Comparison of Liquid Cloud Microphysical Retrievals During the Black Forest, Germany AMF Deployment

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ABSTRACT

We will present preliminary comparisons of single-layer liquid cloud microphysical retrieval products for several cases during the deployment of the ARM Mobile Facility (AMF-1) at the Black Forest Germany in 2007. The retrievals that are compared include a new version of the MICROBASE algorithm which accounts for attenuation at W-band radar frequencies, the mixed-phase cloud property retrieval algorithm (MIXCRA; Turner 2005) which retrieves cloud optical depth and cloud particle effective radius from Atmospheric Emitted Radiance Interferometer (AERI) high-resolution infrared radiance measurements and lidar cloud boundaries, and a combined cloud radar and microwave radiometer retrieval (Ebell 2011). Future plans involve the evaluation of these (and other) retrievals though a radiative closure study.

MOTIVATION

The quantification of cloud microphysical properties (e.g. LWC(z), reff(z)) is an important step towards improving our understanding of cloud processes and the subsequent testing, evaluation and improvement of numerical models of the atmosphere and climate. The accurate retrieval of these properties from remote sensing observations remains an area of active research with a variety of algorithmic approaches of varying complexity. In May 2013 the DOE Climate and Environmental Sciences Division hosted a joint workshop bringing together participants from various European Union programs and the DOE ARM/ASR programs. The primary objective of the workshop was to advance algorithm development and uncertainty quantification for retrieving cloud and precipitation from ground-based remote sensors through international scientific collaboration and data sharing. One of the action items from this workshop was to build a set of real-atmosphere cases that can be used for retrieval algorithm evaluation using data from the ARM/EU Convective and Orographic Precipitation Study (COPS) dataset. The initial focus will be on liquid water content, effective radius and drop number in warm clouds with the goal of utilizing the BroadBand Heating Rate Profile (BBHRP) framework to evaluation the retrievals. This poster presents the initial steps of defining a warm cloud study period, assembling an ensemble of cloud microphysical retrievals, and comparing those retrievals.

ALGORITHMS

New version of MICROBASE retrieval with W-band attenuation correction[1]

Merged Soundings
height
temperature

ARSCL
MPL
CEILOMETE
WACR: height, reflectivity, cloudbase

MWRRET
LWP for LWC Scaling

Attenuation correction for W-band reflectivity

IWC = 2x(height-cbh)xLWP/Cloud$_{dep}^2$

Vali and Haimov 1998
Attenuation = a x θ^b
a = 3.72
b = 2.81
θ = 300/T

Liquid water content
Assumptions:
Adiabaticity - no entrainment
Non-precipitation
Nd = constant
Liao and Sassen (1994)

LWC = (Nd / 3.6 x Z)^1/1.8 g/m^3

Liquid effective radius

Miller and Johnson (2003)
r = (3 x LWC/(4π RHOw N e$^{4.5x\sigma 2}$))^{⅓}
- RHOw is the density of water
- σ is the width of the distribution (0.35)

MIXCRA[2]

AERI: ground-based passive infrared interferometer

SHEBA: a polarization-sensitive lidar

$$X^{n+1} = X_a + (S_a^{-1} + K^T S_\varepsilon^{-1} K)^{-1} \{K^T S_\varepsilon^{-1}[Y - F(X^n) + K(X^n - X_a)]\}$$ (Rodgers 2000)

Forward model: LBLDIS

Cloud emissivity:

$\varepsilon = G[I, B(T), F(P)]$

Cloud reflectivity

Water path calculation

Liquid effective radius | **Ice effective radius** | **Ice fraction** | **cloud optical depth**

Ebell's retrieval[3]

Profiles of hydrometeors presence

Cloudnet target categorization based on cloud radar, lidar, microwave radiometer, radiosonde, NWP, rain sensor

Water clouds

LWC from radar Z–LWC relation (Fox & Illingworth, 1997)

liquid effective radius parameterized from LWC (Frisch et al., 1995; Miles et al., 2000)

PRELIMINARY DISCUSSION

- Good agreement among techniques for single layer, non-drizzling clouds (consistent with Zhao et al.[6] and Huang et al.[4])
- Sometimes significant differences for multi-layer cloud cases (with ice) and drizzling cloud cases
- Next steps are to include additional retrievals of varying complexity

WHAT DO WE DO NEXT?

- Include Loehnert et al. (2004)[5] Integrated Profile Technique, which employs an optimal estimation approach.
- Invite and include additional retrieval products and algorithms.
- Expand comparison and evaluation to mixed-phase and ice clouds.
- Use radiative closure via the Broadband Heating Rate Profile (BBHRP) framework to evaluate retrieval products.

HOW CAN YOU GET INVOLED?

