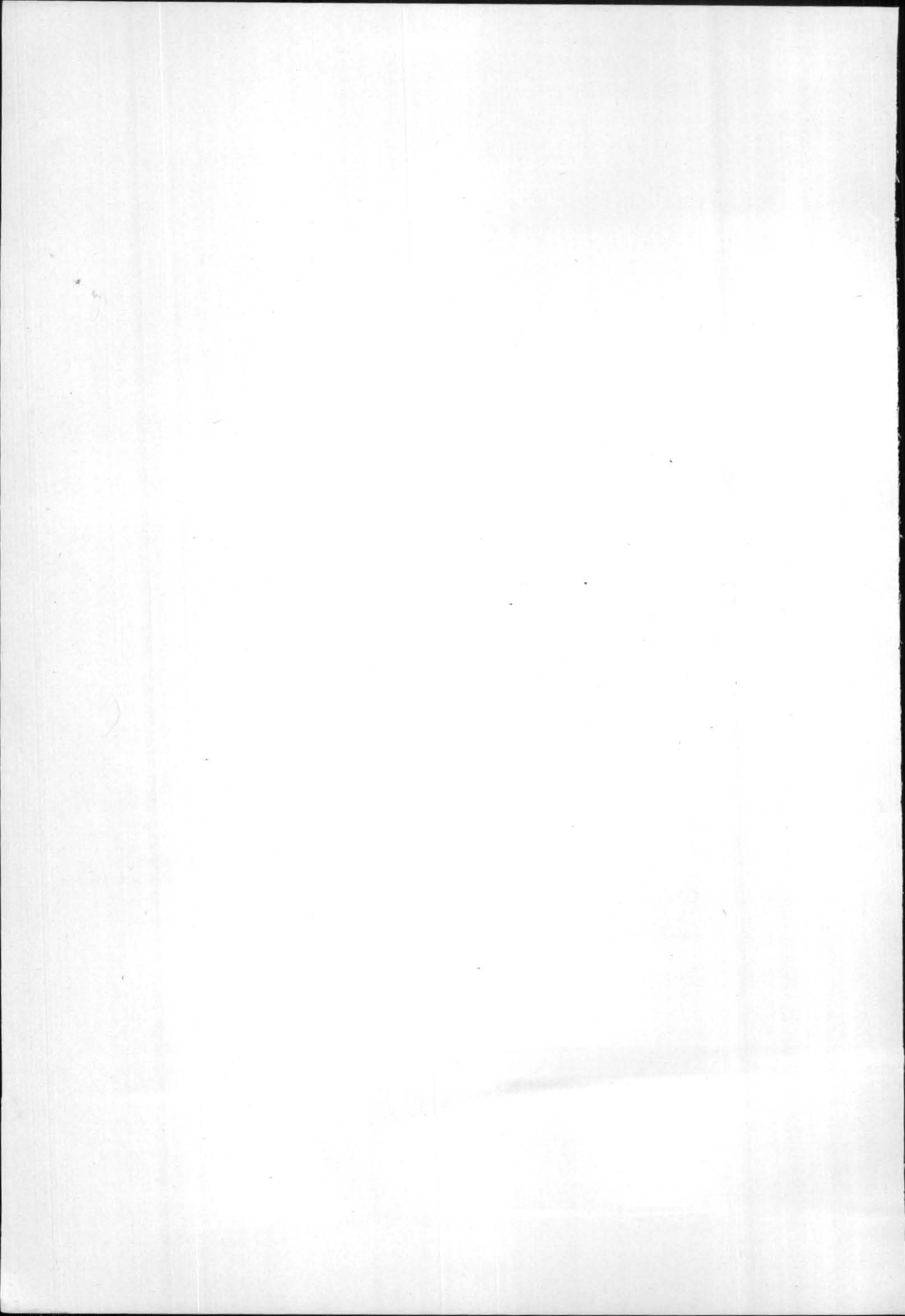


SESSION II

DIAGNOSTIC STUDIES—SYNOPTIC

CHAIRMAN : DR. KENNETH C. SPENGLER

American Meteorological Society, U.S.A.



Onset of summer monsoon in Bangladesh

K. G. MOWLA

Bangladesh Meteorological Department, Dacca

ABSTRACT. The onset of summer monsoon in Bangladesh has been studied by the author in this paper with the help of (i) Rainfall in June 1976 in Bangladesh, (ii) Vertical cross-sections of zonal wind for a number of days of June 1976 along Long. 90°E with particular reference to the influence exerted by the easterly jet stream on the onset of summer monsoon in Bangladesh and (iii) The APT pictures received from NOAA-4 for a number of specific days of June 1976.

