

CRUISE REPORT OF ORV SAGAR KANYA SK-138C

(23 October – 12 November, 1998)

Programme : BOBMEX Pilot Project under ICRP

Area of operation: Southern Bay of Bengal

Port of embarkation: Marmugoa

Port of disembarkation: Tuticorin

12 November, 1998

1. INTRODUCTION

The cruise 138C of ORV Sagar Kanya has been conducted for the 'Bay of Bengal Monsoon Experiment (BOBMEX) Pilot Project' - a component of the Indian Climate Research Programme (ICRP). The study area is confined to the southern part of the Bay of Bengal over which the westerly monsoon winds still normally prevail during late October-early November period while the withdrawal of monsoon usually takes place over the northern and central Bay of Bengal.

The BOBMEX Pilot Project is aimed at evaluating the performance of various sensors and equipment that have been procured recently before deploying them in the main BOBMEX scheduled in 1999. Apart from this objective, the cruise has also been conducted to collect the relevant data with emphasis on the lower atmosphere and upper ocean in association with Inter-Tropical Convergence Zone (ITCZ) characterized by convective clouds. The ship has sailed from Marmugoa port on 23 October 1998 /1054 Hrs. IST with a scientific compliment of 30 members from various national organisations and the cruise has ended at Tuticorin port on 12 November, 1998 / 0136 hrs. IST. The list of the cruise participants along with the ship's compliment is given in Table 1.

The daily INSAT-satellite cloud pictures of 0600 hrs UTC received by FAX from the India Meteorological Department, New Delhi are quite useful during the period of cruise. The AVHRR SST

composite maps prepared at NIO and sent to the ship by FAX are also quite useful.

Cloudy weather conditions with occasional showers and moderate winds prevailed over the study area. Strong winds (~ 30 knots) have been encountered on 9 November 1998.

2. WORK DONE

Scientists from NIO and IISc, the two principal investigating institutes of DST funded ' BOBMEX PILOT Project', have taken the main responsibility to collect the data on hydrological and atmospheric structures. The participation of IMD in this cruise has made it possible to increase the availability of much needed marine meteorological data and the data have been reported in near-real time basis to help the operational weather forecasting. The Indian Navy has taken the advantage of cruise for testing their portable CTD system. Participant from SAC has measured the levels of global incident radiation. The participants from other organizations have been exposed to the collection of marine environmental data in the areas of their interest.

NIO

The main objective of the NIO's physical oceanography team is to collect the temperature and salinity data in the upper 1000 m using CTD system and the currents in the upper ocean (~200m depth)

using the VM-ADCP (Vessel Mounted Acoustic Doppler Current Profiler) in the study area. The observational programme has included the occupation of 19 hydrographic stations. The locations of stations and the summary of operations at these stations are shown in Figure 1 and Table 2. Out of these 19 stations, # 7 (7° N, 87° E); # 10 (10° N, 87° E) and # 13 (13° N, 87° E) are the time series stations where the CTD has been operated at 3 hourly interval. A total of 54 CTD profiles including those of time series nature have been obtained at 19 hydrographic stations during the cruise.

The BOBMEX - Pilot CTD measurements are started from station no. 5 ($6^{\circ} 20'$ N, $85^{\circ} 20'$ E) onwards, as the first 4 stations are occupied off-Goa for chemical oceanographic studies only. At the first and second time series stations (7° N, 87° E & 10° N, 87° E), time-series observations are made for 48 hours during 30 October-01 November, 1998 and during 2-4 November 1998 respectively. At the third time series station (13° N, 87° E), the three hourly data have been collected for 24 hours during 5-6 November 1998. The CTD temperature sensor is pre-calibrated at the shore laboratory, NIO, Goa and the new calibration coefficients are used in the CTD data processing. Fig. 2 a,b,c presents the vertical profiles of temperature, salinity, potential density and fluorescence at stations #7, #10 and #13 respectively. At each CTD station, surface meteorological observations are recorded and the wave recorder is operated for 15 minutes. The Thermo-salinograph has continuously been kept in operation in the study area and surface temperature and surface salinity values are noted down at hourly interval. Water samples at

different depths are also collected for salinity analysis using Autosal in order to compare the CTD salinity values with the Autosal salinity values at the corresponding depths where the Niskin samplers are closed. For this, the Autosal has been standardised with standard seawater.

The Automatic Weather Station (AWS) has been put on for continuous recording of the surface meteorological data. The measured parameters are averaged at ten minutes interval and stored in the personal computer.

The VM-ADCP has been operated for continuous recording of upper ocean currents and the data are obtained between 27m and 205m depth along the 5 transects of the cruise track.

The Chemical Oceanographers have collected water samples at the hydrographic stations and carried out the analysis for dissolved oxygen, nutrients, Dimethyl sulphide (DMS), dissolved organic carbon and Transparent Exopolymer particles. At selected stations, Dimethyl sulphonyl propionate (DMSP) and chlorophyll are also measured. For shore laboratory analysis at NIO, water samples are collected for bacteria and nitrous oxide analyses. They have also collected water samples for dielectric constant determination and corrosion studies at the university of Pune and IISc., Bangalore respectively. The Aerosol samples are also collected for DMS and DMSP analysis.

Irradiance meter and Secchi disc have been operated at 12 stations and 22 profiles of irradiance are obtained.

Further during the cruise, four drifting buoys with ID Nos. 15708, 09080, 15705 and 15711 have been deployed respectively at 05°N, 77°E (0012 hrs. IST/27 October 1998); 6°30'N, 85°37.9'E (1200 hrs. IST/29 October 1998); 7°30'N, 87°E (0545 hrs. IST/01 November 1998) and 10°N, 87°E (1451 hrs. IST/02 November 1998) under DOD's OOS (Ocean Observing System) programme.

IISc

The IISc group commenced their measurements from the afternoon of October 25, 1998 and continued till the afternoon of November 8, 1998. The representatives from SPL and JNCASR have also joined the IISc group in the measurements of atmospheric parameters.

Micro meteorological tower fixed to the boom:- Velocity, temperature, humidity, acceleration, solar radiation and infrared radiation sensors have been mounted on a tower and data have been collected during the cruise. A schematic of the sensor arrangement on the tower is shown in Figure 3. In addition, rainfall is monitored using an automatic rain gauge. The outputs from the sensors have been automatically acquired and stored. Also, all data have been displayed in real time on the monitor to detect any problem with the sensors and data acquisition procedure. The stored data have been

regularly plotted and checked for instrument malfunctioning and data quality. All the sensors have worked well throughout the cruise and the data are obtained as planned without any data gaps. Some atmospheric parameters measured from 0600 hrs. IST to 2100 hrs. IST on November 6, 1998 are shown in Figure 4. During this period, the ship has moved from 12°46' N, 86°50' E to 11°14' N, 86°01' E.

High resolution mini-sonde:- Mini-sonde ascents are launched daily at 0700 and 1430-1500 hours IST when the ship is in Indian and international waters. Two additional sondes a day have been released during time series observations. Altogether 36 soundings are taken. These have provided atmospheric temperature and humidity data as a function of pressure/height. The vertical resolution achieved is typically in 15 to 20 m range and a majority of the launches crossed 12.5km height. A few sondes have gone up as high as 17 km. Temperature, pressure and humidity sensors have worked well and the preliminary analysis indicates that the data are of good quality. Two soundings taken at 1430 hrs IST on October 25, 1998 (Arabian Sea, 9°25' N, 75°7' E) and at 0600 hrs IST on November 6, 1998 (Bay of Bengal, 12°46' N, 86°50' E) respectively are shown in Figure 5. Also shown is the vertical distribution of the virtual potential temperature, on which the vertical stability of the atmosphere depends.

Surface met observations:- Dry and wet bulb temperatures, surface pressure, bucket SST, and sea surface skin temperature using IR temperature gun are manually recorded every 3 hours

throughout the observation period in the Indian and International waters.

