Global Hydrology Resource Center

Data User Guide

GPM Ground Validation Upper Air Radiosonde OLYMPEX

Introduction

The GPM Ground Validation Upper Air Radiosonde OLYMPEX dataset was collected from October 28, 2015 through January 16, 2016 during the GPM Ground Validation Olympic Mountain Experiment (OLYMPEX) held on the Olympic Peninsula in the Pacific Northwest of the United States. Radiosondes were released from 5 locations: 3 in US - KSLE, KUIL, and NPOL site; and 2 in Canada - ECCC site and CYZT. A total of 651 radiosondes were launched and collected during OLYMPEX from these sites. In addition, Level 4 dropsonde data were reprocessed to match the Level-4 data format and content of the radiosonde files and is also provided here. The dropsondes were released from the NASA DC-8 aircraft during specific flights in December 2015 and are published as the AVAPS dataset. This Upper Air Radiosonde dataset contains Level 0 through Level 4 data containing dew point temperature, pressure, air temperature, relative humidity, horizontal wind speed, vertical wind speed, wind direction, rise or drop rate, and geopotential height measurements. The data files are available in ASCII, ASCII-EOL, and netCDF-3 formats, as well as Skew-T and time series plots in PNG format. The lower level datasets (Level 0 raw data through Level 2 data) are only available upon request from the NASA GHRC DAAC.

Citation

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Keywords:

NASA, GHRC, GPM, OLYMPEX, Washington, Radiosonde, dropsonde, soundings, dew point temperature, pressure, air temperature, relative humidity, horizontal wind speed, vertical wind speed, wind direction, rise rate, drop rate, geopotential height , DC-8

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 mid latitude 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)

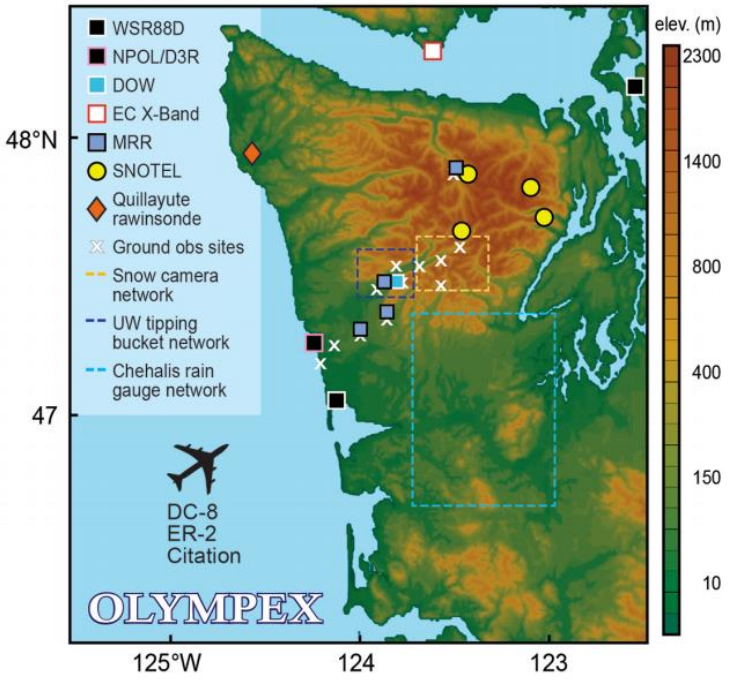

Figure 2: OLYMPEX Field Locations
(Image Source: https://pmm.nasa.gov/OLYMPEX)

Figure 3: Map showing upper air radiosonde release locations for OLYMPEX (red circles).
(Image source: Quality-Control of Upper-Air Soundings for OLYMPEX document)

Instrument Description

The GPM Ground Validation Upper Air Radiosonde OLYMPEX dataset was collected using the Sippican Mark II and the Vaisala RS92 NGP Radiosondes. The radiosondes were launched at 5 sites, as well as AVAPS dropsondes released from the NASA DC-8 aircraft during several flights in December 2015, in the Pacific Northwest for the OLYMPEX field campaign as shown in Figure 3 and Table 1.

