exist. MEM spectral analysis on the data of different latitudes along 80°E revealed the predominancy of the 40-day period to the south of Tibet including the Southern Hemisphere latitudes, as shown in Fig. 3. Over the Northern Hemisphere to the north of Tibet the powers are biased toward the lower frequency ranges, which may be due to the large seasonal pressure tendencies there.

Fig. 4 shows the latitude time section of the filtered pressure for the 40-day period. Similarly to the previous analysis (Yasunari, 1981), the positive (or negative) pressure anomalies propagate northward from the equatorial zone toward the Himalayas, though the phase speed seems to be slightly larger in this year than that of the previous case (1969). The anomalies fluctuate nearly in phase over the equator through the Southern Hemisphere. It is worthwhile to note that the anomalies to the north of Tibet (namely, the mid-latitude westerly zone) show in phase relation to those just to the south of Tibet, though the spectral analysis did not show any significant association with the lower latitudes. This problem should be examined in more detail as a lateral coupling of the waves between the two hemispheres.

Longitude time section along 5°N

Longitude time section of filtered pressure along 5°N is shown in Fig. 5. The oscillation seems to be nearly standing or slightly has a component of eastward propagation. The oscillation of the 40-day period is prominent especially to the east of 40°E. Though this analysis is limited only for the longitudes of the eastern hemisphere (0°-140°E), the gross feature suggests that this oscillation may be a part of the global-scale pressure oscillation described by Madden and Julian (1972). Our previous results (Yasunari, 1979; 1981) suggest that the eastward-moving cloud disturbances near the equator have a great role on the initiation of active phase of monsoon over India. The observations during the MONEX also revealed the importance of the cyclonic vortices over the equatorial Indian Ocean for the onset of monsoon over India (Krishnamurti et. al., 1980). Since the pressure perturbations and the space scales of these disturbances are small compared to those of this large-scale oscillation, individual disturbance has been filtered out in Fig. 5. These transient disturbances seem to be embedded mostly in the negative anomaly phases of the pressure oscillation in Fig. 5.

Nearly the same feature has been found in the longitude time section of the filtered pressure along the subtropical latitudes (20-25°S) in the Southern Hemisphere (not shown). This implies that the oscillation of this mode is not confined within the equatorial zone but is also dominated over the Southern Hemisphere subtropics and possibly over the higher latitudes.

SUMMARY AND REMARKS

The preliminary analysis of the surface pressure data during the summer MONEX'79 has suggested a great role of the zonally-oriented large-scale pressure oscillation of about 40-day period over the equator through the Southern Hemisphere on the major active-break cycle of the monsoon activity over and around India. As commented already (Yasunari, 1981), this oscillation is supposed to be closely associated with the large-scale westerly wave motions in the Southern Hemisphere.

A coupling of this oscillation with the circulations in the Northern Hemisphere was also suggested. Te be sure, some analyses have already shown that the "break" condition over central India occurs when the extended trough from the higher latitudes is located over Tibet adjoining to blocking high(s) on one (both) side(s) of the trough(e.g., Raman and Rao, 1980 etc.).

These two big problems mentioned above should be examined in more detail by using the global data set covering from the surface to the upper troposphere. The FGGE level IIIb data set will be most desirable for this study.

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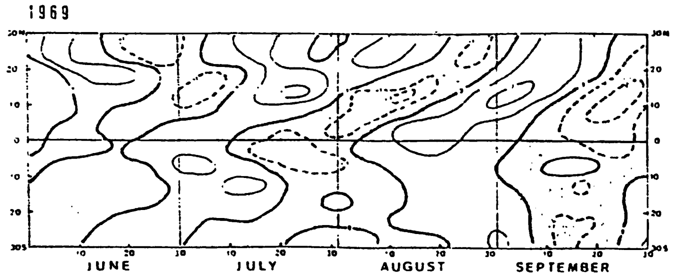

Fig. 1 - Latitude time section of filtered cloudiness for the 40-day period along the sector of70-90°E. Units are 1.0 and negative values are shaded (after Yasunari, 1981).

