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The Contribution of the Microwave Radiometer ADMIRARI to the NASA GPM Ground Validation Field Experiment

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Abstract. The microwave radiometer ADMIRARI has taken part in several NASA Global Precipitation Measurement (GPM) ground validation (GV) field experiments in different locations around the globe. ADMIRARI is a multi-frequency dual-polarized microwave radiometer with the ability to distinguish the cloud and rain component of the liquid water content observed in the atmospheric column. The present is a review of ADMIRARI's participation in four GPM/GV field campaigns from March 2010 to February 2012. Each of these experiments tackled different precipitation regimes, from convective, to mixed-phase, warm to light rain and snowfall.

Keywords: Microwave passive/active remote sensing, NASA GPM/GV, Cloud/rain water content, ADMIRARI.
PACS: 92.60.N-; 92.60.Jq; 07.57.Kp; 42.68.Mj

INTRODUCTION

The NASA Global Precipitation Measurement (GPM) ground validation (GV) provides precipitation measurements from ground based and airborne instruments to support physical validation of satellite-based retrieval algorithms for the coming GPM core satellite. The set of GV instrumentation is comprised of airborne micro-physics probe, multi-frequency radar and radiometer observations (GPM proxy) in addition to ground-based disdrometers and rain gauge network. The GPM-GV instrument suite has been deployed in numerous field campaigns in several different precipitation regimes, ranging from tropical rainfall, light precipitation, mid-latitude continental convective clouds to solid winter precipitation. ADMIRARI, from the University of Bonn, Germany, has contributed with its novel capabilities in all the experiments. The present work is a review of ADMIRARI's participation in four GPM-GV field experiments, showing an ample range of observations for every precipitation regime. The next section introduces the radiometer's characteristics, followed by descriptions of the four field campaigns including the types of measurements and the involved science.

MICROWAVE RADIOMETER ADMIRARI

The University of Bonn's **AD**vanced **MI**crowave **RA**diometer for **R**ain **I**dentification **ADMIRARI** is a triple-frequency (10.7, 21.0 and 36.5 GHz) dual-polarized (H&V) microwave passive radiometer with scanning capabilities. Its main characteristics are: 6° beam-width, 0.5 K RMS @ 1 second integration time, direct detection auto-calibration receivers with Noise injection and Dicke switching and an absolute system stability 1.0 K.

Besides the passive radiometer, ADMIRARI also acquires measurements with two co-located active instruments: a micro rain radar 24.1 GHz and a 902nm cloud lidar (Figure 3 a). They are mounted to the pedestal and have equivalent scanning capabilities like the radiometer [1], http://www2.meteo.uni-bonn.de/admirari.

GPM GROUND VALIDATION EXPERIMENTS

GPM has scheduled a series of field experiments in order to improve the understanding of the physics governing the liquid and solid precipitation, foreseeing the ground validation for the coming GPM core satellite products. In four of them, the radiometer ADMRIARI has participated as is indicated in the following sections.

Radiation Processes in the Atmosphere and Ocean (IRS2012)
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CHUVA, Alcantara-Brazil 2010

The **C**loud processes of t**H**e main precipitation system in Brazil: a contrib**U**tion to cloud resol**V**ing modeling and to the GPM (Glob**A**l Precipitation Measurement) **CHUVA** campaign took place from 1-25 March 2010 at the Alcantara's Launch Center CLA (lat: 2° 23' 8" South, lon: -44° 22' 46" West). The main objective was the study of tropical convective clouds, warm rain (http://gpm.cptec.inpe.br). The measurement strategy was focused on the area between an X-band radar and ADMIRARI located 8 km away. The radar performed RHI and PPI scans while ADMIRARI measured at 30° elevation towards the radar site. A set of rain gauges, disdrometers, MWR profiles and lidar have been installed along the line X-band radar and ADMIRARI (Figure 2 a).

During the CHUVA a total amount of rain of 350 mm at INPE site and 200 mm at the ADMIRARI site were observed. As an example, observations from March 20th are shown in Figure 1.

