Global Hydrology Resource Center

Data User Guide

GPM Ground Validation Autonomous Parsivel Unit (APU) OLYMPEX

Introduction

The GPM Ground Validation Autonomous Parsivel Unit (APU) OLYMPEX dataset was collected during the OLYMPEX field campaign held at Washington's Olympic Peninsula during the intense observation period of November 2015 to the end of January 2016. The dataset consists of data collected by 16 APUs. The APU is an optical laser-disdrometer based on single particle extinction that measures particle size and fall velocity. It consists of the Parsivel^2 developed by OTT in Germany and supporting hardware developed by University of Alabama. This APU dataset provides precipitation data including precipitation amount, precipitation rate, reflectivity in Rayleigh regime, liquid water content, drop diameter, and drop concentration. Data are available in ASCII format.

Notice:
A number of APU sites (apu01, apu02, apu03, apu06, apu07, apu08, apu10, apu11, and apu30) and hrd and snp sites were installed late Summer and Autumn 2015. The early installation and late dismounting was partly due to the continuous record of size distribution observations and partly due to logistic reasons. Due to climate at higher elevations, both mixed and frozen precipitation were observed, though the rain algorithm was used to process the data.

Citation

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Keywords:

NASA, GHRC, OLYMPEX, Washington, Precipitation, Precipitation rate, Precipitation amount, Droplet size, Hydrometeors, Liquid precipitation, Drizzle, rain, Liquid water equivalent,

Precipitation anomalies, Snow water equivalent, Solid precipitation, Total surface precipitation rate, Virga, Atmospheric stability

Campaign

The Global Precipitation Measurement (GPM) mission Ground Validation campaign used a variety of methods for validation of GPM satellite constellation measurements prior to and after launch of the GPM Core Satellite, which launched on February 27, 2014. The 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. More information about the GPM mission is available at https://pmm.nasa.gov/GPM/.

One of the GPM Ground Validation field campaigns was the Olympic Mountains Experiment (OLYMPEX) which was held in the Pacific Northwest. The goal of OLYMPEX was to validate rain and snow measurements in midlatitude frontal systems as they move from ocean to coast to mountains and to determine how remotely sensed measurements of precipitation by GPM can be applied to a range of hydrologic, weather forecasting, and climate data. The campaign consisted of a wide variety of ground instrumentation, radars, and airborne instrumentation monitoring oceanic storm systems as they approached and traversed the Peninsula and the Olympic Mountains. The OLYMPEX campaign was part of the development, evaluation, and improvement of GPM remote sensing precipitation algorithms. More information is available from the NASA GPM Ground Validation web site https://pmm.nasa.gov/olympex, and the University of Washington OLYMPEX web site http://olympex.atmos.washington.edu/.

Figure 1: OLYMPEX Domain

(Image Source: https://pmm.nasa.gov/OLYMPEX)

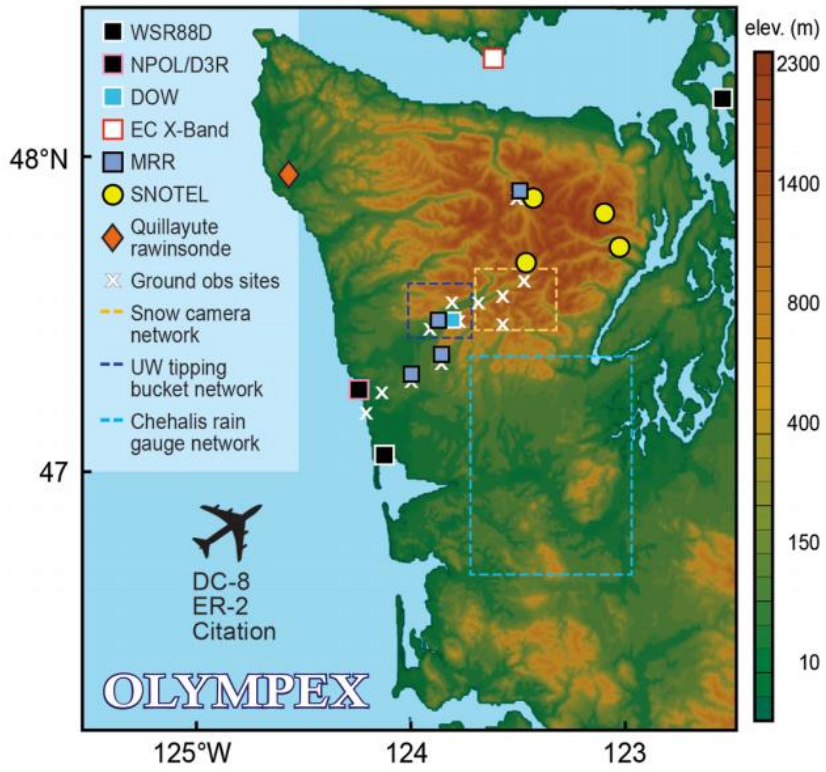

Figure 2: OLYMPEX Field Locations.
(Image Source: https://pmm.nasa.gov/OLYMPEX)

Instrument Description

The Autonomous Parsivel Unit (APU) is an optical laser-based disdrometer that uses single particle extinction to measures particle size and fall velocity. The APU used for the OLYMPEX campaign consists of the Parsivel^2 and supporting hardware to allow for automatic data reporting.

