WHOI-2011-06

Woods Hole Oceanographic Institution

Stratus 11
Eleventh Setting of the Stratus Ocean Reference Station

Cruise On Board RV *Moana Wave*
March 31 - April 16, 2011
Arica - Arica, Chile

by

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William Otto,[2] James Holte,[1] Ludovic Bariteau,[2] Robert A. Weller,[1]

Woods Hole Oceanographic Institution,
Woods Hole, Massachusetts 02543

September 2011

Technical Report

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Upper Ocean Processes Group
Woods Hole Oceanographic Institution
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UOP Technical Report 2011-02

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Approved for Distribution:

John M. Toole, 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 January. A NOAA vessel was not available, so this cruise was conducted on the chartered ship, *Moana Wave*, belonging to Stabbert Maritime.

During the 2011 cruise on the *Moana Wave* to the ORS Stratus site, the primary activities were the recovery of the subsurface part of the Stratus 10 WHOI surface mooring, deployment of a new (Stratus 11) WHOI surface mooring, in-situ calibration of the buoy meteorological sensors by comparison with instrumentation installed on the ship by staff of the NOAA Earth System Research Laboratory (ESRL), and collection of underway and on station oceanographic data to continue to characterize the upper ocean in the stratus region. The Stratus 10 mooring had parted, and the surface buoy and upper part had been recovered earlier. Underway CTD (UCTD) profiles were collected along the track and during surveys dedicated to investigating eddy variability in the region. Surface drifters and subsurface floats were also launched along the track.

The intent was also to visit a buoy for the Pacific tsunami warning system maintained by the Hydrographic and Oceanographic Service of the Chilean Navy (SHOA). This DART (Deep-Ocean Assessment and Reporting of Tsunami) buoy had been deployed in December 2010.

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I. Introduction

A. Timeline

The cruise began Arica, Chile, on March 31 2011, and ended in Arica, Chile, on April16 2011. An overview of the chronology of the cruise is provided below.

Mar 31. Departure from Arica at 22:00 local (UTC -3) after waiting for echosounder equipment. The equipment is finally delivered at 21:00 (UTC -3) but also includes the transducer, which we cannot install ourselves so we won't have a deep echosounder for this cruise.

Apr 1. Heading for DART buoy (266 T, 10.2 kn). Stop at 13:15 (UTC -3) for CTD and acoustic release test. Leave Chile EEZ at 20:00 (UTC -3).

Apr 2. Arrive at last position reading for DART tsunami buoy in the night, around 01:30 (UTC -3), with slow approach, 3 kn. At 02:40 (UTC -3), as we leave area, the buoy is right in front of us. Light on buoy does not work and ship's radar does not detect buoy. The sea is choppy and visibility hazy so we take note of position (19º 18.6639'S, 74º 43.5680'W) and decide to come back to DART at daylight during return trip at end of cruise. Launch floats 1 and 2 and drifters 1, 2, 3 at 11:36 (UTC -3) at (19º 45'S, 76º 00'W). Launch floats 3, 4 and drifters 4, 5, 6 at 14:30 (UTC -3) at (19º 45'S, 76º 30'W). Launch floats 5, 6 and drifters 7, 8, 9 at 17:40 (UTC -3) at (19º 45'S, 77º 00'W). Started watches for drifters. Sea Beaufort 4, winds 15 kn, cloudy, steam east at close to 10 kn.

Apr 3. Launch drifter 10 at 06:00 (UTC -3) at (19º 45'S, 79º 00'W). Bill Otto does balloon launch training at 08:30 (UTC -3). Balloons launches every 6 hours start. At noon (UTC -3), we push back local time 1 hour to UTC -4, to get daylight during morning work, usually around breakfast time at 07:00 local.

Apr 4. Balloons and drifters. Cloudy, swell is weaker and from SSE, wind 10kn. Around 19:00 (UTC -4), arrival at Stratus 9 anchor site where we have Seabeam bathymetry data from a previous cruise. We drift for an hour and go on station 8nm downwind (304º T) of Stratus 9 anchor site. Balloon watches stop.

Apr 5. Ship did weather pattern maneuvers during the night (up and downwind at 1.5 kn). We decide a new position for Stratus 11 anchor target position, slightly to the east. It is a shallower spot than Stratus 9 by about 100m and matches better Stratus 11 mooring design. Started test deployment at 07:50 (UTC -4), going SSE along 130ºT at 1.5 kn. At 11:35 (UTC -4) we have traveled 3.7 nm. Drizzle in the morning and occasional squalls and light showers in afternoon.

Apr 6. Calm sea, small waves. Buoy deployment started after breakfast, around 08:00 (UTC -4). At 12:00 (UTC -4), last instrument in water. Still 3000m of line to pay out and about 5nm to target drop site. Anchor dropped at 15:29 (UTC -4) at (19°41.675'S, 85°33.826'W). Anchor survey then move 1 nm downwind of Stratus 11 buoy. Wrote a new Stratus 10 mooring log using PDF copy.

Apr 7. Leave Stratus 11 around 06:30 (UTC -4) and move to Stratus 10 anchor site. Enable acoustic releases at 07:25 (UTC -4); released at 07:37 (UTC -4), balls surface at 08:28 (UTC -4) about 150 yds on port side of ship. Recovery starts. End of recovery at 15:00 (UTC -4). Many wire wuzzles and few fishing gear. Calm sea and intermittent drizzle. Back to Stratus 11 and start of intercomparison ship vs buoy at 19:00 (UTC -4). Ship is ¼ to ½ mile downwind of buoy, bow into the wind but wind picks up in the evening and the ship has to do crab maneuvers to stay bow into the wind for the first part of the night.

Apr 8. Drizzle in the morning. CTD to 1700m depth at 08:06 (UTC -4) at (19° 39.8'S, 85° 35'W), near Stratus 11. Fire drill at noon. At noon, balloon watches resume, launches every 4 hours. Intercomparison continues. Sean dumps Stratus 10 data.

Apr 9. Cloudy, calm sea (less than Beaufort 3), winds about 5kn. Balloons every 4 hours (0000Z, 0400Z … 2000Z) continue. Intercomparison ends at 07:00 (UTC -4). Move 5nm downwind of buoy. Deep UCTD (850m) at 09:00 (UTC -4). UCTD training from 08:00 to 12:00 (UTC -4). Work on fantail. VMCMs secured. UCTD tow-yo practice run at 16:00 (UTC -4). Noticed that 2 radiations sensors on aft section of O2 deck are partly shaded by aft chimney in the afternoon when sun is behind ship.

Apr 10. Around 07:30 (UTC -4), depart Stratus mooring area. Launch floats 7 and 8 and 3 drifters at (19° 39.8'S, 85° 39.1'W) at 07:55 (UTC -4); pass by Stratus 11 at 08:54 (UTC -4); waterline is 60 – 65 cm. And head east along 19º 40'S latitude at 6 – 6.5 kn. Watches continue, with hourly UCTD in addition to 6-hourly balloons. First UCTD at 09:00 (UTC -4) with 480m line on tail and reaches 480m depth. Calm sea (less than Beaufort 3) with long swell and weak wind.

Apr 11. Steaming east at 8.5 -9 kn max. At 04:00 (UTC -4), UCTD increased to ½ hourly with 400m line on tail and 120s drop time. Sea becomes Beaufort 4, winds around 15 kn, cloudy. Start ridge survey around 23:00 (UTC -4) along 19º 40'S, between 80° 24'W and 80° 14'W, using tow-yo UCTD at 3 kn, with a stop near center of ridge.

Apr 12. End of tow-yo survey of Nazca ridge at 02:20 (UTC -4). Resume ½ hour UCTD. Low speed on UCTD winch barely works anymore. Probe 23 banged on back of ship during retrieval. New probe 29 used. At 03:00 (UTC -4) we reduce sampling to 1 hour to ease off stress on winch. In late afternoon and based on satellite altimetry data, we enter anticyclone near 79 º W, which is west of large cyclone we will focus on. Stop ship at 17:00 (UTC -4) because of repair on UCTD winch; moving again at 17:30.

Apr 13. Eddy survey continues. Spare UCTD winch installed. PC with Nobeltec navigation software turns off during the night. Not sure if it's an automatic update thing or because the track with Nobeltec software is too large. Deep CTD and deep UCTD on west side of cyclonic eddy (waypoint 5 of eddy survey). Deep CTD in center of eddy (waypoint 6 of eddy survey).

Apr 14. CTD at 19° 54.9'S, 75° 40.3'W at 05:39 (UTC -4); end of CTD at 07:20. End eddy survey (waypoint 7). Move towards DART at 9 kn. Arrive at DART at 15:00 (UTC -4): visual inspection. Man over board drill with use of the small boat. Chilean personnel inspect DART closer using small boat. VOS system dismantled and packed. Move east of DART and launch last drifter, then CTD at 19° 18.185'S, 74° 38.979'W. At 18:00 (UTC -4), advance local time one hour to UTC -3. Steam east at 8kn, hourly UCTD resumes. Last balloon at 21:00 (UTC -3).

Apr 15. CTD 19° 19.325'S, 73° 11.629'W at 07:00 (UTC -3). CTD reaches 1700m depth at 07:42 and back on deck and ship around 08:15 (UTC -3). Steaming towards Arica at 08:22 (UTC -3). Captain pushes ship speed close to 10 kn between UCTD stations to give him some buffer time for arrival at pilot station in Arica the next morning. UCTD stop at 15:00 (UTC -3). CTD at 16:00 (UTC -3). End of data collection. Steaming towards Arica.

Apr 16. Enter Arica's port.

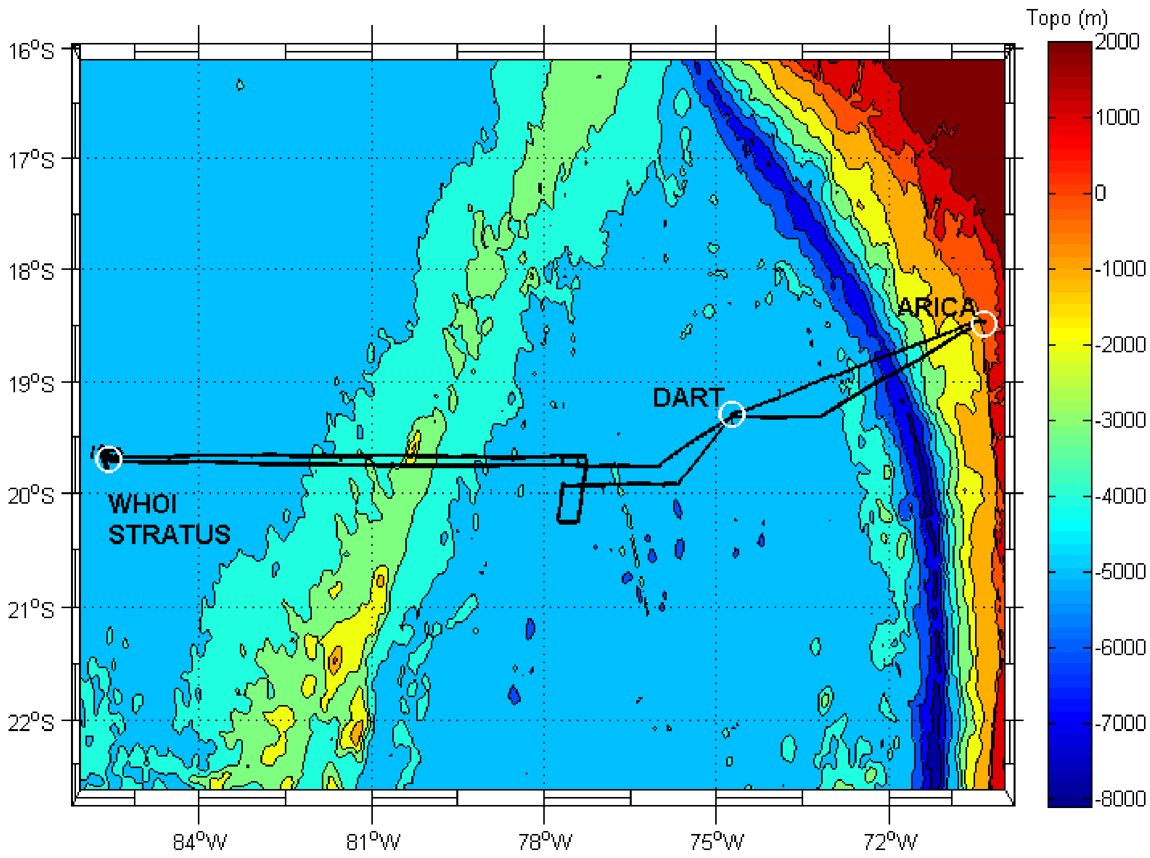

Figure 1-1. Stratus 11 cruise itinerary Arica - SHOA mooring - WHOI mooring - Arica, Chile. Bathymetry in colored contours.

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 January. The Stratus 10 mooring was deployed in January 2010. Its surface buoy broke free in July 2010 and was recovered shortly thereafter. The new mooring was installed in April 2011 during the Stratus 11 cruise which is detailed in this report.

During the 2011 cruise on the *Moana Wave* to the ORS Stratus site, the primary activities were recovery of the lower part of the WHOI Stratus 10 surface mooring, deployment of the new WHOI Stratus 11 surface mooring at a nearby site, and in-situ calibration of the buoy meteorological sensors by comparison with WHOI meteorological sensors mounted on the ship and with instrumentation put on board by staff of the NOAA Earth System Research Laboratory (ESRL, formerly ETL). As part of a collaboration with the Chilean Navy Hydrographic and Oceanographic Service (SHOA), we also visited the tsunami warning buoy operated by SHOA at 20°S, 75°W for a visual check and a few CTD casts. Underway CTD (UCTD) casts were made along a zonal section and across an eddy, reaching depths between 400 and 500m. Finally surface drifters and subsurface floats were also 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. 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 ESRL instrumentation used during the 2011 cruise included sensors for mean and turbulent surface meteorology, as well as atmospheric profiles from radiosondes.

In preparation for the cruise, Weller had applied for clearance to sample in Chilean waters (Figure 1-1) and designed the cruise plan. This plan consisted in first surveying the tsunami warning buoy and then heading west towards the Stratus site for the deployment of Stratus 11, recovery of remaining Stratus 10 instruments and comparison of telemetered data from newly deployed WHOI instrumentation with measurements made on the ship. Following the mooring operations, UCTD casts were planned for the return trip to Arica. However, due to last minute contract negociations between NOAA and Stabbert Maritime, which owns and operates the *Moana Wave*, a few delays occurred just prior to the cruise. First, WHOI and ESRL containers took a couple of days to be cleared from customs in Arica after arrival of our personnel. Second, the echosounder provided by Stabbert Maritime and rated for 6000m depth, was also held longer than anticipated in customs. This instrument was finally delivered on March 31 at 21:00 (local), 5 hours after our initial planned departure time. Once this issue was resolved, the *Moana Wave* departed Arica at 22:00 local time from Arica and headed towards the SHOA mooring. Sampling in the Chilean waters occurred on the return trip to Arica, after the primary goal of the cruise, the ORS mooring operations, had been achieved.

II. Cruise Preparations

A. Sensor Evaluation and Burn-in

Testing for the ASIMET units deployed on the Stratus 11 buoy began at the Woods Hole Oceanographic Institution on October 8 2010, when the primary loggers SN L-04 and L-15 were powered up and populated with shortwave (SWR) and sea surface temperature (SST) instruments. By January 4 2011, these two primary systems and a spare system (logger 17) were populated with SWR, longwave (LWR), SST, humidity and air temperature (HRH and ATMP), and wind (WND). Logger 15 also had a barometric pressure (BPR) sensor. Standalones HRH and WND were also mounted and running. Only precipitation (PRC) and a couple of BPR were still to be mounted but the seasonal cold temperatures and snow falls prevented a good burn-in to continue as the buoy was often placed in the high bay for shelter. On January 11, the 1-minute data recorded by the loggers was extracted and is shown in Figures 2-1 to 2-6. On February 7, logger 15 was replaced with logger 14 and a data dump was done on February 9. The buoy was dismantled on February 11 and shipped shortly after, along with other UOP equipment, in containers to Arica, Chile. See the appendix for the timeline of the burn-in procedure for Stratus 11 buoy.

The data shown in Figures 2.1 to 2.6 correspond to a period when the buoy was outside at WHOI under test, from December 30 to January 1 and January 4 to January 6. Measurements during these periods showed small differences between sensors, which were then tagged as ready for deployment. The differences to note were in SWR and LWR. SWR bias reached up to 20 Wm^{-2} at maximum values (around 400 Wm^{-2} at local noon) when averaged over one hour. Although this seems like a high value, some of this bias is caused by the difference in tilt for similar sensors installed on the buoy, which could account for 30% to 50% of the bias. Bias in LWR is about 5 Wm^{-2} and represents the level of accuracy reached when sensors are calibrated against the standard instrument using comparison of measurements made on the roof of the Clarke building. Other instruments showed very good agreement. In particular, ATMP and HRH measured from the two primary systems on the buoy are very good. The daily variation observed is associated with excess solar heating of one of the instruments compared to the other sensor. When the buoy is deployed and oriented into the wind, this differential heating is greatly reduced. Note that the burn-in pad at WHOI is less than optimal for accurate measurements since wind is typically weak and shadows and reflections from trees, buildings, vehicles and light posts can cause problems. As for SST, burn-in measurements are made in a bucket filled with seawater and differences are to be expected since water in the bucket is not stirred and two sensors measure different parts of the volume of water in the bucket. Finally, comparison between buoy sensors and the spare system will show differences because the spare system is located on a different platform. We usually see some effect of radio-frequency RF noise caused by the Argos PTT transmitters, especially in burn-in data (see for example Figures 2.3 and 2.4; this effect is almost always much less after deployment).

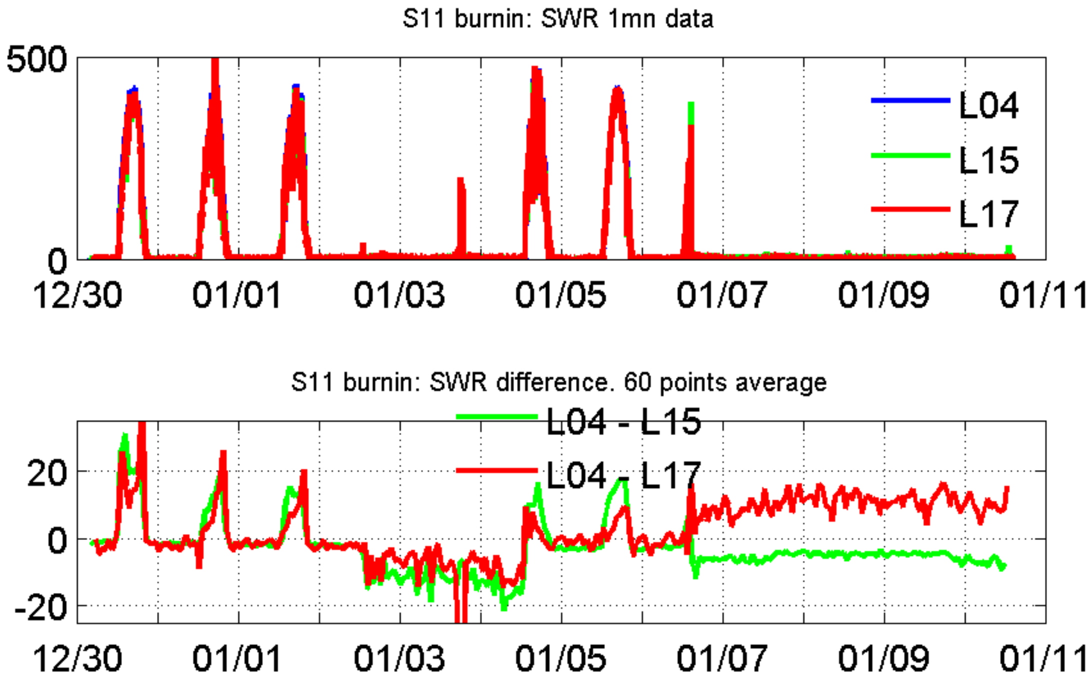

Figure 2-1. Last burn-in period in WHOI when buoy was outside. Upper panel shows time-series from 1-minute downward shortwave solar radiation (SWR) data, in Wm^{-2}. Lower panel shows the difference between sensors, averaged over 1 hour.

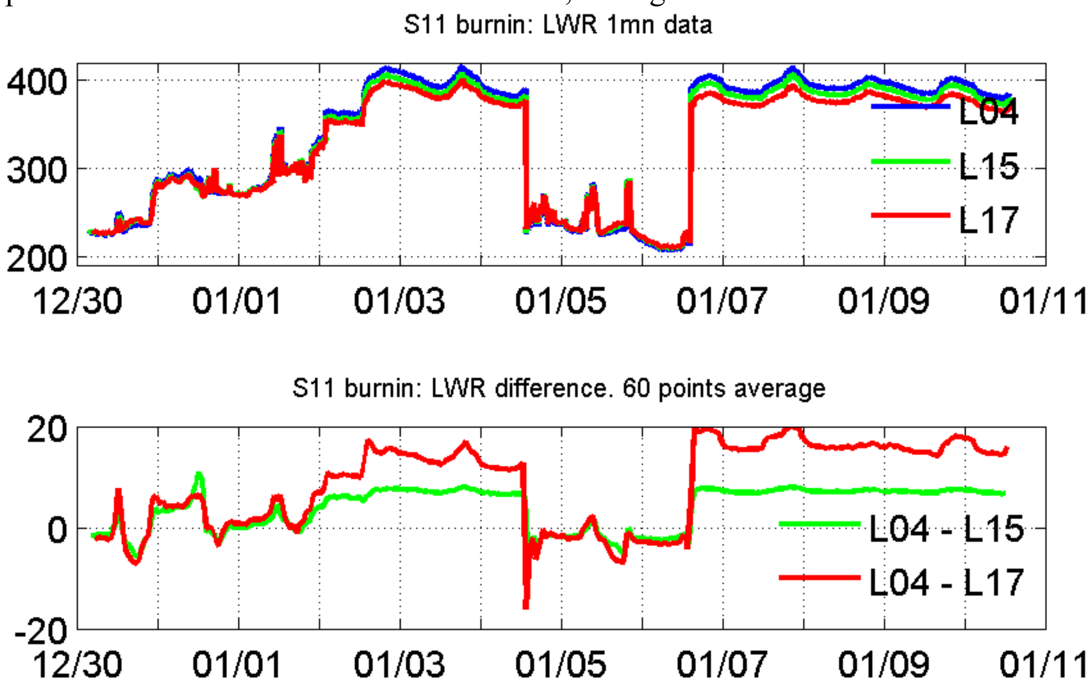

Figure 2-2. Same as Fig. 2-1, but for downward longwave radiation (LWR), in Wm^{-2}.

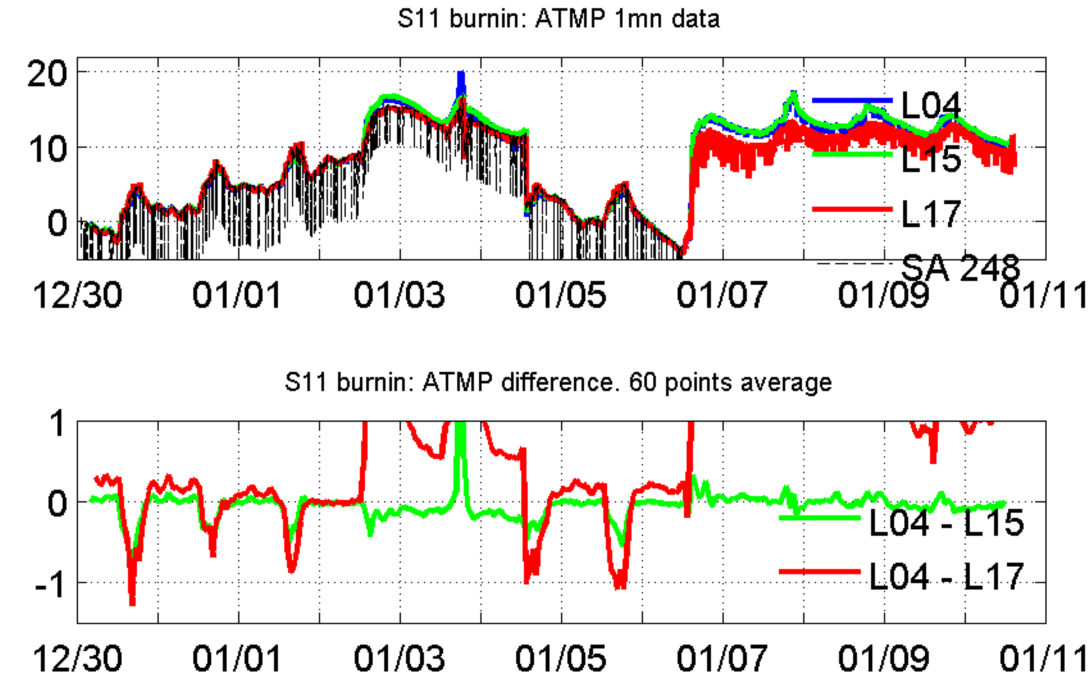

Figure 2-3. Same as Fig. 2-1, but for air temperature (ATMP), in deg °C.

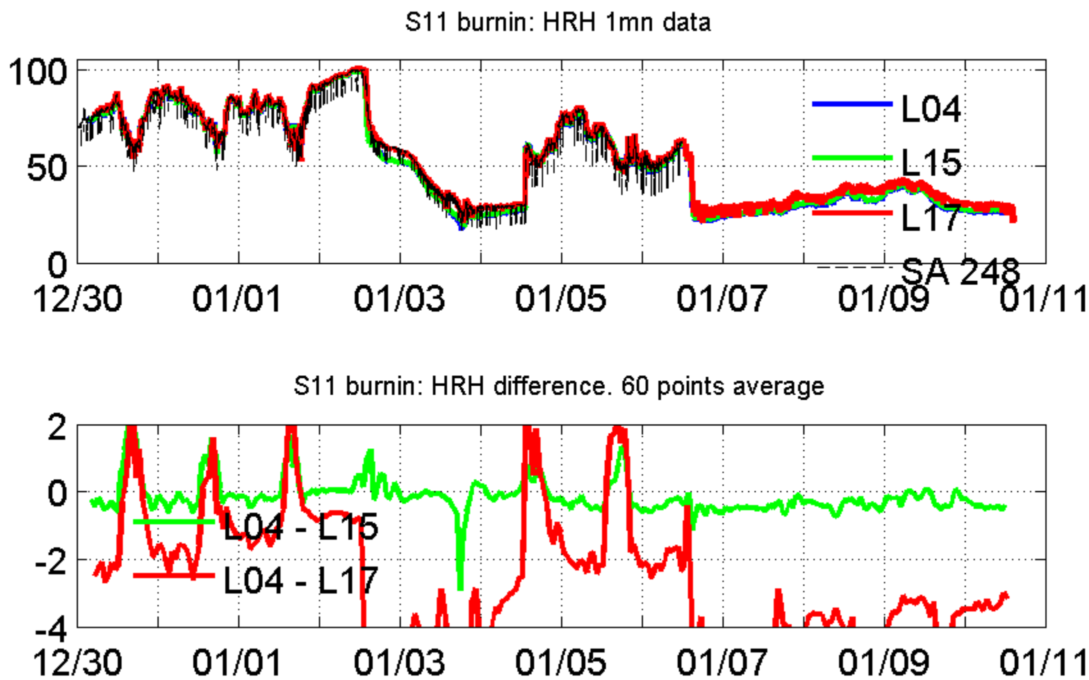

Figure 2-4. Same as Fig. 2-1, but for air relative humidity (HRH), in %RH.

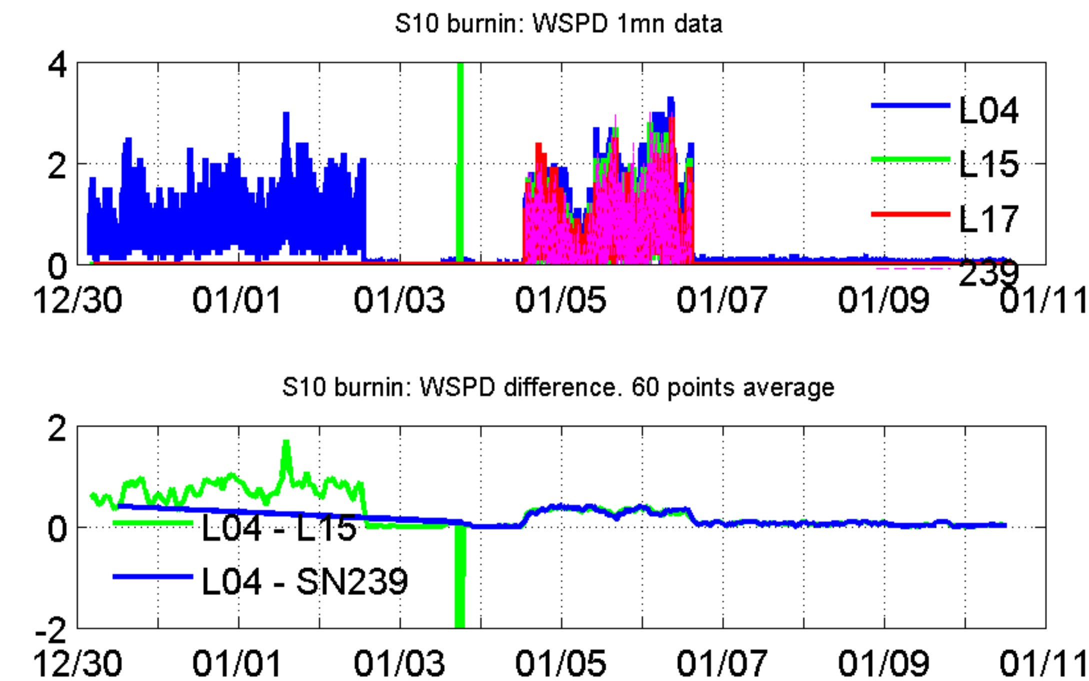

Figure 2-5. Same as Fig. 2-1, but for wind speed (WSPD), in m/s.

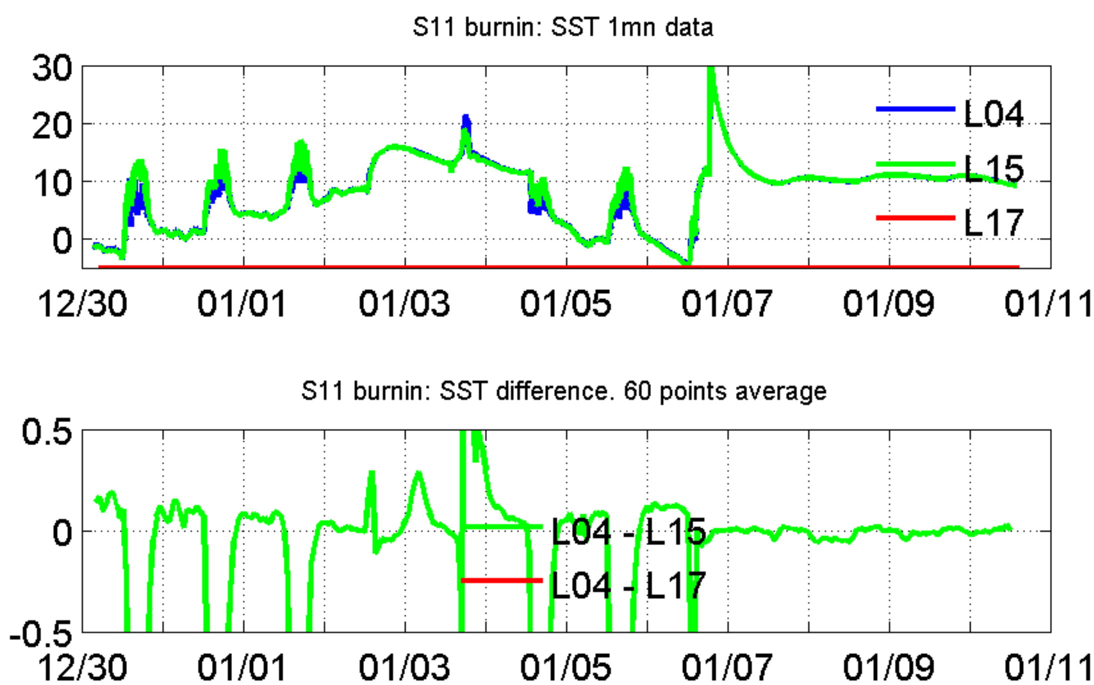

Figure 2-6. Same as Fig. 2-1, but for sea surface temperature (SST), in deg °C.

Once the buoy was reassembled in Arica on the afternoon of March 25, a second period for checking proper measurements from ASIMET sensors on the buoy began. On March 30 at 14:00 local (UTC – 3), the buoy was loaded on the ship, on the starboard side of the back deck. The ship left the dock in Arica on March 31, 22:00 local, and steamed westward at about 10 knots. While the buoy was on the dock in Arica, conditions for measurements were very good. There were no obstructions of wind or solar. Sun exposure in Arica is quite constant and there are no clouds. The wind is also quite stable and varies only with time of day as the sea breeze changes direction. Data collected during this period were dumped from the loggers on April 5 while the ship was on transit to the Stratus buoy site. Figures 2.7 to 2.17 show the comparison between the two primary systems on the buoy during this period. SWR from system 2 had been swapped with spare sensor (SN 208) on Jan 21, and this shows a better agreement with sensor on system1 (SN 502), as can be seen in Figures 2.7 and 2.8. These figures show that SWR bias is now slightly reduced (hourly averaged), with SWR 502 lower than SWR 208 by 15 Wm^{-2} at most for SWR peak mid-day values. Figure 2.8 shows that SWR relative difference between the two sensors is l.5% at mid-day, but larger for low sun angles. Figure 2.10 shows that ATMP difference is within 0.2 °C for night values but can increase to 0.5 °C due to solar heating in the day. Note that the increased difference observed on 4/27 and 4/28 is probably due to shade from the ship, and the several positions the buoy was moved to on the dock to avoid this kind of effect and get away from activity while the ship was loaded. HRH in Fig. 2.11 is quite good with agreement better than 2% RH. Wind speed (WSPD) agreed to within 0.2 to 0.3 m/s for typical winds of 4 to 5 m/s (Fig. 2.12). Precipitation (PRC) was in good agreement when the rain gauges were filled and drained as seen in Fig. 2.16 (there was no rain in Arica).

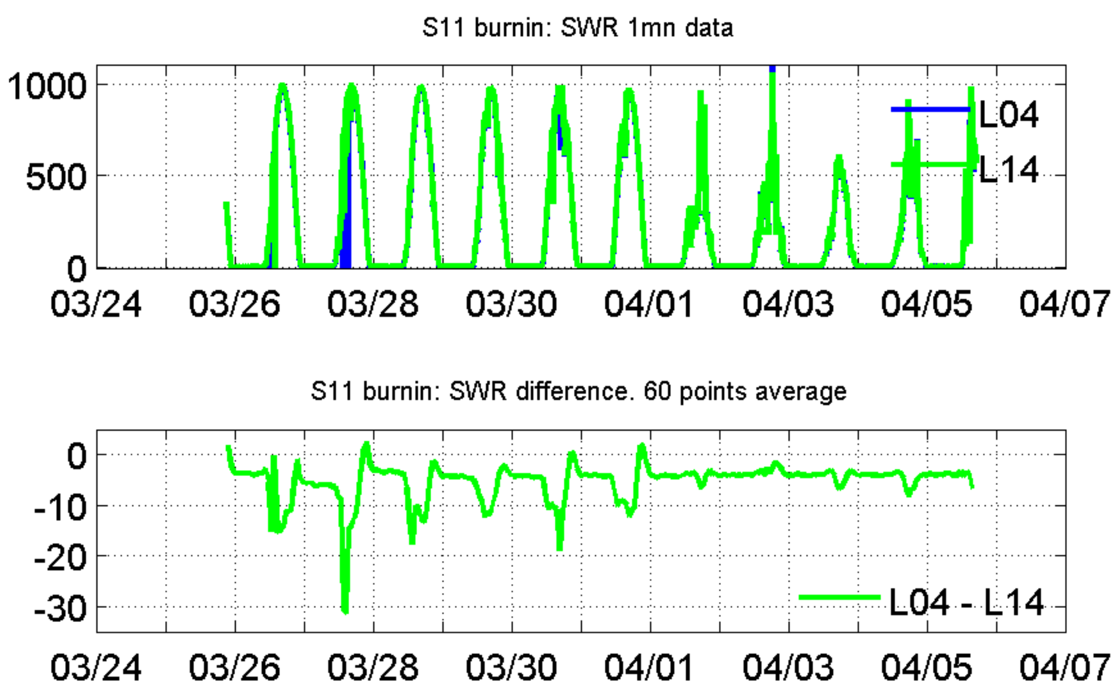

Figure 2-7. As in Fig. 2-1 but for burn-in period in Arica and start of cruise.

