PALMER STATION MONTHLY SCIENCE REPORT

September 2022

Palmer Station Doctor and Lab Manager collecting and processing blood samples for the NASA study. *Image Credits: Ben Rosen-Filardo.*

NEWS FROM THE LAB

Angela Klemmedson, Winter Laboratory Supervisor

September flew by at Palmer Station as we wrapped up winter research projects and prepared for the incoming summer research groups. Similar to August, this month was rather warm and windy. We experienced many rainy days, rapid declines in accumulated snow levels, and for the third month in a row, record-breaking temperatures. See the Weather Synopsis section of this report for more details.

The krill group completed their fourth and final Time Point, which is described in the next section of this report. Members from this research group presented two lectures this month at our weekly Science Tuesday talks. PI Dr. Kim Bernard presented preliminary results from this season, including those presented in the following section. Julia Fontana presented results from her Masters thesis, which she plans to defend this spring. It was a pleasure having this team of scientists on station this season, and we look forward to their return for Winter 2023.

The NASA study completed its fourth and final Time Point as well. In the photos above, Dr. Shawn Wilson and myself are collecting and processing blood samples that will be sent back to the Johnson Space Center (JSC) in Houston, Texas for analysis. This project, led by PI Dr. Brian Crucian, Immunologist at JSC, uses Palmer Station as a ground analog to study countermeasures for mitigating immunological responses astronauts experience during deep-space missions. We would like to thank all of the study participants we had this season – over half of station was involved in monthly collections of blood, saliva, and hair samples. This study will be expanded upon during the next two winters at Palmer, with the addition of countermeasures such as exercise and supplements.

This science report concludes the Winter 2022 season. In a matter of days, we will welcome the arrival of our ASC counterparts and the first three summer research groups. We plan to have ten days to train our replacements, turnover community and emergency-response duties, and prepare for the busy season ahead. Stay tuned for the summer science reports – Summer 2022-23 will be full of fascinating science, with many new and returning projects.

B-459-P: CAREER: "THE OMNIVORE'S DILEMMA": THE EFFECT OF AUTUMN DIET ON WINTER PHYSIOLOGY AND CONDITION OF JUVENILE ANTARCTIC KRILL

Dr. Kim Bernard, Principal Investigator, College of Earth, Ocean, and Atmospheric Sciences, Oregon State University

Personnel on Station: Kim Bernard, Julia Fontana, and Giulia Wood

Long-Term Feeding Experiment: This month, after conducting our 4th and final time point, we have concluded the long-term feeding experiment for this field season. Through the winter, daily growth rates (DGR, mm day^{-1}) increased significantly for those krill that were supplemented with either the copepods (Figure 1.B), diatoms (Figure 1.C), or a mix of both food sources (Figure 1.D). In contrast, DGR of krill that were not supplemented with addition food remained negative and