INDIAN NAVY

The main objective of Indian Navy's participation is to acquaint with the operation of new portable Seacat CTD SBE 19 Profiler procured by them and evaluate it's performance. The methodology of processing the raw data collected by this profiler for deriving various oceanological parameters is also learnt by the participants of the Indian Navy.

During the cruise, the Seacat profiler has been deployed thirty times and the profiles are recorded. Out of 30 profiles, there are 3 time profiles taken at a constant depth (5m, 50m & 100m) for a duration of 45 minutes to check the instrument. The portable Seacat profiler has performed satisfactorily only on two occasions upto 450m depth. Though this equipment is calibrated and meant for operations upto 600m depth, the profiler could give reliable data only upto a maximum of 130m on most occasions. Beyond this depth, the sensors have behaved erratically giving spurious data. A first hand comparison with the ship's CTD profiles indicate a deviation of approx. -0.6 to 1.5 °C in temperature at all levels and consequently, equivalent variations in salinity between -0.4 to 1.2 psu. For comparison purpose, 8 profiles obtained by the Ship's-CTD system have been provided to the Navy team.

IMD

26 Radio Sonde ascents (including 6 slow raising Sondes) are launched. Among these ascents, the maximum height attained is 13.6km with pressure level of 162 mb. Surface met observations at every 3 hour interval at standard synoptic hour are taken since 00 UTC of 24 October 1998 up to 10 November 1998. The surface and upper air data have been transmitted to meteo weather daily

SAC

The global solar radiation data at 3 hour interval during the sailing period and at one hour interval at the time series stations (07° N, 87° E; 10° N, 87° E & 13° N, 87° E) from 23 October 1998 to 10 November 1998 have been collected using a pyranometer.

3. PRELIMINARY RESULTS

- A typical diurnal variation of water temperature is noticed at the surface, 10m and 20m depths with a minimum value at 0600 hours and a maximum value at 1500 hours. At station #13 (13°N & 87°E), the diurnal variation is extended up to 30m depth. The range of diurnal variation of temperature is less than 0.5°C

- The diurnal variation of temperature at 10° N, 87° E is affected by prevailing circulation. A distinct variation of temperature is noticed on the second day of observation when the water temperature decreased drastically below 20m compared to the temperature during the first day. At 50m depth, the decrease in temperature is as high as 3.5°C at midnight hours. This interesting feature may be related to the southward shift of the meso-scale cyclonic gyre centered at 10° N.
- The temperature variation in the upper 100m and the variation of surface mixed layer depth has suggested the presence of the meso-scale gyre between 7° N and 11° N latitudes. The mixed layer is shallow (20-40 m) at 10° N and deep (30-60 m) both at 7° N and 13° N. The mixed layer has become thin (10m) at the time of highest global solar radiation recorded on 3rd November at 10° N (Fig. 6).
- The VM-ADCP measured currents along 87° E and along 85°20' E have supported the presence of the cyclonic gyre with strong westward currents at 87° E and eastward currents at 85° 20' E. Strong westward/northwestward surface currents of intensity 120cm/s and above are measured at 13° N.
- The hydrographic data further show the presence of a subsurface salinity maximum (35.0-35.2 psu.) in the depth interval of 75-125m at the southern latitudes. The salinity maximum is eroded at 13° N, probably due to the mixing between the eastern Bay of Bengal low salinity waters (advected westward) and southern Bay of Bengal high salinity waters (advected northward) under the influence of the cyclonic gyre.

- Subsurface maximum in the fluorescence is noticed just below the mixed layer at all CTD stations.
- Observations off Goa confirmed the denitrification probably in association with the receding upwelling.
- Despite the shallow mixed layer over two days at 7° N (from ~ 60 to 30 m), the nutrients levels have not shown a great variation with nutricline more or less remaining at 20-30 m. At the other two time series stations also no relation could be ascertained.
- At the time series stations, the diurnal variability in Dimethyl sulphide is seen with a maximum value in the afternoon. The DMS abundance is correlated with fluorescence maximum recorded using a probe. DMSP has been found to be marginally higher than DMS.
- Secchi disc depths (light transparency of water) varied between 10 and 26 meters in the study area.
- From the atmospheric soundings, two temperature inversions have been consistently noticed; a low level inversion located between 960 mb and 900 mb (cloud base height) and another between 600 and 500 mb. Further the major difference between the convective and non-convective atmospheres is observed below the 500 mb level and above this level, all soundings look alike.
- The parameter that shows larger variation between convective and non-convective atmospheres is the humidity above 900 mb. In the convective atmosphere, humidity is high all the way upto 400 mb whereas in the non-convective atmosphere, the humidity is typically low.

- Preliminary calculations show that the sensible heat flux is about 20 W.m^{-2} , the latent heat flux is about 50 W. m^{-2} , the outgoing long-wave radiation from the sea surface is about 450 W. m^{-2} and the incoming long-wave radiation is in the range of $300\text{-}375 \text{ W. m}^{-2}$ during the partially raining conditions.

4. SUGGESTIONS

It is suggested that necessary steps may be taken to keep one set of VM-ADCP software diskettes on board the ship and also to see that the standard set up configuration of ADCP software is not to be disturbed since it serves as a reference for obtaining the currents data.

5. ACKNOWLEDGEMENTS

The cruise organisers (NIO and IISc) are thankful to the Department of Ocean Development, Govt. of India, for making available *ORV Sagar Kanya* for this experiment. The financial support provided by the Department of Science and Technology, Govt. of India, to the BOBMEX PILOT experiment is well appreciated. The chief scientist and the participants of the cruise acknowledge the support given by the ship's master, officers and the crew during the scientific operations at sea. Acknowledgements are also due to the NORINCO engineers for their technical support.