Table 1: Upper air radiosonde release locations

Site Name	Location	Number of Soundings	Dates of Retrieved Data
ENVC	48.460, -123.300	71	11/13/2015 - 12/19/2015
CYZT	50.681, -127.367	160	10/29/2015 - 1/16/2016
KUIL	47.938, -124.555	162	10/29/2015 - 1/16/2016
KSLE	44.905, -123.001	160	10/29/2015 - 1/16/2016
NPOL	47.277, -124.211	98	11/11/2015 - 12/19/2015
DROP	varies	53	11/12/2015 - 12/19/2015

The Vaisala RS92 NGP radiosonde offers excellent accuracy of wind, temperature, humidity, and pressure measurements. This radiosonde uses a digital data transmission scheme modulated at 1,680 MHz. The Vaisala RS92 NGP radiosonde consists of a silicon capacitive pressure sensor, a rod type capacitive temperature sensor, and two alternately heated thin film capacitor sensors for relative humidity measurements, as well as a spiral GPM antenna at the top of the radiosonde. Data from the radiosonde is transmitted to the ground stations every second. Figure 4 shows an image of the Vaisala RS92 NGP radiosonde. More information about the Vaisala RS92 NGP radiosonde is available in the National Weather Service's Upper Air Data Continuity Study Test Plan for the Sippican B2 and Vaisala RS92 NGP Radiosondes.

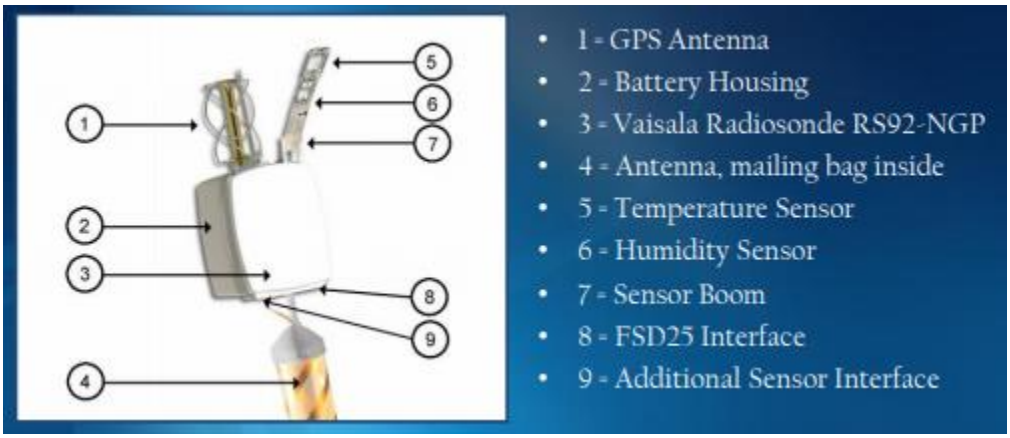

Figure 4: Sensors located on the Vaisala RS92 NGP Radiosonde.
(Image source: National Weather Service's Upper Air Data Continuity Study Test Plan for the Sippican B2 and Vaisala RS92 NGP Radiosondes)

The Sippican Mark II Radiosonde uses a 'hygristor' to measure relative humidity. The hygristor is a strip of plastic dipped in a liquid mixture of carbon particles and celluloid resin. Celluloid is sensitive to relative humidity and expands or contracts with the amount of water vapor in the air. Temperature is measured by a small, thin rod comprised of baked clay and iron filings. Changing temperatures causes a change in the electrical resistance across the rod. A capacitance aneroid cell is used to measure the pressure. Figure 5 shows an image of the Sippican Mark II Radiosonde. More information about the Sippican Mark II Radiosonde can be found in the National Weather Service's Operations and Services Upper Air Program NWSPD 10-14 Rawinsonde Observations document.

Figure 5: Image of a Sippican Mark II Radiosonde.
(Image Source: National Weather Service)

In addition to the radiosondes released from 5 sites, there were AVAPS dropsondes released from the NASA DC-8 aircraft during several flights in December 2015. The lower level data and description of the dropsondes used are within the user guide for the GPM Ground Validation Advanced Vertical Atmospheric Profiling System (AVAPS) OLYMPEX dataset (DOI: http://dx.doi.org/10.5067/GPMGV/OLYMPEX/AVAPS/DATA101).

