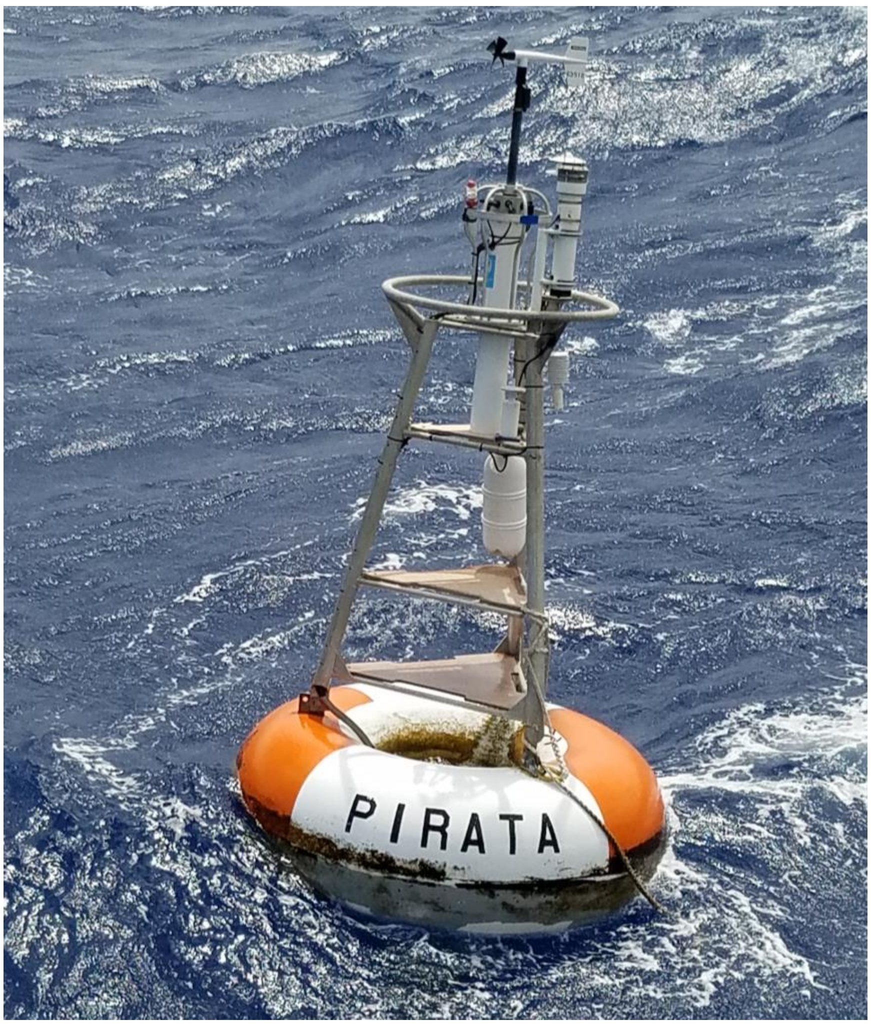
PIRATA Northeast Extension/AEROSE
2017 Cruise Report
NOAA R/V *Ronald H. Brown*
RB-17-01

Leg 1: 11 February - 16 February 2017
Punta Arenas, Chile to Montevideo, Uruguay
Leg 2: 19 February - 25 March 2017
Montevideo, Uruguay to Charleston, South Carolina



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PIRATA Northeast Extension 2017 Scientific Party:

Figure 1: Scientific party (left to right, front): Vernon Morris, Johannes Hahn, Steven Kunze, Ryan Wells; (back) Erik Valdes, Keren Rosado, Carlos Valdes, Daniel Yeager, Shaun Dolk, Jay Hooper, Kafayat Olayinka, Chief Bosun Bruce Cowden, Nick Nalli, Renellys Perez

Oceanographic Observations:

Renellys Perez, Shaun Dolk, Erik Valdes, Jay Hooper (UM/CIMAS, NOAA/AOML), Carlos Valdes (volunteer)

ATLAS, T-FLEX Moorings:

Steven Kunze (NOAA/PMEL), Ryan Wells (UW/JISAO, NOAA/PMEL), Johannes Hahn (GEOMAR)

Atmospheric and Meteorological Observations:

Vernon Morris (Howard University), Nick Nalli (NOAA/NESDIS), Kafayat Olayinka, Keren Rosado, Daniel Yeager (Howard University)

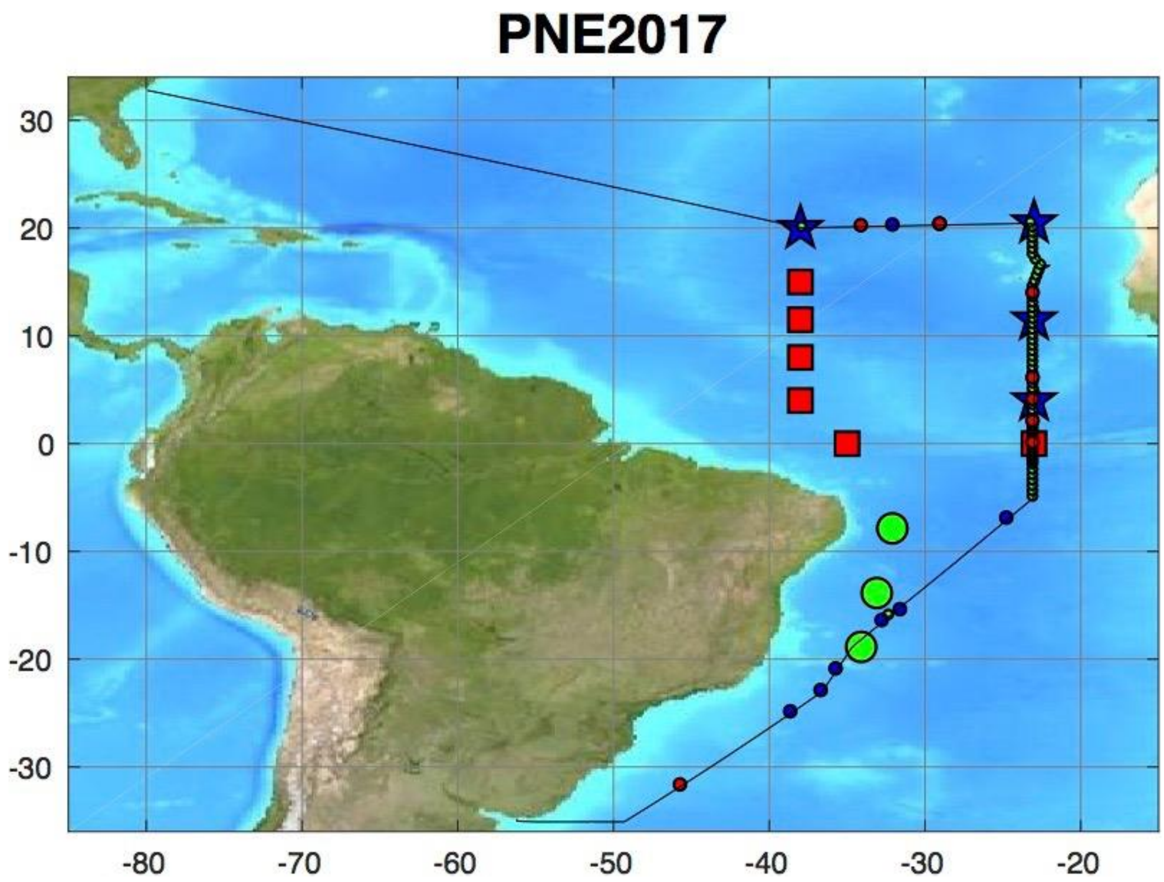


Fig. 1: Cruise track of PNE2017 (black), Montevideo, Uruguay to Charleston, South Carolina. Blue stars indicate the locations of PIRATA Northeast Extension moorings; red squares are PIRATA backbone moorings and green circles are PIRATA Southwest Extension. Green dots are the locations of CTD casts conducted during the cruise; red dots are the locations of surface drifter deployments; and blue dots are the locations of Argo profiling float deployments.

OVERVIEW: The primary goals of the 2017 PIRATA Northeast Extension (PNE2017) and the Saharan Dust AERosols and Ocean Science Expeditions (AEROSE) Cruise (RB-17-01) were to collect observations in the northeast Tropical Atlantic, to service the northeast extension of the PIRATA array, to collect CTD casts at each of the mooring sites and along a cross-equatorial transect along 23°W, and to collect atmospheric observations in support of the AEROSE project, as well auxiliary measurements for the Marine Atmospheric Emitted Radiance Interferometer (M-AERI) project. The cruise track passed through subtropical and tropical regions in both hemispheres of the Atlantic Ocean. Key oceanographic regions sampled include the southeast corner of the subtropical North Atlantic (a region of subduction for the subtropical cell circulation); the western boundary of the subtropical South and North Atlantic (regions with surface and subsurface western boundary currents that transport key water masses); the Guinea Dome and oxygen minimum shadow zone where the subtropical and tropical gyres meet, and the Tropical Atlantic current system and equatorial waveguide. These regions are climatologically significant, and the data collected will provide an improved picture of seasonal-to-interannual oceanic and atmospheric variability in the tropical Atlantic.

All of the major scientific goals of RB-17-01 were achieved. Because of the ports (Montevideo, Uruguay and Charleston, South Carolina), the transits to/from the operation area were significantly longer than usual. However, early arrival times at the moorings, efficient mooring and CTD operations, few weather delays, and good ship speeds saved 1-2 DAS from the total cruise time.

