FRANKLIN

National Facility
Oceanographic Research Vessel

Research Summary

FR 7/96

Depart :	Fremantle	1100 Wednesday	August 14 1996
Arrive:	Christmas Island	1000 Wednesday	September 4 1996
Depart:	Christmas Island	1600 Wednesday	September 4 1996
Arrive:	Fremantle	0730 Wednesday	September 11, 1996

FRESHWATER AND HEAT BUDGETS IN THE TROPICAL INDIAN OCEAN

Principal Investigators

Dr. J.S. Godfrey
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Professor M. Tomczak
Flinders Institute of Atmospheric and Marine Sciences

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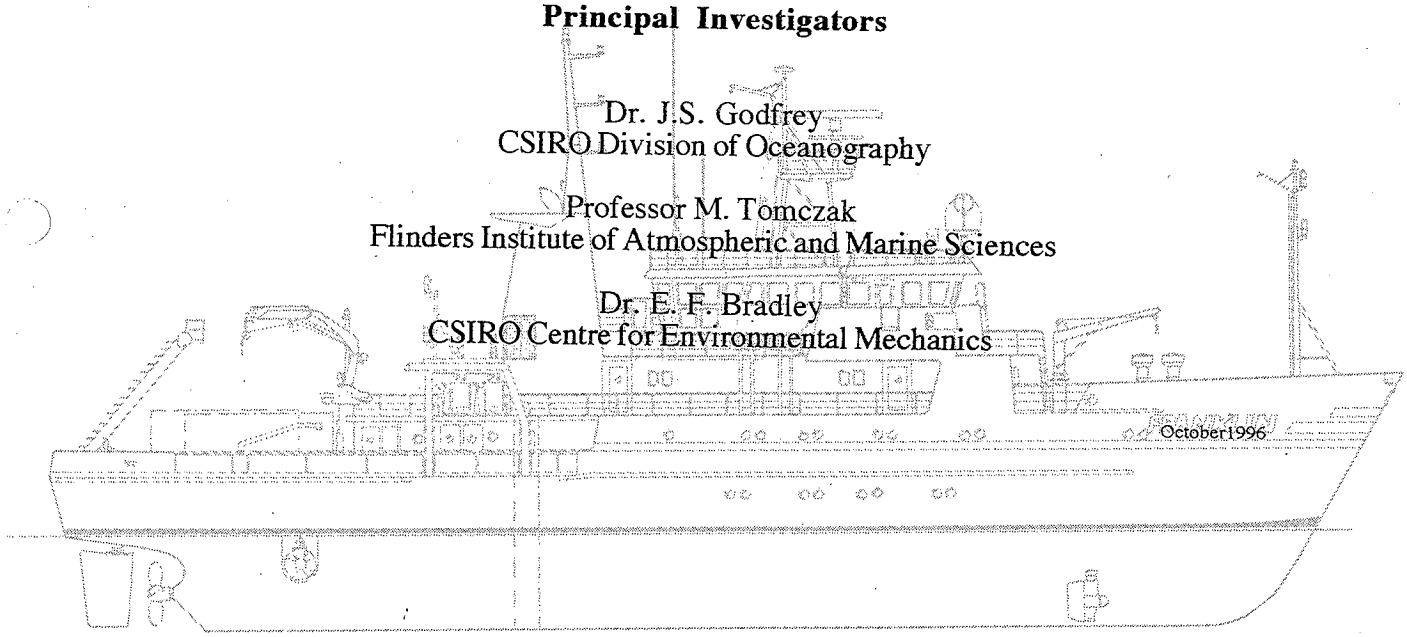

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AUSTRALIA

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RV FRANKLIN CRUISE Fr 7/96

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Aims of the cruise:

The main objectives of this cruise are to undertake a budget closure somewhat similar to that undertaken during TOGA-COARE, but designed primarily to measure the spatially inhomogeneous freshwater input, rather than the much more regular heat budget (although the latter will be obtained as a matter of course). For this purpose, FIAMs scientists have prepared a video camera to place on top of the ship's 3-cm radar. This will provide rainfall estimates over the area seen by the radar, which we will check against estimates obtained from raingauges on the ship and the buoy. We plan to supplement our earlier COARE-style calculation of the heat and freshwater budgets at the buoy with estimates of the change of freshwater (and heat) content along parcels of water, that are intercepted twice by the ship's track.

