U.S. DEPARTMENT OF ENERGY | Office of Science

DOE/SC-ARM-16-033

Parsivel Disdrometer Support for MAGIC Field Campaign Report

P Kollias
MJ Bartholomew

June 2016

ARM
CLIMATE RESEARCH FACILITY

DISCLAIMER

DOE/SC-ARM-16-033

Parsivel Disdrometer Support for MAGIC Field Campaign Report

P Kollias, Stony Brook University
MJ Bartholomew, Brookhaven National Laboratory
Principal Investigators

June 2016

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

Acronyms and Abbreviations

ARM	Atmospheric Radiation Measurement Climate Research Facility
AMF2	Second ARM Mobile Facility
BNL	Brookhaven National Laboratory
DOE	U.S. Department of Energy
2DVD	Two-Dimensional Video Disdrometer
GEWEX	Global Energy and Water Cycle Experiment
GCSS	GEWEX) Cloud System Studies
GPCI	GCSS Pacific Cross-Section Intercomparison
IOP	Intensive Operational Period
KAZR	Ka ARM Zenith Radar
LWP	liquid water path
m	meter
MAGIC	Marine ARM GPCI Investigation of Clouds
MHz	megahertz
mm	millimeter
M-WACR	Marine W-Band ARM Cloud Radar
WACR	W-Band ARM Cloud Radar

Contents

Figures

1.0 Background

In the Marine ARM GPCI Investigation of Clouds (MAGIC) field campaign, the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Climate Research Facility's second Mobile Facility (AMF2) was deployed on the Horizon Lines cargo ship *Spirit* traversing a route between Los Angeles, California and Honolulu, Hawaii for one full year. The transect for this deployment was chosen specifically because it crosses the stratocumulus-to-cumulus transition of the North-East Pacific, a region of great climatic interest and a close approximation to the transect used for several focused model intercomparison efforts. The cloud type and cover along this transect vary from low marine stratocumulus with high areal coverage near the California coast to isolated shallow cumulus with much lower areal coverage in the trade wind regime near Hawaii. The low marine stratocumulus decks, with their high albedo, exert a major influence on the shortwave radiation budget in the ocean environment, and thus provide an extremely important forcing of Earth's climate. The trade cumulus clouds play a large role in the global surface evaporation and also in Earth's albedo.

One of the important science drivers of the MAGIC campaign was to measure the properties of clouds and precipitation, specifically cloud type, fractional coverage, base height, physical thickness, liquid water path (LWP), optical depth, and drizzle and precipitation frequency, amount, and extent. Retrievals of cloud and precipitation properties during the MAGIC campaign relied critically on the calibration of the AMF2 radar systems. For MAGIC this included the KAZR and M-WACR, both fixed zenith-pointing systems, and the 1290 MHz beam steerable wind profiler.

As part of the Parsivel Disdrometer Support for MAGIC intensive operational period (IOP), a pair of Parsivel optical disdrometers were deployed on the ship during MAGIC (Fig. 1). The deployment of the optical disdrometers were to ensure the collection of reliable measurements of rainfall rate and raindrop particle distribution. In addition, the Parsivel measurements were to provide constraints on the calibration of the radars on the ship during MAGIC.