We thank the crew of the *Ronald H. Brown* for their work and input before and during the cruise. Deck space was limited due to the joint staging of two multi-leg projects: PNE2017 and the preceding GO-SHIP P18 cruise. The Field Operations Officer LT Brian Elliott and the deck crew did an exemplary job of developing and executing a plan to move equipment around and keep the deck space as clear as possible. Mooring operations were very efficient thanks to the efforts of Chief Bosun Bruce Cowden and his crew. Experienced maneuvering lead by CAPT Robert Kamphaus allowed mooring deployments and recoveries without launching the small boat. We only needed to launch the small boat for a rain gauge swap at a Brazilian PIRATA mooring. The crew skillfully conducted an emergency recovery of a GEOMAR Sloccum glider that lost the ability to maneuver near 16.5°N, 22°W just east of the Cape Verde islands. Diligent work by the E.T. and survey techs allowed us to quickly troubleshoot CTD technical problems and to conduct around-the-clock CTD work few interruptions, as well as seamlessly collect shipboard and atmospheric observations throughout the cruise.

Note, members of the AEROSE group – see separate AEROSE report – joined the *Ronald H. Brown* for the steam from Punta Arenas, Chile to Montevideo, Uruguay. This is considered to be leg 1 of the PNE2017 cruise. The leg 2 portion of the PNE2017 portion of the cruise began in Montevideo, Uruguay and is the focus of this report.

Introduction

1. PIRATA Northeast Extension (PNE)

PIRATA stands for "Prediction Research Moored Array in the Tropical Atlantic" and is a three-party project between Brazil, France and the United States that seeks to monitor the upper ocean and near surface atmosphere of the Tropical Atlantic via the deployment and maintenance of an array of moored buoys and automatic meteorological stations. This array is the Atlantic's analogue of the Pacific Ocean's Tropical Atmosphere Ocean (TAO) array. The PIRATA array consists of a backbone of ten moorings that runs along the equator and extends southward along 10ºW to 10ºS, and northward along 38ºW to 15ºN.

The northeastern and north central Tropical Atlantic is a region of strong climate variations from intraseasonal to decadal scales, with impacts on rainfall rates and storm strikes for the surrounding regions of Africa and the Americas. The northeastern Tropical Atlantic includes the southern edge of the North Atlantic subtropical gyre, defined by the westward North Equatorial Current (NEC), and the northern edge of the clockwise tropical/equatorial gyre defined by the North Equatorial Countercurrent (NECC). The mean meridional currents in the northeastern Tropical Atlantic are typically weak (on the order of 5 to 10 cm/sec) compared with the robust mean zonal velocities of the South Equatorial Current (SEC), Equatorial Undercurrent (EUC), NEC, and NECC. However, both zonal and meridional velocity can exhibit large fluctuations between 5ºS and 5ºN along 23ºW associated with the passage of tropical instability waves. This area is home to the North Atlantic's oxygen minimum zone (OMZ) at a depth of 400—600m. The size and intensity of this zone is a potential integrator of long-term North Atlantic circulation changes, and the extremely low oxygen values have significant impacts on the biota of the region. The cyclonic Guinea Dome is centered near 10ºN, 24ºW, between the NECC and NEC in the eastern TA. It is driven by trade wind-driven upwelling, and may play an active role in modulating air-sea fluxes in this region.

The tropical North Atlantic is the Main Development Region (MDR) of tropical cyclones. Many major hurricanes that ultimately threaten the eastern United States begin as atmospheric easterly waves that propagate off the African continent. Once over the MDR in the latitude band of 10-20ºN, these waves are exposed to convective instability driven by the upper ocean's heat content. The resulting infusion of energy can result in closed cyclonic circulation and development from tropical depression to tropical storm and hurricane. These hurricanes are known as Cape Verde-type hurricanes, to distinguish them from storms forming further west, and they are often the most powerful storms to strike the US east coast. Prominent examples include Andrew (1992), Floyd (1999) and Ivan (2004). An average season has two Cape Verde hurricanes, but some years have up to five while others have none. There is uncertainty regarding the specific atmospheric/oceanic conditions that determine which atmospheric waves will develop into tropical cyclones and then hurricanes. Specifically, the quantitative effects of the Saharan Air Layer (SAL), anomalous sea surface temperatures (SST), upper layer oceanic heat content and atmospheric wind shear on the formation of tropical cyclones are poorly known.

Seasonal tropical storm and hurricane forecasts are generated annually and based primarily on statistical analyses of historical data and the formulation of empirical predictors (e.g., El Niño South Oscillation index, Atlantic SST, Sahel rainfall, etc.). Recent empirical studies have demonstrated that tropical storm and hurricane activity in the Atlantic Ocean varies on decadal and multi-decadal time-scales and that this variability is correlated with sea-surface temperature anomalies in the MDR. The SST signal in the MDR has been correlated with the North Atlantic Oscillation (NAO) on decadal time-scales. The multi-decadal signal indicates that an extended period of increased hurricane activity is to be expected. Other historical studies have also demonstrated spatial variability in storm formation areas and landfall locations on longer timescales.

Despite the climate and weather significance of the tropical North Atlantic region, it was not sampled by the PIRATA backbone array except for the 38ºW line of moorings extending north to 15ºN. In 2005, a formal Northeast Extension of PIRATA was proposed as a joint project between NOAA/AOML and NOAA/PMEL (Rick Lumpkin, Mike McPhaden and Bob Molinari, co-principal investigators). This PIRATA Northeast Extension (PNE) was proposed to consist of four moorings, three creating a northward arm up 23°W (building on the equatorial backbone mooring there), and a fourth extending the 38°W arm up to 20°N.

In June 2006, the first two moorings of this extension were deployed on *Ronald H. Brown* during RB-06-05a. The mooring at 11.5°N, 23°W was deployed on June 7, and the mooring at 4°N, 23°W was deployed on June 11. Both moorings were replaced in May 2007, during RB-07-03, and two moorings were added at 20.5°N, 23°W and 20°N, 38°W. The four buoys were planned for servicing during the April 2008 cruise RB-08-03. Due to the cancellation of this cruise, the buoys failed and a data gap was introduced in mid to late 2008. All four sites were subsequently serviced in November 2008 by NOAA charter of the French R/V *Antea*. In 2009-2011, the four moorings were serviced by *Ronald H. Brown* cruise during RB-09-04, RB-10-03, and RB-11-01. Cancellation of the cruise RB-12-05 led to another gap in the record. After the make-up cruise in January-February 2013, all four buoys, which need to be serviced annually, were once again reporting meteorological and oceanographic data onto the Global Telecommunications System for weather and climate forecasting. The optimal configuration to conduct a PNE cruise and service the moorings is once every 12 months. The three most recent cruises have occurred within 9-15 months of one another, and have on average met that mark: November-December 2013 on *Ronald H. Brown* during RB-13-06, January-February 2015 on the UNOLS R/V Endeavor, and November-December 2015 on the NATO R/V Alliance.

All four PNE moorings were serviced during the PNE2017 cruise and are currently successfully reporting meteorological and oceanographic data onto the Global Telecommunications System for weather and climate forecasting. In the Memorandum of Understanding from the PIRATA-12 meeting (November 2006), the United States agreed that

> *[I]t is recognized that the Parties are dependent upon year-to-year funding allocations from their governments, and thus commitments for future funding and logistical support cannot be guaranteed. Given this proviso, the Parties affirm that PIRATA is a high priority for Brazil, France, and the United States, and that the institutions are making plans for continued support … NOAA will provide ship time for maintenance of four moorings in the North East Extension.*

Ronald H. Brown's cruise RB-17-01 served to honor this commitment for the fiscal year 2017.

2. Aerosols and Ocean Science Expeditions (AEROSE)

Large uncertainties remain in our understanding of the impact of mineral dust and biomass burning aerosols on the weather and climate of the tropical Atlantic. In order to advance knowledge and improve predictive models, it is important that we address gaps in our understanding of regional and trans-boundary aerosol issues. The African continent is one of the world's major source regions of mineral dust and biomass burning aerosols. This makes the need for understanding the mobilization, transport, and impacts of aerosols originating from natural and anthropogenic processes in Africa a high priority for improving predictive models. Saharan dust storms are estimated to inject over three billion metric tons of mineral aerosols into the troposphere annually, with large quantities advecting westward over the tropical North Atlantic within tropical easterly winds and waves. These aerosols impact phenomena ranging from cloud seeding and precipitation, ocean fertilization, and downstream air quality and ecosystem impacts in the Caribbean and U.S. eastern seaboard. Red tides, increasing rates of asthma, and precipitation variability in the eastern Atlantic and Caribbean have been linked to increases in the quantities of Saharan dust transported across the Atlantic. The contribution of the Saharan air layer (SAL) to the development of the West African Monsoon (WAM) and its role in tropical cyclogenesis are important topics of ongoing research. The interplay between thermodynamics, microphysics, and aerosol chemistry are currently unknown and field measurements are thus desirable for unraveling these complex interactions.

The NOAA Aerosols and Ocean Science Expeditions (AEROSE) constitute a comprehensive measurement-based approach for gaining understanding of the impacts of long-range transport of mineral dust and smoke aerosols over the tropical Atlantic. The project, involving international coordination of monitoring in Puerto Rico, Mali, the Canary Islands, and Senegal, hinges on multi-year, trans-Atlantic field campaigns conducted in collaboration with PNE project over the tropical Atlantic. AEROSE is supported through collaborative efforts with NOAA's National Environmental Satellite Data and Information Service, Center for Satellite Applications and Research (NESDIS/STAR) and the National Weather Service (NWS), as well as NASA and several academic institutions linked through the NOAA Center for Atmospheric Sciences at Howard University.

