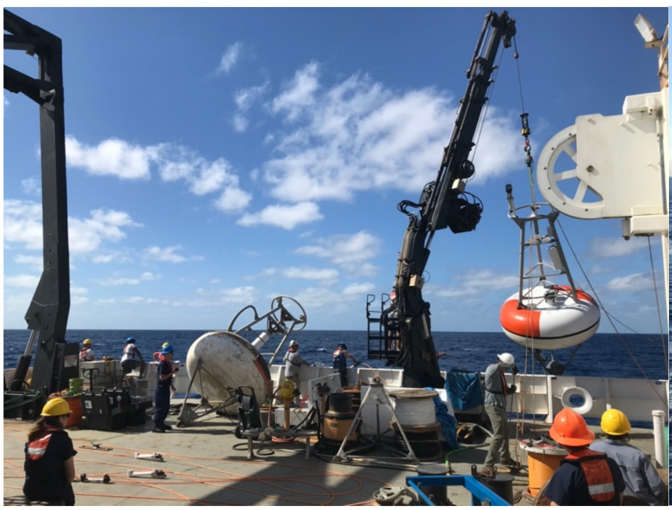
Cruise Report
PIRATA Northeast Extension / AEROSE 2022

NOAA Ship *Ronald H. Brown*
RB-22-04

November 1 – December 9, 2022
Bridgetown, Barbados – Newport, RI USA



Gregory Foltz, Chief Scientist
NOAA/Atlantic Oceanographic and Meteorological Laboratory
Physical Oceanography Division
Miami, FL USA

PIRATA Northeast Extension 2022 Scientific Party

Hydrography: Gregory Foltz (*NOAA/AOML*), Diego Ugaz (*CIMAS/AOML*), Philip Tuchen (*Postdoc, AOML/NRC*), Aurpita Saha (*Postdoc, AOML/CIMAS*), Lev Looney (*Ph.D. student, U. Miami/RSMAS),* Michelle Spencer *(Ph.D. Student, U. Oklahoma)*

Moorings: Steve Kunze (*NOAA/PMEL*), Robert Hagg (*NOAA/PMEL/CICOES*)

AEROSE: Nicholas Nalli (*NOAA/NESDIS/STAR*), Kylie Hoffman (*Univ. Maryland Baltimore County*), Martin Jimenez-Navarro (*Arizona St. Univ.*), Margarita Kulko (*Arizona St. Univ.*)

Sargassum: Alyson Myers (*Fearless Fund*) Michelle Spencer (*for Dennis McGillicuddy, WHOI*)

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 PIRATA Northeast Extension project and is part of a collaborative agreement between AOML and PMEL, funded by NOAA's Climate Program Office. All results reported in this document are subject to revision after post-cruise calibrations and other quality-control procedures have been completed.

OVERVIE

The November-December 2022 PIRATA (Prediction and Research Moored Array in the Tropical Atlantic) Northeast Extension (PNE) cruise RB-22-04 was designed to (1) Recover and redeploy the PIRATA Northeast Extension's four TFlex moorings, deploy one PIRATA backbone mooring, and service two other backbone moorings, (2) Collect oceanographic and meteorological observations in the northeastern tropical Atlantic, (3) Obtain atmospheric profile and aerosol measurements in support of AEROSE (Aerosols and Ocean Science Expeditions), and (4) Collect upper-ocean water samples and Sargassum samples. The oceanographic component of (2) includes measurements of conductivity, temperature, pressure, oxygen concentration, and horizontal velocity from CTD casts, and horizontal velocity measurements from the hull-mounted ADCP. The majority of the CTD measurements were acquired along the 23°W meridian, which samples the southeastern corner of the subtropical North Atlantic (a region of subduction that is important for the subtropical cell circulation), the Guinea Dome and oxygen minimum zone, where the subtropical and tropical gyres meet, and the tropical current system and equatorial waveguide. The meteorological component of (2) focused on measurements of air temperature, relative humidity, wind velocity, shortwave radiation, longwave radiation, and rainfall from the ship's meteorological sensors. Many of the scientific goals of RB-22-04 were achieved. However, we did not recover and deploy the 20ºN, 38ºW PNE mooring due to unplanned ship activities: Approximately 30 hours were spent taking a crewmember to Cape Verde, and it took about 36 hours to respond to a sailboat's distress call. We were also unable to perform approximately 16 of the planned CTD casts, and we were not able to perform any of the planned AEROSE ozonesonde launches.

We thank the crew and officers of the *Ronald H. Brown* for their work during the cruise and their help before, during, and after the cruise. Three surface moorings were successfully recovered and redeployed, and an additional mooring was deployed, by Chief Bosun Michael Lastinger and the deck crew using an efficient method that eliminated the need for small boat operations. Thanks to the survey technicians, Jody and Heather, for their assistance during CTD casts, radiosonde launches, float deployments, and Sargassum collection. Thanks also to the rest of the crew, including the winch operators, engineers, and galley crew, who kept operations running smoothly.

Introduction

1. PIRATA Northeast Extension

The Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) is a three-party project involving 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 with subsurface sensors and automatic meteorological stations. The array consists of 18 moorings, 10 of which were deployed in 1997-1998, running along the equator and extending southward along 10ºW to 10ºS and northward along 38ºW to 15ºN. Following the success of this initial array, additional moorings were deployed in the southwestern tropical Atlantic in 2005 and in the northeastern tropical Atlantic in 2006-2007 (the PIRATA Northeast Extension; Fig. 1). All of these moorings continue to be maintained as part of the sustained ocean observing system.

The Northeast Extension samples a region of strong climate variations on 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). This area is the location of the North Atlantic's oxygen minimum zone, found between depths of 400 m and 600 m. 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 tropical Atlantic. It is driven by trade wind-induced upwelling and may play an active role in modulating air-sea fluxes in this region.

Seasonal tropical storm and hurricane forecasts are generated annually and are based primarily on statistical analyses of historical data and the formulation of empirical predictors (e.g., ENSO 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 SST anomalies in the MDR. There is hope that a better understanding of decadal-multidecadal SST variability in the tropical North Atlantic will lead to improved predictions of Atlantic hurricane activity and rainfall fluctuations over South America and Africa. There is currently great uncertainty regarding the roles of wind-induced evaporative cooling, cloudiness- and dust-induced changes in surface radiation, anthropogenic aerosol-induced surface cooling, and ocean mixed layer dynamics, in driving interannual-multidecadal SST variability in the tropical North Atlantic. Measurements from the moorings of the PIRATA Northeast Extension are valuable for conducting empirical heat budget analyses, which diagnose the causes of SST variability and are also useful for numerical model validation and for improving tropical weather and hurricane situational awareness for forecasters at NOAA's National Hurricane Center.

2. Aerosols and Ocean Science Expeditions (AEROSE)

The NOAA AEROSE project attempts to employ a comprehensive measurement-based approach for gaining understanding of the weather and climate impacts of long-range transport of mineral dust and smoke aerosols over the tropical Atlantic (Morris et al., 2006; Nalli et al., 2011). The African continent is one of the world's major source regions of mineral dust and biomass burning smoke aerosols. These aerosols are transported across the tropical Atlantic as large-scale outflow plumes within the prevailing easterly winds, impacting phenomena ranging from cloud-seeding and precipitation, tropical cyclone development, net surface heat flux, tropospheric ozone and other trace gases, ocean fertilization, air quality and ecosystems in the Caribbean and along U.S. eastern seaboard, and NOAA thermal infrared satellite data products. Red tides, increasing rates of asthma, and precipitation variability in the eastern Atlantic and Caribbean have been linked to increases in the quantity of Saharan dust transported across the Atlantic. The contribution of the Saharan air layer (SAL) to the seasonal development of the West African Monsoon (WAM) and its role in tropical cyclogenesis are still not fully understood. The interplay between thermodynamics, microphysics, and aerosol chemistry are currently unknown. Understanding of the mobilization, transport, and impacts of aerosols originating from natural and anthropogenic processes in Africa on the meteorology and climate of the tropical Atlantic continue therefore to be a high priority. AEROSE has thus sought to address three central scientific questions (Morris et al., 2006): (1) How do Saharan dust, biomass burning aerosol, and/or the SAL affect atmospheric and oceanographic parameters during trans-Atlantic transport? (2) How do the Saharan dust aerosol distributions evolve physically and chemically during transport? (3) What are the capabilities of satellite remote sensing and numerical models for resolving and studying the above processes?

The AEROSE project hinges on multi-year, trans-Atlantic field campaigns conducted in collaboration with the PNE project. AEROSE is supported through collaborative efforts between 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 (NCAS) at Howard University and Arizona State University (ASU). AEROSE trans-Atlantic campaigns have acquired 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 (Nalli et al., 2011), and have been extensively used for NOAA satellite thermal infrared sounder validation (Nalli et al., 2006, 2018)

3. Sargassum Science

Recent evidence suggests a long-term shift in the elemental stoichiometry of the *Sargassum* seaweed (particularly N:P), which may reflect changes in nutrient supply fueling these blooms. During the cruise, a *Sargassum* sampling campaign was conducted by Dennis McGillicuddy from Woods Hole Oceanographic Institution. The main goal was to collect *Sargassum* and ambient water samples in order to improve understanding of *Sargassum* blooms that originate in the eastern tropical North Atlantic.