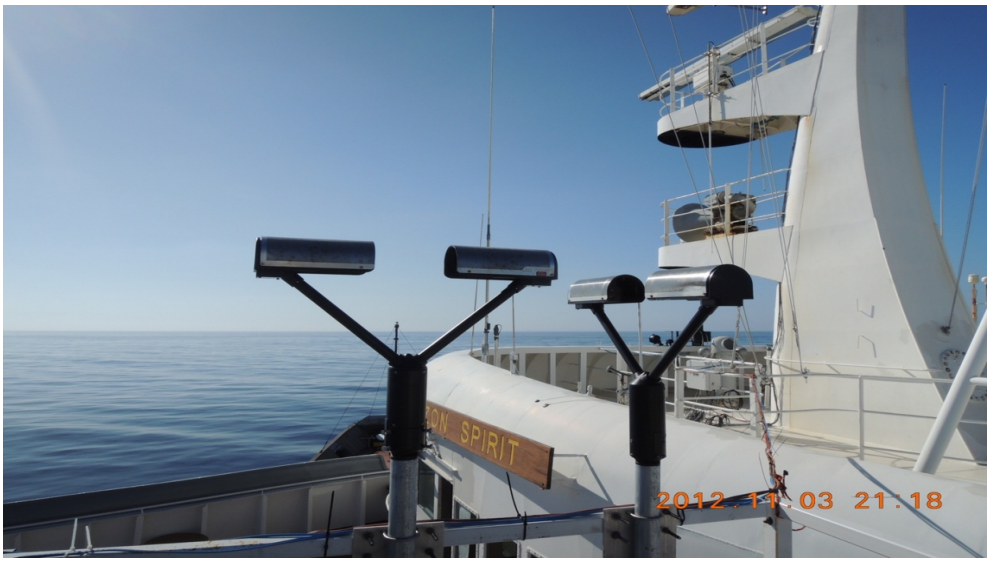

Figure 1. The two Parsivel disdrometers on the *Horizon Spirit* set perpendicular to each other to mitigate the impact of wind direction on the measurements of rainfall and raindrop particle size distribution.

2.0 Notable Events or Highlights

Both Parsivels began collecting data on 09/24/2012 and continued until 01/10/2013. At this time there was a break (the *Horizon Spirit* was in drydock for service), and the data collection from the Parsivels restarted from 05/11/2013 thru 09/26/2013. Besides a few lost hours from the Parsivel 1 (device designated S1) on 06/08/2013, both optical disdrometers operated 24/7 without failure. The accumulated rainfall in mm is shown in Fig. 2.

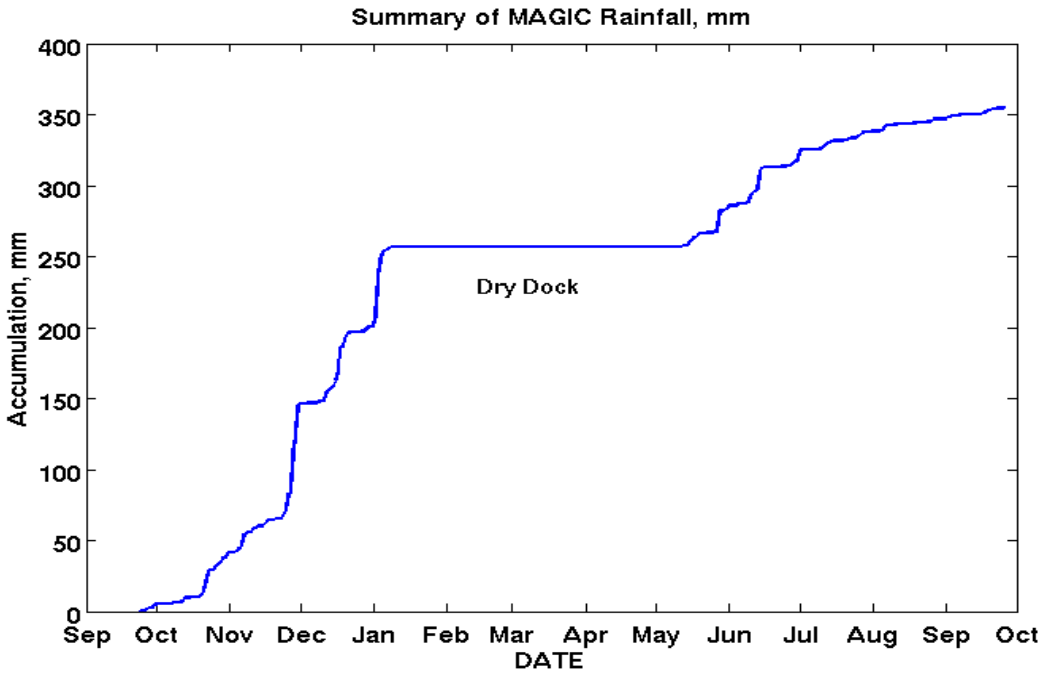

Figure 2. Accumulated precipitation in mm as recorded by the Parsivels for the entire duration of the MAGIC deployment. The period of no accumulation (flat line) corresponds to the period that the ship was in drydock.

