Description of Data Collected by the NOAA 449-MHz and 2.8-GHz Profilers during the Mid-latitude Continental Convective Cloud Experiment (MC3E) 22 April – 6 June 2011

Christopher R. Williams, Ph.D., PMP

CIRES Research Scientist
Cooperative Institute for Research in Environmental Science (CIRES)
University of Colorado at Boulder
in partnership with
NOAA Earth System Research Laboratory
Physical Sciences Division

email: Christopher.Williams@colorado.edu or
Christopher.R.Williams@noaa.gov

Regular Mail:
CIRES, UCB 216
University of Colorado at Boulder
Boulder, CO 80309-0216
Phone: 303-497-3829

Overnight Mail:
Mail Stop R/PSD3
325 Broadway
Boulder, CO 80305
Phone: 303-497-3829

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1. Introduction

This document describes the data collected by the NOAA 449-MHz and 2.8-GHz profilers in support of the Department of Energy (DOE) and NASA sponsored Mid-latitude Continental Convective Cloud Experiment (MC3E). The profiling radars were deployed in Northern Oklahoma at the DOE Atmospheric Radiation Mission (ARM) Southern Great Plans (SGP) Central Facility from 22 April through 6 June 2011.

NOAA deployed three instruments: a Parsivel disdrometer, a 2.8-GHz profiler, and a 449-MHz profiler. The parasivel provided surface estimates of the raindrop size distribution and is the reference used to absolutely calibrate the 2.8 GHz profiler. The 2.8-GHz profiler provided unattenuated reflectivity profiles of the precipitation. The 449-MHz profiler provided estimates of the vertical air motion during precipitation from near the surface to just below the freezing level. By using the combination of 2.8-GHz and 449-MHz profiler observations, vertical profiles of raindrop size distributions can be retrieved.

The profilers are often reference by their frequency band: the 2.8-GHz profiler operates in the S-band and the 449-MHz profiler operates in the UHF band. The raw observations are available as well as calibrated spectra and moments. This document describes how the instruments were deployed, how the data was collected, and the format of the archived data.

2. Instrument Deployment

The NOAA instrumentation was installed at the Department of Energy (DOE) Atmospheric Radiation Mission (ARM) Southern Great Plans (SGP) Central Facility from 22 April through 6 June 2011. Figures 1 and 2 show the instruments installed next to DOE instruments.

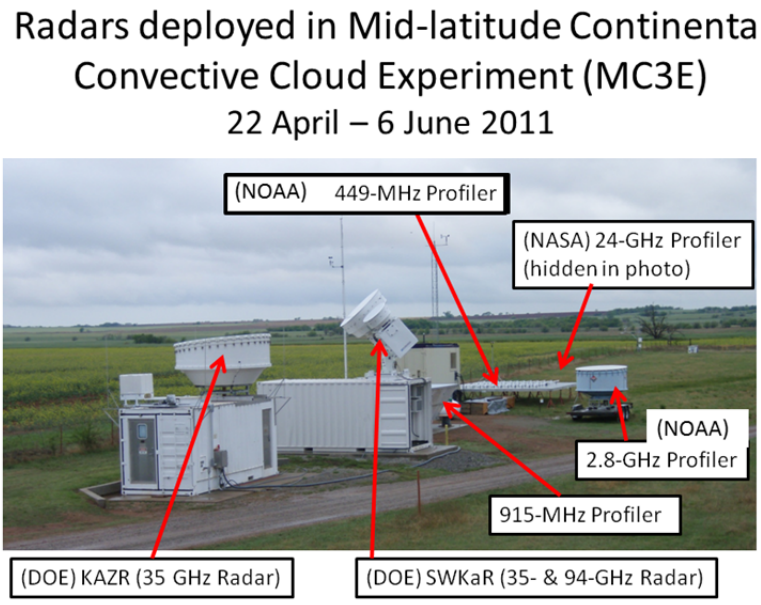

Figure 1. Radars deployed at SGP Central Facility during MC3E. Photo was taken looking toward the West.

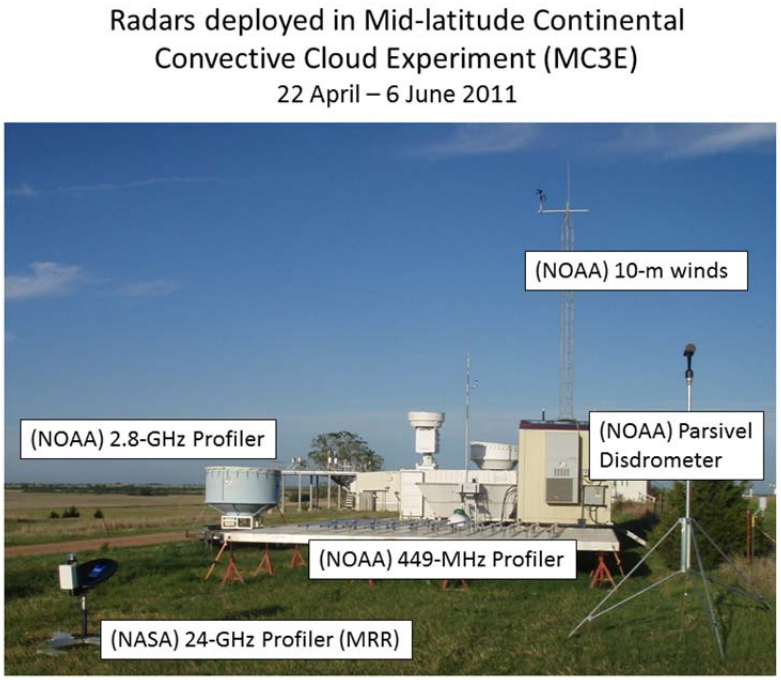

Figure 2. Radars deployed at SGP Central Facility during MC3E. Photo was taken looking toward the East.

3. Surface Met Station

3.1 Installation

A propeller wind monitor was mounted on a 10-m tower to measure the wind speed and direction. A temperature sensor and a humidity sensor were placed on the ground along with a tipping bucket rain gauge. A description of the instruments can be found on the NOAA Earth System Research Laboratory (ESRL) web page http://www.esrl.noaa.gov/psd/data/obs/instruments/SurfaceMetDescription.html.

3.2 Archived Data Files

The raw surface met data are saved in daily files in ASCII format. The filenames follow the DOE filename convention with the following naming format:

sgpsurfmetC1.00.YYYYMMDD.raw.mc3e_noaa_txt.asc

The naming structure is:

sgp	- site identifier – Southern Great Plains
surfmet	- instrument identifier – surface met station
C1	- facility designation – Central Facility
00	- data level – raw data
YYYY	- year
MM	- month
DD	- day of month
raw	- data level – raw data
mc3e	- field experiment name
noaa	- instrument owner
txt	- ASCII data
asc	- ASCII data

All daily files for the MC3E field campaign are zipped into one file with the following format:

sgpsurfmetC1.00.YYYYMMDD.through.YYYYMMDD.raw.mc3e_noaa_txt.asc.zip

3.3 Data Format

The surface met data were recorded at 2-minute intervals and saved in daily ASCII data files. The daily data files contained 14 comma delimited fields in each row with the following forma.

