WHOI-2016-03

Woods Hole Oceanographic Institution

Stratus 15
Fifteenth Setting of the Stratus Ocean Reference Station
Cruise On Board RV *Cabo de Hornos*
June 15 – 29, 2016
Valparaiso, Chile – Valparaiso, Chile

by

Sebastien Bigorre[1], Robert A. Weller[1], Jeff Lord[1], Emerson Hasbrouck[1], Benjamin Pietro[1], Dario Torres Gazale[2], Ignacio Burgos Jiménez[2]

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

October 2016

Technical Report

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

Upper Ocean Processes Group
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543
UOP Technical Report 2016-01

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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 2016 cruise on the *Cabo de Hornos* to the ORS Stratus site, the primary activities were the recovery of the previous (Stratus 14) WHOI surface mooring, deployment of the new Stratus 15 WHOI surface mooring, in-situ calibration of the buoy meteorological sensors by comparison with instrumentation installed on the ship, CTD casts near the moorings. Surface drifters and ARGO floats were also launched along the track.

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I. Introduction

A. Timeline

Stratus 15 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 June 15, 2016 and returned to Valparaiso on the morning of June 29, 2016. The track (Figure 1-1) was set to first deploy the Stratus 15 mooring then recover the Stratus 14 mooring, and complete work at the Stratus site before returning back to Valparaiso, Chile. WHOI Upper Ocean Processes Group staff left Boston for Chile, on June 3 (first group) and June 4 (second group). Twenty surface drifters were deployed for NOAA AOML and 3 Argo floats were deployed for NOAA PMEL. An overview of the chronology of the cruise is provided below. Local Chile time during this cruise was 4 hours off UTC (UTC -4).

June 4, Saturday: First group from WHOI flies to Santiago and takes van to Valparaiso, arriving June 5.

June 6, Monday: Meeting with Broom agency and ship's officers on *Cabo de Hornos*. Agreement on the plan of having the ship sail across the harbor to the commercial pier for loading.

June 7, Tuesday: First two containers available at pier, work begins to assemble buoy.

June 8 -12, Wednesday: - Sunday: Work on the pier. Final container with Hazmat to be delivered ship side on June 13. Buoy assembled on dock and running by June 8.

June 13, Monday: Pack back up into the two containers. End of the day, buoy loaded onto flat bed truck, two containers moved to where *Cabo de Hornos* will load in commercial port. Connect with two Universidad de Concepcion students.

June 14, Tuesday: Board *Cabo de Hornos,* steam to commercial port and load ship. Labs setup. GPS and Alpha Omega antennae installed.

June 15, Wednesday: Finish preparations. Sail at ~1400 local. Welcome aboard briefing by XO. Initially in Chilean waters so no sampling.

June 16, Thursday: Around 14:50 local enter international waters for about 100 nm before re-entering Chilean waters around San Felix Island. In these international waters, deploy drifters. Argo float deployments postponed as test box not working. 16:30 local stop for CTD to 1,500m and to test releases. Unable to talk to releases.

June 17, Friday: Transiting Chilean water around San Felix.

June 18, Saturday: Re-enter international water, deploy drifters, Argo floats still on hold.

June 19, Sunday: On the way to S15. Stop at S14. Try talking to S14 releases – check out fine. Visual inspection, small boat ride to buoy. Attach pick up line with float. One HRH is missing

and square bracket dangling. Continue to S15. Test releases for S15. Assess currents. Practice run along proposed deployment track. Overnight steam square pattern around S15 start to see if currents are shifting – not much seen.

June 20, Monday: Set up for ~0900 local start with buoy and upper instruments in first. Ship is at first holding dynamic position at start point. This causes large wire angle so ship is allowed to drift off start while supporting initial deployment. With buoy aft and mooring being payed out, start back along track to SE. Get about 5 nm along and are ready. Go a little further for good depth and deploy. Anchor survey follows.

June 21, Tuesday: Look at S15, buoy waterline at 55 cm. CTD to 4,000 m at S15. Pass by S15 buoy to grab data on the way to S14. One 4,000 m CTD at S14. Prepare to recover S14. Sit by S14 to record data.

June 22, Wednesday: S14 released at 8:06 local. See glass balls about 8:50 local. Small boat to help to hook up. Takes a long time to pass pickup line to ship. Recover from bottom first. Break mooring about 50 m and go after buoy. Long time to successfully connect to buoy, several passes with ship. All onboard, then start cleaning.

June 23, Thursday: 4,000 m CTD at S14. Winch is having problems. Oil leaking. Then head to S15 for buoy versus ship comparisons with S14 on deck and still running.

June 24, Friday: 4,000 m CTD at S15 then return to do ship versus buoy comparisons.

June 25, Saturday: Sailing back to Valparaiso. Downloading instruments. Deploy last two drifters.

June 26, Sunday: Sailing SE, 11 knots. Data download from Stratus 14 subsurface instrumentation.

June 27, Monday: Sailing SE, 11 knots. Data download from Stratus 14 meteorological instrumentation. Data download from Stratus 14 surface instrumentation. Mooring wire rewinded on spools.

June 28, Tuesday: Data download continues (VMCMs). Packing container with wire reels, air tuggers, lab equipment. Sailing southeastward at 11 kn.

June 29, Wednesday: Ship arrives in Valparaiso around 0800 UTC and anchor outside port. Ship tied up to commercial pier #5 at 11:30 UTC. Unloading of scientific equipment from ship. *Cabo de Hornos* leaves for Navy pier. Loading of scientific equipment into container until 1700 UTC

June 30, Thursday: Meeting with SHOA personnel.

July 1-2: Travel home.

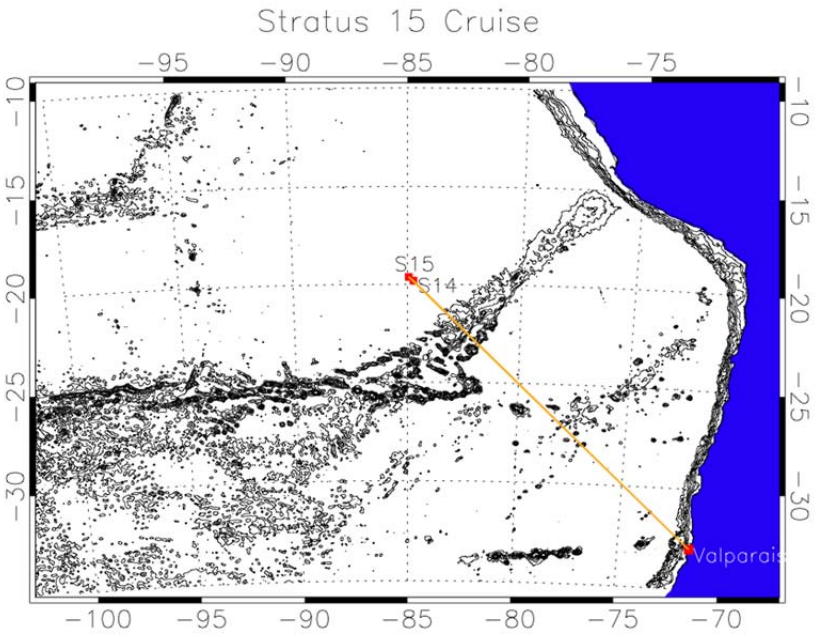


Figure I-1. Stratus 15 cruise itinerary Valparaiso – Stratus 14 and 15 – Valparaiso, Chile.

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 14 mooring was deployed in April 2015. Its replacement, Stratus 15 mooring, was installed on June 20 2016 during the Stratus 15 cruise, which is detailed in this report.

During the 2016 Stratus cruise on the Chilean research ship *Cabo de Hornos*, the primary activities were recovery of the WHOI Stratus 14 surface mooring, deployment of the new WHOI Stratus 15 surface mooring at a nearby site. At the Stratus mooring, in-situ calibration of the buoy meteorological sensors was done through comparison with WHOI stand-alone meteorological sensors mounted on the ship and a Vaisala weather station that is part of the ship's monitoring system. CTD casts were also done near both moorings for comparison with

newly deployed instruments and older Stratus 14 instruments. Finally surface drifters and Argo floats were launched 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 15 buoy was assembled and tested after shipping and final preparations to its moored instrumentation were carried out. Equipment for the Stratus 15 was therefore loaded onto the *Cabo de Hornos* in Valparaiso on June 14, 2016 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.

II. Cruise Preparations

A. Staging and Loading

On the morning of June 6, WHOI personnel had a meeting on the Cabo de Hornos at its berth on the Navy pier. A Broom representative attended this meeting too. Introductions to the ship's officers were made, and details of port operations and mooring operations were discussed.

At 08:00 on June 7, the two 40 foot containers were delivered to a staging area. At 09:00 a forklift was 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.

Buoy assembly and test, and equipment preparation continued until the afternoon of June13, when the gear was moved to commercial pier # 5 where it was staged for loading on June 14. On 14 June forklifts and a shore crane were used to get the WHOI gear loaded onto the ship. June 14-15 were used to get the labs organized and the deck set up and lashed. Cruise personnel setup the local Argos receiver, and GPS stations. The ship was under way at 14:00 on 15 April.

B. Buoy Spin

Buoy spin was conducted in port in Valparaiso on June 8, 2016 (Figure II-1 and Figure II-2; see Appendix 1 for details of the buoy spin). Note that prior buoy spins were conducted in Woods Hole on November 23 2015 and April 21 2016.

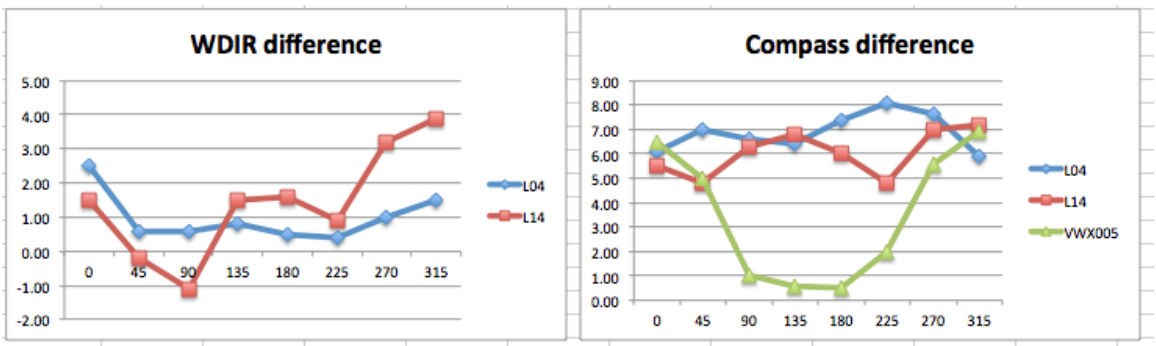


Figure II-1. STRATUS 15 buoy spin on April 21 2016 in Woods Hole. Y-axis: difference between wind direction (L04 and L14), or compass (WXT005), and line-of-sight reference (in degrees). X-axis: angle between buoy and line-of-sight reference (in degrees). Note that operator reoriented the WXT during Turn=90, by small angle (~ 10 degrees).

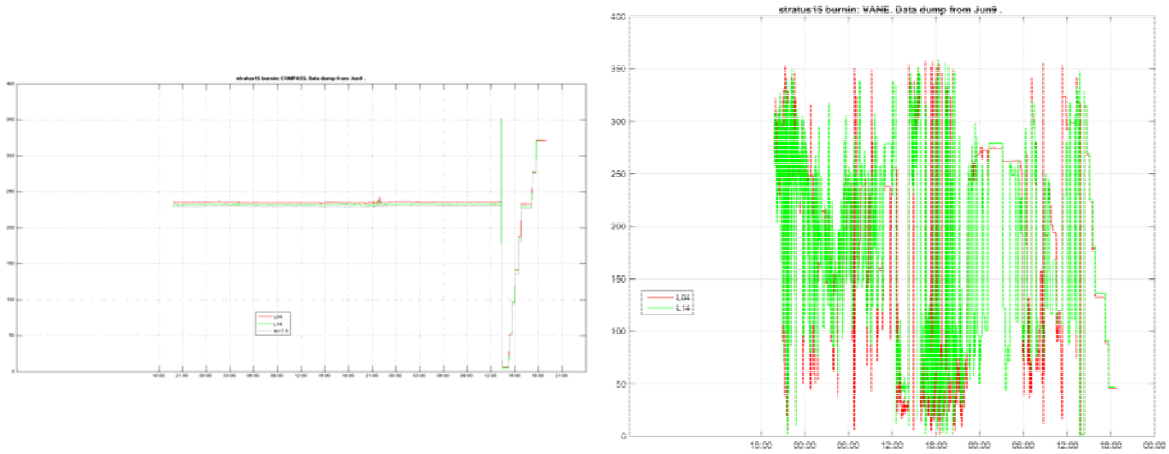


Figure II-2. One-minute data from STRATUS 15 buoy spin on June 9 2016: compass (left) and wind sensor vane (right).

C. Sensor Evaluation and Burn-in

For burn-in, the buoy was mounted with ASIMET (two primaries and one stand-alone systems) and other instrumentation in the same configuration as the one planned for deployment, and placed outside 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 15. Every two week or so, the data was downloaded and processed to ensure all instrument was functioning properly and that their measurements were accurate. Some burn-in occurred in the Fall 2015 and then resumed in the Spring 2016 due to low winter temperatures.

Two data downloads occurred in port in Valparaiso on June 9 and June 18. Buoy spin was included on June 9. Wind conditions in port were very low which implies low or no ventilation and diurnal heating on temperature sensors on clear days. On June 18, data download included two ASIMET loggers, stand-alone sensors, SBE39AT, Lascar and Vaisala WXT. At the time of data dump buoy was upright on starboard side of ship and had been so since departure on June 15. Logger 14 could not receive STOP command before data could be downloaded and had to be power cycled to resume its proper operation. Final data evaluation concluded that all data looked good, HRH from stand-alone HRH216 was high 3-4 %RH, and HRH from WXT 6%RH low (typical).

Figures below present data from June 18th data download, the last one for burn-in.

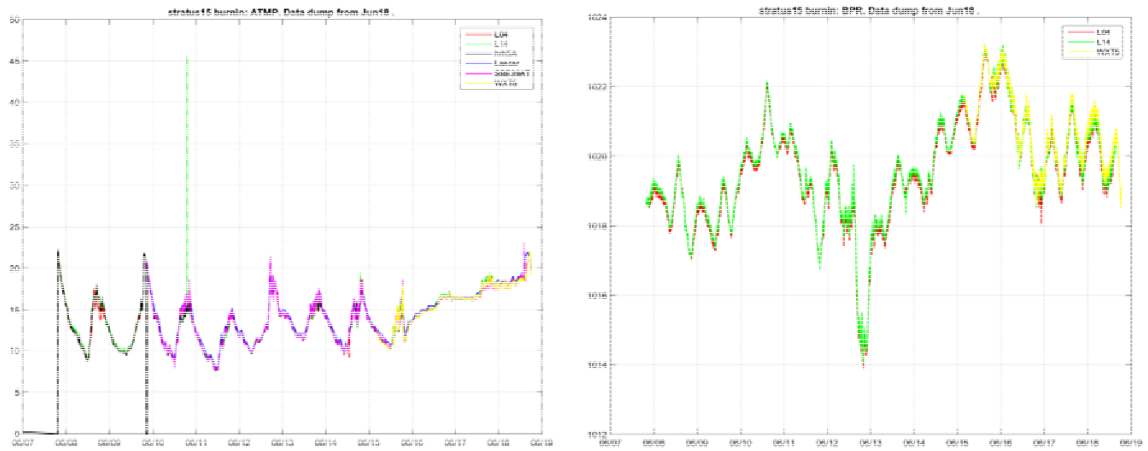


Figure II-3. Stratus 15 data downloaded on June 18 in Valparaiso: air temperature ATMP (left) and barometric pressure BPR (right).

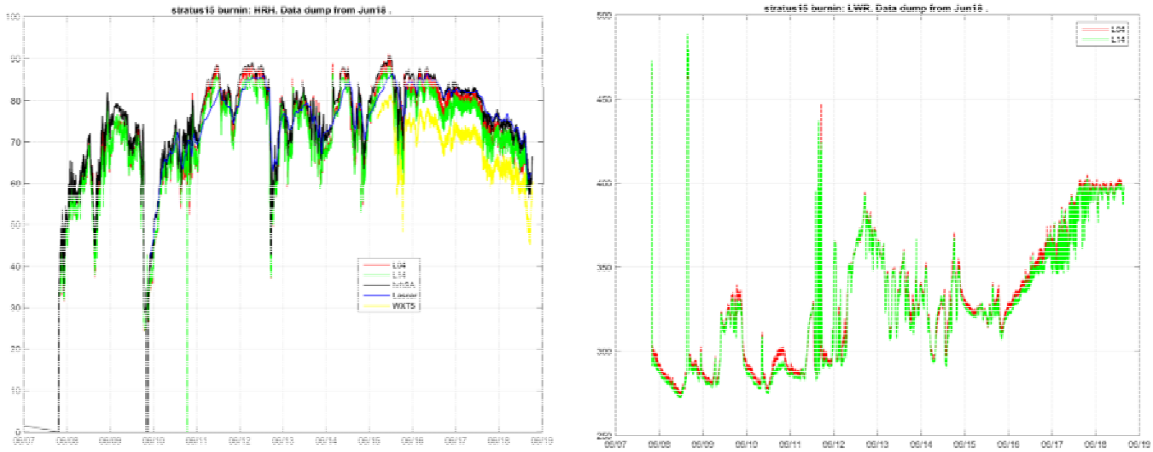


Figure II-4. Same as Figure II-3, but for air relative humidity HRH (left) and Longwave radiation LWR (right).

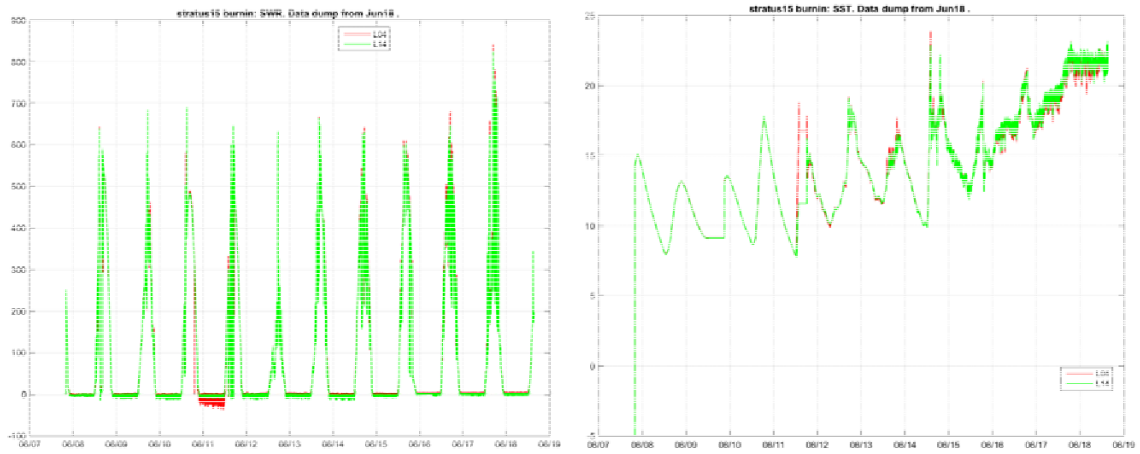


Figure II-5. Same as Figure II-3, but for shortwave radiation SWR (left) and sea surface temperature SST (right).