3.0 Lessons Learned

Accurately measuring rainfall on ships, and even more so drop size distributions, is in general challenging due to ship distortions of the wind flow (e.g., Yuter and Parker 2001). This was expected to be particularly true during MAGIC where strong winds were common due to the ship cruising speed and the prevailing winds along the ship track. Ship vibrations were also problematic for impact disdrometers as were the rather large vertical motions (heave) of the ship expected during MAGIC (±1 to 2 ms-1 being common). Due to calibration and vibration concerns, the sophisticated and expensive two-dimensional video disdrometer (2DVD) was considered impractical for ship deployment. The analysis of the Parsivel observations revealed and confirmed that the Parsivel optical disdrometer is a good choice for measuring drop size distributions on a ship. The ARM Climate Research Facility deploys in many different platforms and many different climatological regimes and needs to develop an array of particle-measuring instruments suitable for each location and hydrometeor type.

4.0 Results

The successful deployment of the Parsivels during MAGIC provided invaluable measurements of rainfall rate that were used to evaluate remote-sensing techniques for the retrieval of the rainfall rate from marine stratocumulus clouds. Edward Luke from Brookhaven National Laboratory (BN)L used the WACR and ceilometer observations below the cloud base to retrieve the drizzle rain rate (black line, Fig. 3), which was compared to 1-min rainfall rate measurements (red dots, Figure 3) from the Parsivel (O'Connor et al. 2005). The excellent agreement between these two estimates of rain rate at the surface provide confidence in the radar/lidar retrievals that, in turn, provide vertical profiles of drizzle rate. More importantly, the excellent agreement also provides a good natural calibration for the WACR during MAGIC.

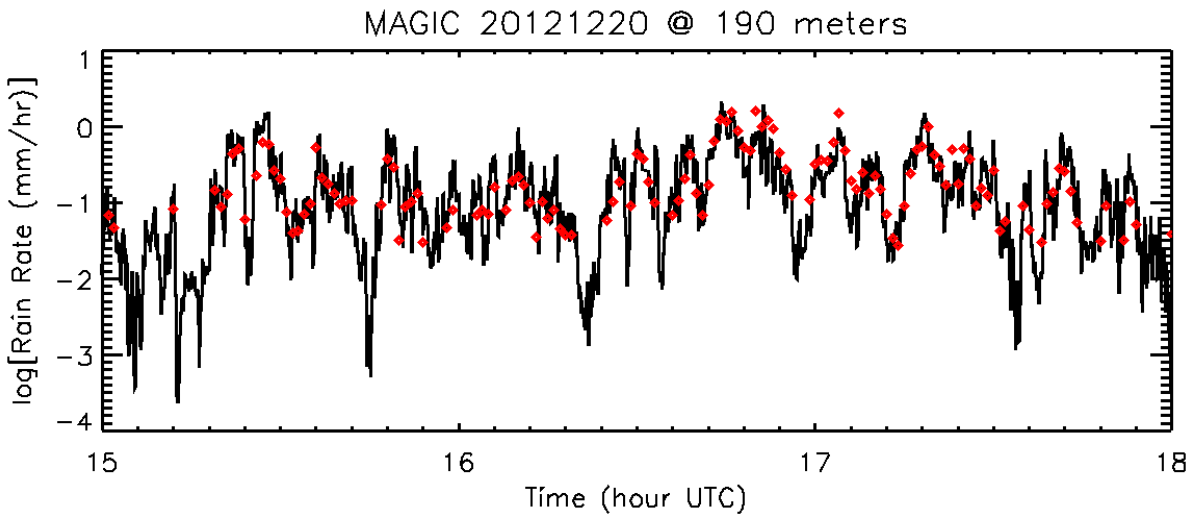

Figure 3. Comparison of the Edward Luke rain rate retrievals (black line) at 190 m above the ship and the 1-minute measurements from the Parsivel (red dots).

5.0 References

O'Connor, EJ, RJ Hogan, and AJ Illingworth. 2005. "Retrieving stratocumulus drizzle parameters using Doppler radar and lidar." *Journal of Applied Meteorology* 44: 14-27, doi:10.1175/JAM-2181.1.

Yuter, SE, and WS Parker. 2001. "Rainfall measurement on ship revisited: The 1997 PACS TEPPS cruise." *Journal of Applied Meteorology* 40: 1003-1018, doi:10.1175/1520-0450(2001)040<1003:RMOSRT>2.0.CO;2.

www.arm.gov

U.S. DEPARTMENT OF
ENERGY

Office of Science