WHOI-2020-03

Woods Hole Oceanographic Institution

Stratus 18

Eighteenth Setting of the Stratus Ocean Reference Station
Cruise On Board RV *Cabo de Hornos*
April 8 - 27, 2019
Valparaiso, Chile - Valparaiso, Chile

by

Sebastien Bigorre,[1] Emerson Hasbrouch,[1] Benjamin Pietro,[1] Francesca Search,[2]
Sasha Alquinta,[2] Sergio Pezoa,[3] Nicolas Llanos,[1]

Woods Hole Oceanographic Institution
Woods Hole, MA 02543

October 2019

Technical Report

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Upper Ocean Processes Group
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
UOP Technical Report 2020-01

1 Woods Hole Oceanographic Institution, Woods Hole, MA
2 Universidad de Concepción, Chile
3 Environmental Systems Research Laboratory NOAA

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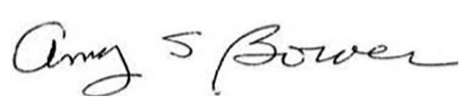

Amy Bower, Chair

Department of Physical Oceanography

Abstract

The Ocean Reference Station at 20°S, 85°W under the stratus clouds west of northern Chile is being maintained to provide ongoing climate-quality records of surface meteorology, air-sea fluxes of heat, freshwater, and momentum, and of upper ocean temperature, salinity, and velocity variability. The Stratus Ocean Reference Station (ORS Stratus) is supported by the National Oceanic and Atmospheric Administration's (NOAA) Climate Observation Program. It is recovered and redeployed annually, with past cruises that have come between October and May. This cruise was conducted on the Chilean research vessel *Cabo de Hornos*.

During the 2019 cruise on the *Cabo de Hornos* to the ORS Stratus site, the primary activities were the recovery of the previous (Stratus 17) WHOI surface mooring, deployment of the new Stratus 18 WHOI surface mooring, in-situ calibration of the buoy meteorological sensors by comparison with instrumentation installed on the ship, CTD casts near the moorings. Ancillary tasks performed were the deployments of surface drifters and ARGO floats along the track.

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Introduction

A. Timeline

Stratus 18 was conducted on the Chilean Navy Research Vessel AGS 61 *Cabo de Hornos*, with the plan of sailing from Valparaiso, Chile to the Stratus site and back to Valparaiso. The ship left Valparaiso, Chile on the morning of April 8, 2019 and returned to Valparaiso on the evening of April 27, 2019. The *Cabo de Hornos* is operated by the Chilean Navy with scheduling oversight by the Chilean National Oceanographic Committee (CONA). The charter of the vessel is done through a contract between WHOI and the Chilean Navy (Armada de Chile). Contract negotiations addressed the dates of the cruise and the status of the equipment on the vessel. The cruise continued an ongoing cooperation between the WHOI Upper Ocean Process Group (UOP) and the Servicio Hidrografico y Oceanografico de la Armada de Chile (SHOA).

The track (Figure 1-1) was set to first deploy the Stratus 18 mooring then recover the Stratus 17 mooring which was drifting, and complete work at the Stratus site before returning back to Valparaiso, Chile. WHOI Upper Ocean Processes Group staff left Boston for Chile, on March 29. Twenty-nine surface drifters were deployed for NOAA AOML and 7 drifters for the Universidad de Valparaiso; and 6 Argo floats were deployed for the WHOI Argo group. An overview of the chronology of the cruise is provided below. Local time at the beginning of the cruise was UTC -4, and was changed to UTC -5 on April 10 at 16:00 local, then again to UTC -6 on April 16 at 16:00 local, UTC -5 on April 20 at 18:00 local.

March 29-30, Friday-Saturday: UOP personnel travel from WHOI to Valparaiso.

April 1, Monday: security and safety training at TPS. First two containers delivered at staging area in port area managed by TPS. Assembly buoy, meteorological system acquisition and telemetry started. Weller, Bigorre, and the agent from Broom met with Captain and ship's officers on *Cabo de Hornos*.

April 2, Tuesday: continue buoy assembly and pCO_2 system, setup computers with navigation, printers, satellite communications, update Matlab, etc.

April 3, Wednesday: buoy data download.

April 4, Thursday: buoy spin. Final container with Hazmat.

April 5, Friday: meeting with SHOA and CONA directors and science presentations at SHOA.

April 6, Saturday: 0637, Cabo leaves Navy and sails across harbor to TPS pier. Ship loading.

April 7, Sunday: Setup deck and lab. Board ship in evening.

April 8, Monday: 0030 depart Valparaiso. Drifters deployment for Universidad de Valparaiso every 11 nm. 1330, orientation meeting. Exit EEZ in evening. 2216, deployed two drifters.

April 9, Tuesday: 0715-0750: CTD test to 500 m outside EEZ. 0810-1010 CTD cast #1 to 2,000 m, with acoustic releases for testing. Data download, then buoy tipped. 1310, deployed one drifter. 1345, re-entered EEZ around San Felix island.

April 10, Wednesday: continue transit towards Stratus 18 deployment site. Mooring line spooled on starboard split net drum. Removed 350 m from Colmega to accommodate shallower ocean depth at Stratus 18. subsurface instrumentation spiked. Final test for pCO_2 system. SSTs mounted on buoy bridle. 1600, turn back clocks one hour to UTC -5.

April 11, Thursday: 1220-1320, sound velocity profile to 1,000 m from T-frame and hydrographic winch. 1400, start bathymetry survey with Multibeam.

April 12, Friday: 0612, bathy survey ends. Start a deployment mock run for training: 0713 set and drift; 0900 ship 10 nm from deployment target and holds station for ½ hour using Dynamic Positioning; 0930, ship starts slow track towards target. After a few hours, ship has made several sharp turns to test different ways of maintaining course and low speed. 1315, meeting with Captain about deployment. 1330, pre-deployment and walk through on back deck with all personnel involved in deployment. 1620, ship now starts real test and is able to maintain low speed (one knot) and constant bearing towards target for several hours. 1645, buoy met sensors spiked.

April 13, Saturday: 0608, wind 13 kts, 136° T. 0700, set and drift 12 nm downwind of target. Ship repositions to start of deployment track, 10 nm downwind of target. 0840, wind has turned a bit (same as yesterday), so we reposition slightly. 0921, first instrument in water. 1843, anchor drop. One hour after drop, anchor survey. Ship then stays on station downwind of buoy for intercomparison. 2347, intercomparison stops as ship leaves area for search and rescue mission to the southwest.

April 14, Sunday: In the morning, ship transits SW then W towards search and rescue area. Around noon, search and rescue mission cancelled. Ship re-routes towards Stratus 17 drifting buoy to the NW. Ship speed varies between 12 and 14 kts.

April 15, Monday: Continue transit towards Stratus 17 buoy. 1542, time on TSG computer changed to UTC.

April 16, Tuesday: 1600, clocks turned back one hour to UTC -6. Gillson line passed through block under A-frame. 1430, drills (evacuation and loss of remote steering).

April 17, Wednesday: 0200, drifter deployed at 100° W. 0800, drifter at 101° W. 1100, meeting with Captain and officers about recovery. 1330, drifter at 102° W. Clocks on SHOA's two CTD instruments (Seabird 9+ and 19) reset to UTC. 1600, pre-recovery and walk through on back deck.1900, drifter at 103° W. 2300, alarm in engine room about power to generators; ship power turned off for 1 ½ hour.

April 18, Thursday: A bit after midnight, drifter deployed at 104° W. 0730, ship arrives within 1.5 nm of last known buoy position. 0745, ship within 2 nm of drifting Stratus 17 buoy. Ship stops 1 nm from buoy for acoustic communications with releases, which do not respond so they are probably not on the drifting mooring. 0900, small boat launched with UOP personnel to go remove HRH instruments in outboard brackets on buoy, and attach line to pickup bail. 0920, ship makes wide turn to get closer to buoy and small boat. 0945, ship backs up towards buoy and small boat. When ship is about 10 m from buoy, Gillson line under A-frame transmitted to small boat and connection made to line on buoy. Ship then stays on DP about 20 m ahead from buoy until end of recovery. UOP personnel come back onboard and small boat remains in the water with two Armada folks inside. 1020, buoy on deck. 1536, recovery of top part of mooring ends. Line is broken not far below VMCM at 1506 m, about 5 m below the top termination of the first 500 m shot of wire. CTD after recovery.

April 19, Friday: 0554, drifter deployed. 1325, first ARGO float, SN 7496. Clean up of recovered instruments and hardware.

April 20, Saturday: 0542, launched second ARGO float, SN 7531. 0734, drifter. 1800, move clocks forward one hour, to UTC -5. 1900, drifter deployed. Rain shower. 2256, deployed third ARGO float, SN 7524; followed by drifter at 95° W.

April 21, Sunday: 0915, offspooling wire from starboard split net drum; only 1/3 reel offspooled as wire catches on termination on the drum and winch operator does not stops winch on time, so tension cart gets damaged. 0958, drifter #21. 1430, deployed fourth float, SN 7532, and two drifters. 2016, drifter #24.

April 22, Monday: 0820, fifth float, SN 7534, and drifter #25. 1100, meeting with Captain and officers about bottom mooring recovery. 1249 drifter #26. 1330, pre-recovery meeting and walk through on back deck. 1746, drifter #27.

April 23, Tuesday: 0500, ship in position 400 yards downwind (NW) of Stratus 17 anchor. 0530, test acoustic communications with acoustic releases gives no result. Ship changes location, first to the East, then South of anchor. Finally, ship goes above anchor position and we can communicate with releases, so we trigger releases (0715 UTC -5) and relocate 470 to NNE of anchor. 0758, glass balls pop up on ship starboard beam, 700 m away. Ship on DP, launch small boat, recovery starts; recovery ends at 1634 with end of broken wire back on deck. Ship then steams towards Stratus 18 buoy.

April 24, Wednesday: Ship arrives at Stratus 18 buoy at 0100 UTC -5, then stay ¼ nm downwind of buoy for intercomparison using DP. Wind weak 10 kts from the West for most of the day. 1400, buoy ride to replace Melo unit with the one recovered from Stratus 17 and add a Rover (also from S17), and take pictures of buoy and waterline (60 cm). 1500, small boat back on deck. 1540, ship moves 1 nm West of buoy for CTD. 1615-1750, on station for CTD to 2,000 m. 1755, ship moves back downwind of buoy.1807, sixth ARGO float launched, SN 7535. 2000 UTC -5, end of intercomparison and science operations at Stratus, ship starts transit towards Valparaiso.

April 25, Thursday: Transit to Valparaiso continues. SOG 14 kts or slightly more for most of the day. Wind 5-10 kts, calm sea. Enter EEZ around San Felix island around 11:00 in the morning. 18:00, clocks moved forward one hour to UTC-4. Ship stops several times due to engine alarms.

April 26, Friday: 0645, wind 9 kts and 134 T, SOG 13.5 kts. Around 1500, exit EEZ. 1600 drifter. ~2000 last drifter.

April 27, Saturday: Enter EEZ in early morning. 0636, wind 14 kts and 173 T, SOG 14.5 kts. Arrive in Valparaiso around 2000. Unload scientific equipment onto commercial pier, then ship moves to Navy pier.

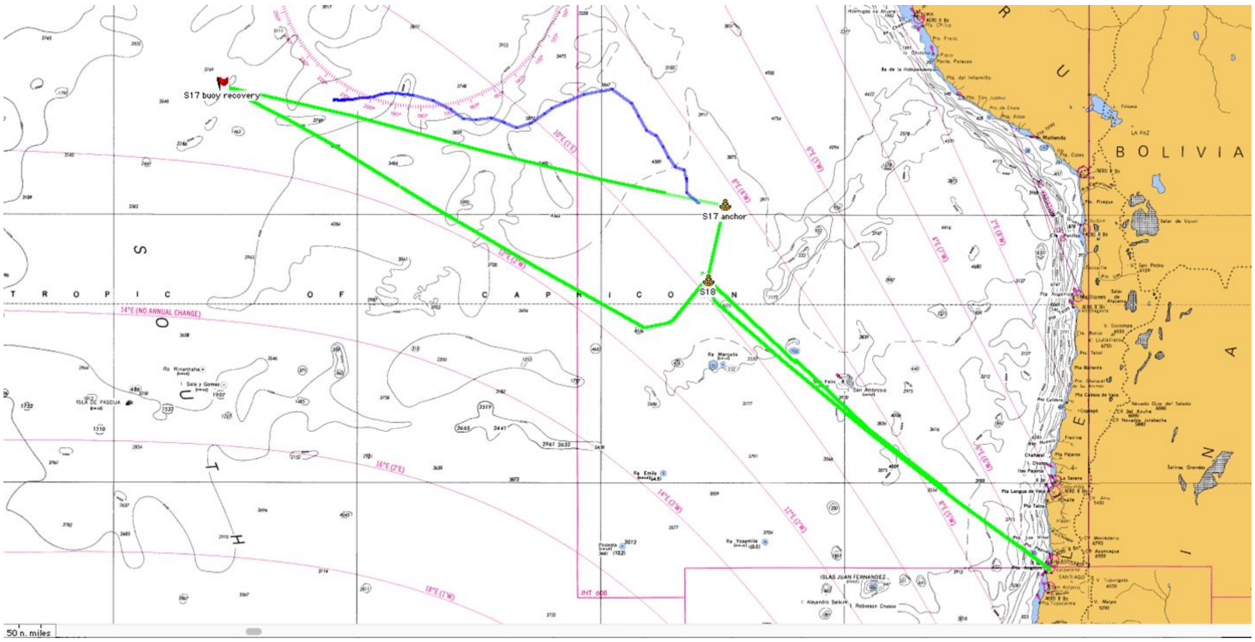


Figure 1-1. Stratus 18 cruise itinerary (green line) Valparaiso – Stratus 18 and 17 – Valparaiso, Chile. Partial track of drifting Stratus 17 buoy (blue line).

B. Background and Purpose

The presence of a persistent stratus deck in the subtropical eastern Pacific is the subject of active research in atmospheric and oceanographic science. Its origin and maintenance are still open to discussion. A better understanding of the processes responsible for this system is desirable not only because better understanding of the nature of air-sea interactions in this region is needed, but also because climate models presently have SST fields that are too warm in the eastern South Pacific. There is also the need to collect in-situ data to provide ground truth for remote sensing.

The Ocean Reference Station (ORS) at 20°S, 85°W under the stratus clouds west of northern Chile is being maintained to provide ongoing, climate-quality records of surface meteorology, of air-sea fluxes of heat, freshwater, and momentum, and of upper ocean temperature, salinity, and velocity variability. The Stratus Ocean Reference Station (ORS Stratus) is supported by the National Oceanic and Atmospheric Administration’s (NOAA) Climate Observation Program. It has been recovered and redeployed annually, with cruises that have come between October and May. The Stratus 17 mooring was deployed in April 2018. Its replacement, Stratus 18 mooring, was installed on April 13 2019 during the Stratus 18 cruise, which is detailed in this report.

During the 2019 Stratus cruise on the Chilean research ship *Cabo de Hornos*, the primary activities were recovery of the WHOI Stratus 17 surface mooring, deployment of the new WHOI Stratus 18 surface mooring at a slightly different site. The Stratus 17 mooring broke in August 2018 and the surface buoy and upper part of the mooring had been drifting since then. Recovery of Stratus 17 was therefore done in two operations, going first for the upper mooring, which was drifting, and later on retrieving the bottom part of the mooring that was still at the anchor site. At the Stratus 18 mooring, in-situ calibration of the buoy meteorological sensors was done through comparison with WHOI stand-alone meteorological sensors mounted on the ship, a meteorological system provided by ESRL, and a Vaisala weather station that is part of the ship's monitoring system. CTD casts were also done near the Stratus 18 surface mooring for comparison with newly deployed instruments. No casts were performed near Stratus 17 due to the risk of entanglement and lack of time. As an ancillary project, surface drifters and Argo floats were launched all along the ship's track during the cruise.

The ORS Stratus buoys are equipped with two Improved Meteorological (IMET) systems, which provide surface wind speed and direction, air temperature, relative humidity, barometric pressure, incoming shortwave radiation, incoming longwave radiation, precipitation rate, and sea surface temperature and salinity. The buoy is outfitted with a PCO_2 sampling system from Chris Sabine (NOAA Pacific Marine Environmental Laboratory, PMEL). It also contains a wave-measuring package designed by NDBC. The IMET data are made available in near real time using satellite telemetry. The mooring line carries instruments to measure ocean salinity, dissolved oxygen, temperature, and currents.

The Stratus 18 buoy was assembled and tested after shipping and final preparations to its moored instrumentation were carried out. Equipment for the Stratus 18 was therefore loaded onto the *Cabo de Hornos* in Valparaiso on April 6, 2019 and pre-deployment preparation was completed on board the ship in port in Valparaiso. The cruise ended in Valparaiso, where the Stratus gear was unloaded and the science party returned home.

I. Cruise Preparations

A. Staging and Loading

On the morning of Monday April 1, two containers were delivered to a staging area managed by TPS, in the eastern part of the port. A forklift and stevedores were available to assist with the unloading of containers. The buoy tower top, and hull were assembled with the forklift. The anchor modules were also assembled using the forklift. Some equipment was shuffled back into the containers. One container was set up with tables and chairs to serve as a lab space for preparations. Weller, Bigorre and San Martin (Broom representative) had a meeting with the officers onboard the *Cabo de Hornos* at the Navy pier. Introductions to the ship's officers were made, and details of port operations, loading and cruise details were discussed.

Buoy system was running on April 2 and monitored using telemetry data. The foam components were assembled. PCO_2 system was assembled and tested, with cable issues requiring troubleshooting. An ASIMET data download was performed on April 3.

The equipment was loaded on the ship on April 6. TPS officials were available to set security perimeters and coordinate with science party needs. Several trucks and a dock cranes were moved further away for our loading operation. Ship moved away from Navy pier and docked to commercial pier at 0900. Removing a few items from fantail (second gangway, bike racks, bags with rope) delayed slightly the load. A shore crane was used to get the WHOI gear loaded onto the ship. Three teams conducted the loading, one on the dock along the stevedores, one on the fantail along Armada personnel and one inside the ship to free space from fantail and populate lab spaces. The large freezers onboard were used as storage areas for drifters and instruments boxes. A couple Armada people helped Sergio Pezoa to load ESRL's equipment on the bow of the ship, using the small bow crane. In the afternoon, cables and antennae for GPS and Iridium were installed from 02 deck and run through stuffing tubes into the main lab on 01 deck. The labs were organized and the deck set up and lashed. The ship was under way at 00:30 on April 8.

B. Buoy Spin

Wind sensor function is confirmed with a "buoy spin". A buoy spin is the process by which the vane and compass are co-varied, such that the sum of their orientation is a known bearing. Buoy spins were conducted at WHOI on November 2 2018 and in the port of Valparaiso on April 4 2019. See Figure I- for details of the buoy spin; note that instrument on logger L01 does not have a measurable WDIR difference as System 1 was deployed with a sonic wind sensor, which does not include a physical vane and cannot be oriented towards a fixed bearing like the propeller/vane module on logger L02. Details of buoy spin are in Appendix A.

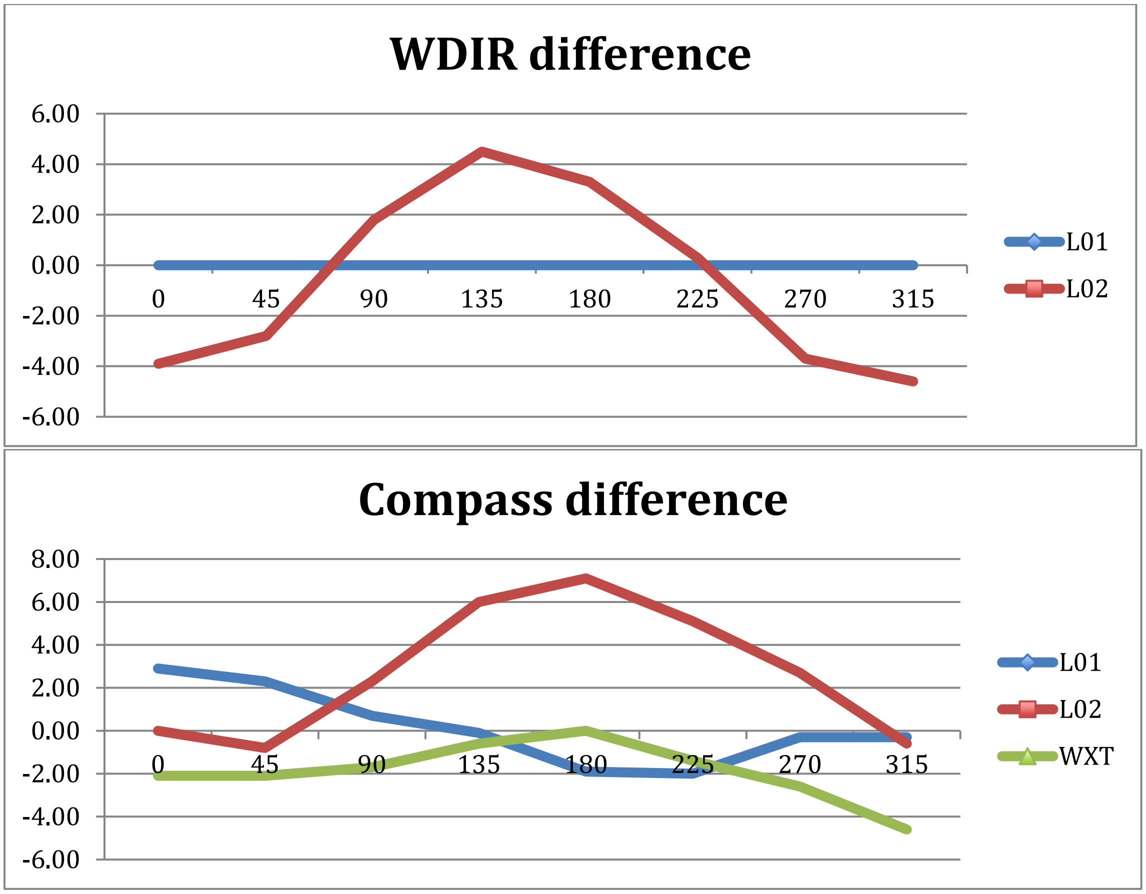
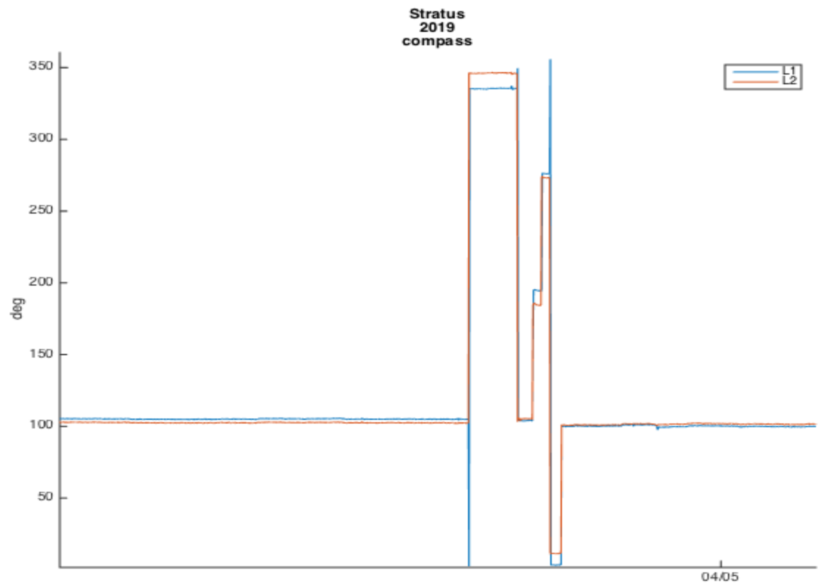


Figure I-2. STRATUS 18 buoy spin on November 2 2018 in Woods Hole. Y-axis: difference between wind direction (L01 and L02), or compass (WXT204), and line-of-sight reference (in degrees). X-axis: angle between buoy and line-of-sight reference (in degrees).

The in-port buoy spin on April 4, 2019 was conducted at a secured worksite on the TPS commercial pier in the port of Valparaiso. The immediate surroundings were not conducive to a successful vane/compass evaluation. Tall container cranes, conex shipping containers, and other heavy machinery surrounded the Stratus18 buoy. Additionally, a large container vessel was berthed directly adjacent (~200 m) to the secured work area provided by the port agent. The reinforced concrete from the pier structure also created a distortion of the local magnetic field. A good indication of the magnitude of the magnetic distortion was observed during the initial set-up of the in-port buoy spin. A compass bearing was attempted to be sighted using landmarks along the shoreline of Valparaiso and a Brunton field compass; the sighting was then verified using Google Maps. Compass sighted heading values were not repeatable. Additionally, the average observed heading and the map indicated bearing were calculated to have a difference of close to 40 degrees (compass heading ~100 degrees, map bearing 140 degrees).



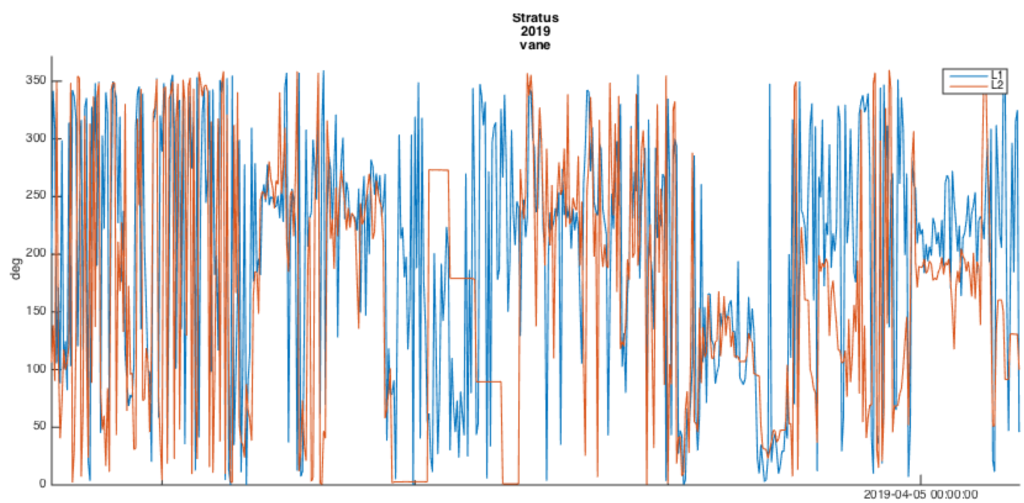


Figure I-3. One-minute data from STRATUS 18 buoy spin on April 4 2018 Valparaiso: compass (top) and wind sensor vane (bottom).

The partial in-port buoy spin was conducted despite the sub-standard environment with the goal of documenting the relative offset in compass heading between each module. Data from the WXT (SN 204) was not downloaded in order to ensure that the instrument compasses would retain the same relative offset as evaluated in the Valparaiso buoy spin. It is imperative that the WTX's post recovery data review includes the buoy spin in Valparaiso, in order to assess the orientation of the instrument with respect to other sensors and the buoy.

C. Sensor Evaluation and Burn-in

During burn-in, the Stratus 18 buoy was mounted with ASIMET (one stand-alone and two primary systems) and other instrumentation in the same configuration as the one planned for deployment, and placed outdoors at WHOI in a clear area. Systems were running, collecting data and telemetry transmitted hourly data. Spare instruments were also mounted on a similar buoy next to Stratus 18. Every two week or so, the data was downloaded and processed to ensure all instrument was functioning properly and that their measurements were accurate. This burn-in occurred in between October and December 2018 and instruments were gradually added to the buoy. Burn-in was interrupted when low outdoors temperatures occurred outdoors and the buoy had to be placed inside the high bay at WHOI. Burn-in and data system were stopped on January 2 2019 for packing and shipping to Chile.

One data download occurred in port in Valparaiso on April 4. This also included a partial buoy spin on the same day, with the buoy rotated in 4 directions about 90 degrees apart form each other. Another data download occurred on the ship on April 9. Wind conditions in port were very low which implies low or no ventilation and diurnal heating on temperature sensors on clear days. On the ship, the buoy was placed on the ship's starboard side during transit. After data download on April 9, buoy was tipped on its chamfered hull, with tower facing aft. Details of setup for instrumentation on Stratus 18 mooring are in Appendix B.

D. Antifouling

General comments: Experience has shown that the fouling potential at STRATUS is extremely high with high amount of barnacle growth on the upper 100 m of instrumentation and the buoy. Instruments below 80 m come up with little more than some sea-slime and are easy to clean up. Copper guards on SBE-37s work best when electrically isolated from the instrument case and are now mandatory on any SBE-37 above ~180m. A few years ago we started to see evidence of birds on the radiometers, so non-magnetized bird wire is now included on the tower top.
SBE-37's conductivity cells and ADCPs' transducer heads on the mooring were covered with Desitin. Desitin has proven to be a safe and effective method to keep biofouling from growing.

Tower top: An "X" of bird wire between the radiometers, standard bird spikes used for PRC and WXT. Additional non magnetic bird wire along the forward rail as a deterrent.
SBE 56 in buoy hull: Apply Aqualube around and inside the protruding probe covers prior to deployment.
SBE-37s on buoy (SST's): Copper sensor guards. Desitin on conductivity cell inside guard and away from cell opening.
SBE-39 on wire or load bars: Paint Desitin on temperature probe.
Workhorse in load cage: Desitin applied to the transducers.

II. Stratus 18 Deployment

A. Mooring Design

The buoys used in the STRATUS project are equipped with surface meteorological instrumentation, including two Improved Meteorological (IMET) systems (see Figure II-1) and standalone sensors. The mooring line below the buoy is heavily equipped with oceanographic instrumentations down to 550 m and one microcat SBE37 at 1,890 m and two more SBE 37s near the bottom (Figure II-2). The radar reflector on the Stratus 18 buoy vane was removed prior to deployment.

After the Stratus 18 mooring was deployed, WHOI technicians who were monitoring systems functions identified that the Melo was missing significant numbers of transmissions. Communications with Xeos suggested an epoch/hardware/firmware compatibility issue. On April 24 2019, a buoy ride was done and the Stratus 18 Melo (IMEI: 300034013207760) was recovered and replaced with the S17 Melo (IMEI: 300034013701980). Additionally, the S17 Rover was installed as a back-up locator beacon should the new S18 Melo undergo similar failure modes.

The beacon is configured to sample every 20 seconds for a duration of 5 minutes, this is repeated every 30 minutes. The 5-minute data is internally logged to the Melo's solid-state on-board memory. Additionally, every four hours the Melo will transmit an SBD message that includes the current latitude and longitude of the Melo unit and the UTC time of the data transmission.

