PALMER STATION MONTHLY SCIENCE REPORT

December 2023

R/V LAURENCE M. GOULD skirting around icebergs as she departs Palmer Station's Arthur Harbor to begin the 2023-2024 LTER cruise. An Adélie penguin can be seen on the center piece of ice in this image.
Image credit: Francis Sheil

NEWS FROM THE LAB
Hannah James, Summer Laboratory Supervisor

December's long summer days with calm stretches of weather allowed for lots of field science to be completed. In addition to the work detailed by individual labs in this report, ASC staff were able to download overwintering data for the B-086-P (van Gestel) group, who was unable to deploy this summer due to berthing and timing constraints for the Palmer Summer 2023-24 season. Open topped chambers were installed in backyard sites. These open-topped chambers mimic a warming climate by allowing sunlight (but not long-wave infrared radiation) through transparent fiberglass cones. The open-top allows precipitation in and excess heat out. ASC staff will download the data, swap batteries, and take down the open-topped chambers at the end of the summer season. More to come in future reports.

Right before the holidays, one of the engines in R/V HADAR experienced a mechanical issue, that was later diagnosed as a spent bearing on the shaft that connects the engine to the outdrive. This, in turn, damaged the bell housing on the aft end of the engine. This disrupted CTD water collection and net tows for the B-285-P (Bowman), C-019-P (Schofield), C-020-P (Steinberg), and C-045-P (Van Mooy) groups. The water collection groups worked with ASC lab staff to set up in-line Go-Flo bottles and the monsoon pump to collect water at depth, and C-020-P (Steinberg) grantee Maya Thomas worked with the Boat House to conduct surface net tows off a small boat for copepod collection. R/V HADAR is currently being tested by the Boat House

staff. We've recently received notice that we can operate on her remaining one engine. This will cut transit time down significantly, and slightly change hauling limits, but the operations and capability of the vessel remain what they were with two engines. I would like to send a huge thank you to the Boat House staff (Barbara Krasinski, Matt Gosselin, and David "Goldie" Goldman), and their off-ice supervisor Hannah Gray for all the work they've done to get the boating program up and running again. I would also like to thank Instrument Technician Lance Roth for all of the work he has put in to ensure that our grantees are able to continue sampling, though it may be limited, at depth at Station E.

Massive icebergs continue to dominate the skyline any way one looks around Palmer Station. The R/V LAURENCE M. GOULD arrived at Palmer Station on December 24th for the first port call of the 2024 LTER cruise. LTER grantees on station were busy preparing cargo to be handed over to their cruise-based counterparts. The ship was scheduled to depart on December 26th, but the icebergs moving into Hero Inlet had other ideas. With some higher winds and tides, the larger bergs moved off the bow of the Gould enough to let the crew sneak her through and out of Hero Inlet on December 27th to start the four week cruise down the Antarctic Peninsula.

B-046-P: MECHANISMS OF ADAPTATION TO TERRESTRIAL ANTARCTICA THROUGH COMPARATIVE PHYSIOLOGY AND GENOMICS OF ANTARCTIC AND SUB-ANTARCTIC INSECTS
Dr. Nicholas Teets Principal Investigator, Department of Entomology, University of Kentucky.
Personnel on station: Cleverson Lima

Environmental conditions are the major drivers of species distribution, and terrestrial Antarctica arguably presents the most dramatic challenges for its inhabitants. This is reflected by its marked low number of species, which is even lower when it comes to endemic species. Antarctica harbors only one species of insect, even though insects are the most abundant animal taxa in the world. The Antarctic midge *Belgica antarctica* (Diptera: Chironomidae) has special physiological adaptations that allow them to tolerate rapid, unpredictable environmental changes, which gave them the ability to colonize the continent since its separation from South America and Australia (over 30 million years ago). This makes *B. antarctica* a key species for studying adaptations to extreme environments, which is the focus of our project.

Figure 1- Belgica antarctica adult male walking on the algae Prasiola crispa. *Image credit: Jack Devlin*

For this season, our project has 5 major objectives. 1) Collect samples on the islands around Palmer station and set up colonies that will be maintained and used for general experiments throughout the season. 2) Repeat last season's stress physiology experiments in December and March, which will allow us to address whether physiological responses to freezing change in preparation to winter by looking at freezing tolerance

early in the summer season and late-summer, early-winter. 3) Set up a long-term experiment with midges from Cormorant Island to look at changes in freezing tolerance and metabolic rates among populations of the same island in a biweekly basis. 4) Collect one sample of midges from every accessible island in the vicinity of the station for a population genetics study that will shed more light on how this tiny, wingless fly disperses. 5) Collect samples of eggs and live midges around the station that will be shipped to our home laboratory for follow-up studies.

Objective 1 was successfully achieved, and objectives 2, 3, and 5 are in progress. With the assistance of the station's personnel, we were able to collect midges on Torgersen, Cormorant, Humble, Outcast, Hermit, and the Joubin Islands, and deploy temperature dataloggers in four collection sites on Cormorant for our objective 3. Early results show that survival to severe freezing slightly differ among midges that inhabit a colder microclimate (1° C) compared to those that inhabit warmer microclimates (6-8° C), suggesting that there may be some variation in physiological responses to stress within populations of the same island. In this sense, the habitat that these animals live in might be more important than the population that they originated from when it comes to determine how much stress they can take (and builds to the idea that phenotypic plasticity has a stronger effect on stress tolerance than genetic differences in this species' basal tolerance). In addition, because *B. Antarctica* adults have a short lifespan (1-2 weeks), we were not expecting to see many adults around during December, but adults were observed (in the order of hundreds) mating and laying eggs in every island that we visited, which allowed us to make good progression on objective 5 and collect eggs for downstream experiments that will provide a better understanding on the embryogenic development of this species.

Figure 2 *Belica antarctica* mating. *Image Credit- Cleverson Lima*

I want to acknowledge the assistance and support of all Palmer personnel throughout this first month of our field season, which was very productive. Many people have volunteered to work with me, which made all collections occur in a rapid, efficient pace, reducing the time spent in the field, and consequently, our disturbance in each of the islands that were visited.

B-285-P: CAREER: IM-HAPPIER: INVESTIGATING MARINE HETEROTROPHIC ANTARCTIC PROCESSES, PARADIGMS, AND INFERENCES THROUGH EDUCATION AND RESEARCH

Dr. Jeff Bowman, Principal Investigator, Scripps Institution of Oceanography, University of California San Diego
Personnel on station: Beth Connors

B-285 (Bowman) had a successful month of environmental sampling and experiments despite many mechanical setbacks. Alongside the LTER, we were successful at retrieving seawater from Station E on four occasions this month: December 4, 14, 20 and 30. We were able to successfully perform dilution experiments on these days despite mechanical failure of both our flow cytometer (the device we use to measure bacterial abundance) on December 6 and one of the

engines of our sampling boat R/V HADAR (where we typically collect water with a winch and CTD) on December 23. We were able to re-plumb the flow cytometer with the help of C-045-P (Van Mooy) grantee Shavonna Bent and ASC Instrument Technician Lance Roth to work around the mechanical failure (a failed solenoid valve) and continue to use the instrument after a successful recalibration. Meanwhile, while the Boat House staff worked on a more permanent solution to the mechanical failure in R/V HADAR's engine, we successfully sampled water from a zodiac with Go-Flos provided by Lance and ASC Lab Manager Hannah James on Dec 30th. We are incredibly grateful for the tenacity and perseverance demonstrated by everyone on station this month.

On each of the successful collection days, our group took water from the mixed layer (10 m), near the subsurface chlorophyll max (30 m) and below the mixed layer (50 m). At each depth we took initial measurements for bacterial abundance and community structure, then we used the remaining water to perform live experiments to monitor microbial dynamics to infer carbon flow through microbial food webs. The most important of these experiments for our group is a dilution series, where water from 10 m is first filtered either by only a 0.2um filter to remove large grazers or filtered by a tangential flow filter (TFF, pore size 30kDa) to remove viruses. These two types of filtered water are then combined with unfiltered seawater at different concentrations in two (30kDa or 0.2um filtered) series (0% whole water, 30% whole water with either 70% 0.2 or TFF filtered water etc). The experimental set up for this experiment is pictured below.