Fearless Fund, a 501(c)3, leads a DOE ARPA-E (Advanced Research Projects Agency - Energy) MARINER (Macroalgae Research Inspiring Novel Energy Resources) research effort in conjunction with NOAA to produce macroalgae at energy (or carbon dioxide removal) scale. The Fearless team includes PNNL (Pacific Northwest National Laboratory), LANL (Los Alamos National Laboratory), the USF (University of South Florida) optical oceanography lab, Texas A&M physical oceanographers, and marine engineers. The focus of the team is to assist management, including sustainable harvest, of *Sargassum natans* and *fluitans* that pose environmental and economic harm to coastal communities. The team joined the PNE cruise for the first time in 2021 to better understand the production system of the Great Atlantic Sargassum Belt in the tropical Atlantic, which has been established since 2011.

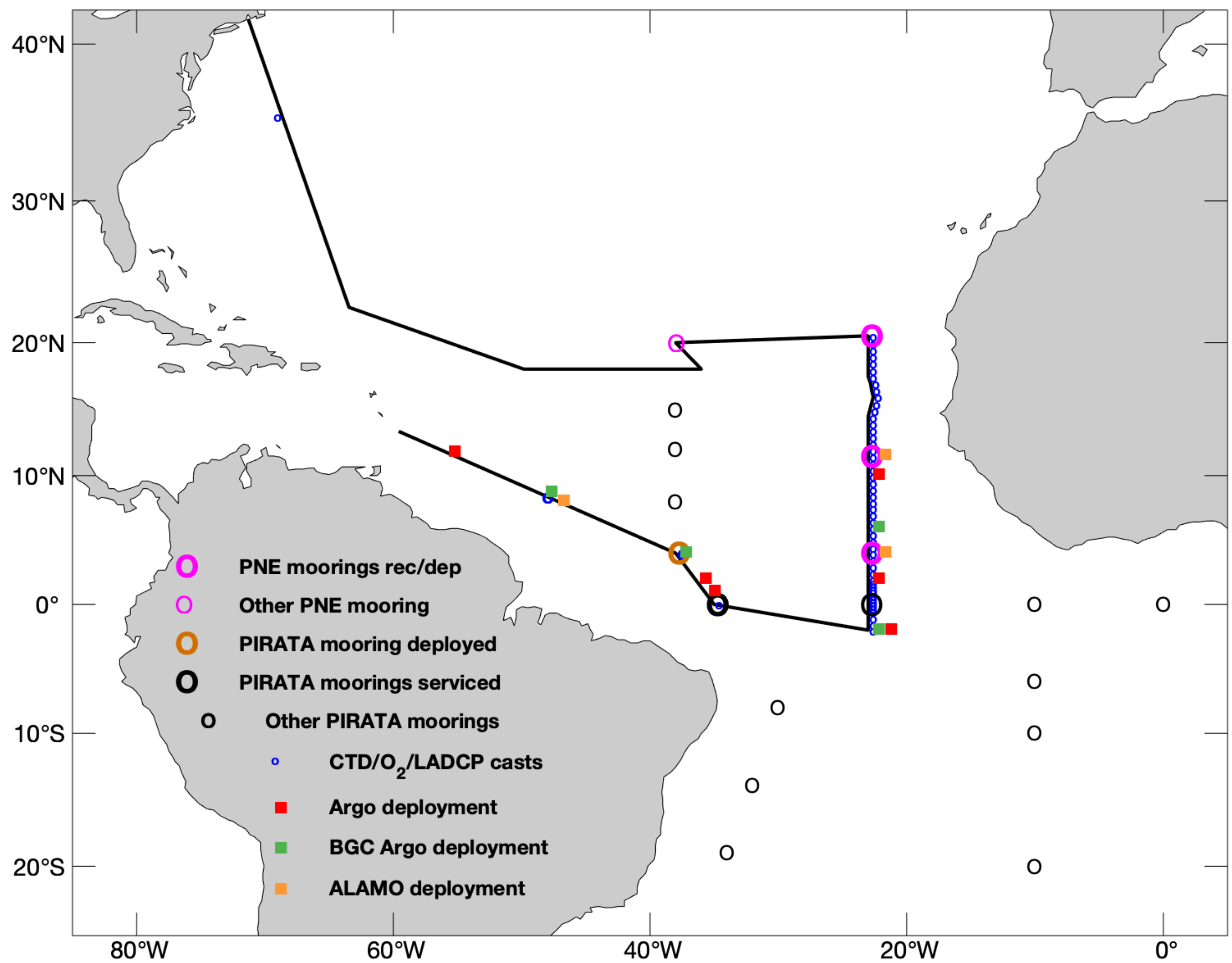


Figure 1 Cruise track (black line) with PNE moorings that were recovered and redeployed (thick pink circles), PNE mooring that was not recovered/redeployed (small pink circle), PIRATA mooring that was deployed (orange circle), PIRATA moorings that were serviced (bold black circles), CTD stations (blue circles), Argo (red squares), BGC Argo (green squares), and ALAMO (orange squares) deployed. Black circles indicate positions of other PIRATA moorings.

Order of Operations

The COVID-19 pandemic necessitated additional safety precautions. All personnel were required to be up to date on COVID-19 vaccinations and to take a rapid test on the ship the day before the start of the cruise. This included the R/V *Ronald H. Brown* (RHB) crew as well.

The RHB departed Bridgetown, Barbados on November 1 at 14:30 UTC and proceeded east-southeastward toward the first mooring site. The RHB's hull-mounted ADCP recorded data during the transit through the Barbados EEZ. On November 2, an Argo float was deployed along the cruise track at 11°45'N, 56°W. Argo floats were provided by Pelle Robbins from Woods Hole Oceanographic Institution. Air-Launched Autonomous Micro Observer (ALAMO) floats were provided by AOML's Physical Oceanography Division. They are smaller and lighter than Argo floats but otherwise provide similar data. On November 4, on the way to the first mooring, a fully instrumented CTD test cast to a depth of 1500 m was performed at 8°29'N, 48°33'W, and 12 bottles were fired. Instruments included in the test cast and all subsequent casts include dual temperature, conductivity, and oxygen, as well as upward- and downward-looking 300 kHz ADCPs. The winch and all CTD equipment performed well. A summary of all CTD casts performed during the cruise is available in Table 1 in Section 2.1 in "Oceanic data". A BGC Argo and ALAMO float were deployed at the CTD site. Table 2 provides details of all 10 Argo and three ALAMO float deployments made during the cruise. On the way to the first mooring site, multiple strands of Sargassum were observed on the ocean's surface. The Sargassum teams collected Sargassum samples using pole nets. A summary of Sargassum collection locations and dates is given in Table 3.

The RHB arrived at the first mooring site (4°N, 38°W) around 05:00 UTC on November 7. First a CTD/ADCP cast was conducted to 500 m. The RHB had trouble with its gyro system, so it was decided to limit the cast to 500 m instead of the normal 1500 m. The buoy was then recovered starting at about 12:00 UTC, and a new one was deployed in the early afternoon (local time). However, upon deployment of the subsurface sensors, it was discovered that they were not transmitting data. The buoy and instruments were recovered, but it was too late in the day to fix the problem and deploy the buoy again. Upon recovery, some rips in the insulation of the nilspin wire were discovered, so it was it was replaced with a new spool. We waited at the mooring location overnight during November 7-8 and conducted a deep (4500 m) CTD/ADCP cast.

On the morning of November 8, the buoy and subsurface instruments were deployed again, but the problem persisted and the buoy and line had to be recovered again. It was discovered that the wiring in the buoy electronics tube was incorrect, and it was corrected by PMEL mooring technicians S. Kunze and R. Hagg. We waited at the mooring site overnight during November 8-9 and conducted another deep (4550 m) CTD /ADCP cast. On the morning of November 9, the buoy was deployed again and all subsurface sensors worked. A BGC Argo float was deployed during the evening of November 9 immediately following the buoy anchor drop and mooring "fly-by" to verify its data transmission.

On the way to the next mooring site (0º, 35ºW), two Argo floats were deployed. We arrived at the mooring around 15:00 local time, leaving only about three hours of daylight for a small boat ride to replace the buoy's electronics tube. After a meeting with the ship's officers, bosun, and deck crew to discuss safety, the small boat was launched and the tube swap was completed shortly before sunset. We proceeded straight to 2ºS, 23ºW to begin the main line of CTDs. A BGC Argo float was deployed at 2ºS, 23ºW. The decision to omit the CTDs between 2ºS and 8ºS was made after spending two extra days to deploy the 4º, 38ºW mooring. We also omitted the 1º45'S, 1º15'S, and 0º45'S CTDs to ensure a morning arrival at the 0º, 23ºW mooring, which required a small boat ride to replace the rain gauge. CTDs were conducted every 0.25º of latitude between the equator and 2ºN, and an Argo float was deployed at 2ºN. The PNE mooring at 4ºN, 23ºW was successfully recovered and redeployed on November 16 and an ALAMO float was deployed. A deep (4160 m) CTD was conducted prior to the mooring recovery. Between the 4ºN and 11.5ºN PNE moorings, a BGC Argo float was deployed at 6ºN. At 11.5ºN, an Argo and ALAMO float were deployed following the buoy deployment. The 11.5ºN mooring was successfully recovered and redeployed on November 19, and a deep (5000 m) CTD cast was conducted following the buoy deployment.

