FLUXES OF SENSIBLE AND LATENT HEAT AT THE AIR-SEA INTERFACE OVER THE EQUATORIAL ARABIAN SEA DURING MONEX-79.

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ABSTRACT

The paper presents results of a study of the fluxes of sensible heat and latent heat at the air-sea interface over the southeast Arabian sea utilizing the meteorological data collected by Russian research ships stationed over this area in the form of a polygon during the first half of June 1979. The observed fluctuations in the fluxes are interpreted in the light of the synoptic scale disturbances which affected the area during this period.

INTRODUCTION

During MONEX-79 five USSR research ships were stationed over the southeast Arabian sea in the form of a polygon around 7°N, 66°E during the period 2 to 14 June 1979 (figure 1). These ships recorded among other observations the *hourly values* of air temperature (T_a); dew point temperature (T_d) and wind speed (V_a) at the deck level of the ship ($\sim$ 10 m a.s.l.) as well as the sea surface temperature (T_s).

The ships were located within the region of the inter-tropical convergence zone (ITCZ) and experienced both disturbed and undisturbed weather conditions during the period of observation. The meteorological records of these ships have been used to compute fluxes of sensible and latent heat at the air-sea interface in the disturbed and undisturbed situations. The contrasting features are presented and briefly discussed in the following sections.