Table 1. Format of daily ASCII Surface Met data files.

Field	Description
1	Data Logger ID (constant at 108)
2	Year
3	Day of Year
4	HoursMinutes (at the end of the average) (Leading zeros are suppressed)
5	Pressure (mb) offset by -400 mb. True Pressure = recorded value + 400 mb
6	Air Temperature (C)
7	Relative Humidity (percent)
8	Scalar Wind Speed (m/s) at 10 meters
9	Vector Wind Speed (m/s) at 10 meters
10	Wind Direction (degrees) at 10 meters
11	Wind Direction Standard Deviation (degrees) at 10 meters
12	Battery Voltage (Volts)
13	Precipitation (mm)
14	Maximum Wind Speed (m/s)

4. Parsivel Disdrometer

4.1 Installation

A Parsivel disdrometer was deployed to measure the surface raindrop size distribution and provide a reference reflectivity to calibrate the S-band profiler. The Parsivel disdrometer sensor head was mounted on a pole and can be seen on the right side of Figure 2. The manufacture's software was used to collect the original observations with a 60-second dwell time.

4.2 Original Data

The original data consists of two manufacturer's data types: the 'raw' and the 'stats' data files. The raw data consists of sequences of 32 x 32 matrices counting the occurrence of raindrops in each of the 32 diameter sizes and 32 velocity ranges. The stats data consists of 1-minute accumulations of raindrop counts for each diameter size and integrated rain quantities including rain rate and reflectivity factor. Both data types are saved in hourly data files.

4.3 Archived Data Files

The raw Parsivel data are saved in hourly files. The two modes (stat and raw modes) have the following naming format:

sgpparsivelC1.00.YYYYMMDD.hh0000.raw.mc3e_stat_txt.asc

sgpparsivelC1.00.YYYYMMDD.hh0000.raw.mc3e_raw_txt.asc

Note that the time of each hourly file is forced to be minute 00 and second 00. The data are in ASCII format.

The 24 hourly files for each day are zipped into daily files with the following format:

sgpparsivelC1.00.YYYYMMDD.raw.mc3e_stat_txt.asc.zip

sgpparsivelC1.00.YYYYMMDD.raw.mc3e_raw_txt.asc.zip

4.4 Processed Data

The Parsivel *stats mode* observations were processed to generate geophysical products. Since the raw counts are converted into a geophysical unit without any quality control, the DOE QC flag is set to 'a1'. The processed data consists of either moment data (e.g., reflectivity and rain rate estimates) or raindrop number concentration estimates.

The hourly Parsivel stats mode data contain geophysical moments of rain observations are processed into moments and The daily data files containing minute quantities that included rain rate and reflectivity. The raindrop counts per minute were converted into a number concentration (the number of raindrops per unit volume per diameter interval). Both of these data files were saved in daily files in ASCII format.

4.4.1 Daily Moment Files

The moments estimated in real time by the Parsivel are reformatted into daily ASCII files. The daily files have the following naming convention:

sgpparsivelC1.a1.YYYYMMDD.moments.mc3e.asc

All of the daily files are zipped into one file with the name:

sgpparsivelC1.a1.20110405.through.20110606.moments.mc3e.asc.zip

In each daily file, each row corresponds to a minute observation and there are 27 columns. The first 7 columns define the observation beginning time. Columns 8-27 contain the moments estimated by the online Parsivel program stored in the hourly stat mode file. The columns are defined in Table 2.

Table 2. Format of Daily Parsivel Moments data files.

Column	Description
1	Year
2	Day of year
3	Month number
4	Day of month
5	Hour
6	Minute (start of observation)
7	Second (start of observation)
	Columns 8-27 are the moments and instrument status flags generated in real time by the Parsivel software
8	Black out
9	Good
10	Bad
11	NumParticle
12	Rain Rate (mm/hr)
13	Rain accumulation (mm)
14	AmountSum (mm)
15	Reflectivity (dBZ)
16	NumError
17	Dirty
18	VeryDirty
19	Damaged
20	SignalAvg
21	SignalStdDev
22	TempAvg (C)
23	TempStdDev (C)
24	VoltAvg (V)
25	VoltStdDev (V)
26	HeatCurrentAvg (A)
27	HeatCurrentStdDev (A)

4.4.2 Daily Raindrop Number Concentration Files

The Parsivel stat mode data files contain the number of drops detected in each raindrop diameter interval. These counts are converted into raindrop number concentration and stored in daily ASCII files. In order to process the number concentration estimates properly, the user needs to also have the raindrop diameter (D), diameter interval (dD), raindrop terminal fall speed (speed using $v = 9.65 - 10.3exp(-0.6D)$), and the sample volume per diameter (volume) used to convert the raindrop count into raindrop number concentration. All ASCII data files are saved as daily files with the following naming convention:

sgpparsivelC1.a1.YYYYMMDD.ND.mc3e.asc	**Number concentration**
sgpparsivelC1.a1.YYYYMMDD.D.mc3e.asc	**Raindrop diameter (mm)**
sgpparsivelC1.a1.YYYYMMDD.dD.mc3e.asc	**Diameter interval (mm)**
sgpparsivelC1.a1.YYYYMMDD.speed.mc3e.asc	**Terminal fall speed (m s^{-1})**
sgpparsivelC1.a1.YYYYMMDD.volume.mc3e.asc	**Volume per diameter (m^{-3})**

All of these ASCII data files are saved in the zipped file named:

sgpparsivelC1.a1.20110405.through.20110606.ND.mc3e.asc.zip

The D, dD, speed, and volume data files contain 32 columns corresponding to 32 diameters used by the Parsivel. The ND data files contains 1440 rows (24 hours x 60 minutes) with 39 columns. The first 7 columns define the beginning of the observation time (start of the minute). Columns 8-39 contain the number concentration N(D) in units of number per volume per diameter (# m^{-3} mm^{-1}) for each of the 32 raindrop diameters as defined in Table 3.

Table 3. Format of Daily Parsivel Number Concentration data files.

Column	Description
1	Year
2	Day of year
3	Month number
4	Day of month
5	Hour
6	Minute (start of observation)
7	Second (start of observation)
	Columns 8-39 correspond to the N(D) for each of the 32 raindrop diameters
8	N(D), D = 0.062 mm
9	N(D), D = 0.187 mm
10	N(D), D = 0.312 mm
11	N(D), D = 0.437 mm
12	N(D), D = 0.562 mm
13	N(D), D = 0.687 mm
14	N(D), D = 0.812 mm
15	N(D), D = 0.937 mm
16	N(D), D = 1.062 mm

17	N(D), D = 1.187 mm
18	N(D), D = 1.375 mm
19	N(D), D = 1.625 mm
20	N(D), D = 1.875 mm
21	N(D), D = 2.125 mm
22	N(D), D = 2.375 mm
23	N(D), D = 2.750 mm
24	N(D), D = 3.250 mm
25	N(D), D = 3.750 mm
26	N(D), D = 4.250 mm
27	N(D), D = 4.750 mm
28	N(D), D = 5.500 mm
29	N(D), D = 6.500 mm
30	N(D), D = 7.500 mm
31	N(D), D = 8.500 mm
32	N(D), D = 9.500 mm
33	N(D), D = 11.00 mm
34	N(D), D = 13.00 mm
35	N(D), D = 15.00 mm
36	N(D), D = 17.00 mm
37	N(D), D = 19.00 mm
38	N(D), D = 21.50 mm
39	N(D), D = 24.50 mm