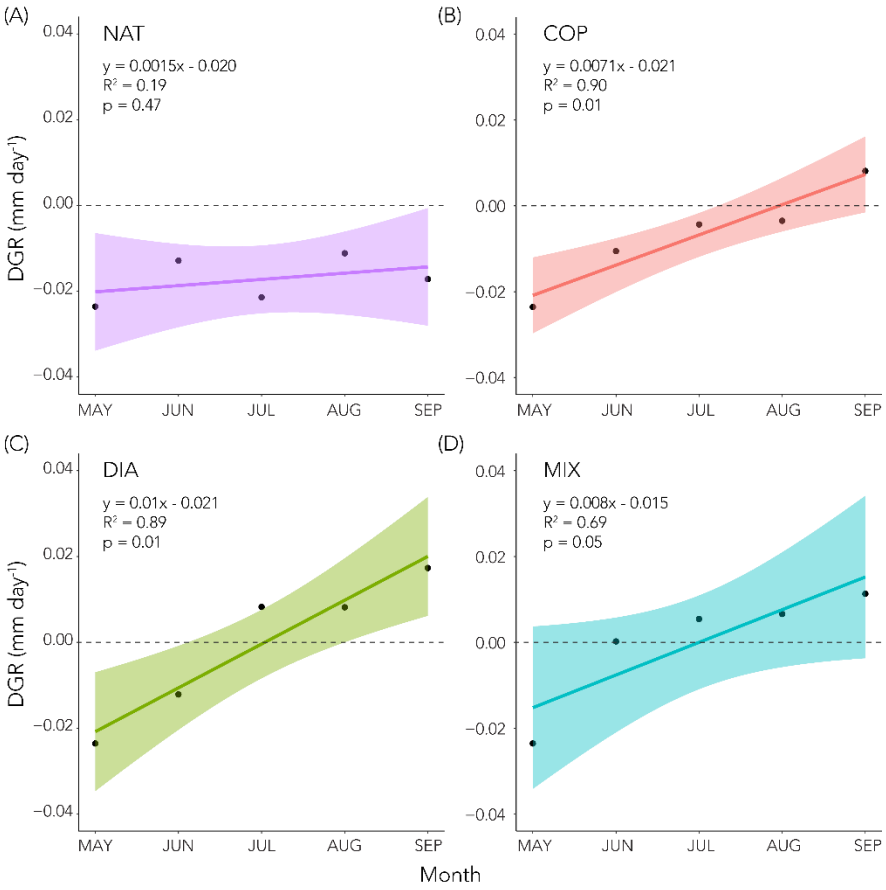

Figure 1. *Mean daily growth rates, DGR (mm day^{-1}), of krill through the winter in (A) the tank not supplemented with additional food (NAT), (B) the tank supplemented with copepods (COP), (C) the tank supplemented with diatoms (DIA), and (D) the tank supplemented with a mix of both diatoms and copepods (MIX). Linear regression equations are provided for each, as are the R^2 and p values.*

there was no significant increase in growth by September (Figure 1.A). This finding supports our previous estimates of the theoretical growth potential of juvenile krill in the winter, which was positive if krill encountered high food concentrations, but remained negative if food concentrations were low (Bernard *et al.*, 2022). It is interesting to note that DGR of krill in the COP tank remained negative until September, where growth was positive (Figure 1.B). In comparison, DGR of krill in the DIA and MIX tanks increased to positive values as early as July (Figure 1.C-D). One possible cause for this difference is that diatoms provide krill with polyunsaturated fatty acids (PUFAs) that krill use for growth, while copepods provide krill with triacylglycerols (TAGs), which they use for

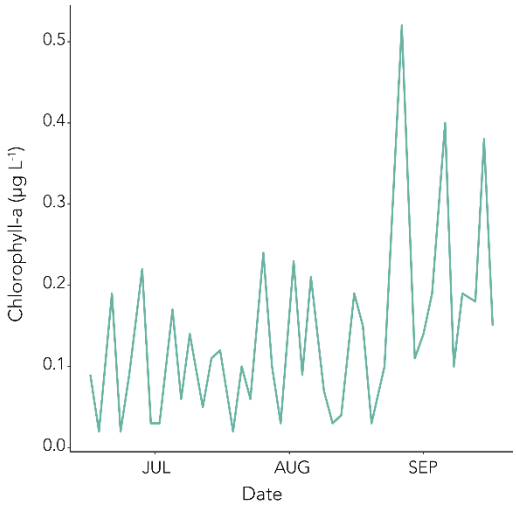

Figure 2. *Chlorophyll-a concentrations (µg L^{-1}) of seawater intake.*

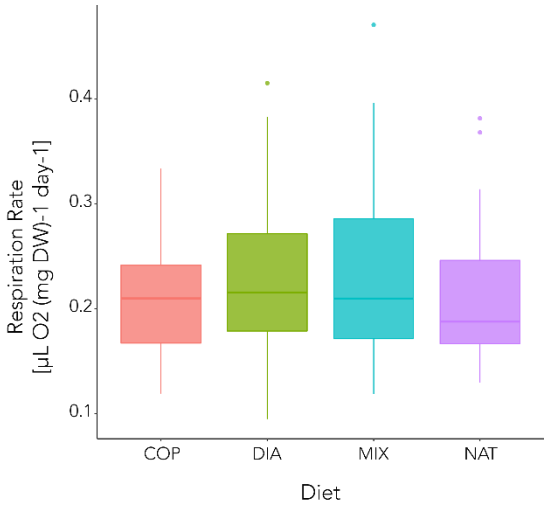

Figure 3. *Mean respiration rate [µL O^2 (mg DW)$^{-1}$ day^{-1}] of krill in each tank.*

