Global Hydrology Resource Center

Data User Guide

ER-2 X-band Radar (EXRAD) IMPACTS

Introduction

The ER-2 X-band Radar (EXRAD) IMPACTS dataset consists of radar reflectivity and Doppler velocity estimates collected by the EXRAD onboard the NASA ER-2 high-altitude research aircraft. These data were gathered 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 (2020-2022). The campaign 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. The EXRAD IMPACTS dataset files are available from January 25 through February 27, 2020 in HDF-5 format.

Notice:
The ER-2 aircraft did not operate each day of the campaign, therefore EXRAD data are only available for aircraft flight days.

Citation

Heymsfield, Gerald, Lihua Li, and Matthew McLinden. 2020. ER-2 X-band Radar (EXRAD) IMPACTS [indicate subset used]. Dataset available online from the NASA Global Hydrology Resource Center DAAC, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/IMPACTS/EXRAD/DATA101

Keywords:

NASA, GHRC, IMPACTS, EXRAD, reflectivity, doppler velocity, clouds, precipitation, X-band, nadir, ER-2, radar

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 (2020-2022) 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 sampled 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.

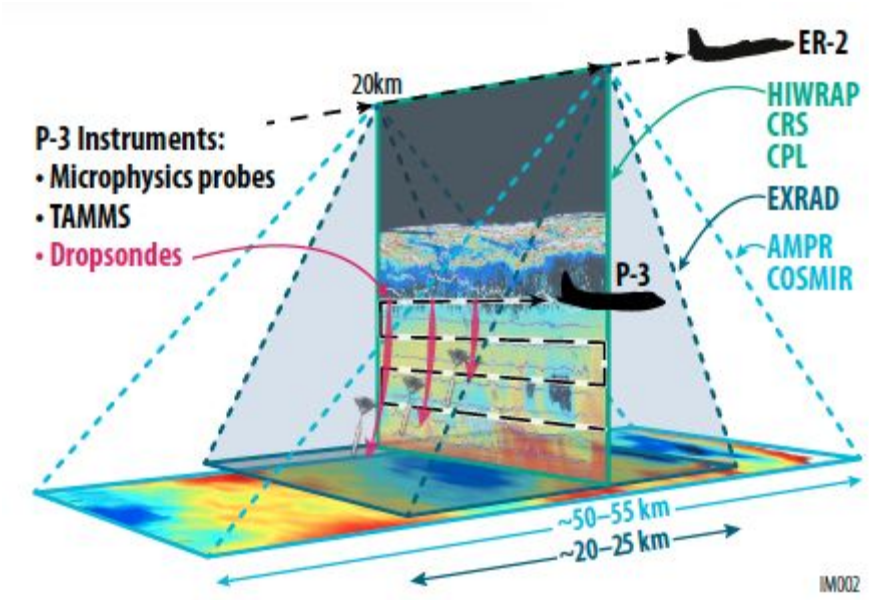

Figure 1: IMPACTS airborne instrument suite
(Image source: NASA IMPACTS ESPO)

Instrument Description

The X-band Radar (EXRAD) is a single-frequency radar that measures radar backscatter at the X-band (9.6 GHz) frequency. This instrument was previously flown on the ER-2 aircraft during the IPHEx campaign. The EXRAD is less affected by signal attenuation from storms than other radars. The instrument has both a conical/cross-track scanning beam and a fixed nadir beam. More information about the EXRAD instrument is available at ER-2 Doppler Radar (EXRAD).

