WHOI-2020-05

Woods Hole Oceanographic Institution

The Northwest Tropical Atlantic Station (NTAS):

NTAS-18 Mooring Turnaround Cruise Report
Cruise On Board RV Ronald H. Brown
January 6 –26, 2020
Bridgetown, Barbados – Bridgetown, Barbados

by

Sebastien Bigorre[1], Benjamin Pietro[1], Emerson Hasbrouck[1]

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

May 2020

Technical Report

Funding was provided by the National Oceanic and Atmospheric Administration
under Grant No. NA14OAR4320158.

Upper Ocean Processes Group
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543
UOP Technical Report 2020-05

[1] Woods Hole Oceanographic Institution, Woods Hole, MA

WHOI-2020-05

The Northwest Tropical Atlantic Station (NTAS):

NTAS-18 Mooring Turnaround Cruise Report
Cruise On Board RV Ronald H. Brown
January 6 - 26, 2020 Bridgetown, Barbados - Bridgetown, Barbados

by

Sebastien Bigorre, Benjamin Pietro, Emerson Hasbrouck

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

May 2020

Technical Report

Funding was provided by the National Oceanic and Atmospheric Administration under Grant No. NA14OAR4320158.

Approved for Distribution:

Amy S Bower

Amy Bower, Chair

Department of Physical Oceanography

Abstract

The Northwest Tropical Atlantic Station (NTAS) was established to address the need for accurate air-sea flux estimates and upper ocean measurements in a region with strong sea surface temperature anomalies and the likelihood of significant local air–sea interaction on interannual to decadal timescales. The approach is to maintain a surface mooring outfitted for meteorological and oceanographic measurements at a site near 15°N, 51°W by successive mooring turnarounds. These observations are used to investigate air–sea interaction processes related to climate variability. The NTAS Ocean Reference Station (ORS NTAS) is supported by the National Oceanic and Atmospheric Administration's (NOAA) Global Ocean Monitoring and Observing (GOMO) Program (formerly Ocean Observing and Monitoring Division).

This report documents recovery of the NTAS-17 mooring and deployment of the NTAS-18 mooring at the same site. Both moorings used Surlyn foam buoys as the surface element. These buoys were outfitted with two Air–Sea Interaction Meteorology (ASIMET) systems. Each system measures, records, and transmits via satellite the surface meteorological variables necessary to compute air–sea fluxes of heat, moisture and momentum. The upper 160 m of the mooring line were outfitted with oceanographic sensors for the measurement of temperature, salinity and velocity.

The mooring turnaround was done by the Upper Ocean Processes Group of the Woods Hole Oceanographic Institution (WHOI), onboard R/V *Ron Brown*, Cruise RB-20-01. The cruise took place between January 6 and 26 2020. The NTAS-18 mooring was deployed on January 10, and the NTAS-17 mooring was recovered on January 15. Inter-comparison between ship and buoys were performed on this cruise. This report describes these operations, as well as other work done on the cruise and some of the pre-cruise buoy preparations.

Other operations during RB-20-01 consisted in the acoustic communications with the Meridional Overturning Variability Experiment (MOVE) subsurface mooring array MOVE 1-13 and acoustic downloads of data from Pressure Inverted Echo Sounders (PIES) was also conducted at MOVE 1. MOVE is designed to monitor the integrated deep meridional flow in the tropical North Atlantic. Two ARGO floats were also deployed on behalf of the WHOI ARGO group. During the cruise, atmospheric measurements of aerosols, as well as radar, Lidar, radiosondes were made as part of the ATOMIC campaign.

Table of Contents

List of Tables

List of Figures

I. INTRODUCTION

I. A. Timeline

The NTAS 18 cruise departed from Bridgetown, Barbados on Monday January 6, 2020 and returned to Bridgetown on January 26, 2020. The cruise plan was to incorporate NTAS and MOVE operations early in the cruise and then focus on ATOMIC objectives. Two wave gliders were deployed during transit to the NTAS site. The NTAS 18 mooring was deployed on January 10, MOVE 1 operations were conducted on January 11, an oceanic front was surveyed on January 13 followed by deployment of drifting SWIFT buoys. Intercomparison at NTAS 17 was done on January 15 and the NTAS 17 mooring was recovered on January 16. During the cruise, the ship remained bow into the wind as much as needed in order to collect aerosol data for the ATOMIC program. On January 18, the ship sailed downwind from the easterly trade winds and away from NTAS region. SWIFT buoys were recovered on January 22. Ship held station on January 23 for a fly-over of the NOAA PC-3 aircraft, then resumed sailing towards Barbados. On January 25 the ship help station 20 nm offshore Barbados for comparison with radar measurements from the Barbados Cloud Observatory (BCO). The ship docked in Bridgetown on Sunday January 26 at 10:00 local, and offloading of NTAS equipment proceeded.

A detailed chronology of the cruise is provided below. Local time on the ship during RB-20-01 cruise remained EST (UTC-4).

January 1, *Wednesday*: WHOI personnel arrive in Bridgetown, Barbados.

January 2, *Thursday*: checking in with security at entrance to commercial port. Meet with agent to finalize staging area. Containers delivered at 11 am, custom officer opens seals on containers. Emptying containers, start buoy assembly (halo to tower mid-section, then tower to buoy well), cables connections and testing of data collection system. 17:30: fill and drain precipitation sensors. During the day we learn that ship is at flour mill, outside of commercial port and will not move until cruise departure. So we start planning for transportation of buoy and equipment to the ship by trucks the next day to avoid expensive weekend rates.

January 3, Friday: 08:45 am custom agent re-opens containers. 09:15 two small flat bed trucks arrive to transport equipment and buoy to the ship. 11:00 am ship loading finished, buoy stays on dock near ship so that burn-in and testing can continue. Setting up hydrolab in port aft.

January 4, *Saturday*: 09:00 – 1800, ship goes at sea for sea trial (testing Z-drive, with technician from manufacturer company), Ben and Seb onboard to secure deck and lab. Ray and Emerson stay on dock with buoy, for buoy spin, data download and cable dressing.

January 5, *Sunday*: Onboard at 08:00, most crew is gone. Buoy loaded on board. Data evaluation.

January 6, *Monday*: WHOI team (Bigorre, Pietro, Hasbrouck) onboard at 07:35 am, while Graham returns to Massachusetts. 08:15 welcome onboard meeting in ship library. 11:45 am ship departs. 18:00 ship back at dock in cruise terminal due to problem with Z-drive (one component is installed with 180 degrees offset and requires no motion and divers for readjustment). Science party remains onboard. 19:00 science meeting in library. Clearance for sampling in Barbados waters comes through.

January 7, *Tuesday*: 10:15 am ship departs Barbados. Short sea-trial for final testing of Z-drive. 14:30 sea-trial successful, Z-drive technician leaves on ship's small boat. Second small boat ride for crew mail pick up. Then ship departs and the cruise starts. Wire wound on TSE winch. Subsurface instruments installed on EM wire for testing overnight.

January 8, *Wednesday*: sailing towards NTAS. 08:30 CTD test to 2,000 m with three acoustic releases; bottles on CTD Rosette tested as well. 12:30 fire and abandon ship drills. 18:55 ARGO float 7494 deployed at 22:55 UTC at 13° 55.116' N, 55° 02.996' W. 19:00 science meeting.

January 9, *Thursday*: Transit to NTAS. Wave gliders (Elizabeth Thomson and Jim Thompson, APL) deployed.

January 10, *Friday*: At NTAS 18 deployment site. 07:30 am set and drift test. Deployment starts after breakfast, around 08:00; ship is 7 nm West-Southwest of anchor drop target. 08:40 buoy in the water. 08:58 instrument at 70 m nominal depth deployed. 12:00 start deploying glass balls. 13:45 bathymetry is confirmed satisfactory, so decide to drop anchor. 15:18 – 16:25 anchor survey. Depart to MOVE 1 site for Scripps work (acoustic data downloads).

January 11, *Saturday*: Ranged and downloaded data from PIES 238. No communications with MOVE 1 mooring. CTD to 5,000 m with bottles. Short rain (drizzle) events at 12:44 and 16:26, about 3 minutes long.

January 12, *Sunday*: Transit back to NTAS. 07:30 arrive at NTAS 18, ship stays bow into the wind ¼ nm from buoy, on starboard forward beam. 10:15 CTD#3 to 250 m. 15:00 CTD#4 to 250 m. 20:00 CTD#5 to 250 m.

January 13, *Monday*: 07:00 leave NTAS 18, drive by for pictures. 08:00 arrive at NTAS 17, ship hove to near buoy, CTD #6 to 250 m. 10:00 ship departs to North-Northwest to survey oceanic front. 16:00 end of front survey. 18:00 CTD#7 to 250 m at end of front survey. Deployment of 6 SWIFT buoys (Elizabeth Thomson and Jim Thompson, APL) starts. Test RBR underway CTD (APL) with hand deployment.

January 14, *Tuesday*: 06:00 end of SWIFT deployments. 08:00 science meeting. Decision to return to second SWIFT buoy deployed for recovery and repair of failed 3D sonic sensor. Also planning for ship to stay next to buoy for comparison of air-sea fluxes between ship and buoys and to sample different wave conditions.

January 15, *Wednesday*: 05:55 arrive at NTAS 17 buoy, ship hove to near buoy. 08:00 CTD#8 to 250 m. 12:00 CTD#9 to 250 m. 13:00 all hands meeting in galley for Lithium battery fire, followed by fire and abandon ship drills. 13:50 anchor survey at NTAS 17 to confirm location (possibility of anchor drag from a storm); anchor location confirmed to be same as after deployment. 16:30 ship 3.5 nm East-Southeast of NTAS 17 buoy for CTD#10 to bottom (CTD at bottom at 18:00, back on deck at 19:45), with 4 bottles fired near bottom. Ship drives back to buoy in reverse to keep wind on the bow for aerosols sampling.

January 16, *Thursday*: NTAS 17 recovery.

January 17, *Friday*: Ship on station 6.5 North-Northwest of NTAS 18 for aerosols sampling.

January 18, *Saturday*: 06:45 balloon launch. 07:00 UCTD on station. Then ship departs from NTAS area, sailing West-Southwest towards drifting SWIFT buoys. 08:00 science meeting. 13:01 UTC float 7502 launched at 14 49' N, 051 16.3' W (a UCTD cast to 70 m depth was done just prior to float launch). 15:00 ship moves tracks a few miles to the north to avoid previous track and optimize Multibeam coverage for Seabed 2030 program. UCTD launches every hour during the day. 20:00 arrive at new site for ATOMIC aerosol sampling, UCTDs every 2 hours. Very good weather all day, clear sky, wind 10 kts.

January 19, *Sunday*: Ship keeping station at 14° 21.8'N, 53° 01.6' W, bow into the wind, for aerosol sampling. UCTDs continue to monitor ocean mixed layer variations. Rain events in early morning at 04:00 and 06:00, very good weather during the day, wind 10 kts.

January 20, *Monday*: Ship remains on station, continues to sample aerosols. UCTDs every 6 hours (problems with winch: line wraps on winch drum due to slack –partially remediated by adding weight to RBR CTD probe; line tends to wraps on one side of drum which makes line counter inaccurate since it counts drum revolutions, which leads to probe stopping to close too davit at recovery; digital display on winch not functional anymore). 18:00 UCTD on station immediately followed by CTD#13 to 150 m for comparison. Large swell from the north, smaller and shorter swell from the east.

January 21, *Tuesday*: Ship remains on station, aerosols sampling and UCTDs continue. Clear sky, clouds on horizon are deeper than what we saw in previous days. Cloud tops appear to have more shear. Wind increase to 23 kts around 07:00 and sea state picks up. 12:00 UCTD followed by CTD#14 to 150 m. Wind and sea state abate in the afternoon.

January 22, *Wednesday*: 03:30 ship leaves station, sails to the Northeast. 07:30 to 16:00 recoveries of SWIFT buoys; UCTD cast at each recovery site. Wind 12 kts from 063° True.

January 23, *Thursday*: 06:30 ship arrives at new station 14° 23' N, 55° 00.00' W for aerosol sampling. 07:00 wind 13 kts from 77° True. 14:25 balloon launch in very clear sky. 18:00 leave station, start transit to Barbados Cloud Observatory.

January 24, *Friday*: Transit to BCO. wind 13 kts, wind from 123° True.

January 25, *Saturday*: On station 20 nm from BCO. 07:48 wind 10 kts from 070° True. Clear sky, long and tall clouds on horizon with anvil shape.

January 26, *Sunday*: 10:00 ship docks at flour mill in Bridgetown, Barbados. Offload NTAS equipment, trucked back to containers inside commercial port.

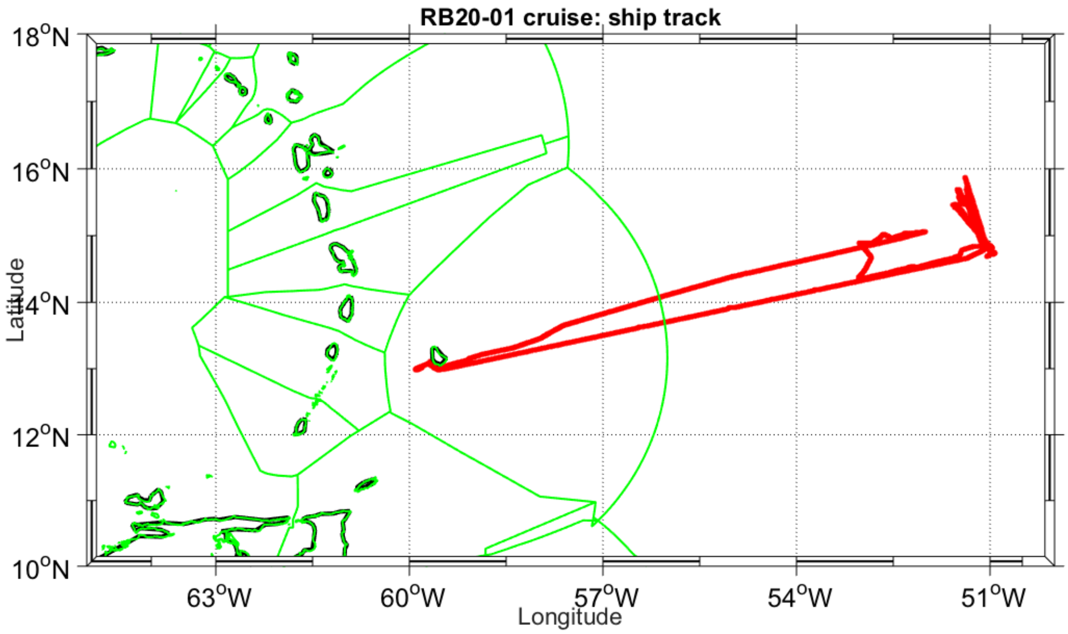


Figure I-1. NTAS 18 cruise track (red) onboard R/V *Ron Brown* (cruise RB20-01). Countries EEZs (green).

I. B. Background and Purpose

The Northwest Tropical Atlantic Station (NTAS) project for air–sea flux measurement was conceived in order to investigate surface forcing and oceanographic response in a region of the tropical Atlantic with strong sea surface temperature (SST) anomalies and the likelihood of significant local air–sea interaction on inter-annual to decadal timescales. Two intrinsic modes of variability have been identified in the ocean–atmosphere system of the tropical Atlantic, a dynamic mode similar to the Pacific El Niño–Southern Oscillation (ENSO) and a thermodynamic mode characterized by changes in the cross-equatorial SST gradient. Forcing is presumed to be due to at least three factors: synoptic atmospheric variability, remote forcing from Pacific ENSO, and extra-tropical forcing from the North Atlantic Oscillation (NAO). Links among tropical SST variability, the NAO, and the meridional overturning circulation, as well as links between the two tropical modes, have been proposed. At present neither the forcing mechanisms nor links between modes of variability are well understood.

The primary scientific objectives of the NTAS project are to determine the in-situ fluxes of heat, moisture and momentum, to use these fluxes to make a regional assessment of flux components from numerical weather prediction models and satellites, and to determine the degree to which the oceanic budgets of heat and momentum are locally balanced. 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 15° N, 51° W by means of annual "turnarounds" (recovery of one mooring and deployment of a new mooring near the same site).

The surface elements of the moorings are Surlyn foam discus buoys outfitted with two complete Air–Sea Interaction Meteorology (ASIMET) systems. Each system measures, records, and transmits via satellite the surface meteorological variables necessary to compute air–sea fluxes of heat, moisture and momentum. The upper 160 m of the mooring line is outfitted with oceanographic sensors for the measurement of temperature, salinity and velocity. The upper 80 m also contain inductive instruments that transmit their data to a logger inside the surface buoy; this data is then telemetered to a satellite.

The NTAS 18 mooring turnaround was achieved on the research vessel R/V *Ron Brown*, cruise RB 20-01, by the Upper Ocean Processes Group (UOP) of the Woods Hole Oceanographic Institution (WHOI). This cruise primarily served the ATOMIC US research program, which focused on atmospheric and cloud research. Note that the NTAs 18 cruise had initially been planned to occur in the summer 2019 but was cancelled due to engine failures that needed repairs.

The cruise was completed in 21 days, during January 6-26 2020. It originated from and returned to Bridgetown, Barbados. The cruise track is shown in Figure I-1. The NTAS primary objectives were:

- To deploy the NTAS-18 mooring.
- To log data from the NTAS-18 buoy and *R/V Ron Brown* shipboard meteorological sensors during an inter-comparison period during which a sequence of CTD casts would also be made.
- To recover the NTAS-17 mooring.
- To do an inter-comparison between the NTAS-17 buoy and *R/V Ron Brown* shipboard data (meteorological sensors and CTD cast).

The NTAS team also deployed two floats on behalf of the WHOI ARGO group.

II. Cruise Preparations

II. A. Staging and Loading

Pre-cruise operations were conducted at WHOI and in port in Bridgetown, Barbados. Instrumentation (sensor, telemetry) were tested at WHOI during burn-in then shipped to Barbados. Four WHOI personnel (Bigorre, Pietro, Hasbrouck, Graham) travelled to Barbados on January 1 2020. The WHOI team unloaded and staged the equipment in the commercial port, about 200 yards away from the cruise ships terminal. The team began assembly of the buoy (hardware, electronics) and turned on the data collection system ASIMET on January 2. R/V *Ron Brown* was moored outside of the commercial port, at the flour mill. Transportation and customs paperwork were arranged with the agent from Massey company hired by WHOI, so that WHOI's equipment and buoy were transported out of the port and to the ship on January 3. All WHOI's equipment was loaded on board that same day, except for the buoy. The ship left the dock for a sea trial of its Z-drives on January 4. That day, two WHOI personnel stayed on land to finalize buoy preparation (buoy spin, data download and cables dressing) while two others went onboard to secure equipment on the deck and in the laboratory. Ship departed Bridgetown on Monday January 6.

II. B. Buoy Spin

The NTAS 18 buoy spin was conducted during burn-in in Woods Hole and again in port prior to son January 2 2020. The buoy spin is a procedure to check the compasses in the wind sensors mounted on the buoy. A visual reference direction is first set using an external compass. The buoy is then oriented successively at 8 different angles with respect to the reference and the vanes of the anemometers are visually oriented towards the reference direction, and blocked. Wind is recorded for 15 minutes at the end of which the average compass and wind direction is read. Their sum should correspond to the reference heading, within errors due to approximations in orientation, compass precision, and any deformation of the magnetic field due to the buoy metallic structure that may affect the compass reading. Buoy spin results from January 4 are shown in Figure II-1 and Figure II-2, where compass error is plotted as a function of buoy orientation. Note that for this second buoy spin, only 6 rotations, instead of the usual 8, were done with the buoy. Compasses on ASIMET wind sensors are slightly outside of the 5° expected accuracy. For this buoy spin, the reference direction was oriented towards 0°.

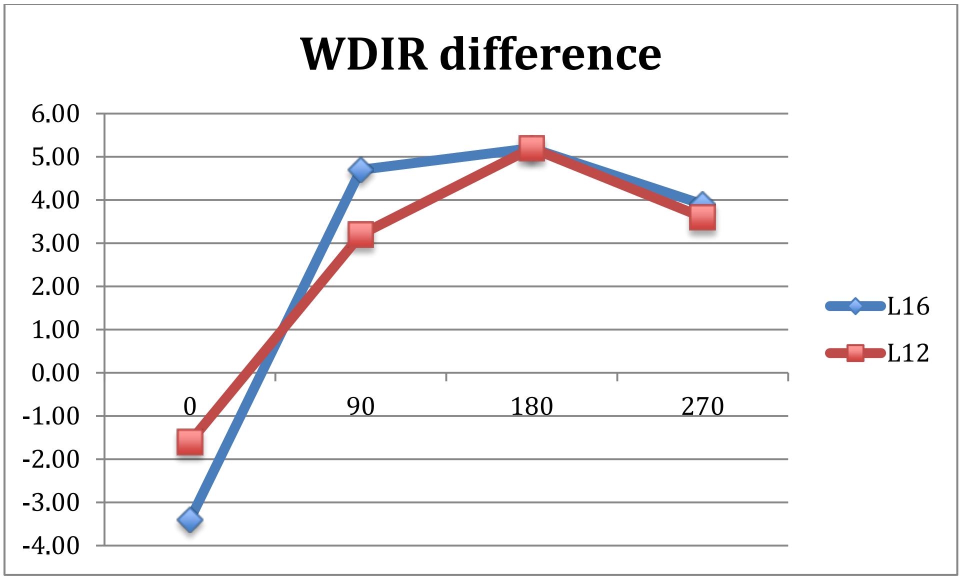


Figure II-1. NTAS 18 buoy spin on January 4 2020 in the port of Bridgetown, Barbados. Y-axis: difference between wind direction (WND225 on L16 and WND344 on L12) and line-of-sight reference (in degrees). X-axis: angle between buoy and line-of-sight reference (in degrees).

