PALMER STATION MONTHLY SCIENCE REPORT

January 2024

Although beautiful to photograph, the icebergs that the tides transport in and out of Arthur Harbor and Hero Inlet can create quite a maze to navigate to and from the boating area, and require R/V HADAR to be hauled at the end of each day. SOLAS Mia can be seen in the middle of the image for scale. *Image credit: Hannah James*

NEWS FROM THE LAB

Hannah James, Summer Laboratory Supervisor

Calm weather through January provided a lovely kickoff to 2024 at Palmer Station. The majority of the snow melted in the backyard and on surrounding islands. ASC staff was able to install the remaining B-086-P (van Gestel) Open Topped Chambers at the final site in the backyard and on Litchfield Island (with permit ACA 2023-007). These chambers will be checked after high wind events, and at the end of the season data will be downloaded and batteries swapped before removing the chambers. The LTER cruise was completed at the end of January, and Palmer Station welcomed back the C-024-P (Friedlaender) team of Ross Nichols and newly-appointed whaler Helena Dodge (previously of the C-013-P (Cimino) team). We bid farewell to C-019-P (Schofield) grantee Sneha Sivaram and C-013-P (Cimino) team members Darren Roberts and Jack Conroy as they sailed north.

As mentioned in the December report, R/V HADAR experienced a significant mechanical issue towards the end of December which considerably affected sampling throughout the month of January. Thanks to the work of our Boat House staff and off-ice support, R/V HADAR was able to get back on the water on January 15th using one of its two engines for water collection, net towing, sediment trap deployments, and acoustic transects. However, due to the boat running on a single engine, our hauling limits with the tides are more limited, which means our sampling remains limited. Due to the ever-persistent grounded iceberg that remains in Hero Inlet, we are required to haul R/V HADAR at the end of each sampling day rather than leave it attached to the mooring (to prevent any damage for if/when the iceberg breaks up or detaches from the ground). These hauling limits are discussed at each weekly boating planning meeting to best prepare for

the week ahead. Small boat water sampling at Station E. continued when tides drastically limited operating hours on R/V HADAR, as C-020-P (Steinberg) net tows were prioritized for the days our RHIB can be on the water. In total, two CTD rosette events, two sediment traps (with a third deployed January 31st and recovered February 1st), three acoustic surveys, and five net tow events occurred from R/V HADAR. Zodiacs with daisy-chained Go-Flo bottles were utilized for seven Station E. water collection events.

I would like to extend 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 R/V HADAR back on the water. 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 water sampling via small boats, though it may be limited, at Station E.

Massive icebergs continue to dominate the boating areas around Palmer Station. The iceberg that is grounded in front of the pier (see above image) prevented a normal port call for the northbound portion of the 2024 LTER cruise. Although everyone on station and the cruise was looking forward to swapping stories and celebrating a successful LTER cruise, we unfortunately had to do all cargo operations and personnel movement via zodiac while the R/V LAURENCE M. GOULD stood off in Arthur Harbor. It took numerous zodiac trips over two days to load and unload the essential northbound samples, cargo, borrowed items from station, passengers, and personal luggage. On the evening of January 26, the ship sailed north to pick up the NOAA gliders and return to port in Punta Arenas, Chile. The next time we will see the ship will be at the summer-to-winter turnover in April.

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

The growing season for *Belgica antarctica* is coming to an end, but the midges looked healthy and happy through the summer. We observed a high number of adults in all islands that were visited through early December to mid-January, and midge eggs were observed being laid both in the field and in the lab, a type of event that is not very common to see (Figure 1).

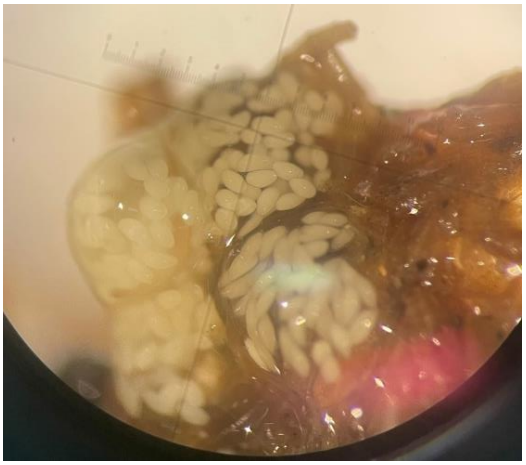

Figure 1- *Belgica antarctica* eggs. *Image Credit: Cleverson Lima*

In the previous monthly report, we discussed our objectives for this field season. Here, we will go through the progress of each of these objectives, some preliminary results, and directions for the rest of the field season. The first set of experiments comparing stress physiology of *B. antarctica* of different islands was concluded (Objective 2). We were able to look at heat and cold stress tolerance in midges from Torgersen, Cormorant, and Outcast Islands (Figure 2. A-D). We observed that larvae from Cormorant show significantly higher tolerance to longer periods of exposure to heat than larvae from other islands. Midges from Cormorant also showed

significantly higher tolerance to extreme cold temperatures than larvae from Torgersen, which was curious given that larvae from Cormorant were smaller than larvae from Torgersen; and size many times correlate with endurance within a species. The next step towards this objective is collecting larvae in these islands closer to the end of the summer (early-mid March) and re-run these experiments to look at differences in the physiology of larvae that emerged early and larvae that will emerge late in the summer.