4.4.3 Images

Daily images were generated from the Parsivel observations and contain the 1-minute reflectivity, rain rate, and number concentration N(D). A daily image from 20 May is shown in Figure 3. The daily Parsivel images are in TIF formation and follow the filename convention:

sgpparsivelC1.a1.YYYYMMDD.ZRND.mc3e.tif

All of the daily files are zipped into one file with the name:

sgpparsivelC1.a1.20110405.through.20110606.ZRND.mc3e.tif.zip

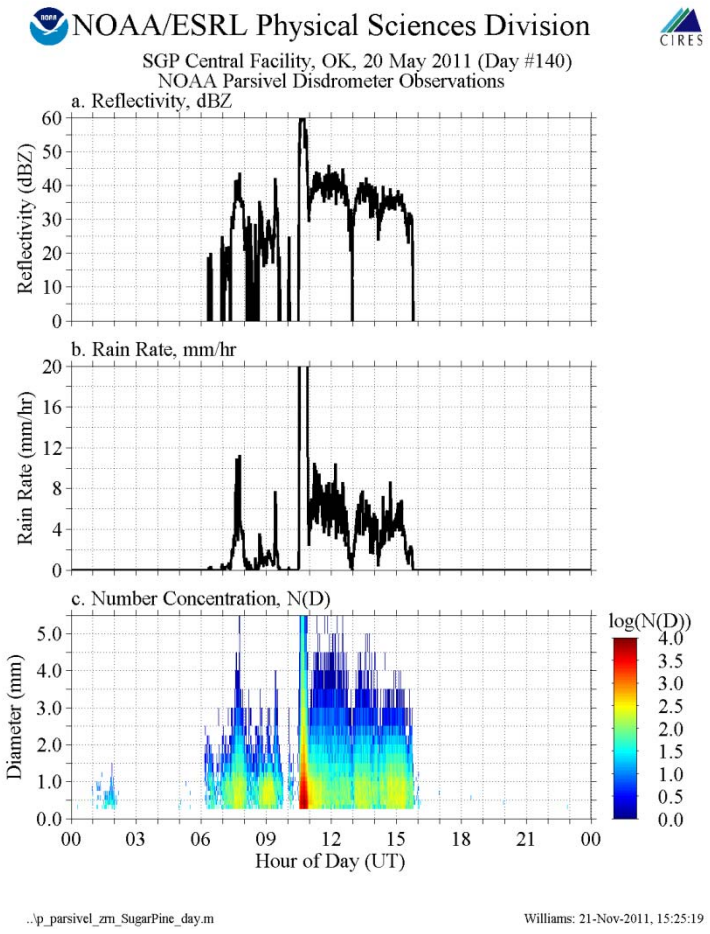

Figure 3. Parsival estimated surface reflectivity (top), rain rate (middle) and number concentration N(D) (bottom) for 20 May 2011.

5. S-band Profiler

5.1 Installation

A profiler operating at 2.835 GHz (in the S frequency band) was deployed in Northern Oklahoma at the DOE Atmospheric Radiation Mission (ARM) Southern Great Plans (SGP) Central Facility from 8 April through 7 June 2011. The S-band profiler was deployed by NOAA (http://www.esrl.noaa.gov/psd/ data/obs/instruments/WindProfilerDescription.html). The purpose of the S-band profiler was to measure the vertical structure of precipitation from approximately 200 meters to 16 km above the ground when precipitation passed over the profiler site. The profiler used a dish antenna that can be seen in the background in Figure 1 and in the foreground in Figure 2.

5.2 S-band Profiler Raw Spectra Data Sets

There are three classes of data sets available from the S-band profiler: *raw data*, *processed data*, and *engineering data*. The raw data consist of uncalibrated Doppler velocity spectra data

that would be useful for advanced profiler users that need the original Doppler velocity spectra in relative power return units for their data analysis. Using the raw data as the input, the processed data consist of calibrated and temporal averaged profiler data. It is expected that most users would use the processed data. The engineering data consists of time series of coherently averaged I and Q voltages to investigate instrument stability and develop new signal processing methods. All three types of data will be archived at DOE and NASA.

The S-band profiler operated in two modes: a precipitation mode and an attenuated mode. The modes are exactly the same except that the power return from the attenuated mode is approximately 30 dB less than the precipitation mode (the actual calibration procedure determined the attenuation had a mean of 29.2 dB with a 2 dB standard deviation). The attenuation mode is designed to observe precipitation at close ranges when the precipitation is so intense that the precipitation mode saturates. In examining the calibrated data, the precipitation mode saturated for only a few minutes during the whole campaign.

The raw S-band profiler data consists of uncalibrated Doppler velocity spectra data in units of relative power return. The S-band profiler operated with a 7-second dwell. Nine consecutive 7-second precipitation mode dwells were collected followed by one 7-second attenuated mode dwell. This 10 profile sequence was repeated throughout the field campaign. (Prior to 25 April, the 10 profile sequence consisted of seven precipitation mode profiles followed by three attenuation mode profiles.) The raw spectra were saved in netCDF format. The profiler operating parameters are shown in Table 4.

Table 4. S-band Operating Parameters

Radar Parameter	Value
Operating Frequency (GHz)	2.835
Wavelength (cm)	10.4
Peak Power (W)	380
Antenna Type	1.2-m shrouded dish
Beamwidth	2.5˚
Interpulse Period (μs)	110
Unambiguous Range (km)	16.5
Pulse Width (ns)	416
Range Resolution (m)	62.4
Range Spacing (m)	62.4
Number of Range Gates	250
Maximum Height Sampled (km)	15.7
Height of First Range Gate (km)	0.16
Number of Coherent Integrations	15
Nyquist Velocity (m s^{-1})	15.8
Number of points in Spectrum	256
Spectral Resolution (m s^{-1})	0.125
Number of Spectra Averaged Together	16
Dwell Time (s)	7
Number of Consecutive profiles w/out Attenuation	7 (pre-25 April) and 9 post-25 April
Attenuation Added During Attenuated Mode	30 dB

5.3 S-band Profiler Raw Spectra Filename Convention

The precipitation and attenuated mode spectra are saved in separate hourly files. The precipitation mode raw spectra data files have the following naming convention:

sgpsbdC1.00.YYYYMMDD.hhmmss.raw.mc3e_precip_popspc.cdf

Each hourly data file is about 105 MB. The attenuated mode raw spectra data files have the following naming convention:

sgpsbdC1.00.YYYYMMDD.hhmmss.raw.mc3e_atten_popspc.cdf

Each hourly data file is about 12 MB. Hourly data files were zipped into daily files named:

sgpsbdC1.00.YYYYMMDD.raw.mc3e_precip_popspc.cdf

sgpsbdC1.00.YYYYMMDD.raw.mc3e_atten_popspc.cdf

The file name structure is:

sgp - site identifier – Southern Great Plains
sbd - instrument identifier – S-band Profiler
C1 - facility designation – Central Facility
00 - data level – raw data

YYYY	- year
MM	- month
DD	- day of month
hhmmss	- hour, minute, second of first profile
raw	- data level – raw data
mc3e	- field experiment name
precip/atten	- operating mode – either precipitation or attenuation mode
popspc	- name of data – POP spectra
cdf	- netCDF data format
zip	- file compression – zip

5.4 Processed Data

The original spectra were processed to generate calibrated reflectivity weighted Doppler velocity spectra and Doppler velocity moments. Two temporal resolution data sets were generated. One set is at the original 7-second dwell and another set at a 1-minute dwell.

