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WHOI Hawaii Ocean Timeseries Station (WHOTS):

WHOTS-7 2010 Mooring Turnaround Cruise Report

by

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Technical Report

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Abstract

The Woods Hole Oceanographic Institution (WHOI) Hawaii Ocean Timeseries (HOT) Site (WHOTS), 100 km north of Oahu, Hawaii, is intended to provide long-term, high-quality air-sea fluxes as a part of the NOAA Climate Observation Program. The WHOTS mooring also serves as a coordinated part of the HOT program, contributing to the goals of observing heat, fresh water and chemical fluxes at a site representative of the oligotrophic North Pacific Ocean. The approach is to maintain a surface mooring outfitted for meteorological and oceanographic measurements at a site near 22.75°N, 158°W by successive mooring turnarounds. These observations will be used to investigate air–sea interaction processes related to climate variability.

This report documents recovery of the WHOTS-6 mooring and deployment of the seventh mooring (WHOTS-7). Both moorings used Surlyn foam buoys as the surface element and were outfitted with two Air–Sea Interaction Meteorology (ASIMET) systems. Each ASIMET system measures, records, and transmits via Argos satellite the surface meteorological variables necessary to compute air–sea fluxes of heat, moisture and momentum. The upper 155 m of the moorings were outfitted with oceanographic sensors for the measurement of temperature, conductivity and velocity in a cooperative effort with R. Lukas of the University of Hawaii. A pCO2 system was installed on the WHOTS-7 buoy in a cooperative effort with Chris Sabine at the Pacific Marine Environmental Laboratory.

The WHOTS mooring turnaround was done on the University of Hawaii research vessel *Kilo Moana*, by the Upper Ocean Processes Group of the Woods Hole Oceanographic Institution. The cruise took place between 27 July and 4 August 2010. Operations began with deployment of the WHOTS-7 mooring on 28 July. This was followed by meteorological intercomparisons and CTDs. Recovery of WHOTS-6 took place on 2 Aug 2010. This report describes these cruise operations, as well as some of the in-port operations and pre-cruise buoy preparations.

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1. Introduction

The Hawaii Ocean Timeseries (HOT) site, 100 km north of Oahu, Hawaii, has been occupied since 1988 as a part of the World Ocean Circulation Experiment (WOCE) and the Joint Global Ocean Flux Study (JGOFS). The present HOT program includes comprehensive, interdisciplinary upper ocean observations, but does not include continuous surface forcing measurements. Thus, a primary driver for the WHOTS mooring is to provide long-term, high-quality air-sea fluxes as a coordinated part of the HOT program and to contribute to the program goals of observing heat, fresh water and chemical fluxes at a site representative of the oligotrophic North Pacific Ocean. The WHOTS mooring also serves as an Ocean Reference Station – a part of NOAA’s Ocean Observing System for Climate – providing time-series of accurate surface meteorology, air-sea fluxes, and upper ocean variability to quantify air-sea exchanges of heat, freshwater, and momentum, to describe the local oceanic response to atmospheric forcing, to motivate and guide improvement to atmospheric, oceanic, and coupled models, to calibrate and guide improvement to remote sensing products, and to provide anchor point for the development of new, basin scale air-sea flux fields.

To accomplish these objectives, a surface mooring with sensors suitable for the determination of air–sea fluxes and upper ocean properties is being maintained at a site near 22°45′N, 158°00′W by means of annual “turnarounds” (recovery of one mooring and deployment of a new mooring near the same site). The moorings use Surlyn foam buoys as the surface element, outfitted with two complete Air–Sea Interaction Meteorology (ASIMET) systems. Each system measures, records, and transmits via Argos satellite the surface meteorological variables necessary to compute air–sea fluxes of heat, moisture and momentum.

Subsurface observations have been made on all WHOTS deployments in cooperation with Roger Lukas at the University of Hawaii (UH). The upper 155 m of the mooring line is outfitted with oceanographic sensors for the measurement of temperature, conductivity and velocity. For WHOTS-7, a pCO2 system for investigation of the air-sea exchange of CO2 at the ocean surface was mounted in the buoy well in cooperation with Chris Sabine at the Pacific Marine Environmental Laboratory (PMEL).

The mooring turnaround was done on the UH Research Vessel *Kilo Moana* by the Upper Ocean Processes Group (UOP) of the Woods Hole Oceanographic Institution (WHOI) with assistance from the UH personnel. The cruise originated from, and returned to, Honolulu, HI (Fig. 1-1). The facilities of the UH Marine Center at Sand Island, and a tent maintained by the Hawaii Undersea Research Lab, were used for pre-cruise staging.

2. Pre-Cruise Operations

a. Staging and Loading

Pre-cruise operations were conducted on the grounds of the UH Marine Center in Honolulu, HI. Two 40' containers held the buoy well, tower mid-section, tower top with modules, spare modules, VMCMs, acoustic releases and deck gear, instrument brackets and load bars, primary mooring components, deck boxes, lab boxes, anchor modules.

Many of the spares and support gear were already in Hawaii and we moved them to the ship with the rest of the gear, including the foam hull.

Three UOP representatives arrived in Honolulu and began offloading the gear to a staging area near the dock. UH personnel also assisted with in-port preparations. The UOP group was grateful for access to the Hawaii Undersea Research Laboratory (HURL) tent to house gear not suitable for outside storage and for use as a staging for electronics. In addition to loading the ship, pre-cruise operations included: assembly of primary and spare anchor, assembly of glass balls onto 4 m chain sections, painting of the buoy hull, assembly of the buoy tower top, insertion of the tower top assembly into the foam buoy hull, a buoy spin, evaluation of ASIMET data, and preparation of the oceanographic instruments.

For continued pre-cruise work in Hawaii, a 20-foot container is maintained at the UH Marine Center. Items left at the Marine Center included the assembled buoy hull, a spare anchor, approximately 80 glass balls, spare wire, nylon, and colmega. A detailed inventory list is maintained.

b. Buoy Spins

A buoy spin begins by orienting the buoy tower section towards a distant point with a known (i.e. determined with a surveyor's compass) magnetic heading. The buoy is then rotated, using a fork-truck, through eight positions in approximate 45-degree increments. At each position, the vanes of both wind sensors are oriented parallel with the sight line (vane towards the sighting point and propeller away) and held for several sample intervals. If the compass and vane are working properly, they should co-vary such that their sum (the wind direction) is equal to the sighting direction at each position (expected variability is plus or minus a few degrees).

The first buoy spins were conducted in the parking lot outside the WHOI Clark Laboratory high bay, with care taken to ensure that cars were not parked within about 30 ft of the buoy. The sighting angle to "the big tree" was about 310°, WHOI buoy spin.

The second buoy spin was conducted in Honolulu Fig 2-1, on an open area of dirt near the pier. A surveyor's compass was used to determine that the magnetic field in the area was constant within a few degrees. A building with tall antennae on top was sighted approximately 4 miles away at a bearing of 90.5° and was used as a sighting point.

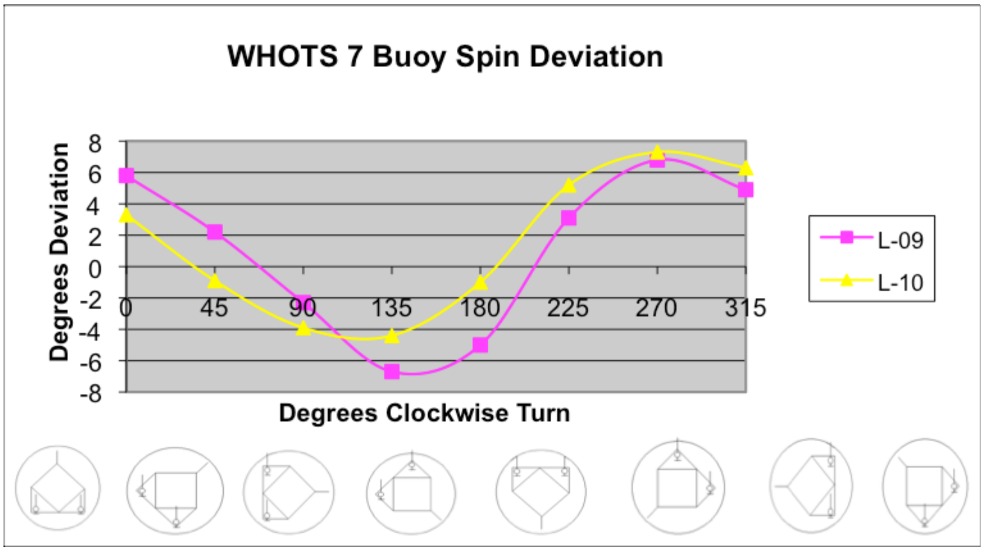

Fig 2-1: Buoy spin data.

c. Sensor Evaluation

Once the buoy well and tower top were assembled, the ASIMET modules were initialized and connected to the loggers. When mechanical assembly was complete, power was applied, the loggers were started, and data acquisition began. Evaluation of the primary sensor suite was done through a series of overnight tests. Both hourly Argos transmissions and 1 min logger data were evaluated.

A series of “sensor function checks,” including filling and draining the PRC modules, covering and uncovering the solar modules, and dunking the STC modules in a salt-water bucket, were done during the in-port evaluation period. The results of these checks, and a final in-port evaluation of hourly Argos data, showed all modules to be functioning as expected.

3. WHOTS-7 Mooring Description

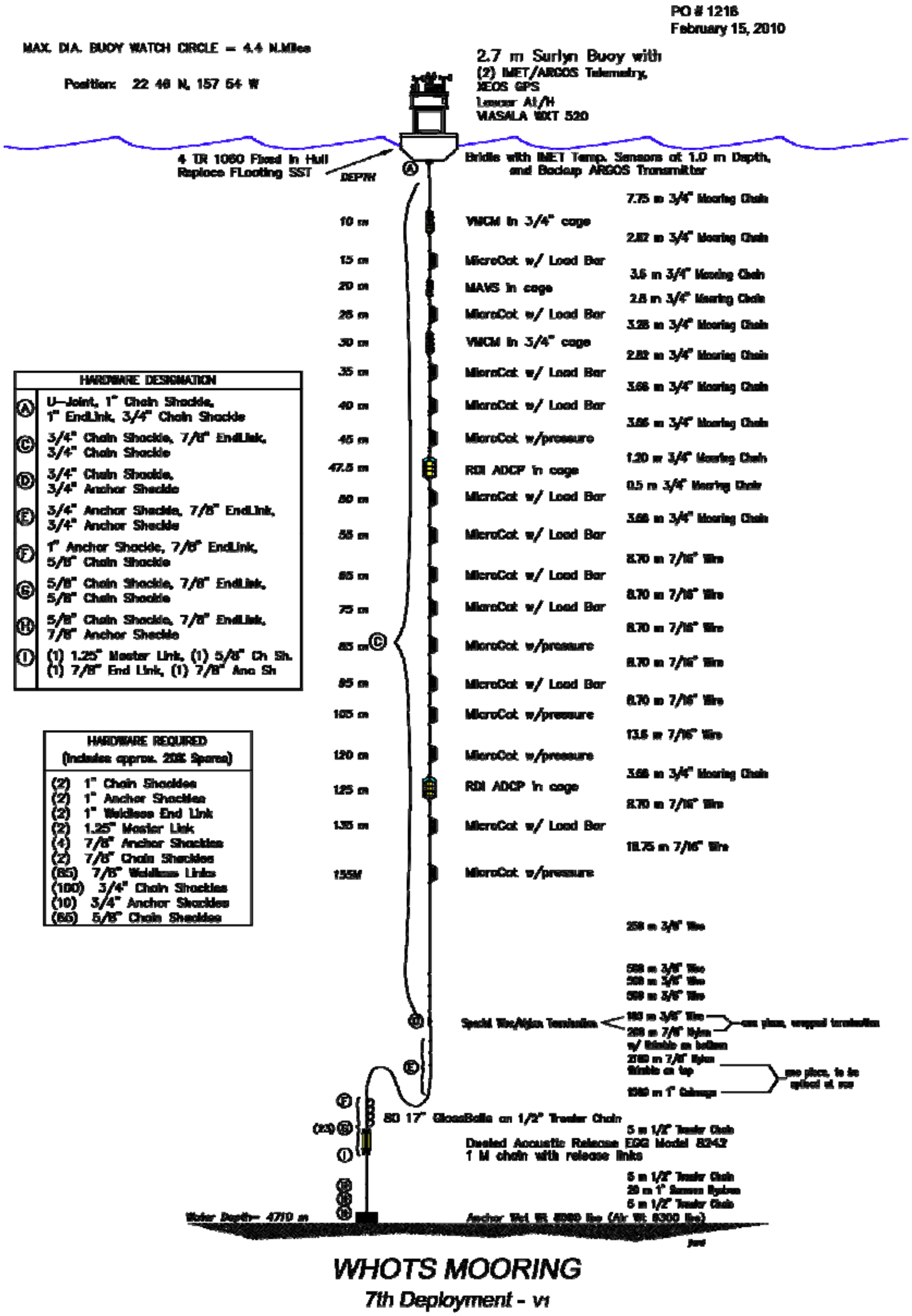

Figure 3-1: WHOTS 7 Mooring Design

a. Mooring Design

The mooring is an inverse catenary design utilizing wire rope, chain, nylon line and polypropylene line. The mooring scope (ratio of total mooring length to water depth) is about 1.25. The watch circle has a radius of approximately 2.2 nm (4.2 km). The surface element is a 2.7-meter diameter Surlyn foam buoy with a watertight electronics well and aluminum instrument tower. The two-layer foam buoy is “sandwiched” between aluminum top and bottom plates, and held together with eight 3/4" tie rods. The total buoy displacement is 16,000 pounds, with reserve buoyancy of approximately 12,000 lb when deployed in a typical configuration. The modular buoy design can be disassembled into components that will fit into a standard ISO container for shipment. A subassembly comprising the electronics well and meteorological instrument tower can be removed from the foam hull for ease of outfitting and testing of instrumentation. Two ASIMET data loggers and batteries sufficient to power the loggers and tower sensors for one year fit into the instrument well. Two complete sets of ASIMET sensor modules are attached to the upper section of the two-part aluminum tower at a height of about 3 m above the water line. The tower also contains a radar reflector, a marine lantern, and two independent Argos satellite transmission systems that provide continuous monitoring of buoy position. A third Argos positioning system was mounted within an access tube in the foam hull. This is a backup system, and would only be activated if the buoy capsized. For WHOTS-7, a self-contained Global Positioning System (GPS) receiver and a PCO_2 sampling system were also mounted on the buoy. Sea surface temperature and salinity are measured by sensors bolted to the underside of the buoy hull and cabled to the loggers through an access tube through the buoy foam.

Temperature-conductivity sensors, Vector Measuring Current Meters (VMCMs) and Acoustic Doppler Current Meters (ADCP) were attached along the mooring using a combination of load cages (attached in-line between chain sections) and load bars. All instrumentation was along the upper 155 m of the mooring line. Dual acoustic releases, attached to a central load-bar, were placed approximately 33 m above the anchor. Above the release were eighty 17” glass balls meant to keep the release upright and ensure separation from the anchor after the release is fired. This flotation is sufficient for backup recovery, raising the lower end of the mooring to the surface in the event that surface buoyancy is lost.

b. Bird Barrier

WHOTS-4 incorporates *Nixalite Premium Bird Barrier Strips Model S* as a physical deterrence for pest birds and their accompanying guano deposition. The anti-bird wire is constructed of 316 stainless steel and is 4 inches high and 4 inches wide and has no less than 120 wire points per foot with full 180-degree coverage. The wire strips were installed fully around the crash bar, the flat top portion, inside lip, and carefully around the solars. Individual strips were 4 foot long and secured with cable ties. Order: S Kit 6 - 4 ft strips 24ft and S Kit 10 - 4ft strips 40ft Kit. The wires are sharp so it is recommended that gloves and eye protection be used for installation. Furthermore, transparent monofilament fishing line was installed in a simple X pattern inside the tower to also serve as a deterrent.

c. Anti-foul Treatment

E-Paint’s products have been refined to best suit the wishes of WHOI- effective products that remain relatively safe to apply. Treatment of the WHOTS-7 mooring was straightforward.

In Addition to one coat of gray E-Primer, the Surlyn foam buoy hull and aluminum bottom plate were treated with 2 gallons of white E-Paint Sunwave.

E-Paint ZO was used to coat the two SBE 37s mounted to the bottom of the buoy. Sea surface temperature probes were inserted into the hull and sprayed with a contrasting gray transducer paint for antifouling as well as high visibility for water line assessment.

E-Paint ZO was also used to treat the instruments mounted on the mooring line down to 50 meters. On the VMCMs, propellers were treated with gray E-Paint and the hubs were sprayed with gray transducer paint prior to deployment.

d. Buoy Instrumentation

i. Surface

WHOTS 7 Serials/Heights			
	System 1		
Module	**Serial**	**Firmware Version**	**Height Cm**
Logger	L-09	LOGR53 v4.11cf	
HRH	506	v4.29cf	239
BPR	505	v4.03cf	237
WND	207	v4.02cf	264.5
PRC	209	v4.03cf	235
LWR	218	v4.02cf	279
SWR	201	v4.01cf	278
SST	1419	2.3b	
	System 2		
Module	**Serial**	**Firmware Version**	**Height Cm**
Logger	L-10	LOGR53 v4.11cf	
HRH	216	v4.29cf	240
BPR	216	v4.03cf	238.5
WND	221	v4.02cf	266.5
PRC	502	v4.03cf	238.5
LWR	212	v4.02cf	279
SWR	505	v4.01cf	278
SST	1306	2.3b	
Vaisala weather station	VWX-001	RH sensor	260
		Wind Fingers	281
XEOS	1980	IMEI# = 300034013701980	
Lascar	11609		231
SIS BEACON	103		

Table 3-1

ii. Sea Surface Temperature Array

The WHOTS 7 buoy was deployed with Brancker TR-1060s and prototype Seabird SBE56 temperature probes. The sampling rate was pushed to 5 seconds for experimentation. Two fixed sea surface probes mounted on bridle will sample for deployment duration at a minute interval.

SBE56	**Sample**	**Start**	**Spike Start**	**Spike End**
0023	5 seconds	7/22 01:28:00	7/22 18:49:00	7/22 19:49:00
0022	5 seconds	7/22 01:38:00	7/22 18:49:00	7/22 19:49:00

TR1060	**Sample**	**Start**	**Spike Start**	**Spike End**
14812	5 seconds	7/22 01:00:00	7/22 18:49:00	7/22 19:49:00
14813	5 seconds	7/22 01:50:50	7/22 18:49:00	7/22 19:49:00
20182	5 seconds	7/22 01:46:30	7/22 18:49:00	7/22 19:49:00
20186	5 seconds	7/22 01:00:00	7/22 18:49:00	7/22 19:49:00
Endurance: memory 100% battery 79%				

Front -80 cm	Starboard -80 cm	Port -80 cm	Aft -80 cm
TR1060 14813 (stbd)	TR1060 14812	TR1060 20186	SBE56 0023 (stbd)
SBE56 0022 (port)			TR1060 20182 (port)

	Serial	Depth Below Deck
SBE37 SST	1419	-150.5
SBE37 SST	1306	-150.5

Table 3-2

Figure 3-2: SST seen at -80 cm below deck

iii.SIS Argos

The buoy hull also contained an emergency beacon. In the event of catastrophic failure where the buoy hill flips upside down, an Argos beacon would activate and relay position information to facilitate recovery.

iv. Global Positioning System

WHOTS 7 deployed a XEOS GPS unit.

v. Telemetry

WHOTS 7 deployed using 2 Argos Satellite data transmission systems.

vi. PCO$_2$

The WHOI Hawaii Ocean Time-series Station (WHOTS) is located near the HOT shipboard time series site (22.75°N, 158°W) in order to maximize the utility of both data sets. There are several advantages of this site. These include: (1) A rich historical database is available for the site; this is useful for setting up new moored instruments, as well as facilitating intercomparisons and interpretations; (2) The HOT site is well away from sources of anthropogenic influence, which is especially important for trace metal, dissolved CO_2, oligotrophic biological and optical, and aerosol studies; (3) The ongoing JGOFS time-series sampling program (approximately monthly frequency) collects a relatively complete suite of physical, chemical (including nutrients and CO_2), and biological data. There are analogous advantages for comparisons and calibrations of present and emerging sensors; (4) Remote sensing data (SeaWiFS, AVHRR, TOPEX/Poseidon and ERS-series altimetry, QuikScat, MODIS, and weather images) are collected, thus providing complementary measurements for our study and *vice versa*; (5) there is a documented need for high temporal resolution/mooring data at the site because of undersampling and aliasing as described above; (6) there is a reasonably high probability of passage of intense storms and occasionally hurricanes; (7) other testing is either ongoing or planned from other platforms near the HOT site (e.g., AUVs); and (8) the region is often used for other scientific studies that can be used to enhance the HOT and WHOTS data sets and *vice versa*.

Adding a pCO_2 system to the WHOTS mooring expands the OceanSITES moored pCO_2 network. The current network is developing in the North Pacific. This site provides the next logical step for an expansion.

CO_2 measurements are made every three hours in marine boundary layer air and air equilibrated with surface seawater using an infra-red detector. The detector is calibrated prior to each reading using a zero gas derived by chemically stripping CO_2 from a closed loop of air and a span gas (470 ppm CO_2) produced and calibrated by NOAA's Earth System Research Laboratory (ESRL). For an overview of the system visit: http://www.pmel.noaa.gov/co2/moorings/eq_pco2/pmelsys.htm. PMEL pCO_2 system was used for this deployment.

A summary file of the measurements is transmitted once per day and plots of the data are posted in near real-time to the web. To view the daily data visit the NOAA PMEL Moored CO_2 Website: http://www.pmel.noaa.gov/co2/moorings/hot/hot_main.htm. Within a year of system recovery, the final processed data are submitted to the Carbon Dioxide Information Analysis Center (CDIAC) for release to the public.

vii. Subsurface Instrumentation

UH provided 15 SBE-37 Microcats, an RDI 300 kHz Workhorse ADCP, an RDI 600 kHz Workhorse ADCP, and a Nobska MAVS acoustic velocity sensor. WHOI provided 2 Vector Measuring Current Meters (VMCMs). The Microcats measure temperature and conductivity; six Microcats also measure pressure. Table 1 provides deployment information for the C-T instrumentation on the WHOTS-7 mooring.

SN:	Instrument	Depth	Pressure SN	Sample Interval (sec)	Start Logging Data(GMT)	Cold Spike In (GMT)	Cold Spike Out (GMT)	Time in Water (GMT)
3382	Microcat	15	N/A	150	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 19:00:20
10261	MAVS	20	N/A	1800	07/26/10 0:00:00	07/27/10 20:25:00	07/27/10 21:05:00	07/28/10 18:54:15
4663	Microcat	25	N/A	150	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 18:52:45
3633	Microcat	35	N/A	150	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 18:48:30
3381	Microcat	40	N/A	150	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 18:44:20
3668	Microcat	45	5579	180	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 18:40:45
3917	600 kHz ADCP	47.5	N/A	600	7/26/2010 0:00:00	07/27/10 19:45:00	07/27/10 20:03:00	07/28/10 18:39:10
3619	Microcat	50	N/A	150	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 18:38:40
3620	Microcat	55	N/A	150	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 19:40:20
3621	Microcat	65	N/A	150	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 19:45:40
3632	Microcat	75	N/A	150	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 19:48:45
4699	Microcat	85	10209	180	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 19:51:37
3791	Microcat	95	N/A	150	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 19:54:05
2769	Microcat	105	2949	180	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 19:56:55
4700	Microcat	120	2479944	180	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 20:04:55
7637	300 kHz ADCP	125	N/A	600	07/26/10 0:00:00	07/27/10 20:05:00	07/27/10 20:23:00	07/28/10 20:05:20
3669	Microcat	135	5700	180	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:33:00	07/28/10 20:07:45
4701	Microcat	155	10211	180	07/22/10 0:00:00	07/22/10 23:21:00	07/23/10 0:21:00	07/28/10 20:11:16

Table 3-3: WHOTS-7 mooring subsurface instrument deployment information. All times are in UTC.

VMCM	Depth	Sample
035	10 meters	1 minute
038	30 meters	1 minute

Table 3-4: WHOTS-7 VMCM configuration and deployment information

The ADCPs were deployed in the upward-looking configuration. The MAVS was deployed in a vertical downward orientation. The instruments were programmed as described in Table 2. ADCP S/N 3917 was observed to have a 30 second clock drift before deployment. Both ADCPs were stopped, clocks reset, and new files were appended to the data record. The Time of First Ping listed in Table 2 reflects the new file start times. The original start files were preserved so that they may be compared to cold spike times to assess the apparent pre-deployment clock drift.

	ADCP S/N 7637	ADCP S/N 3917	MAVS S/N 10261
Frequency (kHz)	300	600	N/A
Number of Depth Cells	30	25	1
Pings per Ensemble	40	80	80
Depth Cell Size	4 m	2 m	N/A
Time per Ensemble	10 min	10 min	30 min
Time per Ping	4 sec	2 sec	2 sec
Time of First Ping	07/28/10, 02:00	07/28/10, 02:00	07/26/10, 00:00
Cold Spike Time	07/27/10, 20:05	07/27/10, 19:45	07/27/10, 20:25
Time in water	07/28/10, 20:05	07/28/10, 18:39	07/28/10, 18:54
Depth	125 m	47.5 m	20 m

Table 3-5: WHOTS-7 mooring ADCP and MAVS deployment information.

4. WHOTS-7 Mooring Deployment

a. Deployment Operations

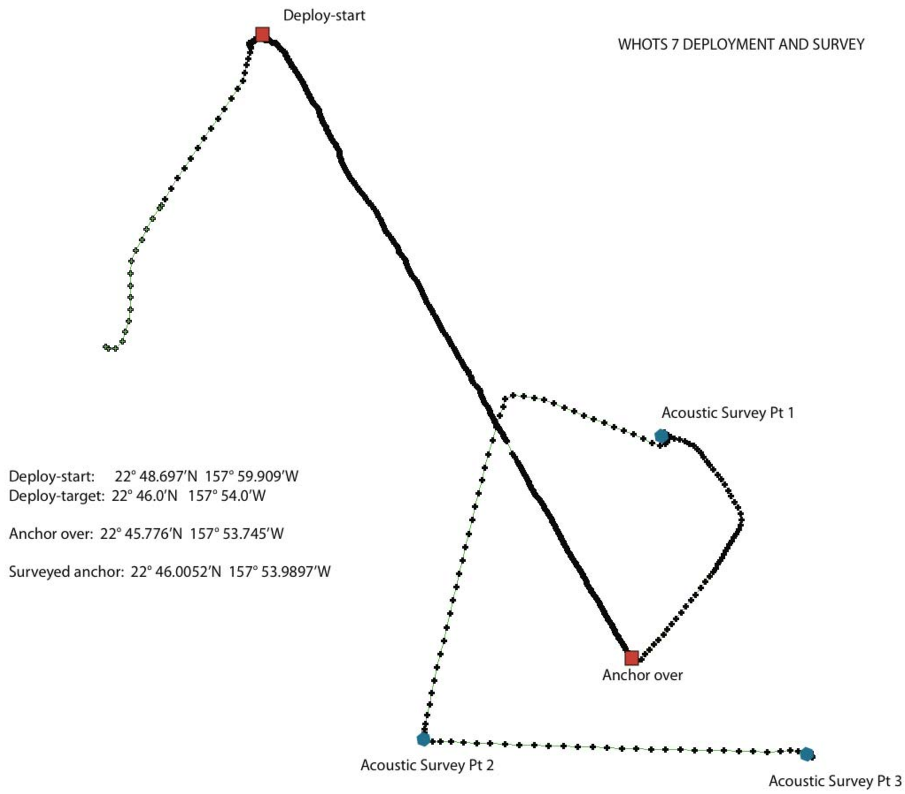

Figure 4-1

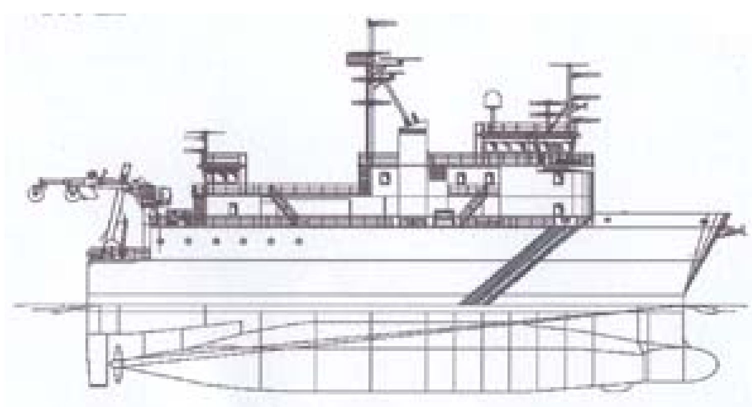

Figure 4-2: R/V *Kilo Moana* Diagram

Mooring deployment operations were conducted on the *Kilo Moana* (KM) using techniques developed and improved from previous cruises. The back deck of the KM, and limitations of crane operations would require that all work be done under the stern A-frame (see Fig. 4-3). The length of the deck on the port and starboard sides is 18 feet, and the central portion of the main deck is only about 34 feet square. All operations must take place in the central portion of the main deck. The buoy, mooring winch, and two capstans must also fit in this area.

Setup for the mooring deployment included hanging a block on a spectra-working line that was reeved through the flag block and guide blocks and then wrapped on the ships capstan and secured on a deck cleat. The block was raised just below the ships flag block. The A-frame was positioned so the block hung slightly aft of the transom. Frapping lines were attached to the bottom of block to keep block centered. The buoy was positioned as to provided a clean lead from TSE to block.

An air tugger was positioned about 15 feet forward of the stern on the port side of the A-frame. The end of the tugger line was fitted with a ¾" chain hook. A deck cleat and stop was also setup.

Instruments from the 0 to 50 meters were pre-rigged with a 3/4" chain shackle, a 7/8" end link, and the stated 3/4" mooring chain shot on top of load bar or cage. The end of the chain also had a shackle and end link. Shackles were tightened and cotter pinned. A 3/4" chain shackle was attached loosely to the bottom of the instrument.

Instruments below 50 meters were pre rigged with 3/4" chain shackle, a 7/8" end link, and the stated 3/4" mooring chain shot on bottom. Shackle was tightened and cotter pinned. Wire rope shots could also be connected to bottom. In this deployment they were mounted on TSE winch. A 3/4" chain shackle was attached loosely to the bottom of the instrument.

To begin the mooring deployment a shot of wire rope was passed from the TSE winch through the block and lowered to the deck. A 150-meter spectra working line was set up. The lined was lead through the A-frame towards the winch but managed at a position port of the A-frame. The spectra working line was shackled to the end link at the bottom of the 50-meter MicroCat load bar. The MicroCat's top chain was shackled directly to the bottom of the next instrument, the ADCP.

The wire from the winch, or a working line from a capstan was shackled into the top chain of the ADCP. To begin the deployment the winch hauled in wire to suspend the chain, ADCP, chain and MicroCat.

Next, the winch payed out wire to lower the instruments and chain to the water. The tender of the 150-meter spectra working line followed out what was being lowered into the water.

When the top of the chain above the ADCP was about .5 meters above the transom, the tugger with chain grab pulled the chain to the deck. The winch lowered the chain to the deck and a backup stopper line was attached to the link on the chain before disconnecting from the winch line. The procedure for inserting the rest of the instruments above 50-meters included: shackling the bottom of the instrument into the end link at the top of the chain suspended in the water, lifting the instrument and attached top chain off the deck with the winch, removing stops, paying out with the winch and Spectra working line simultaneous, stopping off the chain, and repeating this process.

The 7.75 meter shot of chain above the 10 meter depth VMCM was stopped off using a pear link shackled into the chain about 2 meters from the top. A slip line was passed through the link and secured to a cleat. The port side crane was used to move the buoy from its position under the A-frame on the starboard side to a position generally centered under the A-frame, on its chime with tower pointing aft. A ¾ chain shackle, 1" End Link and 1" chain shackle was used to attach the top section of mooring chain to the Universal.

To prepare for the buoy deployment cleats were set up on each side of the buoy hull. Slip lines were passed through the handling rings on the buoy hull and secured. A "west coast" quick release was rigged to the buoy's lifting bale that faced forward with a 4' sling attached to a spectra-working line reeved through the flag block on the A-frame and attached to the ships gray capstan.

The ship was instructed to move ahead slowly. When all preparations for the deployment were complete, aircraft straps securing the buoy were removed. The slip line holding the mooring tension was slowly removed and the mooring load was transferred to the buoy.

The buoy was lifted off the deck with the gray capstan and spectra working line rigged to the A-frame. The A-frame was moved out, and slip lines kept the buoy in check as it moved aft of the transom. When the A-frame was fully extended, the first slip line was removed. The buoy was slowly lowered into the water, and once it settled the quick release was tripped. The second slip line was removed slowly as the ship moved ahead.

The quick release was removed and the blocked was attached to the spectra line wrapped around gray capstan. Frapping lines were attached.

While the ship moved ahead, more of the Spectra working line attached to the bottom of the mooring was payed out to keep the tension down. As the buoy settled in behind the ship and everything appeared stable, this working line was slackened and removed from the cleat. The end of this working line was shackled to the mooring winch. The ship speed was reduced to just enough to provide steerage, and the winch was used to pull in the working line coming from the deployed mooring chain.

When the end of the working line and the bottom of the chain below the 50-meter MicroCat was pulled over the transom, stopper lines with snap hooks were attached to the endlink at the bottom of the chain and made fast. The spectra working line was slacked easy and removed from the bottom of the mooring and quickly offloaded from the TSE. The next instrument, 55-meter MicroCat, was moved into position. The top of the MicroCat load bar was shackled into the mooring chain's end link coming over the stern. The stated wire rope section was pulled out from the winch and put through the hanging block. The wire shot was attached to the bottom of the instrument. The winch hauled in on the wire until it had the load from the mooring. Stopper lines were slacked off and removed.

The winch payed out wire until the bottom end of the stated wire shot was about 1 meter above the deck, stopper lines were attached to the termination's endlink. The winch was slacked easy transferring the load to the stopper lines. The next instrument was inserted and the procedure continued until all instruments had been deployed.

The remaining wire on the TSE winch was payed out through the hanging block on the A-frame. The special wire to nylon wrapped transition passed through the block about 3 feet off the deck. A heavy duty H-Bit was positioned. The wire to nylon component was stopped near the bottom thimble and winch leader with a Yale grip and stopper line. The nylon from the wood lined baskets was dressed through the H-Bit and attached thimble to thimble with (2) 3/4" anchor shackles and a 7/8" endlink to the mooring. Cable ties were used to snug termination. The load was transferred from the winch to the H-Bit. The remaining 2000 meters of nylon and 1500 meters colmega, coiled in three wire baskets, were payed out through a water-cooled H-Bit.

When the end of the polypropylene line was reached, payout was stopped and a Yale grip stopper was attached. The winch leader line was shackled into the thimble end of the colmega. The colemega was wound on the winch, taken off the H-bit. Tension was taken up and the Yale grip stopper was removed. The TSE payed out colmega until the thimble was approximately 2 meters from the ship's transom. At this point, the hanging block was lowered to the deck and removed.

The next step was the deployment of 80 glass balls. A string consists of four balls bolted onto 5 meters of 1/2" trawler chain. The port crane was used to lift each string of glass balls out of the 7 wire baskets and lower them to the deck. Strings were prepped with 5/8" chain shackle and 7/8" endlink, tightened and pinned.

With shackle and endlink towards winch, the first string of balls was dragged aft. It was connected to the bottom of the colemega line with 1" anchor shackle, 7/8 endlink and 5/8 chain shackle. The winch leader was then connected to the bottom end of the string. The winch leader was pulled tight, the stopper lines were removed, and the winch followed the string out. The winch payed out until 3 balls were beyond the transom and the string was stopped. Another string was dragged into place and shackled into the mooring. This procedure continued until all 40 strings were attached to the mooring line.

A five meter shot of ½" trawler chain was shackled into the mooring and stopped off with approximately 2 meters of chain remaining on the deck. The ship towed the mooring toward the drop position in this configuration. Approximately 0.2 nm from the site, the final sections of the mooring were prepared. The top of the tandem-mounted acoustic releases were shackled into the mooring chain at the transom. Another 5-meter shot of chain was attached to the 1.25" master link on the dual release chain with a 7/8 anchor shackle, 7/8" end link, 5/8" chain shackle. This 5 meter chain was then shackled into the 20-meter blue nystron anchor pennant with 7/8 anchor shackle, 7/8 endlink, and 5/8 chain shackle. The chain, and Nystron anchor pennant were wound onto the winch. The stopper lines were removed.

The anchor, was positioned on the port side, just outboard of the A-frame. 5 meters of ½” trawler chain was attached to the anchor. The bolts holding the anchor tip plate to the deck were removed. The chain lashings on the anchor were removed, and an expendable backstay was rigged on the anchor to secure it.

A snatch block was shackled to the working line hanging from the A-Frame’s flag block. A ½” chain grab was attached to a spectra tugger line and reeved through the hanging snatch block. The chain grab gripped the chain just below the acoustic releases. The tugger was pulled up with lifting the releases off the deck. The winch payed out and the A-frame was moved out until the releases were clear of the transom. The working line was lowered and the chain hook removed from the mooring. The winch payed out the 5-meter chain and 20-meter nystron. The chain from the port side anchor, with twists removed, was brought aft and through the A-Frame to meet the bottom of the nystron.

A sling link was shackled into the ½” chain below the anchor pennant. A slip-line was passed through the link and secured to a cleat on the A-frame and another cleat on the deck. The winch passed the load to the slip line. The winch leader was removed and the winch was secured. The crane was positioned with the boom slightly aft of the lifting bridle on the tip plate. Two recovery tag lines were attached to the bottom of tip plate. The crane was then attached to the tip plate bridle and slight tension was taken on the crane wire.

As the ship approached the launch site, the slip line was eased out and the mooring load was transferred to the anchor. At the signal from the Chief Scientist, the backstay was cut, the crane wire was raised, and the tip plate raised enough to let the anchor slip into the water.

b. Anchor Survey

The anchor survey was done by acoustic ranging on one of the releases to determine the exact anchor position and allow estimation of the anchor fall-back from the drop site. Three positions about 2.5 nm away from the drop site were occupied in a triangular pattern (Fig. 4-2). The WHOI over-the-side transducer and deck box were used to obtain slant range (or travel time) to the release at each station. Triangulation from the three sites using Art Newhall’s acoustic survey program gave an anchor position of

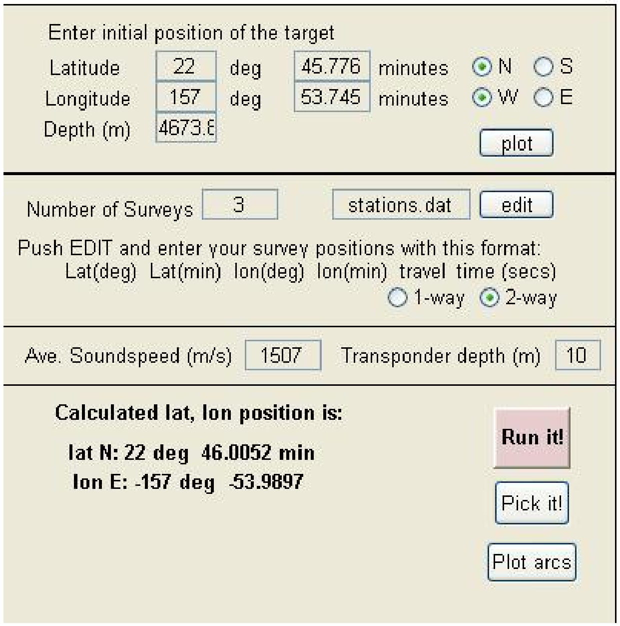

Figure 4-3: anchor drop with calculated anchor position

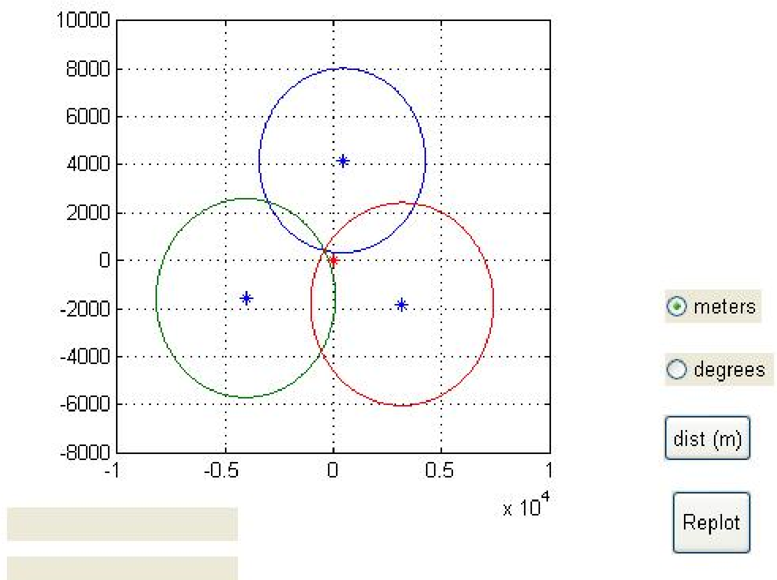

Figure 4-4: WHOTS-7 anchor survey. The anchor drop position (+) is shown along with the three acoustic ranging sites (*), the range circles, and the calculated anchor position (x).

The Edgetech Model 8242XS Dualed Release and Transponder is rated to 6000 Meter Depth, 5500 kg load, and 2 years of battery life using alkaline batteries. This unit also includes status reply which indicates a tilted angle or an upright condition and release status. The anchor survey was conducted sounding on the release.

5. WHOTS-6 Mooring Recovery

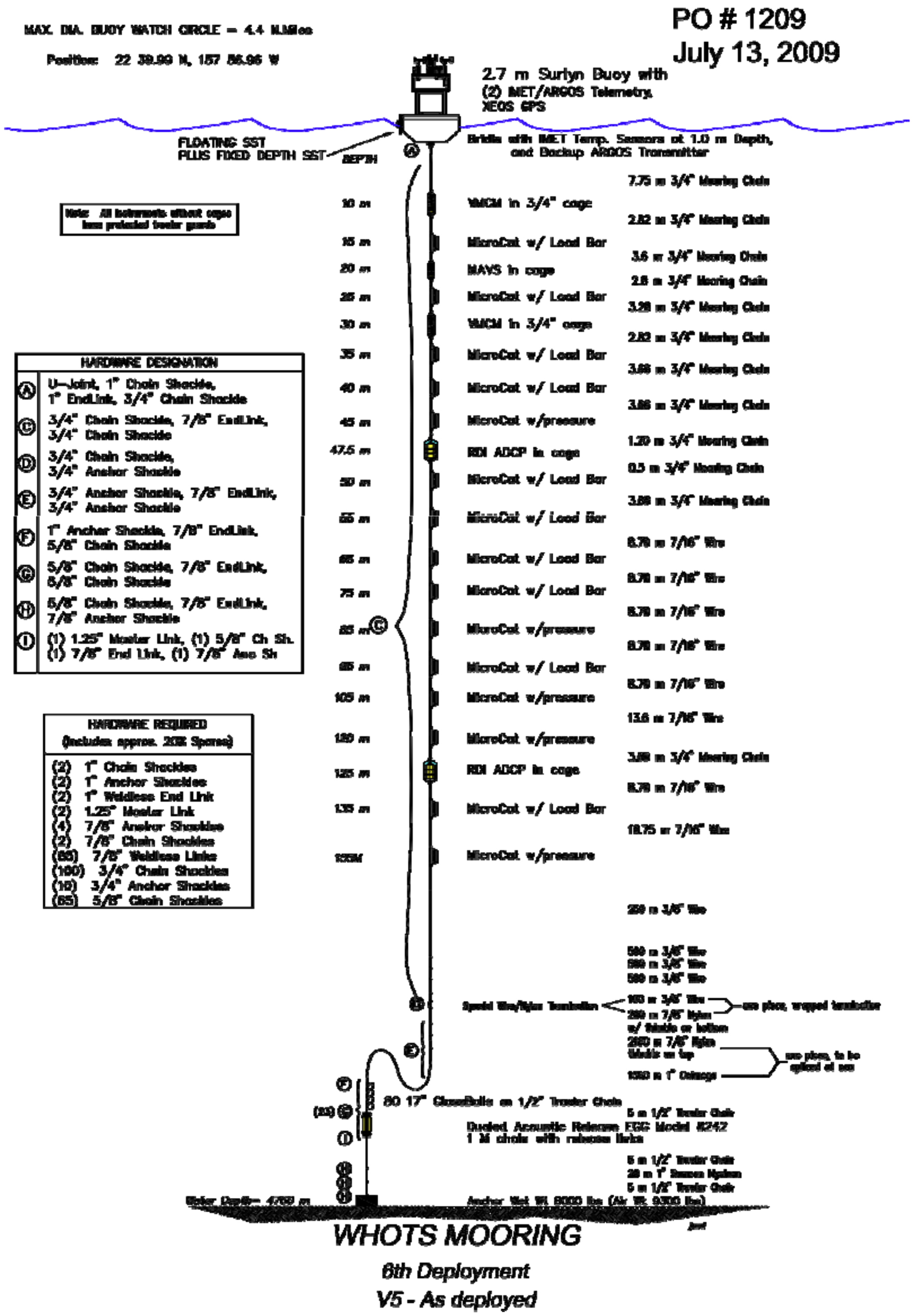

Figure 5-1: WHOTS-6 mooring diagram

a. Recovery Operations

The stern deck was prepared for glass floatation recovery first. The TSE winch, ship's capstan, UH capstan, UH air tuggers and WHOI handling gear were prepared for recovery. A 3/4" Spectra working line was led through the ship's flag block in the center of the A-frame, and through the guide blocks, and wrapped onto the gray captsan. Two air tuggers were positioned facing inboard and were slightly aft, and outboard of the TSE. Seven empty wire baskets remained lashed from deployment day. The recovered glass balls, with the aid of the ships portside crane, would be stored in these baskets.

The WHOTS-6 mooring Fig 5-1 was recovered glass floatation first. The ships rescue boat was launched and attached an 80 foot pendent to the picking bale on the buoy. This pendent was attached in the event we could not launch the rescue boat due to weather. In that event, we would grapple for the pennant.

The R/V Kilo Moana was positioned a ½ nm upwind and off to the side the anchor position. The acoustic release was ranged and fired, releasing the mooring. The ship held position while continuing acoustic ranging to confirm that the release was free of the anchor. Approximately an hour later, the cluster of glass balls were spotted on the surface. The small boat was launched and maneuvered to the stern of the ship, and the spectra working line with a 3 ton snap hook shackled to it was lowered to the boat. The Spectra line was payed out to the small as it made its way to the glass balls. The crew snapped into a section of chain and tension was taken up on the grey capstan.

After hooking into the balls, the small boat was recovered. The A-frame was shifted outboard. The capstan hauled in, pulling the glass balls to the stern and lifting them out of the water. The A-frame was shifted inboard close enough to attach air tugger lines to a section hardware. The A-frame shifted inboard until the glass balls were completely over the deck. The mooring was securely stopped near the colmega line thimble. The spectra line was then removed from the chain and was used in conjunction with the A-frame and grey captsan for additional grabs on the remaining glass balls, 5 meters of chain, and the tandem releases. The glass balls strings were separated placed into the wire baskets with the ships crane, sling, and chain grab.

The 80' spectra pennant removed from the flag block. The 5/8" spectra working line with hanging block was hung about a meter off the deck through the flag block and turns were taken around the grey capstan. A tugger was used to haul the hanging block to the portside of the A-Frame, providing a fair lead to the large white full duty capstan. A 50' nylon line from the capstan was revved through the hanging block and bowlined to the thimble on the colmega. Tension was taken on the captsan and stopper was removed. The white capstan began recovery of all synthetics. Recovered line was stashed in 3 empty wood lined wire baskets lashed in the staging bay.

Once the bottom of the special nylon to wire shot was reached, the capstan was stopped and the winch leader was shackled between the nylon-to-nylon termination. The block was centered and the TSE took tension, recovered nylon was detached, and the capstan was secured. The special nylon to wire shot, and remainder of wire rope was wound on the winch.

Recovering the sub-surface instruments went as followed. The instrument was stopped off and made fast to a deck cleat. The winch pay out slow, and the termination was broken. The instruments were removed and the winch wire was shackled back to the mooring. The winch hauled in to take the load and the stopper line was removed. The recovery continued that way until about 50 meters was still in the water.

A slip line was rigged through a termination and made fast to an eye and wrapped on a deck cleat. The line was slipped and the buoy was set adrift with 50 meters of ballast beneath it. The ship moved ahead and positioned for the small boat deployment. The deck was rigged for the recovery of the buoy.

b. Surface Instrumentation and Data Return

The **WHOTS-6** mooring was outfitted with a full suite of ASIMET sensors on the buoy and subsurface instrumentation from 10 to 155 m depth.

WHOTS 6 Serials/Heights			
	System 1		
Module	**Serial**	**Firmware Version**	**Height Cm**
Logger	L-07	LOGR53 V3.21 keil	
HRH	220	VOS HRH53 V3.2	227
BPR	212	VOS BPR53 V3.3 (Heise)	236
WND	218	VOS WND53 V3.5	267
PRC	211	VOS PRC53 V3.4	247
LWR	505	VOS LWR53 V3.5	278
SWR	219	VOS SWR53 V3.3	275
SST	1835		-153
PTT	14637	7563, 7581, 7582	
	System 2		
Module	**Serial**	**Firmware Version**	**Height Cm**
Logger	L-19	LOGR53 V3.10	
HRH	208	VOS HRH53 V3.2	227
BPR	221	VOS BPR53 V3.3 (Heise)	236
WND	211	VOS WND53 V3.5	267
PRC	504	VOS PRC53 V3.4	247
LWR	215	VOS LWR53 V3.5	278
SWR	202	VOS SWR53 V3.3	275
SST	1727		-153
PTT	18136	14663, 14677, 14697	
	Stand-Alone Module(s)		
Module	**Serial**	**Firmware Version**	**HeightCm**
XEOS	611500	L-07 powered	250
PCo2	0019		69
SIS	25702		~
Larcar 1	288	Start 19:00 7/4/2009 60 Minute Samples	198
Lascar 2	249	Start 19:00 7/4/2009 60 Minute Samples	231
TR1060	14882	Start 22:40 7/3/09 300 Second Samples	-127
SBE39	717	Start 22:30 7/3/09 300 Second Samples	Float
	Horizontal Distances		
	Cm		
WND	121	WND	
LWR	24	LWR	
SWR	24	SWR	
PRC	144	PRC	
BPR	59	BPR	
HRH	242	HRH	

Table 5-1

Module	Variable(s)	Sensor	Precision	Short-term Accuracy [1]	Long-term Accuracy [2]
BPR	barometric pressure	AIR Inc.	0.01 mb	0.3 mb	0.2 mb
HRH	relative humidity	Rotronic	0.01 %RH	3 %RH	1 %RH
	air temperature	Rotronic	0.02 °C	0.2 °C	0.1 °C
LWR	longwave radiation	Eppley PIR	0.1 W/m^2	8 W/m^2	4 W/m^2
PRC	precipitation	RM Young	0.1 mm	[3]	[3]
STC	sea temperature	SeaBird	0.1 m°C	0.1 °C	0.04 °C
	sea conductivity	SeaBird	0.01 mS/m	10 mS/m	5 mS/m
SWR	shortwave radiation	Eppley PSP	0.1 W/m^2	20 W/m^2	5 W/m^2
WND	wind speed	RM Young	0.002 m/s	2%	1%
	wind direction	RM Young	0.1 °	6 °	5 °

[1] Expected accuracy for 1 min values.
[2] Expected accuracy for annual mean values after post calibration.
[3] Field accuracy is not well established due to the effects of wind speed on catchment efficiency. Serra et al. (2001) estimate sensor noise at about 1 mm/hr for 1 min data.

Accuracy estimates are from Colbo and Weller (submitted) except conductivity, which is from Plueddemann (unpublished results).

Table 5-2: ASIMET sensor specifications

c. Subsurface Instrumentation and Data Return

For the sixth WHOTS mooring deployment that took place on 10 July 2009, UH provided 15 SBE-37 Microcats, an RDI 300 kKHz Workhorse acoustic Doppler current profiler (ADCP), and a Nobska MAVS acoustic velocity sensor. The Microcats all measured temperature and conductivity, with 5 also measuring pressure. WHOI provided 2 VMCMs, an RDI 600 kKHz Workhorse ADCP, and all required subsurface mooring hardware.

Table 5-3 provides the deployment information for each C-T instrument on the WHOTS-6 mooring.

Depth (meters)	Seabird Model/Serial #	Variables	Sample Interval (seconds)	Navg	Time Logging Started	Cold Spike Time	Time in the water
15	37SM31486-6893	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 18:35
25	37SM31486-6894	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 18:30
35	37SM31486-6895	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 18:24
40	37SM31486-6896	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 18:19
45	37SM31486-6887	C, T, P	90	1	07/6/09 00:00:00	07/06/09 01:41:00	07/10/09 18:17
50	37SM31486-6897	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 19:49
55	37SM31486-6898	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 19:53
65	37SM31486-6899	C, T	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 19:59
75	37SM31486-3618	C, T	150	2	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 20:03
85	37SM31486-6888	C, T, P	90	1	07/6/09 00:00:00	07/06/09 01:41:00	07/10/09 20:06
95	37SM31486-3617	C, T	150	2	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 20:09
105	37SM31486-6889	C, T, P	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 20:12
120	37SM31486-6890	C, T, P	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 20:16
135	37SM31486-3634	C, T	150	2	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 20:23
155	37SM31486-6891	C, T, P	90	1	07/6/09 00:00:00	07/06/09 00:51:00	07/10/09 20:27

Table 5-3: WHOTS-6 mooring Microcat deployment information. All times are UTC.

Table 5-4 provides the ADCP and MAVS deployment configuration and recovery information.

	ADCP S/N 7637	ADCP S/N 3917	MAVS S/N 10261
Frequency (kHz)	300	600	N/A
Number of Depth Cells	30	25	1
Pings per Ensemble	40	80	80
Depth Cell Size	4 m	2 m	N/A
Time per Ensemble	10 min	10 min	30 min
Time per Ping	4 sec	2 sec	2 sec
Time of First Ping	07/08/09, 00:00	07/10/09, 00:00	07/09/09, 00:00
Time of Last Ensemble	08/03/10, 07:47	08/03/10, 07:00	Shutdown at UH
Number of Ensembles	56,352	56,053	Shutdown at UH
Time in water	07/10/09, 20:19	07/10/09, 19:48	07/10/09, 18:31
Time out of the water	08/02/10, 22:43	08/03/10, 01:53	08/03/10, 01:42
Time of spike	08/03/10, 06:26:00	08/03/10,05:55:00	08/03/10, 06:57:00
Depth	125 m	47.5 m	20 m

Table 5-4: WHOTS-6 mooring ADCP and MAVS deployment and recovery information.

All instruments on the mooring were successfully recovered. Microcat SN 3617 was recovered without a conductivity guard. Most of the instruments had some degree of biofouling, with the heaviest fouling near the surface. Fouling extended down to the ADCP at 125 m, although it was minor at that level.

Table 5-x gives the post-deployment information for the C-T instruments. All instruments returned full data records. Microcat SN 6888 conductivity sensor showed suspect readings beginning in August 2009. The sensor readings rose dramatically, then slowly drifted to near normal levels.

With the exceptions noted above, the data recovered from the Microcats appear to be of high quality, although post-deployment calibrations are required. Figures A1-A15 show the nominally calibrated temperature, conductivity and salinity records from each instrument, and pressure for those instruments that were equipped with pressure sensors.

Depth (meters)	Seabird Serial #	Time out of water	Time of Spike	Time Logging Stopped	Samples Logged	Data Quality	File Name raw data
15	37SM31486-6893	08/03/2010 01:36	08/03/2010 04:40:15	08/03/2010 06:25:00	377,537	good	mc_6893_tc.cap
25	37SM31486-6894	08/03/2010 01:47	08/03/2010 04:40:15	08/03/2010 23:38:00	378,226	good	mc_6894_tc.cap
35	37SM31486-6895	08/03/2010 01:50	08/03/2010 04:40:15	08/03/2010 06:03:00	377,523	good	mc_6895_tc.cap
40	37SM31486-6896	08/03/2010 01:50	08/03/2010 04:40:15	08/04/2010 00:10:00	378,247	good	mc_6896_tc.cap
45	37SM31486-6887	08/03/2010 01:53	08/03/2010 04:40:15	08/03/2010 06:31:00	377,541	good	mc_6887_tcp.cap
50	37SM31486-6897	08/03/2010 01:53	08/03/2010 04:40:15	08/03/2010 05:48:00	377,513	good	mc_6897_tc.cap
55	37SM31486-6898	08/03/2010 01:55	08/03/2010 04:40:15	08/03/2010 23:59:30	378,240	good	mc_6898_tc.cap
65	37SM31486-6899	08/03/2010 02:01	08/03/2010 04:40:15	08/04/2010 00:14:00	378,250	good	mc_6899_tc.cap
75	37SM31486-3618	08/03/2010 02:04	08/03/2010 04:40:15	08/03/2010 19:26:00	226,834	good	mc_3618_tc.cap
85	37SM31486-6888	08/03/2010 02:08	08/03/2010 04:40:15	08/03/2010 05:41:00	377,508	C sensor suspect	mc_6888_tcp.cap
95	37SM31486-3617	08/03/2010 02:11	08/03/2010 05:23:15	08/03/2010 19:38:00	226,839	good	mc_3617_tc.cap
105	37SM31486-6889	08/03/2010 02:14	08/03/2010 04:40:15	08/03/2010 23:54:00	378,236	good	mc_6889_tcp.cap
120	37SM31486-6890	08/03/2010 02:18	08/03/2010 04:40:15	08/03/2010 05:55:00	377,517	good	mc_6890_tcp.cap
135	37SM31486-3634	08/02/2010 22:38	08/03/2010 04:40:15	08/03/2010 19:30:00	226,835	good	mc_3634_tc.cap
155	37SM31486-6891	08/02/2010 22:33	08/03/2010 04:40:15	08/03/2010 05:59:00	377,519	good	mc_6891_tcp.cap

Table 5-5: WHOTS-6 mooring Microcat recovery information. All times are UTC.

The fouling on the 300 kHz ADCP transducer faces (Fig. 7) was minimal most likely due to the depth of deployment (125 m) as well as E-Paint anti-foulant grease used on the faces. The transducer faces for the 47.5 m ADCP were also treated with anti-foulant grease and despite significant algae growth near the faces, the faces themselves did not show the same level of growth (Fig. 8).

