PALMER STATION MONTHLY SCIENCE REPORT

December 2022

***Bartramia patens* moss with sporophytes nestled amongst *Sanionia uncinated* moss as well as various lichens, photographed with the B-086-P (van Gestel) group on Litchfield Island. Not all moss reproduces with spores, but *Bartranua patens* does. Permit ACA 2023-007.** *Image Credits: Hannah James*

NEWS FROM THE LAB

Hannah James, Summer Laboratory Supervisor

Summer is in full swing here at Palmer Station. Six groups of grantees were onsite for the whole month of December, and every one of them took advantage of the long summer days here on the Antarctic Peninsula. At the beginning of the month, the B-198-P (Weissburg) team wrapped up all their experiments and released their live krill back into Hero Inlet before all four team members boarded the R/V LAURENCE M. GOULD for their journey north. Three groups arrived on LMG22-13 to start their Summer 2022-23 field season. The B-285-P (Bowman) and B-308-P (Moline) are both collaborating with the core Palmer LTER groups, adding to and enhancing the data gathered by the C-013-P (Cimino), C-019-P (Schofield), C-024-P (Friedlaender), and C-045-P (Van Mooy) groups. The B-086-P (van Gestel) group, led by Dr. Natasja van Gestel, returned to Palmer Station for the start of her multi-year project studying carbon balance in our local terrestrial ecosystems. In the final days of December, the R/V LAURENCE M. GOULD returned to station for the start of the LTER cruise- but more about that in January's report.

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 on station: Dr. Natasja van Gestel and Sara Bohi Goulart.

Soils worldwide contain more than three times the amount of carbon than the atmosphere, yet we do not understand the magnitude or direction of the changes to soil carbon stocks. Antarctica is a

unique model ecosystem to study changes to carbon fluxes and identifying who is responsible, because it is such a simplified ecosystems compared to ecosystems elsewhere. Antarctica is well-suited to provide a glimpse into the inner-workings of how ecosystem function.

The specific goal of this project is to study how warming affects carbon entering and leaving the land ecosystem. How will warming tip the carbon balance? Will warmer temperatures lead to plants soaking up more carbon (through photosynthesis), or will microbes release more carbon (through respiration)? Who is negatively affected by warming, and who benefits? Using a gradient in vegetative cover, our field warming project aims to unravel these important questions. Our gradient (see Figure 1) starts with our first site nearest the glacier where there is no vegetation, and our fourth site, located on lush Litchfield Island has impressive moss peatbanks.

Figure 1- *Our warming experiment is comprised of four sites that differ in vegetative cover: from no plants near the glacier (site 1) to a site entirely vegetated on Litchfield Island (site 4). Litchfield Island is an ASPA (ASPA 113), because of its diversity and abundance of flora. The massive peatbanks are diverse and its floristic composition is representative of the northwest Antarctic Peninsula. Plants are protected in Antarctica, so care is taken by stepping on rocks (while avoiding the lichen on those rocks! Permit ACA 2023-007. Image credit: Natasja van Gestel and for site 3, Sara Goulart*

It has been a busy season since we arrived. As the snow was melting, we were able to complete our experimental setup in the field. We use cone-shaped open-top chambers as a passive warming method. These chambers are made of transparent fiberglass that allows sunlight, but not long-wave radiation (infrared) through, thereby warming the air inside. They are open on the top, first, because we do not want to exclude precipitation, and second, it would likely overheat inside. We also deployed environmental sensors in all the plots, both to assess microclimate and soil environment. We are collecting air temperature and relative humidity 10 cm above the soil surface, and soil surface temperature (0-5 cm depth).

We believe that outreach is important. To share our experiences to the public and schools, I have created a fun and interactive blog where the public can make comments or ask questions. The blog is linked to my Instagram account @AntarcticResearchAdventures, which was created

specifically for this project. On Instagram, my student Sara is featured in a short video about conservation of plants in Antarctica.
Please see my blog for stories on our travels, wildlife, research, and more:
https://www.nvangestel.com/antarctica

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: Jeff Bowman and Elizabeth (Beth) Connors

B-285-P arrived on December 6th and – thanks to tremendous support from the Palmer Boathouse and lab staff – we were able to start science almost immediately. Our primary activity is a series of grazing experiments to determine the mortality rates of marine bacteria as caused by protists and bacteriophage. The experiments require precise conditions, large volumes of water, and considerable time to set up and execute. To conserve resources, we are joining the Palmer LTER Station E sampling program onboard RHIB Hadar on Mondays and Thursdays for our water collection. Inclement weather required some adjustment to the schedule, but successful collections were made on December 12, 15, 20, 21, 26, and 28. This rapid spin-up was crucial for testing our experimental setup and adjusting protocols. Our most recent experiment on December 28 was a successful validation of our protocol, just in time for Beth Connors to depart on the R/V LAURENCE M. GOULD where she will execute a similar work package during the Palmer LTER cruise.

We are running two flow cytometers to support our experiments this season. The BD Accuri C6 has been a Palmer Station workhorse for many years and allows us to obtain preliminary results fast enough to adjust experimental protocols. The NanoCellect WOLF is a more advanced instrument capable of cell sorting. We believe this is the first USAP deployment of a cell sorter to Antarctica. Used in combination with dyes that are sensitive to metabolic activity, this instrument allows us to physically separate metabolically active bacteria and phytoplankton from the bulk population. The application of molecular tools to these samples in a later phase of the project will allow us to determine the taxonomic structure and metabolic capabilities of these communities. The instrument is also capable of sorting single cells (i.e. into a 96-well plate) and we are using this capability to isolate phytoplankton for a culture collection. We obtained 192 individual cells in a single run on December 30 that are now incubating under controlled light and temperature conditions in the Palmer Station Percival incubator.

Beth Connors departed with the R/V LAURENCE M. GOULD on 31 December. Jeff remains at Station and will continue to execute twice-weekly grazing experiments in coordination with the Palmer LTER Station E sampling program.