Cruise Narrative

This cruise went quite smoothly despite the complexity of the original plan, and there were few mishaps.

The cruise track is shown in Figure 1a, with the track enlarged in the work area in Figure 1b. Basically, the aim of the cruise was to deploy an instrumented drifting buoy and follow it for several days, to test our ability to close heat and freshwater budgets accurately. It was also planned to record the 3cm radar images at 10 minute intervals through the drift, for use in estimating the rainfall field away from the ship and buoy. We had originally planned the deployment at (2°S, 94°E), but decided to move it to (2°S, 93°E) out of concern that the prevailing currents might take the buoy to Indonesian waters. In the event, the buoy moved southwestward, i.e away from Indonesia.

The boom and most of the meteorological equipment was successfully mounted while the ship was still in Fremantle. The long (9 day) run under transit duty (apart from underway instrumentation) proved extremely valuable in permitting detailed preparation before the deployment. In particular, we prepared a program for estimating velocity relative to the drifter, using the ADCP, GPS and buoy fixes. This permitted

budget estimations while the experiment progressed, rather than having to wait for current meter data. The SeaSoar electronics system gave considerable trouble, as it has on many cruises, this time due to two cards that each gave intermittent faults. The SeaSoar electronics system is still the same as it was when it was part of the Bunyip; i.e. much more complex than it needs to be. However, Lindsay Pender and Eric Madsen managed to resolve these problems, which did not reappear during the drift. Ian Helmond assembled the sensors on the new drifting buoy.

Logistics of the experiment:

The buoy was deployed at 0229 UTC, 23rd August. We adopted a strategy of following the triangular paths seen in Fig. 1b, pasing the buoy near the middle of the leg to 225°. About once a day we performed a survey along fixed headings, which lay inside the triangle (relative to the buoy). These are the "whorls" in Figure 1b. SeaSoar was usually recovered early each morning (local time). It would be serviced, a calibration of its sensors performed, and a CTD taken near the buoy. There were the only occasions during the drift when the SeaSoar was out of the water for more than about 2 hours. One occurred when the new deflector on the front of SeaSoar proved to be not strong enough, and had to be replaced early in the drift. The second was on 26th August, when the buoy was retrieved to check that the current meters were properly secured (a securing pin had been found on deck after its first deployment). Progressive budget calculations were performed on most days. An interesting feature was that the mixed layer showed a well-developed "barrier layer" throughout, with a temperature inversion near 55m. Details of SeaSoar deployments are attached; they include a deployment overnight, immediately after the main experiment, on the leg back to Christmas Island.

Th buoy was recovered at 10.42 UTC on 31st August. All current meters provided records, but the data has proved puzzling. The shear between the two current meter records at 17m and 25m is large and rather erratic compared to the shear estimated by the ADCP. This suggests that one or both current meter records is in error. The cause of these problems is still unknown: the 17m record shows suspiciously small currents, while the 25m record shows sharp velocity jumps. A conductivity sensor on the SeaSoar died (justifying the present use of dual sensors!), but otherwise they showed stable calibration throughout. However, it was found that the thermosalinograph read 0.2°C too low relative to the 12 CTDs taken.

Meteorology and near-surface sensors:

The special meteorological sensors were mounted as usual on the foremast. They were augmented on this occasion by a pair of optical raingauges (ORGs) provided by NASA-Goddard, one oriented to starboard and the other fore-and-aft. The purpose of this arrangement was to test our correction scheme for imperfect cosine response. Associated with the meteorological system were two instruments to measure sea temperature. They were the "Seasnake", a high-precision thermistor in the end of a length of garden hose which is towed along the surface from the foredeck side boom which had been extended by about 3 metres for the purpose; and a new infra-red radiation thermometer (by Tasco) being tested for Ian Barton. The latter was mounted on the foredeck gunwale and alternatively pointed at the sea surface and the sky throughout the cruise.

