Global Hydrology Resource Center

Data User Guide

GOES-R PLT Cloud Radar System (CRS)

Introduction

The GOES-R PLT Field Campaign Cloud Radar System (CRS) dataset provides high-resolution profiles of reflectivity and Doppler velocity at aircraft nadir along the flight track. The CRS was flown aboard a NASA ER-2 high-altitude aircraft during the GOES-R Post Launch Test (PLT) field campaign. The GOES-R PLT field campaign took place from March 21 to May 17, 2017 in support of post-launch product validation of the Advanced Baseline Image (ABI) and the Geostationary Lightning Mapper (GLM) aboard the GOES-R, now GOES-16, satellite. The CRS data files are available in netCDF-3 format with browse imagery available in PNG format.

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

Citation

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Keywords:

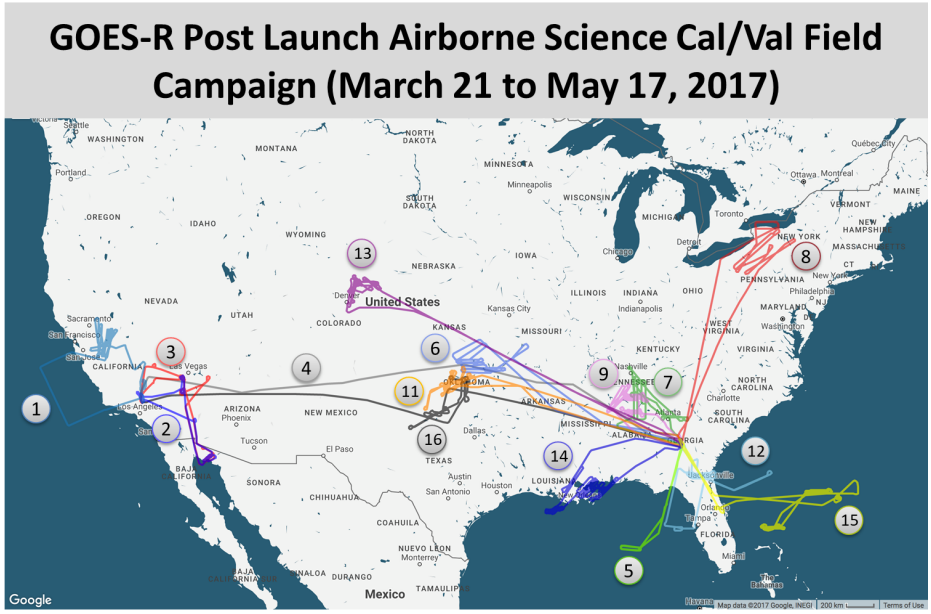
NASA, GHRC, GOES-R PLT, ER-2, CRS, precipitation, aircraft observations, W-Band Doppler radar, polarimetric, reflectivity, Doppler velocity

Campaign

The Geostationary Operational Environmental Satellites - R series (GOES-R) is a geostationary satellite program comprised of a four-satellite fleet including GOES-R, GOES-S, GOES-T, and GOES-U. The GOES-R Series Program is a collaborative development and acquisition effort between the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) to develop, launch

and operate the satellites. The first satellite in the GOES-R series, GOES-R, launched on November 19, 2016 and became GOES-16 when it reached geostationary orbit. GOES-16 replaced GOES-13 as NOAA's operational GOES East satellite at 75.2 degrees west longitude on December 18, 2017. GOES-16 observes North and South America, as well as the Atlantic Ocean all the way to the west coast of Africa. GOES-16 provides high spatial and temporal resolution imagery of the Earth using its Advanced Baseline Imager (ABI). GOES-16's Geostationary Lightning Mapper (GLM) is the first operational lightning mapper flown in geostationary orbit. GOES-16 also includes four other scientific instruments for monitoring space weather and the Sun. More information about the GOES-R mission can be found at the GOES-R website.

