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The Centre for Australian Weather and Climate Research  
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## BLUElink II Workpackage P3 Inner Shelf and Nearshore Field Programs

Stephanie Contardo, Graham Symonds and Nick Mortimer

**CAWCR Technical Report No. 028**

30 June 2010



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# **1 INTRODUCTION**

The Bluelink project aims to provide ocean forecasts of ocean currents and eddies, surface and subsurface ocean properties, that impact and are linked to maritime and commercial operations, defence applications, safety-at-sea, ecological sustainability, regional and global climate. In Bluelink II wave forecasting (Workpackage P3) was added and included a relocatable model for predicting waves and currents in the nearshore. The broad objectives of Workpackage P3 were:

- To implement a coastal wave measurement package using x-band radar and in-water current and pressure sensors.
- To develop an operational surface-wave prediction system, to provide forecasts for the Australian coastal region.
- To implement, test, compare and develop models for predicting surface waves and wave-driven currents in the littoral zone.
- To develop laptop-based software systems to interpret nearshore waves from radar, estimate coastal bathymetry, and provide several-day wave forecasts.
- To establish core capacity in wave dynamics comparable with that available in ocean and atmosphere dynamics.

To achieve these objectives the following four sub-packages were defined

P3.1: Nearshore wave measurement

P3.2: Coastal wave forecasting

P3.3: Littoral (wave-breaking) zone models

P3.4: Littoral-zone software system

This report summarises the data collected in P3.1 during two field programs which ran between September 2008 and March 2009.

## 2 INNERSHELF EXPERIMENT

An X-band radar was deployed on the W.A. Fisheries building at Watermans (Fig.1) and a number of instruments were deployed across-shore from just beyond the surf zone to the limit of the radar range (approximately 5km).

The aims of the experiment were:

- To provide data against which the radar measurements can be validated.
- To provide data to assess wave model predictions of the inner shelf wave field from offshore observations. The strong summer sea breeze cycle in Western Australia provides the opportunity to observe the local growth and decay of waves in the nearshore at diurnal periods and to assess the ability of wave models to simulate these processes.

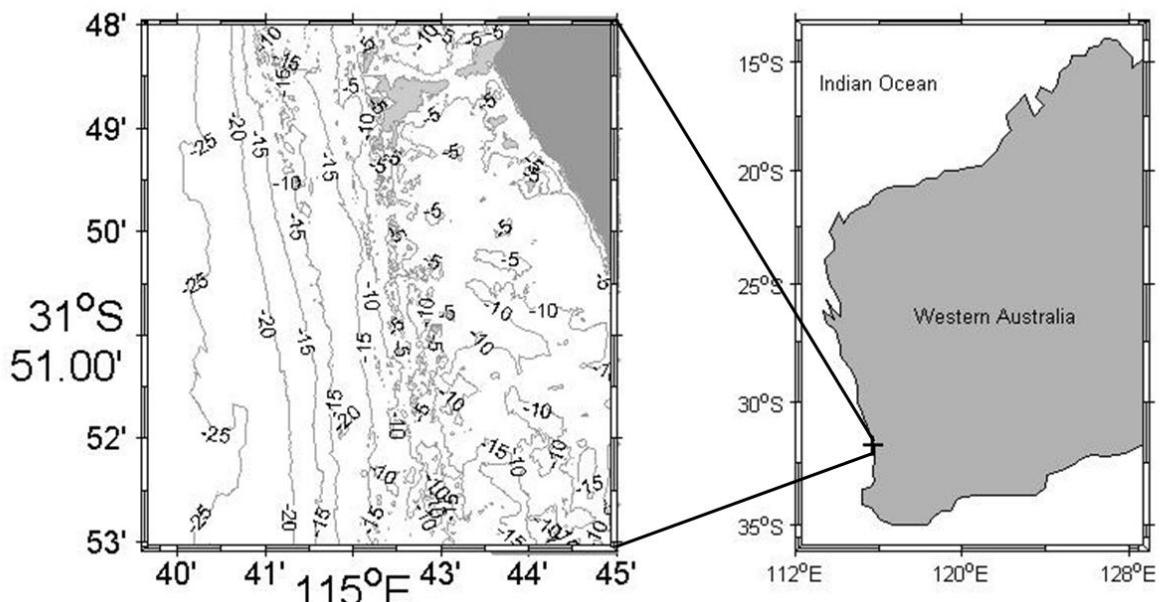


Fig. 1 Location of Innershelf experiment.

### 2.1 Instrument array

An array of instruments was deployed in September 2008 for 8-9 weeks in the Marmion Marine Park (Figs 1 and 2). A summary of the deployment schedule is given in Table 1 which also includes instrument types and measured parameters at each site. Exact locations, start and stop times and sampling details are given in Section 2.2.

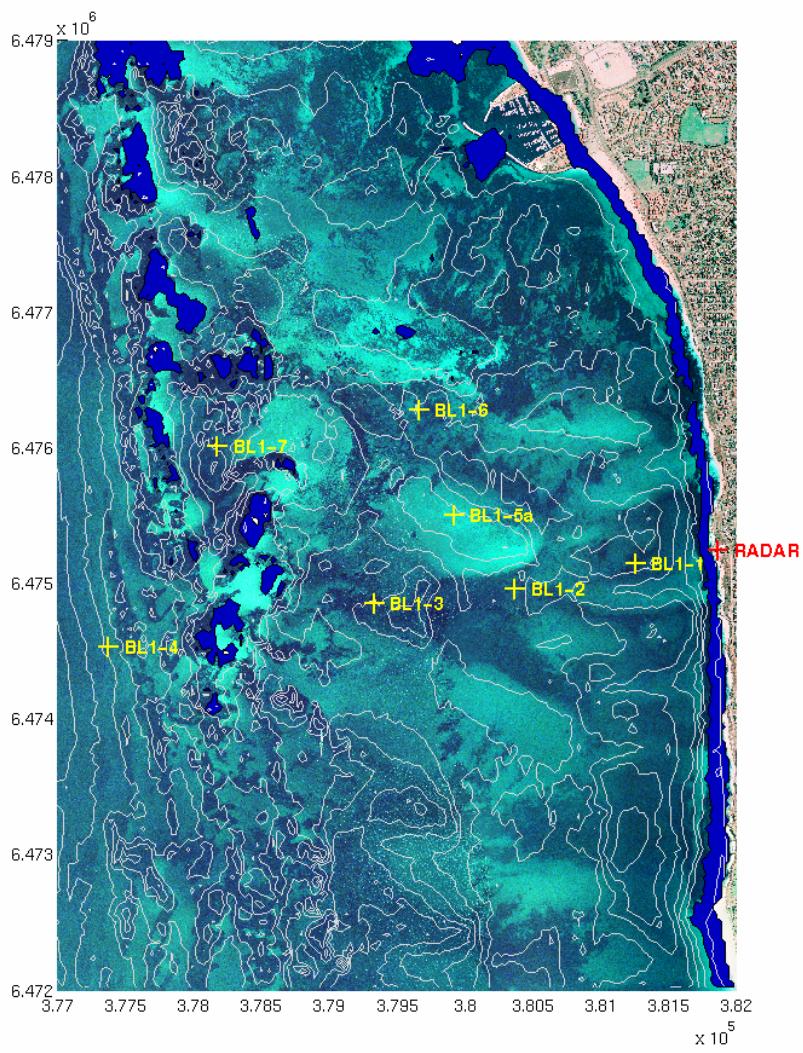


Fig. 2 Measurement sites for the inner shelf experiment. Instrument and measured parameters given in Table 1.

Table 1 Deployment summary for inner shelf experiment. Eastward velocity ( $u$ ), northward velocity ( $v$ ), vertical velocity ( $w$ ), pressure ( $P$ ), temperature ( $T$ ), salinity ( $S$ ), fluorescence and light (PAR).

Site	Instrument	Parameters	Sep			Oct				Nov		
			15	22	29	6	13	20	27	3	10	17
BL1-1	Vector	$u, v, w, P, T$										
BL1-2	Vector	$u, v, w, P, T$										
BL1-3	Vector	$u, v, w, P, T$										
BL1-4	AWAC	$\eta, u(z), v(z), P, T$										
BL1-5a	Vector	$u, v, w, T$										
BL1-6	SBE26	$P, T$										
BL1-7	SBE26	$P, T$										
	SBE19p	$P, T, S, \text{Oxygen}, \text{chl-a}, \text{PAR}$										
Radar	ISR DIR 25.9											

## 2.2 Mooring data

### 2.2.1 BL1\_1

Instrument: Nortek Vector and OBS

- Parameters u,v,w,P,T
- Sampling rate 1 Hz
- Record length 2048 samples
- Interval 3600s

Table 2 BL1\_1 deployment details.

Latitude	31.8532S
Longitude	115.7450E
Depth(m)	14.3
Start	23/09/2008 17:00:00
Stop	12/11/2008 16:00:00
Vector s/n	VEC 1672

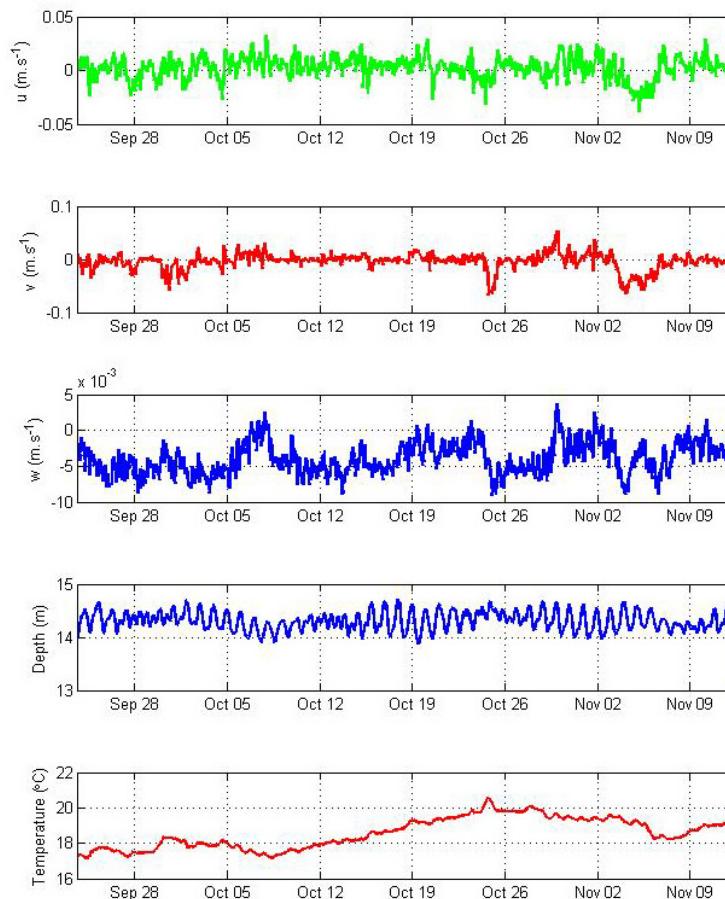


Fig. 3 Time series of current velocity components (eastward, northward, vertical), depth and temperature from Vector instrument at site BL1\_1.

## 2.2.2 BL1\_2

Instrument: Nortek Vector and OBS

- Parameters u,v,w,P,T
- Sampling rate 1 Hz
- Record length 2048 samples
- Interval 3600s

Table 3 BL1\_2 deployment details.