The short- and long-wave radiometer pair were mounted on the main mast as usual, but with modified electronics. Comparison of the net radiative flux as measured by these individual components, and the all-wave net radiometer at the end of the boom, indicate that the system is operating as designed.

All of this equipment performed reliably, without incident, and formed the basis for the calculation of the radiative and turbulent surface fluxes in the energy budget, using the COARE bulk flux algorithm.

The "silverfish" was deployed when conditions were suitable, from the end of the boom. Early ingress of water through the sensor seal created problems which plagued this instrument throughout the cruise, and it was repaired several times by Erik Madsen, working without documentation. This enabled collection of a considerable amount of near-surface temperature and conductivity data, although it seems rather more noisy than when used during McTEX. Eventually it snatched its cable in the large swell and the consequent ingress of water was terminal.

The new drifting buoy designed by Ian Helmond also carried additional sensors this cruise. As well as the usual meteorological set-up and siphon raingauge, another ORG was included and appeared to operate well. A Seacat and acoustic current meter were attached. directly to the buoy frame, and other current meters were hung at 17 and 25 metres depth.

Radar rain observations:

The FIAMS program to estimate rainfall from radar images began on 21 August 01:50h UTC. A specially adapted video camera was installed above the screen of the ship's 3 cm radar. A short sequence of radar images, usually of 1 - 2 minutes length, was recorded on video tape every 10 minutes and annotated with audio comments.

The first 37 hours of radar images were recorded during transit to the experimental area. The aim was to collect information on rain cloud density over an extensive region. A 24 nautical mile range setting was used for this purpose.

From 22 August 14:50h UTC to 31 August 12:05h UTC (the period of the buoy drift) radar images were taken with a 12 nautical mile setting, giving good resolution on the scale of the Seasoar triangles. To provide information on the location of the buoy relative to the large scale rain cloud distribution, additional recordings on a 48 nautical mile range setting were made at hourly intervals.

After conclusion of the buoy drift radar images were continued during transit for 24 hours until 1 September 12:05h UTC, again using the 24 nautical miles range setting.

Return voyage:

On the return voyage, data analysis proceeded (much faster than would be possible in Hobart). A draft paper on the results of the budget calculations has been prepared. On this occasion we have certainly achieved heat budget closure to the desired level of 10 W/m^2, and (for one choice of velocity that is consistent with what we know at present) possibly considerably better. Final conclusions must await postcalibration of the current meters, and clarification of some points regarding the ADCP calibration.

We dropped Chris Surman, the Murdoch University birdwatcher, off at Christmas Island. The short (1000-1600) stay there was much appreciated.

A wire was laid near North West Cape to drag for the missing current meters. The wire showed only two transient changes in tension; yet on recovering the wire, the current meter line was on it! All three current meters were recovered, and all were in good condition with intact data records.

Acknowledgements:

