ARM CLOUD RADARS
A Year in Review and a Look to the Future

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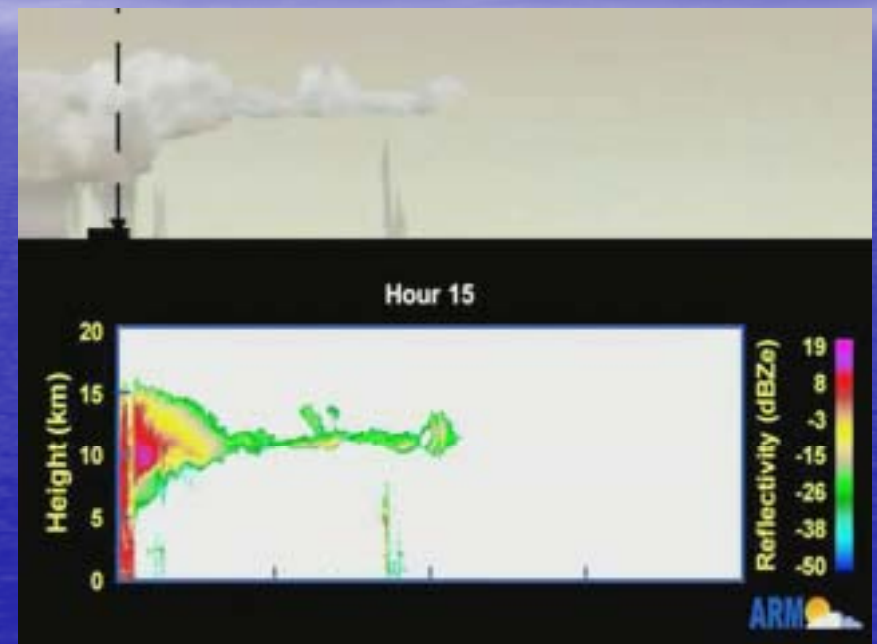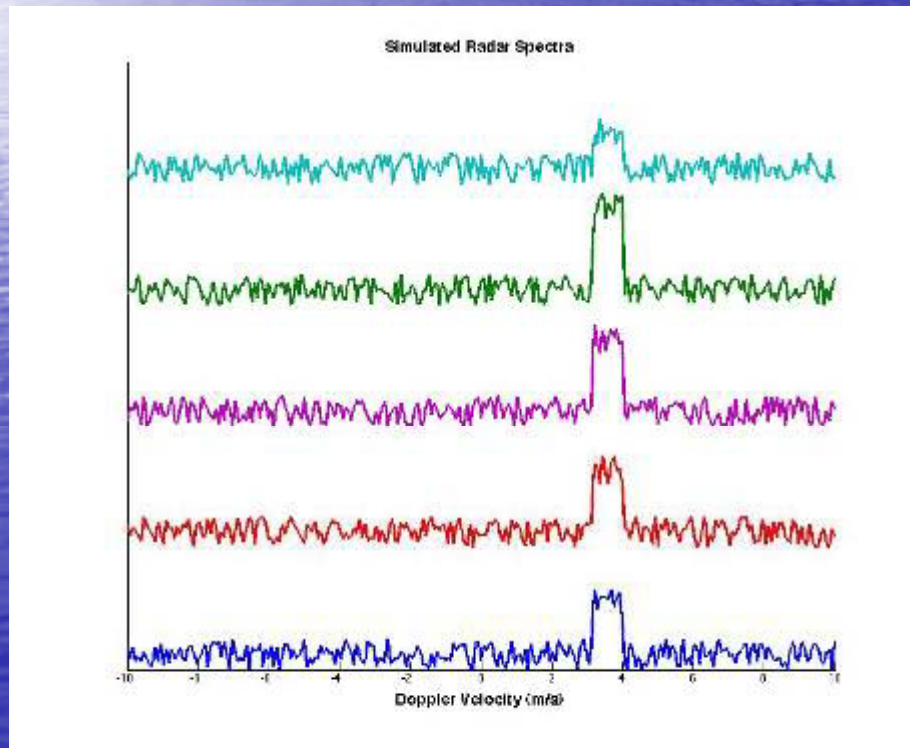Karen Johnson

Brookhaven National Laboratory

Outline

- Quick cloud radar primer
- Looking back
- Current issues
- Looking forward

Cloud Radar 101

0th moment - reflectivity
1st moment - radial velocity
2nd moment - spectral width