The author concludes that the onset of summer monsoon in Bangladesh is heralded by a sudden increase of rainfall and that the influence of the easterly jet stream appears to extend downwards upto the ground level, removing the westerly component of wind and establishing a secondary core of the easterly jet above Bangladesh at the time of onset of summer monsoon. The APT picture indicated approach and presence of huge masses of convective clouds over Bangladesh at the time of onset of monsoon and during the lull period of summer monsoon, these convective clouds remained away from Bangladesh.

The author believes that many of the secrets of summer monsoon of south Asia may be revealed if further understanding of all aspects of the easterly jet stream is achieved.

1. Introduction

The summer monsoon of south Asia is the most important and well-developed secondary circulation in the atmosphere exercising significant influence on the general circulation. Many simultaneous activities are observed when the first monsoon sets in in south and southeast Asia. Sutcliffe and Bannon (1954) showed for 1948-53 that a time relation exists between shift of 200 mb winds from west to east over Aden and Baherin and the disruption from polar to tropical tropopause over Habbaniah with the onset of monsoon in the Malabar coast. Flohn (1960) mentions that during the first half of June, frequency of blocking anticyclones between Iceland, Scandinavia and the British Isles reaches its maximum when burst of monsoon sets in in south Asia. Walker discovered that transport of airmass from Pacific Ocean near Japan to Pacific Ocean near west coast of South America takes place when the southern hemisphere anticyclones travel to north Indian Ocean as southwest monsoon (Ramanathan 1960). Yin (1949) and Riehl (1954) showed that burst of Indian summer monsoon is connected with the disintegration of sub-tropical westerly jet streams over northern India and with the formation of a

new westerly jet at 40°-45°N at the northern edge of the central Asiatic highland and Tibetan Plateau. Flohn (1960) has shown that the development of the summer monsoon in southeast Asia is intimately connected with the formation of a warm anticyclone above the Tibetan Plateau at an altitude of about 20,000 ft.

It is generally believed that monsoon originates in the southeast trades of the southern hemisphere which after crossing the equator and deflection by coriolis force approaches the heated continental area of south Asia as southwest monsoon. Malurkar (1950) contends that small lows (pulses) form in the southern hemisphere and cross the equator at preferred location carrying the equatorial maritime air to northern latitudes.

2. The present study

It is noticed that authors have been laying emphasis on the relationship between onset of monsoon in south/southeast Asia with phenomenon, such as disintegration of westerly jet stream over Southeast Asia and formation of a new one along Lat. 40°-45°N, but less attention has been given to the relationship between onset of summer

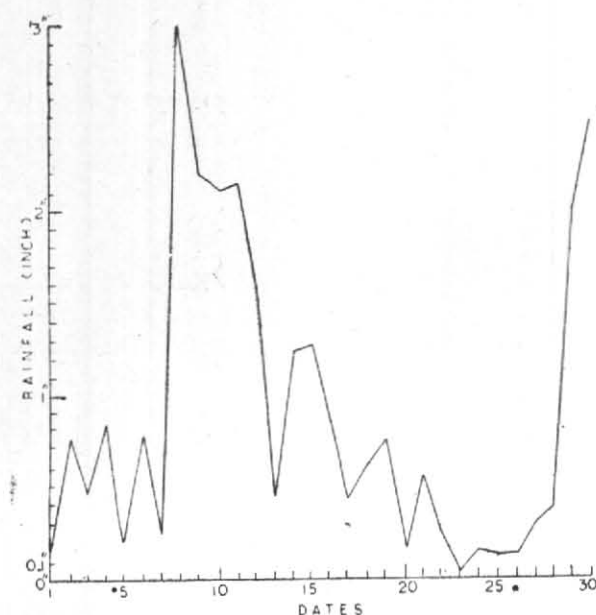


Fig. 1. Rainfall in June 1976 in Bangladesh

monsoon in southeast Asia and the equatorial easterlies and the easterly jet stream.

Vertical cross-sections of mean zonal wind for year and seasons averaged along a number of longitudes is likely to mislead us for this study. Even the cross-sections along 75°E for summer may not lead us to any conclusion regarding onset of monsoon in south Asia. The time averages may be very unrepresentative because of the meridional oscillation in the position of the easterly jet stream and because of the fluctuation in its intensity. On account of this reason, daily positions have been investigated for the study and it has been considered expedient to study daily conditions of a few parameters of June 1976 to get a clear picture of the mechanism involved. Hence, (1) mean rainfall of Bangladesh for each of the 30 days of June 1976 has been studied with the help of Fig. 1, (2) the vertical cross-section of zonal winds for number of individual days of June 1976 along Long. 90°E has also been studied, (3) for the same reason vertical cross-sections of zonal wind for a certain number of individual days of June 1964 was previously studied along Long. 75°E to verify Yin's contention regarding establishment of south-east monsoon and disintegration of westerly jet stream in the sub-continent (Mowla 1965), & (4) study of onset of monsoon in Bangladesh in 1976

has also been made with the help of daily APT pictures for days of June 1976.