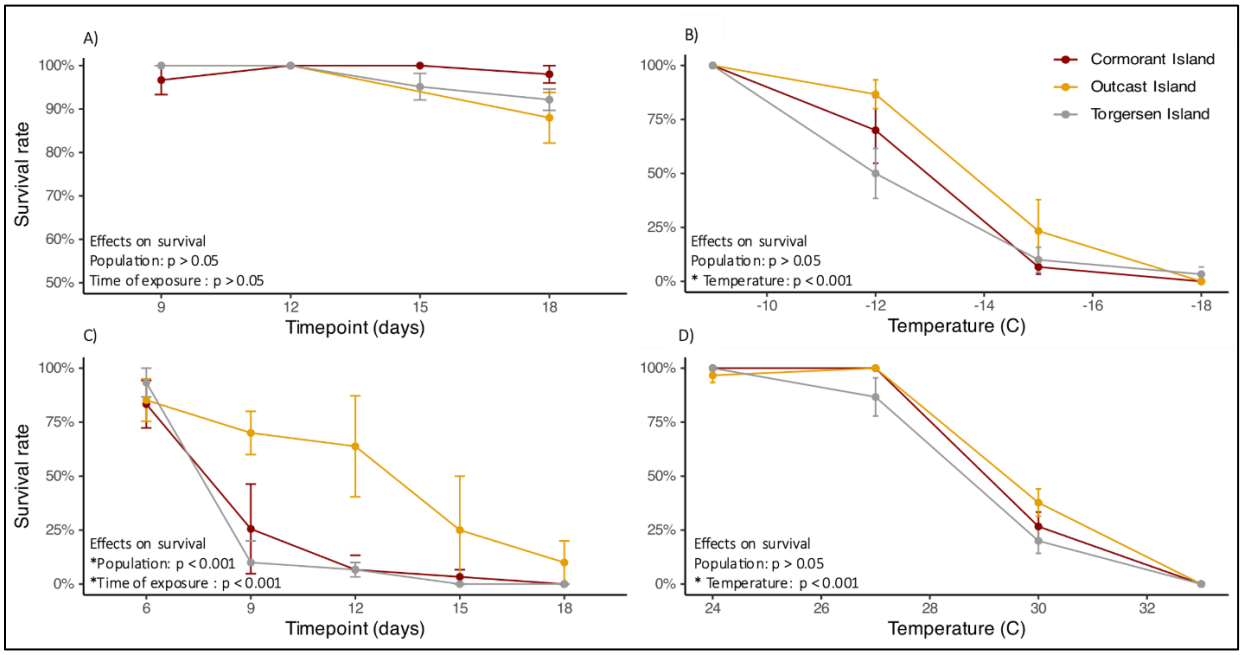

Figure 2- A) Survival at -5C through 9 to 18 days. Duration of stress as well as populations from different islands did not seem to have any effect on survival. B) Survival for 24h to different levels of freeze that ranged through -9C to -18C. Harsher temperatures (e.g., -15C, -18C) significantly reduced survival. C) Survival at 15C through 6 to 18 days. Midges from Cormorant Island showed significantly higher tolerance to heat than midges from other islands. The duration of exposure affected the survival of populations of all islands. D) Survival for 24h to different levels of heat that ranged through 24C to 33C. Harsher temperatures (e.g., 30C, 33C) significantly reduced survival of midges of all islands. *Indicates statistically significant effects.

The field study at Cormorant is in progress (Objective 3), with visits for surveying and collections occur in a biweekly basis. The study is expected to be finished in the end of March. We plan on starting to collect midges from other islands around Palmer Station (Objective 4) around mid-February, and we keep monitoring the embryonic development of this species (Objective 5) in the field and in laboratory.

Lastly, I am conducting a short study to look into how different types of acclimations change responses to stress. *B. antarctica* evolved many adaptations to deal with environmental stress, including the power of seasonally (or slowly) acclimate to prepare for the Antarctic winter and rapid hardening, which consists in an enhancement of tolerance to harsh levels of stress after a mild, sudden bout of stress from the same or from a different nature. One question that arose during this field season was whether longer periods of acclimation have a higher potential to improve stress tolerance than rapid, plastic responses, such as rapid cold hardening (a short exposure to cold that improves tolerance to severe levels of stress). Figure 3 shows how these midges survived to a harsh level of freezing (-13C) post three different types of acclimations: 1) 4C, which is the temperature that they are maintained in the lab; 2) -5C for 2 hours, which is an ecologically relevant level of stress (i.e., they are regularly exposed to this temperature throughout the winter), but for a short period of time; and 3) -5C for a longer period of time (7

days). Larvae that had the opportunity to acclimate the cold for 7 days showed almost 100% survival post exposure to -13C, which was significantly higher than both larvae that were acclimated for only two hours at -5C or larvae that did not experience cold acclimation (Fig. 3).

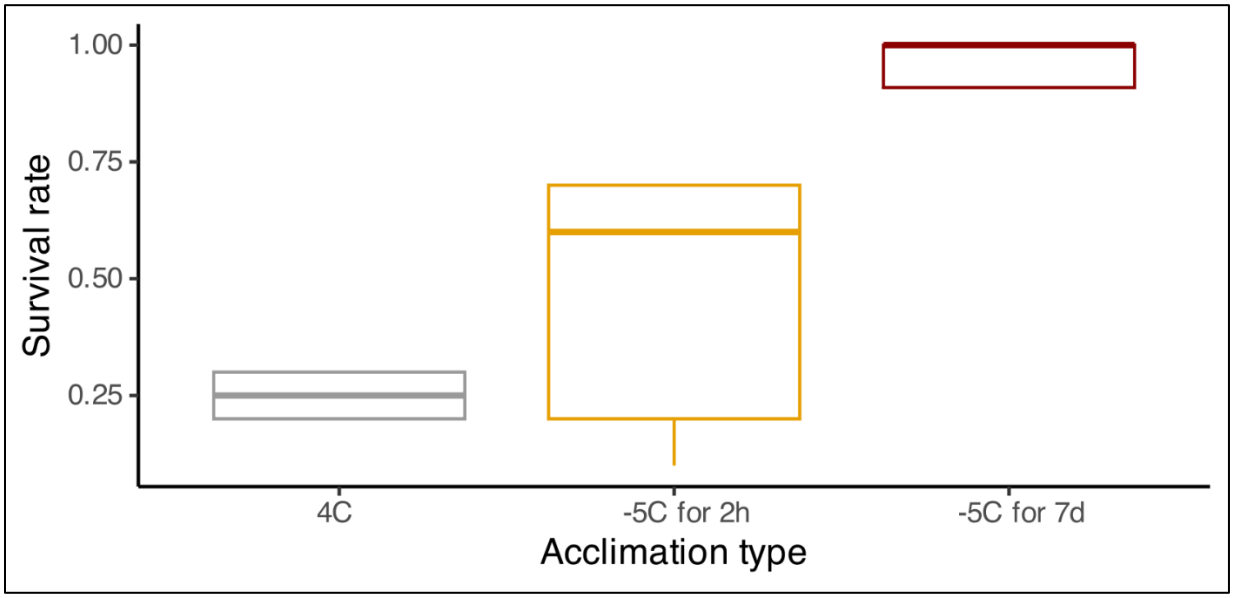

Figure 3- Survival to -13C between animals that experienced acclimation to -5C for to 2h or 7d and a control. Larvae that received more time to acclimate to -5C had significantly better responses to exposure to severe levels of cold than larvae that acclimated for less time or did not acclimate at all.

I would like to thank all the support from the station personnel for providing the materials that were necessary for these laboratory experiments and their assistance in volunteering for field work. January was a very productive month for research in stress physiology of polar animals and it would not be as productive without you.

