

Surface fluxes and the cyclogenesis over north and adjoining central Bay of Bengal during MONTBLEX-1990

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सार- मॉन्टब्लेक्स-1990 के दौरान समुद्री-अनुसंधान जहाज (ओ.आर.वी.) सागरकन्या द्वारा लिए गए प्रेक्षकों का उपयोग करके उत्तर और संलग्न मध्य बंगाल की खाड़ी के ऊपर संवेदनशील ऊष्मा, गुप्त ऊष्मा और संवेग के अभिवाहों का अभिकलन किया गया है। परिणाम दर्शाते हैं कि निम्नदाब/अवदाब की उत्पत्ति के दौरान ऊर्जा अभिवाहों में विशेष वृद्धि होती है और सिस्टम के दूर हो जाने पर वे घट जाते हैं।

ABSTRACT: Fluxes of sensible heat, latent heat and the momentum have been computed over north and adjoining central Bay of Bengal utilising ORV *Sagar Kanya*'s observations recorded during MONTBLEX-1990. The results show that the energy fluxes increase steeply during the development of a low/depression and decrease once the system moves away.

Key words — Surface fluxes, Cyclogenesis, Monsoon trough boundary layer experiment (MONTBLEX).

1. Introduction

Some recent studies have shown that the tropical systems are strongly dependent on air-sea exchange processes (see Pyke 1965, Miller 1966, Garstang 1967, Warsh 1973). Their development usually depends on the atmospheric conditions and the state of the underlying sea surface.

The energy exchange processes at the air-sea interface play a significant role in the establishment of low level convergence and the convective instability which facilitate convection over a cyclogenetic sea area.

One of the objectives of MONTBLEX-1990 was to collect meteorological data from the fields of monsoon depressions/lows over north and adjoining central Bay of Bengal in order to study the exchange processes of heat and momentum. A cruise of Oceanographic Research Vessel (ORV) *Sagar Kanya* was planned during Aug-Sep 1990 for this purpose. In the present paper the energy fluxes of heat and momentum have been computed and studied in relation to three low pressure systems that developed over north and adjoining central Bay of Bengal during 18 Aug-18 September 1990.

2. Data

The 3-hourly surface observations collected by ORV *Sagar Kanya* over north and adjoining central Bay of

Bengal during the period 18 Aug-18 Sep 1990 have been utilised.

3. Method of computation

The energy flux computations were made using the following aerodynamic formulae :

(i) Sensible heat flux :

$$Q_S = \rho_a c_p C_D (T_w - T_a) V \quad (1)$$

(ii) Latent heat flux :

$$Q_E = \rho_a L C_D (q_w - q_a) V \quad (2)$$

(iii) Momentum flux :

$$\tau = \rho_a C_D V^2 \quad (3)$$

where, C_D , the drag coefficient (a function of wind speed and the stability) is given by (see Bunker 1976) :

$$C_D (M, \Delta T) = 0.934 \times 10^{-3} + 0.788 \times 10^{-4} M + \\ + 0.868 \times 10^{-4} \Delta T - 0.616 \times 10^{-6} M^2 \\ - 0.120 \times 10^{-5} (\Delta T)^2 \\ - 0.214 \times 10^{-5} M (\Delta T) \quad (4)$$

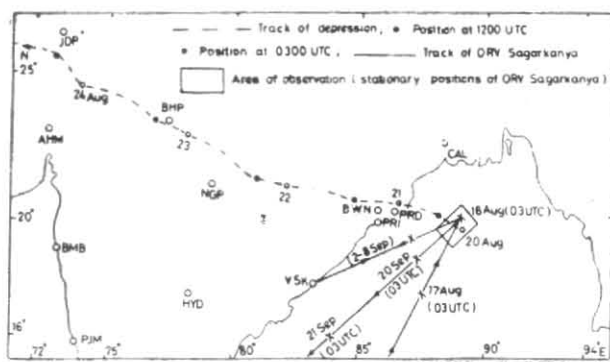
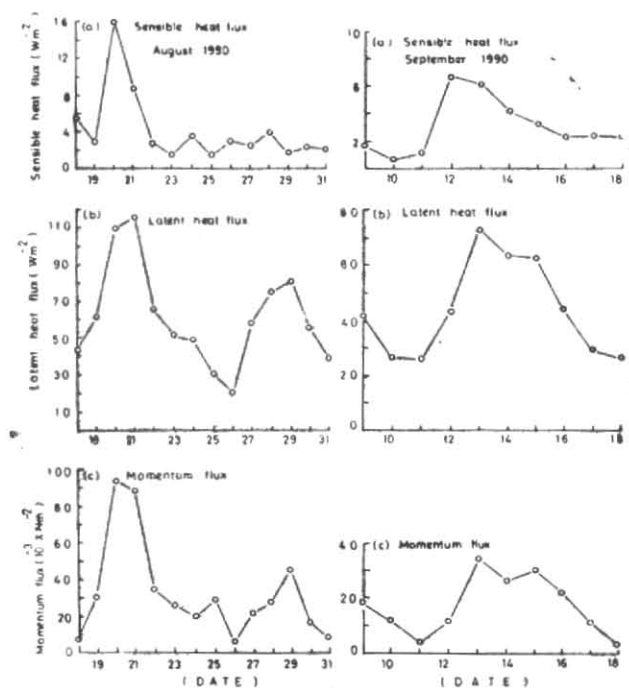


Fig. 1. Positions of ORV *Sagar Kanya* and the track of depression (Aug-Sep 1990)



Figs. 2 (a-c). Daily mean values of the fluxes during August

Figs. 3 (a-c). Daily mean values of the fluxes during September

where, M is $(u^2+v^2)^{1/2}$ (u , v are zonal and meridional components of the wind),

ΔT is the difference between air temperature and SST.

c_p = Specific heat at constant pressure,

L = Latent heat of evaporation,

ρ_a = Air density (1.18 kg m^{-3}),

T_w = SST (Sea Surface Temperature),

T_a = Air temperature,

q_w = Saturation specific humidity at the sea surface (corrected for the salinity of water),

q_a = Specific humidity of the air at deck level, and

V = Wind speed.