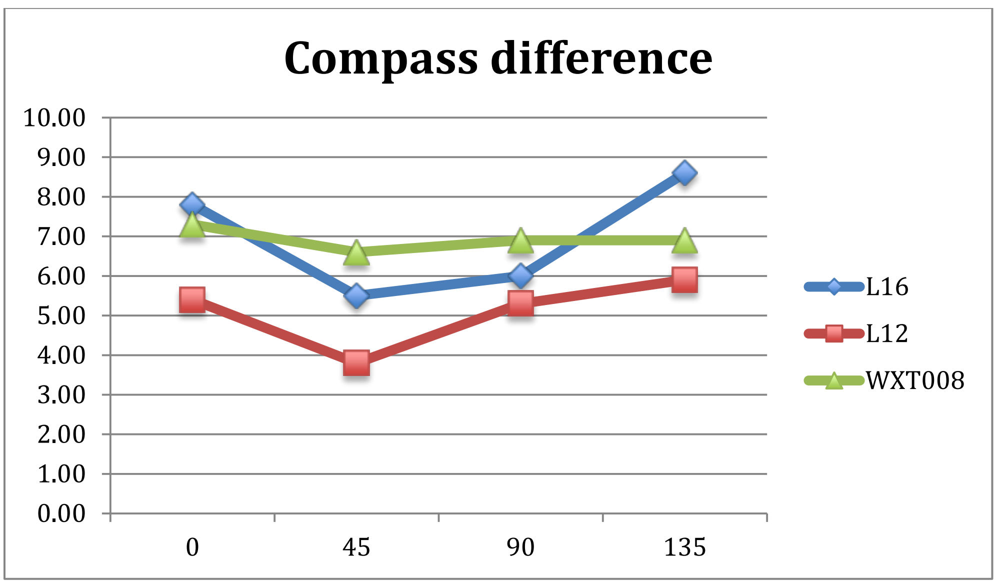


Figure II-2. NTAS 18 buoy spin on January 4 2020 in the port of Bridgetown, Barbados. Y-axis: difference between wind compass (WND225 on L16 and WND344 on L12 and standalone WXT008) and reference compass (in degrees). X-axis: angle between buoy and line-of-sight reference (in degrees).

II.C. Sensor Evaluation and Burn-in

The NTAS meteorological instrumentation consists of two Air-Sea Interaction Meteorology (ASIMET) primary systems, which are connected to loggers and battery packs in the buoy well, and standalone instrumentation, which are not connected to loggers and have independent batteries. For burn-in, the buoy was mounted with ASIMET and standalone sensors in the same configuration as the one planned for deployment, and placed in a clear outdoor area at WHOI. Systems were running, collecting data and telemetry transmitted hourly data. Spare instruments were also mounted on a similar buoy next to NTAS 18. Every two week or so, the data was downloaded and processed to ensure all instruments were functioning properly and that their measurements were accurate. Burn-in occurred in early spring 2019, before the initial cruise planned for June 2019 was cancelled. A quick functional test was reinstated at WHOI in the winter of 2019, and a short burn-in was done in port in Bridgetown and again onboard *R/V Ron Brown* during the three-day transit between Barbados and the NTAS site.

III. NTAS 18 Deployment

A. Mooring Design

The buoys used in the NTAS project are equipped with surface meteorological instrumentation, including two ASIMET systems (see Figure III-1) and standalone sensors (Vaisala WXT, SBE39 temperature, Lascar RH/ATMP). The ASIMET sensors include air temperature and humidity (ATMP/HRH), barometric pressure (BPR), wind speed and direction (WSPD and WDIR), precipitation (PRC), longwave (LWR) and shortwave (SWR) radiations, and seas surface temperature (SST) and salinity (SSS). On NTAS 18, an additional data collection system was also implemented which included some of the same measurements (precipitation, air humidity and temperature, barometric pressure, longwave and shortwave radiations, and a GPS) that were recorded to a Campbell data logger. NTAS 18 also included two wave measurement systems, a WAMDAS system provided by NDBC, which recorded data internally, and a Brizo system from the XEOS company which recorded internally and telemetered data as well. Positions of the buoy were recorded by several two Rover and one Melo sensors from XEOS. The NTAS 18 surface buoy has a 2.7-meter diameter foam buoy with an aluminum tower and rigid bridle. Starting with NTAS 13, buoys on NTAS received a larger wind vane to improve the alignment into the wind. On NTAS 13, NTAS 15 and subsequent deployment (including NTAS 18), the original metal wind vane (used up to NTAS 12) received a Delrin extension. This made for a lightweight addition and easier maneuverability of the buoy on deck. The wind vane on NTAS 14 was made of a single metal piece and larger than the original wind vanes.

The WHOI mooring is an inverse catenary design utilizing wire rope, chain, nylon and Colmega line. The mooring line also carries subsurface instrumentation down to 160 m that measures temperature and conductivity, two acoustic current meters and two profilers, and two deep SBE 37s near the bottom (Figure III-2). Several instruments transmit their data through the upper 80 m of inductive (IM) wire. The upper 5 m of the mooring includes a compliance section (also called EM chain) through which inductive sensors transmit their data to an Iridium logger in the buoy well.

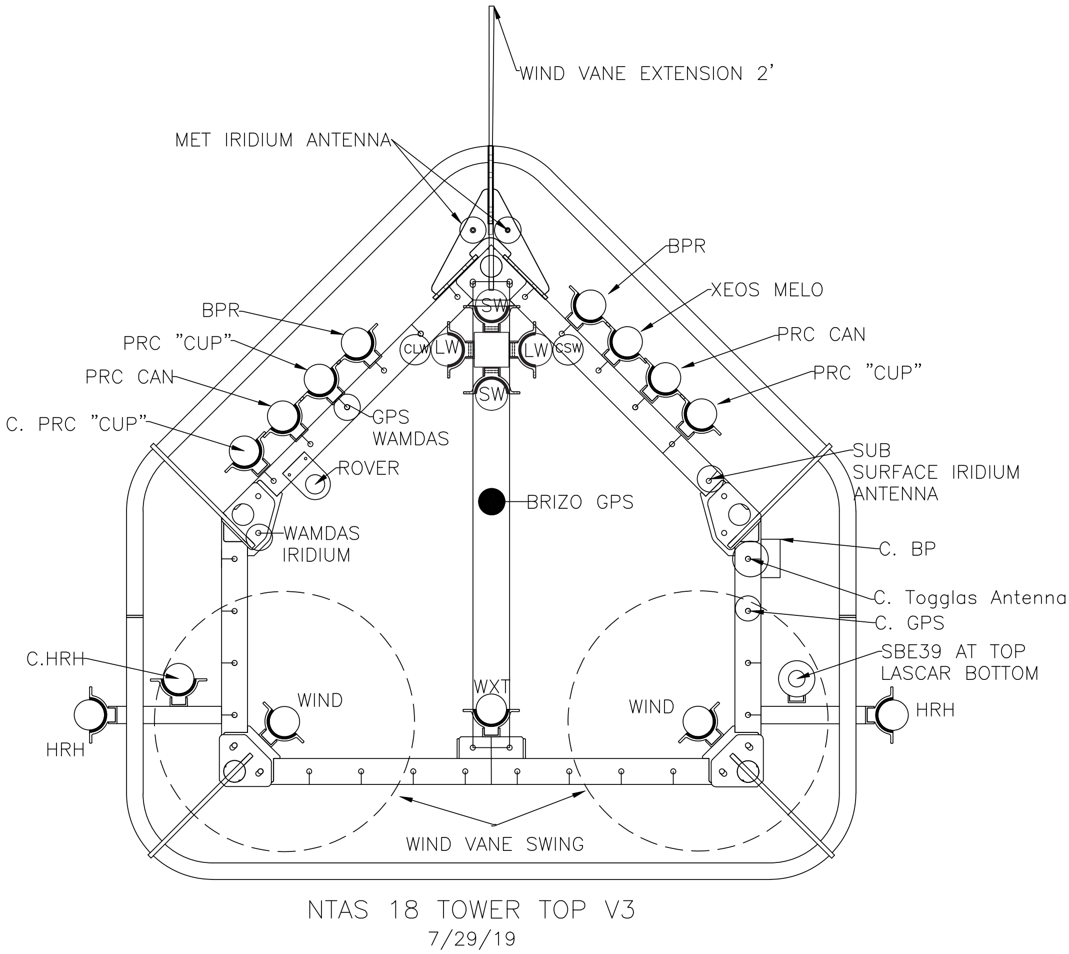


Figure III-1. Top view schematic of the meteorological tower on the NTAS 18 buoy with the location of the ASIMET and other instruments.

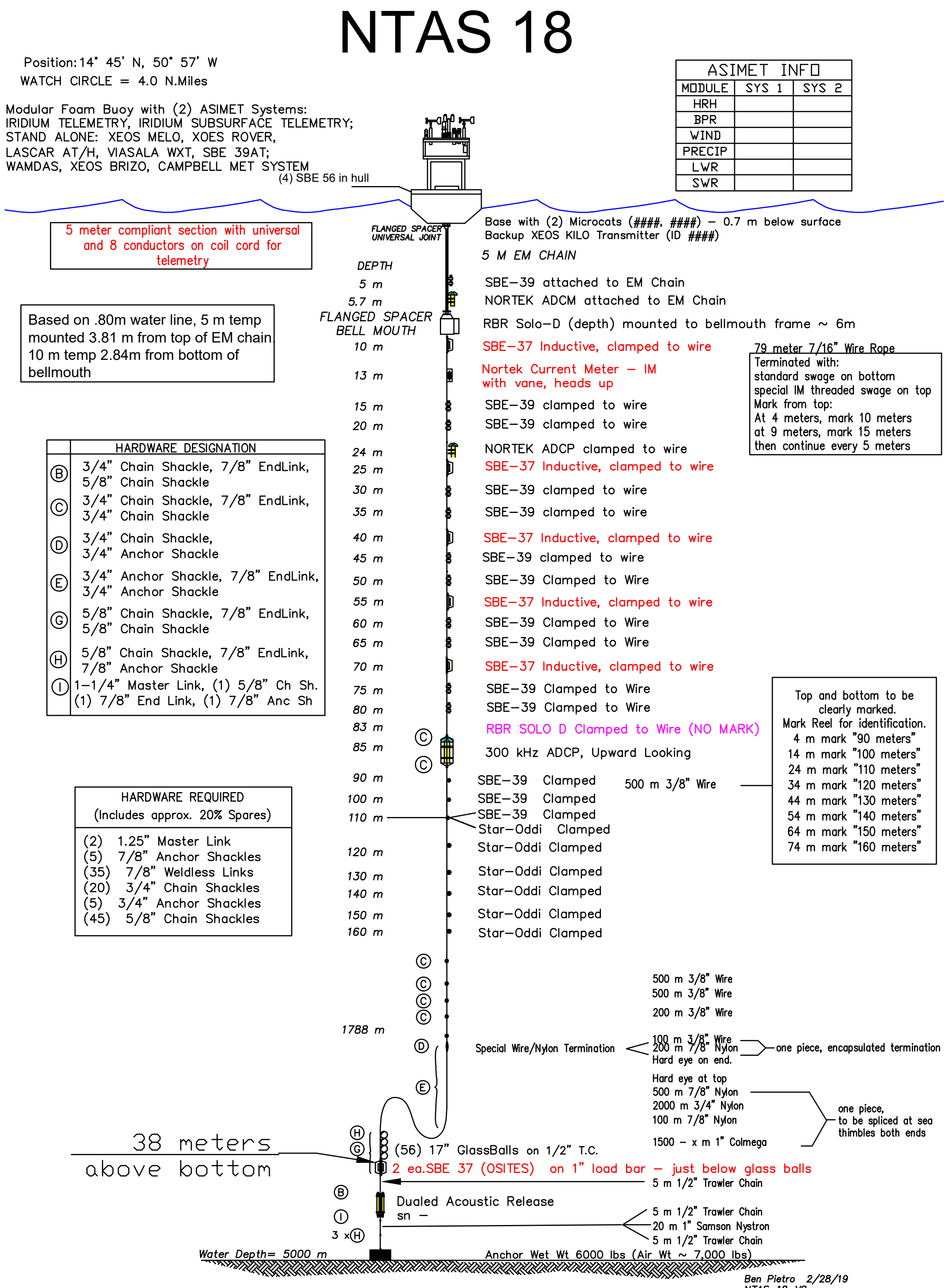


Figure III-2. NTAS 18 mooring diagram.

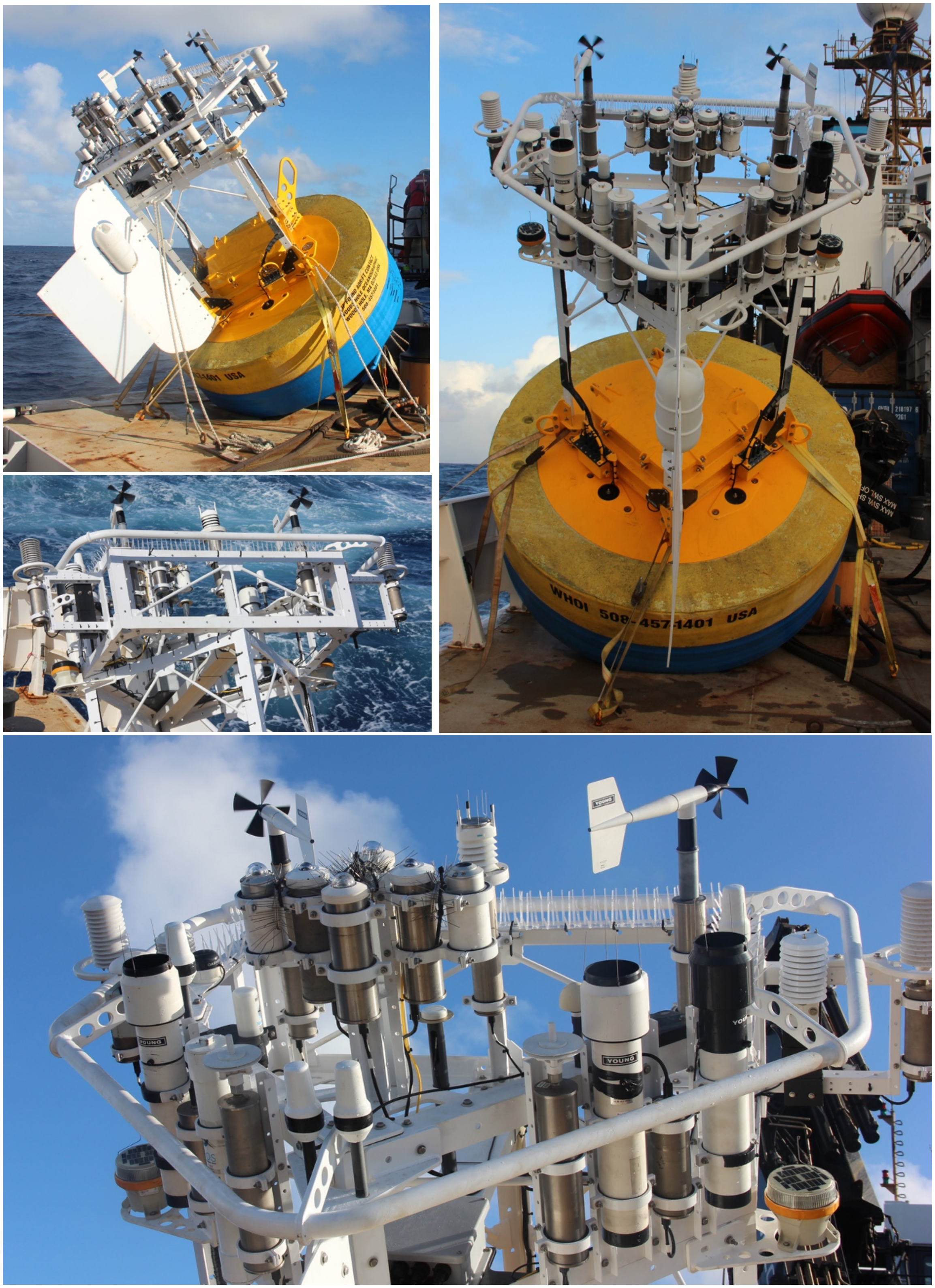


Figure III-3. NTAS 18 buoy and meteorological instrumentation prior to deployment.

Figure III-4. Closeup of ASIMET radiation sensors on NTAS 18 prior to deployment.

B. Deployment

The deployment of NTAS 18 occurred on January 10 2020. At 07:30 that morning, wind was 20 kts coming out of 048° True, while the ship's ADCP indicated a current in the upper ocean of less than 0.5 kt to 271° True. The ship conducted a set and drift test at that time which established that ship drifted at 2 kts out of 062° True. Based on this, the ship would start its deployment track 7 nm from the anchor drop target and use a 062° heading. Deployment operations started after breakfast.

Preparation for deployment included mounting the hardware for the telemetry interface section and the upper mooring wire section. The 79-meter section of mooring wire was led around the A-frame, around the port quarter, and forward to the wire coupling assembly. The universal joint, flanged spacers, compliant section, coupling assembly, and the top of the 79-meter mooring wire were assembled and attached to the buoy. An SBE-39 and Nortek current meter were clamped to the compliant section. All other instruments down to 55 meters were clamped to the mooring wire.

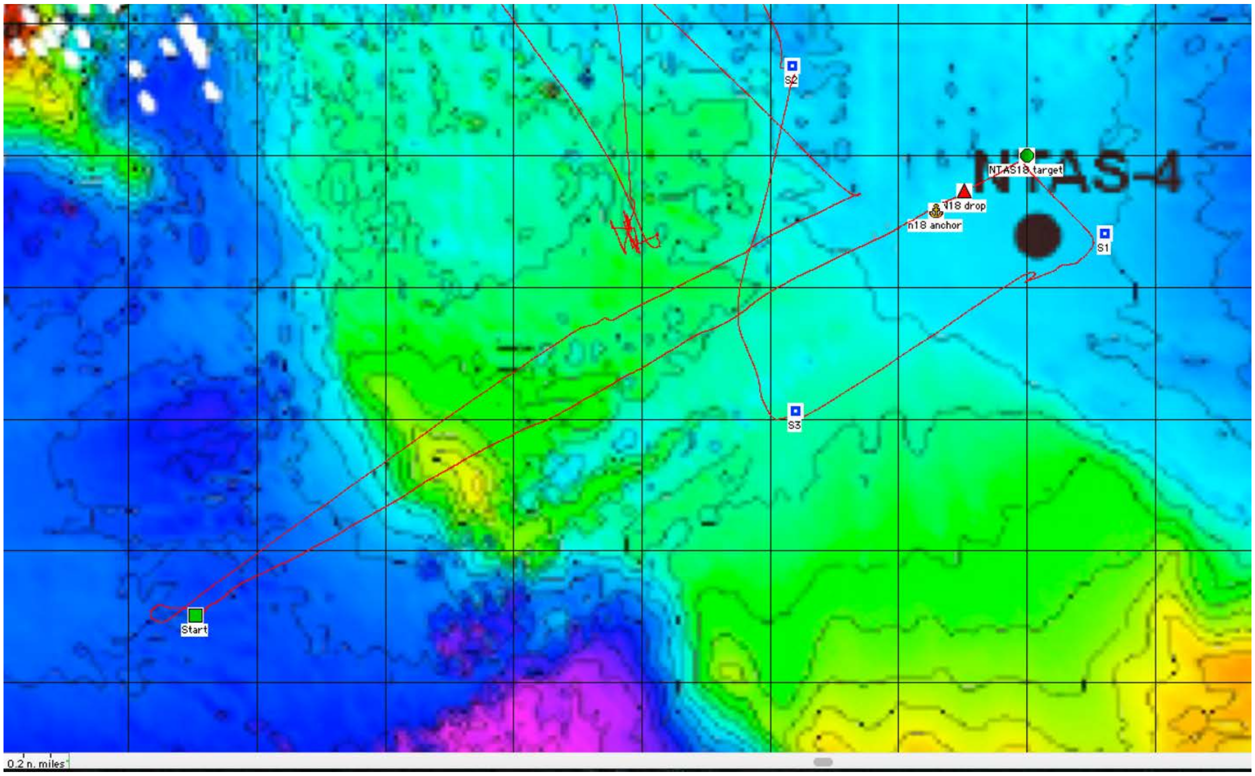


Figure III-5.NTAS 18 deployment track (red line) onboard R/V *Ron Brown* on January 10 2020. Track started (green square) about 7 nm West-Southwest of target (green circle). Anchor drop (red triangle), anchor survey sites (blue squares) and anchor surveyed position (yellow anchor symbol) are also indicated.

Deployment operations began shortly after 08:00 (local) with the ship *R/V Ron Brown* at a distance of 7.0 nm from the drop site. The first step of the deployment procedure was the lowering the assembled telemetry interface section over the port side of the ship. As the compliant section was lowered, using the knuckle crane and a slip line, the mooring wire with instruments clamped to it was fed over the bulwark into the water by wire handlers stationed at the stern and along the port rail. Approximately 50 meters of the mooring wire with instruments attached was lowered in this manner. This formed a loop of wire and instruments hanging from the buoy, and leading back towards the port quarter. The knuckle crane was used to lift the EM chain over the rail. The crane hooked up to the outboard portion of the bottom bell mouth. Nylon line was used to stop off and disconnect the crane. The EM chain was then slipped out.

The next phase of the operation was to launch the surface buoy. Slip lines were rigged on the base, tower, and on the mid-section D handle to maintain control during the lift. The straps lashing the buoy to the deck were removed. The buoy was then raised up and swung outboard as the slip lines kept the hull stable. The bottom slip line was removed first, followed by the tower slip line. Once the buoy settled into the water (approximately 18 ft. from the side of the ship), the quick-release hook was tripped. Local time was then 08:40. The slip line to the buoy deck bale was cleared immediately after the buoy was released. The ship then maneuvered slowly ahead, and the 50-meters of payed out mooring wire and instrumentation provided scope for the buoy to clear the stern.

The remainder of the mooring was deployed over the stern. Once the buoy was behind the ship, ship speed was increased to about 0.25 knots and the remaining portion of the upper top section of instrumented wire rope was slipped off the stern. Once instrument at nominal depth of 70 m was deployed, the ship's speed was increased to 0.5 kts. The bottom of the 79-meter shot of mooring wire was stopped off at the transom and disconnected from the mooring wire on the winch. A snatch block was suspended by the air tugger winch on the A-frame. The mooring wire from the TSE winch drum was passed through this block. The RDI ADCP cage was shackled into the mooring, and the mooring wire from the winch connected to the bottom of the ADCP cage. The mooring tension was pulled up on the winch and the stopper lines were removed from the mooring.

The final section of mooring line on the port winch was the wire to nylon transition. This consists of a 100-meter shot of 3/8" mooring wire and 90 meters of 7/8" Nystron line. The termination is encapsulated in urethane providing a transition from the stiff mooring wire to the flexible nylon line. As the end of the nylon came off the winch, it was payed out slowly until the thimble was 10 feet from the transom at which point it was shackled into a thimble on the 7/8th nylon off the H-bit.

