Data User Guide

ER-2 X-band Radar (EXRAD) 3D Winds IMPACTS

Introduction

The ER-2 X-band Radar (EXRAD) 3D Winds IMPACTS dataset consists of horizontal wind components, uncertainties in the horizontal wind components, and radar reflectivity collected by the EXRAD instrument onboard the NASA ER-2 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 (2020-2023, No deployments occurred in 2021 due to COVID-19). 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 3D Winds IMPACTS dataset files are available from January 25 through February 7, 2020 in netCDF-3 format.

Notice:
The ER-2 aircraft did not operate each day of the campaign; therefore, EXRAD 3D Winds data are only available for aircraft flight days.

Citation

Guimond, Stephen. 2023. ER-2 X-band Radar (EXRAD) 3D Winds IMPACTS. Dataset available online from the NASA Global Hydrometeorology Resource Center DAAC, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/IMPACTS/EXRAD/DATA201

Keywords:

NASA, GHRC, IMPACTS, EXRAD, winds, dynamics, 3D, reflectivity, precipitation, X-band, radar, bands

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.

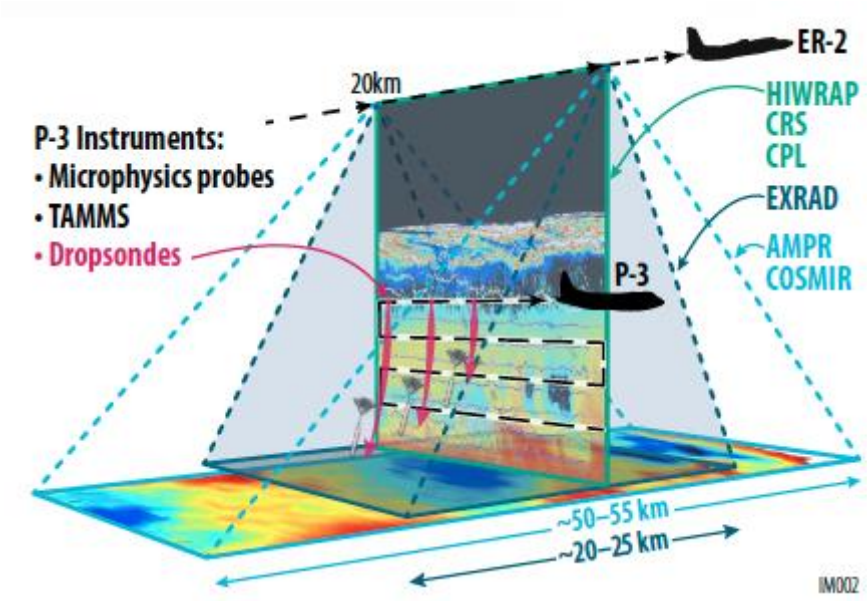

Figure 1: IMPACTS airborne instrument suite
(Image source: NASA IMPACTS ESPO)

Instrument Description

The 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 ER-2 aircraft.
Image credit: NASA GSFC

Investigators

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Data Characteristics

The EXRAD 3D Winds IMPACTS data files are available in netCDF-3 format. These data consist of zonal and meridional wind components and radar reflectivity variables. Data files are at a Level 2 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 1 below.

Table 1: Data Characteristics

Characteristic	Description
Platform	NASA Earth Resources 2 (ER-2) research aircraft
Instrument	ER-2 X-band Radar (EXRAD)

Spatial Coverage	N: 44.726, S: 33.281, E: -71.520, W: -90.885 (United States)
Spatial Resolution	500 m (horizontal), 250 m (vertical)
Temporal Coverage	January 25, 2020 - February 7, 2020
Temporal Resolution	Hourly -< Daily
Parameter	Zonal and meridional wind components including uncertainties, radar reflectivity
Version	1
Processing Level	3

File Naming Convention

The EXRAD 3D Winds IMPACTS data are within netCDF-3 files and use the following naming convention:

Data files: IMPACTS_YYYYMMDD_<start time>_<end time>_EXRAD_3dwinds.nc

Table 2: File naming convention variables

Variable	Description
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
<start time>	Start time in hhmmss format, where: hh: Two-digit hour in UTC mm: Two-digit minute in UTC ss: Two-digit seconds in UTC
<end time>	End time in hhmmss format, where: hh: Two-digit hour in UTC mm: Two-digit minute in UTC ss: Two-digit seconds in UTC
.nc	netCDF-3 format

Data Format and Parameters

The EXRAD 3D Winds data files are innetCDF-3 format. Table 3 describes how these measurements are organized in each file, as well as their units.