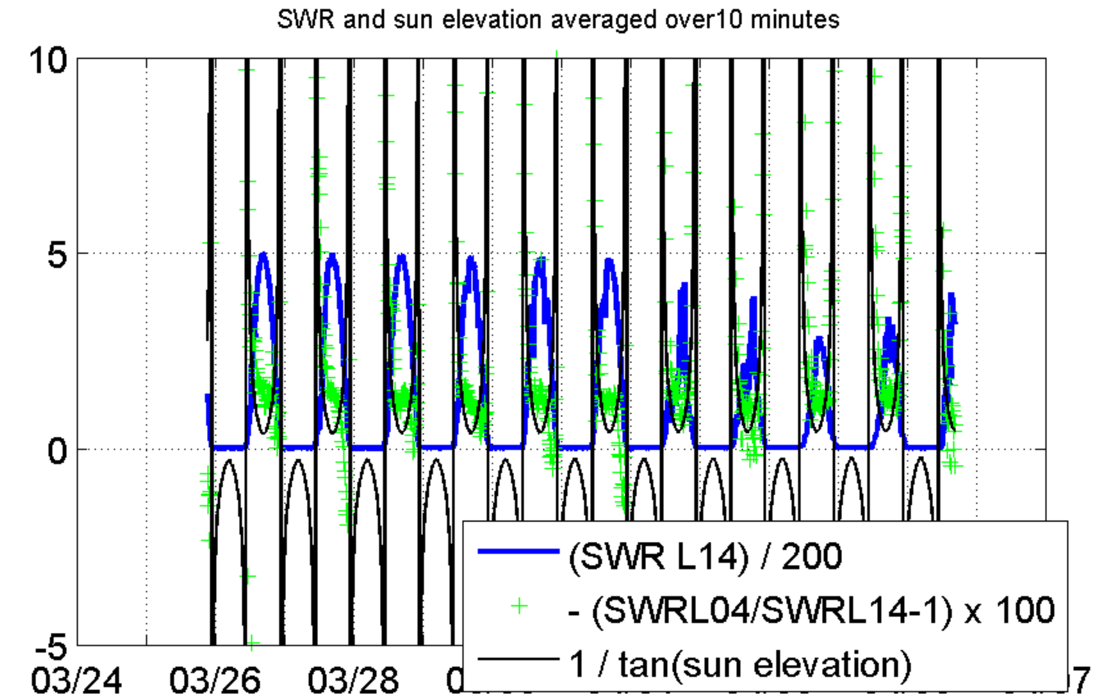

Figure 2-8. 10-minute averages of SWR (factor 1/200), SWR relative difference between systems 1 and 2, and $\tan^{-1}$(sun elevation).

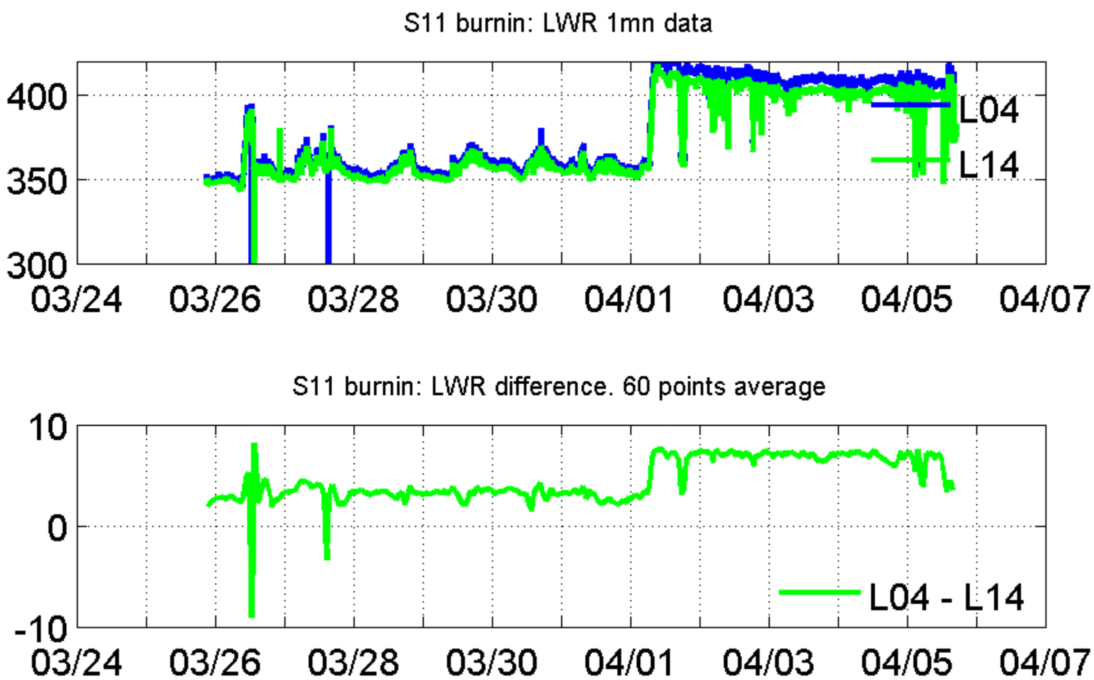

Figure 2-9. as in Fig. 2-7 but for LWR.

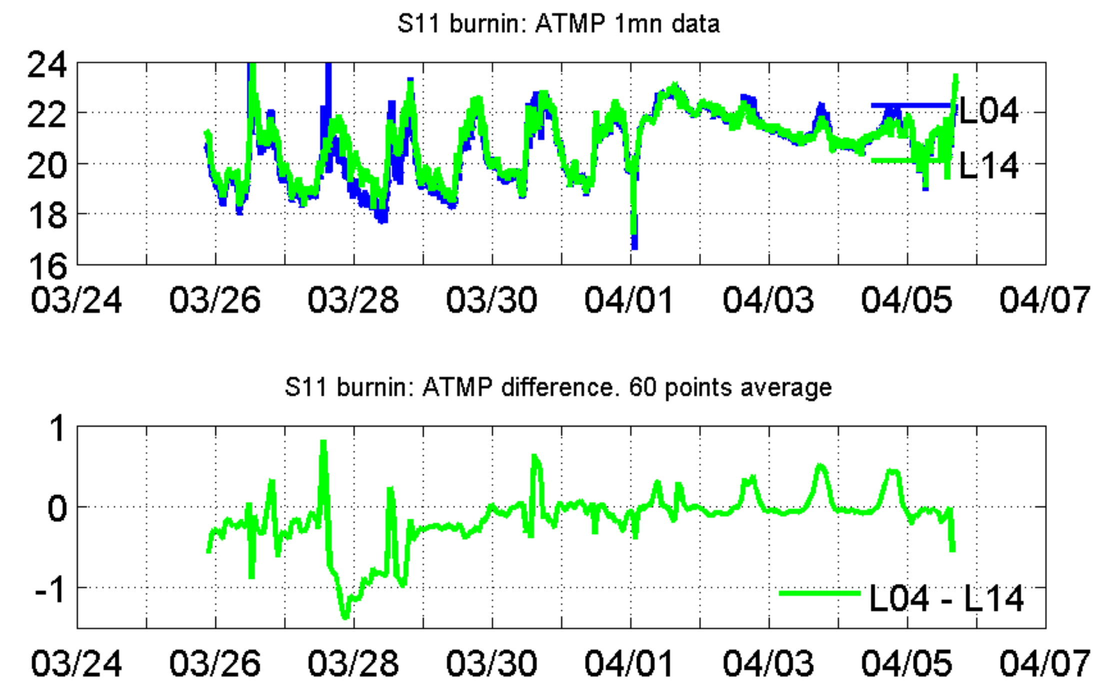

Figure 2-10. As in Fig. 2-7 but for ATMP.

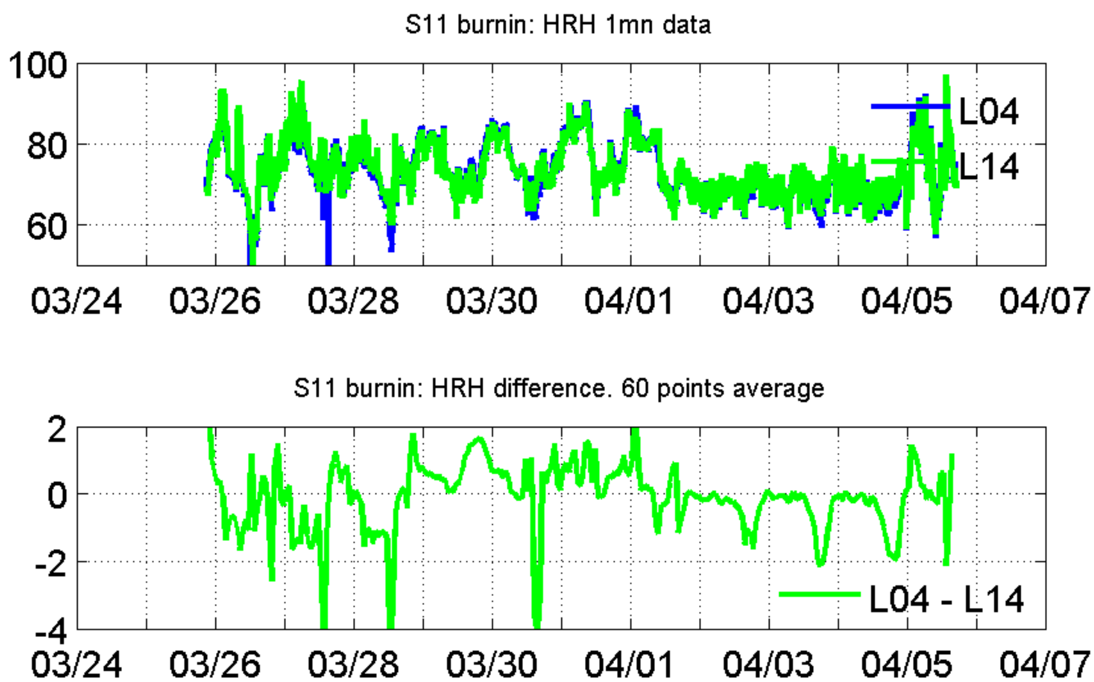

Figure 2-11. As in Fig. 2-7 but for HRH.

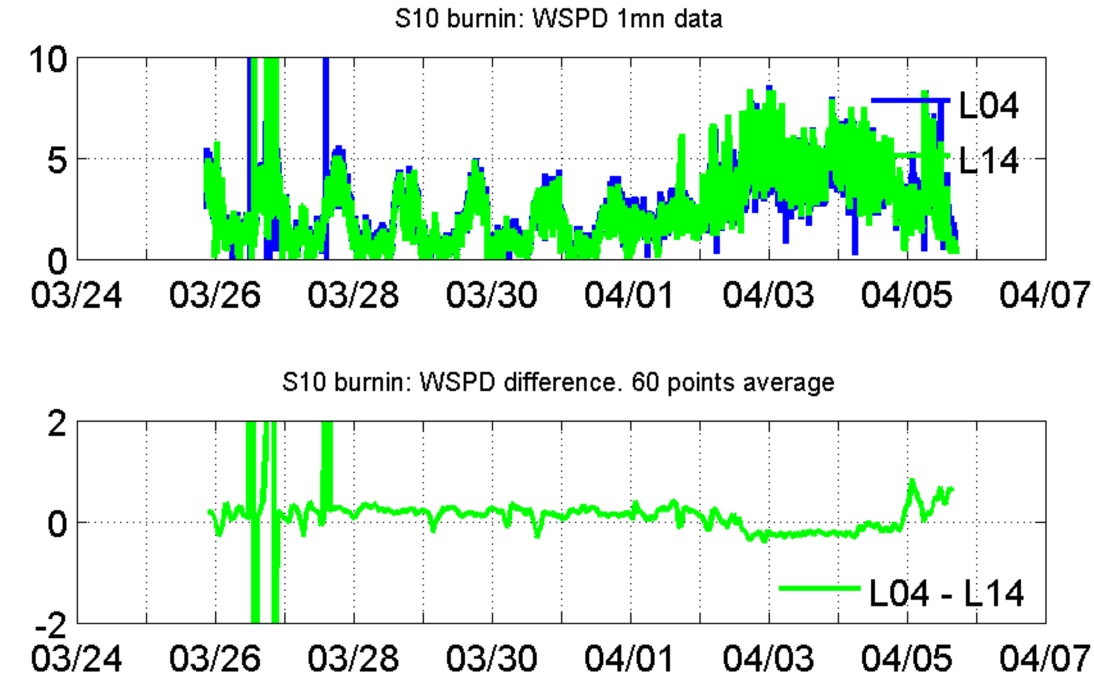

Figure 2-12. As in Fig. 2-7 but for WSPD.

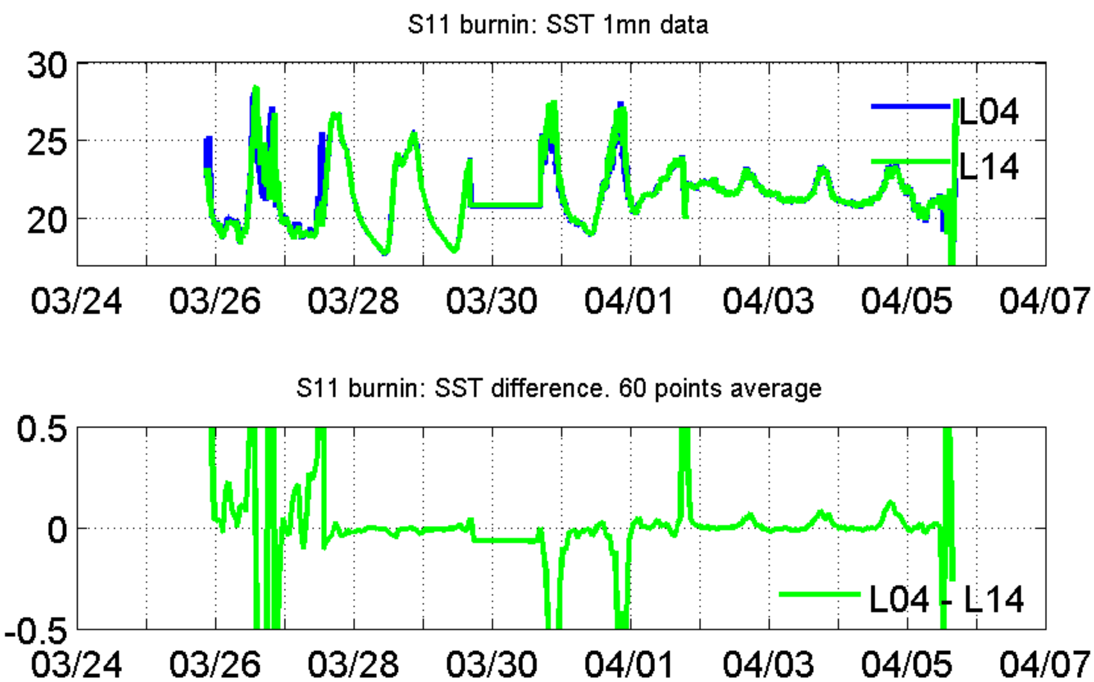

Figure 2-13. As in Fig. 2-7 but for SST.

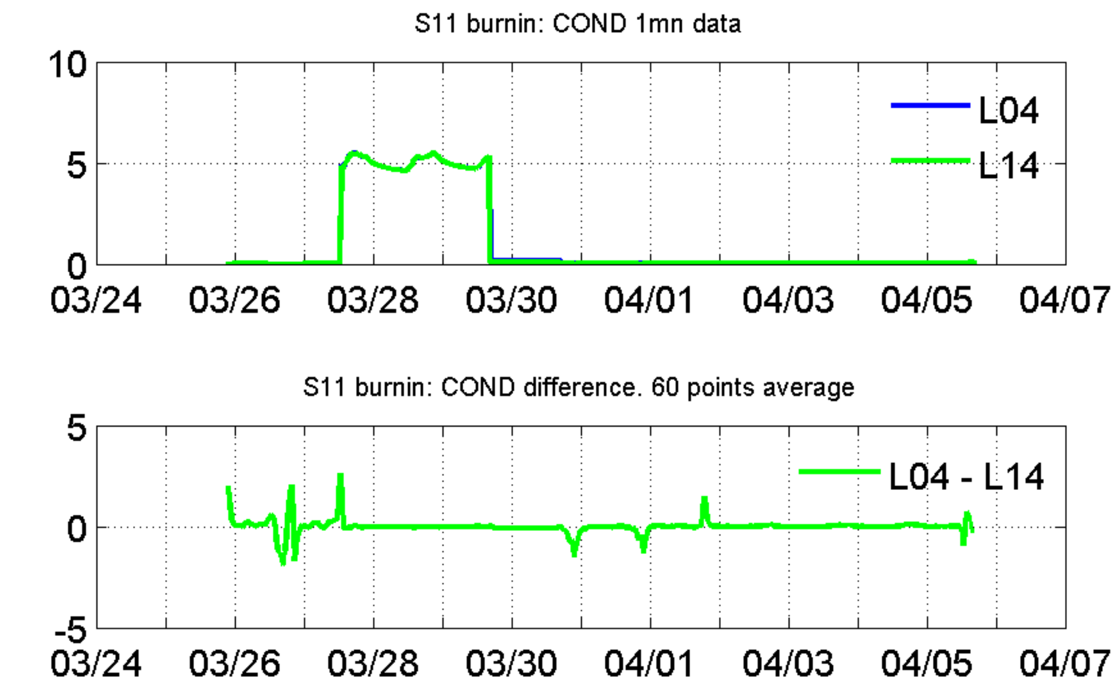

Figure 2-14. As in Fig. 2-7 but for conductivity (COND).

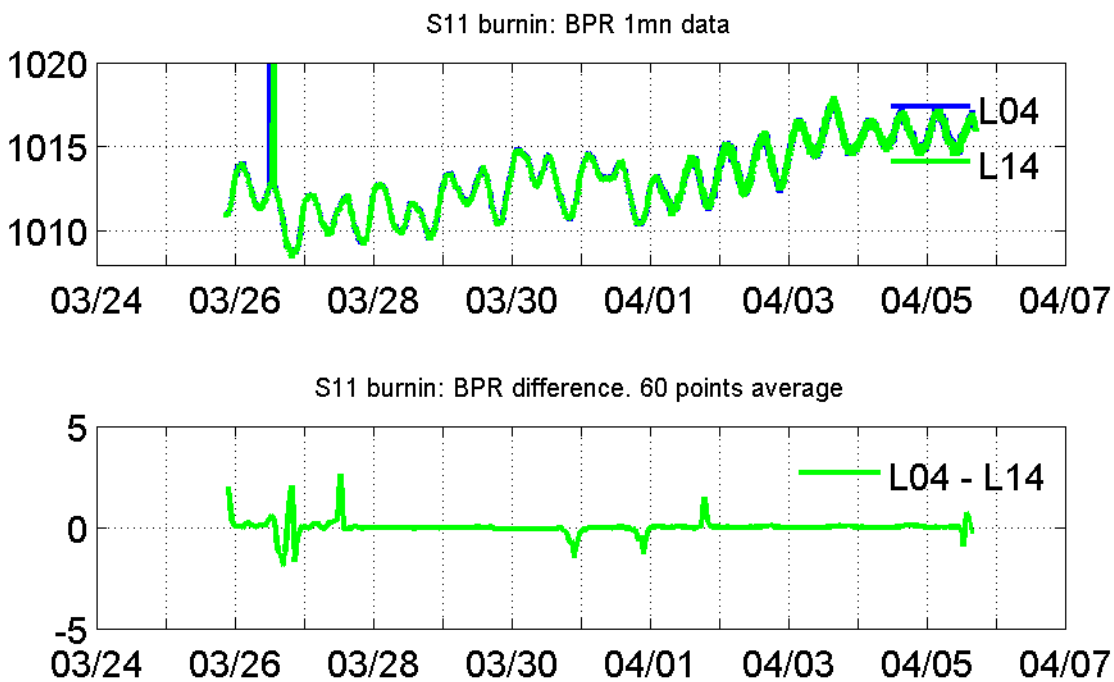

Figure 2-15. As in Fig. 2-7 but for barometric pressure (BPR).

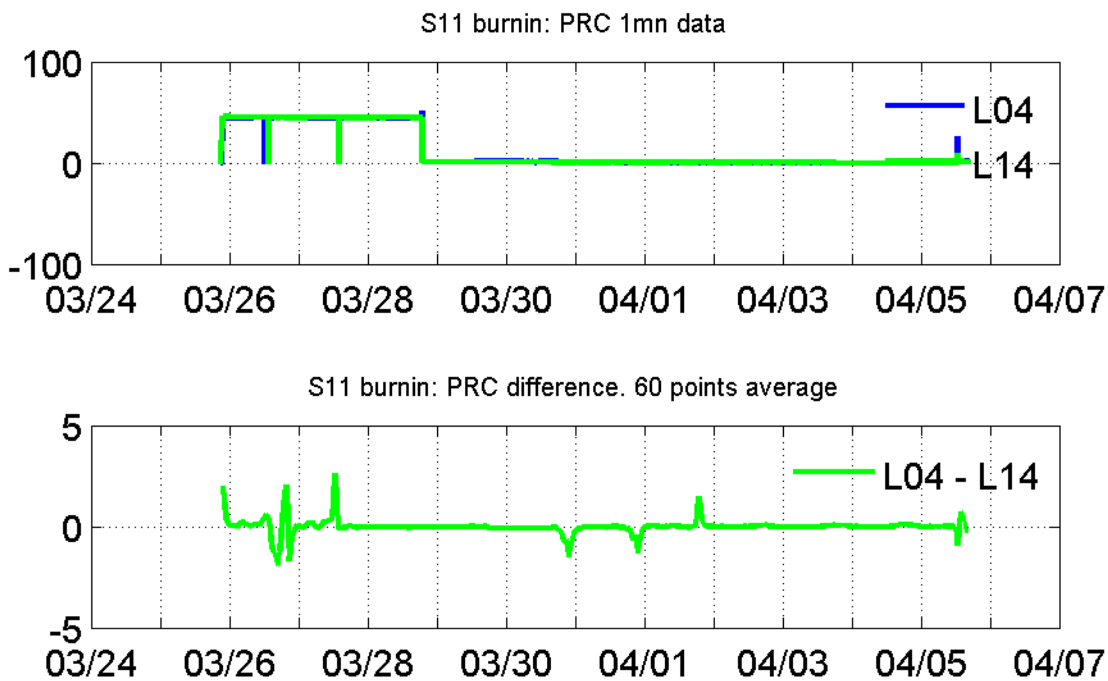

Figure 2-16. As in Fig. 2-7 but for rain accumulation (PRC).

Finally, hourly averages of near real-time ASIMET measurements are available on the UOP website through Argos telemetry. Figure 2.17 shows the latest data transmitted, at time of writing. The differences are similar to the ones seen during burn-in, although ATMP and HRH agree better (0.1 °C and 1%RH, respectively).

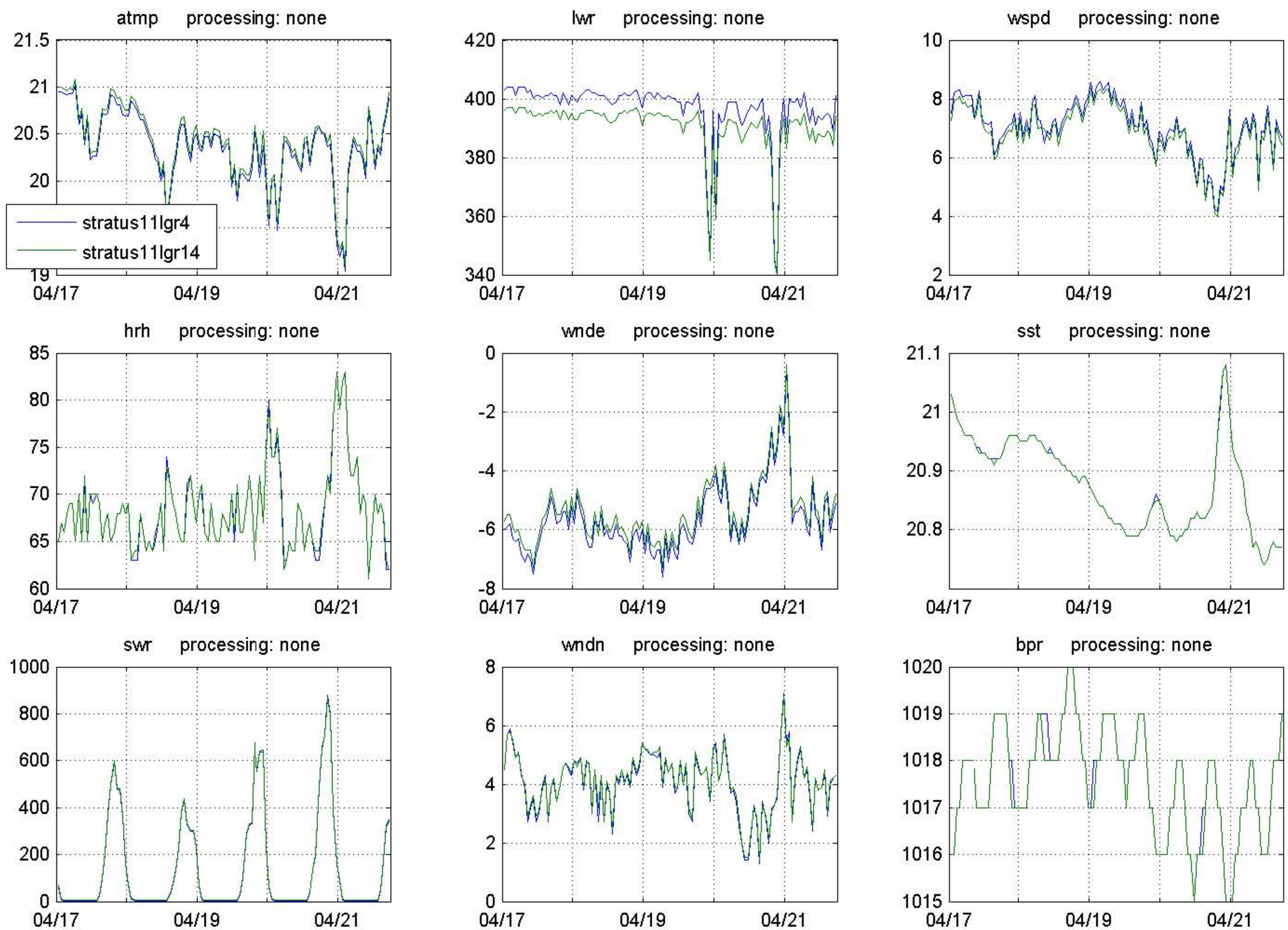

Figure 2-17. Hourly average ASIMET data from Stratus 11buoy, obtained from Argos telemetry on April 22 2011.

B. Staging and Loading in Arica

In mid-February, three forty-foot containers and one 20-foot soft-top container, loaded with the buoy, mooring components, and cruise support gear, were shipped from WHOI to Arica, Chile. Arrangements were made with AJ Broom, our agent in Chile, to accept the equipment and provide support for WHOI. This support included a staging area, forklift support, shore crane, and port access.

On March 17, we learned that NOAA was signing a contract with Stabbert Maritime who would provide the ship *Moana Wave* for the Stratus cruise 2011. A first contingent of the UOP personnel (4 people) flew out of Boston on March 21 and arrived in Arica the next day. On March 23, we met with the representative for Broom, who showed us the working area, but told us our containers had not cleared customs yet. For reasons that are not completely clear, we did not get access to our containers until around noon on March 25. At this time we did get the forklift and support we had asked for. All equipment was removed from the containers. The buoy tower top was assembled and the buoy hull was also assembled. The remaining equipment was stuffed back into containers, so that all equipment was accessible. One container was set up with tables and chairs to serve as a lab space for preparations.

The pCO2 system was installed and checked and a final buoy spin was done. The buoy was ready on March 25 in the afternoon and ASIMET data was transmitted through Argos telemetry; this signal was picked up directly on the dock using an Alpha Omega receiver. Seaguard current meters were checked for compass performance, using a compass spin procedure similar to the one used on the buoy. The Sea-Bird SBE39 ATMP was set up as well, with 5 minutes sampling period. The *Moana Wave* arrived in port on March 27 at 15:00 local. The equipment was loaded onboard the *Moana Wave* the next day, except the anchors, winch, and 20 foot ESRL container. It was determined that the WHOI container could not fit, since there was an open dumpster welded in place on the 01 deck. Three more WHOI people arrived in Arica. On March 29 welders arrived to assist with fixing the ESRL tower and to weld deck eyes in place for lashing the anchors. The giant shore crane arrived late in the afternoon, and the heavy gear was loaded onto the ship. The open top container was moved closer to the ship so that glass balls could be transferred into the open dumpster on the 01 deck. The ship was rigged with VOS instrumentation, the sonic wind on the bow mast, and the scientific laboratory was set up, including wiring for several GPS receivers and the local Alpha/Omega receiver for monitoring the buoy. ESRL people who had arrived a few days earlier were also setting up their equipment on the ship. Two Chilean workers arrived that day, including the national observer. The buoy was loaded onto the ship on March 30 at 14:00 local and readied for transit; work continued getting the gear lashed to the deck and placing the heavy equipment. Most of the deck plugs were completely filled with paint and debris, so much time was spent cleaning and re-tapping plugs for mounting the winch, air tugger, H-bit, cleats, UCTD, etc. The *Moana Wave* left the next day at 22:00 local.

C. Buoy spin

Buoy spins were conducted and were found to meet expectations. The buoy spin is a procedure to check the compasses on the buoy. It is done slightly differently than the previous years because of the use of a portable differential GPS monitor which indicates the direction of true North. There is therefore no need to lock the wind vanes to a reference direction (identified by a distant landmark), but rather the vanes are locked once with respect to the buoy. The buoy is rotated in 8 different directions, with 45° increments. At each of these directions the compass from the wind sensors is read and compared with the GPS value. Once the local value of the magnetic deviation is taken into account, the difference indicates an estimate of the compass error which is reported. Typically, compasses used for ASIMET sensors have an error less than 5°. Part of this error is probably due to soft iron effects from the metallic structure of the buoy tower itself. Fig 2.18 shows the compass error as a function of buoy orientation and the sinusoidal curve is symptomatic of this soft iron effect.

A first buoy spin was made in Woods Hole and a second one in Arica. The latter one may be affected by the metallic structure inserted in the concrete that makes up the dock on which the buoy spin was done. In fact, a manual survey with a hand compass clearly showed a strong and variable magnetic influence at different locations on the pier. But this effect is attenuated as vertical distance from the pier increases and the sensors on the buoy are therefore less subject to it. Buoy spin results are shown in Figure 2.18. See the appendix for the details of the buoy spin.

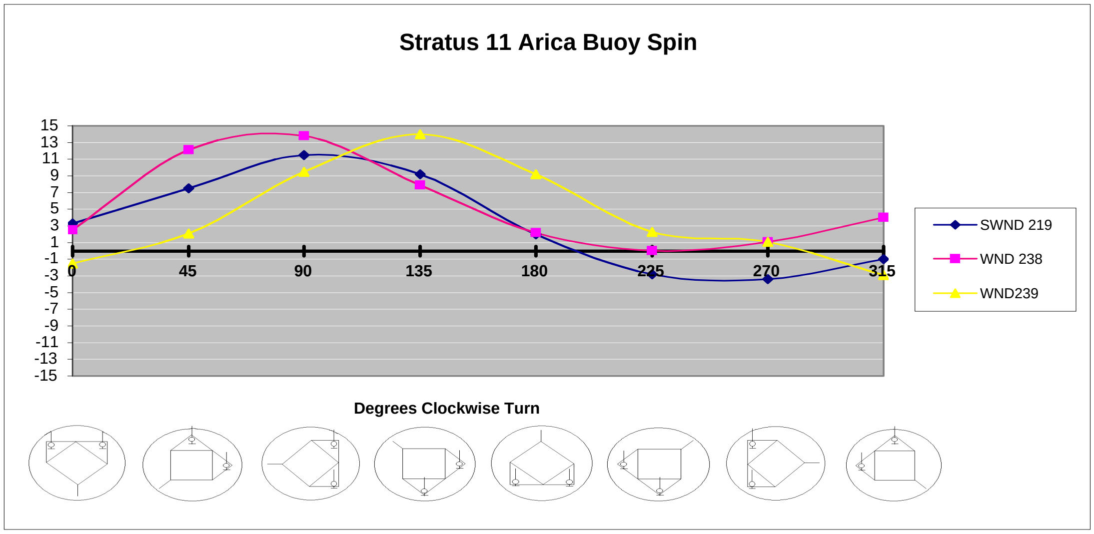

Figure 2-18. Stratus 11 buoy spin, in Arica, Chile.

III. Stratus 11 Mooring

A. Mooring Design

The buoys used in the Stratus project are equipped with surface meteorological instrumentation, including two Improved Meteorological (IMET) systems (see Figure 3-1). The mooring line also carries subsurface instrumentation that measures conductivity and temperature and a selection of acoustic current meters and vector measuring current meters (VMCM).

The WHOI mooring is an inverse catenary design utilizing wire rope, chain, nylon and polypropylene line and has a scope of 1.25 (scope is defined as slack length/water depth). The Stratus 11 surface buoy has a 2.7-meter diameter foam buoy with an aluminum tower and rigid bridle. The design of these surface moorings takes into consideration the predicted currents, winds, and sea-state conditions expected during the deployment duration. See Figure 3-2 for the full mooring drawing.

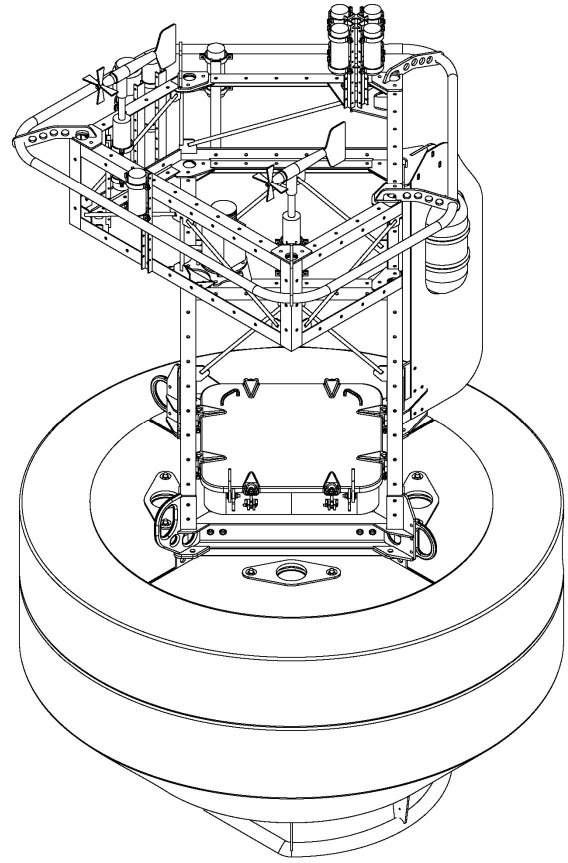

Figure 3-1: Representation of Stratus 9 ASIMET buoy (Stratus 11 is similar).