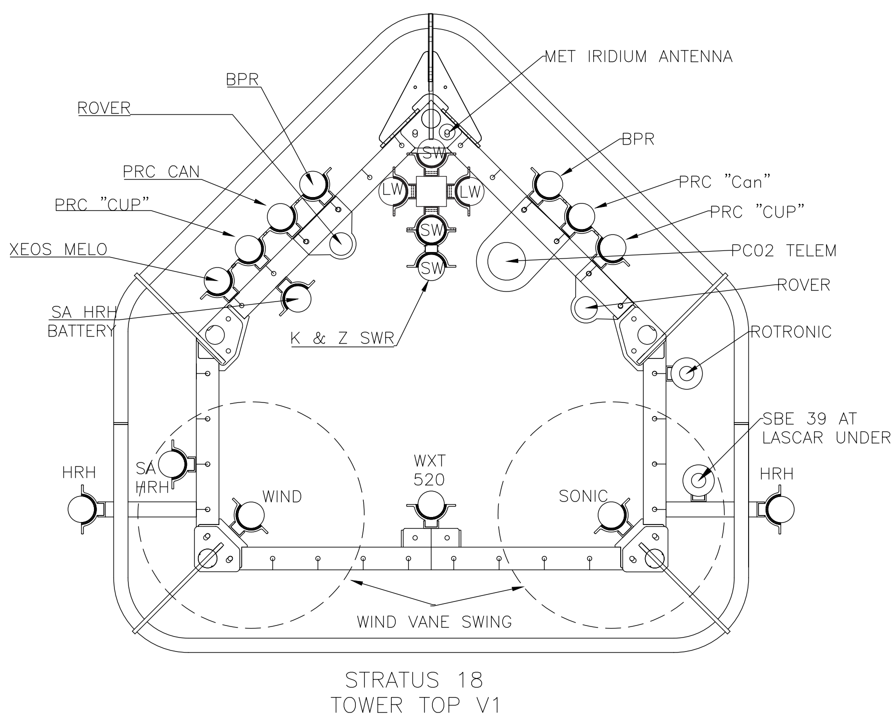


Figure II-1. Top view schematic of the meteorological tower on the STRATUS 18 buoy upon deployment, with the location of the ASIMET and other instruments.

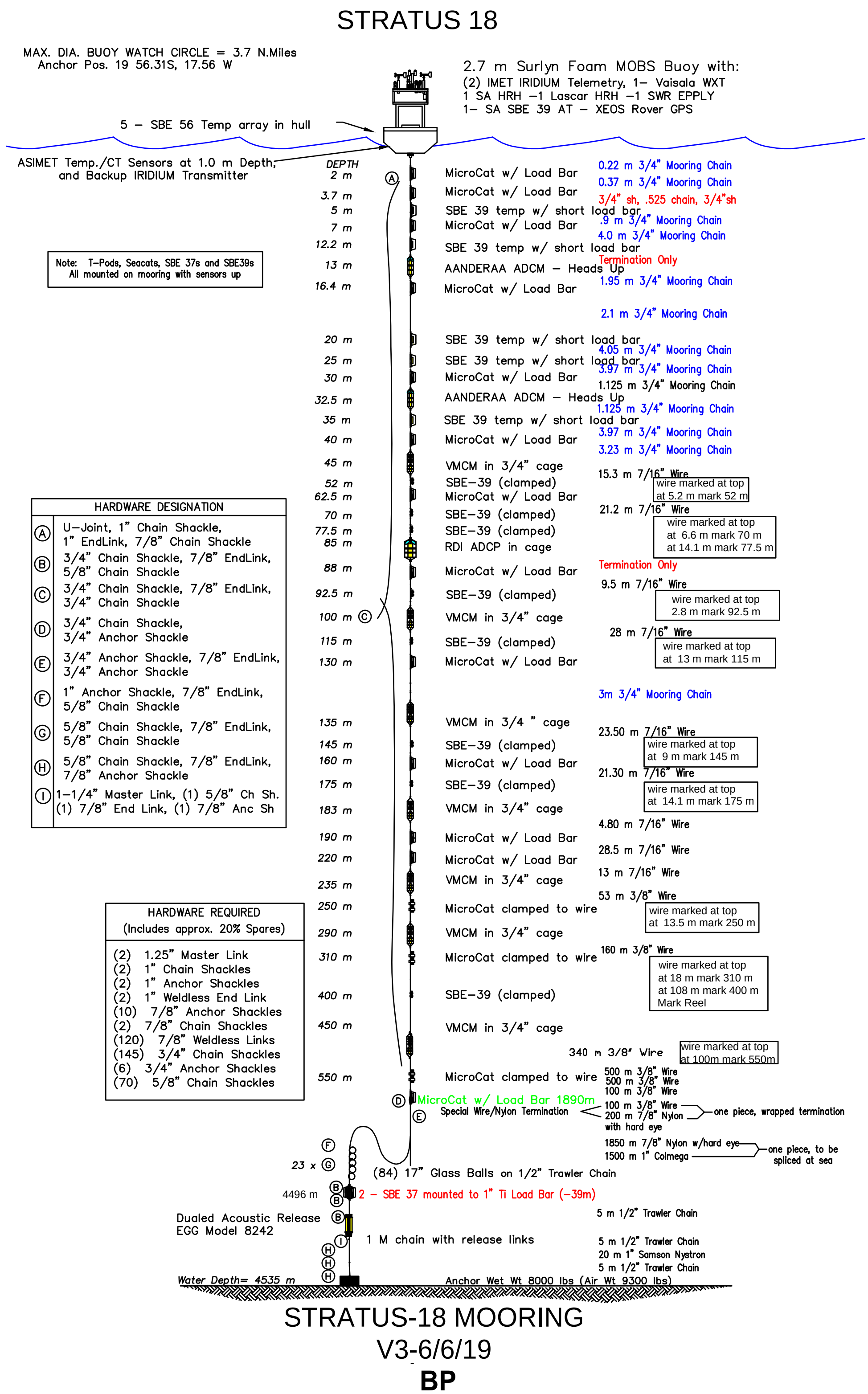


Figure II-2. Stratus 18 mooring diagram.

B. Deployment

1. Deck Operations

The Stratus 18 surface mooring was set using a two-phase mooring technique. Phase 1 involved the lowering of approximately 45 meters of instrumentation followed by the buoy, over the starboard side of the ship. Phase 2 is the deployment of the remaining mooring components through the A-frame on the stern.

The ship's starboard side net drum on the 01 deck was pre-wound (a tension cart was used to pre-tension the nylon and wire on the drum during the transit from Valparaiso) with the following mooring components listed from deep to shallow:

- 200 m 7/8" nylon with overbraid – 100 m 3/8" wire rope (nylon to wire shot)
- 100m 3/8" wire
- 500 m 3/8" wire
- 500 m 3/8" wire
- 340 m 3/8" wire
- 160 m 3/8" wire
- 53 m 3/8" wire
- 28.5 m 7/16" wire
- 21.30 m 7/16"wire
- 23.50 m 7/16" wire
- 28 m 7/16" wire
- 21.2 m 7/16" wire
- 15.3 m 7/16" wire

Prior to the deployment of the mooring, the wire was passed through the Red German block that was hung from the air tugger winch off the center of the A-frame. Then passed around the aft starboard quarter then forward along the rail to the instrument lowering area. Four wire handlers were stationed around the aft starboard quarter rail and A-frame. The wire handlers' job was to keep the line from fouling in the ship's propellers and to pass the line around the stern after the buoy was deployed.

To begin the mooring deployment, the ship was in dynamic position with the bow positioned into the wind. The crane's boom was positioned over the instrument lowering area to allow a vertical lift of at least four meters. All subsurface instruments for this phase had been staged on the deck, in order of their planned deployment. All instrumentation had chain sections shackled to the top of the instrument load bar or cage. A shackle and ring were attached to the top of each shot of chain or wire.

The first instrument segment to be lowered was a VMCM current meter at 45 m. This instrument had a 3.23-meter shot of chain shackled to the top of the instrument cage, and a 15.3-meter shot of 7/16" wire rope shackled to the bottom from the winch. The crane hook, suspended over the instrument deployment area was lowered to approximately 1.3 meters off the deck. A six-foot sling was hooked onto the crane and passed through a ring to the top of the 3.66-meter shot of chain shackled to the top of the current meter.

The crane was raised so the chain and instrument were lifted off the deck. The crane slowly lowered the wire and attached mooring components into the water. The line handlers positioned around the stern eased line over the starboard side, paying out enough to keep the mooring segment vertical in the water, in order to avoid any kink between links. A sling with a snap hook was secured to a deck eyebolt to stop the vertical mooring line and remove it from the crane. Lowering continued with 10 more instruments and chain segments being picked up and placed over the side.

The operation of lowering the upper mooring components was repeated up to the MicroCat at the 7-meter depth. The load from this instrument array was stopped off using a slip line passed through a pear link shackled into the chain above the instrument cage. The 2, 3.7, and 5-meter instruments were shackled to hardware and chain, connecting them to the universal joint on the bottom of the buoy. The vertical instrument array hanging in the water was joined to the two instruments attached to the bottom of the buoy.

The next operation was launching the buoy. Three slip lines were rigged on the buoy to maintain control during the lift. Lines were rigged on the buoy bottom, the tower, and a buoy deck bail. The slip lines were used to stabilize the bottom of the buoy at the start of the lift. Another slip line was rigged to check the tower as the hull swung outboard. Another line on the buoy deck bail was rigged to prevent the buoy from spinning as the buoy settled in the water.

With the three slip lines in place, the crane was positioned over the buoy. The quick release hook, with a 1” sling link, was attached to the crane hook. Slight tension was taken up on the crane to hold the buoy. The ratchet straps securing the buoy to the deck were removed. The buoy was raised up and swung outboard as the slip lines kept the hull in check. The stopper line holding the suspended 45 meters of instrumentation was eased off to allow the buoy to take the hanging load. The lower slip line was removed first, followed by the tower slip line. The slip line rigged to the instrument line was removed as the buoy passed over the rail. Once the buoy had settled into the water and the release hook had gone slack, the quick release was tripped. The crane swung forward to keep the block away from the buoy. The slip line to the buoy deck bail was cleared at about the same time. The ship then maneuvered slowly ahead to allow the buoy to come around to the stern.

The winch operator slowly hauled in the slack wire once the buoy had drifted behind the ship. The ship’s speed was increased to .5 knot through the water to maintain a safe distance between the buoy and the ship. The Red German traveling block was suspended from the A-frame using the air tugger. Two tag lines were then attached to the block to maintain control of the block.

The bottom end of the shot of wire was pulled back in so a SBE 39 temperature logger could be clamped onto the wire, then the wire was payed out and stopped off at the transom. Personnel on the fantail noticed a kink in the chain above the VMCM (45 m depth mark) that was in the water. The line was hauled in further on the fantail and the kink removed and the line and VMCM were slipped off again in the water. After the SBE39, the next instrument was a SBE 37 (microcat) with load bar at the 62.5 meter depth mark. This instrument and its pre-attached wire shot were shackled to the end of the stopped off mooring. The bottom of this wire was shackled into the top of the working line. The hauling line was pulled onto the winch to take up the slack. The winch slowly took the mooring tension from the stopper lines.

The winch line pulled back, lifting the instrument off the deck as it was raised. The instrument was lifted clear of the deck and over the transom. The winch was payed out to the next termination. The termination was stopped off using lines on cleats, and the hauling wire removed while the next instrument was attached to the mooring.

The next several instruments were deployed in a similar manner. Additional instruments were attached to the mooring wire using clamps. When pulling the slack on the longer shots of wire, the terminations were covered with a canvas wrap before being wound onto the winch drum. The canvas covered the shackles and wire rope termination to prevent damage from point loading on the lower layers of wire rope and nylon on the drum. This process of instrument insertion was repeated for the remaining instruments down to 1,890 meters. The winch continued to pay out the wire and nylon line until all mooring components that had been pre-wound rolled off the winch and payout stopped approximately 30 feet from the transom. A heavy-duty H-Bit was positioned mid ship. 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" end-link to the mooring. Cable ties were used to snug the termination. The load was transferred from the winch to the H-Bit. The remaining 1,850 meters of nylon and 1,150 meters of green Colmega line, coiled in three wire baskets, were payed out through a water-cooled H-Bit.

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 main deck 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 12-ton crane was used to lift glass balls out of the open top container. The 88 glass balls (includes one spare set) are bolted on 1/2" trawler chain in 4 balls (4 meter) increments. 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 84 balls were deployed. At this junction the mooring was towed for approximately 1.5 hours.

A 1" titanium load bar with two SBE 37 Conductivity/Temperature (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 winch line running through the block on the A-frame lifted the SBE 37s off the deck. The winch payed out with the tugger, and the instruments were eased over the transom. The tugger 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 ship's winch wound up these components until it held the tension of the mooring. The acoustic releases were lying flat on the deck. A chain hook connected to the Gilson winch (01 deck) line running through the block on the A-frame lifted the acoustic releases off the deck. The winch payed out with the tugger, and the instruments were eased over the transom.

The winch continued to pay out until the final 5-meter shot of chain was just going over the transom. A shackle and link were attached one meter up this segment of chain. A heavy-duty slip line was passed through the link and secured to the winch leader. The winch hauled in until tension was transferred to the slip line. The chain lashings were removed from the anchor. A 3⁄4" sacrificial nylon line was attached to the winch leader using a bowline knot and fed through the sling link on the 5-m chain from the anchor and brought back to the winch leader and tied off with a bowline. The mooring was towed through the water as preparations to tip the anchor were finalized.

The ship's crane was connected to the tip plate bridle to lift the tip plate. A slight strain was applied to the bridle. The sacrificial line transferred the mooring tension to the 1/2" chain and anchor and the line was cut. Once cut, the anchor slid off the plate and into the ocean.

2. Bathymetry Survey

Prior to the cruise, it was decided by the science PI that a new deployment site was needed for Stratus 18 in order to avoid fishing activity and to lower risks of entanglement with fishing gear. A possible site had been identified less than 200 nm to the southwest of the historical Stratus site. Upon arrival in the new zone, a bathymetry survey was conducted to identify a flat area adequate for a mooring deployment. The survey was conducted at 8 knots from April 11 14:00 local, until April 12 at 06:12 local. Figure II-3 shows the bathymetry and ship's track (green line) during the survey, which started in the southeast after transiting from Valparaiso, then conducted north-south sections to the west. A flat area with depth close to the mooring line cut for Stratus 18 was found that extended 10 kms in the NNW-SSE direction and 5 kms in the transverse direction. A 1,000 m high seamount was located on the northwest corner of this area. After the bathymetry survey, the ship operated mock deployment runs, seen as the northwest-southeast tracks in the northwest corner in Figure II-3.

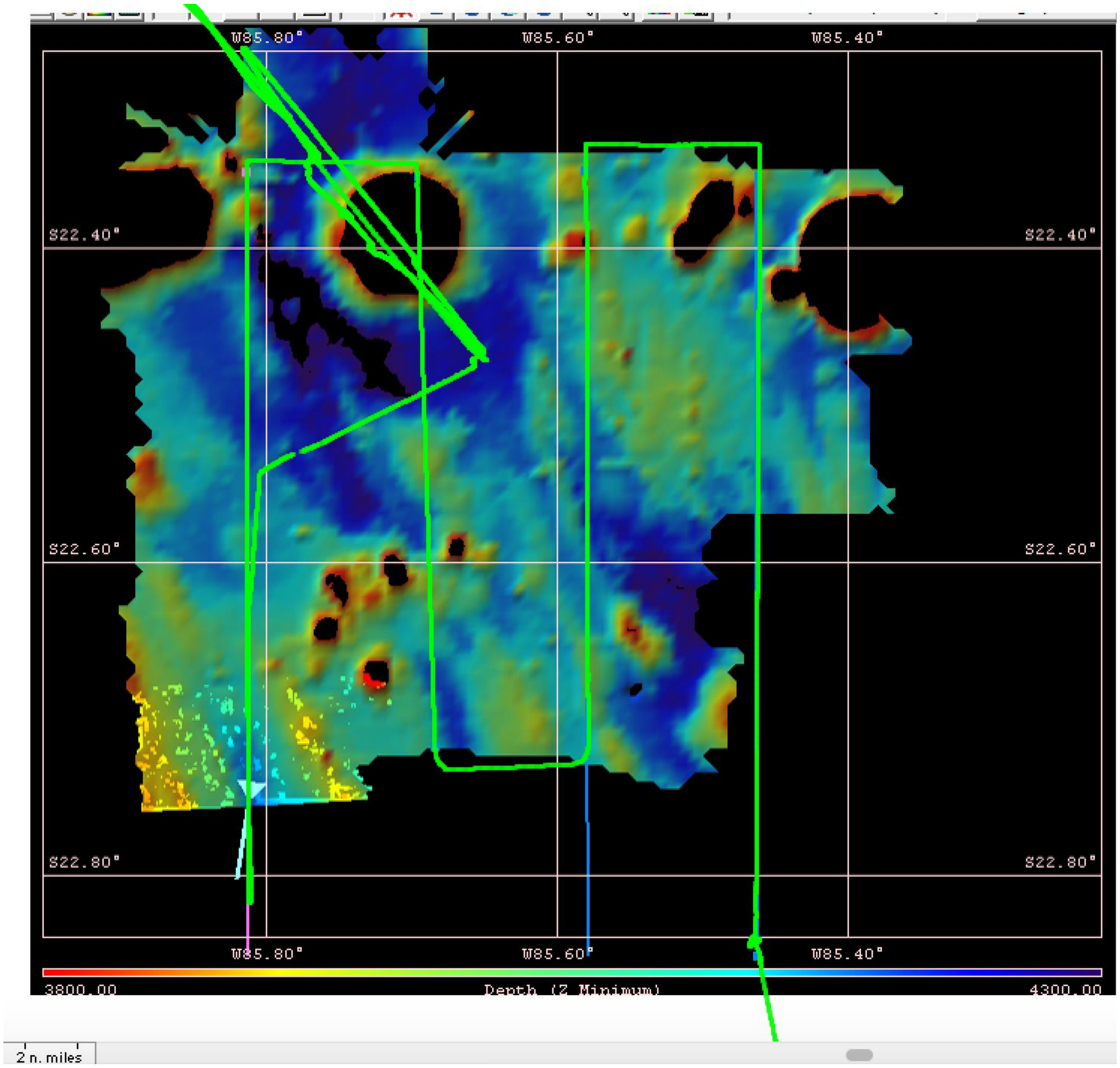


Figure II-3. Screen capture of the bathymetry near the Stratus 18 deployment site. Ship track is green line.

3. Navigation Operations

A course of steaming into the wind along a track toward 130° was planned, with a start point upwind, and a target 10 nm down the track. A safety distance of 4 nm beyond the target was allowed by the relative flat bathymetry. The day before the deployment, the ship ran along that track to assess the ability to steam that line at low speeds. During the first mock run, the ship was able to maintain 0.8 knot over a half hour and the ocean current was assessed as being less than ¼ knot to the Northwest, opposite to the ship's course, so the ship's speed over water was close to 1 knot. For the following 5 hours the navigating crew tested several combinations for propulsion using thrusters and main propeller. After these tests the ship was able to follow the appropriate course towards the target while maintaining near 1 kt or less than 1.5 kt through the water.

At 07:00 local (12:00 UTC) on April 13, the ship was in position at the start point and started a set and drift test. The drift was established as 0.3 to 0.7 kt to the Northwest, similar to the previous day. However, shortly afterward at 08:40 local, the wind changed slightly and the ship repositioned to a location on the starboard side. Finally, the ship was in the start position, 10 nm from the target, and the first instrument to be deployed (VMCM at 45 m depth) was lowered in the water at 14:21 UTC.

With the ship maneuvering to support the buoy deployment and launch of the upper part of the mooring, little progress along the line was made, and the ship fell off to the southwest (Figure II-4). Once the upper 45 m of mooring line and instrumentation were deployed and the buoy launched (15:25 UTC), the ship started to steam toward the target, following a course of 130° True; the ship's speed was first very low (<1 kt) to avoid tipping the buoy, but was increased later on when enough weight was under the buoy.

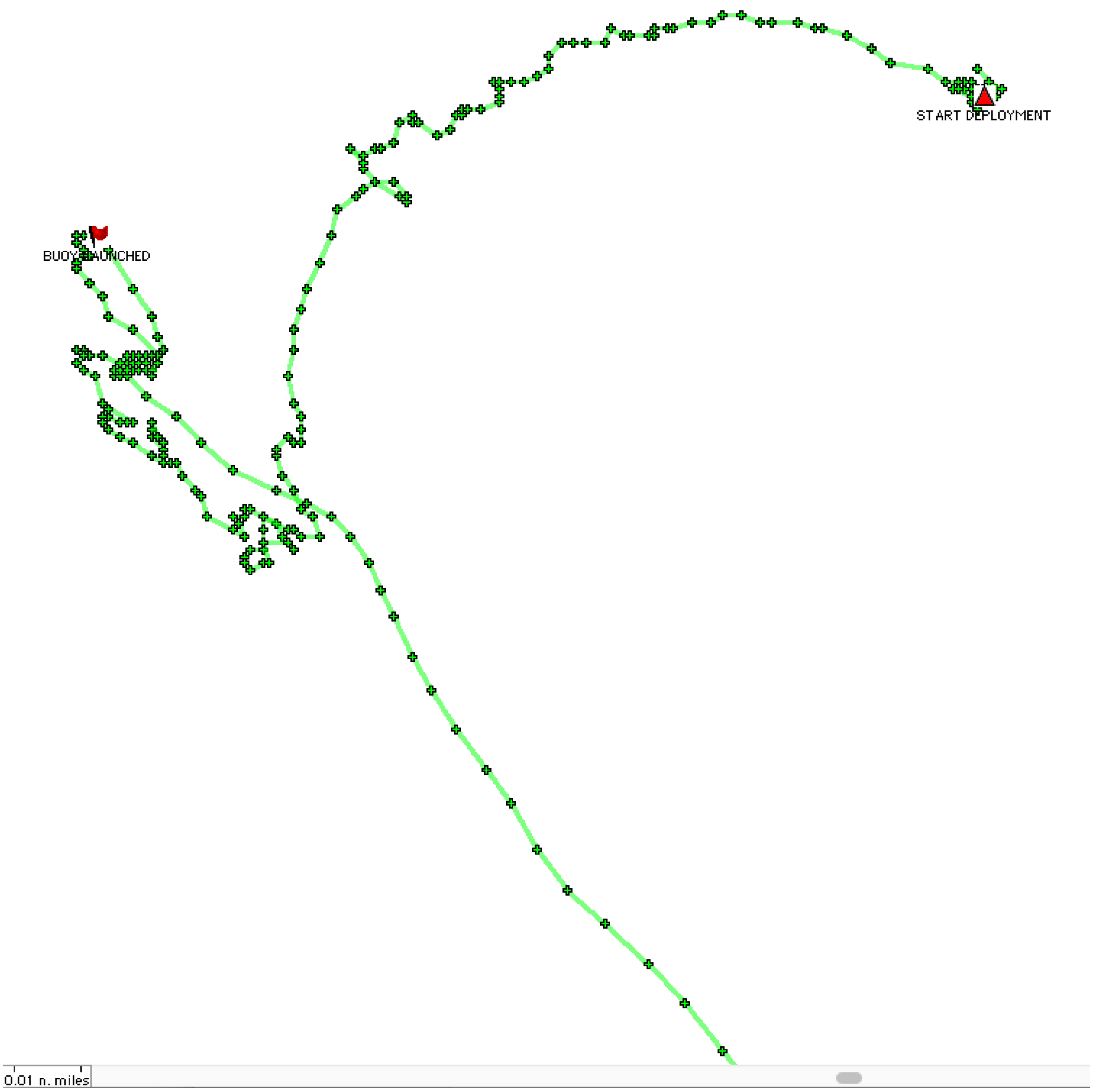


Figure II-4. Start of Stratus 18 deployment track. Location of first instrument in the water (red triangle), followed by buoy in the water (red flag) about an hour later.

In the afternoon, the work reached the point where the anchor was attached, in preparation for its deployment. The anchor deployment was delayed about 30 minutes to ensure we reached an area with a flat seafloor and good depth. Once it was verified that the water depth was suitable, close to 4,300 m, the work proceeded with the anchor being deployed at 23:43 UTC, April 13 2019 at 22° 27.753'S 85° 38.471'W, with water depth 4,287 m according to the Multibeam.

As shown in the actual track plot (**Figure II-5**), after the anchor drop, the ship continued its track to the southeast while the anchor was falling towards the seafloor and the buoy was moving towards it in a pendulum motion. About an hour later, the ship then pulled off to the port side towards the North to begin anchor survey triangulation. The ship used three survey sites to triangulate the position of the anchor using acoustic communications with the bottom releases. The ship then repositioned to a couple of miles to the northwest to stand downwind of the buoy for inter-comparison. A few hours later, a bit before midnight on April 13, the ship was diverted from its science mission and started transit to the southwest for a search and rescue mission

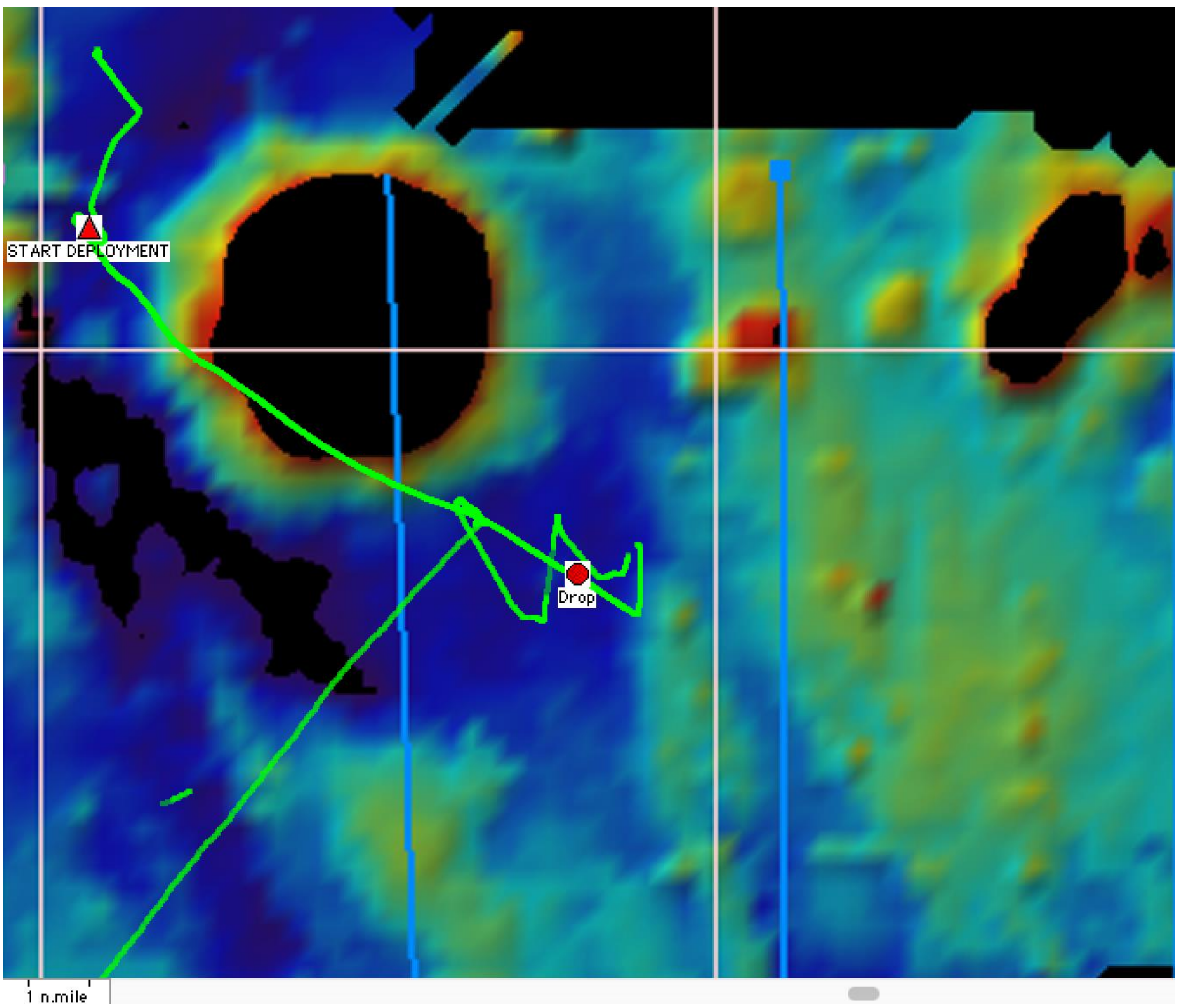


Figure II-5. The track of the *Cabo de Hornos* during the deployment of Stratus 18, with the deployment start (red triangle) in the northwest and anchor drop (red dot) 10 nm to the southeast.

C. Anchor Survey

Three positions were provided to the bridge. At each position the ship stopped (Figure II-6), and the over the side hydrophone and acoustic release deck box were used to obtain ranges and travel times from the ship to the acoustic release above the anchor. The survey points and results are shown in **Error! Reference source not found.**. Three ranges/travel times were obtained at each survey point to ensure the ranging was repeatable.

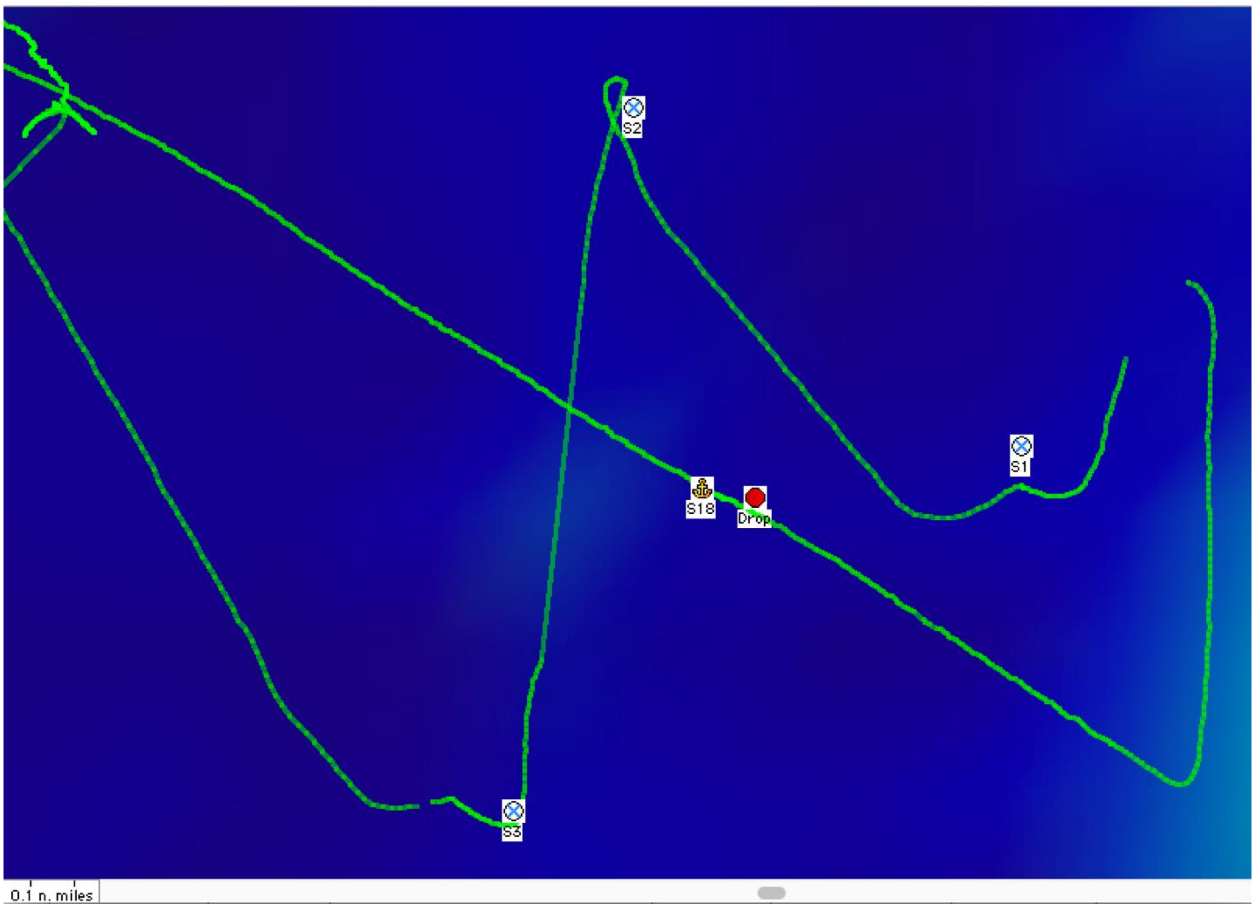


Figure II-6. Ship's track during end of deployment and anchor survey of Stratus 18.

