PALMER STATION MONTHLY SCIENCE REPORT

June 2023

Sunset over Arthur Harbor, taken on one of the shortest days of the year. *Image credit: Angela Klemmedson*

NEWS FROM THE LAB

Angela Klemmedson, Winter Laboratory Supervisor

Happy belated Midwinter from Palmer Station! During the month of June we said goodbye to the B-036-P (O'Brien) group and welcomed the B-459-P (Bernard) group to our over-wintering team. Before the O'Brien group left Palmer Station on June 22, they completed their final, and most successful, four-day fishing cruise and returned to station to finish their hypoxia experiments. See the next section of this report for more details. Following the final O'Brien fishing cruise, the Bernard group accompanied the B-038-L (Huckstadt) group for a 16-day cruise, in which the two groups successfully caught juvenile Antarctic krill and tagged crabeater seals, respectively.

The day after the R/V LAURENCE M. GOULD departed Palmer, the R/V NATHANIEL B. PALMER made an overnight portcall to deliver two new generators, on their way to Punta Arenas from Australia. Following the departure of the R/V NATHANIEL B. PALMER, Palmer Station celebrated Midwinter on June 24 with a delicious feast. We are now officially wintering over until the R/V LAURENCE M. GOULD returns in October.

Since the X-597-P (Crucian) time points are spaced approximately every month and a half, we did not complete a NASA time point in June. However, Palmer lab staff used the time between sample collection to work on PCR analysis and DNA sequencing of saliva samples. This year, the NASA study has increased testing measures of saliva to investigate the reactivation of latent viruses in response to the immune dysregulation associated with over-wintering.

For the majority of the month of June, Palmer experienced less than four hours of (indirect) daylight each day. With the short days came incredible, drawn-out sunrises and sunsets. We have been fortunate to have amazing weather, so that we can enjoy these limited hours of daylight. In June, Palmer experienced much less rainfall and wind than the previous months. We also reached lower temperatures than were reached last winter. See the meteorology section of this report for more details.

Palmer Station 2023 Winterovers celebrating Midwinter with a feast. *Image credit: Tim Lynch*

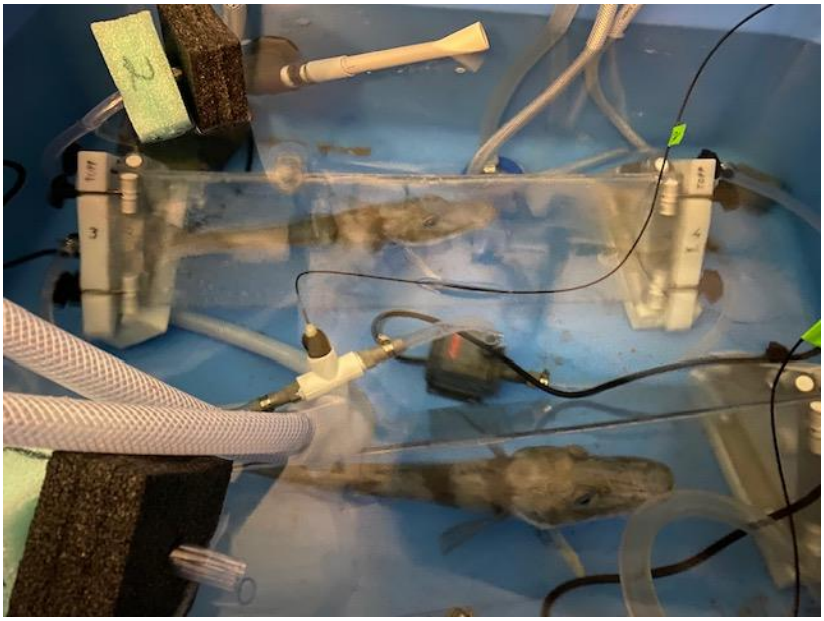
B-036-P: ANT LIA: HYPOXIA TOLERANCE IN NOTOTHENIOID FISHES

Dr. Kristin O'Brien, Principal Investigator, Institute of Arctic Biology, University of Alaska Fairbanks; Dr. Yangfan Zhang, Senior Personnel, Harvard University

Personnel on station: Dr. Kristin O'Brien (UAF), Dr. Yangfan Zhang (Harvard University), Augustus Snyder (UAF), Noelle Picard (UAF), Danae Paredes (Universidad Austral de Chile), and Christian Bolton (UAF)

Christian Bolton, Noelle Picard and Kristin O'Brien participated in the third and final fishing trip of the season on the R/V LAURENCE M. GOULD from May 31 – June 3, while Danae Paredes, Gus Snyder and Yangfan Zhang remained at Palmer Station to conduct experiments. In total, 30 trawls were conducted in north Dallmann Bay and off the southwestern shore of Low Island, resulting in a catch of 102 fishes, including *Notothenia coriiceps, Gobionotothen gibberifrons, Chaenocephalus aceratus* and *Pseudochaenichthys georgianus*.