5.4.1 Calibrated S-band Profiler Spectra Data Sets, 7-sec Dwell

The S-band spectra were calibrated against the surface disdrometer to determine a radar calibration constant. Calibrated spectra were constructed for each profile and are expressed as reflectivity spectral density (units of reflectivity per m s^{-1}, or units of mm^6 m^{-3} (m s^{-1})$^{-1}$). The reflectivity, mean Doppler velocity and spectrum width were also estimated for each profiler. These estimates are saved in the hourly data files with the following filename convention:

sgpsbdC1.a1.YYYYMMDD.hh0000.calspc.mc3e_precip.cdf

sgpsbdC1.a1.YYYYMMDD.hh0000.calspc.mc3e_atten.cdf

The hourly files have been zipped into daily files following the filename convention:

sgpsbdC1.a1.YYYYMMDD.calspc.mc3e_precip.cdf.zip

sgpsbdC1.a1.YYYYMMDD.calspc.mc3e_atten.cdf.zip

The hourly data files are about 100 MB in size. Since the many profiles do not have valid signals are high ranges, the zipped daily files are typically less than 20 MB in size.

The file name structure is:

sgp	- site identifier – Southern Great Plains
sbd	- instrument identifier – S-band Profiler
C1	- facility designation – Central Facility
a1	- data level – converting from raw counts to geophysical units
YYYY	- year
MM	- month
DD	- day of month
hh0000	- hour with minute and second listed as 00 and 00

calspc	- name of data – Calibrated Spectra
mc3e	- field experiment name
precip/atten	- operating mode – either precipitation or attenuation mode
cdf	- netCDF data format
zip	- file compression – zip

5.4.2 Calibrated Moments, 7-sec Dwell

The calibrated moments of reflectivity, mean Doppler velocity and spectrum width contained in the calibrated spectra data file are also saved in separate hourly data files. This facilitates the use of the moments without needing to process the calibrated spectra. These calibrated moments are saved in the hourly data files with the following naming format:

sgpsbdC1.a1.YYYYMMDD.hh0000.calmom.mc3e_precip.cdf

sgpsbdC1.a1.YYYYMMDD.hh0000.calmom.mc3e_atten.cdf

The hourly files have been zipped into daily files following the filename convention:

sgpsbdC1.a1.YYYYMMDD.calmom.mc3e_precip.cdf.zip

sgpsbdC1.a1.YYYYMMDD.calmom.mc3e_atten.cdf.zip

Since the daily attenuated mode files are so small, all of the attenuated moment daily files have been zipped together into a file named:

sgpsbdC1.a1.20110416.through.20110607.calmom.mc3e_atten.cdf.zip

The file name structure is:

sgp	- site identifier – Southern Great Plains
sbd	- instrument identifier – S-band Profiler
C1	- facility designation – Central Facility
a1	- data level – converting from raw counts to geophysical units
YYYY	- year
MM	- month
DD	- day of month
hh0000	- hour with minute and second listed as 00 and 00
calmom	- name of data – Calibrated Moments
mc3e	- field experiment name
precip/atten	- operating mode – either precipitation or attenuation mode
cdf	- netCDF data format
zip	- file compression – zip

5.4.3 Calibrated Spectra, 1-min Dwell

The original 7-sec dwell raw spectra were aggregated into 1-minute dwells and then calibrated to yield 1-minute calibrated spectra. The reflectivity, mean Doppler velocity and spectrum width

were estimated from the minute spectra. Since there is approximately one attenuated mode every minute, the attenuated mode was not averaged into 1-minute dwells. Only the precipitation mode was processed into 1-minute data sets. The minute spectra and moments were saved in hourly data files with the following filename convention (note the '1' in the fourth position indicating the data have 1 minute resolution):

sgp1sbdC1.a1.YYYYMMDD.hh0000.calspc.mc3e_precip.cdf

The hourly files have been zipped into daily files following the filename convention:

sgp1sbdC1.a1.YYYYMMDD.calspc.mc3e_precip.cdf.zip

The hourly data files are about 15 MB in size. But since the profiles contain many heights that don't have valid signals, the zipped daily files are typically less than 4 MB.

The file name structure is:

sgp	- site identifier – Southern Great Plains
1	- Averaging interval in minutes – 1 minute average data
sbd	- instrument identifier – S-band Profiler
C1	- facility designation – Central Facility
a1	- data level – converting from raw counts to geophysical units
YYYY	- year
MM	- month
DD	- day of month
hh0000	- hour with minute and second listed as 00 and 00
calspc	- name of data – Calibrated Spectra
mc3e	- field experiment name
precip	- operating mode – precipitation mode
cdf	- netCDF data format
zip	- file compression – zip

5.4.4 Calibrated Moments, 1-min Dwell

The 1-min calibrated reflectivity, mean Doppler velocity and spectrum width contained in the hourly 1-min calibrated spectra data files were also saved in separate daily data files. These daily moment data files have the following filename convention (note the '1' in the fourth position indicating the data have 1 minute resolution):

sgp1sbdC1.a1.YYYYMMDD.calmom.mc3e_precip.cdf

The daily files for the whole MC3E campaign have been zipped into one file with the name:

sgp1sbdC1.a1.20110416.through.20110607.calmom.mc3e_precip.cdf.zip

The file name structure is:

sgp	- site identifier – Southern Great Plains
1	- Averaging interval in minutes – 1 minute average data
sbd	- instrument identifier – S-band Profiler
C1	- facility designation – Central Facility
a1	- data level – converting from raw counts to geophysical units
YYYY	- year
MM	- month
DD	- day of month
calmom	- name of data – Calibrated Moments
mc3e	- field experiment name
precip	- operating mode – precipitation mode
cdf	- netCDF data format
zip	- file compression – zip

5.5 Calibration of Precipitation Mode using the Parsivel Observations

The S-band profiler was calibrated using the surface parsivel disdrometer. Uncalibrated S-band profiler reflectivities from the lowest 10 range gates were compared with the surface disdrometer reflectivities. Four stratiform rain events were used to calibrate the profiler and are shown in Figures 4 to 7. The calibration constant affects the reflectivity but does not affect the mean Doppler velocity or the spectrum width. The calibration constant varied from -52.6 (24 April), -50.1 (27 April), -52.8 dB (11 May), and -51.5 (20 May). All precipitation mode spectra and resulting moments were calibrated with a calibration constant of -52.0 dB. If a user wants to change the profiler calibration, then just add or subtract a constant reflectivity in dBZ.