energy storage. The fact that the krill in the COP tank shifted from negative to positive growth in September is likely due to the elevated phytoplankton concentrations (likely dominated by diatoms) observed in that month (Figure 2).

Respiration rates of juvenile krill throughout the winter were not significantly affected by diet ($F_{(4,17)}$ = p > 0.05; Figure 3). In addition to our regular time points, we included a respiration rate experiment mid-way between time points 3 and 4. Although we did observe significant variability in respiration rates between some of the time points (see previous monthly reports), a linear regression of mean respiration rate over time indicated that there was no significant linear trend through the period examined ($F_{(1,14)}$ = 1.051; R2 = 0.003; p = 0.32).

***In Situ* Growth Rates of Juvenile Krill:** We have analyzed the growth rate data collected during the June research cruise down the western Antarctic Peninsula (wAP). Juvenile krill in the Gerlache Strait showed negative growth in June, while those over Marguerite Trough exhibited positive growth (Figure 4). This is an important finding because it highlights the importance of the southern wAP as a key overwintering ground for young krill.

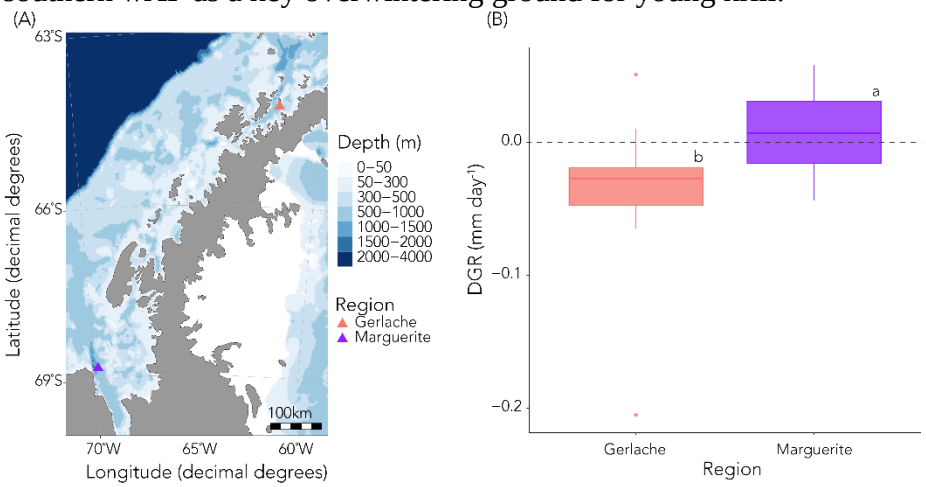

Figure 4. *(A) Map of the western Antarctic Peninsula showing locations where juvenile krill were collected for growth rate experiments in June. (B) Mean daily growth rates (DGR, mm day^{-1}) of juvenile krill in the Gerlache Strait and Marguerite Trough in June, 2022.*

Looking Ahead: This is our final month at Palmer Station and we will be departing on the ARSV *Laurence M. Gould* on October 16th. All remaining samples will be shipped north to our home laboratory at Oregon State University for further analyses.

RESEARCH ASSOCIATE MONTHLY REPORT
September 2022
Ben Rosen-Filardo

A sunny afternoon on the glacier. *Image credit: Ben Rosen-Filardo*

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.