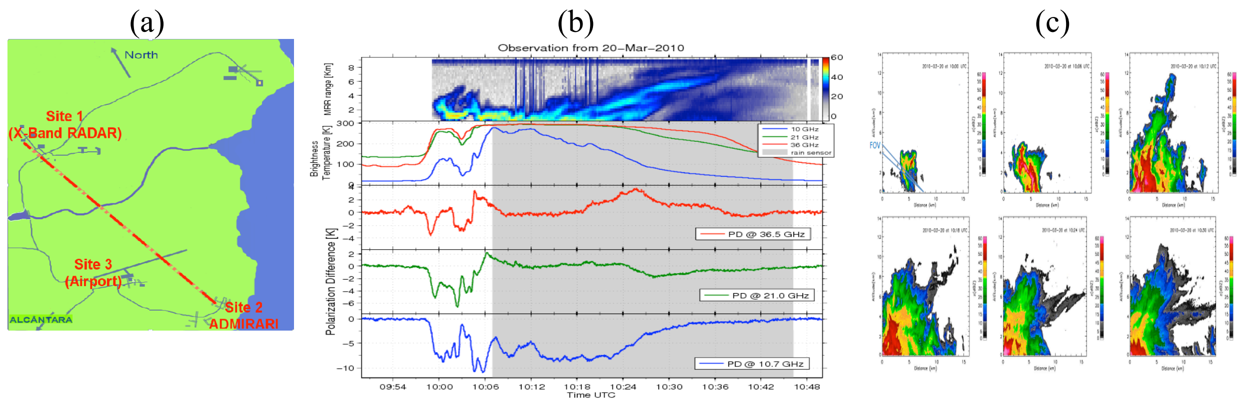

FIGURE 1. (a) Measurement strategy at CLA. (b) ADMIRARI observation from March 20th (c) sequence of reflectivity RHI scans by the X-band radar towards ADMIRARI's site.

First research results have been presented by Battaglia et al. [2], where the ubiquitously observation of radiative 3D effects and non-uniform beam filling effects were studied. Concluding that the incorporation of such effect on the radiometer forward model is mandatory in order to retrieve small-scale convective precipitation during CHUVA.

LPVEx, Parvoo-Finland 2010-2011

The **L**ight **P**recipitation and **V**erification **Ex**periment **LPVEx** in Finland was the second GPM campaign (http://lpvex.atmos.colostate.edu), separated in two periods: from September 15th to October 15th 2010 (light rain obs.) and the Extended Observational Period till January 2011 (winter obs.). ADMIRARI was installed at Emäsalo on the peninsula of Parvoo (lat: 60° 12' 13" North, lon: 25° 37' 30" East) during the first period and in VAISALA backyard for the second, in both cases the radiometer was bearing towards the C-band KUMPULA radar of Helsinki University. LPVEx objectives were the study of light precipitation, melting layer and solid precipitation during winter. ADMIRARI observation of shallow rain events on October 20th with melting layer located at ca. 1 km height is shown in Figure 2 (a) KUMPULA radar RHI over ADMIRARI, (b) the LWC and specific attenuation derived from radar RHI extracted for ADMIRARI's FOV and (c) the estimated bright-band optical thickness derived by the combination of radar, radiometer and disdrometer.

The approach is to identify the melting layer altitude by means of polarimetric radar variables [3], then the LWC and specific attenuation are calculated only below the melting layer i.e. rain layer (Figure 2 b). The total optical thickness is retrieved from ADMIRARI brightness temperatures according to

$$\tau_{admirari} = -\ln\left(\frac{T_{mr} - TB_v}{T_{mr} - TB_{cos}}\right) = \tau_{rain} + \tau_{cloud} + \tau_{ML} + \tau_{gases} \quad \text{,with:} \quad \tau_{cloud} \approx 6\pi\nu \frac{Img\{\epsilon\}}{|\epsilon + 2|^2} \mathrm{LWP}_{cloud}$$

τ_{rain} is obtained from the integral of specific attenuation along the path (Figure 2 b) and τ_{cloud} can be estimated assuming a constant cloud layer with LWP retrieved by ADMIRARI. Therefore the τ_{ML} from Melting Layer can be assessed, as shown in (Figure 2 c). A study on the super-cooled liquid water observed during snow precipitation in Finland is currently being developed and its first results have been presented by Lautaporti et al. [4].

