Data User Guide

Advanced Microwave Precipitation Radiometer (AMPR) IMPACTS

Introduction

The Advanced Microwave Precipitation Radiometer (AMPR) IMPACTS dataset consists of brightness temperature measurements collected by the Advanced Microwave Precipitation Radiometer (AMPR) onboard the NASA ER-2 high-altitude research aircraft. AMPR provides multi-frequency microwave imagery, with high spatial and temporal resolution for deriving cloud, precipitation, water vapor and surface properties. These measurements were taken during the Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) campaign. Funded by NASA's Earth Venture program, IMPACTS is the first comprehensive study of East Coast snowstorms in 30 years. Data files are available from January 18, 2020 through February 28, 2022 in netCDF-4 format.

Citation

Lang, Timothy. 2022. Advanced Microwave Precipitation Radiometer (AMPR) IMPACTS [indicate subset used]. Dataset available online from the NASA Global Hydrometeorology Resource Center DAAC, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/IMPACTS/AMPR/DATA101

Keywords:

NASA, GHRC, IMPACTS, AMPR, radiometer, microwave radiation, brightness temperature, Atlantic coast

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. The second deployment was from January 2022 through March 2022. 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](#).

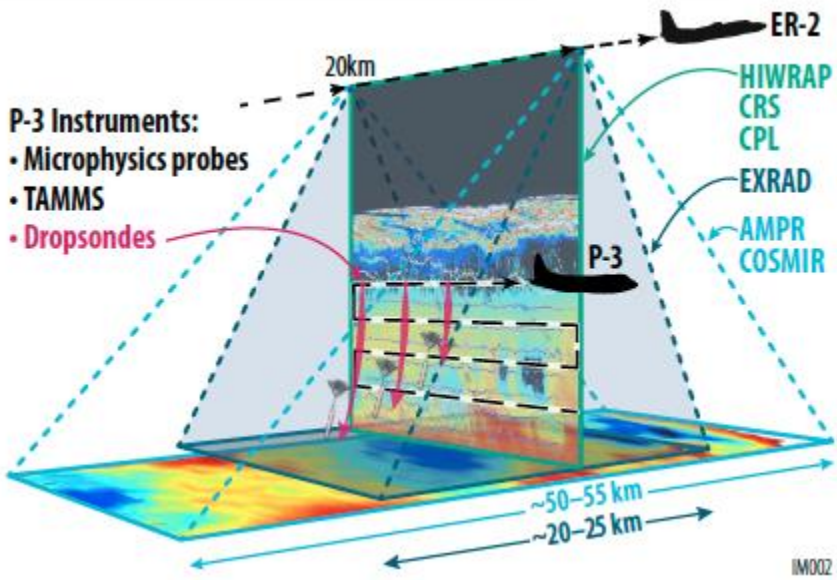

Figure 1: IMPACTS airborne instrument suite.
(Image Source: IMPACTS)