The Parsivel^2 disdrometer produced by OTT Hydromet is a modern, laser-based optical system for measuring all types of precipitation. The transmitter unit of the sensor generates a flat, horizontal strip or sheet of light, which the receiver converts into an electrical signal. When no particles pass through the horizontal beam, the maximum voltage is detected at the receiver. The signal changes whenever a hydrometeor falls through the sheet anywhere within the measurement area. The blocked portion of the laser signal results in a reduced voltage output. The degree of dimming is a measure of the size of the hydrometeor, and together with the duration of the blockage, the fall velocity can be derived. The Parsivel^2 can also classify precipitation particles into 32 separate size classes and 32 velocity classes.

During OLYMPEX, thirteen APUs were operated at various sites throughout the Olympic Peninsula study region. A single Parsivel was also operated at Hurricane Ridge (hrd) and another at Albert Head (ahd), British Columbia by Environment Canada. A number of sites dismounted at the end of the experiment, while three APU sites (apu10, apu13 and apu30), plus the hrd and ahd sites continued operation through Spring 2016. A number of APU sites (apu01, apu02, apu03, apu06, apu07, apu08, apu10, apu11, apu30) and hrd and snp sites were installed late Summer and Autumn 2015 and have data prior to the start of the intense operation field campaign period. A parsivel was placed at Snoqualmie Pass, WA (snp) during January 2015 to Spring 2015 to test the functioning of the APUs in a winter environment. These data are included, but note the data were obtained east of Seattle, WA, not on the Olympic Peninsula.

Table 1: OLYMPEX APU sites.

Site Name	Latitude (°)	Longitude (°)	Elevation (m)	Site ID
Wallace Cabin	47.202533	-124.202342	15	apu01
Seed Orchard	47.266642	-124.118067	260	apu02
Fish Hatchery	47.359944	-123.993067	170	apu03
Neilton Point	47.389839	-123.867039	2155	apu04
Amanda Park (S6)	47.459558	-123.889753	210	apu05
Prairie Creek	47.5117	-123.9332	1780	apu06
Norwood	47.493306	-123.809475	213	apu07
Bishop CRN	47.513542	-123.811894	285	apu08
Bunch Field	47.537411	-123.681375	380	apu09
Wynoochee Trailer	47.496889	-123.580889	3340	apu10
Graves Creek	47.572069	-123.582544	593	apu11
Kalaloch	47.603242	-124.36945	39	apu13
Upper East Fork Quinault	47.679853	-123.384128	2100	apu30
Albert Head, British Columbia	48.387117	-123.478042	unknown	ahd
Hurricane Ridge	47.970358	-123.4821	5260	hrd
Snoqualmie Pass	47.424725	-121.414022	3020	snp

Further information on the Parsivel² can be found at http://www.ott.com/en-us/products/meteorological-sensors-26/ott-parsivel2-laser-weather-sensor-1536/.

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File Naming Convention

The GPM Ground Validation Autonomous Parsivel Unit (APU) OLYMPEX dataset files are in ASCII format at Level 3 processing level. These data files have the following naming convention:

Data files: olympex_parsivel_[diameter|matrix].txt
olympex_apu##_[data|rainevent].txt
olympex_apu##_[dropcounts|rainparameter|raindsd]_min.txt
olympex_apu##_[rainparameter|raindsd]_min_ter.txt

Table 2: Filename convention variables

Variable	Description
apu##	parsivel units (01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11, 13, 30)
min	Data provided as 1- minute interpolated values derived from 10 second measurements
ter	Terminal velocity indicator
.txt	ASCII file format

Data Format Description

The GPM Ground Validation Autonomous Parsivel Unit (APU) OLYMPEX data are available in ASCII format. The ASCII files are L3 data files, which contain precipitation, precipitation amount, precipitation rate, air temperature, reflectivity in Rayleigh regime, liquid water content, drop diameter, and drop concentration measurements. More info on NASA processing levels are available at https://science.nasa.gov/earth-science/earth-science-data/data-processing-levels-for-eosdis-data-products/.