3. Rainfall

The daily rainfall of twenty five stations of Bangladesh for June 1976 and daily average of rainfall for each day of June 1976 were investigated. The results are shown in Fig. 1. It will be noticed that the average rainfall in Bangladesh was less than 0.2 inches on 1 June 1976 and less than 1 inch daily upto 7 June 1976. It was exactly less than 0.3 inches on 7 June but on 8 June the average rainfall in Bangladesh was 3 inches. This rainfall took place from 0300 GMT of 7 June to 0300 GMT of 8 June. The rainfall then recorded slight decrease during next 24 hours, *i.e.*, from 0300 GMT of 8th to 0300 GMT of 9th and remained more than 2 inches upto 0300 GMT of 11th but the average rainfall recorded in Bangladesh from 0300 GMT of 12 June to 0300 GMT of 13 June was less than 0.5 inches. It is, therefore, very clear that the summer monsoon set in Bangladesh in 1976, during 24 hours from 0300 GMT of 7th to 0300 GMT of 8 June 1976. The spell of summer monsoon again increased slightly after 13th to continue upto 15 June when the average daily rainfall was between 1.2 inches to 1.3 inches but from 0300 GMT of 15 June the rainfall started decreasing so much so that it was less than 0.1 inch during 24 hours beginning from 0300 GMT of 22nd to 0300 GMT of 23 June 1976. The rainfall from 23rd upto 28th continued to be less than 0.4 inches each of these days but during 24 hours ending 0300 GMT of 29 June the average rainfall in Bangladesh was 2.0 inches and during next 24 hours it was nearly 2.5 inches. The rainfall of 28 June onward is noticed to be due to another good spell of monsoon over Bangladesh. Ignoring the one of 14 and 15 June 1976 it is noticed that the burst of monsoon took place in Bangladesh during 24 hours ending 0300 GMT of 8 June 1976 and another pulse almost of equal intensity reached Bangladesh during 24 hours ending 0300 GMT of 29 June 1976 which continued beyond 29th to record about $2\frac{1}{2}$ inches of average rainfall in Bangladesh during the 24 hours ending at 0300 GMT of 30 June 1976. The onset of summer monsoon in Bangladesh in June 1976 took place (i) on 7th June, (ii) the spell of monsoon activity revived on 14 and 15 June 1976, and (iii) another spell of monsoon activity, having the same intensity as was observed on 7 June, took place on 29 June to continue upto 30 June 1976.