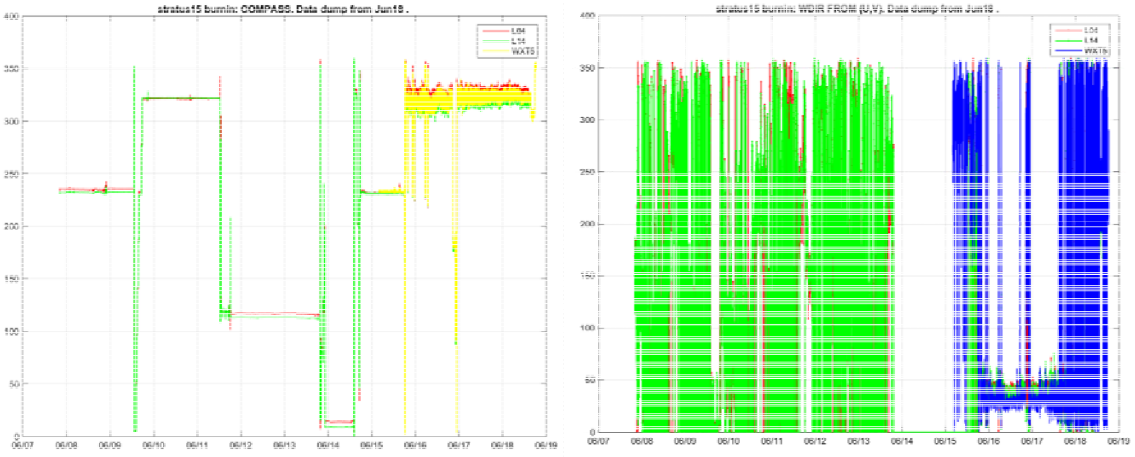


Figure II-6. Same as Figure II-3, but for wind COMPASS (left) and wind direction WDIR (right).

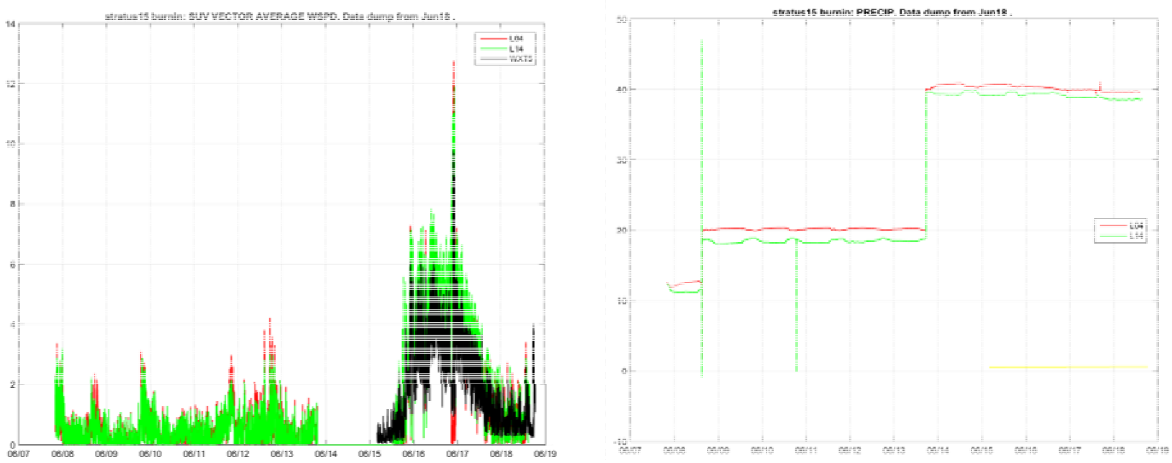


Figure II-7. Same as Figure II-3, but for wind speed WSPD (left) and precipitation PRC (right).

III. Stratus 15 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 III-1) and standalone sensors. The mooring line below the buoy is equipped with oceanographic instrumentations down to 2009 m and two deep SBE 37s near the bottom (Figure III-2).

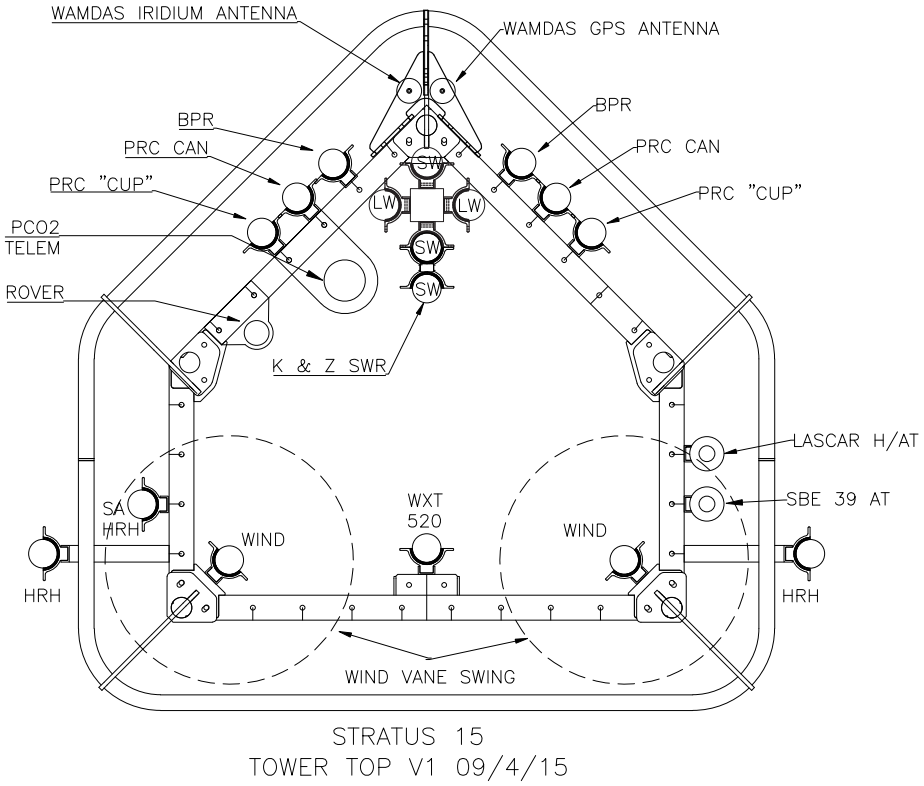
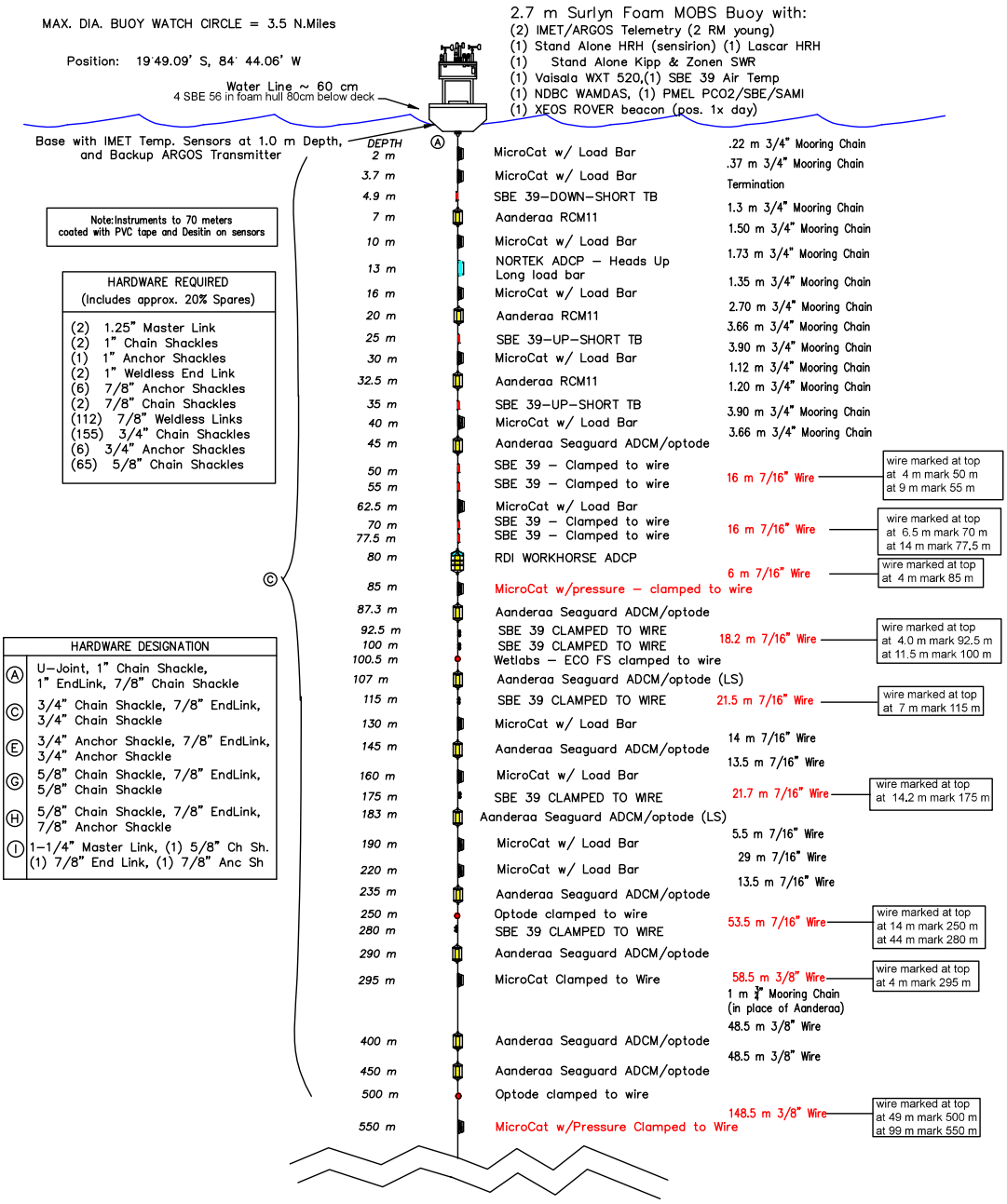


Figure III-1. Top view schematic of the meteorological tower on the STRATUS 15 buoy with the location of the ASIMET and other instruments.

PO # 1281 STRATUS 15TH DEPLOYMENT

Final - Deployed 06/20/2016



SHEET 1 OF 2

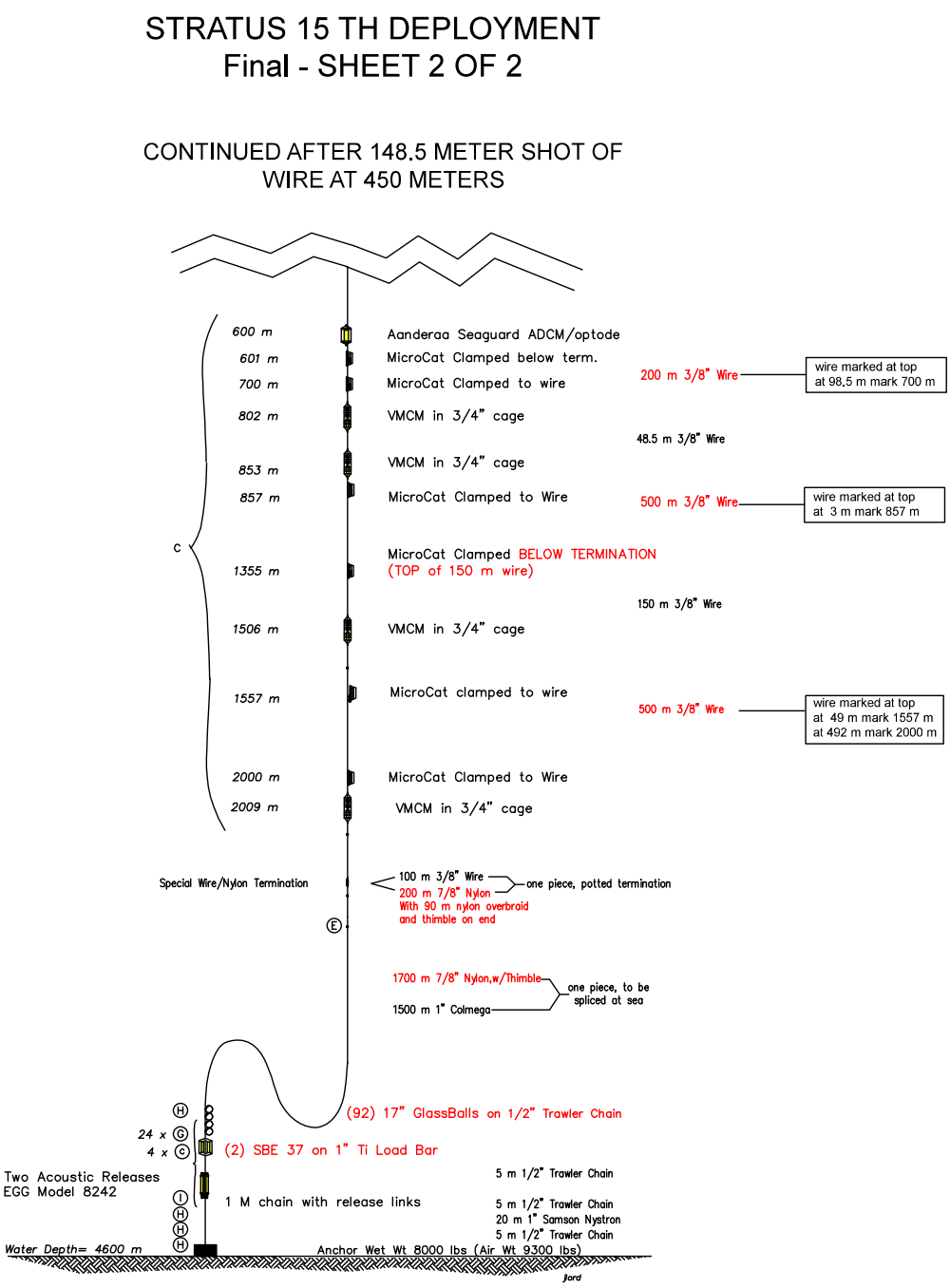


Figure III-2. Stratus 15 mooring diagram.

B. Deployment

1. Deck Operations

The Stratus 14 surface mooring was set using a two-phase mooring technique. Phase 1 involved the lowering of approximately 50 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 was pre-wound (a tension cart was used to pre-tension the nylon and wire during the winding process) 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)
- 100 m 3/8" wire
- 500 m 3/8" wire
- 150 m 3/8" wire
- 500 m 3/8" wire
- 48.5 m 3/8" wire
- 200 m 3/8" wire
- 148.5 m 3/8" wire
- 48.5 m 3/8" wire
- 48.5 m 3/8" wire
- 58.5 m 7/16" wire
- 53.5 m 7/16" wire
- 13.5 m 7/16" wire
- 29 m 7/16" wire
- 50 m 1/2" Tenex working line

Prior to the deployment of the mooring, the working line was passed out through the center of the A-frame, around the aft starboard quarter then forward along the rail to the instrument lowering area. Three wire handlers were stationed around the aft starboard rail and A-frame. The wire handlers' job was to keep the working 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 hove to with the bow positioned with the wind slightly on the starboard bow. The crane 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 deployment, just forward of the buoy. All instrumentation had chain shackled to the top of the instrument load bar or cage. A shackle and ring was attached to the top of each shot of chain or wire.

The first instrument segment to be lowered was an Aanderaa current meter at 45m. This instrument had a 3.66-meter shot of chain shackled to the top of the instrument cage, and a 16-meter shot of 7/16" wire rope shackled to the bottom. This segment of wire was shackled into the working line coming 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. A sling with a snap hook was secured to a deck cleat 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 7-meter Aanderaa current meter. 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 4.9-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 30 ft. slip line was used to stabilize the bottom of the buoy at the start of the lift. The 50 ft. tower slip line was rigged to check the tower as the hull swung outboard. A 75 ft. buoy deck bail slip line was rigged to prevent the buoy from spinning as the buoy settled in the water. This is used so the quick release hook, hanging from the crane, could be released without fouling against the tower. The deck slip line was removed just following the release of the buoy.

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. 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. A traveling block was suspended from the A-frame. The free end of the working line was passed through the block. The bottom end of the shot of wire shackled to the working line was pulled back in so 2-SBE 39 temperature loggers could be clamped onto the wire, then the wire was payed out and stopped off at the transom.

The next instrument, a 62.5 meter depth load bar with SBE 37 (Microcat) and pre-attached wire shot was 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 the lower layers of wire rope and nylon on the drum. This process of instrument insertion was repeated for the remaining instruments down to 2009 meters. The winch continued to pay out wire and nylon line until all mooring components that had been pre-wound were payed out. The end of the 200 m nylon was stopped off about 20 feet from the transom using a sling though the thimble.

An H-bit cleat was positioned approximately 30 feet from the transom, and secured to the deck. The free end of the 3350 meter shot of nylon/Colmega line, stowed in three wood-lined wire baskets was wrapped onto the H-bit and passed to the stopped off mooring line. The shackle connection between the two nylon shots was made. The line handler at the H-bit pulled in all the residual slack and held the line tight against the H-bit. The stopper lines were then eased off and removed. The person handling the line on the H-Bit kept the mooring line parallel to the H-bit with moderate back tension. The H-bit line handler and one assistant eased the mooring line out of the wire basket and around the H-bit at the appropriate payout speed relative to the ship's speed. Another person sprayed water on the H-bit to keep the line from overheating.

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 92 glass balls are bolted on 1/2" trawler chain in 4 ball (4 meter) increments. The first three 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 three more strings of glass balls were inserted into the mooring line. This process was repeated until all 92 balls were deployed.

A 1" titanium load bar with two SBE 37 C/T loggers was shackled to the last glass ball segment. After that, a five-meter shot of ½" chain was connected to the mooring. The winch took tension

on the mooring, stopper lines were removed, and a chain hook connected to the air tugger 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 had the tension of the mooring. The acoustic releases were lying flat on the deck. A chain hook connected to the air tugger line running through the block on the A-frame lifted the acoustic releases off the deck. The winch payed out with the tugger, and the instruments were eased over the transom. The tugger went slack, and the chain hook was removed.

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. The end of the chain was removed from the winch and shackled to the anchor on the tip plate. At this point, the ship was still 5 nm from the target anchor position. The mooring was towed through the water as preparations to tip the anchor were finalized.

The ships trawl winch wire was fed through the A-frame block. The A-frame was positioned above the anchor, and the winch wire was connected to the chain bridle on the anchor tip plate. A slight strain was applied to the bridle. The slip line was removed, transferring the mooring tension to the 1/2" chain and anchor. The line was pulled clear and the trawl winch raised the tip plate until the anchor slid off the plate into the ocean.

2. Navigation Operations

In planning the S15 mooring deployment, the decision was made to make use of an area of ground with suitable bathymetry that had been found to the eastern side of the area previously surveyed. This area is shown in **Figure III-3**. The ship's multibeam was not working, and deploying S15 close to S14 would localize work and keep the two moorings closer together for inter-comparison. The planned track is shown in **Figure III-4** along with the location of S14.

A course of steaming into the wind along a track toward 120° was planned, with a start point upwind, a target 10 nm down the track, and a further 4 nm end point target (
Table **III-1**). Superimposed upon the bathymetric map from previous years, this track line is shown in Figure III-5. The day before the deployment, the ship passed by and stopped at Stratus 14 and then went to the track and ran along that track from end to start with the 12 kHz single point depth sounder running. At start, after a release test, the ship held at the start position and assessed the wind and currents. The currents were out of the southwest and the wind was out of the southeast, so the proposed track made sense. The ship then did a run along the track at 0.5 to 1.0 knots to further assess the ability to steam that line at low speeds.