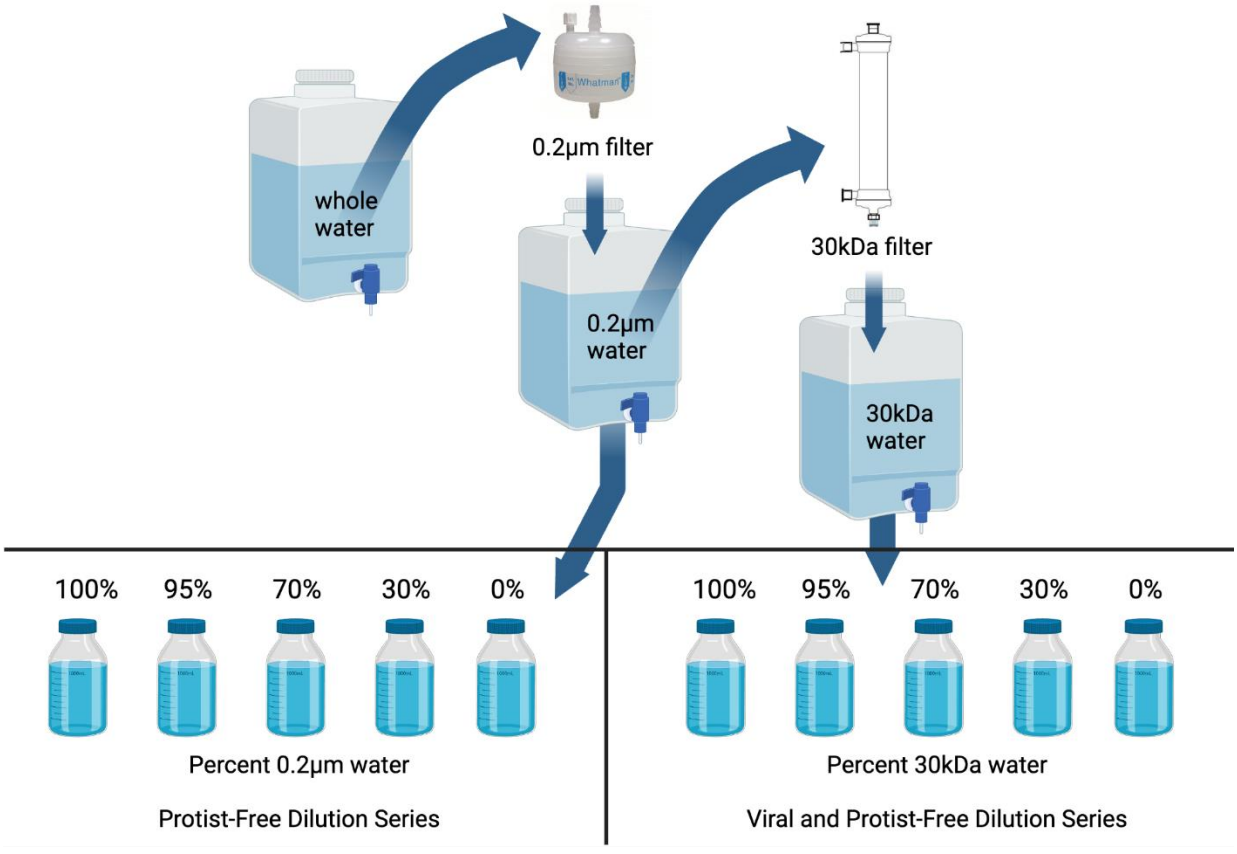

Figure 3- B-285-P (Bowman) Dilution Experimental set up. Viral free water is TFF (pore size of 30kDa) filtered, while protist-free water is only 0.2um filtered. Both are combined with whole water in a dilution series to monitor growth rate in the absence of bacterial predators. *Image credit Beth Connors.*

Once the experiment was set up, we took initial measurements for bacterial abundance from the dilution series and incubated the two series for 24 hours in an incubator set to in situ conditions. After the incubation, we again measured for bacterial abundance and for community structure. From the initial and final measurements for bacterial abundance, we can calculate the change in growth rate for the bacteria in the absence of either just grazers, or grazers and viruses across either dilution series. We can then subtract the growth rates over both dilution series to determine the influence of just viruses on bacterial growth rate. Obtaining a better understanding of the influence of viral predation on bacteria is critical to understand microbial carbon flow along the WAP as it is currently very poorly understood. We included measurements for bacterial community structure in our experiment for this reason, as it is also unknown if bacterial predators (either viruses or protists) preferentially target particular bacteria.

C-013-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (LTER): LAND-SHELF-OCEAN CONNECTIVITY, ECOSYSTEM RESILIENCE AND TRANSFORMATION IN A SEA-ICE INFLUENCED PELAGIC ECOSYSTEM, SEABIRD COMPONENT

Dr. Megan Cimino, Principal Investigator, University of California at Santa Cruz.
Personnel on Station: Helena Dodge and Darren Roberts

Conditions in December allowed for boat-based field work on 26 days of the month. Many icebergs have been observed in the area, and at this time they have not limited boating activity significantly. The LTER cruise began at the end of the month. Helena Dodge and Allison Northey are representing our team this year on the cruise.

We continued the daily monitoring of nesting Adélie penguins on Humble and Torgersen Islands as well as maintaining regular censuses of all local Adélie colonies. We completed several trips to Dream Island to conduct Adélie and Chinstrap penguin counts and to Biscoe Point for Adélie and Gentoo penguin counts. Additionally we conducted Adélie, Gentoo, and Chinstrap penguin surveys at the Joubin Islands.

Figure 4 Icebergs near Shortcut Island. *Image Credit: Darren Roberts*

Preparations for the Humble Island Adélie penguin radio transmitter project continued; equipment was installed on Humble Island and remote data collection and transfer was tested. We prepared for the deployment of satellite transmitters and dive depth recorders on Adélie and Gentoo penguins, and began tagging Adélie penguins at Torgersen Island. Diet sampling began at Humble. Late in the month we deployed radio tags at Humble Island, initiating the presence absence study of Adélie penguins.

Skua work continued this month as we began checking nests for newly hatched Brown skua chicks on local islands as well as on Dream and Biscoe Islands. Our South polar skua mark-recapture and breeding monitoring study on Shortcut Island continued with nest initiation checks and band recording. Our census of the Blue-eyed shag colony on Cormorant Island continued with the first chicks of the season observed in early December. A gull survey was completed at all local kelp gull colonies.

Our all-island census of giant petrel nests was started in December; breeding pairs were identified and new breeders were banded. Our work tracking giant petrel foraging began in December with satellite transmitter deployments at Litchfield, Elephant Rocks and Humble Islands. We recovered several more of our over winter tags from giant petrels at Litchfield.

Figure 5- A white morph giant petrel at Elephant Rocks with a GPS logger attached. *Image Credit: Darren Roberts*

We would like to sincerely thank Hector Plaza for his help and expertise in getting the Humble Island radio receiver fully functional.

C-019-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (LTER): LAND-SHELF-OCEAN CONNECTIVITY, ECOSYSTEM RESILIENCE AND TRANSFORMATION IN A SEA-ICE INFLUENCED PELAGIC ECOSYSTEM, PHYTOPLANKTON COMPONENT

Dr. Oscar Schofield, Principal Investigator, Rutgers University, Institute for Earth, Ocean, and Atmospheric Sciences, Department of Marine and Coastal Sciences
Personnel currently on station: Sneha Sivaram

Figure 6- View at the Pumphouse highlighting ice conditions. *Image Credit: Sneha Sivaram*

December was a busy month for the Schofield Lab between preparing for the LTER cruise, local Palmer Pumphouse sampling, and LTER Station E sampling. The LTER cruise began at the end of the month, and the QFT-ICAM was passed to the ship-based lab for the cruise. Pumphouse sampling continues for the Palmer-Station based Schofield Lab, adding to the time series of local Palmer Station primary production seasonality. This month, thirteen pumphouse samples were taken in a variety of different ice, wind, and sea state conditions. The weather and ice prevented much of the sampling throughout the month at Station E, but still a total of four LTER timepoints were taken, adding to the long-term time series for the Palmer Canyon region. This season, a large number of icebergs have been observed in the area, making boating and sampling more challenging. Towards the end of the month, the small research vessel RHIB HADAR went down due to mechanical issues, so much of the efforts were focused on creating a contingency sampling plan that allowed for LTER sampling to continue on zodiacs.

Figure 7- View from Station E on a calm day. *Image Credit: Sneha Sivaram*

The new sampling plan involves using Go-Flo bottles (shown below) to collect water at five different depths: surface, 10 meters, 20 meters, 35 meters, and 50 meters to still get an adequate profile of the water column. Similar to the Niskin bottles on the CTD/rosette, the Go-Flo bottles are cocked open so that the bottle allows for water to pass through. It is then lowered down on a line to the desired depth. A messenger weight is sent down to close the bottle, capturing the water at the desired depth inside. Although much heavier and difficult to manage by hand, it is possible to string these bottles in series, to collect multiple depths in one cast. CTD casts are done using a mini-CTD by Ruskin RBR. While this CTD does not measure transmission, PAR, or fluorescence, having the base measurements of temperature, depth, and salinity is still important in understanding the water column, especially moving into bloom conditions. The chlorophyll values have been increasing and the current conditions reflect the first summer bloom of phytoplankton which is important to the rest of the marine food web. Phytoplankton are the foundation of the marine trophic system and the summer blooms are important in feeding the upper trophic levels such as fish and krill which then feed whales, seals, and penguins.

Figure 8- Go-Flo Bottles of various sizes used for manual sampling at Station E from zodiacs. *Image credit: Sneha Sivaram*

Through great collaboration between B-285 (Bowman) and C-045 (Van Mooy) as well ASC Lab and Boat House staff, sampling for the LTER continues into the month of January. The Schofield Lab extends sincere gratitude for being able to continue to sample for the LTER despite many challenges to this season.

