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Onset of monsoon 1979

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ABSTRACT. The onset of monsoon has been studied with the help of north-south time cross sections along 75°E at various levels in the atmosphere. The study of flow, changes of temperature and moisture along this section show important developments and features in Arabian Sea during the onset of monsoon. Finally, the advance of monsoon with the movement of depression off west coast has been associated.

1. Introduction

The summer monsoon over the northern hemisphere may be seen as "an extension of the southeast trade winds from the southern hemisphere which on crossing the equator, are deflected and become southwesterlies".

Some of the significant observed features or mechanisms during the period of monsoon circulation are:

(*i*) Substantial amount of the moisture required for monsoon precipitation over Southeast Asia is supplied through the southwesterlies over the Arbian Sea (Saha 1970, 1974).

(*ii*) An inversion layer exists over the flat low lands of eastern Africa and over most parts of the Arabian Sea, inhibiting the development of deep clouds.

(*iii*) One of the most intriguing phenomena over eastern Africa and the Arabian Sea is the low-level jet, which is most pronounced at heights upto 1.5 km (Findlater 1969, 1971, 1972).

(*iv*) During the monsoon period depressions are formed over the Bay of Bengal and also in Arabian Sea which are considered an important component of Indian weather.

In some years the southwest monsoon is ushered along the west coast of India in the wake of a depression which forms over the east Arabian Sea and moves north or northwestwards (Raman *et al.* 1979).

In this paper an attempt has been made to describe the significant features of the onset of monsoon 1979 over Indian subcontinent.

Normally, onset of monsoon over India occurs in the last week of May, and its variance is about 10 days (GARP Publication Series, No. 18, 1976). This year the synoptic conditions during the first week of June 1979 were not favourable for the onset of monsoon even at the end of first week of June (Wahid *et al.* 1980).

2. Evidence about the onset of monsoon 1979 from the time cross section of meteorological elements around 75° E

2.1. *Time Variation of Wind around* 75°*E*

Time variation of wind from 850 mb to 100 mb analysed and a few sections are given in Figs. 1 to 4.

In the analysis the continuous lines which are in shape similar to streamlines are the lines of wind changes or shifts with time, the broken lines represent the trough lines or shear lines and continuous lines represent the ridges or axis of anticyclones. The vortices which are shown in the figures have good consistency with the vortices or cyclonic circulation on the synoptic maps.

From Figs. 1 to 3 it is seen that around 75° E the winds from 5° N to equator are southwesterly with the maximum speed of 10 kt from 4 June till 10 June, and between 10 June and 12 June the maximum speed increased to 30 kt

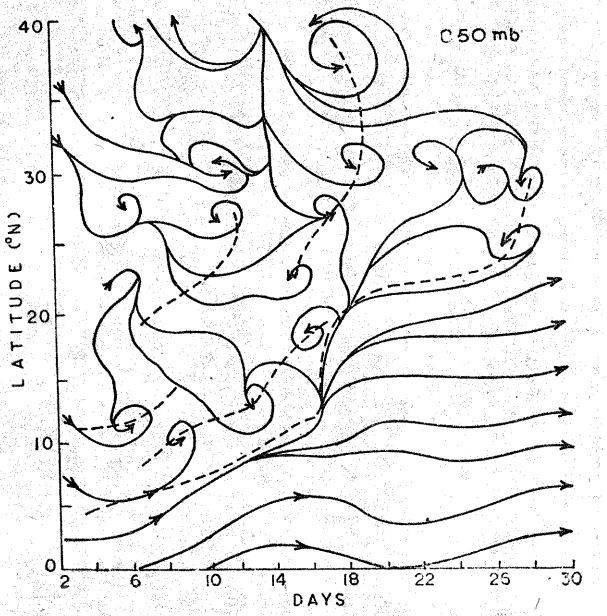

Fig. 1.