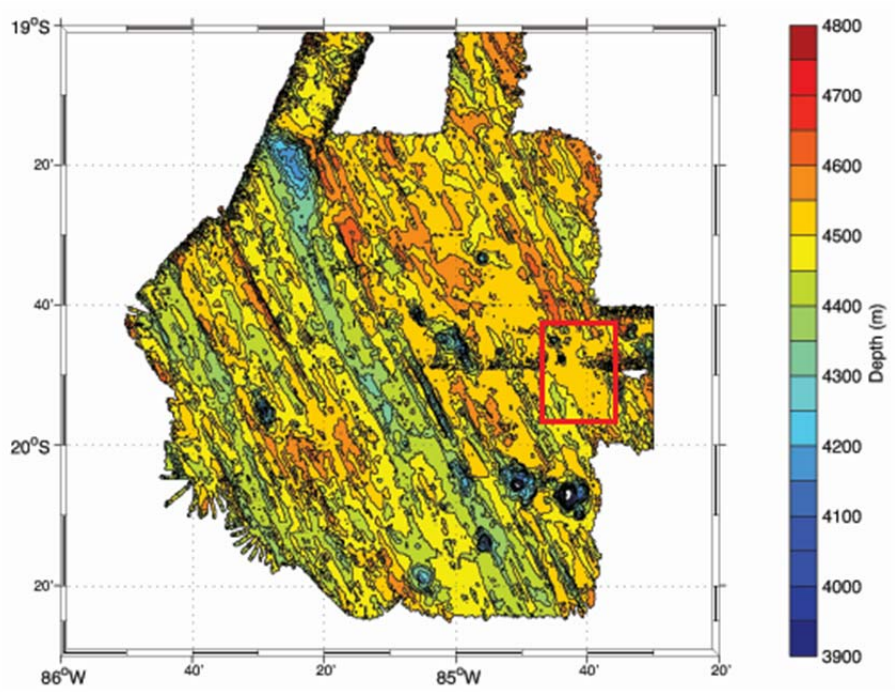


Figure III-3. Target area for Stratus 15 deployment indicated by red rectangle.

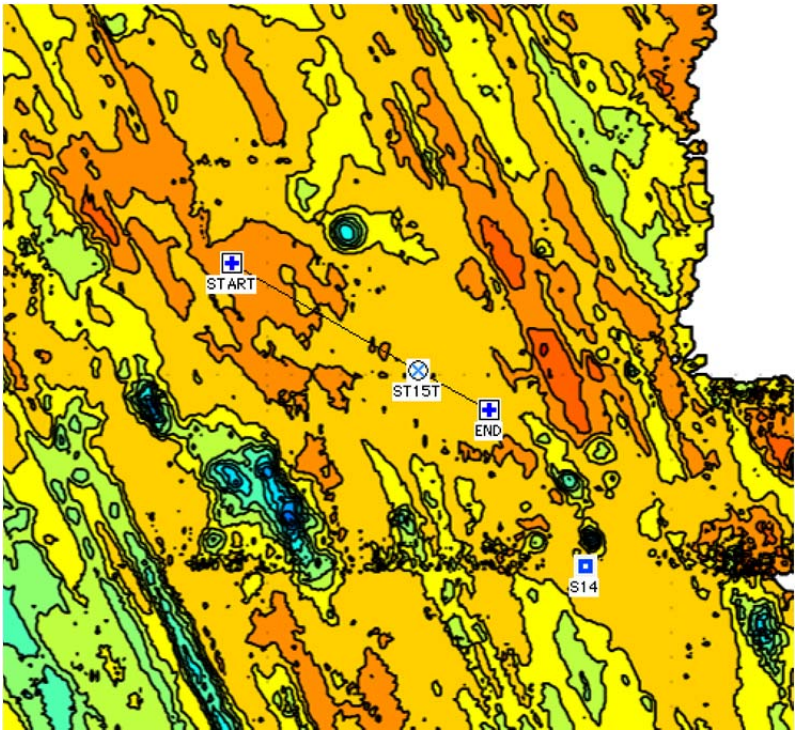


Figure III-4. Planned track line for S15 deployment with anchor position of S14 also shown.

Table III-1. Planned deployment track for Stratus 15.

	Latitude	Longitude	Distance along track
Start	19° 34.825'S	85° 01.887'W	0
Anchor target	19° 39.842'S	84° 52.630'W	10 nm
End	19° 41.666'S	84° 49.153'W	14 nm

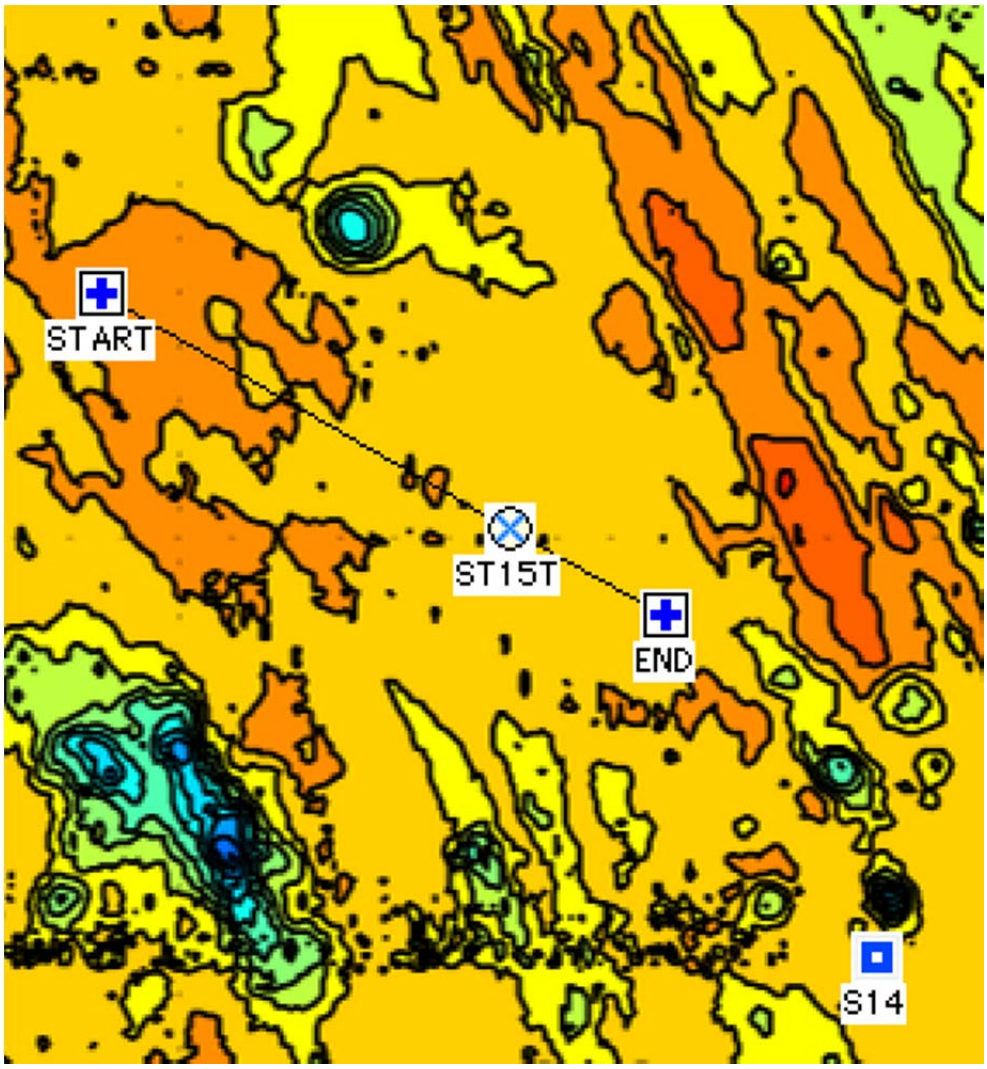


Figure III-5. Proposed track line for Stratus 15. Note the location of the Stratus 14 anchor up to the southeast.

On June 20 the ship was in position at the start point by 08:30 local (12:30 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. Then the ship started to steam toward the target, as shown in Figure III-6

In the afternoon, the work reached the point where the anchor was attached, in preparation for its deployment. At that point, about 5 nm progress had been made along the line toward the target site. At that time, the ship was in water about 50 m to 100 m deeper than planned. The anchor deployment was delayed about 30 minutes. Once it was verified that the water depth was suitable, close to 4,600 m, the work proceeded with the anchor being deployed at 21:48 UTC, June 20 2106 at 19°37.627'S 84° 56.687'W.

As shown in the actual track plot (**Figure III-6**), the ship pulled off to one side and sat for an hour while the anchor settled to the bottom. The ship then did the three-point acoustic survey of the anchor position. The night before the ship steamed a box pattern around the site to assess wind and currents. The ship then went to the start for the buoy deployment. The ship proceeded down the track toward ST15T (target), but deployment was short of that at about 5 nm along the track. Also shown is the ship's track during the three-point survey.

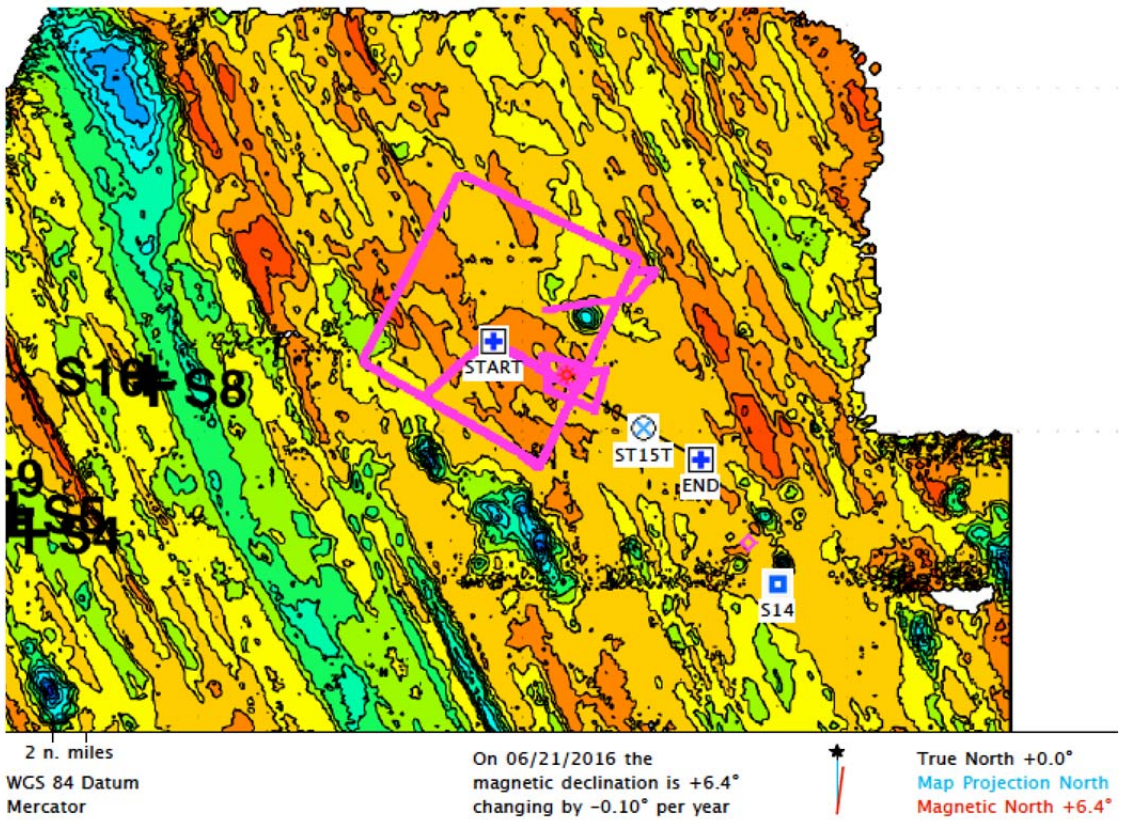


Figure III-6. The track of the *Cabo de Hornos* during the deployment of Stratus 15 and its anchor survey as well as the night prior (square pattern).

C. Anchor Survey

Three positions were provided to the bridge. At each position the ship stopped, 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 Table III-2. Three ranges/travel times were obtained at each survey point to ensure the ranging was repeatable.

Based on previous cruises, an average sound speed at Stratus is taken to be 1509 m s^{-1}. The manual for the release box (Edgetech 8011XS deck unit) indicates that its default setting uses 1490 m s^{-1} as sound speed. This is corrected for in the anchor program. The program also takes into account that the release is 32 m above the bottom. A Matlab routine (Weller code) gave Figure III-7.

Table III-2. Survey points, ranges in meters and travel time in ms. Locations converted for decimal degrees for input into anchor locations.

Site	Latitude (dd mm.mm)	Latitude (dd.ddd)	Longitude (dd mm.mm)	Longitude (dd.ddd)	Range (m)	Time (s)
Survey 3	19° 37.611'S	-19.62685	84° 58.492'W	-84.97487	5325	7.16
Survey 3	19° 37.607'S	-19.62678	84° 58.499'W	-84.97498	5335	7.174
Survey 3	19° 37.607'S	-19.62678	84° 58.505'W	-84.97508	5342	7.183
Survey 2	19° 38.806'S	-19.64675	84° 55.668'W	-84.92780	5388	7.245
Survey 2	19° 38.806'S	-19.64675	84° 55.674'W	-84.92790	5383	7.238
Survey 2	19° 38.806'S	-19.64675	84° 55.680'W	-84.92800	5381	7.235
Survey 1	19° 36.571'S	-19.60952	84° 55.076'W	-84.91793	5692	7.653
Survey 1	19° 36.568'S	-19.60947	84° 55.079'W	-84.91798	5691	7.652
Survey 1	19° 36.570'S	-19.60950	84° 55.081'W	-84.91802	5690	7.650

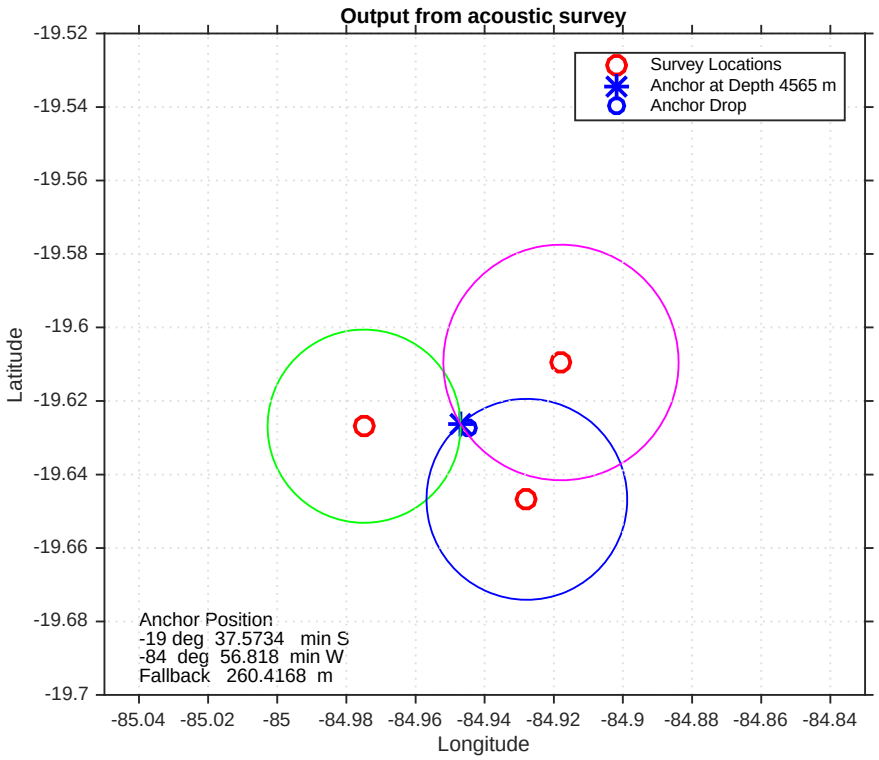


Figure III-7. Anchor survey results using Anchpos code from Weller.

Thus, the Stratus 15 anchor position is (19° 37.5734' S, 84° 56.818' W), with water depth 4,565 m based on the program's solution. An inspection of the buoy showed the waterline to be about 55 cm below the top of the buoy foam.

D. STRATUS 15 and STRATUS 14 Inter-comparisons

R/V *Cabo de Hornos* was stationed near Stratus 14 and 15 buoys on several occasions during this cruise. On June 19, the ship arrived at the Stratus 14 site and stayed there for a couple hours for a visual check and a buoy ride. The ship then moved 30 km to the Northwest towards the future Stratus 15 site to prepare for its deployment. Stratus 15 buoy was in the water on June 20 at 13:47 UTC and anchor drop at 21:48 UTC. On June 21, a visual check was done on Stratus 15 and then a CTD (CTD#2 at 16:49 UTC, 19° 35.5' S, 84° 58.9' W), after which the ship moved away and back to Stratus 14 site for inter-comparison there. Upon arrival at Stratus 14, a CTD was done (CTD#3 at 22:46 UTC, 19° 49.7' S, 84° 44.1' W) after which the ship remained stationed near Stratus 14. On June 22 12:06 UTC, the anchor from Stratus 14 was released and the buoy was back on board at 20:39 UTC. The buoy was left running on the back deck for a couple days. Another CTD was done at the site the next morning (CTD#4, June 23 16:38 UTC, 19° 49.1' S, 84° 44.0' W) and then the ship departed again towards the Stratus 15 buoy for inter-comparison there. On June 24, a last CTD was done at Stratus 15 (CTD#5 at 17:11 UTC, 19° 38.0' S, 84° 56.7' W). The ship departed the work site on June 25 for its transit back towards Valparaiso.

The plots below present the time-series of the data collected from Stratus 14 and 15 buoys, the ship sensors, the UOP stand-alones sensors mounted on the ship (BPR, LWR and SWR sensors mounted on port side railing on forward main deck). No height adjustment was done for measurements from the UOP stand-alones. Meteorology measurements on the ship come from a Vaisala weather station located on the wheelhouse. Ship measurement of ATMP, HRH, WSPD and BPR were therefore adjusted assuming a measurement height of 24.5 m (this value may not be accurate), down to height of similar measurement on buoys (approximately 3 m). The barometric pressure from the ship was adjusted to the mean sea level, as issued in the data stream from the Vaisala weather station.

Comparison from measurements on each buoy does not show any obvious bias. Conductivity data from both ASIMET systems (logger 1 and 2) are slightly offset and post-cruise calibration will be needed to ensure which measurement is best.