ARM's Cloud Radars - MMCRs

Manus

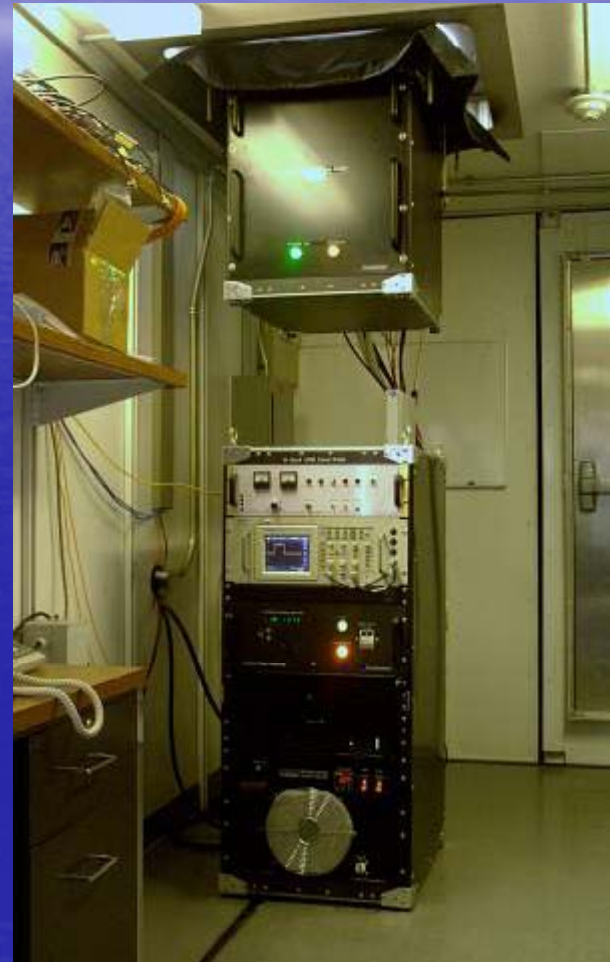
Darwin

Barrow

Nauru

SGP

ARM's Cloud Radars - WACRs

ARM's Cloud Radars - Inside Views

Acknowledgements

- Ken Moran and team at NOAA ESRL
- Jim Mead and team at ProSensing
- ARM Site Operations
  - SGP
  - NSA
  - TWP/AMF
- ARM Data Team
- ARM DQ Office
- Pavlos Kollias & Eugene Clothiaux

A Brief History

- November 1996, 1st MMCR installed by NOAA at SGP (Moran, et. al.)
- MMCRs subsequently installed at Barrow ('98), Nauru ('98), Manus ('99), Darwin ('02)
- Y2K (Urghhh…)
- Signal processor upgrade to C40 DSP at SGP ('03) and Barrow ('04)
- Signal processor upgrade to PIRAQ-3 at Darwin ('05), Nauru ('06), and Manus ('06)

