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Atmospheric Physics

LATITUDINAL AND VERTICAL VARIATION OF THERMODYNAMIC INSTABILITY OVER INDIA AS REVEALED BY MONEX 1979*

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The static stability parameters σ_d and σ_m for dry air and moist air respectively which give a direct insight into the vertical variation of stability, have been computed, besides mixing ratio for select Indian stations situated in different latitude belts, by making use of the 2030hr observations of MONEX 1979.

The study revealed that the atmosphere upto 500mb is convectively unstable in all latitude belts. The spatial variation of this stability revealed that the central parts are unstable. The middle layer (850–700mb) is found to be highly unstable compared to other parts.

An intercomparison for different months is made and discussed.

Keywords : Static Stability; Equivalent Potential Temperature; Mixing Ratio; Monex

INTRODUCTION

THE thermodynamic stability and the moisture content of the atmosphere are the two important parameters to be studied with special reference to monsoon season which accounts for 75 per cent of the rainfall over most parts of India. Hitherto such studies have been carried out by Rao (1958) for India and by Singh (1976) over northern hemisphere, but only for main synoptic hours. An interesting speculation is whether or not the same variations will be there at other times also. To this end, the data during the MONEX 1979 programme taken at times other than the main synoptic hours have been made use of in computing the stability of the atmosphere. A comparison of the same is made with the climatological values computed by Rao (1958). The spatial variation of the stability over India has been studied.

DATA AND ANALYSIS

The temperature and humidity data obtained during MONEX 1979 programme at 2030hr has been made use of to compute the required parameters for select stations situated in different latitude belts depending upon the availability of the data and for the months May, June, July and August.

The potential temperature, equivalent potential temperature and the mixing ratio have been computed at various standard pressure levels. For the sake of convenience the atmosphere upto 500mb is divided into three layers, namely, surface

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to 850mb, 850–700mb and 700–500mb. The geopotential heights of these levels have also been computed for the days in which data are available.

The static stability parameters σ_d and σ_m are given by

$$\sigma_d = \frac{\partial \phi}{\partial P} \frac{\partial}{\partial P} (\ln \theta) \quad \text{(For dry air)}$$

and

$$\sigma_m = \frac{\partial \phi}{\partial P} \frac{\partial}{\partial P} (\ln \theta_e) \quad \text{(For moist air)},$$

where $\partial \phi$ is thickness in geopotential metres for a pressure difference of ∂P in mb of the layer under consideration, θ is potential temperature and θ_e is equivalent potential temperature.

σ_d and σ_m have been computed for the three layers mentioned above for the months of May, June, July and August for which the data were available. Positive values of either σ_d or σ_m indicate stable conditions and negative values indicate unstable conditions. Mixing ratios have been obtained for the same stations at