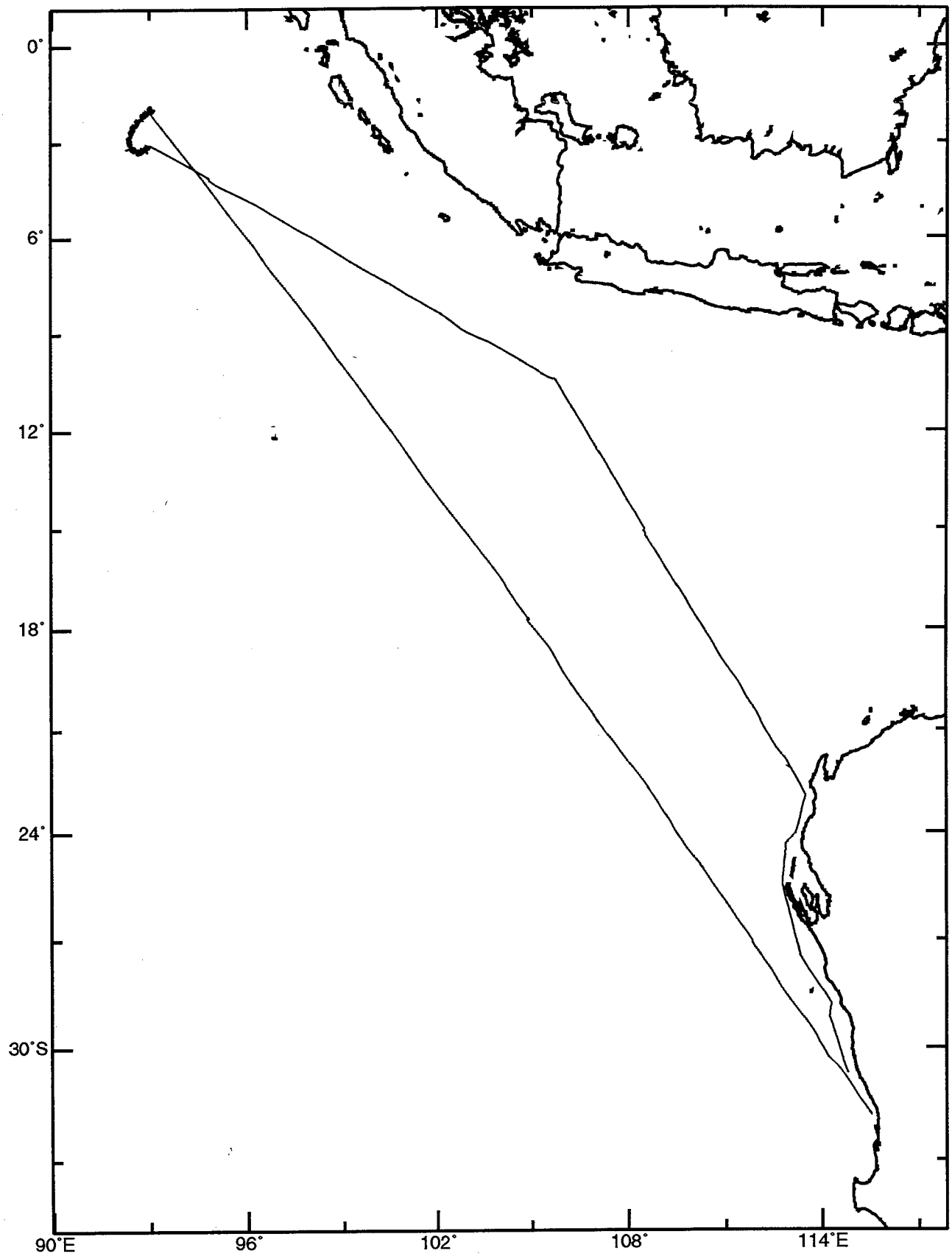
The success of this experiment is largely due to the conscientiousness of the ship's officers and crew; they reliably carried out quite intricate ship maneouvres for us, and in general provided a friendly and professional environment for us to work in. We also appreciate their permission to dedicate one of the ship's radar systems to the rain monitoring program, which allowed us to obtain a video of rain over the region of interest.

