Global Hydrology Resource Center

Data User Guide

GPM Ground Validation Advanced Microwave Precipitation Radiometer (AMPR) OLYMPEX

Introduction

The GPM Ground Validation Advanced Microwave Precipitation Radiometer (AMPR) OLYMPEX dataset was collected by the AMPR instrument flown on the high altitude ER-2 research aircraft from November 9 - December 15, 2015, during the Olympic Mountains Experiment (OLYMPEX) field campaign conducted at Washington State's Olympic Peninsula. AMPR is an airborne passive microwave radiometer from which cloud, precipitation, water vapor, wind speed and wind direction can be obtained using advanced algorithms with the 10.7, 19.35, 37.1, and 85.5 GHz microwave frequency brightness temperatures measured by AMPR. The primary goal of OLYMPEX was to validate rain and snow measurements in midlatitude frontal systems moving from ocean to coast to mountains. AMPR data at the Global Hydrology Resource Center (GHRC) DAAC include netCDF format data files of brightness temperature and PNG browse files of Quality Control Flags and Brightness Temperatures.

Notice:

If you use AMPR instrument data in a publication please contact the PI to discuss potential co-authorship. Contact Timothy Lang, timothy.j.lang@nasa.gov.

Citation

Lang, Timothy and Anthony Guillory. 2017. AMPR Brightness Temperature and Quality Control Flag OLYMPEX [indicate subset used]. Dataset available online from the NASA EOSDIS Global Hydrology Resource Center Distributed Active Archive Center, Huntsville, Alabama, U.S.A. doi: http://dx.doi.org/10.5067/GPMGV/OLYMPEX/AMPR/DATA101

Keywords:

NASA, GHRC, OLYMPEX, Washington, ER-2, airborne, Global Precipitation Measurement, GPM, Brightness Temperature, Clouds, Microwave Radiometer

Campaign

The Global Precipitation Measurement (GPM) mission Ground Validation campaign used a variety of methods for validation of GPM satellite constellation measurements prior to and after launch of the GPM Core Satellite, which launched on February 27, 2014. The instrument validation effort included numerous GPM-specific and joint agency/international external field campaigns, using state of the art cloud and precipitation observational infrastructure (polarimetric radars, profilers, rain gauges, and disdrometers). Surface rainfall was measured by very dense rain gauge and disdrometer networks at various field campaign sites. These field campaigns accounted for the majority of the effort and resources expended by GPM GV. More information about the GPM mission is available at https://pmm.nasa.gov/GPM/.

One of the GPM Ground Validation field campaigns was the Olympic Mountains Experiment (OLYMPEX) which was held in the Pacific Northwest. The goal of OLYMPEX was to validate rain and snow measurements in midlatitude frontal systems as they move from ocean to coast to mountains and to determine how remotely sensed measurements of precipitation by GPM can be applied to a range of hydrologic, weather forecasting, and climate data. The campaign consisted of a wide variety of ground instrumentation, several radars, and airborne instrumentation monitoring oceanic storm systems as they approached and traversed the Peninsula and the Olympic Mountains. The OLYMPEX campaign was part of the development, evaluation, and improvement of GPM remote sensing precipitation algorithms. More information is available from the NASA GPM Ground Validation web site https://pmm.nasa.gov/olympex and the University of Washington OLYMPEX web site http://olympex.atmos.washington.edu/.

Figure 1: OLYMPEX Domain
(Image Source: https://pmm.nasa.gov/OLYMPEX)