C-020-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (LTER): LAND-SHELF-OCEAN CONNECTIVITY, ECOSYSTEM RESILIENCE AND TRANSFORMATION IN A SEA-ICE INFLUENCED PELAGIC ECOSYSTEM, ZOOPLANKTON COMPONENT

Dr. Deborah Steinberg, Principle Investigator, Virginia Institute of Marine Science, Department of Biological Oceanography

Personnel currently on station: Maya Thomas

Another month is in the books for the C-020-P (Steinberg) team at Palmer Station! Primarily this month was used to get into the regular sampling groove. This includes going out Monday and Thursday (weather permitting) each week to Station E to conduct zooplankton tows and then opportunistically going out on Tuesday or Wednesday for penguin foraging area transects in collaboration with the C-019-P (Schofield) and C-013-P (Cimino) LTER group projects.

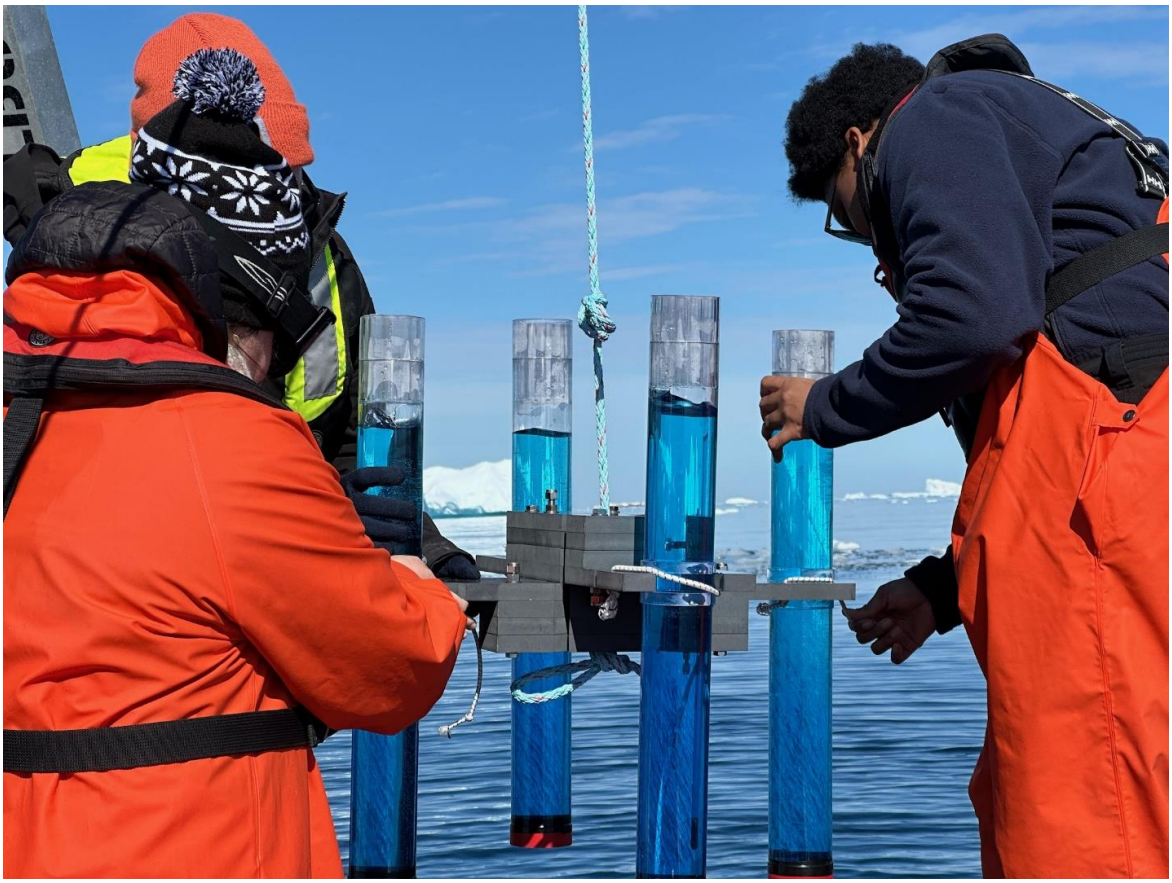

Figure 9- C-020-P (Steinberg) and C-045 (Van Mooy)'s first test of the PIT sediment trap deployment. Blue food dye was substituted in place of our regular brine to more easily see if there were any problems with our deployment methodology *Image Credit: Sneha Sivaram*

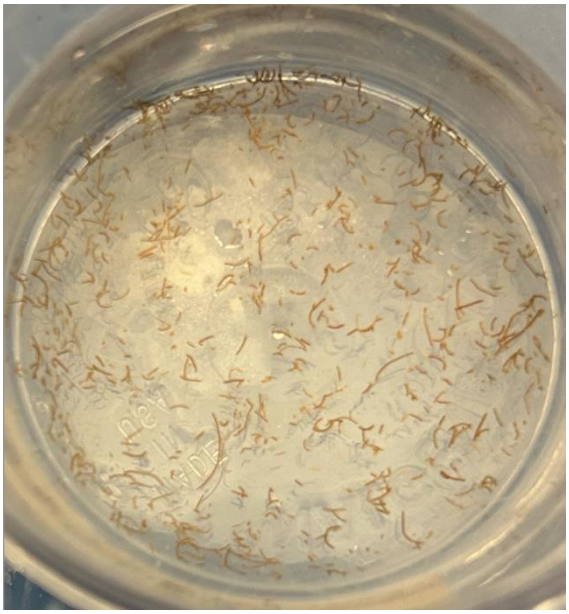

Figure 10- - Fecal pellets that sink into the gel during sediment trap deployment. *Image credit: Maya Thomas*.

Along with regular weekly sampling, we are working in collaboration with the C-045-P (Van Mooy) group to deploy and recover sediment traps. In mid-December we conducted this operation successfully by deploying one sediment trap for two days near Station E. This marked the first sediment trap to be deployed off of R/V HADAR. We used Particle Inceptor Traps (PIT) to capture particles that sink throughout the water column. Sinking particles can include phytoplankton, marine snow, animal carcasses, and the material of particular interest to PhD student Maya Thomas: zooplankton fecal pellets. A jar with polyacrylamide gel is placed into the PIT trap so that sinking particles can settle into the gel. This makes it easier to identify individual particles since the gel allows the pellets to better retain their original shape and be kept separate from other particles.

A microscope camera is then used to image the entire gel and count/measure each fecal pellet. Based on the size and shape of the fecal pellet it can also be assumed which zooplankton species made each pellet. For instance, long, cylindrical pellets (the majority of pellets seen in the above image) are commonly produced by krill, while smaller pellets that are more ovoid are produced by copepods. Once each pellet is measured, it is then possible to calculate the amount of carbon in each pellet using literature values as well as estimate the amount of zooplankton-mediated fecal pellet carbon flux at Station E.

Since this sediment trap was so successful we are eagerly awaiting for out next opportunity to deploy another!

C-045-P: PALMER, ANTARCTIC LONG TERM ECOLOGICAL RESEARCH (LTER): LAND-SHELF-OCEAN CONNECTIVITY, ECOSYSTEM RESILIENCE, AND TRANSFORMATION IN A SEA-ICE INFLUENCE PELAGIC ECOSYSTEM-MICROBIAL, BIOGEOCHEMICAL COMPONENT

Dr. Benjamin Van Mooy, Senior Scientist, Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution

Personnel on station: Shavonna Bent

December was a busy month for the C-045-P (Van Mooy) group on station. Sampling from Station E continued for our standard parameters (lipids, carbohydrates, particulate organic carbon (POC), flow cytometry, nutrients, and $\delta^{18}O$), in conjunction with the other LTER groups and the B-285-P (Bowman) group. In addition to standard water collection, we successfully deployed and recovered a sediment trap at Station E alongside the C-020-P (Steinberg group). Our group collected samples for POC, lipids, and carbohydrates, while the Steinberg group collected a sample for gel trap analysis. Preliminary analysis shows that the majority of the flux stemmed from krill fecal pellets. This process would not have been possible without support

from the boathouse team, who provided invaluable feedback throughout the process of deployment and recovery.

Due to mechanical issues with R/V HADAR, the water collection team has begun to sample from zodiacs. This process has necessitated methods testing to ensure that we are able to successfully and safely collect water from Station E.; the platforms which were available in 2016 that pre-dated Hadar have since been decommissioned. We have worked out a system for daisy-chaining of Go-Flo bottles (see Figure 11), which allows for collection from up to four depths at a time (limited by personnel on-board, space constraints, and sea-state). Additionally, the C-045-P (Van Mooy) group will primarily be using the monsoon pump – the Palmer Instrument Tech (Lance Roth) has been hard at work to expand the depths available via this faster/less labor intensive method of water collection. In addition, we specifically thank the following station-based ASC members for their invaluable contributions to allowing our science to continue despite the current setbacks: Station Lab Manager (Hannah James) and the boathouse personnel (Barb Krasinski, David Goldman, and Matt Gosling).

