SSAI Science Systems and Applications, Inc.

Radar and Disdrometer Observations During the Mid-Latitude Continental Convective Clouds Experiment (MC3E)

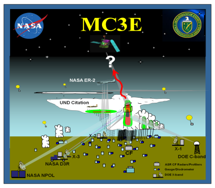
David B. Wolff[1,2], David A. Marks[1,2], Ali Tokay[1,3], Walter A. Petersen[1,4], John Gerlach[1,4], Patrick Gatlin[5], Matt Wingo[5], and Larry Carey[5]

[1]NASA Goddard Space Flight Center, Greenbelt, MD
[2]Science Systems & Application, Inc., Lanham, MD
[3]Joint Center for Earth Systems Technology, University of Maryland Baltimore County, Baltimore, MD
[4]NASA Wallops Flight Facility, Wallops Island, VA
[5]University of Alabama-Huntsville, Huntsville, AL

MC3E

April 22 – June 6, 2011

- Collaboration between NASA/GPM and DOE/ARM
- Deployed multiple ground and airborne instruments
  - Aircraft (ER-2, UND-Citation
  - Multiple radars (C- and S-band)
  - Sounding sites
  - Disdrometers
  - Rain gauges
  - Profilers



Science Team PI Goals

•The PI/Co-I's principal contribution to MC3E is to provide support for disdrometer and NPOL operations and analyses, including…

√ Quality control
Reflectivity (dBZ) and differential reflectivity (Z_{DR})

√ Calibration
Utilizing dual-pol observations

•DSD characterization [In progress]
○Use disdrometer observations to derive coefficients for converting Z_H, Z_{DR} and K_{DP} observations from NPOL for large-area DSD characterization.
○Key parameters: D_0, N_W, N_T, LWC

•Hydrometeor classification [In progress]

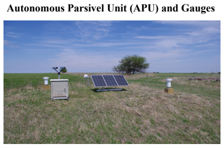
•Improved rain rates [In progress]

Key Instrumentation

NASA Polarimetric Radar (NPOL)

- 10 cm (S-band) scanning radar;0.95° beam width
- Combination of PPIs, sector scans and RHIs
- Recorded the following fields: Z_H, V_{rad}, SW, SQI, Z_{DR}, φ_{DP}, K_{DP}, ρ_{HV}

Autonomous Parsivel Unit (APU) and Gauges



Two-Dimensional Video Disdrometer (2DVD)

Disdrometer & Gauge Operations

•UAH/NASA deployed 16 Autonomous Parsivel Units (APU)

•Seven 2DVDs were deployed (five NASA and two DOE)

•Dual-gauges collocated at each site

•On-board Linux box and USB hard drive provided data storage

•Solar panels provided power

•Used wireless communications from each site to Central Facility (CF)

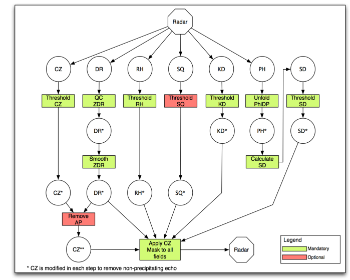
•Data transmitted in near-real-time to GSFC for processing

Key Science Missions

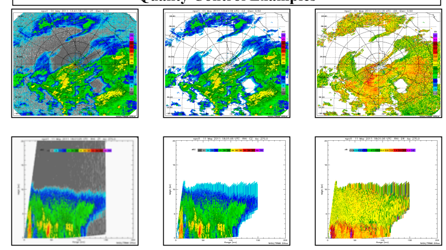
Date	Time	Aircraft	Weather
110422	22-00Z	Cit	Thin line of showers
110425	09-12Z	Cit	Strong convection
110427	08-11Z	Cit	Rain with embedded convection
110501	16-18Z	Cit	Light/mod rain over CF
110507	18-23	ER2	Surface mission or precip elsewhere
110508	17-21Z	ER2	Surface mission or precip elsewhere
110510	21-00Z	Cit	Strong convection
110511	15-19Z	Cit+ER2	Rain with convection over CF
110518	05-09Z	Cit+ER2	Convection over CF
110520	13-18Z	Cit+ER2	Widespread rain and convection (limited data)
110523	21-02Z	Cit+ER2	Strong convection (limited data)
110524	20-22Z	Cit	Intense convection (limited data)
110529	17-23Z	ER2	Surface mission or precip elsewhere
110530	17-21Z	Cit	Surface mission or precip elsewhere
110601	19-22Z	Cit	Isolated showers and cells

NPOL Quality Control

- Modular, physically based quality control (QC) algorithm using DP fields was developed for NPOL data
- DPQC algorithm developed with NASA's RSL-in-IDL
- DPQC algorithm can easily be used with other polarimetric radars via passing of an RSL "radar" structure
- Significant QC challenges
  - Intense convection
  - Ground clutter
  - Range-ambiguous (multiple trip) echo
  - Anomalous propagation (AP) from both density gradients and nocturnal atmospheric decoupling



Quality Control Examples



Z_{DR} Calibration

•Differential reflectivity (Z_{DR}) was calibrated by analysis of the vertical profile of reflectivity in light rain.