Latitude	31.8549S
Longitude	115.7355E
Depth(m)	13.2
Start	23/09/2008 17:00:00
Stop	12/11/2008 16:00:00
Vector s/n	VEC 1674

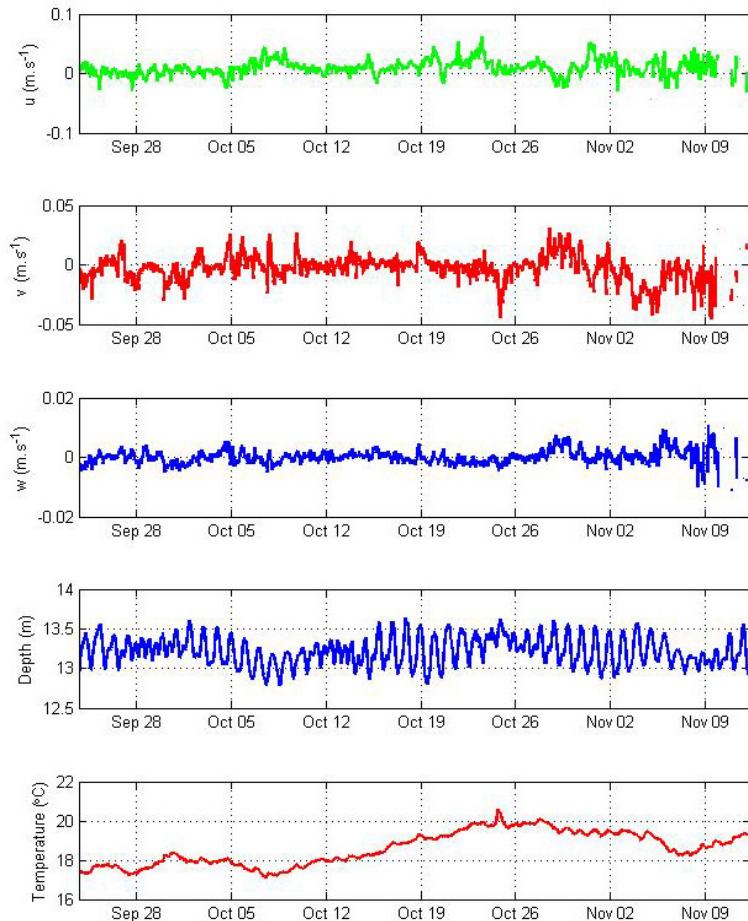


Fig. 4 Time series of current velocity components (eastward, northward, vertical), depth and temperature from Vector instrument at site BL1\_2.

### 2.2.3 BL1\_3

Instrument: Nortek Vector and OBS

- Parameters u,v,w,P,T
- Sampling rate 1 Hz
- Record length 2048 samples
- Interval 3600s

Table 4 BL1\_3 deployment details.

Latitude	31.8557S
Longitude	115.7245E
Depth(m)	13.1
Start	23/09/2008 17:00:00
Stop	12/11/2008 16:00:00
Vector s/n	VEC 1670

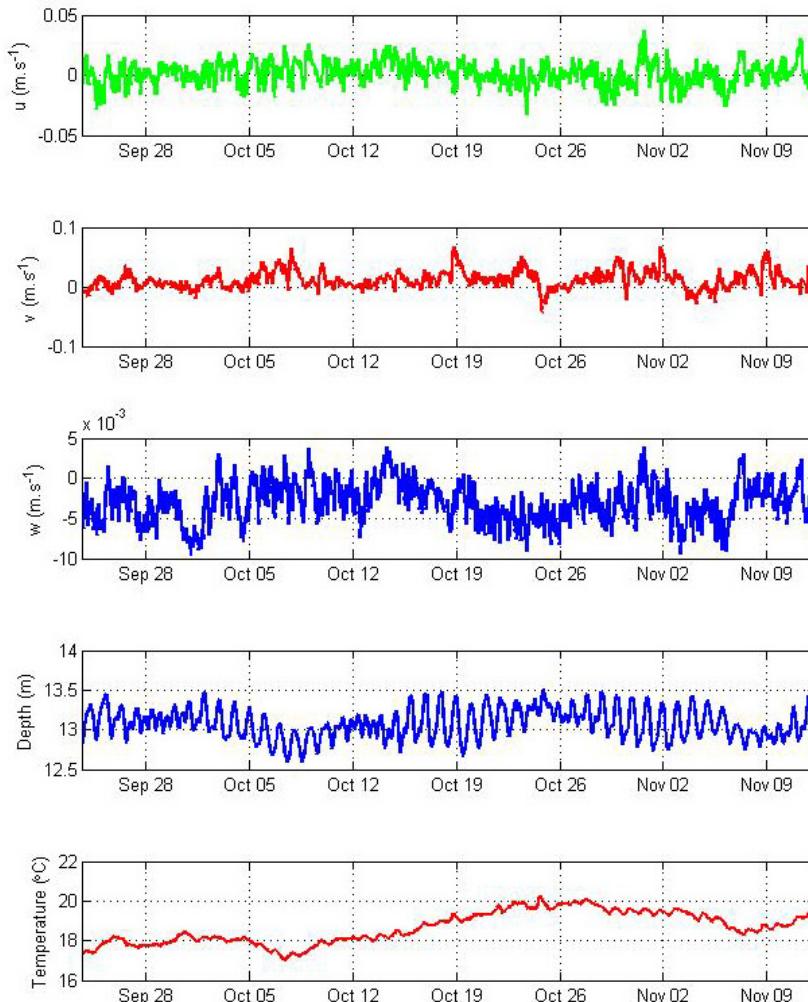


Fig. 5 Time series of current velocity components (eastward, northward, vertical), depth and temperature from Vector instrument at site BL1\_3.

## 2.2.4 BL1\_4

Instrument: Nortek AWAC

Current profile

- Parameters u,v
- Profile interval 3600s
- Cell size 0.5m

Waves

- Parameters u,v,AST,P,T
- Sample rate 1Hz
- Record length 2048
- Interval 7200s

Table 5 BL1\_4 Deployment details.

Latitude	31.8400S
Longitude	115.7038E
Depth(m)	4
Start	16/09/2008 17:00:00
Stop	12/11/2008 16:00:00
AWAC s/n	WPR 0411

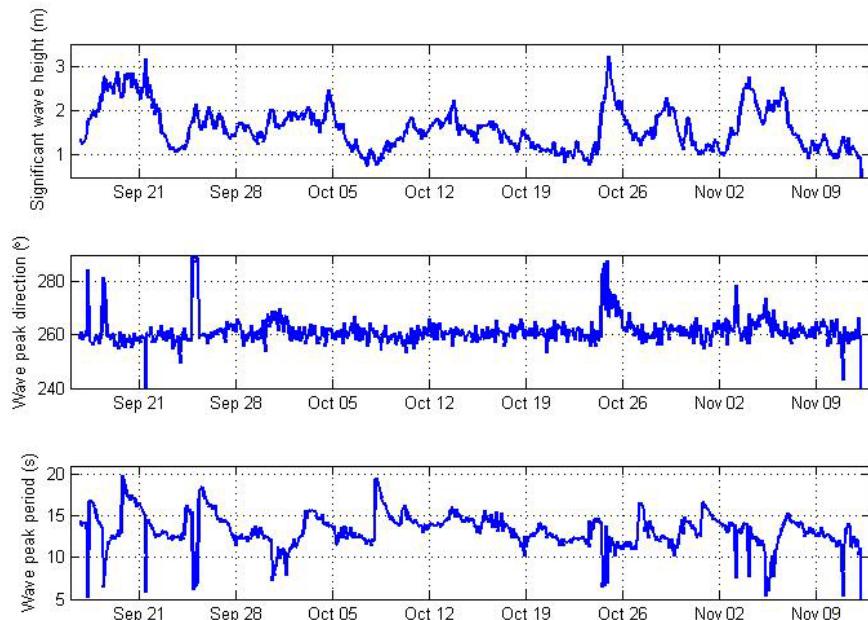


Fig. 6 Time series of significant wave height, peak direction and peak period from AWAC instrument.

Comments: The AWAC was deployed off reef.

## 2.2.5 BL1\_5

Instrument: Nortek Vector and OBS

- Parameters u,v,w,T
- Sampling rate 1 Hz
- Record length 2048 samples
- Interval 3600s

Table 6 BL1\_5 deployment details.

Latitude	31.8499S
Longitude	115.7308E
Depth(m)	39.6
Start	23/09/2008 17:00:00
Stop	12/11/2008 16:00:00
Vector s/n	VEC 1670

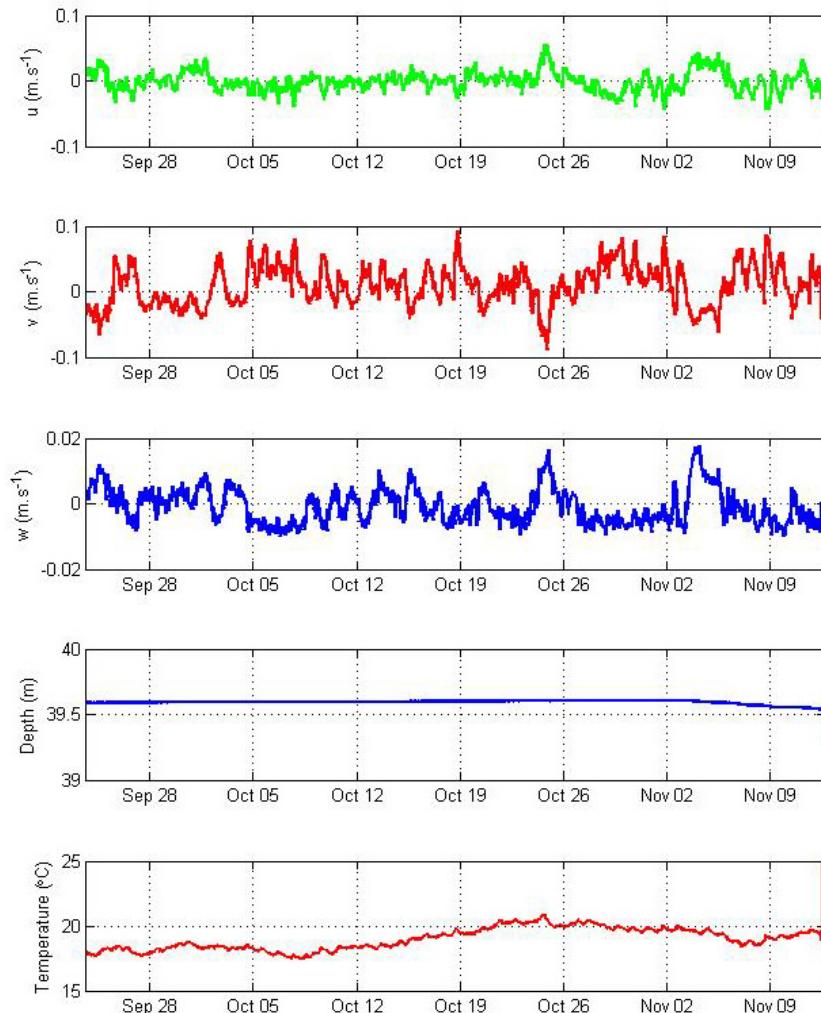


Fig. 7 Time series of current velocity components (eastward, northward, vertical), depth and temperature from Vector instrument at site BL1\_5.

## 2.2.6 BL1\_6

Instrument: SeaBird SEAGAUGE wave and tide recorder SBE26

- Parameters P,T
- Wave interval 6\*3600s
- Tide interval 3600s

Table 7 BL1\_6 deployment details.

Latitude	31.8429S
Longitude	115.7282E
Depth(m)	10.5
Start	16/09/2008 18:40:03
Stop	13/11/2008 06:40:01
Seagauge s/n	0409

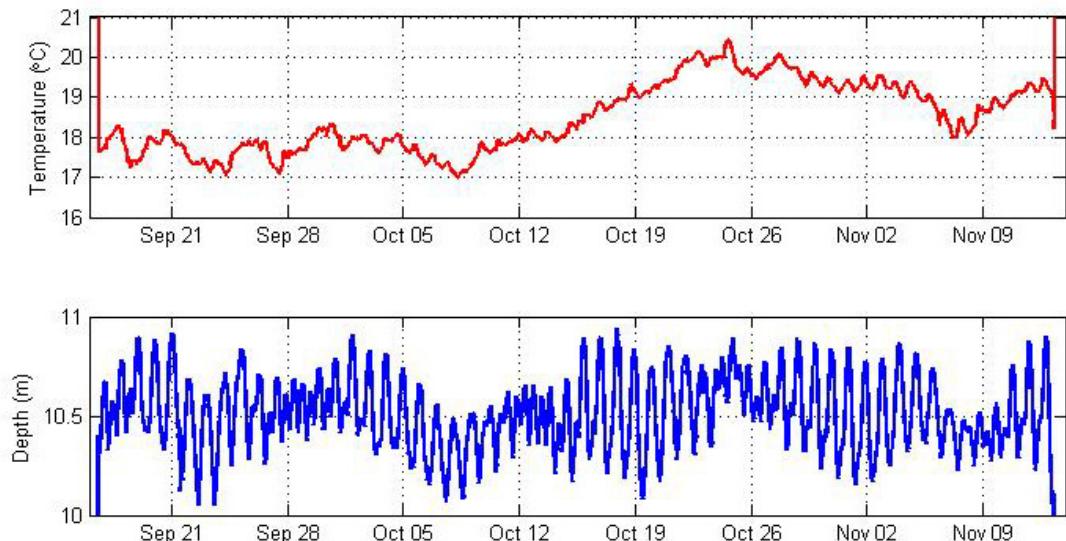


Fig. 8 Time series of temperature and depth from SBE26 at site BL1\_6.