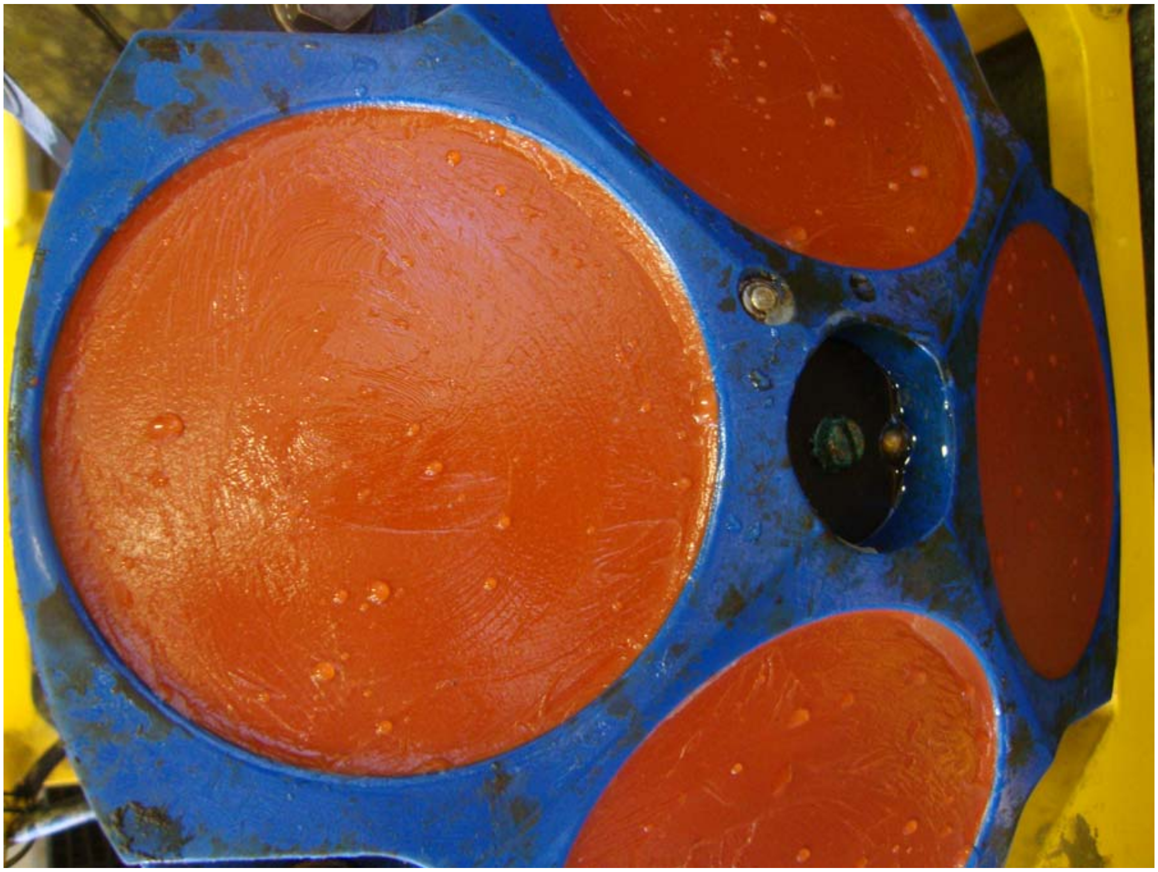

Figure 5-2: WHOTS-6 ADCP deployed at 125 m after recovery.

Figure 5-3: WHOTS-6 ADCP deployed at 47.5 m after recovery.

The data from the upward-looking 300 kHz ADCP at 125 m appears to be of high quality, however the instrument's clock on retrieval was offset by 10 minutes 6 seconds ahead of UTC. The heading, pitch and roll information from the ADCP (Fig. 5-4) provide useful information about the overall behavior of the mooring during its deployment.

Figure 10 shows the variations of the horizontal and vertical components of velocity in depth and time. The acoustic returns from the upper 40 m of the water column are intermittent, due to very low levels of scattering material near the surface. Diurnal migration of plankton often allowed good data returns to near the surface at night, however. The high spurious speeds due to sideband reflections near the surface are apparent.

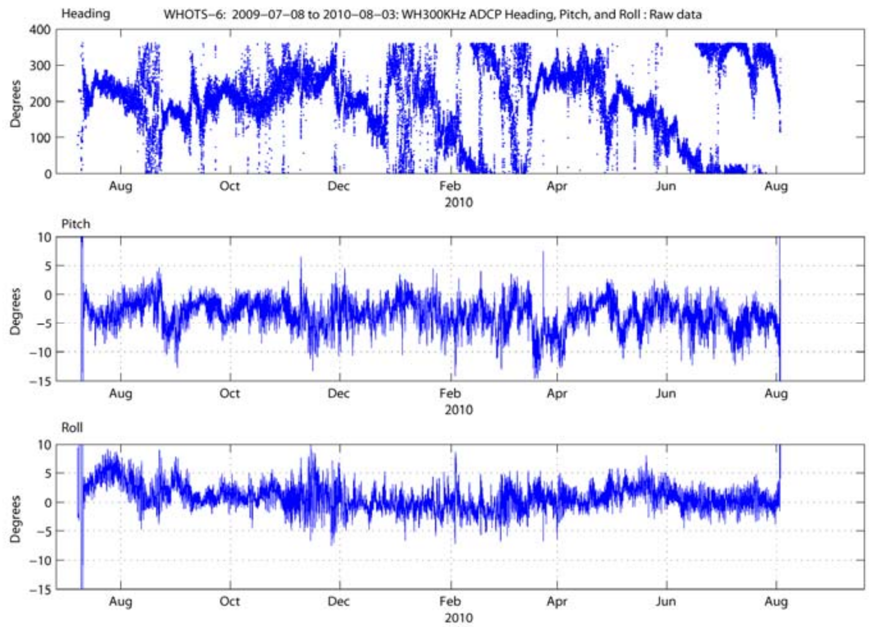

Figure 5-4: Heading, pitch and roll variations measured by the ADCP at 125 m depth on the WHOTS-6 mooring.

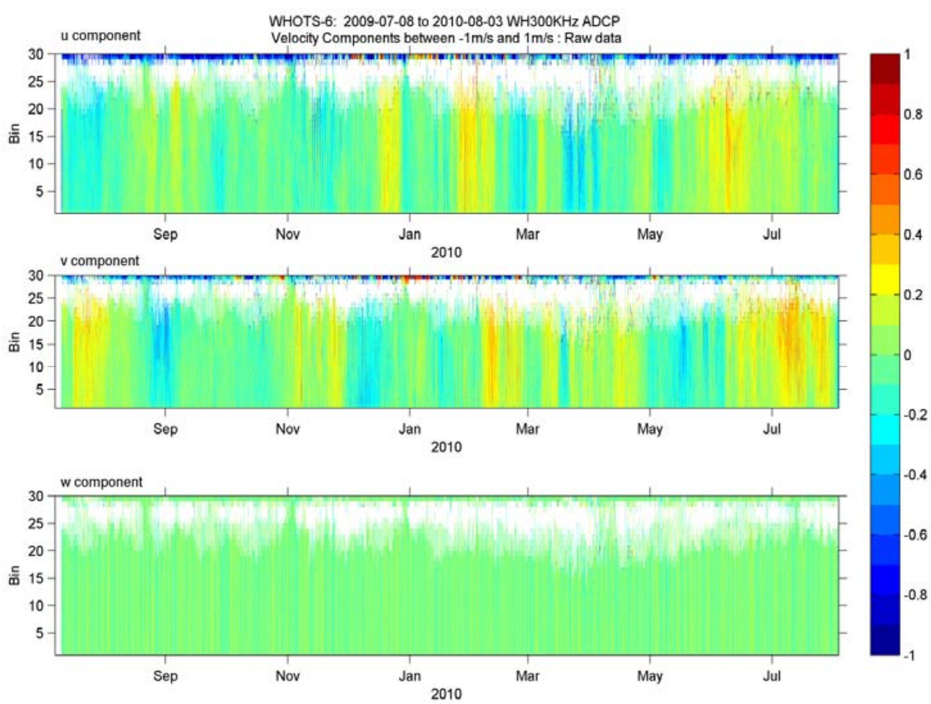

Figure 5-5: Time-series of eastward, northward and upward velocity components versus bin number measured by the ADCP at 125 m depth on the WHOTS-6 mooring. Height in meters above the transducer is approximately 4 times the bin number.

The data from the upward-looking 600 kHz ADCP at 47.5 m appears to be of high quality, however the instrument's clock on retrieval was offset by 3 minutes 8 seconds ahead of UTC. Figure 11 shows the heading, pitch and roll information from the ADCP.

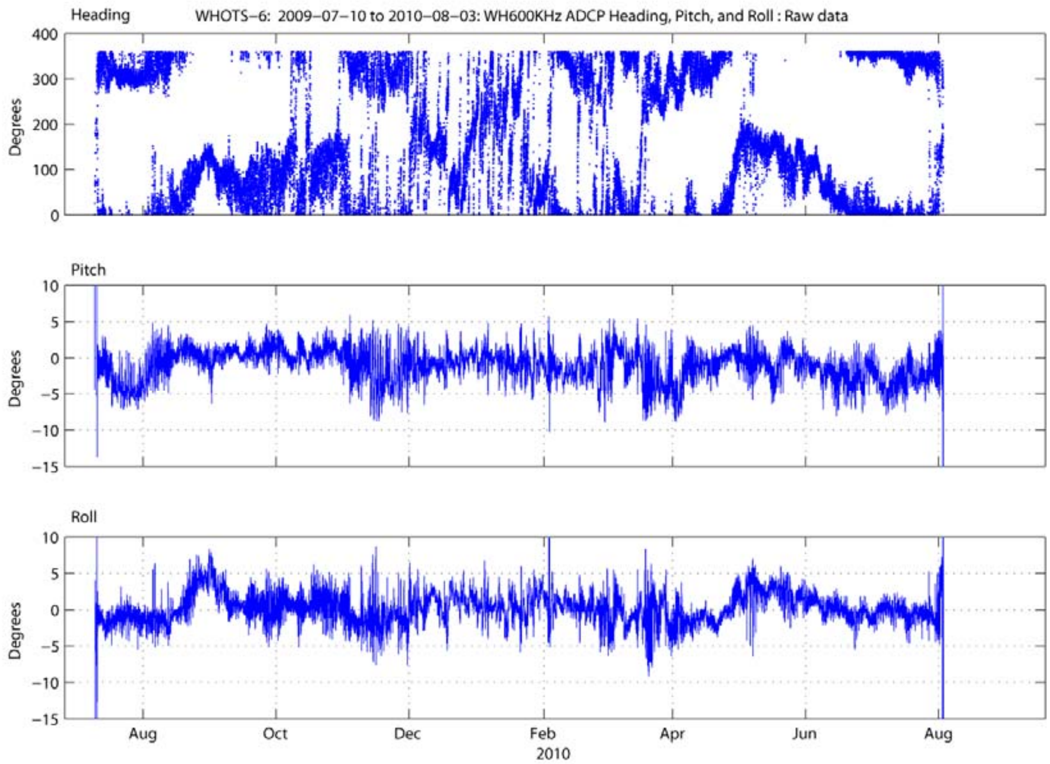

Figure 5-6: Heading, pitch and roll variations measured by the ADCP at 47.5 m depth on the WHOTS-6 mooring.

Figure 5-7 shows the variations of the horizontal and vertical components of velocity in depth and time. The three bins closest to the transducer exhibit contamination possibly from ringing from the transducer or reflection from the nearby instruments, this will be examined closely during data processing.

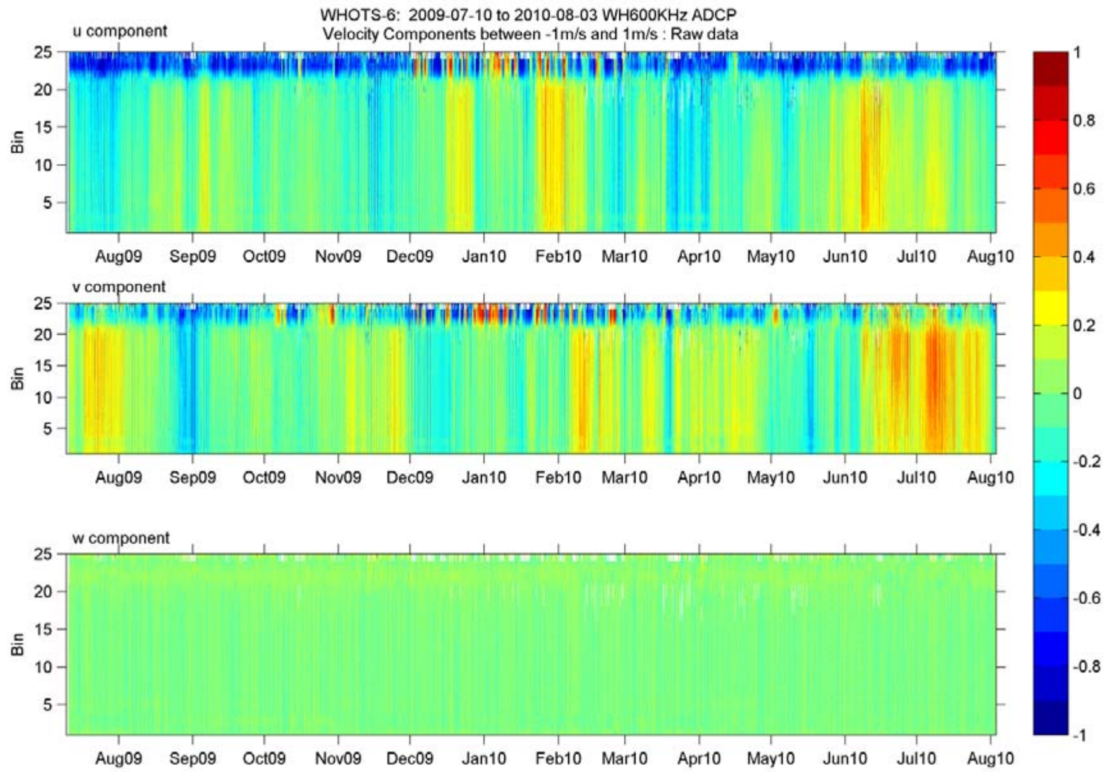

Figure 5-7: Time-series of eastward, northward and upward velocity components versus bin number measured by the ADCP at 47.5 m depth on the WHOTS-6 mooring. Height in meters above the transducer is approximately 2 times the bin number.

The MAVS at 20 m was recovered with some fishing line caught on its frame. Due to the slow data transfer rate of the MAVS, the data will be downloaded after the cruise at UH. The MAVS does have the ability to transfer data via Flash memory however such a data transfer would bias the compass calibration planned for the instrument after the cruise

Instrument	**Serial**	**Depth Meters**	**Sample**	**Start Date**	**Start Time**	**Spike Start**	**Spike Stop**
VMCM	10	10	1	07-Jul-09	17:00:00	7/10/09 16:02	7/10/09 16:04
VMCM	58	30	1	07-Jul-09	17:00:00	7/10/09 16:02	7/10/09 16:04
Instrument	**Serial**	**Depth Meters**	**Sample**	**Start Date**	**Start Time**	**Spike Start**	**Spike Stop**
SBE39	717	FSST	300 Secs	03-Jul-09	22:30:00	7/9/09 22:55	7/10/09 0:19
TR1060	14882	FSST	60 Secs	03-Jul-09	22:40:00	7/9/09 22:55	7/10/09 0:19

		TIME CHECK				DATA		Post Recovery Spike			
Instrument	SERIAL	UTC Time	UTC Date	Internal Time	Internal Date	Stop Sampling	Records	Start Time	Start Date	Stop Time	Stop Date
NGVM	058	22:28:00	4-Aug-10	22:45:16	4-Aug-10	8/4/10 22:30	564825			~	~
NGVM	010	22:25:00	4-Aug-10	22:32:37	4-Aug-10	8/4/10 22:31	564813			~	~
SBE37	1835	6:13:00	4-Aug-10	6:12:09	4-Aug-10	8/4/14 6:12	113883	4:52:00	4-Aug-14	5:22:00	4-Aug-14
SBE37	1727	power lost				9/3/13 0:00	17541	4:52:00	4-Aug-14	5:22:00	4-Aug-14

Table 5-6: WHOTS 6 Recovery

6. Meteorological Intercomparisons

Overview

During the WHOTS-7 cruise, Station ALOHA was under the influence of the eastern North Pacific high pressure system, and subject to moderate east-northeasterly trade winds (Figure 1). Winds were light (10-15 kts) during July 27-28th. Easterly waves were well developed, bringing the ITCZ northward (Figure 2), strengthening the surface pressure gradient near the wave crests. An upper level trough extended from the northeast of ALOHA towards the southwest, trailing a surface trough with a moist tropical air mass. This resulted in somewhat greater vertical development of trade wind cumulus, and occasional light rainfalls, resulting in showery, breezy weather for July 29th – August 3rd. This synoptic situation may have been enhanced by the onset of deep convection in the western equatorial Pacific, with enhanced trade wind inflows (Figure 3).

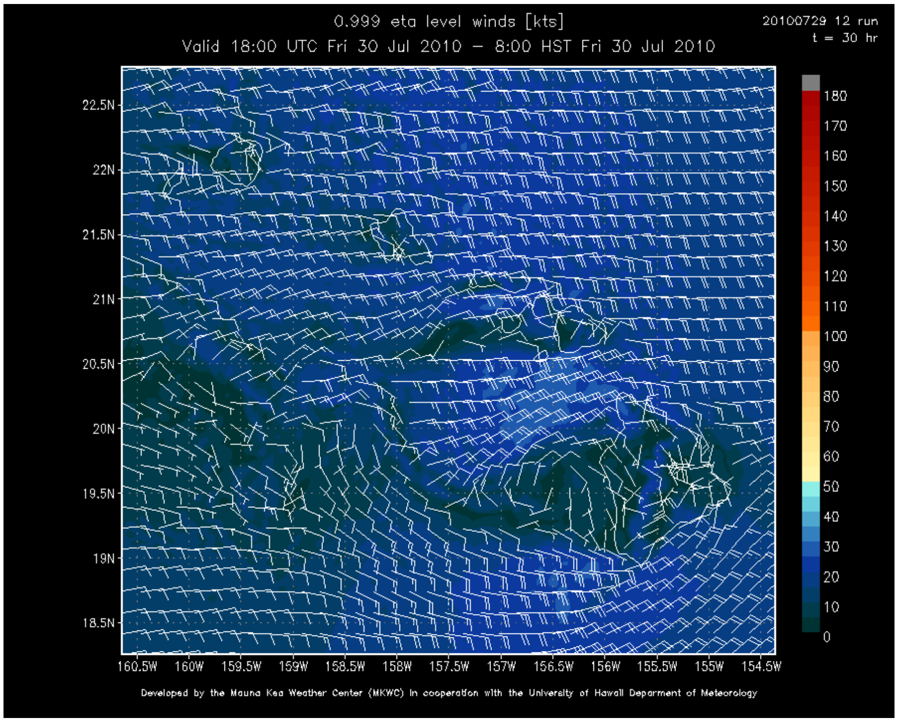

Figure 6-1: The NOAA/NCEP WRF surface wind and sea level pressure analysis for the central-eastern North Pacific, valid for 1800Z on July 30th, 2010.

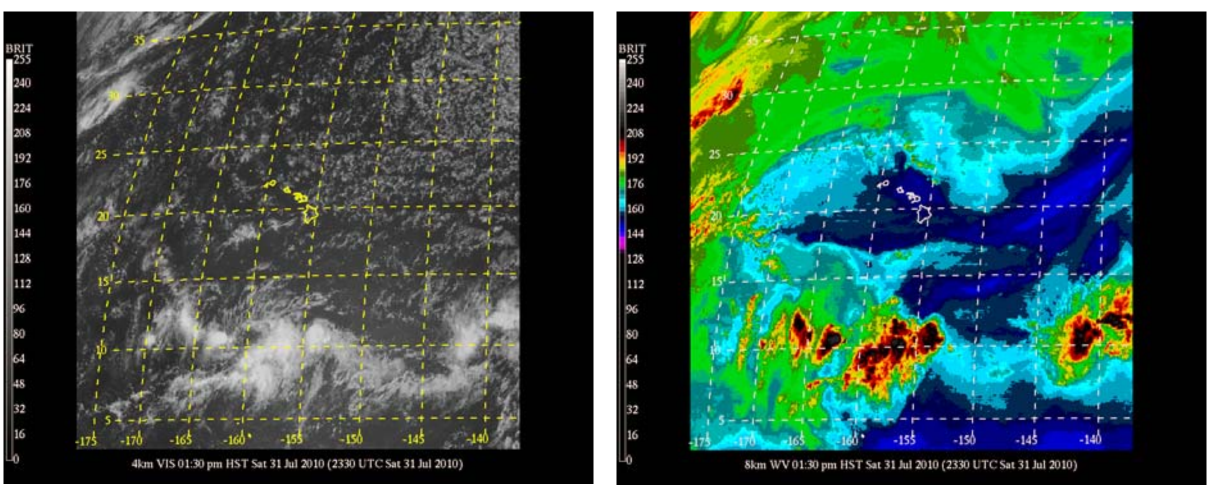

Figure 6-2: GOES-West visible (left) and water vapor (right) channels for 31 July 2010.

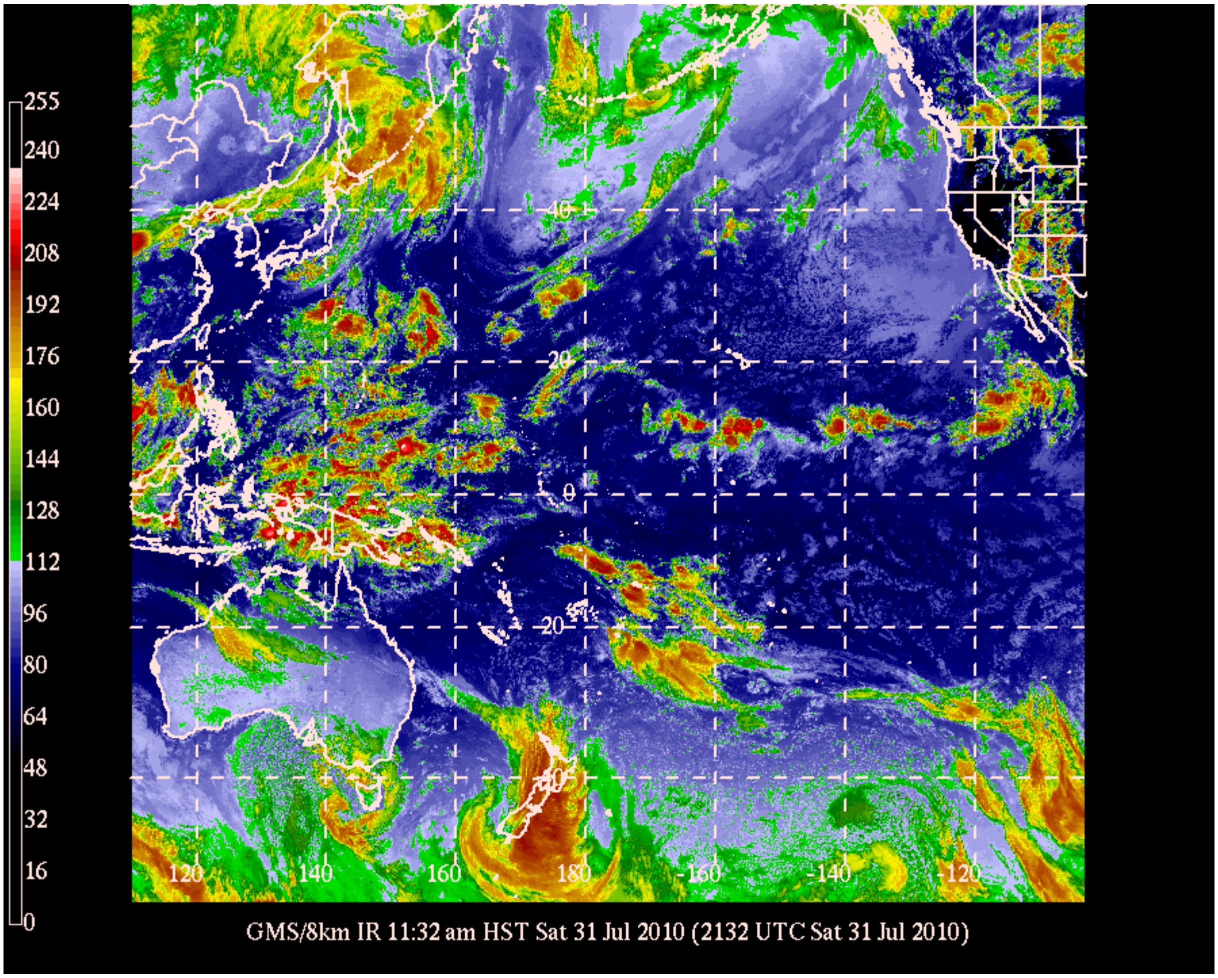

Figure 6-3: GMS and GOES-West infrared mosaic for 31 July 2010.

The near surface (27 m) currents were southeastward near Oahu (Figure 6-4). During the transit to Station ALOHA, the Hawaiian Ridge Current was evident with northwestward flow between Oahu and ALOHA. At Station ALOHA, the currents were mainly northward during the first three days, along the westward flank of a nearly stationary anticyclonic eddy to the east of ALOHA (Figure 6-5). The currents were also influenced by M2 internal tides (strongest in the upper 100 m) and by inertial waves (Figure 6-6). During the cruise, the strong northward flow diminished, while the zonal flow switched from eastward to westward as the eddy elongated westward (Figure 6-5).

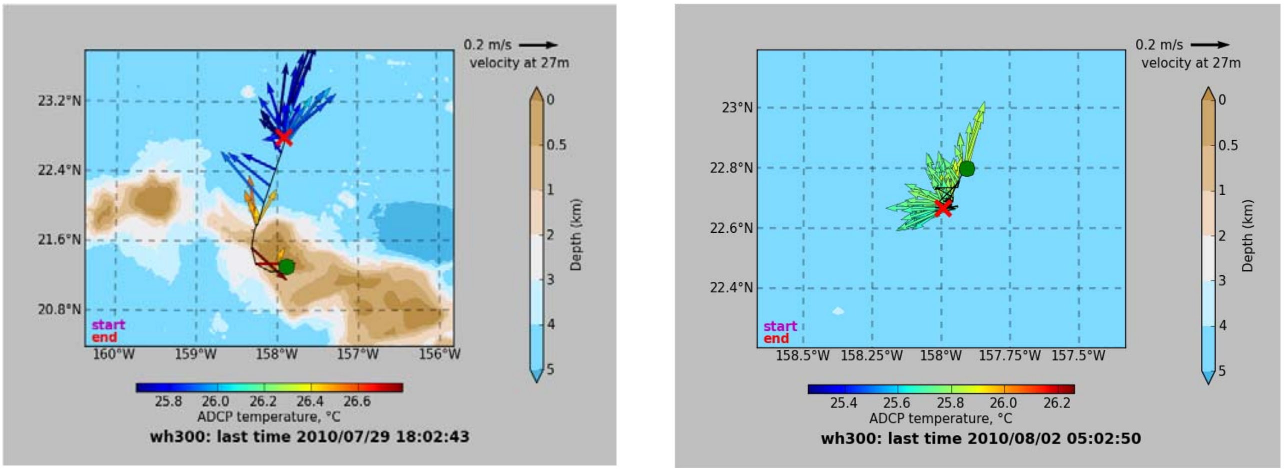

Figure 6-4: Shipboard 300 kHz ADCP currents from July 27-29th, 2010 (left) and from July 28th – August 2nd (right) at a depth of 27 m. Water temperature at the transducer depth is indicated by the color bar on the right.

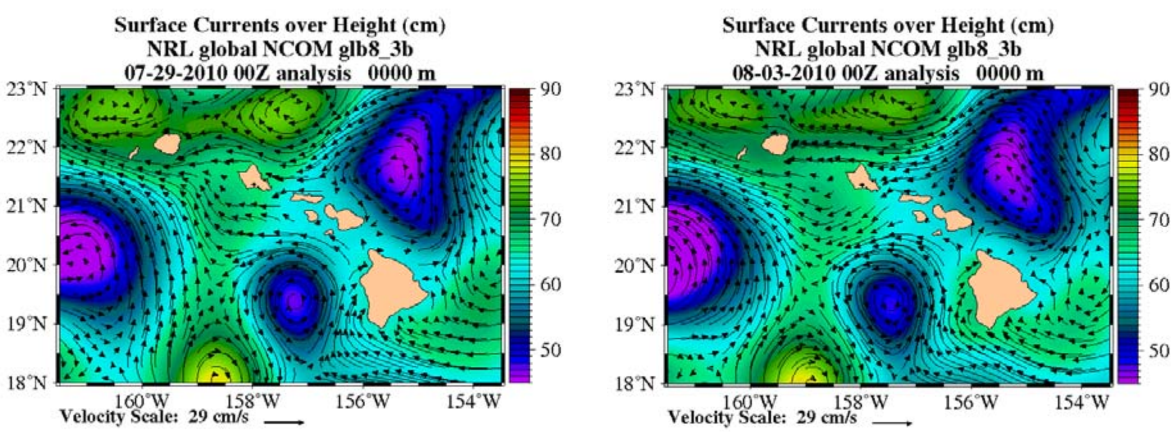

Figure 6-5: Surface currents (vectors) overlaid on sea surface height anomaly (colors) from the Naval Oceanographic Office NCOM analysis for 0Z on July 29th, 2010 (left) and 0Z on August 3rd, 2010.

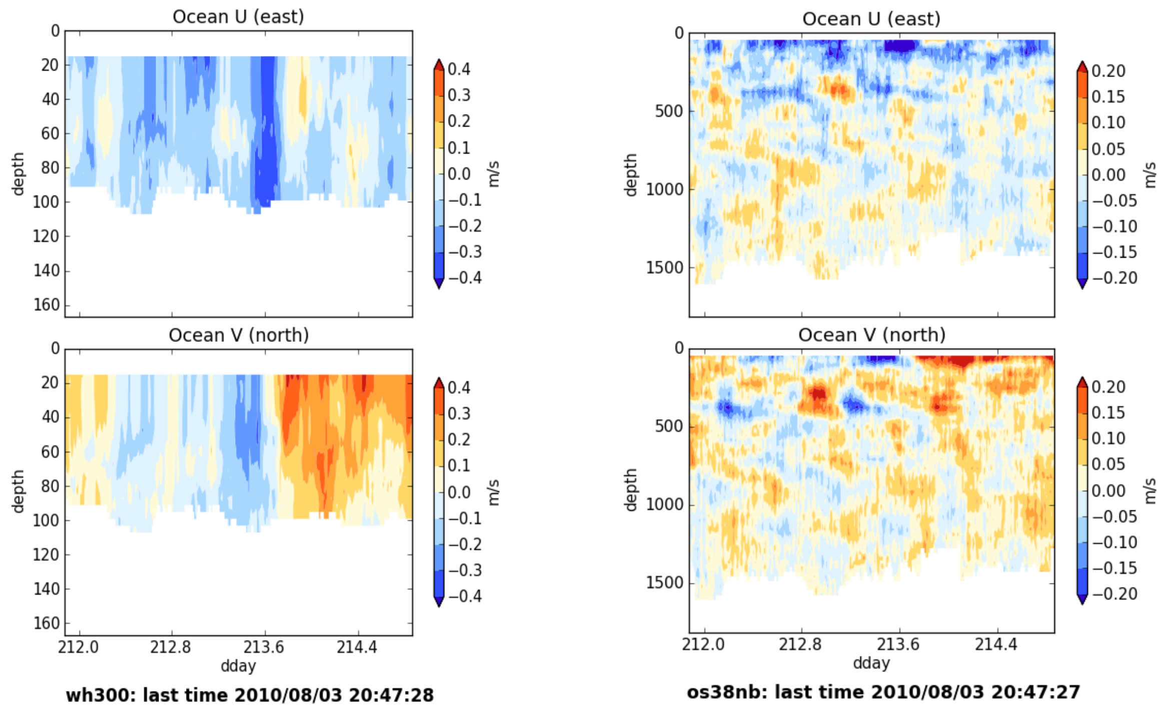

Figure 6-6: Shipboard ADCP currents (left – 300 kHz; right – 38 kHz) from July 27th – August 3rd as a function of depth and time. Inertial waves can be seen as upward trending, but nearly horizontal, maxima and minima in the velocity components with a period of ~ 32 hours. The M2 internal tides can be seen as the nearly vertically aligned maxima and minima in the velocity components with a period of ~ 12 hours.

The primary contributions by the UH group to the WHOTS-7 cruise were preparing and handling subsurface instruments, managing data for most of the subsurface instrumentation on the WHOTS moorings, conducting CTDO_2 profiling and rosette water sampling, and salinity sampling for thermosalinograph calibration. UH personnel worked with OTG personnel to document and diagnose several problems with the Kilo Moana meteorological measurement and logging systems. UH personnel also participated in the deck operations for mooring recovery and deployment.

7. CTD Stations

UH provided CTD and water sampling equipment, including a Seabird 9/11+ CTD sampling pressure, dual temperature, dual conductivity and dual oxygen sensors at 24 Hz. Seabird sensors used by UH routinely as part of the Hawaii Ocean Time-series were used to more easily tie the WHOTS cruise data into the HOT CTD dataset. The CTD was installed inside a twelve-place General Oceanics rosette with six 5-liter Niskin sampling bottles controlled by a Seabird carousel.

Station/cast	Date	Time (UTC)	Location	Maximum pressure (dbar)
Test	7/28/10	04:05	21° 47.09´ N, 158° 15.13´ W	1020
50 / 1	7/29/10	15:59	22° 47.98´ N, 157° 55.29´ W	1020
50 / 2	7/29/10	19:59	22° 48.14´ N, 157° 54.75´ W	500
50 / 3	7/29/10	23:57	22° 48.33´ N, 157° 55.05´ W	500
50 / 4	7/30/10	03:53	22° 48.00´ N, 157° 54.43´ W	500
50 / 5	7/30/10	07:56	22° 48.34´ N, 157° 54.86´ W	500
50 / 6	7/30/10	11:57	22° 48.11´ N, 157° 55.46´ W	500
52 / 1	7/30/10	15:56	22° 41.67´ N, 157° 58.55´ W	500
52 / 2	7/30/10	19:48	22° 41.78´ N, 157° 58.31´ W	500
52 / 3	7/30/10	23:57	22° 41.75´ N, 157° 58.79´ W	500
52 / 4	7/31/10	03:55	22° 41.60´ N, 157° 58.06´ W	500
52 / 5	7/31/10	07:50	22° 41.83´ N, 157° 58.63´ W	500
52 / 6	7/31/10	11:53	22° 41.31´ N, 157° 59.25´ W	500

Table 7-1: CTD stations occupied during the WHOTS-7 cruise.

A total of 13 CTD casts were conducted at stations 52 (near the WHOTS-6 buoy), station 50 (near the WHOTS-7 buoy) and a test station. The first cast at station 50 was to a depth of 1000 m for the purpose of calibrating the CTD conductivity cells. Six CTD casts were conducted to obtain profiles for comparison with subsurface instruments on the WHOTS-6 mooring before recovery, and six more casts were conducted for comparison with the WHOTS-7 mooring after deployment. These were sited approximately 200 to 500 m from the buoys. The comparison casts consisted of 5 yo-yo cycles between 5 dbar and 200 dbar and then to 500 dbar (6th yo-yo cycle of each cast) except for the first cast at station 50 which went to 1000 dbar and only had 5 cycles. Station numbers were assigned following the convention used during HOT cruises. Table 6 provides summary information for all CTD casts, and figures B1-B25 show the water column profile information that was obtained.

Water samples were taken from all casts; 6 samples for the 1000 dbar casts and 3 samples each for the and 500 dbar casts. These samples will be analyzed for salinity and used to calibrate the CTD conductivity sensors.

8. Thermosalinograph

R/V Kilo Moana has an Uncontaminated Scientific Sea Water (USSW) system that includes an internal Seabird Seacat thermosalinograph (TSG) model SBE-45, with an SBE-38 external temperature sensor installed in the bow thruster chamber close to the seawater intake. The intake is located on the starboard hull, 20’ 8” from the bow, at a mean depth of 8 m. Sensor information for the TSG system during WHOTS-7 is as follows:

Temperature: SBE-38 Sensor SN0150 was used to measure temperature near the seawater intake, and was last calibrated on September 16, 2009, and installed on February 25, 2010. The SBE-45 thermosalinograph used temperature sensor SN0267, which was last calibrated on November 3, 2009, and installed on January 10, 2010.

Conductivity: The SBE-45 thermosalinograph used conductivity sensor SN0267, which was most recently calibrated on November 3, 2009, and installed on January 10, 2010.

Water samples were drawn from the shipboard Seabird thermosalinograph system every 8 hours during the cruise for post-calibration of that dataset. The TSG data are shown in Figures C1-C9.

9. Shipboard ADCPs

R/V Kilo Moana is equipped with an RDI 300 kHz Workhorse Mariner ADCP and an RDI OS38 ADCP. The University of Hawaii ADCP processing system is installed, producing real-time profiles and other products. In addition to providing an intercomparison with the upward-looking ADCP on the WHOTS moorings, the shipboard ADCP systems revealed interesting regional current features as shown in Figure 6-4.

10. ALOHA Cabled Observatory Thermistor Array

As part of the ALOHA Cabled Observatory efforts (Howe et al., 2010), a bottom thermistor array mooring was deployed at 22° 43.992’N, 158° 01.088'W on October 26, 2008. This mooring was intended to observed cold overflow events from the Maui Deep into the Kauai Deep where Station ALOHA is located. The water depth at the mooring was 4427 m. The mooring consisted of jacketed steel wire with ten SBE-39 temperature sensors clamped to the wire (see mooring diagram in Figure 13) at 10, 20, 30, 40, 50, 65, 80, 100, 150, and 200 m above the bottom.

On July 31st, the UH bottom thermistor array mooring was recovered. After determining that the currents were favorable for this recovery, given the proximity to the UW/APL profiler mooring at Station ALOHA, the release command was sent. Confirmation was not received immediately, perhaps due to insufficient gain in the deck box. A second command was sent, and confirmation was again not received. Ranging on the release showed, however, that the release had left the bottom. When the gain on the deck box was increased, the confirmation pings were heard. The release codes were sent at 1948Z and 1950Z.

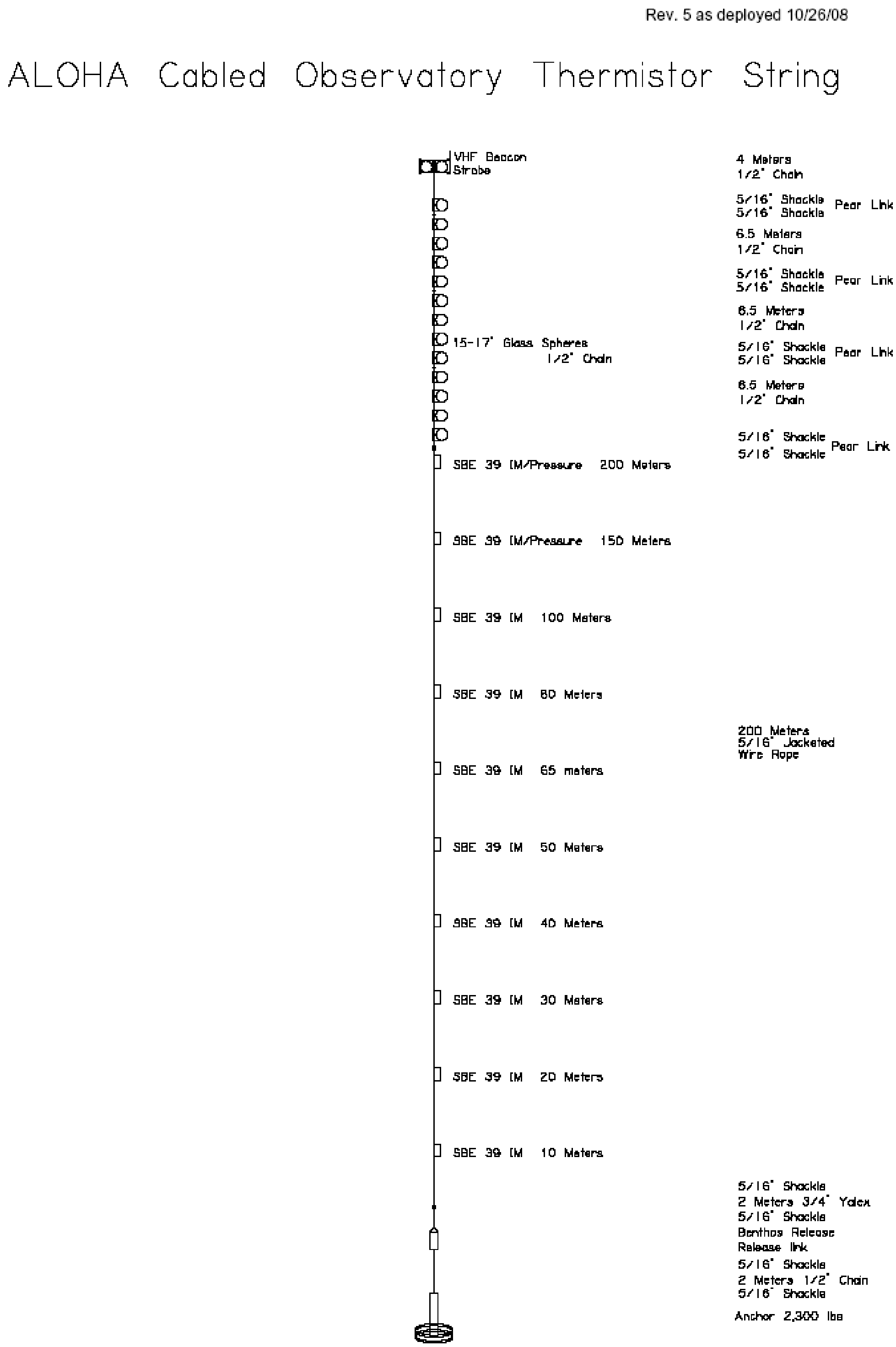

Figure 10-1: Mooring diagram for the bottom thermistor array deployed in October 2008, and recovered during WHOTS-7.

The radio beacon was heard as soon as the glass balls surfaced about 50 m ahead of the vessel at 2037Z. After a grappling hook brought the glass balls and chain to the port quarter of the ship, spectra line was shackled into the chain. After hoisting with the crane, the glass balls were pulled inboard from the stern with an air tugger. When all glass balls were on deck, a stopper line was shackled into the ring above the wire termination. The wire was pulled through a snatch block hung from the A-frame and onto the TSE winch, stopping to take SBE-39 temperature sensors off the wire. Instruments were at their original tape marks except for one, which was marked. (It is suspected, though not yet verified, that the tape slipped on the wire, rather than the instrument slipping. This will be verified when the wire is inspected at the UH Marine Center.) Finally, the release was brought aboard, glass ball strings separated, and the wire wound off the winch onto a spool.

The chain used for the glass balls had some superficial rust. Shackles and rings appeared to be in good condition. The sacrificial anode on the Benthos acoustic release had a large amount of reddish brown material, apparently due to proximity (5 m) to the anchor (3100 lbs of railroad wheels.) None of the glass balls imploded.

All instruments were recovered and logged as they came aboard. The instruments were not fouled. Subsequently, they were immersed in an ice bath to provide a reference time mark on the temperature records to check clock stability in each instrument during the deployment.

The instrument start and stop times, cold spike times, etc. are given in Table 7.

Depth Above Seafloor (m)	Serial Number	Time In the Water (UTC)	Time Out of Water (UTC)	Para-meters	Cold Spike Time In (UTC)	Cold Spike Time Out (UTC)	Samples Logged
200	4533	10/26/08 23:13	7/31/10 20:52	T, P	7/31/10 22:30:00	7/31/10 23:30:00	462,974
150	4532	10/26/08 23:20	7/31/10 20:53	T, P	7/31/10 22:30:00	7/31/10 23:30:00	463,165
100	3334	10/26/08 23:23	7/31/10 21:00	T	7/31/10 22:30:00	7/31/10 23:30:00	462,593
80	3333	10/26/08 23:25	7/31/10 21:02	T	7/31/10 22:30:00	7/31/10 23:30:00	463,000
65	3332	10/26/08 23:28	7/31/10 21:04	T	7/31/10 22:30:00	7/31/10 23:30:00	462,970
50	3331	10/26/08 23:32	7/31/10 21:06	T	7/31/10 22:30:00	7/31/10 23:30:00	463,005
40	3330	10/26/08 23:34	7/31/10 21:07	T	7/31/10 22:30:00	7/31/10 23:30:00	463,167
30	3329	10/26/08 23:36	7/31/10 21:09	T	7/31/10 22:30:00	7/31/10 23:30:00	463,163
20	3327	10/26/08 23:37	7/31/10 21:11	T	7/31/10 22:30:00	7/31/10 23:30:00	462,965
10	3325	10/26/08 23:43	7/31/10 21:13	T	7/31/10 22:30:00	7/31/10 23:30:00	462,996

Table 10-2: ALOHA Cabled Observatory thermistor array deployment and recovery information.

The pressure sensor on the 200 mab (meters above bottom) instrument exhibited an exponential drift to deeper depth (Figure 14). The overall change was about 10 dbar. The 150 mab pressure transducer also exhibited a drift that appeared to continue through the record.

The ten SBE-39 instruments clamped to the mooring wire returned complete data records. The potential temperatures are shown in Figure 15, along with the mean potential temperature for each instrument. Several cold events can be seen, with largest signal closer to the bottom.

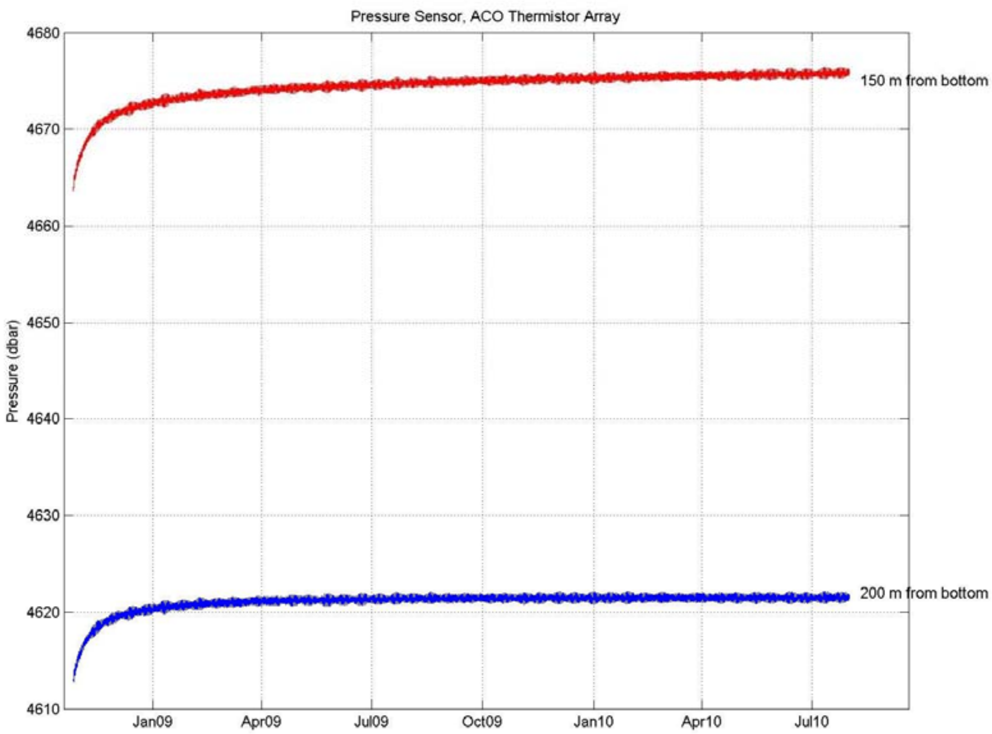

Figure 10-3: Pressure records from SBE-39 instruments (serial #4532 and #4533) from the bottom thermistor array at Station ALOHA recovered during WHOTS-7.

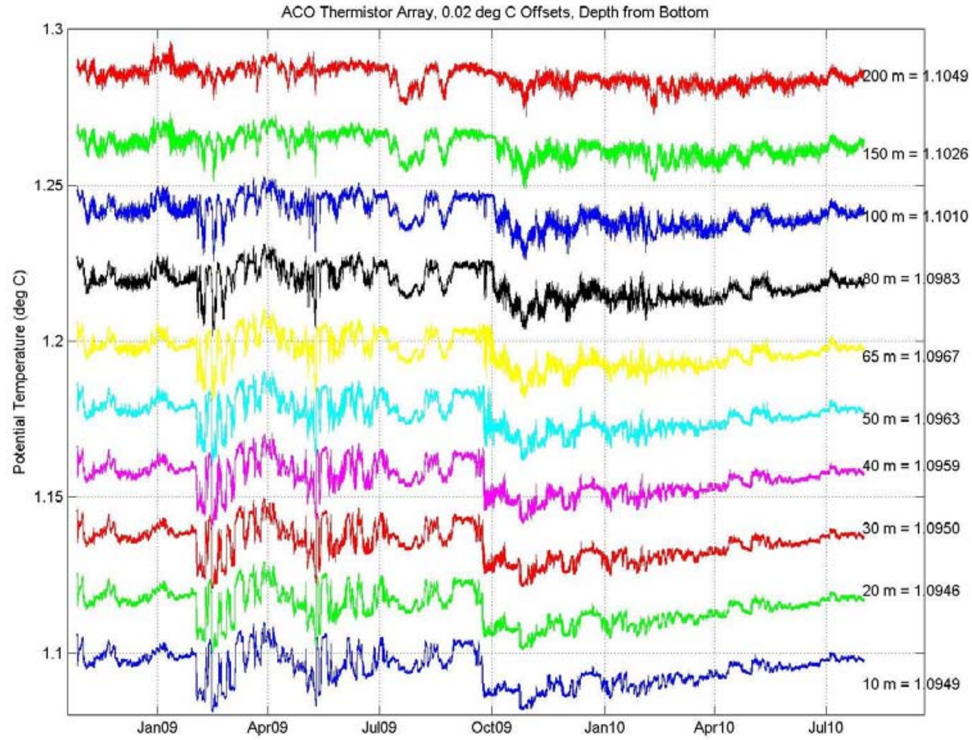

Figure 10-4: Potential temperature records from the bottom thermistor array mooring. Each record is offset upward by 0.02°C from the record below. The mean potential temperature for each instrument is given along with the height above the bottom.

12. Shipboard Meteorological Data

Summary

The WHOTS-7 deployment cruise (KM10-14) departed Snug Harbor on the 27 July, 2010 at 10:00am and returned on 4 August, 2010 at 08:00am, (Year day 208 – 216). A number of problems with the meteorological data collected during HOT-223 had been identified. By the departure date of WHOTS-7 these problems were still present and were not resolved successfully during the cruise. In summary:

1. Air temperature data from both the RM Young RTD and from the Rotronics humidity-temperature probe are not accurate enough to be usable.
2. Wind direction data are severely impacted by glitches but as the glitches are large and put the relative wind direction to between 130° and 140° some data can be recovered with additional effort.
3. Radiation data were affected by electronic spiking which were coherent across multiple sensors. Spikes were not single point glitches but consisted of multiple points. In some cases the spiking is fairly large in relation to the signal and can be removed such as for the long wave radiation from the PIR sensor. However in other cases the signal and the spikes are of similar magnitude and harder to identify, as in the case of the PAR sensor.
4. Precipitation data from the RM Young rain gauge are heavily affected by spiking. These spikes do not seem to be related to the occurrence or non-occurrence of rain as measured with the optical rain gauge. The spikes do have some coherence with spiking observed in other sensors.
5. The PAR dark value from the calibration sheet is much different to dark values observed during the night. This discrepancy brings the whole dataset into question and a need for a post-cruise calibration. If there is an offset apparent within the sensor itself then this will need to be quantified in order to make any data collected during the cruise of value.
6. Barometric air pressure data have some unexplained jumps. The cause of this is not known. The breather tube that connects the sensor to the outside world needs to be secured properly and labeled so as not to be inadvertently moved by persons unfamiliar with the ship.

Instrumentation

Metrological sensors installed on the RV Kilo Moana and their calibration dates are listed in table 12-1. The majority of sensors are located at the top of a tower positioned above the wheelhouse at a height of approximately 20 m (68 feet) from the sea surface. Data are logged with a Campbell Micrologger CRX2000. The barometric pressure is measured towards the rear of the ship on the main deck at an approximate height of 5 m above sea level.

Instrument	Serial Number	Calibration Date
Biospherical PAR - QSR-2200	20289	3-Nov-09
Eppley Labs PSP Precision Spectral Pyranometer	31247F3	30-Mar-10
Eppley Labs PIR Precision Infrared Radiometer	34952F3	23-Mar-10
RM Young RTD Model 41342VC platenized temp	1952	8-Apr-10
RM Young Aspirated Radiation shield model	43408F (2)	n/a
RM Young Precipitation Gauge model 50203	00604	n/a
Rotronic Hygrometers (Humidity) MP101A-C5	41994	27-Jan-09
RM Young Wind Anemometer – STBD	24203	22-Apr-09
RM Young Wind Anemometer – PORT	24201	22-Apr-09
Vaisala PTB220 Class A digital Barometer	C2750001	23-Jun-09
Optical Scientific Optical Rain Gauge ORG-815-Dr	091000291	23-Mar-10

Table 12-1: *Kilo Moana* meteorological instrument suite

Issues

Prior to the WHOTS-7 cruise (27th July – 4th August, 2010) meteorological data collected during HOT-223 (7 – 11 July, 2010) were examined and compared with coincident data collected by the WHOTS-6 buoy and with the regular meteorological observations gathered by HOT personnel during HOT-223. Data formats had been changed since the ship was last used by HOT (Oct 2009) and lack of documentation hindered efforts to inspect the data. This was true of both the raw near real-time data available during the cruise and final data received at the end of the cruise. Progress was made during HOT-223 to address the outdated documentation by Justin Smith (OTG), resulting in an up-to-date description of the data types collected, formats, instrumentation used, and calibration documents available just before the start of the WHOTS-7 cruise.

Five issues with the data were identified and communicated to OTG a week prior to the departure of the WHOTS-7 cruise. However, by departure day for the WHOTS-7 cruise none of the issues had been resolved. These issues were present throughout the WHOTS-7 cruise and by the end of the cruise still remained unresolved. Problems identified with meteorological data collected during HOT-223 and WHOTS-7 are discussed below.

1. Air Temperature

The RM Young RTD is installed in an aspirated radiation shield and was recently certified on 8 April, 2010. Temperature measurements recorded by this sensor were consistently lower by about 1 °C than air temperatures recorded during routine manual meteorological observations on HOT-223 and observations made by officers on watch on the bridge. Furthermore hourly averaged air temperatures measured by the WHOTS-6 buoy show good agreement with the manual meteorological observations. This problem was identified during WHOTS-5 in June 2008 and WHOTS-6 in July 2009.

Air temperature is also measured by a Rotronic humidity-temperature probe installed in an aspirated radiation shield similar to that used for the RM Young RTD sensor. The calibration date was 27 January, 2010. Air temperatures recorded by this sensor were again consistently lower than the manual observations and the WHOTS-6 buoy measurements but the difference was slightly greater being closer to 2 °C. It should be noted that the relative humidity measurements with this probe agree well with HOT-223 calculations made using a psychrometer wet and dry bulb temperature and with the WHOTS-6 buoy measurements. Mean relative humidity was 5 % lower during day 190 and 7 % lower during day 191 than mean buoy and mean manual observations, (See figs. 1 & 6 [middle]). Some portion of this disparity maybe due to the height difference that the measurements were taken.

2. Wind Direction

Wind speed and direction are measured with a pair of RM Young marine wind monitor anemometers. Both anemometers have a calibration date of 22 April, 2009. Examination of data collected during HOT-223 showed that at times there were spikes that affected both anemometers occurring in the relative wind direction data. The spikes in port and starboard data did not necessarily occur at the same point in time. During the WHOTS-7 cruise, spiking was more prevalent than experienced during HOT-223. One reason for this was that while on station during HOT-223, the ship was pointed to the south due to a strong northward current while the winds were from the east. During the WHOTS-7 cruise the ship was pointed towards east for the majority of the cruise and as a result the relative wind direction was in the 350° - 10° region.

RM Young anemometers have a deadband region between 355° and 0°. Within this region no resistance is measured for a position change. Calibration sheets indicate that the actual deadband region was 2.5° for sensor WM24201 and 1.75° for sensor WM24203. It is thought that when the anemometer turns through this deadband region an incorrect voltage is read causing the translator box to erroneously output a wind direction approximately 130° – 140°. As jumps in the relative wind direction are reasonably large and result in values close to 130° a median filter could be used to correct the data and recalculate the true wind direction. The majority of the glitches are made up of single point outliers but there are some cases where they consist of multiple points.

Towards the end of WHOTS-7 after one of the trouble shooting sessions some doubt was cast upon whether the port and starboard anemometer data streams were recording from their respective sensors. It was confirmed during departure of HOT-224 that indeed these were incorrect. It is not known when the switch had been made. This is important because there are mean differences between the two depending on heading. It should be noted that data from these anemometers is fed into the ship’s dynamic position system and is also used in general by the bridge.

3. Coherent spikes in several sensors
It became apparent that during HOT-223 that there was serious spiking present in data from several sensors. The sensors affected were the RM Young precipitation gauge, the Eppley Precision Infrared Radiometer (PIR), the Biospherical Photosynthetically Available Radiation sensor (PAR), and the Rotronic humidity-temperature probe. HOT personnel observed that these spikes occurred at the same time in each of the sensors suggesting a grounding fault or some other system wide problem with the data logger. Appendix D shows a small subsample of data from the affected sensors over a period of nearly 5 hours covering the hours before and after sunrise. Spikes can be clearly seen in all the above mentioned sensors occurring at the same time. Spiking can be easily seen in the PAR sensor during periods of darkness but become much more difficult to pick out during daylight hours. It should be noted that the RM Young RTD sensor is not affected by the spikes but was included to examine the coherence between its measurements and those taken by the humidity probe. Closer examination of the spikes revealed that they consist of several bad points over several seconds. This makes their identification and successful removal problematic.

4. PAR Sensor
The PAR dark voltage recorded is -4.5 V. According to the manufacturers manual there should be a small positive output voltage and the calibration sheet indicates that it was 1.5 mV. OTG have noted that during the replacement of the meteorological sensors (between KM10-09 and KM 10-10) there was a corroded pin on the female connector on the wire side. The calibration date of the sensor is 3 November, 2009.

5. Barometric Pressure
Atmospheric pressure is measured with a Vaisala digital barometer with a calibration date of 23 June, 2009. The sensor is located in lab 1 towards the rear of the ship and connected to the outside with a length of tubing through a conduit. During loading day for HOT-223 it was noticed that the open end of the tubing was inside the lab. It is most likely that during one of the previous offloads it was inadvertently pulled inside when another user had retrieved cabling that had also been passed through this conduit. **The end of this tube needs to be clearly marked and fixed so as not to be mistakenly moved.** In addition it should not be left hanging in the air flow that emanates through this conduit due to the pressure differential built up by the air conditioning system; this air flow induces dynamic pressure errors to the measurement of air pressure.

Pressure data compare well with pressure measured at the WHOTS-6 buoy but there are there are some small jumps that are a cause for concern.

Trouble shooting conducted during WHOTS-7

Trouble shooting on the meteorological system was conducted several times during the WHOTS-7 cruise by Vic Polidoro. A diary of troubleshooting events follows:

July 30, 2010 Day 211 13:00Z – The PAR sensor dark voltage was noted to be -4.5 mV instead of the stated voltage of 1.5 mV from the calibration sheet. It was noted that there was a corroded pin found on the previous sensor and that **the connector and cable being currently used should be replaced.**

July 30, 2010 Day 211 20:08Z – Wind translator box was inspected. Relative direction was seen to be alternating between 355° and 5° with jumps to 147°. The wind translator box located in the chart room was power cycled.

July 30, 2010 Day 211 23:11Z – The port anemometer was manually turned 360° to check if there was a specific direction that correlated with the erroneous readings in relative direction. None was found.

July 30, 2010 Day 211 23:13Z – The starboard anemometer was manually turned 360° for the same reasons as for the port anemometer. No correlation was found.