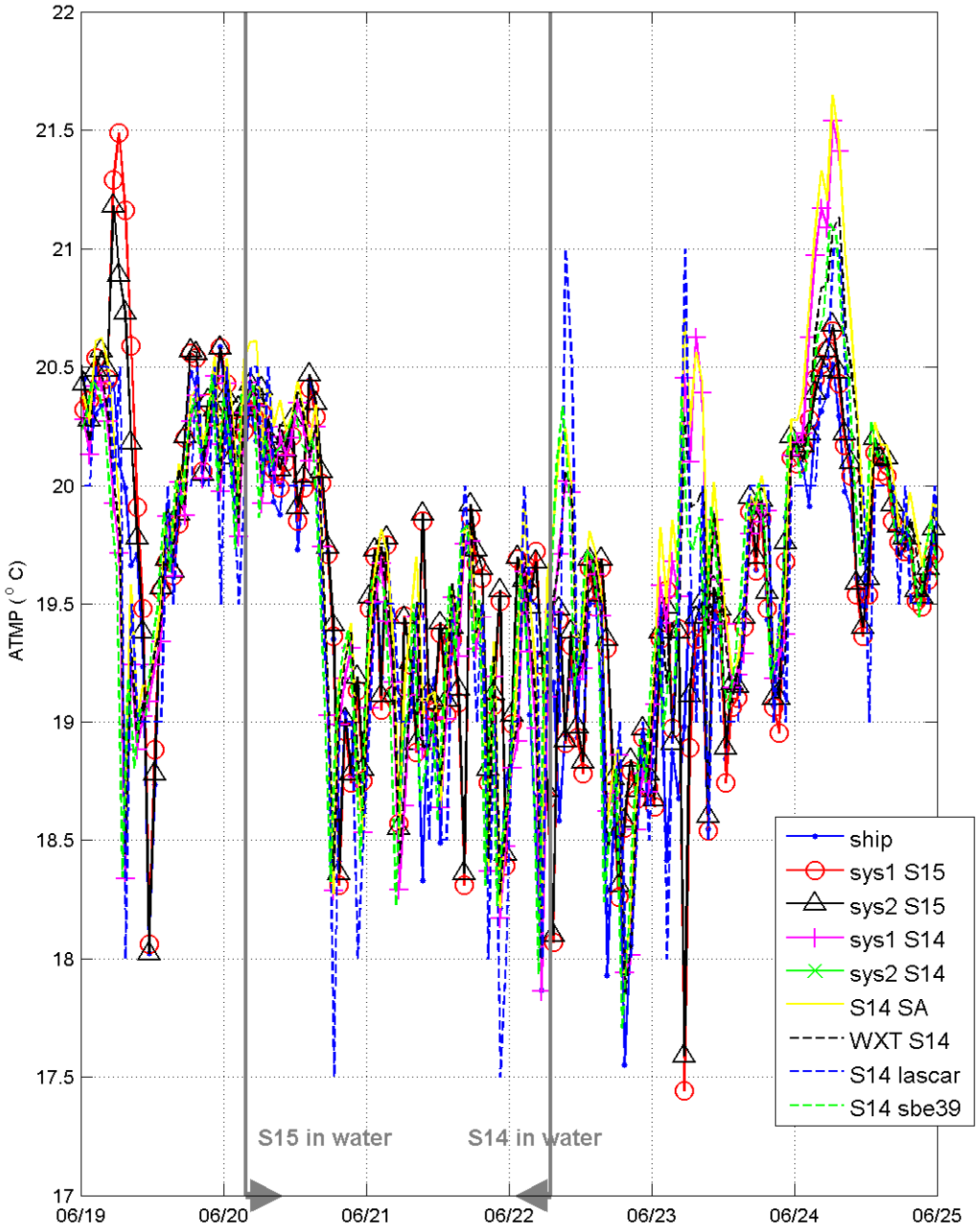


Figure III-8. Inter-comparison between Stratus 14 and 15 buoys and sensors on ship: air temperature (ATMP).

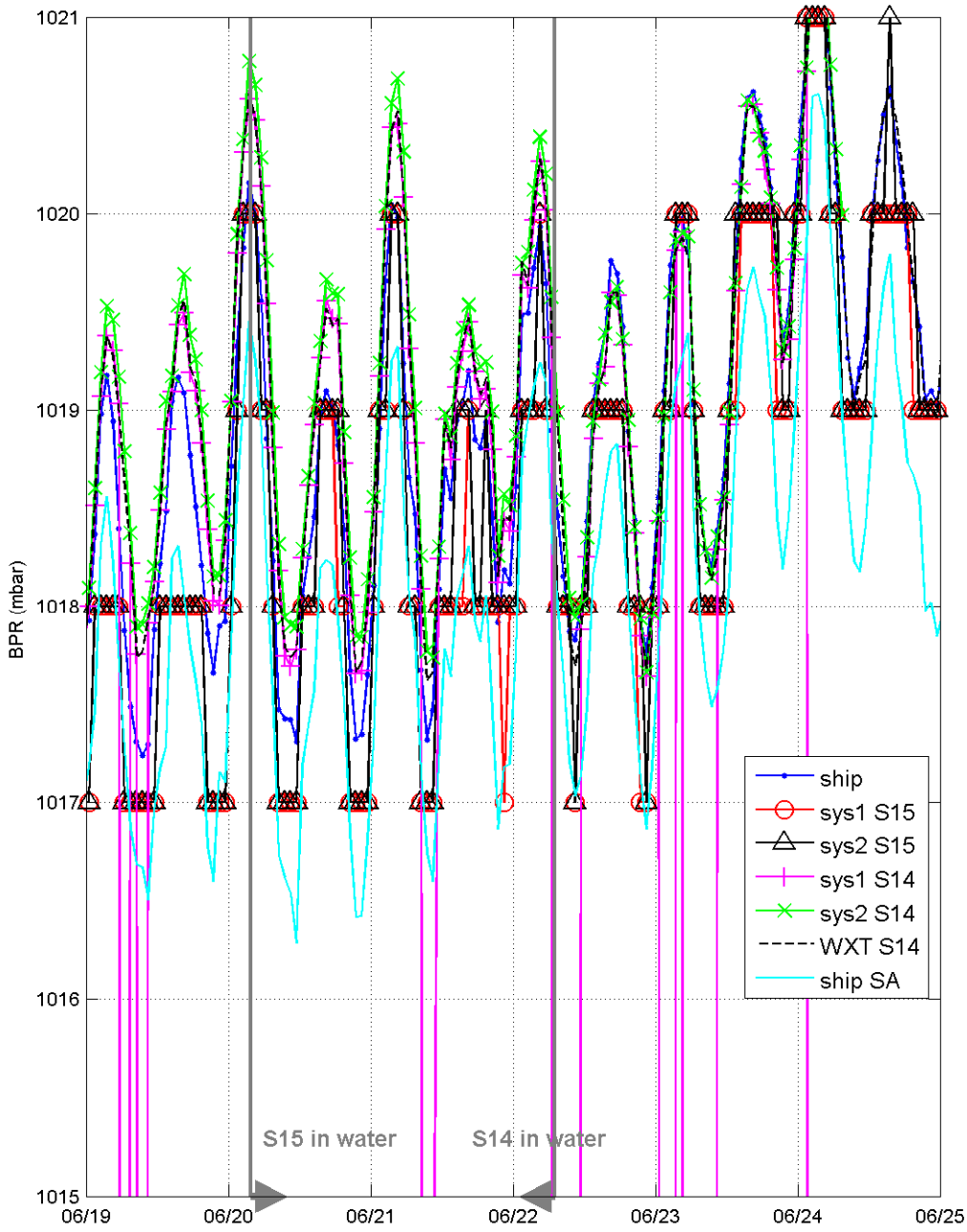


Figure III-9. Same as Figure III-8 but for barometric pressure (BPR).

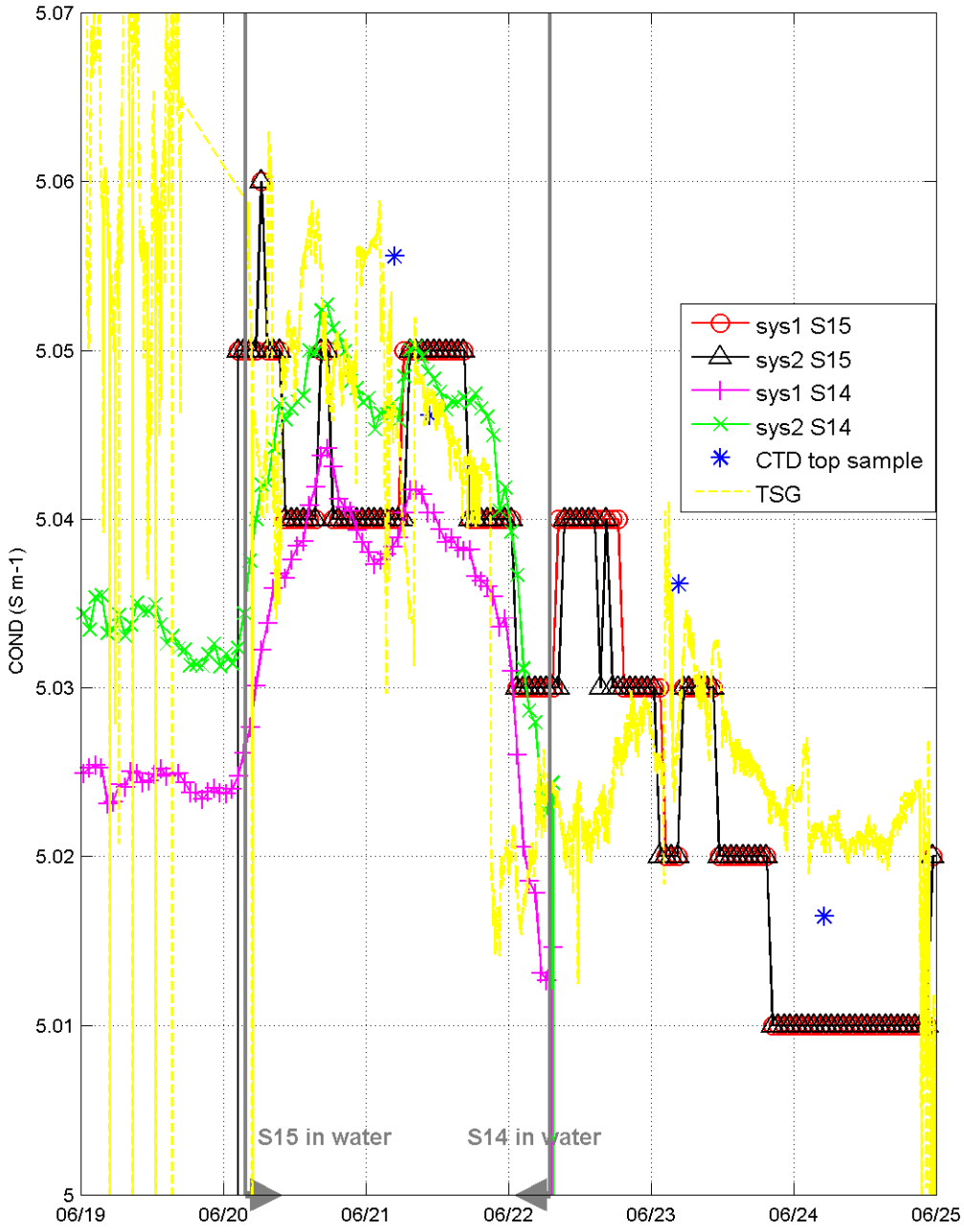


Figure III-10. Same as Figure III-8 but for surface conductivity (COND).

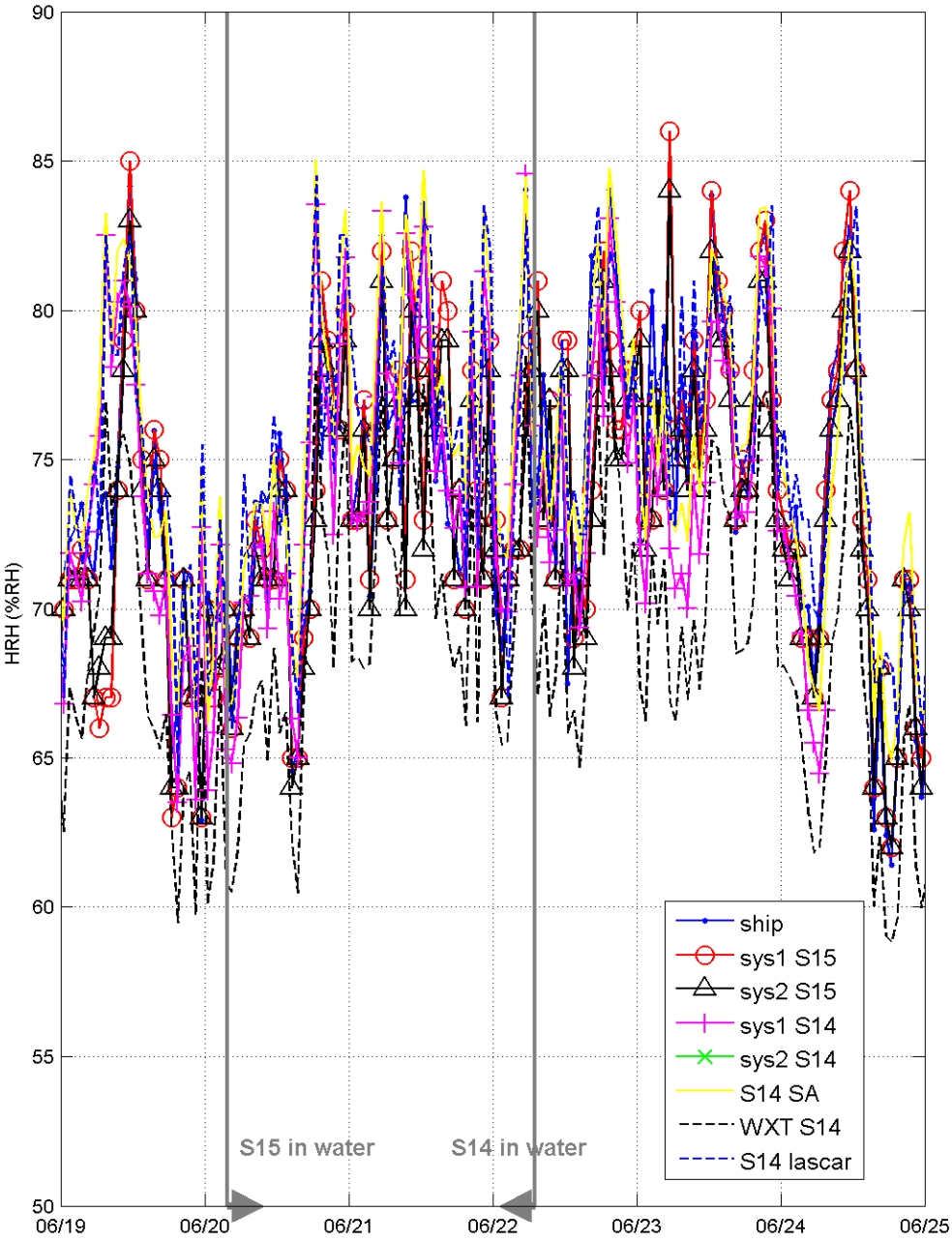


Figure III-11. Same as Figure III-8 but for air relative humidity (HRH).

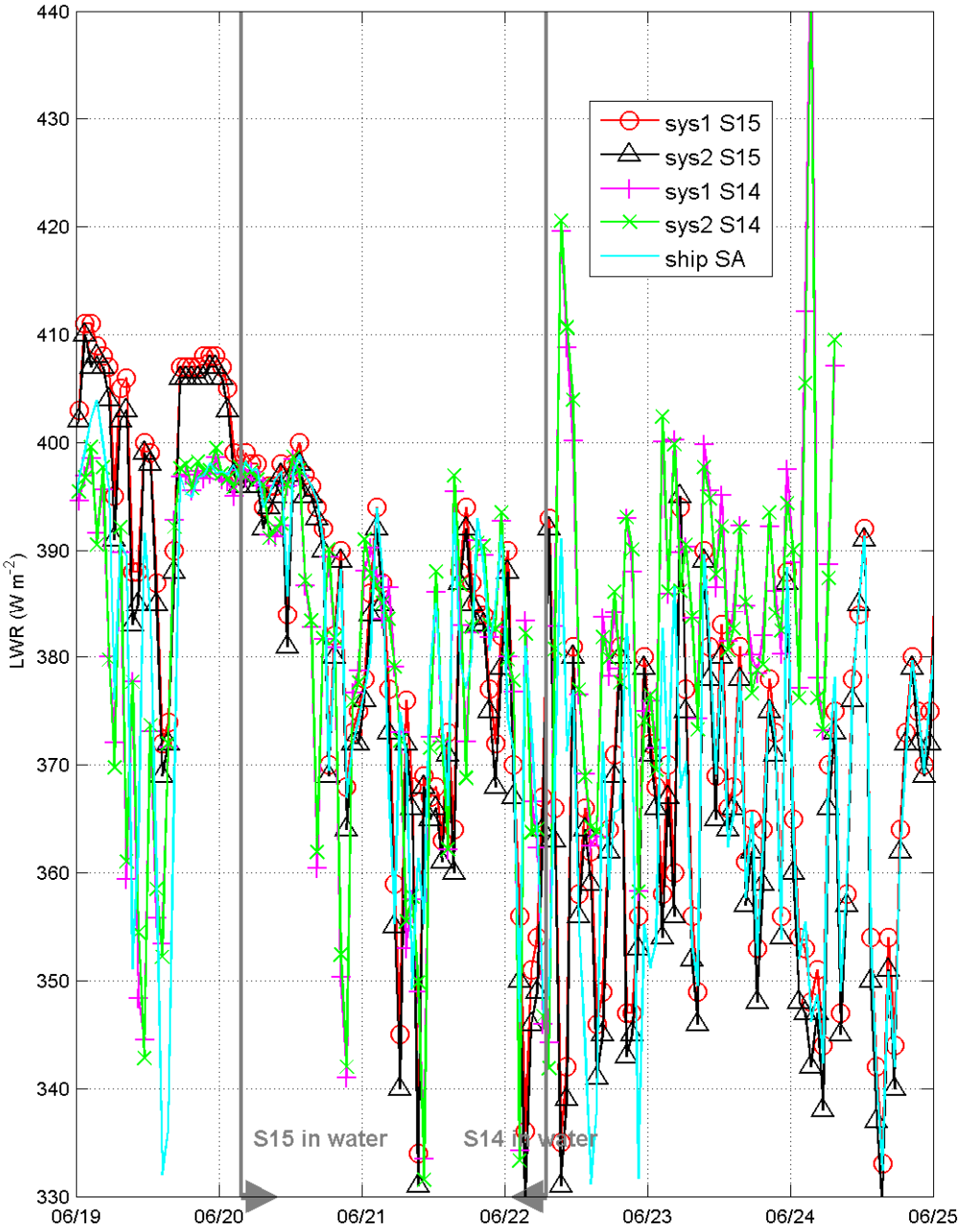


Figure III-12. Same as Figure III-8 but for downwelling Longwave radiation (LWR).

