Application of ARM Ground-Based Simulator to GCMs

SHAOCHENG XIE AND YUYING ZHANG

LAWRENCE LIVERMORE NATIONAL LABORATORY

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ARM Cloud Radar Simulator for GCMs

Zhang, Y., S. Xie, et al., 2017: BAMS.

- Bridge the gap between detailed ARM cloud OBS and GCM clouds
- It has been merged into COSP v2 for climate model applications

ARM Radar Simulator Homepage

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**DATA**
- CAPABILITIES
- RESEARCH
- NEWS & EVENTS
- ABOUT

**RADARCFAD**
RADARCFAD: ARM RADAR CONTOURED FREQUENCY BY ALTITUDE DIAGRAM (CFAD) DATA PRODUCTS

**TPP6: EVALUATION MAP**
The data products are generated from the ARM Active Remote Sensing of Clouds (ARSLC) value-added products. Radar reflectivity profiles are generated with 100 meter vertical resolution and at the original temporal resolution. The profiles of minimum detectable signal and maximum record signal are applied to the original radar reflectivity. The hourly radar CFADs are generated from the processed radar reflectivity with 100 meter resolution.

**PURPOSE**
The goal of this task is to create a Contoured Frequency by Altitude Diagram (CFAD) from ARM measurements for evaluating ARM radar simulator output generated from climate model outputs.

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**ARSLC-KAZR Reflectivity Best Estimate**

**SGP-C1 20110426**

- Instrument outputs
- CloudSat
- CALIPSO
- ISCCP
- MISR
- MODIS
- RTTOV
- Statistical aggregation
- COSP outputs

“down-scaler”
forward models
retrieval algorithms

Every output has a direct satellite equivalent
Support Cloud Evaluations

- Create CFAD with calibrated MMCR/KAZR data for both ARM permanent sites and selected AMF sites
- Assist major modeling centers to implement ARM radar simulator to their models in support of cloud parameterization development and evaluation
  - E3SM, CAM5, ECMWF, MIROC, Metoffice
  - GFDL, Tsinghua, GEM (Canada NWP)
- Assist ASR scientists to apply the ARM radar simulator in cloud research using detailed ARM cloud observations
  - Larry Berg - ECMWF clouds with TCAP
  - Xue Zheng – E3SM SCM for MAGIC
Diurnal cycle of no-precipitating clouds (<-20 dBZ)

- Lack of shallow non-precipitation clouds in E3SM v0
- Notable improvements seen in E3SM v1 for both low and high clouds. Likely due to the use of CLUBB and increase of vertical levels
- The high-res E3SM captures the diurnal variability very well
Diurnal cycle of precipitating clouds (>20dBZ)

- Models overestimate the precipitating clouds and have difficulty in capturing the diurnal cycle.
- Less high cloud over 8km in E3SM v1 and better diurnal cycle in the high-res model.
Diurnal cycle of no-precipitating clouds

- **Obs**
  - Occurrence Frequency (< -20dBZ)

- **ACMEv0**
  - Occurrence Frequency (< -20dBZ)

- **E3SM V1 1 deg**
  - Occurrence Frequency (< -20dBZ)

- **E3SM V1 0.25 deg**
  - Occurrence Frequency (< -20dBZ)

- **MIROC**
  - Occurrence Frequency (< -20dBZ)

- **ECMWF**
  - Occurrence Frequency (< -20dBZ)

MJJA SGP
Diurnal cycle of precipitating clouds (>20dBZ)

- ARM
- E3SM V1 1 deg, L72
- E3SM V0 1 deg, L30
- E3SM V1 0.25 deg, L72
- MIROC
- ECMWF

MJJASGP
Test Model Clouds over Different Climate Regimes

Radar CFAD – Joint histogram of the radar reflectivity and altitude
Assist ASR scientists to improve cloud evaluation with the ARM radar simulator

Evaluate E3SM simulation of marine BL clouds

Use the ARM cloud radar simulator to better constrain model precipitation

Xue Zheng & Steve Klein of LLNL.
FY18 Plan

• ARM radar simulator code will be released with COSP2.0 in 2018

• Create CFAD with calibrated MMCR/KAZR data for both ARM permanent sites and selected AMF sites

• Assist major modeling centers to implement ARM radar simulator to their models in support of cloud parameterization development and evaluation
  • E3SM, CAM5, ECMWF, MIROC, Metoffice
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• Address both simulator and data uncertainties
  • Data uncertainties (Radar calibration, Clutter, Radar changes (MMCR vs. KAZR, ...)
  • Vertical resolution, Subcolumn #, etc.
  • Particle size distribution of hydrometeors (Lognormal, exponential, gamma)
  • Precipitation area fraction (***) (most models do not have the information)
• ARM Ground-based cloud radars have difficulty detecting the small cloud particles present at the top of many high altitude cirrus clouds.
• Need to address issues associated with lidar attenuation by low clouds and aerosols
• A ground based lidar simulator has been created at Institute of Pierre Simon Laplace (IPSL)
  • Marjolaine Chiriaco of LATMOS-IPSL
The END