The H-bit cleat was positioned approximately 20 feet from the transom, and secured to the deck. The free end of the 4,100 meter shot of nylon/Colmega line, stowed in three wood-lined wire baskets was wrapped onto the H-bit and passed to the stopped off mooring line. The shackle connection between the two nylon shots was made. The line handler at the H-bit pulled in all the residual slack and held the line tight against the H-bit. The stopper lines were then eased off and removed. The person handling the line on the H-Bit kept the mooring line parallel to the H-bit with moderate back tension. The H-bit line handler and one assistant eased the mooring line out of the wire basket and around the H-bit at the appropriate payout speed relative to the ship's speed. Another person sprayed water on the H-bit to keep the line from overheating.

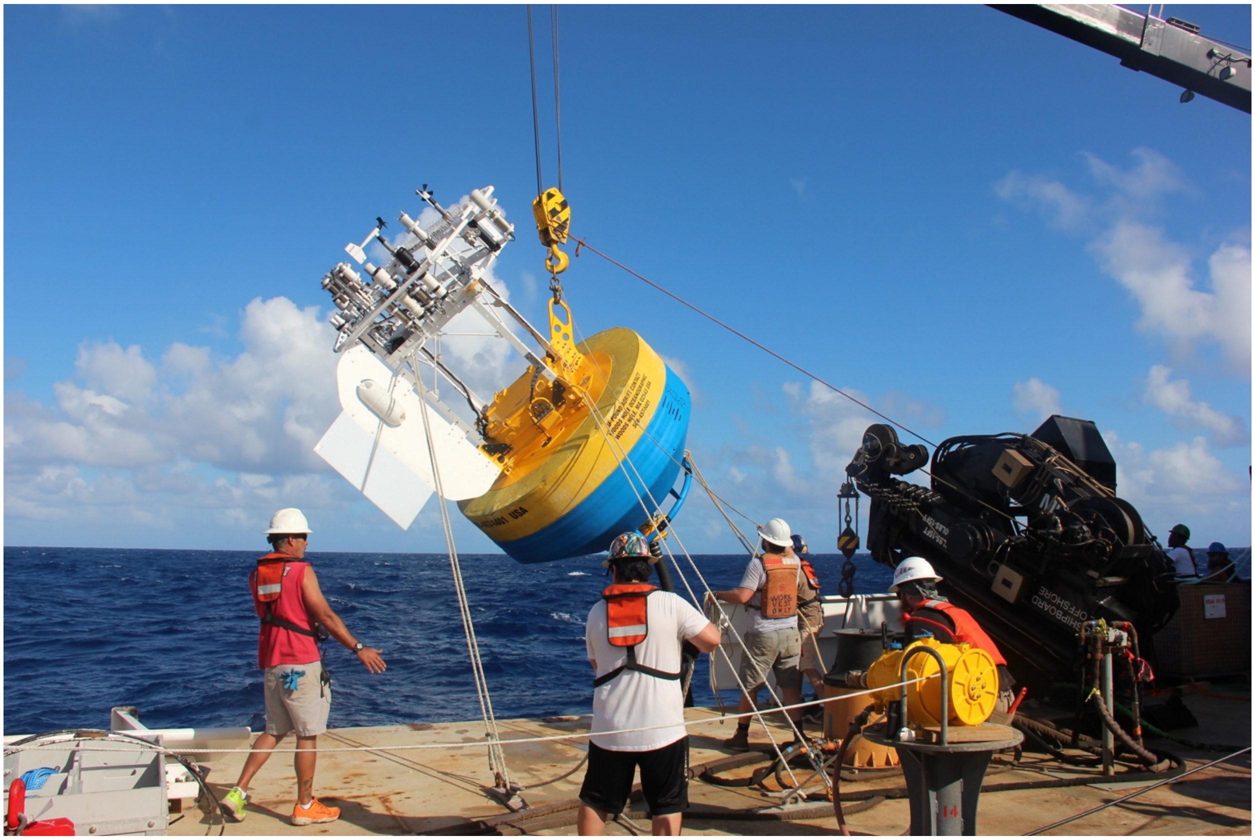


Figure III-6. Deployment of NTAS 17: (top) buoy lifted in the air with crane and tag lines attached to control lateral motion, (bottom) buoy in the water and crane separated from buoy using quick release hook, tag lines loose and slowly removed from buoy.

When the end of the Colmega line was reached, pay out was stopped and a Yale grip was used to take tension off the line. The winch tag leader was shackled to the end of the Colmega line. The line was removed from the H-Bit. The winch line and mooring line were wound up taking the mooring tension away from the stopper lines on the Yale grip. The stopper lines and Yale grip were removed. The winch payed out the mooring line until all but one meter of the Colmega line was over the transom.

The first two sets of glass balls were dragged into position (fore and aft) and shackled together. One end was attached to the mooring at the transom. The other end was shackled to the winch leader. The winch pulled the mooring line tight, stopper lines were removed, and the winch payed out until only one ball remained on the deck. Stopper lines were attached, the winch leader was removed, and two more strings of glass balls were inserted into the mooring line. This process was repeated until all 56 balls were deployed.

A 1" titanium load bar with two SBE 37 C/T loggers was shackled to the last glass ball segment. After that, a five-meter shot of ½" chain was connected to the mooring. The winch took tension on the mooring, stopper lines were removed, and a chain hook connected to the air tugger lifted the SBE 37s off the deck. The winch payed out and the instruments were eased over the transom. The outhaul went slack, and the chain hook was removed. The acoustic releases were shackled to the chain. Another 5-meter chain section was shackled to the releases. A 20-meter Nystron anchor pendant was shackled to that chain, and another 5-meter section of ½" chain was shackled to the anchor pendant. The winch wound up these components until it had the tension of the mooring. The acoustic releases were lying flat on the deck. A chain hook connected to the air tugger line running through the block on the A-frame lifted the acoustic releases off the deck. The winch payed out with the air tugger, and the instruments were eased over the transom.

The anchor, positioned on the starboard side inboard of the A-frame, was rigged with a 5-meter section of 1⁄2" chain. The 5-meter chain section was shackled to the 20 meter Nystron line. An expendable backstay was rigged from the eye of the anchor to a deck eye to secure it. With approximately 1/2 hour still to go until the anchor drop, a screw pin shackle and pear link were connected to the middle of the 5 m 1⁄2" chain from the anchor. A 3⁄4" bull rope was attached to the winch leader using a bowline knot and fed through a 7/8th endless link on the 5m chain and brought back to the winch leader and tied off with another bowline.

With about 10 minutes to the drop site and after checking bathymetry from Multibeam reading, the chain binders holding the anchor in place were removed and the 3/4" bull rope slip line that was tied with bowlines on the winch took the load from the stopper line. The crane was positioned over the forward end of the tip plate and hooked into the tip plate bridle. As the ship approached the launch site, the winch payed out slowly and put the load to the anchor and the backstay. The backstay was cut in the last minute, the crane hook was raised, and the tip plate raised enough to let the anchor slip into the water. The anchor was dropped at 17:45 UTC on 10 January, 2020 at 14° 44.581' N, 050° 56.706' W in (corrected) water depth 5055 m.

The buoy waterline was determined from R/V *Ron Brown* bridge the morning after deployment. Visual observations showed the tower top instrumentation intact and the buoy riding smoothly with a nominal waterline about 75 cm below the buoy deck. The wind vane appeared to be functioning as intended, with an orientation approximately parallel to the wind direction.

C. Anchor Survey

NTAS 18 anchor was dropped at 14° 44.728' N, 50° 56.488' W (measured on fantail using handheld GPS) on January 10 2020 at 17:45 UTC. The acoustic survey of the anchor position was carried out the same day. The three triangulating positions were occupied in a triangular pattern (see Figure III-5 and Table III-1) around the drop site. WHOI's Edgetech 8011M deck gear was used with the portable transducer lowered (about 5 m below the waterline) over the starboard side by the CTD launch in order to range on one of the mooring releases. The releases are about 38 meters above the anchor, which rests on the seafloor. The ship's Multibeam measured the water depth as 5018 m in the area of the anchor drop. Correcting for local speed of sound (1511 m s-1), the water depth is 5055 m. Triangulation using the horizontal range to the release from the three sites, gave an anchor position of 14 ° 44.581' N, 50 ° 56.706' W (in decimal convention 14.7430° N, 50.9451 ° W). Fallback from the drop site was 482 m or 9.5% of the water depth (Table III-2).

Table III-1. Acoustic ranges for NTAS 18 anchor survey.

Waypoint	Latitude (dd mm.mmm N)	Longitude (dd mm.mmm W)	Travel time (s)
1	14 44.054	50 55.933	6.984
2	14 42.999	50 57.895	8.168
3	14 45.644	50 57.837	7.598

Table III-2. NTAS 18 anchor coordinates based on acoustic survey.

Anchor Drop	14 44.728' N	50 56.488 W
Anchor position, Weller's code	14° 44.581' N	50° 56.706' W
Depth at anchor position	5018 m (Multibeam, SoS=1500 m s^{-1})	5055 m (corrected for SoS=1511 m s^{-1})
Fallback	482 m	9.5% water depth

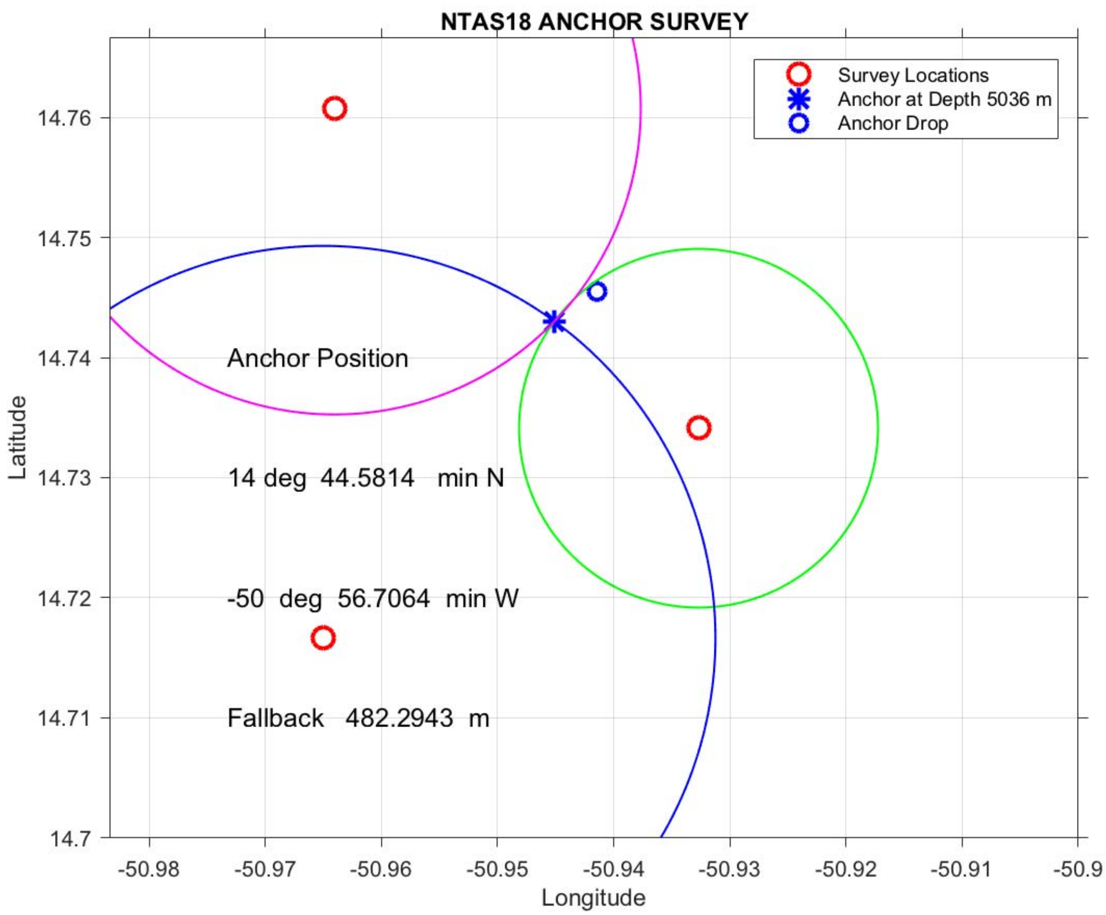


Figure III-7. NTAS 18 anchor survey: screen capture of Weller's Matlab code (anchpos2c.m) results.

IV. NTAS 17 Recovery

A. Mooring Recovery

Recovery of the NTAS 17 mooring occurred on January 16 2020. At 05:40 local (UTC-4), winds were 16 kts and out of 065° True. At 10:41 UTC the ship *R/V Ron Brown* was positioned roughly 500 meters upwind from the anchor position and the release command was sent to the acoustic release to separate the anchor from the mooring line. After about 50 minutes, the glass balls surfaced pretty much above the anchor position. Figure IV-1 shows the track of *R/V Ron Brown* during the recovery.

In preparation for recovery of the glass balls the TSE winch leader was fed through the A-frame block and run around the port quarter and up to the side of the ship. Once the glass balls were on the surface, the ship deployed their Fast Rescue Boat (FRB) to make the attachment to the glass balls. After the FRB made a secure connection to the ball cluster and reported the heading of the Colmega line on the surface, the ship maneuvered to meet the small boat on the port side. A heaving line connected to a hauling line was passed from the ship to the small boat. The hauling line was connected to the TSE winch. The small boat connected the line and backed away from the ball cluster. The ship maneuvered the hauling line around the port quarter so that the ball cluster was trailing behind the ship. The ship continued ahead slowly (0.25 kt) to straighten out the line while the FRB went to the buoy. After the FRB connected the titanium pick up hook to the buoys pick up bail they came back to the ship and the FRB was recovered.

Once the mooring was trailing behind the ship, the winch hauled in to bring the cluster of glass balls up over the stern. Tag lines and an air tugger were used to control the glass balls as they were pulled forward and lowered to the deck. Once all of the glass balls were on board, a stopper line was snapped into a sling link leading to the acoustic releases and then made fast to a deck cleat. Another stopper was attached to the end of the Colmega line leading off the stern. The winch leader was attached to the shot of chain above the releases, which were hauled aboard.

The next step was the disassembly and removal of the glass balls from the working area. Once the glass balls were clear from the deck, a nylon line was tied around the thimble of the Colmega and wrapped around the ship's capstan. The capstan took the load of the mooring, and the stopper lines were removed. The capstan was used to haul in approximately 4,100 meters of Colmega and nylon line. Once the wire to nylon termination came through the block the load was transferred to the TSE winch. The winch was used to haul in the reaming portions of the mooring.

Several instruments were clamped to the mooring wire above 180 meters. As each instrument was removed from the mooring, it was inspected, photographed, and recorded. When the 85-meter ADCP was pulled over the transom, stopper lines were attached to the termination, and the ADCP was removed from the mooring. The two sections of mooring wire were shackled together, and the recovery continued. More instruments were removed as the wire was hauled in. When there was 45 meters left between the buoy and the ship, the wire was cut, and the buoy set adrift.

After the buoy was set adrift the deck was set up for a port side recovery. This included adjusting both air tuggers to face the port side and removing two sections of bulwark. Once the deck was set up the ship made an approach to recover the buoy along the port side.

After the buoy was hooked up to the titanium pick up pendant, the port side crane lifted the buoy out of the water and two tag lines where attached. One line was attached to the D-handle on the buoy and one tag line was on the halo. During the pick the crane had issues and wasn't able to lift the buoy over the deck. With the buoy secured to the ship with the tag lines, the knuckle boom crane was unfolded and hooked up to the buoy pick up bail. The knuckle boom crane took the load from the main crane and safely maneuvered the buoy on deck.

The buoy was strapped to the deck and the knuckle boom crane was inserted into the bellmouth at the bottom of the EM chain. The crane picked up the EM chain from the bellmouth until it cleared the rail. After the flange on the EM chain was clear it was pulled on board and lowered to the grated deck. The remaining wire and instruments were hauled in by hand. The last instrument was back on deck at 19:24 UTC.

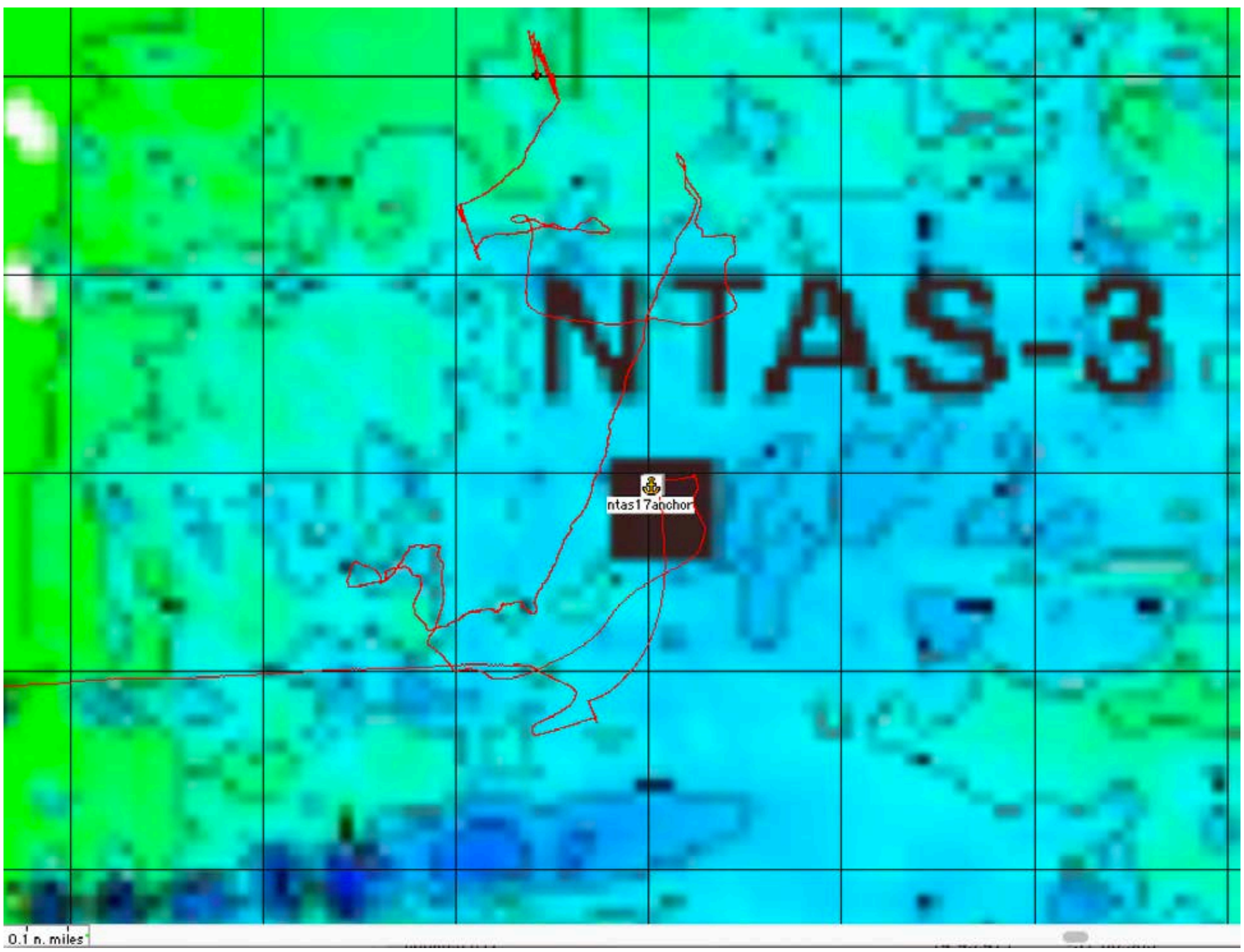


Figure IV-1. Track (red line) of R/V *Ron Brown* during recovery of NTAS 17 on January 16 2020. NTAS 17 anchor (yellow anchor symbol) is in the center. Colored contours are bathymetry from screen capture of navigation software MacGPSPro. The ship was initially located to the west of the anchor, near the buoy. The ship repositioned closer to the anchor to trigger the release of the mooring and then start the recovery of the glass balls that surfaced almost on top of the anchor position.

Following recovery, instrumentation was removed from the EM chain, which was then disconnected from the buoy. The buoy was then repositioned and secured inboard for transit. The bulwarks were also reinstalled on the port side.

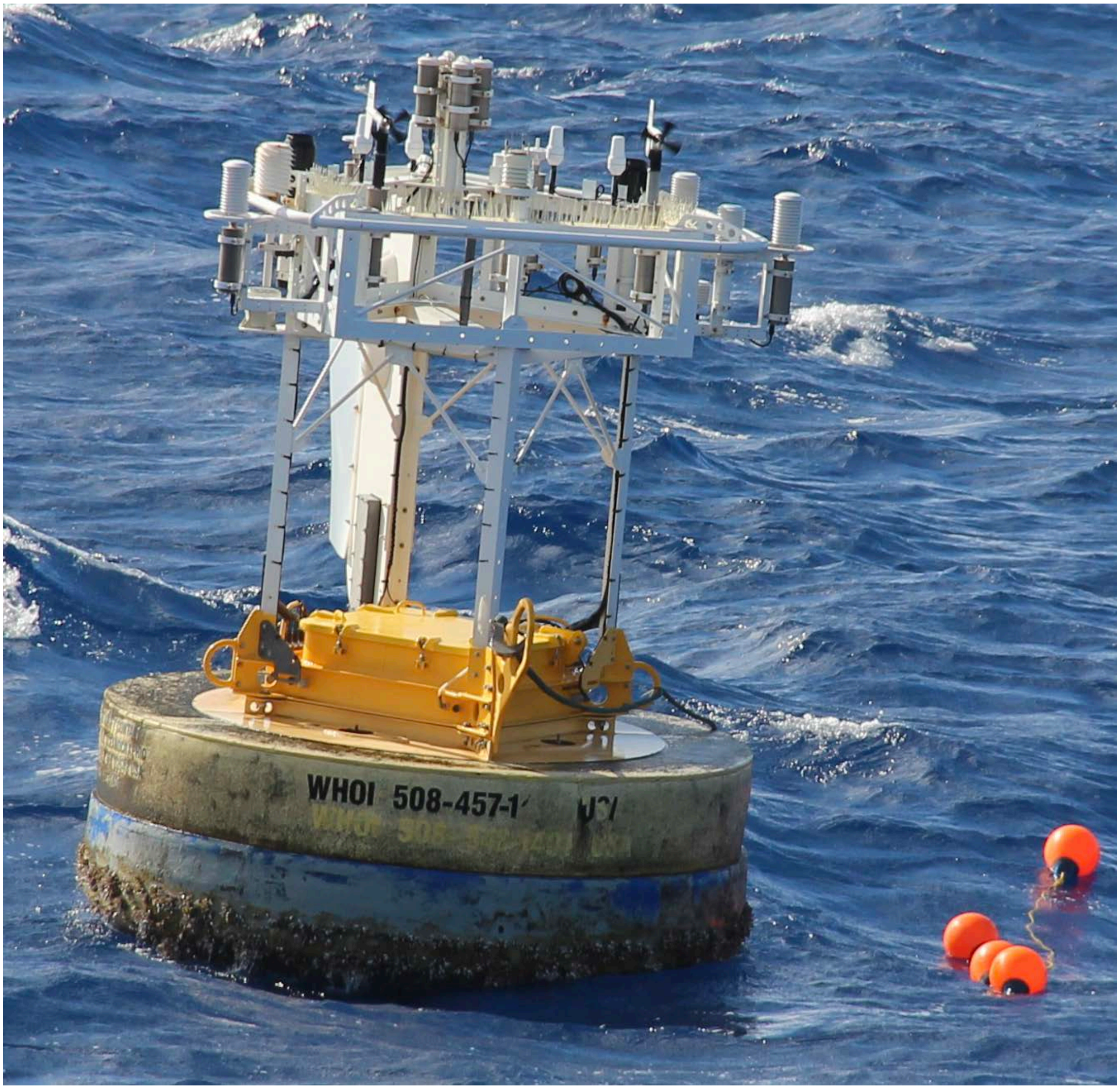


Figure IV-2. NTAS 17 just before recovery on January 16 2020.