July 31, 2010 Day 212 04:34Z – Vic and Paul climbed the met mast. Several Psychrometer readings of dry bulb temperature were taken to compare with temperature from the RM Young RTD and the Rotronic Humidity-temperature probe. Temperatures recorded with the psychrometer were consistently 25.5 °C. The voltage from the RM Young RTD was 743 mV which equates to 24.3 °C, (The conversion is (mV * 0.1) -50 = temperature (°C)). Temperature at this time was logged as 24.3 °C by the system indicating that the temperature difference was not due to the micrologger, but that the incoming voltage is low. The PAR sensor was briefly unplugged to inspect the corroded pin. Values jumped from 173 to 3200 when disconnected. It is unclear why it did not go to zero. While up the mast the anemometers could be seen to be slightly offset from each other. A third temporary anemometer was present on the tower (WHOI IMET system) which seemed to be aligned more with the starboard vane. Wind waves were observed to be more inline with the starboard anemometer. The optical rain gauge may be creating local flow disturbances to the port anemometer.

August 1, 2010 Day 213 02:28Z – Vic improved the wiring to the back of the wind translator box in the chartroom. Many bad crimps were found. It was also noted that this had been re-wired recently as the type of crimps used were a type that had been recently purchased by OTG. Furthermore, the crimping was done incorrectly with the insulation being crimped and not the conductor. It was suspected that the bad wiring was causing the jumps in relative wind direction. The wind translator box was also replaced with a spare following the re-wiring. Several ground wires were connected together using an ordinary household electrical twist connector which is unsuitable for this application. This was corrected using a terminal strip and crimped wires. Following the re-wiring the jumps were still present.

August 1, 2010 Day 213 23:09Z – Vic climbed the met mast. Port anemometer junction box was opened and the wiring checked. No loose connections were found and normal voltages were measured.

August 1, 2010 Day 213 23:16Z – Port anemometer was rotated.

August 1, 2010 Day 213 23:17Z – Port and starboard wiring going into the translator box was found to be labeled incorrectly. It was not sure if the previous box was labeled incorrectly of if the translator box is programmed differently.

August 1, 2010 Day 213 23:19Z – Port anemometer was rotated.

August 1, 2010 Day 213 23:20Z – Port anemometer was rotated.

August 1, 2010 Day 213 23:22Z – Starboard anemometer was rotated.

August 1, 2010 Day 213 23:24Z – Port and starboard anemometer rotors were stopped.

August 1, 2010 Day 213 23:25Z – Port anemometer was rotated.

August 1, 2010 Day 213 23:35Z – Starboard anemometer was rotated.

August 1, 2010 Day 213 23:51Z – Serial feed was removed and reattached from back of translator box.

11. Teacher at Sea Commentary

As the Teacher At Sea for this mooring mission, I am amazed at the preparation and care taken to deploy the buoy. Being on the ship with the scientists and crew makes me realize that an inordinate amount of teamwork and cooperation take place in running the mission successfully. Consequently, I believe it is important to teach children that success in science not only depends on individual accomplishments, but it also depends on teams of professional working cohesively with one another. It has been informative, exciting, and fascinating being part of this mission.

This experience has also made me realize that I can do a better job of teaching about the ocean's importance in our lives. Up to this point in my teaching career, I have only really had students examine the ocean as a habitat. Being on this mission makes me realize that the ocean is also used to understand weather, climates, atmospheres, and as a barometer of the overall health of the world. It is important for students to know that the ocean holds a wealth of information, and we must capture that information to better understand our world. I believe it is imperative that my students realize the importance of oceanography.

With that being said, I am going to use my Teacher at Sea experience as a way to show students the opportunities available at places such as Woods Hole Oceanographic Institution, NOAA, and on a ships such as the Kilo Moana. Students need to realize that science-oriented careers, such as engineering and computer science, can lead to exciting jobs where they get to travel the world, and experience the natural world and its secrets.

Steven King, Shepherd Elementary, Teacher at Sea, August 3, 2010

Acknowledgments

Shore-side support from the University of Hawaii (UH) Marine Center, including facilities provided by the Hawaii Undersea Research Laboratory, was critical to successful cruise preparation. The Captain and crew of the *Kilo Moana*, and the UH Marine Technicians, were flexible in accommodating the science mission, and exhibited a high degree of professionalism throughout the cruise. Nan Galbraith and Frank Bahr provided shore support for real-time Argos and AutoIMET logging. This project was funded by the National Oceanic and Atmospheric Administration (NOAA) through the Cooperative Institute for Climate and Ocean Research (CICOR) under Grant No. NA17RJ1223 to the Woods Hole Oceanographic Institution. We would like to acknowledge the hard work and dedication of the following individuals. Justin Smith, who helped update the data format documentation during HOT-223. Vic Polidoro, Kuhio Vellalos, and Trevor Goodman spent many hours trouble shooting the meteorological system and climbing the mast in between their duties on the back deck during the WHOTS-7 cruise.

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Appendix A. Moored C-T Time Series Figures

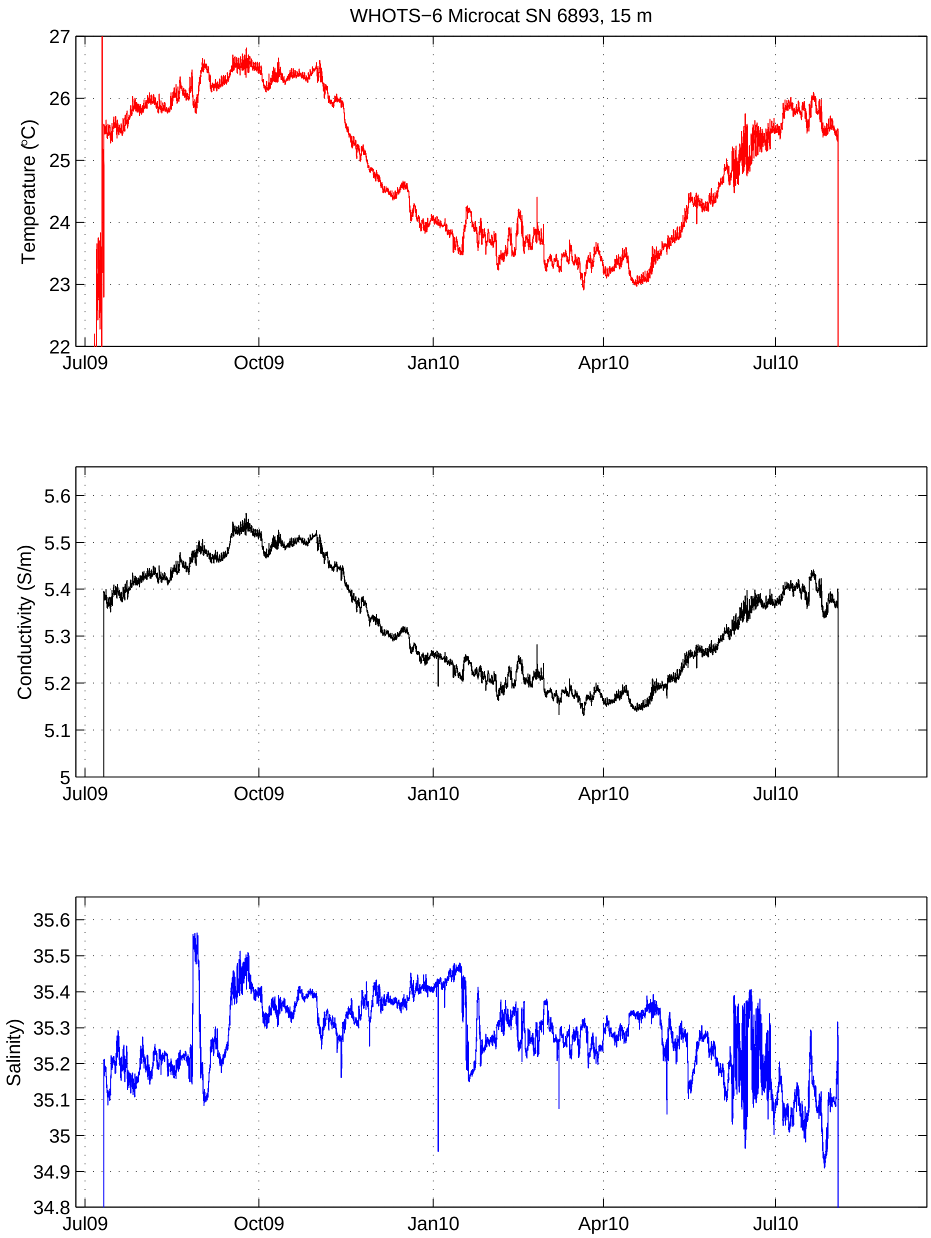

Figure A1. Preliminary temperature, conductivity and salinity from Microcat SBE-37 SN 6893 deployed at 15 m on the WHOTS-6 mooring. Nominal pressure was used to calculate salinity.

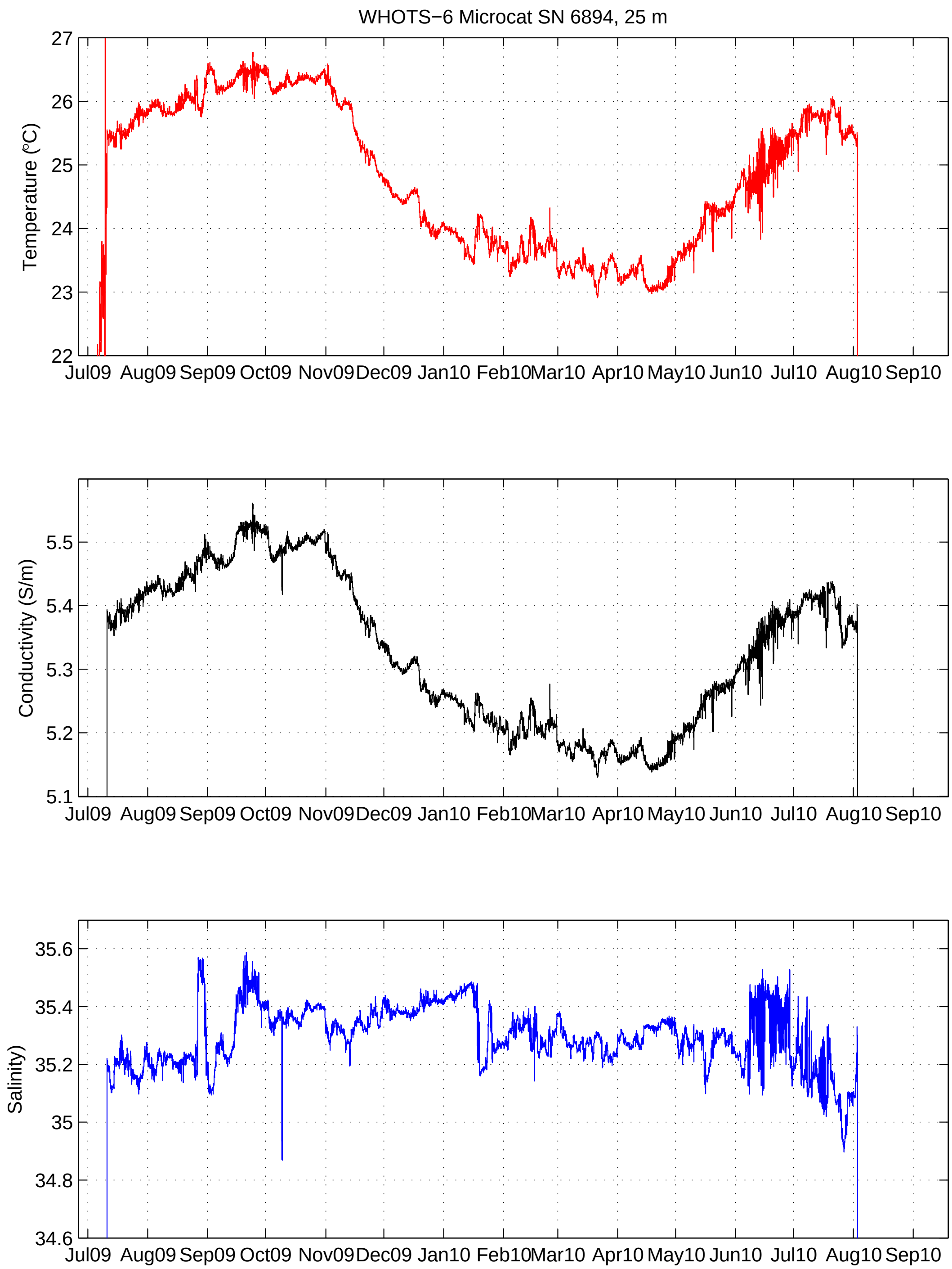

Figure A2. Preliminary temperature, conductivity and salinity from Microcat SBE-37 SN 6894 deployed at 25 m on the WHOTS-6 mooring. Nominal pressure was used to calculate salinity.

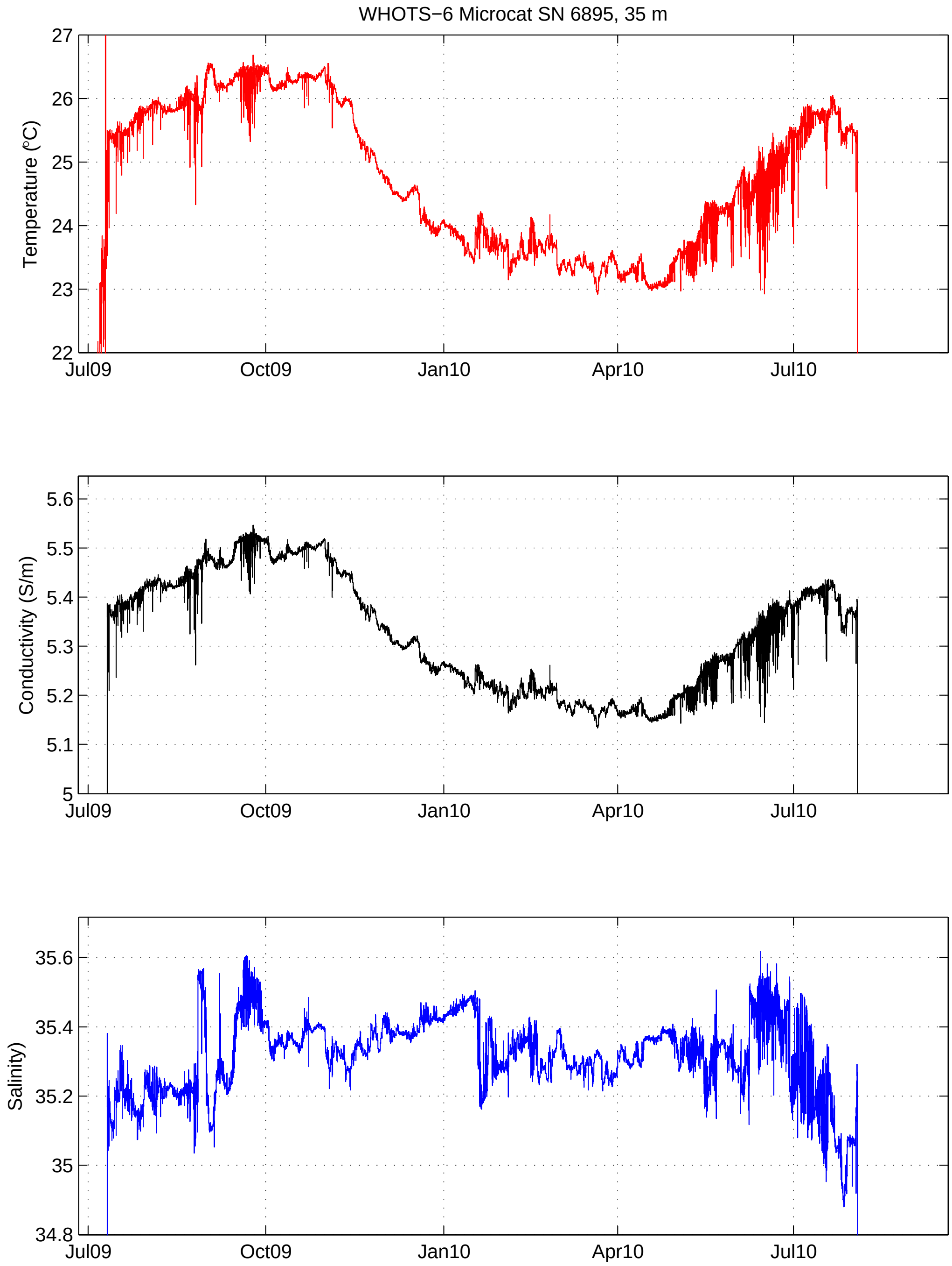

Figure A3. Preliminary temperature, conductivity and salinity from Microcat SBE-37 SN 6895 deployed at 35 m on the WHOTS-6 mooring. Nominal pressure was used to calculate salinity.

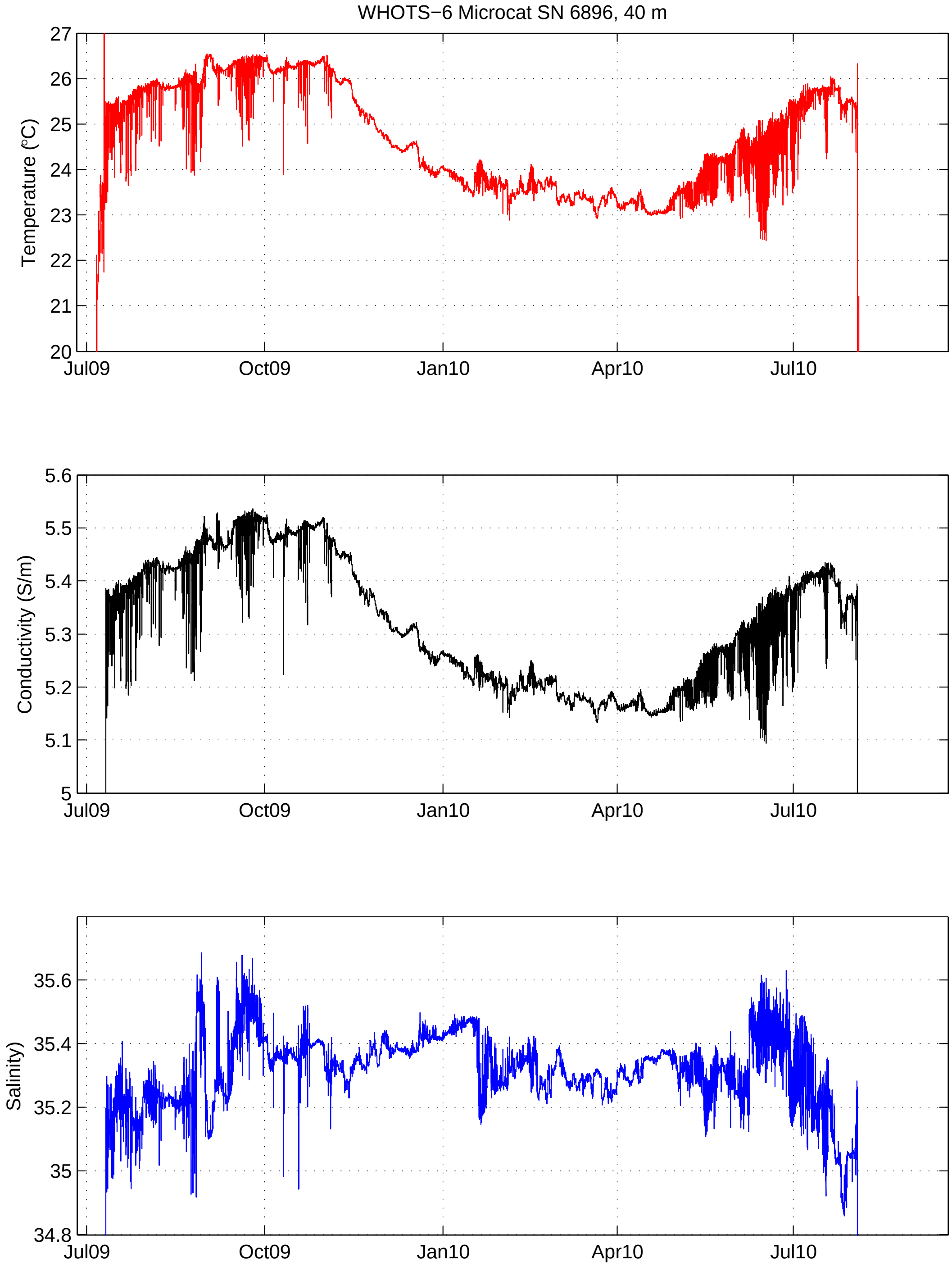

Figure A4. Preliminary temperature, conductivity and salinity from Microcat SBE-37 SN 6896 deployed at 40 m on the WHOTS-6 mooring. Nominal pressure was used to calculate salinity.

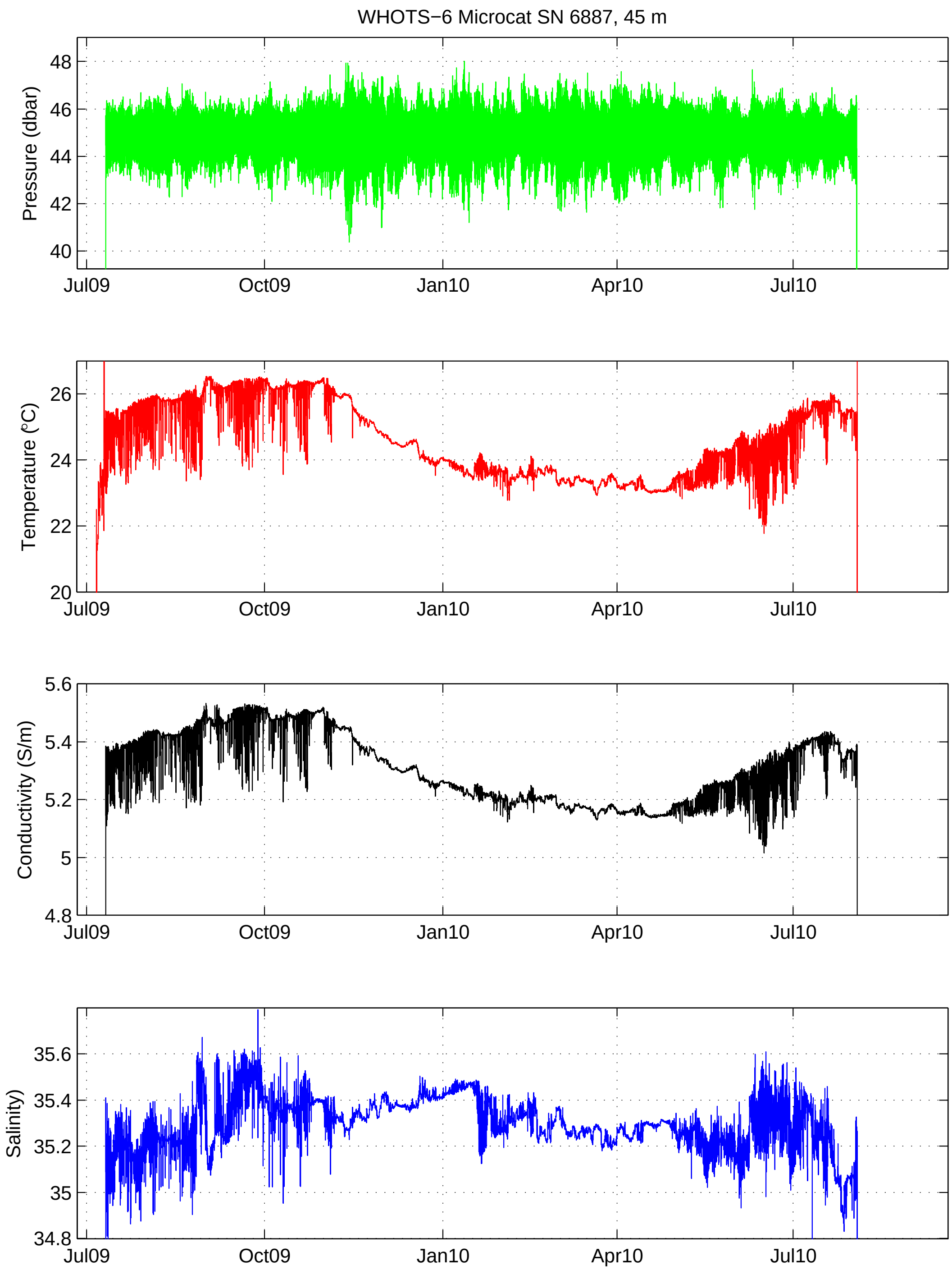

Figure A5. Preliminary pressure, temperature, conductivity and salinity from Microcat SBE-37 SN 6887 deployed at 45 m on the WHOTS-6 mooring.

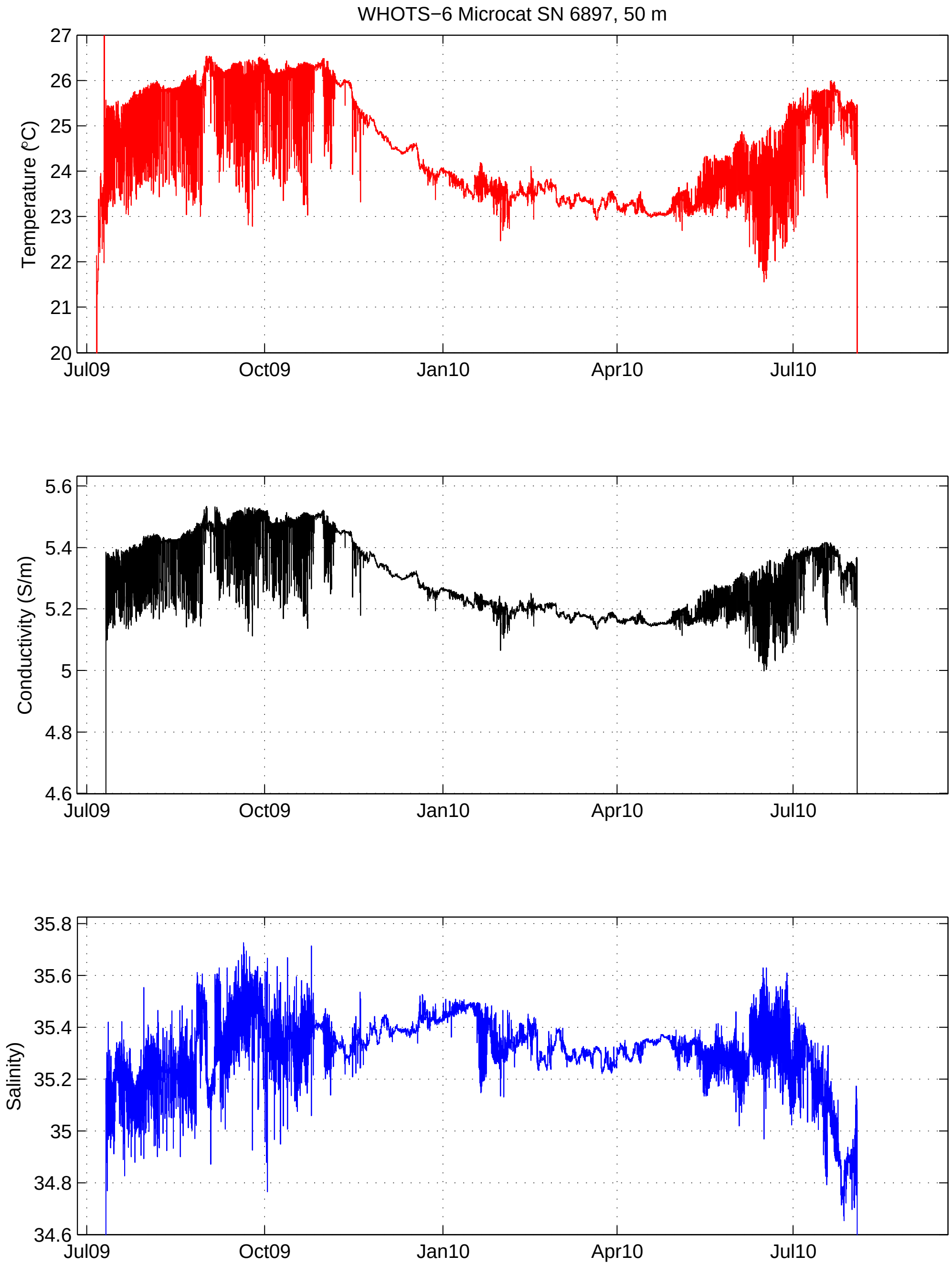

Figure A6. Preliminary temperature, conductivity and salinity from Microcat SBE-37 SN 6897 deployed at 50 m on the WHOTS-6 mooring. Nominal pressure was used to calculate salinity.

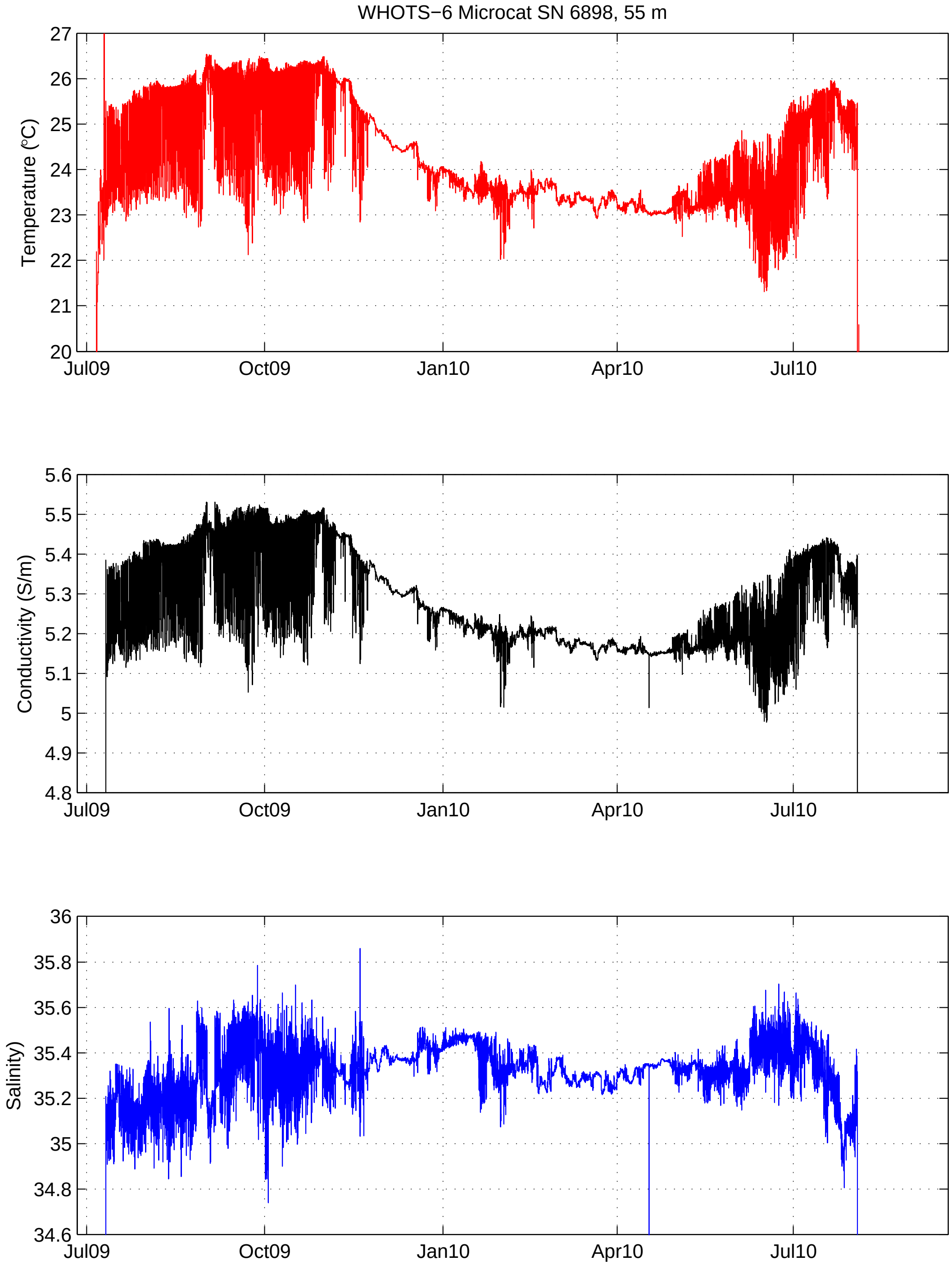

Figure A7. Preliminary temperature, conductivity and salinity from Microcat SBE-37 SN 6898 deployed at 55 m on the WHOTS-6 mooring. Nominal pressure was used to calculate salinity.

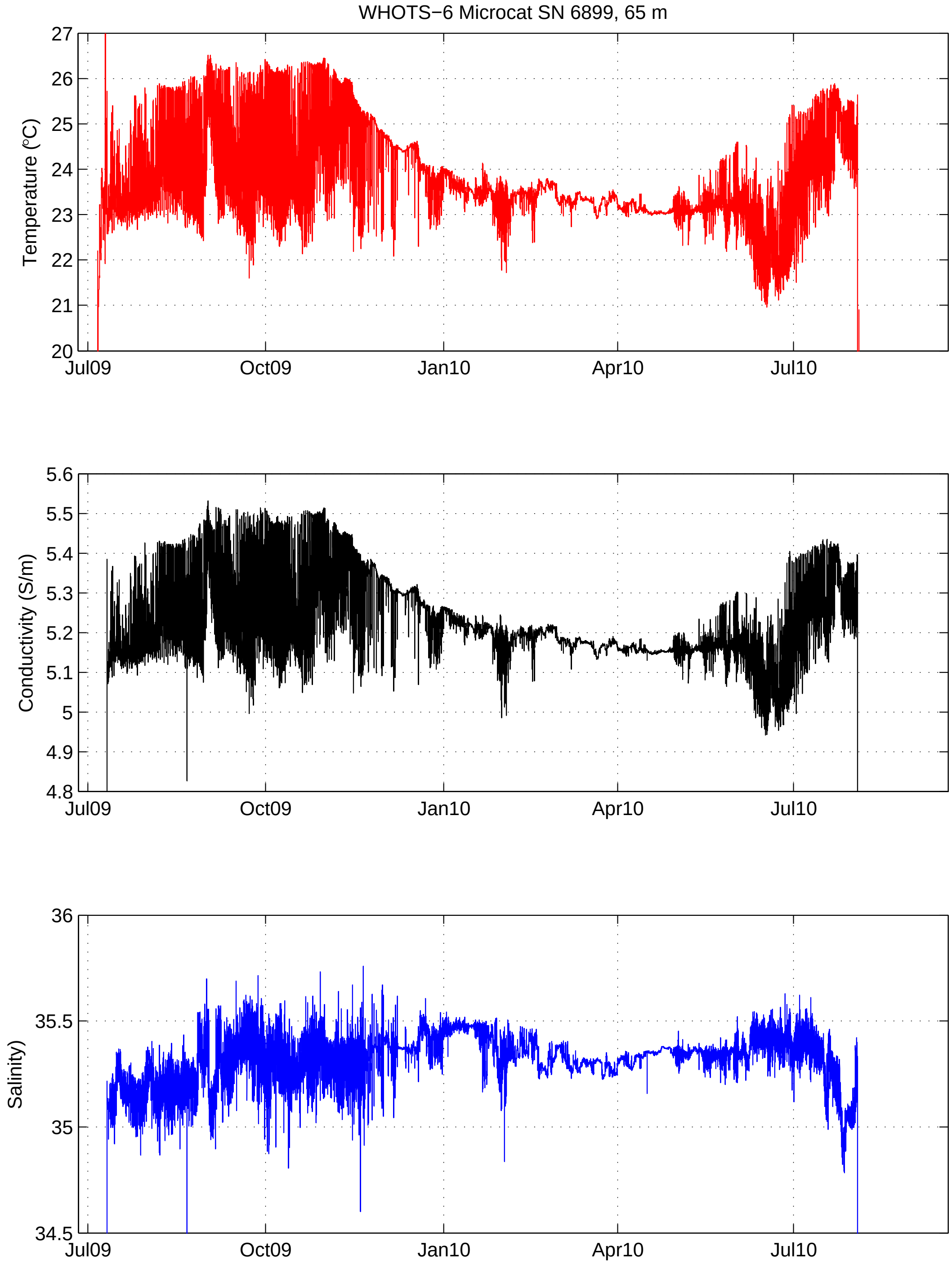

Figure A8. Preliminary temperature, conductivity and salinity from Microcat SBE-37 SN 6899 deployed at 65 m on the WHOTS-6 mooring. Nominal pressure was used to calculate salinity.

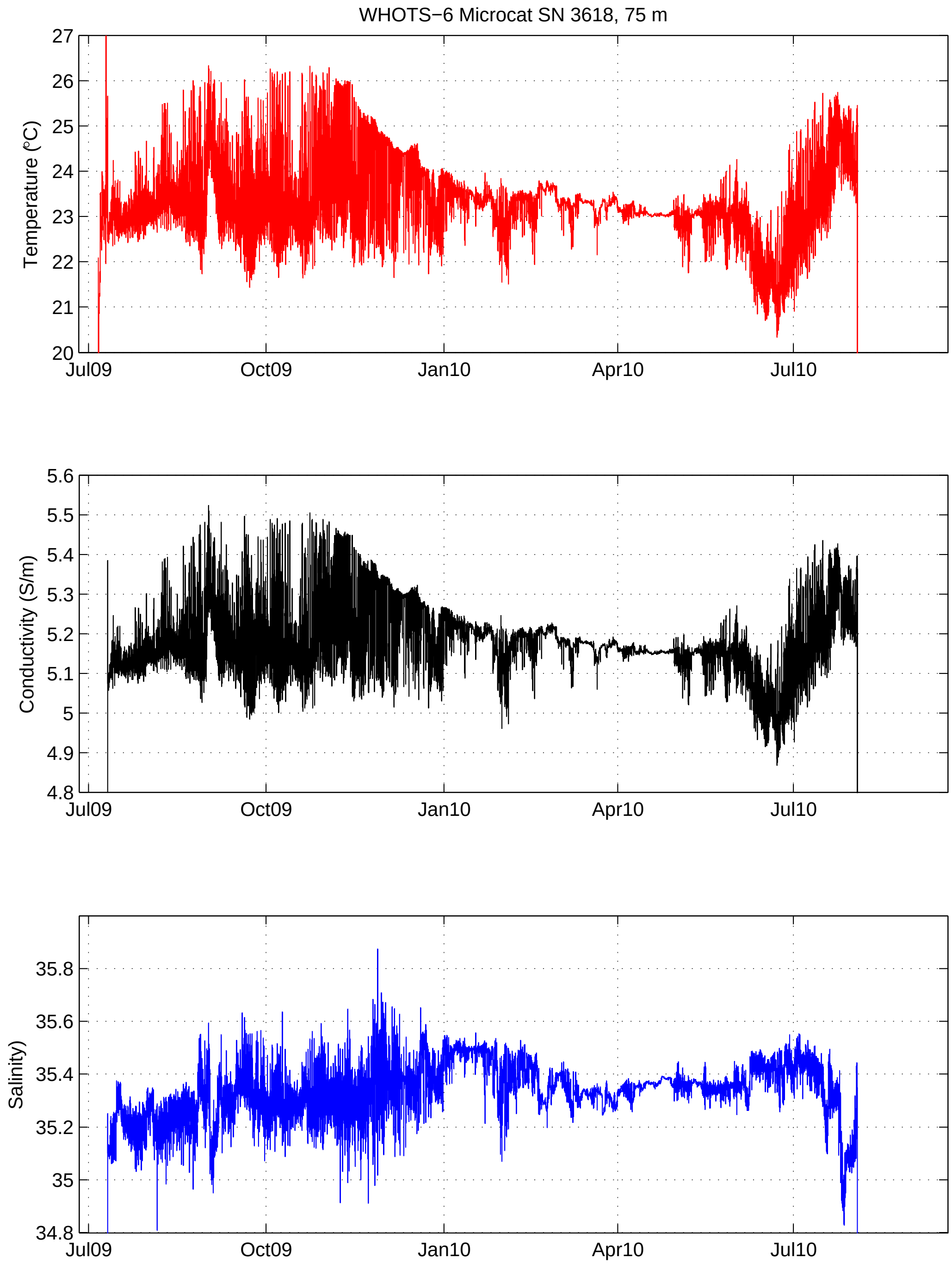

Figure A9. Preliminary temperature, conductivity and salinity from Microcat SBE-37 SN 3618 deployed at 75 m on the WHOTS-6 mooring. Nominal pressure was used to calculate salinity.

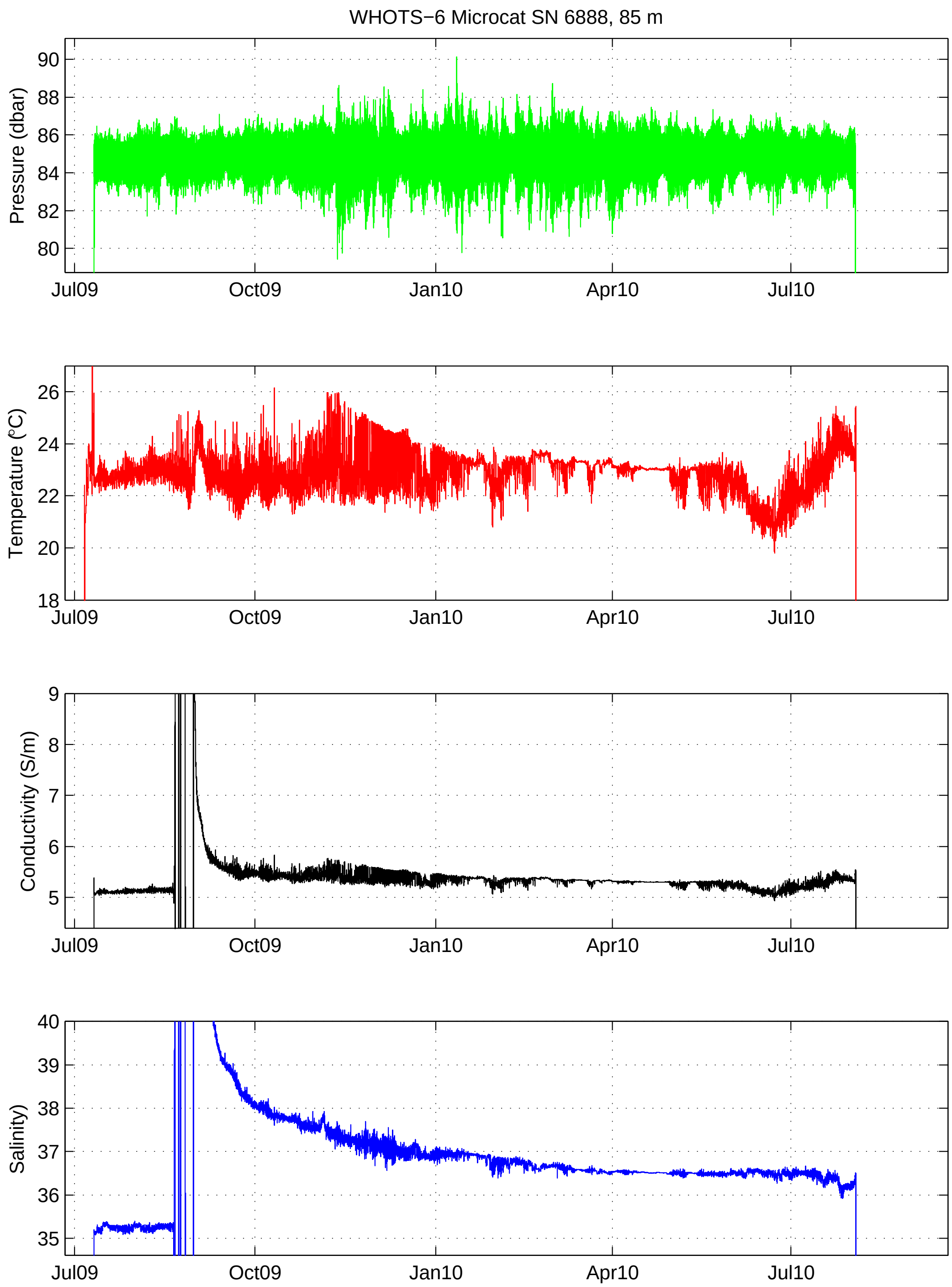

Figure A10. Preliminary pressure, temperature, conductivity and salinity from Microcat SBE-37 SN 6888 deployed at 85 m on the WHOTS-6 mooring.

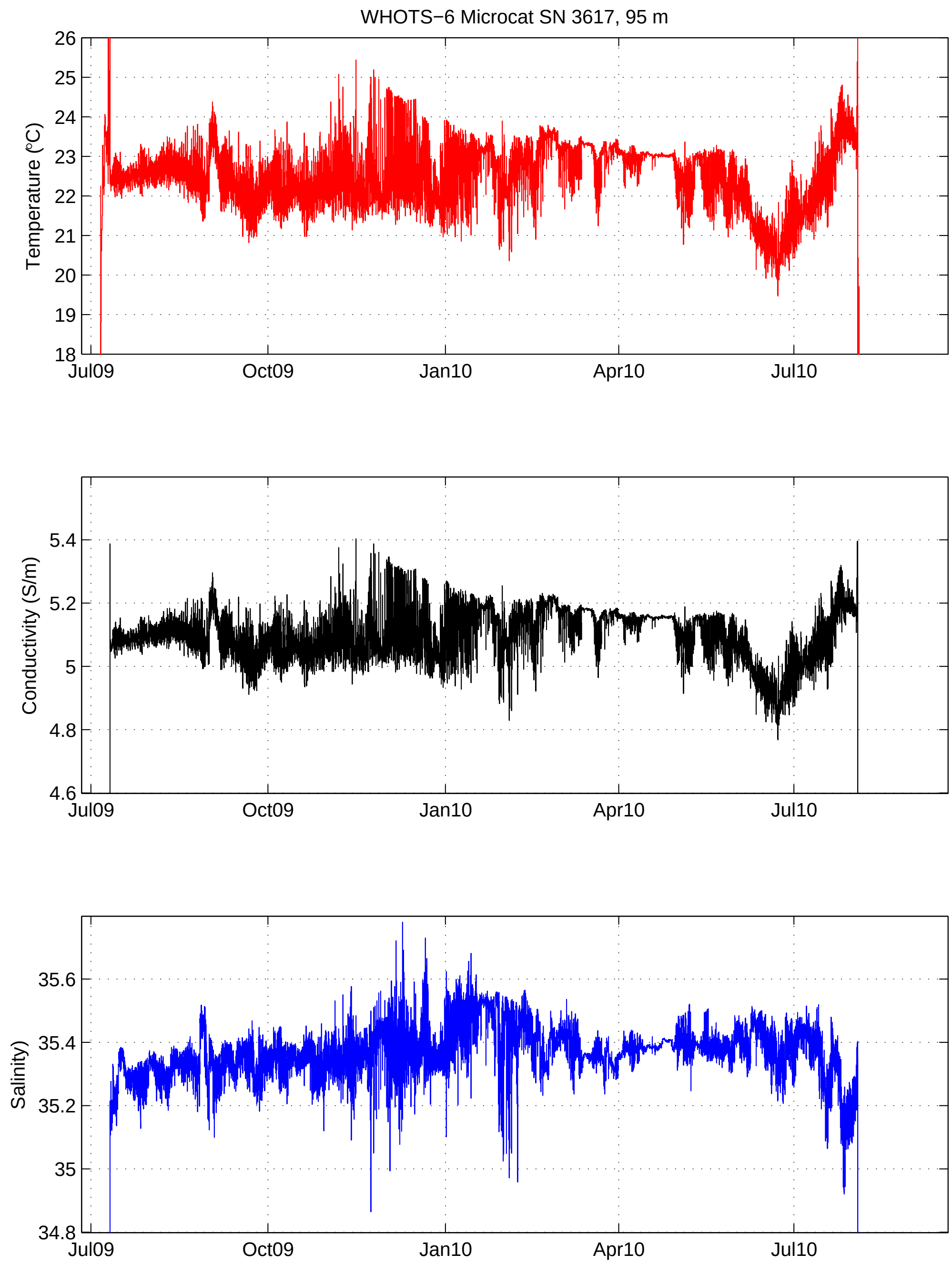

Figure A11. Preliminary temperature, conductivity and salinity from Microcat SBE-37 SN 3617 deployed at 95 m on the WHOTS-6 mooring. Nominal pressure was used to calculate salinity.

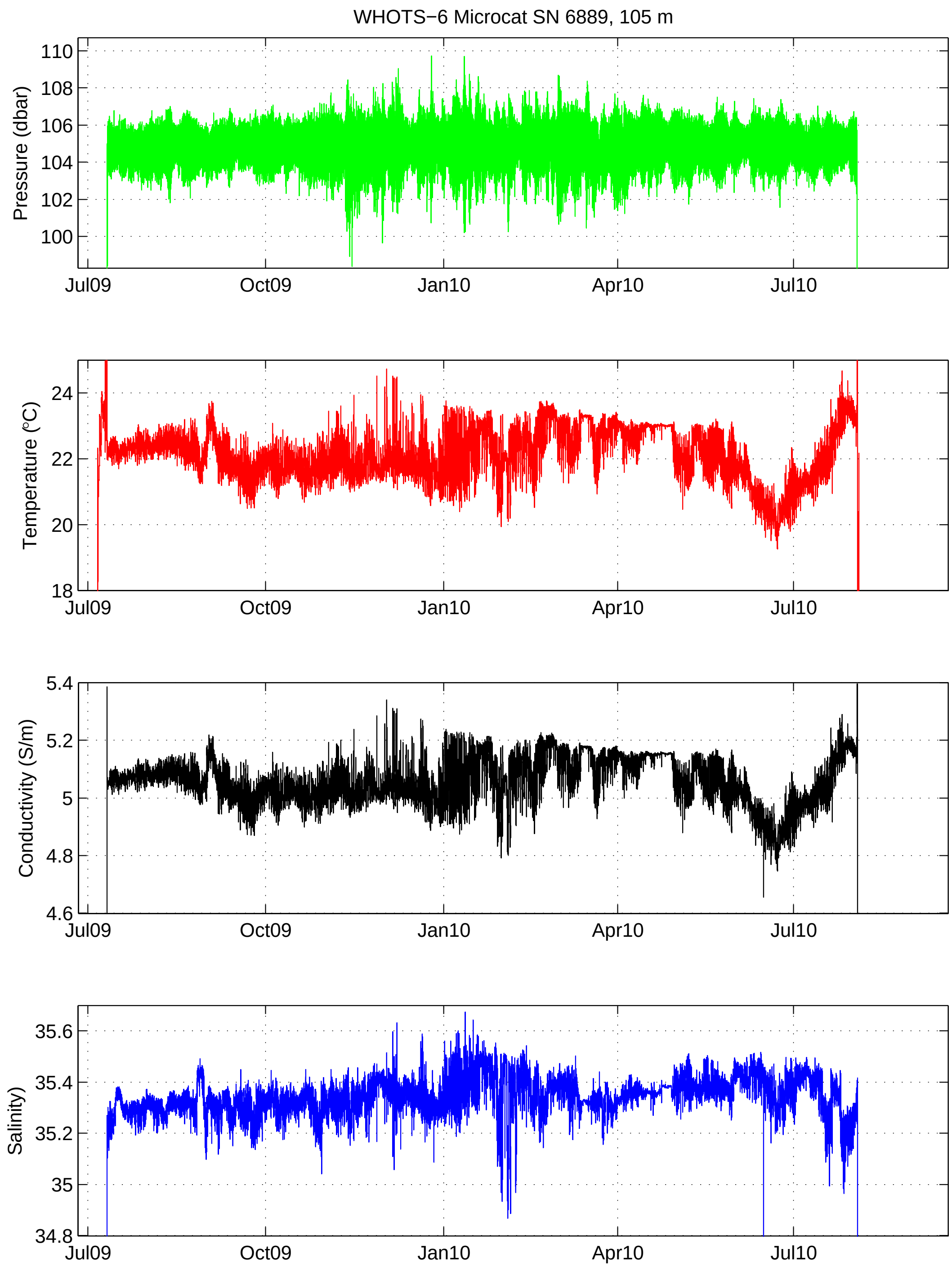

Figure A12. Preliminary pressure, temperature, conductivity and salinity from Microcat SBE-37 SN 6889 deployed at 105 m on the WHOTS-6 mooring.

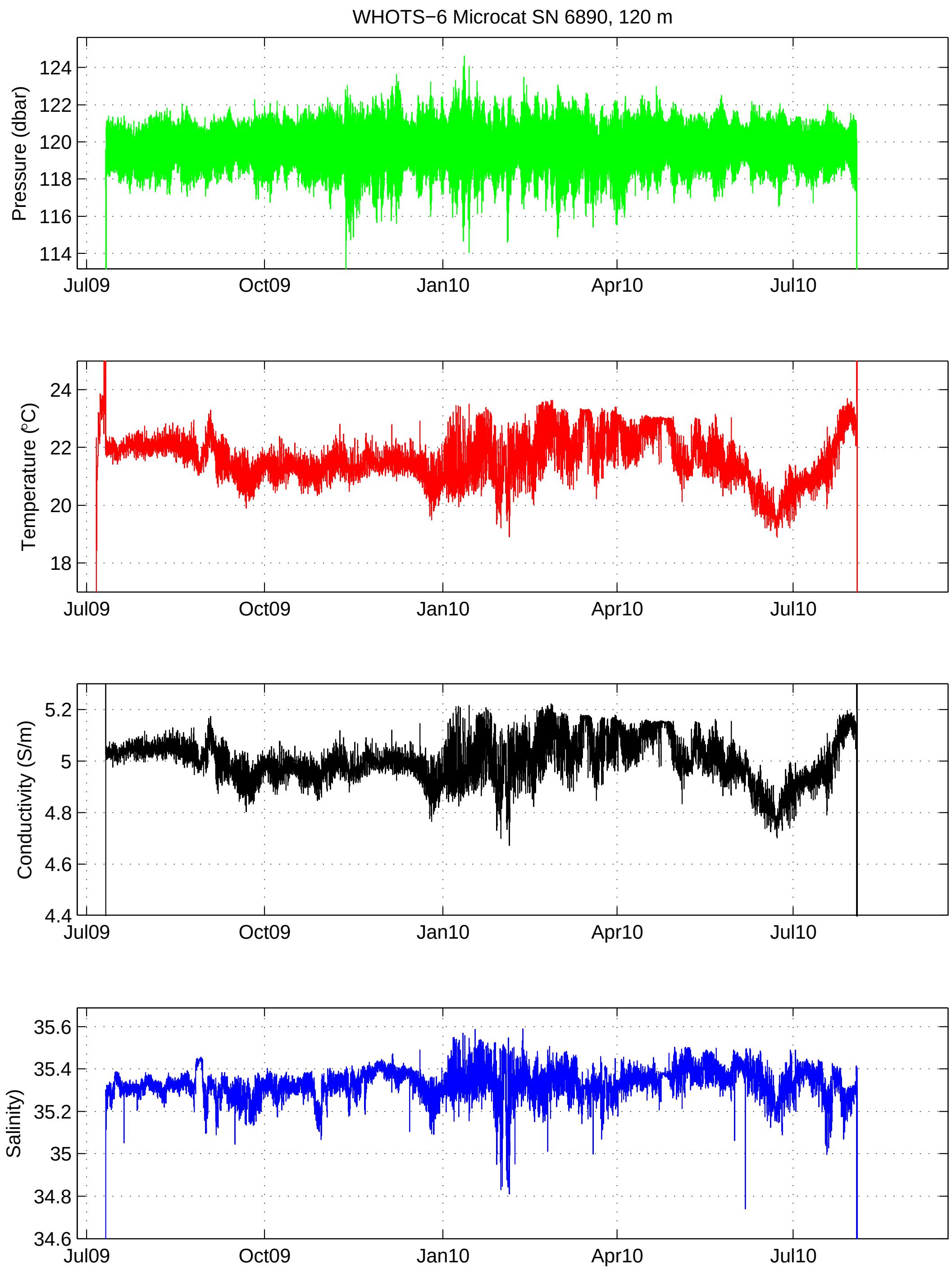

Figure A13. Preliminary pressure, temperature, conductivity and salinity from Microcat SBE-37 SN 6890 deployed at 120 m on the WHOTS-6 mooring.

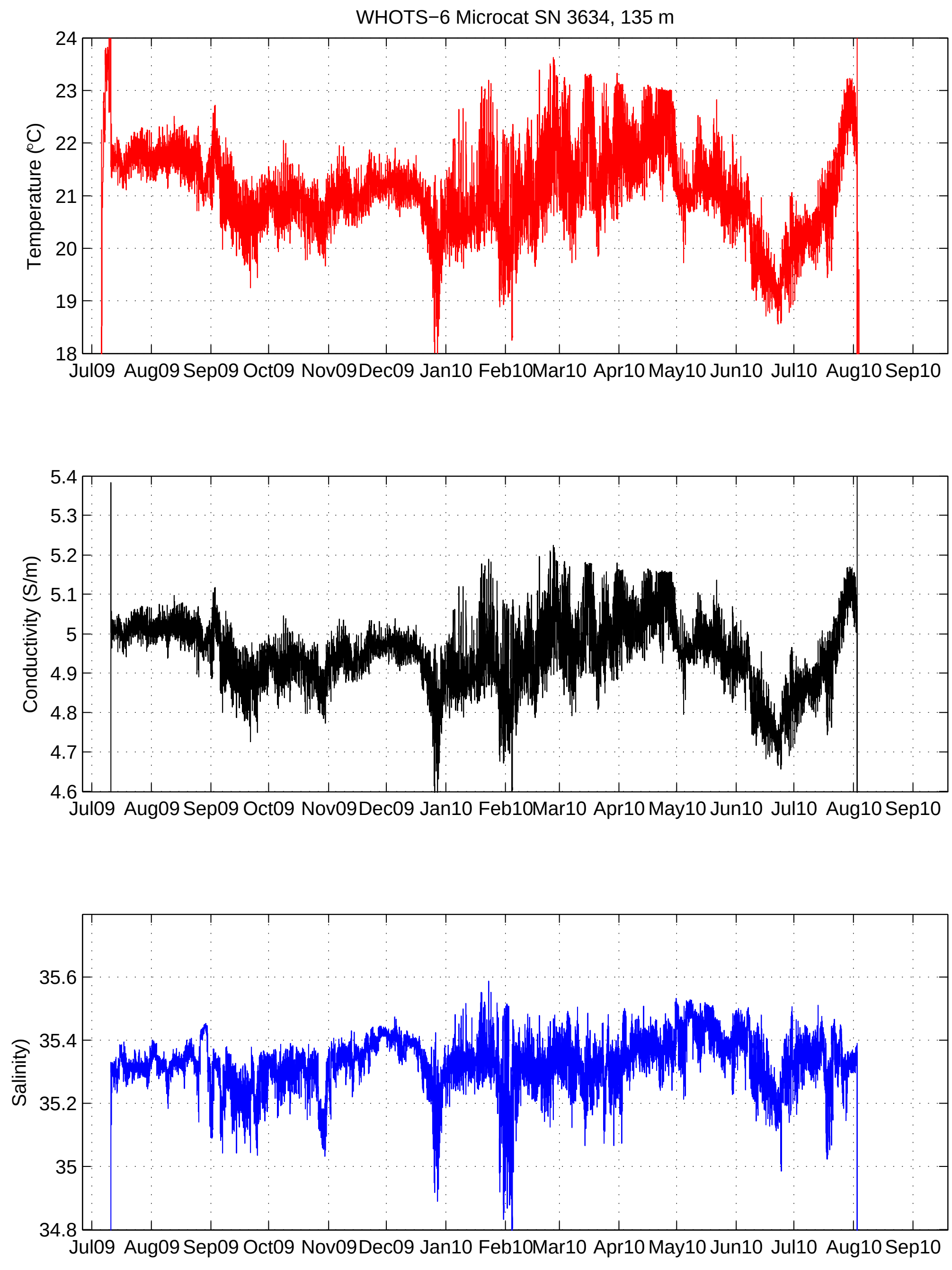

Figure A14. Preliminary temperature, conductivity and salinity from Microcat SBE-37 SN 3634 deployed at 135 m on the WHOTS-6 mooring. Nominal pressure was used to calculate salinity.

