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Integrated Precipitation and Hydrology Experiment (IPHEx)/Orographic Precipitation Processes Study Field Campaign Report

AP Barros
W Petersen
AM Wilson

April 2016

ARM
CLIMATE RESEARCH FACILITY

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Executive Summary

Three Microwave Radiometers (two 3-channel and one 2-channel) were deployed in the Southern Appalachian Mountains in western North Carolina as part of the Integrated Precipitation and Hydrology Experiment (IPHEx), which was the first National Aeronautics and Space Administration (NASA) Global Precipitation Mission (GPM) Ground Validation (GV) field campaign after the launch of the GPM Core Satellite (Barros et al. 2014). The radiometers were used along with other instrumentation to estimate the liquid water content of low-level clouds and fog. Specifically, data from the radiometers were collected to help, with other instrumentation, to characterize fog formation, evolution, and dissipation in the region (by monitoring the liquid water path in the column) and observe the effect of that fog on the precipitation regime. Data were collected at three locations in the Southern Appalachians, specifically western North Carolina: a valley in the inner mountain region, a valley in the open mountain pass region, and a ridge in the inner region.

This project contributes to the U.S. Department of Energy (DOE)'s Atmospheric Radiation Measurement (ARM) Climate Research Facility mission by providing in situ observations designed to improve the understanding of clouds and precipitation processes in complex terrain. The end goal is to use this improved understanding of physical processes to improve remote-sensing algorithms and representations of orographic precipitation microphysics in climate and earth system models.

Acronyms and Abbreviations

ANL	Argonne National Laboratory
ARM	Atmospheric Radiation Measurement Climate Research Facility
DOE	U.S. Department of Energy
GPM	Global Precipitation Mission
GV	ground validation
IPHEx	Integrated Precipitation and Hydrology Experiment
MWR	Microwave Radiometer
NASA	National Aeronautics and Space Administration
SGP	Southern Great Plains
UND	University of North Dakota

Contents

Figures

1.0 Background

The analysis of five years of rain gauge, vertically pointed radar, and disdrometer observations suggests that low-level processes exert a major influence on the precipitation regime in the Southern Appalachian Mountains and contribute significantly to the yearly water budget (Wilson and Barros 2014). The main objective of including the microwave radiometers in this study was to test the hypothesis that seeder-feeder mechanisms govern the enhancement of light rainfall in this region through increased coalescence efficiency in stratiform rainfall due to interactions with low-level clouds, cap clouds, and topography-modulated fog.

The three radiometers were deployed at locations optimized to assess this hypothesis. The locations are shown, along with those of other ground-based instrumentation, in the map in Figure 2.

The deployments of the Microwave Radiometers (MWRs) lasted from February 2014-January 2015, with some missing periods that are discussed in Section 3.0. The three setups are pictured in Figure 1.

Figure 1. Left to right: MWR2C, eastern MWR3C, and inner region valley MWR3C.

