

Tropospheric moisture field over the Arabian Sea during Monex 1973

S. K. GHOSH

Meteorological Office, Safdarjung Airport, New Delhi
and

R. V. GODBOLE

Indian Institute of Tropical Meteorology, Poona

(Received 3 November 1973)

ABSTRACT. During the Indo-USSR joint expedition, MONEX-1973, zonal cruises were undertaken in May and July 1973 by four USSR research ships in rectangular formations along the mean latitude of 10°N on the Arabian Sea. Analyses of dew-point depressions based on aerological data obtained from these ships are made. It is found that during the pre-monsoon season, although the air in the lower and mid-troposphere is of continental origin, the lower troposphere undergoes modification due to evaporation and becomes very moist but the mid-troposphere remains dry. Tropical maritime air prevails in the upper troposphere and is, therefore, relatively moist. In the monsoon period, moisture contents increase generally in the mid and upper troposphere. Also, whereas the depths of the moist layers increase, that of the dry mid-troposphere decreases.

1. Introduction

In order to study the behaviour of the Indian summer monsoon, a joint Indo-USSR expedition, MONEX-1973, was undertaken during May to July 1973. Four ships (*Ocean*, the *Flagship*, *Priliv*, *Shokalskiy* and *Voeikov*) of the USSR Hydrometeorological Service participated in this expedition. They set off from Cochin (India) on 15 May 1973 and formed a rectangle by the mid-day of 18 May (Fig. 1) with the initial positions at Lats. $8^{\circ}30' \text{N}$ and $11^{\circ}30' \text{N}$ and Longs. $74^{\circ}30' \text{E}$ and $71^{\circ}30' \text{E}$. The ships moved due west upto about 60°E keeping the rectangular formation always unchanged. This part of the MONEX was completed in the pre-monsoon period on 21 May. Similar rectangular formation but in the reverse direction was also made during monsoon period between 5 and 8 July 1973. Based on aerological observations taken from the ships during the cruises, the present study was undertaken to examine the moisture field of the troposphere over the Arabian Sea.

2. Data

Each of the four ships took four RS/RW observations at 00, 04, 12 and 18 GMT daily. Vertical cross-sections of dew point depression were prepared from these observations. Dew point depression has been taken as a parameter to estimate whether air is dry or moist as is customarily done from a thermodynamic diagram.

3. Analysis and discussions

3.1. Pre-monsoon period (18-31 May 1973)

Isopleths of dew point depressions have been drawn at intervals of 5°C . The cross-sections for the four ships are presented in Fig. 2 representing the pre-monsoon condition.

It is seen from the cross-section for *Priliv* (Fig. 2 a) that the lowest layer (*i. e.*, between 1000 and 850 mb), is moist at all the longitudes from 75°E to 62°E . A relatively dry air mass, however, exists in the mid and upper troposphere (*i. e.*, between 800 and 250 mb) west of 71°E . To the east of 71°E the air is dry between 850 and 700 mb and moist above 700 mb.

The cross-section for *Shokalskiy* is at Fig. 2 (b). As in Fig. 2 (a) the moist layer in this case also is confined in the lower troposphere between 1000 and 850 mb at all longitudes with a remarkably dry air mass overlying in the mid and upper troposphere (750 to 250 mb) west of 71°E . Again, to the east of 71°E dry air exists between 850 and 700 mb and moist air above 700 mb.

Fig. 2 (c), the cross-section for *Voeikov* shows, as in the previous figures, the existence of the moist layer between 1000 and 850 mb at all longitudes. The dry air mass also exists in the mid and upper troposphere between 600 and 300 mb to the west of 68°E . The features to the east of 68°E are similar to those to the east of 71°E in Figs. 2 and 3.