The calibration constant was calculated as a function of height and is shown in Figure 8. The decrease in calibration constant on 27 April near 1400 m is due to the height of the radar brightband.

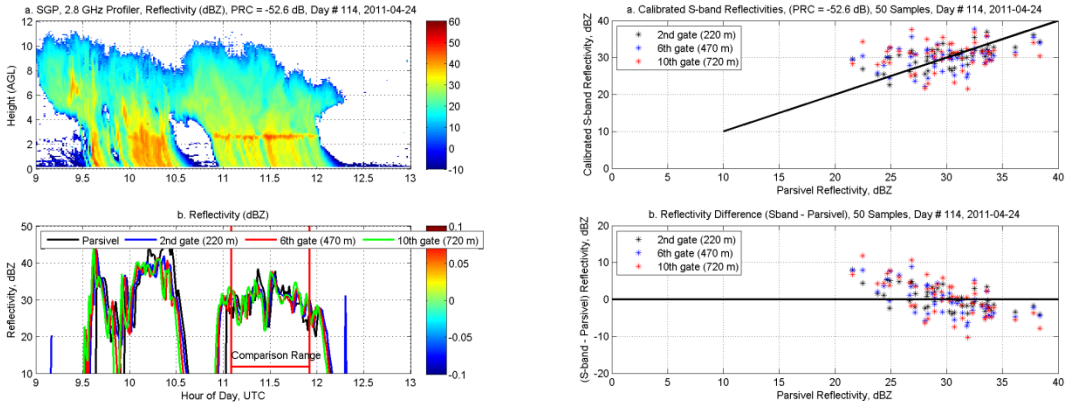

Figure 4. Time series calibration section (left), scatter plot (right), 24 April 2011.

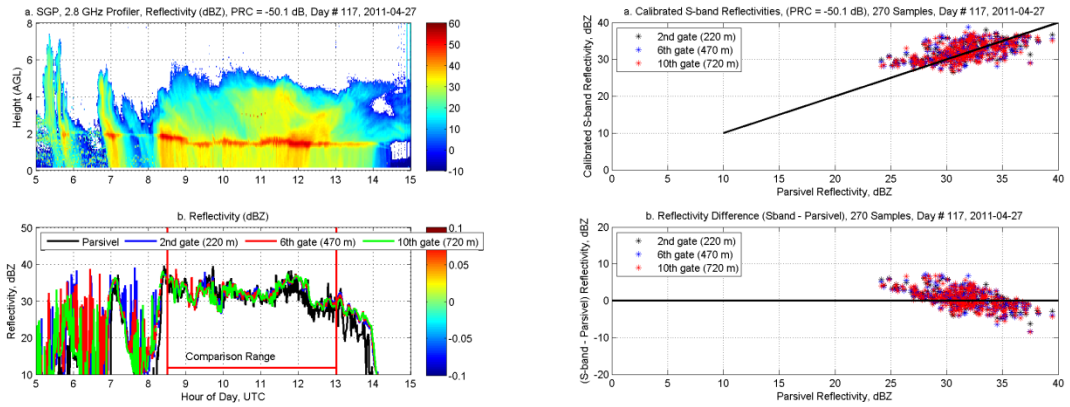

Figure 5. Time series calibration section (left), scatter plot (right), 27 April 2011.

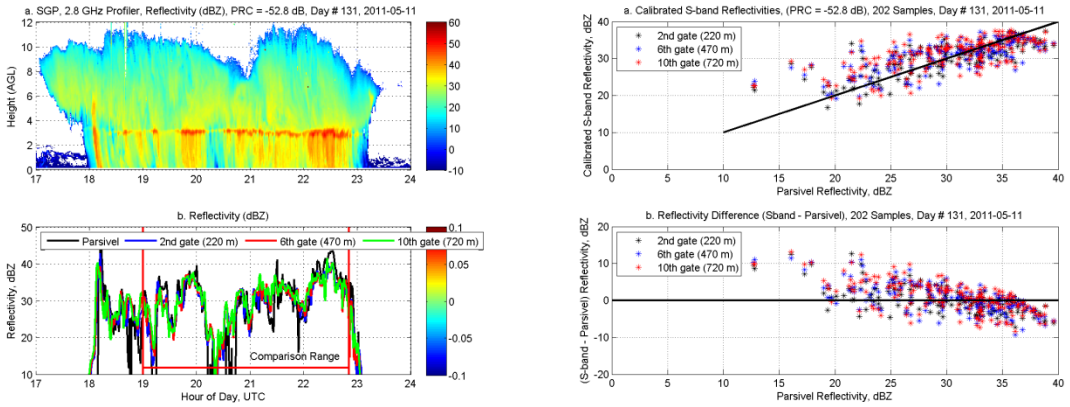

Figure 6. Time series calibration section (left), scatter plot (right), 11 May 2011.

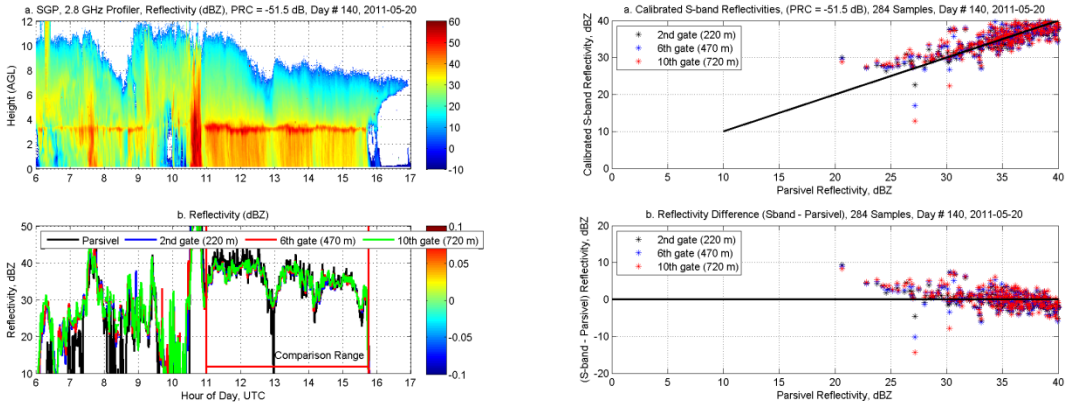

Figure 7. Time series calibration section (left), scatter plot (right), 20 May 2011.

