



## Data User Guide

# *TCSP ER-2 Navigation Data*

## Introduction

The TCSP ER-2 Navigation Data contains information recorded by the on-board navigation and data collection systems of the NASA ER-2 high-altitude research aircraft. In addition to typical navigation data (e.g., date, time, latitude/longitude, and altitude) it contains outside meteorological parameters such as wind speed, wind direction, and temperature. These data were collected during the Tropical Cloud Systems and Processes (TCSP) field campaign in July 2005, with flights based out of Juan Santamaria Airport in San Jose, Costa Rica. The main goal of the campaign was to gain further insight into the structure and lifecycle of tropical weather systems. These navigation dataset files are available from July 2 through July 27, 2005 in ASCII and PDF formats.

### Notice:

There is one file per NASA ER-2 flight. Since flights did not occur each day of the campaign, data are only available on flight days.

## Citation

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### Keywords:

*NASA, NOAA, GHRC, TCSP, ER-2, GPS, navigation data, meteorological parameters, tropical weather systems*

## Campaign

The Tropical Cloud Systems and Processes (TCSP) mission was a research campaign sponsored by the Science Mission Directorate of NASA. The field phase of the campaign was conducted from July 1 through July 27, 2005, during the active Atlantic and eastern Pacific hurricane seasons; flying missions out of Juan Santamaria Airport in San Jose, Costa Rica.

There were 12 NASA ER-2 flights taken during the campaign along with 18 coordinated P-3 flights by the NOAA Hurricane Research Division aimed at studying the evolution of tropical weather systems. These airborne missions collected various types of data to be used for research related to the dynamic and thermodynamic properties of tropical disturbances as well as their development and intensification processes. During the campaign, observations were collected for Hurricanes Dennis and Emily, Tropical Storm Gert, and an eastern Pacific mesoscale complex that may have later developed into Tropical Storm Eugene (Figure 1). The airborne and surface observations collected during the campaign provided a deeper understanding of the structure and lifecycle of tropical weather systems and helped to improve the numerical modeling of these systems. More information about the campaign is available on the [TCSP Field Campaign webpage](#) and in [Halverson et al. \(2007\)](#).