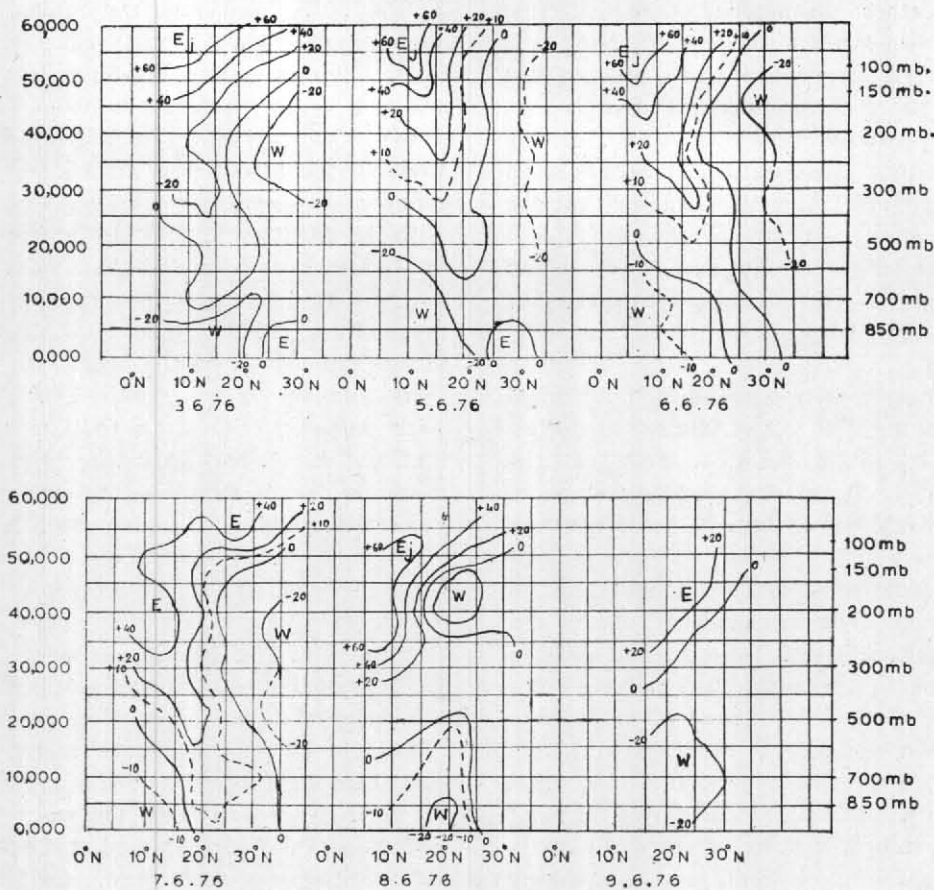


Fig. 2. Vertical cross-section, June 1976, Zonal wind (in knot) of individual days along Long. 90°E

4. Vertical cross-section

Attempt has been made to see how burst of monsoon in Bangladesh is influenced by the easterly jet stream observed over south Asia during the summer season. For this purpose vertical cross-sections of zonal wind have been drawn individually for 3-9 and 13 June 1976 along approximately longitude 90°E. The cross-sections are reproduced in Fig. 2 (except those for 4th and 13th). It will be noticed from Fig. 2 that on 3 June 1976 the easterly jet stream does not reach below 500 mb level in Bangladesh and below 700 mb level over Port Blair. The cross-section of 4 June also shows that the influence of easterly jet stream does not reach below 500 mb level either in Bangladesh or in south Bay of Bengal upto Port Blair. The air mass below 500 mb level is westerly and the easterly wind is above 500 mb level. On 5 June, however, the vertical cross-section of zonal winds show that the influence of easterly jet stream spread slightly below 500 mb level over Bangladesh, a thin layer of westerly

persisted at 700 mb level. Easterlies prevailed over Bangladesh upto 850 mb level. Condition in the Bay of Bengal was such that westerlies prevailed upto 300 mb and easterlies were predominant from 300 mb level and above. The position depicted by the vertical cross-section of zonal wind along 90°E on 6 June indicates that the influence of easterly jet stream is felt upto the surface level over Bangladesh spreading northwards in the lower layer and replacing the entire westerlies upto Lat. 22°N. Westerlies above 27°N at 300 mb level were weak. The position on 7 June remained almost the same as on 6 June, i.e., the influence of easterly jet stream reaches upto ground level. This day however, a small portion in southern part of the country has the sweep of southwesterly current and westerlies at 300 mb level above Lat. 27°N were weaker than that on 6th. On 8 June 1976 it is noticed that the southwesterly current increased and reached upto 500 mb over Bangladesh but the easterly jet stream still continued to exert its influence from above that level. It is further noticed that the westerly component of prevailing

esterlies of northern hemisphere increased from 400 mb level to 100 mb level above Chittagong and the southwesterly component was predominant from ground to 500 mb level in Bangladesh. Gauhati had easterly component upto 300 mb level. The vertical cross-section of zonal wind along 90°E of 9 June 1976 shows that the influence of easterly jet stream shrinks and it does not reach below 300 mb level anywhere and the lower layer is controlled by southwesterlies from equator upto Bangladesh.

The vertical cross-section along 90°E of zonal winds for 13 June 1976 shows an entirely different picture. It should be mentioned that the average rainfall in Bangladesh during 24 hours ending at 0300 GMT of 13 June 1976 was less than $\frac{1}{2}$ inch. The cross-section shows that westerly components of westerly jet stream was controlling the entire circulation. The demarcating zone of the equatorial easterlies, lying to the south and westerly jet stream lying to the north, was passing from 40000 ft over Gauhati to about 12000 ft over Port Blair. Contrast may be made between this cross-section and the two cross-sections for 6 and 7 June 1976. It will be noticed that during the burst of monsoon in Bangladesh the influence of easterly jet stream extends upto ground layer and during break monsoon the easterly jet stream shrinks and withdraws to about 30000 ft in Bangladesh. From these cross-sections it appears that easterly jet stream controls the onset of summer monsoon of Bangladesh. The onset of summer monsoon might be assisted by other simultaneous phenomena mentioned in the introduction but the easterly jet stream appears to be the most deciding factor for the burst of monsoon in Bangladesh. However, since this study has been made only for one year it should be verified for a number of years for confirmation of this conclusion.

