MMCR Upgrades: Present Status and Future Plans

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Abstract

In September 2003, the Southern Great Plains (SGP) millimeter wave cloud radar (MMCR) was upgraded to a new digital signal processor that significantly increases the temporal resolution and the processing capability of the MMCR. The Barrow MMCR upgrade will be completed in early 2004. We will discuss the hardware and software C40 upgrade to the MMCRs at SGP and Barrow and the plans for upgrades at the Tropical Western Pacific (TWP) sites. Increased temporal resolution, new modes, and new file formats will be demonstrated. We are now collecting spectral data 24/7 and we will discuss how to obtain these large datasets.

Introduction

When the MMCR was originally designed in the mid-1990s, the desire to have a cloud radar that could run continuously hands-off led us to the decision to use the digital signal processors (DSPs) used on the National Oceanic and Atmospheric Administration (NOAA) wind profiler network. Running a modified version of the Profiler On-line Program (POP) software under OS/2, the radar computer generates files every 30 minutes. These files are transferred to the radar data management computer (running Solaris), where the POP files are processed to produce calibrated spectral moment NetCDF files that are collected by the site data system. MMCRs were deployed with this configuration at SGP, Barrow, Nauru, Manus, and Darwin.

Although the MMCRs performed well, processing was limited to the employed DSP and computing technology. The radar processing efficiency (defined here as the amount of radar returns processed) was only about 10%. Although we had the ability to collect spectral data, the low FFT resolution did not make this very useful. In addition to these processing deficiencies, we started to see degradation in operational performance. The Year 2000 (Y2K) fixes for OS/2 proved to be very "buggy" and we started getting random hang-ups. Hardware replacements (specifically CPUs and disks) were becoming very difficult to obtain. We needed to upgrade the MMCRs processing!

Upgrade Development

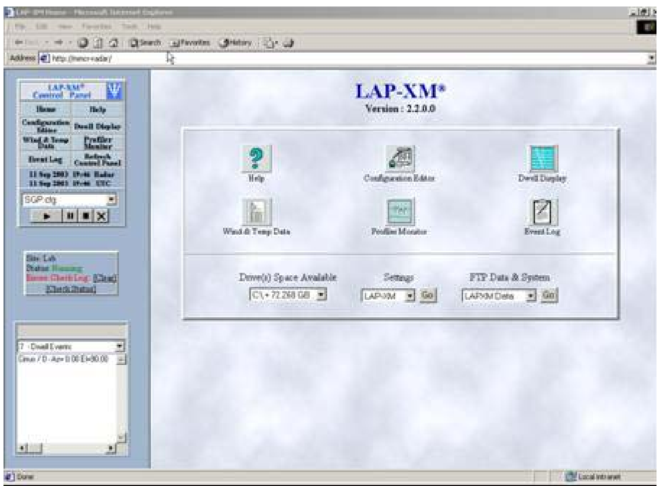
Through a Cooperative Research and Development Agreement (CRADA), NOAA Environmental Technology Laboratory (ETL) transferred MMCR technology to Radian, Inc. Radian, already a manufacturer of wind profilers, added the MMCR to their product line and Atmospheric Radiation Measurement (ARM) Program bought its fifth MMCR from Radian (Radian has since sold this division to Vaisala). With support from ARM and NOAA, Radian began the design of a new DSP board for the MMCR. Based on the C40 DSP from Texas Instruments, the new processor board design looked quite promising. Processing efficiency was initially projected to be between 80% and 100%. In addition to the new DSP board, POP software was going to be replaced by Radian's new LAP-XM software and new higher resolution analog-to-digital converters were incorporated. There were significant delays but NOAA/ETL completed the Radian work and the upgrade was finally installed in September 2003.