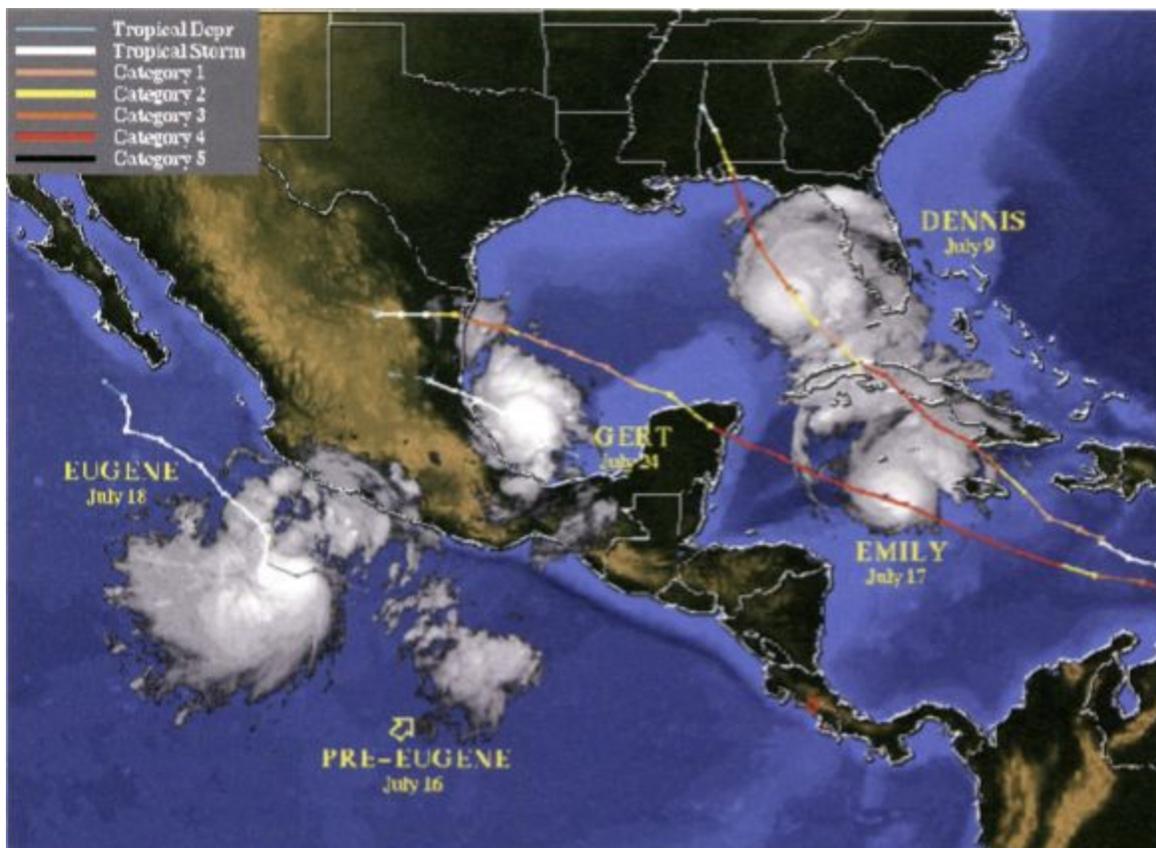


Figure 1: Storms observed by the NASA ER-2 and NOAA P-3 during TCSP, including storm tracks and intensities

(Image source: [Halverson et al., 2007](#))

## Instrument Description

The NASA Earth Resources 2 (ER-2) is a high-altitude research aircraft used for various NASA science missions. During the TCSP field campaign, the ER-2 carried various research instrumentation (Figure 2) including the Lightning Imaging Package (LIP), Advanced

Microwave Precipitation Radiometer (AMPR), MODIS Airborne Simulator (MAS), Cloud Radar System (CRS), ER-2 Doppler Radar (EDOP), High Altitude MMIC Sounding Radiometer (HAMSR), and Microwave Temperature Profiler (MTP). The aircraft has a maximum payload of around 2900 lbs and can operate at altitudes from 20,000 to 70,000 ft, within the lower stratosphere. The ER-2 has a cruise speed of 410 knots with a standard range of 3,000 to 5,000 nautical miles, enabling mission times from 8 to 10+ hours depending on the aircraft's payload. During the TCSP field campaign, the ER-2 aircraft played a major role in capturing observations of tropical storm development and intensification.

In addition to data from the instruments, navigation data for the ER-2 aircraft were also collected during flight. The ER-2 Navigation Recorder (NAVREC) system is the general-purpose housekeeping data system located onboard the aircraft. The system handles the processing, distribution, and logging of housekeeping data (altitude, temperature, air and ground speed, pressure, etc.) as geolocated records collected at one-second intervals. The NAVREC system includes an Inertial Navigation System (INS), Global Positioning System (GPS) receivers, and temperature and pressure probes. The INS uses various sensors to provide navigation data without the need for external references. Post-flight processing software generates aircraft flight tracks, time-series plots of measured parameters, tabular ASCII files with time-stamped parameter measurements, and flight reports. More information about the NAVREC system is detailed in the [NASA ER-2 Aircraft Handbook](#).