Figure 2- *PhD Student Beth Connors collects water for grazing experiments onboard RHIB Hadar. Photo: Sneha Sivaram*

B-308-P: LINKING PREDATOR BEHAVIOR AND RESOURCE DISTRIBUTIONS: PENGUIN-DIRECTED EXPLORATION OF AN ECOLOGICAL HOTSPOT

Dr. Mark Moline, Principal Investigator, University of Delaware.
Personnel on Station: Erik White, Leila Character, and Matthew Breece

The Moline Group arrived at Palmer Station in Early December to begin Autonomous Underwater Vehciles (AUV) missions to determine the spatial and temporal distributions and density of penguin and forage foods in and around Palmer Canyon. The team spent the first few days repairing AUV components and sensors damaged in shipping and were able to deploy AUVs for sampling of prey distributions on Dec. 16 just after a significant weather system moved through. The AUVs are outfitted with two EK80 echosounders with 200kHz and 333kHz transducers; one set looks upward and the other is downward facing. Additionally the AUVs have a flurometer to measure primary productivity and backscatter, a Photosynthetically Active Radiation (PAR) sensor, a YSI CTD to measure water column properties and a forward facing camera. On the first few deployments the team found high densities of prey items just off of Janus Island in the main channel leading from the Station. Diving as deep as 75m and then utilizing a triangle depth pattern near the highest densities, the AUVs sample the oceanography within the preyfields.

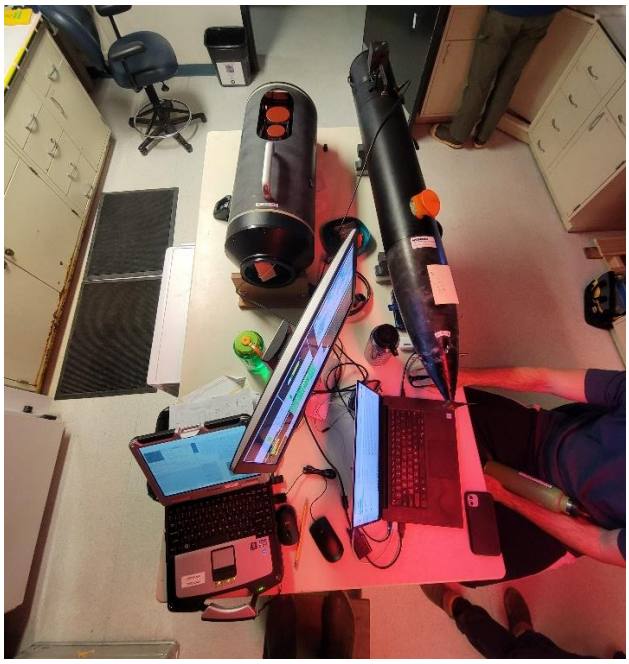

Figure 3- *REMUS Autonomous Underwater Vehicle being tested on in the lab to confirm all systems are up and running. Image credit: Matthew Breece*

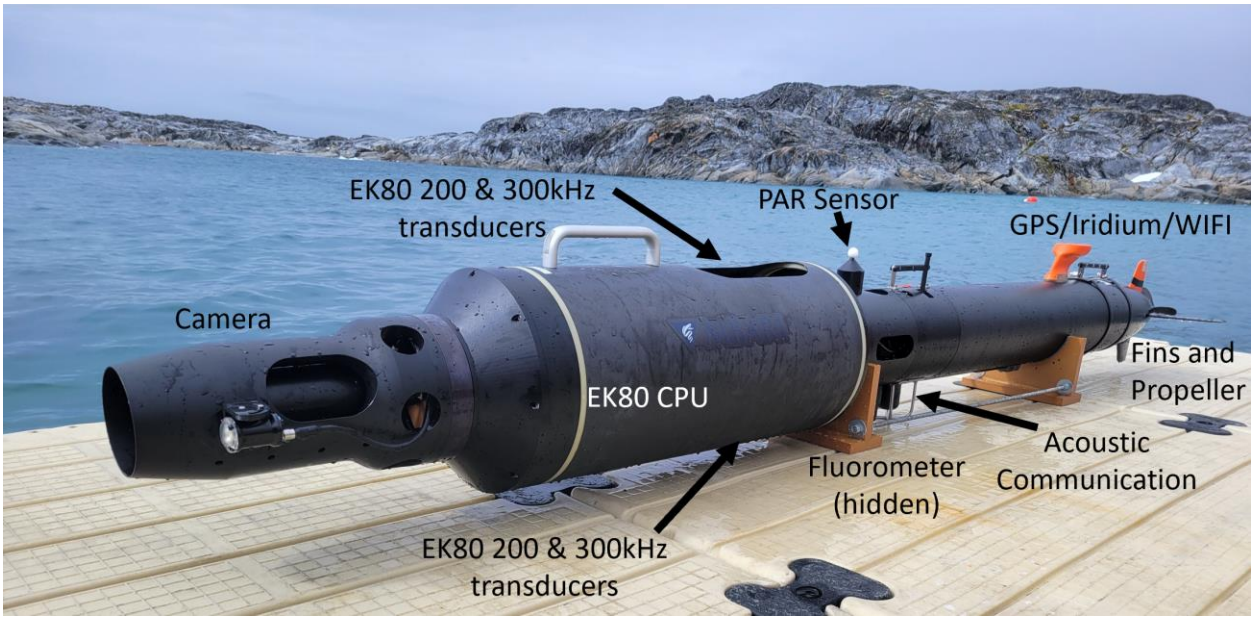

Figure 4- *REMUS Autonomous Underwater Vehicle dockside ready for deployment. Image credit: Matthew Breece*

In December 2022, the Moline group conducted three test missions and nine AUV sampling missions in six different survey areas that relate to historic foraging zones. These zones were determined by previous satellite tagging and tracking of penguins in addition to historic visual observations.

