

PALMER STATION MONTHLY SCIENCE REPORT

August 2023



The glacier face at the base of Hero Inlet on a sunny day, August 29, 2023. Image credit: Angela Klemmedson

NEWS FROM THE LAB

Angela Klemmedson, Winter Laboratory Supervisor

August came and went in the blink of an eye, and so much happened in that time. Both B-459-P (Bernard) and X-597-P (Crucian) completed their second to last time points, station celebrated [World Krill Day](#), and we created and submitted three films to the Winter International Film Festival of Antarctica ([WIFFA](#)). Through all of that, grantees and ASC staff, alike, worked to wrap up projects and prepare for the swiftly approaching end of season.

As winter comes to an end and we enter springtime, it is now light for the entire workday (7:30am to 5:30pm) and significantly brighter outside (see Figure 8 showing UV Index on page 10). It is disappointing that another winter passed without the formation of any sea ice in Arthur Harbor. Global news sources have been reporting on the record low sea ice around Antarctica this year, and that trend is present at Palmer as well. What used to be an annual occurrence has not happened since Winter 2021. See the Research Associate section of this report for more information on this topic.

If you are interested in watching Palmer Station's 2023 WIFFA films, you can watch them here: [Ultra Spy: Antarctic Patrol](#), [Washed Up](#), [Small but Mighty](#) (World Krill Day animation created by the Bernard group).



Lab staff, Ben Rosen-Filardo (left photo) and Kimberly Sonderland (right photo) drawing blood from NASA study participants. Image credits: Angela Klemmedson

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: This was a busy month for our team. We conducted four sets of respiration experiments to test the effects of increased seawater temperature on sub-adult krill metabolism (this is part of REU student Abby Tomita’s research), ran our third growth experiment at Time Point 2 (TP2), processed ammonium excretion samples, and collected hundreds of krill for measurements of reproductive development (n=325), carbon:nitrogen ratios (n=40), lipids (n=40), proteins (n=40), caloric content (n=40), and stable isotope analysis (n=40). Our preliminary results indicate that daily growth rates (DGR, mm day^{-1}) have shifted to positive for sub-adult males and females on the diatom diet, while those fed copepods are still shrinking (Figure 1). In contrast, growth rates of juvenile krill remain negligible, regardless of the diet (Figure 1). Overall, growth rates have been significantly higher in krill receiving the diatom diet ($p=0.019$, $F=5.71$, ANOVA). Overall growth rates showed significant variability between time points ($p<0.001$, $F=59.81$, ANOVA), with growth at TP1 and TP2 being significantly

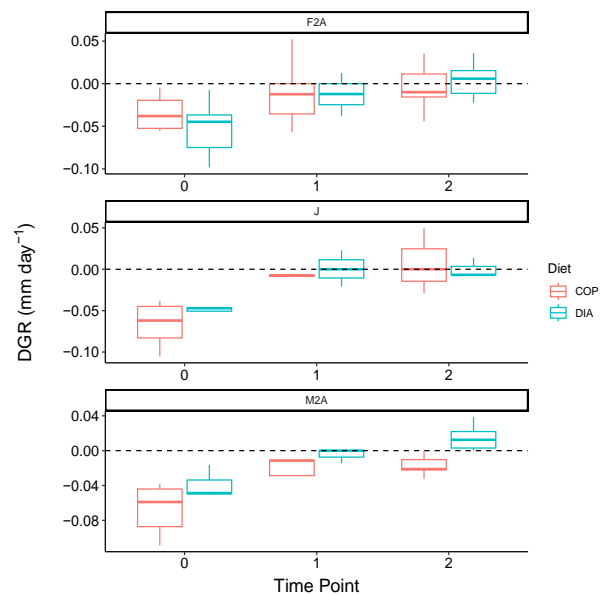


Figure 1. Daily growth rate (DGR, mm day^{-1}) of krill fed either a copepod diet (COP) or a diatom diet (DIA) at time points 0, 1 and 2 for sub-adult females (F2A, top panel), juveniles (J, middle panel), and sub-adult males (M2A, bottom panel). The dashed line in each panel represents zero growth, values below the line indicate shrinking, while values above indicate growth.

higher ($p < 0.05$ for both) than that at TP0 (Tukey HSD). We have seen no overall differences in growth rates by stage ($p = 0.59$, $F = 0.53$, ANOVA).