4. Results and discussion

Daily means of different meteorological variables were worked out and the energy fluxes were computed. The results were used to study the following periods of cyclogenesis over north and adjoining central Bay of Bengal.

4.1. Depression of 20-25 August 1990

A depression developed over northwest Bay of Bengal in the morning of 20 August. The system was initially observed as a cyclonic circulation extending up to mid-tropospheric levels over north Bay of Bengal on the 18th. *Sagar Kanya* had already positioned herself near 20°N , 89°E by the morning of 18th. Thus the vessel could collect very useful observations from the field of the system. The positions of *Sagar Kanya* and the track of depression are shown in Fig. 1. The temporal variations of different energy fluxes during the period of the system are depicted in Figs. 2(a-c).

4.1.1. *Sensible heat flux*—The variation of sensible heat flux is shown in Fig. 2(a). There was a steep rise from 2.9 Wm^{-2} on 19th to 15.9 Wm^{-2} on 20th when the system intensified into a depression. On 21st the value fell sharply to 8.9 Wm^{-2} . On 22nd it further decreased to 2.9 Wm^{-2} . It is interesting to note that the depression moved away rapidly from the area of observation and was located close to Paradeep in the morning of 21st. On 22nd it further moved westnorth-westwards.

4.1.2. *Latent heat flux*—The distribution of latent heat flux is shown in Fig. 2(b). The maximum value of latent heat flux is observed on 21st. On 19th the value was only 61.0 Wm^{-2} which increased to 109.4 Wm^{-2} on 20th. On 21st it was 115.9 Wm^{-2} . On 22nd when the system was located far away from the area of observation the value of the latent flux was only 65.6 Wm^{-2} . It

may be mentioned that unlike sensible heat flux which reached its maximum on 20th the latent flux attained maximum on 21st.

4.1.3. *Momentum flux*—Fig. 2(c) depicts the distribution of momentum flux. The peak value again coincides with the depression period, i.e., 20th. On 19th the value of the momentum flux was $30.6 \times 10^{-3} \text{ Nm}^{-2}$ which increased to $93.3 \times 10^{-3} \text{ Nm}^{-2}$ on 20th. On 21st it fell to $88.4 \times 10^{-3} \text{ Nm}^{-2}$ which further fell to $34.8 \times 10^{-3} \text{ Nm}^{-2}$ on 22nd.

The above discussion reveals that all the three energy fluxes, viz., sensible heat flux, latent heat flux and the momentum flux increased sharply at the time of intensification of the system to the depression stage. The fluxes decreased rapidly when the depression moved away from the area of observation.

4.2. Low pressure area of 27 August-1 September 1990

While *Sagar Kanya* was still recording observations over northwest Bay of Bengal another system developed in the form of a low pressure area over northwest Bay in the morning of 27 August. The system persisted over there up to 29th evening. On 30th morning the system moved away from the area of observation and was located over Orissa and neighbourhood.

The distributions of different energy fluxes during the period of this system are shown in the Figs. 2(a-c). All fluxes attain their maximum during 28-29 August, i.e., during the stay of the low pressure area over the area of observation. The peak observed in the distribution of sensible heat flux is not as significant as the peaks of the distributions of other two fluxes. This may be because of the variations in the SST-air temperature values. The mean (SST—air temperature) difference was about 1.3°C on 20 August which fell to about 0.6°C on 28 August. From the Eqns. (1)–(3) it can be seen that small changes in SST—air temperature values will be significantly reflected in the sensible heat flux distribution while the dependence of other fluxes on this quantity is not that much pronounced.

4.3. Well marked low pressure area of 11-20 September 1990

Third system that developed over northwest and adjoining west central Bay of Bengal during the period of observations of *Sagar Kanya* was a well marked low pressure area. The system first appeared in the evening of 11 September. It persisted over northwest Bay on 12 and 13 September. On 14th it was located over land away from the area of observation. During the period of this system the distribution of different fluxes are shown in Figs. 3(a-c). The values attained their maximum during 12-13 September, which was the duration of the system over the area of observations. Excepting the peak of sensible heat flux the peaks in remaining two distributions are comparable to corresponding peaks observed during the low pressure area of 27 August-1 September 1990. However, the peaks during the depression of 20-25 August 1990 were the sharpest,

5. Conclusions

The following conclusions are drawn from the study :

(i) The fluxes of sensible heat, latent heat and the momentum increase steeply during the development/intensification of a low/depression.

(ii) The fluxes show a systematic decreasing trend after the system moves away.

(iii) Except in some cases the maximum values of the sensible heat flux are attained a day earlier than the corresponding values of latent heat and the momentum fluxes.

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