Global Hydrology Resource Center

Data User Guide

GPM Ground Validation Cloud Radar System (CRS) OLYMPEX

Introduction

The GPM Ground Validation Cloud Radar System (CRS) OLYMPEX dataset provides radar reflectivity and Doppler velocity data collected during the Olympic Mountain Experiment (OLYMPEX). This dataset is used to estimate cloud droplet distribution for the storms monitored during the field campaign. The CRS instrument is a 94GHz W-band Doppler radar with a 3mm wavelength. CRS can be deployed as both an airborne instrument onboard NASA's high-altitude science aircraft, the Earth Resource 2 (ER-2), as well as a ground based radar system. Only the airborne mode was used during OLYMPEX. In addition to reflectivity and Doppler velocity, the data files include aircraft flight information. The CRS was flown on 10 different days between November 10, 2015 and December 10, 2015. Each data file contains one hour of flight measurements during flight in UTC time. Files for this dataset are in netCDF-3 format and readily accessible without the need of specialized software.

Citation

Heymsfield, Gerald M. and Lin Tian. 2017. GPM Ground Validation Cloud Radar System (CRS) 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/CRS/DATA101

Keywords:

NASA, GHRC, GPM, OLYMPEX, radar, W-band, radar reflectivity, Doppler velocity, mean radial velocity, radar backscatter, radar cross-section, return power, radar imagery, precipitation, clouds, cloud droplet distribution

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, several 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)

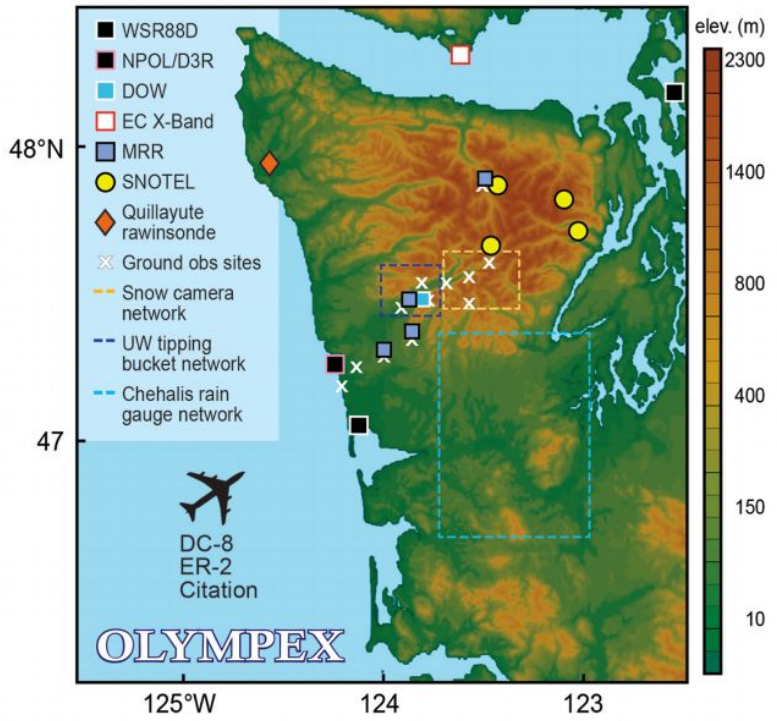

Figure 2: OLYMPEX Field Locations
(Image Source: https://pmm.nasa.gov/OLYMPEX)

Instrument Description

The Cloud Radar System (CRS) is a 94 GHz, W-band Doppler radar at 3 millimeter wavelength developed for autonomous operation in the NASA Earth Resources 2 (ER-2) high-altitude science aircraft and also for ground-based operation. It provides high-resolution profiles of reflectivity and Doppler velocity in clouds and has important applications to atmospheric remote sensing studies. The CRS was designed to fly with the Cloud Lidar System (CLS) in the tailcone of the ER-2 superpod (Figure 3). There are two basic modes of operation of the CRS: (1) ER-2 mode, with reflectivity, Doppler, and linear-depolarization measurements and (2) ground-based mode, with full polarimetric capability. The ER-2 mode was used during the OLYMPEX campaign and collected high-resolution profiles of reflectivity and Doppler velocity at aircraft nadir with an average radar range of one kilometer (1 km). Specification of the CRS radar instrument is outlined in Table 1.