**PILOT BOBMEX CRUISE TRACK
SAGAR KANYA CRUISE No: SK138 C
PERIOD : 23-10-98 TO 11-11-98 (GOA - TUTICORIN)**

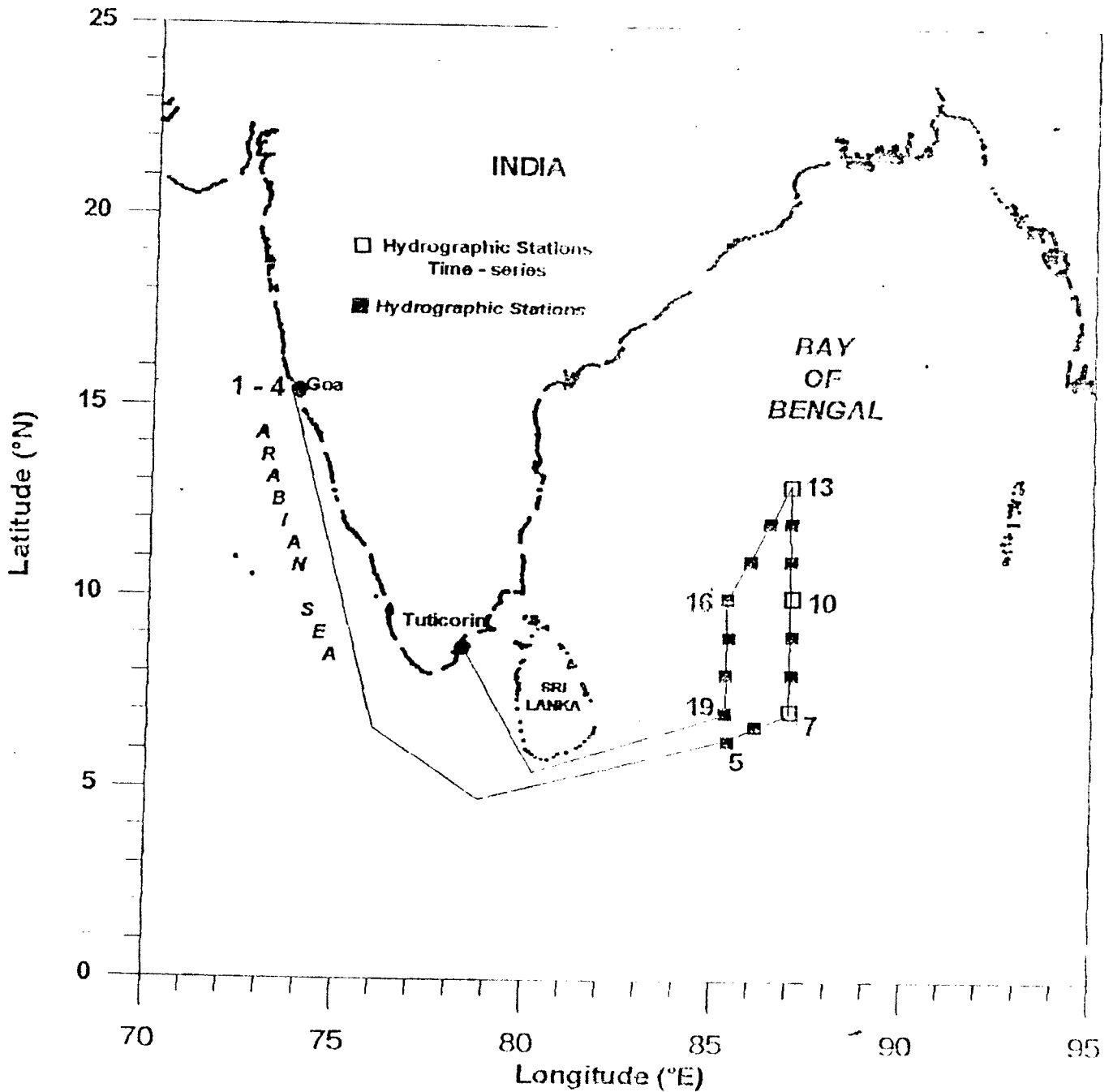
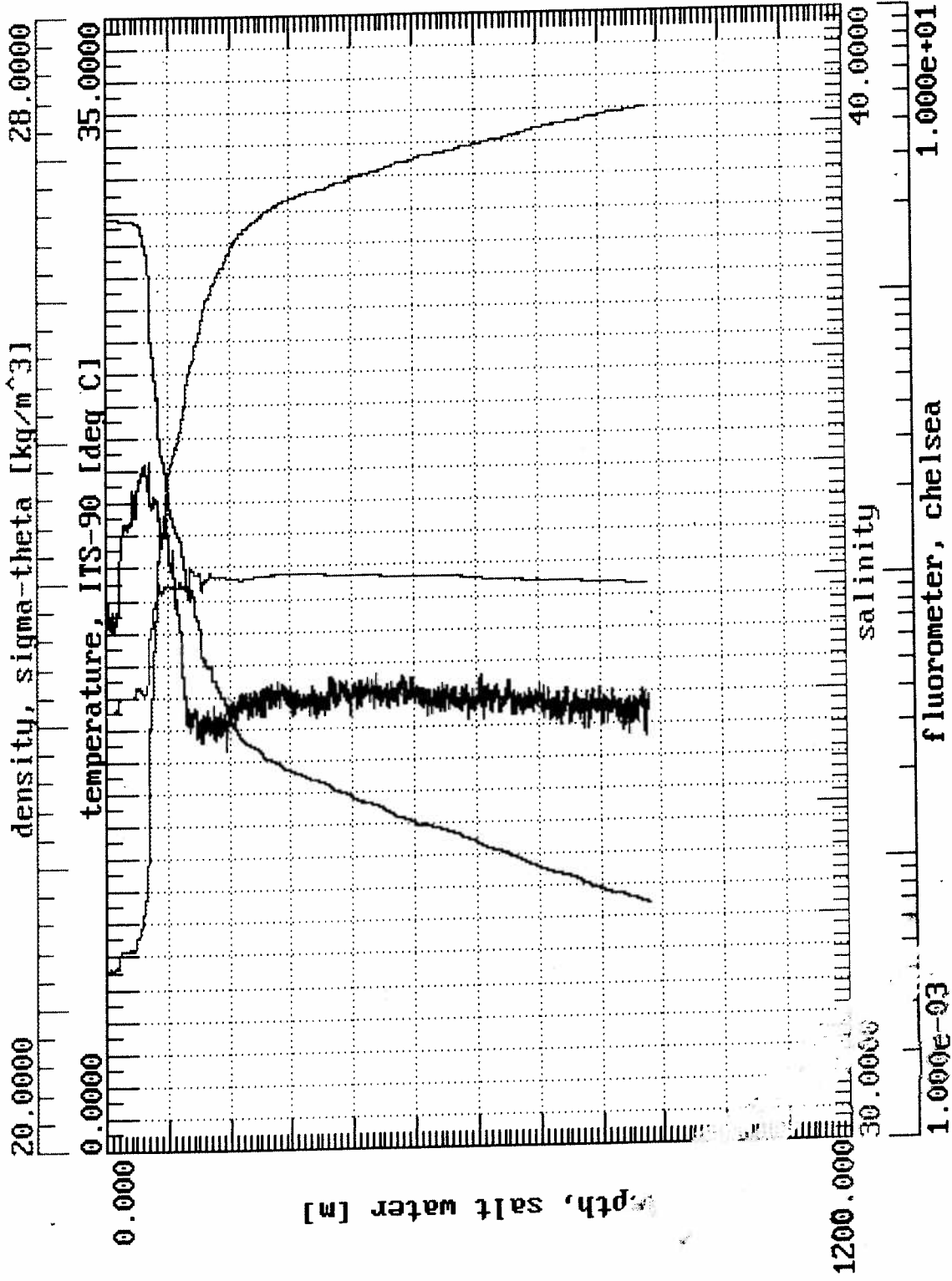