Based on previous cruises, an average sound speed at Stratus is taken to be 1500 m s^{-1}. The manual for the release box (Edgetech 8011XS deck unit) indicates that its default setting uses 1500 m s-1 as sound speed. This is configurable in the anchor position program. The distance of the releases above the bottom (32 m) is also configurable in the anchor position program. The Matlab routine (Anchpos2 from Weller) provided Figure II-7.

Thus, the Stratus 18 anchor position is (22° 27.6989' S, 85° 38.5901' W), with water depth 4,268 m based on the program's solution. The depth is also consistent with the Multibeam reading in the area. An inspection of the buoy showed the waterline to be about 60 cm below the top of the buoy foam.

Table II-1. Survey points, ranges in meters and travel time in ms. Locations converted to decimal degrees for input into anchor locations.

	LAT		LON		Distance	Travel time
STATION	deg	decimal	degree	decimal	m	ms
1	22	0.461633333	85	0.629433333	4468	5.958
1	22	0.461533333	85	0.629516667	4463	5.951
1	22	0.461533333	85	0.6296	4458	5.945
AVG	22	0.461566667	85	0.629516667	4463	5.951333333
2	22	0.447466667	85	0.64685	4536	6.048
2	22	0.447283333	85	0.646966667	4547	6.063
2	22	0.44705	85	0.646983333	4557	6.076
AVG	22	0.447266667	85	0.646933333	4546.666667	6.062333333
3	22	0.474416667	85	0.651	4537	6.05
3	22	0.47445	85	0.651066667	4539	6.052
3	22	0.474483333	85	0.65115	4541	6.055
AVG	22	0.47445	85	0.651072222	4539	6.052333333

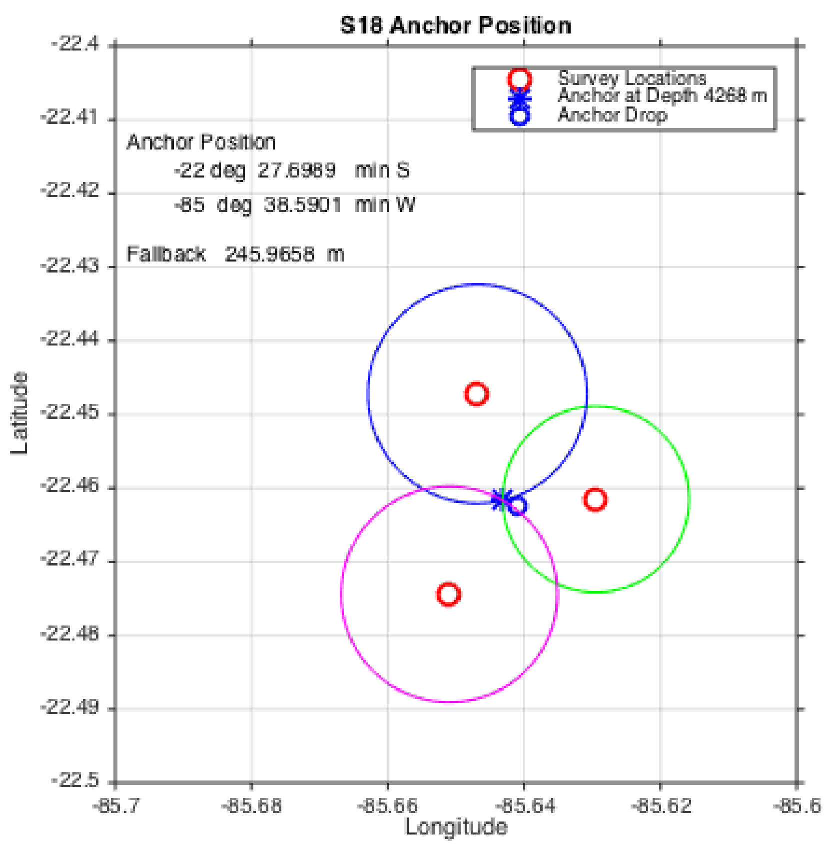


Figure II-7. Anchor survey results using Anchpos2 from Weller.

D. STRATUS 18 – Ship Inter-comparison

The plots below (Figure II-8 to Figure II-15) present the time-series of the data collected from the Stratus 18 buoy and the ESRL sensors during the intercomparison, when R/V *Cabo de Hornos* was stationed near Stratus 18 buoy on April 24 2019. Following the Stratus 17 bottom recovery, the ship arrived at Stratus 18 at 00:30 local (UTC-5) in the morning and stayed there until 20:00 (UTC-5), when it started its transit return towards Valparaiso. Almost 20 hours of intercomparison are therefore available. Using its dynamic positioning, the ship hoved to ¼ nm downwind of the buoy. At 14:00 local (UTC-5), the small boat was deployed for a buoy ride and the replacement of Xeos GPS units (Melo and Rover sensors) on the buoy. At 15:40 local, the ship moved 1 nm West of the buoy for a CTD cast at (22° 27.745' S, 85° 41.483' W). The CTD was in the water from 16:15 until 17:50 local, after which the last float (#6, SN 7535) was deployed at (22° 27.434' S, 85° 40.885' W) at 18:07. The ship moved back near the buoy until 20:00 at which point science operations ended and the ship steamed towards Valparaiso. The ship's track during intercomparison is shown in Figure II-16. Ship's motion during this period is shown in Figure II-17.

ESRL sensors on the ship were placed either on the bow mast (wind, air temperature and humidity and barometric pressure), the flying bridge (radiations) or the seasnake (SST). ASIMET data from the buoy was provided by satellite telemetry, which was emailed as text to an Iridium GO phone onboard the ship. This telemetry data is hourly averaged, does not include quality control, and has lower resolution due to bandwidth constraints during transmissions.

Air temperature from system 1 on Stratus 18 is biased high during the afternoon compared to other sensor on system 2 and ESRL sensor on the ship. Air relative humidity from buoy sensors agree with each other and are 2%RH higher than ESRL's measurements adjusted for height. Air specific humidity on system 2 (1) is 0.1 (0.3) g kg^{-1} higher than ESRL. Barometric pressure on system 2 is also slightly high. Wind speeds on buoy are lower but within 10% of ESRL after height adjustment, and system 1 agrees best with ESRL. Wind direction from system 2 is 10° to 15° lower than ESRL and system 1. Shortwave radiation from ESRL is higher than buoy ASIMET sensors during first part of the day and lower later on. Maximum shortwave value at noon was close to 860 W m^{-2} and ASIMET sensors were 15 to 20 W m^{-2} (or 2.5%) lower than ESRL at that time. The ship does list down on starboard side. A manual reading with a high-accuracy Smart Tool digital level indicated the radiations sensors were indeed listing 2° to 3° towards starboard. The pitch on the other hand was quite small (about 1° towards the bow). These tilts could explain some of the difference between radiation sensors on the ship and on the buoy. For the first (second) half of the day, longwave radiation from ESRL was about 10 W m^{-2} higher (lower) than ASIMET systems 1 and 2, which agreed with each other well. It is possible that the ESRL sensor, being located above the wheelhouse, received infrared radiations from nearby equipment and structures. Note that a second ESRL longwave sensor had wrong reading around this time as flap cover around the dome became bent due to wind action. For details on ESRL instrumentation, see Appendix E.

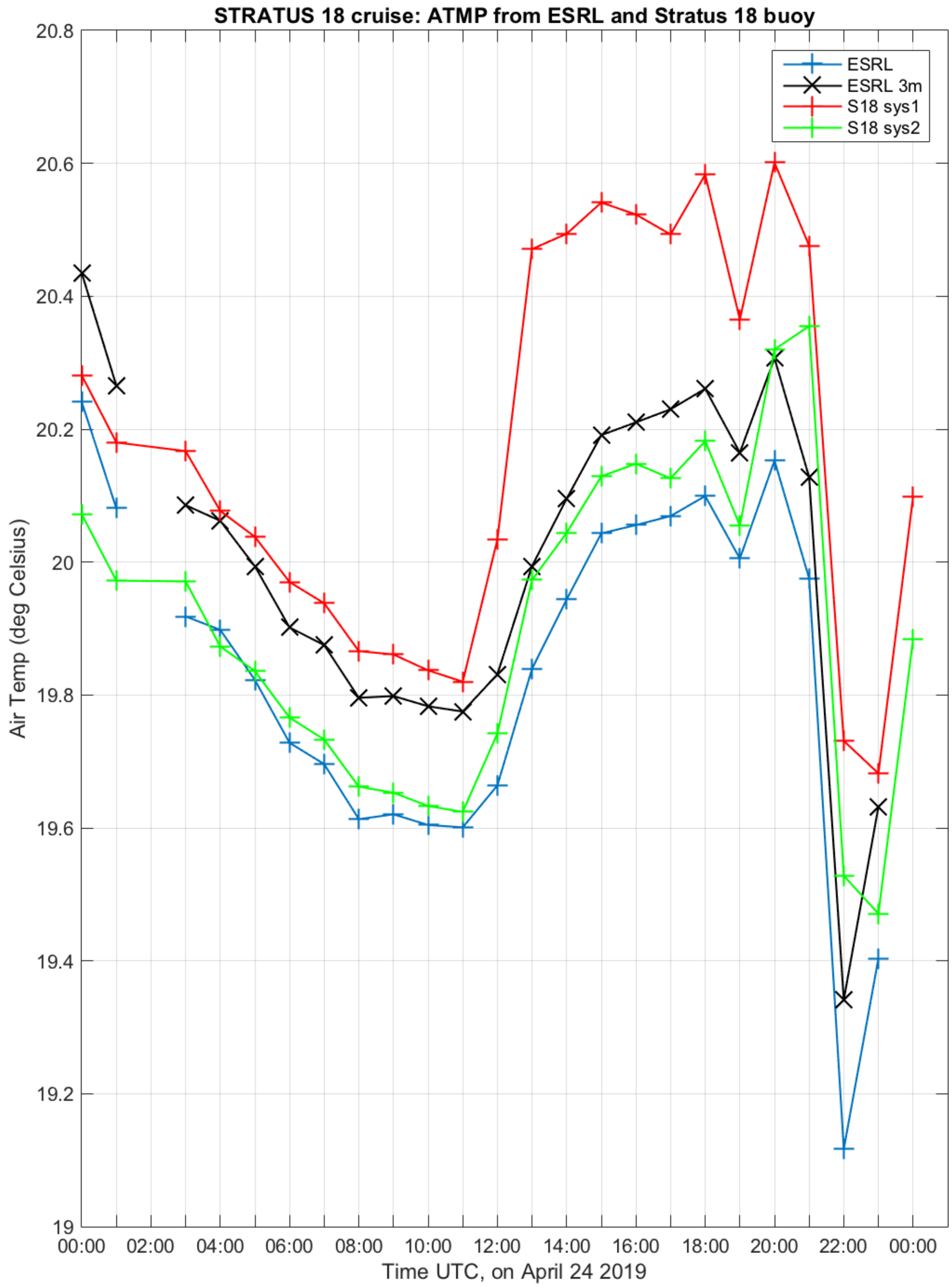


Figure II-8. Inter-comparison between Stratus 18 and ESRL sensors on ship: air temperature (ATMP).

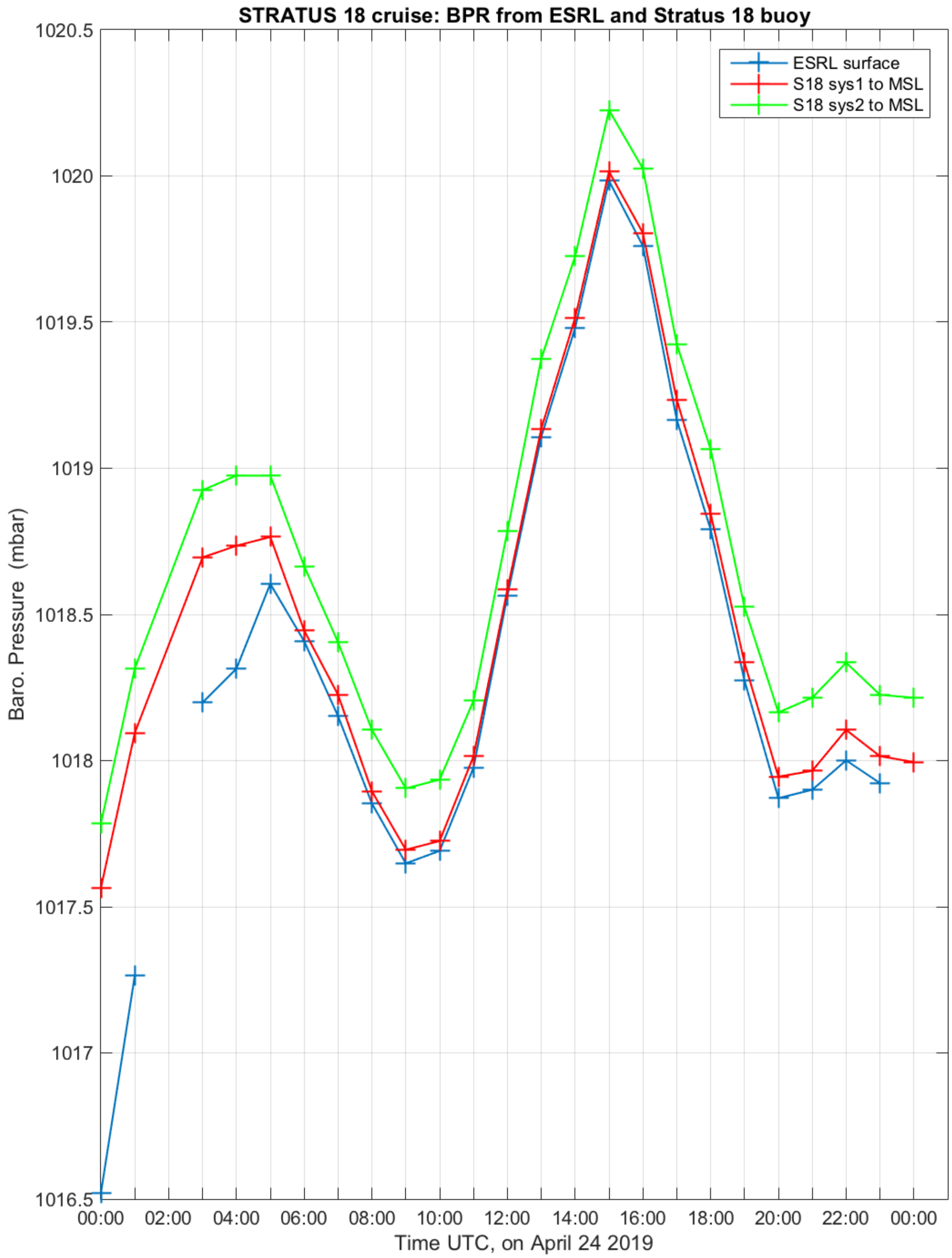


Figure II-9. Same as Figure II-8 but for barometric pressure (BPR).

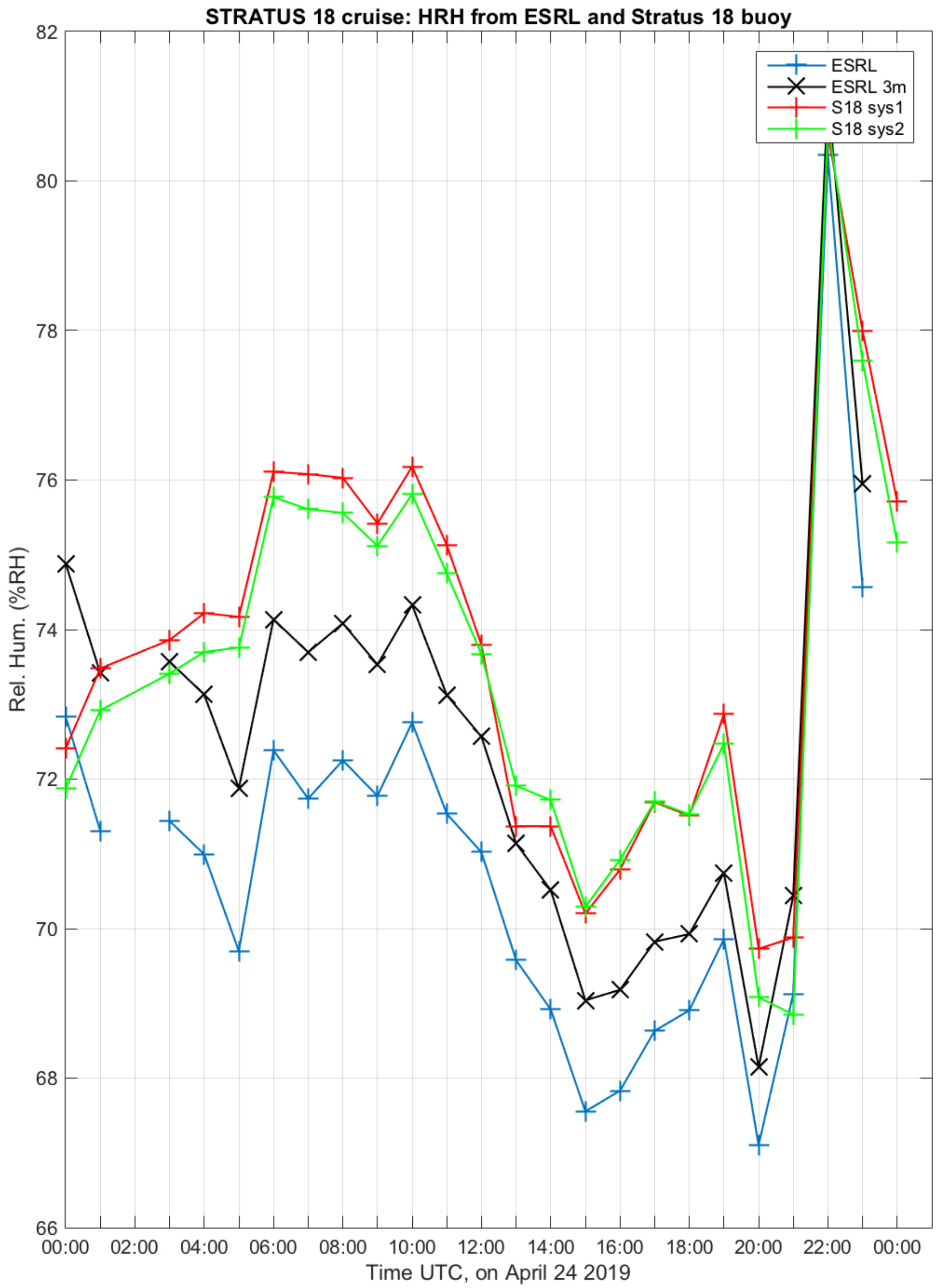


Figure II-10. Same as Figure II-8 but for air relative humidity (HRH).

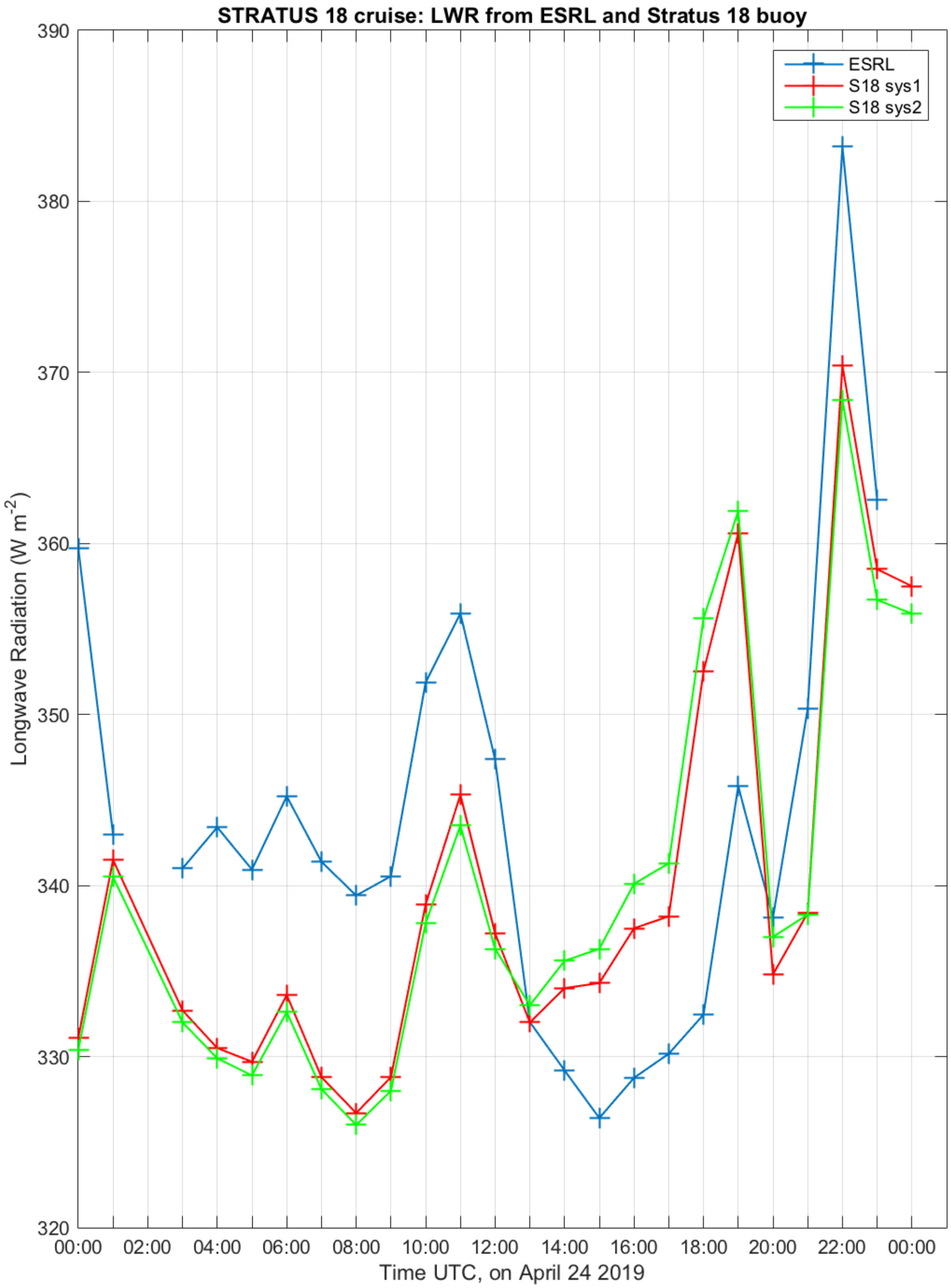


Figure II-11. Same as Figure II-8 but for downwelling Longwave radiation (LWR).

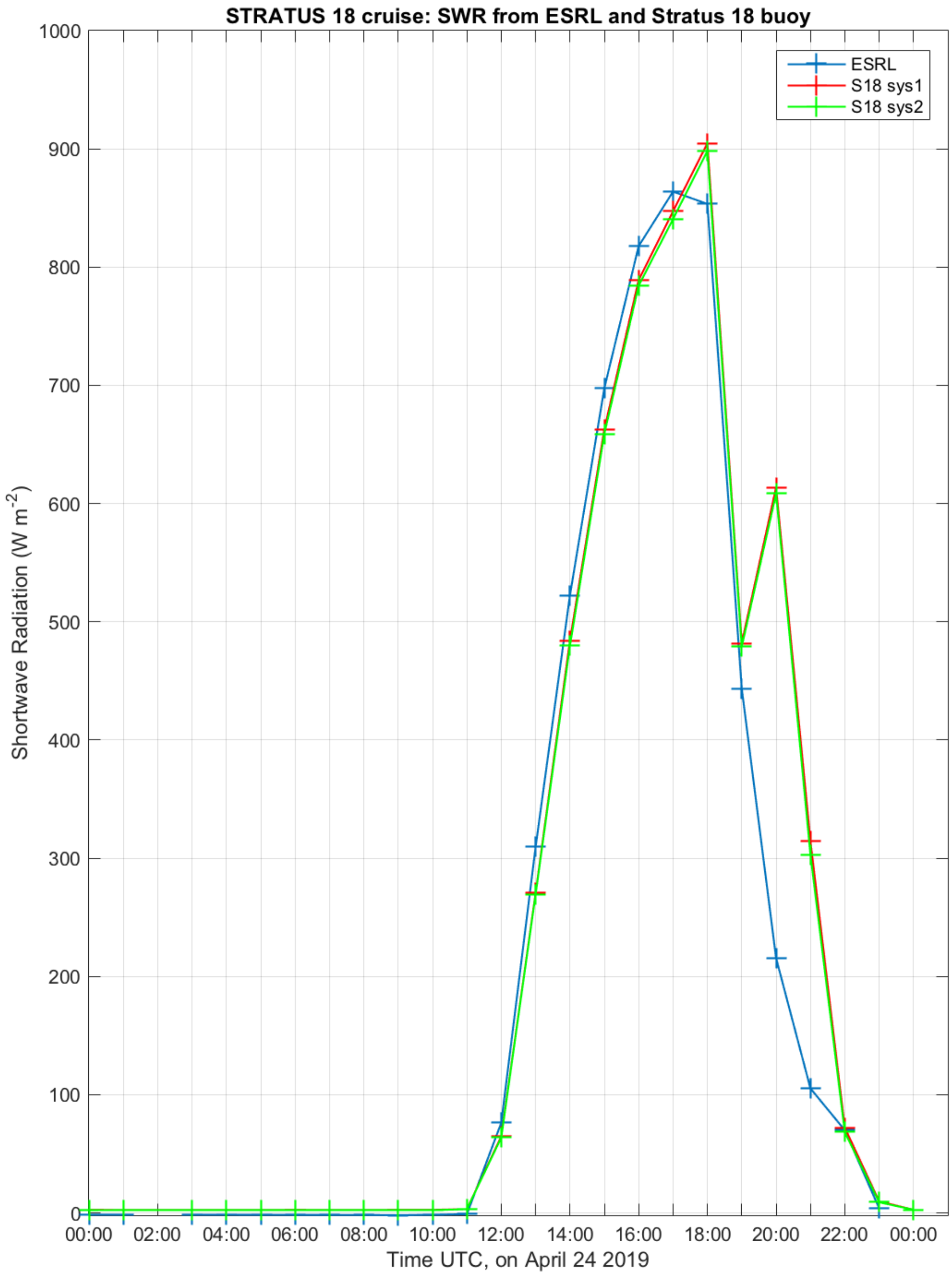


Figure II-12. Same as Figure II-8 but for downwelling shortwave radiation (SWR).

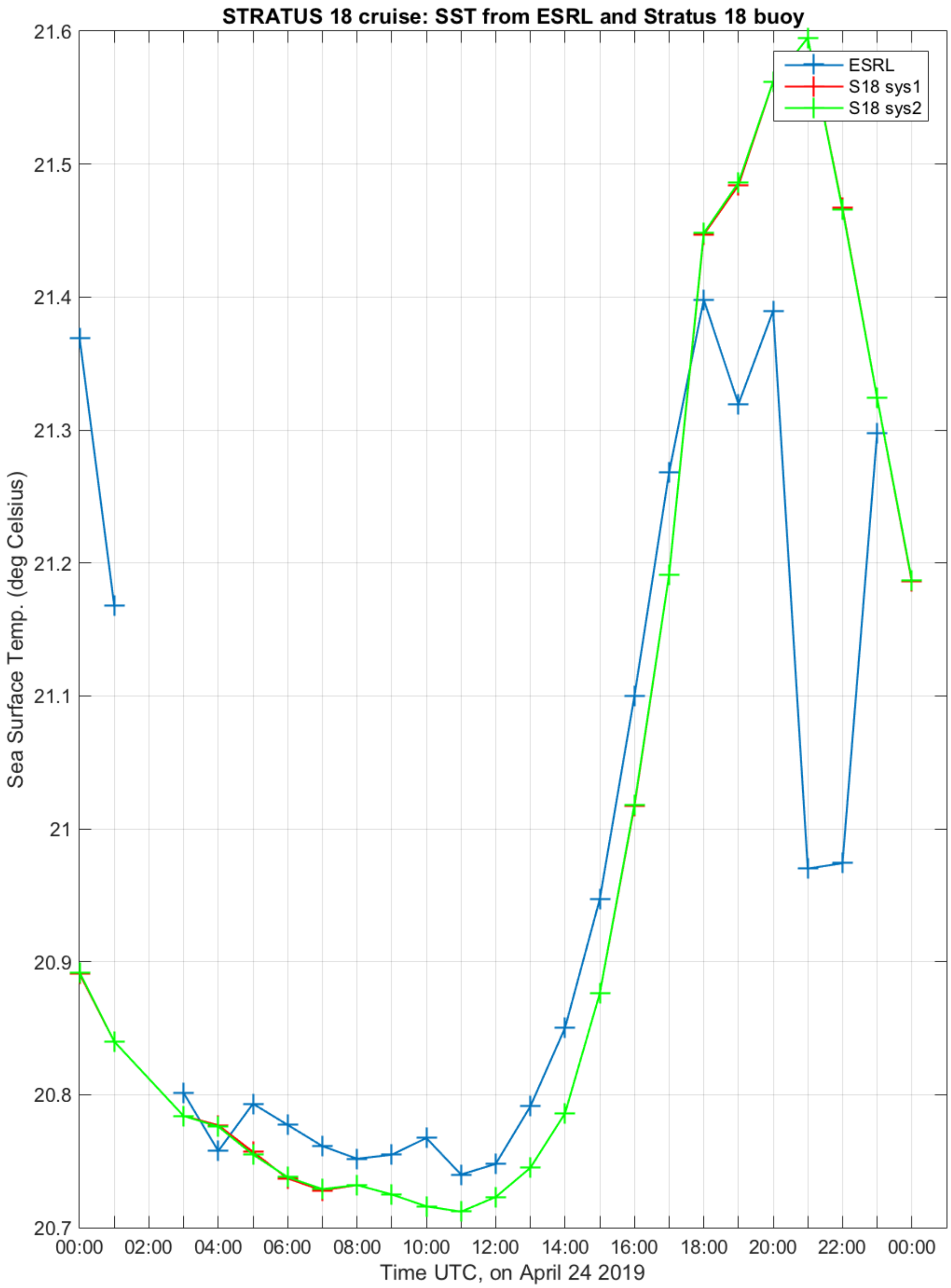


Figure II-13. Same as Figure II-8 but for sea surface temperature (SST).