5. Onset of summer monsoon and behaviour of westerly jet stream over India

(a) In 1964, the burst of summer monsoon took place on 5 June when Malabar coast got its first monsoon rainfall. The author (Mowla 1965) showed the position of northern limit of the monsoon at 1.5°N during June 1964 in a figure. It was stated then that the summer monsoon affected south India, south of Madras by 7 June 1964; the whole of the Deccan (approximately south

of $\text{Lat. } 20^{\circ}\text{N}$) was under the influence of summer monsoon by 11 June that year. The whole of south Asia excluding West Pakistan was under the grip of the summer monsoon by 29 June 1964. The observations of Yin and Riehl as mentioned in the introductory remark that the burst of monsoon in south Asia takes place simultaneously with the disintegration of the subtropical westerly jet stream over southeast Asia was investigated by the author to find out its reliability. For this purpose 10 vertical cross-sections of zonal winds along 75°E for 3rd, 7th, 11th, 15th, 19th, 25th, 29th and 30 June as well as for 1 July 1964 were prepared. It was noticed in those figures that on 3 June 1964 when there was no summer monsoon over south Asia, the easterly jet stream was existing above Trivandrum (9.5°N) at a height of about 16 km with central speed more than 73 kt. On that particular day the subtropical westerly jet stream was lying at about 10 km with its core at about $\text{Lat. } 26.5^{\circ}\text{N}$. It was rather weak. This was the position two days before the burst of monsoon over Malabar coast. The cross-section for 7 June showed the existence of easterly jet stream almost the same as on the 3rd but shifted towards the north by about 1° Lat. The westerly jet stream with its core shifted to about $\text{Lat. } 28.5^{\circ}\text{N}$ while the same altitude was maintained. On 11 June it was noticed that the easterly jet stream approximately remained at an altitude of 16 km with central speed of about 70 kt but the upper troposphere was easterly at 18 km over New Delhi. The westerly jet stream, on 11 June, suddenly shifted further north and was lying at an altitude of 12 km above $\text{Lat. } 34^{\circ}\text{N}$. This is a remarkable shift after 7 days of burst of monsoon at Malabar coast. The westerly jet stream did not disintegrate from south Asia, south of the Himalayas, even 7 days after the burst of monsoon. The observation of Yin and Riehl is not confirmed this year. The position on 15 June was almost the same with the difference that easterly jet stream above 16 km extended further north and the 60 kt isotach extended upto $\text{Lat. } 15^{\circ}\text{N}$. The 40 kt isotach extended as far north as $\text{Lat. } 20.5^{\circ}\text{N}$. The westerly jet stream was confined in the vicinity of 34°N on 19 June 1964 and the easterly jet stream took over almost the whole of troposphere right from 5°N (excepting the lower monsoon layer with southwesterly approximately at 9 km over Trivandrum and 2 km over Ahmedabad). The westerly jet stream still existed above 34°N with its speed in the core as 81 kt at 14 km. The 60 kt isotach of the westerly jet stream extended southward upto 31°N at 12.5 km.

It is seen, upto 25 June 1964, that the westerly jet stream was not disintegrated though the easterly jet stream took over the entire wind circulation to the south of Lat. 28.5°N . On 29 June the easterly jet stream strengthened further, its central speed was about 100 kt and was controlling the entire troposphere and lower troposphere upto 30°N . The monsoon current was extending from about 8 km above Trivandrum to 2 km at Lat. 28°N . The westerly jet stream still existed at Lat. 34°N at a height of about 12 km. Its speed in the core was about 60 kt. So after the burst of monsoon over Malabar coast on 5 June 1964, the subtropical westerly jet stream continued over the south Asia upto 29th and did not disintegrate. From the cross-section of 30 June 1964 it was noticed that the westerly jet stream suddenly disappeared. Srinagar reported only 20 kt of westerly component at 14 km. It might have shifted to the north Himalayas or might have disintegrated but the position remains that the subtropical westerly jet stream remained continuously in existence for 24 days after the burst of monsoon in south Asia in June 1964. This special phenomenon indicates that the subtropical westerly jet stream probably does not oppose to the burst of monsoon in the subcontinent. On the other hand it appears that the burst of monsoon is closely connected with the movement of the easterly jet stream. It is pointed out from 10 cross-sections of zonal winds, (9 for June 1964 and one for 1 July 1964) that the basic current over south Asia and also over southeast Asia during the summer season was the prevailing equatorial easterlies centring the easterly jet stream. The westerly jet stream shifted to the north of Himalayas which probably facilitates in the extension of the easterlies.