B-086-P: Antarctica as a Model System for Responses of Terrestrial Carbon Balance to Warming

Dr. Natasja van Gestel, Principal Investigator, Department of Biological Sciences, Texas Tech University

Personnel currently on station: none (work performed by ASC staff)

The specific goal of this project is to study how warming affects the carbon cycle in Antarctica; specifically, how warming affects carbon entering (i.e., via photosynthesis) and leaving (i.e., via respiration) the land ecosystem. The major players in the carbon cycle of the western Antarctic Peninsula are plants and microbes. A major strength of the Palmer Station environs is that the receding Marr Ice Piedmont glacier conveniently provides for a successional gradient, such that we can examine warming-induced changes to the carbon balance as we shift from a solely microbial dominated system (close to the glacier edge) to a fully vegetated system: the moss peatbanks of Litchfield Island.

This year, because of logistical challenges, our field experiment was continued thanks to ASC staff who deployed the open-top chambers along the successional gradient (e.g., see Figure 4). Chambers were deployed as soon as the areas became snow-free.

Figure 4- Lab manager Hannah James and Research Associate Marissa Goerke after completing the setup at site 2 (circa 25 year post-deglaciation). *Image credit: Hannah James.*

All 40 field plots contain TEROS12 sensors inserted perpendicular into the soil (0-5 cm) that are linked to a ZL6 data logger (METER Group, Inc, Pullman, WA). The data were downloaded in late December of 2023 or early January 2024, and the equipment (loggers and sensors) received some maintenance – all done by ASC staff. Figure 5 shows daily average temperatures of soil in control and warmed plots as measured by the sensors. This data set covers an entire year of soil temperatures. For comparison, Figure 5 also shows the air temperature data obtained from the AMRDC website https://amrdcdata.ssec.wisc.edu/). The air temperature data is from the weather station on in the backyard, which is maintained by the Research Associate.

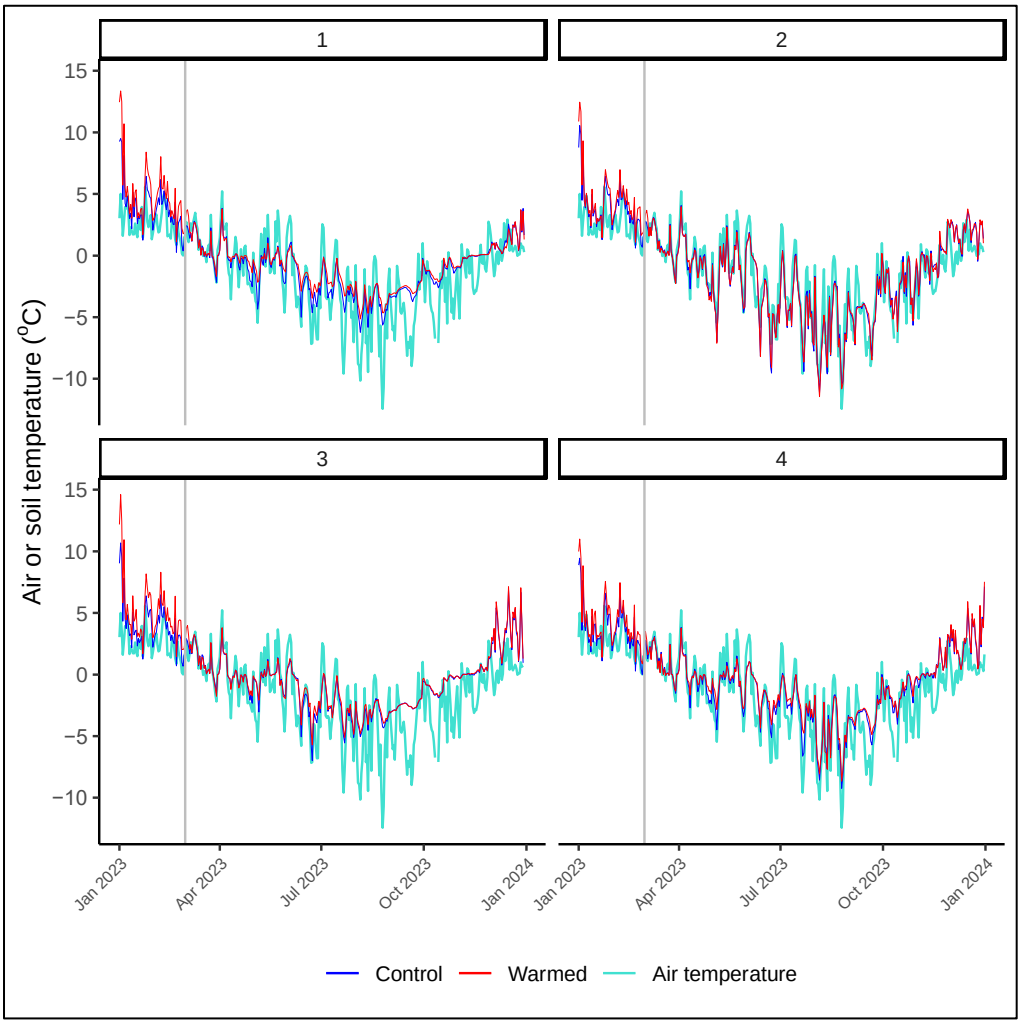

Figure 5- Daily average temperature data of soils in control and warmed plots, and daily average air temperature data (https://amrdcdata.ssec.wisc.edu/). The gray line indicates the date when the open-top chambers were removed from the site - hence, soil temperatures of control and warm plots converge thereafter. The data are separated for each successional site, with 1 being the youngest site (no plants) and 4 being the oldest successional site (Litchfield Island peatbanks).

Open-top chambers are deployed each austral summer and removed at the end of summer before the snow accumulates (circa first week of March) to prevent altering snow input. The removal date is shown as the gray vertical line in Figure 5. Two things to note are that: 1) Soil temperatures become similar irrespective of the preceding warming treatment after removal of the chambers, and 2) Soil temperatures are more stable from day-to-day than air temperatures. Soil temperatures at Site 2 fluctuate more compared to the other sites, because it is more exposed and, based on personal experience, also the windiest. Surprisingly, soil temperatures fluctuate more than expected in the austral winter, despite that there is insulative snow cover (so, maybe not that insulative?).

Figure 6 highlights the austral summer months of the 2022/2023 season. The results show that the open-top chambers increased the daily maximum, minimum and average soil temperatures (averaged by month) compared to control plots.

