J3.6 AIR-SEA FLUX MEASUREMENTS IN THE BAY OF BENGAL DURING THE JASMINE FIELD PROGRAM

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1. INTRODUCTION

In May and early June of 1999 the Joint Air-Sea Monsoon Experiment (JASMINE) was conducted in the Indian Ocean and Bay of Bengal aboard the NOAA *R/V Ronald. H. Brown*. A group of government laboratory and university researchers cooperated on this investigation of ocean, near-surface, and atmospheric processes before and during the summer monsoon. The ship made several transects from south of the equator to 12 degrees N. latitude along 89 E. longitude. Two 5-day surveys were also conducted near 10 degrees N. latitude; the first survey was in suppressed conditions and the second was in fully developed monsoon conditions. In this paper we will give results of preliminary analysis of the air-sea flux data including cruise-averages plus suppressed versus disturbed conditions.

2. MEASUREMENTS

Jasmine featured an ensemble of instruments to make measurements in the ocean and atmosphere with a combination of *in situ* and remote sensing methods. On the atmospheric and near-surface ocean side, measurements included gps rawinsondes, bulk near-surface meteorology, air-sea turbulent fluxes, radiative fluxes, numerous raingages, three profiling Doppler radars, microwave and IR radiometers, a cloud ceilometer, and a scanning C-band Doppler precipitation radar. Only the near-surface measurements will be discussed here.

The ETL ship-based air-sea interaction system was used for bulk meteorology, radiative, and turbulent fluxes with additional measurements provided by the ship's operational instruments and CSIRO. The majority of the sensors were mounted on a scaffold unit just aft of the bow ; the turbulence sensors were mounted on a forward-facing boom on the ship's jackstaff. The ETL measurement system is described in detail by Fairall *et al.* (1997). A sonic anemometer/thermometer is used to make turbulent measurements of stress and buoyancy flux; a high-speed infrared hygrometer is used with the sonic velocity data to obtain latent heat flux. An inertial navigation system is used to correct for ship motions. Fluxes are computed using covariance, inertial-dissipation, and bulk techniques (Fairall et al., 1996). Sea-surface temperature is derived from bulk water measurements at a depth of 5 cm with a floating thermistor. Mean air temperature and humidity are derived from a conventional aspirated T/RH sensor. CSIRO provided a pair of aspirated thermocouple wet/dry bulb psychrometers, a dual (upward and downward facing) IR thermal radiometer (for ocean skin temperature), and two STI Mini-ORG raingages that have been calibrated in the CSIRO rain tower.

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3. FLUX TIME SERIES

Fig. 1 show the daily averages of the main components of the net heat flux to the ocean

$$H_{net} = R_{snet} + R_{lnet} + H_s + H_l + H_{rain} \qquad (1)$$

where R_{snet} is the net solar radiative flux, R_{lnet} the net longwave radiative flux, H_s the sensible heat flux, H_l the latent heat flux, and H_{rain} (not shown) the heat flux carried by precipitation . A positive value warms the ocean. Fig. 2 shows the daily average of rain fall; convective conditions associated with the monsoon active phase are apparent near the end of the record. Cruise averages are given in Table 1 along with results from other cruises.

4. STAR TIME SERIES

Surveys were conducted near 10 N and 89 E on two occasions. The surveys consisted of a series of CTD stations taken on a 5-pointed star pattern to define a spatial pattern in the ocean mixed layer evolution. The first star was done during suppressed conditions; the second was done during full monsoon active conditions. All terms for the net heat budget for each star period are shown in Figs. 3 and 4.