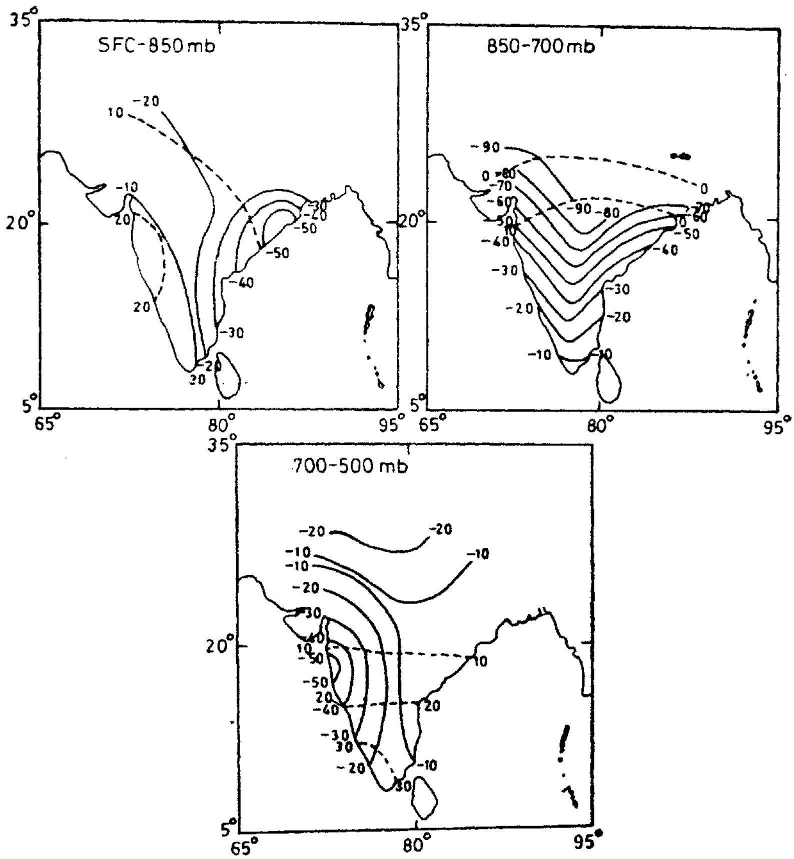

FIG. 1*a*.

different heights. The average values of each of the above parameters namely σ_d, σ_m, and mixing ratio have been obtained for each of these four months and presented.

Results and Discussion

Figs. 1*a* to 1*d* show the space variation of dry static stability (dashed line in the figures) and moist static stability (solid line in the figures) over India for the months of May, June, July and August of 1979 respectively, for the three layers surface to 850mb (lower layer), 850–700mb (middle layer) and 700–500mb (upper layer).

It can be seen from Fig. 1*a* that there is no significant variation of dry static stability in the month of May for all the three layers but for the relatively higher values in the upper layer. Eastern portions and the region along the southeast coast of India are convectively unstable compared to other parts of the country in the lower layer and this instability has been found to decrease towards northwest. The convective instability is well established in the middle layer and spread over the whole India, the maximum being in the central parts. Convective instability in the upper layer is concentrated over western parts and south western parts of the country.

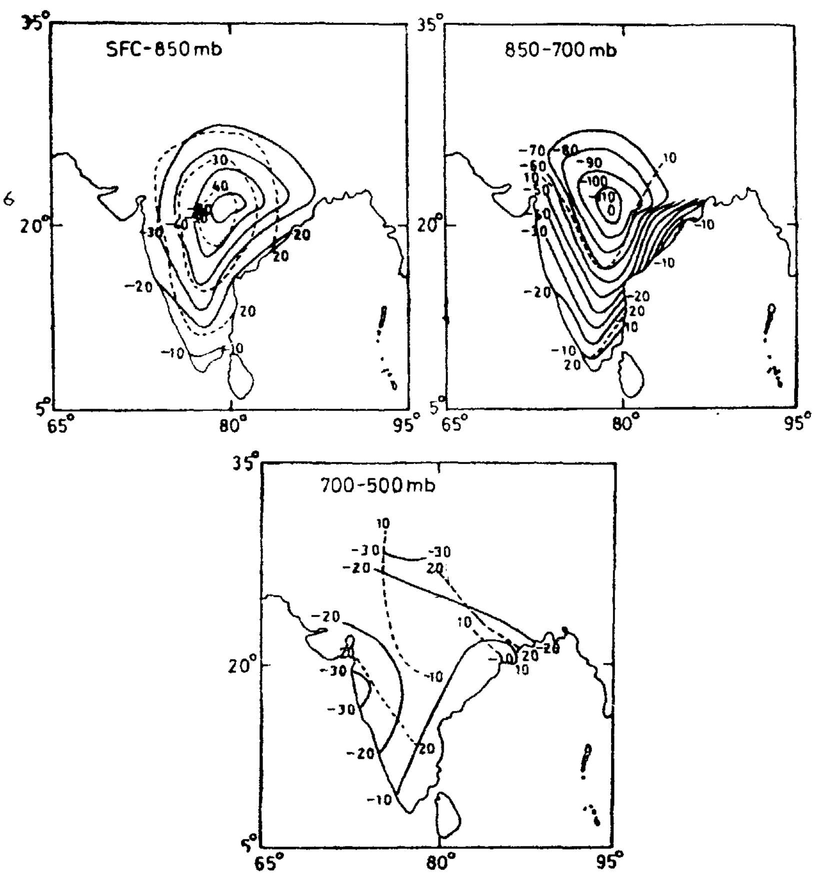

Fig. 1*b*.