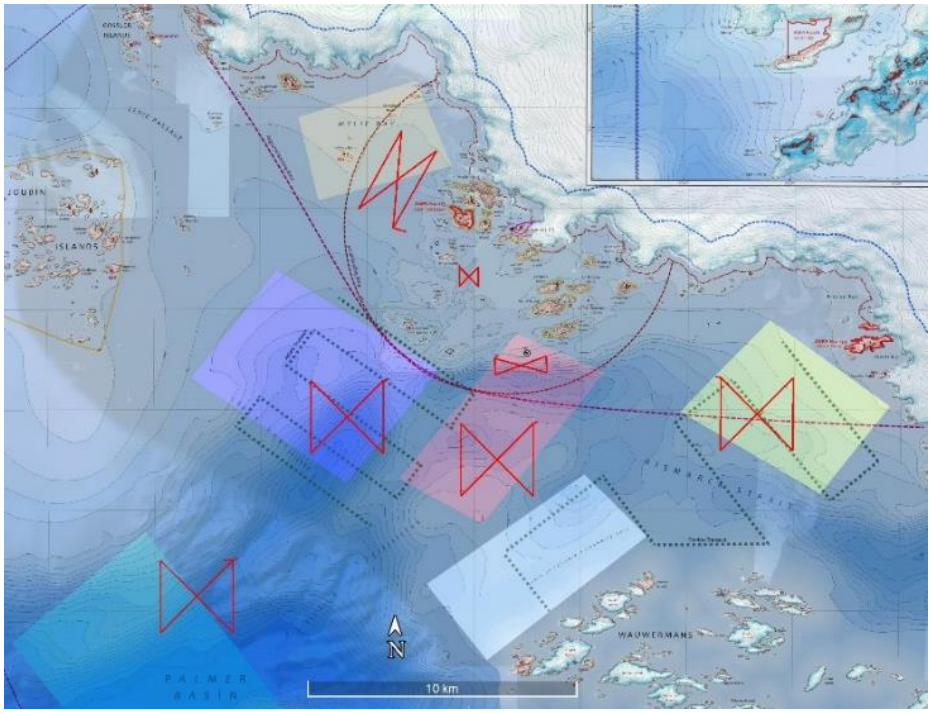

Figure 5- *Map of sampling zones (shaded regions) and mission patterns (red bowties) where prey surveys were conducted in December 2022*

Figure 6- *REMUS Autonomous Underwater Vehicle beginning sampling mission in the Gentoo foraging area. (note the Gentoo Penguin observing the AUV underwater). Image credit: Matthew Breece.*

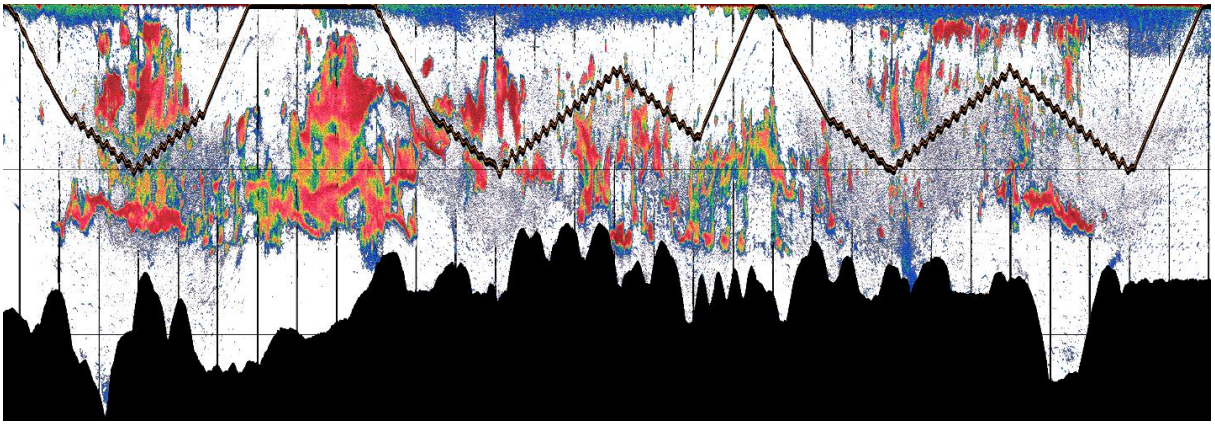

Figure 7- *Prey fields detected by the 200kHz echosounders on the upward and downward EK80s. The thin orange line is the AUV path, the black buffer around the orange AUV path is the transducer blanking distance. The black strip at the bottom of the figure is the bathymetry. Acoustic return of the prey field is indicated by the heat map (red is high density, blue is low density).*

In January of 2023, the Moline group will continue sampling the previously determined forage zones. Additional AUV sampling will also be directed via feedback from co-occurring penguin satellite and video tagging.

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: Megan Cimino, Megan Roberts, Helena Dodge, Darren Roberts, Allison Northey

Wind conditions improved throughout December allowing for boat-based field work on 26 days of the month. 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 8- *Heavy snow conditions at the Joubin Islands.*

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 penguin, and began tagging Adélie penguins at Torgersen Island. Diet sampling began at Torgersen Island. Late in the month we deployed radio tags at Humble Island, initiating the presence absence study of Adélie penguins. Additionally we were able to recover the majority of the over winter tags on Adélie and Gentoo penguins from Biscoe Point. These tags track location, as well as dive depth for an entire year. We know very little about what these animals do over the winter, and we are looking forward to getting this data processed.

Figure 9- *An Adélie penguin colony at the beginning and at the end of December on Dream Island*

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 as well as on Dream Island.

Our all-island census of giant petrel nests was started in December; breeding pairs were identified and new breeders were banded. Foraging ecology studies of giant petrels were also conducted in December with satellite transmitter deployments at Shortcut, Elephant Rocks and Humble Islands. Additionally, we successfully deployed our first video tag on a giant petrel.

We would like to sincerely thank Chris Borghesani, 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 on station: Quintin Diou-Cass, Sneha Sivaram, Malarie O'Brien

December marked a productive month for the Schofield group and an increase in station population that brought additional lab teams of the LTER to the ice. We said goodbye to Malarie O'Brien midway through the month, but briefly welcomed team members onboard the R/V LAURENCE M. GOULD as it arrived at Palmer Station around Christmas time. We were able to help the ship team in prepping lab spaces and supplies before they departed to conduct a month-long expedition up and down the Western Antarctic Peninsula. The end of the year brought two new sampling schemes into the lab's roster, which we are very excited to be doing!

Our first scheme is a set of bi-weekly acoustic transects, which are a core measurement of the LTER developed from a collaboration between the Phytoplankton, Zooplankton, and Predator (Birds, Whales, etc.) components of the LTER. For an acoustic transect, an EK80 echo-sounder integrated into the hull of RHIB Hadar is used to capture acoustic profiles of the water column. The size, density, depth, and even relative age group of the krill swarm can be quantified using EK80 data and mathematical models. In addition to information on krill distribution, we conduct 4-5 CTD casts and continuous visual surveys of penguins, whales, and seabirds as the RHIB motors along collecting EK80 data. These give us information on the water column physics, mixed layer depths, phytoplankton distributions, and the presence/absence of the predators that eat the krill. All of this data paired together gives us a broad overview of the ecological dynamics between predators and prey in the Palmer Deep Canyon area. We conduct the acoustic transects in two specific areas of interest: a Gentoo penguin foraging area and an Adélie penguin foraging area. These sites spread out over the regions where members of the respective penguin colonies are often seen looking for prey (e.g., krill). This way, we can monitor the prey densities, pair that with data from predator surveys and tagged animals for each site, and then compare the two to see the differences and patterns. We visit each site once a week and conduct the 7-8hr transects through the span of a day. In December, we were able to begin running transects earlier than any previous year, netting us significant data from a new seasonal time period.