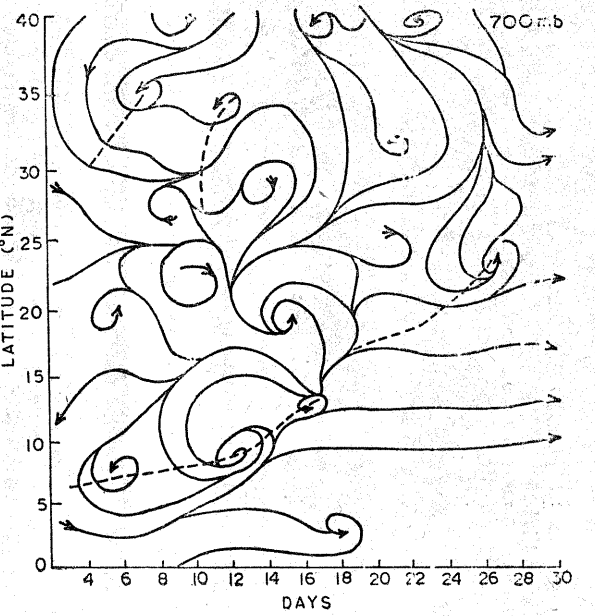

Fig. 2.

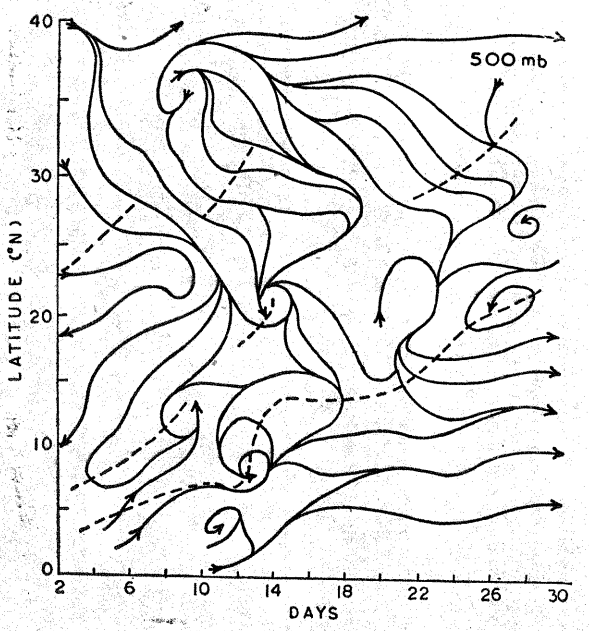

Fig. 3.

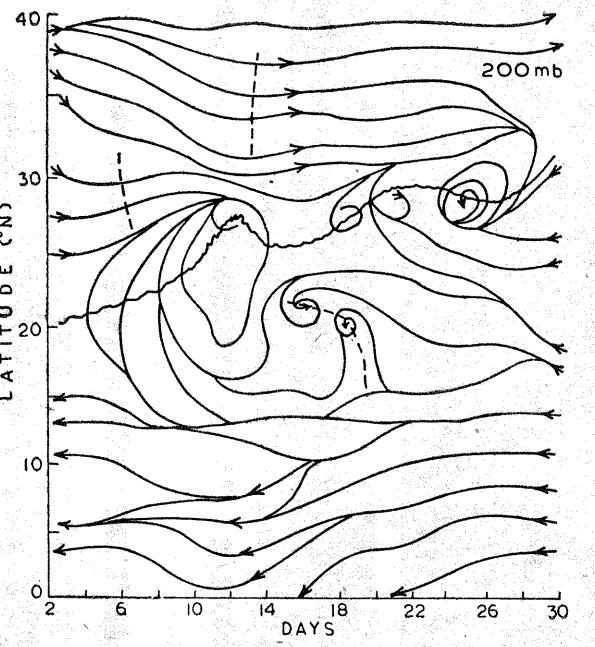

Fig. 4.

at 850 & 700 mb and 20 kt at 500 mb. Southwesterly winds are observed on 12 June from equator to about 8° N at 850 to 500 mb. Vortices are seen on 850 and 700 mb around 10°N and at 500 mb around 8°N on 13 June. With the appearance of these vortices the westerly and southwesterly winds become strong with time and shifted northwards on 14 June.

Considering the shearline which can be traced at 850, 700 and 500 mb (Figs. 1-3) between southwesterly or westerly winds on one side and northeasterly or southeasterly on the other side as the monsoon trough it can be concluded that from 6 June to 10 June there were unfavourable conditions for onset of monsoon over the southeast Arabian Sea. The conditions seem to be better and favourable on 12 June where southwesterly winds were observed at 850 mb from 15° to about 7° N with the maximum speed of 30 kt (Fig. 1). Besides thse features, vortices were seen at 850, 700 and 500 mb on 13 June.