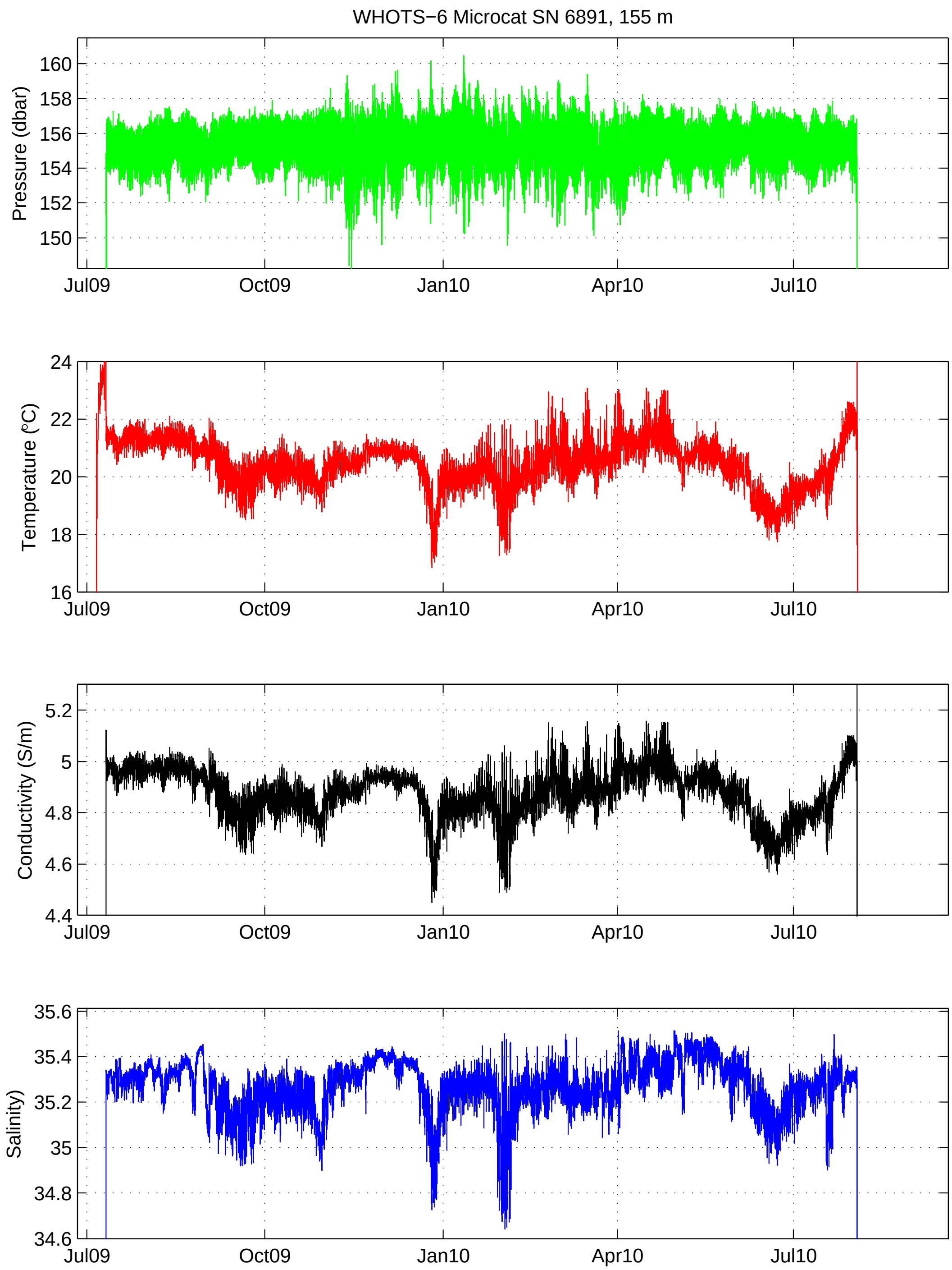

Figure A15. Preliminary pressure, temperature, conductivity and salinity from Microcat SBE-37 SN 6891 deployed at 155 m on the WHOTS-6 mooring.

Appendix B. CTD Casts Figures

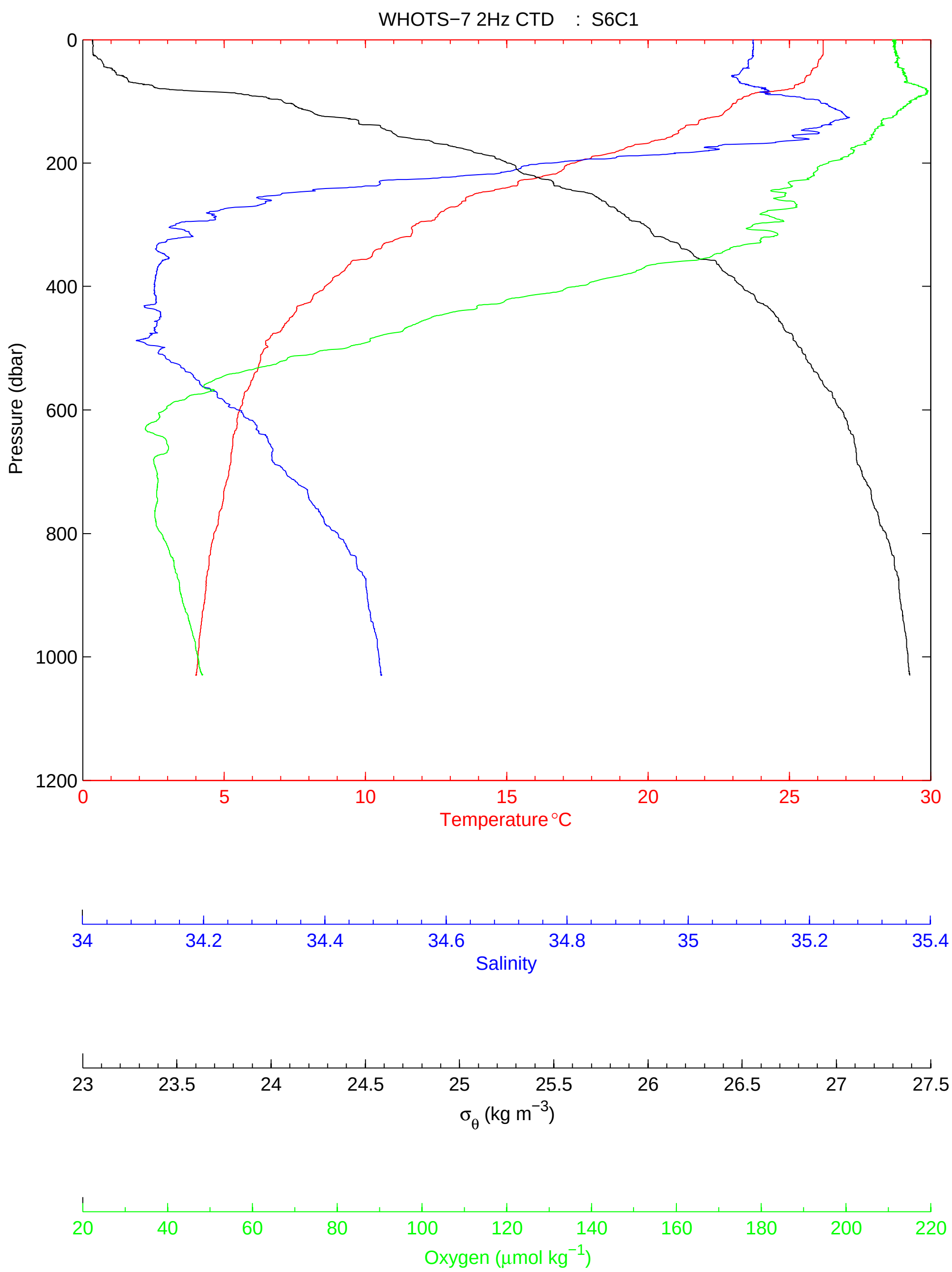

Figure B1. Profiles of 2 Hz temperature, salinity, potential density and oxygen data during test CTD station.

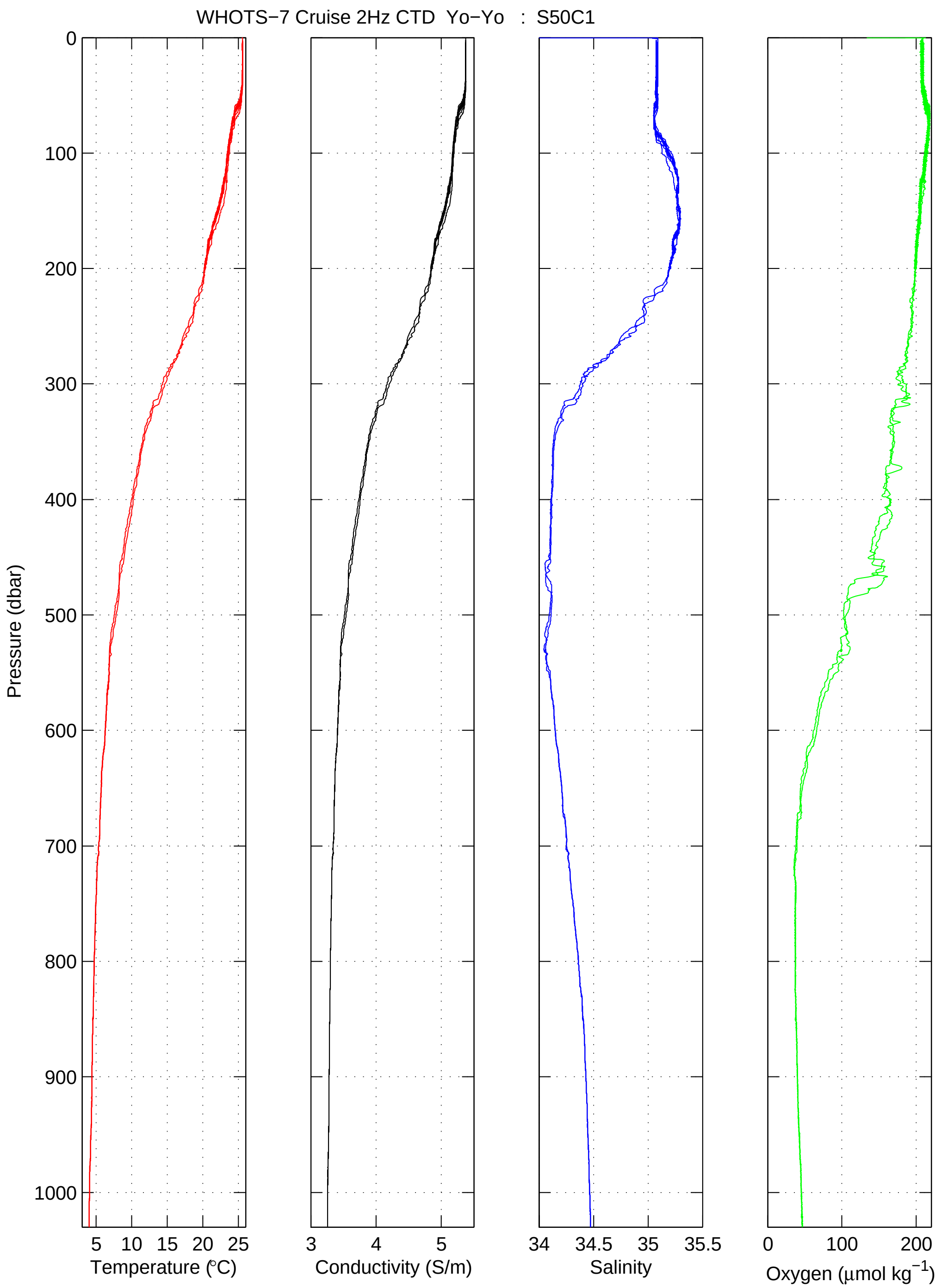

Figure B2. Profiles of 2 Hz temperature, conductivity, salinity, and oxygen data during CTD S50C1.

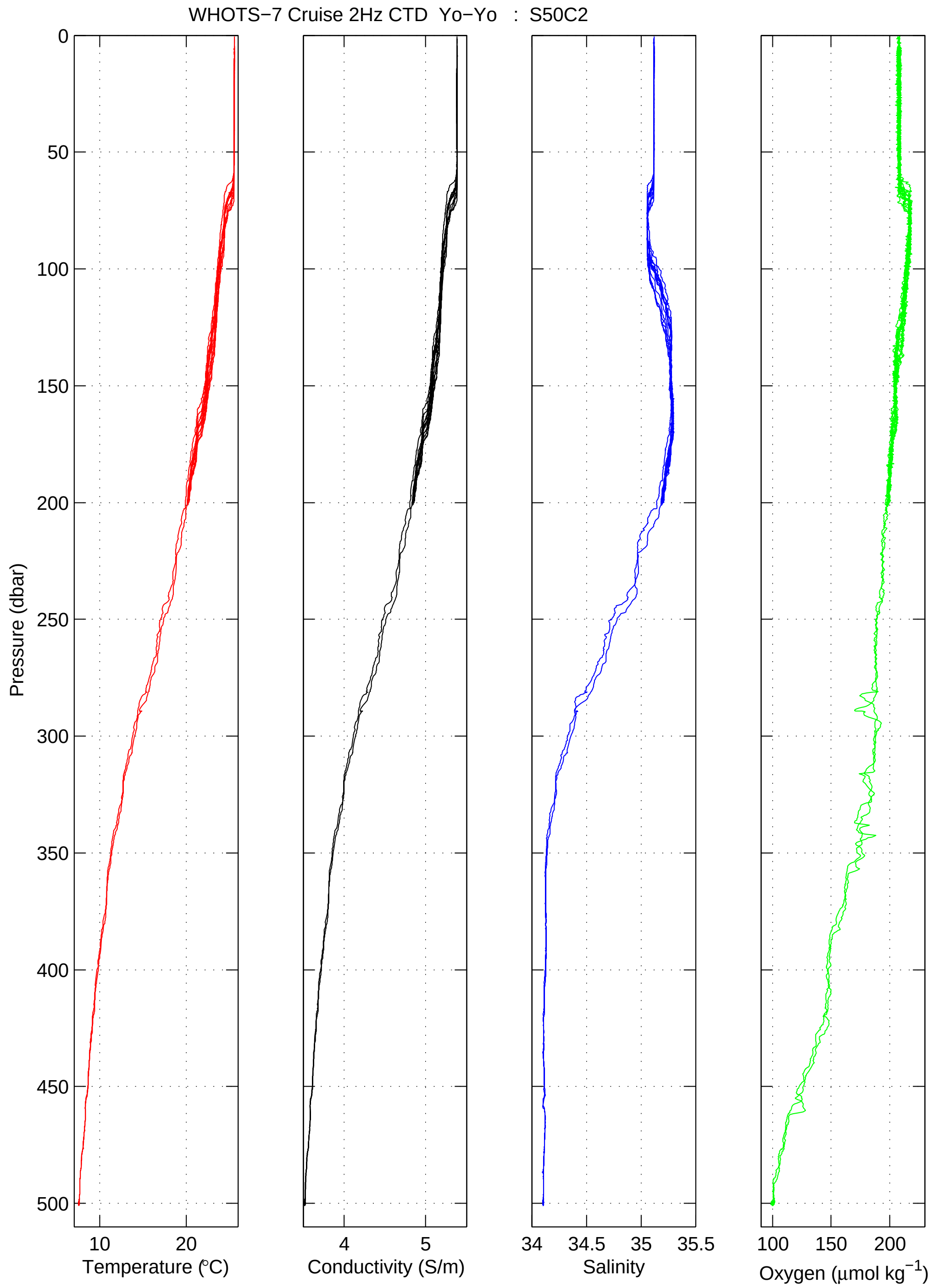

Figure B3. Profiles of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S50C2.

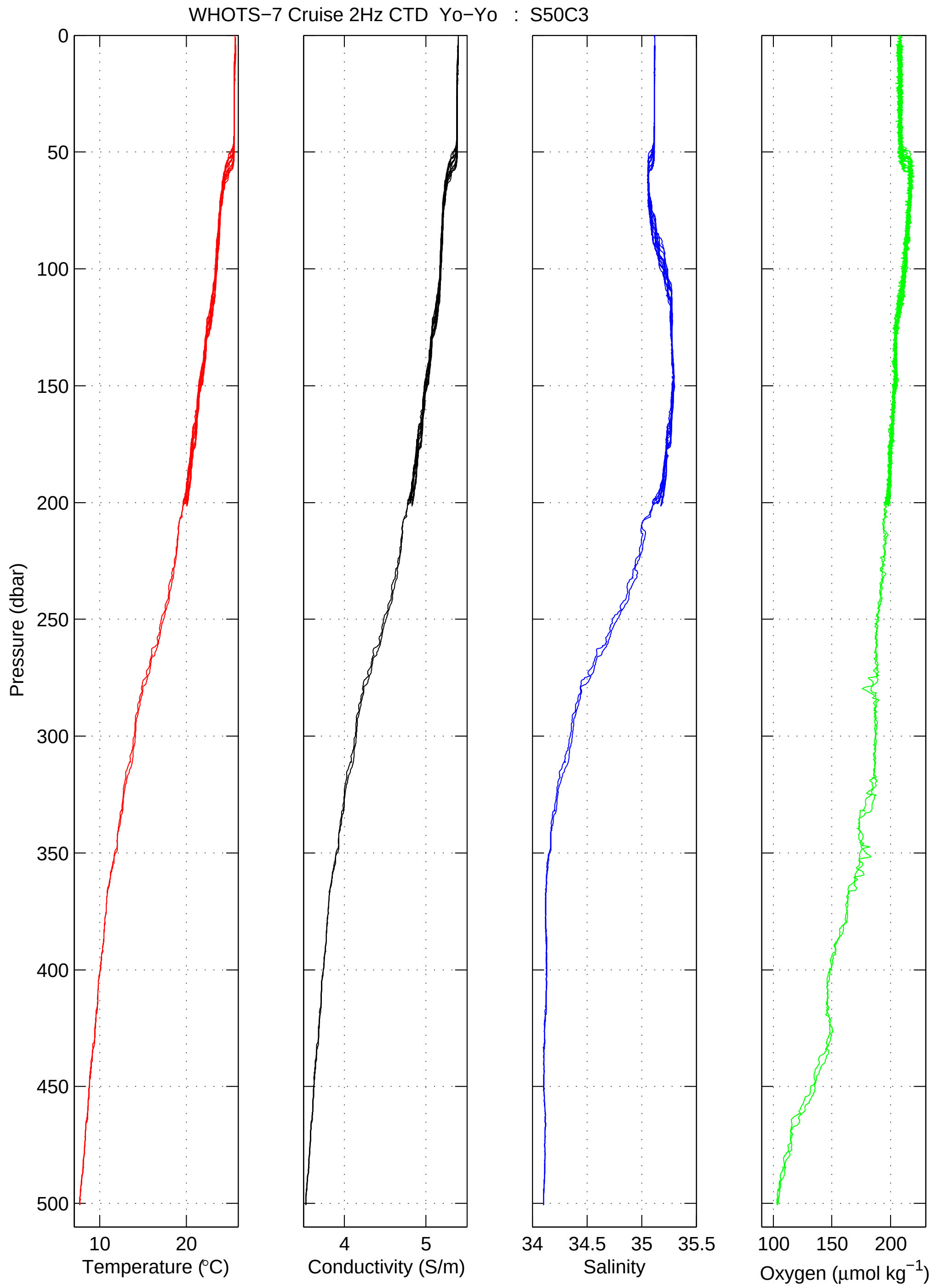

Figure B4. Profiles of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S50C3.

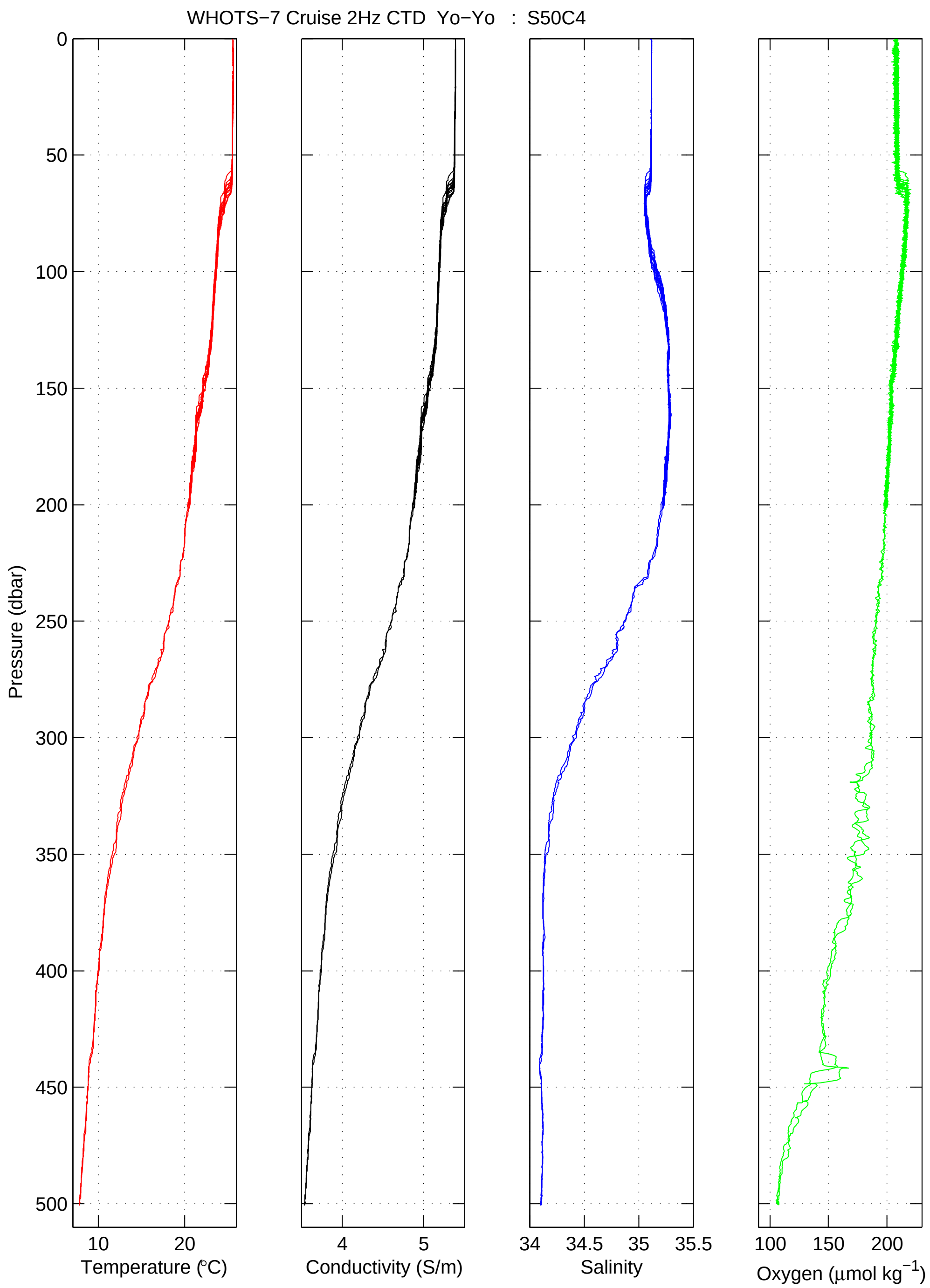

Figure B5. Profiles of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S50C4.

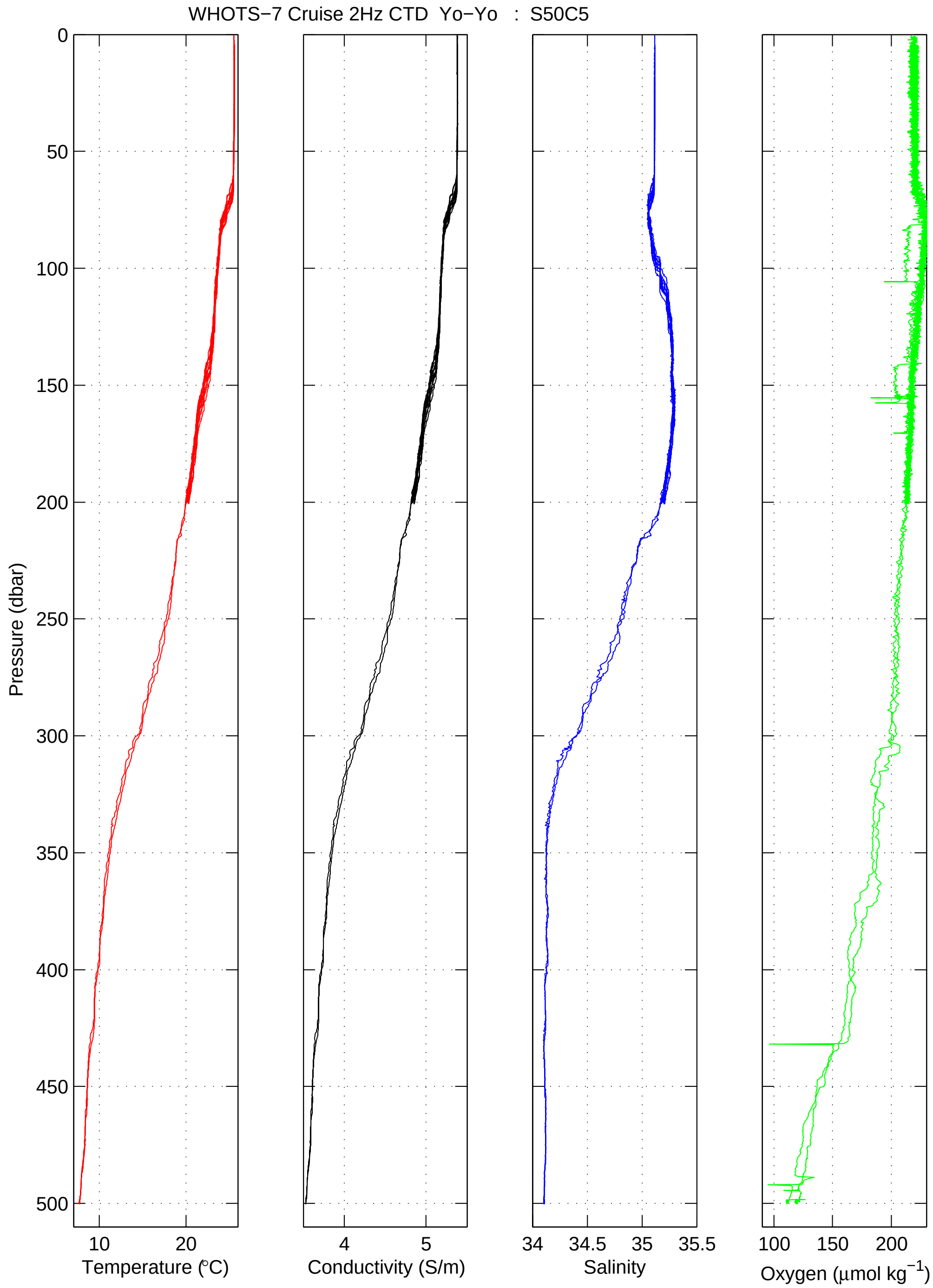

Figure B6. Profiles of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S50C5.

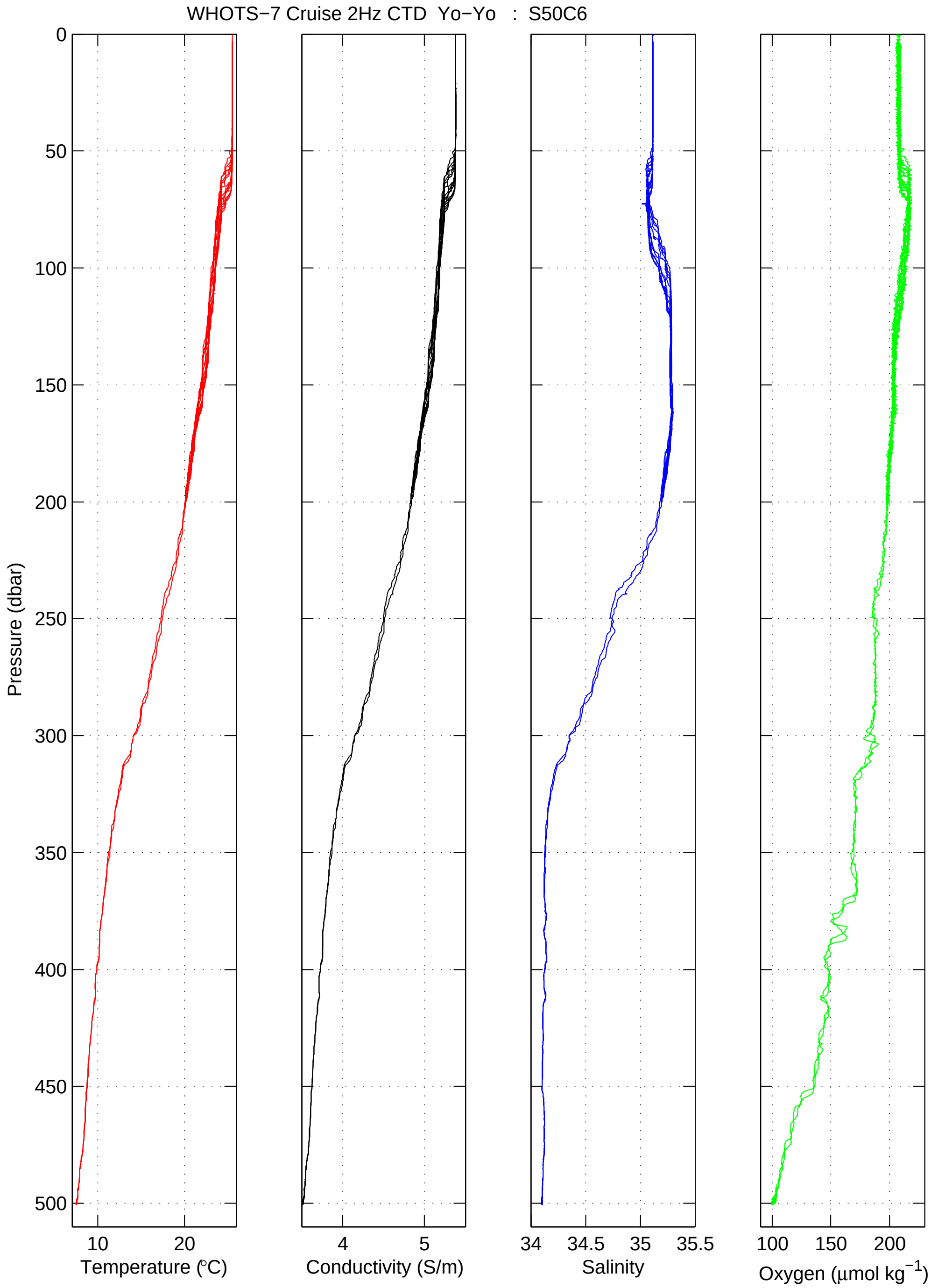

Figure B7. Profiles of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S50C6.

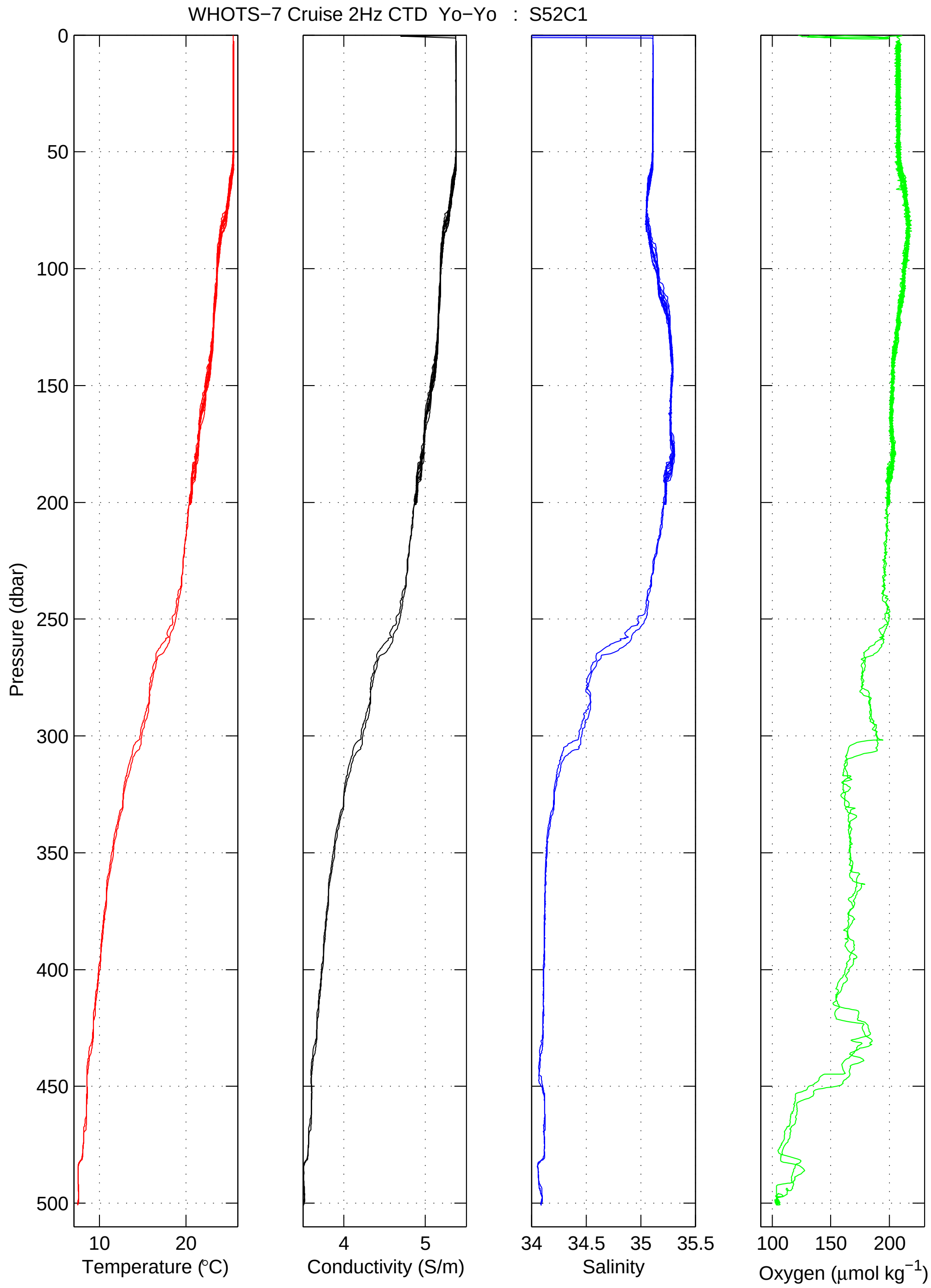

Figure B8. Profiles of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S52C1.

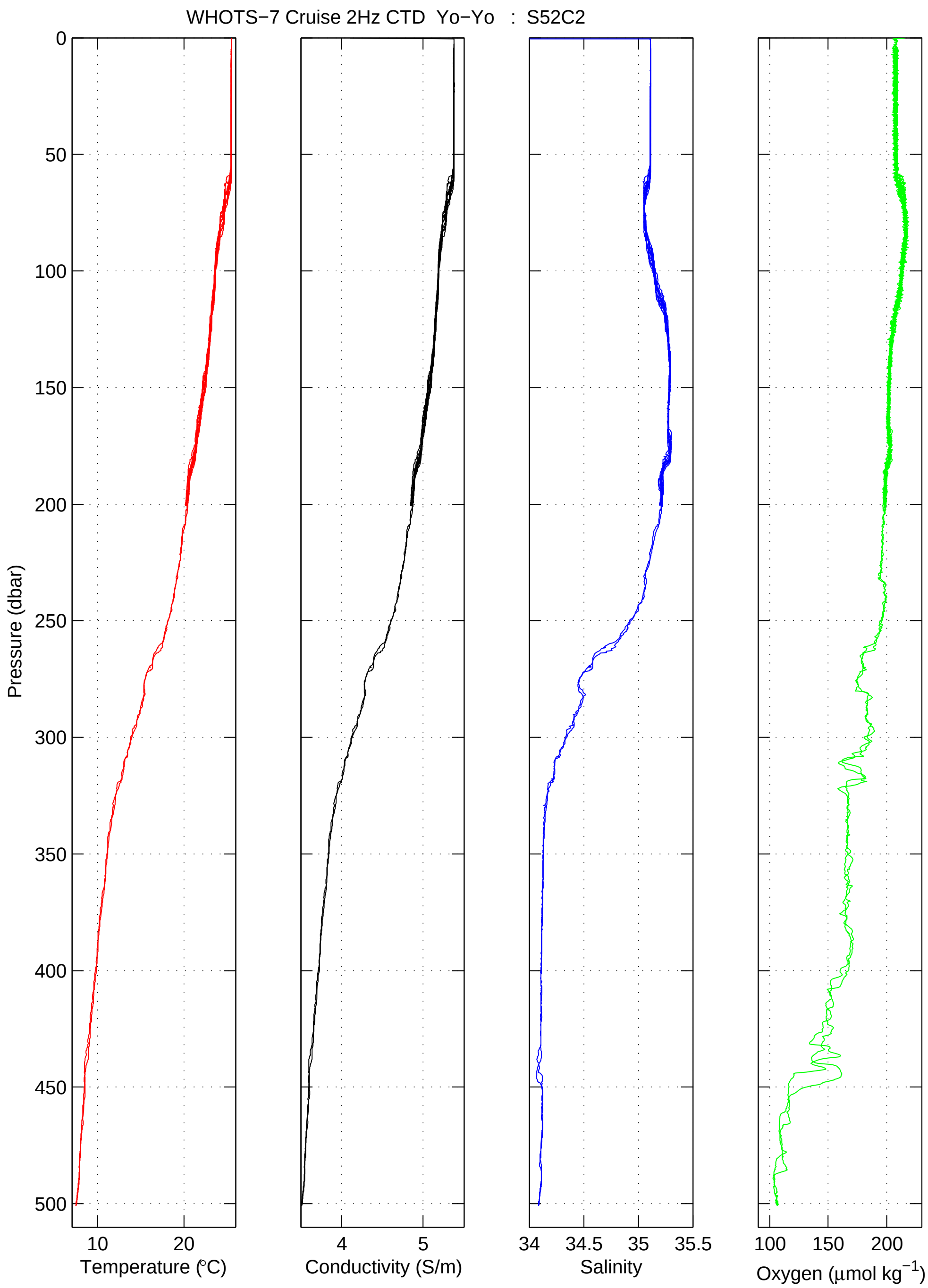

Figure B9. Profiles of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S52C2.

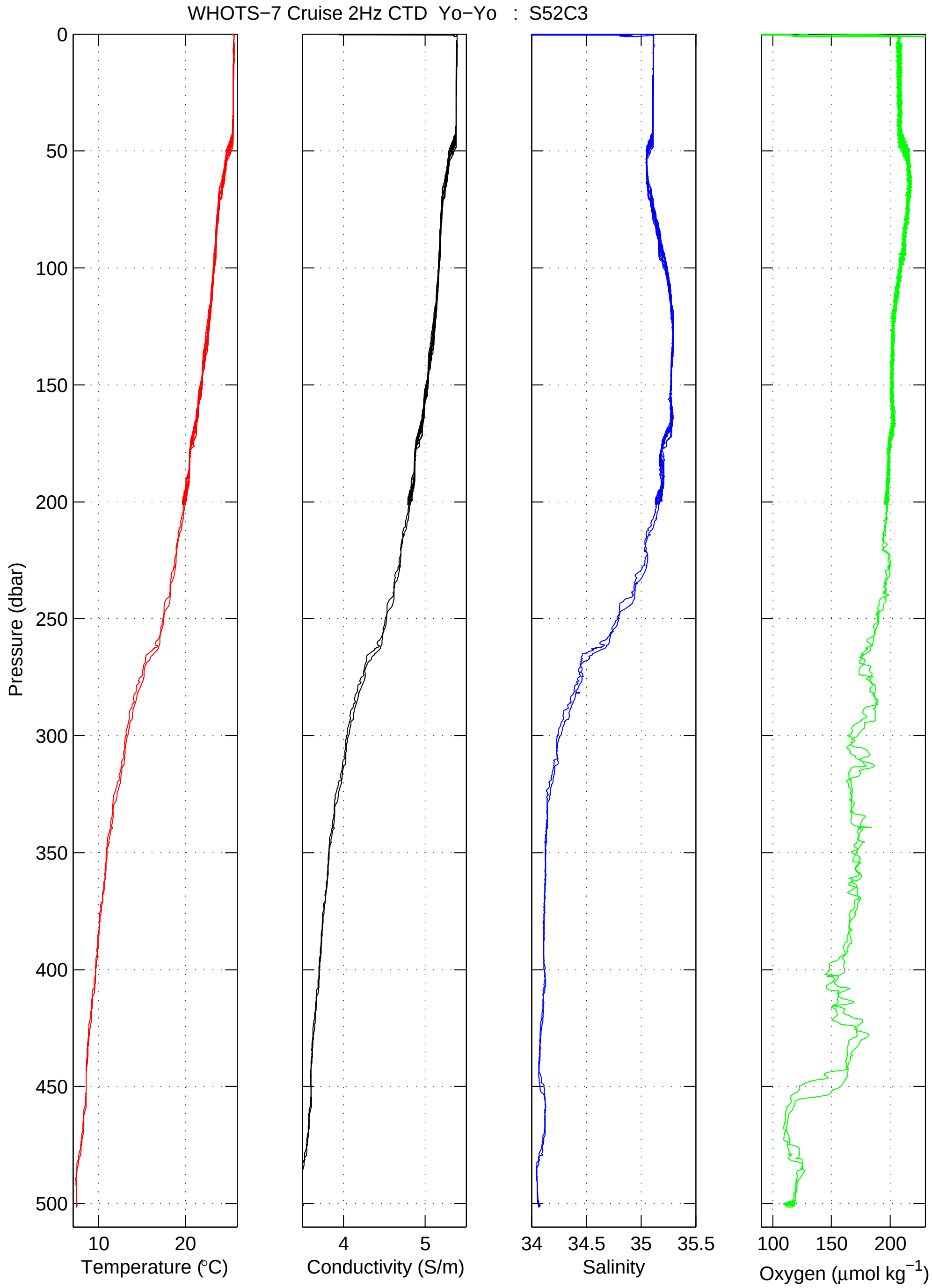

Figure B10. Profiles of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S52C3.

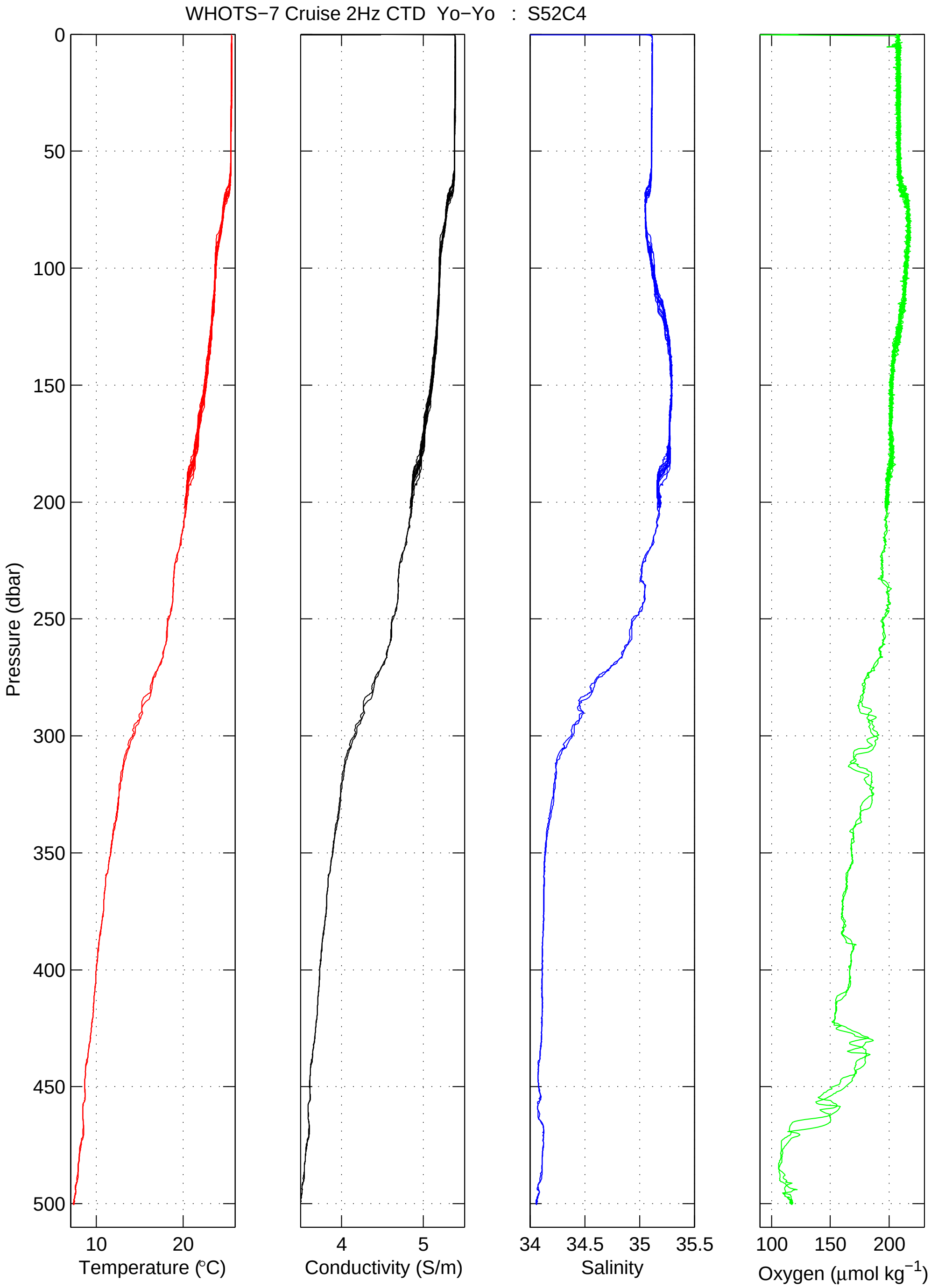

Figure B11. Profiles of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S52C4.

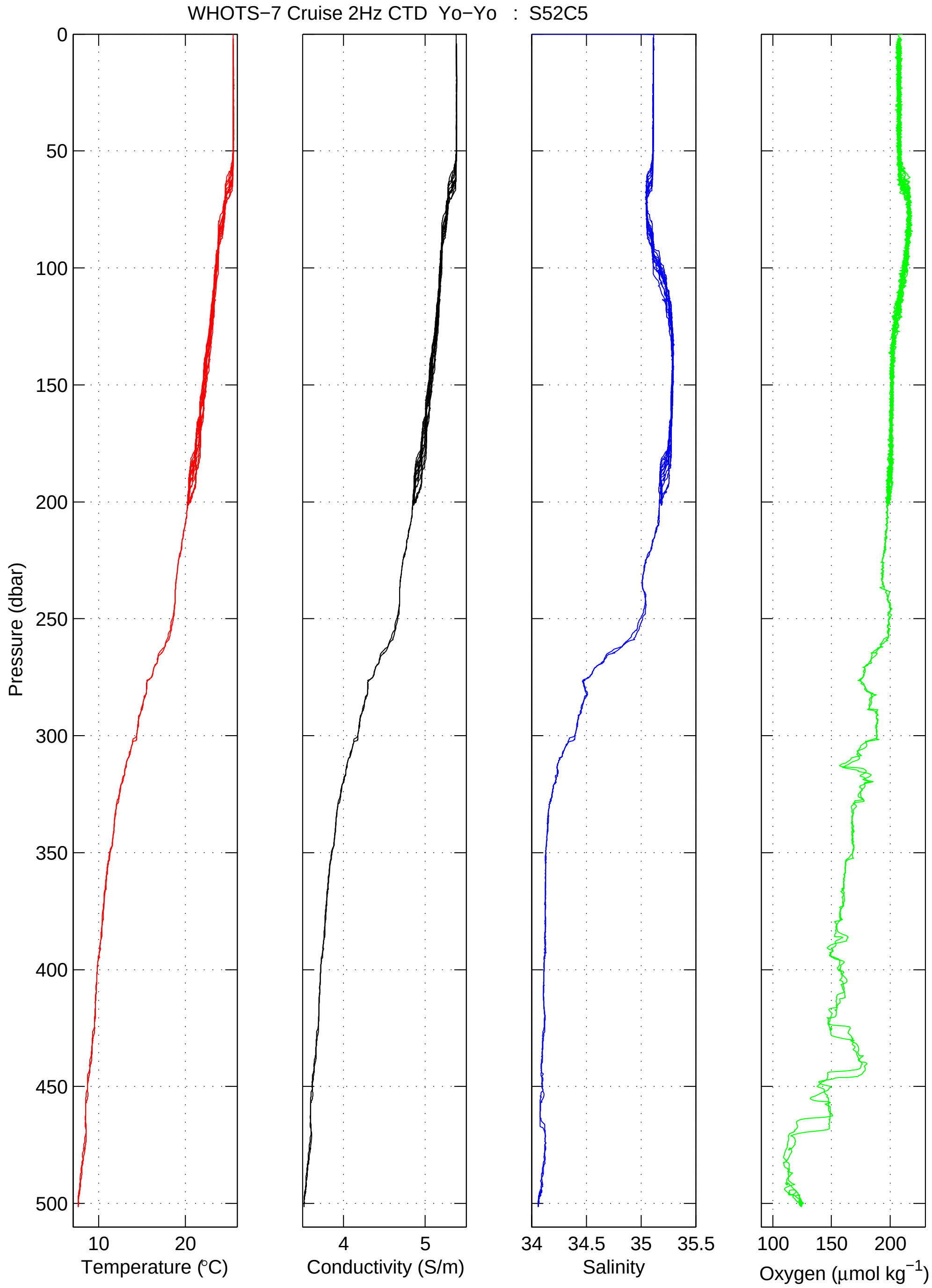

Figure B12. Profiles of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S52C5.

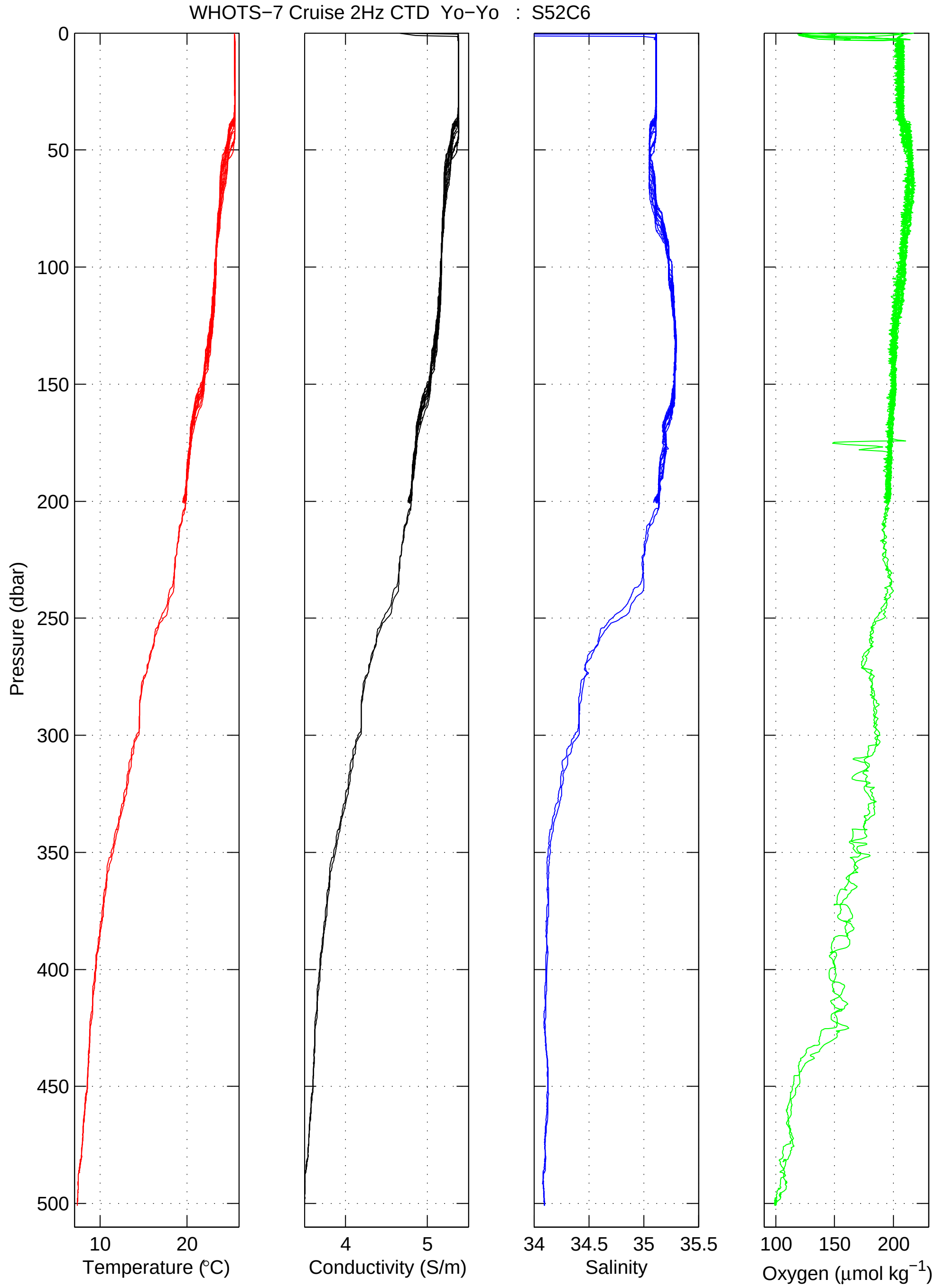

Figure B13. Profiles of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S52C6.

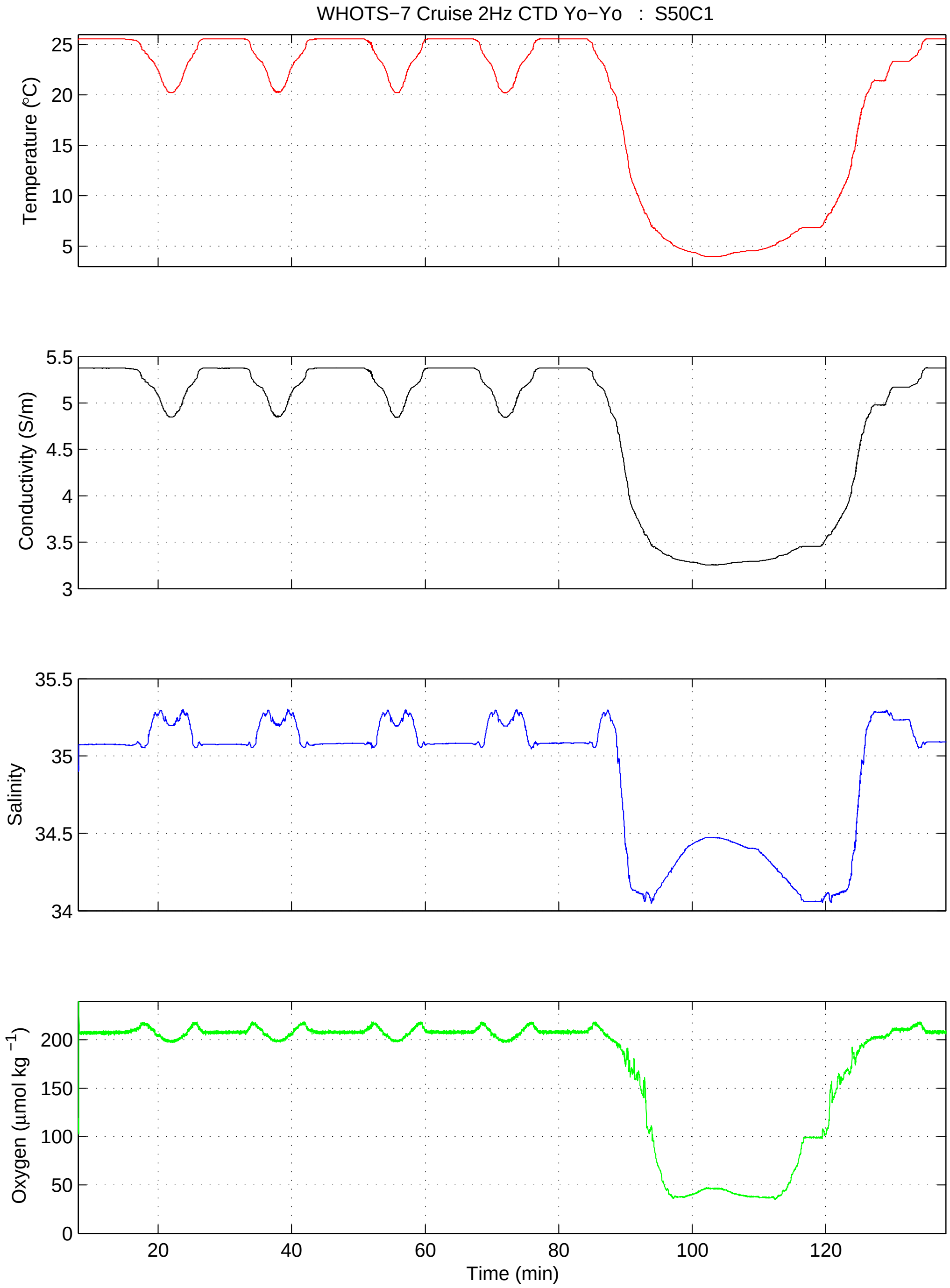

Figure B14. Time-series of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S50C1.