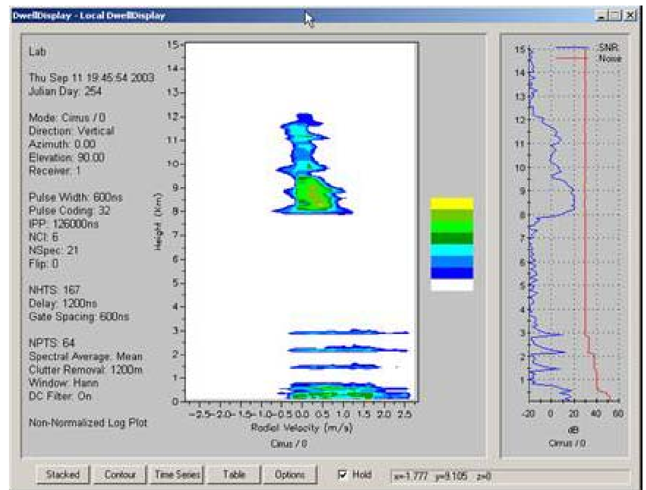
Radar Computer

The MMCR radar computer is currently a Windows 2000 industrial rack mount computer running LAP-XM with the C40 processor board on its PCI bus. This computer replaces the OS/2 computer. LAP-XM allows the setting of radar operational modes such as pulse repetition frequency, pulse width, number of pulse code bits, FFT length, etc. The radar computer computes the spectral moments (power, Doppler velocity, and spectral width) for the spectra data. The moments are stored on a shared disk physically attached to the data management computer. The spectra files are stored on a removable Firewire disk attached to the radar computer.

The spectra files are stored in NetCDF format as hourly files. These files can be fairly large and the MMCR can generate approximately 3 GB – 6 GB per day (depending on mode parameters). The networking infrastructure cannot handle moving this amount of data to the ARM Archive. We are currently set up to swap disks every couple of weeks. A copy of the disk is made and kept onsite until we are assured the ARM Archive has received the files. There is currently no further processing of the MMCR spectra files.

The figures below show screens of LAP-XM including a contour plot.





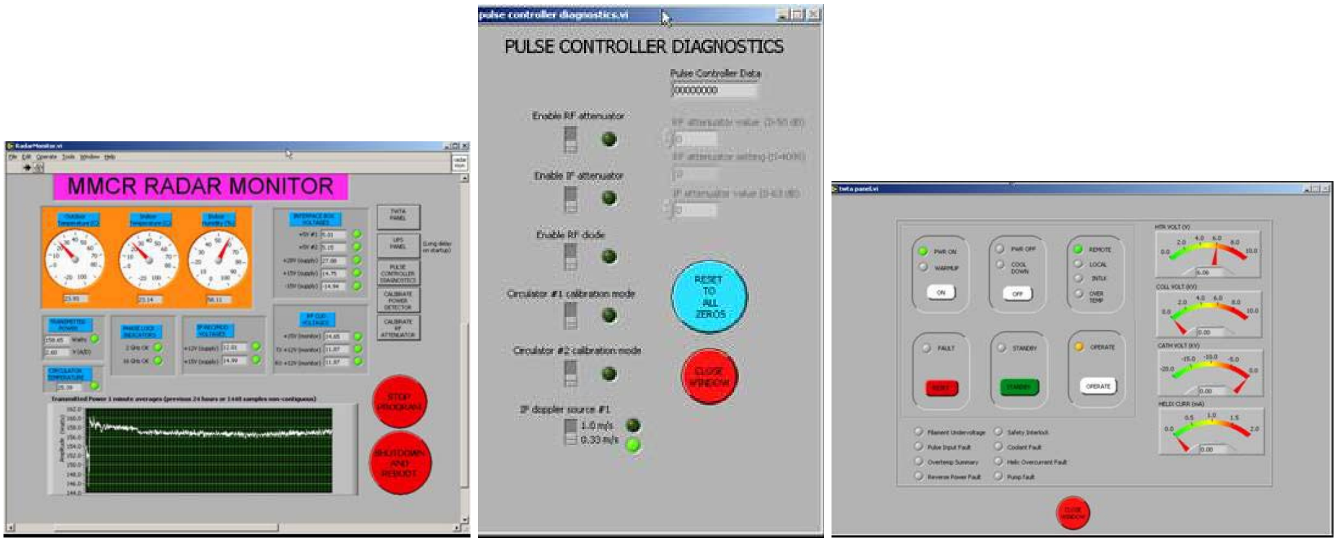
Data Management Computer

The data management computer controls the routine calibration of the MMCR on a monthly interval, compresses raw radar moment files for redirection to the ARM Archive and monitors the system health and status. This computer replaces the old Solaris computer. User interface is handled through Labview code. Screenshots are shown on the following page. These screens allow remote control and monitoring of the radar that we did not have under the old MMCR software.

Polarization Measurements

The SGP MMCR will be modified with the addition of an orthomode transducer to measure the cross-polar received signal. The MMCR will transmit one polarization and receive on the orthogonal polarization. This will allow us to further investigate techniques for removing insect returns from the co-polar signal.