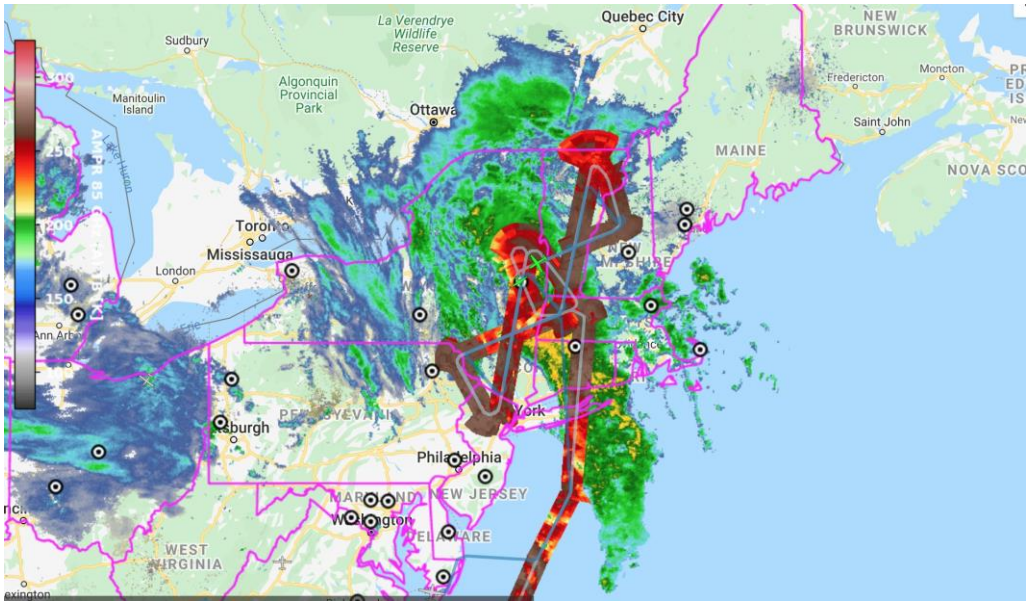

Figure 2: IMPACTS field campaign operations on January 25, 2020 with plots of ER-2 and P-3 flight tracks in addition to ground radar sites and radar reflectivity over the region (Image source: Dr. Timothy Lang, NASA MSFC)

Instrument Description

The Advanced Microwave Precipitation Radiometer (AMPR) is a multi-frequency, dual-polarized, cross-track scanning microwave radiometer flown onboard the NASA Earth Resources 2 (ER-2) high-altitude research aircraft. AMPR is a passive remote sensor that measures the intensity of radiation at four microwave frequencies: 10.7, 19.35, 37.1, and 85.5 GHz. The measured intensity is then used to calculate brightness temperatures. AMPR scans at 90 degrees cross-track, perpendicular to the direction of aircraft motion. AMPR can measure radiation oriented in both the horizontal and the vertical. From these microwave measurements various cloud, precipitation, water vapor and surface properties can be derived. Table 1 lists several of the AMPR performance characteristics. More information about the AMPR instrument is available in the AMPR instrument micro article and the NASA AMPR webpage. More information about radiometers and remote sensors in general is available on the NASA Earthdata Remote Sensors webpage.

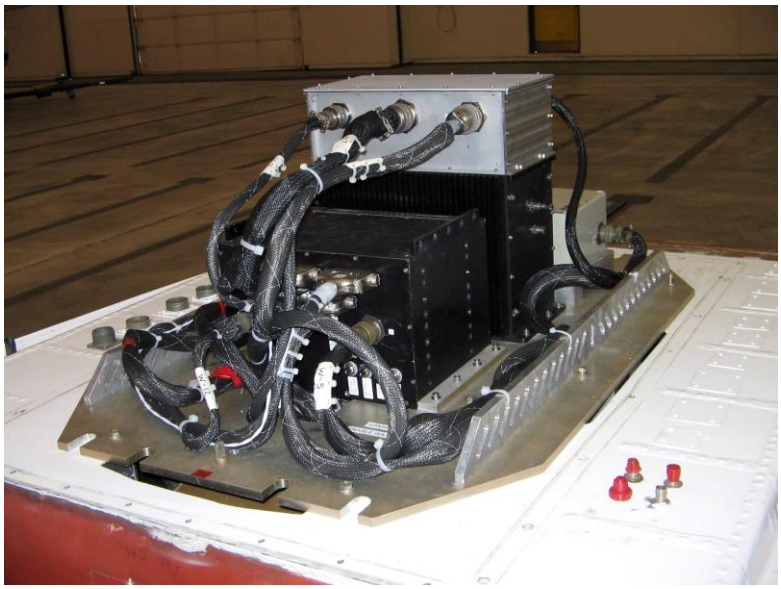

Figure 3: Advanced Microwave Precipitation Radiometer (AMPR)
(Image source: NASA IMPACTS ESPO)