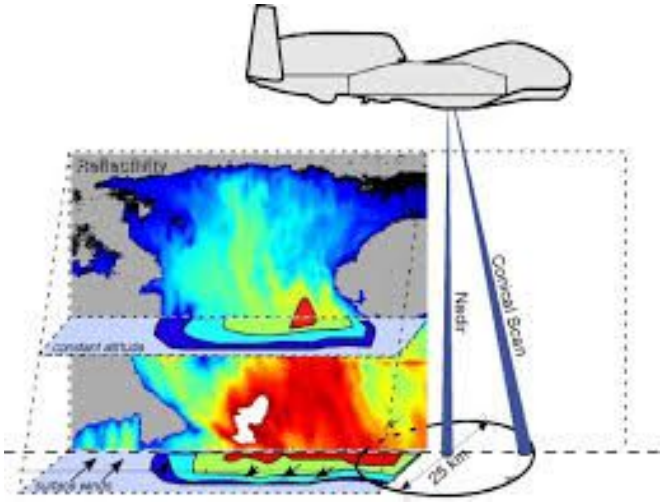

Figure 2: Image of the measurement concept of EXRAD.
Image credit: First Flights of ER-2 X-band Radar - EXRAD

Investigators

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Data Characteristics

The ER-2 X-band Radar (EXRAD) IMPACTS dataset consists of calibrated radar products stored in nested HDF-5 files. These data are available at a Level 1B processing level. More information about the NASA data processing levels is available on the EOSDIS Data Processing Levels webpage. The characteristics of this dataset are listed in Table 2 below.

Table 2: Data Characteristics

Characteristic	Description
Platform	NASA Earth Resources 2 (ER-2) research aircraft
Instrument	ER-2 X-band Radar (EXRAD)
Spatial Coverage	N: 44.760 , S: 32.392, E: -71.691, W: -90.774 (Eastern United States of America)
Spatial Resolution	300 m
Temporal Coverage	January 25, 2020 - February 27, 2020

Temporal Resolution	Hourly -< Daily
Sampling Frequency	0.25 seconds
Parameter	Reflectivity, Doppler velocity
Version	1
Processing Level	1B

File Naming Convention

The ER-2 X-band Radar (EXRAD) IMPACTS dataset files are stored in HDF-5 format and named using the following convention:

Data files:
IMPACTS_EXRAD_[Scan|Nadir]_L1B_RevA_<start date>T<start time>_to_<end date>_to_<end time>.h5

Table 3: File naming convention variables

Variable	Description
[Scan|Nadir]	Conical Scan or Nadir file
start_date	*YYYYMMDD* where: YYYY = Four-digit year MM = Two-digit month DD = Two-digit day
start_time	*hhmmss* where: hh = Two-digit hour in UTC mm = Two-digit minute in UTC ss = Two-digit second in UTC
end_date	*YYYYMMDD* where: YYYY = Four-digit year MM = Two-digit month DD = Two-digit day
end_time	*hhmmss* where: hh = Two-digit hour in UTC mm = Two-digit minute in UTC ss = Two-digit second in UTC
.h5	HDF-5 format

Data Format and Parameters

The ER-2 X-band Radar (EXRAD) IMPACTS dataset is stored in nested HDF-5 files.The top-level groups of the HDF-5 files are: Information (general information), Time (time-stamps), Products (radar data products), and Navigation (radar position and pointing information). More details about the EXRAD HDF-5 data format are available in the EXRAD IMPACTS Level1B Data Description document. The EXRAD HDF-5 data field

descriptions are listed in Table 4 below. The top-level groups and subgroups heading each section are listed in bold.