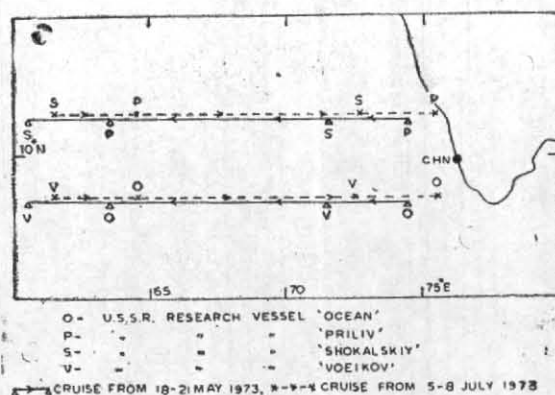


Fig. 1

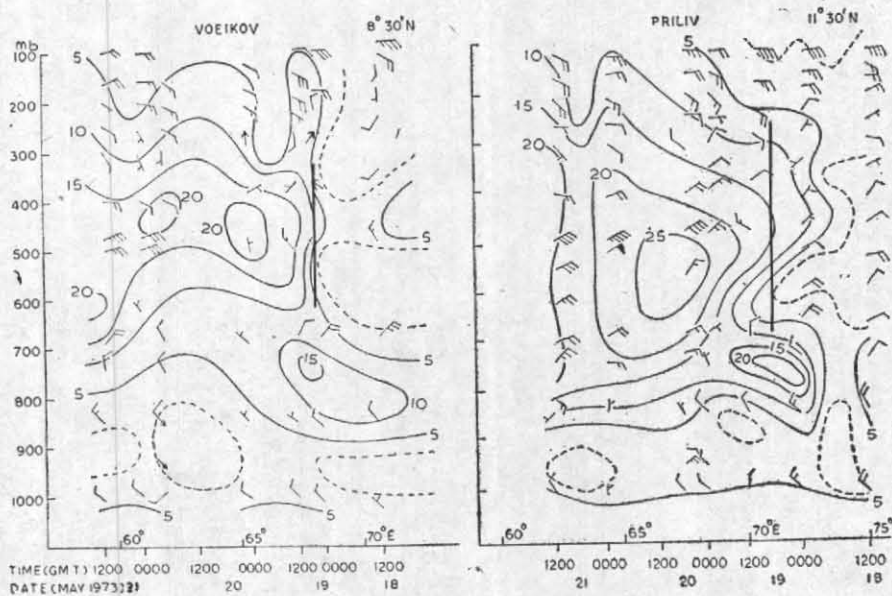


Fig. 2 (a)

Fig. 2 (b)

Thick line separates moist air from dry air

The cross-section for *Ocean*, Fig. 2 (d), also has moist layer between 1000 and 850 mb at all longitudes. The pattern in the mid and upper troposphere appears rather complex. The dryness of the mid and upper troposphere between 600 and 300 mb west of 70°E is evident except a narrow layer between 750 and 550 mb at about 63°E. To the east of 70°E, the pattern is too complex to be defined, although the broad features similar to those in Figs. 2 (a) to 2 (c) are discernible. From the above four cross-sections it is apparent that there is a line joining 8°30'N, 69°E (mean from Figs. 4 and 5) and 11°30'N, 71°E which divides the layer between 700 and 300 mb into two parts — dry to the west and moist to the east.

Very close to the sea surface, observations suggest the presence of relatively less moist air than

the air immediately above (1000 to 850 mb) at all longitudes, a common feature in all the cross-sections. An examination of the method of taking radiosonde observations indicates the possibility of instrumental errors in the readings soon after the release of the balloon.

The broad features that stand out have been schematically shown in Fig. 3. A line of demarcation between dry and moist air in the layer from 700 to 300 mb has been drawn at a mean longitude of 70°E (by taking the mean from Figs. 2 a to 2 d). Mean values of relative humidity (R.H.) calculated with the data of *Ocean* for different layers have also been indicated in Fig. 3. The findings are following —