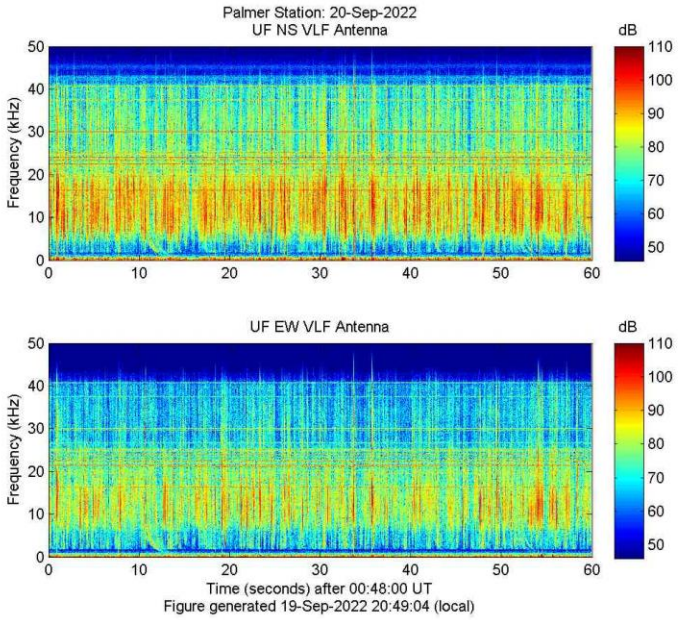

Figure 5. *Real-Time broadband VLF Spectrogram from Palmer Station, Antarctica.*

Both the Extremely Low Frequency and Very Low Frequency systems operated well this month. 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.

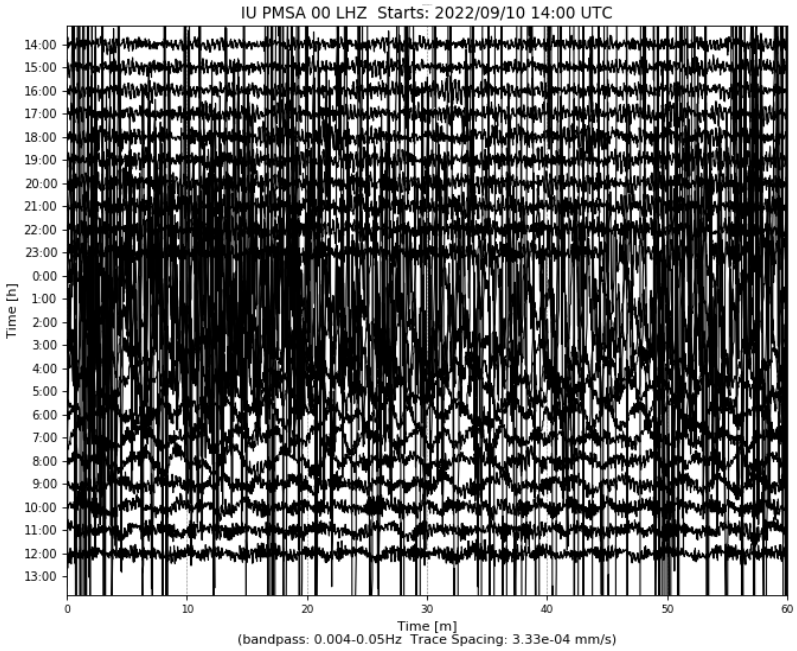

Figure 6. *Two earthquakes occurring on September 10, 2022 in Indonesia and Papua New Guinea.*

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.