The GOES-R Post Launch Test (PLT) field campaign took place between March 21 and May 17, 2017 in support of the post-launch validation of NOAA's new generation of geostationary Earth observing instruments: ABI and GLM. The campaign was comprised of two phases: the first centered on the U.S. west coast, providing tests primarily for the ABI instrument, and the second focused on the central and eastern U.S. with tests primarily for the GLM instrument (Figure 1). The validation effort included targeted data collections from the NASA ER-2 high-altitude aircraft integrated with nine payloads (both passive and active instruments) coordinated with ground based and low earth-orbit referenced data from several operational and research satellite missions. Sixteen ER-2 aircraft validation missions, totaling 105.1 mission flight hours, were conducted over ideal Earth validation targets, such as deserts and oceans, thunderstorms, active wildfires, and an expansive set of cloud and moisture phenomenology. Dedicated ABI 30-second mesoscale (MESO) imagery collections were conducted concurrent with the ER-2 high-altitude aircraft based sensors during each GLM mission. The GOES-R PLT field campaign provided critical reference data and new insights into the performance NOAA's new generation of geostationary Earth observing instrument products. More information about the GOES-R PLT field campaign is available on the GOES-16 Field Campaign webpage.



*Flight #10 - April 27, 2017 - Huntsville, AL not shown due to aircraft navigation not reporting

Figure 1: The GOES-R PLT Field Campaign study area
(Image source: Frank Padula)

Instrument Description

The Cloud Radar System (CRS) is a 94 GHz, W-band polarimetric Doppler radar at a 3 millimeter wavelength that was developed to operate without pilot assistance aboard the NASA ER-2 high-altitude science aircraft. CRS provides high-resolution profiles of reflectivity and Doppler velocity in clouds in addition to measurements for other important atmospheric properties. The CRS resides in the tailcone of the ER-2 superpod (Figure 3) and its radar beam points downward toward earth's surface. Due to the instrument's high-frequency transmissions, the CRS is highly-sensitive and can therefore be used to study cirrus clouds. The ER-2 aircraft generally flies at an altitude of about 20 km, in the lower stratosphere, and can detect clouds and precipitation from the aircraft level down to the surface. Specifications of CRS are outlined in Table 1.

Table 1: GOES-R PLT CRS Instrument Characteristics

Characteristic	Value
Frequency	94.155 GHz
Instrument	Cloud Radar System utilizing a 94.155 GHz W-band 3mm airborne polarimetric Doppler radar
Transmitter Type	30 W Solid State Power Amplifier (SSPA)
Peak Power	30 W
Beamwidth	0.46 degrees
Pulse Repetition Frequency	High: 4464.29 Hz, Low: 3571.43 Hz
Range Resolution	161 meters (horizontal resolution at surface) at 20km range

Gate Spacing	75 meters

For more information about the NASA ER-2 CRS, refer to the NASA Airborne Science Program CRS webpage, NASA GSFC CRS webpage, and Li, Heymsfield, Racette, Tian, and Zenker (2004), describing the radar system in detail.

Figure 2: CRS setup in laboratory with the airborne antenna configuration
(Image Source: Li et al. (2004))

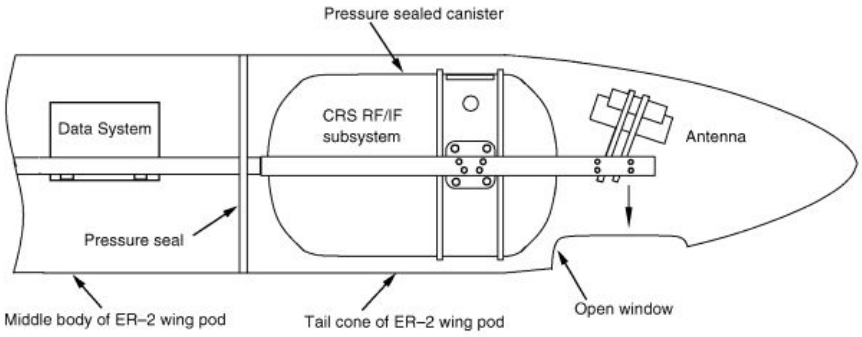


Figure 3: CRS configuration with airborne antenna in the tailcone of the ER-2 superpod.
(Image Source: Li et al. (2004))

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Data Characteristics

The GOES-R PLT Cloud Radar System (CRS) data are available in netCDF-3 file format at level 1B processing level. Browse imagery of the CRS reflectivity and doppler wind plots are available in PNG file format. More information about the NASA data processing levels is available on the EOSDIS Data Processing Levels webpage. Table 2 outlines key GOES-R PLT CRS dataset characteristics.