Table 1: AMPR Performance Characteristics

Characteristic	85.5 GHz	37.1 GHz	19.35 GHz	10.7 GHz
Bandwidth (MHz)	1400	900	240	100
Integration Time (ms)	50	50	50	50
Horn Type*	SSM/I	SSM/I	SSM/I	GTRI
Lens Diameter (inches)	5.3	5.3	5.3	9.7
Beam width (degrees)	1.8	4.2	8.0	8.0
Footprint (km) [@ 20 km ER-2 alt. 500 kts]	0.64	1.48	2.78	2.78
Beam Efficiency (%)	N/A	98.8	98.7	97.8
Cross Polarization (%)	N/A	0.4	1.6	0.2

*The horn that feeds the three higher frequency channels is a copy of the Special Sensor Microwave/Imager (SSM/I) space borne multi-frequency lens horn aboard the Defense Meteorological Satellite Program (DMSP) satellites. A separate lens horn, which was built by the Georgia Technology Research Institute (GTRI), accommodates the 10.7 GHz frequency.

Investigators

Timothy Lang
NASA Marshall Space Flight Center
Huntsville, AL

Data Characteristics

The Advanced Microwave Precipitation Radiometer (AMPR) IMPACTS dataset consists of brightness temperature data stored in netCDF-4 format. The AMPR data are available from January 18, 2020 through February 28, 2022 at a Level 2 processing level. More information about the NASA data processing levels are available on the EOSDIS Data Processing Levels webpage. There is one ER-2 flight per data file. The characteristics of this dataset are listed in Table 2 below.

Table 2: Data Characteristics

Characteristic	Description
Platform	NASA Earth Resources 2 (ER-2) aircraft
Instrument	Advanced Microwave Precipitation Radiometer (AMPR)
Spatial Coverage	N: 48.258, S: 30.692, E: -64.366, W: -118.509 (U.S. Atlantic Coast)
Spatial Resolution	0.6 - 2.8 km footprint; varies with flight altitude and scan
Temporal Coverage	January 18, 2020 - February 28, 2022
Temporal Resolution	2-4 hours per ER-2 flight; 1 flight per data file
Sampling Frequency	3 seconds
Parameter	Brightness temperature
Version	1
Processing Level	2

File Naming Convention

The Advanced Microwave Precipitation Radiometer (AMPR) IMPACTS dataset files are available in netCDF-4 format. The dataset files are named using the following convention:

Data files: IMPACTS_AMPR_L2_YYYYMMDD_v1.nc

Table 3: File naming convention variables

Variable	Description
L2	Level 2 data
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
v1	Version 1
.nc	netCDF-4 format

There are two additional data files in this dataset. These use the file naming convention as shown above, but with the additions listed below.

Data file: IMPACTS_AMPR_L2_20200125_fullrate_v1.nc - AMPR did not record data during the second half of the 25 January 2020 flight. The “fullrate” file is this incomplete observation.

Data file: IMPACTS_AMPR_L2_20200125_complete_v1.nc - This is a complimentary file to the “fullrate” listed above. The “complete” file provides AMPR data for the full flight on 25 January 2020, but at a reduced resolution.

Additional details are in the AMPR IMPACTS Science Data document.

Data Format and Parameters

The Advanced Microwave Precipitation Radiometer (AMPR) IMPACTS dataset files include brightness temperature (TB) measurements, quality control (QC) metrics, flight profile characteristics, and water fraction information in netCDF-4 format. The TB, QC, and water fraction data are available for all four bands (10, 19, 37, and 85 GHz). The TB and QC data are also available from both the A (vertical) and B (horizontal) polarization channels. Table 4 below includes the description, data type, and unit for each variable. These are also provided in Appendix A of the AMPR IMPACTS Science Data.