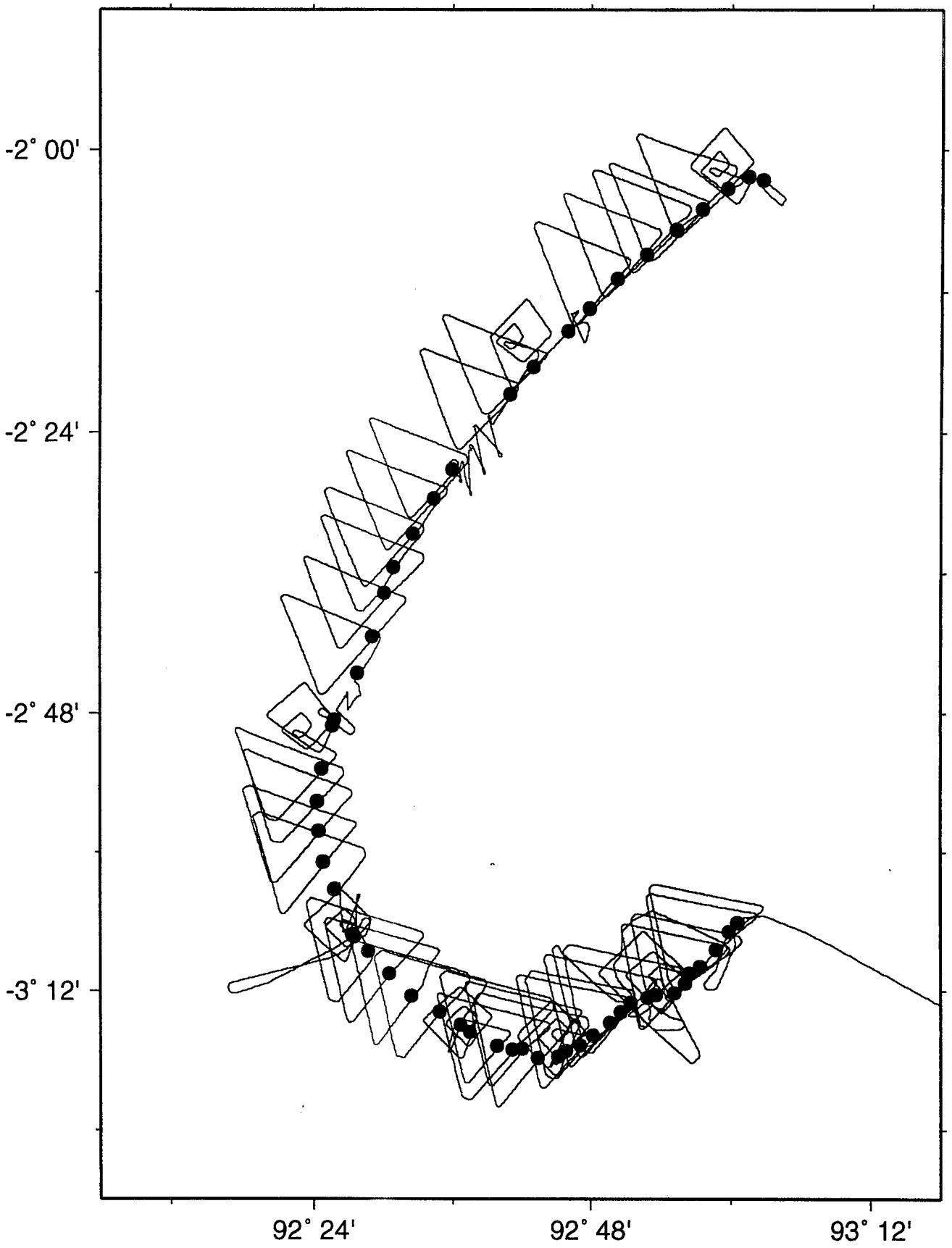
Scientific complement:

Frank Bradley	Chief Scientist - CSIRO CEM	
Stuart Godfrey	Cruise Manager - CSIRO DO	
Eric Schulz	CSIRO - DO	
Matt Tomczak	FIAMS	
Ivan Lebedev	FIAMS	
Ian Helmond	CSIRO ORV	
Lindsay Pender	CSIRO ORV	
Eric Madsen	CSIRO ORV	
Val Latham	CSIRO ORV	
Chris Surman	Fremantle - Christmas Island	Murdoch University

Ship's complement:

Ian Moss (master)
Ian Menzies
Franky Valeran
Terry Carruthers
Lindsay Cole
Don Roberts
Jannick Hansen
Wayne Browning
Norm Marsh
Gerry O'Halloran
Les Clark
John Tilley
Gary Hall
Peter Dux


0°
6°
12°
18°
24°
30°S
90°E
96°
102°
108°
114°E


-2° 00'
-2° 24'
-2° 48'
-3° 12'
92° 24'
92° 48'
93° 12'