Please see: Moran, K. P., T. Ayers, B. E. Martner, and M. J. Post, 2000: Dual Polarization Observations on an MMCR: Implementation and First Results. In *Proceedings of the Tenth Atmospheric Radiation Measurement (ARM) Science Team Meeting*, U.S. Department of Energy, Washington, D.C. Available URL: http://www.arm.gov/docs/documents/technical/conf_0003/moran-kp.pdf



File Formats and Variables

The MMCR can operate in a number of different modes to optimize cloud measurements for different types of clouds. With the old format files (mmcrmomentsC1.a1 and mmcrcalC1.a1), the data user had to determine the mode of operation by reading several variables such as InterPulsePeriod, PulseWidth, NumberCoherentIntegrations, and NumCodeBits. Depending on the installation, the modes can be different from radar to radar. The data files for the upgraded radar (mmcrcalC1.b1) have a ModeNum variable that identifies the mode the radar is in as a function of time. This allows the data user to easily separate out the other time based variables (such as Reflectivity).

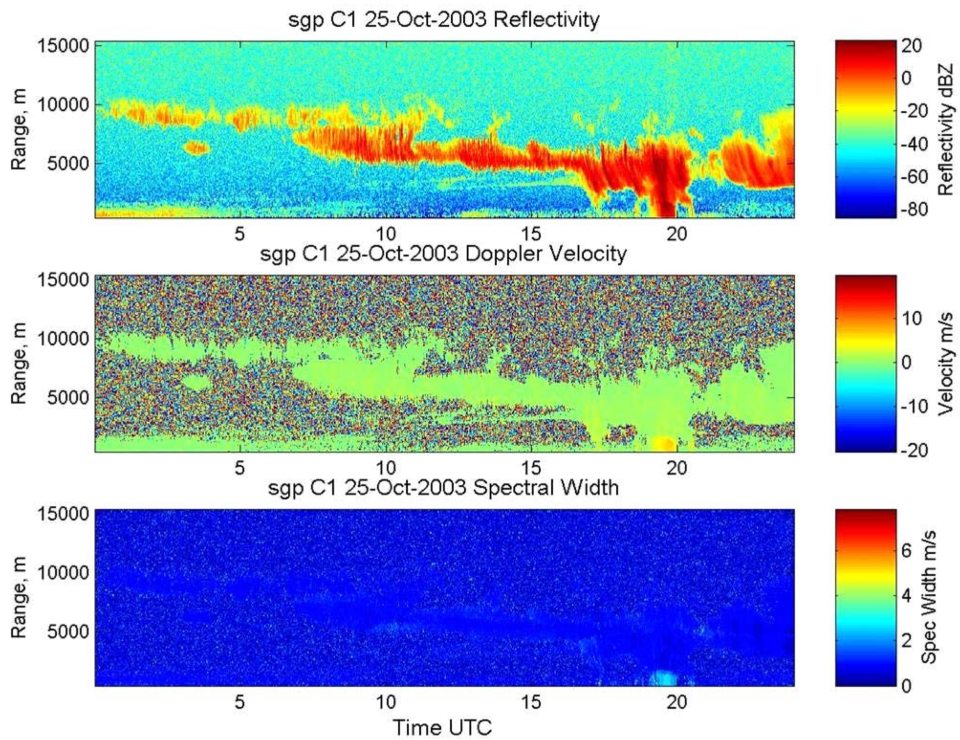
For a complete listing of variable changes in the upgraded files, please see the table located at the following web page: http://www.gim.bnl.gov/armclouds/mmcr/mmcrMomNewVsOldDataStreams.html

