Global Hydrology Resource Center

Data User Guide

Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR) IMPACTS

Introduction

The Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR) IMPACTS dataset consists of brightness temperature measurements collected by the Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR) flown onboard the NASA ER-2 aircraft 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. IMPACTS 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. CoSMIR is a conical and cross-track scanning radiometer with frequencies centered at 50.3, 52.8, 89.0, 165.5, 183.31±1, 183.31±3, and 183.31±7 GHz. The brightness temperature data from CoSMIR are available from January 15 through February 27, 2020 in netCDF-4 format.

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

Citation

Kroodsma, Rachael. 2020. Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR) 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/COSMIR/DATA101

Keywords:

NASA, GHRC, IMPACTS, GPM GMI, CoSMIR, radiometer, ER-2, brightness temperature

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 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].

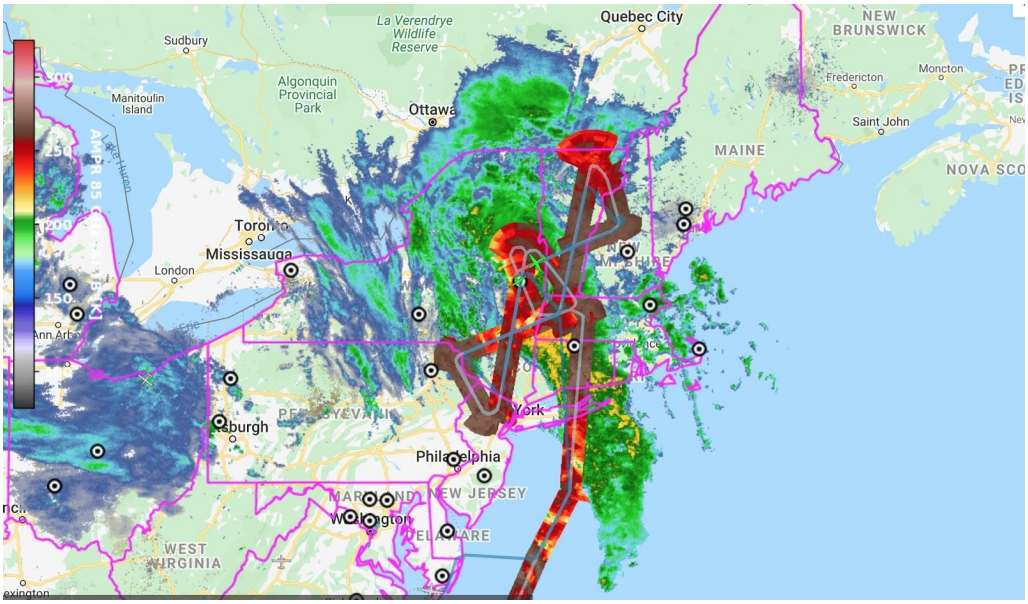

Figure 1: IMPACTS field campaign operations on January 25, 2020 with plots of ER-2 and P-3 flight tracks in addition to ground radar sites and radar reflectivity over the region (Image source: Dr. Timothy Lang, NASA MSFC)

Instrument Description

The Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR) instrument is a 9-channel airborne radiometer originally used to calibrate and validate the Defense Meteorological Satellite Project (DMSP) F-Series Special Sensor Microwave/Imager/Sounder (SSMIS). It was adapted to the channel set of the GPM Microwave Imager (GMI). CoSMIR has four receivers near 50, 91, 150, and 183 GHz which measure horizontally polarized radiation with vertically polarized measurement capability at 89.0 and 165.5 GHz. The 9 channels of CoSMIR are 50.3H, 52.8H, 89.0H&V, 165.5H&V, 183.31±1H, 183.31±3H, and 183.31±7H GHz. CoSMIR performs both conical and cross-track scanning from left to right with conical scanning in the forward direction (aircraft direction of travel) only. The CoSMIR instrument measurement footprint size varies with aircraft altitude and instrument look direction. Receivers and radiometer electronics on the CoSMIR instrument are housed in a 21.5 cm diameter and 28 cm long cylindrical scan head, which is rotated by a two-axis gimbaled mechanism. There are two in-flight external calibration targets at cruising altitude: one heated to 328 K, and the other maintained at ambient temperature. Due to these onboard calibration targets, the data between 50 to 183 GHz have an accuracy of ±1 K. More information about the CoSMIR instrument can be found on the NASA Airborne Science Program CoSMIR webpage.