Acknowledgments

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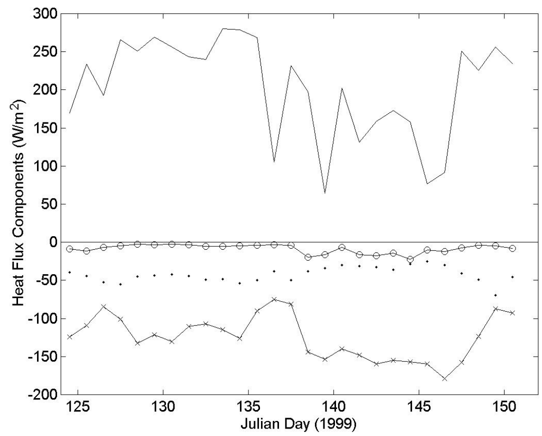

Figure 1. Daily averages of net solar (line), net IR (dots), sensible (circles), and latent (x's) heat fluxes.

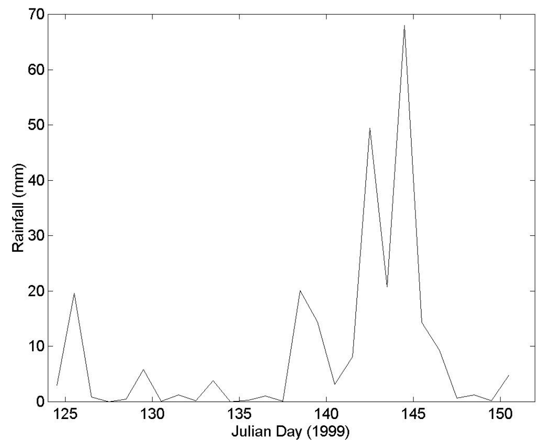

Figure 2. Daily averages of rainrate.

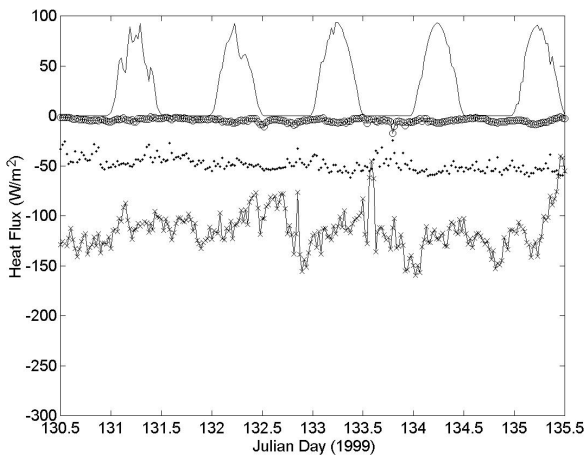

Figure 3. Time series of flux components for star-1. Symbols as in Fig. 1; solar flux is divided by 10.

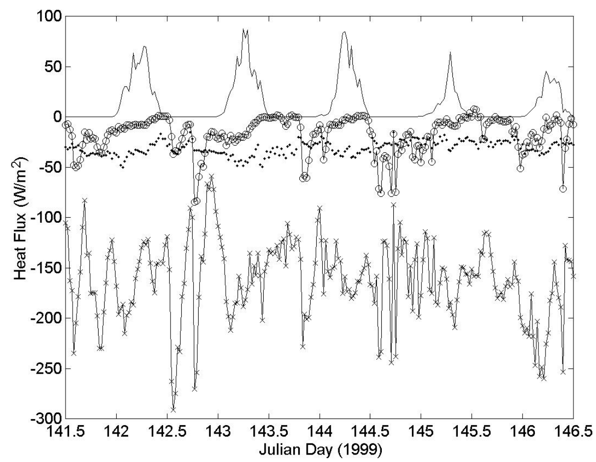

Figure 4. As in Fig. 3, but for star-2.

Table 1. Sea-air surface flux components in the tropics [W/m^2]; variables defined in text.

Experiment	R_{snet}	R_{lnet}	H_s	H_l	H_{rain}	H_T	H_{net}
Earlier 6-Cruise Average	**204**	**-49**	**-8**	**-107**	**-2.0**	**-120**	**35**
JASMINE	205	-43	-9	-125	-1.9	-135	27
NAURU99	216	-54	-5	-123	-.5	-129	33
KWJEX-1	220	-47	-7	-95	-2.5	-105	69
KWJEX-2	214	-44	-8	-102	-2.9	-113	57
σ_X	18	5	2.5	11	1.1	12	26