Global Hydrology Resource Center

Data User Guide

GPM Ground Validation NOAA X-band Polarimetric Radar (NOXP) IPHEx

Introduction

The GPM Ground Validation NOAA X-band dual-Polarimetric radar (NOXP) IPHEx dataset consists of differential reflectivity, differential phase shift, co-polar cross correlation, radial Doppler velocity, spectrum width, signal index, melting layer index, reflectivity, drop size distribution, and rainfall rate observations, as well as other radar parameters, collected by NOXP mobile radar during the GPM Integrated Precipitation and Hydrology Experiment (IPHEx) field campaign. The IPHEx field campaign occurred in the Southern Appalachians, spanning into the Piedmont and Coastal Plain regions of North Carolina. The NOXP radar, operated by the NOAA National Severe Storm Laboratory (NSSL), was positioned in the Pigeon River basin of the Great Smoky Mountains of North Carolina. NOXP data are available in netCDF-3 format for dates between April 21, 2014 through June 15, 2014. The dataset includes weather condition photos taken at the NOXP radar site in JPG format.

Notice: It is requested that users refer to the National Oceanic and Atmospheric Administration's (NOAA) X-band Polarimetric Radar (NOXP) when using or presenting these data in any public or scientific forum including conferences, workshops, meetings, technical reports and publications. Use the digital object identifier (DOI) as an appropriate reference.

The NOXP data were created using algorithms developed at the National Observatory of Athens, Greece. Users are advised to cite the specific publication for algorithm components as listed in the 'Algorithm' section of this user guide provided below.

Further, third-parties that wish to make use of the U.S. Government works should be aware of the provisions of 17 U.S.C. § 403, in the event that the third-party claims copyright on the subsequent work. Section 403 encourages the Publisher to disclaim any copyright over U.S. Government works that are incorporated into larger works on which copyright is claimed.

Duplicating Analysis Methods in Order to Mimic the Dataset: Portions of the dataset were developed by the National Oceanic and Atmospheric Administration (NOAA), U.S.

Department of Commerce. For these portions, NOAA requests that users not duplicate analysis methods in order to mimic the dataset.

Excessive Revealing of Errors (related to this dataset) Without Communicating Findings to the Developers: Collaborators/Users are encouraged to communicate discovery of errors or other limitations of this dataset as means to constructively improve future product development.

Sharing these Data with Users Outside of the Intended Audience and Purpose: Users are requested not to share the data with other users, even within the same institute or group, without obtaining permission from the NASA data providers.

Holding the NSSL scientists liable for decisions, legal actions, or conclusions stemming from use of the datasets: The NOXP dataset is being provided in-kind for the advance of science and the NSSL and NASA scientists shall not be held liable for decisions made in the provision of the data. Moreover, these data are experimental and subject to revision as improvements to processing algorithms are continually being made.

Citation

Gourley, Jonathan J., Dave Jorgensen, Rob Cifelli, and Pierre Kirstetter. 2018. GPM Ground Validation NOAA X-band dual-Polarimetric Radar (NOXP) IPHEx [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/IPHEX/NOXP/DATA101

Keywords:

NOAA, NSSL, GHRC, GPM GV, IPHEx, North Carolina, X-band Radar, Polarimetric Radar, NOXP, Differential reflectivity, differential phase shift, co-polar cross correlation, radial Doppler velocity, spectrum width, signal index, melting layer index, reflectivity, drop size distribution, rainfall rate

Campaign

The GPM Ground Validation campaign used a variety of methods for validation of GPM satellite constellation measurements prior to and after launch on 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). These field campaigns accounted for the majority of the effort and resources expended by the GPM Ground Validation mission. More information about the GPM Ground Validation mission is available at https://pmm.nasa.gov/index.php?q=science/ground-validation.

One of the GPM Ground Validation field campaigns was the GPM IPHEx, which was held in North Carolina during 2014 with an intense study period from May 1 to June 15, 2014. The goal of the IPHEx campaign was to contribute to the development, evaluation, and improvement of remote sensing precipitation algorithms in support of the GPM mission through NASA GPM Ground Validation field campaign (IPHEX_GVFC) and the evaluation of Quantitative Precipitation Estimation (QPE) products for hydrological forecasting and water resource applications in the Upper Tennessee, Catawba-Santee, Yadkin-Pee Dee, and Savannah river basins (IPHEX-HAP, H4SE). NOAA Hydrometeorology Testbed (HTM) has synergy with this project. More information about IPHEx is available at http://gpm.nsstc.nasa.gov/iphex/.