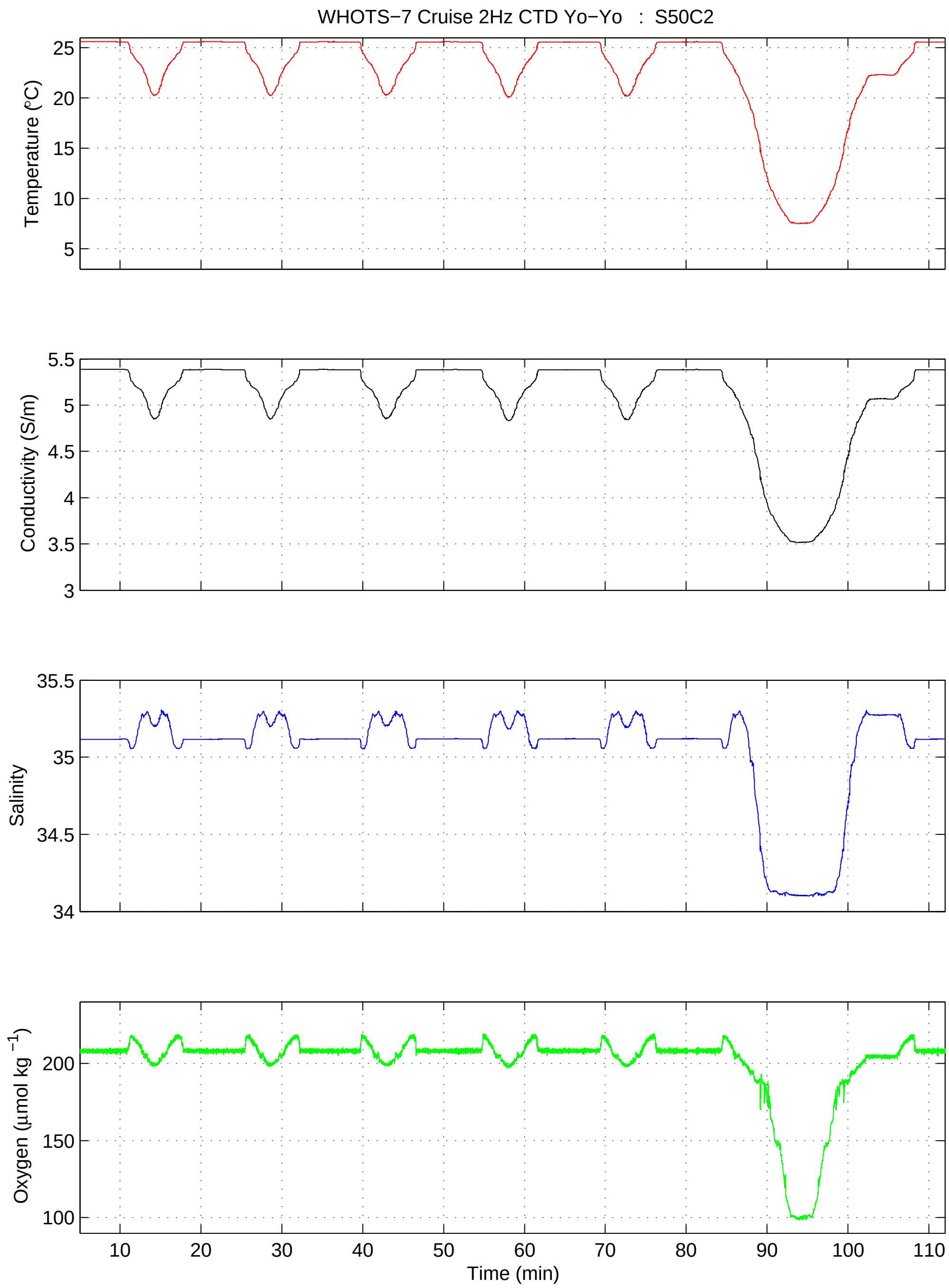

Figure B15. Time-series of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S50C2.

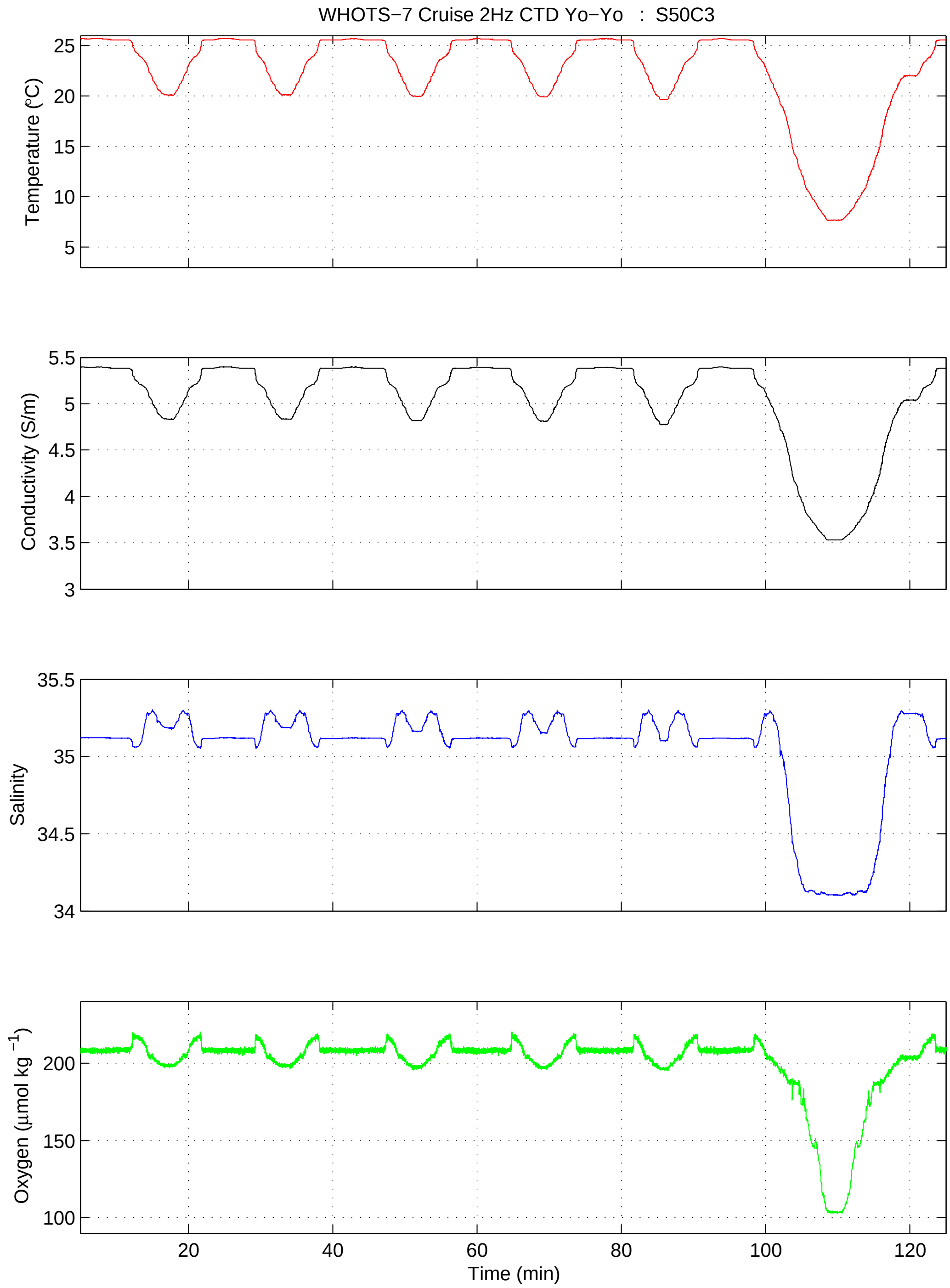

Figure B16. Time-series of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S50C3.

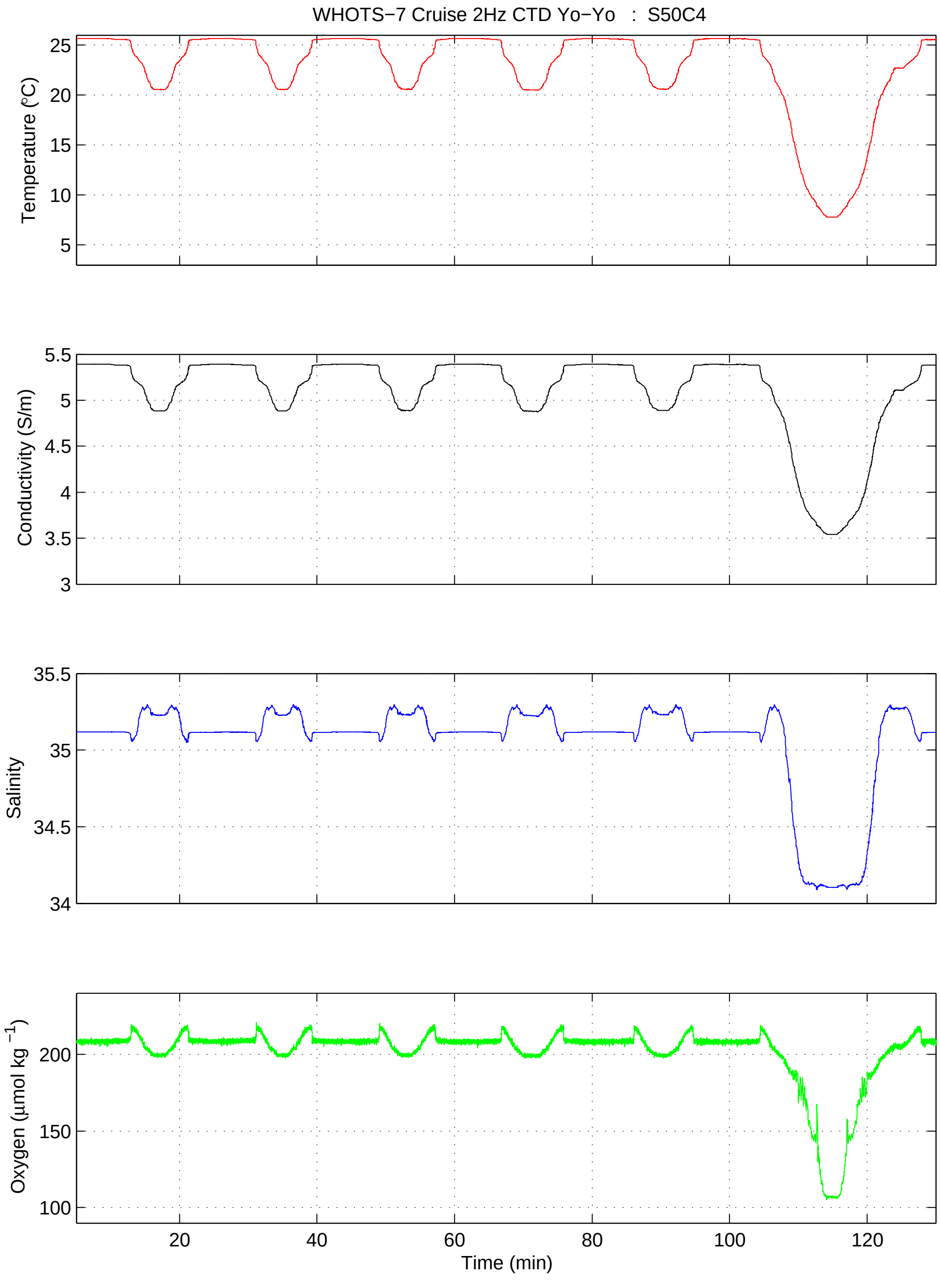

Figure B17. Time-series of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S50C4.

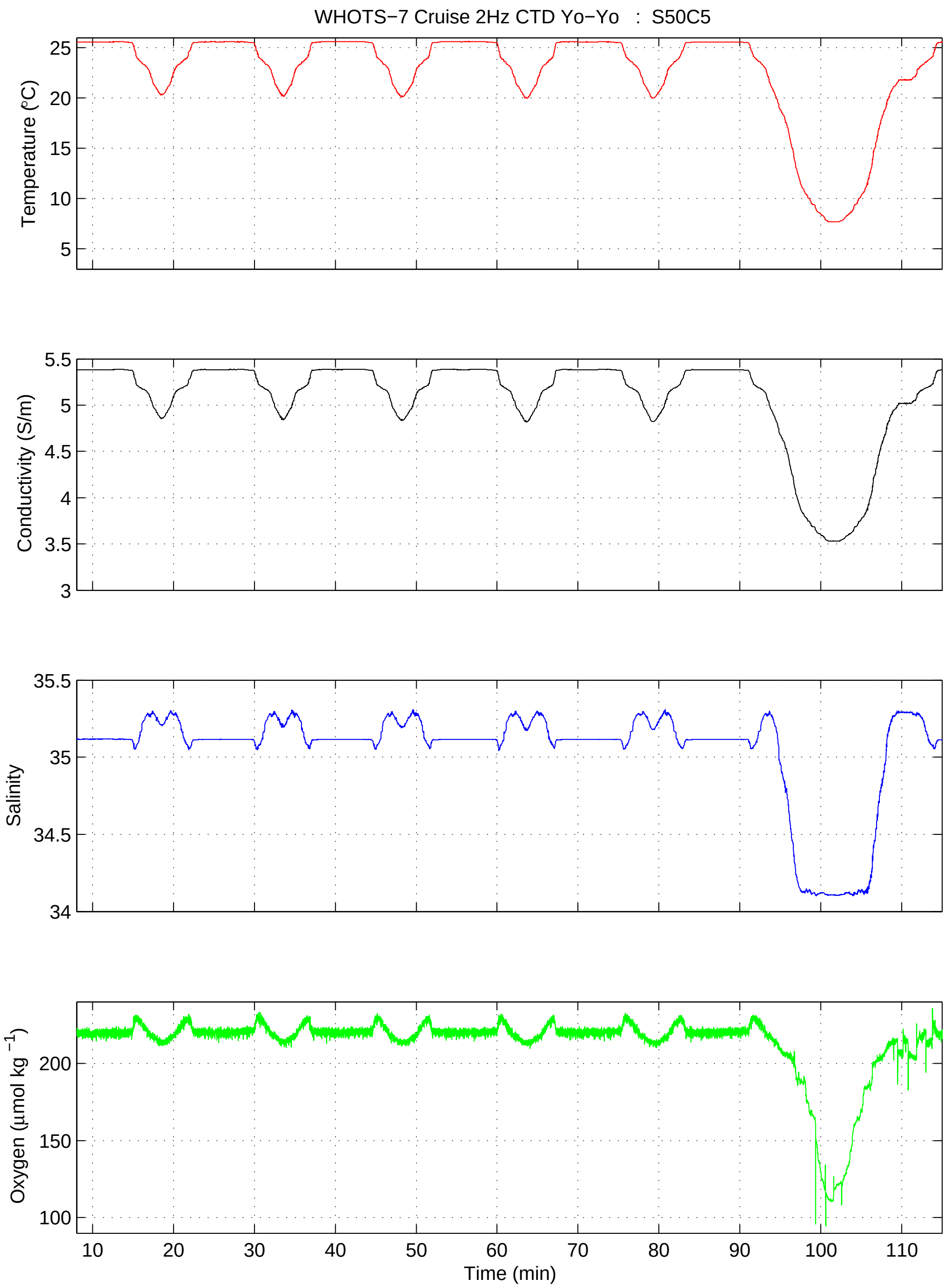

Figure B18. Time-series of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S50C5.

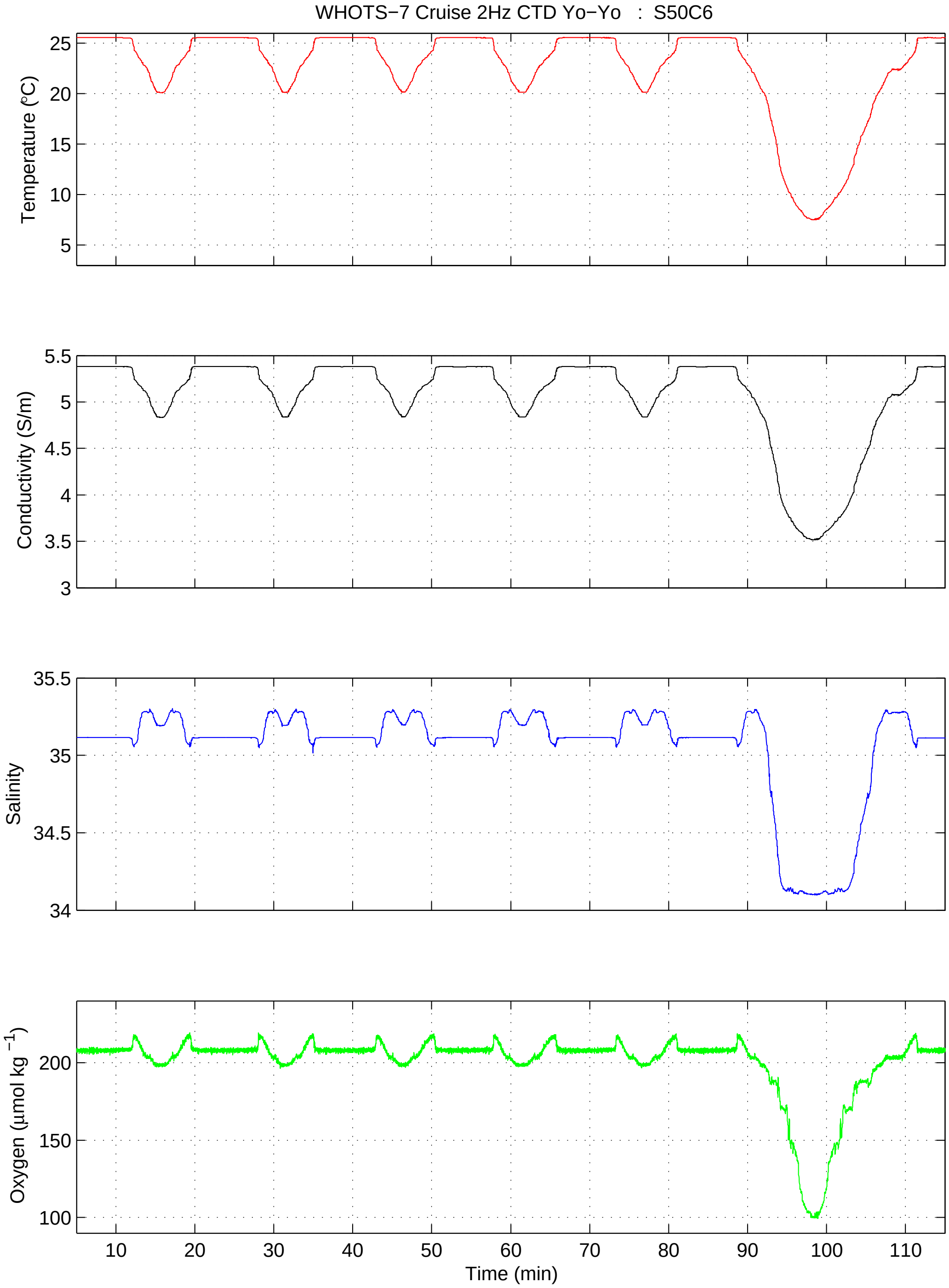

Figure B19. Time-series of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S50C6.

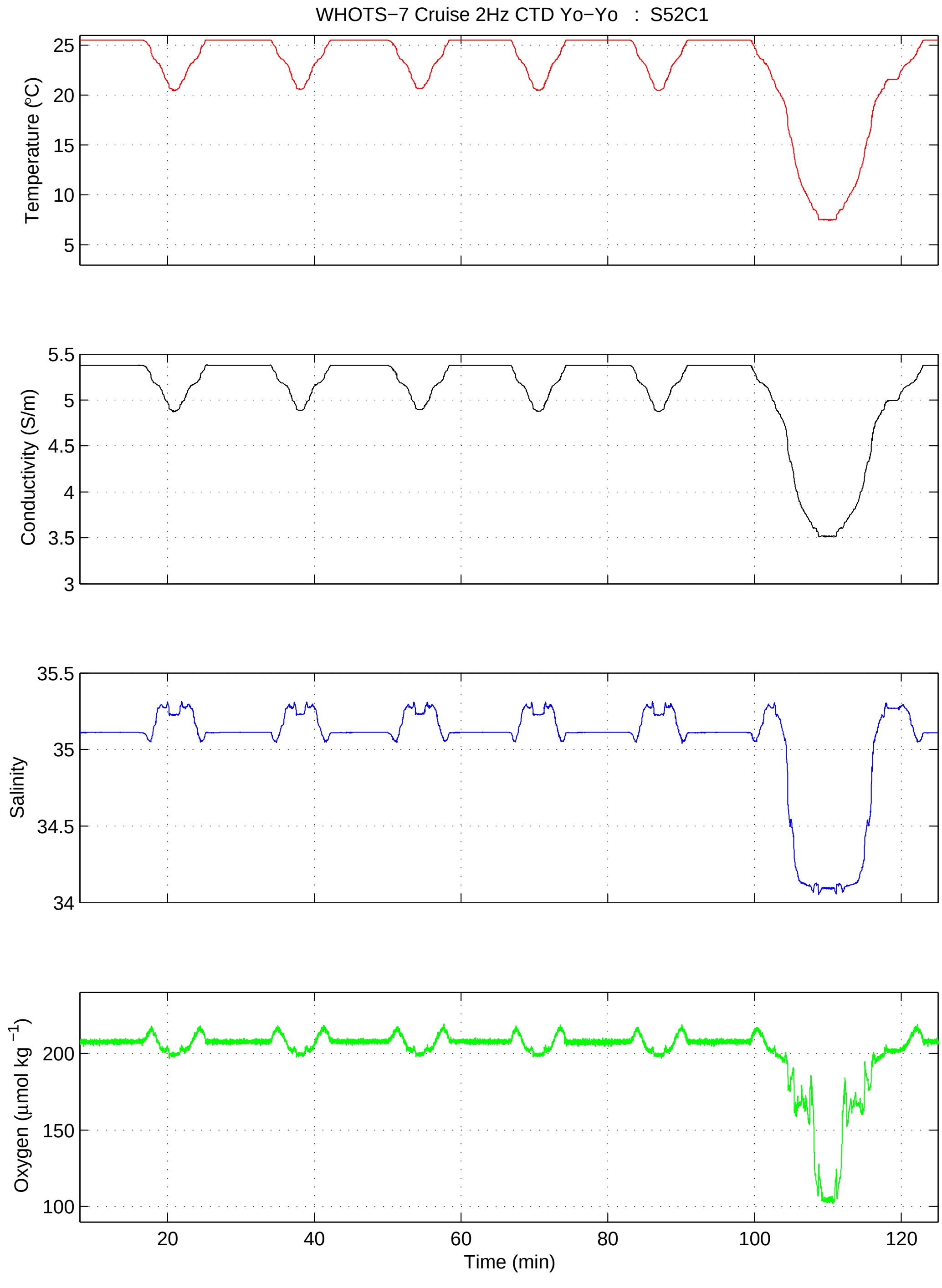

Figure B20. Time-series of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S52C1.

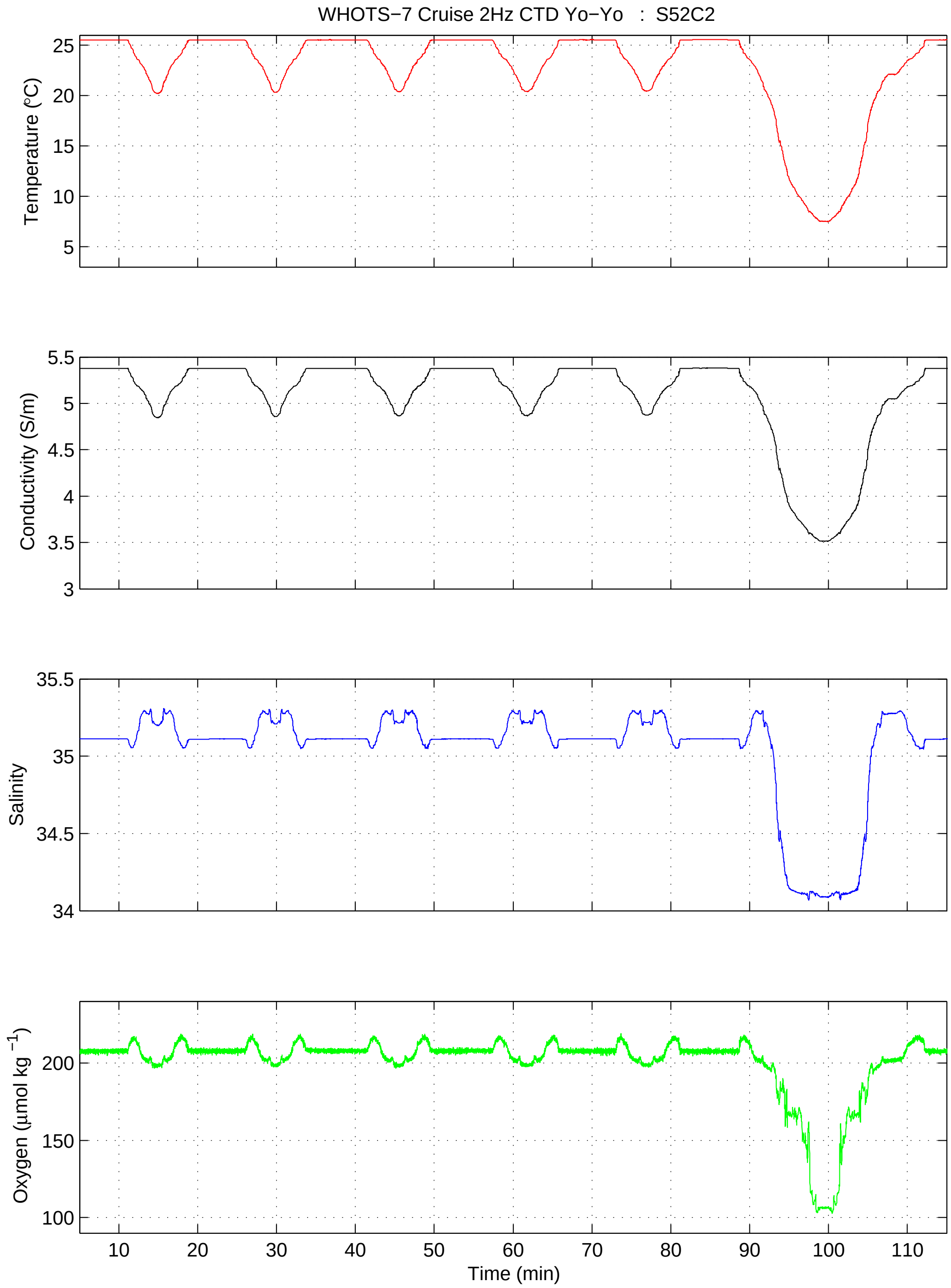

Figure B21. Time-series of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S52C2.

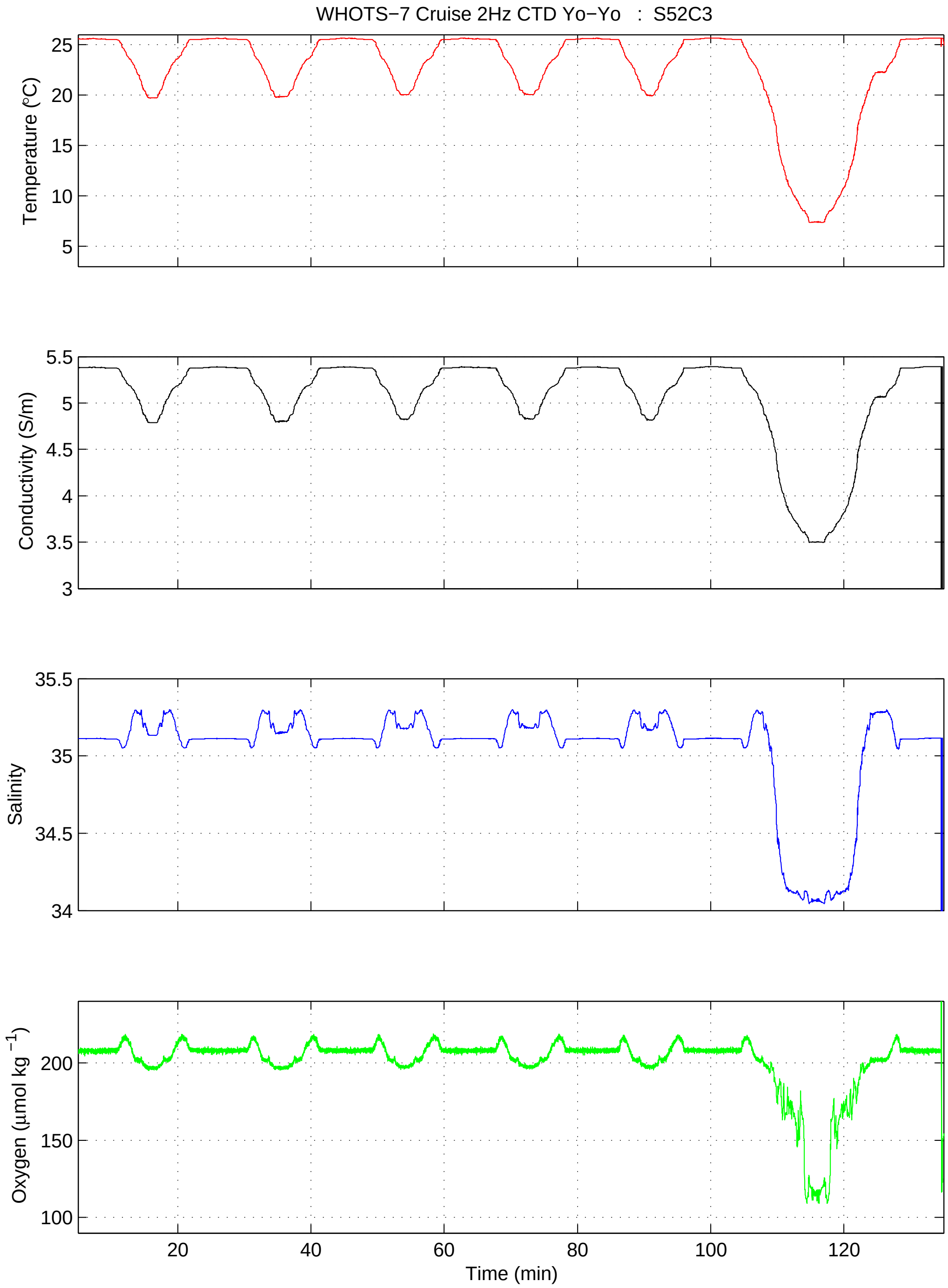

Figure B22. Time-series of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S52C3.

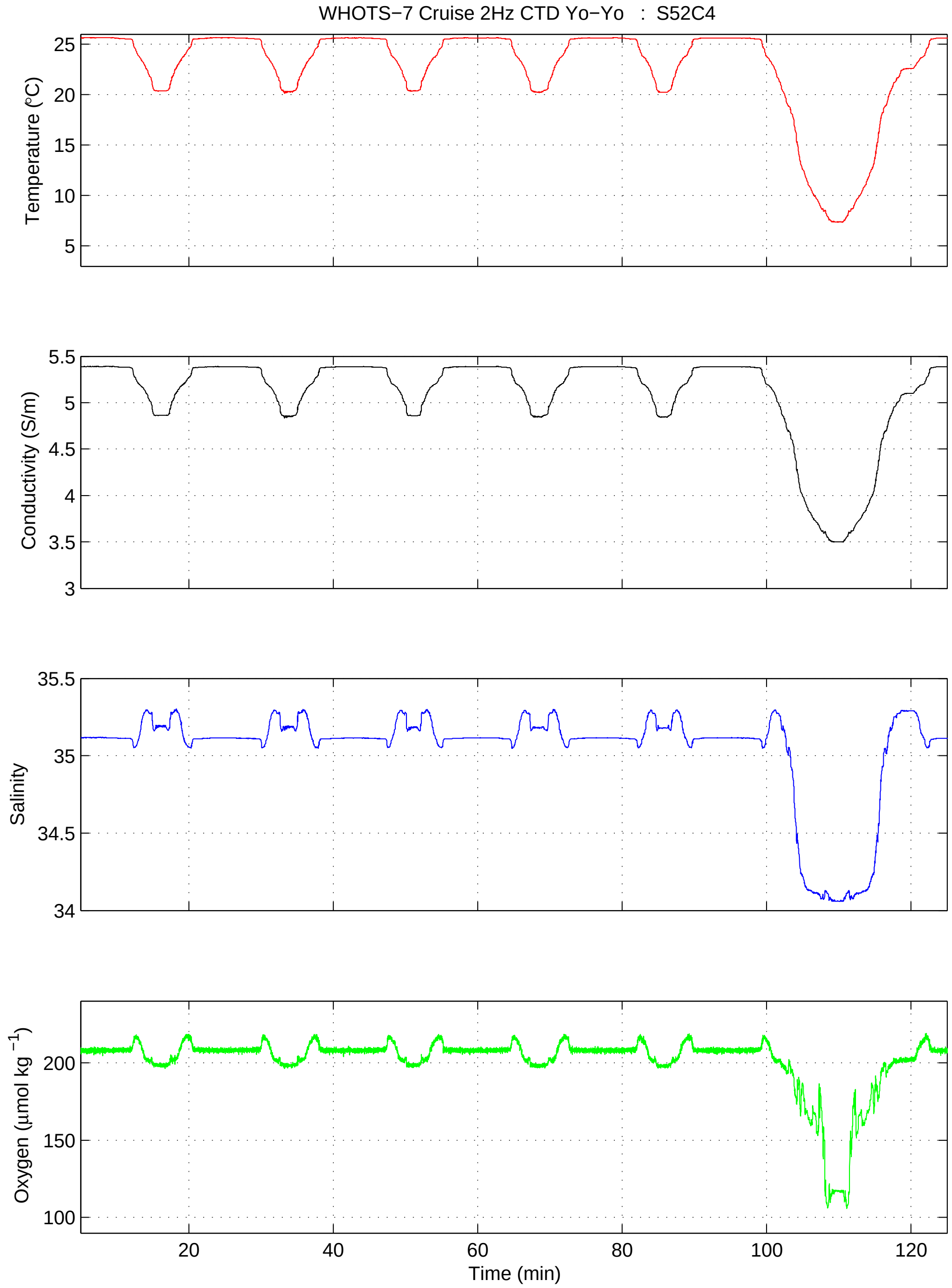

Figure B23. Time-series of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S52C4.

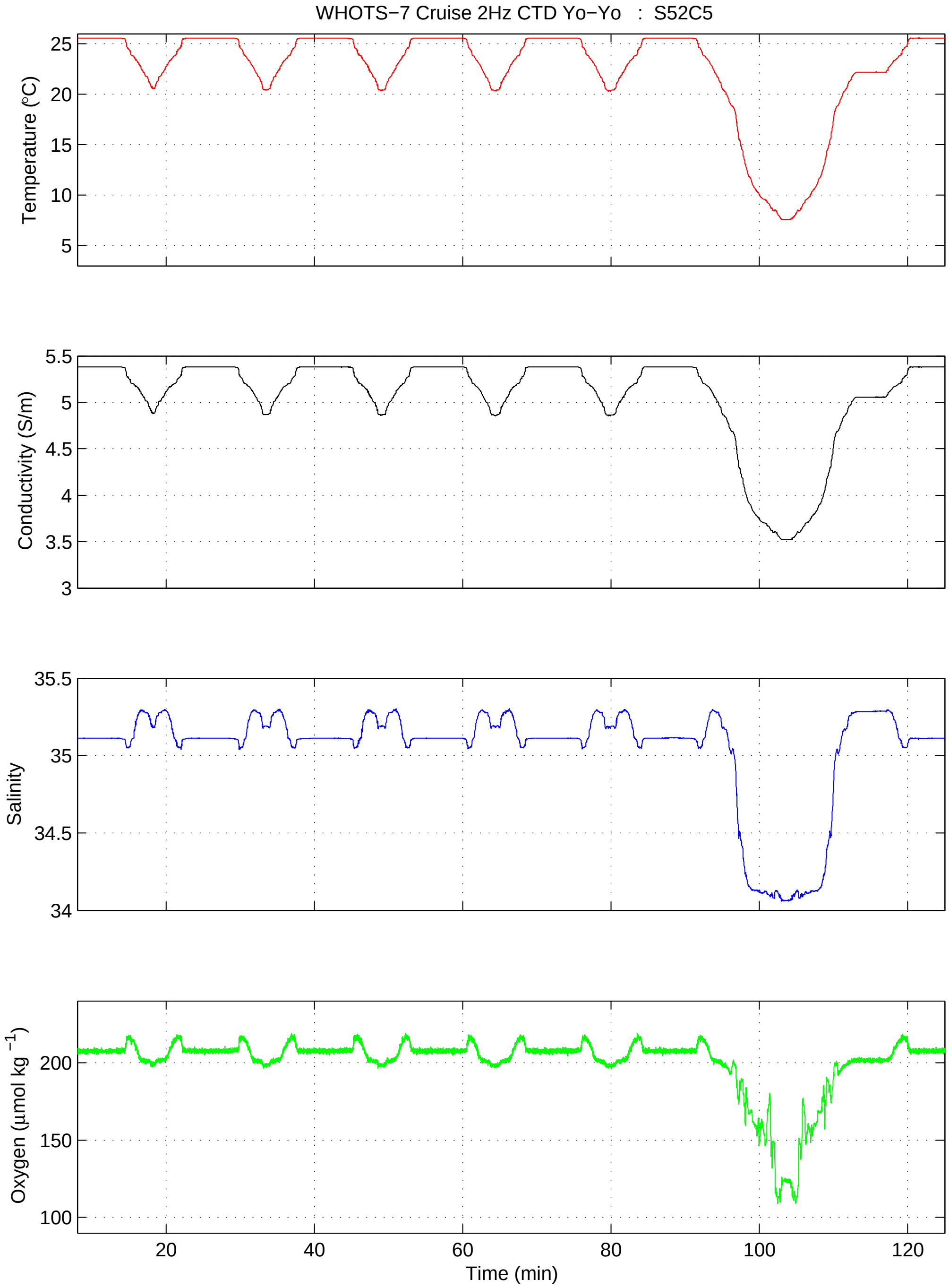

Figure B24. Time-series of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S52C5.

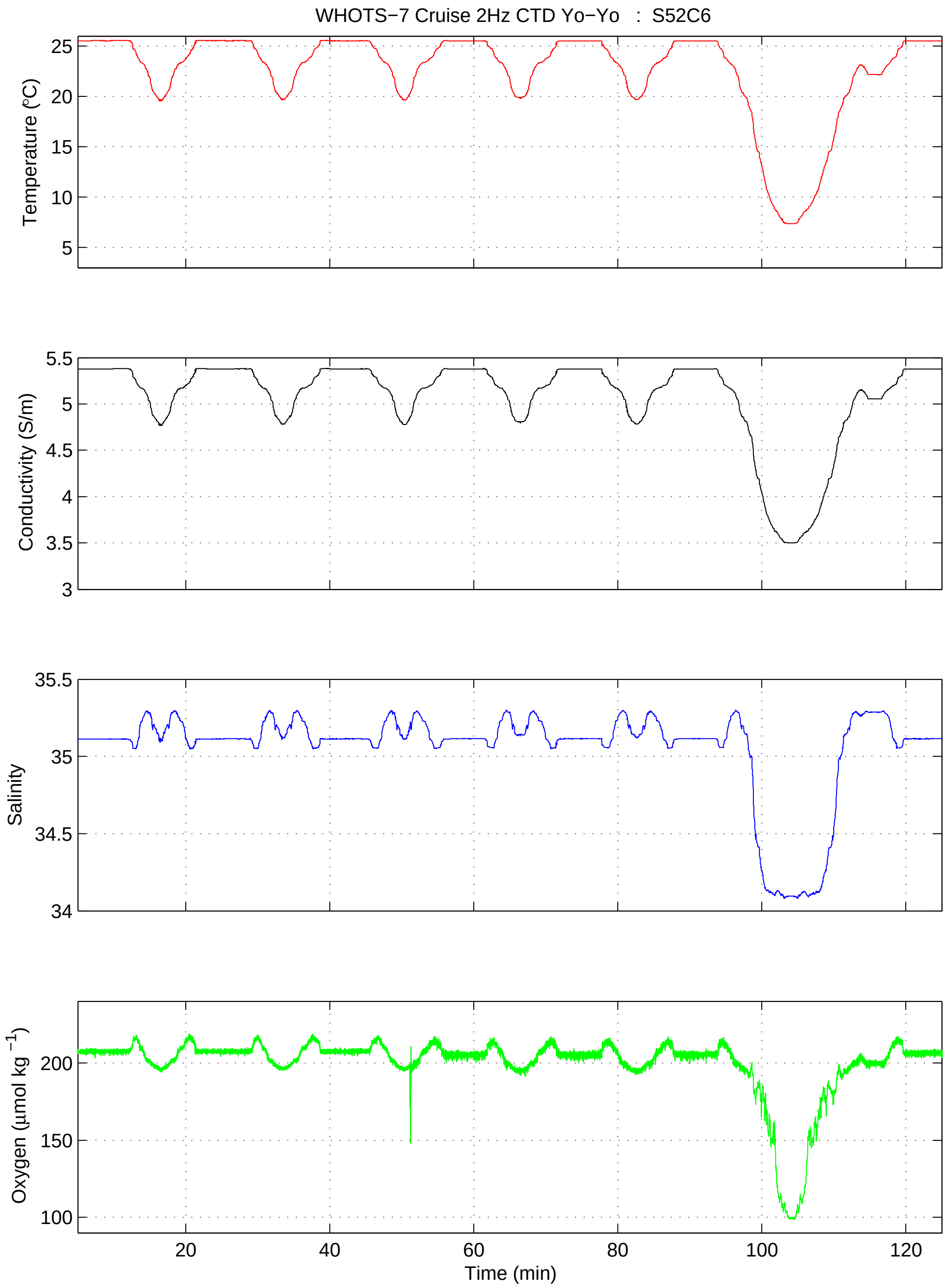

Figure B25. Time-series of 2 Hz temperature, conductivity, salinity and oxygen data during CTD S52C6.

Appendix C. Thermosalinograph Figures

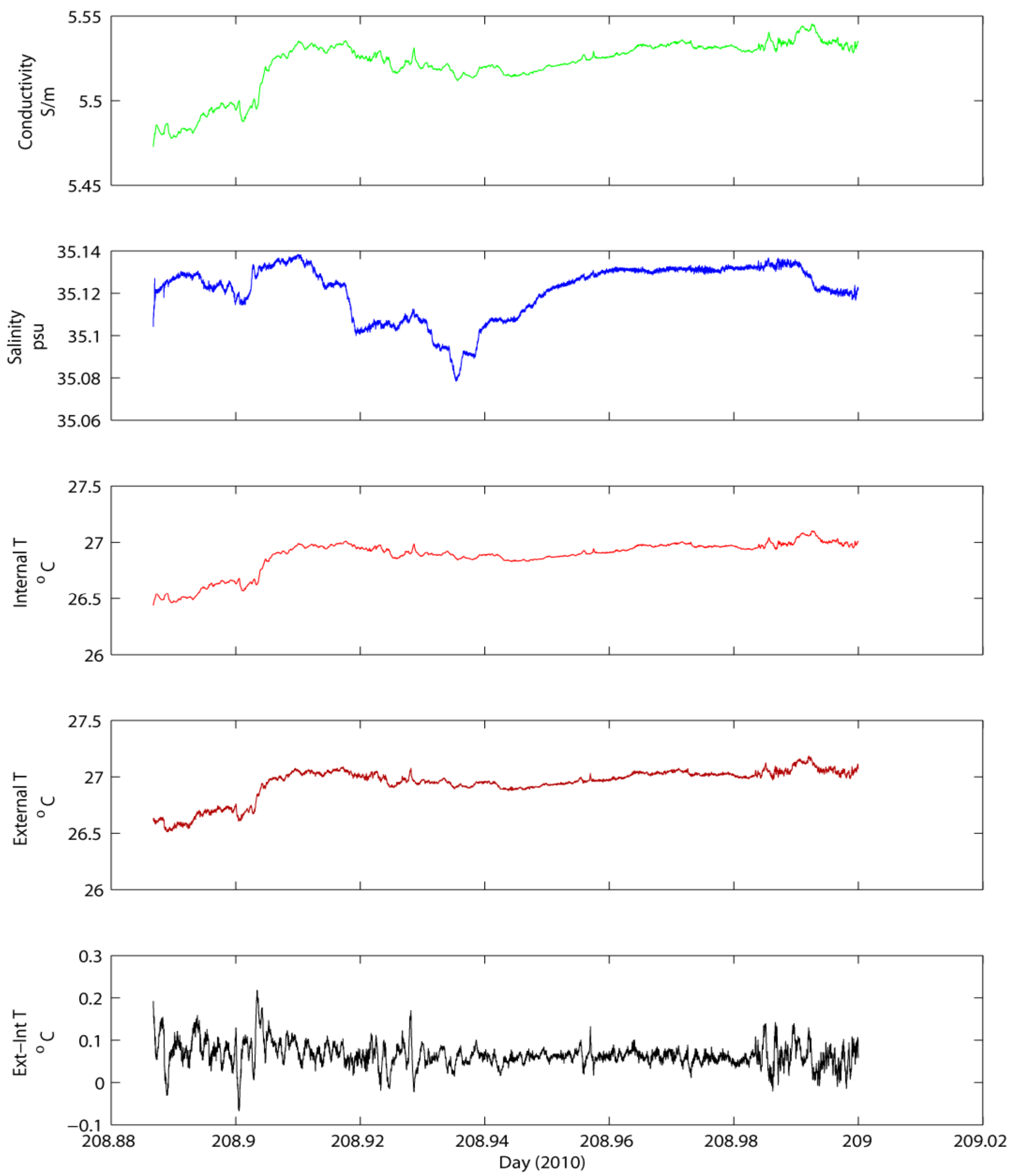

Figure C1. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 27 July 2010. The time axis is in Julian days.

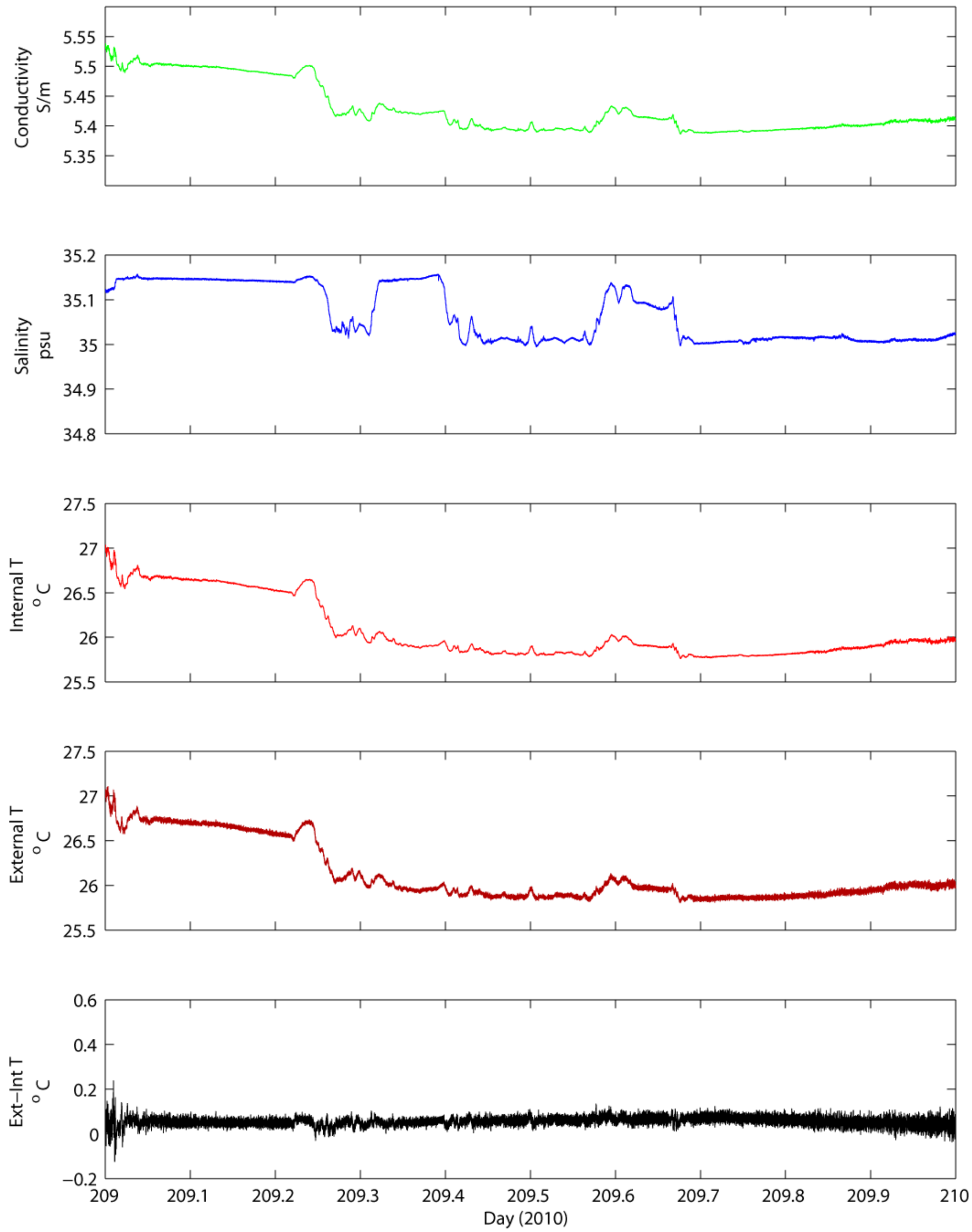

Figure C2. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 28 July 2010. The time axis is in Julian days.

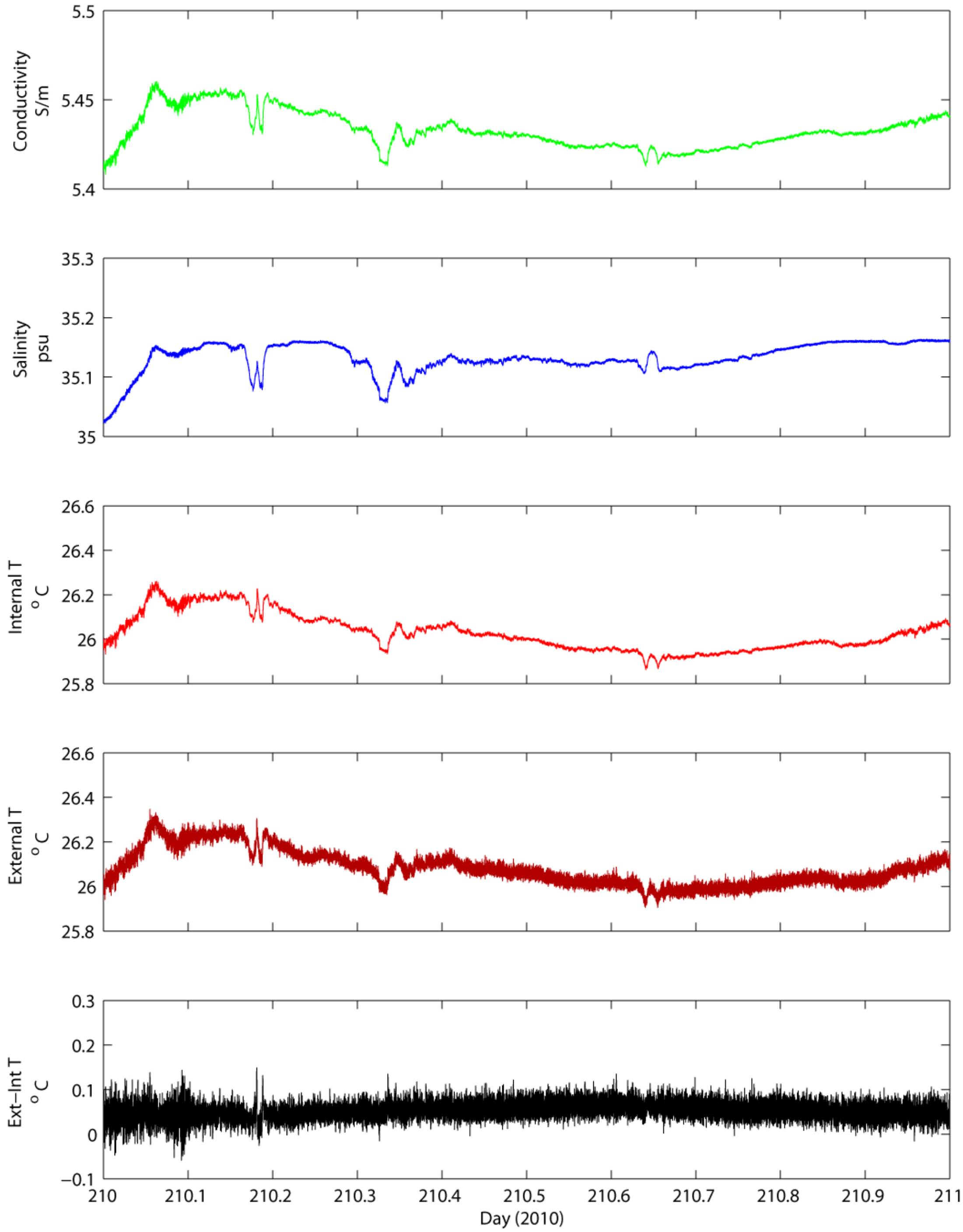

Figure C3. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 29 July 2010. The time axis is in Julian days.

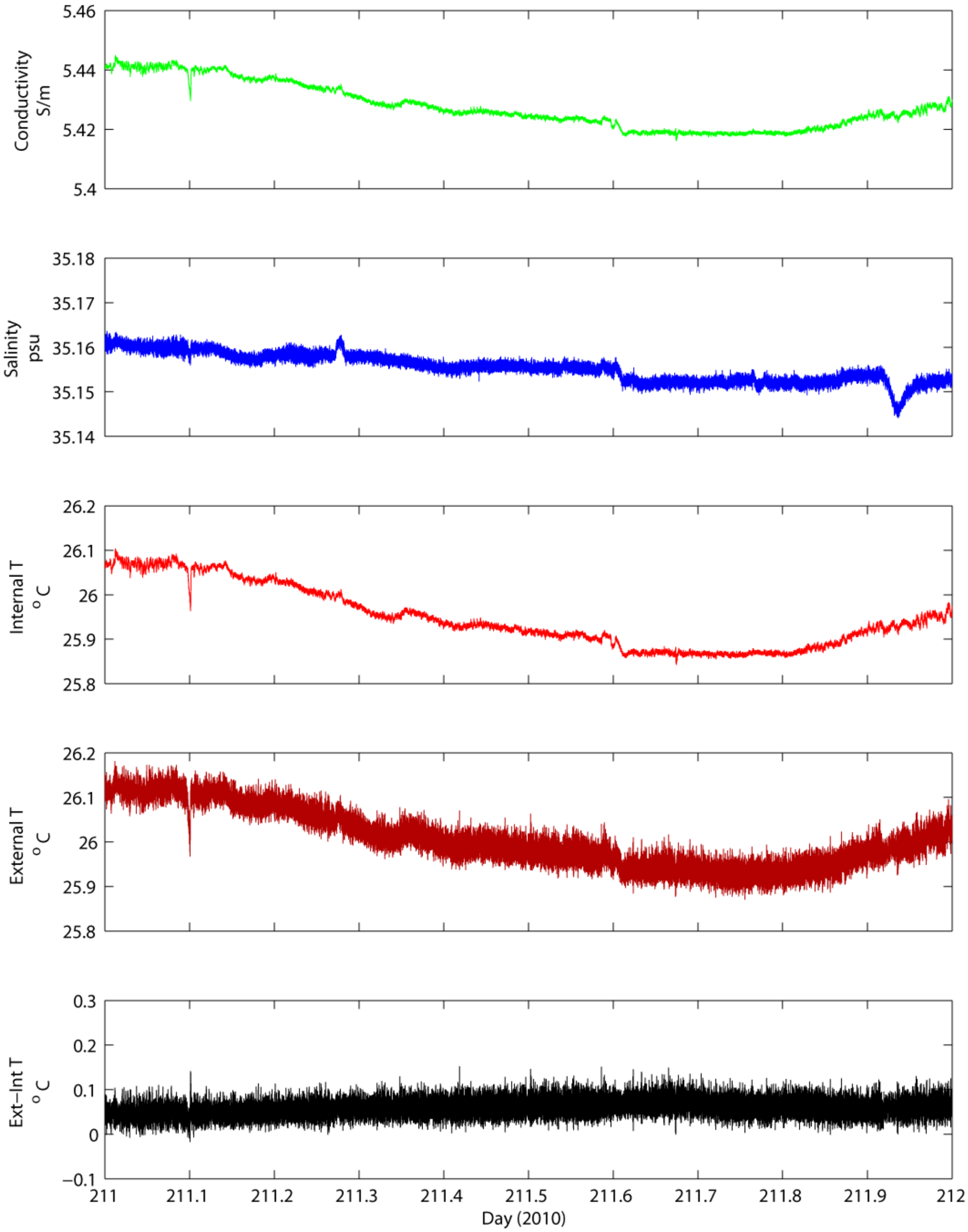

Figure C4. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 30 July 2010. The time axis is in Julian days.

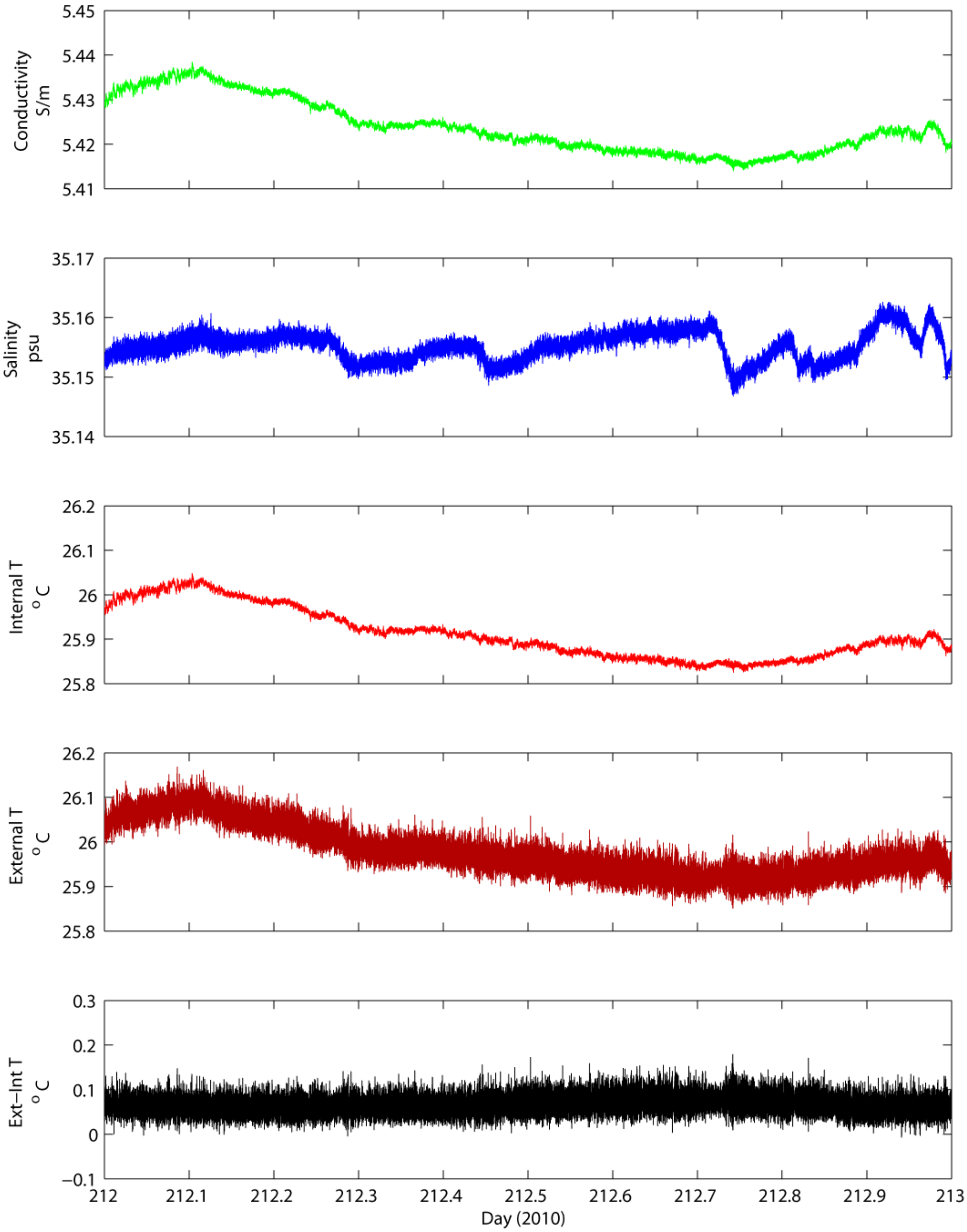

Figure C5. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 31 July 2010. The time axis is in Julian days.