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Data Characteristics

The GPM Ground Validation Upper Air Radiosonde OLYMPEX data files are available in ASCII-EOL, ASCII, and netCDF-3 formats, as well as Skew-T and time series plot in PNG format. For this radiosonde upper-air sounding dataset, the data file levels are described as:

Level 0 (L0)	Raw, original data
Level 1 (L1)	Data in common ASCII (i.e., GLS) format, native resolution
Level 2 (L2)	Data processed with ASPEN, native resolution (ASCII and netcdf formats)
Level 3 (L3.0)	Data checked for sonde biases, native resolution (ASCII and netcdf formats)
Level 4 (L4.0)	Soundings visually inspected with QC flags; hi-res data interpolated to uniform 5-hPa intervals (ASCII and netcdf formats); skew-T diagrams for all soundings

The readily available data are Level 3 and Level 4. The Level 0, Level 1, and Level 2 (lower level) data files are available upon request from the NASA GHRC DAAC. These data levels

coincide with the NASA data processing levels described on the NASA Data Processing Level website.

Table 2: Data Characteristics

Characteristic	Description
Platform	Ground station
Instrument	Vaisala RS 92 and Sippican Mark II radiosondes
Projection	n/a
Spatial Coverage	N: 50.680, S: 43.547, E: -120.439, W: -128.880 (Washington)
Spatial Resolution	5-10 m
Temporal Coverage	October 28, 2015 - January 16, 2016
Sampling Frequency	1-2 seconds for radiosondes, 0.25 seconds for dropsondes
Parameter	Dew point temperature, atmospheric pressure, air temperature, relative humidity, horizontal wind speed, vertical wind speed, wind direction, rise rate, geopotential height
Version	1
Processing Level	Level 0 through Level 4

File Naming Convention

The GPM Ground Validation Upper Air Radiosonde OLYMPEX dataset has the file naming convention shown below. The data files are available in ASCII-EOL, ASCII, and netCDF-3 formats, as well as Skew-T and time series plots in PNG format.

Data files: OLYMPEX_upaL#_site.[netcdf.tar.gz|tar.gz|gz]
Browse files: olympex_upa_[skewt|skewt_ts]_site_YYYYMMDD_hh.png

Table 3: File naming convention variables

Variable	Description
L#	Data processing level (only L3 and L4 readily accessible, lower levels available on request
site	ground site locations are shown in Figure 3: cyzt: Port Hardy, BC envc: Environment Canada radar site ksle: Salem, Oregon kuil: Quillayute, Washington npol: OLYMPEX NPOL instrument location site Level 4 data files also contain: drop: dropsondes from NASA DC-8 aircraft
[netcdf.tar.gz|tar.gz|gz]	Netcdf.tar.gz: gzipped netCDF-3 data files tar.gz: gzipped ASCII-EOL data files gz: gzipped ASCII data files
[skewt|skewt_ts]	skewt: image of Skew-T plot skewt_ts: time series plot of pressure, wind speed,

	wind direction, and relative humidity
.png	Portable Network Graphics format

Data Format and Parameters

The GPM Ground Validation Upper Air Radiosonde OLYMPEX dataset consists of atmospheric pressure, geopotential height, temperature, relative humidity, and wind measurements obtained by radiosondes released at 5 locations in the region of the OLYMPEX field campaign. Three of the locations were in the United States - two standard weather sites: Quillayute, WA (KUIL) and Salem, OR (KSLE) and radiosondes released at the NPOL radar location for OLYMPEX (NPOL). Two locations were in Canada - the ECCC radar site (ENVC) and a standard weather site at Port Hardy, BC (CYZT).

In addition to the radiosonde data, the Level 4 data files contain dropsonde data from the NASA DC-8 AVAPS dataset that have been reprocessed to match the format and content of these radiosonde data. The dropsonde data are labeled as (DROP) files.

All Level 3 and Level 4 data files are provided in three formats: ASCII-EOL, ASCII, and netCDF-3. More information on the ASCII-EOL format is provided in the EOL Sounding Data File Format document and at the EOL UCAR webpage. Browse images of Skew-T graphs and time-series plots are provided in PNG format. Lower level data products are available on request.

Table 4 describes the variables in the Level 3 gzipped netCDF-3 data files, while Table 5 describes the variables in the Level 4 gzipped netCDF-3 data files. Table 6 describes the variables in the Level 3 gzipped ASCII-EOL data files, and Table 7 describes the variables in the Level 4 gzipped ASCII data files.

