Data User Guide

High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) IMPACTS

Introduction

The High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) IMPACTS dataset consists of Equivalent reflectivity factor, Doppler velocity, Doppler velocity spectrum width, Linear Depolarization Ratio (LDR), Ocean normalized radar cross-section, Co-polarization signal-to-noise mask estimates collected by the HIWRAP onboard the NASA ER-2 aircraft during the Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) field campaign. IMPACTS was a three-year sequence of winter season deployments conducted to study snowstorms over the U.S. Atlantic coast. IMPACTS aimed to (1) Provide observations critical to understanding the mechanisms of snowband formation, organization, and evolution; (2) Examine how the microphysical characteristics and likely growth mechanisms of snow particles vary across snowbands; and (3) Improve snowfall remote sensing interpretation and modeling to significantly advance prediction capabilities. These data are available from January 25, 2020, through February 28, 2023, in HDF-5 format.

Notice:
This dataset is not continuous as flights did not occur every day.

Citation

Li, Lihua, Matthew McLinden, and Gerald Heymsfield. 2020. High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) IMPACTS [indicate subset used]. Dataset available online from the NASA Global Hydrometeorology Resource Center DAAC, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/IMPACTS/HIWRAP/DATA101

Keywords:

NASA, GHRC, IMPACTS, HIWRAP, ER-2, Equivalent reflectivity factor, Doppler velocity, Doppler velocity spectrum width, Linear Depolarization Ratio (LDR), Ocean normalized radar cross-section, Co-polarization signal-to-noise mask

Campaign

The Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS), funded by NASA's Earth Venture program, is the first comprehensive study of East Coast snowstorms in 30 years. IMPACTS will fly a complementary suite of remote sensing and in-situ instruments for three 6-week deployments (2020-2023) on NASA's ER-2 high-altitude aircraft and P-3 cloud-sampling aircraft. The first deployment began on January 17, 2020, and ended on March 1, 2020. IMPACTS samples U.S. East Coast winter storms using advanced radar, LiDAR, and microwave radiometer remote sensing instruments on the ER-2 and state-of-the-art microphysics probes and dropsonde capabilities on the P-3, augmented by ground-based radar and rawinsonde data, multiple NASA and NOAA satellites (including GPM, GOES-16, and other polar-orbiting satellite systems), and computer simulations. IMPACTS addressed three specific objectives: (1) Provide observations critical to understanding the mechanisms of snowband formation, organization, and evolution; (2) Examine how the microphysical characteristics and likely growth mechanisms of snow particles vary across snowbands; and (3) Improve snowfall remote sensing interpretation and modeling to significantly advance prediction capabilities. More information is available from NASA's Earth Science Project Office's IMPACTS field campaign webpage.

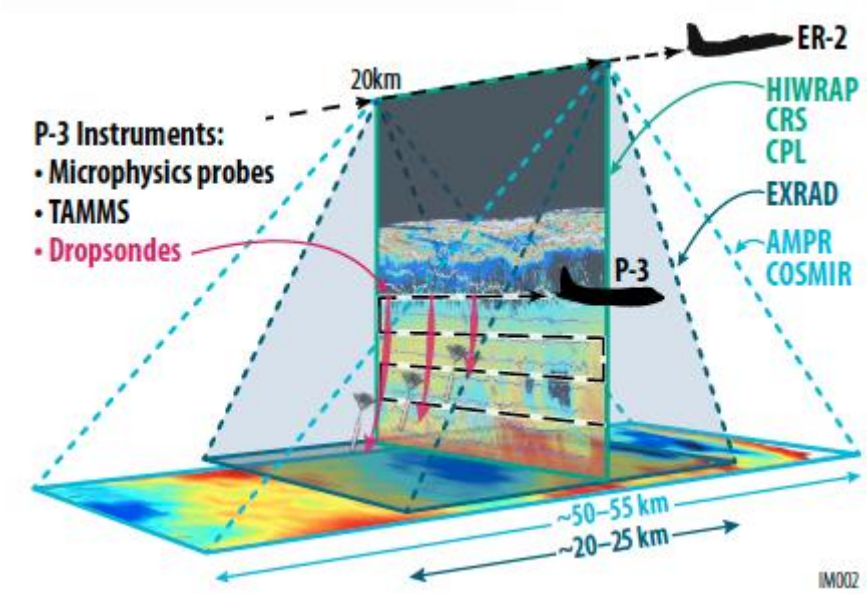

Figure 1: IMPACTS airborne instrument suite
(Image source: NASA IMPACTS ESPO)

