Characterizing the ARSCL Product Record

Karen Johnson[1], Michael Jensen[1], Shannon Baxter[2], Meng Wang[1], Tami Toto[1], Pavlos Kollias[3], Eugene Clothiaux[4]

[1]Brookhaven National Laboratory, Upton, NY [2]State University of New York at Geneseo [3]McGill University, Montreal, Canada [4]Pennsylvania State University, State College, PA

1. Background on ARSCL

The ARM program operated vertically-pointing 35-GHz Millimeter Cloud Radars (MMCRs) at five fixed sites from the late 1990's until early 2011, before upgrading to the Ka-band Zenith Radars (KAZRs). The MMCRs cycled through four operating modes (eventually an additional polarization mode was added) in order to observe a wide a range of climatological cloud conditions.

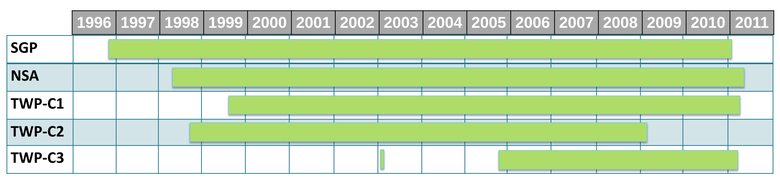
The original Active Remote Sensing of Clouds (ARSCL) Value-Added Product (VAP) combines MMCR observations with micropulse lidar and ceilometer observations to provide cloud (hydrometeor) boundaries, best-estimate reflectivities, mean Doppler velocities and spectral widths.

2. Analysis Goals

This analysis, which is still in progress, is intended to **clarify numerous aspects of ARSCL data quality** over the full data record at each site:

- Identify MMCR calibration shifts
- Identify saturated reflectivities **(BELOW LEFT)**
- Detect instrument failure timing / impact **(BELOW RIGHT)**
- Determine effect of gradual sub-system degradation on overall ARSCL data quality

Years of MMCR-based ARSCL Record



MMCR observations and ARSCL products are available for the North Slope of Alaska (NSA), Southern Great Plains (SGP), and three Tropical Western Pacific (TWP) sites.

3. Approaches

Among the quantities to be examined are:

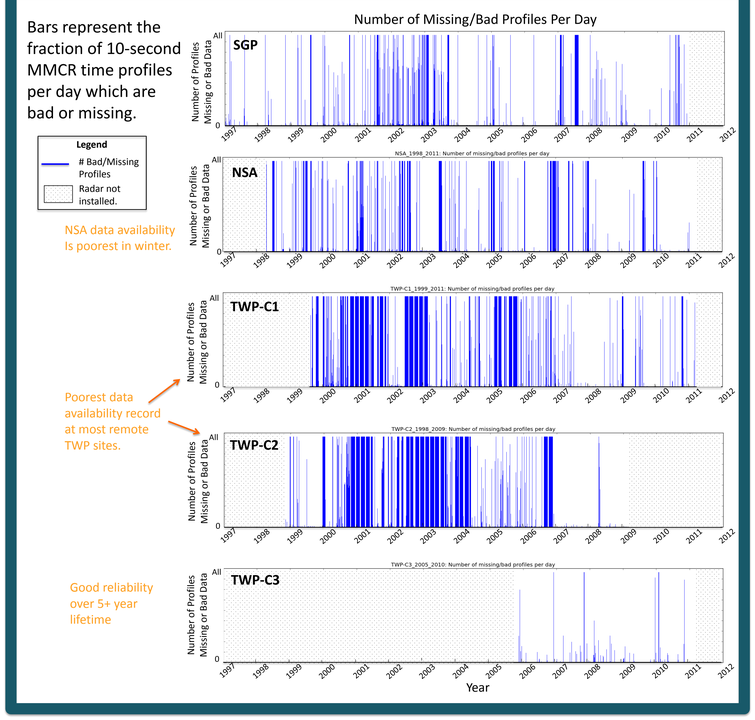
- Cirrus minimum reflectivity **(BELOW RIGHT)**
- Maximum low-level reflectivity **(BELOW LEFT)**
- Noise power trends
- Polarimetric depolarization drift
- Clutter average power **(BELOW CENTER)**

4. Future Work

- The work continues, and will include analysis of polarimetric circular polarization drift and noise power trends
- The eventual goal is end-to-end ARSCL reprocessing, adding data quality flags and making the formats more similar to the new KAZR-based ARSCL VAP.

MMCR Data Availability

Bars represent the fraction of 10-second MMCR time profiles per day which are bad or missing.



NSA data availability Is poorest in winter.

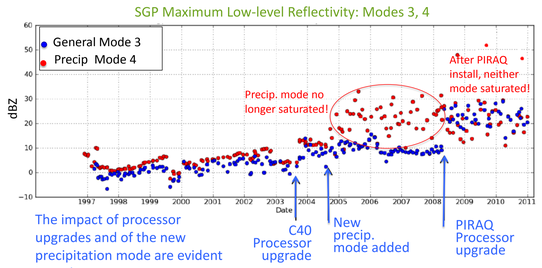
Poorest data availability record at most remote TWP sites.