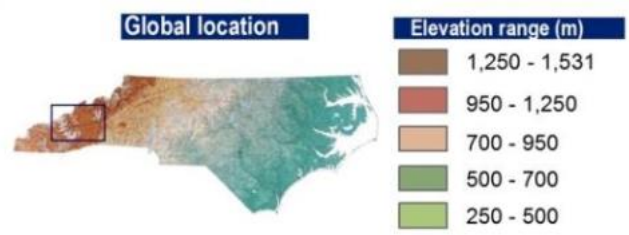

Figure 1: Region of North Carolina IPHEx campaign ground validation (image source: http://gpm-gv.gsfc.nasa.gov/Gauge/)

Instrument Description

The NOAA X-POL (NOXP) radar is a mobile dual-polarized X-Band Doppler radar developed and operated by the National Severe Storm Laboratory (NSSL). The Doppler radar instrument is mounted on a truck and for the IPHEx campaign was positioned in the Pigeon River basin of the Great Smoky Mountains of North Carolina. NOXP operates at a 3 cm wavelength (X-band, frequency 9410 MHz) that is more sensitive to smaller particles allowing for detection of tiny water droplets, light rain, and snow. The NOXP dual polarization signals (energy pulses with both vertical and horizontal orientations) provide additional details on the microphysics of storms, including precipitation size and density, as well as cloud particle shapes. The NOXP measurements and derived parameters include differential reflectivity, differential phase shift, co-polar cross correlation, radial Doppler velocity, spectrum width, signal index, melting layer index, reflectivity, drop size distribution, and rainfall rate observations, as well as other radar characteristics. More information about the NOXP radar can be located on the National Severe Storms Laboratory webpage and the references in the reference section below.

For IPHEx, the NOXP mobile radar truck was located on a ridge below the Chambers Mountain fire station near Clyde, and the center of the Pigeon River basin at an altitude of approximately 1000 m above mean sea level. The exact location is provided in Table 1. The scanning strategy for the radar was devised to meet the primary goal of generating basinwide measurements over the basin. A series of plan position indicator (PPI) surveillance scans in a modified volume coverage pattern (VCP) were used with the addition of a 0.18 tilt. PPI scans occur approximately every 5 minutes with a 20 sec gap

between scans. The spatial resolution is 1 deg by 75 m out to 100km at 15 elevation angles from 0.1deg to 19.5 deg. Given a pulse repetition frequency of 1350 s21, the radar data had an unambiguous range of 111 km. Unfortunately, the radar experienced severe blockage due to nearby trees and terrain at lower elevation angles from about 3308 to 1158 in azimuth. RHI scans were also made at irregular intervals in coordination with aircraft overflights and other radar operation. Details of instrument use in IPHEx are provided in Erlingis et al., 2018 and Porcacchia et al., 2017.

Figure 2: NSSL's NOXP mobile radar.
(Image Source: The National Severe Storms Laboratory)

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Data Characteristics

The GPM Ground Validation NOAA X-band Polarimetric Radar (NOXP) IPHEx data files are available in netCDF-3 format at a Level 2 data processing level. More information about the NASA data processing levels are available on the NASA Data Processing Levels website. Table 1 shows the characteristics of the data.

Table 1: Data Characteristics

Characteristic	Description
Platform	Ground station
Instrument	NOAA X-band Polarimetric Radar (NOXP)
Projection	n/a
Instrument Location	35.56149 degrees N, 82.91123 degrees W
Instrument Altitude	1,176 m above MSL
Spatial Coverage	N: 36.561, S: 34.567 E: -81.914, W: -83.908 (North Carolina)
Truck HD	5 degrees
Spatial Resolution	111 km
Temporal Coverage	April 21, 2014 - June 15, 2014
Temporal Resolution	5 minutes with a 20 second gap between each file
Sampling Frequency	<1 second
Parameters	Differential reflectivity, differential phase shift, co-polar cross correlation, radial Doppler velocity, Doppler spectrum width, signal index, melting layer index, reflectivity, drop size distribution, rainfall rate
Version	1
Processing Level	2

File Naming Convention

The GPM Ground Validation NOAA X-band Polarimetric Radar (NOXP) IPHEx dataset has the file naming convention shown below. These data are available in netCDF-3 format with photos that were taken at the NOXP radar site in JPG format.