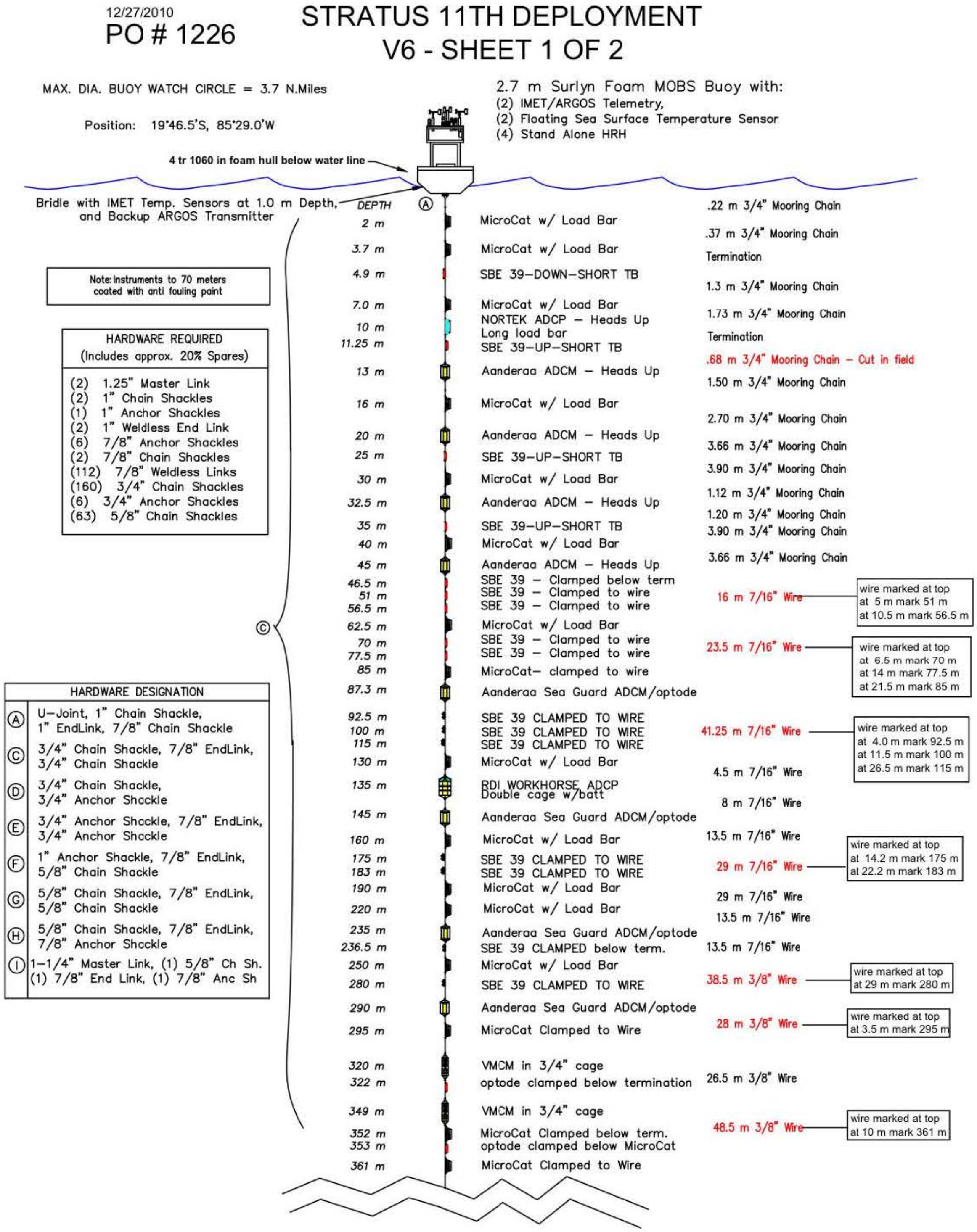

Figure 3-2. Stratus 11 mooring diagram.

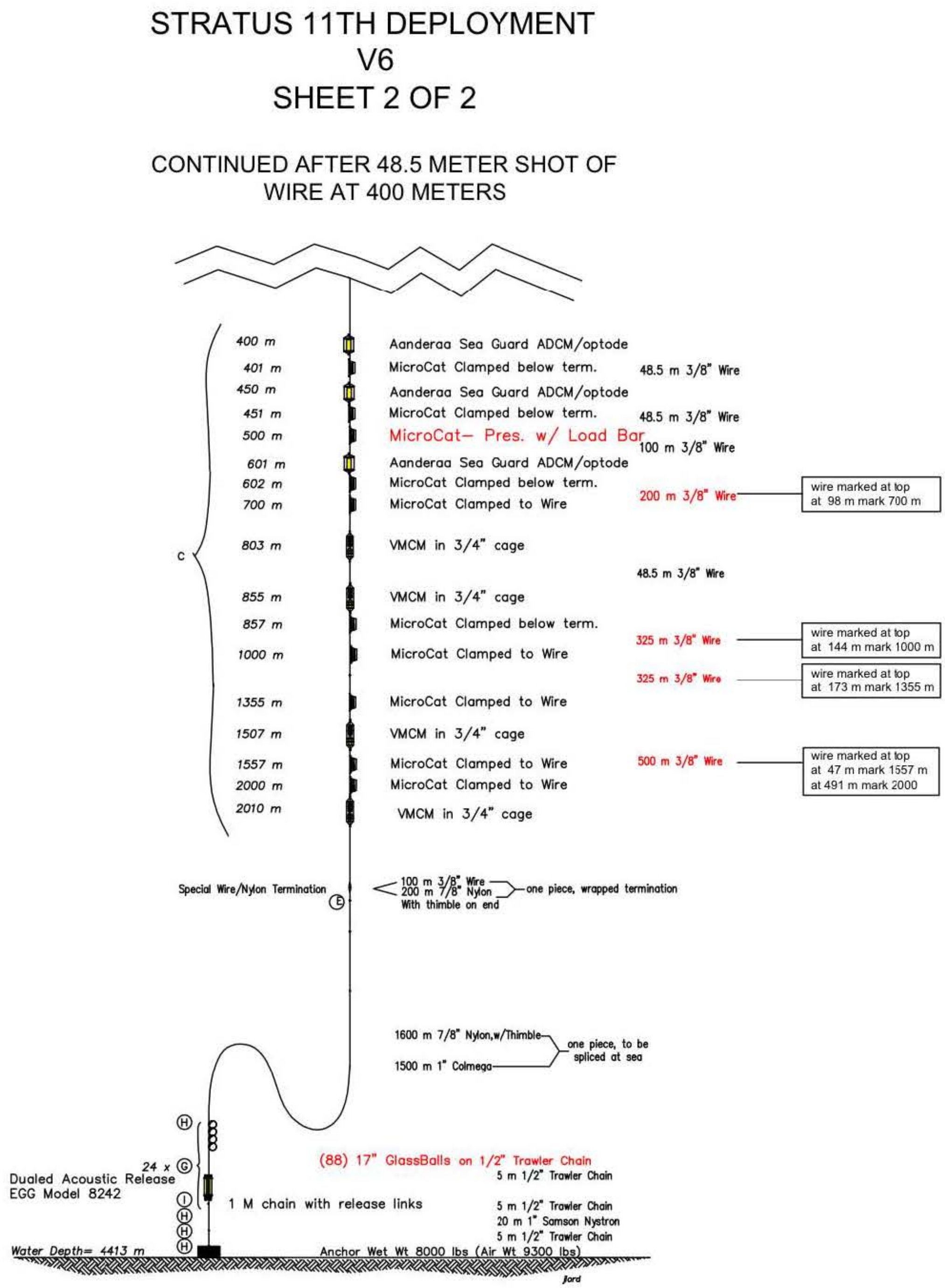

Figure 3-2. Stratus 11 mooring diagram (bottom part).

B. Buoy Instrumentation

The Air-Sea Interaction Meteorology (ASIMET) system is the present version of IMET, which is a suite of meteorological and sea surface sensors that are deployed with different housing and packaging depending on the application. ASIMET modules (one or more sensors plus front-end electronics) may be self-powered and self-logging, connected to a central power supply and logger, or both. Together, these modules measure Air temperature (ATMP), relative humidity (HRH), sea surface temperature and conductivity (SST, SSC), wind speed and direction (WSPD, WDIR), barometric pressure (BPR), shortwave radiation (SWR), longwave radiation (LWR), and precipitation (PRC). These variables are used to compute air-sea fluxes of heat, moisture and momentum using bulk aerodynamic formulas.

On buoys, modules are packaged in titanium cylinders that include provisions for batteries and internal logging. Buoy modules are typically deployed in pairs, with 6 meteorological module pairs mounted on the buoy tower and a pair of temperature-conductivity sensors attached to the bridle leg. A central logger records one minute data from all the modules on a common time base, and also creates hourly averaged data that are transmitted to shore via Argos satellite telemetry. Some of the one minute data are averages within each minute (see ASIMET documentation on http://frodo.whoi.edu/asimet). The Stratus mooring also includes a pCO2 system from Dr. Chris Sabine of NOAA PMEL and an NDBC wave sensor package.

1) ASIMET

Table 3-1 lists the ASIMET sensors deployed on Stratus 11, while Table 3-2 has the time of the spikes imposed in their data records before deployment.

Table 3-1. ASIMET instrumentation on stratus 11 buoy.

System 1			
Module	**Serial**	**Firmware Version**	**Height (cm)**
Logger	4	LOGR53 V4.11 cf	
HRH	247	VOS HRH53 V4.29 cf	226.5
BPR	503	VOS BPR53 V4.03 cf (Heise)	236
SWND	219	SONIC WND53V4.11 cf	267.5
PRC	207	VOS PRC53 V4.03 cf	250
LWR	503	VOS LWR53 V4.02 cf	279.5
SWR	502	VOS SWR53 V4.01 cf	279.5
SST	2053		
PTT	12789	ID's = 27916, 27917, 27918	

System 2			
Module	**Serial**	**Firmware Version**	**Height (cm)**
Logger	14	LOGR53 V4.11cf	
HRH	250	VOS HRH53 V4.29 cf	226.5
BPR	212	VOS BPR53 V4.03 cf (Heise)	236.5
WND	238	VOS WND53V4.02 cf	267
PRC	206	VOS PRC53 V4.03 cf	249
LWR	224	VOS LWR53 V4.02 cf	279.5
SWR	208	VOS SWR53 V4.01 cf	279.5
SST	1838		
PTT	18171	ID's = 27919, 27920, 27921	
Stand-Alone Modules			
Module	**Serial**		**Height (cm)**
WND	239	VOS WND53V4.02 cf	266
HRH	248	VOS HRH53 V4.29 cf	224.5
SBE39	1447	Sample 300 seconds	232
MINIMET	1	Top	232
MINIMET	2	bottom	201
PC02			84
WAMDAS	28558	Iridium = 24277	
SIS		ID	
Buoy waterline (as observed 2011/4/7)			60 – 65 cm

Table 3-2: Stratus 11 surface instrumentation spikes and notes.

Spikes for Surface Instrumentation		
PRC	Fill / drain	
	3/28/11 18:30	
	4/5/11 12:46	
SST spikes	on	off
	4/5/11 15:19	

2) Sea Surface Temperature

Two Sea-Bird SBE 37s are mounted to the bottom of the buoy hull at approximately 1 meter depth. These instruments are part of the IMET system and provide data of temperature and conductivity near the sea surface from one single measurement each minute. Hourly averages are also transmitted through Argos in near real time. The full 1-minute data are transmitted to the logger whereas the internal memory of the SBE 37 records only 5-minute data.

In addition to these SST sensors, an array of TR-1060s was placed in holes in the buoy hull. Table 3-3 lists the SST instrument array on the buoy hull.

Table 3-3: Stratus 11 Sea Surface Temperature Array

Instrument	Serial	Location	Meters Below Deck	Orientation
TR-1060	14880	Hole #1	0.80	forward
TR-1060	14875	Hole #2	0.80	aft
TR-1060	14879	Hole #3	0.80	starboard
TR-1060	14883	Hole #4	0.80	port

3) Air Temperature and Relative Humidity

Rotronic MP-101A sensor. Accuracy after UOP lab calibration, 1%RH, 0.05°C. Drift (post vs. pre cal after 1 yr): 1%RH, 0.05°C (Colbo and Weller, 2009). The sensor probe is protected by a Rotronic MF25 membrane filter and placed inside a modified R.M. Young multi-plate radiation shield for standard use. Sensors are installed opposite to the buoy vane to provide unobstructed air flow and minimize heat-island effects. Measurement is formed from one single snapshot each minute. There are indications from recent deployments during the past two years that the Rotronic sensors can drift from their calibration after shipping and lead to unacceptable biases. An additional air temperature was therefore installed on Stratus 11; it consisted of a Seabird SBE 39 with solar shield and sampled air temperature once every 5 minutes.

4) Precipitation

RM Young 50202 Self-siphoning rain gauge. Accuracy of rain rate after lab calibration, 1 mm/hr (Serra et al., 2001). Measurement is formed from one single snapshot each minute.

5) Shortwave radiation

Eppley Precision Spectral Pyranometer (PSP). Accuracy from comparison to standard, 2 W/m^2 (Colbo and Weller, 2009). Drift (post vs. pre calibration after 1 yr): 2 W/m^2 (Colbo & Weller, 2009). Sensor mounted higher than other instruments on buoy to avoid shadowing. One minute sample is formed by averaging over 6 snapshot measurements taken 10 seconds apart.

6) Longwave radiation

Eppley Precision Infrared Radiometer (PIR). Accuracy from comparison to standard, 2 W/m^2 (Colbo and Weller, 2009). Drift (post vs. pre calibration after 1 yr): 2 W/m^2 (Colbo and Weller, 2009). Measurement is formed from one single snapshot each minute.

7) Barometric pressure

Heise DXD (Dresser Instruments). Accuracy after UOP lab calibration, 0.2 mb. Drift (post vs. pre cal after 1 yr): 1.5 mb (Colbo and Weller, 2009). Measurement is formed from one single snapshot each minute.

8) Wind

R.M. Young 5103 wind monitor. Accuracy after UOP lab calibration, 1%, 3 degrees. Drift (post vs. pre cal after 1 yr): 0.1 m/s, 2.0 deg (Colbo and Weller 2009). Sensor is mounted opposite to the buoy vane to avoid flow disturbance. Velocity speed is measured from propeller rotations over 5 seconds, one vane measurement each second, and a single snapshot of compass during these 5 seconds. For each 5 seconds segment, a vector average is formed from the 5 seconds average vane and single snapshot compass. Eleven of these 5 seconds velocity vector are averaged at the end of the minute interval to form the final velocity output. A scalar average of wind speed is also computed from the rotations of the propellers, but this measurement is noisier.

A Gill Sonic Wind Sensor was incorporated on the Stratus 9 and 10 buoy. The anemometer measures the time taken for an ultrasonic pulse to travel from one transducer to the opposite transducer and then compares it with the time taken for another pulse to travel in the opposite direction. Likewise, differences are measured between other pairs of transducers allowing calculations of both wind speed and direction. This sensor samples at 40 Hz and the one minute data is formed from eleven 5-seconds averages, similar to the RM Young wind processing.

9) Subsurface Argos Transmitter

A Subsurface Mooring Monitoring Beacon (SMM 500), built by Sensoren Instrumente Systeme GmbH (SiS), was mounted upside down on the bottom of the buoy. This is a backup recovery aid in the event that the mooring parts and the buoy capsizes.

10) Telemetry

Each ASIMET module onboard the buoy samples data every minute and records it on a dedicated flashcard. The logger receives and stores this data. It also computes hourly averages for Argos transmissions. These Argos transmissions can be picked up as well by an Alpha Omega Uplink receiver directly from the Argos antenna on the buoy. The hourly averages help to monitor the status of instruments and the quality of data they provide.

11) PCO_2

Upwelling in the equatorial Pacific leads to enhanced productivity and degassing of CO2 across a region ranging from the coast of South America to past the International Date Line. The vast area affected makes this region a significant contributor to global biogeochemical cycles. Variability in the South American upwelling region has been linked to a wide range of ecosystem and biogeochemical changes. Understanding this variability is a primary reason for the ongoing work at the Stratus site. The PCO2 system on the Stratus mooring is a component of the OceanSITES moored PCO2 network.

CO2 measurements are made every three hours in marine boundary layer air and air equilibrated with surface seawater using an infra-red detector. The detector is calibrated prior to each reading using a zero gas derived by chemically stripping CO_2 from a closed loop of air and a span gas (414 ppm CO_2) produced and calibrated by NOAA's Earth System Research Laboratory (ESRL).

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

12) Wave Package

The WAMDAS wave system used on the Stratus 11 buoy is made by Neptune Sciences and acquired from NDBC. This includes wave measurements, GPS positions, and GPS times. It utilizes a 3-axis motion package made by MicroStrain Inc. The WAMDAS is capable of transmitting and storing data. The transmitted data is sent via Iridium communications on an hourly basis. This message is ultimately transmitted to NDBC where the data are subjected to automated quality-control checks and then posted on the NDBC web site. The data are stored in raw and processed format on a 1 GB compact flash card in the instrument.

C. Subsurface Instrumentation

The following sections describe individual instruments on the buoy bridle and mooring line. The Stratus 11 mooring received two oxygen sensors on behalf of Lotha Stramma at IFM-Geomar. Where possible, instruments were protected from being fouled by fishing lines using “trawl-guards” designed and fabricated at WHOI. These guards are meant to keep lines from hanging up on the in-line instruments.

Before a buoy launch and after its recovery, different physical signals are imprinted in the instruments’ records at determined times. These spikes reveal the possible presence of a drift in the internal clock of instruments. Temperature and salinity sensors are plunged into a large bucket filled with ice and fresh water for about an hour. VMCM rotors are spun and then blocked.

Table 3-4 summarizes the subsurface instrumentation set up. The details of the set up are shown in Setup Appendixes. Mooring Log Appendix contains the mooring log of Stratus 11 mooring at deployment, with a list of all the instruments that were deployed.

Table 3-4. Set up of Stratus 11 subsurface instrumentation.

Instrument	Serial	Depth (m)	Sample (s)	Start Date	Start Time	Spike Start	Spike Stop
SBE37 SST	2053	sst	300				In bucket
SBE37 SST	1838	sst	300				In bucket
SBE37	1325T	2	300	28-Mar-11	1400	3/29/11 17:47	3/29/11 18:39
SBE37	1326T	3.7	300	28-Mar-11	1400	3/29/11 17:47	3/29/11 18:39
SBE37	1328T	7	300	28-Mar-11	1400	3/29/11 17:47	3/29/11 18:39
SBE37	1329T	16	300	28-Mar-11	1400	3/29/11 17:47	3/29/11 18:39
SBE37	1330T	30	300	28-Mar-11	1400	3/29/11 17:47	3/29/11 18:39
SBE37	8211T	40	300	28-Mar-11	1400	3/29/11 17:47	3/29/11 18:39
SBE37	8212T	62.5	300	28-Mar-11	1400	3/29/11 17:47	3/29/11 18:39
SBE37	1909Pc	85	300	28-Mar-11	1400	3/29/11 17:47	3/29/11 18:39
SBE37	8213T	130	300	28-Mar-11	1400	3/29/11 17:47	3/29/11 18:39
SBE37	8214T	160	300	28-Mar-11	1400	3/29/11 17:47	3/29/11 18:39
SBE37	8215T	190	300	28-Mar-11	1400	3/29/11 17:47	3/29/11 18:39
SBE37	8216T	220	300	28-Mar-11	1400	3/29/11 17:47	3/29/11 18:39
SBE37	8217T	250	300	28-Mar-11	1400	3/29/11 17:47	3/29/11 18:39
SBE37	1906c	295	300	28-Mar-11	1400	3/29/11 18:42	3/29/11 19:47
SBE37	1908c	352	300	28-Mar-11	1400	3/29/11 18:42	3/29/11 19:47
SBE37	2012c	361	300	28-Mar-11	1400	3/29/11 18:42	3/29/11 19:47
SBE37	2015c	401	300	28-Mar-11	1400	3/29/11 18:42	3/29/11 19:47
SBE37	8218c	451	300	28-Mar-11	1400	3/29/11 18:42	3/29/11 19:47
SBE37	3733Tp	500	300	28-Mar-11	1400	3/29/11 18:42	3/29/11 19:47
SBE37	8219c	602	300	28-Mar-11	1400	3/29/11 18:42	3/29/11 19:47
SBE37	8220c	700	300	28-Mar-11	1400	3/29/11 18:42	3/29/11 19:47
SBE37	8221c	857	300	28-Mar-11	1400	3/29/11 18:42	3/29/11 19:47
SBE37	8222c	1000	300	28-Mar-11	1400	3/29/11 18:42	3/29/11 19:47
SBE37	8223c	1355	300	28-Mar-11	1715	3/29/11 18:42	3/29/11 19:47
SBE37	8224c	1557	300	28-Mar-11	1400	3/29/11 18:42	3/29/11 19:47
SBE37	8225c	2000	300	28-Mar-11	1400	3/29/11 18:42	3/29/11 19:47
SBE39	35	4.9	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	38	11.25	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	44	25	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	48	35	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	49	46.5	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	102	51	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	103	56.5	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	203	70	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	276	77.5	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	284	92.5	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	719	100	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	720	115	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	721	175	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	1498	183	300	28-Mar-11	1300	3/28/11 15:40	n/a

SBE39	1499	236.5	300	28-Mar-11	1300	3/28/11 15:40	n/a
SBE39	1500	280	300	28-Mar-11	1300	3/28/11 15:40	n/a
TR-1060	14880	hull	60	28-Mar-11	1500	3/28/11 15:40	n/a
TR-1060	14875	hull	60	28-Mar-11	1500	3/28/11 15:40	n/a
TR-1060	14879	hull	60	28-Mar-11	1500	3/28/11 15:40	n/a
TR-1060	14883	hull	60	28-Mar-11	1500	3/28/11 15:40	n/a
Nortek 2mhz Profiler	357	10	600 (80 pings)	20-Mar-11	01:00	3/28/11 15:48:30	3/28/11 18:36
RCM11	13	13	1800	28-Mar-11	15:48:30	3/28/11 16:36	3/28/11 18:36
RCM11	78	20	1800	28-Mar-11	15:48:30	3/28/11 16:36	3/28/11 18:36
RCM11	79	32.5	1800	28-Mar-11	15:48:30	3/28/11 16:36	3/28/11 18:36
VMCM	4	320	60	27-Mar-11	14:37:30	3/27/11 16:34	3/27/11 16:36
VMCM	31	349	60	27-Mar-11	14:37:30	3/27/11 16:34	3/27/11 16:36
VMCM	32	803	60	27-Mar-11	14:37:30	3/27/11 16:34	3/27/11 16:36
VMCM	42	855	60	27-Mar-11	14:37:30	3/27/11 16:34	3/27/11 16:36
VMCM	62	1507	60	27-Mar-11	14:37:30	3/27/11 16:34	3/27/11 16:36
VMCM	83	2010	60	27-Mar-11	14:37:30	3/27/11 16:34	3/27/11 16:36
RDI ADCP	1218	135	3600 (60s)	20-Mar-11	0100	3/29/11 12:20	3/29/11 13:40
Seaguard	138	45	1200 (200 pings)	31-Mar-11	14:00	3/31/11 21:33	0:05:00
Seaguard	140	87.3	1200 (200 pings)	31-Mar-11	14:00	3/31/11 21:33	0:05:00
Seaguard	141	145	1800 (300 pings)	31-Mar-11	15:00	3/31/11 21:33	0:05:00
Seaguard	142	235	1800 (300 pings)	31-Mar-11	15:00	3/31/11 21:33	0:05:00
Seaguard	143	290	1800 (300 pings)	31-Mar-11	15:00	3/31/11 21:33	0:05:00
Seaguard	144	400	1800 (300 pings)	31-Mar-11	15:00	3/31/11 21:33	0:05:00
Seaguard	181	450	1800 (300 pings)	31-Mar-11	15:00	3/31/11 21:33	0:05:00
Seaguard	182	601	1800 (300 pings)	31-Mar-11	15:20	3/31/11 21:33	0:05:00
Optode	691	322					
Optode	943	353					

1) VMCMs

The VMCM has two orthogonal cosine response propeller sensors that measure the components of horizontal current velocity parallel to the axles of the two-propeller sensors. The orientation of the instrument relative to magnetic north is determined by a flux gate compass. East and north components of velocity are computed continuously, averaged and then stored. All the VMCMs deployed from Stratus 4 onward have been next generation models that have newer circuit boards and record on flash memory cards instead of cassette tape. Temperature was also recorded using a thermistor mounted in a fast response pod, which was mounted on the top end cap of the VMCM.

2) RDI Acoustic Doppler Current Profiler

The RD Instruments (RDI) Workhorse Acoustic Doppler Current Profiler (ADCP, Model WHS300-1) is mounted looking upwards on the mooring line. The RDI ADCP measures a profile of current velocities.

3) Nortek

The Nortek Aquadopp current profiler uses Doppler technology to measure currents. It has 3 beams tilted at 25 degrees and has a transmit frequency of 2 MHz. The internal tilt and compass sensors give current direction.

4) Aanderaa RCM 11s

The Aanderaa RCM 11 measures the horizontal current speed and direction, as well as temperature. The instrument can operate continuously or in eight intervals from 1 to 120 minutes.

5) Aanderaa SEAGUARD RCM

The new SEAGUARD RCM series replaces the industry Standard RCM 9 and RCM 11 series. It has been completely redesigned from bottom up and employs modern technology in the datalogger section and in the different sensor solutions. On stratus 11, these instruments also included an oxygen sensor.

6) SBE-39 Temperature Recorder

The Sea-Bird model SBE-39 is a small, light weight, durable and reliable temperature logger. It is a high-accuracy temperature recorder (pressure optional) with internal battery and non-volatile memory for deployment at depths up to 10,500 meters (34,400 feet).

7) SBE37 MicroCat Conductivity and Temperature Recorder

The MicroCat, model SBE37, is a high-accuracy conductivity and temperature recorder with internal battery and memory. It is designed for long-term mooring deployments and includes a standard serial interface to communicate with a PC. Its recorded data are stored in non-volatile FLASH memory. The temperature range is -5° to +35ºC, and the conductivity range is 0 to 6 Siemens/meter. The pressure housing is made of titanium and is rated for 7,000 meters. The instruments were mounted on in-line tension bars and deployed at various depths throughout the moorings. The conductivity cell is protected from bio-fouling by the placement of antifoulant cylinders at each end of the conductivity cell tube. Upon recovery of Stratus 10 instruments from the seafloor, two of the SBE 37 with pressure sensors appeared to have leaked. This is probably due to the pressure data port which is not rated for high pressures.

8) Brancker XR-420 Temperature and Conductivity Recorder (Stratus 10)

The Brancker XR-420 CT is a self-recording temperature and conductivity logger. The operating temperature range for this instrument is -5° to 35°C. It has internal battery and logging, with the capability of storing 1,200,000 samples in one deployment. A PC is used to communicate with the Brancker via serial cable for instrument set-up and data download.

9) Acoustic Release

The acoustic release used on the Stratus 11 mooring is an EG&G Model 8242. This release can be triggered by an acoustic signal and will release the mooring from the anchor. Releases are tested at depth prior to deployment to ensure that they are in proper working order (Table 3-5).

Table 3-5: Stratus 11 releases test on 2011/04/01

		enable	range	disable	fire	disable
Stratus 11 #1	depth 200	y	y	y	y	y
	depth 1500	y	y	y	y	y
Stratus 11 #2	depth 200	y	y	y	y	y
	depth 1500	y	y	y	y	y

D. Current Meter Setup

On Stratus 11 mooring, 2 current profilers (1 Nortek and 1 RDI) and 11 acoustic current meters (3 RCM 11, 8 Seaguards) were deployed. These acoustic instruments were deployed in the upper water column (above 55m, except for the RDI at 135m). The Nortek ADCP was deployed at 10m and the RDI Workhorse Sentinel at 135m. The three RCM 11 were above 32.5 m depth. The Seaguards spanned the depth range between 45m and 601m. In addition, 6 VMCMs were deployed, the shallowest at 320m and the deepest at 2010m depth.

The setup of these sensors is a trade off between measurement precision and length of the record (battery life). For profilers, the number of cells and subsequent range is also a criterion. The setup of acoustic current meters and profilers is summarized in Table 3-6.

Norteks sample at 1 Hz and we chose an averaging period of 80s so each velocity output is based on an averaging over 80 pings. Our setup for the Nortek profiler has 11 cells (1 m size), a blanking distance of 0.4 m and a sampling output period of 10 minutes. Power level for pinging was set to HIGH- (this is 6 dB less than HIGH, which was the setting chosen in previous deployments) since this instrument is near the surface and plenty of backscatter material should be present. With this configuration, battery utilization computed by the Nortek software during instrument setup is 289%, and an assumed duration of 548 days. This estimate is based on a 50 W.h Alkaline batteries. We usually used Lithium batteries, with for example, 160 W.h capacity. The housing was extended to accommodate 2 extra battery packs. In the future it may be desirable to increase the averaging period to, say 160s, in order to properly average out the swell (~15s period at Stratus site) signal. The compass update rate was set at 1s, which is important for consistency with sampling rate of 1 Hz.

The RDI Workhorse Sentinel operates at 307,200 Hz, with 4 beams at 20^o from the vertical. For Stratus 11 we increased the blanking distance to its maximum, namely 2.5m, because data from previous deployments indicated that velocity in the first bin was smaller than other bins and we suspect this is caused by flow distortion from barnacle growth on the instrument cage. As in previous deployments we chose 12 cells of 10 m size, 60 pings per ensemble and 1s per ping and 1hr for output sampling.

Note that for a profiler near the surface, by choosing cells that are higher than the water surface, it is possible to diagnose possible problems in the data because there is a lot of backscatter caused by the air-water interface. For example, if a beam does not show a maximum in the signal intensity near the surface, its record should be used with caution. Also, if the maximum in intensity appears in different cells for different beams, it indicates that the instrument (and therefore the mooring line) was probably tilted. However, the signal is valid only below and away from the surface because of the side lobe reflections (maximum distance is therefore a function of $\cos(\alpha)$, where α is the angle of the beam with the vertical).

It was noted from previous deployments that one bin in ADCP data may be slightly anomalous in terms of backscatter and velocity. We suspect that reflection on an instrument located above may cause enhanced backscatter and bias velocity towards zero. On several occasions, the reflection was probably caused by the flat metallic surface at the bottom of a SBE 37. One way to remediate this would be to change this surface so that it scatters the incoming acoustic signal from the ADCP below. A cone shape would probably do and will be tested next year. This issue is enhanced on a 1 MHz signal since the main lobe width is twice as big as a 2 MHz. However, both signals tend to show the velocity anomaly.

Table 3-6. Setup of acoustic current meters and profilers for Stratus 11.

Instrument	Nortek 357	RDI 1218	Aanderaa RCM 11 (13, 78, 79)	Aanderaa Seaguard (138, 140)	Aanderaa Seaguard (141 to 144, 181, 182)
Sampling Freq kHz	2000	307.2			
Measurement Interval (s)	600	3600	1800	1200	1800
Number cells	11	12	1	1	1
Cell size (m)	1	10		2.5	2.5
Blanking distance (m)	0.4	1.76		1	0.5
Average Interval (s)	80	60		200 pings	300 pings
Measurement load (%)	9	n/a	n/a	n/a	n/a
Power level	HIGH-	n/a	n/a	n/a	n/a
Battery utilization (%)	289	n/a	n/a	n/a	n/a
Battery days	548			698	706
Compass update rate (s)	1	n/a	n/a	n/a	n/a
Vertical precision (cm/s)	0.4	n/a	n/a	n/a	n/a
Horizontal precision (cm/s)	1.2				

(* battery utilization based on alkaline batteries)

E. Compass Spins on current meters/profilers

Before deployment, current meters and profilers are spinned to check the accuracy of their compasses. Similar to the buoy spin, the instrument is rotated 360°, in small increments (15° in Fig. 3-3 below) and the difference between the compass reading from the instrument and a standard checked. We typically accept error in compass less than 5°. Figure 3-3 below shows the results from the compass spin made at the hotel in Arica on the Seaguards Aanderaas. Three of these instruments (141, 143, 144) had failed an earlier spin made at WHOI (January 2011) and had been sent back to Aanderaa's factory in Norway for recalibration, after some defective parts with magnetized stainless steel had been replaced.

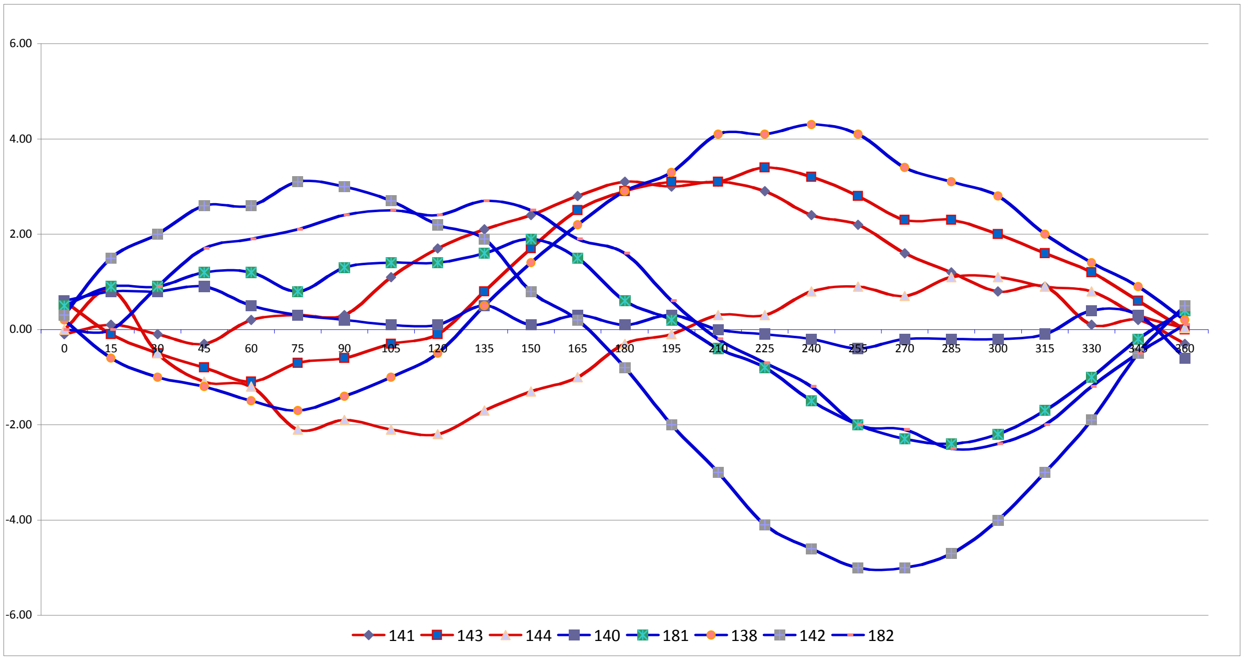

Figure 3-3. Compass error during Seaguard Aanderaa spin, deployed on Stratus 11.