MMCR Transmitter History

- Traveling Wave Tube Amplifiers (TWTAs)
- ~ 20,000 hours of lifetime (2.3 years)
- We've had 3 different TWT manufacturers
  - CPI (formerly Varian) - quality problems
  - Thales (formerly Thomson) - low lifetime
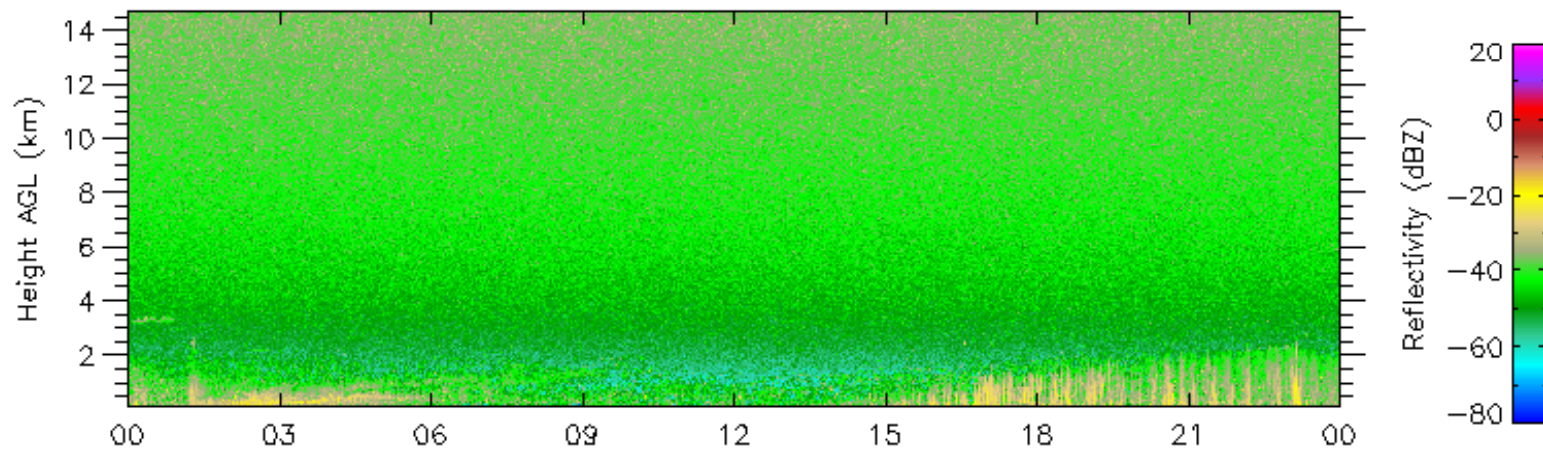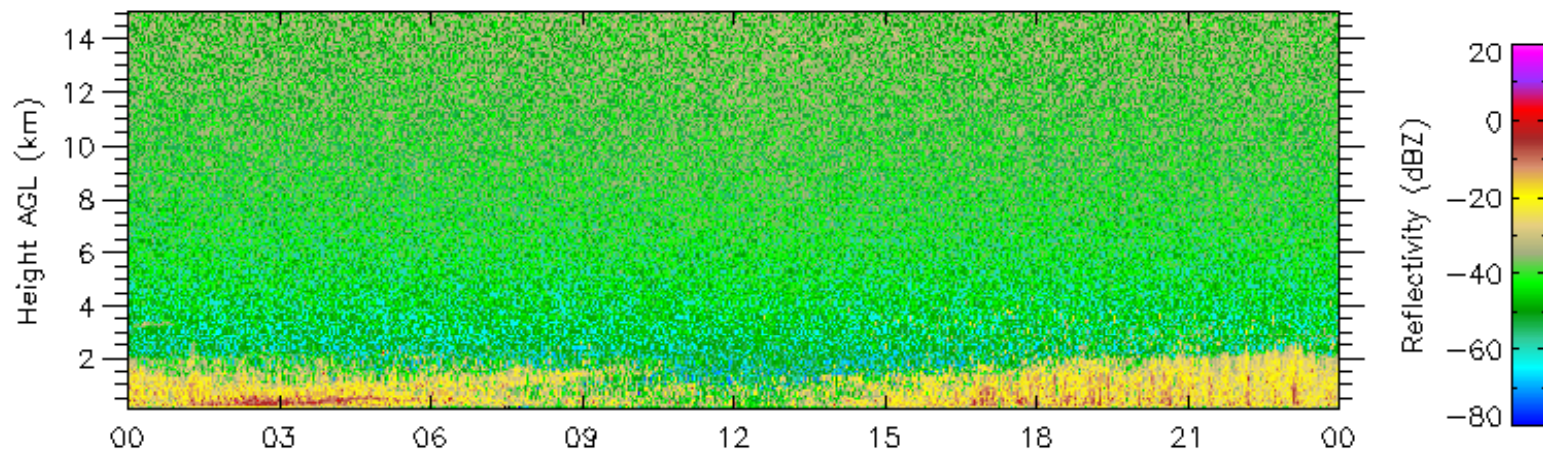 - L3 (formerly Boeing) - current, 200 watts

WACR History

- Need driven by atmospheric plankton at SGP

- W-band ARM Cloud Radar (WACR) installed at SGP ('05) by ProSensing (Mead et. al.)

- WACR installed with AMF in Niamey, Niger ('06)

MMCR/WACR Comparison

20060905
sgpmmcrmomC1.b1, General, Mode 3

Maintenance Challenges - An Example

1. Problem identified on Manus
2. BoM techs and mentor troubleshoot and suspect coherent up/down converter has failed
3. Spare CUDC shipped to Manus (~8 weeks depending on PNG Customs)
4. BoM techs schedule visit (~4 weeks minimum, often longer)
5. Techs hopefully fix and recalibrate the radar. If not, go to step 2 and start clock again
6. Intermittent problems are extremely difficult to troubleshoot at remote sites!