Thanks to ASC staff, the warming treatment continues this austral summer and year-round temperature data were made available. A heart-felt thanks to Hannah James, Lance Roth, Marissa Goerke, and Jesse Patton for helping to make the B-086-P project successful!

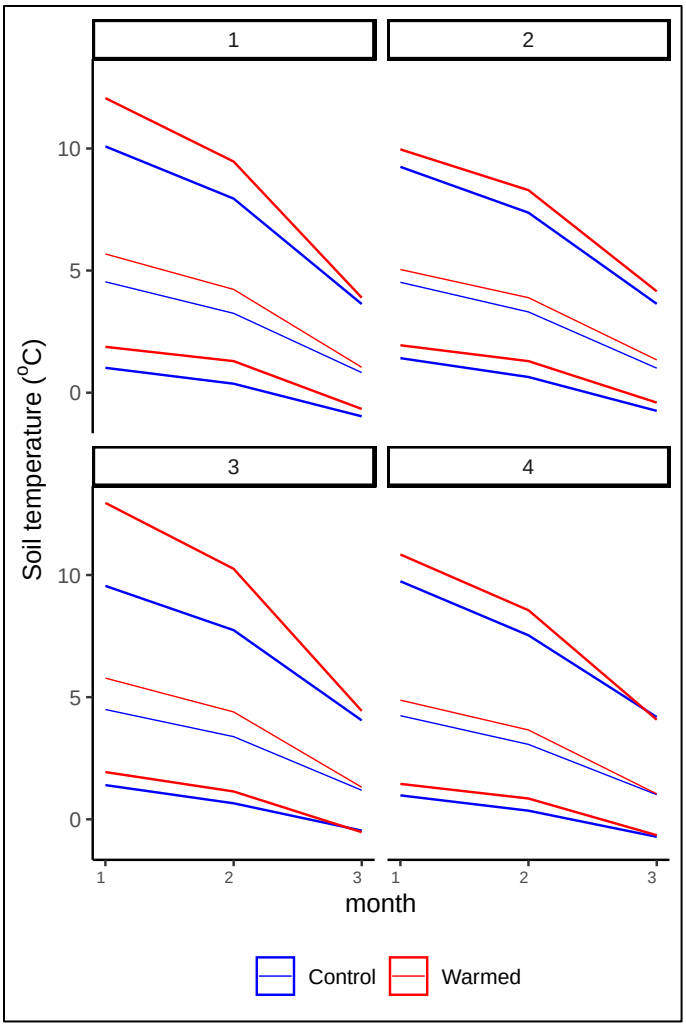

Figure 6- Average monthly maximum, minimum, and mean soil temperatures of control and warmed plots for January, February and March of 2023 (but data are now just available). The shading represents how much soil temperatures vary on average on a daily basis during the three months. The data are separated for each successional site, with 1 being the youngest site (no plants) and 4 being the oldest successional site (Litfchield Island peatbanks).

B-285-P: Understanding Microbial Heterotrophic Processes in Coastal Antarctic Waters

Dr. Jeff Bowman, Principal Investigator, Scripps Institution of Oceanography, University of California San Diego

Personnel on station: Beth Connors

The B-285-P (Bowman) lab had a productive month of environmental sampling and experiments, and successfully took over C-019-P (Schofield) sampling for the remaining season alongside C-045-P (Van Mooy) grantee Shavonna Bent. This past month, we were successful at retrieving seawater from Station E on nine occasions: January 2, 5, 8, 12, 16, 19, 22, 25 and 29. We were able to successfully perform experiments on these days with 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 dilution series is incubated at 2°C for 24 hours, and we use our measurements to determine the influence of both protists and viruses on bacterial growth rate. Obtaining a better understanding of the influence of predation on bacterial growth is critical to understand microbial carbon flow along the wAP as it is currently very poorly understood.

In addition to the dilution experiment, our lab is undertaking an induction experiment with the chemical mitomycin-C, which induces viral lysis from bacterial cells. We add this chemical to Station E. seawater from 10 m, 30 m, and 50 m and take an initial measurement for viral abundance, which can only count free viruses outside bacterial cells (lytic viruses). During a 24 hour incubation, mitomycin-C destroys bacterial membranes and all of the viruses inside the bacterial cells (called lysogenic bacteria) are now outside the bacterial cells. We can then measure for a true viral count (those outside and inside bacterial cells) and calculate the viral count inside bacterial cells (final viral abundance minus viral abundance before adding mitomycin-C). Figure 7 below depicts the viral life cycle, and why this experiment is an important step to not undercount viral abundances. Previous research has indicated the presence of lysogenic viruses is extremely seasonal, but given only one year has been studied previously, it is important to collect these measurements this year and expand our understanding of viral dynamics.

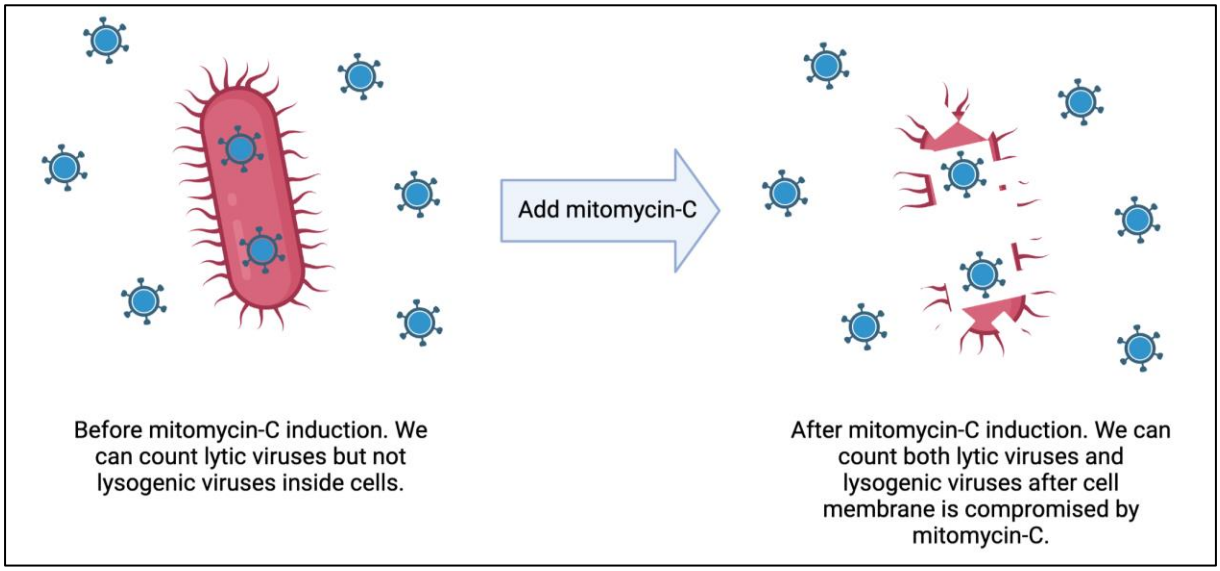

Figure 7- Not-to-scale diagram demonstrating how mytomycin-C induces the lytic (outside bacterial cell, blue circles in diagram) phase from typically lysogenic (inside bacterial cells, red cell in diagram) viruses in order for us to successfully count all viruses present**.** *Figure credit- Beth Connors*