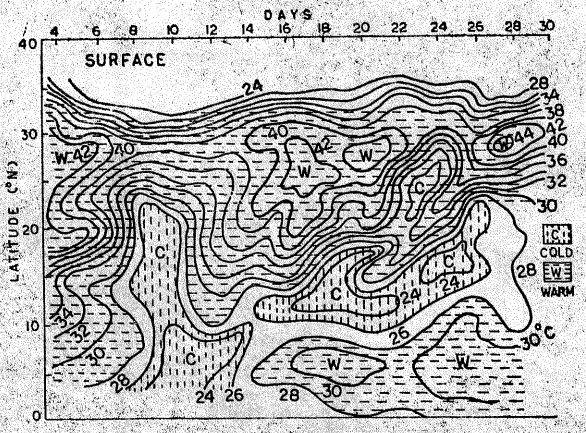

Fig. 5. Time variation of surface temperature around 75°E

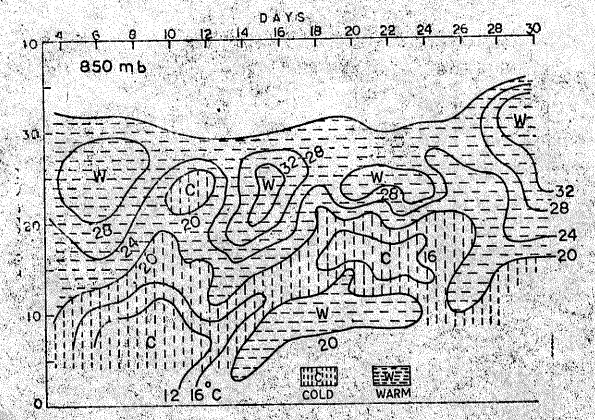

Fig. 6. Time variation of 850 mb temperature around 75°E

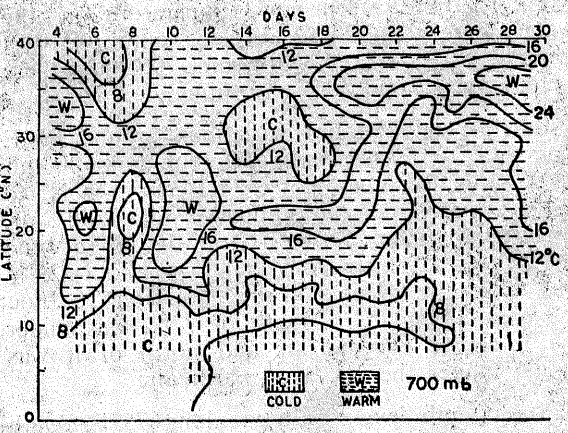

Fig. 7. Time variation of 700 mb temperature around 75°E

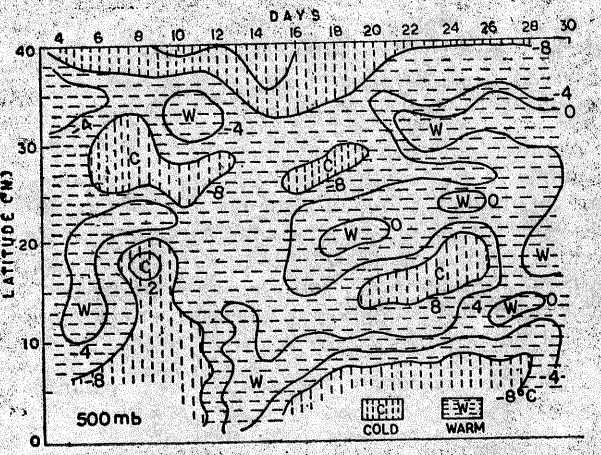

Fig. 8. Time variation of 500mb temperature around 75°E

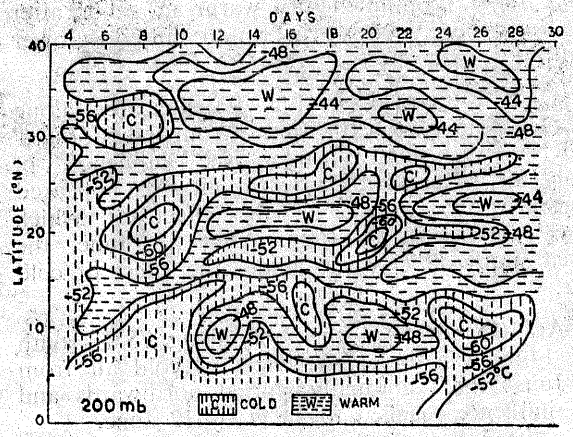

Fig. 9. Time variation of 200 mb temperature around 75°E

The conclusion was that the onset of monsoon 1979 occurred over the Arabian Sea by about 12 June and in conjunction with the occurrence with well marked precipitation on the extreme southern part of the west coast of Indian subcontinent on the same day. Refering to upper tropospheric levels it can be seen that the position of the subtropical ridge on 300 mb level was from 4 to 10 June south of 20°N. between 10 and 16 June, it was located around 25°N and from 16 June, it shifted to 28°N within two days. On the 200 mb level (Fig. 4) the position of subtropical ridge was around 75° E which showed northward shift from 4 to 12 June. From 12 to 16 June it remained at the same position. It again shifted thereafter towards north to a nearly normal position. This was in simultaneous with the shift of monsoon trough in mid-troposphere to its proper position.