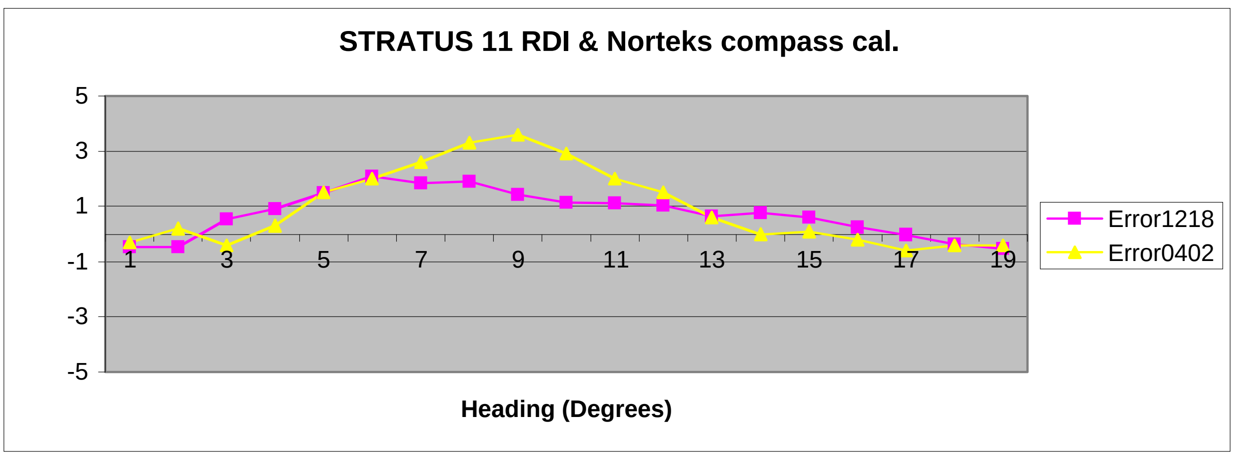

Figure 3-4. Compass error from ADCPs RDI Workhorse Sentinel (SN 1218, deployed at 135m depth)) and Nortek (SN 357 deployed at 10m), deployed on Stratus 11. Note that there is a mistake in the legend: the Nortek serial number is 357, not 402.

F. Antifouling Coatings

Early moorings at this site have been used as test beds for a number of different antifouling coatings. The desire has been to move from organotin-based antifouling paints to a product that is less toxic to the user, and more environmentally friendly. These tests have previously led the Upper Ocean Process group to rely on E Paint Company's, Sunwave and Ecominder products as the anti fouling coating used on the buoy hull, and ZO for the majority of instruments deployed from the surface down to 70 meters. After a full year in the ocean, the instruments have a considerable amount of biofoouling regardless of the paint used on instrument housings. The bio-grease used on transducer heads has been very effective, but it is also very toxic, and is used as little as possible. For STRATUS 11, only PVC tape was used on instrument bodies. This should make cleaning the instruments much easier, but will not act as an antifoulant. Copper guards were used on the SBE 37 C/T instruments, and Desitin diaper rash paste was used around all sensors on transducer heads. The Desitin is a viscous, zinc-based paste that has been used as an alternative to the poison paints and greases typically used. The poison bio-grease was used on the 10-meter Nortek and one of the SSTs on the buoy. Table 3-7 below shows methods used for coating the buoy hull and instrumentation for the Stratus 11 deployment.

Table 3-7. Stratus 11 Anti Fouling Application

DEPTH	INSTRUMENT	ANTI FOULING APPLIED
Surface	Buoy Hull	E-prime base coat E-Paint Ecominder – 5 coats – blue.
Surface	Fixed SSTs (4)	(1) Desitin on vane side, (3) Aqua lube on three sides
1 M	SBE 37 – SST (2)	PVC tape & copper guards (1)Desitin (1) bio grease
2, 3.7, 7, 16, 30, 40, 62.5 M	SBE 37 (C/T)	PVC tape, copper shield. Desitin around cell
4.9, 11.25, 25, 35	SBE - 39	PVC tape, Desitin around sensor
10	NORTEK ADCP	PVC tape, bio grease around sensor. **bio grease appeared to slough off on deployment
13, 20, 32.5, 45, 87.3 M	Aanderaa ADCM	PVC tape on body. Desitin on transducer heads and all around stem

G. Mooring Operations

1) Deployment of Stratus 11

The Stratus 11 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 TSE winch drum was pre-wound with the following mooring components listed from deep to shallow:

- 200 m 7/8” nylon - nylon to wire shot
- 100 m 3/8” wire - nylon to wire shot
- 500 m 3/8” wire
- 325 m 3/8” wire
- 325 m 3/8” wire
- 48.5 m 3/8” wire
- 200 m 3/8” wire
- 100 m 3/8” wire
- 48.5m 3/8” wire
- 48.5 m 3/8”wire
- 48.5 m 3/8” wire
- 26.5 m 3/8” wire
- 28 m 3/8’ wire
- 38.5 m 3/8” wire
- 41.25 m 7/16” wire
- 50 m ¾” spectra working line

A tension cart was used to pre-tension the nylon and wire during the winding process. The ship was positioned 8 nautical miles downwind and down current from the center the target site. An earlier bottom survey indicated this track would take the ship over large area with consistent ocean depth.

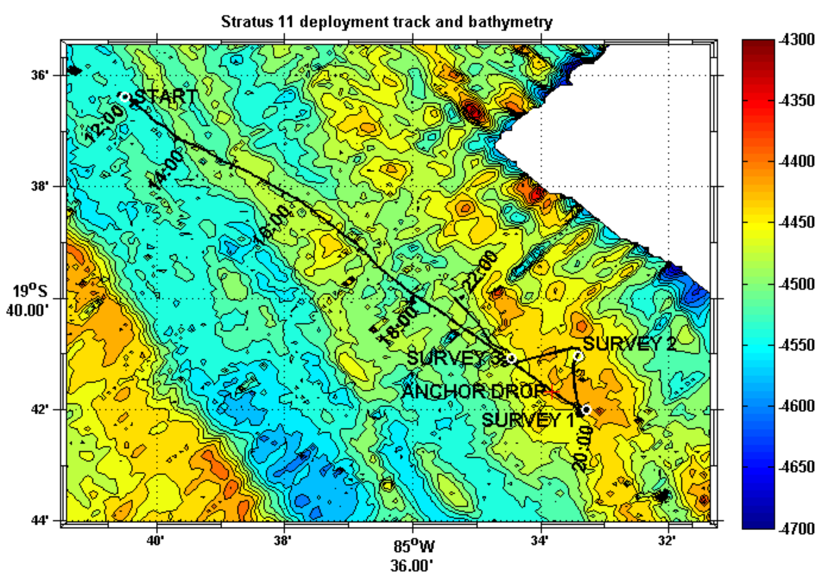

Figure 3-5. Stratus 11 deployment track on April 6 2011. Start of track is about 8 nm downwind of target anchor drop. Three anchor survey points are shown too. Time (UTC) of day is indicated along track. Color contours are bathymetry (in m; contour interval 20m) from Seabeam data (not corrected for speed of sound or transducer depth; correction should be +10m) collected during Stratus 9 cruise.

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 port 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 lease five meters. All subsurface instruments for this phase had been staged in order of deployment on the starboard side main deck. All instrumentation had chain or wire rope 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 a MicroCat C/T logger at 40m. This instrument had a 3.9-meter shot of chain shackled to the top of the instrument cage, and a 3.66-meter shot of chain shackled to the bottom. This segment of chain was shackled into the working line coming from the winch. The crane hook, suspended over the instrument lowering, area was lowered to approximately 1 meter off the deck. A six-foot sling was hooked onto the crane and passed through a ring to the top of the 3.9-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. An air tugger with a chain hook was used to haul on the chain and take the load from the crane. A stopper was attached to the top link of the instrument array as a back up. The hook on the crane was removed. Lowering continued with 15 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 SBE 37 MicroCat. The load from this instrument array was stopped off using a slip line passed through a pear link shackled into the chain above the load bar. 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 three 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 40 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 (approximately 15 ft. from the side of the ship), and the release hook had gone slack, the quick release was tripped. The crane swung aft 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 1 knot through the water to maintain a safe distance between the buoy and the ship. The bottom end of the shot of wire shackled to the working line was pulled in and stopped off at the transom.

A traveling block was suspended from the crane. The free end of the working wire was passed through the block. The next instrument, a 45 meter depth frame with a Aanderaa ADCM current meter and pre-attached wire shot was shackled to the end of the stopped off mooring. The bottom of this wire was shackled into top of the working line. The hauling line was pulled onto the TSE winch to take up the slack. The winch slowly took the mooring tension from the stopper lines.

The winch line pulled back, lifting the current meter 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. 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 2010 meters. Smaller instruments were clamped to the wire rope as the wire was payed off the winch.

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 15 feet from the transom using a sling though the thimble.

An H-bit cleat was positioned aft of the TSE winch and secured to the deck. The free end of the 3000 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 heating up.

While the nylon and Colmega line was being payed out, the crane was used to lift the 88 glass balls out of the open top container. These balls were staged fore and aft, in four ball segments, on the starboard side of the deck.

When the end of the Colmega line was reached, pay out was stopped and a Yale grip was used to take tension off the line. The winch tag line 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 TSE winch payed out the mooring line until all but one meter of the Colmega line was over the transom.

The 88 glass balls are bolted on 1/2" trawler chain in 4 ball (4 meter) increments. The first two sets of glass balls were dragged into position 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 seven of the eight balls were off the stern. Stopper lines were attached, the winch leader was removed, and the process repeated until all 88 balls were deployed.

A 5-meter shot of chain was shackled to the last glass ball segment. 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 mooring winch wound up these components until it had the tension of the mooring. The acoustic releases were laying flat on the deck.

The crane was positioned above the releases on deck. A chain hook on a sling was fastened to the crane's hook. The chain hook was attached to the mooring about two meters below the acoustic releases. The crane wire was pulled in to lift the releases off the deck. As the winch payed out, the crane also lowered its wire and eased the releases over the transom without touching the deck. The winch stopped, and the crane let out enough wire to free the chain hook from the mooring.

The winch continued to pay out until the final 5-meter shot of chain was just going over the transom. A shackle and link was 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 two miles from the target anchor position. The ship speed was increased to two knots, while the mooring was towed through the water.

The starboard crane was set up so the boom would hang over, and slightly aft of the anchor. The crane was lowered and the hook secured to the tip plate bridle. 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 crane raised 0.5 meters lifting the forward side of the tip plate causing the anchor to slide overboard.

The deployment started at 08:00 local (UTC -4), 06 April, and the anchor was dropped at 15:29 local (UTC -4).

2) Anchor Survey

Following the anchor drop, the *Moana Wave* moved off the deployment line and allowed time for the anchor to reach the sea floor. Three points were selected for the anchor survey at ranges approximately 1000 meters from the estimated anchor location (Fig. 3-6).

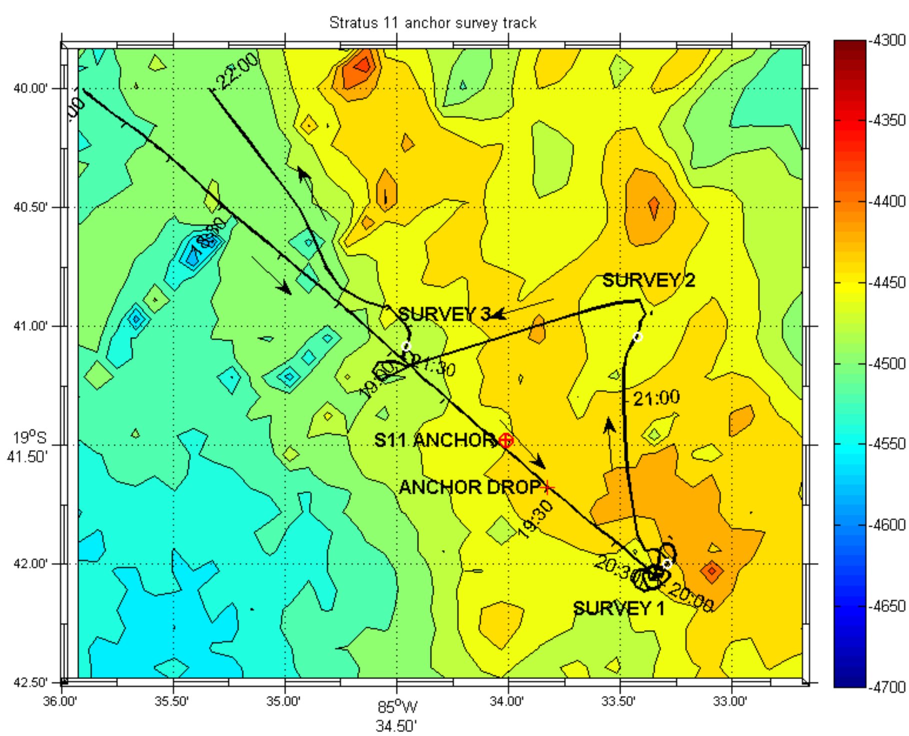

Figure 3-6. Stratus 11 deployment track. Same as Fig. 3-5 but Seabeam data is corrected for speed of sound (+5m) and transducer depth (+5m). Stratus 11 anchor location on seafloor indicated by red circle with cross. Depth at anchor location is 4440m.

At each of these sites an Edgetech 8011A deck unit was used to communicate with the acoustic release on the mooring. Signal travel time was recorded at each site. Travel time and ship's coordinates for each site were entered into Arthur Newhall's Acoustic Survey Software to calculate anchor position. The program uses the intersection of each range arc to calculate anchor position, see Figure 3-7.

The fallback between the anchor drop location and the surveyed anchor location on the seafloor is about 480m. It is probably slightly less since the anchor drop location was verified about 1 minute after the anchor was actually dropped (time to go inside the lab and check the GPS) and the ship was moving at about 2 knots. In any case, the fallback represents about 10% of the water column. Although somewhat large, this value is realistic since the buoy was towed behind the ship at close to 2 knots when the anchor was dropped.

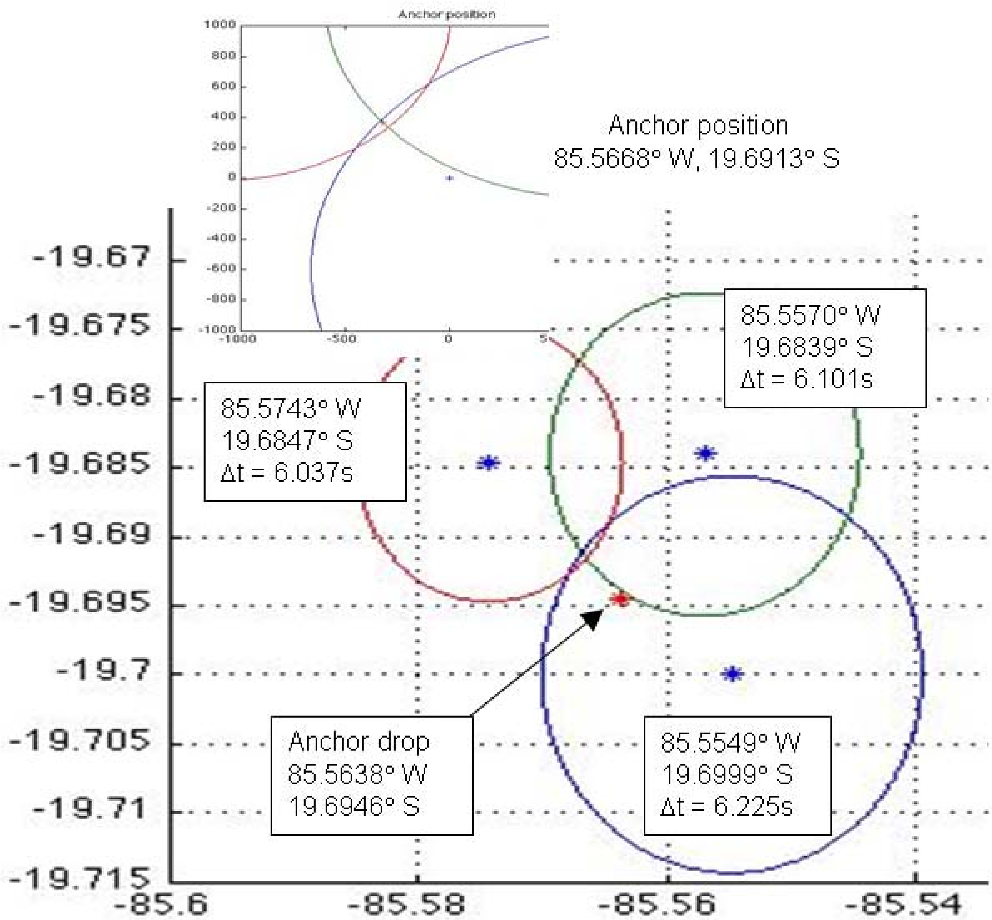

Figure 3-7. Stratus 11 Anchor Survey. Insert shows zoom on triangulated position of anchor , distances (m) and anchor drop position.

H. Instrument Intercomparisons

After the deployment of the Stratus 11 surface mooring and the anchor survey, the *Moana Wave* was parked ¼ to ½ mile, downwind of the buoy for a 36 hours period of inter-comparison between the buoy and the ship sensors, starting at 23:00 UTC on April7 and ending at 11:00 UTC on April 9, 2011 (yeardays 97 to 99). The buoy sensors heights are described in Table 3-1 (note that sensors heights in Table 3-1 are relative to the buoy deck, which is 60 to 65 cm higher than the waterline). Sensors on the ship consist of the VOS and ESRL systems. Data acquired during the inter-comparison period on the ship were averaged to 1 hour values to match the data received from the buoy through Argos satellite transmissions. Using COARE 3.0, the ship data were further adjusted to heights of corresponding sensors on the buoy.

Data available for inter-comparison with the Stratus 11 buoy came from three systems; a UOP AutoImet (VOS) logger on the flying bridge and the 01 deck, an ESRL flux system on the bow mast, and a WHOI-AOP&E Sonic Flux system on the bow. Hourly averaged data from the Stratus 11 ASIMet systems were acquired with an AlphaOmega Argos Uplink receiver and processed with our standard Matlab software, Argplot. The VOS and ESRL data directories were accessed using Windows networking; there was no access to IP based internet on the laptops that comprised the real-time processing system. The VOS system was identical to previous installations, with a continuous log file used to facilitate data access.

1) Earth System Research Laboratory (ESRL) Observations

The Physical Sciences Division (PSD) of the Earth System Research Laboratory (ESRL) ran its turbulent flux system in support of the overall meteorological part of the Stratus 11 cruise. The turbulent flux system was mounted on a portable tower system and not on the jack staff as in cruises in the past. The tower was mounted just behind the ship's jack staff, and it allows the sensors to extend beyond the top of the jack staff. The PSD Turbulent flux system consists of four components. A fast turbulence system with ship motion corrections mounted on the jack staff, which includes an ultrasonic anemometer, Gill Wind Master model R3A, and a Systron Donner Inertia Motion-pak unit with serial number 0681. Solar and IR radiation sensors are radiometers from The Eppley Lab, two pyranometers and two pyrgeometers mounted in a high and unobstructed sky-see location on the flying bridge. The bulk meteorology sensors are a Vaisala T/RH sensor in aspirator, a skin surface semperature (SST) made with a floating (YSI 46040) thermistor deployed off port side with outrigger, and an Optical Scientific Inc.-Optical Precipitation Sensor model ORG-815 DA. Finally, a fast sampling humidity sensor, Li-COR 7500 fast CO2/H2Ogas analyzer is mounted near the top of tower.

Figure 3-8. Turbulence Flux system setup on the tower in behind the jack staff of the R/V *Moana Wave*. WHOI turbulent anemometer is at lowest level.

All the data files are in ASCII text format. The description of the data format for each data file is covered in the attached document “NOAA/PSD Ship-based Primary Turbulent Flux Data Acquisition System.” In conjunction with the flux system PSD ran a Vaisala CL31 ceilometer for the measurement of cloud base altitude. The first processing of the raw data from the ceilometer produces 2 plots for each day. One of the plots is of the laser backscatter intensity, and the other plot is the cloud base altitude determined from the backscatter. The Vaisala output format is read by a Matlab code named “read_daily_rawceilo_CL31_STRATUS_2011.m.”

The area is known for very little rainfall. Rainfall is reported for this area even though these clouds frequently drizzle, especially at night when they are driven by radiative cooling. Often times, the drizzle will evaporate before it reaches the surface, altering the boundary layer conditions yet recording little to no measurements in rain gauges. During the cruise the optical rain gauge recorded periods of precipitation on 5 different days. For example, on April 5 and 7, observations from the crew and the optical rain gauge recorded periods of rain. Some of the more significant periods of rain fall are shown below.

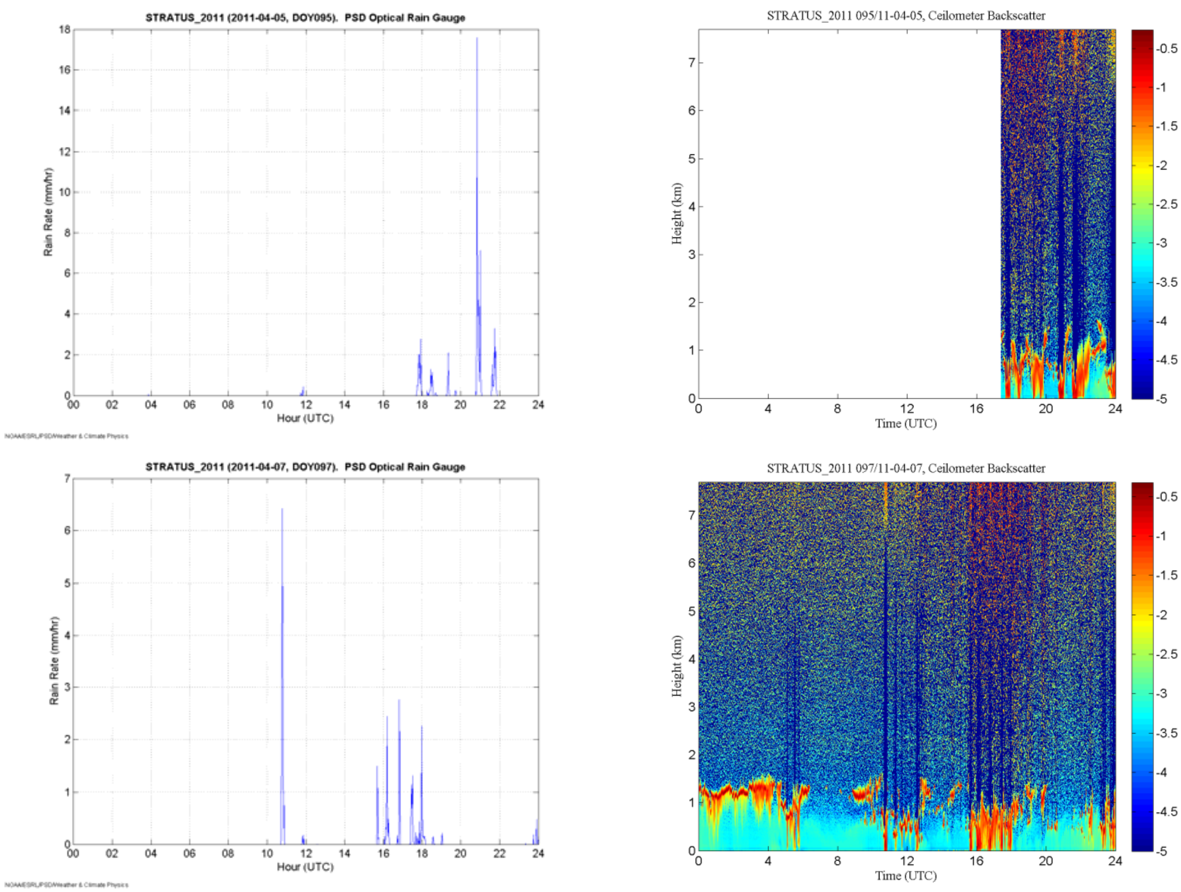

Figure 3-9. Optical rain gauge and ceilometer backscatter showing 2 periods of rain during the Stratus 11 cruise.

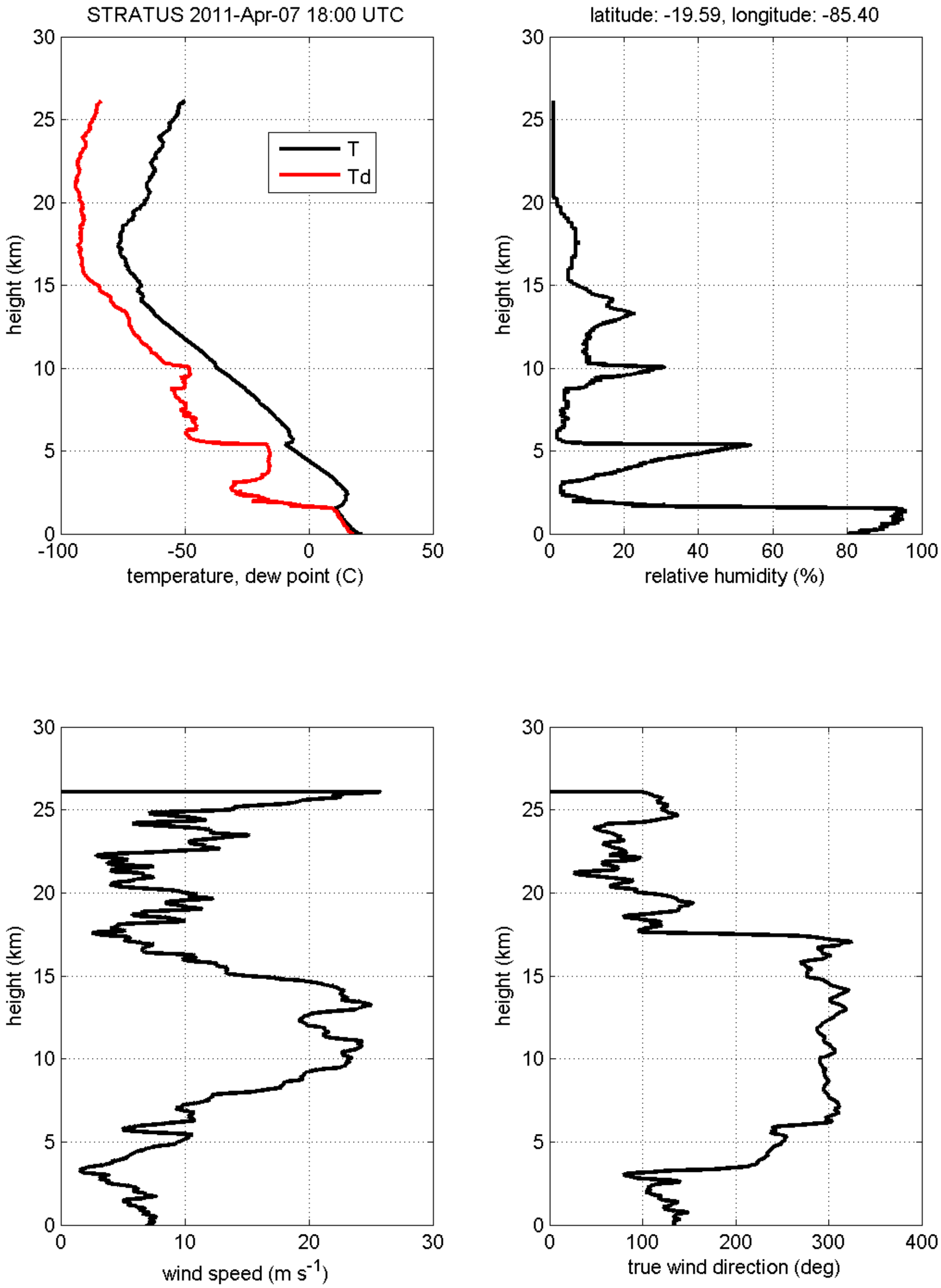

Figure 3-10. Radiosonde profile during one of the rain events, April 7, 2011 1800 UTC.

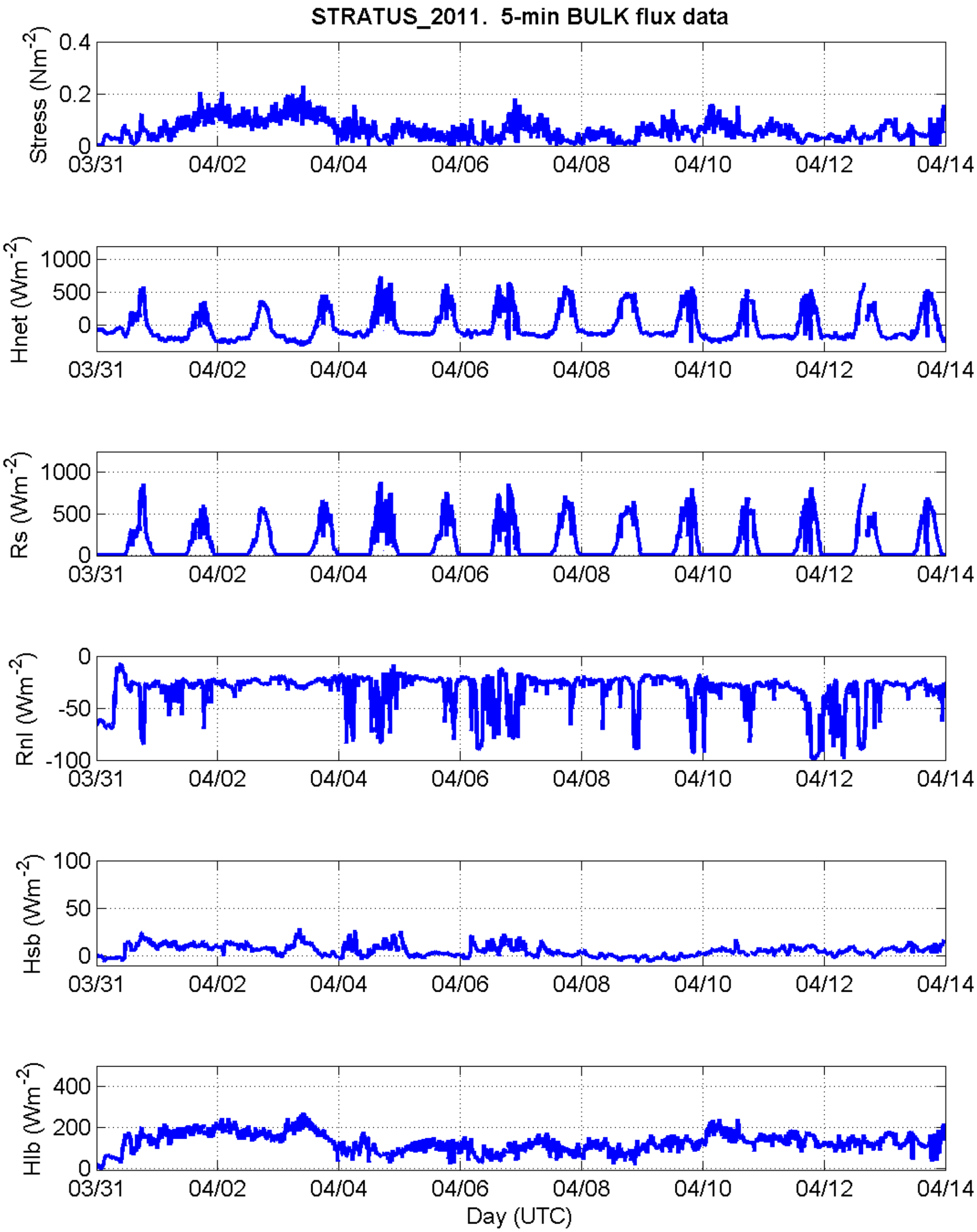

Figure 3-11 (part 1). Time series of the bulk fluxes collected during the Stratus 11 cruise.

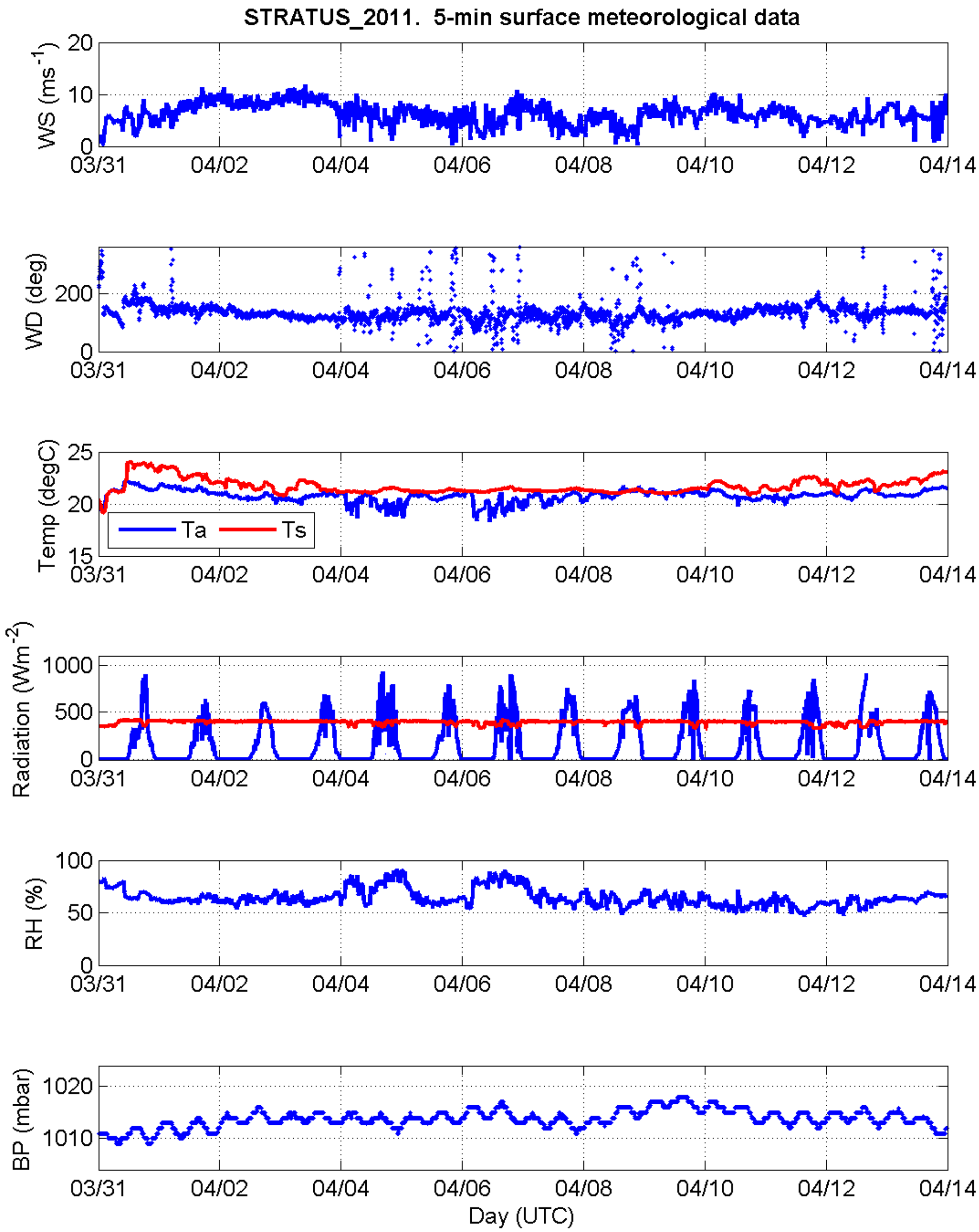

Figure 3-11 (part 2). Time series of the surface meteorological data collected during the Stratus 11 cruise.

2) Intercomparison data sources

ESRL System

The ESRL software system was updated before this cruise, so our software was re-written to accommodate new file structures. There were daily, quality controlled files made available once per day as well as real-time, raw data available continuously. During the cruise, we plotted the processed daily files and appended the raw, real-time data as needed to compare with the real time buoy data. Winds, corrected for ship motion and heading were only available in the daily files, so these were compared in somewhat delayed mode.

The ESRL sample rates and sensor heights were recorded and are shown in Table 3-8.

Table 3-8. ESRL sensors heights and sampling rates.

Sensor	Sample rate	Height (m)
Bow sonic	10 Hz	15
Motion Pack	10 Hz	14.2
ORG	0.1Hz, averaged to 1 sample/min	12.3
AT/RH	0.1Hz, averaged to 1 sample/min	12.8
Licor (CO_2&H_2O)	10 Hz	13.4
Radiometers (top wheelhouse)	0.1Hz, averaged to 1 sample/min	10.7
Radiometers (2nd deck)	0.1Hz, averaged to 1 sample/min	8.9
Barometer	0.1Hz, averaged to 1 sample/min	9.8
SST (seasnake, portside)	0.1Hz, averaged to 1 sample/min	-0.05 to -0.10

VOS System

The VOS system uses standard sensors that are identical to ASIMet buoy sensors. A Linux laptop creates an ASCII text log file with 2-minute subsamples of the internally-recorded 1-minute data.