Figure 11- C-045-P (Van Mooy) grantee Shavonna Bent demonstrates the daisy-chain system of Go-Flo bottles for small-boat at-depth water collection at Station E. *Image Credit: Maya Thomas*

Finally, the remainder of the month of December was spent largely in preparation for the LTER cruise, which arrived to station on December 24th. We had a successful port-call, transferring prepared brine for the particle interceptor traps (PITs) that will be deployed along the peninsula, the flow cytometer for sampling during the cruise, and other critical sampling supplies. During the port-call, C-045-P (Van Mooy) grantee Shavonna Bent helped with the C-021-L (Moffat) group's preparation for Winkler titrations (oxygen sampling) during the cruise by assisting with reagent mixing. Finally, the C-045-L (Van Mooy) team had an overview of sampling techniques and the overall agenda for the cruise before the R/V LAURENCE M. GOULD departed for the LTER cruise. Thank you to ASC for all the assistance in swinging cargo and making the port-call go smoothly!

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Marissa Goerke

Figure 12- Ice bergs on the way to service the Joubins AWS, December 29, 2023. *Image credit: Marissa Goerke*

A-111-P: THE NEXT GENERATION OF GEOSPACE RESEARCH FACILITIES AT PALMER STATION

Andrew Gerrard, Principal Investigator, New Jersey Institute of Technology

Extremely Low Frequency/Very Low Frequency (ELF/VLF) radio wave observations at Palmer Station are used to provide a deeper understanding of lightning and its effects on the Earth's inner radiation belt. Lightning source currents are estimated or directly measured by experimental observations of individual natural and rocket−triggered lightning flashes in North America. Together, the North American and Antarctic data sets are used to experimentally identify and analyze the components of lightning and the effects of lightning, such as lightning-induced electron precipitation (LEP), that are observed in the Antarctic, more than 10,000 km away.

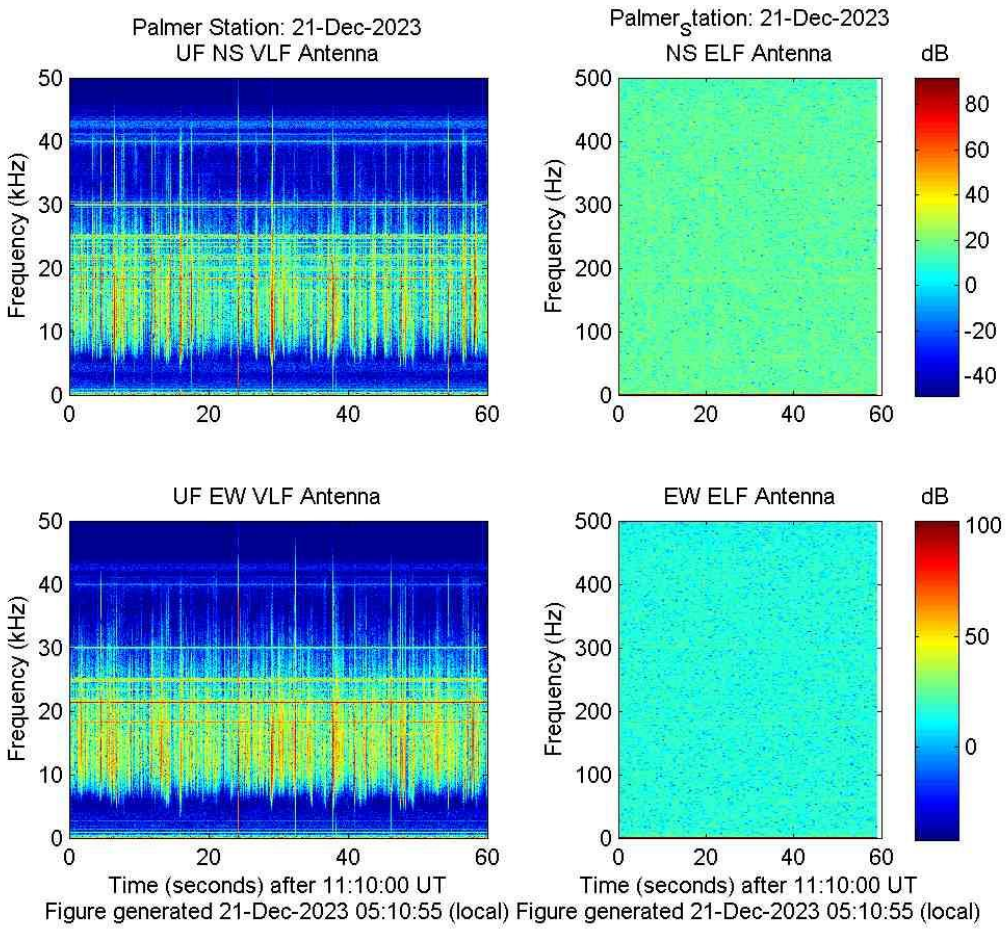

Figure 13- Real-Time broadband VLF and ELF Spectrogram from Palmer Station, Antarctica.

Both the Extremely Low Frequency and Very Low Frequency systems suffered a 4 day outage during the power outage in early October. The GPS receiver did not weather this outage and remains unlocked. A replacement GPS receiver is being prepared for shipment. Both systems continue to run without the GPS lock through December. The spectrograms were reviewed daily and bi-weekly antenna inspections were done as weather allowed.

Current VLF/ELF data from Palmer Station can be observed at:
http://halo.ece.ufl.edu/realtime_palmer_bb.php.

A-111-P: SAMBA MAGNETOMETER

Andrew Gerrard, Principal Investigator, New Jersey Institute of Technology

The three-axis fluxgate magnetometer at Palmer is one in a chain of eleven longitudinal, ground-based magnetometers extending down though South America and into Antarctica. The primary scientific goals are the study of Ultra Low Frequency (ULF) waves and the remote sensing of mass density in the inner magnetosphere during geomagnetically active periods. Palmer's magnetometer is also a conjugate to the Canadian Poste de la Baleine Station, allowing the study of conjugate differences in geomagnetic substorms and general auroral activity.

SAMBA stands for South American Meridional B-field Array. The sites are approximately along the 0° geomagnetic longitude and ranging from -5° to -48° geomagnetic latitude. In combination with other magnetometer chains, including the AGO (Automated Geophysical Observatory) systems elsewhere in Antarctica, the stations create an almost complete, cusp-to-cusp-long meridional chain at approximately 0° magnetic meridian.

The magnetometer was originally installed at Palmer in 2005, and a replacement installed in April of 2008. In 2017 the project was taken over by Andrew Gerrard. On March 27th, 2017 the USAP IT blocked all northbound VPN traffic under a larger umbrella of blocking all northbound encrypted-tunnel traffic. Since that time there has been much discussion, but the magnetometer is still considered a security vulnerability. The Research Associate has been working with the home institution at the University of California, Los Angeles to resolve this issue. As of September 30th, 2020 at 7:45am local time, the magnetometer was removed from the network. The instrumentation and computer are still operational. Data will continue to be collected and stored locally. A new Raspberry Pi arrived to replace the existing BeagleBone computer but has not yet been installed. Once installed, the Pi will permit the system to connect to the USAP network. The system operated normally this month. More information can be found at: http://magnetometers.bc.edu/index.php/palmer.

G-090-P: GLOBAL SEISMOGRAPH NETWORK (GSN) SITE AT PALMER STATION.
Kent Anderson, Principal Investigator, Incorporated Research Institutions for Seismology (IRIS)

Palmer's seismic station, code named PMSA, is part of the Global Seismic Network (GSN), a collection of 150+ sites worldwide, operating under the aegis of the Incorporated Research Institutions for Seismology (IRIS), and managed by the United States Geological Survey's Albuquerque Seismological Laboratory (ASL). The site was installed in March 1993. As of August 2006, PMSA is also used as an ancillary seismic system for the CTBT/IMS installation; CTBT-specific protocols for the seismic system are covered in the CTBT (T-998-P) section this document.

A standard seismic station consists of three seismometers oriented to detect ground motion along three mutually perpendicular lines. Most of the time the directions chosen are north-south, east-west, and up-down. The seismometers in the Palmer Station installation are “forced balanced” instruments, which means that they work by keeping an inertial mass stationary with respect to the instrument (and the earth). When a seismic wave arrives, the ground moves, carrying along the housing of the seismometer. The inertial mass tends to remain stationary and not move with the instrument, but it is electronically “forced” to travel along with the instrument (and the earth). The amount of “force” necessary to make it move with the rest of the instrument is proportional to the ground acceleration and is recorded as the raw data from the seismometer.

By examining time of arrival, azimuth, magnitude, frequency and wave type of the incoming waves, seismologists can determine the location, depth of focus, magnitude, type of faulting that occurred, ground acceleration in gravitational force and the structure of the medium (the earth) through which the waves traveled to reach the station. The Research Associate operates and maintains on-site equipment for the project.