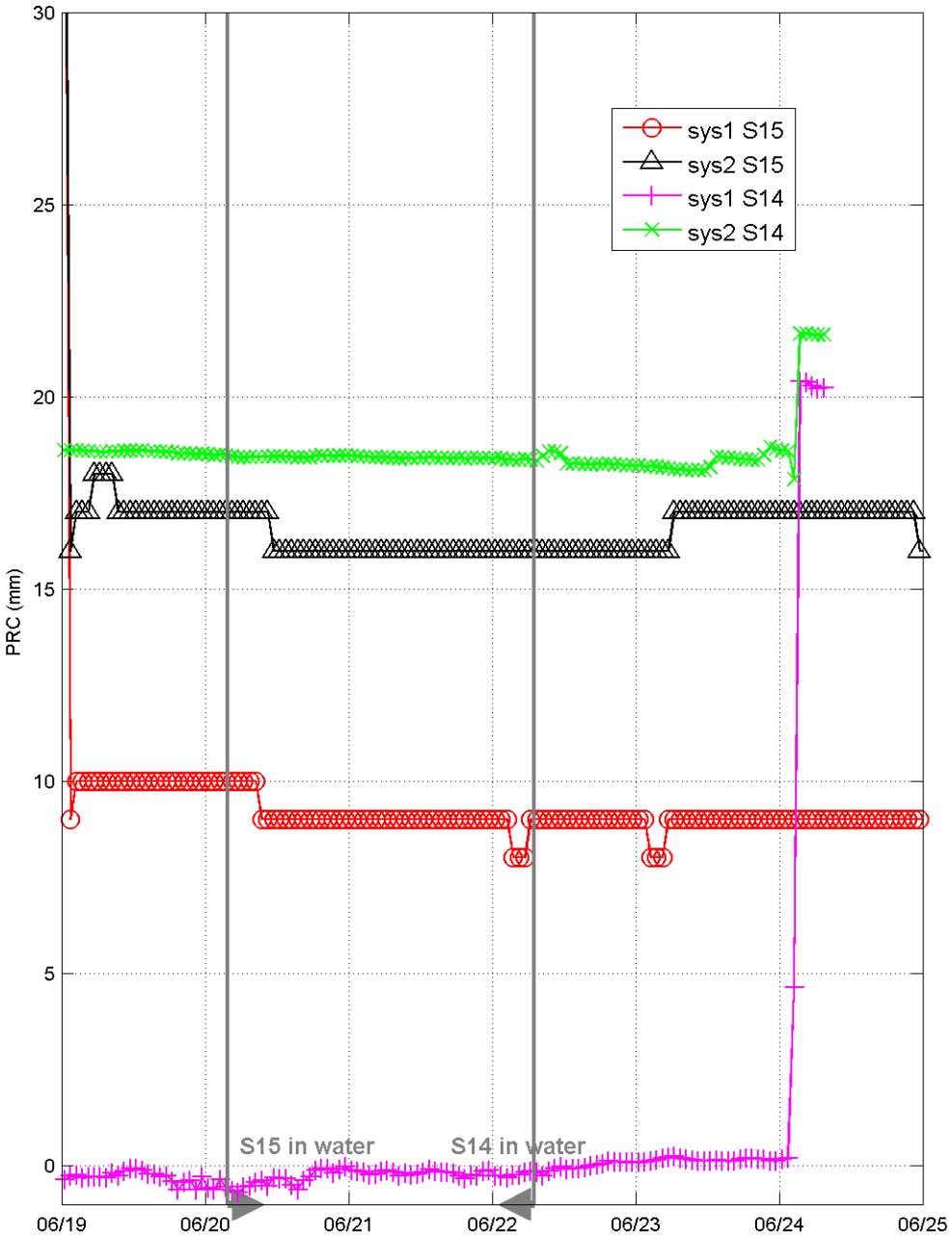


Figure III-13. Same as Figure III-8 but for but for precipitation (PRC).

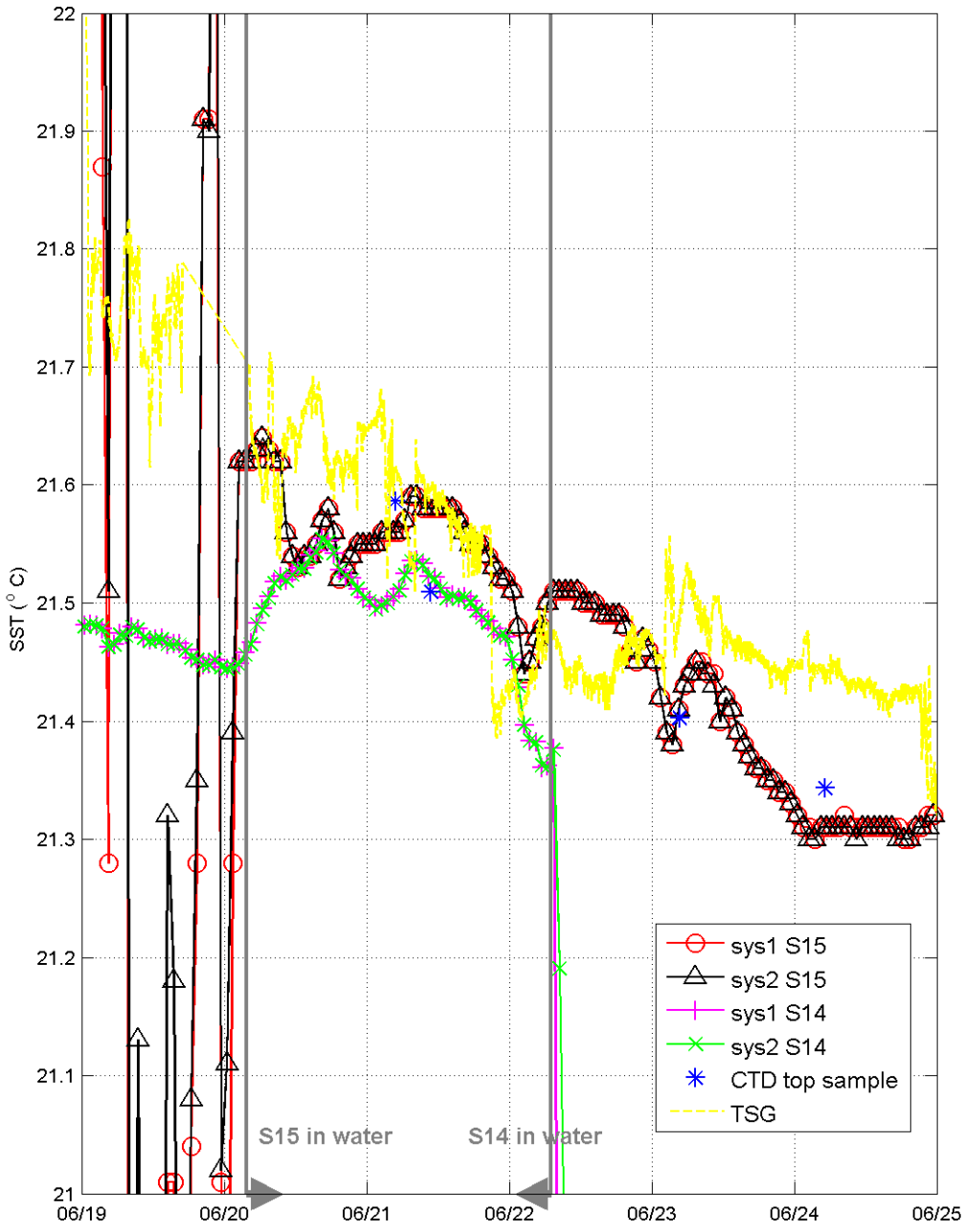


Figure III-14. Same as Figure III-8 but for sea surface temperature (SST).

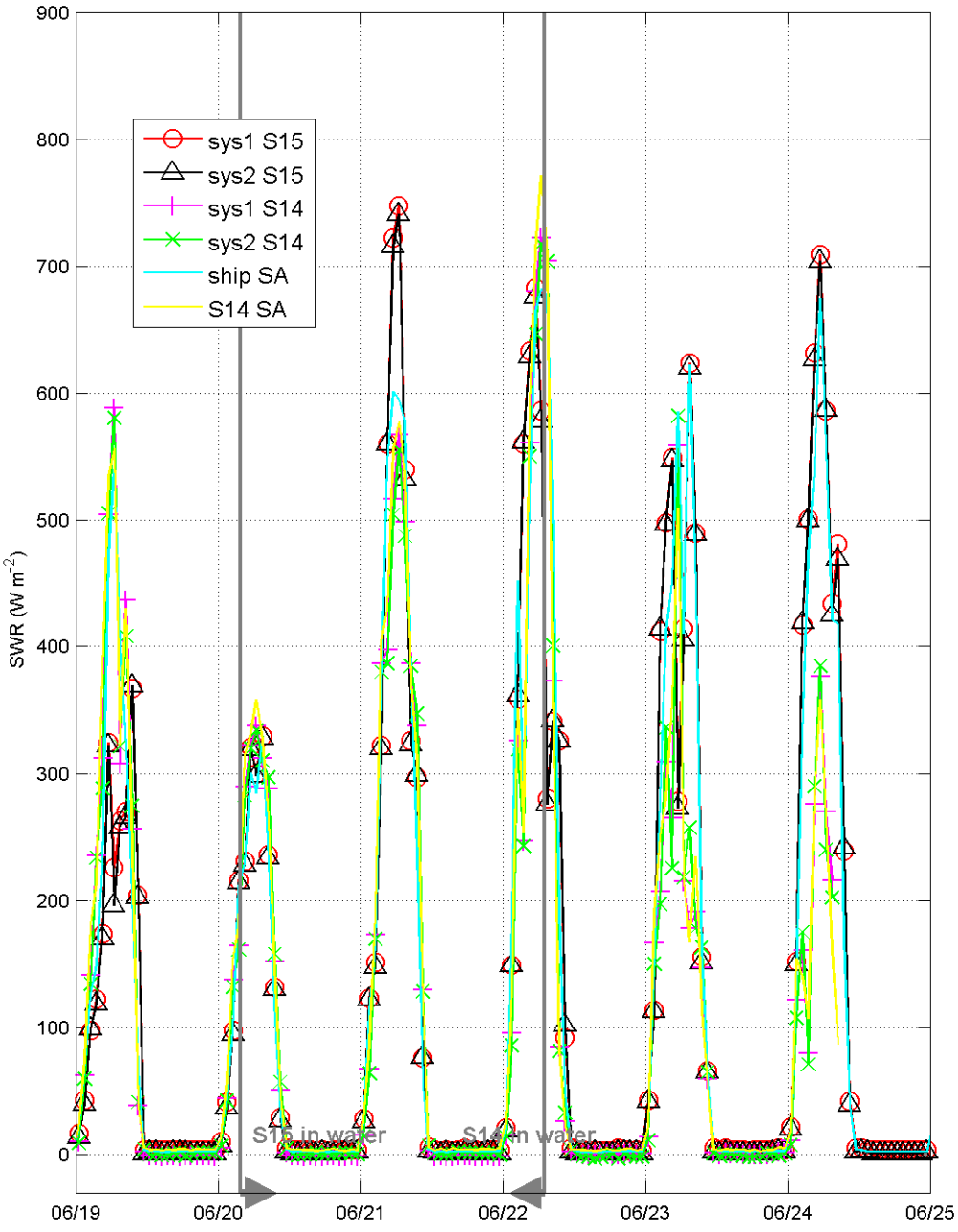


Figure III-15. Same as Figure III-8 but for downwelling shortwave radiation (SWR).

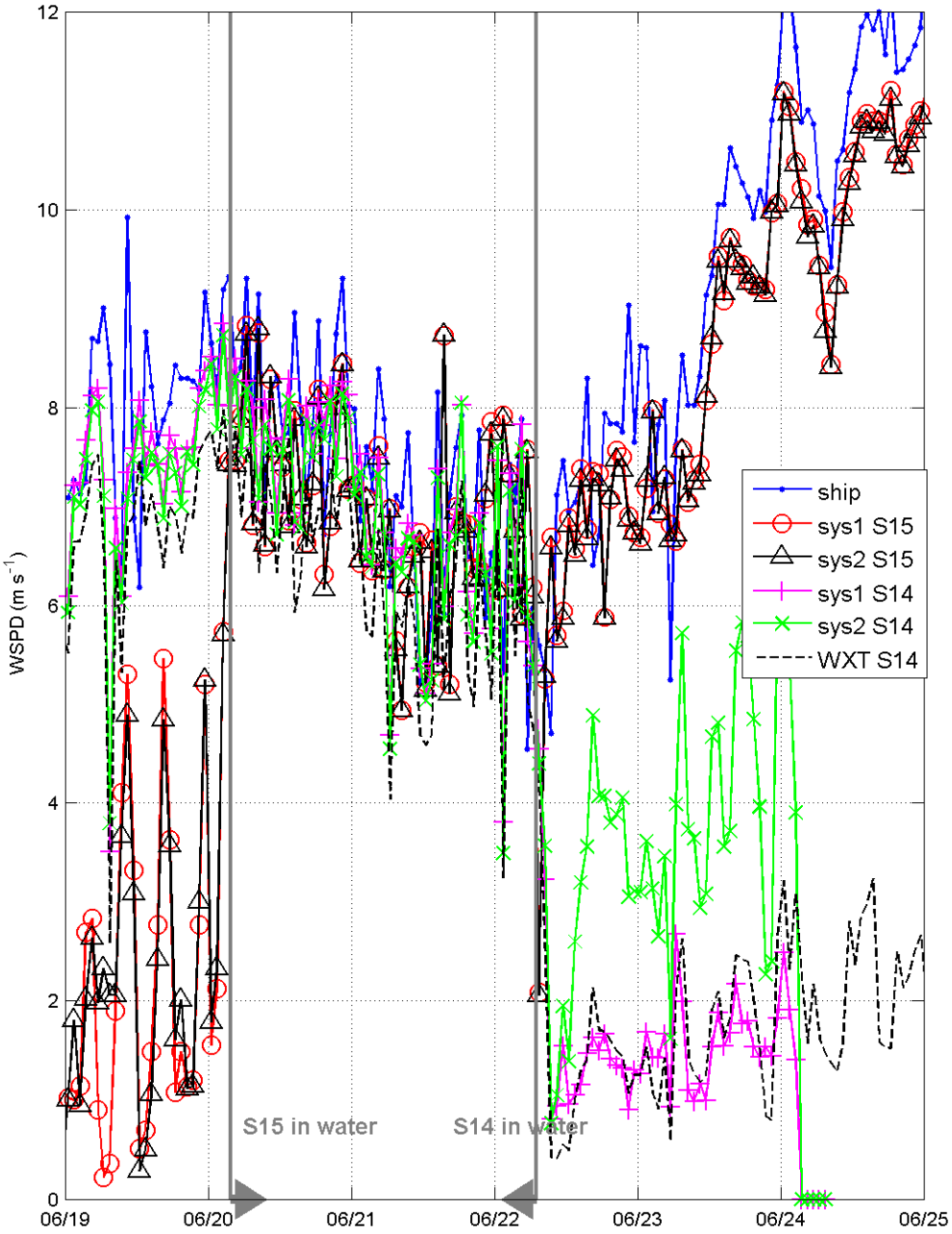


Figure III-16. Same as Figure III-8 but for wind speed (WSPD).

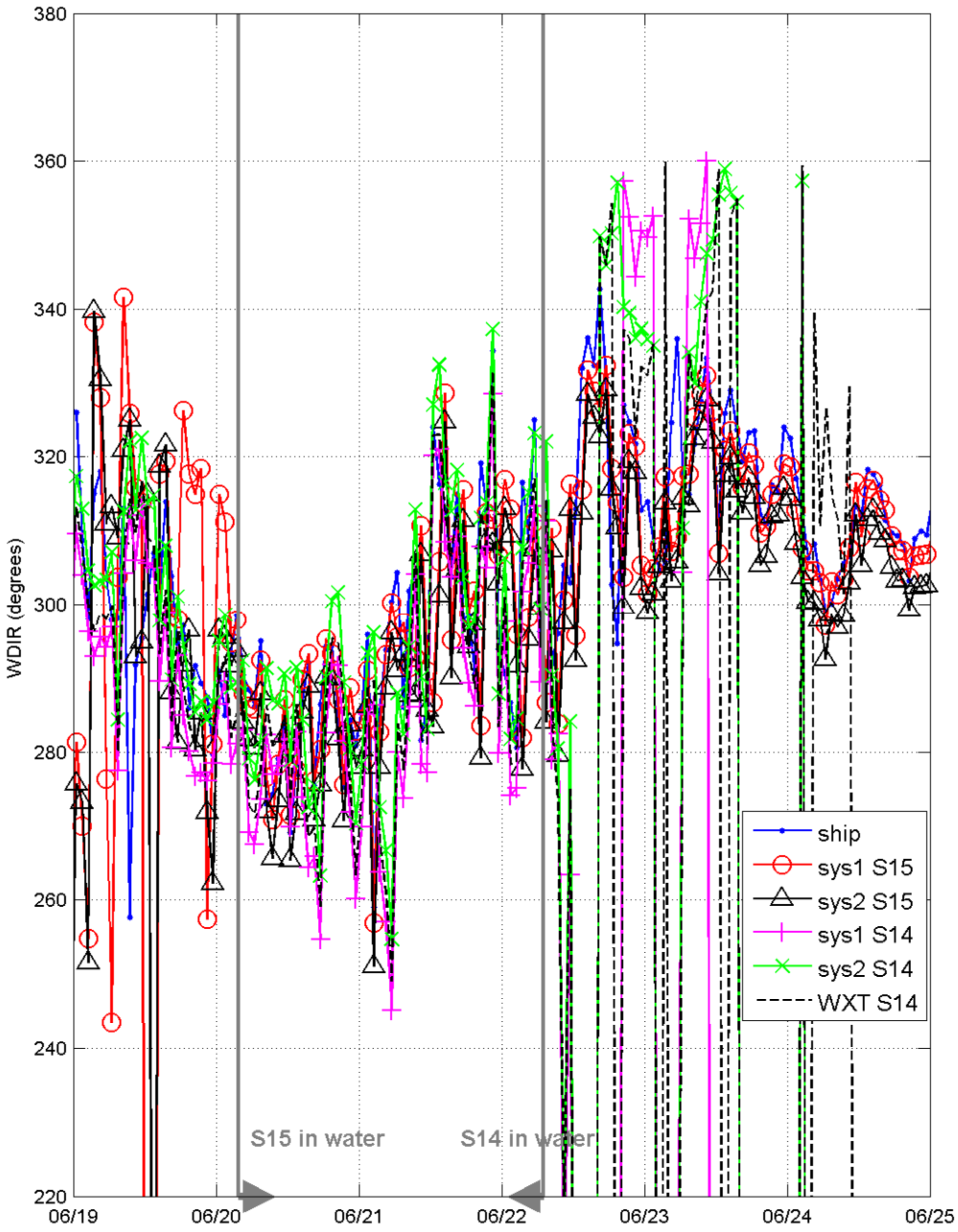


Figure III-17. Same as Figure III-8 but for wind direction (WDIR).

IV. Stratus 14 Recovery

The Stratus 14 mooring was recovered on June 22, 2016. To prepare for recovery the vessel was positioned roughly ¼ mile to the side of the anchor position, with the buoy streaming down wind. The release command was sent to the acoustic release to separate the anchor from the mooring line. After about 50 minutes, the glass balls surfaced. Once the glass balls were on the surface, the ship approached the cluster of balls along the starboard side. The ship's small workboat was deployed to connect a lifting sling into the glass ball cluster. A messenger line was used to pass the lifting line from the ship to the small boat, where the lifting sling and lifting line were shackled together.

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 rest of the mooring trailing behind. 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. Two air tuggers were used to stabilize the cluster, and haul it 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 by crane into the open top container. The ship continued to steam slowly into the wind during this operation. Once the deck was clear, a traveling block was hung from A-frame, using the large air tugger to adjust the height. The winch leader on the 01 deck net drum was connected to the thimble on the Colmega line. The winch hauled in all of the 3300 meters of synthetic line and all of the wire rope. All subsurface instruments were removed as they came to the surface.

For instrument recovery, the A-frame was positioned about 4 feet forward of the stern. A traveling block remained in place. Height was adjusted with the large air tugger. The winch hauled in the wire. Instruments on load bars or in cages were stopped about 3 feet above the deck. Two stopper lines were hooked into the sling link and made fast to the deck cleats. The winch payed out slowly, lowering the instrument to the deck. The instrument was 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 continued until the next instrument.

The above procedure was continued throughout the recovery operation until the Sea-Bird SBE 37 at 62.5 meters was recovered. Then a slip line, passed through the link at the bottom of the 16-meter wire shot was used to set the buoy and remaining 60 meters of instruments adrift.