During June, all measurements of the hypoxia tolerance of the hemoglobinless icefishes *P. georgianus* and *C. aceratus* and red-blooded species *N. coriiceps* and *G. gibberifrons* were completed. Data collected included the minimum oxygen level required to maintain standard metabolic rate (O2crit), the incipient lethal oxygen saturation (ILOS), and accumulation of oxygen deficit (AOD). All four species were also acclimated to hypoxia for 48 hours and tissues collected for biochemical and molecular analyses at our home institution to determine the underlying



Chaenocephalus aceratus **in respirometer tanks used to measure hypoxia tolerance.** *Image credit: Kristin O'Brien*

molecular mechanisms contributing to hypoxia tolerance. *N. coriiceps* were also acclimated to hypoxia for five days and tissues harvested. Tissues from normoxic controls, in which animals were handled similarly to the hypoxic animals but held at normoxic dissolved oxygen levels, were also collected from all four species. Nuclei were isolated from livers to quantify levels of the master transcriptional regulator oxygen homeostasis, HIF-1α, and gills were preserved for quantifying changes in structure.

We are grateful for the outstanding support from the staff at Palmer Station, the Masters and crew of the R/V LAURENCE M. GOULD, and other ASC staff members, especially, Jamee Johnson, who enabled us to successfully complete all of our planned experiments this season. Thank you!

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, Rachel Kaplan, and Abby Tomita

Operations and Activities: After spending a total of 26 days aboard the R/V LAURENCE M. GOULD on two separate cruises, we are now back at Palmer Station and have begun the long-term feeding experiment. During our second cruise, we collected ~ 20,000 juvenile krill and ~10,000 adults. This field season, we will be running a long-term feeding experiment that includes both juveniles and adult krill. Two of the large circular tanks in the Aquarium Room will contain juveniles that will be fed a diet of either diatoms or copepods (depending on the tank) and two will contain adult krill that will also be fed either diatoms or copepods. The supplemental food will be provided three times a week. In the last week of June, we conducted the first growth rate experiment, which represents Time Point 0 of our long-term feeding experiment. In addition, we collected krill from each tank to measure protein, lipids, caloric content, carbon and nitrogen, and stable isotopes. These also represent Time Point 0 of the long-term feeding experiment. During the field season, we will conduct three sets of time points at monthly intervals.

Kim Bernard (*left*) **and Abby Tomita** (*right*) **empty a cooler-full of juvenile krill into an Xactic tank aboard the RV Laurence M. Gould.** *Image credit: Rachel Kaplan*

Looking ahead: Towards the end of July, we will conduct Time Point 1 of the long-term feeding experiment. During this time point, we will conduct a growth rate experiment and will collect krill for measurements of body condition and dietary history. In addition, we will run respiration rate experiments to assess the effect of temperature on winter respiration rates of krill. In preparation for World Krill Day (August 11), we will work on several outreach activities (including a stop-motion animation produced by our team, and an Instagram takeover with the NSF) that will be part of the celebration on August 11.

PALMER STATION
RESEARCH ASSOCIATE MONTHLY REPORT
June 2023
Ben Rosen-Filardo

Happy Pride from Terra Lab! *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.