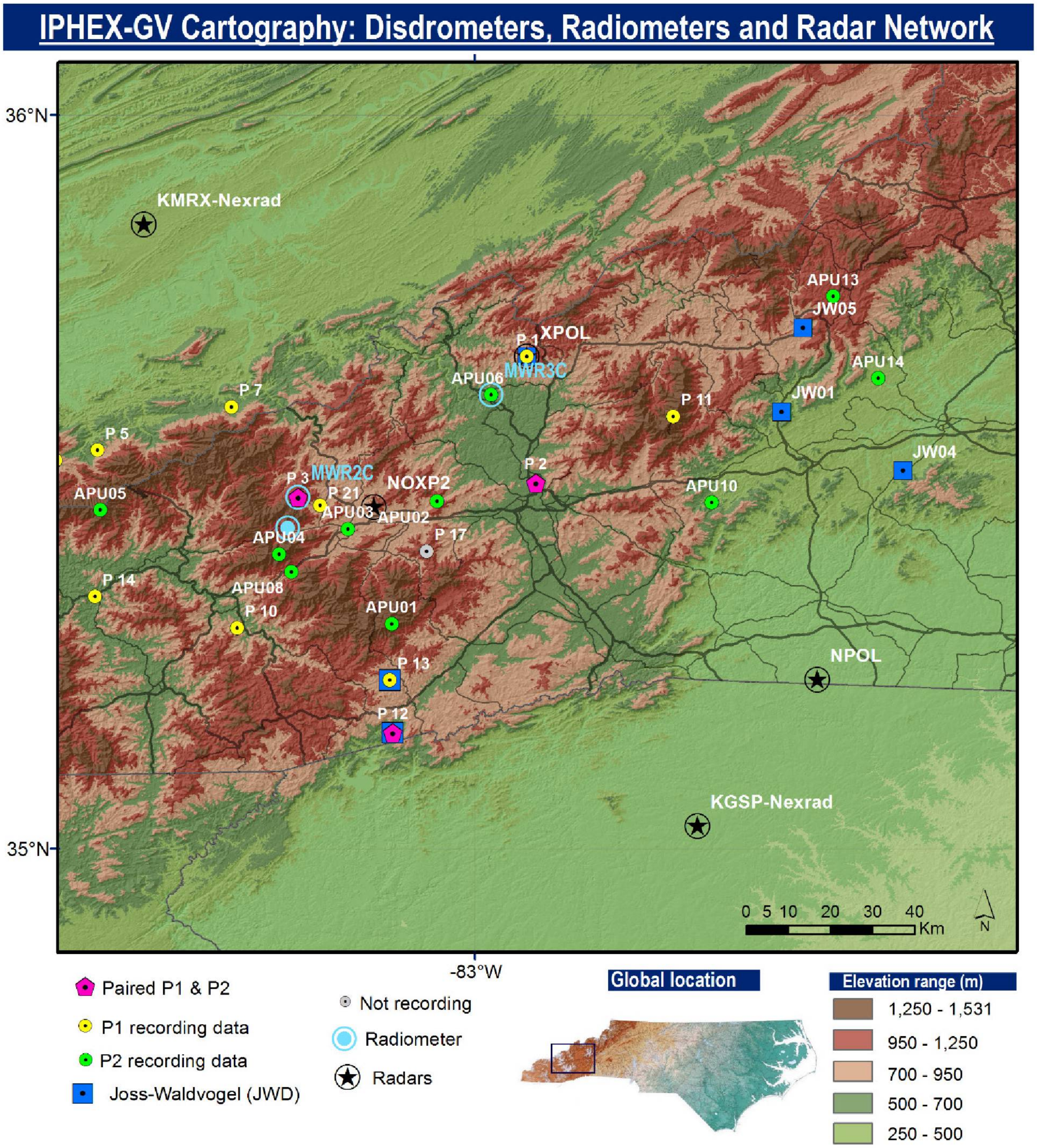

Figure 2. Map of MWR locations along with disdrometers and selected ground-based radars.

2.0 Notable Events or Highlights

A summary of the events is presented in Figure 3. Details on the measurements conducted for each event as well as all data can be found at https://fcportal.nsstc.nasa.gov/iphex/content/home. There were a few notable events where we recorded excellent, robust data sets with the microwave radiometers. Notable events included a frontal system on May 15 (e.g., Wilson and Barros 2015) and a deep congestus with raining convection on June 12. The latter was sampled by ground-based radar in the inner mountain region as well as the radiometers at ridge and valley, other ground-based sensors, and dual aircraft—the NASA Earth Resources ER-2 Lockheed flying laboratory and the University of North Dakota (UND) Cessna Citation atmospheric research jet.

Mission Targets	**A**	**B**	**C**	**D**	**E**	**X**
MCS Convection		5	1		5	4
MCS Stratiform	1	7	1		5	2
Non severe isolated/multi-cell	4	6		5	13	2
Anvil precipitation			1		4	1
Baroclinic/widespread stratiform	1	2	2	2	2	2
Orographic seeder-feeder					1	
Severe Thunderstorm	1	1		2	3	1
Ocean Cumuliform weak/non-precipitating			4	1		1
Ocean anvil, ice, Precipitating			1			1
Ocean MCS			1			1
Clear air land surface		2			17	1
Clear air calibration loop			2	2		3

A= aircraft coordinated and over watershed,
B= aircraft coordinated within NPOL domain,
C= aircraft ocean external domain;
D= a,b,c with GPM overpass;
E= sampled by ground platform only
X=observed

Figure 3. IPHEx campaign score card (i.e., number of events) with regard to mission targets.

