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ON THE VAGARIES OF THE INDIAN SOUTHWEST MONSOON

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ABSTRACT

A comprehensive review of the more recent work done on the vagaries of the southwest monsoon with special emphasis on the break monsoon and interannual variations is presented here. Importance of the northern hemispheric middle latitude forcing for the failure of the monsoon is stressed and a brief review of the Southern Oscillation and El Nino and their effect on the Indian summer monsoon is also given.

Key-words : Monsoon, South oscillation, El Nino

INTRODUCTION

The Asian summer monsoon is a boon to the countries in South and East Asia as it gives a bountiful of rainfall. South and East Asia is also a region of the world's most dense population. More than 60% of the world's population is concentrated in this region alone. The animal and vegetative production, hence the rate of biomass production in this area is one of the highest in the world. Temperature being one of the meteorological factors, rainfall is another that is favourable for the high biomass production. The Asian summer monsoon which is mainly responsible for the rains in this region is thus very important.

Failure of the monsoon rains in any part of this area would adversely affect the food production in the respective countries. Though there are excellent irrigation facilities in some areas, there are still vast areas cultivated under rainfed conditions. The rainfed areas as well as the irrigation facilities largely depend on the monsoon rainfall. While the monsoon rainfall is by no means uniform during the monsoon season, the total seasonal rainfall varies considerably from year to year. Copious rains in some years cause floods and severe damage to crops while large deficits in rainfall cause droughts and crop failure in some other years. Hence intraseasonal and interannual monsoon rainfall variations, their causative factors and their understanding are very important for the Asian meteorologists.

In India the subnormal and abnormal activity of the monsoon to the extent of affecting the seasonal total rainfall over a wide area are known as vagaries of the monsoon. These are generally caused by late/early onset or withdrawal of the monsoon and prolonged breaks of the monsoon within the season. Forecasting not only the total seasonal rainfall, but also the nature of the monsoon rainfall such as onset, breaks, etc., and possibly the proportion of the day or night time rainfall on which the crop production depends are important.

Intraseasonal variations of the monsoon rainfall :

During the monsoon season the rainfall is accentuated by the depressions that form at the head of the Bay of Bengal and widespread,copious rains are received by almost all parts of India. About six depressions form on the average during the three months, July–September (Rao and Jayaraman, 1958; Subbaramayya and Subba Rao, 1981). However, the period of these depressions is reported to be 7–8 days by Bhaskararao (1975) and about 5 days by Murakami (1978). Different aspects of these depressions like their formation, structure and movement have been studied by several workers. Their structure, more recently has been studied by Mulky and Banerjee (1960) and Godbole (1977), and the associated rainfall distribution was examined in detail by Bedekar and Banerjee (1969) and Venkataraman, Chowdary and Banerjee (1974). Heaviest rainfall occurs to the west of the centre upto distances as far as 700 km and it is more in the night than during day.

Ramamurti (1972) showed that the monsoon would be very vigorous when there are two low pressure systems, one over Kutch and another over Orissa and both are connected by an anomaly trough.

Harwood (1924) was the first to report that the monsoon activity was poor when the monsoon air over North India moved eastward which means that the monsoon trough is pushed towards the Himalayan foot hills. This situation is being known as the break monsoon and it has been investigated by several workers. Malurkar (1945) was probably the first person to indicate that the eastward moving extratropical disturbances initiate the breaks. Ramaswamy (1962, 1965) reiterated the same and further stressed that extended troughs in the middle latitude westerlies, during the periods of low index circulation, while passing over the Indian longitudes weaken the Tibetan anticyclone and displace it to the east. This is responsible for the break monsoon. He also noted a pressure ridge in the middle troposphere north of peninsular India during the break which could be an extension from Arabia and Iran, or, from northwest Pacific. Ramamurti (1972) reported an anomaly ridge over north peninsula during weak monsoon, in the lower and middle troposphere. Because of this ridge westerlies are stronger over India and weaker over Peninsula. Ramamurti's observations were further examined by Alexander, Kesavamurty, De, Challappa, Das and Pillai (1978) and reported that the anomaly ridge and trough associated with the weak and strong monsoon advance northward. It is interesting to note that Yasunari (1979, 1980) found an active/break cycle of the Indian summer monsoon of period 40 days which propagates northward from the equator to the middle latitudes.

Some of the above observations and several others confirm that the break is the result of interaction of circulations in the northern hemispheric middle latitudes and the monsoon circulation. In view of the fact that the monsoon stream is fed by the Somalia Jet, it was felt that the southern hemispheric synoptic events may also influence the southwest monsoon. Sikka (1980) tried to show that a transient intensification of the Mascarene high was responsible for the onset of the monsoon in 1979. Sikka and Gray (1981) also attempted to show that the passage of baroclinic waves across South African — Malgassy region caused the formation of the monsoon depressions. But Cadet (1981) in a systematic analysis showed that the 6–7 days period surges along the jet caused by the middle latitude circulations are limited to the southern hemisphere. On the otherhand he reported upstream propagation of maxima and minima along the jet axis from India down to the Mozambique channel. There is, however, need for more detailed investigations on the interaction of the southern hemispheric systems with monsoon circulation.