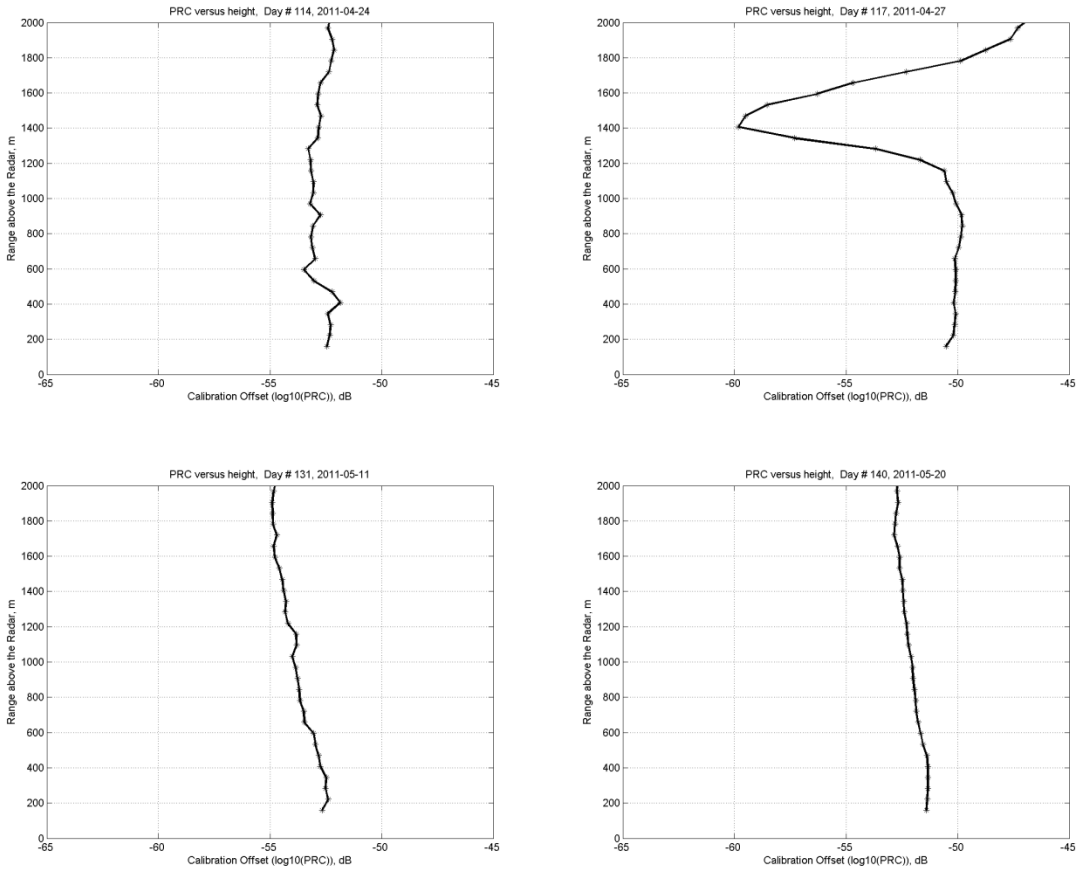

Figure 8. Calibration constant as a function of height, 24 April (top left), 27 April (top right), 11 may (bottom left), 20 May (bottom right).

5.6 Calibration of Attenuated Mode using the Precipitation Mode

The attenuation mode calibration constant is determined by comparing the attenuation mode against the calibrated precipitation mode. The difference in signal-to-noise ratio (SNR) between the two modes was determined by comparing the SNR at the same range gate from neighboring attenuation and precipitation profiles. The scatter plot of precipitation SNR vs. attenuation SNR and (Precip – Atten SNR) vs. attenuation SNR for three different rain events are shown in Figures 9, 10, and 11. As long as the attenuation mode SNR is greater than 0 dB, the mean SNR difference was about 29.2 dB with a standard deviation of about 2 dB. The hardware was designed to have a nominal attenuation of 30 dB.

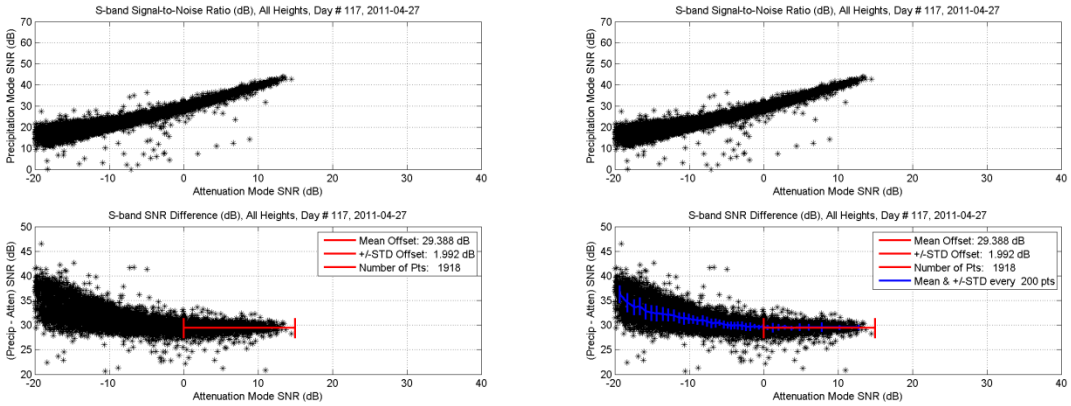

Figure 9. Scatter plot of SNR at the same range gates for neighboring attenuation and precipitation profiles for 27 April using hours 5 through 14 UTC.

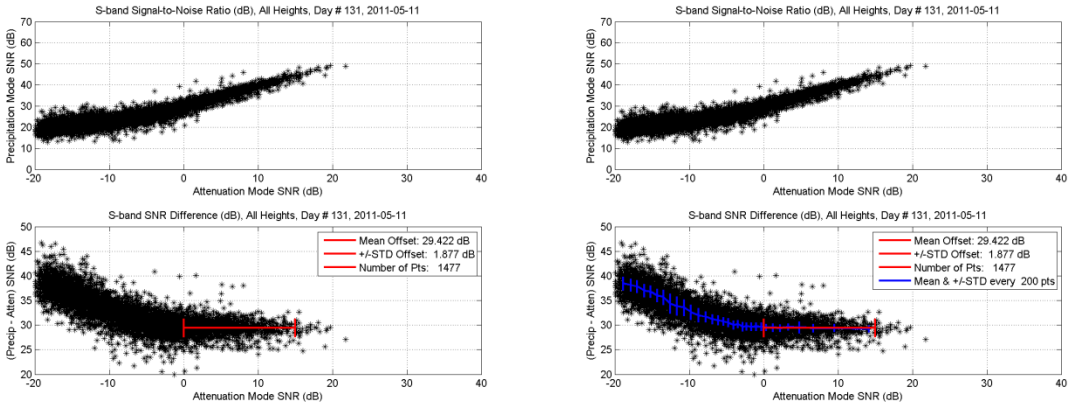

Figure 10. Same as Figure 9, except for 11 May and hours 17 through 23.

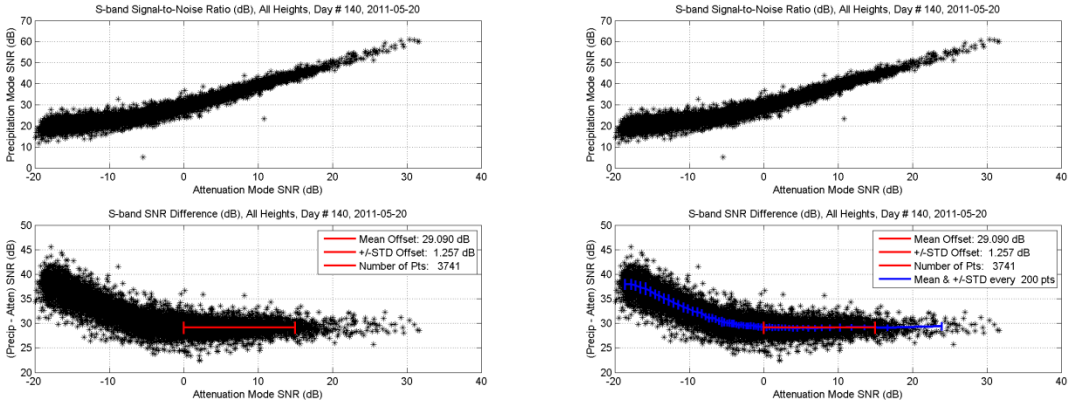

Figure 11. Same as Figure 9, except for 20 May and hours 6 through 16.