The low-level jet, was not seen around 75° E before or at the beginning or after the onset of monsoon 1979 till 28 June. This may be one of the most significant reasons for the weak monsoon 1979 over Indian subcontinent. But over the Arabian Sea the low level jet was observed on 17 June. Intermittent appearance of easterly jet was seen at 200mb level around

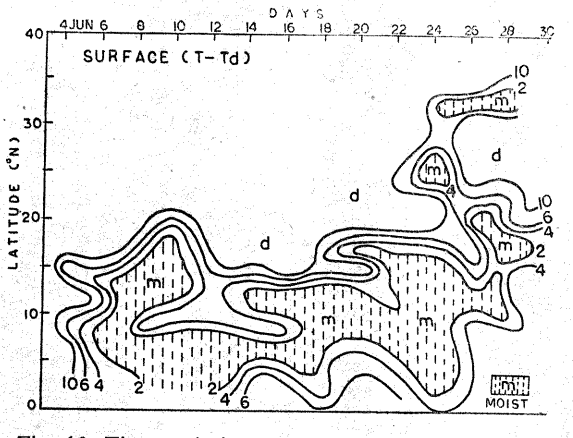

Fig. 10. Time variation of surface (T—T_d) around 75°E

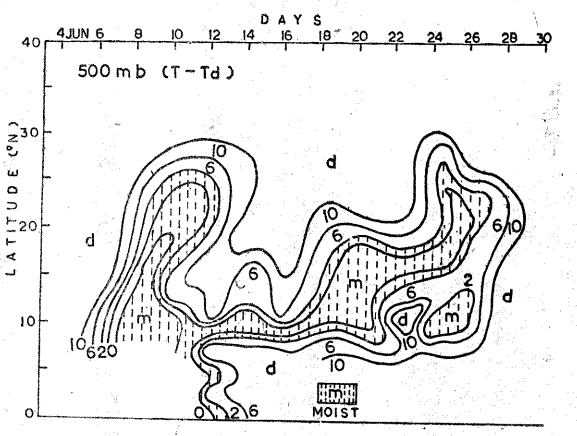

Fig. 11. Time variation of 500mb (T—T_d) around 75°E

75°E on 20 June and 26 June around 8°N. At 100 mb level, continuous easterly jet was observed from 14 June, south of 9°N and from 18 June between 13 and 16°N.

Another conclusion was that the easterly jet around 75°E, south of 10°N (southernmost part of Indian sub-continent) at 100 mb level was seen just at the stage of the formation of a cyclonic circulation at 700 mb in the southeastern part of Arabian Sea, and between 12°N and 16°N after the formation of cyclonic circulation at 500 mb level.

2.2. *Time variation of temperatures around 75°E*

Time variation of temperatures from surface to 100 mb level were analysed and given in Figs. (5) to (9).