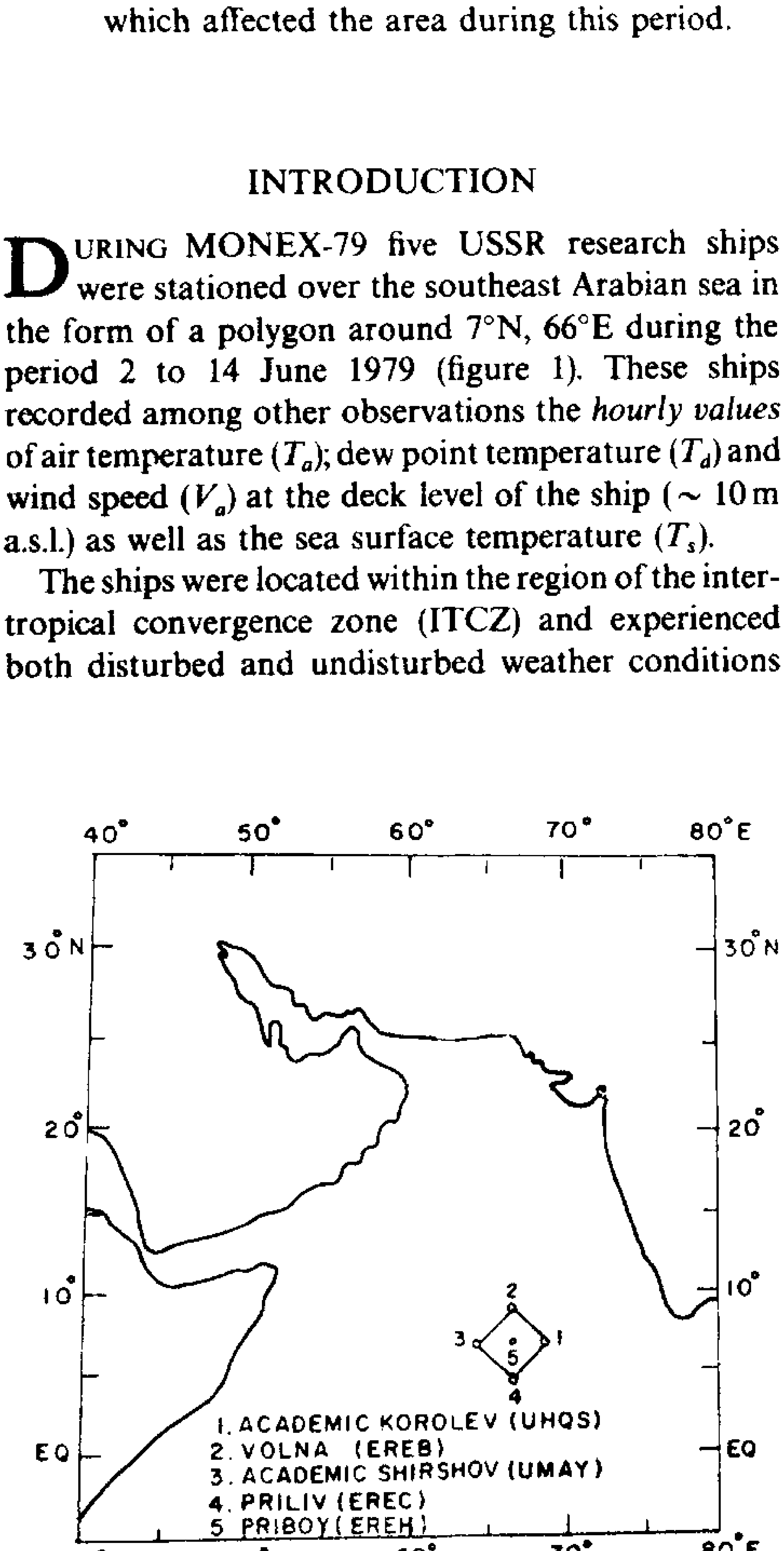

Figure 1. Locations of the stationary Russian research ships during MONEX-79 from 2 to 14 June.

COMPUTATIONS OF SENSIBLE AND LATENT HEAT FLUXES

The sensible heat flux (F_H) and the latent flux (F_E) at the air-sea interface are computed using the following standard equations[1]

$$F_H = C_p \rho C_H (T_s - T_a) V_a \quad (1)$$

$$F_E = L\rho C_E (q_s - q_a) V_a \quad (2)$$

where ρ is the density of air, q_s, the saturation specific humidity at the sea surface, q_a, the specific humidity of the air at the deck level of the ship, C_p, the specific heat of air at constant pressure, L, the latent heat of evaporation of water at temperature T_a, C_H, the bulk aerodynamic transfer coefficient for heat flux, C_E, the bulk aerodynamic transfer coefficient for moisture flux, and F_H and F_E are finally expressed in watts/m^2. From hourly observations of T_s, T_a, q_s, q_a and V_a, values of F_H and F_E were computed for each chronological hour providing a time series of these parameters. Figure 2 shows the time series of V_a, T_s, T_a, q_s, q_a F_E and F_H for the ship No. 3 of Figure 1, for the period 6 to 9 June 1979. The location of this ship was at 7°N, 64.5°E. The weather phenomena encountered by the ship during this period are depicted symbolically at the bottom of figure 2.

It may be noted that significant fluctuations in the parameters occurred in association with synoptic weather situations that gave rise to weather pheno-

