Data User Guide

GPM Ground Validation Passive Aquatic Listener (PAL)

Introduction

The GPM Ground Validation Passive Aquatic Listener (PAL) dataset contains underwater hydrophone data at a one-minute time step with a typical 5 km diameter footprint when deployed or drifting at 1 km depth. Areal rain rate and wind speed estimates are mutually exclusive, meaning that time periods that are unambiguously identified as rain are used to estimate rain rate, and wind speed is only estimated in the absence of rain. The data are available in netCDF-4 format and include time, interpolated geolocation data, the rain rate or wind speed estimates for each time, and location pair. PALs are deployed irregularly on Argo ocean profiling floats and moorings, typically as part of field campaigns. As such, the number of PALs collecting data is inconsistent in time and space. The entire dataset covers the period from October 18, 2010, through July 28, 2021.

Citation

Thompson, Elizabeth J., Haonan Chen, Jie Yang and Janice L. Bytheway. 2023. GPM Ground Validation Passive Aquatic Listener (PAL) [indicate subset used]. Dataset available online from the NASA Global Hydrometeorology Resource Center DAAC, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/GPMGV/PAL/DATA101.

Keywords:

NASA, NOAA, GPM, PAL, ground validation, passive aquatic listener, precipitation

Campaign

The Global Precipitation Measurement (GPM) mission Ground Validation (GV) campaign used a variety of methods for validating GPM satellite constellation measurements prior to and after the launch of the GPM Core Satellite, which occurred on February 27, 2014. The

GPM instrument validation effort included numerous GPM-specific and joint agency/international external field campaigns, using state-of-the-art cloud and precipitation observational infrastructure (polarimetric radars, profilers, rain gauges, and disdrometers). Surface rainfall was measured by very dense rain gauge and disdrometer networks at various field campaign sites. These field campaigns accounted for the majority of the effort and resources expended by GPM GV. This dataset results from a continuous effort as part of the GPM GV program. More information about the GPM mission is available on the NASA GPM webpage.

Instrument Description

Passive Aquatic Listeners (PALs) provide high-quality, high-resolution estimates of precipitation over ocean regions, but have been underutilized as a reference dataset for the evaluation of satellite-based precipitation estimates (SPEs) (Yang et al., 2015). PALs are uniquely suited for this purpose due to their 5 km surface listening area when sampling at 1 km depth on drifting Argo floats, providing rain rate estimates on a spatial scale similar to the native grid spacing of many SPEs (see Figure 1 and 2). In support of the NASA Precipitation Measurement Missions (PMM), a dataset of ~12 years of research-based precipitation and wind observations from PALs is produced, which included 58 PALs deployed on moorings and drifting Argo floats. The trajectories of these 58 PALs are illustrated in Figure 3. The 58 PALs include those deployed as part of the NASA Salinity Processes in the Upper Ocean Regional Study (SPURS-1 and SPURS-2), the Tropical Pacific Observing System (TPOS) project, and some other field programs (see Table 1). More information about the PAL can be found in Yang et al., 2015, Rise et al., 2019, and Thompson et al., 2022.

Figure 1: PAL deployed over the ocean
(Image Source: Thompson et al., 2022)

Figure 2: Image of a PAL.
(Image Source: Thompson et al., 2022)

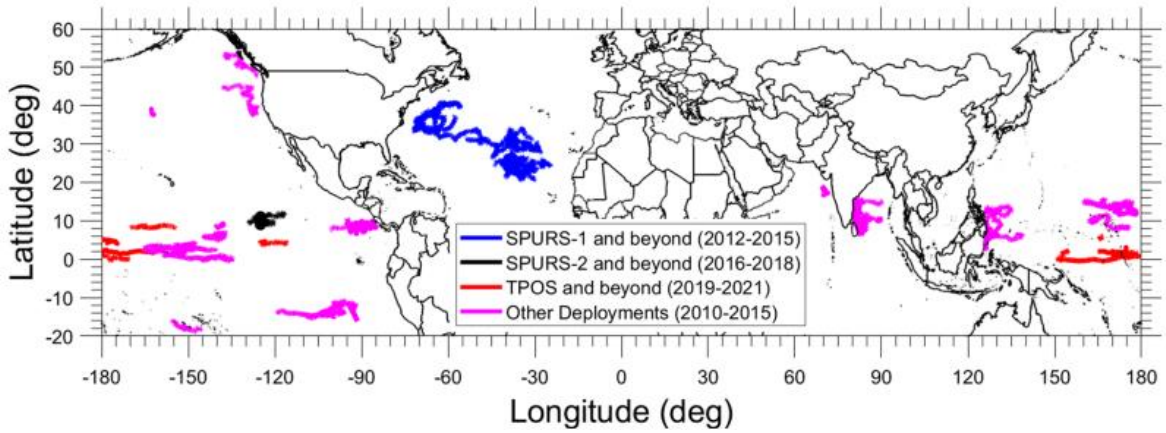

Figure 3: Location of PALs deployed from 2010-2021. Different colors are used for different field projects to aid visibility.
(Image Source: Thompson et al., 2022)

Table 1: PALs deployed for different field projects from 2010 through 2021.