The AEROSE campaigns (to date, comprised of twelve separate trans-Atlantic Project legs) have provided a set of *in situ* measurements to characterize the impacts and microphysical evolution of continental African aerosol outflows (including both Saharan dust and sub-Saharan and biomass burning) across the Atlantic Ocean. AEROSE has sought to address three central scientific questions:

1) How do Saharan mineral dust aerosols, biomass burning aerosols, and/or the SAL affect atmospheric and oceanographic parameters during trans-Atlantic transport?
2) How do the aerosol distributions evolve physically and chemically during transport?
3) What is the capability of satellite remote sensing and numerical models for resolving and studying the above processes?

Note: This report provides detailed information about the hydrographic measurements and mooring operations carried out during the cruise. This work is in support of the PNE project and is part of a collaborative agreement between AOML and PMEL and is funded by NOAA's Climate Program Office. Work performed by the AEROSE team is described in detail in separate documents. All results reported in this document are subject to revision after post-cruise calibrations and other quality control procedures have been completed.

<u>Order of operations:</u>

Loading for the PNE2017 was conducted in San Diego, California on October 26, 2016. Because we were onboarding for two multi-leg projects, PNE2017 and the preceding GO-SHIP P18 cruise, shoreside cranes were used. A shoreside crane was rented to move containers onto ship in San Diego, another crane was rented to reposition the containers on the ship in Punta Arenas, Chile prior to PNE2017, and then another crane offloaded the containers in Charleston, South Carolina after PNE2017. The Field Operations Officer LT Brian Elliott and the deck crew did an exemplary job of developing and executing a plan to move equipment around and keep the deck space as clear as possible.

The *Ronald H. Brown* left Montevideo, Uruguay and commenced Leg 2 of the PNE2017 (see separate AEROSE report for details about Leg 1) on Sunday, February 19 at noon. The MAERI crew did not to send a person on the cruise (due to a dental emergency), but did send a team to repair the MAERI system prior to the ship leaving for the leg 2 of PNE2017. The MAERI system had sustained some damage during the first leg of PNE2017. The repairs took longer than anticipated and the MAERI team had to quickly instruct the AEROSE and AOML hydrography teams on how to use the MAERI system and Hardhat system (to measure skin SST during the CTD operations) prior to the ship leaving.

The *Ronald H. Brown* had a long steam to the first mooring - a pre-arranged stop at a Brazilian PIRATA mooring (~19°S, 34°W) to swap out a rain gauge and conduct a 3500 m CTD cast. On the way to the Brazilian mooring, the hydrography team set up the CTD frame with sensors and Niskin bottles. We deployed 6 Argo floats and 2 drifters at prearranged locations (see Tables) during the transit from Montevideo to 5°S, 23°W (see Table). The first test CTD cast was on Wednesday February 22 near ~29°S, 42°W. The LADCP component of the cast was successful, but we had many challenges with the test CTD cast. We changed many things and ran diagnostic tests. What finally worked was changing the CTD fish, and swapping out an oxygen sensor.

We arrived at the 19°S, 34°W Brazilian PIRATA mooring on Saturday, February 25. The rain gauge swap was successful, but the PMEL team couldn't get the subsurface sensors back online. At this site, we tried to do the deep CTD cast, but we saw huge spikes in the data at 1200m and 2000m depth. We brought the CTD to the surface, switched from the forward winch to the aft winch thinking that the problem was the termination. We tried to deploy with the aft winch, we got "module" errors before we even put the package in the water and had to stop. We decided not to wait and continued steaming to the main PNE operating area. The crew re-terminated the forward wire (after cutting 30 m) and we redeployed the CTD the following day using the forward winch. However, the re-termination did not solve all of the problems. Jay greased and reseated all of the connections, and he discovered a problem with the primary salinity cable. After swapping the primary salinity cable, we were able to do a successful test cast down to 2000 db near 16°S, 32°W and considered that to be our first successful cast (001), although we did not run samples and the data from this cast was not post-processed.

We arrived at our first 23°W CTD site (002) and began normal hydrography operations on Wednesday March 1 with stations every 0.5 degrees latitude apart from 5°S to 2°S. The day CTD shift consisted of Renellys Perez (Chief Scientist) and Jay Hooper (5:30am – 5:30pm). The night shift consisted of Shaun Dolk, Erik Valdes (watch leader), and Carlos Valdes (5:30pm – 5:30am).

The LADCP worked very well during the whole cruise, and downloading data from the LADCP was straightfoward. Throughout the cruise we continued a policy of deploying XBTs just as we were leaving each CTD station. This worked fairly well – except the ship wanted us to go as far aft of the ship as possible which created some communication issues. Note, the XBT GPS feed would sometimes freeze up and we had to always make sure that it was still logging the proper location. These XBTs will be used for comparisons with the CTD data. We made a plan to deploy the majority of the surface drifting buoys in drifter pairs at 5 latitudes along 23°W (approximately 0°N, 2°N, 4°N, 6°N, and 12.5°N and 20.5°N, see table for actual locations).

We had some issues with the MAERI Hardhat, but after a few emails with MAERI scientists at the University of Miami, we resolved the issues. We deployed the MAERI hardhat after starting the CTD section and took the MAERI hardhat out of the water when the CTD was at about 200 db during the upcast. Since we only had 2 people on day shift and 3 people on night shift, we relied heavily on the survey techs. We had a tech available on each shift and they worked from 12-to-12.

One of the early casts (003) had problems with not being able to fire bottles properly because the survey techs modified the PSA file. That cast got processed differently and we didn't have usable bottle data.

We affixed Johannes Hahn's total dissolved oxygen (TDO) sensors on the frame to do calibration dips prior to the TDO sensors being deployed on the PNE moorings. The first cal-dip was for TDO sensors deployed on the 4°N, 23°W mooring. We did 3 min bottle stops on cast 008 for these sensors. Cal dips were also done at cast 041 and cast 048 prior to the 11.5°N, 23°W and 20.5°N, 23°W moorings, respectively.

Because our cruise track went from south to north we reached the segment of the transect with high-density CTD stations (0.25° latitude spacing between 2°S and 2°N) before we could really start running salt bottles through the Autosal. We only had 10 cases of salt bottles, and there wasn't a large enough time during the shifts to do the high-density stations and running salts in between stations. Erik Valdes worked really hard to get us caught up on samples. But, Jay Hooper was concerned about the long time it was taking to run 2 cases (~8 hours) because of the frequent interruptions to do the next station. Once we finished the high-density part of the 23W line, and resumed 0.5° latitude spacing of the hydrographic casts from 2°N to 20.5°N, Jay and Erik were able to catch up on running samples. Note, Shaun Dolk ran dissolved oxygens efficiently during the night shift, and we had sufficient oxygen bottles.

On Friday March 3, the *Ronald H. Brown* intercepted the French ship R/V Thalassa at 0′45°S, 23°W. The Thalassa was steaming southward along 23°W for the French PIRATA cruise. During this rendezvous both ships did simultaneous CTDs (our station 013) for joint comparison. The *Ronald H. Brown* crew also took a small boat to meet the ship (Chief Scientist, Renellys Perez joined the small group) to quickly greet the scientists and exchange gifts. The seas were too rough for more than a short small boat operation.

The French Chief Scientist asked us to do a drive by of the 0°N, 23°W French PIRATA mooring which they had just deployed a half day before. We visited this mooring that evening, but were unable to wake up the mooring's RF modem to acquire data for inter-comparison. Communications couldn't be established. We conducted an equatorial deep cast down to 3500 m (016) at 0°N, 23°W. We noticed some issues in the equatorial CTD during the upcast and shortly thereafter some large disagreements between the conductivity and oxygen sensors in casts 018 and 019. Jay swapped the sensors, but it turned out to be a clog in the tubing that needed to be cleaned out.

At 020 we noticed a serious weld break on the PNE CTD frame. We made decision to take 6 hours and move all of the equipment to the back up yellow CTD frame on loan from PMEL. The day shift transferred the CTD sensors, and the night shift transferred the ADCP sensors and finished the plumbing/safety line attachment. CTD 021 was the first cast on the new frame. After this change we had about a dozen successful CTD casts.

Monday, March 6, was our first full mooring operation day at 4°N, 23°W. The ATLAS mooring was recovered without incident. And, the TFLEX mooring was deployed with two German TDO sensors (not reporting in real-time due) and ten Aquadopp acoustic meters were installed in addition to the standard PNE acoustic meter at 11.6 meters in support of the Tropical Atlantic Currents Observations Study (TACOS). The CTD at this station was obtained before the mooring operations.

CTDs continued to go smoothly until we noticed serious upcast issues at 8.5°N, 23°W on Wednesday March 8th (station 037). We started having noisy upcasts at varying depth levels between 1250 db and 600 db during the upcasts, and module errors in upper 300db. All of the downcasts seemed normal. We communicated with folks back at AOML and they had lots of suggestions. We tried to ride it out until we get to the mooring where we could then take the time to re-terminate the wire. The situation worsened. We made the decision to re-terminate and skip station 040 (we did collect two XBT profiles there). We made this decision so as not to lose our daytime arrival at 11.5°N, 23°W mooring. Otherwise we would arrive late and set up a cascade of night arrivals for all of the subsequent moorings. Note, we did a TDO cal dip at station 041 but the 3 minute stops were done on the downcast since we were only experiencing errors on the upcast.