Gordon Deployments -FR07/96

No.	Deployment Date and Position	Retrieval Date and Position	Files	Narrative
1	0420 19/8/96 14° 13.49S, 102° 12.18E	0503 19/8/96 10° 10.74S, 122° 09.90E	fr0796002	Deployment to test new wake avoidance device. Noticed large roll which was not adequately handled by the aileron. Retrieved to adjust aileron. Wake avoidance device found to be bent.
2	0833 19/8/96 13° 41.95S, 101° 47.35E	0946 19/8/96 13° 35.09S, 101° 41.80E	fr0796003	Strengthened wake avoidance device. Good wake avoidance. Obtained profiling data (tow speed 8 knots - 300m of cable) from the surface to 150m for tuning CTD processing software. Towards the end of the deployment, data was collected to determine parameters for the flight control servo system. Wake avoidance device found to be bent on retrieval.
3	0201 23/8/96 2° 04.27S, 93° 03.63E	0130 24/8/96 2° 15.30S, 92° 46.24E	fr0796006 - fr0796012	First deployment after deploying the drifting buoy. Started with a survey grid in sunny conditions and very slight seas. Some storm cells around, but no rain in the near vicinity. Around 0612 there was heavy rain, but had cleared by 0638. Finished survey at 0638. Buoy position at the beginning of the survey was 2° 02.30S, 93° 01.41E. Then followed 5 triangles. Buoy positions and times, at the start of each triangle (buoy passing positions) were 2° 03.30S; 92° 59.62E (0638); 2° 05.02S, 92° 57.48E (1019); 2° 06.78S, 92° 55.25E (1358); 2° 08.86S, 92° 52.72E (1743); 2° 10.95S, 92° 50.26E (2126) respectively. Buoy position at the completion of the last triangle was 2° 13.45S, 92° 47.87E (0110 24/8). Weather remained fine, occasionally overcast, with light winds. Wake avoidance device found to be bent on retrieval. Strengthened further.
4	0354 24/8/96 2° 15.80S, 92° 47.66E	1619 24/8/96 2° 21.25S, 92° 40.84E	fr0796014 - fr0796016	Deployment started with a modified grid survey. Data stopped logging from halfway through the survey and wasn't corrected until the beginning of the regular triangle tracks. The survey started with a buoy passing at 2° 15.33S; 92° 46.01E (0419). The weather throughout the day was partially sunny with high cloud, 10-12 knots of wind and no rain. Buoy positions and times, at the start of each triangle (buoy passing positions) were 2° 18.41S; 92° 43.01E (0908); 2° 20.79S, 92° 40.96E (1248); 2° 06.78S, 92° 55.25E (1358) respectively. Deployment was shorted due to flight instability resulting from excessive free play in the wing coupling. Wake avoidance device found to be missing a screw and bent. Both faults fixed.
5	0008 25/8/96 2° 27.95S 92° 36.68E	2249 25/8/96 2° 45.04S, 92° 27.68E	fr0796018 -	No survey during this deployment. The day started with overcast conditions, slight seas and wind to 10 knots. By 0608, the wind had died down and there was very light rain.