Instrument Description

The High Altitude Wind and Rain Airborne Profiler (HIWRAP) instrument is a Doppler radar designed to measure tropospheric winds by 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. 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: High-altitude Radar: HIWRAP.

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)

Investigators

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Data Characteristics

The High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) IMPACTS data are available in HDF-5 format at a Level 1B data processing level. More information about the NASA data processing levels are available on the EOSDIS Data Processing Levels webpage. The characteristics of this dataset are listed in Table 1 below.

Table 1: Data Characteristics

Characteristic	Description
Platform	NASA Earth Resources 2 (ER-2) aircraft
Instrument	High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP)
Spatial Coverage	N: 48.657, S: 31.072, E: -64.893, W: -95.460 (United States of America)
Spatial Resolution	150 meter in vertical, 6 kilometers in horizontal, 1 km footprint
Temporal Coverage	January 25, 2020 - February 28, 2023
Temporal Resolution	1 file per flight
Sampling Frequency	0.05 seconds
Parameter	Equivalent reflectivity factor, Doppler velocity, Doppler velocity spectrum width, Linear Depolarization Ratio (LDR), Ocean normalized radar cross section, Co-polarization signal-to-noise mask
Version	1
Processing Level	1B

File Naming Convention

The High Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) IMPACTS dataset files are available in HDF-5 format and are named using the following convention:

Data files: IMPACTS_HIWRAP_L1B_RevC_YYYYMMDD.h5

Table 2: File naming convention variables

Variable	Description
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
.h5	HDF-5 format

Data Format and Parameters

The HIWRAP IMPACTS data files are in HDF-5 format. There are 15 data fields, including vector components of electric fields and aircraft parameters, in each data file (Table 3).

Table 3: Data Fields for HIWRAP HDF-5 files

Field Name	Description	Unit
/Information - General Information		
Aircraft	Aircraft: NASA ER-2	-
DataContact	Data Contact: Matthew L. Walker McLinden ('matthew.l.mclinden@nasa.gov')	-
ExperimentName	Experiment name: IMPACTS2020	-
FlightDate	Flight date	-
InstrumentPI	Instrument PI: Lihua Li, NASA/GSFC	-
L1A_ProcessDate	L1A File Process Date	-
L1B_ProcessDate	L1B File Process Date	-
L1B_Revision	L1B Revision	-
L1B_Revision_Note	L1B Revision Note	-
MissionPI	Mission PI: Lynn McMurdie, University of Washington	-
RadarName	Radar Name: HIWRAP	-
/Time/Data - Time Data		
TimeUTC	UTC profile time in Unix Epoch format (seconds since 1970). Obtained from aircraft NTP. Note that HIWRAP produces a profile every 0.5 seconds, but profiles are overlapping. See the ResolutionHorizontal16dB field for horizontal resolution.	seconds
/Time/Information - Time Information		
TimeUTC_01Jan2020	Time of 0 UTC, January 1, 2020, for reference if the user does not have an easy Linux time converter.	seconds
TimeUTC_01Jan2020_description	Description for TimeUTC_01Jan2020 variable	-
TimeUTC_description	Description for TimeUTC variable	-
TimeUTC_units	Units for TimeUTC variable	-
/Products/Information - Radar Product Information		
AircraftMotion	Estimated aircraft motion in the direction of the beam that has been subtracted from the Doppler estimate.	m/s
AircraftMotion_description	Description for AircraftMotion variable	-
AircraftMotion_units	Units for AircraftMotion variable	-
AntennaSize	Antenna Diameter (0.5 meters)	meters
AntennaSize_description	Description for AntennaSize variable	-
AntennaSize_units	Units for AntennaSize variable	-
GateSpacing	Range gate spacing (26.25 meters)	meters
GateSpacing_description	Description for GateSpacing variable	-

