



Data User Guide

GPM Ground Validation High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) OLYMPEX

Introduction

The GPM Ground Validation High-Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) OLYMPEX dataset was collected from November 10, 2015 to December 12, 2015 during the GPM Ground Validation Olympic Mountains Experiment (OLYMPEX) field campaign, which was held in the Pacific Northwest. HIWRAP is a Doppler radar that combines conical scan mode measurements at two different frequency bands (Ka- and Ku-band) and two different incidence angles (30 and 40 degrees). HIWRAP was flown on the NASA ER2 during OLYMPEX. These Level 1B HIWRAP data files are provided in netCDF-3 format and contain radar reflectivity and Doppler velocity profiles along with aircraft attitude and other navigation information.

Note: HIWRAP was flown on the ER2 aircraft as part of the Radar Definition Experiment (RADEX) a coordinated field campaign performed in conjunction with GPM GV OLYMPEX. HIWRAP data files have RADEX in the filename instead of OLYMPEX.

Citation

Heysmsfield, Gerald M and Lin Tian. 2016. GPM Ground Validation High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) OLYMPEX [indicate subset used]. Dataset available online from the NASA EOSDIS Global Hydrology Resource Center Distributed Active Archive Center, Huntsville, Alabama, U.S.A. doi: <http://dx.doi.org/10.5067/GPMGV/OLYMPEX/HIWRAP/DATA101>

Keywords:

GHRC, NASA, OLYMPEX, Washington, HIWRAP, ER-2, Doppler Velocity, Radar Reflectivity, Radial Velocity, Radar Backscatter, Radar Cross-Section, Return Power, Sensor Counts

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>)

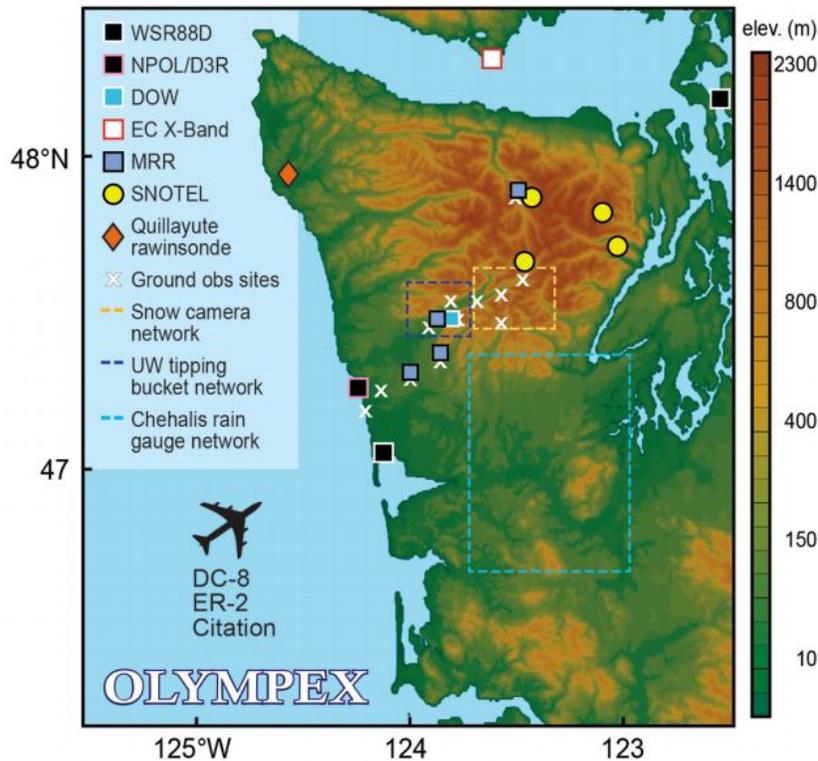


Figure 2: OLYMPEX Field Locations
 (Image Source: <https://pmm.nasa.gov/OLYMPEX>)

Instrument Description

The High Altitude Wind and Rain Airborne Profiler (HIWRAP) instrument is a Doppler radar designed to measure tropospheric winds through deriving Doppler profiles from cloud and precipitation volume backscatter. (Li et al. 2016). The winds are generated by combining conical scan mode measurements at two different frequency bands (Ka- and Ku-band) and two different incidence angles (30 and 40 degrees). HIWRAP utilizes solid state transmitters along with a novel pulse compression scheme resulting in a system that is considerably more compact and requires less power than typical radars used for precipitation and wind measurements. HIWRAP was originally designed to fly on the NASA Global Hawk, but was since modified to fly on the NASA ER-2 with a fixed nadir pointing configuration as part of RADEX, a field campaign coordinated with OLYMPEX designed to develop algorithms for the ACE Decadal Mission Ka-/W-band Doppler radar. A more detailed description of the HIWRAP system and system parameters can be found in Li et al., 2016. More information about HIWRAP can be found at the Goddard Space Flight Center High Altitude Radar Group: <https://har.gsfc.nasa.gov/index.php?section=13>.