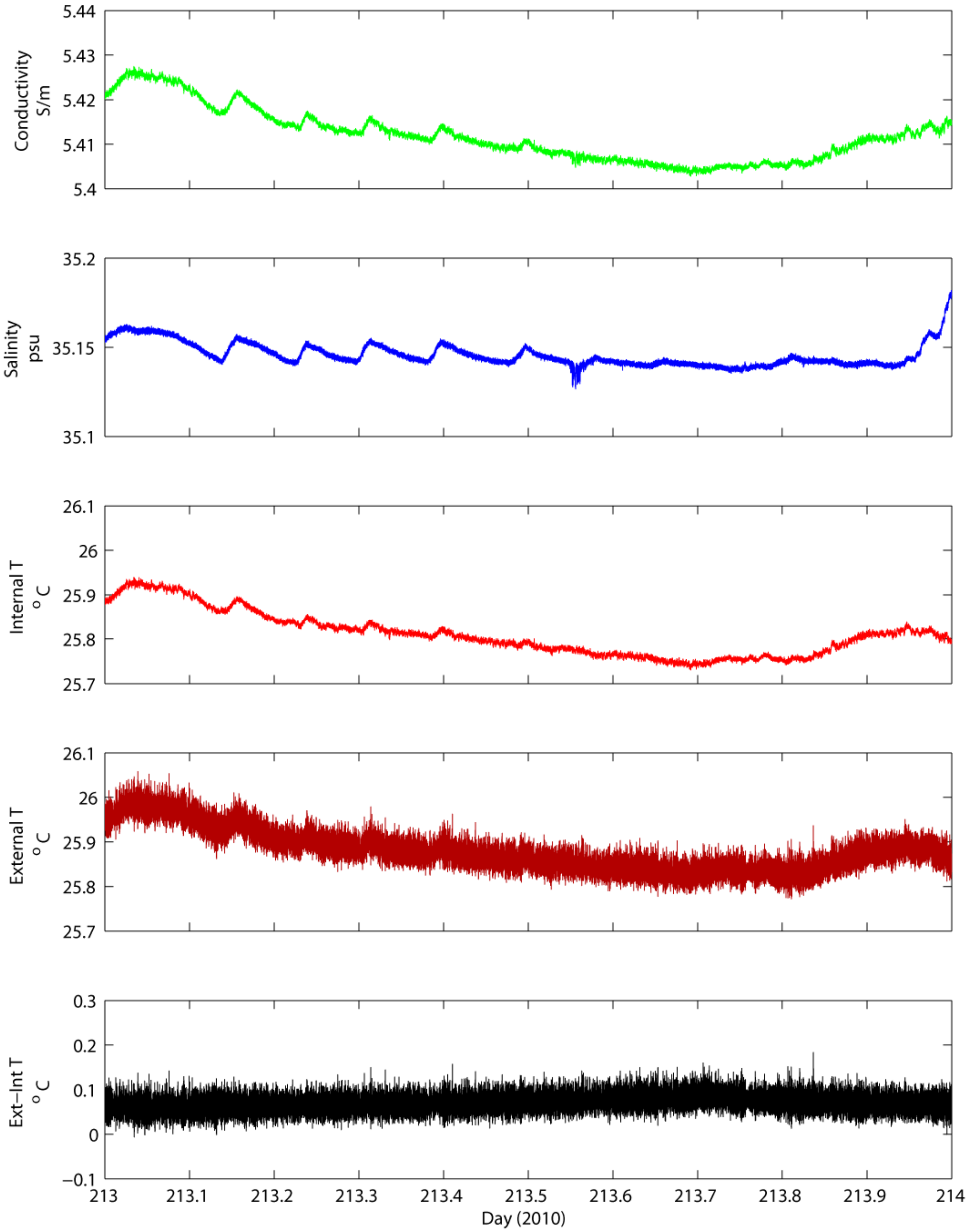

Figure C6. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 1 August 2010. The time axis is in Julian days.

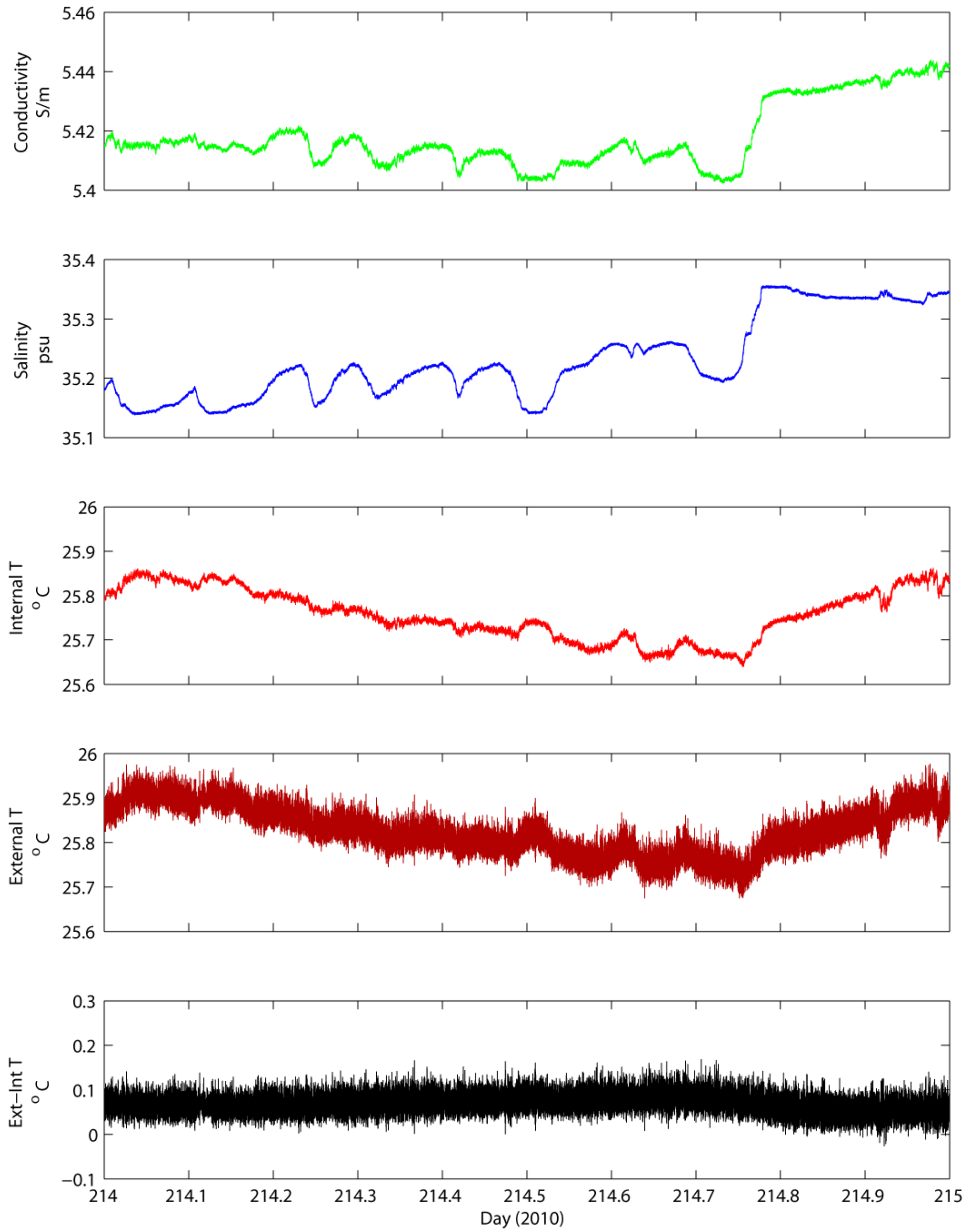

Figure C7. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 2 August 2010. The time axis is in Julian days.

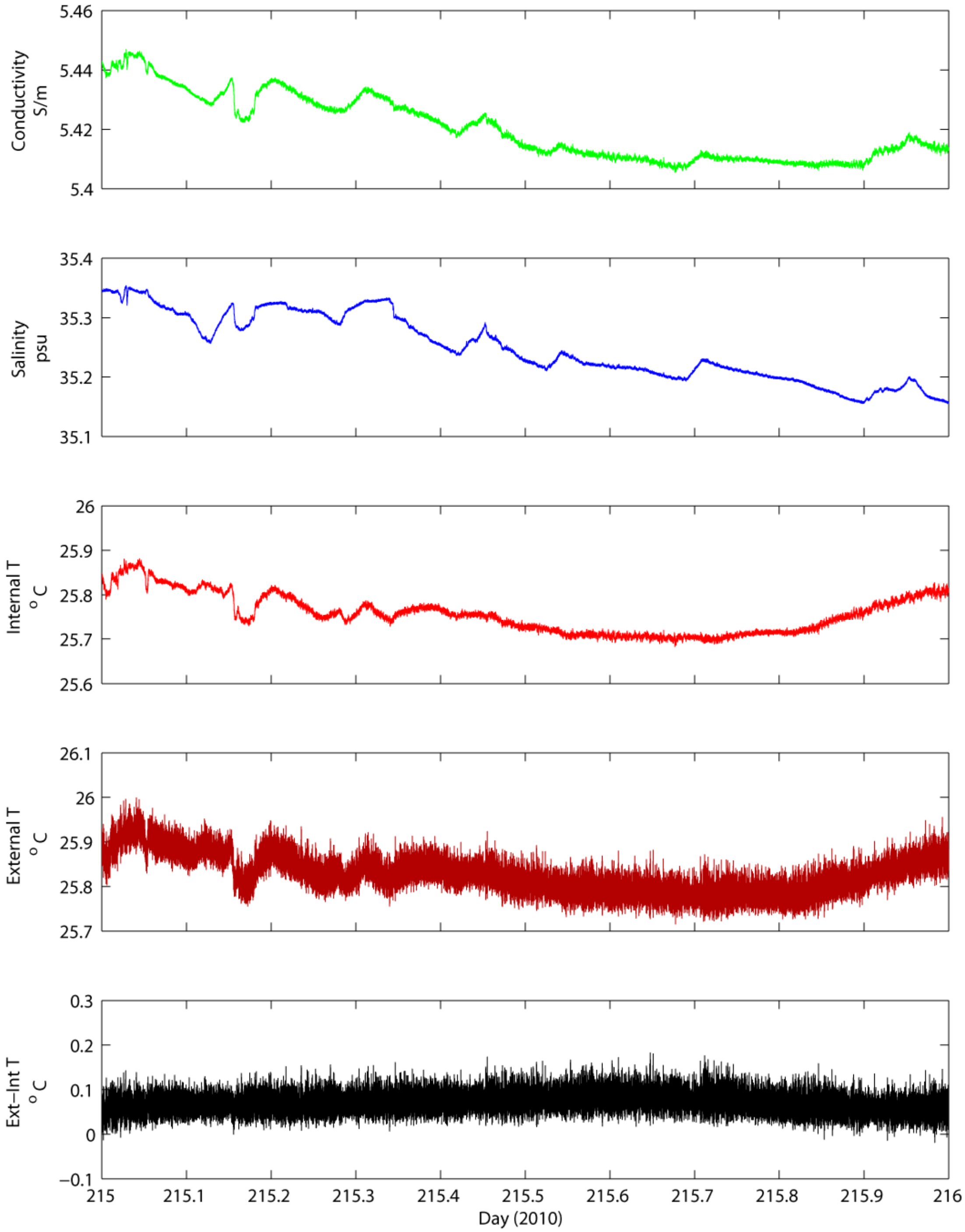

Figure C8. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 3 August 2010. The time axis is in Julian days.

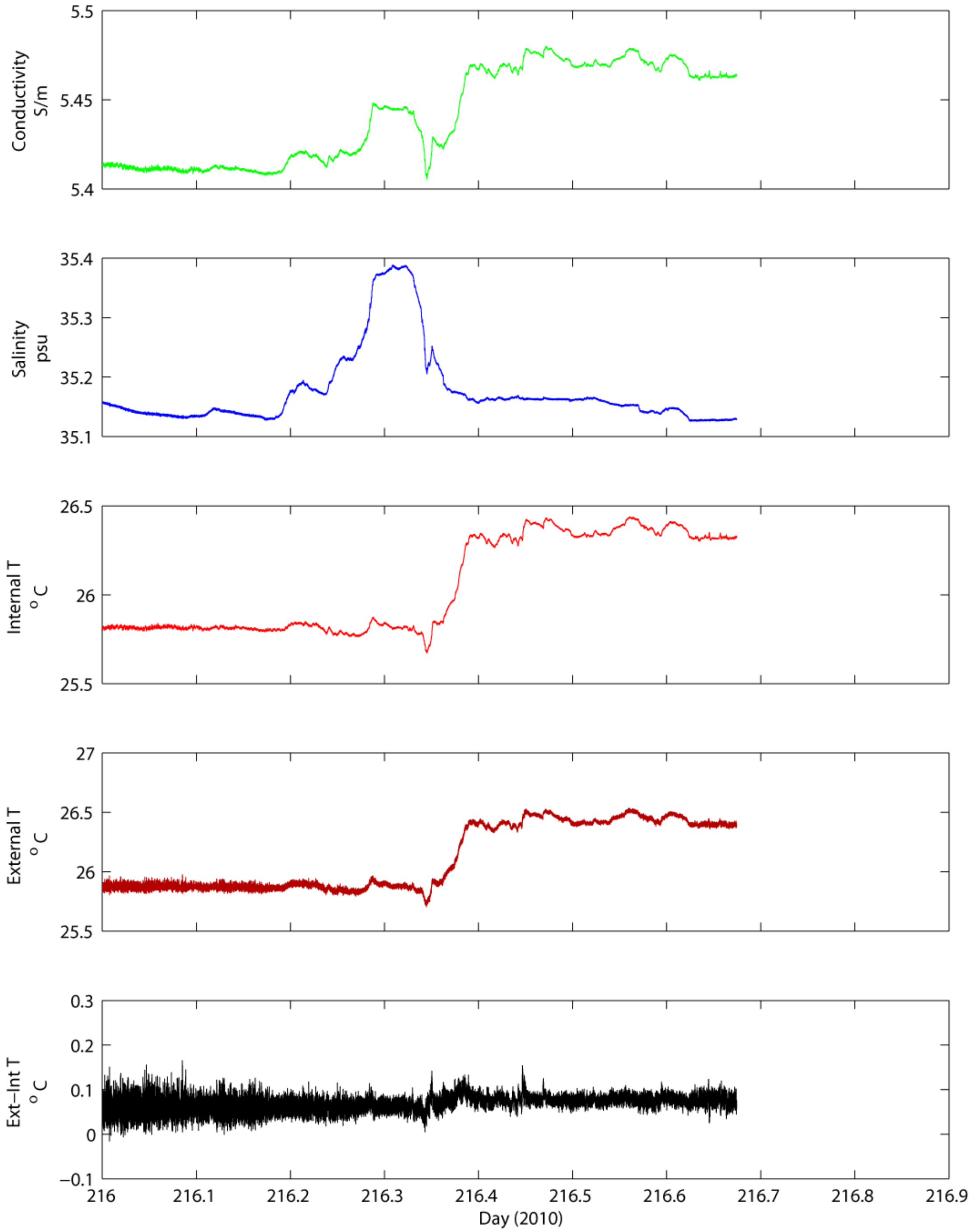

Figure C9. Time-series plots of thermosalinograph conductivity, salinity, internal sensor temperature, remote sensor temperature, and remote - internal temperature difference data during 4 August 2010. The time axis is in Julian days.

Appendix D. Shipboard Meteorological Figures

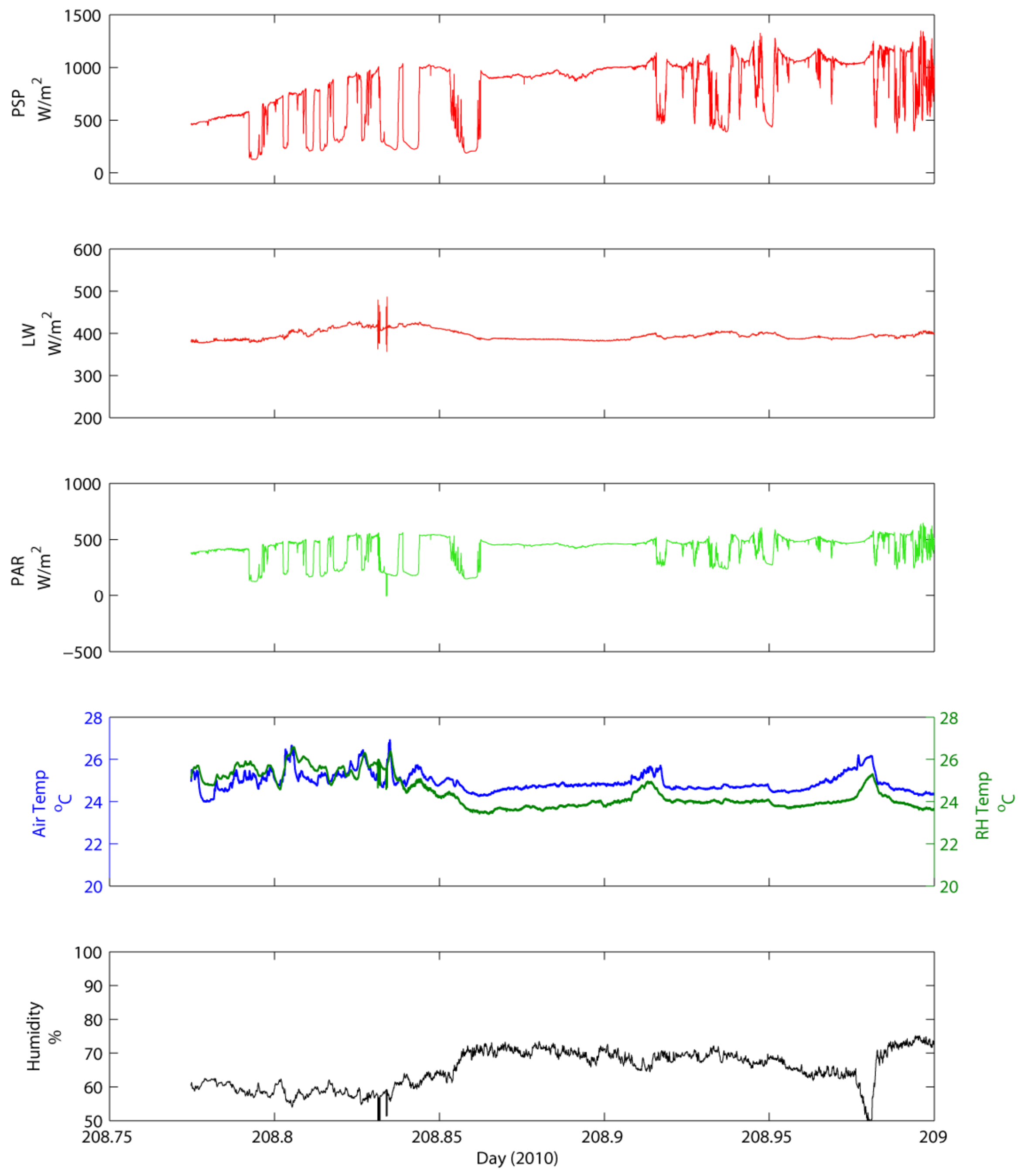

Figure D1. Time-series plots of PSP, Longwave Radiation, PAR, Air Temperature and Humidity data during 27 July 2010. The time axis is in Julian Days.

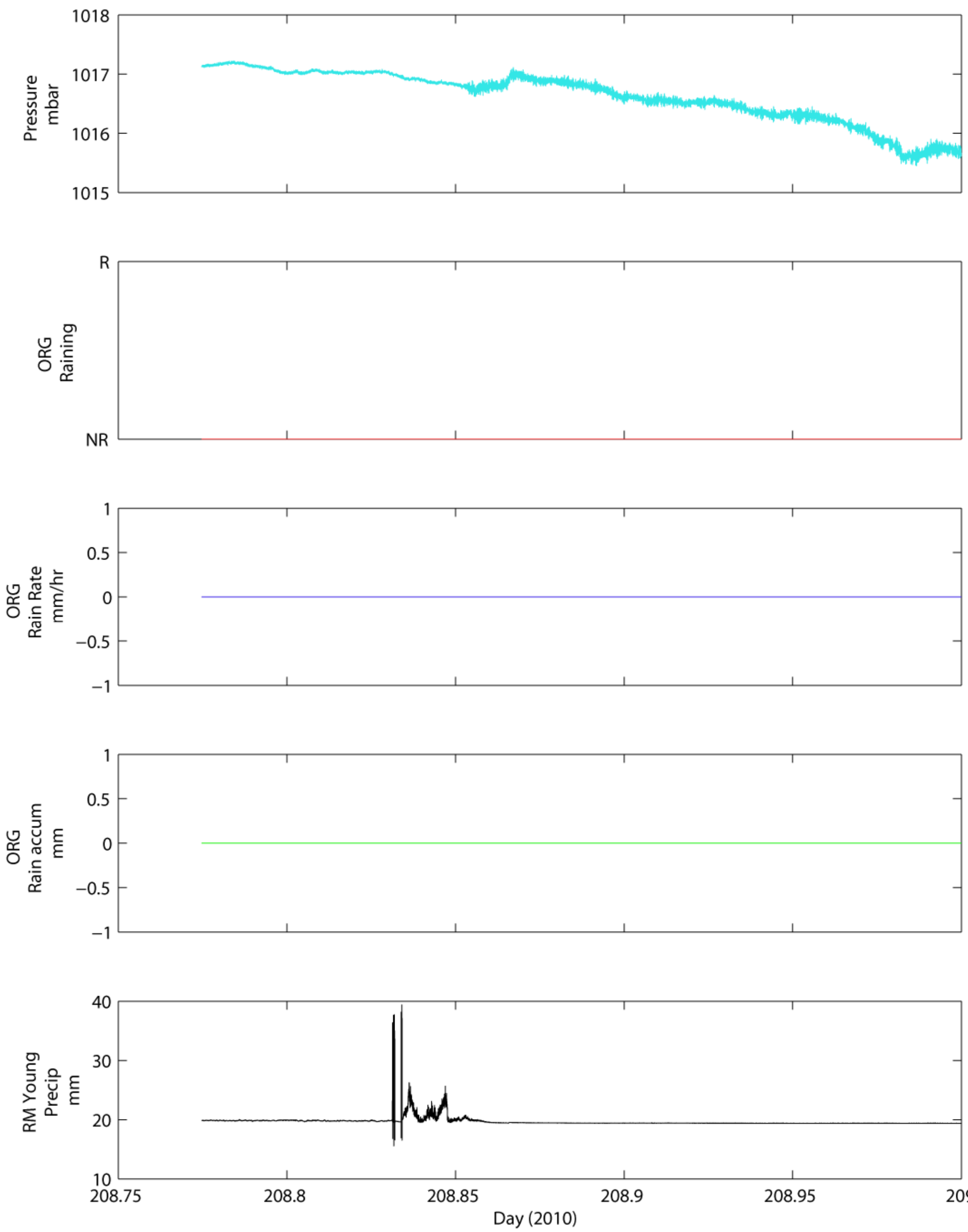

Figure D2. Time-series plots of Air Pressure, Optical Rain Gauge (Incidence, Rain Rate and Accumulation) and RM Young precipitation data during 27 July 2010. The time axis is in Julian Days.

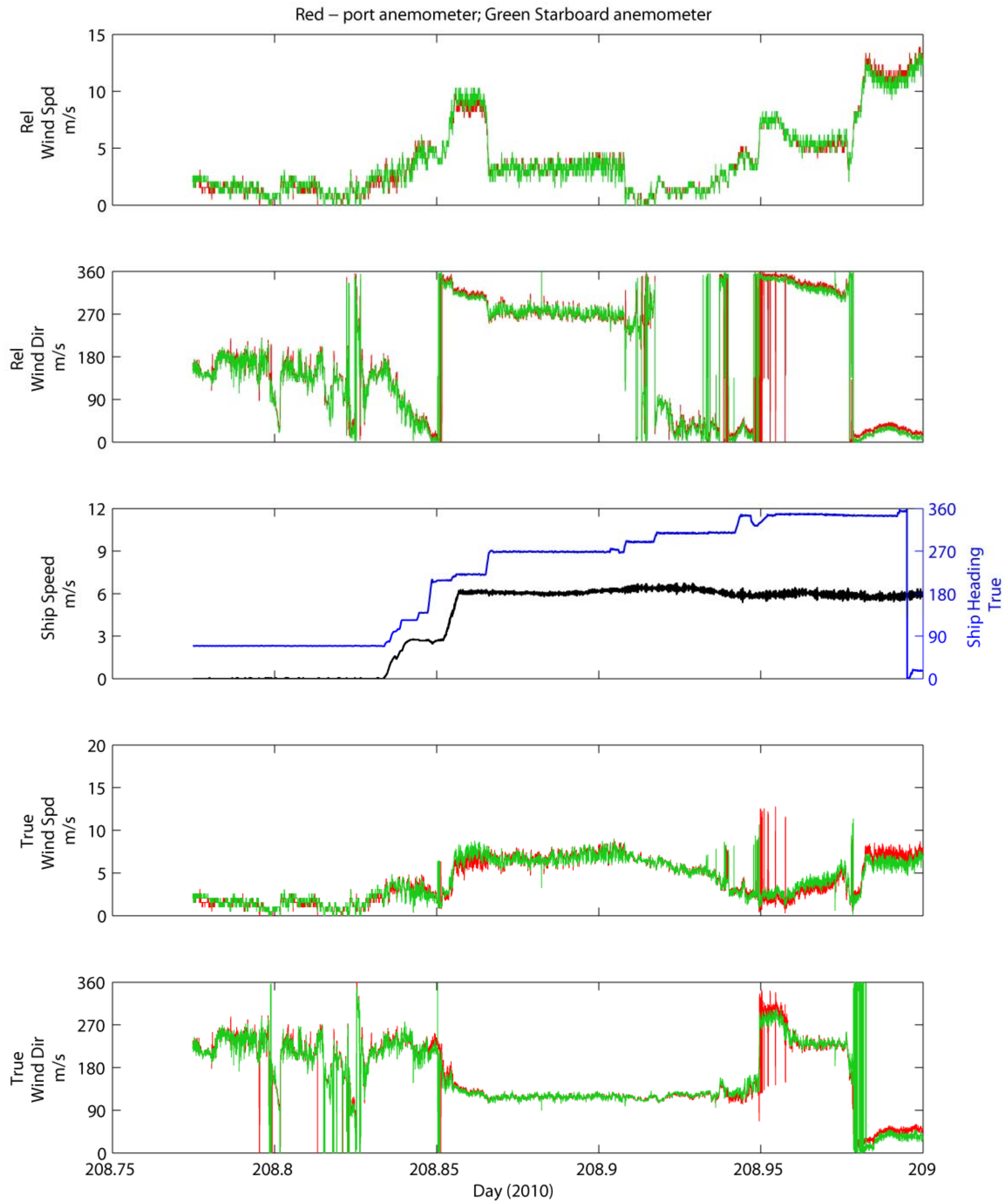

Figure D3. Time-series plots of Relative Wind Speed and Direction, Ship's Speed and True Wind Speed and Direction data during 27 July 2010. The time axis is in Julian Days.

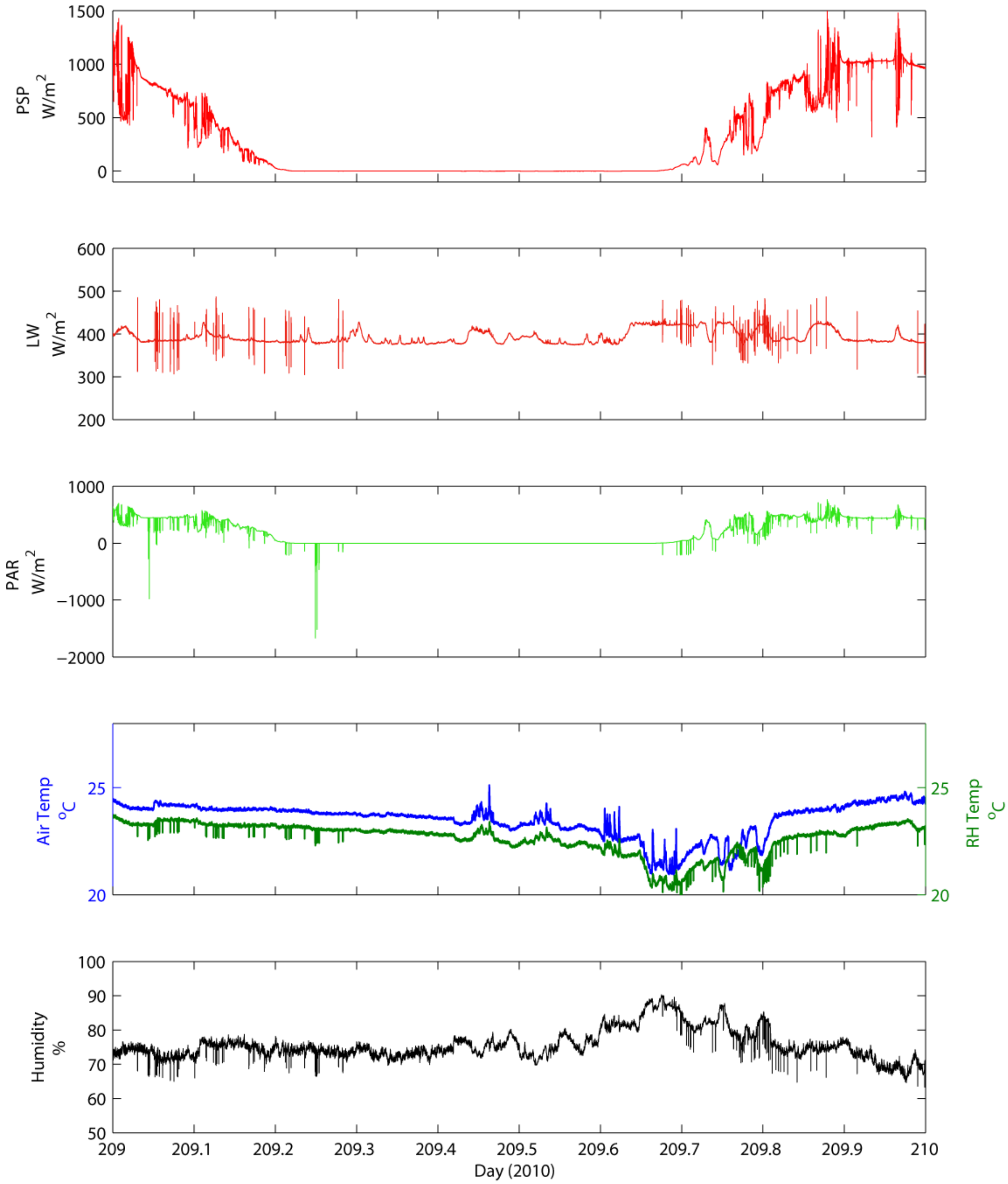

Figure D4. Time-series plots of PSP, Longwave Radiation, PAR, Air Temperature and Humidity data during 28 July 2010. The time axis is in Julian Days.

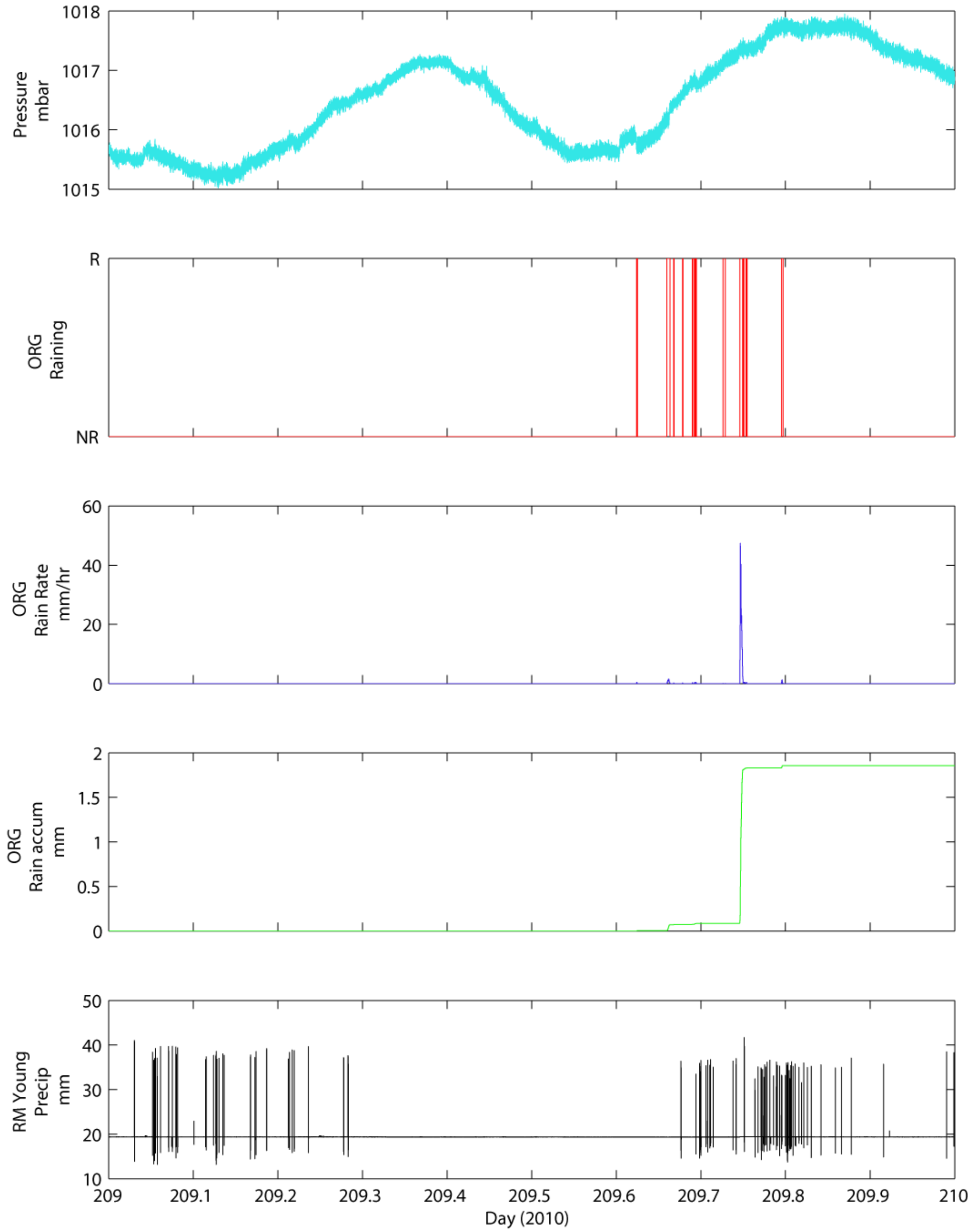

Figure D5. Time-series plots of Air Pressure, Optical Rain Gauge (Incidence, Rain Rate and Accumulation) and RM Young precipitation data during 28 July 2010. The time axis is in Julian Days.

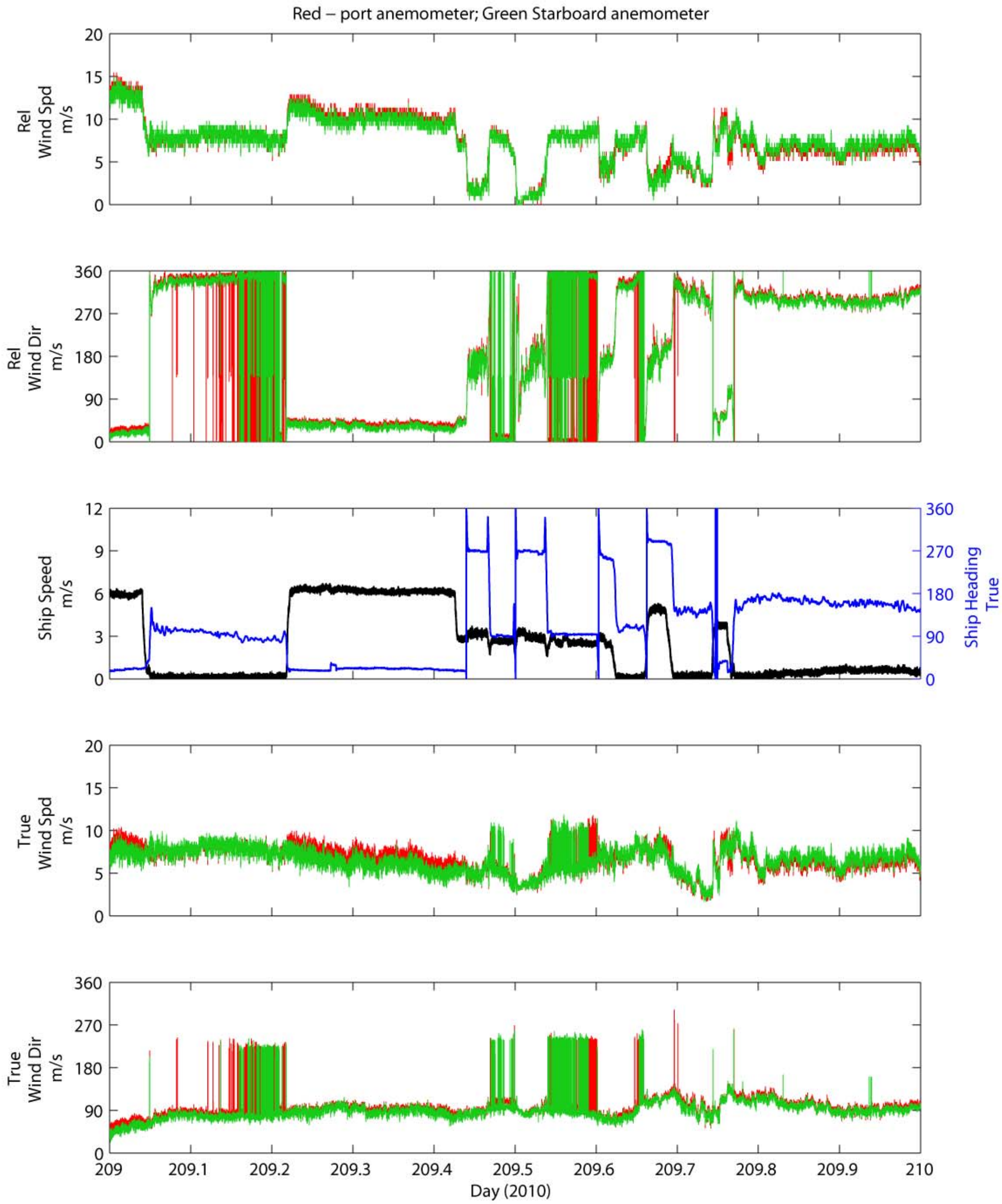

Figure D6. Time-series plots of Relative Wind Speed and Direction, Ship's Speed and True Wind Speed and Direction data during 28 July 2010. The time axis is in Julian Days.

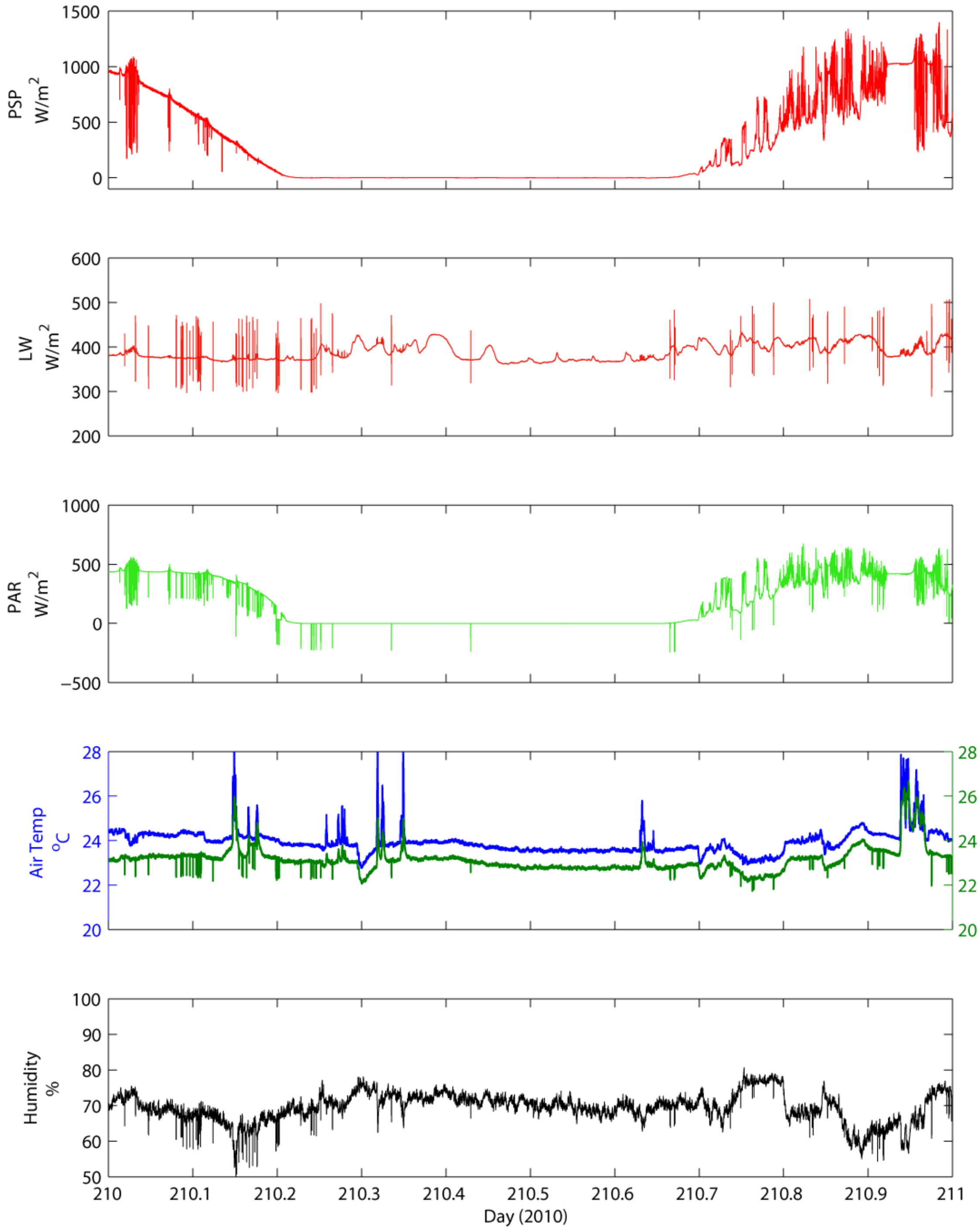

Figure D7. Time-series plots of PSP, Longwave Radiation, PAR, Air Temperature and Humidity data during 29 July 2010. The time axis is in Julian Days.

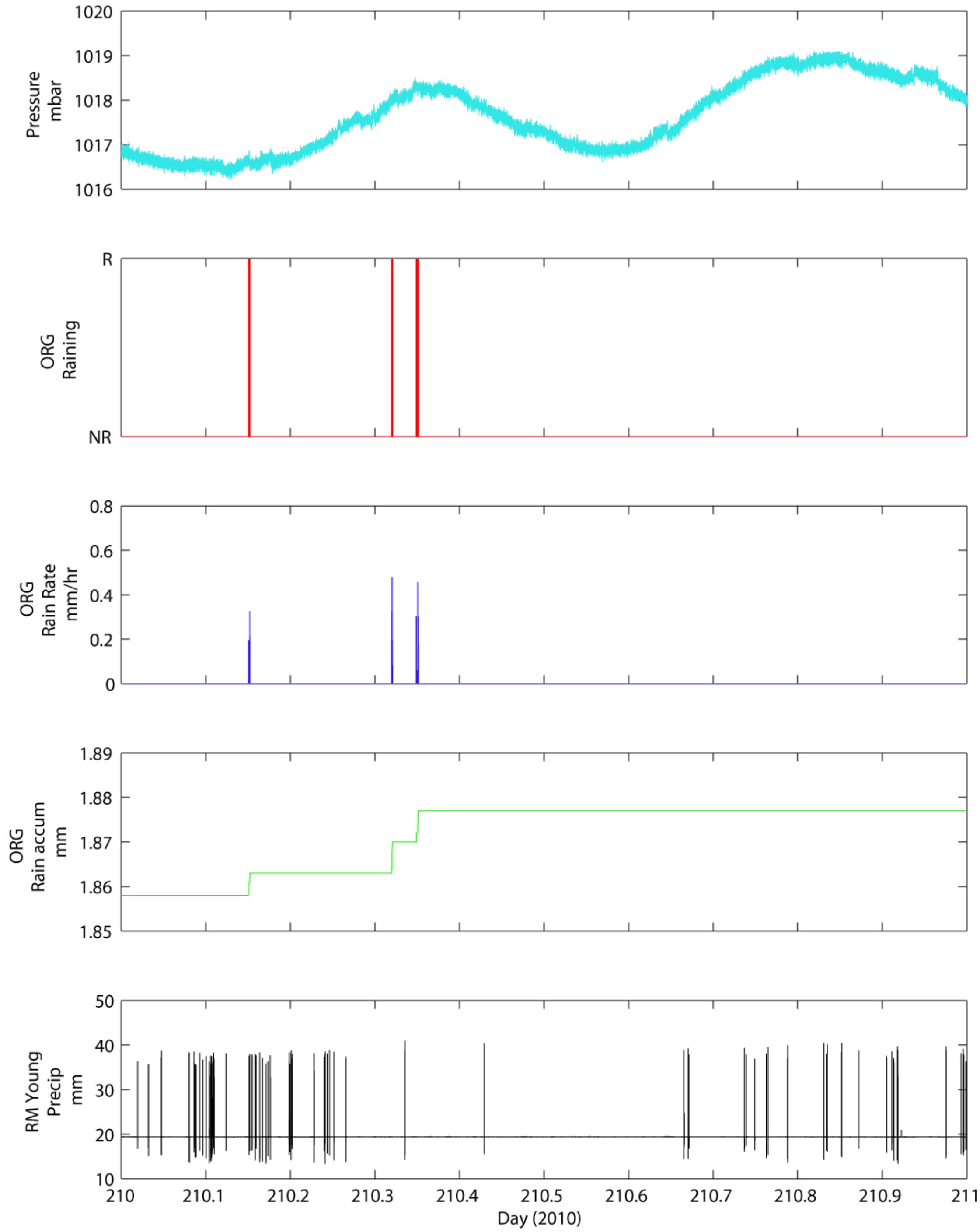

Figure D8. Time-series plots of Air Pressure, Optical Rain Gauge (Incidence, Rain Rate and Accumulation) and RM Young precipitation data during 29 July 2010. The time axis is in Julian Days.

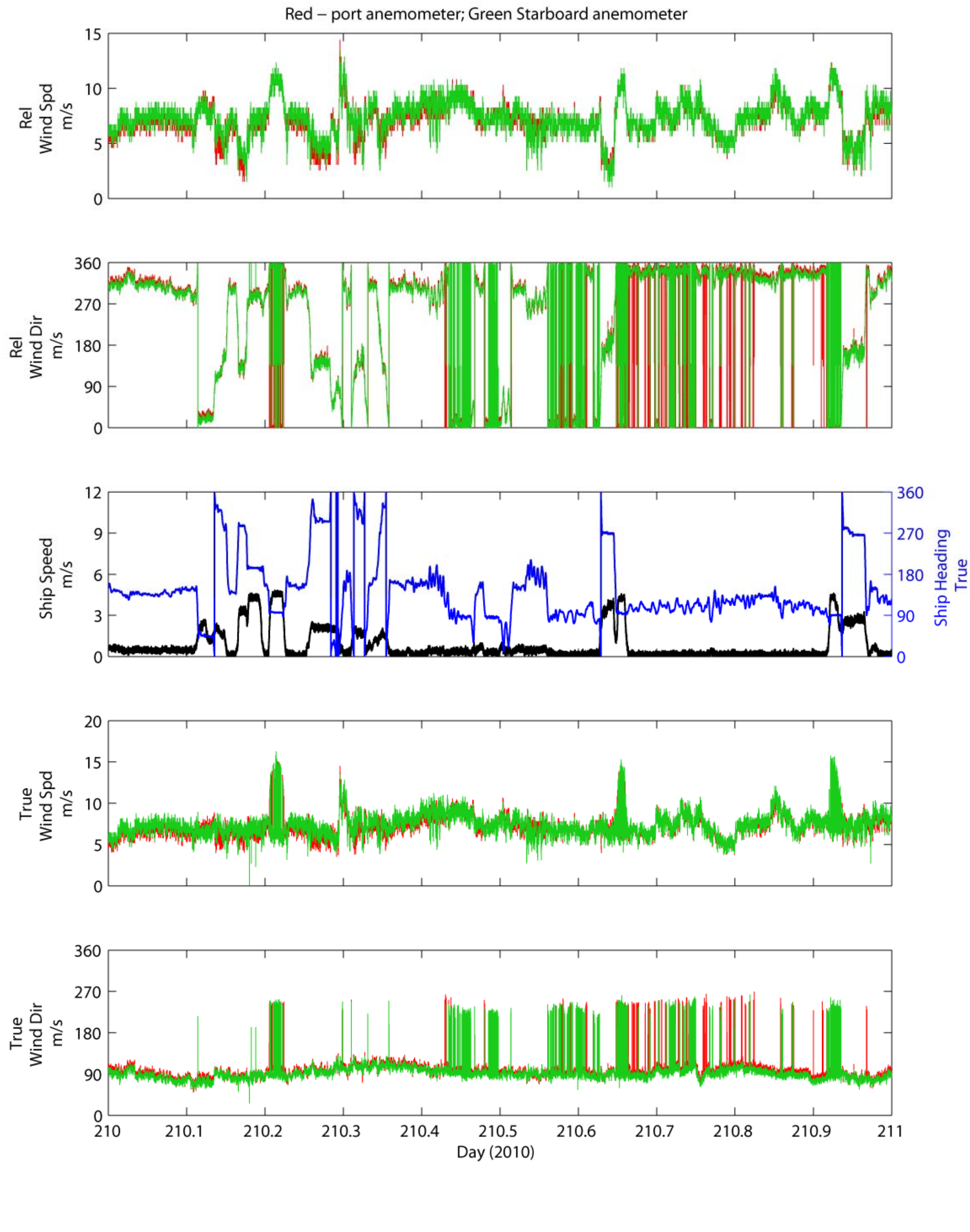

Figure D9. Time-series plots of Relative Wind Speed and Direction, Ship's Speed and True Wind Speed and Direction data during 29 July 2010. The time axis is in Julian Days.

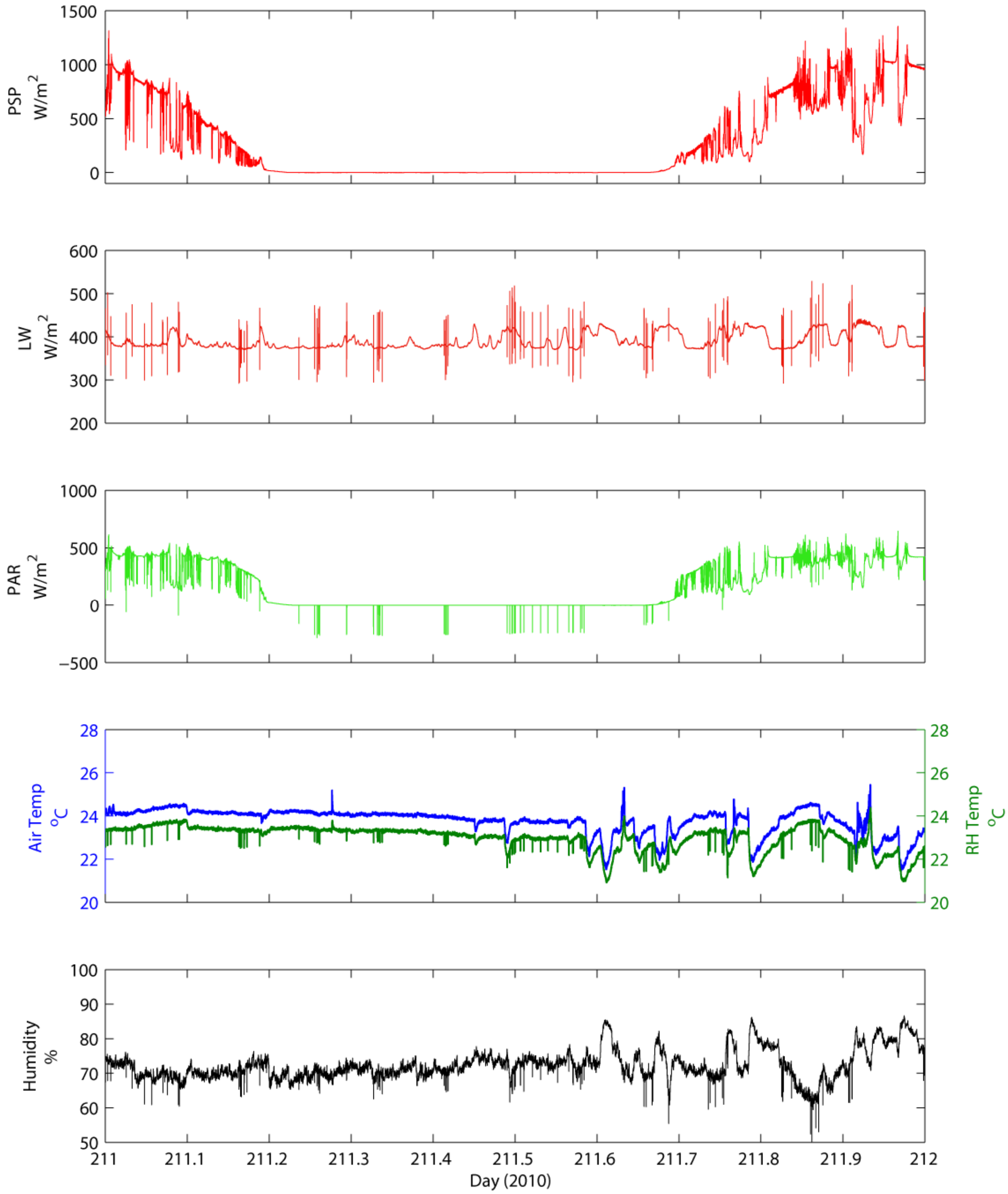

Figure D10. Time-series plots of PSP, Longwave Radiation, PAR, Air Temperature and Humidity data during 30 July 2010. The time axis is in Julian Days.

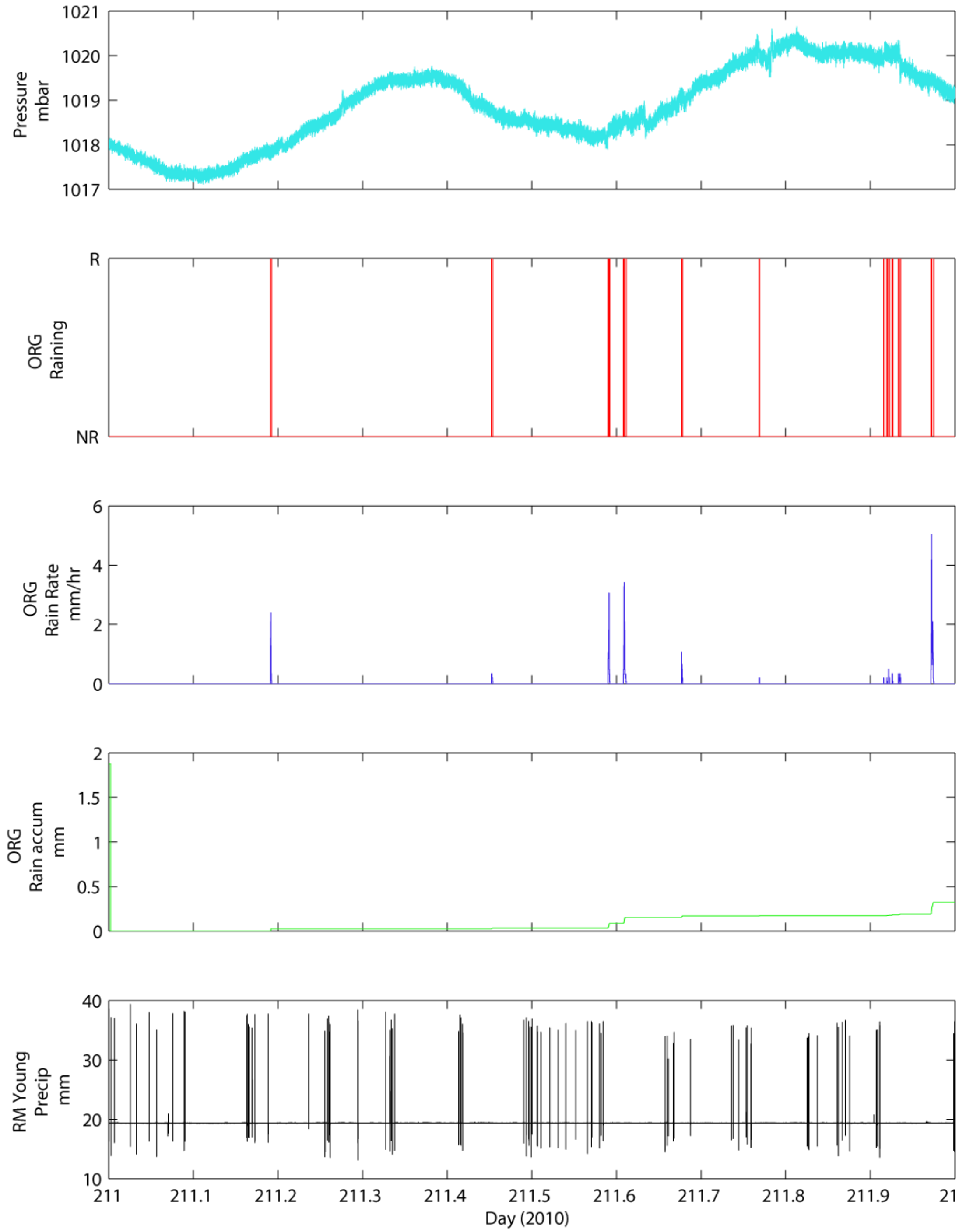

Figure D11. Time-series plots of Air Pressure, Optical Rain Gauge (Incidence, Rain Rate and Accumulation) and RM Young precipitation data during 30 July 2010. The time axis is in Julian Days.