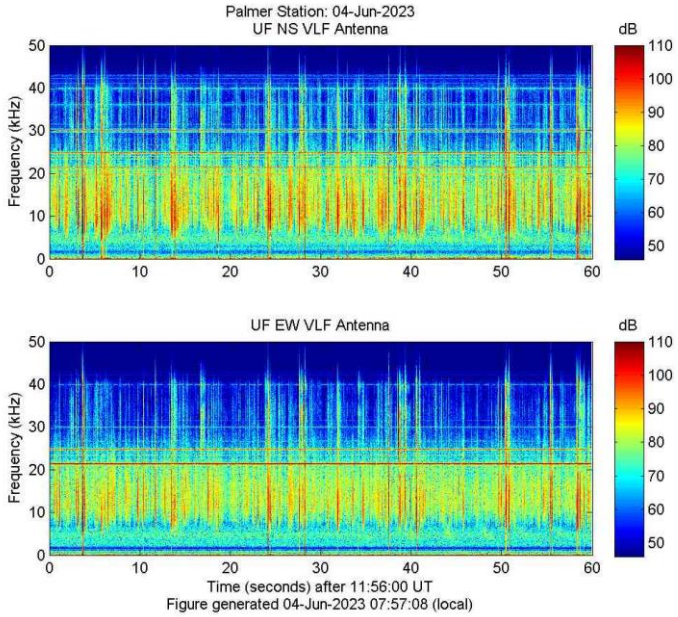


Figure 1. *Real-Time broadband VLF Spectrogram from Palmer Station, Antarctica.*

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 March 27th, 2017 the USAP IT blocked all northbound VPN traffic under a larger umbrella of blocking all northbound encrypted-tunnel traffic. Since that time there has been much discussion, but the magnetometer is still considered a security vulnerability. The Research Associate has been working with the home institution at the University of California, Los Angeles to resolve this issue. As of

September 30th, 2020 at 7:45am local time, the magnetometer was removed from the network. The instrumentation and computer are still operational. Data will continue to be collected and stored locally. The project is preparing to ship the new system that will be compatible with the network down this year. 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.

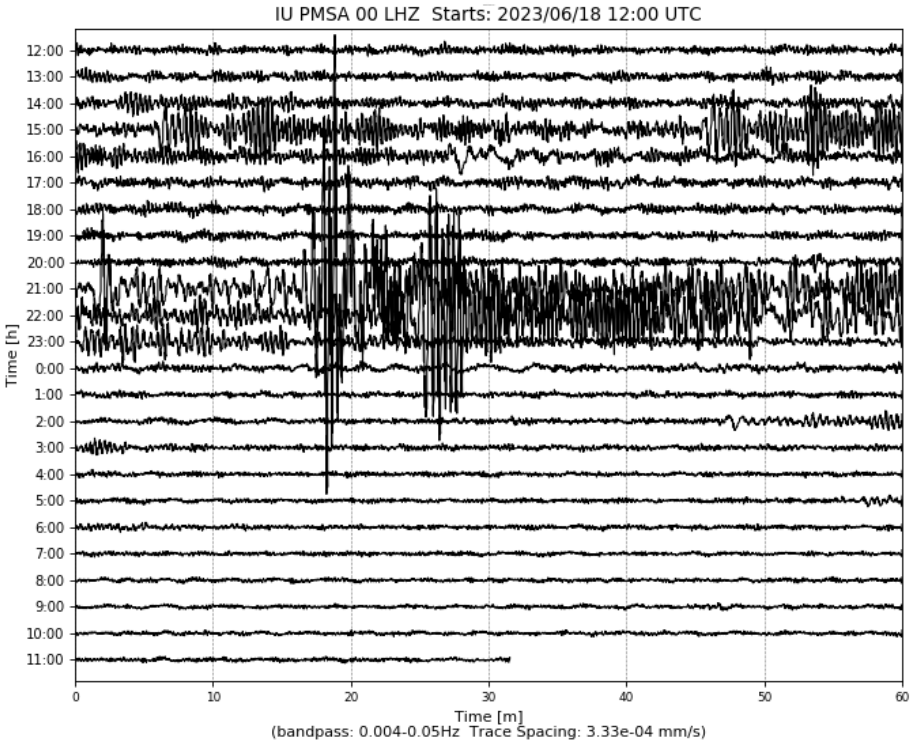


Figure 2. *Two earthquakes on June 18, 2023 as recorded from the Palmer seismic station. The first occurred in the Gulf of California, and the second occurred 1,700 km off the southern coast of South Africa.*

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.