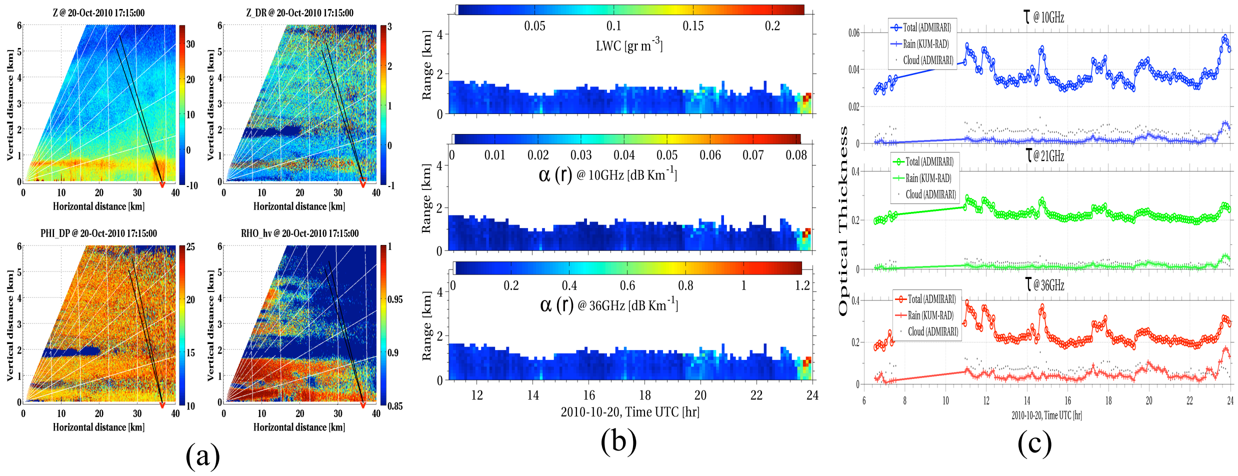

FIGURE 2. (a) KUMPULA radar RHI with ADMIRARI's FOV indicated in black lines. (b) LWC and Optical thickness at 10.7 and 36.5GHz, (c) Bright-band optical thickness for three ADMIRARI frequencies (see text).

MC3E, South Great Plains, Oklahoma-USA 2011

In 2011 the **M**idlatitude **C**ontinental **C**onvective **C**loud **E**xperiment **MC3E** took place at the ARM South Great Plains Facility (lat: 36° 36' 5" North, lon: -97° 28' 52" West) in Oklahoma from May to June (http://campaign.arm.gov/mc3e). Although ADMIRARI has faced mechanical problems in its pedestal's azimuthal driver, data was collected from convective systems. The major highlight for these observations are the strong attenuation on the MRR and near saturation for ADMIRARI's higher frequencies. Figure 3 depicts an example of observations (b) and retrievals (c) according to Saavedra et al. [1].

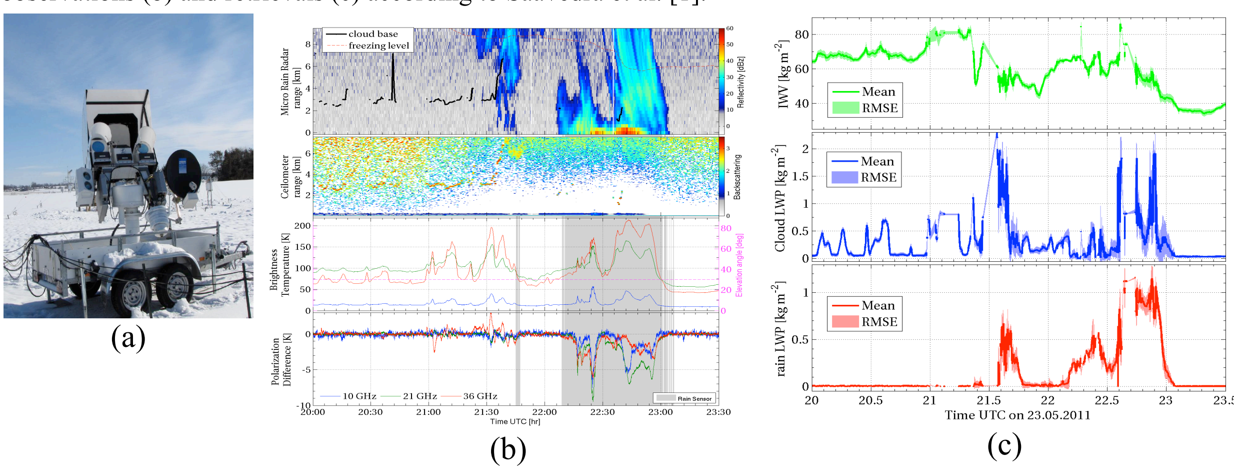

FIGURE 3. (a) Radiometer ADMIRARI, with auxiliary instruments attached to the pedestal: cloud lidar (left) and micro rain radar (right). (b) ADMIRARI observation from May 23th (c) corresponding IWV, cloud and rain LWP retrievals for the event.