FIG. 1

BOBMEX PILOT Cruise SK138C

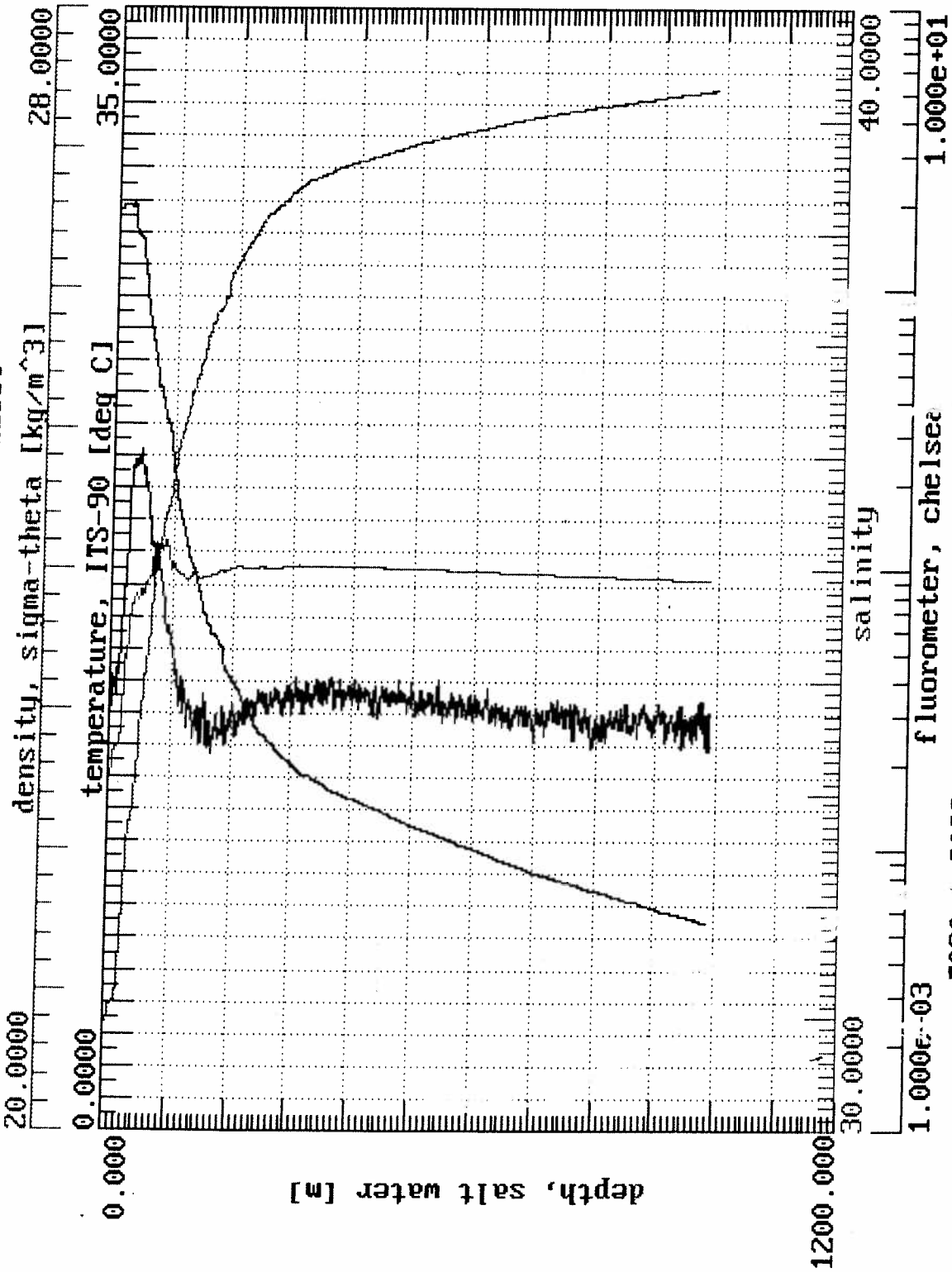


TO=7.4773 Sal= 34.9520 DepS=879.057 007-01.DAT

fluorometer, chelsea 1.000e+01

FIG. 2a

BOBMEX PILOT Cruise SK138C



T090=.8088 Sal= 34.9201 DepS=29.492 10-03.DAT

FIG. 2b

BOBMEX PILOT Cruise SK138C

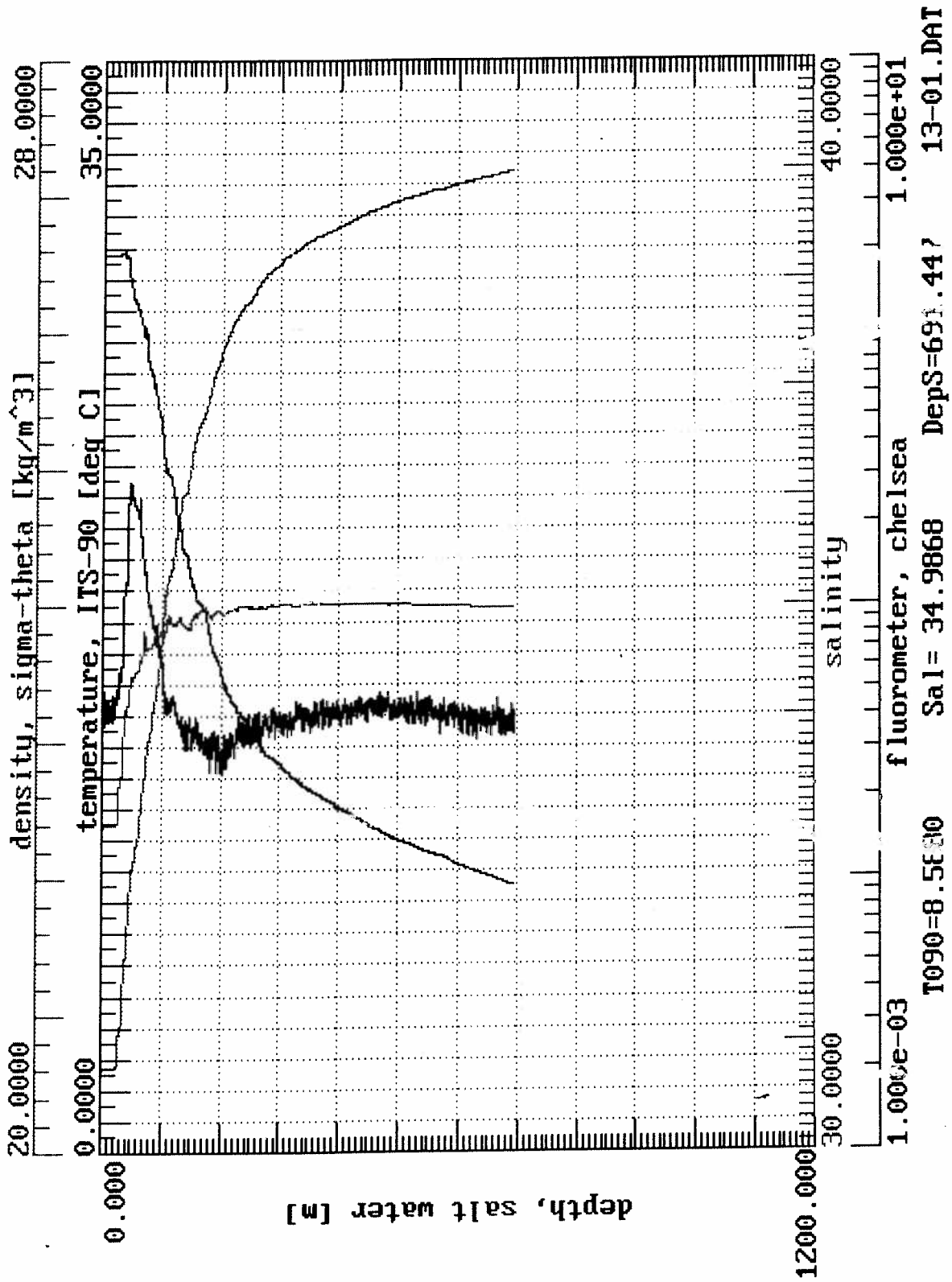


FIG. 2c

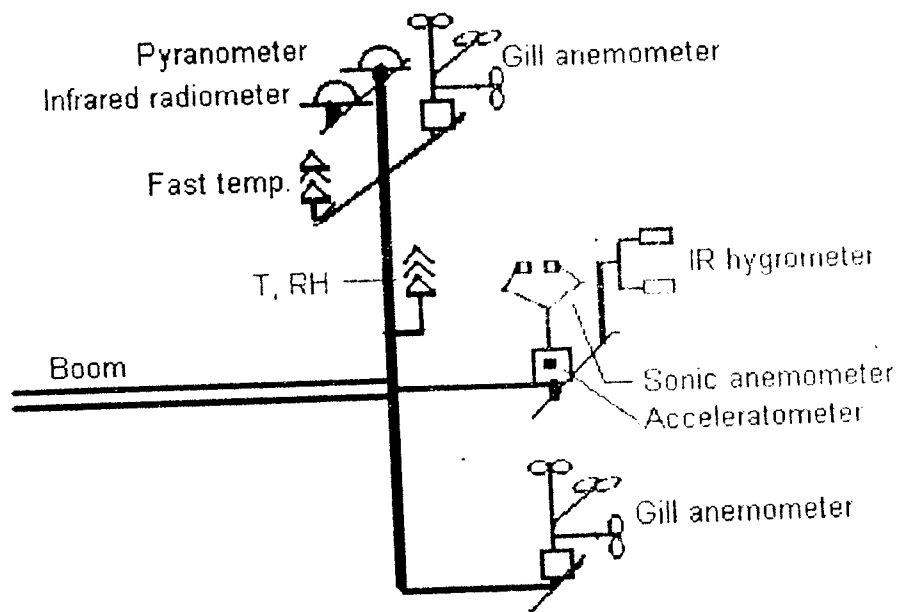