(b) The 10 cross-sections of June & July 1964 further showed that the easterlies of the easterly jet stream sweep down to surface over India and Pakistan in the region north of Lat. 20°N . This was clear from the cross-sections of 19th, 29th, 30th and 1 July 1964. We have a notion that the southeasterly current over the Gangetic plain from Bangladesh upto Pakistani Punjab or even upto Frontier Region of Pakistan is the deflected monsoon current due to position of mountain to the north and northeast and also due to low pressure area lying over northwest India and northern Pakistan. The southwesterly current is certainly brought by this low pressure area but the easterly component of the current over the Gangetic valley

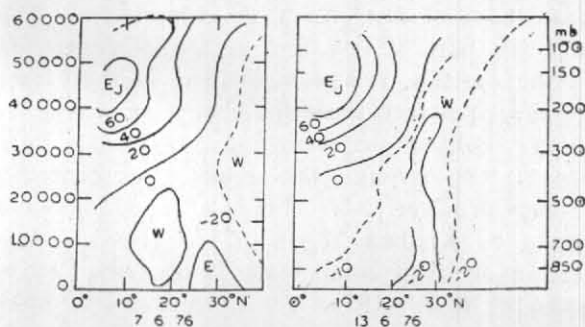


Fig. 3. Vertical cross-section, June 1976, Zonal wind (in knot) of individual days along Long. $75^{\circ}\text{--}80^{\circ}\text{E}$

approximately from Lat. 23°N , Long. 90°E to Lat. 30°N , Long. 75°E appears to be a part from the equatorial easterlies.

The few vertical cross-sections of zonal wind for June 1976 along Long. 90°E discussed in Sec. 4 above show that at the time of onset of monsoon in Bangladesh the easterly jet stream over Lat. 10°N slightly shifts towards north and then spread its influence downwards upto the surface over Bangladesh replacing the westerly wind in the lower region. But after the onset of the monsoon, when the monsoon activity becomes rather weak, the easterly jet stream again shifts slightly to the south and also withdraws its lower portion from the surface of Bangladesh to the height of about 600 to 500 mb level. During these days of lesser activity of monsoon in Bangladesh the westerly jet stream to the north Himalayas appears to increase its influence southwards and westerly component of zonal winds over Bangladesh above 500 mb level to 200 mb level increases.

Two vertical cross-sections of zonal winds along Long. 80°E , one for 7 June and other for 13 June 1976 (Fig. 3), show that the core of the easterly jet stream shifts slightly southwards during the lesser activity of the monsoon over Bangladesh but the lower layer south of Lat. 20°N along Long. 80°E is covered by westerly components of zonal winds. This westerly component from Lat. 20°N further and upto equator is certainly the southwesterly monsoon.

(c) Vertical cross-sections of mean zonal wind of summer from 10°S to 80°N show that the equatorial easterlies fill up the entire troposphere from Lat. 30°N to equator southwards. The spring cross-section of the mean zonal winds shows the entire troposphere from Lat. 30°N (m.s.l.) to about Lat. 10°N (200 mb level) is demarcated by transi-

tional zone of east and west components. The northern part of this zone is totally controlled by the westerly jet stream and the southern part by the equatorial easterlies. But the easterlies to the south of the transitional zone do not become very strong. In summer, it is generally 15 mps or lower. (See Fig. 1.1. for summer and spring by Krishna Murti 1975). Vertical cross-section of mean zonal wind along Long. 80°W given by Riehl (1954) for summer also shows the same. It is, however, noticed that the mean cross-section given by Krishna Murti does not show the westerly component in the lower layer; but the figure by Riehl shows that the lower layer from about 12°N to equator was covered by westerly wind.

(d) The vertical cross-section of mean zonal wind along 80°E or 75°E always shows the presence of westerly wind in the lower layer upto about Lat. 20° to 30°N during summer season. This is the summer monsoon current which is, by far, the most important local circulations in the south Asia during the summer season. But for this southwesterly monsoon, the whole equatorial zone upto 25°N in the northern hemisphere is totally predominated by equatorial easterlies. In the mean cross-section for summer for zonal winds along 75°E to 80°E it is noticed that the easterly wind has a very strong core, though not as strong as the core of the westerly jet stream, but it is not that weak also and is generally about 100 kt at about 55000 ft over tropics along this longitude. It appears that the same position is prevailing along Long. 90°E, as is evident from the 10 cross-sections of June 1976 mentioned at Sec. 4 above. It appears from the June 1976 upper air chart that the equatorial easterlies are having a core of strong easterlies at a height of about 55000 ft along Lat. 10° to 15°N during the height of the summer even along Long. 100°E. So the entire upper wind circulation during summer season over the tropics in south Asia and southeast Asia is controlled by this easterly jet stream and the onset of monsoon in Bangladesh appears to be controlled by this easterly jet stream. The author found, from another ten cross-sections of vertical zonal winds (Mowla 1965) along 75°E that during the normal monsoon activity, the core of the easterly jet stream persists at a height of about 17 km along Lat. 10°N but a secondary core of easterly jet developed along Lat. 24°N, at a height of about 14 km. This also shows that monsoon activity in southeast Asia is controlled by

the easterly jet stream. Southwesterly current in the lower layer is the deflected southeasterly current of southern hemisphere which crosses equator during summer season and approaches southern India as southwesterly current in the lower layer. The same current approaches, as southerly and southeasterly current, in Bangladesh (*vide* Krishna Murti 1975).