Following the CTD at 16.5ºN, 23ºW, the Chief Scientist was informed that a crewmember was going to be removed from the ship for disciplinary reasons and that it would take about 30 hours to drop the person off in Praia, Cape Verde. As a result, the 17ºN CTD was started at 04:00 UTC on November 23, about 32 hours after the completion of the 16.5ºN cast. After the 19ºN CTD cast, we skipped the 19.5ºN and 20ºN CTDs and proceeded directly to the 20.5ºN, 23ºW mooring to ensure arrival in the morning. The mooring was successfully recovered and redeployed on November 24. We then travelled southward and completed the 20oN and 19.5oN CTDs before heading westward toward the 20ºN, 38ºW PNE mooring.

At about 20:00 local time on November 27, when the RHB was about four hours from the 20ºN, 38ºW PNE mooring site, the Chief Scientist was informed that the Bridge had received a "ship in distress" call from the Coast Guard. The ship was a sailboat with a broken mast located about 200 miles south-southeast of the RHB. We immediately headed toward the sailboat to provide assistance and arrived the morning of November 28. Three of the sailboat's crew were successfully rescued and brought aboard the RHB. The RHB's CO and officers then decided to proceed directly westward, bypassing the 20ºN, 38ºW mooring in the process. The decision was made without the knowledge of or consultation with the Chief Scientist. The reason given by the CO was that seas of 8-10 ft were predicted at the mooring site the following day, when recovery and deployment would have been conducted. In addition, the CO plotted a circuitous route to the west, then west-northwest, and finally northward to Newport, RI in order to avoid 10-15 ft seas that would have been encountered on the North Atlantic great circle route to Newport. An alternate pre-cruise plan had an ending port of Mayport, Florida. The added time for the route to Newport left no time to wait for conditions to improve before recovering and deploying the 20ºN, 38ºW mooring. The Chief Scientist and AOML, PMEL, and GOMO directors were unsuccessful in their attempts to persuade the CO to (1) stop at the mooring site to assess conditions during the morning of November 29 and/or (2) request that the cruise be extended a day or two to allow time for recovery/deployment in case conditions were not conducive on November 29. The buoy at 20ºN, 38ºW has 15 Nortek current meters, 14 of which were part of an AOML/PhOD project (Tropical Atlantic Current Observations Study, TACOS) to measure the upper-ocean horizontal velocity and its vertical shear.

The 12-hour CTD watches consisted of Greg Foltz, Philip Tuchen, and Michelle Spencer (12 pm – 12 am), and Diego Ugaz, Aurpita Saha, and Lev Looney (12 am – 12 pm). Ugaz and Spencer conducted all oxygen titration of CTD water samples. Looney, Tuchen, Saha, Spencer, and Foltz performed all salinity calibration readings in the temperature-controlled autosal room.

Throughout the cruise, the AEROSE group from NOAA/NESDIS, Arizona State University, and University of Maryland Baltimore County deployed radiosondes at NOAA and EUMETSAT satellite overpass times, and also measured total column aerosol optical depth (AOD) from a handheld sun photometer (see Section 4 in "Oceanic data"). They also collected dust samples from the PNE buoys' meteorological sensors. The Marine-Atmospheric Emitted Radiance Interferometer (M-AERI), an instrument maintained by Peter Minnett and Miguel Izaguirre at RSMAS, operated during the cruise. It measured spectra of thermal infrared radiation emitted by the ocean surface and atmosphere, and took all-sky camera images of clouds. Standard meteorological variables and incident short-wave and long-wave radiation were also measured as part of the M-AERI project.

Summary of oceanographic and atmospheric work performed and data collected during the cruise:

1. Recovery and redeployment of TFlex moorings at 4°N, 23°W; 11.5°N, 23°W; 20.5°N, 23°W.
2. Deployment of ATLAS mooring at 4°N, 38°W.
3. Replacement of electronics tube on 0°, 35°W ATLAS mooring.
4. Replacement of rain gauge on 0°, 23°W mooring.
5. CTD/O_2/ADCP profiles to 1500 m (or bottom, whichever is shallower) at 50 locations, including each TFlex/ATLAS mooring site where there was a recovery/deployment/servicing.
6. Deep CTD/O_2/ADCP casts at four locations (4°N, 38°W; 0°N, 23°W; 4°N, 23°W; 11.5°N, 23°W).
7. Salinity of the CTD bottle samples collected with Niskin bottles.
8. Dissolved oxygen concentration of the CTD bottle samples collected with Niskin bottles.
9. Sargassum tissue (Sargassum groups).
10. Deployment of Sargassum tissue, housed in a container, to the bottom of the ocean on the 11°30'N mooring's acoustic release (Sargassum, mooring groups).
11. Deployment of 6 Argo, 4 BGC Argo, and 3 ALAMO floats.
12. Continuous recording of shipboard ADCP data.
13. Continuous recording of Thermosalinograph (TSG) data.

14. Heading data from the Meridian Attitude and Heading Reference System (MAHRS) and the Position and Orientation Systems for Marine Vessels (POS MV).
15. Weatherpak meteorological sensors (Univ. Miami).
16. Microwave radiometer (Univ. Miami).
17. Marine Atmospheric Emitted Radiance Interferometer (M-AERI) (an infrared Fourier transform spectrometer (FTS)) to measure uplooking and downlooking spectral radiances, marine boundary layer profiles of temperature and water vapor, and skin SST (Univ. Miami).
18. Total column aerosol optical depth (AOD) from a handheld sun photometer (AEROSE/ASU/Howard University).
19. Atmospheric profiles of temperature, humidity, pressure, and wind velocity from radiosondes (AEROSE/NOAA/NESDIS).
20. Dust samples from PNE buoys' meteorological sensors (AEROSE/ASU).
21. Automated surface pCO_2 (NOAA/PMEL).

Oceanic Data

1. TFlex moorings (from Steve Kunze, NOAA/PMEL)

S M O		
Site	**Mooring ID #**	**Operation**
4N38W	PI276A	Depl
0-35W	PI275B	Repair
0-23W	PT052	Repair
4N23W	PT049A / PT056A	Rec / Depl
11.5N23W	PT048A / PT057A	Rec / Depl
20.5N23W	PT047A / PT058A	Rec / Depl

L D I E *(from rec moorings)*				
Site	**Mooring ID**	**Sensor type**	**Serial No**	**Comments**
4N38W	PI276	TC120	15803	Flooded during failed deployment
0 23W	PT052 (Repair)	Rain	1650	Ripped off tower leaving severed pigtail
4N23W	PT049	SBE37IM 120m	9224	Case fell off sensor body underwater during recovery and was resting on 140m sensor
11.5N23W	PT048	SBE37SMP	15277	Pigtail ripped from bulkhead connector. Pins bent/broken. Conductivity cell dislodged on one end.
11.5N23W	PT048	SBE37IM 40m	9202	Case fell off sensor body after surfacing and came to rest on 60m sensor

11.5N23W	PT048	German O2 79m	2532	Inductive assy broke away from body and was resting on 80m sensor
11.5N23W	PT048	German O2 299m	2530	Inductive assy broke away from sensor body but held in place by bulkhead connector locking sleeve
20.5N23W	PT047	Gill Wind	17400069	Ship contact on recovery approach broke the sensor
20.5N23W	PT047	Rain	1651	Ship contact on recovery approach breaking funnel off
20.5N23W	PT047	SWR	35958	Ship contact on recovery approach. Bent shield, mast, and gusset

O -		***(pre-deployment)***
Sensor type	**Serial No**	**Comments**
ATLAS top section cables	846, 847	Inductive connectors mis-wired
SBE39IM	6194	Dead batteries as received
SBE39IM	6197	No comms
AT/RH (MP101A)	104898	Swapped out just prior to deployment. RH to zero after deluge of rain. May have 'turned over'. Replaced as precaution.

A R		
Model	**Serial no**	**Comments**

F V		
Site	**Mooring ID**	**Comments**
0 35W	PI275 (Repair)	Heavy hawser tied to base of tower, SWR shield bent, tower ring weld broken off one gusset and ring broken in half in another spot leaving 1/3 of useable ring area to work from for the tube swap. Removed hawser, and pushed SWR shield back into place.
0 23W	PT052 (Repair)	Chain and line tied off to buoy padeye. Removed. AT/RH sensor bent horizontally, LWR shield bent, Rain gauge missing leaving severed portion of sensor pigtail.
4N23W	PT049	TC60 fouled in longline, hooks, and lights.
11.5N23W	PT048	SSTC cable pulled out of bulkhead connector. Pins bent/broken. Pigtail worn through exposing bare wire.
20.5N23W	PT047	Minor residual evidence of fishing net in bridle

N O D :

4N38 D PI276:

A multibeam survey was conducted over the region that the Brazilians had previously surveyed in order to upgrade their bathymetry which consisted of only a map covered with depth readings. It soon became clear that this was not an ideal area for deploying moorings. During the approach from the Northwest prior to the survey, and adjacent to this region, the multibeam recorded relatively consistent depths over a large area. We overnighted there and collected more multibeam data before beginning operations the following morning.