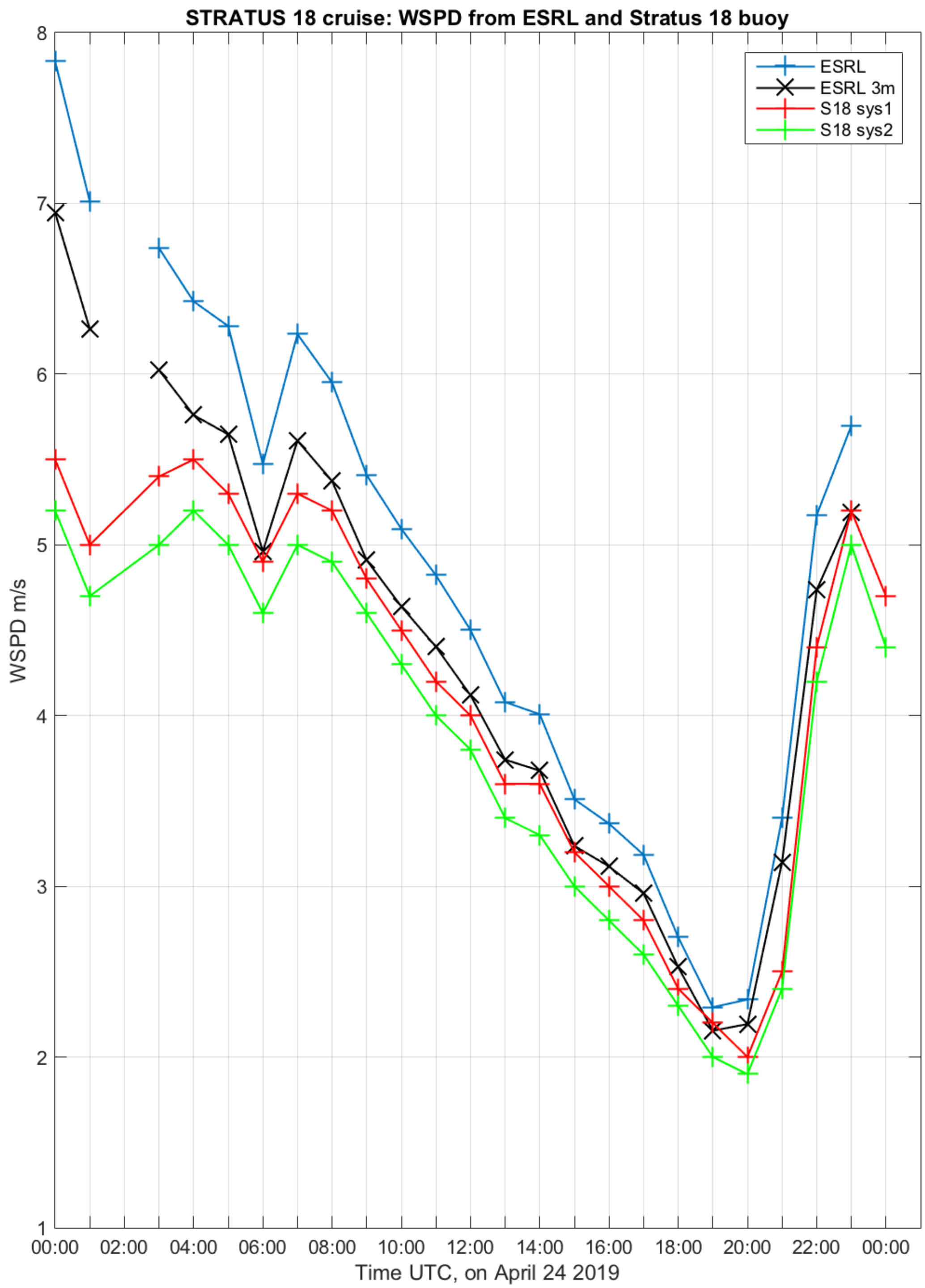


Figure II-14. Same as Figure II-8 but for wind speed (WSPD).

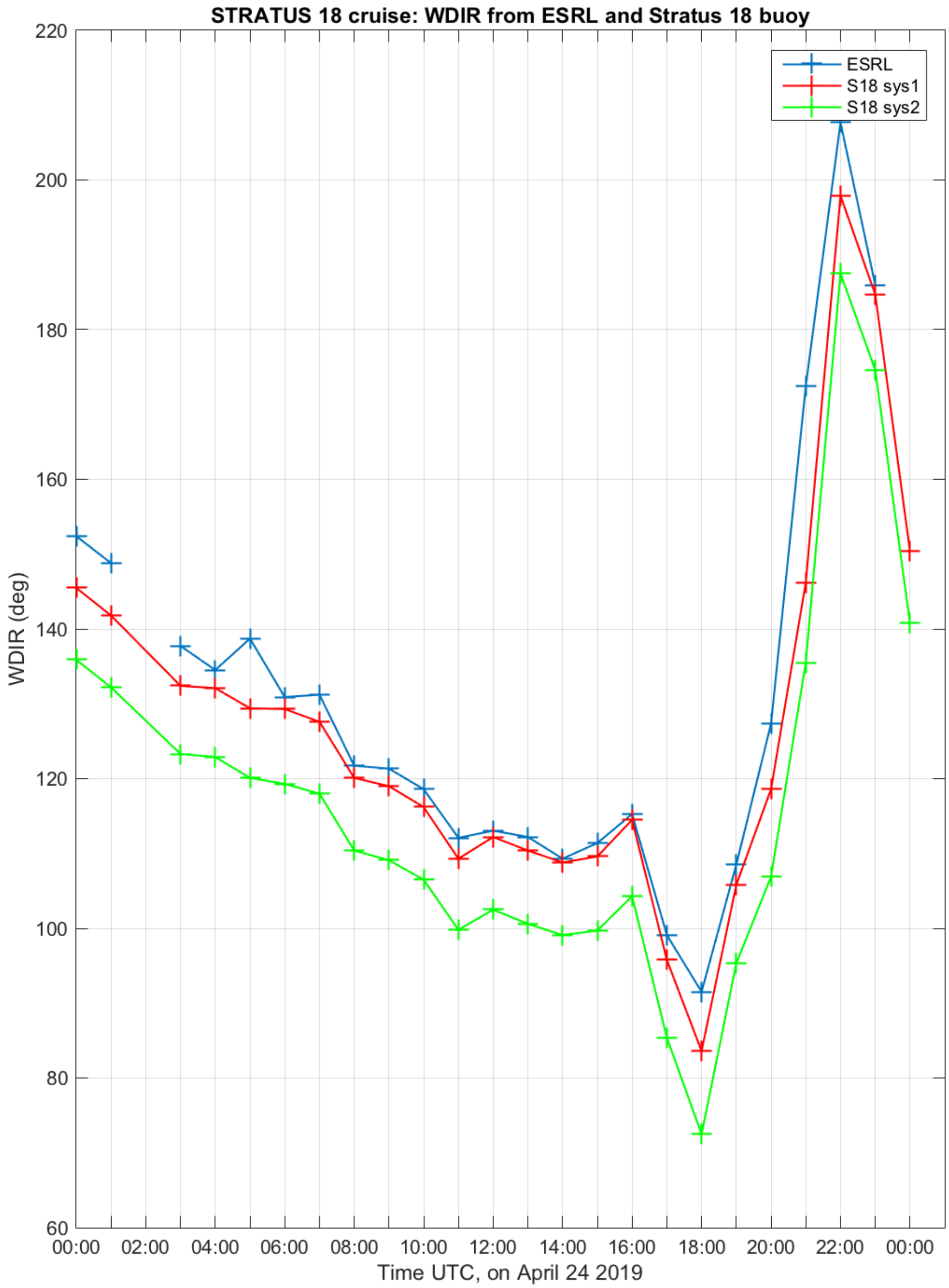


Figure II-15. Same as Figure II-8 but for wind direction (WDIR).

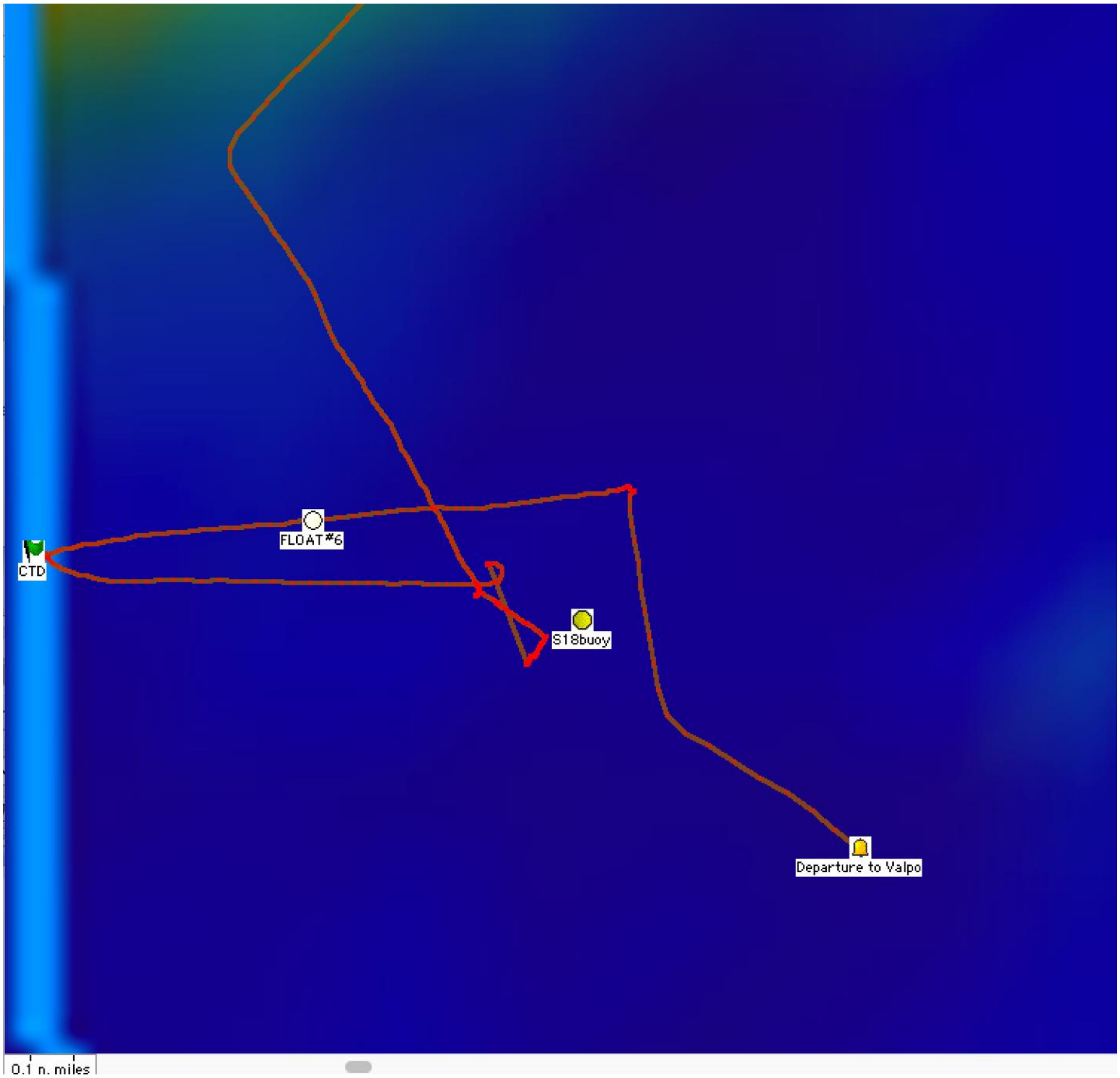


Figure II-16. Intercomparison at Stratus18 buoy on April 24 2019. Ship track (red line), Stratus 18 buoy (yellow dot), CTD cast (green flag), float #6 launch (white dot), and departure towards Valparaiso (yellow bell).

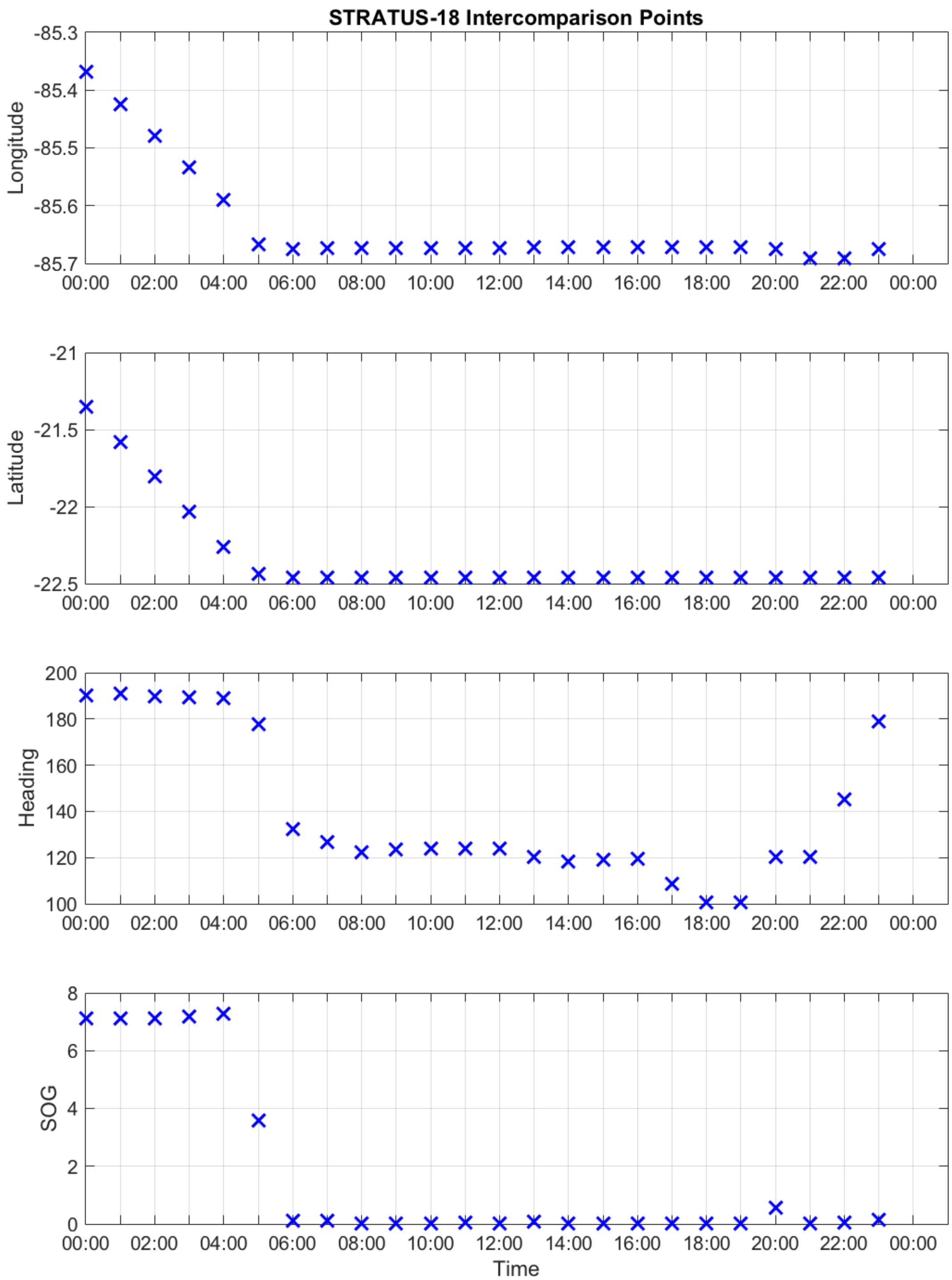


Figure II-17. Ship motion during intercomparison period on April 24 2019.

III. Stratus 17 Recovery

A. Drifting Mooring Recovery

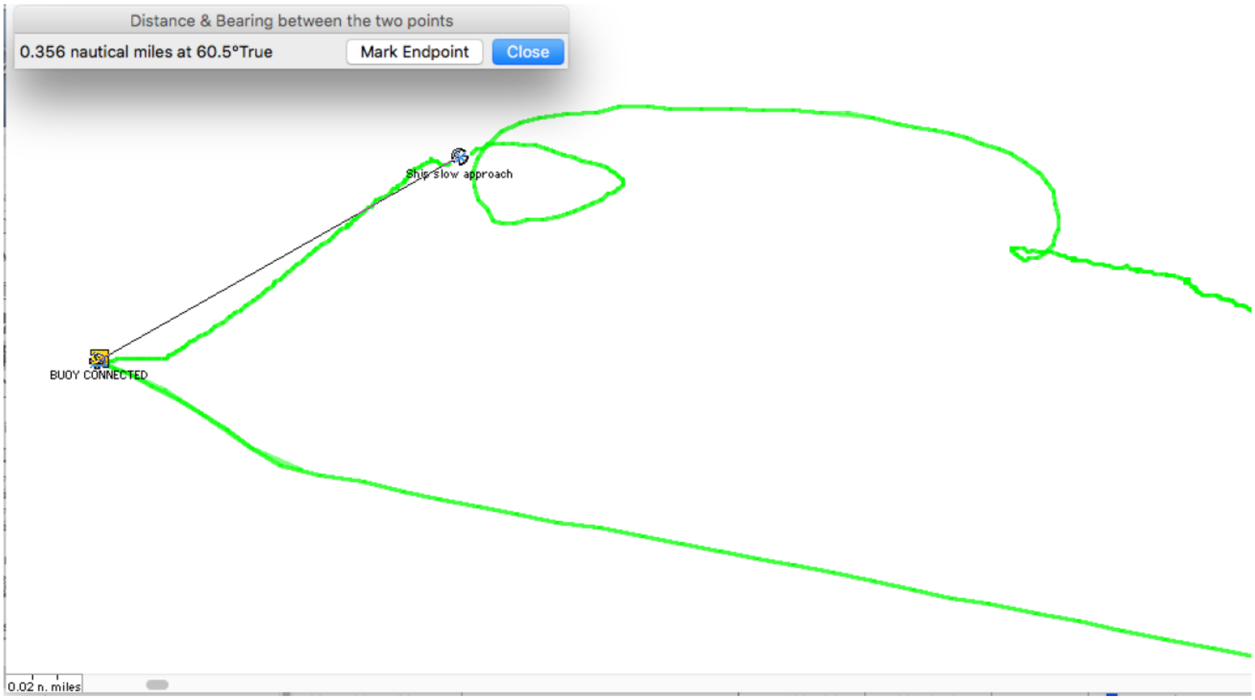


Figure III-1. Ship's track during recovery of Stratus 17 drifting buoy on April 18 2019.

The Stratus 17 mooring broke free on August 16, 2018 and drifted westward at a speed of ¼ knot until its recovery on April 18 2019. Ship arrived within 1.5 nm of Stratus 17 drifting buoy at 07:30 (UTC-6) on April 18. Acoustic communications were attempted to check if releases were still on the mooring line. Without knowing how much weight was under the drifting buoy, the WHOI personnel made the decision to use the strongest devices on board (Gilson winch and A-frame).

At 09:00, two WHOI personnel were in the small boat to remove some instrumentation from the buoy and to attach a 12 feet long Spectra line in anticipation of the recovery and lifting under the A-frame. At this point the ship was still 0.4 nm and upwind from the buoy. The ship started a very slow approach by first making a wide loop away and back towards the buoy, then backing up into the wind towards the buoy on its stern (Figure III-1). In the meantime, personnel onboard prepared faked out all 30 m of the available line from the Gilson winch on the fantail. This line was fed through the A-frame block, faked out on the grating deck and a heaving line was tied into the end. A small boat was deployed to hook up to the buoy pick up bail using the Gilson line that was tossed to them from the ship. The small boat attached a 5-ton titanium hook to the buoy pick up bail and shackled the hook's pendent to the Gilson thimble. The ship was then less than 20 m ahead of the buoy, bow into the swell, and using its dynamic positioning to keep its position.

After crew and scientist were back on the ship hauling in of the Gilson line started with the ship still using its DP. The A-frame was positioned outboard and the buoy was elevated in the air. Once the buoy was clear of the transom the A-frame came in. The buoy came back on deck at 10:20. To stabilize the buoy two tags lines were attached to the buoys D-handles. The A-frame came in and the winch payed out lowering the buoy to the grated deck. Stopper lines were placed on the link just below the 3.7 m microcat instrument. To relieve the tension off the buoy and put it on the stopper lines the buoy was picked back up using the A-frame and elevated by moving the A-frame aft. Once tension was on the stopper lines the connection from the mooring chain to the buoy was disconnected. Using the crane, the buoy was then repositioned on the starboard rail to create a larger working area on the back deck. Three tag lines were positioned in a triangle pattern to keep the buoy from swinging. Once the buoy was moved it was secured to the deck using ratchet straps and the mooring recovery continued.

To recover the remaining instruments and wire a traveling block was hung off the center block. The Red German block was hung using the Gilson winch. The Gilson winch had problems starting. Two tag lines were attached to it to ease the swinging motion of the block. A winch leader was wound on the starboard side split net drum and fed through the block. The winch leader was then attached to the mooring chain and the recovery of the mooring line got underway. Instruments on load bars or in cages were stopped about 1 foot below the block. Two stopper lines were hooked into sling links and made fast to the deck cleats. The winch payed out slowly to lower the instruments to the deck. The instruments were disconnected from the hardware and moved to a staging area for pictures. The wire rope from the winch was then shackled to the load. The winch took up the slack and the stopper lines were eased off and then cleared. Hauling in of instrumentation and wire continued for approximately 6 hours.

Figure III-2. Recovery of the Stratus 17 buoy onboard Cabo De Hornos.

Stratus moorings are typically subject to heavy biofouling with large barnacles growing on the buoy hull and instrumentation in the upper ocean. On the recovered Stratus 17 mooring, the growth was heavy in the upper 50 m and suddenly decreased at 55 m and below (Figure III-4).

The mooring broke free about 5m under the VMCM at the 1506 m nominal depth (Figure III-3). At the time of the breakup, the sudden release of tension on the mooring line created entanglements or “wuzzles” between the line and instruments (**Figure III-5**).

Figure III-3. Break of the Stratus 17 mooring line, a few meters below a VMCM. The plastic jacket shows signs of abrasions for several meters, exposing the wire inside to corrosion.

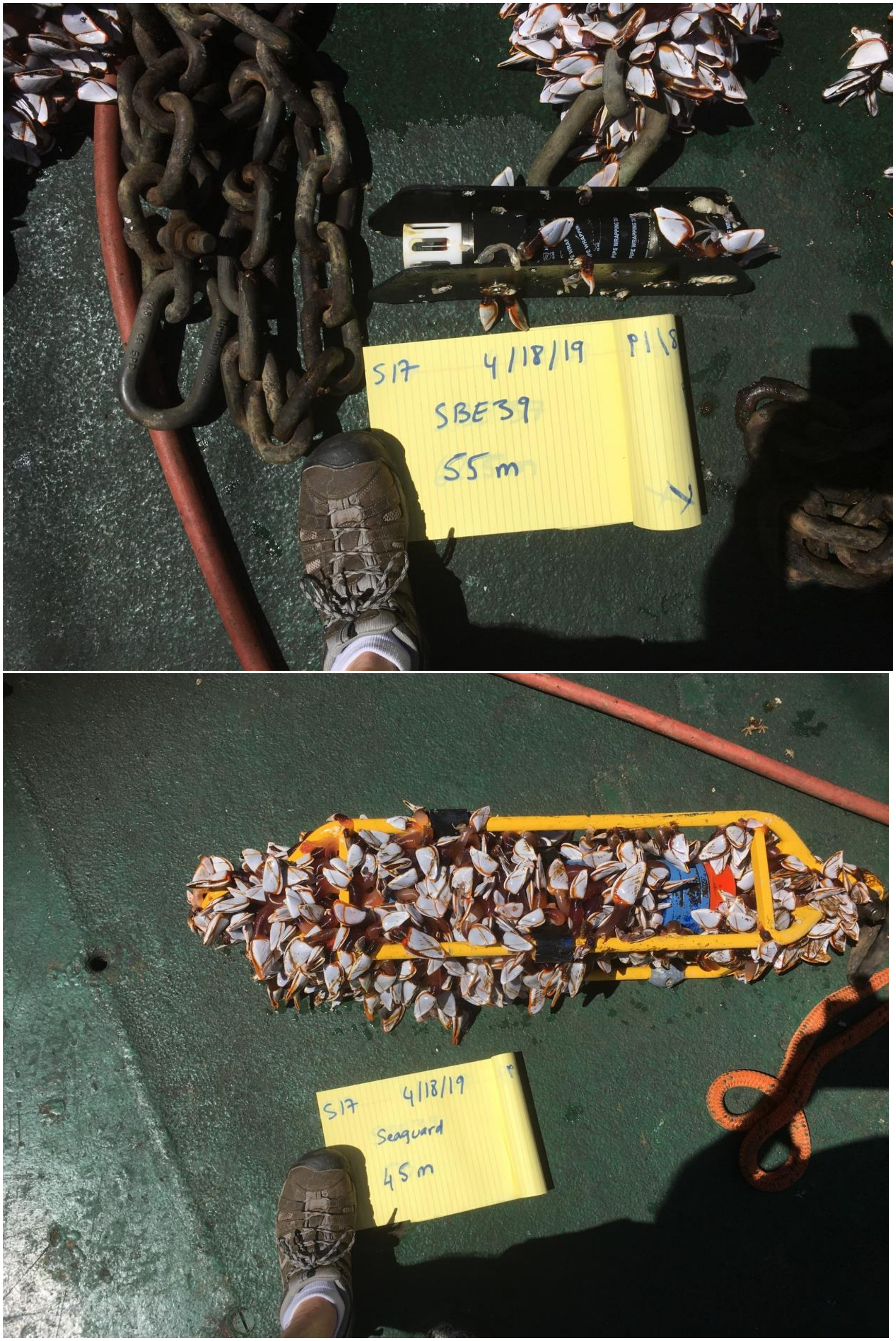


Figure III-4. Heavy biofouling on instrumentation in the upper 50 m.

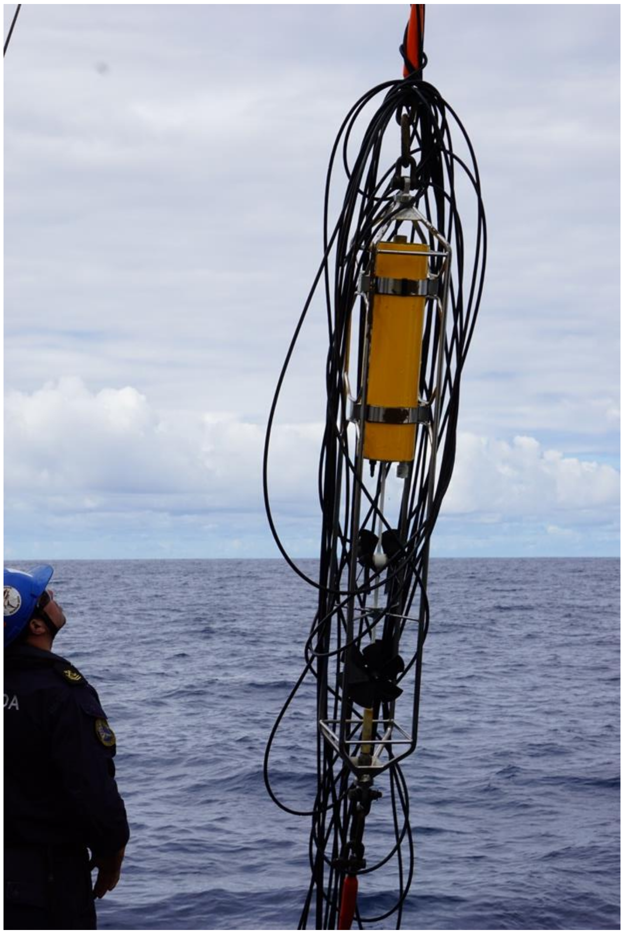


Figure III-5. Mooring line entangled ("wuzzle") around one of the instruments of the broken Stratus 17 mooring.

B. Mooring Bottom Recovery

On April 23 2019, R/V *Cabo De Hornos* was in position near the Stratus 17 anchor position. At 05:00 (UTC-5), the ship was 400 yards to the northwest of the anchor. Acoustic communications with the bottom releases were unsuccessful, so the ship moved to alternate locations, first east then south of the anchor. Finally, at 07:15, the ship was positioned roughly 20 m from the top of the anchor position and the release command was successfully sent to the acoustic releases to separate the anchor from the mooring line. The ship then moved 470 m to the north-northeast of the anchor. Winds were 8 knots to 132° True. At 07:58, the glass balls surfaced 700 yards on the ship's starboard beam, and recovery operations started. Radio communications with a fishing vessel 20 nm away indicated the presence of three fishing buoys with nets between them, which would be about 1 nm from our initial planned track to the southeast. So instead the Captain plans for a recovery track to the south first, then southwest and finally west.

A winch leaded was pre wound on the Gilson Winch then fed through a block on the A-frame and the line was faked out on deck. The ship deployed the small boats to make a secure connection on the glass balls. The winch leader line was thrown to the small boat and the connection was made.

The winch hauled in as the ship steamed ahead to get the balls lined up behind it. At this point, the ship was towing the glass balls from the winch, with the mooring line trailing behind. The scientists aboard the small boat were then transferred back to the ship, and the operation continued. With the A-frame positioned outboard, the glass balls were slowly lifted from the water. The A-frame was brought inboard as the winch hauled in, lifting the cluster of glass above the deck. The ship's winch on the main deck was used to stabilize the glass balls as well as to haul them forward. When the cluster was clear of the transom, it was lowered to the deck. A stopper line was used to secure the chain hanging over the stern with two SBE 37s and two acoustic releases attached to it. Another stopper line was connected to the thimble on the end of the Colmega line. The winch was disconnected from the glass ball cluster, and shackled to the release chain. The chain was disconnected from the glass ball cluster, and the winch hauled in to get the SBE 37s and releases onto the deck.

The glass balls were disconnected and hauled forward to be lifted later by crane into the open top container. The remaining synthetics and wire were recovered and wound onto the ship's split net drum. One more VMCM and two clamped on microcats were successfully recovered.

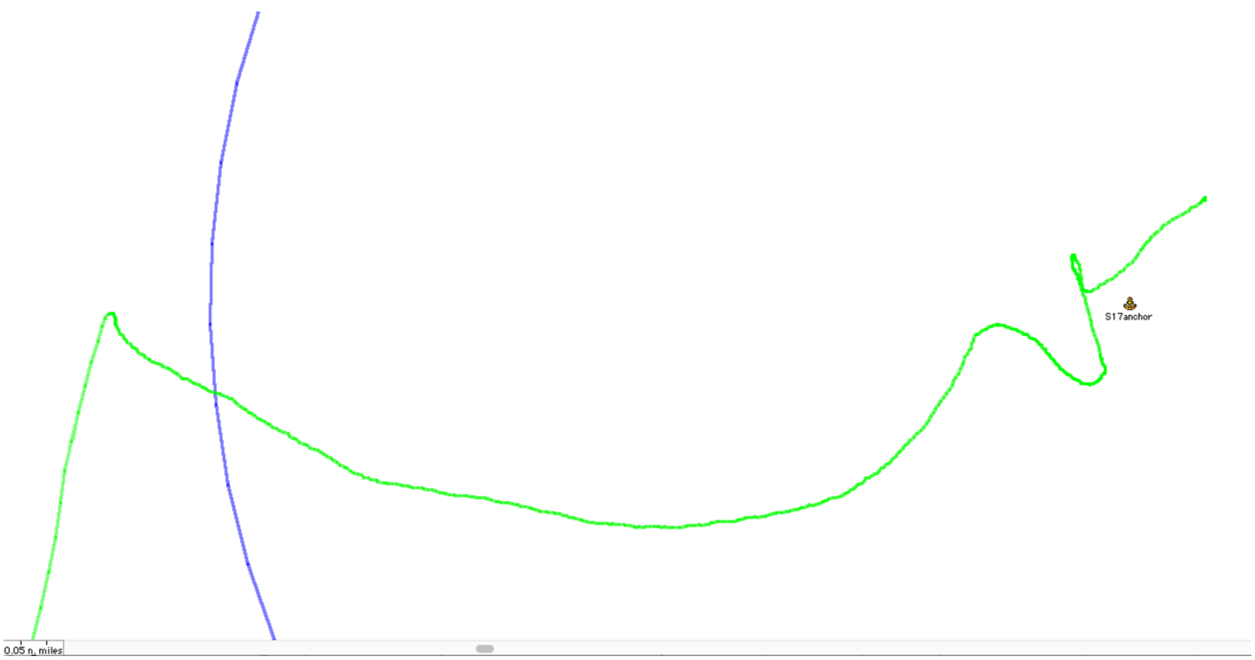


Figure III-6. Ship's track during recovery of Stratus 17 bottom mooring section.

