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

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April 2016
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Work supported by the U.S. Department of Energy,
Office of Science, Office of Biological and Environmental Research
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

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ANL</td>
<td>Argonne National Laboratory</td>
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<tr>
<td>ARM</td>
<td>Atmospheric Radiation Measurement Climate Research Facility</td>
</tr>
<tr>
<td>DOE</td>
<td>U.S. Department of Energy</td>
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<tr>
<td>GPM</td>
<td>Global Precipitation Mission</td>
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<tr>
<td>GV</td>
<td>ground validation</td>
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<tr>
<td>IPHEx</td>
<td>Integrated Precipitation and Hydrology Experiment</td>
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<tr>
<td>MWR</td>
<td>Microwave Radiometer</td>
</tr>
<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>SGP</td>
<td>Southern Great Plains</td>
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<tr>
<td>UND</td>
<td>University of North Dakota</td>
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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.](image)
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.

<table>
<thead>
<tr>
<th>Mission Targets</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>X</th>
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<tbody>
<tr>
<td>MCS Convection</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>4</td>
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<tr>
<td>MCS Stratiform</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>5</td>
<td>2</td>
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<tr>
<td>Non severe isolated/multi-cell</td>
<td>4</td>
<td>6</td>
<td>5</td>
<td>13</td>
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<tr>
<td>Anvil precipitation</td>
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<td>4</td>
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<tr>
<td>Baroclinic/widespread stratiform</td>
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<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Orographic seeder-feeder</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Severe Thunderstorm</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td></td>
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<tr>
<td>Ocean Cumuliform weak/non-precipitating</td>
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<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
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<td>Ocean MCS</td>
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<tr>
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<td>17</td>
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<tr>
<td>Clear air calibration loop</td>
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<td>2</td>
<td></td>
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</table>

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


6.0 References