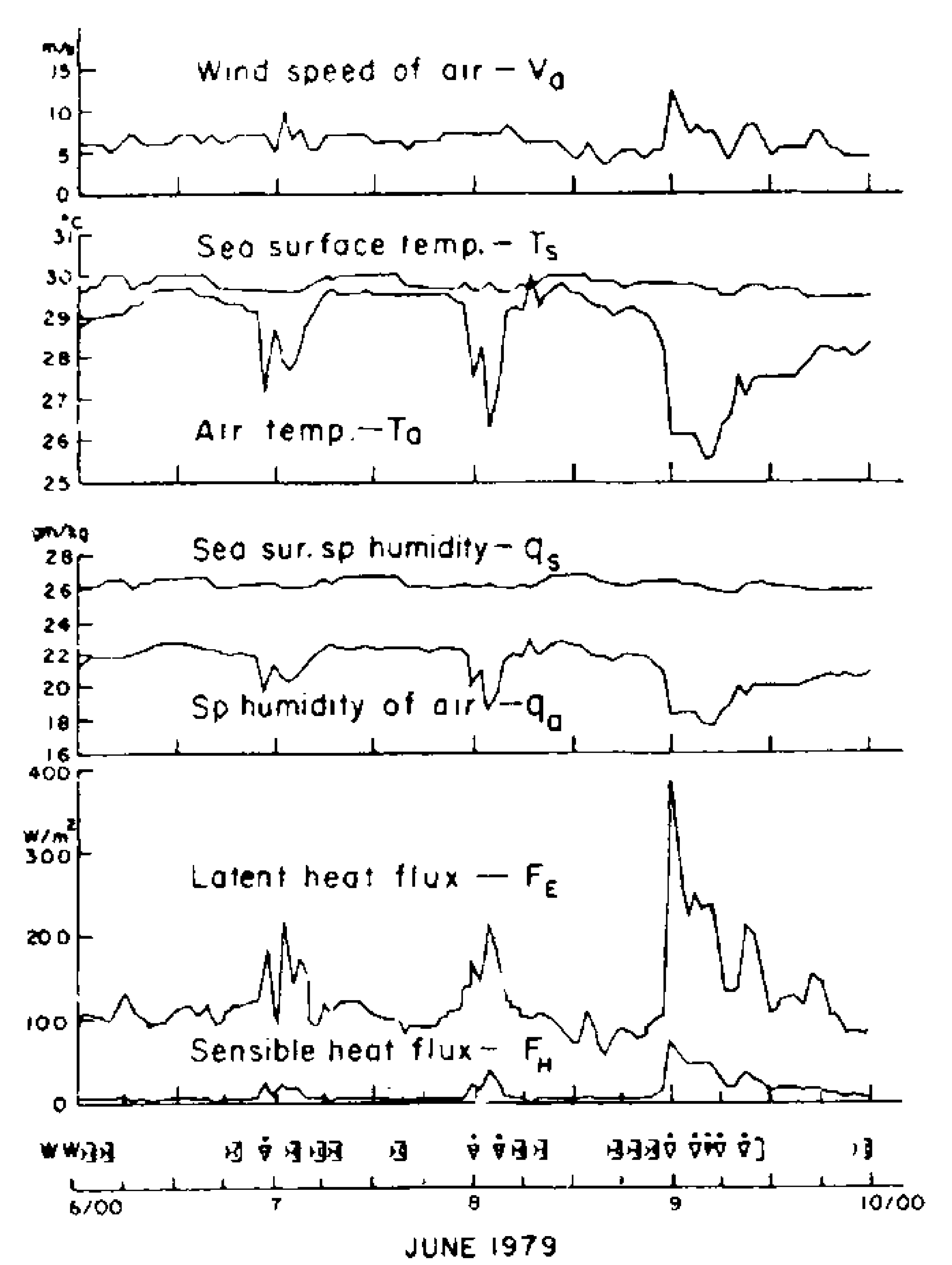

Figure 2. Time-series of V_a, T_s, T_a, q_s, q_a, F_E and F_H at the ship-location UMAY for the period 6 to 9 June 1979. The important weather parameters are shown symbolically.

mena such as rain-showers, thunderstorms etc over the ship-locations; e.g. on 7, 8 and June around 00Z. On these occasions there occurred sudden decrease in T_a and q_a which later recovered to their original values after the passage of the weather system. The values of F_H and F_E show increased fluxes of sensible and latent heat during these situations. Notice that in figure 2, T_a and q_a show large fluctuations while T_s and q_s show little change.

For the stratification of the observed data into disturbed (D) and undisturbed (UD) types the following criteria were used to delineate D-type situations: (i) an abrupt fall of T_a by 1°C or more from the previous undisturbed value which remained more or less constant for the previous four hours, and (ii) the lowered value persisted for an hour or more and gradually recovered to the original undisturbed value.

The data relating to the various observed parameters and the calculated flux values were categorized into D and UD-types. The results are briefly discussed in the next section.

RESULTS AND DISCUSSION

In the field phase of MONEX-79 over the equatorial Arabian sea from 2 to 14 June the ITCZ was south of its normal position and fluctuated by 2° to 4° of latitude in a north-south direction across the ship polygon. The analysis of average wind over the polygon in the lower and middle troposphere revealed that the following synoptic-scale disturbances passed over the polygon[2]: (a) an easterly wave moved from east to west during 2–4 June; (b) a cyclonic vortex moved from east to west during 8–9 June; (c) a cyclonic circulation which developed on 12 June at the middle levels moved from south to north and led to the vortex which ushered in the south-west monsoon over the west coast of India.