The first attempt to deploy the mooring was aborted when the subsurface data completely failed after the end of the nilspin went into the water. The mooring was parted on deck at the end of the 700m section and subsequently recovered. Damage to the nilspin jacketing was discovered just below the top section connection which exposed bare wire effectively shorting out the underwater circuit. The nilspin was replaced and a second deployment was attempted but it too failed in the same fashion. After we recovered the buoy again it was found that the top section cable had been mis-wired in manufacturing due to an error in the latest version of the EDD engineering drawing. We found this to be the case with the spare ATLAS top section as well. We successfully rewired the inductive cable connector on the spare cable and installed it onto the buoy. The third deployment was successful. It should be noted that this problem was not evident during deck testing with the top section prior to the first deployment attempt. It is not understood why this was the case and we could only speculate that it may have been related to a floating ground situation as the buoy is not earth grounded while deck testing.

After the second deployment attempt we noticed that the 120m TC module had flooded so it was replaced prior to the third deployment. The top termination on the nilspin used for the first deployment attempt had been subjected to severe torqueing around the capstan during the recovery so the spare was used for the second and third tries. The engineering diagram was updated at PMEL and we ended up with three days of multibeam data around the area when operations concluded.

0 35 R PI275:

This repair had not been scheduled during cruise planning as the issue was discovered after the shipment had departed PMEL. The logic circuitry voltage on this ATLAS mooring was declining at a rapid rate. The Chief Scientist was contacted prior to the cruise and permission was given to stop at this location to conduct a tube swap. The spare ATLAS tube was used for the buoy repair and it was successful however the cause of the rapid battery drain is still to be determined. Each stack of cells in the battery pack had drained equally. This dispelled the notion that there was a faulty stack, which was what had been suspected. When communications were established with the tube it indicated that the compact flash card, which is used for data storage, could not be detected thus no data was recovered. Failed compact flash cards are a known problem in the ATLAS systems as our inventory ages. All attempts to acquire a compatible replacement card have failed. High battery drains associated with faulty compact flash cards have not been observed before but this will be investigated too.

As for the physical state of the buoy, there was heavy hawser tied to the base of the tower, the rad shield was bent and the tower ring had a broken weld at a gusset and was broken in half in another spot, leaving only 1/3 of the area to perch upon for replacing the tube. The SWR shield was bent back into place, somewhat, and the hawser was cut off.

0-23 R PT052:

This was also an unscheduled repair. The rain gauge had failed prior to the start of the cruise and it went unnoticed. Repairs at this French serviced site are very common on PNE cruises so stopping here for a buoy ride wasn't entirely unexpected. The rain gauge was missing and it looked like it was broken off. The severed sensor pigtail still remained. The micarta mount was still usable so it was a simple matter to replace the gauge. The AT/RH sensor had been bent over to an almost horizontal position and we forcefully straightened it up. The LWR shield was bent too but it was left that way. There was chain attached to a buoy pad eye and medium heavy line tied to that. It was removed. The integrity of the buoy tower looked okay.

4N23 R PT049:

TC120, which had looked just fine on the latest iridium call prior to recovery, came out of the water without its case and shield. The case was resting on T140 with no visible damage. It looked like the screws had just backed out of it. Water was sizzling on one of the circuit boards. Data could not be recovered. There was some light longline fouling at TC60 but no damage. The sargassum vessel that had been mounted to the acoustic release was recovered undamaged and was not replaced on the subsequent deployment.

11.5N23 R PT048:

Similar to the previous recovery, TC40 lost its shield and case but the case fell off after the sensor surfaced and before we got our hands on it. The case was recovered at the 60m sensor. Data was successfully recovered from this unit. The SSTC data had been reporting the error code 1E+35 and was found to have had the pigtail pulled off of the sensor bulkhead connector leaving bent exposed pins. The pigtail jacketing was also worn through exposing some bare wire and the conductivity cell was also dislodged at one end. If this was due to fishing activity then that was the only evidence. Data was recovered from this sensor via the internal connector behind the bulkhead connector cover. The Aquadopp at this site had failed too and was physically okay on recovery. The data file was small and we used the interface software to convert the downloaded file. The resulting truncated file showed that the last sample was taken on 12/6/21. This was five days after the deployment. Two of the O2 sensors, 79m and 299m, were damaged in that the inductive coupler assemblies had broken away from the bodies which in turn had severed the wiring. The 79m coupler was resting on the 80m sensor and the coupler for the 299m was held in place by the locking sleeve on its terminal connector. The sargassum vessel mounted on the acoustic release was recovered undamaged.

11.5N23 D PT057:

After it was apparent that the case screw problem with the SBE37s was not a one-off issue we started checking the screws on all of them prior to deployment and found that most of them were loose. We carried this practice over to the remaining deployments as well and found that the vast majority of shield and case screws on all of the 37s were loose.
Alyson Myers of the Fearless Fund, who was our collaborator for the sargassum deployments, approached us the evening before the 11.5N23W operations and asked if we would re-deploy the sample that we were going to recover from PT048 for a second year of submersion and we agreed to.

20.5N23 R PT047:

Thanksgiving Day Operations. The recovery was rough on the buoy. The ship made several unsuccessful passes and the seas and winds weren't helping matters. All of the sensors above the ring were damaged and the SWR mount on the tower was bent resulting in a cracked weld. The Aquadopp had some severe gouges on it which damaged one of the transducer heads. The body clamp had rotated resulting in a heavily warped vane. The 300m yellow jacketed wire that had been used on the prior deployment at this location and then subsequently recovered and reused here was retired. The dynamics of this wire had been suspected of contributing to a knot that was found on the nilspin on the recovery of the prior deployment. There was no knot on found on the recovery of this mooring.

20.5N23 D PT058:

On deployment, this buoy also hit the ship and suffered a bent SWR shield. All sensors were reporting fine on flyby.

2. Conductivity-Temperature-Depth (CTD) and Acoustic Doppler Current Profiler (ADCP) casts

2.1 CTD casts

AOML's CTD package was configured with 18 Niskin bottles: 12 bottles to be fired at various depths during the casts (to collect water samples for salinity and dissolved oxygen calibration) and six spare bottles. The sensors on the CTD frame consisted of primary and secondary temperature, conductivity, and oxygen (six total) and upward- and downward-looking 300 kHz ADCPs.

A total of 57 CTD/ADCP casts, including one instrumented test cast, was conducted by Greg Foltz, Diego Ugaz, Philip Tuchen, Aurpita Saha, Lev Looney, and Michelle Spencer, with assistance from the Survey Technicians (Table 1). CTD processing was performed using Seabird software. After acclimating in the autosal room for at least two days, salinity samples were calibrated using an autosal provided by AOML. Oxygen titration was performed by Diego Ugaz and Michelle Spencer in order to calibrate dissolved oxygen concentration obtained from the CTD sensors.

Table 1 Date (UTC), start time (UTC), end time (UTC), latitude, and longitude of CTD casts.