Data files: iphex_[PPI|RHI]_YYYYMMDD_hhmmss_[el#|az###]_*.nc
Photo files: NOXP_Chambers_Mtn_[direction]_YYYYMMDD_hhmmss.jpg

Table 2: File naming convention variables

Variable	Description
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
hh	Two-digit hour in UTC for end time of PPI scan
mm	Two-digit minute in UTC for end time of PPI scan
ss	Two-digit second in UTC for end time of PPI scan
[el#|az###]_*	el#_*: elevation angle

	az###_*: azimuth angle
.nc	netCDF-3 data format
[direction]	Direction in which the camera was pointing for the image: towards Maggie Valley or a pan view
.jpg	JPG file format

Data Format and Parameters

The GPM Ground Validation NOAA X-band Polarimetric Radar (NOXP) IPHEx dataset consists of netCDF-3 data files containing Differential reflectivity, differential phase shift, co-polar cross correlation, radial Doppler velocity, spectrum width, signal index, melting layer index, reflectivity, drop size distribution, and rainfall rate observations, as well as other radar parameters, for the time period April 21, 2014 through June 15, 2014. Table 3 lists and describes these parameters in the data files.

Table 3: Data Fields

Field Name	Description	Data Type	Unit
Altitude	Radar altitude above mean sea level	float	m
AZ	Ray azimuth	float	degrees
BLK	Beam blockage by terrain 0: no blockage 1: complete blockage	short	-
D01	Median volume diameter of normalized Gamma drop size distribution	short	mm
D02	Median volume diameter of normalized Gamma drop size distribution	short	mm
Distance	Distance from radar on Earth surface	short	km
dZDR	Attenuation correction of differential reflectivity	short	dB
dZDRVPR	Vertical profile of reflectivity correction of differential reflectivity	short	dB
dZH	Attenuation correction of horizontal polarization reflectivity	short	dB
dZHVPR	Vertical profile of reflectivity correction of horizontal polarization reflectivity	short	dB
EL	Ray elevation	float	degrees
Height	Height above Earth surface above mean sea level	short	km
KDP	Measured preprocessed differential phase shift	short	degrees
KDPM	Modeled specific differential phase shift	short	degrees/km
Latitude	Radar latitude	float	degrees
Longitude	Radar longitude	float	degrees
m1	Shape parameter of normalized Gamma drop	short	-

	size distribution		
m2	Shape parameter of normalized Gamma drop size distribution	short	-
ML	Melting layer index 0 below detected melting layer 1 in detected melting layer 2 above detected melting layer	short	-
Nw1	Log10 of the intercept parameter of normalized Gamma drop size distribution	short	-
Nw2	Log10 of the intercept parameter of normalized Gamma drop size distribution	short	-
R1	Rainfall rate (not corrected for Vertical Profile of Rainfall)	short	mm/hr
R2	Rainfall rate (not corrected for Vertical Profile of Rainfall)	short	mm/hr
Range	Range from radar	short	km
RHOHV	Co-polar cross correlation	short	-
RVPR1	Vertical profile of rainfall rate correction	short	-
RCPR2	Vertical profile of rainfall rate correction	short	-
SIG	Signal index 1: good rain signal based on RHOHV, VR, and SVR Else, 0	short	-
SVR	Doppler spectrum width	short	m/s
time	Ray time	double	Fractional number of days from a fixed, preset date (January 0, 0000) in UTC
VR	Radial Doppler velocity	short	m/s
ZDR	Differential reflectivity (not corrected for attenuation or Vertical Profile of Reflectivity)	short	dB
ZH	Horizontal polarization reflectivity (not corrected for attenuation or Vertical Profile of Reflectivity)	short	dBZ

This dataset includes a collection of photos taken at the NOXP radar site on Chambers Mountain overlooking the Pigeon Basin during IPHEx in June 2014. They are divided into directories for each day the pictures were taken. The direction will be a rough compass direction (e.g. SSW = South-Southwest), or, if the direction is Maggie Valley, then the picture is centered on Maggie Valley, which was slightly north of SW. The middle corresponds to approximately the 255 degree radial of NOXP data. If the direction is pan, then this is a panorama roughly centered to the South (north was blocked by the mountain). No attempt was made for common repeat time of the pictures, instead they were taken, as possible, during radar operation.