We are also conducting a series of targeted light experiments, conducted in a controlled lab setting on Palmer Station. These experiments are part of an ongoing investigation into how the environment (and prevailing climate) is exerting its control on the productive phytoplankton of Palmer Deep. The phytoplankton community harness almost all of the energy that goes on to feed the vast multitude of fish, krill, penguins, whales, seals, and seabirds in the Palmer ecosystem. These experiments take phytoplankton from the water and place them into light environments that mimic different light intensities and daily light cycles. Most notably, they mimic changes in light from different mixed layers to create more realistic light environments. We place the algae in these environments and give them either the same amount of light that they had already, significantly less light, or significantly more light. We then measure their responses frequently over the span of 24hrs, and then once per day over the span of 6 days, to see how well they handle these changes. The data from these experiments will reveal the rates at which the algae can adapt their light harvesting systems, something that is not well defined in the region. It will also tell us how well they handle different levels of light and different degrees of light variability. Once we understand how resilient/adaptable the phytoplankton can be in the face of changing light, we can better predict how ongoing shifts in ocean mixing and annual sea ice dynamics will impact the food base of the Palmer ecosystem. We conducted an initial light experiment in December, and have five more planned from January-March.

The Schofield lab will continue running acoustic transects and light experiments, in addition to regular Station E, daily and weekly sampling. We are excited to have finished out 2022 with

such amazing productivity, and we want to give a huge thanks to the many volunteers from ASC staff and the operators in the boathouse who offer so much of their time assisting in the long hours of the transects and the miscellaneous sampling schemes of the last few months. None of the data we have collected would be possible without them!

Heading into the new year, we look forward to finalizing our data products and analyzing the seasonal signals we have been able to collect from early spring to peak summer, particularly in terms of daily photosynthetic health and efficiency in the phytoplankton community (which is new data to us all on this high of a time scale).

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: Mackenzie Curtice

With science in full swing now at Palmer Station, the Van Mooy group continues to sample Station E for the Long Term Ecological Research (LTER). Many new groups have joined the Palmer Station labs, including the B-285-P (Bowman) group, led by Dr. Jeff Bowman at Scripps Oceanography at UCSD. The Bowman group also samples Station E for bacteria in parallel to the LTER. At the end of the month, Principal Investigator Ben Van Mooy and graduate student Daniel Lowenstein will be joining the Palmer Station community with season opener Mackenzie Curtice moving onto the ship for the LTER cruise. The weather this month has been the most cooperative since the science groups arrived back in October. Station E has been sampled on Monday and Thursday mornings with the three groups on board. The teams have been working efficiently with one another to successfully collect the water needed on each day. Field sampling of oxygen isotopes, nutrients, and flow cytometry has continued to be collected at Station E. The remaining 21L of water samples collected are filtered back in the lab as soon as possible. These samples are collected to look at the lipids, carbs and particulate organic carbon (POC) in the water column from Station E. Using a vacuum pump system, the water is filtered through Durapore filters to capture the microorganisms that live in the water column. The filters are transferred into storage until it is time to analyze. The labs have been remarkably busy with experiments and sampling happening around the station. The LTER cruise is approaching and there will be many more moving parts around the building and labs. The Van Mooy group has collected a generous amount of data from Station E since they arrived. There were early season delays due to weather but we had managed to make it work.

The science community would not have completed all this research and sampling without the help from the support staff on station and those helping virtually. The Van Mooy group would like to thank everyone for their cooperation and support this month. We are looking forward to another productive month in January!


Figure 10 (Left)- *C-045-P grantee Mackenzie Curtis conducts nutrient filtration with the flowing seawater available on station at Palmer. Image Credit: Marissa Goerke* Right- *Shuttling out to HADAR with science equipment. The CTD rosette is ready to deploy at Station E for the day. The groups were fortunate enough to be able to show our station COMMs personnel, the sampling and processes of water collection at station E. Image Credit: Chris Borghesani*

PALMER STATION
RESEARCH ASSOCIATE MONTHLY REPORT
December 2022
Marissa Goerke

Approaching Palmer on a bluebird day, December 4, 2022. *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.

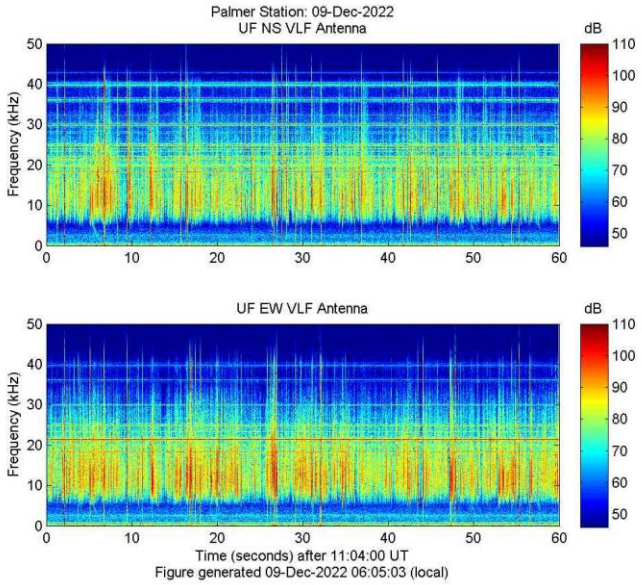

Figure 11. *Real-Time broadband VLF Spectrogram from Palmer Station, Antarctica.*

Both the Extremely Low Frequency and Very Low Frequency systems operated well this month. The full hard drives were swapped out on November 30. 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 February 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. The RA is working with the IT department to send out the data to UCLA when requested. More information can be found at: http://magnetometers.bc.edu/index.php/palmer.

B-005-P: COASTAL OCEAN DYNAMICS APPLICATIONS RADAR (CODAR)
Josh Kohut, Principal Investigator, Rutgers University Department of Marine

Coastal Ocean Dynamics Applications RADAR (CODAR) was developed between 1973 and 1983 by NOAA's Wave Propagation Laboratory. It is a high frequency radar that operates at 12 MHz so can receive signals from over the horizon. There are CODAR antennas at Palmer (just below Terra Lab near Hero Inlet) and also at the Joubins and the Wauwerman Islands. Each system measures the radial component of ocean wave velocity by transmitting a fundamental frequency at 12 MHz and receiving a reflected signal at twice the fundamental frequency (half the wavelength). By combining the measured velocity components from the three stations, the total wave velocity can be determined. The Doppler shifts of the reflected signals can be used to measure surface currents. Wave velocity can be affected by currents at depths of 1 meter and shallower and thus a measureable with CODAR.