The T-FLEX Mooring at 11.5°N, 23°W was successfully recovered and a T-FLEX mooring was successfully deployed on Thursday March 9th. This was the first mooring deployed utilizing version 1.16 TFLEX software for real-time TDO sensors. All sensors were reporting as expected. The CTD at this location was obtained after the PNE mooring.

CTD problems continued after the mooring. The re-termination did not work. We tried swapping out multiple things: the fish, reseating lower connections, etc. What finally worked was replacing the pump cable. Our best assessment was that the pump cable was failing (possibly salt water intrusion or bubbles) under pressure. The first cast after the problem was fixed was 044. After this the CTD casts went really well for stations 044 – 062. However, a small conductivity drift was noted that slowly increased during the remainder of the cruise.

We were contacted during the cruise (via Johannes Hahn's GEOMAR colleagues) out about a German glider that lost maneuverability and would almost intersect our trajectory near Cape Verde. We diverted station 053 a small amount to the east (16.5°N, 22.5°W) to enable the successful glider recovery by the *Ronald H. Brown* crew on Saturday, March 11.

Our Monday March 13, day-time arrival at the 20.5°N, 23°W mooring was not impacted by the glider rescue. The ATLAS mooring at 20.5°N, 23°W was successfully recovered, and the TFLEX mooring was successfully redeployed. This was the second mooring deployed utilizing version 1.16 TFLEX software for real-time TDO sensors. All sensors were reporting as expected. We successfully completed our last CTD along 23°W (061) just before the PNE mooring was recovered.

The *Ronald H. Brown* then steamed for 3 days – making fast speeds due to favorable winds and currents. During the steam we deployed the remaining two drifters and Argo floats at even spacing along the track (see table). We arrived at the last PNE mooring at 20°N, 38°W on Thursday, March 16. We successfully recovered the ATLAS mooring and deployed the TFLEX version 1.12 mooring. The last CTD of the cruise (062) was obtained at this site.

From there the ship steamed home to Charleston, South Carolina (home port for the *Ronald H. Brown*). This was the first homecoming in nearly 4 years. Early arrival times at the moorings, efficient mooring and CTD operations, few weather delays, and fast ship speeds reduced the total cruise time. As a result, the *Ronald H. Brown* arrived in Charleston, South Carolina on Saturday, March 25, two days ahead of schedule.

Offloading of the 20' AOML container, 20' AEROSE container, 2 20' GOSHIP P18 containers, and mooring equipment (onto a 40' flatbed) was conducted in stages on Tuesday and Wednesday, March 28-29. The offload was scheduled on those days to avoid a "welcome home" ceremony for the *Ronald H. Brown* on Monday March 27. The majority of the members of the science party departed between Monday, March 27 and Wednesday, March 29.

Problems/Issues

The aft winch not working during the cruise. Any attempts to use the aft winch with our CTD frame (or the ship's frame) produced module errors. This was not resolved during the cruise. Fortunately, the forward winch was operating well.

Chemicals. Overuse of chemicals during the GOSHIP P18 cruise meant that the PNE hydrography team had to be very frugal with their oxygen titration chemicals. We had sufficient chemicals, however for our 61 CTD stations.

Many CTD troubleshooting problems. As detailed in the previous section, we had many issues troubleshooting the CTD package. We did not have any issues, however, with the LADCP data.

Excessive paperwork for Charleston FLETC access. The paperwork required for our end port, Charleston, South Carolina, was a bit excessive due to it being a Federal Law Enforcement Training Center (FLETC). Some of the scientific crew had trouble getting clearance to be on the base – despite having already obtained NOAA clearance to be on the ship.

Summary of PNE2017 data collected and operations conducted on this cruise:

1. Successful recovery of PNE moorings along 23°W at 4°N (ATLAS), 11.5°N (T-Flex) and 20.5°N (ATLAS), and 20°N, 38ºW (ATLAS) and redeployment of T-Flex moorings at all four locations.
2. Along 23°W, the 4°N, 11.5°N, and 20.5°N T-Flex moorings were deployed with total dissolved oxygen loggers with real-time data being reported at 11.5°N and 20.5°N.
3. The 4°N mooring was deployed with 11 Nortek Aquadopps to sample velocities in the upper 100 m at high vertical resolution.
4. We replaced the rain gauge on ATLAS mooring at 19°S, 35°W. Due to CTD issues we were unable to obtain a cast at this mooring.
5. We passed by the ATLAS mooring at 0°, 23°W. We were not able to establish communications with the mooring, but no repairs were required as the French just redeployed the mooring the day before.
6. 61 CTD/LADCP profiles at test cast locations, along 23°W, and at the PNE mooring locations. Only one CTD station at 10°N, 23°W was cancelled to trouble shoot CTDs and to guarantee morning arrival at the 11.5°N, 23°W mooring at decision of Chief Scientist. Two XBTs were deployed in lieu of a CTD at this location. XBT profiles obtained at all of the CTD sites.
7. Most of the casts extended down to 1500 m (or just above the seafloor), but some special casts went down to 3500 m (equator) or had 3-minute stops at 8 depths (for calibration of the total dissolved oxygen loggers to be deployed along 23°W, at the 4°N, 11.5°N, and 20.5°N T-Flex moorings).
8. LADCP profiles showed very strong zonal and meridional currents along 23°W (some extending far below the surface) that will be further investigated.
9. Salinity of the water samples collected from 12 Niskin bottles on the CTD rosette.
10. Dissolved oxygen concentration in the water samples collected with the bottles.
11. Successful autosal analysis and Winkler titrations to calibrate the CTD cast data.
12. Successful deployment of 8 Argo profiling floats.
13. Successful deployment of 16 surface drifters.
14. Continuous recording of shipboard ADCP data.
15. Shipboard heading data for ADCP processing
16. Continuous recording of Thermosalinograph (TSG) data

ATLAS and T-FLEX moorings (text and photo inputs from Steven Kunze)

Summary of Mooring Operations		
Site	**Mooring ID #**	**Operation**
19S 34W	PI235	Rain Gauge Repair
0 23W	PT008	TFLEX Visit
4N 23W	PI233 / PT009	Rec ATLAS / Depl TFLEX
12N 23W	PT005 / PT011	Rec TFLEX / Depl TFLEX
21N 23W	PI234 / PT012	Rec ATLAS / Depl TFLEX
20N 38W	PI232 / PT013	Rec ATLAS / Depl TFLEX

Lost or Damaged Instruments and Equipment *(from rec moorings)*				
Site	**Mooring ID**	**Sensor type**	Serial No	**Comments**
4N23W	PI233	Rain	1642	Funnel missing
4N23W	PI233	SWR	35958	Plate missing
4N23W	PI233	TC	15855	Missing
21N23W	PI234	TC	15608	Missing
20N38W	PI232	Sontek	D645	Fin broken off
20N38W	PI232	T	15147	Missing

On-deck instrument or hardware failure *(pre-deployment)*		
Sensor type	**Serial No**	**Comments**
Rain	890	Failed -1E35
Rain	966	Failed -1E35, and tripped sensor power in TFLEX tube
SBE-39IM	7745	Batteries dead upon setup
SBE-39IM	6194	No comms. Batts checked ok.
Top section	TFLEX 14	Bad internal SST/C connection

Acoustic Releases		
Model	**Serial no**	**Comments**
8242XS	50931 (Recovered from 20N38W)	Replies at 1 sec intervals vs 2 sec for all commands sent regardless if released or not

Fishing and Vandalism		
Site	**Mooring ID**	**Comments**
4N23W	PI233	Cable cut to core just below 80m sensor, longline fouling in places between 12m and 200m
21N23W	PI234	Cable cut to core just below 40m sensor

Shipping notes:

Shipments were domestically trucked from Seattle to San Diego for loading and from Charleston to Seattle post cruise.

Noteworthy Operational Details:

Nortek Aquadopps:

All deployments of these units were done in accordance with the new policy of mounting them inverted on the wire. A minor position adjustment was needed to maintain consistency of the measurements at the established depths. It required mounting them .8 meter shallower on the nilspin wire hence the old standard 12.4 meter head position was shifted to 11.6 meters for all deployments. The ten additional Aquadopps installed on the 4°N, 23°W mooring were all repositioned as well. This was measured out on deck as new nilspin wire with the redefined positions was not available at the time.

There is also a glitch in the TFLEX software version 1.16 that will cause the system to hang when it doesn't detect an expected Aquadopp in the inductive data. During a deployment the inductive loop circuit is technically open until all 700 meters of sensor equipped nilspin wire are in the water. This presents a scenario that can cause the system to hang so prior to a deployment a modified calibration file is sent to it with any intended Aquadopps 'commented out', thus ignoring them. Once the end of the 700 meters of wire is in the water, and while the buoy is still in communicable range, the original calibration file is resent to it to include the Aquadopp current meters.

TFLEX software version 1.16 for Real-time O2:

This version of software was written to accommodate the inclusion of the new GEOMAR supplied inductively coupled real-time oxygen data loggers to the subsurface component of the moorings. Initial testing at PMEL was promising however field testing the units was problematic. The Seabird installed IMM firmware (1.16) for these sensors was newer than the version tested at PMEL (1.14) and was incompatible with our system. This is not to be confused with the TFLEX system version of software. Flashing the IMM firmware in the O2 loggers back to version 1.14 took care of the incompatibility issue. Further testing uncovered an internal data handling problem causing the IMMs to shut down after a short period. Additional flashing of the O2 logger main boards (version 5.20 to 5.20d) fixed this bug and did not affect the output data format. Fortunately, this was sorted out immediately before the first system was to be deployed. The 11.5°N, 23°W, and 20.5°N, 23°W sites were successfully deployed with this TFLEX software version and all sensors were reporting acceptably. There is a minor periodic issue with date and time in the O2 data stream which is caused by varying lengths of the data but it is not a deal breaker and can be managed. Dr. Johannes Hahn was the GEOMAR scientist who accompanied us on the cruise. See the Ancillary Projects information below for his input regarding this collaborative effort.