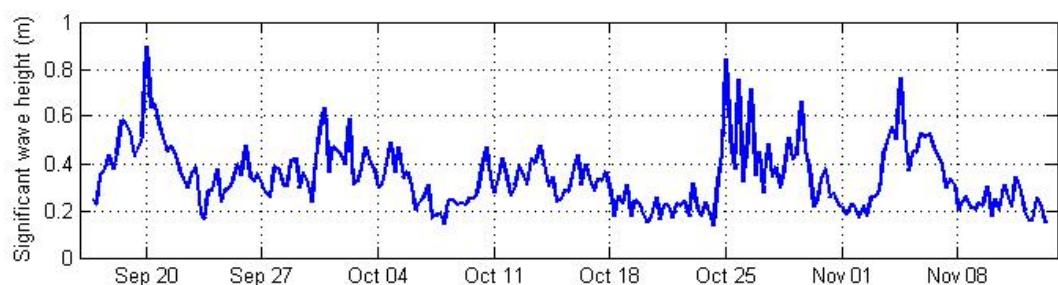


Fig. 9 Time series of significant wave height from SBE26 at site BL1\_6.

## 2.2.7 BL1\_7

Instruments: SeaBird SEAGAUGE wave and tide recorder SBE26 and SEACAT profiler

SBE19p  
SBE26

- Parameters P,T
- Wave interval 6\*3600s
- Tide interval 3600s

SBE19p

- Parameters P,T,S,Oxygen, chl-a,PAR
- Sampling interval 900s
- Measurements per sample 4

Table 8 BL1\_7 deployment details.

Latitude	31.8451S
Longitude	115.7125E
Depth(m)	9.5
SEAGAUGE start	16/09/2008 18:49:59
SEAGAUGE stop	13/11/2008 06:49:59
SEAGAUGE s/n	0408
SEACAT start	16/09/2008 17:00:01
SEACAT s/n	4534

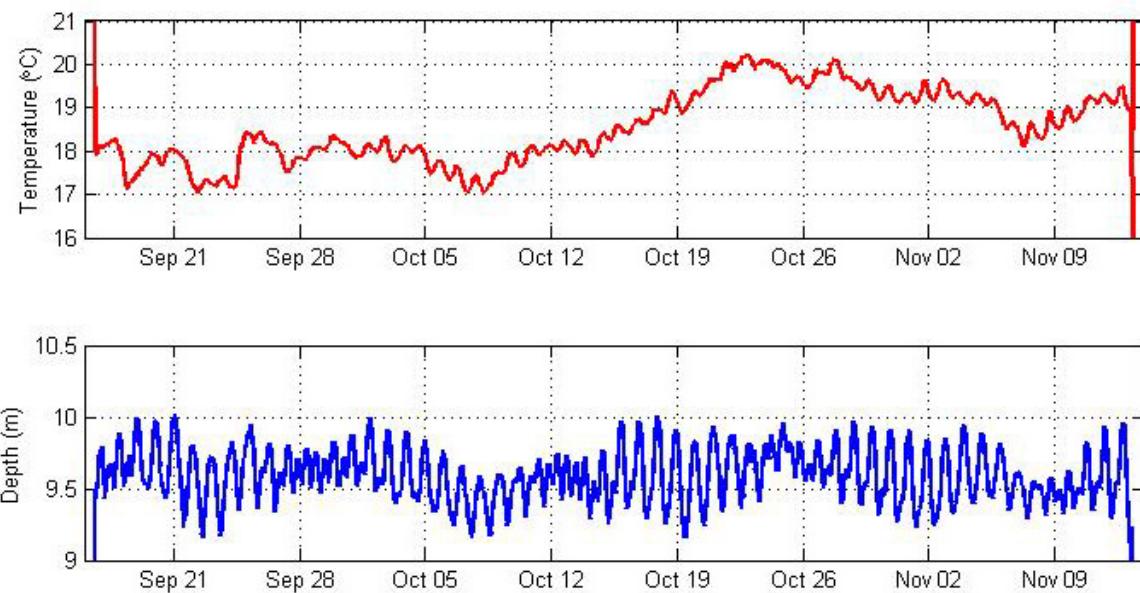


Fig. 10 Series of temperature and depth from SBE26 at site BL1\_7.

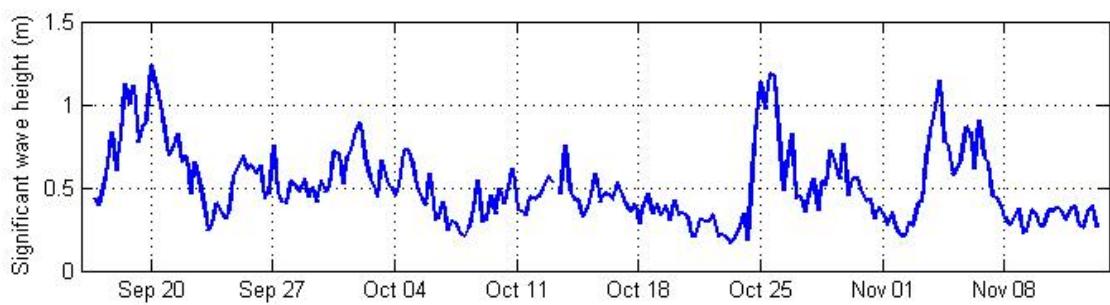


Fig. 11 Time series of significant wave height from SBE26 at site BL1\_7.

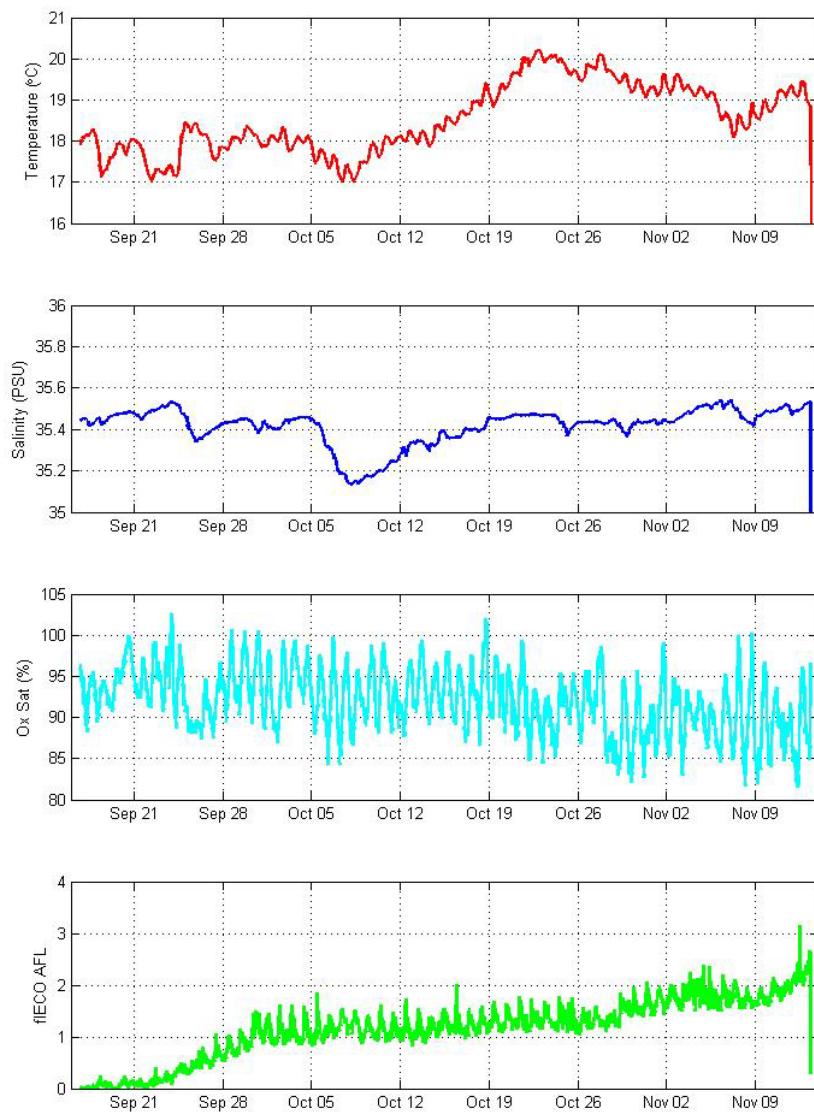


Fig. 12 Time series of temperature, salinity, oxygen saturation and fluorescence from SBE19plus at site BL1\_7.

## 2.2.8 Radar

Instrument: ISR DIR 25.9

- Transmit pulse rate 80 nS
- Pulse repetition frequency 2000 Hz
- Duty cycle 0.00016
- Period 1.25 seconds
- Sampling interval 10 minutes, every hour
- Rotation per sample 512

Antenna:

- 9 foot open scanning array (2.74m)
- Horizontal beam width 0.8°
- Vertical beam width 25°
- Gain 30 dB



Fig. 13 Installation of the radar.

Table 9 Radar deployment details.

Latitude	31.8525S
Longitude	115.7513E
Start	15/09/2008
Stop	11/11/2008

Table 10 Daily averages of wave and wind parameters.

day	Wave height (m)	Wave period (s)	Wave direction (degrees)	Wind speed (m/s)	Wind direction (degrees)
16/09/2008	1.29	14.09	259	4.81	177
17/09/2008	1.78	14.52	261	8.36	261
18/09/2008	2.44	11.32	263	11.65	278
19/09/2008	2.52	14.3	258	9.6	249
20/09/2008	2.65	17.07	258	7.27	273
21/09/2008	2.47	14.04	256	10.93	212
22/09/2008	1.74	12.83	259	4.22	103
23/09/2008	1.15	12.37	258	5.03	60
24/09/2008	1.43	13.13	265	7.2	268
25/09/2008	1.8	14.71	267	5.44	198
26/09/2008	1.8	15.39	261	7.54	166
27/09/2008	1.49	13.41	262	4.97	200
28/09/2008	1.65	12.33	261	4.02	208
29/09/2008	1.41	12.92	261	4.43	190
30/09/2008	1.73	10.65	265	8.15	246
1/10/2008	1.75	10.45	264	8.09	279
2/10/2008	1.88	12.13	260	7.42	182
3/10/2008	1.87	15.3	260	4.51	147
4/10/2008	1.98	14.16	260	8.56	184
5/10/2008	1.65	12.82	260	6.88	149
6/10/2008	1.17	12.67	261	5.64	131
7/10/2008	0.95	12.08	261	5.99	139
8/10/2008	0.97	17.03	259	4.9	127
9/10/2008	1.28	14.38	259	6.46	165
10/10/2008	1.62	14.99	258	5.29	146
11/10/2008	1.51	13.72	261	5.63	216
12/10/2008	1.69	13.91	261	7.11	180
13/10/2008	1.89	15.01	260	6.44	138
14/10/2008	1.58	14.62	260	5.04	120
15/10/2008	1.53	13.87	259	6.93	190
16/10/2008	1.66	14.4	261	6.49	198
17/10/2008	1.4	13.73	260	4.97	185
18/10/2008	1.3	12.08	262	5.95	169
19/10/2008	1.25	12.73	261	5.49	107
20/10/2008	1.11	13.09	260	6.04	115
21/10/2008	1.04	12.03	262	3.76	170
22/10/2008	1.07	12.13	261	4.18	140
23/10/2008	0.96	12.76	259	4.93	122
24/10/2008	1.9	11.68	269	9.56	272
25/10/2008	2.34	11.25	270	8.01	204
26/10/2008	1.61	11.36	263	4.59	145
27/10/2008	1.4	14.40	260	6.23	156
28/10/2008	1.73	12.59	260	9.00	177
29/10/2008	1.99	11.55	262	11.86	193
30/10/2008	1.46	13.79	261	7.04	167