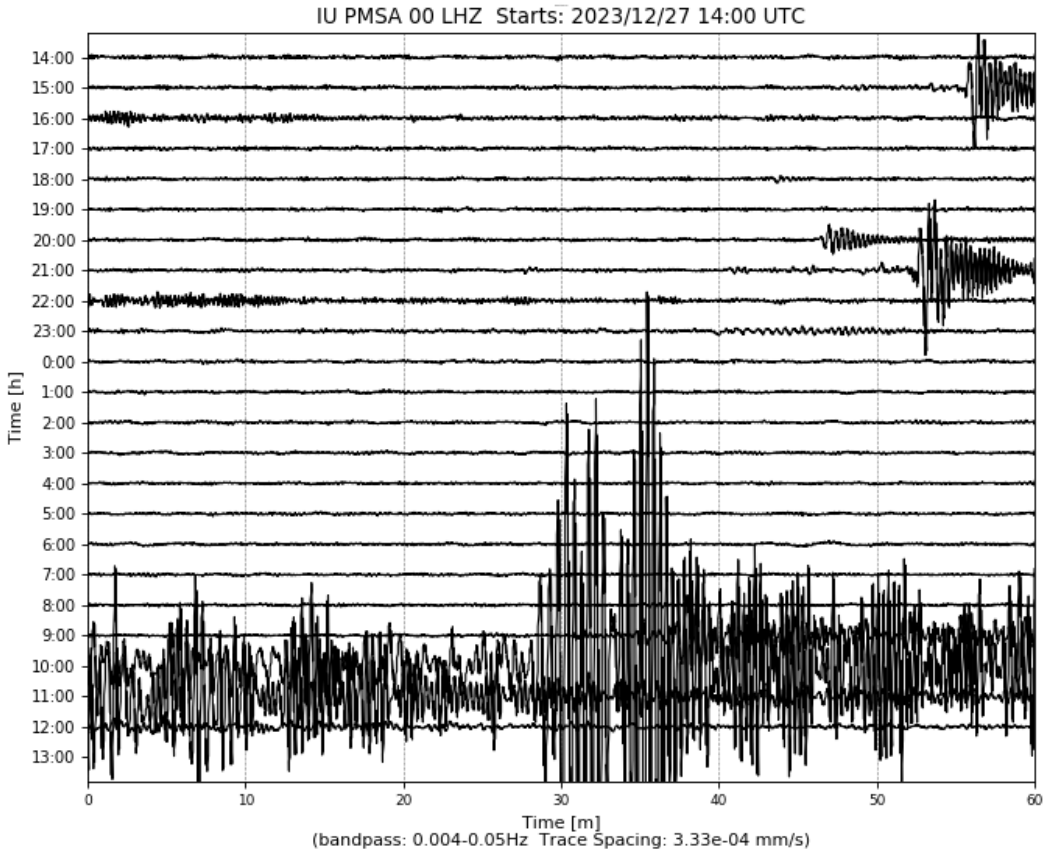

Figure 14- The December 27, 2023 5.3 earthquake on the Pacific-Antarctic Ridge, as recorded from the Palmer seismic station.

The system suffered several multiday network related outages throughout December. The underlying problem has not yet been resolved. The time stamp and seismic activity found on the Heliplot was checked daily. Current data from Palmer station can be found on the USGS site: https://earthquake.usgs.gov/monitoring/operations/stations/IU/PMSA/#heliplot.

O-264-P: A STUDY OF ATMOSPHERIC OXYGEN VARIABILITY IN RELATION TO ANNUAL DECADAL VARIATIONS IN TERRESTRIAL AND MARINE ECOSYSTEMS.

Ralph Keeling, Principal Investigator, Scripps Institution of Oceanography

The goal of this project is to resolve seasonal and inter-annual variations in atmospheric O_2 (detected through changes in O_2/N_2 ratio), which can help to determine rates of marine biological productivity and ocean mixing as well as terrestrial and oceanic distribution of the global anthropogenic CO_2 sink. The program involves air sampling at a network of sites in both the Northern and Southern Hemispheres.

The Scripps Institution of Oceanography flask sampling project analyzes air samples to assess variations in the atmospheric oxygen content caused by exchanges of O_2 between the atmosphere and the Southern Ocean. The oceans tend to be a source of oxygen to the air in the spring and

summer, and a sink for oxygen in the fall and winter. The spring emissions are mostly due to photosynthesis in the water, while the winter uptake is due to mixing processes, which bring oxygen depleted waters from depth up to the surface. These exchanges lead to variations in the oxygen content of the air above the water, and these changes are rapidly mixed around the latitude band by zonal winds. Measurements of the seasonal variations in oxygen content at Palmer and other sites may be valuable for documenting changes in the biological productivity of the southern oceans over time.

The percentage changes in oxygen are very small. Relative to the 20.95% background, the summer-winter differences are only about 0.01%. Some special precautions are necessary so that the O_2 content of the samples isn't perturbed at this low level. Among these precautions are maintaining a constant pressure and temperature in the flasks during sampling. This dictates the installation of the sampling station indoors and the use of a pump module with a bypass valve for avoiding pressure buildup. The Research Associate collects samples fortnightly from Terra Lab.

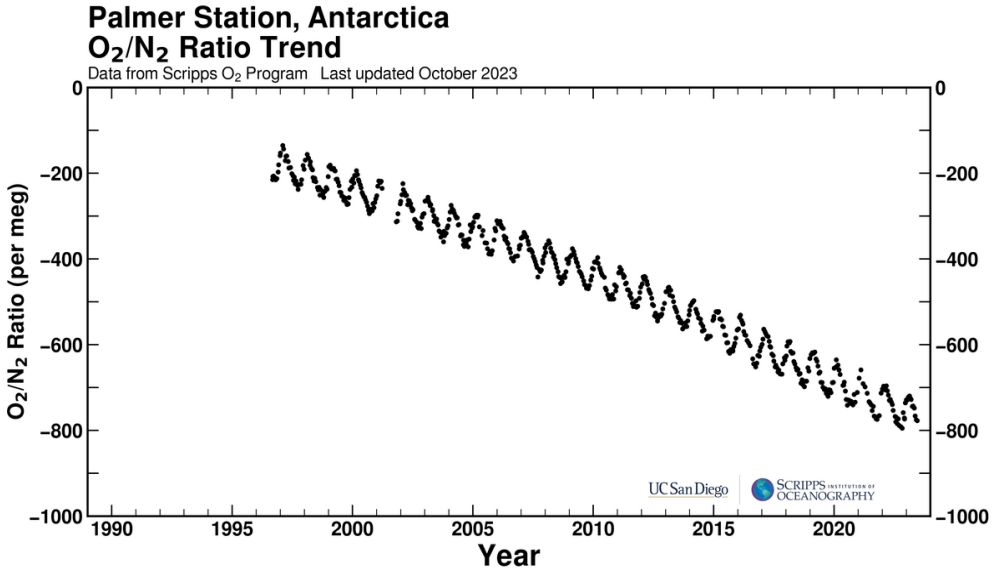

Figure 15- Historical plot of $\mathbf{O_2/N_2}$ ratio per meg and $\mathbf{CO_2}$ ppm updated October 2023.

Air samples were collected on December 2 and December 15. Wind conditions must equal or exceed 5 knots from a direction between 5° to 205° constantly for over an hour with no interference from human traffic on foot or in vessels. These air samples are shipped to the Scripps Institution of Oceanography in California for analysis. More information and data can be found at: https://scrippso2.ucsd.edu/osub2sub-data.html.

O-264-P: COLLECTION OF ATMOSPHERIC AIR FOR THE NOAA/GMD WORLDWIDE FLASK SAMPLING NETWORK

Don Neff and Steve Montzka, Principal Investigators, National Oceanic and Atmospheric Administration / Global Monitoring Laboratory; Boulder, CO

The NOAA ESRL Carbon Cycle Greenhouse Gases (CCGG) group makes ongoing discrete measurements to document the spatial and temporal distributions of carbon-cycle gases and provide essential constraints to our understanding of the global carbon cycle. The Halocarbons and other Atmospheric Trace Species (HATS) group quantifies the distributions and magnitudes of the sources and sinks for atmospheric nitrous oxide (N_2O) and halogen containing compounds.

The Research Associate collects weekly air samples for the CCGG group and fortnightly samples for the HATS group. Wind must be between 5 and 15 knots and consistently blow from one sector with no people, equipment, or boats upwind of the sampling location.

Carbon Cycle Greenhouse Gases (CCGG) samples were collected on December 4, December 11, December 18, and December 25 during favorable wind conditions. More information and data for the Carbon Cycle group can be found at: https://gml.noaa.gov/ccgg/.