Table 1: Instrument Characteristics

Characteristic	Value
Frequency	94.15 GHz
Instrument	Cloud Radar System (94.15 GHz W-band 3mm airborne Doppler radar)
Transmitter Type	Solid-State Power Amplifier (SSPA)

Peak Power	30 Watts
Beam Width	0.46 degrees
Pulse Repetition Frequency	Low: 3571 Hz; High: 4464 Hz
Range Resolution	75 meters
Gate Spacing	37.5 meters

For more information about NASA's high altitude cloud radar system, refer to NASA's airborne science website describing the science data collected by CRS https://airbornescience.nasa.gov/instrument/CRS and the original paper describing the radar system in detail (https://doi.org/10.1175/1520-0426(2004)021<1378:AGCRSO>2.0.CO;2).

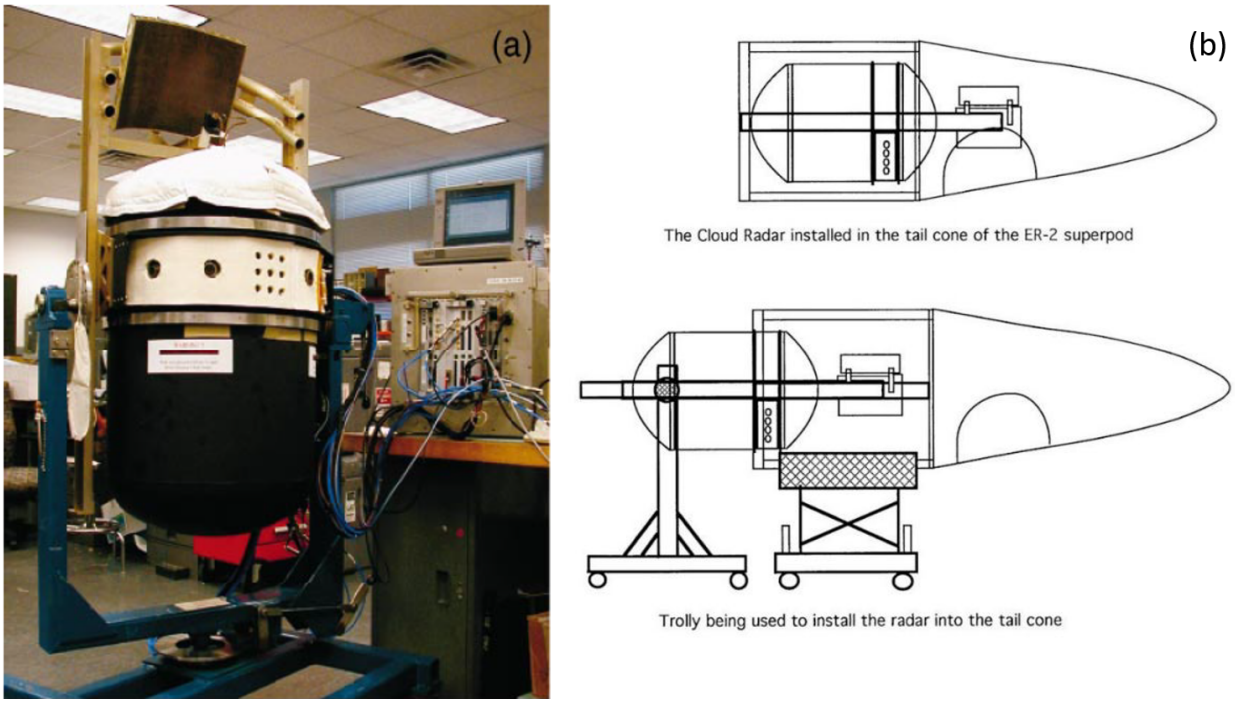

Figure 3: (a) CRS setup in laboratory with the airborne antenna configuration; (b) CRS configuration with airborne antenna in the tailcone of the ER-2 superpod. (Image Source: https://doi.org/10.1175/1520-0426(2004)021<1378:AGCRSO>2.0.CO;2)

Investigators

Gerry Heymsfield
NASA Goddard Space Flight Center
Greenbelt, Maryland

Lin Tian
Morgan State University / Goddard Space Flight Center
Baltimore, Maryland

Data Characteristics

The GPM Ground Validation Cloud Radar System (CRS) OLYMPEX radar data are available in netCDF-3 file format at level 1 processing level. More details regarding NASA's data processing levels can be found at this link. Table 2 outlines key dataset characteristics about the the CRS data.