- Limited opportunity to perform "birdbath" scans given precipitation occurrence
- May 01, 2011 did provide one such opportunity
- **Results show excellent Z_{DR} calibration (within +/- 0.1 dB)**

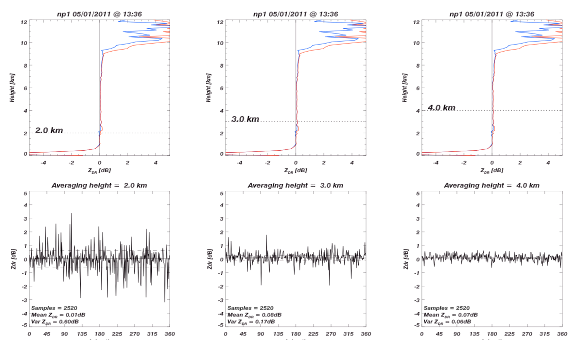
Reflectivity Calibration

•Use self-consistency approach of Ryzhkov et al. 2005 with data from Oklahoma

•Iterative approach

•Results show reflectivity calibration < 1 dB high

Ryzhkov, A.V., S.E. Giangrande, V.M. Melnikov, and T.J. Schuur, 2005: Calibration issues of dual-polarization radar measurements. J. Atmos. Oceanic Technol., **22**, 1138-1155.



Calculate area-time integral of measured K_{DP} (from radar).

$$I_1 = \int_{Z\min}^{Z\max} \langle Kdp(Z)\rangle n(z)\,dz$$

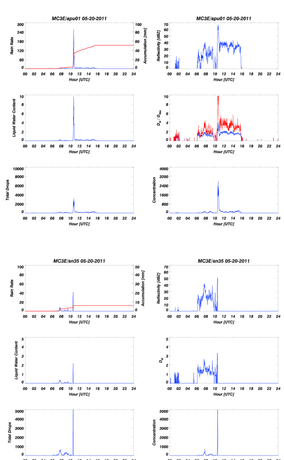
Calculate area-time integral of retrieved K_{DP} (Z_H,Z_{DR}) from consistency principle.

$$I_2 = \int_{Z\min}^{Z\max} 10^{-a/b+Z/b-c\langle Zdr(Z)\rangle/b}\, n(z)\,dZ$$

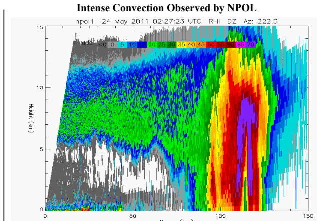
Refectivity bias is adjustment (in dB) needed for integrals to match

$$Z_{Hbias}(dB) = 10\log\left(\frac{I_2}{I_1}\right)$$

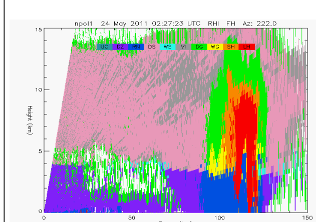
Large Drops Sampled by APU's and 2DVD May 20, 2011



Intense Convection Observed by NPOL

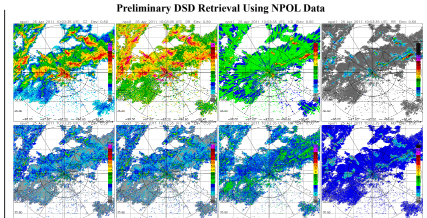


May 24, 2011 @ 0227 UTC: Bounded Weak Echo Region (BWER)



Hydro-Class Image Courtesy of B. Dolan (CSU)

Preliminary DSD Retrieval Using NPOL Data



DSD retrievals produced using the PolZR technique of Bringi et al. 2004. Panels show, from top left to bottom right, QC'd and calibrated reflectivity (Z_H), differential reflectivity (Z_{DR}), specific differential phase (K_{DP}), rain rate (R), median volume diameter (D_0), mass-weighted mean Diameter (D_m), log of the normalized intercept parameter ($\log(N_W)$), and shape parameter (mu).

Bringi V. N., T. Tang and C. Chandrasekar, 2004: Evaluation of a New Polarimetrically Based Z–R Relations, *Jou. Atmos. Ocean. Tech.*, **21**, 612-623.

Acknowledgements
This research is funded by NASA ROSES Grant NNG10HP11C. The authors would like to acknowledge the support of the following individuals for their support

•Dr. Arthur Hou, GPM Project Scientist, NASA GSFC
•Dr. Mathew Schwaller, GPM GV Program Manager, NASA GSFC
•Dr. Scott Braun, TRMM GV Project Scientist, NASA GSFC
•TRMM Office support staff at NASA GSFC
- Jianxin Wang, SSAI
- Jason Pippitt, SSAI
- David Makofski, SSAI