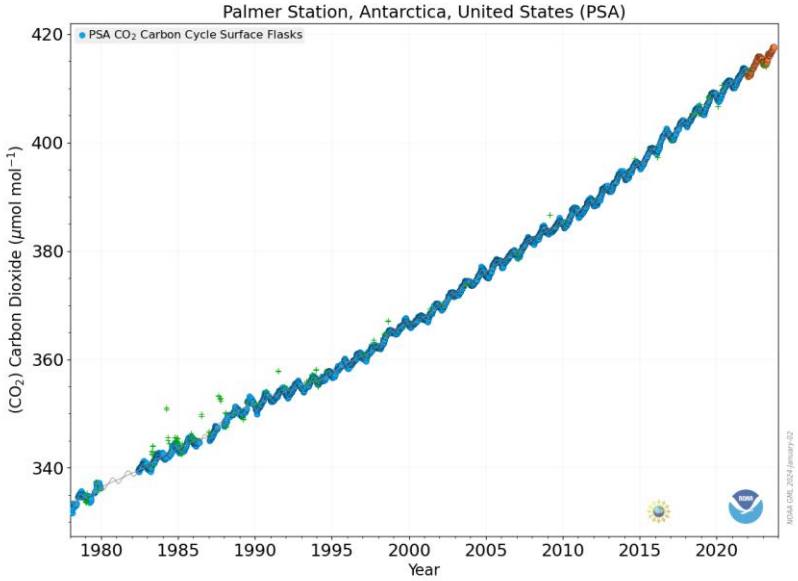

Figure 16- Carbon Dioxide (CO_2) levels at Palmer Station dating back to 1978. Orange dots are preliminary data.

HATS samples were collected on December 15 during favorable wind conditions. More information and data for the Halocarbons and other Atmospheric Trace Species group can be found at: https://gml.noaa.gov/hats/

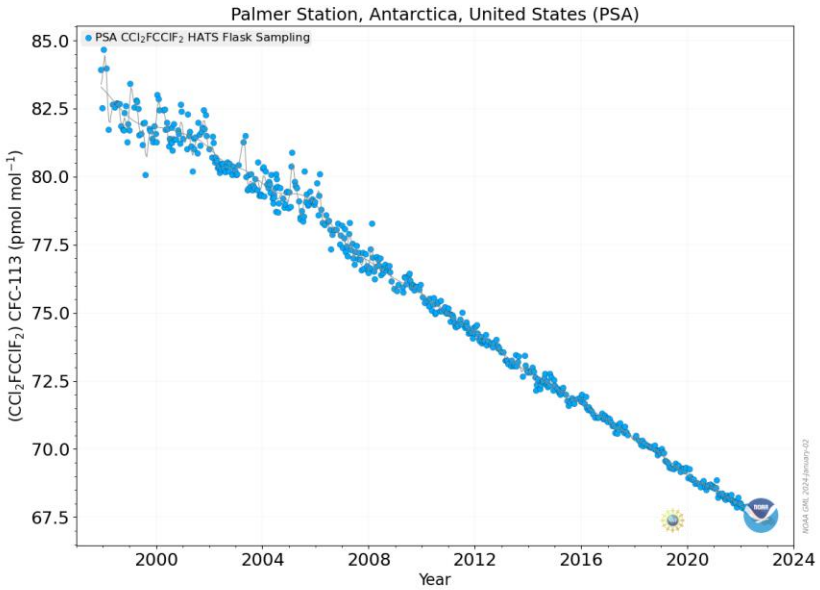

Figure 17- CFC-113 levels at Palmer Station dating back to 1997, one of the Halocarbon and Trace Gases measured at Palmer Station. Orange dots are preliminary data.

All samples collected on station are sent back to the Earth System Research Laboratories in Boulder, Colorado for analysis.

O-264-P: ULTRAVIOLET (UV) SPECTRAL IRRADIANCE MONITORING NETWORK
Scott Stierle, Principal Investigator, National Oceanic and Atmospheric Administration / Global Monitoring Laboratory; Boulder, CO

A Biospherical Instruments (BSI) SUV-100 UV spectroradiometer produces full sky irradiance spectra ranging from the atmospheric UV cutoff near 290nm up to 605nm, four times per hour. A BSI Ground-based Ultraviolet (GUV-511) filter radiometer, an Eppley Precision Spectral Pyranometer (PSP), and an Eppley Total Ultra Violet Radiometer (TUVR) also continuously measure hemispheric solar flux within various spectral ranges. The Research Associate operates and maintains on-site equipment for the project.

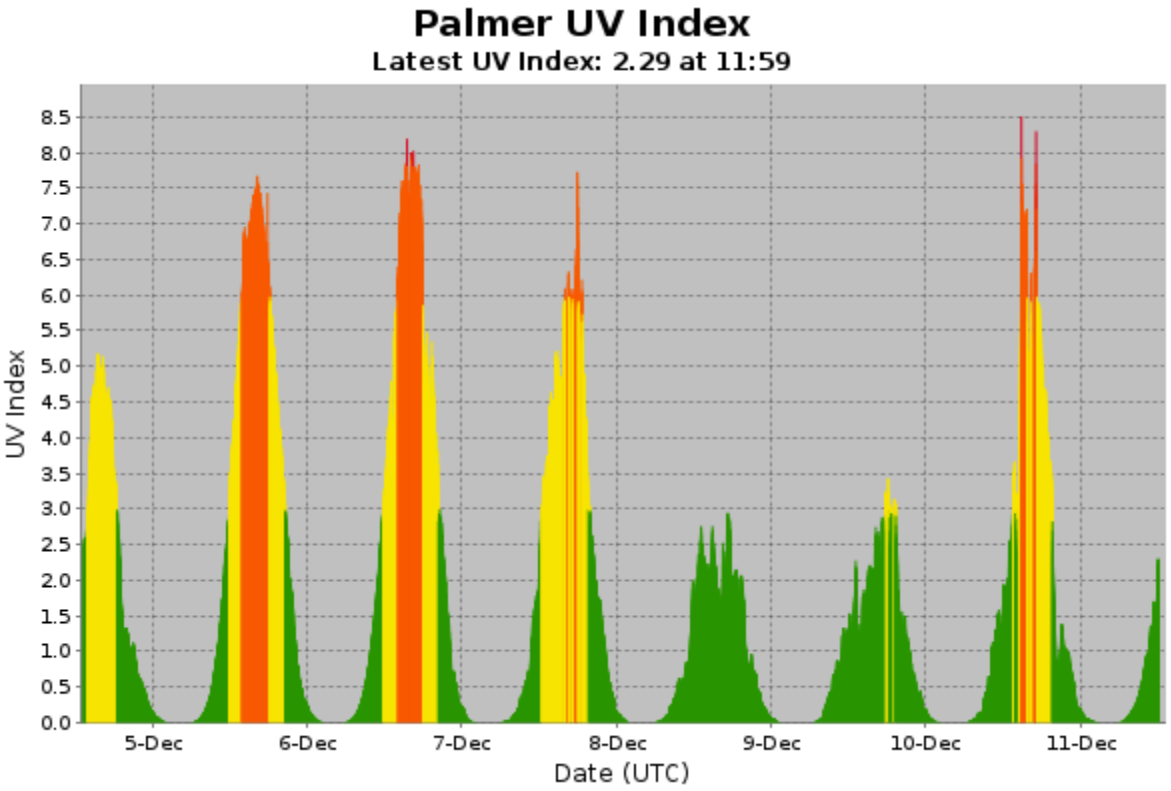

Figure 18- UV index generated from the GUV-511 radiometer in real time.

The log was filled out and collectors were cleaned on a daily basis. Once a week level checks were performed to confirm that the instrumentation was within +/- 0.2 degrees. The weekly log was sent out each Monday, and an SUV-100 Absolute Scan was performed on December 4 and the quarterly triple lamp SUV-100 Absolute Scan was performed on December 19 without issues. For more information, visit: https://esrl.noaa.gov/gmd/grad/antuv/.

R-938-P: TERASCAN SATELLITE IMAGING SYSTEM
Justin Maughmer, Principal Investigator, System Administrator, United States Antarctic Program

TeraScan is an integrated system of hardware and software designed for automated reception of data from meteorological/environmental satellites and for processing the data into images and data overlays. The system collects, processes, and archives DMSP and NOAA satellite telemetry, capturing approximately 25-30 passes per day. The data files for these images and overlays are of a special format called TeraScan Data Format (TDF). The Research Associate operates and maintains on-site equipment for the project. The TeraScan weather and ice imagery is used for both research and station operations.