FIG. 3

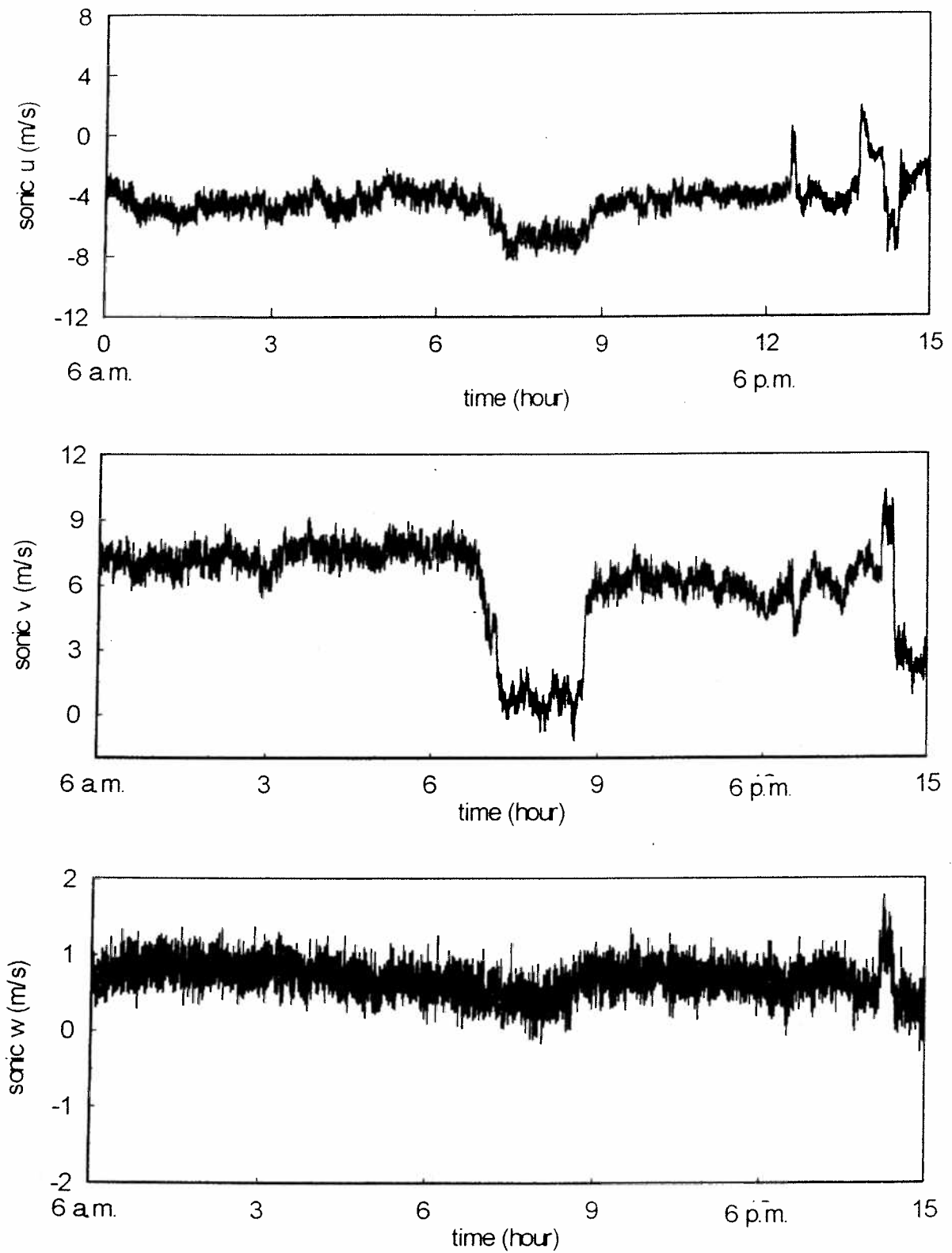


Figure 4. Velocity components measured by the sonic anemometer on November 6, 1998. During this period, the ship moved from 12 46 N, 86 50 E to 11 14 N, 86 01 E.

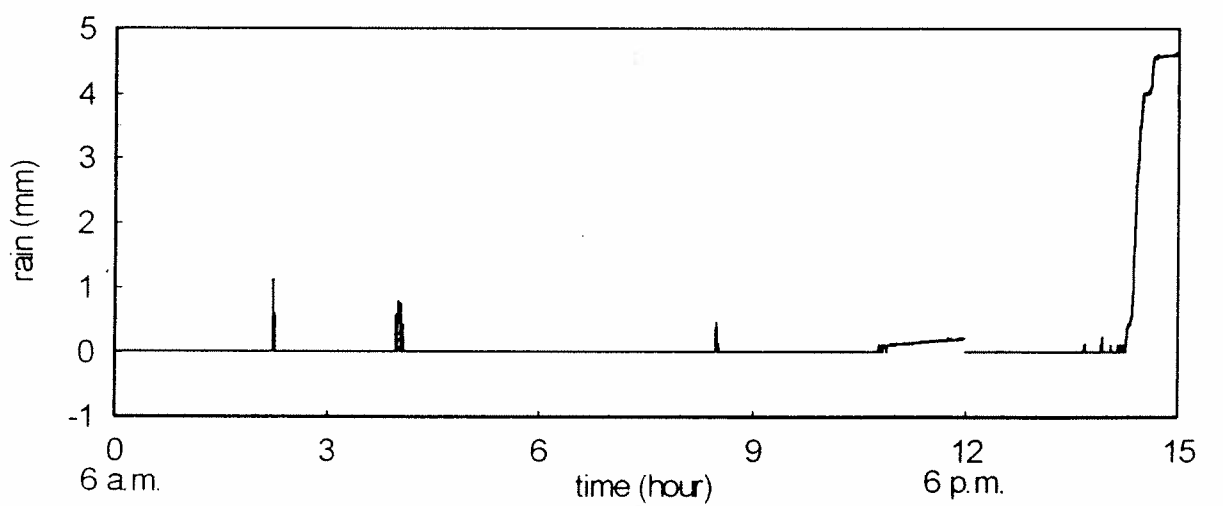
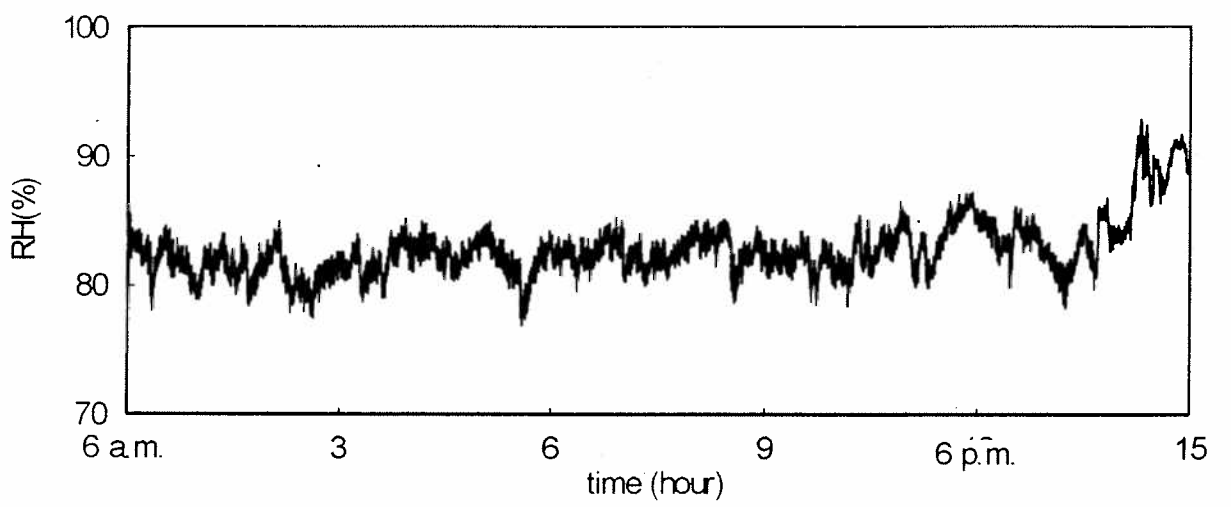
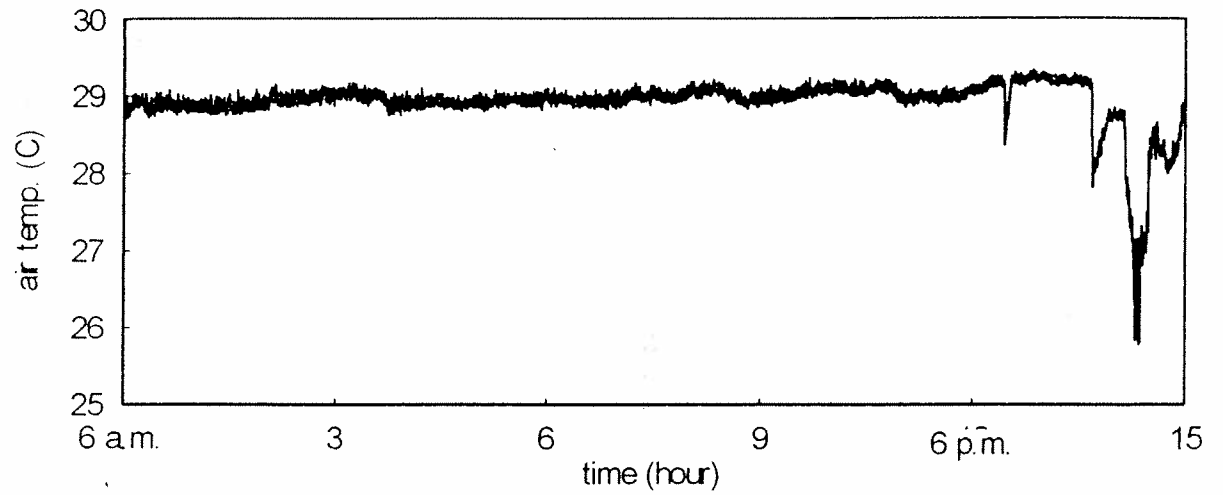