C-013-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (PAL-LTER): ECOLOGICAL RESPONSE TO "PRESS-PULSE" DISTURBANCES ALONG A RAPIDLY CHANGING WEST ANTARCTIC PENINSULA

Dr. Megan Cimino, Principal Investigator, University of California at Santa Cruz.
Personnel on Station: Megan Cimino, Darren Roberts, Jack Conroy.

Favorable weather allowed us to conduct boating field work on 29 days in January. We monitored Adélie, gentoo and chinstrap penguin breeding chronology and breeding success with indicator colony counts as well as an all-colony chick census on local, Dream, Biscoe, and the Joubin Islands. Adélie penguin chick measurements were made; unfortunately, we were not able to do concurrent measurements this year at Avian Island due to the earlier-than-normal cruise timing. Foraging ecology studies of Adélie and gentoo penguins continued this month with a total of 61 deployments (and recoveries!) of GPS, depth, radio and/or video camera tags at Torgersen, Humble, and Biscoe Island. Diet sampling of Adélie and gentoo penguins was conducted several times throughout the month.

Figure 8- The three Pygoscelid penguin species pose for a picture with Palmer Station in the background. *Image credit: Megan Cimino*

Brown skua work continued this month documenting hatches and monitoring chick growth on local, Dream, Biscoe, and the Joubin Islands. South polar skua nesting and chick growth was also monitored on Shortcut Island. Monitoring of the blue-eyed shag colony on Cormorant Island continued. For giant petrels, we maintained GPS tagging efforts, chick growth/survival monitoring, and continued our local island census and banding project, visiting all giant petrel nesting sites locally (~25 islands) as well as a few of the Gossler Islands.

Monitoring of marine mammals continued. Antarctic fur seals are slowly arriving to the Palmer area and humpback whales were the frequently observed.

We video chatted with a kindergarten class that had endless questions about things we have seen and our favorite animals. We also cleared up common misconceptions about the Arctic vs. Antarctica, including penguins and polar bears don't actually live in the same place.

Figure 9- Southern giant petrel chick enjoying a warm day. *Image credit: Megan Cimino*

At the end of January, Helena Dodge (former birder, now whaler) and Allison Northey returned from the LTER cruise. Allie and Helena inventoried and packed cruise gear, and quality checked cruise data. We are grateful Helena helped us during a few (long) days in the field before becoming a full-time whaler and while Megan and Allie transition to a team of two. We also said goodbye to Darren and Jack who surely enjoyed resting on the transit back to PA.

We are incredibly grateful for the positive attitudes and support provided by ASC as January is our busiest month. Chefs Francis Sheil and Aleah Greene provided delicious food. The Boat House had our boat available daily, launching and picking us up at all hours. Hector Plaza thoughtfully delivered us a replacement radio one day as we headed out. FMC put in new island landing pins, and carpenter Ian Mannix built us a new time-lapse camera stand. Instrument Tech Lance Roth helped with instrumentation and his forward thinking is helping the LTER to be better setup in the future. Research Associate Marissa Goerke provided us with numerous satellite images to guide field operations, and we are always grateful for her incredible local knowledge. Lab Manager Hannah James aided with communications between groups and kept us organized amid shifting priorities. Finally, we are thankful for the many volunteers that helped us out in the field!

C-019-P: Palmer, Antarctica Long Term Ecological Research (PAL-LTER): Ecological Response to "Press-Pulse" Disturbances Along a Rapidly Changing West Antarctic Peninsula

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

This month, along with the B-285-P (Bowman) and C-045-P (Van Mooy) groups, zodiac sampling was well underway. With the main sampling platform, R/V HADAR, being down for most of the month, zodiac sampling became the main contingency to sample at Station E. A total of seven samples were taken at Station E this month. R/V HADAR came back online towards the end of the month with reduced sampling availability as with a single engine, the tides must be high enough to be able to

Figure 10- Diatom bloom under the microscope. *Image credit: Sneha Sivaram*

recover the boat. It is anticipated that the zodiac sampling will continue with opportunistic sampling on R/V HADAR.

Pumphouse sampling also continued this month with the first bloom of the season. A total of 11 pumphouse samples were taken this month. Under the microscope, the bloom was mainly dominated by diatoms which are a group of ecologically significant phytoplankton. As phytoplankton are the base of the marine food web, it is great to see the start of summer production that will feed the higher trophic levels like krill, penguins, seals, and whales. Diatoms are also important in carbon sequestration as they convert dissolved carbon dioxide in the water through photosynthesis into oxygen. It is estimated that around 20% of the oxygen in the atmosphere is produced by diatoms.

The C-019-P (Schofield) lab sampling will be taken over by the B-285-P (Bowman) and C-045-P (Van Mooy) labs for the rest of the season in a reduced capacity. The samples that have been taken so far will be sent to Rutgers for processing. The main focus will be on HPLC filtration and preserved samples for the imaging flow cytobot (IFCB). There will likely be another bloom as the season transitions into autumn, and the Schofield lab looks forward to seeing some of the interesting dynamics as the season continues into April.

C-020-P: Palmer, Antarctica Long Term Ecological Research (PAL-LTER): Ecological Response to "Press-Pulse" Disturbances Along a Rapidly Changing West Antarctic Peninsula

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! As usual, this January was busy for the group, both at Palmer Station and on the Palmer, Antarctica Long Term Ecological Research (PAL LTER) cruise aboard the R/V LAURENCE M GOULD. The LMG got to Station in late December and delivered with it the 1-m^2 frame Metro net and depressor to replace the previous one and the C-020-L (Steinberg) research team with our principle investigator, Dr. Deborah Steinberg!