Table 2: Data Characteristics

Characteristic	Description
Platform	Earth Resource 2 (ER-2)
Instrument	Cloud Radar System (94.15 GHz W-band 3mm airborne Doppler radar)
Projection	N/A
Spatial Coverage	N: 49.634, S: 34.158, E: -129.328, W: -117.774 (Olympics Mountain Range, Washington)
Spatial Resolution	1 km radar range; footprint ~0.16 km at 20 km altitude
Temporal Coverage	November 10, 2015 - December 10, 2015
Temporal Resolution	One file is created per hour of operation while in flight (may overlap GMT day)
Sampling Frequency	Pulse Repetition Frequency (PRF) when instrument is operating (Low: 3571 Hz; High: 4464 Hz)
Parameter	Radar reflectivity, doppler velocity
Version	Version 1
Processing Level	Level 1B

File Naming Convention

The GPM Ground Validation Cloud Radar System (CRS) OLYMPEX dataset contains radar reflectivity and Doppler velocity profiles for cloud droplet distribution as well as aircraft location and orientation information for the ER-2 airborne mode of CRS. The files in the dataset are organized per hour of flight operation, with several files per day that may overlap GMT days. The file naming convention provides the date and time of the profiles. Some missing data points are outlined in the Known Issues and Missing Data section below. Table 2 shows the file naming convention for the CRS OLYMPEX dataset.

Data files:

olympex_CRS_<start date>_<start time>-<end date>_<end time>_2_v<version number>.nc

Table 3: File naming convention variables for data files

Variable	Description
<start date> <end date>	Start/End date in YYYYMMDD where, YYYY: Four-digit year

	MM: Four-digit month DD: Four-digit day
<start time> <end time>	Start/End time of measurement in UTC in hhmmss where, hh: two-digit hour mm: two-digit minute ss: two-digit second
v<version number>	Dataset version number. The CRS data collected during OLYMPEX is all version 01a
.nc	netCDF-3 file extension

Data Format and Parameters

The GPM Ground Validation Cloud Radar System (CRS) OLYMPEX radar dataset contains radar reflectivity and Doppler velocity collected during flight operations from the ER-2 high altitude science aircraft. Each data file also provides flight information such as aircraft altitude, orientation, and GPS location. The Doppler velocity field values (doppcorr) are CRS Doppler velocity measurements after correction for the motion and orientation of the aircraft. Table 4 provides additional information about each data field.

Table 4: Data Fields

Field Name	Description	Data Type	Unit
altitude	Aircraft altitude at measurement	float	meters
doppcorr	CRS Doppler Velocity after correction for aircraft motion and folding	float	meters per second
evel	East aircraft ground speed	float	meters per second
gatesp	Gate range of CRS radar	float	meters
gspeed	Ground speed of aircraft	float	meters per second
head	Azimuth heading of aircraft	float	degrees
incid	Incidence angle of radar from aircraft nadir	float	degrees
lat	GPS latitude of aircraft (Note: negative sign means south)	float	degrees
ldr	CRS Linear Depolarization Ratio (LDR)	float	dB
lon	GPS longitude of aircraft (Note: negative sign means West)	float	degrees
missing	Missing value in dataset	float	None
noise_db	Noise estimate for each profile measurement	float	dB
nvel	North aircraft ground speed	float	meters per second
pitch	Pitch angle of aircraft orientation	float	degrees
pku	Power	float	mm6/m3
range	Range from radar	float	meters
roll	Roll angle of aircraft orientation	float	degrees
rot	Antenna rotation angle	float	degrees
sigm0	Surface sigma naught	float	dB
surfvel	Doppler velocity at surface	float	meters per second
tilt	Nominal tilt angle	float	degrees
timed	UTC time of measurement	float	hour

track	Track angle of aircraft	float	degree
vacft	Estimated Doppler component of aircraft	float	meters per second
wlku	Wavelength length of radar	float	meters
wvel	Vertical speed of aircraft	float	meters per second
year	Year the data was collected	short	Year
zku	CRS radar reflectivity	float	dBZ

Software

This dataset is in netCDF-3 format and does not require any specific software to read. However, the data is easily readable and viewed in Panoply.

Known Issues or Missing Data

There are several instances of missing data caused by hardware or calibration issues during the OLYMPEX CRS flights. All instances of missing data are flagged in the data files under the "Missing" field name. The PI provides a detailed radar flight summary in Heymsfield, 2017.