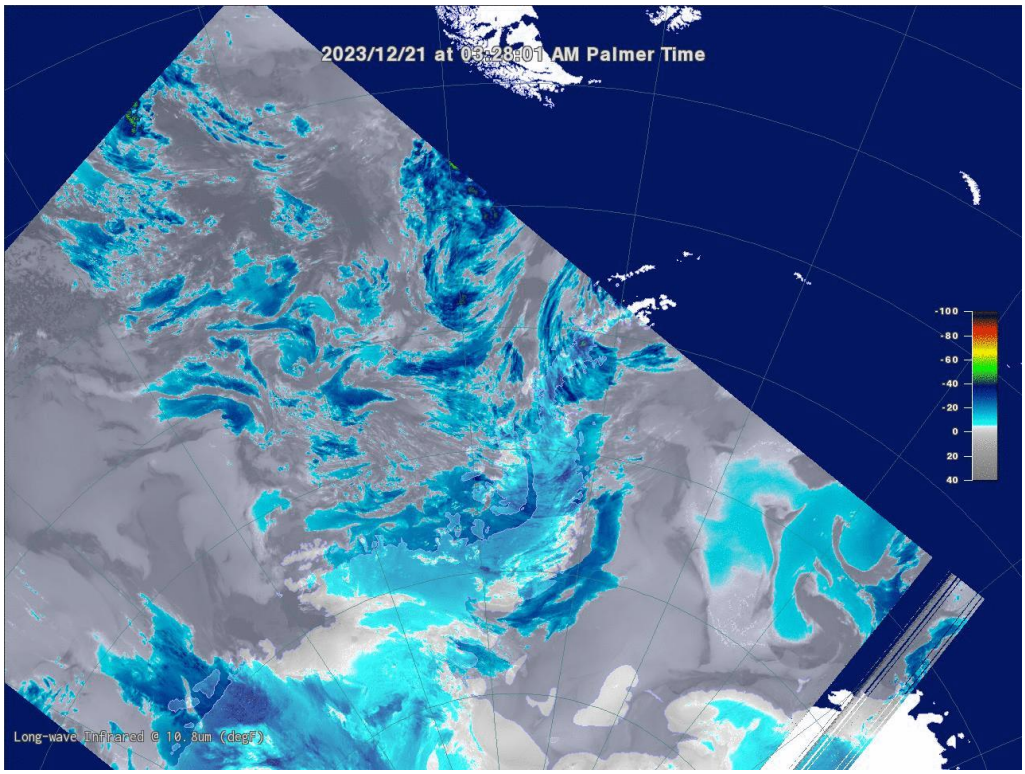

Figure 19- NOAA-18 December 21 satellite pass

The imagery was checked daily. The system received a check up from visiting IT personnel. Both the METOP and NOAA satellite passes were captured normally this month.

T-295-P: GPS CONTINUOUSLY OPERATING REFERENCE STATION.
Joe Pettit, Principal Investigator, UNAVCO

The National Science Foundation (NSF) tasked and funded the USGS Antarctic Program to establish a GPS (Global Positioning System) Continuous Operation Reference Station (CORS) at Palmer to serve a variety of scientific investigations in Antarctica. A permanent GPS CORS known as PALM (1003) was established during April and early May of 1997. Four reference marks were set and, along with 10 existing survey marks, PALM was tied in by differential GPS methods.

The GPS data collected supports the International GPS Service (IGS). This system is used for global geophysical studies such as crustal motion monitoring and determination of the global frame. PALM also provides Palmer scientists with real-time differential GPS positioning

capabilities. Continuous 15-second epoch interval GPS data files are collected at station PALM, compressed, and transmitted to the NASA-JPL in Pasadena, CA.

JPL/NASA is contracted to maintain the system, and they have sub-contracted to UNAVCO. While operation and maintenance of the GPS/CORS base station is the responsibility of the Research Associate, it is available for grantees who wish to use the roving systems and/or differential post-processing using data from the fixed reference station. Users are expected to have proper training prior to deployment to Palmer. The Research Associate may offer support to visiting grantees at their discretion. The system's splitter failed again and the system is operating on only one GPS receiver instead of the normal two.

For more information, visit: https://www.unavco.org/projects/project-support/polar/base_stations_and_survey_systems/palmer/base.html.

T-998-P: INTERNATIONAL MONITORING STATION (IMS) FOR THE COMPREHENSIVE NUCLEAR TEST BAN TREATY ORGANIZATION. (CTBTO)
Managed by General Dynamics

The Comprehensive Nuclear Test Ban Treaty (CTBT) bans all nuclear explosions. Although not ratified, the U.S.A. is following through with the treaty, including the installation monitoring stations around the world. The global verification regime for monitoring compliance is called the International Monitoring System (IMS). The radionuclide air particulate sampling station was installed at Palmer in October of 2005. Palmer's radionuclide sampler/analyzer (RASA) is a primary station in the IMS, known by its treaty code USP73 (and RN73). The pre-existing USGS seismic system is an auxiliary station, treaty code AS106.

Data collected by Palmer's RASA unit is relayed real-time via a virtual private network (VPN) across the Internet back to the CTBT Organization (CTBTO) in Vienna. As of August 2006, both the RASA and seismic systems have been certified by CTBTO. Palmer is now officially part of the IMS. The automated RASA continually filters ambient air and tests for particulates with radioisotope signatures indicative of a nuclear weapons test. The Research Associate operates and maintains the instrument.

The system operated consistently this month. The RASA GUI was checked daily. The amount of filter material was checked as needed and no anomalies were heard coming from the blower. Daily filters were processed as needed and the monthly log was sent on time. The system operated normally this month.

Additional details about the treaty and monitoring stations can be found on the CTBTO website, http://ctbto.org/.

PHYSICAL OCEANOGRAPHY

Palmer Station has a tide and conductivity gauge located on the west side of the pier at -64.774558° -64.055580° at a depth of 11.46 meters (WGS-84). It was reinstalled at this deeper depth after the completion of the Palmer Pier.

The Research Associate acts as the station's physical oceanography observer by maintaining and observing the sea state. Observations of sea ice extent and growth stage is recorded along with continuous tidal height, ocean temperature, and ocean conductivity. Observations of sea ice around station were made daily. The system operated normally this month.

Palmer Station Average Sea Surface Temperature (°C)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Max	Year
January	0.5	1.2	1.8	1.2	1.6	1.0	1.5	0.2	1.6	0.5	0.7	0.6	2.0	1.2	1.5	1.6	1.3	x	1.7	2.0	2017
February	0.3	1.4	1.5	1.1	1.7	1.1	1.1	0.7	0.9	0.8	0.5	0.3	1.9	1.2	1.1	1.4	1.3	x	1.8	1.9	2017
March	0.4	1.0	0.6	0.8	1.1	0.5	0.8	0.9	0.4	-0.1	0.0	-0.2	1.1	0.9	0.6	1.2	0.9	x	1.3	1.3	2023
April	x	0.3	-0.1	0.1	x	-0.1	0.1	-0.1	-0.1	-0.5	-0.8	-1.1	0.0	-0.2	0.5	0.5	0.1	x	0.6	0.6	2023
May	-0.9	-0.5	-0.8	-0.7	x	-0.7	-0.4	-0.5	-0.5	-1.0	-1.0	-1.6	-0.5	-1.0	0.0	-0.6	-0.5	x	-0.1	0.0	2019
June	-1.4	-0.9	x	-1.1	x	-1.0	-1.1	-1.3	-1.5	-1.6	-1.6	-1.6	-1.3	-1.3	-1.2	-1.1	-1.1	-0.9	-0.70	-0.9	2022
July	x	-1.4	x	-1.4	x	-1.6	-1.6	-1.6	-1.8	-1.7	-1.7	-1.7	-1.5	-1.7	-1.5	-1.4	-1.4	-1.3	-1.20	-1.3	2022
August	-1.7	-1.4	-1.7	-1.5	x	-1.5	-1.6	-1.7	-1.9	-1.8	-1.8	-1.7	-1.7	-1.6	-1.7	-1.5	-1.7	-1.3	-1.54	-1.3	2022
September	-1.6	-1.7	-1.7	-1.3	x	-1.5	-1.5	-1.7	-1.9	-1.7	-1.8	-1.5	-1.8	-1.7	-1.7	-1.6	-1.5	-1.2	-1.34	-1.2	2022
October	-1.4	-1.2	-1.3	-0.8	x	-1.2	-1.4	-1.5	-1.4	-1.7	-1.7	-1.2	-1.6	-1.5	-1.5	-1.4	-1.1	-1.1	-1.31	-0.8	2008
November	-0.4	-0.2	-0.8	-0.1	x	-0.6	-0.7	-0.8	-1.2	-1.2	-1.4	-0.9	-1.1	-0.8	-1.2	-1.0	-0.3	-0.4	-0.73	-0.1	2008
December	-0.1	1.1	0.4	0.5	x	0.7	-0.4	1.5	-0.3	-0.8	-0.6	0.1	0.0	0.1	0.0	0.1	-0.3	1.0	0.53	1.5	2012

Figure 20- Seawater temperature at the pier over time

Tide level, sea water conductivity, and sea water temperature data is archived on the AMRC website: http://amrc.ssec.wisc.edu/data/ftp/pub/palmer/.