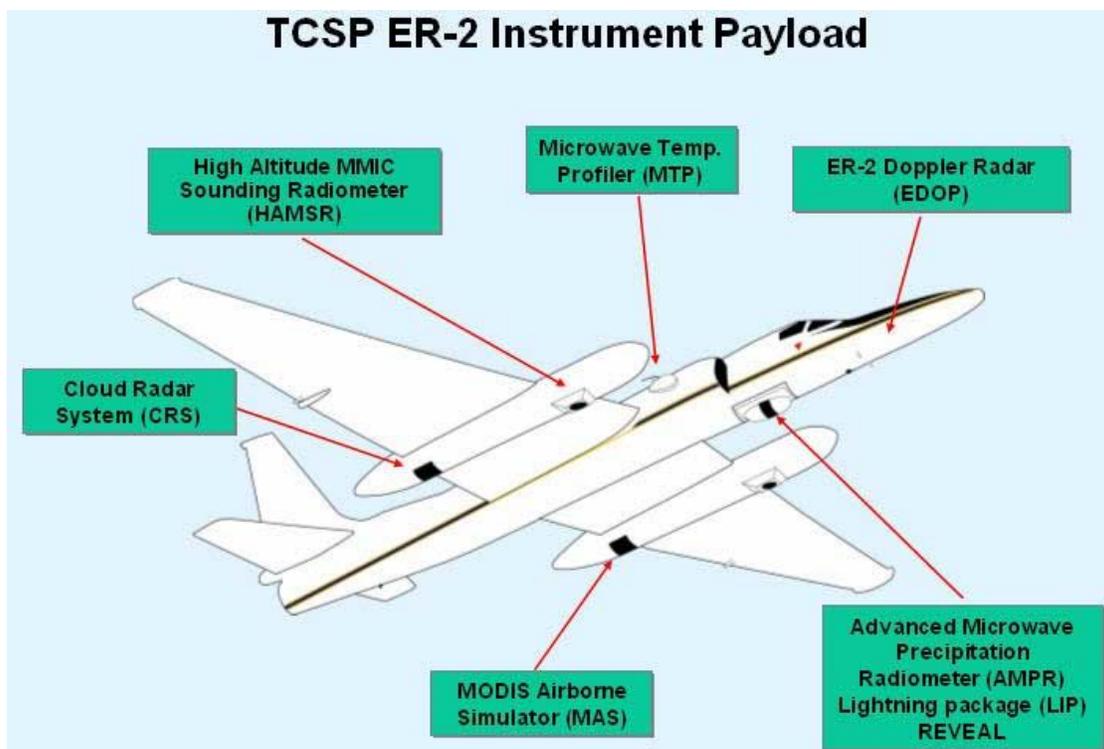


Figure 2: The TCSP ER-2 Instrument Payload  
(Image source: [GHRC TCSP webpage](#))

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## Data Characteristics

The TCSP ER-2 Navigation Data files contain navigation data organized into one file per ER-2 flight. These data are available at a Level 1A 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	Navigation Recorder (NAVREC) system (INS, GPS, temperature and pressure probes)
Spatial Coverage	N:24.785 , S: 4.684, E: -65.917, W: -99.737 (Central American tropical waters)
Temporal Coverage	July 2, 2005 - July 27, 2005
Temporal Resolution	1 file per flight
Sampling Frequency	1 second
Parameter	Aircraft navigation data
Version	1
Processing Level	1A

## File Naming Convention

The TCSP ER-2 Navigation Data are available in ASCII file format. Two files are provided per flight day; one file containing the aircraft navigation data and the other containing the flight report information. Browse files are available in PDF file format and include parameter plots and flight tracks. The files are named with the following convention:

**Data files:** tcsp\_naver2\_YYYYMMDD\_####.txt

**Flight report files:** tcsp\_naver2\_NavRep\_YYYYMMDD\_####.pdf

**Browse files:** tcsp\_naver2\_YYYYMMDD\_####\_[plots|track].pdf

Table 2: File naming convention variables

Variable	Description
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day

####	ER-2 Flight number
[plots track]	Browse image type: plots= ER-2 state parameter plot images track= ER-2 aircraft flight track image
.txt	ASCII text file format
.pdf	Portable Document Format (PDF)

## Data Format and Parameters

The TCSP ER-2 Navigation Data include ASCII data files, and PDF flight reports and browse imagery. Each of these file types are detailed below.

### ASCII Data Files

The ASCII text data files begin with a header that first lists placeholder numbers. Following these are a list of the data field column headings followed by the first line of data. From thereon, the data are listed in columnar format. These data fields are listed in Table 3 below.

Table 3: Data Fields

Field Name	Description	Unit	Output format
[]G	GPS status (G=Go/N=No Go)	-	XX
day:hh:mm:ss	Julian day and two-digit hour, minute and second in UTC	-	XX:XX:XX:XX
iLatitude	Present position latitude	degrees	N/S XX.XXXXXX
iLongitude	Present position longitude	degrees	E/W XXX.XXXXXX
tHead	True heading	degrees	XXX.XX
Pitch	Pitch angle (up+)	degrees	+/- XX.XXXX
Roll	Roll angle (rt. +)	degrees	+/- XX.XXXX
gSpeed	Ground speed	m/s	XXX.XX
TrackA	Track angle true	degrees	XXX.XX
iWsp	Inertial wind speed	m/s	XX.X
iWdir	Inertial wind direction	degrees	XXX.X
bLongA	Body long. acceleration	m/s <sup>2</sup>	+/- X.XXX
bLatIA	Body lat. acceleration	m/s <sup>2</sup>	+/- X.XXX
bNormA	Body norm. acceleration	m/s <sup>2</sup>	+/- X.XXX
TArat	Track angle rate	deg/s	+/- XX.X
pRate	Pitch rate	deg/s	+/- XX.X
rRate	Roll rate	deg/s	+/- XX.X
iVsped	Inertial vertical speed	m/s	+/- XX.XX
gAlt	GPS altitude	m	XXXXX.X
gLatitude	GPS latitude	degrees	N/S XX.XXXXXX
gLongitude	GPS longitude	degrees	E/W XXX.XXXXXX