Results of the four respiration experiments conducted in August indicate a significant linear increase in respiration rate with increasing temperature ($p < 0.05$; Figure 2). Analysis of atomic

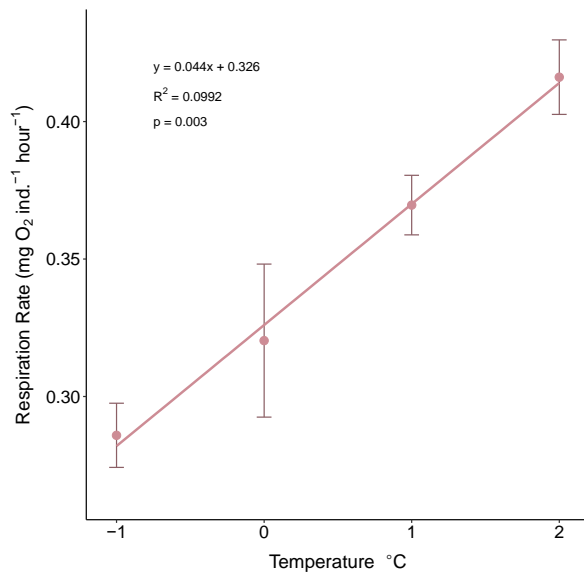


Figure 2. Effect of temperature on respiration by juvenile krill. Points indicate mean values across multiple experiments for each experimental treatment temperature. Error bars are standard error.

O:N ratios (oxygen taken up and nitrogen released, as ammonium) indicated that krill used in the respiration experiments were primarily metabolising lipids (rather than proteins) – O:N ratios averaged 104 (range from 19 – 339).

In addition, August 11th was World Krill Day, and our team contributed through numerous means to global outreach on that day.

Looking ahead: In our final full month on station, we will run four additional respiration experiments to continue assessing the effects of temperature on krill. Towards the end of September, we will conduct Time Point 3 of the long-term feeding experiment. As with the time points before, we will conduct a growth rate experiment and will collect krill for measurements of body condition and dietary history. We will also process protein and ammonium samples prior to departing Palmer Station.

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



Navigating through pancake ice and nilas, August 27, 2023. 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.

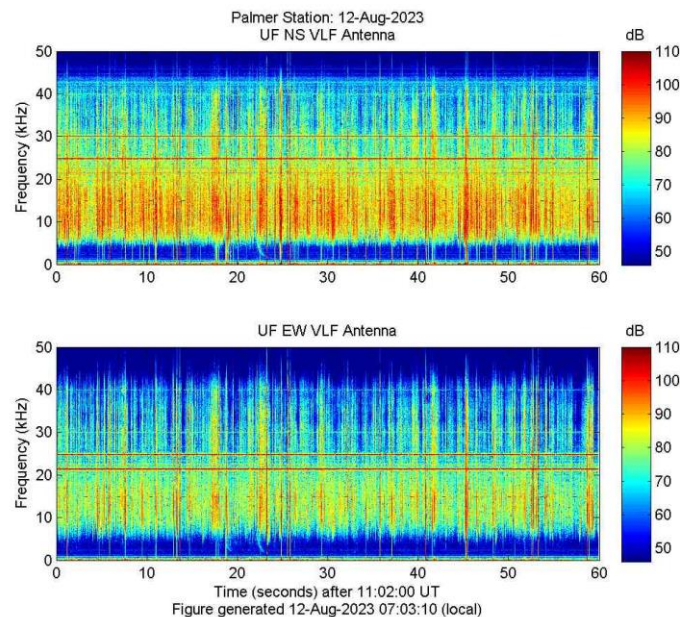


Figure 3. Real-Time broadband VLF Spectrogram from Palmer Station, Antarctica.

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 through South America and into Antarctica. The primary scientific goals are the study of Ultra Low Frequency (ULF) waves and the remote sensing of mass density in the inner magnetosphere during geomagnetically active periods. Palmer's magnetometer is also a conjugate to the Canadian Poste de la Baleine Station, allowing the study of conjugate differences in geomagnetic substorms and general auroral activity.