CTD #	D	S	E	L	L	D
0	Nov 04	11:55	13:20	08°29.2'N	48°34.0'W	test cast (1500 m)
1	Nov 07	05:10	06:00	04°01.8'N	38°04.2'W	at mooring (500 m)
2	Nov 07	20:50	00:00	04°01.8’N	38°04.7’W	at mooring (4500 m)
3	Nov 08	21:10	00:15	04°01.8’N	38°04.6’W	at mooring (5554 m)
4	Nov 10	21:10	22:30	00°06.7’S	35°01.4’W	at mooring (1500 m)
5	Nov 13	14:15	15:30	02°00.0’S	23°00.0’W	(1500 m)
6	Nov 13	18:15	19:30	01°30.0’S	22°59.9’W	(1500 m)
7	Nov 13	22:15	23:30	00°59.9’S	22°59.9’W	(1500 m)
8	Nov 14	02:15	03:45	00°29.9’S	23°00.0’W	(1500 m)
9	Nov 14	05:10	06:45	00°14.8’S	23°00.0’W	(1500 m)
10	Nov 14	10:15	13:10	00°00.2’S	22°59.5’W	at mooring (3800 m)
11	Nov 14	14:35	15:55	00°15.0’N	23°00.0’W	(1500 m)
12	Nov 14	17:20	18:30	00°30.0’N	23°00.0’W	(1500 m)
13	Nov 14	20:00	21:45	00°45.1’N	23°00.1’W	(1500 m)
14	Nov 14	23:10	00:25	01°00.0’N	23°00.0’W	(1500 m)
15	Nov 15	02:00	03:15	01°15.0’N	23°00.0’W	(1500 m)
16	Nov 15	04:50	06:05	01°30.1’N	22°59.9’W	(1500 m)
17	Nov 15	07:40	09:00	01°45.0’N	22°59.8’W	(1500 m)
18	Nov 15	10:30	12:00	02°00.0’N	23°00.0’W	(1500 m)
19	Nov 15	14:40	15:55	02°30.0’N	23°00.0’W	(1500 m)
20	Nov 15	18:25	19:35	03°00.1’N	23°00.0’W	(1500 m)
21	Nov 15	22:15	23:30	03°30.0’N	23°00.0’W	(1500 m)
22	Nov 16	02:50	05:50	04°01.7’N	22°58.4’W	at mooring (4166 m)
23	Nov 16	21:20	22:35	04°30.0’N	22°59.9’W	(1500 m)
24	Nov 17	01:20	02:45	05°00.1’N	22°59.9’W	(1500 m)
25	Nov 17	05:45	07:05	05°30.1’N	23°00.0’W	(1500 m)
26	Nov 17	09:55	11:20	06°00.0’N	23°00.0’W	(1500 m)
27	Nov 17	14:25	15:40	06°30.1’N	23°00.0’W	(1500 m)
28	Nov 17	18:25	19:30	07°00.0’N	23°00.0’W	(1380 m)
29	Nov 17	22:10	23:25	07°30.1’N	22°59.9’W	(1500 m)
30	Nov 18	02:10	03:35	08°00.1’N	22°59.9’W	(1500 m)
31	Nov 18	06:20	07:40	08°30.0’N	23°00.0’W	(1500 m)
32	Nov 18	10:40	12:00	08°59.9’N	22°59.9’W	(1500 m)
33	Nov 18	14:50	16:05	09°29.9’N	23°00.0’W	(1500 m)
34	Nov 18	18:50	20:05	09°59.8’N	23°00.0’W	(1500 m)
35	Nov 18	22:55	00:05	10°30.0’N	22°59.9’W	(1500 m)
36	Nov 19	03:00	04:20	10°59.9’N	23°00.0’W	(1500 m)
37	Nov 19	19:50	23:05	11°28.1’N	23°00.0’W	at mooring (5000 m)
38	Nov 20	02:30	03:45	12°00.0’N	23°00.2’W	(1500 m)
39	Nov 20	06:55	08:00	12°29.9’N	23°00.1’W	(1500 m)
40	Nov 20	11:20	12:40	12°59.9’N	23°00.0’W	(1500 m)
41	Nov 20	15:50	17:05	13°30.0’N	23°00.0’W	(1500 m)
42	Nov 20	20:35	21:45	14°00.1’N	23°00.1’W	(1500 m)
43	Nov 21	01:10	02:30	14°29.9’N	23°00.0’W	(1500 m)

44	Nov 21	05:40	07:00	15°00.0'N	22°52.1'W	(1500 m)
45	Nov 21	10:10	11:35	15°30.0'N	22°44.1'W	(1500 m)
46	Nov 21	14:45	15:20	15°59.8'N	22°36.0'W	(546 m)
47	Nov 21	18:50	20:05	16°30.0'N	22°44.0'W	(1500 m)
48	Nov 23	04:05	05:15	17°00.0'N	22°49.1'W	(1160 m)
49	Nov 23	08:30	09:50	17°29.9'N	23°00.0'W	(1500 m)
50	Nov 23	13:15	14:30	17°59.8'N	23°00.0'W	(1500 m)
51	Nov 23	18:00	19:10	18°30.0'N	23°00.1'W	(1500 m)
52	Nov 23	22:15	23:30	18°59.9'N	23°00.0'W	(1500 m)
53	Nov 24	18:55	20:05	20°26.2'N	23°08.5'W	at mooring (1500 m)
54	Nov 24	22:50	00:05	19°59.0'N	23°00.0'W	(1500 m)
55	Nov 25	02:55	04:20	19°30.0'N	23°00.0'W	(1500 m)
56	Dec 07	13:05	16:30	35°32.8'N	69°05.8'W	(4848 m)

The latitude-depth section of temperature from the CTD casts shows the warmest sea surface temperatures (SSTs) concentrated in the 5°-10°N latitude band of the intertropical convergence zone (ITCZ) (Fig. 2a). SSTs in the ITCZ region exceed 27°C and drop to 22°C-26°C to the north and south. A sharp seasonal thermocline is present at the base of the mixed layer at all locations, with the temperature decreasing approximately 10°C over a distance of 10-20 m. The meridional slopes of the isotherms are consistent with the dominant zonal currents in the eastern tropical Atlantic: the westward North Equatorial Current (NEC) between 10°N-20°N, the eastward North Equatorial Countercurrent (NECC) between 3°N-10°N, and the westward South Equatorial Current between 1°S-3°S.

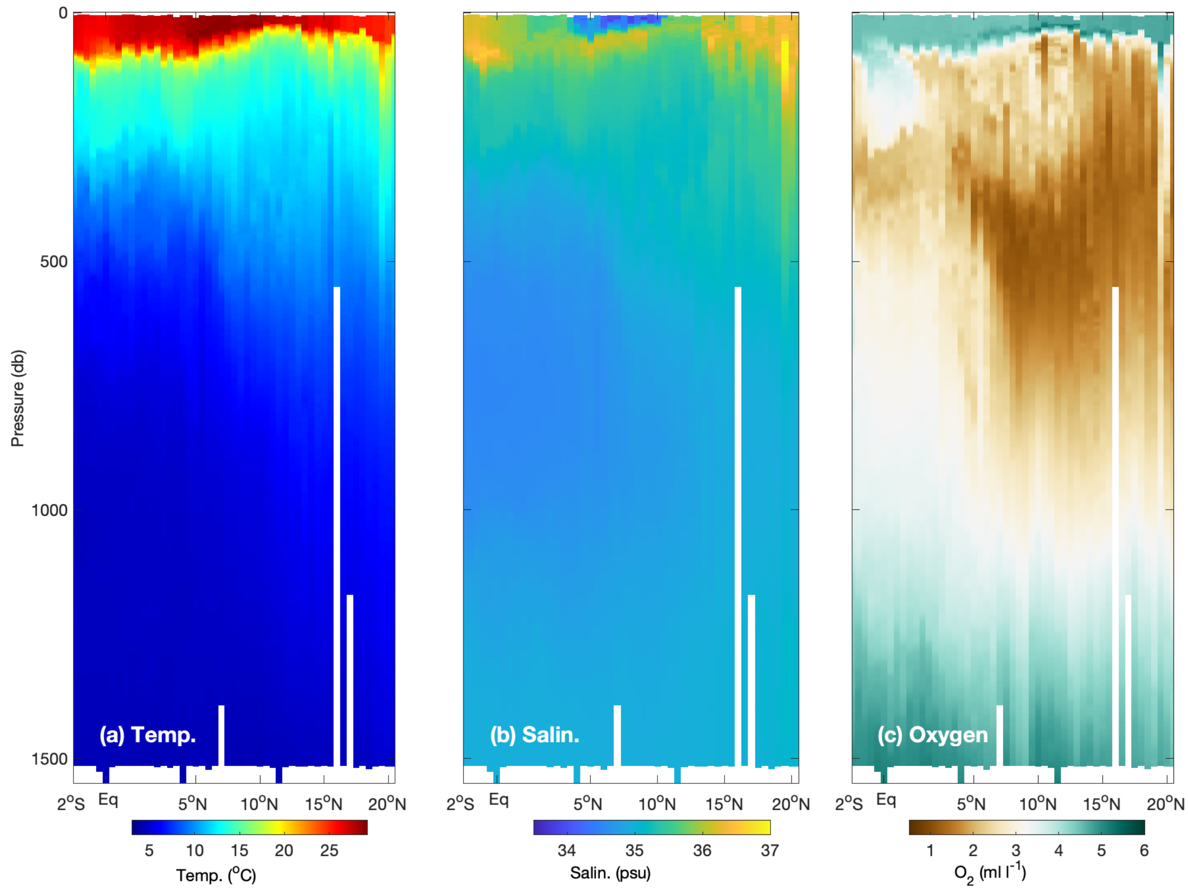


Figure 2 Latitude-depth sections of (a) temperature, (b) salinity, and (c) oxygen acquired along 23°W during the cruise.

The salinity section shows the low-salinity core of the Antarctic Intermediate Water between 400 and 1200 dbar, freshest at 2°S and becoming saltier to the north (Fig. 2b). High-salinity subtropical water (>36.5 PSS) is apparent at depths of 0-100 m between 18°N and 20°N and to a lesser extent between 40-70 m near 3°-5°N and just south of the equator. The 18°-20°N high-salinity water mass can be traced in part to the subtropical North Atlantic, where an excess of surface evaporation over precipitation leads to the highest surface salinity in the global ocean. The subtropical salinity maximum water subducts and travels poleward in the eastern tropical North Atlantic. In the subtropical South Atlantic, high-salinity water subducts and travels northward to the equator, where it is carried eastward in the Equatorial Undercurrent. The high-salinity features visible at 20°N and near the equator in the latitude-depth section are consequences of the subduction of subtropical salinity maximum water in the North and South Atlantic, respectively. Much lower values of salinity (34.5-35.5) in the upper 40 m between 4°N and 10°N result from an excess of precipitation over evaporation in the ITCZ.