ER-2 Radar Flight Summary

Date	Description	ER-2	EXRAD	HIWRAP	CRS	Issues
10-Nov-16	Ridge condition with little precip over mountains		Y	Y	Y	
18-Nov-16	Shallow post-frontal convection with an overrrunning altostatus ice layer	1759-0033	N	Y	Y	CRS: Missing data in the middle of the flight due to datasystem overheating.
23-Nov-16	Wide zone of precip in an approaching weak trough and collapsing frontal system	1402-2214	Y	Y	Y	
24-Nov-16	Part 2 of dying frontal system, weak snow at hurriane ridge, postfrontal clouds	1508-2216	N	Y	Y	CRS: navigation file corrupted, low resol. aircraft nav used.
1-Dec-16	Weak trough and front with extensive stratiform modified by topography	2103-0208	Y	Y	Y	
3-Dec-16	Complex baroclinic system with orographically enhanced rain & GPM overpass	1408-1733	Y	Y	Y	
4-Dec-16	Post frontal convection over the ocean and mountains	1305-2006	N	Y	Y	Calibration change (~10 dBZ) after ~18:00
5-Dec-16	Broad frontal cloud system with strong wind shear	1359-1757	Y	Y	Y	Lose cable, occasional stripes
8-Dec-16	Orographic enhancement of an "Atmospheric River"	1827-~0030	Y	Y	Y	Lose cable
10-Dec-16	Occlulded front and post-frontal convection	1434-1702	N	Y	Y	Lose cable
12-Dec-16	Precipitation associated with an occluded front and warm sector	1800-2206	Y	Y	N	CRS canister lost pressure; inoperative
13-Dec-16	Convection following the passage of an occlusion	1603-0002	N	Y	N	CRS pressure issues.

Figure 4: Slide 3 from PI presentation outlining ER-2 flight operations and recorded hardware/software issues. Image source: Heymsfield, 2017.

Quality Assessment

Both internal and external calibration methods are used on the GPM Ground Validation Cloud Radar System (CRS) OLYMPEX data. Radar calibration helps to minimize erroneous reflectivity measurements and the distinction between different sizes of water vapor and cloud properties. The external calibration of the CRS W-band relies on the Tropical Rainfall Measuring Mission (TRMM) Ku-band radar as base reflectivity values. An internal calibration of the CRS receiving system is periodically injected for each radar pulse during OLYMPEX flights with in-flight temperature and aircraft location/orientation data. This information is used to process the corrected Doppler velocity measurements. For more information about the calibration methods, please refer to the PI presentation and Li et al., 2004.

References

Heymsfield, G. (2017): ER-2 Radars During RADEX/OLYMEX. Retrieved from http://olympex.atmos.washington.edu/presentations/2017/170321Seattle_OLYworkshop_HeymsfieldG.pptx

Li, L., Heymsfield, G., Carswell, J., Schaubert, D. H., McLinden, M. L., Creticos, J., … Emory, A. (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., Heymsfield, G. M., Racette, P. E., Tian, L., & Zenker, E. (2004): A 94-GHz cloud radar system on a NASA high-altitude ER-2 aircraft. J*ournal of Atmospheric and Oceanic Technology*, 21(9), 1378–1388. https://doi.org/10.1175/1520-0426(2004)021<1378:AGCRSO>2.0.CO;2

Related Data

All data from other instruments collected during the OLYMPEX field campaign are related to this dataset. Other OLYMPEX campaign data can be located using the GHRC HyDRO 2.0 search tool. In particular, the ER-2 high-altitude science aircraft navigation data user guide is available for the OLYMPEX campaign flight sorties (http://dx.doi.org/10.5067/GPMGV/OLYMPEX/NAV/DATA201).

Additionally, the Cloud Radar System has been used in previous field campaigns, for example, the Integrated Precipitation and Hydrology Experiment (IPHEx) which also employed the ER-2 mode of NASA's Cloud Radar System (https://ghrc.nsstc.nasa.gov/hydro/details/gpmcrsiphx).

Contact Information

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

NASA Global Hydrology Resource Center DAAC
User Services
320 Sparkman Drive
Huntsville, AL 35805
Phone: 256-961-7932
E-mail: support-ghrc@earthdata.nasa.gov
Web: https://ghrc.nsstc.nasa.gov/

Created: November 14, 2017