All Quality Flags in the data files have the same value set as shown below:

1: good
2: objectively questionable
3: visually questionable
4: objectively bad
5: visually bad
6: interpolated
7: estimated
8: unchecked

Table 4: Data Fields in Level 3 GZipped netCDF-3 radiosonde data files

Field Name	Description	Data Type	Unit

alt	Altitude above mean sea level	float	m
base_time	Sounding launch time	int	Seconds since 1970-01-01 00:00:00 UTC
dp	Dew Point temperature	float	Degrees Celsius
dz	Rise rate	float	m/s
gpsalt	GPS reported altitude above mean sea level	float	m
lat	North latitude	float	degrees
lon	East longitude	float	degrees
mr	Mixing ratio	float	g/kg
pres	Atmospheric pressure	float	hPa
qp	Quality-controlled pressure	float	hPa
qrh	Quality-controlled relative humidity	float	%
qt	Quality-controlled temperature	float	Degrees Celsius
qu	Quality-controlled horizontal wind speed	float	m/s
qv	Quality-controlled vertical wind speed	float	m/s
qwind	Quality-controlled wind speed	float	m/s
range	Travel range of sounding	float	km
rh	Relative humidity	float	%
tdry	Dry adiabatic temperature	float	Degrees Celsius
theta	Potential temperature	float	K
theta_e	Equivalent potential temperature	float	K
theta_v	Virtual potential temperature	float	K
time	Time sounding was launched	double	Seconds since 1970-01-01 00:00:00 UTC
time_offset	Time offset showing seconds since base_time	float	Seconds since base_time
u_wind	Horizontal wind speed	float	m/s
v_wind	Vertical wind speed	float	m/s
vt	Virtual temperature	float	K
wdir	Wind direction	float	degrees
wspd	Wind speed	float	m/s

Table 5: Data Fields in Level 4 gzipped netCDF-3 data files

Field Name	Description	Data Type	Unit
alt	Altitude above mean sea level	float	m

alt_qcf	Quality flag for altitude	short	-
CAPE	Convective Available Potential Energy	float	J/kg
CIN	Convective Inhibition	float	J/kg
corrections	Corrections applied to sounding: 0: no corrections applied 1: humidity corrected 2: surface pressure corrected 3: surface temperature and dewpoint temperature corrected 4: low-level temperature and dewpoint temperature corrected	short	-
EL	Equilibrium level	float	hPa
lat	Latitude	float	Degrees North
launch_time	Sounding launch time	double	Seconds since time given in file name
LCL	Lifting Condensation Level	float	hPa
level	Vertical level. First value represents the surface	int	-
LFC	Level of free convection	float	hPa
lon	Longitude	float	Degrees East
n_levels	Number of levels	int	-
n_soundings	Number of soundings	int	-
p	Atmospheric Pressure	float	hPa
p_qcf	Quality control flag for pressure	short	-
site_elev	Elevation of sounding site above mean sea level	float	m
site_id	Sounding site ID number	int	-
site_lat	Latitude of sounding site	float	Degrees North
site_lon	Longitude of sounding site	float	Degrees East
sounding	Sounding number	int	-
T	Air temperature	float	Degrees Celsius
T_qcf	Quality control flag for temperature	short	-
Td	Dew Point temperature	float	Degrees Celsius
Td_qcf	Quality control flag for dew point temp	short	-
TPW	Total Precipitable Water	float	mm
wdir	Wind direction	float	degrees
wind_qcf	Quality control flag for wind values	short	-
wspd	Wind speed	float	m/s

Table 6: Data Fields in Level-3 gzipped ASCII-EOL data files

Column	Field Name	Description	Unit
1	Time	Seconds since sounding has been launched	s
2-4	UTC	Time of measurement Column 2: hour in UTC Column 3: minute in UTC Column 4: second in UTC	UTC
5	Press	Pressure	mb
6	Temp	Air Temperature	Degrees Celsius
7	Dewpt	Dew Point temperature	Degrees Celsius
8	RH	Relative humidity	%
9	Uwind	Horizontal wind speed	m/s
10	Vwind	Vertical wind speed	m/s
11	Wspd	Wind speed	m/s
12	Dir	Wind direction	degrees
13	dZ	Rise rate	m/s
14	GeoPoAlt	Geopotential Altitude	m
15	Lon	Longitude	Degrees East
16	Lat	Latitude	Degrees North
17	GPSAlt	GPS reported altitude above mean sea level	m