Parameters	Specifications			
	Inner Beam		Outer Beam	
Frequency (GHz)	13.91	35.56	13.47	33.72
Tx Peak Power (W) *	25.0	8.0	25.0	8.0
Antenna Gain (dBi)	35.4	42.2	35.2	42.6
AZ 3 dB Beamwidth (°)	2.9	1.2	3.1	1.3
EL 3 dB Beamwidth (°)	3.0	1.2	2.9	1.2
Antenna Beams (°)	30.0		39.6	
Polarization	H		V	
Antenna Sidelobe (dB)	< -26.4	-27.2	< -23.2	- 26.6
PRF (Hz)	5000/4000 Dual PRF			
Pulsewidth (µs)	0-60			
Rx Bandwidth (MHz)	0-4, programmable			
Chirp Bandwidth (MHz)	0-4, programmable			
Dynamic Range (dB)	> 65			
Min. Detect. Reflectivity (dBZe, 150m range res., 10 km range, 20 µs/1 MHz chirp, 16 RPM scanning rate.)	7.8	1.5	7.8	1.5
Doppler Velocity (m/s)	0-110 (accuracy 1.5 m/s for SNR > 10)			
Scanning	Conical, 10-30 RPM			

*: The Ka-band was upgraded with a 45 W (peak power) SSPA after 2013. Upgrade on the Ku-band with an 80 W (peak power) SSPA is under way.

Figure 3: HIWRAP Specifications
(Image Source: Lihua Li et al., 2016)

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File Naming Convention

The GPM Ground Validation High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) OLYMPEX dataset files are Level-1B instrument data in netCDF-3 format, and have the following naming convention:

Data files: RADEX_HIWRAP_L1B_<start date>_<start time>-<end date>_<end time>_H##_dist_v01a.nc

Note that the files list RADEX as the field campaign instead of OLYMPEX as HIWRAP was flown on the ER-2 as part of the coordinated RADEX project for development of algorithms for ACE Decadal Mission Ka-/W-band Doppler radar.

Table 1: File naming convention variables

Variable	Description
<start date>	YYYYMMDD YYYY: Four-digit year MM: Two-digit month DD: Two-digit day
<start time>	hhmmss hh: Two-digit hour in UTC mm: Two-digit minute in UTC ss: Two-digit second in UTC
<end date>	YYYYMMDD YYYY: Four-digit year MM: Two-digit month DD: Two-digit day
<end time>	hhmmss hh: Two-digit hour in UTC mm: Two-digit minute in UTC ss: Two-digit second in UTC
H##	Either HKa or HKu (for the different frequency bands [Ka-band and Ku-band])
v##	Version number of dataset
.nc	netCDF-3 file format

Data Format Description

The GPM Ground Validation High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) OLYMPEX data are available in netCDF-3 format. The netCDF-3 files are L1B data files which contain calibrated reflectivity and Doppler velocity profiles along with aircraft attitude and other information. More info on NASA processing levels at <https://science.nasa.gov/earth-science/earth-science-data/data-processing-levels-for-eosdis-data-products/> No wind information is available in these files. Winds are derived from the calibrated doppler velocities and release in a higher level product.

Table 2: HIWRAP Data Characteristics

Characteristic	Description
Platform	NASA Earth Resources-2 (NASA ER-2)
Instrument	High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP)
Spatial Coverage	N: 48.8322, S:34.15762 , W: -130.0448, E: -117.7745 (Olympic Mountains/Washington state region)
Spatial Resolution	150 meter in vertical, 6 kilometers in horizontal, 1 km footprint
Temporal Coverage	Start date: November 10, 2015 Stop date: December 12, 2015
Temporal Resolution	Each file contains 30 to 60 minutes with some overlap
Parameter	Radar Reflectivity, Doppler Velocity
Version	1a
Processing Level	1B

Data Parameters

The GPM Ground Validation High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) OLYMPEX dataset consists of radar reflectivity and Doppler velocity measurements along with aircraft attitude and other information. Table 3 shows gives a description, data type, and unit for each parameter provided in the data files.