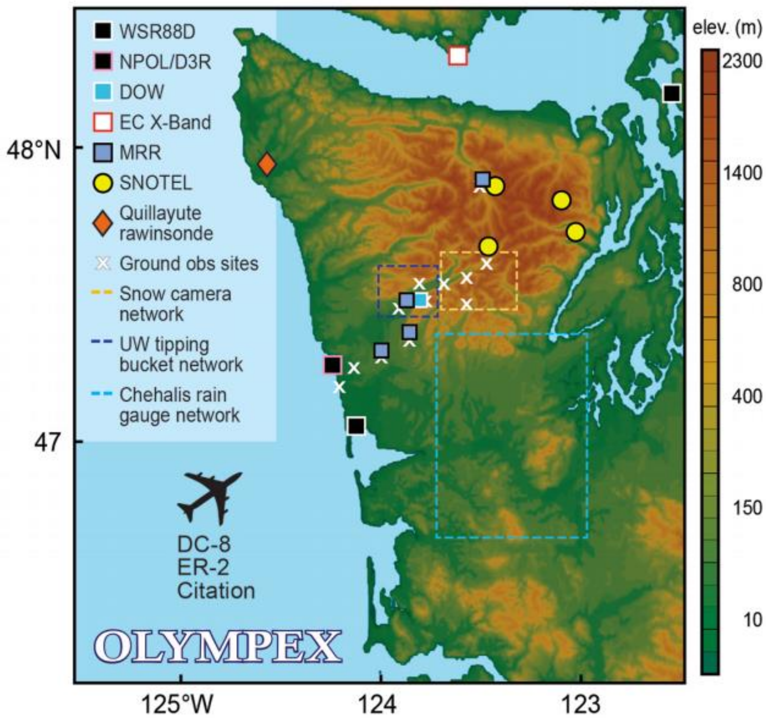

Figure 2: OLYMPEX Field Locations
(Image Source: https://pmm.nasa.gov/OLYMPEX)

Instrument Description

The Advanced Microwave Precipitation Radiometer (AMPR) is a multi-frequency, dual-polarized, cross-track scanning microwave radiometer managed by NASA Marshall Space Flight Center (MSFC). The AMPR Instrument was flown on NASA's Earth Resources 2 (ER-2) high-altitude airborne science aircraft. AMPR measures microwave brightness temperatures at four calibrated microwave frequencies: 10.7, 19.35, 37.1, and 85.5 GHz, from which cloud, precipitation, water vapor, and surface properties (including ocean winds) can be derived. These frequencies are sensitive to the emission and scattering of precipitation-sized ice, liquid water, and water vapor (Hood et al. 2006). AMPR scans at 90 degrees cross-track, perpendicular to the direction of aircraft motion. The data are geolocated based on scan angle and aircraft position and attitude information. AMPR has a dual-lens antenna to accommodate two separate feed horns. The higher frequency channel horn is a copy of the Special Sensor Microwave/Imager (SSM/I) spaceborne multi-frequency feed horn currently flying onboard the Defense Meteorological Satellite Program (DMSP) satellites. A separate AMPR feed horn, built by the Georgia Technology Research Institute (GTRI), accommodates the 10.7 GHz frequency.

More information about AMPR can be found at https://weather.msfc.nasa.gov/ampr/.

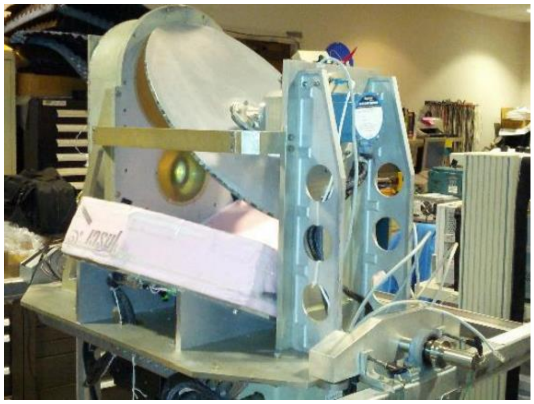

Figure 3: AMPR Instrument at MSFC
(Image Source: https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150022943.pdf)

Investigators

Timothy Lang
NASA Marshall Space Flight Center
Huntsville, Alabama

Anthony Guillory
NASA Marshall Space Flight Center
Huntsville, Alabama

Data Characteristics

The GPM Ground Validation Advanced Microwave Precipitation Radiometer (AMPR) OLYMPEX dataset was collected during the OLYMPEX field campaign held at Washington's Olympic Peninsula. The dataset contains brightness temperatures obtained during ER-2 flights that occurred from November 9 through December 15, 2015. Data are available in netCDF-4 file format. Each file contains AMPR data from one ER-2 flight, which typically lasted between 4-8 hours and occurred every 2-6 days when a significant weather system approached the area. The spatial resolution at a typical ER-2 altitude of 20km MSL is roughly a 30 km wide swath with the spatial resolution per microwave frequency as outlined in Table 1.