From the time variation of surface temperature (Fig. 5) it may be seen that south of 10°N around 75°E, the temperatures were higher than 26°C till 8 June. Therefore, the situation with warm temperatures was favourable for onset of monsoon over the southeastern part of Arabian Sea. But from 8 to 10 June, the region along 75°E from 20°N to about 4°N was under the effect of cold air (below 26°C at the surface), from the surface upto 500 mb. It may be interpreted that south of 10°N cloudiness and even precipitation had occurred from 8 June because of the presence of new airmass which reduced the air temperature, north of 10°N and upto 22°N it was under the influence of a westerly trough from 8 to 10 June. Again from Fig. 5 it may be seen that the effect of cold air on the surface south of 10°N which was seen from 8 to 12 June shifted northward and reached 24° N on 26 June. It indicated that the cloudiness and precipitation which were located around 75°E, south of 10°N, shifted northward after 12 June. After 12 June warm air temperature on the water more than 28°C affected south of 10°N around 75°E. At 850 mb and 700 mb, there were similar conditions prevailing.

But the temperature variations around 75°E from 500 to 100 mb was different. On 500 mb level (Fig. 8) area along 75°E from 5°N to 20°N was under the influence of cold air, from 8 to 10 June. Again from 10 to 16 June 1979 the area, nearly from equator to about 32° N was under the effect of warm air. After 16 June the area along 75°E, south of 7°N, was under the influence of cold air and north of it was mainly under the effect of warm air.

At 300 mb level the area along 75°E, south of 15°N, from 11 June to about 12 June was under the effect of cold air, whereas from 12 to 16 June the area along 75°E south of 14°N was under the influence of warm air, while after 16 June the influence of warm air shifted to lower latitudes.

On 200 mb level (Fig. 9) the area along 75°E from 4 to 10 June (from equator to 40°N) was maily under the influence of cold air. After 10th a warm airmass appeared between 5°N and 12°N, the effect of which was seen upto 14 June. After 14 June, the area south of 7°N was under the effect of cold air.

At 100 mb level the area along 75°E south of 14°N was under the effect of cold air from 4 June which gradually shifted northwards and its influence reached to 28°N by 12 June.

2.3. *Moisture field around 75°E*

The variation of moisture field around 75°E showed that from surface to 500mb (Figs. 10 and 11) there had been an increase of humidity (T-Td 2°C) from 10°N toward north-

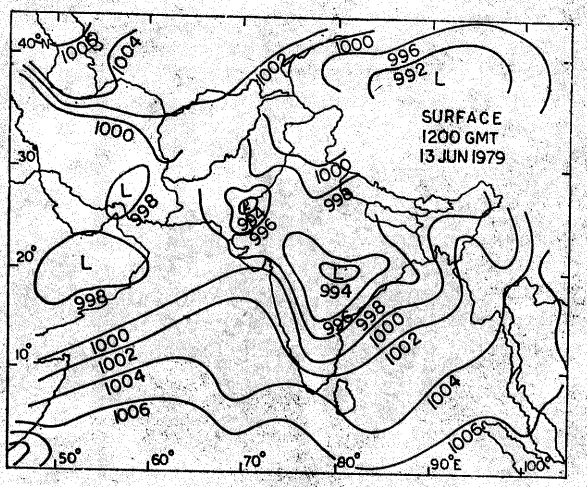

Fig. 12.

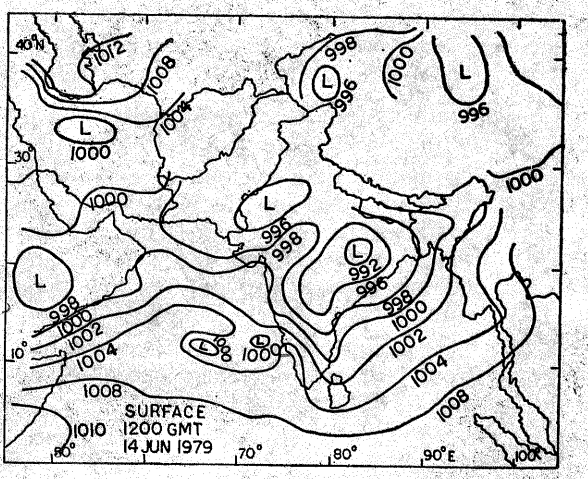

Fig 13.

ern latitude after 12 June. This fact also confirmed the onset of monsoon 1979 over Indian subcontinent on 12 June and supply of moisture from the Arabian Sea.