(a), (b) and (c) produced disturbed weather situations over the polygon resulting in cooling of the air and reduction in specific humidity which lasted for varying durations with gradual recovery to the undisturbed values. The period of recovery differed from one situation to another.

Table 1 presents the following mean values of various parameters for undisturbed and disturbed situations at the five ship locations and also the values averaged for all the ships.

V_a = Wind speed (m/s)
T_a = air temperature (°C)
T_s = sea surface temperature (°C)
q_a = specific humidity at deck level of ship (g/kg)
q_s = saturation specific humidity at T_s (g/kg)
F_H = flux of sensible heat (watts/m^2)
F_E = flux of latent heat (watts/m^2)

It can be seen that the difference between sea temperature and air temperature which is of the order of about 1.5°C in undisturbed weather increased to about 3.5°C due to the enhanced cooling of the air in the disturbed situations. At the same time difference in specific humidity between the sea level and the deck level of the ship increased from about 5.5 g/kg to about 7.5 g/kg. The sensible heat flux increased about 3-fold and the latent heat flux about 2-fold in disturbed situations. These changes are a combined effect of the increase in the wind speed and enhanced values of (T_s-T_a) and (q_s-q_a) respectively.

Interpreted as evaporation of water, a flux of 100 watts/m^2 corresponds to an evaporation of about 3.5 mm/day. Thus the mean rates of evaporation associated with undisturbed and disturbed weather situations work out to 5.3 mm/day and 10 mm/day respectively. It is of interest to note that the mean monthly rate of evaporation utilizing bulk aerody-

Table 1 *Mean values of temperatures, specific humidities, wind speeds and sensible/latent heat fluxes at the USSR ship locations for disturbed and undisturbed weather situations*

Ship's Name	UD or D	V_a	T_s	T_a	T_s-T_a	q_s	q_a	q_s-q_a	FH	FE
UHQS	UD	7.6	30.0	28.6	1.4	26.7	21.3	5.4	17.7	165.3
	D	11.3	29.9	26.4	3.5	26.5	18.7	7.8	66.7	357.8
EREB	UD	6.8	30.3	28.9	1.4	27.2	21.7	5.5	17.9	157.3
	D	9.3	30.2	27.1	3.1	27.2	19.8	7.4	47.0	278.6
UMAY	UD	7.5	29.6	28.9	0.7	26.0	21.7	4.3	8.3	130.9
	D	8.7	29.6	26.3	3.3	26.0	18.7	7.3	49.2	264.5
EREC	UD	7.8	29.6	28.4	1.2	26.1	20.9	5.2	15.0	157.4
	D	9.0	29.5	26.7	2.8	25.8	19.0	6.8	42.9	253.1
EREH	UD	6.8	30.0	28.7	1.3	26.9	21.3	5.6	12.8	139.6
	D	8.9	30.0	26.7	3.3	26.9	19.1	7.8	47.7	272.1
Average	UD	7.3	29.9	28.7	1.2	26.6	21.4	5.2	14.3	150.1
	D	9.4	29.8	26.6	3.2	26.5	19.0	7.4	50.7	285.0

namic formula and climatological ships' data over the polygon location in the Arabian sea has been estimated[3] as about 4 mm/day.

CONCLUDING REMARKS

The study of the sensible and latent heat flux (F_H and F_E respectively) at the air-sea interface over equatorial Arabian sea, using the data collections of the USSR research ships, from 2 to 14 June during MONEX-79 shows that the F_H becomes about 3-fold and F_E becomes about 2-fold in the disturbed weather situations as compared to their values in the undisturbed weather situations. The increases in F_H and F_E are effected by (i) the increase in the wind speed at the deck level of the ship and (ii) the increase in the difference of the temperature and specific humidity respectively between the sea surface and the air at the deck level of the ship. When interpreted as evaporation the F_E-values in the disturbed and undisturbed conditions work out to 10 mm/day and 5.3 mm/day respectively. These values are comparable to the climatological monthly mean rate of evaporation over the polygon-location in the Arabian sea.

ACKNOWLEDGEMENT

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