(a) A very moist layer (R.H. greater than 80

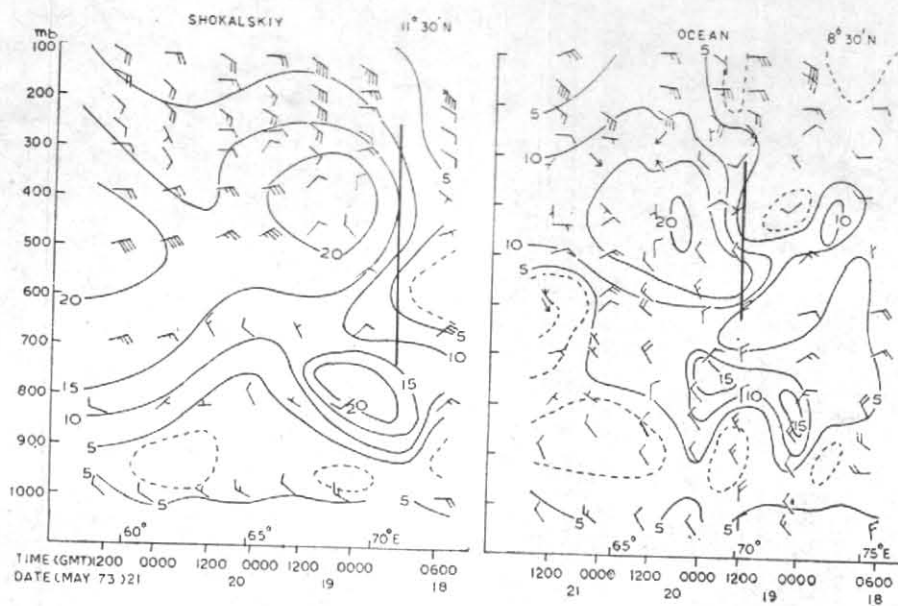


Fig. 2 (c)

Fig. 2 (d)

Thick line separates moist air from dry air

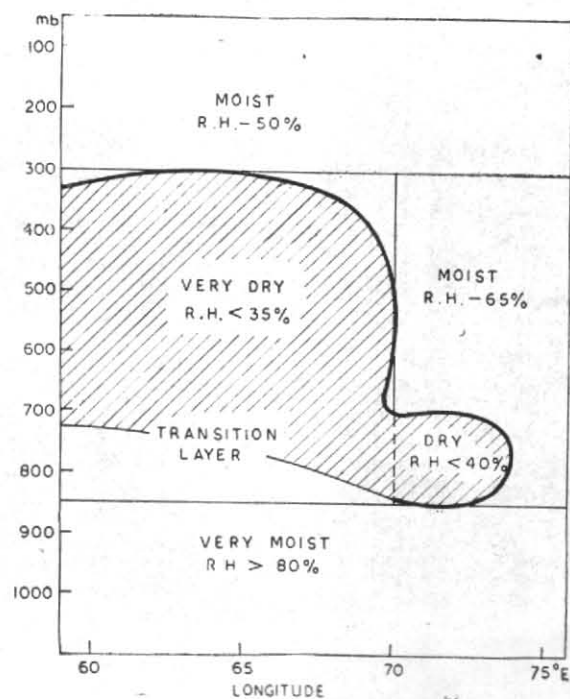


Fig. 3

per cent) between the sea surface and 850 mb exists at all longitudes.

- (b) Between 850 and 700 mb, there is a transition layer west of 70°E representing gradual change from very moist air in the lower to very dry air (R. H. less than 35 per cent) in the mid-troposphere. To

the east of 70°E , however, dry air (R. H. less than 40 per cent) prevails.

- (c) Between 700 and 300 mb, very dry air (R.H. less than 35 per cent) exists to the west of 70°E and moist air (R.H. approx. equal to 65 per cent) to the east of the line.