The VOS sensor heights relative to the water line were measured are shown in Table 3-9.

Table 3-9. VOS sensors heights and sampling rates.

Sensor	Height (m)
SWR	9.93
LWR	9.93
HRH/AT	9.45
BPR	9.83
PCR	10.01
WND	11.18

Sonic Flux System

The WHOI Sonic Flux system is comprised of a Gill R3A Utrasonic Anemometer, a Crossbow DMU-AHRS motion package, and an Onset TT8 interface. The wind sensor was mounted on the forward mast on the *Moana Wave* (9.75m above waterline).

The rate sensor was not cleared, and hard and soft iron constants were not cleared before the cruise. The "SonFlux" logging software was run at 1-minute interval instead of the usual hourly rate. Preliminary comparison with ESRL sonic anemometer shows very good agreement between angles rates, accelerations and vertical velocity.

Figure 3-12. Picture of *Moana Wave*. Meteorological ESRL tower is installed behind the bow mast, on O1 deck. Sonic wind is installed on bow mast and VOS sensors are on top of the wheelhouse.

3) Intercomparison results

The results are presented in Figures 3-13 to 3-23.

Barometric pressure and precipitation rate:
The VOS and buoy BPR measurements reflect the different locations of the sensors, with the VOS at nearly 10 m and the buoy sensors at about 3 m. The difference between these and the ESRL sensor is unexplained. The ESRL BPR sensor is on the bow mast at about the same height as the VOS sensor.

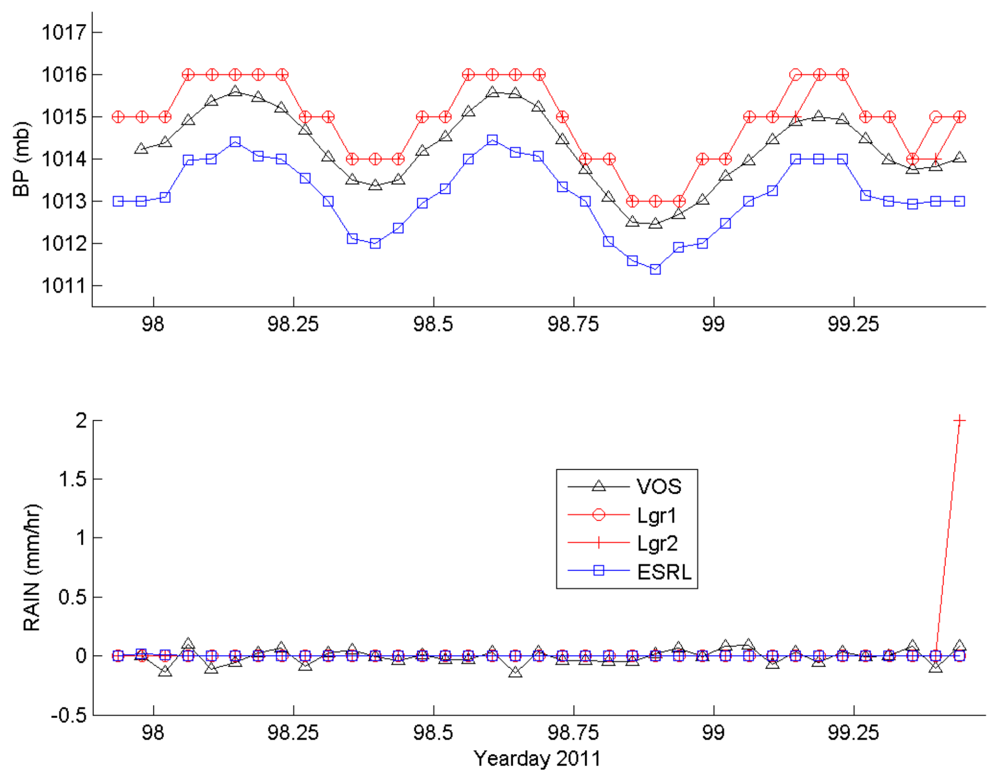

Figure 3-13. Barometric pressure and rain rate during Stratus 11 deployment intercomparison.

Radiometers:
Measured values for downward shortwave radiation are spread among different sensors. Some of this spreading is the natural variability caused by environmental conditions (cloud edge when the buoy is off the ship, shadows when it is on the ship). But there is some indication that SWR from buoy second system (Logger 14) is a bit high. First, its night value is high. Second, while the buoy was on the pier in Arica, its value was higher than SWR on Logger 4 and the VOS value from the sip, which was parked nearby. This

high bias is between 10 and 20 Wm^{-2} for peak values near local noon (this represents a relative difference of 3 to 5% of SWR) and the night values are about 6 Wm^{-2} above zero.

The ASIMET LWRs displayed approximately the same offset as was observed during the burn-in in Woods Hole. LWR on logger 14 on the buoy is low by about 5 Wm^{-2}.

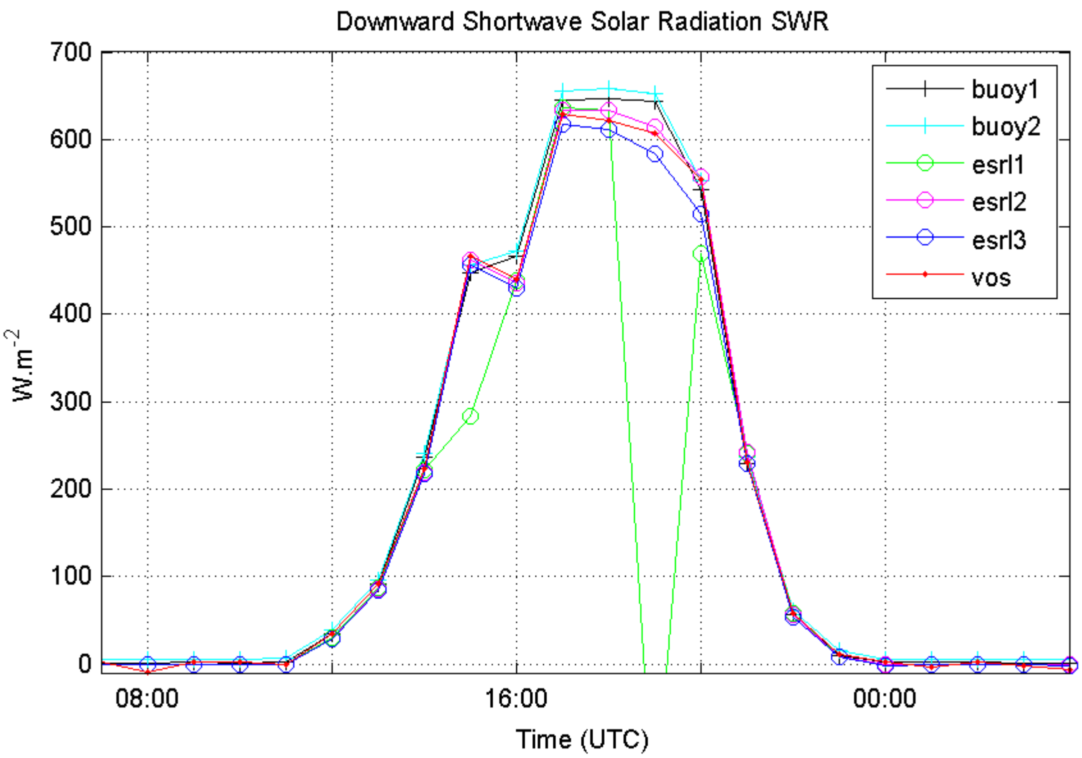

Figure 3-14. Downward SWR on April 8 2011 during Stratus 11 deployment intercomparison. ESRL sensors 1 to 3 are Eppley on bridge, Kipp & Zonen on bridge, and Eppley on O2 deck, respectively.

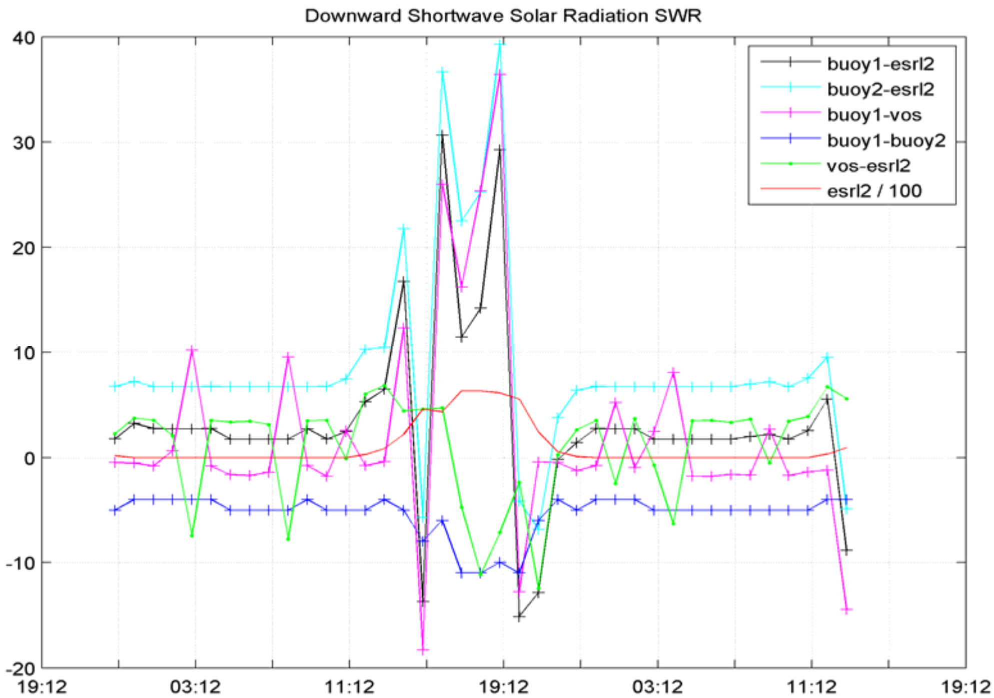

Figure 3-15. Stratus 11 SWR comparison with measurements on *Moana Wave*. Difference in downward SWR during intercomparison.

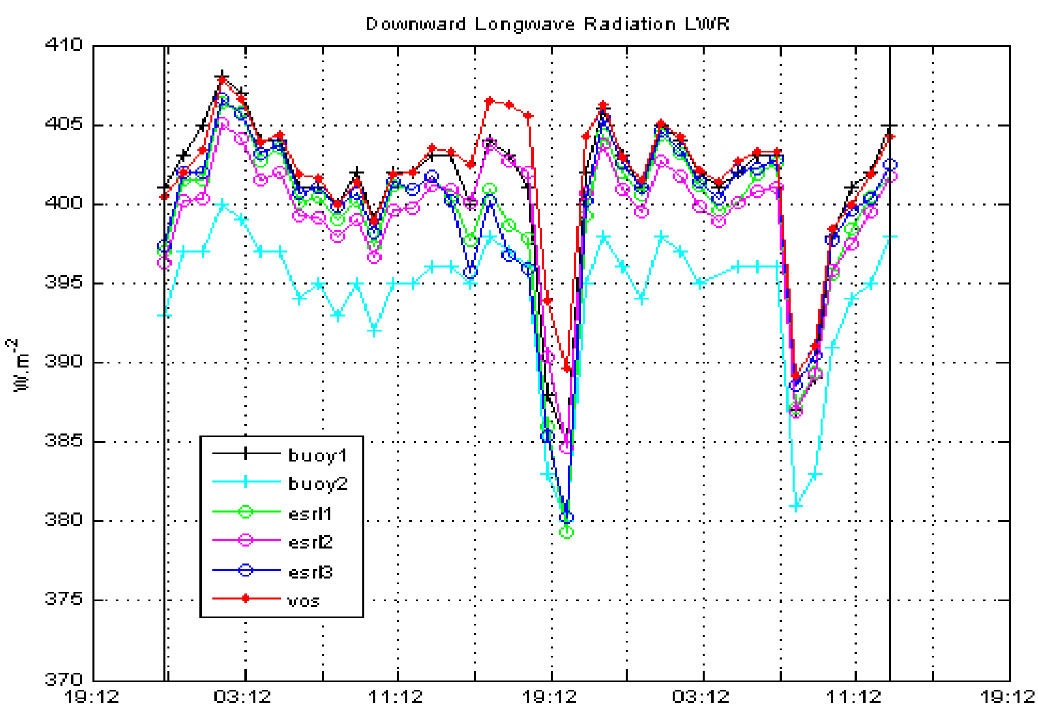

Figure 3-16. Downward LWR on during Stratus 11 deployment intercomparison. ESRL sensors 1 to 3 are Eppley above bridge, Kipp & Zonen on bridge, and Eppley on O2 deck, respectively. VOS is Eppley above bridge. Vertical black lines denote start and end of intercomparison period.

Sea surface temperature and salinity:
Sea surface temperature and salinity: The ESRL sst is from the "sea snake;" there was no salinity measurement made for comparison with the buoy. The sea snake appeared to be tracking the sea surface well during the cruise. The conductivity sensors on the SBE37s on the ASIMet loggers agreed to within specs, for the most part, although there was an apparent problem for about 7 hours with the conductivity sensor on logger 1.

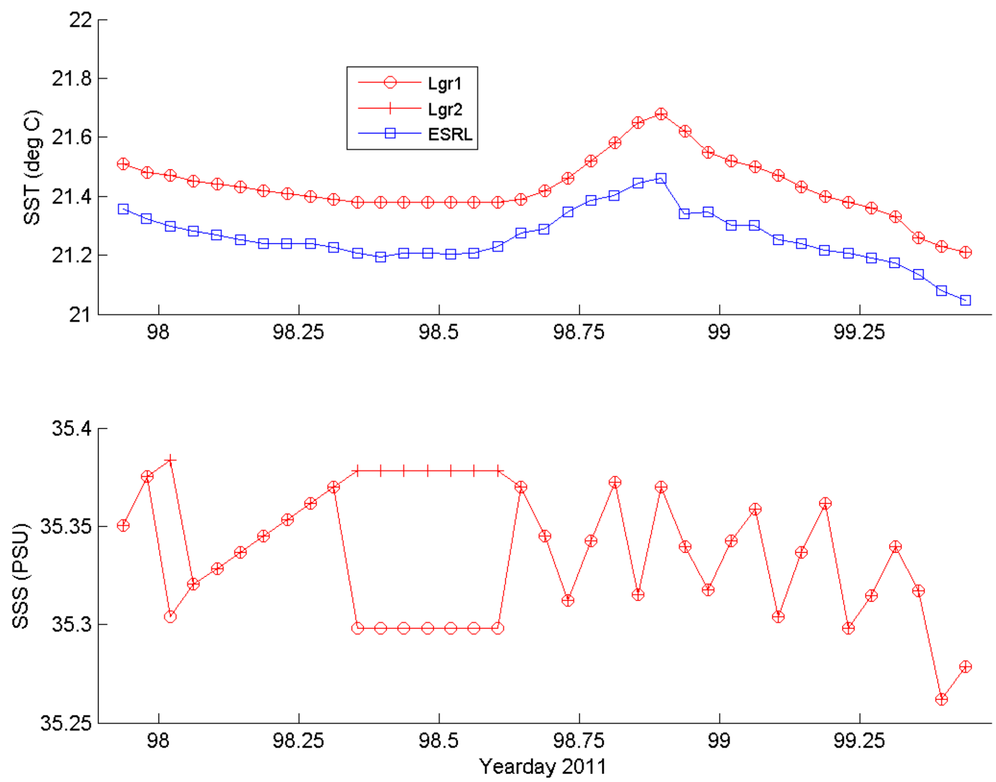

Figure 3-17. Sea surface temperature. Ships values adjusted to skin value, buoy data unchanged. Vertical black lines delimit the inter-comparison period.

Air Temperature:
Air temperature measured from the buoy is warmer than the one on the ship, even after height adjustment (between 0.1 and 0.2 C at night). There is indication that ESRL sensor is also less sensitive to diurnal warming than other sensors (VOS is the worse in that respect). Note that the ESRL AT/RH sensor is the only one that is aspirated. This could also be due to the SST measured by the ESRL seasnake being about 0.2 C warmer than the measurement at the buoy. The COARE 3.0 algorithm indicates that a warm layer can be present during the day with a 0.3 C maximum in early afternoon. However, the profile shown here is for night time when the warm layer has disappeared. So the observed difference in SST may be a real feature of oceanic variability. This would lead to a corresponding shift in the air temperature profile.

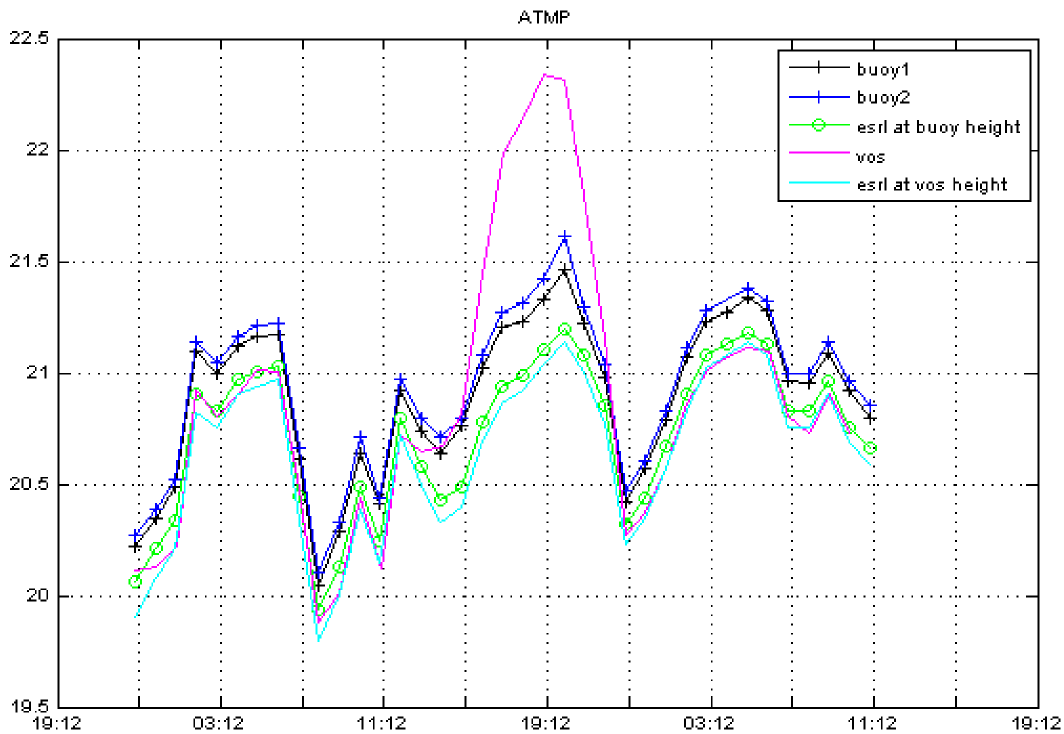

Figure 3-18. Air temperature (°C) during Stratus 11 deployment intercomparison.

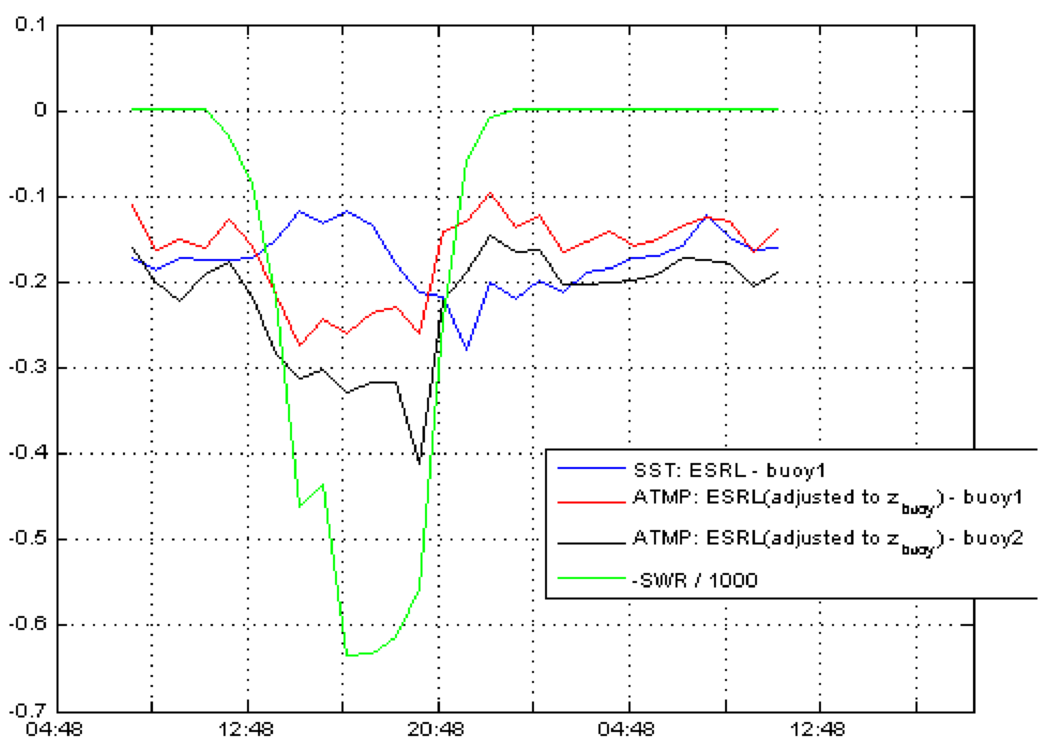

Figure 3-19. Air temperature (°C) difference between ESRL and Stratus 11 buoy during intercomparison period. For reference, SST difference and SWR / 1000 also plotted.

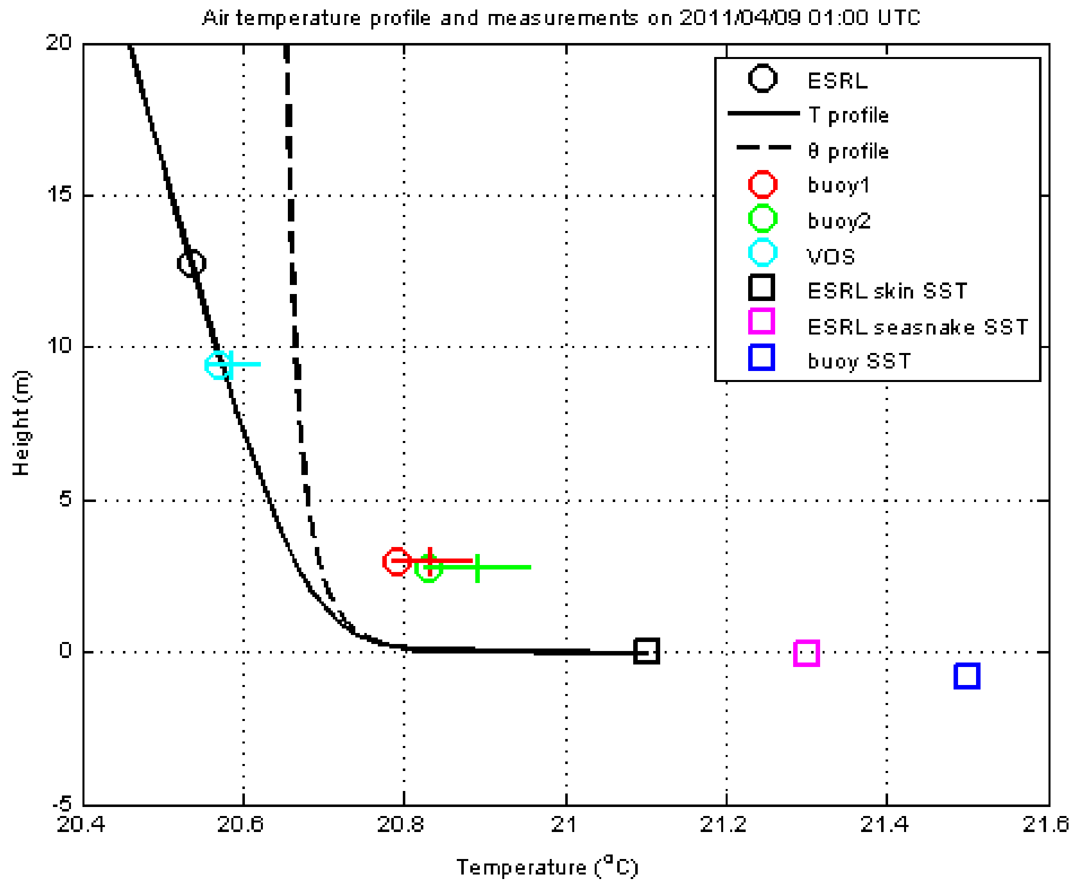

Figure 3-20. Air temperature measured on ship and buoy. Vertical profile from COARE 3.0 in black (dashed line is potential temperature), using hourly averaged value for time 01:00 UTC on 04/09/2011 (night time). Measurements at this hour are denoted by circles or squares. Small vertical bars indicate the average distance between the profile and measurements over the last 24 hours of the intercomparison, whereas the horizontal lines denote its standard deviation.

Air Humidity:

Air specific humidity measured from the buoy is higher than the one on the ship, even after height adjustment. The bias is 0.5 g/kg. The air temperature bias discussed above could explain only about 10% of this. So there is some question here about a possible instrument bias. Indeed, ESRL personnel think that their Vaisala RH is 5% RH low when they compared its measurements with their Licor sensor. The biases decrease during daylight; this decrease is not as important for the VOS.

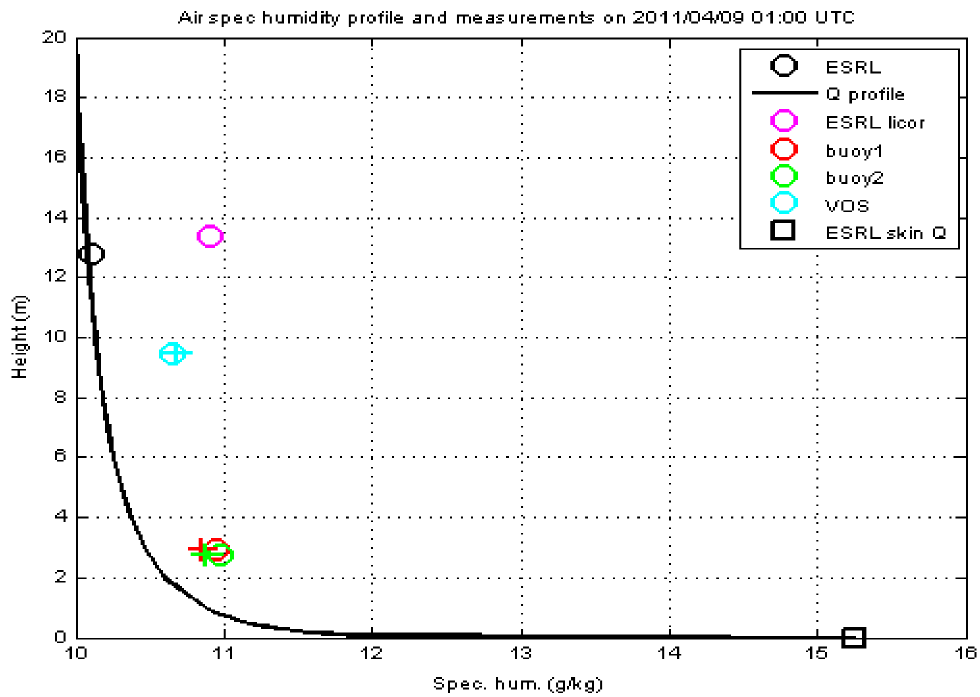

Figure 3-21. Air specific humidity measured on ship and buoy. Vertical profile from COARE 3.0 in black. (See Figure 3-20 for symbols).

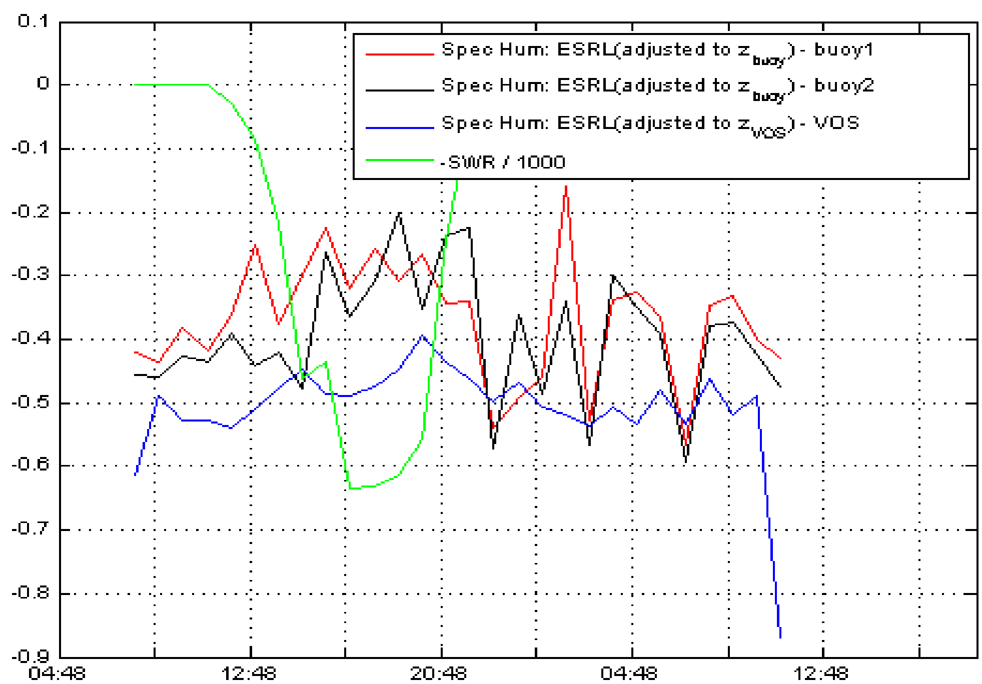

Figure 3-22. Time series of air specific humidity (g/kg) difference ESRL – buoy or VOS. ESRL measurements adjusted for height using COARE 3.0. Downward SWR also plotted.

Wind speed:
Wind speed agrees quite well across sensors and platform, except for the VOS. The VOS wind sensor was a R. M. Young propeller that measures horizontal wind. Since we expect a substantial vertical wind due to flow distortion near the bridge, it is not surprising the VOS underestimates wind speed.

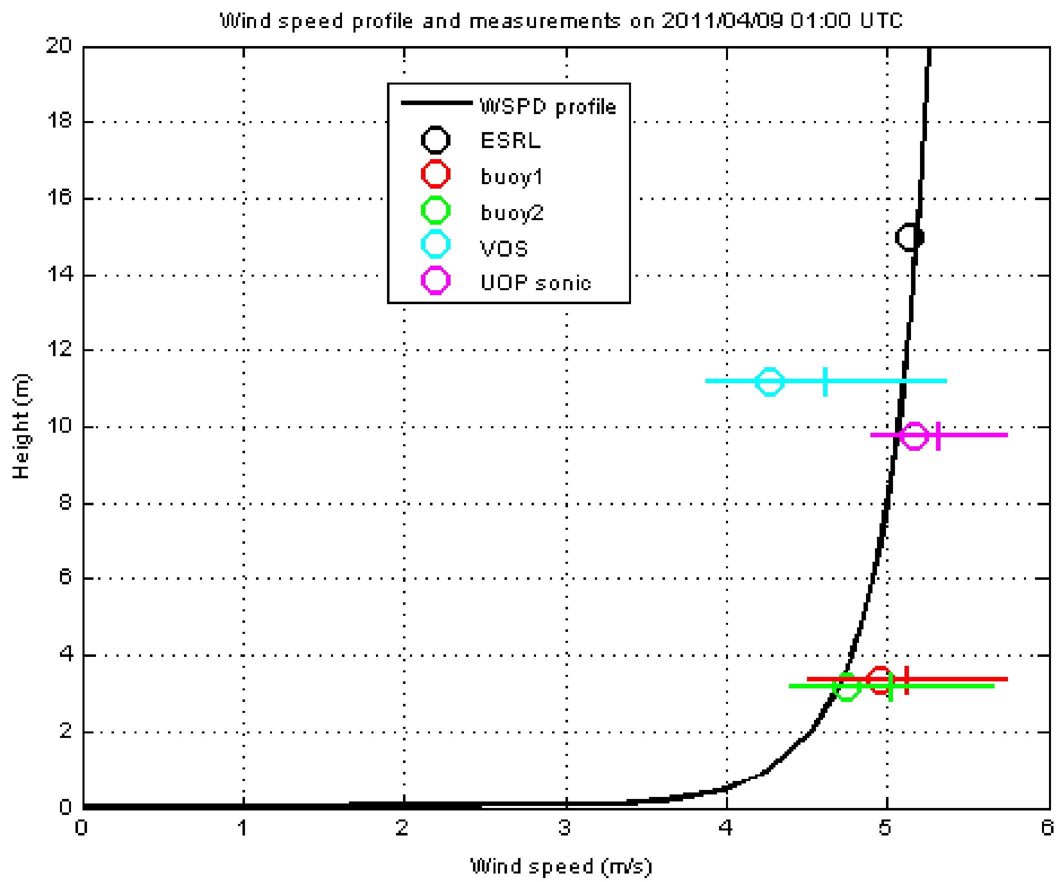

Figure 3-23. Wind speed measured on ship and buoy. Vertical profile from COARE 3.0 in black. (See Figure 3-20 for symbols).

IV. Stratus 10 Mooring

A. Recovery

The STRATUS 10 buoy and 45 meters of instruments and mooring components were recovered in July 2010 on the Peruvian Navy's vessel BIC Humboldt.

The remainder of the Stratus 10 mooring was recovered on April 7, 2011. To prepare for recovery, the *Moana Wave* was positioned roughly 1/10 mile upwind of the anchor position. The release command was sent to the acoustic release to separate the anchor from the mooring line at 11:30 UTC. After about 60 minutes, the glass balls surfaced. Once the glass balls were on the surface, the ship approached the cluster of balls along the starboard side. Recovery commenced by grappling the glass balls, and connecting them to the winch leader with a pickup pole and snap hook.

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 A-frame positioned at the transom, the glass balls were slowly lifted from the water. The cluster of balls was stopped off temporarily using the overhead winch on the A-frame. The snap hook was removed from the winch leader, and a shackle made a positive connection from the winch leader to a end link in between segments of chain. The A-frame was moved out, and the glass balls were lifted completely out of the water using the winch and overhead winch on the a-frame. The A-frame was brought inboard as the winch hauled in, lifting the cluster of glass above the deck. An air tugger was 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 acoustic releases attached to it. 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 releases onto the deck.

A Yale grip was installed on the Colmega line leading into the water, and stopper lines were used to remove mooring tension from the glass balls. The glass ball segments were separated and hauled to the forward and to the starboard side to be lifted by crane into the open container on the 01 deck. The ship continued to steam slowly into the wind during this operation. Once the deck was clear, the deck was rigged for recovery using the large block hung from the aft crane boom positioned inside the a-frame. A working line was led around the capstan and connected to the thimble on the end of the Colmega line. Load was transferred from the stopper lines to the capstan. The Yale grip was removed. The 1500m of Colmega, and 1750 m of 7/8" nylon were hauled in slowly and fed into three wire baskets.

Tension on the mooring increased line as the top section of the mooring was dragged along the sea floor. The ship tried to hold position while the mooring was hauled in. When the termination between the nylon line and the wire to nylon transition piece was at the transom the mooring was stopped of to make the transition from the capstan to the winch for the remainder of the recovery.

Hauling stopped at the end of the 1750-meter shot of nylon. Stopper lines were connected into the link between the 1750 and 200-meter shots of nylon and made fast to the deck cleats. The mooring load was then transferred from the capstan to the stopper lines. The shackle to the 1750-meter shot of nylon was removed. A traveling block was rigged using the overhead crane on the a-frame. The winch leader was led through the traveling block and shackled to the mooring line on the stoppers. The winch then took the load and the stopper lines were removed. The block was hauled up to the top of the a-frame.

The winch continued recovering the 200 nylon/100m 3/8" wire rope with special termination and wire rope. Before long, the first "wuzzle" (a tangled mess of wire rope and instruments) appeared at the surface.