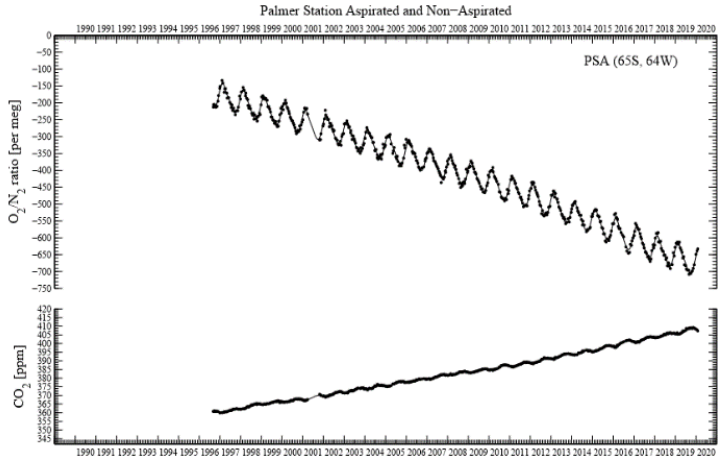


Figure 3. *Historical plot of* $\boldsymbol{O_2/N_2}$ *ratio per meg and* $\boldsymbol{CO_2}$ *ppm updated on July 29, 2020.*

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

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

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

The NOAA ESRL Carbon Cycle Greenhouse Gases (CCGG) group makes ongoing discrete measurements to document the spatial and temporal distributions of carbon-cycle gases and provide essential constraints to our understanding of the global carbon cycle. The Halocarbons and other Atmospheric Trace Species (HATS) group quantifies the distributions and magnitudes of the sources and sinks for atmospheric nitrous oxide (N_2O) and halogen containing compounds. The Research Associate collects weekly air samples for the CCGG group and fortnightly samples for the HATS group. Wind must be between 5 and 15 knots and consistently blow from one sector with no people, equipment, or boats upwind of the sampling location.

Carbon Cycle Greenhouse Gases (CCGG) samples were collected on June 6, June 13, June 19, and June 28 during favorable wind conditions. More information and data for the Carbon Cycle group can be found at: https://gml.noaa.gov/ccgg/.

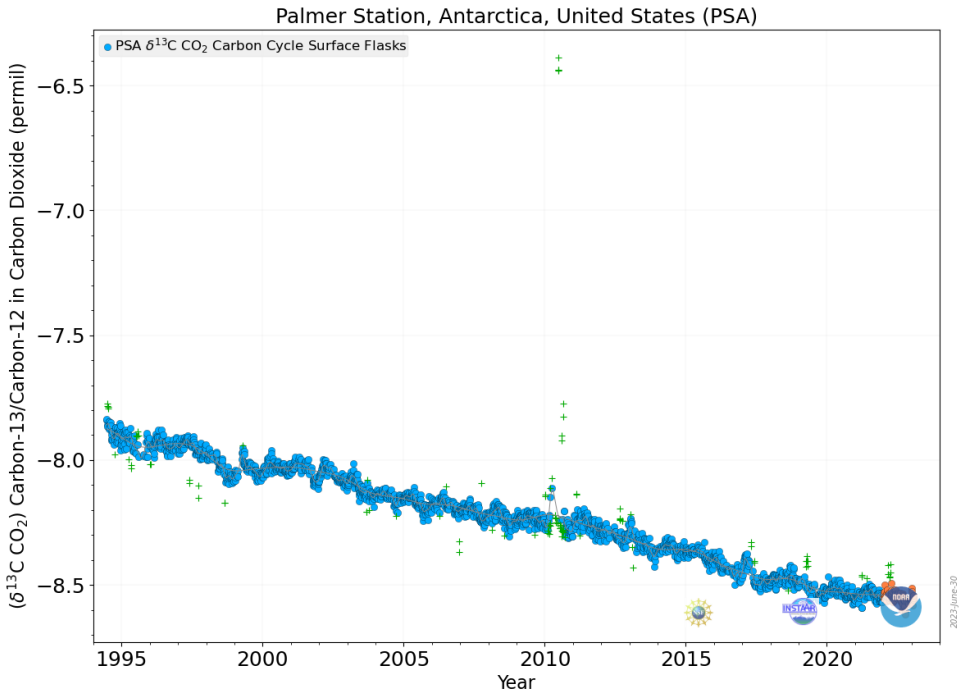


Figure 4. *Carbon-13/Carbon-12 in Carbon Dioxide ($\delta^{13}C$ CO_2) levels at Palmer Station dating back to 1994. Orange dots are preliminary data.*

