High Altitude Wind and Rain Airborne Profiler (HIWRAP) Data Description

IMPACTS 2023 Level 1B RevA Data Description

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HIWRAP Level 1B data consist of calibrated radar products (reflectivity, linear depolarization ratio, Doppler velocity, normalized radar cross section) with associated time and spatial information. The data products have been processed with a running average, sampled every 0.5 seconds.

NOTE: Rev A added noiseFloor variable and reduced precision of some variables; added SNR; fixed sigma0 for all channels; adjusted KU (KA) calibration coefficient by -0.8 (+0.8) dbZe from Rev-

HIWRAP is a frequency diversity pulse compression radar. It transmits three channels:

- Chirp: A pulse compression chirp with high resolution and sensitivity, but with range sidelobes from the surface.
- HiResPulse: A short pulse with resolution comparable to the chirp, but with reduced sensitivity.
- LowResPulse: A longer pulse with reduced resolution but better sensitivity than the high resolution pulse.

We have combined these pulses into composite images. Use the combined data for initial looks and regular data processing. We have included the individual chirp and pulse channels for reference if desired. Individual channels can be used to find any potential data artifacts resulting from combining the channels to a single image.

Level 1B data is in a nested HDF5 file. Groups are:

- **/Information** (for general information)
- **/Time** (for timestamps)
    - /Data
    - /Information
- **/Products** (for radar data products)
    - /Chirp
        - /Data
        - /Information
    - /Combined **<- Start Here!**
        - /Data
        - /Information
    - /HiResPulse
        - /Data
        - /Information
    - /LowResPulse
        - /Data

        - /Information
    - /Information
- **/Navigation** (for radar position and pointing information)
    - /Data
    - /Information

This RevA data does not use HDF5 attributes, so most data fields have associated data fields describing the information and units. Look in the '/Information' subgroups. For example, the description of radar reflectivity ('/Products/Ku/Chirp/Data/dBZe') is found in /Products/Ku/Chirp/Information/dBZe_description. These 'units' and 'description' fields are not listed in this document.

Please contact Matt L. Walker McLinden (matthew.l.mclinden@nasa.gov) with questions or comments about these data.

Data Field	Units	Dim.	Information
/Information – General Information			
Aircraft	Text		Aircraft ('NASA ER-2')
DataContact	Text		Matthew L. Walker McLinden, ('matthew.l.mclinden@nasa.gov')
ExperimentName	Text		IMPACTS2022
FlightDate	Text		Flight date
InstrumentPI	Text		Instrument PI, ('Lihua Li, NASA/GSFC')
L1A_ProcessDate	Text		L1A File Process Date
L1B_ProcessDate	Text		L1B File Process Date
L1B_Revision	Text		Revision Letter
L1B_Revision_ Note	Text		Describes updates per revision.
MissionPI	Text		Mission PI, ('Lynn McMurdie, University of Washington')
RadarName	Text		Radar Name ('HIWRAP')
/Time/Data – Time Data			
TimeUTC	Seconds	Time	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 ResolutionHorizontal6dB field for horizontal resolution
/Time/Data – Time Auxiliary Information			
TimeUTC_ 01Jan2020	Seconds	1	Time of 0 UTC, Jan 01, 2020, for reference if the user does not have an easy Linux time converter.
/Products/Chirp|Combined|HighResPulse|LowResPulse/Data – Radar Product Data			