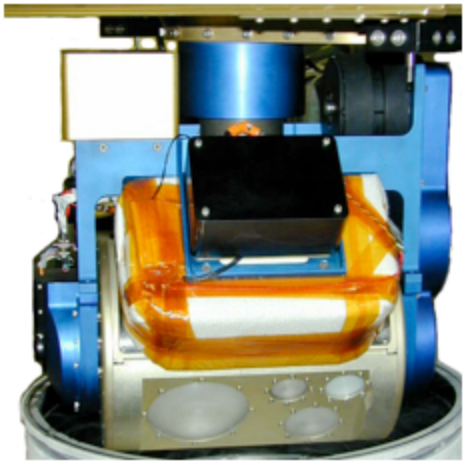

Figure 2: CoSMIR instrument
(Image source: Mesoscale Atmospheric Processes webpage)

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Data Characteristics

The Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR) IMPACTS dataset files contain CoSMIR brightness temperature data along with aircraft and date/time

information. The data are available in netCDF-4 format at a Level 1B data 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	Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR)
Spatial Coverage	N: 45.770 , S: 32.417, E: -70.266, W: -116.516 (United States of America)
Spatial Resolution	At a flight altitude of 20 km, surface footprint resolution: 2.3 km x 3.9 km at a look angle of 53 degrees 1.4 km x 1.4 km at nadir
Temporal Coverage	January 15, 2020 - February 27, 2020
Temporal Resolution	1 file per flight
Sampling Frequency	Approx. 6-10 seconds between different scan lines in a swath Approx. 50 milliseconds between individual pixels in a scan line
Parameter	Brightness temperatures
Version	1
Processing Level	1B

File Naming Convention

The Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR) IMPACTS dataset files are available in netCDF-4 format. The dataset files are named using the following convention:

Data files:
impacts_cosmir_YYYYMMDD_[forward_conical|cross_track|aft_conical|along_track|nadir]_v1.nc

Table 2: File naming convention variables

Variable	Description
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
[forward_conical|cross_track|aft_conical|along_track|nadir]	Scanning mode that CoSMIR operated in. There are five different modes as shown. Not every day will have all five options. Each flight will have 2-3 scanning modes.
.nc	netCDF-4 format

Data Format and Parameters

The Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR) IMPACTS dataset consists of CoSMIR brightness temperature data along with aircraft and date/time information in netCDF-4 format. There are five CoSMIR scan types: forward conical (scans left to right), aft conical, cross-track, along-track, and nadir stare. There are separate files for each scan type however the data fields remain the same. The data field descriptions for each file are listed in Table 3 below.

Table 3: Data Fields for CoSMIR netCDF-4 files

Field Name	Description	Unit
Year	Year (UTC)	-
Month	Month (UTC)	-
DayOfMonth	Day of the month (UTC)	-
Hour	Hour of day (UTC)	-
Minute	Minute (UTC)	-
Second	Second (UTC)	-
MilliSecond	Millisecond (UTC)	-
AC_Altitude	Aircraft GPS altitude	meters
AC_Pitch	Aircraft pitch	degrees
AC_Roll	Aircraft roll	degrees
AC_Heading	Aircraft heading	degrees
AC_Latitude	Aircraft latitude	Degrees North
AC_Longitude	Aircraft longitude	Degrees East
Tb	Calibrated brightness temperature	K
IncidenceAngle	Earth incidence angle of CoSMIR	degrees
Latitude	Latitude of CoSMIR center of footprint	Degrees North
Longitude	Longitude of CoSMIR center of footprint	Degrees East
Azimuth	Azimuth angle of CoSMIR with respect to the aircraft	degrees
Elevation	Elevation angle of CoSMIR with respect to the aircraft	degrees

Algorithm

CoSMIR was originally modified to replicate the GPM GMI measurement channels for validation efforts. The GPM radiometer algorithms use a range of passive frequencies as well as a priori information to derive precipitation measurements from brightness temperature retrievals. CoSMIR's 9 frequencies of measurement and the various retrieval algorithms allow for the estimation of a wide range of parameters, from water vapor content to snowfall rates. More information about the GPM radiometer algorithms is available on the NASA GPM Radiometer Algorithms webpage.