SPURS-1	SPURS-2	TPOS	Other deployments (26 platforms)
Argo float 6923	Argo float 8435	Argo float 17350	Argo float 6862
Argo float 7547	Argo float 8444	Argo float 12780	Argo float 6872
Argo float 7569	Argo float 9302	Argo float 12792	Argo float 6874
Argo float 7572	Argo float 12360	Argo float 19644	Argo float 6877
Argo float 7582	SPURS-2 central mooring (500 m)	Argo float 19090	Argo float 6879

Argo float 7587	SPURS-2 central mooring (1,000 m)	Argo float 19412	Argo float 6915
Argo float 7607	SPURS-2 south mooring (650 m)	Argo float 19017	Argo float 6918
Argo float 7635			Argo float 6919
Argo float 7660			Argo float 6920
Argo float 7681			Argo float 6921
Argo float 7699			Argo float 6922
Argo float 7574			Argo float 7543
Argo float 7595			Argo float 7548
Argo float 7598			Argo float 7576
Argo float 7599			Argo float 7586
Argo float 7605			Argo float 7589
Argo float 7611			Argo float 7600
Argo float 7585			Argo float 7606
			Argo float 7609
			Argo float 7610
			Argo float 7612
			Argo float 7648
			Argo float 7650
			Argo float 7695
			Argo float 7704
			Argo float 8469

Investigators

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Data Characteristics

The GPM GV PAL dataset are available in netCDF-4 format at a Level 2 processing level. More information about the NASA data processing levels are available on the EOSDIS Data Processing Levels webpage. Table 2 shows the characteristics of these data files.

Table 2: Data Characteristics

Characteristic	Description
Platform	Ground station
Instrument	Passive Aquatic Listener (PAL)
Spatial Coverage	N: 53.335, S:-18.928, E: 179.999, W: -179.999 (Global)
Spatial Resolution	5 km
Temporal Coverage	October 18, 2010 - July 28, 2021
Temporal Resolution	~9.5 days
Sampling Frequency	1-minute
Parameter	Ocean currents depth, wind speed
Version	1
Processing Level	2

File Naming Convention

The GPM GV PAL data files are in netCDF-4 format. These data files have the following file naming convention, with each part described in Table 3.

Data files: PAL_precip_*_wind_[Argo_float_####|^]_v1.nc

Table 3: File naming convention variables

Variable	Description
*	Field campaign
[Argo_float_####|^]	Argo_float_####: Argo float number ^: central mooring level
.nc	netCDF-4 format

Data Format and Parameters

The GPM GV PAL data are in netCDF-4 format which include rain rate and wind speed measurements. Table 4 describes how these measurements are organized in each file, as well as their units.

Table 4: Data Fields in netCDF-4 files

Field Name	Description	Data Type	Unit
day	Day of measurement	int	-
hour	Hour of measurement	int	-
lat	Latitude of the PAL instrument.*	double	Degrees North

lon	Longitude of the PAL instrument.*	double	Degrees West
minute	Minute of measurement	int	-
month	Month of measurement	int	-
rain_rate	Instantaneous rain rate at the surface*	double	mm/hr
time	Time of measurement. Original irregular 2-9 min samplings are resampled to regular 1-min intervals.*	double	Seconds since 1970-01-01 00:00:00UTC
wind_speed	Surface wind speed.*	double	m/s
year	Year of measurement	int	-

*More information in the Algorithm and Quality Assessment section.

Algorithm

The PAL acoustic rain gauge has been developed by the Applied Physics Laboratory at the University of Washington (APL-UW) for making routine measurements of rain rate and wind speed over the ocean. A PAL consists of broadband, low noise hydrophone, control electronics for data collection and signal processing, and a battery pack. Typically, it records a 4.5 second long time series of sound pressure and converts it to a frequency spectrum of sound pressure levels (SPL) over the frequency range of 1-50 kHz. The spectrum is then sampled at 8 discrete frequencies (1, 2, 5, 8, 15, 20, 30, and 40 kHz) and averaged over a 1 kHz bandwidth. These discrete values are used to classify the spectra to determine the dominant noise source. Once the noise source is identified, and assuming the source to be either wind or rain, the SPLs at specific frequencies can then be used to estimate wind speed or rain rate, respectively. More information about this process can be found in Yang et al., 2015.

Quality Assessment

Irregular 2-9 minute rain rate samplings were resampled to the regular 1-minute rain rate interval. Interpolated position GPS fixes occur when the float comes to the surface, which happens about every 9.5 days. The float drifts slowly with 1 km depth ocean currents between vertical profiles and GPS fixes. More information can be found in Thompson et al., 2022.

Software

These data are in netCDF-4 format, so no special software is required to view these data; however, Panoply may be used to easily view the data.

Known Issues or Missing Data

The fillvalue of -9999 are missing data because these are times when the PAL was not listening during float descent, ascent, and when telemetering data at the ocean surface. This

also occurs for a few hours at a time about every 9.5 days. More information can be found in Thompson et al., 2022

References

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Related Data

All other datasets collected as part of the GPM GV project are considered related and can be located by searching the term “GPM Ground Validation” in the Earthdata Search.

Contact Information

To order these data or for further information, please contact:

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320 Sparkman Drive
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