Halocarbons and other Atmospheric Trace Species (HATS) samples were collected on June 9 and June 28 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/

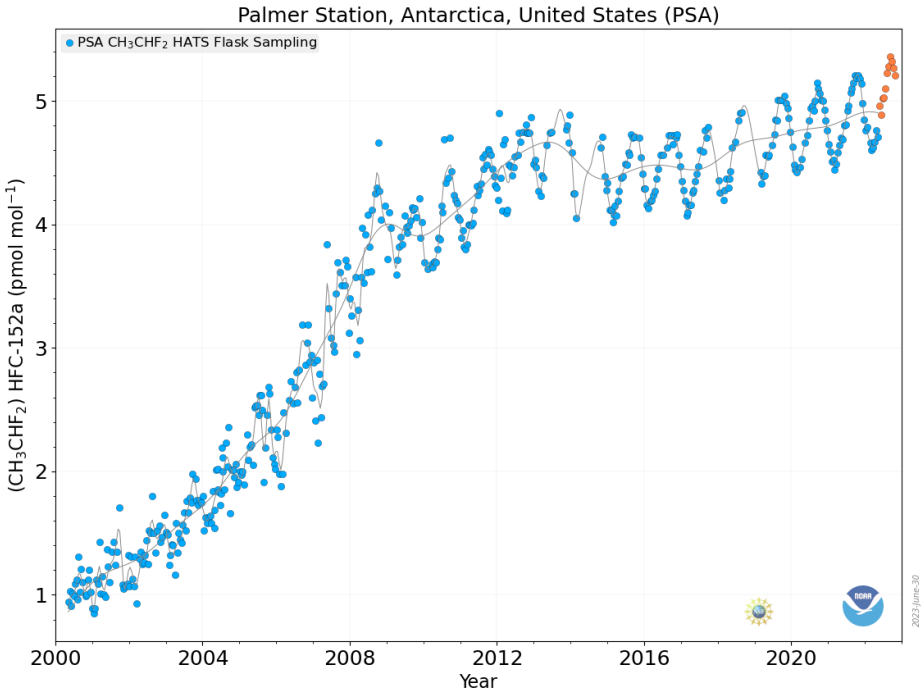


Figure 5. *HFC-152a (CH_3CHF_2) levels at Palmer Station dating back to 2000, one of the Halocarbon and Trace Gases measured at Palmer Station.*

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 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.

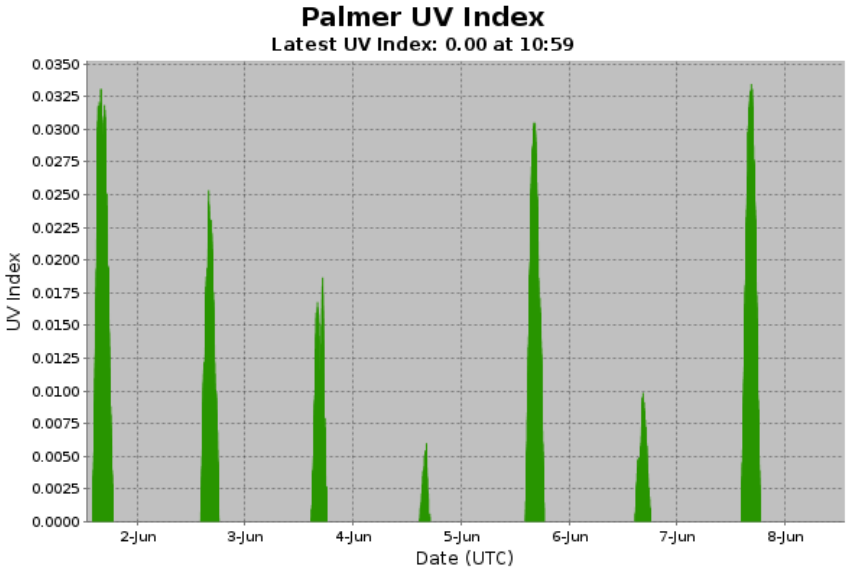


Figure 6. *UV index generated from the GUV-511 radiometer in real time.*

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 June 5 and June 23 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.