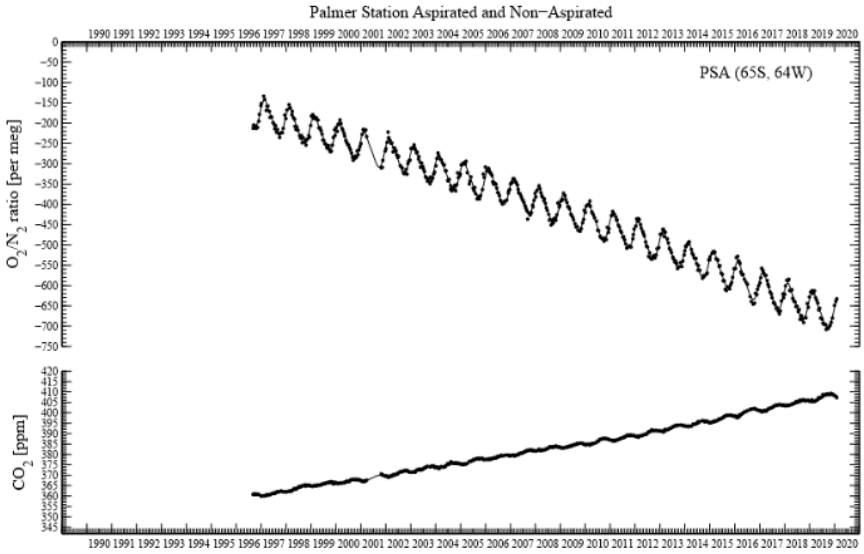

Figure 7. *Historical plot of* $\boldsymbol{O_2/N_2}$ *ratio per meg and* $\boldsymbol{CO_2}$ *ppm updated on July 29, 2020.*

Air samples were collected on August 31 and September 14. 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 September 5, September 12, September 22, and September 27 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/.

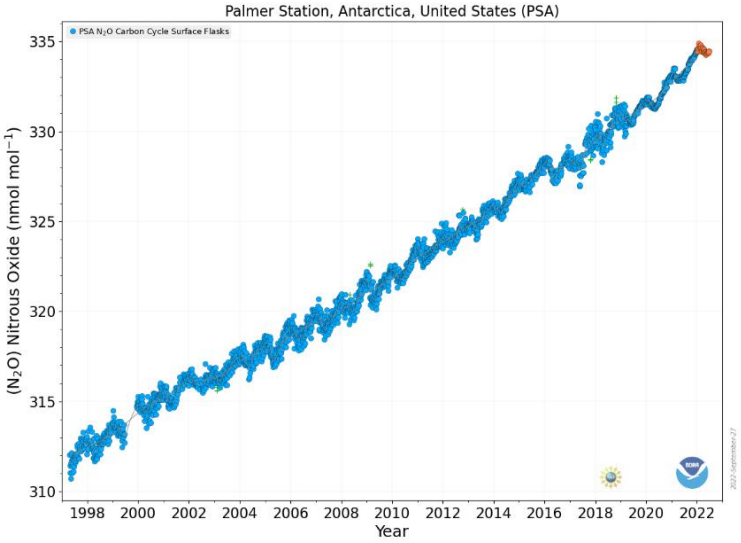

Figure 8. *Nitrous Oxide (N_2O) levels at Palmer Station dating back to 1997. Orange dots are preliminary data.*

Halocarbons and other Atmospheric Trace Species (HATS) samples were collected on September 8 and September 24 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.

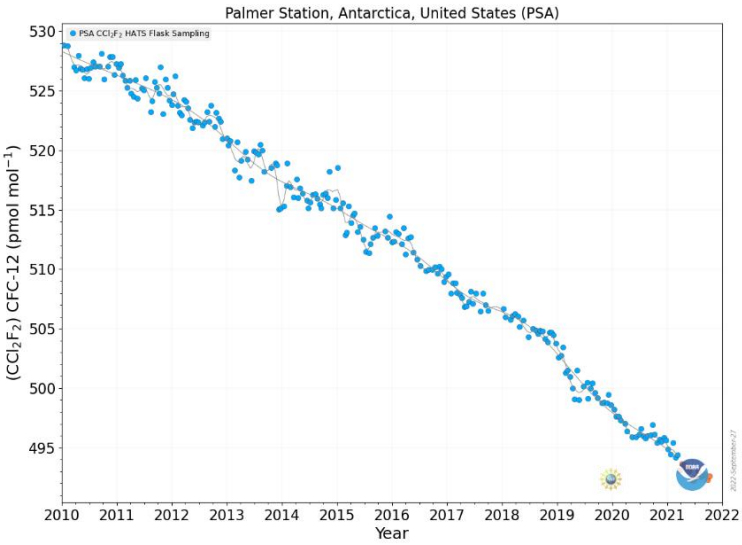

Figure 9. *CFC-12 (CCl_2F_2) levels at Palmer Station dating back to 1998, one of the Halocarbon and Trace Gases measured at Palmer Station.*

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.