Two of the three sites' transmitter and receivers were shipped north on LMG21-11. The system is still continuously collecting data from the remaining site. The PI has deemed the data useful information from the single site.

The data will be available in the future at: https://marine.rutgers.edu/~codaradm/.

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) 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.

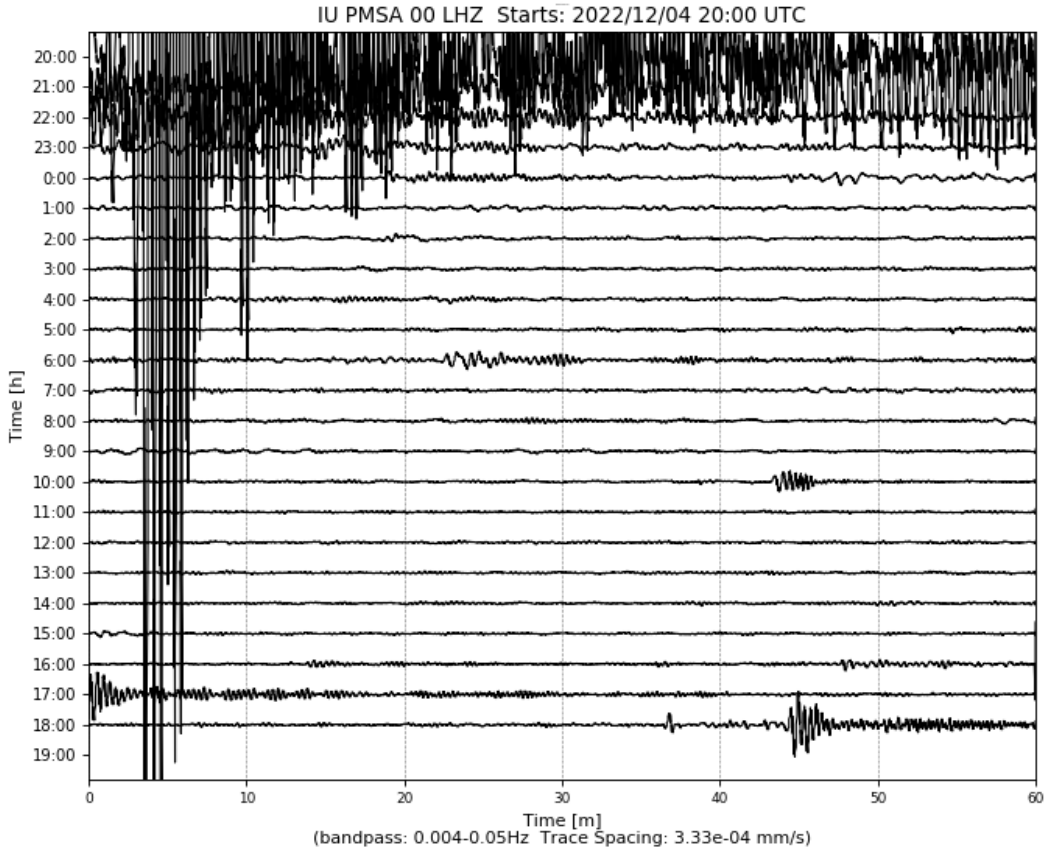

Figure 12- *An earthquake on December 4, 2022 in the Samoa Islands region*

The system operated consistently throughout the month. 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.

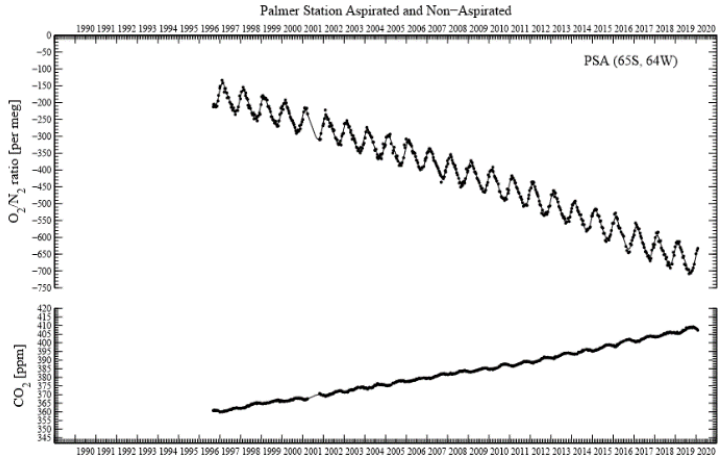

Figure 13. *Historical plot of* $\boldsymbol{O_2/N_2}$ *ratio per meg and* $\boldsymbol{CO_2}$ *ppm updated on July 29, 2020.*

Air samples were collected on December 10 and December 25. 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 will be shipped to 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 Division; 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 6, December 13, December 20, and December 26 during favorable wind conditions. More information and data for the Carbon Cycle group can be found at: https://www.esrl.noaa.gov/gmd/ccgg/trends/.

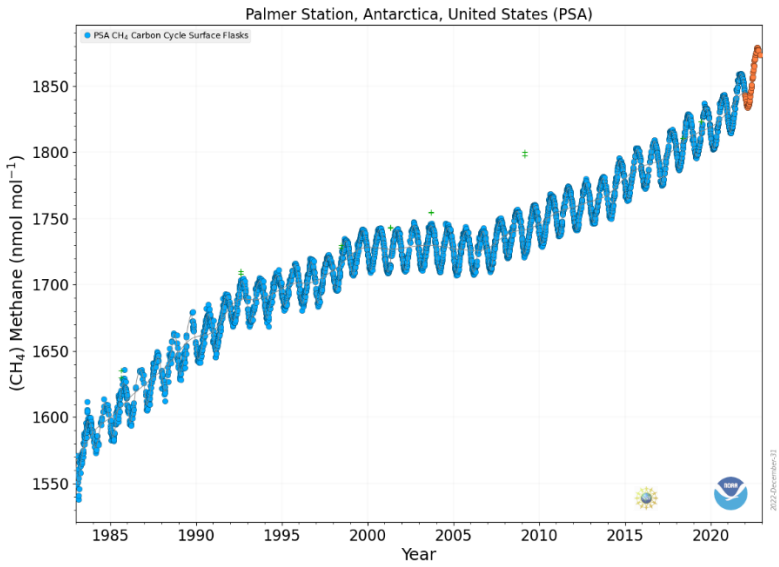

Figure 14. *Methane (CH_4) levels at Palmer Station dating back to 1984. Orange dots are preliminary data.*

Halocarbons and other Atmospheric Trace Species (HATS) samples were collected on December 10 and December 25 during favorable wind conditions. You can visit https://www.esrl.noaa.gov/gmd/hats/ for more information about the Halocarbons and other Atmospheric Trace Species group.