19°S, 34°W
PI235 Repair. This site had been flagged as having a high percent time raining without any rain, and intermittent inductive communications with several modules. It had also been deployed without the proper configuration leaving the 4th buffer (current meter buffer) offline. This had the impact of having T11, T12, C6, and C7 absent from real-time observations. The mooring is equipped with a stand-alone Nortek current meter thus no real-time data was expected from that. Since this site was not too far off of our trackline to 23°W a rain gauge swap was inserted into the schedule.

This type of a rain gauge symptom has been shown in the lab to be influenced by the way the ATLAS tubes route the grounding of the rain gauge shields. Modifications have recently been incorporated into the ATLAS tubes to remedy this. A quick check of the ATLAS tube on the buoy indicated that it had not been modified yet. A rain gauge swap was performed but new gauge data may also be questionable.

The buoy looked to have been vandalized in that the AT/RH shield was bent upward significantly and there were two broken welds on the tower ring. After repositioning the sensor and securing cables the AT/RH output was temporarily lost. Re-adjusting cable positions fixed this. It had to be left this way due to lack of ATLAS equipment for this cruise. Look for possible future intermittent issues with this. Most subsurface data was missing including T11, T12, C6, and C7 after re-configuring, correcting the time, and restarting the tube. The clock was reading 2m39s fast.

0°, 23°W
PT008 Visit. The French R/V Thalassa had just very recently deployed this mooring. Attempts were made to wake up the mooring's RF modem to acquire data for inter-comparison but communications couldn't be established.

4°N, 23°W
PI233 Recovery. There were two Sonteks on this mooring including an AOML supplied unit at 22 meters which had failed upon deployment. The SSC was reported as reading high and TC60, T100, T120, T140, T180, TP300, and TP500 were reported as being intermittent at various times during the life of the deployment. TP500 was observed to be reading extreme low values through ARGOS as well. The rain gauge was also flagged with a zero rain rate and high percent time of rain.

Upon recovery the SWR shield and rain gauge funnel were both missing, TC60 was missing, and the nilspin jacketing was cut through to the core below the 80 meter sensor. Fishing line was removed from various depths between 12m and 200m. The mooring was in a transmit window on arrival and the relative humidity sensor was observed as failed. Inspection of the RH sensor on the unit didn't reveal any obvious problem.

Data was successfully recovered from all underwater sensors except the AOML Sontek which had a dead battery pack and would not communicate with external power applied. The unit was opened up and the battery pack had evidence of cell leakage as observed on the cardboard bottom of the pack. The unit is an older model with the flush heads. An old version of SonUtils was also attempted unsuccessfully to establish communication.

PT009 Deployment: This version 1.12 TFLEX mooring was deployed with two oxygen sensors not reporting in real-time due to adverse impact concerns from version 1.16 for the Aquadopp heavy subsurface component at this site. Ten Aquadopp current meters were installed in addition to the unit at 11.6 meters in support of the Tropical Atlantic Current Observations Study (TACOS).

12°N, 23°W
PT005 Recovery: This mooring had been documented at one point as having complete subsurface failure and had rain rates of frequent large negative values. TP300 and TP500 were documented as constant at 1E35. The subsurface component on the Rudics page on the date of recovery indicated only TP300 and TP500 were failures. Their batteries were dead and only small amounts of data were able to be recovered from them. There was no evidence of damage to the subsurface component of the mooring. The OTN sensor was recovered at the tape mark on the wire indicating the 'end of fairings' which typically is at 250m. It was intended to be at 200m. There was no 200m tape marking on the nilspin. The buoy had a significant amount of dust buildup on it.

PT011 Deployment: This was the first mooring deployed utilizing version 1.16 TFLEX software for real-time oxygen sensors. All sensors were reporting as expected.

21°N, 23°W
PI234 Recovery: This mooring was also reported to have had 100% subsurface failure at one point. Most of the sensors had been unflagged at a later time then others became intermittent. The nilspin jacketing had been cut, exposing the steel core just below 40 meters. T40 was missing. The buoy

was in a transmit window on arrival and the Sontek was not reporting either. Data was recovered from all underwater sensors including the Sontek. The buoy had slightly less dust accumulation on it than the previous one.

PT012 Deployment: This was the second mooring deployed utilizing version 1.16 TFLEX software for real-time oxygen sensors. All sensors were reporting as expected. An error in the calibration file was later discovered in that there were no coefficients for the air temperature sensor.

20°N, 38°W
PI232 Recovery: The rain gauge at this site was flagged as having low or zero accumulation with a high percent time of rain since deployment. TC10 and T100 were later flagged as being intermittent, and the SSC started to read high. T10 and TP300 were recovered out of their mounts, T100 was missing, and the Sontek fin had been broken off. TC20 battery level was too low to recover the data from it without replacing one of the three 9 volt batteries. The date and time were not lost and the record count was two shy of the other modules recovered.

PT013 Deployment. Deployed with TFLEX version 1.12. Due to rain gauge failures experienced on deck we used the recovered gauge from 19°S, 34°W as a substitute. There was also a similar air temperature coefficient error in the original calibration file as was for the PT012 buoy. A new calibration file was sent to the system prior to deployment however the file that it superseded had been modified for two previous sensor swapouts undertaken during deck testing and the new file did not reflect those previous changes. The lab was notified of the errors in the new file.

Software Notes:

Baud rate errors were encountered while attempting to download data on some Seabird instruments.

Ship Notes or issues:

All of the mooring recoveries were conducted without the use of the small boat (RHIB). The ship carefully maneuvered alongside of the buoys and a ‘happy hooker’ device was used to choke off a lifting strap to the tea-cup handles, which in turn was connected to the working line for recovery through the a-frame block. Once the buoy was lifted out of the water and before placing it on deck it was pinned to the fantail with the aid of hydraulic tugger assisted tag lines. Instruments were then removed from above the tower ring prior to completing the lift onto the deck. The 20□N, 38□W mooring had no handle so an aluminum pole shaped as a shepherd hook with a loop of small diameter line tied at the end of it was placed around the base of a tower leg. The other end was tied to the lifting strap. A boat hook was used to grab the loop of small line and pull it through along with the lifting strap which was then choked to the base of the tower leg. The rest of the recovery was performed as described above.

The anchor drops were performed utilizing the tension of the mooring line to pull the anchors off of the fantail. The anchors were held in place for the tow with the aid of a secondary expendable chain section secured to the deck via a Peck & Hale release. This can be fashioned from recovered hardware. About ten minutes before the anchor was dropped the ship speed was increased to 3 knots which provided sufficient tension to pull the anchors overboard when the release was tripped.

Ancillary Projects:

GEOMAR oxygen data loggers (written by Johannes Hahn)

GEOMAR oxygen data loggers (consisting of an *Aanderaa AADI* oxygen optode combined with a GEOMAR in-house manufactured logging unit) have been deployed in PNE array at mooring sites 4°N, 23°W and 11.5°N, 23°W since 2009. The installation of GEOMAR oxygen data loggers at these mooring sites was initially motivated within the framework of the German *Collaborative Research Centre 754* (*SFB 754*) entitled '*Climate-Biogeochemistry Interactions in the Tropical Ocean*'. The *SFB 754* included the goal of one decade long moored observations at different key regions in the oxygen minimum zone of the eastern tropical North Atlantic. In addition to that, the new European research project *AtlantOS*, which has the goal of sustainable long-term observations of essential ocean variables in key regions in the Atlantic Ocean, has pushed forward the initiative of real-time oxygen observations in the Tropical Atlantic. As a result, an increased number of eight GEOMAR oxygen data loggers were installed at the three different PNE mooring sites along 23°W (4°N, 11.5°N and 20.5°N), whereby the six instruments in the 11.5°N and the 20.5°N mooring were included in the buoy TFlex system for real-time data transmission.

Despite successful laboratory tests at PMEL prior to the cruise, initial onboard tests regarding the transmission of real-time data from the GEOMAR oxygen data loggers failed. Onboard trouble shooting with substantial onshore support from PMEL and GEOMAR finally solved the issues. For details on that, see the section about TFlex-Firmware 1.16.

In order to achieve best data quality of moored observations, GEOMAR oxygen data loggers need to be calibrated prior to as well as subsequent to a mooring deployment period. On the one hand, these sensors have long-term stability when deployed in the field, but on the other hand sudden drifts may happen when instruments are stored in dry conditions outside the field.

Thus, CTD-O_2 cast calibrations were performed for all GEOMAR oxygen data loggers as pre-deployment in-situ calibrations (CTD casts 008, 041 and 048) by attaching the instruments to the CTD frame. During the upcasts of CTD casts 008 and 048, eight calibration stops were done, which were evenly distributed in the depth range between 800m and 10m (depths were chosen at low gradient-regimes for oxygen and temperature). Due to intermittent CTD data transmission issues during a few consecutive CTD casts, which only occurred during respective upcasts, calibration stops needed to be done during the downcast of CTD 041 for the three attached GEOMAR oxygen data loggers. For all three CTD-O_2 calibration casts, each stop had a duration of 3 min in order to ensure sensor equilibration to the respective reference points.