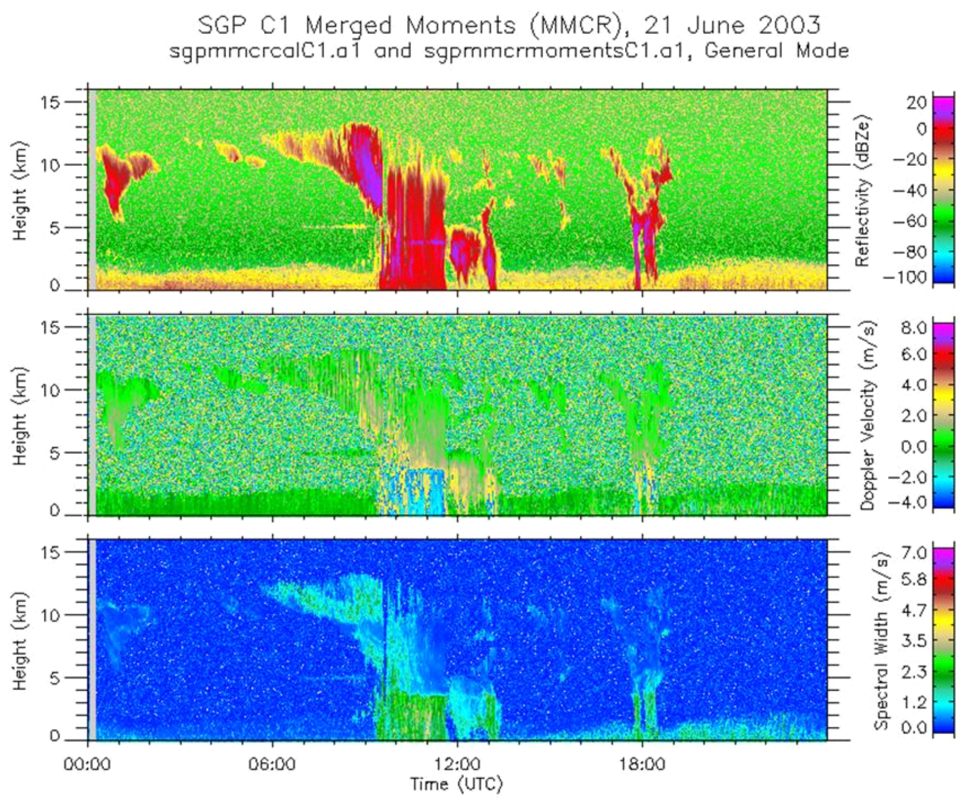
Increased Performance

The most obvious improvement that one sees with the upgraded MMCR is the increased temporal resolution. Running the same modes with the upgraded MMCR, the temporal resolution has increased by a factor of four (the files are four times as big too!). You can notice in the two plots (shown on the next page) the clearer definition of the clouds from the upgraded radar. The upper plot is courtesy of the ARM DQ Office.

Increased Reliability

More important than the increased temporal resolution has been the increase in MMCR "up-time". Since the installation in mid-September 2003, we have not had a single computer malfunction (hardware or software). The only downtime on the MMCR has been for planned maintenance. Data availability at SGP for the old MMCR was approximately 70% in 2003 up to the time of the upgrade. Since the upgrade, data availability has been greater than 98%!


sgp C1 25-Oct-2003 Reflectivity
Range, m
Reflectivity dBZ
sgp C1 25-Oct-2003 Doppler Velocity
Range, m
Velocity m/s
sgp C1 25-Oct-2003 Spectral Width
Range, m
Spec Width m/s
Time UTC


SGP C1 Merged Moments (MMCR), 21 June 2003
sgpmmcrcalC1.a1 and sgpmmcrmomentsC1.a1, General Mode
Height (km)
Reflectivity (dBZe)
Doppler Velocity (m/s)
Spectral Width (m/s)
Time (UTC)

MMCR Upgrades – The Path Forward

All is not bright and rosy with the C40 Upgrade. Only three analog-digital converters required in the Radian Interface were manufactured. These boards contain programmable logic devices that Vaisala may not be able to find the programs for. Reverse engineering the board could take significant engineering time. Although developed by Radian, this board set is not a supported product line. Furthermore, the C40 processor board has also been slated for discontinuation. A replacement board will require more DSP software development. There are enough components to upgrade the Barrow MMCR. We plan on going ahead with this upgrade in April 2004.

The National Center for Atmospheric Research (NCAR) developed the PC-Integrated Radar Data Acquisition System (PIRAQ) and this radar processor has been used on a number of research radars. NCAR licensed Vaisala to use this technology and Vaisala is currently delivering wind profiler systems with PIRAQ-III boards running under LAP-XM. The code has been already written that will allow the PIRAQ-III to work with the MMCR. The hardware and software are currently undergoing testing at NOAA/ETL.

The benefit of migrating to PIRAQ is that the boards and software are supported products of Vaisala. The data management computer would not be a Vaisala supported product but since the software that was written for it was in National Instrument's Labview, supporting this code is relatively simple. Labview is data acquisition and control software that has enormous industrial acceptance.

The current plan is to upgrade the TWP MMCRs to the PIRAQ-III boards and then backfit the SGP and Barrow MMCR so that we once again have all MMCRs identical. These upgrades should commence this fiscal year!

New Operating Modes

With the new capabilities of the MMCR, new operating modes to capitalize on these improvements are required. Pavlos Kollias coordinated the discussion within the ARM Cloud Properties Working Group to come up with a consensus on what these modes should be for all of the ARM MMCRs. These are presented on his poster The ARM MMCRs new operational modes and the ARSCL VAP new merge strategy at this conference.

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