With the A-frame positioned near the transom, the winch hauled in as much wire as possible, bringing the clump of wire and instruments up to the deck level. The air tugger helped to bring the clump onto the deck and hold the mooring in place. At the bottom of the clump, the deck crew determined which pieces of wire rope had tension, and which were just loose loops of wire. Using wire clamps, and cable grips, the crew got control of the mooring and cut the first clump away from the mooring line. The winch continued hauling up wire until another clump of instruments and wire came to the surface.

The same procedure was used to secure the mooring each time a clump of instruments came to the surface, until the entire mooring had been recovered.

B. Mooring Failure

Figure 4-1 shows the failed part, which was at 45 m depth.

Figure 4-1. Stratus 10 mooring failed part, which was just below the 45 meter SBE 37 on a Ti load bar.

C. Stratus 10 data return

Instruments above 55 meters were recovered with the Stratus 10 buoy in July, 2011. The deeper instruments, recovered on April 7, 2011, were processed at sea using our standard UOP software. All data is preliminary and subject to further processing.

Basic metadata, including some required for OceanSITES inclusion, was added to each file during translation to Matlab, as indicated in Table 4-1.

Table 4-1. Metadata for Stratus 10 recovered instrumentation.

site	Stratus
deployment	10
start_year	2010
experiment	Stratus Ocean Reference Station
principal_investigator	Robert. Weller
institution	WHOI
data_assembly_center	WHOI-UOP
source	Mooring observation
platform_type	surface mooring
naming_authority	OceanSITES
cdm_data_type	Station
wmo_platform_code	38400
latitude	19^{o} 36.8088' South
longitude	85^{o} 23.1242' West
depldate	17-Jan-2010 20
anchor_times	[17-Jan-2010 18:23:00, 07-Apr-2011 11:37:30]
duration	444.7184
water_depth	4460
deployment_cruise	RB-10-01
recovery_cruise	MoanaWave201103
deck_height_cm	65
watch_circle_nm	3.7000
magvar_source	NOAA > NESDIS > NGDC
magvar_to_be_used	7.2167
instrument_type	(sbe37, sbe39, or vmcm)
SN	
samplerate_m	(sample rate in minutes)
inputfile	(raw instrument file, *.asc pr *.dat)
decode_program	
decode_program_version	
processing_date	

1) Status upon recovery

Two SBE37 with pressure sensors appeared to have leaked and one Nortek profiler was destroyed after falling to the seafloor when the mooring broke in July 2010. Details for other instruments are described below.

2) Data Return

i) SBE 37

Two SBE 37s with pressure, SN 1912 at 160m and 1910 at 250m, flooded and did not communicate after recovery. Two of the remaining 6 instruments stopped on January 28; the other 4 recorded until March 25 2011.

Dates in the table 4-2 reflect the time of the last record written before the instruments were recovered.

Table 4-2. SBE 37s data return from Stratus 10, recovered on April 2011.

File	Depth	Records	Start	End
1903	62	132077	2010/01/05 01:05	2011/03/25 18:10
1905	85	132076	2010/01/05 01:05	2011/03/25 18:10
1907	130	132077	2010/01/05 01:05	2011/03/25 18:10
1912P	160	NA		
0009	190	112865	2010/01/05 01:05	2011/01/19 05:00
2011	220	132102	2010/01/05 01:05	2011/03/25 18:10
1910P	250	NA		
0010	295	115596	2010/01/05 01:05	2011/01/28 16:35

SBE37 data was converted to ASCII with SBE processing software, and to Matlab using standard UOP software, get_sbe37.m. Clocks were checked and basic inventory plots made.
The actual time of the ice bath is indicated by a black line; the pre-deployment spike, on 1/7/2010 was from 14:28 to 14:49. All instruments agreed, to within one record interval (Fig. 4-2). The post recovery spike is unavailable for instruments 9 and 10, because they did not record after recovery. Instruments 1903,1905,1907 and 2011 are within one record interval of the spike times (Fig. 4-3).

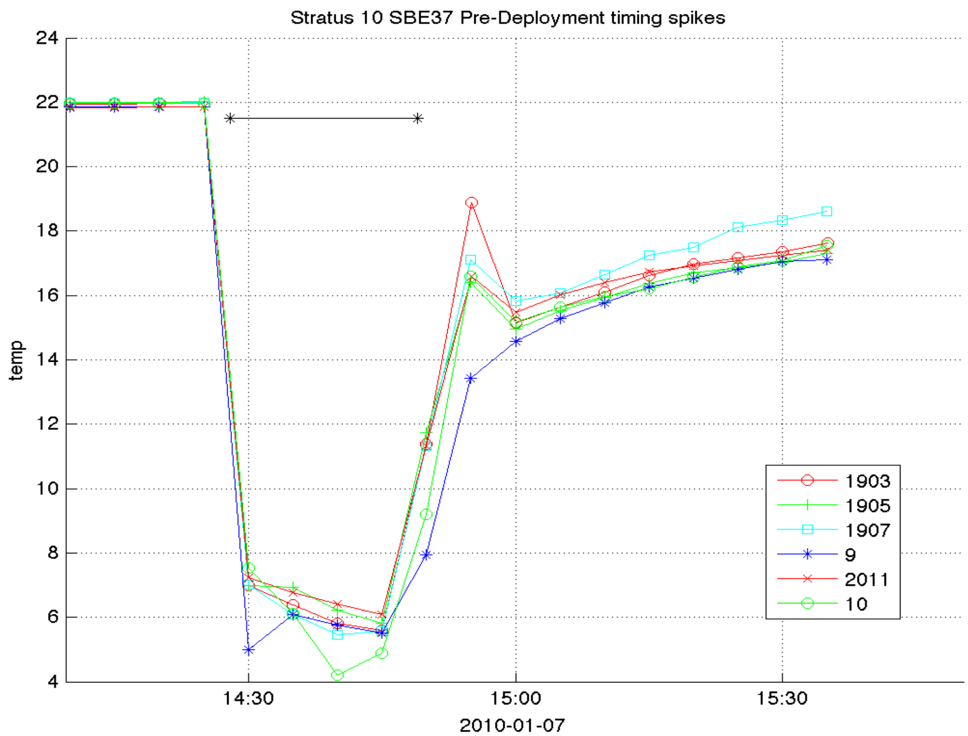

Figure 4-2. Stratus 10 SBE 37 pre-deployment spikes.

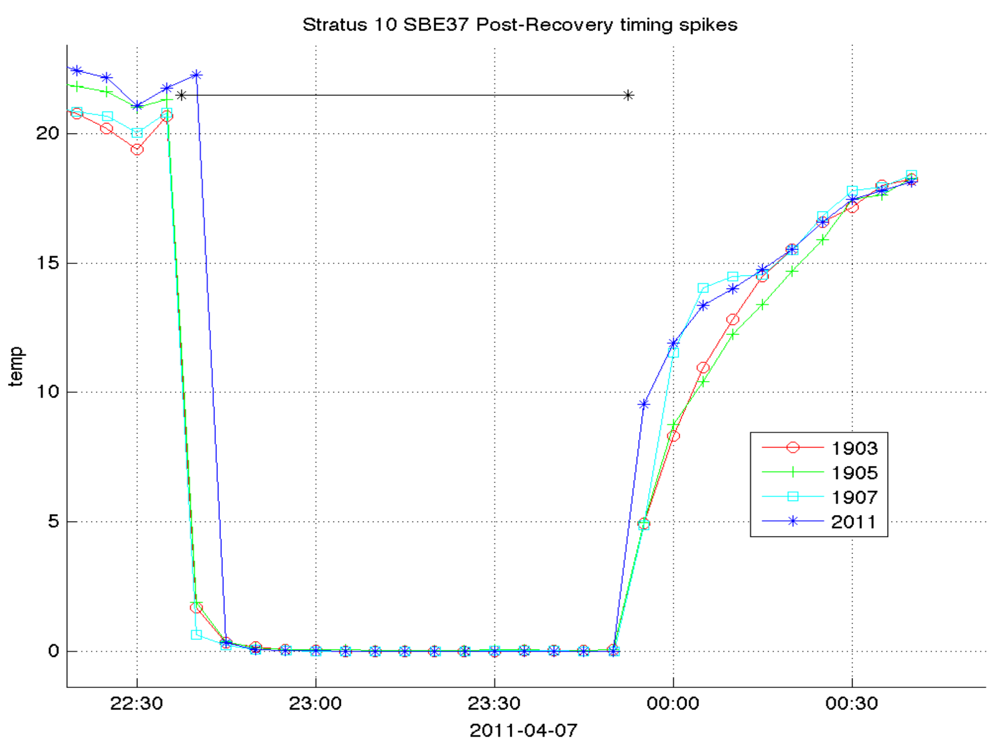

Figure 4-3. Stratus 10 SBE 37s post-recovery spikes.

ii) SBE 39

Seven SBE39s (Microcats) were recovered. All performed well but data ended on March 25, 2011. Data was converted to ASCII with SBE processing software, and to Matlab using standard UOP software. Clocks were checked and basic inventory plots made. An adjustment had to be made to the time word for SBE39 SN 3437. A check of the pre-deployment spike and the first difference of the time word showed that the first 5000 records, up to 22-Jan-2010 21:35:00, needed 12 hours added to the clock. All other SBE39 clocks were satisfactory.

The table 4-3 shows the total number of records from each instrument. The end date/time is the time of the last record before recovery; the instruments were revived for the post-deployment ice spike.

Table 4-3. SBE 39s data return from Stratus 10, recovered on April 2011.

SN	Depth	Records	Start	End
1502	70	132069	2010/01/05 01:00	2011/03/25 18:05
3423	78	132061	2010/01/05 01:00	2011/03/25 18:05
3434	92	132068	2010/01/05 01:00	2011/03/25 18:05
3435	115	132061	2010/01/05 01:00	2011/03/25 18:05
3437	175	131917	2010/01/05 01:00	2011/03/25 18:02
3438	361	132062	2010/01/05 01:00	2011/03/25 18:05
3439	411	132069	2010/01/05 01:00	2011/03/25 18:05

The pre-deployment ice bath was done on January 7, 2010 16:47 to 17:56 UTC (Fig. 4-4). The plot uses the time-adjusted file for SBE 39 3437. The SBE39s were revived for the post-recovery ice bath; all but SN 3437 were iced on April 7, 2011, from 22:03:30 to 22:34:00 UTC (Fig. 4-5). SN 3437 was spiked separately on April 7, from 22:37:30 to 23:52:30 and its clock looks good (Fig. 4-6).

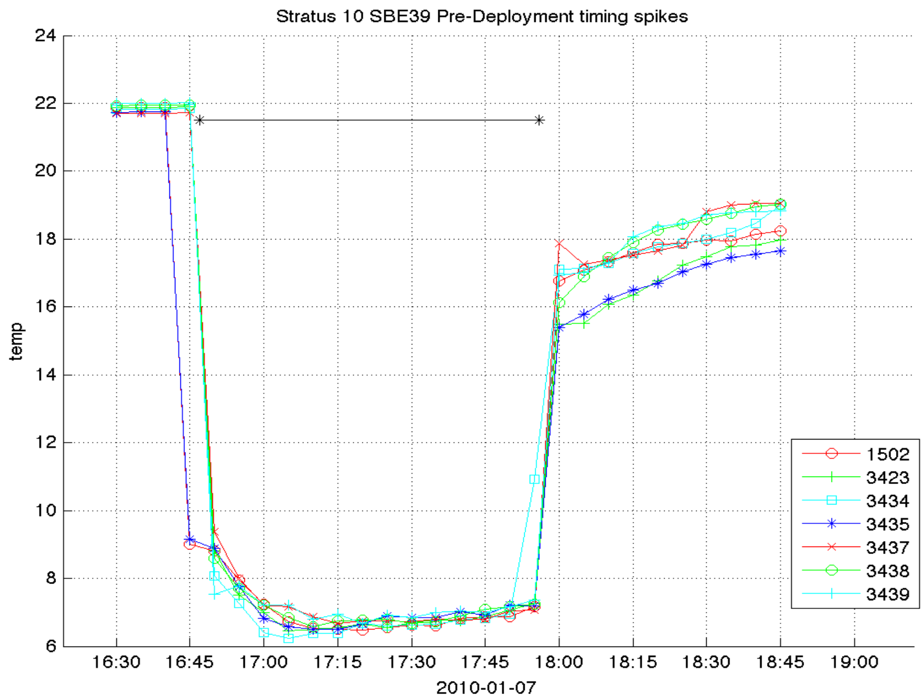

Figure 4-4. Stratus 10 SBE 39 pre-deployment spikes.

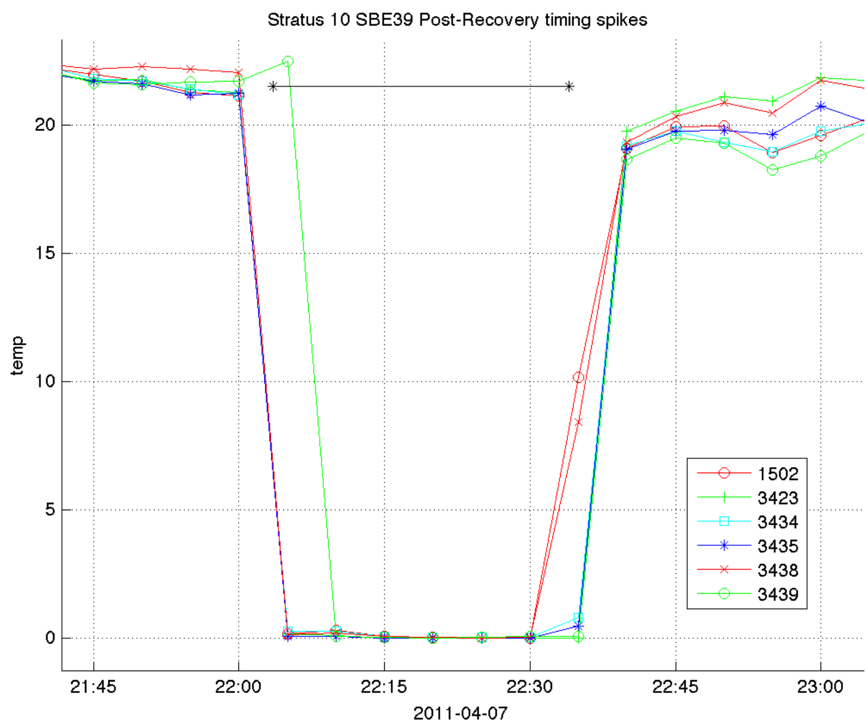

Figure 4-5. Stratus 10 SBE 39 post-recovery spikes.

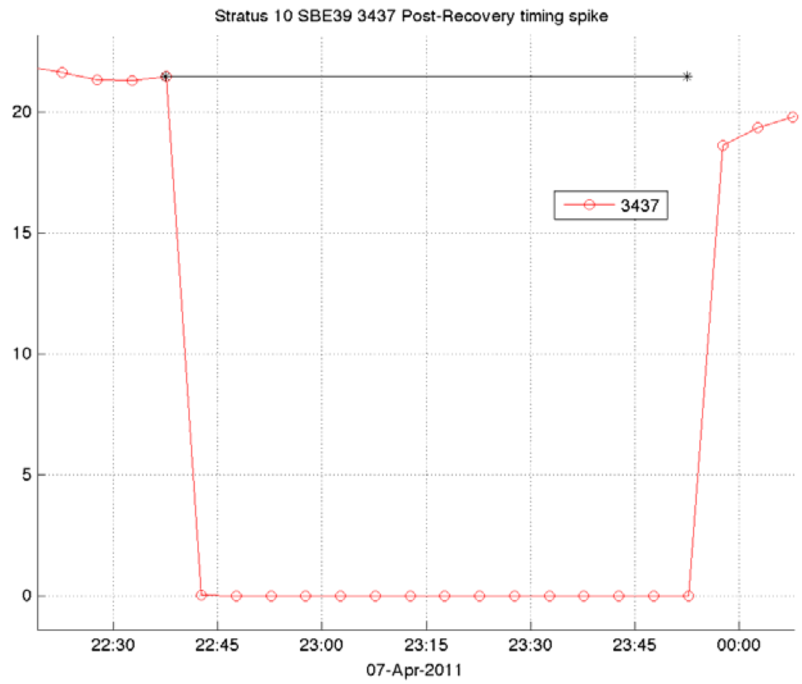

Figure 4-6. Stratus 10 SBE 39 SN 3437 post-recovery spike.

iii) VMCM

Eight VMCMs were recovered. All had Intel Type II memory cards, which were read on Linux laptop and transferred to Mac laptop for decoding in Matlab. All the cards were readable, although the VMCM 40 card had to be tried many times before the PCMCIA driver would recognize it; this card should probably not be reused. The card in VM 29, which had to be dried with dessicants, was read with no problem.

The standard UOP decoding program was used, Matlab program vm_to_asc.m from UOPSoftware directory. There were no prespikes to check, but we were able to look at timing of mooring line break, which showed some clock errors.

No records from VMCM 14 could be found beyond January 16, a few days after deployment. VMCM 3 had fishing gear on one propeller. No other problems were found, other than some time offsets, shown in Table 4-4. VMCM clocks were checked by plotting the velocities at the time of the mooring failure (Fig. 4-7).

Table 4-4. VMCMs data return from Stratus 10, recovered on April 2011.

SN	Depth	Records	Start	End
003	100	612954	2010/01/10 18:41	2011/03/05 10:51
014	145	8322	2010/01/10 18:54	2010/01/16 13:34
029	183	612954	2010/01/10 19:17	2011/03/05 12:03
034	235	612954	2010/01/10 18:23	2011/03/05 10:14
037	280	612954	2010/01/10 19:01	2011/03/05 11:31
040	311	431089	2010/01/10 19:06	2010/10/30 04:34
053	814	612954	2010/01/10 19:11	2011/03/05 11:51
076	1517	603774	2010/01/10 18:47	2011/02/27 02:02

An inventory plot of the VMCM velocities before the mooring failure is shown in Figure 4-8.

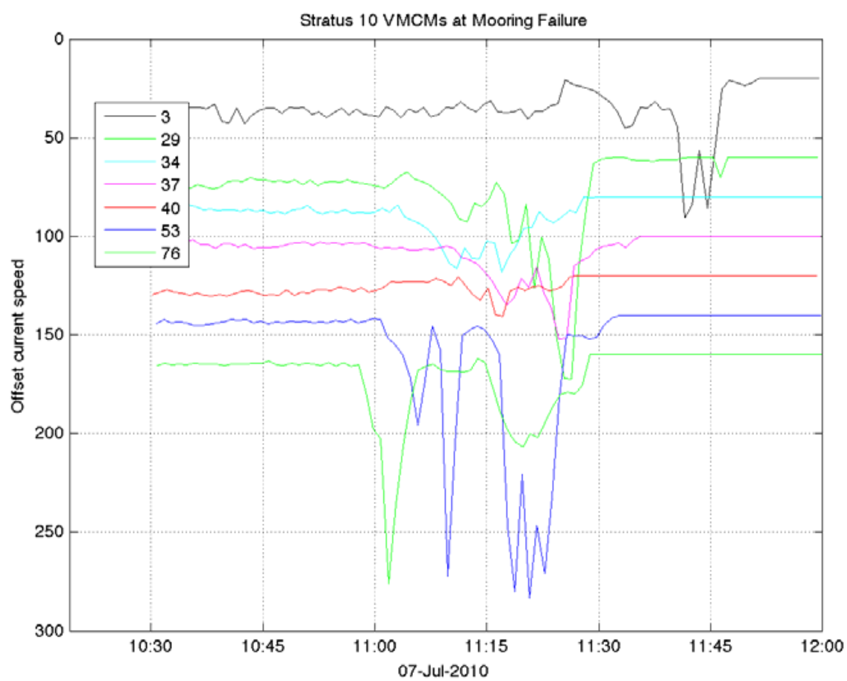

Figure 4-7. Stratus 10 VMCMs at time of mooring failure.

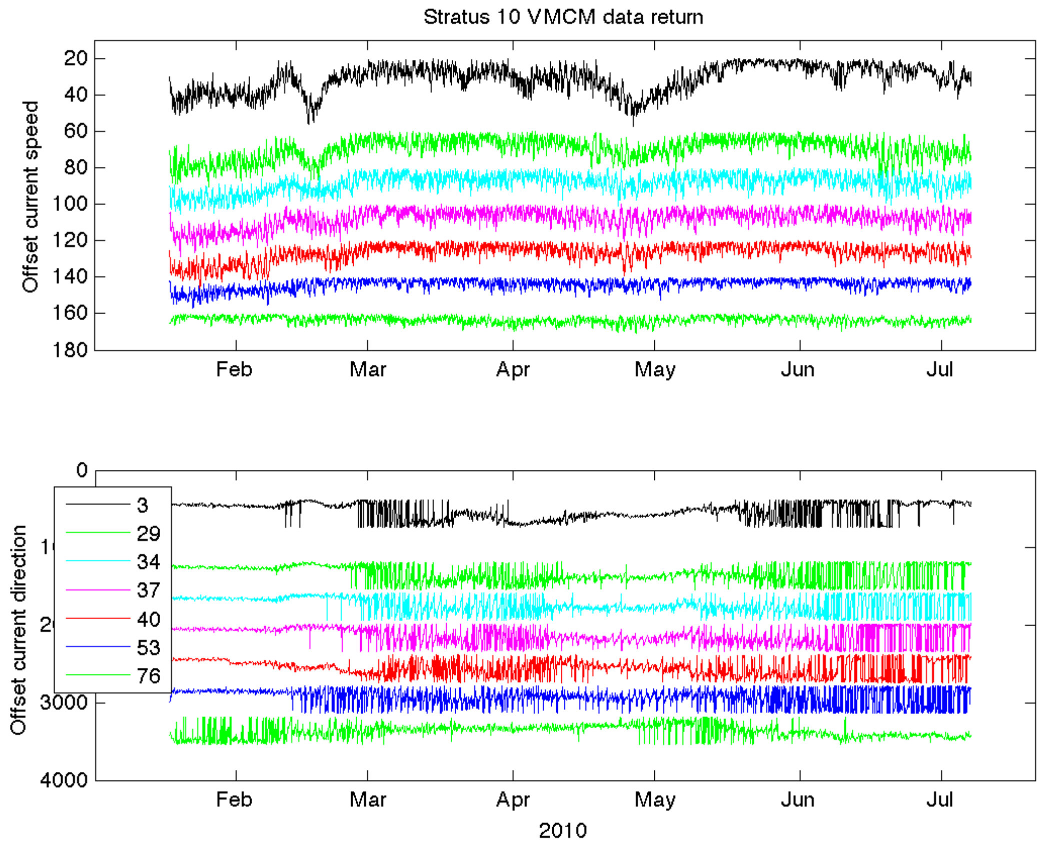

Figure 4-8. VMCM data return on Stratus 10.

iv) ADCP

The Teledyne-RDI 300 KHz Workhorse ADCP was deployed upward-facing at 135m with the configuration shown in Table 4-5. It was processed with our standard Matlab script, upkadcp, and then converted to more standard structures with proc_rdi.m. There was a predeployment spike, however it occurred before the instrument began recording, on 07-Jan-2010 at 16:45:57 UTC. Data continued after the mooring failure, ending on 21-Nov-2010 at 13:45:57 UTC.

Table 4-5. Stratus 10 RDI ADCP setup configuration.

NumRangeBins	12
RangeBinLen	1000
CenterRangeBin1	1200
BlankAfterXmit	176
XmitPulseLen	998
PingsPerEns	60
LowCorrThresh	64
MinPercentGood	0
ErrorVelThresh	2000
FalseTargetThresh	50
ADCP frequency	300
BeamGeometry	'convex'
BeamDirection	'upward'
BeamAngle	20
Units	'All distances in cm'

A plot (Fig. 4-9) of a single bin velocity at launch indicates that the clock was set correctly.

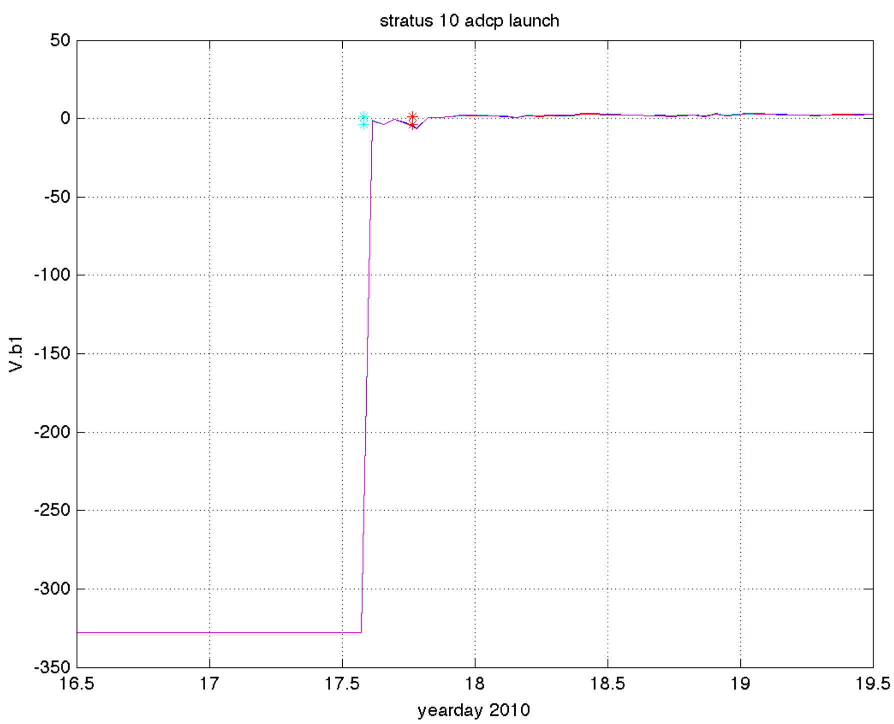

Figure 4-9. Stratus 10 RDI ADCP indicating start of measurements (velocity V from beam 1) in January 2010.

An inventory plot of velocities before the mooring break, bin 8 (top) to 1 (bottom) is shown in Figure 4-10.

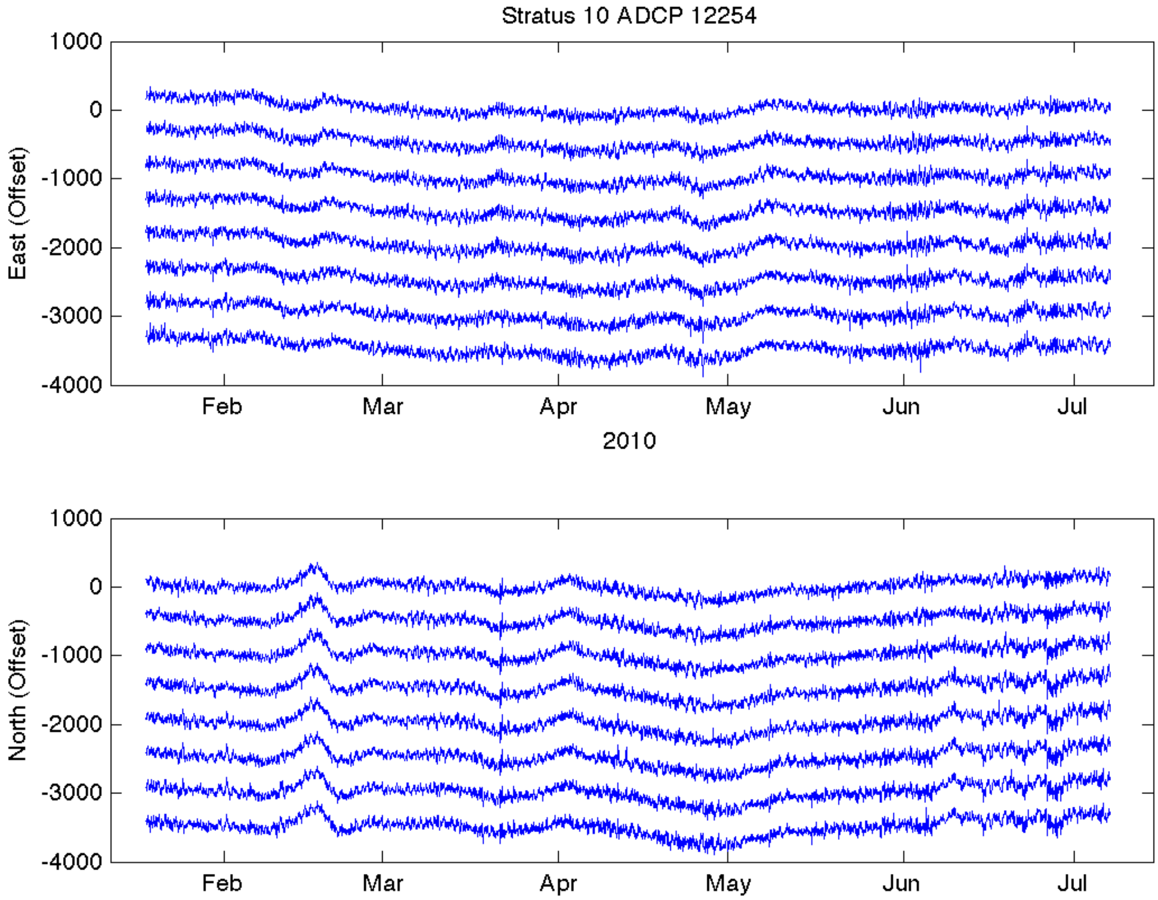

Figure 4-10. Stratus 10 RDI ADCP: time-series of east and north velocities during Stratus 10 sampling period (January to July 2010).

v) Temperature record inventory

An overall timing check was done by plotting the temperatures from all recovered instruments around the time of the mooring failure on July 7, 2010 (Fig. 4-11). Figure 4-12 shows the time-series of temperature for the whole Stratus 10 sampling period, starting in January 2010 and ending at mooring failure; SBE37s are plotted in blue, SBE39s are green, and VMCMs are black.

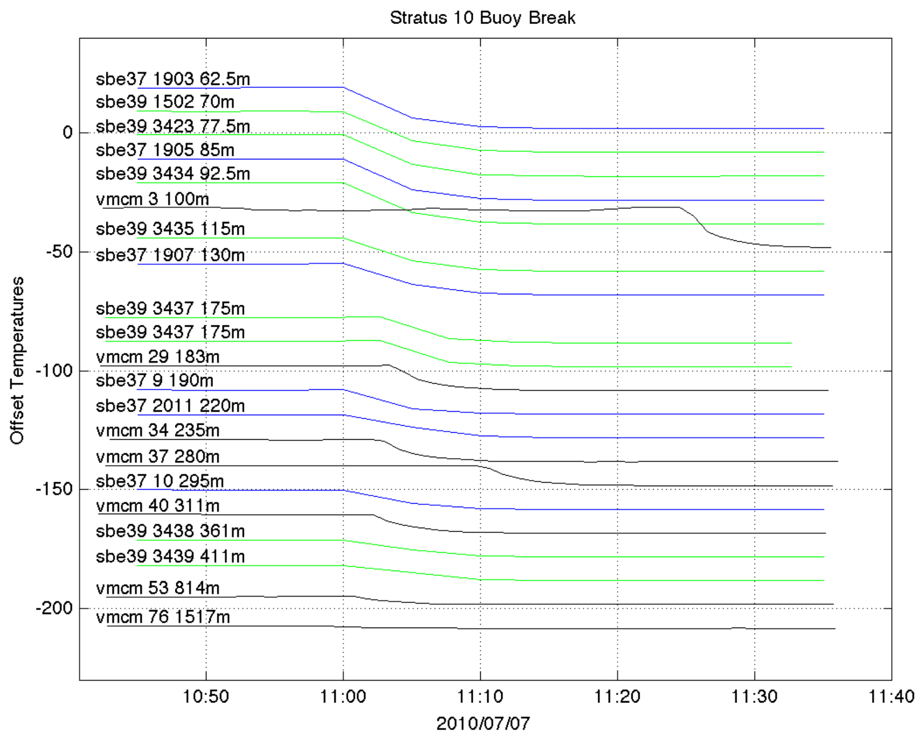

Figure 4-11. Temperature record for Stratus 10 subsurface instrumentation near time of mooring failure (July 7 2010). These instruments were recovered in April 2011.

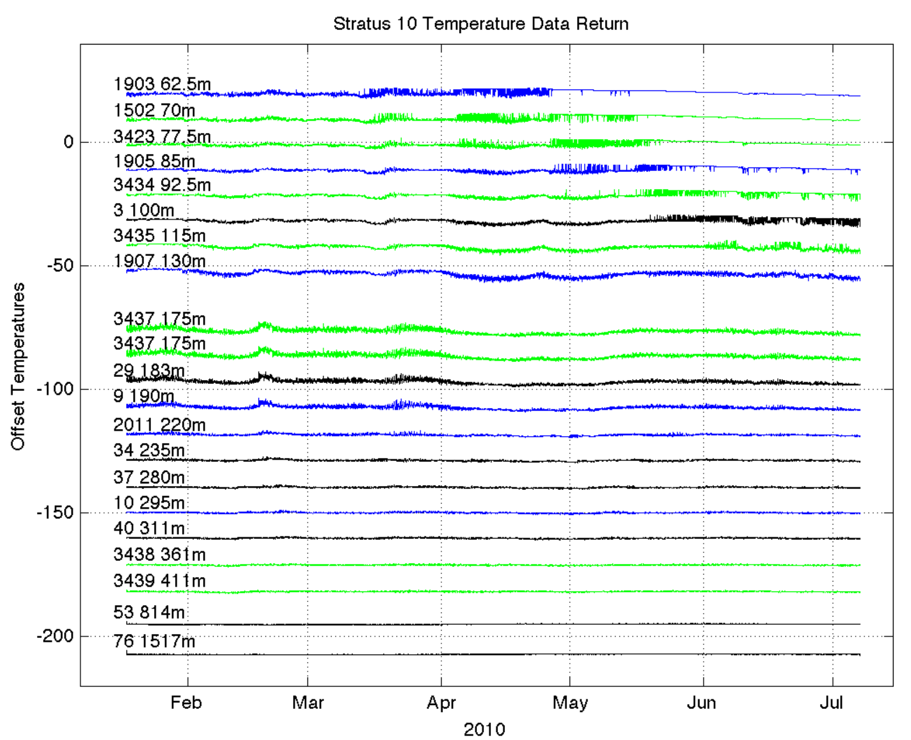

Figure 4-12. Overall temperature record for Stratus 10 subsurface instrumentation recovered in April 2011.

V. Ancillary Projects

A. Hydrography: UCTD and CTD

1) Operation

The UCTD is an underway system for acquiring conductivity and temperature profiles at ship speed up to and exceeding 13 knots. It is manufactured, packaged, and sold by *Oceanscience* in Oceanside, California. Our experience during the Stratus 11 cruise was that a maximum ship speed of 9 knots was preferable to attain a depth between 400 and 500m, using a 500 lbs line.

The system was operated from the after portion of the stern deck. A length of line equal to the desired cast depth was wound onto the CTD's tail spool. While the ship steamed away from the drop site, the probe plunged vertically with a nearly constant drop rate independent of the ship’s speed.

Line was spooled automatically off the probe’s tail while it dropped through the water and line was manually payed out from the winch spool. The simultaneous payout of line from the probe’s tail and winch effectively made the line horizontal velocity through water zero, allowing freefall.

The CTD probe sampled conductivity, temperature, and depth at a sampling rate of 16 Hz while descending vertically through the water column at ~4 meters per second. Data was stored internally in flash memory and downloaded wirelessly via Bluetooth to a host computer or PDA after recovery. Figure 5-1 shows the UCTD winch installed on the fantail of the *Moana Wave*.

The latitude and longitude of individual casts was obtained by matching an internal time stamp in the data file header to an externally collected GPS file. Synchronization of instrument and GPS time was important. MATLAB scripts were used for processing.

Figure 5-1: UCTD assembled.