B. Instrument Performance

The NTAS 17 was recovered on January 16 2020 after having remained 583 days on station. The meteorological instrumentation on the buoy tower looked in good working condition (Figure IV-3). Subsurface instrumentation also showed little biofouling (Figure IV-4 to Figure IV-6).

Figure IV-3. ASIMET meteorological sensors immediately following recovery of NTAS17.

Figure IV-4. NTAS 17 subsurface instrumentation at recovery: lower instruments.

Figure IV-5.. NTAS 17 subsurface instrumentation at recovery: upper instruments.


Figure IV-6. . NTAS 17 buoy bridle's instrumentation at recovery.

Initial data conversion and evaluation are described in a separate document (NTAS17InitialDataProcessing.docx), and are summarized here:
- ASIMET primary systems collected data for the whole deployment, except for SST on logger 5 and precipitation on logger 3, which stopped a few months before recovery and after deployment respectively (see Figure IV-7 to Figure IV-10).
- WXT data record showed issues with time stamps
- SBE39#7692 has no samples recorded. This instrument could not issue its serial number during communications after recovery
- SBE39s #7694, 7680, 7682 had shorter datasets (Figure IV-14), ending on Jan 29 2019 at 00:05:01 instrument time (clock set to UTC)
- Aquadopp ADCP 12393 data has a gap in June-July 2019 and stopped early in September 2019
- Aquadopp ADCM 12309 has a data gap in Aug-Nov 2019 (Figure IV-11)
- Aquadopp ADCM 12688 has a noisy signal on Beam 2 for several months (Figure IV-11). It was noted at recovery that a lifting sling, installed near the instrument and wrapped on the EM chain at deployment to help with recovery, was a bit loose and may have been in the way of the transducers.
- Starmon Oddis had multiple data .DAT files, which indicates repeated power failures.

The SBE37s and SBE56s (mounted in the buoy foam) collected data for the whole deployment (Figure IV-12, Figure IV-13, and Figure IV-15).

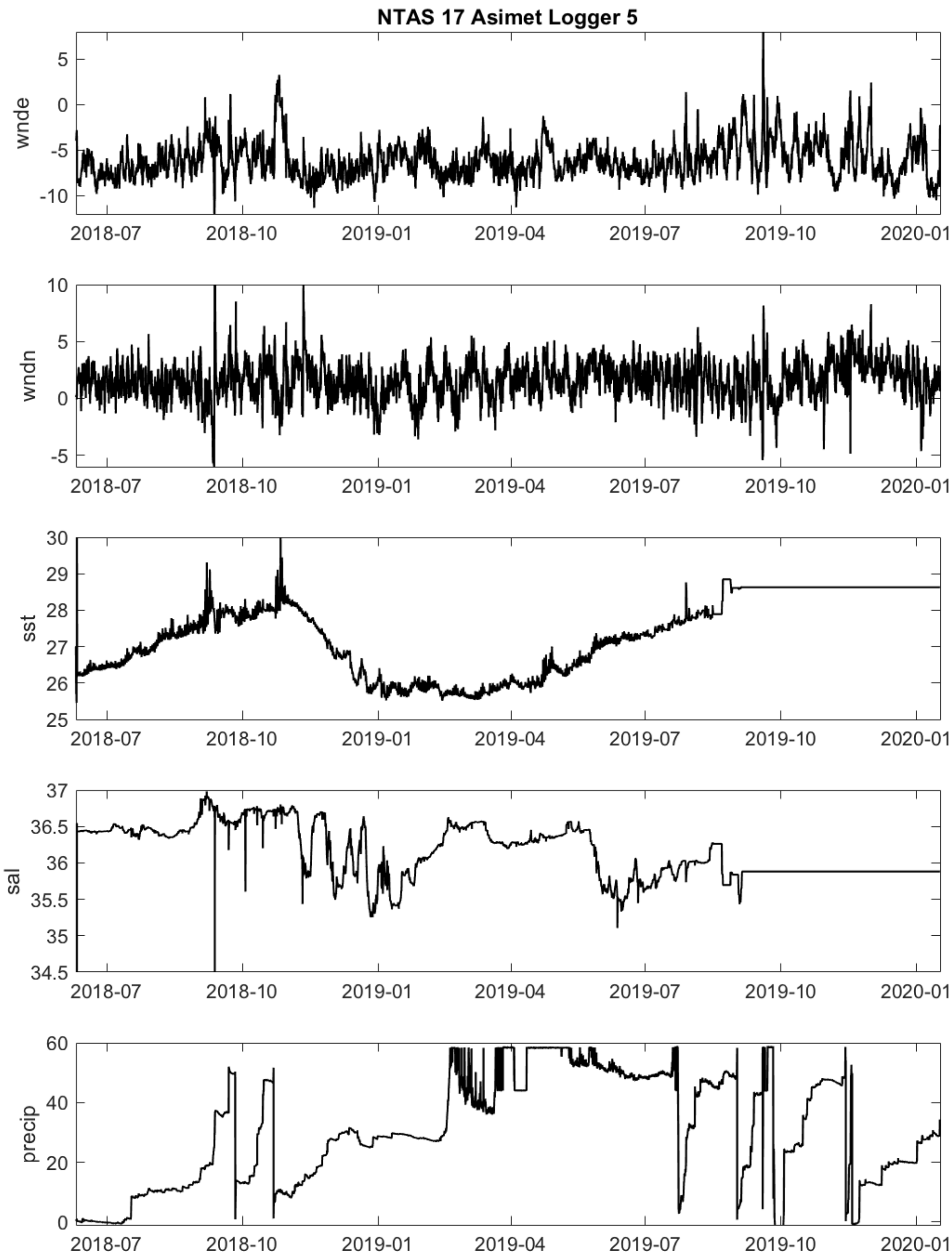


Figure IV-7. Logger 5 data from NTAS 17: wind U (m/s), wind V (m/s), SST (°C), surface salinity (psu), precipitation (mm).

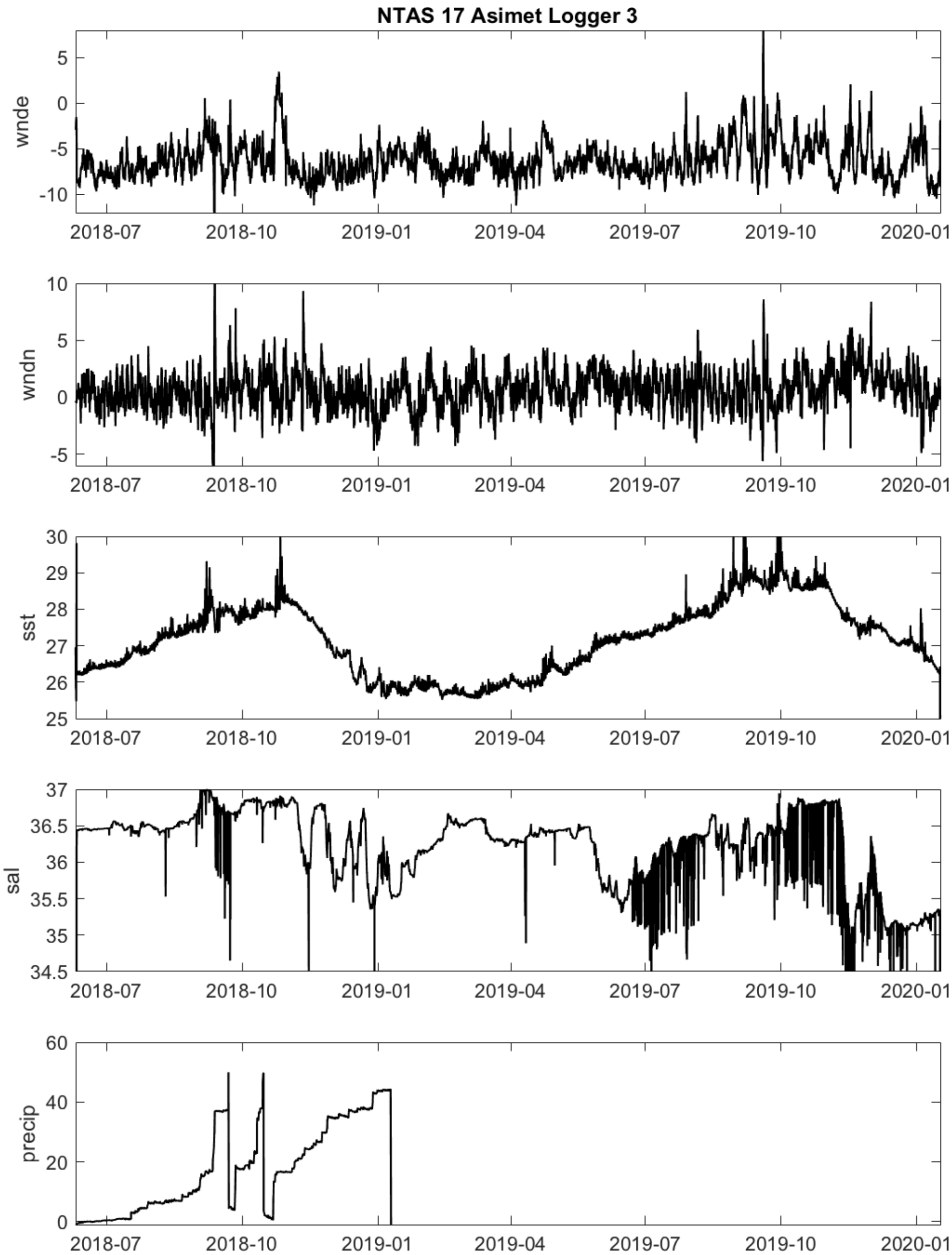


Figure IV-8. Logger 3 data from NTAS 17: wind U (m/s), wind V (m/s), SST (°C), surface salinity (psu), precipitation (mm).

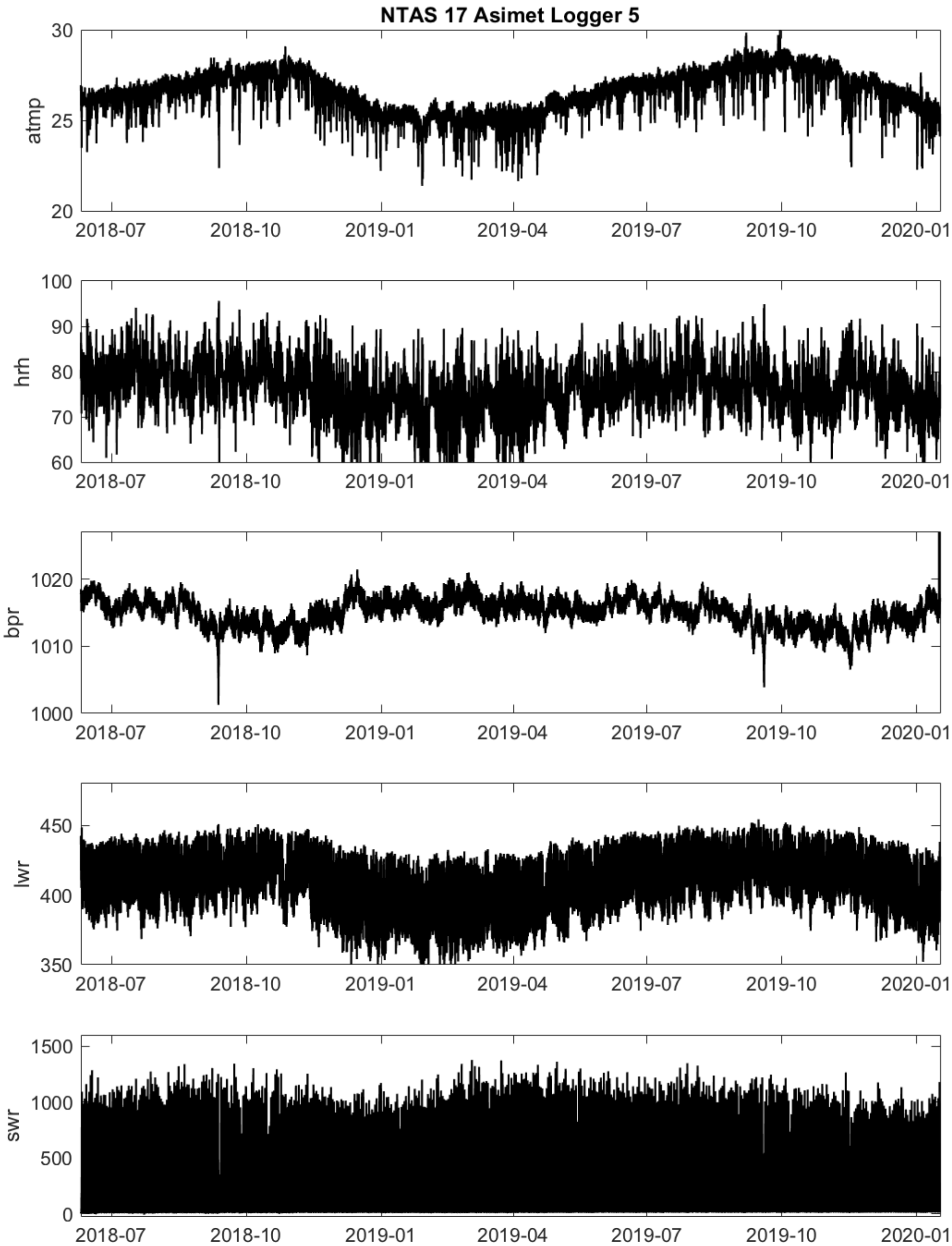


Figure IV-9. Logger 5 data from NTAS 17: Air temperature (°C), relative humidity (%RH), barometric pressure (mbar), Longwave radiation (W/m^2), Shortwave radiation (W/m^2).

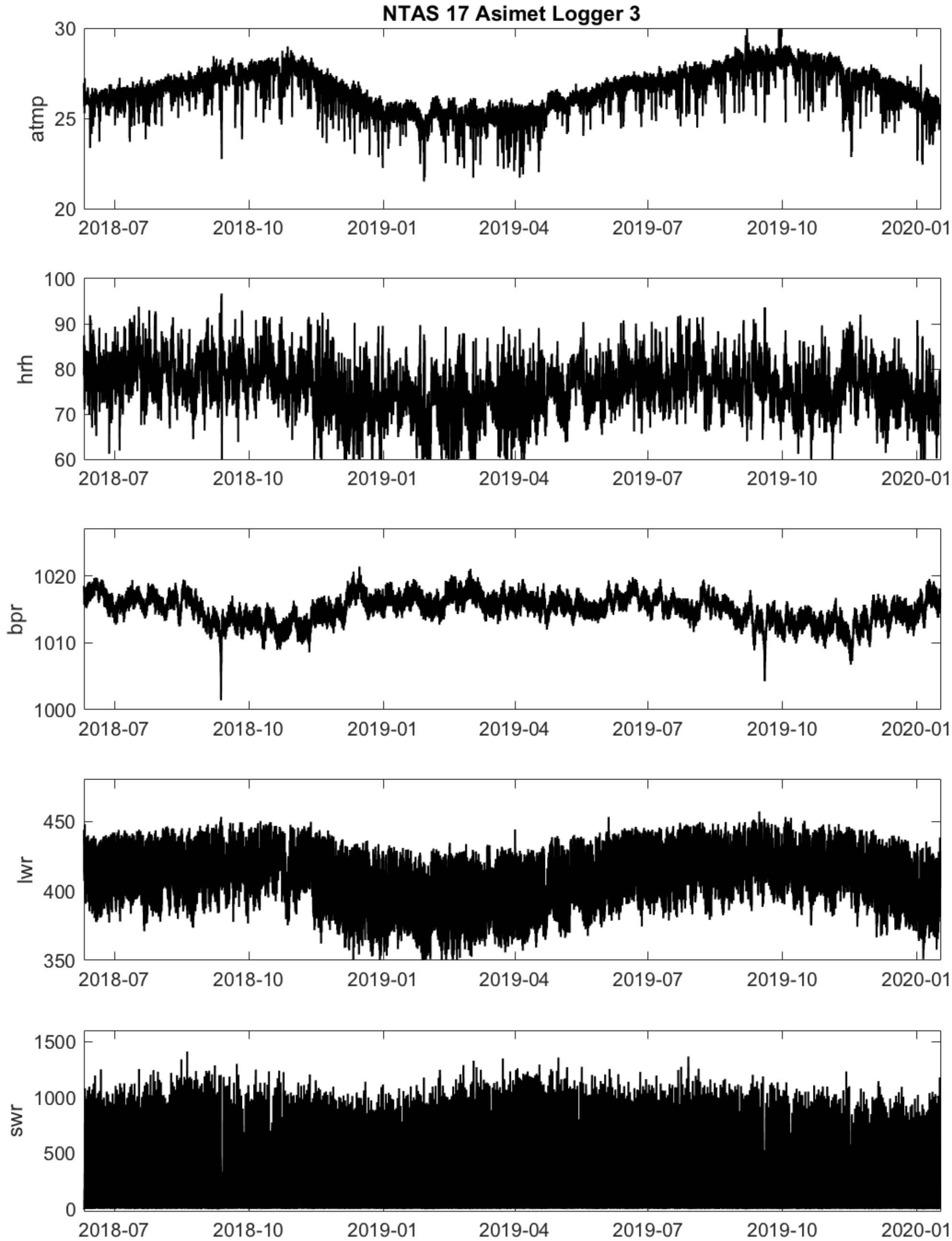


Figure IV-10. Logger 3 data from NTAS 17: Air temperature (°C), relative humidity (%RH), barometric pressure (mbar), Longwave radiation (W/m^2), Shortwave radiation (W/m^2).

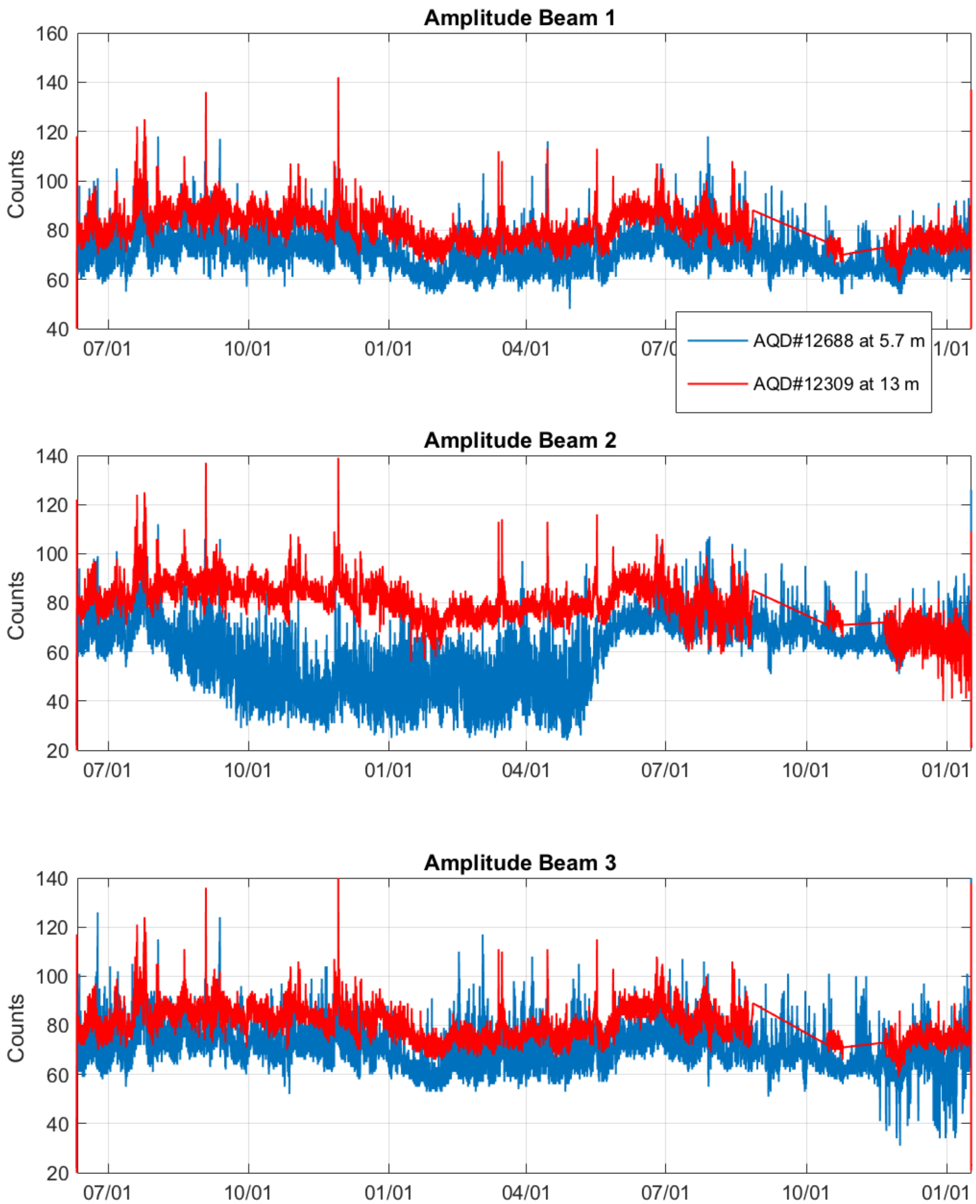


Figure IV-11. NTAS 17 Aquadopps at 5.7 m and 13 m depths: signal amplitude during all deployment.