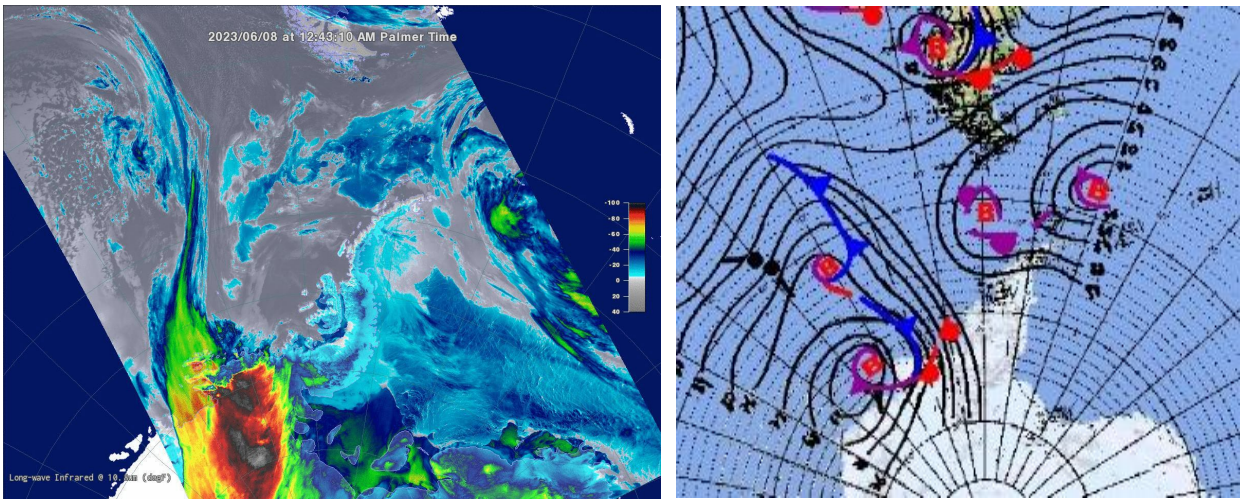


Figure 7. *NOAA-18 June 8 satellite pass (left) explained by the Chilean meteorological chart (right).*

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.

Last month’s antenna issue was discovered to be caused by a faulty antenna splitter. The splitter was removed from the system, and the antenna was connected directly to the Septentrio receiver. As of June 13, this receiver is now fully operational. A new splitter will be arriving on the next boat, at which point the Trimble receiver will be reconnected to the antenna.

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. A Send Sample Request, along with five quarterly archive boxes (2021Q4 – 2022Q4) were sent north on LMG23-05NB. A filter media replacement was performed on June 17.

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 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.

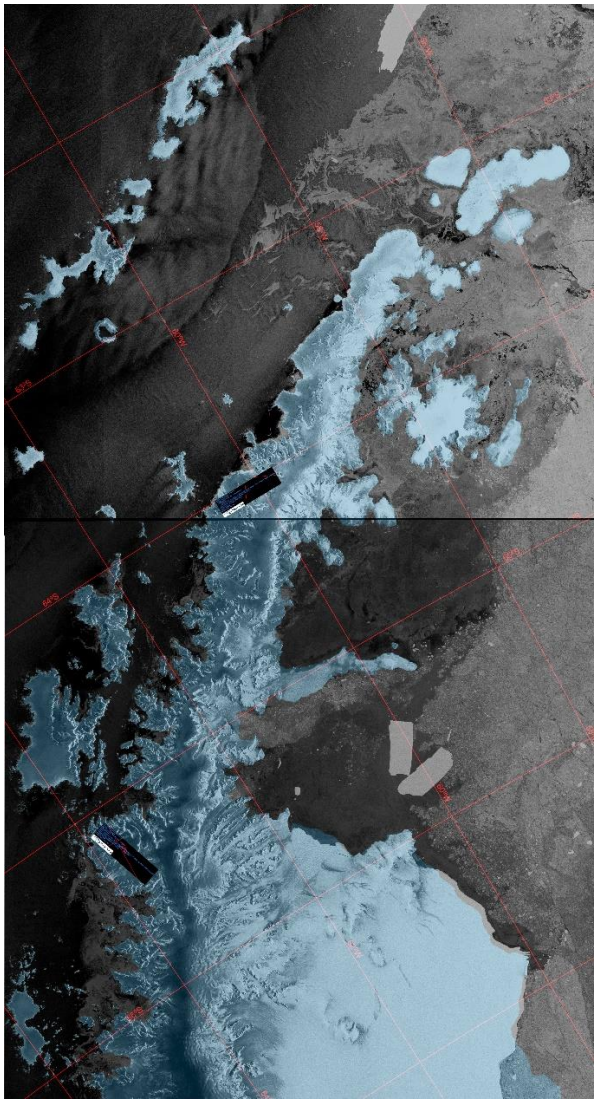


Figure 8. *Sea ice imagery provided to the R/V Laurence M. Gould.*
Source: Composite of Polar View Sentinel-1 images from June 16, 2023.