C. Stratus 17 Instrumentation Notes and Validation

VMCM

VMCM SN 017 was recovered with the glass ball section of the S17 mooring on 4/23/2019. Immediately upon recovery the instrument was rinsed with freshwater and the propeller vanes were secured. The recovery check-in procedure was started on the following day. The instrument did not respond to initial interrogation via the bulkhead I/O. The electronics chassis was removed

from the pressure case and inspected for any visual faults. The battery voltage measured 0.9 VDC. Positive communication was established by applying external power. The status command yielded:
VM001
Model: STAR ENGINEERIN
SerNum: VM2017
CfgDat: 08APR02
Firmware: VMCM2 v3.24
RTClock: 2019/04/25 18:43:03
Logging Interval: 60; Current Tick: 18
Compass Ontime=2 Offtime=13
EDI Intel-compatible 20MB PCMCIA CARD present - CARD OK!
FLASH card capacity: 20840436
Records used: 33; available: 612921
Main Battery Voltage: 0.00
No TPOD installed?
Sampling GO

The preliminary assessment, including review of the deployment documentation, indicates a rapidly discharged battery as the cause of malfunction. The diagnostic tools required to properly evaluate the board-set and identify any electronic faults were not available on the vessel, so further testing would need to be conducted at the UOP lab upon return to WHOI.

CTD Comparison

A CTD cast (#1) was conducted right after recovery of the drifting mooring Stratus 17, at the site where the last instrument was recovered from the water. The CTD occurred at 22:00 UTC on 4/18/2019. Comparison between CTD data and sensors on the drifting mooring was done. Mooring data used covered 2 hours, from 14:00 to 16:00 UTC; this time window ended shortly before the mooring recovery started. The CTD cast and mooring data are therefore not concomitant, nor collocated, but the comparison has probably some validity for deeper sensors where temporal and spatial variability are low. This comparison is shown below as a profiles and differences between averages of the mooring data from the two hour time window mentioned above, and a vertical average of the CTD data (10 m bin centered on the nominal depth of each SBE37 instrument recovered on the drifting mooring on 4/18/2019); see Figure III-7 and Figure III-8.

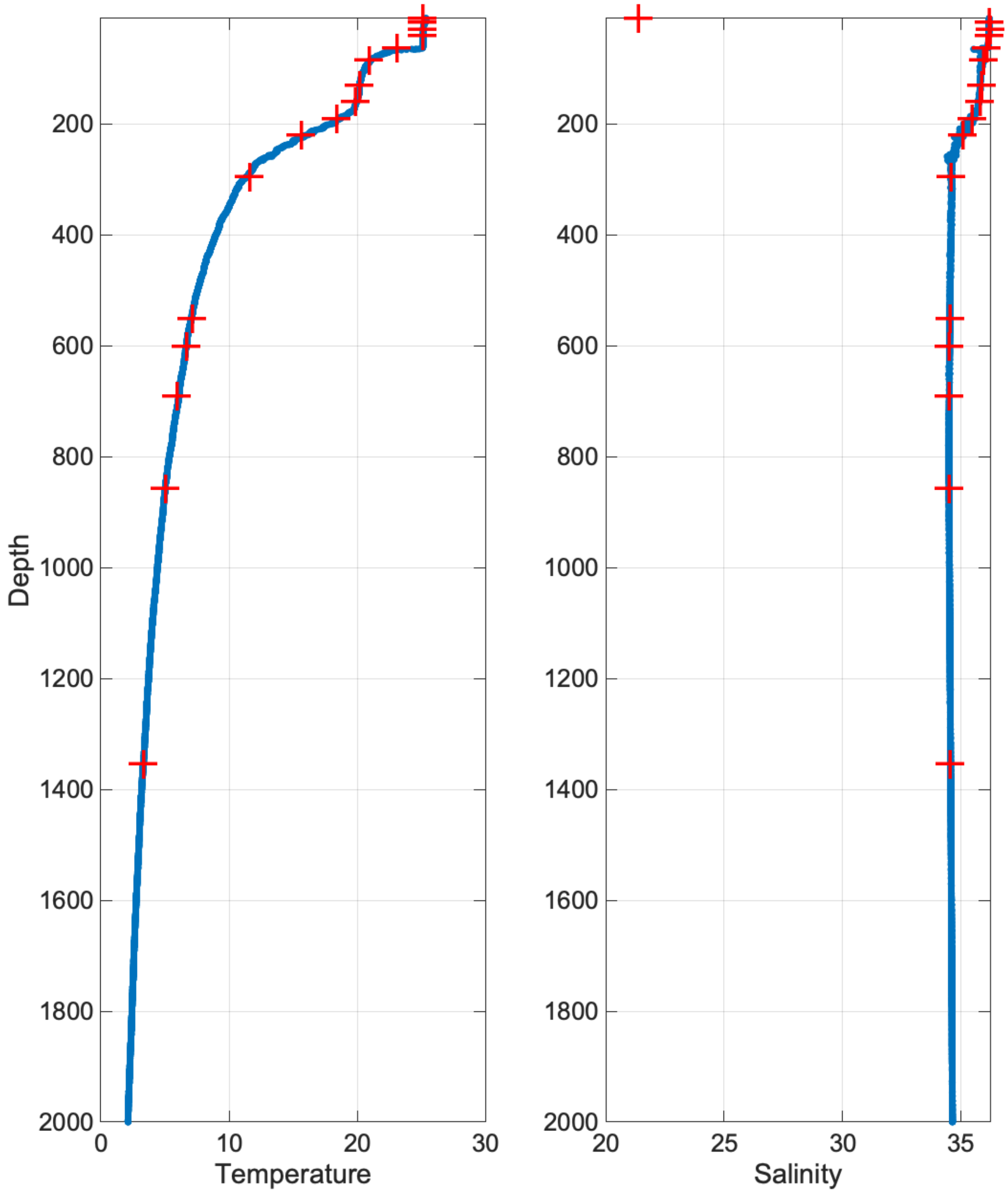


Figure III-7. Comparison between data from CTD cast #1 (blue line) and SBE37 data recovered from Stratus 17 drifting mooring (red crosses): profiles of temperature (left) and salinity (right).

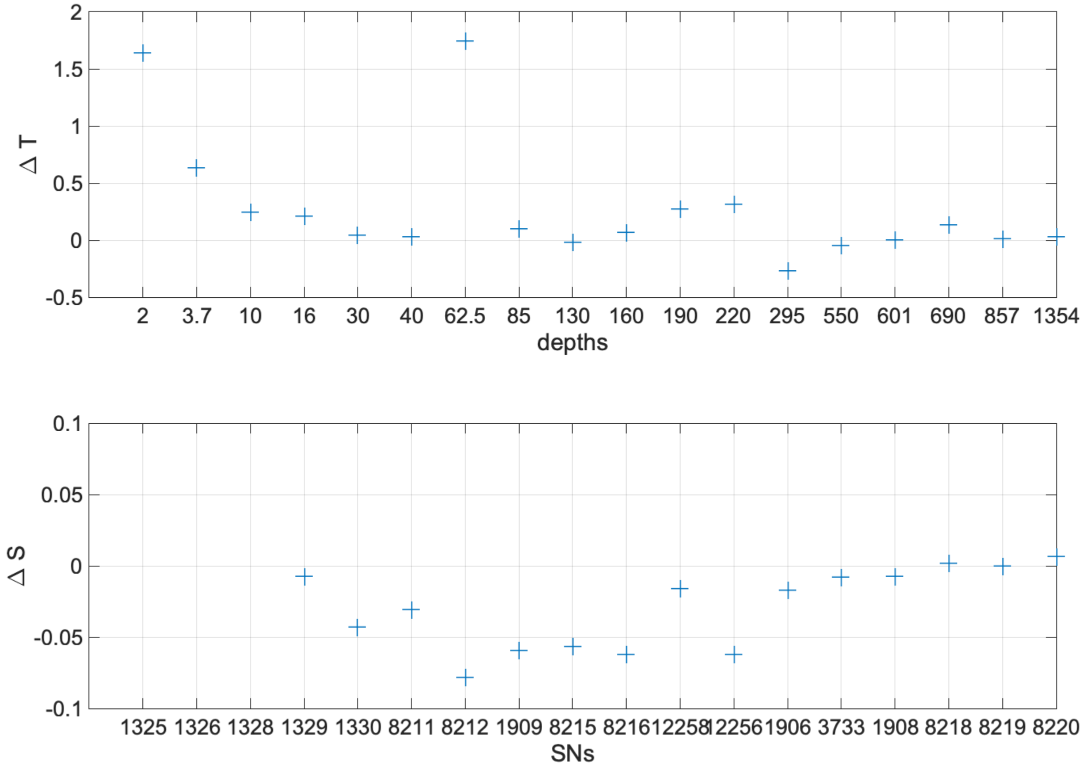


Figure III-8. Difference between data from CTD cast #1 and SBE37 data recovered from Stratus 17 drifting (CTD – SBE37): temperature (top, in °C) and salinity (bottom, in psu).

IV. Ancillary Work

A. CTDs

During the Stratus 18 cruise, a total of three CTD casts were operated. The first one was located just outside the Chilean EEZ, and served as a test for the acoustic releases that were to be deployed on the Stratus 18 mooring. For this CTD test, two casts were done; the first one was only to 500 m and the second one went down to 1,500 m and included the acoustic releases on the Rosette but not the UOP CTD sensor. The second cast was done right after recovery of the drifting Stratus 17 buoy on April 18. The third CTD was done 1 nm west of Stratus 18 mooring on April 24. Locations and times of the CTD casts are summarized in Table IV-1.

Table IV-1. Time and locations of the CTD casts made during the Stratus 18 cruise.

CTD #	Event	Date and Time (UTC)	Latitude	Longitude	Depth (m)
0	Release test	4/9/19 11:00	29° 31.7’S	77° 2.4’ W	1,500 (500)
1	S17 recovery	4/18/19 22:00	19° 35.5’ S	84° 58.9’ W	2,000
2	S18 intercomparison	4/24/19 21:10	22° 27.74’ S	85° 41.48’ W	2,000

The CTD sensors used by SHOA (Servicio Hidrográfico y Oceanográfico de la Armada) during the cruise were a SBE 9plus and a SBE 19 sensors. The SBE 9plus sampled at 1 s interval, and included Temperature (SN5386), Conductivity (SN3944), Pressure (SN1066) and Oxygen (SBE43 SN2208) sensors which had last been calibrated in March-April 2017. The pumped SBE 19 sampled at 0.25 s interval, and included Temperature (SN4208), Conductivity (SN4208), Pressure (SN4208) and Oxygen (SBE43 SN0077) sensors which had last been calibrated in June-July 2018. The CTD instrument used by UP was a SBE 19 sensor (V3.1, serial number 2361). The sensor was calibrated in November 2018 and sampled every 0.5 s. Figures below show the profiles for the CTD casts.

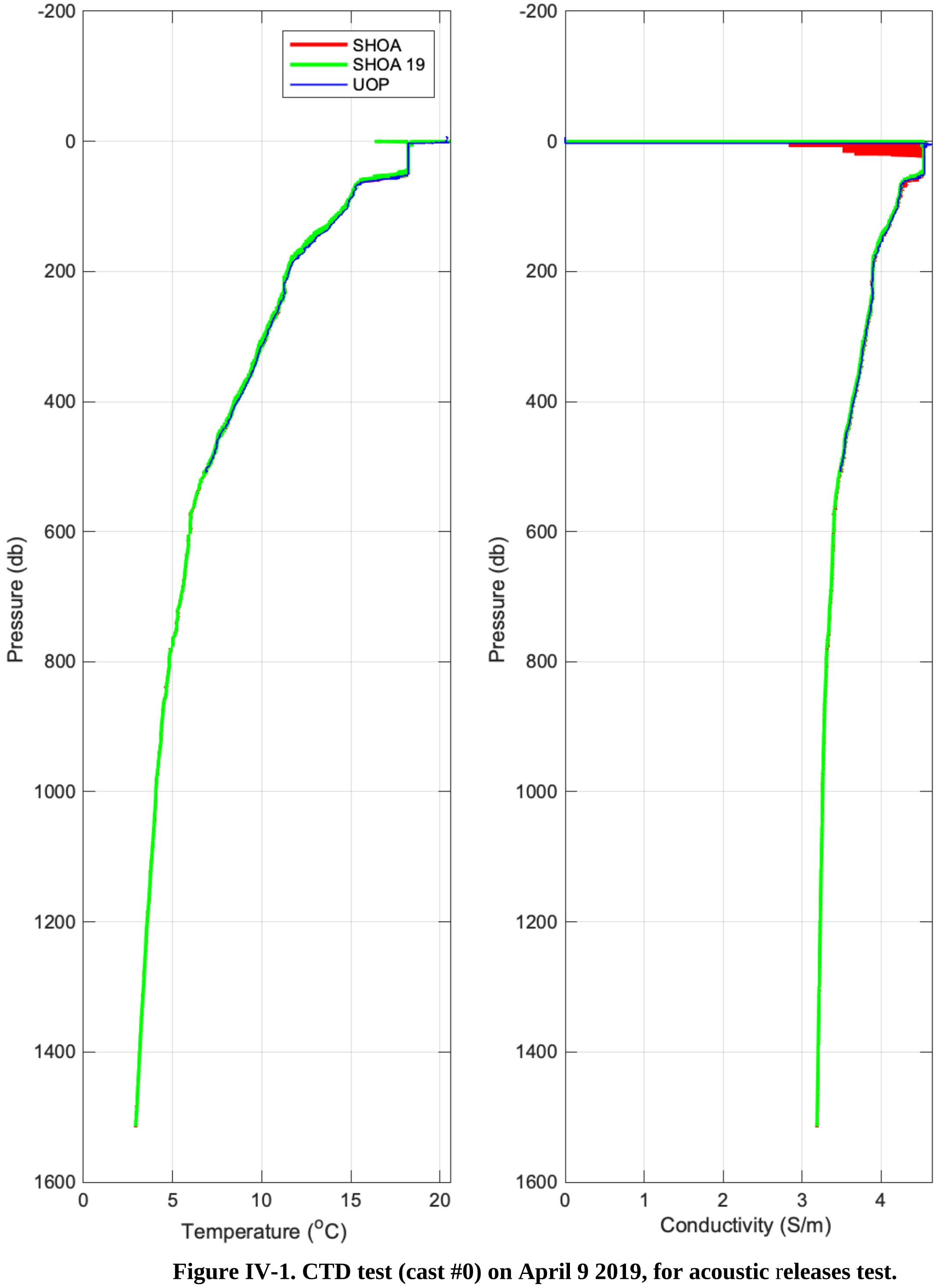


Figure IV-1. CTD test (cast #0) on April 9 2019, for acoustic releases test.

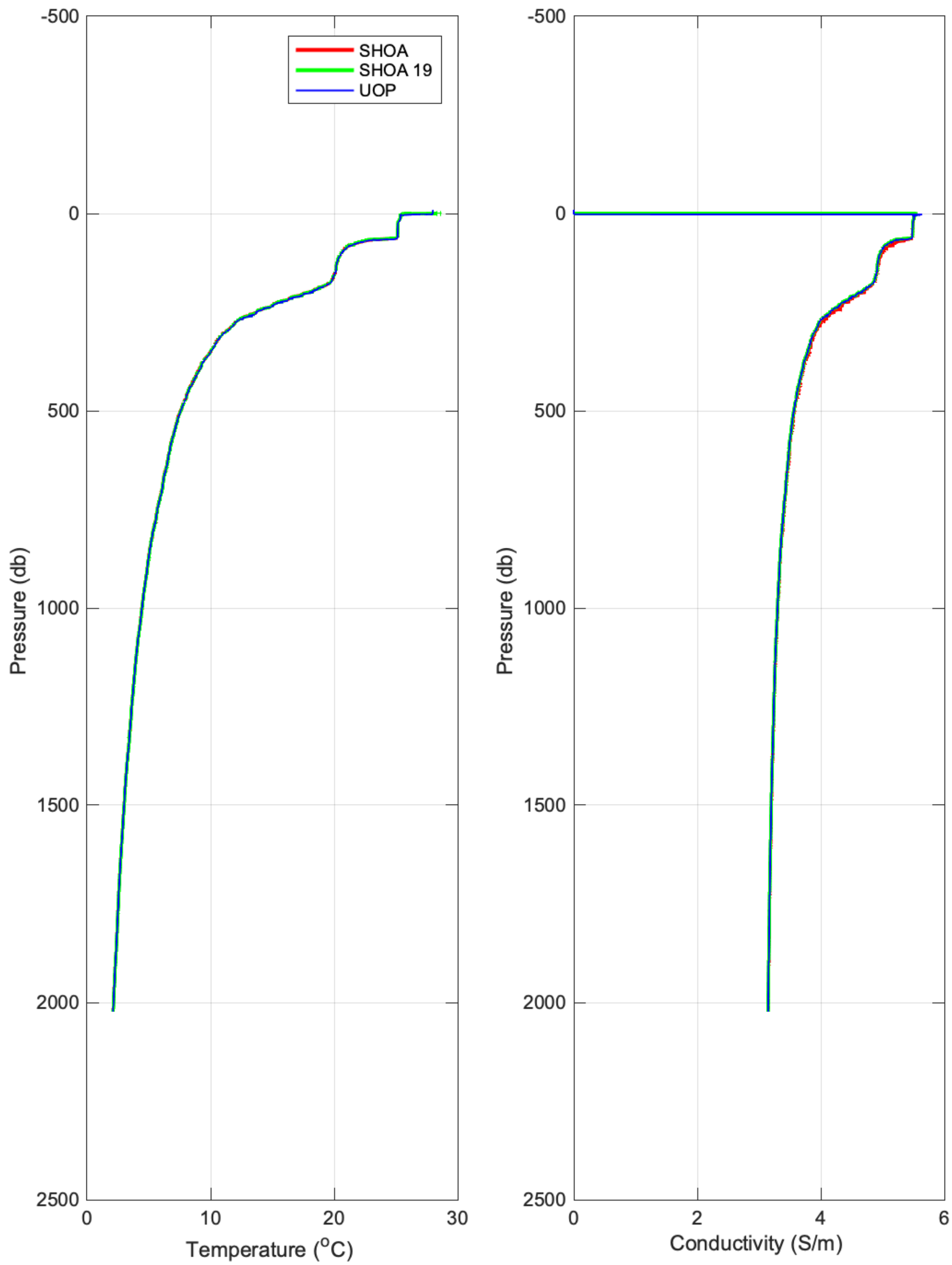


Figure IV-2. CTD cast#1 on April 18, after recovery of Stratus 17 buoy and upper 1,500 m of mooring, at location of last instrument recovered.

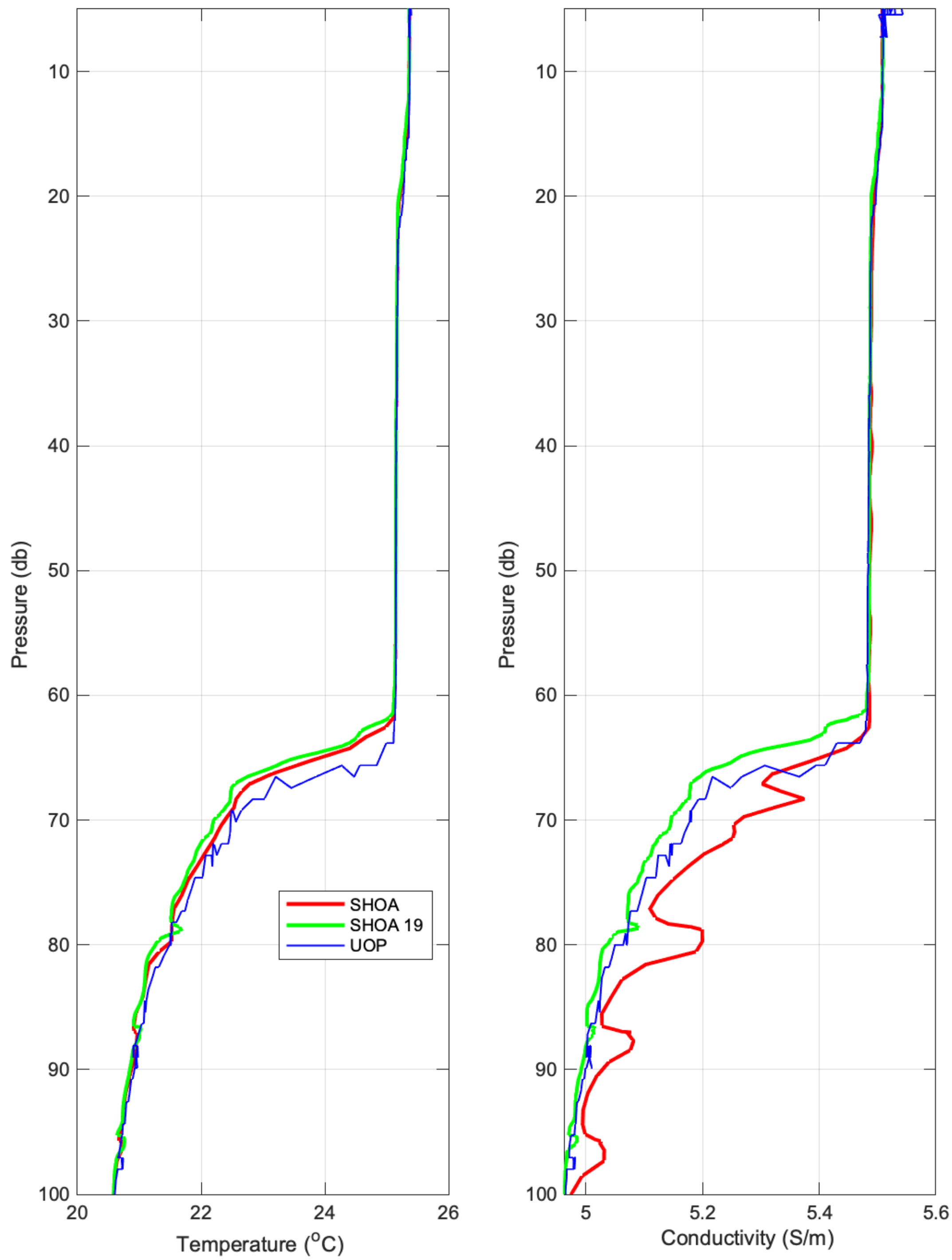


Figure IV-3. CTD cast#1 on April 18, after recovery of Stratus 17 buoy and upper 1,500 m of mooring, at location of last instrument recovered (upper 500).

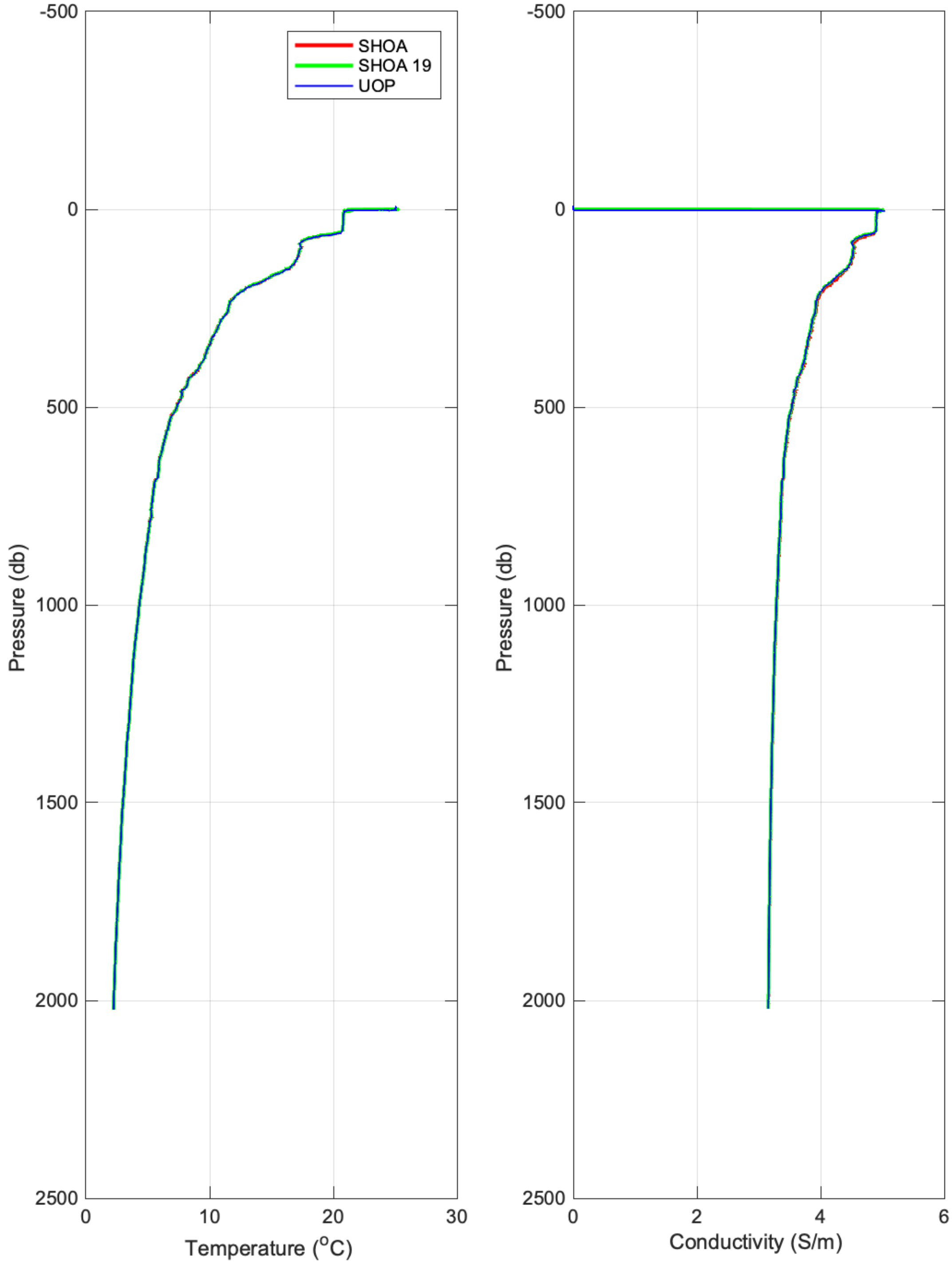


Figure IV-4. CTD cast#2 on April 24, near Stratus 18 buoy Error! Reference source not found..

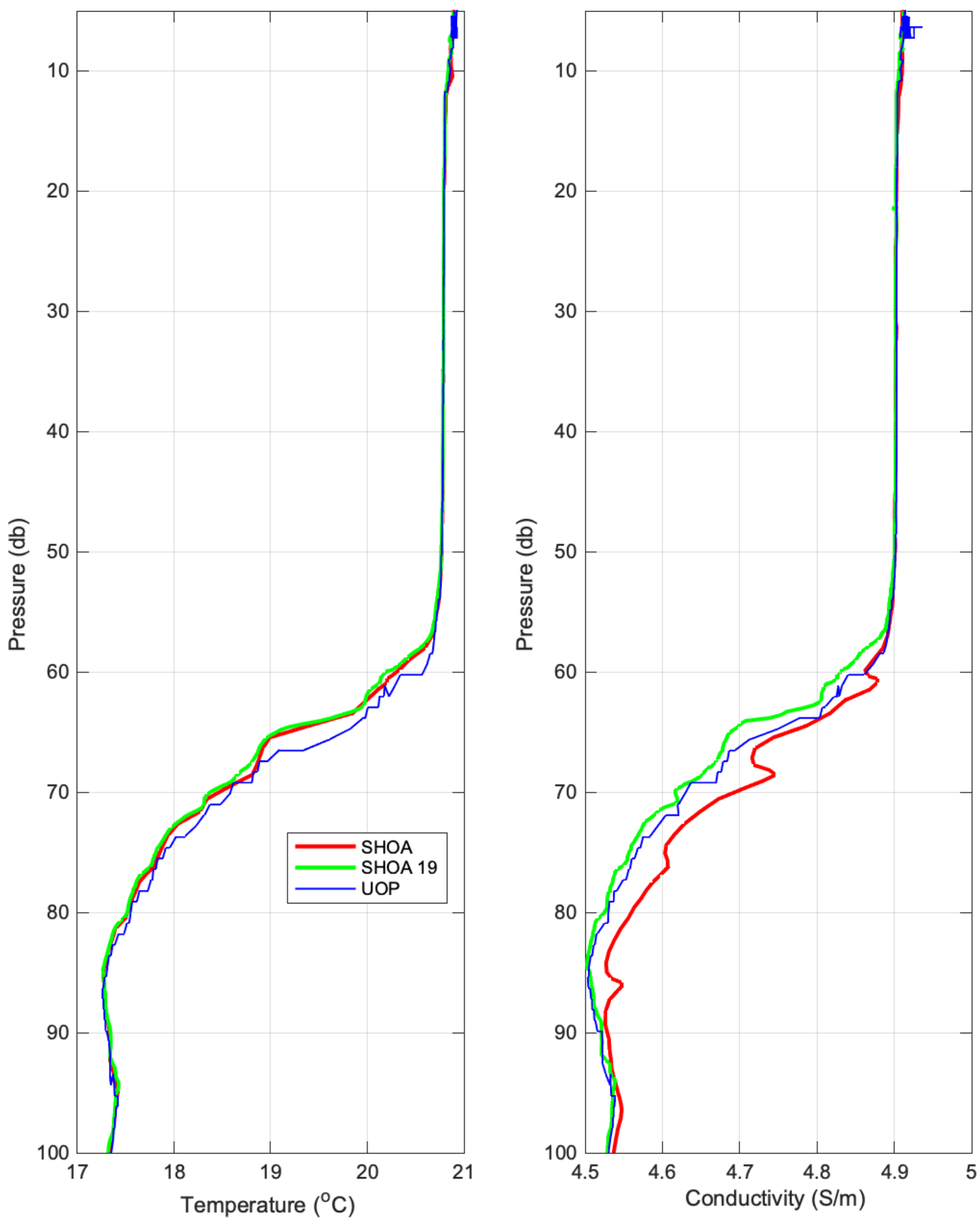


Figure IV-5 CTD cast#2 on April 24, near Stratus 18 buoy (upper 100 m).

B. Surface Drifters and Argo Floats

During the Stratus 18 cruise, 36 surface drifters and 6 Argo profiling floats were launched. Seven floats were deployed inside Chilean EEZ on behalf of Mario Caceres at University of Valparaiso. The remaining surface drifters were provided by NOAA AOML (Atlantic Oceanographic and Meteorological Laboratories, Miami, Florida) by the NOAA Global Surface Drifter Program. The ARGO floats were provided by WHOI ARGO group. The Stratus program contacted both AOML and the ARGO float group and volunteered to deploy their drifters and floats in international waters.

Table IV-2 provides a tabular summary of surface drifter deployments.

Table IV-2. Surface drifter deployment summary for Stratus 18 cruise (* UV= University of Valparaiso).