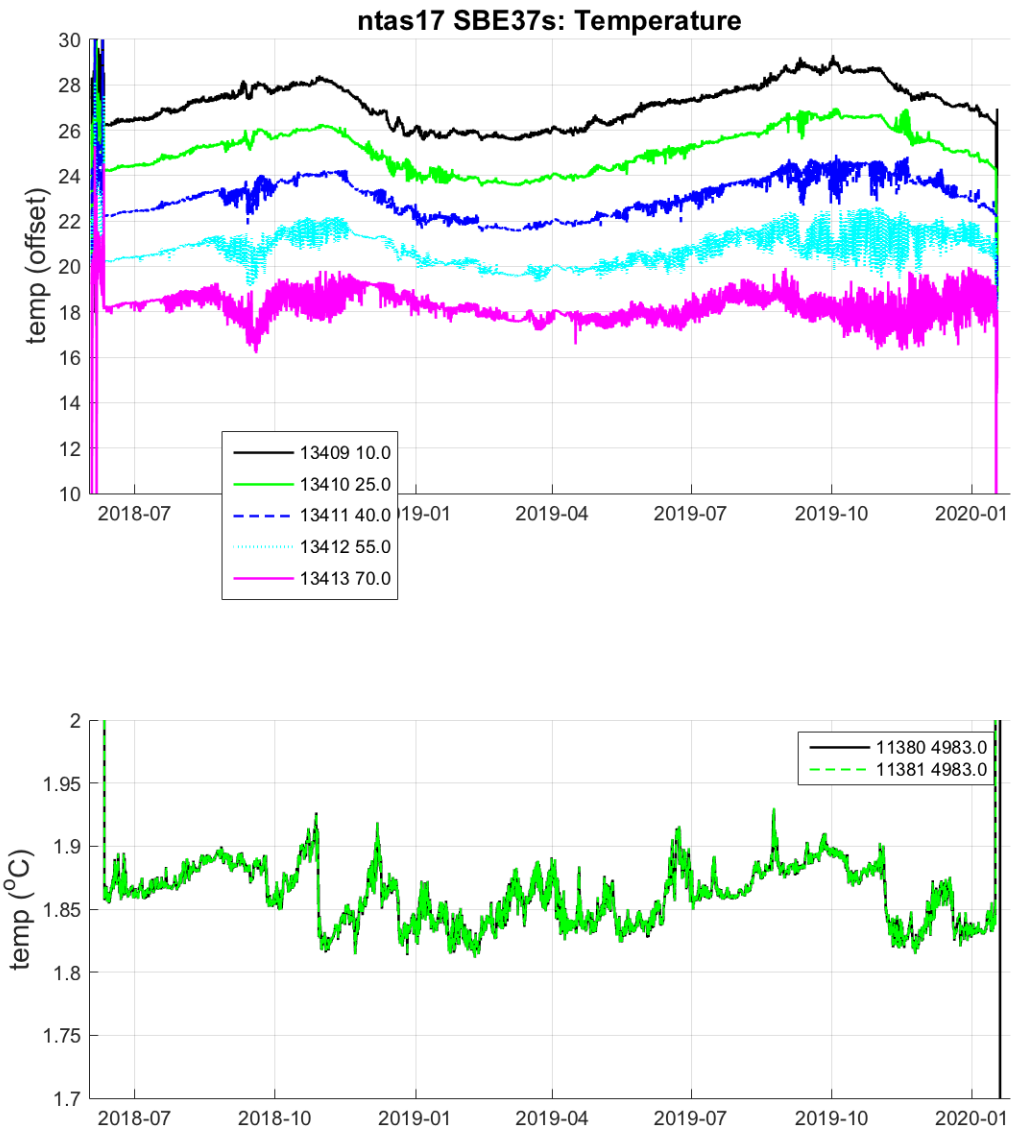


Figure IV-12. NTAS 17 Seabird SBE37s temperature record, with added offset for readability.

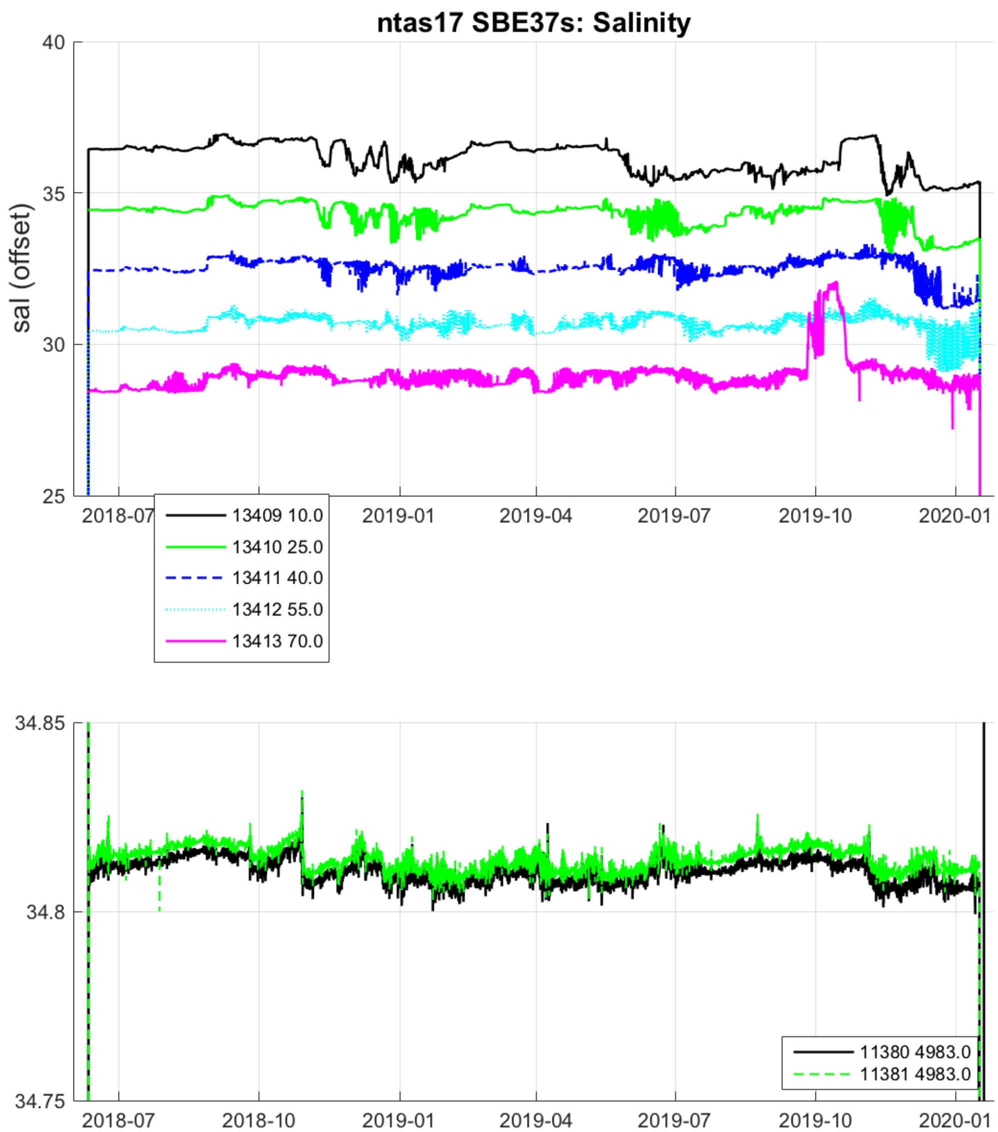


Figure IV-13. NTAS 17 Seabird SBE37s salinity record, with added offset for readability.

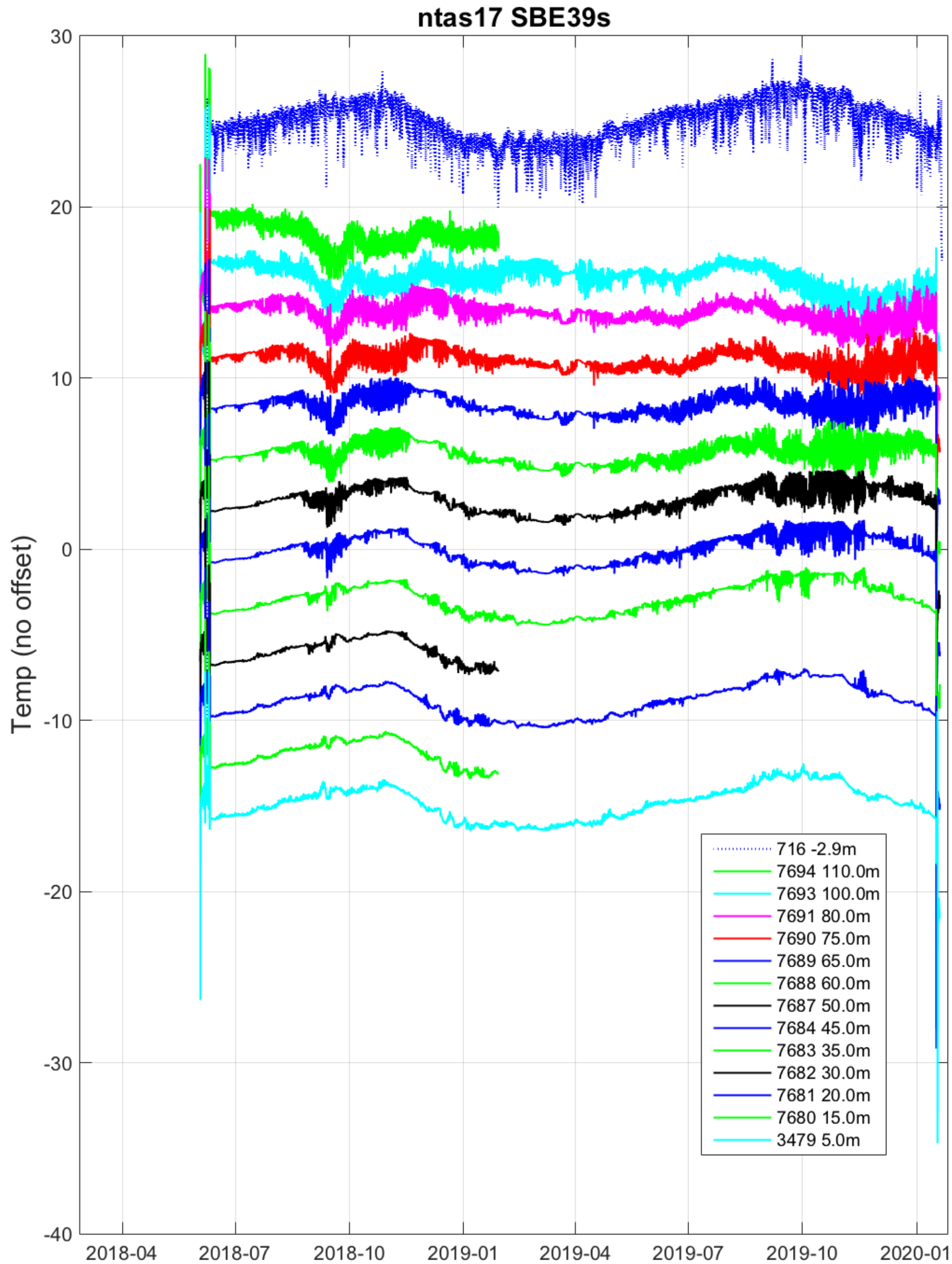


Figure IV-14. NTAS 17 Seabird SBE39s temperature record, with added offset for readability.

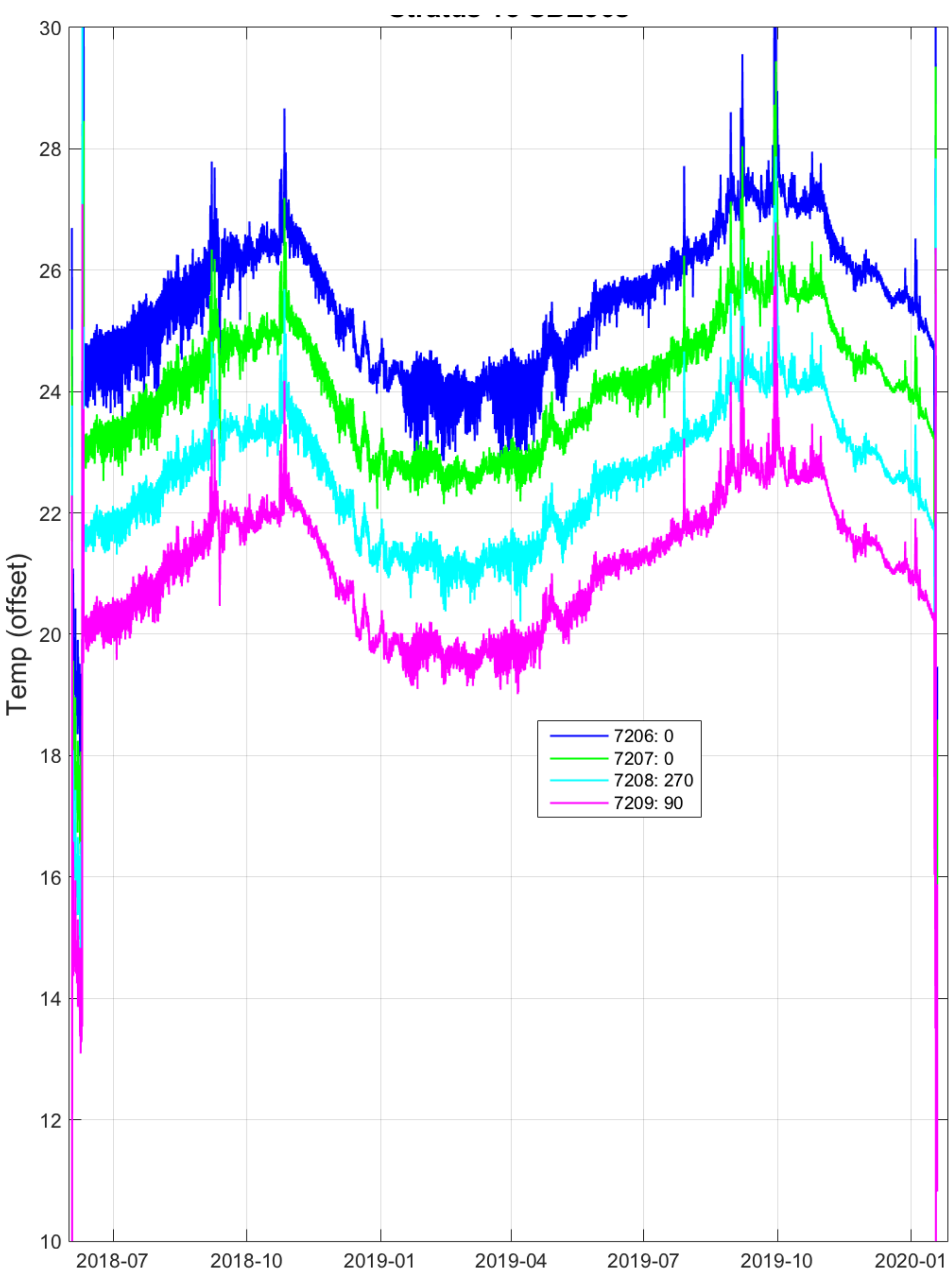


Figure IV-15. NTAS 17 Seabird SBE56s temperature record.

C. NTAS 18 and NTAS 17 Inter-comparisons

The two buoys NTAS 18 and 17 were both in the water from January 10 when NTAS18 was deployed, to January 16 when NTAS 17 was recovered. Meteorological measurements from both platforms collected during this period and transmitted through telemetry (hourly averages, with no data quality control) are shown below. These plots are time-series for each variable measured from redundant sensors (there are two ASIMET sensors on each buoy); there are also scatter plots comparing like measurements from redundant sensors. These plots can serve both to identify variations in the surface meteorology in the region, and to evaluate the functionality and accuracy of the measurements. Note that some difference should be expected between similar measurements from redundant sensors on the same buoy and between buoys, due to errors such as flow distortion on the buoy or instrument errors, and also because the two buoys were several miles from each other. However, this comparison is useful as a preliminary evaluation of possible biases, which can be investigated in the WHOI calibration laboratory.

The data show a clear diurnal cycle with air temperature about 0.5 °C warmer during the day. A small rain event occurred early on January 12, concomitant with an anomalous drop in air temperature. Wind speed also varied diurnally with higher wind speeds in the morning. Wind speed is dominated by the zonal wind component, which is expected in this region of the Trade winds. Sea surface temperature and salinity showed decreasing and increasing trends respectively, probably part of the seasonal cycle.

Comparisons of the time-series and scatter plots indicate that for both NTAS 17 and 18 air temperature measurements on each buoy were within 0.1 °C. Similarly, redundant measurements of air relative humidity on each buoy were within ASIMET's stated accuracy (less 2 %RH). The difference between the two buoys was slightly larger, with measurements on the new NTAS 18 being warmer and wetter than on NTAS 17, for day and night periods. Downwelling longwave radiation (LWR) on system 2 NTAS18 was lower than the other three similar measurements (system 1 NTAS 18 and systems 1 and 2 NTAS17); the scatter plot also indicates that this bias (roughly 5 W m^{-2}) may increase for low and high values of LWR. For downwelling shortwave radiation (SWR), this inter-comparison shows both systems on NTAS18 agreed well, however system 2 on NTAS17 may have been 15 W m^{-2} lower than system 1 on the same buoy. There was some larger difference between the two buoys which is not surprising as a light but patchy cloud cover was observed in the NTAS region during this cruise. Finally, wind speed agreed rather well between all sensors. However, the northward wind component, which is much smaller than the eastward component at NTAS (Trade wind region), showed a bias between sensors on each buoy and between buoys (NTAS 18 had a smaller northward wind component). This impacts the error in wind heading, which reached 10 degrees and was in the form of a bias. On each buoy, there was a bias in wind heading with both systems 2 having lesser values than their systems 1 counterparts. Since NTAS buoys are deployed with systems 2 on the starboard side of the buoys, meaning that these sensors were on the right side of the buoy when it faced the Trade winds; systems 1 are on the port side. The wind heading bias seen here is consistent with flow distortion identified in previous studies (Bigorre et al 2013, Schlundt et al 2020). Seabird 37s mounted on the buoy bridle measured temperature and conductivity, to provide measurements of sea surface temperature (SST) and salinity (SSS). System 1 on NTAS17 was not functioning during this inter-comparison.

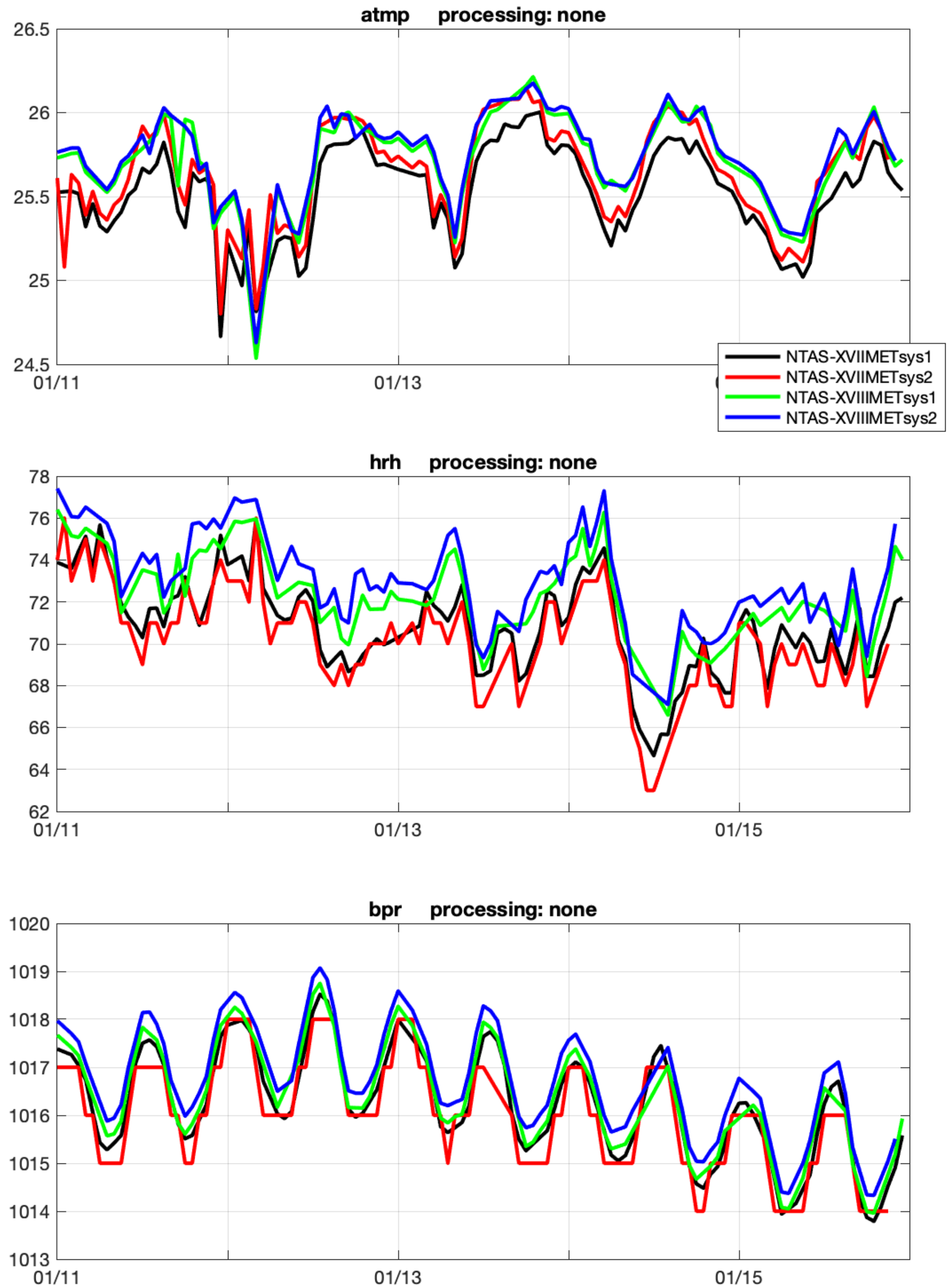


Figure IV-16. Timeseries (hourly averages transmitted through Iridium (Argos for system 2/logger 3 on NTAS 17) telemetry) of near surface meteorology from ASIMET instrumentation on NTAS 17 (black, red lines) and NTAS 18 (green, blue lines) buoys, while both platforms were deployed from January 11 to 16 2020: air temperature in °C (top), air relative humidity in %RH (center) and barometric pressure in mbars (bottom).