Once the buoy was set adrift from the stern recovery operation, the Cabo de Hornos made an approach on the starboard side to recover the buoy. A pickup sling with a 50-meter piece of buoyant line and a float had been attached to the buoy pickup bale three days earlier. The crane

was positioned above the recovery area. As the ship maneuvered by the buoy, a grappling hook was used to recover the pickup line and connect the lifting sling to the crane hook. The crane lifted the buoy from the water and swung inboard so the buoy would rest on the side of the ship. Air tugger lines were attached to the buoy deck bale and buoy base. Another line was attached to the buoy tower. The buoy was hoisted up and then swung inboard while the tuggers and line kept the buoy from swinging.

Once the buoy was on deck aircraft straps were used to secure the buoy. A stopper line was used to stop off on the .75 m shot of 3/4" chain between the third and fourth instruments. Tugger lines were removed from the buoy. The shackle below the 3.7-meter SBE 37 was removed to disconnect the mooring line from the buoy.

A 6-foot sling was placed through the link at the top of the first instrument and onto the crane's hook. The crane took the load, and the stopper line was eased off and cleared. The crane hoisted the first two instruments. A stopper was attached to the chain below the instruments hanging from the crane. Once the tugger had the load, the crane lowered the instruments to the deck. The instruments were disconnected and the crane was repositioned over the load. The sling was placed through the sling at the top of the remaining instrument array hooked into the crane. The crane took the load and the stopper line was cleared. The crane lifted the next section of instruments and the above procedure was repeated to recover the remaining instruments.

V. Ancillary Work

A. CTDs

During the Sratus 15 cruise, five 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 15 mooring. Two CTDs were done at the Stratus 14 and 15 sites each. The second CTD at Stratus 14 was done a few hours after recovery of the mooring. Both CTDs at Stratus 15 were done post-deployment, about 2 nm downwind of the buoy. Locations and times of the CTD casts are summarized in Table V-1.

Table V-1. Time and locations of the CTD casts made during the Stratus 15 cruise.

CTD #	Event	Date and Time (UTC)	Latitude	Longitude	Depth (m)
1	Release test	6/16/16 23:16	29° 36.8'S	75° 48.1' W	1,500
2	S15	6/21/16 16:49	19° 35.5' S	84° 58.9' W	4,000
3	S14	6/21/16 22:46	19° 49.7' S	84° 44.1' W	4,000
4	S14	6/23/16 16:38	19° 49.1' S	84° 44.0' W	4,000
5	S15	6/24/16 17:11	19° 38.0' S	84° 56.7' W	4,000

The CTD sensor used during the cruise was a SBE 19 sensor (V3.1, serial number 2361). The sensor was calibrated in September 2015 and set to sample every 0.5 second. On June 17, outside the Chile EEZ, a CTD cast was done to 1,500 m depth in order to test the SBE 19 sensor and three acoustic releases. This test release revealed no problems with the CTD sensor. Later, four CTDs were done to 4,000 m near the Stratus 15 buoy and the Stratus 14 buoys as part of the inter-comparison. For post processing we used the SBE DataProcessing tool V7.23.1. For the temperature, pressure and salinity profiles, we used an average of 8 bin. The T-S diagram has no averages. Figures following next show the profiles for the CTD casts.

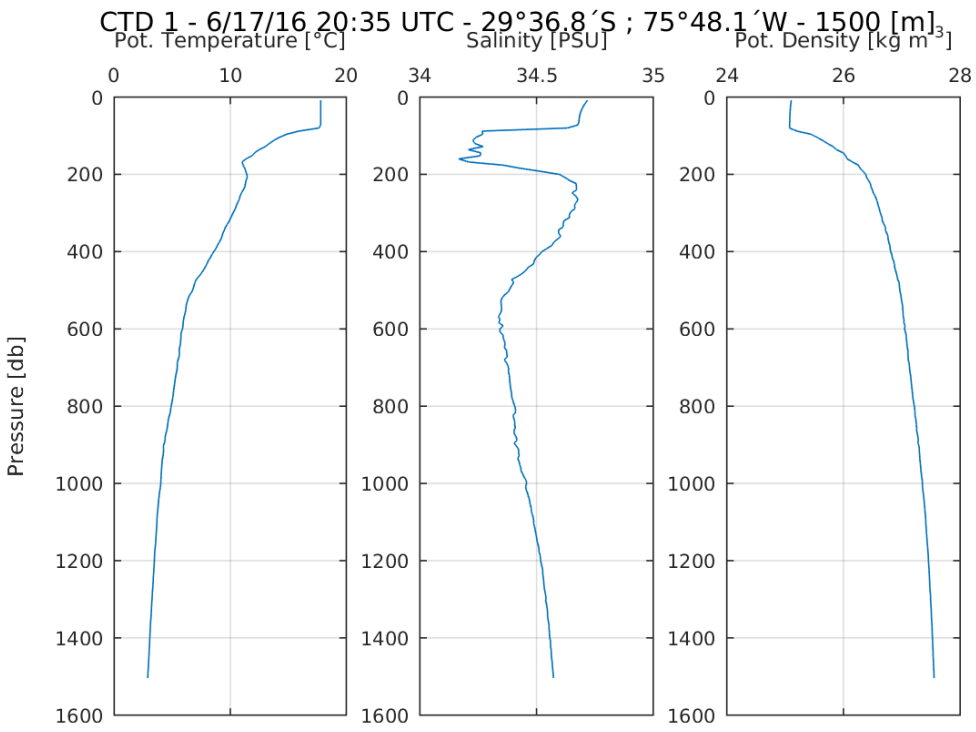


Figure V-1. CTD profile data collected on June 17 2016, for acoustic releases test.

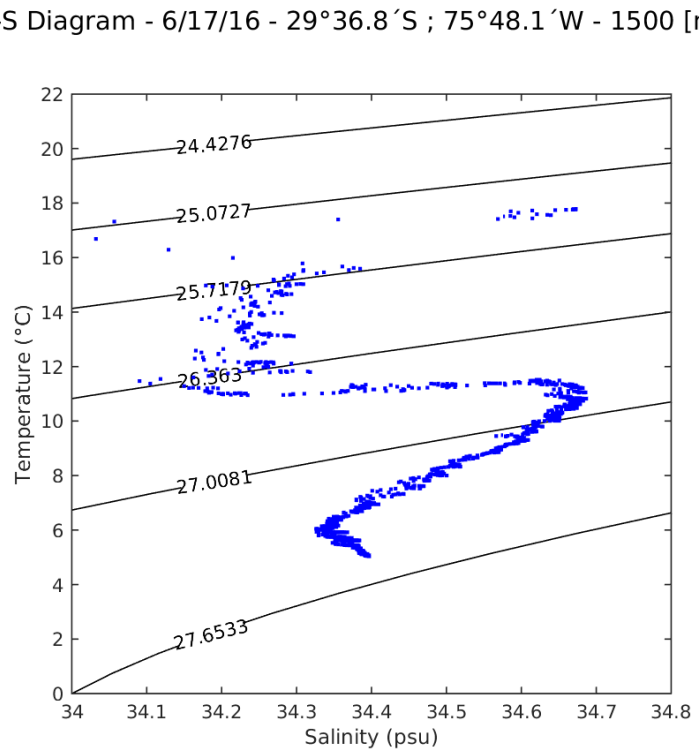


Figure V-2. T-S plot using the data from the release test.

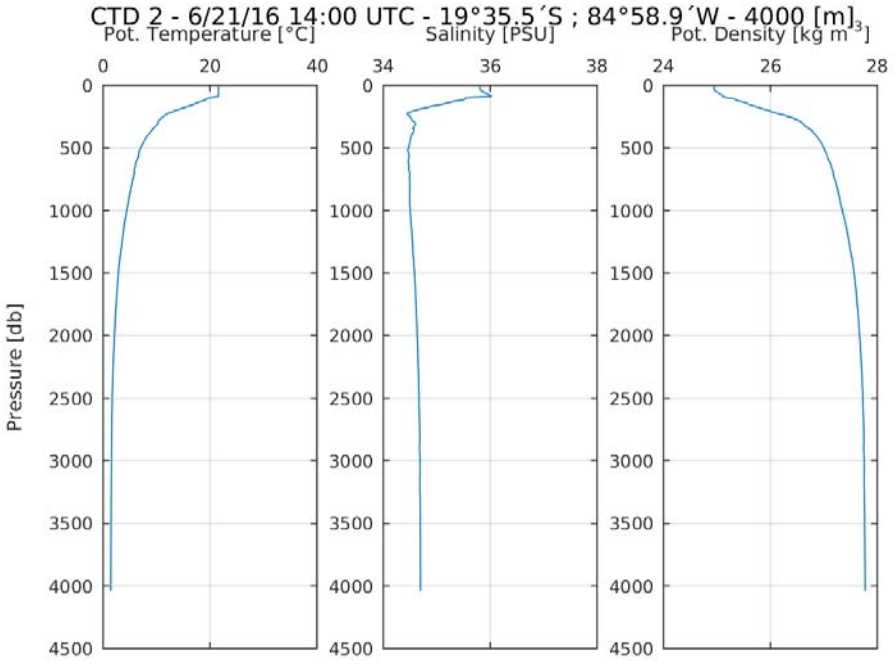


Figure V-3. CTD profile data collected on June 21 2016, near the Stratus 15 buoy.

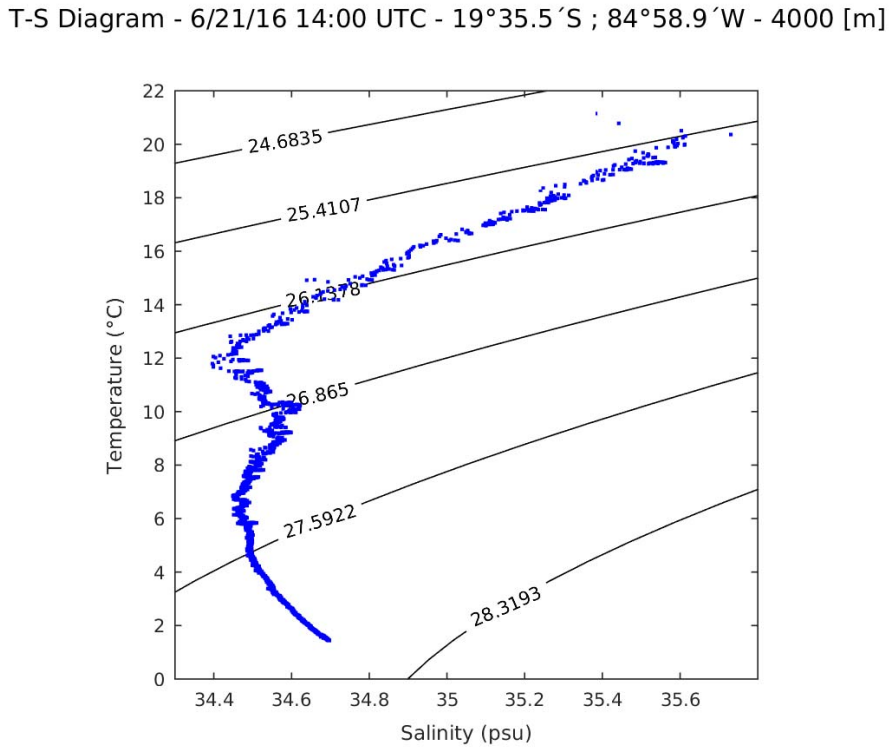


Figure V-4. T-S plot using the same data as in .

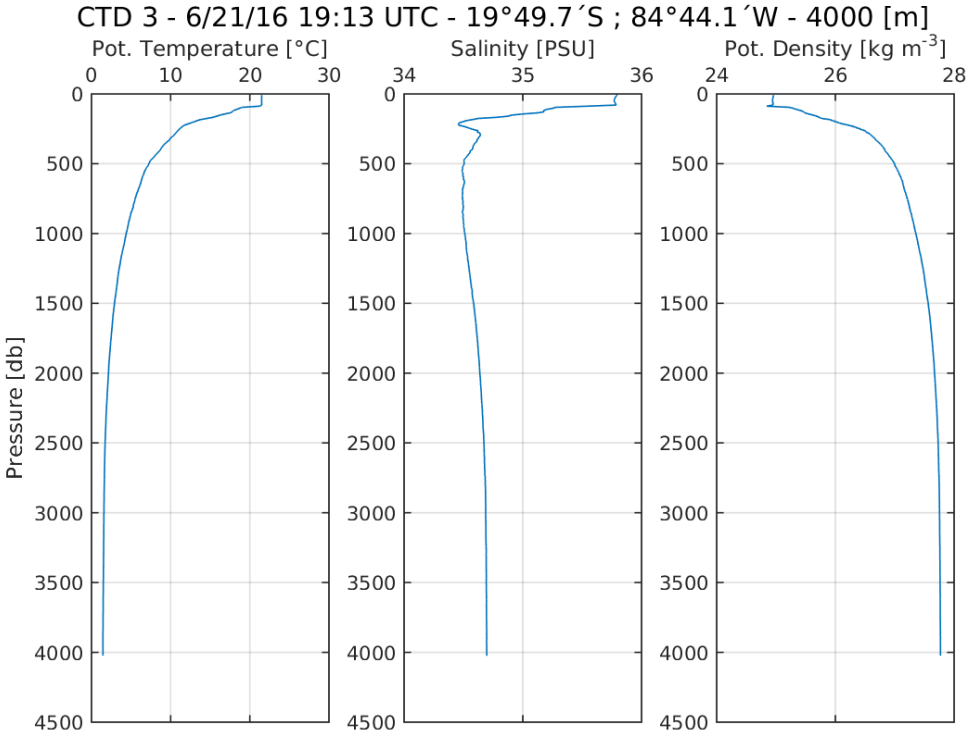


Figure V-5 CTD profile data collected on June 21 2016, near the Stratus 14 buoy.

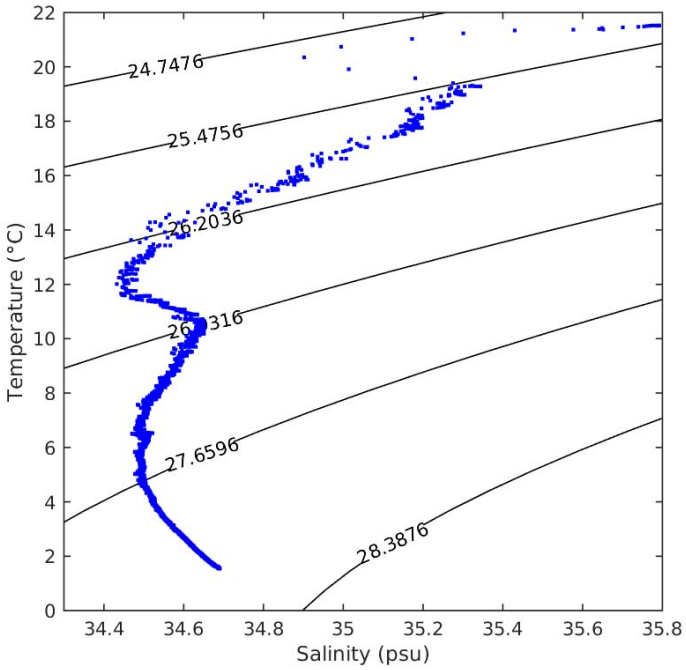


Figure V-6. T-S plot using the same data as in Figure V-5.

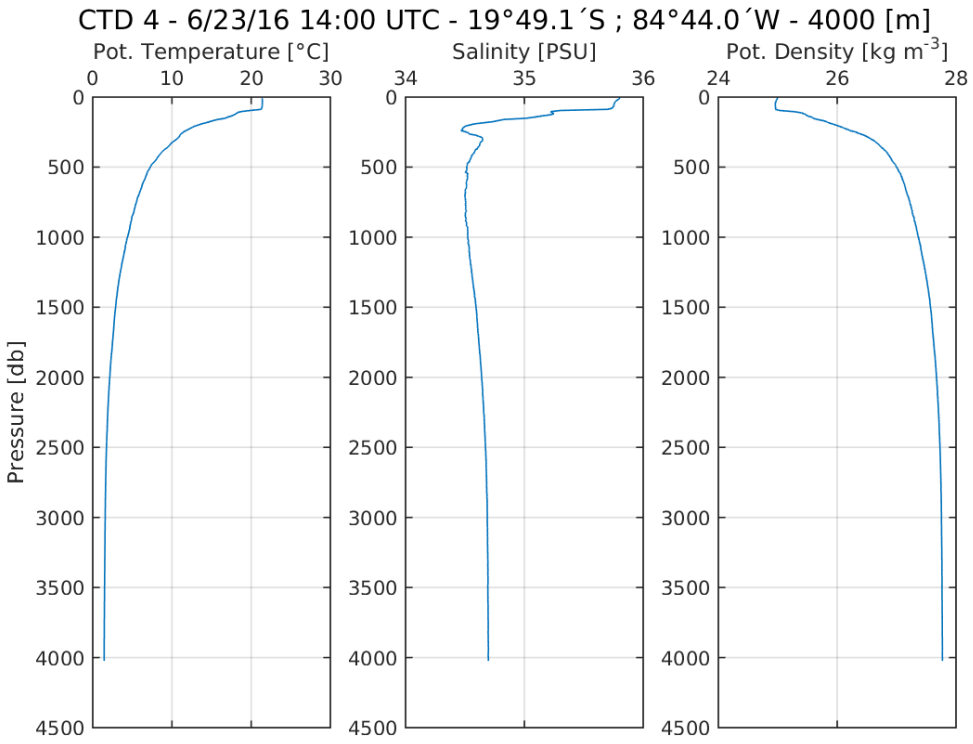


Figure V-7. CTD profile data collected on June 23 2016, near the Stratus 14 buoy.

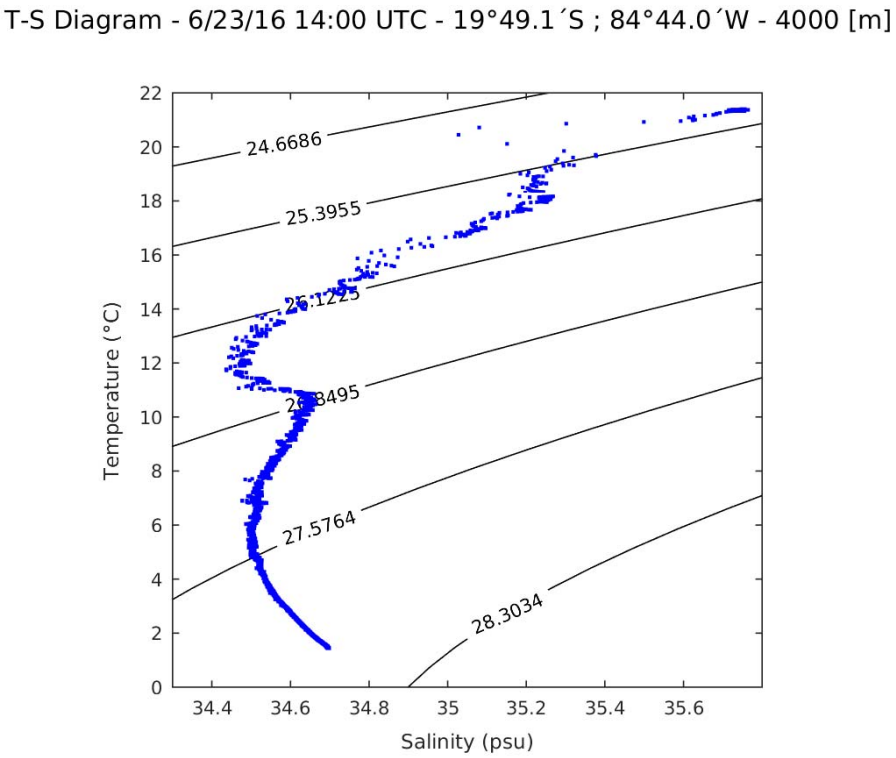


Figure V-8. T-S plot using the same data as in Figure V-7.