Figure 11- The entirety of the C-020 team. Left to Right: Joe Cope, Hannah Gossner, Connor Shea, Meredith Nolan, Debbie Steinberg, Maya Thomas. *Image credit: Laura Motta.*

After an exciting port call to start, the month continued to be successful. Maya was able to successfully conduct shallow zooplankton net tows for experimental animals off of one of the Solas boats on stations – SOLAS Bellatrix. During these tows, we were able to collect juvenile krill (*Euphausia superba)*. They became the subjects of our third DOM excretion experiment and will serve as a great comparison point to many previous DOM experiments conducted only on adult krill.

Figure 12- Conducting a zooplankton net tow off of SOLAS Bellatrix. *Image credit: Beth Connors*

In even better news, our primary research vessel that was down for repairs for a few weeks was able to be fixed and is ready to conduct more science. Along with biweekly Station E. net tows, the C-020-P (Steinberg) and C-045-P (Van Mooy) groups were able to deploy and recover another two sediment traps throughout this January. This data will prove to be vital for Maya's dissertation work as she will look at both the sediment trap data collected at Palmer Station and the data collected with the three sediment traps deployed during the PAL LTER cruise. Having traps deployed throughout the season at Station E. will provide temporal data – looking at how fecal pellet export changes throughout the season. Similarly, having traps at Station E. and Palmer Deep in the northern Western Antarctic Peninsula (WAP) and at different locations (including off the continental shelf) in the southern WAP from the cruise will provide spatial data – looking at how fecal pellet export changes based on location. Together we hope to gain a better understanding of fecal pellet export and how it relates to the biological pump for the entirety of the WAP.

As we enter February, we are hoping for more of the beautiful weather (and amazing zooplankton) that was seen this January.

C-045-P: PALMER, ANTARCTICA LONG TERM ECOLOGICAL RESEARCH (PAL-LTER): ECOLOGICAL RESPONSE TO "PRESS-PULSE" DISTURBANCES ALONG A RAPIDLY CHANGING WEST ANTARCTIC PENINSULA

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

Personnel on station: Shavonna Bent

January was a month of good weather and lots of sample collection the 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 $\delta^{18}O$), via both zodiac and R/V HADAR, in conjunction with the other LTER groups and the B-285-P (Bowman) group. We have also successfully deployed and recovered three sediment traps in

conjunction with the C-020-P (Steinberg) group, honing the process to increase efficiency in both deployment and recovery. Of note is that the best method for recovery is via the davit on R/V HADAR, rather than off the main A-frame and winch (which is required for deployment while ballast is attached). R/V HADAR being back online also allowed for the resumption of acoustic transects, although the weather and tide windows are smaller for the remainder of the season due to hauling limits.

Training for continuation of a skeleton sampling scheme for the C-019-P (Schofield) phytoplankton group, after the departure of their lab tech on the LTER cruise also occurred during the month of January. In conjunction with the B-285-P (Bowman) on station personnel Beth Connors, Shavonna will continue sampling for chlorophyll, HPLC, and IFCB samples from Station E and the pumphouse for the remainder of the season. In addition, the two groups are taking over instrument and data management for the various CTDs and sensors used during water collection.

Processing of diet samples from Adélie and gentoo penguins was fully underway during the month of January, with over 50 samples collected by the C-013-P (Cimino) birder team and homogenized by Shavonna for use in her PhD dissertation. Additionally, Shavonna was able to join the Birders in the field three times, and collected approximately half of the fecal samples required for this season.

PALMER STATION
RESEARCH ASSOCIATE MONTHLY REPORT
January 2024
Marissa Goerke

Figure 13- Spectacular clouds over the icebergs in the harbor, January 23, 2024. *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.

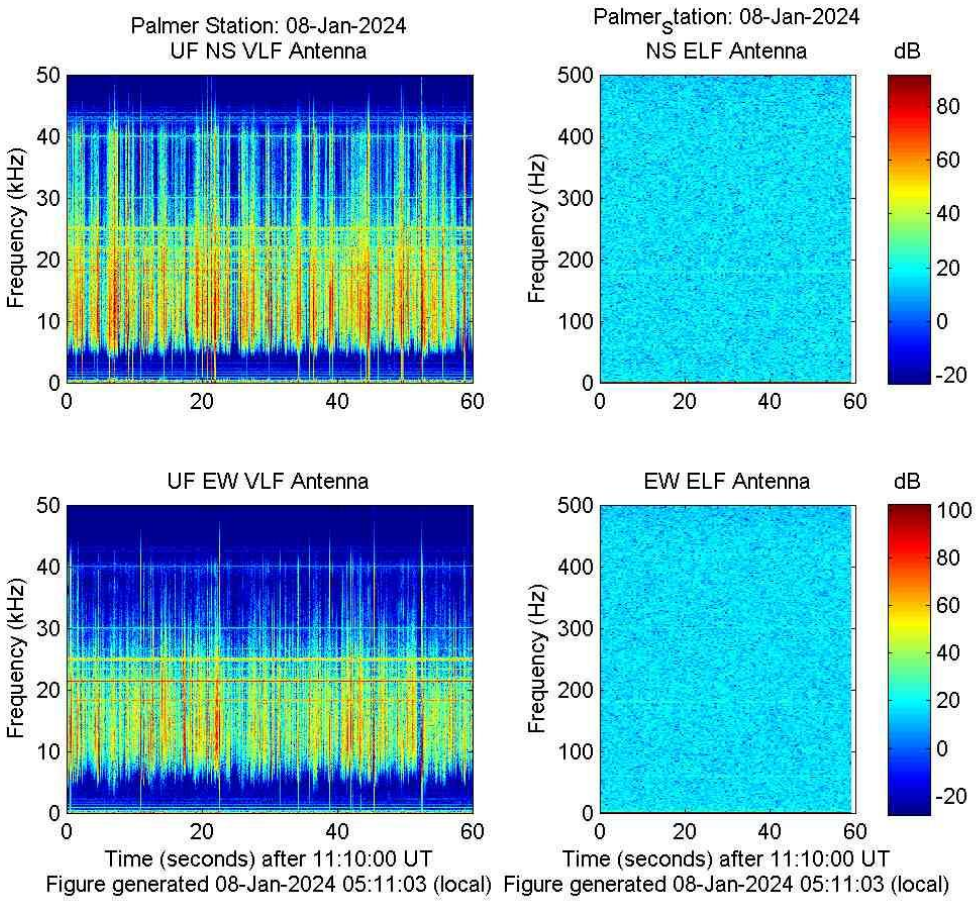

Figure 14. Real-Time broadband VLF and ELF Spectrogram from Palmer Station, Antarctica.