Table 3: EXRAD 3D Winds Data Fields

Field Name	Description	Data Type	Unit
across_track_grid	Distance of grid point across the aircraft track	float	km
along_track_grid	Distance of grid point along the aircraft track	float	km
latitude	Latitude of grid point	double	degrees

longitude	Longitude of grid point; Values in range [0,360]	double	degrees
meridional_wind	Earth-relative horizontal wind component, positive is wind blowing from south to north.	float	m/s
meridonal_wind_std	Standard deviation of meridional_wind	float	m/s
vertical_grid	Distance of grid point above the surface	float	km
X_band_reflectivity	X-band radar reflectivity interpolated to 3D grid	float	dBZ
zonal_wind	Earth-relative horizontal wind component, positive is wind blowing from west to east.	float	m/s
zonal_wind_std	Standard deviation of zonal_wind	float	m/s

Algorithm

Calculations of the three-dimensional wind field are performed using a three-dimensional variational (3DVAR) methodology that minimizes the misfit between the measured and computed Doppler velocities as well as the anelastic mass continuity equation. Numerical noise is removed using a 2 – 3 point running mean filter in post-processing.
More information about the algorithm theory, instrument simulations, and science examples can be found in Guimond et al. (2014). The effective resolution of the wind fields are analyzed with large eddy simulations in Guimond et al. (2018a). Evaluation of the algorithm with in-situ data and more science examples can be found in Guimond et al. (2018b).

Quality Assessment

Quality control has already been performed on the data and regions with low signal-to-noise ratios and high uncertainties have been removed. While a combination of parameters have been studied, the best quality fields were found by removing data with standard deviations larger than 6 m/s. The data in this repository have this threshold applied.
Validation of the EXRAD 3D winds with flight level in-situ data from the NASA ER-2 aircraft during IMPACTS 2020 have been performed (Figure 3). This validation showed zonal wind root mean square errors (RMSEs) of 3.99 m/s with a correlation coefficient of 0.92. For the meridional wind, the RMSEs are 4.53 m/s with a correlation coefficient of 0.89. These statistics are collected at various locations across the radar swath and for different time offsets.

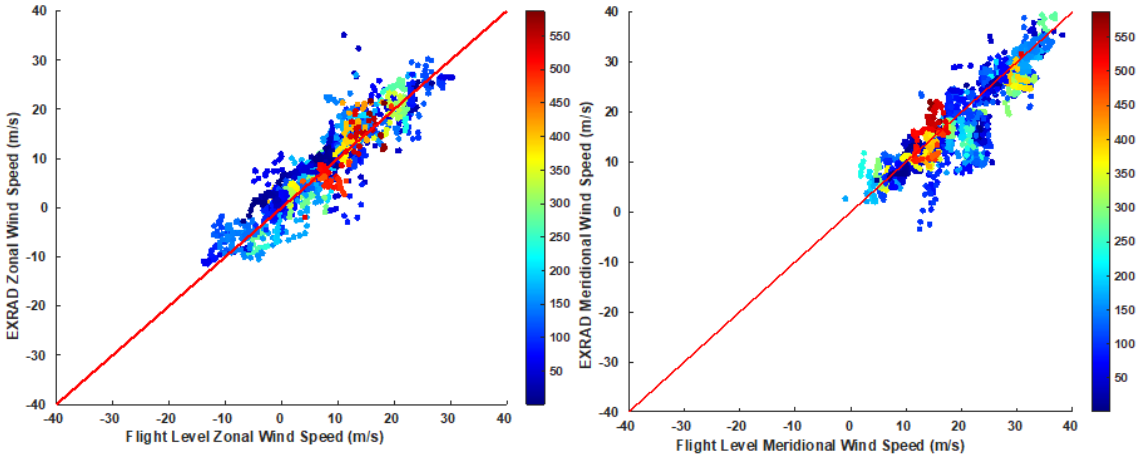

Figure 3: Validation of EXRAD 3D winds with flight level data during IMPACTS 2020. The points are colored by time offset in seconds.
(image source: Stephen Guimond)

Software

No software is required to view these data; however, Panoply can be used to easily view these data.

Known Issues or Missing Data

The ER-2 aircraft did not operate each day of the campaign; therefore, EXRAD 3D Winds data are only available for aircraft flight days.

References

Guimond, S. R., L. Tian, G. M. Heymsfield, and S. J. Frasier, 2014: Wind Retrieval Algorithms for the IWRAP and HIWRAP Airborne Doppler Radars with Applications to Hurricanes. Journal of Atmospheric and Oceanic Technology, 31 (6): 1189-1215 [10.1175/JTECH-D-13-00140.1]

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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 Earthdata Search. You can find other Radiosonde data by searching the term ‘EXRAD’.

Contact Information

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

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