	DRIFTER ID	Latitude South (dd mm.mmm)	Longitude West (dd mm.mmm)	Date (mm/dd/yyyy)	Time UTC	Organization
1	700700	32 56.37	71 42.98	4/8/2019	6:20	UV
2	701640	32 51.400	71 51.307	4/8/2019	7:05	UV
3	701700	32 45.853	72 00.331	4/8/2019	7:54	UV
4	700740	32 39.415	72 10.737	4/8/2019	8:53	UV
5	701580	32 33.490	72 20.342	4/8/2019	9:43	UV
6	701630	32 27.608	72 29.846	4/8/2019	10:35	UV
7	701590	32 21.536	72 39.526	4/8/2019	11:27	UV
8	65517540	30 37.617	75 25.667	4/9/2019	2:16	NOAA
9	65517690	30 37.371	75 25.037	4/9/2019	2:18	NOAA
10	65517390	29 09.621	77 34.637	4/9/2019	17:10	NOAA
11	65517530	20 43.545	95 00.471	4/16/2019	5:00	NOAA
12	65517410	20 10.677	96 00.164	4/16/2019	10:31	NOAA
13	65517750	19 38.753	96 57.840	4/16/2019	15:50	NOAA
14	66718480	19 01.580	98 01.170	4/16/2019	21:49	NOAA
15	66436190	18 26.804	99 00.207	4/17/2019	2:39	NOAA
16	65332440	17 51.381	100 00.107	4/17/2019	8:14	NOAA
17	65517560	17 15.800	101 00.100	4/17/2019	13:54	NOAA
18	66436100	16 43.143	102 00.011	4/17/2019	19:32	NOAA
19	66436010	16 10.830	102 59.812	4/18/2019	1:00	NOAA
20	66436050	15 40.557	104 01.658	4/18/2019	6:58	NOAA
21	65517740	14 56.085	105 29.070	4/18/2019	23:58	NOAA
22	66719300	15 02.584	105 00.891	4/19/2019	2:09	NOAA
23	66718470	15 02.627	104 59.707	4/19/2019	2:09	NOAA
24	66718020	15 30.640	102 53.760	4/19/2019	11:54	NOAA
25	66719010	16 40.988	97 59.520	4/20/2019	13:34	NOAA

	DRIFTER ID	Latitude South (dd mm.mmm)	Longitude West (dd mm.mmm)	Date (mm/dd/yyyy)	Time UTC	Organization
26	66020060	17 15.554	95 46.608	4/21/2019	0:09	NOAA
27	66020090	17 26.652	95 03.370	4/21/2019	4:04	NOAA
28	66719040	17 54.755	93 02.246	4/21/2019	14:58	NOAA
29	66717340	18 08.380	92 03.392	4/21/2019	19:36	NOAA
30	66020040	18 08.414	92 03.252	4/21/2019	19:37	NOAA
31	66718010	18 22.642	91 01.732	4/22/2019	1:16	NOAA
32	66020100	18 51.423	88 47.685	4/22/2019	13:19	NOAA
33	66718130	19 01.602	87 57.267	4/22/2019	17:49	NOAA
34	66718460	19 13.151	87 00.075	4/22/2019	22:46	NOAA
35	66020220	29 12.663	77 30.222	4/26/2019	20:11	NOAA
36	66020110	29 53.327	76 30.827	4/27/2019	0:58	NOAA

Table IV-3. ARGO floats deployment summary for Stratus 18 cruise.

	FLOAT ID	Latitude South (dd mm.mmm)	Longitude West (dd mm.mmm)	Date (mm/dd/yyyy)	Time UTC	Comments
1	7496	15 49.325	101 29.570	4/19/2019	19:25	
2	7531	16 35.574	98 20.280	4/20/2019	11:42	
3	7524	17 26.320	95 04.705	4/21/2019	3:56	
4	7532	18 08.137	92 04.402	4/21/2019	19:31	
5	7534	18 51.324	88 48.144	4/22/2019	13:16	
6	7535	22 27.434	85 40.885	4/24/2019	23:07	following CTD to 2,000 m

C. Ship Based Meteorological Observations

Meteorological data were sampled by a Vaisala meteorological station, situated above the bridge of the R/V *Cabo de Hornos* (AGS61). Two samples were taken every 1 minute for the duration of the cruise, though the sampling interval was not always constant. Data spikes were removed from each data set and plotted (Fig. 1). Time was taken in UTC.

Wind direction was constant (north-westerly and north-easterly) with a couple of southerly episodes of very short duration and smaller magnitude (Fig. 1a, 1f). Air temperature steadily increased, reaching its maximum around the 19th , after which it steadily decreased (Fig. 1f). Possible diurnal and semidiurnal variations can be observed. Large variations in the relative humidity can be observed (Fig. 1c).The barometric pressure had semidiurnal fluctuations (Fig. 1d).

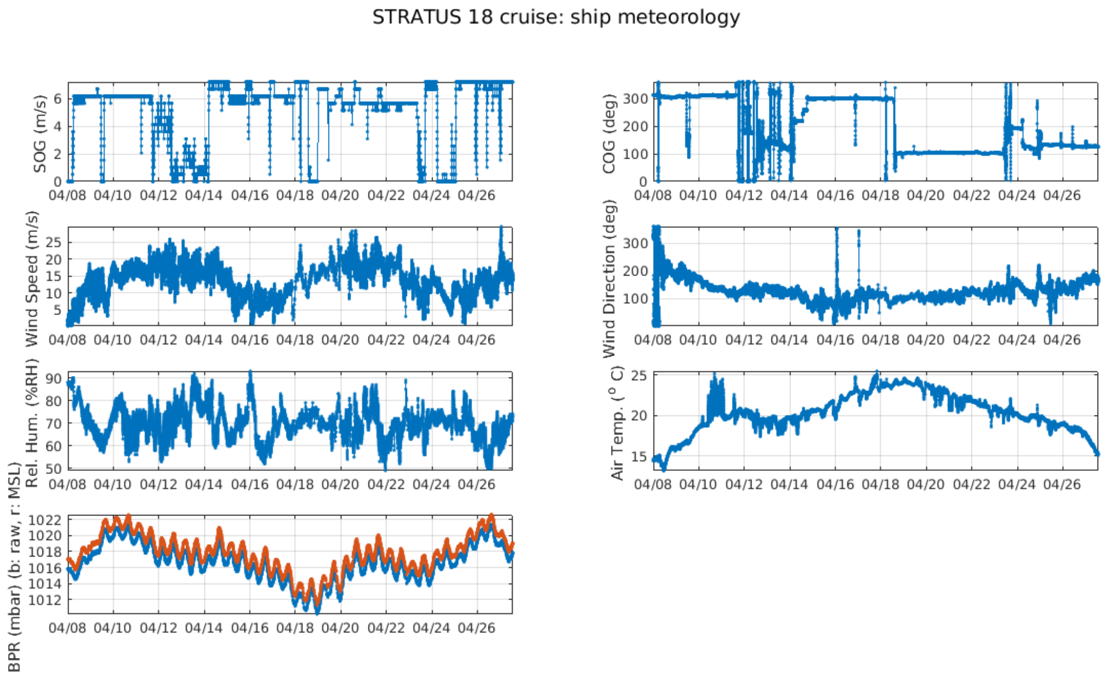


Figure IV-6. R/V *Cabo de Hornos* meteorology data and ship speed and heading from 8th to 27th of April 2019.

<u>Sea water parameters:</u>

Basic water parameters (conductivity, salinity, temperature, density) were obtained using the on-board thermosalinograph (TSG) every 10 seconds. The water sample inlet was situated 5 meters below the water line. Time was taken in UTC. Salinity and sea water temperature data form the TSG were compared with wind direction and speed, air temperature and relative humidity from the ship meteorology data (Figure IV-7 to Figure IV-13).

Wind vectors were calculated from the wind speed (ms^{-1}) and wind direction (degrees °), where U is defined as positive for wind blowing W-to-E and V is positive for wind blowing S-to-N:

Uw = spd .* cos((dir+180)*pi/180)

Vw = -spd .* sin((dir+180)*pi/180)

Air temperature and relative humidity data showed an inverse tendency, a rise in one would cause a fall in the other (panel b in Figure IV-8 through Figure IV-13). Wind speed and direction showed little effect on air temperature and relative humidity. Salinity and sea water temperature tended to follow a similar pattern, except for the data from April 21 to 23 (Figure IV-11) where the salinity presented more variation.

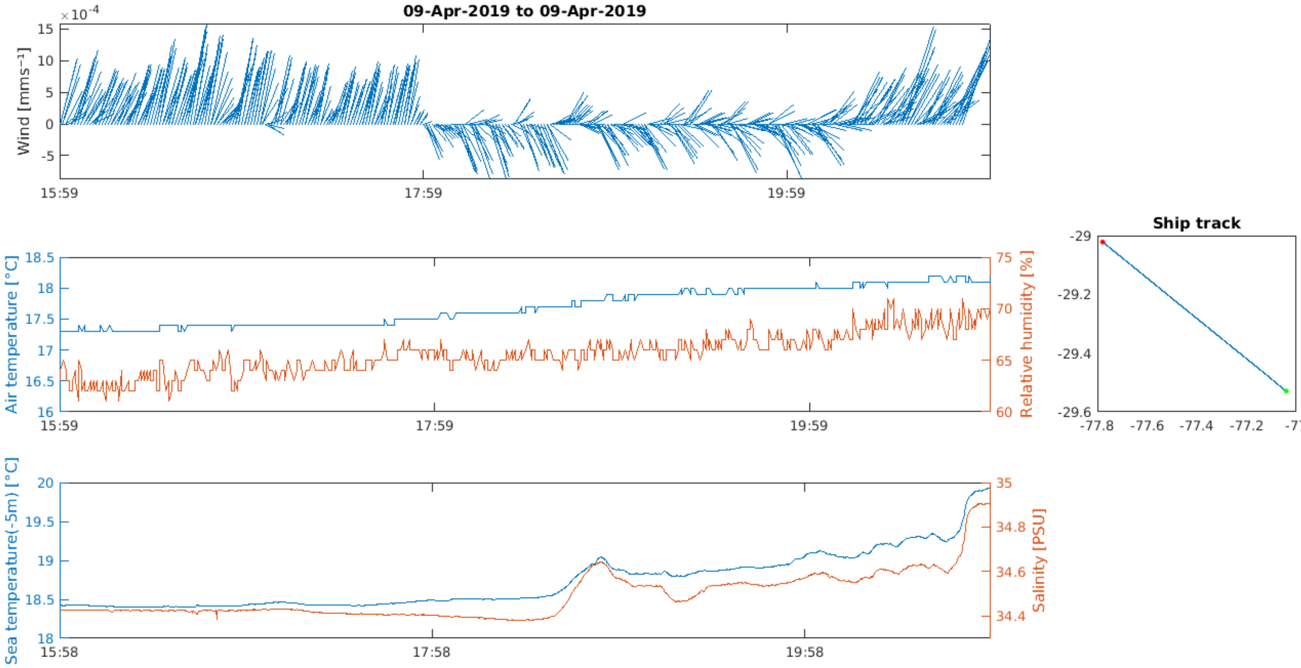


Figure IV-7. TSG data series 1: wind vector diagram (a), air temperature and relative humidity (b), salinity and sea water temperature (c), and ship track (d).

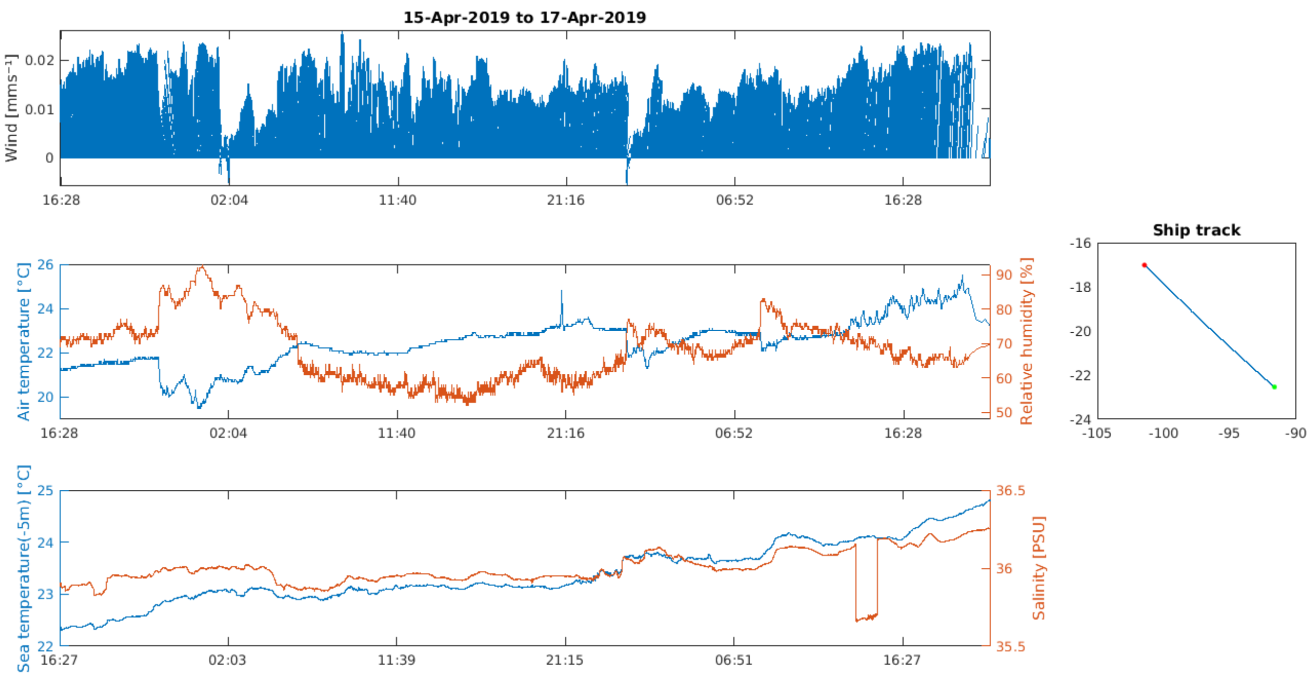


Figure IV-8. TSG data series 2: wind vector diagram (a), air temperature and relative humidity (b), salinity and sea water temperature (c), and ship track (d).

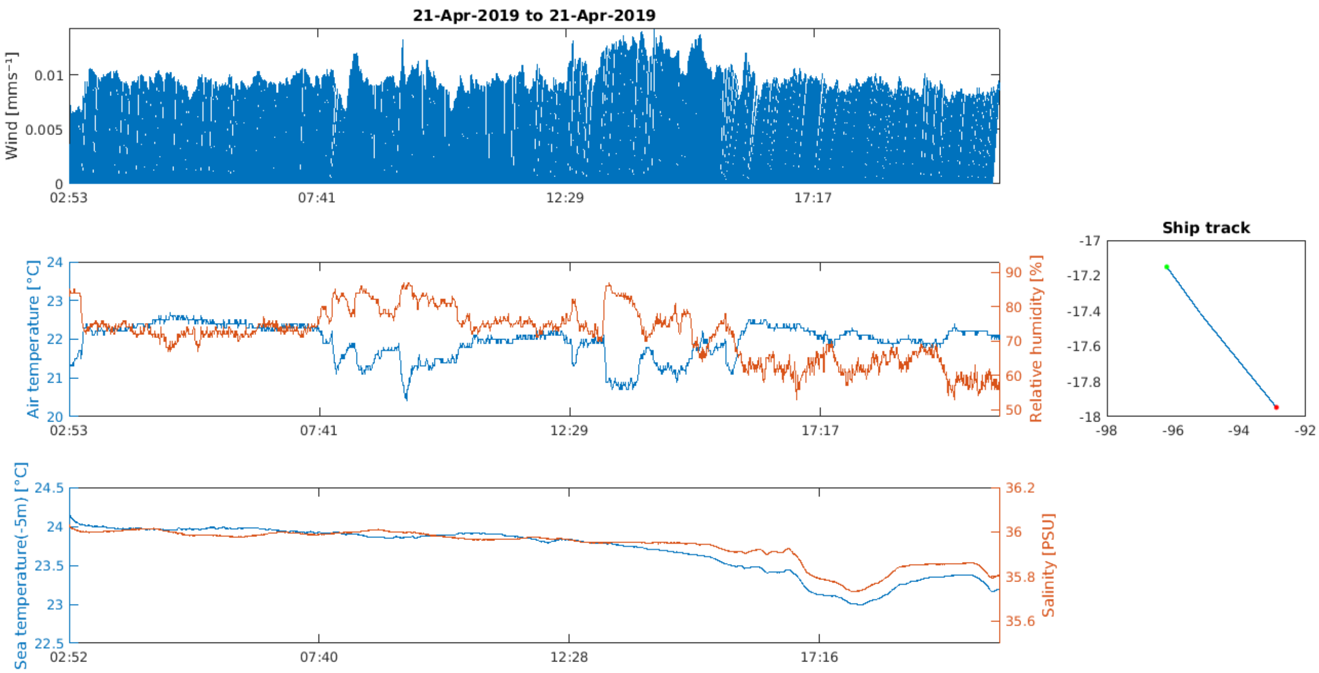


Figure IV-9. TSG data series 3: wind vector diagram (a), air temperature and relative humidity (b), salinity and sea water temperature (c), and ship track (d).

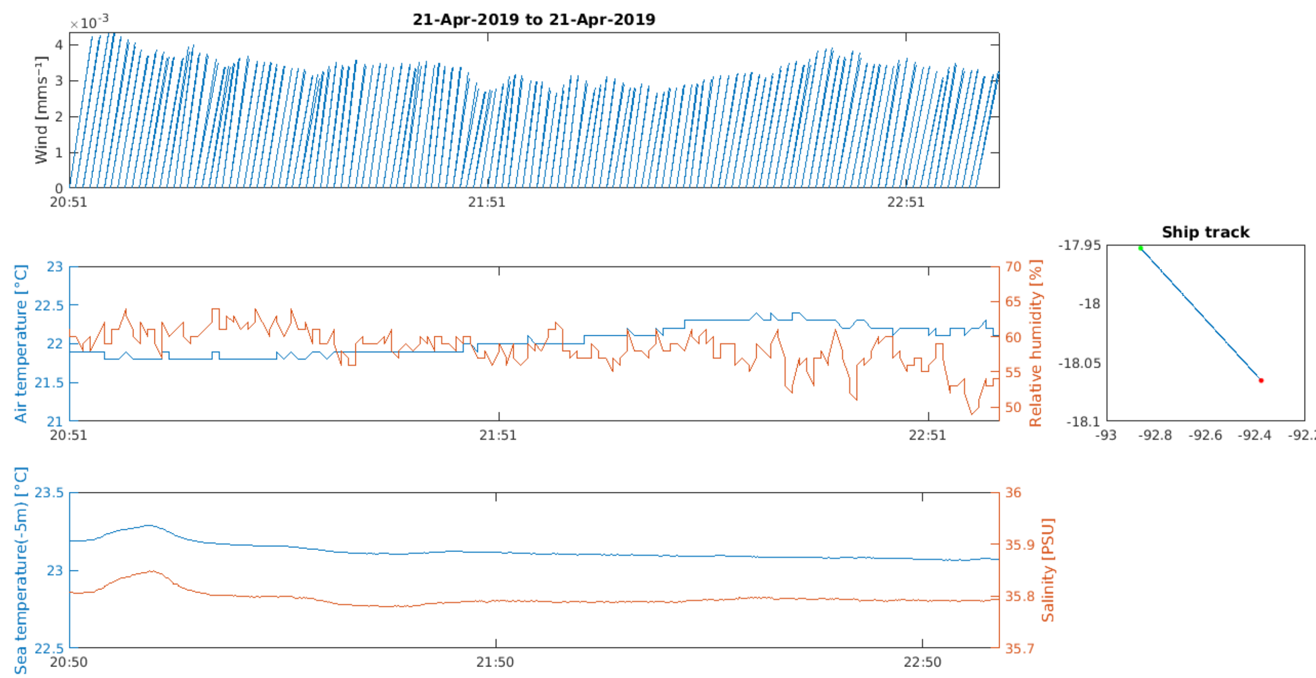


Figure IV-10. TSG data series 4: wind vector diagram (a), air temperature and relative humidity (b), salinity and sea water temperature (c), and ship track (d).

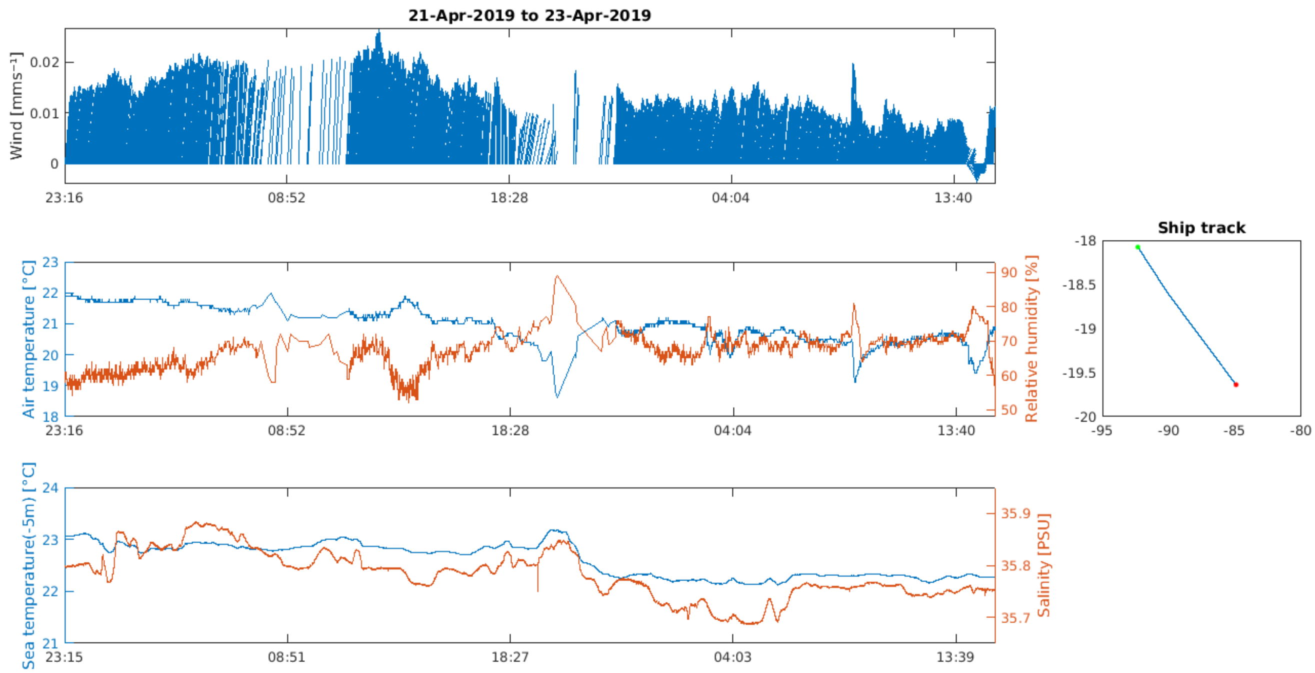


Figure IV-11. TSG data series 5: wind vector diagram (a), air temperature and relative humidity (b), salinity and sea water temperature (c), and ship track (d).

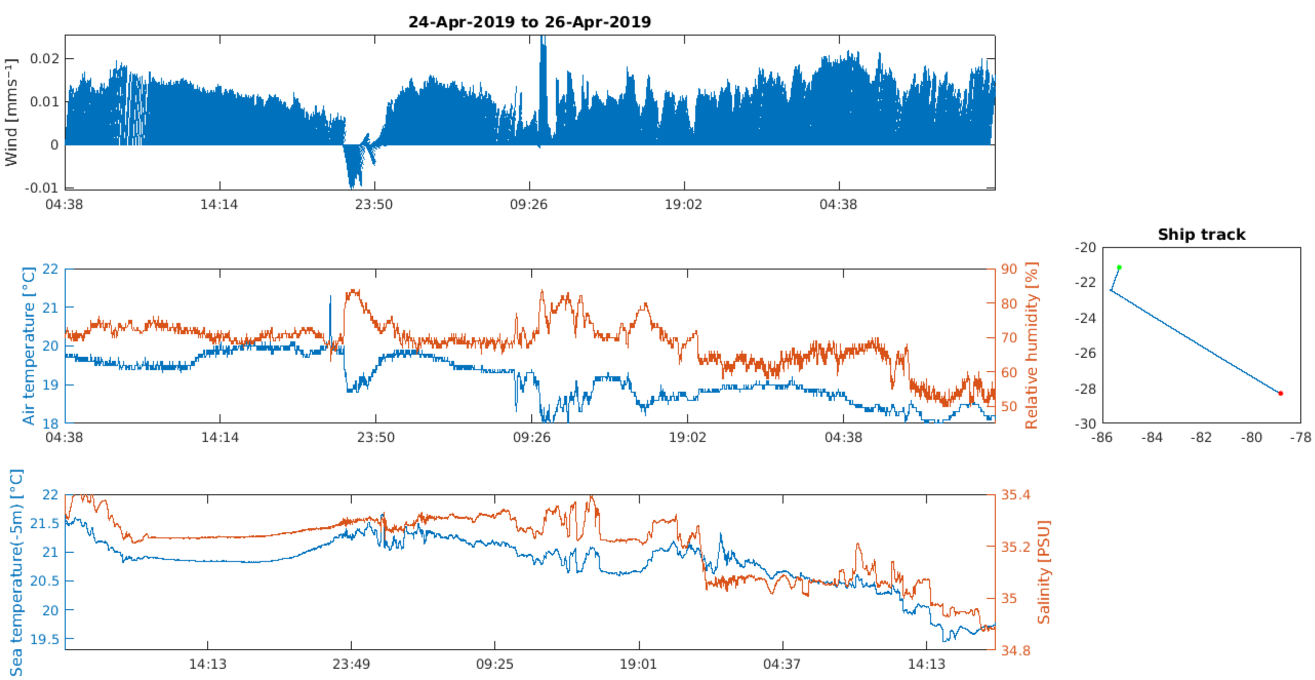


Figure IV-12. TSG data series 6: wind vector diagram (a), air temperature and relative humidity (b), salinity and sea water temperature (c), and ship track (d).

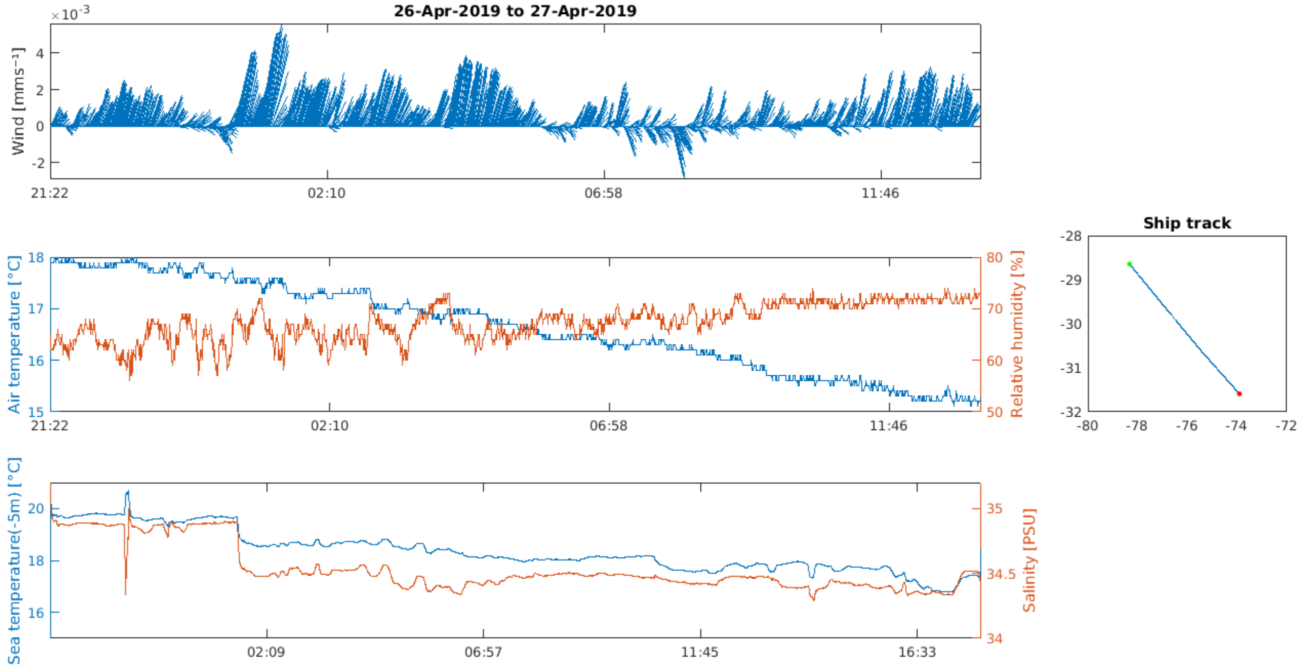


Figure IV-13. TSG data series 7: wind vector diagram (a), air temperature and relative humidity (b), salinity and sea water temperature (c), and ship track (d).

D. Ship Based Currents Observations

Current data was obtained underway using a 76.8 kHz Teledyne RD Ocean Surveyor Acoustic Doppler Current Profiler (ADCP). The ADCP was situated 7 m below the sea surface on a retractable keel. The first bin depth was at 27 m and the bin size was 20 m. The number of bins varied between 10 and 50 due to changes in settings. Heading and GPS data was obtained from the ship, but pitch and roll were not available to the real-time data acquisition display system (VmDAS). Short time averaging interval was every 2 minutes and the long time averaging interval was every 10 minutes. Time was taken in UTC. An attempt was made to post-process the ADCP data directly, using the WinADCP software to correct for the ship velocity using the heading information. However, there was no correction for pitch and roll. East-west (U) and north-south current velocities (V) and the echo amplitude (backscatter) are plotted below.

Figure IV-14 indicates the presence of a surface current to the northeast near Stratus 18 target site on April 12. It is encouraging that the computed current does not vary with the reversed directions of the ship along the different sections of the survey. However, surface altimetry acquired on April 8 indicates a nearby eddy that induces a small flow to the northwest (not shown). Figure IV-15 shows a current direction that bears similarity to the altimetry. The backscatter has a lot of structure in the upper 300 m, maybe related to the presence of an eddy as suggested in the altimetry data. Throughout the cruise, echo amplitude showed a local minimum around 400-500 meters, around the depth of the southeastern Pacific oxygen minimum zone.

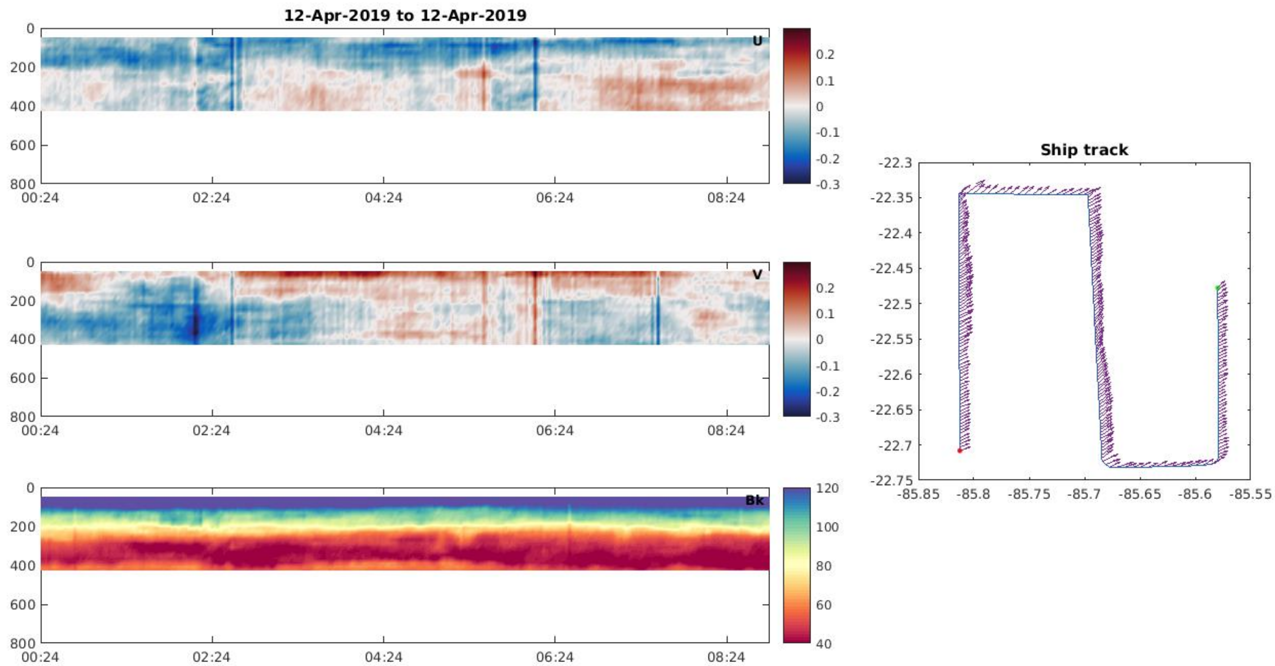


Figure IV-14. ADCP on April 12 2019 during bathymetry survey at Stratus 18 target site: east-west current velocities U (top left), north-south current velocities V (center left), backscatter (echo amplitude) (bottom left), and ship track with 50 m average current vectors (center right).