6. Onset of summer monsoon as seen through APT pictures

The APT pictures of 7 June 1976 shows huge masses of convective clouds covering Bangladesh and adjoining areas of India to the west, in such a manner that such convective clouds are bound to give heavy precipitations. In fact, the rainfall recorded by 25 stations in Bangladesh during 24 hours ending 0300 GMT of 7 June 1976 was very negligible but rainfall during 24 hours ending at 0300 GMT of 8 June 1976 was quite heavy and widespread. 25 stations selected for this study recorded during this 24 hours a total of 75 inches of rain. This amount of rain was expected from the APT pictures of 7 June 1976. It is mentioned here that, of the 75 inches of rain recorded (i) five stations recorded 6 to 8 inches, (ii) three stations recorded 4 to less than 6 inches, (iii) six stations recorded 2 to less than 4 inches, (iv) three stations recorded 1 inch to less than 2 inches, and (v) three stations recorded no rainfall at all. All the three stations having no rainfall during these 24 hours were in North Bengal, *i.e.*, Bogra, Rangpur and Ishurdi. Total rainfall recorded by the same 25 stations from 0300 GMT to 1200 GMT of 7 June 1976 was 11.60 inches or on the average each station had 0.464 inches of rainfall. But Sandwip alone recorded 5.40 inches during these 9 hours. As such the onset took place in the evening of 7 June 1976. The cloud picture of 13 June 1976 indicates no convective cloud over Bangladesh and rainfall recorded on 13 June 1976 was very small in Bangladesh. The cloud picture on 22 June 1976 indicates that there was no convective cloud anywhere over Bangladesh or in the neighbourhood.

Bangladesh Meteorological Department acquired its first APT Ground Station in 1967 and it started functioning from April 1968. Our difficulty regarding observation from the Bay of Bengal and Indian Ocean was very much redressed when we started getting APT pictures at Dacca. The onset of monsoon was also watched through APT pictures.

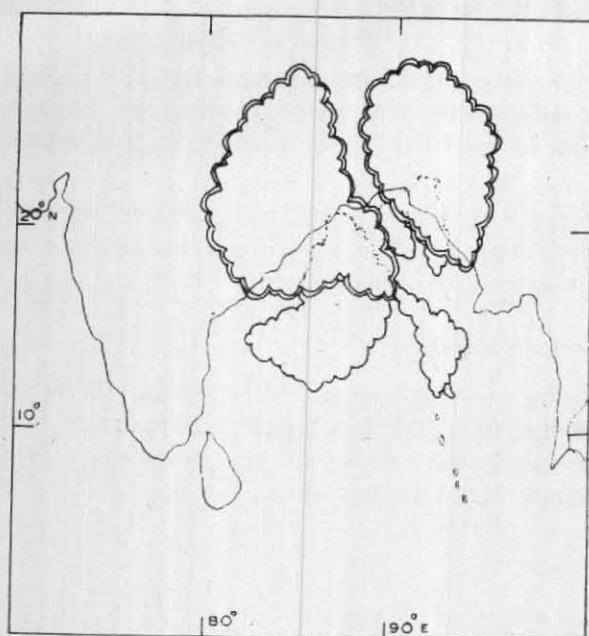


Fig. 4. APT picture reproduced from NOAA-4, 6 and 7 June 1976

From Fig. 1 it is clear that the burst of monsoon took place in Bangladesh around 1200 GMT of 7 June 1976. The APT pictures received at Dacca on 6 and 7 June 1976 indicate the presence of convective clouds as may be seen from Fig. 4.

It will be noticed that on 6 June 1976 the convective cloud coverage was lying to the south of Bangladesh. Practically no convective cloud was visible over Bangladesh. But the area, Lat. 12°N to Lat. 20°N , Long. 87°E to Long. 90°E , was covered by huge mass of convective cloud. There were only some broken clouds over Bangladesh. But on 7 June 1976 (at about 1400 GMT) the position was different as shown by the APT pictures of that day. Two huge masses of convective clouds covered the entire area from Lat. 16°N to Lat. 28°N , Long. 80°E to Long. 95°E with a small gap approximately from the area Lat. 17°N , Long. 90°E to the area Lat. 27°N , Long. 86°E with a width less than one degree latitude. The time of this picture was approximately 1400 GMT of 7 June. This alone can justify the heavy widespread rainfall in Bangladesh recorded at 0300 GMT of 8 June 1976 for the preceding 24 hours. The APT picture cloud positions of 6 and 7 June 1976 are approximately shown in Fig. 4.