Preemptive Measures

- Buy major components (TWTA and CUDC) as spares located on site for TWP
- Other components are hand carry able by engineer/technicians
- SGP spare parts serve SGP and Barrow MMCRs
- SGP WACR is "hot spare" for AMF WACR
- Spare WACR transmitter at SGP

Current Health Monitoring

- Internal signal injection - daily calibration check
- Data flow status used by site operations
- DQ Quicklooks - used by DQ Office and mentors
- Emails directly from MMCR if discernable problem from monitoring software
- Instrument intercomparisons
  - MPL
  - WACR/MMCR @ SGP
  - Ceilometer
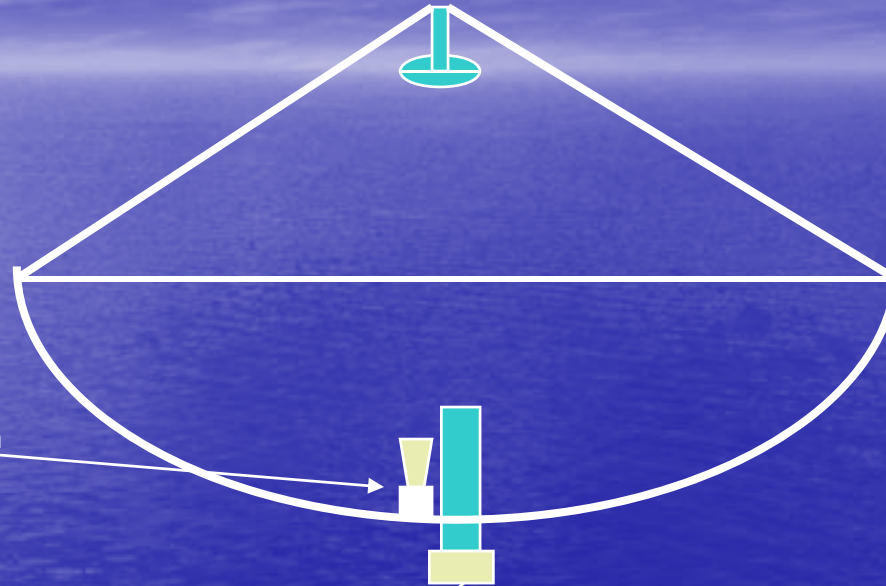- Remote access to computers available with higher network bandwidths

What We're Missing!