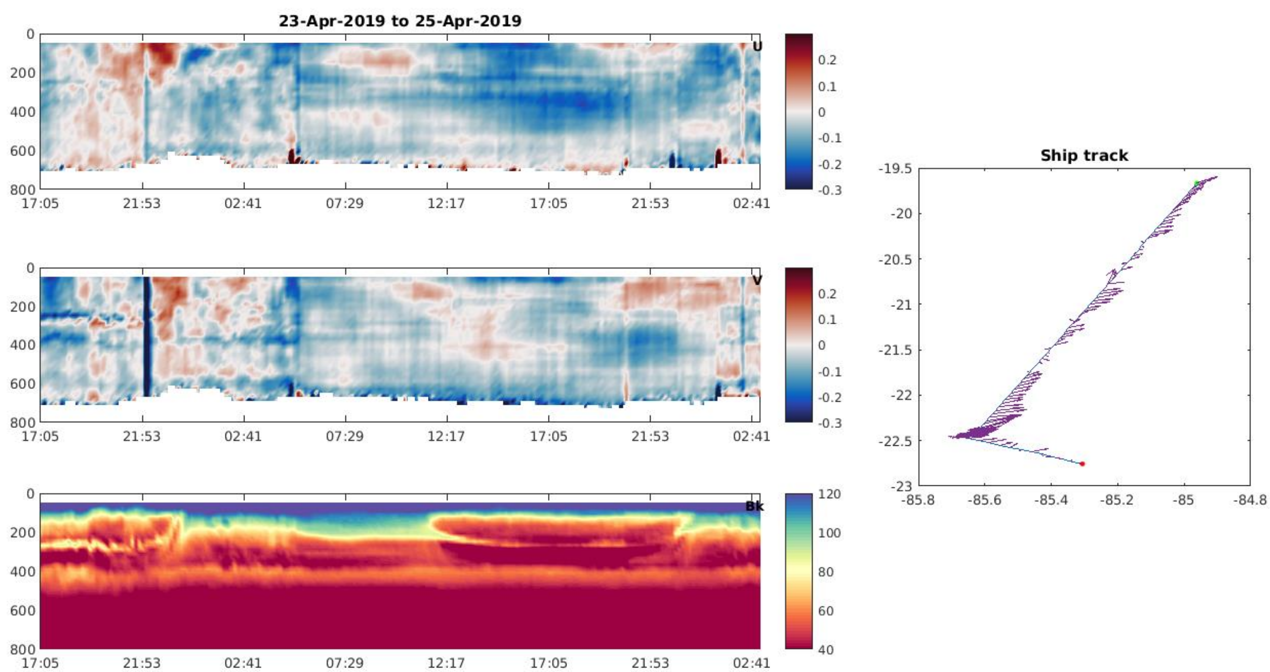


Figure IV-15. ADCP on April 23-25 2019 during transit from Stratus 17 anchor to Stratus 18 buoy, intercomparison at Stratus 18 and start of transit back to Valparaiso: east-west current velocities U (top left), north-south current velocities V (center left), backscatter (echo amplitude) (bottom left), and ship track with 50 m average current vectors (center right).

Acknowledgements

The Upper Ocean Processes group at WHOI is very thankful for the crew of the research vessel *Cabo de Hornos*. The help and welcome from the Chilean Navy and its Hydrographic Services (SHOA) are also very much appreciated. Finally, thanks go to the National Ocean and Atmospheric Administration (NOAA) for its continued support and funding. The Stratus program work is funded by the Climate Observation Division, Climate Program Office (FundRef number 100007298), National Oceanic and Atmospheric Administration, U.S. Department of Commerce, under grant NA14OAR4320158.

Appendix A Stratus 18 Buoy Spin

		Vane (deg)	Compass (deg)	Direction (deg)	Sample Time
Heading = 0; Turn = 0					
Vanes Secured: 11/2/2018 1:22:00 PM UTC					
System 1					
Logger	**L01**				
SWND	**217**		2.90	2.90	13:33:10
System 2					
Logger	**L02**				
WND	**222**	356.10	0.00	356.10	13:31:10
Stand Alone					
WXT	**204**	N/A	357.90	N/A	13:44:45
Heading = 0; Turn = 45					
Vanes Secured: 11/2/2018 1:52:00 PM UTC					
System 1					
Logger	**L01**				
SWND	**217**		47.30	47.30	14:05:00
System 2					
Logger	**L02**				
WND	**222**	313.00	44.20	357.20	13:57:20
Stand Alone					
WXT	**204**	N/A	42.90	N/A	14:02:10
Heading = 0; Turn = 90					
Vanes Secured: 11/2/2018 2:11:00 PM UTC					
System 1					
Logger	**L01**				
SWND	**217**		90.70	90.70	14:17:10
System 2					
Logger	**L02**				
WND	**222**	269.50	92.30	1.80	14:19:00
Stand Alone					
WXT	**204**	N/A	88.30	N/A	14:21:40

Heading = 0; Turn = 135					
Vanes Secured: 11/2/2018 2:28:00 PM UTC					
System 1					
Logger	**L01**				
SWND	**217**		134.90	134.90	14:42:00
System 2					
Logger	**L02**				
WND	**222**	223.50	141.00	4.50	14:41:00
Stand Alone					
WXT	**204**	N/A	134.40	N/A	14:43:20
Heading = 0; Turn = 180					
Vanes Secured: 11/2/2018 2:48:30 PM UTC					
System 1					
Logger	**L01**				
SWND	**217**		178.10	178.10	14:57:50
System 2					
Logger	**L02**				
WND	**222**	176.20	187.10	3.30	14:55:20
Stand Alone					
WXT	**204**	N/A	180.00	N/A	14:59:15
Heading = 0; Turn = 225					
Vanes Secured: 11/2/2018 3:08:00 PM UTC					
System 1					
Logger	**L01**				
SWND	**217**		223.00	223.00	15:13:55
System 2					
Logger	**L02**				
WND	**222**	130.20	230.10	0.30	15:15:30
Stand Alone					
WXT	**204**	N/A	223.60	N/A	15:17:30

Heading = 0; Turn = 270					
Vanes Secured: 11/2/2018 3:27:30 PM UTC					
System 1					
Logger	**L01**				
SWND	**217**		269.70	269.70	15:34:15
System 2					
Logger	**L02**				
WND	**222**	83.60	272.70	356.30	15:35:44
Stand Alone					
WXT	**204**	N/A	267.40	N/A	15:37:20
Heading = 0; Turn = 315					
Vanes Secured: 11/2/2018 3:45:45 PM UTC					
System 1					
Logger	**L01**				
SWND	**217**		314.70	314.70	15:52:20
System 2					
Logger	**L02**				
WND	**222**	41.00	314.40	355.40	15:54:00
Stand Alone					
WXT	**204**	N/A	310.40	N/A	15:55:55
Heading = 0; Turn = 360					
Vanes Secured: 11/2/2018 4:01:35 PM UTC					
System 1					
Logger	**L01**				
SWND	**217**		0.10	0.10	16:07:00
System 2					
Logger	**L02**				
WND	**222**	356.90	357.40	354.30	16:08:40
Stand Alone					
WXT	**204**	N/A	354.90	N/A	16:10:30

Appendix A Stratus 18 Surface and Subsurface Instrumentation Configuration

Surface:

Module	Serial	Firmware Version	Height Cm	Spike Date	Spike Start Time	Spike End Time
SYSTEM 1						
Logger PORT	L01	LOGR53 v4.38-1spurs2				
HRH	215	VOSHRH53 v4.29cf	235			
BPR	206	VOSBPR53 v4.03cf (Heise)	240			
SWND	217	SONICWND53 v4.11cf	268	20190412	21:13	21:31
PRC	213	VOSPRC53 v4.03cf	252	20190402	11:43	11:43
LWR	212	VOSLWR53 v4.02cf	283	20190412	21:15	21:32
SWR	223	VOSSWR53 v4.01cf	283	20190412	21:15	21:32
SST	1836	V 2.3b	-145			
IR IMEI	300234063166220					
SYSTEM 2						
Logger STARBOARD	L02	LOGR53 v4.38-1spurs2				
HRH	230	VOSHRH53 v4.29cf	235			
BPR	205	VOSBPR53 v4.03cf (Heise)	240			
WND	222	VOSWND53 v4.02cf	266	20190412	21:13	21:31
PRC	275	VOSPRC53 v4.03cf	252	20190402	~11:50	~11:50
LWR	502	VOSLWR53 v4.02cf	283	20190412	21:15	21:32
SWR	352	VOSSWR53 v4.01cf	283	20190412	21:15	21:32
SST	2054	V 2.3b	-145			
IR IMEI	300234063269760					

Module	Serial	Firmware Version	Height Cm	Spike Date	Spike Start Time	Spike End Time
STAND ALONES MODULES						
Rotronics Hygroclip	12718274/20208310		225			
SBE-39-AT	3800	V 3.0b	230			
VWX	204	VAISALA24 v5.65	240			
SA HRH	221	VOSHRH53 v4.29cf	235			
SA SWR	801	VOSSWR53 v4.01cf	283	20190412	21:15	21:32
XEOS KILO	300234062945460					
XEOS Mello	300034013701980					
XEOS Rover (Primary)	300434060447400					
XEOS Rover (Secondary)	300434061508050					

Stratus 18 Sea Surface Temperature Array				
		CM	CM	Orientation
Instrument	Serial	Below Deck	below waterline**	Degrees
SBE56	1211	90	30	90* (STBD)
SBE56	1207	90	30	0* (BOW)
SBE56	1208	120	60	0* (BOW)
SBE56	1209	140	80	0* (BOW)
SBE56	2069	90	30	270* (PORT)

**Waterline = 60cm

*In hull SSTs orientation convention has bow (pick-up bale) a 0° positive degrees go clockwise so STBD is 90° wind vane is 180° and port is 270°

Subsurface:

Instrument	Serial	Depth Meters	Sample rate (s)	Start Date	Start Time	Spike Date	Spike Start Time	Spike Stop Time
AANDERAA ADCM	238	13.0	300/1500	20190405	0100	20190410	14:55	15:05
AANDERAA ADCM	235	32.5	300/1500	20190405	0100	20190410	14:55	15:05
MicroCat	1304	2	300	20190405	0100	20190410	14:22	14:38
MicroCat	3821	3.7	300	20190405	0100	20190410	14:00	14:18
MicroCat	3824	7	300	20190405	0100	20190410	14:00	14:18
MicroCat	1899	16.4	300	20190405	0100	20190410	14:00	14:18
MicroCat	1900	30	300	20190405	0100	20190410	14:22	14:38
MicroCat	1901	40	300	20190405	0100	20190410	14:22	14:38
MicroCat	1902	62.5	300	20190405	0100	20190410	14:22	14:38
MicroCat	8004	85	300	20190406	0100	20190410	14:23	14:38
MicroCat	1903	130	300	20190405	0100	20190410	13:59	14:11
MicroCat	1905	160	300	20190405	0100	20190410	14:00	14:18
MicroCat	1907	190	300	20190405	0100	20190410	13:59	14:11
MicroCat	8214	220	300	20190406	0100	20190410	13:59	14:11
MicroCat	2011	250	300	20190406	0100	20190410	13:59	14:11
MicroCat	7836	310	300	20190406	0100	20190410	14:00	14:18
MicroCat	8223	550	300	20190406	0100	20190410	14:00	14:18
MicroCat	12245	1890	300	20190406	0100	20190413	13:00z	13:00z
MicroCat	10600	4496	300	20190406	0100	20190410	14:00	14:18
MicroCat	10601	4496	300	20190406	0100	20190410	14:00	14:18
RDI ADCP	12254	88	300/3600	20190405	0100	20190410	14:55	15:05
SBE 39	39	5	300	20190405	0100	20190410	14:12	14:27
SBE 39	41	12.2	300	20190405	0100	20190410	14:12	14:27

Instrument	Serial	Depth Meters	Sample rate (s)	Start Date	Start Time	Spike Date	Spike Start Time	Spike Stop Time
SBE 39	53	20	300	20190405	0100	20190410	14:12	14:27
SBE 39	101	25	300	20190405	0100	20190410	14:12	14:27
SBE 39	721	35	300	20190405	0100	20190410	14:12	14:27
SBE 39	1502	52	300	20190405	0100	20190410	14:12	14:27
SBE 39	1509	70	300	20190405	0100	20190410	14:12	14:27
SBE 39	1511	77.5	300	20190405	0100	20190410	14:12	14:27
SBE 39	3423	92.5	300	20190405	0100	20190410	14:12	14:27
SBE 39	1498	115	300	20190405	0100	20190410	14:12	14:27
SBE 39	3435	145	300	20190405	0100	20190410	14:12	14:27
SBE 39	3437	175	300	20190405	0100	20190410	14:12	14:27
SBE 39	3438	400	300	20190405	0100	20190410	14:12	14:27
SBE 56	1206	0.35	60	20190405	0100			
SBE 56	1208	0.65	60	20190405	0100			
SBE 56	2069	0.85	60	20190405	0100			
SBE 56	1210	0.35	60	20190405	0100			
SBE 56	1211	0.35	60	20190405	0100			
VMCM	11	45	60	20190404	17:57	20190413	14:15	14:15
VMCM	16	100	60	20190404	18:49	20190413	16:30	16:30
VMCM	38	135	60	20190404	18:27	20190413	16:53	16:53
VMCM	59	183	60	20190404	19:25	20190413	17:06	17:06
VMCM	61	235	60	20190404	17:14	20190413	17:22	17:22
VMCM	62	290	60	20190404	19:07	20190413	17:33	17:33
VMCM	83	450	60	20190404	19:39	20190413	17:45	17:45

SBE56s: no T spike. Instruments installed and greased prior to spike attempt.
VMCMs: spike is just prior to deployment - cut zip ties and spin rotors.

Setup for Aanderaa ADCPs:

SN	235
DCS	451
0	1.29
45	44.6
90	91.1
135	138
180	182.7
225	225.8
270	270.1
315	315.2
360	0.9
O2 optode	2514
air saturation	98
breath	88
Temp	2514
ambient	22.4
finger	25
Pressure	N/A
ambient	
finger	
Conductivity	N/A
time set	yes
battery	7.8/7.6
desiccant	yes - new
start	20190405 01:00:00

SN	238
DCS	455
0	0.78
45	46.3
90	92.3
135	138.5
180	183.6
225	228.3
270	272
315	316.8
360	1.7
O2 optode	n/a
air saturation	
breath	
OPT. Temp	n/a
ambient	
finger	
Pressure	n/a
ambient	
finger	
Conductivity	n/a
time set	yes
battery	7.6/7.6
desiccant	yes-new
start	20190405 01:00:00

Setup for ADCP RDI:

Instrument S/N: 12254
Frequency: 307200 HZ
Configuration: 4 BEAM, JANUS
Match Layer: 10
Beam Angle: 20 DEGREES
Beam Pattern: CONVEX
Orientation: UP

Sensor(s): HEADING TILT 1 TILT 2 TEMPERATURE
Temp Sens Offset: -0.15 degrees C;
CR1
CF11101
EA0
EB0
ED800
ES35
EX11111
EZ1111101
WA50
WB0
WD111100000
WF200
WN45
WP300
WS200
WV175
RNSTR18
TE01:00:00.00
TP00:01.00
TF19/04/05 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 = YES
;Ice Track = NO
;Surface Track = NO
;Beam angle = 20
;Temperature = 18.00
;Deployment hours = 10560.00
;Battery packs = 1
;Automatic TP = NO
;Memory size [MB] = 256
;Saved Screen = 3
;Consequences generated by PlanADCP version 2.06:
;First cell range = 4.44 m
;Last cell range = 92.44 m
;Max range = 74.91 m
;Standard deviation = 0.40 cm/s
;Ensemble size = 1054 bytes
;Storage required = 10.61 MB (11130240 bytes)
;Power usage = 1204.17 Wh
;Battery usage = 2.7

SN	12254
Hz	300
firmware	50.41
0	395.9
45	44
90	88.2
135	133.5
180	179.2
225	224.6
270	268.9
315	315.8
360	359.3
Pressure	N/A
recorder	2Gb
compass cal	yes 0.9
time set	yes
battery	35vdc
desiccant	yes

RDI:

Ambiguity Velocity: WV175 (Default) ambiguity velocity. Formula is WV = (Max. Apparent Vel. cm/s) * sin(beam angle) * 1.2. At Stratus, if we assume max currents about 50 cm/s and max ADCP (mooring speed, if broken or moving inside watch circle), then max apparent velocity is 100 cm/s and WV = 41.

- Speed of sound: computed from temperature sensor inside instrument, constant salinity set by user as ES = 35 psu, and pressure based on nominal depth set by user ED = 80 m.
- EX11111 (Default) Coordinates rotations. Output velocity in Earth coordinates. Use EA and EB cmds. Use tilts in transformation. Allow 3-beam solution with one beam is below correlation threshold. Allow bin mapping.
- Magnetic deviation set to zero (EB0 command).

Aandera Seaguards:

Tilt compensation - yes
z-pulse active - yes
x-axis: 1+3
y-axis: 2+4
Forward ping - yes
Use fixed heading - no
Burst - no

Table: Setup of Acoustic Doppler Current Profiler (ADCP, RDI) and Meter (ADCM, Aanderaa Seaguards) deployed on Stratus 18 mooring.

Instrument Type and Serial Number	RDI 12254	Aanderaa Seaguard (238, 235)
Sampling Freq kHz	307.2	1900-2000
Depth internal setting (m)	80	n/a
Measurement Interval (s)	3600	1500
Number cells	45	1
Cell size (m)	2	2.5
Broadband mode	yes	yes
Blanking distance (m)	2	1
Average Interval (s)	300	300 pings
Battery utilization (%)	n/a	n/a
Ambiguity velocity	175	n/a
Battery days		n/a
Time between pings (s)	1	
Horizontal precision (cm/s)	0.4	

Appendix B Mooring Log Stratus 17

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. STRATUS 17 MOORED STATION NO. ______

Launch (anchor over)

Date (day-mon-yr) 10-April-2018 | Time 23:24 UTC

Deployed by Ben Pietro | Recorder/Observer Sebastien Bigorre

Ship and Cruise No. Cabo de Hornos | Intended Duration 365 days

Depth Recorder Reading ______ m | Correction Source Bathymetry map

Depth Correction ______ m | (based on multibeam surveys)

Corrected Water Depth 4565 m | Magnetic Variation (E/W) ______

Anchor Drop Lat. (N/S) 19 38.38' | Lon. (E/W) 084° 55.273'

Surveyed Pos. Lat. (N/S) 19°38.3203' | Lon. (E/W) 084° 55.099'

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

Acoustic Release Model ______ | Tested to 1,500 m

Release No. 1 (sn) 48274 | Release No. 2 (sn) 35319

Interrogate Freq. 11 | Interrogate Freq. 11

Reply Freq. 12 | Reply Freq. 12

Enable 567 402 | Enable 111 446

Disable 567 421 | Disable 111 465

Release 551 071 | Release 127 476

Recovery (release fired)

Date (day-mon-yr) 18-04-19 | Time 1620 (buoy back on deck) UTC → drifting since 17 Aug 2018

23/4/19, 1215 anchor release.

Latitude (N/S) 14°55.648' S | Longitude (E/W) 105° 30.986 W

Recovered by Pietro | Recorder/Observer Bigorre

Ship and Cruise No. AGS61 Cabo de Hornos | Actual duration 129 (on station) 373 (station + drifting) days

Distance from waterline to buoy deck 60 cm

1

ARRAY NAME AND NO. STRATUS 7 MOORED STATION NO.________

Surface Components

Buoy Type DIB Color(s) Hull Tower Yellow (top), Blue (bottom)

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

Surface Instrumentation

Item	ID #	Height*	Comments
ASIMET logger	L04		Port side
HRH	213	240	
BPR	210	242	
WND	343	264	
PRC	506	252	
LWR	208	284	
SWR	349	285	
SST	1725		
Iridium	J10CJ1		3002 3406 3167 110
ASIMET logger	L14		Starboard side
HRH	249	243	
BPR	219	236	
WND	346	264	
PRC	219	253	
LWR	243	284	
SWR	216	285	
SST	1839		
PTT	18171		Ids: 27919, 27920, 27921
Standalones			
WXT	201	240	
Lascar	10031713	210	
SBE39 AT	477	235	
HRH	269	238	
SWR	206	284	

*Height above buoy deck in centimeters

2

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

Subsurface Instrumentation on Buoy and Bridle

Item	ID #	Depth†	Comments
Surface	GPS	beacons.	
XEOS ~~[illegible]~~ ~~[illegible]~~ Kilo			3002 3406 2943 610
XEOS Melo			3000 3401 3701 980
Subsurface			
XEOS ~~[illegible]~~ ~~[illegible]~~ rover			300 434 061 50 80 50
SBE56	2065	90	Port, 270°
SBE56	2066	90	Bow, ~~180°~~ 0°
SBE56	2067	120	Bow, ~~180°~~ 0°
SBE56	2068	90	Stbd, 90°
PCO2			

†Depth below buoy deck in centimeters

3

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

out of water for last time (→ Time Back)

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		Buoy			13:36	1620	→ on deck
2	0.22	3/4 chain					
3		SBE37	2	1325	13 36		
4	0.37	3/4 chain					
5		SBE37	3.7	1326	13 36		
6							
7		SBE39	4.9	35	13 36	1658	Down, short TB.
8	1.3	3/4 chain					
9		Aanderaa RCM 11 *	7	78	13 36	1740	
10	1.5	3/4 chain					
11		SBE37	10	1328	13:32	1746	
12	1.73	3/4 chain					
13		Nortek ADCP	13	357	13:06	1746	Heads up
14	1.35	3/4 chain					
15		SBE37	16	1324	13:01	1750	
16	2.7	3/4 chain					
17		Aanderaa RCM 11(P)	20	79	12:57	1750	
18	3.66	3/4 chain					
19		SBE39	25	38	12:55	1754	Up, short TB.
20	3.9	3/4 chain					
21		SBE 37	30	1330	12:51	1757	
22	1.12	3/4 chain					
23		Aanderaa RCM 11 (P)	32.5	13	12:48	1758	
24	1.2	3/4 chain					
25		SBE39	35	44	12:48	1802	Up, short TB.

* was out of water for until 13:50

4

ARRAY NAME AND NO. STRATUS 7 MOORED STATION NO.

out of water for last time

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26	3.9	3/4 chain					
27		SBE37	40	8211	12:42	1802	
28	3.66	3/4 chain					
29		Aanderaa Seaguard	45	138	12:29	1824	w optode.
30	16	7/16 wire					
31		SBE39	50	48	13:51	1833	clamped.
32		SBE39	55	49	13:53	1836	clamped.
33		SBE37	62.5	8212	13:58	1838	load bar.
34	16	7/16 wire					
35		SBE39	70	102	14:04	1846	clamped
36		SBE39	77.5	103	14:18	1847	clamped
37		RDI ADCP	80	1218	14:25	1847	
38	6	7/16 wire					
39		SBE37(P)	85	1909	14:29	1855	clamped
40		Aanderaa Seaguard	87.3	140	14:33	1855	w optode.
41	18.2	7/16 wire					
42		SBE39	92.5	203	14:33	1901	clamped.
43		SBE39	100	276	15:40	1904	clamped. (without clock) 14:39 things) +131
44		Fluorometer Wetlabs	~~100.5~~ 104	2866	15:41	1906	clamped. * depth 104 m
45		Aanderaa Seaguard	107	961	15:41	1906	Lothar Stramma's. w optode.
46	21.5	7/16 wire					
47		SBE39	115	284	15.44	1915	clamped.
48		SBE37	130	8215	15:52	1917	load bar.
49	14	7/16 wire					
50		Aanderaa Seaguard	145	141	15:58	1924	w optode

5

ARRAY NAME AND NO. STRATUS17 MOORED STATION NO.________

out of water for last time

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
51	13.5	7/16 wire					
52		SBE37	160	8216	16:05	1930	load bar.
53	21.7	7/16 wire					
54		SBE39	175	719	16:06	1935	clamped.
55		Aanderaa Seaguard	183	964	16:11	1938	Lothar Stramma's. w Optode.
56	5.5	7/16 wire					
57		SBE37	190	12258	16:17	1942	load bar.
58	29	7/16 wire					
59		SBE37	220	12256	16:24	1949	load bar.
60	13.5	7/16 wire					
61		Aanderaa Seaguard	235	142	16:29	1954	w optode.
62	53.5	7/16 wire					
63		SBE39	280	720	16:36	2009	clamped.
64		Aanderaa Seaguard	290	143	16:42	2012	w optode.
65	58.5	3/8 wire					
66		SBE37	295	1906	16:47	2016	clamped.
67		Aanderaa Seaguard	350	969	16:56	2020	Lothar Stramma's. w optode.
68	48.5	3/8 wire					
69		VMCM	400	053	17:05	2026	16:57 blade spin
70	48.5	3/8 wire					wire chaffed up
71		Aanderaa Seaguard	450	181	17:11	2034	w optode.
72	148.5	3/8 wire	✱				Oxygen no osts.
73		SBE37 (P)	550	3733	17:18	2042	clamped.
74		Aanderaa Seaguard	600	182	17:26	2046	w optode.
75	100	3/8 wire					

6

ARRAY NAME AND NO. STRATUS 17 **MOORED STATION NO.** ________

out of water for last time

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
76		SBE37	601	1908	17:26	2046	clamped below top term.
77		SBE37	698	8218	17:36	2053	clamped above bottom term. * change depth to 696
78		Aanderaa Seaguard	700	144	17:36	2055	w Optode
79	100	3/8 wire					
80		VMCM	802?	17?	17:44	2101	17:37 blade spun VM SN# 020
81	48.5	3/8 wire					
82		VMCM	853?	1	17:53	2106	17:46 blade spun
83	145	3/8 wire					
84		SBE37	857	8219	17:53	2112	clamped. Dummy plug bent
85		VMCM	1000	16?	18:02	2117	17:56 blade spun. One broken wing on each rotor
86	500	3/8 wire					VM SN# 091
87		SBE37	1354	8220	18:15	2129	clamped.
88		VMCM	1506	80	18:25	2136	18:16 blade spun
89	500	3/8 wire					wire broken ~5 below top.
90		SBE37	1557	8221	18:28	1634	clamped.
91		SBE37	2000	8224	18:48	1640	clamped.
92		VMCM	2009	17??	18:53	1630	* there is another 17 above. 18:50 blade spun.
93	100	3/8 wire			18:59		one piece termination (potted)
94	200	7/8 Nylon			19:35		
95	1700	7/8 Nylon			[illegible]	1550	spliced at sea
96	1500	Colmega			20:05	1514	
97		glass balls (92)			21:21	1402	~~IIII~~ ~~IIII~~ ~~IIII~~ ~~IIII~~ III 6 balls broken
98		SBE37		11394	23:14	1410	dualed with pressure
99		SBE37		12257	23:14	1410	connector lock slightly loose
100	5	1/2 chain					

all come back in one wozzle with mud (items 89–92)

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

Date/Time			Comments			
Item No.	Item	Depth	Int. No	Time Over	Time Back	Notes
101	Acoustic releases			23:14	1415	
102	chain (1m)					
103	1/2 chain (5 m)					
104	1" Samson (20m)					
105	1/2 chain (5m)					
106	Anchor			23:24		

* 19 38,39 S
84 55,41 W

09G0135

Appendix C Mooring Log Stratus 18

Moored Station Log

(fill out log with black ball point pen only)

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

Launch (anchor over)

Date (day-mon-yr) 04-13-2019 Time 23:43 UTC

Deployed by Pietro / Llanos Recorder/Observer S. Biggore

Ship and Cruise No. AGS61 "Cabo de Hornos" Intended Duration 365 days

Depth Recorder Reading 4268. m Correction Source Multibeam EM122

Depth Correction 0 m with local sound speed profile (1000 m)

Corrected Water Depth 4268 m Magnetic Variation (E/W) ________

Anchor Drop Lat. (N/S) 22 27.753' Lon. (E/W) 085 38.471'

Surveyed Pos. Lat. (N/S) 22 27.699' Lon. (E/W) 085 38.590'

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

Acoustic Release Model Edgetech 8242XS Tested to 1500m m

Release No. 1 (sn) 32479 Release No. 2 (sn) 31270

Interrogate Freq. 11 kHz Interrogate Freq. 11 kHz

Reply Freq. 12 kHz Reply Freq. 12 kHz

Enable 114510 Enable 360042

Disable 114533 Disable 360061

Release 132060 Release 344214

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 60 cm

1

ARRAY NAME AND NO. S18 MOORED STATION NO.

Surface Components			
Buoy Type MOB Color(s) Hull Tower Blue/yellow / white			
Buoy Markings			

Surface Instrumentation

Item	ID #	Height* mm	Comments
Logger	LØ1	—	System 1 (Port side)
IR Modem			IMEI-300234063166220
HRH	215	235	
BPR	206	240	
SWND	217	268	
PRC	213	252	
LWR	212	283	
SWR	223	283	
SST	1836	-145	
Logger	LØ2	—	System 2 (STBD side)
IR Modem			IMEI-300234063269760
HRH	230		
BPR	205		
WND	222		
PRC	275		
LWR	502		
SWR	352		
SST	2054		
HC2A-S3	20208310	225	Rotronic sensor w/ Logger
SBE39-AT	3800	230	
VWX	204	240	measured to white ring
SA HRH	221	235	
SA SWR KZ	801	283	

*Height above buoy deck in centimeters

ARRAY NAME AND NO. S18 MOORED STATION NO.