Figure 4 (cont.). Air temperature, relative humidity and rainfall measured on November 6, 1998.

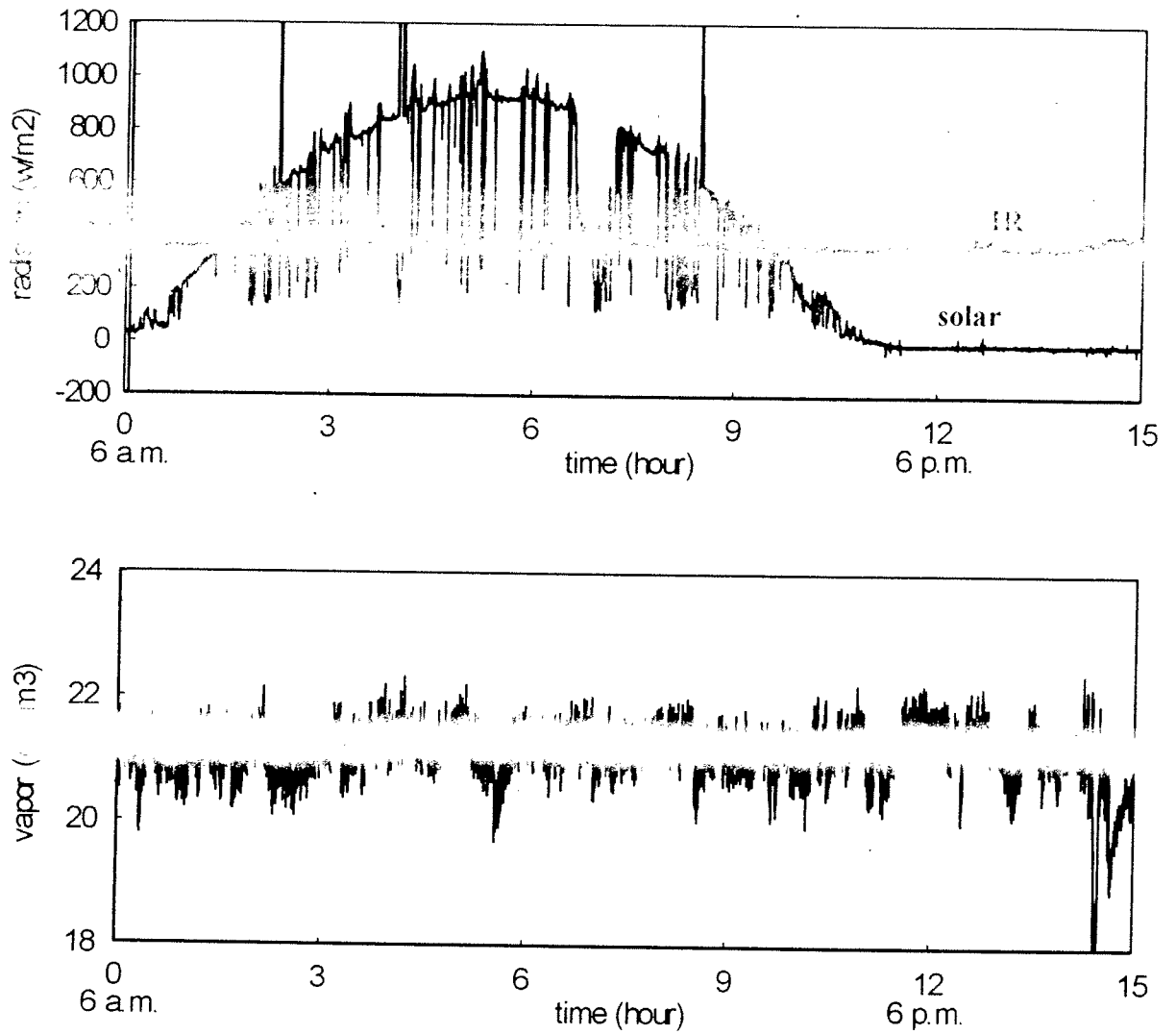


Figure 4 (cont.). Solar and incoming IR radiation, and the water vapor concentration (using the IR hygrometer) measured on November 6, 1998.