Table 1: Data Characteristics

Characteristic	Description
Platform	Earth Resource-2 (ER-2)
Instrument	Advanced Microwave Precipitation Radiometer (AMPR)
Spatial Coverage	N: 48.354 , S: 46.221, E: -97.181, W: -126.129 (Washington)
Spatial Resolution at 20 km flight altitude	10.7GHz: 2.8km 19.35GHz: 2.8km 37.1GHz: 1.5km 85.5GHz: 0.6km
Temporal Coverage	9 November 2015 - 15 December 2015

Temporal Resolution	2-4 hours per ER-2 flight, one flight per data file
Sampling Frequency	3 seconds
Parameter	Microwave Brightness Temperatures
Version	1
Processing Level	2

File Naming Convention

The file naming convention for the GPM Ground Validation Advanced Microwave Precipitation Radiometer (AMPR) is shown below. The data files are netCDF-4 and browse files are available as PNG. The "_level2_" designation in the file name refers to the EOSDIS processing level (refer to this NASA documentation for further information about processing levels.) The browse files naming convention is the same as the level 2B processed data with the designation of the plotted image as "_tb" (brightness temperature values) or "_qc" (quality control flags). For more information about these values, refer to the presentation by the Timothy Lang (PI) titled "AMPR and radar observations from IPHEx: Data quality control and product generation" from 2015.

Data files: olympex_ampr_YYYMMDD_hhmmss_level2_version1.cdf
Browse files: olympex_ampr_YYYYMMDD_hhmmss_[qc|tb].png

Table 2: File naming convention variables

Variable	Description
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day of month
hh	Two digit hour in UTC
mm	Two digit minute in UTC
ss	Two digit second in UTC
.cdf	NetCDF-4 format
[qc|tb]	qc: Browse image of Quality Control Flag tb: Browse image of brightness temperature
.png	File extension (Portable Network Graphics)

Data Format and Parameters

The AMPR Brightness Temperature (TB) and Quality Control Flag (QC) data consists of brightness temperature measurements and associated flight profile characteristics in netCDF format. TB, QC, and Water Fraction are available from all four bands (at 10, 19, 37, and 85 GHz). Additionally, TB and QC are available from both polarization channels, e.g. channels A and B in both V (vertical) and H (horizontal) polarizations. Table 3 below illustrates the variables including data type and units.

Table 3: Data Fields

Field Name	Description	Data Type	Unit

AirSpeed	Derived air speed	double	m/s
FovWaterFrac10	Water Fraction in 10GHz Field Of View	double	Water Fraction [0-1]
FovWaterFrac19	Water Fraction in 19GHz Field Of View	double	Water Fraction [0-1]
FovWaterFrac37	Water Fraction in 37GHz Field Of View	double	Water Fraction [0-1]
FovWaterFrac85	Water Fraction in 85GHz Field Of View	double	Water Fraction [0-1]
GPSAltitude	GPS estimated aircraft altitude above mean sea level	double	m
GPSLatitude	GPS estimated aircraft latitude	double	Degrees North
GPSLongitude	GPS estimated aircraft longitude	double	Degrees East
GroundSpeed	INS estimated ground speed	double	m/s
Heading	Aircraft true heading, clockwise from North	double	degrees
iLat	INS Latitude	double	Degrees North
iLon	INS Longitude	double	Degrees East
incidence_angle	Angle from surface normal at georeferenced location	double	degrees
iWindDir	INS estimated wind direction, clockwise from north	double	degrees
iWindSpeed	INS estimated wind speed	double	m/s
Lat	Latitude of georeferenced pixel	double	Degrees North
Lon	Longitude of georeferenced pixel	double	Degrees East
Pitch	aircraft pitch (+ up)	double	degrees
qcIncidence	1= 0-45 degree, 2= >45.0 degree incidence angle	short	none
qctb10a - qctb85b	Flags are based on TB Difference within 9x9 kernel of surrounding pixels. 0: no check 1: 0K<TBDiff<=5K 2: 5K<TBDiff<=10K 3 - 8: TBDiff>35K 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; greater than 4 usually indicative of some noisy scenes are considered bad data or local outliers. 10.7, 19.35, 37.1, and 85.5 designate the frequency and the	short	Flag Value [0-8]