Table 7: Data Fields in Level 4 gzipped ASCII data files

Column	Field Name	Description	Unit
1	P	Pressure	mb
2	HT	Sounding height above mean sea level	m
3	TC	Air temperature	Degrees Celsius
4	TD	Dew point Temperature	Degrees Celsius
5	DIR	Wind direction	degrees
6	SPD	Wind speed	m/s
7	QP	Quality control flag for atmospheric pressure	-
8	QH	Quality control flag for relative humidity	-
9	QT	Quality control flag for air temperature	-
10	QD	Quality control flag for dew point temperature	-
11	QW	Quality control flag for wind speed	-
12	LON	Longitude	Degrees

			East
13	LAT	Latitude	Degrees North

Algorithm

The FORTRAN code used to create the Skew-T diagrams in the PNG browse files are included in this dataset. These programs are named read_upaL2_eol.f and read_upaL4.f. The Level 2 and Level 3 data are considered to be the same at this time, so the routine read_upaL2_eol.f can also be used to plot the Level 3 data.

Quality Assessment

The Vaisala RS92 NGP Radiosonde has a pressure discrepancy of ±3 hPa, a temperature discrepancy of ±1 degrees Celsius, and a relative humidity discrepancy of ±4 %. More information about these discrepancies can be found in the Vaisala RS92 user guide.

The Sippican Mark II Radiosonde has an accuracy of ±5 hPa for pressure, ±0.3 degrees Celsius for temperature, and ±5 % for relative humidity. More information about the accuracy of the Sippican Mark II Radiosonde can be found in the National Weather Service's Operations and Services Upper Air Program NWSPD 10-14 Rawinsonde Observations document.

Quality-control procedures were executed on these data. An outlined methodology of how these quality-controlled data were processed can be found in the Quality-Control of Upper-Air Soundings for OLYMPEX document.

Software

Software is not required to view these ASCII, ASCII-EOL, and netCDF-3 data files. However, Panoply can be used to easily view the netCDF-3 data files. The FORTRAN code used to create the Skew-T diagrams plotted in the PNG browse files are included in this dataset. These programs are named read_upaL2_eol.f and read_upaL4.f. The Level 2 and Level 3 data are considered to be the same, so read_upaL2_eol.f can also be used to plot the Level 3 data.

Known Issues or Missing Data

Due to power outages at the KUIL site, no soundings were deployed from December 17th 12 UTC through December 29th 12 UTC. Also prior to the November 18th 23 UTC sounding at the NPOL site, 23 soundings had missing data (particularly winds) at the upper-levels (pressure < 300 hPa). After this time, use of a different UHF antenna greatly improved the upper-level data reception at this site. It should also be noted that no baseline ground check was performed on the NPOL soundings prior to November 23rd 12 UTC due to the lack of adequate desiccant for the ground check system. The absence of this ground check did not appear to adversely impact the quality of the NPOL thermodynamic data. More

information about these missing data are available in the Quality-Control of Upper-Air Soundings for OLYMPEX document.

References

National Weather Service: Upper Air. https://www.weather.gov/epz/upperair

National Weather Service (2010): Operations and Services Upper Air Program NWSPD 10-14 Rawinsonde Observations. http://www.nws.noaa.gov/directives/sym/pd01014001curr.pdf

NWS Observing Systems Branch (2012): Upper Air Data Continuity Study Test Plan for the Sippican B2 and Vaisala RS92 NGP Radiosondes. http://www.nws.noaa.gov/ops2/ops22/sfsc%20html/DCS%20Test%20Plan%20with%20Attachments.pdf

Vaisala (2015): Vaisala Radiosonde RS92-SGP User's Guide. https://www.vaisala.com/sites/default/files/documents/Vaisala%20Radiosonde%20RS92%20Users%20Guide_M210295EN-J.pdf

Related Data

The dropsonde data from the DC-8 are published as the AVAPS OLYMPEX dataset: GPM Ground Validation Advanced Vertical Atmospheric Profiling System (AVAPS) OLYMPEX (http://dx.doi.org/10.5067/GPMGV/OLYMPEX/AVAPS/DATA101). This dataset contains raw and minimally processed data files. The level 4 data files included here have been quality corrected and reformatted to match the radiosonde data format.

Contact Information

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

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