2) CTD Sensor Specifications

The range of the temperature sensor is 5 to 43°C; conductivities can be measured from 0 to 9 S/m, and the pressure range is 0 to 2000 m. The pressure housing is rated for a depth of 2000 meters although the operating depth is normally less than 1000 meters. According to the manufacturer, typical accuracies of the processed data are 0.005-0.02°C for temperature, 0.002-0.005 S/m for conductivity, 1 dbar for pressure, and 0.02 -0.05 psu for salinity. For more information about the UCTD, see http://www.oceanscience.com/uctd.html and also Rudnick and Klinke (2007).

3) Data processing

We brought 4 UCTD probes (# 23, 27, 29 and 30) on the Stratus 11 cruise. Probe 23 was the first probe used. A deep UCTD (~1000m) was done shortly after a regular CTD cast, while the ship almost stopped. The CTD sensor was an SBE 19 with pump which had been calibrated in May 2009. The SBE 19 samples at 2Hz and the UCTD probes at 16Hz. The CTD was lowered throughout the water column at a speed of 1 ms^{-1}. The comparison between these sensors is shown in Figure 5-6 and 5-7. The uctd folder contains all of the uctd profiles, to full depth. The profiles have been averaged into 1 dbar bins starting at 3 m, using only the downcast. No alignment of temperature and conductivity was performed. The tow-yo sections were broken up into individual profiles and identified by their time during the tow yo. The file stratus11uctd.mat contains the upper 500 m of each profile, as well as the date and location of each profile.

Table 5-1. Periods of use for the different UCTD probes used during Stratus 10 cruise.

SN	Usage period
23	04.09.2011 13:10 to 04.12.2011 09:01
27	04.12.2011 09:35 to 04.15.2011 18:00

4) UCTD Results

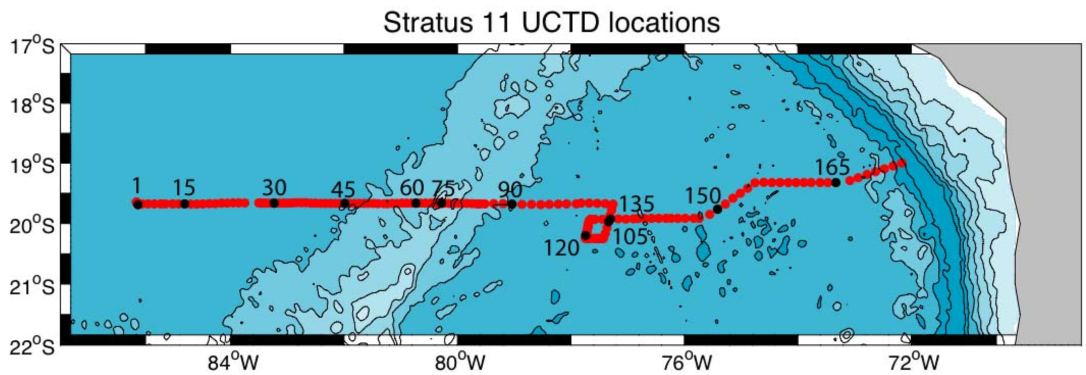

Figure 5-2. Map of UCTD locations during the transit WHOI Stratus buoy to Arica.

172 UCTD profiles were collected during the return leg from Stratus, starting at ~85.5 W to nearly 72 W. Figure 5-2 is a map of the UCTD locations. Every 15th profile is labeled. For the majority of the profiles, we spun 400 m of line onto the UCTD tail, and let the probe drop for 2 minutes before retrieving. We initially attempted to collect UCTD profiles every half hour, but the UCTD winches could not handle the load, and we reduced the profiling frequency to once every hour. Ship speed was generally less than 9 knots, so the maximum profile spacing is on the order of 9 miles. At various times we tow-yoed the UCTD; rather than retrieving the probe and rewinding the tail, we used the winch to bring the probe to the surface, and then immediately lowered it again off of the winch's spool. For the tow-yos, we let the probe descend for 4 minutes before retrieving it to the surface and repeating. Speed varied during the tow-yos; we averaged 5-6 profiles per hour, at speeds less than 9 knots. Tow-yos were used to sample the Nazca Ridge, as well as a cyclonic eddy and its edges. The square survey sampled the area

between a cyclonic eddy to the east and an anticyclonic eddy to the west. We used two different UCTD probes, 23 and 27. The cell on probe 23 appeared broken after hard contact with the ship during retrieval. We also used both UCTD winches, eventually settling on winch 1 when winch 2 broke.

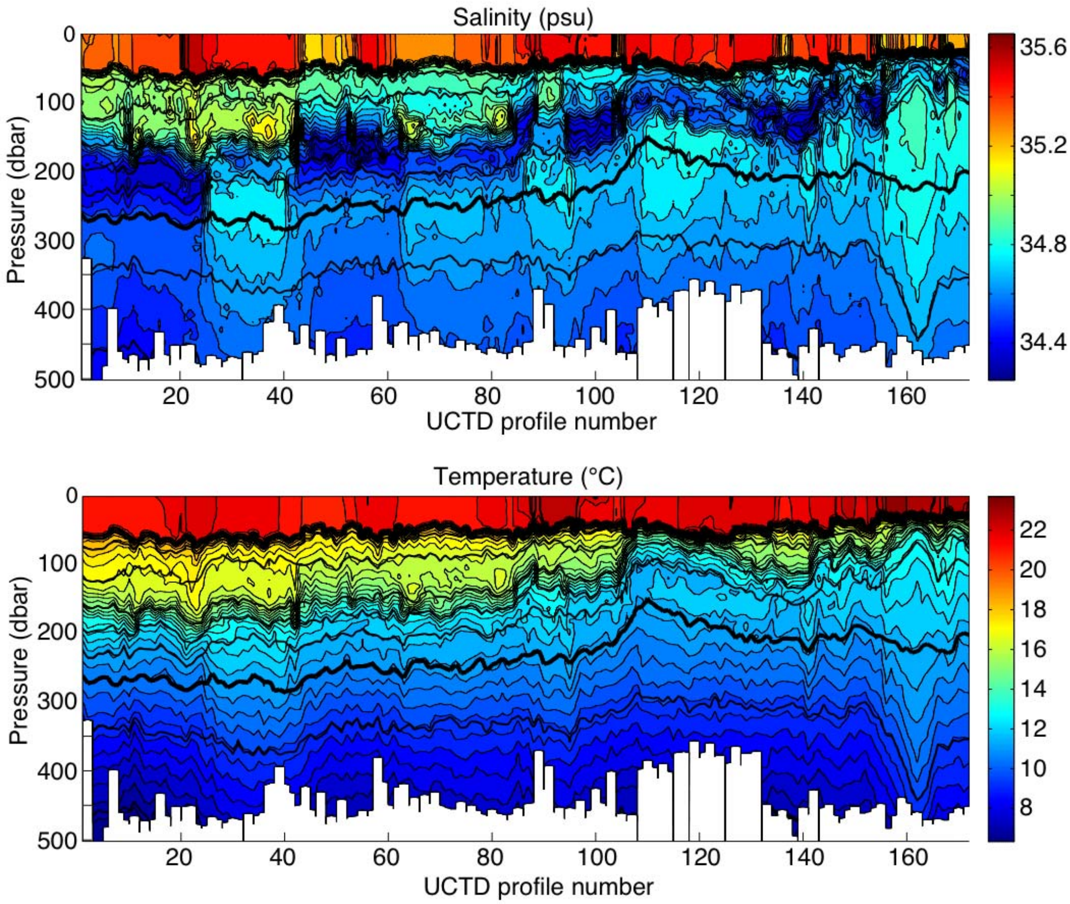

Figure 5-3. Salinity and temperature profiles during Stratus 11 UCTD section, eastward from WHOI Stratus buoy to Arica.

UCTD temperature and salinity sections are plotted in Figure 5-3. Isopycnals are contoured with bold lines at 0.25 kg/m3 intervals; the 26.5 isopycnal is particularly thick. The isopycnals generally rise toward the coast, though eddies modulate their depth. The salinity minimum layer, at depths ranging from approximately 100-200 m, is an obvious feature. Its salinity varies considerably; the freshest salinity minimum layer had a salinity of ~34.2 psu. The salinity minimum layer shoaled and gained salt in the eddies sampled during the cruise. Besides the salinity minimum layer variations, eddies were evident by higher salinity along the 26.5 isopycnal. Salinity along the 26.5 isopycnal is commonly used to identify eddies in the eastern subtropical Pacific. The eddies form near the coast, where they trap the high salinity signal of the poleward coastal undercurrent at approximately 26.5 kg/m3, subsequently transporting it offshore. The spreading of 26.75

and 26.25 isopycnals and high salinity between them near UCTD profile 162 is typical of anticyclonic eddies. There is also a rich structure in the remnant mixed layer between the salinity minimum layer and the warm, salty surface mixed layer.

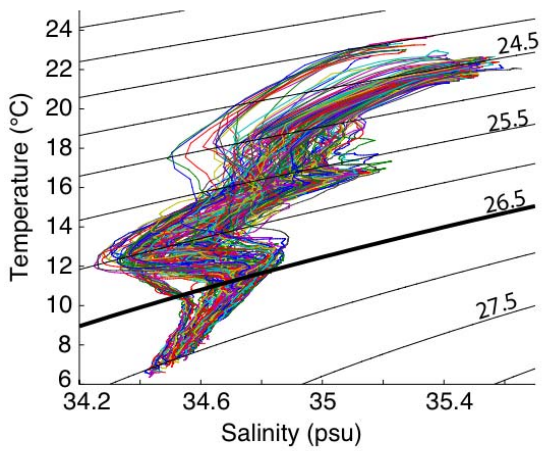

Figure 5-4. T-S relationship from UCTD casts made during stratus 11 cruise.

In T-S, we again see the signature of eddies in the higher salinities along the 26.5 isopycnal. The profiles with the lowest salinities along the 26.5 isopycnal were collected closest to Stratus, where much of the water column was colder and fresher than normal.

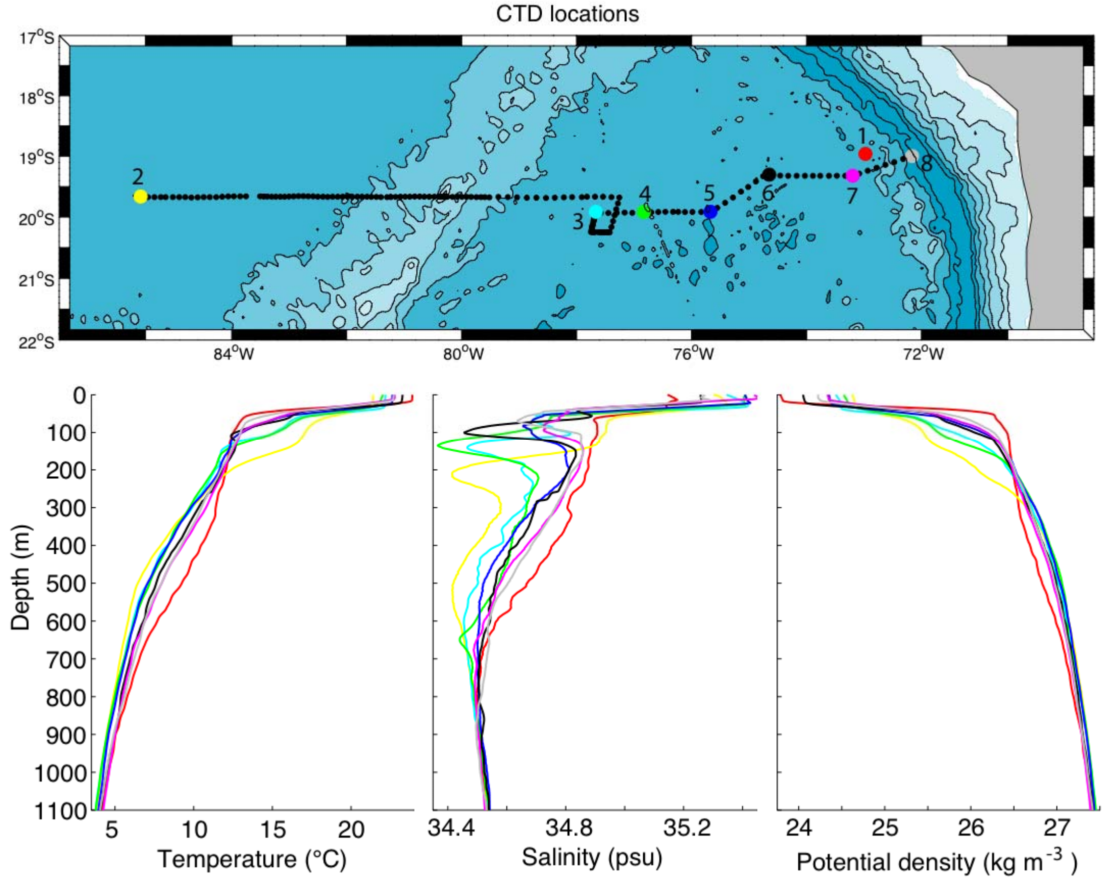

Figure 5-5. CTD casts made during Stratus 11 cruise.

The locations, density profiles, and T-S plots for the 8 CTD profiles are plotted in Figure 5-5 (top). The profiles ranged in depths from ~1600-1800 m. CTD profiles 3,4, and 5 sampled a cyclonic eddy. We again see the variability of the salinity minimum layer depth and salinity.

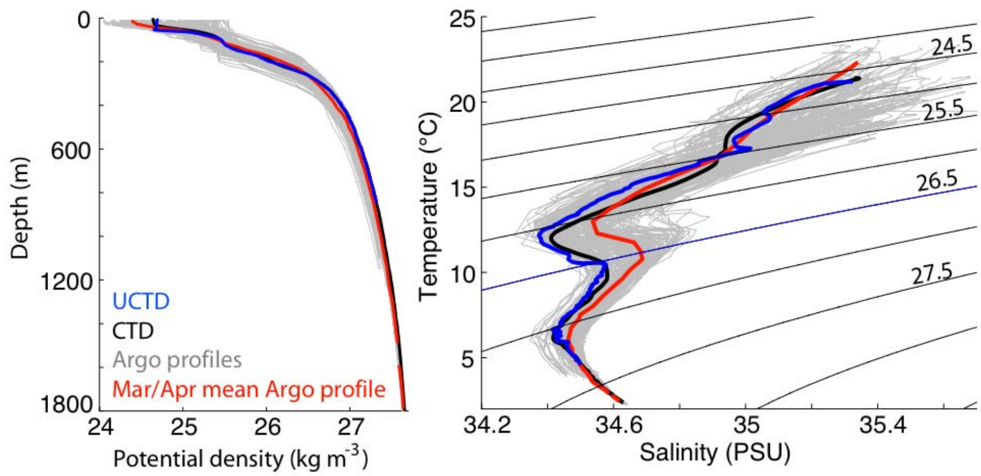

Figure 5-6. UCTD casts made with first probe used (#23) during stratus 11 cruise.

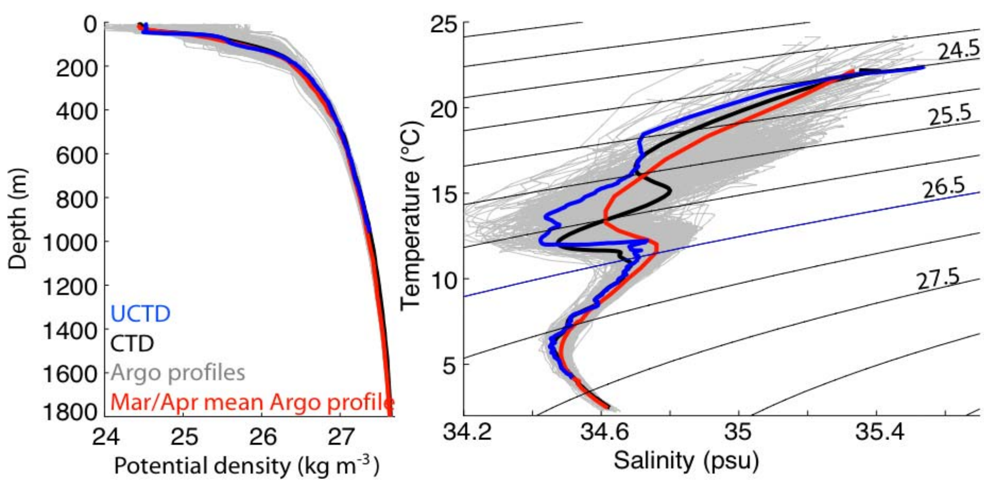

Figure 5-7. UCTD casts made with second probe used (#27) during stratus 11 cruise.

Figures 5-6 and 5-7 compare neighboring CTD and UCTD profiles with Argo profiles collected within 2 degrees of each CTD location. Probe 23 comparison was done at Stratus (CTD 2) and probe 27 comparison was done during the eddy survey (CTD 3). Roughly 200 Argo profiles are represented in each plot. The mean Argo profile from March and April is also plotted. There is generally good agreement at depth between both UCTD probes and the CTD. All profiles are generally within the range observed by Argo.

B. Deployment of Apex Floats and Drifters

During the Stratus 11 cruise, a 24-hour under way watch schedule was established. Watch standers were responsible under way CTD casts, and for surface drifter deployments.

Figure 5-8. Apex Float of the type deployed during stratus 11 cruise.

Eight Apex floats were provided by IFM Geomar (Lothar Stramma) to deploy on the STRATUS 11 cruise track. The floats were equipped with optional oxygen optodes. The floats were ballasted for 400-meter and 1000-meter profile depths, and were deployed in pairs. Deployment positions were selected by the chief scientist, using satellite altimetry (Figure 5-9) to select areas of interest. The SVP drifters were deployed with each pair of floats.

Table 5-2. Float Deployment Log, shows the dates and positions of float deployments.

FLOAT ID	START DATE/TIME (UTC)	DEPLOY DATE/TIME (UTC)	DEPLOYMENT POSITION
5613	4/2/11 11:00	4/2/11 14:30	19 44.8 S 75 59.6 W
5631	4/2/11 11:00	4/2/11 14:30	19 44.8 S 75 59.6 W
5614	4/2/11 14:40	4/2/11 17:30	19 44.7 W 76 29.7 W
5632	4/2/11 14:40	4/2/11 17:30	19 44.7 W 76 29.7 W
5615	4/2/11 18:00	4/2/11 20:35	19 44.8 S 76 59.9 W
5633	4/2/11 18:00	4/2/11 20:35	19 44.8 S 76 59.9 W
5616	4/10/11 8:30	4/10/11 12:00	19 39.8 S 85 38.9 W
5634	4/10/11 8:30	4/10/11 12:00	19 39.8 S 85 38.9 W

The surface drifter, Figure 5-9, is a high-tech version of the "message in a bottle". It consists of a surface buoy and a subsurface drogue (sea anchor), attached by a long, thin tether. The buoy measures temperature and other properties, and has a transmitter to send the data to passing satellites. The drogue dominates the total area of the instrument and is centered at a depth of 15 meters beneath the sea surface. More information on the Global Drifter Program can be found at http://www.aoml.noaa.gov/phod/dac/gdp.html. The drifters were deployed at specified locations. The ship was not slowed for deployments of the surface drifters.

Figure 5-9. Typical Surface Drifter

Table 5-3. Drifter Deployment Log

DRIFTER ID	DATE	TIME (UTC)	DEPLOYMENT POSITION
90260	4/2/11	14:30	19 44.8 S 75 59.6 W
90263	4/2/11	14:30	19 44.8 S 75 59.6 W
90264	4/2/11	14:30	19 44.8 S 75 59.6 W
90257	4/2/11	17:30	19 44.7 S 076 29.7 W
90258	4/2/11	17:30	19 44.7 S 076 29.7 W
90259	4/2/11	17:30	19 44.7 S 076 29.7 W
90255	4/2/11	20:35	19 44.8 S 76 59.9 W
90256	4/2/11	20:35	19 44.8 S 76 59.9 W
90261	4/2/11	20:35	19 44.8 S 76 59.9 W
102582	4/3/11	8:45	19 44.4 S 79 00.8 W
40436	4/3/11	14:25	19 44.6 S 80 00 W
40435	4/3/11	20:10	19 43.4 S 81 00.2 W
40438	4/4/11	2:00	19 43.9 S 81 59.6 W
40434	4/4/11	7:56	19 43.5 S 83 00 W
102584	4/4/11	13:43	19 42.8 S 84 00.5 W
102585	4/4/11	19:35	19 42.8 S 85 00.9 W
102583	4/10/11	12:00	19 39.8 S 85 38.9 W
40437	4/10/11	12:00	19 39.8 S 85 38.9 W
102586	4/10/11	12:00	19 39.8 S 85 38.9 W
90262	4/14/11	20:00	19 19.2 S 74 39.0 W

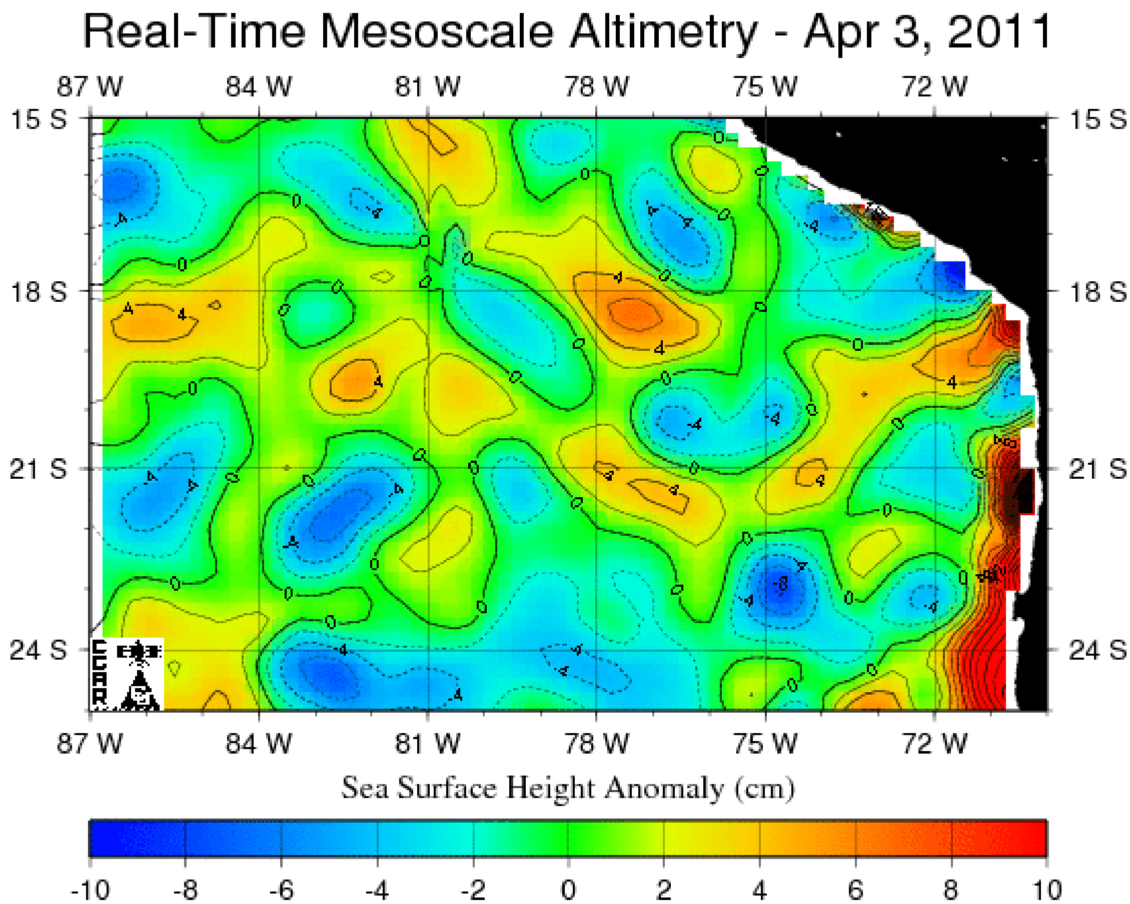

Figure 5-10. Sea Surface Height anomaly on April 03 2011 in area of Stratus 11 cruise (data from http://argo.colorado.edu/~realtime).

C. DART

The Hydrographic and Oceanographic Service of the Chilean Navy (SHOA) made an effort to acquire and deploy a DART II system (Deep-Ocean Assessment and Reporting of Tsunami) for its early tsunami detection and real-time reporting capability. Although seismic networks and coastal tide gauges are indispensable for assessing the hazard during an actual event, an improvement in the speed and accuracy of real-time forecasts of tsunami inundation for specific sites requires direct tsunami measurement between the source and a threatened community. Currently, only a network of real-time reporting, deep-ocean bottom pressure (BPR) stations can provide this capability.

The DART mooring system is illustrated in Figure 5-10. Each system consists of a seafloor BPR and a moored surface buoy with related electronics for real-time communications. The BPR uses a pressure transducer manufactured by Paroscientific, Inc., to make 15-second averaged measurements of the pressure exerted on it by the overlying water column. These transducers use a very thin quartz crystal beam, electrically induced to vibrate at their lowest resonant mode. In DART II applications, the transducer is sensitive to changes in wave height of less than a millimeter. An acoustic link is used to transmit data from the BPR on the seafloor to the surface buoy. The data are then relayed via Iridium satellite link to ground stations, which demodulate the signals for immediate dissemination to Sistema Nacional de Alarma de Maremotos (SNAM) in SHOA, via internet.

The buoy, installed on the ocean's surface establishes real-time communication with the Iridium satellite. The system has two ways of reporting the information, one standard system, and one warning system. The standard is the normal operation mode by which four assessments of the ocean level, averaged every 15 minutes, are received every hour. When the internal software detects the generation of an event, a variation of more than 4 cm, the system stops the standard operation mode and switches to the warning mode. While in warning mode, it submits average assessments every 15 seconds; these are forwarded for a few minutes during the first messages, then following are one-minute average messages for at least three hours if no other event is detected.

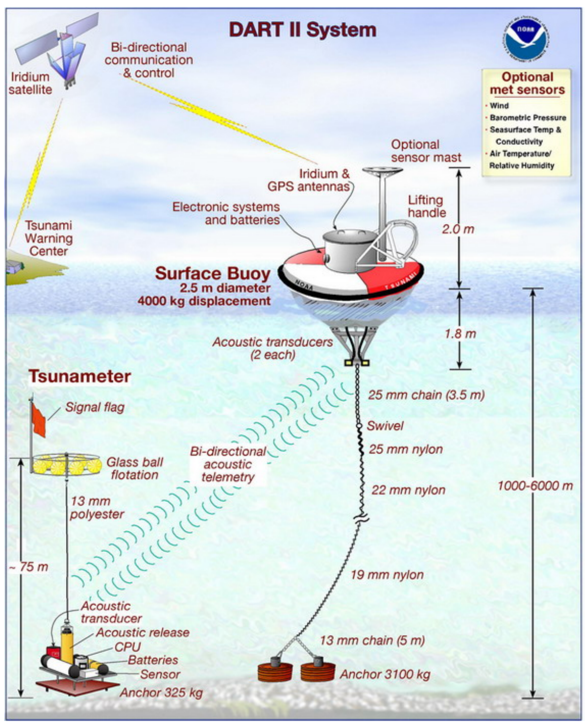

Figure 5-11. Schematic of the DART mooring system.

Figure 5-12. DART II surface mooring inspected during Stratus 11 cruise.

Thanks and Acknowledgements

We wish to thank the crew of the *Moana Wave* who were amazing hosts and did a very professional work. Captain John Seville as well as Dale Johnson and Bud Hanson were very accommodating when we had to change plans and showed great skills positioning the ship in front of the buoy. The crew helped us greatly during the deployment and recovery of our moorings. Thanks also go to Bill Otto for his participation to our work in addition to his work with the balloons. Two Chileans from SHOA helped us as well, Patricio Opazo and Ivan Salazar and proved a great help with UCTD watches and work on deck.

References

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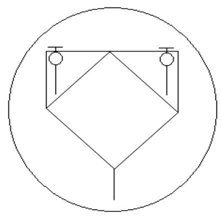
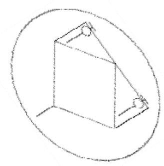
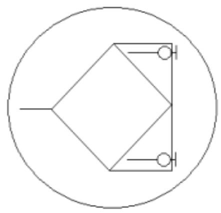
APPENDIX 1: Buoy Spins

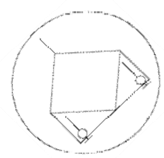
Stratus 11 Buoy Spin Arica, Chile					
Deviation Correction	**4.1**				
	Azimuth	**0.00**			
					
Vanes Locked					
3/26/11 17:46					
			Correction		
	True	**Magnetic**	**Local**		
Logger: L-04	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
SWND 219	0.00	359.20	4.1	3.30	3/26/11 17:47
	True	**Magnetic**	**Local**		
Logger : L-14	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND 238	0.00	358.40	4.1	2.50	3/26/11 17:47
	True	**Magnetic**	**Local**		
Stand Alone	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND239	0.00	354.40	4.1	-1.50	3/26/11 18:36
Vanes Unlocked					
3/26/11 18:36					

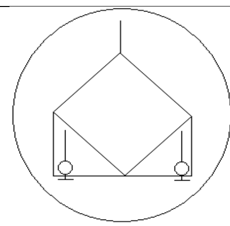
Stratus 11 Buoy Spin Arica, Chile					
Varation for Arica Chile	**-7.2**	**East**			
	Azimuth	**45.00**			
					
Vanes Locked					
3/26/11 18:45					
			Correction		
	True	**Magnetic**	**Local**		
Logger: L-04	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
SWND 219	45.00	48.40	4.1	7.50	3/26/11 18:46
	True	**Magnetic**	**Local**		
Logger : L-14	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND 238	45.00	53.00	4.1	12.10	3/26/11 18:50
	True	**Magnetic**	**Local**		
Stand Alone	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND239	45.00	43.00	4.1	2.10	3/26/11 19:25
Vanes Unlocked					
3/26/11 19:25					

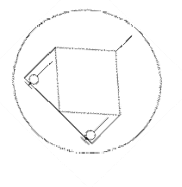
Stratus 11 Buoy Spin
Arica, Chile

Varation for Arica Chile	**-7.2**	**East**			
	Azimuth	**90.00**			
					
Vanes Locked					
3/26/11 19:36					
			Correction		
	True	**Magnetic**	**Local**		
Logger: L-04	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
SWND 219	90.00	97.40	4.1	11.50	3/26/11 19:39
	True	**Magnetic**	**Local**		
Logger : L-14	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND 238	90.00	99.70	4.1	13.80	3/26/11 19:48
	True	**Magnetic**	**Local**		
Stand Alone	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND239	90.00	95.40	4.1	9.50	3/26/11 19:53
Vanes Unlocked					
3/26/11 19:54					

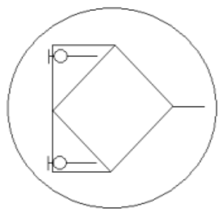
Stratus 11 Buoy Spin
Arica, Chile

Varation for Arica Chile	**-7.2**	**East**			
	Azimuth	**135.00**			
					
Vanes Locked					
3/26/11 20:02					
			Correction		
	True	**Magnetic**	**Local**		
Logger: L-04	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
SWND 219	135.00	140.10	4.1	9.20	3/26/11 20:11
	True	**Magnetic**	**Local**		
Logger : L-14	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND 238	135.00	138.80	4.1	7.90	3/26/11 20:13
	True	**Magnetic**	**Local**		
Stand Alone	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND239	135.00	144.90	4.1	14.00	3/26/11 20:04
Vanes Unlocked					
3/26/11 20:14					

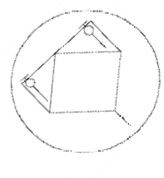
Stratus 11 Buoy Spin Arica, Chile					
Varation for Arica Chile	**-7.2**	**East**			
	Azimuth	**180.00**			
					
Vanes Locked					
3/26/11 20:20					
			Correction		
	True	**Magnetic**	**Local**		
Logger: L-04	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
SWND 219	180.00	177.90	4.1	2.00	3/26/11 20:22
	True	**Magnetic**	**Local**		
Logger : L-14	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND 238	180.00	178.10	4.1	2.20	3/26/11 20:25
	True	**Magnetic**	**Local**		
Stand Alone	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND239	180.00	185.10	4.1	9.20	3/26/11 20:28
Vanes Unlocked					
3/26/11 20:30					

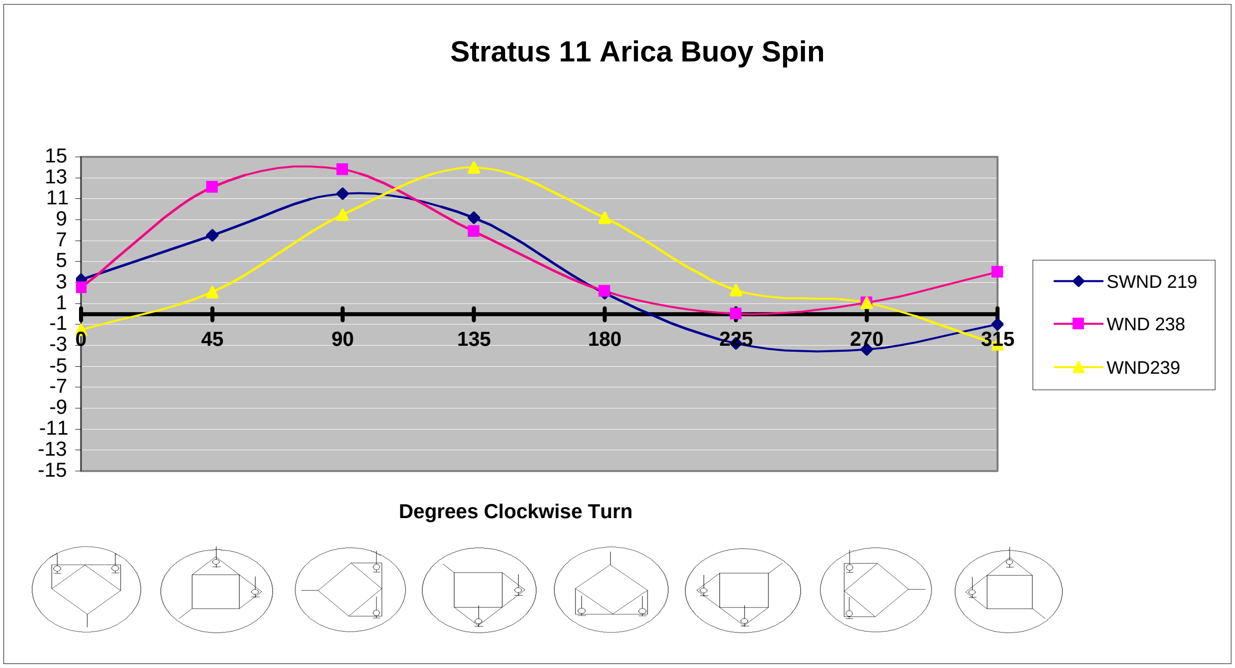
Stratus 11 Buoy Spin Arica, Chile					
Varation for Arica Chile	**-7.2**	**East**			
	Azimuth	**225.00**			
					
Vanes Locked					
3/26/11 20:35					
			Correction		
	True	**Magnetic**	**Local**		
Logger: L-04	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
SWND 219	225.00	218.10	4.1	-2.80	3/26/11 20:42
	True	**Magnetic**	**Local**		
Logger : L-14	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND 238	225.00	220.90	4.1	0.00	3/26/11 20:44
	True	**Magnetic**	**Local**		
Stand Alone	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND239	225.00	223.20	4.1	2.30	3/26/11 20:36
Vanes Unlocked					
3/26/11 20:50					

Stratus 11 Buoy Spin
Arica, Chile

Varation for Arica Chile	**-7.2**	**East**			
	Azimuth	**270.00**			
					
Vanes Locked					
3/26/11 20:52					
			Correction		
	True	**Magnetic**	**Local**		
Logger: L-04	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
SWND 219	270.00	262.50	4.1	-3.40	3/26/11 20:56
	True	**Magnetic**	**Local**		
Logger : L-14	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND 238	270.00	267.00	4.1	1.10	3/26/11 20:59
	True	**Magnetic**	**Local**		
Stand Alone	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND239	270.00	267.00	4.1	1.10	3/26/11 20:52
Vanes Unlocked					
3/26/11 21:00					