31/10/2008	1.12	13.85	260	4.94	124
1/11/2008	1.2	15.03	260	6.16	122
2/11/2008	1.2	13.81	262	6.43	142
3/11/2008	1.95	13.03	263	9.12	243
4/11/2008	2.31	12.17	263	10.49	258
5/11/2008	1.94	8.8	266	10.36	258
6/11/2008	2.22	13.04	261	10.24	197
7/11/2008	1.46	14.21	261	6.38	163
8/11/2008	1.12	13.11	261	6.00	155
9/11/2008	1.24	12.75	263	6.06	171
10/11/2008	1.07	11.35	260	4.44	198
11/11/2008	1.15	12.41	260	5.5	163

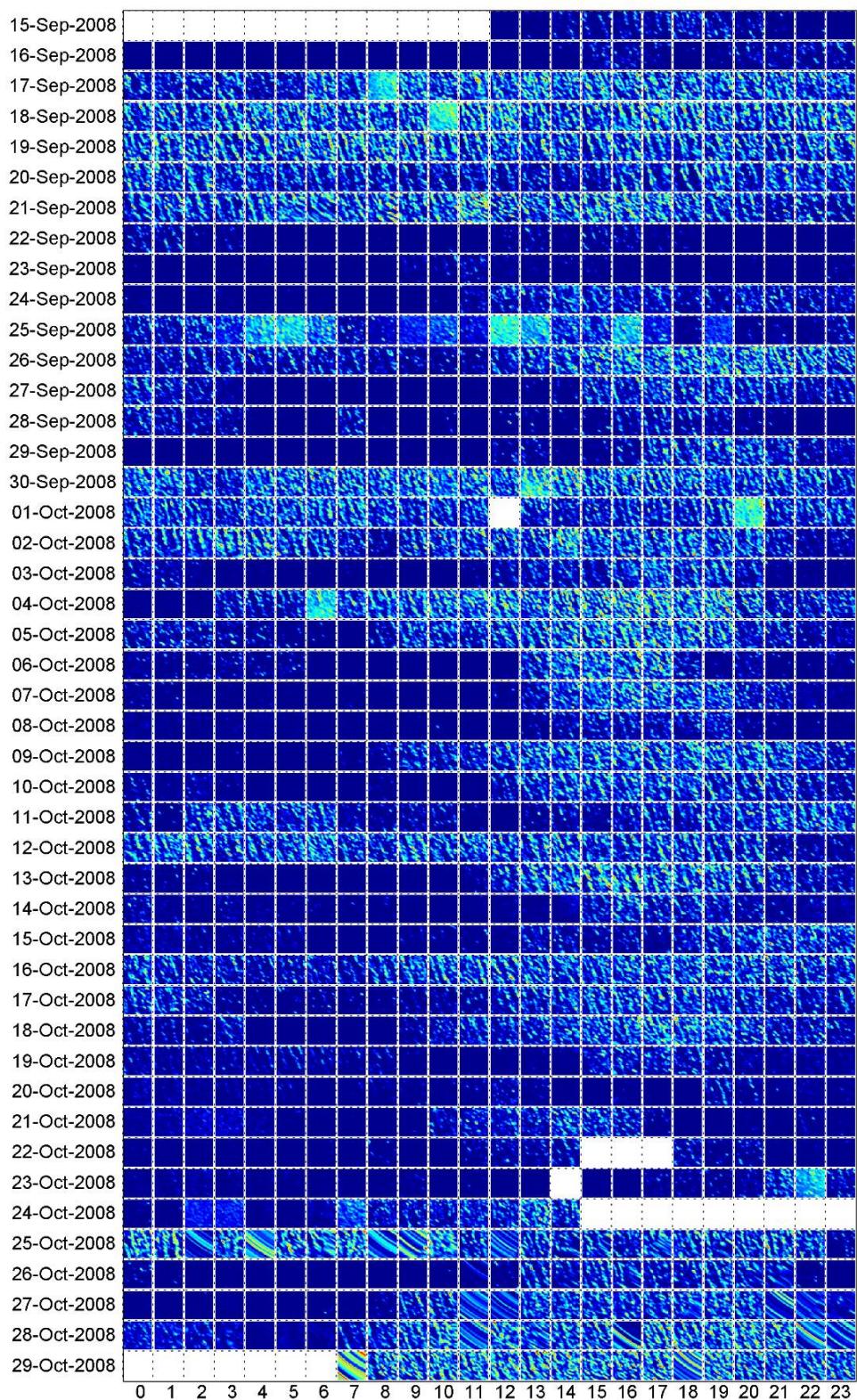


Fig. 14 Snapshot of hourly images of radar intensities from 15 September to 29 October.

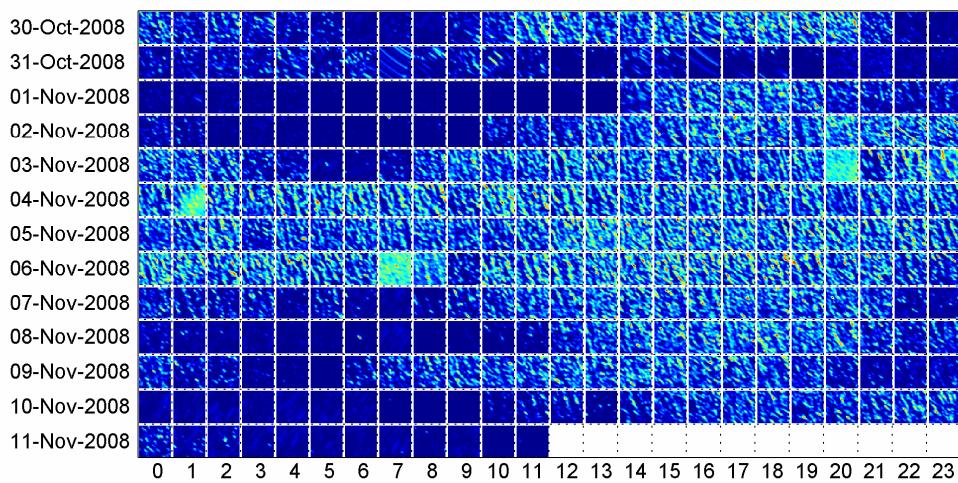


Fig. 15 Snapshot of hourly images of radar intensities from 30 October to 11 November.

### 3 NEARSHORE EXPERIMENT

At Secret Harbour beach, current meters were deployed across-shore spanning the surf zone and out to approximately one surf zone width beyond the breakpoint. Secret Harbour beach was chosen because it is a relatively straight and alongshore uniform beach typical of some of the Perth metropolitan beaches. The aims of this experiment were:

- To measure wave driven, cross-shore and alongshore currents during summer sea breeze cycles. Previous measurements of alongshore currents have focussed on steady conditions while the strong sea breeze cycle along Perth metropolitan beaches provides an opportunity to measure the temporal growth and decay of the wave driven flows.
- To provide data against which the Littoral Ocean Modelling System, developed as part of workpackage P3.3, can be tuned and validated.

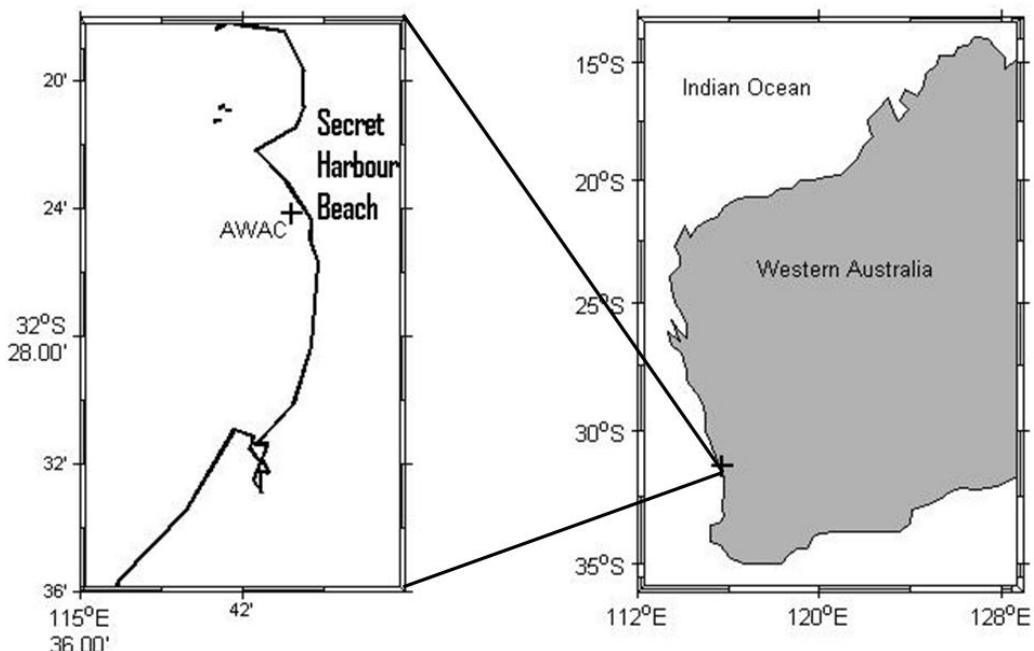


Fig. 16 Location of Nearshore experiment.

In order to quantify the wave incident on the site, an AWAC was deployed about one kilometre offshore, as shown on Fig. 16.

#### 3.1 Weather condition

The experiment was conducted during the summer month of February, when strong sea breeze cycle is present. Four days, from 16 to 20 February are identified when distinct sea breeze signal is present (Fig. 17).

The maximum wind speed doesn't exceed 15 m/s.

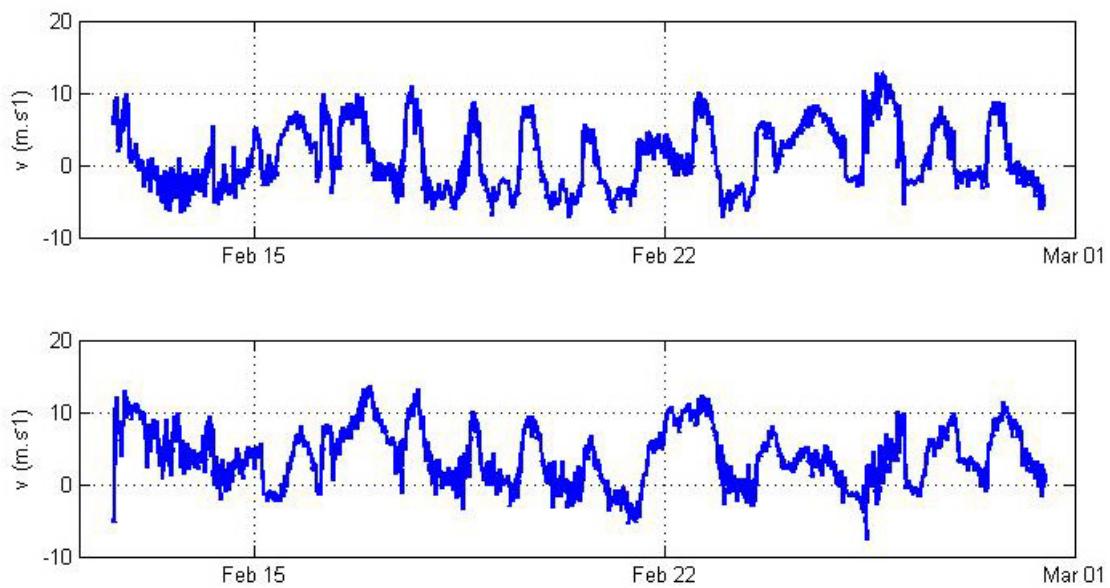


Fig. 17 Time series eastward and northward wind speed components from anemometer at radar site.