Table 3: Data Fields in the HIWRAP netCDF-3 data files

Field Name	Description	Data Type	Unit
altitude	Aircraft altitude	float	m
dopcorr	ka/ku Doppler velocity after correct for aircraft motion and folding	float	ms ⁻¹
evel	East aircraft ground speed	float	ms ⁻¹
gatesp	Radar range gate	float	m
gspeed	Aircraft ground speed	float	ms ⁻¹
head	Aircraft heading	float	°
incid	Incidence angle from nadir	float	°
lat	GPS aircraft latitude Minus sign = south	float	°
ldr	ka Linear Depolarization Ratio	float	dB
lon	GPS aircraft longitude Minus sign = west	float	°
missing	Missing value	float	-
noise_db	Noise estimate for each profile	float	dB
nvel	North aircraft ground speed	float	ms ⁻¹
pitch	Aircraft pitch angle	float	°
pku	Power	float	mm ⁶ m ⁻³
range	Range from radar	float	m
roll	Aircraft roll angle	float	°
rot	Antenna rotation angle	float	°
sigm0	Surface sigma0 (backscatter)	float	dB
surfvel	Surface Doppler Velocity	float	ms ⁻¹
tilt	Nominal tilt angle	float	°
timed	UTC time	float	hour
track	Aircraft track angle	float	°
vacft	Estimate of aircraft Doppler component	float	ms ⁻¹
wlku	Wavelength length of radar	float	m
wvel	Aircraft vertical speed	float	ms ⁻¹
year	Year the data was collected	short	-
zku	ka/ku radar reflectivity	float	dBZ

Quality Assessment

The HIWRAP instrument is calibrated in three steps: using parameters of individual components to calibrate the system, using the return of the ocean surface as an external

reference, and calibrating the system internally using a pulse-by-pulse calibration while processing post-flight data. To maintain high temporal and spatial resolutions, the transceiver supports simultaneous operation at the two center frequencies for each band so they align with one of the two incident angles. HIWRAP is externally calibrated at Ku-band to TRMM 10 deg incidence angle values. Ka-band data are then tied to Ku-band. More information is available at Li et al., 2016. HIWRAP Ku-band linear depolarization ratio data experienced radio frequency interference from the ground-based D3R radar much of the time

Software

No software is needed to view the GPM Ground Validation High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) OLYMPEX dataset; however, [Panoply](#) can be used to easily view the data.

Known Issues or Missing Data

During OLYMPEX, HIWRAP Ku-band linear depolarization ratio data experienced radio frequency interference from the ground-based D3R radar much of the time. Within each data file, there is a variable named 'missing', which indicates missing values within the data.

References

Heymsfield G.M., L. Tian,, A. Heymsfield, L. Li., and S. Guimond, 2010, Characteristics of Deep Tropical and Subtropical Convection from Nadir-viewing High-altitude Airborne Doppler Radar, *J. Atmos. Sc*, 67(2), 285-308.

Li, L. et al., 2016, The NASA High-Altitude Imaging Wind and Rain Airborne Profiler, *IEEE Transactions on Geoscience and Remote Sensing*, 54(1), 298-310, <https://doi.org/10.1109/TGRS.2015.2456501>

Li, L., G.M. Heymsfield, J. Carswell, D. Schaubert, M. McLinden, M. Vega, M. Perrine, 2011, Development of the NASA High-Altitude Imaging Wind and Rain Airborne Profiler, presented at IEEE Aerospace Conference, <https://doi.org/10.1109/AERO.2011.5747415>

Related Data

All data from other instruments collected during the OLYMPEX field campaign are related to this HIWRAP dataset. Other OLYMPEX campaign data can be located using HyDRO with the search term OLYMPEX.

In addition, the HIWRAP instrument was flown in previous GPM Ground Validation and Hurricane Science field campaigns. The following datasets are HIWRAP data from other field campaigns:

GPM Ground Validation High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP)
IPHEX (<http://dx.doi.org/10.5067/GPMGV/IPHEX/HIWRAP/DATA101>)

GPM Ground Validation High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP)
MC3E (<http://dx.doi.org/10.5067/GPMGV/MC3E/HIWRAP/DATA101>)

GRIP High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP)
(<http://dx.doi.org/10.5067/GRIP/HIWRAP/DATA101>)

Hurricane and Severe Storm Sentinel (**HS3**) High-altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) (<http://dx.doi.org/10.5067/HS3/HIWRAP/DATA101>)

Contact Information

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

NASA Global Hydrology Resource Center DAAC

User Services

E-mail: support-ghrc@earthdata.nasa.gov

Web: <https://ghrc.nsstc.nasa.gov/>

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Created: May 16, 2017