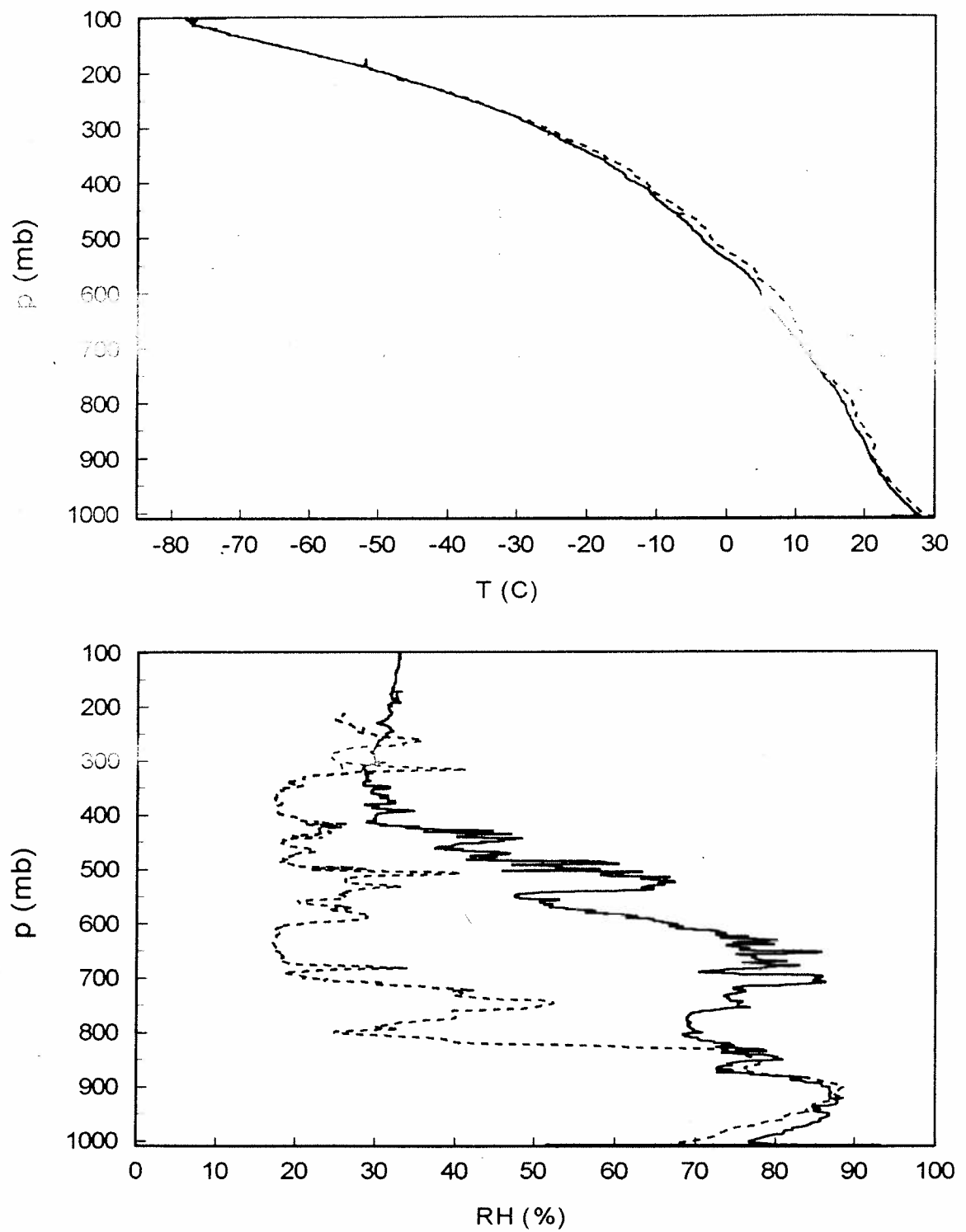


Figure 5. The vertical distribution of temperature and humidity measured by the mini-sonde. The continuous line corresponds to data taken at 6 a.m. on 6-11-1998 (Bay of Bengal) and the dashed line that at 2.30 p.m. on 25-10-1998 (Arabian Sea).

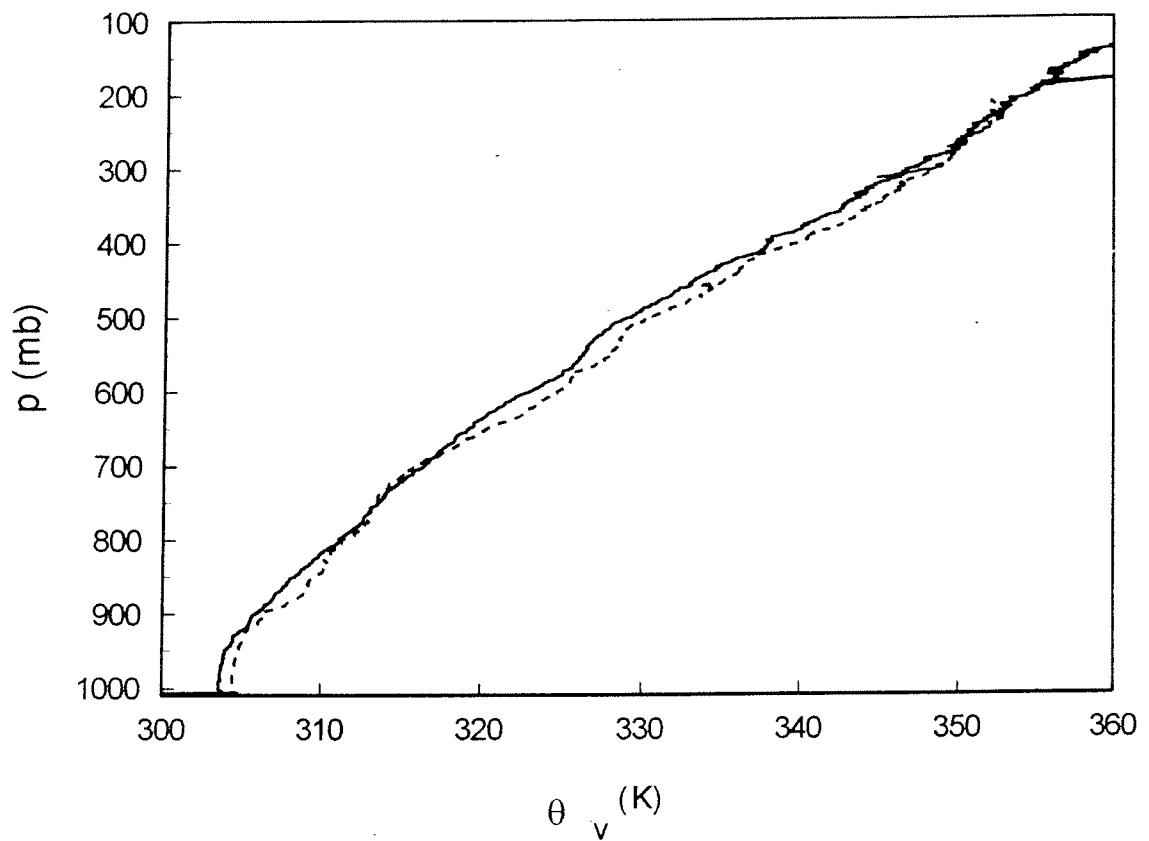


Figure 5 (continued). The vertical distribution of virtual potential temperature. The continuous line corresponds to data taken at 6 a.m. on 6-11-1998 (Bay of Bengal) and the dashed line that at 2.30 p.m. on 25-10-1998 (Arabian Sea). Nearly a constant θ_v near the surface indicates the atmospheric mixed layer.