Quality Assessment

CoSMIR has two in-flight external calibration targets at cruising altitude: one heated to 328 K, and the other maintained at ambient temperature. Due to these calibration methods, the data between 50 to 183 GHz have an accuracy of ±1 K. Previous CoSMIR flight data have been compared to DMSP SSMIS brightness temperatures as described in Wang et al. (2008).

Software

No special software is required to view these data, however, Panoply can be used to easily open and view the CoSMIR netCDF-4 data files.

Known Issues or Missing Data

Azimuth and elevation angles listed in the CoSMIR data files are with respect to the aircraft. The aircraft pitch, roll, and heading were not taken into account. The conical scan off-nadir angle was set at *53* degrees for flights through 01/25/2020, and changed to 49.2 degrees for all flights from 02/01/2020 on. The following section lists details of the CoSMIR scan modes over the course of the campaign:

(1) Forward conical/cross-track
Flights: 12/16/2019 (check flight), 01/15/2020 (ferry flight), 01/18/2020, & 01/25/2020
Forward conical scans left to right (looking in direction of aircraft nose). Azimuth angle *-60* to *+60* and Elevation angle *+53* or *+49.2*. Cross-track scans left to right. Azimuth angle *+90* degrees and Elevation angle *-53* to *+53* or *-49.2* to *+49.2*.

(2) Forward conical/along-track
Flights: 02/01/2020, 02/05/2020, 02/25/2020, & 02/27/2020
Forward conical scans left to right. Azimuth angle *-90* to *+90* and Elevation angle *+53* or *+49.2*. Along-track scans front to back. Azimuth angle *+180* and Elevation angle *+53* to *-53* or *+49.2* to *-49.2*.

(3) Forward conical/aft conical with nadir stare
Flights: 02/07/2020 & 02/23/2020 (calibration flight)
Forward conical scans left to right (looking in direction of aircraft nose). Azimuth angle *-60* to *+60* and Elevation angle *+53* or *+49.2*. Aft conical scans right to left (looking in direction of aircraft nose). Azimuth angle *+120* to *+240* and Elevation angle *-53* or *-49.2*.

The ER-2 aircraft did not operate each day of the campaign, therefore CoSMIR data are only available for aircraft flight days. Missing data values are indicated by *-999*.

References

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Wang, J. R., Racette, P. E., and Piepmeier, J. R. (2008). A comparison of Near Concurrent Measurements from the SSMIS and CoSMIR for some Selected Channels over the Frequency Range of 50-183 GHz. *IEEE Transactions on Geoscience and Remote Sensing*, 46(4), 923-933. doi: https://doi.org/10.1109/TGRS.2007.904038

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. Listed below are datasets from other field campaigns and studies that used the CoSMIR instrument:

GPM Ground Validation Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR) OLYMPEX dataset
(http://dx.doi.org/10.5067/GPMGV/OLYMPEX/COSMIR/DATA301)

GPM Ground Validation Conical Scanning Millimeter-wave Imaging Radiometer (CoSMIR) IPHEx dataset
(http://dx.doi.org/10.5067/GPMGV/IPHEX/CoSMIR/DATA101)

GPM Ground Validation Conical Scanning Millimeter-wave Imaging Radiometer (COSMIR) GCPEx dataset
(http://dx.doi.org/10.5067/GPMGV/GCPEX/CoSMIR/DATA101)

GPM Ground Validation Conical Scanning Millimeter-wave Imaging Radiometer (COSMIR) MC3E dataset
(http://dx.doi.org/10.5067/GPMGV/MC3E/CoSMIR/DATA101)

Contact Information

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

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