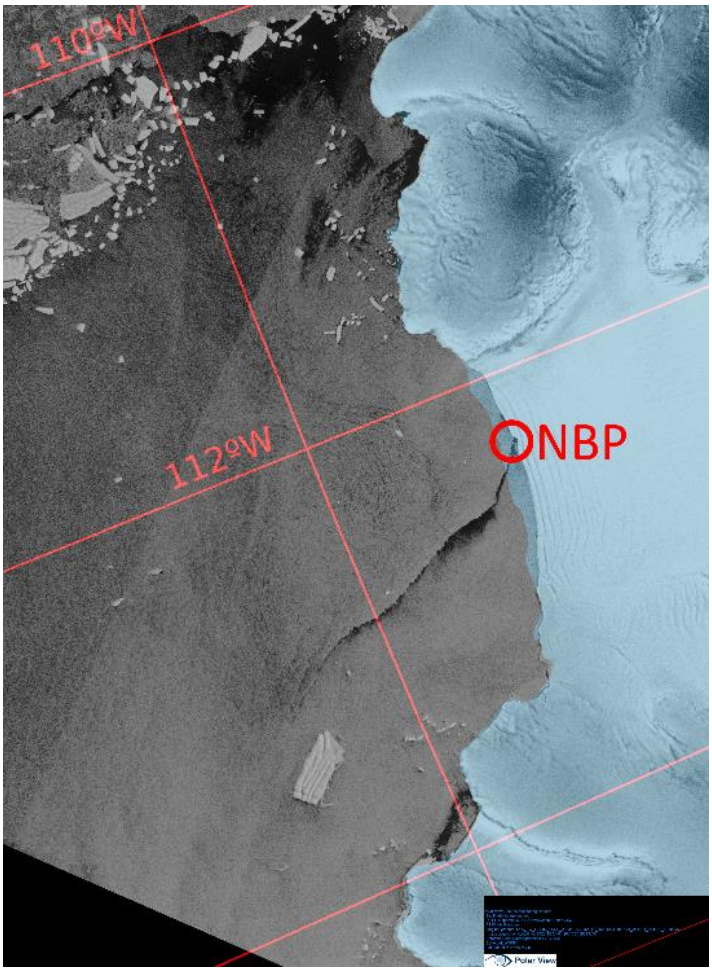

Figure 21- Sentinel 1 Imagery from December 24, 2023 – Showing the NBP near the Dotson Ice Shelf.
Source: Polar View

METEOROLOGY
Mike Carmody, Principal Investigator, United States Antarctic Program

Palmer Station is Station 89061 in the World Meteorological Organization (WMO) Worldwide Network. Automated surface synoptic observations are made 8 times each day and emailed to the National Atmospheric and Oceanographic Administration (NOAA) for entry into the Global Telecommunication System (GTS).

The Palmer Automatic Weather Station (PAWS) is a collection of sensors, computers, and software that records the meteorological data and generates synoptic reports. PAWS began recording data in September of 2015. It was a replacement for the Palmer Meteorological Observing System (PalMOS) that was taken down in November 2017. The PAWS sensors and data acquisition hardware are located on a ridge in the backyard at -64.774130° -64.047440° at an elevation of 38.3 meters above sea level using the World Geodetic System-84. In addition to the synoptic and METAR reporting, PAWS also archives the current conditions at one-minute intervals and displays both raw data and graphs of the sensor data on our local intranet.

The Research Associate acts as Chief Weather Observer on station, measuring, compiling and distributing all meteorological data. Snow accumulation is physically observed by taking an average of five accumulation stakes found near the PAWS system. All weather data is archived locally and forwarded to the University of Wisconsin on the first day of each month for archiving and further distribution. The system operated normally this month.

One minute weather data is archived on the AMRC website:
http://amrc.ssec.wisc.edu/data/ftp/pub/palmer/.

Palmer Monthly Met summary for December, 2023

Temperature
Average: .6 °C / 33 °F
Maximum: 4.9 °C / 40.82 °F on 18 Dec 09:45
Minimum: -2.7 °C / 27.14 °F on 4 Dec 03:50
Air Pressure
Average: 981.9 mb
Maximum: 997.2 mb on 17 Dec 19:15
Minimum: 963.7 mb on 13 Dec 11:50
Wind
Average: 8 knots / 9.3 mph
Peak (5 Sec Gust): 45 knots / 52 mph on 9 Dec 21:57 from NNE (14 deg)
Prevailing Direction for Month: SW
Surface
Total Rainfall: 40.6 mm / 1.6 in

Total Snowfall: 8 cm / 3.1 in
Greatest Depth at Snow Stake: 111.2 cm / 43.4 in
WMO Sea Ice Observation: 6-10 bergs, bergy bits, growlers, brash ice
Average Sea Surface Temperature: 0.53 °C / 33 °F

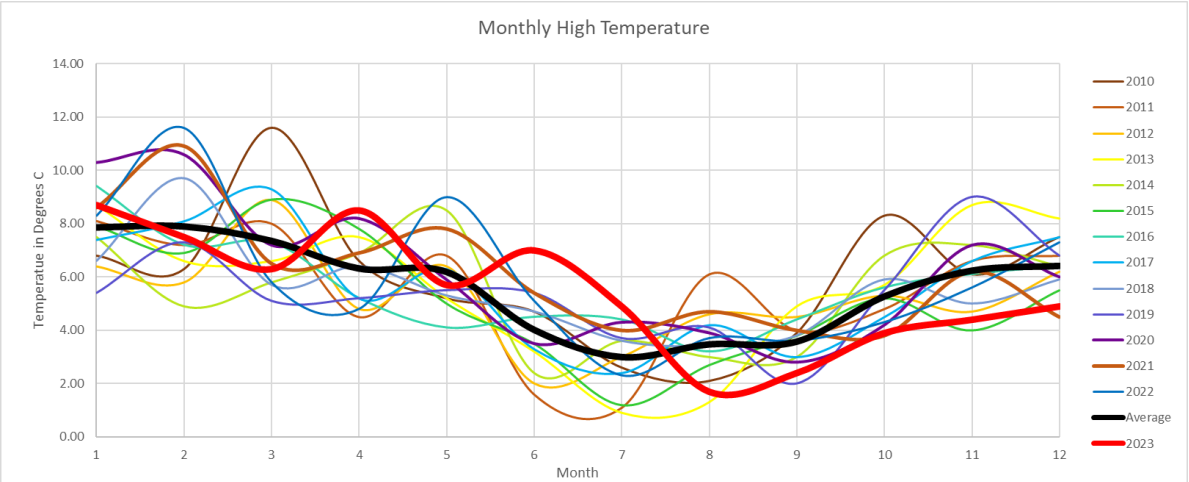

Figure 22- Monthly High Temperature (highest 1 minute for the month) for 2023 (in red) compared to the last 12 years. Data extracted from the PAWS system and historical archives. *Figure credit: Palmer Station Research Associates.*

The monthly high temperatures were lower during the second half of the year. The monthly average temperatures were either average or slightly below average. 2023 saw more than average precipitation, but less than the previous two-year period, which were both, record breaking wet years.

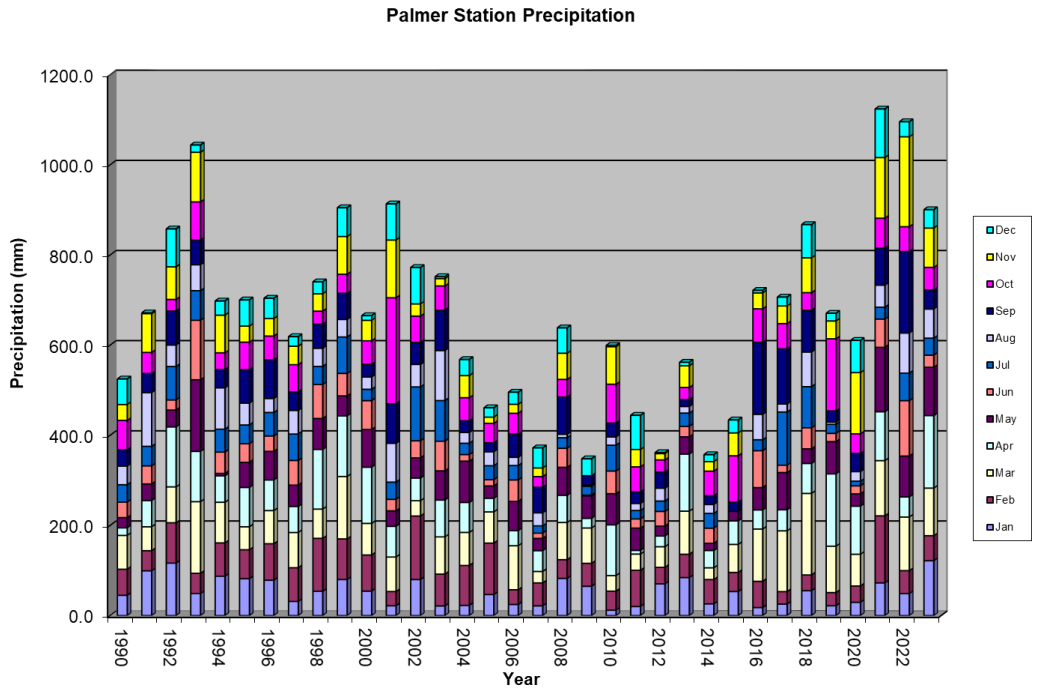

Figure 23- Melted Equivalent Precipitation from the Backyard rain gauge since 1990 in millimeters. Data extracted from the PAWS system and historical archives. *Figure credit: Palmer Station Research Associates.*