### 3.2 Instrument array

An array of instruments as shown in Fig. 18 was deployed in early February 2009 and recovered after a month. A summary of the deployment schedule is given in

Table 2 which also includes instruments types and measured parameters at each site. Exact location, start and stop times and sampling details are given in section 3.3.

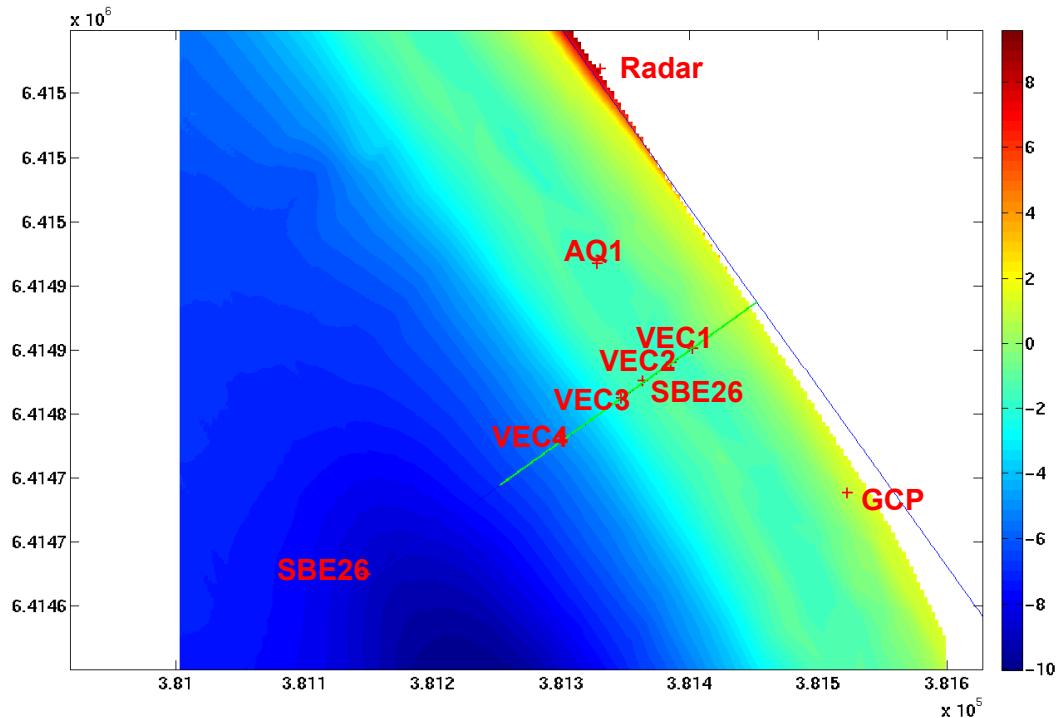


Fig. 18 Bathymetry at Secret Harbour beach and location of instruments.

Table 11 Deployment summary for Nearshore experiment. Eastward velocity ( $u$ ), northward velocity ( $v$ ), vertical velocity ( $w$ ), elevation ( $\eta$ ), pressure ( $P$ ), temperature ( $T$ ).

Site	Instrument	Parameters	Feb				Mar
			9	16	23	30	2
VEC1	Vector	$u, v, w, P, T$					
VEC2	Vector	$u, v, w, P, T$					
VEC3	Vector	$u, v, w, P, T$					
VEC4	Vector	$u, v, w, P, T$					
AQ1	Aquadopp ADCP	$u, v, P, T$					
AWAC	AWAC	$\eta, u(z), v(z), P, T$					
SBE26_1	SBE26	$P, T$					
SBE26_2	SBE26	$P, T$					
GCP							
Radar	ISR DIR 25.9						

### 3.3 Mooring data

#### 3.3.1 VEC1

Instrument: Nortek Vector and OBS

- Parameters u,v,w,P,T
- Sampling rate 1 Hz
- Record length 2048 samples
- Interval 3600s

A typical mooring frame used at the VEC sites is shown in Fig. 19.

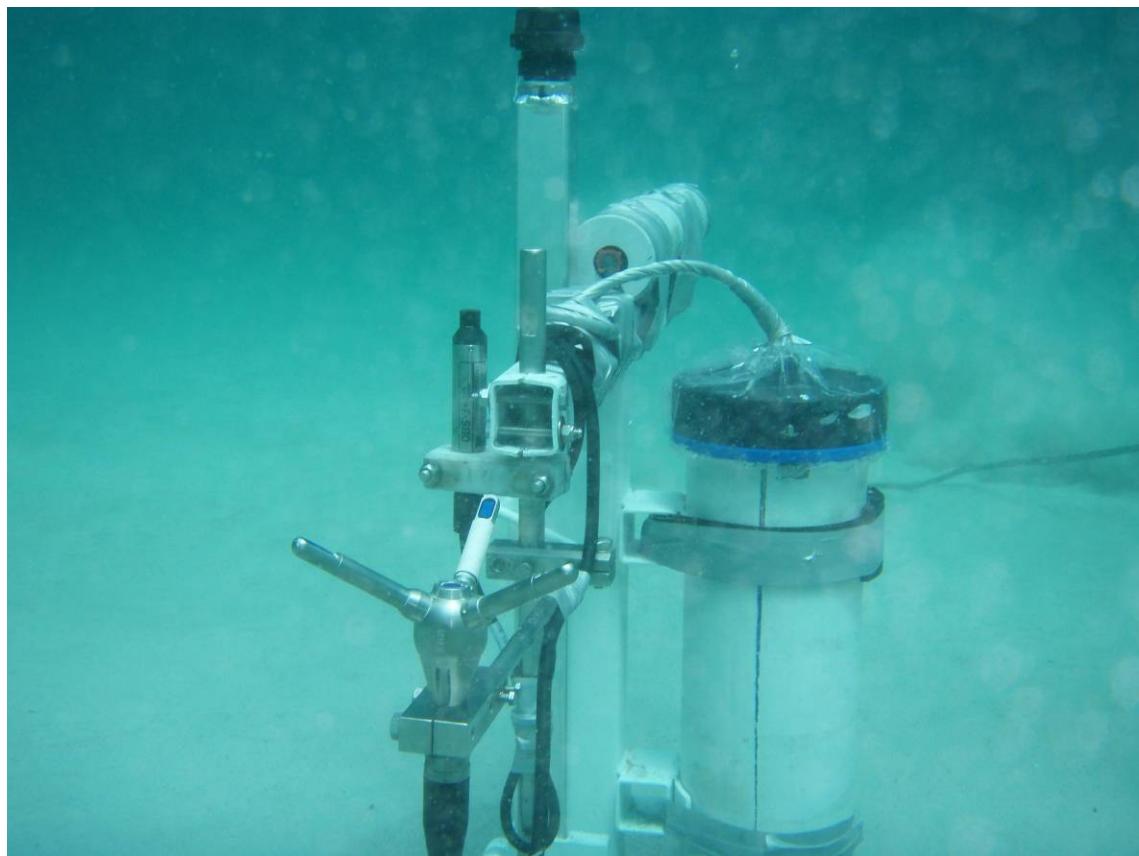


Fig. 19 VEC mooring frame.

Table 12 VEC1 deployment details.

Latitude	32.3971S
Longitude	115.7390E
Depth(m)	1.26
Start	11/02/2009 17:00:00
Stop	28/02/2009 18:34:06
Vector s/n	VEC 1674

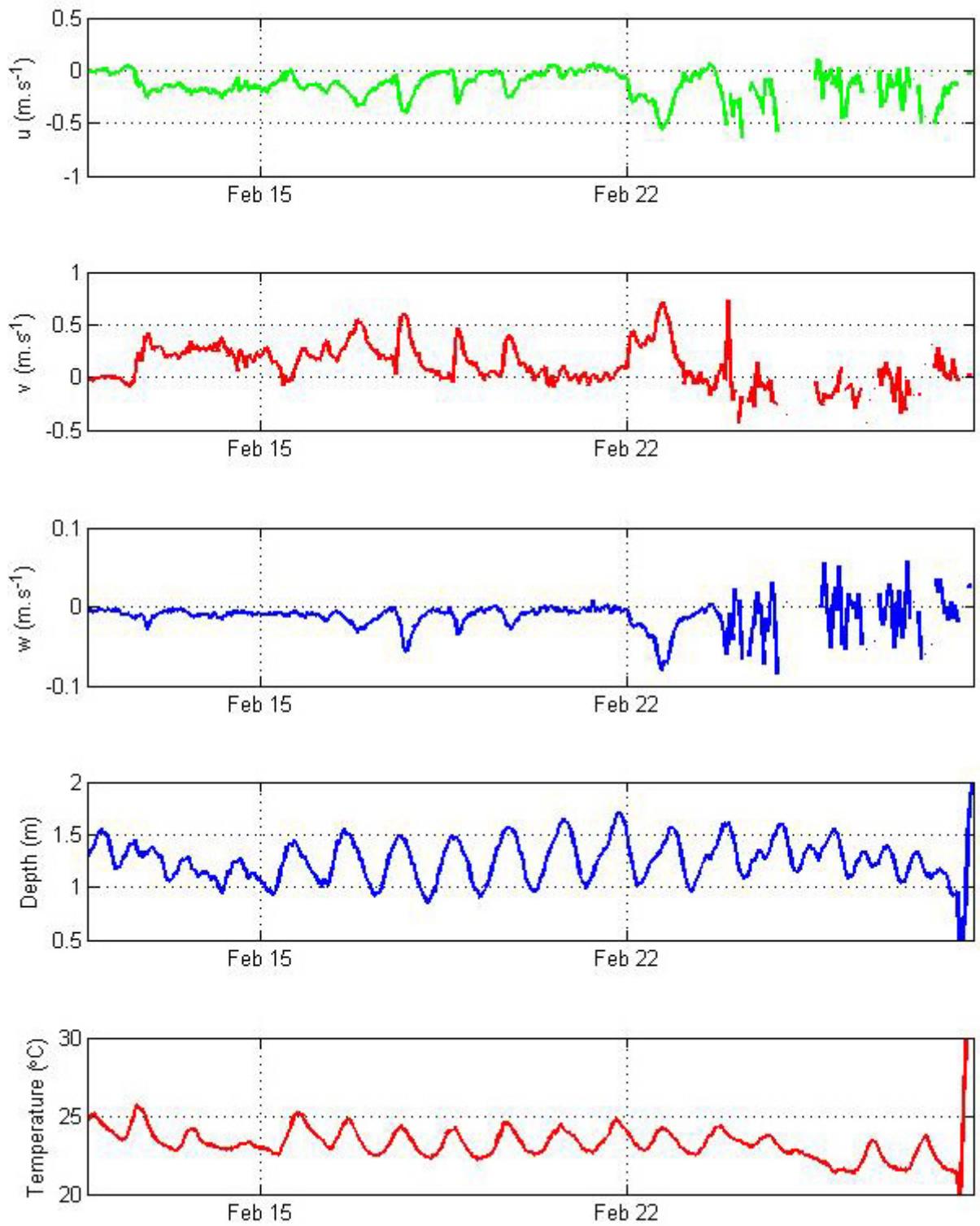


Fig. 20 Time series of current velocity components (eastward, northward, vertical), depth and temperature from Vector instrument at site VEC1.

### 3.3.2 VEC2

Instrument: Nortek Vector and OBS Parameters u,v,w,P,T

- Sampling rate 1 Hz
- Record length 1024 samples
- Interval 3600s
- 

Table 13 VEC2 deployment details.

