



## Data User Guide

# ***CAMEX-3 ER-2 Doppler Radar (EDOP)***

### **Introduction**

The CAMEX-3 ER-2 Doppler Radar (EDOP) dataset is a browse-only dataset that consists of plotted reflectivity and Doppler velocity data collected by the ER-2 Doppler Radar (EDOP) during the third field campaign in the Convection And Moisture EXperiment (CAMEX) series, CAMEX-3. This field campaign took place from August to September 1998 based out of Patrick Air Force Base in Florida, with the purpose of studying the various aspects of tropical cyclones in the region. EDOP was mounted onboard the NASA ER-2 high-altitude research aircraft from which it obtained vertical profiles of convection within tropical cyclones. The daily browse files are available from August 5 through September 27, 1998 in GIF format.

### **Notice:**

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

### **Citation**

Hood, Robbie E. 2019. CAMEX-3 ER-2 Doppler Radar (EDOP) [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/CAMEX-3/EDOP/DATA101>

### **Keywords:**

*NASA, GHRC, CAMEX, CAMEX-3, ER-2, EDOP, Doppler radar, reflectivity, Doppler velocity*

### **Campaign**

The Convection And Moisture EXperiment (CAMEX) is a series of field research investigations sponsored by the Earth Science Enterprise of NASA. The third field campaign in the CAMEX series, CAMEX-3, ran from August to September 1998 and was based out of Patrick Air Force Base, Florida. CAMEX-3 focused on the study of tropical cyclone development, tracking, and intensification impacts using NASA-funded aircraft and surface

remote sensing instrumentation. The ultimate goal of the campaign was to improve the efficiency of hurricane evacuations and warnings. The campaign successfully studied Hurricanes Bonnie, Danielle, Earl, and Georges (Figure 1). CAMEX-3 yielded high-resolution spatial and temporal data on hurricane structure, dynamics, and motion. These data, when analyzed within the context of more traditional aircraft, satellite, and ground-based radar observations, provided additional insight to hurricane modelers and forecasters who continually strive to improve hurricane predictions. More information about CAMEX-3 can be found on the [CAMEX-3 Field Campaign webpage](#) and in [Kakar, Goodman, Hood, and Guillory \(2006\)](#).

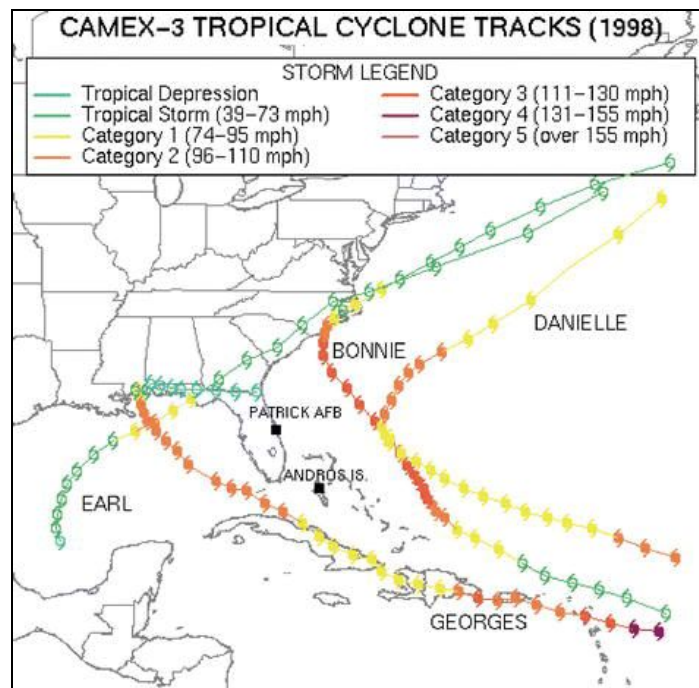


Figure 1: Tropical cyclone tracks during CAMEX-3  
(Image source: [Kakar et al. 2006](#))

## Instrument Description

The ER-2 Doppler Radar (EDOP) was a single-frequency Doppler radar onboard NASA's ER-2 high-altitude research aircraft that measured radar backscatter at the X-band (9.6 GHz) frequency. This instrument was mounted in the nose of the ER-2 during the CAMEX-3 field campaign. EDOP takes measurements of reflectivity and Doppler velocity. It has both a fixed nadir beam (pointing straight down towards Earth's surface) and a forward-pointing beam (33 degrees ahead of nadir). This unique combination allows for the measurement of vertical hydrometeor velocities within precipitation (Figure 2). EDOP's purpose during CAMEX-3 was to measure the vertical structure of reflectivity and vertical velocity in the hurricane precipitation region; especially within the inner core region and the upper-level outflow. More information about EDOP is available on the [NASA Airborne Science EDOP webpage](#).