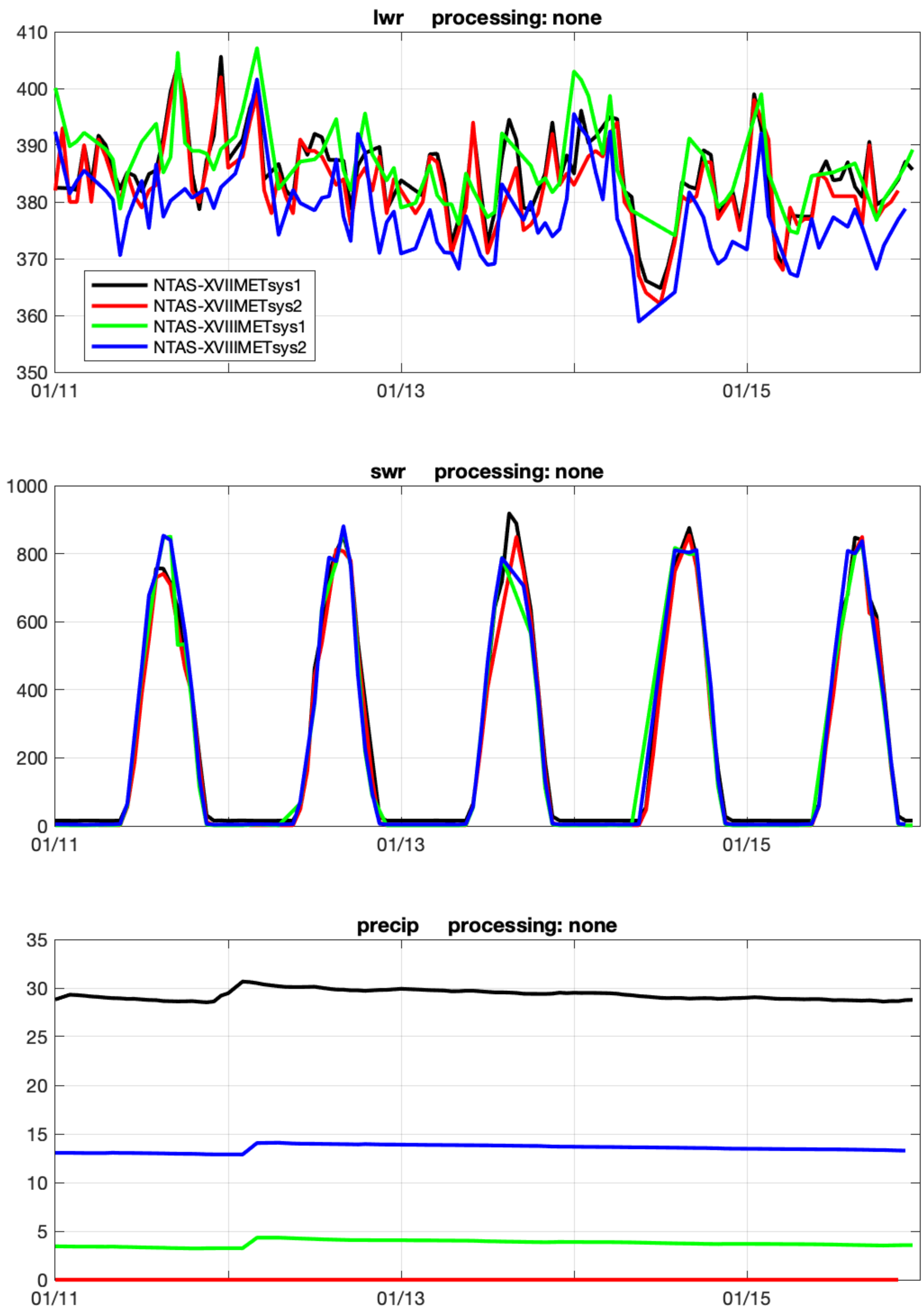


Figure IV-17. Same as Figure IV-16 but for downwelling longwave radiation in W m^{-2} (top), downwelling shortwave radiation in W m^{-2} (center) and precipitation accumulation in mm (bottom).

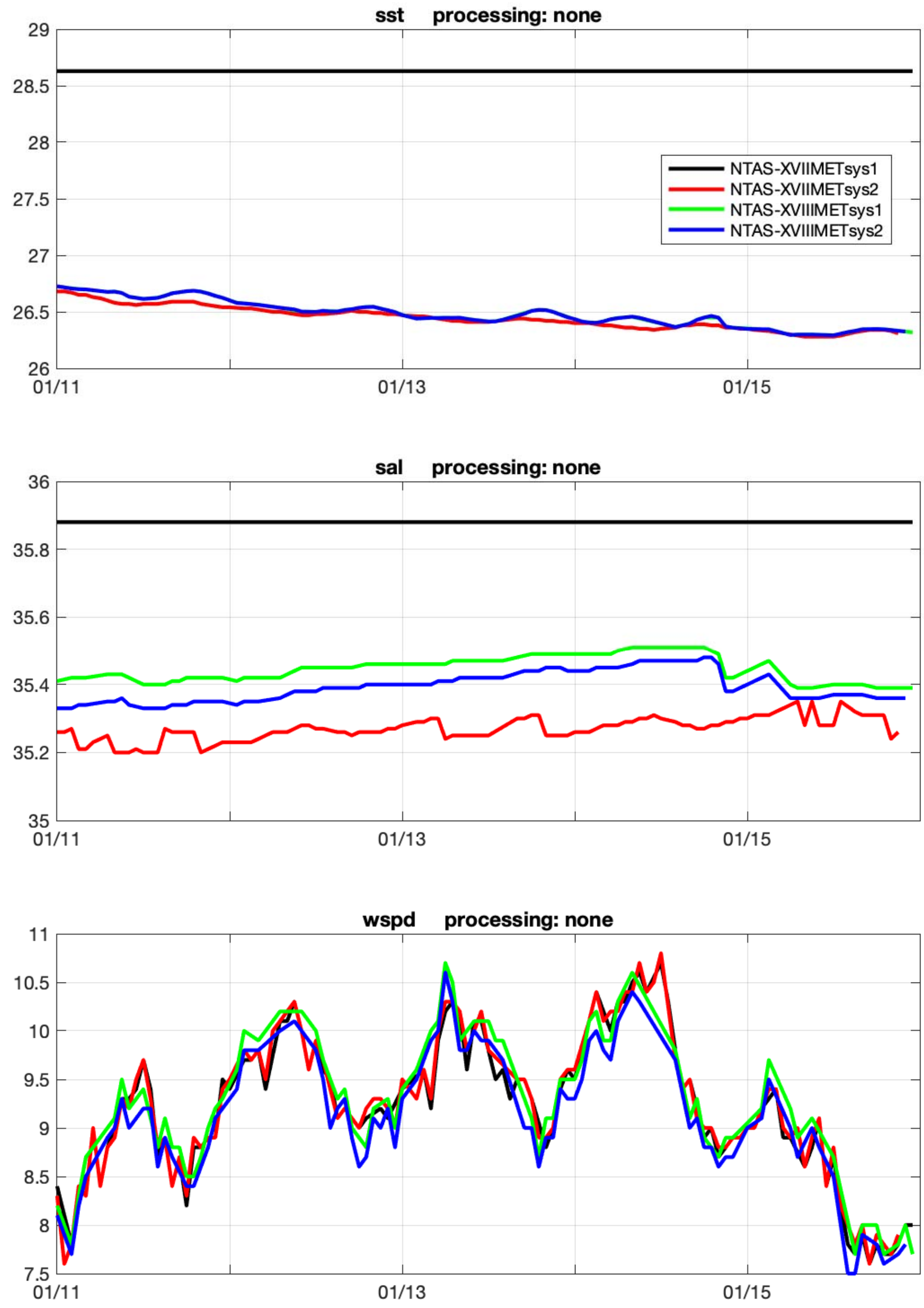


Figure IV-18. Same as Figure IV-16 but for sea surface temperature in °C (top), sea surface salinity in psu (center) and wind speed in m s^{-1} (bottom).

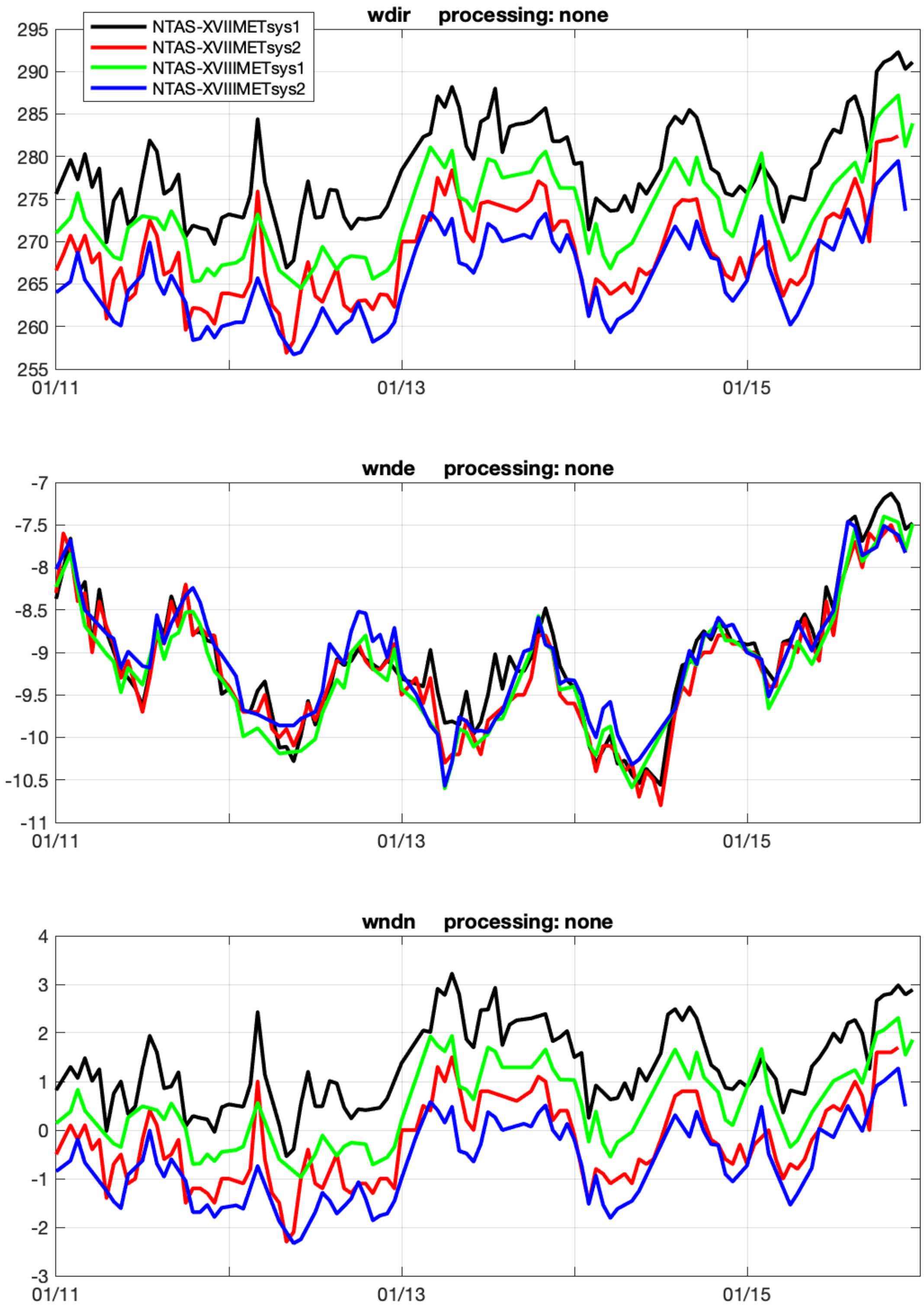


Figure IV-19. Same as Figure IV-16 but for wind heading in degrees (top), wind speed to the east in m s^{-1} (center) and wind speed to the north m s^{-1} (bottom).

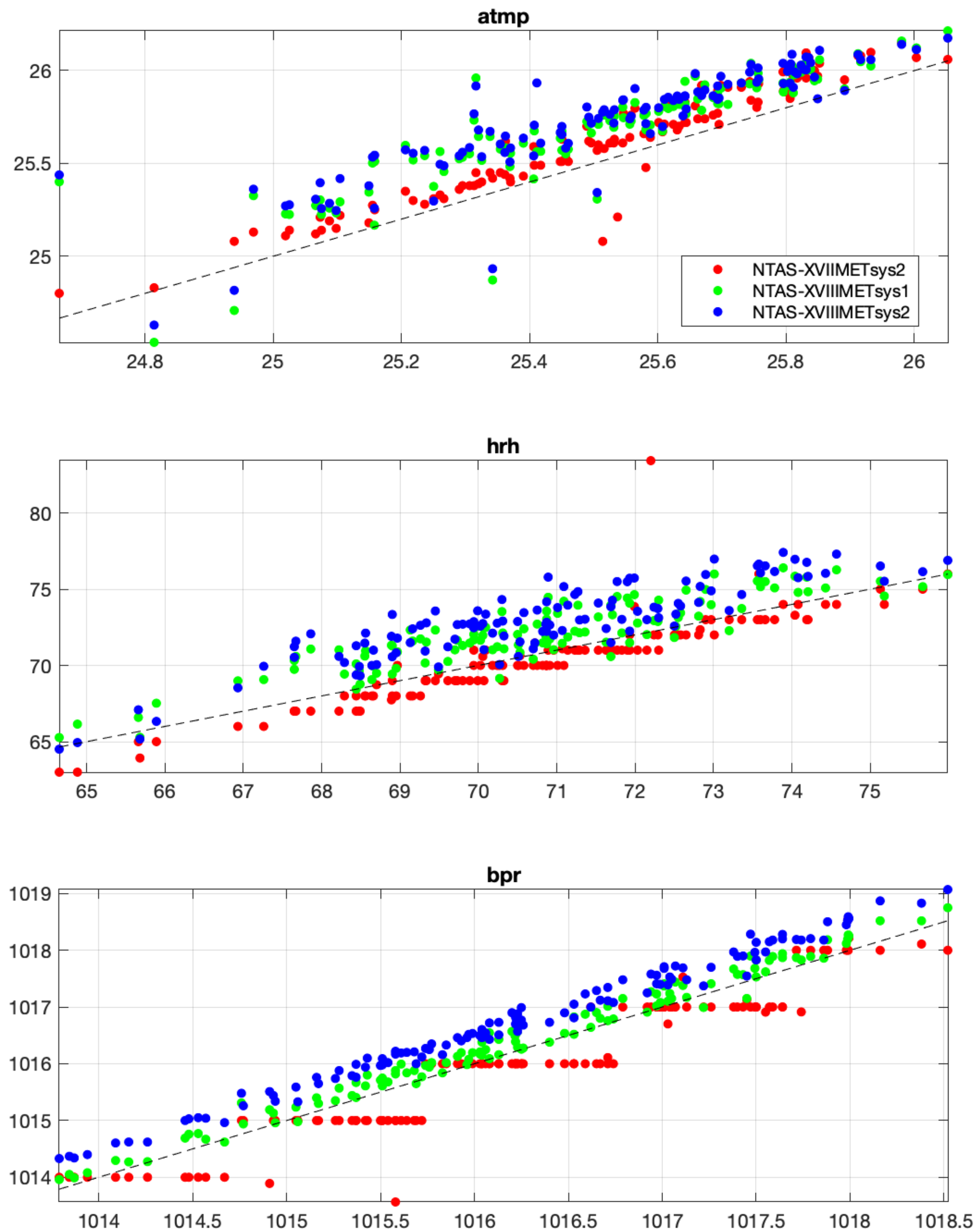


Figure IV-20. Scatter-plots of ASIMET measurements collected between January 11-16 2020 from systems 1 and 2 on NTAS18 and system 2 on NTAS17 versus system 1 on NTAS17 using same data as in Figure IV-16. Note that data from NTAS 17 are telemetered using Iridium (system 1) or Argos (system 2, which has coarse resolution). Air temperature in °C (top), air relative humidity in %RH (center) and barometric pressure in mbars (bottom).

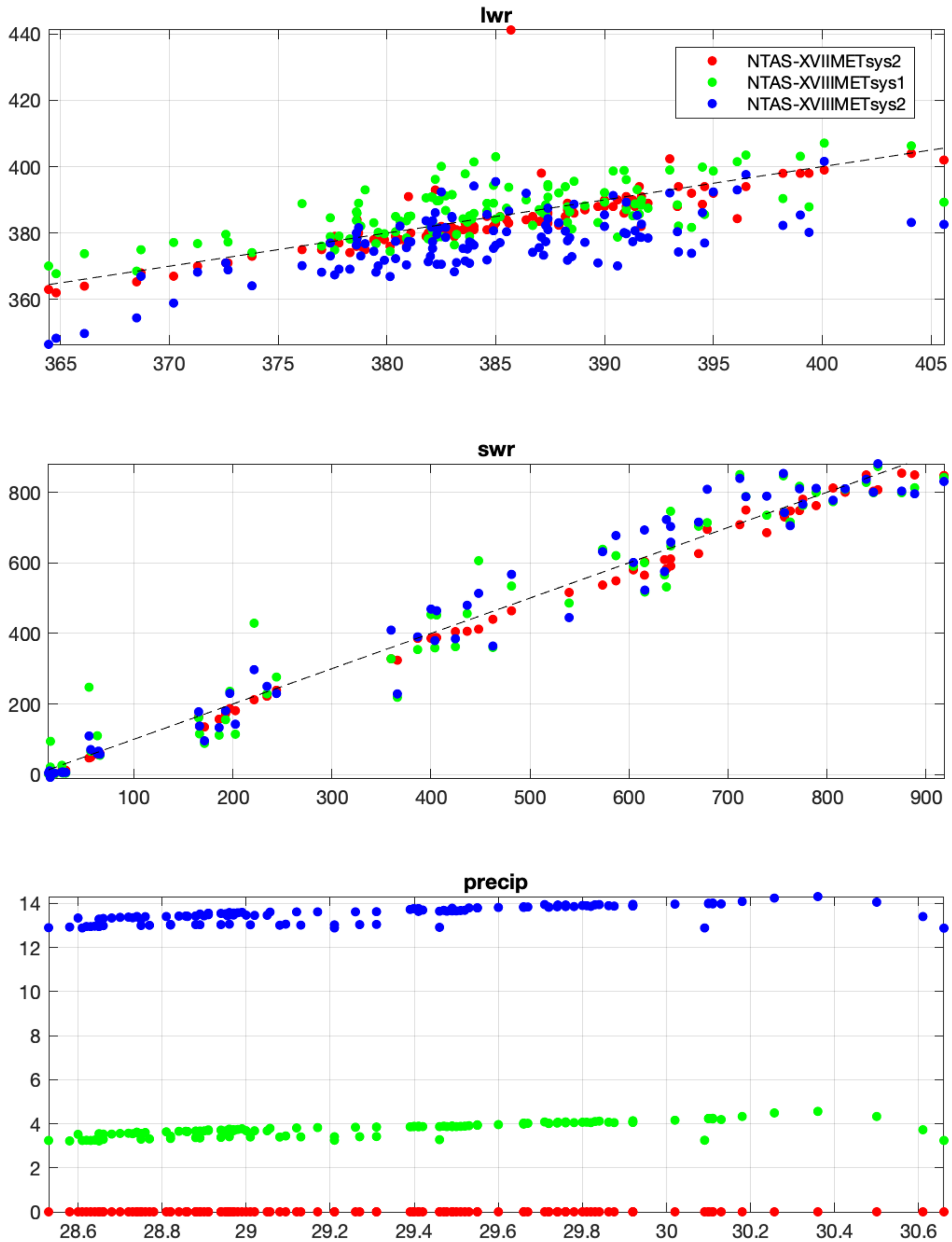


Figure IV-21. Similar to Figure IV-20 with data corresponding to Figure IV-17. Downwelling longwave radiation in W m^{-2} (top), downwelling shortwave radiation in W m^{-2} (center) and precipitation accumulation in mm (bottom).