Latitude	32.3972S
Longitude	115.7388E
Depth(m)	2.44
Start	11/02/2009 17:00:00
Stop	28/02/2009 18:15:50
Vector s/n	VEC 3325

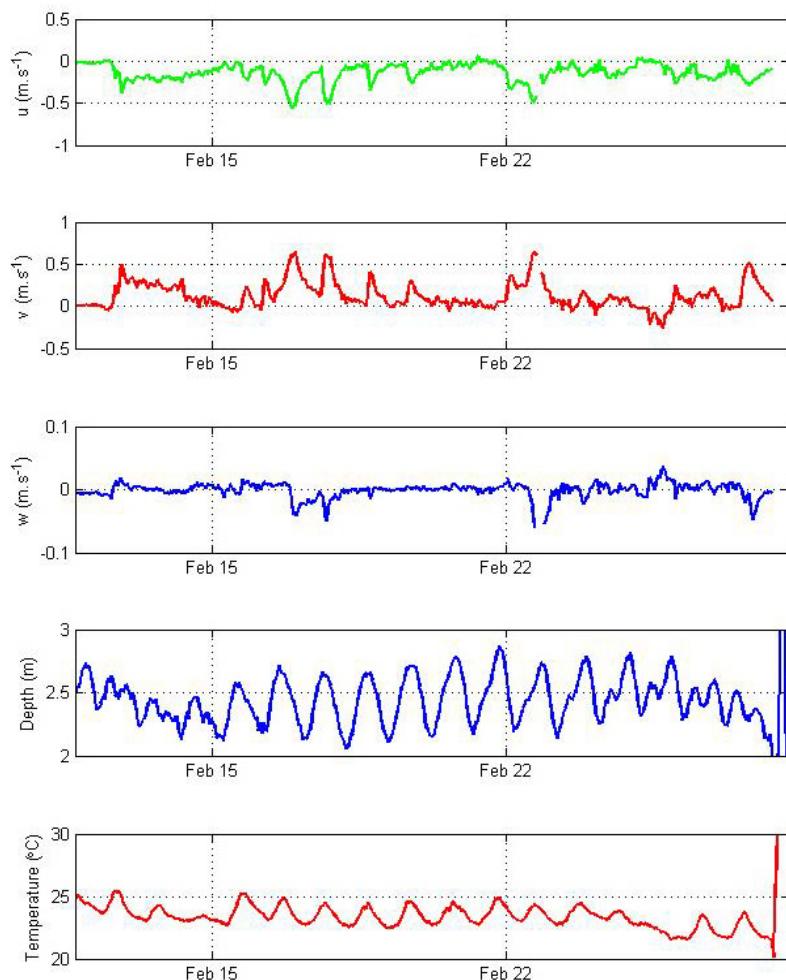


Fig. 21 Time series of current velocity components (eastward, northward, vertical), depth and temperature from Vector instrument at site VEC2.

### 3.3.3 VEC3

Instrument: Nortek Vector and OBS

- Parameters u,v,w,P,T
- Sampling rate 1 Hz
- Record length 2048 samples
- Interval 3600s

Table 14 VEC3 deployment details.

Latitude	32.3974S
Longitude	115.7384E
Depth(m)	1.83
Start	11/02/2009 17:00:00
Stop	27/02/2009 18:34:06
Vector s/n	VEC 1672

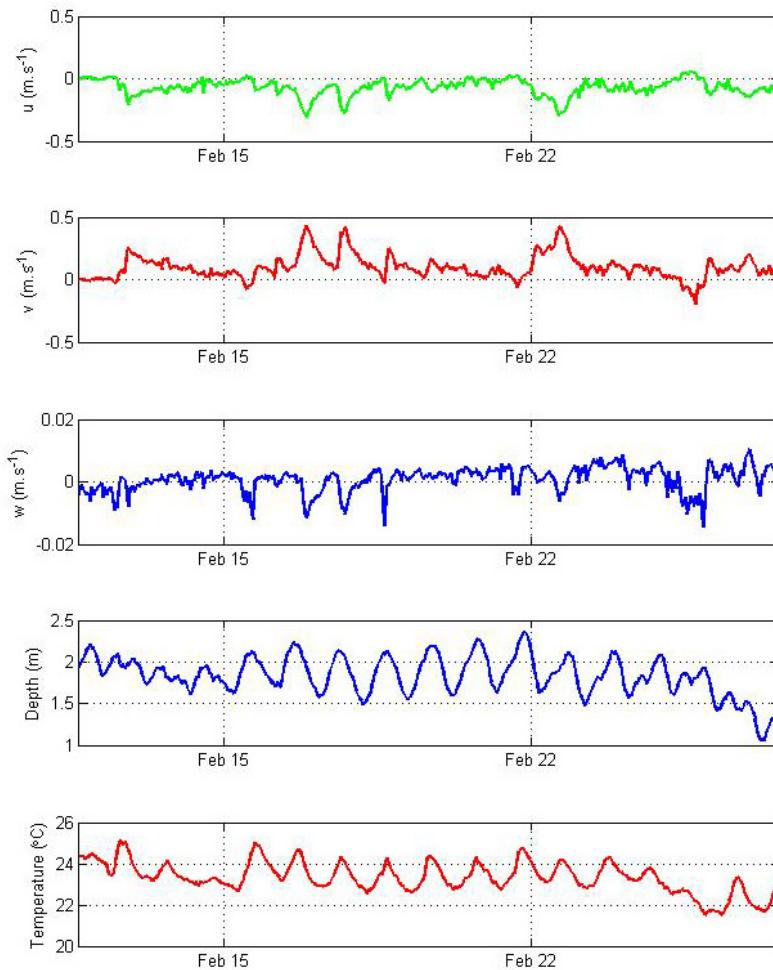


Fig. 22 Time series of current velocity components (eastward, northward, vertical), depth and temperature from Vector instrument at site VEC3.

### 3.3.4 VEC4

Instrument: Nortek Vector and OBS

- Parameters u,v,w,P,T
- Sampling rate 1 Hz
- Record length 2048 samples
- Interval 3600s

Table 15 VEC4 deployment details.

Latitude	32.3977S
Longitude	115.7379E
Depth(m)	5.01
Start	10/02/2009 17:00:00
Stop	28/02/2009 18:34:06
Vector s/n	VEC 1670

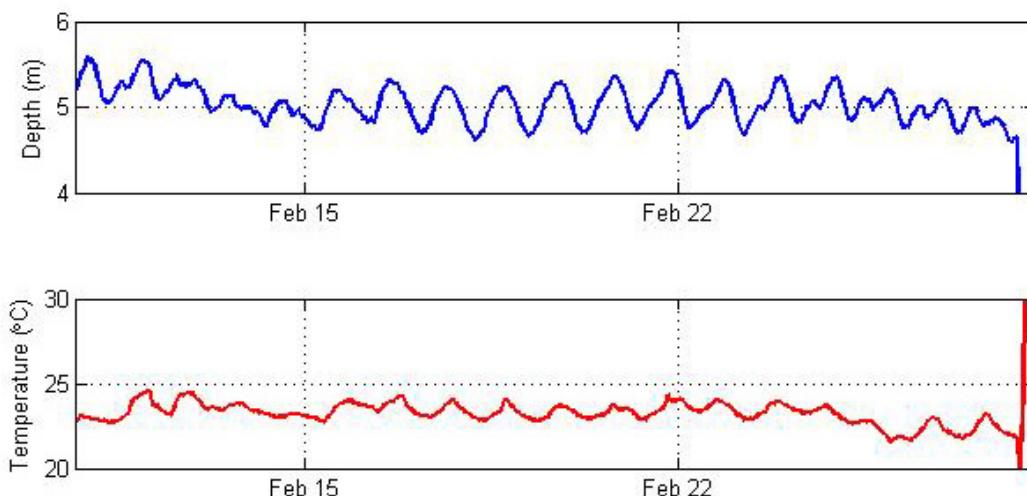


Fig. 23 Time series of depth and temperature from Vector instrument at site VEC4.

Comment:

Due to instrument malfunction no velocity data were recorded at this site.

### 3.3.5 AWAC

Instrument: Nortek AWAC

Current profile

- Parameters u,v
- Profile interval 1800s
- Cell size 0.5m

Waves

- Parameters u,v,AST,P,T
- Sample rate 1Hz
- Record length 2048
- Interval 3600s

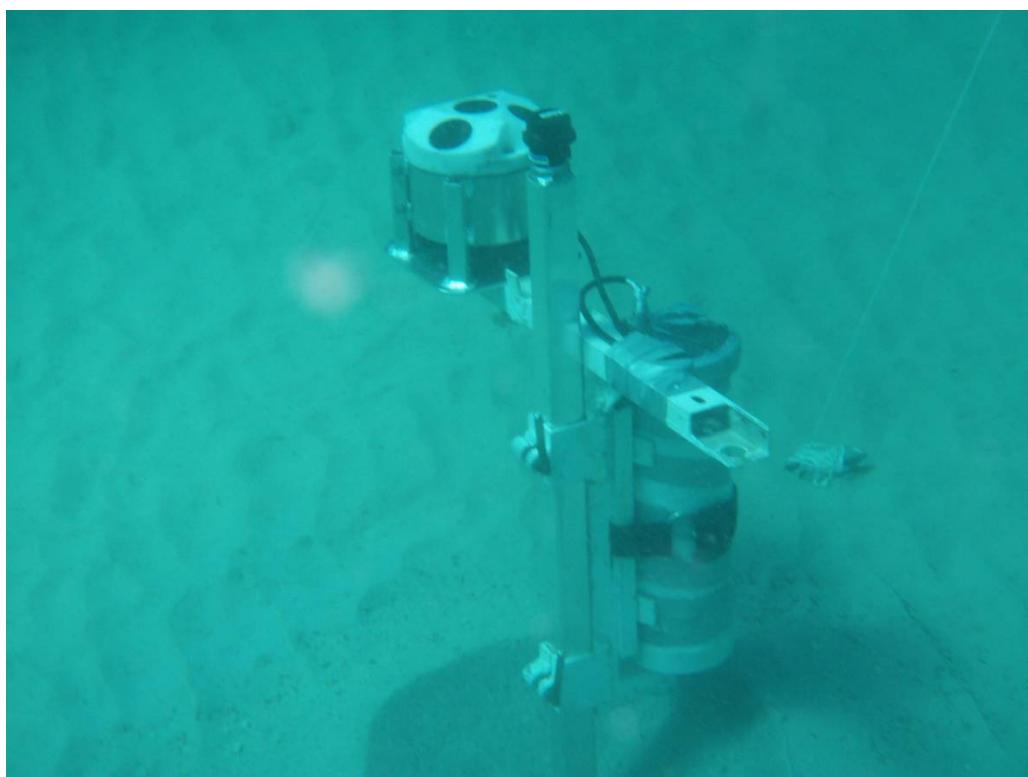


Fig. 24 AWAC.

Table 16 AWAC deployment details.

Latitude	32.4025S
Longitude	115.7297
Depth(m)	8.9
Start	10/02/2009 17:10:01
Stop	28/02/2009 17:44:07
s/n	WPR 0411

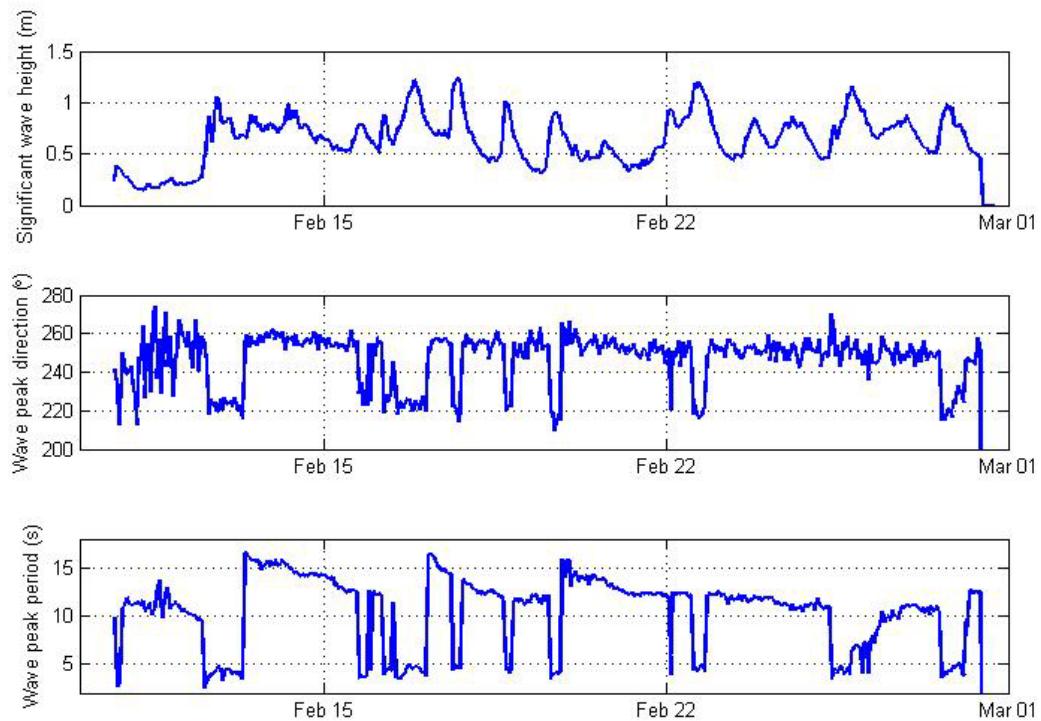


Fig. 25 Time series of significant wave height, peak direction and peak period from AWAC instrument.