5.7 Quick Look Images

Hourly, daily, and spectra plots were generated for all processed S-band data sets discussed in section 5.4. These images allow the user to examine the data and identify events before accessing the netCDF data files. The images show the occasional radio frequency interference (RFI) as well as scattering from insects. Very little quality control is performed on the raw data so that all atmospheric signals are retained. It is expected that the end user will need to perform a small amount of QC to remove unwanted signals.

5.7.1 Calibrated Precipitation Moments: 7-Sec Dwell

The 7-sec dwell estimates of reflectivity, mean Doppler velocity and spectrum width are shown in hourly time-height cross-sections. An example is shown in Figure 12.

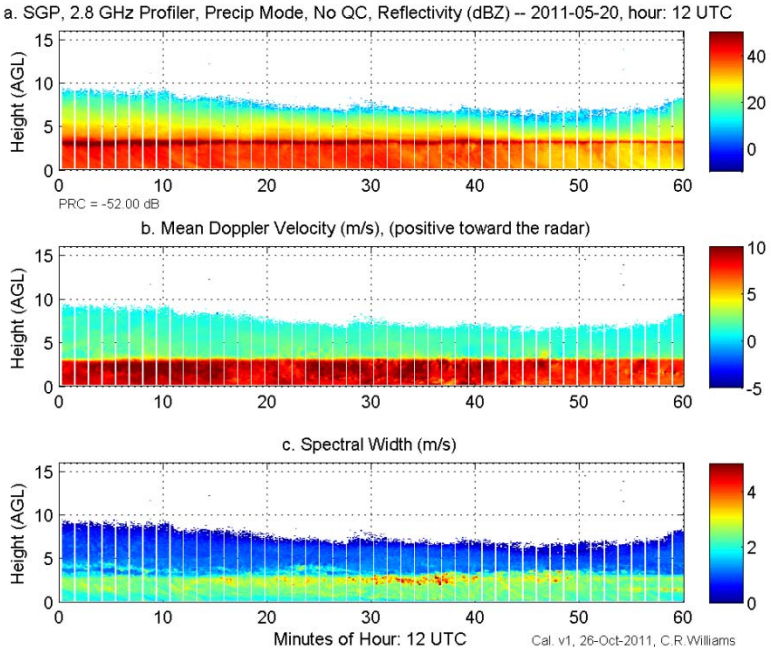

Figure 12. Time-height cross-section of 7-sec dwell reflectivity (top), mean Doppler velocity (positive is toward the observer – positive toward the ground – middle), and spectrum width (bottom) for 20 May 2011, hour 12 UTC.

The input netCDF file is named:

sgpsbdC1.a1.YYYYMMDD.hh0000.calmom.mc3e_precip.cdf

The output TIF image is named:

sgpsbdC1.a1.YYYYMMDD.hh0000.calmom.mc3e_precip.tif

5.7.2 Calibrated Precipitation Moments: 1-min Dwell

The 1-min dwell estimates of reflectivity, mean Doppler velocity and spectrum width are shown in hourly and daily time-height cross-sections. An example of an hourly 1-min cross-section image is shown in Figure 13 and an example daily image is shown in Figure 14.

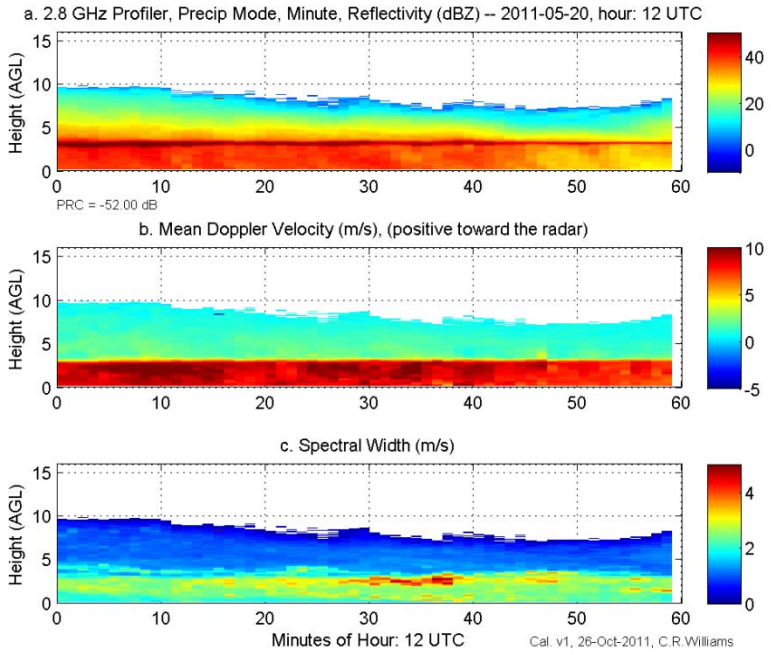

Figure 13. Same as Figure 12, except using 1-min dwell data.

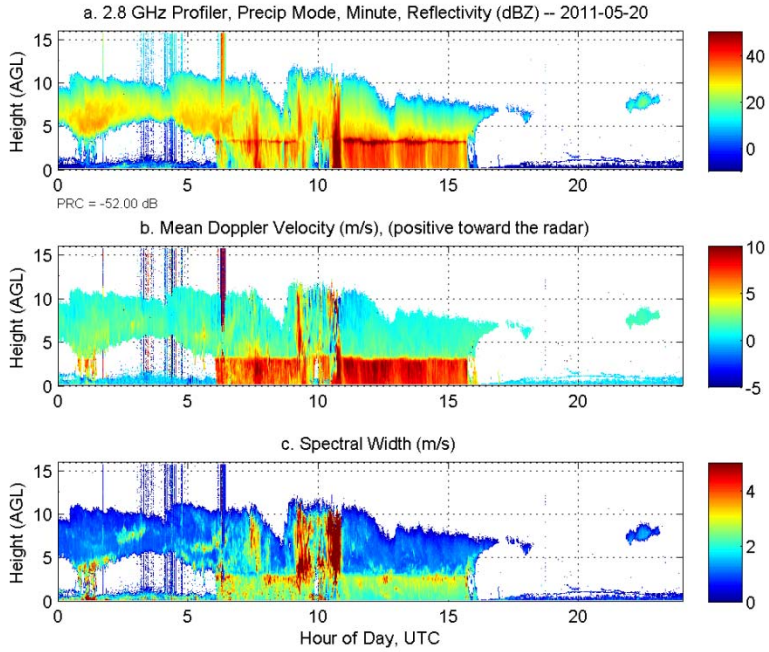

Figure 14. Time-height cross-section of 1-min dwell reflectivity (top), mean Doppler velocity (positive is toward the observer – positive toward the ground – middle), and spectrum width (bottom) for 20 May 2011.