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

The magnetometer was originally installed at Palmer in 2005, and a replacement installed in April of 2008. In 2017 the project was taken over by Andrew Gerrard. On March 27th, 2017 the USAP IT blocked all northbound VPN traffic under a larger umbrella of blocking all northbound encrypted-tunnel traffic. Since that time there has been much discussion, but the magnetometer is still considered a security vulnerability. The Research Associate has been working with the home institution at the University of California, Los Angeles to resolve this issue. As of September 30th, 2020 at 7:45am local time, the magnetometer was removed from the network. The instrumentation and computer are still operational. Data will continue to be collected and stored locally. A new Raspberry Pi is on its way down to replace the existing BeagleBone computer. Once installed, the Pi will permit the system to connect to the USAP network. 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.

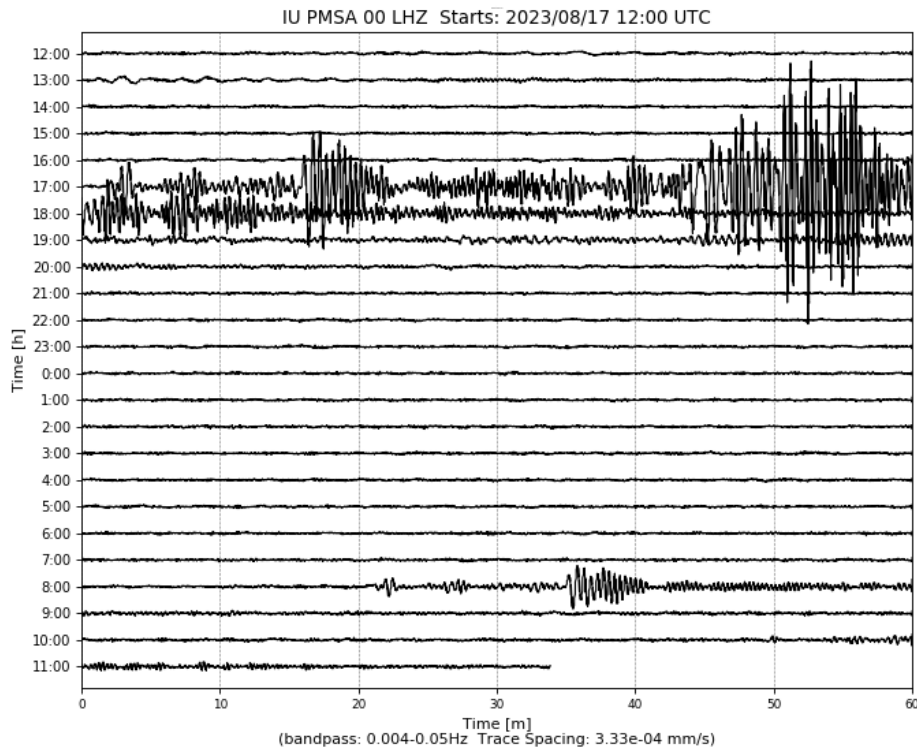


Figure 4. An August 17, 2023 earthquake near Bogota, Colombia, as recorded from the Palmer seismic station.

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 O₂ (detected through changes in O₂/N₂ 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 CO₂ 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 O₂ 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 O₂ 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.

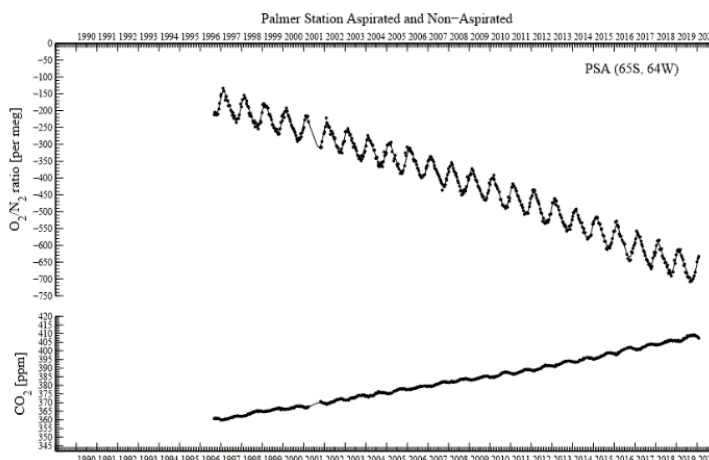


Figure 5. Historical plot of O₂/N₂ ratio per meg and CO₂ ppm updated on July 29, 2020.