Comment:

The AWAC was deployed off reef.

### 3.3.6 AQ1

Instrument: Nortek Aquadopp (2MHz)

Current profile

- Parameters u,v,P,T
- Profile interval 900s
- Average interval 300s

Table 17 AQ1 deployment details.

Latitude	32.3965S
Longitude	115.7382
Depth(m)	1.99
Start	11/02/2009 20:00:00
Stop	06/03/2009 03:30:00

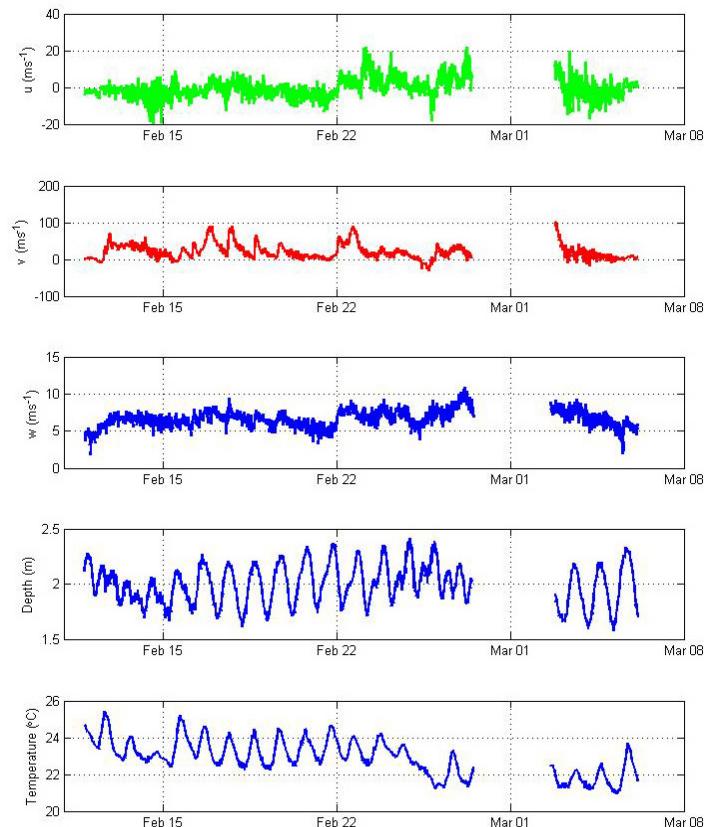


Fig. 26 Time series of current velocity components (eastward, northward, vertical), depth and temperature from Aquadopp instrument at site AQ1.

Comment:

This instrument was buried for a few days from 27 February when the sand bar apparently migrated over the instrument and was exposed again on 2 March.

### 3.3.7 SBE26\_1

Instrument: Seabird SBE26

- Tide interval 1800s
- Waves every 4 tide sample
- 2400 wave sample/burst at 2 scans/sec

Table 18 SBE26\_1 deployment details.

Latitude	32.3973S
Longitude	115.7386E
Depth(m)	0.9
Start	10/02/2009 12:45
Stop	27/02/2009 16:45
s/n	0409

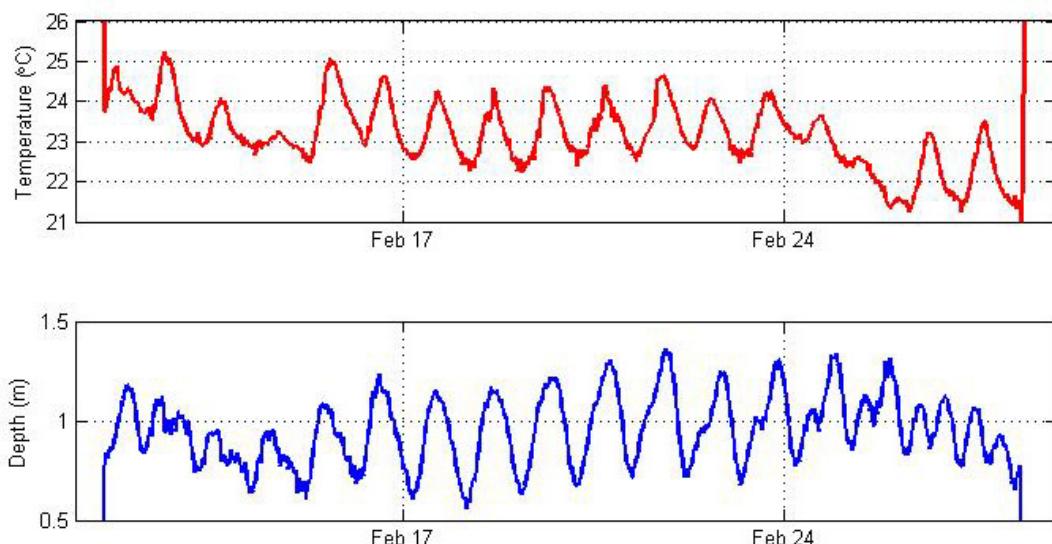


Fig. 27 Time series of temperature and depth from SBE26 at site SBE26\_1

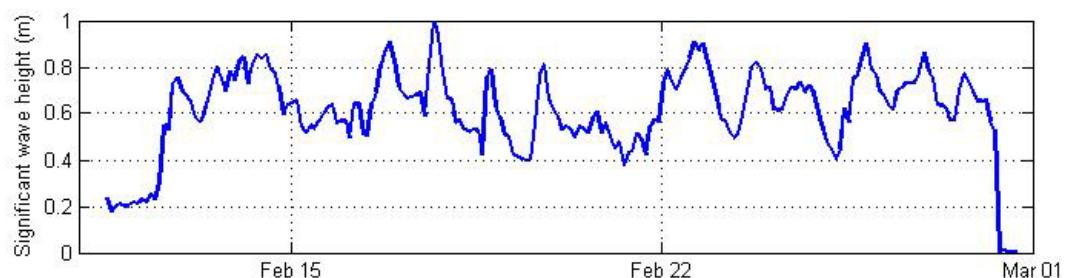


Fig. 28 Time series of significant wave height from SBE26 at site SBE26\_1.

### 3.3.8 SBE26\_2

Instrument: Seabird SBE26

- Tide interval 1800s
- Waves every 4 tide sample
- 2400 wave sample/burst at 2 scans/sec

Table 19 SBE26\_2 deployment details.

Latitude	32.3986S
Longitude	115.7362E
Depth(m)	8.6
Start	09/02/2009 12:00:00
Stop	27/02/2009 18:00:00
s/n	0408

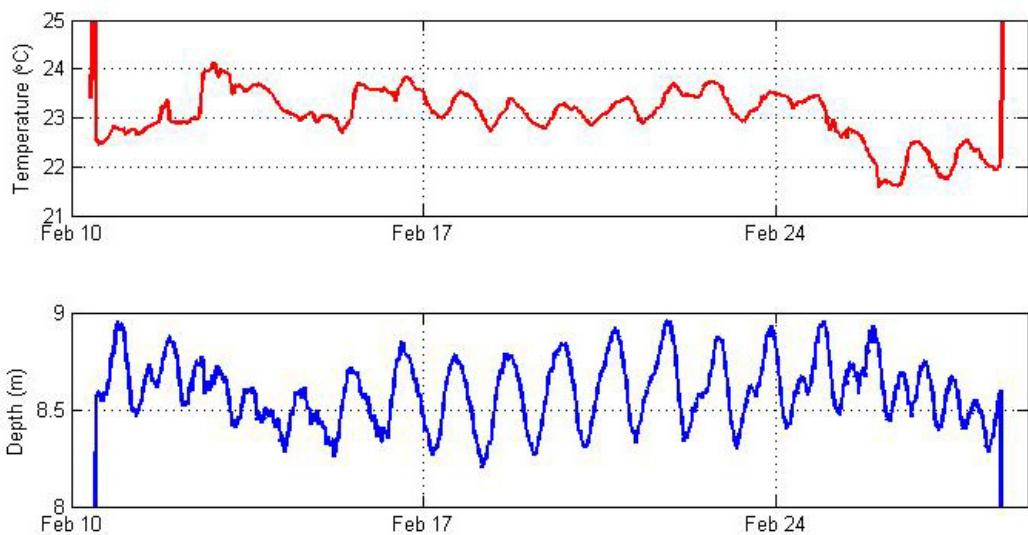


Fig. 29 Time series of temperature and depth from SBE26 at site SBE26\_2.

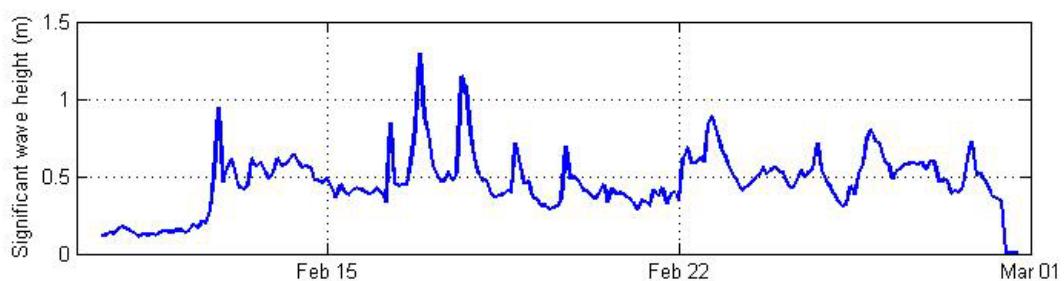


Fig. 30 Time series of significant wave height from SBE26 at site SBE26\_2.

### 3.3.9 Radar

Instrument: ISR DIR 25.9

- Transmit pulse rate 80 nS
- Pulse repetition frequency 2000 Hz
- Duty cycle 0.00016
- Period 1.25 seconds
- Sampling interval 22 minutes, every hour
- Rotation per sample 1029

Antenna:

- 9 foot open scanning array (2.74m)
- Horizontal beam width 0.8°
- Vertical beam width 25°
- Gain 30 dB



Fig. 31 Radar at Secret Harbour beach.

Table 20 Radar deployment details.