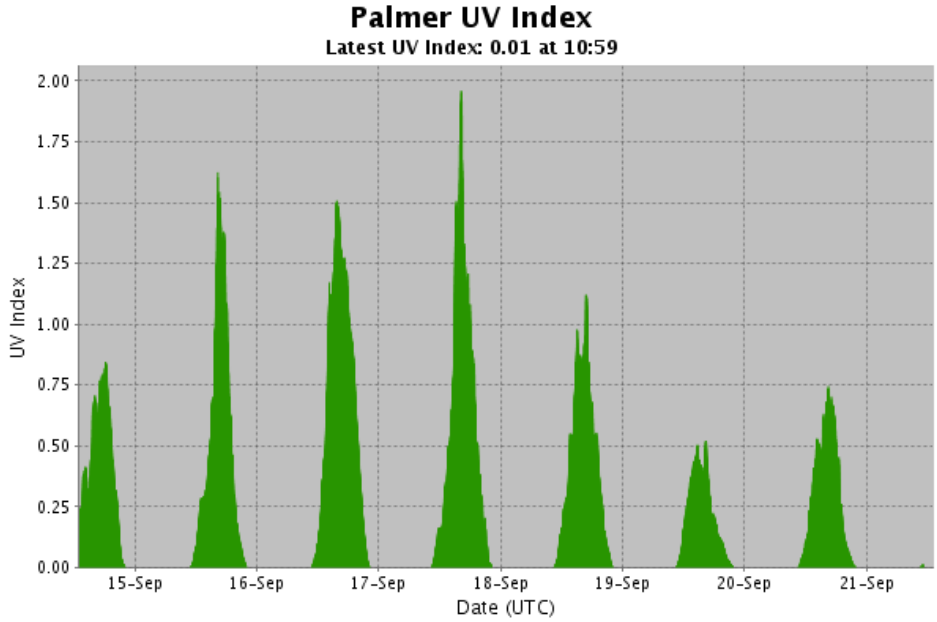

Figure 10. *UV index generated from the GUV-511 radiometer in real time.*

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 September 10 and September 26 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.

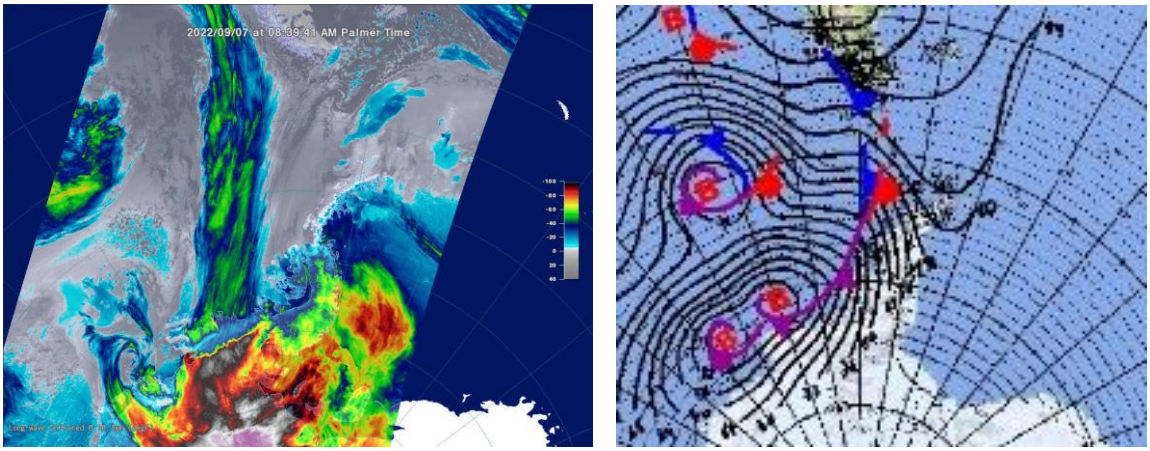

Figure 11. *NOAA-19 Sep-7 satellite pass (left) explained by the Chilean Navy Meteorological Map (right).*

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. On September 7 and September 16, the Trimble R7 roving receiver was used to perform a survey of the glacier flag lines. 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.