3. Synoptic conditions in a period of 4 days after the monsoon onset over the Indian subcontinent

Considering the surface chart of 1200 GMT of 13, June 1979 (Fig. 12) we see that the thermal low was well organized over the central India, with troughs extending southwards to the southern part of the continent and eastwards to the northern parts of the Bay of Bengal.

Cells of thermal lows were located southeast of Pakistan, south of Iran and east of Saudi Arabia. Inspite of no data over China and Tibetean plateau, it seems that the thermal low there was also well organized with pressure lower than 992 mb. The isobars from the Somalia coast ran in a southwest to northeast direction over the Arabian Sea.

Other features on the surface chart were troughs around 69°E from 4°N to 10°N and around 83°E nearly from equator to 5°N.

In the area from 4°N to 10°N and 65°E to 73°E the weather was cloudy to overcast and a station reported rain. In this area the surface wind was westerly or southwesterly from 10 to 15 kt.

Cross-equatorial flow around 45°E with 10 kt winds was observed.

At 850 mb, from equator to about 17°N over Arabian Sea and Bay of Bengal the streamline show westerly to southwesterly flows. The trough which was located in the northwest of Arabian Sea and the trough which was originated from the cyclonic centred over the east of Bangladesh (23°N, 90°E) induced over

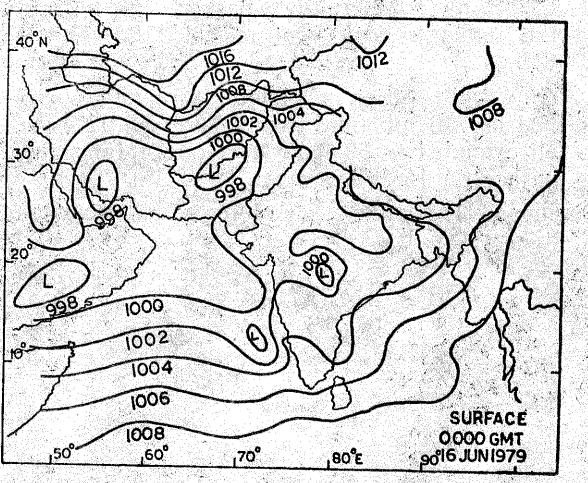

Fig. 14.

the central and northern parts of India, wind nearly from northwesterly direction.

At 700 mb a cyclone was located for the first time just at the time of the onset of monsoon over the south-eastern parts of Arabian Sea, and another vortex on the southwestern part of the Bay of Bengal.

The trough which was seen at 850 mb over the eastern part of the Bay of Bengal was also seen at 700 mb.

At 500 mb a trough which had no western origin was located over the most southern part of Arabian Sea with axis orientated east to west between latitudes 10°N and 15°N.

The important development in the pressure field on the surface (Fig. 13) on 14 June 1979 was a trough over the southeastern part of Arabian Sea with two small closed cells (1000 mb). This trough on 15 June deepened and on 16th, a cyclonic circulation (depression) was

seen on the surface (Fig. 14). This cyclonic circulation was also seen at 850, 700 and 500 mb levels.

Consequently the main synoptic mechanism at the time of the onset of monsoon 1979 were:

(*i*) Formation of a cyclonic circulation at 700 mb level on 13 June over the southeastern part of Arabian Sea which was seen on the surface and 500 mb level as troughts of low pressure.

(*ii*) The extension of cyclonic circulation from 700 mb to surface on 16 June and to 500 mb on 14 June.

4. Conclusions

(i) From the daily variations of winds, temperature and humidity fields along 75°E it is seen that onset of monsoon 1979 occurred over Indian subcontinent on 12 June. On that day Trivandrum (southernmost part on west coast of the Indian subcontinent recorded 82 mm of rainfall.

(ii) At the onset, a cyclonic circulation was formed at 700 mb (mid-troposphere) on 12 June which extended to 500 mb level on 14 June and to surface on 16 June.

(iii) In 1979 the onset of monsoon occurred over Indian subcontinent (west coast) in association with a depression which was seen at 700 mb on 13 June over the southeast Arabian Sea and had moved westnorthwestwards over the Arabian Sea.

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