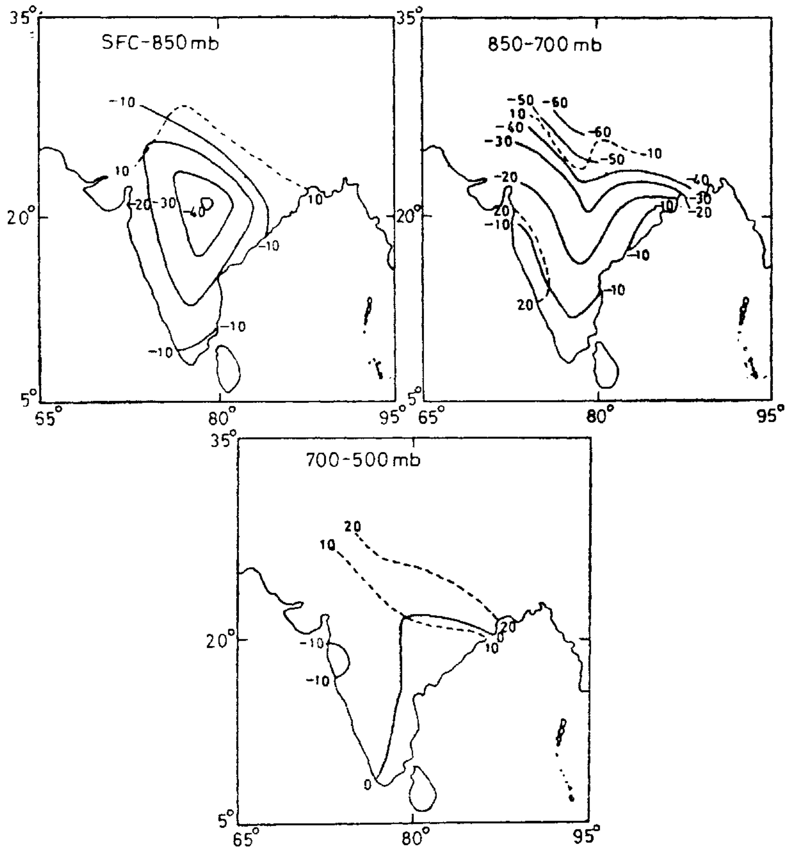

FIG. 1c.

The pattern in June is more or less similar to that in May but for very low convective instability in the upper layer and the uniform spread of the same in the lower layer. The middle layer again is highly unstable compared to other layers.

No significant variation in dry static stability is observed in the month of July (Fig. 1*c*). The convective instability is more in the central parts and is found to decrease in all directions in the lower layer. In the middle layer, northern portions are convectively unstable and this instability decreases towards south. Though, again, middle layer is relatively covectively unstable compared to other layers the difference is not large. The upper layer is practically neutral and dry static stability is more pronounced here.

Extremely low values of convective instability is the predominant feature observed in August in all the layers. Even though the relative variation of the same in the layers is the same as in the other months very low values are conspicuous. The upper layer is convectively neutral but dry stable.