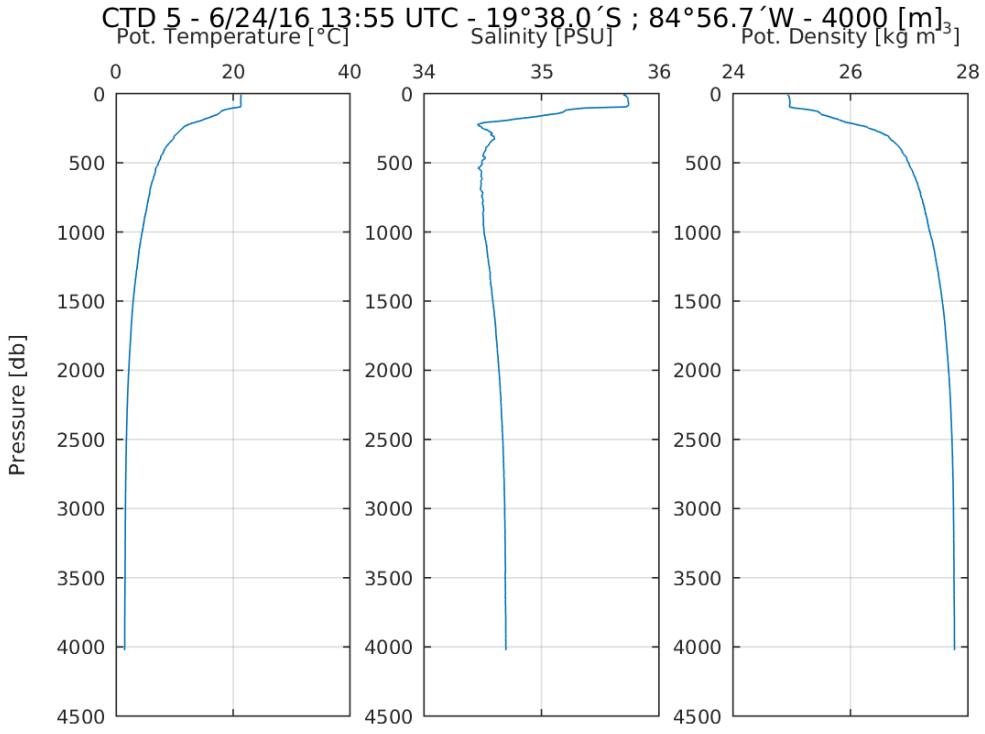


Figure V-9. CTD profile data collected on June 24 2016, near the Stratus 15 buoy.

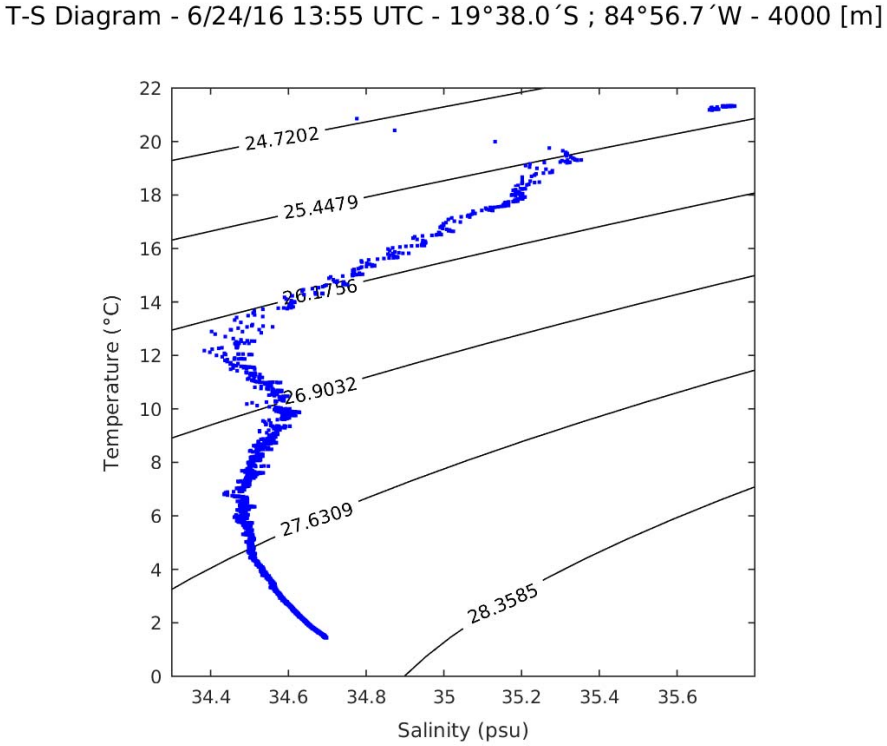


Figure V-10. T-S plot using the same data as in Figure V-9.

B. Surface Drifters and Argo Floats

During the Stratus cruise 20 surface drifters and 3 Argo profiling floats were launched. The 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 NOAA PMEL (Pacific Marine and Environmental Laboratory, Seattle, Washington). The Stratus program contacted both the Global Surface Drifter Program and the U.S. ARGO float program and volunteered to deploy drifters and floats.

The surface drifter deployments were done (1-18) on the outbound leg, with numbers 19 and 20 going in just as the ship departed the mooring site. Last year the ship was diverted by the Chilean Navy to do a bathymetric survey off Antofagasta, Chile so there was some risk that the return to Valparaiso might be only inside the Chilean EEZ, so the decision was made to deploy on the outbound leg in international waters. Figure V-11 shows the deployments; international waters are located between Valparaiso and the San Felix Island region and then again to the northwest of the San Felix Island region.
Table V-2 provides a tabular summary of surface drifter deployments.

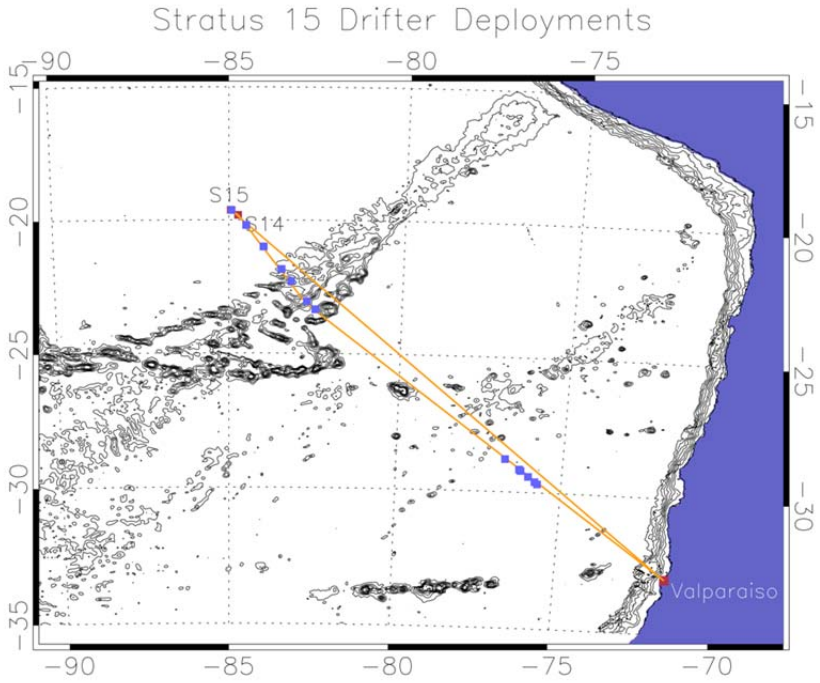


Figure V-11. Locations of surface drifter deployments.

Table V-2. Surface drifter deployment summary for Stratus 15 cruise.

6/26/16 STRATUS 13 WEBB FLOAT DEPLOYMENT LOG S15_DRIFTER_LOG

STRATUS 15 DRIFTER DEPLOYMENT LOG

	DRIFTER ID	DEPLOY DATE/TIME (UTC)	DEPLOYMENT POSITION
1	976670	6/16/16 20:00	29 41.05 S, 75 43.11 W
2	476660	6/16/16 22:46	29 36.41 S, 75 48.10 W
3	476670	6/17/16 0:13	29 25.16 S , 76 00.55 W
4	475620	6/17/16 1:33	29 12.68 S, 76 14.63 W
5	476520	6/17/16 2:05	29 09.74 S , 76 54.42W
6	476640	6/17/16 4:41	28 47.44 S , 76 44.02 W
7	475670	6/18/16 16:50	23 21.210 S, 82 30.273 W
8	476570	6/18/16 16:50	23 21.210 S, 82 30.273 W
9	477570	6/18/16 18:43	23 03.156 S, 82 45.084 W
10	477670	6/18/16 18:43	23 03.156 S, 82 45.084 W
11	477550	6/18/16 22:52	22 18.043 S, 83 12.935
12	478560	6/18/16 22:52	22 18.043 S, 83 12.935 W
13	477660	6/19/16 1:26	21 51.016 S, 83 29.628 W
14	477560	6/19/16 1:26	21 51.016 S, 83 29.628 W
15	477580	6/19/16 6:04	21 00.345 S, 84 00.807 W
16	477570	6/19/16 6:04	21 00.345 S, 84 00.807 W
17	478580	6/19/16 10:35	20 11.7 S, 84 30.5 W
18	476590	6/19/16 10:35	20 11.7 S, 84 30.5 W
19	475630	6/25/16 12:19	19 38.185 S, 84 55.29 W
20	476580	6/25/16 12:19	19 38.185 S, 84 55.29 W

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 1: Stratus 15 Buoy Spin

Stratus 15 Buoy Spin					
Heading	**5**				
Turn	**0**				
	Time	**Date**			
Vanes Secured UTC	13:50:00	9-Jun-16			
System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L04**				
WND	**217**	1.40	6.10	7.50	14:10:00
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L14**				
WND	**210**	1.00	5.50	6.50	14:15:00
		VANE	**Compass**	**Direction**	**Sample Time**
VWX005	Stand Alone	N/A	6.50	N/A	14:08:00
Heading	**5**				
Turn	**45**				
	Time	**Date**			
Vanes Secured UTC	14:22:00	9-Jun-16			
System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L04**				
WND	**217**	313.60	52.00	5.60	14:33:00
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L14**				
WND	**210**	315.00	49.80	4.80	14:36:00
		VANE	**Compass**	**Direction**	**Sample Time**
VWX005	Stand Alone	N/A	50.00	N/A	14:38:00
Heading	**5**				
Turn	**90**				
	Time	**Date**			
Vanes Secured UTC	14:42:00	9-Jun-16			
System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L04**				
WND	**217**	267.6	96.6	4.20	14:59:00

System 2		Vane	Compass	Direction	Sample Time
Logger	**L14**				
WND	**210**	269.00	96.30	5.30	14:56:00
		VANE	**Compass**	**Direction**	**Sample Time**
VWX005	Stand Alone	N/A	91.00	N/A	14:55:00
Heading	**5**				
Turn	**135**				
	Time	**Date**			
Vanes Secured UTC	15:05:00	9-Jun-16			
System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L04**				
WND	**217**	224.40	141.40	5.80	15:20:00
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L14**				
WND	**210**	224.70	141.80	6.50	15:23:00
		VANE	**Compass**	**Direction**	**Sample Time**
VWX005	Stand Alone	N/A	135.60	N/A	15:27:00
Heading	**5**				
Turn	**180**				
	Time	**Date**			
Vanes Secured UTC	15:30:00	9-Jun-16			
System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L04**				
WND	**217**	178.10	187.40	5.50	15:48
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L14**				
WND	**210**	180.60	186.00	6.60	15:46:00
		VANE	**Compass**	**Direction**	**Sample Time**
VWX005	Stand Alone	N/A	180.50	N/A	15:45:00
Heading	**5**				
Turn	**225**				
	Time	**Date**			
Vanes	15:55:00	9-Jun-16			

Secured UTC					
System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L04**				
WND	**217**	132.30	233.10	5.40	17:02:00
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L14**				
WND	**210**	136.10	229.80	5.90	17:04
		VANE	**Compass**	**Direction**	**Sample Time**
VWX005	Stand Alone	N/A	227.00	N/A	17:06:00
Heading	**5**				
Turn	**270**				
	Time	**Date**			
Vanes Secured UTC					
System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L04**				
WND	**217**	88.40	277.60	6.00	17:41:00
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L14**				
WND	**210**	91.20	277.00	8.20	17:40:00
		VANE	**Compass**	**Direction**	**Sample Time**
VWX005	Stand Alone	N/A	275.60	N/A	17:35:00
Heading	**5**				
Turn	**315**				
	Time	**Date**			
Vanes Secured UTC	17:45:00	9-Jun-16			
System 1		**VANE**	**Compass**	**Direction**	**Sample Time**
Logger	**L04**				
WND	**217**	45.60	320.90	6.50	17:58:00
System 2		**Vane**	**Compass**	**Direction**	**Sample Time**
Logger	**L14**				
WND	**210**	46.70	322.20	8.90	18:00
		VANE	**Compass**	**Direction**	**Sample Time**
VWX005	Stand Alone	N/A	321.90	N/A	18:02:00

Appendix 2: Stratus 15 Surface and Subsurface Instrumentation Configuration

Surface:

Stratus 15 Surface				
SYSTEM 1				
Module	Serial	Height Cm	Event	Notes
Logger PORT	L04			
HRH	299	230		
BPR	218	245		
WND	217	271	vanes chocked: ON 12:55 / OFF 13:36 UTC	
PRC	214	253	fill to drain 12:57 -- spike w/ 100 ml @ 13:05 UTC	
LWR	255	278	caps ON 13:18 / OFF 13:35	
SWR	212	279	caps ON 13:18 / OFF 13:35	
SST	1838	152	spike: ice ON 20:25 / OFF 20:45	
PTT	12789			27916, 27917, 27918
SYSTEM 2				
Module	Serial	Height Cm	Event	Notes
Logger STARBOARD	L-14			
HRH	256	230		
BPR	210	243		
WND	210	271	vanes chocked: ON 12:55 / OFF 13:36 UTC	
PRC	501	253	fill to drain 12:57 -- spike w/ 200ml @ 13:06 UCT	
LWR	221	278	caps ON 13:18 / OFF 13:35	
SWR	214	279	caps ON 13:18 / OFF 13:35	
SST SBE37	2053	152	spike: ice ON 20:25 / OFF 20:45	
PTT	18171			27919, 27920, 27921

STAND ALONES MODULES				
Module	Serial	Height Cm	Event	Notes
WAMDAS:	6014			
IMEI #	300224010100810			
SIM #	89881 69312 00205 1278			
3DM-GX1 #	8470			
NDBC partner Platform	32ST0			
NDBC Wave Station	32012			
HRH	216	230		
VWX	5	245 (top of white collar)		
Lascar AT/RH	356	205	start: 20160618 20:00 UTC	sample rate: 3600s
SBE-39-AT	1447	223	start: 20160618 19:20 UTC	sample rate: 300s
XEOS Kilo Beacon	300234062945460			
XEOS Rover Beacon	300434060815350			
PC02 (air block)	112			
SAMI	P0044			
SBE16	6566			

Subsurface:

Stratus 15 Subsurface								
Instrument	Serial	Depth Meters	Sample	Start Date	Start Time	Spike Date	Spike Start Time	Spike End Time
Nortek 2 MHZ Profiler	357	13	300/1800	20160618	0100	20160618	1300	15:15
Optode	943	250	GEOMAR	GEOMAR	GEOMAR	20160619	12:46	15:00
Optode	691	500	GEOMAR	GEOMAR	GEOMAR	20160619	12:46	15:00
RCM11	78	7	1800	20160618	0102	20160618	1331	15:15
RCM11p	79	20	1800	20160618	0100	20160618	1331	15:15
RCM11p	13	32.5	1800	20160618	0101	20160618	1331	15:15
RDI 300 KHZ	1218	80	3600	20160601	0100	20160618	1330	15:15
SBE37	11394	4503	300	20160612	1825	20160612	17:29	19:00
SBE37	12257	4503	300	20160612	1820	20160612	17:29	19:00
SBE37	1325t	2	300	20160601	0100	20160612	17:00	17:30
SBE37	1326t	3.7	300	20160601	0100	20160612	17:00	17:30
SBE37	1328t	10	300	20160601	0100	20160612	17:00	17:30
SBE37	1329t	16	300	20160601	0100	20160612	17:00	17:30
SBE37	1330t	30	300	20160601	0100	20160612	17:00	17:30
SBE37	8211t	40	300	20160612	1600	20160612	17:00	17:30
SBE37	8212t	62.5	300	20160612	1600	20160612	17:00	17:30
SBE37 P clamped	1909pc	85	300	20160601	0100	20160612	17:00	17:30
SBE37	8215t	130	300	20160612	1600	20160612	17:00	17:30
SBE37	*8216t*	160	300	20160612	1600	20160612	17:00	17:30
SBE37 - tabs	12258	190	300	20160612	1600	20160612	17:00	17:30

Instrument	Serial	Depth Meters	Sample	Start Date	Start Time	Spike Date	Spike Start Time	Spike End Time
SBE37 - tabs	12256	220	300	20160612	1600	20160612	17:00	17:30
SBE37 clamped	1906c	295	300	20160601	0100	20160612	17:00	17:30
SBE37 P clamped	3733tp	550	300	20160601	0100	20160612	17:00	17:30
SBE37 clamped	1908c	601	300	20160601	0100	20160612	17:00	17:30
SBE37 clamped	8218c	700	300	20160601	0100	20160612	17:00	17:30
SBE37 clamped	8219c	857	300	20160612	1600	20160612	17:00	17:30
SBE37 clamped	8220c	1355	300	20160612	1600	20160612	17:00	17:30
SBE37 clamped	8221c	1557	300	20160612	1600	20160612	17:00	17:30
SBE37	8224c	2000	300	20160612	1600	20160612	17:00	17:30
SBE39	35	4.9	300	20160601	0100	20160612	17:59:40	18:30
SBE39	38	25	300	20160601	0100	20160612	17:59:40	18:30
SBE39	44	35	300	20160601	0100	20160612	17:59:40	18:30
SBE39	48	50	300	20160601	0100	20160612	17:59:40	18:30
SBE39	49	55	300	20160601	0100	20160612	17:59:40	18:30
SBE39	102	70	300	20160601	0100	20160612	17:59:40	18:30
SBE39	103	77.5	300	20160601	0100	20160612	17:59:40	18:30
SBE39	203	92.5	300	20160601	0100	20160612	17:59:40	18:30
SBE39	276	100	300	20160601	0100	20160612	17:59:40	18:30
SBE39	284	115	300	20160601	0100	20160612	17:59:40	18:30
SBE39	719	175	300	20160601	0100	20160612	17:59:40	18:30
SBE39	720	280	300	20160601	0100	20160612	17:59:40	18:30
SBE56	2065	0	60	20160601	0100	20160612	17:59:40	18:30
SBE56	2066	0	60	20160601	0100	20160612	17:59:40	18:30
SBE56	2067	0	60	20160601	0100	20160612	17:59:40	18:30
SBE56	2068	0	60	20160601	0100	20160612	17:59:40	18:30