Table 4: AMPR netCDF-4 Data Fields

Field Name	Description	Data Type	Unit
airSpeed	Aircraft Air Speed	double	m/s
channel	Polarization channel A: Left scan edge pure vertical polarization, right edge pure horizontal B: Opposite of A H: Deconvolved horizontal polarization V: Deconvolved vertical polarization	character	-
frequency	Central frequency of AMPR sensor channel	float	GHz
GPSAltitude	Altitude	double	m
GPSLatitude	Latitude	double	Degrees North
GPSLongitude	Longitude	double	Degrees East
GroundSpeed	Aircraft Ground Speed	double	m/s
Head	Aircraft true heading 0, 360 north	double	degrees
IncidenceAngle	Angle from surface normal at georeferenced location	double	degrees
IncidenceAngleQC	Incidence angle quality control index	short	-
LandFraction	Fraction of land in instantaneous field of view (IFOV) at each frequency [0-1]	double	-
Lat	Mean Sea Level (MSL) pixel latitude	double	Degrees North
Lon	Mean Sea Level (MSL) pixel longitude	double	Degrees East
Pitch	Aircraft pitch (+ up)	double	degrees
Pressure	Aircraft Static Air Pressure	double	hPa
QC	Quality control field	short	-
RelativeAzimuth	Azimuth of georeference pixel relative to aircraft heading	double	degrees
Roll	Aircraft roll (+ right)	double	degrees
ScanAngle	Off-nadi scan angle (+ starboard)	double	degrees

TB	Brightness temperature in four frequencies (10, 19, 37, and 85) and up to four channels (A, B, H, and V)	double	degrees K
Temperature	Aircraft total air temperature	double	degrees C
Time	Observation time (UTC) in	double	Seconds since 1970-01-01 00:00:00.000
WindDirection	Wind direction, clockwise from North	double	degrees
WindSpeed	Wins speed	double	m/s
Yaw	Aircraft yaw (track angle)	double	degrees

Algorithm

The AMPR instrument collects brightness temperature measurements to identify atmospheric parameters, such as water vapor and precipitation. Certain algorithms are used to convert the brightness temperature measurements into precipitation information. AMPR uses four different passive frequencies (10, 19, 37, and 85 GHz) that detect different types of precipitation, ranging from raindrops to cloud ice. Additional information about the AMPR measurement concept is available in this GTRI AMPR document.

Quality Assessment

As described in section 2 of the AMPR IMPACTS Science Data, an objectively determined quality control (QC) metric is provided. The QC metric is estimated based on the brightness temperature difference of a pixel within a 9x9 kernel of neighboring brightness temperatures. The QC metric is a discretized indicator of the difference within 5-Kelvin increments. Typical scene values fall in the QC 1 and 2 bins. However, very noisy scenes - generally indicative of instrument issues or potential scene contamination or excessive instrument noise - are isolated to values >= 4. As with any objective measure based on thresholding, however, there is a gray area in the higher bins where some of the data is of high quality but physical phenomena are generating sharp, local features that are flagged as suspect. This, in and of itself, could be useful for those wanting to isolate features (e.g., the edges of a strong convective cell). The quality control features are listed in Table 5.

Table 5: Quality Control Fields

Value	Description
0 to >4*	The quality control metric is estimated based on the brightness temperature of neighboring pixels.
1 = 0-45 degree, 2= >45.0 degree incidence angle	The incidence angle flag marks the pixels with high incidence angles, usually edge pixels, that result from aircraft roll maneuvers. A typical observation angle is -45 to 40 degrees.
FOV < 0.1 (Mostly land) FOV > 0.9 (Mostly water)	The pixel FOV water fraction provides an estimate of a pixel's percent FOV that contains surface water features.

*Typically, QC flags less than 2 are good data; values of 3 are more suspect but can arise from sharp transitions related to physical phenomenon; >4 usually indicative of some very noisy scenes (bad data) or local outliers.