In addition to the in-situ calibrations, onboard lab calibrations were conducted for all GEOMAR oxygen data loggers in water-filled beakers of 0% and 100% oxygen saturated water at two different temperatures (~2°C and ~18°C) following the manual for Aanderaa optode oxygen sensors.

Ocean Tracking Network (OTN)

Sensors mounted at 200 meters were recovered from each of the moorings and replaced for new deployments.

Rendezvous with the French R/V Thalassa

A French PIRATA cruise was occurring at the same time as the PNE/AEROSE cruise and we had a brief rendezvous with the French R/V Thalassa at 0′45°S, 23°W. The Ronald H. Brown was heading northward along 23°W and the Thalassa was sailing southward along 23°W. Tandem CTDs were collected at this location (013). The Chief Scientist Bernard Bourlès also requested that we track sightings of Sargassum as they had recorded several instances of Sargassum.

Rendezvous with French R/V Thalassa at 0′45°S, 23°W

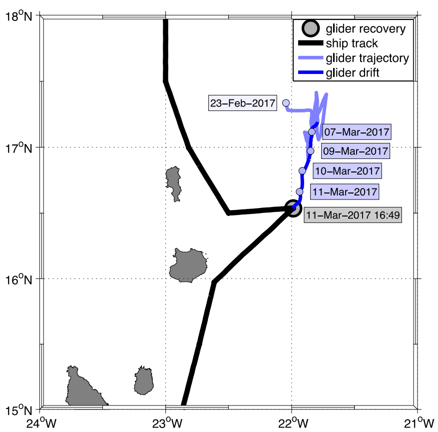
DATE	TIME (GMT)	LAT/LONG	
07MAR	0958	5°45.661′N / 022 59.985′W	START
07MAR	1030	5° 51.424′N / 023 00.000′W	END
Ø7MAR	1348	Ø6°11.5ØØ′N / Ø23° ØØ.ØØØ′W	START
Ø7MAR	~~12Ø8~~ 15Ø8	Ø6°15.Ø98′N / Ø23° ØØ.ØØØ′W	END
07MAR	1253	06° 23.071′N / 022° 59.959′W	
07MAR	~~1523~~ 1723	Ø6°32.762′N / Ø22° 59.997′W	
Ø7 MAR 17	154Ø	Ø6° 35.7′ N / Ø23° W	START
Ø7 MAR 17	1555	Ø6° 38.5′ N / Ø23°W	END
Ø8MAR 17	ØØ4Ø	Ø7° 29.981′N / Ø23° ØØ.Ø25′W	
Ø8MAR17	Ø638	Ø8°3Ø.Ø′N / Ø23° ØØ.Ø′W	
Ø8MAR17	1446	Ø9° Ø4.374′N / Ø23° ØØ.Ø23′W	

Ship crew kept a log of Sargassum sightings along 23°W. Future cruises should come up with a best practices for documenting Sargassum sightings.

<u>German Glider rescue</u> (text input from Johannes Hahn)

During the cruise, an urgent request was received from German scientists from GEOMAR (Kiel, Germany). A Sloccum glider, which GEOMAR had deployed around two weeks before east of the Cape Verde Islands, got in sudden trouble due to a malfunctioning fin and needed to be recovered.

Being non-maneuverable, the glider drifted toward south/southeast close to the scheduled PNE2017 cruise track. The Ronald H. Brown diverted slightly from the cruise track and recovered the glider on the afternoon of March 11, 2017 near 16.5°N, 22°W just east of the Cape Verde islands. The emergency glider recovery was done directly from the ship's aft deck (near the CTD) without any complications.



Conductivity-Temperature-Depth (CTD)/LADCP casts

AOML's yellow-frame PNE CTD package was initially set up with 12 Niskin bottles, but as mentioned above, we had to change to a secondary frame (big yellow-frame on loan from PMEL) to a weld break on the PNE yellow frame. Dual upward- and downward-looking 300kHz ADCPs were included on the package. We had to change CTD sensors, tubing, the CTD fish, and the tubing multiple times. Careful notes were taken of all of these changes.

CTD processing was performed using Seabird software, with calibration done by Matlab routines developed at AOML. Salinity samples were calibrated by Erik Valdes (night shift) and Jay Hooper (day shift). Oxygen samples were titrated by Shaun Dolk during the night shift.

During the course of the cruise, 61 CTD casts were conducted (see table below), including 58 along 23°W.

CTD stations (minus unsuccessful test CTDs)										
Activity	Latitude			Longitude					Time	Comments
	Deg.	Min		Deg.	Min.		Month	Day	(GMT)	
CTD 001	15	59.33	S	32	15.83	W	2	26	15:43:38	Not processed – just a test cast
CTD 002	5	00.07	S	23	00.11	W	3	1	19:27:14	
CTD 003	4	30.11	S	23	00.06	W	3	1	23:46:00	Not processed - bottles misfired
CTD 004	4	00.01	S	23	00.01	W	3	2	4:09:00	
CTD 005	3	30.00	S	23	00.00	W	3	2	8:25:27	
CTD 006	3	00.00	S	23	00.01	W	3	2	12:39:32	
CTD 007	2	30.07	S	23	00.01	W	3	2	16:45:49	
CTD 008	2	00.00	S	23	00.00	W	3	2	20:51:00	TDO Cal Dip #1
CTD 009	1	45.03	S	23	00.04	W	3	3	0:14:00	

CTD 010	1	29.97	S	23	00.02	W	3	3	3:15:30	
CTD 011	1	15.04	S	23	00.04	W	3	3	6:11:00	
CTD 012	1	00.01	S	23	00.01	W	3	3	9:15:34	
CTD 013	0	45.56	S	22	59.96	W	3	3	12:10:08	Dual CTD with the Thalassa
CTD 014	0	30.01	S	23	00.04	W	3	3	16:14:44	
CTD 015	0	15.08	S	22	59.98	W	3	3	19:09:48	
CTD 016	0	00.26	S	22	57.68	W	3	3	22:59:54	Equatorial Deep Cast, different pressure calibration applied >1800m
CTD 017	0	15.13	N	23	00.74	W	3	4	3:15:49	
CTD 018	0	30.02	N	23	00.01	W	3	4	6:27:44	Bottles above 400m vent caps open and not sampled
CTD 019	0	44.96	N	23	00.05	W	3	4	11:04:59	
CTD 020	0	59.95	N	23	00.04	W	3	4	14:03:31	AOML weld break noticed
CTD 021	1	14.99	N	23	00.00	W	3	4	22:29:48	First cast with PMEL frame
CTD 022	1	30.20	N	23	00.00	W	3	5	1:34:47	
CTD 023	1	44.94	N	23	00.24	W	3	5	4:28:54	
CTD 024	1	59.98	N	23	00.05	W	3	5	7:30:39	
CTD 025	2	30.03	N	23	00.07	W	3	5	12:10:44	
CTD 026	2	59.96	N	22	59.99	W	3	5	16:47:32	
CTD 027	3	30.00	N	22	59.99	W	3	5	21:24:28	
CTD 028	3	59.95	N	23	00.00	W	3	6	2:05:40	Before PNE mooring
CTD 029	4	30.05	N	22	59.97	W	3	6	22:35:37	
CTD 030	4	59.95	N	22	59.96	W	3	7	2:42:20	
CTD 031	5	30.01	N	22	59.99	W	3	7	6:52:08	
CTD 032	5	59.98	N	23	00.05	W	3	7	11:21:49	
CTD 033	6	30.05	N	22	59.99	W	3	7	15:36:55	
CTD 034	7	00.03	N	23	00.00	W	3	7	19:56:00	Sierra Leone Rise, Topo: 1475m
CTD 035	7	30.00	N	23	00.01	W	3	8	0:06:30	
CTD 036	8	00.01	N	23	00.03	W	3	8	4:17:59	
CTD 037	8	29.95	N	22	59.99	W	3	8	8:35:00	Upcast issues
CTD 038	8	59.97	N	23	00.02	W	3	8	12:59:45	Upcast issues
CTD 039	9	30.00	N	23	00.02	W	3	8	17:15:07	Upcast issues
CTD 040	10	00.00	N	23	00.00	W	3	8	0:00:00	Station skipped, 2 XBTs instead
CTD 041	10	29.97	N	23	00.01	W	3	9	0:28:22	Upcast issues, TDO Cal Dip #2
CTD 042	10	59.98	N	23	00.01	W	3	9	5:22:53	Upcast issues
CTD 043	11	29.06	N	22	58.78	W	3	9	18:51:26	Upcast issues, After PNE mooring
CTD 044	11	59.98	N	23	00.00	W	3	9	23:47:54	Upcast issues fixed!
CTD 045	12	29.99	N	22	59.99	W	3	10	4:05:35	
CTD 046	13	00.00	N	23	00.00	W	3	10	8:21:00	Conductivity drift first noted
CTD 047	13	29.99	N	23	00.02	W	3	10	12:48:01	
CTD 048	14	00.01	N	23	00.03	W	3	10	17:00:12	TDO Cal Dip #3
CTD 049	14	29.98	N	23	00.01	W	3	10	21:35:42	
CTD 050	14	59.98	N	22	52.04	W	3	11	1:59:03	Moving east of Cape Verde