Transmitter

Receiver

Noise source
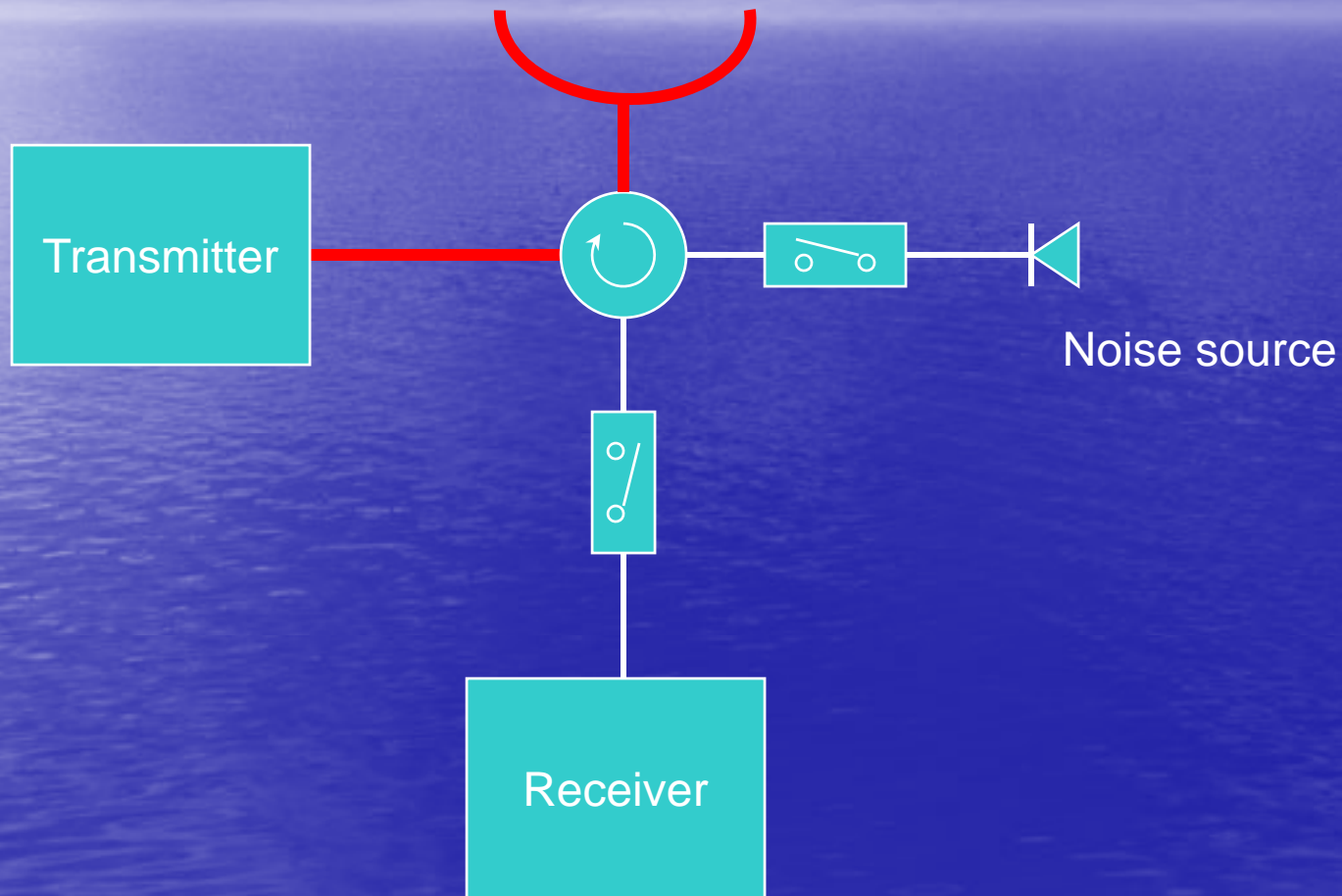
Annual Calibration/Inspection

Gunn diode with horn antenna

Power Meter

Calibration

- We need to provide end-to-end calibration of all of our radars.
- We can do this easily with the SGP WACR but not easy with the other radars.
- Use of radiometer modes.

Antenna Refurbishment

- Antennas are in some fairly harsh environments
- Key component in reflectivity calibration
- Procured 2 meter antenna and will be rotating it through the sites while antenna is refurbished
- New feeds to improve polarization isolation and prevent corrosion
- New radome covers

Antenna Wear & Tear

Spectra Compression

- Large volume of spectra data requires swapping disks and shipping them to the Archive ~ 15 GB/day

- Testing underway to apply cloud mask and compress with the hope that spectra can be transferred via Internet

MMCR Transceiver Upgrade

- Common method of calibration between MMCR and WACR

- Digital transceiver to allow nonlinear modulation techniques to reduce range side lobes