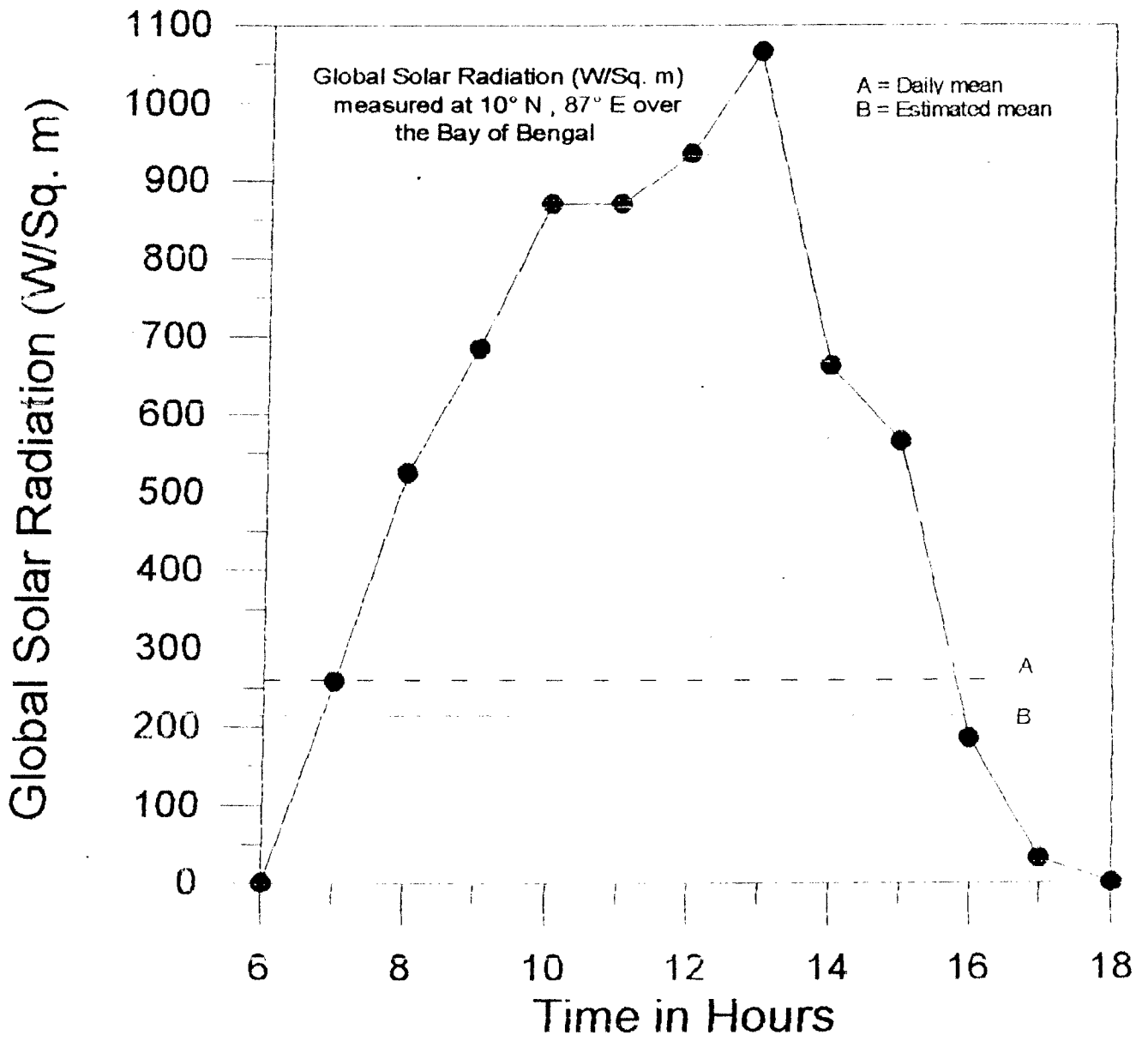


FIG. 6

Table 1

List of participants

A) Scientific compliment

S. No.	Name	Organisation
1.	V. Ramesh Babu Chief Scientist	N.I.O., Goa
2.	V.S.N. Murty	-do-
3.	R.J.K. Charyulu	-do-
4.	Ms. Charuta V. Prabhu	-do-
5.	Ms. Dora Pereira	-do-
6.	M. Dileep Kumar	-do-
7.	V.V.S.S. Sarma	-do-
8.	D.M. Shenoj	-do-
9.	Vishal Pawar	-do-
10.	G.S. Bhat	IISc., Bangalore
11.	S. Ameenulla	-do-
12.	J.V.S. Raju	-do-
13.	G. Ravi	-do-
14.	C.P. Chandrasekhara	-do-
15.	Retish Senan	-do-
16.	M. V. Ramana	SPL, Trivendrum
17.	Saji Virghis	JNCSAR, Bangalore
18.	P. Seetaramayya	IITM, Pune
19.	Rakesh Kumar	IMD
20.	V.K. Pandey	-do-
21.	P.S. Narayana	-do-
22.	S.H. Bhagwat	-do-
23.	P. Sreeram	SAC, Ahmedabad
24.	T.S.V. Vijayakumar	Andhra Univeristy
25.	Baby Chakrapani Edakunni	Cochin University
26.	Nelson V. Sam	IIT, Delhi
27.	Lt. Cdr. D. Vijaya Kumar	Indian Navy
28.	V.N. Kader	-do-

Cont.

29.	K.C. Rajeev	NORINCO
30.	Rohit J. Hermon	-do-

B) Ship's Compliment

Sl. No.	Name	Rank
1.	Capt. N. Sreekumar	Master
2.	P. G. Prakash	Chief Officer
3.	L.C. Lohani	2 nd Officer
4.	Packirisamy Akilan	-do-
5.	G. R. Kamat	Radio officer
6.	H.V. Subrahmanyam	Medical Officer
7.	R.G.S. D' Silva	Purser Officer
8.	Aniruddha Home	Chief Engineer
9.	A.K. Neogi	2 nd Engineer
10.	H.K. Jain	3 rd Engineer
11.	M.N. Muralidharan	-do-
12.	J.C. Sharma	Electrical Officer
13.	A.R. D' Cruz	-do-
14.	M.F. Rodrigues	Catering Officer

TABLE 2
PILOT BOBMEX CRUISE (NO. SK138C) - SUMMARY OF HYDROGRAPHIC STATIONS

STATIONS	LAT (DEG. N)	LONG (DEG. E)	SONIC DEPTH(m)	DATE	TIME(ST)		CTD	SEACAT CTD	WATER SAMPLING	IRRADIANCE METER	WAVE READER	MET. OBS.	T-S GRAPH
					SHIP STOP	SHIP START							
1	15°24.48'	73°39.98'	20	23.10.98	1247	1355	X	-	X	-	-	-	-
2	15°27.10'	73°24.10'	50	23.10.98	1615	1700	X	-	X	-	-	-	-
3	15°21.00'	73°18.58'	67	23.10.98	1830	1920	X	-	X	-	-	-	-
4	15°22.64'	73°07.13'	90	23.10.98	2100	2130	X	-	X	-	-	-	-
5	06°20.60'	85°22.50'	3800	29.10.98	700	1010	X	X	X	X	X	X	X
6	06°40.00'	86°05.00'	3900	29.10.98	1620	2000	X	X	X	X	X	X	X
7	07°00.00'	87°00.00'	3900	30.10.98/01.11.98	241	135	X(14)	X(9)	X(6)	X(3)	X	X	X
8	08°00.00'	87°00.00'	3700	01.11.98	1000	1105	-	X	-	X	X	X	X
9	09°00.90'	87°00.30'	3600	01.11.98	1900	2016	X	X	X	X	X	X	X
10	10°00.00'	87°00.00'	3450	02.11.98/04.11.98	237	255	X(16)	X(11)	X(7)	X(8)	X	X	X
11	11°00.00'	87°00.00'	3400	04.11.98	910	1036	X	-	X	X	X	X	X
12	12°00.00'	86°59.90'	3300	04.11.98	1725	1847	X	-	X	X(2)	X	X	X
13	13°00.00'	86°59.92'	3200	05.11.98/06.11.98	150	341	X(9)	X(6)	X(5)	X	X	X	X
14	11°59.90'	86°25.80'	3300	06.11.98	1255	1435	X	-	X	X	X	X	X
15	11°00.00'	85°52.00'	3300	06.11.98	2320	115	X	-	X	-	X	X	X
16	10°00.00'	85°20.00'	3500	07.11.98	950	1125	X	-	X	X	X	X	X
17	09°00.00'	85°20.00'	3650	07.11.98	1900	2012	X	-	X	-	X	X	X
18	07°59.97'	85°19.92'	3500	08.11.98	346	500	X	-	X	-	X	X	X
19	07°00.00'	85°19.96'	3800	08.11.98	1241	1420	X	-	X	X	X	X	X

NOTE: NO. IN BRACKET INDICATES THE NO. OF OPERATIONS AT THE TIME SERIES STATIONS.