If you have cloud property retrievals for the AMF Black Forest, Germany deployment or a retrieval algorithm that you would like to apply to this dataset and include in the comparison and evaluation exercise, please contact Meng Wang (mwang@bnl.gov) or Michael Jensen (mjensen@bnl.gov).

REFEERENCES

[1] Maureen Dunn, Karen Johnson, Michael Jensen, **The Microbase Value Added Product: A Baseline Retrieval of Cloud Microphysical Properties**, *ARM Technical Reports, 2011.*

[2]David D. Turner, **Arctic Mixed-Phase Cloud Properties from AERI Lidar Observations: Algorithm and Results from SHEBA**, *Journal of Applied Meteorology, Volume 44, Issue 4, April 2005.*

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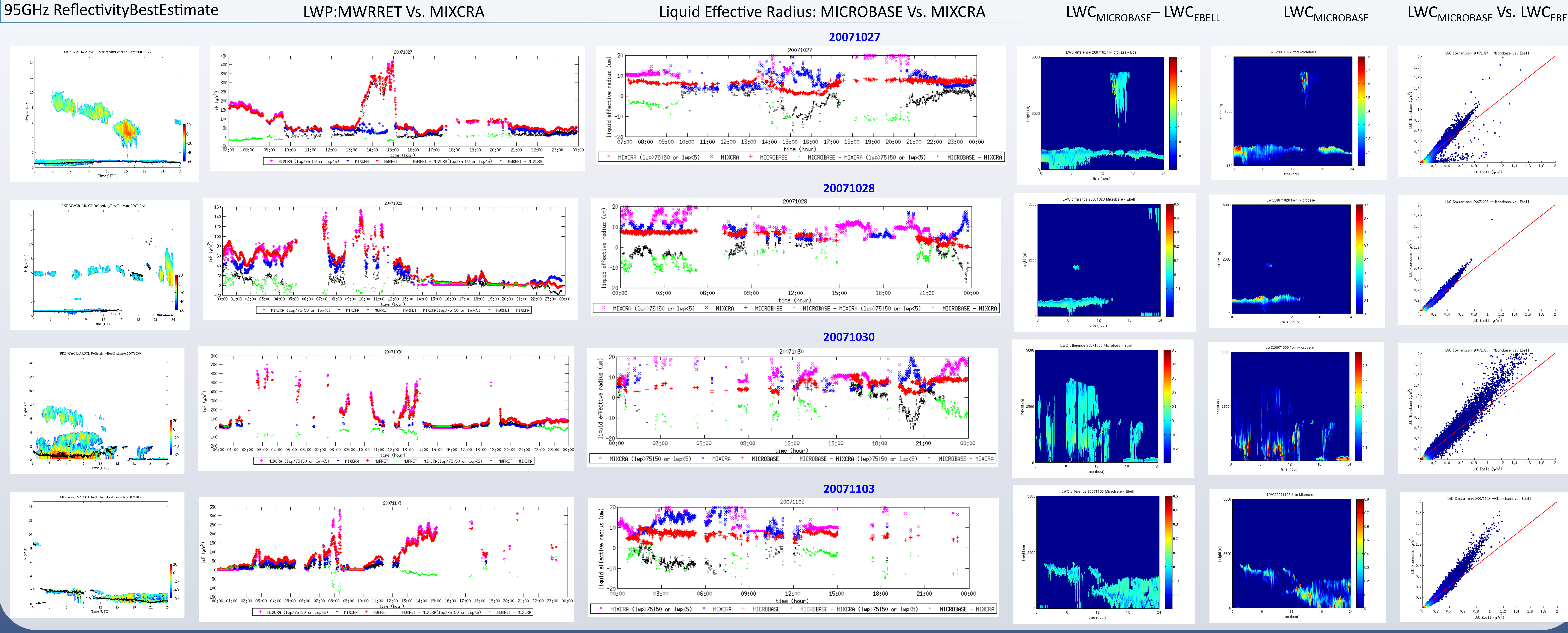
COMPARISONS: Daily plots at Black Forest Germany in 2007

95GHz ReflectivityBestEstimate | LWP:MWRRET Vs. MIXCRA | Liquid Effective Radius: MICROBASE Vs. MIXCRA | LWC$_{MICROBASE}$– LWC$_{EBELL}$ | LWC$_{MICROBASE}$ | LWC$_{MICROBASE}$ Vs. LWC$_{EBELL}$



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[6] Zhao, C., S. Xie, S. A. Klein, A. Protat, M. D. Shupe, S. A. McFarlane, J. M. Comstock, J. Delanoe, M. Deng, M. Dunn, R. J. Hogan, D. Huang, M. P. Jensen, G. G. Mace, R. McCoy, E. J. O'Connor, D. D. Turner and Z. Wang, **Toward understanding of differences in current cloud retrievals of ARM ground-based measurements,** J. Geophys. Res., 117, D10, doi:10.1029/2011JD16792. 2012.