	polarization channel A/B		
relative_azimuth	Azimuth of georeferenced pixel relative to the aircraft heading	double	degrees
Roll	INS estimated roll angle, right (+)	double	degrees
scan_angle	Off-Nadir scan angle, negative (positive) for port	double	degrees
scan_number	Scene scan number	long	count
scan_position	Position of scene scan, starting from port side of aircraft	long	count
staticPressure	Analog estimated static pressure	double	mbar
TB	Brightness Temperature in four frequencies (10, 19, 37 and 85) and up to four channels (A, B, H, and V). Negative values indicate missing or bad data. TB10A, TB10B - 10 GHz brightness temperatures (A: Left V -> Right H, B: Left H -> Right V) TB19A, TB19B - 19 GHz brightness temperatures (V->H, H->V) TB37A, TB37B - 37 GHz brightness temperatures (V->H, H->V) TB85A, TB85B - 85 GHz brightness temperatures (V->H, H->V)	double	K
Time	Time of scene scan	double	Seconds since 1970-01-01 00:00:00.000
totalTemp	Analog estimated total temperature	double	Celsius
Track Angle	INS estimated true track angle, clockwise from north	double	degrees

Quality Assessment

The AMPR data collected during the OLYMPEX GPM Ground Validation Campaign contains Quality Control Flag (QC Flag) data. The brightness temperature product contains calibrated values, however, this quality control metric is also provided. The QC flag is estimated on the brightness temperature difference of a pixel within a 9x9 kernel neighborhood and is a discrete indicator of brightness temperature difference within five kelvin (5K) increments. The QC Flag data can be used to determine poor quality data or identify local outliers that are flagged as suspect values in a scene. 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 read and viewed in Panoply. The data provider has also developed a Python Toolkit (PyAMPR) that contains scripts and iPython Notebooks for reading the data files and for data visualization and analysis. This toolkit can be found on the NASA Github Repository (https://github.com/nasa/PyAMPR). PDF files of Jupyter notebooks used to preliminarily analyze the data from each flight are available on the GHRC server in the doc directory. A Word document that discusses any significant QC issues from each flight is also provided. Finally, for those with Python, a working Jupyter notebook is provided demonstrating how to use PyAMPR to ingest and display the data.

Table 4: 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 opensource.

Known Issues or Missing Data

The objective quality control metric described in the Quality Assessment section and the QC Flag data help identify suspect values typically associated with instrument issues, potential scene contamination, or interference with another instrument. Within the AMPR QC Flag product, values greater than 4 are usually indicative of noisy scenes and are considered bad data or local outliers. The QC Flag data can be helpful in determining useful data values found within areas flagged as suspect but are generated by local, physical phenomena and could help users isolate certain features within the scene, for instance, the edges of strong convective cells. Users are advised to read the PI documentation provided on the GHRC server.

When over clear ocean, the HIWRAP instrument (also operating on the ER-2 aircraft) often produces a surface reflection near nadir in the AMPR 37 GHz (B) channel. This has been flagged with a high QC index (8).

References

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 (Vol. Section 3., pp. 160–163).

Lang, T., Roberts, B., Meyer, P., Cantrell, E., Wolff, D. (2015). AMPR and radar observations from IPHEx: Data quality control and product generation. Retrieved from https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150022943.pdf

Leppert, K. D., & Cecil, D. J. (2015). Signatures of hydrometeor species from airborne passive microwave data for frequencies 10-183 GHz. Journal of Applied Meteorology and Climatology, 54(6), 1313–1334. http://doi.org/10.1175/JAMC-D-14-0145.1

Skofronick-Jackson, G. M., Gasiewski, A. J., & Wang, J. R. (2002). Influence of microphysical cloud parameterizations on microwave brightness temperatures. IEEE Transactions on Geoscience and Remote Sensing, 40(1), 187–196. http://doi.org/10.1109/36.981360

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(40), 849–857.https://doi.org/10.1175/1520-0426(1994)011<0849:HRIORS>2.0.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 data collected during the OLYMPEX field campaign should be considered related datasets. Other OLYMPEX campaign and instrument data can be located using the GHRC HyDRO 2.0 search tool with the search word 'OLYMPEX'.

GHRC also provides other AMPR data collections from previous field campaigns. These can be located using the GHRC HyDRO 2.0 search tool with the search word 'AMPR'.

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
Web: https://ghrc.nsstc.nasa.gov/

Created: **20 October 2017**