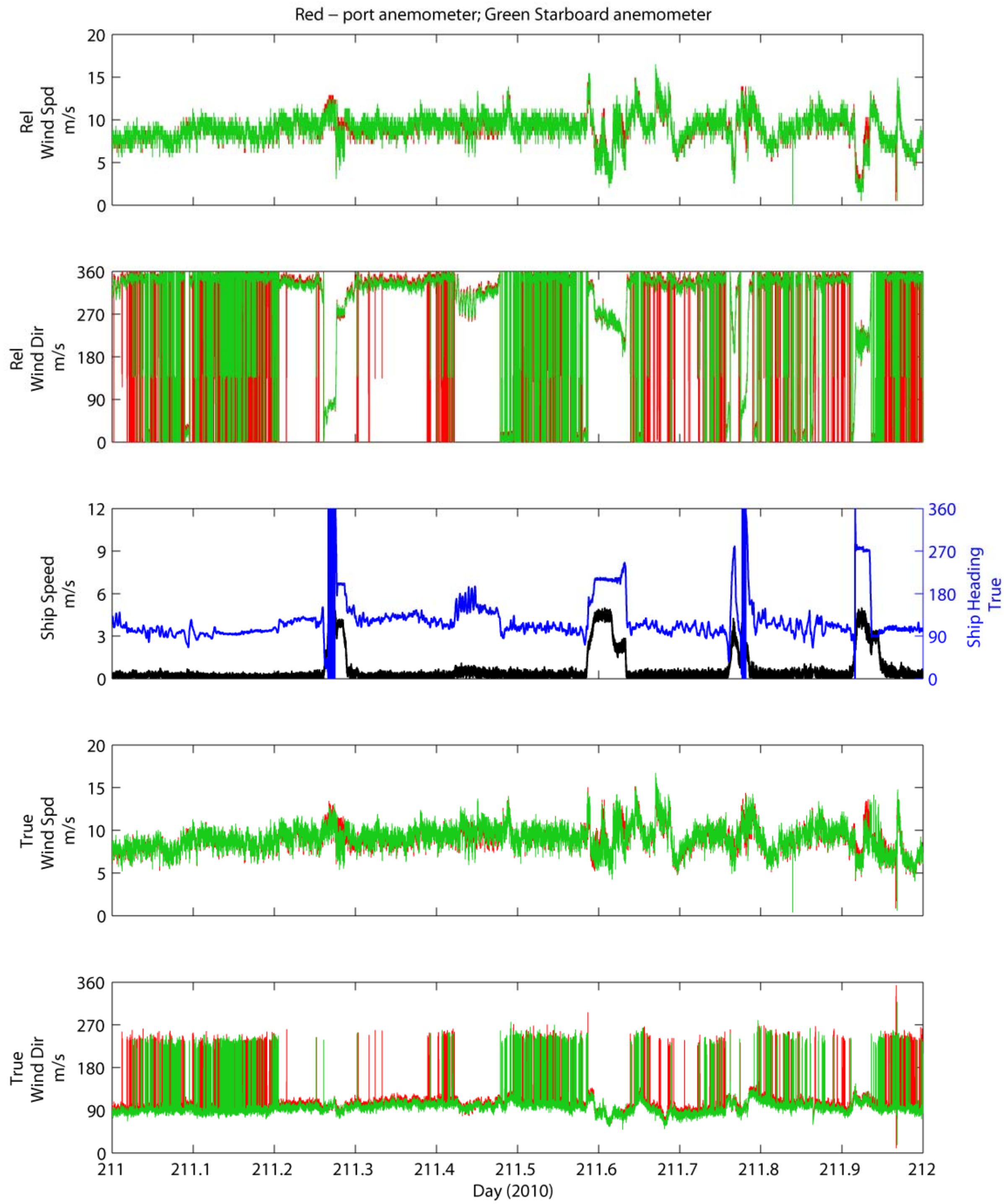

Figure D12. Time-series plots of Relative Wind Speed and Direction, Ship's Speed and True Wind Speed and Direction data during 30 July 2010. The time axis is in Julian Days.

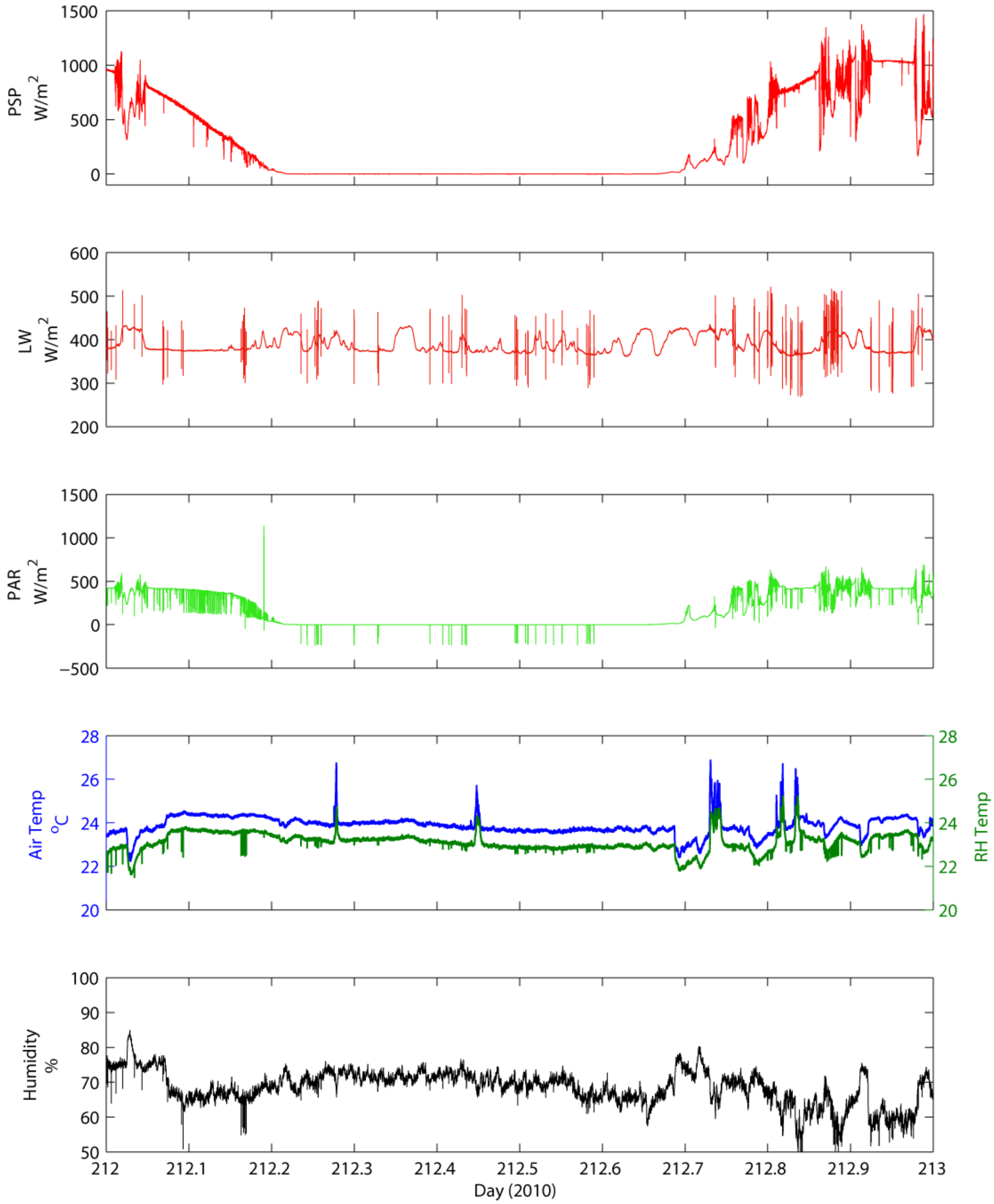

Figure D13. Time-series plots of PSP, Longwave Radiation, PAR, Air Temperature and Humidity data during 31 July 2010. The time axis is in Julian Days.

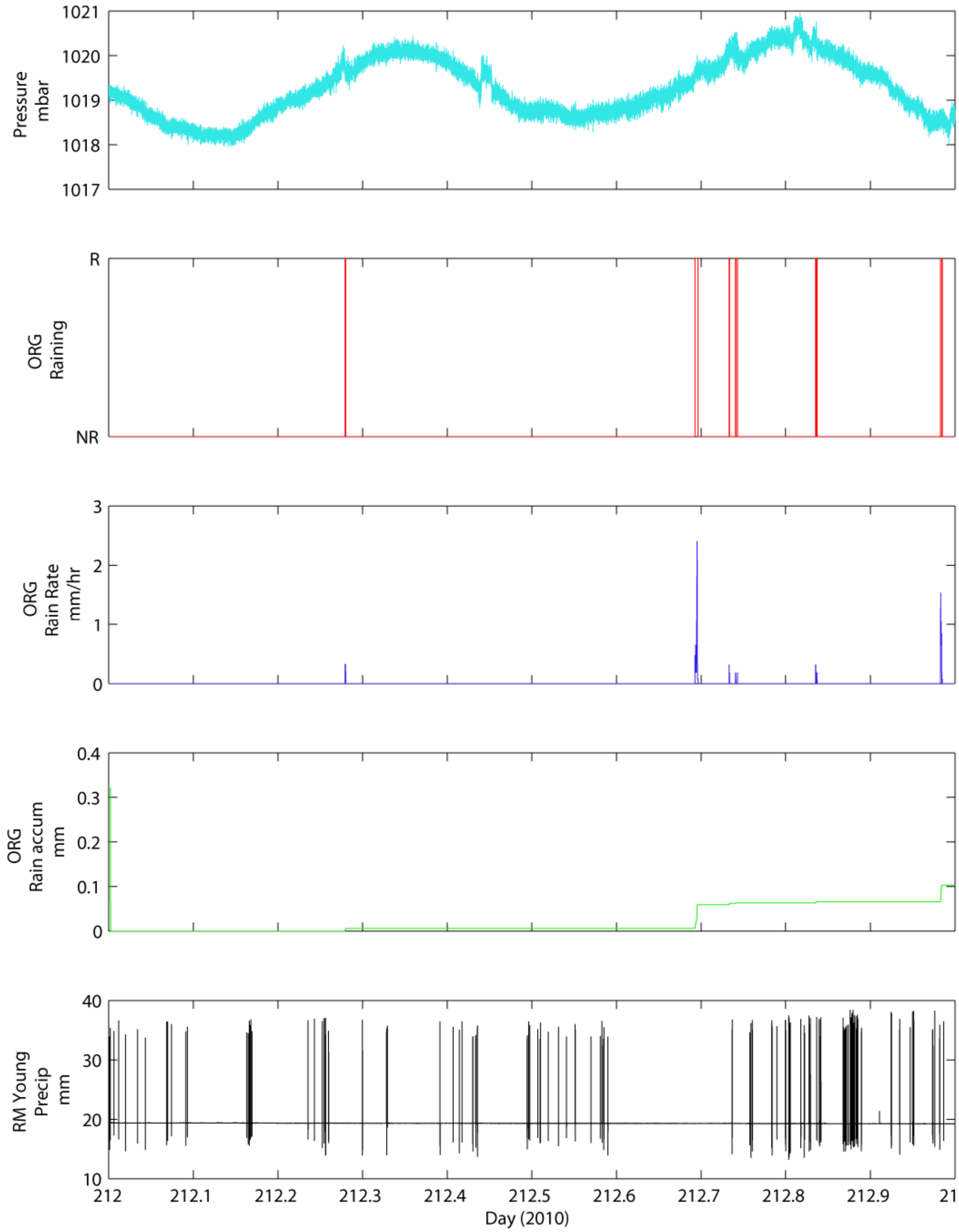

Figure D14. Time-series plots of Air Pressure, Optical Rain Gauge (Incidence, Rain Rate and Accumulation) and RM Young precipitation data during 31 July 2010. The time axis is in Julian Days.

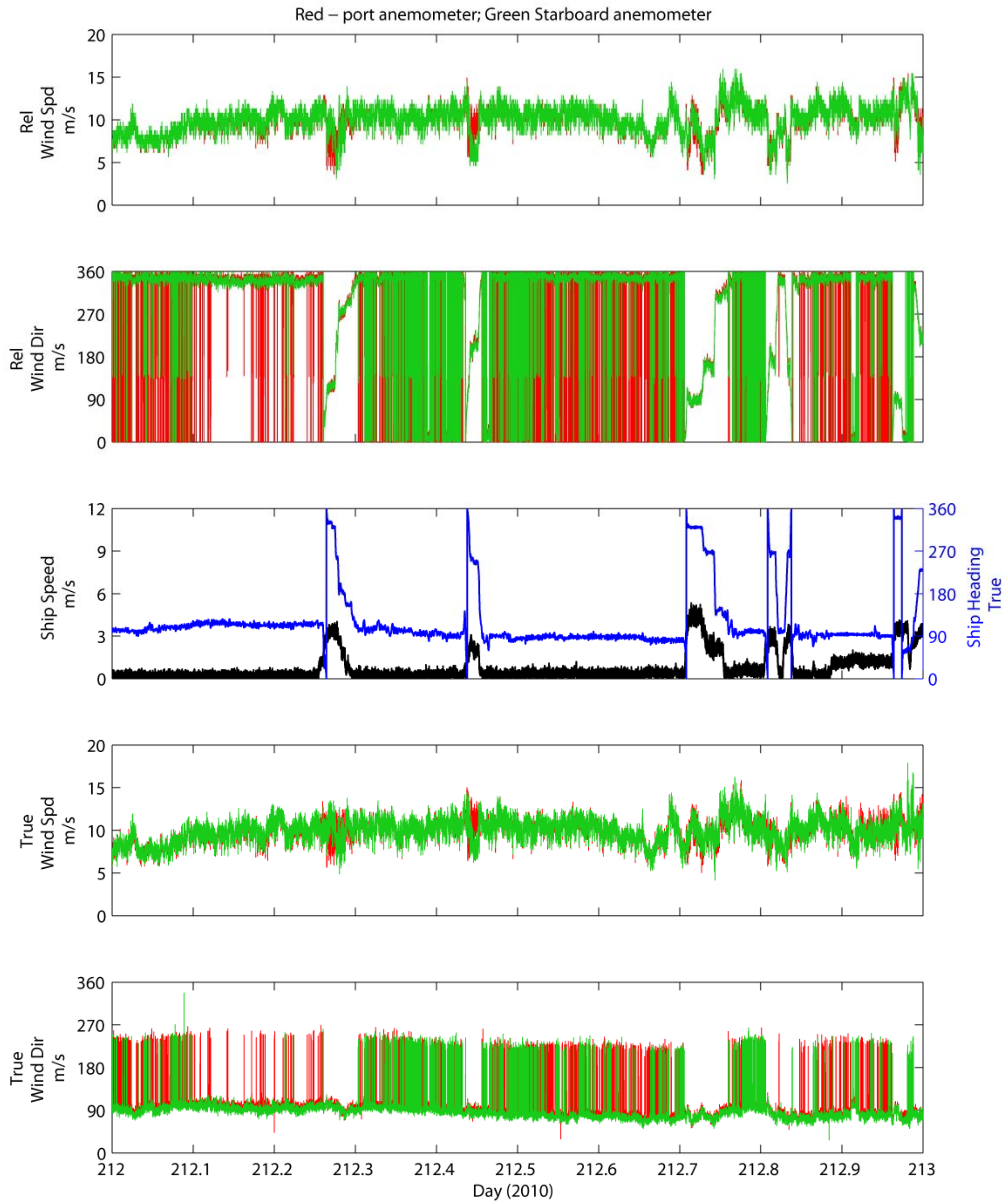

Figure D15. Time-series plots of Relative Wind Speed and Direction, Ship's Speed and True Wind Speed and Direction data during 31 July 2010. The time axis is in Julian Days.

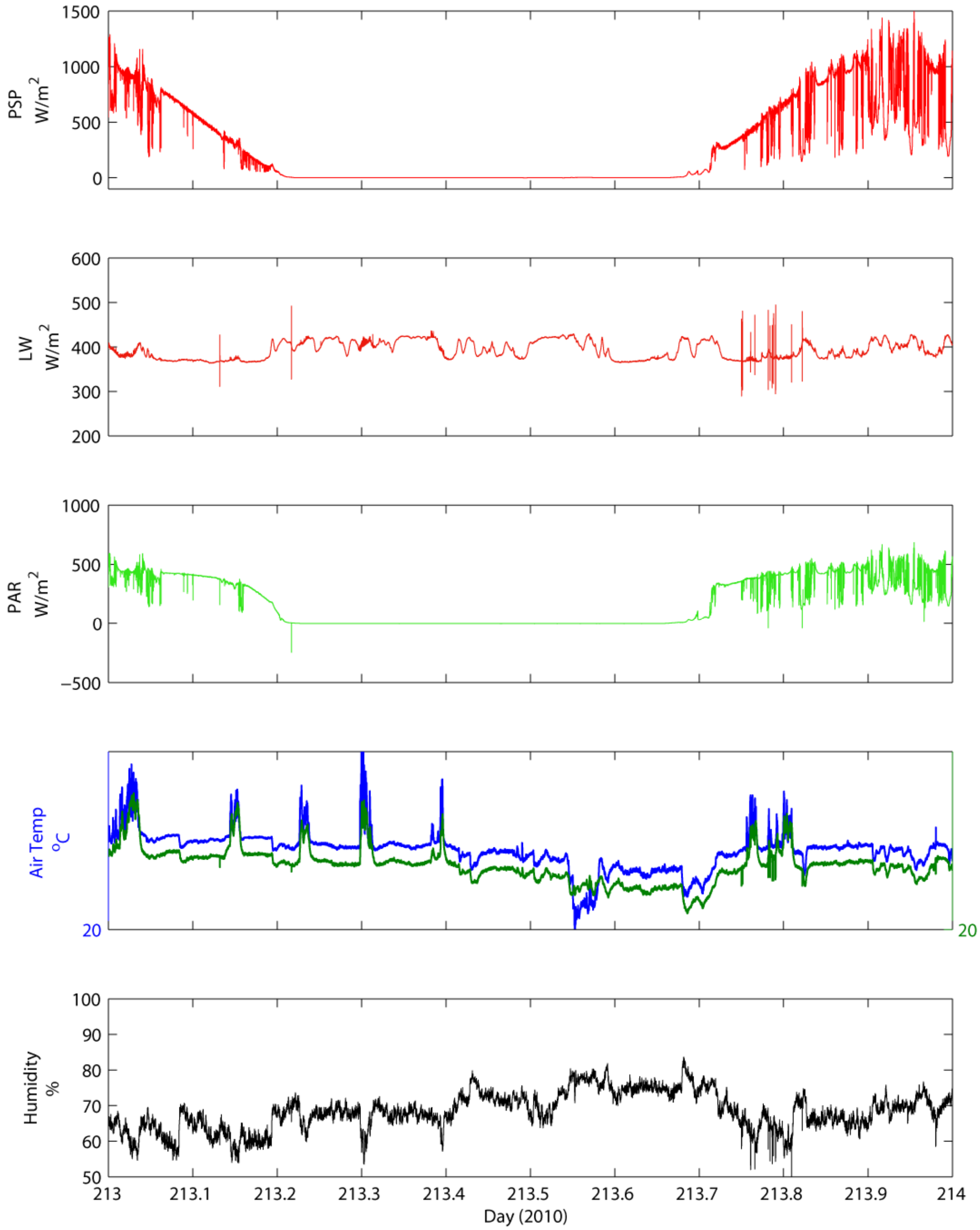

Figure D16. Time-series plots of PSP, Longwave Radiation, PAR, Air Temperature and Humidity data during 1 August 2010. The time axis is in Julian Days.

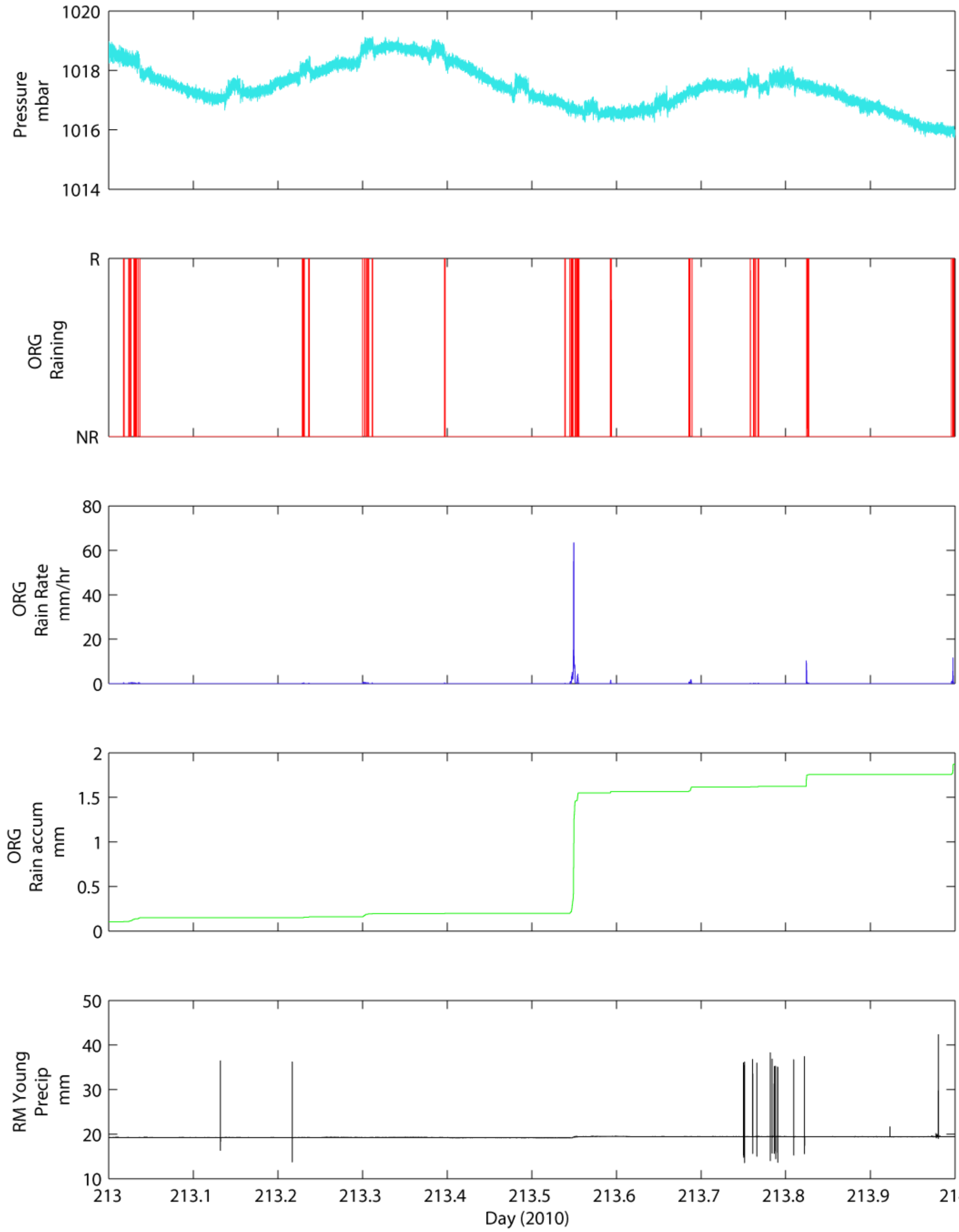

Figure D17. Time-series plots of Air Pressure, Optical Rain Gauge (Incidence, Rain Rate and Accumulation) and RM Young precipitation data during 1 August 2010. The time axis is in Julian Days.

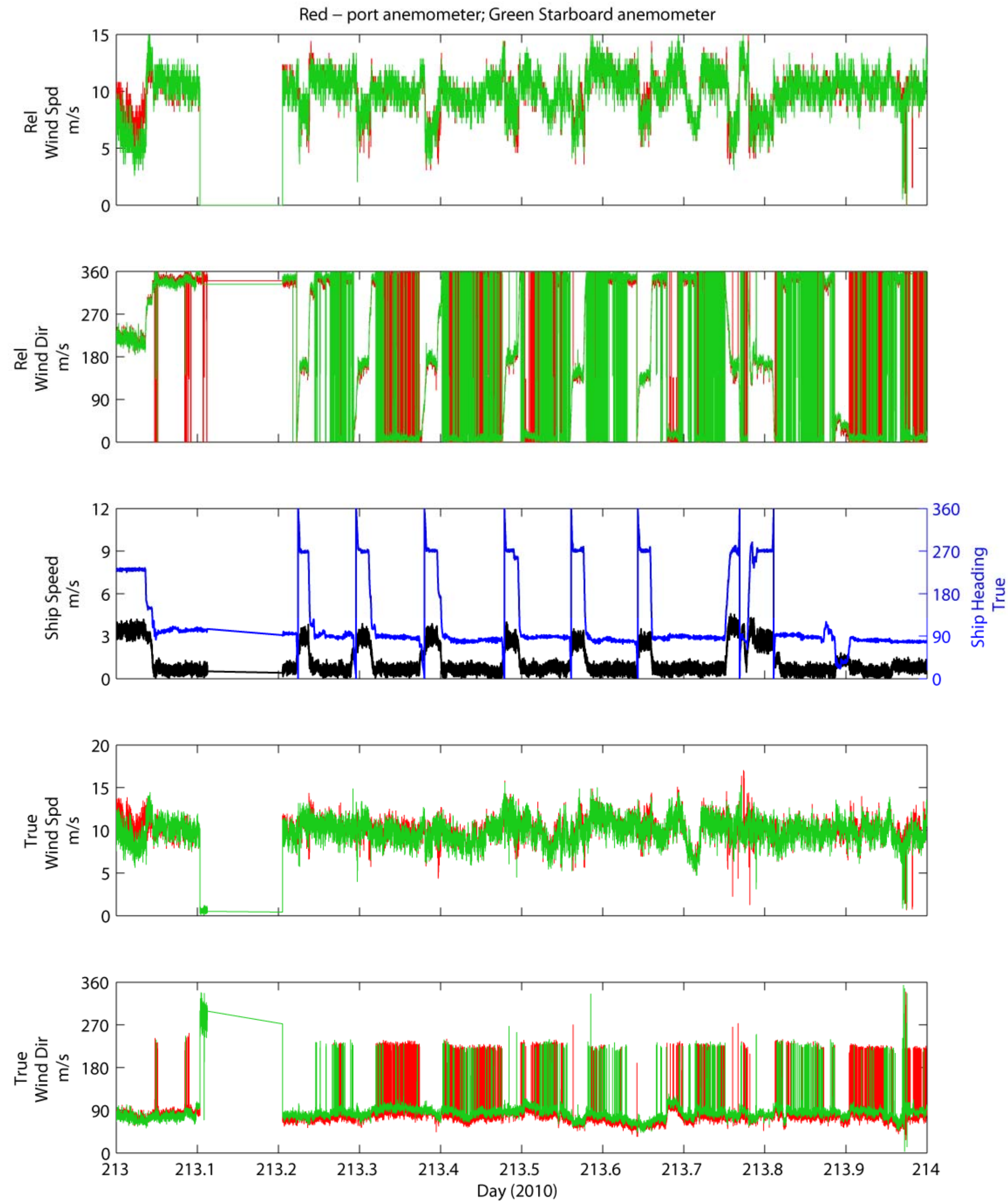

Figure D18. Time-series plots of Relative Wind Speed and Direction, Ship's Speed and True Wind Speed and Direction data during 1 August 2010. The time axis is in Julian Days. Period of no data due to maintenance.

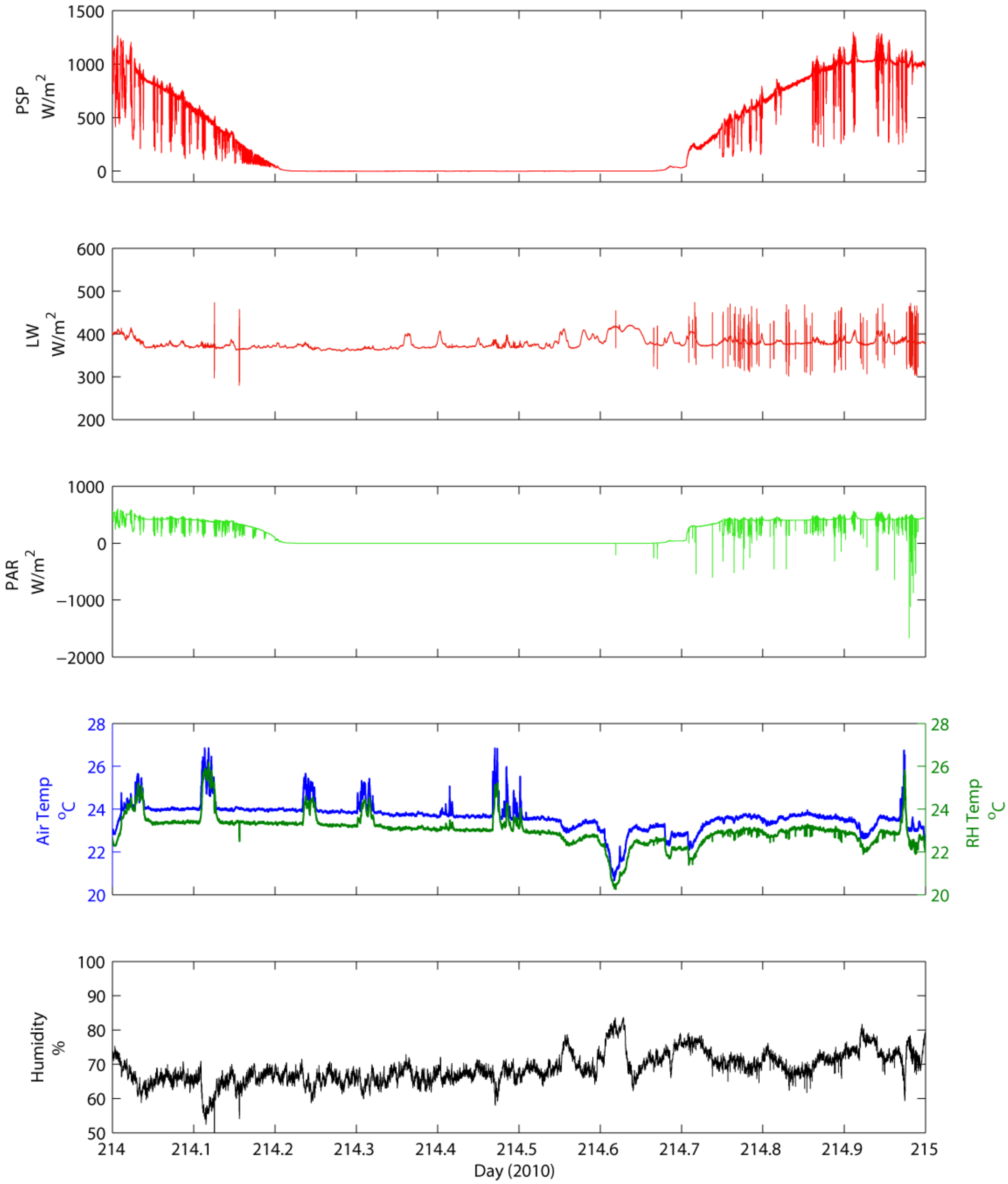

Figure D19. Time-series plots of PSP, Longwave Radiation, PAR, Air Temperature and Humidity data during 2 August 2010. The time axis is in Julian Days.

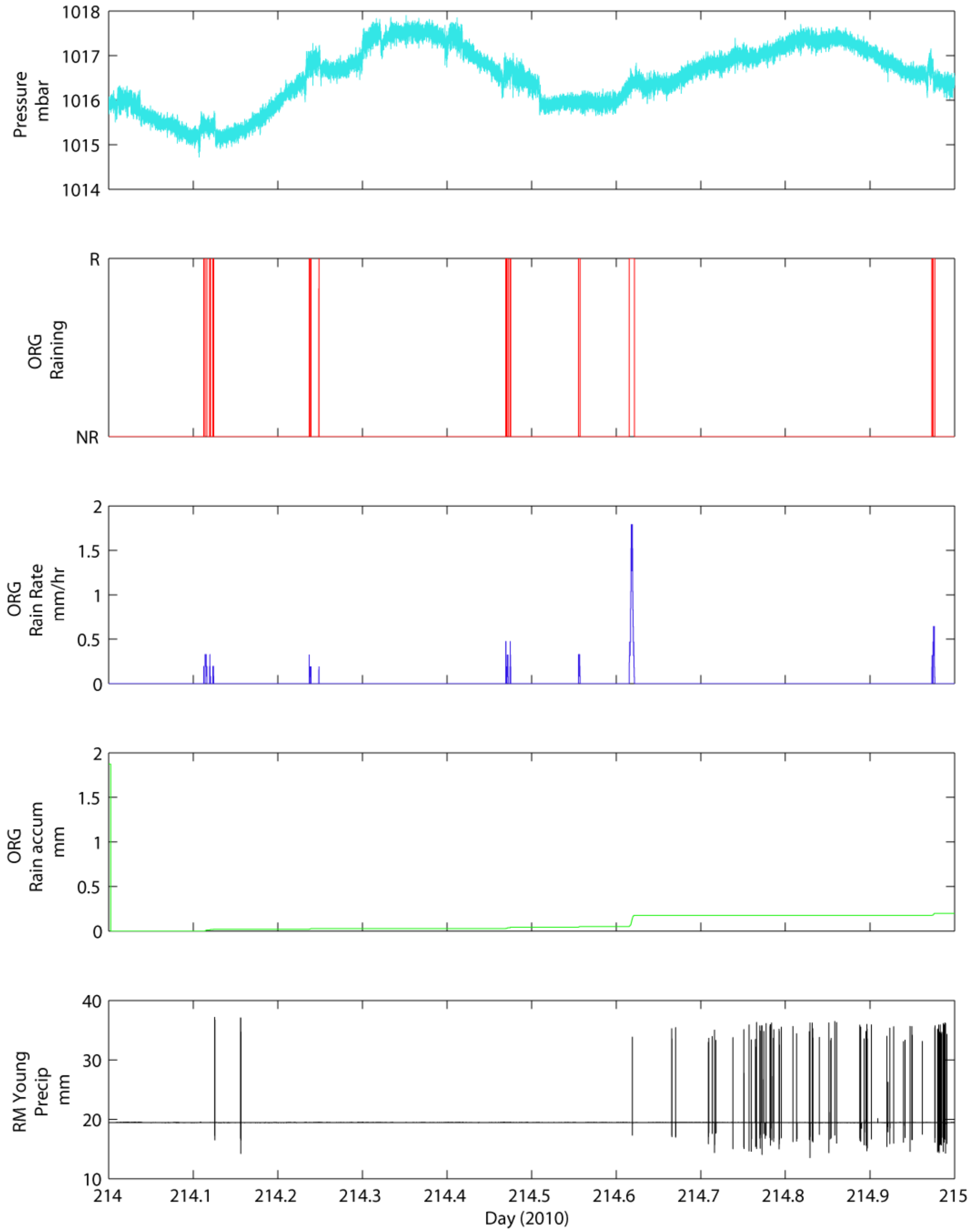

Figure D20. Time-series plots of Air Pressure, Optical Rain Gauge (Incidence, Rain Rate and Accumulation) and RM Young precipitation data during 2 August 2010. The time axis is in Julian Days.

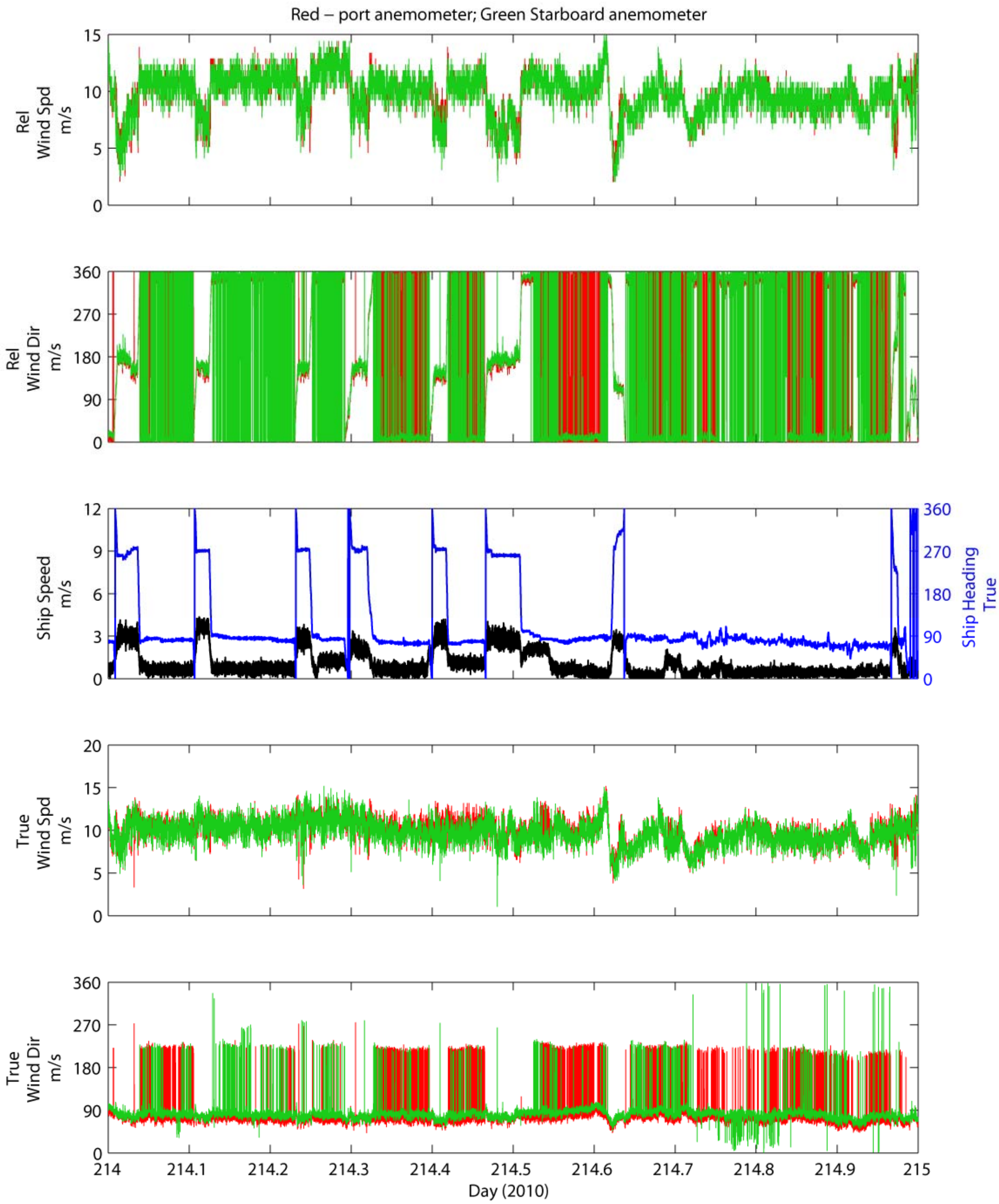

Figure D21. Time-series plots of Relative Wind Speed and Direction, Ship's Speed and True Wind Speed and Direction data during 2 August 2010. The time axis is in Julian Days.

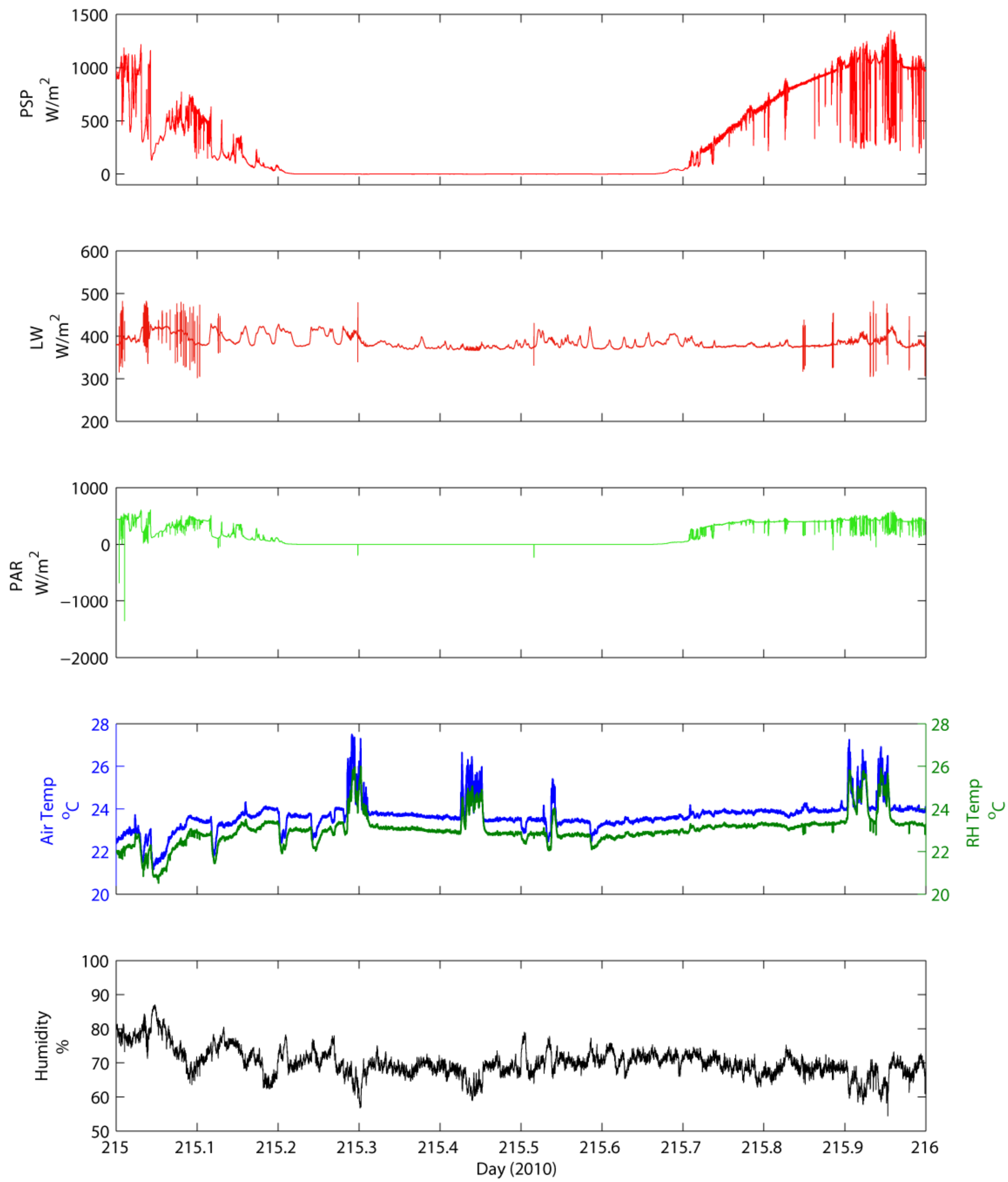

Figure D22. Time-series plots of PSP, Longwave Radiation, PAR, Air Temperature and Humidity data during 3 August 2010. The time axis is in Julian Days.

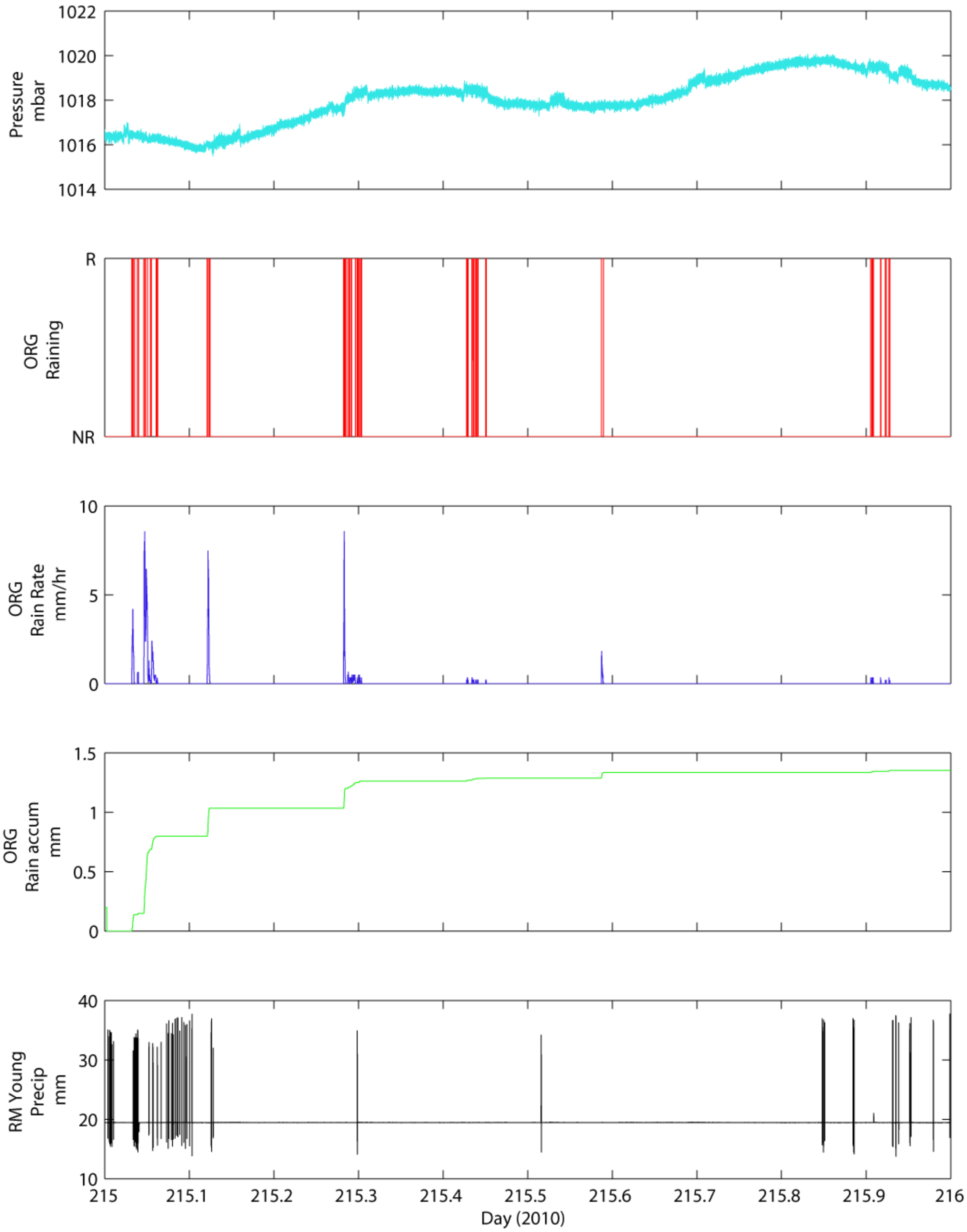

Figure D23. Time-series plots of Air Pressure, Optical Rain Gauge (Incidence, Rain Rate and Accumulation) and RM Young precipitation data during 3 August 2010. The time axis is in Julian Days.

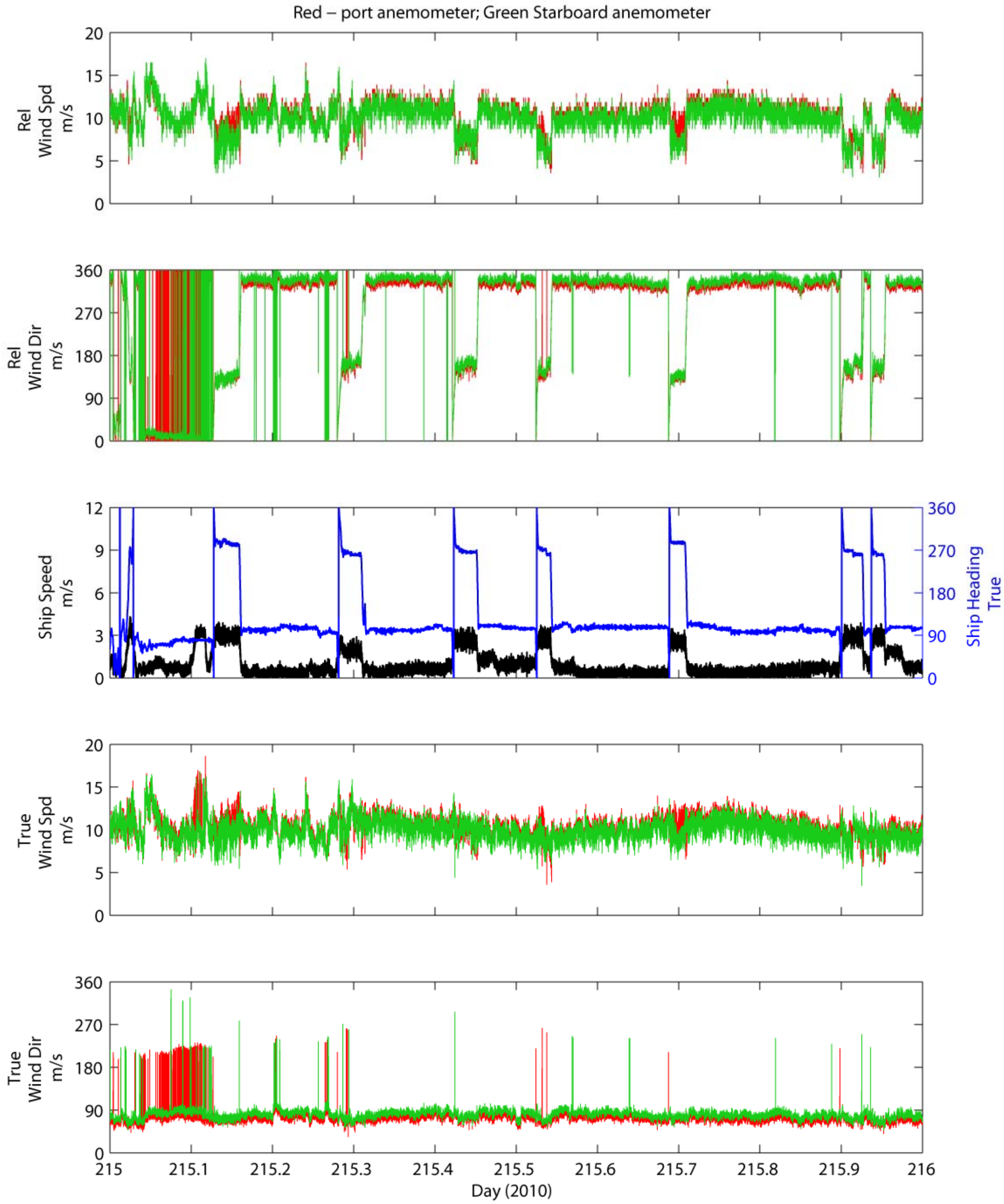

Figure D24. Time-series plots of Relative Wind Speed and Direction, Ship's Speed and True Wind Speed and Direction data during 3 August 2010. The time axis is in Julian Days.

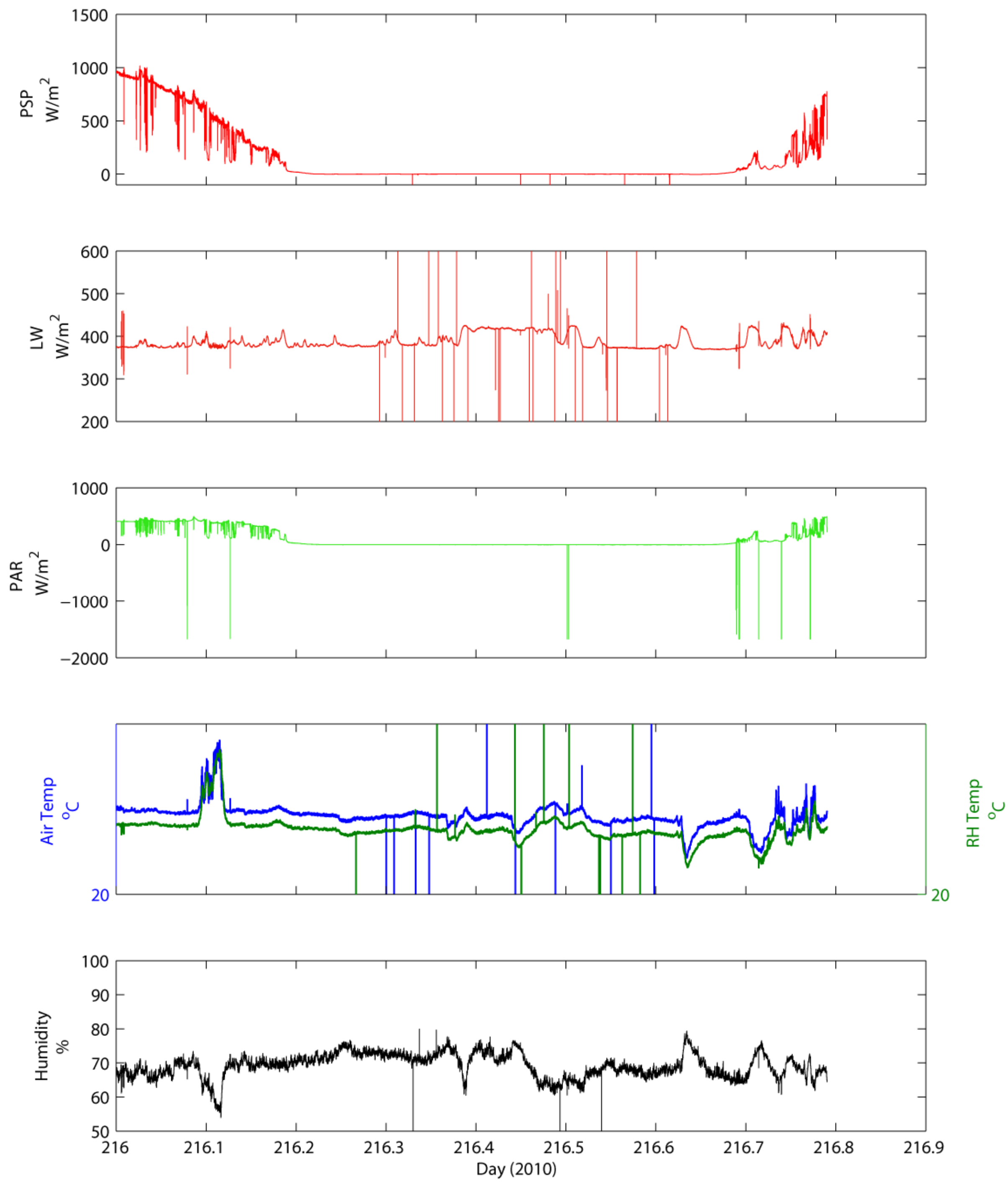

Figure D25. Time-series plots of PSP, Longwave Radiation, PAR, Air Temperature and Humidity data during 4 August 2010. The time axis is in Julian Days.

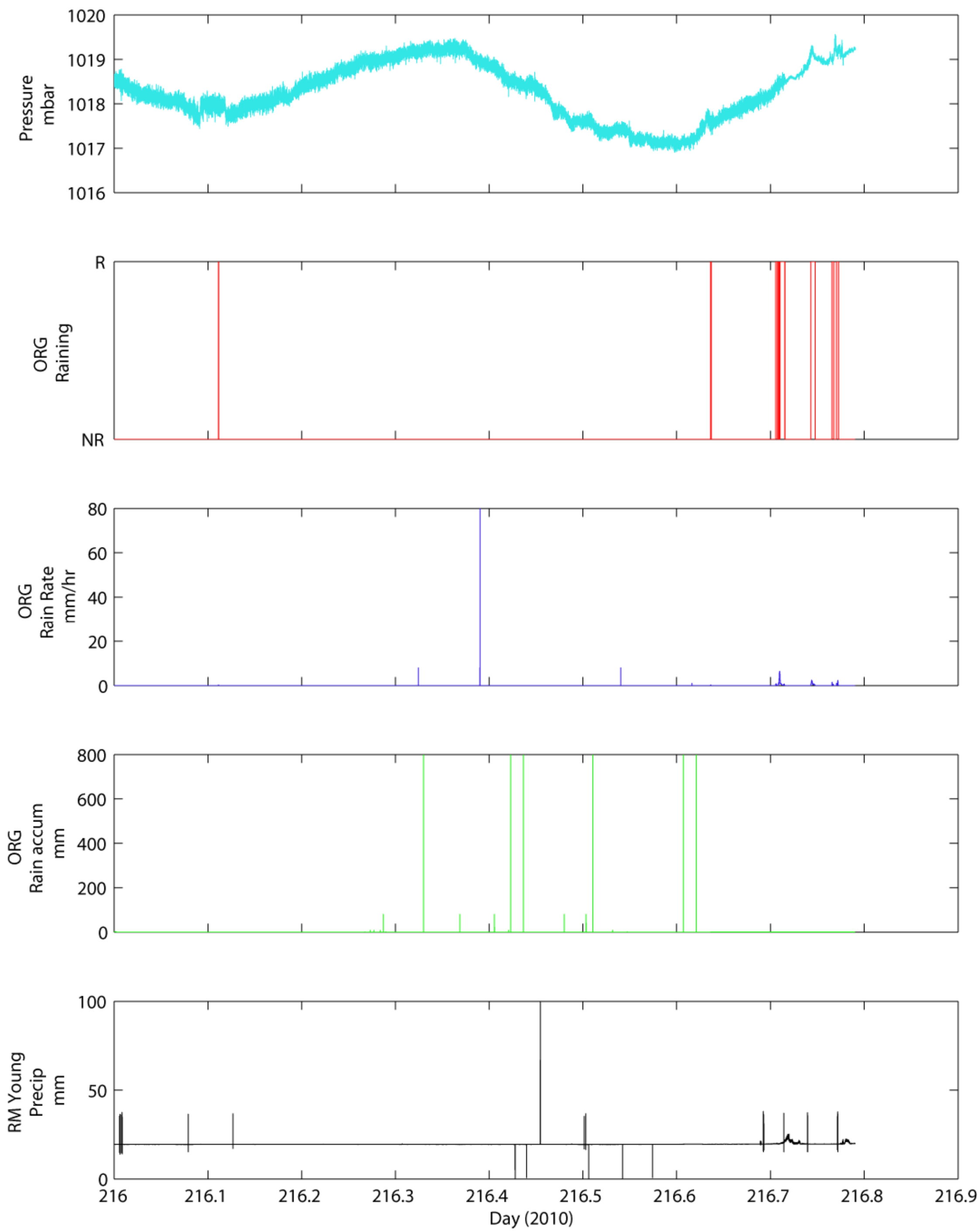

Figure D26. Time-series plots of Air Pressure, Optical Rain Gauge (Incidence, Rain Rate and Accumulation) and RM Young precipitation data during 4 August 2010. The time axis is in Julian Days.

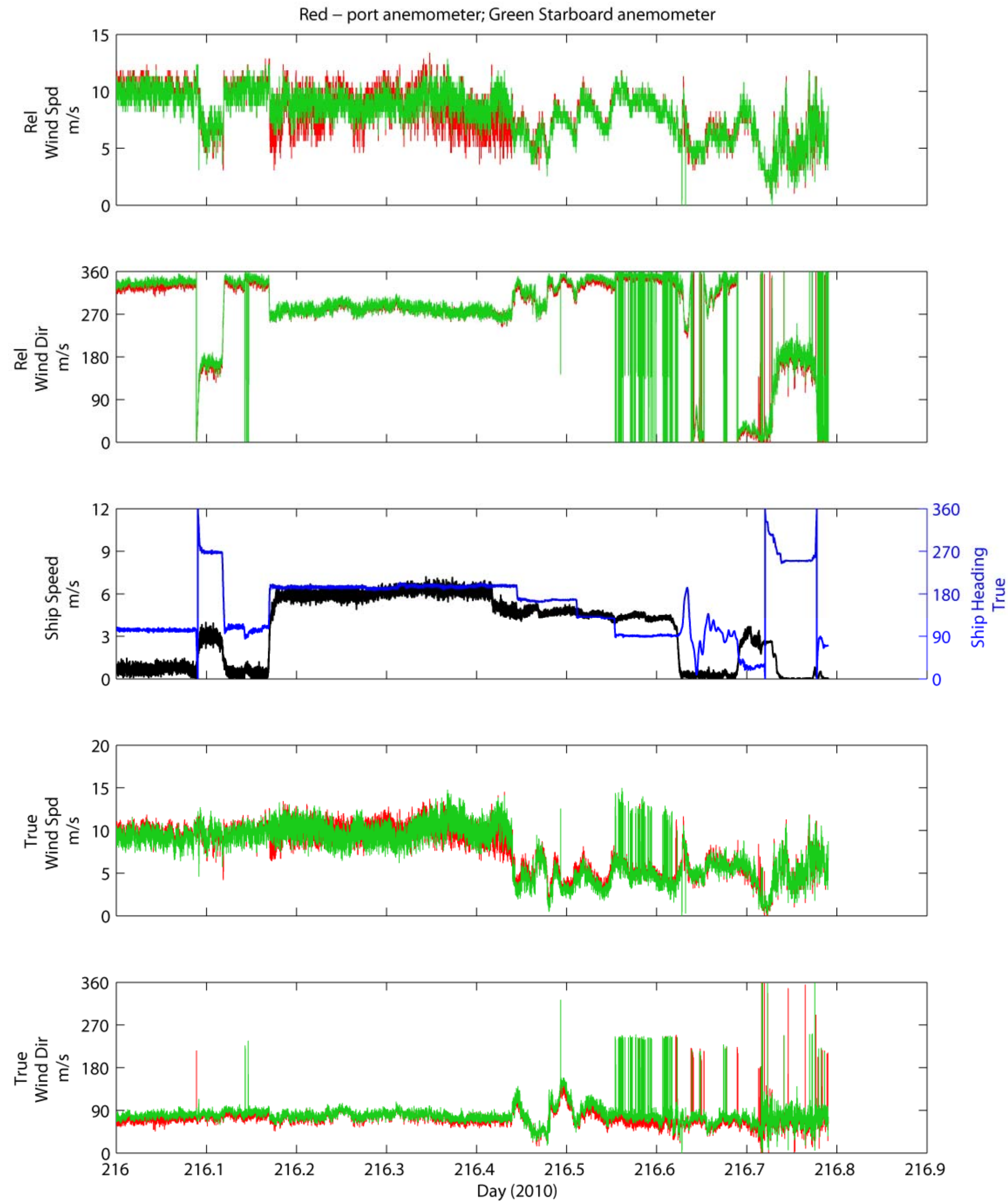

Figure D27. Time-series plots of Relative Wind Speed and Direction, Ship's Speed and True Wind Speed and Direction data during 3 August 2010. The time axis is in Julian Days.