AMPR data from previous campaigns have been compared to radar precipitation measurements in Vivekanandan et al., 1993.

Software

The AMPR netCDF-4 files can be viewed using Panoply. A Python toolkit (PyAMPR) has also been developed to allow for reading, plotting, and analysis of the AMPR data files.

Table 6: Software/Tool Information Table

Name	Type	Access	Software	License
PyAMPR	Data Visualization and Analysis	https://github.com/nasa/PyAMPR	Python 2.7 or 3.4, numpy, matplotlib, Basemap, os, time, simplekml, datetime, calendar, codecs, gzip, netCDF4.	All of this software, including software requirements, are open source.

Known Issues or Missing Data

- AMPR did not record data in the final few minutes of the 18 January 2020 flight due to a Compact Flash card reader issue
- AMPR did not record data during the second half of the 25 January 2020 flight due to a Compact Flash card reader issue.
    - Incomplete file: ends in '*_fullrate_v1.nc'
    - Low resolution, full flight file: ends in '*_complete_v1.nc'
- The 37 GHz (B) and 85 GHz (B) channels experienced significant noise during most IMPACTS flights. The 37B channel was especially affected and the end user is cautioned against using this channel's data. The 37A data were okay. The 85B data were less affected and these data may be usable provided great care is taken. The 85A data were okay.
- Figure 4 shows the preliminary analysis of when noise occurred on the 37B and 85B channels for all IMPACTS flights.

A	B	C	D	E	F	G	H	I	J
date	37B start		stop		85B start		stop		notes
	early bound	later bound	early bound	later bound	early bound	later bound	eary bound	later bound	
2020/1/15	17:12:48	17:14:30	22:40:24	22:41:02	17:14:01	17:15:16	18:47:24	18:49:01	Static also in 85A, end
2020/1/18	13:53:08	13:53:29		20:04:30	13:53:08	13:52:08	19:58:10	20:04:30	85B static occasionally
2020/1/25	17:59:09	18:01:00	21:30:38	22:30:38	NA	NA	NA	NA	
2020/2/1	11:42	11:42:37	17:14	17:15	11:41:16	11:44:36	15:27:14	15:27:52	
2020/2/6	21:00:53	21:01:31	1:38:53	1:39:04	21:03:29	21:05:28	1:01:07	1:07:36	Could not discern hard
2020/2/7	12:24:00	12:24:47	18:55:12	18:55:50	unsure	unsure	unsure	unsure	Some grainy features (
2020/2/23	16:44:00	16:44:30	19:07:30	19:08:15	NA	NA	NA	NA	Clearly-distinguishable
2020/2/25	19:45:55	19:45:29	3:57:50	3:58:28	20:44:31	20:46:08	2:00:23	2:01:01	
2020/2/27	7:02:55	7:03:29	15:18:37	15:20:19	NA	NA	NA	NA	

Figure 4: Preliminary analysis of noise occurrence on the 37B and 85B channels. (Image source: AMPR IMPACTS Science Data)

References

Advanced Microwave Precipitation Radiometer (AMPR): https://weather.msfc.nasa.gov/ampr

Galliano, J. A. & Platt, R. H. (1989). Advanced microwave precipitation radiometer. Proceedings of the *International Conference on Millimeter Wave and Far-Infrared Technology*, IEEE Xplore Digital Library. https://doi.org/10.1109/ICMWFT.1989.763744

Hood, R. E., Cecil, D. J., LaFontaine, F. J., Blakeslee, R. J., Mach, D. M., Heymsfield, G. M., & Goodman, M. (2006). Classification of tropical oceanic precipitation using high-altitude aircraft microwave and electric field measurements. *Journal of the Atmospheric Sciences*, *63(1)*, 218–233. http://doi.org/http://doi.org/10.1175/jas3606.1

Hood, R. E., Spencer, R. W., LaFontaine, F. J., & Smith, E. A. (1994). Simulation of Future Microwave Satellite Instruments Using High Resolution AMPR Aircraft Data. *In Seventh Conference on Satellite Meteorology and Oceanography*, *3*, 160–163.