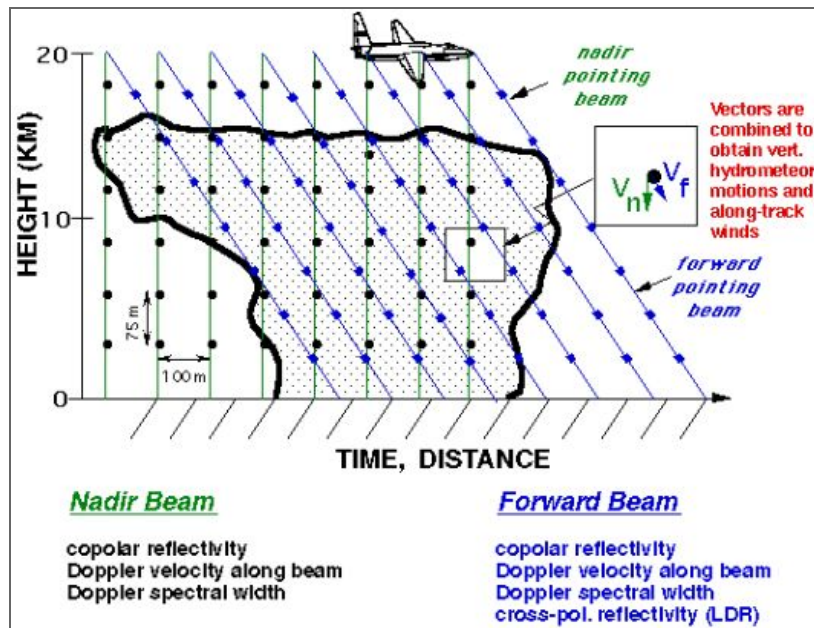


Figure 2: The EDOP measurement concept  
(Image source: [NASA GHRC](https://ghrc.nasa.gov/))

## Investigators

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## Data Characteristics

The CAMEX-3 ER-2 Doppler Radar (EDOP) dataset contains tarred daily browse image files that are available in GIF format. These images display time-height plots of reflectivity and Doppler velocity data at a Level 1A processing level. More information about the NASA data processing levels is available on the [EOSDIS Data Processing Levels webpage](https://eodis.nasa.gov/data-processing-levels). 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	ER-2 Doppler Radar (EDOP)
Spatial Coverage	N: 34.588 , S: 13.976 , E: -63.22 , W: -89.971 (Caribbean)
Temporal Coverage	August 8, 1998 - September 27, 1998
Temporal Resolution	Daily
Parameter	Reflectivity, Doppler velocity
Version	1

Processing Level	1A
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## File Naming Convention

The CAMEX-3 ER-2 Doppler Radar (EDOP) dataset includes tarred GIF imagery of EDOP reflectivity and Doppler velocity measurements. These files are named using the following convention:

**Tarred Browse files:** camex3\_er2edop\_yyyy.ddd\_daily.tar

**Untarred Browse files:** EDOP\_YYMMDD\_<start time - end time>\_[n|f].gif

Table 2: File naming convention variables

Variable	Description
yyyy	Four-digit year
ddd	Day of the year (Julian day)
YY	Two-digit year (e.g. 98 = 1998)
MM	Two-digit month
DD	Two-digit day
<start time - end time>	Start and end time of plotted data in <i>hhmm</i> where: hh= Two-digit hour in UTC mm= Two-digit minute in UTC
[n f]	The beam data that is being displayed: n = nadir-pointing beam f = forward-pointing beam
.tar	Unix "tape archive" (tar) file
.gif	Graphics Interchange Format (GIF) file