			fr0796023	Clear sky at 1116, rain at 1715. Wind light throughout and rarely greater than 10 knots. Completed 6 triangles. Buoy positions and times, at the start of each triangle (buoy passing positions) were 2° 27.16S; 92° 35.92E (0040); 2° 29.71S, 92° 34.37E (0422); 2° 32.70S, 92° 32.65E (0807); 2° 35.55S, 92° 30.86E (1145); 2° 38.29S, 92° 30.10E (1523); 2° 41.45S, 92° 29.04E (1904) respectively. Buoy position at the completion of the last triangle was 2° 44.58S, 92° 27.75E (2246).
6	0300 26/8/96 2° 48.88S, 92° 27.15E	2310 26/8/96 3° 03.81S, 92° 25.79E	fr0796025 - fr0796029	Started with a grid survey, first passing the buoy at 2° 49.06S, 92° 25.62E (0400). Sunny, slight seas, wind to 10 knots and no rain during the survey. Then straight into the first of 4 triangles. Buoy positions and times, at the start of each triangle (buoy passing positions) were 2° 52.81S; 92° 24.70E (0822); 2° 55.60S, 92° 24.33E (1158); 2° 58.22S, 92° 24.50E (1536); 3° 00.84S, 92° 24.86E (1920) respectively. Buoy position at the completion of the last triangle was 3° 03.24S, 92° 25.79E (2306). Rain reported around 1500. The wake avoidance device was missing on retrieval. Replaced with a stainless steel sheet.
7	0610 27/8/96 3° 09.09S, 92° 24.38E	0212 28/8/96 3° 15.51S, 92° 36.49E	fr0796031 - fr0796035	Started with a grid survey, first passing the buoy at 3° 07.30S, 92° 27.48E (0716). Rain early in the survey, heavy at times, but had stopped by 0839. Light wind (less than 8 knots) and slight seas. Following the survey came of 4 triangles, with intermittent periods of overcast and clear sky. Wind remained light. Buoy positions and times, at the start of each triangle (buoy passing positions) were 3° 08.60S; 92° 28.65E (1106); 3° 10.51S, 92° 30.46E (1454); 3° 12.39S, 92° 32.43E (1842); 3° 13.78S, 92° 34.84E (2222) respectively. Buoy position at the completion of the last triangle was 3° 14.94S, 92° 36.74E (0206 28/8).
8	0330 28/8/96 3° 14.65S, 92° 36.82E	2327 28/8/96 3° 17.98S, 92° 44.92E	fr0796037 - fr0796041	Started again with a grid survey, first passing the buoy at 3° 15.55S, 92° 37.51E (0359). Very overcast conditions, no rain and very light wind during the survey. Following the survey came of 4 triangles, with the cloud cover slowly becoming lighter during the day. Little if any rain. Wind remained very light. Buoy positions and times, at the start of each triangle (buoy passing positions) were 3° 16.76S; 92° 39.89E (0815); 3° 13.78S, 92° 41.22E (1202); 3° 17.01S, 92° 42.15E (1544); 3° 17.75S, 92° 43.47E (1933) respectively. Buoy position at the completion of the last triangle was 3° 17.66S, 92° 45.21E (2322).
9	0115 29/8/96 3° 15.80S, 92° 45.83E	0240 30/8/96 3° 12.95S, 92° 52.76E	fr0796043 - fr0796049	Started with a grid survey, first passing the buoy at 3° 17.19S, 92° 45.95E (0157). Mostly sunny conditions during the survey with light winds. Following the survey came of 4 triangles, a butterfly and then another triangle. Weather remained sunny until

				about 0900, and then became increasingly overcast. No rain was noted. Light winds throughout. Buoy positions and times, at the start of the first 4 triangles (buoy passing positions) were 3° 16.66S; 92° 48.18E (0610); 3° 15.87S, 92° 48.26E (0957); 3° 14.73S, 92° 49.75E (1334); 3° 13.86S, 92° 50.66E (1723) respectively. Buoy position at the centre of the butterfly was 3° 14.70S, 92° 49.51E (2020). Buoy positions at the start and completion of the last triangle were 3° 13.00S, 92° 51.50E (2248) and 3° 12.61S, 92° 52.91E (0237 30/8) respectively.
10	0532 30/8/96 3° 14.37S, 92° 55.18E	0848 3° 07.59S, 93° 00.63E	fr0796051 - fr0796056	Started with the final grid survey. This time the survey was centred on the buoy, and thus no initial passing time. Sunny conditions early with wind around 8 knots. Light rain had developed by 0830, but cleared quickly to a sunny day. Passed the buoy at the completion of the survey (the start of the first triangle). Following the survey came of 5 triangles. Buoy positions and times, at the start of each triangle (buoy passing positions) were 3° 12.18S; 92° 55.19E (1213); 3° 11.36S, 92° 56.12E (1603); 3° 10.53S, 92° 56.46E (1953); 3° 09.96S, 92° 57.41E (2343); 3° 08.46S, 92° 58.77E (0331 31/8) respectively. Finally passed the buoy at 3° 06.89S, 92° 59.90E (0720). About 0730 there was heavy rain which we followed for some time before turning back to the buoy to retrieve it.
11	11 29 31/8/96 3° 05.66S, 93° 03.30E	0100 1/9/96 3° 57.35S, 94° 34.39E	fr0796058 - fr0796062	A straight tow out of the survey area while heading for Christmas Island. Around 1715, noticed structure in the top 5m and decided to limit profile to 0 - 20m. Continued in this mode for the rest of the deployment, with one deeper dive to 130m every 20 min.