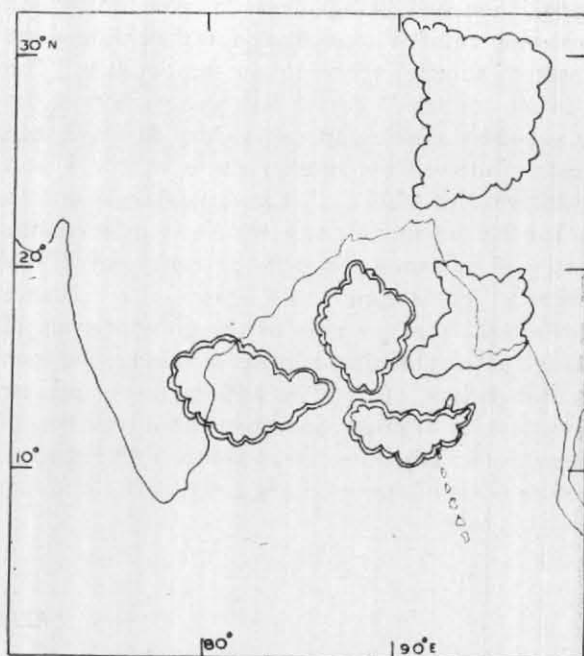


Fig. 5. APT picture reproduced from NOAA-4, 13 and 22 June 1976

Fig. 5 shows cloud condition on 13 June 1976 and on 22 June 1976 over south Asia. It will be noticed from Fig. 1 that rainfall suddenly stopped in Bangladesh on 13 June 1976 and also for a few days, around 22 June 1976. Bangladesh and its neighbouring areas were free from any convective clouds on both these occasions.

There was again heavy and widespread rainfall in Bangladesh on 29 and 30 June 1976. This is also evident from the APT pictures of both days showing cloud coverage over South Asia. It is almost similar to that of 7 June 1976.

8. Conclusions

(a) It is evident from this study that individual daily rainfall in Bangladesh in June 1976, vertical cross-section of zonal wind along Long. 90°E for critical days of June 1976 and APT pictures received at Dacca showing cloud coverage over Bangladesh and neighbouring land and sea areas for each day of June 1976 can themselves, on the merit of each, provide definite information regarding onset of summer monsoon in Bangladesh.

(b) (i) There has been sudden increase in rainfall with fairly widespread heavy to very heavy rainfall over Bangladesh to indicate the onset of monsoon. Fig. 1 shows, as if, a sudden pulse from the Bay of

Bengal touched Bangladesh to give immediate incessant rainfall over Bangladesh heralding the onset of summer monsoon in the country. The rainfall continued for a number of days to be followed by a few comparatively dry days and then again, followed by another pulse of heavy and widespread rainfall. (ii) The vertical cross-section of zonal wind along Long. 90°E also indicates the onset of monsoon through the behaviour of the easterly jet stream which spreads its influence downward from the core to the ground levels of Bangladesh at the time of onset of summer monsoon in Bangladesh. (iii) The APT pictures indicate an existence of huge convective cloud over Bay of Bengal and adjoining areas south of Bangladesh before onset of monsoon and convective clouds are

present over whole of Bangladesh and adjoining areas at the time of onset of summer monsoon.

(c) Each of the above parameters appears to be a self-sufficient tool for pin-pointing the date and time of onset of summer monsoon in Bangladesh.

(d) For investigating problems connected with summer monsoon in the subcontinent we may depend probably more on tropical parameters than on extra-tropical parameters.

Acknowledgement

The author is grateful to the Director, Bangladesh Meteorological Department for allowing this paper to be presented to the symposium and published.

REFERENCES

- | | | |
|------------------------------------|------|---|
| Bryson, A. | 1976 | Abstract of International Symposium on Recent Climatic Change and Food Problems, October 4-8, 1976, Tsukuba and Tokyo, pp. 87 and 88. |
| Flohn, H. | 1960 | <i>Monsoons of the World</i> , India met. Dep., New Delhi, pp. 81-88. |
| Krishna Murti | 1975 | Lectures on Tropical Meteorology, FSU Report No. 75-8, Nov. 1975, p. 13. |
| Malurkar, S. L. | 1950 | <i>Mem. India met. Dep.</i> , 28, Pt. 4 pp. 139-215. |
| Mowla, K. G. | 1965 | <i>Pak. Jour. Health</i> , 15 (1), pp. 5-6. |
| Ramanathan, K. R. | 1960 | <i>Monsoons of the World</i> , India met. Dep., New Delhi, p. 64. |
| Riehl, H. | 1954 | <i>Tropical Meteorology</i> , McGraw Hill Book Co., p. 19. |
| Sutcliffe, R. C. and Bannon, J. K. | 1954 | <i>Proc. Int. Assoc. Met.</i> , X. Gen. Ass. Rome, pp. 322-334. |
| Yin, M. T. | 1949 | <i>J. Met.</i> , 6, p. 393. |