The dissolved oxygen section along 23°W shows high concentrations (> 4 ml l^{-1}) in the surface mixed layer and below 1200 dbar (Fig. 2c). There is a pronounced oxygen minimum zone centered at a depth of about 300-500 m between 5°N-20°N. This water is in the stagnant shadow zone of the North Atlantic, which is not part of the circulation associated with the ventilated thermocline of the subtropical gyre.

Salinity calibration values from the CTD bottle samples are available for each cast. The autosal performed reasonably well and the room temperature remained fairly stable, within about one degree of 24°C. The offset between each CTD bottle value and the associated autosal calibration value is shown in Fig. 3a. The error for the calibrated salinity is 0.0084 psu, which is higher than the WOCE standard of 0.002 psu. Before correcting the CTD sensor values based on the calibration readings, the calibration readings were corrected for any spurious trends identified during each autosal run, using the Matlab code provided by Jay Hooper.

Oxygen calibration values from the CTD bottle samples are available for each cast. The oxygen titration for the samples was performed during the cruise by Diego Ugaz and Michelle Spencer. One of the chemical dispensers broke after cast 035. Fig. 3b clearly shows a decreased range in residual oxygen values (CTD sensor compared to titrated sample) after cast 035 and then a negative trend. We therefore omitted casts 036-056 when deriving the bottle-based correction to the CTD-measured oxygen data. Overall, the offset between the sensor and calibration readings show the expected dependence on depth, with larger offsets (sensor value too low) at greater depths (Fig. 3b). The error for the calibrated oxygen is 0.051 ml/l, which is roughly 1% of the measured oxygen concentrations and within the range recommended by WOCE.

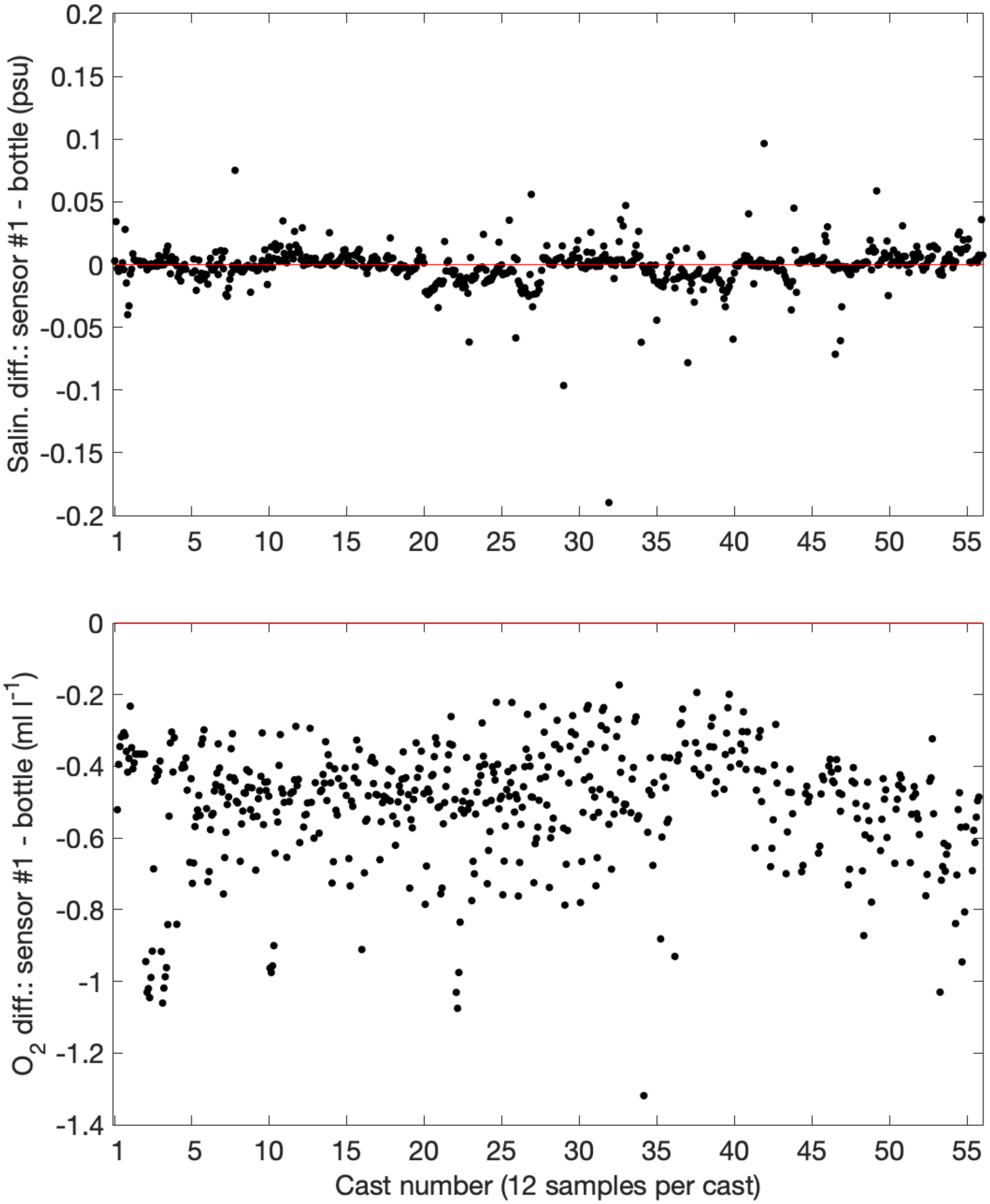


Figure 3 (a) Difference between salinity value from CTD primary sensor and bottle sample. Negative values indicate that bottle sample was higher than sensor value. Red line shows a difference of zero. (b) Same as (a) except for oxygen concentration.

2.2. ADCP casts

A total of 57 lowered ADCP casts was obtained using upward- and downward-looking 300 kHz ADCPs. The resultant meridional sections of zonal and meridional velocity are shown in Fig. 4. The equatorial undercurrent is clearly visible within about 1.5° of latitude from the equator, with eastward velocities reaching close to 1 m/s. Strong westward flow of the South Equatorial Current is noticeable north of the undercurrent core.

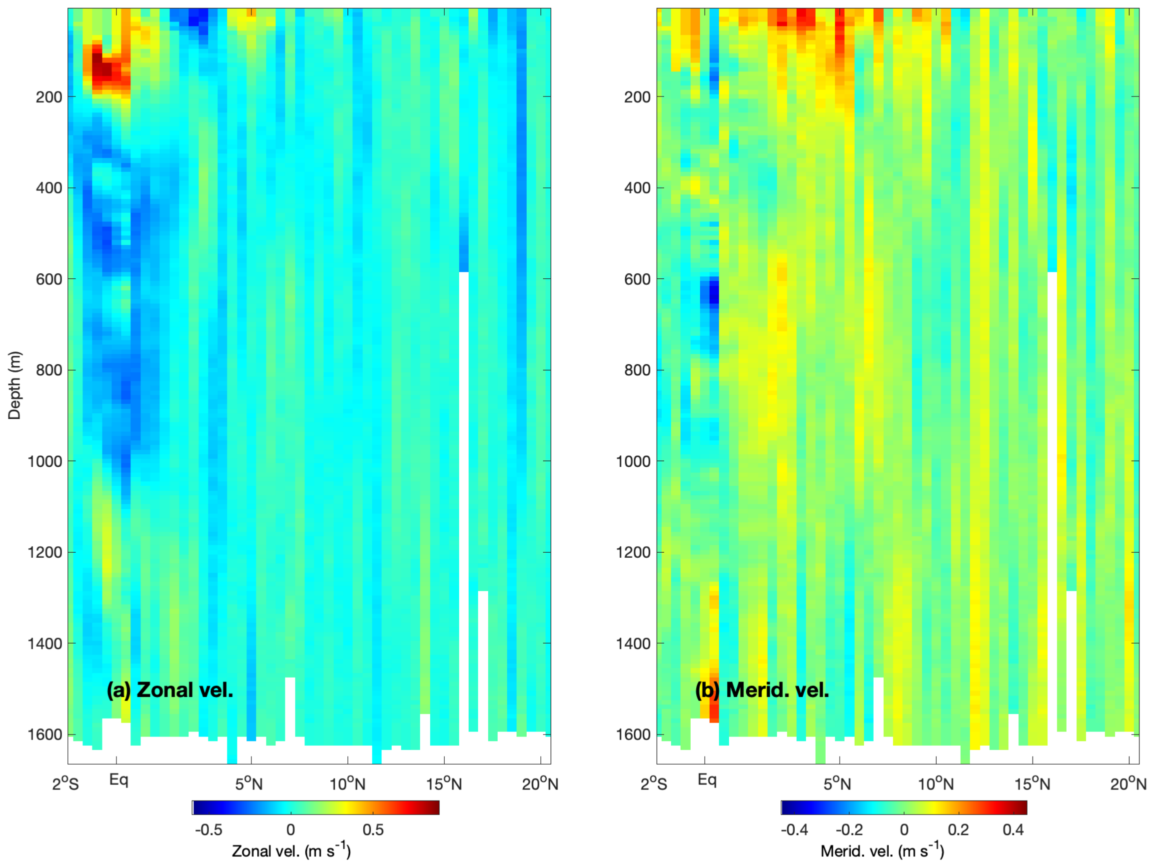


Figure 4 Zonal (a) and meridional (b) velocity sections along the 23°W cruise track from the lowered ADCP casts.