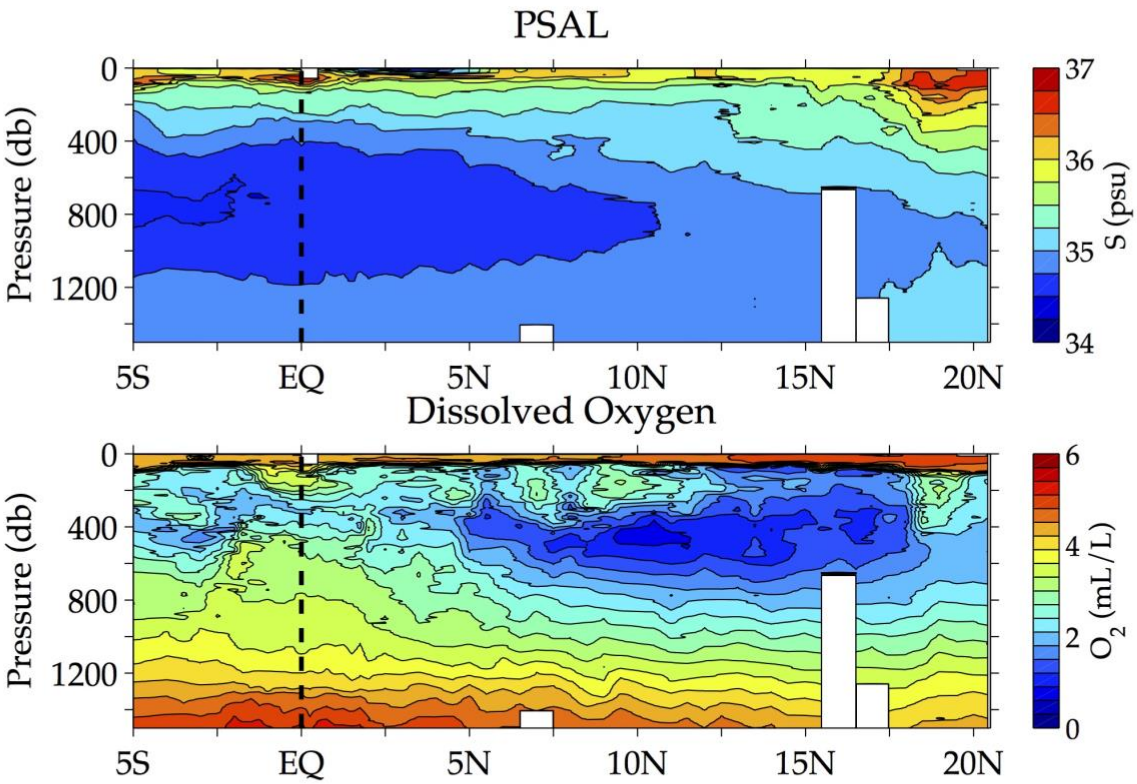
CTD 051	15	29.93	N	22	44.00	W	3	11	6:19:44	
CTD 052	15	58.39	N	22	36.79	W	3	11	10:36:51	Shallow cast, Too: 650m
CTD 053	16	30.03	N	22	30.01	W	3	11	19:37:38	Station moved east for glider recovery
CTD 054	16	59.82	N	22	49.00	W	3	12	0:20:03	
CTD 055	17	29.96	N	23	00.01	W	3	12	4:39:04	
CTD 056	17	59.98	N	23	00.01	W	3	12	8:57:10	
CTD 057	18	29.95	N	23	00.05	W	3	12	13:21:01	
CTD 058	18	59.98	N	23	00.00	W	3	12	17:37:12	
CTD 059	19	30.00	N	22	59.98	W	3	12	21:54:50	
CTD 060	19	59.98	N	23	00.01	W	3	13	2:07:40	
CTD 061	20	26.13	N	23	08.40	W	3	13	6:05:43	Before PNE mooring
CTD 062	20	01.45	N	37	50.25	W	3	16	22:09:19	After PNE mooring

For the upcast issues that developed during casts 037 to 043 for the deeper part of the profile (between 1250db and 600db), those bottle values were collected but excluded from the analysis of the performance of the sensors. For those casts, the downcast data was fine. It was only a problem that manifested during the upcasts.

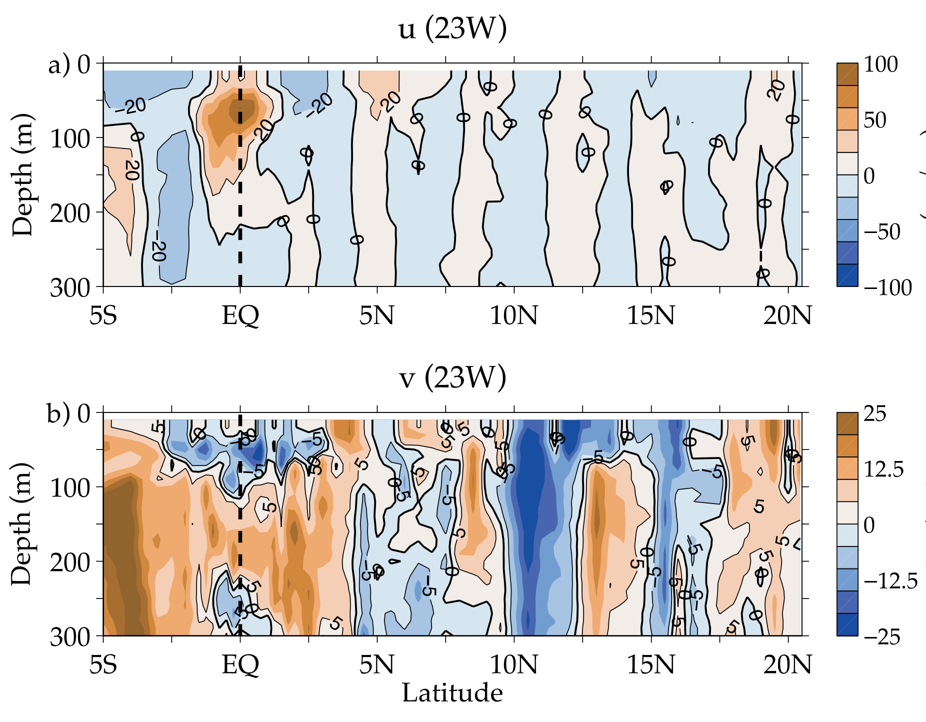
At around CTD cast 046, a drift between the primary and secondary salinity sensors was detected. Analysis against the autosal data, suggest that while the primary salinity sensor exhibiting a small drift for the first few casts, the primary salinity sensor – autosal salinity differences didn't have a substantial trend after the first few casts. The initial salinity drift is likely due to the autosal runs taking longer than usual to complete while we were in the high-frequency casts between 2°S and 2°N, as mentioned earlier in the report. The secondary salinity sensor, however, developed a noticeable trend in the latter part of the cruise from cast 046 onwards. In addition, standard deviation of the primary salinity values after the model fit (to correct for sensor drifts) was 2.4 $\times 10^{-3}$ psu (just above 2 x 10^{-3} psu WOCE standards), whereas the standard deviation of the secondary salinity values after the model fit was slightly larger, 2.7×10^{-3} psu (with far more outliers remaining).

Given the drift in the secondary salinity sensor, density from the primary sensor was used to convert bottle oxygen values from the Winkler titrations from µM/kg to mL/L. This was an unnecessary precaution, as it turns out the results were not very sensitive to using primary *vs.* secondary density for the unit conversion. Regardless of which density was used, the largest oxygen drift over the course of the cruise was found in the secondary O2 sensor values. Both primary and secondary O2 sensors, however, had almost identical standard deviations of the O2 sensor values after the model fit, 1.76 $\times 10^{-2}$ mL/L and 1.75 $\times 10^{-2}$ mL/L, respectively. Due to the more pronounced drifts in the secondary sensors over the course of the cruise, the primary salinity and oxygen sensors were used as the calibrated data set.

LADCP processing was done by Renellys Perez (day shift) and Shaun Dolk (night shift), and the LADCPs worked well throughout the entire cruise. LADCP profiles showed very strong zonal and meridional currents along 23°W (some extending far below the surface) that will be further investigated.



Calibrated salinity and dissolved oxygen along 23°W (post-cruise calibration by Renellys Perez)



Processed LADCP section along 23°W (post-processing done by Ryan Smith after the cruise)

Satellite-tracked Surface Drifters

Sixteen satellite-tracked drifters were deployed during the cruise. The drifters are mini-Surface Velocity Program (SVP) types, drogued at 15 m to follow mixed layer currents; all included a thermistor on the surface buoy for SST. Their data are transmitted in real time via the Iridium system. All of the drifters were launched from either side of the A-frame on the fantail. Several drifters were deployed in pairs, however communication procedures for deploying caused delays in a few deployments causing larger temporal and/or spatial separation between the pair of drifters than is typically ideal. For more information on these instruments, see http://www.aoml.noaa.gov/phod/dac.