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. WHOTS-6 MOORED STATION NO. 1209

Launch (anchor over)

Date (day-mon-yr) 11-07-2009 Time 01:18:48 UTC

Latitude (N/S, deg-min) 22 39.944 Longitude (E/W, deg-min) 157° 56.771

Deployed by Ryder/Whelan Recorder/Observer Plueddemann

Ship and Cruise No. Kilo Moana KM-09-16 Intended Duration 12 mo

Depth Recorder Reading — m Correction Source soundspeed profile

Depth Correction — m

Corrected Water Depth 4758 m Magnetic Variation (E/W) ____

Argos Platform ID No. See pg 2 Additional Argos Info on pages 2 and 3

Surveyed Anchor Position

Lat (N/S) 22° 39.989' Long. (E/W) 157° 56.961'

Acoustic Release Model EG&G 8242, dual

Release No. 31271 / 30847 Tested to 1500 m

Receiver No. ____ Release Command 444214/151411

Enable 460366/166620 Disable 460401/166645

Interrogate Freq. 11 kHz Reply Freq. 12 kHz

Recovery (release fired) 17:

Date (day-mon-yr) 02/08/2010 Time 17:11:25 Response 17:11:45 UTC

Latitude (N/S, deg-min) 22° 39.677 Longitude (E/W, deg-min) 157° 58.001

Recovered by Ostrom/Whelan Recorder/Observer Signell

Ship and Cruise No. Kilo Moana KM-10-14 Actual duration 12 mo days

Distance from actual waterline to buoy deck 75 cm ~~m~~

recovery release ops [5034 slant range sent
4941 slant range response

Surface Components

Buoy Type Foam Hull MOB Color(s) Hull yellow/white Tower white

Buoy Markings "B" IS found adrift contact U. Hawaii 808-956-7896

Surface Instrumentation

Item	ID #	Height*	Comments
ASIMET	L07	logger	System 1
HRH	220	227	
BPR	212	236	
WND	218	267	VANES MISSING, DAMAGED - TOOK WATER
PRC	211	247	
LWR	505	278	DOMES BROKEN · TOOK WATER
SWR	219	275	DOMES BROKEN - TOOK WATER
SST	1835	-153	RECOVERED FROM BRIDLE 01 27
PTT	14637	(WildCat)	ID's 7563, 7581, 7582
ASIMET	L19	logger	system 2
HRH	208	227	NOT RECOVERED - LOST AT SEA
BPR	221	238	
WND	211	267	DAMAGED - TOOK WATER
PRC	504	247	
LWR	215	278	DOMES BROKEN - TOOK WATER
SWR	202	275	DOMES BROKEN - TOOK WATER
SST	1727	-153	RECOVERED, SN NOT FOUND
PTT	18136	WILDCAT	IDs 14663, 14667, 14697
SIS Argos	25702	buoy hull	
Float SST	717	floating	SBE-39
Fixed SST	14882	-127	RBR-1060
Xeos GPS	611500	250	pwr from well
pCO_2	0019	69	air intake
Lascar	288	198	RECOVERY: ONE LOST AT SEA; ONE RETURNED DAMAGED
Lascar	249	231	

*Height above buoy deck in centimeters

Moored Station Number 1209

7/10/09

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
1		buoy	—	1931			0	00:59	
2	7.75	3/4 chain	—						
3		VMCM	010	1840	rotor spin 1834		10	01:35	LOWER ROTOR FOULED w/ FISHING LINE ROTOR SPIN 03:03:00
4	2.82	3/4 chain	—						
5		µCAT	6893	1835			15	01:36:20	FISHING LINE
6	3.6	~~#~~ 3/4 chain	—						
7		MAVS	10260	1831	sensor down		20	01:42:10	GROWTH ON UPPER BLADES
8	2.8	3/4 chain	—						
9		µCAT	6894	1830			25	01:47:30	
10	3.28	3/4 chain	—						
11		VMCM	058	1825	rotor spin 18:19		30	01:47:45	ROTOR SPIN 02:58:00
12	2.82	3/4 chain	—						
13		µCAT	6895	1824			35	01:50:10	
14	3.66	3/4 chain	—						
15		µCAT	6896	1819			40	01:50:55	
16	3.66	3/4 chain	—						
17		µCAT	6887	1817	w/pressure ✓		45	01:53:15	
18	1.2	3/4 chain	—						
19		ADCP	1825	1948	heads up, 600 kHz ~~1200 kHz~~ batt case		47.5	01:53:40	
20	0.5	~~0~~ 3/4 chain	—						
21		µCAT	6897	1949	~~w/pressure~~		50	01:53:50	
22	3.66	3/4 chain	—						

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
23		µCAT	6898	1953	~~w/pressure~~ bumped on deck		55	01:55:00	
24	8.7	7/16 wire	—			9014-5			
25		µCAT	6899	1959	~~w/pressure~~		65	02:01:05	
26	8.7	7/16 wire	—			9014-4			
27		µCAT	3618	2003	~~w/press~~		75	02:04:50	
28	8.7	7/16 wire	—			9014-6			
29		µCAT	6888	2006	w/press ✓		85	02:08:25	
30	8.7	7/16 wire	—			9014-7			
31		µCAT	3617	2009	~~w/press~~		95	02:11:10	RETRIEVED w/o GUACO
32	8.7	7/16 wire	—			9014-3			
33		µCAT	6889	2012	w/press ✓		105	02:14:50	
34	13.6	7/16 wire	—			9014-2			
35		µCAT	6890	2016	w/press ✓		120	02:18:30	OUT OF WATER 22:41:20 BACK IN WATER 22:47
36	3.66	3/4 chain	—			~~9014-8~~			
37		ADCP	4891	2019	batt case 3169 beams up, 300 kHz		125	22:43:25	
38	8.7	7/16 wire	—			9014-8			
39		µCAT	3634	2023	~~w/press~~		135	22:38:45	
40	18.75	7/16 wire	—			9014-1			
41		µCAT	6891	2027	w/press ✓		155	2233	
42	250	3/8 wire	—	2027		7221-12		2226 2233	
43	500	3/8 wire	—	2035		7212-3		2213 2225	fishing line
44	500	3/8 wire	—	2048		9014-11		2158 2212	
45	500	3/8 wire	—	2059		9014-9		2157 2141	

Moored Station Number 1209

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
46	100	3/8 wire	–	~~9014-13~~	} one piece w/	9014-13		21:38	
47	200	7/8 nylon	–	2116	} wrapped termination			21:24	
48	2100	7/8 nylon	–	2127				19:45:10	20:02:25 splice 20:29:59 splice 20:57:30 splice
49	1500	1" colmega	–	2215				1839 19:45:10	
50		glass balls	–	2325-2358	80 balls on chain			18:20 18:27	8 imploded
51	5	1/2' chain	–	7/11/09	(count = 80 balls) ✓				
52	–	release	31271	0053	} dual, on			18:30:15	
53	–	release	30847	0053	} strongback				
54	5	1/2 chain	–					–	
55	20	Nystron	–					–	
56	5	chain	–					–	
57		Anchor	–	0119				–	
58									
59									
60									
61									
62									
63									
64									
65									
66									
67									

ARRAY NAME AND NO. WHOTS-7 MOORED STATION NO. 1216

Item No.	Length (m)	Item	Depth (m)	Inst No.	Time Over	Time Back	Notes
1		buoy		19:20:34			
2	7.75	3/4" chain					
3		VMCM	10	035	19:03:10		Go SPIN TIME 18:53:45 07/28/2010
4	2.82	3/4" chain					
5		MCAT	15	3382	19:00:20		
6	3.6	3/4" chain					
7		MAVS	20	10261	18:54:15		
8	2.8	3/4" chain					
9		MCAT	25	4663	18:52:45		
10	3.28	3/4" chain					
11		VMCM	30	038	18:51:10		Go SPIN TIME 18:42:45
12	2.82	3/4" chain					
13		MCAT	35	3633	18:48:30		
14	3.66	3/4" chain					
15		MCAT	40	3381	18:44:20		
16	3.66	3/4" chain					
17		MCAT	45	3668	18:40:45		
18	1.2	3/4" chain					
19		RDI ADCP 600	47.5	13917	18:39:10		did not come out of water after deployment
20	0.5	3/4" chain					
21		MCAT	50	3619	18:38:40		out of water 19:25:10 back in water 19:40:01
22	3.66	3/4" chain					
23		MCAT	55	3620	19:40:20		
24	8.7	7/16" wire					
25		MCAT	65	3621	19:45:40		rough handling

ARRAY NAME AND NO. WHOTS 7 MOORED STATION NO. 1216

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26	8.7	7/16" wire					
27		MCAT	75	3632	19:48:45		
28	8.7	7/16" wire					
29		MCAT	85	4699	19:51:37		
30	8.7	7/16" wire					
31		MCAT	95	3791	19:54:05		
32	8.7	7/16" wire					
33		MCAT	105	2769	19:56:55		
34	13.6	7/16" wire					
35		MCAT	120	4700	20:04:55		
36	3.66	3/4" chain					
37		300 RDI ADCP	125	7637	20:05:20		
38	8.7	7/16" wire					
39		MCAT	135	3669	20:07:45		
40	18.75	7/16" wire					
41		MCAT	155	4701	20:11:16		
42	250	3/8" wire			20:11:16 20:23		water time to start block time to end stop 45s
43	500	3/8" wire			20:24 20:55		block times
44	500	3/8" wire			20:57 21:20		↓
45	500	3/8" wire			21:22 21:40		
46	100	3/8" wire			21:41 21:43		one piece w/ wrapped termination
47	200	7/8" nylon			21:43 21:50		w/ thimble on bottom
48	2100	7/8" nylon			21:53 22:54		thimble on top
49	1500	1" colmega			22:54 23:38		one piece to be spliced at sea
50		glass balls			00:03 00:43		80, 17" balls on 1/2" trawler chain

5

ARRAY NAME AND NO. WHOTS-7 MOORED STATION NO. 1216

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
51	5	½" chain					trawler chain
52		release		32478	00:44 UTS		dual, 1m chain w/ release links
53		release		32482	00:44 UTS		
54	5	½" chain					trawler chain
55	20	1" Nystron					
56	5	½" chain					trawler chain
57		anchor			02:37		
58					07/29/2010		
59							
60							
61							
62							
63							
64							
65							
66							
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74							
75							

6

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. WHOTS-6 MOORED STATION NO. 1209

Launch (anchor over)

Date (day-mon-yr) 11-07-2009 Time 01:18:48 UTC

Latitude (N/S, deg-min) 22 39.944 Longitude (E/W, deg-min) 157° 56.771

Deployed by Ryder/Whelan Recorder/Observer Plueddemann

Ship and Cruise No. Kilo Moana KM-09-16 Intended Duration 12 mo

Depth Recorder Reading — m Correction Source soundspeed profile

Depth Correction — m

Corrected Water Depth 4758 m Magnetic Variation (E/W)

Argos Platform ID No. See pg 2 Additional Argos Info on pages 2 and 3

Surveyed Anchor Position

Lat (N/S) 22° 39.989' Long. (E/W) 157° 56.961'

Acoustic Release Model EG&G 8242, dual

Release No. 31271 / 30847 Tested to 1500 m

Receiver No. Release Command 444214/151411

Enable 460366/166620 Disable 460401/166645

Interrogate Freq. 11 kHz Reply Freq. 12 kHz

Recovery (release fired) 17:

Date (day-mon-yr) 02/08/2010 Time 17:11:25 Response 17:11:45 UTC

Latitude (N/S, deg-min) 22° 39.677 Longitude (E/W, deg-min) 157° 58.001

Recovered by Ostrom/Whelan Recorder/Observer Signell

Ship and Cruise No. Kilo Moana KM-10-14 Actual duration 12 mo days

Distance from actual waterline to buoy deck 75 cm m

recovery release ops [5034 slant range sent; 4941 slant range response]

Surface Components

Buoy Type Foam Hull MOB Color(s) Hull yellow/white Tower white

Buoy Markings "B" IS found adrift contact U. Hawaii 808-956-7896

Surface Instrumentation

Item	ID #	Height*	Comments
ASIMET	L07	logger	System 1
HRH	220	227	
BPR	212	236	
WND	218	267	VANES MISSING, DAMAGED - TOOK WATER
PRC	211	247	
LWR	505	278	DOMES BROKEN - TOOK WATER
SWR	219	275	DOMES BROKEN - TOOK WATER
SST	1835	-153	RECOVERED FROM BRIDLE 01 27
PTT	14637	(WildCat)	ID's 7563, 7581, 7582
ASIMET	L19	logger	system 2
HRH	208	227	NOT RECOVERED - LOST AT SEA
BPR	221	238	
WND	211	267	DAMAGED - TOOK WATER
PRC	504	247	
LWR	215	278	DOMES BROKEN - TOOK WATER
SWR	202	275	DOMES BROKEN - TOOK WATER
SST	1727	-153	RECOVERED, SN NOT FOUND
PTT	18136	WildCAT	IDs 14663, 14667, 14697
SIS Argos	25702	buoy hull	
Float SST	717	floating	SBE-39
Fixed SST	14882	-127	RBR-1060
Xeos GPS	611500	250	pwr from well
pCO_2	0019	69	air intake
Lascar	288	198	RECOVERY: ONE LOST AT SEA; ONE RETURNED DAMAGED
Lascar	249	231	

*Height above buoy deck in centimeters

Moored Station Number 1209

7/10/09

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
1		buoy	–	1931			0	00:59	
2	7.75	3/4 chain	–						
3		VMCM	010	1840	rotor spin 1834		10	01:35	LOWER ROTOR FOULED w/ FISHING LINE ROTOR SPIN 03:03:00
4	2.82	3/4 chain	–						
5		μCAT	6893	1835			15	01:36:20	FISHING LINE
6	3.6	~~[illegible]~~ 3/4 chain	–						
7		MAVS	10260	1831	sensor down		20	01:42:10	GROWTH ON UPPER BLADES
8	2.8	3/4 chain	–						
9		μCAT	6894	1830			25	01:47:30	
10	3.28	3/4 chain	–						
11		VMCM	058	1825	rotor spin 18:19		30	01:47:45	ROTOR SPIN 02:58:00
12	2.82	3/4 chain	–						
13		μCAT	6895	1824			35	01:50:10	
14	3.66	3/4 chain	–						
15		μCAT	6896	1819			40	01:50:55	
16	3.66	3/4 chain	–						
17		μCAT	6887	1817	w/pressure ✓		45	01:53:15	
18	1.2	3/4 chain	–						
19		ADCP	1825	1948	heads up, ~~1200 kHz~~ 600 kHz batt case		47.5	01:53:40	
20	0.5	~~[illegible]~~ 3/4 chain	–						
21		μCAT	6897	1949	~~w/pressure~~		50	01:53:50	
22	3.66	3/4 chain	–						

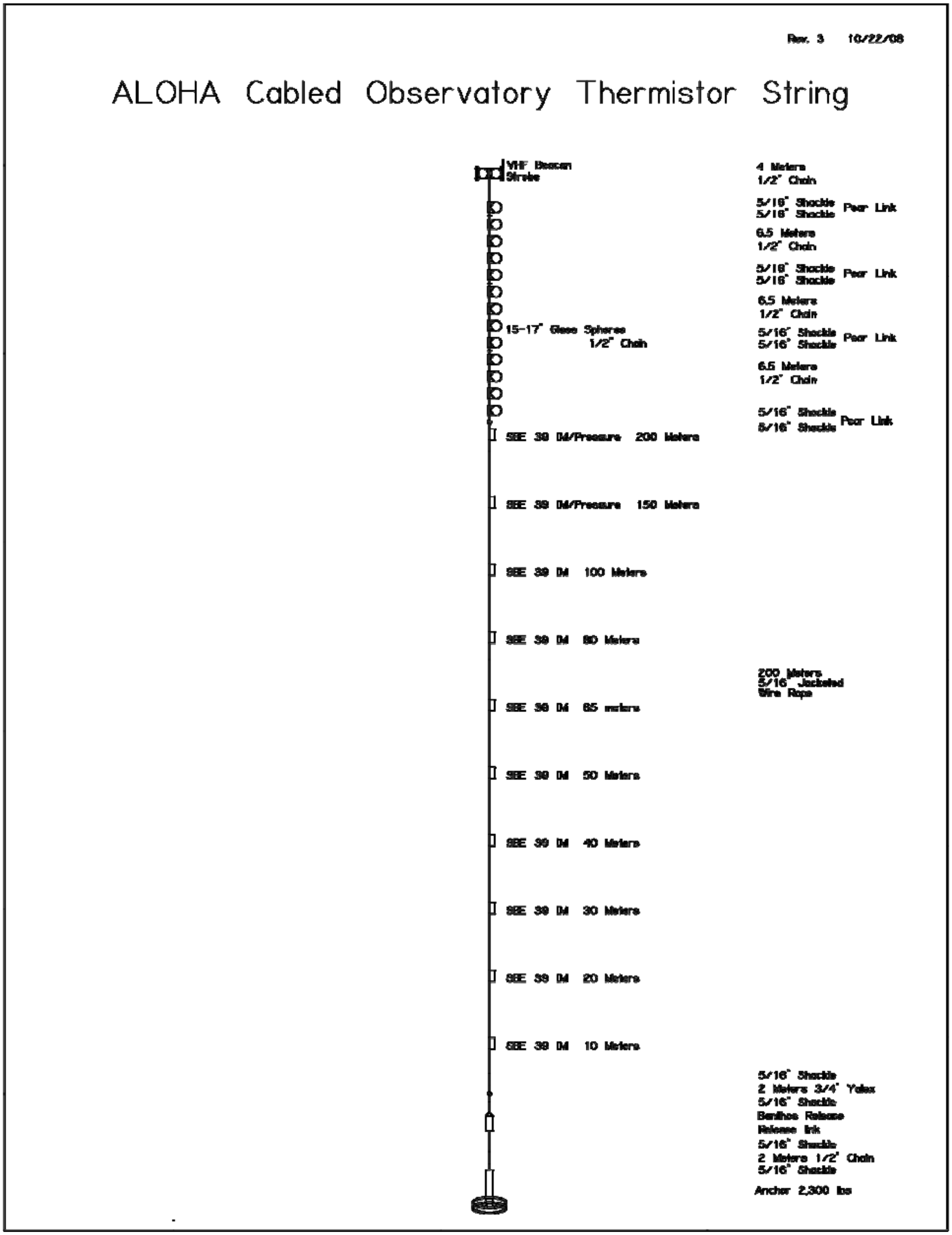
Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
23		μCAT	6898	1953	~~w/pressure~~ bumped on deck		55	01:55:00	
24	8.7	7/16 wire	—			9014-5			
25		μCAT	6899	1959	~~w/pressure~~		65	02:01:05	
26	8.7	7/16 wire	—			9014-4			
27		μCAT	3618	2003	~~w/press~~		75	02:04:50	
28	8.7	7/16 wire	—			9014-6			
29		μCAT	6888	2006	w/press ✓		85	02:08:25	
30	8.7	7/16 wire	—			9014-7			
31		μCAT	3617	2009	~~w/press~~		95	02:11:10	RETRIEVED w/o GUARD
32	8.7	7/16 wire	—			9014-3			
33		μCAT	6889	2012	w/press ✓		105	02:14:50	
34	13.6	7/16 wire	—			9014-2			
35		μCAT	6890	2016	w/press ✓		120	02:18:30	OUT OF WATER 22:41:20 BACK IN WATER 22:47
36	3.66	3/4 chain	—			~~9014-8~~			
37		ADCP	4891	2019	batt case 3169 beams up, 300 kHz		125	22:43:25	
38	8.7	7/16 wire	—			9014-8			
39		μCAT	3634	2023	~~w/press~~		135	22:38:45	
40	18.75	7/16 wire	—			9014-1			
41		μCAT	6891	2027	w/press ✓		155	2233	
42	250	3/8 wire	—	2027		7221-12		2226 2233	
43	500	3/8 wire	—	2035		7212-3		2213 2225	fishing line
44	500	3/8 wire	—	2048		9014-11		2158 2212	
45	500	3/8 wire	—	2059		9014-9		2157 2141	

5

Moored Station Number 1209

Item No.	Length (m)	Item	Inst No.	Time Over	Notes	Data No.	Depth (m)	Time Back	Notes
46	100	3/8 wire	—	~~9014-13~~	} one piece w/	9014-13		21:38	
47	200	7/8 nylon	—	2116	} wrapped termination			21:24	
48	2100	7/8 nylon	—	2127				19:45:10	20:02:25 splice 20:29:59 splice 20:57:30 splice
49	1500	1" colmega	—	2215				1839 19:45:10	
50		glass balls	—	2325-2358	80 balls on chain			18:20 18:27	8 imploded
51	5	1/2" chain	—	7/11/09	(count = 80 balls) ✓				
52	—	release	31271	0053	} dual, on			18:30:15	
53	—	release	30847	0053	} strongback				
54	5	1/2 chain	—					—	
55	20	Nystron	—					—	
56	5	chain	—					—	
57		Anchor	—	0119				—	
58									
59									
60									
61									
62									
63									
64									
65									
66									
67									

Appendix I: Aloha Diagram and Log



Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. ALOHA CABLED OBSERVATORY THERMISTOR STRING | MOORED STATION NO. ______

Launch (anchor over)

Date (day-mon-yr) ______	Time ______ UTC
Deployed by ______	Recorder/Observer ______
Ship and Cruise No. ______	Intended Duration ______
Depth Recorder Reading 4718 m	Correction Source ______
Depth Correction ______ m	______
Corrected Water Depth ______ m	Magnetic Variation (E/W) ______
Anchor Drop Lat. (N/S) 22° 43.992	Lon. (E/W) 158° 01.00
Surveyed Pos. Lat. (N/S) ↓	Lon. (E/W) ↓
Argos Platform ID No. ______	Additional Argos Info on pages 2 and 3

Acoustic Release Model BENTHOS	Tested to ______ m
Release No. 1 (sn) ______	Release No. 2 (sn) ______
Interrogate Freq. 9kHz	Interrogate Freq. ______
Reply Freq. 10kHz	Reply Freq. ______
Enable D	Enable ______
Disable ______	Disable ______
Release F	Release ______

times are -33 seconds compared to Pos-MV

19:44:55 RELEASE CODE SENT (#1), 19:47:40 (#2) SIGHTED 20:39 APPROX.

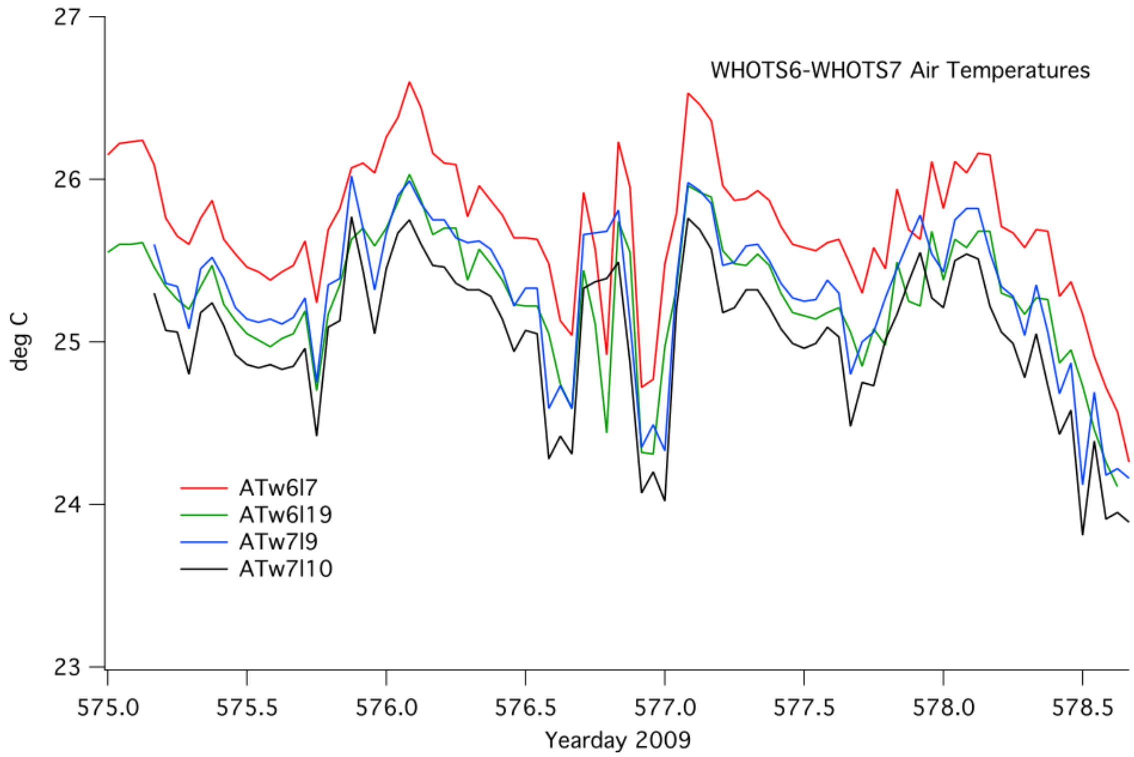
19:49:40 RESPONSE (15 pings) START

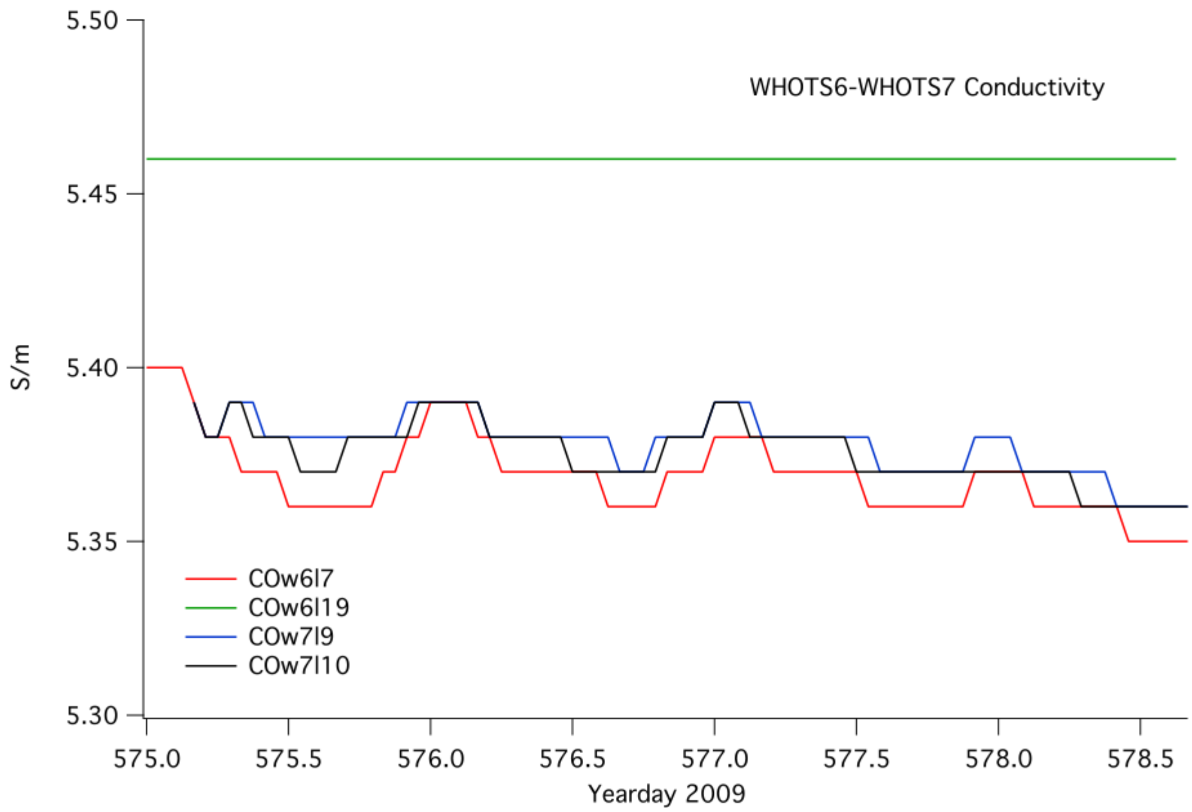
Recovery (release fired)

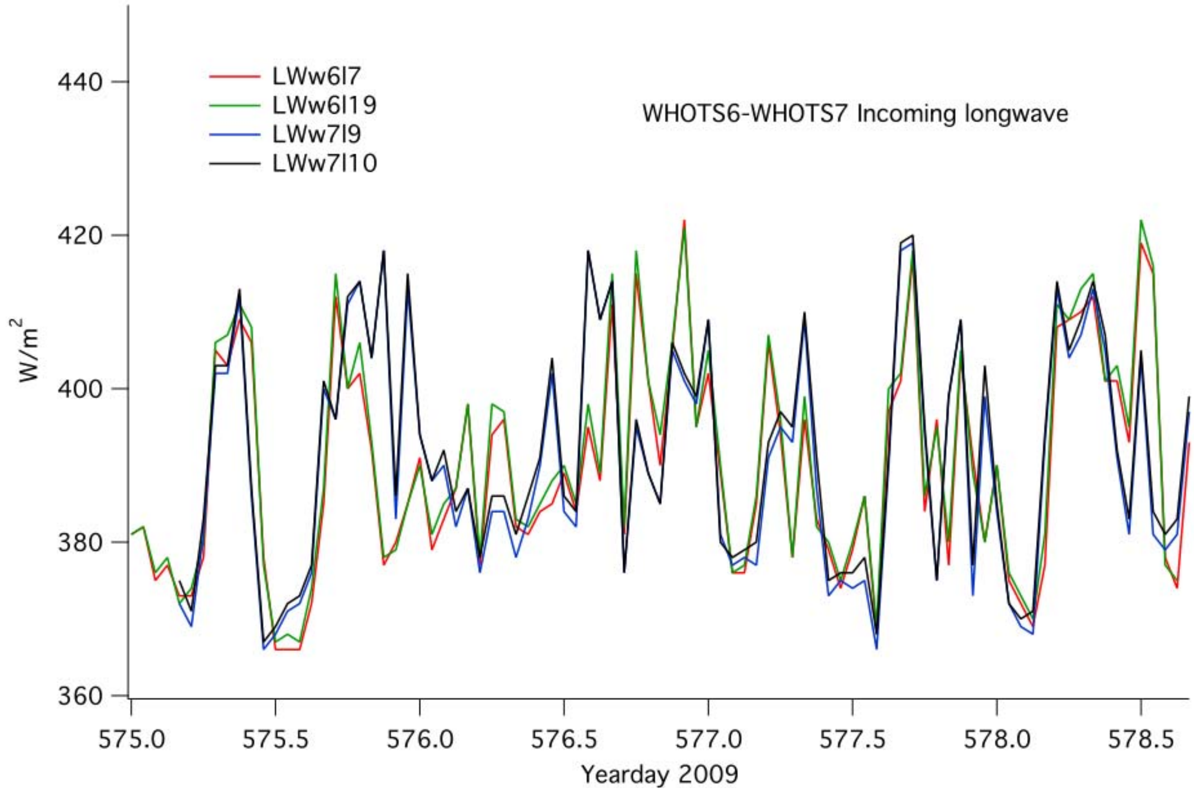
Date (day-mon-yr) ______	Time ______ UTC
Latitude (N/S) ______	Longitude (E/W) ______
Recovered by ______	Recorder/Observer ______
Ship and Cruise No. ______	Actual duration ______ days

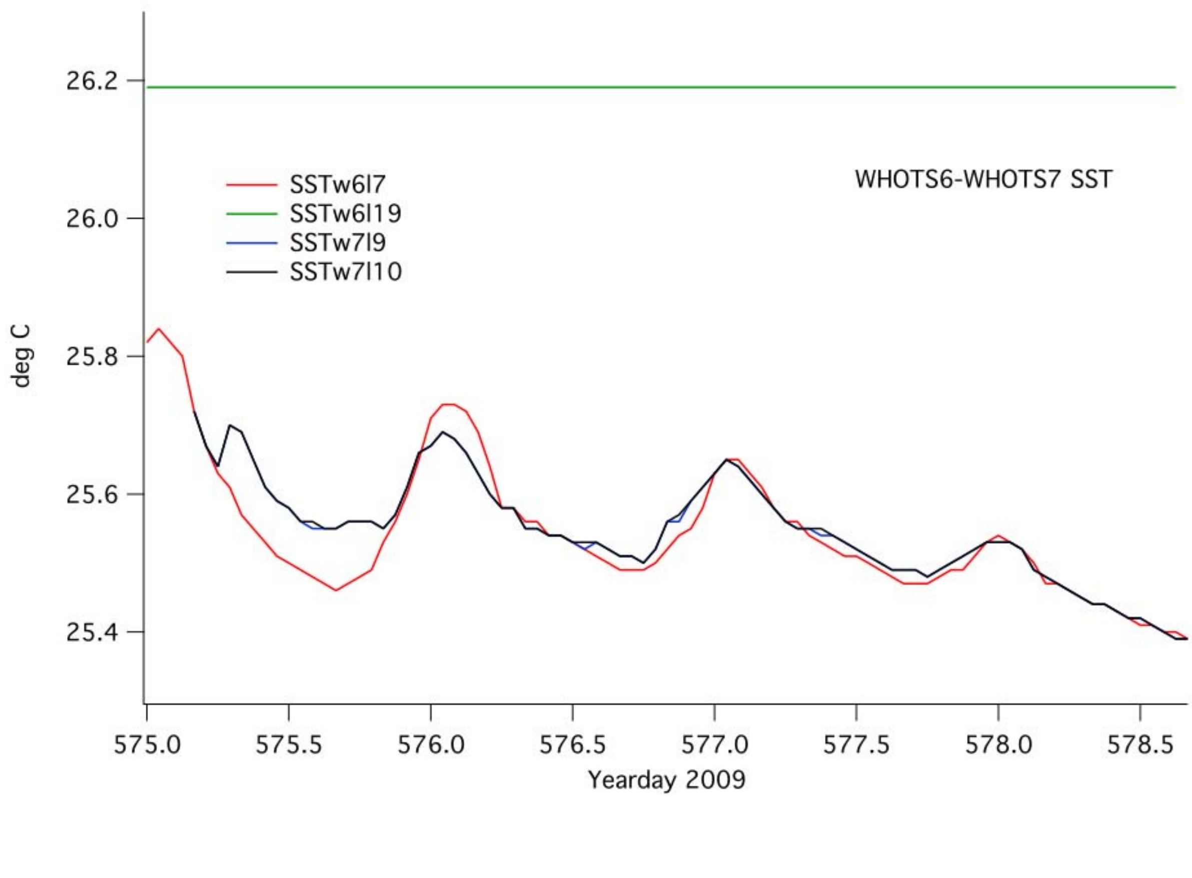
Distance from waterline to buoy deck ______

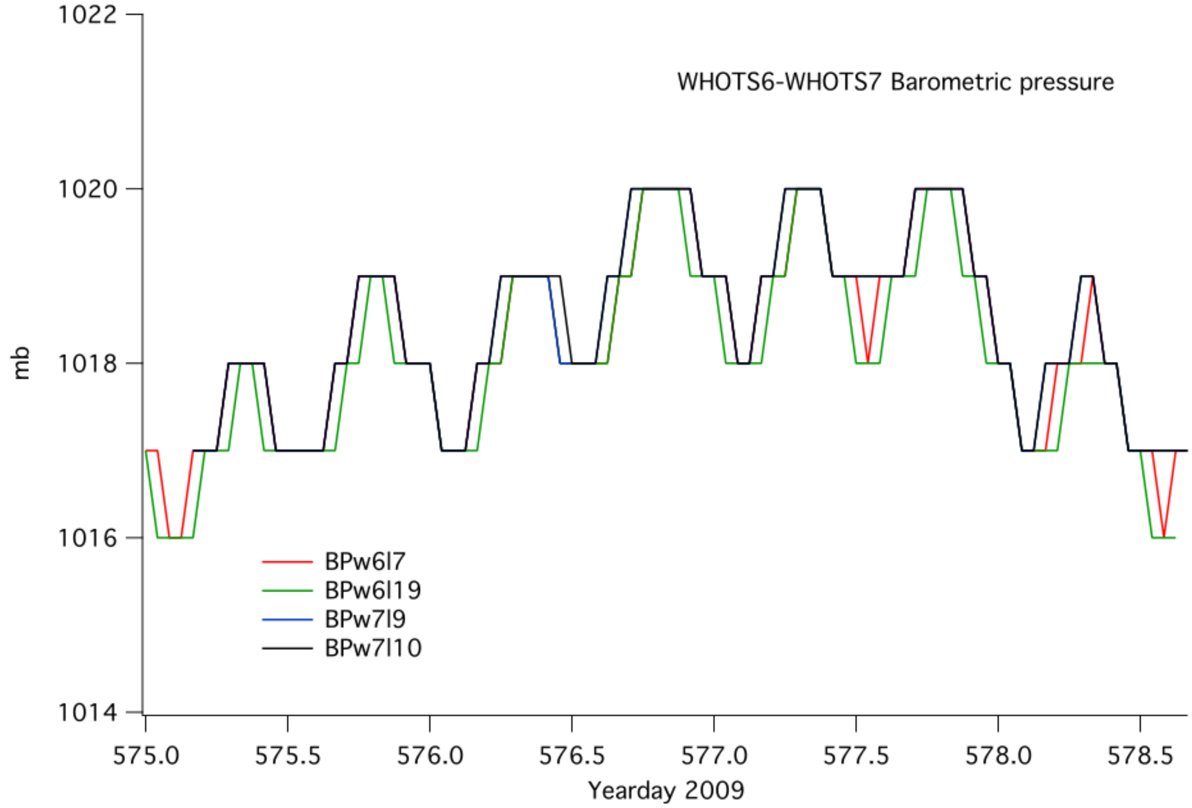
Appendix J: Meteorological Intercomparison Plots



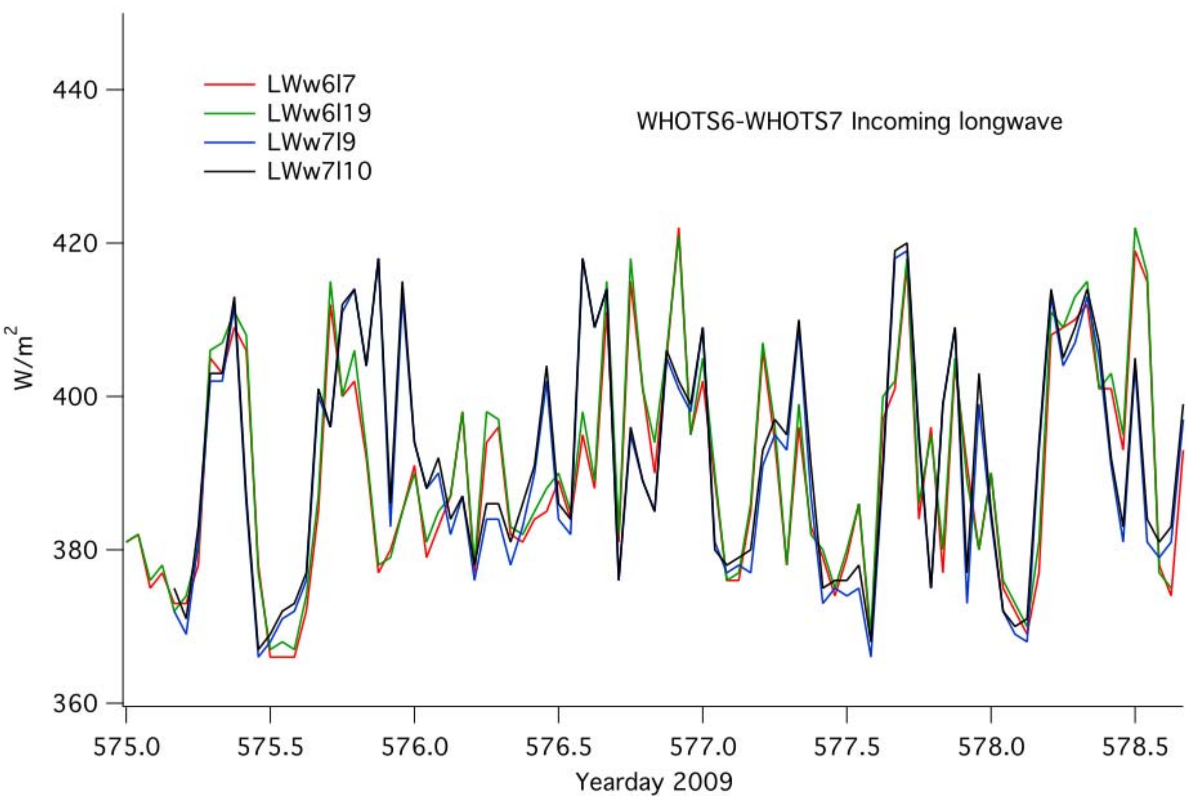



LWw6l7
LWw6l19
LWw7l9
LWw7l10
WHOTS6-WHOTS7 Incoming longwave
W/m^2
440
420
400
380
360
575.0
575.5
576.0
576.5
577.0
577.5
578.0
578.5
Yearday 2009

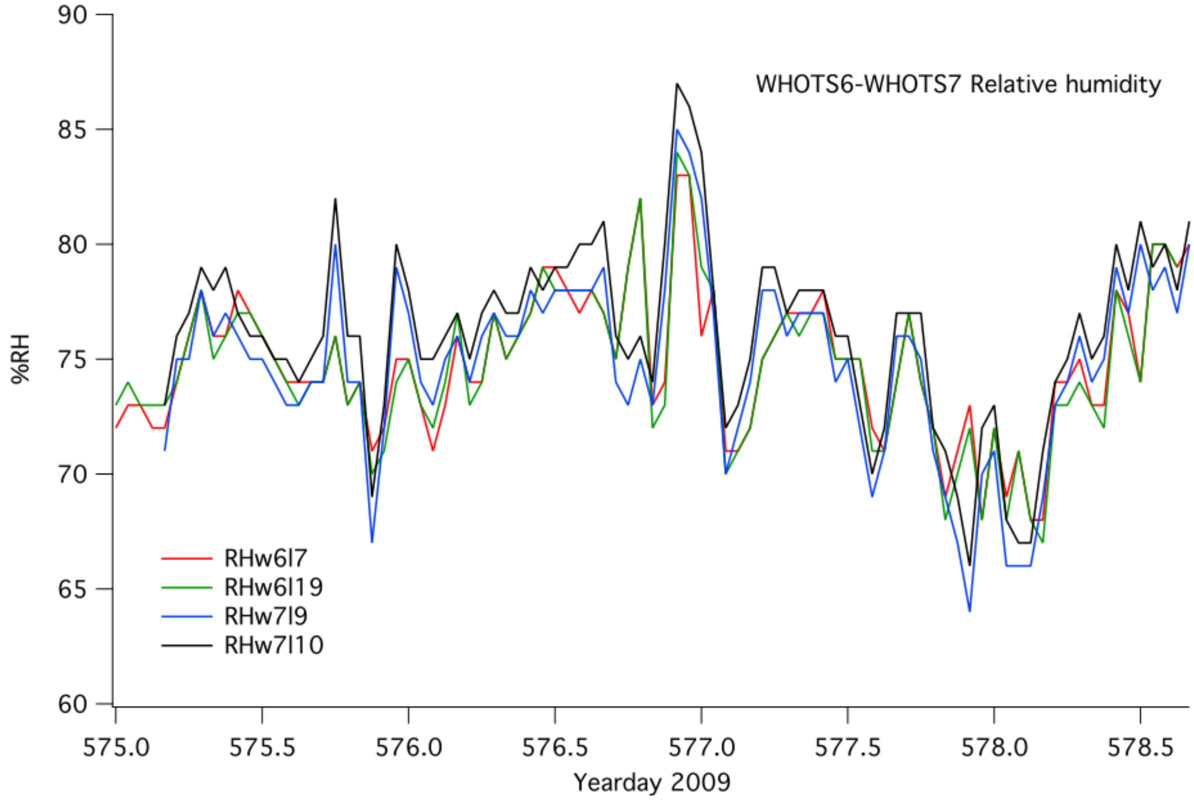

SSTw6l7
SSTw6l19
SSTw7l9
SSTw7l10
WHOTS6-WHOTS7 SST
deg C
26.2
26.0
25.8
25.6
25.4
575.0
575.5
576.0
576.5
577.0
577.5
578.0
578.5
Yearday 2009

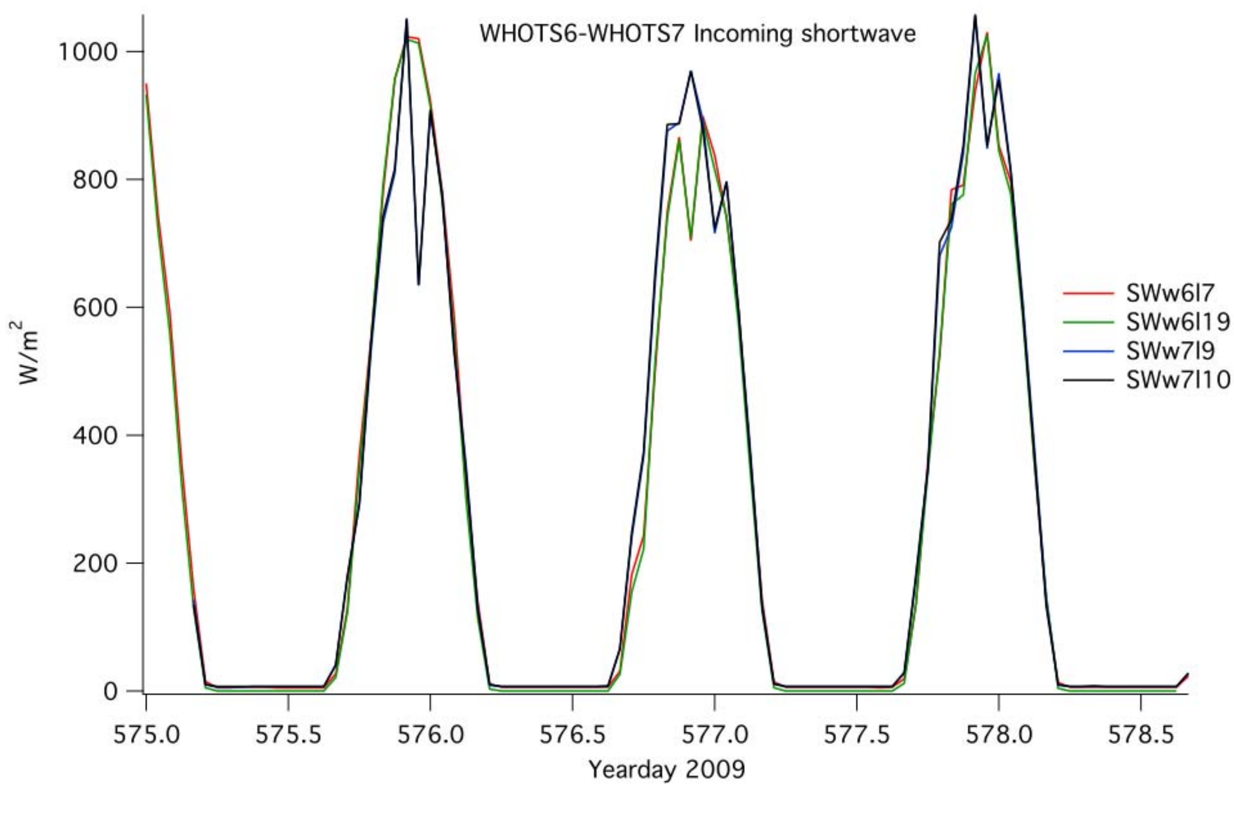


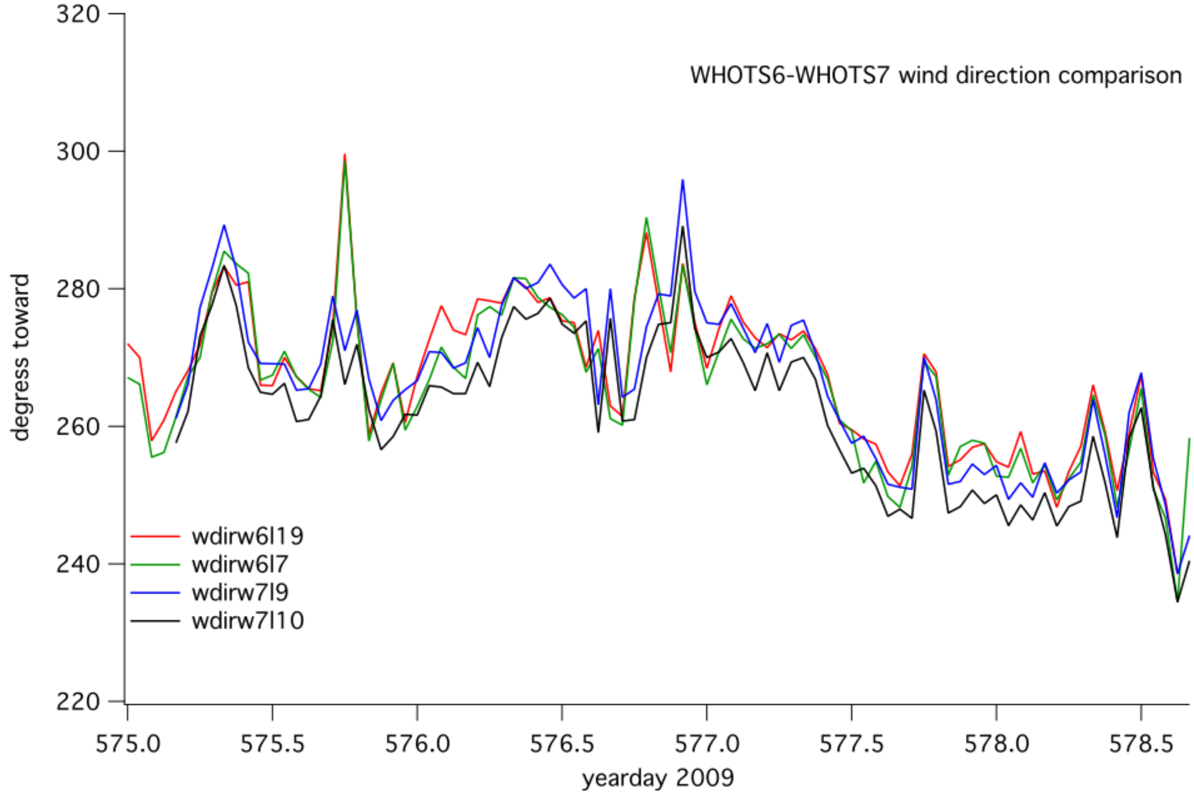
WHOTS6-WHOTS7 Barometric pressure
mb
1022
1020
1018
1016
1014
BPw6l7
BPw6l19
BPw7l9
BPw7l10
575.0
575.5
576.0
576.5
577.0
577.5
578.0
578.5
Yearday 2009

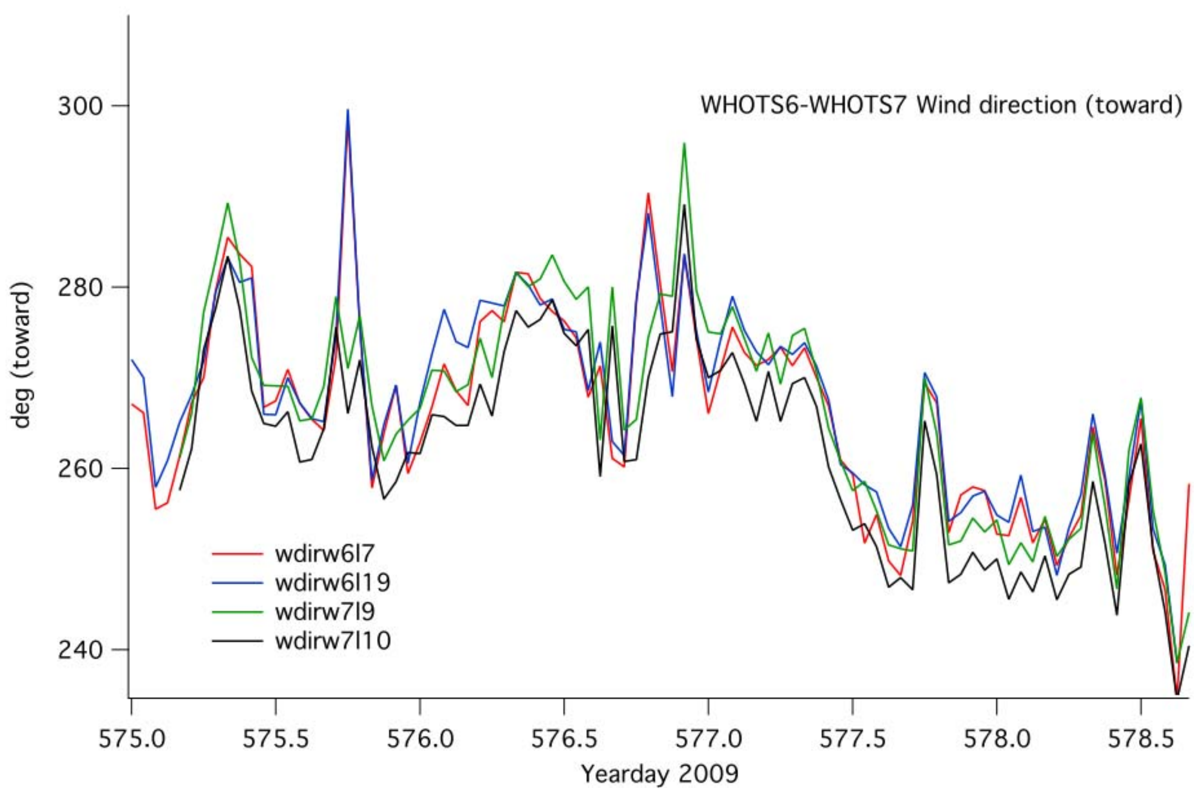


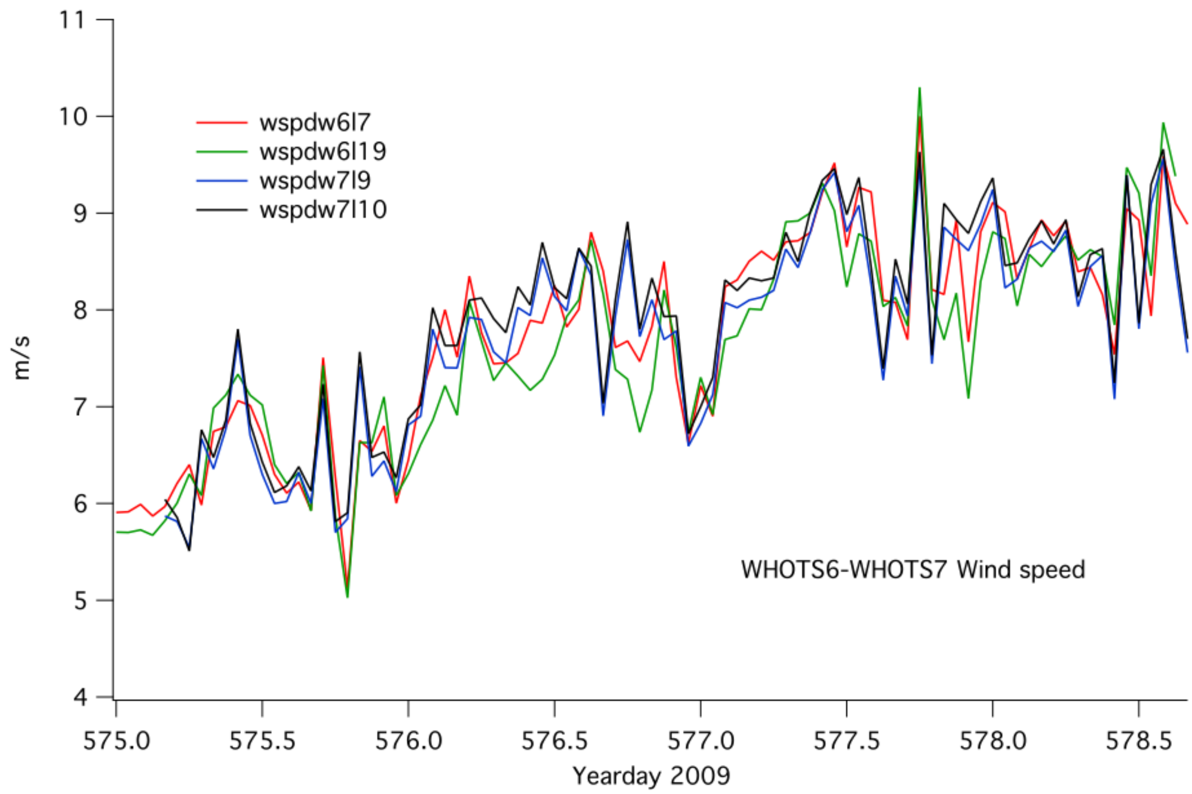
WHOTS6-WHOTS7 Incoming longwave
W/m2
440
420
400
380
360
LWw6l7
LWw6l19
LWw7l9
LWw7l10
575.0
575.5
576.0
576.5
577.0
577.5
578.0
578.5
Yearday 2009


WHOTS6-WHOTS7 Relative humidity
%RH
RHw6l7
RHw6l19
RHw7l9
RHw7l10
Yearday 2009


WHOTS6-WHOTS7 Incoming shortwave
W/m^2
SWw6l7
SWw6l19
SWw7l9
SWw7l10
Yearday 2009


WHOTS6-WHOTS7 wind direction comparison
degress toward
yearday 2009
wdirw6l19
wdirw6l7
wdirw7l9
wdirw7l10
320
300
280
260
240
220
575.0
575.5
576.0
576.5
577.0
577.5
578.0
578.5


WHOTS6-WHOTS7 Wind direction (toward)
deg (toward)
Yearday 2009
wdirw6l7
wdirw6l19
wdirw7l9
wdirw7l10
300
280
260
240
575.0
575.5
576.0
576.5
577.0
577.5
578.0
578.5


11
10
9
8
7
6
5
4
m/s
wspdw6l7
wspdw6l19
wspdw7l9
wspdw7l10
WHOTS6-WHOTS7 Wind speed
575.0
575.5
576.0
576.5
577.0
577.5
578.0
578.5
Yearday 2009