3.0 Lessons Learned

We had some challenges with deploying the 2-channel microwave radiometer in the inner mountain region ridge, which was the one location that was in the Great Smoky Mountains National Park. In two different incidents, the radome was damaged by a curious bear (Figure 4).

Figure 4. Bear damage to MWR2C radome.

We eventually moved the location to the rooftop of a nearby building. We also had trouble with malfunctioning equipment, which caused some periods of missing data while we had receivers replaced.

On another matter, calibration of the MWR retrieval algorithm was not initially included in the project, but it should be in the future in order to expedite the use of the data as well as their utility (See note in Section 4.0).

4.0 Preliminary Results

The microwave radiometer data, when integrated with the rest of our ground-based in situ observations, will help us to further elucidate the hydrometeorological regime in the different regions of the Southern Appalachians where they were deployed. The current estimates of liquid water path and precipitable water vapor based on collected MWR observations are preliminary because the coefficients used in the retrieval algorithm are from a different site (e.g., the ARM Southern Great Plains [SGP] site). We are working with Dr. Maria Cadeddu of Argonne National Laboratory (ANL) to estimate IPHEx coefficients using radiosonde and ceilometer data from the experiment.

5.0 Publications

5.1 Journal Articles

No journal articles specifically analyzing the microwave radiometer data collected during this campaign have been published yet. One is in preparation corresponding to the presentation made at the 2016 conference of the AMS by Duan and Barros.

5.2 Conference Presentations

Barros, AP. 2014. "IPHEX—The score card: Overview and preliminary findings." NASA PMM Science Meeting, Baltimore, MD, August 4-8, 2014.

Barros, AP, and W Petersen. 2014. "The Integrated Precipitation and Hydrology Experiment in the southern Appalachians—Observations and modeling." International Symposium on Weather Radar and Hydrology. Washington D.C. April 7-9, 2014. (Invited)

Barros, AP, et al. 2014. "IPHEx 2014—Observations of orographic processes in the southern Appalachians." American Geophysical Union Fall Meeting, Session on Global Precipitation Measurement, Validation and Applications, San Francisco, CA. December 14-19, 2014.

Barros, AP, et al. 2014. "The GPM GV Integrated Precipitation and Hydrology Experiment (IPHEx) in the southern Appalachians—Focus on water cycle processes." American Geophysical Union Fall Meeting, Session on Large-Scale Field Experimentation and Networks, San Francisco, CA, December 14-19, 2014.

Duan, Y, and AP Barros. 2016. "Mapping the impact of aerosol-cloud interactions on warm season low-Level rainfall in mountainous regions—First interpretive results from IPHEx 2014 using a cloud parcel model." 96th American Meteorological Society Annual Meeting, New Orleans, LA, January 1014, 2016, 4B.7. (Oral presentation)

Wilson AM, J Tao, Y Duan, M Arulraj, M Cadeddu, G Cutrell, K Dawson, M Petters, D Miller, and AP Barros. 2015. "IPHEx data sets and ongoing studies." Precipitation Measurement Mission Science Team Meeting. Baltimore, MD. July 13-17, 2015.

6.0 References

Barros AP, W Petersen, M Schwaller, R Cifelli, K Mahoney, C Peters-Liddard, M Shepherd, S Nesbitt, D Wolff, G Heymsfield, and D Starr. 2014. NASA GPM-Ground Validation: Integrated Precipitation and Hydrology Experiment 2014 Science Plan. EPL/Duke University (Pub.): 64pp. http://dx.doi.org/10.7924/G8CC0XMR.

Wilson, AM, and AP Barros. 2014. "An investigation of warm rainfall microphysics in the southern Appalachians: orographic enhancement via low-level seeder-feeder interactions." *Journal of Atmospheric Sciences* 71: 1783-1805, doi:10.1175/JAS-D-13-0228.1.

Wilson, AM, and AP Barros. 2015. "Landform controls on low-level moisture convergence and the diurnal cycle of warm season orographic rainfall in the southern Appalachians." *Journal of Hydrology* 531(2): 475-493, doi:10.1016/j.jhydrol.2015.10.068.

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