Stratus 11 Buoy Spin
Arica, Chile

Variation for Arica Chile	**-7.2**	**East**			
	Azimuth	**315.00**			
					
Vanes Locked					
3/26/11 21:04					
			Correction		
	True	**Magnetic**	**Local**		
Logger: L-04	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
SWND 219	315.00	309.90	4.1	-1.00	3/26/11 21:09
	True	**Magnetic**	**Local**		
Logger : L-14	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND 238	315.00	314.90	4.1	4.00	3/26/11 21:06
	True	**Magnetic**	**Local**		
Stand Alone	**AZ point**	**Module Compass**	**Declination**	**Error**	**Sample time/date**
WND239	315.00	308.00	4.1	-2.90	3/26/11 21:10
Vanes Unlocked					
3/26/11 21:16					



	Difference		
Azimuth	**SWND 219**	**WND 238**	**WND239**
0	3.30	2.50	-1.50
45	7.50	12.10	2.10
90	11.50	13.80	9.50
135	9.20	7.90	14.00
180	2.00	2.20	9.20
225	-2.80	0.00	2.30
270	-3.40	1.10	1.10
315	-1.00	4.00	-2.90

APPENDIX 2: Subsurface Instrument Setup (and SBE 39 ATMP)

Subsurface SBE 37s:

SBE37-SM 485 V 2.3b SERIAL NO. 2053
26 Mar 2011 14:33:24
logging data
sample interval = 300 seconds
samplenumber = 1, free = 233015
store time with each sample
do not output salinity with each sample
do not output sound velocity with each sample
reference pressure = 0.0 db
do not output density with each sample
do not output depth with each sample
A/D cycles to average = 4
internal pump not installed
temperature = 23.79 deg C

SBE37-SM 485 V 2.3b SERIAL NO. 1838
26 Mar 2011 14:32:40
logging data
sample interval = 300 seconds
samplenumber = 1, free = 233015
store time with each sample
do not output salinity with each sample
do not output sound velocity with each sample
reference pressure = 0.0 db
do not output density with each sample
do not output depth with each sample
A/D cycles to average = 4
internal pump not installed
temperature = 24.10 deg C

SBE37-SM V 2.6b SERIAL NO. 1325   29 Mar 2011 17:05:12
logging data
sample interval = 300 seconds
samplenumber = 38, free = 232978
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
reference pressure = 0.0 db
serial sync mode disabled
wait time after serial sync sampling = 30 seconds
internal pump not installed
temperature = 24.78 deg C

SBE37-SM V 2.6b SERIAL NO. 1326   29 Mar 2011 17:00:13
logging data
sample interval = 300 seconds
samplenumber = 37, free = 232979
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
reference pressure = 0.0 db
serial sync mode disabled
wait time after serial sync sampling = 30 seconds
internal pump not installed
temperature = 24.59 deg C

SBE37-SM V 2.6b SERIAL NO. 1328   29 Mar 2011 17:03:31
logging data
sample interval = 300 seconds
samplenumber = 37, free = 232979
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
reference pressure = 0.0 db
serial sync mode disabled
wait time after serial sync sampling = 30 seconds
internal pump not installed
temperature = 24.69 deg C

SBE37-SM V 2.6b SERIAL NO. 1329   29 Mar 2011 17:03:03
logging data
sample interval = 300 seconds
samplenumber = 37, free = 232979
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample

store time with each sample
number of samples to average = 4
reference pressure = 0.0 db
serial sync mode disabled
wait time after serial sync sampling = 30 seconds
internal pump not installed
temperature = 24.61 deg C

SBE37-SM V 2.6b SERIAL NO. 1330 29 Mar 2011 17:00:37
logging data
sample interval = 300 seconds
samplenumber = 37, free = 232979
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
reference pressure = 0.0 db
serial sync mode disabled
wait time after serial sync sampling = 30 seconds
internal pump not installed
temperature = 24.65 deg C

SBE37SM-RS232 3.0j SERIAL NO. 8211
29 Mar 2011 17:21:53
vMain = 6.92, vLith = 3.28
samplenumber = 41, free = 838819
logging
sample interval = 300 seconds
data format = converted engineering
transmit real-time = no
sync mode = no
pump installed = no
reference pressure = 0.0 decibars

SBE37SM-RS232 3.0j SERIAL NO. 8212
29 Mar 2011 17:22:33
vMain = 6.91, vLith = 3.28
samplenumber = 41, free = 838819
logging
sample interval = 300 seconds
data format = converted engineering
transmit real-timence pressure = 0.0 decibars

SBE37-SM V 2.6b SERIAL NO. 1909 29 Mar 2011 16:58:27
logging data
sample interval = 300 seconds
samplenumber = 36, free = 190614
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
serial sync mode disabled
wait time after serial sync sampling = 30 seconds
internal pump not installed
temperature = 24.62 deg C

SBE37SM-RS232 3.0j SERIAL NO. 8213
29 Mar 2011 17:23:00
vMain = 7.00, vLith = 3.27
samplenumber = 41, free = 838819
logging
sample interval = 300 seconds
data format = converted engineering
transmit real-time = no
sync mode = no
pump installed = no
reference pressure = 0.0 decibars

SBE37SM-RS232 3.0j SERIAL NO. 8214
29 Mar 2011 17:21:27
vMain = 7.02, vLith = 3.28
samplenumber = 41, free = 838819
logging
sample interval = 300 seconds
data format = converted engineering
transmit real-time = no
sync mode = no
pump installed = no
reference pressure = 0.0 decibars

SBE37SM-RS232 3.0j SERIAL NO. 8215
29 Mar 2011 17:23:49
vMain = 7.02, vLith = 3.27
samplenumber = 41, free = 838819
logging
sample interval = 300 seconds
data format = converted engineering
transmit real-time = no
sync mode = no
pump installed = no
reference pressure = 0.0 decibars

SBE37SM-RS232 3.0j SERIAL NO. 8216
29 Mar 2011 17:24:19
vMain = 6.99, vLith = 3.27
samplenumber = 41, free = 838819
logging
sample interval = 300 seconds
data format = converted engineering
transmit real-time = no
sync mode = no
pump installed = no
reference pressure = 0.0 decibars

SBE37SM-RS232 3.0j SERIAL NO. 8217
29 Mar 2011 17:20:38
vMain = 6.98, vLith = 3.29
samplenumber = 41, free = 838819
logging
sample interval = 300 seconds
data format = converted engineering
transmit real-time = no
sync mode = no
pump installed = no
reference pressure = 0.0 decibars

SBE37-SM V 2.6b SERIAL NO. 1906   29 Mar 2011 16:59:49
logging data
sample interval = 300 seconds
samplenumber = 36, free = 232980
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
reference pressure = 0.0 db
serial sync mode disabled
wait time after serial sync sampling = 30 seconds
internal pump not installed
temperature = 24.58 deg C

SBE37-SM V 2.6b SERIAL NO. 1908   29 Mar 2011 17:05:35
logging data
sample interval = 300 seconds
samplenumber = 38, free = 232978
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
reference pressure = 0.0 db
serial sync mode disabled
wait time after serial sync sampling = 30 seconds
internal pump not installed
temperature = 24.59 deg C

SBE37-SM V 2.6b SERIAL NO. 2012   29 Mar 2011 16:58:01
logging data
sample interval = 300 seconds
samplenumber = 36, free = 232980
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
reference pressure = 0.0 db
serial sync mode disabled
wait time after serial sync sampling = 30 seconds
internal pump not installed
temperature = 24.60 deg C

SBE37-SM V 2.6b SERIAL NO. 2015   29 Mar 2011 17:06:01
logging data
sample interval = 300 seconds
samplenumber = 38, free = 232978
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
reference pressure = 0.0 db
serial sync mode disabled
wait time after serial sync sampling = 30 seconds
internal pump not installed
temperature = 24.83 deg C

SBE37SM-RS232 3.0j SERIAL NO. 8218
29 Mar 2011 17:25:29
vMain = 6.97, vLith = 3.28
samplenumber = 42, free = 838818
logging
sample interval = 300 seconds

data format = converted engineering
transmit real-time = no
sync mode = no
pump installed = no
reference pressure = 0.0 decibars

SBE37-SM V 2.6 SERIAL NO. 3733 29 Mar 2011 17:04:44
logging data
sample interval = 300 seconds
samplenumber = 37, free = 190613
do not transmit real-time data
do not output salinity with each sample
do not output sound velocity with each sample
store time with each sample
number of samples to average = 4
serial sync mode disabled
wait time after serial sync sampling = 30 seconds
internal pump not installed
temperature = 24.78 deg C

SBE37SM-RS232 3.0j SERIAL NO. 8219
29 Mar 2011 17:26:09
vMain = 6.99, vLith = 3.28
samplenumber = 42, free = 838818
logging
sample interval = 300 seconds
data format = converted engineering
transmit real-time = no
sync mode = no
pump installed = no
reference pressure = 0.0 decibars

SBE37SM-RS232 3.0j SERIAL NO. 8220
29 Mar 2011 17:26:34
vMain = 6.90, vLith = 3.29
samplenumber = 42, free = 838818
logging
sample interval = 300 seconds
data format = converted engineering
transmit real-time = no
sync mode = no
pump installed = no
reference pressure = 0.0 decibars

SBE37SM-RS232 3.0j SERIAL NO. 8221
29 Mar 2011 17:25:08
vMain = 6.99, vLith = 3.27
samplenumber = 42, free = 838818
logging
sample interval = 300 seconds
data format = converted engineering
transmit real-time = no
sync mode = no
pump installed = no
reference pressure = 0.0 decibars

SBE37SM-RS232 3.0j SERIAL NO. 8222
29 Mar 2011 17:20:12
vMain = 6.96, vLith = 3.29
samplenumber = 41, free = 838819
logging
sample interval = 300 seconds
data format = converted engineering
transmit real-time = no
sync mode = no
pump installed = no
reference pressure = 0.0 decibars

SBE37SM-RS232 3.0j SERIAL NO. 8223
29 Mar 2011 17:19:36
vMain = 6.91, vLith = 3.29
samplenumber = 1, free = 838859
logging
sample interval = 300 seconds
data format = converted engineering
transmit real-time = no
sync mode = no
pump installed = no
reference pressure = 0.0 decibars

SBE37SM-RS232 3.0j SERIAL NO. 8224
29 Mar 2011 17:24:44
vMain = 6.99, vLith = 3.27
samplenumber = 41, free = 838819
logging
sample interval = 300 seconds
data format = converted engineering
transmit real-time = no
sync mode = no
pump installed = no
reference pressure = 0.0 decibars

SBE37SM-RS232 3.0j SERIAL NO. 8225
29 Mar 2011 17:21:03
vMain = 6.92, vLith = 3.27
samplenumber = 41, free = 838819
logging
sample interval = 300 seconds
data format = converted engineering

transmit real-time = no
sync mode = no

pump installed = no
reference pressure = 0.0 decibars

Subsurface SBE 39s:

SBE 39 V 1.7a SERIAL NO. 00035 28 Mar 2011 13:16:04
logging data
sample interval = 300 seconds
samplenumber = 4, free = 299589
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 23.43 deg C

SBE 39 V 1.7a SERIAL NO. 00038 28 Mar 2011 13:17:59
logging data
sample interval = 300 seconds
samplenumber = 4, free = 299589
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 23.97 deg C

SBE 39 V 1.7a SERIAL NO. 00044 28 Mar 2011 13:19:41
logging data
sample interval = 300 seconds
samplenumber = 4, free = 294322
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 23.91 deg C

SBE 39 V 1.7a SERIAL NO. 00048 28 Mar 2011 13:21:48
logging data
sample interval = 300 seconds
samplenumber = 5, free = 299588
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 24.18 deg C

SBE 39 V 1.7a SERIAL NO. 00049 28 Mar 2011 13:00:20
logging data
sample interval = 300 seconds
samplenumber = 1, free = 299592
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 24.04 deg C

SBE 39 V 1.7a SERIAL NO. 00102 28 Mar 2011 13:26:33
logging data
sample interval = 300 seconds
samplenumber = 6, free = 299587
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 24.14 deg C

SBE 39 V 1.7a SERIAL NO. 00103 28 Mar 2011 13:29:32
logging data
sample interval = 300 seconds
samplenumber = 6, free = 299587
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 25.90 deg C

SBE 39 V 1.7 SERIAL NO. 00203 28 Mar 2011 13:31:40
logging data
sample interval = 300 seconds
samplenumber = 7, free = 299586
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 25.08 deg C

SBE 39 V 1.7a SERIAL NO. 00276 28 Mar 2011 13:32:18
logging data
sample interval = 300 seconds
samplenumber = 7, free = 299586
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 24.58 deg C

SBE 39 V 1.7a SERIAL NO. 00284 28 Mar 2011 13:34:07
logging data
sample interval = 300 seconds
samplenumber = 7, free = 299586
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 24.33 deg C

SBE 39 V 1.7a SERIAL NO. 00719 28 Mar 2011 13:35:48
logging data
sample interval = 300 seconds
samplenumber = 8, free = 299585
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 24.03 deg C

SBE 39 V 1.7a SERIAL NO. 00720 28 Mar 2011 13:38:21
logging data
sample interval = 300 seconds
samplenumber = 8, free = 299585
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 24.57 deg C

SBE 39 V 1.7a SERIAL NO. 00721 28 Mar 2011 13:38:59
logging data
sample interval = 300 seconds
samplenumber = 8, free = 299585
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 23.51 deg C

SBE 39 V 2.2 SERIAL NO. 1498 28 Mar 2011 13:40:15
battery voltage = 9.1
logging data
sample interval = 300 seconds
samplenumber = 9, free = 599177
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 23.80 deg C

SBE 39 V 2.2 SERIAL NO. 1499 28 Mar 2011 13:41:46
battery voltage = 9.3
logging data
sample interval = 300 seconds
samplenumber = 9, free = 596836
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 23.69 deg C

SBE 39 V 2.2 SERIAL NO. 1500 28 Mar 2011 13:42:57
battery voltage = 9.2
logging data
sample interval = 300 seconds
samplenumber = 9, free = 597421
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 23.85 deg C

Surface Air Temperature SBE 39

SBE 39 V 2.2 SERIAL NO. 1447 25 Mar 2011 21:18:29
battery voltage = 9.0
logging data
sample interval = 300 seconds

samplenumber = 4, free = 599182
serial sync mode disabled
real-time output disabled
SBE 39 configuration = temperature only
binary upload does not include time
temperature = 24.89 deg C

Nortek current profiler
Deployment : STR11
Current time : 1/27/2011 6:52:01 PM
Start at : 3/20/2011 1:00:00 AM
Comment: STRATUS 11
Profile interval (s) : 600
Number of cells : 11
Cell size (m) : 1.00
Blanking distance (m) : 0.40
Measurement load (%) : 9
Average interval (s) : 80
Power level : HIGH-
Number of wave samples : N/A
Wave interval (s) : N/A
Wave sampling rate (Hz) : N/A
Wave cell size (m) : N/A
Compass upd. rate (s) : 1
Coordinate System : ENU
Speed of sound (m/s) : MEASURED
Salinity (ppt) : 35
Analog input 1 : NONE
Analog input 2 : NONE
Analog input power out : DISABLED
File wrapping : OFF
Serial output/TellTale : OFF

Assumed duration (days) : 548.0
Battery utilization (%) : 289.0
Battery level (V) : 11.2
Recorder size (MB) : 25
Recorder free space (MB) : 24.973
Memory required (MB) : 9.9
Vertical vel. prec (cm/s) : 0.4
Horizon. vel. prec (cm/s) : 1.2

Instrument ID : AQD 0357
Head ID : AQP 0274
Firmware version : 1.17

AquaPro Version 1.34
Copyright (C) Nortek AS

APPENDIX 3: Stratus 10 Mooring Log

Moored Station Log

(fill out log with black ball point pen only)

THIS IS A COPY MADE ON APR 7 2011. THE ORIGINAL IS NOT AVAILABLE

ARRAY NAME AND NO. STRATUS 10 MOORED STATION NO. 1210

Launch (anchor over)

Date (day-mon-yr) 17-01-2010 Time 1823 UTC

Deployed by LORD Recorder/Observer GALBRAITH

Ship and Cruise No. RON BROWN 10-01 Intended Duration 13 MONTHS

Depth Recorder Reading PDR 4451 SEABEAM 4454.9 m Correction Source MATHEWS TABLES

Depth Correction +5 m

Corrected Water Depth PDR 4456 4460 m Magnetic Variation (Ⓔ/W) 7.2

Anchor Drop Lat. (N/Ⓢ) 19° 36.93' Lon. (E/Ⓦ) 85° 23.05'

Surveyed Pos. Lat. (N/Ⓢ) 19° 36.8088' Lon. (E/Ⓦ) 85° 23.1242'

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

Acoustic Release Model 8242XS BACS Tested to 1500 m

Release No. 1 (sn) 30288	Release No. 2 (sn) ~~3~~ 30841
Interrogate Freq. 11	Interrogate Freq. 11
Reply Freq. 12	Reply Freq. 12
Enable 256454	Enable 166312
Disable 256477	Disable 16633
Release 253013	Release 151241

Recovery (release fired)

Date (day-mon-yr) 7-04-2011 Time 11:37:30 UTC

Latitude (N/Ⓢ) 19 36.948 Longitude (E/Ⓦ) 85 23.605

Recovered by LORD Recorder/Observer GALBRAITH

Ship and Cruise No. MOANA WAVE Actual duration 445 days

Distance from waterline to buoy deck 65 cm (2010/01/18 OBS)

1

ARRAY NAME AND NO. STRATUS 10 MOORED STATION NO. 1210

Surface Components

SURLYN FOAM

Buoy Type 2.7m **Color(s) Hull Tower** YELLOW, BLUE HULL, WHITE TOWER

Buoy Markings IF FOUND ADRIFT CONTACT

Surface Instrumentation

Item	ID #	Height*	Comments
HRH (ON LOGGER SN 1)	239	228	WATER INSIDE, SMASHED ON RECOVERY
BPR (ON LOGGER SN 1)	502	237	
SWND (ON LOGGER SN 1)	210	298	COMPLETELY FLOODED
PRC (ON LOGGER SN 1)	218	247	
LWR (ON LOGGER SN 1)	502	279	
SWR (ON LOGGER SN 1)	210	279	
HRH (ON LOGGER SN 2)	223	226	
BPR (ON LOGGER SN 2)	210	237	
WND (ON LOGGER SN 2)	348	270	WATER INSIDE
PRC (ON LOGGER SN 2)	219	247	
LWR (ON LOGGER SN 2)	221	279	
SWR (ON LOGGER SN 2)	~~221~~ 218	279	
LASCAR	~~211~~ 238	231	
LASCAR	310	198	
HRH	240	228	WATER INSIDE
BPR	506	237	
WND	343	270	WATER INSIDE
PRC	205	247	
LWR	208	279	
SWR	504	279	
WAMDAS	4002		NDBC WAVE PACKAGE
PCO2			PMEL

*Height above buoy deck in centimeters

ARRAY NAME AND NO. STRATUS 10 MOORED STATION NO. 1210

Subsurface Instrumentation on Buoy and Bridle

Item	ID #	Depth†	Comments
SBE 39	1446	FLOAT	
TR 1050	10983	.94	AT BOTTOM OF FSST FRAME
TR1060	14881	.66 *	IN HOLE IN BUOY HULL AT 90°
TR1060	14876	.83	" SMASHED ON RECOVERY
TR1060	14877	.9	" SMASHED ON RECOVERY
SBE 37	1725		ON ASIMET LOGGER 1
SBE 37	1839		ON ASIMET LOGGER 2
		IDS	
ARGOS PTT	99538	14664, 14652, 14653	ON LOGGER SN 1
"	14709	9805, 9807, 9811	ON LOGGER SN 2
WAMDAS MODEM	24277	300124000010620	
SIS	SN 22	11427	SUBSURFACE ARGOS
		* 2010/10/18	.66 TR1060 IS OUT OF WATER ~ 50% OF TIME
			.83 IS RIGHT AT THE SURFACE

†Depth below buoy deck in centimeters

3

ARRAY NAME AND NO. STRATUS 10 MOORED STATION NO. 1210

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		BUOY			1316		HRH TOOK HIT ON BOTTOM DURING LAUNCH CRANES HOOK ASSEMBLY
2	.22	3/4" CHAIN					
3		SBE37	2	1304	1316		BUOY + 45m INSTRUMENTS
4		XR420	2	10515	1316		RECOVERED JULY 22 2010
5	.37	3/4" CHAIN					SEE NOTES #8
6		SBE37	3.7	3639	1308		
7	1.95	3/4 CHAIN					
8	SBE 37	~~NORTEK ADCP~~	7	1899	1302		
9	1.95	3/4 CHAIN					
10		NORTEK ADCP	10	333	1302		
11	3.66	3/4 CHAIN					
12		NORTEK ADCM	15	1666	1300		
13		SBE37	16	1900	1300		
14	2.55	3/4 CHAIN					
15		NORTEK ADCM	20	1688	1258		
16	3.66	3/4 CHAIN					
17		SBE 39	25	203	1256		
18	3.66	3/4 CHAIN					
19		SBE 37	30	1901	1254		
20	1.05	3/4" MCHAIN					
21		NORTEK ADCP	32.5	357	1252		
22	1.2	3/4 MC					
23		SBE 39	35	721	1252		
24	3.66	3/4 MC					
25		SBE 37	40	1902	1250		

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ARRAY NAME AND NO. STRANS 10 MOORED STATION NO. 1210

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26	3.66	3/4 MC					RECOVERED 7-22-2010
27		NORTEK ADCM	45	2064	1248		UP ↑
28	8.75	7/16 WIRE					INSTRUMENTS BELOW REC. 2011/07/02
29		NORTEK ADCM	55	2082	1333	1718	CRUSHED
30	6.1	7/16 WIRE					
31		SBE 37	62.5	1903	1338	1726	LOAD BAR
32	21.1	7/16 WIRE					
33		SBE 39	70	1502	1340	1735	
34		SBE 39	77.5	3423	1342	1737	
35		SBE 37	85	1905	1346	1737	LOAD BAR
36	13.3	7/16 WIRE					
37		SBE 39	92.5	3434	1347	1737	
38		VMCM	100	3	1393 49	LAST UP	FISHHOOK IN UPPER PROP, BANDS OFF ~1251 JAMMED
39	27.8	7/16 WIRE					
40		SBE 39	115	3435	1354		
41		SBE 37	130	1907	1357	1801	
42	3.66	3/4 CHAIN					
43		RDI ADCP	135	12254	1400	1801	
44	8	7/16 WIRE					
45		VMCM	145	14	1403	1859	
46	12.8	7/16 WIRE					
47		SBE 37	160	1912	1406	1749	LOAD BAR
48	21.3	7/16 WIRE					
49		SBE 39	175	3437	1408	1759	
50		VMCM	183	29	1410	1801	BANDS OFF 1410

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ARRAY NAME AND NO. STRATUS 10   MOORED STATION NO. 1210

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
51	4.8	7/16 WIRE					
52		SBE 37	190	2009	1413	~1805	
53	28.5	7/16 WIRE					
54		SBE 37	220	2011	1417	1806	
55	13	7/16 WIRE					
56		VMCM	235	34	1421	1835	BANDS OFF 1420
57	13	7/16 WIRE					
58		SBE 37	250	1910P	1423	1844	
59	28.5	7/16 WIRE					
60		VMCM	280	37	1427	1835	BANDS OFF ~1425
61	13	7/16 WIRE					
62		SBE 37	295	2010	1430	1839	
63	8	7/16 WIRE		TERMIN			
64	6.1	7/16 WIRE		ATED			
65		VMCM	311	40	1433	1835	
66	500	3/8 WIRE				149	
67		SBE 39	361	3438	1435	1833	
68		SBE 39	411	3439	1438	~1833	NOT SURE OF RECOVERY TIME
69		VMCM	814	53	1450	1619	PROPS GOOD ON RECOVERY BANDS OFF 1449
70	500	3/8 WIRE				1619	> THIS TERM UP @ 1712
71	200	3/8 WIRE					
72		VMCM	1517	76	1519	1652	PROPS SPINNING ON RECOVERY BANDS OFF 1516
73	300	3/8 WIRE			1519 -	1609	WUZZLE
74	100	3/8 WIRE		ONE PIECE WRAPPED	1528 -	1604 -	NO WUZZLE
75	200	7/8 NYLON		TERMIN ATION	1539 -	1547 -	

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ARRAY NAME AND NO. STRATUS 10 MOORED STATION NO. 1210

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
76	1750	7/8 NYLON			1556 –	1445 –	LOOKS MUDDY ~1500
77	1500	1 COLMEGA				1444	
78		84 GLASS BALLS				1252	ON SURFACE ~1230, HOOKED ON ~ 1242. ON DECK 1249 – 1252
79	5	1/2 CHAIN					2 BALLS CRUSHED
80		RELEASES				1302	
81							
82							
83							
84							
85							
86							
87							
88							
89							
90							
91							
92							
93							
94							
95							
96							
97							
98							
99							
100							

ARRAY NAME AND NO. STRATUS 10 MOORED STATION NO. 1210

Date/Time	Comments
7-7-10 ~1100 UTC	STRATUS 10 MOORING FAILED, DRIFTING NW
7-21-10 2200	BUOY FLIPPED OVER IN 4 m WAVES
7-22-10 2000	BUOY AND 45 m OF INSTRUMENTS RECOVERED BY
	LORD + PIETRO ON B.I.C. HUMBOLT OF PERU.
	RECOVERY POSITION 17.927 S 8~~8~~.265 W
	MAIN POWER OFF 2155 UTC
	STANDALONE POWER OFF 2210

09G0135

APPENDIX 4: Stratus 11 Mooring Log

Moored Station Log

(fill out log with black ball point pen only)

ARRAY NAME AND NO. STRATUS XI MOORED STATION NO. 1226

Launch (anchor over)

Date (day-mon-yr) 6 APR 2011 | Time 1928 UTC

Deployed by LORD | Recorder/Observer GALBRAITH

Ship and Cruise No. MOANA WAVE | Intended Duration 12 MONTHS

Depth Recorder Reading ______ m | ~~Correction~~ DEPTH Source SEABEAM MAP SOURCE

Depth Correction 10 m | (+5m MATHEWS TABLE + 5m DUCER DEPTH)

Corrected Water Depth 4440 m | Magnetic Variation (E/W) ______

Anchor Drop Lat. (N/S) 19° 41.675 | Lon. (E/W) 85° 33.826

Surveyed Pos. Lat. (N/S) 19° 41.4783 | Lon. (E/W) 85 34.0093

WATCH CIRCLE NM 3.7

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

Acoustic Release Model EDGETECH ORE ~~842~~ 8242 XS | Tested to ______ m

Release No. 1 (sn) 30843 | Release No. 2 (sn) 35118

Interrogate Freq. 11 | Interrogate Freq. 11

Reply Freq. 12 | Reply Freq. 12

Enable 166433 | Enable 202705

Disable 166456 | Disable 202726

Release 151313 | Release 224233

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 ~65 cm

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ARRAY NAME AND NO. STRATUS XI MOORED STATION NO. 1226

Surface Components
Buoy Type FOAM Color(s) Hull Tower YELLOW, BLUE BELOW WHITE TOWER
Buoy Markings VANE: WHOI USA 508 548 1401. SAME ON HULL, + "IF FOUND CONTACT.."

Surface Instrumentation

Item	ID #	Height*	Comments
HRH	247	226.5	ON LOGGER SN 4
BPR	503	236	
SWND	219	267.5	
PRC	207	250	
LWR	503	279.5	CLEANED 1142 APR 6 '11
SWR	502	279.5	
SST-SBE37	2053		
HRH	250	226.5	ON LOGGER SN 14
BPR	212	236.5	↓
WND	238	267	
PRC	206	249	
LWR	224	279.5	
SWR	208	279.5	
SST-SBE37	1838		
HRH	248	224.5	
WND	239	266	
LASCAR HRH	1	232	
LASCAR HRH	2	201	
SBE 39	1447	232	
PCO2			
WAMDAS	4002	MODEM 24297	IMEI 300124000010620
ARGOS MET PTT	12789	LGR 4	IDS 27916 27917 27918
ARGOS MET PTT	18171	LGR 14	IDS 27919 27920 27921

*Height above buoy deck in centimeters

ARRAY NAME AND NO. STRATUS XI MOORED STATION NO. 1226

Subsurface Instrumentation on Buoy and Bridle			
Item	ID #	Depth†	Comments
TR1060	14880	80. fwd	
TR1060	14875	80. aft	
TR1060	14879	80. stb	
TR1060	14883	80. port	
SIS	ID 11427		SN: Argos subsurface

†Depth below buoy deck in centimeters

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ARRAY NAME AND NO. Stratus XI MOORED STATION NO. 1226

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
1		BUOY					
2	.22	3/4" CHAIN					
3		SBE 37	2	1325	1226		
4	.37	3/4" CHAIN					
5		SBE37	3.7	1326	1226		
6		SBE 39	4.9	35	1226		DOWN
7	1.3	3/4" CHAIN					
8		SBE 37	7	1328	1214		
9	1.73	3/4" CHAIN					SWIVEL
10		ADCP NORTEK	10	357	1212		
11		SBE 39	11.25	38	1212		
12	.68	3/4" CHAIN					
13		AANDERAA ADCM	13	13	1211		HEADS UP
14	1.5	3/4" CHAIN					
15		SBE 37	16	1329	1211		
16	2.7	3/4" CHAIN					
17		AANDERAA ADCM	20	78	1209		
18	3.66	3/4" CHAIN					
19		SBE 39	25	44	1207		UP
20	3.9	3/4" CHAIN					
21		SBE 37	30	1330	1203		
22	1.12	~~AANDERAA ADCM~~	3/4" CHAIN				
23		AANDERAA ADCM	32.5	79	1202		
24	1.2	3/4" CHAIN					
25		SBE 39	35	48	1202		

ARRAY NAME AND NO. STRATUS XI MOORED STATION NO. 1226

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
26	3.9	3/4" CHAIN					
27		SBE37	40	8211	1200		
28	3.66	3/4 CHAIN					
29		AANDERAA ADCM	45	138	1240		SEAGUARD W OPTODE
30	16	7/16 WIRE					#10242 24B
31		SBE 39	46.5	49	1247		
32		SBE 39	51	102	1248		
33		SBE 39	56.5	103	1249		
34		SBE 37	62.5	8212	1255		
35	23.5	7/16 WIRE SBE 39	70	203	1300 ~~1255~~		#102 42 23A
36		SBE 39	77.5	276	1301		
37		SBE 37	85	1909	1303		WITH P
38		ADCM	87.3	140	1312 ~~1307~~		AANDERAA SEAGUARD W/OPTODE
39	41.25	7/16 WIRE					#10242 -19
40		SBE 39	92.5	284	1315		
41		SBE 39	100	719	1315		
42		SBE 39	115	720	1316		
43		SBE 37	130	8213	139		
44	4.5	7/16 WIRE					#10242 32AB
45		ADCP	135	1218	1325		RDI WORKHORSE
46	.38	3/4 CHAIN					
47	8	7/16 WIRE					#10242 30B
48		ADCM	145	141	1329		ANDERAA SEAGUARD, OPTODE
49	13.5	7/16 WIRE					#102 42 25
50		SBE 37	160	8214	1333		

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ARRAY NAME AND NO. STRATUS XI MOORED STATION NO. 1226

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
51	29	7/16 WIRE					# 1014221
52		SBE 39	175	721	1334		
53		SBE 39	183	1498	1336		
54		SBE 37	190	8215	1340		
55	29	7/16 WIRE					# 1024222
56		SBE 37	220	8216	1342		
57	13.5	7/16 WIRE					# 1024226
58		ADCM	235	142	1347		AANDERAA SEAGUARD, OPTODE
59	13.5	7/16 WIRE					# 1024227
60		SBE 39	236.5	1499	1347		AT TERMINATION
61		SBE 37	250	8217	1356		
62	38.5	3/8 WIRE					# 1024215
63		SBE 39	280	1500	1359		
64		ADCM-O	290	143	1405		AANDERAA SEAGUARD W OPTODE
65	28	3/8 WIRE					# 1024217
66		SBE 37	295	1906	1408		
67		VMCM	320	4	1420		BANDS OFF 1414 SPIN in water 1420
68	26.5	3/8 WIRE					# 1024218
69		OPTODE	322	691	1420		in water 14:20
70		VMCM	349	31	1425		bands off, spun 14:22
71	48.5	3/8 WIRE					10242-11
72		SBE37	352	1908	1426		
73		OPTODE	353	943	1429		
74		SBE 37	361	2012	1430		
75		ADCM-O	400	144	1434		

ARRAY NAME AND NO. STRATUS XI MOORED STATION NO. 1126

Item No.	Length (m)	Item	Depth	Inst No.	Time Over	Time Back	Notes
76	48.5	3/8 WIRE					#1024214
77		SBE 37 ~~ADCM-O~~	401	2015	1435		
78		ADCM-O	450	181	1439		
79	48.5	3/8 WIRE					# 10242 12
80		SBE 37	451	8218	1439		
81		SBE 37	500	3733	1443		WITH PRESS
82	100	3/8 WIRE					#10242-9
83		ADCM-O	601	182	1449		
84	200 ~~200~~	3/8 WIRE ~~SBE37~~	~~603~~				# 10242 5
85		SBE 37	602	8219	1449		
86		SBE 37	700	8220	1452		
87		VMCM	803	32	1456		BANDS OFF SPIN 1452
88	48.5	3/8 WIRE					#10242-10
89		VMCM	855	42	1501		BANDS OFF SPIN 1458
90		SBE 37	857	8221	1501		ON 10242-4
91	325	3/8 WIRE					#10242-4
92		SBE 37	1000	8222 ~~8222~~	1509		CLAMPS HAD TO BE REDRILLED FOR 3/8 WIRE
93	325	3/8 WIRE					#10242-3
94		SBE 37	1355	8223	1518		
95		VMCM	1507	62	1524		BAND OFF, SPIN 1519
96	500	3/8 WIRE					#102-42-1
97		SBE 37	1557	8224	1526		
98		SBE 37	2000	8225	1539		
99		VMCM	2010	83	1540		BANDS OFF SPIN 1527
100	100	3/8 WIRE			1540 –		9074-6 WRAPPED TERMINATION

ARRAY NAME AND NO. Stratus XI **MOORED STATION NO.** 1226

Date/Time	Comments
ITEM# LENGTH	ITEM
200	7/8 NYLON } WRAPPED TERMINATION 15:44 in water
1600]	7/8 NYLON ON H BIT START 1557 -
1500]	1" COLMEGA START (BEFORE) ~ 1630 -
	88 GLASS BALLS DONE 1741
5	CHAIN -1753
1	RELEASES (ON 1 M CHAIN)
5	CHAIN
20	NYSTRON
5	CHAIN
	ANCHOR OVER 1928

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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 January. A NOAA vessel was not available, so this cruise was conducted on the chartered ship, Moana Wave, belonging to Stabbert Maritime. During the 2011 cruise on the Moana Wave to the ORS Stratus site, the primary activities were the recovery of the subsurface part of the Stratus 10 WHOI surface mooring, deployment of a new (Stratus 11) WHOI surface mooring, in-situ calibration of the buoy meteorological sensors by comparison with instrumentation installed on the ship by staff of the NOAA Earth System Research Laboratory (ESRL), and collection of underway and on station oceanographic data to continue to characterize the upper ocean in the stratus region. The Stratus 10 mooring had parted, and the surface buoy and upper part had been recovered earlier. Underway CTD (UCTD) profiles were collected along the track and during surveys dedicated to investigating eddy variability in the region. Surface drifters and subsurface floats were also launched along the track. The intent was also to visit a buoy for the Pacific tsunami warning system maintained by the Hydrographic and Oceanographic Service of the Chilean Navy (SHOA). This DART (Deep-Ocean Assessment and Reporting of Tsunami) buoy had been deployed in December 2010.

17. Document Analysis a. Descriptors

Ocean Reference Station
Cruise Report
Climate Observation Program

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

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