Latitude	32.3951S
Longitude	115.7382E
Start	11/02/2009
Stop	28/02/2009
s/n	

Table 21 Daily averages of wave and wind parameters and time averaged (10 minutes).

day	Wave height (m)	Wave period (s)	Wave direction (degrees)	Wind speed (m/s)	Wind direction (degrees)
11/02/2009	0.19	11.27	245	6.04	116
12/02/2009	0.48	7.29	242	9.24	141
13/02/2009	0.75	11.3	244	12.65	168
14/02/2009	0.77	14.69	257	7.21	176
15/02/2009	0.62	10.78	248	5.73	210
16/02/2009	0.83	6.21	231	10.11	194
17/02/2009	0.85	11.33	244	11.84	175
18/02/2009	0.6	10.95	249	8.37	154
19/02/2009	0.54	10.22	245	7.94	145
20/02/2009	0.51	13.8	255	6.8	132
21/02/2009	0.44	12.34	251	7.27	130
22/02/2009	0.93	9.63	241	12.37	184
23/02/2009	0.6	11.89	252	7.13	145
24/02/2009	0.7	11.21	251	5.98	237
25/02/2009	0.74	7.3	252	7.56	263
26/02/2009	0.77	8.96	248	8.24	194
27/02/2009	0.7	8.33	239	9.14	166
28/02/2009	0.59	9.64	242	8.26	141

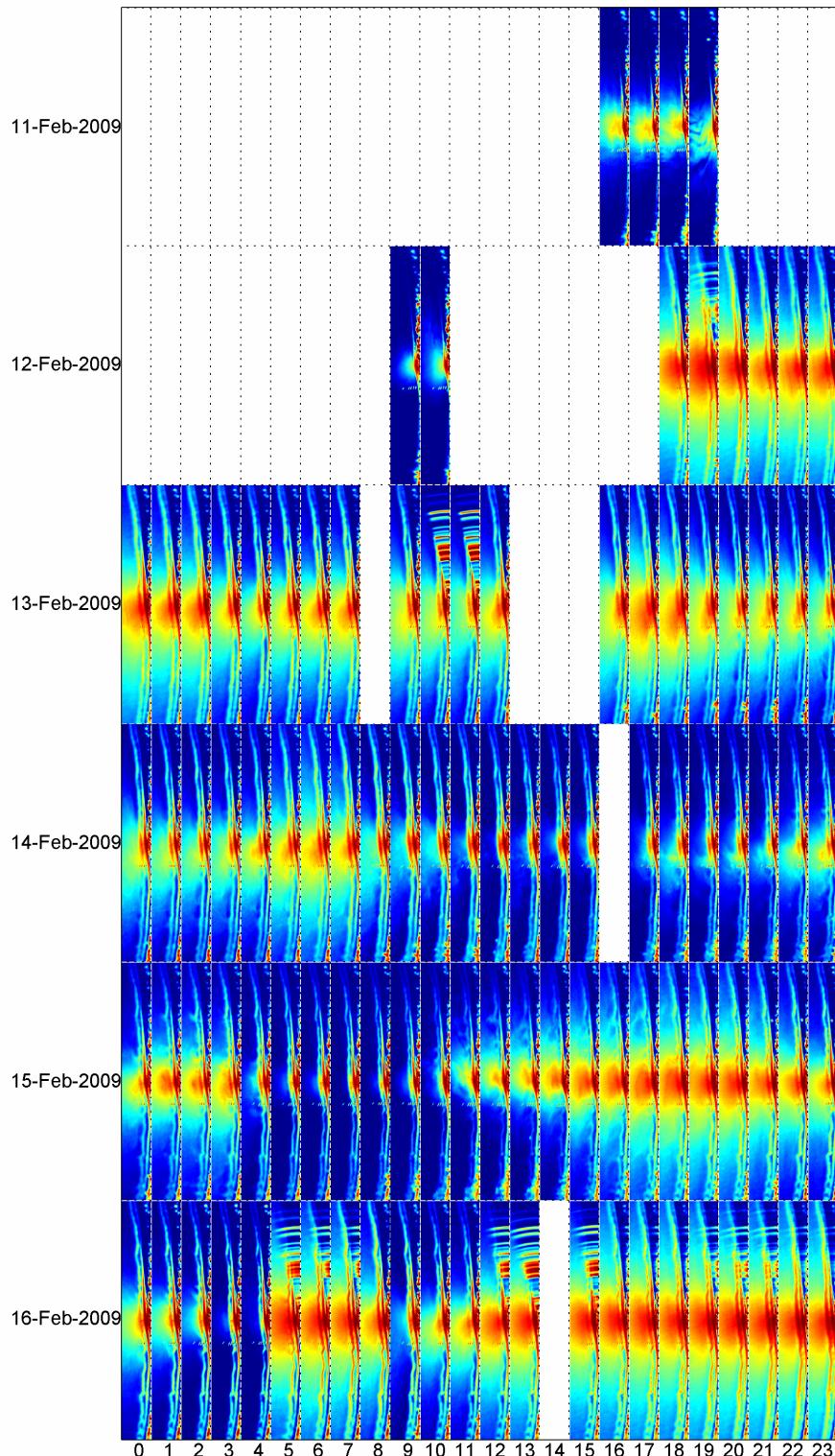


Fig. 32 Hourly images of 22 minute time averaged radar intensities from 11 to 16 February. Periods of larger waves (stronger winds) indicated by higher intensity shown in red.

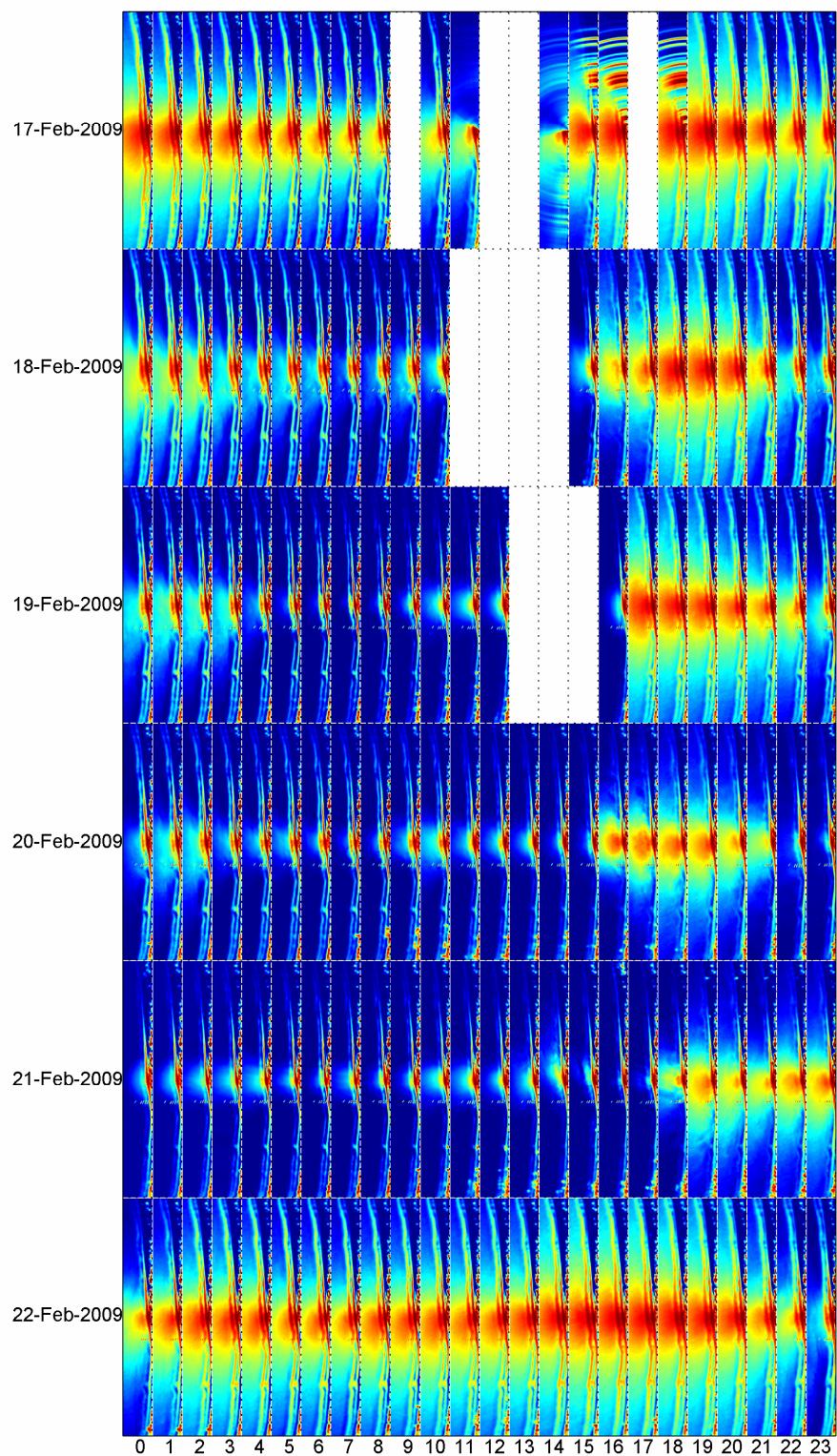


Fig. 33 Hourly images of 22 minute time averaged radar intensities from 17 to 22 February. Periods of larger waves (stronger winds) indicated by higher intensity shown in red.

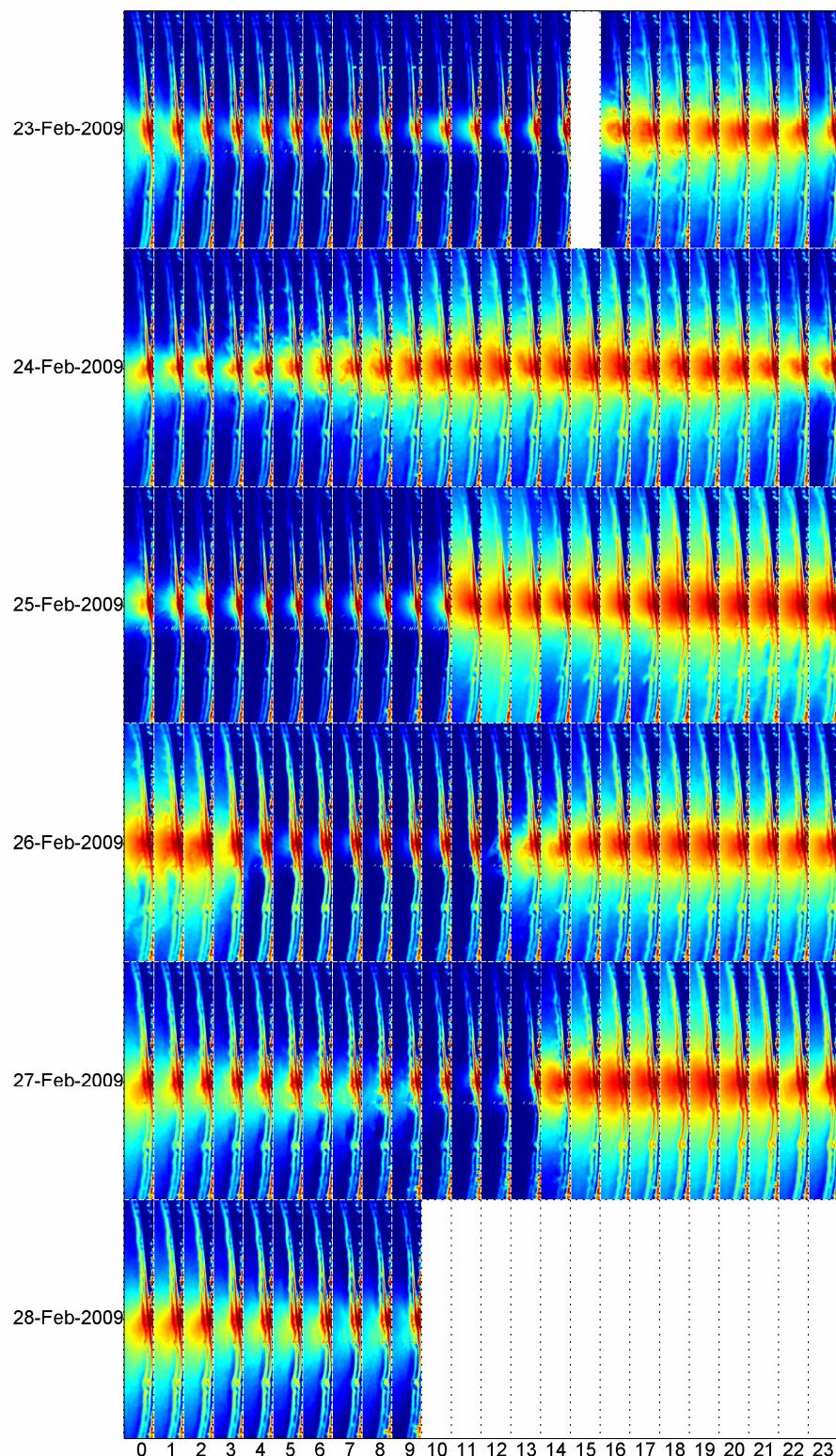
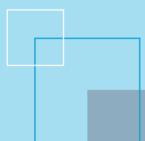


Fig. 34 Hourly images of 22 minute time averaged radar intensities from 23 to 28 February. Periods of larger waves (stronger winds) indicated by higher intensity shown in red.

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