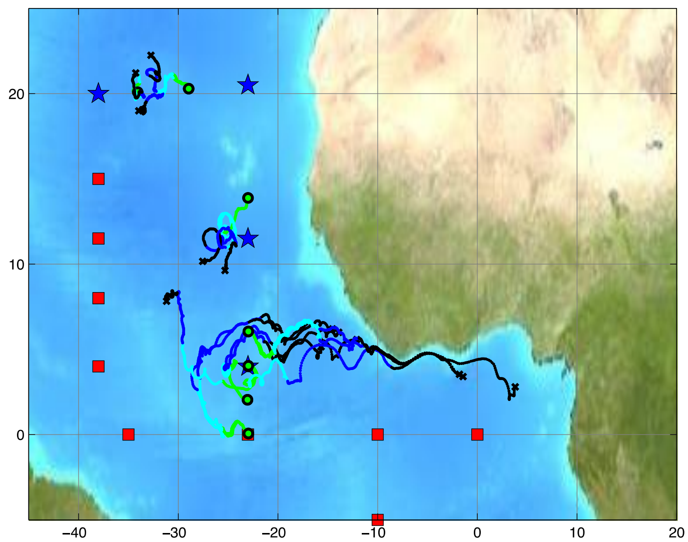
Drifter deployments conducted during the cruise were:

Lat			Lon			Time			Drifter
Deg.	Min		Deg.	Min.		Month	Day	(GMT)	ID Number
31	45.69	S	45	38.38	W	2	21	N.R.	63997380
31	45.69	S	45	38.38	W	2	21	N.R.	63996540
0	00.00	N	23	00.00	W	3	3	N.R.	63999550
0	00.00	N	23	00.00	W	3	3	N.R.	63996590
2	02.12	N	23	00.01	W	3	5	10:11:00	63997560
2	02.33	N	23	00.01	W	3	5	10:12:00	63998520
4	02.09	N	22	58.96	W	3	6	19:51:00	63995570
4	02.22	N	22	58.93	W	3	6	19:53:00	63996520
6	01.47	N	23	00.02	W	3	7	12:50:00	63997540
6	01.72	N	23	00.01	W	3	7	12:52:00	63997430
13	53.56	N	23	00.01	W	3	10	16:21:00	63997390
13	53.70	N	23	00.01	W	3	10	16:22:00	63996470
20	16.70	N	28	58.10	W	3	14	21:02:00	63998580
20	16.70	N	28	58.10	W	3	14	21:02:00	63998470
20	07.91	N	34	01.61	W	3	15	20:06:00	63999460
20	07.90	N	34	01.80	W	3	15	20:08:00	63999510

N.R. = not recorded. We were testing the Thorium X app on the CLS America tablet to record deployment information. However, it required Iridium and WiFi access on the ship was extremely limited. As a result, the tablet did not always properly report the day and time of deployment. Battery life of the tablet was also a concern. After a few problematic attempts with the tablet, we manually recorded the times as a backup.

The figure shown below provides the first four months of trajectories of the drifters that were deployed north of 0°N (green shows trajectories in March, cyan in April, blue in May and black in June).

PNE2017

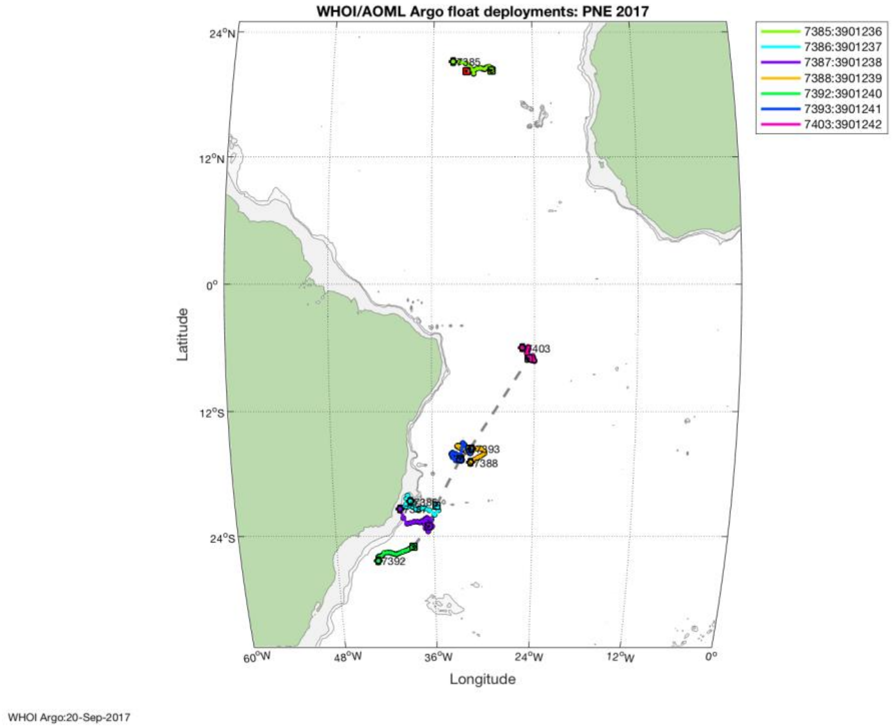


Satellite-tracked Argo profiling floats

Eight Argo profiling floats were deployed from the sides of the A-Frame on the fantail. All the instruments were MRV S2A profiling floats equipped with Seabird 41cp CTDs and Iridium telecommunications. The floats were programmed to perform the standard Argo mission - measuring a 2000 dbar profile every 10 days with drift at 1000 dbar in between. Data will be reported to the Argo GDAC (Global Data Assemble Center) and the GTS (Global Telecommunications System) via the US Argo DAC at AOML.

Latitude			Longitude			Time			WMO Number
Deg.	Min		Deg.	Min.		Month	Day	(GMT)	
24	58.50	S	38	33.40	W	2	23	23:15:00	3901240
23	00.17	S	36	36.13	W	2	24	13:18:00	3901238
20	59.62	S	35	38.81	W	2	25	2:29:00	3901237
16	30.25	S	32	41.12	W	2	26	21:05:00	3901241
15	30.12	S	31	31.06	W	2	26	21:05:00	3901239
7	00.00	S	24	40.98	W	3	1	5:53:00	3901242
20	16.70	N	28	58.10	W	3	14	21:05:00	3901236
20	11.47	N	32	00.00	W	3	15	10:54:00	3901235

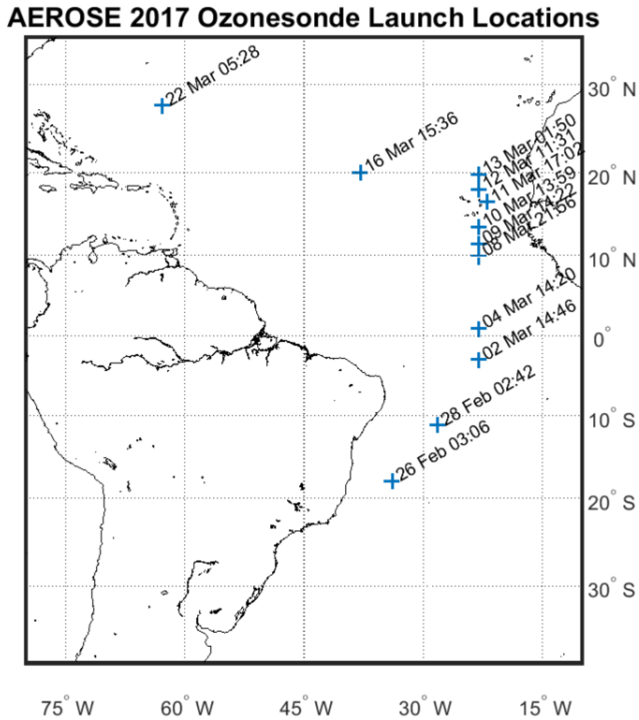
The figure shown below provides the trajectories of Argo profiling floats as of September 2017. The last Argo float to be deployed, 3901235, failed on deployment.



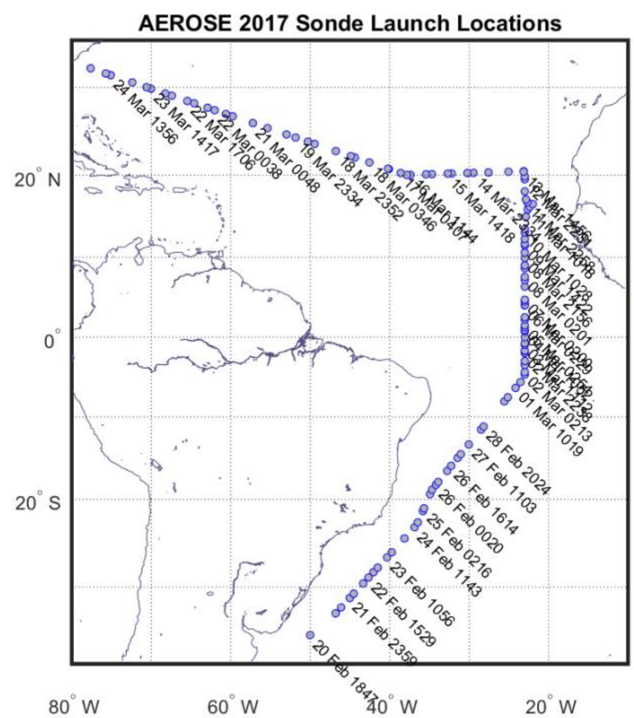
AEROSE

During Leg 2, the AEROSE team were responsible for the atmospheric sciences mission, which included continuous observations of the atmospheric chemistry and physics, launches of balloon-borne instrumentation, sampling of the air and airborne particulate originating from the Saharan Desert, filter sampling and measurement of trace gaseous pollutants.

Operations during this portion of the cruise included launching radiosondes and ozonesondes on a higher frequency (four per day) and intensifying sample collections. The ship encountered several interesting atmospheric conditions including an extended heavy fog event lasting over 48 hours, several "silver" days, a stratospheric injection event, three biomass burning regimes, and two distinct Saharan Air Layer (SAL) events. The SAL, in particular, was expected to be rich in Saharan dust and particulate from biomass fires, which can strongly influence the chemistry of the atmosphere. The team successfully collected data during Saharan dust events, biomass outflows, and "mixed" air masses that contained both dust and smoke particulate. These are very rare and unique observations that will contribute to the rich data set that AEROSE has generated over the past decade. The locations and the dates of the radiosonde and ozonesonde launches are shown in the figures below.



Locations and times of the AEROSE ozonesonde launches.



Locations and times of the AEROSE radiosonde launches.