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.

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

Palmer Monthly Met summary for June, 2023

Temperature
Average: -2.7 °C / 27.1 °F
Maximum: 7 °C / 44.6 °F on 2 Jun 19:38
Minimum: -9.2 °C / 15.44 °F on 23 Jun 03:46
Air Pressure
Average: 989.7 mb
Maximum: 1009.7 mb on 29 Jun 23:05
Minimum: 963.6 mb on 10 Jun 21:57
Wind
Average: 10.4 knots / 12 mph
Peak (5 Sec Gust): 53 knots / 61 mph on 19 Jun 08:28 from NE (35 deg)
Prevailing Direction for Month: NNE
Surface
Total Rainfall: 26.9 mm / 1.06 in
Total Snowfall: 52 cm / 20.3 in
Greatest Depth at Snow Stake: 42.8 cm / 16.7 in
WMO Sea Ice Observation: 1-5 bergs, bergy bits, growlers, brash ice, grease ice, and pancake ice
Average Sea Surface Temperature: -0.7 °C / 30.7 °F

On Jun 23, the air temperature reached -9.2 °C, the coldest since September 2021. Nonetheless, warming trends continue. The high temperature this month was the second highest on record for June (1989-present), at 7.0 °C. (The highest was 7.1 °C in June, 1997.) In addition, June's sea surface temperature was the warmest on record (2005-present), at -0.7 °C.

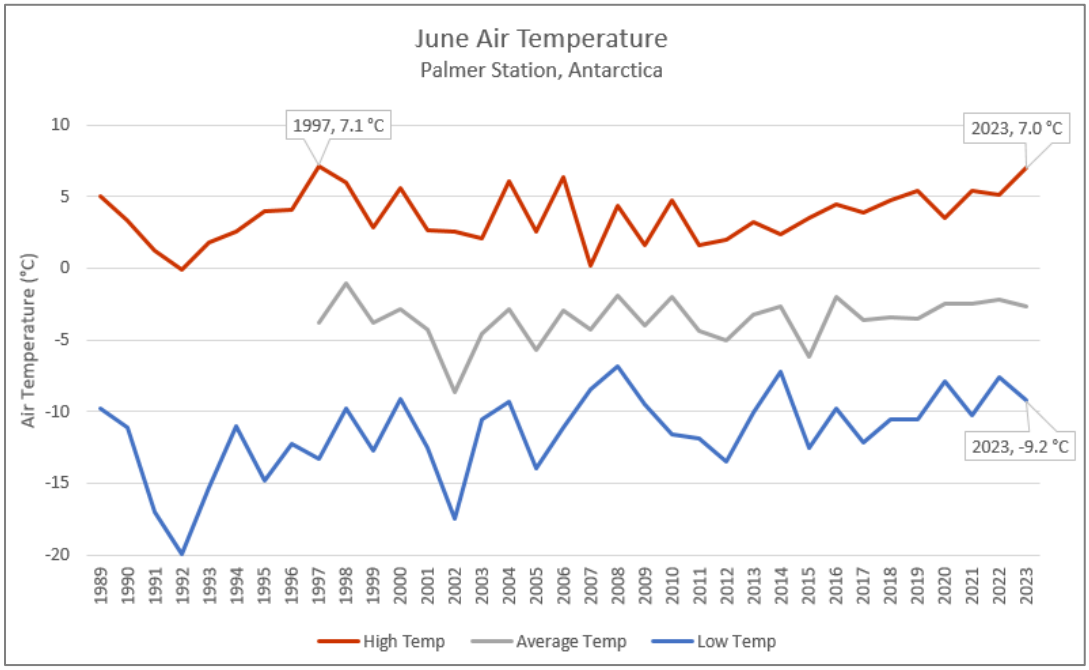


Figure 9. *Palmer Station June air temperature, 1989-present.*