Subsurface Instrumentation on Buoy and Bridle

Item	ID #	Depth†	Comments
SST	1211	90	SBE56 (90° STBD)
SST	1207	90	SBE 56 (0° BOW)
SST	1208	120	SBE 56 (0° BOW)
SST	1209	140	SBE 56 (0° BOW)
SST	2069	90	SBE 56 (270° PORT)
Melo	IMEI-	[illegible]	surface
Rover	IMEI-	300434060447400	surface
Kilo	IMEI- 300234062945460		Sub-surface
PMEL	PCO2 System		
pCO_2	0153	+70	Battelle MAPCO2
SBE16	6569	-150	
SAMI	100419	-150	
			Radar reflector was removed prior to deploym^t

†Depth below buoy deck in centimeters

ARRAY NAME AND NO. S18 MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		buoy	0	—	1525		
2	0.22	3/4 Chain					
3		SBE 37	2	1304	1525		Load BAR
4	0.37	3/4 chain					
5		SBE 37	3.7	3821	1525		Load BAR
6	0.525	3/4 chain					3/4" shackle, chain, 3/4" shackle
7		SBE 39	5	0039	1525		Load BAR
8	0.9	3/4 Chain					
9		SBE 37	7	3824	1525		LOAD BAR
10	4.0	3/4 chain					
11		SBE 39	12.2	0041	1447		LOAD BAR
12		ADCM	13	238	1447		AAnderAA - CAGE ~~optode SN 2514~~
13	1.95	3/4 chain					
14		SBE 37	16.4	1899	1447		LOAD BAR
15	2.1	3/4 chain					
16		SBE 39	20	0053	1442		LOAD BAR
17	4.05	3/4 chain					
18		SBE 39	25	0101	1436		LOAD BAR
19	3.97	3/4 chain					
20		SBE 37	30	1900	1432		LOAD BAR
21	~~1.125~~ 1	3/4 chain					chain is slightly shorter: 1m
22		ADCM	32.5	235	1432		AAnderAA CAGE · With DO sensor SN 2514
23	1.125	3/4 chain					
24		SBE39	35	0721	1432		LOAD BAR
25	~~3.79~~ 3.97	3/4 chain					

Removed Cap ✓

4

ARRAY NAME AND NO.________ MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26		SBE 37	40	1901	1425		LOAD BAR
27	3.23	3/4 chain					
28		VMCM	45	11	1421		CAGE . Props spinned @ 1415 Back out at 1550 to remove hockle
29	15.3	7/16 wire					~~CLAMPED~~
30		SBE 39	52	1502	1557		Clamped
31		SBE37	62.5	1902	1602		LOAD BAR
32	21.2	7/16 wire					
33		SBE39	70	1509	1604		CLAMPED
34		SBE39	77.5	1511	1608		CLAMPED
35		SBE37	85	8004	1627		LOAD BAR . with Pressure ~~TERMINATION ONLY~~ (swapped order)
36		TRDI	88	12254	1627		CAGE
37	9.5	7/16 wire					
38		SBE39	92.5	3423	1629		CLAMPED
39		VMCM	100	16	1635		CAGE . Props spinned 1630
40	28	7/16 wire					
41		SBE39	115	1498	1645		CLAMPED
42		SBE 37	130	1903	1651		Load BAR
43	3	3/4 chain					
44		VMCM	135	38	1655		CAGE . Props spinned @ 1653
45	23.50	7/16 wire					
46		SBE 39	145	3435	1659		CLAMPED
47		SBE37	160	1905	17:04		LOAD BAR
48	21.3	7/16 wire					
49		SBE 39	175	3437	1710		CLAMPED
50		VMCM	183	59	1714		CAGE prop spin 17:06

ARRAY NAME AND NO. ________ MOORED STATION NO. ________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
51	4.8	7/16 wire					
52		SBE37	190	1907	1717		LOAD BAR
53	28.5	7/16 wire					
54		SBE 37	220	8214	1725		LOAD BAR
55	13	7/16 wire					
56		VMCM	235	61	1728		CAGE , Spiked @ 1722
57	53	3/8 wire					
58		SBE 37	250	2011	1730		CLAMPED
59		VMCM	290	62	1736		CAGE spiked@1733
60	160	3/8 wire					
61		SBE37	310	7836	1740		CLAMPED
62		SBE39	400	3438	1748		CLAMPED
63		VMCM	450	83	1754		CAGE spiked @ 1745
64	340	3/8 wire					
65		~~SBE37~~	~~550~~	~~8223~~	1802		~~CLAMPED~~
66	500	3/8 wire			1812		
67		SBE37	550	8223			CLAMPED
68	500	3/8 wire			1840		jacket opened ~ 1 inch near bottom (2m from termination) + taped
69	100	3/8 wire			1902		
70		SBE 37	1890	12245	1911		LOAD BAR · with Pressure
71	100	3/8 wire			~~2116~~		SPECIAL TERMINATION
72	200	7/8 Nylon					HARD EYE
73	1850	7/8 Nylon					SPLICED
74	1150	1" Colmega			2005		
75		glass	BALLS ~~(84)~~ 88				卌 卌 卌 卌 II

6

ARRAY NAME AND NO.________ MOORED STATION NO.________

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
76							
77		SBE37	4230	10600	2300		with Pressure
78		SBE37	4230	10601	2300		with Pressure
79	5	1/2" Trawl Chain					
80		8242XS		32479	2330		
81		8242XS		31270	2330		
82	5	1/2" Trawl Chain					
83	20	1" Nystron			2334		
84	5	1/2" Trawl Chain					
85		Anchor	4268				9300 lbs (Air)/8000 (wet)
86							
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Appendix D ESRL meteorological instrumentation

The PSD Flux Measurement System used on R/V Cabo de Hornos consists of several components:

- Solar and infrared radiation sensors. Radiometers are mounted on top of bridge house, 16m above sea surface.
- Bulk Meteorology sensors (air temperature, relative humidity, atmospheric pressure and precipitation). Instruments are mounted on the top of a portable weather tower 16.4 meters from sea level.
- One differential GPS units measuring heading and pitch information, installed above pilot house-port side about 16.4 meters from sea level.
- A sea surface temperature measurement made with a floating thermistor deployed on the port side with outrigger (seasnake).

Table IV-4. Instruments and measurements for air-sea interaction studies.

Item	System	Measurement
1	Bulk Meteorology	Air Temp, Relative Humidity,Wind Speed,Wind Direction, Atmospheric Pressure, Rain Rate.
2	Pyranometer &Pyrgeometer	Downward solar radiative, IR flux
3	GPS and Heading	Ship SOG, COG,Lat,Lon GPS and Heading
4	Sea Snake	Near Surface Sea Temp

Instrument measurements were logged in a PC supplied by PSD. The systems ran continuously through the cruise, with special attention on Julian days 103, 104, 108 and 114 on Stratus18 and 17 data comparison during buoy deployment and recovery. The ship's SCS data was provided in ASCII format from a Vaisala bulk meteorology system located in the main ship mast. This data has been stored for later processing.

Table IV-5. Stratus 2018 Flux System Ship-Based Sensors Coefficients.

Sensor	Calibration coefficient	Make / Model	Serial Number	Date of calibration
Precision Spectral Pyranometer	0.009	K&Z/ CM22	15713050122	June, 2018
Precision Spectral Pyranometer	0.00951	K&Z/CMP22	15521170518	May, 2018
Precision Infrared Radiometer	0.00392	Eppley / PIR 1	38521F3	April, 2018
Precision Infrared Radiometer	0.0026	Eppley / PIR 2	38519F3	April, 2018
Vaisala Weather Transmitter		WXT-520	G2950002	Feb, 2017
Temp / Humidity	n/a	Vaisala/HMT335	C1110008	
Class A Barometer	n/a	Vaisala/ PTB220	A2710002	
Sea Snake thermistor 0C to 40C	C4=0.001399937 C5=0.00237854 C6=0.000000097	YSI 46031 series	n/a	
GPS and Heading		Hemisphere/Crecent VS110	072235040014	
Datalogger		Campbell/CR1000	46973	

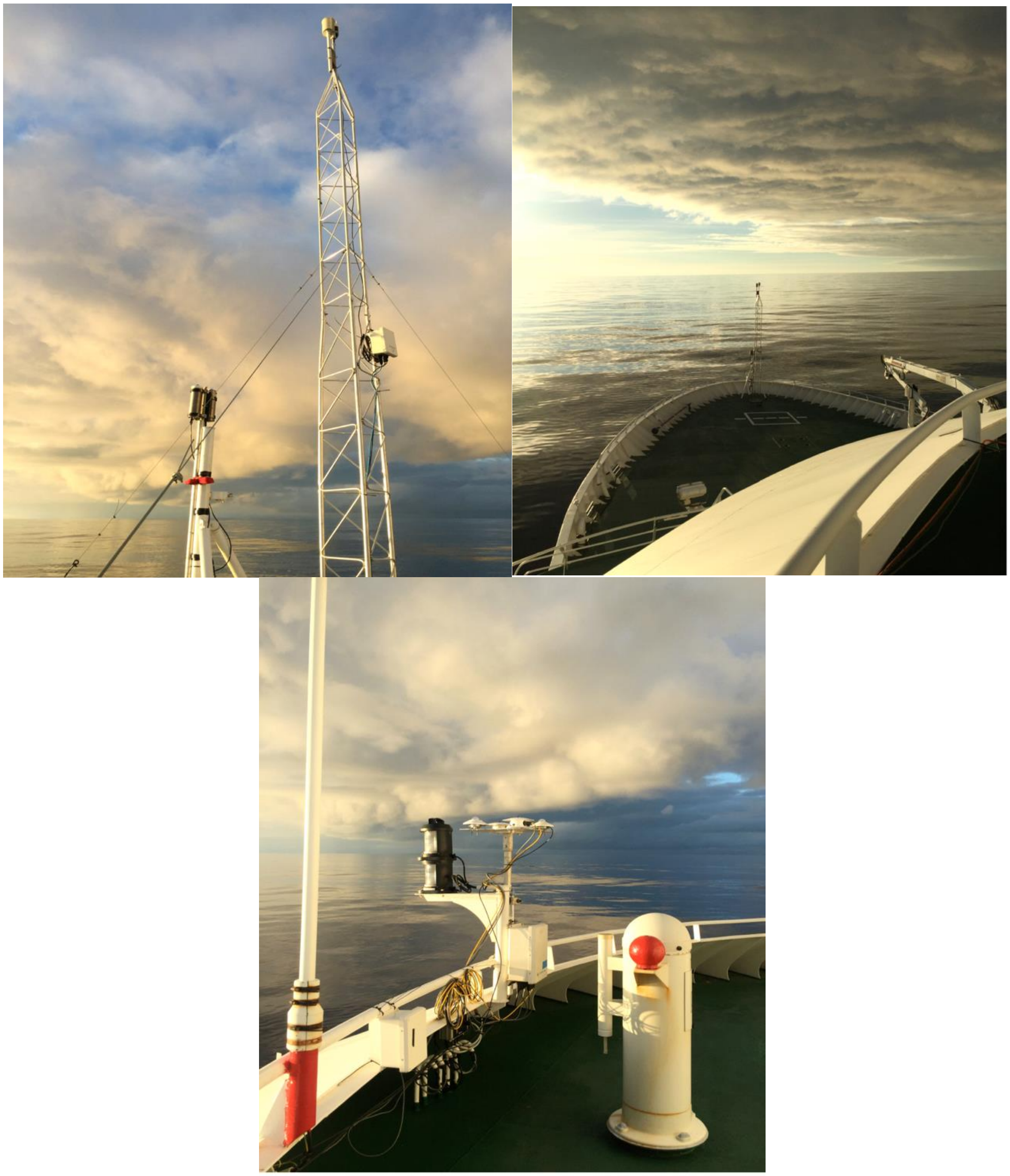

Figure IV-16. **ESRL/PSD instrumentation on the *Cabo de Hornos*, during Stratus 18 deployment cruise: mast mounted weather tower on the bow (top left). location of weather tower (top right), radiometers mounted on deck above the pilot house about 16.4m from sea level (bottom left).**

Stratus 2018 Flux measurements results:

Adjustments and modifications to hardware and software were finalized three day after leaving Valparaiso (April 9) on route to Stratus 18 deployments. Seasnake extension cable needed to be remade due to water in the connector (the cable was drop in sea water in installation at the pier). PIR1 umbrella came loose on day 114 (fixed on day 115). PSD measurements compared well to ship heading, wind direction and speed and atmospheric temperature and pressure. Issues with Campbell datalogger started on April 13, intermittent minute timestamps were not created while files were written, making some hours of the days unprocessed (Figure IV-18). Different attempts were made to correct this problem, increasing the datalogger buffer and adding a serial port flush to the end of the scan resolved the problem (Figure IV-19). The lack of testing the PSD system before sailing created issues that could have been potentially avoided, hardware setup was done in a 1-1/2 days leaving many steps undone, there was not enough time for setup due the loading logistics.

Days 108 and 114 could be used to compare Stratus 18 deployment, changes on scheduled deployment and comparison brought the ship to deployment site on a later day due to ship emergency calls at sea. Attempt to run Stratus comparison matlab were made unsuccessfully but Stratus personnel was able to use our data to stablish a preliminary comparison that looks in agreement between PSD and buoy hourly data, post processing is expected to follow.

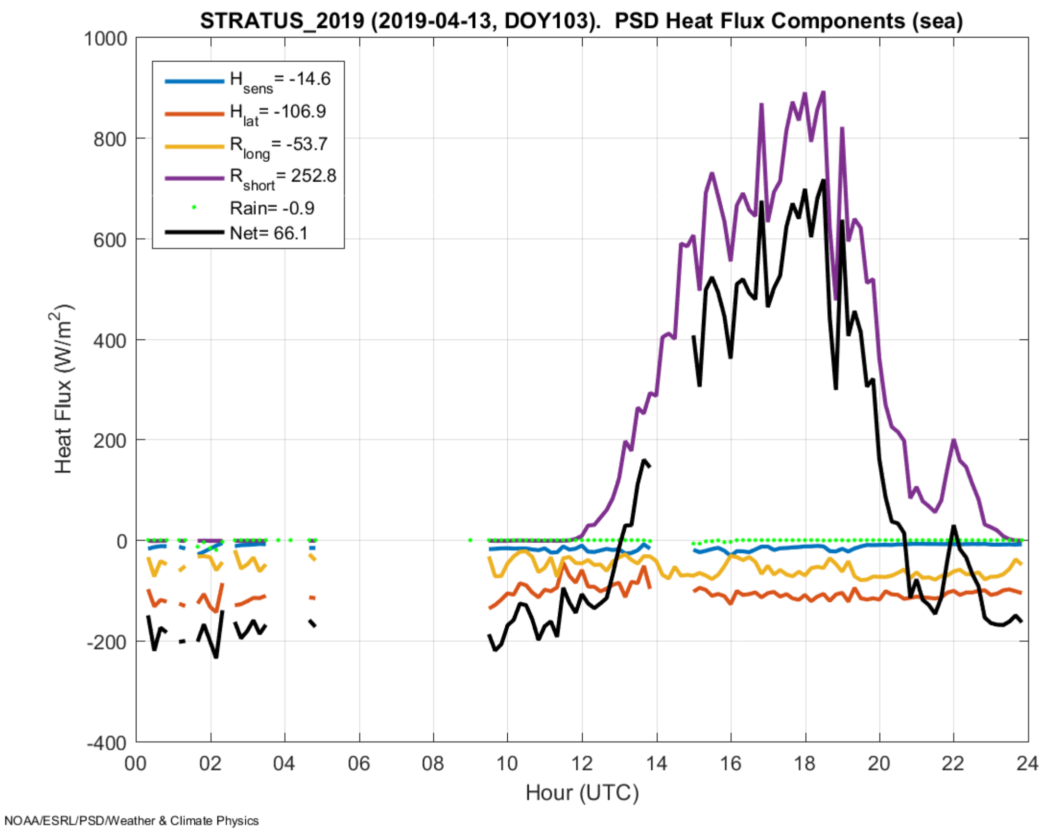

Figure IV-17. ESRL air-sea flux estimates during Stratus 18 cruise, year day 103.

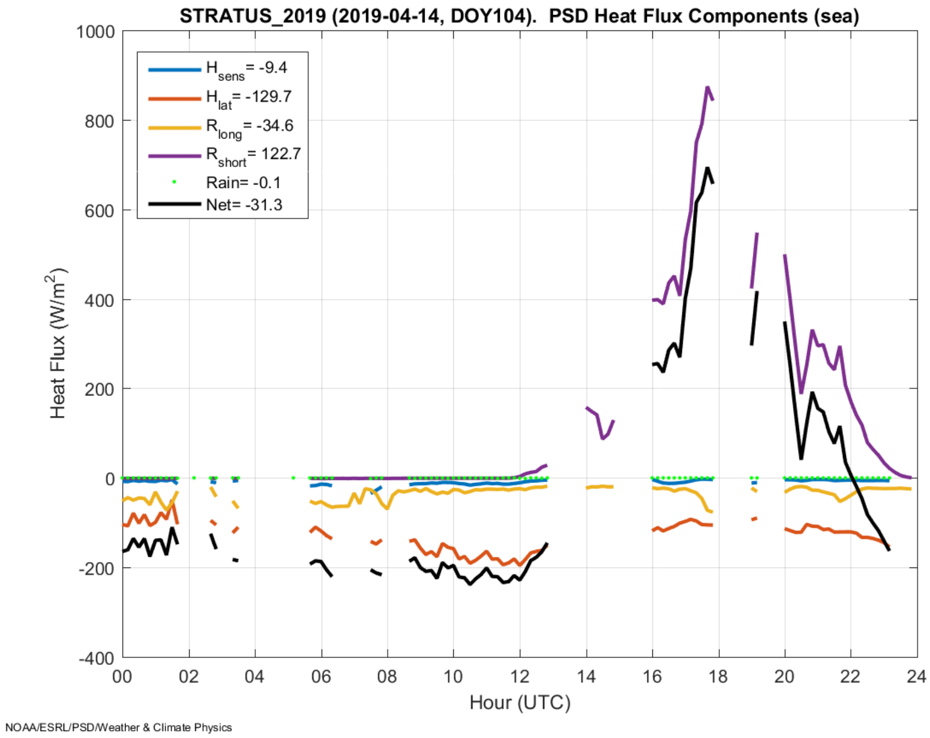

Figure IV-18. Same as Figure IV-17, but for year day 104.

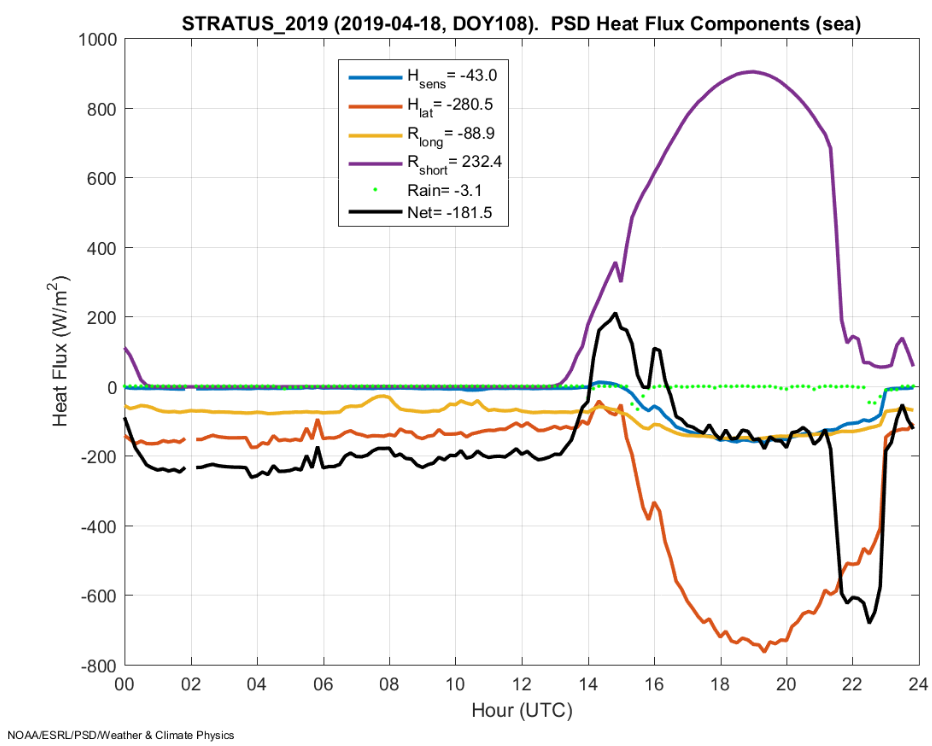

Figure IV-19. Same as Figure IV-17, but for year day 108.

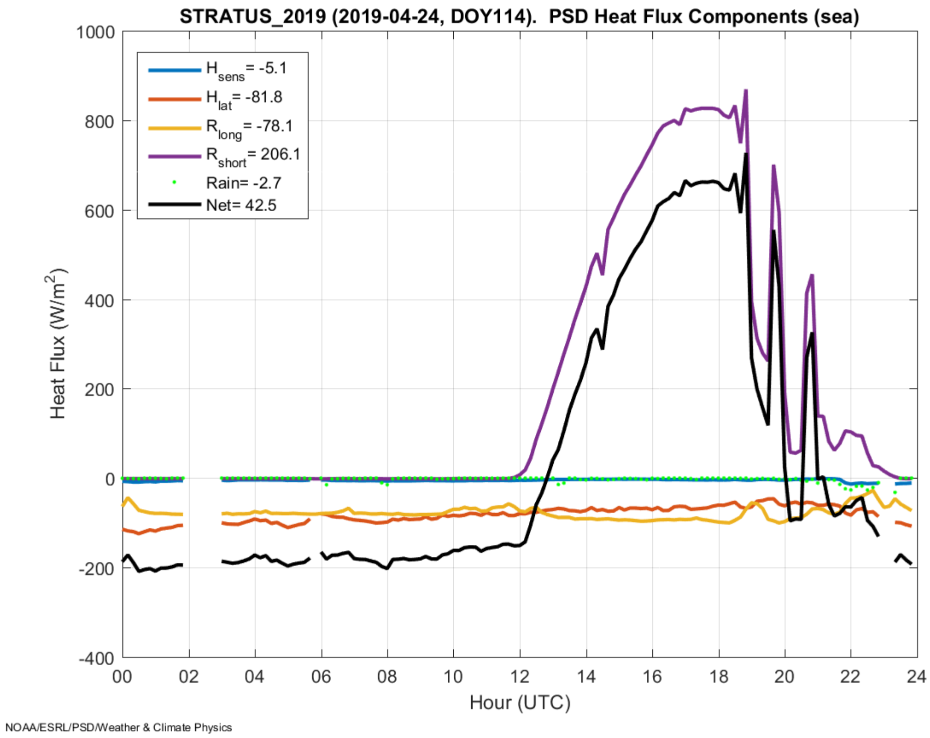

Figure IV-20. Same as Figure IV-17, but for year day 114.

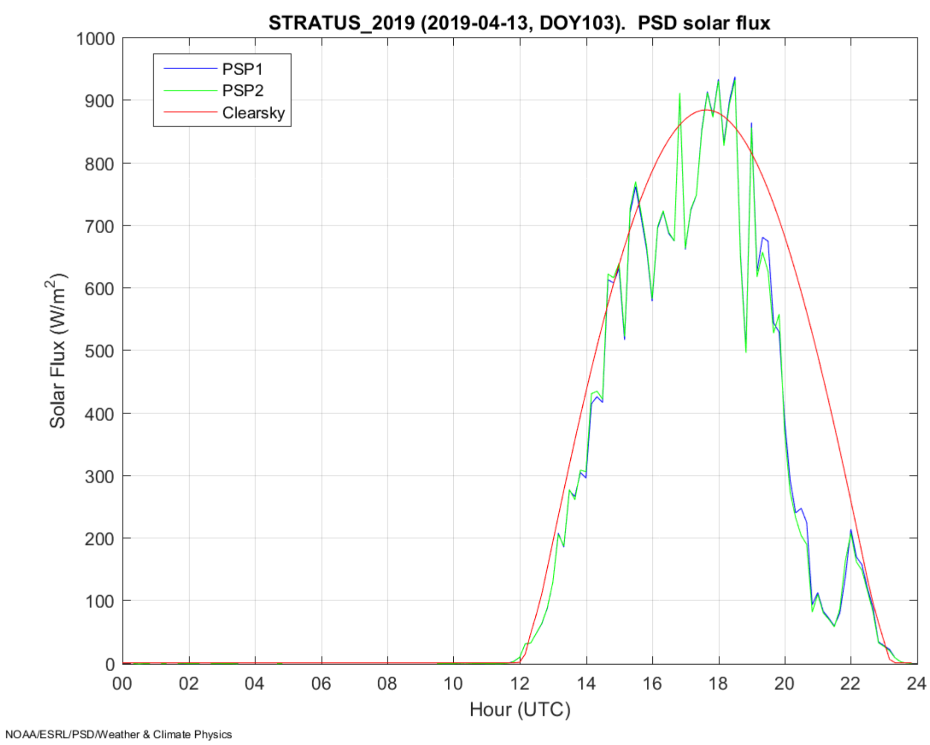

Figure IV-21. ESRL shortwave radiation, for year day 103.

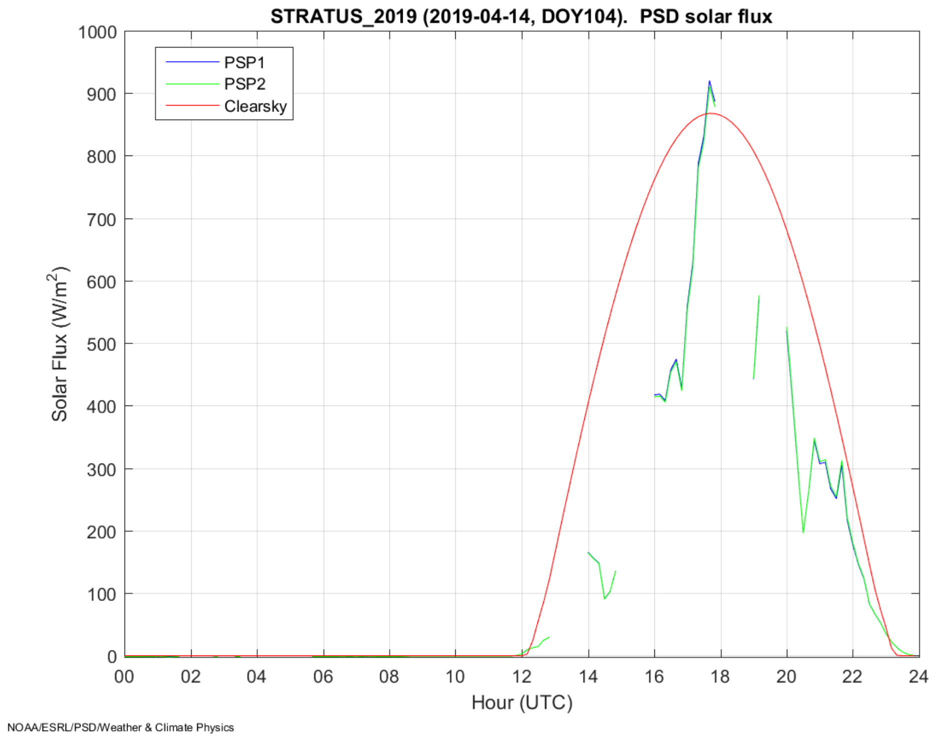

Figure IV-22. Same as Figure IV-21, but for year day 104.

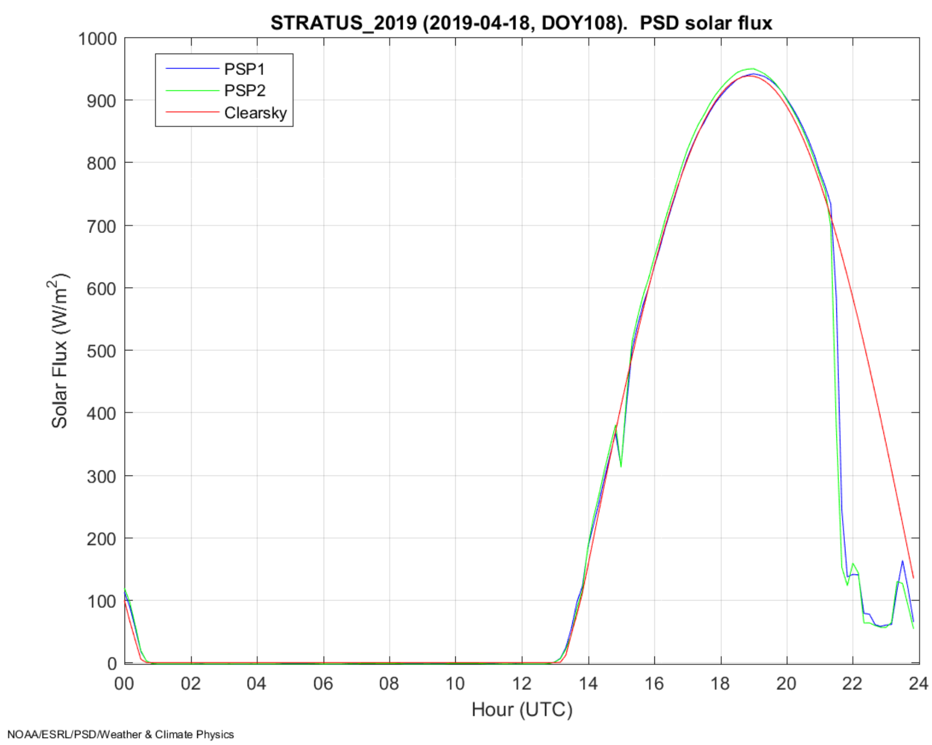

Figure IV-23. Same as Figure IV-21, but for year day 108.

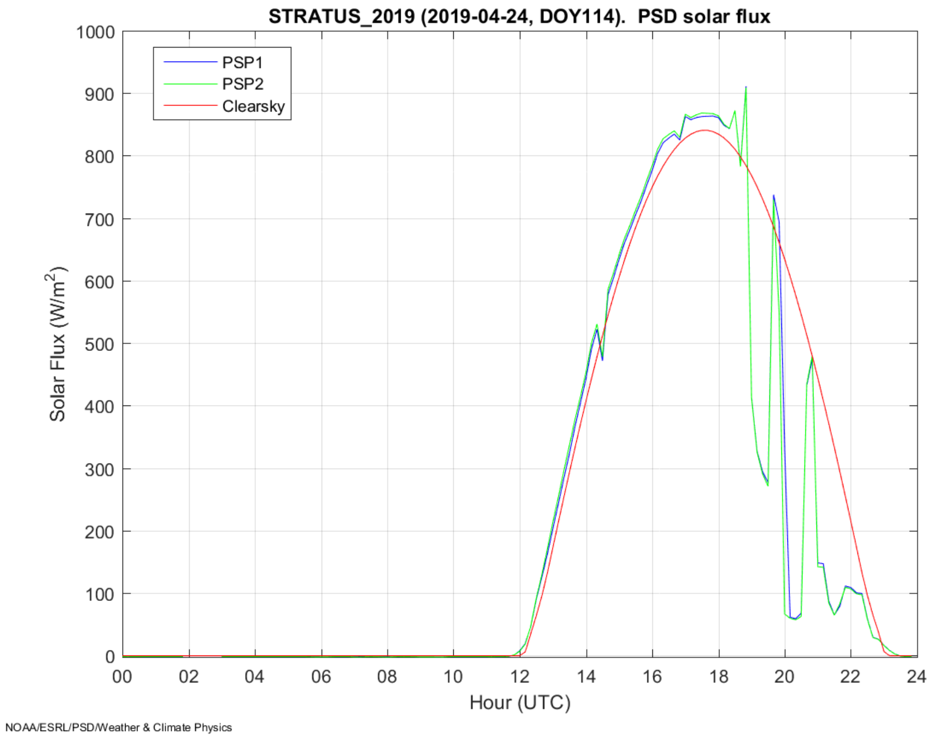

Figure IV-24. Same as Figure IV-21, but for year day 114.

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16. Abstract (Limit: 200 words)

The Ocean Reference Station at 20°S, 85°W under the stratus clouds west of northern Chile is being maintained to provide ongoing climate-quality records of surface meteorology, air-sea fluxes of heat, freshwater, and momentum, and of upper ocean temperature, salinity, and velocity variability. The Stratus Ocean Reference Station (ORS Stratus) is supported by the National Oceanic and Atmospheric Administration's (NOAA) Climate Observation Program. It is recovered and redeployed annually, with past cruises that have come between October and May. This cruise was conducted on the Chilean research vessel Cabo de Hornos.

During the 2019 cruise on the Cabo de Hornos to the ORS Stratus site, the primary activities were the recovery of the previous (Stratus 17) WHOI surface mooring, deployment of the new Stratus 18 WHOI surface mooring, in-situ calibration of the buoy meteorological sensors by comparison with instrumentation installed on the ship, CTD casts near the moorings. Ancillary tasks performed were the deployments of surface drifters and ARGO floats along the track.

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Valparaiso, Chile

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