Air samples were collected on August 1 and August 22. 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://scrippsco2.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 (N₂O) 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 August 3, August 7, August 15, August 21, and August 28 during favorable wind conditions. More information and data for the Carbon Cycle group can be found at: <https://gml.noaa.gov/ccgg/>.

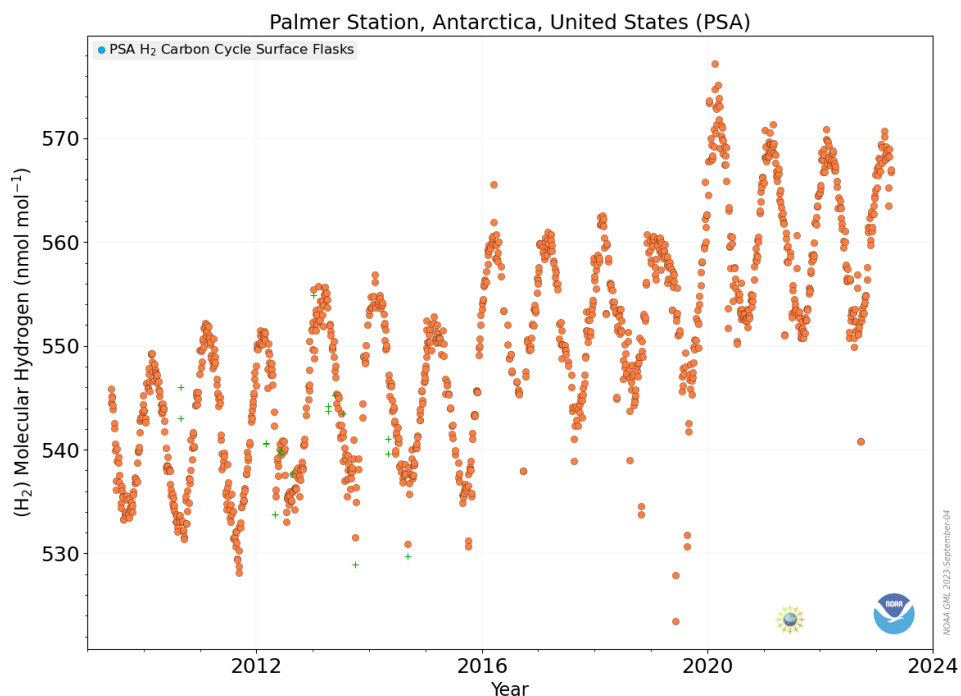


Figure 6. Molecular Hydrogen (H_2) levels at Palmer Station dating back to 2009. Orange dots are preliminary data.

Halocarbons and other Atmospheric Trace Species (HATS) samples were collected on August 12 and August 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/>