Table 2: Data Characteristics

Characteristic	Description
Platform	NASA Earth Resources 2 (ER-2) aircraft
Instrument	Cloud Radar System (CRS)
Projection	n/a
Spatial Coverage	N: 43.57246 , S: 26.44884 , E: -72.20187 , W: -117.1842 (United States of America)
Spatial Resolution	161 meters (horizontal resolution at surface) at 20km range
Temporal Coverage	April 11, 2017 - May 17, 2017
Temporal Resolution	Daily
Sampling Frequency	0.25 sec
Parameter	Reflectivity, Doppler velocity
Version	1
Processing Level	1B

File Naming Convention

The GOES-R PLT Cloud Radar System (CRS) dataset contains netCDF-3 data files and PNG browse imagery with the following naming convention:

Data files: GOESR_CRS_L1B_YYYYMMDD_v0.nc
Browse files: GOESR_CRS_YYYYMMDD_[start time]-[end time].png

Table 3: File naming convention variables

Variable	Description
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
[start time]-[end time]	Start and end time of data in [hhmmss]-[hhmmss] where:

	hh= two-digit hour in UTC mm= two-digit minute in UTC ss= two-digit second in UTC
v0	Version 1
.nc	netCDF-3 format
.png	Portable Network Graphics format

Data Format and Parameters

The GOES-R PLT Cloud Radar System (CRS) dataset contains radar reflectivity and Doppler velocity measurements collected during flight by the radar while mounted on the NASA ER-2 high altitude science aircraft. Each data file also contains flight information such as aircraft altitude, orientation, and GPS location. Please refer to Table 4 for additional data field information.

Table 4: Data Fields

Field Name	Description	Data Type	Unit
dop	Doppler Velocity after corrected for aircraft motion and folding	float	m/s
evel	East aircraft ground speed	float	m/s
frequency	Frequency of radar	float	GHz
gatesp	Range gate spacing	float	m
head	Aircraft heading	float	deg
height	Aircraft altitude	float	meter
incid	Incidence Angle	float	deg
lat	GPS latitude (minus sign = South)	float	degree
lon	GPS aircraft longitude (minus sign = West)	float	degree
missing	Missing value*	float	-
nvel	North aircraft ground speed	float	m/s
pitch	Aircraft pitch angle	float	degree
pwr	Return power	float	dB
range	Range from radar	float	m
ref	Radar Reflectivity	float	dBZ
roll	Aircraft roll angle	float	degree
time	Time in UTC	float	hours
track	Aircraft track angle	float	degree
vacft	Estimate of aircraft Doppler component	float	m/s
wvel	Aircraft vertical speed	float	m/s

*Scalar variable has value: NaN

Algorithm

The CRS data processing system uses dual pulse repetition frequencies to obtain clear, definitive Doppler velocity measurements. The Doppler processing was done using the pulse pair estimation method, which requires less computation that other methods. This method is often used in pulse Doppler radar signal processing. The mean Doppler and spectrum width are calculated in post-processing. More detail on how the CRS data was obtained can be found in Li et al. (2004).

Quality Assessment

Both internal and external calibration methods are used on the CRS. Radar calibration helps to minimize erroneous reflectivity measurements. Internal calibration of the CRS included monitoring receiver performance and transmitter stability. External calibration was done by using target calibration methods and intercomparing CRS measurements with those of other radars. Also, CRS Doppler velocity values have been corrected for the motion and orientation of the aircraft. More information about the ER-2 CRS calibration methods can be found in Li et al. (2004).

Software

This dataset is in netCDF-3 format and does not require any specific software to read. However, Panoply is an easy-to-use free tool for reading and visualizing the data within the netCDF-3 files.

Known Issues or Missing Data

Within each data file, there is a variable named 'missing', which indicates missing data values. The ER-2 aircraft did not operate each day of the campaign, so CRS data are only available for aircraft flight days. Lastly, around the midpoint of the campaign, there were some intermittent Doppler problems that were caused by electromagnetic interference. No additional information is available, but efforts are being made to reduce this problem in future field campaigns.

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Related Data

All datasets collected during the GOES-R PLT field campaign are considered related datasets and can be located by searching the term 'GOES-R PLT' in the GHRC HyDRO2.0 search tool. The CRS instrument was also used in other field campaigns. These datasets can be located by searching the term 'CRS' in HyDRO2.0 and are listed below.

GPM Ground Validation Cloud Radar System (CRS) OLYMPEX (http://dx.doi.org/10.5067/GPMGV/OLYMPEX/CRS/DATA101)

GPM Ground Validation Cloud Radar System (CRS) IPHEx (http://dx.doi.org/10.5067/GPMGV/IPHEX/CRS/DATA101)

TCSP Cloud Radar System (CRS)
(http://dx.doi.org/10.5067/TCSP/CRS/DATA101)

Contact Information

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

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