dBZe	10*log10 (mm^6 /m^3)	Range, Time	Equivalent reflectivity factor in dB with 1-sigma noise threshold applied for individual channels and 2-sigma noise threshold applied for the combined channel data. $\|K\|^2 = 0.92$. Use /Products/xx/xx/Information/MaskCoPol for thresholding greater than the default.
Velocity_ uncorrected	m/s	Range, Time	Doppler velocity with aircraft motion correction default thresholding. Positive velocity is upward. Use /Products/xx/xx/Information/MaskCoPol for thresholding greater than the default. Note possible intrusion of horizontal winds into the Doppler measurement due to slight off-nadir pointing. Check Navigation data (roll/pitch) to estimate possible impact or contact the radar team.
Velocity_ corrected (Combined channels only)	m/s	Range, Time	Doppler velocity with aircraft motion, non-uniform beam filling (NUBF) [Ku only], and horizontal wind intrusion corrections applied. Positive velocity is upward. NUBF correction is estimated based on the local reflectivity gradient. HRRR reanalysis winds were interpolated to the flight grid, converted to along/cross track components and scaled by aircraft pitch/roll to create an offset.
SpectrumWidth	m/s	Range, Time	Doppler velocity spectrum width estimate including aircraft motion and beamwidth. Default noise threshold applied. Use /Products/xx/xx/Information/MaskCoPol for thresholding greater than the default.
LDR (combined channel only)	dB	Range, Time	Linear Depolarization Ratio (LDR) with 3-sigma noise threshold applied. The LDR uses the chirp for cross-polarization data and the high-resolution pulse for co-polarization data. The resolution is well matched, but has slight differences that can cause small artifacts at the edge of the surface return.
sigma0 (not for Combined Data)	10*log10 (m^2 /m^2)	Time	Ocean Normalized Radar Cross Section. Only valid over ocean.
/Products/Information – Radar Product Information			
AircraftMotion	m/s	Time	Estimated aircraft motion in the direction of the beam that has been subtracted from the Doppler estimate.
AircraftTurnFlag	0 or 1	Time	Flag is 1 when plane is flying level without turns. Flag is 0 elsewhere.

AntennaBeamwidth	Degrees	1	Antenna 3 dB one-way beamwidth in degrees.
AntennaSize	meters	1	Antenna Diameter (0.5 meters)
AveragedPulses	#	1	Number of averaged pulses per profile. Note that profiles are not independent, and are overlapping.
Frequency	Hz	1	Radar frequency (35.56 GHz Ka, 13.91GHz Ku)
GateSpacing	meters	1	Range gate spacing (26.25 meters)
HRRR_AlongWind	m/s	Range, Time	HRRR along-track winds, interpreted to the flight grid.
HRRR_CrossWind	m/s	Range, Time	HRRR cross-track winds, interpreted to the flight grid.
NominalAntenna Pointing	Text		Nadir
PRI	Text		'224 us / 280 us staggered'. Description of the pulse repetition interval.
Range	meters	Range	Range in meters from the aircraft of each range gate.
Resolution Horizontal6dB	meters	Range	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.
Wavelength	m	1	Radar wavelength
/Products/Chirp|Combined|HighResPulse|LowResPulse/Information – Radar Product Information (Pulse-type specific)			
MaskCoPol (not for Combined Data)	Special	Range, Time	Co-polarization signal-to-noise mask. (Mask >= N) corresponds with (SNR > N-sigma) noise thresholding.
ChannelMask (Combined Data only)	Special	Range, Time	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.
noiseFloor	Relative power	Time	Uncalibrated estimate of noise floor.
SNR	W/W	Range, Time	Estimated Signal-to-Noise Ratio.
Velocity_ horizwind_offset (Combined only)	m/s	Range, Time	The horizontal wind offset removed from the NUBF-corrected Doppler velocity to yield horizontal-wind corrected Doppler velocity.
Velocity_ nubf_offset (Combined Ku only)	m/s	Range, Time	The NUBF offset removed from the uncorrected Doppler velocity to yield NUBF-corrected Doppler velocity.
/Navigation/Data – Navigation Data			
Drift	degrees	Time	Difference between track and heading
EastVelocity	m/s	Time	Eastward portion of velocity

Heading	degrees	Time	Aircraft heading in degrees from north. 90 degrees is Eastward.
Height	meters	Time	Aircraft height above sea level.
Latitude	degrees	Time	Latitude
Longitude	degrees	Time	Longitude
NominalDistance	meters	Time	Nominal total along-track distance calculated by integrating instantaneous velocity. Used for simple plotting.
NorthVelocity	m/s	Time	Northward portion of velocity
Pitch	degrees	Time	Pitch
Roll	degrees	Time	Roll
Track	degrees	Time	Direction of motion in degrees from north. 90 degrees is Eastward motion.
UpVelocity	m/s	Time	Upward velocity.
dxdr	m/m	Time	Data cross-track distance from aircraft per radar range. Positive is in the starboard direction.
dydr	m/m	Time	Data along-track distance from aircraft per radar range. Positive is in the forward direction.
dzdr	m/m	Time	Data vertical distance from the aircraft per radar range. Positive is in upward direction.