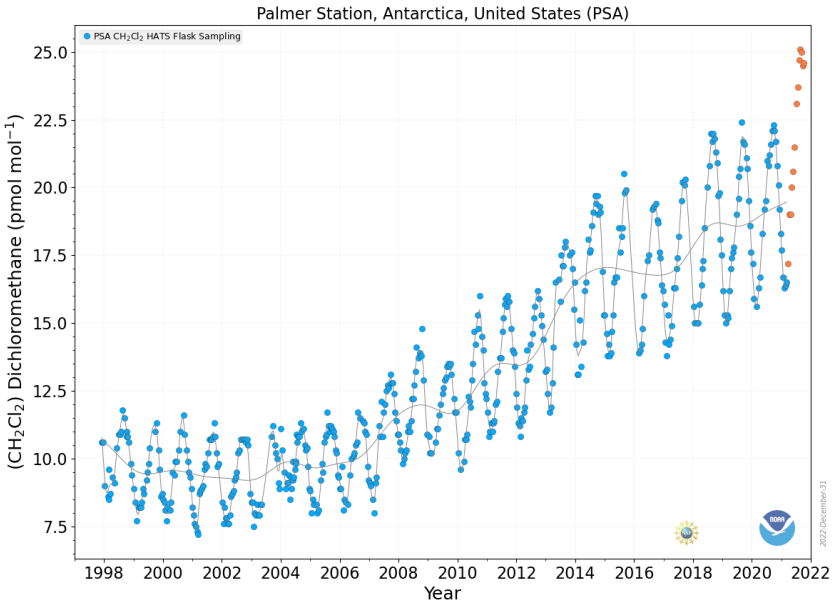

Figure 15. *Dichloromethane (CH_2CL_2) levels at Palmer Station dating back to 1998, one of the Halocarbon and Trace Gases measured at Palmer Station.*

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 Division; 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.

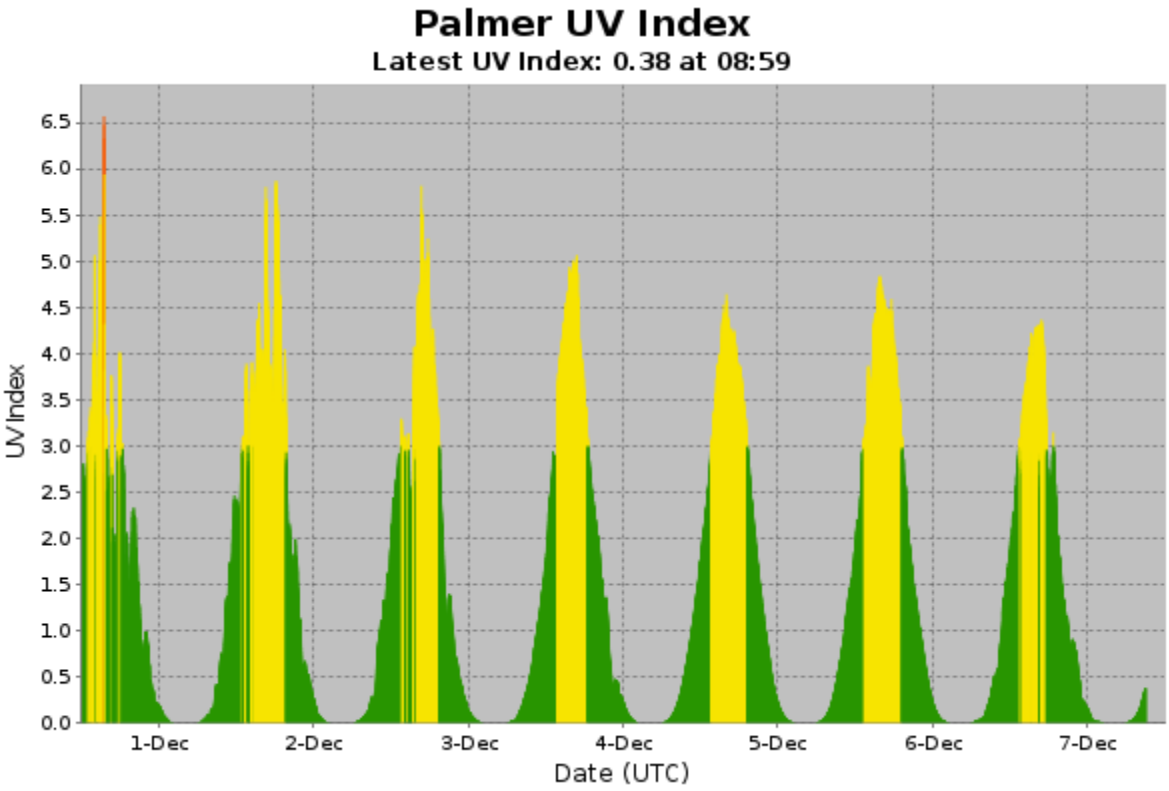

Figure 16. *UV index generated from the GUV-511 radiometer in real time.*

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 bi-weekly SUV-100 UV Absolute Scans were performed on November 3 and December 31 without issues. The quarterly SUV-100 UV triple absolute scans were performed on December 17 without issues. The highest UV levels for December were reached on December 1 at 6.5 on the UV index.
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.