Algorithm

The derived data parameters were obtained using algorithms developed at the National Observatory of Athens, Greece. Below is a summary of the publications that should be cited for each of the algorithm components. Full references are listed in the reference section below.

VPR and bright band correction component:

Kalogiros, et al., 2013: Correction of Polarimetric Radar Reflectivity Measurements and Rainfall Estimates for Apparent Vertical Profile in Stratiform Rain. http://dx.doi.org/10.1175.JAMC-D-12-0140.1

Attenuation correction component:

Kalogiros,et al., 2013: Evaluation of a new Polarimetric Algorithm for Rain-Path Attenuation Correction of X-Band Radar Observations Against Disdrometer Data, http://dx.doi.org/10.1109/TGRS.2013.2250979

DSD parameter and rainfall estimation components:

Kalogiros, et al., 2013: Optimum Estimation of Rain Microphysical Parameters from X-Band Dual-Polarization Radar Observables, http://dx.doi.org/10.1109/TGRS.2012.2211606

Anagnostou, et al., 2013: Performance Evaluation of a New Dual-Polarization Microphysical Algorithm Based on Long-Term X-Band Radar and Disdrometer Observations. http://dx.doi.org/10.1175/JHM-D-12-057.1

Quality Assessment

Attenuation corrections were made and are included in these data. Table 4 lists each data field what have been corrected/quality-controlled.

Table 4: Corrected/Quality-Controlled Data Fields

Field Name	Description	Data Type	Unit
dZDR	Attenuation correction of differential reflectivity	short	dB
dZDRVPR	Vertical profile of reflectivity correction of differential reflectivity	short	dB
dZH	Attenuation correction of horizontal polarization reflectivity	short	dB
dZHVPR	Vertical profile of reflectivity correction of horizontal polarization reflectivity	short	dB
RVPR1	Vertical profile of rainfall rate correction	short	-
RCPR2	Vertical profile of rainfall rate correction	short	-

Comparisons with nearby disdrometer data and comparisons with other precipitation products are reported in Erlingis et al., 2018.

Software

These data are available in netCDF-3 format, so no software is required. Panoply can be used to easily view the netCDF data file contents.

References

Erlingis, J. M., Jonathan J. Gourley, Pierre-Emmanuel Kirstetter, Emmanouil N. Anagnostou, John Kalogiro, et al. (2018): Evaluation of Operational and Experimental Precipitation Algorithms and Microphysical Insights during IPHEx, *Journal of Hydrometeorology*, 19, 113-125. doi: https://doi.org/10.1175/JHM-D-17-0080.1

Kalogiros, J., M. N. Anagnostou, E. N. Anagnostou, Mario Montopoli, Errico Picciotti, and Frank S. Marzano (2013): Correction of Polarimetric Radar Reflectivity Measurements and Rainfall Estimates for Apparent Vertical Profile in Stratiform Rain. *J. Appl. Meteor. Climatol.*, 52, 1170-1186. doi: http://dx.doi.org/10.1175/JAMC-D-12-0140.1

Kalogiros, J., M. N. Anagnostou, E. N. Anagnostou, M. Montopoli, E. Picciotti, and F. S. Marzano (2013): Evaluation of a new Polarimetric Algorithm for Rain-Path Attenuation Correction of X-Band Radar Observations Against Disdrometer, *IEEE Transactions of Geoscience and Remote Sensing*, 52:2, 1369-1380. doi: http://dx.doi.org/10.1109/TGRS.2013.2250979

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Porcacchia, L., P.E. Kirstetter, J.J. Gourley, V. Maggioni, B.L. Cheong, and M.N. Anagnostou (2017): Toward a Polarimetric Radar Classification Scheme for Coalescence-Dominant Precipitation: Application to Complex Terrain. *J. Hydrometeor.*, 18, 3199–3215. doi: https://doi.org/10.1175/JHM-D-17-0016.1

Related Data

All data from other instruments collected during the IPHEx field campaign are related to this dataset. Other IPHEx campaign data can be located using the GHRC HyDRO 2.0 search tool using the search term 'IPHEx'.

All raw sigmet-formatted PPIs and RHIs are available by request by sending an email to jj.gourley@noaa.gov.

Contact Information

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

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