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. The new Raspberry Pi system was installed and the Magnetometer system is now connected to the network once again and is no longer considered a security vulnerability by the IT department. 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.

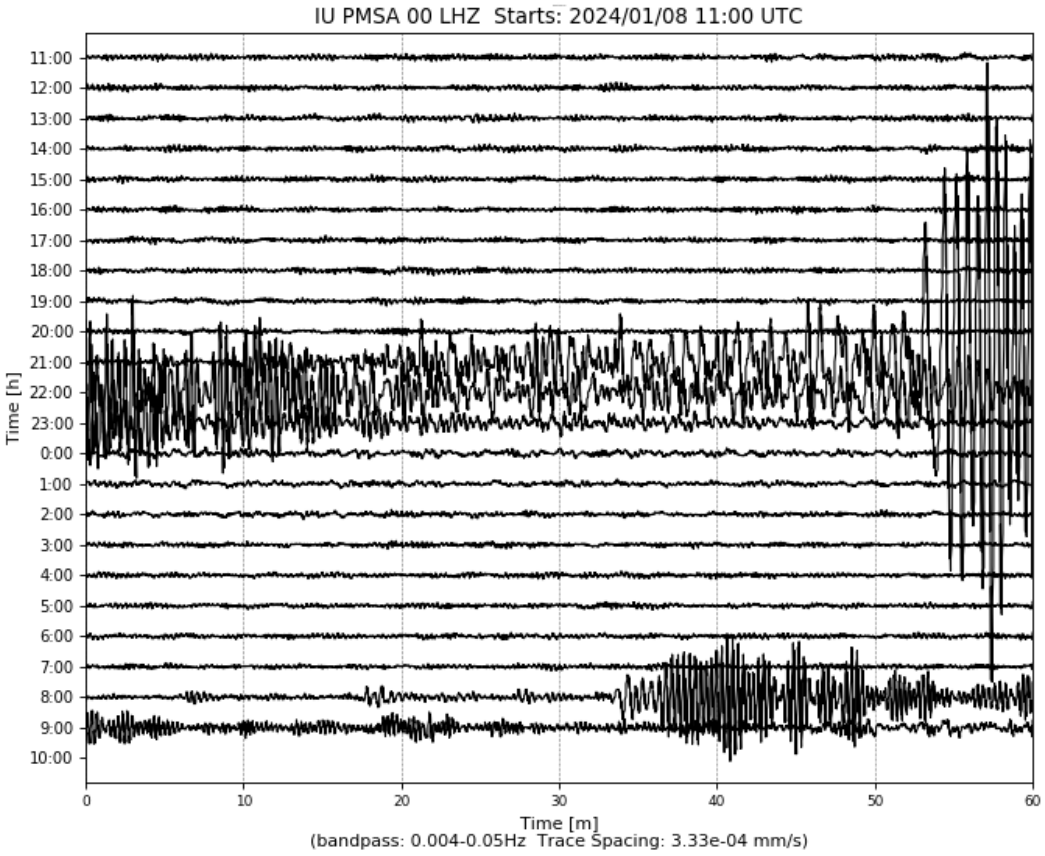

Figure 15. The January 8, 2024 6.7 earthquake in Pulau-Pulau Talaud, Indonesia, as recorded from the Palmer seismic station.

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.

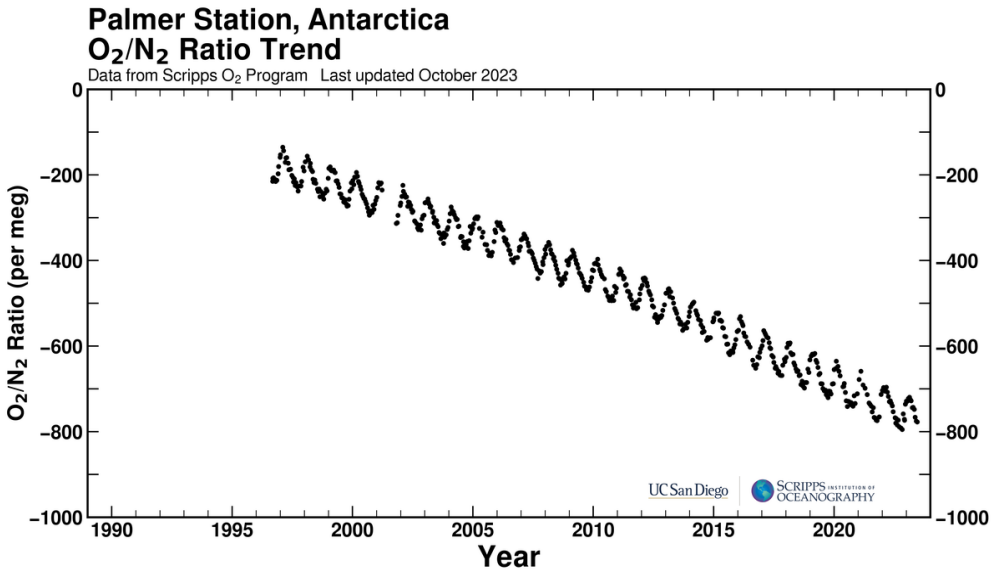

Figure 16. Historical plot of $\mathbf{O_2/N_2}$ ratio per meg and $\mathbf{CO_2}$ ppm updated October 2023.

Air samples were collected on January 3 and January 16. 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 January 2, January 8, January 15, and January 24 during favorable wind conditions. More information and data for the Carbon Cycle group can be found at: https://gml.noaa.gov/ccgg/.

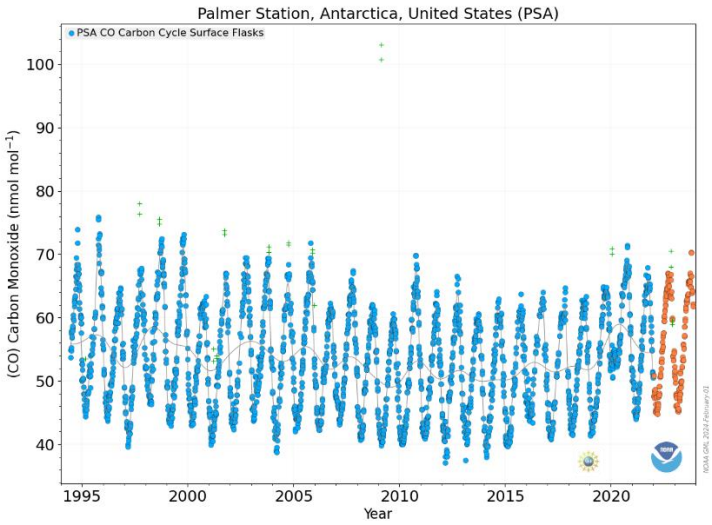

Figure 17. Carbon Monoxide (CO) levels at Palmer Station dating back to 1994. Orange dots are preliminary data.