Table 4: EXRAD HDF-5 File Data Fields

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: Gerry Heymsfield, NASA/GSFC	-
L1A_ProcessDate	L1A File Process Date	-
L1B_ProcessDate	L1B File Process Date	-
L1B_Revision	L1B Revision	-
MissionPI	Mission PI: Lynn McMurdie, University of Washington	-
RadarName	Radar Name: EXRAD	-
/Time/Data - Time Data		
TimeUTC	UTC profile time in Unix Epoch format (seconds since 1970). Obtained from aircraft NTP. Note that CRS produces a profile every 0.25 seconds, however profiles are overlapping.	seconds
/Time/Information - Auxiliary Time Information		
TimeUTC_01Jan2020	Time of 0 UTC, Jan 01, 2020, for reference if the user does not have an easy Linux time converter	seconds
/Products/Data - Radar Product Data		
dBZe	Equivalent reflectivity factor in dB with 1-sigma noise threshold applied. $\|K\|^2 = 0.92$. Use /Products/Information/MaskCoPol or /Products/Information/SNR for thresholding other than 1-sigma	10*log10 (mm^6/m^3)
Velocity	Doppler velocity with aircraft motion correction and 1-sigma noise threshold applied. Positive velocity is upward. Use /Products/Information/MaskCoPol for thresholding other than 1-sigma. Possible intrusion of horizontal winds into Doppler measurement due to slight off-nadir pointing. Check Navigation data (roll/pitch) to estimate impact or contact radar team.	m/s
Velocity_nubf_fix	Doppler velocity with aircraft motion correction and non-uniform beam filling (NBUF) correction applied. Positive velocity is upward. NUBF correction is estimated based on the local reflectivity gradient. Possible intrusion of horizontal winds into the Doppler measurement due to slight off-nadir pointing.	m/s

	Check Navigation data (roll/pitch) to estimate the impact or contact the radar team.	
SpectrumWidth	Doppler velocity spectrum width estimate including aircraft motion and beamwidth. 1-sigma noise threshold applied. Use /Products/Information/MaskCoPol or /Products/Information/SNR for thresholding other than 1-sigma.	m/s
sigma0	Ocean Normalized Radar Cross Section. Only valid over the ocean.	10*log10 (m^2/m^2)
/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
AntennaBeamwidth	Antenna 3 dB one-way beamwidth	degrees
AntennaSize	Antenna Diameter (0.66 meters)	meters
AveragedPulses	Number of averaged pulses per profile. Note that profiles are not independent, and are overlapping.	#
Frequency	Radar frequency (9.624 GHz)	Hz
GateSpacing	Range gate spacing (18.747 meters)	meters
MaskCoPol	Co-polarization signal-to-noise mask. (Mask >= N) corresponds with (SNR > N-sigma) noise thresholding.	Special
PRI	Description of the pulse repetition interval: 200 µs/250 µs staggered	-
Range	Range in meters from the aircraft of each range gate	meters
ResolutionHorizontal6dB	Approximate horizontal resolution defined as the -6 dB width of spatial weighting as a function of the antenna pattern, horizontal averaging, and range	meters
ResolutionVertical6dB	Approximate vertical resolution defined as the -6 dB width of the range weighting function	meters
SNR	Estimated Signal-to-Noise Ratio	W/W
/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

Algorithm

High-resolution cross-sections of vertical air motions within precipitation regions of a storm are calculated by factoring out hydrometeor fallspeeds and aircraft motions from the EXRAD nadir beam measurements. The instrument's dual-beam technology can also provide measurements of horizontal air motions and assist with attenuation estimates. More information about EXRAD measurement capabilities is described in Heymsfield et al. (1996).

Quality Assessment

Meteorological targets are usually distorted by the radar antenna main- and sidelobes, especially in sharp hydrometeor gradient areas. More information about errors in radar measurements is available in Heymsfield et al., 2000 and Caylor et al., 1997.

Software

No special software is required to read these data. Panoply is an easy-to-use free tool for reading and visualizing the data within the CRS HDF-5 files.

Known Issues or Missing Data

The ER-2 aircraft did not operate each day of the campaign, therefore EXRAD data are only available for aircraft flight days.

References

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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 HyDRO2.0 search tool. Other datasets collected by EXRAD can be located by searching “EXRAD” in HyDRO2.0 and are listed below.

GPM Ground Validation ER-2 X-band Radar (EXRAD) IPHEx (http://dx.doi.org/10.5067/GPMGV/IPHEX/EXRAD/DATA101)

Contact Information

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

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