Calibration, characterization, and data quality of the Scanning ARM Cloud Radar (SACR)

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Overview

- ARM provides scientific community with strategic, global in-situ measurements
- Operates and manages a wide variety of remote sensing instrumentation, including mmwave radar
- Calibration is an important part of ensuring research quality data reaches end users
- Special considerations and techniques are developed to facilitate and verify calibration

ABOUT

Pacific Northwest National Laboratory

The Pacific Northwest National Laboratory, located in southeastern Washington State, is a U.S. Department of Energy Office of Science laboratory that solves complex problems in energy, national security, and the environment, and advances scientific frontiers in the chemical biological, materials, environmental, and computational sciences. The Laboratory employs more than 4,000 staff members, has an annual budget in excess of \$1 billion, and has been managed by Ohio-based Battelle since

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U.S. DEPARTMENT OF ENERGY

Atmospheric Radiation Measurement (ARM)... Mission

Strengthen the **understanding** and **representation** atmospheric models

Current Efforts

- Provide atmospheric data over a broad range of frequencies
- Produce continuous, dense, volumetric sampling at strategic global locations
- Aid scientists in development and validation of climate models



Scanning ARM Cloud Radar (SACR) **System Overview**

- Dual-frequency systems with a single pedestal operate at Ka-, and either X- or W-bands
- Powered by TWT or Klystron amplifier to facilitate pulse compression
- Complex waveforms to mitigate velocity and range ambiguities (Bharadwaj 15B.4)

Deployment

- Systems are deployed at both fixed and mobile facilities
- System is chosen based on phenomena of interest (clouds = Ka/W, precipitation = Ka/X)





 $T_1 \mid T_2 \mid T_3 \mid T_4 \mid T_5$

SACR Mode 18 Waveform

2nd Generation Ka/W-SACR @ ENA

Calibration and Data Quality Subsystem Measurements

- A complete characterization of the various radar subsystems is performed through on-site measurements
- Built-in test equipment is used to continuously monitor key measurements for relative changes

External Sources/Comparisons

- Corner reflectors are used when terrain criteria are met to validate on-site measurements
- Regular comparisons between systems are used to validate results as well as monitor for anomalies

Data Masks

- General data quality masks are produced to provide users with the best possible data
- Masks include significant echo, clutter, blanking, and blockage.

Examples and Results

Corner Reflector Measurements

- Measurements collected at the Eastern North Atlantic (ENA) site
- Corner reflector returns agreed with the on-site measurements to within 1 dB

Cross-platform Comparisons

- Density plots are regularly used to assess the relative agreement between the radar systems
- Relative agreement between the ENA Ka-SACR and the Ka-band ARM Zenith Radar (KAZR) is shown to be within 2 dB
- Discrepancies in scattering effects between the Ka- and W-SACR returns are the likely cause of much of the 1.6-dB bias





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Transmit Chain Receive Chain





ENA Blockage/Blanking KaSACR - EI = 5



Corner Reflector @ ENA

orner Reflector Raster - Raw Power (dBr







-40 -20 0 KAZR Burst H-Channel Ref (dBZ)





-40 -20 0 KAZR Burst H-Channel Ref (dBZ)

Conclusions

- ► ARM radar group has developed calibration methodology that ensures research-quality data is delivered to end users through:
 - On-site measurements
 - External calibration sources
 - Data masks
- Recent results from experiments at the ENA site show the success of the methodology through corner reflector measurements and comparisons with colocated radar systems
- The successful methodology will be regularly applied to SACRs at fixed sites and as they continue to be deployed at mobile facilities

References

Feng, Z., et al. (2011). "Top-ofatmosphere radiation budget of convective core/stratiform rain and anvil clouds from deep convective systems." Journal of Geophysical Research-Atmospheres 116.

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