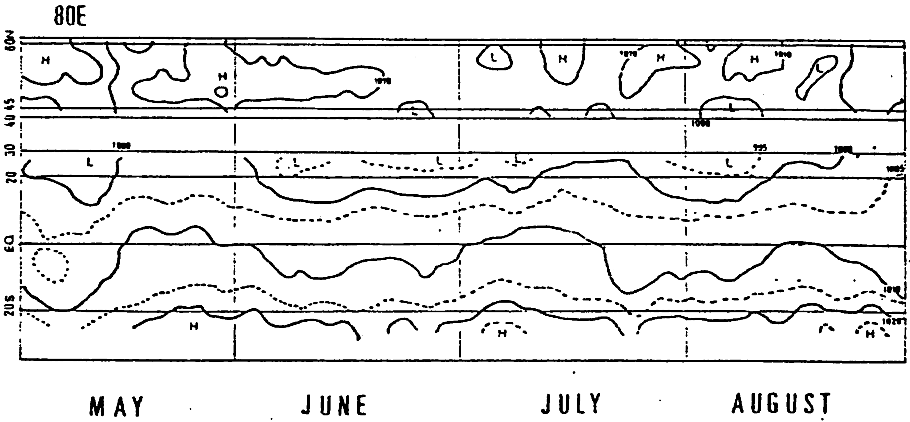

Fig. 2 - Latitude time section of smoothed surface pressure along 80°E for 1979.

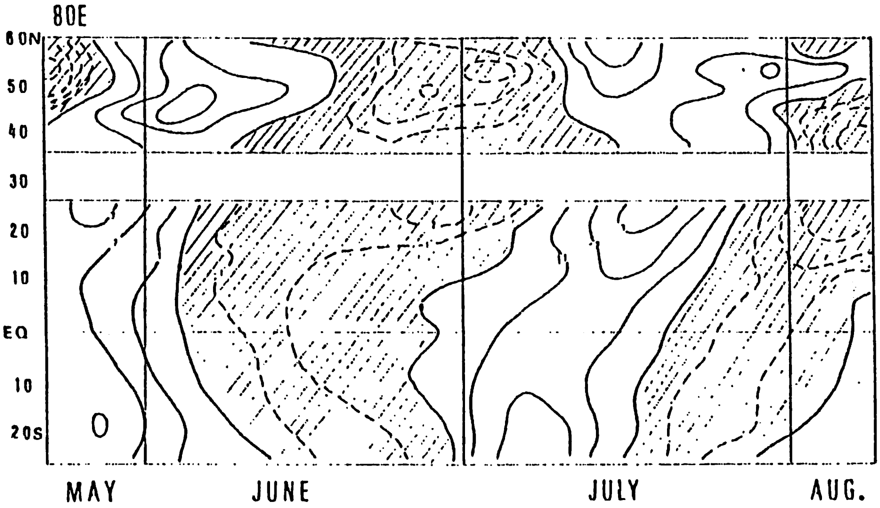

Fig. 4 - Latitude time section of filtered surface pressure for the 40-day period along 80°E for 1979. Units are 1 mb and negative values are shaded.

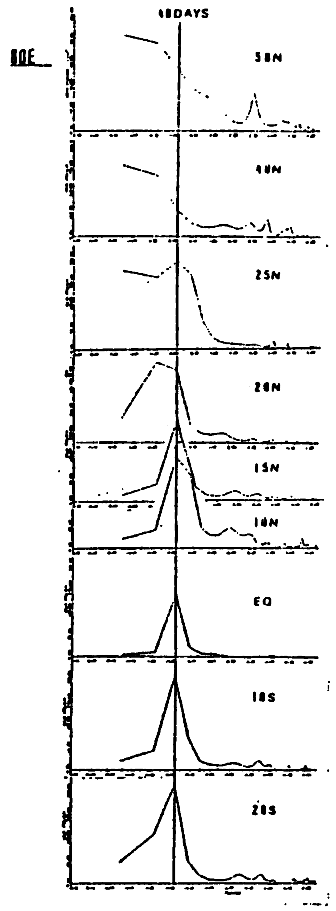

Fig. 3 - Power spectra of surface pressure at some latitudes along 80°E. Periodicity of 40 days is indicated with solid line. Units are $mb^2 \cdot day$.

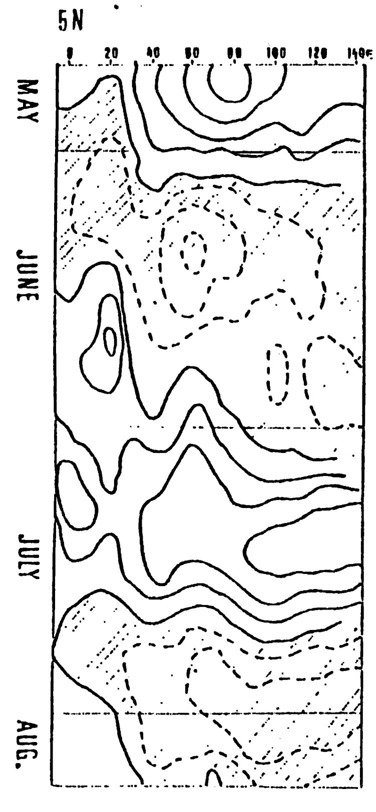

Fig. 5 - Longitude time section of filtered surface pressure for the 40-day period along 5°N. Units are 0.5 mb and negative values are shaded.