Range Side Lobe Example

20060506
sgpwacrC1.b1, Copolarization Mode

20060506
sgpmmcrmomC1.b1, General, Mode 3
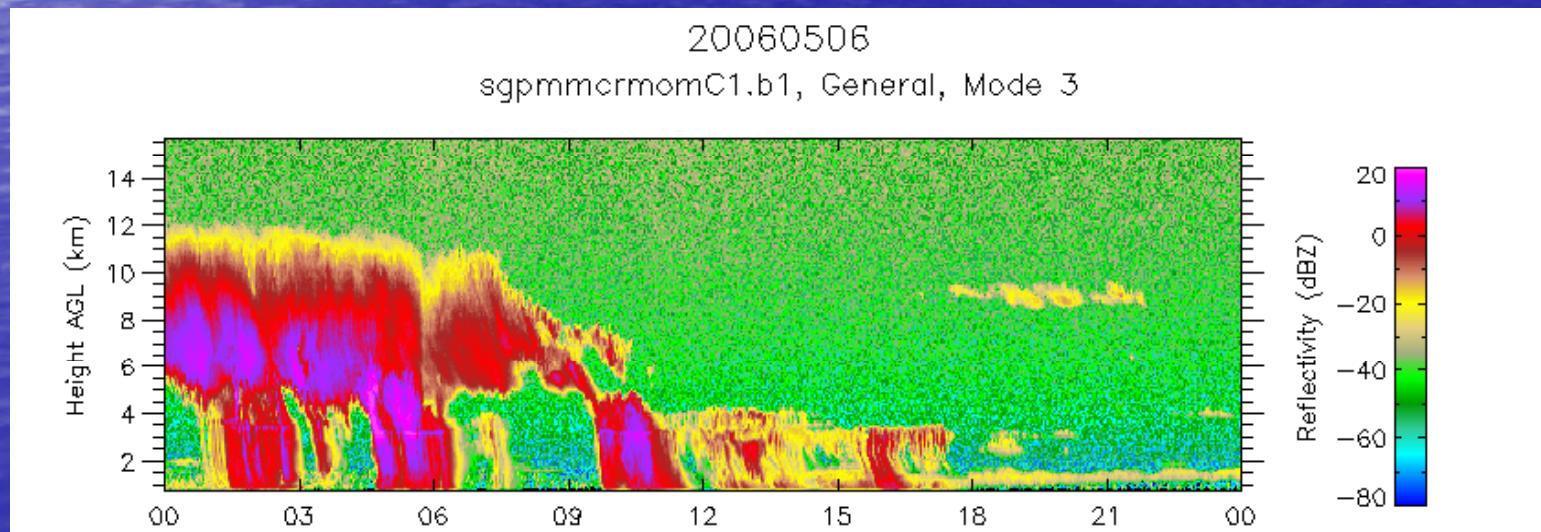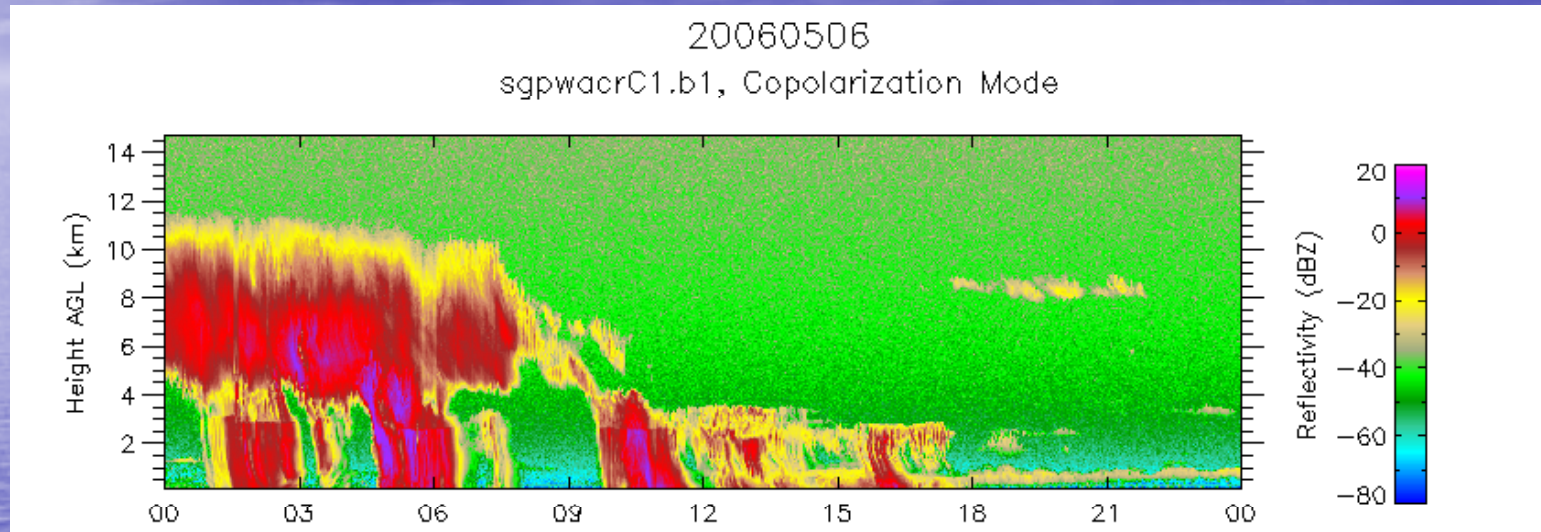
ARSCL Update

See poster "ARSCL Suite of VAPs" by Johnson et. al.

Summary

- The ARM cloud radar network has made a significant contribution to climate science.
- There are significant challenges in keeping these radars operating 24/7.
- ARM is committed to meeting these challenges while providing increased capability to improve scientific understanding by the ARM Science Team and other users.