2.3. Argo and ALAMO deployments

Six Argo floats and four BGC Argo floats were deployed (see Fig. 1 and Table 2 for details). The Argo floats were housed in individual cardboard boxes with straps around them that were held together by a water-activated release. A long rope was provided for lowering the box over the railing off the back of the ship. Within a few seconds of hitting the water, the release activated, setting free the float in the box and allowing us to pull up the straps and release. The straps and releases were saved and placed in the AOML storage container for later shipment to WHOI. After the water release failed to open during the first deployment, we tried an alternate method recommended by Pelle Robbins of WHOI, and it worked very well. It consists of tying each end of a rope to the ship's railing, holding onto the middle of the rope, placing the float on top of the middle portion of the rope, and lowering the float into the water. The BGC Argo floats were deployed over the railing at the rear of the ship, starboard side, using a rope looped through the float's collar. We also deployed three ALAMO floats (see Fig. 1 and Table 2). They were programmed to profile from about 900 dbar to the surface approximately every 8 hours. The ALAMOs were deployed by wrapping a strap around the float and securing it with a large metal pin. A rope was attached to the strap and another rope to the pin. One person lowered the float to the water and the other pulled the pin out as it hit the water, releasing the float.

Table 2 Date (UTC), latitude, and longitude of Argo and ALAMO deployments.

D	T	L	L
Nov 02	Argo	11°45'N	56°00'W
Nov 04	BGC Argo	08°29'N	48°34'W
Nov 04	ALAMO	08°10'N	48°00'W
Nov 07	BGC Argo	04°01'N	38°05'W
Nov 09	Argo	02°00'N	36°30'W
Nov 09	Argo	01°00'N	35°45'W
Nov 13	Argo	02°00'N	23°00'W
Nov 13	BGC Argo	02°00'N	23°00'W
Nov 15	Argo	02°00'N	23°00'W
Nov 16	ALAMO	04°00'N	23°00'W
Nov 17	BGC Argo	06°00'N	23°00'W
Nov 18	Argo	10°00'N	23°00'W
Nov 19	ALAMO	11°30'N	23°00'W

3. Sargassum Science

3.1 Satellite imagery for opportunistic harvest

The Sargassum teams (WHOI and Fearless Fund) received satellite imagery from multiple sources as indicators of the presence of Sargassum. The teams also set up watch to observe lines of biomass for opportunistic harvest as the ship stopped for mission-related data gathering. The purpose was to ground-truth satellite imagery and determine the extent of biomass that was not shown in satellite imagery at its current resolution.

Harvesting was conducted by dip net or Neuston net. Dip net was the preferred method due to its ease of use on a high deck compared to the Neuston net. A Neuston net requires approximately 8-10 min to deploy and 3-4 minutes to recover. The purpose of the harvest was to collect samples for analysis and observe organisms that co-locate in or near the biomass. Biomass samples were collected for analysis of nutrient content and trace metals. Table 3 gives details of the samples collected for Dennis McGillicuddy (WHOI).

Table 3 Date (UTC), latitude, longitude, and time Sargassum samples were taken, and identification of Sargassum species and quantity obtained.

D	L	L	T	S	# B
Nov 02	11°52.968'N	56°29.563'W	14:45	S. natans VIII Par	3
Nov 09	04°01.301'N	38°05.057'W	14:15	S. natans VIII Par	1
Nov 18	08°59.862'N	22°59.870'W	11:14	S. natans VIII Par	3
Nov 19	11°28.693'N	22°59.361'W	08:20	S. natans VIII Par	1
Nov 19	11°28.060'N	22.59.903'W	18:35	S. fluitans	6
Nov 20	13°29.950'N	22.59.980'W	15:50	S. fluitans	3
Nov 21	15°59.885'N	22.36.129'W	15:05	S. fluitans	3
Nov 23	17°59.875'N	23.00.183'W	13:45	S. natans I Par	3
Dec 07	35°32.800'N	69°05.800'W	13:15	S. fluitans	6

3.2 Deep-sea CO_2 sequestration test

Increasing interest in ocean Carbon Dioxide Removal (CDR) led the Sargassum team to design a biomass degradation test for deployment during the 2021a PNE cruise, assisted by the NOAA/PMEL team (see PNE2021a cruise report). The goal of the experiment is to test degradation of biomass in the deep sea. During the November-December 2022 cruise, the Sargassum was recovered from the 11.5°N, 23°W mooring line and was deployed again at a similar depth above the mooring's acoustic release.

4. AEROSE

4.1 Aerosol Optical Depth (AOD)

Solar-spectrum, multichannel AOD was measured under clear (cloud-free) sky conditions by a calibrated, handheld Microtops II sunphotometer. The sunphotometer retrieves AOD from the measured attenuation of downwelling solar radiance, and this provides a measure of the integrated total-column aerosol concentration from dust, haze, and smoke. Multichannel measurements allow calculation of the Angstrom exponent, which is a parameter associated with the particle size distribution.

In practice, the Microtops II requires good operating procedure and a steady hand, especially when used on ships. Microtops data were taken approximately every 30 minutes during favorable sky conditions, with 30 scans each time, from 3 November to 4 December 2022. These measurements help to understand the Saharan dust flowing from West African Saharan regions to the United States and flowing through the Atlantic Ocean. The AEROSE Microtops raw data will be processed and incorporated within the NASA Goddard Maritime Aerosol Network (MAN) database.

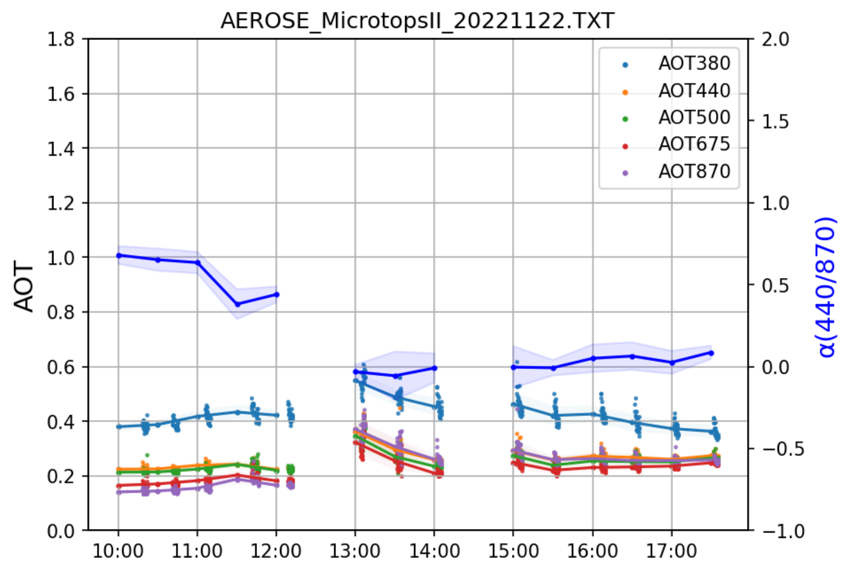


Figure 5 Microtops derived multichannel aerosol optical depth (AOD) and Angstrom exponent (α), derived from 440 and 870 nm, taken 22 November 2022. Elevated levels of aerosols are evident, with coarse-mode aerosols (e.g., Saharan dust) becoming more dominant around midday.

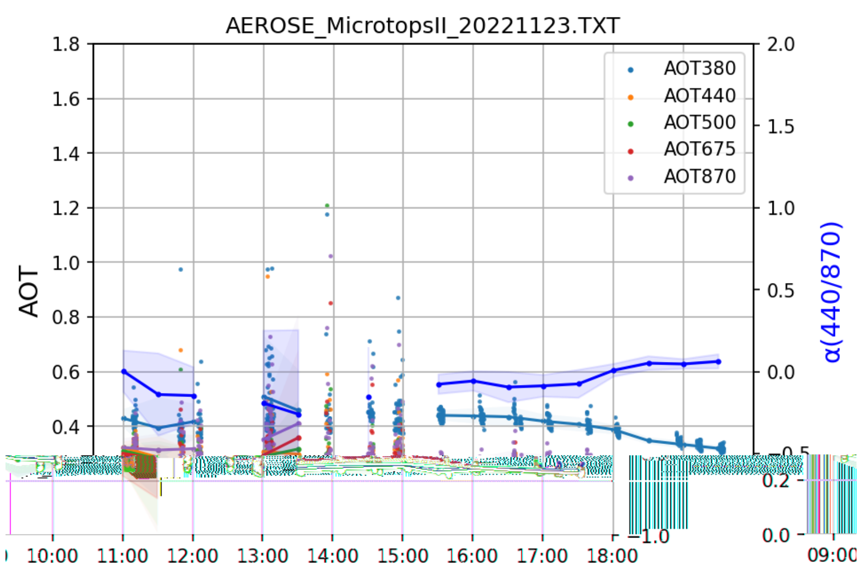


Figure 6 As Figure 5 except for 23 November 2022.