Good reliability over 5+ year lifetime

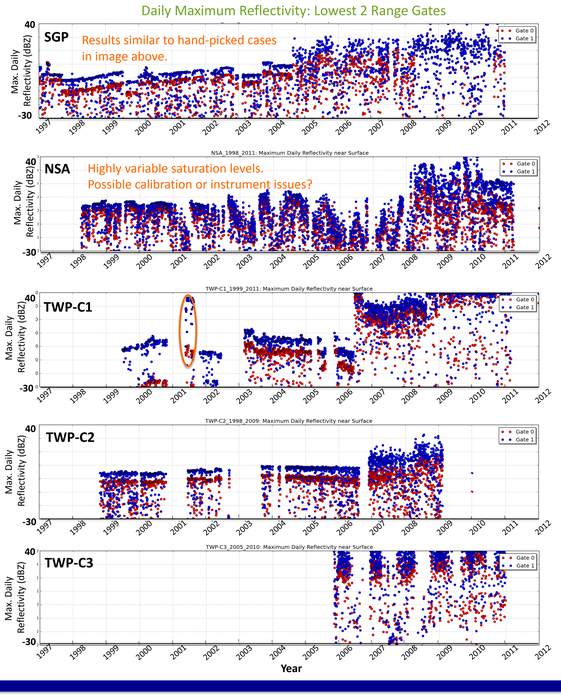
Reflectivity Saturation

MMCR Saturation:

Approximately one day per month with a significant period of drizzle or precipitation was selected over the SGP MMCR's deployment period. **At right**, maximum recorded reflectivity at the MMCR's lowest range gate is plotted for each date.



At right:
Maximum daily ARSCL best-estimate reflectivity for lowest two range volumes, for the full MMCR deployment, for each site. Note that saturation is no longer an issue following processor upgrades.



TWP-C1:
Inconsistent, non-physical values seen in mid-2001, suggesting an instrument issue.

TWP-C2:
Saturation reflectivities have long stable periods, much more stable than at SGP, above. May imply stable calibrations, as well.

TWP-C3:
Note annual monsoon cycle.

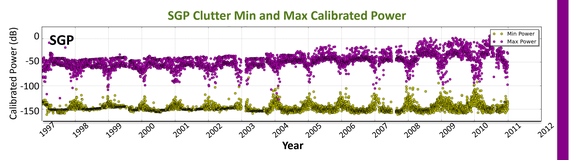
Clutter Power

Dynamic Range of Observed Clutter Power

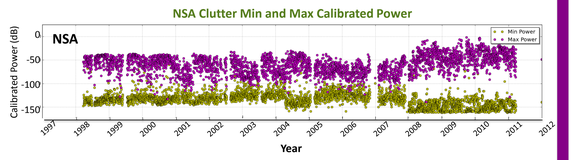
Tracking the dynamic range of clutter observations over time may also provide some insight into radar performance.

As a first step, maximum and minimum calibrated power observed each day are determined over the entire deployment of the MMCR at each site, with some interesting results, shown below.

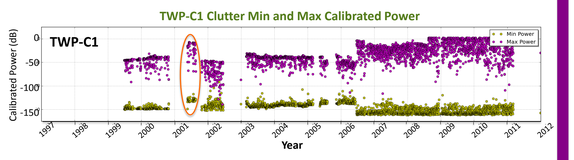
At the SGP site only, an interesting annual cycle in clutter dynamic range was observed throughout the 15-year deployment. A wider reflectivity range was seen in summer than in mid-winter.



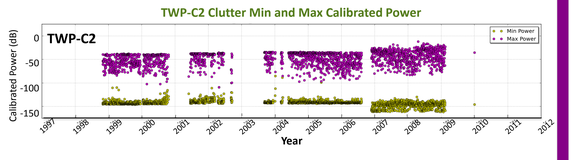
At NSA, maximum power returns fluctuated quite a bit, possibility indicative of varying radar calibration or instrument instability.



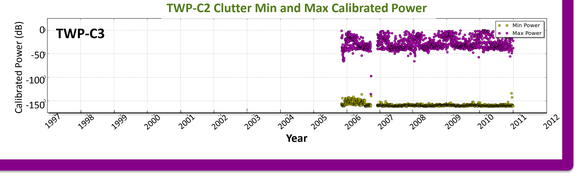
Offsets in min/max clutter power in mid-2001 are consistent with TWP-C1 saturation images to left



At TWP-C2, consistent 'clutter saturation' levels seen for long periods of time, through 2006, suggesting a stable calibration?



Power levels at TWP-C3 do not show saturation and remain quite stable over the site's five year operational deployment.



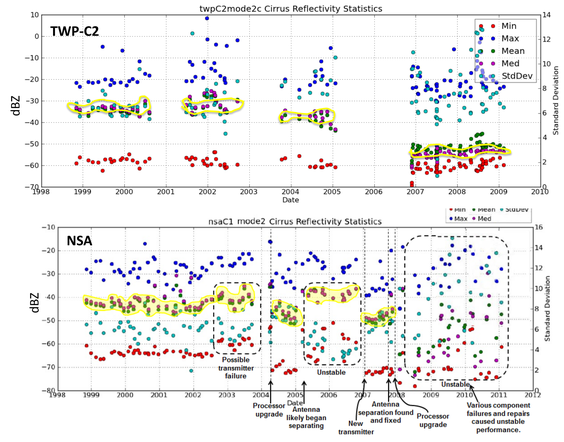
MMCR Sensitivity

Shedding Light on Impact and Timing of Instrument Failures

To assess changes in MMCR sensitivity, we selected approximately one day per month having primarily single-layer cirrus clouds. This was done for the entire MMCR deployment period at each site. Cirrus reflectivity statistics were computed over all cirrus cloud data points for each selected day.

TWP-C2 (immediately below) displays fairly stable cirrus sensitivity as shown by the yellow-outlined median cirrus reflectivity values, until the new PIRAQ processor was installed in mid-2006. At that point, sensitivity increased substantially.

The NSA image, below TWP-C2, illustrates the sensitivity impacts from many MMCR issues.



Below, daily minimum cirrus cloud calibrated power was determined from Cirrus mode and General mode best-estimate reflectivities.

At SGP, cirrus mode cloud detection is much more stable throughout the MMCR's lifetime than at TWP-C1.