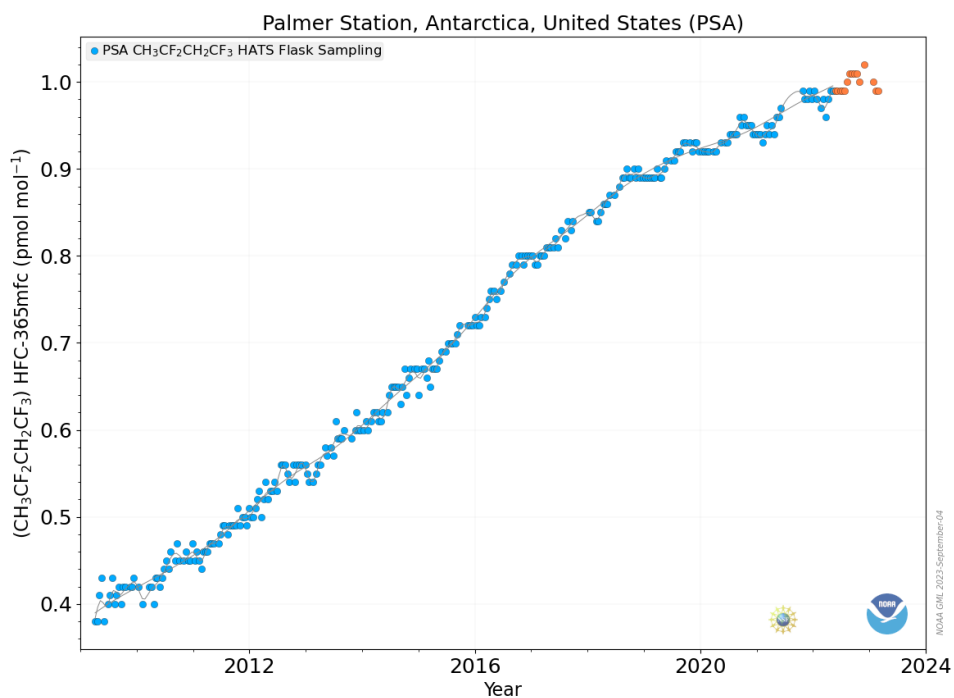


Figure 7. HFC-365mfc ($CH_3CF_2CH_2CF_3$) levels at Palmer Station dating back to 2009, one of the Halocarbon and Trace Gases measured at Palmer Station. Orange dots are preliminary data.

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



Ben Rosen-Filardo, the Palmer Research Associate smiles after a successful double air sample (CCGG & HATS). *Image credit: Kim Sonderland*

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.

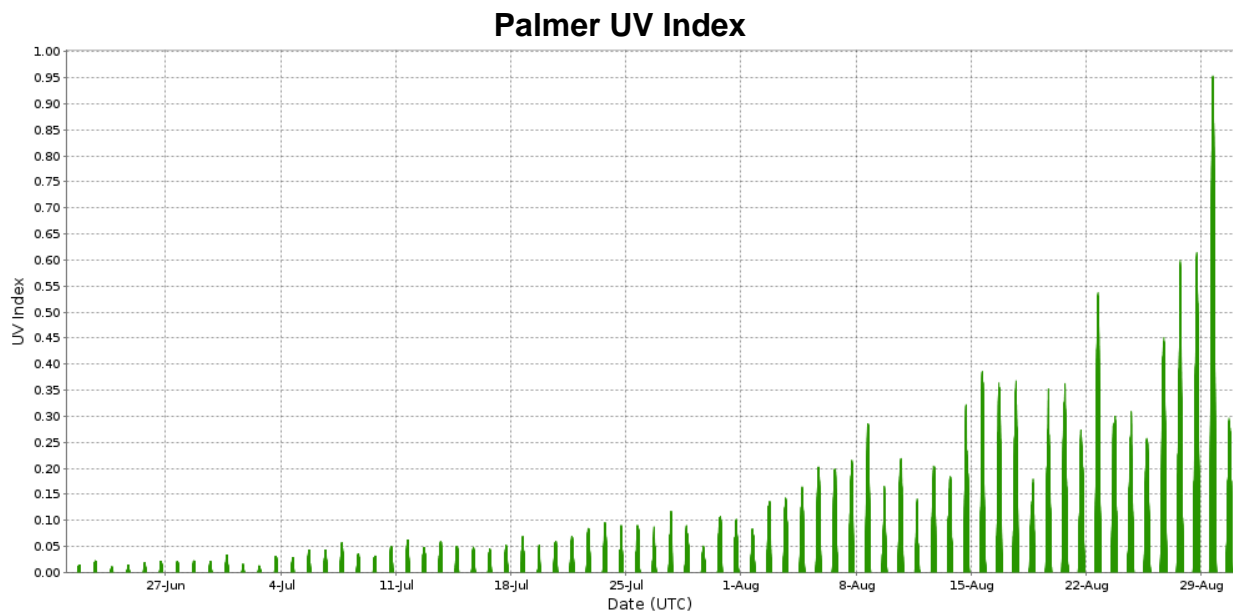


Figure 8. UV index generated from the GUV-511 radiometer, Midwinter (June 21, 2023) – August 31, 2023

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 August 3, August 15, and August 29 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.