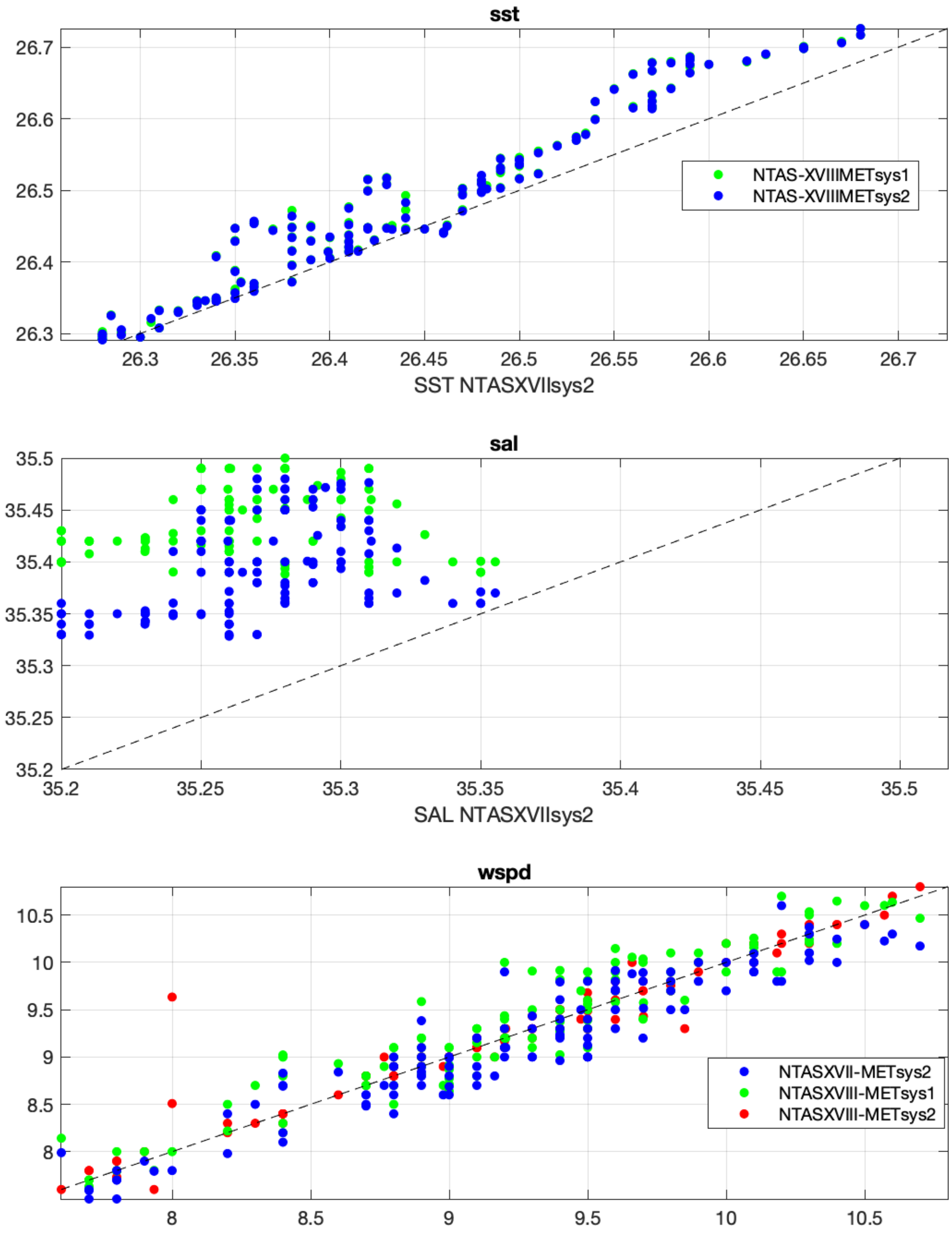


Figure IV-22. Similar to Figure IV-20 with data corresponding to Figure IV-18. Sea surface temperature in °C (top), sea surface salinity in psu (center) and wind speed in m s^{-1} (bottom). X-axis for SST and Sea Surface Salinity is based on data from ASIMET system 2 on NTAS17.

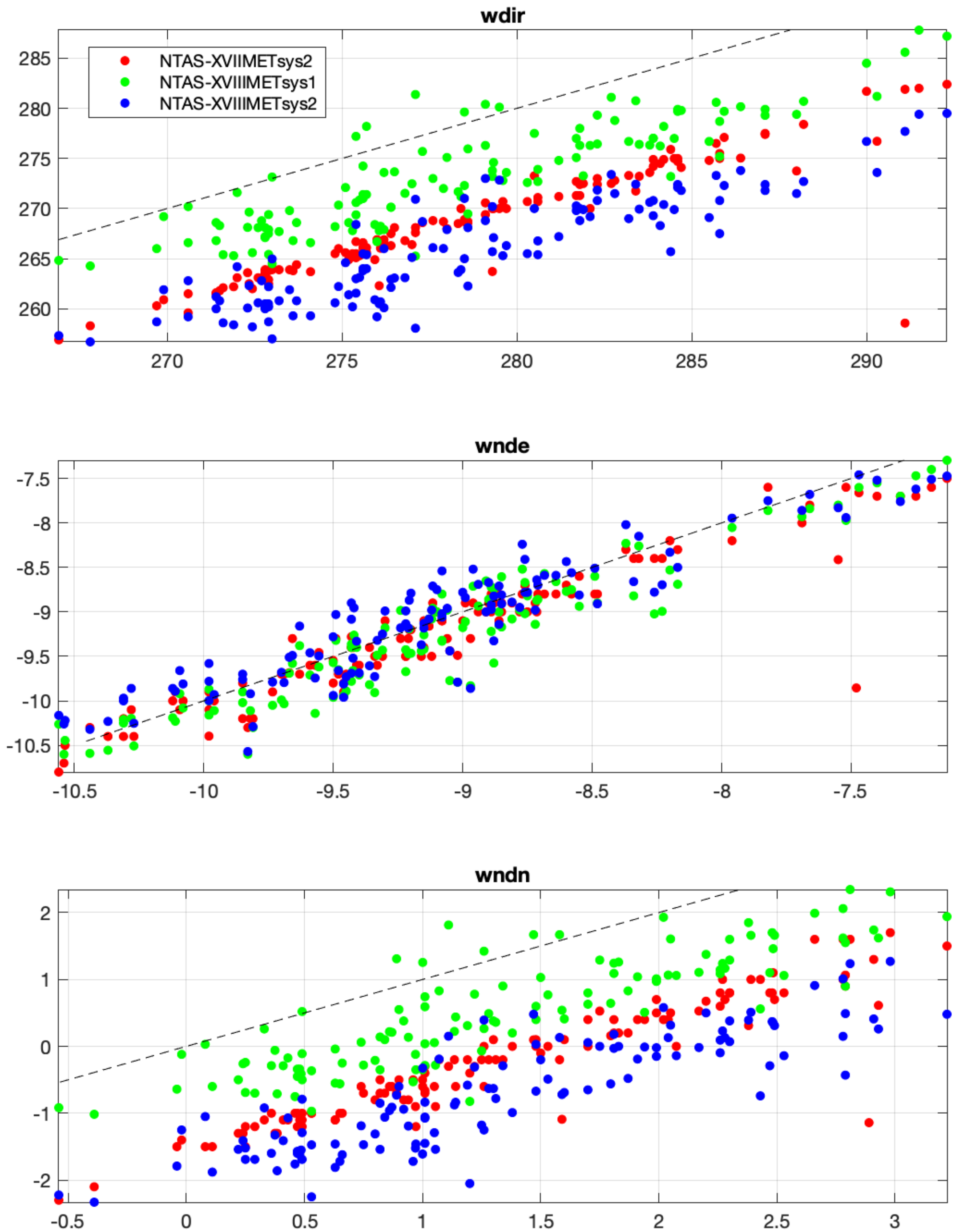


Figure IV-23. Similar to Figure IV-20 with data corresponding to Figure IV-19. Wind heading in degrees (top), wind speed to the east in m s^{-1} (center) and wind speed to the north m s^{-1} (bottom).

V. Ancillary Work

A. CTDs

During the NTAS 18 cruise, 14 CTD casts were operated. The first cast, located offshore of Barbados, was a test of the CTD and bottles, and of the acoustic releases planned for NTAS18. Three casts were made on January 12 within ¼ nm of NTAS18 buoy. Three shallow casts (250 m) were done within ¼ nm of NTAS17 buoy. The first of these casts was done on January 13 at the beginning of inter-comparison between ship and NTAS17, which was interrupted to survey an oceanic front prior to the deployment of 6 SWIFT buoys (APL project for ATOMIC). The intercomparison at NTAS17 resumed on January 15 and included two CTD casts within ¼ nm of NTAS17 buoy. A deep cast (down to 20 m above ocean bottom) was done 3.5 nm East of NTAS17 anchor on January 15. Table V-1 shows time and location of CTD casts during RB-20-01 cruise.

Table V-1. CTD casts during RB 20-01 cruise.

CTD cast#	NMEA Date and Time (UTC)	NMEA Latitude N (dd mm.mm)	NMEA Longitude W (dd mm.mm)	Notes	Max Pressure (dbar)
1	1/8/2020 12:16	13 36.78	056 27.48	test	2030
2	1/11/2020 01:32	15 26.15	051 29.39	MOVE	4916
3	1/12/2020 14:06	14 44.34	050 59.17	NTAS18	253
4	1/12/2020 19:03	14 44.27	050 59.02	NTAS18	253
5	1/13/2020 00:00	14 44.38	050 59.09	NTAS18	253
6	1/13/2020 12:18	14 49.26	051 03.37	NTAS17	253
7	1/13/2020 21:51	15 51.72	051 23.00	Front survey	253
8	1/15/2020 12:02	14 49.24	051 03.22	NTAS17	253
9	1/15/2020 16:09	14 49.44	051 03.18	NTAS17	253
10	1/15/2020 20:15	14 48.43	050 57.62	3.5 nm East-Southeast from NTAS17	5074
11	1/17/2020 19:28	14 50.74	051 01.41	6.5 nm North-Northwest of NTAS18	3041
12	1/17/2020 22:36	14 50.77	051 00.83	Check two Ntas17 microcats	507
13	1/20/2020 22:36			No data recorded	
14	1/21/2020 16:15	14 21.60	053 01.74	UCTD comparison	153

The two figures below show profiles of temperature, salinity, density and speed of sound from CTD cast#10, which was a full water column cast. Note that the speed of sound averaged over the whole column from this cast is 1514.4 m s^{-1}.

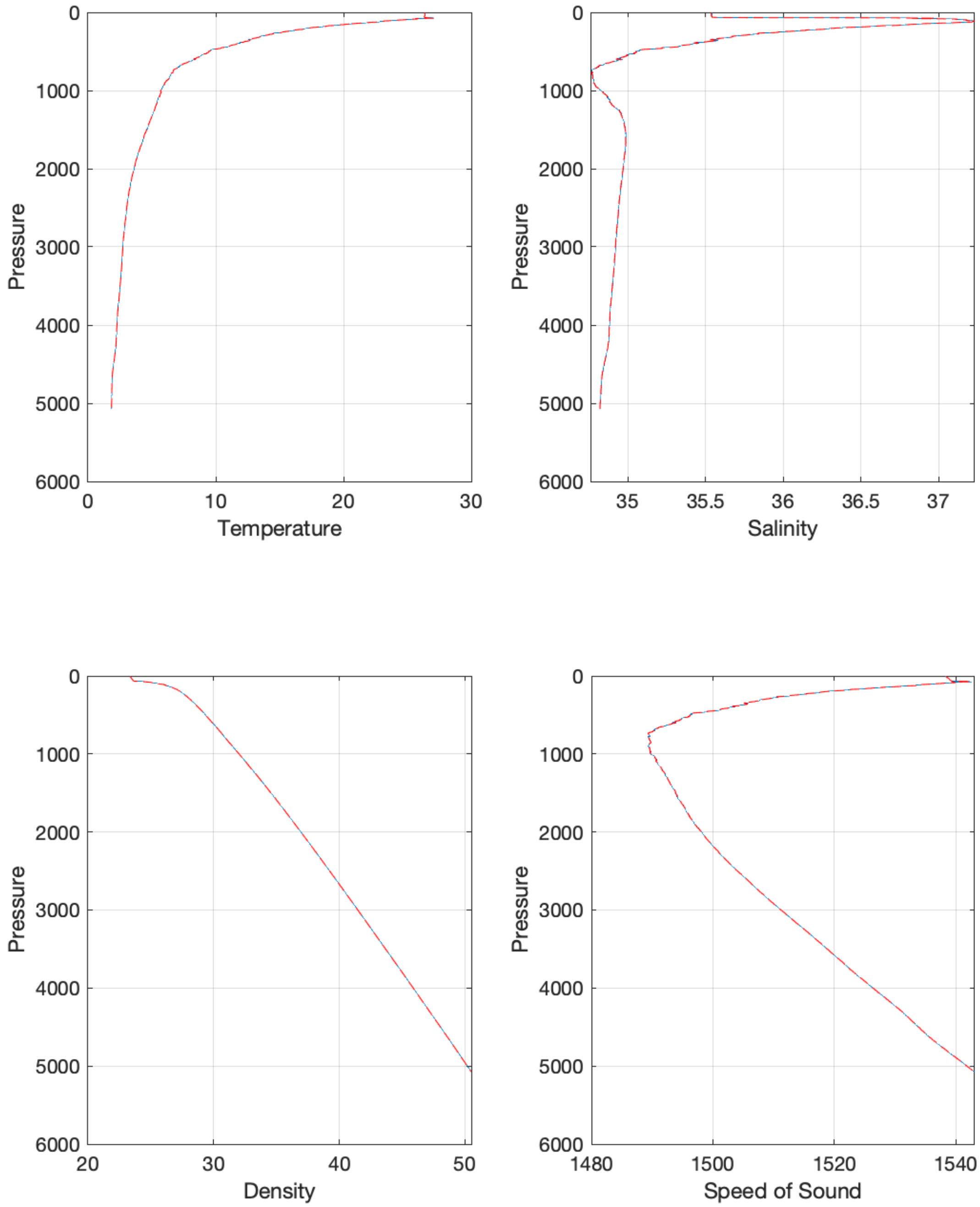


Figure V-1. Profiles from CTD cast#10. From left to right, top to bottom: temperature (°C), salinity (psu), density anomaly (kg m^{-3}) and speed of sound (m s^{-1}).

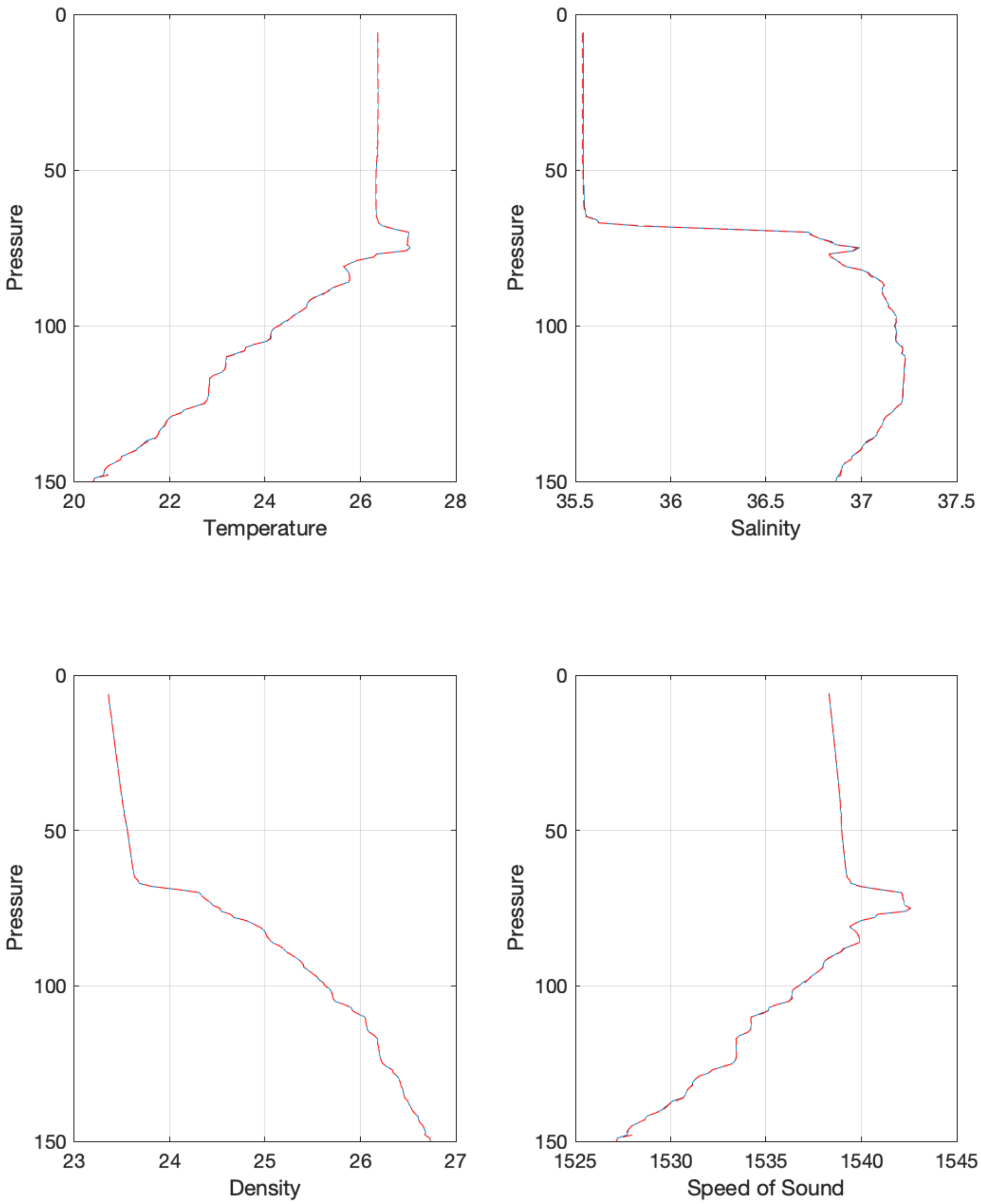


Figure V-2. Same data as in Figure V-1, but zoomed on upper 150 m.

References

Bigorre S., R. Weller, J. Edson, J. Ware, 2013. A surface mooring for air-sea interaction research in the Gulf Stream. Part 2: Analysis of the observations and their accuracies. *J. Atmos. Ocean. Tech*., v. 30 (3), pp. 450-469. doi: http://dx.doi.org/10.1175/JTECH-D-12-00078.1

Schlundt, M., J.T. Farrar, S.P. Bigorre, A.J. Plueddemann, and R.A. Weller, 2020: Accuracy of Wind Observations from Open-Ocean Buoys: Correction for Flow Distortion. *J. Atmos. Oceanic Technol.,* **37**, 687–703, https://doi.org/10.1175/JTECH-D-19-0132.1

Acknowledgements

We thank the captain and crew of the NOAA R/V Ron Brown for accommodating the science mission, and providing expertise critical to the success of the mooring operations. We also thank the chief scientist, science party of the ATOMIC project as well as ATOMIC's program manager at NOAA for incorporating the NTAS work into the ATOMIC cruise. This research was supported by the National Oceanic and Atmospheric Administration (NOAA), Global Ocean Monitoring and Observing (GOMO) Program (formerly Ocean Observing and Monitoring Division), through the Cooperative Institute for the North Atlantic Region (CINAR) under Cooperative Agreement NA14OAR4320158, FundRef number (100007298).

Appendix 1: NTAS 17 Mooring Log

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. NTAS 17 MOORED STATION NO.

Launch (anchor over)

Date (day-mon-yr) 10 - 6 - 18 Time 20:53 UTC

Deployed by Ben Pietro / Jason Smith Recorder/Observer S. Bigorre

Ship and Cruise No. Pisces PC 18-03 Intended Duration 365 days

Depth Recorder Reading 4985 m Correction Source average SoS 1511 m/s

Depth Correction +36 m leads to multiplying factor 1511/1500

Corrected Water Depth 5021 m Magnetic Variation (E/W) ____

Anchor Drop Lat. (N/S) 14° 49.452' Lon. (E/W) 051° 00.823'

Surveyed Pos. Lat. (N/S) 14° 49.4682' Lon. (E/W) 051° 00.9941'

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

Acoustic Release Model Edgetech Tested to 1,500 m

	Release No. 1 (sn) 51915	Release No. 2 (sn) 48277
Interrogate Freq.	11 kHz	11 kHz
Reply Freq.	12 kHz	12 kHz
Enable	337703	567550
Disable	337720	567573
Release	335322	551146

Recovery (release fired)

Date (day-mon-yr) 16-01-20 Time 1041 UTC

Latitude (N/S) 14 48.566' Longitude (E/W) 050 58.135'

Recovered by Pietro/Mashbrook/Lastinger Recorder/Observer S. Bigorre

Ship and Cruise No. RB 20-01 Actual duration 583 days

Distance from waterline to buoy deck 75 cm

1

ARRAY NAME AND NO. NTAS 17 MOORED STATION NO.________

Surface Components

Buoy Type MOB **Color(s) Hull Tower** Blue hull, yellow deck, White tower

Buoy Markings________________________________

Surface Instrumentation

Item	ID #	Height*	Comments
ASIMET logger	L05		PORT side, System 1.
HRH	258	238	
BPR	234	242	
WND	221	265	
PRC	235	244	
LWR	253	279.5	
SWR	213	279.5	Forward on center line.
SST	3601		SBE37.
Iridium	J10F2S		IMEI 300234063854580
ASIMET logger	L03		STBD side. System 3 (spare)
HRH	299	238	
BPR	213	242	
WND	210	265	
PRC	214	244	
LWR	221	279.5	
SWR	208	279.5	Aft on centerline.
SST	3604		SBE37.
Argos PTT	12785		IDs 15448, 15449, 15450.
Standalones:			
VWX	202	254	On centerline, front.
Lascar	10021028	198	PORT and MID buoy.
SBE39 AT	716	220	PORT side and FWD.
Rotronic HRH/AT	~~20208420~~ 12718277	241	Young shield. PORT and AFT.
Rotronic HRH AT	12718282	241	Barani shield. STBD and AFT

*Height above buoy deck in centimeters

ARRAY NAME AND NO. NTAS 17 MOORED STATION NO.__________

Subsurface Instrumentation on Buoy and Bridle

Item	ID #	Depth†	Comments
SST SBE56	7206	80	FWD
SST SBE56	7207	90	FWD
SST SBE56	7208	90	PORT
SST SBE56	7209	90	STBD
WAMDAS	6014		NDBC # 26829
			IMEI 3002 2401 0100 810
			S/N 89881 69312 00205 1278
			3DM-GX1 8470
			IR 6004 NDBC 25723
			NDBC Station 41060
			S/N SN 432 S/N IMEI 3002 2401 0237 100
Xeos KILO			3002 3406 1853 510 (Subsfce)
Xeos MELLO			3000 3401 3707 580 (surface)

†Depth below buoy deck in centimeters

ARRAY NAME AND NO. NTAS 17 MOORED STATION NO.___________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		buoy			1442	1910	
2	5	EM chain				1910	
3		SBE39	5	3479	1436	1922	
4		Nortek ADCM	5.7	12688	1436	1922	
5	79	7/16" wire					
6		SBE37 IM	10	13409	1430	1924	
7		Nortek ADCM IM	13	12309	1430	1924	w vane, heads up
8		SBE39	15	7680	1430	1924	
9		SBE39	20	7681	1430	1924	
10		Nortek ADCP	24	12393	1430	1924	
11		SBE 37 IM	25	13410	1430	1924	
12		SBE39	30	7682	1430	1924	
13		SBE39	35	7683	1442	1924	
14		SBE 37 IM	40	13411	1443	1924	
15		SBE 39	45	7684	1443	1924	
16		SBE39	50	7687	1448	1751	wire cut above @ rcvry
17		SBE37 IM	55	13412	1449	1750	
18		SBE39	60	7688	1450	1750	
19		SBE39	65	7689	1452	1749	
20		SBE37 IM	70	13413	1456	1748	
21		SBE39	75	7690	1458	1746	
22		SBE39	80	7691	1503	1745	
23		RDI ADCP	85	23281	1507		No ADCP in cage (faulty instr/battery)
24	500	3/8" wire					
25		SBE39	90	7692	1508	1738	

ARRAY NAME AND NO. NTAS 17 MOORED STATION NO.