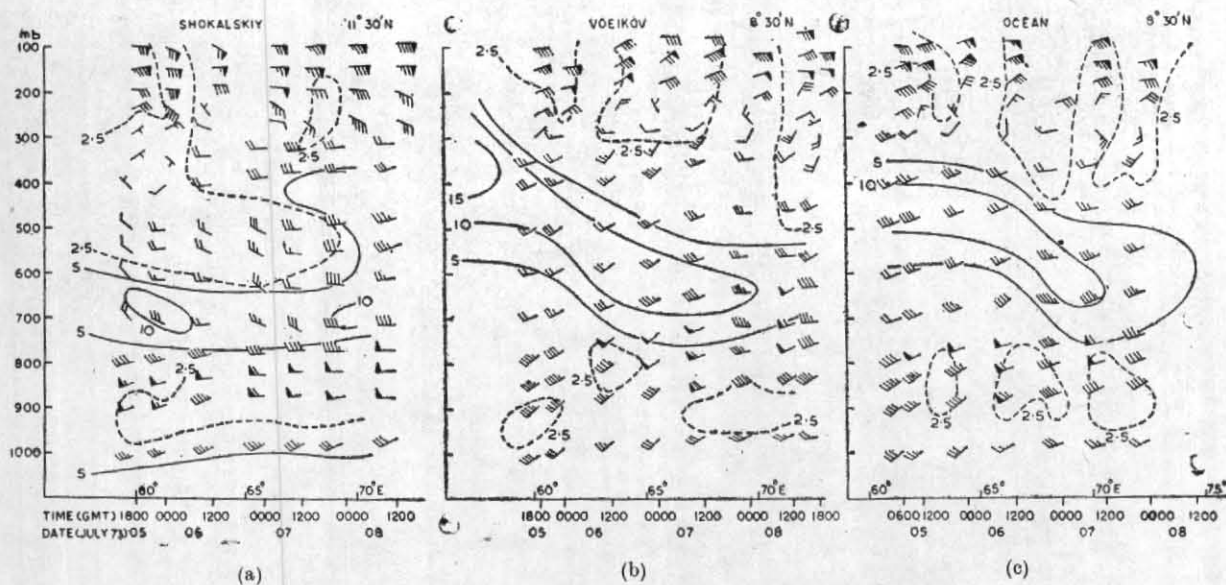
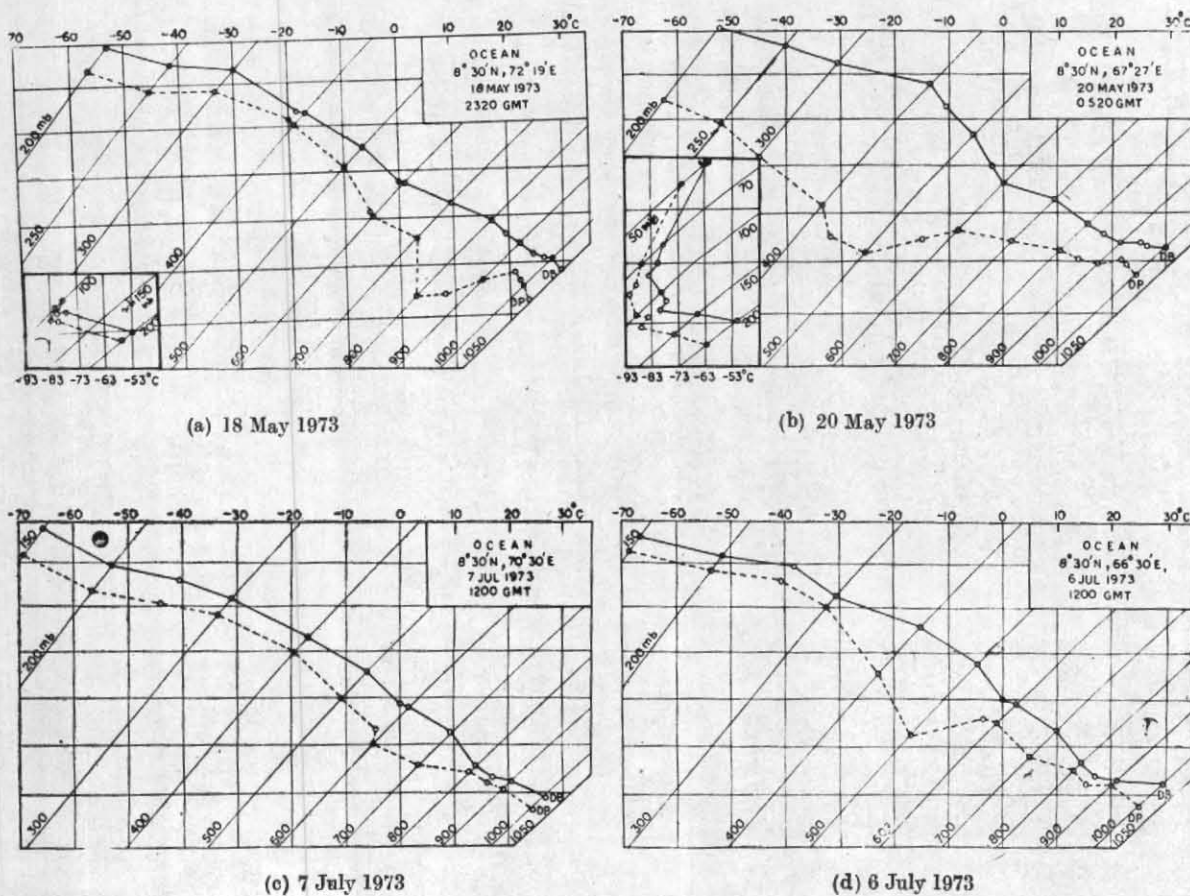