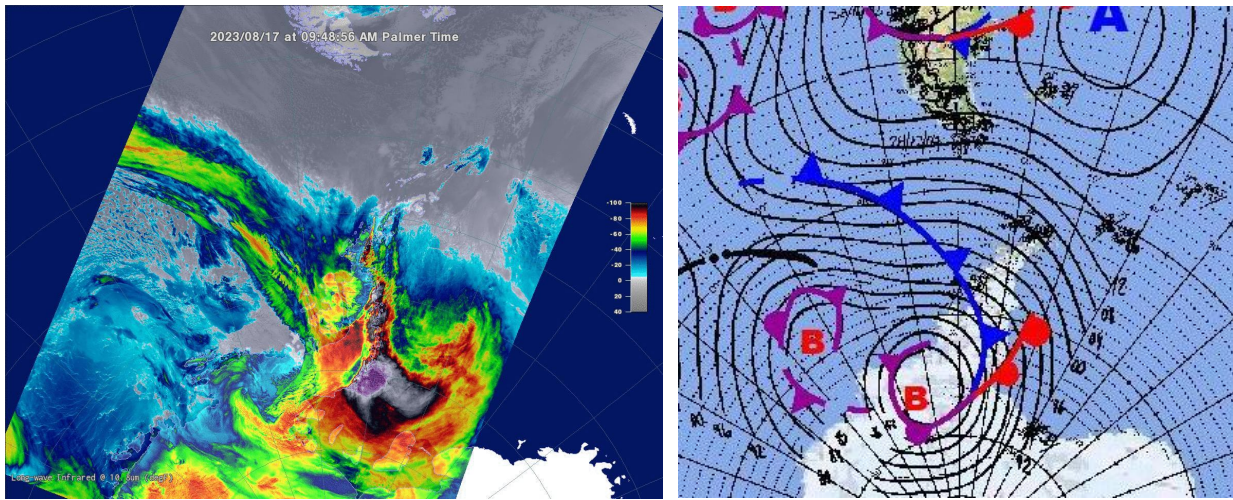


Figure 9. NOAA-18 August 17 satellite pass (left) explained by the Chilean meteorological chart (right).

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.

Due to a faulty antenna splitter, only the Septentrio receiver is operational at this time. 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.

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

PHYSICAL OCEANOGRAPHY

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

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

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/>.

Like the Antarctic continent as a whole, sea ice at Palmer Station is less abundant than usual and this year we have not yet seen ice extend past Hero Inlet.



Figure 10. Sea ice in Hero Inlet as seen from the glacier, August 29, 2023.

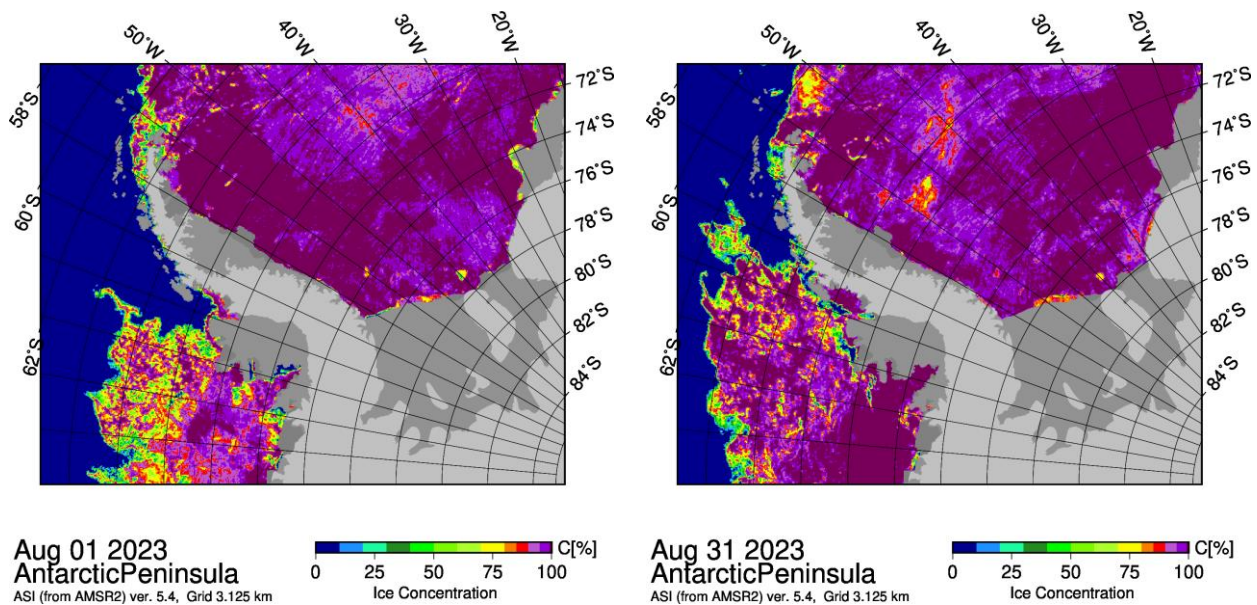


Figure 11. AMSR2 sea ice concentration maps from August 2023. Source: University of Bremen