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26		SBE39	100	7693	1509	1738	
27		SBE39	110	7694	1511	1736	
28		Starmon Oddi	110	5275	1511	1736	
29		Starmon Oddi	120	5276	1512	1735	
30		Starmon Oddi	130	5277	1513	1734	
31		Starmon Oddi	140	5278	1514	1733	
32		Starmon Oddi	150	5279	1515	1732	
33		Starmon Oddi	160	5280	1516	1731	
34	500	3/8" wire			1529	1715	
35	500	3/8" wire			1544	1702	
36	200	3/8" wire			1559		
37	100	3/8" wire			1605		} encapsulated termination.
38	200	7/8" nylon			1610		}
39	500	7/8" nylon			1635	1640	
40	2000	3/4" nylon				1630	
41	100	7/8" nylon					
42	1500	1" Colmega			1725	1530	
43		Glass balls (56)			1820	1420	~~卌 卌~~ IIII 3 broken balls at recovery
44		SBE37	4983	11380	2038	1401	} dualed on load bar.
45		SBE37	4983	11381	2038	1401	}
46	5	1/2" chain					
47		acoustic release		51915	2039	1403	} dualed.
48		acoustic release		48277	2039	1403	}
49	5	1/2" chain					
50	20	1" Samson Nystron					

ARRAY NAME AND NO. NTAS17 MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
51	5	1/2" chain			2053		
52		anchor			2053		7000 lbs dry (6000 lbs wet)
53							
54							
55							
56							
57							
58							
59							
60							
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
75							

Appendix 2: NTAS 18 Mooring Log

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. NTAS 18 MOORED STATION NO. ______

Launch (anchor over)

Date (day-mon-yr) 10-01-20

Time 17:45 UTC

Deployed by Pietro / Hasbrouck

Recorder/Observer Bigorre

Ship and Cruise No. Ron Brow RB 20-01

Intended Duration 365 days

Depth Recorder Reading 5018 m

Correction Source historical sound speed 1511 m s⁻¹ (not 1500)

Depth Correction +37 m

Corrected Water Depth 5055 m

Magnetic Variation (E/W) ______

Anchor Drop Lat. (N/S) 14° 44.728'

Lon. (E/W) 050° 56.488'

Surveyed Pos. Lat. (N/S) 14° 44.581'

Lon. (E/W) 050° 56.706'

Argos Platform ID No. ______

Additional Argos Info on pages 2 and 3

Acoustic Release Model Edgetech 8242XS

Tested to 2,000 m

Release No. 1 (sn)	30844	Release No. 2 (sn)	33041
Interrogate Freq.	11 kHz	Interrogate Freq.	11
Reply Freq.	12 kHz	Reply Freq.	12
Enable	166475	Enable	314277
Disable	166504	Disable	314306
Release	151330	Release	332235

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 ~~70~~ 75 cm

1

ARRAY NAME AND NO. NTAS 18 MOORED STATION NO.________

Surface Components

Buoy Type MOB Color(s) Hull Tower Blue hull, Yellow deck, white tower

Buoy Markings If found adrift, contact Woods Hole Oceanographic Institution, Woods Hole MA 02543 USA, 508 457 1401

Surface Instrumentation

Item	ID #	Height*	Comments
ASIMET logger	L16		Port side
HRH	223	231	
BPR	216	240	
WND	225	266	
PRC	210	254	
LWR	206	283	
SWR	214	283	
SST	3602		SBE 37
Iridium	J10CZM		imei 3002 3406 3167 170
ASIMET logger	L12		Starboard side
HRH	246	231	
BPR	240	240	
WND	344	266	
PRC	702	254	
LWR	256	283	
SWR	215	283	
SST	1419		SBE 37
Iridium	J10D2M		imei 3002 3406 3164 170
Standalone WXT	209	248 (white ring)	
SA Lascar AT/HRH	32208	200	
SA SBE39 AT	1446	229	
CAMPBELL HRH		231	
CAMPBELL BPR		217	
CAMPBELL PRC		254	
CAMPBELL LWR		282.5	
CAMPBELL SWR		282.5	

*Height above buoy deck in centimeters

2

ARRAY NAME AND NO._________ MOORED STATION NO._________

Subsurface Instrumentation on Buoy and Bridle

Item	ID #	Depth†	Comments
SST SBE 56	6980	85	FWD (Bow)
SST SBE 56	6981	95	FWD (Bow)
SST SBE 56	6979	92	Port (315°)
SST SBE 56	6982	92	Starboard (045°)
WANDAS	4003		
Brizzo	116		imei 3001 2506 0055 060
SIM	1		imei 3002 2401 0043 720
Xeos kilo			3002 3406 2644 350
Xeos Melo			3000 3401 3709 960
Xeos Rover			3004 3406 3297 420
Xeos Rover			3004 3406 3547 190

†Depth below buoy deck in centimeters

ARRAY NAME AND NO. NTAS 18 MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		buoy			1240		
2	5	EM chain					
3		SBE39	5	8743	1239		
4		Nortek ADCM	5.7	9407	1239		
5		RBR Solo-D	6 m	78197	1239		
6	79	7/16" wire					
7		SBE37 IM	10	669	1239		inductive, clamped
8		Nortek ADCM	13	5973	1239		inductive, clamped
9		SBE39	15	7697	1239		clamped
10		SBE39	20	7695	1239		clamped
11.		Nortek ADCP	24	12391	1239		clamped
12		SBE37 IM	25	683	1239		inductive, clamped
13		SBE39	30	8744	1239		clamped
14		SBE39	35	8745	1239		clamped
15		SBE37 IM	40	684	1241		inductive, clamped
16		SBE39	45	8746	1243		clamped
17		SBE39	50	8747	1248		clamped
18		SBE37 IM	55	685	1249		inductive, clamped
19		SBE39	60	8748	1254		clamped
20		SBE39	65	8749	1256		clamped
21		SBE37 IM	70	686	1258		inductive, clamped
22		SBE39	75	8750	1300		clamped
23		SBE39	80	8751	1306		clamped
24		RBR Solo-D	83	78198	1308		clamped
25		RDI ADCP	85	23281	1308		upward looking

ARRAY NAME AND NO. NTAS 18 MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26	500	3/8" wire					
27		SBE39	90	8752	1308		clamped
28		SBE39	100	8753	1313		clamped
29		SBE39	110	8754	1316		clamped
30		Star-Oddi	110	5282	1316		clamped
31		Star-oddi	120	5283	1318		clamped
32		Star-oddi	130	5284	1319		clamped
33		Star-oddi	140	5285	1320		clamped
34		Star-oddi	150	5286	1322		clamped
35		Star-oddi	160	5287	1322		clamped
36	500	3/8" wire					
37	500	3/8" wire			1339		
38	200	3/8" wire			1407		
39	100	3/8" wire			1418		} encapsulated termination
40	200	7/8" nylon					}
41	500	7/8" nylon			1440		} spliced at sea
42	2000	3/4" nylon					}
43	100	7/8" nylon					}
44	1500	1" Colmega			1510		
45		glass balls (56)			1630 (end)		~~IIII~~ ~~IIII~~ IIII
46	5	SBE37	5017	11392	1740		} Deep T/S for OSITES on load bar
47		SBE37	5017	11393	1740		}
48	5	1/2" chain					
49		acoustic release		30844	1742		} dualed
50		acoustic release		33041	1742		}

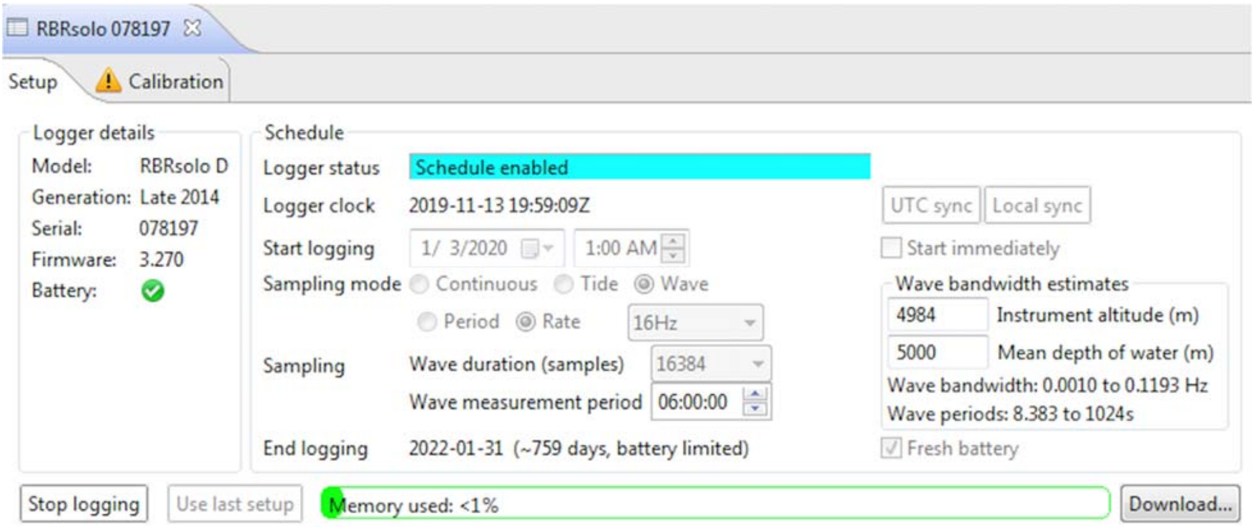
ARRAY NAME AND NO. NTAS 18 MOORED STATION NO. ______

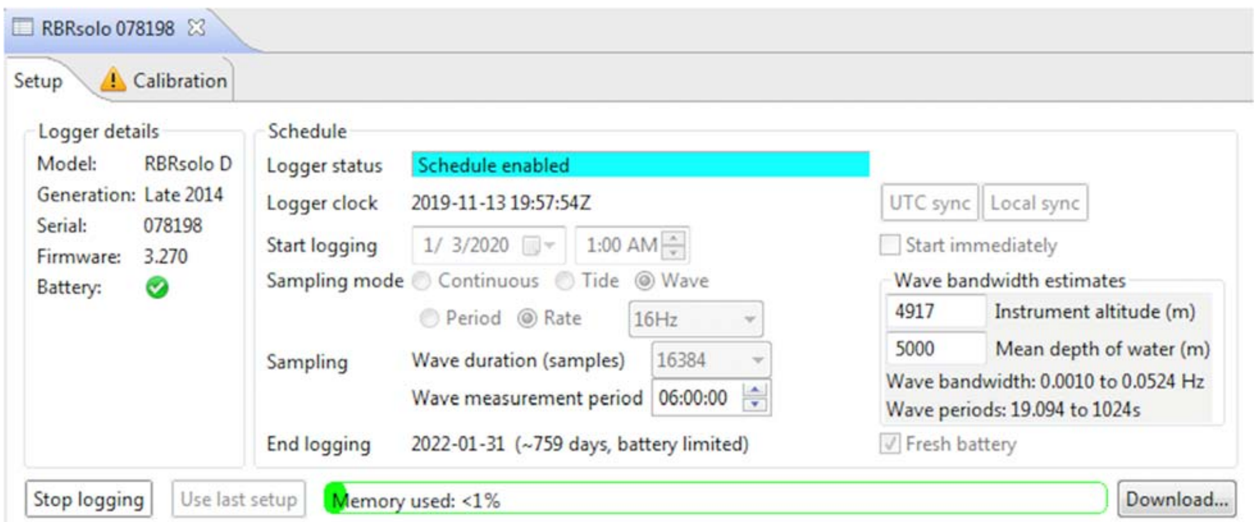
5018

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
51	5	1/2" chain					
52	20	1" Nystron					
53	5	1/2" chain					
54		anchor			1745	~~174~~	air weight ~7,000 lbs
55							
56							
57							
58							
59							
60							
61							
62							
63							
64							
65							
66							
67							
68							
69							
70							
71							
72							
73							
74							
75							

Appendix 3: NTAS 18 Instrument Setup

RBR Solo D 78197 (6 m) and 78198 (83 m):





Starmon ODDI:

Filename: C:\Software\Star-Oddi\SeaStar\Starmon mini\T5284\T5284.RDT

SeaStar 7.13

Recorder type : Starmon mini
Recorder number : T5284
Recorder version : 23 CRC8/38400/HighRes
Recorder measures : Temperature
Recorder memory(byte/meas.) : 524063 / 349375

Measurement sequence number : 2
Recorder started from PC : 11/21/19 8:08:24 PM

Measurement interval def. : Single interval = 00:10:00
Measurement start time : 1/3/20 1:00:00 AM

Measurement settings: [dd:hh:mm:ss] x number

Start delay : 42:04:51:36
1. interval period : 00:10:00 x 25700
2. interval period : 00:10:00 x 100
Estimated time duration and battery usage for NMS

Battery energy at start (%): 82.6

Cycle 1

Seq/Inr	Date&Time	Batt.used(%)	Mem.used(%)	Meas.taken	Temp
1/1	4/2/21 3:30:00 AM	5	25	65535	
2/2	7/1/22 6:00:00 AM	11	50	131070	

Cycle 2

Seq/Inr	Date&Time	Batt.used(%)	Mem.used(%)	Meas.taken	Temp
1/1	9/29/23 8:30:00 AM	16	75	196605	

Memory full : 12/26/24 5:00:00 PM
After (days:hours) : 1819:16
In Cycle : 2
In sequence : 2
In Interval : 1
In measurement : 65427
Total meas. taken : 262032
Battery used (%) : 22.2
Battery left (%) : 60.4

TRDI ADCP 23281 (85 m):

```
CR1
CF11101
EA0
EB0
ED850
ES35
EX11111
EZ1111101
WA50
WB0
WD111100000
WF300
WN25
WP180
WS400
WV175
TE01:00:00.00
TP00:01.00
TF20/01/03 01:00:00
CK
CS
;
;Instrument        = Workhorse Sentinel
;Frequency         = 307200
;Water Profile     = YES
;Bottom Track      = NO
;High Res. Modes   = NO
;High Rate Pinging  = NO
;Shallow Bottom Mode= NO
;Wave Gauge        = NO
;Lowered ADCP      = NO
;Ice Track         = NO
;Surface Track     = NO
;Beam angle        = 20
;Temperature       = 5.00
;Deployment hours  = 12960.00
;Battery packs     = 3
;Automatic TP      = NO
;Memory size [MB]  = 256
;Saved Screen      = 2
;
;Consequences generated by PlanADCP
version 2.06:
;First cell range  = 7.41 m
;Last cell range   = 103.41 m
;Max range         = 104.17 m
;Standard deviation = 0.26 cm/s
;Ensemble size     = 654 bytes
;Storage required  = 8.08 MB (8475840
bytes)
;Power usage       = 1078.36 Wh
;Battery usage     = 2.4
;
; WARNINGS AND CAUTIONS:
; Advanced settings have been changed.
; Expert settings have been changed.
```

Nortek current meter 9407 (5.7 m):

```
Deployment   : N18
Current time : 11/13/19 6:10:24 PM
Start at     : 1/3/20 1:00:00 AM
Comment:
AQD 9407, 5.7m, N18, 2 Li BATS
---------------------------------------------------
Measurement interval  (s) : 1200
Average interval      (s) : 180
Blanking distance     (m) : 1.01
Measurement load      (%) : 4
Power level               : HIGH-
Diagnostics interval(min) : 1440:00
Diagnostics samples       : 100
Compass upd. rate     (s) : 1
Coordinate System         : ENU
Speed of sound      (m/s) : MEASURED
Salinity            (ppt) : 36
Analog input 1            : NONE
Analog input 2            : NONE
Analog input power out    : DISABLED
Raw magnetometer out      : OFF
File wrapping             : OFF
TellTale                  : OFF
AcousticModem             : OFF
Serial output             : OFF
Baud rate                 : 9600
---------------------------------------------------
Assumed duration   (days) : 540.0
Battery utilization   (%) : 84.0
Battery level         (V) : 11.2
```

Recorder size (MB) : 9
Recorder free space (MB) : 8.973
Memory required (MB) : 3.7
Vertical vel. prec (cm/s) : 1.4
Horizon. vel. prec (cm/s) : 0.8

Instrument ID : AQD 9407
Head ID : AQD 4758
Firmware version : 3.39

Aquadopp Version 1.40.14
Copyright (C) Nortek AS
==================================

Nortek current meter 5973 (13 m):

Deployment : N18
Current time : 11/13/19 6:53:56 PM
Start at : 1/3/20 1:00:00 AM
Comment:
AQD-5973, NTAS 18, 13m, SIM ID# 041, 2 Li BATS

Measurement interval (s) : 1200
Average interval (s) : 180
Blanking distance (m) : 0.35
Measurement load (%) : 4
Power level : HIGH-
Diagnostics interval(min) : 1440:00
Diagnostics samples : 50
Compass upd. rate (s) : 1
Coordinate System : ENU
Speed of sound (m/s) : MEASURED
Salinity (ppt) : 36
Analog input 1 : NONE
Analog input 2 : NONE
Analog input power out : DISABLED
Raw magnetometer out : OFF
File wrapping : OFF
TellTale : OFF
AcousticModem : OFF
Serial output : OFF
Baud rate : 9600

Assumed duration (days) : 540.0
Battery utilization (%) : 85.0
Battery level (V) : 11.1
Recorder size (MB) : 9
Recorder free space (MB) : 8.973
Memory required (MB) : 2.7
Vertical vel. prec (cm/s) : 1.4
Horizon. vel. prec (cm/s) : 0.8

Instrument ID : AQD 5973
Head ID : ALD 3619
Firmware version : 3.36

Inductive modem : ENABLED
Device ID : 41
Transmit power level : HIGH
Data format : ASCII
Coupler impedance : Z = 1469

Aquadopp Version 1.40.14
Copyright (C) Nortek AS
==================================

Nortek ADCP 12391 (24 m):

Deployment : N18
Current time : 11/13/19 6:37:16 PM
Start at : 1/3/20 1:00:00 PM
Comment:
600kHz profiler, 24m, AQD 12391, N18, 2 Li BATS

Profile interval (s) : 3600
Number of cells : 15
Cell size (m) : 2.00
Blanking distance (m) : 0.50
Measurement load (%) : 25
Average interval (s) : 240
Power level : HIGH
Wave data collection : DISABLED
Compass upd. rate (s) : 1
Coordinate System : ENU
Speed of sound (m/s) : MEASURED
Salinity (ppt) : 36
Analog input 1 : NONE
Analog input 2 : NONE

Analog input power out : DISABLED
File wrapping : OFF
TellTale : OFF
Acoustic modem : OFF
Serial output : OFF
Baud rate : 9600

Assumed duration (days) : 540.0
Battery utilization (%) : 98.0
Battery level (V) : 11.1
Recorder size (MB) : 3773
Recorder free space (MB) : 3772.972
Memory required (MB) : 2.1
Vertical vel. prec (cm/s) : 0.5
Horizon. vel. prec (cm/s) : 1.6

Instrument ID : AQD12391
Head ID : AQP 7427
Firmware version : 3.40
ProLog ID : 1062
ProLog firmware version : 4.22

SD Card Inserted : YES
SD Card Ready : YES
SD Card Write protected : NO
SD Card Type : SDHC
SD Card Supported : YES

AquaPro Version 1.37.08
Copyright (C) Nortek AS
==================================

Subsurface Instrumentation Deployment configurations: (next page)

NTAS 18 Subsurface

INSTRUMENT	SERIAL	IM ADDRESS	DEPTH (m)	SAMPLE RATE (s)	SAMPLE START DATE	SAMPLE START TIME	SPIKE DATE	SPIKE START TIME	SPIKE STOP TIME
SBE 37 IM	669	3	10	600	20200103	0100	20200108	19:44	
SBE 37 IM	683	4	25	600	20200103	0100	20200108	20:43	
SBE 37 IM	684	5	40	600	20200103	0100	20200108	21:45	
SBE 37 IM	685	7	55	600	20200103	0100	20200108	22:43	
SBE 37 IM	686	8	70	600	20200103	0100	20200108	23:40	
SBE 37 Deep	11392		4962	300	20200103	0100	20200108	1807	1832
SBE 37 Deep	11393		4962	300	20200103	0100	20200108	1807	1832
SBE 39	8743		5	300	20200103	0100	20200108	18:34	20:10
SBE 39	7697		15	300	20200103	0100	20200108	18:34	20:10
SBE 39	7695		20	300	20200103	0100	20200108	18:34	20:10
SBE 39	8744		30	300	20200103	0100	20200108	18:34	20:10
SBE 39	8745		35	300	20200103	0100	20200108	18:34	20:10
SBE 39	8746		45	300	20200103	0100	20200108	18:34	20:10
SBE 39	8747		50	300	20200103	0100	20200108	18:34	20:10
SBE 39	8748		60	300	20200103	0100	20200108	18:34	20:10
SBE 39	8749		65	300	20200103	0100	20200108	18:34	20:10
SBE 39	8750		75	300	20200103	0100	20200108	18:34	20:10
SBE 39	8751		80	300	20200103	0100	20200108	18:34	20:10
SBE 39	8752		90	300	20200103	0100	20200108	18:34	20:10
SBE 39	8753		100	300	20200103	0100	20200108	18:34	20:10
SBE 39	8754		110	300	20200103	0100	20200108	18:34	20:10
SBE 56	6979		0.2	60	20200108	1822	20200108	1823	1831
SBE 56	6980		0.1	60	20200103	0100	20200108	1808	1831
SBE 56	6981		0.2	60	20200103	0100	20200108	1808	1831
SBE 56	6982		0.1	60	20200103	0100	20200108	1808	1831
Star-Oddi	5282		110	600	20200107	2100	20200108	2027	2205
Star-Oddi	5283		120	600	20200107	2100	20200108	2027	2205
Star-Oddi	5284		130	600	20200103	0100	20200108	2027	2205
Star-Oddi	5285		140	600	20200107	2100	20200108	2027	2205
Star-Oddi	5286		150	600	20200103	0100	20200108	2027	2205
Star-Oddi	5287		160	600	20200107	2100	20200108	2027	2205
Nortek ADCM	9407		5	240/3600	20200103	0100	20200108	2324	0016
Nortek ADCM - IM	5973	41	13	180/1200	20200103	0100	20200108	2040	2205
Nortek ADCP	12391		24	180/1200	20200103	0100	20200108	2324	0016
RBR Solo D	78197		6	6hrs	20200103	0100			
RBR Solo D	78198		83	6hrs	20200103	0100			
TRDI 300 kHz	23281		85	180/3600	20200103	0100	20200108	1745	1820