GateSpacing_units	Units for GateSpacing variable	-
HRRR_AlongWind	HRRR Along Wind	-
HRRR_AlongWind_description	Description for HRRR_AlongWind variable	-
HRRR_AlongWind_units	Units for HRRR_AlongWind variable	-
HRRR_CrossWind	HRRR Cross Wind	-
HRRR_CrossWind_description	Description for HRRR_CrossWind variable	-
HRRR_CrossWind_units	Units for HRRR_CrossWind variable	-
NominalAntennaPointing	Nominal antenna pointing	-
PRI	Description of the pulse repetition interval: 224 μs/280 μs staggered	-
PRI_description	Description for PRI variable	-
PRI_units	Units for PRI variable	-
Range	Range in meters from the aircraft of each range gate	meters
Range_description	Description for Range variable	-
Range_units	Units for Range variable	-
/Products/Ka|Ku/Information - Radar Product Information (Ka/Ku specific)		
AntennaBeamWidth	Antenna beam width	meters
AntennaBeamWidth_description	Description for AntennaBeamWidth variable	-
AntennaBeamWidth_units	Units for AntennaBeamWidth variable	-
AveragedPulses	Averaged pulses	-
AveragedPulses_description	Description for AveragedPulses	-
AveragedPulses_units	Units for AveragedPulses	-
Frequency	Radar frequency (35.56 GHz Ka, 13.91GHz Ku)	Hz
Frequency_description	Description for frequency variable	-
Frequency_units	Units for frequency variable	-
ResolutionHorizontal6dB	Approximate horizontal resolution defined as the -6 dB width of spatial weighting as a function of range based on the antenna pattern and horizontal averaging.	meters
ResolutionHorizontal6dB_description	Description for ResolutionHorizontal6dB variable	-
ResolutionHorizontal6dB_units	Units for ResolutionHorizontal6dB	-
Wavelength	wavelength	u
Wavelength_description	Description for Wavelength variable	-
Wavelength_units	Units for Wavelength variable	-

/Products/Ka|Ku/Chirp|Combined|HighResPulse|LowResPulse/Data - Radar Product Data (Pulse-type specific)		
dBZe	dbZe	Hz
LDR	LDR	-
sigma0	sigma0	-
SpectrumWidth	Spectrum width	u
Valocity_corrected	Velocity corrected	m/s
Velocity_uncorrected	Velocity uncorrected	m/s
/Products/Ka|Ku/Chirp|Combined|HighResPulse|LowResPulse/Information - Radar Product Information (Pulse-type specific)		
dBZe_description	Description for dBZe variable	-
dBZe_units	Units for dBZe variable	-
MaskCoPol (not for combined data)	Co-polarization signal-to-noise mask. (Mask >= N) corresponds with (SNR > N-sigma) noise thresholding.	-
ChannelMask (combined data only)	Mask indicating which channel each range/time is using. 1: low resolution pulse 2: high resolution pulse 3: chirp This field can be used to investigate/detect any potential image artifacts associated with the combining algorithm.	-
ChannelMask_description	Description for ChannelMask variable	-
LDR_description	Description for LDR variable	-
LDR_units	Units for LDR variable	-
MaskCoPol_description	Description for MaskCoPol variable	-
MaskCoPol_units	Units for MaskCoPol variable	-
sigma0_description	Description for sigma0 variable	-
sigma0_units	Units for sigma0 variable	-
SpectrumWidth_description	Description for SpectrumWidth variable	-
SpectrumWidth_units	Units for SpectrumWidth variable	-
Velocity_beam_angle_offset	Velocity beam angle offset	degrees
Velocity_beam_angle_offset_description	Description for Velocity_beam_angle_offset variable	-
Velocity_beam_angle_offset_units	Units for Velocity_beam_angle_offset variable	-
Velocity_corrected_description	Description for Velocity_corrected variable	-
Velocity_corrected_units	Units for Velocity_corrected	-