## Data Format and Parameters

The CAMEX-3 ER-2 Doppler Radar (EDOP) dataset consists of daily browse imagery of EDOP radar reflectivity and Doppler velocity time-height sections. The plots display reflectivity ( $Z$ ) and Doppler velocity ( $V$ ) data from the nadir-pointing beam,  $Z_N$  (dBZ) and  $V_N$  (dBZ), and the forward-pointing beam,  $Z_F$  ( $m s^{-1}$ ) and  $V_N$  ( $m s^{-1}$ ). Upon unzipping an EDOP daily TAR file, there will be a folder containing images of data collected for different time periods during that day's mission. There are two images per time period; one for the nadir-pointing beam (\*\_n.gif) and the other for the forward-pointing beam (\*\_f.gif). Each image file name includes the time period for which the data is plotted (see Table 2).

Within each image are two plots. The top plot displays reflectivity data while the bottom plot displays Doppler velocity data (Figure 3). The vertical profiles of data are plotted along the flight path. The data are plotted with the height scale (in kilometers) on the y-axis and the distance scale (in kilometers) on the x-axis. The reflectivity (in dBZ) and Doppler velocity (in  $m s^{-1}$ ) scale bars are displayed to the right of the plot for the top and bottom plot respectively. An example image is shown in Figure 3 below.

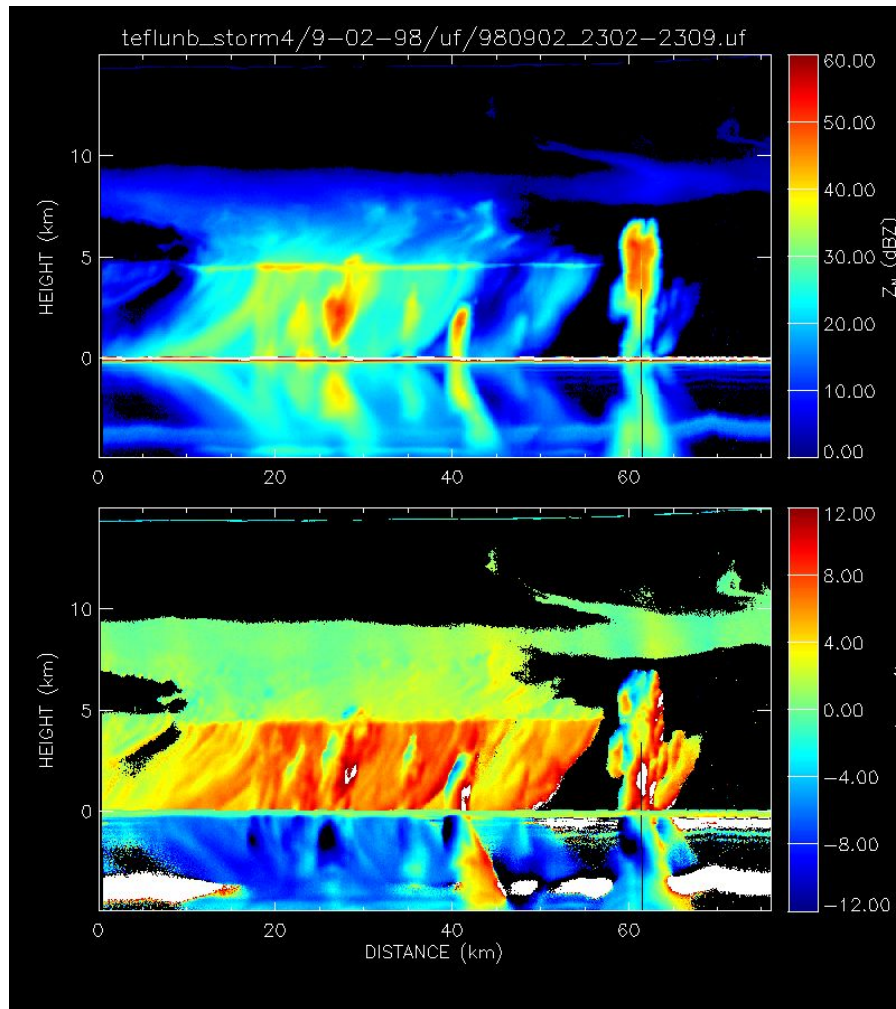


Figure 3: CAMEX-3 EDOP profiles of reflectivity (top) and Doppler velocity (bottom) from the nadir-pointing beam

## Algorithm

High-resolution cross-sections of vertical air motions within precipitation regions of a storm are calculated by factoring out hydrometeor fall speeds and aircraft motions from the EDOP 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 EDOP measurement capabilities is described in [Heymsfield et al. \(1996\)](#).