Fig. 4. Vertical cross-section of different ships at different locations during July 1973



Figs. 5 (a-d). Tephigrams during pre-monsoon and monsoon

- (d) A relatively moist layer (R.H. approximately equal to 50 per cent) prevails in the upper troposphere above 300 mb.

It may be mentioned that the synoptic situation was practically the same during the period and over the area under consideration.

3.2. Monsoon period

Isopleths of dew point depressions have been drawn at intervals of 5°C as in the pre-monsoon period. The cross-sections for the ships are presented in Figs. 4(a) to (c) which represent monsoon conditions (the data of *Priliv* were not available for analysis).

The cross-section for *Shokalskiy* is at Fig. 4 (a). The moist layer is found from the surface upto 750 mb at all longitudes. A relatively dry air mass exists between 750 and 600 mb. Above 600 mb moist layer prevails.

Fig. 4 (b) shows the cross-section for *Voeikov*. In this case the moist layer extends from the surface upto 600 mb at about 50°E and progressively decreases to 750 mb near 70°E. The mid-tropospheric dry air mass is confined between 600 and 350 mb near 60°E and between 750 and 500 mb near 70°E. Above this layer exists the upper tropospheric moist air as in the previous diagrams.

The cross-section for *Ocean*, Fig. 4 (c) shows a similar pattern as that of *Voeikov*.

Thus the moist layer (R.H. greater than 80 per cent) in the lower troposphere extends from the surface upto a mean level of about 700 mb. The mid-tropospheric relatively dry air (R. H. approximately equal to 50 per cent) has a mean thickness of about 200 mb. Above a mean level of about 500 mb moist air (R. H. approximately equal to 70 per cent) prevails.

In order that the moisture field in the pre-monsoon period may be compared with that during monsoon, typical T- ϕ gram representing conditions east and west of 70°E are reproduced respectively in Figs. 5 (a), 5 (b) (pre-monsoon) and 5 (c) & 5(d) (monsoon)

A comparison of moisture field between pre-monsoon and monsoon periods brings out the following:

- (a) Moisture content in the monsoon generally increases in the mid and upper tropospheres.
- (b) Height of the lower tropospheric moist layer increases from 850 mb in the pre-monsoon to about 700 mb in the monsoon period.
- (c) Depth of the upper tropospheric moist layer increases from 300 mb in the pre-monsoon to a mean level of 500 mb in the monsoon period.

4. Conclusions

The troposphere over the Arabian Sea in both pre-monsoon and the monsoon periods may broadly be divided into three distinct layers:

- (i) The moist lower troposphere,
- (ii) The dry mid troposphere and
- (iii) The relatively moist upper troposphere.

However, during monsoon moisture content increases generally in the mid and upper troposphere; also, the thickness of both the moist lower and upper tropospheres increases.

The observations recorded by the ships have been taken to represent the characteristics of air mass as stationary phenomena during the period of observations. As such, the findings are subject to the limitations of the above assumptions.

Acknowledgements

The authors wish to express their sincere thanks to Dr. N. I. Lisogurskiy, the Project Leader of the MONEX-1973 for his encouragement, helpful discussions and for providing all facilities to undertake the study. They also wish to place on record their thanks to the Director General of Observatories, India Meteorological Department and the Director, Indian Institute of Tropical Meteorology for deputing them to participate in MONEX-1973.