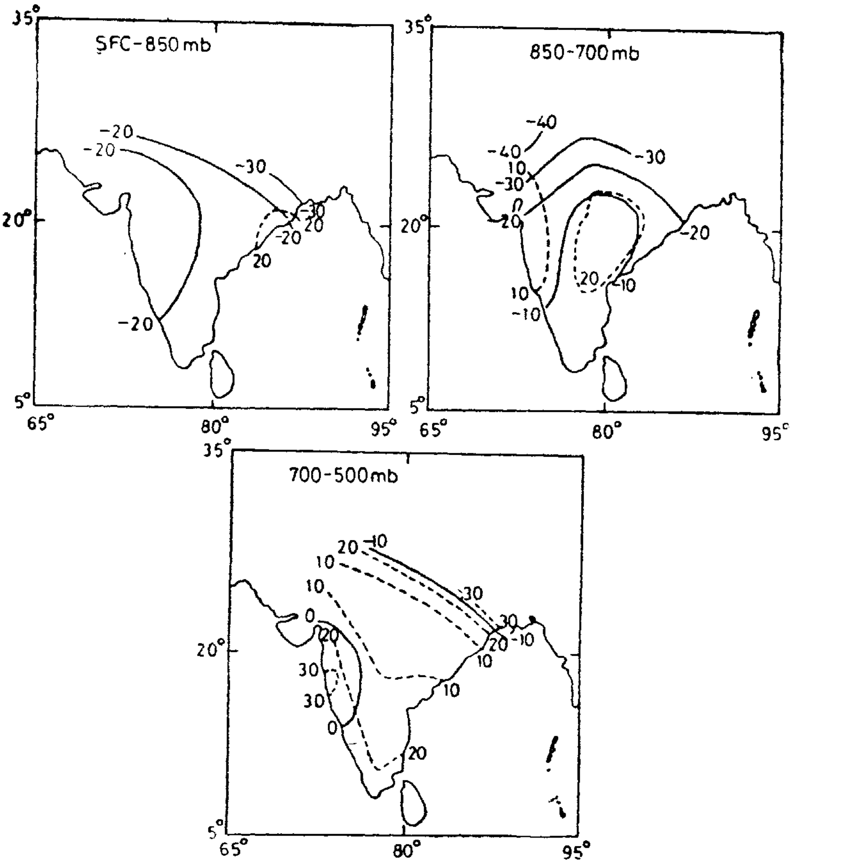

FIG. 1*d*.

The exceptionally low values in August may be due the break monsoon conditions. While the lower values in July may be due to weak monsoon, the maximum instability in June is due to the establishment phase of monsoon when unstable conditions are common. In all the cases middle layer is convectively unstable than the other layers which leads to conclude partly, that the upper air circulation has profound influence on the activity of monsoon. An interesting point is whether it is before the onset of the monsoon or in the weak or in break conditions of the monsoon, the middle layer is always characterized by high convective instability compared to other layers.

Fig. 2 shows the variation of mixing ratio with latitude and higher for the four months. In all the cases excepting May, the mixing ratio is increasing with latitude, that is the mixing ratio is increasing towards north having its maximum value around 25° latitude and maintaining the same variation at all heights. However, in May, the mixing ratio is decreasing towards north and the values are in general lower than those in other months. As the monsoon does not establish by May, the influence of the same is conspicuous between May and the other Monsoon months. The monsoon brings a

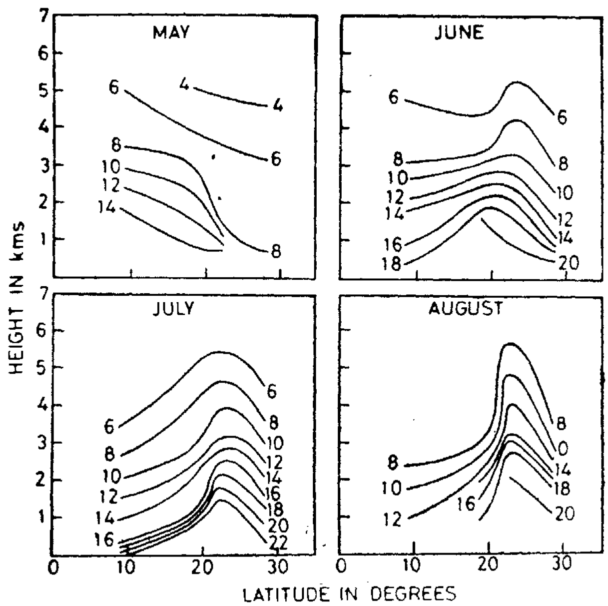

FIG. 2.

lot of moisture to the interior while this is absent in May and this accounts for a marked difference. The presence of monsoon trough may partly be responsible for the higher values of mixing ratio near 20–25° latitude. As is the case in general the mixing ratio decreases with height at all latitudes.

In general the climatological values reported by Rao (1958) are in agreement with the ones computed here.

CONCLUSIONS

At the outset it can be said that there is practically no significant variation of dry static stability.

The middle layer is convectively unstable compared to other layers irrespective of the monsoon activity. The instability in this layer may have considerable effect on the monsoon activity.

The month of June is characterized by high convective instability compared to other values. Central parts are found to be convectively unstable in most of the cases.

The mixing ratio decreases from north to south and with height.

The maximum values of mixing ratio are observed in 20–29° latitude.

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