Instrument	Serial	Depth Meters	Sample	Start Date	Start Time	Spike Date	Spike Start Time	Spike End Time
Seaguard	138	45	300/1500	20160618	0100	20160618	1300	15:15
Seaguard	141	145	300/1500	20160618	0100	20160618	1300	15:15
Seaguard	142	235	300/1500	20160618	0100	20160618	1331	15:15
Seaguard	143	290	300/1500	20160618	0100	20160618	1300	15:15
Seaguard	144	400	300/1500	20160618	0100	20160618	1300	15:15
Seaguard	181	450	300/1500	20160618	0100	20160618	1331	15:15
Seaguard	182	600	300/1500	20160618	0100	20160618	1300	15:15
Seaguard (LS)	961	107	300/3300	20160618	0100	20160618	1300	15:15
Seaguard (LS)	964	183	300/3300	20160618	0100	20160618	1300	15:15
Seaguard (LS)	969	87.3	300/3300	20160618	0100	20160618	1300	15:15
VMCM	1	802	60	2016/06/10	15:40	20160620	1618	N/A
VMCM	17	853	60	2016/06/09	13:11:30	20160620	1626	N/A
VMCM	80	1506	60	2016/06/09	14:39:06	20160620	1712	N/A
VMCM	91	2009	60	20160608	18:56:27	20160620	1739	N/A
Wetlabs FLSB	2866	100.5	6000	20160613	1718	20160618	234845	234849
SBE37_SST	2053	-152	300	N/A	N/A	20160619	20:25	20:45
SBE37_SST	1838	-152	300	N/A	N/A	20160619	20:25	20:45

Appendix 3: Mooring Log Stratus 14

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. Stratus 14 MOORED STATION NO. 1277

Launch (anchor over)

Date (day-mon-yr) 21 - 04 2015 Time ~~16 58~~ 1958 UTC

Deployed by LORD Recorder/Observer GALBRAITH

Ship and Cruise No. AGS61 Cabo de Hornos Intended Duration 1 year

Depth Recorder Reading ~~4488~~ 4510 m Correction Source Sound vel profile

Depth Correction depth from multibeam m 1500m SVP profile taken

Corrected Water Depth ~~4488~~ 4510 m m Magnetic Variation (E/W) 6.75°

Anchor Drop Lat. (N/S) 19° 49.114 Lon. (E/W) 84° 44.2361

Surveyed Pos. Lat. (N/S) ~~19° 49.1215~~ 19°48.9713' Lon. (E/W) ~~84°~~ 44.3744' ← ships log 84 44 22.4

Argos Platform ID No. P2,3. WATCH CIRC 3.7 nm Additional Argos Info on pages 2 and 3

Acoustic Release Model _____ Tested to 500 m

Release No. 1 (sn) 33042 Release No. 2 (sn) 33039

Interrogate Freq. 11 Interrogate Freq. 11

Reply Freq. 12 Reply Freq. 12

Enable 314325 Enable 314170

Disable 314340 Disable 314212

Release 332250 Release 332174

Recovery (release fired)

Date (day-mon-yr) 22-06-16 Time 12:06 UTC

Latitude (N/S) 19° 49.277 Longitude (E/W) 84° 44.377

Recovered by Lord / Pietro Recorder/Observer Bigorre

Ship and Cruise No. AGS 61 Cabo de Hornos Actual duration 428 days days

Distance from waterline to buoy deck 55 to 60 cm 55 to 60 cm

1

ARRAY NAME AND NO. Stratus 14 MOORED STATION NO. 1277

Surface Components

Buoy Type MOOS Color(s) Hull Tower _____

Buoy Markings _____

Surface Instrumentation

Item	ID #	Height*	Comments
ASIMET	1		
HRH	503	235	
BPR	234	238	
WND	344	269	
PRC	504	247	
LWR	219	284	
SWR	216	284	
SST	1839		
PTT	99538		IDS 14644 14652 14653
ASIMET	2		
HRH	250	235	
BPR	213	238	
WND	205	269	
PRC	219	247	
LWR	503	284	
SWR	215	284	
SST	1725		
PTT	14709		IDS 9805 9807 9811
HRH-SENS	233	243	SENSIRION SENSOR
WXT520	8	252	
LASCAR	10023643	234	
SBE39	5275	228	
SWR-KZ	801		1
XEOSRUVCR			3004 3406 0447 400

WATCH CIRCLE 3.7nm *Height above buoy deck in centimeters

ARRAY NAME AND NO. Stratos 14 MOORED STATION NO. 1277

Subsurface Instrumentation on Buoy and Bridle			
Item	ID #	Depth†	Comments
WAMDAS	4003		
KILO	~~300 434 060 447 400~~		GPS BEACON 300 234 062 943 610
SBE 56	1208	90	PORT 90°
SBE 56	1211 ~~1209~~	120	FWD 180°
SBE 56	1210	90	FWD 180°
SBE 56	2089 ~~1211~~	140	FWD 180°
SBE 56	1206	90	STBD 225°
PCO2	PH 62		PMEL
	SBE 16 6483		

†Depth below buoy deck in centimeters

ARRAY NAME AND NO. STRATOS 14 MOORED STATION NO. 1277

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		BUOY			1218	2039	on deck
2	.22	3/4 CHAIN					
3		SBE 37	2	1304	1218	2039	
4	.37	3/4 CHAIN					
5		SBE 37	3.7	3821	1219	2039	PRE-ATTACHED TO BRIDLE
6	.525	CHAIN					
7		SBE 39	5	39	1157	2039	
8	.9	3/4 CHAIN					
9		SBE 37	7	3824	1157	2039	
10	4	3/4 CHAIN					
11		SBE 39	12.2	41	1154	2100	
12		AA ADCM	13	235	1154	2100	
13	1.95	3/4 CHAIN					
14		SBE 37	16.4	1899	1150	2108	
15		AA DCP	18.5	1500	1150	2108	HEADS DOWN
16	.675	3/4 CHAIN					
17		SBE 39	20	53	1150	2108	
18	4.05	3/4 CHAIN					
19		SBE 39	25	101	1148	2111	
20	3.97	3/4 CHAIN					
21		SBE 37	30	1900	1144	2114	
22	1.125	3/4 CHAIN					
23		AA ADCM	32.5	238	1140	2117	HEADS UP
24	1.125	3/4 CHAIN					
25		SBE 39	35	721	1140	2117	

ARRAY NAME AND NO. STRATUS 14 MOORED STATION NO. 1277

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26	3.97	3/4 CHAIN					
27		SBE 37	40	1901	1131	2121	WADAR
28	3.23	3/4 CHAIN					
29		VMCM	45	35	1135	2124	#1 props secured 6/23/2016 1133 BANDS off ~1225UTC 4/23/16
30	15.3	7/16 WIRE					
31		SBE 39	52	1502	1244	2124	clamped
32		SBE 37	62.5	1902	1253	1847	load cage
33	21.2	7/16 WIRE					
34		SBE 39	70	1509	1256	1845	clamped A few large barnacles
35		SBE 39	77.5	1511	1258	1841	"
36		SBE 37	85	8004	1303	1838	
37	1.2	3/4 CHAIN					
38		VMCM	88	2058	1309	1834	A couple barnacles on props BANDS off 1304 Props secured 2006
39	9.5	7/16 WIRE					
40		SBE 39	92.5	3423	1311	1833	
41		VMCM	100	2068	1318	1831	props secured 2006 BANDS off 1310
42	28	7/16 WIRE					screw accelerator
43		SBE 39	115	3434	1322	1828	BENT T sensor
44		SBE 37	130	1903	1327	1824	1330
45	3.3	3/4 CHAIN					
46		RDI ADCP	135	12254	1336	1822	small barnacles
47	23.5	7/16 WIRE					
48		SBE 39	145	3435	1341	1820	
49		SBE 37	160	1905	1349	1818	small barnacles, including T sensor
50	21.3	7/16 WIRE					

5

ARRAY NAME AND NO. STRATUS 14 **MOORED STATION NO.** 1277

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
51		SBE 39	175	3437	1351	1815	
52		VMCM	183	2059	1357	1811	small barnacles, including on ~~80~~ 1350 PROPS SEVERAL PROPS ~~Props secured 2006~~
53	4.8	7/16 WIRE					
54		SBE 37	190	1907	1403	1808	some small corrosion on link
55	28.5	7/16 WIRE					
56		SBE 37	220	2011	~1407	1803	FISHING GEAR + a couple barnacles
57	13	7/16 WIRE				1803	
58		VMCM	235	61	1417	1757	FISHING GEAR ON ~~MOORING~~ 1408 PROPS + couple barnacles ~~Props secured 2006~~
59	53	3/8 WIRE					
60		SBE 37	250	10	1422	1754	CLAMPED BROKEN COND CELL
61		VMCM	290	2010	1428	1748	props secured 2006 ~~ALSO ON~~ 1414
62	500	3/8 WIRE					
63		SBE 37	310	7836	1438	1745	CLAMPED
64		SBE 39	400	3438	1441	1737	
65		SBE 39	450	3439	1444	1735	
66	500	3/8 WIRE			1454 -	1724	START TIME FOR THIS SHOT
67	500	3/8 WIRE		11237-3	1508 -	1717	11237-3
68	180	3/8 WIRE		12200-3-A	1527		12200-3-A ~~time over~~
69	100	3/8 WIRE			1528 -	1705	WRAPPED TERMINATION
70	200	7/8 NYLON			1535 -	1700	OVER @ 1543
71	18.50	7/8 NYLON			N1600 -		SPLICED
72	1500	1 COLMEGA			1629 -	1615 ~~1624~~	1624 : nylon / colmega splice
73		84 GLASSBALLS			1740 - N1841	1424	All balls intact.
74		SBE 37	4496	10600	1854	1445	37m FROM BOTTOM
75		SBE 37	4496	10601	1854	1445	

ARRAY NAME AND NO. STRATUS14 MOORED STATION NO. 1277

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
76	5	1/2 CHAIN					
77		RELEASE			1904	1449	
78	5	1/2 CHAIN					
79	20	SAMSON					
80	5	1/2 CHAIN					
81		ANCHOR			19:58		
82							
83							
84							
85							
86							
87							
88							
89							
90							
91							
92							
93							
94							
95							
96							
97							
98							
99							
100							

Appendix 4: Mooring Log Stratus 15

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. STRATUS 15 MOORED STATION NO. _____

Launch (anchor over)

Date (day-mon-yr) 20-06-16 Time 21:48 UTC

Deployed by Lord / Pietro Recorder/Observer Bigorre

Ship and Cruise No. AGS61 Cabo de Hornos Intended Duration 1 year

Depth Recorder Reading 4600 (12kHz) m Correction Source Mathews table + past CTDs (sound velocity = 1509 m/s)

Depth Correction -35 m m

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

Anchor Drop Lat. (N/S) 19° 37.627' Lon. (E/W) 84° 56.687'

Surveyed Pos. Lat. (N/S) 19° 37.5734' Lon. (E/W) 84° 56.818'

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

Acoustic Release Model Edgetech Tested to 500 m

Release No. 1 (sn) 48274	Release No. 2 (sn) 48281
Interrogate Freq. 11 kHz	Interrogate Freq. 11 kHz
Reply Freq. 12 kHz	Reply Freq. 12 kHz
Enable 567402	Enable 567743
Disable 567421	Disable 567760
Release 551071	Release 551241

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 55 cm

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ARRAY NAME AND NO. STRATUS 15 MOORED STATION NO. _____

Surface Components

Buoy Type MOBS Color(s) Hull Tower Yellow (top), Blue (bottom), White (tower)

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

Surface Instrumentation

Item	ID #	Height* cm, above deck	Comments
ASIMET logger	L04		Port side. System 1
HRH	299	230	
BPR	218	245	
WND	217	271	
PRC	214	253	
LWR	255	278	
SWR	212	279	
SST	1838	-152	
PTT	12789		27916, 27917, 27918
ASIMET logger	L14		Starboard side. System 2
HRH	256	230	
BPR	210	243	
WND	210	271	
PRC	501	253	
LWR	221	278	
SWR	214	279	
SST	2053	-152	
PTT	18171		27919, 27920, 27921
WXT	5	250 (245 at top of white collar)	Center front
LASCAR	~~243~~ 356	205	port
SBE39	1447	223	port
HRH	216	230	starboard
XEOS Rover			300434060815350
PCO2			

*Height above buoy deck in centimeters

ARRAY NAME AND NO. STRATUS 15 MOORED STATION NO. _____

Subsurface Instrumentation on Buoy and Bridle			
Item	ID #	Depth†	Comments
WAMDAS	6014		3002 2401 0100 810
XEOS kilo			3002 3406 2945 460
SBE 56	2065	-80	bow
SBE 56	2066	-80	starboard
SBE 56	2067	-80	stern
SBE 56	2068	-80	port
PCO2	112		
SAMI	P0044		
SBE 16	6566		
WAMDAS	6014		SIN # 89881 69312 00205 1278
			3DM-GX1 # 8470
			NDBC wave station 32012
			32STO
†Depth below buoy deck in centimeters			

ARRAY NAME AND NO. STRATUS 15 MOORED STATION NO. _____

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		Buoy			1347		
2	.22	3/4 chain					
3		SBE37	2	1325	1346		
4	.37	3/4 chain					
5		SBE 37	3.7	1326	1346		
6		termination					
7		SBE39	4.9	35	1346		down
8	1.3	3/4 chain					
9		RCM 11	7	78	1346		
10	1.5	3/4 chain					
11		SBE 37	10	1328	1326		
12	1.73	3/4 chain					
13		Nortek ADCP	13	357	1324		Heads up - 2 MHz
14	1.35	3/4 chain					
15		SBE37	16	1329	1319 ~~1316~~		
16	2.70	3/4 chain					
17		RCM 11	20	79	1316		
18	3.66	3/4 chain					
19		SBE39	25	38	1310		up
20	3.90	3/4 chain					
21		SBE 37	30	1330	1306		
22	1.12	3/4 chain					
23		RCM 11	32.5	13	1305		
24	1.2	3/4 chain					
25		SBE39	35	44	1303		up

ARRAY NAME AND NO. STRATUS 15 MOORED STATION NO. _____

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26	3.9	3/4 chain					
27		SBE37	40	8211	1300		
28	3.66	3/4 chain					
29		Seaguard ADCM	45	138	1259		with optode
~~30~~		~~SBE39~~	~~50~~	~~48~~			~~clamped~~
31	16m	7/16 wire					
32		SBE39	50	48	1259		clamped
33		SBE39	55	49	1408		clamped
34		SBE37	62.5	8212	1413		load bar
35	16m	7/16 wire					
36		SBE39	70	102	1416		clamped
37		SBE39	77.5	103	1421		clamped
38		RDI ADCP	80	1218	1426		
39	6	7/16 wire					
40		SBE37	85	1909	1432		clamped. with pressure
41		Seaguard ADCM	87.3	969	1432		with optode (LS)
42	18.2	7/16 wire					
43		SBE39	92.5	203	1434		clamped
44		SBE39	100	276	1439		clamped
45		Fluorometer FLSB	100.5	2866	1439		clamped, cap off. moved above SBE39 #276
46		Seaguard ADCM	107	961	1445		with optode. (LS)
47	21.5	7/16 wire					
48		SBE39	115	284	1445		clamped
49		SBE37	130	8215	1449		with load bar.
50	14	7/16 wire					

ARRAY NAME AND NO. STRATUS 15 MOORED STATION NO. _____

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
51		Seaguard ADCM	145	141	1456		with optode
52	13.5	7/16 wire					
53		SBE 37	160	8216	1501		load bar
54	21.7	7/16 wire					
55		SBE 39	175	719	1503		clamped
56		Seaguard ADCM	183	964	1509		with optode (LS)
57	5.5	7/16 wire					
58		SBE37	190	12258	1515		load bar
59	29	7/16 wire					
60		SBE37	220	12256	1520		load bar
61	13.5	7/16 wire					
62		Seaguard ADCM	235	142	1526		with optode
63	53.5	7/16 wire					
64		Optode	250	~~699~~ 943	1530		clamped (LS)
65		SBE39	280	720	1534		clamped
66		Seaguard ADCM	290	143	1539		with optode
67	58.5	3/8 wire					
68		SBE37	295	1906	1542		clamped
69	1	3/4 chain					
70	48.5	3/8 wire					
71		Seaguard ADCM	400	144	1555		with optode
72	48.5	3/8 wire					
73		Seaguard ADCM	450	181	1559		with optode
74	148.5	3/8 wire					
75		Optode	500	~~945~~ 691	1603		(LS)

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ARRAY NAME AND NO. STRATUS 15 MOORED STATION NO. _____

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
76		SBE37	550	3733	1607		clamped, with pressure
77		Seaguard ADCM	600	182	1615		with optode
78	200	3/8 wire					
79		SBE37	601	1908	1617		clamped
80		SBE37	700	8218	1612		clamped
81		VMCM	802	1	1625		1618 rotors spunned up
82	48.5	3/8 wire					
83		VMCM	853	17	1631		1625 spin up
84	500	3/8 wire					
85		SBE37	857	8219	1637		clamped
86		SBE37	1355	8220	1706		clamped, small depth change during deployment (initially 1354 m)
87	150	3/8 wire					
88		VMCM	1506	80	1717		1712 spin up
89	500	3/8 wire					
90		SBE37	1557	8221	1721		clamped
91		SBE37	2000	8224	1740		clamped
92		VMCM	2009	91	1744		1739 spin up
93	100	3/8 wire					potted termination
94	200	7/8 nylon					
95	1700	7/8 nylon			1815 (start)		spliced at sea
96	1500	1" Colmega					
97		glassballs (92)			2048		IIII IIII IIII IIII III (23) one ball broken
98		SBE37	4528	~~2057~~ 12257	~2125		on same load bar, 37m above bottom
99		SBE37	4528	~~1838~~ 11394	~2125		
100	5	1/2 chain					

ARRAY NAME AND NO. STRATUS 15 MOORED STATION NO. _____

Date/Time	Comments			
Item no Length	Item Depth	Inst. No.	Time Over	Time Back
101	Acoustic	48274	~2130	
→ 1m chain	Releases	48281		
102 5	1/2 chain			
103 20	1" Nystron			
104 5	1/2 chain			
105	Anchor		2148	
	Depth at anchor drop 4600 m			

09G0135

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. WHOI-2016-03	2.	3. Recipient's Accession No.

4. Title and Subtitle
Stratus 15 Fifteenth Setting of the Stratus Ocean Reference Station Cruise On Board RV *Cabo de Hornos* June 15 - 29, 2016 Valparaiso Chile - Valparaiso, Chile

5. Report Date
October 2016

6.

7. Author(s) Sebastien Bigorre, Robert A. Weller, Jeff Lord, Emerson Hasbrouck, Benjamin Pietro, Dario Torres Gazale, Ignacio Burgos Jiménez

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)NA14OAR4320158
(G)

12. Sponsoring Organization Name and Address

13. Type of Report & Period Covered
Technical Report

14.

15. Supplementary Notes
This report should be cited as: Woods Hole Oceanographic Institution Technical Report, WHOI-2016-03.

16. Abstract (Limit: 200 words)
The Ocean Reference Station at 20°S, 85W 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 2016 cruise on the Cabo de Hornos to the ORS Stratus site, the primary activities were the recovery of the previous (Stratus 14) WHOI surface mooring, deployment of the new Stratus 15 WHOI surface mooring, in-situ calibration of the buoy meteorological sensors by comparison with instrumentation installed on the ship, CTD casts near the moorings. Surface drifters and ARGO floats were also launched along the track.

17. Document Analysis **a. Descriptors**

Upper Ocean Processes Group - Ocean Reference Station
Cruise Report
Valparaiso, Chile

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement
Approved for public release; distribution unlimited.

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)

21. No. of Pages
75

22. Price

(See ANSI-Z39.18) *See Instructions on Reverse* **OPTIONAL FORM 272 (4-77)**
(Formerly NTIS-35)
Department of Commerce