Spencer, R.W., Hood, R.E., Lafontaine, F. J., Smith, E. A., Platt, R., Galliano, J., . . . Lobl, E. (1994). High-Resolution Imaging of Rain Systems with the Advanced Microwave Precipitation Radiometer. *Journal of Atmospheric and Oceanic Technology*, *11*, 849-857. https://doi.org/10.1175/1520-0426(1994)011%3C0849:HRIORS%3E2.0.CO;2

Vivekanandan, J., Turk, J., & Bringi, V. N. (1993). Comparisons of Precipitation Measurements by the Advanced Microwave Precipitation Radiometer and Multiparameter Radar. *IEEE Transactions on Geoscience and Remote Sensing*, *31(4)*, 860–870. http://doi.org/10.1109/36.239909

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 Earthdata Search Portal search tool. Other datasets collected by AMPR can be located by searching “AMPR” in GHRC Earthdata Search Portal and are listed below..

GPM Ground Validation Advanced Microwave Precipitation Radiometer (AMPR) OLYMPEX
(http://dx.doi.org/10.5067/GPMGV/OLYMPEX/AMPR/DATA101)

GPM Ground Validation Advanced Microwave Precipitation Radiometer (AMPR) IPHEx
(http://dx.doi.org/10.5067/GPMGV/IPHEX/AMPR/DATA202)

GPM Ground Validation Advanced Microwave Precipitation Radiometer (AMPR) MC3E
(http://dx.doi.org/10.5067/GPMGV/MC3E/AMPR/DATA101)

TC4 AMPR Brightness Temperature (TB)
(http://dx.doi.org/10.5067/TC4/AMPR/DATA101)

TCSP AMPR Brightness Temperature (TB)
(http://dx.doi.org/10.5067/TCSP/AMPR/DATA101)

CAMEX-4 AMPR Brightness Temperature (TB)
(http://dx.doi.org/10.5067/CAMEX-4/AMPR/DATA101)

AMPR Brightness Temperature (TB) KWAJEX
(http://dx.doi.org/10.5067/KWAJEX/AMPR/DATA101)

TRMM LBA (Large Scale Biosphere-Atmosphere) Experiment (AMPR)
(http://dx.doi.org/10.5067/TRMMLBA/AMPR/DATA101)

CAMEX-3 AMPR Brightness Temperature (TB)
(http://dx.doi.org/10.5067/CAMEX-3/AMPR/DATA101)

AMPR FIRE III ACE
(http://dx.doi.org/10.5067/FIREACE/AMPR/DATA101)

AMPR TELFUN-A Brightness Temperature (TB)
(http://dx.doi.org/10.5067/TEFLUNA/AMPR/DATA101)

AMPR Brightness Temperature CAMEX-2
(http://dx.doi.org/10.5067/CAMEX-2/AMPR/DATA101)

AMPR Brightness Temperature CAMEX-1
(http://dx.doi.org/10.5067/CAMEX-1/AMPR/DATA101)

AMPR Brightness Temperature CAPE Experiment
(http://dx.doi.org/10.5067/CAPE/AMPR/DATA101)

AMPR Brightness Temperature (TB) TOGA COARE
(http://dx.doi.org/10.5067/TOGACOARE/AMPR/DATA101)

AMPR Jacksonville Brightness Temperature (TB)
(http://dx.doi.org/10.5067/JAKSONVILLE/AMPR/DATA101)

Contact Information

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

NASA Global Hydrometeorology Resource Center DAAC
User Services
320 Sparkman Drive
Huntsville, AL 35805
Phone: 256-961-7932
E-mail: support-ghrc@earthdata.nasa.gov
Web: https://ghrc.nsstc.nasa.gov/

Updated: 12/8/2022