Interannual variations of the monsoon :

Subbaramayya (1968) attributed the wide spread failure of the monsoon seasonal rainfall to the relatively eastward location of the Tibetan anticyclone. Ramanadham, Subbaramayya and Ramakrishnarao (1970) found that failure of the monsoon in 1965 was due to influx of cold air into North India in the middle troposphere from the northwest. Kesavamurty and Awade (1974) also noted below normal temperatures over Afghanistan in 1972 when the monsoon was a failure. Joseph (1978) observed in the years of monsoon failure, protrusion of subtropical westerlies to the south in the upper troposphere immediately to the west of India in the monsoon as well as in the premonsoon and the preceding winter season. The above observations indicate, conditions similar to those of break monsoon operate on a monthly to seasonal scale causing failure of the monsoon. Raman and Rao (1981), probably with this in view, further enquired into the interaction between middle latitude circulations and the southwest monsoon and reported that the middle latitude trough which affects the monsoon persisted in the Indian longitudes because of two blocking ridges one over West Asia at 50°E and the other over East Asia between 90°E and 120°E. But it is not clear how the original concept of blocking can be applied to ridges in the westerlies. Bedi, Billa and Mookerjee (1981) reported a blocking high between 50°E and 90°E north of 45°N during the prolonged break in 1979 that caused monsoon failure. Subbaramayya and Subbarao (unpublished) found, in the years of monsoon failure, the subtropical westerlies extending to the north Indian latitudes with a trough to the east of New Delhi in the lower and middle troposphere in contrast to the prevailing southeasterlies in normal and active monsoon years. At the central and south Indian stations no such significant difference could be perceived. Thus at the seasonal scale also, the failure of the monsoon appears to be mainly due to the effect of the middle latitude circulations of the northern hemisphere.

Yasunari (1981) while investigating the 40-day periodicity in the Indian region during the summer monsoon season, which he claims to be related to active/break monsoon cycle, indicated that the forcing of this mode in the monsoon activity could be derived from the large-scale westerly waves in the southern hemisphere. But Subbarao (1983) found large variations of 35–45 days *period* in the winds at the north Indian stations and they were pronounced in the years of monsoon failure rather than in the years of active monsoon. Thus there are more questions related to the interannual variations of the Indian summer monsoon unanswered than answered.

The Indian summer monsoon, southern oscillation and El Nino :

Walker (1924) in his pursuit to find predictors for the monsoon rainfall discovered "Sea-Saw" variation of sea level pressure between East Pacific and Indian Ocean, which he called the Southern Oscillation. The generally used Southern Oscillation Index (SOI) is the sea level pressure difference between Tahiti and Darwin. It has been found that this index has a good positive correlation with the intensity of the Indian southwest monsoon (Walker and Bliss, 1937; and Troup, 1965). The Southern Oscillation index itself was investigated by Trenberth (1976). Many interesting studies have been made correlating SOI with several meteorological and oceanographic parameters such as the precipitation and trade-wind in the equatorial Pacific, N.E. Australian rain and Nile floods by Troup (1965), and Quinn and Burt (1972), surface and upper air circulations over Pacific and Indian Ocean by Bjerknes (1966) and Troup (1967), zonal circulations in the vertitical plane by Bjerknes (1969), and Julian and Chervin (1978) and sea surface temperatures and ocean currents by Troup (1965), Bjerknes (1966, 1969), Quinn (1974), Wyrtki (1974, 1975) and Rassmusson and Carpenter (1982). The time scale of the Southern Oscillation is reported (Trenberth, 1976) to be in the range 3 to 6 years.

The most important of the above observations is the association of warm waters off the Peru coast, called El Nino, with the low index phase of the Southern Oscillation (Troup, 1965). But later detailed studies have indicated some phase differences (Rassmusson and Carpenter, 1982). However, the Southern Oscillation and El Nino phenomena seem to be inseparable and some scientists abbreaviated it as ENSO.

The effect of the sea surface temperature of the equatorial East Pacific, hence El Nino, on the summer monsoon rainfall of India was studied by Angell (1981) and Rassmusson and Carpenter (1983). An El Nino year is noted to be an year of monsoon failure. The three phenomenon, Indian summer monsoon, Southern Oscillation and El Nino are physically interlinked and a careful monitoring of the East Pacific sea surface temperature would help foreshadowing the Indian summer monsoon rainfall.

Before concluding the paper the authors wish to comment that there are substantial interannual variations of sea surface temperature in the Indian ocean, though not of the same degree as in the East Pacific ocean, and their effect on Indian monsoon and vice versa are yet to be investigated. Ofcourse there are a few studies (Sukla and Misra, 1977; Joseph and Pillai, 1984) in this direction but a lot more is yet to be done.

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