The input netCDF file is named:

sgp1sbdC1.a1.YYYYMMDD.calmom.mc3e_precip.cdf

The output hourly and daily TIF images are named:

sgp1sbdC1.a1.YYYYMMDD.hh0000.calmom.mc3e_precip.tif (hourly)

sgp1sbdC1.a1.YYYYMMDD.calmom.mc3e_precip.tif (daily)

5.7.3 Spectra Profiles, 7-Sec and 1-min Dwells

Vertical profiles of calibrated reflectivity spectral density were generated for rain events. The images contain the reflectivity spectral density, the mean Doppler velocity, spectrum width, and the reflectivity at each range gate. Images were generated at both the 7-sec and 1-min dwells. Only the hours with precipitation were processed to generate spectra images. An example of the two dwell is shown in Figure 15.

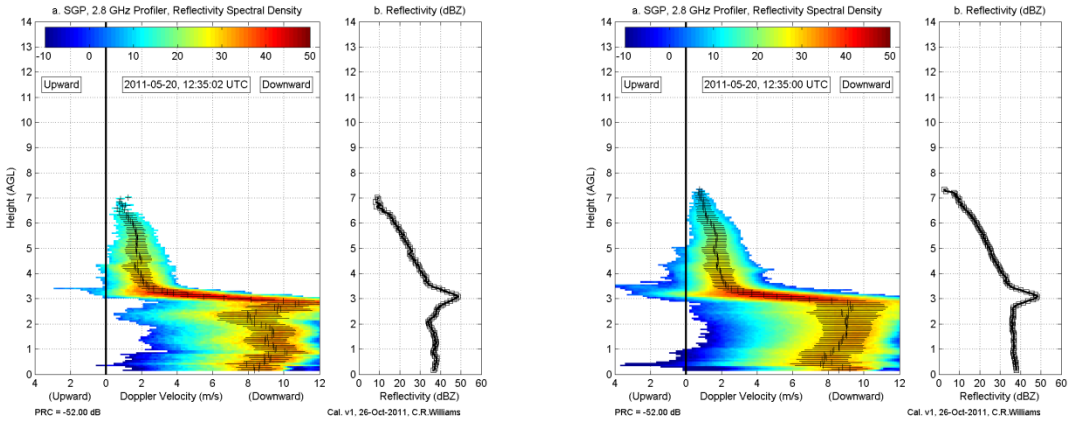

Figure 15. Vertical profiles of reflectivity spectral density (colored images) and reflectivity (line images). Both profiles are from 20 May 2011 during hour 12 and minute 35 UTC. The image on the left is a 7-sec dwell spanning seconds 02 through 09. The image on the right is a 1-min dwell accumulating all profiles during the 60 seconds of minute 35. At each range gate, the mean Doppler velocity is shown with plus symbols and spectrum width is shown with horizontal lines.

The input netCDF files are named:

sgpsbdC1.a1.YYYYMMDD.hh0000.calspc.mc3e_precip.cdf (7-sec dwell)

sgp1sbdC1.a1.YYYYMMDD.hh0000.calspc.mc3e_precip.cdf (60-sec dwell)

The output spectra TIF images are named:

sgpsbdC1.a1.YYYYMMDD.hhmmss.calspc.mc3e_precip.tif (7-sec dwell)

sgp1sbdC1.a1.YYYYMMDD.hhmm00.calmom.mc3e_precip.tif (60-sec dwell)

For days 23 and 24 May 2011, additional spectra images were generated with wide Nyquist velocities of +/- 16 m s^{-1} to allow for observing strong vertical air motions. These images are named:

sgpsbdC1.a2.YYYYMMDD.hhmmss.calspc.mc3e_precip.tif (7-sec dwell)

6. 449-MHz Profiler

6.1 Installation

A profiler operating at 449 MHz was deployed in Northern Oklahoma at the DOE Atmospheric Radiation Mission (ARM) Southern Great Plans (SGP) Central Facility from 8 April through 7 June 2011. The 449-MHz profiler was deployed by NOAA (http://www.esrl.noaa.gov/psd/data/obs/instruments/WindProfilerDescription.html). The purpose of the 449 MHz profiler was to measure the vertical air motion from approximately 200 to 2000 meters above the ground when precipitation passed over the profiler site. The profiler used a phased array antenna and was

configured to only point in the vertical direction. The phased array antenna can be seen in the background in Figure 1 and in the foreground in Figure 2.

6.2 449-MHz Profiler Raw Spectra Data Sets

The raw 449-MHz profiler data consists of uncalibrated Doppler velocity spectra data in units of relative power return. The 449-MHz profiler is sensitive to both Bragg scattering resulting from turbulence and humidity gradients and to Rayleigh scattering from raindrops and ice particles. Additional data analysis and quality control is needed to separate the Bragg and Rayleigh scattering signals to estimate the vertical air motion during precipitation.

The 449-MHz profiler operated in one mode and continuously observed in the vertical direction. It took about 45 seconds to collect one profile of Doppler velocity spectra. The raw spectra were saved in netCDF format. The 449-MHz profiler operating parameters are shown in Table 5.

Table 5. 449-MHz Profiler Operating Parameters

Radar Parameter	Value
Operating Frequency (MHz)	449
Wavelength (cm)	66.8
Peak Power (W)	6000
Antenna Type	Collinear coaxial array
Beamwidth	9˚
Interpulse Period (μs)	120
Unambiguous Range (km)	18
Pulse Width (ns)	1417
Range Resolution (m)	212
Range Spacing (m)	212 (pre-9 May) 106 (post-9 May)
Number of Range Gates	77 (pre-9 May) 154 (post-9 May)
Maximum Height Sampled (km)	16.3
Height of First Range Gate (km)	0.16
Number of Coherent Integrations	88
Nyquist Velocity (m s^{-1})	15.7
Number of points in Spectrum	256
Spectral Resolution (m s^{-1})	0.124
Number of Spectra Averaged Together	16
Dwell Time (s)	45

6.3 449-MHz Profiler Raw Spectra Filename Convention

The raw spectra were saved in hourly netCDF format data files using the filename convention:

sgp449MHzC1.00.YYYYMMDD.hhmmss.raw.mc3e_popspc.cdf

Each hourly file is about 7 MB in size. Hourly data files were zipped into daily files with filename convention:

sgp449MHzC1.00.YYYYMMDD.raw.mc3e_popspc.cdf.zip

The file name structure is:

sgp	- site identifier – Southern Great Plains
449MHz	- instrument identifier – 449-MHz Profiler
C1	- facility designation – Central Facility
00	- data level – raw data
YYYY	- year
MM	- month
DD	- day of month
raw	- data level – raw data
mc3e	- field experiment name
popspc	- name of data – POP Spectra
cdf	- netCDF data format
zip	- file compression - zip