HATS samples were collected on January 3 and January 17 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/

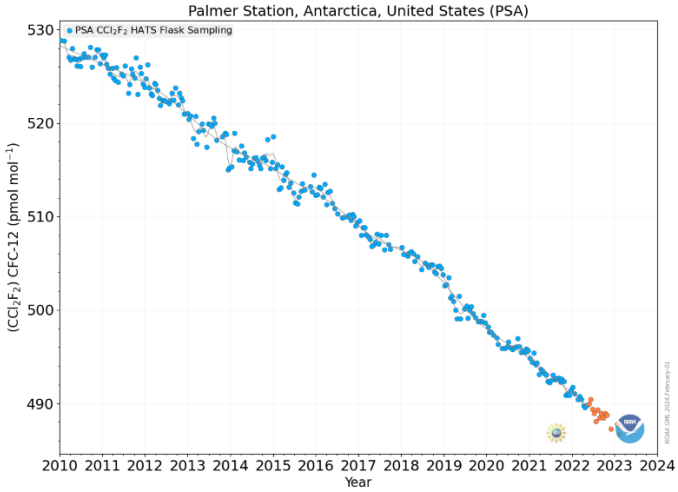

Figure 18. CFC-12 levels at Palmer Station dating back to 2010, one of the Halocarbon and Trace Gases measured at Palmer Station. Orange dots are preliminary data.

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.

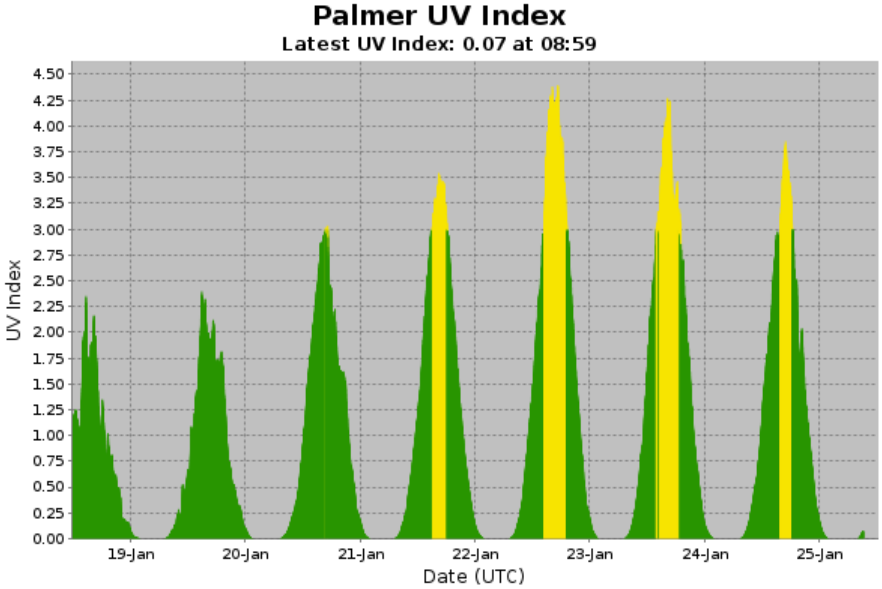

Figure 19. UV index generated from the GUV-511 radiometer in real time.

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 SUV-100 Absolute Scans were performed on January 2 and January 15 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.

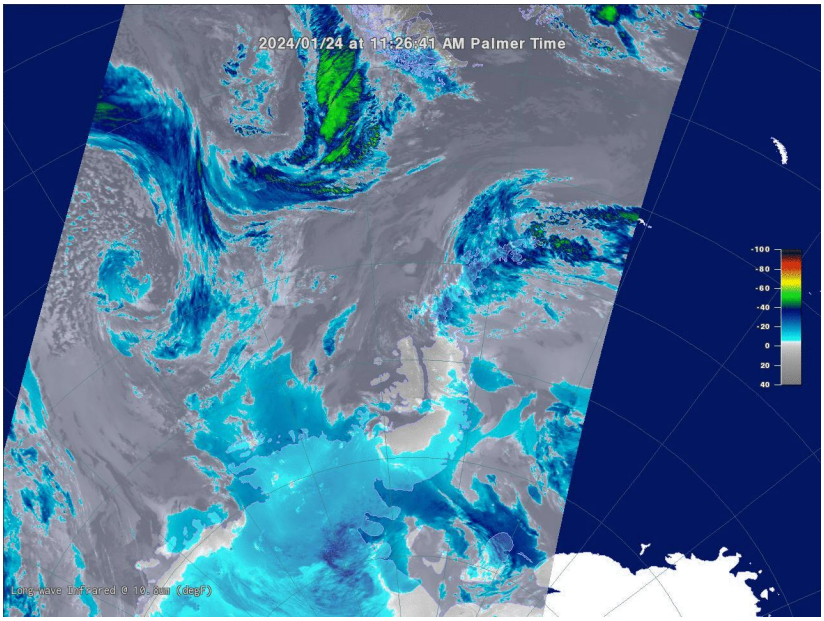

Figure 20. NOAA-18 January, 2024 satellite pass

The imagery was checked daily. 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 in December 2023 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.

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/.

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 January, 2024

Temperature
Average: 1.8 °C / 35.2 °F
Maximum: 5.7 °C / 42.26 °F on 31 Jan 17:29
Minimum: -2 °C / 28.4 °F on 15 Jan 08:14
Air Pressure
Average: 980.9 mb
Maximum: 994.4 mb on 30 Jan 21:50
Minimum: 969.1 mb on 12 Jan 18:46
Wind
Average: 7.9 knots / 9.1 mph
Peak (5 Sec Gust): 45 knots / 52 mph on 26 Jan 09:27 from NE (34 deg)
Prevailing Direction for Month: NNW
Surface
Total Rainfall: 16 mm / 0.63 in
Total Snowfall: 0 cm / 0 in
Greatest Depth at Snow Stake: 65.2 cm / 25.4 in
WMO Sea Ice Observation: More than 20 bergs, bergy bits, growlers, brash ice
Average Sea Surface Temperature: 1.18 °C / 34.1 °F