Table 3: Data Characteristics

Characteristic	Description
Platform	Ground-Based Observations
Instrument	Autonomous Parsivel Unit (APU)
Spatial Coverage	N: 47.68, S: 47.20, E: -123.58, W: -124.37 (Olympic Mountains Washington)
Spatial Resolution	point
Temporal Coverage	Start date: January 10, 2015* Stop date: January 31, 2016
Temporal Resolution	One file per site, each site had various operation periods
Sampling Frequency	10 seconds integrated into 1 minute
Parameter	Precipitation, precipitation amount, precipitation rate, reflectivity in Rayleigh regime, liquid water content, drop diameter, drop concentration
Version	1
Processing Level	3

* this dataset contains data from instrument testing in January 2015 at Snoqualmie Pass, WA. The actual OLYMPEX study dataset consists of data from late summer 2015 through Spring 2016.

There are two files required as input for data processing, the olympex_parsivel_diameter.txt and the olympex_parsivel_matrix.txt. Table 4 describes the olympex_parsivel_diameter.txt file organization. It should be noted that terminal fall velocities above 6.0 mm in diameter are subject to error. A linear interpretation was performed for drops larger than 6.0 mm.

The olympex_parsivel_matrix.txt data file is a 32 x 32 matrix that corresponds to the drop size and fall velocities of the manufacturer output. The file screens the drops following ±50% terminal fall speed limit. If the drop fall is outside the ±50% its terminal fall speed, it is regarded as a secondary drop and eliminated from the processing. The matrix consists of '1' for accepted and '0' for rejected drops.

The product files consist of 7 files per parsivel site. Table 5 lists the olympex_apu##_data.txt file contents. This file provides evidence of instrument operation by showing time stamp of the 10-second observations. This allows us to distinguish between the non-rainy periods from non-data collection periods.
The olympex_apu##_dropcounts_min.txt data files provide the total number of drops at each bin size at 1-minute intervals as listed in Table 6. The 10 second data are integrated into 1 minute values. The file contains 36 columns.

The olympex_apu##_rainparameter_min.txt files contain the integral rain parameters based on *measured* fall velocities at 1-minute integrations. It should also be noted that four of these rain parameters, total concentration, liquid water content, reflectivity in Rayleigh regime, and mass-weighted drop diameters require fall speed information in their formulations. The olympex_apu##_rainparameter_min_ter.txt files in Table 7 provide the integral rain parameters based on *terminal* fall velocities at 1-minute integration. More

information on the disdrometer-based calculation of integral rain parameters can be found in Tokay et al. (2001).

The olympex_apu##_raindsd_min.txt files provide the raindrop size distribution based on *measured* fall velocities at 1-minute integration. The olympex_apu##_raindsd_min_ter.txt files provide the raindrop size distribution based on *terminal* fall velocities at 1-minute integration. Contents are listed in Table 8.

The olympex_apu##_rainevent.txt files contain rain event summaries. The events are separated by 1 hour or more rain-free periods in rain rate time series that can be extracted from olympex_apu##_rainparameter_min.txt or olympex_apu##_rainparameter_min_ter.txt files. The events that are less than 3 minutes or the rain total that is less than 0.1 mm are excluded. Table 9 describes file organization.

Table 4: Data format within olympex_parsivel_diameter.txt

Column	Description	Units
1	Drop shape corrected mid bin size diameters	mm
2	Corresponding bin width	mm
3	Corresponding terminal fall speed	m/s
4	Corrected mid bin fall velocities	m/s
5	+50% fall velocity threshold	m/s
6	-50% fall velocity threshold	m/s

Table 5: Data format within olympex_apu##_data.txt files

Column	Description	Units
1	Year	-
2	Day of the year	-
3	Hour	Hour in UTC
4	Minute	Minutes in UTC
5 -10	Maximum of 6 columns, each representing a 10 second value (0,10,20,30,40,50)	Seconds in UTC

Table 6: Data format within olympex_apu##_dropcounts_min.txt files

Column	Description	Units
1	Year	-
2	Day of the year	-
3	Hour	Hour in UTC
4	Minute	Minute in UTC

5 - 36	Drop counts for each size bin	-

Table 7: Data format within olympex_apu##_rainparameter_min.txt and olympex_apu##_rainparameter_min_ter.txt files

Column	Description	Units
1	Year	-
2	Day of the year	-
3	Hour	Hour in UTC
4	Minute	Minute in UTC
5	Total number of drops	-
6	Total concentration	drops/m^3 of air
7	Liquid water content	g/m^3
8	Rain rate	mm/h
9	Reflectivity in Rayleigh regime	dBZ
10	Mass-weighted drop diameter	mm
11	Maximum drop diameter	mm