sPress*	Static pressure	mbar	XXXX.XXX
tPress	Total pressure	mbar	XXXX.XXX
dPress	Differential pressure	mbar	XX.XXX
tTemp*	Total temperature	deg C	+/- XX.XX
sTemp*	Static temperature	deg C	+/- XX.XX
pAlt*	Barometric altitude	m	XXXXX.X
Mach*	Mach number	-	X.XXX
pTAS*	True airspeed	m/s	XXX.XX
pWsp*	Wind speed	m/s	XX.X
pWdir*	Wind direction	degrees	XXX.X
sElev	Sun elevation	degrees	+/- XX.XX
sAzim	Sun azimuth	degrees	+/- XXX.XX
DAV-1	Analog channel	V	+/- X.XXX
DAV-2	Analog channel	V	+/- X.XXX
DAV-3	Analog channel	V	+/- X.XXX
DAV-4	Analog channel	V	+/- X.XXX
DAV-5	Analog channel	V	+/- X.XXX
DAV-6	Analog channel	V	+/- X.XXX
DAV-7	Analog channel	V	+/- X.XXX
DAV-8	Analog channel	V	+/- X.XXX
DAV-9	Analog channel	V	+/- X.XXX
DAV-10	Analog channel	V	+/- X.XXX
DAV-11	Analog channel	V	+/- X.XXX
DAV-12	Analog channel	V	+/- X.XXX
bsPres	Body static pressure	mbar	+/- XXX.XXX
biPres	Body differential pressure	mbar	XX.XXX
bAlt	Body altitude	m	XXXXX.X
bTAS	Body true airspeed	m/s	XXX.XX
bMach	Body mach number	-	X.XXX
fTemp	Flight-level temperature	deg C	+/- XX.XX

\*These values are not valid at an aircraft altitude below 10km

More information about the navigation recorder output can be found in the [ER-2 Experimenter Handbook](#).

### **Flight Reports**

The flight reports include the ER-2 navigation recorder report and data information. The navigation report header includes the aircraft number, pilot, date, day of the year, takeoff and landing time in UTC, departure and arrival airport, campaign, and additional information and remarks. The remainder of the report includes the data file information such as file duration, date and time, the power switch on and off times, and the altitude at which the ER-2 aircraft was flying when switch changes were made. Additional information

about the ER-2 flights during TCSP is available in the ER-2 Flight Summaries inside the [TCSP Mission Reports directory](#).

### **Browse Image Files**

There are two types of browse imagery: the ER-2 “plots” files (\_plots.pdf) and the flight “track” files (\_track.pdf). The “plots” files include time-series plots for the aircraft navigation and meteorological parameters such as Inertial Navigation Unit (INU) altitude, static air pressure, true airspeed, INU pitch angle, and total air temperature. These parameter measurements are 5-second averaged. There is a flight track image included in the “plots” file that is also stored separately in the “track” file. The “track” files include a single image of the ER-2 aircraft flight track. The track includes a background map, latitude and longitude lines, UTC time-stamps along the flight path, and wind barbs indicating the wind speeds at different points during the flight.

### **Algorithm**

As described in the [NASA ER-2 Aircraft Handbook](#), the ER-2 INS functions by sensing accelerations from a gyro-stabilized platform. The system computer then combines this information to determine the location (latitude & longitude), altitude (pitch & roll), and course of the aircraft. The data are acquired at one-second intervals and then converted into engineering units.

### **Quality Assessment**

The ER-2 navigation system utilizes a GPS-update function that helps to avoid INS drift errors. The GPS measurements are accurate within approximately 20 meters. Additionally, aircraft sensors remain powered for a short time after landing for calibration. More information about the ER-2 navigation system accuracy procedures is available in the [NASA ER-2 Aircraft Handbook](#).

### **Software**

No software is required to view these data files. The TCSP ER-2 Navigation Data ASCII text files can be viewed in a text editor or in spreadsheet software, such as Microsoft Excel or Notepad++.

### **Known Issues or Missing Data**

There is one file per flight. Since flights did not occur each day of the campaign, data are only available on flight days.

### **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>

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NASA Dryden Flight Research Center (2002). ER-2 Airborne Laboratory Experimenter Handbook. [https://www.nasa.gov/centers/dryden/pdf/90464main\\_ER2handbook.pdf](https://www.nasa.gov/centers/dryden/pdf/90464main_ER2handbook.pdf)

## Related Data

All data collected during the TCSP field campaign are considered related to this ER-2 Navigation dataset. These data can be located using the GHRC [HyDRO2.0](#) search tool and searching the term 'TCSP'.

## Contact Information

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

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User Services  
320 Sparkman Drive  
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Web: <https://ghrc.nsstc.nasa.gov/>

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