4.2 Radiosonde Observations (RAOBs)

Satellite-dedicated Vaisala RS41-SGP radiosonde launches commenced on 15 November 2022 two weeks following the start of the PNE cruise. The delay in the radiosonde launches resulted from several issues with the sounding system, the primary problem being a faulty MRR111 telemetry antenna card in the Vaisala Sounding Processing System (SPS). The AEROSE team methodically tested cables, software configuration, antennas, connectors, and worked

Worked with Vaisala, NOAA/PSL, and the ship Electronics Tech (Dave Moore) to troubleshoot problem. ET Moore was finally able to perform the necessary patches to the antenna card and the SPS error was cleared, but additional problems were then encountered. The radiosondes were originally purchased in 2020, but were not used due to COVID-19 cancellations. A couple sondes had pressure readings that were out of calibration from the reference by over 3 hPa; these sondes had to be discarded. However, we additionally had problems with losing signal on the sondes after launch; at first, these were happening about 50% of the time. The AEROSE team troubleshooted this by deferring the launch by over 20 min, letting the sonde transmit on the aft deck within the line-of-sight of the antennas on the aft 02-Level. This process then allowed the radiosonde to lock properly with GPS satellites, and after this 100% sounding success rate was achieved; 75 radiosondes were eventually launched (Figure 7), resulting in 67 complete atmospheric soundings of pressure, temperature, water vapor and winds, and 6 partial soundings (Figure 8).

To optimize the sounding sample, soundings were obtained on both the balloon ascent and descent after balloon burst (Figure 9). Helium was still used as the balloon inflation gas for the 2022 cruise, but hydrogen (an inflammable gas that will require additional precautions) may be desirable for future cruises given the worldwide helium shortage.

Depending on the local zenith angle, dedicated radiosondes were launched for EUMETSAT Metop-B and -C (~09:30 and 21:30) and NOAA-20 (01:30 and 13:30) overpasses. The AEROSE RAOBs will provide a fully independent truth dataset for NOAA satellite sounder validation, given that they are not assimilated, decoupled from land-based sites, and sample the SAL environment over eastern Atlantic basin.

Unfortunately, a number of issues discouraged the AEROSE team from attempting launches of the ozonesondes it came equipped with. First, the number of AEROSE personnel was about half that of previous campaigns, with three new personnel who had limited experience with launching ozonesondes (which requires a coordinated effort on the part of 5+ individuals). This meant that there would have been an initial learning curve that would have required additional flexibility, support, and patience from the ship. But, as described previously, there were several other delays and problems that had already been encountered, including the sounding system problems, buoy problems, and departures from the original cruise plan that detracted from available sea-time (Cape Verde and ship-in-distress excursions). The ship also had also adopted a more risk-averse stance than in previous campaigns, and did not favor sonde launches during periods of other activity (e.g., buoy ops, drills, small boat ops, EEZs, etc.). Finally, there were no formal tag-up meetings between the science and department leads whereby the ozonesonde logistic and support needs could be openly discussed such that everyone would be on the same page. Because of these reasons, it was felt that any ozonesonde attempts would interfere further in the PNE main mission, and thus they were descoped.

The AEROSE group also partners with the UM/RSMAS group in utilizing the thermal IR spectral data obtained from the MAERI (U-Miami). The MAERI during this cruise was specially configured with multi-scanning for sea-surface emissivity validation. The MAERI data are complementary with the concurrent dedicated radiosonde launches timed for overpasses with satellite thermal IR sounder instruments similar to MAERI.

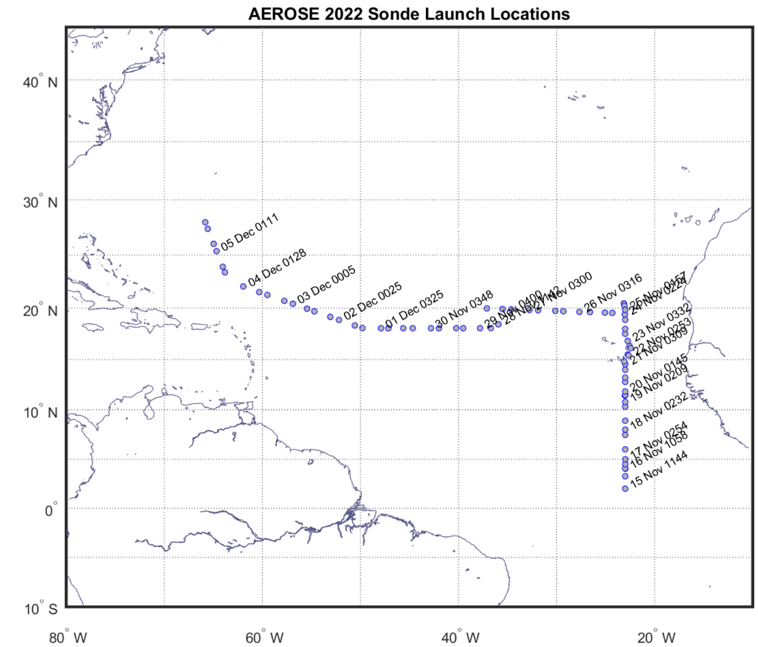


Figure 7 Locations of satellite-dedicated radiosonde launches during the 2022 PNE/AEROSE campaign.

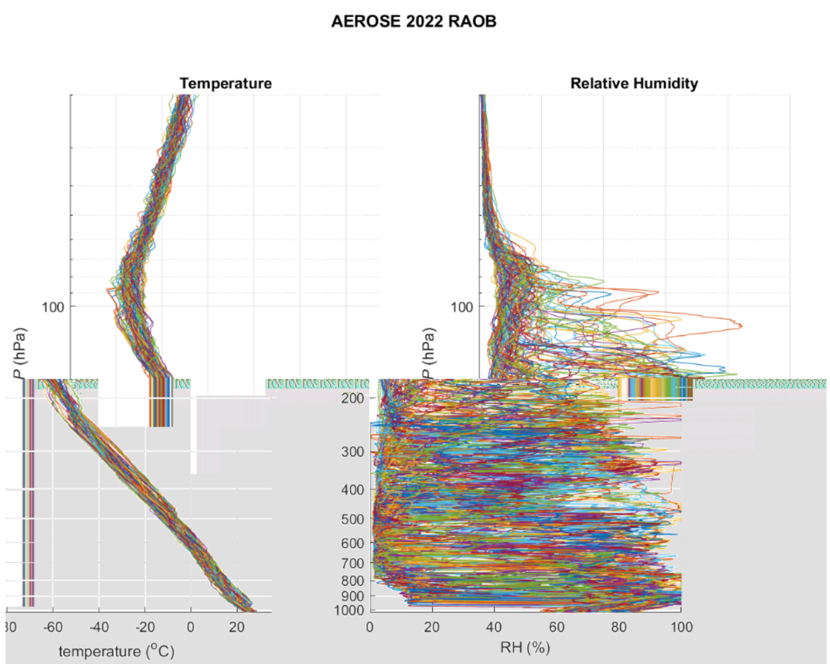


Figure 8 AEROSE 2022 temperature (left) and relative humidity (right) RAOB profiles.

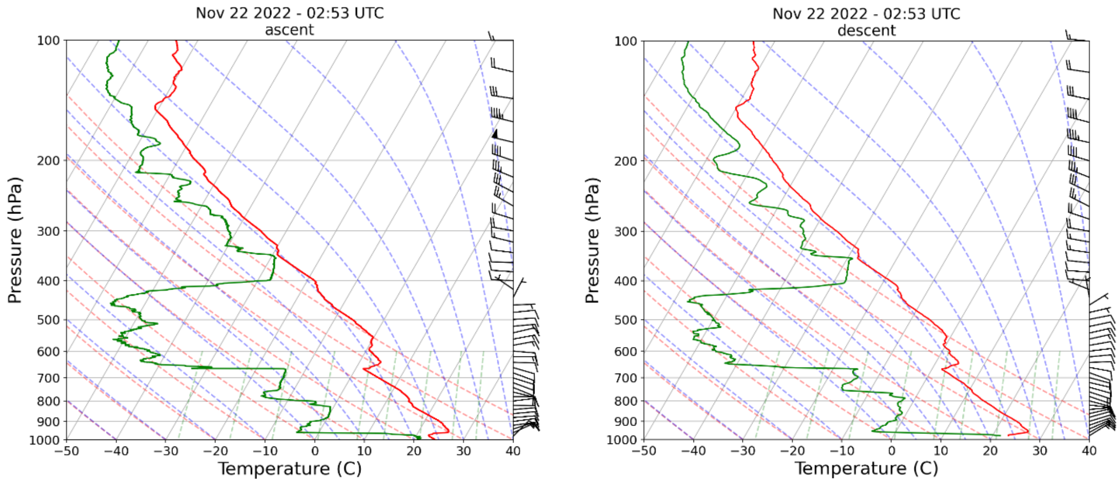


Figure 9 Skew-T diagrams of AEROSE RAOB launched on 22 November 2022: (left) ascent profile, (right) descent profile.

4.3 Dust samples

Dust samples were collected at different locations from the buoys. Dust samples will be analyzed in order to determine the different particles in the dust and their temporal and spatial distribution over the Atlantic Ocean.