Table 8: Data format within olympex_apu##_raindsd_min.txt files

Column	Description	Units
1	Year	-
2	Day of the year	-
3	Hour	Hour in UTC
4	Minute	Minute in UTC
5-36	32-bin raindrop size distribution	Drops m^{-3} mm^{-1}

Table 9: Data format within olympex_apu##_rainevent.txt files

Column	Description	Units
1	Year	-
2	Event start day of the year	-
3	Event start hour and minute	hh:mm hh = two-digit hour in UTC mm = two-digit minute in UTC
4	Event end day of the year	-
5	Event end hour and minute	hh:mm hh = two-digit hour in UTC mm = two-digit minute in UTC
6	Event rainy minutes	Minutes
7	Event maximum rain rate	mm/h
8	Event rain total	mm
9	Event maximum drop diameter	mm

Data Parameters

The GPM Ground Validation Autonomous Parsivel Unit (APU) OLYMPEX dataset consists of precipitation, precipitation amount, precipitation rate, reflectivity in Rayleigh regime, liquid water content, drop diameter, and drop concentration measurements. Tables 4-9 describe how these measurements are organized in each file, as well as their units.

Algorithm

For the minute-integrated data files, the 10-second observations are integrated to 1-minute; however, the timestamp of the 10-second observations has been documented in the olympex_apu##_data.txt file to distinguish the non-rainy periods from non-data collection periods. It should also be noted that the thresholds of 10 drops and 0.01 mm/h were applied to the 1-minute observations to eliminate noise from rainy minutes.

In the 'olympex_apu##_rainparameter_min.txt' files, four of the rain parameters, total concentration, liquid water content, reflectivity in Rayleigh regime, and mass-weighted drop diameter requires fall speed information in their formulations. More information on the disdrometer-based calculation of integral rain parameters can be found in Tokay et al., 2001. The corresponding terminal fall speed in m/sec followed the method of Beard (1976).

Quality Assessment

For the 'olympex_parsivel_diameter.txt' file used as input, the terminal fall velocities above 6.0 mm in diameter (bin 22 through bin 32) are subject to error since the Beard (1976) does not extend for drops larger than 6.0 mm in diameter. More information about this is available in Beard, 1976.

For the 'parsivel_matrix.txt" file, the file screens the drops following ±50% terminal fall speed limit. If the drop fall is outside the ±50% of its terminal fall speed, it is regarded as a secondary drop and eliminated from the processing.

If rain events that are less than 3 minutes or the rain total is less than 0.1 mm, then it is not included in the olympex_apu##_rainevent.txt' files.

Parsivel data have been validated using other disdrometer types as reported in Tokay et al. (2001) and Jaffrain and Berne (2011). Friedrich et al. (2013) identified a typical misclassification of particles by different stationary disdrometers that can occur at high wind speed and/or heavy rainfall. The authors hypothesize that when particles do not fall perpendicularly through the disdrometer sampling area the misclassification can occur. The Parsivel processing software assumes snowflakes as spheres and therefore provides only a one-dimensional length which is not necessarily representative of the equivalent diameter of the particle.

Software

Since these data files are in ASCII format, no software is required to read the data.

References

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Related Data

All data from other instruments collected during the OLYMPEX field campaign are considered related datasets OLYMPEX data can be located using HyDRO 2.0 search tool with the search term “OLYMPEX”.

In addition, the APU instrument was used in the previous GPM Ground Validation field campaign. The following datasets are APU data from other field campaigns:

GPM Ground Validation Autonomous Parsivel Unit (APU) **GCPEx** (http://dx.doi.org/10.5067/GPMGV/GCPEX/APU/DATA301)

GPM Ground Validation Autonomous Parsivel Unit (APU) **IPHEx** (http://dx.doi.org/10.5067/GPMGV/IPHEX/APU/DATA301)

GPM Ground Validation Autonomous Parsivel Unit (APU) **IFloodS** (http://dx.doi.org/10.5067/GPMGV/IFLOODS/APU/DATA301)

GPM Ground Validation Autonomous Parsivel Unit (APU) **MC3E**
(http://dx.doi.org/10.5067/GPMGV/MC3E/APU/DATA301)

GPM Ground Validation Autonomous Parsivel Unit (APU) **HyMeX**
(http://dx.doi.org/10.5067/GPMGV/HYMEX/APU/DATA301)

GPM Ground Validation Autonomous Parsivel Unit (APU) **LPVEx**
(http://dx.doi.org/10.5067/GPMGV/LPVEX/APU/DATA301)

GPM Ground Validation Autonomous Parsivel Unit (APU) **NSSTC**
(http://dx.doi.org/10.5067/GPMGV/NSSTC/APU/DATA201)

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

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