Research Associate performing a GPS survey of the glacier flag lines. *Image credit: Nerissa Fisher.*

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.

Observations of sea ice around station were made daily. 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/.

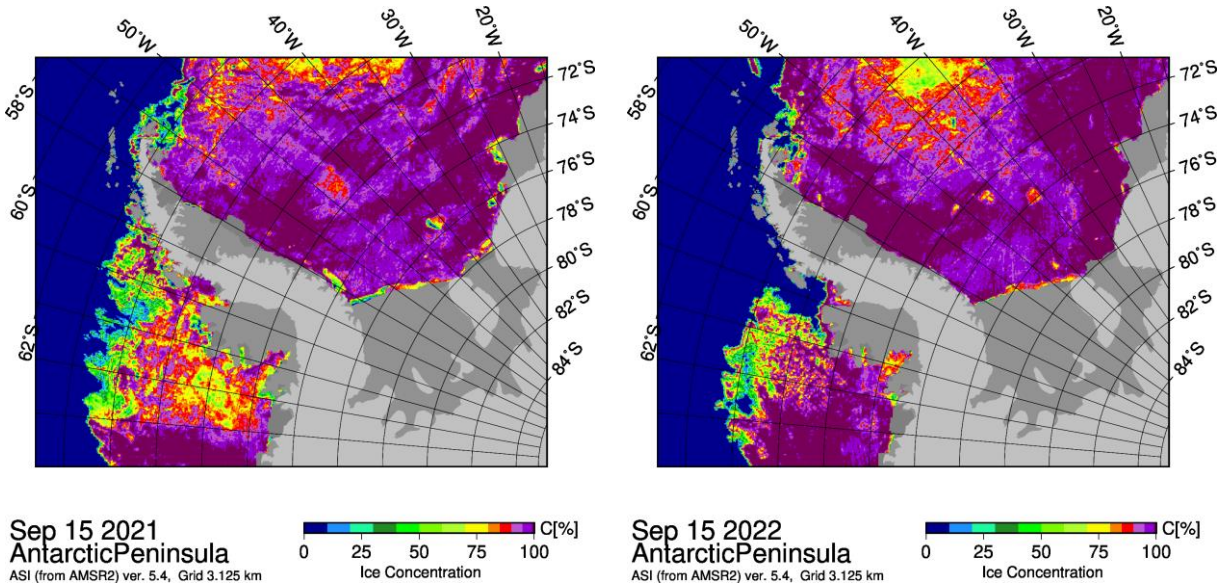

Figure 12. *Sea ice concentration near the Antarctic Peninsula, September 2021 vs. September 2022. Source: University of Bremen*

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. All three remote AWS sites require maintenance so their functionality this season were sporadic at best. One minute weather data is archived on the AMRC website: http://amrc.ssec.wisc.edu/data/ftp/pub/palmer/.

Monthly Weather Synopsis

Like July and August, September 2022 experienced record-breaking temperatures. This was the warmest September on record (1996 – present), with an average temperature of 31°F. In addition, September's minimum temperature of 23°F was the highest on record (1989 – present). The sea surface temperature also broke a September record (2015 – present), with an average temperature of -1.2°C / 29°F. Lastly, the September rainfall record was broken (1990 – present), with 7 inches of melted precipitation.