## Quality Assessment

EDOP undergoes pre-deployment, during flight, and post-deployment quality control procedures. For example, the EDOP antennas are calibrated in a laboratory where known

RF (radio frequency) power levels are fed into the antennas before and after deployment. The antennas are also calibrated at regular intervals during flight. The EDOP antenna pointing angles undergo calibration to ensure the accuracy of velocity measurements. There is some deviation in measurements from airborne nadir pointing weather radars due to errors in surface cross-sectional estimates. Correction filters are applied and sampling rates adjusted to account for these inaccuracies. More information about EDOP calibration procedures and errors in radar measurements is available in [Heymsfield et al. \(1996\)](#) and [Heymsfield et al. \(2000\)](#).

## Software

No special software is needed to view the browse imagery. The GIF files can be viewed in most image software.

## Known Issues or Missing Data

The ER-2 aircraft did not operate each day of the campaign, therefore, data are only available on flight days. There were also days during the campaign when the ER-2 was not able to collect data due to environmental conditions or equipment issues. These and other mission events are included in the [CAMEX-3 Mission Reports dataset](#).

## References

Gibbs, Y. (2014). NASA Armstrong Fact Sheet: ER-2 High-Altitude Airborne Science Aircraft. <https://www.nasa.gov/centers/armstrong/news/FactSheets/FS-046-DFRC.html>

Heymsfield, G.M., Bidwell, S. W., Caylor, I. J., Ameen, S., Nicholson, S., Boncyk, W., ... Dod, L. R. (1996). The EDOP Radar System on the High-Altitude NASA ER-2 Aircraft. *Journal of Atmospheric and Oceanic Technology*, 13, 795–809. [https://doi.org/10.1175/1520-0426\(1996\)013<0795:TERSOT>2.0.CO;2](https://doi.org/10.1175/1520-0426(1996)013<0795:TERSOT>2.0.CO;2)

Heymsfield, G. M., Halverson, J. B., Simpson, J., Tian, L., & Bui, T. P. (2000). ER-2 Doppler Radar (EDOP) Investigations of the Eyewall of Hurricane Bonnie During CAMEX-3. *Journal of Applied Meteorology*, 40, 1310-1330. [https://doi.org/10.1175/1520-0450\(2001\)040%3C1310:EDRIOT%3E2.0.CO;2](https://doi.org/10.1175/1520-0450(2001)040%3C1310:EDRIOT%3E2.0.CO;2)

Kakar, R., Goodman, M., Hood, R., & Guillory, A. (2006). Overview of the Convection and Moisture Experiment (CAMEX). *Journal of the Atmospheric Sciences*, 63, 5–18. <https://doi.org/10.1175/JAS3607.1>

## Related Data

All datasets from the CAMEX-3 field campaign are considered related to this CAMEX-3 EDOP dataset. Other CAMEX-3 campaign data can be located using the GHRC [HyDRO2.0](#) search tool and entering the term 'CAMEX-3' in the search box. EDOP was flown in other

field campaigns as well. The EDOP data from other campaigns can be located by searching the term 'EDOP' in [HyDRO2.0](#) and are also listed below:

TCSP ER-2 DOPPLER RADAR (EDOP)  
(<http://dx.doi.org/10.5067/TCSP/EDOP/DATA101>)

CAMEX-4 ER-2 Doppler Radar  
(<http://dx.doi.org/10.5067/CAMEX-4/DOPPLER/DATA201>)

## Contact Information

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

NASA Global Hydrology Resource Center DAAC  
User Services  
320 Sparkman Drive  
Huntsville, AL 35805  
Phone: 256-961-7932  
E-mail: [support-ghrc@earthdata.nasa.gov](mailto:support-ghrc@earthdata.nasa.gov)  
Web: <https://ghrc.nsstc.nasa.gov/>

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