Velocity_horizontal_offset	Velocity horizontal offset	m/s
Velocity_horizontal_offset_description	Description for Velocity_horizontal_offset variable	-
Velocity_horizontal_offset_units	Units for Velocity_horizontal_offset variable	-
Velocity_uncorrected_description	Description for Velocity_uncorrected variable	-
Velocity_uncorrected_units	Units for Velocity_uncorrected variable	-
/Navigation/Data - Navigation Data		
Drift	Difference between track and heading	degrees
EastVelocity	Eastward portion of velocity	m/s
Heading	Aircraft heading in degrees from north. 90 degrees is Eastward.	degrees
Height	Aircraft height above sea level	meters
Latitude	Latitude	degrees
Longitude	Longitude	degrees
NominalDistance	Nominal total along-track distance calculated by integrating instantaneous velocity. Used for simple plotting.	meters
NorthVelocity	Northward portion of velocity	m/s
Pitch	Pitch	degrees
Roll	Roll	degrees
Track	Direction of motion in degrees from north. 90 degrees is Eastward motion.	degrees
UpVelocity	Upward velocity	m/s
dxdr	Data cross-track distance from aircraft per radar range. Positive is in the starboard direction.	m/m
dydr	Data along-track distance from aircraft per radar range. Positive is in the forward direction.	m/m
dzdr	Data vertical distance from the aircraft per radar range. Positive is in the upward direction.	m/m
/Navigation/Information - Navigation Information		
Drift_description	Description for Drift variable	-
Drift_units	Units for Drift variable	-
EastVelocity_description	Description for EastVelocity variable	-
EastVelocity_units	Units for EastVelocity variable	-
Heading_description	Description for Heading variable	-
Heading_units	Units for Heading variable	-
Height_description	Description for Height variable	-
Height_units	Units for Height variable	-
Latitude_description	Description for Latitude variable	-

Latitude_units	Units for Latitude variable	-
Longitude_description	Description for Longitude variable	-
Longitude_units	Units for Longitude variable	-
NavigationSource	Navigation source	-
NominalDistance_description	Description for NominalDistance variable	-
NominalDistance_units	Units for NominalDistance variable	-
NorthVelocity_description	Description for NorthVelocity variable	-
NorthVelocity_units	Units for NorthVelocity variable	-
Pitch_description	Description for Pitch variable	-
Pitch_units	Units for Pitch variable	-
Roll_description	Description for Roll variable	-
Roll_units	Units for Roll variable	-
Track_description	Description for Track variable	-
Track_units	Units for Track variable	-
UpVelocity_descrption	Description for UpVelocity variable	-
UpVelocity_units	Units for UpVelocity variable	-
dxdr_description	Description for dxdr variable	-
dxdr_units	Units for dxdr variable	-
dydr_description	Description for dydr variable	-
dydr_units	Units for dydr variable	-
dzdr_description	Description for dzdr variable	-
dzdr_units	Units for dzdr variable	-

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.

Software

No software is needed to view this dataset; however, Panoply can be used to easily view the data.

Known Issues or Missing Data

This dataset is not continuous as flights did not occur every day.

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, https://doi.org/10.1175/2009JAS3132.1

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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 other datasets collected as part of the IMPACTS campaign are considered related and can be located by searching the term "IMPACTS'' in the GHRC Earthdata Search Portal search tool. Other datasets collected by HIWRAP can be located by searching "HIWRAP" in GHRC Earthdata Search Portal and are listed below.

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

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) OLYMPEX (http://dx.doi.org/10.5067/GPMGV/OLYMPEX/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)

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

GRIP Global Hawk Navigation and Housekeeping data (http://dx.doi.org/10.5067/GRIP/NAV/DATA102)

Contact Information

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

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