GCPEx, Ontario-Canada 2012

The last campaign was the **G**PM **C**old-season **P**recipitating **Ex**periment **GCPEx** during winter 2012 in Canada at the EC CARE site (lat: 44° 13' 58" North, lon: -79° 46' 54" West). ADMIRARI measured in a sequence of 30° elevation and RHI at the same azimuth that the King-City Radar, the NASA D3R and in synergy with the radiometer DPR (90, 150 GHz H&V) from University of Cologne. The main objective was to identify the presence of super-cooled liquid water during snow precipitation, thus a statistical retrieval has been implemented with information of 30 years radiosondes from nearby WMO station. Retrievals of IWV and total LWP are presented in Figure 4.

The synergy with other instruments is in progress in order to identify correlations with cloud micro-physic footprints in polarimetric radar observations, as well as in ground-based snowflakes video images.

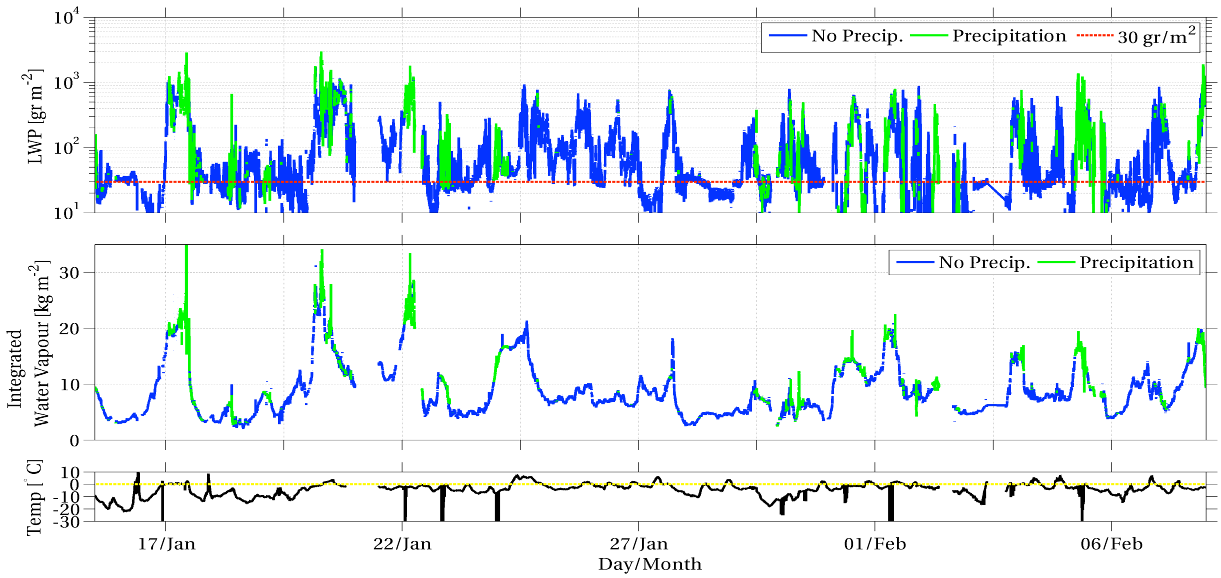

FIGURE 4. Time series of LWP (top) and IWV (middle) observed in the slant column for the entire period. The periods with precipitation are highlighted in color green. The red dotted line indicates the minimum detectable by the radiometer's retrieval.

CONCLUSIONS

ADMIRARI has successfully taken part in four GPM-GV experiments, giving an important contribution in terms of IWV and Cloud/Rain LWP during a wide range of events from liquid to solid precipitation. Therefore complementing the observation of rain from disdrometers at ground level, profiles from radars with the total water content information on the atmospheric column. The next state is to analyze the data with dedicated retrievals for every regime by building representative *a-priori* data-set combining NWP and auxiliary instruments. More information and a list of publications as well as posters are found at http:// www2. meteo. unibonn.de/ admirari/ admirari_publications.html.

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REFERENCES

1. P. Saavedra, A. Battaglia and C. Simmer, *J. Geo. Research* **117**, D05203, doi:10.1029/2011JD016382 (2011).
2. A. Battaglia, P. Saavedra, C. A. Morales and C. Simmer, *J. Geo. Research* **116**, D09204, doi:10.1029/2010JD015335 (2011).
3. L. Baldini and E. Gorgucci, *J. Atmos. Oceanic Technol.* **23**, p. 829-839 (2006).
4. S. Lautaporti, D. Moisseev, P. Saavedra, A. Battaglia and V. Chandrasekar, "Dual-Polarization Radar and Microwave Radiometer Observations of Winter Precipitation during LPVEx", *Extended Abstract in ERAD 2012*, Toulouse-France (2012).