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 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 August, 2023

Temperature
Average: -5.5 °C / 22 °F
Maximum: 1.7 °C / 35.06 °F on 9 Aug 18:05
Minimum: -13.4 °C / 7.88 °F on 25 Aug 16:44
Air Pressure
Average: 981.9 mb
Maximum: 1008.7 mb on 17 Aug 17:37
Minimum: 953.8 mb on 1 Aug 20:07
Wind
Average: 14.1 knots / 16.2 mph
Peak (5 Sec Gust): 71 knots / 81 mph on 21 Aug 02:30 from NNE (26 deg)
Prevailing Direction for Month: SW
Surface
Total Rainfall: 64.5 mm / 2.54 in
Total Snowfall: 63 cm / 24.6 in
Greatest Depth at Snow Stake: 107.6 cm / 42 in
WMO Sea Ice Observation: 6-10 bergs, bergy bits, growlers, brash ice, grease ice, nilas, and pancake ice
Average Sea Surface Temperature: -1.54 °C / 29.2 °F

This month, we reached our lowest temperature of the season: -13.4 °C on August 25.

2023 continues to experience greater-than-usual precipitation. August saw 64.5 mm of melted precipitation and a year to date (YTD) total of 680.0 mm, compared to a historical average of 438.1 mm (YTD).

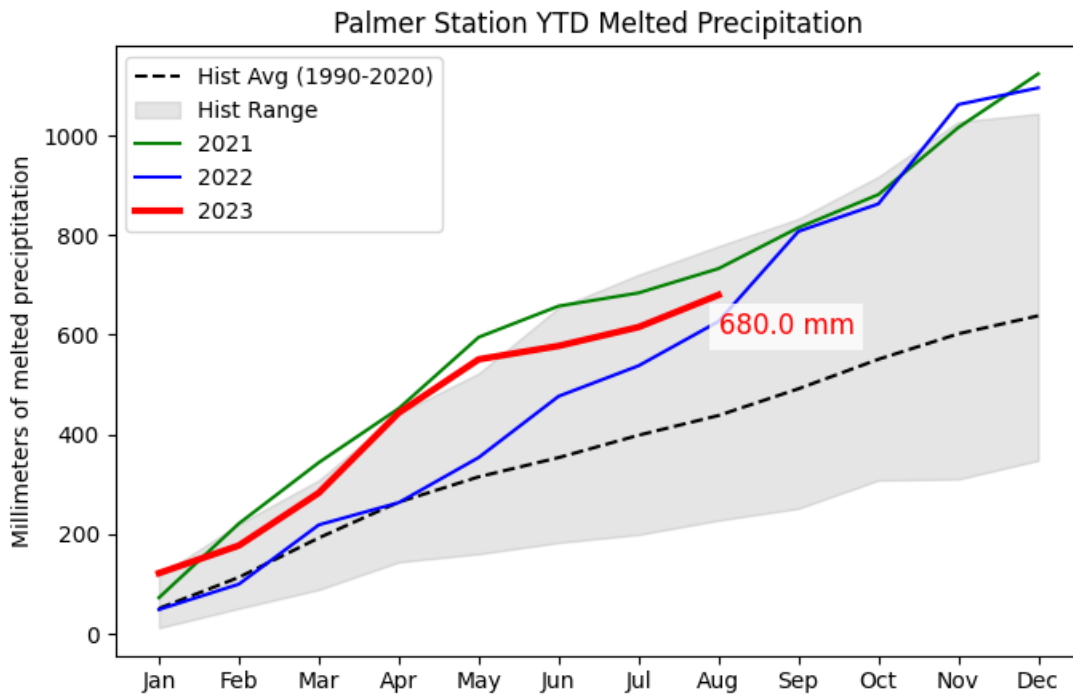


Figure 12. Palmer Station year to date (YTD) melted precipitation, 1990-present.