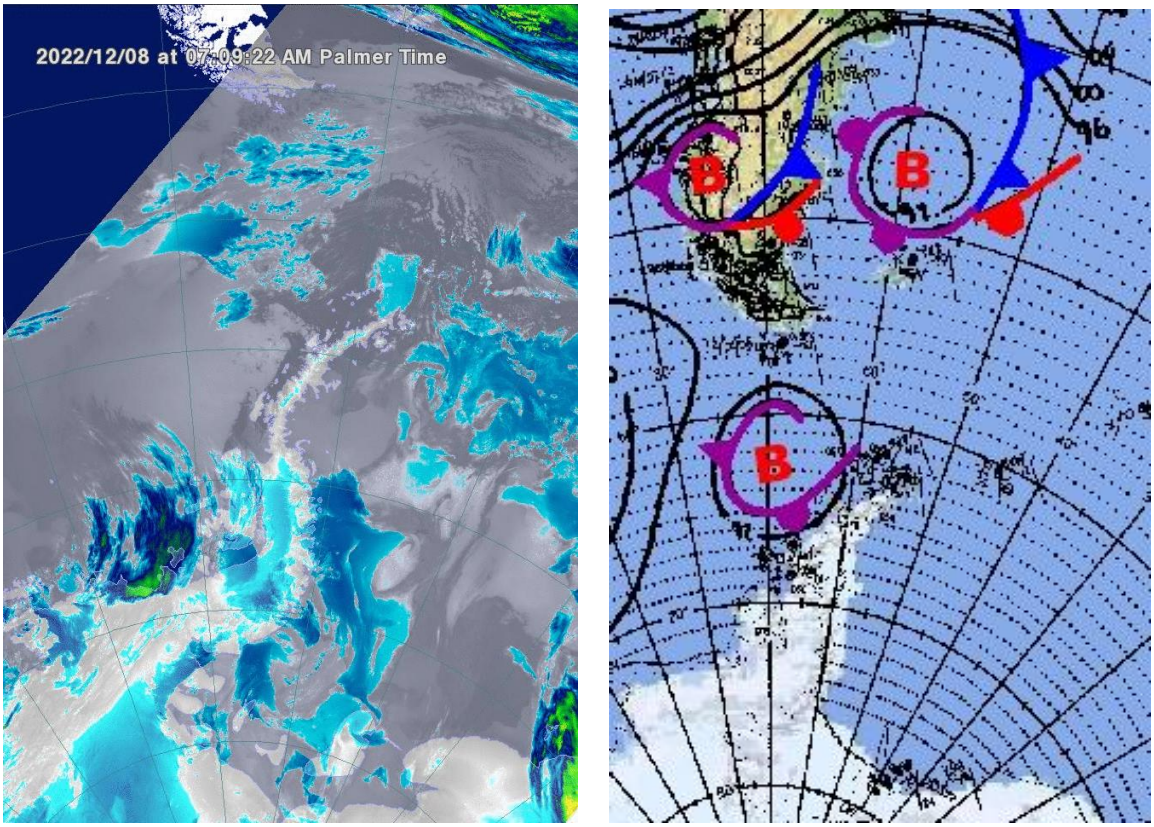

Figure 17. *METOP-3 December-08 satellite pass (left) explained by the Chilean Navy Meteorological Map (right).*

The imagery was checked daily. Both the METOP and NOAA satellite passes were captured normally.

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 operated consistently throughout the month. The lights on the Trimble and Septentrio receivers were all illuminated in the correct pattern and showed no signs of interruption. More information can be found at the following website: 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. Additional details about the treaty and monitoring stations can be found on the CTBTO web site, 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 height 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.

2015	2016	2017	2018	2019	2020	2021	2022
	0.62	2	1.24	1.45	1.6	1.32	x
0.5	0.3	1.92	1.23	1.05	1.44	1.26	x
0	-0.21	1.14	0.86	0.62	1.21	0.88	x
-0.8	-1.1	0	-0.15	0.52	0.51	0.1	x
-1	-1.61	-0.49	-0.98	0	-0.63	-0.5	x
-1.6	-1.59	-1.25	-1.28	-1.17	-1.09	-1.09	-0.86
-1.7	-1.7	-1.52	-1.66	-1.53	-1.36	-1.39	-1.3
-1.8	-1.66	-1.67	-1.62	-1.68	-1.47	-1.66	-1.3
-1.8	-1.51	-1.75	-1.68	-1.67	-1.63	-1.54	-1.21
-1.71	-1.18	-1.61	-1.49	-1.52	-1.36	-1.12	-1.05
-1.35	-0.91	-1.13	-0.84	-1.15	-0.99	-0.3	-0.43
-0.57	0.07	0.04	0.07	-0.04	0.09	-0.27	0.99
						only includes until 17 of dec	

Figure 18. *Water temperature in Celsius at the Palmer pier for the last seven years*

Observations of sea ice around station were made daily. Due the to the pier build there was no sea water monthly average water temperatures recorded for the first five months of 2022.

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 19. *Charcot Island ice free, December 29 2022.*
Source: EOSDIS Worldview

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 once per month to the University of Wisconsin on the first day of each month for archiving and further distribution.

The local weather station (PAWS) operated well throughout the month. The Joubins weather station was visited on December 5 and functionality was restored despite significant corrosion on the power cable and antenna. The Wauwermans weather station was attempted on one occasion during December but swell and wave action prohibited a safe landing.

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

Pal Palmer Monthly Met summary for December, 2022

Temperature
Average: 1.6 °C / 34.8 °F
Maximum: 7.3 °C / 45.14 °F on 14 Dec 14:11
Minimum: -3.2 °C / 26.24 °F on 1 Dec 09:14
Air Pressure
Average: 979.9 mb
Maximum: 998.4 mb on 23 Dec 21:59
Minimum: 953.4 mb on 1 Dec 00:00
Wind
Average: 9.8 knots / 11.3 mph
Peak (5 Sec Gust): 55 knots / 63 mph on 16 Dec 02:42 from NNE (23 deg)
Prevailing Direction for Month: NNE
Surface
Total Rainfall: 33.5 mm / 1.32 in

Total Snowfall: 9 cm / 3.5 in
Greatest Depth at Snow Stake: 116.8 cm / 45.6 in
WMO Sea Ice Observation: 1-5 bergs, bergy bits, growlers, and brash ice
Average Sea Surface Temperature: .99 °C / 33.8 °F

December continued our trend of warm temperatures and quick snow melt. Several broad and weak pressure systems brought periods of mild conditions. We returned to average snow levels and average wind speeds for the month. December was the driest month this year with only 33 mm precipitation.