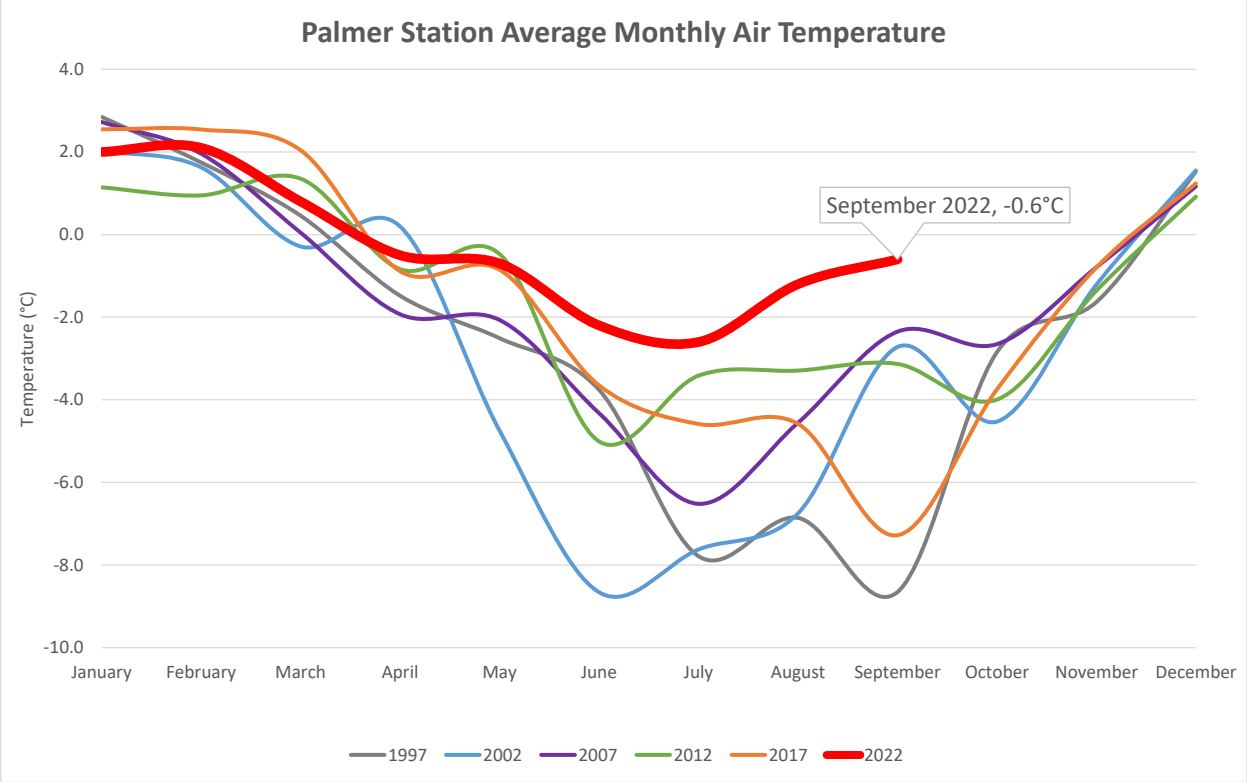

Figure 13. *Palmer Station average monthly air temperature, 1997-present.*

Palmer Monthly Met summary for September, 2022

Temperature
Average: -.6 °C / 30.9 °F
Maximum: 3.6 °C / 38.48 °F on 21 Sep 14:45
Minimum: -5.2 °C / 22.64 °F on 4 Sep 01:51
Air Pressure
Average: 981.2 mb
Maximum: 1008.4 mb on 19 Sep 07:10
Minimum: 952 mb on 5 Sep 18:56
Wind
Average: 17.9 knots / 20.6 mph
Peak (5 Sec Gust): 66 knots / 76 mph on 21 Sep 20:34 from NNE (27 deg)
Prevailing Direction for Month: NNE
Surface
Total Rainfall: 180.8 mm / 7.12 in
Total Snowfall: 29 cm / 11.3 in
Greatest Depth at Snow Stake: 124 cm / 48.4 in
WMO Sea Ice Observation: 1-5 bergs, bergy bits, growlers, pancake ice, and brash ice
Average Sea Surface Temperature: -1.21 °C / 29.8 °F