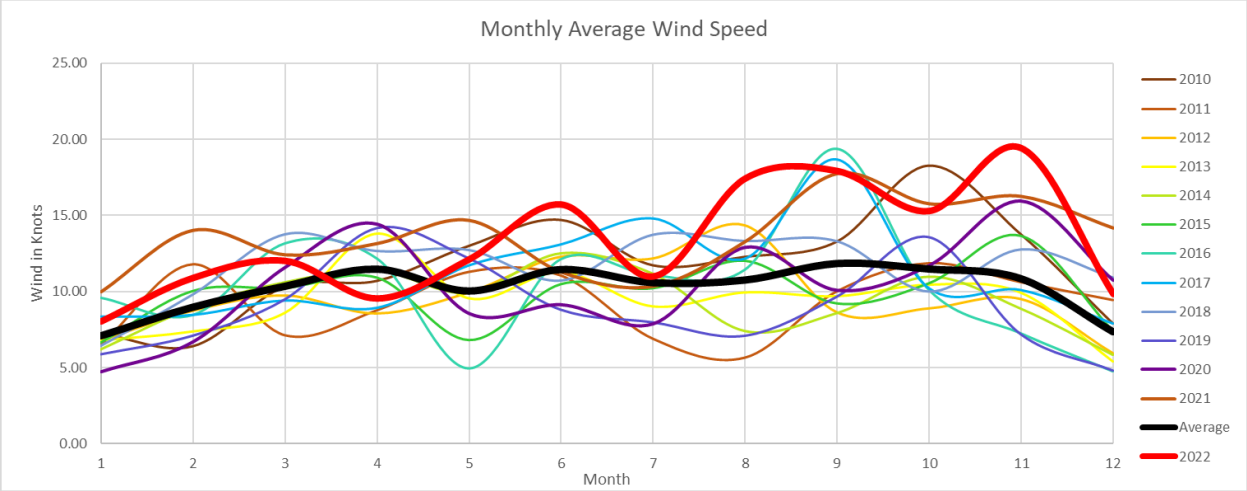

Figure 20. *Monthly average wind speeds for 2022 compared with the last twelve years*

This year was constantly warm, windy, and wet. Average winds were above the twelve year average for all months except for April. The warmer winter conditions led to 2022 being the highest average temperature year since 1997. This graph is the monthly average temperatures plotted with the annual average temperature defining the background color.

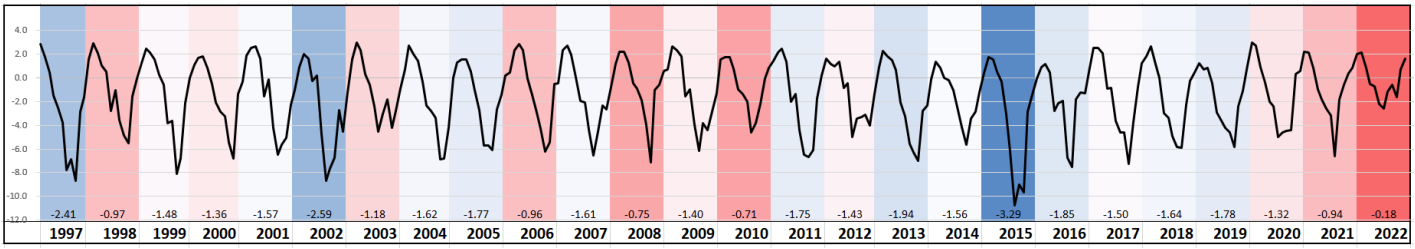

Figure 21. *Monthly average temperatures from 1997 through 2022 plotted with the annual temperature average*

This year was another high precipitation year, although not quite as wet as last year. Here are the monthly melted precipitation totals since 1990.

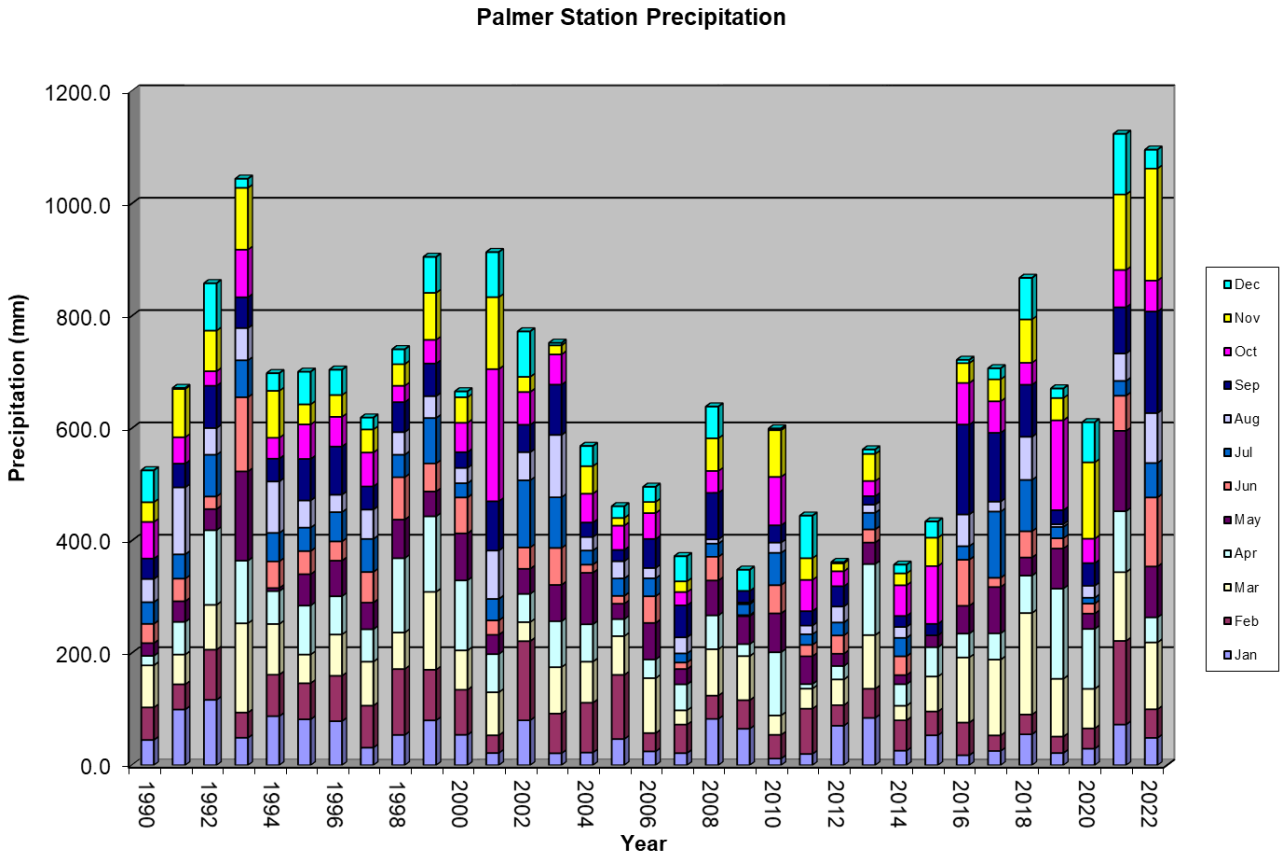

Figure 22. *Monthly precipitation totals in millimeters since 1990*